M. A. Murphy
Curragh Military Hospital.

A MANUAL

of

ANATOMY

By

HENRY ERDMANN RADASCH, M. Sc., M. D.

ASSISTANT PROFESSOR OF HISTOLOGY AND EMBRYOLOGY IN JEFFERSON MEDICAL COLLEGE; INSTRUCTOR IN ANATOMY IN THE PENNSYLVANIA ACADEMY OF FINE ARTS, PHILADELPHIA

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PREFACE

This book was originally intended as a Visceral Anatomy for the use of first-year medical students. Although there are numerous and excellent anatomies published, they are all large and voluminous. There being a need for an anatomy of intermediate size, the original manuscript has been enlarged at the suggestion of the publishers. Chapters in Osteology, Syndesmology, and Myology have been added and the chapters on the Blood-Vascular and Nerve Systems have been extended so as to include the appendages and their plexuses, thereby making this work desirable for medical students, medical preparatory students and nurses.

The anatomy and histology of the nerve system is taken up in a manner different from that used in most anatomies. The external anatomy is continued from one segment to another, uninterruptedly, and the histology is taken up in the same manner. In this way the student has a more connected idea of the parts and their relations to one another. In addition the various pathways are given separate and rather full consideration, so that impulses may be traced, in a connected manner, from origin to termination.

The semilunar valves of the aorta and pulmonary artery are described in all anatomies under the ventricles, without justification from a standpoint of anatomy and embryology. In this work they are described in their respective vessels, where they should be taken up.

Although the B. N. A., as a whole, is not all that could be desired this nomenclature is given in parentheses. The author has used the terms ventral and dorsal instead of anterior and posterior, respectively, in order to avoid confusion arising between anatomists and embryologists. The latter use the terms anterior and posterior exclusively for head and tail directions, and not synonymously with ventral and dorsal. For this reason the author uses cephalad and caudad for headward and tailward, discarding anterior and posterior altogether and avoiding confusion arising in comparative anatomy.

The illustrations of the first three chapters are from Sobotta and McMurrich's work. Many of those of the visceral portion are adapted from standard works as Cunningham, Gray, Piersol, Morris and Rauber-Kopsch. A number of the illustrations were made from photographs of organs and preparations at the Daniel Baugh Institute of Anatomy and Biology.

The author desires to thank Dr. J. J. Fauz for his assistance in the preparation of the photographs and some of the drawings and Mr. Smoczynski for his assistance in the preparation of the outlines of the organs; also the publishers for their suggestions and many courtesies.

H. E. Radasch.

Malvern, Pa.,
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CONTENTS

A MANUAL OF ANATOMY

CHAPTER I

OSTEOLOGY

The *skeleton* is a framework of bone and cartilage that serves for the attachment of the muscles. The *axial* portion comprises the head and trunk and is comparatively rigid or fixed, while the *appendicular* portions, the *appendages*, are extremely mobile; the bones of the extremities represent a system of levers actuated by the muscles and acting upon the joints, which constitute the fulcra. The human skeleton is an endoskeleton which is more or less completely invested by the muscles and completely covered by the skin.

The adult skeleton comprises 206 individual bones arranged as follows:

		Single bones	Pairs	Total	
Axial Skeleton........	The vertebral column	26	....	26	
	The ribs		12	24	
	The sternum	1		1	
	The skull	6	8	22	
	The hyoid bone	1		1	
					74
Appendicular Skeleton	Pectoral appendage		32	64	
	Pelvic appendage		31	62	
					200
Auditory Ossicles			3	6	6
					206

Bone is a derivative of the mesoderm and represents the most highly differentiated of the connective tissues. It is mainly a secondary tissue as in most instances it is derived from cartilage. It consists of *cells* and *intercellular substance*. The *latter* is a hard, tough resistant, yet elastic substance to which the peculiar characteristics of bone are due. Osseous tissue consists of about 66 per cent. of inorganic, or earth salts and of 34 per cent. of organic material. The inorganic salts comprise phosphates, carbonates and fluorid of calcium, also chlorid of sodium and phosphate of magnesium. The organic material includes fats, collagen, etc. If a fresh bone be burned or calcined, the organic material will be removed and a porous cast of the bone, representing the earthy salts, will remain. If a bone be subjected to the action of a mineral acid, the earthy material is removed and flexible bone, representing the organic substances, remains. The elasticity and toughness of the bone is due to the organic substance while the inorganic salts impart hardness to it.

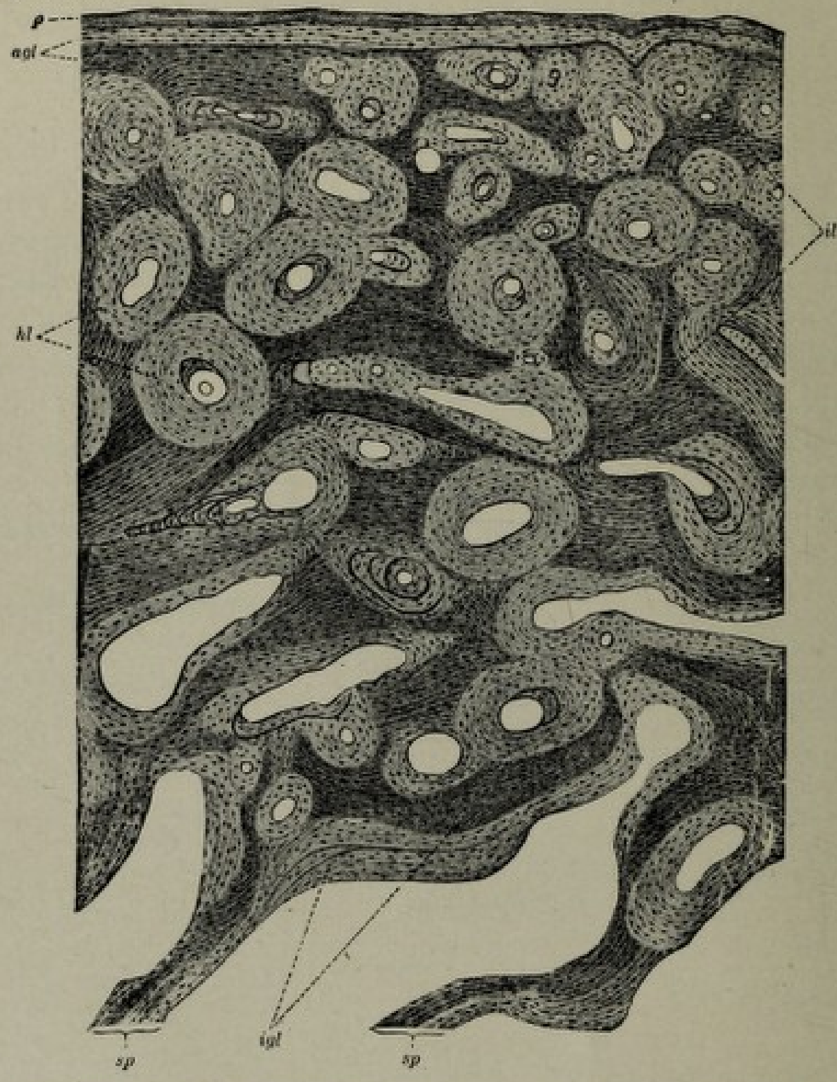


FIG. 1.—Portion of a cross-section of a decalcified human radius. × about 4.8. (*Sobotta and Huber*, "*Atlas of Human Histology*.") The figure shows the lamellar systems of compact bone, as well as some trabeculæ of spongy bone. *agl*, periosteal lamellæ; *igl*, perimedullary lamellæ; *il*, interstitial lamellæ; *hl*, Haversian lamellæ; *p*, periosteum; *sp*, trabeculæ of spongy bone.

Fresh bone upon examination shows the presence of an enveloping membrane, the *periosteum*. This is tough, does not strip readily and serves for the attachment of muscles and tendons. The articular portions of a bone are covered with hyalin cartilage. Cleaned specimens are devoid of these two structures.

In order to study bone under the microscope it must be decalcified and sectioned, or pieces must be ground so thin that their structure is readily discernible.

There are *two varieties* of bone, *compact* and *cancellous*.

The **compact variety** is the more abundant and exhibits a characteristic structure. Surrounding all bones there is a fibrous sheath, the *periosteum*. This consists of white fibrous connective tissue and its deep layer is rich in blood-vessels and *cells*, the future *osteoblasts*. From its inner layer bundles of fibers (*Sharpey's*) penetrate the bone. The real osseous tissue is arranged in four varieties of lamellæ and between the lamellæ are the lacunæ and canaliculi.

1. The *periosteal lamellæ* are few in number and lie just beneath the periosteum. These constitute the circumference of the bone and between them are the lacunæ, containing osteoblasts, and the canaliculi. *Howship's lacunæ* are on the surface and canals (*Volkmann's*) pierce the layers and transmit blood-vessels for a short distance.

2. The *Haversian lamellæ* are hollow cylinders of bone that fit into one another, the central one containing the *Haversian canal*. The number in a system varies from three to eight. Between the layers are the lacunæ and canaliculi. The Haversian canals of the various systems anastomose with one another. These canals are for the transmission of blood-vessels.

3. The *intermediate lamellæ* fill in the areas between the cylindrical Haversian systems. They are irregular in course and contain lacunæ and canaliculi.

4. The *perimedullary lamellæ* are irregular in number and extent and when present they are seen on the marrow-cavity surface of the bone and are comparable to the periosteal lamellæ.

The *lacunæ* are irregular, stellate spaces and contain the osteoblasts. The *canaliculi* serve to connect the various lacunæ together and to support the processes of the osteoblasts.

An *osteoblast* is an irregular, stellate cell with a flattened body. Its processes are numerous, but short and heavy. These cells have to do with the formation of osseous tissue, but in what manner they do it is unknown.

Compact bone constitutes the shafts of the long bones, covers their extremities and forms the outer portion of the short, irregular and flat bones.

Cancellous bone consists of delicate bars of osseous tissue that form a network resembling a sponge. Lacunæ, canaliculi and osteoblasts are present but Haversian systems are absent. This variety is found in the ends of the marrow-cavity of the long bones, forms the bulk of the extremities of these bones and of the flat, short and irregular bones. This variety imparts lightness and permits of an increase in size without sacrificing strength.

The *medullary*, or *marrow-cavity*, is long, narrow and contains the marrow; it is found in the shafts of the long bones. It is lined by the *endosteum* which serves as an internal periosteum and a covering for the marrow.

Bone Marrow.—In the adult there are *two varieties of bone marrow, red* and *yellow*. In early life only red marrow is found. The *red marrow* consists of a delicate network of reticulum connected with the endosteum. It supports various cellular elements and blood-vessels, nerves and lymphatics. The cellular elements are as follows:

1. *Myelocytes* are large, nucleated masses of granular protoplasm that exhibit ameboid movements. These are seen only in marrow under normal conditions.

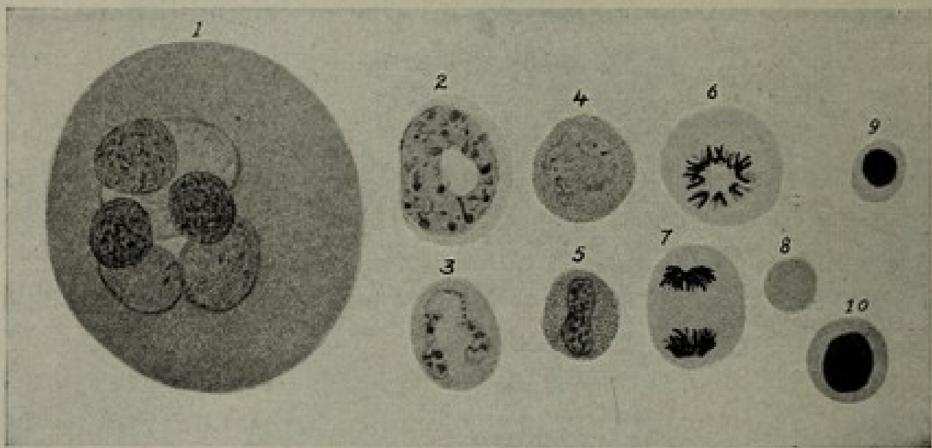


FIG. 2.—Blood. Elements of the bone-marrow of a mouse. × 700. (*Sobotta and Huber, "Atlas of Human Histology."*) The preparation was taken from the femur of a full-grown mouse. 1. Polynuclear giant-cell (myeloplax); 2–7, marrow-cells; 2, marrow-cell with annular nucleus (goes through the nuclear stage of 4 into that of 3—that is, into the ordinary polymorphonuclear cell); 4 and 5, acidophile cells; 6 and 7, mitoses; 8, ordinary erythrocyte; 9 and 10, nucleated erythrocytes.

2. *Erythroblasts* are nucleated red blood cells and are very numerous as the red marrow is practically the only tissue in which they are formed.

3. *Erythrocytes* are normal red blood cells that have just been formed from the preceding and are ready to go into the blood stream.

4. *Leukocytes* are white blood cells and are of the finely and coarsely granular eosinophilic and basophilic types.

5. *Myeloplaxes*, or *osteoclasts*, are large, irregular masses of protoplasm that may contain one or more nuclei. They are bone-destroying cells and are of great importance in the growth and repair of bone. They are capable of ameboid motion and are also phagocytic in action.

6. *Osteoblasts* are mentioned in bone marrow but they are chiefly at the periphery and are not essential to the marrow.

Fat is seen in small quantities in red marrow but predominates in yellow marrow.

In the adult, red marrow is found in the extremities of the long bones and in the centers of the flat and irregular bones, or wherever cancellous bone is found.

Yellow bone marrow is the result of the deposition of a great quantity of fat in the red marrow of the shafts of the long bones. As a result the cellular elements are greatly reduced and its function as a seat of blood-cell formation is practically nil. It is found only in adults.

Serous, or *mucoid marrow* results when the fat and cellular elements are absorbed and replaced by a serous infiltrate, as in old age, starvation and certain diseases. It thereby loses its function of making blood cells.

Bone Development.—There are two methods, *endochondral* and *intramembranous*.

In the *endochondral* form the hyalin cartilage is replaced by osseous tissue. All of the bones of the body except those of the face and vault of the cranium are said to be formed by this method but the endochondral bones are really formed by a combination of the two methods, as will be seen. The point at which bone formation first begins is called the *center of ossification*. There are several of these centers for each of the bones and these will be considered later.

At the center of a ossification the cartilage cells reproduce rapidly and arrange themselves in rows parallel to the long axis of the bone (proliferation). Calcareous salts are deposited in the cartilage partitions and most of the cartilage cells disappear (calcification). New cells, *chondroclasts*, appear and destroy some of the partitions, forming a series of small spaces called *primary areolæ*. Osteoblasts gain access to these spaces and lay down a thin veneer of osseous tissue upon the cartilaginous and calcareous partitions. The perichondrium becomes the periosteum and its cells form a layer of periosteal bone. Blood-vessels and osteoblasts penetrate the little bone and enter the areolæ which have been converted into a fewer number of larger spaces by the destruction of many of the partitions (vascularization). The first, or primary marrow, is then formed. The blood-vessels and osteoblasts proceed toward the extremities of the little shaft, almost to the area of proliferation. Gradually all of the calcareous material of all of the partitions is removed and replaced by osseous tissue. After this no more cartilage appears in the changed area. Each extremity is ossified from an independent center at a later date so that a pad of cartilage, the *epiphyseal disc*, intervenes between the shaft and each extremity until the bone has reached its full length. Then this disc ossifies and the parts are united so that this area can no longer be distinguished. The bone continues to grow in length by cartilage being formed a little more rapidly, in the epiphyseal disc, than it is converted into bone. The bone grows in diameter by the continual addition of new layers of periosteal bone. After a number of periosteal lamellæ have been formed, osteoclasts destroy all of the central cancellous bone and establish the primary adult marrow-cavity. They continue to destroy the oldest or innermost periosteal lamellæ but less rapidly than the new ones are formed upon the outside. As a result the marrow-cavity is formed and continues to grow at the expense of the compact bone but never as rapidly as the bone is formed. In the meantime Haversian systems are being formed from the periosteal lamellæ, and the remnants of the latter constitute the irregular lamellæ.

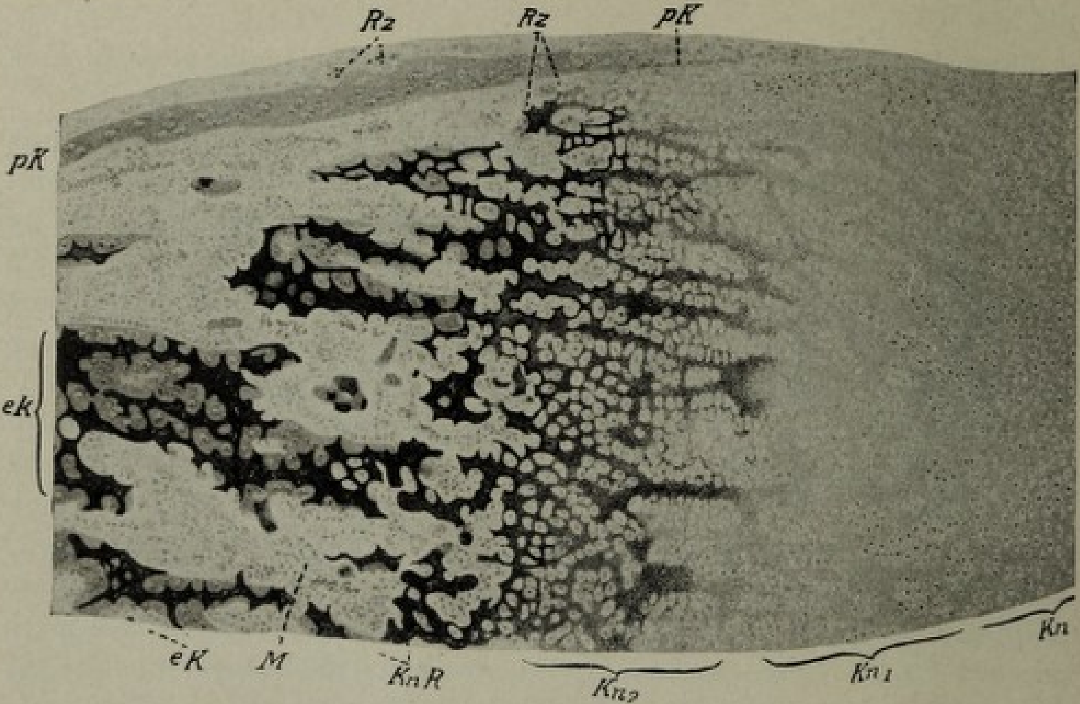


FIG. 3.—Bone development. Portion of a longitudinal section of a metacarpal bone of a five-month embryo. × 50. (*Sobotta and Huber, "Atlas of Human Histology."*) Outside in the perichondrium (periosteum) is a layer of periosteal bone. *eK*, bone formed by endochondral ossification; *Kn*, cartilage; Kn_1, zone in which the cartilage cells are arranged in rows; Kn_2, zone of enlarged cartilage cells and calcification of ground substance; *KnR*, remains of calcified cartilaginous matrix. *M*, marrow; *pK*, bone formed by periosteal ossification; *Rz*, giant-cells (osteoclasts).

In the extremities of the long bones and in the flat and irregular bones no marrow-cavity is formed. The cancellous tissue practically remains and is added to by the constant honeycombing action of the osteoclasts upon the innermost periosteal lamellæ. In this manner the central portions of these bones always remain cancellous and are covered by only a thin layer of compact bone.

In *intramembranous bone formation* ossification occurs without the intervention of cartilage. At the center of ossification (say of a skull bone) the mesodermal cells form a membrane from which fibers radiate in all directions and upon which calcareous material is deposited. The inner and outer boundary layers of this membrane become somewhat denser and constitute the periosteum. These layers give rise to the osteoblasts that secrete osseous tissue as above, forming periosteal lamellæ and a veneer for the calcareous trabeculæ. More periosteal lamellæ are added and the process spreads gradually in all directions. The calcific material is removed and replaced with bone and osteoclasts honeycomb the innermost or oldest layers of periosteal bone thereby increasing the amount of cancellous bone. The thin covering of compact bone constitutes the tables of the skull bones.

Bones are usually classified, as to *shape*, as *long*, *flat*, *short* and *irregular*. The **long bones** (ninety) are found in the extremities and include the femur, tibia, fibula, humerus, radius, ulna, clavicle, metacarpal and metatarsal bones and the phalanges. The name indicates the presence of a central, more or less cylindrical portion called the *diaphysis*, or *shaft*, and *two* more or less expanded portions the *epiphyses*, or *extremities*. The *diaphysis* is a hollow cylinder of compact bone that contains the yellow marrow in the adult. In the longer examples of this class the shaft is not straight but curved, thereby greatly strengthening the bone. The *epiphyses* are usually enlarged for articulation and muscle attachment. Each consists of a thin covering of compact bone surrounding a mass of cancellous bone that contains red marrow throughout life.

The **flat bones** (thirty-eight) are the scapulæ, ossa coxæ, sternum, ribs, frontal, vomer, parietals, nasals, lacrimals and patellæ. These are adapted for protection and consist mainly of a central mass of cancellous bone covered by a thin layer of compact bone. In the cancellous bone red marrow is found throughout life.

The **short bones** (thirty) are the carpal and tarsal bones. These serve to give strength to the parts and yet permit limited motion. Each consists of a central mass of cancellous bone, containing red marrow, surrounded by a layer of compact bone.

The **irregular bones** (thirty-eight) comprise the vertebræ, temporals, sphenoid, zygomatics, maxillæ, palatals, conchals, ethmoid, hyoid and sacrum. These are very irregular in shape and also consist of a mass of cancellous bone, containing red marrow, surrounded by a layer of compact bone. Some parts of these bones, however, are so thin as to be nearly transparent and these portions contain no cancellous bone.

Some place the patellæ and hyoid bones and the auditory ossicles (incus, malleus, and stapes) as *unclassified bones*. *Wormian bones* are found along the cranial sutures but are inconstant. *Sesamoid bones* are found in certain tendons of the muscles of the extremities; they are variable in number.

Very few of the bones show extensive smooth areas, but *lines*, *crests*, *ridges*, *spines*, *tubercles*, *processes*, *protuberances* and the like are seen. On the other hand, depressions of various kinds, as *pits*, *fossæ*, *cavities*, *furrows*, *grooves*, *fissures*, and *foramina*, or *canals*, *sinuses*, or *air spaces* are seen. Each serves its purpose as will be pointed out in each bone.

THE VERTEBRAL COLUMN (COLUMNA VERTEBRALIS)

The vertebral column comprises twenty-six individual bones in the adult; in early life thirty-three are present but certain ones fuse as will be indicated later. These bones are the **vertebræ** and they are classified as *true*, or *movable* and *false*, or *fixed*.

True, or movable		False, or fixed	
Cervical................	7	Sacrum............	(5 fused)
Thoracic................	12	Coccyx............	(4 fused)
Lumbar.................	5		

A **typical vertebra** comprises the *body* (ventral segment), the *neural arch* (dorsal segment) and a *number of processes*.

The *body* (*corpus vertebræ*) is the largest part but varies in size and form in the different segments of the vertebral column. It is nearly

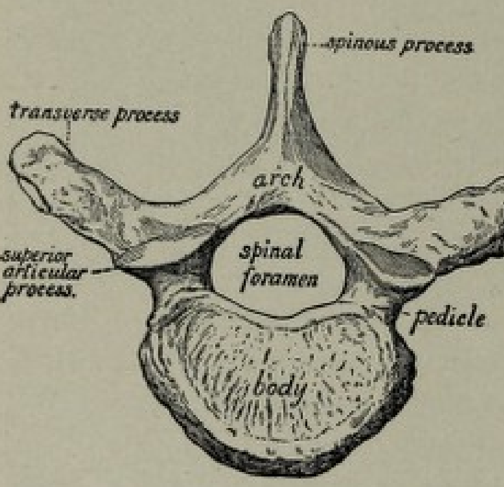


FIG. 4.—A vertebra seen from above. (*Sobotta and McMurrich.*)

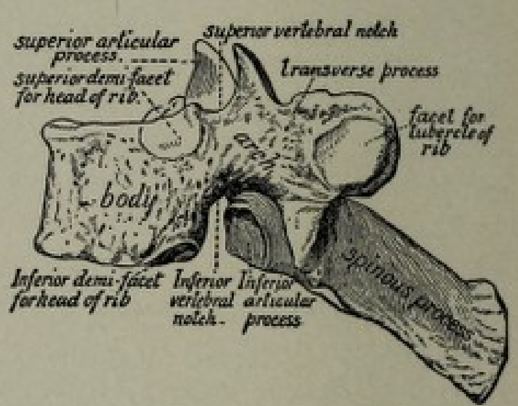


FIG. 5.—A vertebra seen from the side. (*Sobotta and McMurrich.*)

cylindrical in shape and its *superior* and *inferior surfaces* are flattened or slightly concave, to accommodate the intervertebral discs. Ventrally and at the sides the body is concave from above downward, as well as from side to side. The *dorsal surface* is concave from side to side. All parts exhibit numerous foramina that transmit the nutrient vessels of the bones.

The *neural arch* (*arcus vertebræ*) is formed by the *two roots of the vertebra* and *two laminæ*. The *pedicles*, or *roots of the vertebral arch* (*radix arcus vertebræ*) are two flattened bars of bone that pass dorsally from the body to the points of attachment of the articular processes. As these processes are not of the same height as the body, a distinct notch is formed between the body and the articular processes, above and below these roots. These are the *superior* and *inferior intervertebral notches* (*incisuræ vertebræ superior et inferior*). In the articulated vertebral column these become the *intervertebral foramina* for the transmission of the spinal nerves and vessels.

The *laminæ* are two, flat, rather broad, sloping plates of bone which extend dorsally, converge toward the midline and fuse with the root of the spinous process. These serve to complete the neural arch which, with the body, forms the *vertebral* or *spinal foramen.*

The *processes* are *muscular* and *articular*. The *muscular processes* are as follows: The *transverse processes*, two in number, vary in size and function in the different vertebræ. They extend laterally from the junction of the root of the arch and the lamina of each side. The *spinous process* is that mass of bone that extends dorsally, in the median plane of the body, from the junction of the fused laminæ. Its shape, size and direction varies in the different segments of the vertebral column.

The *articular processes* (zygapophyses) are *four* in number, *two superior* and *two inferior*. These are placed upon the upper and lower parts of the neural arch at the junction of the roots of the arch and laminæ. Each *superior process* (*processus articularis superior*) projects superiorly and faces, generally, dorsally. Each *inferior process* (*processus articularis inferior*) project inferiorly and faces, generally, in a ventral direction. These directions, however, differ in the various regions.

THE CERVICAL VERTEBRÆ

The cervical vertebræ are seven in number and are the smallest of the true vertebræ. The first and second are considerably modified and the seventh somewhat so. In all, the transverse processes are perforated by a foramen.

The *body* is oblong and the dorsoventral dimension is greater than the transverse. The *superior surface* is markedly concave from side to side and slopes dorsoventrally. The *lateral margins* are sharp and project superiorly while the *ventral edge* is rounded and smooth. The *inferior surface* is concave, dorsoventrally, and convex from side to side. The ventral edge overlaps the vertebra beneath. The *ventral surface* of the body is mainly flat but becomes concave at the sides. The *dorsal surface* is flat and rough and presents numerous foramina. At the superior part of the lateral surface of the body is attached the *transverse process*. Each is pierced by the *transverse foramen* (*foramen transversarium*) and consists of two parts, one dorsal and the other ventral to the foramen. The *dorsal portion* arises from the vertebral arch and represents the true transverse process; the *ventral portion* represents the ribs of the thoracic region.

These are united by a small bar of bone that completes the foramen and each division terminates in a small tubercle called *tubercula anterius et posterius*. These *processes* are grooved for the accommodation of the spinal nerve trunks. The vertebral artery and vein pass through the transverse foramina of the superior six cervical vertebræ. The *roots of the vertebral arches* arise from the middle of the side (dorsal portion) of the body and are directed dorsally and laterally, in a horizontal direction. Above and below these are the intervertebral notches. The *laminæ* are rather long and broad; they fuse in the midline dorsally. The *spinous processes* are short, bifid, flattened from above downward and are dorsally directed. The *articular processes* are dorsal to the transverse processes. The

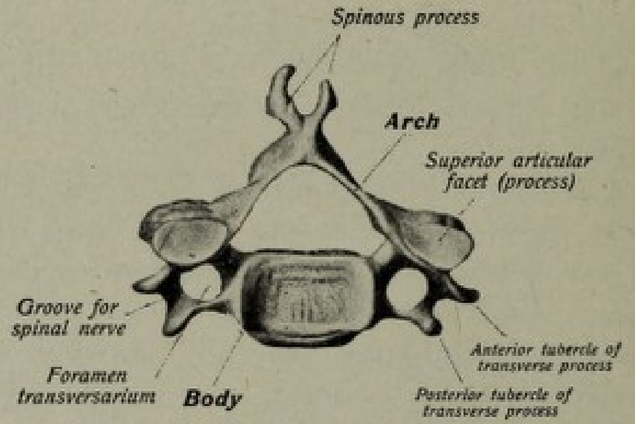


FIG. 6.—The fifth cervical vertebra seen from above. (*Sobotta and McMurrich.*)

facets are circular and the *superior* face upward and dorsally, while the *inferior* face downward and ventrally.

The Atlas.—This is the first cervical vertebra and it possesses neither body nor spinous process. It consists of *two lateral masses* connected to each other by a *ventral* and a *dorsal arch*. Each *lateral mass* is irregular and its ventral end is closer to the midline than the dorsal end. Superiorly it possesses an oval *articular facet* (*fovea articularis superior*) that receives a condyle of the occipital bone. Each facet is concave and slopes dorsally and toward the midline. The *inferior articular facets* (*foveæ articulares inferiores*) are circular and nearly flat. Each surface faces downward and toward the midline. Upon the medial surface of each lateral mass there is a small *tubercle* to which the transverse ligament of the atlas is attached. Behind each tubercle is a nutrient foramen. The *ventral arch* (*arcus anterior*) is thickest in the middle forming here, on its *ventral surface*, the *ventral tubercle* (*tuberculum anterior*); its *dorsal surface* exhibits a facet (*fovea dentis*) for articulation with the dens of the epistropheus or axis. The *dorsal arch* (*arcus posterior*) arises from the lateral mass and transverse processes. At its origin it is flattened from above downward and bounds a groove, dorsal to the articular facet, that extends to the transverse foramen. This groove is occupied by the vertebral artery and suboccipital nerve. The dorsomedian part of the arch may present a small *tubercle* (*tuberculum posterior*) which represents a rudimentary spinous process. Each *transverse process* arises from the lateral mass by two roots that are united, enclosing the transverse foramen. The anterior and posterior tubercles are usually fused into one. The extremely large *vertebral foramen* of the atlas is

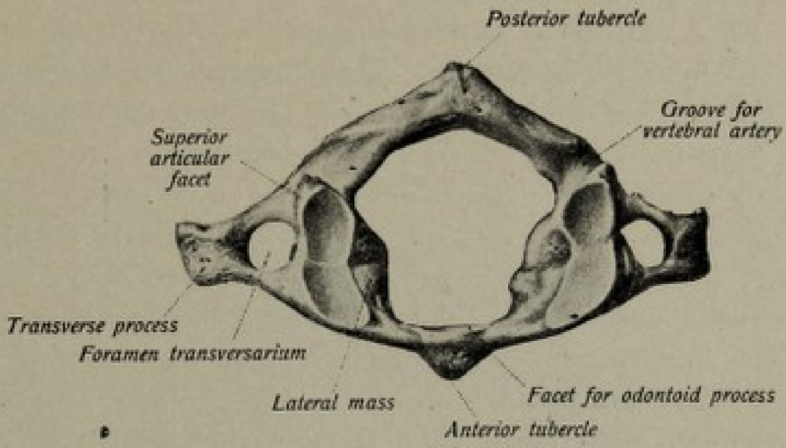


FIG. 7.—The atlas seen from above. (*Sobotta and McMurrich.*)

divided into two portions by the transverse ligament that extends between the two median tubercles. The smaller ventral division contains the dens of the epistropheus while the larger dorsal portion accommodates the spinal cord.

The Epistropheus.—This is the second cervical vertebra and it

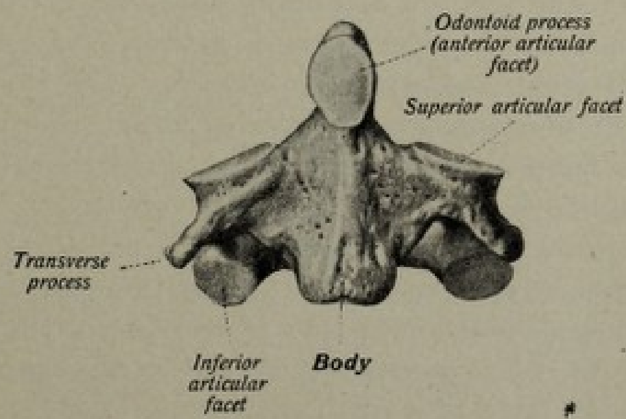


FIG. 8.—The axis (epistropheus), from in front. (*Sobotta and McMurrich.*)

possesses a tooth-like process called the *dens*. The *superior part of its body* is continued as the dens. The *apex* of this process is blunt, and to it are attached the alar ligaments. Where it joins the body of the vertebra, the process is constricted and its dorsal surface at this region is smooth and grooved to accommodate the transverse ligament. The *ventral surface of the dens* has a facet for articulation with the dorsal surface of the ventral arch of the atlas. The *inferior surface* is somewhat concave and slopes sharply downward and overlaps the body of the third cervical vertebra. The *ventral surface* of the body is irregular and has a ridge that extends onto the neck of the dens. The *dorsal surface* is flattened and presents numerous foramina. The *roots of the vertebral arches* are deeply grooved, inferiorly, but superiorly they support the superior articular facets. The laminæ are short and thick and form the short, bifid *spinous process.* Each *transverse process* slopes downward and has but one terminal tubercle. The *superior articular processes* cover the roots of the vertebral arches. They are nearly circular, flattened or slightly concave; they face upward and a little laterally. Dorsal to each is a groove in which the second cervical nerve courses. The *inferior articular facets* are nearly circular and face inferiorly and forward or ventrally. These lie dorsal to the transverse processes.

The **seventh cervical vertebra** is called the **vertebra prominens** because its spinous process projects beyond the level of the other vertebræ. This process is not bifid. The *transverse processes* are wider and more prominent than those of the sixth vertebra. The foramen does not usually transmit the vertebral artery as it is too small. The ventral tubercle is small and the costal element may be separate, constituting a cervical rib.

THE THORACIC VERTEBRÆ (VERTEBRÆ THORACALES)

The thoracic vertebræ are twelve in number and they articulate with the ribs. The body of a thoracic vertebra is usually described as heart-shaped. The *superior* and *inferior surfaces* are slightly concave or flattened, smooth and rimmed. The *ventral* and *lateral surfaces* are concave from above downward and rough. The *body* is thicker behind than in front, thus forming the thoracic curve of the vertebral column (concavity ventrally directed). Dorsally it is concave and shows numerous foramina. Near the junctions of the roots of the arches and the body (along the superior and inferior margins) there are *four costal facets* (*foveæ costales*) *two superior* and *two inferior.* In two successive vertebræ the contiguous facets accommodate the head of a rib.

The *roots of the vertebral arches* slope upward and backward so that the superior intervertebral notch is slight and the inferior notch is deep. The laminæ are flat and broad and slope downward and outward, thus overlapping those of the vertebra below. The vertebral foramen is circular and smallest in this portion of the vertebral column as this portion of the spinal cord is smallest in diameter. The *spinous processes* vary; in the upper part of the thoracic region they are short and nearly horizontal, while in the lower part they are longer, heavier and successively more oblique. Each may possess a tubercle at its extremity.

The *transverse processes* are larger in the upper thoracic vertebræ and gradually decrease in length. They are directed laterally and dorsally. Near the extremity of each there is a concave facet for articulation with the tubercle of the rib.

The *superior articular facets* are nearly vertical, facing dorsally and a little laterally. The *inferior facets* are directed downward and face ventrally and a little medially.

The **first thoracic vertebra** resembles, somewhat, a cervical vertebra. The superior costal facet is more on the side of the body; the

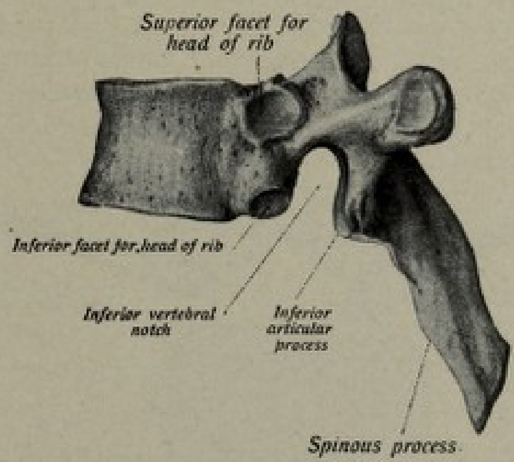


FIG. 9.—The sixth thoracic vertebra from the side. (*Sobotta and McMurrich.*)

transverse processes are quite long and the superior intervertebral notches are well marked. The superior articular facets are more sloping and are directed upward and dorsally.

The **ninth thoracic vertebra** has usually no inferior costal facets.

The **tenth thoracic vertebra** has only a superior costal facet and the facet upon the transverse process is small or absent.

The **eleventh thoracic vertebra** has one costal facet below the superior margin and none upon the short transverse process.

The **twelfth thoracic vertebra** has one costal facet upon the root of the vertebral arch. The transverse process is thick and presents a number of tubercles resembling those of the lumbar vertebræ. Its inferior articular processes face laterally.

THE LUMBAR VERTEBRÆ (VERTEBRÆ LUMBALES)

The lumbar vertebræ are the largest of the true vertebræ and are five in number.

The *body* is reniform and the ventrodorsal dimension is about half the transverse dimension. The *superior* and *inferior surfaces* are smooth and somewhat concave and rimmed. The *ventral* and *lateral surfaces* are quite concave from above downward and show numerous foramina. The *dorsal surface* is concave from side to side as well as from above downward. The *body* is slightly thicker behind than in front giving a curve to this part of the column, with the convexity forward. The *roots of the vertebral arches* are directed dorsally and are short and thick. Both intervertebral notches are well marked. The laminæ are broad and nearly vertical. The *vertebral foramen* is large and triangular. The *spinous process* is short, flat and broad; each is directed dorsally and slightly downward. The *transverse processes* are somewhat slender and are directed laterally and horizontally. In the successive vertebræ the laminæ

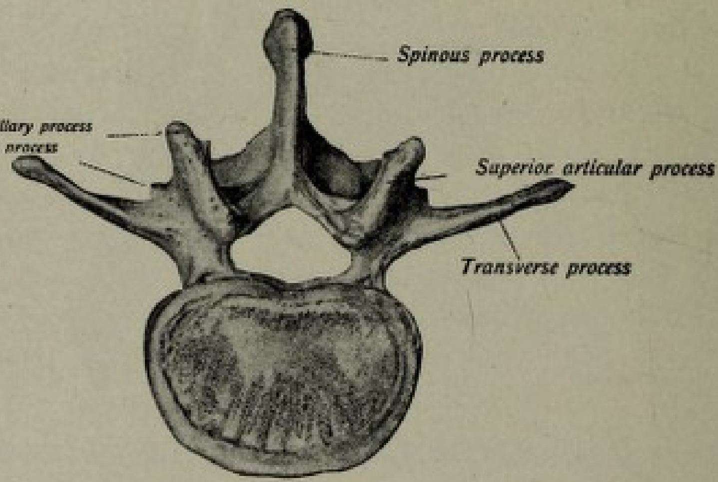


FIG. 10.—The third lumbar vertebra seen from above. (*Sobotta and McMurrich.*)

arise at a more ventral level from the roots of the vertebral arches. They apparently represent the costal elements of the thoracic vertebræ. Upon the dorsal surface of each transverse process are the *accessory tubercles.* The *superior articular processes* are oval and lie at the junction of the roots of the arches and the *laminæ.* The *articular facets* are concave, vertical and face medially. The *inferior articular processes* are at the inferior margin of each lamina at the root of the spinous process. The oval and nearly flat facets face laterally. These processes are nearer the median plane than are the superior ones and so are overlapped by these when articulated.

The **fifth lumbar vertebra** has the largest body. Its ventral vertical dimension is much greater than the dorsal vertical measurement and so assists the sacrum in forming the *sacrovertebral angle.* The transverse processes are pyramidal in shape and arise from the sides of the body and the vertebral arches. The superior articular facets are directed more dorsally than medially. The inferior facets face ventrally and laterally and are in a line with the superior processes. The spinous process is short and narrow.

Ossification.—The vertebræ are of endochondral origin and each develops from *four primary* (two for the laminæ and two for the body) and *three secondary centers,* usually. The *centers* for the *laminæ* appears during the sixth week of fetal life and spread into the base of the spinous process, the roots of the arches and the transverse processes. The *centers* for the *body* appear during the eighth week and these centers soon fuse. At birth the vertebra consists of three parts. During the first year the laminæ fuse dorsally (in the lumbar region first and then upward) and during the third year the body and laminæ fuse. The *secondary centers* appear at about the sixteenth year. There is *one* for the *tip of each transverse process* and *one* for the *tip of the spinous process.* All parts are fused into one mass by the twenty-fifth to the thirtieth years.

The number of *centers* for the *atlas* is variable (two to five). Usually *three centers* appear, *one* for each *lateral mass* (sixth week of fetal life) and *one* for the *ventral arch* (end of the first year).

The *epistropheus* is usually developed from *five* or *six primary* and *two secondary* centers. The *primary centers* are *one* for each *lamina* (seventh to eighth week), *one* (or two) for the *body* (fourth month) and *two* for the *dens* (sixth month). During the second year a *secondary center* appears for the *apex of the dens* and this unites with the main mass at about the twelfth year. The *other center* is for a *thin epiphyseal disc* on the inferior surface of the body.

THE FIXED OR FALSE VERTEBRÆ

The **sacrum** represents the fusion of five vertebræ. It is said to be roughly triangular in shape (better like a curved wedge). Its *ventral* or *pelvic surface* is smooth, concave from side to side as well as from above downward. It presents *four transverse ridges* that terminate at the *ventral sacral foramina.* These *foramina* extend laterally as shallow grooves and dorsally they communicate with the vertebral canal. That portion on each side lateral to the foramina constitutes the *lateral mass* (*pars lateralis*). Its *lateral surface* (upper part) is large and ear-shaped (*articular surface*) and articulates with the os innominatum on each side. Dorsal to this area is the *sacral tuberosity.* The *superior surface* articulates with the fifth lumbar vertebra; it resembles that vertebra in this part and possesses superior articular processes.

The *dorsal surface* is rough, convex from above downward and shows a median as well as two pairs of lateral ridges and four pairs of dorsal sacral foramina. The *crest* (*crista sacralis media*) is in the midline and consists of the *spinous processes* of the upper four sacral vertebræ. The fifth spinous process is absent and the laminæ separated so that the vertebral canal is exposed. This gap is the *hiatus sacralis.* Lateral to the crest is the *sacral groove* on each side. This groove is bounded laterally by a *crista sacralis articularis,* which is formed by the row of fused articular processes. Lateral to each crest is a row of *dorsal sacral foramina* through which pass the dorsal branches of the sacral spinal nerves. Lateral to the foramina is a row of tubercles forming the *lateral ridge* (*crista sacralis lateralis*) of each side. This represents the transverse processes of the true

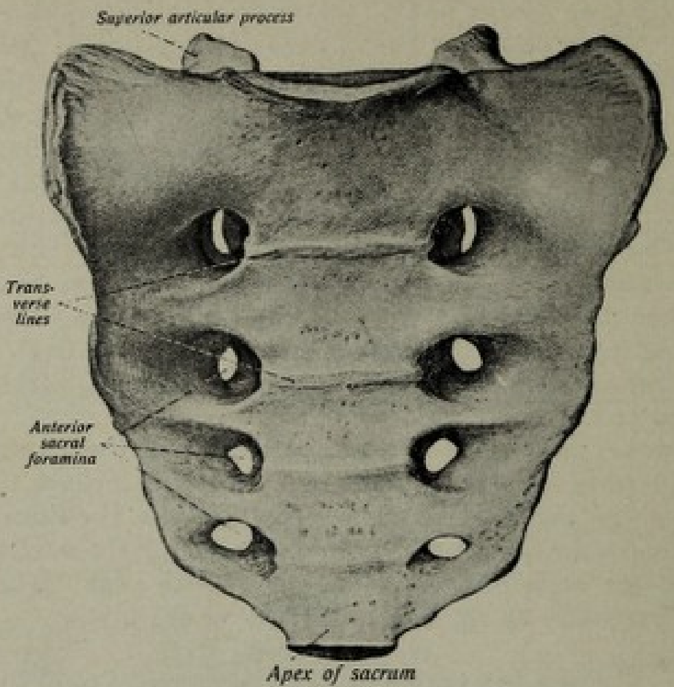


FIG. 11.—The sacrum seen from in front (pelvic surface). (*Sobotta and McMurrich.*)

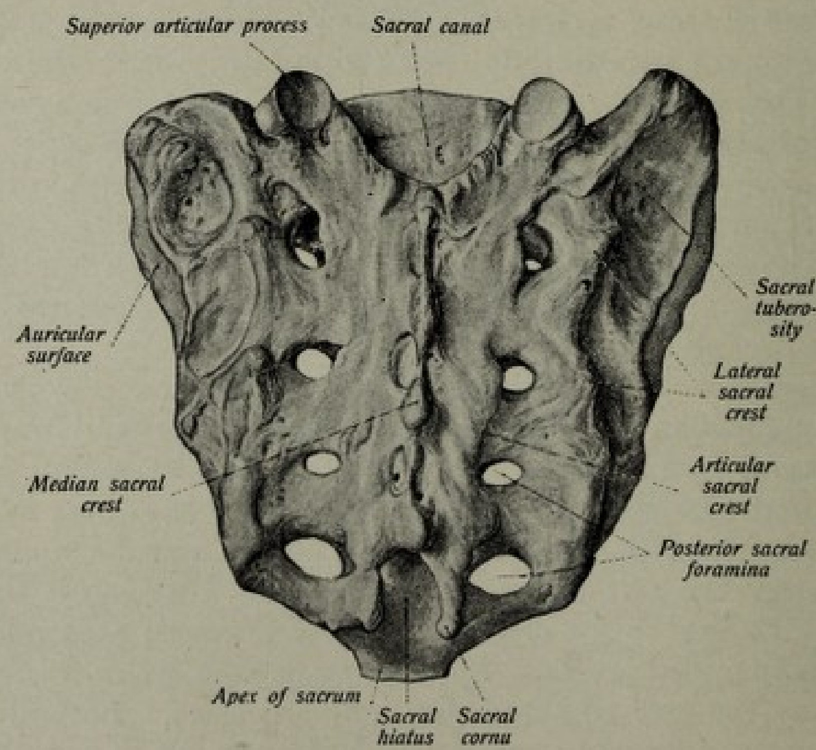


FIG. 12.—The sacrum seen from behind (dorsal surface). (*Sobotta and McMurrich.*)

vertebræ. The *sacral cornua* are the downward-projecting inferior articular processes of the last sacral vertebra. The *apex* of the sacrum represents the oval body of the fifth sacral vertebra.

The *sacral canal* is flattened dorsoventrally and curves with the bone. It communicates with the dorsal and ventral sacral foramina.

The sacrum of the *female* is shorter, broader and less curved than in the male. In the *male* it is directed more obliquely backward.

Ossification.—The *sacrum* has *thirty-five centers* of ossification. The *body* of each segment has *three centers, each arch two*, the *lateral mass* has *six* (two for each of the first three segments) and each of the *lateral surfaces* has *two centers*. The first centers appear during the eighth or ninth week of fetal life and all are fused between the twenty-fifth and thirtieth years.

Muscles Attached.—To the ventral surface the mm. pyriformis, the coccygeus and part of the iliacus. To the dorsal surface the mm. gluteus maximus, the latissimus dorsi, sacrospinalis and multifidus.

THE COCCYX (OS COCCYGIS)

The coccyx represents the fusion of four rudimentary vertebræ. The *first segment* is the largest and the others are successively smaller. The *superior surface* of the first segment shows an oval concave facet

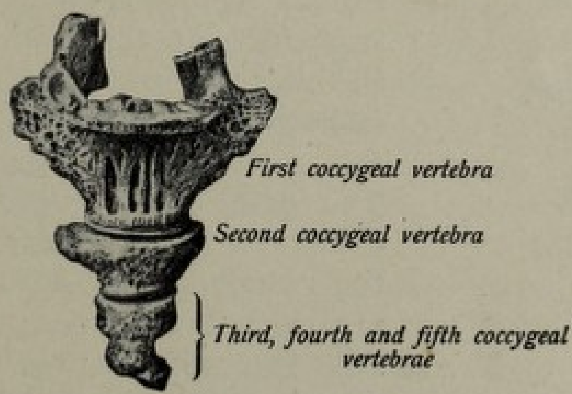


FIG. 13.—The coccyx seen from in front. (*Sobotta and McMurrich.*)

that articulates with the sacrum. The *dorsal surface* presents two upward-projecting processes (*cornua coccygea*) representing articular processes for articulation with the cornua sacralis. These assist in forming two foramina for the fifth pair of sacral nerves. Laterally this segment presents a rudimentary *transverse process* on each side. The *second* may also present such processes but the remaining segments are rudimentary nodules of bone.

Ossification.—The *coccyx* is developed from *four centers, one for each segment*. That for the first segment appears during the first to the fourth years, the second, from the fifth to the tenth years, the third, from the tenth to the fifteenth and the fourth, from the fourteenth to the twentieth years. The fusion of the parts is complete about the thirtieth year.

Muscles Attached.—To the dorsal surface the m. gluteus maximus; to the lateral margin the mm. coccygeus and levator ani on each side; to the tip the m. sphincter ani externus.

THE VERTEBRAL COLUMN AS A WHOLE

When the vertebræ are articulated a peculiarly curved, and for the most part movable, column is formed. The adult vertebral column averages from 27½ inches to 28¾ inches (70 to 73 cm.) in length, in the male, and in the female about 23¾ inches (60 cm.). The individual parts in the male are as follows: cervical, 13 to 14 cm.; thoracic 27 to 29 cm.; lumbar, 17 to 18 cm.; sacrococcygeal, 12 to 15 cm.

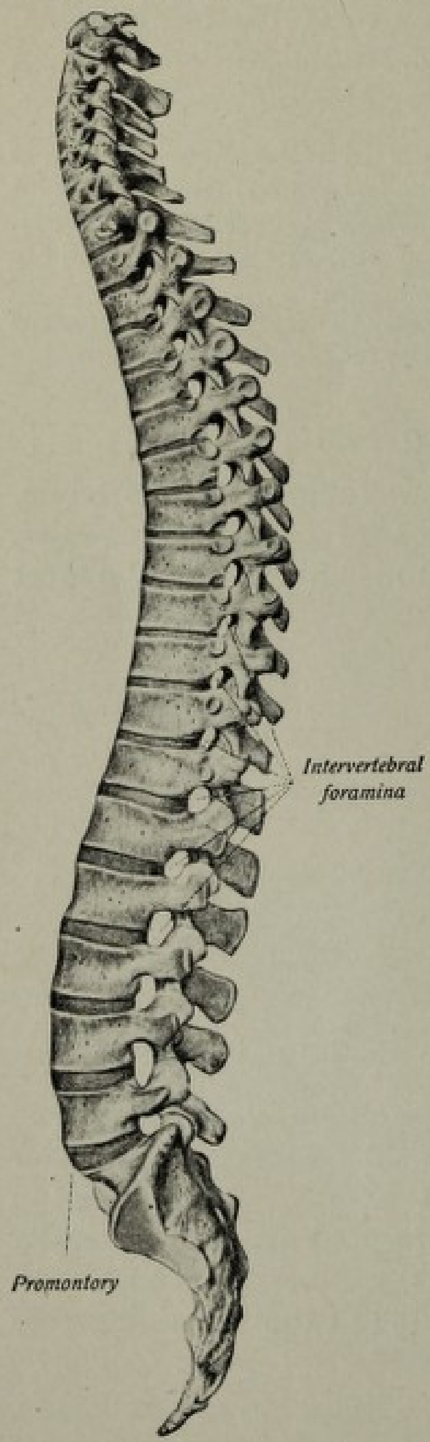


FIG. 14.—The vertebral column seen from the left side. (*Sobotta and McMurrich.*)

The ventral part consists of the bodies of the vertebræ that serve as a support for the head and trunk. The vertebral arches and laminæ form the vertebral canal that contains the spinal cord and its membranes. This canal is largest in the cervical and lumbar regions and is open at the last sacral segment. At the side of the column the intervertebral notches now form the *intervertebral foramina* through which the roots of the spinal nerves pass. The first two cervical foramina are dorsal to the articular processes and the remainder (as far as the sacrum) are ventral to these processes. Dorsally the spinous processes produce a dorsal median ridge and the transverse processes a lateral ridge, on each side. As a result a groove is formed on each side of the median ridge called the *vertebral grooves* and these are occupied by the muscle that operate the vertebral column.

Curves are also noted. When viewed from the ventral surface the vertebral column may have a slight lateral curve in the thoracic region with the convexity to the right; this is due, probably, to the greater use of the right side and right upper extremity or by pressure exerted by the thoracic aorta upon the thoracic vertebræ. Viewed from the side the vertebral column presents *four dorsoventral curves,* *cervical*, *thoracic*, *lumbar* and *sacral*. The thoracic and sacral are *primary curves*, existing during fetal life, while the other two are *acquired curves;* they are formed after the child begins to walk. The *cervical curve* is slight and has its convexity ventral; the *thoracic curve* is marked and its concavity is ventrally directed. The lower part of this curve becomes continuous with the lumbar curve which is also marked and has its convexity ventrally directed. The *sacral curve* has its concavity ventrally directed and from its length is the deepest and most marked curve. The sudden dorsal curve of the first segment of the sacrum causes the fifth lumbar vertebra to form a prominent projection called the *sacrovertebral angle*.

THE STERNUM

The sternum constitutes the middle portion of the ventral boundary of the thorax and is a fairly long, flat and thin bone; it is pointed at its inferior extremity, constricted near its middle and consists of three parts, the manubrium, body and xyphoid process.

The *manubrium*, or *handle*, is the superior portion and its *ventral surface* is smooth and somewhat saddle-shaped. To it are attached the mm. pectoralis major and sternomastoideus. Its *superior margin* is thickened and uneven exhibiting a median notch, the *suprasternal notch*, or *incisura jugularis*, that is more pronounced when the clavicles are in position. On each side of this notch there is an oblique facet for articulation with the clavicle, the *incisura clavicularis*. Just inferior to this another facet is noted, on the lateral margin, for articulation with the cartilage of the first rib. Inferior to this the bone becomes narrower and the inferior corner is absent, forming a facet with a like area upon the next portion of the sternum, for the second costal cartilage. The *inferior margin* of the manubrium is connected with the second segment by cartilage or it may be fused with it. The *dorsal surface* is smooth and slightly concave and shows numerous foramina. It affords attachment to the mm. sternohyoideus and sternothyroideus.

The *body* (*corpus sterni*) is the middle and longest segment. It is nearly flat from side to side and convex from above downward. Its superior portion is narrower than the inferior part. The *ventral surface* (*planum sternale*) is smooth but shows three more or less marked transverse ridges that indicate the four segments that fuse to form this portion of the sternum. It affords attachments to the m. pectoralis major upon each side. The *superior margin* is attached or fused to the manubrium forming an angle at the junction that is usually appreciable to the touch. This is the *sternal angle* (*angulus sterni*). The lateral portions of this margin complete the facet for the second costal cartilage. The *inferior margin* is convex and its middle part is connected to the xyphoid process. Lateral to this the sixth and seventh costal cartilages are attached. Each lateral margin is thick and irregular presenting facets at the extremities of the ridges that accommodate the third, fourth and fifth costal cartilages. The *dorsal surface* is concave from above downward and may exhibit the transverse ridges. Its superior portion affords attachment to the m. transversus thoracis, or triangularis sterni, while the remainder is in relation with the pericardium and pleuræ.

The *xyphoid process* (*processus xyphoideus*) is the smallest segment and variable in form. Its *base* is attached to the body of the sternum

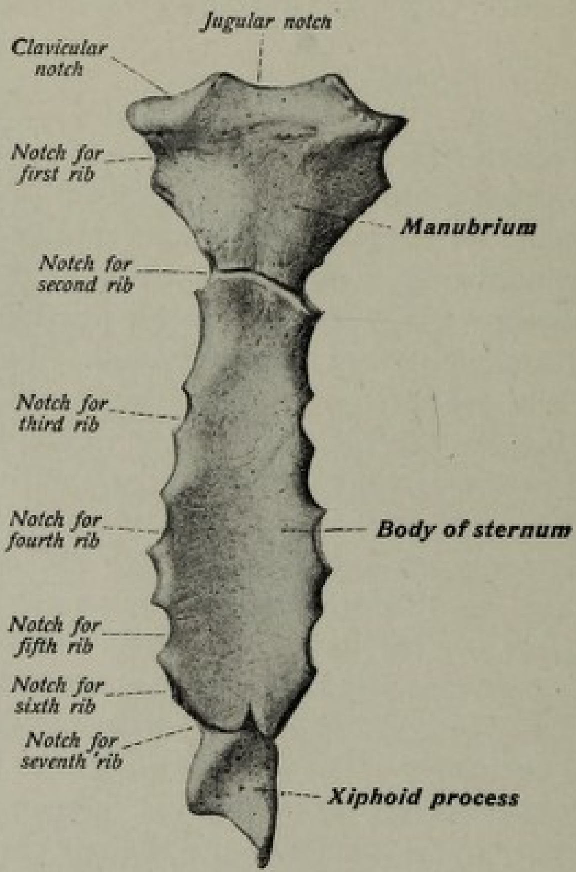


FIG. 15.—The sternum seen from in front. (*Sobotta and McMurrich.*)

while its apex affords attachment to the linea alba of the abdomen. The process slopes dorsally forming the pit of the stomach, or *infrasternal depression.* To its *lateral margins* the aponeuroses of the abdominal muscles are attached, while the dorsal surface affords attachment to a portion of the m. transversus thoracis and diaphragm.

In the *male* the sternum is longer and broader than in the female, its direction is more oblique and variations of the different segments are also noted.

Ossification.—The sternum is an endochondral bone and the cartilaginous sternum is formed by the fusion of two lateral bars. Ossification begins during the sixth month of fetal life with the appearance of the center for the manubrium.

Secondary centers may appear for the clavicular facets. The body develops from four single, or double centers (one for each segment) and their appearance usually follows that for the manubrium; the last one appears just before birth. One center appears for the xyphoid process during the third year. The segments of the body fuse between early childhood and the twentieth to the twenty-fifth years. The manubrium and body may never fuse while the body and xyphoid process fuse at about the fortieth to fiftieth years.

Muscles Attached.—The mm. pectoralis major, sternohyoidens, sternothyroideus, transversus thoracis the diaphragm and the aponeuroses of the mm. obliquus internus abdominis, obliquus externus abdominis and transversalis abdominis—nine pairs.

THE RIBS (COSTÆ)

The ribs, or **hemal arches,** twelve in number on each side, form a bony protection for the thoracic contents. They are movable as they articulate with the thoracic vertebræ, dorsally, and with the costal cartilages, ventrally; by means of the latter they are connected with the sternum. The *first seven* constitute the *true ribs* (*costæ veræ*) as their cartilages articulate individually with the sternum. The *remainder* are called *false ribs* (*costæ spuriæ*); of these the cartilages of the eighth, ninth and tenth ribs join that of the seventh rib (*vertebrochondral ribs*) while the costal cartilages of the eleventh and twelfth ribs are free at their ventral extremities (*floating ribs*).

A *typical rib* presents a *head*, *neck*, *tubercle*, *shaft* and *angle*. The **head** (**capitullum costæ**) is slightly enlarged and represents the dorsal or vertebral extremity of the rib. Its medial surface has an *articular facet* divided by a *ridge* (*crista capituli*) into a larger inferior portion that rests in the superior facet of the body of a thoracic vertebræ (from which it takes its number); the smaller superior facet articulates with the inferior facet of the body above. To the crista is attached the interarticular ligament. The **neck** (**collum**) is a narrow part of the rib connecting the head to the shaft and here a *tubercle* is seen dorsally. The *ventral surface* of the neck is smooth and the *dorsal surface* roughened for the attachment of the ligaments of the neck. The *superior margin* may present a ridge for the attachment of the ventral costotransverse ligament. The *inferior margin* is smooth and continuous with the costal groove.

The **tubercle** is on the dorsal surface of the rib at the junction of the neck and shaft. It presents an oval articular portion that faces inferiorly and dorsally. It articulates with the facet on the transverse process of a thoracic vertebra. The nonarticular portion affords attachment to the fibers of the ligament of the tubercle. A *groove*, occupied by the lateral division of the dorsal branch of a thoracic spinal nerve, separates tubercle from shaft and neck.

The **shaft** is thin, curved and band-like. It varies in length in the different ribs. The seventh and eighth are the longest and the first the shortest. The curvature is not uniform but varies in the different regions and gives the peculiar shape of the thorax. From the tubercle the rib proceed first laterally and at a variable distance in the different ribs, then it turns rather sharply in a ventral direction. This change of direction produces the *angle* (*angulus costæ*). The distance from tubercle to angle is greater in the eighth rib and nil in the first rib. The rib is also twisted so that the ventral end is at a lower level than the head, when the rib is placed upon a plane surface. This is most noticable in the seventh and eight ribs and least in the first and last ribs.

The *shaft* is flattened and has *two surfaces, lateral* and *medial*. The *lateral surface* is smooth and convex and faces according to the part of the thorax in which it is placed, *i.e.*, superiorly in the upper part, laterally in the middle of the thorax and slightly downward in the lower part. The *medial surface* is smooth and faces in the opposite

FIG. 16.—The seventh rib of the left side seen from within. (*Sobotta and McMurrich.*)

direction. The *superior margin* is thick and rounded and affords attachments to the mm. intercostales externus et internus. The *inferior margin* is sharp and dorsally it is grooved; here it forms the *costal groove* (*sulcus costalis*) which disappears ventrally. The inferior margin, between the angle and the tubercle, is ridged and affords attachment to the m. iliocostalis. The costal groove contains the intercostal vessels and the lip affords attachment to the external and internal intercostal muscles. In the groove are seen the nutrient foramina that are directed toward the vertebral extremity.

Peculiar Ribs.—The **first rib** is the smallest. The head is small and the head articulates with only one vertebral body, the first. The neck is short and flattened from above downward. The tubercle, at the junction of the neck and shaft, is prominent and bears a small facet, on its under surface, for articulation with the transverse process of the first thoracic vertebra. The angle and tubercle are coincident. The medial margin is thin and presents, near its middle, the *tuberculum scaleni;* this margin affords attachment to Sibson's fascia. The superior surface is uneven and at the tubercle area a ridge passes ventrally and laterally separating two grooves; the ventral, deeper, one is for the subclavian vein, while the dorsal one is for the subclavian artery and ventral division of the first thoracic nerve (*sulcus subclaviæ*). Dorsal to the latter groove the surface is roughed for the attachment of the m. scalenius medius. The inferior surface is smooth and covered with pleura. The lateral margin is thickened and rough dorsally for attachment of the first digitation of the m. serratus anterior.

In the **second rib** there is no twist and the surfaces are turned so that they are obliquely directed. The head presents two facets and the angle is distinct from the tubercle. The lateral surface presents a roughened area for the attachment of part of the first and the entire second digitation of the m. serratus anterior. The margin likewise affords attachment to the external and internal intercostal muscles.

On the **tenth rib** there is only one facet on the head and usually none on the tubercle.

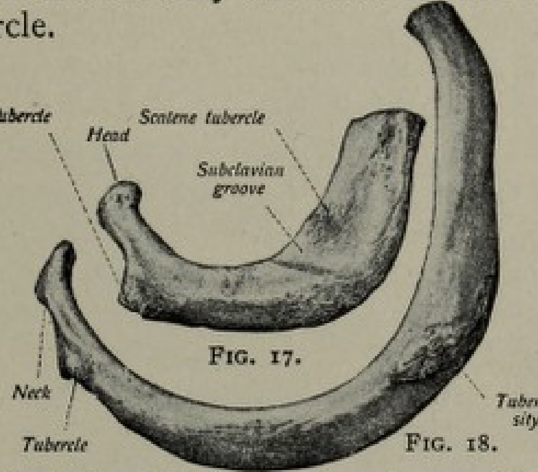


FIG. 17.

FIG. 18.

FIG. 17.—The first rib of the right side seen from above and from the side. (*Sobotta and McMurrich.*)

FIG. 18.—The second rib of the right side seen from above and from the side. (*Sobotta and McMurrich.*)

On the **eleventh** and **twelfth ribs** the heads show only one facet; the tubercles and angles are faint. The ventral ends are pointed and tipped with cartilage. Both ribs are short.

Ossification.—The ribs are of endochondral origin and each rib is developed from *three centers*, except the last two pairs. The *center* for the *shaft* appears during the ninth or tenth week of fetal life. The *centers* for the *head* and the *tubercle* appear about the sixteenth to the twentieth years. Fusion is complete about the twenty-fifth year. The last two ribs have *two centers* each, *one* for the *shaft* and *one* for the *head*.

Muscles Attached.—The mm. intercostales interni et externi, scalenus anterior, scalenus medius, scalenus posterior, pectoralis minor, serratus anterior, latissimus dorsi, diaphragma, quadratus lumborum, obliquus externus abdominis, serratus posterior superior, serratus posterior inferior, iliocostalis lumborum, iliocostalis dorsi, iliocostalis cervicis, longissimus, levatores costorum and infracostales (nineteen).

THE COSTAL CARTILAGES

The costal cartilages are the bars of cartilage attached to the ribs, on the one hand, and on the other directly or indirectly to the sternum, except the eleventh and twelfth pairs. The first seven pairs articulate with the sternum at the designated notches and usually a synovial membrane exists at the joints. The eighth, joined by the ninth and tenth cartilages, on each side, is attached to the seventh cartilage. The eleventh and twelfth are small and merely tip these ribs. The cartilages increase in length from the first to the seventh and then again shorten. Their direction and obliquity vary as can be noted in the illustration.

THE THORAX AS A WHOLE

The thorax or chest consists of a framework of bones and cartilages. Between the ribs lie the intercostal muscles and membranes com-

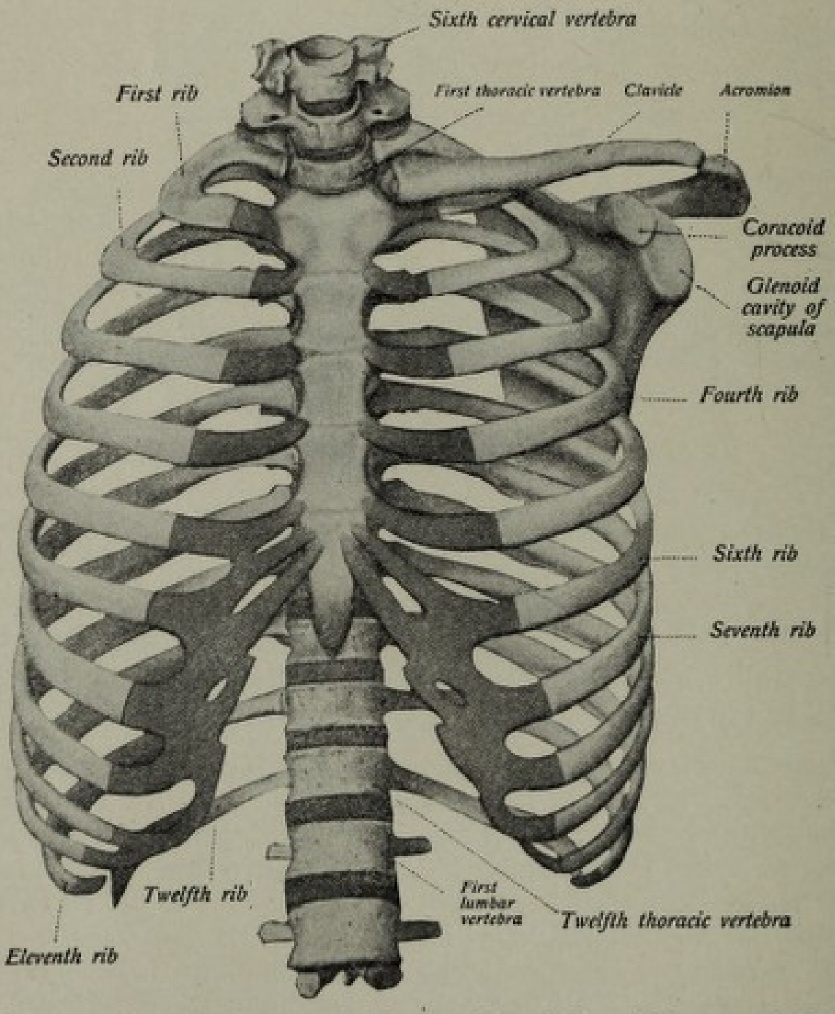


FIG. 19.—Ventral view of thorax and left shoulder girdle. (*Sobotta and McMurrich.*)

pletely closing these intervals. The thorax has the shape of a truncated cone, flattened from before backward, shorter in front than behind. It presents **four walls,** or *boundaries, dorsal, two lateral* and *ventral;* it has *two apertures, superior* and *inferior.*

The **dorsal wall** consists of the twelve thoracic vertebræ and the ribs to their angles. On each side of the midline is seen a deep groove, the *vertebral groove.* The bodies of the vertebræ project into the cavity of the thorax and reduce its dorsoventral dimension markedly. The **lateral walls** consist of the shafts of the ribs. The **ventral wall** consists of the sternum and the costal cartilages. This wall is the shortest and slopes downward and forward.

The **superior,** or **cephalic aperture,** is kidney-shaped, about 4 inches (10 cm.) from side to side and about 2 inches (5 cm.) dorsoventrally. Its boundaries are as follows: *dorsally,* the body of the first thoracic vertebra; *laterally,* the first ribs; *ventrally,* the upper margin of the sternum. This aperture slopes downward and forward so that its ventral margin is on a level with lower border of the body of the second thoracic vertebra, in the male, and in the female at the lower border of the third thoracic vertebra. The main structures transmitted are the esophagus, trachea, thoracic duct, the innominate, left common carotid and left subclavian arteries, the right and left innominate veins, the vagal, phrenic and sympathetic nerves and the apex of each lung covered by the cervical extension of the parietal pleura.

The **inferior,** or **caudal aperture** is not a true aperture as it is closed in by the diaphragm. Its boundaries are as follows: *dorsally* the body of the twelfth thoracic vertebra; *laterally* the twelfth ribs; *ventrally* the eleventh, tenth, ninth, eighth and seventh costal cartilages. These joined cartilages sloping upward and inward form with their fellows of the opposite side the *subcostal angle* at the midline.

The thorax is widest at the level of the eight or ninth ribs, deeper behind than in front and deeper on the left than on the right side. In the *female* the capacity is less, the ribs more movable, the inlet has a greater slant and the sternum is shorter than in the *male.* Upon transverse section the thorax is kidney-shaped.

THE BONES OF THE SKULL (OSSA CRANII)

This portion of the skeleton, comprising the entire head, is made up of twenty-two bones; it is divided into *cranium cerebrale* and *cranium viscerale.* The **cranium cerebrale** consists of fifteen bones, the occipital, sphenoid, ethmoid, frontal, parietal (two), temporal (two), inferior nasal conchæ (two), lacrimal (two), nasal (two), and vomer. The **cranium viscerale** consists of the ossa faciei which are the mandible, maxillæ (two), zygomatic (two), palatal bones (two). The hyoid bone will be described in this section.

THE FRONTAL BONE (OS FRONTALE)

The frontal bone constitutes the front part of the cerebral cranium and consists of *frontal, orbital* and *nasal portions.*

The **frontal portion (pars frontalis)** is nearly vertical in direction and convex ventrally. Upon each side of the midline the most marked part of the convexity constitutes the *frontal tuberosity*. The *inferior margin* presents an arch on each side of the midline made by the curved superior orbital margin; this presents the *supraorbital notch* or *foramen*. Each arch is bounded by two processes; laterally is the *zygomatic process* from which the *linea temporalis* arches upward and backward upon the temporal portion of the bone (*facies temporalis*). This surface is smooth and concave and constitutes a part of the temporal fossa and here the m. temporalis arises. Medially the arch is bounded by the *medial angular process* which articulates with the nasal bone. Between the two medial angular processes lies

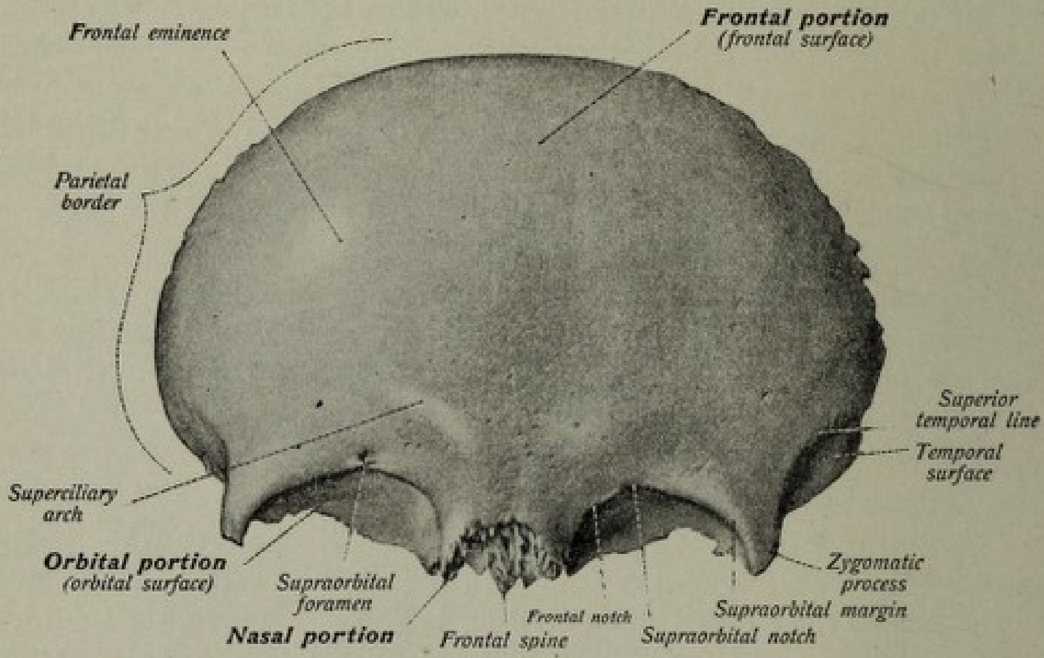


FIG. 20.—The frontal bone seen from in front. (*Sobotta and McMurrich.*)

the *nasal notch* and here the nasal bones and maxillæ articulate. Above this area is the *glabella* which is more prominent in the male. From this the *supercilliary arch* (*arcus supercilliaris*) arises on each side.

The **orbital portion (pars orbitalis)** comprises the horizontal, arched part on each side of the midline. Each forms about one-sixth of a circle. The *medial edge* of each is honeycombed and separated dorsally by the *ethmoidal notch* (*incisura ethmoidalis*). Ventral to this is the nasal notch from which arises the *nasal process* that projects downward as the frontal *spine;* this articulates with the (two) nasal and ethmoidal bones. The grooved bone on each side of the nasal process constitutes the roof of a nasal fossa. Just within the medial part of the orbital margin is the *trochlear pit*, or *spine* (*fovea vel spina trochlearis*) to which is attached the pulley of the m. obliquus superior of the eyeball. Just within the lateral part of the orbital margin is the *lacrimal fossa* for the lacrimal gland (*fossa glandulæ lacrimalis*).

The **cerebral surface** is concave and accommodates the frontal lobes of the cerebrum. It is smooth but uneven due to the pressure of the meningeal vessels and the gyri of the frontal lobes. From the center of the upper margin a groove (*sulcus sagittalis*) descends and terminates in a crest at the end of which is the *foramen cecum.* Here the superior sagittal sinus begins.

Articulations.—Dorsally, with the parietals and sphenoid; laterally, with the zygomatic bones; inferiorly and medially, with the nasals, maxillæ, lacrimals and ethmoid bones.

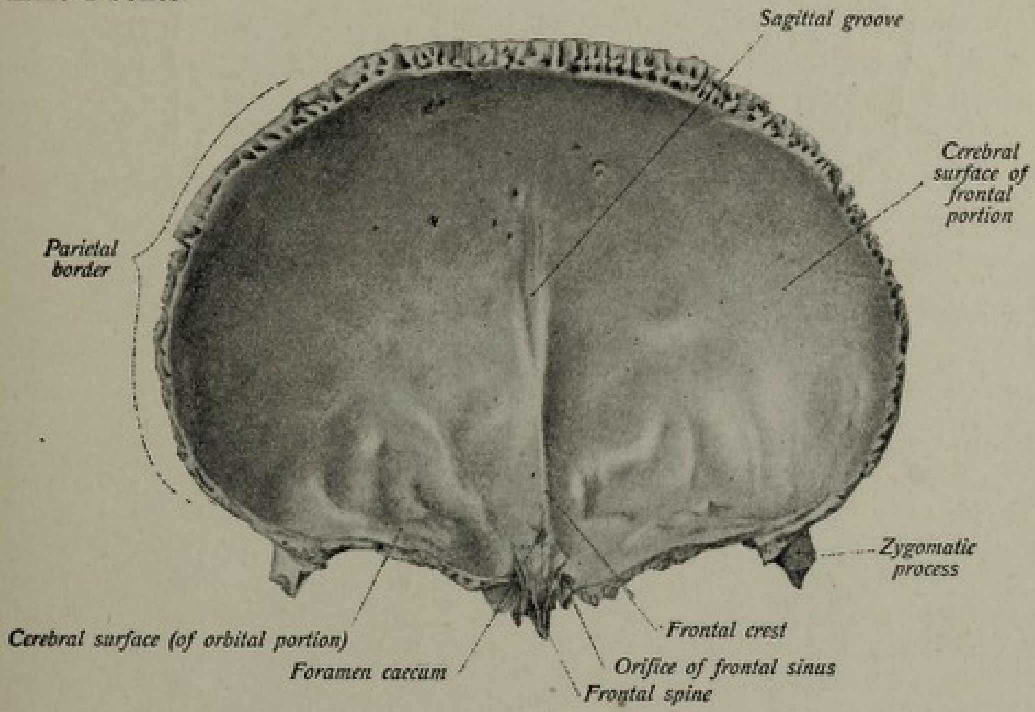


FIG. 21.—The frontal bone seen from behind (cerebral surface). (*Sobotta and McMurrich.*)

Ossification.—*Two* lateral *primary centers* and *three pairs of secondary centers.* The *primary centers* appear about the sixth or seventh week of fetal life and form the bulk of the bone. The *secondary centers* appear later, one pair for the frontal spine, one center for each zygomatic process and a center on each side at the region of the trochlear pit. These centers fuse on each side by the sixth or seventh month of fetal life and the two halves are usually fused by the seventh year.

Muscles Attached.—Mm. corrugator supercilli, orbicularis palpebræ and temporalis (three pairs).

THE PARIETAL BONES (OSSA PARIETALES)

The two parietal bones form the lateral portions of the vault of the cranium. Each has *two surfaces, parietal and visceral,* and *four margins* and *four angles.*

The **parietal surface** is smooth and convex in both directions; its middle portion is quite bulged constituting the *parietal tuberosity* (*tuber parietale*). Between this and the inferior margin are two

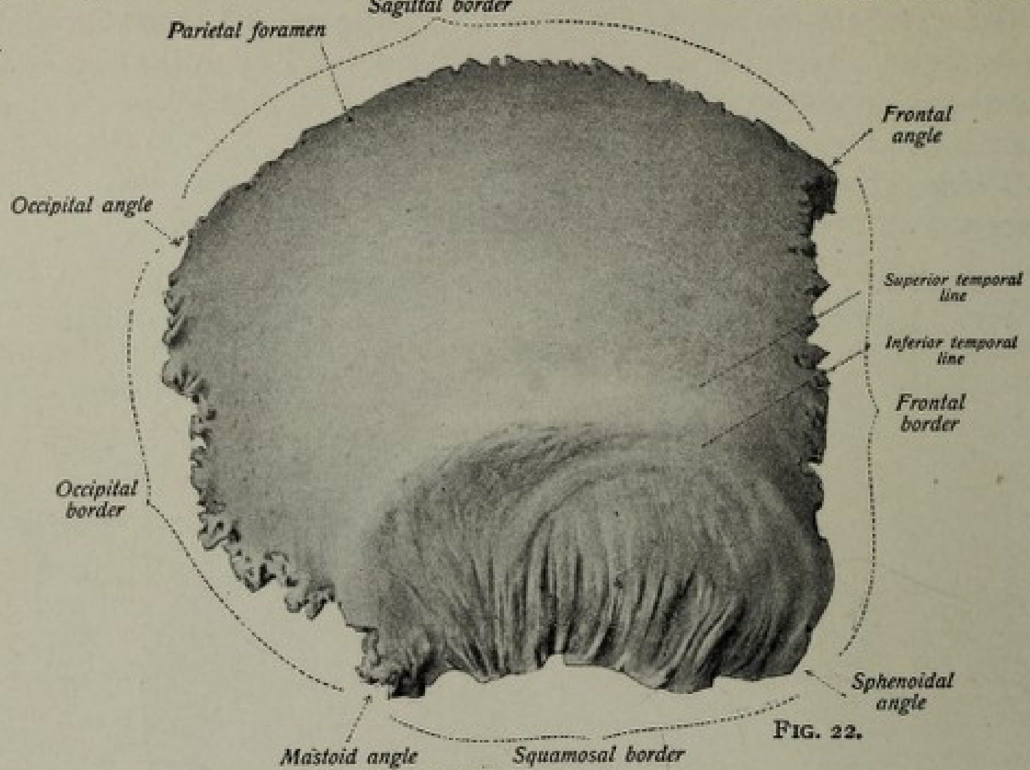


FIG. 22.

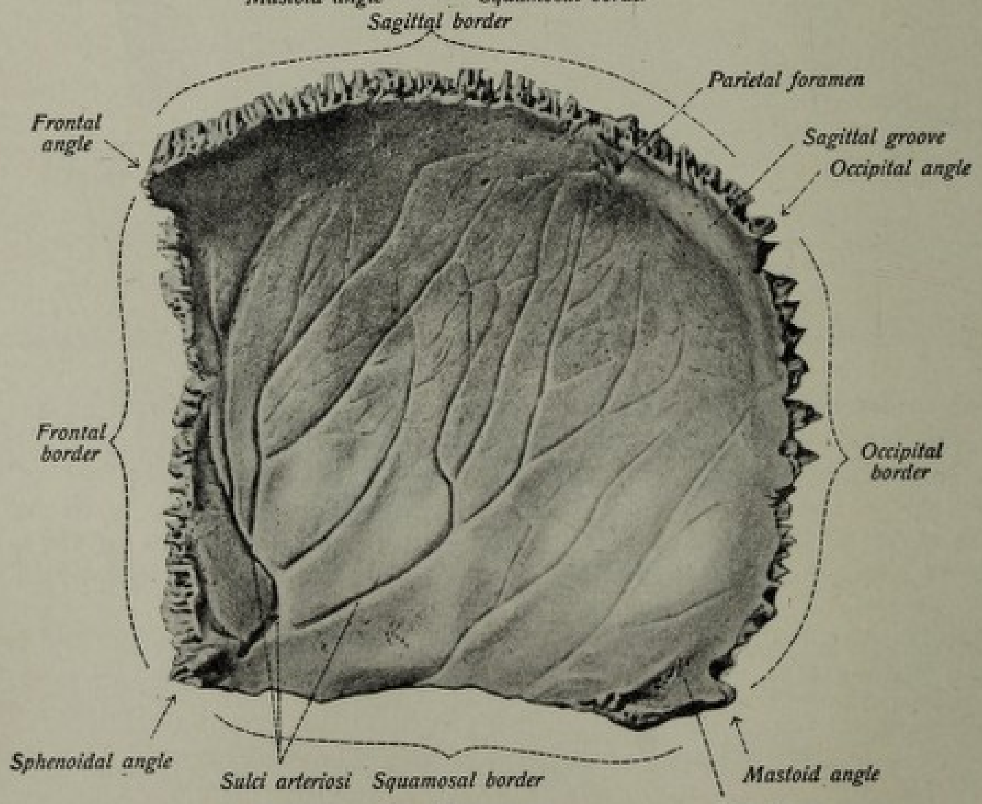


FIG. 23.

FIG. 22.—The right parietal bone, outer surface. (*Sobotta and McMurrich.*)
FIG. 23.—Right parietal bone, inner (cerebral) surface. (*Sobotta and McMurrich.*

nearly parallel curved lines, the *superior* and *inferior temporal lines* (*lineæ temporalis superior et inferior*). The upper one serves for the attachment of the temporal fascia and the lower limits the attachment of the m. temporalis. The bone below the *inferior line* (*planum temporale*) forms a part of the floor of the temporal fossa and may show arterial grooves. Near the occipital part of the superior margin is the *parietal foramen*, for the transmission of a small artery and vein.

The **cerebral surface** is concave in both directions and may show impressions of the gyri of the parts of the brain covered. The surface is smooth but uneven due to the well-marked blood-vessel grooves and arachnoideal granulations. Along the *superior margin* is a half groove (completed by the other parietal bone) constituting, when completed, the *sagittal sulcus* (*sulcus sagittalis*) in which is lodged the superior sagittal sinus; to the edges of the groove the falx cerebri is attached. At the *mastoid angle* is a portion of the *transverse sulcus*.

The *ventral* (frontal), *superior* (medial) and *dorsal* (occipital) *margins* are deeply serrated and articulate with the bones indicated. The *inferior margin* (*margo squamosus*) is the shortest and most irregular; it is beveled and overlapped by the squamous portion of the temporal bone. The *angles* are the *frontal*, *occipital*, *mastoid* and *sphenoidal* and indicate the bones with which they articulate.

Articulations.—Frontally, with the frontal; medially with the opposite parietal; occipitally, with the occipital; inferiorly, with the squamous portion of the temporal and the sphenoid bone frontally.

Ossification.—This bone is purely of intramembranous origin. Ossification starts at *two centers* near the middle of the bone at about the eighth week of fetal life. During the fourth month these centers become confluent at the tuber parietale area. At the angles ossification is not so rapid foreshadowing the fontanelles.

Muscle Attached.—Each affords attachment to the m. temporalis.

OCCIPITAL BONE (OS OCCIPITALE)

The occipital bone forms the dorsoinferior portion of the cranium and its four parts are arranged around the foramen magnum. The four parts are the *tabular*, *basilar* and *exoccipitals*.

The **tabular part** (**squama occipitalis**) is convex in both directions. It consists of two parts, the *occipital plane* (*planum occipitale*) which is nearly vertical and the *nuchal plane* (*planum nuchale*) which is horizontal. The dividing line between these parts is represented by the *external occipital protuberance* (*protuberentia occipitalis externa*) which is near the middle of the bone; the *superior curved line* (*linea nuchæ superior*) extends laterally from the protuberance, on each side. To the protuberance is attached the ligamentum nuchæ. To the superior curved line are attached the galea aponeurotica, the mm. trapezius, occipitalis, sternomastoideus and the splenius capitis. The surface of the planum occipitale is smooth and bulging. The planum nuchale is irregular, rough and divided into lateral halves by a central *crest* (*crista occipitalis externa*) that extends from the protuberance to the foramen magnum. Each area is transversely bisected by the inferior nuchal line. Each area gives attachment to the mm. semispinalis capitis, the obliquus capitus superior and the rectus capitis posterior major and minor.

The *cerebral surface* is concave, smooth but irregular. A cross-like arrangement of ridges form the *eminentia cruciata* at the center of which is the *internal occipital protuberance*. From the upper part of this extends the superior sagittal sulcus. At right angles to the protuberance extend the *two transverse grooves* (*sulci transversi*) in

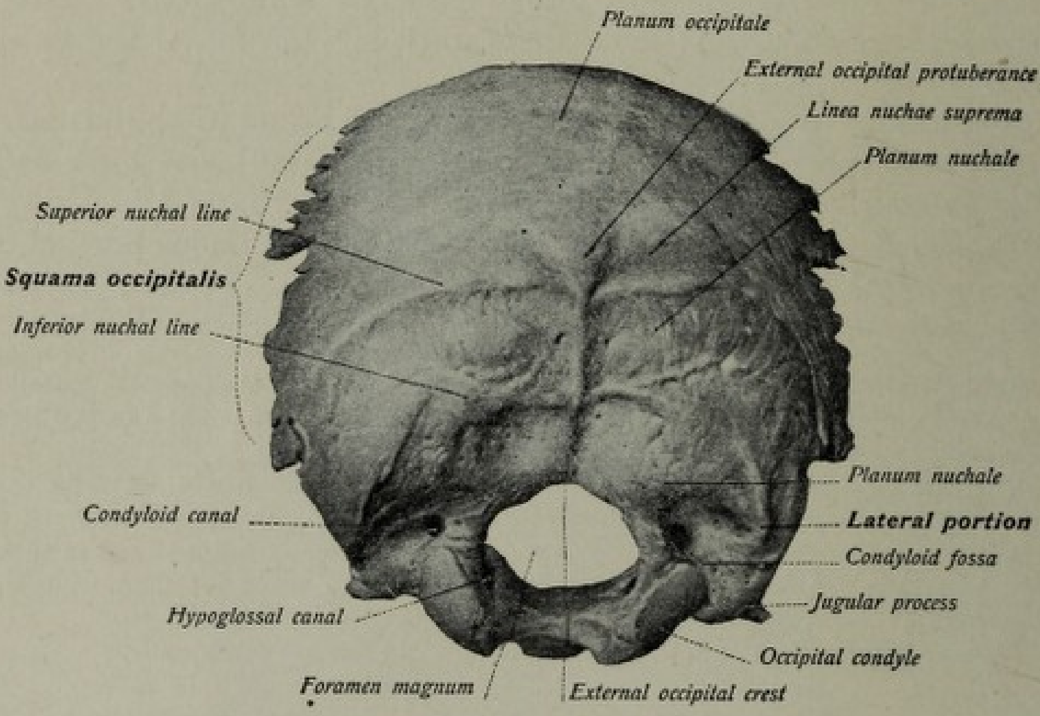


FIG. 24.—The occipital bone seen from behind. (*Sobotta and McMurrich.*)

which are lodged the transverse sinuses and to the edges of which is attached the tentorium cerebelli. Extending from the protuberance to the foramen magnum is seen the *internal occipital crest* to which the falx cerebelli is attached. The area of junction of the sinuses constitutes the *confluens sinuum*.

Of the *angles* the *superior* is somewhat pointed and is inserted between the parietal bones (posterior fontanelle region); the *lateral angle* articulates with the petrous portion of the temporal bone. The two *serrated superior* or *parietal margins* form with the parietal bones the *lamdoidal suture*. The *lateral margins* are irregular and extend from the lateral angle on each side to the corresponding jugular process and they articulate with the mastoid portion of the temporal bone.

The **lateral,** or **exoccipital parts** bound the foramen magnum laterally. The *inferior surface* of each bears a large *condyle* which serves for articulation with the atlas of the vertebral column. Each *condyle* is oval or reniform and obliquely placed; the articular surface is convex dorsoventrally and flattened from side to side and faces downward and a little laterally. Each is raised from the main mass of the exoccipital and this supporting mass is pierced by the *hypoglossal canal* (*canalis hypoglossi*) which transmits the hypoglossal nerve, the meningeal branch of the ascending pharyngeal artery and its accompanying vein. The canal terminates laterally at the ventral side of the condyle. Dorsal to the condyle is the *condyloid fossa*

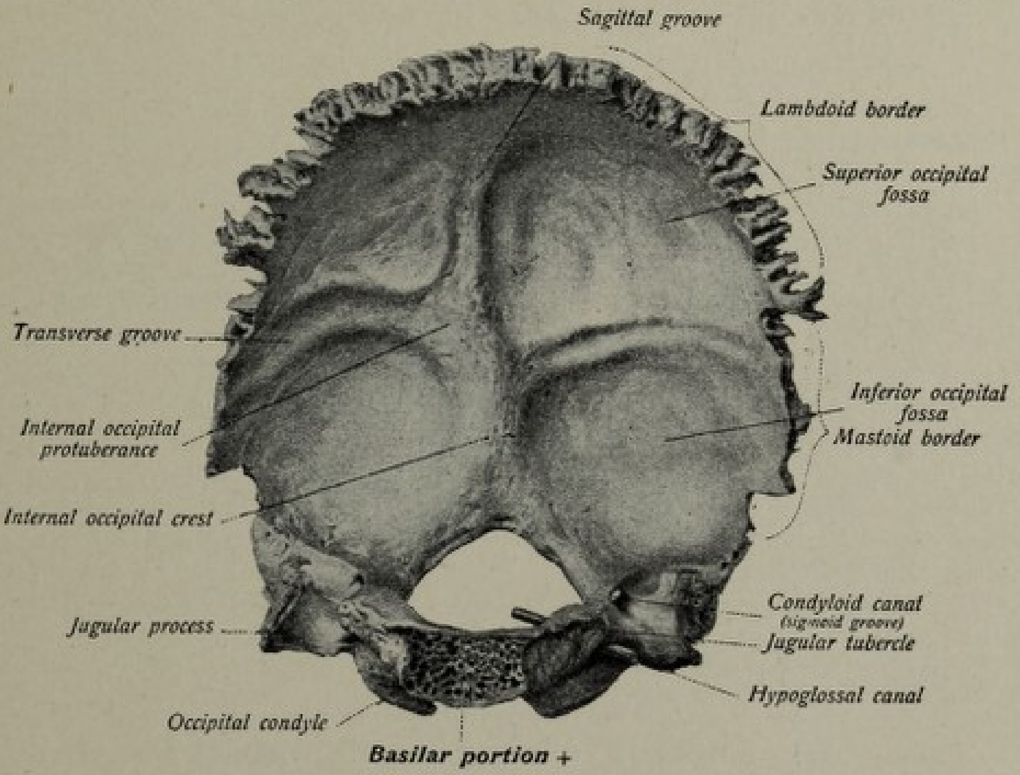


FIG. 25.—The occipital bone seen from in front (cerebral surface). (*Sobotta and McMurrich.*)

(*fossa condyloidea*) that may continue through the bone as the *condyloid canal* (*canalis condyloideus*). Projecting from the bone at the side of each condyle is the *jugular process* (*processus jugularis*) which is notched ventrally to assist in forming the *jugular foramen.* The *cerebral surface* of the exoccipital is smooth but uneven, exhibiting a projection, the *jugular tubercle* (*tuberculum jugulare*) at the side of the foramen magnum. This is just over the orifice of the hypoglossal canal and it may be grooved for the glossopharyngeal, vagal and accessory nerves.

The **basilar portion** forms the ventral boundary of the foramen magnum and extends to the sphenoid bone; to this it is attached by a firm osseous union. Its *inferior surface* is horizontal, irregular and roughened. In the median line is the *pharyngeal tubercle* for the attachment of the pharyngeal aponeurosis. Laterally the roughened surface gives attachment to the mm. longus capitis and rectus capitis anterior. The *cerebral surface* slants upward and forward and is smooth and concave, contains the basilar groove and supports the (medulla) oblongata.

The *foramen magnum* is oval and variable in size. It is narrower ventrally than dorsally (condylic encroachment) and faces inferior and somewhat ventrally. To its margins are attached the cerebral meninges and the ligaments that connect it to the atlas and epistropheus. It transmits the (medulla) oblongata, the cranial end of the spinal cord, the accessory nerves, the vertebral arteries and meningeal vessels.

Articulations.—With the parietals, temporals, sphenoid and atlas—six bones.

Ossification.—It is mainly of endochondral origin, the squamous portion, above the occipital crest, developing intramembranously. The *basilar portion* develops from *two centers* (sixth week) which soon fuse. Each *exoccipital* portion ossifies from *one center* (about the eighth week). The endochondral portion of the *squamous part* ossifies from *several centers* (two to four during the sixth or seventh week). The *superior part* of the bone arises in membrane from *four centers*, two near the midline (sixth to seventh week) and two more lateral to these (third month). These two lateral masses fuse about the fourth month of fetal life. The exoccipital and squamous parts are united by about the third year; the exoccipitals and the basilar portion are united by the fourth or fifth year; the basilar part and the sphenoid bone fuse about the twenty-fifth year.

Muscle Attached.—To the superior nuchal line the mm. occipitalis, the trapezius and sternomastoideus; to the space below this line the mm. semispinalis capitis, the splenius capitis and the obliquus capitis superior; to the inferior curved line and the space below, mm. the rectus capitis posterior major and minor; to the jugular process the mm. rectus capitis anterior and the superior constrictor of the pharynx.

THE SPHENOID BONE (OS SPHENOIDALE)

The sphenoid bone is in the base of the skull and assists in forming a number of fossæ. It consists of a *body*, *two greater*, *two lesser wings* and *two pterygoid processes*. The **body** (**corpus**) is a hollow, cuboidal mass of bone placed in the median line. It contains two air sinuses separated by a nearly vertical median septum; these are extensive and communicate with the nasal fossæ. The *cerebral surface* is saddle-shaped and contains a deep depression, the *sella turcica* (*fossa hypophyseos*) that serves for the lodgment of the hypophysis. The dorsal limit of the fossa is a ridge of bone, the *dorsum sellæ*, which is continuous with the basilar part of the occipital bone. This is smooth and supports the pons and the basilar artery. The lateral portions of the dorsum sellæ project laterally as the *posterior clinoidal processes* (*processi clinoidei posteriores*) and to these the tentorium cerebelli is attached. The ventral boundary ridge is the *tuber-*

culum sellæ in front of which is the *sulcus chiasmatis* that continues on each side into the *optic foramen.* In front of the sulcus the bone is smooth and continues for a short distance and then articulates with the ethmoid. On the irregular articular area there is often a projection in the midline called the *spine of the sphenoid.* Most of each *lateral surface* is fused with the greater wing and pterygoid process, but curving above the root of the greater wing there is an S-shaped groove for the internal carotid artery (*sulcus caroticus*). This groove is bounded dorsally by the *petrous process* (for articulation with that portion of the temporal bone); above this there may be a groove for the abducens nerve. The nonarticular portion of the anterior part is smooth and somewhat concave on each side of the midline due to the presence of the median *sphenoidal crest* (*crista*

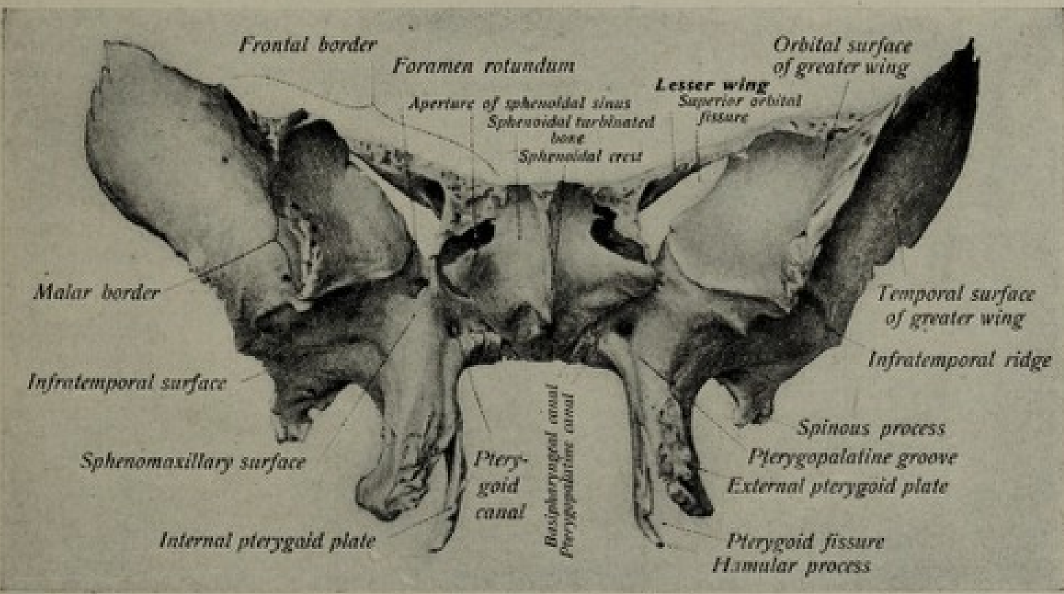


FIG. 26.—The sphenoid bone seen from in front. (*Sobotta and McMurrich.*)

sphenoidalis); this articulates with the perpendicular plate of the ethmoid. The crest ends in the *sphenoidal rostrum.* At the lateral limit of each depression is seen an opening that leads into the air sinus of each side. The remainder of this surface articulates with the ethmoid and palatal bones. The *inferior surface* presents a ridge-like continuation of the sphenoidal rostrum and this ridge fits between the alæ of the vomer. The dorsal end of this surface is rougher and serves for the attachment of the mucosa of the roof of the pharynx. The *posterior surface* of the body is fused with the basilar portion of the occipital bone.

The **greater, or temporal wing (ala magna)** is nearly horizontal and the cerebral surface forms a considerable portion of each middle fossa of the skull. The *lateral*, or *squamosal margin*, starts at the parietal angle and downward and then backward and medially to end at the *spina angularis* where the bone is grooved for the cartilaginous portion of the auditory tube (*sulcus tubæ*). The more extensive margin starts at the parietal angle, passes downward and medially to the body; the first half (frontal) articulates with the frontal bone while the medial half is free and forms the inferior margin of the superior orbital fissure, which transmits the oculomotor, trochlear, ophthalmic division of the trigeminal and the abducens nerves and the ophthalmic veins. The margin then continues backward along the body of the bone forming, posteriorly, the *lingula* that constitutes the lateral boundary of the carotid groove; this is fused underneath with the root of the pterygoid process. The remaining portion of this margin is directed laterally; its first part is free, forming the anterior boundary of the foramen lacerum; the rest (petrosal) is

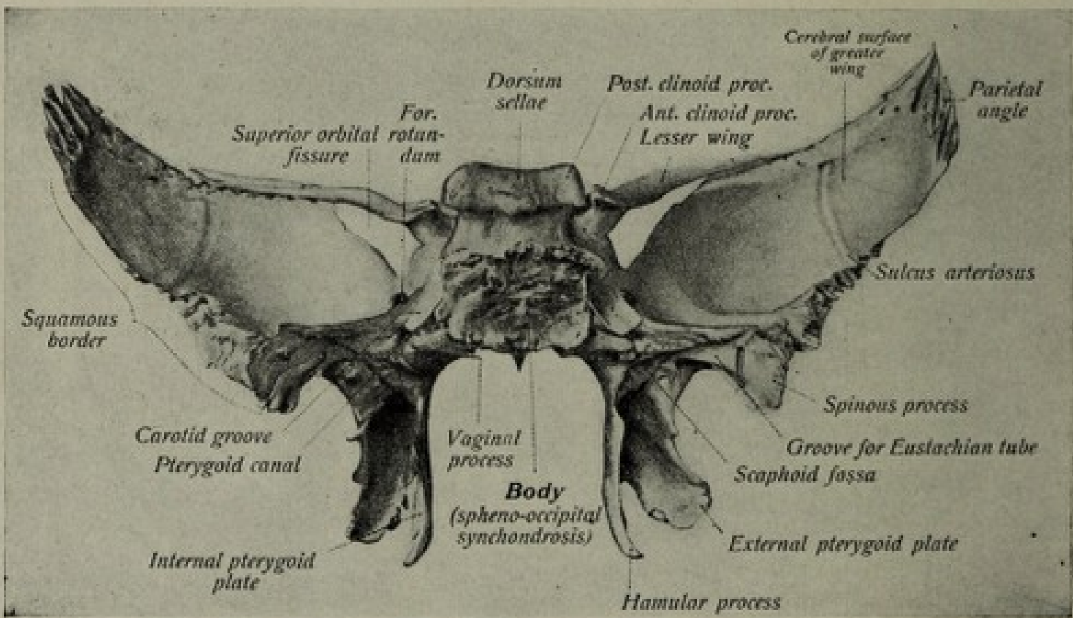


FIG. 27.—The sphenoid bone seen from behind. (*Sobotta and McMurrich.*)

rough for articulation with the petrous part of the temporal bone and ends as the spina angularis. In the broad root of origin of the greater wing are seen three foramina, the *foramen rotundum* (for the transmission of the maxillary division of the trigeminal nerve); the large *foramen ovale* (for the transmission of the mandibular division of the trigeminal nerve and a branch of the middle meningeal artery); the *foramen spinosum* (for the transmission of the middle meningeal artery and vein and the nervus spinosum, from the mandibular division of the trigeminal nerve). The *cerebral surface* of this wing is concave and exhibits the foregoing foramina and may also show impressions of the gyri of the temporal lobe of the brain and a sulcus arteriosus. Its *orbital surface* (*facies orbitalis*) is smooth and forms a part of the orbital fossa and lies below and lateral to the superior orbital fissure; near this there may be the spina recti lateralis to which is attached the common ligament of the ocular muscles. Its *inferior margin* or *orbital crest*, is free and assists in bounding the *inferior orbital fissure* (*fissura orbitalis inferior*). Below this is seen the opening of the foramen rotundum.

The concavo-convex *temporal surface* (*facies temporalis*) is the largest and is separated from the preceding by the zygomatic margin. The nearly horizontal *infratemporal crest* (*crista infratemporalis*) separates the planum temporale (above) from the infratemporal surface (below). The *infratemporal surface* is divided by the low *sphenomaxillary ridge* into a lateral, infratemporal surface proper (showing the openings of the foramina ovale and spinosum) and an anterior, medial spenomaxillary surface. The entire temporal surface enters into the formation of the infratemporal, and pterygopalatine (sphenomaxillary) fossæ.

The **lesser,** or **orbital wings** (**alæ parvæ**) are narrow, triangular and nearly horizontally placed. Each arises by *two roots* that embrace the optic foramen. The *posterior root* forms the *anterior clinoidal process* on each side (*processus clinoideus anterior*). The *cerebral surface* forms a part of the anterior cranial fossa; the *inferior surface* forms a part of the orbit and the upper boundary of the superior orbital fissure. Its *anterior margin* articulates with the frontal bone and its *posterior*, sickle-shaped *margin* is sharp and separates the anterior and middle cranial fossæ.

The **pterygoid processes** (**processus pterygoidei**) are two vertical processes that project downward from the under surface of the bone at the junction of the greater wings and body. Each consists of two *laminæ* (*laminæ processus pterygoidei lateralis et medialis*) between the roots of which extends the *pterygoid canal* for the pterygoid nerve and artery. The two plates are almost at right angles to each other, fused behind (except below at the pterygoid notch) and separated in front where they form the *pterygoid fossa.* Thd *medial pterygoid plate* is narrow and stout; its posterior free margin forms, below, the pterygoid hook (*hamulus pterygoideus*) and, above, it divides to enclose the scaphoid fossa. This fossa gives origin to the m. tensor veli palati. This margin affords attachment to the pharyngobasilar fascia, pharyngeal aponeurosis, superior constrictor of the pharynx and the m. pharyngopalatinus. At the root of this plate are the *vaginal processes* (*processus vaginalis*) and the *pterygopalatine groove.* The lateral *pterygoid plate* is thin and broad and is directed laterally. It affords attachment to the inferior head of the m. pterygoideus lateral and to the m. pterygoideus medialis. The *anterior surface* of the root of the pterygoid process forms a part of the pterygopalatine fossa.

The *sphenoidal conchæ* (*conchæ sphenoidales*) are hollow and each is shaped like a three-sided pyramid. The *apex* is in contact with the vaginal process of the medial plate while the *base* is attached to the lateral mass of the ethmoid bone. The *superior surface* is in contact with the inferior surface of the front part of the body of the sphenoid and the apposed walls have been absorbed to form the sphenoidal sinus of each side. The *inferior surfaces* assist in forming the roof of each nasal fossa and a part of the pterygopalatine fossa. They are separate bones up to the fifth year at which time fusion, as above given, takes place.

Articulations.—With the frontal, parietals, temporals, occipital, ethmoid, vomer, palatals and zygomatic bones (twelve).

Ossification.—This bone is mainly of endochondral origin, the medial pterygoid plate developing in membrane. There are *fourteen centers* of which *six* form the *presphenoid* (the lesser wings and the front part of the body); the other *eight centers* form the *postsphenoid*, or remainder of the bone, except the medial pterygoid plates. The first center on each side are for the greater wing and it appears about the eighth week of fetal life and the last ones are for the hamular processes and appear during the fourth fetal month. The centers are great wings two, po tsphenoid body two, lingulæ two, lesser wings two, presphenoid body two, medial pterygoid plates two, hamular processes two. The presphenoid and main part of the body unite about the eighth month of fetal life so that at birth the greater wings with the pterygoid processes are still separate from the body; they are all united usually by the end of the first year.

Muscle Attached.—Mm. temporalis, pterygoideus lateralis, pterygoideus medialis, constrictor pharyngeus superior, tensor veli palati, levator palpebræ, obliquus superior and the four recti of the eyeball (eleven pairs).

THE TEMPORAL BONES (OSSA TEMPORALIA)

The temporal bones form the middle portion of the base of the cranium. Each consists of three parts—the *squamous*, *tympanic* and *petromastoid portions*.

The **squamous part** (**squama temporalis**) is the vertical portion that forms part of the lateral boundary of the cranium. The *cerebral surface* is smooth but bears the impressions of the gyri of the temporal lobe of the brain and the middle meningeal artery. The *temporal surface* is smooth and assists in forming a part of the temporal fossa; here it gives attachment to the m. temporalis. At the anteroinferior part of this surface is the *zygomatic process* (*processus zygomaticus*). This is a twisted bar of bone that at its anterior extremity articulates with the zygomatic bone; its inferior and medial aspects give attachment to the m. masseter. Its *superior margin* continues backward over the external acoustic meatus as the superior root of the zygomatic process and becomes continuous with the *supramastoid crest*. The *inferior margin* turns medially and constitutes the anterior root. About half way along this margin is the *tuberculum articulare* that bounds the *mandibular fossa* (*fossa mandibularis*) in front. Just in front of the external auditory meatus the anterior root has another projection, the *postglenoid tubercle*. In the depths of this fossa is the partly closed *petrotympanic fissure*, the middle portion of which transmits the tympanic branch of the internal maxillary artery and also lodges the anterior process of malleus. Near this is a canaliculus that transmits the chorda tympani nerve. That portion of the mandibular fossa behind the fissure is nonarticular and lodges a portion of the parotid gland (which becomes enlarged in mumps and causes the pain when the mandible is lowered). The anterior part is articular and with the articular tubercle and the condyle of the mandible forms the temperomandibular articulation; this contains an interarticular fibrocartilage. The *posteroinferior surface* of the squamosa forms a part of the posterior wall of the external auditory canal. The *superior margin* is convex and beveled at expense of the cerebral surface. The *posterior*, *inferior* and *medial*

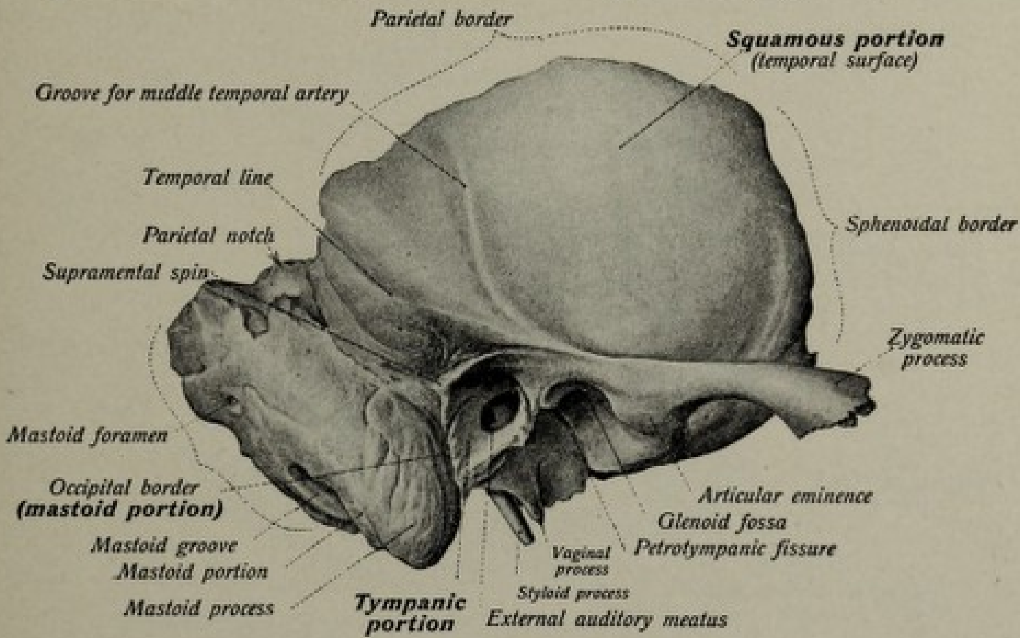


FIG. 28.—The right temporal bone seen from the outer (lateral) surface. (*Sobotta and McMurrich*.)

margins of the squama are fused with the petrous part. Inferiorly and in front is the petrotympanic fissure separating it from the corresponding part of the bone.

The **tympanic portion** (**pars tympanica**) forms the posterior part of the mandibular fossa, the anterior and inferior walls and a part of the posterior wall of the external auditory canal. Its lower edge embraces the styloid process as the *vaginal process*. Although fused with the other parts of the bone it is separated, laterally, from the mastoid and squamous divisions by the *tympanomastoid fissure*. To that part bounding the canal the cartilaginous portion of the external ear is attached.

The *external auditory canal* (*meatus auditorius externus*) is slightly curved, oval on section and twisted upon its long axis. For details see page 350.

The **petromastoid portion (pars petrosa et pars mastoidia)** is the most massive division and is pyramidal in form. The petrous part (*pyramis*) is a long, three-sided pyramid with an *apex, a base, three surfaces* and *three margins.* The *apex* is near the middle line of the base of the cranium at the body of the sphenoid. The *base* is fused with the squamous and tympanic portions. The *anterior surface* forms a part of the floor of the middle cranial fossa and is smooth but irregular; it may show impressions of the gyri of the temporal lobe of the cerebrum. Near the apex is the *impressio trigemina* which lodges the semilunar ganglion of the trigeminal nerve. On this surface are seen the *eminentia arcuata*, made by the superior semicircular canal; near this is the slit-like *hiatus canalis facialis*, for the facial nerve; a little lateral to the hiatus may be a small opening, the

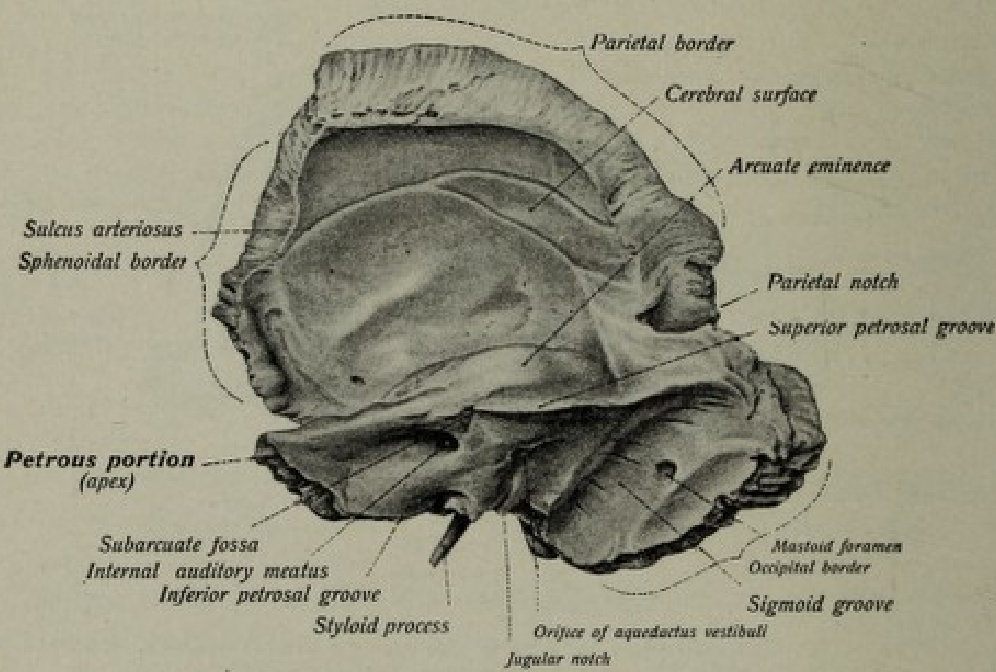


FIG. 29.—The right temporal bone seen from the cerebral surface. (*Sobotta and McMurrich.*)

apertura superior canalis tympani. The *posterior surface* forms part of the posterior cranial fossa and is concave, smooth but uneven. Here the following are seen: (1) *Internal auditory meatus* (*meatus auditorius internus*) a long, oval opening in the depths of which the opening of the canalis facialis may often be noted. The meatus transmits the acoustic nerve and vessels. (2) The *aqueduct of the vestibule* (*apertura externa aqueductus vestibuli*) is in front of the preceding; this lodges the saccus endolymphaticus. (3) The ridge of the *posterior semicircular canal* is above this. The *inferior surface* is very irregular and mostly rough. The most prominent structure is the *styloid process* (*processus styloideus*) that gives attachment to the mm. styloglossus, stylohyoideus and stylopharyngeus and the stylohyoid and stylomaxillary ligaments. Behind the process is the *foramen styloideum*, for the facial nerve and the mastoid artery. The *jugular fossa* (*fossa jugularis*) is medial to the process and assists in forming the jugular foramen. In the jugular fossa is the *canalis mastoideus* for the auricular branch of the vagus. In front of and lateral to the fossa is the *carotid canal* (*canalis caroticus*) for the transmission of the internal carotid artery and the sympathetic plexus. Upon the ridge separating the fossa and canal is the *canaliculus tympanicus* for the transmission of the tympanic branch of the glossopharyngeal nerve. The *fossula fenestræ cochleæ*, with the opening of the aqueduct of the cochlea (*apertura externa aqueductus cochleæ*), are seen anteromedial to the jugular fossa. In the fossula is lodged

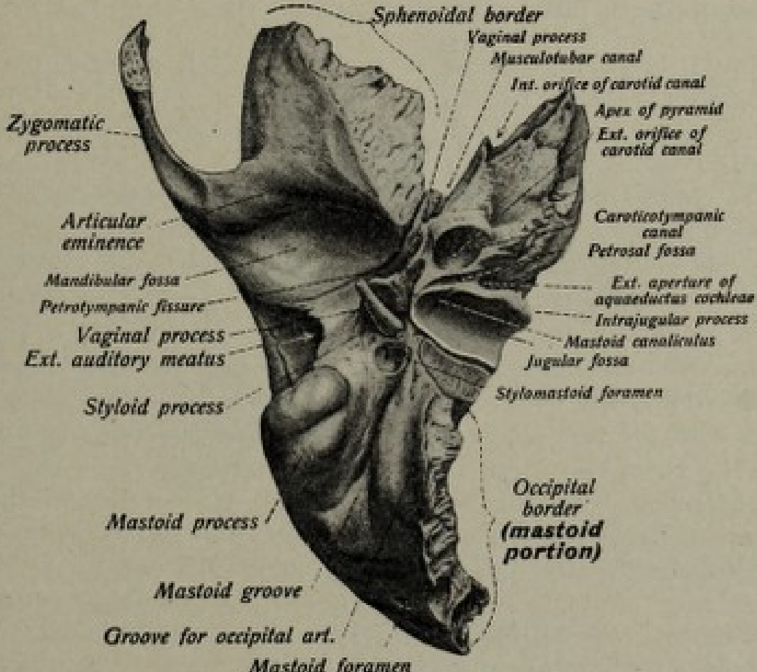


FIG. 30.—Right temporal bone seen from below. (*Sobotta and McMurrich.*)

the petrous ganglion of the glossopharyngeal nerve. From the roughened bone near the apex the m. tensor veli palatini arises.

The *superior angle*, or *margin*, separates the anterior and posterior surfaces and also separates the middle and posterior cranial fossæ from each other. It is grooved for the *superior petrosal sinus* and to it is attached the tentorium cerebelli. The *posterior angle*, or *margin*, is in part free or nonarticular where it forms a part of the jugular foramen; the remainder is articular and usually presents a groove for the *inferior petrosal sinus*. The *anterior angle*, or *margin*, is the shortest and extends from the apex to the squamous part. Near the squama is seen the osseous portion of the *auditory tube* (*canalis musculotubarius*). This is divided by a bony septum into a smaller division (*semicanalis m. tensor tympani*) for the tensor tympani muscle;

the larger portion (*semicanalis tubæ auditivæ*) is the osseous portion of the pharyngotympanic, or auditory tube.

The *mastoid portion* of the temporal bone lies posterior to the external auditory meatus and forms a nipple-like process that is variable in size. Its lateral surface is rough and with the *inferior margin* affords insertion to the mm. sternomastoideus, splenius capitis and longissimus capitis. Its *inferior surface* shows a groove (*incisura mastoidea*) along the root of the apex which gives origin to the posterior belly of the m. digastricus. Medial to this groove is another for the occipital artery. The *cerebral surface* of the mastoid division forms a part of the floor of the posterior cranial fossa; on it are seen a deep wide groove for the transverse, or sigmoid sinus which leads to the jugular fossa; the mastoid foramen for a small artery and vein.

Articulations.—Each articulates with the occipital, parietal, sphenoid, mandible and zygomatic bones (5).

Ossifications.—It is mainly of endochondral origin and develops from *ten centers*, as follows: (*a*) the *center for the squamozygomatic part* appears at about the end of the second month of fetal life; (*b*) *one* for the *tympanic plate* during the third month; (*c*) *six* for the *petromastoid portion* during the fifth to the sixth months; (*d*) *two* for the *styloid process*, one just before and the other just after birth. The squamozygomatic portion develops in membrane. The mastoid process develops during the second year and toward the age of puberty it becomes cellular. The squamous and tympanic parts fuse just before birth and the petromastoid and the squama during the first year. The base of the mastoid process fuses with the rest about the same time and the lower end of the styloid process and the basal end unite about the age of puberty.

Muscles Attached.—To the squama, the m. temporalis; to the zygomatic process, the m. masseter; to the mastoid portion, mm. sternomastoideus, splenius capitis, longissimus capitis, digastricus and auricularis posterior; to the styloid process; the mm. styloglossus, stylohyoideus and stylopharyngeus; to the petrous portion the mm. tensor veli palatini, stapedius, the tensor tympani and levator veli palatini (fifteen).

THE ETHMOID BONE (OS ETHMOIDALE)

The ethmoid bone is a light, thin-walled, honeycombed bone that forms a part of the floor of the anterior cranial fossa and fits in between the orbital parts of the frontal bone. The bone is T-like and consists of a median vertical plate that is topped by the cribriform plate. From this the ethmoidal labyrinth of each side is suspended.

The **perpendicular plate** (*lamina perpendicularis*) is irregular and pentagonal in form and projects into the cranial cavity as a sharp, median *crest* (*crista galli*); to this is attached the falx cerebri, at its frontal extremity is a notch forming the *foramen cecum* with the frontal bone. This plate is usually deflected to one or the other side and has smooth surfaces. Its *posteroinferior surface* is fused with the vomer while its anterior margin articulates with the cartilaginous nasal septum.

The **cribriform plate** (*lamina cribrosa*) bridges the space between the two orbital plates of the frontal bone and is pierced by numerous foramina for the passage of the olfactory nerves. On each side of the midline the *cerebral surface* shows a groove for the olfactory lobe. Along each lateral edge are notches that become the ethmoidal foramina upon articulation. Anteriorly, there is a slit that transmits the nasociliary nerve into the nose. The *inferior surface* forms the roof of the nasal fossæ.

The **ethmoidal labyrinths** (*labyrinthi ethmoidales*) are two thin-walled masses enclosing numerous *air cells*, *anterior*, *middle* and *posterior*. The *lateral*, or *orbital wall* (*lamina papyracea*) forms a part

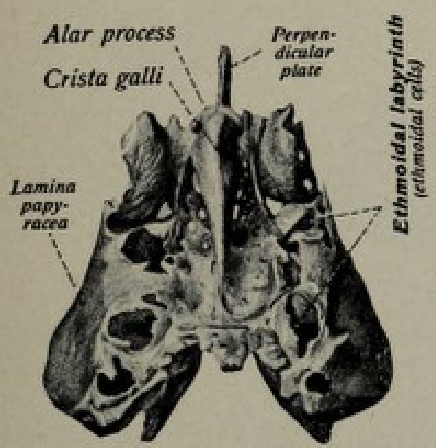


Fig. 31.—The ethmoid bone seen from above. (*Sobotta and McMurrich.*)

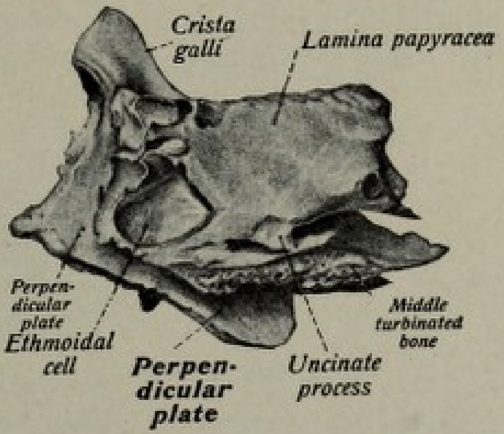


Fig. 32.—The ethmoid bone seen from the side. (*Sobotta and McMurrich.*)

of the medial wall of the orbit. The anterior and posterior ethmoidal foramina are seen here; these transmit small ethmoidal vessels and the anterior nasociliary nerves. Upon the *medial surface,* that forms a part of the lateral wall of each nasal fossa, are seen the *two ethmoidal turbinals* (*conchæ ethmoidales*). These are two thin, convoluted plates of bone of which the middles is much the larger. Between the middle and superior conchæ is the *superior meatus* of the nasal fossa and into this the posterior ethmoidal cells open. The *middle meatus* lies between the middle and inferior conchæ and into it open the middle and anterior ethmoidal cells and the frontal sinus (see "Nasal Fossæ, page 272).

Articulations.—With the sphenoid frontal, two nasal, two palatal, two lacrimal, two maxillæ, two inferior conchæ and vomer bones (thirteen).

Ossification.—It is of endochondral origin and is developed for *four centers, one* for *each labyrinth* and *two* for the *perpendicular plate.* The centers for the labyrinths appear at about the fifth month of fetal life and also form the lateral part of the perpendicular plate. The centers for the perpendicular plate appear at the end of the first year; they form this plate and the medial portion of the cribriform plate. Fusion of all parts is complete by the sixth year. The sphenoidal fusion is complete by about the twenty-fifth year but vomerine fusion is not completed until the fortieth or fiftieth year. The ethmoidal cells are usually completed at birth.

Muscles Attached.—None.

THE INFERIOR CONCHÆ (CONCHÆ NASALES INFERIOR)

Each inferior concha is a scroll-shaped bone located on the lateral wall of the inferior part of the nasal fossa. The superior margin is thin and articulates with the maxilla and the palatal bone and by a process (*processus lacrimalis*) with the lacrimal bone. Here it assists in forming the *nasolacrimal canal.* Its *posterior edge* unites with the ethmoid bone by means of the ethmoidal process (*processus ethmoidalis*). From this margin the *maxillary process* extends forming a part

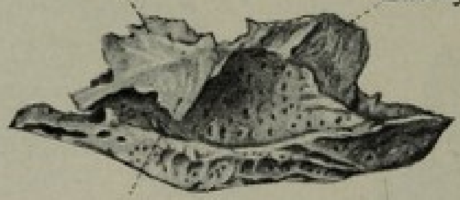


FIG. 33.—The inferior turbinated (conchal) bone seen from its lateral surface. (*Sobotta and McMurrich.*)

of the medial wall of the maxillary sinus. The *medial margin* is free and slightly curved. The *medial surface* is convex from above downward, projects into the nasal fossa and forms the floor of the middle meatus. The *lateral surface* is concave and overhangs the inferior meatus.

Articulations.—With the maxilla, lacrimal, ethmoidal and palatal bones (four).

Ossification.—It is developed in cartilage and from a *single center.* This appears at about the fifth month of fetal life.

Muscles Attached.—None.

LACRIMAL BONES (OSSA LACRIMALIA)

The lacrimal bones are thin bones that form a part of the orbital fossæ. Each has *two surfaces* and *four margins* and is quadrilateral in shape.

The *lateral*, or *orbital surface*, is smooth and is divided by a vertical ridge (*crista lacrimalis posterior*) into two areas; the *anterior* is the *lacrimal groove* (*sulcus lacrimalis*) for the lacrimal sac; the *posterior area* is the orbital surface proper. The ridge ends below in a hooklet (*hamulus lacrimalis*) that forms part of the upper boundary of the nasolacrimal duct. The *medial wall* of the lacrimal groove ends as the descending process. Part of the crest gives attachment to the tendo oculi and lacrimal part of the m. orbicularis oculi. The *medial surface* is uneven and closes in the anterior ethmoidal cells and forms a part of the lateral boundary of the middle meatus of the nose. The *margins* are uneven and articulate with various bones.

Articulations.—With the frontal, ethmoidal, maxilla and inferior concha (four).

Ossification.—Of intramembranous origin and from *one center* that appears during the eighth or ninth week of fetal life.

Muscles Attached.—M. orbicularis oculi (lacrimal part).

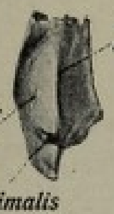


FIG. 34.—Left lacrimal bone seen from its median surface. (*Sobotta and McMurrich.*)

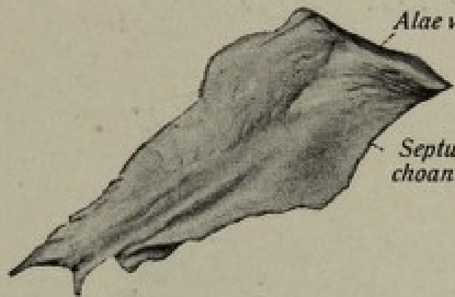


FIG. 35.—The vomer seen from the side. (*Sobotta and McMurrich.*)

THE VOMER

The vomer is an irregular, quadrilateral bone that forms the posterior portion of the nasal septum. It is usually deflected to one or the other side. The *right* and *left surfaces* are smooth. The *superior* margin possesses two lips, or *alæ* by means of which it is held fixedly in position. The *posterior*, or *free margin* is the posterior margin of the nasal septum and separates the two choanæ. The *inferior margin* is irregular for articulation with the palatal bones and the maxillæ. The *anterior* (longest) *margin* is sloping and articulates with the ethmoidal bone and the cartilaginous nasal septum. Its anterior extremity is irregular and articulates with the maxillæ.

Articulations.—With the maxillæ, palatals, sphenoid and ethmoid bones (six.)

Ossification.—It is of intramembranous origin and developes from *two centers* (one on each side of the midline). These appear during the end of the second month. These centers begin to fuse during the third fetal month and fusion is usually completed at the age of puberty.

Muscles Attached.—None.

NASAL BONES (OSSA NASALES)

The **two nasal bones** form the bridge of the nose. Each has *two surfaces* and *four margins*. The *lateral surface* is convex from side to side, concave from above downward and constricted near the middle. Upon this surface is seen a small opening for the nutrient vessel.

The *medial surface* is small, concave from side to side and forms a part of the lateral boundary of the nasal fossa. It is traversed by a narrow groove (*sulcus ethmoidalis*) in which is lodged a branch of the nasociliary nerve. The *margins* are roughened and irregular for articulation with the neighboring bones.

Articulations.—With the opposite nasal, the frontal, ethmoidal and maxilla (four).

Ossification.—It is of intramembranous origin and is developed from *one center* that appears about the eighth week of fetal life.

Muscles Attached.—None.

Fig. 36.—The left nasal bone seen from the lateral surface. (*Sobotta and McMurrich.*)

Fig. 37.—The left nasal bone seen from its medial surface. (*Sobotta and McMurrich.*)

THE FACIAL BONES (OSSA FACIEI)

These comprise the **two maxillæ, two palatals, two zygomatics and the mandible.**

THE MAXILLÆ

The maxillæ (two) form the front of the face and constitute the upper jaw. The main portion is the *body*, and from this extend *four processes*. The **body (corpus)** although apparently massive is light and hollow (maxillary sinus). It has four surfaces. The *lateral*, or *anterior surface* (*facies anterior*) although smooth is irregular showing ridges that correspond to the sockets of the teeth (*processus alveolaris*). Of these ridges that for the canine tooth is the most prominent separating two fossæ, *incisor fossa* (medially) and *canine fossa* (laterally). Its *superior oblique margin* (*margo infraorbitalis*) is free and beneath it is the *infraorbital foramen*. The *medial margin* has the nasal notch limited below by the anterior nasal spine.

The *orbital surface* (*planum orbitale*) is smooth and nearly horizontal. Posteriorly it forms part of the posterior boundary of the inferior orbital fissure. The first part of the *medial margin* is notched forming the *lacrimal groove* (*sulcus lacrimalis*). Through the planum extends the *infraorbital canal* which may be open for a variable distance. The canal has two openings (invisible unless the canal is laid open) that lead into the maxillary sinus and these transmit vessels to the anterior and middle teeth.

The *infratemporal surface* is posteriorly and laterally placed, convex from side to side and smooth. The *upper margin*, with the posterior margin of the orbital surface, forms the anterior boundary of the inferior orbital fissure. Near the middle of the posterior portion it is pierced by several alveolar canals (*foramina alveolaria*) that transmit vessels and nerves to the molar teeth. That part of the bone

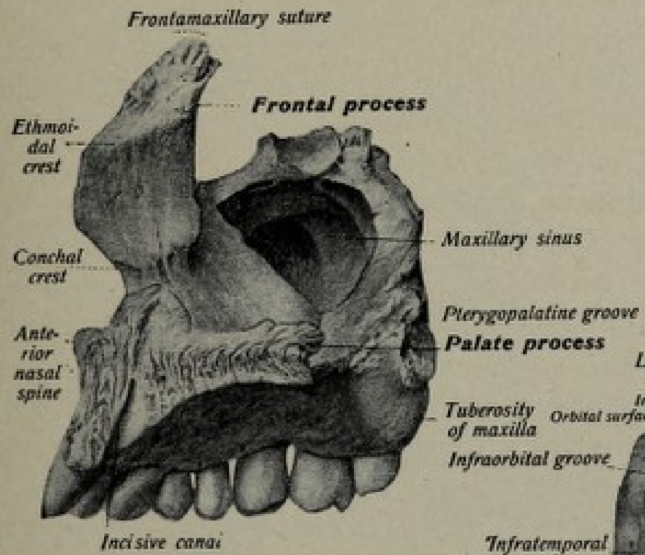


FIG. 38.—The right maxilla seen from the medial surface. (*Sobotta and McMurrich.*)

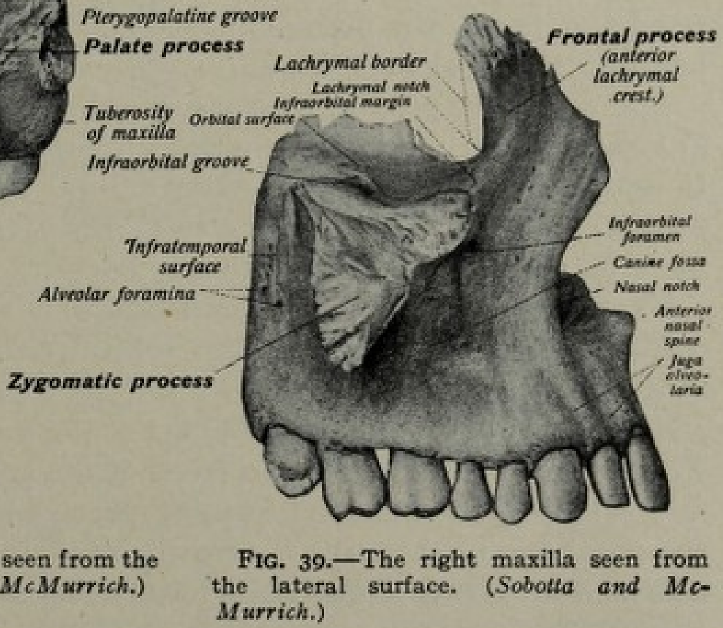


FIG. 39.—The right maxilla seen from the lateral surface. (*Sobotta and McMurrich.*)

that extends beyond the last molar tooth is called the *maxillary tuberosity* (*tuber maxillare*).

The *nasal*, or *medial surface* (*facies nasalis*) forms a part of the lateral wall of the nasal fossa. It exhibits the *nasal notch*, in front, the *lacrimal groove*, above, and along the posterior margin the *pterygopalatine groove*, which becomes a canal upon articulation (for the posterior palatine nerve and the great palatine artery). Near the upper and back part of this surface is the opening into the maxillary sinus which is smaller in the articulated skull. The **sinus** is pyramidal in shape (as is the body) and communicates with the middle meatus of the nasal fossa. Its walls, the surfaces of the body, are for the most part thin, especially over the sockets of the teeth. In the recent state it is lined with a mucous membrane which is continuous with that of the nasal fossa.

The **palatal process** is a horizontal shelf of bone at the lower margin of the nasal surface of the body and extends as far back as the second molar tooth. Its *superior surface* forms most of the floor of the nasal fossa. The rough inferior surface is concave from side to side and, with its fellow, forms the anterior three-fourths of the vault of the hard palate and about one-half of the roof of the oral cavity. It is grooved by the pterygopalatine groove. Its *medial margin* helps form the *nasal crest* (*crista nasalis*) for articulation with the vomer. In front the nasal crest forms the *incisor crest* that ends in the *anterior nasal spine*. Back of the nasal spine the medial margin is grooved and with its fellow forms the *incisive foramen* (*foramen incisivum*). Into this open the *foramina of Stensen* and *Scarpa*.

The **alveolar process (processus alveolaris)** is that part below the level of the palatal process. It represents half of the superior dental arch and bears the teeth of its respective side. It is present only when the teeth are present, being absorbed when the permanent teeth are lost.

The **zygomatic process (processus zygomaticus)** is concave behind, in keeping with the infratemporal surface, and flattened anteriorly. It separates the facial and infratemporal surfaces and is attached to the body above the first molar tooth. Its extremity is irregular for articulation with the zygomatic bone.

The **frontal process (processus frontalis)** is a thin plate of bone extending above the level of the orbital surface. The *infraorbital margin* is continued upon it as the *crista lacrimalis anterior*, behind which the grooved area forms a part of the fossa for the lacrimal sac. The tendo oculi is attached in front of the groove. The *medial surface* is smooth but uneven forming part of the lateral boundary of the nasal fossa. Upon it is seen the oblique ethmoidal crest (*agger nasi*). Its edges are roughened for articulation with the neighboring bones.

Articulations.—It articulates, above, with the nasal, frontal, lacrimal and ethmoidal bones; posteriorly and medially with the palatal and opposite maxilla; laterally with the zygomatic bone; it also articulates with the inferior concha and the vomer (nine).

Ossification.—It is of intramembranous origin and is developed from *six centers*. These are the *orbitonasal*, *zygomatic*, *palatal*, *nasal*, *infravomerine* and *premaxillary* (probably two). These centers appear about the eighth week and by the tenth week the first five have fused into one mass. Later these two fuse but the suture between them is noted on the palate up to middle life. The *maxillary sinus* begins to form during the fourth month and reaches its full size after the second dentition.

Muscles Attached.—Mm. orbicularis oculi, obliquus inferior, caput angulare, caput infraorbitale, caninus, nasalis, depressor alæ nasi, dilatator naris posterior, masseter, buccinator, orbicularis oris and pterygoideus medialis (twelve).

PALATAL BONES (OSSA PALATINA)

Each palatal bone is very delicate and of irregular shape. It assists in forming the following fossæ: nasal, orbital, pterygopalatine, infratemporal and pterygoid. It has two main portions, *horizontal* and *vertical*.

The **horizontal portion** (**pars horizontalis**) forms about one-third of the hard palate. Its *superior surface*, smooth and concave, constitutes a part of the floor of the nasal cavity. The *inferior surface* is rougher and forms part of the roof of the mouth. The *medial* and *anterior margins* articulate with the neighboring bones while the *lateral margin* fuses with the pars perpendicularis. The *posterior margin* is free and has the aponeurosis of the palate attached to it.

FIG. 40.

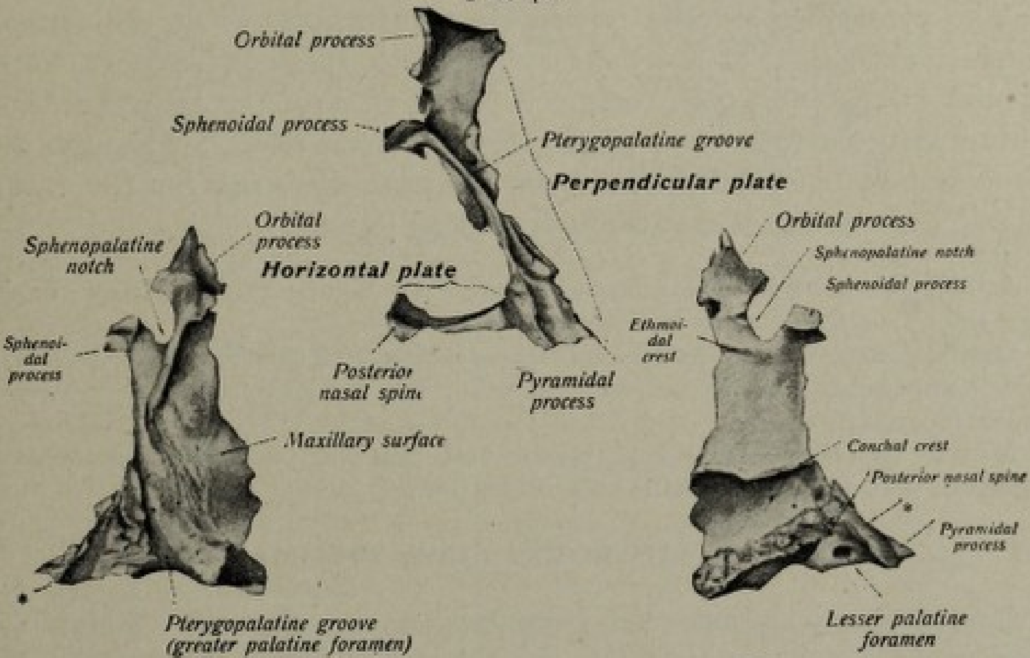


FIG. 41. FIG. 42.

FIG. 40.—The right palate bone seen from behind. (*Sobotta and McMurrich.*)

FIG. 41.—The right palate bone seen from lateral surface. (*Sobotta and McMurrich.*)

FIG. 42.—The right palate bone seen from the medial surface. *, Surface which completes the pterygoid fossa. (*Sobotta and McMurrich.*)

The posterior part of the medial margin constitutes the *posterior nasal spine.*

The **perpendicular portion** (**pars perpendicularis**) is narrow below. Its *medial surface* forms the back of the lateral wall of the nasal fossa and is crossed by the conchal crest (*crista conchalis*); above this crest is the middle meatus and below it is the inferior meatus. Near its upper part is the *ethmoidal crest.* The *lateral wall* is a part of the pterygopalatine fossa wall. It is quite irregular and shows the pterygopalatine groove. Its front part constitutes the *maxillary process.* The *anterior margin* is irregular for articulation. The *posterior margin* exhibits, below, the *pyramidal process.* The inferior margin joins the horizontal part. The *superior margin* supports two processes, the *sphenoidal* and *orbital*.

The **sphenoidal process** (**processus sphenoidalis**) is small and dorsally directed. Its *superior surface* is smooth and assists in forming the pharyngeal canal for the pharyngeal artery and the pharyngeal branch of the sphenopalatine ganglion. Its *medial surface* forms a part of the nasal fossa. Its *lateral surface* forms a part of the wall of the pterygopalatine fossa.

The hollow **orbital process** (**processus orbitalis**) is the highest part of the bone and its medially directed opening communicates with the sphenoidal sinus. The nonarticular surfaces are as follows: superior, that forms a part of the floor of the orbit; medial, that forms a part of the lateral nasal wall; lateral, that forms a part of the wall of the pterygopalatine fossa.

The **pyramidal process** (**processus pyramidalis**) is at the antero-inferior extremity of the bone. A smooth, V-shaped groove forms a part of the pterygoid fossa. A small part of the lateral surface enters into the formation of the infratemporal fossa. Through this process pass, vertically, the *lesser palatine foramina* for the transmission of the lesser palatine nerves and vessels.

Articulations.—With the ethmoid, vomer, sphenoid, maxilla, inferior concha and the opposite palatal bones (six).

Ossification.—It is of intramembranous origin and usually from *one center*, which appears in the second fetal month. The orbital process may have a separate center.

Muscle Attached.—The mm. tensor veli palatini, constrictor pharyngeus superior, pterygoideus medialis and uvulæ (four).

THE ZYGOMATIC BONES (OSSA ZYGOMATICA)

The zygomatic bones are irregular, constituting the cheek bones and assisting in forming the orbital, infratemporal and temporal fossæ.

The *lateral surface* (*facies malaris*) of each is convex, smooth and exhibits the *zygomaticofacial canal*. The most prominent part of this surface is the *malar tuberosity*. The surface is roughly quadrilateral in form and the angles are represented by processes. The *femporal process* is broad and is posteriorly directed. The *frontosphenoidal process* is the most prominent and is superiorly directed. The *marginal process* is anterior and somewhat curved. The *inferior process* is the least marked. The margins connecting these processes are mostly thin and sharp. The *temporal margin* has a projection, the *processus marginalis*, and with the orbital and masseteric margins is free. To the latter is attached the m. masseter. The *maxillary margin* is articular.

The *medial surface* is divided by the orbital process which separates the concave infratemporal from the orbital areas (also called surfaces). Part of the orbital process is nonarticular and forms the anterior boundary of the inferior orbital fissure. The orbital area of the medial surface exhibits two foramina (*zygomaticoorbitale*) one of which is the internal opening of the *zygomatocofacial canal* (for the zygomaticofacial branch of the zygomatic nerve); the other is the *zygomaticotemporal canal* (for the zygomaticotemporal nerve). The former canal opens upon the lateral surface of the bone and the latter in the temporal fossa.

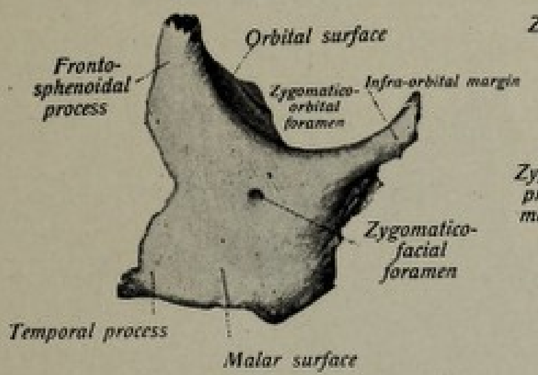


FIG. 43.—The right malar bones seen from the lateral surface. (*Sobotta and McMurrich.*)

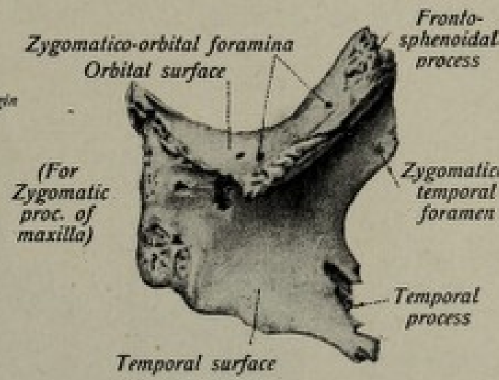


FIG. 44.—The right malar bone seen from the medial or temporal surface. (*Sobotta and McMurrich.*)

Articulations.—With the temporal, frontal, sphenoidal and maxillary bones (four).

Ossification.—It is of intramembranous origin and is developed from *three centers*. The *center for the orbital portion* appears about the eighth to the tenth week and forms the bulk of the body and the temporal process; a *second center* forms the *temporal fossa* part of the body and the *third* forms the *lower part of the body*. These fuse at about the fifth month of fetal life but sutures may persist between these throughout life.

Muscle Attached.—Mm. caput infraorbitale, zygomaticus, caput zygomaticum and masseter (four).

THE MANDIBLE (MANDIBULA)

The mandible is V-shaped with its extremities turned upward. It constitutes the entire lower jaw and is the strongest bone of the face. It supports the lower teeth and consists of a *body* and *two rami*.

The **body** (**corpus mandibulæ**) has *two surfaces* and *two margins*. The *lateral surface* is convex from side to side and concave from above downward. In the median line is a vertical ridge, the *symphysis*, below which is the *mental protuberance* (*protuberantia mentalis*) which is divided into *two tubercles* (*tubera mentalia*). The sockets of the front teeth project somewhat. At each side of the symphysis is the *incisor fossa* and in line with the second premolar tooth is the *mental foramen*, for the mental nerve and vessels. The *oblique line* (*linea obliqua*) extends upward and backward from the mental tubercle. The *medial surface* is convex from above downward and concave from side to side. Upon each side of the median line are the *mental spines* (*spina mentales*) the upper giving attachment to the mm. genioglossus and the lower to the geniohyoideus. Above the spine is a *nutrient foramen*. Below and to the side is the *digastric fossa* (*fossa digastrica*) for the attachment of the anterior belly of the m. digastricus. This surface is traversed and divided by an oblique line below and in front over the digastric fossa. This is the *mylohyoid line* (*linea mylohyoidea*) to which the mm. mylohyoideus and constrictor pharyngeus superior are attached. The bone below this

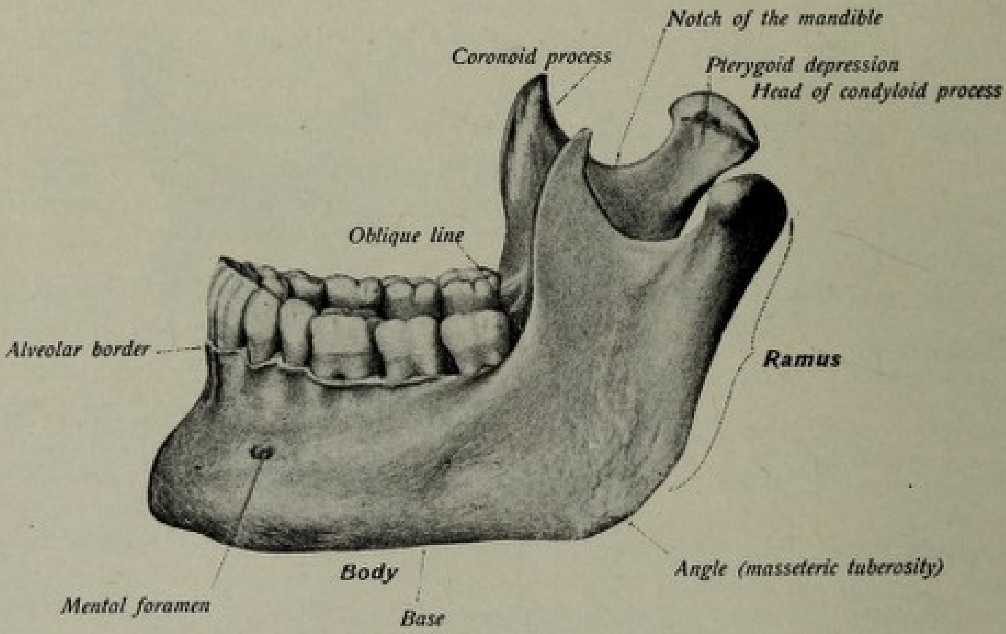


Fig. 45.—The mandible seen from the lateral surface. (*Sobotta and McMurrich.*)

line is hollow (*fossa submaxillaris*) for the submaxillary gland and in front is another hollow area the *fossa sublingualis*.

The *superior*, or *alveolar margin*, supports the lower teeth. The *inferior margin* (*basis mandibulæ*) is thicker than at the junction of the alveolar margin and the body. This margin is longer than the superior, rounded and grooved near the junction with the ramus for the external maxillary artery.

The **rami** (**rami mandibulæ**) are flat and nearly vertical in direction. The *lateral surface* of each is smooth but uneven due to ridges for muscle attachment (masseter). The *medial surface* is smooth and irregular. Near the middle is the *foramen mandibulare* that leads into the inferior alveolar canal (for the vessels and nerves of the same name). The shelf of bone overhanging the opening is the *lingula mandibulæ*. An oblique groove (*sulcus mylohyoideus*) extends downward from the foramen lodges the mylohyoid artery and nerve. The *angle* (*angulus mandibulæ*) represents the junction of the base and rami. The *anterior margin* is free and continuous with the oblique line. The *posterior margin* is thick, smooth and covered by the parotid gland. The *inferior margin* represents the fusion of ramus and body. The *superior margin* is thin and presents the *coronoid* and *condyloid processes* with an intervening *mandibular notch* (*incisura mandibulæ*).

The *coronoid process* (*processus coronoideus*) is a flat triangular process that affords attachment, laterally, to the mm. masseter and temporalis, and medially to the m. temporalis. The *condyloid process* (*processus condyloideus*) is more massive and presents a condyle and a neck. The *condyle* (*capitulum mandibulæ*) is oblong with its long axis transversely placed. Its surface is convex and

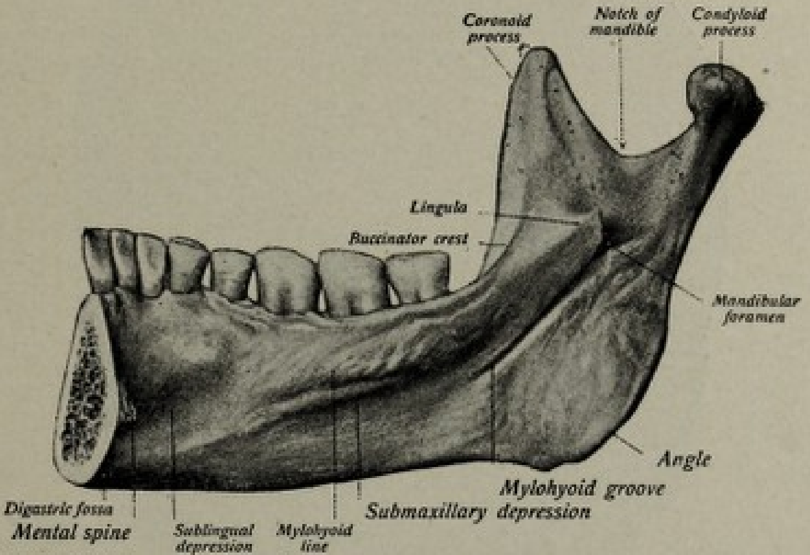


FIG. 46.—One-half of the mandible seen from the medial surface. (*Sobotta and McMurrich.*)

mainly articular. The *neck* (*collum mandibulæ*) is flattened from before backward and ridged. Upon its medial surface, anteriorly, there is a deep depression (*fovea pterygoidea*) for insertion of the m. pterygoideus medialis.

Articulations.—With the temporal bones (two).

Ossification.—It is of intramembranous origin and develops from *two centers, one* for *each half*. These centers appear about the forty-fifth day of fetal life. At birth the mandible consists of two halves that fuse, usually, by the end of the first year.

Muscles Attached.—The mm. mentalis, quadratus labii inferioris, triangularis, platysma, buccinator, masseter, orbicularis oris, geniohyoglossus, geniohyoideus, mylohyoideus, digastricus, constrictor pharyngeus superior, temporalis and pterygoidei medialis and lateralis (sixteen pairs).

THE SKULL AS A WHOLE

Only a general description of the skull in various views will be given, as *frontal*, *lateral*, *occipital*, *basal*, *medial* and *internal*.

The **frontal aspect** (*norma frontalis*) exhibits the following important features for consideration: The frontal region, the orbital fossæ, pyriform aperture and dental arches.

The *frontal region*, above the level of the orbits, is convex in both directions and its breadth and height vary in the different races. The lower border is sharply outlined, on each side, by the *supraorbital margins*, each of which shows the *supraorbital notch* (*incisura supraorbitalis*). In the median line, near the lower margin is the *glabella* and passing to each side from this are the *superciliary arches*.

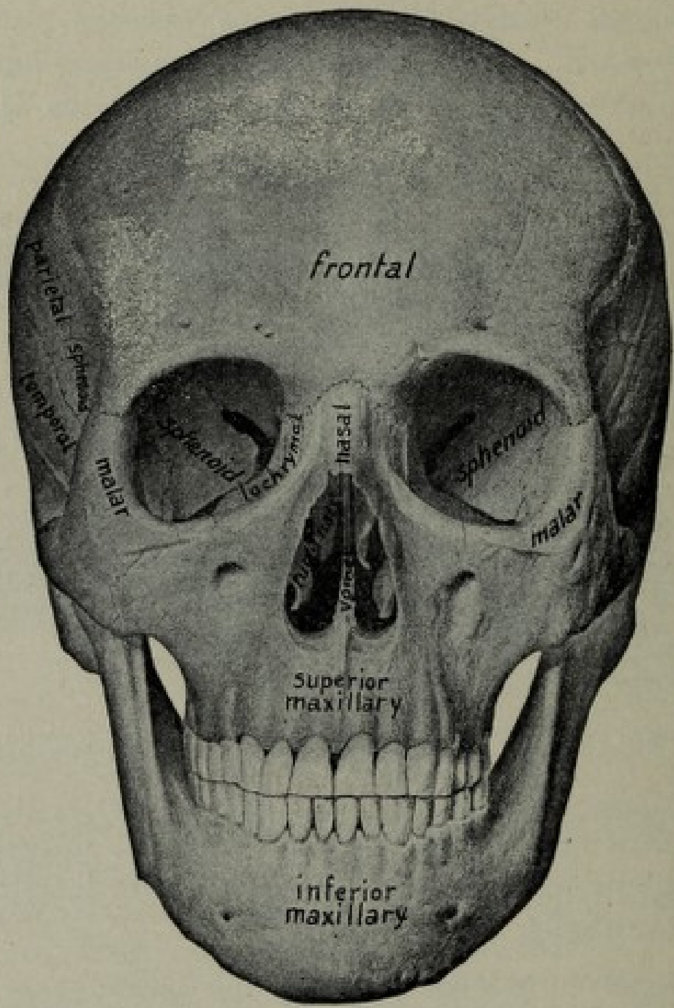


FIG. 47.—The skull seen from in front. (*Sobotta and McMurrich.*)

The lateral borders of the frontal region are sharp, below, but not above; no superior border is present as the curve of the bone blends with the vertex.

The **orbital fossæ** (two) are pyramidal in shape with the base (orbital aperture) at the face and the apex directed backward and medially. The *apex* is practically the *optic foramen* (for the optic nerve and ophthalmic artery); below and medial to this is the *superior orbital fissure*, for the oculomotor, trochlear, ophthalmic division of the trigeminal, and the abducens nerves and the ophthalmic veins. In the temporal part of the orbit is the *fossa for the lacrimal gland*. The *roof* is formed by the orbital portion of the frontal bone and the small wing of the sphenoid. The *floor* is formed by the orbital surfaces of the maxilla and zygomatic bones and the orbital process of the palatal bone. Here is seen the *inferior orbital fissure* that transmits the maxillary division of the trigeminal nerve, the zygomatic branch of that division, the infraorbital vessels and some branches from the palatine ganglion. Through the floor passes the *infraorbital canal*. The *lateral wall* is formed by the great wing of the sphenoid and the orbital surface of the zygomatic bone. It is bounded by the two orbital fissures, behind. In it are seen two openings, the *foramina zygomaticoorbitalis*, for the transmission of the zygomaticofacial and zygomaticotemporal nerves from the maxillary division of the trigeminal nerve. The *medial wall* is formed by the frontal process of the maxilla, the lamina papyracea of the ethmoid and the body of the sphenoid bones. At the inferior and medial part (in front) is seen the *fossa for the lacrimal sac*.

The **pyriform aperture** (*apertura pyriformis*) lies below and between the orbits and varies in the different races. It is bounded by the nasal bones and the frontal processes of the maxillæ. In the medial line is seen the anterior nasal spine and, deeper in, the vomer. The middle and inferior conchæ are seen upon each lateral wall.

The **dental arches** are transversely placed and the upper overlaps the lower, slightly. In the mandible, on each side of the midline, is seen the mental foramen for the transmission of the mental vessels and nerves.

The **lateral aspect** (*norma lateralis*) is mainly cranial. This portion is bounded by the frontal, temporal, parietal and occipital bones, and lies above a line drawn from the tip of the mastoid process to the nasofrontal suture. The temporal fossa lies above the level of the zygomatic process and extends upward to the superior temporal line. The fossa contains the m. temporalis, with its nerves, vessels and fascia, and the zygomaticotemporal nerve. Below the level of the zygomatic arch the temporal fossa continues as the *infratemporal fossa*, under cover of the ramus of the mandible. Into this fossa open the foramina ovale and spinosum which are best seen on the basal view. Under the root of the zygomatic arch is the *mandibular fossa*, for the condyle of the mandible, and behind this is the *external auditory meatus*. The *pterygopalatine fossa* is small and somewhat hidden. It lies between the maxilla, in front, and the root of the pterygoid process, behind. It communicates with the infratemporal fossa through the pterygomaxillary fissure.

The **occipital aspect** (*norma occipitalis*) is formed by the squamous portion of the occipital bone and the lower part of each parietal bone. Its lower limit is the superior curved line and in the middle of this is the external occipital protuberance, or *inion*.

The **vertex** (*norma verticalis*) is the superior aspect of the skull and varies greatly. The sutures are quite pronounced. In the midline is the *sagittal suture* between the parietal bones. This joins the *lamboidal suture,* between the occipital and parietal bones, behind. This junction indicates the *posterior fontanelle* of the fetus. In front, the sagittal suture meets the *coronal suture,* between the parietal and frontal bones. This junction corresponds to the *anterior fontanelle* of the fetus.

The **basalar aspect** (*norma basalis*), with the mandible off, is quite complicated. In front are seen the *superior dental arch* and the *hard palate* with its foramen incisivum. Back of the hard palate are the *choanæ,* or *posterior nares* to the side of which are the *pterygoid* and

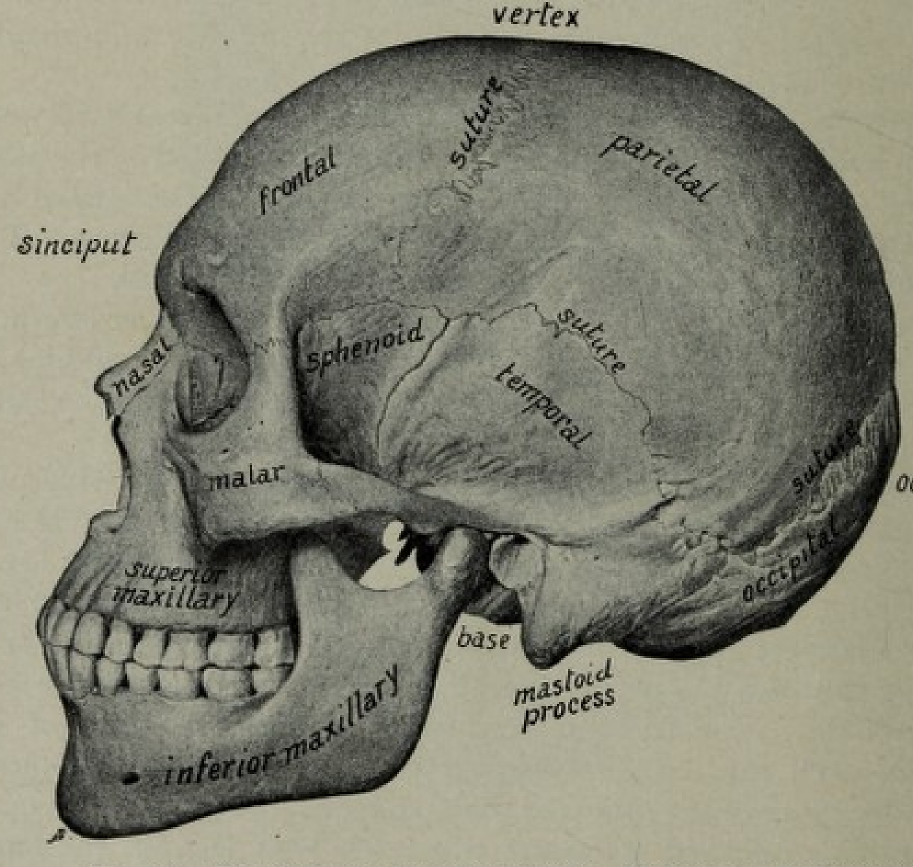


Fig. 48.—The skull seen from the left side. (*Sobotta and McMurrich.*)

scaphoid fossæ. At about the middle of the base is seen the *foramen magnum* (for the spinal cord and vertebral arteries) with the two *condyles* and *condyloid foramina* (for the hypoglossal nerve) at each side. Back of the foramen magnum is the *external occipital crest* with the *external occipital protuberance* at its superior end, from the latter the *superior nuchal lines* extend laterally.

Lateral to the midline the following are seen, from before backward: The *infraorbital fissure,* the *infratemporal fossa, foramen ovale* (for mandibular branch of the trigeminal nerve) *for. spinosum* (for middle meningeal artery and vein) and the *mandibular fossa;* the *fora-*

men lacerum (for the carotid artery and great superficial petrosal nerve), the *auditory tube*, the *carotid canal*, the *jugular foramen* (for the jugular vein and the glossopharyngeal, vagal and hypoglossal nerves), the *styloid process* and the *external auditory meatus;* the *stylomastoid foramen* (for the facial nerve), the *mastoid notch*, the *mastoid process* and the *mastoid foramen.*

The **basis cranii interna** is exposed by removing the vault of the cranium. Three fossæ, anterior, middle and posterior are then seen. The *anterior*, the smallest, lies at the highest level. It is bounded, in front, by the vertical portion of the frontal bone and behind, by the edges of the small wings of the sphenoid bone. In the middle are seen the *foramen cecum* and the *crista galli;* at the sides of the latter are the *olfactory grooves* (for the olfactory lobes) and the *cribriform plate* of the ethmoid. This plate is pierced for the transmission of the olfactory nerves. The frontal lobes of the cerebrum lie in this fossa.

The *middle fossa* lies between the edges of the small wings of the sphenoid bone and the superior margins of the petrous portions of the two temporal bones. This is narrow in the midline and here is seen the *pituitary fossa* for lodgment of the pituitary gland. This fossa contains in addition the cruri cerebri and the temporal lobes of the cerebrum. At each side, and from before backward, are the *optic foramen*, *internal opening of the carotid canal*, and the *carotid groove*. Far to the side the *foramina rotundum*, *ovale*, *spinosum* and *lacerum*, the depression for the semilunar ganglion and the *hiatus facialis*. The superior orbital fissure is here but it is hidden by the overhanging posterior edge of the small wing of the sphenoid.

The *posterior fossa* is the largest, deepest and at the lowest level. It contains the cerebellum. It lies between the superior margins of the petrous portions of the two temporal bones, in front, and the vertical portion of the occipital bone, behind. It is roofed over by the tentorium cerebelli. In the midline are the *foramen magnum* with the *canalis hypoglossi* upon each side; then follow the *internal occipital crest* and *internal occipital protuberance.* At the sides of the midline are seen the *internal acoustic meatus*, the *jugular foramen* and *grooves* for the superior and inferior petrosal sinuses and the lateral and sigmoid sinuses.

In a **median sagittal section** of the skull, the bulk is represented by the cavity of the cranium, for the brain. In the frontal bone is seen the *frontal sinus;* within the body of the sphenoid is the *sphenoidal sinus* and in the superior surface of the body is the *pituitary fossa.* In the posterior fossa is the internal acoustic meatus. The facial portion of this section presents the *nasal cavity* (*cavum nasi*). This and its connections are described on page 271.

At *birth* the facial portion of the skull represents only about one-eighth the mass of the cranial portion. The median line junction of the frontal and parietal bones is incomplete, constituting the *frontal fontanelle* (*fonticulus frontalis*); this is diamond-shaped, covered in by membrane and is closed by bone by about the middle of the second year. Between the parietal and occipital bones there is also an area where the bones are incomplete and this is the *posterior fontanelle* (*fonticulis occipitalis*). This is closed usually by the second month after birth. *Lateral fontanelles* are usually present at the sphenoidal angles of the parietal bones. The *parietal eminences* are unusually prominent at birth and represent the less-marked tubera parietalia of the adult.

The forehead bulges prominently at the regions of the frontal

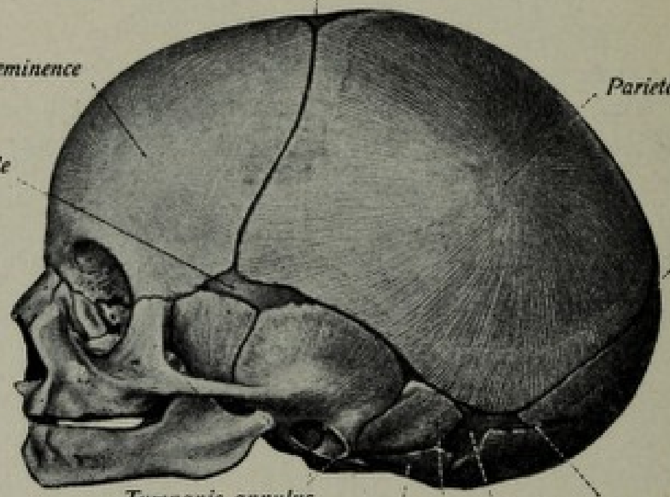


FIG. 49.—Skull of a new-born child seen from the left side. (*Sobotta and McMurrich.*)

tuberosities. The apertura pyriformis is relatively wider than in the adult, the maxillæ are low and the alveolar margins poorly marked. The maxillary sinus is merely indicated by a groove. The mastoid process is barely noticeable. The mandible consists of lateral halves united by fibrous tissue and the alveolar margin is poorly marked. The ramus is wide and the angle is obtuse.

In the *adult* the face constitutes about one-half of the mass of the cranium. This is mainly due to the eruption of the teeth and the development of the air sinuses.

As regards *sex*, the skull of the average female is smaller than that of the average male by about one-tenth. It is lighter, smoother and less well marked in regard to ridges for muscle attachment. The forehead is usually more vertical though the frontal and occipital regions are less capacious. The vertex is usually flatter and the face more oval.

BONES OF THE SUPERIOR (PECTORAL) EXTREMITY

The bones of each *pectoral appendage* are the *clavicle*, *scapula* (forming one-half of the shoulder girdle) the *humerus* (arm), the *radius* and *ulna* (forearm), *carpal bones* (wrist), *metacarpal bones* (palm) and the *phalanges* (fingers).

THE CLAVICLE

The clavicle, or collar bone, is a ∼-shaped bone that forms the ventral portion of the pectoral girdle on each side. It consists of a *shaft* and *two extremities*.

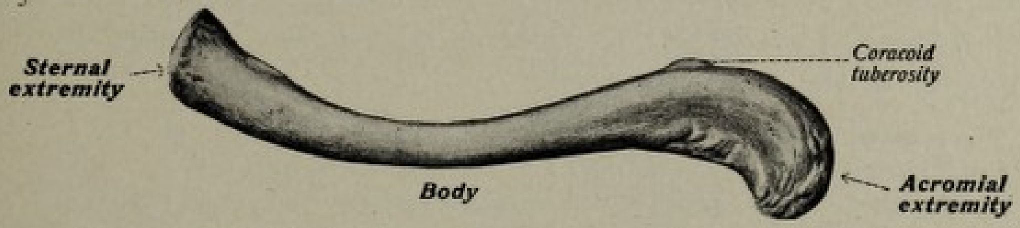


FIG. 50.—The left clavicle seen from above. (*Sobotta and McMurrich.*)

The **sternal extremity (extremitas sternalis)** is enlarged, oval and somewhat concave, from above downward. Its articular surface is smooth, and articulate with the manubrium sterni; from this bone, however, it is separated by the interarticular fibrocartilage. This extremity also rests upon the first costal cartilage. The edge of the articular area serves for the attachment of the capsular ligament.

The **shaft** has a double curve. The sternal two-thirds is cylindrical

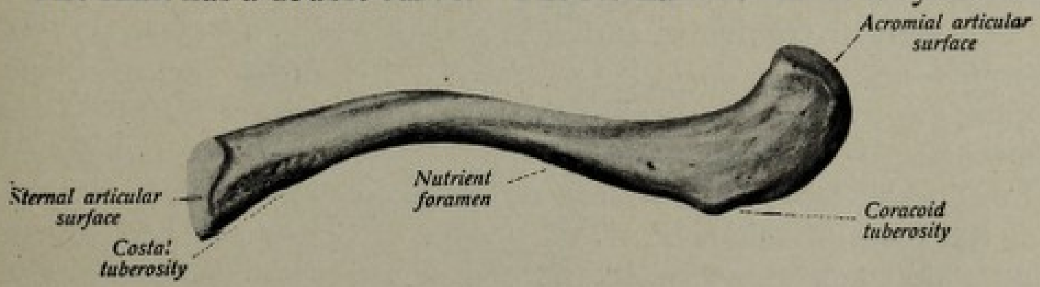


FIG. 51.—The left clavicle seen from below. (*Sobotta and McMurrich.*

and convex in front, and the acromial one-third is flattened and concave in front. The shaft has *two surfaces* and *two margins*. The *superior surface* is smooth and subcutaneous. The *inferior surface* shows, near the sternal extremity, a depression (*tuberositas costalis*) for the attachment of the costoclavicular ligament. Beyond this a *groove* extends to the acromial extremity and here the m. subclavius is inserted. The *ventral*, or *anterior margin*, is roughened and from its sternal portion arises the clavicular part of the m. pectoralis major; from its acromial end a portion of the m. deltoideus arises.

The *dorsal*, or *posterior margin* is broad at its sternal end and here the clavicular portion of the m. sternomastoideus arises; immediately below this the m. sternohyoideus has its origin. Near the acromial end of this margin is a small projection, the *coracoid process* (*tuberositas coracoidea*) for attachment of the conoid ligament.

The **acromial extremity** presents, at its end, an oval facet for articulation with the acromion of the scapula; to the edges of this area is attached the capsular ligament. Its *superior surface* is roughened and mainly subcutaneous. The *inferior surface* shows the oblique *trapezoid ridge* at the dorsal end of which is the *tuberositas coracoidea*. These are for the attachment of the trapezoid and conoid portions of the coracoclavicular ligament, respectively. The *ventral*, or *anterior margin* is thin and gives origin to the m. deltoideus. The *dorsal*, or *posterior margin* is roughened for the insertion of the m. trapezius.

The **nutrient foramina** are large and on the dorsal margin.

Articulations.—With the scapula and sternum (indirectly).

Ossification.—It is endochondral in origin and develops from *two centers*, *one* for the *shaft* and *acromial extremity* (fifth to sixth week) and *one* for the *sternal extremity* (fifteenth to twentieth year). It is the first bone to ossify and fusion of the two parts is completed by about the twenty-fifth year.

Muscles Attached.—*Origins*.—Mm. sternomastoideus, deltoideus, pectoralis major, and sternohyoideus. *Insertions*.—Mm. trapezius and subclavius (six).

THE SCAPULA

The scapula, or shoulder blade forms the dorsal half of the pectoral girdle on each side. It is flat, somewhat triangular and presents a *body*, a *spine* and *two processes*.

The **body** is triangular and thin and presents *two surfaces*, *three margins* and *three angles*. The *ventral*, or *costal surface* (*facies costalis*) is concave in both directions and forms a fossa. Along its *medial*, or *vertebral margin* the m. serratus anterior is inserted. The superior half of the *lateral*, or *axillary margin* is thick deepening the fossa in this area. The surface of the bone shows several ridges that converge toward the neck. The fossa and ridges give origin to the m. subscapularis.

The *dorsal surface* (*facies dorsalis*) is crossed, almost horizontally, by the spine, which divides this surface into two portions or fossæ. The upper, smaller *supraspinous fossa* is above the spine and the latter forms its floor. From the outer part arises the m. supraspinatus. This fossa communicates with the infraspinous fossa by means of the *great scapular notch* that transmits the transverse scapular artery and suprascapular nerve. The *infraspinous fossa* is triangular and roofed by the inferior surface of the spine. The bulk of this area gives origin to the m. infraspinatus. Along the vertebral margin the m. rhomboidei is inserted; along the upper

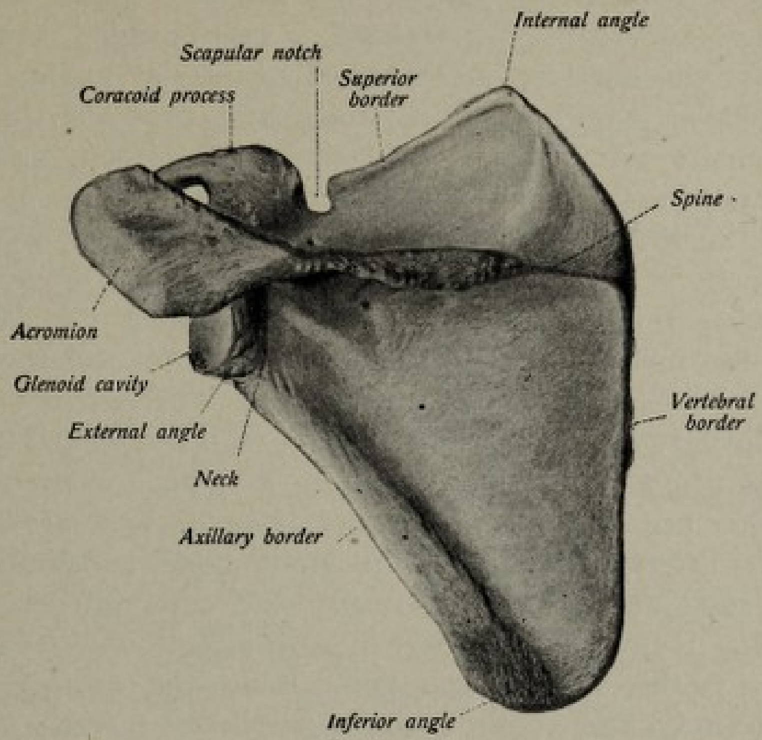


FIG. 52.—The dorsal surface of the left scapula. (*Sobotta and McMurrich.*)

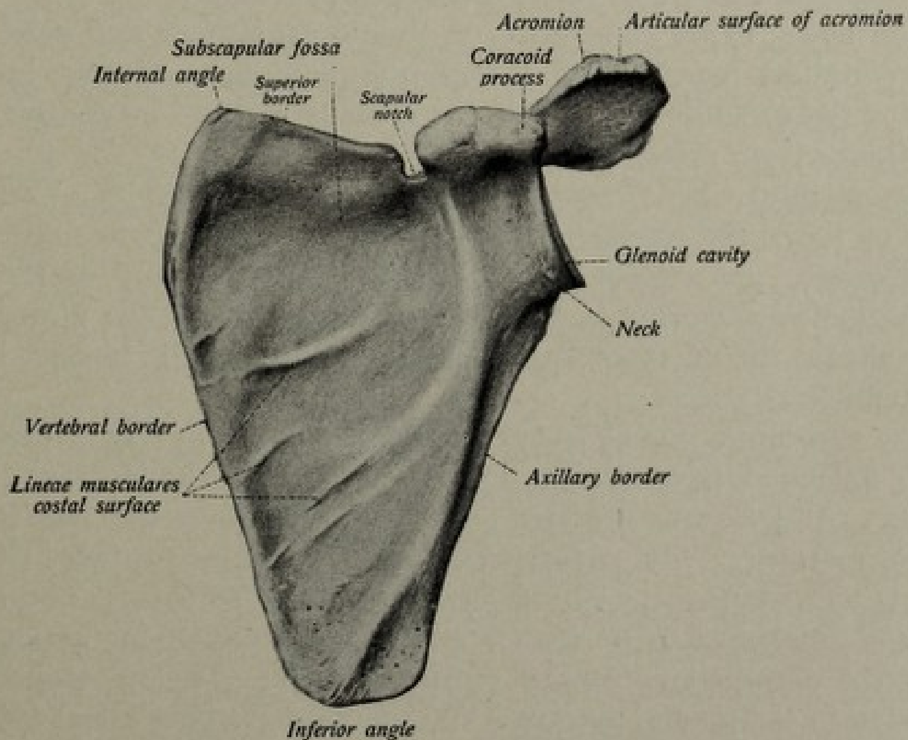


FIG. 53.—The costal surface of the left scapula. (*Sobotta and McMurrich.*)

two-thirds of the axillary margin the m. teres major arises while from the lower third the m. teres minor takes origin. Occasionally the m. latissimus dorsi has an origin at the inferior angle.

The *superior margin* is thin, sharp and presents the *scapular notch.* Usually this notch is bridged by a ligament and through the foramen thus formed passes the suprascapular nerve while above the ligament courses the transverse scapular artery. The posterior belly of the m. omohyoideus arises near the notch. The *vertebral margin* (*margo vertebralis*) is the longest. It is irregular and to it are inserted the mm. levator scapulæ, and rhomboideus major et minor (from above downward). The *axillary margin* is thick. The part just below the glenoid fossa is roughened (*tuberositas infraglenoidalis*) and from this arises the long head of the m. triceps.

The *angles* are *medial*, *inferior* and *lateral.* The *medial* and *inferior angles* are rather blunt. The *lateral angle*, occasionally called the *head*, supports the glenoid cavity and coracoid process. The *glenoid cavity* is oval and concave in both directions; its edge affords attachment to the capsular ligament. Below the cavity is the *infraglenoid tuberosity* and above is the *supraglenoid tubercle* (*tuberositas supraglenoidialis*) from which arises the long head of the m. biceps brachii. The *neck* (*collum scapulæ*) connects the glenoid cavity to the body. It is constricted and is indicated by a line connecting the scapular notch and the infraglenoid tuberosity.

The **spine** (*spina scapulæ*) is on the dorsal surface and arises near the vertebral margin and passes obliquely upward and laterally toward the glenoid cavity; here the spine twists and leaves the dorsal surface to form a free projecting mass of bone called the acromion. At its glenoid edge it forms the great scapular notch. The main part of the spine separates the supra- and infraspinous fossæ, from each other. Its *ventral margin* is fused to the body of the bone while its *dorsal margin* is free and subcutaneous; to the upper lip of this margin the m. trapezius is inserted and from the inferior lip the m. deltoideus arises.

The **acromion,** one of the processes, is a continuation of the spine. It is flattened from above downward and overhangs the glenoid cavity. It presents *superior* and *inferior surfaces* and *medial* and *lateral margins.* The *superior surface* slopes upward, faces dorsally and is subcutaneous. The *inferior surface* is smooth. The *medial margin* presents a *facet* (*facies articularis acromii*) for articulation with the acromial extremity of the clavicle. The m. trapezius is inserted to the medial margin while the m. deltoideus arises from the lateral margin.

The **coracoid process** (*processus coracoideus*) is attached to the upper part of the head just lateral to the scapular notch. It is bent in such a manner so as to overhang the glenoid cavity. To the *upper surface*, near the bend, are attached the trapezoid and conoid ligaments. Its *dorsal margin* affords attachment to the coraco-acromial ligament and near its *apex* the m. pectoralis minor is inserted. From the apex the mm. coracobrachialis and short head of the biceps arise.

Nutrient foramina are numerous around the glenoid cavity and upon the surfaces of the spine.

Articulations.—With the clavicle and humerus (two).

Ossification.—It is of endochondral origin and is developed from *seven centers*. The *center* for the *body* appears about the seventh to eighth week of fetal life; *two centers* appear for the *coracoid process*, one during the first year and the other about the tenth year; *two centers* appear for the *acromion* at about the age of puberty; *one center* appears for the *inferior angle* about the sixteenth year and *one* for the *vertebral margin* at about the seventeenth year. All parts are usually fused by the twenty-fifth year.

Muscles Attached.—**Origin.**—Mm. subscapularis, omohyoideus, supraspinatus, infraspinatus, teres major, teres minor, deltoideus, coracobrachialis, long head of the triceps, short head of the biceps and occasionally the latissimus dorsi.

Insertions.—Mm. trapezius, levator scapulæ, rhomboidei major et minor, serratus anterior and pectoralis minor (seventeen).

THE HUMERUS

The humerus constitutes the support of the arm muscles. It consists of a *proximal extremity*, a *shaft* and a *distal extremity*.

The *proximal extremity* comprises the *head*, *neck* and *two tubercles*. The *head* (*caput humeri*) forms about one-third of a sphere and is articular, resting in the glenoid cavity of the scapula. Its dorsal half is the more convex, and the whole surface faces medially and somewhat upward and dorsally. It is set off from the rest of the bone by a constriction, the *anatomical neck* (*collum anatomicum*) to which the capsular ligament is attached. The *tubercles* are *large* and *small*. The *larger* (*tuberculum majus*) seems to be a projection of the shaft and presents *three facets* for the insertion of the mm. supraspinatus, infraspinatus and teres minor (from above downward). It has numerous nutrient foramina. The *smaller tubercle* (*tuberculum minor*) is attached to the front of the proximal extremity and is separated from the preceding by the *bicipital groove* (*sulcus intertubercularis*). The two tubercles are connected by the transverse humeral ligament. To the small tubercle the m. subscapularis is inserted. The part of the bone succeeding these parts is the *surgical neck* (*collum chirurgicum*) and is the part most liable to fracture.

The *shaft* (*corpus humeri*) is partly cylindrical and partly flattened (distally). It presents *ventral* and *dorsal surfaces* and *medial* and *lateral margins*. The proximal half of the *ventral surface* is divided into lateral and medial portions by the intertubercular groove. The tips of this groove are the *crests* of the larger and smaller tubercle; (they are called the *crista tuberculi majoris* (lateral) and *minoris* medial). The muscles inserted here are the mm. pectoralis major (lateral lip), latissimus dorsi (floor of groove), teres major (medial lip). At the end of the lateral part of the ventral surface is the V-shaped *deltoid tuberosity* (*tuberositas deltoidea*) for the insertion of the m. deltoideus. The *medial ventral surface*, near the middle of the shaft, receives the fibers of the m. coracobrachialis. The distal por-

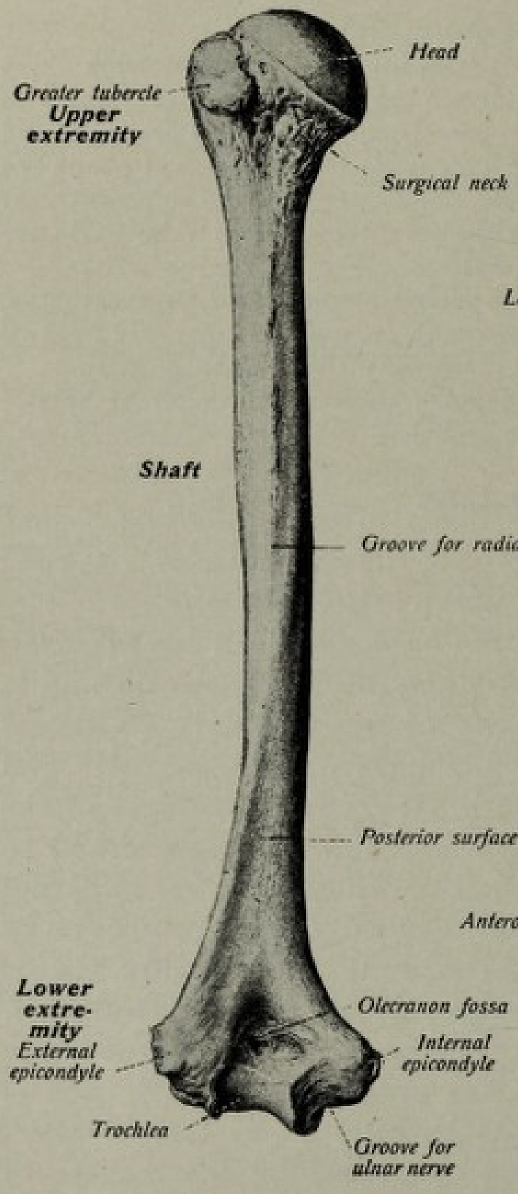


FIG. 54.—The left humerus seen from behind. (*Sobotta and McMurrich.*)

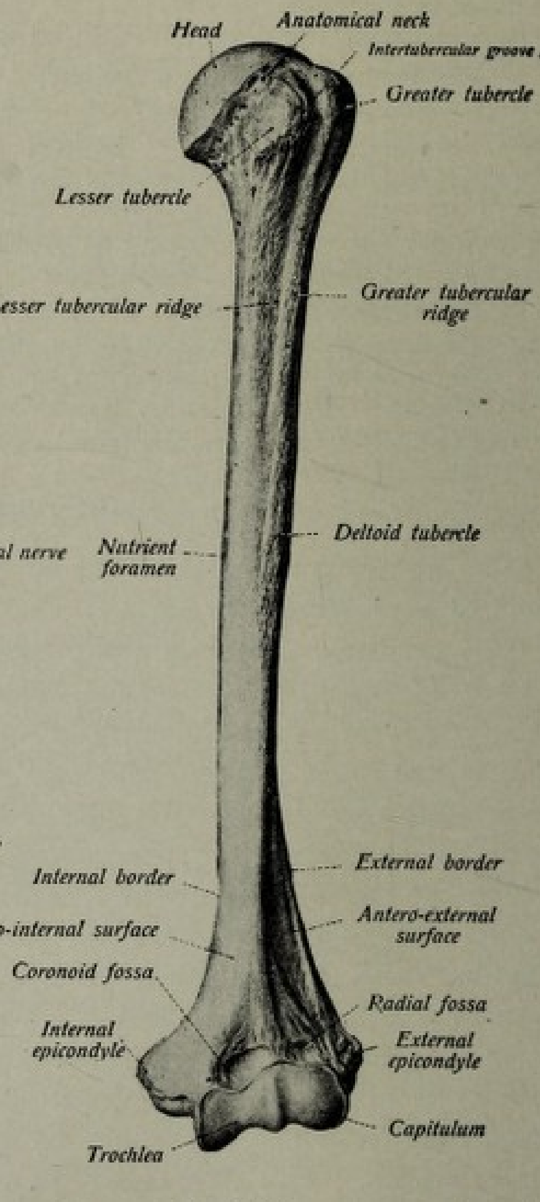


FIG. 55.—The left humerus seen from in front. (*Sobotta and McMurrich.*)

tion of the ventral surface presents a ridge that begins at the deltoid tubercle that forms two sloping surfaces from which the m. brachialis anterior arises. The *dorsal surface* is divided into *proximal* and *distal* (greater) portions by the *oblique groove* for the radial nerve (*sulcus nervus radialis*). The nerve is accompanied by the profunda brachii artery. Its course is downward and laterally. Upon the upper part there is a ridge from which the lateral (small) head of the m. triceps arises. Distal to the groove the surface is smooth, extensive and gives origin to the medial head of the m. triceps. The *medial margin* (*margo medialis*) is rounded and indistinct, proximally, while distally its prominent *epicondylic ridge* ends at the medial epicondyle. At about the middle of this margin is seen the insertion of the m. coracobrachialia. The *lateral margin* (*margo lateralis*) is more prominent, especially at its distal extremity where it is grooved for the radial nerve and the profunda brachii artery. This distal portion constitutes the *lateral epicondylic ridge* from which arise the mm. brachioradialis (proximal two-thirds) and extensor carpi radialis longus (distal one-third).

The *distal extremity* comprises the *epicondyles*, *trochlea* and *capitulum*. The *lateral epicondyle* (*epicondylus lateralis*) is small and from it arises the m. anconeus and the common tendon of origin of the extensor muscles. The *medial epicondyle* (*condylus medialis*) is more prominent and affords origin to the m. pronator teres and the superficial flexor muscles of the forearm.

The *trochlea* is a spool-shaped articular surface for the proximal extremity of the ulna. Its ventral surface is more extensive than the dorsal surface. It is placed obliquely to the long axis of the bone. The *coronoid fossa* (*fossa coronoidea*) is just proximal to the trochlea on the ventral surface of the bone. This receives the coronoid process of the ulna during flexion of the forearm. In a corresponding position upon the dorsal surface is the deeper *olecranon fossa* (*fossa olecrani*) for the reception of the olecranon process of the ulna during extension of the forearm.

The *capitulum* is lateral to the trochlea and articulates with the head of the radius. It is separated from the trochlea by a groove. Its articular portion is rounded ventrally and distally but not dorsally. It is attached to the ventral surface of the humerus. Just proximal to the capitullum is the *radial fossa* (*fossa radialis*) for the reception of the head of the radius during flexion of the forearm.

Nutrient foramina are numerous; the two largest (distally directed) are near the insertions of the mm. deltoideus and coracobrachialis. The smaller ones are in the region of the anatomical neck.

Articulations.—With the scapula, radius and ulna (three).

Ossification.—It is of endochondral origin and is developed from six *centers*. *One* for the *shaft* appears during the seventh week of fetal life; *one* for the *head* appears during the fifth or sixth month (postnatal); *one* for the *large tubercle* during the second or third year; *one* for the *small tubercle* at the end of the third year. The first three are fused by the seventh year and this epiphysis is fused with the shaft by the twenty-fifth year. The *center* for the *capitulum* and *lateral half of the trochlea* appears during the second or third years; *that* for the *medial part of the trochlea* about the sixth year; *that* for the *lateral condyle* about the twelfth year. The medial condyle fuses with the shaft at about the nineteenth year and the others by about the seventeenth year.

Muscles Attached.—Origin.—Mm. triceps, brachialis, pronator teres, flexor carpi radialis, palmaris longus, flexor carpi ulnaris, flexor digitorum sublimis, brachioradialis, extensor carpi radialis longus, extensor carpi radialis brevis, extensor digitorum communis, extensor digiti quinti proprius, extensor carpi ulnaris, anconeus and supinator (brevis).

Insertions.—Mm. subscapularis, supraspinatus, infraspinatus, teres minor, pectoralis major, latissimus dorsi, teres major, coracobrachialis and deltoideus.

THE ULNA

The ulna constitutes the medial bone of the forearm and consists of a *proximal extremity*, *shaft* and a *distal extremity*.

The *proximal extremity* comprises the *olecranon* and *coronoid processes*. The *olecranon process* is a direct continuation of the shaft and represents the dorsal part of the extremity. Its *dorsal surface* is triangular, covered with a bursa and subcutaneous. The *superior* (*proximal*) *surface* is nearly at a right angle with the dorsal surface and forms at this junction the tip of the elbow where the tendon of the m. triceps is inserted. The *ventral*, or *volar surface*, is smooth and concave, from above downward, and convex, from side to side. It articulates with the trochlea of the humerus. The sharp margin between these two surfaces serves for attachment of the ligaments of the elbow joint.

The *coronoid process* (*processus coronoideus*) projects, shelf-like, from the ventral surface of the bone. The *proximal surface*, with the ventral surface of the olecranon, forms the *semilunar notch* for articulation with the trochlea of the humerus. The *ventral* or *volar surface* of the coronoid process is rough, triangular and continuous with the corresponding surface of the shaft. It usually presents a *tubercle* (*tuberositas ulnæ*) for insertion of the tendon of the m. brachialis. The margin affords attachment to ligaments of the elbow joint. The ventral surface also affords origin to the mm. flexor digitorum sublimis and pronator teres and occasionally to the flexor pollicis longus.

The *semilunar notch* (*incisura semilunaris*) articulates with the trochlea of the humerus. This notch is narrowest across the middle and is uneven so as to approximate closely to the trochlear surface.

The *radial notch* (*incisura radialis*) is at the lateral margin of the coronoid process. It is concave dorsoventrally and comparatively small, accommodating the head of the radius. Medially it joins the semilunar notch and all of its other margins serve for attachment of ligaments.

The *shaft* (*corpus ulnæ*) is tapering and its distal extremity is slightly curved, laterally. It presents *three surfaces* and *three margins*. The *ventral*, or *volar surface*, is smooth and concavo-convex. It affords origin for the mm. supinator, flexor digitorum profundus, pronator teres and pronator quadratus (from above downward). The *medial surface* is smooth and not sharply defined from the ventral surface; it affords origin to the m. flexor digitorum profundus and is often described with the ventral surface. The *dorsal surface* is quite well defined and faces somewhat laterally.

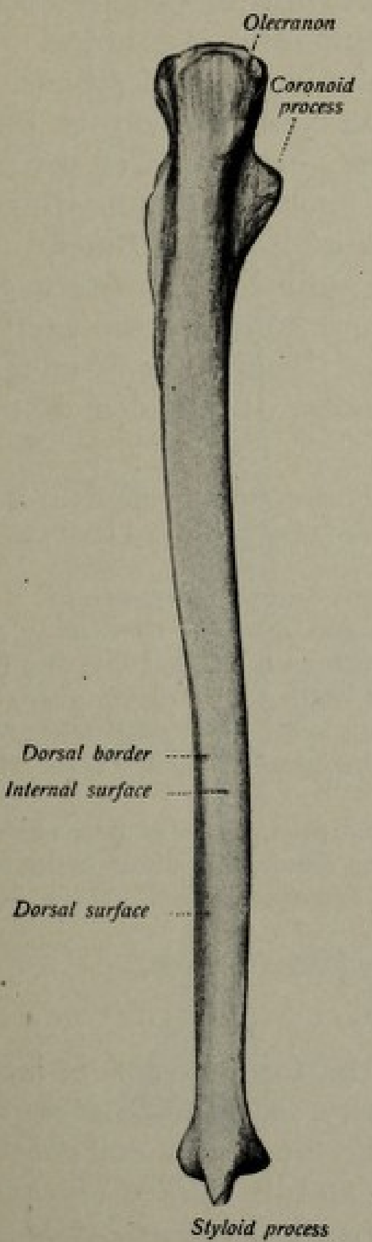


FIG. 56.—The left ulna seen from behind. (*Sobotta and McMurrich.*)

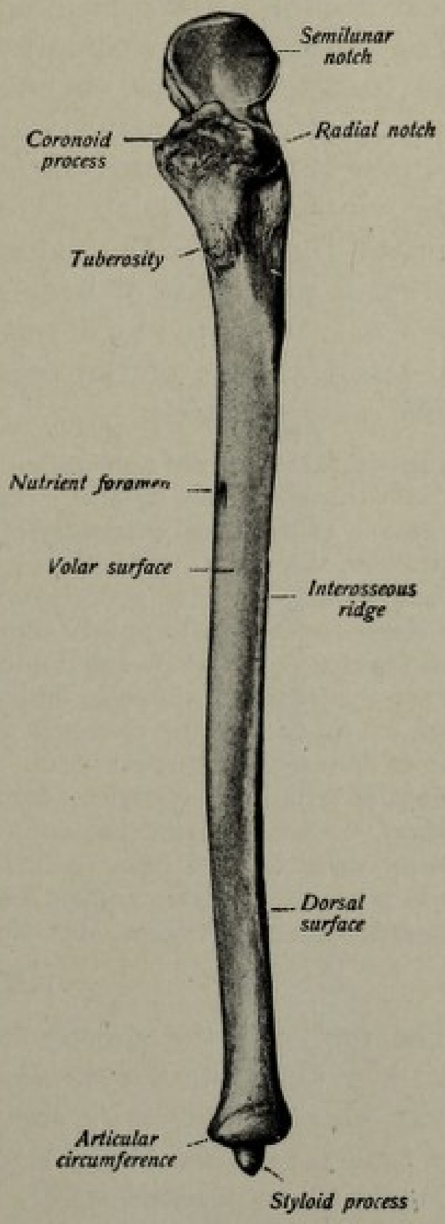


FIG. 57.—The left ulna seen from in front. (*Sobotta and McMurrich.*)

It is smooth and concave in its proximal two-thirds and the distal portion is rounded and not sharply separated from the medial surface. Its proximal portion affords origin to the mm. anconeus and then in order (but along its lateral margin) the abductor pollicis longus, extensor pollicis longus and extensor indicis proprius.

The *ventral*, or *volar margin* is rounded extending from the tuberosity to the styloid process and affords origin to the m. flexor digitorum profundus. The *dorsal margin* (*margo dorsalis*) is sharp and subcutaneous. To it is attached the aponeurosis of the mm. flexor carpi ulnaris, extensor carpi ulnaris and flexor digitorum profundus. The *lateral margin*, or *interosseous crest* (*crista interossei*), is sharp and well defined in its proximal three-fourths. To almost its entire extent it affords attachment to the interosseous membrane.

The *distal extremity* comprises a *head* and a *styloid process*. The *head* (*capitulum ulnæ*) in its ventrolateral portion is smooth, convex, narrow and articulates with the ulnar notch of the radius. Its *distal*, flat, semilunar *surface* rests upon the interarticular cartilage of the wrist joint. The *margin* affords attachment to the ligament that holds this bone to the radius. The *styloid process* is a small projection of bone medial and dorsal to the head from which it is separated by a small groove. This *groove* extends upon the dorsal surface of the bone and lodges the tendon of the m. extensor carpi ulnaris.

Nutrient foramina are numerous. The main ones (distally directed) is on the ventral surface near the middle. Others are seen near the radial notch and near the groove at the distal extremity of the bone.

Articulations.—With the radius (at both ends) and the humerus.

Ossification.—It is of endochondral origin and develops from *three centers*. The *center* for the *shaft* appears about the eighth week of fetal life; *that* for the *distal extremity* appears during the fourth year (sixth to the eighth year (Pryor) and for the *proximal extremity* about the tenth year. The shaft and proximal extremity fuse about the sixteenth year and the distal extremity fuses with the shaft at about the twentieth year.

Muscles Attached.—Origin.—Mm. supinator, pronator teres, flexor digitorum sublimis, flexor digitorum profundus, pronator quadratus, flexor carpi ulnaris, extensor carpi ulnaris, flexor pollicis longus, extensor pollicis brevis, extensor indicis proprius, extensor pollicis longus.

Insertions.—Mm. triceps, anconeus and brachialis (fourteen).

THE RADIUS

The radius is the shorter bone of the forearm and is laterally placed. It consists of a *proximal extremity*, *shaft* and *distal extremity*.

The *proximal extremity* comprises the *head*, *neck* and *tuberosity*. The *head* (*capitulum radii*) is disc-like and its surface concave and articular (*fovea capituli radii*). Its *margin* is broad and smooth and its medial portion articulates with the radial notch of the ulna. The remainder of the margin is enclosed by the annular ligament of this joint. The *neck* (*collum radii*) is the smooth, constricted portion of bone between the head and shaft. The *tuberosity* (*tuberositas radii*) is an oval projection on the medial and proximal part of the radius. Its dorsal surface is roughened for the insertion of the tendon of the m. biceps brachii; its ventral surface is smooth and covered by a bursa.

The *shaft* (*corpus radii*) is larger distally than proximally and has a lateral convex curve. It has *three surfaces* and *one* well-marked *margin*. The *ventral*, or *volar surface* is smooth and slightly convex proximally and broad and flat distally. It is crossed by the *ventral oblique line*, from which the m. flexor digitorum sublimis takes origin, and proximal to which the m. supinator is inserted. The bulk of this surface gives origin to the m. flexor pollicis longus;

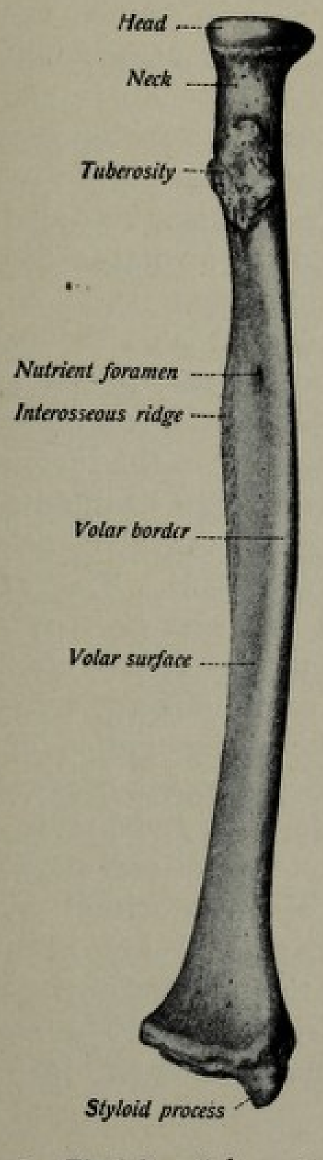


FIG. 58.—The left radius seen from in front. (*Sobotta and McMurrich.*)

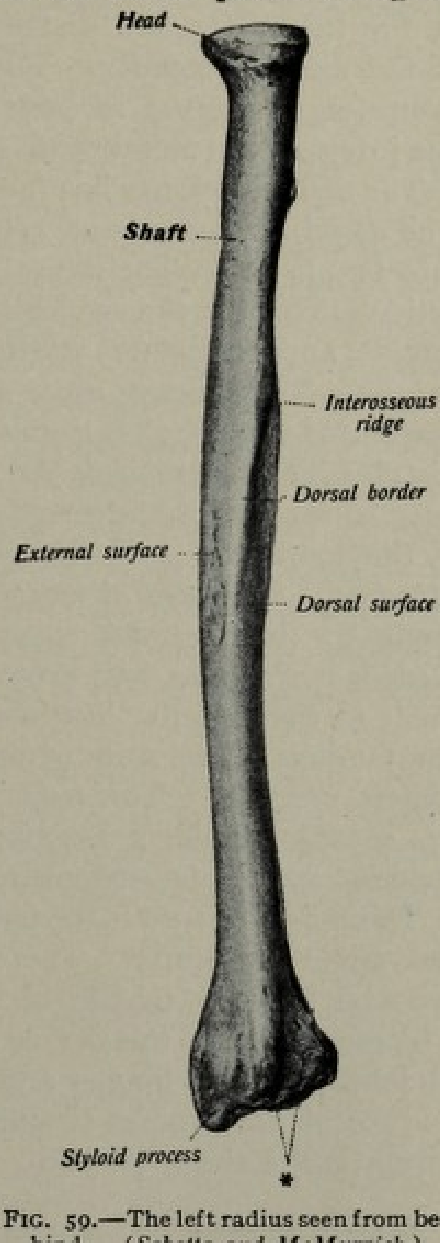


FIG. 59.—The left radius seen from behind. (*Sobotta and McMurrich.*)

to the distal part the m. pronator quadratus is inserted. The *lateral surface* (*margin*) is broader proximally than distally where it is more ridge-like passing into the base of the styloid process. The m. supinator is inserted to the proximal portion (as well as the neck); the m. pronator teres to the middle part and the distal part is covered by muscles. The *dorsal surface* (*facies dorsalis*) is broadest at its distal portion and narrow proximally. It is crossed by the *dorsal oblique line* proximal to which the m. supinator is inserted. Distal to the line the mm. extensor pollicis longus and extensor pollicis brevis respectively arise. The distal quarter of the surface is subcutaneous and has several grooves that continue onto the extremity. The *interosseous crest* (*crista interossei*) is the *lateral margin* and is the only one that is well defined. It begins proximally at the tuberosity and distally divides to embrace the ulnar notch of the distal extremity. To the triangular area so formed the m. pronator quadratus is inserted. The crest gives attachment to the interosseous membrane.

The *distal extremity* has *two articular surfaces* and a *styloid process*. The *distal surface* (carpal articular) is slightly concave and divided into two facets. The lateral of these surfaces is triangular and for articulation with the navicular (scaphoid) and the medial is quadrilateral and articulates with the lunate (semilunar) bones of the carpus. The concave *ulnar notch* (*incisura ulnaris*) is on the medial margin of the distal extremity of the head of the radius and to its distal edge is attached the articular cartilage that supports the head of the ulna and prevents it from participating in the formation of the wrist joint. To the ventral and dorsal edges ligaments are attached. The *ventral margin* of the distal extremity gives attachment to the capsular ligament of the wrist joint. The *dorsal margin* is irregular and grooved for tendons and also gives attachment to the capsular ligament. The broad medial groove contains the tendons of the mm. extensor digitorum communis and extensor indicis proprius. The next one accommodates the tendon of the m. extensor pollicis longus; the last groove accommodates the tendons of the mm. extensores carpi radialis longus and brevis.

The *styloid process* is the pointed projection of the lateral surface of the distal extremity. The *lateral surface* of its proximal end is grooved and the tendon of the m. brachioradialis is here inserted. The remainder of the groove accommodates the tendons of the mm. abductor pollicis longus and extensor pollicis brevis. The *medial surface* of the process is smooth and articular and enters into the formation of the wrist joint.

Nutrient foramina are numerous around the neck. The main one for the shaft is in the proximal third and is proximally directed. Small foramina are also present in the distal extremity.

Articulations.—With the humerus, ulna (both ends) and the navicular and lunate carpal bones.

Ossification.—It is of endochondral origin and is developed from *four centers*. *That* for the *shaft* appears about the eighth week; *that* for the *distal extremity* during the second or third year (eighth to the fifteenth month (Pryor); *that* for the *head* from the fifth to the seventh year; *that* for the *tuberosity* during the fourteenth year. By the twenty-third year all are fused with the shaft.

Muscles Attached.—Origins.—Mm. flexor digitorum sublimis, flexor pollicis longus, abductor pollicis longus, extensor pollicis brevis.

Insertions.—Mm. biceps brachii, supinator, pronator teres, pronator quadratus and brachioradialis (nine).

THE BONES OF THE HAND

The hand comprises the *wrist* (carpus, eight bones), the *palm* (metacarpus, five bones) and the *digits* (phalanges, fourteen bones).

THE CARPUS

The **carpal bones** are arranged in *two rows* of which the *first*, or *proximal row* contains the *navicular* (*scaphoid*), *os lunatum* (*semilunar*), *os triquetrum* (*cuneiform*) and the *os pisiforme*. The *second*, or *distal row* contains the *greater multangular* (*trapezium*), the *lesser multangular* (*trapezoid*), the *os capitatum* (*os magnum*) and the *os hamatum* (*unciform*) *bones*. These are given from radial to ulnar side. They are all irregular bones. The *dorsal surfaces* form an irregular convex surface and are rough for the attachment of ligaments. The *ventral surfaces* are irregular and together form a concave or groove-like area which is bridged by the transverse carpal ligament and constitutes thus a canal for the flexor tendons of the fingers. The *other surfaces are articular* except for those bones that form the ends of the rows and here the exposed surface of each is nonarticular. The navicular and os lunatum articulate with the distal extremity of the radius and the distal row articulates distally with the metacarpal bones.

These bones are of endochondral origin and are usually cartilaginous at birth. According to J. N. Pryor the centers appear earlier than formerly supposed. They appear earlier in the female than in the male. Each has *one center* of ossification that appears as follows:

		Usually given	Pryor
Capitatum	appears about	12th mo.	(1). 3d to 10th mo.
Os hamatum	" "	14th mo.	(2). 5th to the 12mo.
Os triquetrum	" "	3d year	(3). 2nd to 3d year
Os lunatum	" "	5th to 6th year	(4). 3d to 4th year
Greater multangular	" "	6th year	(7). 4th to 6th year
Navicular	" "	6th year	(5). 4th to 5th year
Lesser multangular	" "	6th to 7th year	(6). 4th to 6th year
Os pisiforme	" "	11th to 12th year	(8). 9th to 13th year

Ossification is completed about the 15th year.

Muscles Attached.—

Navicular.—M. Abductor pollicis brevis (origin).

Os Pisiforme.—Abductor quinti digiti (origin), flexor carpi ulnaris (insertion).

Great Multangular.—Abductor pollicis brevis, opponens pollicis, flexor pollicis brevis (deep head)(all origins).

Lesser Multangular.—Deep head of flexor pollicis brevis (origin)

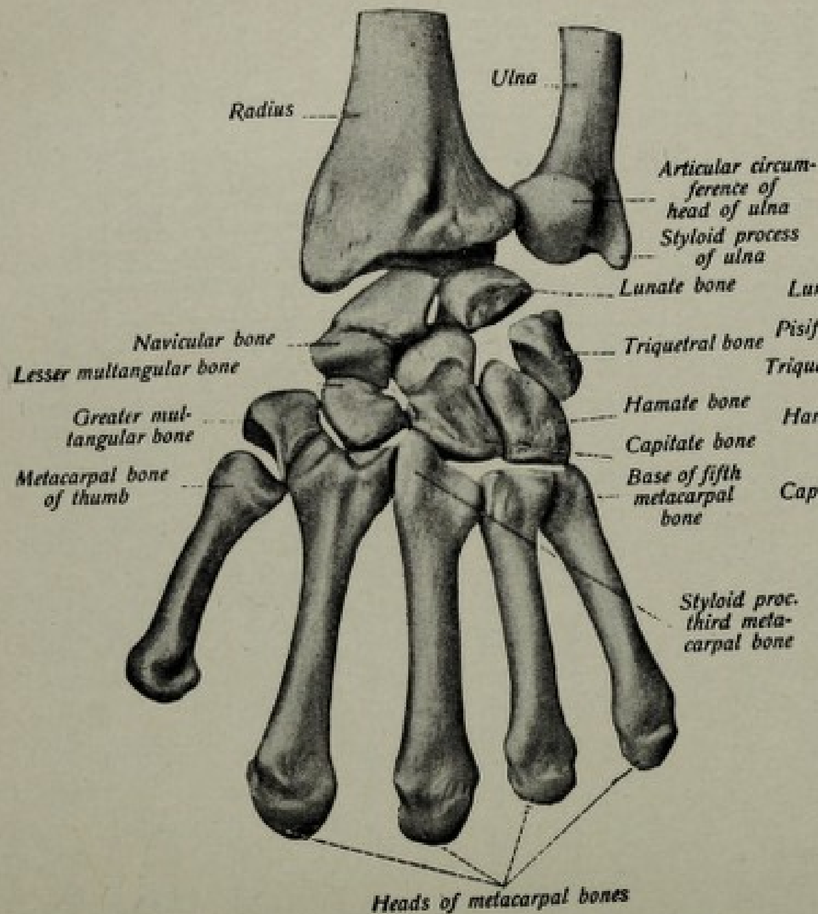


FIG. 60.—The lower ends of the bones of the forearm, and the carpal and metacarpal bones in their natural positions, seen from the dorsal surface. The preparation was made from a frozen hand whereby the relative position of the bones could be perfectly determined. (*Sobotta and McMurrich.*)

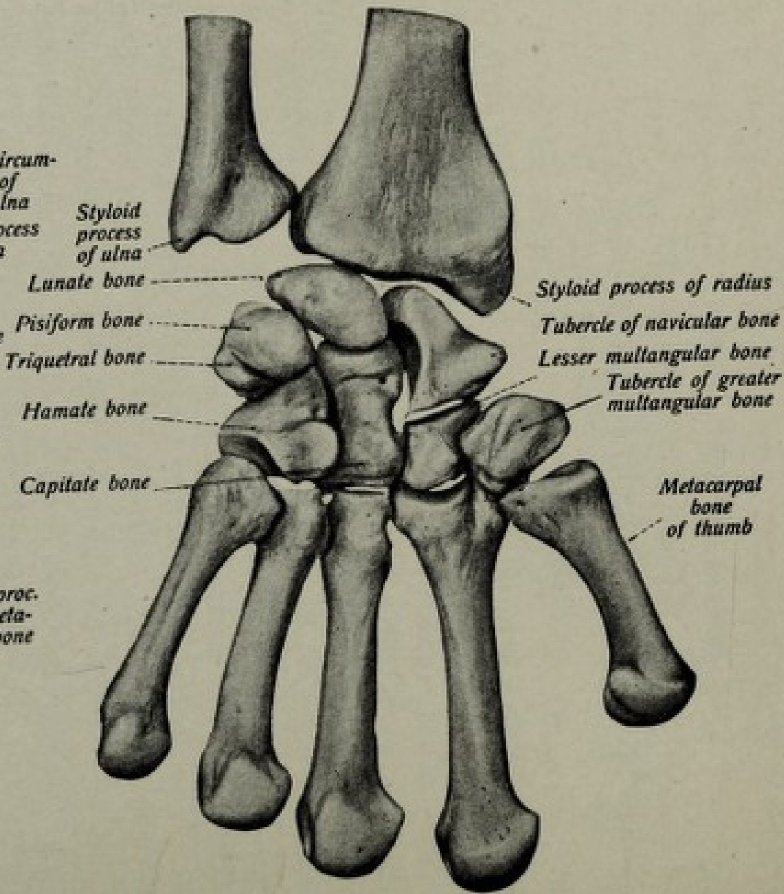


FIG. 61.—The same preparation as Fig. 60 seen from the volar surface. (*Sobotta and McMurrich.*)

Os Capitatum.—Deep head of flexor pollicis brevis, adductor pollicis (origins).

Os Hamatum.—Opponens quinti digiti, flexor quinti digiti brevis (origins), flexor carpi ulnaris (insertion).

THE METACARPAL BONES (OSSA METACARPALIA)

The metacarpal bones are five in number and articulate with the distal carpal bones and each other, proximally, and with the first row of phalanges, distally. The first, or thumb metacarpal, is the most mobile. Each consists of a *base*, *shaft* and *head*.

The *base* is the carpal extremity, each is wedge-shaped and the articular surface varies with the joint that it forms. The *first* (*thumb*) is the shortest and strongest. The *second* (index finger) is the longest. The *shaft* of each is smooth and narrow in the middle. The *dorsal surface* is triangular and broad distally. The *ventral surface* is narrow and more like a ridge. The *medial* and *lateral surfaces* are concave and afford origin for the mm. interossei. The *head* (*capitulum*) has an articular surface for the base of the proximal phalanx. This surface is rounded and more extensive ventrally than dorsally. The *ventral edge* is grooved for the passage of tendons. To the *margins* of the head ligaments are attached.

Nutrient Foramina.—There is one for each bone. In the first it is directed distally while in the others it is proximally directed.

Ossification.—Each of the *four medial metacarpal* bones has *one center* for the *shaft* and *base* and one for the head. The shaft and *base center* appears (successively and in order) during the ninth or tenth week of fetal life; the *center* for each *head* appears during the third year and fuses completely with the shaft by the twentieth year. The *center* for the *shaft* and *head* of the *first metacarpal bone* appears after the tenth week and for the *base* during the third year. Fusion with the shaft takes place about the twentieth year.

Muscle Attached.—*First Metacarpal.*—Mm. First dorsal interosseous (origin), flexor pollicis brevis, opponens pollicis, abductor pollicis longus (insertions) (four).

Second Metacarpal.—First and second dorsal interossei, first palmar interosseous, adductor pollicis (origins); flexor carpi radialis, extensor carpi radialis longus (insertions) (six).

Third Metacarpal.—Second and third dorsal interossei, adductor pollicis transversus and obliquus (origins); extensor carpi radialis brevis, flexor carpi radialis (insertions) (six).

Fourth Metacarpal.—Third and fourth dorsal interossei and second palmar interosseous (origins) (three).

Fifth Metacarpal.—Extensor carpi ulnaris, flexor carpi ulnaris, opponens quinti digiti (insertions) (three).

THE PHALANGES (PHALANGES DIGITORUM MANUS)

The phalanges are *fourteen* in number, three for each finger and two for the thumb. The first, or proximal phalanges, are the longest and the distal are the smallest. The *proximal end* of each *first phalanx* is rather large and bears a concave articular facet for the head of the metacarpal bone. The *shaft* is somewhat flattened

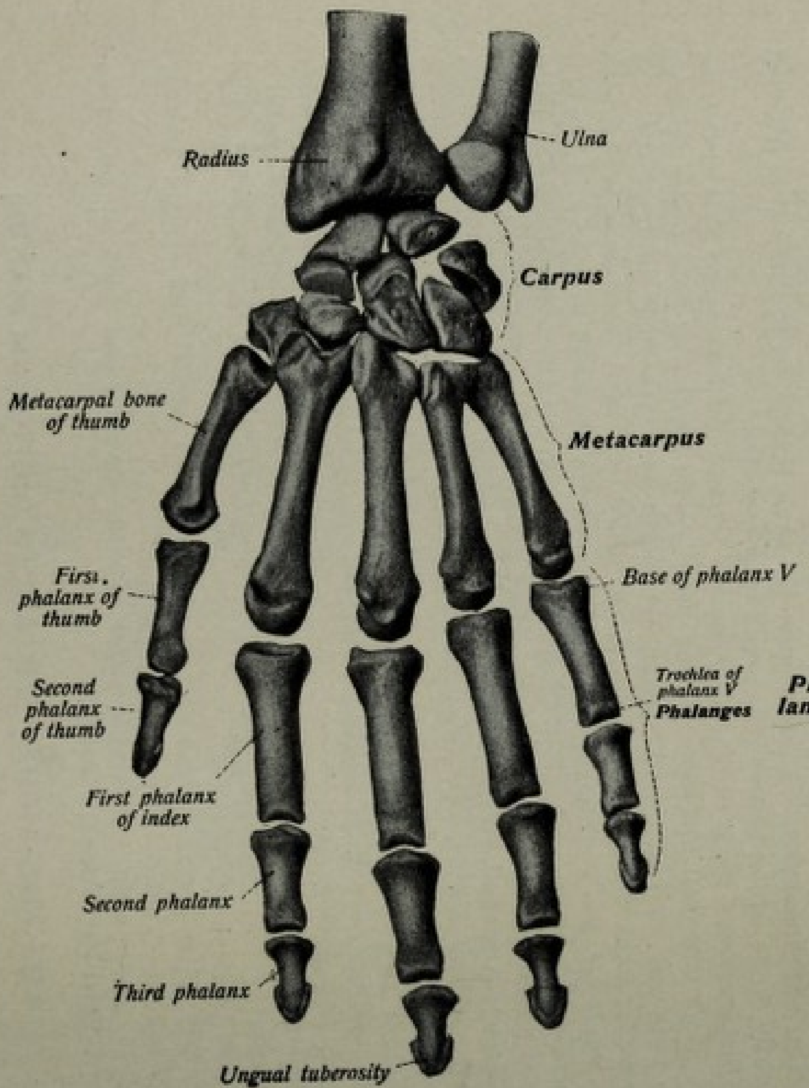


FIG. 62.—Frozen preparation of the bones of the left hand, together with the lower ends of the radius and ulna, seen from the dorsal surface. (*Sobotta and McMurrich.*)

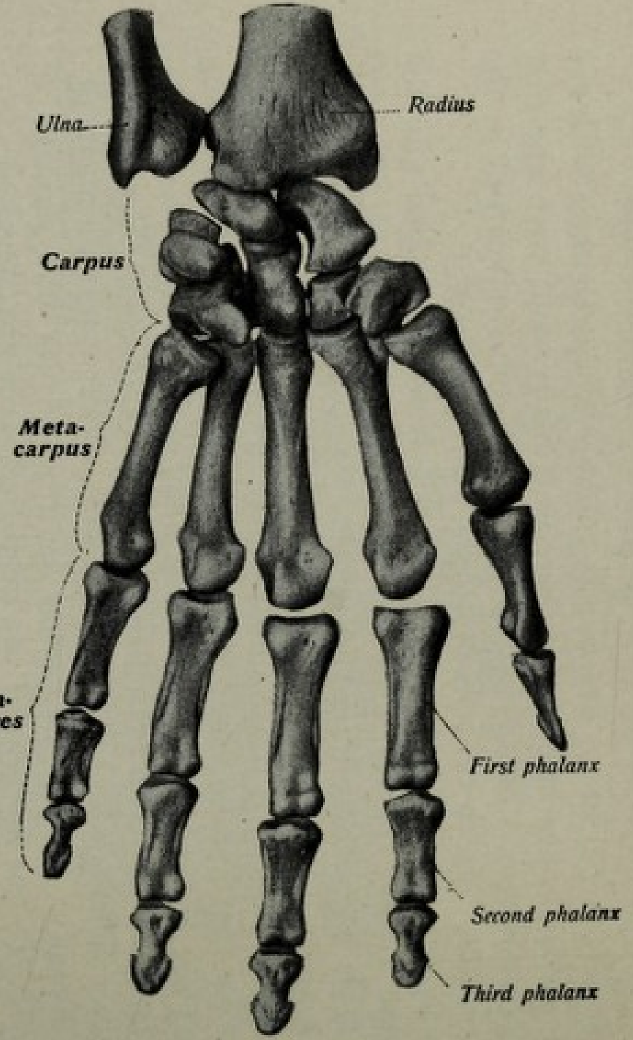


FIG. 63.—The same preparation as Fig. 62 seen from the volar surface. (*Sobotta and McMurrich.*)

and presents a smooth convex *dorsal surface;* the *ventral surface* is smooth and concave for the accommodation of the flexor tendons. The *head* bears a convex articular facet for the second phalanx. The *second phalanges* resembles the first generally. The *proximal facet*, however, is convex. The *third phalanges* are the smallest and shortest. The *proximal extremity* is large and its articular surface is convex. Its *distal extremity* is flattened for the support of the nail.

Nutrient Foramina.—There are usually *two nutrient foramina* for each phalanx, distally directed and upon the ventral, or palmar surface.

Ossification.—These are of endochondral origin and each is developed from *two centers.* The *center* for the *shaft* and *distal extremity* appears during the ninth to the tenth week of fetal life and *that* for the *proximal extremity* during the third year. According to Pryor most of these centers appear between the first and early part of the third years. Fusion of these parts occurs at the eighteenth or twentieth year.

Muscles Attached.—These are all insertions.

Thumb.—

First Phalanx.—Mm. Extensor pollicis brevis, flexor pollicis brevis, adductor pollicis, abductor pollicis brevis, adductores pollicis obliquus and transversus (five).

Second Phalanx.—Mm. Flexor pollicis longus, extensor pollicis longus (two).

Index Finger.—

First Phalanx.—First dorsal and first palmar interossei (two).

Second Phalanx.—Mm. Flexor digitorum sublimis, extensor digitorum communis, extensor indicis (three).

Third Phalanx.—Mm. Flexor digitorum profundus, extensor digitorum communis (two).

Middle Finger.—

First Phalanx.—Second and third dorsal interossei (two).

Second Phalanx.—Mm. Flexor digitorum sublimis, extensor digitorum communis (two).

Third Phalanx.—Mm. Flexor digitorum profundus, extensor digitorum communis (two).

Ring Finger.—

First Phalanx.—Fourth dorsal and second palmar interossei (two).

Second Phalanx.—Mm. Flexor digitorum sublimis, extensor digitorum communis (two).

Third Phalanx.—Mm. Flexor digitorum profundus, extensor digitorum communis (two).

Little Finger.—

First Phalanx.—Third palmar interosseus, flexor quinti digiti brevis, abductor quinti digiti (three).

Second Phalanx.—Mm. Flexor digitorum sublimis, extensor digitorum communis (two).

Third Phalanx.—Mm. Flexor digitorum profundus, extensor digitorum communis, extensor digiti quinti (three).

THE LOWER LIMB (PELVIC APPENDAGES)

The **pelvic appendages** comprises the *pelvic girdle* and the *appendages proper.* The *girdle* is formed by the *two innominate bones*, articulating with each other ventrally and with the sacrum dorsally.

THE HIP BONE (OS COXÆ)

The *hip bone* is classed as a flat bone; it is shaped like a propeller, one blade of which is perforated by a foramen (obturator). It represents the fusion of three segments, the *ilium*, *ischium* and *os pubis*. These surround and form the *acetabular cavity*.

The **ilium** is the largest division and presents *two surfaces, three margins* and *four spines*. The *lateral surface* is divided into a larger (gluteal) and a smaller (acetabular) portion. The *gluteal portion* is large, concavoconvex and is marked by the *three gluteal lines*. The *inferior gluteal line* (*linea glutea inferior*) lies just over the acetabular margin and between these two the reflected head of the m. rectus femoris arises. The *ventral* (*anterior*) *line* is the largest and starts near the ventral end of the iliac crest and arches dorsally to the greater sciatic notch. The *dorsal* (*posterior*) *gluteal line* is a short curved line near the dorsal portion of the lateral surface; dorsal to this line the m. gluteus maximus arises. The m. gluteus medius arises between the ventral and dorsal lines and the iliac crest. The *medial surface* is divided into *dorsal* and *ventral portions*. The *dorsal part* is partly articular (*facies articularis*) for articulation with the sacrum. Superiorly and dorsally the bone is roughened and presents a *tuberosity* (*tuberositas iliaca*) and serves for the attachment of ligaments. The superior edge here gives origin to the mm. multifidus, sacrospinalis and quadratus lumborum. The *ventral portion* is mainly concave, smooth and presents the extensive *iliac fossa* from which the m. iliacus arises. The *oblique iliopectineal line* (*linea arcuata*), which bounds the fossa inferiorly, ends ventrally in the *iliopectineal eminence*. The dorsosuperior portion of this surface gives origin to the m. obturator internus.

The *iliac crest* (*crista iliaca*) has a *lateral lip* (*labrum lateralis*), a *medial lip* (*labrum medialis*) and an *intervening area* (*linea intermedia*). The crest is in the form of a quarter circle and extends from the ventral superior spine to the dorsal superior spine in a double curve. From the dorsal part of the crest the mm. quadratus lumborum, latissimus dorsi and sacrospinalis arise; on the ventral part the mm. obliquus abdominis internus and transversus abdominis arise and the oblique abdominis externus is inserted. The *ventral superior spine* (*spina iliaca anterior superior*) is a blunt process that affords origin to the m. sartorius and laterally to the m. tensor fasciæ latæ and the inguinal ligament. The *ventral inferior spine* (*spina iliaca anterior inferior*) is below the preceding and gives origin to the m. rectus femoris and the iliofemoral ligament. The *ventral margin* connects the two ventral spines. The *dorsal superior spine* is at the termination of the iliac crest. From it the *dorsal margin* starts and a short distance below its origin it presents the

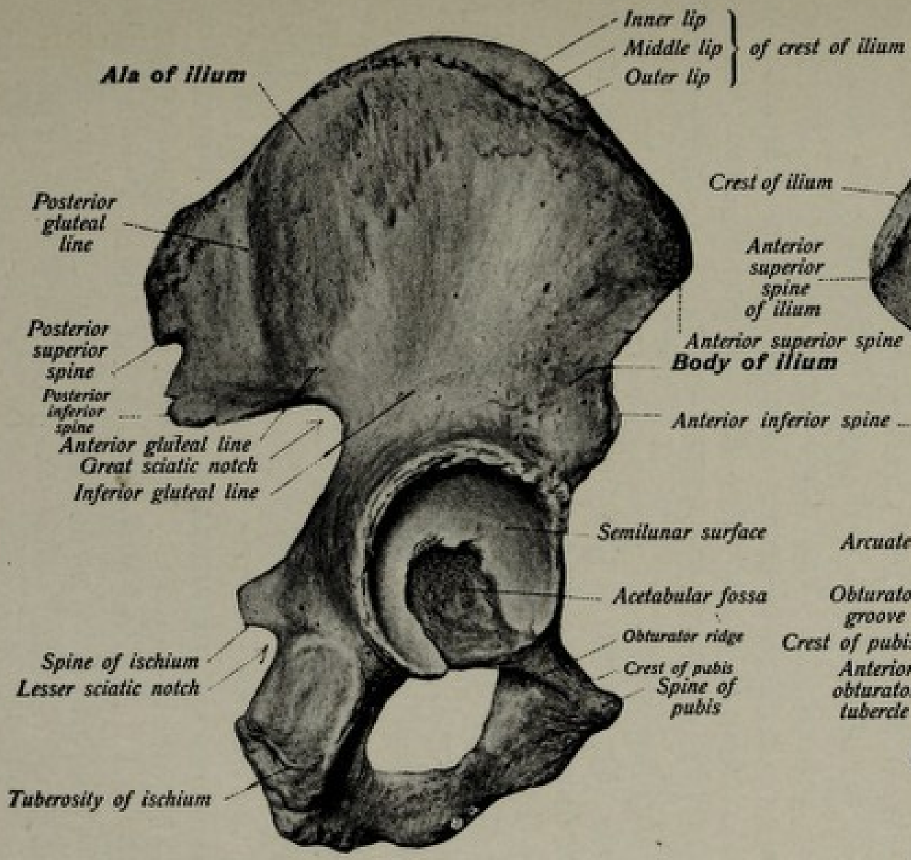


FIG. 64.—The right innominate bone seen from the lateral surface. (*Sobotta and McMurrich.*)

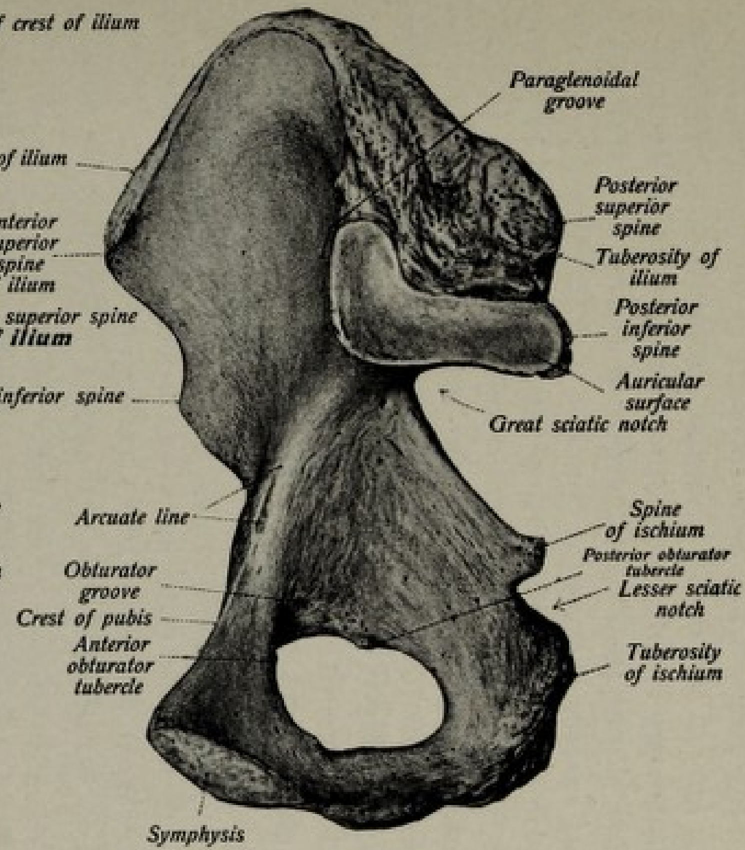


FIG. 65.—The right innominate bone seen from the medial surface. (*Sobotta and McMurrich.*)

dorsal inferior spine; below this the margin is deeply notched; this constitutes the *greater sciatic notch* (*incisura ischiadica major*).

The **ischium,** the dorsoinferior portion of the os coxæ, presents a *body* and *two rami.* The *body* (*corpus*) is the superior part of the bone. Its *lateral surface* is irregular, presenting a deep *acetabular notch* that forms two-fifths of the acetabular cavity. The bone beyond this slopes from the margin of the cavity and is smooth. The *medial surface* is smooth, concave and forms a part of the wall of the pelvic cavity. The *short ventral margin* assists in forming the obturator foramen. The *medial margin* presents the *ischial spine* (*spina ischiadica*); this bounds the lesser sciatic notch superiorly and affords origin to the m. gemellus superior and the sacrospinous ligament; laterally it gives origin to the m. coccygeus and medially to the m. levator ani. The *rami* are two wedge-shaped bars of bone that join each other at nearly a right angle. The *ventral surface* of each is concave and the inferior affords origin to the mm. obturator externus, and adductor magnus. The *medial surfaces* are flat and afford an origin to the crus penis (or clitoridis) and mm. ischiocavernosus, obturator internus and transversus perinei. The *medial margin* of each ramus is thin and assists in forming the boundary of the obturator foramen. The *dorsolateral margin* of the superior ramus presents a rough irregular mass of bone, the *tuberosity* (*tuber ischiadicum*); from this arise the mm. semitendinosus (superiorly and laterally) and the biceps femoris and semimembranosus (inferiorly and medially).

The **pubis (os pubis)** is the smallest division and is ventrally placed. It comprises a *body* and *two rami.*

The *body* (*corpus*) presents *two surfaces.* The *dorsoinferior surface* is smooth and affords origin to the m. levator ani and the puboprostatic ligament. The *ventroinferior surface* is rough and affords origin to the mm. gracilis, adductores longus et brevis and the obturator externus. The *medial margin* (*facies symphyseos*) is oval, covered with cartilage and joins its fellow of the opposite side to form the symphysis pubis. The *superior margin* is thick and extends so as to form the *crest* and *tubercle.* The crest gives origin to the mm. rectus abdominus and pyramidalis and the tubercle affords attachment to the inguinal ligament. The *superior ramus* slopes superiorly and laterally and its lateral extremity forms a part of the acetabular cavity. Its *ventrosuperior surface* affords origin to the m. pectineus. The *dorsosuperior* (*medial*) *surface* is concave and forms a part of the pelvic wall. The *ventroinferior surface* is concave. The *inferior margin* (*crista obturatoria*) forms a part of the boundary of the obturator foramen. The *dorsosuperior margin* is a continuation of the iliopectineal line and is called the *pecten ossis pubis.* The *inferior ramus* is flattened and has a downward and lateral direction; it completes the boundary of the obturator foramen and with its fellow forms the *pubic arch*. Its *ventral surface* gives origin to the mm. gracilis and adductores magnus et brevis. Its *smooth medial surace* and *inferior margin* give attachment to the crus penis or clitoritis and the arcuate ligament.

The **obturator foramen** (*foramen obturatum*) is the opening between the above bones. This is closed in by a membrane in the fresh condition.

The **acetabulum** is a deep cavity formed by the above bones; the *ilium* forms a little less than two-fifths, the *ischium* a little more than two-fifths and the *pubis* one-fifth. Opposite the obturator foramen the margin, to which the capsular ligament is attached, is interrupted and this is the *acetabular notch* (*incisura acetabuli*). The articular portion of the floor is horseshoe-shaped and the central depressed area (*fossa acetabuli*) is continuous with the acetabular notch.

Nutrient foramina are numerous; for the *ilium* in the iliac fossa and pelvic and gluteal areas; for the *ischium* near the acetabulum and upon the pelvic portion; for the *pubis* in the acetabular fossa and in the body.

Articulations.—With the femur, sacrum and fellow of the opposite side.

Ossification.—It is of endochondral origin. The *primary centers* appear early; the *center* for the *ilium* about the ninth week of fetal life; for the *ischium* about the fourth month; for the *pubis* about the fifth to the sixth month of fetal life. Up to the twelfth year these bones are still separated from one another by cartilage in the acetabular cavity; at that time about *three centers* appear here and fusion is completed by the sixteenth year. At about the age of puberty *other centers* appear; *one* for the *ventroinferior spine*, twelfth year; *one* for the *ventral two-thirds of the iliac crest and superior spine*, fifteenth year; *one* for the *dorsal one-third of the iliac crest and the dorsal superior spine*, fifteenth year; *one* for the *tuberosity of the ischium*, fifteenth year: *one* or *two* for the *tubercle* and *angle of the pubis*. These all fuse with the body by the twenty-fifth year.

Muscle Attached.—Origins.—Mm. tensor fasciæ latæ, latissimus dorsi, transversus abdominis, quadratus lumborum, sacrospinalis, obliquus abdominis internus, gluteus maximus, gluteus medius, gluteus minimus, rectus femoris, iliacus, pyriformis, rectus abdominis, pyramidalis, obturator internus, obturator externus, ischiocavernosus, transversus perinei, gemelli superior and inferior, levator ani, coccygeus, biceps femoris, semitendinosus, semimembranosus, adductores magnus and brevis, pectineus, gracilis and adductor longus.

Insertion.—M. obliquus abdominis externus.

THE PELVIS

The pelvis consists of the *two ossa coxæ*, *sacrum* and *coccyx*. That portion superior to the iliopectineal lines constitutes the *false pelvis* (*pelvis major*) and that below the *true pelvis* (*pelvis minor*). The *pelvis minor* is bounded, *ventrally*, by the symphysis pubis, the bodies and superior rami of the pubic bones; *laterally* by the body of the ischium and its rami and *dorsally* by the sacrum and coccyx. The *superior aperture*, or *brim*, slopes downward and forward at an angle of 60° to the horizontal plane; it is bounded, *ventrally*, by the bodies of the ossa pubes, *laterally* by the iliopectineal lines and *dorsally* by the promontory of the sacrum. The *inferior aperture*, or *outlet*, is bounded, *ventrally* and *superiorly*, by the bodies of the ossa pubes, *laterally* by the rami of pubes and ischii and ischial tuberosity and *dorsally* by the tip of the coccyx and sacrotuberous ligaments. The *ventral wall* is only 1½ to 2 inches vertically and the *dorsal wall* 5 to 6 inches in extent.

The *female pelvis* is lighter and smoother and the iliac bones do not flare out as much as in the male. The cavity is more capacious, the sacrum shorter and wider, the sacral curve less uniform and the pelvic arch is wider in the female. The superior aperture is large and more oval; the outlet is larger and the ischial tuberosities are farther apart in the female.

THE FEMUR

The femur is the longest bone in the body and comprises a *proximal extremity*, *shaft* and a *distal extremity*.

The *proximal extremity* consists of *head*, *neck* and *two trochanters*. The *head* (*caput femoris*) is the articular portion. It is hemispherical in shape, fits into the acetabular cavity and near its summit exhibits a *depression* (*fovea capitas femoris*) in which the ligamentum teres is attached. The *neck* (*collum femoris*) is shaped like an old-fashioned mortar, supports the head and is attached by its base to the shaft, at an angle of 125°. Ventrally and dorsally its junction with the shaft is marked by *oblique ridges;* the *ventral ridge* is the superior portion of the intertrochanteric line and to it is attached the iliofemoral ligament. The *dorsal ridge* connects the two trochanters and is called the *intertrochanteric crest;* part of this, the *quadrator tubercle*, affords insertion to the m. quadratus femoris. Vascular foramina are numerous in the neck.

The *greater trochanter* (*trochanter major*) is a quadrilateral mass of bone that projects from the shaft above the level of the neck. Its *medial surface* is quite concave, forming the *trochanteric fossa* where the m. obturator externus is inserted. The *lateral surface* is somewhat convex and presents an oblique ridge into which the m. gluteus minimus is inserted. To its *proximal*, or *superior margin* the mm. obturator internus and gemelli are inserted (ventrally) and the pyriformis (dorsally). The *dorsal margin* is the superior portion of the intertrochanteric crest.

The *lesser trochanter* (*trochanter minor*) is a blunt, cone-shaped mass of bone upon the dorsal surface at the junction of the shaft and neck and at a lower level than the greater trochanter. Here the intertrochanteric crest ends. To this trochanter the m. iliopsoas is inserted.

The *shaft* is cylindrical and curved from above downward with the convexity ventrally directed. It becomes broader where it supports the distal extremity. *Margins* are not present as the general curvature of the circumference causes the surfaces to blend insensible with one another. Upon the *dorsal surface* is a narrow

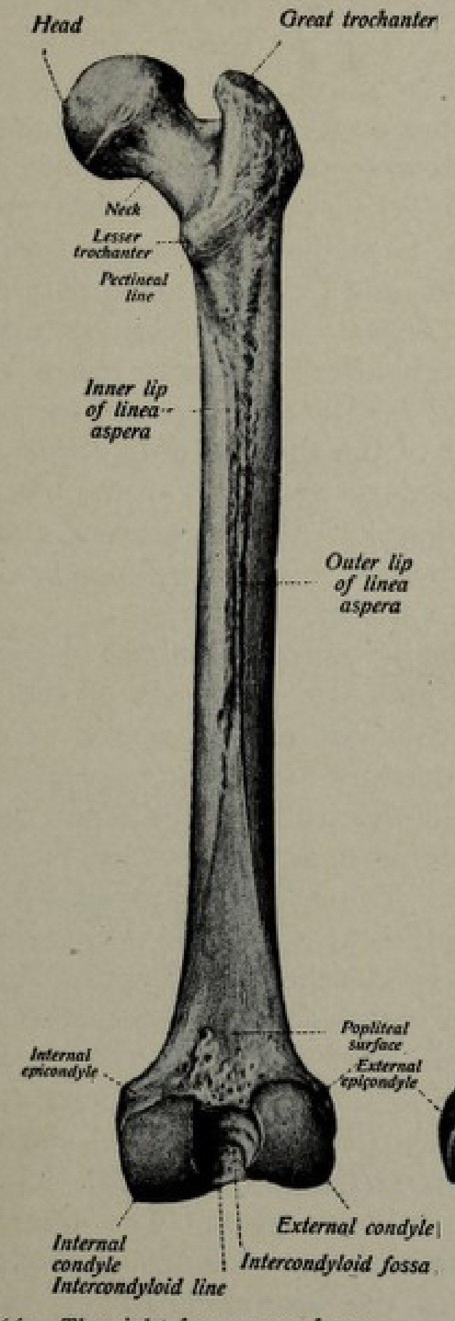


FIG. 66.—The right femur seen from behind. (*Sobotta and McMurrich.*)

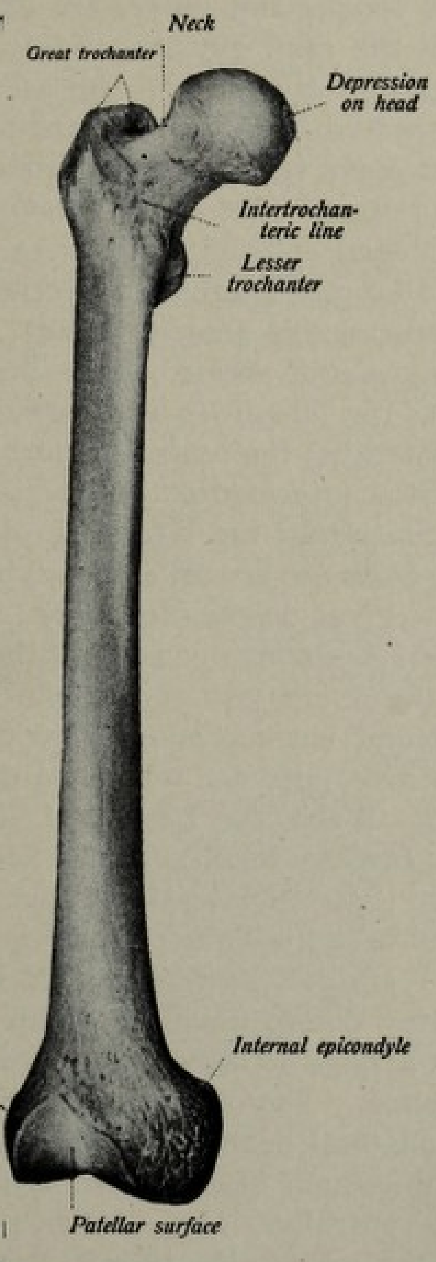


FIG. 67.—The right femur seen from in front. (*Sobotta and McMurrich.*)

rough area called the *linea aspera.* The *medial edge, or lip,* of the linea aspera continues, superiorly, around the base of the trochanter minor where it becomes continuous with the ventral intertrochanteric line; these two constitute the *spiral line* from which the m. vastus medialis arises. The *lateral lip* of the *linea aspera* is continued, superiorly, to the level of the trochanter minor as the *gluteal tuber-*

osity. This is rough and serves for the insertion of the m. gluteus maximus. The *pectineal line* lies between these two and serves for the insertion of the m. pectineus. In the middle of the shaft the lips of the linea aspera are most prominent. The mm. adductores magnus, longus and brevis are inserted into the proximal portion between the mm. gluteus maximus and pectineus. In the distal third the lips diverge and end at the corresponding epicondyles as the *epicondylic lines*. The triangular area between these lines is the *popliteal plane* (*planum popliteum*) which is part of the floor of the popliteal fossa. The *adductor tubercle* is a small eminence at the end of the medial epicondylic line; to its medial surface the tendon of the m. adductor magnus is inserted and from its dorsal surface the m. gastrocnemius (medial head) arises. The *medial lip* and the adjoining *medial surface* of the shaft afford origin for the m. vastus medialis; the *lateral lip* and *lateral surface* afford origin for the m. vastus lateralis; the *ventral surface* of the shaft affords origin to the mm. vastus intermedius and articularis genu. The m. biceps femoris arises from the lateral lip distal to the m. gluteus maximus and also from the lateral epicondylic line. The distal portion of the same line gives origin (dorsally) to the m. plantaris.

The *distal extremity* consists of the *two condyles* and *two epicondyles*. The *condyles* are two rocker-like articular processes of the bone; the articular surface of the two condyles are connected ventrally (*patellar area*) and are separated dorsally by the *intercondylic notch* or *fossa*. When the bone is held vertically the medial condyle projects farther distally but is narrower and less extensive dorsoventrally than the lateral condyle. The *intercondylic notch* is quite deep and broad. To the *medial wall* is attached the dorsal cruciate ligament and on its *lateral wall* is attached the ventral cruciate ligament. Where the floor of the notch joins the popliteal plane there is a ridge to which the dorsal part of the capsular ligament is attached. The *medial epicondyle* affords attachment to the tibial collateral ligament of the knee joint. The *lateral epicondyle* is less prominent and presents a *dorsal groove* (*popliteal*) that ends in a pit ventrally. Here the m. popliteus arises. The dorsal portion of the epicondyle affords attachment to the fibular collateral ligament of the knee joint and to the lateral head of the m. gastrocnemius.

The *articular surface* consists of the *patellar* and *condylic portions*. The *patellar* part (*facies patellaris*) is concave in the middle and is separated from each condylar surface by an oblique groove. The *lateral condylic* surfaces are convex in both directions and are on the distal and dorsal portions of the condyle. The *medial* is narrower than the *lateral*.

Nutrient foramina are found in the fossa for the ligamentum teres, the neck, on the great trochanter, on the linea aspera (proximally directed) and in the intercondylic fossa.

Articulations.—With the hip bone, tibia and patella.

Ossification.—It is of endochondral origin and is developed from *five centers.* The *centers for* the shaft appears during the second fetal month; *that* for the *distal extremity* during the ninth month; *that* for the *head* during the first year; the *center* for the *greater trochanter* about the second to the third year; *that* for the *lesser trochanter* about the twelfth to the thirteenth year. All fuse with the shaft by the twentieth to the twenty-second year.

Muscles Attached.—Origins.—Mm. vasti medialis, lateralis and intermedius, short head of biceps femoris, gastrocnemius, popliteus, plantaris and articularis genu.

Insertions.—Mm. glutei maximus, medius and minimus, gemelli superior and inferior, pyriformis, obtutatores internus and externus, psoas, iliacus, quadratus femoris, adductores magnus, brevis, and longus, and pectineus (twenty-three).

THE PATELLA

The patella is a sessamoid bone, that is one that is developed in a tendon. It protects the knee joint ventrally. It is flattened, of a triangular outline (inverted) and possesses an *apex*, a *base*, *two surfaces* and *two margins.*

The *apex* (*apex patellæ*) is distal and affords attachment to the ligamentum patellæ. The *base* (*basis patellæ*) is broad and thick and

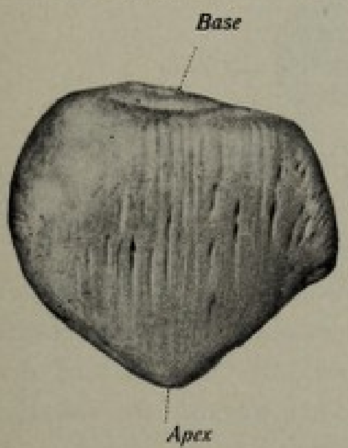


Fig. 68.—The patella seen from in front. (*Sobotta and McMurrich.*)

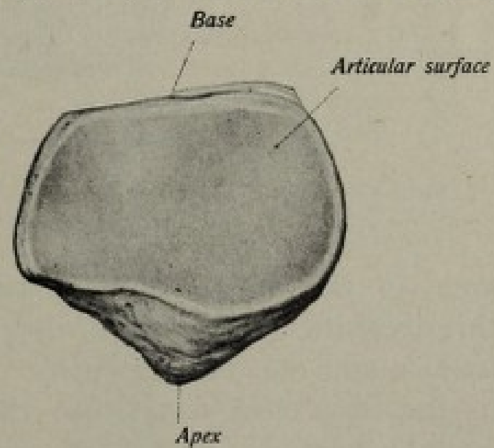


Fig. 69.—The patella seen from behind. (*Sobotta and McMurrich.*)

receives, ventrally, the insertion of the tendon of the m. quadriceps extensor. The ventral surface is convex, somewhat rough, subcutaneous and has numerous foramina. The dorsal surface is mainly articular. A vertical ridge divides it into a larger, concave lateral facet, for the lateral condyle of the femur, and a smaller, concave medial facet for the medial condyle of the femur. The nonarticular portion is the dorsal surface of the apex and here the synovial membrane of the knee joint is attached. The *medial* and *lateral margins* are convex and afford insertion to the mm. vasti medialis and lateralis, respectively.

Nutrient foramina are seen upon the ventral surface.

Articulations.—With the femur.

Ossification.—It is of endochondral origin and develops from *one*, or *two centers*, which appear during the third year. Ossification is usually completed by the age of puberty.

Muscles Attached.—Insertions.—Mm. vasti medialis, lateralis and intermedius and the rectus femoris (four).

THE TIBIA

The tibia or *shin bone* is the larger and stronger bone of the leg. It consists of *a proximal extremity*, *shaft* and *distal extremity*.

The *proximal extremity* comprises the *condyles*, the *intercondylic* eminence and the tuberosity. The condyles constitute a flat mass that caps the proximal end of the shaft. The *proximal surface* of each condyle is concave and articular. The *lateral* is the smaller and nearly circular in outline. Near the middle of the intercondylic

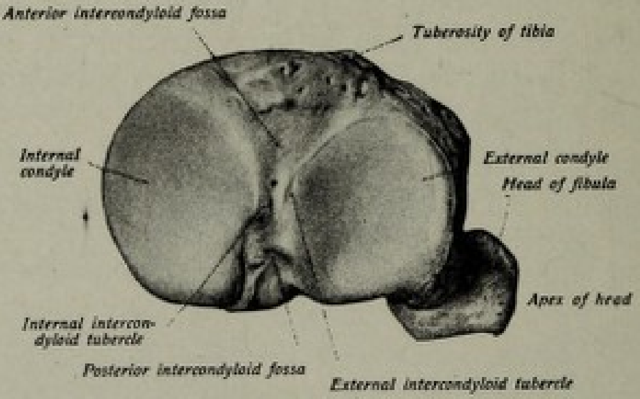
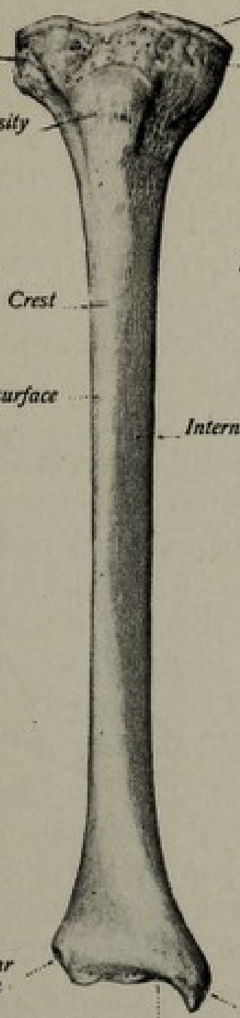


Fig. 70.—The proximal extremities of the right tibia and fibula seen from above. (*Sobotta and McMurrich.*)

area is the *intercondylic eminence* (*eminentia intercondyloidea*); this presents two peaks, or *tubercles*, the *tuberculum intercondyloideum laterale* and *tub. inter. mediale.* The depression ventral and dorsal to the eminence constitute the *ventral* and *dorsal intercondyloid fossæ.* Here are attached the ventral and dorsal cruciate ligaments and the menisci of the knee joint. The lateral condyle projects well beyond the side of the shaft and presents a small dorsolateral facet for articulation with the proximal extremity of the fibula. Ventrally the iliotib al band (*trachis iliotibialis*) is attached, the tendon of the m. biceps femoris is inserted and the mm. extensor digitorum longus and peroneus longus arise. The *dorsomedial margin* of the medial condyle is grooved for the insertion of the m. semimembranosus. The *tuberosity* is slightly distal to the condyles; its proximal portion is covered by a bursa while the distal part receives the insertion of the ligamentum patellæ.

The *shaft* (*corpus tibiæ*) presents *three surfaces* and *three margins.* Its proximal three-fourths is wedge-shaped (triangular in section) and its distal one-fourth is somewhat flattened. The *medial surface*, flat or convex, is extensive but mainly subcutaneous. On its proximal portion the mm. gracilis and semitendinosus are inserted.



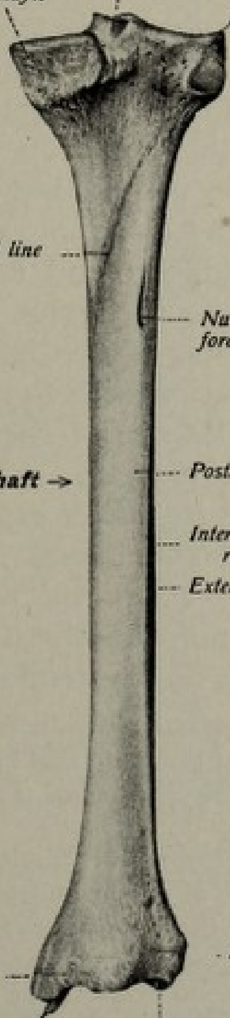


FIG. 71.—The right tibia seen from in front. (*Sobotta and McMurrich.*)

FIG. 72.—The right tibia, seen from behind. (*Sobotta and McMurrich.*)

The proximal portion of the lateral surface is quite extensive and affords an extensive origin to the m. tibialis anterior; distally it turns and blends with the medial surface a sort of ventral surface. This is covered by the tendons of the mm. tibialis anterior, extensor hallucis proprius and the ext. digitorum communis. The *dorsal* *surface* is extensive and is usually convex proximally and flat distally. The convex portion is crossed by the *oblique popliteal line* proximal to which the m. popliteus is inserted; from the oblique line the m. soleus arises. From the bulk of the remainder of the surface the mm. tibialis posterior (laterally) and the flexor digitorum longus (medially) arise. The distal portion is merely covered by these tendons and the tendon of the m. flexor hallucis proprius. A *nutrient canal* (distally directed) is present on this surface. The *ventral margin*, or *crest* is prominent in the proximal three-fourths and subcutaneous. The *medial margin* is prominent in its middle third only. The *lateral margin*, or *interosseous crest* (*crista interossea*) is sharp and to it the interosseous membrane is attached. Distally it is divided into two lines that diverge and enclose the articular surface for the distal extremity of the fibula and the area for the attachment of the ligaments of this joint.

The *distal extremity* is quite large and exhibits an *articular surface* and a *malleolus*. The *articular surface* is on the inferior, or distal portion; this is triangular and saddle-shaped and rests upon the articular surface of the astragalus (talus). Upon the lateral margin of the extremity (base of the triangle) there is a *notch* (*incisura fibularis*) for articulation with the fibula and the articular cartilage lines the notch. The *medial angle* of this extremity projects inferiorly as the *medial malleolus*. The *medial aspect* of the malleolus is subcutaneous and its *lateral aspect* is articular forming a part of the ankle joint. It also serves for the attachment of the tibial collateral ligament. Its *dorsal surface* has two grooves, one for the tendons of the mm. tibialis posterior and the flexor digitorum longus and the other for the tendon of the m. flexor hallucis longus.

Nutrient foramina are numerous in the condylar portion, the intercondyloid fossæ and the eminence; the main one for the shaft is on the dorsal surface and is distally directed. The margins of the distal extremity also shows numerous foramina.

Articulations.—With the femur, fibula and astragalus.

Ossification.—This is of endochondral origin and develops from *three* or *four centers*. The *center* for the *shaft* appears during the second fetal month. The *center* for the *proximal extremity* appears before birth and for the *distal extremity* between the first and second years. The *center* for the *tuberosity*, when independent, appears at about the eleventh year. Complete fusion with the shaft takes place by the twentieth to the twenty-fourth year.

Muscle Attached.—Origins.—Mm. tibialis anterior, extensor digitorum longus, soleus, flexor digitorum longus, tibialis posterior, peroneus longus.

Insertions.—Mm. biceps femoris, semimembranosus, semitendinosus, sartorius, gracilis, popliteus, quadriceps extensor (thirteen).

THE FIBULA

The fibula is the slender bone on the lateral side of the leg but it does not support the body. It consists of *two extremities* and a *shaft*.

The *proximal extremity* or *head* (*capitulum fibulæ*) is broad, flat, and pointed. This point is the *apex* to which the fibular collateral ligament is attached and the m. biceps femoris is inserted. The *medial surface* slopes medially and distally and has an articular facet that fits against the articular facet upon the lateral condyle of the tibia. The *lateral surface* is somewhat roughened. The

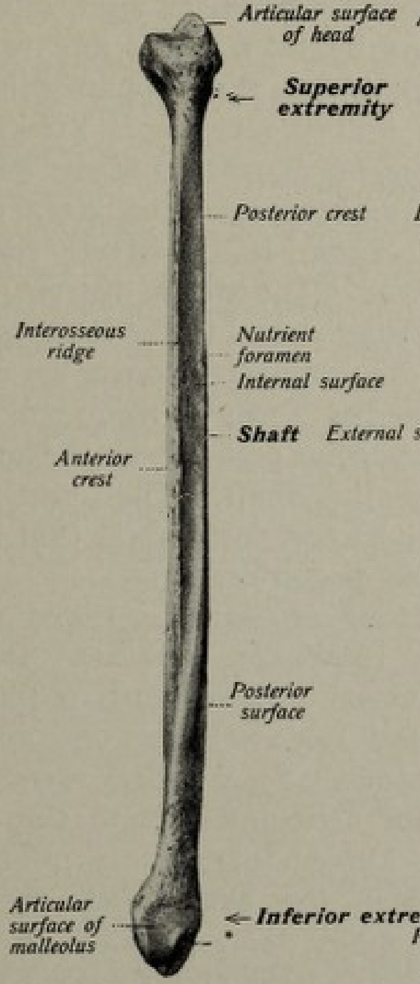


FIG. 73.—The right fibula, seen from the medial surface. (*Sobotta and McMurrich.*)

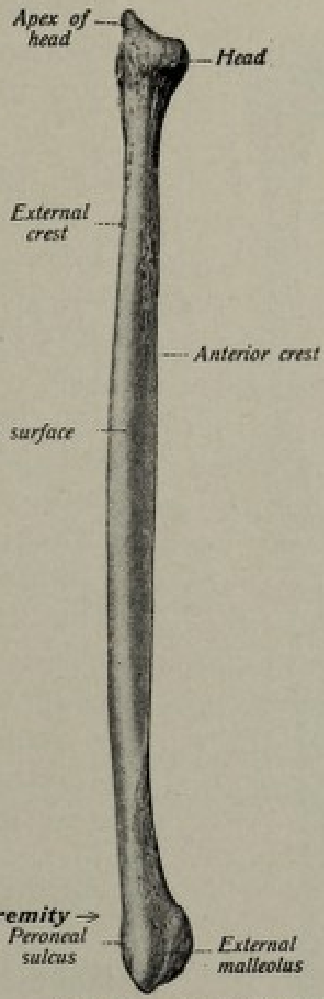


FIG. 74.—The right fibula, seen from the lateral surface. (*Sobotta and McMurrich.*)

tendon of the m. biceps femoris is inserted to the ventral and proximal surface and below this the m. peroneus longus arises; its dorsal part gives origin to the m. soleus. The next portion of the bone is somewhat constricted and is called the *neck*.

The *shaft* (*corpus fibulæ*) is exceedingly variable as to shape and form. It has *three surfaces*, *three margins* and an *interosseous crest*. The *medial surface* is divided into ventral and dorsal areas by the interosseous crest to which the interosseous membrane is attached. The *ventral* part of this surface is variable in width and affords origin to the mm. extensor digitorum communis, extensor hallucis longus and peroneus tertius. The *dorsal* part of this surface is less extensive, lies dorsal to the interosseous crest and affords origin to the m. tibialis posterior. The *lateral*, or *peroneal surface*, in its proximal part, faces ventrally and in its distal part faces dorsally. It gives origin to the mm. peronei longus and brevis. The *dorsal surface* is fairly extensive but irregular. Proximally the m. soleus arises while distally the m. flexor hallucis longus arises.

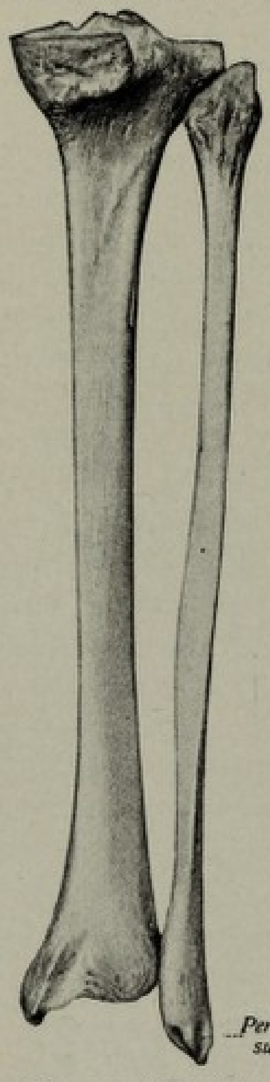


FIG. 75.—The tibia and fibula seen from behind. (*Sobotta and McMurrich.*)

The *ventral margin*, or *crest*, separates the medial and lateral surfaces and to it the intermuscular fascia that separates the peroneal from the ventral muscles is attached. The *lateral margin*, or *crest* is fairly well marked (distally) and separates the lateral and dorsal surfaces. From its proximal end the m. soleus arises. The *medial margin*, or *crest*, is a curved ridge dorsal to the interosseous crest and serves to separate the smaller dorsal part of the medial surface (from which the m. tibialis posterior arises) from the larger dorsal surface of the shaft. The crest gives attachment to the deep fascia that covers the m. tibialis posterior.

The *distal extremity* is called the *lateral malleolus* (*malleolus lateralis*). It is an irregular mass of bone with a blunt point. The *lateral surface* is convex and mainly subcutaneous. The *medial surface* exhibits a facet for articulation with the astragalus (talus). Dorsal to this is a pit for the attachment of the astragulofibular ligament, and proximally the roughened surface gives attachment to the interosseous ligaments. The *dorsal surface* shows a *groove* (*sulcus malleolaris*) for the passage of the tendons of the mm. peronei longus and brevis. The *ventral margin* gives attachment to the astragalofibular and calcaneofibular ligaments.

Arterial Foramina.—These are numerous, some in the head and some in the malleolus. The largest is on the dorsal surface of the shaft and is distally directed.

Articulations.—With the tibia (proximally and distally) and with the astragalus (talus).

Ossification.—It is of endochondral origin and arises from *three centers*. The *center* for the *shaft* appears during the middle of the second month of fetal life. The *center* for the *distal extremity* appears during the second year and for the *proximal extremity* during the third or fourth year. Fusion with the shaft is completed between the twentieth and twenty-fourth years.

Muscles Attached.—Origins.—Mm. soleus, peronei longus, brevis and tertius, tibialis anterior and posterior, flexor hallucis longus, extensor digitorum communis and extensor hallucis longus.

Insertions.—M. biceps femoris.

THE BONES OF THE FOOT

The foot comprises the *tarsus*, *metatarsus* and the *phalanges*.

THE TARSUS

The tarsal bones (*ossa tarsi*) are the *astragalus*, *calcaneum*, *scaphoid*, *three cuneiform* and *cuboid bones*. All are irregular in shape.

The **astragalus** (**talus**) forms the tarsal part of the ankle and supports the tibia. It consists of a *body*, *head* and *neck*.

The *body* presents a *superior*, saddle-shaped *facet* for articulation with the tibia. The articular surface extends laterally for articulation with the malleolus of the fibula and medially for articulation with the malleolus of the tibia. Around these areas ligaments of the joint are attached. The *distal surface* presents two articular facets; the dorsal one (dorsal calcaneal facet) is concave for articulation with the dorsal facet upon the calcaneus. The ventral facet (middle calcaneal facet) is slightly convex for articulation with the facet upon the sustentaculum tali of the calcaneum. Between the two there is a deep groove (*sulcus tali*). The *oval head* presents a convex articular facet on its ventral surface; this articulates with the scaphoid (navicular) bone. Ventral and lateral to the middle calcaneal facet is the ventral calcaneal facet. Upon the *inferomedial surface* of the head is another facet that rests upon the plantar calcaneonavicular ligament. The *neck* is a groove and is best marked dorsally where it separates the body and head.

Articulations.—With the tibia, fibula, calcaneum and scaphoid (navicular).

Muscles Attached.—None.

The **calcaneum, or heel bone,** is the largest of the tarsal bones. It is an irregular mass the dorsal portion of which projects as the heel and is called the *tuberosity* (*tuber calcanei*). To the middle of its dorsal surface the tendo Achillis (calcaneus) is attached. The *medial surface* of the main part of the bone presents a heavy shelf of bone, the *sustentaculum tali* the plantar surface of which is grooved for the tendons of the m. flexor hallucis longus. Its *superior surface* presents the middle calcaneal facet (for the astragalus). The *superior surface* of the main portion of the bone presents a large dorsal calcaneal facet and a small ventral calcaneal facet in front of the middle one. These are for articulation with the corresponding facets upon the astragalus. The dorsal facet is separated from the others by a deep groove (*sulcus calcanei*). The *lateral surface* is somewhat concave. The *ventral extremity* is a concave articular facet for articulation with the scaphoid (navicular) bone.

Articulations.—With the astragalus (talus) and the scaphoid (navicular) bones.

Muscles Attached.—Origins.—Mm. flexor digitorum brevis, abductores hallucis and digiti quinti, flexor quadratus plantæ and extensor digitorum brevis.

Insertions.—Mm. plantaris, tibialis posterior and tendo Achillis (calcaneus) (eight).

The **scaphoid bone (os naviculare)** is somewhat concavoconvex. Its *proximal* (correctly dorsal) *surface* is a concave articular facet

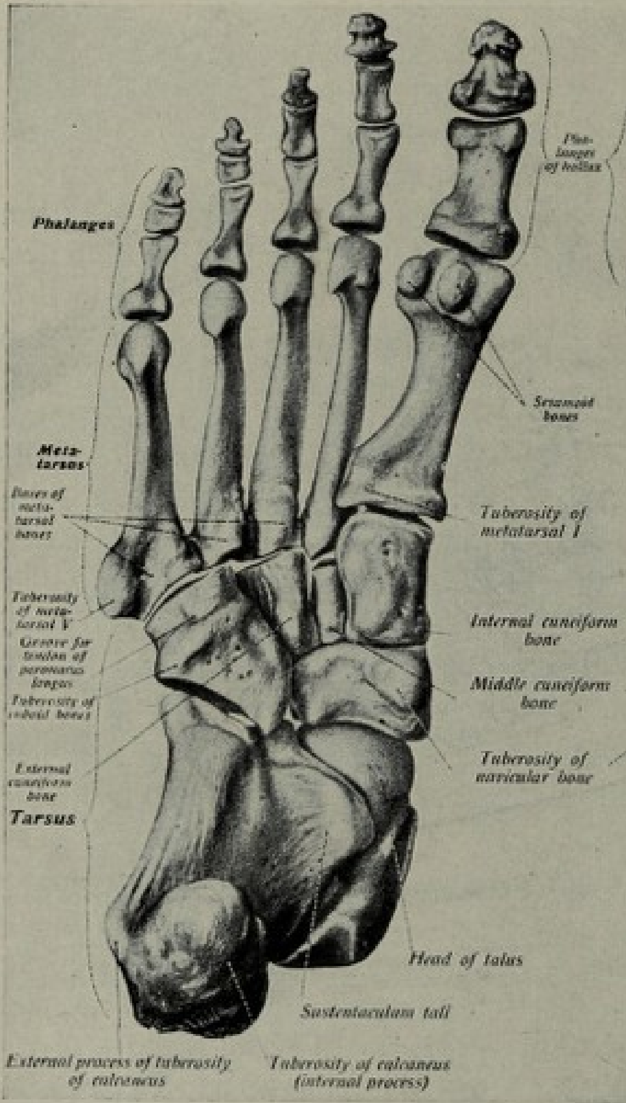


Fig. 76.—A frozen preparation of the bones of the foot seen from the plantar surface. (*Sobotta and McMurrich.*)

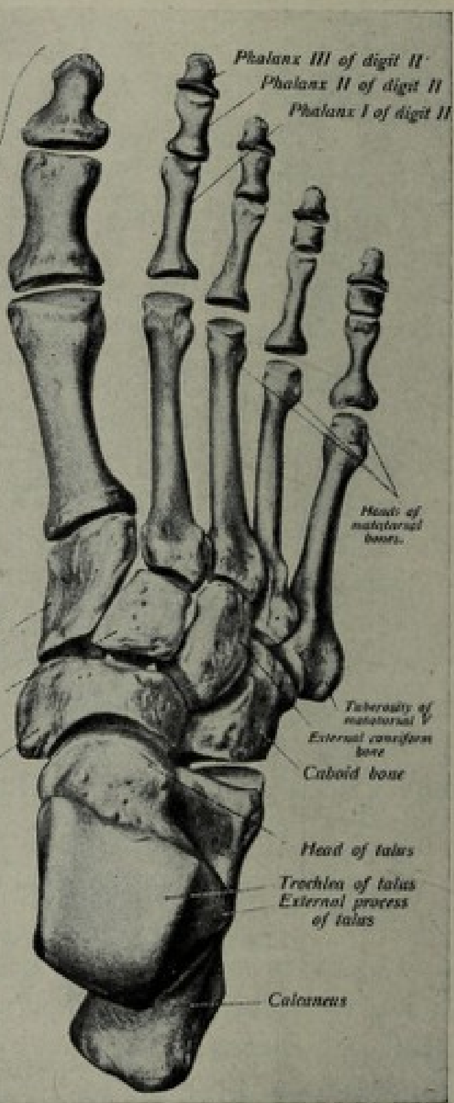


Fig. 77.—The same preparation seen from the dorsal surface. (*Sobotta and McMurrich.*)

for the head of the astragulus. The *distal* (ventral) *surface* presents three confluent quadrate facets for articulation with the three cuneiform bones. The *medial space* projects as the *tuberosity*. The other surfaces are roughened.

Articulations.—With the astragalus and three cuneiform bones (four).

Muscles Attached.—M. tibialis posterior (inserted).

The **cuboid (os cuboideum)** is laterally placed and is roughly cuboidal in form. Its *medial surface* presents a facet for articulation with the lateral cuneiform bone and occasionally with the navicular bone. The *proximal surface* has a concave facet for articulation with the calcaneum. The *distal* surface presents two articular facets for the fourth and fifth metatarsal bones. The *plantar surface* bears a *groove* (*sulcus peronei*) for the tendon of the m. peroneus longus.

Articulations.—With the calcaneum, lateral cuneiform, fifth and fourth metatarsal bones and occasionally with the navicular bone.

Muscle Attached.—Origin.—M. flexor hallucis brevis.

Insertion.—Part of the m. tibialis posterior.

The **three cuneiform bones** are wedge-shaped and form with the cuboid the distal row of tarsal bones.

The **first** or **medial cuneiform** bone is the largest and articulates with the first metatarsal bone, distally, the navicular, proximally and the second metatarsal and second cuneiform bones, laterally.

Muscles Attached.—Mm. tibialis anterior, tibialis posterior and peroneus longus (inserted).

The **second (middle) cuneiform** bone is the smallest. It articulates distally, with the second metatarsal bone, laterally, with the third cuneiform bone and medially, with the first cuneiform and proximally with the navicular bone.

Muscles Attached.—Part of the tendon of the m. tibialis posterior is inserted.

The **third (lateral) cuneiform** bone articulates distally with the third metatarsal bone laterally with the fourth metatarsal and cuboid, proximally with the navicular and medially with the second cuneiform and second metatarsal bones.

Muscle Attached.—Origin.—M. flexor hallucis brevis.

Insertion.—M. tibialis posterior.

Ossification.—The tarsal bones are of endochondral origin. The calcaneum develops from *two centers* and the others from *one* each. The *centers* appear in the following order:

Calcaneum (body)	sixth month of fetal life
Astragalus (talus)	seventh month of fetal life
Cuboid	ninth month of fetal life
Lateral cuneiform	first year
Medial cuneiform	third year
Scaphoid and middle cuneiform	fourth year
Tuberosity of the calcaneum about the	tenth year and fuses with

the body about the age of puberty.

THE METATARSUS

The metatarsus, like the palm, consists of *five bones. Each* presents a *proximal extremity* or *base*, a *shaft* and a *distal extremity*, or *head*. The *proximal extremities* articulate with the distal row of tarsal bones and with each other. The first is the shortest and stoutest and the second the longest. The fifth presents a *tuberosity* at the lateral part of the proximal extremity to which the tendon of the m. peroneus tertius is attached.

Ossification.—These are of endochondral origin and *each* develops from *two centers, one* for the *shaft* and *one* for the *digital extremity* of the *four outer metatarsals* and *one* for the *shaft* and *one* for the *base* of the first metatarsal. The *center* for the *shaft* appears during the ninth week of fetal life; the *center* for the *base* of the first metatarsal appears during the third year; the *centers* for the *distal extremities* of the others appear between the fifth and eighth years. Fusion of shaft and epiphysis is usually completed by the eighteenth to the twentieth years.

Muscles Attached.—

First Metatarsal.—**Origin.**—First dorsal interosseous. **Insertions.**—Mm. tibialis posterior, peroneus longus (three).

Second Metatarsal.—**Origin.**—Mm. adductor hallucis obliquus, first and second dorsal interossei. **Insertions.**—Mm. tibialis posterior, peroneus longus (five).

Third Metatarsal.—**Origins.**—Mm. adductor obliquus hallucis, second and third dorsal interossei, first plantar interosseous. **Insertions.**—M. tibialis posterior (five).

Fourth Metatarsal.—**Origins.**—Mm. adductor hallucis obliquus, third and fourth dorsal interossei, second plantar interosseous. **Insertions.**—M. tibialis posterior (five).

Fifth Metatarsal.—**Origins.**—Mm. flexor quinti digiti brevis, adductor hallucis transversus, fourth dorsal and third plantar interossei. **Insertions.**—Mm. peroneus brevis and peroneus tertius (six).

THE PHALANGES

The phalanges of the foot resemble those of the hand in number, form and arrangement. Their nutrient foramina are similar. *Each* consists of a *proximal extremity*, *shaft* and *distal extremity*. Their articulations are also similar.

Ossification.—These are of endochondral origin and each is developed from *two centers.* The *center* for the *shaft* appears during the tenth week of fetal life and those for the *proximal extremities* appear between the fourth and tenth years. Fusion between these parts occurs about the eighteenth year.

Muscles Attached.—All are insertions.

First Phalanx of the Great Toe.—Mm. extensor digitorum brevis (innermost tendon), abductor hallucis, adductores hallucis transversus and obliquus, flexor hállucis brevis (five).

First Phalanx of the Second Toe.—First and second dorsal interossei, first lumbricale (three).

First Phalanx of Third Toe.—Third dorsal interosseous, first plantar interosseous, second lumbricale (three).

First Phalanx of the Fourth Toe.—Fourth dorsal interosseous, second plantar interosseous, third lumbricale (three).

First Phalanx of the Little Toe.—Mm. flexor digitorum quinti brevis, abductor digiti quinti brevis, third plantar interosseous, fourth lumbricale (four).

Second Phalanx of the Great Toe.—Mm. extensor hallucis longus, flexor hallucis longus (two).

Second Phalanx of the Other Toes.—Mm. flexor digitorum brevis, one slip of the common tendon of the extensor digitorum longus and the extensor digitorum brevis (except the fifth toe).

Third Phalanges.—Two slips of the common tendon of the extensor digitorum longus, the extensor digitorum brevis and flexor digitorum longus.

THE FOOT AS A WHOLE

The bones of the foot are arranged in the form of an **arch** and this supports the weight of the body in the erect position. The foot is placed at a right angle to the leg. There are **two arches, longitudinal** and **transverse.**

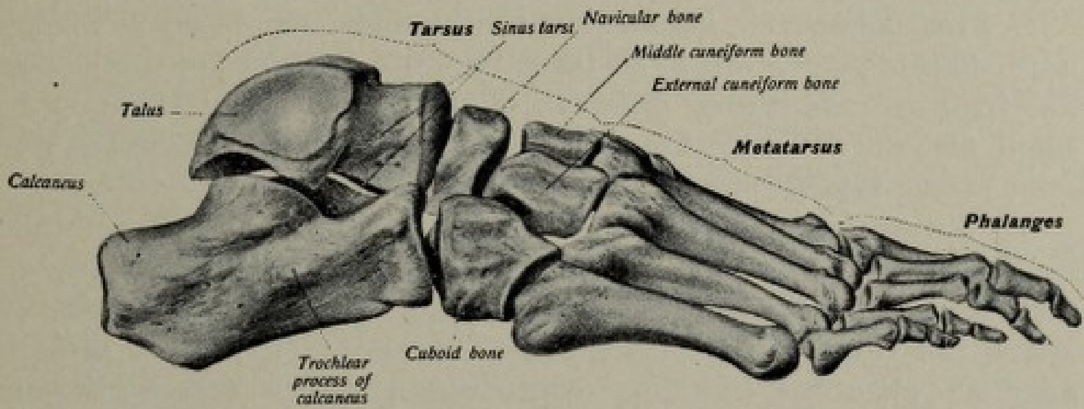


FIG. 78.—A frozen preparation of the bones of the right foot seen from the outer side. (*Sobotta and McMurrich.*)

The **longitudinal arch** is the larger and the longer; the curvature of the arch is greater on the medial aspect than it is on the lateral aspect. The heel (back) part of the arch is made up of the calcaneum and the proximal part of the astragalus and is about 3 inches in length; the front part of the arch consists of the other tarsal and the metatarsal bones and measures about 7 inches in length. The *weakest part* of the arch is at the joint between the astragalus and scaphoid bones. It is especially supported here by ligaments (the calcaneoscaphoid and the tendon of the m. tibialis posterior). Whenever these give, the arch becomes lower and causes *flat-foot.*

The **transverse arch** of each foot is only a half arch and the whole is formed when the two feet are placed in apposition. This half arch represents the difference in height of the longitudinal arch at its lateral and medial aspects.

CHAPTER II

SYNDESMOLOGY

THE JOINTS

A **joint,** when movable, is the fulcrum at which the levers (bones) are moved by the muscles. There are two main divisions of joints, the **immovable** and the **movable.**

1. **Synarthroses,** or **immovable articulations,** are those in which no motion is perceptible. In these the apposed edges of the bones are irregular and fit, or dove-tail, into one another. There is a small amount of white fibrous tissue separating the bones, but no joint cavity exists. There are *four varieties.*

(*a*) **Suture** (**sutura**) is that form found in the skull. When the irregularities of the connecting bones are well marked they form a **true suture** (*sutura vera*), otherwise a **false suture** (*sutura notha*). When the sutural projections are tooth-like they form a **sutura dentata**; when saw-like they constitute a **sutura serrata**; when ridge-like they form a **sutura limbosa.** The false suture may be a *sutura squamosa* (squamoparietal), a *sutura harmona* (palatal processes of the maxillæ).

(*b*) **Schindylesis** is that variety in which a bone is placed in a cleft between two lamellæ of another, as the articulation of the vomer with the maxillæ.

(*c*) **Gomphosis** is that form in which a conical process fits into a special socket, as the articulation of the teeth with the mandible and maxillæ.

(*d*) **Synchondrosis** is that variety in which hyalin cartilage intervenes between the articular surfaces of certain bones, early in life, to be later ossified. This is represented by the epiphyseal cartilage separating shaft and extremities of long bones, before adult life.

Movable joints comprise two classes, **partly movable,** or **amphiarthroses** and **freely movable,** or **diarthroses.**

1. **Amphiarthroses** exhibit slight movement and they resemble somewhat in structure the diarthroses. Two varieties are noted.

(*a*) **Symphysis,** that form in which the two articular surfaces of the bones are connected by an intervening plate of fibrocartilage. All parts are held together by ligaments and a rudimentary joint cavity may be present. Examples are the symphysis pubis and the articulations between the bodies of the true vertebræ.

(*b*) **Syndesmosis,** that form in which the bony surfaces are connected by an interosseous ligament, as the inferior tibiofibular articulation.

2. **Diarthroses.**—Most of the articulations come under this class and a number of varieties are given.

(*a*) **Arthrodia** is that variety in which there is a somewhat limited gliding movement, as between the bones of the carpus, the tarsus and the articular processes of the vertebræ.

(*b*) **Ginglimus,** or **hinge joint,** is that form in which motion occurs only in one plane, that is at right angles to the long axis of the bones taking part (as in a hinge). The best examples are the interphalangeal articulations and the elbow joint. The knee and ankle joints belong to this variety but permit of some lateral movement.

(*c*) **Condyloid,** or **biaxial** articulations, permit of movement in two planes, at right angles to each other, permitting flexion, extension, abduction and adduction and circumduction, as in the radiocarpal articulation.

(*d*) **Trochoid,** or **rotary** joint, is that variety in which there is rotation only, as in the proximal and distal radioulnar articulations, as well as that between the dens of the epistropheus with the atlas and transverse ligament.

(*e*) **Reciprocal reception,** or **saddle joint,** is a term applied to the carpometacarpal articulation of the thumb. Such permits of flexion, extension, abduction, adduction and circumduction.

(*f*) **Enarthrosis,** or **ball and socket** joint, is the variety that permits of motion about practically any number of axes from a common center, as the hip and the shoulder joints.

A number of structures are required in order to have a diarthrodial joint, as **bones, cartilage, ligaments** and **synovial membrane. Two bones** are necessary and their articular surfaces are so formed and adapted to each other so as to permit of certain movements. The parts of these bones that actually rub against each other are covered with a layer of **hyalin cartilage. Ligaments** connect the bones together so as to prevent them from separating. A **synovial membrane** lines the inner surface of the capsular ligament and covers all parts of the bones within the joint cavity except that part covered with hyalin cartilage (real articular surfaces).

The **structure of bone** has been discussed in the chapter on "Osteology."

Cartilage.—There are *three varieties:* (*a*) *hyalin,* (*b*) *fibrocartilage,* (*c*) *elastic cartilage.*

Cartilage is surrounded by an investing, genetic membrane called the *perichondrium,* which is analogous to the periosteum of bones. From it the *cartilage cells,* or *chondroblasts*, arise. Within the perichondrium is the *matrix* containing the cartilage cells. In **hyalin** cartilage this matrix is apparently homogeneous. In special preparations, however, a groundwork of white fibrous tissue may be recognized. The cartilage cells beneath the perichondrium are small, elongated and close together. Near the middle of the cartilage they are larger, oval and each usually lies in a distinct space, or *lacuna*.

Hyalin cartilage is found covering the articular surfaces of bones, and as the costal, tracheal, bronchial and the larger laryngeal cartilages. It may calcify or even ossify.

In **fibrocartilage** the *matrix* is chiefly white fibrous tissue in which the fibers are mostly parallel to one another. The cartilage cells lie in little scattered islands of hyalin matrix.

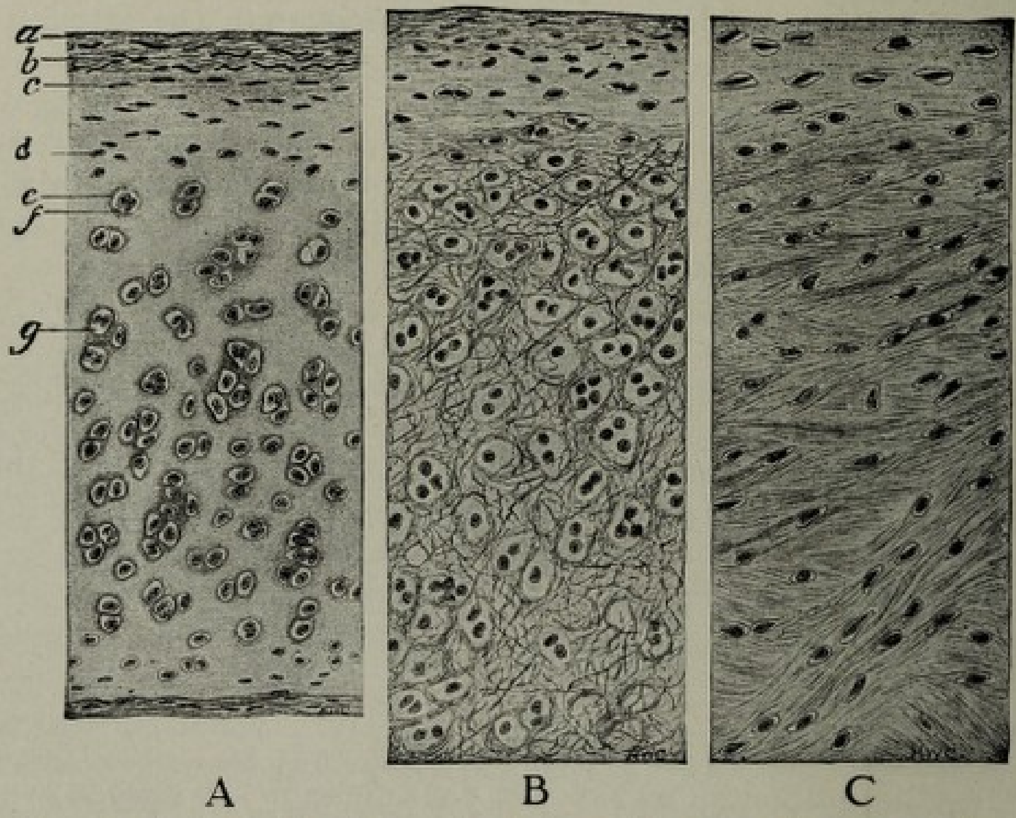


FIG. 79.—Sections of cartilage. A, Hyalin cartilage. *a*, Fibrous layer of perichondrium; *b*, genetic layer of perichondrium; *c*, youngest chondroblasts; *d*, older chondroblasts; *e*, capsule; *f*, cells; *g*, lacuna. B, Elastic cartilage. C, White fibro-cartilage. (*Radasch's Histology.*)

Fibrocartilage is found as the intervertebral discs, interarticular cartilages and deepening joint cavities. It may calcify in old age.

Elastic cartilage does not concern us here.

Ligaments are those bands of dense white fibrous tissue that hold the bones together. They resemble the fasciæ in structure and consist of bundles of white fibrous tissue, most of which are parallel to one another; other bundles pass obliquely or transversely to the preceding and bind all together into a firm sheet or band. A variable quantity of elastic tissue is present. The connective-tissue cells lie between the bundles of fibers and are comparatively few in number. Ligaments are whitish and shiny in appearance and are arranged as capsules with accessory strengthening portions, or as individual bands or intraarticular ligaments.

A **synovial membrane** is a thin, delicate *serous membrane* that lines the joint cavity. It consists of a single layer of *endothelial cells* that are flat and plate-like with irregular edges that fit into one another. At intervals small gaps or *stomata* exist. These cells rest upon a thin layer of fibroelastic *subendothelial tissue*. This membrane does not extend over the hyalin cartilage of the articular surfaces in the adult. These membranes *transude* (*not secrete*) a thick, viscid substance, called synovia, that lubricates the joint. Synovial membranes are found elsewhere as in bursæ, and vaginal synovial membranes.

Bursæ are sacs of white fibrous tissue lined with a synovial membrane; they may be **cutaneous,** as those placed between the skin and a prominent bony process (over the patella, olecranon and malleoli). The **subtendinous bursæ** are those intervening between a tendon and a bone or cartilage, facilitating the action of the muscle. Some bursæ are over joints.

A **vaginal synovial membrane** (synovial sheath) is one that lines a groove or canal in the bone, through which a tendon passes, thus facilitating its action. These are seen in connection with the flexor and extensor tendons of the fingers and toes, especially.

ARTICULATIONS OF THE VERTEBRAL COLUMN AND HEAD

The articulations of the vertebral column are those between the *bodies* and those between the *articular processes*. In addition there are ligaments connecting the spinous processes, transverse processes and laminæ.

Bodies.—These articulations are *amphiarthrodial* and the ligaments are *intervertebral*, *ventral longitudinal* and *dorsal longitudinal*.

The *intervertebral discs* vary in thickness in the various parts of the vertebral column. Each conforms in shape to the surfaces of the bodies to which it is firmly attached. Its peripheral portion (*annulus fibrosus*) is dense and tough white fibrocartilage, while its central portion (*nucleus pulposus*) is soft, pulpy and elastic.

The *ventral longitudinal ligament* (*lig. longitudinale anterius*) is a broad, fibrous band that extends from the epistropheus to the superior segment of the sacrum. It is attached to the projecting superior and inferior edges of the ventral portion of each body and the intervertebral disc. Some of its fibers are of short course and others extend over three or four vertebræ.

The *dorsal longitudinal ligament* (*lig. longitudinale posterius*) connects the dorsal surfaces of the bodies in the same manner. It lies in the vertebral canal.

Articular Processes.—The articular processes form *arthrodial* articulations. Each contiguous pair of processes is surrounded by

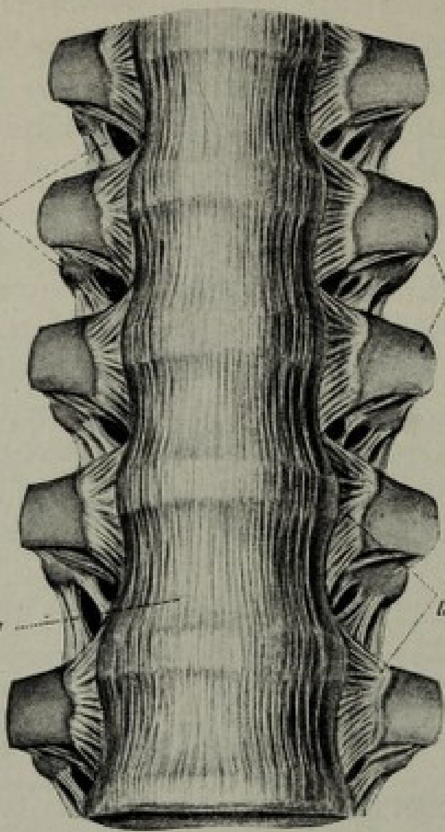


FIG. 80.—The ventral longitudinal ligament in the lower thoracic portion of the vertebral column, together with the costo-vertebral ligaments seen from in front. (*Sobotta and McMurrich.*)

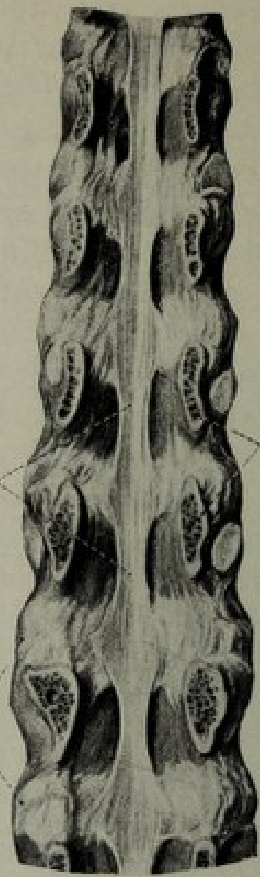


FIG. 81.—The dorsal longitudinal ligament in the lower thoracic and upper lumbar portions of the vertebral column. The vertebral arches have been removed. (*Sobotta and McMurrich.*)

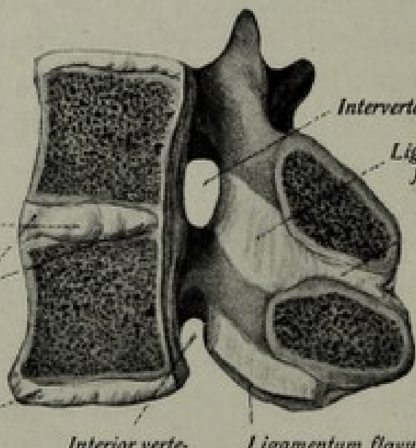


FIG. 82.—Two thoracic vertebræ divided longitudinally in the median line and showing the ligamenta flava. (*Sobotta and McMurrich.*)

a thin *capsular ligament* (*capsula articularis*) that is usually completed by the ligamenta flava. These ligaments are loosest in the cervical region, where movement is most extensive, and are attached to the bone adjoining the articular surfaces.

Other ligaments are as follows:

Ligamenta Flava.—The laminæ of adjoining vertebræ are connected to each other by the short, yellow, elastic ligamenta flava. These close in gaps in the osseous vertebral canal.

Ligamenta intertransversaria are short ligaments that connect the transverse process of the vertebræ, except in the cervical and upper thoracic region.

Ligamenta supraspinalia form a strong band that connects the tips of the spinous processes together. In the neck it is usually more highly developed and consists, mainly, of yellow elastic tissue. This part is called the *ligamentum nuchæ* and is important and highly developed in quadrupeds.

Ligamenta interspinalia are the short, thin bands that connect one spine with another, and extend dorsoventrally from the supraspinous ligaments to the ligamenta flava.

The **lumbosacral articulation** is similar to that of the typical vertebræ. *Two accessory lumbosacral ligaments* are present. Each extends from the transverse process of the last lumbar vertebra to the ventral aspect of the ala of the sacrum; occasionally there is an extension from the lateral part of the body of the last lumbar vertebra to each ala.

The **sacrococcygeal articulation** is a symphysis. The last segment of the sacrum and the first of the coccyx are connected by strong *ventral, dorsal* and *lateral sacrococcygeal ligaments.* An *intervetebral fibrocartilage* is present.

The **vertebral column** is capable of *flexion, extension, lateral flexion, rotation* and some *circumduction.* The movements are most extensive in the cervical and lumbar regions and while the movement of one vertebra upon its neighbor may be small, the motion as a whole becomes considerable.

ATLAS AND AXIS

This articulation (*atlantoepistrophica*) comprises those of the *articular processes* and that between the *dens* and *atlas.*

The articulation between the processes are *arthrodial.* Each joint possesses a *capsular ligament* and an *accessory ligament;* the latter is located in the vertebral canal and represents a thickening of the capsular ligament.

The *ventral atlantoepistropheal ligament* connects the ventral surface of the body of the epistropheus to the ventral surface of the ventral arch of the atlas. This is reinforced by the fibers of the ventral longitudinal ligament. The *dorsal atlantoepistropheal ligament* extends from the dorsal arch of the atlas to the laminæ of the epistropheus (like a ligamentum flavum).

The *transverse ligament* (*lig. transversum atlantis*) extends transversely between the two tubercles of the atlas and dorsal to the neck of the dens of the epistropheus; between these two structures there exists a synovial sac. The *cruciform ligament* (*lig. cruciatum atlantis*) is formed by the transverse ligament sending fibers from its superior margin to the ventral margin of the foramen magnum

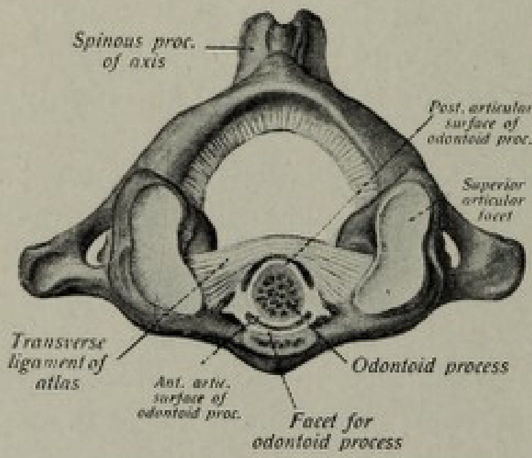


FIG. 83.—The atlanto-odontoid articulation. The odontoid process (*dens epistrophei*) and the ventral arch of the atlas have been cut. (*Sobotta and McMurrich.*)

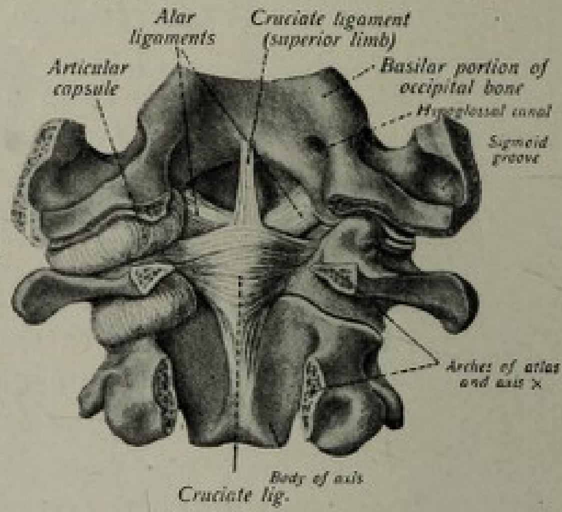


FIG. 84.—The cruciate ligament after removal of the tectorial membrane. The articular capsules have also been removed on the right side. (*Sobotta and McMurrich.*)

and fibers from its inferior margin to the dorsal surface of the body of the axis.

Movements.—The head and the atlas *rotate* upon the axis or epistropheus.

ATLAS AND OCCIPITAL BONE

The **atlantooccipital articulation** (*articulatio atlantooccipitalis*) is a *diarthrosis*. The *ligaments* are as follows:

1. A *capsular ligament* that surrounds each condyle of the occipital bone and corresponding facet of the atlas.

2. The *ventral atlantooccipital membrane* (*membrana atlantooccipitalis anterior*) extends from the ventral arch of the atlas to the ventral margin of the foramen magnum and is thickened in the median line.

3. The *dorsal atlantooccipital membrane* extends from the dorsal arch to the dorsal margin of the foramen magnum. Both are continuous with the capsular ligaments.

4. The *alar*, or *check*, *ligaments* (*ligg. alaria*) are two short, strong

cords extending right and left from the sides of the apex of the dens to the condylar portions of the occipital bone.

5. The *ligament of the apex* (*lig. apicis dentis*) extends from the apex of the dens to the ventral margin of the foramen magnum.

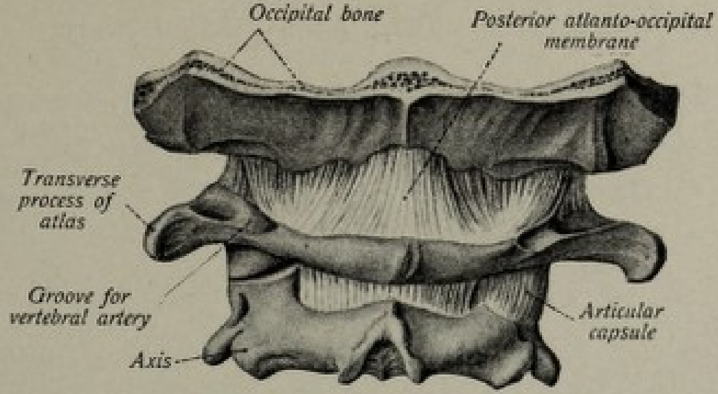


FIG. 85.—A portion of the occipital bone together with the atlas and axis (epistropheus) and their ligaments seen from behind. On the left side the capsule of the atlanto-epistropheal articulation has been removed. (*Sobotta and McMurrich.*)

Movements.—Between the occipital bone and the atlas, a *rocking motion* is accomplished (nodding) as well as a limited amount of *oblique motion.*

THE MANDIBULAR ARTICULATION

The mandibular articulation (*articulatio mandibularis*) is a *ginglymo-arthrosis* and the parts concerned are the condyles of the mandible and the mandibular fossæ of the temporal bones. An *intraarticular cartilage* (*disc*) intervenes between these bones, however.

1. The loose *capsular ligament* is attached to the edges of the fossa and to the neck of each condyle.

2. The *temporomandibular ligament* (*lig. temporomandibulare*) is a thickening of the lateral wall of the capsule and extends between the inferior margin of the zygoma and the neck of the mandible (dorsally and laterally).

3. The *articular disc* (*discus articularis*) is a concavo-convex mass of fibrocartilage that is attached, peripherally, to the capsule so as to divide the joint cavity into two compartments, each of which has its own synovial membrane.

4. The *sphenomandibular ligament* (*lig. sphenomandibulare*) is a thin, flat band extending between the spine of the sphenoid bone and lingula of the mandible. It is an *accessory* ligament.

5. The *stylomandibular ligament* (*lig. stylomandibulare*) extends from the styloid process of the temporal bone to the dorsal margin of the angle of the mandible. It is an *accessory* ligament.

Movements.—*Depression, elevation, forward, backward, lateral* (grinding).

ARTICULATIONS OF THE THORAX

Two articulations exist between each rib and the vertebral column. The *head* articulates with the bodies and the *tubercle* with a transverse process.

COSTOVERTEBRAL ARTICULATIONS

The **articulations of the heads of the ribs** (*articulationes capitulorum*) are of the *ginglymoid* variety of diarthrosis. The head articu-

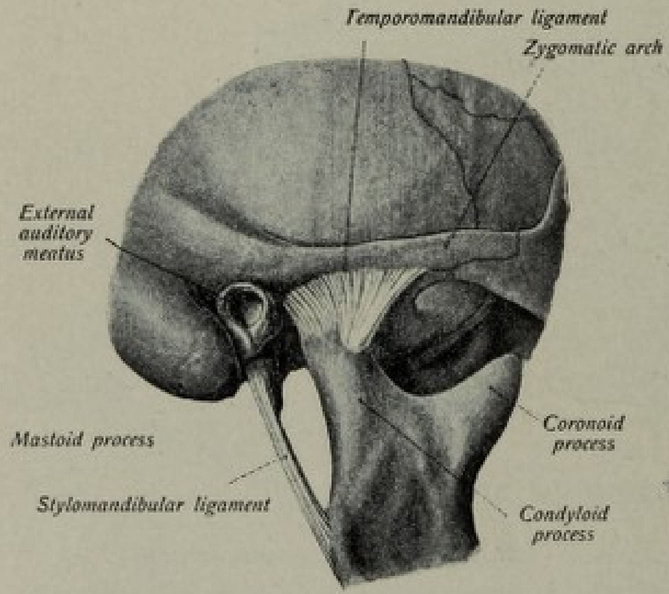


FIG. 86.—The right temporo-mandibular articulation seen from the outer side. (*Sobotta and McMurrich.*)

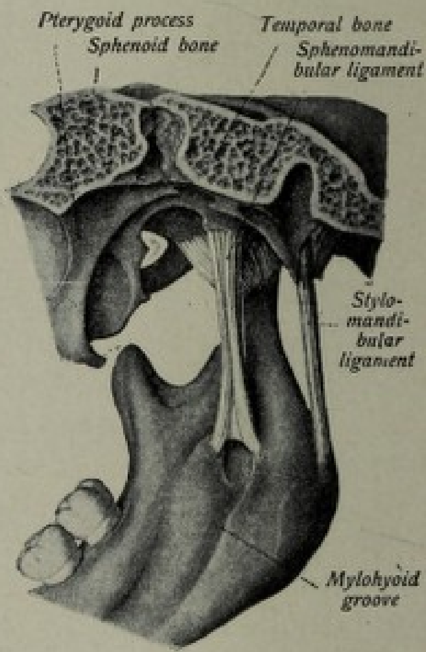


FIG. 87.—The right temporo-mandibular articulation seen from the inner side. (*Sobotta and McMurrich.*)

lates with the demifacet of the two adjoining vertebral bodies. A *capsular ligament* surrounds these parts. The ventral portion of the capsule is reinforced by three radiating bundles of fibers called the *radiate ligaments* of the head (*lig. capituli costæ radiatum*). These start at the head; the middle one is attached to the intervertebral disc and the others to the vertebral bodies.

The *intraarticular ligament* (*lig. capituli costæ intraarticulare*) is within the joint; it is attached to the ridge on the head, between the two facets, and to the intervertebral disc.

The **costotransverse articulations** (*articulationes costotransversariæ*) of the typical ribs are those between the tubercles of the ribs and the transverse processes of the lower vertebra with which the head

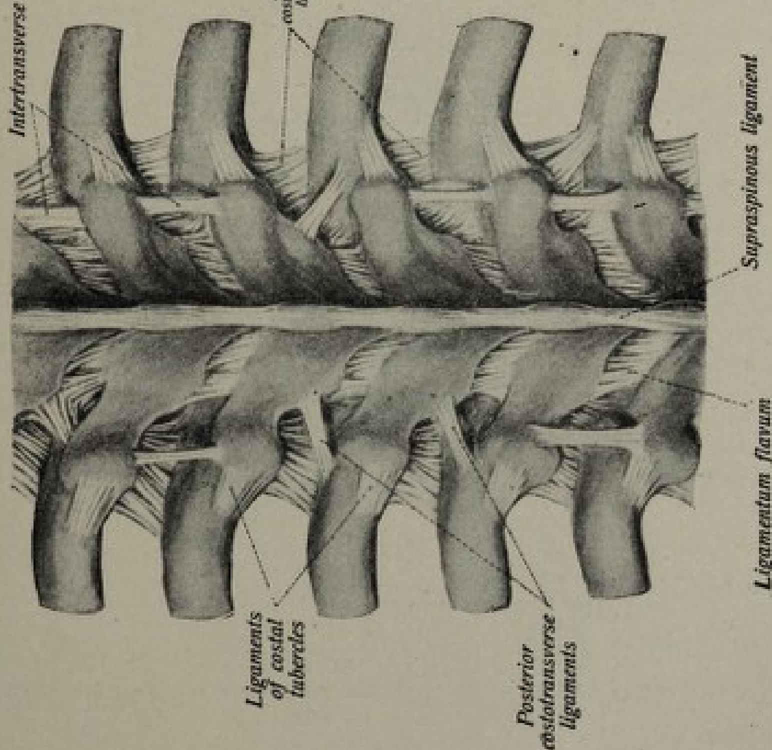


FIG. 88.—The ligaments of the middle and lower thoracic vertebræ and their ribs seen from behind. (*Sobotta and McMurrich.*)

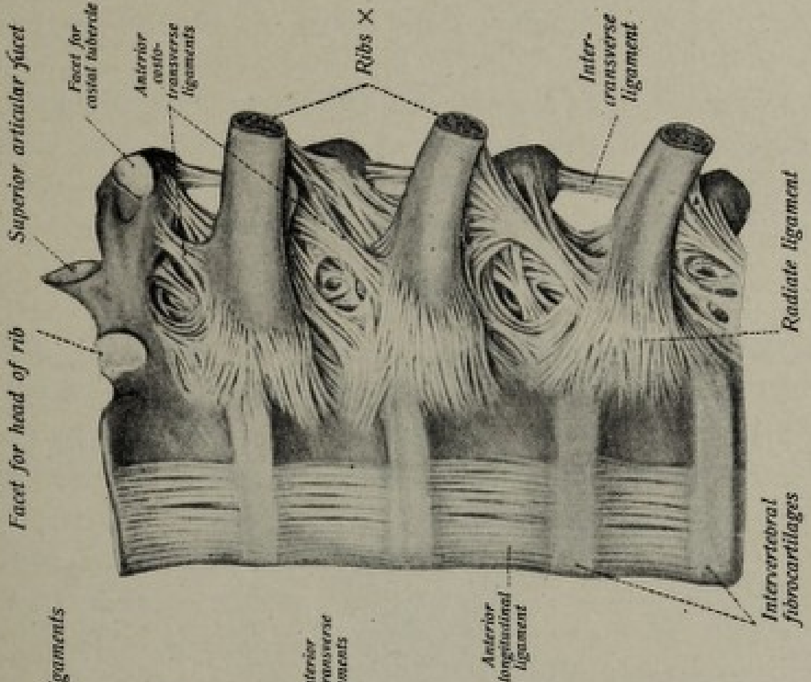


FIG. 89.—The ligaments of the middle and lower thoracic vertebræ and their ribs seen from the left side. The uppermost rib has been disarticulated and removed. (*Sobotta and McMurrich.*)

articulates. These are *arthrodial* joints. The *capsular ligament* is thin but is not found on the eleventh and twelfth ribs.

The *ventral costotransverse ligament* (*lig. costotransversarium anterior*) is short and strong; it connects the neck and tubercle of the rib with the transverse process above and to its costotransverse capsular ligament.

The *dorsal costotransverse ligament* is a short and oblique fasciculus that connects the transverse process with the nonarticular portion of the tubercle. Such ligaments are absent on the eleventh and twelfth ribs.

The *ligament of the neck of the rib* (*lig. colli costæ*) consists of short fibers that connect the dorsal surface of the neck with the ventral surface of the transverse process, though some of the fibers pass to the inferior articular process of the upper vertebra.

STERNOCOSTAL ARTICULATIONS

The **articulations of the costal cartilages** of the true ribs, except the first, are of the *arthrodial* variety.

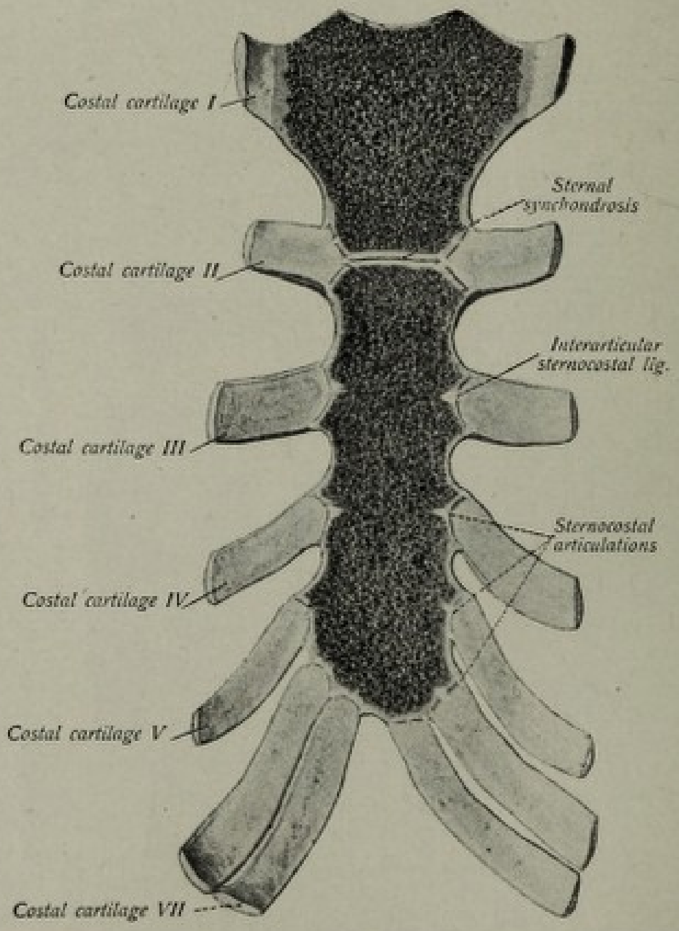


FIG. 90.—A frontal longitudinal section of the sternum and costal cartilages. (*Sobotta and McMurrich.*)

A thin *capsular ligament* surrounds each joint.

The *ventral sternocostal*, or *radiate ligaments* pass from the ventral surfaces of the costal cartilages to the ventral surface of the sternum, interlacing with those of the opposite side forming the *membrana sterni.*

The *dorsal sternocostal ligaments* are like the preceding but less prominent.

The *intraarticular sternocostal ligaments* (*lig. sternocostale intra-articulare*) are inconstant in all except the second sternocostal articulation. When these are present, they extend transversely between the costal cartilage and the sternum and divide the joint cavity into two distinct (superior and inferior) portions.

The *xiphoid ligament* passes from the ventral surface of the xiphisternum to the ventral surface of the seventh and sometimes the sixth costal cartilage.

INTERCHONDRAL ARTICULATIONS

The cartilages of the sixth, seventh and eighth (ninth and tenth sometimes) ribs articulate with each other forming *arthrodial* joints. Each joint is surrounded by a thin *capsule*. The ventral and dorsal portions of the capsule are thickened by fibers connecting the adjacent cartilages. These constitute the *external* and *internal interchondral ligaments*.

Each costal cartilage fits into a depression on the sternal end of the shaft of a rib. There is no true joint as these structures are held together by the blending of the periosteum and perichondrium.

ARTICULATIONS OF THE STERNUM

The **sternal synchondrosis** is the *amphiarthrodial articulation* between the manubrium and body of the sternum. Ventrally and dorsally are found the *intersternal ligaments* supported by the membrana sterni.

THE ARTICULATIONS OF THE SUPERIOR EXTREMITY

The superior extremity, or pectoral appendage comprises the pectoral girdle (clavicles and scapulæ) and the appendages proper. The pectoral girdle articulates with the axial skeleton ventrally, only, at the sternum. Each clavicle articulates with its corresponding scapula.

THE STERNOCLAVICULAR ARTICULATION

The sternoclavicular articulation (*articulatio sternoclavicularis*) is of the *arthrodial* variety. The parts concerned are the enlarged sternal end of the clavicle, a facet upon the superolateral angle of the manubrium, the superior surface of the first rib and an intraarticular fibrocartilage.

A *capsular ligament* encloses the joint.

The *intraarticular cartilage* (*discus intraarticularis*) is thinner in the middle than at its circumference. It is attached peripherally to the capsular ligament, as well as to the clavicle superiorly and the first costal cartilage inferiorly.

The *ventral sternoclavicular ligament* (*lig. sternoclaviculare anterius*) consists of fibers strengthening the capsule and connecting the ventral surfaces of the clavicle, sternum and first costal cartilage.

The *dorsal sternoclavicular ligament* is similar to the preceding.

The *interclavicular ligament* (*lig. interclaviculare*) is a strong *accessory* ligament connecting the sternal ends of the two clavicles across the interclavicular notch; this ligament is attached to the upper margin of the sternum also.

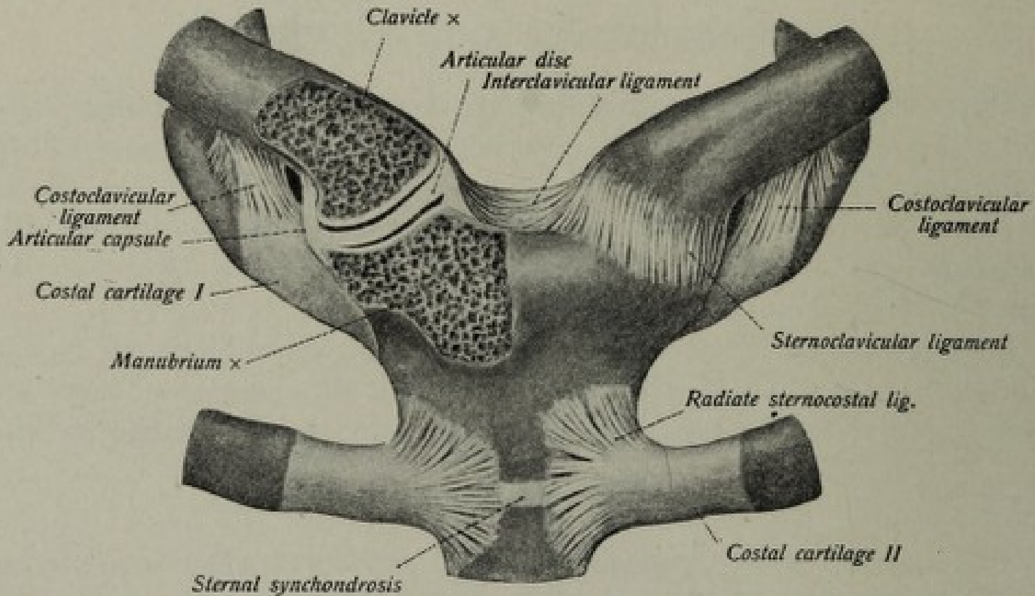


FIG. 91.—The two sternoclavicular joints, together with the costosternal articulations of the two upper ribs seen from in front. The right sternoclavicular joint has been opened by a saggital section. (*Sobotta and McMurrich.*)

The *costoclavicular ligament* (*lig. costoclaviculare*), also *accessory*, is a strong, oblique band connecting the first costal cartilage with the inferior aspect of the sternal end of the clavicle.

THE ACROMIOCLAVICULAR ARTICULATION

The acromioclavicular articulation (*articulatio acromioclavicularis*) is also an *arthrodial joint*.

A *capsular ligament* is present.

The *superior* and *inferior acromioclavicular ligaments* are thickened portions of the capsule connecting adjoining portions of the clavicle and acromion of the scapula.

An *intraarticular cartilage* is inconstant and when present it is obliquely placed and is attached by its circumference to the capsule.

The *coracoclavicular ligament* (*lig. coracoclavicularis*) is an *accessory* ligament and connects the coracoid process of the scapula and the acromial end of the clavicle; it consists of *two parts*.

The *trapezoid ligament* (*lig. trapezoideum*) is attached, inferiorly, to the basal half of the superior surface of the coracoid process and superiorly to the inferior surface of the acromial end of the clavicle.

The *conoid ligament* (*lig. conoideum*) is somewhat triangular; its blunt apex is attached to the base of the coracoid process (near the scapular notch) and its base is attached to the coracoid tuberosity of the clavicle. It lies medial to the preceding ligament.

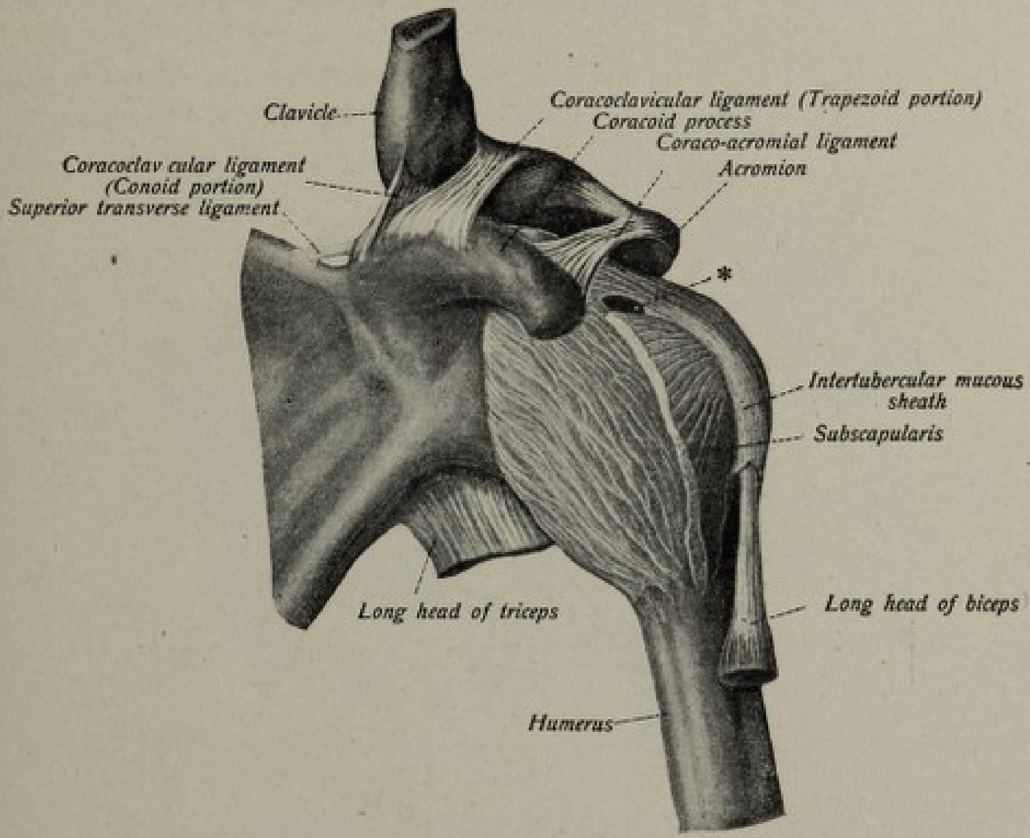


FIG. 92.—The left shoulder and acromioclavicular joints seen from above and from the inner surface. (*Sobotta and McMurrich.*)

The scapula has several *intrinsic ligaments* that are not articular. The *coracoacromial ligament* (*lig. coracoacromiale*) is attached, inferiorly, to the apical half of the dorsolateral margin of the coracoid process and, superiorly, to the tip of the acromion. It is tense and tends to protect the shoulder joint.

The *superior transverse ligament* (*lig. transversum scapulæ superius*) bridges the scapular notch.

The *inferior transverse scapular ligament* connects the lateral margin of the scapular spine with the dorsal aspect of the head of the scapula.

THE SHOULDER JOINT (ARTICULATIO HUMERI)

The shoulder joint is of the *enarthrodial* variety and permits of the widest range of movement of any joint of the body. It is formed by the glenoid fossa of the scapula and the head of the humerus.

The *glenoid ligament* (*labrum glenoidale*) is a ring-like mass of dense white fibrous tissue that deepens the glenoid fossa. It is firmly attached to the margin of that fossa.

The *capsule* (*capsula articularis*) is attached, proximally, to the circumference of the glenoid fossa and the labrum glenoidale; distally it is attached to the anatomical neck of the humerus. It is strongest superiorly. It is strengthened by fusion with the tendons of the mm. subscapularis, supraspinatus and infraspinatus, near their insertions.

The *transverse humeral ligament* is a portion of the capsular ligament that bridges the groove between the tubercles of the humerus.

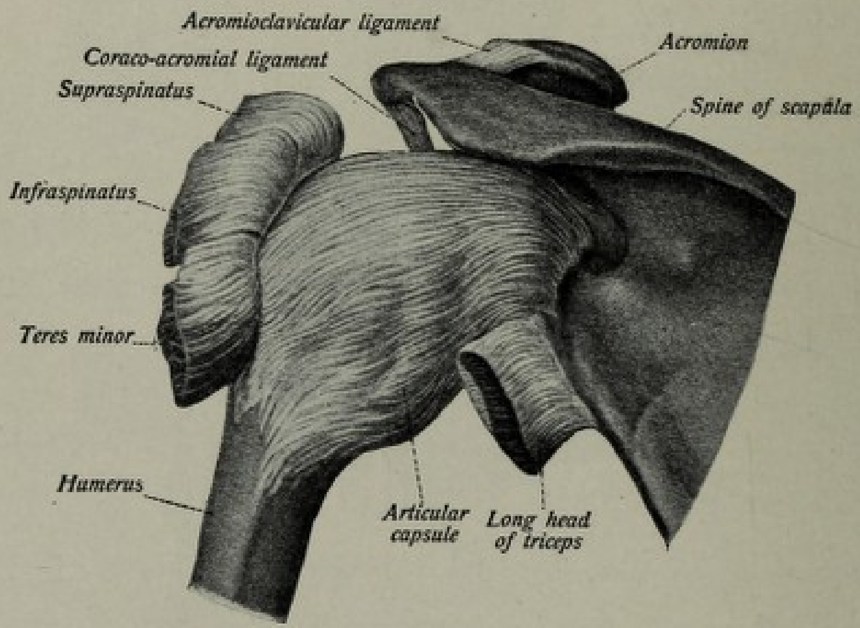


FIG. 93.—The left shoulder joint seen from behind, the long head of the triceps being cut and the terminal portions of the supraspinatus, infraspinatus, and teres minor muscles cut and turned outward. (*Sobotta and McMurrich.*)

The *coracohumeral ligament* (*lig. coracohumerale*) is an *accessory* ligament that extends the base of the coracoid process and the base of the greater tubercle of the humerus. It is partially fused with the capsular ligament.

The *glenohumeral ligament* consists of three bands of fibers that strengthen the ventral part of the capsule and are seen only upon its inner aspect. They extend from the ventral margin of the glenoid fossa to the ventral part of the neck of the humerus.

The head of the humerus is held against the glenoid fossa by muscular action and atmospheric pressure as the ligaments themselves are too lax to do this.

The *synovial membrane* lines the capsule and extends over the nonarticular portions of the bones within the capsular ligament. The proximal end of the tendon of the long head of the m. biceps brachii arise within and passes through the joint cavity and leaves at the groove between the tubercles. The tendon is enclosed within the synovial membrane which is prolonged upon it into the groove but the cavity here is closed. Where the subscapularis tendon lies over the capsule there is a *bursa* and its cavity and synovial membrane are continuous with the joint cavity. The *subdeltoid*, or *subacromial bursa* does not communicate with the joint cavity.

Movements.—This joint is capable of *flexion*, *extension*, *abduction*, *adduction*, *rotation* and *circumduction*.

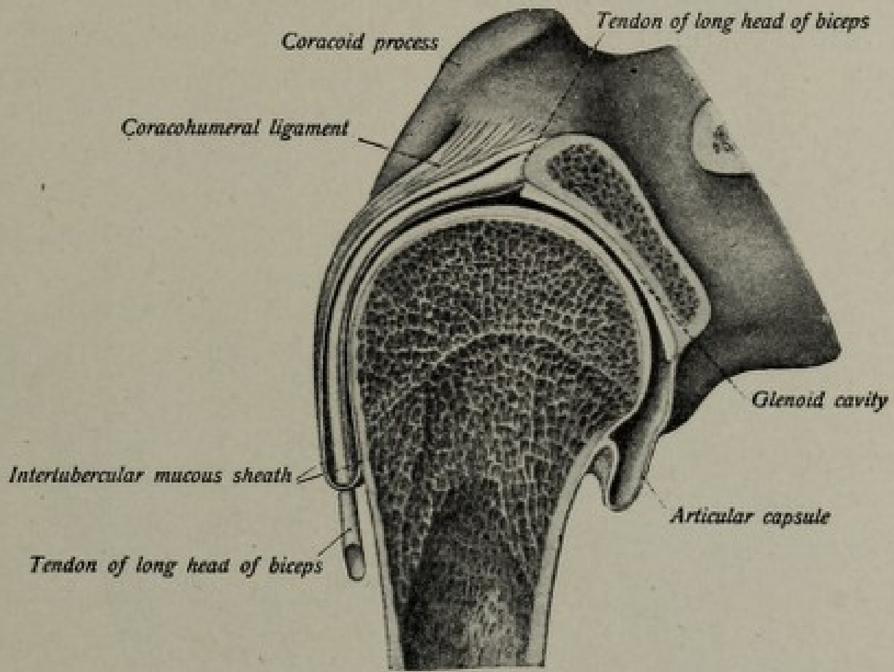


FIG. 94.—A frontal longitudinal section of the shoulder joint, parallel to the tendon of the long head of the biceps. (*Sobotta and McMurrich.*)

THE ELBOW JOINT (ARTICULATIO CUBITI)

The elbow joint is of the *ginglymus*, or *hinge* variety. The bones concerned are the humerus, ulna and radius. The **humeroulnar articulation** comprises the trochlea of the humerus and the semilunar notch of the ulna. The **humeroradial articulation** comprises the capitulum of the humerus and the head of the radius.

The *capsule* surrounds the joint and is made up of individual ligaments of varying thickness that join so as to make a complete investment of the joint.

The *ventral ligament* (*lig. anterius*) consists of vertical, oblique and transverse fibers. It is attached, proximally, to the bone just beyond the coronoid and radial fossæ of the humerus and, distally, to the margin of the coronoid process of the ulna and the annular ligament of the radioulnar articulation. The middle portion is the strongest.

The thin *dorsal ligament* (*lig. posterius*) is attached, proximally, to the margin of the olecranon fossa and capitulum of the humerus and, distally, to the margins and tip of the olecranon process of the ulna and the dorsal aspect of the radial notch of the ulna.

The *ulnar collateral ligament* (*lig. collaterale ulnare*) is triangular and fills in the medial part of the capsule between the two preceding ligaments. It is attached, proximally, to the edge of the medial epicondyle and, distally, to the medial margin of the semilunar notch of the ulna. Its fibers are formed into three bands that are called *ventral*, *dorsal* and *transverse*.

A *synovial membrane* lines the capsule and is reflected over the nonarticular portions of the bones within the joint cavity. Pads

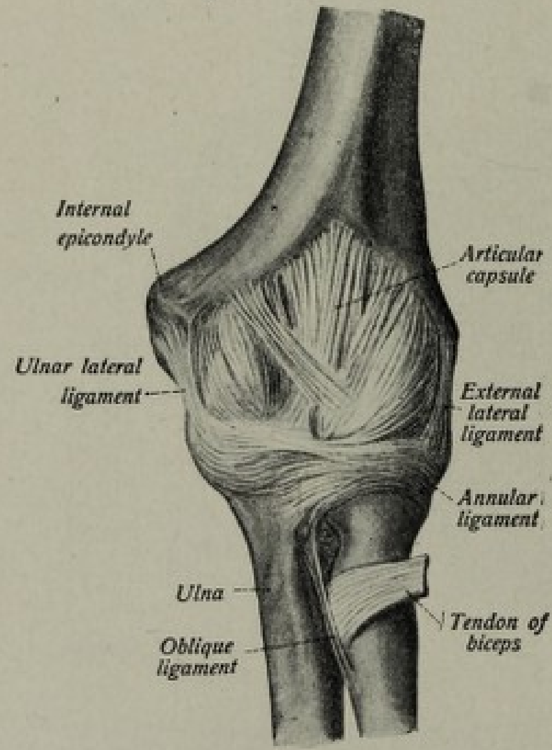


FIG. 95.—The left elbow joint seen from in front. (*Sobotta and McMurrich.*)

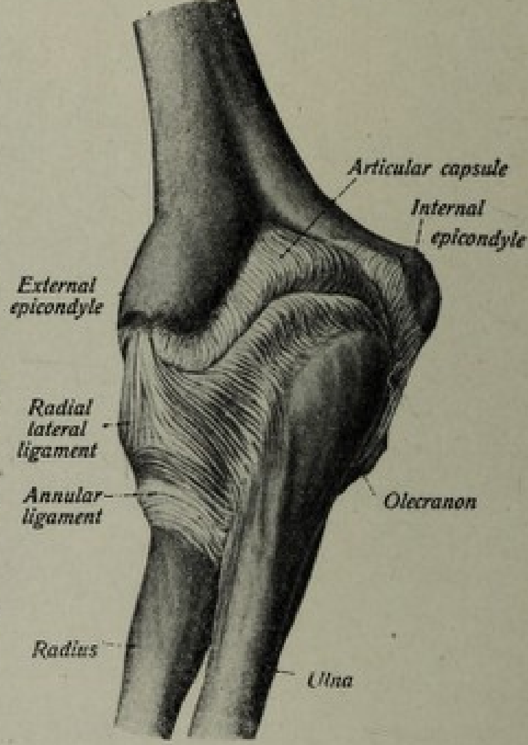


FIG. 96.—The left elbow joint seen from behind and from the radial side. (*Sobotta and McMurrich.*)

of fat separate it from the capsule in the coronoid and olecranno fossæ.

The **movements** of the elbow joint are of *flexion* and *extension*.

RADIOULNAR ARTICULATIONS

There are two radioulnar articulations, one between the proximal extremities of the two bones and the other between their distal extremities. They both represent the **rotary**, or *lateral ginglymus* variety.

The **proximal radioulnar articulation** (*articulatio radioulnaris proximalis*) consists of the radial notch of the ulna and the head of the radius.

The *annular ligament* (*lig. annulare radii*) holds these bones in apposition. It is attached to the ventral and dorsal margins of the radial notch and is obliquely placed so as to form a funnel. Its *synovial membrane* is continuous with that of the elbow joint.

The **distal radioulnar articulation** (*articulatio radioulnaris distalis*) comprises the head of the ulna and the ulnar notch of the radius. The *ventral* and *dorsal radioulnar ligaments* are transverse bands of fibrous tissue that connect the adjoining nonarticular surfaces of the bones. A distinct capsular ligament does not exist.

The *triangular articular disc* is important in binding these bones together. Its apex is attached to the depression at the root of the styloid process of the ulna and its base to the ridge between the ulnar notch and the distal carpal articular surface of the radius.

A *synovial membrane* closes the joint cavity and, covering the articular surfaces of the bones extends proximally between the ulna and radius as the *recessus sacciformis*.

Accessory Ligaments.—The *oblique ligament* (*chorda obliqua*) is an oblique band connecting the coronoid process of the ulna and the tuberosity of the radius.

The *interosseous membrane* (*membrana interossea antebrachii*) is a strong, sheet-like band that connects the adjacent margins of the ulna and radius, distal to the oblique chord. Between these two ligaments there is a gap, the *hiatus interosseus*.

Movements are of *pronation* and *supination*.

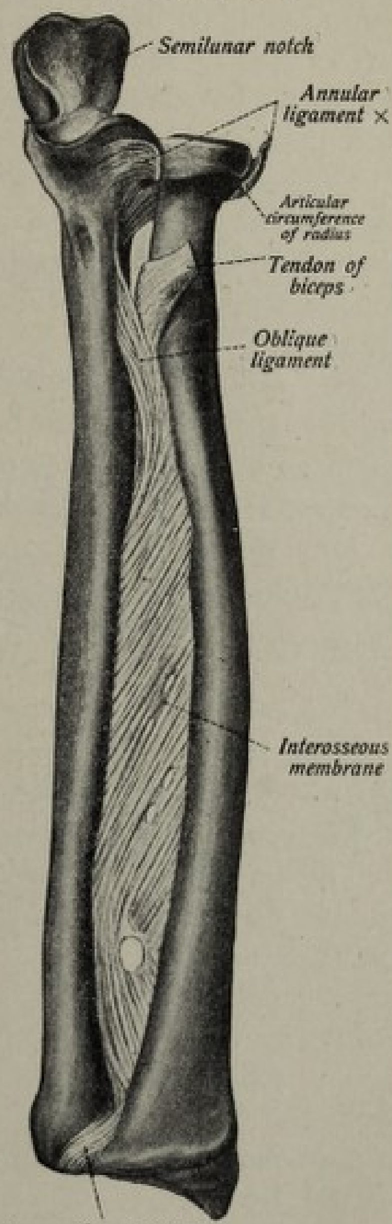


FIG. 97.—The bones of the left forearm with the interosseous membrane; the annular ligament has been divided. (*Sobotta and McMurrich.*)

THE RADIOCARPAL ARTICULATION (ARTICULATIO RADIOCARPEA)

The radiocarpal articulation is of the *condyloid*, or *biaxial* variety. It comprises the distal extremity of the radius, the discus articularis, on the one side, and the scaphoid (os naviculare), semilunar (os lunatum), and cuneiform (os triquetrum) bones, on the other.

The *capsule* is loose and its thickened portions constitute the following ligaments.

The *lateral radiocarpal ligament* (*lig. radiocarpeum laterale*) extends from the tip of the styloid process of the radius to the tuberosity of the navicular bone.

The *medial ulnocarpal ligament* (*lig. ulnocarpeum mediale*) is cord-like and extends from the styloid process of the ulna to the triquetral and pisiform bones.

The *ventral radiocarpal ligament* (*lig. radiocarpeum volare*) extends between the ventral margin of the distal end of the radius and the styloid process of the ulna to the ventral surfaces of the navicular, lunate and triquetral bones and sometimes to the os capitatum (magnum).

The *dorsal radiocarpal ligament* (*lig. radiocarpeum dorsale*) extends from the dorsal margin of the distal end of the radius to the dorsal surfaces of the first row of carpal bones.

A *synovial membrane* lines the joint.

The **movements** are of *flexion* and *extension*, *abduction* and *adduction*.

THE CARPAL ARTICULATIONS (ARTICULATIONES INTERCARPEÆ)

The carpal articulations are all of the arthrodial variety.

First Row.—The *dorsal ligaments* run transversely and connect the navicular and lunate bones and the lunate and triquetral bones.

The *ventral*, or *volar ligaments*, are thinner but and similarly placed.

The *interosseous ligaments* are *two* in number, one connecting the lunate and the navicular bones and the other the lunate and triquetral bones. These are at the proximal ends of the bones and extend from ventral to dorsal surfaces and shut out the wrist joint from the intercarpal joints.

The **pisiform bone** has *three ligaments*. The *capsule* connects it with the triquetral bone and it has its own *synovial membrane*. Its *two palmar ligaments* connect it with the hamate and fifth metacarpal bones.

Second Row.—The *dorsal ligaments* connect the great multangular (trapezium) with the lesser multangular (trapezoid), the latter with the os capitatum (magnum) and this with the os hamatum (unciform).

The *ventral*, or *volar ligaments* are similarly arranged.

The *interosseous ligaments* are *three* in number and connect the bones somewhat as in the first row, but not so completely.

The **articulation between** the **first** and **second rows** of carpal bones is surrounded by a short *capsular ligament*.

The *ventral*, or *volar ligament* (*lig. carpi radiatum*), extends between the two rows on their ventral surfaces.

The *dorsal ligament* is thinner but similarly arranged.

The *radial collateral carpal ligament* extends between the lateral surfaces of the navicular and greater multangular bones.

The *ulnar collateral ligament* extends between the medial surfaces of the triquetral and hamate bones.

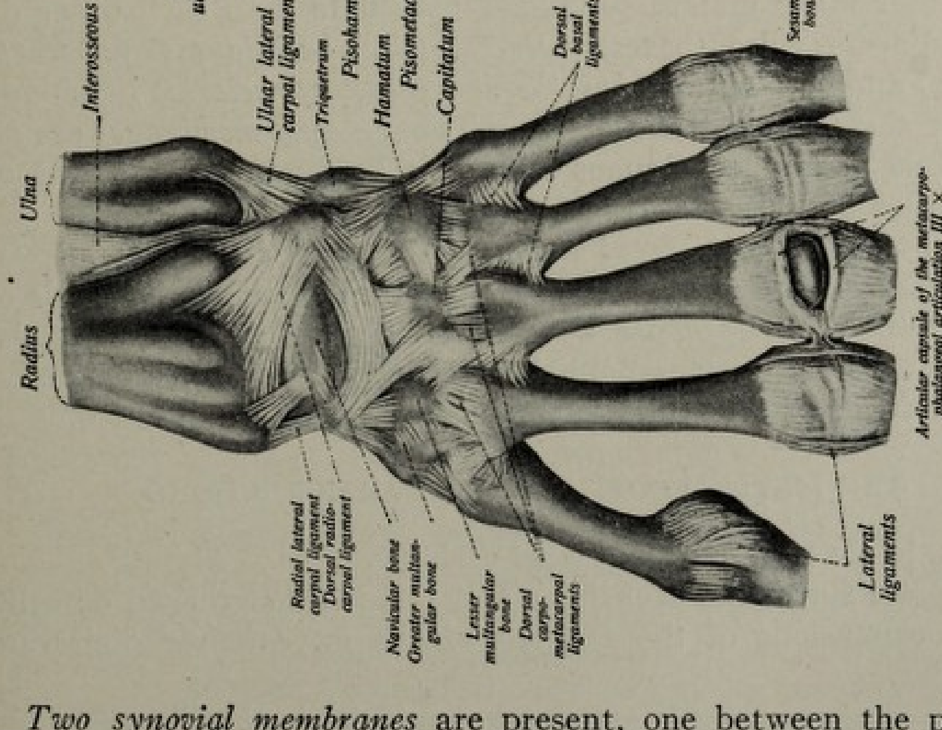


FIG. 98.—Articulations and ligaments of the hand seen from the dorsal surface. (*Sobotta and McMurrich.*)

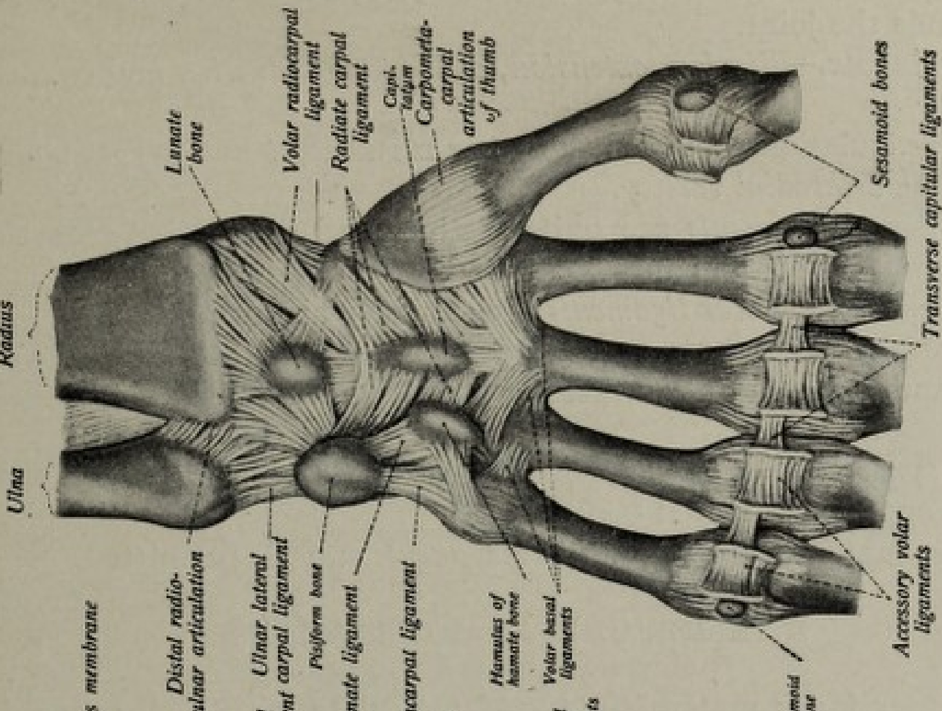


FIG. 99.—Articulations and ligaments of the hand seen from the volar surface, the transverse carpal ligament having been removed. (*Sobotta and McMurrich.*)

Two synovial membranes are present, one between the pisiform and triquetral bones (already mentioned) and the other is between the two rows with extensions between the various bones forming a labyrinthine cavity.

Movements.—Between the first and second rows, *flexion*, *extension* and *slight rotation*.

CARPOMETACARPAL ARTICULATIONS

The **articulation of the first** (thumb) metacarpal with the great multangular bone is one of *reciprocal reception*. It permits of the greatest movement of any of these joints and a loose *capsule* surrounds the joint.

Movements.—*Flexion*, *extension*, *abduction*, *adduction* and *circumduction*.

The **articulations** between the **other metacarpal** and **carpal bones** are of the *arthrodial variety*.

The *dorsal ligaments* are quite distinct and extend between the dorsal surfaces of the bones concerned.

The *ventral*, or *volar ligaments* are similarly arranged.

Interosseous ligaments extend between the capitate and hamate bones and the adjacent surfaces of the third and fourth metacarpal bones.

The *synovial membrane* is continuous with that between the first and second row of carpal bones.

Movements.—A slight *gliding movement*, only, is permitted.

INTERMETACARPAL ARTICULATIONS

The **four inner metacarpal bones** articulate with each other on their adjacent sides (bases). *Dorsal* (*ligg. basalia oss. metacarp. dorsalia*) and *ventral* (*ligg. basalia oss. metacarp. volaria*) ligaments connect their bases transversely. The *synovial membranes* are all extensions of and continuous with that between the two rows of metacarpal bones.

The *transverse metacarpal ligament* (*lig. capitulorum oss. metacarpalium transversum*) is a strong band that connects the heads of the four inner metacarpal bones (ventral surfaces). It blends, distally, with the metacarpophalangeal ligaments and, proximally with the fascia of the interosseous muscles.

THE METACARPOPHALANGEAL ARTICULATIONS

These joints are of the *condyloid* variety.

A *capsule* surrounds each joint and this is strengthened dorsally by the expansions of the tendons of the m. extensor digitorum communis.

The *ventral*, or *volar ligament* (*lig. vaginale*) is thick, strong and grooved for the flexor tendons.

The *collateral ligaments* (*ligg. collateralia*) are cord-like thickenings of the lateral parts of the capsule.

Movements.—*Flexion*, *extension* and some *abduction*, *adduction* and *circumduction*.

ARTICULATIONS OF THE PHALANGES (ARTICULATIONES DIGITORUM MANUS)

These joints are of the *ginglymus* variety.

A *capsule* is present and is strengthened by a *ventral*, or *volar*, and *two collateral ligaments* arranged similarly to those in the preceding articulations.

Each of these joints has a *complete synovial membrane* lining the joint cavity.

Movements.—*Flexion* and *extension*.

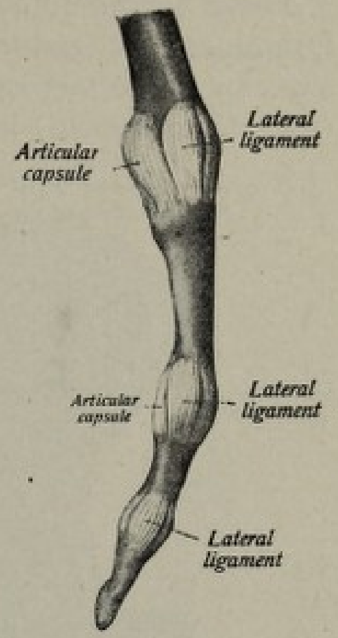


FIG. 100.—Articulations of the middle finger seen from the side. (*Sobotta and McMurrich.*)

THE ARTICULATIONS OF THE INFERIOR EXTREMITY (PELVIS APPENDAGE)

This *appendage* comprises one-half of the pelvic girdle and the appendage proper. The pelvic girdle comprises the two ossa coxæ (innominate bones), that articulate with each other ventrally at the symphysis pubis, and with the sacrum dorsally. Upon each side the girdle articulates with the proximal extremity of the femur. Accessory ligaments are also present.

THE SACROILIAC ARTICULATION (ARTICULATIO SACROILIACA)

This articulation is of the *amphiarthrodial* variety. A joint cavity is barely preceptible.

A *capsule* is formed by the following ligaments.

The *ventral sacroiliac ligament* is short, thin but strong and extends between the ala of the sacrum and the iliac fossa of the hip bone.

The *dorsal sacroiliac*, or *interosseous ligament* extends from the supraauricular area of the ilium to the tubercles of the first and second sacral segments and the adjacent bone. There are two parts, as follows:

The *short dorsal sacroiliac ligament* extends from the dorsal superior spine of the ilium to the first and second transverse tubercles of the sacrum.

The *long dorsal sacroiliac ligament* extends from the dorsal superior spine of the ilium to the transverse tubercles of the third and fourth sacral segments.

Accessory Ligaments.—The *sacrotuberous*, or *great sacrosciatic, ligament* (*lig. sacrotuberosum*) is of a triangular outline but narrow in the middle; it extends from the dorsal inferior spine of the ilium to the transverse tubercles and the lateral margins of the third, fourth and fifth sacral and first coccygeal segments and to the tuberosity of the ischium, inferior to the groove for the m. obturator internus. From this attachment a portion passes along the medial aspect of the ramus of the ischium as the *processus falciformis*.

9

The *sacrospinous*, or *small sacrosciatic ligament* (*lig. sacrospinosum*) is of a triangular outline and lies ventral to the preceding ligament. It extends from the last two sacral and the first coccygeal segments to the spine of the ischium.

These ligaments convert the sciatic notches of the hip bone into foramina; the *greater foramen* (*foramen ischiadicum majus*) lies superior to the sacrospinous ligament and the *lesser foramen* (*foramen ischiudicum minus*) lies inferior to the same ligament.

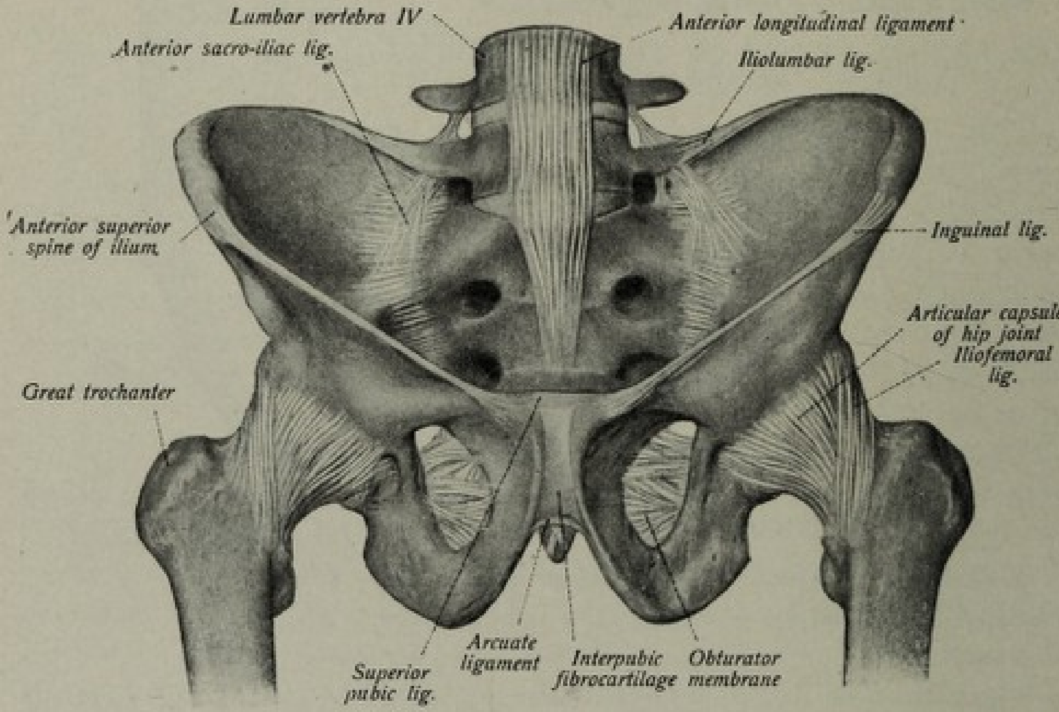


FIG. 101.—The male pelvis with its ligaments seen from in front. (*Sobotta and McMurrich.*)

THE SYMPHYSIS PUBIS (SYMPHYSIS OSSIUM PUBIS)

This articulation is of the *amphiarthrodial* variety and completes the pelvic girdle ventrally.

The *ventral pubic ligament* (*lig. pubicum anterius*) is short and thick and extends between the adjacent surfaces of the two pubic bones. Its superficial surface is strengthened by the interlacement of fibers from the tendons and aponeuroses of the adjacent muscles.

The *dorsal pubic ligament* (*lig. pubicum posterius*) is similarly arranged but weaker.

The *superior pubic ligament* (*lig. pubicum superius*) is weak and extends from one pubic crest to the other.

The *arcuate*, or *inferior ligament* (*lig. arcuatum pubis*), is quite strong and extends from the descending ramus of the one pubic bone across the inferior surface of the joint to the inferior ramus of the other pubic bone.

The *interpubic disc* (*lamina fibrocartilaginea interpubica*) is covered with hyalin cartilage and is attached to the adjacent surfaces of the two pubic bones. It may contain a cleft-like cavity which, however, does not contain a synovial membrane.

The **obturator membrane** almost completely fills in the obturator foramen of the hip bone. At its highest part there is a U-shaped gap that completes the obturator canal.

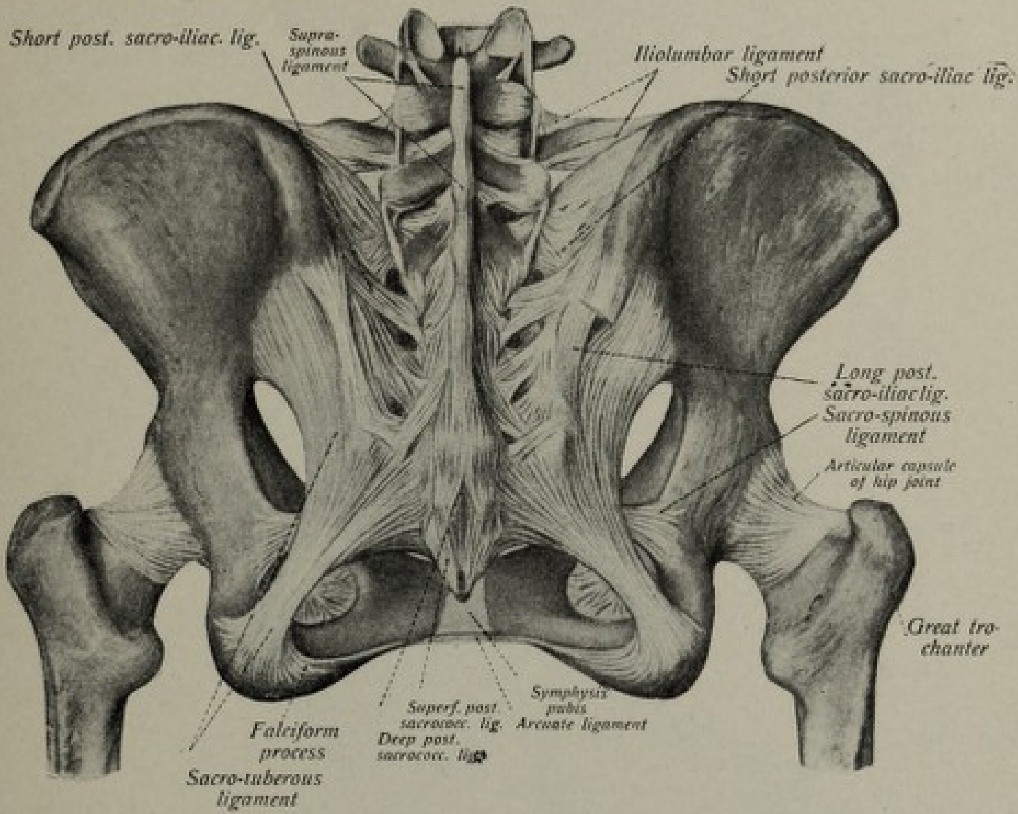


FIG. 102.—The female pelvis with its ligaments seen from behind. (*Sobotta and McMurrich.*)

THE HIP JOINT (ARTICULATIO COXÆ)

The hip joint is of the *enarthrodial* variety. It comprises the head of the femur and the acetabular cavity of the hip bone.

The *labrum glenoidale*, or *cotyloid ligament* is a C-shaped mass of fibrocartilage that is attached to the rim of the acetabular cavity to deepen it and to make it narrower. The gap is at the *acetabular notch* and here the two ends of the labrum are connected by the *transverse ligament* (*lig. transversarum acetabuli*). This ligament converts the notch into a foramen through which the vessels and nerves pass into and out of the acetabular cavity. The inner surface of the labrum is articular.

The *capsule* is a hollow cylinder. It is attached, proximally, to the labrum glenoidale and the transverse ligament and the adjoining bone; distally, it is attached, above, to the medial aspect of the

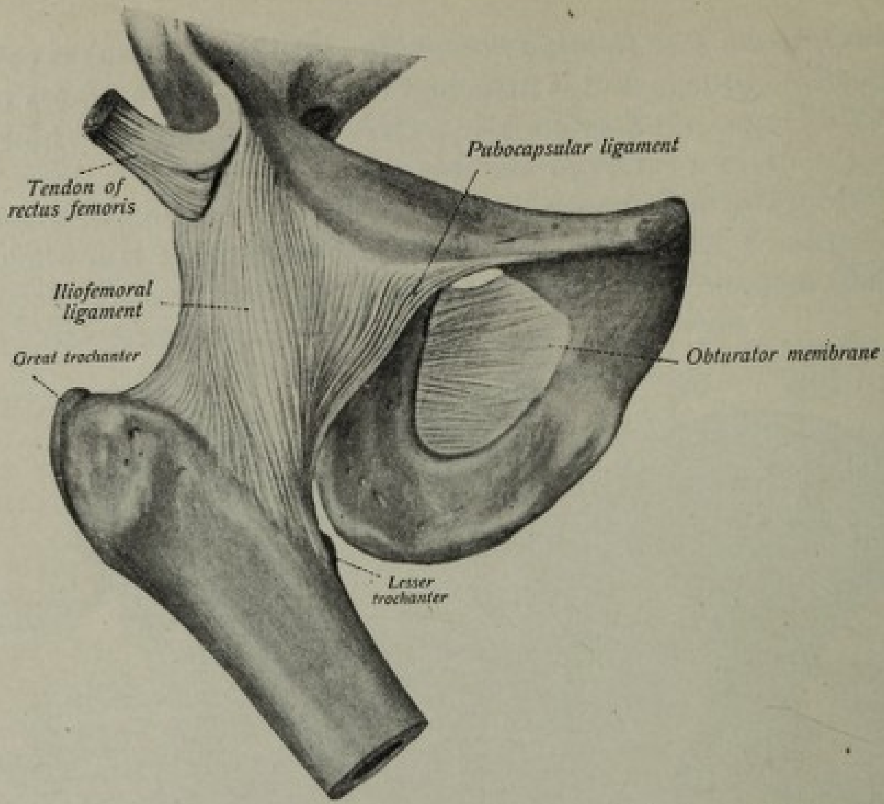


FIG. 103.—The right hip joint seen from in front. (*Sobotta and McMurrich.*)

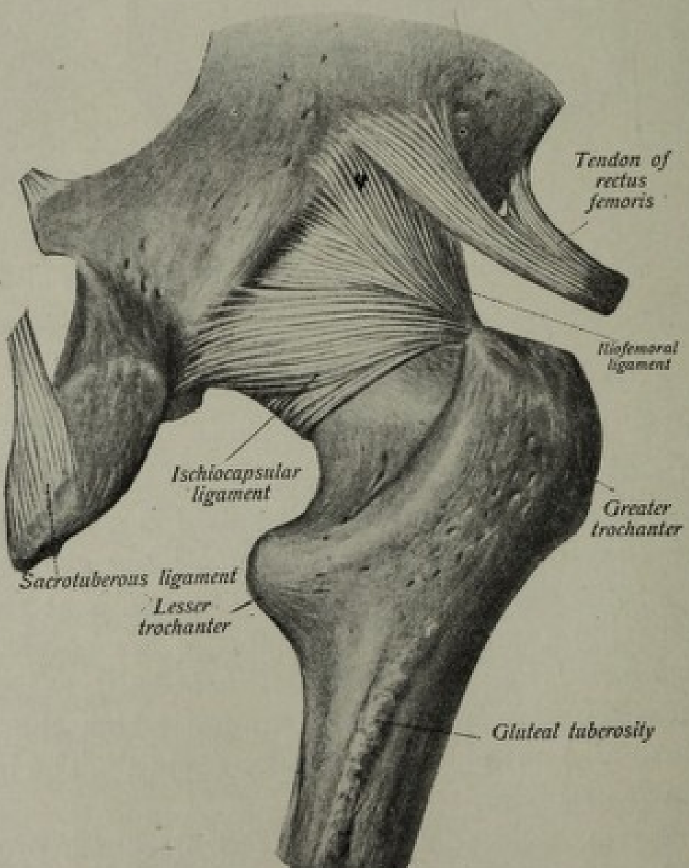


FIG. 104.—The right hip joint seen from behind. (*Sobotta and McMurrich.*)

greater trochanter; ventrally, to the intertrochanteric line; dorsally, to the junction of the middle and lateral third of the neck and inferiorly to the region of the lesser trochanter. Most of the dorsal surface of the neck is not intrascapular while all of the remainder is.

The *iliofemoral ligament* (*lig. iliofemorale*) is λ-shaped and supports the capsule ventrally. It extends between the inferior margin of the superior spine of the ilium to the intertrochanteric line of the femur, splitting as it descends.

The *pubocapsular ligament* (*lig. pubocapsularis*) extends from the superior ramus of the pubis and obturator crest to the capsule, with which it blends.

The *ischiocapsular ligament* (*lig. ischiocapsularis*) consists of fibers

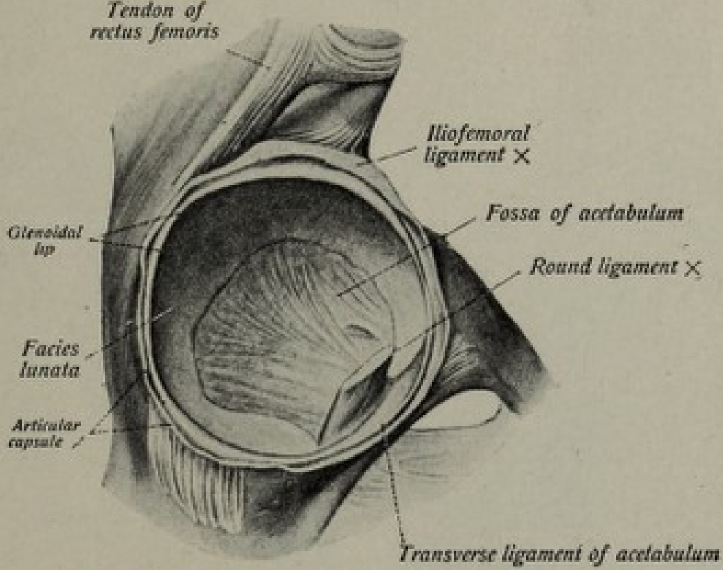


FIG. 105.—Socket of the right hip joint after cutting through the articular capsule and the round ligament. The head of the femur has been removed. (*Sobotta and McMurrich.*)

that extend from the region of the lesser sciatic notch to the acetabular portion of the capsule to blend therewith.

The *round ligament* (*lig. teres femoris*) is a flattened band extending from the superior portion of the depression in the head of the femur to the lower margin of the transverse ligament and to the adjacent margins of the acetabular notch.

The fossa in the acetabular cavity contains a mass of fat that is called the *Haversian gland*. This is covered by the synovial membrane so that it lies external to this membrane.

The *synovial membrane* lines the capsule and covers all parts of the bones within the joint except the actually articulating portions. Occasionally a *bursa* is found communicating with the ventral part of the synovial sac. This is beneath the tendon of the m. iliopsoas.

Movements.—This joint is capable of *flexion*, *extension*, *abduction*, *adduction*, *rotation* and *circumduction*.

THE KNEE JOINT (ARTICULATIO GENU)

The knee joint is the largest joint in the body and is of the *ginglymus* variety. Three bones, the femur, tibia and patella enter into its formation. The condyles of the femur articulate ventrally

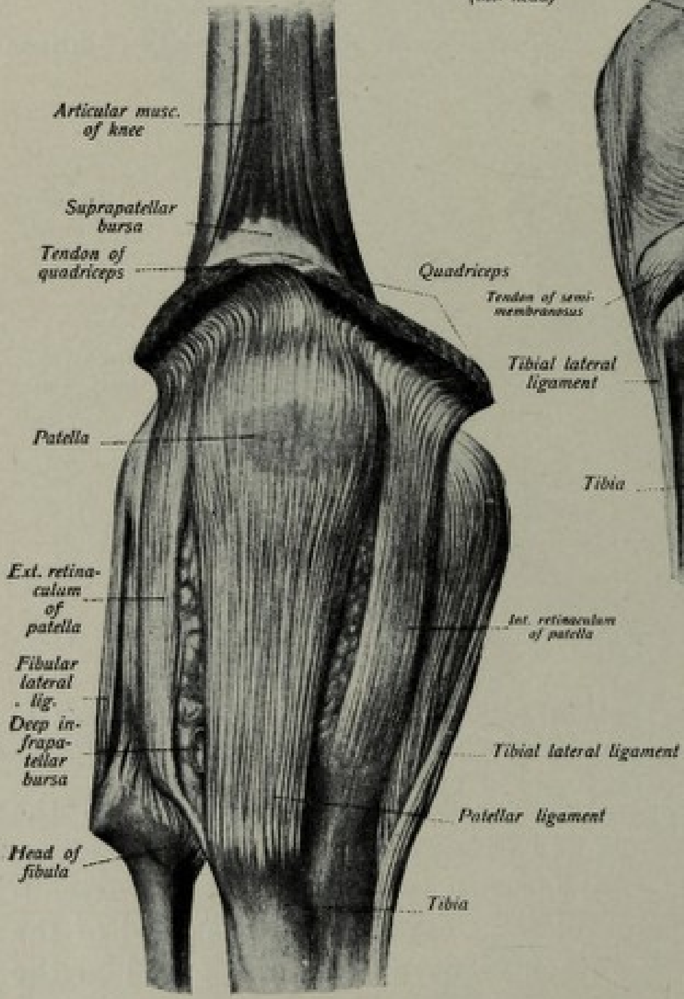


FIG. 106.—The right knee joint in extension seen from in front. (*Sobotta and McMurrich.*)

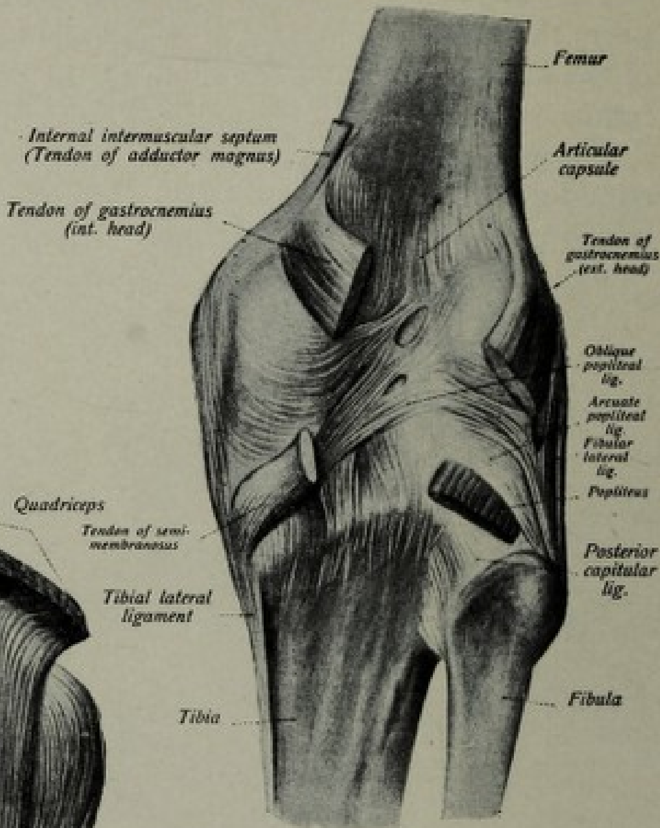


FIG. 107.—The right knee joint seen from behind. (*Sobotta and McMurrich.*)

with the patella and distally with the condylar facets upon the head of the tibia.

The *capsule* in itself is not a complete investment nor are the special portions sufficient to form a complete capsule. The latter is completed and strengthened by expansions from the various tendons about it.

The *patellar ligament* (*lig. patellæ*), a ventral ligament, connects the apex of the patella with the tuberosity of the tibia.

The *dorsal ligament* (*lig. posterius*) is thin laterally and thick medially. It extends from the margins of the femoral condyles and popliteal surface just superior to the intercondylic notch to the dorsal margin of the head of the tibia. The tendon of the m. semimembranosus contributes the *oblique popliteal ligament* (*lig. popliteum obliquum*).

The *tibial collateral ligament* (*lig. collaterale tibiale*), or *internal*

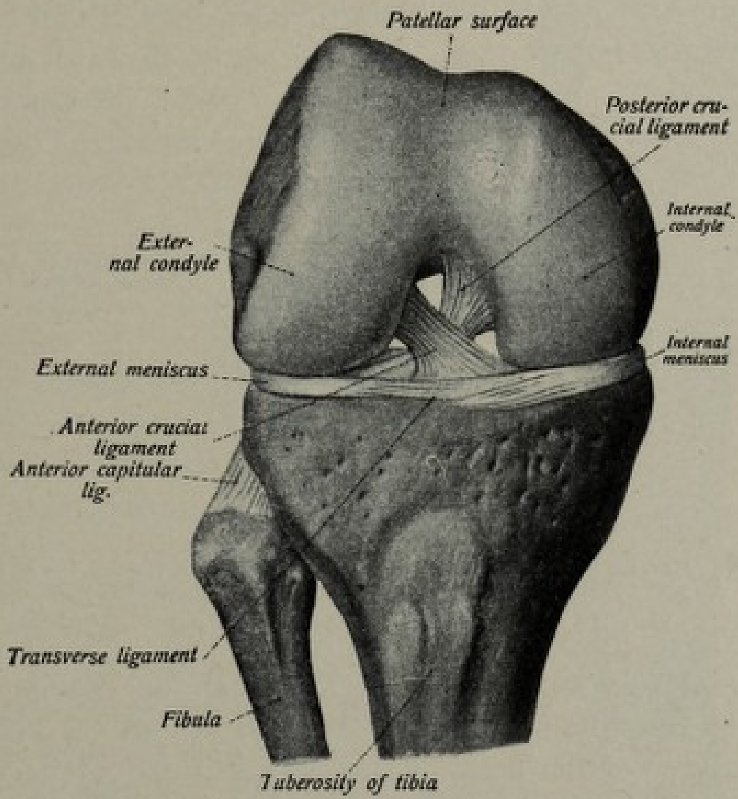


FIG. 108.—The right knee joint in flexion after removal of the articular capsule and the lateral ligaments. (*Sobotta and McMurrich.*)

lateral ligament, is short and strong, extending from the medial condyle of the femur, inferior to the adductor tubercle, to the medial surface of the head of the tibia.

The *fibular collateral*, or *external lateral ligament* (*lig. collaterale fibulare*), is a cord-like band extending from the lateral condyle of the femur to the head of the fibula, ventral to the styloid process. It is split by the tendon of the m. biceps femoris.

Within the joint cavity a number of important ligaments will be found.

The *cruciate ligaments* (*lig. cruciata genu*) are ventral and dorsal. The *ventral one* (*lig. cruciatum anterius*) extends obliquely (laterally and dorsally) from the front of the intercondylic eminence of the tibia to the dorsal part of the lateral condyle and the intercondylic notch.

The *dorsal one* (*lig. cruciatum posterius*) is shorter than and dorsal to the preceding. It extends obliquely (ventrally and medially) from the area dorsal to the intercondylic eminence of the tibia to the medial condyle near the ventral end of the intercondylic notch.

Two fibrocartilages deepen the facets upon the head of the tibia.

The *medial meniscus* (*meniscus medialis*), or *internal semilunar cartilage*, is C-shaped. Its ends, or *cornua* are attached to the head of the tibia in front of and behind the ventral cruciate ligament. Its margin is attached to the margin of the head of the tibia by the *short coronary ligament.*

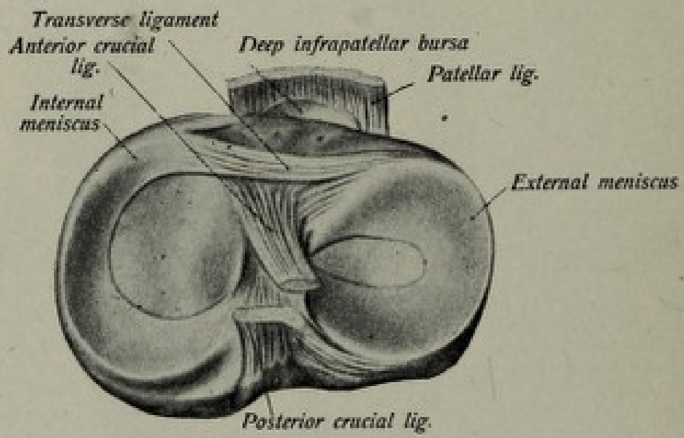


FIG. 109.—The condyles of the tibia with the two menisci and the origins of the crucial ligaments. (*Sobotta and McMurrich.*)

The *lateral meniscus* (*meniscus lateralis*), or *external semilunar cartilage*, is roughly semilunar. Its *cornua* are attached to the superior surface of the head of the tibia but are farther apart than the cornua of the other cartilage. It is also attached to the margin of the head of the tibia by a *coronary ligament.*

The *transverse ligament* (*lig. transversum genu*) binds the ventral margins of the menisci together.

The *synovial membrane* lines the capsule, covers the bones within the capsule and also invests the intraarticular ligaments. Between it and the patellar ligament is the *infrapatellar pad*. In this region the synovial membrane forms folds, the *plica synovialis patellaris* and the *plicæ alares* (two). *Bursæ* exist in relation with the joint. The *prepatellar bursa* lies between the patella and the skin. The *deep infrapatellar bursa* lies between the ligamentum patellæ and the tuberosity of the tibia. The *suprapatellar bursa* lies between the femur and the tendon of the m. quadriceps extensor. The *subcutaneous tibial bursa* lies between the tuberosity of the tibia and the skin.

Movements.—This joint permits of *flexion* and *extension*. Under certain conditions a *slight rotation* is permitted.

THE TIBIOFIBULAR ARTICULATIONS

An articulation of the *arthrodial* variety exists between the proximal extremities and another between the distal extremities of the tibia and fibula.

The **proximal tibiofibular articulation** is the smaller and less important. A *capsule* surrounds the joint and this is strengthened by additional ligaments.

The *ventral ligament of the head of the fibula* (*lig. capituli fibulæ anterius*) extends between the head of the fibula and the adjacent part of the lateral tibial condyle.

The *dorsal ligament of the head of the fibula* (*lig. capituli fibulæ posterius*) is similarly placed but thinner.

A *synovial membrane* is present and may connect with that of the knee joint.

The **distal tibiofibular articulation, a** *synchondrosis*, is merely a lateral support to ankle joint.

The *ventral ligament of the lateral malleolus*, or *anterior inferior tibiofibular ligament*, extends between the ventral surfaces of the distal end of the tibia and the lateral malleolus of the fibula.

The *dorsal ligament of the lateral malleolus*, or *posterior inferior tibiofibular ligament* is similar in position.

The *distal ligament of the lateral malleolus*, or *transverse inferior tibiofibular ligament* extends from the dorsal margin of the tibia to the pit on the dorsomedial portion of the lateral malleolus.

The *interosseous ligament* is strong and connects the adjacent surfaces of the distal extremities of the tibia and fibula. It is continuous superiorly with the interosseous membrane.

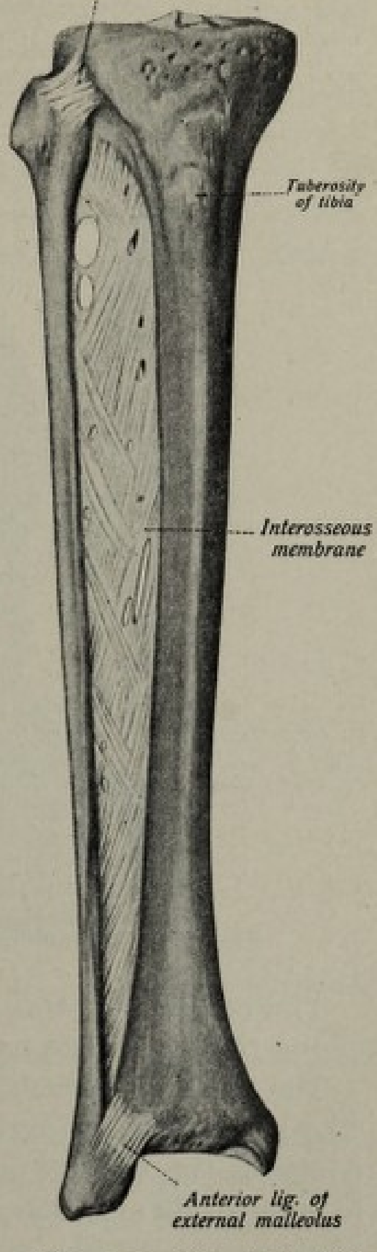


FIG. 110.—The right tibia and fibula with their ligaments. (*Sobotta and McMurrich.*)

The *interosseous membrane*, like that of the forearm, connects the adjacent margins of the two bones and separates ventral and dorsal muscles. Superiorly there is a gap for the anterior tibial vessels and inferiorly another opening for the peroneal vessels.

The *synovial membrane* of the joint is an extension of that of the ankle joint.

THE ANKLE JOINT (ARTICULATIO TALOCRURALIS)

The ankle joint, or **tibiotarsal articulation** is of the *ginglymus* variety. The bones concerned are the tibia, fibula and talus (astragalus).

A *capsule* is formed by the various ligaments and these vary in strength.

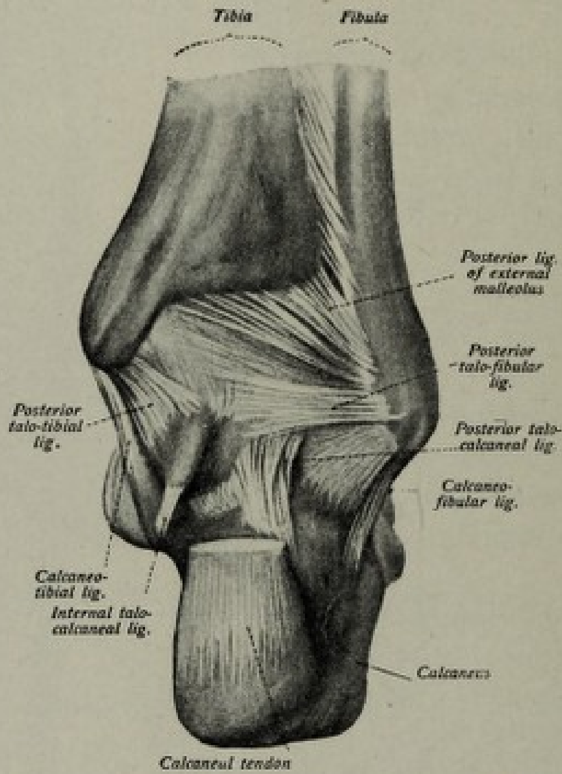


FIG. 111.—The ankle joint seen from behind. (*Sobotta and McMurrich.*)

The *ventral ligament* is thin and connects the margin of the head of the tibia with the margin of the head of the talus.

The *dorsal ligament* is very strong and consists of *three parts.* The *ventral fasciculus* (*lig. talofibulare anterius*) is the shortest and connects the ventral margin of the lateral malleolus with the talus in front of its articular surface. The *medial fasciculus* (*lig. calcaneofibulare*) is cord-like and connects the tip of the malleolus with the side of the calcaneum. The *dorsal fasciculus* (*lig. talofibulare posterius*) is the strongest and is transversely placed. It extends from the fibular fossa of the malleolus to the dorsal surface of the talus.

The *deltoid ligament* (*lig. deltoideum*), or *medial ligament*, is triangular in shape and the strongest ligament of the ankle joint. It extends from the medial malleolus to the navicular, talal and calcaneal bones. It has a number of divisions, as *anterior*, *posterior* and *deep* (all talotibial) and *tibionavicular* and *tibiocalcaneal.*

The *synovial membrane* that lines the capsule and invests the non-articular portions of the bones within the joint sends an extension into the inferior tibiofibular articulation. Pads of fat separate it from the bones at the front and back of the joint.

Movements.—These are of *flexion* and *extension.*

THE INTERTARSAL ARTICULATIONS (ARTICULATIONES INTERTARSEÆ)

The intertarsal articulations are of the *arthrodial* variety.

The **talocalcaneal joint** is formed by the talus and the calcaneum. In addition to a *capsule* there are the *anterior*, *posterior*, *lateral*,

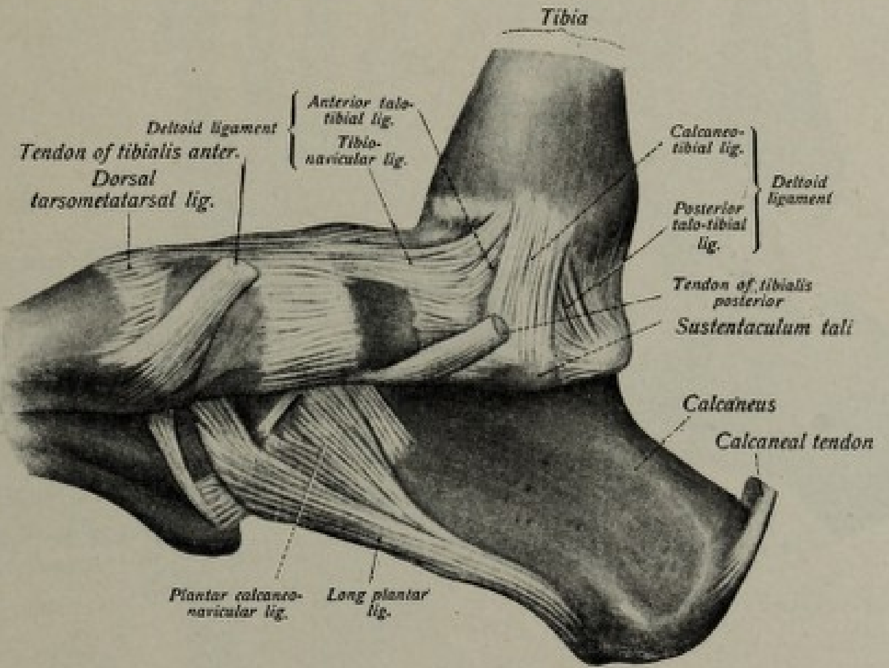


FIG. 112.—The ligaments of the tarsus seen from the inner side. (*Sobotta and McMurrich.*)

medial and *interosseous talocalcaneal ligaments*, which connect corresponding areas of the two bones.

The **talocalcaneonavicular joint** is formed by the talus, calcaneum and naviculare. It is at the summit of the anteroposterior arch of the foot. The most important ligament is the *plantar calcaneonavicular ligament* as it gives support to the arch and forms part of the articulation. It blends with the deltoid ligament of the ankle joint. Other ligaments are, the *calcaneonavicular part of the bifurcate ligament* and the *posterior talonavicular ligament.*

The **calcaneocuboid articulation** is surrounded by a *capsule* which is supported by other ligaments as, the *medial calcaneocuboid* (the *calcaneocuboid part of the bifurcate ligament*), *dorsal*, *lateral* and *inferior calcaneocuboid ligaments.*

The **cuneonavicular articulation** concerns the navicular and three cuneiform bones. In addition to the *capsule* there are the *dorsal* and *plantar cuneonavicular ligaments.*

The **intercuneiform articulations** are two in number, the middle bone taking part in both. The *ligaments* are the *dorsal* and *plantar intercuneiform ligaments.*

The **cuneocuboid articulation** is between the cuboid and the third cuneiform bones. The *ligaments* are the *dorsal, plantar* and *interosseous cuneocuboid ligaments.*

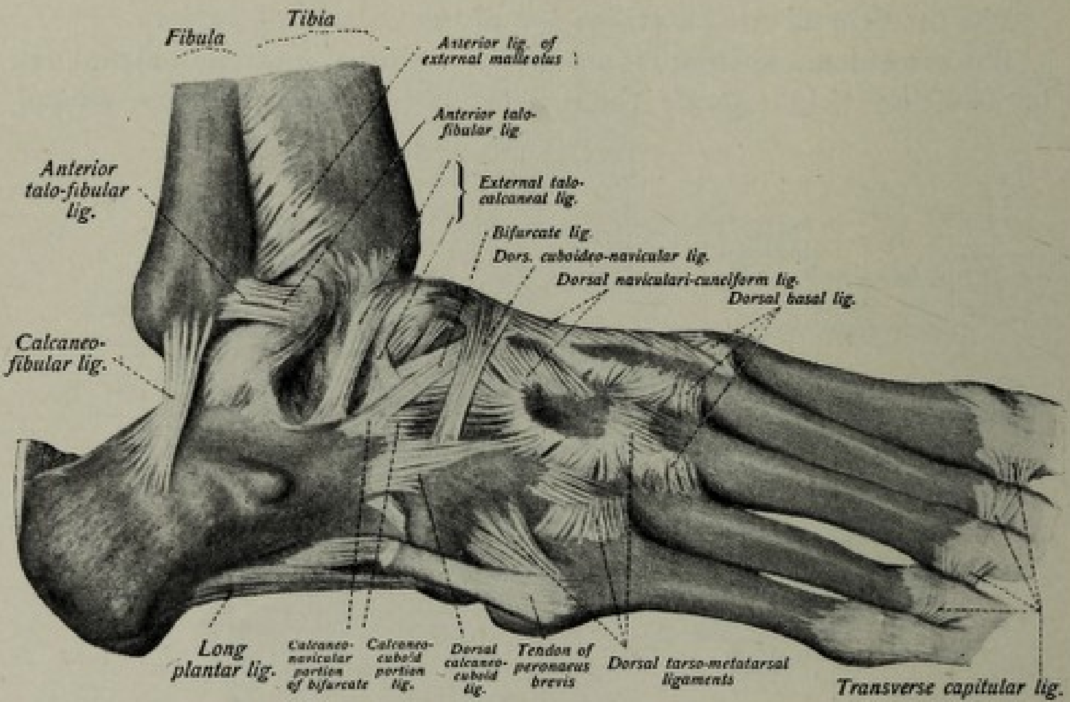


FIG. 113.—The ligaments of the foot seen from above and from the outer side. (*Sobotta and McMurrich.*)

THE TARSOMETATARSAL ARTICULATIONS (ARTICULATIONES TARSOMETATARSEÆ)

These joints are formed by the cuboid and three cuneiform bones, proximally, and the bases of the five metatarsal bones, distally. There are three joints and they are of the *arthrodial variety.*

The **medial tarsometatarsal articulation** comprises the internal cuneiform bone and the base of the first metatarsal bone (great toe). The ligaments are the *capsule*, and *dorsal* and *plantar tarsometatarsal ligaments.*

The **intermediate tarsometatarsal joint** comprises the three cuneiform bones and the bases of the second, third and a part of the fourth metatarsal bones. The ligaments are *dorsal, plantar* and *interosseous.*

The **lateral tarsometatarsal articulation** involves the cuboid and the bases of the fourth and fifth metatarsal bones. The ligaments are *dorsal* and *plantar*.

Each of the three joints has a separate *synovial membrane*.

Movements.—The intertarsal and tarsometatarsal articulations permit of a *gliding movement*. In the tarsus *inversion, eversion* and a *slight rotation* may be produced.

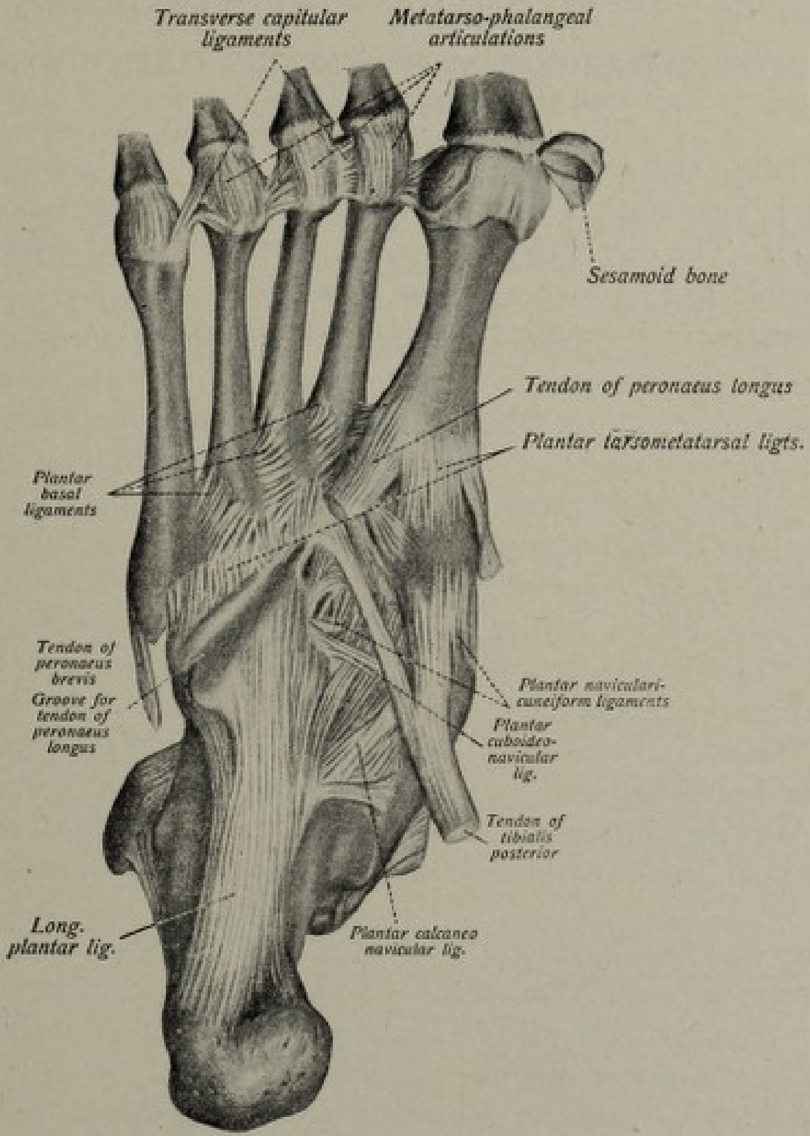


FIG. 114.—The ligaments of the foot seen from the plantar surface. (*Sobotta and McMurrich.*)

THE INTERMETATARSAL ARTICULATIONS

These joints comprise the adjacent surfaces of the outer four metatarsal bones only. The *ligaments* are the *dorsal, ventral* (*plantar*) and *interosseous ligaments of the bases*. In addition *transverse metatarsal ligaments* bind the bases on their plantar surfaces. The *synovial membrane* is an extension of the preceding joints.

THE METATARSOPHALANGEAL ARTICULATIONS

These joints are of the *condyloid* variety. They resemble those of the hand and each is provided with a *modified capsule*, a *plantar* (*accessory*) and *two lateral* (*collateral*) *ligaments*. The *dorsal ligament* is supplied by the expansion of the extensor tendon as it passes over the joint.

Movements.—*Flexion*, *extension*, *abduction* and *adduction*.

THE INTERPHALANGEAL ARTICULATIONS (ARTICULATIONES DIGITORUM PEDIS)

These joints also resemble those of the hand. The *capsule* is thin. The other ligaments are the *plantar* (*accessory*) and *two lateral* (*collateral*). The *dorsal ligament* is supplied by the extensor tendon. Each capsule has its own *synovial membrane*.

Movements.—These are of *flexion* and *extension*.

CHAPTER III

MYOLOGY

Muscle tissues are those that produce the various movements of the different parts and organs of the body. **Myology** is that division of Anatomy that treats of the *origin, insertion* and *actions* of the muscles. There are **three varieties** of *muscle tissue, voluntary striated, involuntary nonstriated* and *involuntary striated.*

Voluntary striated, or **skeletal muscle tissue** consists of units called muscle *cells.* These are cylindrical in shape, vary in length from 2.5 cm. to 12 cm. and in from 25μ to 80μ in diameter. Each cell or fiber shows *longitudinal* and *cross-striations.* Each fiber consists of a large number of delicate *fibrillæ*, or *sarcostyles*, imbedded in the homogeneous *sarcoplasm* and is surrounded by a delicate membrane called the *sarcolemma.* The fibrillæ are composed of sarcous substance which stains deeply while the sarcoplasm stains faintly, thereby causing the longitudinal striations. Each fibril is not an uninterrupted thread but consists of segments (*sarcous elements*) of equal length and separated from one another by an interval filled in with sarcoplasm. These segments are all at the same level at any given part of the fiber causing, thus, the cross-striations or alternating dark and dim discs. In special preparations the dim discs are seen to be crossed by a fine dark line called the *membrane of Krause,* or *Dobie's line.* The *nuclei* are numerous and are located at the periphery of the sarcous substance just beneath the sarcolemma.

A **muscle** consists of a collection of muscle fibers and exhibits a definite structure. Each muscle is surrounded by a sheath of white fibrous tissue called the *epimysium.* From this septa are sent in which divide the muscle into large secondary bundles; these are further subdivided into *primary bundles,* or *fasciculi* each of which is surrounded by a sheath called the *perimysium.* Incomplete septa extend into the primary fasciculi and ultimately give rise to a delicate meshwork all of which constitutes the *endomysium;* this supports the muscle fibers, smaller nerves and vessels.

This variety of muscle is found as the skeletal, and external ocular muscles, in the tongue, pharynx, upper part of the esophagus, anus, diaphragm, larynx and external ear.

The **involuntary,** or **smooth muscle tissue,** consists of small spindle-shaped *cells.* Each cell measures from 25μ to 200μ in length

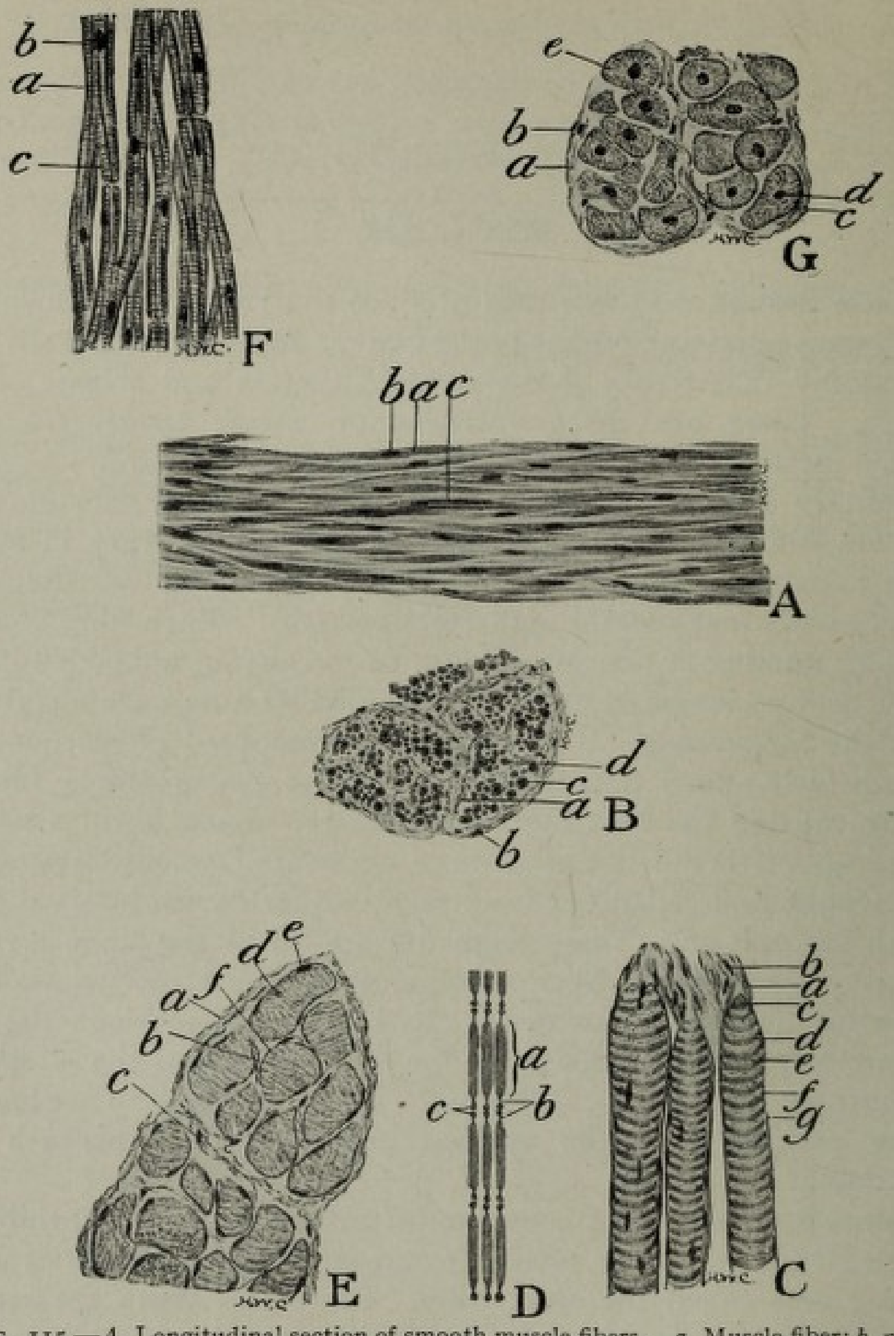


FIG. 115.—*A*, Longitudinal section of smooth muscle fibers. *a*, Muscle fiber; *b*, nucleus; *c*, fibrous tissue between fibers. *B*, Cross-section of smooth muscle fibers. *a*, Perimysial connective tissue; *b*, blood-vessel; *c*, nucleated fiber; *d*, nonnucleated fiber. *C*, Longitudinal section of voluntary muscle fibers. *a*, Sarcolemma; *b*, nucleus; *c*, end of muscle fiber; *d*, dark bands; *e*, intermediate disc; *f*, nucleus; *g*, lateral disc. *D*, Diagrammatic section of cross and long striations. *a*, Dark disc; *b*, lateral discs; *c*, intermediate disc. *E*, Cross-section of voluntary muscle. *a*, Perimysium; *b*, endomysium; *c*, nucleus of perimysium; *d*, fibrillæ; *e*, nucleus of muscle; *f*, sarcolemma. *F*, Longitudinal section of cardiac muscle fiber. *a*, Muscle fiber; *b*, nucleus; *c*, branch. *G*, Cross-section of cardiac muscle fibers. *a*, Perimysial sheath; *b*, nucleus of sheath; *c*, muscle fiber; *d*, nucleus; *e*, radial plates of fibrillæ. (*Radasch, Histology.*)

and 5μ to 7μ in diameter; each fiber contains a single, long, slender, centrally placed *nucleus*. The fibers are arranged in bundles that form layers in the hollow organs. It is found in the gastrointestinal tract, trachea, bronchial tubes, within the eyeball, in the genitourinary system, in the blood vascular and lymph vascular systems and the capsules of some organs.

The **involuntary striated,** or **cardiac muscle tissue,** is found in the heart only. Each *cell* is a short, stubby cylinder measuring from 25μ to 200μ in length and 25μ to 40μ in diameter. According to some the heart muscle is considered a *syncytium*. Each cell has cross- and longitudinal striations; the fibrillæ are radially arranged but are not present in the nuclear area. A single, broad, oval *nucleus* is found near the center of each fiber. The cells are arranged in bundles that do not form muscle masses as in the first variety, nor are they arranged in regular layers as in the second variety. For their general arrangement see "The Heart."

A **muscle** has two points of attachment; that which usually acts as the fixed point (the part from which the muscle usually acts) is called its *origin*, while the point acted upon (moved) is called the *insertion*. Muscles are usually attached to the periosteum of the bone (but may be attached to the bone directly, to ligaments or to the skin) by means of *tendons*, or *aponeuroses*. The main mass of the muscle (between the tendons) constitutes the *venter* or *belly*.

Movements are not the result of the action of a single muscle but of a variable number. While one (or more) muscle is concerned directly with the action produced other muscles (fixation muscles) steady various joints during the action. The actions of muscles are of importance in the displacement of fractured bones and the deformities in dislocations.

Muscles are often named from their *action* (extensors, flexors, pronators, supinators); *number of heads* (biceps, triceps); *points of attachments* (sternomastoid, sternohyoid); *shape* (deltoid, trapezius, rhomboideus); *situation* (ulnaris, radialis, tibialis); *direction* (rectus, obliquus, transversalis); *course* (orbicular, or sphincter).

The fibers of the muscles are *arranged* in various ways. When *parallel*, or nearly so, they form *quadrilateral* and *fusiform muscles*. When they *converge* toward a common point, they form *triangular* muscles (temporalis). When arranged *obliquely* and attached to one or both sides of the tendon, they constitute *penniform muscles*. On one side they are called *unipennate* (*peronei*); on both sides, they constitute *bipennate* muscles (rectus femoris); when the tendinous bands are numerous and the fibers are obliquely attached, the result is a *multipennate* muscle (deltoid).

More or less directly connected with the muscles are the **fasciæ**. The **superficial fascia** (*fascia superficialis*), or **panniculus adiposus** is that loose areolar tissue just beneath the skin where the fat is deposited. It supports the cutaneous nerves and vessels and is the one affected in dropsical conditions.

The **deep fascia** (*fascia profunda*) is in close relation with the bones, ligaments and muscles. It is of variable thickness in the various regions of the body. It envelops the entire extremities and sends in septa, the *intermuscular fasciæ*, that separates the muscles from one another. It assists in strengthening joints and as aponeuroses affords attachment to muscles.

There are said to be 347 pairs of muscle and two single muscles in the body.

THE MUSCLES OF THE HEAD

The muscles of the head comprise those of the *scalp* and *auricular*, *nasal*, *oral* and *orbital regions* as well as those of *mastication*.

THE MUSCLES OF THE SCALP

The *superficial fascia of the scalp* is firm and dense and is attached to the skin; it contains the superficial vessels, nerves and considerable fat.

The **m. epicranius** (*occipitofrontalis*) consists of two bellies with an intervening tendon. The *frontal portion* (*frontalis*) *arises* from the galea aponeurotica (epicranial aponeurosis) and at the orbital arch *blends* with the mm. orbicularis oculi and corrugator supercilii. The *occipital portion* (*occipitalis*) *arises* from the lateral two-thirds of the superior nuchal line of the occipital bone and *terminates* in the galea aponeurotica. The **galea aponeurotica** is a broad and extensive mass of dense fibrous tissue that connects the two bellies together; it is attached laterally to the temporal ridges and dorsally, between the dorsal bellies, to the middle of the superior nuchal line.

Actions.—The *frontal portion* draws the scalp forward and elevates the skin over the root of the nose and the eyebrows. This action is increased in fright and terror. The *occipital portion* draws the scalp backward.

Nerves.—*Occipitalis.*—Posterior auricular branch of the facial nerve.

Frontalis.—Temporal branch of the same nerve.

THE EXTRINSIC MUSCLES OF THE EAR

The **m. auricularis anterior**, the smallest, *arises* from the temporal fascia and is *inserted* into the top of the root of the auricle.

The **m. auricularis superior,** the largest, is fan-shaped and *arises* from the temporal fascia and is *inserted* into the top of the auricle.

The **m. auricularis posterior** *arises* from the surface of the mastoid process and is *inserted* into the cranial surface of the auricle.

Actions.—Practically functionless.

Nerves.—*Auricularis anterior* and *superior.*—Temporal branch of the facial nerve.—*Auricularis posterior.*—Posterior auricular branch of the same nerve

FIG. 116.—The superficial layer of the facial muscles and the neighboring muscles of the neck seen from the side and slightly from in front. (*Sobotta and McMurrich.*)

THE NASAL REGION

The **m. procerus,** or **pyramidalis nasi,** *arises* from the frontalis muscle and the skin of the glabella and is *inserted* into the membrane that stretches over the nose.

The **m. nasalis,** or **compressor naris,** *arises* from the maxilla above the incisor fossa and is *inserted* into the above membrane.

The mm. dilatatores nasi are *attached* to the margin of the nostril, one anterior to the other.

The **m. depressor alæ nasi** *arises* from the upper part of the incisor fossa of the maxilla; it divides, one part being *inserted* into the ala and the other into the septum of the nose.

The **caput angulare,** or **levator labii superioris et alæque nasi,** *arises* from the root of the frontal process of the maxilla and is *inserted* into the ala of the nose and joins the m. orbicularis oris.

Actions.—The *procerus* wrinkles the skin over the bridge of the nose. The *caput angulare* elevates the upper lip (disdain and contempt). The other muscles act as indicated by their names.

Nerves.—*All* are supplied by the facial nerve.

THE ORAL REGION

The **m. orbicularis oris** is a sphincter muscle connected with the other muscles that converge at the mouth. The **superior part** is attached to the nasal septum (*nasolabial band*) and the incisor fossa (*superior incisive fasciculus* which is continuous with the mm. buccinator and caninus); the **inferior part** is attached to the mandible at each side of the symphysis (*inferior incisive fasciculis* which is continuous with the mm. buccinator and caninus); laterally it is joined by the buccinator, the elevators and depressors of the lower lip at the angle of the mouth.

The **m. quadratus labii superioris** consists of the *three* following muscles:

The **caput infraorbitale,** or **levator labii superioris,** *arises* from the maxilla just above the infraorbital foramen and *joins* the orbicularis oris muscle.

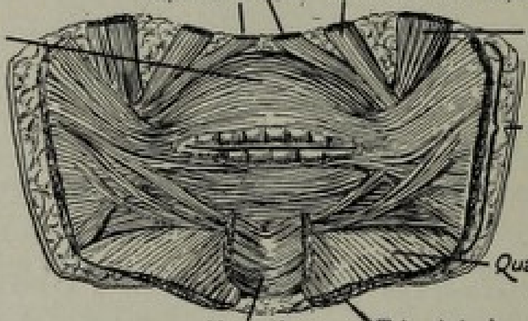


FIG. 117.—The oral musculature seen from behind. The muscles, together with the integument, have been separated from the bones, and the mucous membrane covering the muscles has been removed. (*Sobotta and McMurrich.*)

The **caput angulare** has been described above.

The **caput zygomaticus,** or **zygomaticus minor** *arises* from the zygomatic bone and is *inserted* into the margin of the orbicularis oris muscle.

The **m. caninus,** or **levator anguli oris,** *arises* from the canine fossa of the maxilla and is *inserted* into the orbicularis oris and the skin of the angle of the mouth.

The **m. zygomaticus (major)** *arises* from the zygomatic arch and is *inserted* into the skin and into the orbicularis oris muscle.

The **m. triangularis,** or **depressor anguli oris,** *arises* from the oblique line of the mandible and is *inserted* into the skin and the orbicularis oris muscle.

The **m. risorius** is a portion of the platysma muscle *arising* from the fascia over the parotid gland; it is *inserted* into the skin of the angle of the mouth.

The **m. quadratus labii inferioris,** or **depressor,** *arises* from the mandible close to the triangularis; it is *inserted* into the skin of the lower lip and into the orbicularis oris.

The **m. mentalis,** or **levator menti** *arises* from the incisor fossa of the mandible and is *inserted* into the skin of the chin.

The **m. buccinator** forms the bulk of the cheek. It *arises* from the pterygomandibular raphé and the alveolar processes of the mandible and maxilla. At the angle of the mouth its fibers *blend* with those of the muscles there.

Actions.—These are the *muscles of expression* and by their actions produce the effect of emotions upon the face. The *m. orbicularis oris* causes the lips to pout, protrude unevenly, or compresses the lips in various degrees. The *mm. quadratus superioris* and *zygomaticus* draw the lips upward; the *mm. zygomaticus, risorius, buccinator* and *triangularis* draw the angle of the mouth laterally; the *mm. triangularis* and *quadratus inferioris* draw the lips downward. The *m. buccinator* flattens the cheek and draws the angle laterally and the *m. mentalis* protrudes the lower lip.

Nerve Supply—All are supplied by the facial nerve.

THE ORBITAL REGION

The *external muscles* include three.

The **m. orbicularis oculi** is a sphincter muscle of the eyelids. Its *orbital portion* spreads over the cheek, temple and forehead (*pars orbitalis*) and the *palpebral portion* (*pars palpebraris*) is contained in the eyelid. Medially the palpebral portion is *attached* to the medial palpebral ligament and the borders of the nasolacrimal groove.

The **pars lacrimalis,** or **tensor tarsi,** is a portion of the above muscle that lies behind the lacrimal sac and extend from the nasolacrimal groove to the tarsal ligaments. It closes the eyelids.

The **m. corrugator supercilii** *arises* from the medial portion of the superciliary arch and *blends* with the deep fibers of the orbicularis oculi. It throws the skin of the forehead into vertical folds.

Nerve Supply.—All are supplied by the facial nerve.

Within the orbit are the **orbital muscles,** the **fascia bulbi** and the eyeball, vessels and nerves. These structures are embedded in the orbital fat. The **fascia bulbi,** or **capsule of Tenon,** represents a bursa upon which the eyeball moves. *One layer* is attached to the posterior surface of the eyeball while the *other* is applied to the adjacent fat. The layers are continuous at the conjunctival region. This fascia is pierced by the optic nerve and the tendons of the ocular muscles upon which it is prolonged in the form of sheathes.

The **m. levator palpebræ superioris** *arises* from the upper part of the optic foramen and as it passes forward it spreads out and is *inserted* into the lid, mainly into the superior border of the superior tarsal plate. It is also *inserted* into the conjunctiva, the orbicularis oculi and skin of the upper lid.

Action.—Elevates the upper lid.

Nerve Supply.—Superior division of the oculomotor nerve.

The **mm. recti** are the *superior*, *inferior*, *lateral* and *medial*, and they all *arise* from a ring of fibrous tissue that surrounds the optic foramen. The **superior, medial** and **superior head of the lateral rectus** all *arise* from the upper part of this ring while the **inferior rectus** and the **inferior head of the lateral rectus** *arise* from the inferior portion of this ring. The **medial** and **lateral recti** are *inserted* into the transverse plane of the eyeball about 8 mm. behind the corneoscleral junction. The **superior** and **inferior recti** are

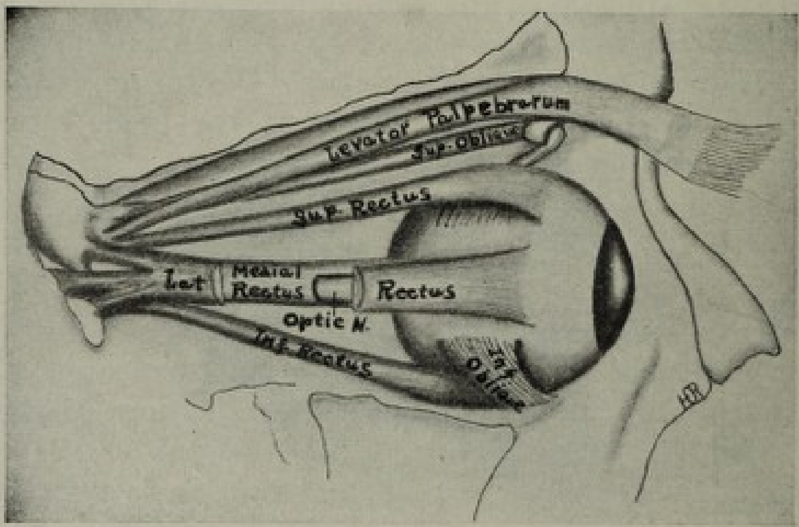


Fig. 118.—Muscles of the right orbit.

inserted a little medial to the vertical axis of the eyeball about 8 mm. behind the corneoscleral junction.

The **m. obliquus superior** *arises* from the lateral margin of the optic foramen, passes obliquely to the superomedial part of the orbit where its middle tendon passes through a *fibrous pulley* that is here attached. It then turns laterally and passes between the superior rectus and the eyeball to be *inserted* into the sclera at the equator of the eyeball between the lateral and superior recti muscles.

The **m. obliquus inferior** *arises* from the anteromedial part of the floor of the orbit at the margin of the nasolacrimal groove. It passes laterally between the inferior rectus and the floor of the orbit and then between the lateral rectus and the eyeball to be *inserted* into the sclera between the superior and lateral recti muscles but at a more posterior level than the superior oblique.

Actions.—The *medial* and *lateral recti* muscles move the eyeball medially and laterally in the horizontal plane. The *superior* and *inferior recti* tend to move the eyeball in the vertical plane but their insertion and oblique direction cause them to produce some inward movement as well as some rotation. This action of the superior rectus is corrected by the inferior oblique while the same action of the inferior oblique is corrected by the superior oblique muscle. Diagonal movements are produced by the two contiguous recti muscles acting at the same time. The *oblique muscles* acting alone produce movements upon the anteroposterior axis of the eyeball.

Nerve Supply.—The *lateral rectus* by the abducent nerve.

The *superior oblique* by the trochlear nerve.

The *remainder* of the orbital muscles by the oculomotor nerve.

The **m. orbitalis,** or **Mueller's muscle** consists of smooth muscle tissue and *spans* the inferior orbital fissure and infraorbital groove.

Action.—Probably assists in protrusion of the eyeball.

Nerve Supply.—Sympathetic nerves.

MUSCLES OF MASTICATION

The **m. temporalis** *arises* as a fan-shaped mass from the temporal fossa and the temporal fascia. It is *inserted* into the coronoid process and the anterior margin of the ramus of the mandible.

Action.—*Closes* the mouth, *protrudes* and *retracts* the mandible.

Nerve Supply.—Mandibular division of the trigeminal nerve.

The **m. masseter** *arises* superficially from the anterior two-thirds of the inferior margin of the zygomatic arch and deeply from the medial surface of the entire zygomatic arch; it is *inserted* into the lateral surface of the coronoid process, ramus and angle of the mandible.

Action.—*Closes* the mouth.

Nerve Supply.—Mandibular division of the trigeminal nerve.

The **m. pterygoideus externus** *arises* from the infratemporal surface of the greater wing of the sphenoid bone (superficial head), and from the lateral surface of the lateral plate of the pterygoid process of the same bone (deep head). It is *inserted* into the anterior part of the neck of the mandible just below the condyle and into the capsule of the joint and the articular disc.

Action.—*Protrusion* and *lateral movements* of the mandible.

Nerve Supply.—Mandibular division of the trigeminal nerve.

The **m. pterygoideus internus** *arises* from the medial surface of the lateral pterygoid plate and from the tuberosity of the maxilla; it is *inserted* into the medial surface of the angle and ramus of the mandible behind the mylohyoid groove.

Action.—*Closes* the mouth and *assists in protrusion* and *lateral movements* of the mandible.

Nerve Supply.—Mandibular division of the trigeminal nerve.

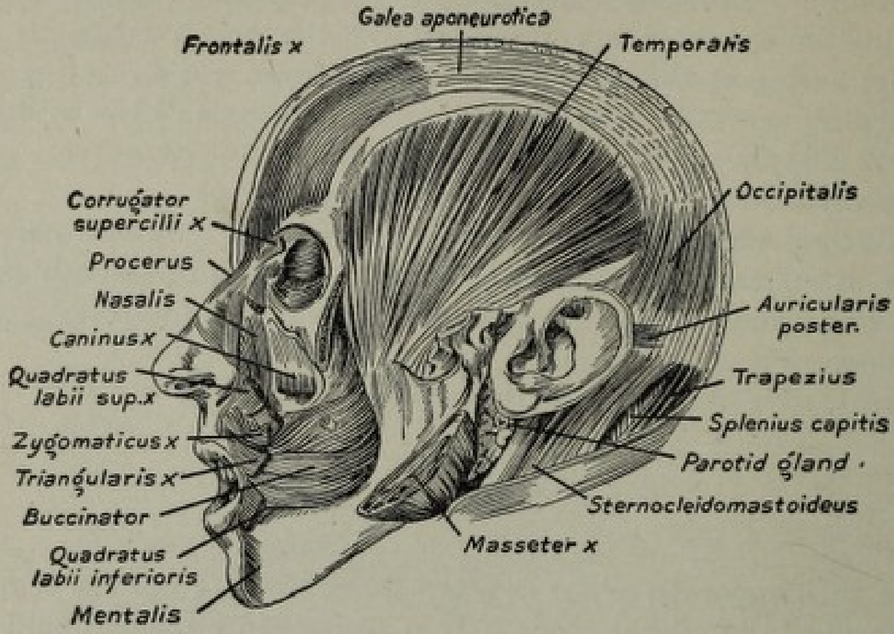


FIG. 119.—The deepest layer of the facial muscles and the temporalis. The caninus, the zygomatic arch, a portion of the zygomatic bone with the origin of the masseter and the temporal fasciæ have been removed. (*Sobotta and McMurrich.*)

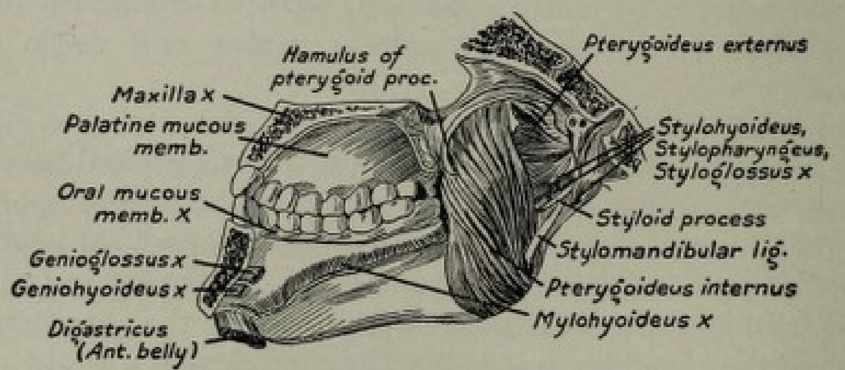


FIG. 120.—The two pterygoidei seen from the inner surface. The anterior portion of the skull has been divided in the sagittal plane, and the temporal bone in an oblique plane; the tongue and soft palate have been removed. (*Sobotta and McMurrich.*)

× indicates that the structures so marked, in the muscle illustrations, have been cut.

THE MUSCLES AND FASCIA OF THE NECK

The **superficial fascia** is very thin and invests the m. platysma.

The **m. platysma** is a broad thin sheet of muscle that *arises* from the pectoral and deltoid fasciæ and passes obliquely upward and inward over the neck; some of its fibers are *inserted* into the mandible while the remainder pass onto the lower part of the face to be *inserted* into the skin and to blend with the other muscles at the angle of the mouth.

Action.—Wrinkles the skin of the neck, *assists in depressing* the angles of the mouth and may *assist in depressing* the mandible.

Nerve Supply.—Facial nerve.

The **deep fascia** (*fascia colli*) surrounds all of the muscles of the neck, forms the carotid sheath and sends in septa that have received special names. Dorsally it is attached to the ligamentum nuchæ and as it passes ventrally it splits at the dorsal margin of the sternomastoid muscle to envelop it, uniting again at the ventral margin of this muscle to envelop the infrahyoid muscles and then passes to the midline of the neck. It is attached, superiorly, to the inferior nuchal line of the occipital bone and the entire length of the body of the mandible; inferiorly, it is attached to the sternum, the clavicle, first rib and to the acromial process of the scapula.

The **prevertebral fascia** (*fascia prevertebralis*) is the transverse septum that passes in front of the vertebral column and the prevertebral muscles. The **pretracheal fascia** is a septum that arches across the neck ventral to the trachea and thyroid gland, assisting in forming the carotid sheath on each side. These two septal fasciæ form a compartment containing the larynx, trachea, thyroid gland, esophagus and pharynx. The **carotid sheath** forms a tubular compartment that encloses the carotid artery, the jugular vein, the vagal and descendens hypoglossi nerves. The *prevertebral fascia* lies dorsal to the parotid gland and assists in forming the stylomandibular, sphenomandibular and pterygomandibular ligaments.

The **m. sternomastoideus** *arises* from the ventral surface of the manubrium sterni (sternal head) and from the medial third of the superior surface of the clavicle (clavicular head). It passes superiorly and dorsally in an oblique manner to be *inserted* into the lateral surface of the mastoid process of the temporal bone and the superior nuchal line of the occipital bone.

Action.—Flexes the head laterally and *rotates* it toward the opposite side if acting alone. *Both acting flex* the head upon the neck and assist in raising the clavicle and sternum in forced inspiration.

Nerve Supply.—Accessory nerve and a branch from the second cervical nerve through the cervical plexus.

INFRAHYOID MUSCLES

The **m. omohyoideus** consists of two bellies; the *dorsal one arises* from the superior margin of the scapula and the transverse scapular ligament and ends in a tendon that continues as the *ventral belly*

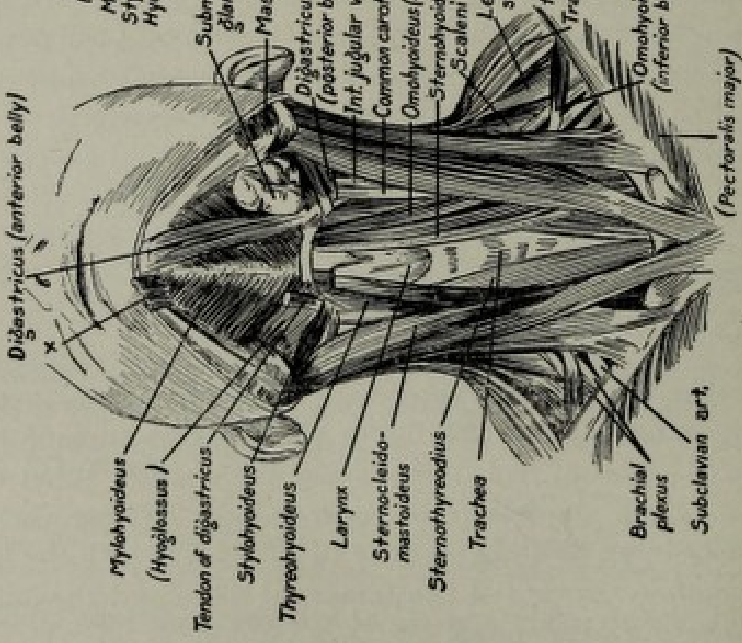


FIG. 121.—Superficial layer of the muscles of the neck, seen from in front. On the rightside the sternohyoid, anterior belly of the digastric, and the submaxillary gland have been removed. (*Sobotta and McMurrich.*)

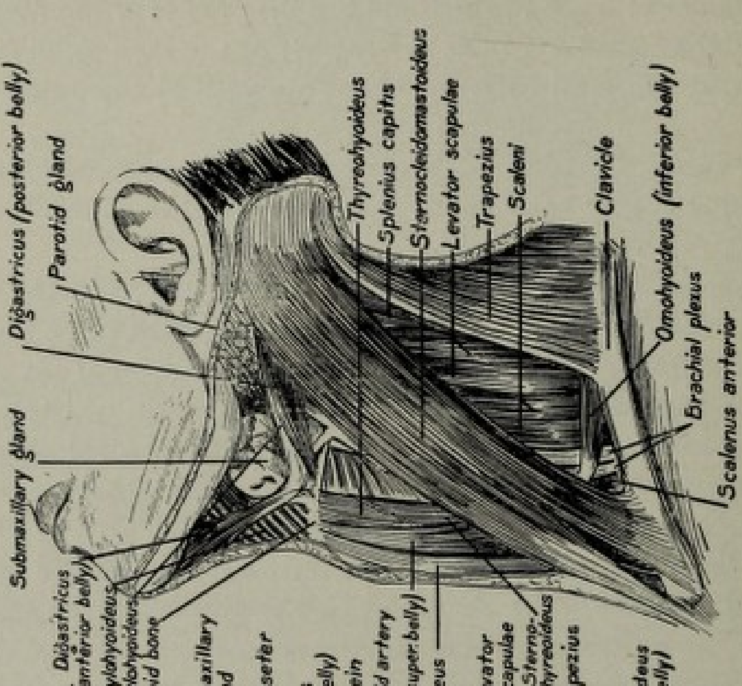


FIG. 122.—Superficial layer of the muscles of the neck, seen from the left side. (*Sobotta and McMurrich.*)

that is *inserted* into the body of the hyoid bone along its inferior margin. The muscle has an oblique direction and the middle tendon is held in position by a process of cervical fascia that is attached to the clavicle and first rib.

Action.—Depresses hyoid bone (after elevation) and draws it to one side and backward if one alone is acting.

Nerve Supply.—Ansa cervicalis formed by the first three cervical nerves.

The **m. sternohyoideus** is narrow and *arises* from the dorsal surface of the manubrium sterni, the first costal cartilage and the adjacent part of the clavicle. It is *inserted* into the inferior margin of the body of the hyoid bone.

Action.—Depressor of the larynx and hyoid bone after elevation in deglutition.

Nerve Supply.—Ansa cervicalis.

The **m. sternothyreoideus** *arises* from the dorsal surface of the manubrium sterni and the first costal cartilage and is *inserted* into the oblique line of the thyreoid cartilage of the larynx.

Action.—Depressor of the larynx and hyoid bone.

Nerve Supply.—Ansa cervicalis.

The **m. thyreohyoideus,** apparently a continuation of the preceding, *arises* from the oblique line of the thyreoid cartilage and is *inserted* into the body and greater cornu of the hyoid bone.

Action.—Depressor of the hyoid bone and elevator of the thyreoid cartilage.

Nerve Supply.—Ansa cervicalis.

SUPRAHYOID MUSCLES

The **m. digastricus** consists of two bellies, the *dorsal one* of which *arises* from the digastric notch of the mastoid process. This is directed toward the hyoid bone where the middle tendon is held in place by a band of cervical fascia. The *ventral belly* continues from this tendon and is *inserted* into the digastric fossa of the mandible (near the symphysis on the medial surface).

Actions.—Elevator of the hyoid bone and the ventral belly *depresses* the mandible.

Nerve Supply.—Ventral belly by the mylohyoid branch of the inferior alveolar division of the trigeminal nerve; dorsal belly by the facial nerve.

The **m. stylohyoideus** arises from the dorsolateral portion of the base of the styloid process of the temporal bone and is *inserted* into the body of the hyoid bone near the omohyoideus.

Action.—Elevator of the hyoid bone.

Nerve Supply.—Facial nerve.

The **m. mylohyoideus** is broad and extensive forming the floor of the buccal cavity. It *arises* from mylohyoid ridge of the mandible and is *inserted* into the body of the hyoid bone and a fibrous median raphé that extends from the hyoid bone toward the chin.

Actions.—Elevates the hyoid bone and *depresses* the mandible.

Nerve Supply.—Mylohyoid branch of the inferior dental nerve (trigeminal).

The **m. geniohyoideus** *arises* from the inferior mental spines (medial surface of the symphysis menti) and is *inserted* into the ventral surface of the body of the hyoid bone.

Actions.—Elevates the hyoid bone and *depresses* the mandible.

Nerve Supply.—First and second cervical nerves through the hypoglossal nerve.

LINGUAL MUSCLES

The *intrinsic muscles* are given in the description of the "Tongue" (page 288). The *extrinsic muscles* are given below.

The **m. genioglossus** is a fan-shaped muscle *arising* from the superior mental spines; its *inferior fibers* are *inserted* into the body of the hyoid bone while the *remainder* are *inserted* into the tongue from its tip to the base.

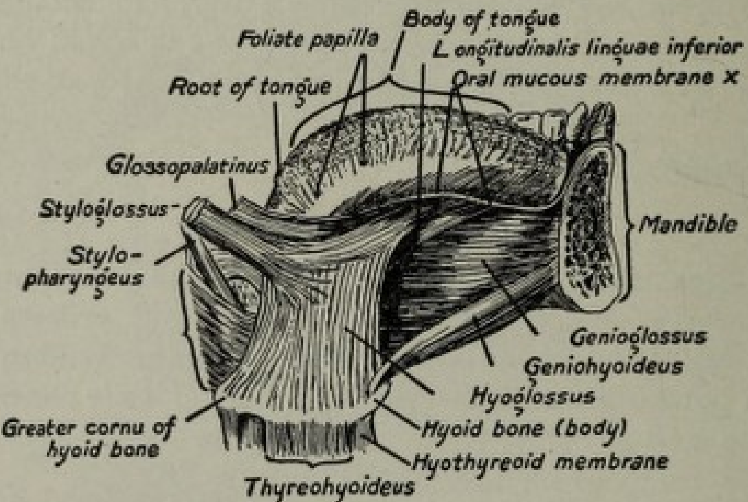


FIG. 123.—The superficial layer of the musculature of the tongue seen from the right side. The mandible has been divided immediately to the right of the median line. (*Sobotta and McMurrich.*)

Actions.—Elevates the hyoid bone, *depresses* the mandible and *assists in protracting*, *retracting* and *depressing* the tongue.

Nerve Supply.—Hypoglossal nerve.

The **m. hyoglossus** *arises* from the body and greater cornu of the hyoid bone and is *inserted* into the side of the tongue.

Actions.—Elevates the hyoid bone and *depresses* the tongue.

Nerve Supply.—Hypoglossal nerve.

The **m. styloglossus** *arises* from the tip of the styloid process and the stylohyoid ligament and is *inserted* into the side and inferior surface of the tongue, decussating with the mm. hyoglossus and the glossopalatinus.

Actions.—Elevates the tongue and *assists in retracting* the tongue.

Nerve Supply.—Hypoglossal nerve.

The **m. glossopalatinus** *arises* from the inferior surface of the soft palate and is *inserted* into the side of the tongue blending with the m. styloglossus and intrinsic muscles.

Action.—Elevates the base of the tongue.

Nerve Supply.—Accessory nerve through the pharyngeal plexus.

The **m. chondroglossus** is a variable muscle and when present it *arises* from the lesser cornu of the hyoid bone and *blends* with the intrinsic muscles of the tongue.

Action.—Negligible.

Nerve Supply.—Hypoglossal nerve.

PHARYNGEAL AND PALATAL MUSCLES

The **m. constrictor pharyngeus superior** is thin and *arises* from the inferior portion of the dorsal margin of the medial pterygoid plate, from the pterygomandibular ligament, the mylohyoid line and the mucous membrane of the floor of the mouth. Its fibers radiate dorsally and are *inserted* into the pharyngeal tubercle of the occipital bone and the median raphé. Its inferior portion is overlapped by the middle constrictor.

The **m. constrictor pharyngeus medius** *arises* from the stylohyoid ligament and both cornua of the hyoid bone. It is *inserted* into the dorsal median raphé. It is overlapped by the inferior constrictor.

The **m. constrictor pharyngeus inferior** *arises* from the oblique line of the thyreoid cartilage and cricoid cartilage and is *inserted* into the dorsal median raphé.

Actions.—These are the muscles of deglutition.

Nerve Supply.—Accessory nerve through the pharyngeal plexus. The inferior receives branches from the vagal nerve in addition.

The **m. stylopharyngeus** *arises* from the root of the styloid process and is *inserted* into the wall of the pharynx and the superior and dorsal margins of the thyreoid cartilage of the larynx.

Actions.—Elevates and *draws laterally* the wall of the pharynx.

Nerve Supply.—Glossopharyngeal nerve.

The **m. pharyngopalatinus** *arises* from the soft palate and is *inserted* into the dorsal margin of the thyreoid cartilage near the m. stylopharyngeus.

Action.—Draws the pharynx over the bolus of food in deglutition.

Nerve Supply.—Accessory through the pharyngeal plexus.

The **m. salpingopharyngeus** is a small muscle that *arises* from the inferior part of the auditory (Eustachian) tube and *blends* with the m. pharyngopalatinus.

The **m. levator veli palatini** *arises* from the inferior part of the cartilaginous auditory tube and from the apex of the petrous portion of the temporal bone. It is *inserted* into the aponeurosis of the soft palate.

Action.—*Elevates* the soft palate.

Nerve Supply.—Accessory nerve through the pharyngeal plexus.

The **m. tensor veli palatini** *arises* from the cartilaginous portion of the auditory tube and from the scaphoid fossa of the pterygoid process and the spine of the sphenoid bone. It is *inserted* into the dorsal margin of the soft palate and into the palatal aponeurosis.

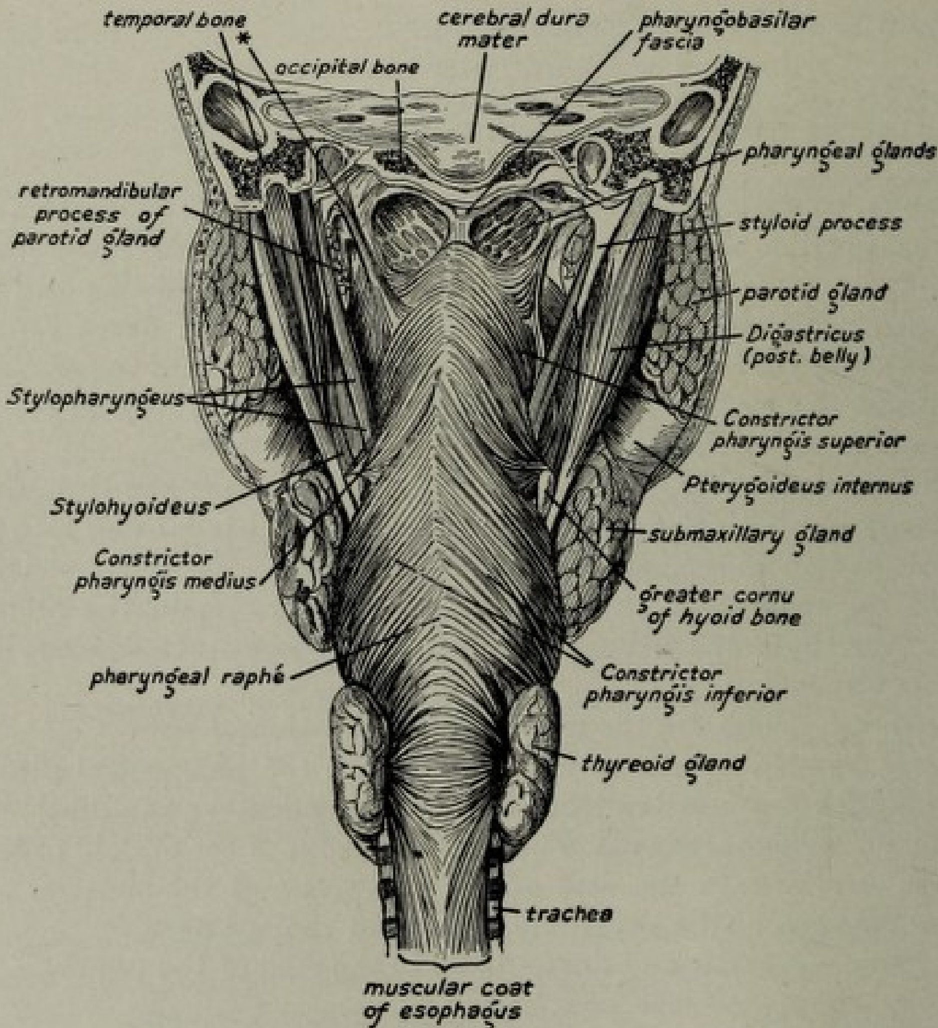


FIG. 124.—The constrictors o. the pharynx seen from behind. The posterior part of the skull has been removed. *, A bundle of the superior constrictor arising from the base of the skull. (*Sobotta and McMurrich.*)

Action.—Renders the palate *tense.*

Nerve Supply.—Trigeminal nerve through the otic ganglion.

The **m. glossopalatinus** (see lingual muscles).

The **m. uvulæ** is really a *pair of muscles* and these are the only intrinsic muscles of the palate. Each *arises* from the posterior nasal spine and palatal aponeurosis and is *inserted* into the tissues of the uvula.

Action.—Elevates the uvula.

Nerve Supply.—Accessory nerve through the pharyngeal plexus.

THE LATERAL AND PREVERTEBRAL CERVICAL MUSCLES

The **m. scalenus anterior** *arises* from the anterior tubercles of the transverse processes of the third, fourth, fifth and sixth cervical

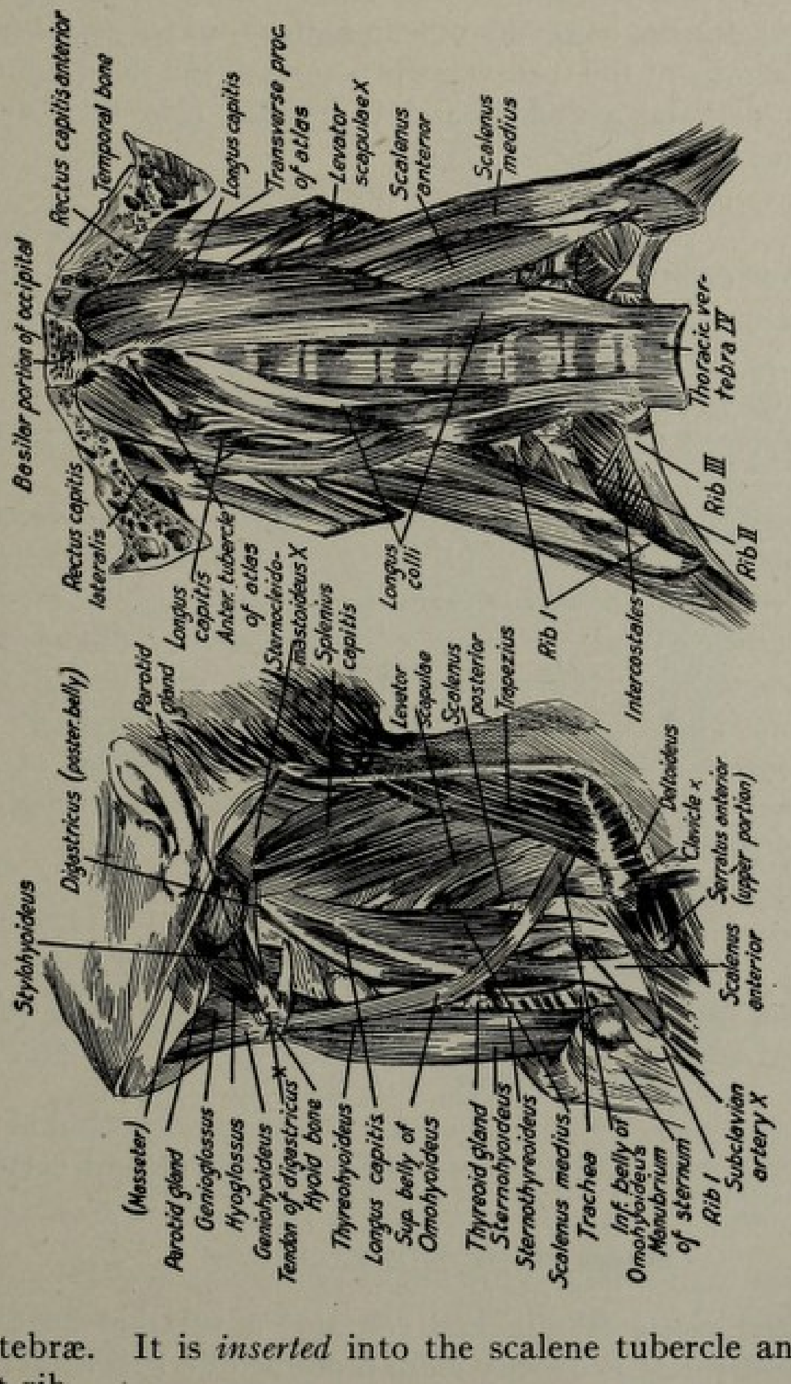


FIG. 126.

FIG. 125.

FIG. 125.—Deep layer of the muscles of the neck, seen from the left side. The anterior belly of the digastric, the mylohyoid, the sternocleidomastoid, and the sternal end of the clavicle have been removed. (*Sobotta and McMurrich.*)

FIG. 126.—The deep muscles of the neck, seen from in front. On the right side the longus capitis has been drawn outward. (*Sobotta and McMurrich.*)

vertebræ. It is *inserted* into the scalene tubercle and ridge of the first rib.

The **m. scalenus medius** *arises* from the posterior tubercles of the transverse processes of the inferior six cervical vertebræ and is *inserted* into the first rib dorsal to the subclavian groove.

The **m. scalenus posterior** *arises* from the posterior tubercles of the transverse processes of the fourth, fifth and sixth ribs and is *inserted* into the lateral surface of the second rib.

Actions.—Lateral flexion of the vertebral column and *accessory to respiration.*

Nerve Supply.—Ventral rami of the lowest four cervical nerves.

The **m. longus capitis,** or **rectus capitis anticus major** *arises* from the anterior tubercles of the transverse processes of the third, fourth, fifth and sixth cervical vertebræ and is *inserted* into the basilar portion of the occipital bone.

Action.—Flexes the head and the cervical vertebræ.

Nerve Supply.—Ventral rami of the first four cervical nerves.

The **m. rectus capitis anterior,** or **rectus capitis anterior minor** *arises* from the lateral mass of the atlas and is *inserted* into the basilar portion of the occipital bone.

Action.—Flexes the head upon the vertebral column.

Nerve Supply.—From the loop between the first and second cervical nerves.

The **m. longus colli** is divisible into *three portions.* The **vertical part** *arises* from the bodies of the last three cervical and the first three thoracic vertebræ and is *inserted* into the bodies of the second, third and fourth cervical vertebræ. The **superior oblique part** *arises* from the anterior tubercles of the third, fourth and fifth cervical vertebræ and is *inserted* into the anterior tubercle of the atlas. The **inferior oblique portion** *arises* from the bodies of the first three thoracic vertebræ and is *inserted* into the anterior tubercles of the fifth and sixth cervical vertebræ.

Action.—Flexes the vertebral column.

Nerve Supply.—Ventral rami of the second, third and fourth cervical nerves.

The **m. rectus capitis lateralis** *arises* from the transverse process of the atlas and is *inserted* into the jugular process of the occipital bone.

Action.—Flexes the head laterally upon the vertebral column.

Nerve Supply.—The loop between the first and second cervical nerves.

MUSCLES OF THE BACK

The **superficial fascia** is thin and contains a variable quantity of fat. The **deep fascia** is usually more prominent. It is attached, superiorly, to the superior nuchal line of the occipital bone and is continuous with the cervical fascia. It is continuous with the axillary fascia and the fascia of the abdomen and thus covers the superficial muscles and even ensheathes them. In the middorsal line it is attached to the ligamentum nuchæ and the vertebral spines; it is also attached to the spine of the scapula and to the crest of the ilium. The muscles are superficial and deep and are usually described under *four layers.*

The **mm. trapezius** and the **latissimus dorsi** form the *superficial layer.*

The **m. trapezius** is broad, thin, flat and of a triangular form. It *arises* from the medial portion of the superior nuchal line of the

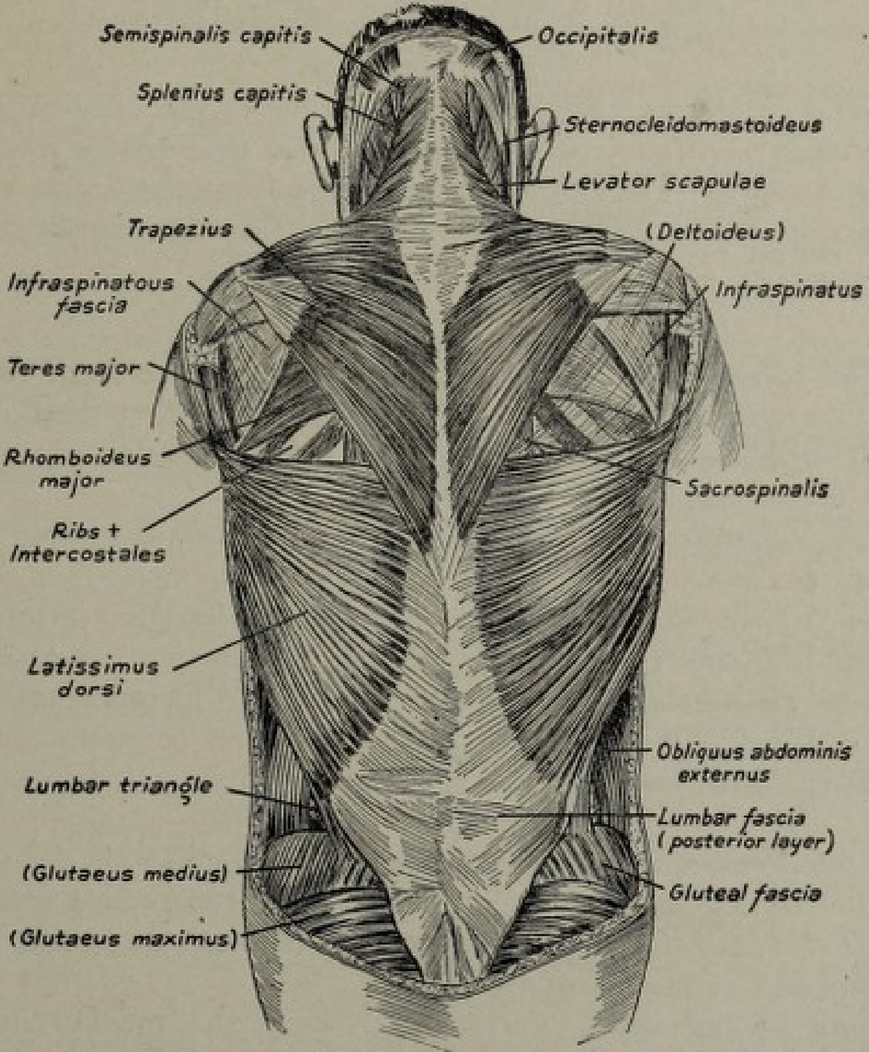


FIG. 127.—The superficial layer of the flat muscles of the back together with the neighboring muscles of the head, neck, abdomen, and buttock. Upon the right side the rhomboideus major and the teres major are represented covered by fascia. (*Sobotta and McMurrich.*)

occipital bone, from the ligamentum nuchæ and from the spines of the seventh cervical and all of the thoracic vertebræ as well as the supraspinous ligaments. The *superior fibers* are *inserted* into lateral third of the dorsal margin of the clavicle; the *middle fibers* are *inserted* into the medial margin of the acromion and the superior margin of the spine of the scapula; the *inferior fibers* are *inserted* into the base of the spine of the scapula.

Action.—The whole muscle *rotates* the scapula. The superior portion *elevates* the shoulder girdle while the inferior fibers *depress* the vertebral margin.

Nerve Supply.—The accessory nerve and the third and fourth cervical nerves through the cervical plexus.

The **m. latissimus dorsi** is also a flat, triangular muscle. It *arises* from the lumbosacral fascia, from the lower three or four ribs (interdigitating with the m. obliquus abdominis externus) and occasionally from the inferior angle of the scapula. Toward its insertion the muscle becomes narrow and thick and its ribbon-like tendon is *inserted* into the floor of the intertubercular sulcus (bicipital groove).

Action.—*Depresses* and *rotates* the humerus medially and as a muscle of *extraordinary inspiration* it *elevates* the inferior ribs.

Nerve Supply.—The thoracodorsal nerve from the dorsal cord of the brachial plexus (representing sixth, seventh and eighth cervical nerves).

SECOND LAYER

The **m. levator scapulæ** is a narrow muscle that *arises* from posterior tubercles of the transverse processes of the first three or four cervical vertebræ and is *inserted* into the superior angle and vertebral margin of the scapula.

Action.—*Elevates* the superior angle and vertebral margin of the scapula.

Nerve Supply.—Dorsal scapular nerve of the brachial plexus (fifth cer.) and branches from the third and fourth cervical nerves.

The **m. rhomboideus minor** *arises* from the ligamentum nuchæ and the spines of the seventh cervical and first thoracic vertebræ. It is *inserted* into vertebral margin of the scapula at the base of the spine.

The **m. rhomboideus major** *arises* from the spines of the second, third, fourth and fifth thoracic vertebræ and supraspinous ligaments. It is *inserted* into the vertebral margin of the scapula at the base of the spine and at the inferior angle.

Actions.—They *elevate* and *draw* toward the median line the vertebral margin of the scapula.

Nerve Supply.—Dorsal scapular nerve of the brachial plexus (fifth cer.).

THIRD LAYER

The **m. serratus posticus superior** *arises* from the ligamentum nuchæ and the spines of the seventh cervical and first three thoracic vertebræ. It is *inserted* into the second, third, fourth and fifth ribs.

The **m. serratus posticus inferior** *arises* from the lumbosacral fascia attached to the last two thoracic and first two lumbar spines; after a horizontal course it is *inserted* into the last four ribs.

Actions.—Extensors of the vertebral column and *accessory muscles of respiration.*

Nerve Supply.—Dorsal rami of the superior and inferior thoracic nerves, respectively.

The **m. splenius** is a band-like muscle that arises from the lig. nuchæ, the last cervical and the first six thoracic spines and the

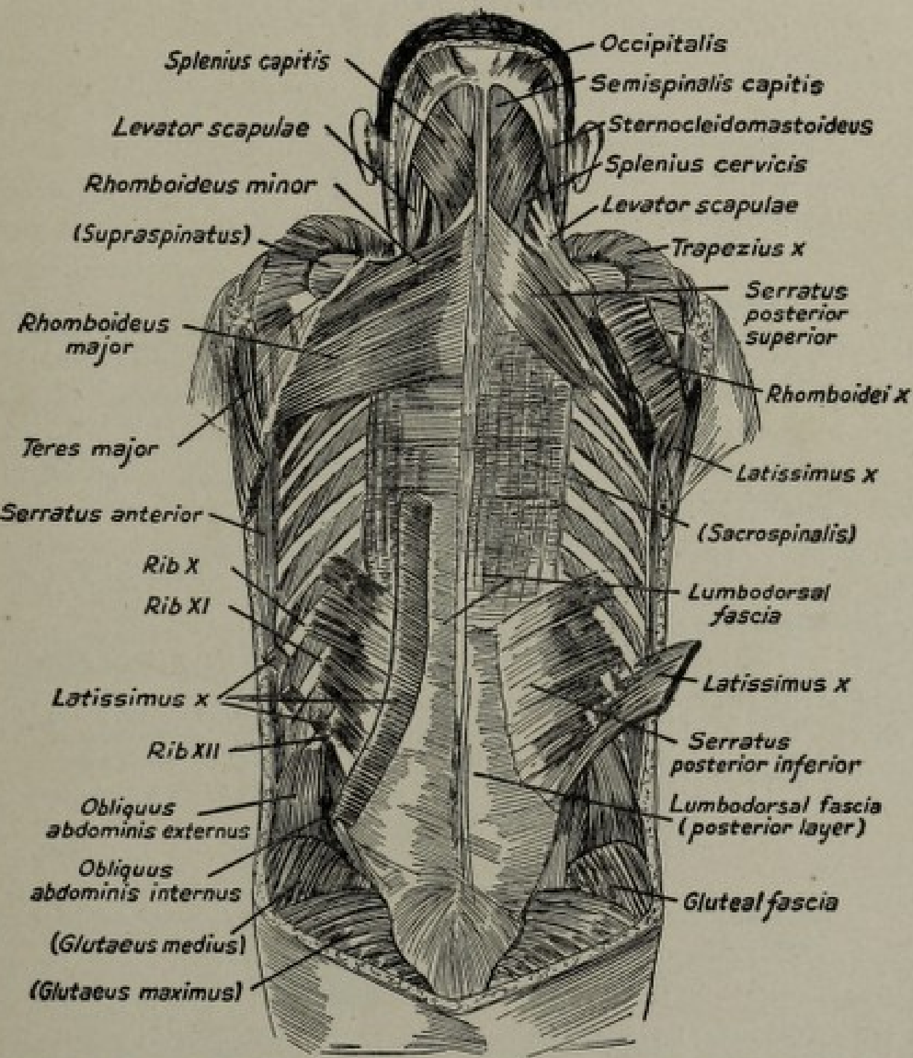


FIG. 128.—The deeper layers of the flat muscles of the back. On the left side the trapezius and latissimus have been cut away; on the right side the rhomboidei have also been cut and reflected and the lumbodorsal fascia has been retained only where it is in relation with the origin of the serratus posterior inferior and below. (*Sobotta and McMurrich.*)

supraspinous ligaments. The *superior portion* is *inserted*, as the **splenius capitis** into the mastoid process and the superior nuchal line. The *inferior portion*, as the **splenius cervicis,** is *inserted* into dorsal tubercles of the first three or four cervical vertebræ.

Actions.—Extension and *lateral movement* of the vertebral column. The splenius capitis *assists* in *flexion, rotation* and *raising* the head.

Nerve Supply.—Dorsal rami of the cervical and superior thoracic nerves.

FOURTH LAYER

The **m. sacrospinalis,** or **erector spinæ,** is the large muscle mass that fills the vertebral groove on each side of the spinous processes. It *arises* from the iliac crest, from the dorsal sacral ligament and from the dorsum of the sacrum and the spinous processes of the

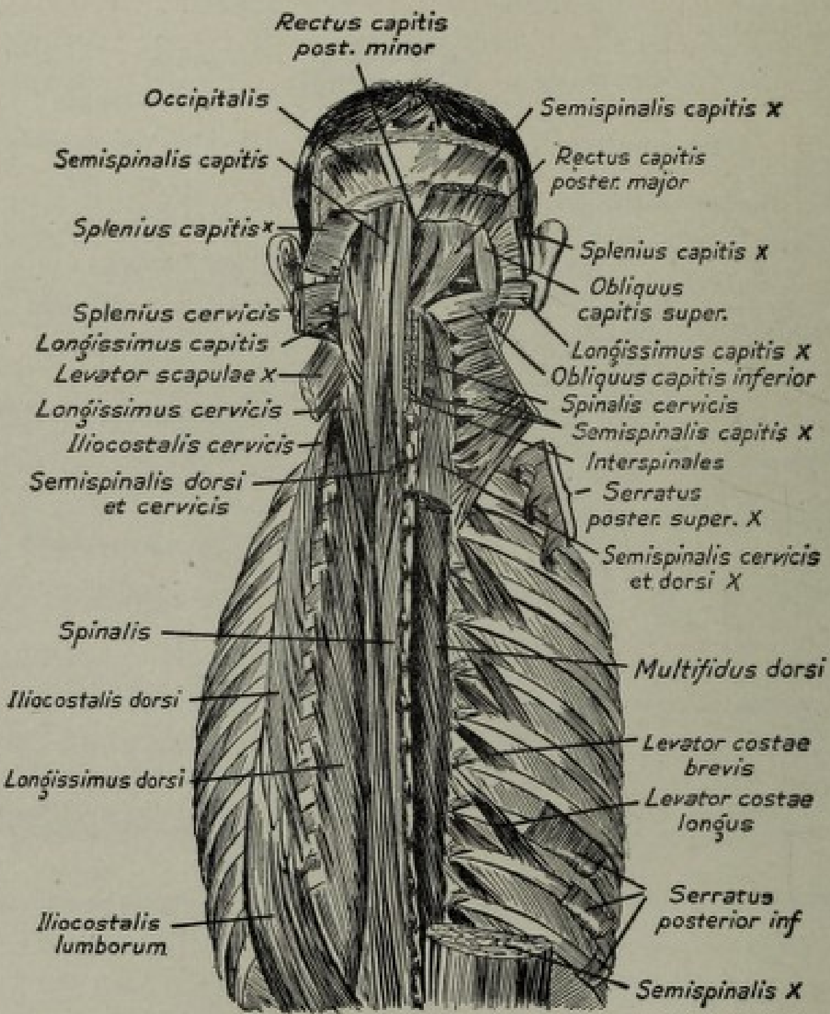


FIG. 129.—The deeper layers of the long muscles of the back. On the left side the sacrospinalis has been partly removed and the semispinalis has been cut and reflected. (*Sobotta and McMurrich.*)

lumbar and superior sacral vertebræ. Near the last rib the muscle divides into several portions, as follows:

The **m. iliocostalis lumborum,** or **lateral portion,** is *inserted* into the six inferior ribs.

The **m. iliocostalis dorsi,** or **accessorius,** is the successor of the preceding in the upper thoracic region. It *arises* from the inferior six ribs, medial to the iliocostalis lumborum and is *inserted* into the six superior ribs.

The **m. iliocostalis cervicis,** or **cervicis ascendens,** succeeds the m. iliocostalis dorsi in the cervical region. It *arises* from the superior six ribs medial to the insertion of the preceding muscle and is *inserted* into the dorsal tubercles of the fourth, fifth and sixth cervical vertebræ.

The **m. longisimus** is the medial and largest portion of the m. sacrospinalis. It is *inserted* into all of the ribs and into the transverse processes of the thoracic and lumbar vertebræ.

The **m. longisimus cervicis,** or **transversalis cervicis,** *arises* from the transverse processes of the first six thoracic vertebræ and is *inserted* into the dorsal tubercles of the transverse processes of the third, fourth, fifth and sixth cervical vertebræ.

The **m. longisimus capitis,** or **trachelomastoideus,** *arises* in common with the preceding and from the articular processes of the lower four cervical vertebræ. It is *inserted* into mastoid process of the temporal bone.

The **m. spinalis dorsi** lies just lateral to the midline in the thoracic region. It *arises* from the spinous processes of the first two lumbar and the last two thoracic vertebræ and is *inserted* into the spines of the first four, or more, thoracic vertebræ.

The **m. semispinalis capitis,** or **complexus,** is a broad muscle that arises from the transverse processes of the first six thoracic and the articular processes of the last four cervical vertebræ. It is *inserted* into the occipital bone between the superior and inferior nuchal lines.

Actions.—Assists in *extension* and *lateral movements* of the pelvis and vertebral column. *Extension*, *lateral movement* and *rotation* of the head (mm. long. capitis and semispinalis capitis). *Accessory* to *inspiration* (mm. longisimus and iliocostales).

Nerve Supply.—Dorsal rami of the spinal nerves.

FIFTH LAYER

The **m. semispinalis** comprises two portions.

The **m. semispinalis dorsi** *arises* from the transverse processes of the last six thoracic vertebræ and is *inserted* into the spines of the first four thoracic and last two cervical vertebræ.

The **m. semispinalis cervicis,** or **colli,** arises from the transverse processes of the first six thoracic and the articular processes of the last four cervical vertebræ and is *inserted* into the spines of the second to the fifth cervical vertebræ.

Actions.—Extension, *rotation* and *lateral movement* of the vertebral column.

Nerve Supply.—Dorsal rami of the spinal nerves.

The **m. rotatores** are eleven pairs of small, thoracic muscles. Each *arises* from the transverse process and is *inserted* into the lamina of the vertebra superior to it.

Action.—*Extension* and *rotation* of the vertebral column.

Nerve Supply.—Dorsal rami of the thoracic spinal nerves.

The **mm. interspinales** are paired muscles connecting the transverse processes of the vertebræ. They *extend* the vertebral column and are supplied by the dorsal rami of the spinal nerves.

The **mm. intertransversarii,** or **intertransversales,** are small muscles connecting the adjacent transverse processes. In the neck and lumbar region they are paired on each side of the midline. These *assist in lateral movement* and *rotation* of the vertebral column and are supplied by the ventral rami of the spinal nerves.

The **m. rectus capitis posterior major** *arises* from the spine of the second cervical vertebra and is *inserted* into the occipital bone below the middle of the inferior nuchal line.

The **m. rectus capitis posterior minor** *arises* from the dorsal tubercle of the atlas and is *inserted* into the occipital bone medial to the preceding muscle.

Actions.—Both muscles *assist in elevation, rotation* and *lateral movement* of the head.

Nerve Supply.—Dorsal ramus of the suboccipital, or first cervical, nerve.

The **m. obliquus capitis superior** *arises* from the transverse process of the atlas and is *inserted* into the lateral portion of the occipital bone between the superior nuchal line and the jugular process.

The **m. obliquus inferior** *arises* from the spine of the epistropheus (axis) and is *inserted* into the transverse process of the atlas.

Actions.—The superior produces *elevation, rotation* and *lateral movement* of the head upon the atlas. The inferior produces *extension, lateral movement* and *rotation* of the atlas in the axis.

Nerve Supply.—Posterior ramus of the suboccipital or first cervical nerve.

The **m. rectus capitis lateralis** connects the jugular process of the occipital bone with the transverse process of the atlas. It assists in *lateral movement* and *rotation* of the head and is supplied by the suboccipital nerve.

MUSCLES OF THE THORAX, OF RESPIRATION

The **mm. intercostales** are placed between the ribs and are eleven pairs in number on each side.

Each **external intercostal muscle** (*m. intercostalis externus*) *arises* from the inferior margin of a rib, passes downward and ventrally to be *inserted* into the superior margin of the rib beneath. It does not quite reach the sternum in front and the space is spanned by the *ventral intercostal aponeurosis.*

Each **internal intercostal muscle** (*m. intercostalis internus*) *arises* from the costal cartilage and the medial margin of the costal groove and passes downward and dorsally to be *inserted* into the superior margin of the costal cartilage and rib beneath. It extends to the angle of the rib only and the remainder of the intercostal space is spanned by the *dorsal intercostal aponeurosis*.

The **mm. levatores costarum** are twelve in number *arising* from the transverse processes of the seventh cervical and the first eleven thoracic vertebræ; each is *inserted* into the rib dorsal to the angle.

The **mm. subcostales** are on the medial surfaces of the inferior ribs near their angles. These are in series with the internal intercostal muscles.

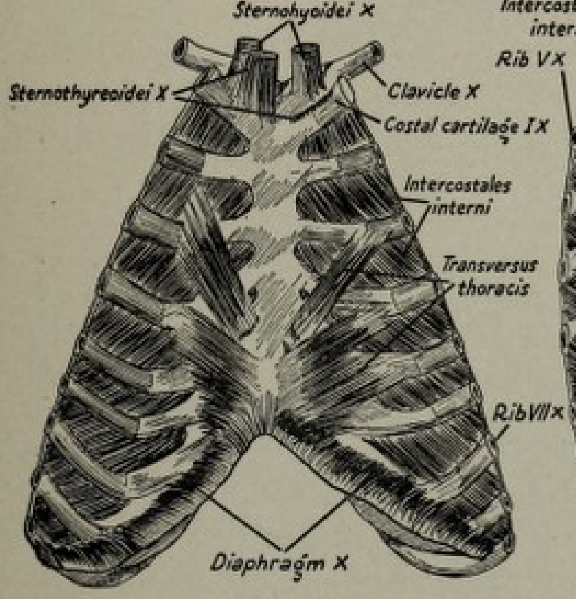


FIG. 130.

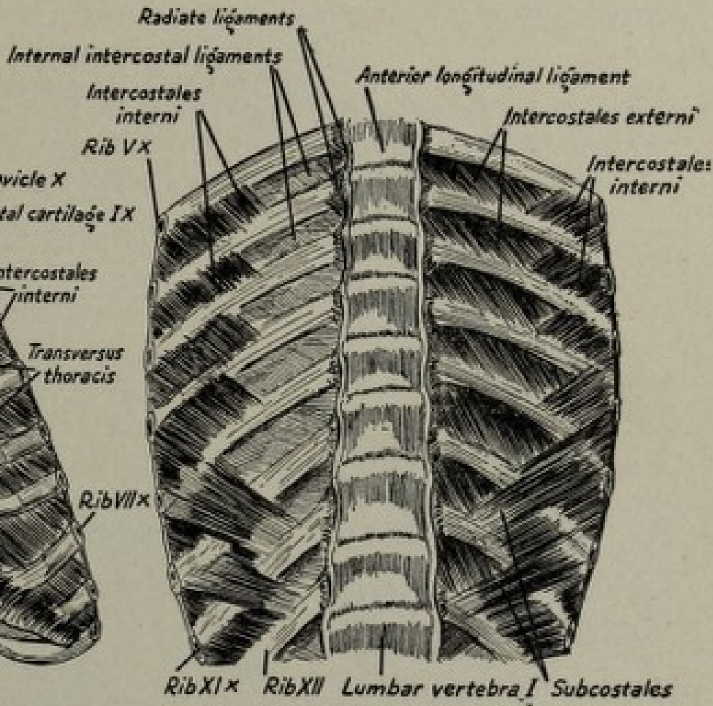


FIG. 131.

FIG. 130.—The sternum, sternal ends of the clavicles and the ribs, with the intercostales, and the transversus thoracis, seen from behind. (*Sobotta and McMurrich.*)

FIG. 131.—The fifth to the twelfth thoracic vertebræ and the vertebral extremities of the corresponding ribs, with the intercostales and subcostales seen from in front. On the left side the intercostal ligaments have been removed. (*Sobotta and McMurrich.*)

The **m. transversus thoracis, or triangularis sterni,** is within the thoracic cavity. It *arises* from the dorsal surface of the xiphoid process and most of the body of the sternum and is *inserted* into the second, third, fourth, fifth and sixth costal cartilages of both sides.

The **diaphragm** (*diaphragma*) is a musculomembranous partition between the thorax and abdomen. The muscular portion *arises* as follows: *dorsally* by *two crura* (*pars lumbalis*) the *right crus arising* from the first, second and third lumbar vertebræ and the left from the first and second lumbar vertebræ; from the *middle arcuate ligament* in front of the aorta; from the *internal arcuate ligament* (*arcus lumbocostalis medialis*) that stretches from the body of the first lumbar vertebra to its transverse process; from the *external arcuate* *ligament* (*arcus lumbocostalis lateralis*) that stretches from the transverse process of the first lumbar vertebra to the apex and lower margin of the twelfth rib. *Ventrally*, the diaphragm *arises* from the dorsal surface of the ensiform cartilage of the sternum (*pars sternalis*) and from the dorsal surface of the six lower costal cartilages; *laterally*, it *arises* from the lower six ribs (*pars costalis*). The muscle fibers are all *inserted* into the central tendon.

The *central tendon* (*centrum tendineum*) consists of three leaflets of which the right is the largest and the left the smallest. There are three chief openings in the diaphragm. The *aortic orifice* (*hiatus aorticus*) is the lowest and most dorsal; it transmits the aorta, the

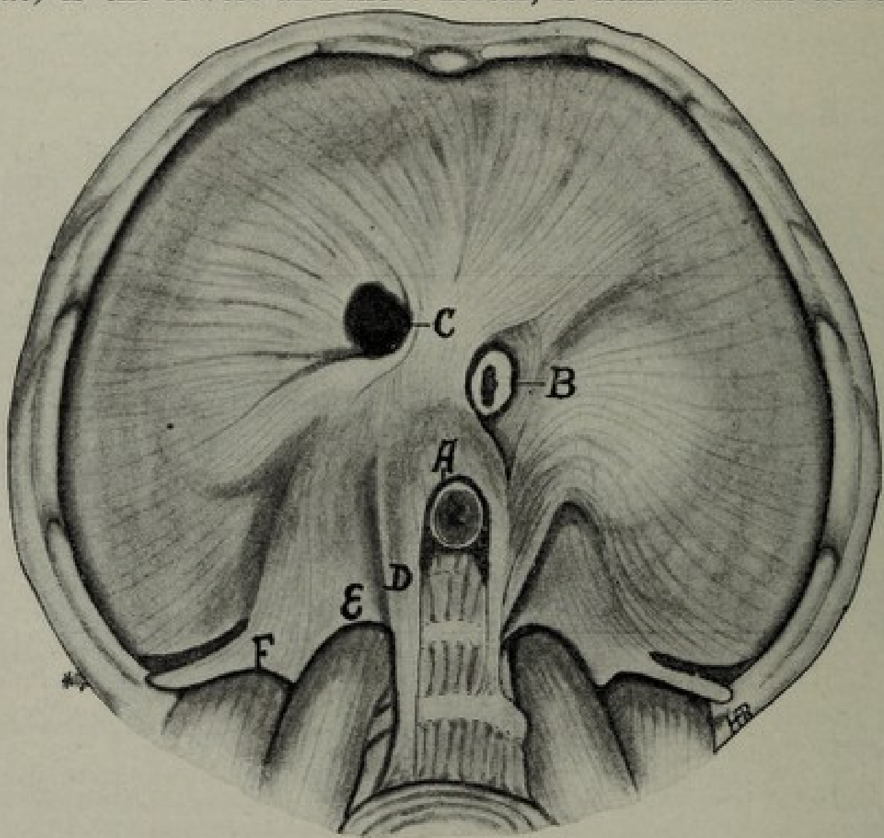


Fig. 132.—The abdominal surface of the diaphragm. *A*, Middle arcuate ligament and aortic orifice; *B*, esophageal orifice; *C*, caval orifice; *D*, right crus; *E*, medial arcuate ligament; *F*, lateral arcuate ligament.

vena azygos major and the thoracic duct. The *esophageal orifice* (*hiatus esophageus*) is to the left of the preceding and at a more ventral level; it transmits the esophagus and vagal nerves. The *caval orifice* (*foramen venæ cavæ*) is the highest and is situated to the right of the midline. It is quadrate in form and transmits the inferior vena cava.

The diaphragm is dome-shaped and when viewed from the side shows that the ventral attachment is at a higher level than the dorsal; when viewed from the front it exhibits two domes of which the right is the higher, reaching the level of the fifth interspace in the midclavicular line; the left dome reaches the level of the sixth left sternochondral junction. The position varies with inspiration and expiration, its excursion at times being as great as 2 inches.

Actions.—Inspiration is accomplished mainly by the diaphragm and intercostal muscles assisted by the mm. scalenei, serrati posteriores, levatores costarum and the subcostal muscles. The *diaphragm depresses* its central tendon and *elevates* the inferior ribs. The *external intercostal muscles elevate* the ribs. The *internal intercostal muscles* are supposed to do the same. The *accessory muscles of inspiration* are the mm. pectorales, quadratus lumborum sternomastoideus, latissimus dorsi, infrahyoid muscles and extensors of the vertebral column.

Expiration is accomplished by the relaxation of the above muscles and elevation of the diaphragm causing the thoracic cavity to become smaller, by the elasticity of the lungs and by the contraction of the abdominal muscles.

THE MUSCLES AND FASCIA OF THE ABDOMEN

The **superficial fascia** of the abdomen contains a variable quantity of fat and consist of a single layer in the superior portion of the abdominal wall. In the groin region it is separable into *two layers*, the *superficial* one of which is continuous with that of the thigh; the *deeper layer* is attached to the inguinal ligament and fascia lata of the thigh thus preventing the passage of fluids from the abdominal wall to the thigh. These fascial layers also pass along the spermatic cord and form part of the scrotum.

The **deep fascia** is closely applied to the muscles even investing some. It is variable in its thickness in different regions.

The abdominal cavity side of the muscles is covered by fascia that is named according to the muscle covered (transversalis, quadratus lumborum, psoas, diaphragmatic). At the thigh it forms the *femoral sheath* for the femoral vessels and at the inguinal ring the *infundibuliform fascia*. Upon the deep surface of this fascia are the extraperitoneal tissue and the peritoneum.

The **extraperitoneal tissue** usually contains a great quantity of fat in which are embedded the extraperitoneal abdominal organs. The *peritoneum* is a serous membrane that lines the abdominal cavity and invests some organs completely, some incompletely and others not at all.

The **m. obliquus externus abdominis** is broad and thin and *arises* from the eight inferior ribs interdigitating with the mm. serratus anterior and latissimus dorsi. It is *inserted* into the ventral half of the external iliac crest and aponeurosis by means of which it is attached to the xyphoid process, the linea alba and the symphysis pubis. This *aponeurosis* is extensive forming various ligaments and assisting in forming the external abdominal ring.

The **inguinal ligament** (*lig. inguinale Pouparti*) is the inferior margin of the aponeurosis of the m. obliquus externus abdominis and extends from the ventral superior spine of the ilium to the tubercle of the pubis. It affords attachment to some muscles and also forms the floor of the inguinal canal.

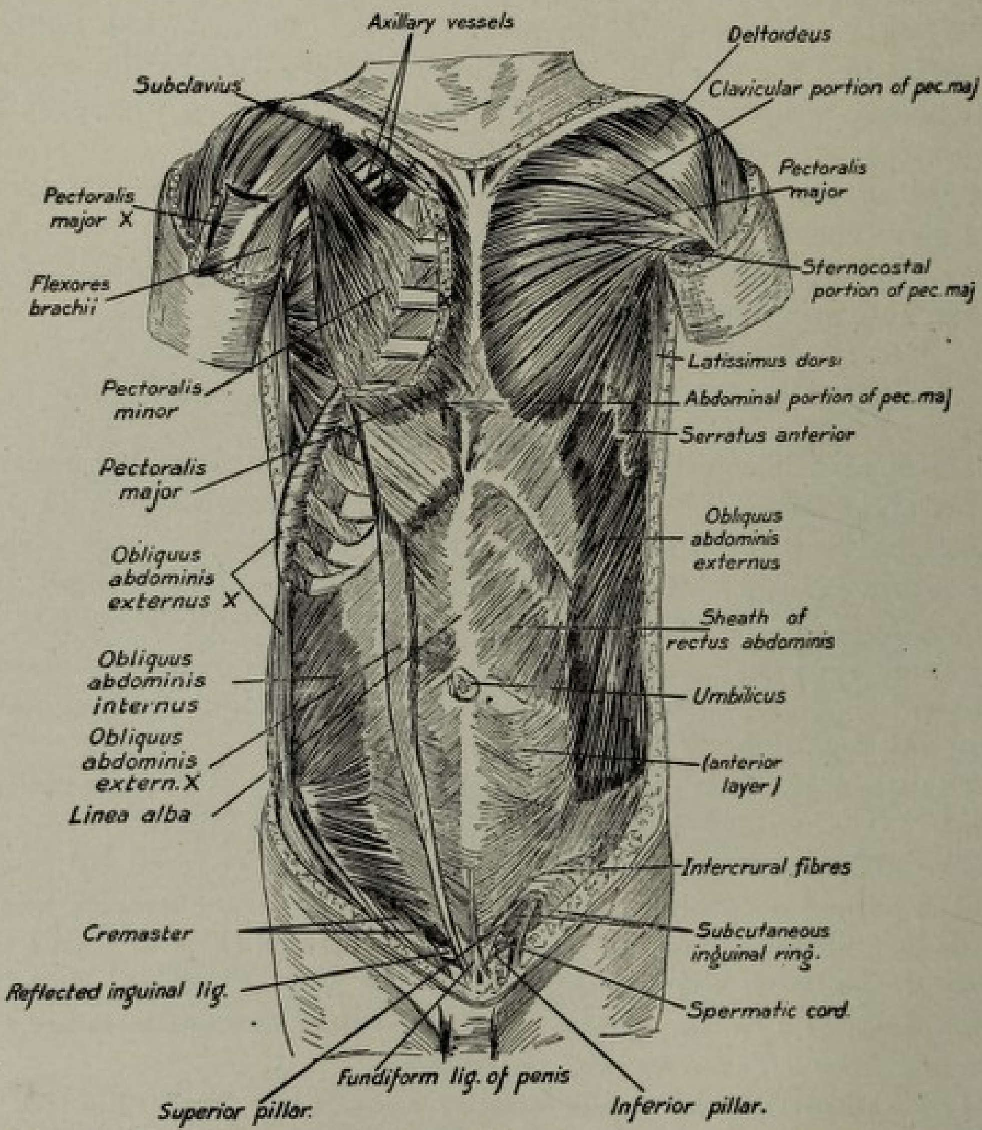


FIG. 133.—Superficial and second layers of the abdominal and pectoral muscles seen from in front. On the right side the pectoralis major and the obliquus abdominis externus have been removed. (*Sobotta and McMurrich.*)

The **lig. lacunare,** or *Gimbernat's lig.*, is a triangular reflection of the medial extremity of the inguinal ligament toward the iliopectineal line.

The **subcutaneous inguinal ring,** or **external abdominal ring,** is just over the tubercle of the pubis and through it pass the spermatic cord, or round ligament of the uterus, and the cremaster muscle and its fascia. The margins of the ring are called the *crura* and these are thin. From the margins of the ring a thin tubular sheath of fascia, the *intercolumnar*, or *external spermatic fascia*, passes over the spermatic cord.

The **reflex inguinal ligament of Colles,** or the *triangular fascia*, consists of fascial fibers from the opposite side that are attached to the crest and tubercle of the pubis.

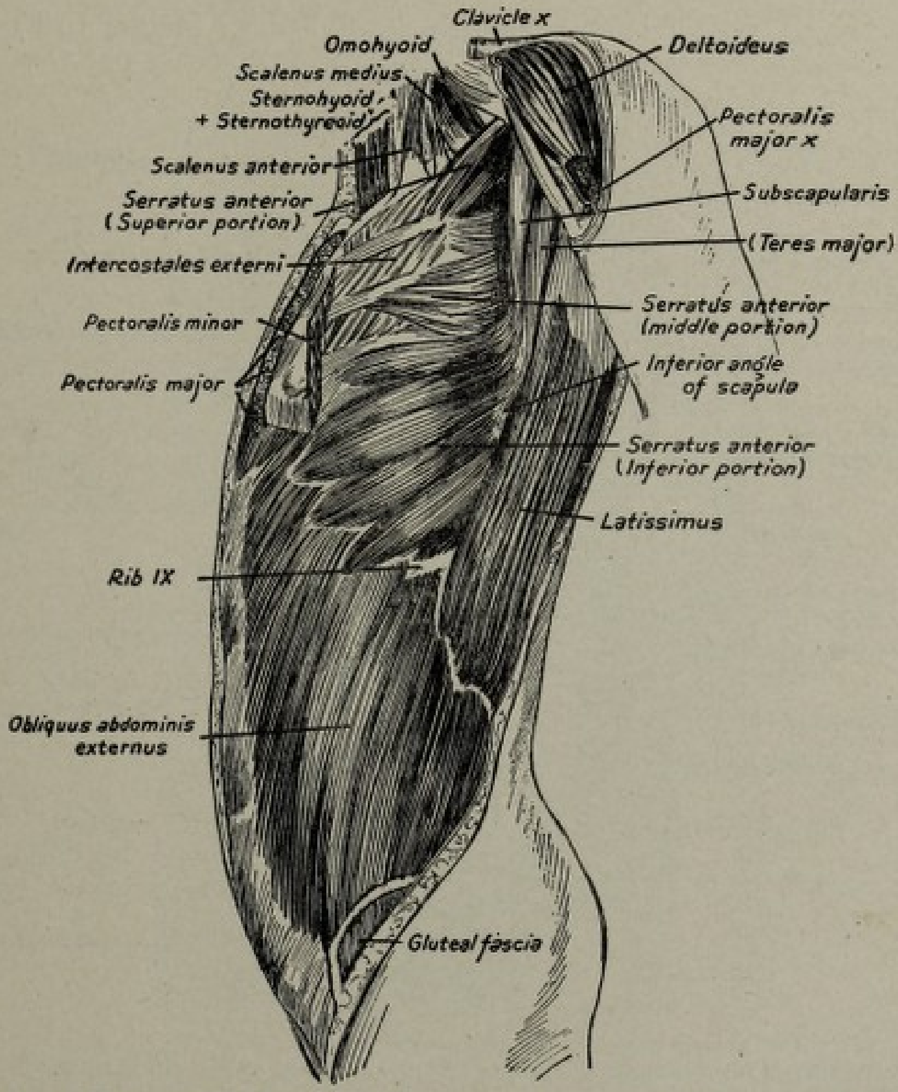


FIG. 134.—The superficial layer of the abdominal muscles and the serratus anterior seen from the left side. The pectoralis major and minor and the inner portion of the clavicle have been removed and the arm has been drawn backward. (*Sobotta and McMurrich.*)

The **m. obliquus internus abdominis,** broad and thin, *arises* from the lumbodorsal fascia, the ventral two-thirds of the iliac crest and from the lateral portion of the inguinal ligament. Its fibers are directed superiorly and medially, the *superior ones* are *inserted* into the three lower ribs and the *remainder* are *inserted* into an aponeurosis that joins that of the external oblique and transversalis muscles. This *conjoined fascia* splits to envelop the rectus abdominis muscle forming, at the lateral margin of the muscle the *linea semilunaris* and at the medial margin the *linea alba*. The inferior margin of the aponeuroses is joined by fibers from the transversalis fascia forming the *conjoined tendon*, or *falx aponeurotica inguinalis;* this is attached to the pubic crest and iliopectineal line.

The **m. cremaster** *arises* from the inferior margin of the internal oblique muscle and is *inserted*, in part, to the tubercle of the pubis.

The **m. transversus abdominis** *arises* from the deep surfaces of the lower six costal cartilages, the lumbosacral fascia, the medial

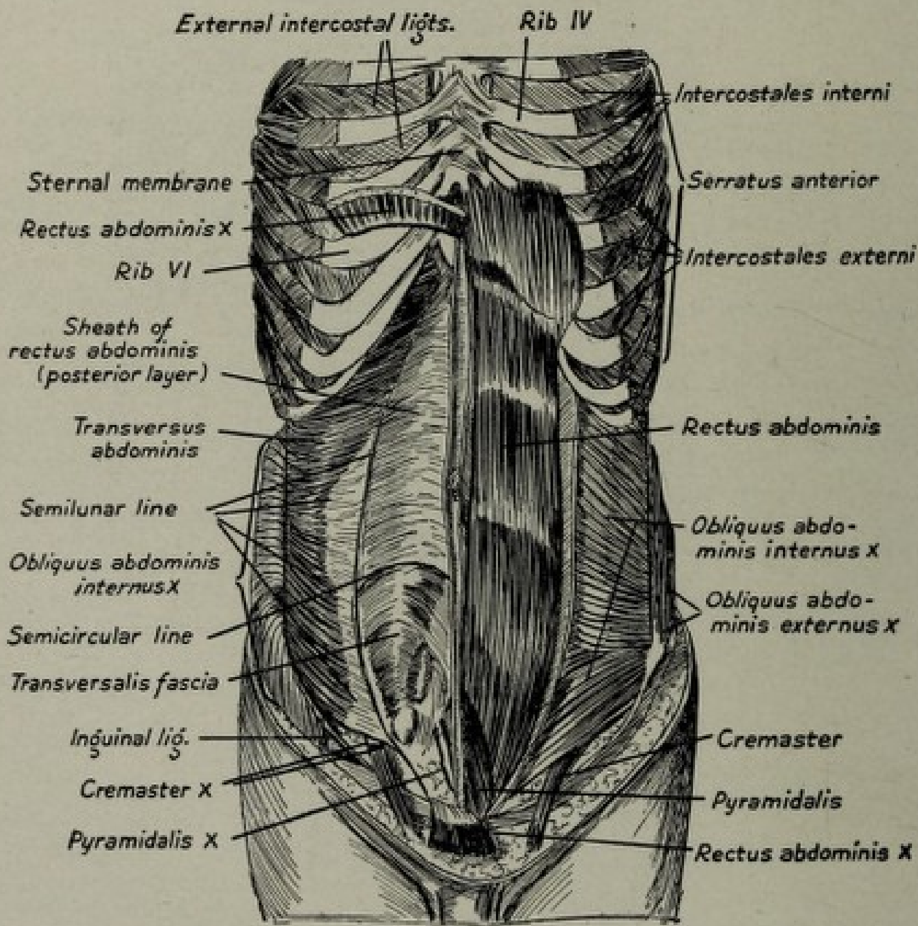


FIG. 135.—The deeper layers of the abdominal muscles. On the left side the anterior layer of the sheath of the rectus abdominis and the obliquus abdominis externus have been removed; on the right side, in addition, the rectus abdominis, the pyramidalis, and the obliquus abdominis internus. The external intercostal ligaments have been removed on the left side. (*Sobotta and McMurrich.*)

crest of the ilium and from the lateral part of the inguinal ligament. After a horizontal course the fibers are *inserted* into an aponeurosis that joins that of the internal oblique to form the sheath of the rectus muscle; this aponeurosis is *inserted* into the xyphoid cartilage, the linea alba and the crest of the pubis. The *inferior fibers form the conjoined tendon* described above.

The **m. pyramidalis abdominis** is small and *arises* from the pubic crest and is *inserted* into the ilea alba.

The **m. rectus abdominis** *arises* from the symphysis and crest of the pubis and is *inserted* into the ventral surface of the xyphoid process and of the fifth, sixth and seventh costal cartilages. The muscle is divided transversely by three or more tendinous bands, the *inscriptiones tendineæ*. The lateral margin of the muscle is indicated by the *linea semilunaris*. At this line the abdominal aponeurosis splits to form the two layers of the rectus sheath. The in-

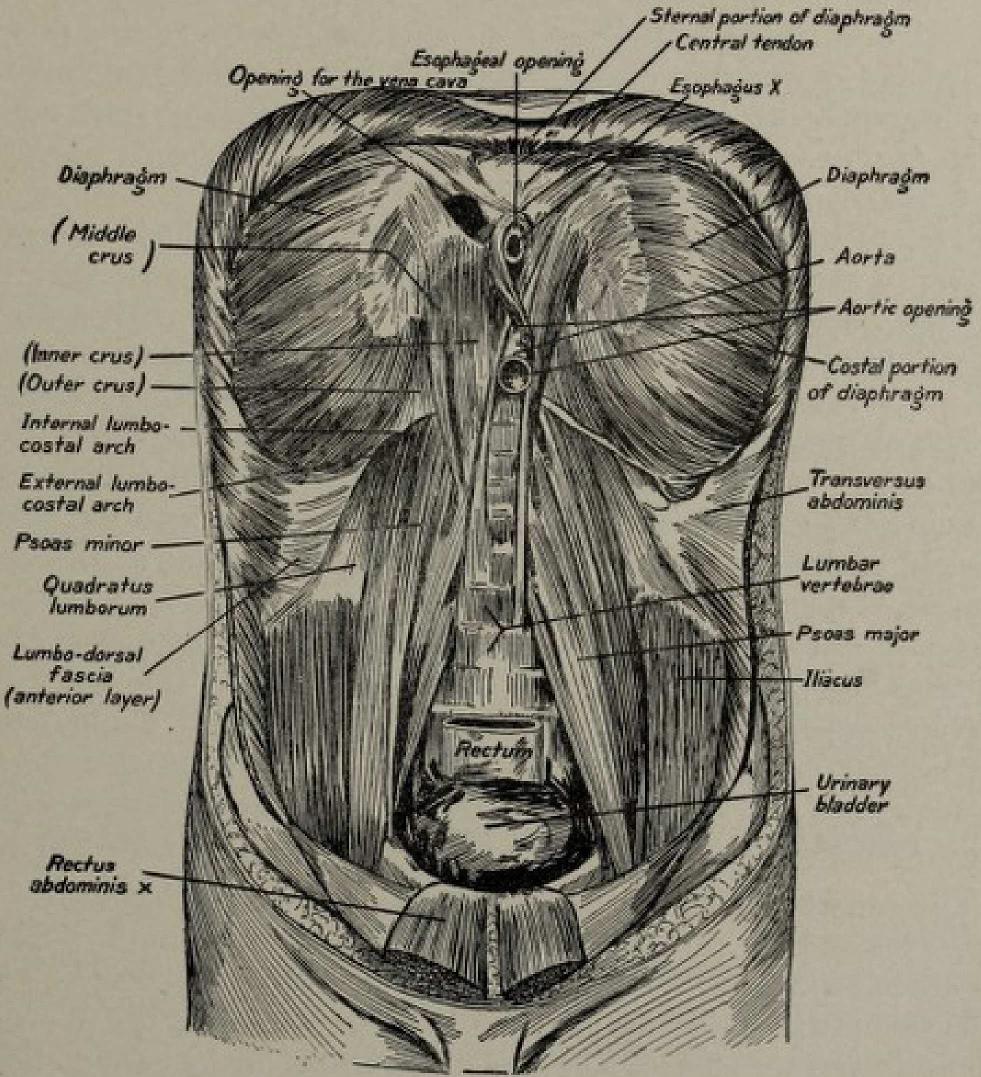


FIG. 136.—The diaphragm and the muscles of the dorsal abdominal wall. The ventral abdominal wall and the abdominal viscera have been removed; the thorax has been bent backward so that the lumbar vertebræ are strongly convex forward. (*Sobotta and McMurrich.*)

ferior portion of the dorsal layer of the sheath is not present and the *linea semicircularis* marks the inferior limit of the layer.

The **inguinal canal** (*canalis inguinalis*) begins at the abdominal inguinal ring and continues to the subcutaneous inguinal ring. The *abdominal*, or *internal ring*, lies about 1 cm. superior to the middle of the inguinal ligament. The *floor* of the canal is formed by the inguinal ligament; the *ventral wall* by the aponeurosis of the external oblique and the muscle fibers of the internal oblique; the *dorsal wall* consists of the transversalis fascia and falx aponeurotica inguinalis (conjoined tendon). At the abdominal ring is the *infundibuliform*, or *internal spermatic fascia*. In the canal lies the spermatic cord and it is invested by the infundibuliform, cremasteric and intercolumnar fasciæ.

The triangular area between the inguinal ligament, inferiorly, the rectus abdominis, medially, and the inferior epigastic artery, laterally is called *Hesselbach's triangle*. A hernia at this point is called a *directing ing. hernia*, whereas when the intestine traverses the inguinal canal and appears at the subcutaneous ring then it is an *oblique ing. hernia*.

Actions.—To *compress* the abdominal wall as in defecation, vomiting, micturition, parturition and deep respiration. They also act as *flexors* of the vertebral column and pelvis.

Nerve Supply.—Pyramidalis from the last thoracic nerve; the cremaster from the genitofemoral (L. 1, 2); the remainder are supplied by the ventral rami of the last six thoracic nerves.

The **m. quadratus lumborum** *arises* from the dorsal portion of the iliac crest from the transverse processes of the lower lumbar vertebræ and from the iliolumbar ligament; it is *inserted* into the inferior margin of the last ribs and the transverse processes of the upper lumbar vertebræ.

Action.—*Assists in inspiration* and *flexion* and *extension* of the vertebral column.

Nerve Supply.—Branches from the ventral rami of the first three lumbar nerves.

FASCIA AND MUSCLES OF THE PERINEUM AND PELVIS

The **superficial fascia** extends into the scrotum to form there the *dartos fascia* and the *scrotal septum*, in the male, while in the female it assists in forming the *mons veneris* and *labia majora*, containing considerable fat in the latter places. It also passes over the penis and connects with the superficial fascia of the thigh, buttocks and abdominal wall. In the dorsal part of the perineum there is a considerable space between the rectum and ischium on each side and this constitutes the *ischiorectal fossa* which is filled with a mass of fat contained in the superficial fascia here. Ventrally, the superficial fascia comprises *two layers* as in the groin. The *superficial layer* is continuous with that of abdomen and thigh. The *deeper layer* is attached to the pubic arch, the fascia of the urinogenital diaphragm and to the root of the penis and the scrotal septum. The attachment of this layer prevents the urine that extravasates, when the perineal portion of the urethra is ruptured, from entering the thigh and the ischiorectal fossa.

The **deep fascia** is thin and tends to invest the muscles. In the midline of the perineum about 1 cm. ventral to the anal canal, there is a fibrous area called the *central tendinous point of the perineum* and four muscles are here attached.

The **m. sphincter ani externus** is a flattened, spindle-shaped muscle around the anus and anal canal connected ventrally with other muscles at the central tendinous point and dorsally it is connected with anococcygeal ligament.

Action.—Closes the anus voluntarily.

Nerve Supply.—By the third and fourth sacral nerves through the pudendal and perineal nerves.

The **m. corrugator cutis ani** are radiating bundles of smooth muscle tissues at the margin of the anal opening and superficial to the external sphincter.

The **m. transversus perinei superficialis** is a variable muscle. When present, it *arises* from the inferior ramus of the ischium and the fascia of the urinogenital diaphragm: it is *inserted* into the central point of the perineum.

Action.—They *fix* the central tendinous point of the perineum.

Nerve Supply.—Deep perineal branch of the pudendal nerve (S. 3, 4).

The **m. bulbocavernosus,** or **accelerator urinæ** of the male, surrounds the root of the penis, the bulb of the urethra and the corpus spongiosum, in the male. It *arises* from the central point of the perineum and median raphé and the fibers are *inserted* into the fascia of the urinogenital diaphragm, the dorsal surface of the corpus cavernosum and into the fascia of the dorsum of the penis.

The **bulbocavernosus,** or **sphincter vaginæ** of the female *arises* from the central point of the perineum and is *inserted* into the root of the clitoris somewhat as in the male.

Action.—Compresses the urethra in the emission of semen and urine and *assists in the erection of the penis* in the male. In the female it *contracts the vaginal orifice* and *compresses* the bulb of the vestibule.

Nerve Supply.—Deep branch of the perineal nerve (S. 3, 4).

The **m. ischiocavernosus,** or **erector penis,** invests the crus penis of the male. It *arises* from the tuberosity of the ischium and is *inserted* to the fascia of the crus penis and to the corpus cavernosum of the penis.

The **m. ischiocavernosus,** or **erector clitoridis,** of the female is smaller and similar in attachments.

Action.—Erection of penis or *clitoris.*

Nerve Supply.—Deep branch of the perineal nerve (S. 3, 4).

The **urinogenital diaphragm** comprises several muscles and two layers of fascia.

The **m. sphincter urethræ membranaceæ** *arises* from the inferior pubic ramus and is *inserted* into the median raphé partly ventral and partly dorsal to the urethra.

The **m. transversus perinei profundus** *arises* from the inferior ramus of the ischium and is *inserted* into the median raphé.

The **m. sphincter urethræ** in the female is smaller and some of the fibers are *inserted* into the side of the vagina with the transversus perinei profunda.

Action.—Slight compression of the urethra and *slight constriction* of the vagina.

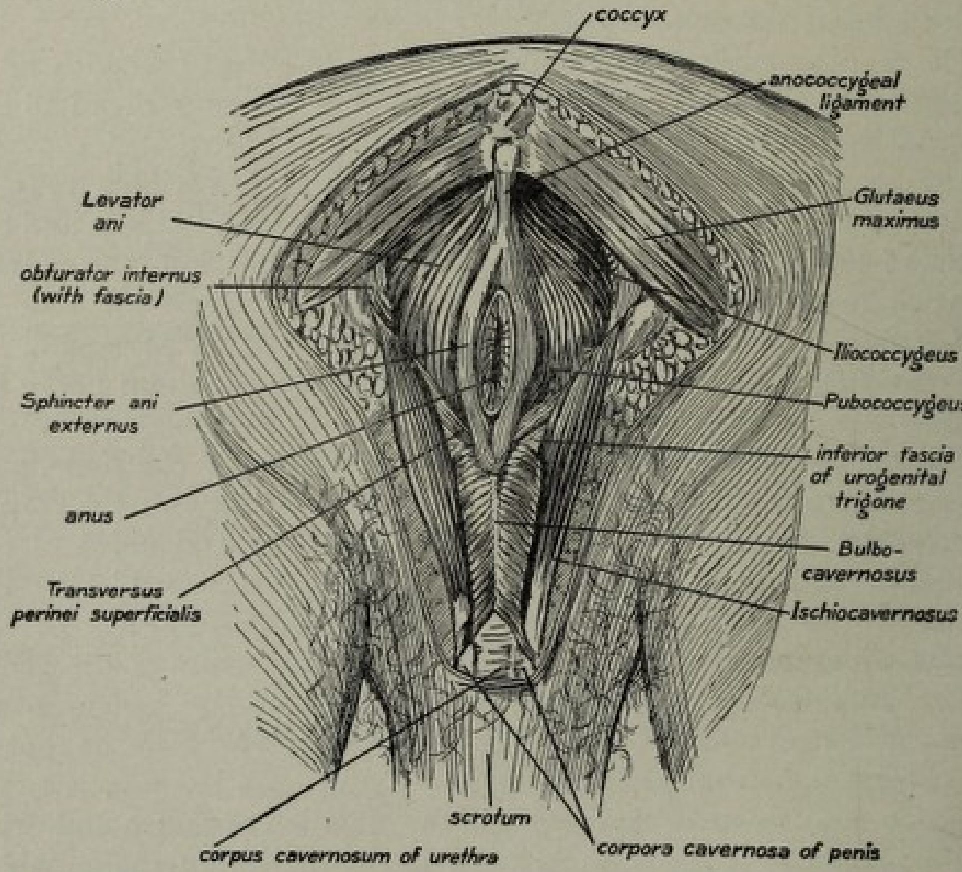


FIG. 137.—Superficial muscles of the male perineum. (*Sobotta and McMurrich.*)

The **fascial portion** constitutes the **fascia urinogenitalis diaphragmatis inferior et superior.** The **inferior fascia,** or **superficial layer of the triangular ligament,** fills in the pubic arch and is about 3.5 cm. in height. Between its apex and the subpubic ligament passes the dorsal vein of the penis. Laterally the fascia is attached to the rami of ischium and pubis. This fascial layer is perforated by the urethra, ducts of Cowper's glands and various arteries, veins and nerves. In the female this fascia is not as strong and it is pierced by the vagina. The **deep layer,** or **fascia diaphragmatis urinogenitalis superior** is a portion of the pelvic fascia and is perforated by the urethra. Between its two layers are found the dorsal vein of the penis, the membranous part of the urethra, the bulbocavernosus muscle, the glands of Cowper and their ducts and arteries, veins and nerves in the male. In the female the dorsal nerve and vessels of the clitoris, a part of the urethra, the bulbocavernosus muscle, the glands of Bartholin, the vestibular bulbs and arteries, veins and nerves.

The **pelvic fascia** (*fascia pelvina*) forms a lining for the pelvic cavity and an investment for the muscles here. It is connected, superiorly, with the fascia of the abdominal cavity while inferiorly, it is attached to the bony and ligamentous boundary of the inferior pelvic outlet. Different portions have been given special names; that portion in relation with the pyriformis muscle is the *pyriformis fascia* while the *obturator fascia* is in relation with the m. obturator internus. The *fascia diaphragmatis urinogenitalis superior* has already been discussed, and with the various muscles previously discussed constitutes the *ventral portion of the pelvic floor*. The *dorsal part of the floor* consists of the mm. levatores ani and the anal fascia, the perineal body and the anococcygeal body. The *white line*, or *tendinous arch*, is a taut band of fascia that extends from the dorsal surface of the symphysis pubis to the ischial spine. The pelvic fascia also forms the true ligaments of the bladder and the sheath of the prostate gland.

The **m. levator ani** *arises* from the dorsal surface of the body of the pubis, the tendinous arch and the spine of the ischium. It is *inserted* into central tendon of the perineum into the external sphincter, to the anococcygeal ligament and to the sides of the lower coccygeal segments.

Actions.—*Supports* and *raises* the pelvic floor; *assists* in defecation; *elevates* the prostate gland, or *contracts* the vagina; *assists* in childbirth.

Nerve Supply.—Directly by the third and fourth sacral nerves and by branches from the perineal nerve.

The **m. coccygeus** *arises* from the spine of the ischium and the sacrospinous ligament. It is *inserted* into the lateral aspect of the inferior portion of the sacrum and the superior part of the coccyx.

Action.—Mainly to *assist* the levator ani in supporting the pelvic floor.

Nerve Supply.—By the third and fourth sacral nerves.

THE SUPERIOR EXTREMITY OR PECTORAL APPENDAGE

Fascia and Muscles of the Pectoral Region.—The **superficial fascia** is thin and contains a variable quantity of fat and the mammary glands.

The **deep fascia** invests the pectoral muscles and connects with the abdominal fascia. Medially, it is attached to the sternum, superiorly, to the clavicle and laterally, forms the axillary fascia. This fascia forms the *costocoracoid membrane* and *ligament*. The *costocoracoid membrane* is a layer of the deep fascia extending from the superior margin of the m. pectoralis minor to the clavicle. This layer, before it reaches the clavicle, splits to envelop the m. subclavius and then it is attached to the inferior surface of the clavicle. Medially,

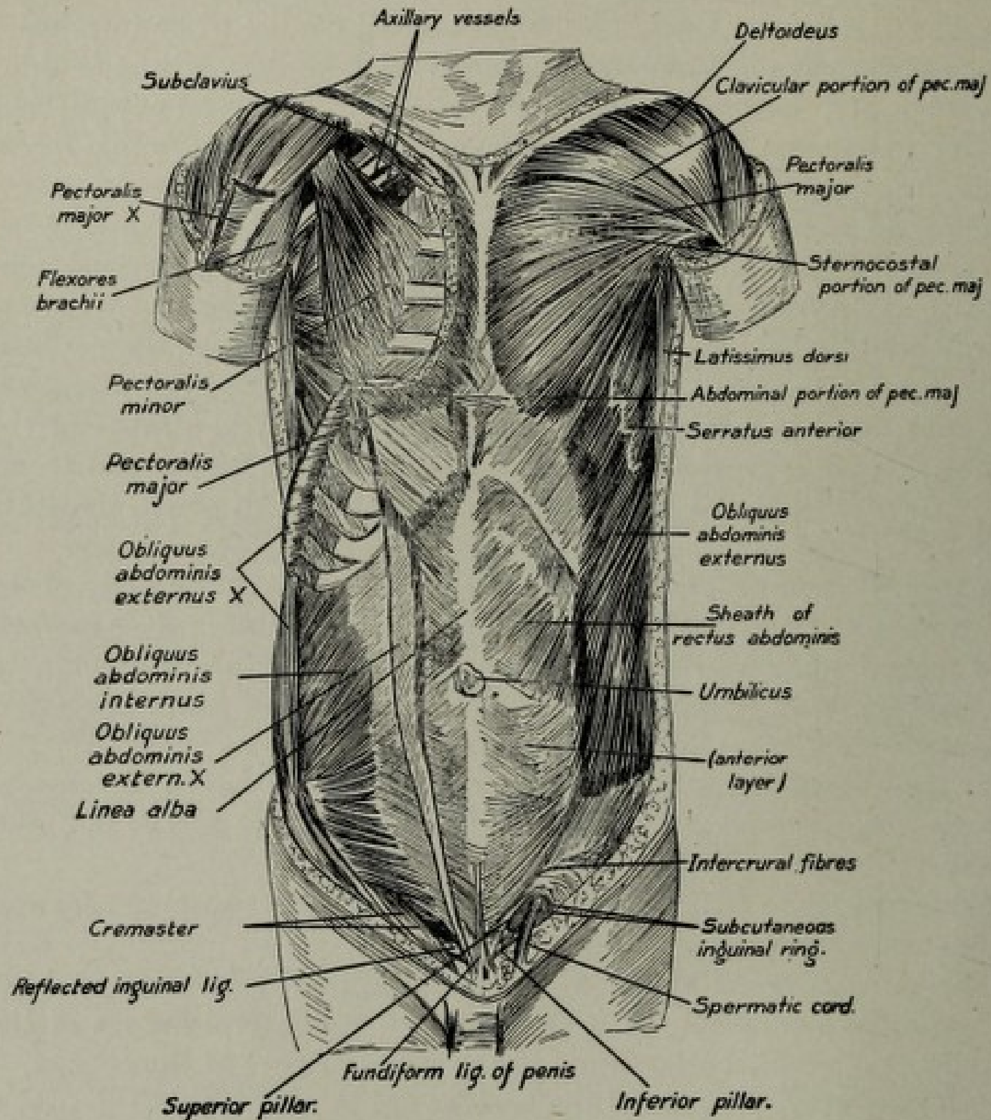


FIG. 138.—Superficial and second layers of the abdominal and pectoral muscles seen from in front. On the right side the pectoralis major and the obliquus abdominis externus have been removed. (*Sobotta and McMurrich.*)

this membrane is attached to the first costal cartilage and laterally to the coracoid process and as this part of the membrane is quite well developed it is called the *costocoracoid ligament*. The membrane is pierced by the cephalic vein, the branches of the lateral ventral thoracic nerve and thoracoacromial artery and vein.

The **m. pectoralis major** is large and fan-shaped, *arises* from the sternal half of the ventral margin of the clavicle, from the ventral surface of the sternum and the first six costal cartilages and, a small part, from the aponeurosis of the external oblique muscle. It is *inserted* as a rather broad thick tendon into the lateral margin of the intertubercular sulcus, or bicipital groove. The clavicular part of the muscle forms the inferior part of the tendon while the costosternal portion forms the superior part.

Action.—Assists in drawing the arm to the side of the thorax; *adduction* and *medial*, or *inward rotation* while bringing the arm across the ventral part of the thorax.

Nerve Supply.—Lateral ventral thoracic nerve, from the lateral cord of the brachial plexus (C. 5, 6, 7) and the medial ventral thoracic nerve from the medial cord of the brachial plexus (C. 8, T. 1).

The **m. pectoralis minor,** small and triangular, *arises* from the ventral surfaces of the chondral extremities of the third, fourth and fifth ribs and the third and fourth intercostal fasciæ; it is *inserted* into the margin of the coracoid process near the origin of the mm. biceps and coracobrachialis.

Action.—Depresses and *draws* the shoulder forward.

Nerve Supply.—Same as pectoralis major.

The **m. subclavius** *arises* from the superior surface of the first costal cartilage and sternal end of the first rib and is *inserted* into the subclavian groove on the inferior surface of the clavicle.

Action.—Depresses the clavicle and shoulder and *assists in inspiration* by fixing the first rib.

Nerve Supply.—Branch from the brachial plexus (C. 5, 6).

The **m. serratus anterior,** or **serratus magnus,** *arises* by eight or nine digitations from the first eight ribs and is *inserted* into the vertebral margin and ventral surfaces of the superior and inferior angles of the scapula.

Action.—Draws the scapula forward, assists in rotating the scapula and is an important muscle in *inspiration.*

Nerve Supply.—The long thoracic nerve (from the ventral rami of the fifth, sixth and seventh cervical nerves).

MUSCLES OF THE SHOULDER REGION

The **m. deltoideus,** a large multipennate muscle, *arises* from the lateral third of the ventral margin of the clavicle, from the lateral margin of the acromion, from the inferior margin of the spine of the scapula and from the fascia covering the infraspinatus muscle. It is *inserted* into the deltoid tubercle of the shaft of the humerus.

Action.—Abducts the humerus to a right angle with the glenoid fossa of the scapula. *Assists in drawing* the arm forward (ventrally) and backward (dorsally).

Nerve Supply.—Axillary, or circumflex nerve (C. 5, 6).

The **m. supraspinatus** *arises* from the bulk of the supraspinous fossa and the fascia covering the muscle and is *inserted* into the proximal facet of the greater tubercle of the humerus and into the capsular ligament.

Action.—Assists the deltoid in *abducting* the arm.

Nerve Supply.—Suprascapular nerve (C. 5, 6).

The **m. infraspinatus** *arises* from the bulk of the infraspinous fossa and the fascia covering it and is *inserted* into the middle facet of the greater tubercle of the humerus.

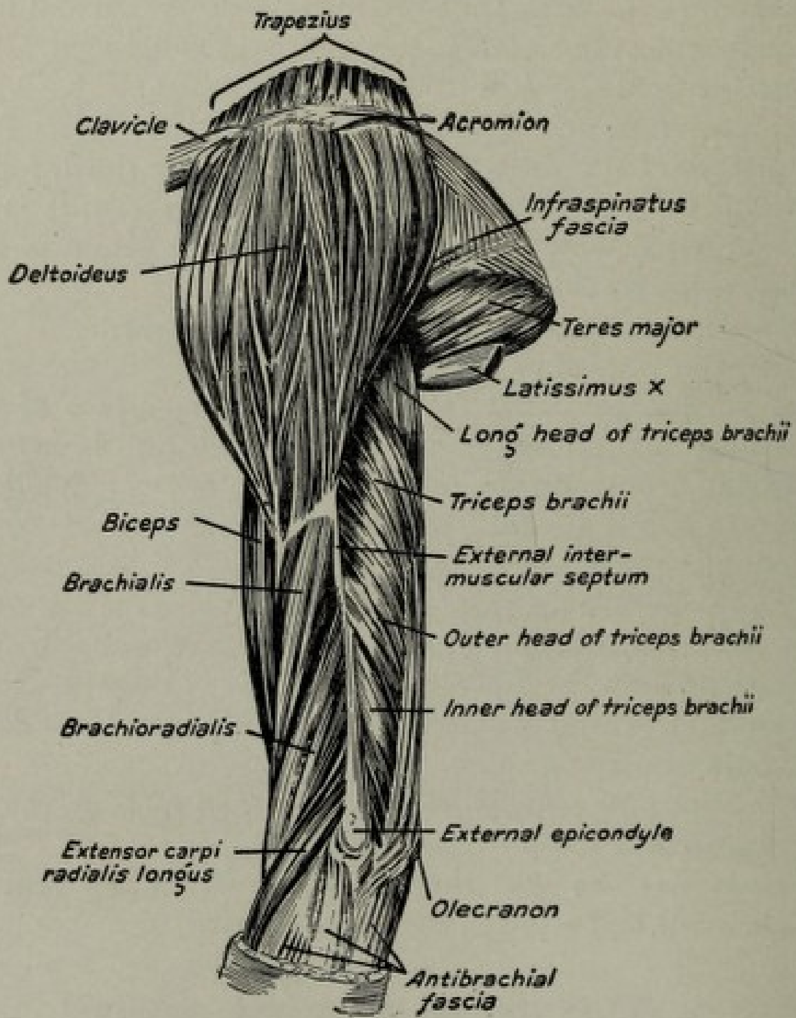


FIG. 139.—The deltoid and muscles of the upper arm seen from the side. (*Sobotta and McMurrich.*)

Action.—Assists in abducting the arm and when raised *assists in drawing* the arm dorsally.

Nerve Supply.—Suprascapular nerve (C. 5, 6).

The **m. teres minor** *arises* from the dorsal surface of the axillary margin of the scapula (proximal two-thirds) and the intermuscular septa and is *inserted* into the distal facet of the greater tubercle of the humerus.

Action.—Rotates the humerus laterally.

Nerve Supply.—Axillary, or circumflex nerve (C. 5, 6).

The **m. teres major** *arises* from the inferior third of the dorsal aspect of the axillary margin of the scapula and from the intermuscular septa and is *inserted* into the medial margin of the intertubercular sulcus (bicipital groove) of the humerus.

With the margins of the teres minor and subscapularis muscles and the neck of the humerus, the teres major forms a triangular space. The long head of the triceps muscle divides this into a *medial, quadrilateral space,* transmitting the axillary nerve and the posterior circumflex artery and a *lateral, triangular space,* transmitting the circumflex scapulæ artery.

Action.—*Rotates* the humerus medially.

Nerve Supply.—Lower scapular nerve (C. 5, 6).

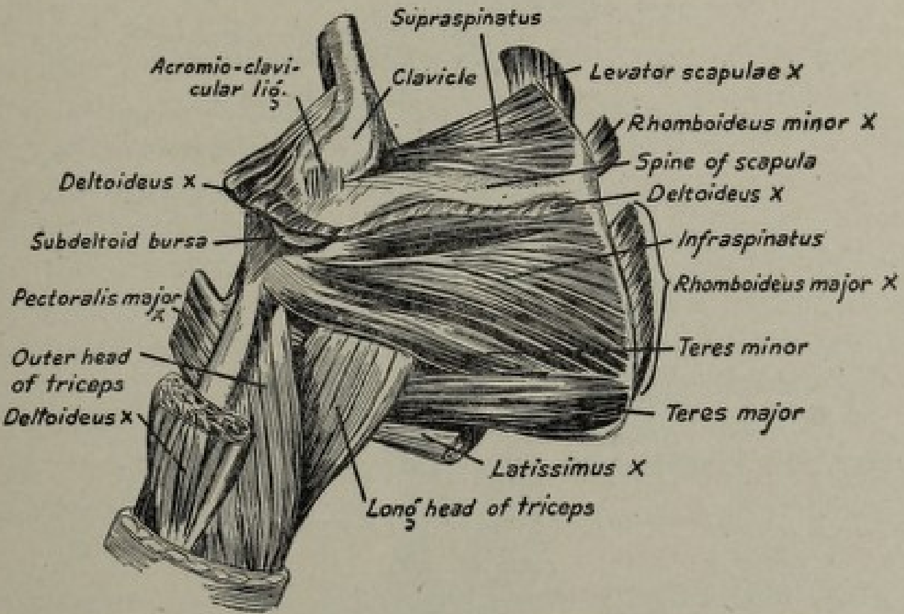


FIG. 140.—The muscles of the dorsal surface of the left scapula and the neighboring portion of the extensor surface of the upper arm. The deltoid has been removed with the exception of its origin and insertion; portions of the dorsal muscles inserting into the vertebral border of the scapula and also of the latissimus dorsi and pectoralis major have been retained. (*Sobotta and McMurrich.*)

The **m. subscapularis** *arises* from the entire subscapular fossa and is *inserted* into the lesser tubercle of the humerus and into the capsular ligament and even into the surgical neck of the bone.

Action.—*Medial rotator* of the humerus and *assists in drawing* the arm ventrally.

Nerve Supply.—Long and short subscapular nerves (both C. 5, 6).

FASCIA AND MUSCLES OF THE ARM

The **superficial fascia** is thin and presents a bursa over the olecranon.

The **deep fascia** is continuous with that of the shoulder muscles and the axilla and with that of the forearm. It sends in a medial septum, that separates the brachialis muscle from the medial head of the triceps, and a thin lateral septum, that separates the brachialis and brachioradialis muscles from the triceps, behind. These septa are only in the distal half of the arm and are attached to the epicondyles distally.

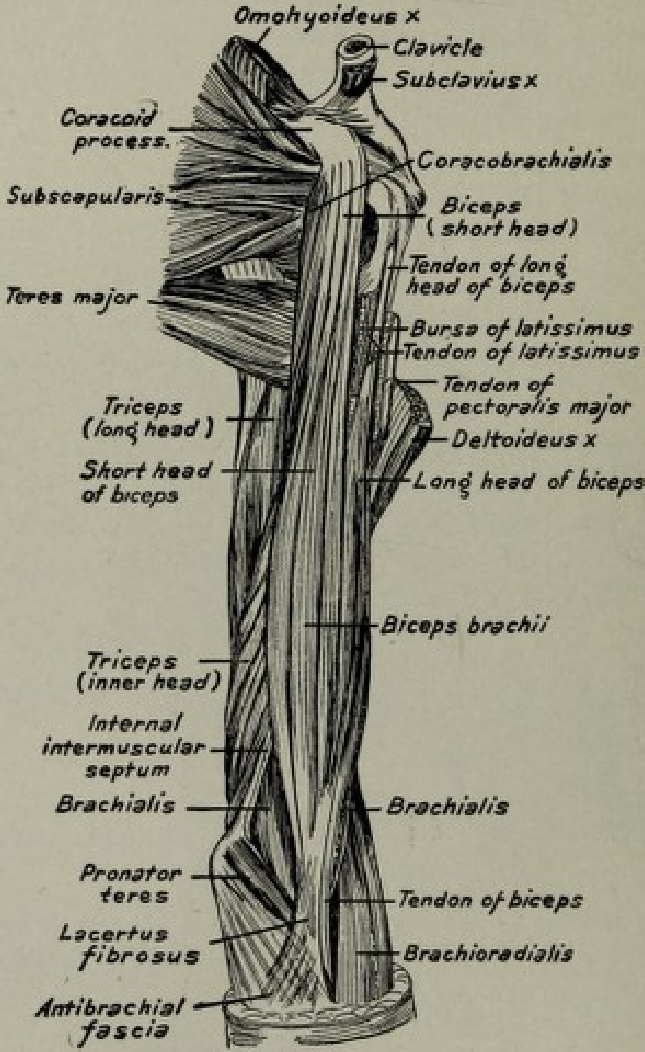


FIG. 141.—The muscles of the flexor surface of the upper arm, superficial layer. The deltoid has been removed. (*Sobotta and McMurrich.*)

The **m. coracobrachialis** *arises* in common with the short head of the biceps muscle, from the tip of the coracoid process of the scapula and is *inserted* about the middle of the medial margin of the humerus.

Action.—*Assists* the biceps in *raising* and *drawing* the arm medially.

Nerve Supply.—Musculocutaneous nerve (C. 7).

The **m. biceps brachii** *arises* from the tip of the coracoid process (*short head*, or *caput breve*) and from the supraglenoid tuberosity and glenoid ligament (*long head*, or *caput longum*). The *latter tendon* passes through the shoulder joint and into the bicipital groove and then forms a fleshy belly that lies beside the belly from the short head; these form a common tendon that is *inserted* into the dorsal surface of the tubercle of the radius. The *bicipital fascia* (*lacertus fibrosus*) is a strong fascial band that arises from the tendon in front of the elbow joint and passes medially to join the deep fascia of the forearm.

Action.—*Draws* the humerus *forward* at the shoulder joint, *flexes* the elbow joint and *supinates* the forearm.

Nerve Supply.—The musculocutaneous nerve (C. 5, 6).

The **m. brachialis (anterior)** *arises* from the distal two-thirds of the ventral surface of the humerus and the intermuscular septa and is *inserted* into the ventral ligament of the elbow joint and the coronoid process of the ulna.

Action.—*Flexes* the forearm at the elbow.

Nerve Supply.—Musculocutaneous nerve (C. 5, 6) and radial nerve (C. 5, 6).

The **m. triceps brachii,** the only dorsal muscle of the arm, *arises* by *three heads*. The **long head (caput longum)** *arises* from the infraglenoid tuberosity of the scapula; the **lateral head** *arises* from the lateral margin (proximal one-third) and the intermuscular septa; the **medial head** has the most extensive *origin* from the dorsal surface of the shaft of the humerus and the intermuscular septa. The common tendon is *inserted* into the tip of the olecranon process of the ulna and into the deep fascia of the forearm on each side of this.

Action.—Mainly an *extensor* of the forearm; the long head may *assist* in adducting the humerus at the shoulder-joint.

Nerve Supply.—Branches from the radial nerve of the dorsal cord of the brachial plexus (C. 6, 7, 8).

FASCIÆ AND VENTRAL MUSCLES OF THE FOREARM AND HAND

The **superficial fascia** is as usual containing fat and the superficial vessels and nerves. It contains one muscle in the palm.

The **m. palmaris brevis,** in the medial side of the palm, *arises* from the medial margin of the central palmar aponeurosis and is *inserted* into the skin of the medial border of the hand. It wrinkles the skin here, when acting, and deepens the hollow of the hand.

The **deep fascia** is quite strong at the elbow region due to reinforcement from the tendon of the biceps and triceps muscles. It sends in intermuscular septa one of which is attached to the dorsal margin of the ulna. At the wrist it is strengthened by transverse bands that form important ligaments. The *transverse carpal*, or *anterior annular ligament* (*lig. carpi transversum*), is a broad band stretching between the navicular and greater multangular bones, laterally, and the pisiform and hamate bones, medially. This holds the flexor tendons and median nerve in place. The space between the bones and the ligament is divided into *two compartments*, the *larger* for the flexor tendons of the digits and the median nerve, and the *smaller* for the flexor carpi radialis tendon. *Three synovial sheaths* lie beneath this ligament.

The *dorsal carpal*, or *posterior annular ligament* (*lig. carpi dorsale*), is another broad ligamentous band upon the dorsal surface of the wrist joint. Beneath it are *six compartments* each lined with a synovial membrane. These are, lateromedially, as follows: (*a*) mm. abductor pollicis longus and extensor pollicis brevis; (*b*) mm. extensores carpi radialis longus and brevis; (*c*) m. extensor pollicis longus; (*d*) mm. extensores digitorum communis and indicis proprius; (*e*) m. extensor digiti quinti proprius; (*f*) m. extensor carpi ulnaris.

In the palm the *deep fascia* constitutes the *palmar aponeurosis.* The *medial part* of this is the largest and most extensive as well as the strongest portion. It is triangular in shape with its *apex* blending with lig. carpi transversum; its *base* is opposite the bases of the four medial digits and here a slip is given off for each finger; each slip divides into two slips that are attached to the sides of the metacarpophalangeal joints and the first phalanx of each finger. The *digital sheaths* are continuations of the palmar aponeurosis upon the ventral surface of each finger. Each sheath is attached to the sides of the phalanges and serves to keep the flexor tendons in place. Each is lined with a synovial membrane. The *synovial space of the little finger* is continuous with the large synovial sac of the palm that also extends into the forearm under the transverse carpal ligament. The synovial spaces of the outer three fingers are independent of one another. The synovial space, or sheath of the thumb extends through the palm and under the transverse carpal ligament into the forearm.

SUPERFICIAL MUSCLES OF THE FOREARM

The **m. pronator teres** *arises* from the medial epicondylic ridge and its intermuscular septum, from the medial epicondyle of the humerus and the fascia over it and from intermuscular septa here; this constitutes the *caput humerale.* The *caput ulnare*, or *deep head arises* from the medial surface of the coronoid process of the ulna. The muscle is *inserted* into the middle of the lateral surface of the shaft of the radius.

Action.—Flexes the elbow joint and *pronates* the forearm.

Nerve Supply.—Median nerve (C. 6).

The **m. flexor carpi radialis** *arises* from the medial condyle through the common tendon, from the intermuscular septa and fascia over it and is *inserted* into the proximal extremities of the second and third metacarpal bones.

Action.—Flexes the elbow and wrist joints and *assists in pronating* the forearm.

Nerve Supply.—Median nerve (C. 6).

The **m. palmaris longis** *arises* from the common tendon of the medial epicondyle, the fascia over it and the intermuscular septa and is *inserted* into the transverse carpal ligament and the apex of the palmar aponeurosis.

Action.—*Assists in flexion* of the elbow and wrist joints and makes the palmar fascia tense.

Nerve Supply.—Median nerve (C. 6).

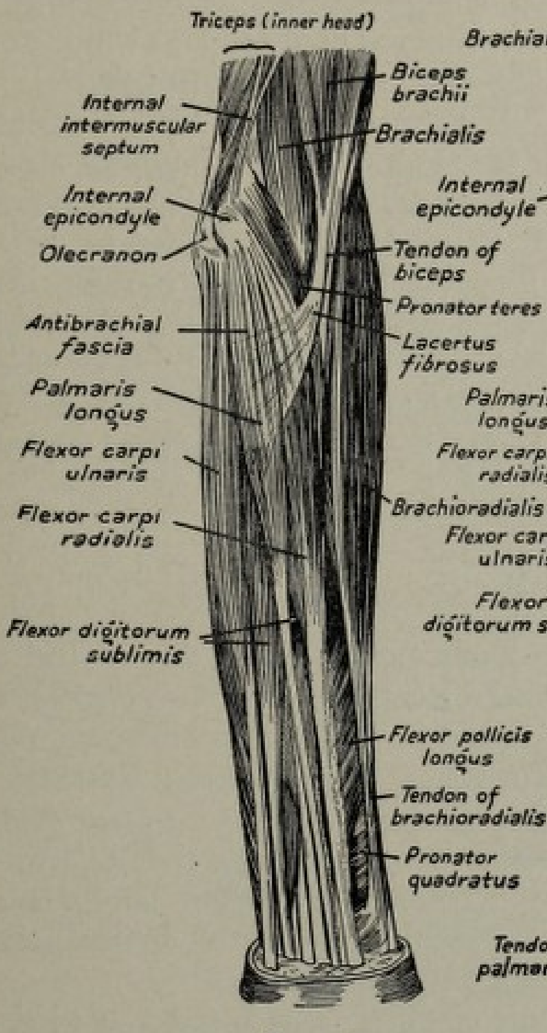


FIG. 142.

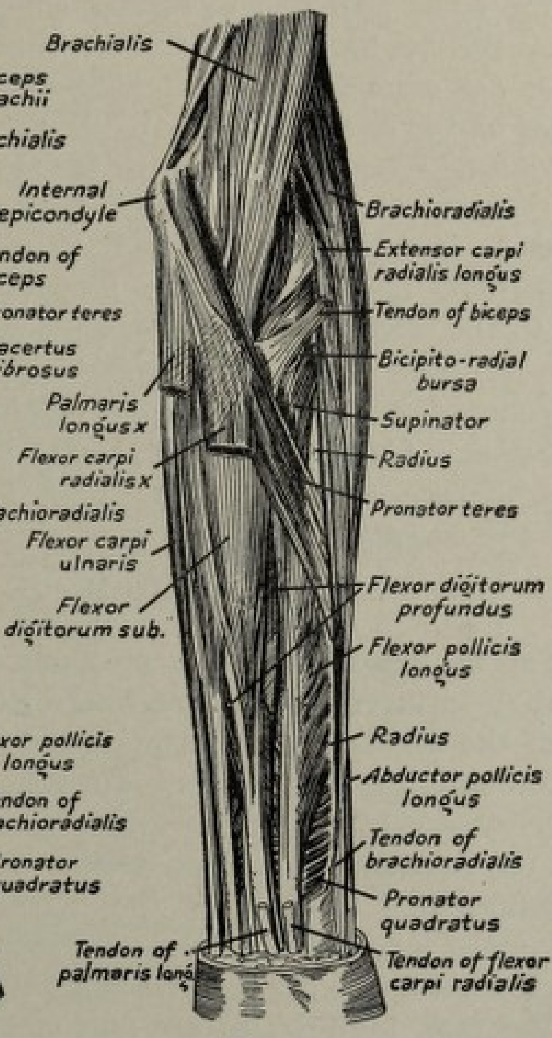


FIG. 143.

FIG. 142.—The superficial layer of the muscles of the flexor surface of the forearm together with the brachioradialis, seen from in front. (*Sobotta and McMurrich.*)

FIG. 143.—The superficial layer of the muscles of the flexor surface of the forearm after removal of the palmaris longus and the flexor carpi radialis, seen from in front and slightly from the radial side. The brachioradialis is drawn outward to show e supinator and the insertion of the tendon of the biceps. (*Sobotta and McMurrich.*)

The **m. flexor carpi ulnaris** *arises* from the common tendon of the medial epicondyle of the humerus, the fascia over it and the intermuscular septa and from the medial margin of the olecranon and the first two-thirds of the dorsal margin of the ulna. The muscle is *inserted* into the pisiform and hamate bones and the proximal extremity of the fifth metacarpal bone.

Action.—Flexes and *adducts* the wrist and *assists in flexing* the elbow joint.

Nerve Supply.—Ulnar nerve (C. 8, Th. 1).

The **m. flexor digitorum sublimis** has three heads. The **caput humerale** *arises* from the common tendon, the ulnar collateral ligament and from the intermuscular septa. The **caput radiale** *arises* from the first two-thirds of the ventral surface of the radius. The **caput ulnare** *arises* from the medial margin of the coronoid process of the ulna. All join to form a common belly that divides in the distal third of the forearm and continues as four tendons which at the wrist are arranged in pairs, middle and ring fingers (superficial) and index and little fingers (deep). Here these tendons are contained in a common synovial sheath with the tendons of the profundus muscle. In the palm the four tendons separate and over the base of the first phalanx of each finger the tendons split to give passage to the corresponding tendon of the flexor digitorum profundus muscle. Dorsal to the latter tendon these slips partially reunite to be *inserted* into the sides of the second phalanges of the fingers. The *vincula longa* and *brevia* are delicate *accessory portions* of each tendon.

Action.—Flexes the elbow, wrist, metacarpophalangeal and first interphalangeal joints.

Nerve Supply.—Median nerve (C. 6).

DEEP LAYER

The **m. flexor digitorum profundus** *arises* from the ventral and medial surfaces of the ulna and olecranon (first two-thirds) and from the middle third of the medial half of the interosseous membrane and the deep fascia. Its broad tendon passes beneath the transverse carpal ligament and in the palm divides into *four tendons* for the four fingers. Each *tendon* passes through the split in the corresponding tendon of the m. flexor digitorum sublimis and is *inserted* into the ventral surface of the base of the distal phalanx. Each tendon also gives off *vincula longa* and *brevia*.

The **mm. lumbricales** are *four* small muscles connected with the tendons of the preceding muscle in the palm. *Each of the two lateral muscles arises* by a single head from the radial side of the tendon for the index and middle fingers and is *inserted* into the side of the capsule of the metacarpophalangeal articulation and into the side of the corresponding extensor tendon dorsally. *Each of the two medial muscles arises* by two heads from the adjacent sides of the second, third and fourth tendons and is *inserted* in the same manner.

Action.—The flexor digitorum profundus *flexes* the wrist and the fingers at all of their joints. The lumbricales *flex* the fingers at the metacarpophalangeal joints and *assist in extending* the fingers at their interphalangeal joints.

Nerve Supply.—Flexor digitorum profundus: Volar interosseous branch of the median nerve (C. 7, 8, Th. 1) and the ulnar nerve (C. 8, Th. 1). The two lateral lumbricales: Median nerve (C. 6, 7). The two medial lumbricales: Ulnar nerve (C. 8, Th. 1).

The **m. flexor pollicis longus** *arises* from the middle third of the ventral surface of the shaft of the radius and from the medial margin of the coronoid process of the ulna. It is *inserted* by means of a long tendon that passes beneath the carpal ligament, in its own synovial sheath, to the base of the distal phalanx of the thumb.

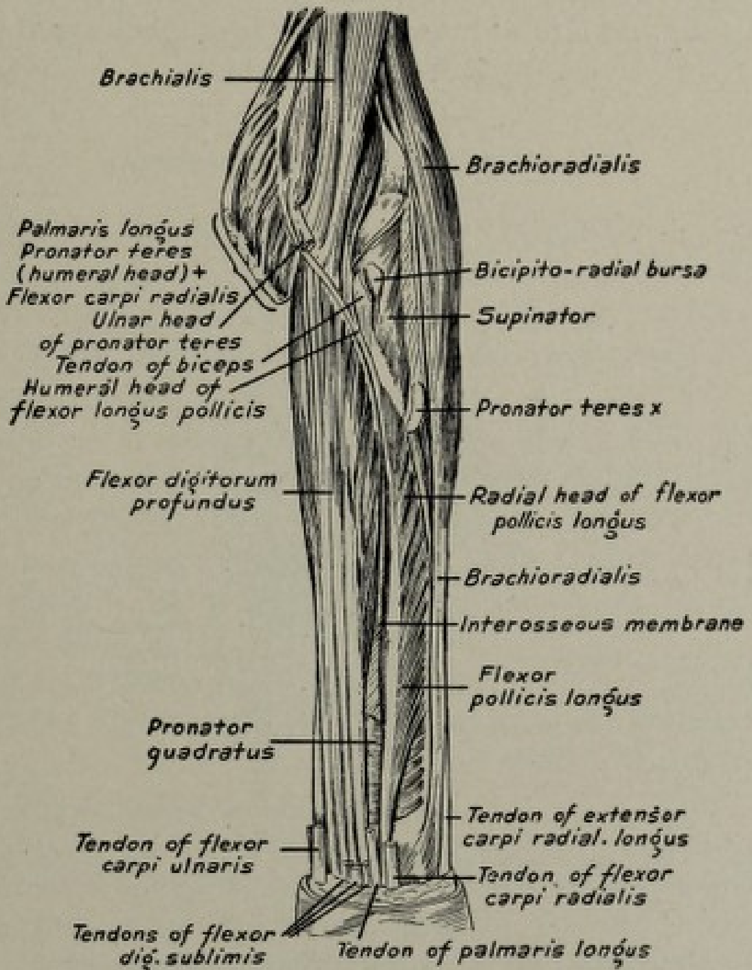


FIG. 144.—The deep layer of the muscles of the flexor surface of the forearm after removal of the superficial layer, seen from in front. (*Sobotta and McMurrich.*)

Action.—*Flexes* the wrist and the thumb.

Nerve Supply.—Volar interosseous branch of the median nerve (C. 7, 8, Th. 1.).

The **m. pronator quadratus** *arises* from the ventral surface and medial margin of the distal quarter of the ulna and passing transversely across the forearm is *inserted* into the distal quarter of the ventral surface of the radius.

Action.—*Assists in pronating* the forearm.

Nerve Supply.—Volar interosseous branch of the median nerve (C. 7, 8, Th. 1).

SHORT MUSCLES OF THE THUMB

The **m. abductor pollicis brevis** *arises* from the tubercle of the navicular and the greater multangular bones and from the transverse carpal ligament. It is *inserted* into the first phalanx of the thumb (radial side) and into the capsule of the metacarpophalangeal joint.

Action.—*Abducts* the thumb.

Nerve Supply.—Median nerve (C. 6, 7).

The **m. opponens pollicis** *arises* from the transverse carpal ligament and the ridge of the greater multangular bone. It is *inserted* into the ventral surface and lateral margin of the first metacarpal bone.

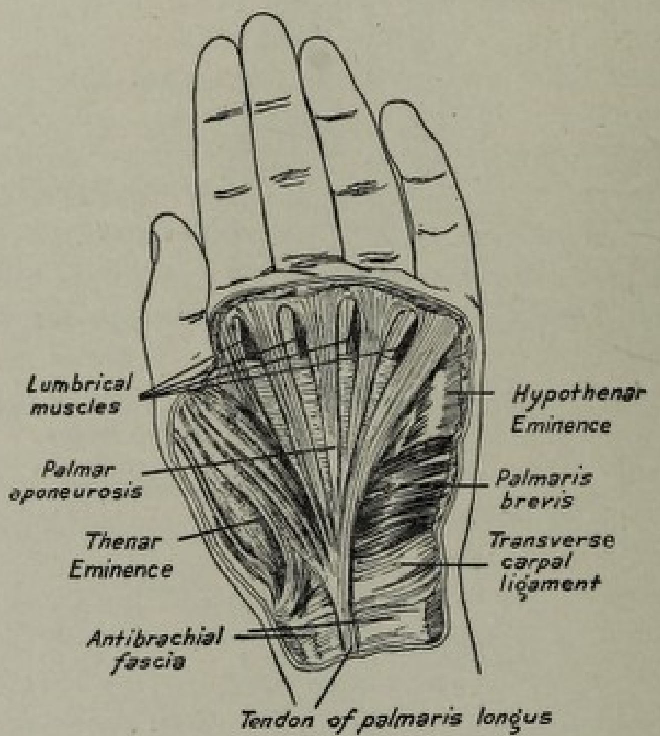


FIG. 145.—The palmar aponeurosis and the palmaris brevis. The thenar and hypothenar muscles are shown covered by the fascia. (*Sobotta and McMurrich.*)

Action.—*Draws* the metacarpal bone over the palm.

Nerve Supply.—Median nerve (C. 6, 7).

The **m. flexor pollicis brevis** consists of *two parts* of which the *superficial portion arises* chiefly from the transverse carpal ligament and is *inserted* into the radial side of the base of the first phalanx of the thumb. The *deep portion,* or **first palmar interosseous muscle,** *arises* from the base of the first metacarpal bone (medial side). It is *inserted* into the medial side of the base of the first phalanx of the thumb.

Action.—*Flexes* the thumb and *assists in opposing* it to the fingers.

Nerve Supply.—Median nerve (C. 6, 7).

The **m. adductor pollicis** also consists of *two parts*. The *oblique* *head arises* from the ventral surface of the greater and lesser multangular and the capitate bones and from the bases of the second, third and fourth metacarpal bones and their ligaments. It is *inserted* into the medial side of the base of the first phalanx of the thumb.

The *transverse head arises* from the median ridge of the ventral aspect of the third metacarpal bone and the fascia covering the adjacent interosseous muscles. It is *inserted* into the medial side of the base of the first phalanx of the thumb.

Action.—Adducts the thumb and *assists in opposing* it to the fingers.

Nerve Supply.—Deep branch of the ulnar nerve (C. 8, Th. 1).

MUSCLES OF THE LITTLE FINGER

The **m. abductor digiti quinti** *arises* from the pisiform bone and the tendon of the flexor carpi ulnaris muscle. It is *inserted* into the medial side of the base of the first phalanx of the little finger.

Action.—Draws the little finger from the ring finger and *flexes* it at the metacarpophalangeal joint.

Nerve Supply.—Deep branch of the ulnar nerve (C. 8, Th. 1).

The **m. opponens digiti quinti** *arises* from the transverse carpal ligament and the hamate bone. It is *inserted* into the medial margin and medial half of the ventral surface of the fifth metacarpal bone.

Action.—Draws the metacarpal forward so as to deepen the hollow of the hand.

Nerve Supply.—Deep branch of the ulnar nerve (C. 8, Th. 1).

The **m. flexor digiti quinti brevis** *arises* from the transverse carpal ligament and the hamate bone and is *inserted* into the medial side of the first phalanx of the little finger.

Action.—Flexes the proximal phalanx of the little finger.

Nerve Supply.—Deep branch of the ulnar nerve (C. 8, Th. 1).

There are *two sets of interosseous muscles, palmar* and *dorsal.*

The **mm. interossei volares,** or **palmar interossei,** are *three* in number. Each arises by *one head:* the **first** *arises* from the medial side of the second metacarpal bone, the **second** and **third** from the lateral sides of the fourth and fifth metacarpal bones. The **first** is *inserted* into the extensor tendon, the capsule of the metacarpophalangeal joint and the medial side of the first phalanx of the second finger. The **second** and **third** are *inserted* into the lateral sides of the first phalanges of the fourth and fifth fingers and their respective extensor tendons and capsular ligaments.

The **mm. interossei dorsales** are *four* in number. Each *arises* by a head from each of the two bones that bound its interosseous space. The **first** is *inserted* into lateral side of the first phalanx of the index finger and its extensor tendon. The **second** is *inserted* in the same manner to the middle finger. The **third** is *inserted* into the medial side of the same finger and the **fourth** into the medial side of the ring finger.

Action.—The *dorsal interossei abduct* the fingers from a line through the middle finger while the *palmar muscles adduct* the fingers to this line. The interossei also *assist* the lumbricales to *flex* the first phalanges at the metacarpophalangeal joint and *extend* the second

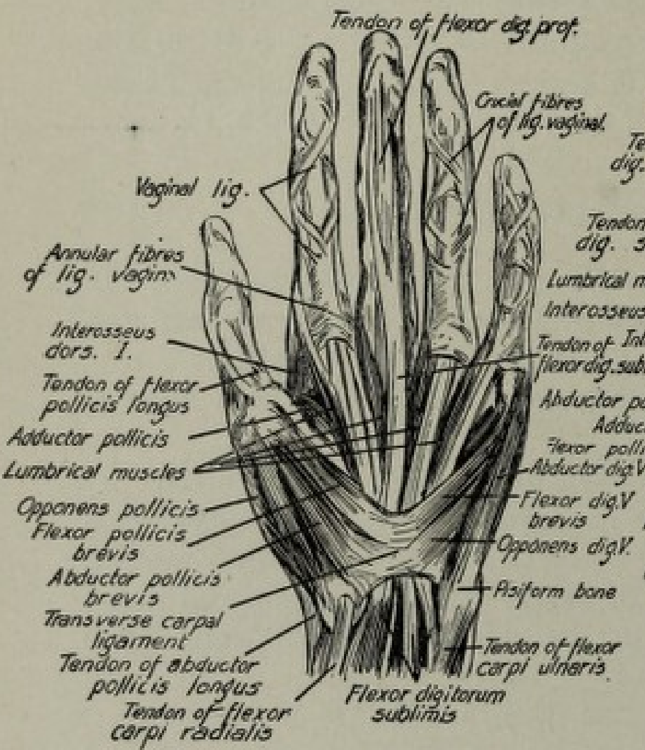


FIG. 146. FIG. 147.

FIG. 146.—The palmar muscles after removal of the palmar aponeurosis. The tendon-sheath of the middle finger has been split lengthwise. (*Sobotta and McMurrich.*)

FIG. 147.—The deep layer of the palmar muscles. The transverse carpal ligament and the abductores digiti V and pollicis brevis have been removed. The tendons of the long flexors have been removed from the carpal canal and, after splitting the tendon-sheaths of the fingers, have been partly removed and partly drawn aside. (*Sobotta and McMurrich.*)

and third phalanges through their attachment to the extensor tendons.

Nerve Supply.—Deep branch of the ulnar nerve (C. 8, Th. 1).

DORSAL AND LATERAL MUSCLES OF THE FOREARM

The superficial muscles are *seven* in number.

The **m. brachioradialis** *arises* from the lateral epicondylic ridge (proximal two-thirds) and from the intermuscular septum. It is *inserted* at the beginning of the groove upon the lateral side of the distal extremity of the radius.

Action.—*Flexes* the elbow joint, *assists* the pronators and supinators and is a semipronator and a semisupinator.

Nerve Supply.—Branch from the radial nerve (C. 5, 6).

The **m. extensor carpi radialis longus** *arises* from the distal third of the lateral epicondylic ridge, from the intermuscular septum and from the common tendon of the lateral epicondyle. It is *inserted* into the radial side dorsal surface of the base of the second metacarpal bone.

Action.—*Extends* the wrist and *assists in flexing* the elbow.

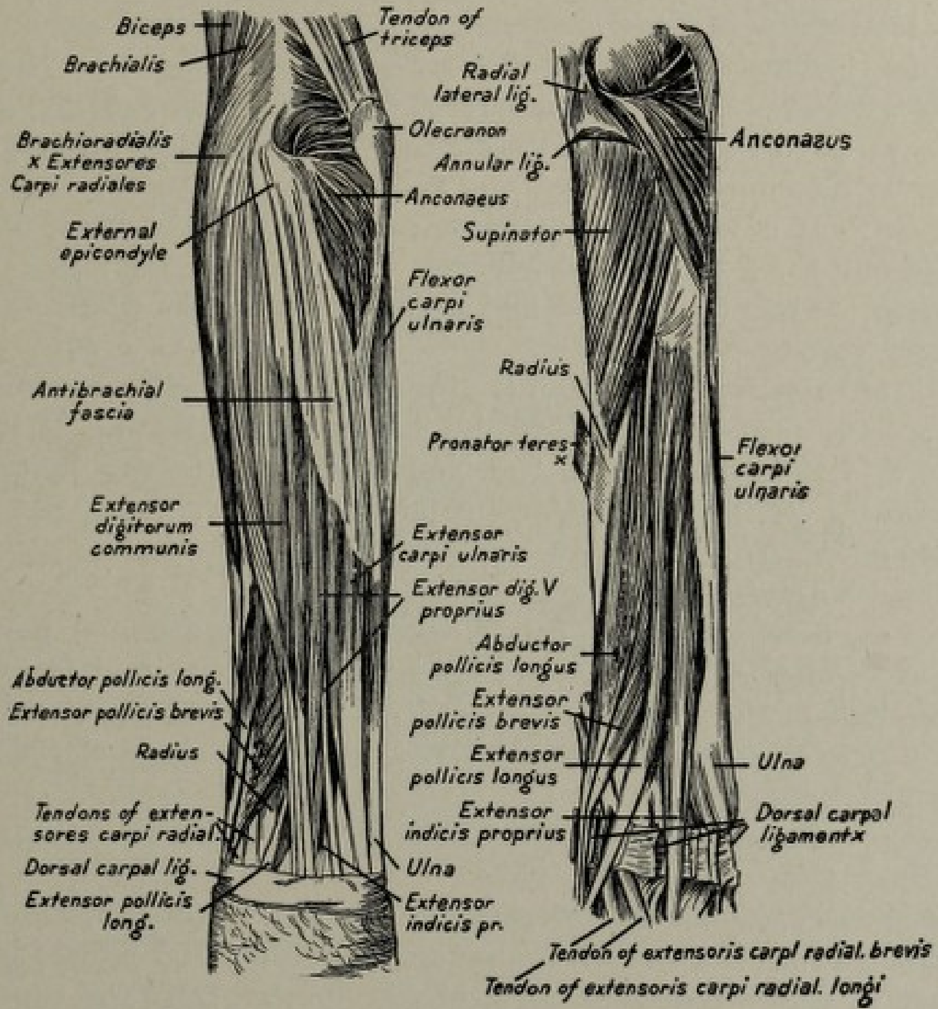


FIG. 148. FIG. 149.

FIG. 148.—The superficial layer of muscles of the extensor surface of the forearm. (*Sobotta and McMurrich.*)

FIG. 149.—The deep layer of muscles of the extensor surface of the forearm. The superficial layer of the extensors has been removed, the cavities of the dorsal carpal ligament have been opened and the tendons of the superficial muscles removed. (*Sobotta and McMurrich.*)

Nerve Supply.—Radial nerve (C. 5, 6, 7, 8).

The **m. extensor digitorum communis** *arises* from the common tendon, from the lateral epicondyle of the humerus, from the fascia of the region and the intermuscular septa. Near the wrist it continues as four tendons that pass beneath the dorsal carpal ligament with the tendon of the extensor indicis proprius. Upon the dorsum of the palm the tendons separate and pass toward the dorsal surface of each finger. Over the first phalanx of each finger the tendon receives the tendons of the interossei and lumbricales muscles. At the distal extremity of the first phalanx each tendon separates into three portions, the *median* of which is *inserted* into the base of the second phalanx. The *lateral slips* unite and are *inserted* into the base of the third phalanx. Upon the dorsum of the palm the second and third, and the third and fourth tendon are connected to each other by an oblique tendinous slip, which interferes with the individual extension of these fingers.

Action.—Extends the elbow, wrist and fingers.

Nerve Supply.—Dorsal interosseous nerve (C. 5, 6, 7, 8).

The **m. extensor carpi radialis brevis** *arises* from the common tendon, the intermuscular septa and fascia and the radial collateral ligament. It is *inserted* into the dorsal surface of the bases of the second and third metacarpal bones.

Action.—Extends the wrist and assists in *flexing* the elbow.

Nerve Supply.—Deep branch of the radial nerve (C. 5, 6).

The **m. extensor digiti quinti proprius** *arises* from the common tendon, the fascia over it and the intermuscular septa. It is *inserted* into the expansion of the tendon of the extensor digitorum communis over the first phalanx of the little finger.

Action.—Extends, elbow, wrist and little finger.

Nerve Supply.—Dorsal interosseous nerve (C. 6, 7, 8).

The **m. extensor carpi ulnaris** *arises* from the common tendon, the fascia over the muscle, the intermuscular septa and from the middle half of the deep fascia attached to the dorsal margin of the ulna. It is *inserted* into the medial surface of the base of the fifth metacarpal bone.

Action.—Extends and *adducts* the wrist and *assists in extension* of the elbow joint.

Nerve Supply.—Dorsal interosseous nerve (C. 5, 6, 7, 8).

The **m. anconeus,** a small triangular muscle, *arises* from the dorsal surface of the lateral epicondyle of the humerus and the capsular ligament and is *inserted* into the lateral surface of the olecranon and the dorsal surface of the proximal part of the ulna to the oblique line.

Action.—Extends the elbow joint.

Nerve Supply.—Radial nerve (C. 7, 8).

The **deep muscles** are *five* in number.

The **m. supinator (brevis)** *arises* from the lateral epicondyle of the humerus, the collateral and annular ligaments of the joint, the fascia over it and from the surface of the ulna just distal to the radial notch. It is *inserted* to the lateral and ventral surface of the radius from the neck to the oblique line.

Action.—Main supinator of the forearm and *extends* the elbow.

Nerve Supply.—Deep branch of the radial nerve (C. 7, 8).

The **m. abductor pollicis longus**, or **extensor ossi metacarpi pollicis,** *arises* from the proximal part of the lateral half of the dorsal surface of the ulna, from the middle part of the dorsal surface of the radius and from the intervening part of the interosseous membrane. It is *inserted* into the lateral side of the base of the first metacarpal bone.

Action.—Abducts the metacarpal bone of the thumb, and *assists in abducting* and *extending* the wrist.

Nerve Supply.—Dorsal interosseous nerve (C. 6, 7, 8).

The **m. extensor pollicis longus** *arises* from the middle part of the dorsal surface of the ulna and the interosseous membrane and is *inserted* into the dorsal surface of the second phalanx of the thumb.

Action.—Extends and *abducts* the thumb and wrist.

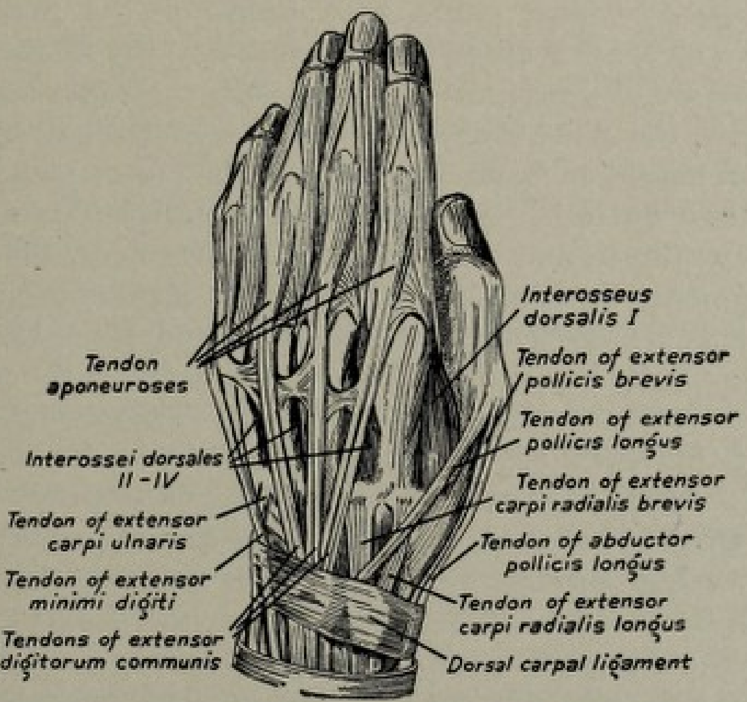


FIG. 150.—Tendons and muscles (interossei dorsales) of the dorsum of the hand. The dorsal carpal ligament is retained, the rest of the dorsal fascia being removed. (*Sobotta and McMurrich.*)

Nerve Supply.—Dorsal interosseous nerve (C. 5, 6, 7, 8).

The **m. extensor pollicis brevis** *arises* from the distal part of the dorsal surface of the radius and from the adjoining portion of the interosseous membrane. It is *inserted* into the dorsal surface of the base of the first phalanx of the thumb.

Action.—Extends and *abducts* the thumb and wrist.

Nerve Supply.—Dorsal interosseous nerve (C. 5, 6, 7, 8).

The **m. extensor indicis proprius** *arises* from the dorsal surface of the ulna (just distal to the extensor pollicis longus) and from the interosseous membrane. It is *inserted* into the index finger by joining the tendon of the m. extensor communis digitorum.

Action.—Extends the index finger and the wrist.

Nerve Supply.—Dorsal interosseous nerve (C. 5, 6, 7, 8).

THE INFERIOR EXTREMITY, OR PELVIC APPENDAGE

FASCIÆ AND MUSCLES OF THE BUTTOCK AND THIGH

The **superficial fascia** of the buttock and thigh is continuous with the fascia of the adjoining parts of the body. In the buttocks it contains a large quantity of fat which gives these parts their full appearance. In the inguinal region, or groin, the superficial fascia consists of a *superficial* and a *deep layer;* the *superficial layer* contains considerable fat and the superficial vessels and nerves. The *deep layer* is attached to the medial half of the inguinal ligament, to the pubic arch (medially) to the deep fascia of the thigh (laterally) and below, it joins the superficial layer. By its attachment to the inguinal ligament and pubic arch fluids of the perineum and abdominal wall are prevented from passing into the thigh. Between these two layers of superficial fascia are seen the superficial inguinal lymph nodes, the great saphenous vein and its tributaries.

The **deep fascia,** or **fascia lata,** invests the muscles and vessels of the thigh and buttock. Superiorly (proximally) it is attached to the pubic symphysis and crest, the inguinal ligament, the iliac crest, the sacrotuberous ligament, the ischium and the pubic arch; inferiorly (distally) it is attached to the patella, the condyles of the tibia, the head of the fibula, forms the collateral ligaments of the patella and is continuous with the deep fascia of the leg. The ventral and lateral portions of this fascia are thick and strong and in the distal part of the thigh it sends in muscular septa. Near the pubic region the fascia is pierced by the great saphenous vein and this area constitutes the *fossa ovalis*, or *saphenous opening.* This is oval in shape and covered by the *fascia cribrosa* and superficial fascia. The lateral margin of the fossa, *margo falciformis*, is sharp, while the medial margin is shelf-like and is called the *fascia pectinea.* This is attached, superiorly, to the iliopectineal line and capsule of the hip joint after passing dorsal to the femoral sheath and over the muscles here. The distal margin of the fossa is called the *inferior cornu.* The proximal margin is the *superior cornu.* The lateral portion of the fascia shows a band-like thickening that is called the *tractus iliotibialis*, or *iliotibial band* into which the m. tensor fasciæ latæ and part of the m. gluteus maximus are inserted. The distal portion of this band strengthens the knee joint laterally. The *lateral intermuscular septum* extends medially from the fascia lata, separates the ventral and dorsal muscles and is attached to the linea aspera and the lateral epicondylic line. The *medial intermuscular septum* passes laterally and is attached to the linea aspera and the medial epicondylic line and forms the ventral wall, or roof of the adductor canal. Over most of the buttock this fascia is thick.

The **femoral sheath** is a cone-shaped prolongation of the iliac (dorsally) and transversalis fasciæ (ventrally) into the thigh. It contains the femoral vessels and is divided into *three compartments:* the *medial compartment*, or *femoral canal* contains some fat, the intermediate the femoral vein and the lateral one the femoral artery. The abdominal opening of the femoral canal constitutes the *femoral ring*. That portion of the inguinal ligament ventral to the ring is called the *superficial femoral arch*, while the thickened part of the femoral sheath under cover of the inguinal ligament is called the *deep femoral arch*. The tissues that fill the ring constitute the *femoral septum*. The femoral sheath is about 1½ inches in length.

VENTRAL MUSCLES OF THE THIGH

The **m. sartorius** *arises* from the ventral superior spine of the ilium and the notch below, passes to the medial side of the thigh and is *inserted* into the superior extremity of the tibia just below the medial condyle; it also is attached to the capsular ligament and the fascia lata. It is a strap-like muscle and forms the lateral boundary of the femoral triangle.

Action.—Flexes the knee and *everts* the thigh.

Nerve Supply.—The two intermediate cutaneous branches of the femoral nerve (L. 2, 3).

The **m. quadriceps femoris** is composed of *four* muscles.

The **m. rectus femoris** *arises* by *two heads, one* from the ventral inferior spine of the ilium and the *other* from the roughened area of the acetabulum. The two heads join and ultimately form a tendon that is *inserted* into the superior or proximal margin of the patella.

The **m. vastus lateralis,** or **externus,** has an extensive *origin* from the capsule, the hip joint, tubercle of the femur, from the margin of the great trochanter, from the gluteal tuberosity, part of the linea aspera, from the fascia lata and the intermuscular septum. It is *inserted* into the lateral margin of the patella and tendon of the rectus femoris and into the capsular ligament of the knee joint.

The **m. vastus medialis,** or **internus,** *arises* from the spiral line, the linea aspera, the part of the line leading from this to the medial condyle, from the membranous roof of the adductor canal, from the intermuscular septum and from the tendon of the adductor magnus. It is *inserted* into the medial margin of the patella and the rectus femoris tendon and the capsular and lateral ligaments of the knee joint.

The **m. vastus intermedius,** or **crureus,** *arises* from the ventral and lateral surfaces (proximal two-thirds) of the femur, the intermuscular septum and from the end of the linea aspera and line leading to the lateral condyle. It is *inserted* into the deep surfaces of the preceding three tendons.

The **m. articularis genu,** or **subcrureus,** *arises* from the distal portion of the ventral surface of the femur and is *inserted* into the capsule of the knee joint.

The *real insertion of the quadriceps femoris* is the tubercle of the tibia by means of ligamentum patellæ, the patella being a sessamoid bone.

Action.—The muscle as a whole *extends* the leg. The *rectus femoris* also *flexes* the hip joint. The *articularis genu draws* the capsule and synovial sheaths out of the way during extension of the leg.

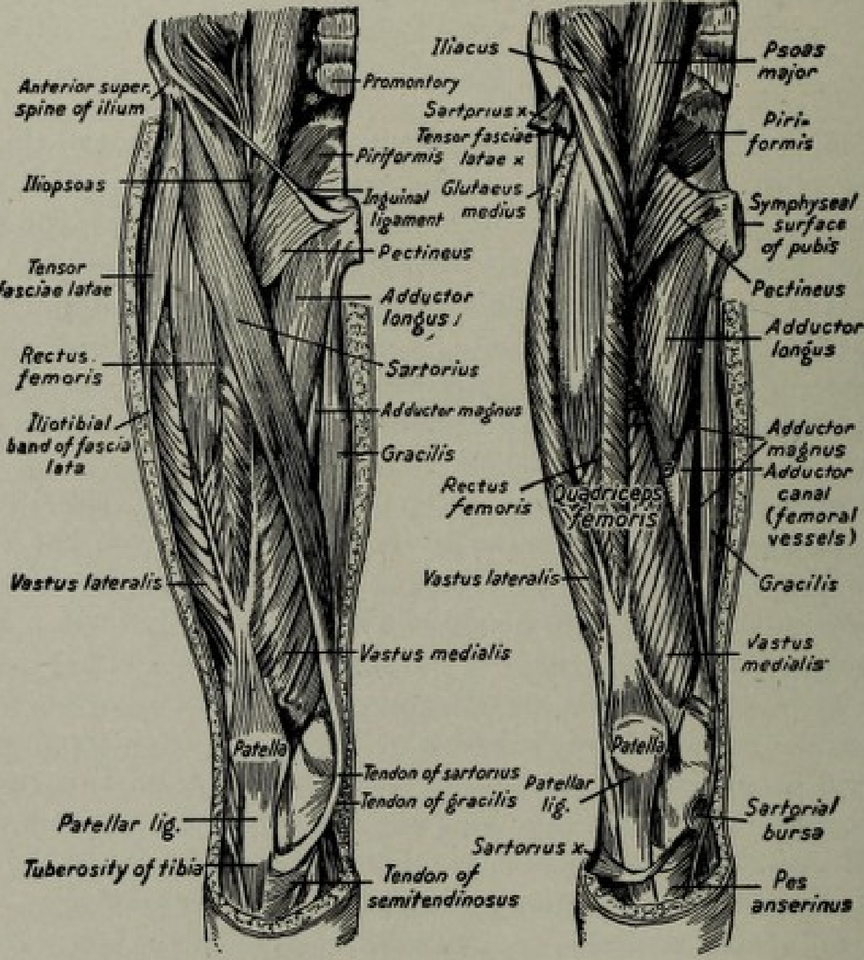


FIG. 151. FIG. 152.

FIG. 151.—The superficial layer of muscles of the ventral surface of the thigh. (*Sobotta and McMurrich.*)

FIG. 152.—The muscles of the ventral surface of the thigh after removal of the sartorius. The inguinal ligament has also been removed. (*Sobotta and McMurrich.*)

Nerve Supply.—Branches of the femoral nerve supply each individual division (L. 3, 4).

The **m. iliopsoas** consists of *three parts.*

The **m. psoas major** *arises* from the last thoracic and the first four lumbar intervertebral discs and the margins of the adjacent vertebræ, from tendinous arches over the bodies of the first four lumbar vertebræ and from the transverse processes of all of the lumbar vertebræ. A spindle-shaped muscle is formed the tendon of which is *inserted* into the apex of the lesser trochanter of the femur.

The **m. psoas minor** is often absent but when present it *arises* from the last thoracic intervertebral discs and the margins of the adjacent vertebræ and is *inserted* into the iliopectineal line.

The **m. iliacus** is a fan-shaped muscle that *arises* from the margin of the iliac fossa, the ala of the sacrum and the neighboring pelvic ligaments and from the capsule of the hip joint. It is *inserted* into the lateral portion of the psoas tendon, the lesser trochanter and the neighboring part of the shaft of the femur and into the capsule of the hip joint (**m. iliocapsularis**).

Actions.—The *psoas* muscles *flexes* the vertebral column ventrally and laterally. The *iliopsoas flexes* the thigh upon the pelvis, or *vice versa.*

Nerve Supply.—Psoas minor, first and second lumbar nerves; psoas major, second and third lumbar nerves; iliacus, femoral nerve (L. 2, 3, 4).

The **m. pectineus** *arises* from the iliopectineal line and bony surface adjacent, from the lig. lacunare (Gimbernat's) and the fascia over the muscle. It is *inserted* into the proximal half of the line from the lesser trochanter to the linea aspera.

Actions.—*Adducts* and *assists in flexing* the thigh.

Nerve Supply.—Femoral nerve (L. 2, 3) and obturator nerve (L. 2, 3).

MEDIAL MUSCLES OF THE THIGH

The **m. gracilis,** long and slender, *arises* from the inferior half of the pubic symphysis and the margin of the pubic arch. It is *inserted* into the proximal and medial extremity of the shaft of the tibia dorsal to the m. sartorius and ventral to the m. semitendinosis.

Actions.—*Adducts*, *flexes* and *rotates* the thigh medially.

Nerve Supply.—Obturator nerve (L. 2, 3).

The **m. adductor longus** *arises* from the ventral surface of the body of the pubic bone between the crest and symphysis. It is *inserted* into the medial lip of the linea aspera (medial two-fourths).

Actions.—*Adducts* and *assists in flexing* the thigh.

Nerve Supply.—Obturator nerve (L. 2, 3).

The **m. adductor brevis** *arises* from the body and first portion of the inferior ramus of the pubic bone. It is *inserted* into the distal portion of the line from the lesser trochanter to the linea aspera, dorsal to the pectineus.

Actions.—*Adducts* and *flexes* the thigh.

Nerve Supply.—Obturator nerve (L. 2, 3, 4).

The **m. adductor magnus** is the largest of this group and *arises* from the lateral margin and inferior surface of the tuberosity of the ischium, from the margin of the inferior ramus of the ischium and the ventral surface of the inferior ramus of the pubic bone. It is *inserted* into the femur superior to the linea aspera and continues all along the linea aspera and the line leading to the medial epicondyle of the femur and its adductor tubercle; is is also attached to the medial intermuscular septum. Where the medial epicondylic line begins

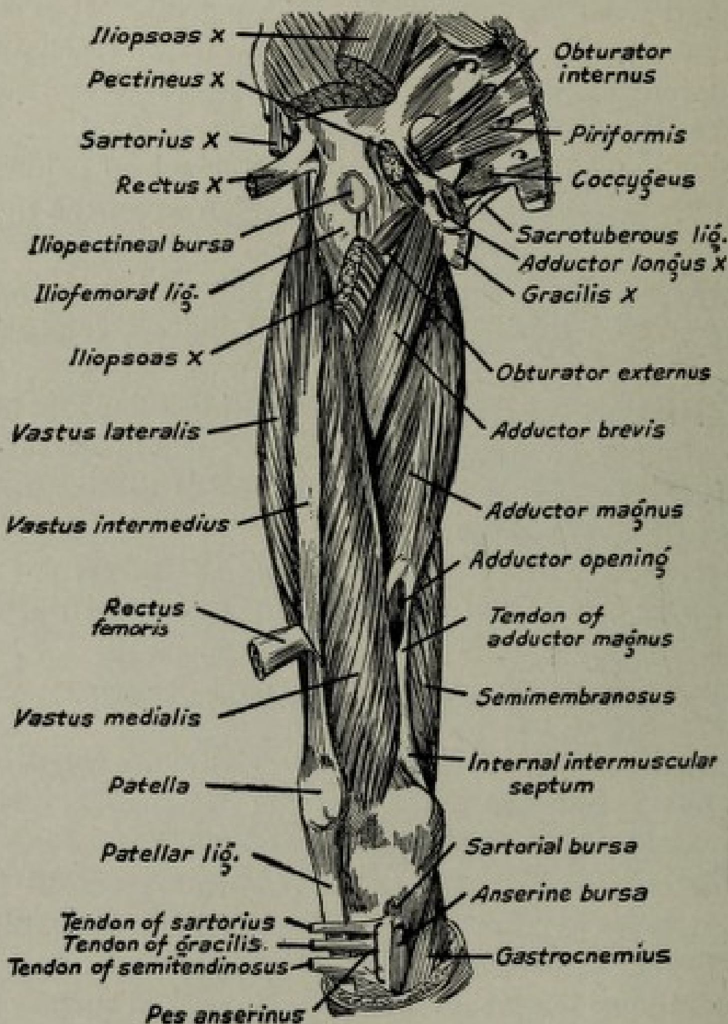


FIG. 153.—The deep layer of muscles of the medial surface of the thigh. The iliopsoas, sartorius, rectus femoris, pectineus, adductor longus, and gracilis have been removed. (*Sobotta and McMurrich.*)

there is a gap in the insertion for the transmission of the femoral vessels.

Actions.—Adducts and *extends* the thigh.

Nerve Supply.—Medial portion, tibial, or internal popliteal nerve (L. 4, 5, S. 1). Lateral portion, obturator nerve (L. 3, 4).

The **m. obturator externus** *arises* from the inferior half of the margin of the obturator foramen (ischium and pubis) and from the adjacent portion of the obturator membrane. It is *inserted* into the fossa on the medial side of the greater trochanter.

Actions.—Rotates the thigh laterally and *assists in flexion* and *adduction* of the thigh.

Nerve Supply.—Obturatur nerve (L. 3, 4).

The **trigonum femorale,** or **Scarpa's triangle,** is located on the ventral surface of the proximal portion of the thigh. Its *base* is formed by the inguinal ligament, its *lateral boundary* by the sartorius muscle and the *medial boundary* by the adductor longus muscle. Its *floor* is formed by the iliopsoas, pectineus, the adductor longus and sometimes a part of the adductor brevis muscles. It contains the femoral vessels and nerve.

The **adductor,** or **Hunter's canal** (*canalis adductorius Hunteri*), is in the medial side of the middle third of the thigh and is bounded *ventrally,* or *superficially* by the sartorius muscle and fascia between the vastus medialis and the adductor muscles; *dorsally* and *medially* by the vastus medialis. It contains the femoral artery and vein and the saphenous nerve.

MUSCLES OF THE BUTTOCK

The **m. gluteus maximus** is a large quadrilateral muscle composed of very coarse fibers. It *arises* from the iliac bone above the dorsal gluteal line, from the dorsal surfaces of the sacrum and coccyx and the sacrotuberous ligament and from the tendon of the sacrospinalis muscle. It is *inserted* into the gluteal tuberosity of the femur but mainly into the fascia lata.

Actions.—Extends the thigh and *assists in adduction* and *lateral rotation* (inferior fibers).

Nerve Supply.—Inferior gluteal nerve from the sacral plexus (L. 5, S. 1, 2).

The **m. tensor fasciæ latæ** *arises* from iliac crest near the ventral superior spine and the fascia covering it and is *inserted* into the fascia lata at the level of the greater trochanter.

Actions.—Assists in *abduction* and *rotation* of the thigh and in supporting the knee joint when in extension.

Nerve Supply.—Superior gluteal nerve of the sacral plexus (L. 4, 5, S. 1).

The **m. gluteus medius** *arises* from the ilium between the dorsal and ventral gluteal lines and the iliac crest and the fascia over it. It is *inserted* into the dorsosuperior portion of the greater trochanter.

Actions.—Abducts and *rotates* the thigh medially.

Nerve Supply.—Superior gluteal nerve from the sacral plexus (L. 4, 5, S. 1).

The **m. gluteus minimus** *arises* from the ilium between the ventral and inferior gluteal lines. It is *inserted* into the ventral surface of the greater trochanter.

Actions.—Abducts the thigh. The ventral fibers produce *medial rotation* and the dorsal fibers *lateral rotation.*

Nerve Supply.—The superior gluteal nerve from the sacral plexus.

The **m. pyriformis** *arises* from the ventral surface of the roots of the vertebral arches of the second, third and fourth sacral segments and from the grooves here, from the superior margin of the sacrosciatic notch and ligament. It is *inserted* into the depression on the medial surface of the greater trochanter of the femur.

Actions.—Abducts and *rotates* the thigh laterally.

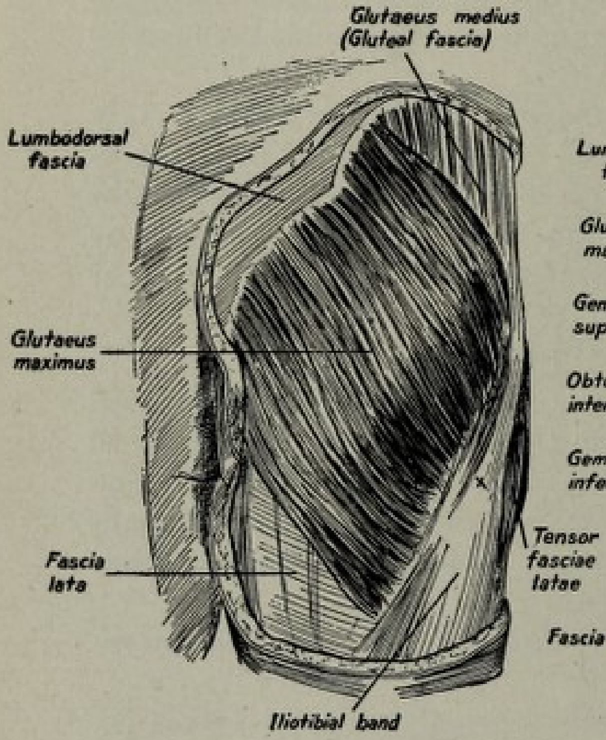


FIG. 154.

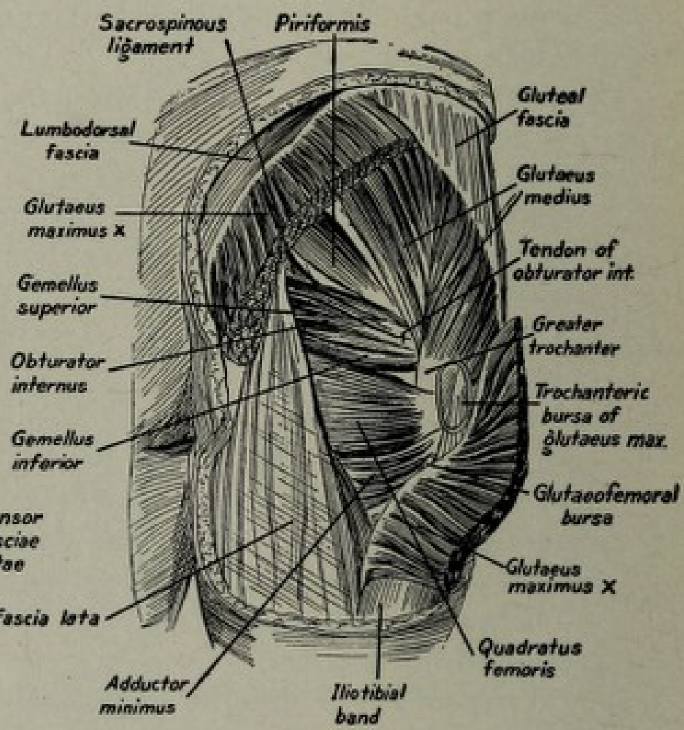


FIG. 155.

FIG. 154.—Superficial layer of the dorsal muscles of the hip. The portion of the superficial layer of the fascia lata which covers the tensor fasciæ latæ has been removed. ×, position of greater trochanter. (*Sobotta and McMurrich.*)

FIG. 155.—Middle layer of the dorsal muscles of the thigh. The glutæus maximus has been divided and reflected. (*Sobotta and McMurrich.*)

Nerve Supply.—Branches from the ventral rami of the first and second sacral nerves.

The **m. obturator internus** *arises* from the margin of the obturator foramen (pelvic side), form the hip bone superior and dorsal to the foramen, from the obturator membrane and the fascia over the muscle. It is *inserted* into a small facet upon the medial surface of the greater trochanter.

The **m. gemelus superior** *arises* from the lateral surface of the ischial spine and is *inserted* into the superior margin of the tendon of the obturator internus muscle.

The **m. gemellus inferior** *arises* from the superior aspect of the ischial tuberosity and is *inserted* into the inferior margin of the tendon of the obturator internus muscle.

Actions.—Abduct and *rotate* the thigh laterally.

Nerve Supply.—Obturator internus and superior gemellus, special branch of the sacral plexus (S. 1, 2, 3). The inferior gemellus, a branch from the nerve to the quadratus femoris muscle from the sacral plexus (L. 4, 5, S. 1).

The **m. quadratus femoris** *arises* from lateral margin of the ischial tuberosity and is *inserted* into the quadrate line and tubercle of the dorsal aspect of the femur.

Actions.—Adducts and *rotates* the thigh laterally.

Nerv Supply.—Special nerve from the sacral plexus (L. 4, 5, S. 1).

MUSCLES (HAMSTRING) ON THE DORSAL PART OF THE THIGH

The **m. biceps femoris** has *two heads* of which the *long one arises* from inferomedial facet of the ischial tuberosity in conjunction with the semitendinosis. The *short head arises* from the entire lateral lip of the linea aspera and the bulk of the lateral epicondylic line and from the lateral intermuscular septum. The fibers of the short head join the tendon of the long head and this tendon is *inserted* into the head of the fibula and the lateral condyle of the tibia.

Actions.—Flexes the leg and *rotates* it laterally when semiflexed and when acting from the fibula *assists in extending* the pelvis upon the thigh (raises it from a stooping position).

Nerve Supply.—Sciatic nerve through the tibial division (L. 5, S. 1, 2).

The **m. semitendinosis** *arises* in conjunction with the long head of the biceps from the tuberosity of the ischium (medial facet). It is *inserted* into the medial surface of the proximal extremity of the tibia dorsal to the sartorius and below the gracilis; it is also *attached* to the deep fascia of the leg.

Actions.—Flexes and *rotates* the leg medially and *extends* the pelvis.

Nerve Supply.—Tibial nerve (L. 5, S. 1. 2).

The **m. semimembranosus** *arises* from the lateral facet of the tuberosity of the ischium and is *inserted* into the groove upon the medial side of the medial condyle of the tibia and by extensions to the tibial collateral ligament, the popliteal fascia and the dorsal surface of the lateral condyle of the femur (oblique popliteal ligament).

Actions.—Flexes and *rotates* the leg medially and *assists in extension* of the pelvis.

Nerve Supply.—Tibial nerve (L. 5, S. 1, 2).

THE FASCIÆ AND MUSCLES OF THE LEG AND FOOT

The **superficial fascia** is the same as elsewhere, in the leg, but in the foot pads of fat are placed under the heel and the balls of the toes.

The **deep fascia** is continuous with that of the thigh and around the knee joint it is especially well developed. Here it forms the *collateral patellar ligaments* and the (dorsal) *popliteal fascia* which is reinforced by the expansions of the various neighboring tendons. In the leg two *intermuscular septa* are found laterally and these enclose the peronei muscles separating them from the extensor, ventrally, and the flexors, dorsally. At the ankle the deep fascia is also strengthened forming the *annular ligaments*.

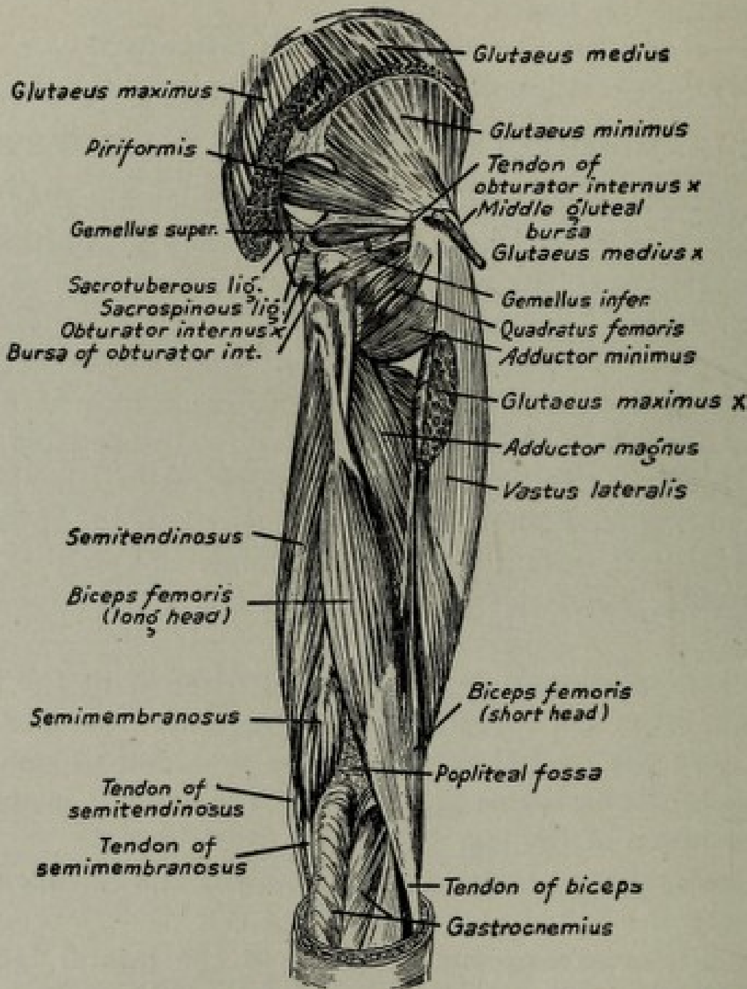


FIG. 156.—The deep layer of the dorsal hip muscles and the superficial layer of the flegors of the thigh region. The glutæus maximus) and medius and the obturator internus have been removed. (*Sobotta and McMurrich.*)

The *ligamentum transversum cruris*, or *ventral annular ligament* is broad and extends between the two malleoli. It holds the tendons of the tibialis anterior and extensor muscles of the toes in place.

The *ligamentum cruciatum cruris*, or *lower band of the ventral annular ligament* is a fascial band upon the dorsum of the foot. A part of this band holds the tendons of the tibialis anterior, the extensor longus hallucis and the extensor digitorum longus and peroneus tertius muscles in place. A synovial sheath surrounds each of these tendons except the last which is included with the third tendon.

The *superior peroneal retinaculum*, or *lateral annular ligament* connects the lateral malleolus and the calcaneus. This holds the peroneal tendons in place and has one synovial sheath.

The *ligamentum laciniatum*, or *medial annular ligament* connects the medial malleolus with the tuberosity of the calcaneus. It gives attachment to certain muscles, is pierced by the calcaneal vessels and nerves and the dorsal tibial vessels and nerve; it also holds the tendons of the tibialis posterior, flexor digitorum longus and flexor hallucis longus muscles in place. Each tendon has a separate synovial sheath.

In the *sole of the foot the deep fascia* forms the **plantar aponeurosis.** The *central portion* is the largest and strongest part. It is triangular in shape and is attached dorsally, to the tuberosity of the calcaneus; near the toes the base of the triangle gives off five slips, one for each toe. Each slip joins the digital sheath and splits into two portions each of which is attached to the opposite side of the first phalanx of the same toe. This *central aponeurosis* is of assistance in maintaining the arch of the foot. The *deep fascia* on each side of the central part is thin and at the junction of each with the central portion an *intermuscular septum* is sent into the depths separating the various muscles and forming sheaths for others. The *digital sheaths* are arranged like those of the hand.

MUSCLES OF THE VENTRAL PART OF THE LEG AND OF THE DORSUM OF THE FOOT

The **m. tibialis anterior** *arises* from the lateral condyle of the tibia, from the upper two-thirds of the lateral surface of the shaft, from the interosseous membrane and intermuscular fascia. The long tendon passes over the medial side of the dorsum of the foot and is *inserted* on the medial side of the first cuneiform and first metatarsal bones.

Actions.—Flexes the foot dorsally and *assists in inverting* the foot.

Nerve Supply.—Deep peroneal nerve (L. 4, 5, S. 1).

The **m. extensor digitorum longus** *arises* from the lateral condyle of the tibia, from the medial surface of the shaft of the fibula (ventral part) and from the fascia and intermuscular septum. It is *inserted* into the four lesser toes. Over the first phalanx of each toe each tendon is joined by tendons from the lumbricales, interossei and the extensor digitorum brevis. This conjoined tendon splits into three portions, the **central one of** which is *inserted* into the distal phalanx and the **two side tendons** into the middle phalanx.

Actions.—Flexes the foot dorsally and *extends* the four lesser toes.

Nerve Supply.—Deep peroneal nerve (L. 4, 5, S. 1).

The **m. peroneus tertius** *arises* with the preceding from the medial surface of the shaft of the tibia and the intermuscular septum and is *inserted* into the dorsal surface of the base of the fifth metatarsal bone.

Actions.—*Flexes* the foot dorsally and *raises the lateral margin* of the foot.

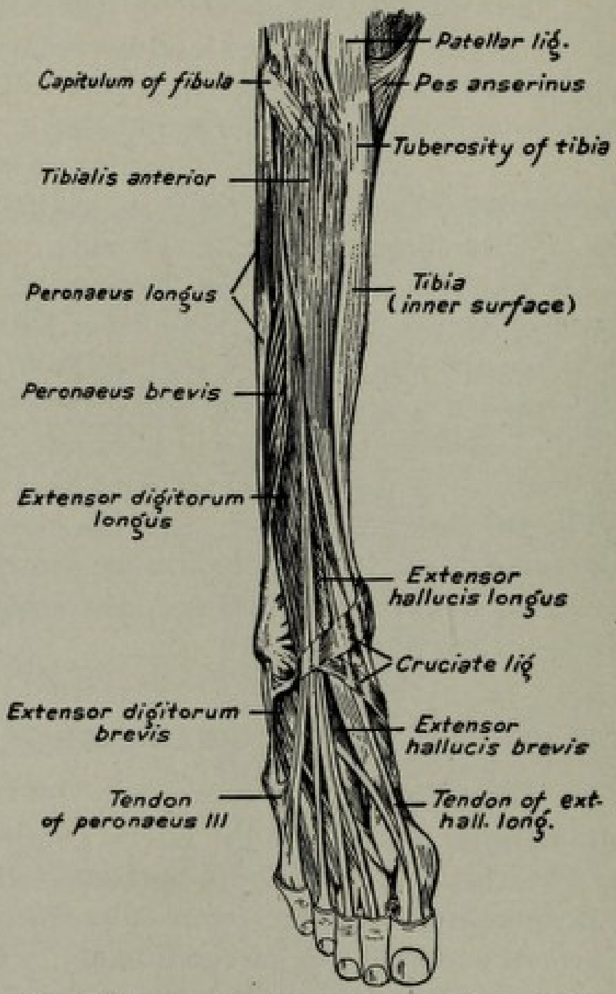


FIG. 157.—The muscles of the ventral surface of the lower leg and of the dorsum of the foot. The transverse crural ligament has been removed. (*Sobotta and McMurrich.*)

The **m. extensor hallucis longus** *rises* from the middle two-thirds of the medial surface (ventral part) of the fibula and from the interosseous membrane. The tendon passes over the dorsum of the foot and is *inserted* into the base of the distal phalanx of the great toe.

Actions.—*Extends* the great toe and *flexes* the foot dorsally.

Nerve Supply.—Deep peroneal nerve.

The **m. extensor digitorum brevis** *arises* from the dorsal surface of the calcaneus and from the lig. cruciatum cruris. Its four tendons are *inserted* into the four inner toes. The innermost tendon is inserted into the base of the first phalanx of the great toe while the other three tendons join the long extensor tendons of the next three toes.

Action.—Extends the four inner toes.

Nerve Supply.—Deep peroneal nerve.

LATERAL MUSCLES OF THE LEG

The **m. peroneus longus** *arises* from the head and upper two-thirds of the lateral surface of the fibula and from the intermuscular septa. It is *inserted* into the first cuneiform bone and the base of the fifth metacarpal bone (lateral aspect). The tendon passes behind the lateral malleolus, over the side of the calcaneus and through a groove in the cuboid bone on its way to the sole of the foot.

Actions.—Everts the foot, *extends* the foot and strengthens the arch.

Nerve Supply.—Superficial peroneal nerve (L. 4, 5, S. 1).

The **m. peroneus brevis** *arises* from the distal half of the lateral surface of the fibula and intermuscular septum. It is *inserted* into the tuberosity on the base of the fifth metatarsal bone.

Actions.—Extends and *everts* the foot.

Nerve Supply.—Superficial peroneal nerve.

DORSAL MUSCLES OF THE LEG

The **superficial muscles** are *three* in number the *gastrocnemius*, the *soleus*, constituting the *m. triceps suræ*, and the *plantaris*.

The **m. plantaris** *arises* from the lateral epicondyle of the femur and the adjacent part of the popliteal surface and is *inserted* into the tendo calcaneus (Achillis) or the tuberosity of the calcaneus.

Actions.—Assists in flexing the leg and *extending* the foot.

Nerve Supply.—Tibial nerve (L. 4, 5, S. 1).

The **m. gastrocnemius** *arises* by **two heads.** The **medial head** *arises* from the politeal surface of the femur close to the medial epicondyle and from the capsular ligament of the knee joint. The **lateral head** *arises* from the dorsolateral portion of the lateral condyle of the femur and the epicondylic line and from the capsular ligament. Each head is *inserted* into a broad membrane that forms the tendo calcanea (Achillis) which is *inserted* into the dorsal surface of the calcaneus.

Actions.—Flexes the leg and *extends* the foot.

Nerve Supply.—Tibial nerve (S. 1, 2).

The **m. soleus** *arises* from the upper dorsal surface of the head and shaft of the fibula, from the tendinous arch over the popliteal vessels and tibial nerve and from the oblique line of the tibia. It is *inserted* into the tendo calcanea, not far from the heel.

Actions.—Extends the foot.

Nerve Supply.—Tibial nerve by two branches; that to the superficial surface is from the first and second sacral nerves; that for the deep surface is from the fifth lumbar and first and second sacral nerves.

The **deep muscles** are *four* in number.

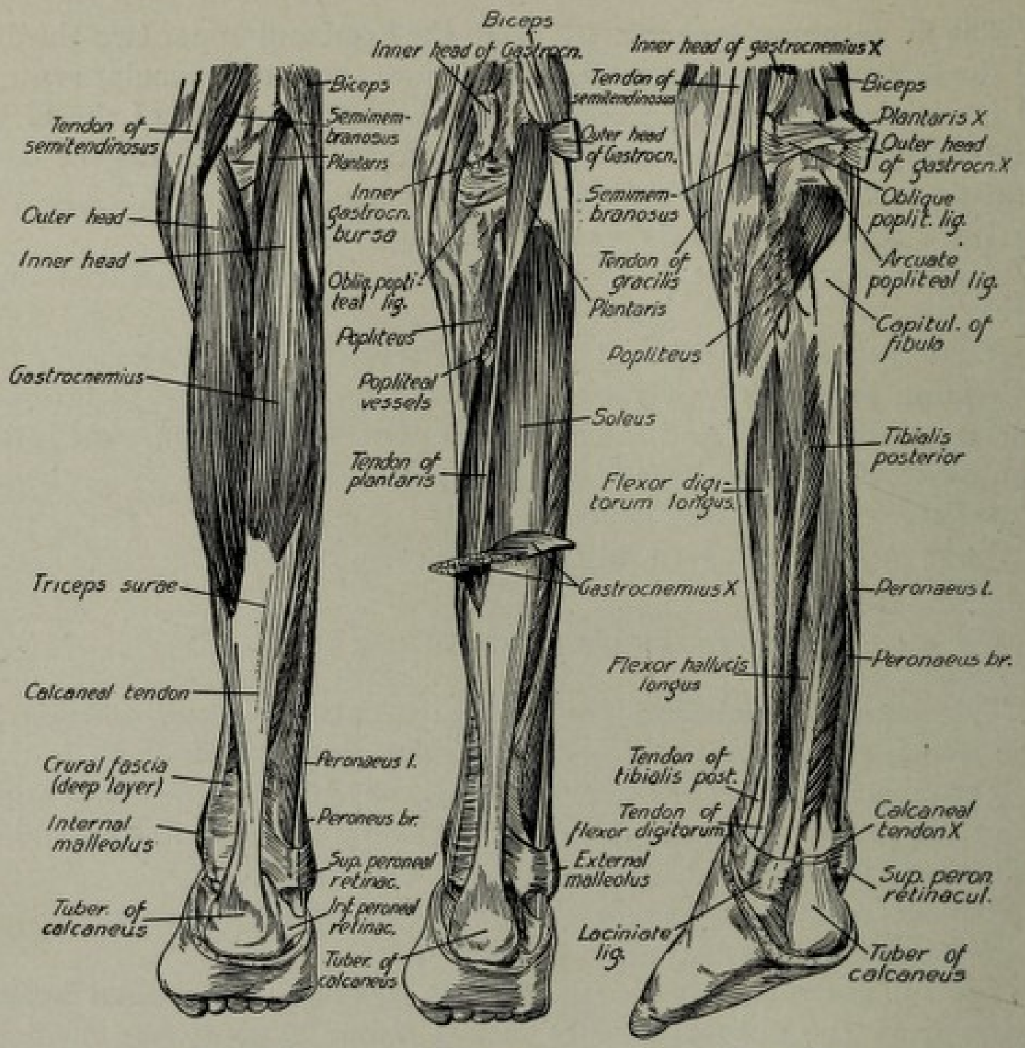


FIG. 158. FIG. 159. FIG. 160.

FIG. 158.—The superficial muscles of the calf of the leg. (*Sobotta and McMurrich.*)

FIG. 159.—The second layer of the calf muscles. The gastrocnemius has been removed. (*Sobotta and McMurrich.*)

FIG. 160.—The deep musculature of the calf, seen from behind and from the inner side. The triceps suræ has been removed. (*Sobotta and McMurrich.*)

The **m. politeus** *arises* from the lateral epicondyle of the femur and is *inserted* into the dorsal surface of the tibial proximal to the oblique line.

Actions.—Flexes and *rotates* the leg medially.

Nerve Supply.—Tibial nerve (L. 4, 5, S. 1).

The **m. flexor digitorum longus** *arises* from the medial part of the dorsal surface of the tibia below the oblique line and from the intermuscular septa. It is *inserted* into the base of the last phalanx of the four outer toes. The tendons pass through the split tendons of the flexor digitorum brevis. With this muscle the lumbricales and the quadratus plantæ, or accessorius muscles are associated.

Actions.—Flexes the four outer toes and *extends* the foot.

Nerve Supply.—Tibial nerve (L. 5, S. 1).

The **m. flexor hallucis longus** *arises* from the lower or distal half of the dorsal surface of the fibula and from the fascia and intermuscular septa. It is *inserted* into the base of the last phalanx of the great toe.

Actions.—Flexes the great toe, *extends* the foot and *assists in supporting* the arch of the foot.

Nerve Supply.—Tibial nerve (L. 5, S. 1, 2).

The **m. tibialis posterior** *arises* from the lateral part of the dorsal surface of the tibia, from the interosseous membrane, from the medial surface of the fibula and from the intermuscular septa. The tendon passes into the sole of the foot and has a very extensive *insertion* as follows: into the plantar surfaces of the navicular, first and second cuneiform bones; into the plantar surfaces of the second, third and fourth metatarsal bones; the groove of the cuboid and the medial margin of the sustentaculum tali of the calcaneus.

Actions.—Extends and *inverts* the foot.

Nerve Supply.—Tibial nerve (L. 5, S. 1).

THE MUSCLES OF THE SOLE OF THE FOOT

The **plantar muscles** are usually described as arranged in *four layers*.

First Layer.—The **m. abductor hallucis** *arises* from the medial surface of the tuberosity of the calcaneus, from the lig. laciniatum (internal annular lig.), the plantar aponeurosis and intermuscular septum. It is *inserted* into the medial side of the first phalanx of the great toe.

Actions.—Flexes and *abducts* the great toe.

Nerve Supply.—Medial plantar nerve (L. 4, 5, S. 1).

The **m. flexor digitorum brevis** *arises* from the ventral part of the medial process of the tuberosity of the calcaneus and from the central plantar aponeurosis and intermuscular septa. It is *inserted* by four tendons into the sides of the second phalanges of the four lesser toes. Each tendon splits to permit the corresponding tendon of the m. flexor digitorum longus to pass through.

Actions.—Flexes the toes.

Nerve Supply.—Medial plantar nerve (L. 4, 5, S. 1).

The **m. abductor digiti quinti** *arises* from the tuberosity of the calcaneus, from the lateral part of the plantar aponeurosis and intermuscular septum. It is *inserted* into the lateral surface of the base of the first phalanx of the little toe.

Actions.—Flexes and *abducts* the little toe.

Nerve Supply.—Lateral plantar nerve (S. 1, 2).

Second Layer.—The **mm. lumbricales** are *four* muscles associated with the flexor digitorum longus tendons. The *first arises* from the medial side of the tendon for the second toe and the *others arise* from the adjacent side of all four tendons. Each muscle is *inserted* into the extensor tendon and the base of the first phalanx of the four outer toes, as in the hand.

Actions.—*Flex* the metatarsophalangeal joints and *extend* the interphalangeal joints of the four outer toes.

Nerve Supply.—The first or medial lumbricale, medial plantar nerve (L. 4, 5, S. 1); the other three, lateral plantar nerve (S. 1, 3).

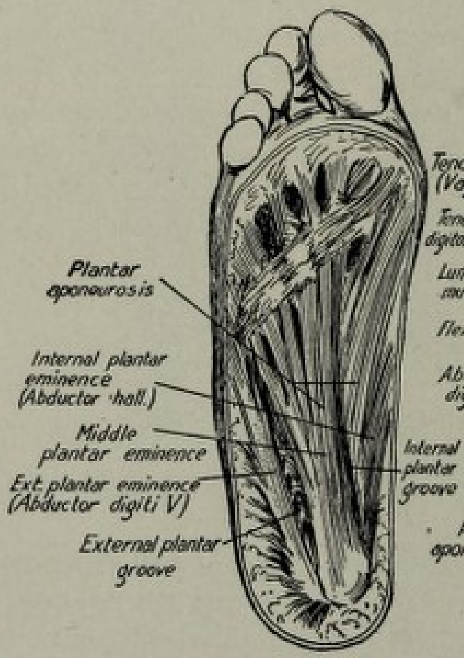


Fig. 161.—The plantar aponeurosis. (*Sobotta and McMurrich.*)

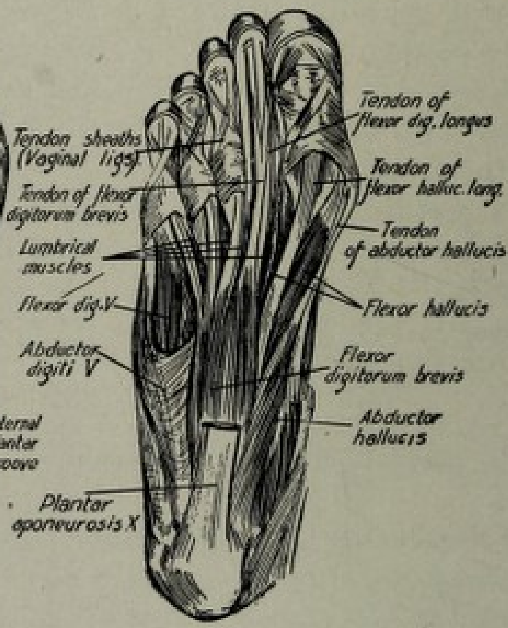


Fig. 162.—The superficial layer of the plantar muscles. The plantar fascia has been largely removed from the surface of the flexor digitorum brevis. (*Sobotta and McMurrich.*)

The **m. quadratus plantæ** or **accessorius,** *arises* from the lateral margin of the plantar ligament and the adjacent portion of the plantar surface of the calcaneus; a *medial head arises* from the medial margin of the long plantar ligament and from the medial surface of the calcaneus. Its flattened tendon is *inserted* into the tendons of the flexor digitorum longus (mainly for the second, third and fourth toes).

Actions.—*Assists in flexing* the toes and draws the long tendons into the middle of the sole of the foot.

Nerve Supply.—Lateral plantar nerve (S. 1, 2).

The tendons of the mm. flexor hallucis longus and flexor digitorum longus are included in this layer.

Third Layer.—The **m. flexor hallucis brevis** *arises* from the tendon of the tibialis posterior and the plantar surface of the cuboid bone. It forms two tendons (between which the tendon of the m. flexor hallucis longus passes) which are *inserted* into the medial and lateral surfaces of the base of the first phalanx of the great toe, blending with the other tendons inserted here.

Action.—*Flexes* the great toe at the metatarsophalangeal joint.

Nerve Supply.—Medial plantar nerve (L. 4, 5, S. 1).

The **m. adductor hallucis** *arises* by *two heads*. The *oblique head arises* from the plantar surfaces of the second, third and fourth meta-

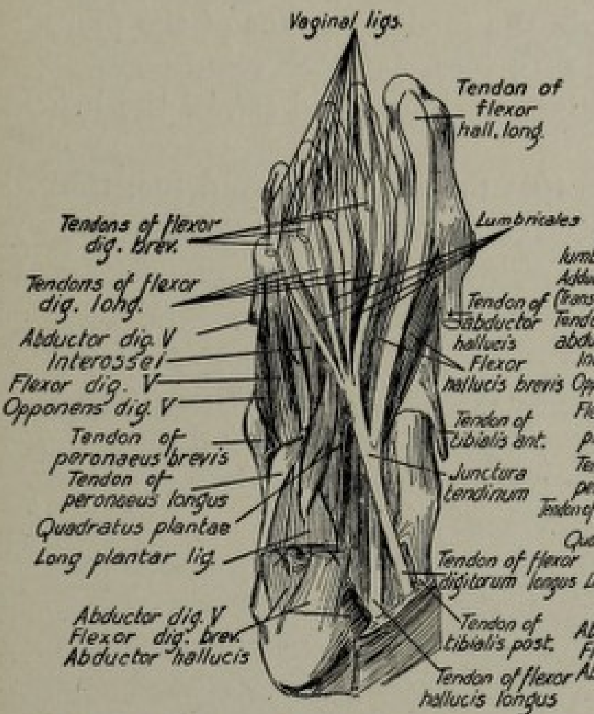


Fig. 163.—The middle layer of plantar muscles. The flexor digitorum brevis, the abductor hallucis, and the abductor digiti quinti have been removed; the tendon-sheaths of the digits and of the peronæus longus have been opened. (*Sobotta and McMurrich.*)

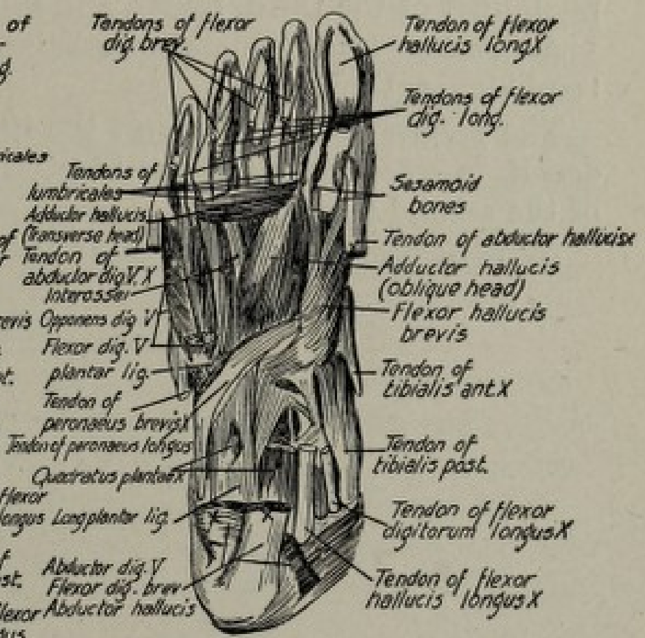


Fig. 164.—The deep layer of plantar muscles. The tendons of the flexor digitorum longus, the flexor hallucis longus, and the quadratus plantæ have been removed. (*Sobotta and McMurrich.*)

tarsal bones and from the sheath of the m. peroneus longus and is *inserted* into the lateral surface of the base of the phalanx of the great toe. The *transverse head arises* from the transverse metatarsal ligaments and the capsules of the metatarsophalangeal joints (outer four). It is *inserted* with the oblique head.

Actions.—*Adducts* and *flexes* the great toe.

Nerve Supply.—Lateral plantar nerve.

The **m. flexor digiti quinti brevis** *arises* from the base of the fifth metatarsal bone and the sheath of the m. peroneus longus. It is *inserted* into the lateral surface of the base of the first phalanx of the little toe.

Action.—*Flexes* the little toe.

Nerve Supply.—Lateral plantar nerve.

Fourth Layer.—The **mm. interossei** are *seven* in number, *four dorsal* and *three plantar.*

The **dorsal muscles** occupy the four interosseous spaces and each *arises* from the adjacent surfaces of two metatarsal bones. The tendons of the **first** and **second** are *inserted* into the first phalanx of the second toe (medial and lateral surface). The **third** and **fourth** are *inserted* into the lateral surfaces of the first phalanges of the third and fourth toes.

The **three plantar interossei** are located in the three lateral spaces. Each *arises* from the medial surface of the third, fourth and fifth metatarsal bones and is *inserted* into the medial surface of the first phalanges of the third, fourth and fifth toes.

Actions.—*Flex* the metatarsophalangeal joints and *extend* the interphalangeal joints.

The *plantar interossei adduct* the toes toward the second toe; the *dorsal interossei abduct their* respective toes from the middle line of the second toe.

Nerve Supply.—Lateral plantar nerve (S. 1, 2).

CHAPTER IV

THE BLOOD-VASCULAR SYSTEM

The chief organs found in the thorax are the heart with its pericardium and the great vessels as the aorta, pulmonary arteries, innominate, left common carotid and subclavian arteries, the innominate veins and the superior and inferior venæ cavæ; the lungs and pleuræ; the esophagus, trachea and bronchi; the vagal, phrenic and sympathetic nerves, the thoracic duct and part of the thymus body.

In order to comprehend that an organ is enlarged or displaced it is necessary to know its normal size, position and outline upon the body wall. In order to facilitate physical diagnosis certain lines are drawn upon the body and these bound certain definite regions. Bony landmarks are used wherever possible. The various lines and regions of the thorax will be first considered.

Lines of the Thorax.—For the convenience of outlining the organs upon the body surface, a number of vertical and transverse lines are drawn. The chief *vertical lines* are the *midsternal*, *midclavicular*, *lateral sternal*, *parasternal*, *midaxillary*, *scapular* and *midvertebral*.

The *midsternal line* (one) is drawn from the midsternal notch and if continued upon the abdominal wall would pass through the umbilicus and symphysis pubis.

The *midclavicular lines* (two) are drawn from the middle of the clavicle through the nipple of the male and if continued upon the abdomen would pass through the middle of the inguinal ligament.

The *lateral sternal lines* are two lines at the right and left borders of the sternum.

The *parasternal lines* are two vertical lines midway between the midsternal and midclavicular lines. Some place these lines midway between the lateral sternal and the midclavicular lines.

The *midaxillary lines* (two) are drawn from the apex of the axilla (armpit) with the arms extended at a right angle to the body.

The *scapular lines* (two) are drawn vertically through the inferior angle of each scapula.

The *midvertebral line* (one) is drawn along the spinous processes of the thoracic vertebræ.

The *horizontal lines* upon the ventral surface are as follows:

1. At the lower border of the cricoid cartilage.
2. Through the clavicles.

3. Through the third chondrosternal junction.

4. Through the sixth chondrosternal junction.

With the two lines at the sternal borders the following regions are outlined:

1. *Suprasternal*, containing the trachea, thyreoid gland and the esophagus.

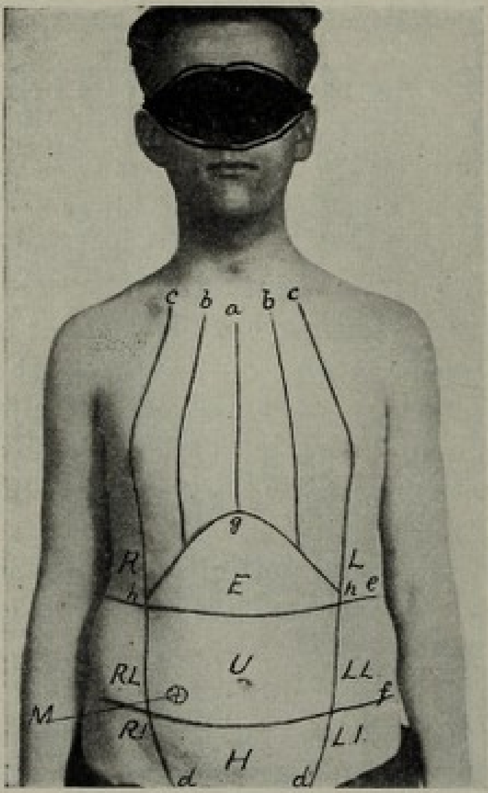


FIG. 165.—Lines and regions of the ventral thoracic and abdominal walls. (*From a Photograph.*) *a*, Midsternal; *b*, *b*, parasternal; *c*, *c*, midclavicular lines; *e*, subcostal line; *f*, intertubercular lines; *g*, subcostal angle; *hd*, *hd*, midinguinal lines. *RL* right and left hypochondriac regions; *RL*, *LL*, right and left lumbar regions; *RI*, *LI*, right and left inguinal regions; *E*, epigastric; *U*, umbilical; *H* hypogastric regions; *M*, McBurney's point.

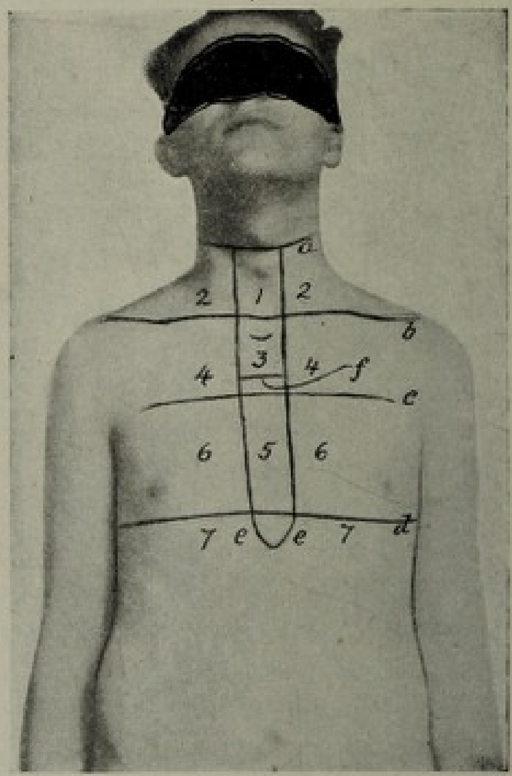


FIG. 166.—Outline of regions on the ventral thoracic wall. (*From a Photograph.*) *a*, Line through cricoid cartilage; *b*, line through clavicles; *c*, line through third chondrosternal articulation; *d*, line through sixth chondrosternal articulation; *e*, *e* lateral sternal lines; *f*, angle of Ludovicius. 1, Suprasternal region; 2, 2, supraclavicular regions; 3, upper sternal region; 4, 4, infraclavicular regions; 5, lower sternal region; 6, 6, mammary regions; 7, 7, inframammary regions.

2, 2. The *supraclavicular* regions containing the apex of each lung and the cervical pleura.

3. *Upper sternal* region containing the thymus, the arch of the aorta and the medial border of the upper border of each lung.

4, 4. The *infraclavicular* regions containing the upper lobe of each lung where tuberculous bronchopneumonia is first manifested.

5. *Lower sternal* region containing the ventral border of the right lung and the uncovered area of the heart.

6, 6. The *mammary* regions containing the bulk of the lungs and the bulk of the heart.

7, 7. The *inframammary* regions containing the lower portions of the lungs and the costophrenic sinuses. These regions overlap the right lobe of the liver upon the right side and on the left side the left lobe of the liver, the fundus of the stomach and the spleen. Upon the left is *Traube's semilunar space.*

The *horizontal lines* upon the dorsal surface are as follow

1. At the upper borders of the scapulæ.
2. Through the spines of the scapulæ.
3. Through the inferior angles of the scapulæ.

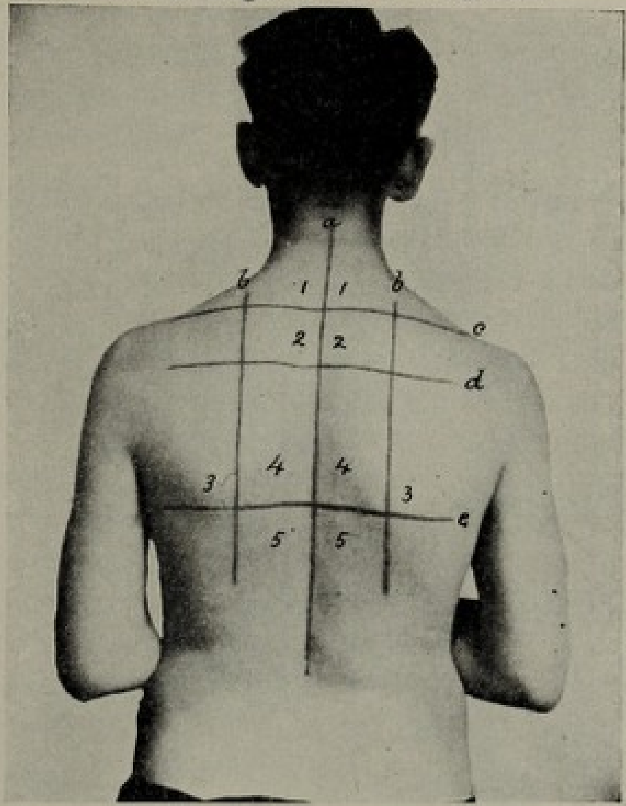


FIG. 167.—Lines and regions on the dorsal thoracic wall. *a*, Midvertebral line; *b*, *b*, scapular lines prolonged headward; *c*, a line at the upper borders of the scapulæ; *d*, a line through the spines (bases) of the scapulæ; *e*, a line at the apex of the inferior angles of the scapulæ. 1,1, Suprascapular regions; 2, 2, supraspinous regions; 3,3, infraspinous regions; 4, 4, interscapular regions; 5, 5, infrascapular regions. (*From a photograph.*)

In conjunction with the midvertebral and the scapular lines prolonged upward to the shoulder the following regions are outlined:

1, 1. *Scapular* regions.
2, 2. *Supraspinous* regions.
3, 3. *Infraspinous* regions.
4, 4. *Interscapular* regions.
5, 5. *Infrascapular* regions.

Occupying the bulk of each side of the thoracic cavity are seen the lung and pleural membranes. The region between the two pleural sacs is called the **interpleural space,** or **septum mediastinale.** This region is not a space in the true sense as it is occupied by various organs and structures.

The **mediastinal septum** is divided into two main portions, *superior* and *inferior*. The *superior mediastinum* lies above the level of the pericardium, extending from the junction of the manubrium and

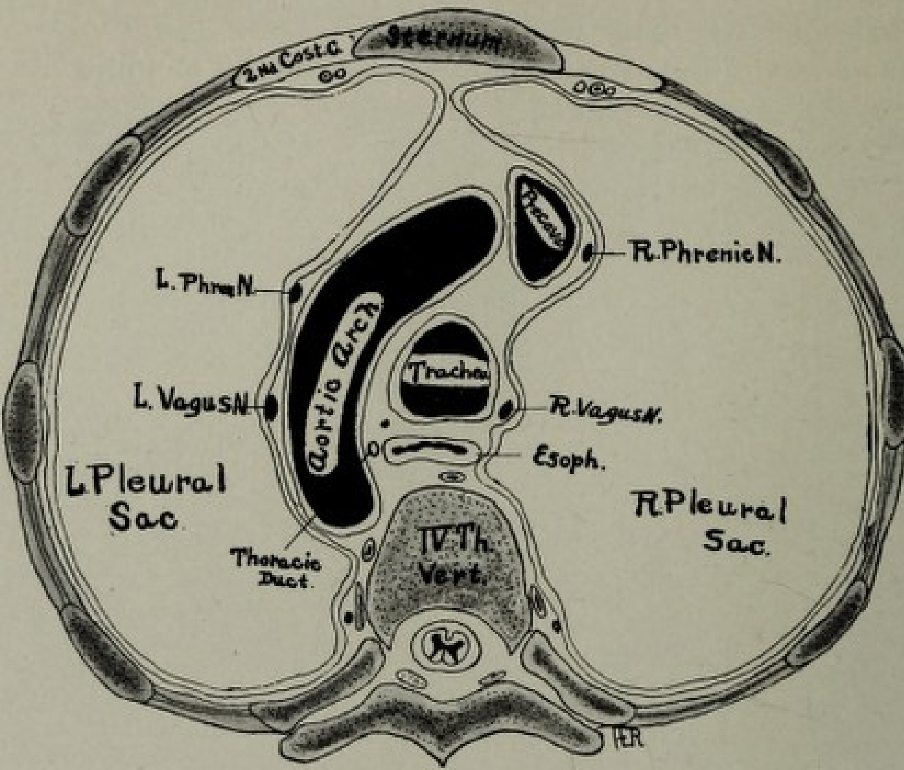


FIG. 168.—The superior mediastinum (at the level of the fourth thoracic vertebra.)

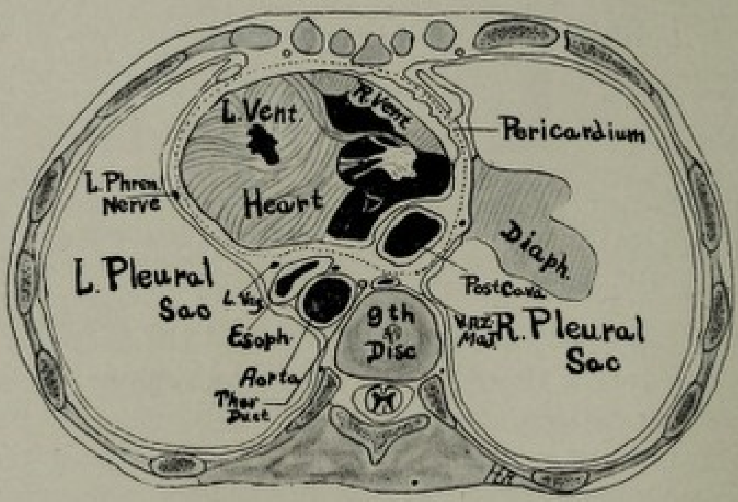


FIG. 169.—The ventral, middle and dorsal mediastinal spaces (at the level of the disc between ninth and tenth thoracic vertebræ).

gladiolus sterni to the lower border of the fourth thoracic vertebra. In this region lie the arch of the aorta and its three branches, the upper part of the superior vena cava and the innominate veins, the esophagus, trachea, thoracic duct, the vagal, phrenic, cardiac, recurrent laryngeal and sympathetic nerves and the thymus gland.

The *inferior mediastinum* is the widest portion and is divided into *ventral*, *middle* and *dorsal* portions. The *ventral* lies between the sternum and the pericardium and contains some lymph nodes, branches of the internal mammary artery and areolar tissue.

The *middle* portion is the largest and is bounded by the pericardium. Its contents are the pericardium, heart, roots of the great vessels and the phrenic nerves.

The *dorsal mediastinum* lies behind the pericardium. Its contents are the descending thoracic aorta, the thoracic duct, vena azygos major, vagal nerves and esophagus.

The **blood vascular system** consists of the *heart*, *arteries*, that carry the blood away from the heart, *veins*, that carry the blood toward the heart and *capillaries* that connect the arteries and veins. There are *two main circulations*, the *systemic* and the *pulmonary*. The *systemic* is farther divided into the *general systemic* and the *portal circulations*.

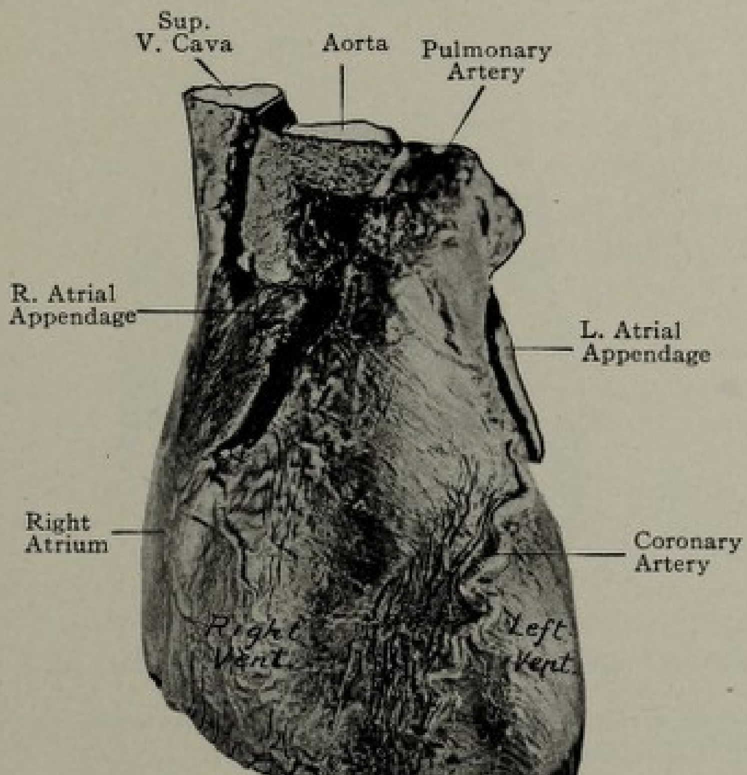


FIG. 170.—Ventral view of the heart. (*From a photograph.*)

THE HEART

The heart (cor) is a hollow muscular organ of a flattened, conical shape situated in the thoracic cavity. It is contained in a serous sac called the *pericardium*. About one-third lies to the right of the midsternal line and two-thirds to the left. Its long axis is directed downward (caudad) to the left and forward (ventrad). Its dimensions are 5 inches (12.5 cm.) long, 3.5 inches (8.75 cm.) wide and 2.5 inches (6.25 cm.) thick. It weighs 10 to 12 ounces in the male and 8 to 10 ounces in the female.

It presents a *base*, an *apex*, *two surfaces* and *two margins*. The *base* (*basis cordis*) is directed upward (cephalad) and backward (dorsad) and is formed by the *atria*, chiefly the left. It lies ventral to the bodies of the fifth, sixth, seventh and eighth thoracic vertebræ but separated from them, mainly, by the esophagus and the thoracic aorta. It presents the openings of the pulmonary veins and the superior and inferior venæ cavæ, the oblique vein and fold of Marshal.

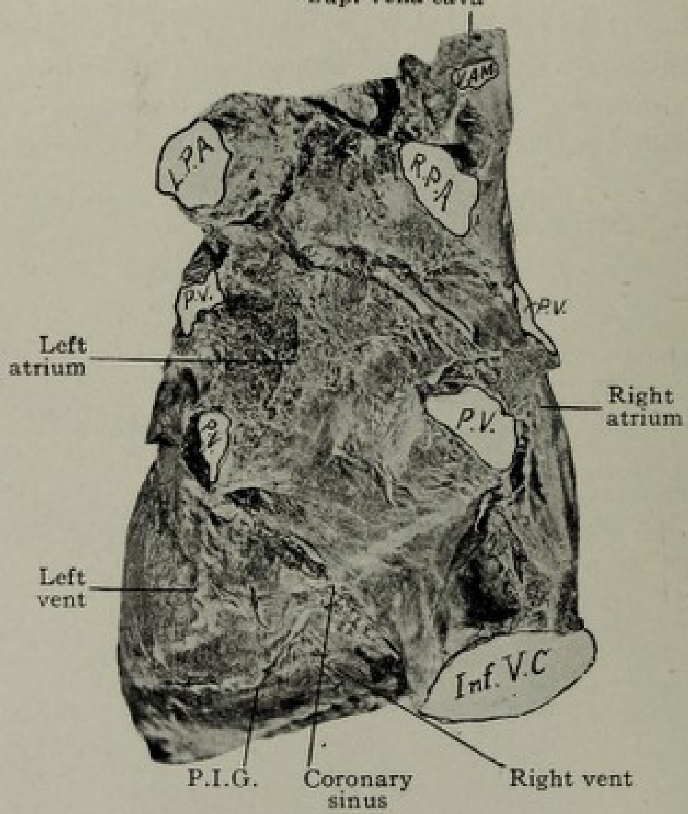


FIG. 171.—Dorsal view (base and diaphragmatic surface) of the heart. The vessels are filled with cotton to make them stand open. (*From a photograph.*) *L.P.A.*, *R.P.A.*, Left and right pulmonary arteries; *P.V.*, pulmonary veins; *V.A.M.*, vena azygos major. *P.I.G.*, dorsal (inferior) interventricular sulcus.

The base is limited below by the atrioventricular groove which contains the *coronary sinus*.

The *apex* (*apex cordis*) is blunt and rounded representing the left ventricle; it is situated in the fifth left intercostal space 8 cm. from the midline.

The *sternocostal surface* (*facies sternocostalis*) looks upward (cephalad) and forward (ventrad) and to the left. It lies dorsal to the sternum and the third, fourth, fifth and sixth costal cartilages, mainly of the left side. The upper part consists of the two atria and roots of the pulmonary artery and aorta. The greater part of the surface consists of the ventricles separated incompletely from the preceding by the ventral atrioventricular groove. This ventricular area is convex and is divided into a *larger*, right, and *smaller*, left, portion by the *ventral* (*superior*) *interventricular sulcus* which goes to the right of the apex.

The *diaphragmatic surface* (*facies diaphragmatica*) is flattened and rests chiefly upon the central tendon of the diaphragm. It consists of the ventricles and is divided into a *greater*, left ventricle, and *smaller*, right ventricle portions by the *dorsal interventricular sulcus*.

The *right margin* consists of a *vertical* and a *horizontal portion*. The *vertical part* is curved and is formed by the right atrium; it is marked by the *sulcus terminalis*. The *horizontal portion* is thin and sharp and is formed by the right ventricle; this latter part is called also the *inferior margin*, or *margo acutus*.

The *left margin* is convex and is formed mainly by the left ventricle. It is rounded and is called the *margo obtusus*. It is obliquely directed with its convexity to the left.

The *chambers of the heart* are *four* in number: *right* and *left atria* and *right* and *left ventriculi*. The right atrium communicates with the right ventriculus and the left atrium with the left ventriculus. The capacity of each ventricle is about 100 c.c. and that of each atrium slightly less.

Right Atrium.—Make an incision with the scissors connecting the inferior and superior cavæ; from the middle of this incision make another into the auricular appendage. By these incisions the atrium is laid open and the various points of interest may be readily examined.

Right Ventricle.—From the right atrium cut into the right ventricle along the inferior margin of the chamber to the apex. From the middle of this incision carry another to the interventricular groove and follow the interventricular septum into the pulmonary artery.

Left Atrium.—Make an incision connecting the right and left superior pulmonary veins; make another from the left superior pulmonary vein into the appendage.

Left Ventricle.—Make an incision from the left atrium into the left ventricle following the left border of the heart to the apex; then continue along the interventricular sulcus into the aorta using a finger of the left hand as a guide to the scissors.

The **right atrium** (*atrium dextrum*) consists of the main chamber and the *auricle* (*auricula dextra*). The points of interest in the interior are as follows:

1. *Crista terminalis*, a ridge running from in front (ventral margin) of the superior vena cava to in front of the inferior vena cava. This ridge is marked externally by a groove, the *sulcus terminalis*.

2. The *tricuspid* (*right atrioventricular*) *orifice* leading into the right ventricle.

3. The *orifice of the superior vena cava* at the upper (cephalad) and back (dorsal) part of the atrium.

4. The *orifice of the inferior vena cava* at the lowest part of the atrium.

5. The *Eustachian valve* (*valvula venæ cavæ inferioris*) situated in front of (ventral to) the orifice of the inferior vena cava and extending to the fossa ovalis.

6. The *coronary sinus* (*sinus coronarius*) opening between the orifice of the inferior vena cava and the tricuspid orifice.

7. The *coronary valve* (*valvula sinus coronarii*) that protects the orifice of the coronary sinus.

8. *Foramina thebesii* (*venæ cordis minimæ*) openings of small veins in the walls of the atrium.

9. *Fossa ovalis*, a depression in the lower part of the interatrial septum.

10. *Annulus ovalis* (*limbus fossæ ovalis*) the incomplete ridge forming the boundary of the fossa ovalis.

11. The *musculi pectinati*, the muscle columns in the auricle.

12. The *openings of the anterior cardiac veins* at the lower part of the front (ventral) wall of the atrium.

13. The *tubercle of Lower* (*tuberculum intervenosum*) a small projection between the fossa ovalis and the superior and inferior venæ cavæ, not prominent in man.

The **right ventricle** (*ventriculus dexter*) is pyramidal in form and the cavity consists of the main part, or *body*, and the *conus arteriosus*, that leads into the pulmonary artery. These two parts are separated by a slight ridge, the *supraventricularcrest*. The walls in the body portion are thinner than those of the left ventricle and are irregular, due to the presence of the *trabeculæ carneæ*. The walls of the conus arteriosus are smooth. The points of interest are as follows:

1. The *tricuspid orifice* communicating with the right atrium, guarded by the tricuspid valve. It is oval and is directed obliquely downward (caudad) and to the right.

2. The *pulmonary artery orifice* at the upper (cephalic) and front (ventral) part of the chamber and at the end of the conus arteriosus.

3. *Venæ cordis minimæ*, the openings of small veins in the walls.

4. *Trabeculæ carneæ*, or muscle columns of three varieties, ridges, arches and papillary muscles. The last, *musculi papillares*, are more or less massive projections attached to the ventricular wall by their bases. The papillary muscles usually number three: (1) a large ventral, (2) a smaller dorsal, (3) a single, or group of papillæ (septal) attached to the interventricular septum. To the summit of each are attached the chordæ tendineæ.

5. The *moderator band*, a modified column attached at one end to the interventricular septum and at the other to the base of the ventral

papillary muscle. It tends to prevent over-distention of the ventricle and is prominent in lower animals.

6. The *tricuspid valve* (*valvula tricuspidalis*) consists of three somewhat triangular leaflets. The base of each is attached to the atrioventricular orifice and the free edges are serrated; from the serrations delicate tendinous threads, the *chordæ tendineæ*, pass to the papillary muscles. The *left*, or *infundibular cusp*, is the largest and is situated over the conus arteriosus. The *right*, or *marginal cusp*, is in relation with the right part of the ventral wall; the *medial*, or *septal cusp*,

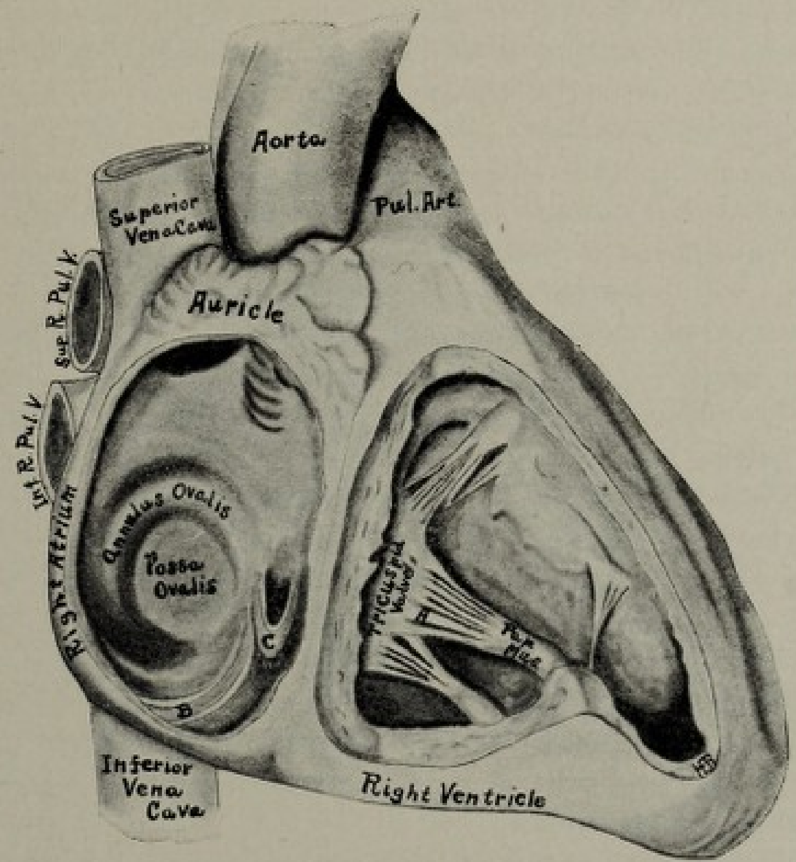


FIG. 172.—Heart dissected so as to show the interior of the right atrium and the right ventricle. *A*, Chordæ tendineæ; *B*, eustachian valve; *C*, coronary valve.

is in relation with the interventricular septum. This valve guards the atrioventricular orifice.

7. The *chordæ tendineæ* are delicate cords that attach the valve edges and central parts of the valve leaflets to the papillary muscles and prevent the leaflets from passing into the atrium.

The **left atrium** (*atrium sinistrum*) consists of the *body* and the *auricle*. The *body* is smooth-walled while the auricular wall is roughened. The points of interest are as follows:

1. *Orifice of the four pulmonary veins* opening into the upper (cephalic) part of the dorsal wall.

2. The *atrioventricular orifice* communicating with left *ventricle*.
3. *Venæ cordis minimæ*.
4. *Musculi pectinati* in the auricula.

The **left ventricle** (*ventriculus sinister*) has thicker walls than the right ventricle (3 to 1) and is somewhat cylindrical in form. The cavity is divided into *body* (irregular wall) and *vestibule* (smooth-walled) that leads to the aorta. The points of interest are as follows:

1. *Bicuspid orifice* that communicates with the left atrium and is guarded by the bicuspid valve.
2. The *aortic orifice* that leads into the aorta and is situated at the upper, front part at the summit of the vestibule. It is circular in outline and lies ventral to the preceding orifice.
3. *Venæ cordis minimæ*.
4. *Trabeculæ carneæ: ridges, arches* and *papillary muscles*. The *papillary muscles* (*musculi papillares*) are two in number, *ventral* and *dorsal*, or *inferior* and they are much larger than those of the right ventricle. To these the chordæ tendineæ are attached.
5. The *bicuspid valve* (*valvula mitralis*) consists of two leaflets, the *ventral*, or *aortic cusp* is the larger, the *inferior*, or *marginal cusp* is the smaller. Usually two smaller cusps are found at the angles of junction of the larger cusps. The free edges of the leaflets are serrated and have the chordæ tendineæ attached here as well as to the under surfaces of the valve leaflets.
6. The *chordæ tendineæ* are attached like those of the right ventricle but are thicker and stronger.

The *interventricular septum* (*septum ventriculorum*) separates the two ventricles. It corresponds to the interventricular sulcus and has an oblique position. The bulk of it consists of muscle tissue, the upper (cephalic) and ventral part in membranous and is, therefore, called the *pars membranacea*.

The **muscle tissue of the heart** is arranged differently in the atria than in the ventricles. In the atria *two layers* are noted. The *superficial layer* runs transversely and is common to both chambers. The *deep layer* consists of fibers that loop over each atrium from front to back (dorsoventrally) and form circular bands around the auriculæ and orifices of the veins. In the ventricles the arrangement is more complex. The *superficial set* consists of fibers that arise from the conus arteriosus and pass across the right ventricle around the apex and thence to the papillary muscles of the left ventricle. Other fibers arise from the right atrioventricular ring, pass beneath the preceding, around the apex to the dorsal papillary muscle of the left ventricle. Some fibers arise from the left atrioventricular ring and pass to the right ventricle and its papillary muscles. The *deep set* (larger) consists of fibers that arise in the papillary muscles of one ventricle, describe an S-shaped course and pass under the papillary muscles of the other ventricle. There are three sets of these and the course is very complicated.

The **atrioventricular bundle** (**His**) connects the right atrium directly with the ventricles. This bundle of muscle fiber *arises* near the fossa ovalis as small bundles of fibers that converge to form its *node;* it then continues as a single bundle in the lower part of the pars membranacea to the muscular portion of the interventricular septum. Here the bundle divides into right and left portions one for each ventricle. Each passes down its respective side of the interventricular septum, beneath the endocardial lining, to ultimately divide to numerous bundles that pass to the papillary muscles and then spread out over the entire ventricular muscle.

The heart receives its **blood supply** through the *right* and *left coronary arteries* that arise from the aorta in the sinuses of Valsalva. The blood is returned to the right atrium through the coronary sinus and the anterior cardiac veins. The tributaries of the coronary sinus are the small, or right cardiac vein and the middle, or posterior cardiac veins. The *lymph* drains into the right lymphatic and thoracic ducts.

The **nerve supply** is from the vagal, accessory and sympathetic nerves.

The **pericardium** is a fibrous sac lined by a serous membrane. It is conical in shape with its base downward (caudad) and apex upward (cephalad). The base is attached to the central tendon of the diaphragm while the apex is continuous with the cervical fascia. The sac contains the heart and the cardiac ends of the great vessels. Its ventral wall gives attachment to the *superior* and *inferior sternopericardial ligaments.* It constitutes the boundary of the middle mediastinal space as well as assists in bounding the ventral and dorsal mediastinal spaces. At its base it is pierced by the inferior vena cava and at its apex (dorsally) it is pierced by, and its fibrous part also ensheaths the superior vena cava, pulmonary veins, right and left pulmonary arteries and aorta.

The serous portion consists of a *visceral layer,* upon the heart, and a *parietal layer,* lining the fibrous sac. These two are continuous over the great vessels of the heart but all of the vessels do not receive a complete investment. As a result *recesses,* or *sinuses,* are formed. The *great transverse sinus* lies between the pulmonary artery and the aorta (ventrally) and the two atria (dorsally). The *great oblique sinus* lies between the inferior vena cava (to the right and below) and the left inferior pulmonary vein (to the left and above).

The **vestigial fold of Marshall** is a fold of serous pericardium enclosing the *ligamentum venæ cavæ sinistræ.* It passes from the left pulmonary artery region to the left superior pulmonary vein.

To *outline the heart* upon the ventral thoracic wall the following points are used: (1) 3 cm. from the midsternal line upon the upper margin of the third right costal cartilage; (2) 2.5 cm. from the midsternal line at the sixth chondrosternal junction; (3) 8 cm. from the midsternal line in the left fifth interspace (apex point); (4) 4.5 cm. from the midsternal line in the second left interspace. The line 1, 2 should be curved to the right so as to be 3.5 cm. from the midsternal line at the fourth interspace. This line represents the right atrium.

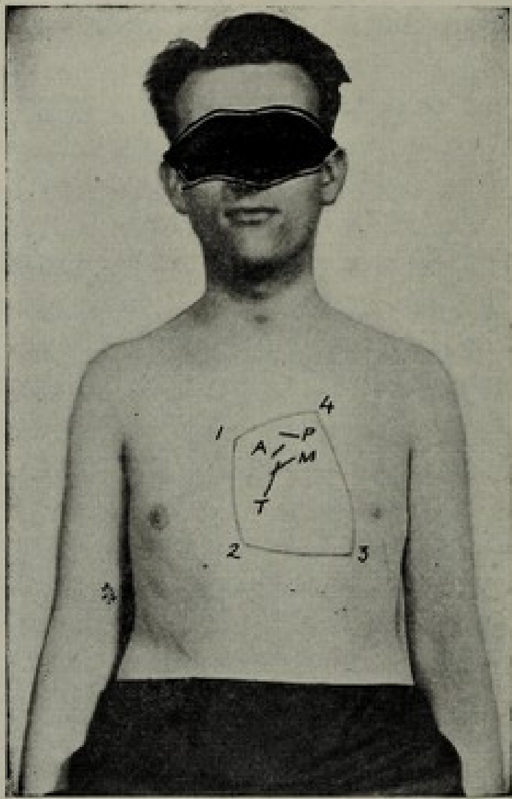


FIG. 173.—Outline of the heart upon the ventral thoracic wall. (*From a photograph.* *P*, Pulmonary valve; *A*, aortic valve; *M*, mitral valve; *T* tricuspid valve. 1, 2, 3, 4, point for outlining the heart.

The line 2, 3 represents the right ventricle. The line 3, 4 should be curved a little to the left and represents the left border and mainly left ventricle. The line 1, 4 represents the base line. The *valves* are located as follows: The *pulmonary valve* is placed horizontally beneath the middle of the third left chondrosternal junction. The *aortic valve* is below this and toward the midline and at an angle. The *mitral valve* is opposite the third left interspace and nearly horizontal, while the *tricuspid valve* is below this near the midline and at an angle, slightly overlapping the mitral valve. These areas indicate the position of the valves but do not indicate the regions where the valve sounds are best heard. These latter are called the *puncta maxima* and are as follows:

1. *Pulmonary punctum maximum* (*p. m.*) is at the sternal end of the second left intercostal space.

2. *Aortic p. m.* is at the second right costal cartilage.

3. *Mitral p. m.* is just above the area of the apex point.

4. *Tricuspid p. m.* is at the sternal ends of the fifth and sixth costal cartilages.

That portion of the heart that lies immediately beneath the ventral thoracic wall and separated from it by only the pericardium and

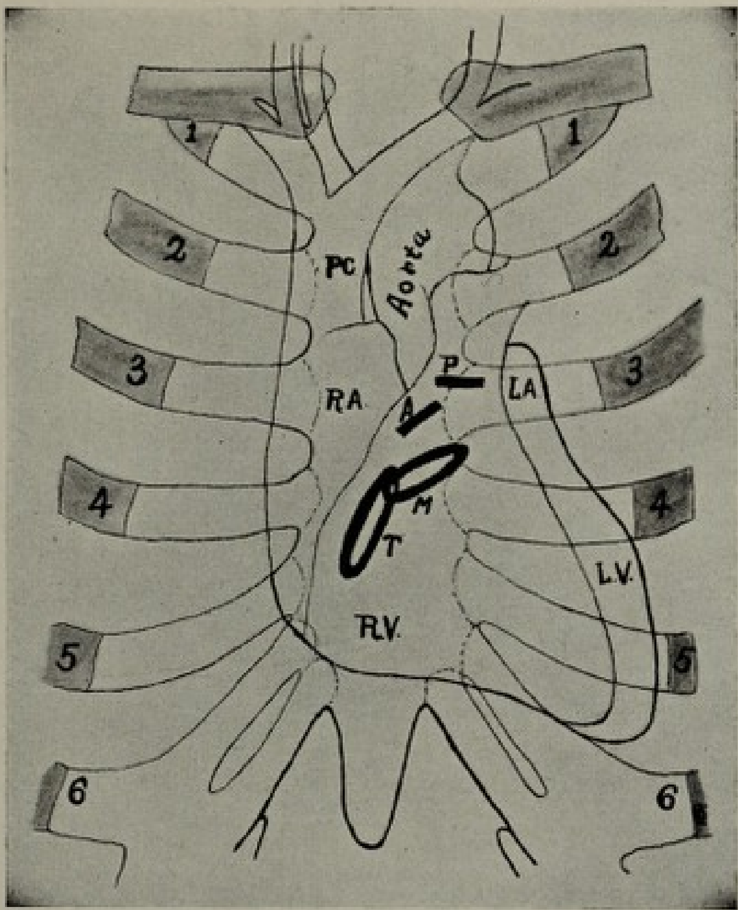


FIG. 174.—Diagram of the heart and valves in relation to the skeleton of the ventral thoracic wall. *PC*, Superior vena cava; *RA*, right atrium; *RV*, right ventricle; *LA*, left atrium; *LV*, left ventricle; *P*, pulmonary valve; *A*, aortic valve; *M*, mitral valve; *T*, tricuspid valve.

pleuræ is called the *area of superficial cardiac dulness* and is chiefly ventricular; the remainder is overlapped by the lungs and gives the *deep cardiac dulness*.

THE ARTERIES

The *circulations* are the *pulmonary* and *systemic;* the *systemic* is divided into *general systemic* and *portal*.

The **pulmonary circulation** comprises the right ventricle, the pulmonary aorta and the pulmonary arteries, the lungs, pulmonary veins and the left atrium.

The **pulmonary aorta,** or **artery** (*arteria pulmonalis*), leaves the right ventricle at the summit of the conus arteriosus. The vessel is about 2 inches (5 cm.) long and 1¼ inches (30 mm.) in diameter. It passes upward (cephalad) and dorsally and under the arch of the aorta it divides into right and left pulmonary arteries which further divide and ramify the lungs. The base of the pulmonary aorta has three dilatations called the *sinuses of Valsalva*, two ventral and one dorsal. Here are seen the *semilunar valves*, three in number; each valve is semilunar in shape and is attached by its peripheral

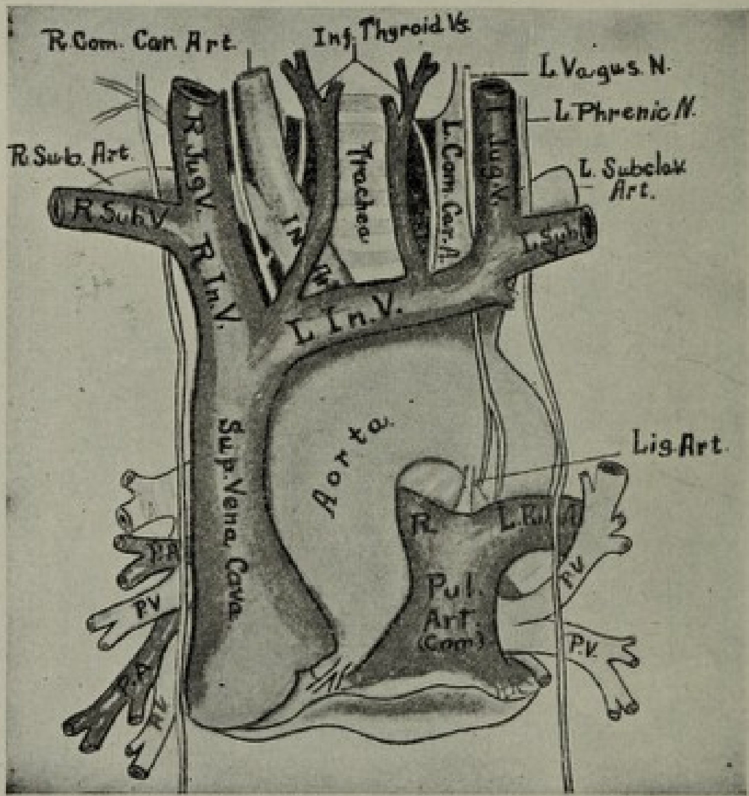


Fig. 175.—Arch of the aorta and its branches; the superior vena cava and its tributaries; the pulmonary arteries and veins.

margin to the base of the pulmonary artery (*annulus fibrosus*). The inner, or free edge, near its middle possesses a nodule called the *corpus arantii* (*nodulus valvulæ semilunaris*). From each side of this a minute semilunar fold extends and is called *lunule* (*lunula*). The right pulmonary artery is larger and longer than the left. Its first branch lies below the first branch bronchus. The first branch of the left pulmonary artery passes above the first branch bronchus.

The **pulmonary veins** (*venæ pulmonales*) are four in number. The lobular divisions unite to form one vein for each lobe, three in the right lung and two in the left lung. The middle vessel on the right side joins that of the upper lobe so that two veins leave each lung to empty into the left atrium. No valves are present.

In the *pulmonary circulation* the venous or deoxygenated blood passes from the right ventricle into the pulmonary artery, through its right and left branches to the lungs where it is oxygenated in the capillaries. The blood then continues into the radicals of the pulmonary veins and through these veins to the left atrium.

The **systemic circulation** is more extensive and more complicated; it comprises the left ventricle, the aorta and its branches, the systemic capillaries, the superior and inferior venæ cavæ and their tributaries and the right atrium.

The **aorta** consists of an *ascending portion*, *arch* and *descending portion;* the last is divided into *thoracic* and *abdominal parts.*

The *ascending portion* (*aorta ascendens*) arises from the summit of the vestibule of the left ventricle. It is about 2 inches (5 cm.) in length and 1⅙ inches (28 mm.) in diameter. At its root (*bulbus aortæ*) it possesses three dilatations, the *sinuses of Valsalva*, two dorsal and one ventral. Here are seen the *semilunar valves* and these are the same in structure as those of the pulmonary artery. From the ventral sinus arises the *right coronary artery* and from the left dorsal sinus arises the *left coronary artery.* These arteries nourish the heart.

The *ascending aorta* passes obliquely upward (cephalad), ventrally and to the right, to the level of the upper border of the second right costal cartilage. Here the *arched part* (*arcus aortæ*) continues upward (cephalad), dorsally and to the left across the trachea and thence downward (caudad) to the level of the lower border of the fourth thoracic vertebra; here it constitutes the beginning of the *descending aorta.* The arch has three branches, the innominate, left common carotid, and left subclavian arteries.

The **innominate artery** (*arteria innomyna*) is the largest branch of the aorta and measures 1½ to 2 inches (3.5 to 5 cm.) in length. It lies in the posterior mediastinum and extends to the root of the neck, where it divides into the right common carotid and right subclavian arteries.

THE ARTERIES OF THE HEAD AND NECK

The **right common carotid** (*arteria carotidis communis dexter*) arises in the root of the neck and extends to the upper margin of the thyreoid cartilage; it is about 3½ inches (8.5 cm.) in length. It lies in the carotid sheath with the internal jugular vein and the vagal nerve and divides into the right internal and external carotid arteries.

The **left common carotid artery** (*arteria carotidis communis sinister*) arises from the arch of the aorta and extends to the upper margin of the thyreoid cartilage. It consists of a *thoracic* and a *cervical portion.* The *thoracic part* is about 1 to 1½ inches (2.5 to 3.5 cm.) in length and extends to the left sternoclavicular articulation. The *cervical portion* starts here and continues as on the right side.

The *course of either common carotid artery* is indicated as follows: Draw a line from the sternal end of the clavicle to a point midway between the mastoid process and the angle of the mandible. That portion of the line inferior to the upper margin of the thyreoid cartilage lies over the artery.

The **external carotid artery** (*arteria carotis externa*) is the smaller of the two branches of the common carotid and extends from the upper margin of the thyreoid cartilage to the back of the neck of the mandible, where it divides into the internal maxillary and superficial temporal arteries. It is about 2½ inches (6.1 cm.) in length. It gives off the following branches:

1. The **superior thyreoid** (*art. thyreoidea superior*) is the first branch and arises on a level with the tip of the greater cornu of the hyoid bone. It passes to the superior portion of the thyreoid gland, which it supplies, and in addition gives branches to the larynx and sternomastoid muscle.

2. The **lingual artery** (*arteria lingualis*) is the second branch mainly for the supply of the tongue. Its chief branches are the *hyoid*, *dorsal lingual* and *sublingual* (for the sublingual gland) *arteries*.

3. The **external maxillary,** or **facial artery** (*arteria maxillaris externa*) arises just above the lingual artery, passes up the neck, over the body of the mandible and terminates at the angle of the mouth as the angular artery. In the *neck* this artery gives off the following arteries: (*a*) The *ascending palatine*, for the soft palate, tonsil, pharynx wall and the auditory tube. (*b*) The *tonsillar artery*, for the tonsil and constrictor muscles of the pharynx. (*c*) The *submaxillary artery*, for the submaxillary gland. (*d*) The *submental artery*, for the submaxillary and sublingual glands and the mylohyoid muscle.

In the *face* the following branches are given off: (*a*) The *superior labial*, or *coronary artery*, that supplies the upper lip and part of the septum of the nose. (*b*) The *masseteric branch*, for the masseter muscle. (*c*) The *lateral nasal artery*, that arises near the angle of the mouth and supplies the ala of the nose. (*d*) The *angular artery* is the terminal part of the external maxillary artery and runs along the side of the nose to the medial commissure of the eyelids.

4. The **occipital artery** (*art. occipitalis*) arises near the inferior margin of the posterior belly of the digastric muscle and extends to the inferior nuchal line where it divides into its terminal branches. This gives off a number of branches. (*a*) *Muscular branches* to the neighboring muscles. (*b*) *Meningeal branches* that enter the skull through the hypoglossal canal and jugular foramen and supply the meninges here. (*c*) The *descending branch*, or *princeps cervicis artery*, supplies muscles of the dorsal vertebral region. (*d*) The *terminal branches* (*medial* and *lateral*) supply the scalp of the neighborhood.

5. The **posterior auricular artery** (*art. auricularis posterior*) arises above the level of the posterior belly of the digastric muscle and ends back of the auricle. This has a number of branches. (*a*) The *muscular branches* supply the sternomastoid, digastric and styloid muscles. (*b*) The *parotid branches* pass to the parotid gland. (*c*) The *stylomastoid artery* enters the stylomastoid foramen and supplies the external auditory canal, the tympanum, vestibule, semicircular canals and mastoid cells. (*d*) The *auricular branch* supplies the

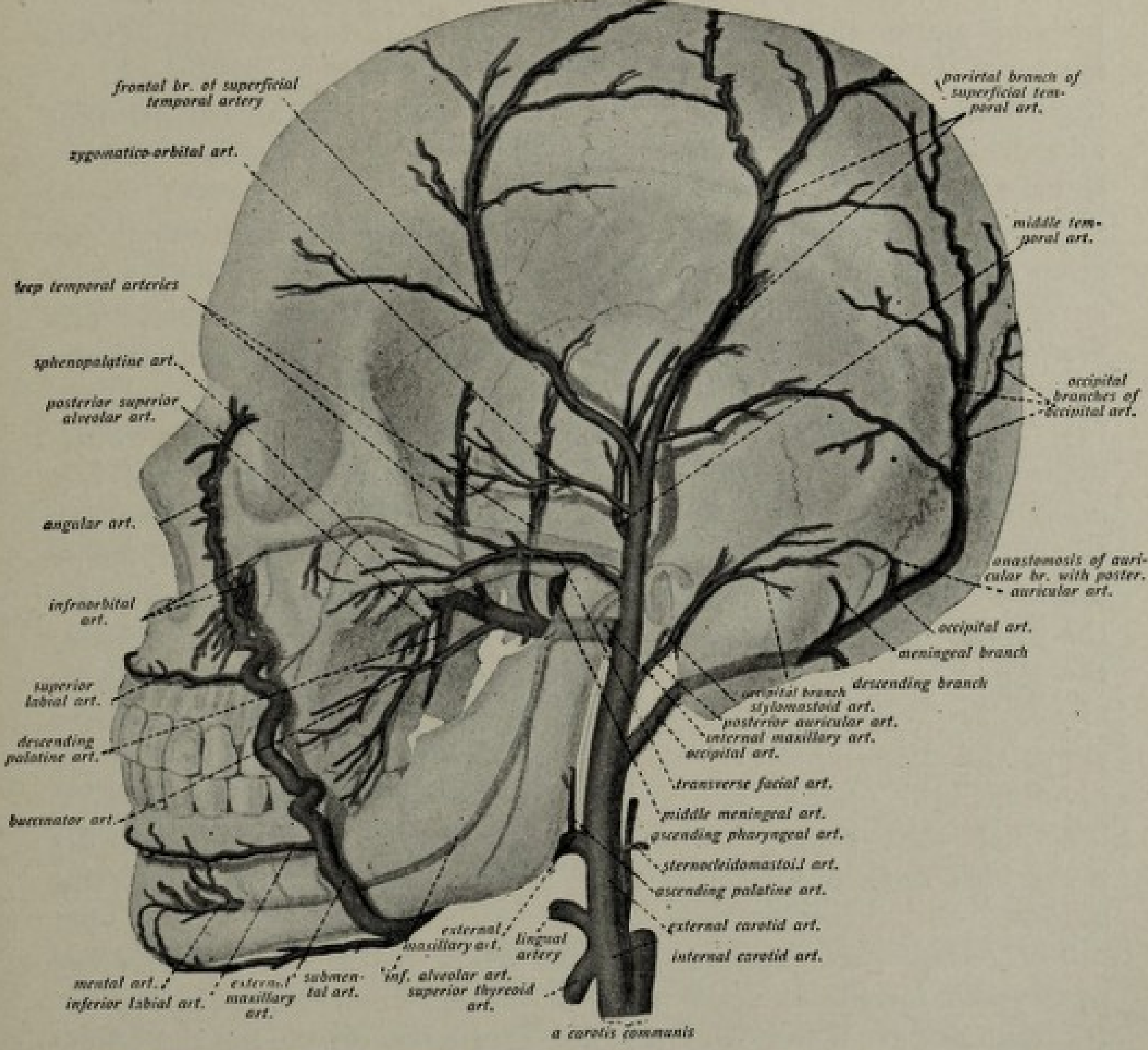


FIG. 176.—Ramification of the external carotid artery in the head (diagrammatic). (*Sobotta and McMurrich.*)

posterior auricular muscle, the auricle and scalp of the region. (*e*) The *occipital branch* supplies the sternomastoid and occipitalis muscles and the scalp here.

6. The **ascending pharyngeal artery** (*art. pharyngea ascendens*) arises from the lower part of the carotid artery and passes to the pharynx and soft palate. Its branches are as follows: (*a*) *Pharyngeal branches* to the wall of the pharynx and tonsil. (*b*) The *prevertebral branches* for the prevertebral muscles, deep lymph nodes and

large nerves. (*c*) The *posterior meningeal* for the meninges; these enter the skull through the hypoglossal canal and jugular foramen. (*d*) The *inferior tympanic* for the tympanum.

7. The **superficial temporal artery** (*art. temporalis superficialis*), one of the terminal branches of the external carotid artery, is about 1 to 2 inches (2.5 to 5 cm.) in length. Its branches are numerous. (*a*) *Parotid branches*, for the parotid gland. (*b*) *Articular*, for the temporomandibular articulation. (*c*) *Anterior auricular*, for the auricle and external auditory canal. (*d*) *Transverse facial*, for the parotid gland and duct, masseter muscle and skin. (*e*) *Middle temporal*, for the temporal muscle. (*f*) The *zygomaticoörbital*, for the orbicularis oculi muscle. (*g*) The *frontal branch*, for the frontalis and orbicularis oculi muscles. (*h*) The *parietal branch* for the auricular muscles, fascia and skin.

8. The **internal maxillary artery** (*art. maxillaris interna*) is the other terminal branch of the external carotid artery. This is under cover of the parotid gland and the ramus of the mandible. The *first part* extends from the neck of the mandible to the lower margin of external pterygoid muscle. Its main branches are as follows: (*a*) *Deep auricular*, for the mandibular articulation, parotid gland, external auditory meatus and the tympanic membrane. (*b*) The *middle meningeal artery*, the largest branch, enters the middle fossa of the skull through the foramen spinosum. It gives off a number of branches before and after it enters the skull. These are mainly for the supply of the meninges, tympanic cavity, semilunar ganglion of the trigeminal nerve, and structures in the orbit. (*c*) The *inferior alveolar artery* enters the mandible at the mandibular foramen, passes along the mandibular canal and ends at the mental foramen by dividing into mental and incisive branches. This gives rise to branches that supply the mucous membrane of the cheek, the mylohyoid muscle, all of the teeth and the quadratus labii inferior muscle.

The *second part* extends from the lower margin of the external pyterygoid muscle to upper head of the external pterygoid muscle. Its branches are as follows: (*a*) The *masseteric artery*, for that muscle. (*b*) The *two deep temporal arteries*, for the temporal muscle. (*c*) The *pterygoid branches*, for these muscles. (*d*) The *buccinator branch*, for that muscle, the mucosa and skin of the cheek.

The *third part* extends from the interval between the two heads of the external pterygoid muscle through the pterygomaxillary fissure into the pterygopalatine fossa. Its branches are as follows: (*a*) The *infraorbital branch* passes through the orbit in the infraorbital canal and appears upon the face at the infraorbital foramen. It supplies branches to the incisor teeth, the maxillary sinus, some of the ocular muscles, the lacrimal gland, the lower eyelid, lacrimal sac and skin of this region. (*b*) The *posterior superior alveolar artery* supplies the molar and premolar teeth, the gums and maxillary sinus. (*c*) The *descending palatine* supplies the mucosa of the roof of the mouth. (*d*) The *pharyngeal branch* supplies the roof of the nose and pharynx, the sphenoidal sinus and the auditory tube. (*e*) The *sphenopalatine branch* supplies the sphenoidal sinus and the nasal cavity.

The *course of the external carotid artery* is indicated by a line drawn from the posterior end of the greater cornu of the hyoid bone to the lobule of the ear.

The **internal carotid artery** (*arteria carotis interna*) extends from the end of the common carotid artery to the middle fossa of the skull; it enters the skull through the carotid canal and foramen lacerum and divides into the middle and anterior cerebral arteries. These are considered under the "Circulation of the Brain," page 430, with the exception of the *ophthalmic artery* (*arteria ophthalmica*). This artery passes into the orbit through the optic foramen and gives off a number of branches. Some of these are for the muscle of the eyeball, others for the lacrimal gland and tissues of the orbit, nasal cavity, eyelid, ethmoidal cells and meninges. One of its most important branches is the *central retinal artery* that enters the eyeball through the optic nerve and supplies the retina. The *supraorbital branch* reaches the forehead through the supraorbital foramen and supplies the frontalis muscle and skin. The *frontal artery* is the terminal branch of the ophthalmic artery and supplies the scalp.

The **subclavian arteries** (*arteriæ subclaviæ*). The *right subclavian artery* is shorter than the left as it arises from the innominate artery while the left arises from the arch of the aorta. The right one is about 3 inches (7.5 cm.) in length while the left is about 4 inches (10 cm.) in length. Each consists of *three parts*. The *first part* of each extends from the origin to the medial margin of the scalenus anterior muscle. The *second part* extends from the medial to the lateral margin of the scalenus anterior muscle. The *third part* extends from this point to the outer margin of the first rib.

The branches are as follows: (*a*) The **vertebral artery** (*art. vertebralis*) is the first branch and it passes up through the foramina in the upper six cervical vertebra, enters the skull through the foramen magnum and anastomoses with the vertebral artery of the other side to form the basilar artery. The branches are given under the "Circulation of the "Brain," page 430.

(*b*) **The thyreocervical trunk** (*truncus thyreocervicalis*) is only a few millimeters in length and divides into *three branches:* (1) The *inferior thyreoid artery*, that gives branches to the thyreoid gland, muscles of the neighborhood, esophagus, larynx, trachea and the structures within the vertebral canal. (2) The *transverse cervical artery* (*art.*

transversus colli) that terminates as the *ramus ascendens*, or *superficial cervical artery* and the *ramus descendens*, or *posterior scapular artery*. These vessels supply the neighboring muscles. (3) The *transverse scapular artery* (*art. transversa scapulæ*) terminates in the infraspinous fossa of the scapula. It gives off a number of branches that supply the dorsal and ventral scapular, sternomastoid and sub-

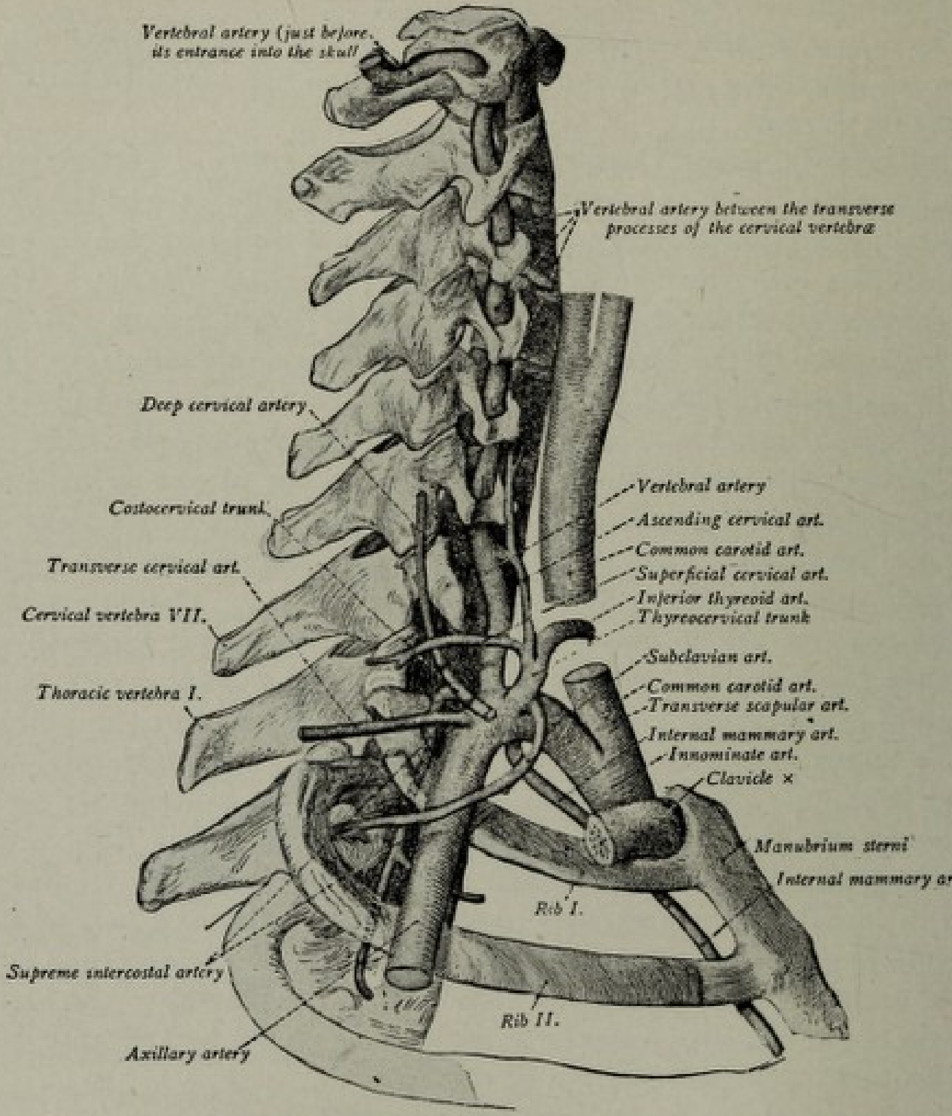


FIG. 177.—The branches of the subclavian artery and the course of the vertebral artery in the neck (schematic). (*Sobotta and McMurrich.*)

clavius muscles, the acromioclavicular, sternoclavicular and shoulder joints.

(*c*) The **internal mammary artery** (*art. mammaris interna*) extends from its origin to the sixth intercostal space where it divides into the *musculophrenic* and *superior epigastric arteries*. This lies within the thorax and gives off branches to the diaphragm, thymus, mediastinum, intercostal spaces and the skin. The *musculophrenic artery* is one of its terminal branches and this supplies the diaphragm and the lower intercostal spaces. The *superior epigastric artery* continues into the abdominal wall and anastomoses with the inferior epigastric artery. It gives branches mainly to the muscles and skin along its course.

(*d*) The **costocervical trunk** (*truncus costocervicalis*) gives rise to two branches. (1) The *deep cervical artery* (*art. cervicis profunda*) passes to the back of the neck, supplies muscles there and sends branches into the vertebral canal. (2) The *superior intercostal artery* (*art. intercostalis suprema*) gives rise to the *first two dorsal intercostal arteries* that pass ventrally in the intercostal spaces, anastomose with the branches from the internal mammary artery and give nutrient branches to the ribs.

THE AXILLARY ARTERY (ARTERIA AXILLARIS) AND AXILLA

The **axillary artery,** the continuation of the subclavian artery, lies in the axillary space and extends from the outer margin of the first rib to the lower margin of the tendon of the teres major muscle. It is described under *three parts*, the *first* lying above the upper margin of the pectoralis minor muscle, the *second part* lying under cover of that muscle and the *third part* constituting the remainder.

The branches of the *first part* are the (*a*) **superior thoracic artery** (*art. thoracis suprema*) that supplies the pectoralis major and minor, subclavius, serratus anterior and intercostal muscles. (*b*) The **thoracoacromial artery** (*art. thoracoacromialis*) a short trunk that gives off four branches; the *clavicular branch* supplies the sterno-clavicular articulation and adjacent muscles; the *pectoral branch* supplies the pectoral and deltoid muscles and the skin; the *deltoid branch* supplies the deltoid muscle and skin; the *acromial branch* supplies the deltoid muscle and completes the circulation around the shoulder.

(*c*) The **lateral,** or **long thoracic artery** (*art. thoracis lateralis*) is a branch of the second part. It passes along the lower margin of the pectoralis minor muscle and supplies this and adjacent muscles.

The remaining branches are from the *third part* of the artery.

(*d*) The **subscapular artery** (*art. subscapularis*) is about 1½ inches (3.7 cm.) long and divides into *two branches*, the *circumflex scapulæ*, or *dorsalis scapulæ artery* is the larger and gives branches to the infraspinatus, teres major and minor, triceps and deltoid muscles. The *thoracodorsal*, or *long subscapular artery*, is the continuation of the main stem and supplies the muscles at the lateral wall of the thorax.

(*e*) The **posterior circumflex artery** (*art. circumflexa humeri posterior*) passes to the back of the neck of the humerus and supplies the teres major and minor, the triceps and deltoid muscles, the shoulder joint and the head of the humerus.

(*f*) The **anterior circumflex artery** (*art. circumflexa humeri anterior*) is small and passes toward the bicipital groove supplying the long head of the biceps and the adjacent muscles.

The *course of the axillary artery* is indicated by drawing a line from the middle of clavicle to the lower margin of the pectoralis major muscle where it crosses the prominence caused by the coracobrachialis muscle. The arm must be extended at a right angle.

The **axillary space,** or **axilla** is a pyramidal space situated between the upper part of the arm and the side of the thorax. Its *apex* is directed toward the root of the neck between the first rib, clavicle and scapula and here the various structures enter the space. The *base*, formed by the skin and axillary fascia, is directed downward and outward. The *ventral wall* is formed by the pectoral major and minor muscles, the clavicle, the costocoracoid membrane and the subclavius muscle. The *dorsal wall* is formed by the subscapularis, teres major and latissimus dorsi muscles. The *medial boundary* consists of the first four ribs and their intercostal muscles and the serratus anterior muscle. The *lateral boundary* is narrow and consists of the humerus, coracobrachialis and biceps muscle. The *contents* are the axillary artery and vein, the brachial plexus of nerves and its branches, some branches of the intercostal nerves, lymph nodes and fat.

The **brachial artery** (*art. brachialis*) is the continuation of the axillary artery and extends to the neck of the radius. It courses along the medial side of the arm and gives rise to several branches. (*a*) The *profunda artery* (*art. profunda brachii*) accompanies the radial, or musculospiral nerve. It supplies the triceps and shaft of the humerus and assists in forming the anastomosis around the elbow joint.

(*b*) The *superior ulnar collateral*, or *inferior profunda artery* (*art. collateralis ulnaris superior*) mainly assists in the anastomosis around the elbow joint.

(*c*) The *inferior ulnar collateral*, or *anastomotic artery* (*art. collateralis ulnaris inferior*) supplies the triceps and brachialis muscles and aids in forming the anastomosis around the elbow joint.

The *course of the brachial artery* is indicated by drawing a line along the medial margin of the biceps (at the junction of the anterior and middle thirds of the outlet of the axilla) to the middle of the elbow.

At the neck of the radius the brachial artery divides into *radial* and *ulnar arteries*.

The **radial artery** (*art. radialis*) is the smaller and extends into the palm of the hand forming there the deep palmar arch. Its *first part* extends from the elbow to the apex of the styloid process of the radius; the *second part* extends around the side of the wrist to the first interosseous space; the *third part* passes into the palm of the hand to join the deep branch of the ulnar artery.

The branches of the **first part** are the *radial recurrent*, that supplies the brachioradialis, supinator, extensores carpi radialis longus and brevis muscles and assists in the anastomosis around the elbow joint; the *muscular branches* for the muscles of the radial (ventral) side of the forearm; the *superficial volar artery* is small and arises near the end of the first part, passes through the muscles of the ball of the thumb and joins the main part of the ulnar artery to form the superficial palmar arch. The *volar carpal branch* helps form the volar carpal arch for the wrist joint.

The branches of the **second part** are, the *dorsalis pollicis* (two) that pass along the sides (dorsally) of the thumb to supply the skin, tendons, ligaments and joints. The *dorsalis indicis radialis artery* is small and passes along the radial margin of the index finger for the skin, tendon and joints. The *first dorsal metacarpal* and *dorsal radial carpal arteries* are small and pass to the dorsal aspect of the palm.

The branches of the **third part** are, the *princeps pollicis* which passes to the distal end of the metacarpal bone of the thumb and divides into two branches (*collateral*) that pass along the sides of the thumb. The *volaris radialis indicis* runs along the radial side of the index finger.

The *course of the radial artery* is indicated by drawing a line from the hollow of the center of the elbow to the side of the styloid process of the radius.

The **ulnar artery** extends from the neck of the radius to the palm of the hand where it forms the superficial palmar arch and assists in forming the deep palmar arch. It has a number of branches. (*a*) The *volar ulnar recurrent* is small and assists in forming the anastomosis around the elbow joint. (*b*) The *dorsal ulnar recurrent* supplies the brachialis and adjacent muscles and assists in the elbow joint anastomosis. (*c*) The *common interosseous artery* extends to the superior edge of the interosseous membrane and then divides into *dorsal* and *ventral interosseous arteries*. The *ventral*, or *volar artery*, runs between the deep muscles of the forearm giving branches to these, to the radius and the ulna, the *median artery* and other small branches. The *dorsal artery* gives off the *interosseous recurrent artery* (elbow-joint anastomosis), *muscular branches* to the deep muscles of the back of the forearm and branches to the skin of this region and the wrist. (*d*) The *volar carpal artery* is small and assists in the carpal arch formation. (*e*) The *dorsal carpal artery* passes to the back of the wrist and assists in forming the dorsal carpal arch. (*f*) The *profunda artery* is the last branch of the ulnar artery and passes into the depths of the palm to assist in forming the deep palmar arch.

The *course of the ulnar artery* is indicated by *two lines*, as the artery curves. Draw a line from the medial epicondyle of the humerus to the medial surface of the pisiform bone; the *distal two-thirds* represents the distal two-thirds of the ulnar artery. From the center of the cubital fossa draw another line to the junction of the upper and middle thirds of the first line and that new line will indicate the course of the *first part* of the ulnar artery.

In front of the elbow joint there is a triangular, somewhat depressed area called the **cubital fossa,** or **antecubital space.** Here the brachial artery sinks in quite deeply. The *base*, directed upward, is a line connecting the two epicondyles of the humerus; the *medial boundary* is the lateral margin of the pronator teres; the *lateral boundary* is the medial margin of the brachioradialis; the *floor* consists of the supinator and brachioradialis. This space contains the brachial artery and its venæ commites, the radial and ulnar arteries, the median and radial nerves and the tendon of the biceps muscle.

Upon the ventral aspect of the ligaments of the wrist lies the **ventral** or **volar carpal arch.** This is formed by the volar carpal branches of the radial and ulnar arteries assisted by branches from the deep palmar arch and volar interosseous artery. It supplies the ligaments and synovial membranes of the joints here.

The **dorsal carpal arch** is similar and formed by the dorsal carpal branches of the ulnar and radial arteries assisted by branches from the interosseous arteries.

The **superficial palmar arch** (*arcus volaris superficialis*) is formed by the main portion of the ulnar artery and the superficialis volæ branch of the radial artery. It lies just beneath the deep palmar aponeurosis. It gives off *four volar common digital arteries* of which the one on the ulnar side passes to the ulnar side of the little finger. The other three pass to the clefts between the fingers where each divides into *two branches* (*proper digital arteries*) that go to the adjacent sides of index, middle, ring and little fingers.

The *position of the superficial palmar arch* is indicated by a curved line extending from the pisiform bone to the base of the cleft between the thumb and index finger. The convexity should extend to about the middle third of the palm.

The **deep palmar arch** (*arcus* **volaris profunda**) is deeeply placed. It lies upon the bases of the metacarpal bones and their ligaments. It gives rise to *recurrent branches* for the volar carpal arch; *articular branches* of the adjacent joints; *volar carpal arteries* that pass to the dorsum of the hand and form the digital branches; and *communicating branches* that connect with the proper volar digital arteries.

The *course of the deep palmar arch* is indicated by a line parallel to the line of the superficial arch about ½ to ¾ inch nearer the wrist.

THE DESCENDING AORTA

The **descending aorta (aorta descendens)** begins at the lower border of the fourth thoracic vertebra, passes downward (caudad) to the left of the midline, through the diaphragm into the abdominal cavity where it divides ventral to the body of the fourth lumbar vertebra into right and left common iliac arteries. That portion (prediaphragmatic) above the diaphragm (above the twelfth thoracic vertebra) constitutes the thoracic aorta while that below (post-diaphragmatic) constitutes the abdominal aorta.

The **thoracic aorta (aorta thoracalis)** is 7 to 8 inches (17.5 to 20 cm.) in length and is reduced in diameter from 23 mm., at the beginning, to 21 mm., at the diaphragm. The branches are:

Parietal	Intercostal, nine pairs, for the lower nine intercostal spaces that supply the intercostal muscles, the vertebral column and the skin of the back and sides of the thorax. Subcostal, one pair. Superior phrenic, one pair; that supply the superior surface of the diaphragm.
Visceral	Esophageal, one pair. Bronchial, four to five pairs. Pericardial, three to four pairs. Mediastinal, several.

The **abdominal artery (arteria abdominalis)** extends from the twelfth thoracic vertebra to the fourth lumbar vertebra, is from 7 to 8 inches (17.5 to 20 cm.) in length and lies in the epigastric and umbilical regions. Its branches may be divided into parietal and visceral but they will be given in order of origin.

1. Inferior phrenic (two) parietal.
2. Celiac axis (one) visceral { Gastric. Hepatic. Splenic.
3. Suprarenal (two) visceral.
4. First lumbar (two) parietal.
5. Superior mesenteric (one) visceral.
6. Renal (two) visceral.
7. Spermatic, or ovarian (two) visceral.
8. Second lumbar (two) parietal.
9. Inferior mesenteric (one) visceral.
10. Third lumbar (two) parietal.
11. Fourth lumbar (two) parietal.
12. Common iliac (two) { External (two) parietal. Internal (two) parietal and visceral.
13. Middle sacral (one) parietal.

The **inferior phrenic arteries** supply the inferior, or abdominal surface of the diaphragm and give off a *pair of superior adrenal arteries*.

The **celiac axis** is only ½ inch in length but is of large caliber. It supplies the liver, stomach, spleen, pancreas and part of the duodenum. Its branches are as follows: the *left gastric*, or *coronary;* the *splenic*, which gives off the *pancreatic*, *short gastric* (*vasa brevia*) and *left gastroepiploic branches;* the *hepatic artery* that gives off the *right gastric*, *gastroduodenal*, *right gastroepiploic* and *superior pancreaticoduodenale arteries.*

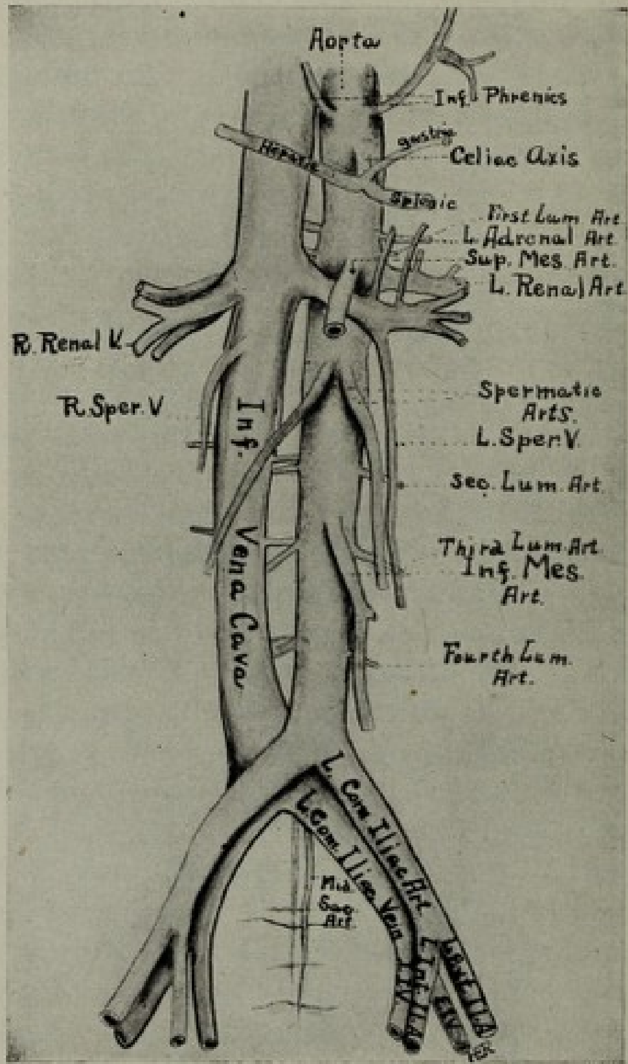


FIG. 178.—The abdominal aorta and its branches, and the inferior vena cava and its tributaries.

The **suprarenal arteries** supply the adrenal glands and represent the middle suprarenal arteries.

The **superior mesenteric artery** supplies the duodenum, jejunum, ileum, cecum, appendix, ascending and transverse colons. Its branches are *intestinal* (ten to sixteen) for the jejunum and ileum; the *inferior pancreaticoduodenale;* the *middle colic; right colic, ileocolic* and *terminal*, for the end of the ileum, cecum, appendix, ascending and transverse colons.

The **renal arteries** are two large arteries that supply the kidneys. Each gives off the *inferior suprarenals*, *ureteral*, *perinephric branches* and some branches to the *lumbar lymph nodes*.

The **spermatic (testicular) arteries** accompany the vas and pass to the testes in the spermatic cords. Each gives off branches to the *ureter*, *peritoneum* and *lumbar lymph nodes*.

The **ovarian arteries,** of the female, pass to the ovaries and uterus through the broad ligament. Each gives off branches to the ureter, peritoneum, lumbar lymph nodes to the uterine tubes, uterus and its round ligament.

The **inferior mesenteric artery** is a large branch that supplies the descending colon, iliac and pelvic colons and the upper third of the rectum. Its branches are the *left colic*, *sigmoid branches* and the *superior hemorrhoidal arteries*.

The four pairs of **lumbar arteries** correspond to the intercostal arteries of the thorax. They supply the muscles and skin of the dorsal and lateral portions of the abdominal wall.

The **middle sacral artery** is a small artery that passes along the sacrum and coccyx and ends in the coccygeal gland.

The **common iliac arteries** represent the terminal branches of the aorta and start at the middle of the fourth lumbar vertebra to the left of the midline. The *right artery* is about 2 inches (5 cm.) in length and the *left* is about 1¾ inches (4.3 cm.) in length. Each divides into *external* and *internal iliac arteries*.

The **internal iliac,** or **hypogastric artery** (*arteria hypogastrica*), arises opposite the sacroiliac articulation and passes into the pelvis for about 1½ inches (3.7 cm.) before dividing into its terminal branches. These arteries supply the greater part of the pelvic wall and viscera, the buttocks, thighs and the external organs of reproduction. Each gives rise to *parietal* and *visceral branches*. The *parietal branches* are as follows: The *iliolumbar artery* supplies the iliacus, psoas and quadratus lumborum muscles and also the vertebral canal. The *lateral sacral artery* supplies the pyriformis muscle and also sends branches to the sacral canal and sacral nerves. The **superior gluteal artery** leaves the pelvis and passes into the buttock and lies on the deep surface of the gluteus maximus. It gives off a number of *muscular branches* to the glutei, obturator internus and tensor fasciæ latæ muscles and *nutrient vessels* to the hip bone. The **obturator artery** passes into the buttock and gives off a number of *muscular branches* to the obturator internus, iliopsoas and levator ani muscles; *nutrient branches* to the ilium; *vesical branches* to the bladder; *pudic branch* that is mainly for collateral circulation. These branches all arise within the pelvis. The **terminal part** of the artery gives off branches to the obturator externus and adjacent muscles, to the hip joint, head of the femur and ligaments. The **internal pudic artery** is a large branch that enters the buttock and passes to the perineum. In the buttock it supplies the neighboring muscles. In the perineum it gives off the *inferior hemorrhoidal artery* that supplies the lower part of the rectum and the anal canal; the *perineal artery* for the scrotum of the male, or the labia of the female; the *transverse perineal artery* supplies the sphincter ani, the sphincter vaginæ, or bulbocavernosus muscle, the bulb of the urethra, the corpus spongiosum and penile portion of the urethra (in the male) and the bulb of the vestibule (in the female); the *profunda artery of the penis* or *clitoris* supplies the corpus cavernosum of the penis or clitoris; the *dorsal artery of the penis* or *of the clitoris* supplies the dorsal portion of the penis or clitoris as well as the corpus cavernosum and glans penis, or clitoris. The *inferior gluteal*, or *sciatic artery* passes into the buttock and then the upper part of the thigh. It gives of *muscular branches* for the proximal parts of the hamstring muscles; *coccygeal branch; cutaneous branches* to the skin; a branch that accompanies the sciatic nerve.

The **visceral branches** are as follows: (*a*) The *superior vesical artery* supplies the upper part of the bladder. (*b*) The *inferior vesical artery* supplies the base of the bladder, the seminal vesicles, vas and prostate gland. (*c*) The *artery of the ductus deferens* accompanies the vas, supplies it and extends to the testicle. (*d*) The *middle hemorrhoidal artery* gives branches to the seminal vesicles, vas, prostate and terminates in the rectum where it supplies the middle third. (*e*) The *vaginal artery* supplies the vagina and also the rectum, bulb of the vestibule and base of the bladder. (*f*) The *uterine artery* supplies the uterus, round ligament and the vagina.

The **external iliac artery** (*art. iliaca externa*) is about 3½ to 4 inches (8.7 to 10 cm.) in length and ends at the thigh side of the inguinal ligament. It gives rise to two main branches. The **inferior epigastric artery** (*art. epigastrica inferior*) passes along the medial side of the abdominal inguinal ring into the ventral abdominal wall to the umbilical region where it anastomoses with branches from the superior epigastric branch of the internal mammary artery. It gives rise to *muscular branches*, an *external spermatic artery*, *cutaneous branches* and a *pudic branch*. The **deep circumflex iliac artery** (*art. circumflexa ilium profunda*) passes toward the ventral superior spine of the ilium and gives off *muscular* and *cutaneous branches*.

The **femoral artery** (*arteria femoralis*) is the continuation of the external iliac artery and extends from the inguinal ligament to the lower part of the thigh where it passes through the adductor magnus muscle. The first inch and a half was called the common femoral and the remainder the *deep* and *superficial portions*. Its branches are as follows: (*a*) The *superficial circumflex iliac artery* (*art. circumflex ilium superficialis*) supplies the lymph nodes of the groin and the skin here. (*b*) The *superficial epigastric artery* (*art. epigastrica superficialis*) passes to the ventral abdominal wall and supplies the superficial fascia and skin in its course. (*c*) The *superficial external pudic artery* (*art. pudenda externa superficialis*) supplies the skin of the pubis, scrotal, or labial regions. (*d*) The *muscular branches* pass to the adductors, pectineus, sartorius and vastus medialis muscles. (*e*) The *deep external pudic artery* (*art. pudendar externa profunda*) passes to the scrotum or labium majus. (*f*) The *deep femoral artery* (*art. profunda femoralis*) is the largest branch of the femoral artery and passes in between the deep muscles of the thigh and gives rise to numerous branches. These are the *lateral circumflex, medial circumflex, muscular* and *four perforating arteries.* These are for the supply of the deep muscles of the thigh and the perforating arteries pass to the dorsal part of the thigh and anastomose with vessels there. (*g*) The *anastomotic artery*, or *arteria genu suprema,* supplies the skin of the medial side of the leg muscles near the knee and the knee joint.

The *course of the femoral artery* is indicated by a line drawn from a point midway between the ventral superior spine of the ilium and the symphysis pubis to the adductor tubercle on the medial condyle of the femur. The *superior two-thirds* of this line represents the femoral artery. The thigh should be abducted and rotated laterally.

The **popliteal artery** (*art. poplitea*) is the continuation of the femoral artery back of the knee; it lies in the popliteal fossa at the distal end of which it divides into anterior and posterior tibial arteries. It is deeply placed and gives rise to the following branches: *Muscular branches* to the hamstring and upper leg muscles; *articular* (*five*) *branches* to the knee joint; *cutaneous branches* to the skin of the popliteal space.

The **popliteal fossa,** or **space,** is back of the knee joint and is of a diamond shape. It is bounded *superolaterally* by the biceps; *inferolaterally* by the lateral head of the gastrocnemius and plantaris; *supermedially* by the semimembranosus, semitendinosus, sartorius and gracilis; *inferomedially* by the medial head of the gastrocnemius. The *floor* is formed by the popliteal plane of the femur, the dorsal ligament of the knee joint and the fascia covering the popliteus muscle. It *contains* the popliteal artery and its branches, the popliteal vein, the termination of the external saphenous vein, the common peroneal (external popliteal) and tibial (internal popliteal) nerves, some lymph nodes and fat.

The *course of the popliteal artery* is indicated by a line drawn from the outer margin of the semimembranosus muscle (at the beginning of the lower third of the thigh) to the middle of the popliteal space; this indicates the *upper part* of the artery. The *lower part* is represented by a line drawn from this point vertically downward to the level of the tuberosity of the tibia.

The **anterior tibial artery** (*art. tibialis anterior*) is the smaller branch of the popliteal artery and passes distally upon the ventral surface of the interosseous membrane. It gives off the following branches: (*a*) *Fibular branch* that supplies the soleus, peroneus longus and skin of this region. (*b*) The *posterior tibial recurrent branch* for anastomosis around the knee joint. (*e*) The *anterior tibial recurrent* is for the same purpose and also supplies the tibialis anterior and the tibiofibular articulation. (*d*) *Muscular branches* for the muscles of the front of the leg. (*e*) *Cutaneous branches* for the skin of the front of the leg. (*f*) *Medial anterior malleolar branch* for the skin of the lateral malleolus and the ankle joint. (*g*) The *lateral anterior malleolar branch* for the skin of that region and the ankle joint and adjoining articulations.

The **dorsalis pedis artery** is the direct continuation of the anterior tibial artery. It extends from the front of the ankle joint to the base of the first interosseous space. Its branches are as follows: (*a*) *Cutaneous branches* for the skin of the dorsum and medial side of the foot. (*b*) *Medial* and *lateral tarsal branches* that supply the extensor digitorum brevis and the articulations here. (*c*) The *arcuate artery* arches across the bases of the metatarsal bones and gives off first three metatarsal arteries; each of these divides into *digital arteries* that supply the adjacent sides of the outer four toes. (*d*) The *first dorsal metatarsal artery* arises from the dorsalis pedis artery and supplies the two sides of the great toe and the medial side of the next toe. (*e*) The *profunda artery* passes through the foot to the plantar part and anastomoses with vessels there.

The *course of the anterior tibial artery* is indicated by drawing a line from the inner side of the head of the fibula to a point midway between the two malleoli. All of this line, except the first 1¼ inches, represents the artery.

The *course of the dorsalis pedis artery* is indicated by drawing a line from the point midway between the two malleoli to the base of the first interosseous space.

The **posterior tibial artery** is the larger branch of the popliteal artery. It lies between the superficial and deep muscles of the back of the leg and extends from the lower margin of the popliteus muscle to a point midway between the medial malleolus and the most prominent part of the heel, where it divides into medial and lateral plantar arteries.

It gives off the following branches: (*a*) *Muscular branches* to the soleus, tibialis posterior, flexor digitorum longus and flexor hallucis longus. (*b*) A *fibular branch* to the adjacent muscles and for anastomosis around the knee joint. (*c*) The *peroneal artery* is its largest branch and passes to the dorsal part of the lateral malleolus. It gives off *muscular branches* to the muscles along its course; a *nutrient branch* to the fibula; a *communicating branch* to the posterior tibial artery; a *perforating artery* that passes along the inferior margin of the interosseous membrane to the front of the ankle and anastomoses with the vessels here. (*d*) The *nutrient artery* supplies the tibia. (*e*) The *communicating branch* that communicates with the peroneal artery. (*f*) *Cutaneous branches* for the skin of the medial and dorsal surfaces of the leg. (*g*) The *posterior medial malleolar branch* anastomoses with the corresponding branch of the anterior tibial artery.

The *course of the posterior tibial artery* is indicated by drawing a line from a point 1 inch below the center of the popliteal space to a point midway between the medial malleolus and the most prominent part of the heel.

The **plantar arteries** are *medial* and *lateral*.

The **medial plantar artery** (*art. plantaris medialis*) is the smaller, passes along the medial side of the foot to the head of the metatarsal bone of the great toe; here it is joined by a branch of the dorsalis pedis artery and supplies the medial side of the great toe and the muscles, skin and articulations along its course. It also gives off *three branches* that join the metatarsal branches of the lateral plantar artery.

The **lateral plantar artery** (*art. plantaris lateralis*) is deeply placed, courses toward the lateral side of the foot and at the base of the fifth metatarsal bone it arches medially to the base of the first metatarsal bone where it anastomoses with the dorsalis pedis artery. The arched part constitutes the plantar arch.

The branches of the main vessel are as follows: (*a*) *Muscular branches* to the muscles of the foot. (*b*) *Cutaneous branches* to the lateral side of the foot. (*c*) The *medial calcaneal branch* to the skin and tissues of the heel. The *arch* gives off the following branches: (*d*) *Four plantar metatarsal arteries* that form the *digital arteries* that supply the adjacent sides of the four inner toes. (*e*) *Three perforating arteries* that join the dorsal metatarsal arteries. (*f*) *Articular branches* to the tarsal joints. (*g*) The *fifth metatarsal branch* supplies the outer side of the little toe, the joints and tendon sheathes along its course.

The *course of the medial plantar artery* is indicated by a line drawn from the point midway between the medial malleolus and the prominence of the heel to a point at the middle of the under surface of the great toe. The *course of the lateral plantar artery* is indicated by a line from the same starting point to a point about ½ inch internal to the tuberosity of the little toe. The *plantar arch* is indicated by a line drawn from this point transversely across the foot to the base of the first interosseous space.

VEINS (VENÆ)

The blood passes from the arteries to the capillaries and then is carried by the veins to the heart. The *main veins* are the **superior**

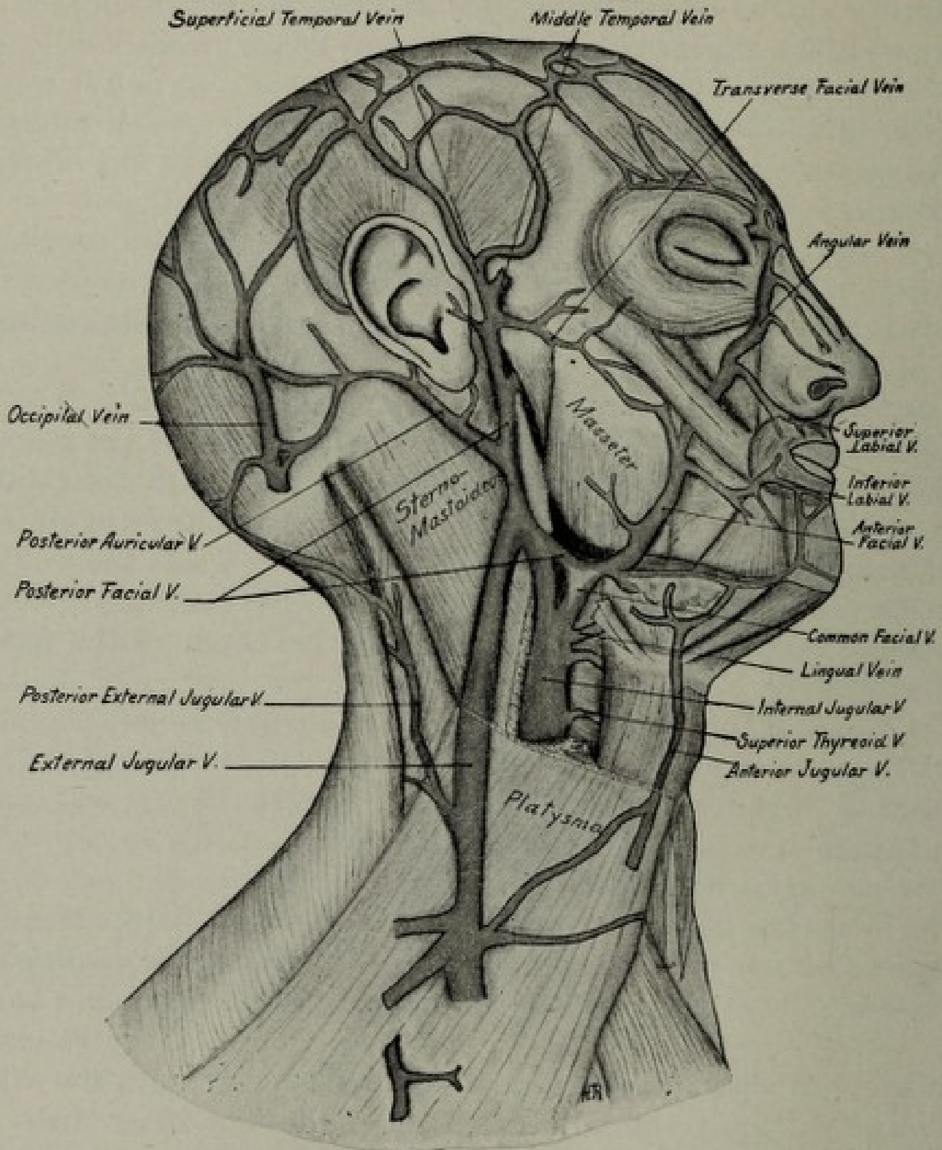


FIG. 179.—The veins of the right side of the head and neck.

and inferior venæ cavæ, the **pulmonary veins** and the **azygos system.**

The blood is returned from the *head* and *neck* chiefly by the **internal jugular veins** (**right** and **left**) which correspond to the common carotid arteries. The blood that enters the cranial cavity by means of the internal carotid and vertebral arteries is carried to the **venous sinuses** of the skull (see the "Circulation of the Brain"). Of these sinuses the transverse sinus on each side continues as the

internal jugular vein. This vein passes down the neck, in the carotid sheath, and behind the sternoclavicular articulation each is joined by the corresponding subclavian vein forming the innominate vein of each side. The *tributaries* to each internal jugular vein are the *common facial, lingual, pharyngeal, superior* and *middle thyreoid veins.*

The **common facial vein** receives the blood from parts supplied by several of the branches of the external carotid artery. The *anterior facial division* corresponds to the external maxillary artery while the *posterior facial vein* corresponds to the temporal and internal maxillary branches of the external carotid artery.

The **lingual vein** corresponds to the lingual artery.

The **pharyngeal veins** start at the venous plexus of the pharynx and represent the various branches distributed to the pharynx.

The **occipital vein** corresponds to the occipital artery.

The **superior** and **middle thyreoid veins** correspond to the branches of the superior thyreoid artery.

The **external jugular vein** is in the neck but it is a tributary of the subclavian vein. This vein is formed, back of the angle of the mandible, by a branch of the posterior facial and the posterior auricular veins. This receives the *transverse cervical, transverse scapular* and *anterior jugular veins* and is usually quite large.

The blood of the **superior extremity** is returned ultimately by the **subclavian vein.**

In the *hand* the blood is returned from the fingers by the **superficial volar** and **dorsal digital veins** (a pair of each to each finger). These vessels anastomose with each other on the dorsal and ventral portions of the palm and through the palm and carry the blood to the vessels of the forearm.

In the *forearm* there are two main (superficial) longitudinal venous channels, the **cephalic vein** on the radial side and the **basilic vein** on the ulnar side and occasionally a **median vein** on the ventral surface. The **cephalic vein** starts from the radial side of the dorsal venous arch of the palm and turns to the radial side of the ventral surface; it continues to the cubital fossa and from there continues up the arm on the lateral margin of the biceps muscle to the interval between the deltoid and pectoralis major muscles, near the clavicle; here it turns in and empties into the axillary vein of which it is a tributary. In the cubital fossa it is connected to the basilic vein by the **median cubital vein** which also connects it with the *deep veins* of the forearm.

The **basilic vein** begins on the ulnar side of the dorsal venous plexus of the hand and continues along the dorsal surface of the forearm to the upper third of the forearm where it turns to the ventral surface; it continues into the arm along the medial margin of the biceps muscle, and at about the middle it pierces the fascia and accompanies the branchial artery and in the axilla continues as the axillary vein. The median cubital vein connects it to the cephalic and deep veins of the forearm.

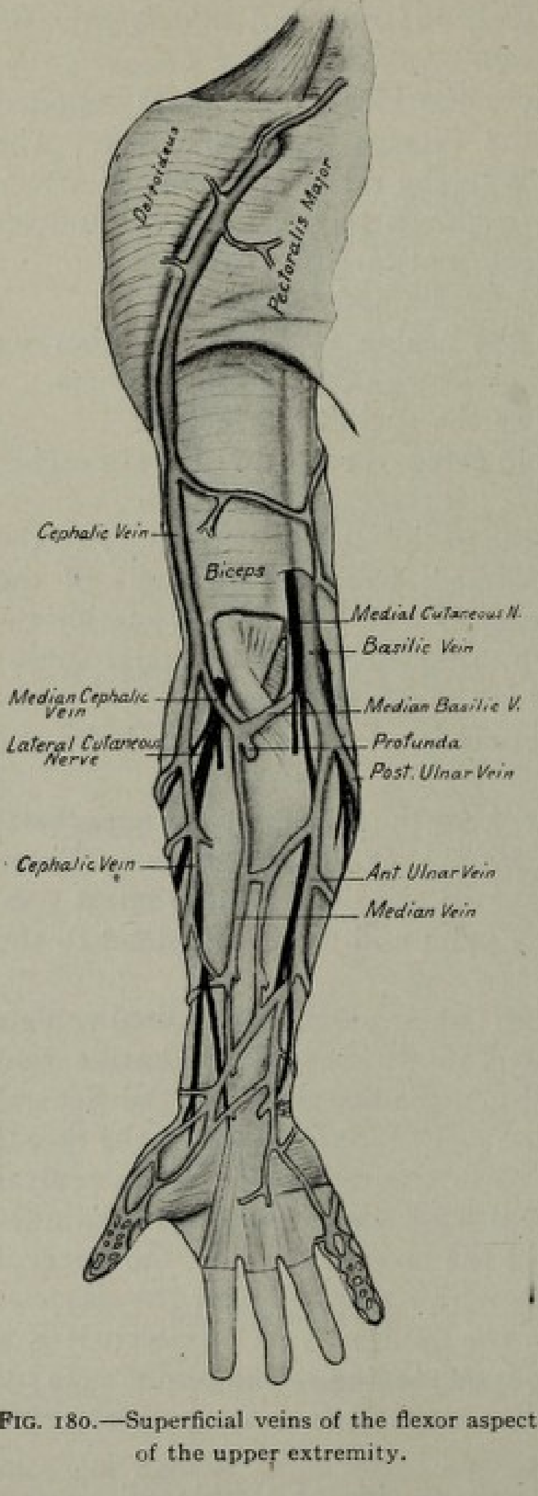


FIG. 180.—Superficial veins of the flexor aspect of the upper extremity.

The **median vein,** when present, starts at the plexus in the palm, continues along the ventral surface of the forearm and at the cubital region receives the deep median vein and then divides into *median cephalic* and *median basilic veins* that empty into the corresponding veins. The median cubital vein is then absent.

Deep veins accompany the various arteries (as *venæ commites*) and carry the blood to the axillary vein.

The **axillary vein** (*vena axillaris*) starts at the lower margin of the teres major muscle and is the direct continuation of the basilic vein. At the lower margin of the first rib it continues as the subclavian vein. Its *tributaries* are the *cephalic vein* and the *vena commites of the brachial artery.*

The **subclavian vein** (*vena subclavia*) extends from the lower margin of the first rib to the dorsal surface of the sternal end of the clavicle where it is joined by the internal jugular vein to form the innominate. Its main *tributary* is the *external jugular vein.*

The **innominate veins** are *right* and *left.*

The **right innominate vein** (*vena innomyna dexter*) is about 1 inch (2.5 cm.) in length and extends from the medial extremity of the right clavicle to a little inferior to the cartilage of the first (right) rib. Its course is almost vertical and close to the right margin of the sternum.

The **left innominate vein** (*vena innomyna sinister*) is about 2½ inches (6 cm.) in length and extends from the medial extremity of the left clavicle obliquely downward and to the right to join the right innominate vein to form the superior vena cava. This junction is just inferior to the first right costal cartilage. The *tributaries* to the innominate veins are the *vertebral*, *inferior thyreoid* and *internal mammary veins*.

The **superior vena cava, or precava** (*vena cava superior*), is about 3 inches (7.5 cm.) in length and extends from the inferior margin of

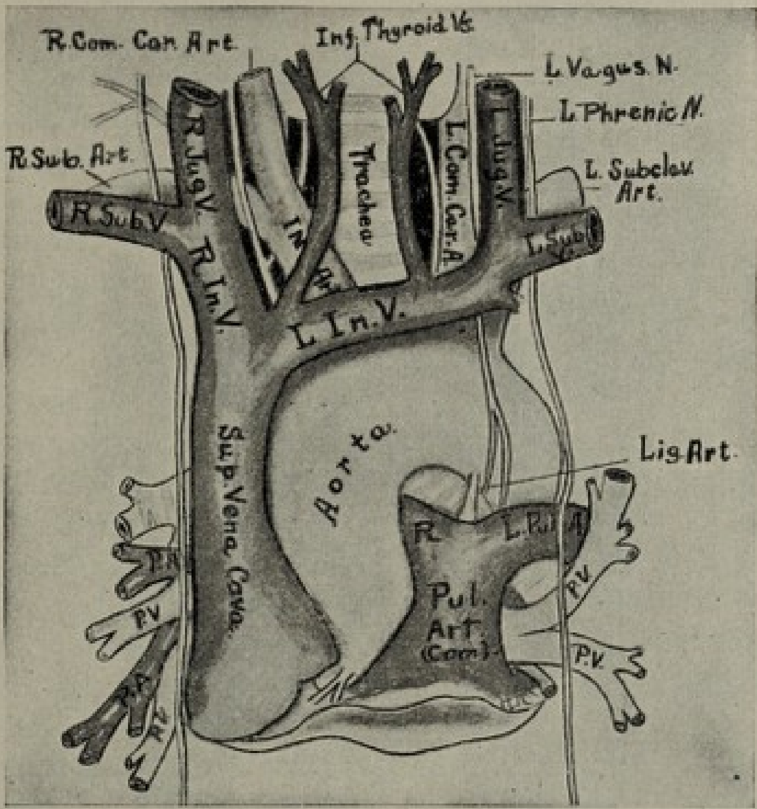


FIG. 181.—Arch of the aorta and its branches; the superior vena cava and its tributaries; the pulmonary arteries and veins.

the first right costal cartilage to the level of the upper margin of the third right costal cartilage, where it empties into the right atrium of the heart. Its course is vertical and its inferior half is within the pericardium. In addition to the innominate veins it also *receives* the *vena azygos major*.

The *superficial veins* of the *inferior extremity* are the *great* and *small saphenous veins*.

The **great saphenous vein** (*vena saphena magna*) begins at the dorsal venous arch which is formed by the dorsal digital veins of the foot. From the medial side of this arch the great saphenous vein passes in front of the medial malleolus, along the medial margin of the tibia to the back of the medial condyle of the femur; it then gradually turns to the ventral surface of the thigh and at the *fossa* *ovalis* (saphenous opening) it passes through the deep fascia and empties into the femoral vein. It receives *tributaries* from the dorsum of the foot, the front and back of the leg, from the front and

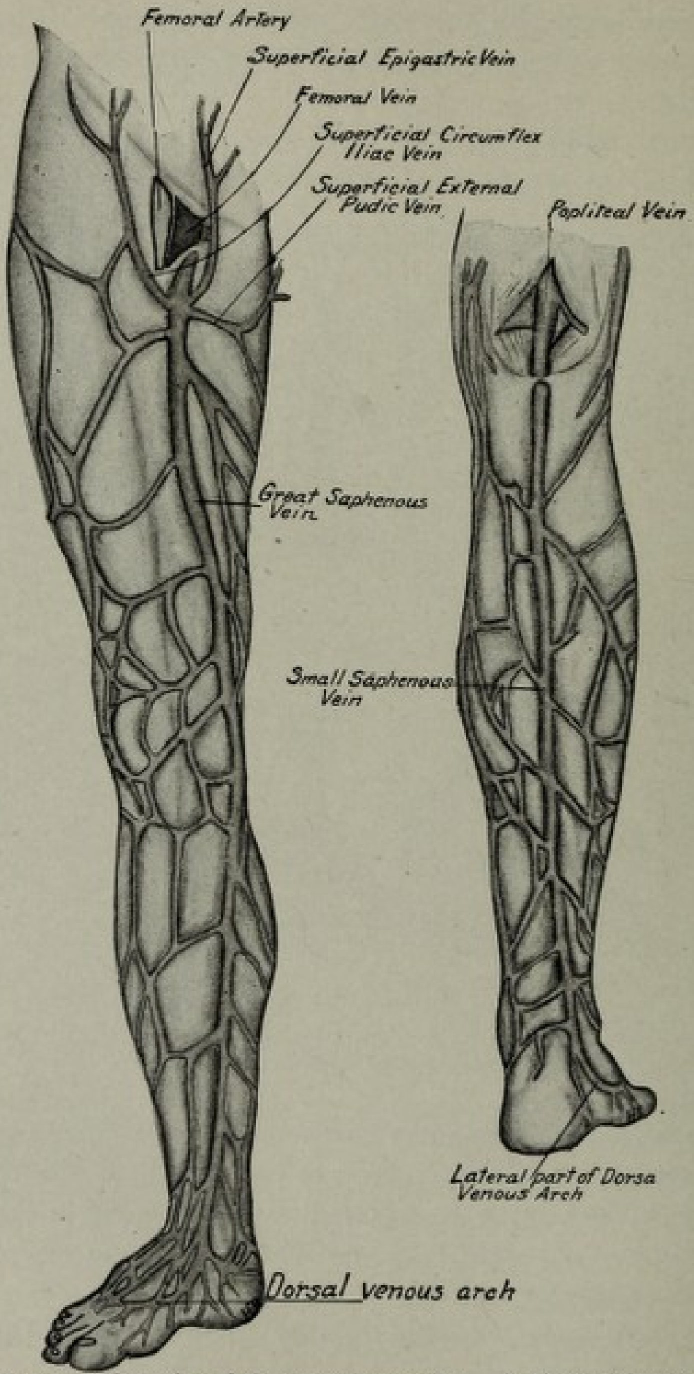


FIG. 182.—The superficial veins of the lower extremity. *A*, the great saphenous vein and its tributaries. *B*, the small saphenous vein and its tributaries.

back of the thigh (the superficial femoral veins) and the superficial circumflex iliac, superficial epigastric and superficial external pudic veins.

The **small saphenous vein** (*vena saphena parva*) starts at the lateral portion of the venous arch of the foot, passes back of the lateral malleolus, up the dorsal surface of the calf to about its middle where it pierces the fascia and passes to the popliteal space to empty into the popliteal vein It receives *tributaries* from the back and lateral surfaces of the heel and leg.

The **deep veins** of the foot and leg are two in number for each artery and are called *venæ commites.* In the popliteal space the venæ commites of the anterior and posterior tibial veins join to form the **popliteal vein.** This vein receives the small saphenous vein and tributaries that correspond to the branches of the popliteal artery.

The **femoral vein** accompanies the femoral artery and is the continuation of the popliteal vein. Its *tributaries* are the *great saphenous vein* and vessels that correspond to branches of the femoral artery.

The **external iliac vein** is the direct continuation of the femoral vein and at the level of the lumbosacral articulation it is joined by the internal iliac or hypogastric vein to form the common iliac vein of each side. Its *tributaries* are the *deep circumflex iliac* and *inferior epigastric veins.*

The **internal iliac** or **hypogastric vein** (*vena hypogastrica*) is short and is formed by the junction of vessels that correspond to the branches of the hypogastric artery. Its *tributaries* are superior and inferior gluteal, inferior hemorrhoidal, lateral sacral, middle hemorrhoidal, uterine (two veins from the uterine plexus), vaginal (one vein from the vaginal plexus), veins from the superior and inferior vesical plexuses and the vesicoprostatic plexus, and the dorsal veins of the penis, or clitoris.

The **common iliac veins** are *right* and *left.*

The **right common iliac vein** (*vena iliaca communis dexter*) is smaller and more vertical in direction than the left. The *tributaries* to each common iliac vein are the middle *sacral* (to the left) and the *iliolumbars* to both.

The **inferior vena cava,** or **postcava** (*vena cava inferior*) is formed by the junction of the two common iliac veins on the right side of the body of the fifth lumbar vertebra. It passes through the abdomen, through the diaphragm, enters the pericardium and empties into dorsoinferior portion of the right atrium of the heart. Its *tributaries* are the *inferior phrenic, suprarenal, renal, spermatic,* or *ovarian, lumbar* and *hepatic veins.* (See Fig. 178.)

The *inferior phrenic veins* (two) return a part of the blood from the diaphragm.

The *suprarenal veins* (two) return the blood from those glands.

The *renal veins* (two) return the blood from the kidneys. The *right renal vein* is about 1 inch (2.5 cm.) in length and the *left* is about 3 inches (7.5 cm.) in length.

The *lumbar veins* are four pairs of veins that correspond to the four pairs of lumbar arteries.

The *spermatic*, or *testicular veins* (two) return the blood from the testes. Each vein begins at the *pampiniform plexus of veins* upon the spermatic cord, passes through the inguinal canal, enters the abdomen and that of the *right side* empties into the *inferior cava* while that of the *left side* empties into the *left renal vein.*

The *ovarian vein* of each side starts at the *pampiniform plexus of veins* and terminates like the corresponding vein of the male.

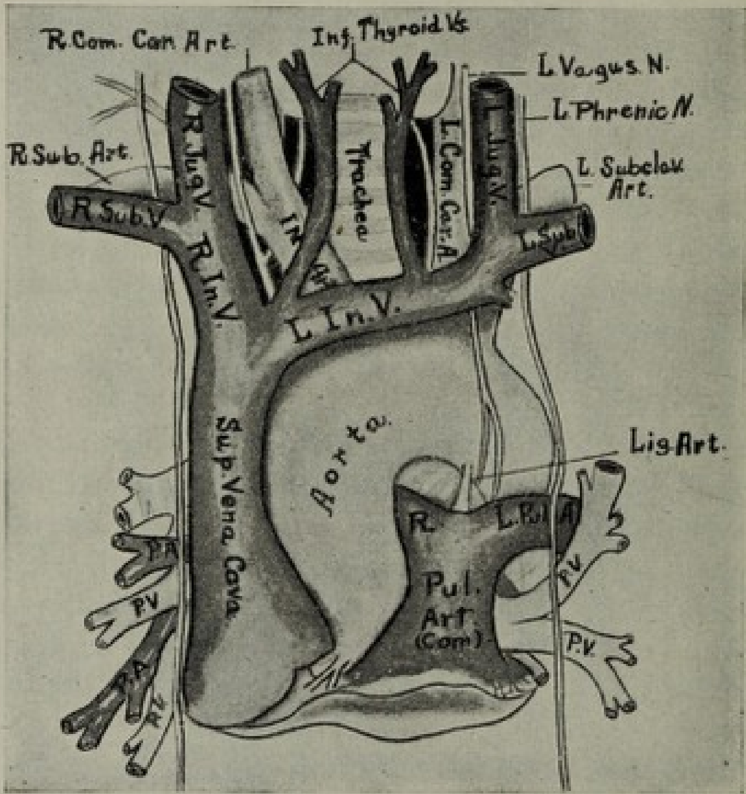


FIG. 183.—Arch of the aorta and its branches; the superior vena cava and its tributaries; the pulmonary arteries and veins.

The blood that passes from the aorta through the *celiac axis, superior* and *inferior mesenteric arteries does not pass directly to the inferior cava* but passes first through the liver (through the portal vein). The blood, after passing through the liver, leaves this organ through two vessels called the *hepatic veins;* these open into the inferior vena cava just before this vessel passes through the diaphragm. This peculiar course constitutes the *portal circulation.*

The **pulmonary veins** are usually *five in number*, *three right* and *two left.* These start at the root of the lung and the two left proceed directly to the left atrium where they empty their blood. On the right side the veins from the *superior* and *middle lobes* of the lung usually unite to form *one vessel* and this and the vein from the inferior lobe proceed directly to the left atrium where they empty their blood.

The **azygos veins,** three in number, collect the blood from most of the intercostal spaces and serve to connect the superior and inferior venæ cavæ.

The *azygos major* (*vena azygos major*) arises opposite the first or second lumbar vertebra by a branch from the right lumbars, right renals or inferior vena cava. It passes up the right side of the vertebral column, through the aortic orifice in the diaphragm

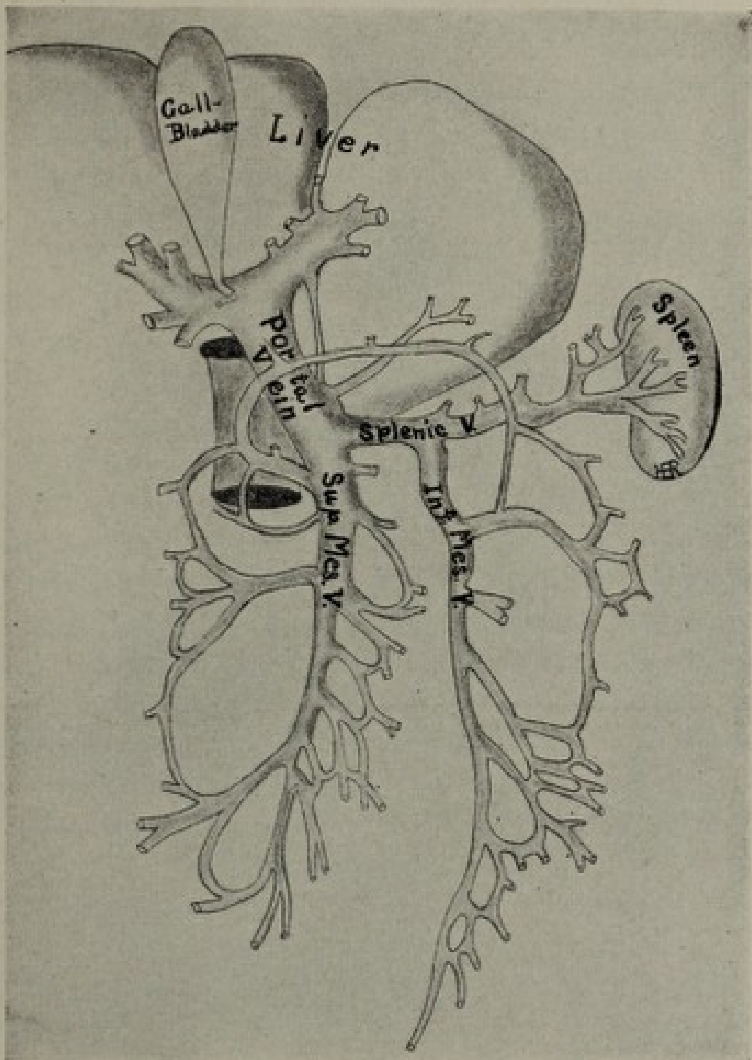


FIG. 184.—The portal vein and its tributaries.

to the fourth thoracic vertebra where it arches over the root of the right lung to empty into the superior vena cava. Its *tributaries* are the lower ten posterior intercostal veins of the right side, the right superior intercostal vein, the azygos minor veins, the right bronchial vein and several veins from the esophagus, mediastinum and pericardium.

The *vena azygos minor inferior* (*vena hemiazygos*) arises in the abdomen by a branch from one of the left lumbar veins or from the left renal vein. It enters the thorax through the left crus of the diaphragm and passes upward to the ninth or eighth thoracic vertebra where it passes across to the right and terminates in the vena azygos major. Its tributaries are the lower one or two intercostals and veins from the esophagus and mediastinum.

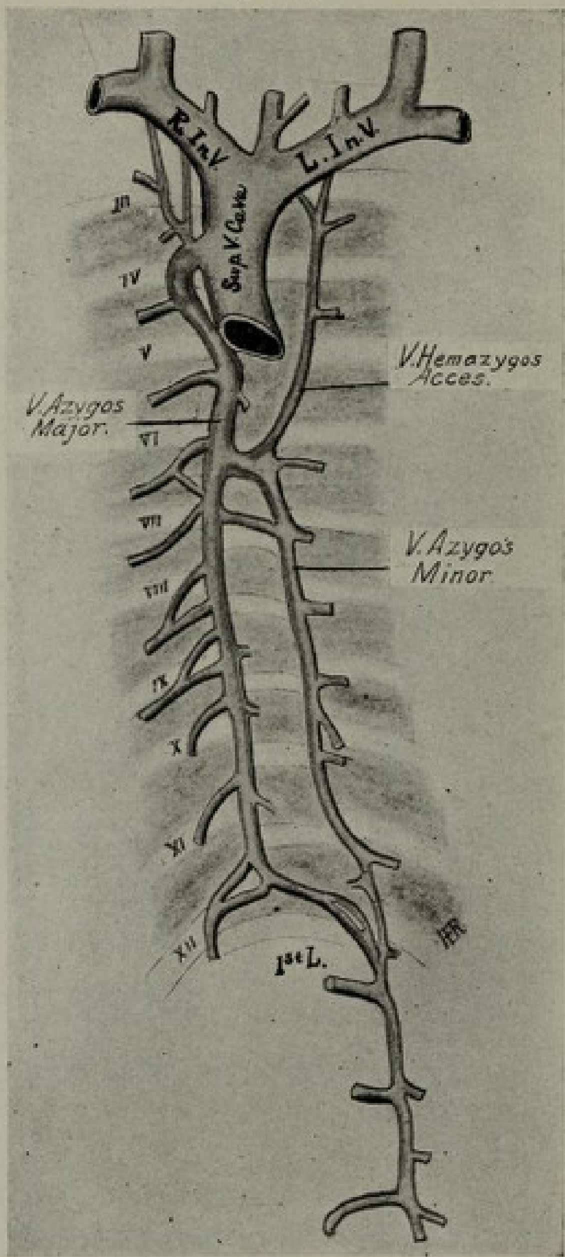


FIG. 185.—The azygos system of veins.

The *vena azygos minor superior* (*vena azygos accessoria*) is usually small and joins the vena azygos major or the preceding vessel.

THE SYSTEMIC CIRCULATION

The **general systemic circulation** is as follows: The blood leaves the left ventricle through the aorta and through the branches at the arch is distributed to the head, neck and upper extremities. From the thoracic aorta it is distributed to the lesser organs and walls of the thorax and partly to the lungs, from the abdominal aorta to the walls and viscera of the abdomen and pelvis, and lastly to the lower extremities. The blood from the head and upper extremities is returned upon each side through the internal jugular and subclavian veins respectively. On each side these form the innominate or brachiocephalic veins which join to form the superior vena cava that empties the blood into the right atrium. From the lower extremities the blood is returned by the two common femoral veins, which continue as the external iliac veins in the abdomen and are joined by the internal iliac veins to form the common iliac vein of each side. The common iliac veins unite to form the inferior vena cava which then receives the blood through the tributaries above mentioned. The blood is then emptied into the right atrium.

The **portal circulation** is as follows: The blood leaves the aorta through the celiac axis, superior and inferior mesenteric arteries. From the celiac axis the blood passes to the liver, stomach, spleen, pancreas and duodenum. From the inferior mesenteric artery it passes to the pancreas, duodenum, jejunum, ileum, cecum, appendix, ascending and transverse colons. From the inferior mesenteric artery the blood passes to the descending colon, sigmoid flexure and upper part of the rectum. The blood from the spleen, most of that from the stomach, pancreas and duodenum is returned by the splenic vein; that from the distribution of the superior mesenteric artery by the superior mesenteric vein; that from the distribution of the inferior mesenteric artery by the inferior mesenteric vein. The inferior mesenteric vein joins the splenic vein and the splenic vein then joins the superior mesenteric vein to form the *portal vein.*

The *portal vein* (*vena portæ*) is about 3 inches (7.5 cm.) long, passes upward and to the left, enters the transverse fissure of the liver where it divides into two main branches, the right and left lobar branches.

CHAPTER V

THE LYMPH VASCULAR SYSTEM

The lymp vascular system is in close relation to the blood vascular system and through it the liquor sanguinis of the blood, as lymph, comes into direct contact with the cells of the body. It differs from the blood vascular system in several ways: (1) It contains no blood but lymph. (2) The flow is in one direction, from the periphery toward the center. (3) It is no true circulatory system as it has no separate organ to force the lymph along. (4) Like the veins, many of the lymph vessels possess valves but unlike veins these lymph vessels are interrupted at frequent intervals by lymph nodes through which the lymph must filter before it can course onward. These lymph vessels communicate directly with the large serous cavities of the body (peritoneal, pleural, pericardial, joint cavities, bursæ and tendon sheaths) by means of *stomata*. These serous cavities are really enormously dilated lymph spaces lined with endothelial cells.

This system consists of *lymph spaces*, *lymph vessels*, *lymphatic organs* and the *lymph*.

Lymph spaces do not represent the beginning of the lymph vessel system but here the lymph has its origin and passes from these spaces into the vessels. They are mere tissue spaces and are not lined with endothelial cells except in a few isolated instances, as those around the ganglion cells of the sensor ganglia, and the large lymph space above mentioned. There are three sets of these spaces: (1) the *intercellular*, or *pericellular;* (2) the *perineural*, around the nerves; (3) the *perivascular*, around the blood-vessels.

The **lymph vessels** (*vasa lymphatica*) vary in size, the smallest being *capillaries* that are mere tubes of endothelial cells and varicose in form. It is into these that the lymph passes directly from the intercellular spaces. The next vessels are thin-walled and *resemble venules*, and lastly, the largest are the *lymphatic* and *thoracic ducts*. Certain structures as the brain, cartilage, epidermis, nails and avascular structures are devoid of lymphatic vessels.

The **lymphatic organs** are the *cisterna chyli*, *lymph nodes*, *spleen*, *thymus* and *tonsils*, and *lymphoid tissue* comprising the *diffuse form*, *solitary nodules* and *Peyer's patches*.

Lymph nodes are collections of lymphoid tissue varying in size from that of a pin head to that of a lima bean. They are scattered throughout the body, being usually arranged in groups. The lymph must filter through one or more groups before it enters the blood vascular system.

The lymph is practically the liquor sanguinis of the blood containing only the leukocytes, or white blood cells. It passes out of the blood capillaries into the tissue spaces, bathes the tissues and cells, giving up its nutritive elements and receiving effete material in return. It then passes through the walls of the lymph capillaries entering here the real vessel system. It then passes into the larger vessels, through one or more node groups and is ultimately returned to the blood vascular system by the right lymphatic and thoracic ducts. These empty into the right and left subclavian-internal jugular vein junctions, respectively.

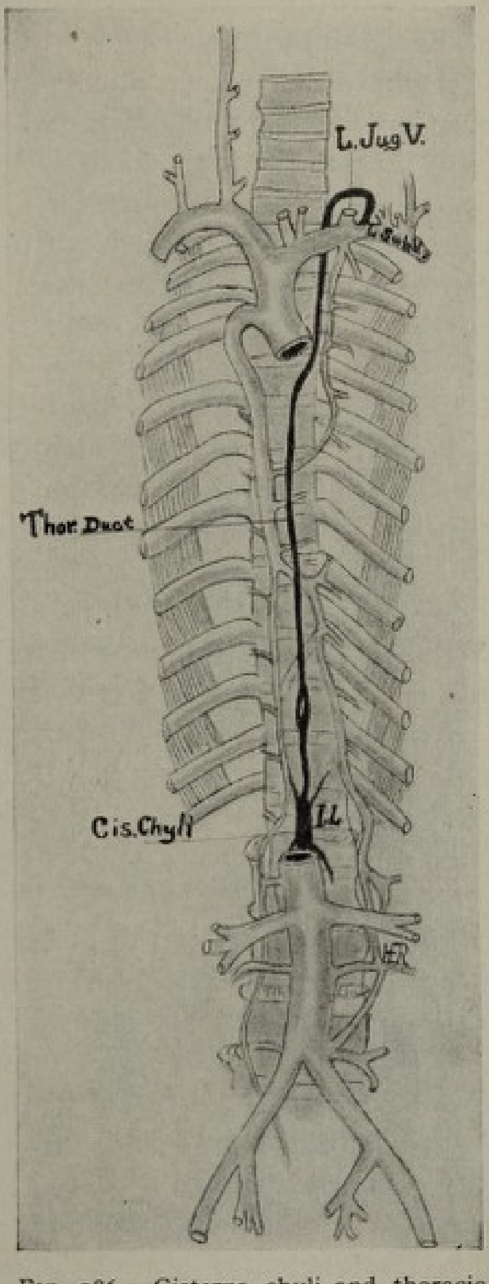


Fig. 186.—Cisterna chyli and thoracic duct. IL, first lumbar vertebra.

Throughout the body the lymphatics are divided into a *superficial* and a *deep set.* The *superficial set* drains the outside of the organs and the body, while the *deep set* drains the muscles, bones and deeper parts of the organs. This will be further explained as the various structures are discussed.

The **receptaculum chyli** (*cisterna chyli*) is a delicate, thin-walled reservoir, 5 to 7.5 cm. long and 6 to 8 mm. wide. It is located in the abdominal cavity on the right side of the first or second lumbar vertebra between the aorta and the vena azygos major. This thin-walled structure is difficult to find when empty. It receives the lymph from various regions through the following tributaries: two ascending lumbar trunks, two descending (lumbar) trunks, one common intestinal trunk and occasionally one retroaortic trunk. It is drained by the thoracic duct.

The **thoracic duct** is 15 to 18 inches (37.5 to 45 cm.) long and starts from the cisterna chyli at about the first lumbar vertebra. It passes up (cephalad) through the aortic orifice of the diaphragm into the thoracic cavity (dorsal mediastinum) in the midline to the level of the fifth or fourth thoracic vertebra where it crosses to the left side of the vertebral column. It continues through the superior mediastinum into the neck to the level of the seventh cervical vertebra where it curves downward over the subclavian artery and empties into the angle formed by the left subclavian-internal jugular vein junction. Its orifice is guarded by a valve and valves are numerous along its course. The thoracic duct receives the lymph from the lower extremities, the abdomen and its contents, the left thorax, left lung and the left side of the heart, from part of the lower half of the right thorax and from the left side of the head and neck and the left upper extremity.

The **right lymphatic duct** (*ductus lymphaticus dexter*) is about ¾ inch in length. It is formed by the junction of the right subclavian, the right jugular and right bronchomediastinal trunks and empties into the right subclavian-internal jugular vein junction. Its orifice is guarded by a valve. The right lymphatic duct receives the lymph from the right side of the head and neck, the right upper extremity, the right thorax (upper half), the right lung, the right side of the heart and from part of the convex surface of the liver.

For the sake of convenience the lymphatic drainage of the body will be considered in regions, as *head* and *neck*, *upper extremity*, *lower extremity*, *abdomen* and *thorax*.

LYMPHATICS OF THE HEAD AND NECK

The lymphatics of the outside of the head and neck are divided into *superficial* and *deep*. The node groups of the head are as follows (those marked (**S**) are superficial and those marked (**D**) are deep):

1. **Occipital** (*Lymphoglandulæ occipitales*) (**S**).—This group consists of one to three nodes in the occipital region on the upper part of the trapezius muscle; these drain the occipital portion of the scalp and their efferents carry the lymph to the upper deep cervical nodes.

2. **Postauricular** (*Lymphoglandulæ auriculares posteriores*) (**S**).—This group comprises usually two or three nodes near the mastoid process of the temporal bone. These drain the posterior temporoparietal region, part of the pinna of the ear and the posterior wall of the external auditory canal. Their efferents carry the lymph to the upper deep cervical nodes.

3. **Preauricular** (*L. auriculares anteriores*) (**S** and **D**).—The *superficial nodes* are placed over the parotid gland and the *deep* are within its substance. The *latter* are the more numerous. These

nodes drain the eyelids, eyebrows, frontotemporal part of the scalp, root of the nose, the front wall of the external auditory canal, part of the pinna, the middle ear, soft palate, deep portion of the cheek and back part of the nasal fossæ. Their efferents drain into the upper deep cervical nodes.

4. The **superficial facial** (*L. facialis superficialis*) (**S**).—This group consists of three subgroups: (*a*) the *infraorbital*, or *maxillary nodes*

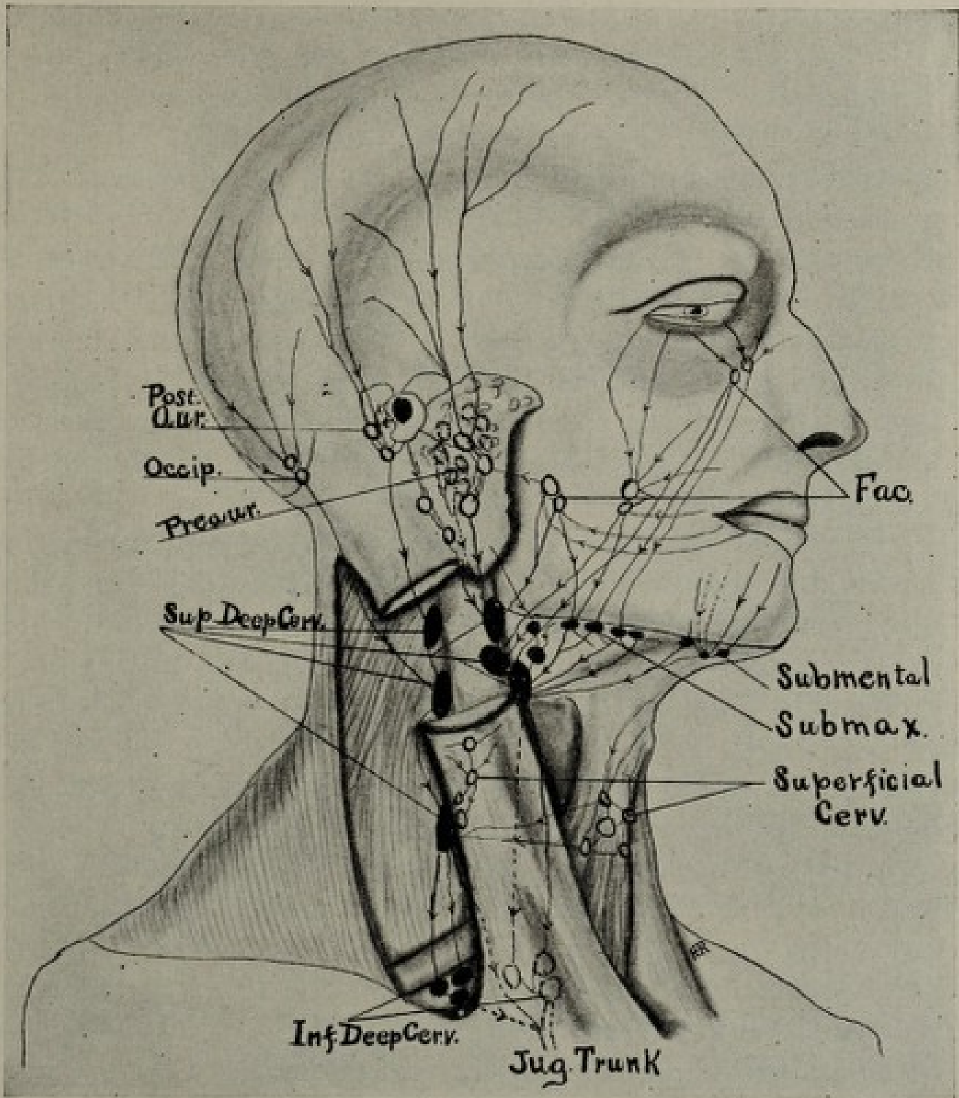


FIG. 187.—Lymph nodes and lymphatic drainage of the head and neck. Superficial nodes indicated as circles and deep nodes in solid black.

in the infraorbital region; (*b*) the *buccal* or *buccinator group* in the cheek; (*c*) the *supramandibular group* upon the mandible at the anterior edge of the masseter muscle. These groups drain the eyelid, conjunctiva, skin and mucous membrane of the nose and cheek. Their efferents carry the lymph to the submaxillary nodes and to the upper deep cervical nodes.

5. **Deep facial** (*L. faciales profundæ*) (**D**).—This group consists of several nodes along the lateral wall of the pharynx near the internal

maxillary artery. These drain orbit, temporal fossa, the nasopharynx, palate, nasal fossæ and the cerebral meninges. Their efferents pass to the upper deep cervical nodes.

6. **Lingual** (*L. linguales*) (**D**) nodes are at the base of the tongue and are intervening nodes in the tongue drainage. Their lymph passes into the upper deep cervical nodes.

The node groups of the neck are as follows:

Superficial cervical (*L. cervicales superficiales*) (**S**).—These comprise the *external jugular group* that lies upon the external jugular vein just a little below the parotid gland. These nodes drain the lower part of the pinna of the ear, the parotid region, the occipital and mastoid regions and their efferents pass to the upper deep cervical and supraclavicular nodes.

2. **Submaxillary** (*L. submaxillares*) (**D**).—This consists of three to six nodes located in the submaxillary triangle. These drain the superficial part of the nose, lower and front part of the face, upper and lower lips, gums, anterior part of the margin of the tongue and the floor of the mouth, either directly or through the facial and submental nodes. Their efferents carry the lymph to the upper deep cervical nodes.

3. The **submental,** or **suprahyoid nodes** (**S**) lie beneath the fascia just within the symphysis of the mandible; they drain the skin of the chin, skin and mucous membrane of the middle of the lower lip, the gums, the floor of the mouth and the tip of the tongue. Their efferents pass to the submaxillary and upper deep cervical nodes.

4. The **prelaryngeal nodes** (**D**) are variable and when present are found in front of the lower (tracheal) end of the larynx. They drain the lower part of the larynx, the upper part of the trachea and the thyreoid body. Their efferents carry the lymph to the upper deep cervical nodes.

5. The **pretracheal nodes** (**D**) lie upon the front of the trachea and receive the lymph from the trachea and thyreoid body. Their efferents pass to the upper deep cervical nodes.

6. The **retropharyngeal nodes** (*L. retropharyngeæ*) (**D**) lie behind the upper part of the dorsal wall of the pharynx and drain the nasal fossæ, the nasopharynx and the auditory tubes. Their efferents pass to the upper deep cervical nodes.

7. The **deep cervical nodes,** although they form an almost continuous chain, are divided into *two sets*, the *upper* and the *lower.* Each group may be divided into *medial* and *lateral subgroups.* The **upper** lie beneath the sternomastoid muscle (the *lateral subgroup*) and upon the internal jugular vein (the *medial subgroup*). These drain the occipital region of the scalp, the back of the neck, the pinna of the ear, the tongue, larynx, trachea, thyreoid body,

nasopharynx, palate, nasal fossæ, esophagus and face through the above-mentioned node groups. The **lower group** lies in relation with the lower part of the internal jugular vein (*medial subgroup*) and in relation with the brachial plexus and the subclavian artery (*lateral subgroup*). This group drains the back of the neck, scalp, the superficial pectoral region in addition to receiving lymph from the upper deep nodes. The lymph from the upper nodes passes partly to the lower nodes and partly into a trunk that joins a similar trunk from the lower nodes. These two trunks unite to form the *jugular lymph trunk* upon each side of the neck. Upon the right side of the body this trunk joins the subclavian trunk to form the right lymphatic duct, while upon the left side it empties into the thoracic duct, or directly into the subclavian-jugular vein junction.

THE UPPER EXTREMITY

The nodes and vessels of the upper extremity are *superficial* and *deep*. They are as follows:

The **superficial cubital nodes** (*L. cubitales superficiales*) (**S**) are the first nodes of the extremity. These are located upon the medial side of the basilic vein just above the medial epicondyle. They drain both surfaces of the hand and forearm and also its ulnar border. Their efferents pass to the deep cubital or the lateral axillary nodes.

2. The **Deep Cubital Nodes** (*L. cubitales profundæ*) (**D**).—Occasionally some small nodes are found along the ulnar and radial arteries. The *deep cubital nodes*, however, lie at the terminal part of the brachial artery upon the volar side of the elbow; they drain the deep structures of the hand and forearm. The efferents pass to the lateral axillary nodes.

3. The **axillary group** (*L. axillares*) (**D**) comprises the following subgroups:

(*a*) The **lateral axillary nodes** (one to six) lie along the axillary vein. They receive the lymph, both superficial and deep, from the ventral and dorsal pectoral regions either directly or through the node groups previously mentioned. Their efferents pass to the central axillary nodes and the subclavian group and even to the lower deep cervical nodes.

(*b*) The **ventral axillary,** or **pectoral nodes** (two to four) lie along the lower border of the pectoralis major muscle from the third to the sixth intercostal spaces; they receive the lymph from the superficial part of the ventral and lateral thoracic walls above the umbilicus and the lateral two-thirds of the mammary gland. Their efferents pass to the central, lateral and subclavian nodes.

(*c*) The **dorsal axillary,** or **subscapular nodes** lie upon the dorsal wall of the axilla near the subscapular artery. They drain the superficial parts of the dorsal and lateral walls of the thorax above the level of the umbilicus and the lower part of the neck. Their efferents carry the lymph to the central group, or to the subclavian nodes, or even to the jugular trunk.

(*d*) The **central axillary group** consists of three to six large nodes near the base of the axilla. They drain more or less completely the

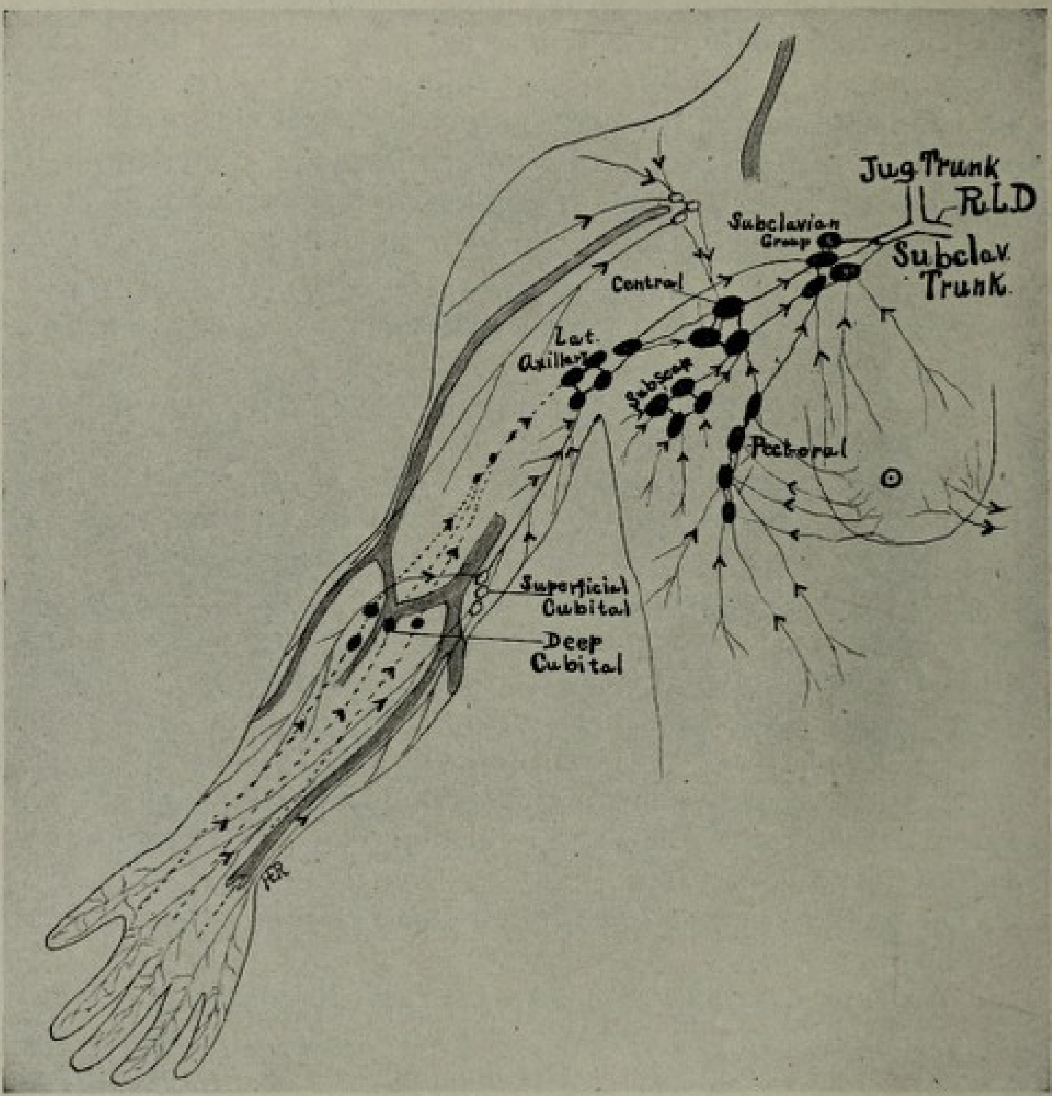


FIG. 188.—Lymph nodes and lymphatic drainage of the upper extremity, mammary gland and thoracic wall. *RLD*, Right lymphatic duct.

preceding groups. Their efferents carry the lymph to the subclavian group.

4. The **deltopectoral nodes (S)** lie in the interval between the pectoralis major and the deltoid muscles. They receive the lymph from the outer side of the shoulder and arm. Their efferents pass to the lateral axillary nodes, or the lower deep cervical group.

5. The **subclavian nodes (infraclavicular) (D)** lie upon the axillary artery between the pectoralis minor muscle and the clavicle. They

receive the lymph from the upper extremity, ventral, lateral, and dorsal thoracic walls and mammary gland. From these nodes the *subclavian trunk* carries the lymph though some efferents may pass to the lower deep cervical nodes.

Upon the right side the jugular and subclavian trunks unite to form the short *right lymphatic duct* that empties into the junction of the right subclavian and internal jugular veins. Upon the left side they may empty into the thoracic duct, or into the left subclavian-internal jugular vein junction.

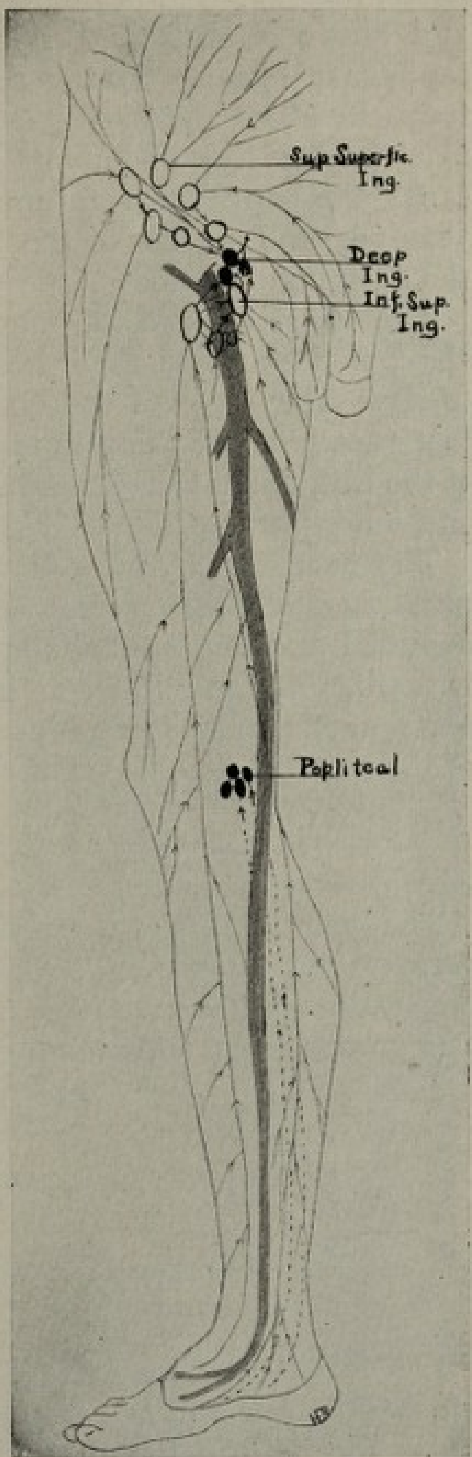


FIG. 189.—Lymph nodes and lymphatic drainage of the lower extremity.

THE LOWER EXTREMITY

The lymphatics of the lower extremity are *superficial* and *deep*.

The node groups are as follows:

1. The **anterior tibial nodes** (**D**) is inconstant and when the present is located at the upper part of the anterior surface of the interosseous membrane. It receives the lymph from the deep parts of the sole, the dorsum of the foot and deep structures of the front of the leg. The efferents pass to the popliteal nodes.

2. The **popliteal nodes** (*L. popliteæ*) (**D**) are four or five in number and lie in the popliteal space around the popliteal artery. They receive lymph from the deep parts of the foot, deep structures of back of the calf and from the anterior tibial node, also from the superficial structures of the lateral part of the foot and heel and back of the leg (parts drained by the external saphenous vein). The efferents carry the lymph to the deep femoral nodes. Occasionally a node is found where the small saphenous vein pierces the deep fascia.

3. The **inguinal nodes** are divided into *two sets*, the *superficial* and *deep*. The *superficial inguinal nodes* (*L. inguinales superficiales*)

consist of *two sets*, *proximal* and *distal* and they lie superficial to the deep fascia. The *superior*, or *proximal superficial inguinal nodes*, four to seven in number, lie just below the inguinal ligament and above a horizontal line drawn through the middle of the saphenous opening in the deep fascia. They receive the lymph from the outer and back part of the thigh and buttock, the superficial part of the abdominal wall (below the umbilicus), the anal canal, the perineum, scrotum and penis of the male and the labia, vestibule and vagina of the female. The lymph then passes into the deep inguinal nodes.

The **inferior,** or **distal superficial inguinal nodes** lie below the above nodes around the internal saphenous vein and number three to six. They receive the lymph from the superficial parts of the foot (not lateral), the sole (except the heel), inner, front and sides of the calf, and all the superficial parts of the thigh except the upper and outer parts. The efferents pass to the deep inguinal nodes.

The **deep inguinal nodes** (*L. subinguinales profundæ*), three to seven, lie along the femoral vein. They receive the lymph from the popliteal and superficial inguinal nodes as well as from the deep structures of the outer and front portions of the thigh, also deep parts of the clitoris and penis. The efferents carry the lymph to the external iliac nodes of the abdomen.

THE LYMPH NODES OF THE ABDOMEN

The lymph nodes of the abdomen are divided into *two groups*, the *parietal* and *visceral*. The parietal drain the deep structures of the walls and extremities, while the visceral drain the viscera. The groups are as follows:

Parietal		Visceral
1. External iliac		1. Celiac
2. Internal iliac	Preaortic	2. Superior mesenteric
3. Common iliac		3. Inferior mesenteric
4. Subaortic.		
5. Lateral aortic		
6. Retroaortic		

1. The **external iliac nodes** consist of three chains, *one lateral*, *one intermediate* and *one medial* to the external iliac artery. These nodes receive the lymph from the lower extremity through the various inguinal nodes, from the glans penis or the glans clitoris, the deeper structures of the abdominal wall (below the umbilicus), from the upper part of the vagina, cervix of the uterus, prostate, bladder, membranous urethra, some from the internal iliac nodes and from the structures along the course of the obturator artery. The efferents carry the lymph to the common iliac nodes.

2. The **internal iliac,** or **hypogastric nodes** (*L. hypogastricæ*), surround the internal iliac artery. They receive the lymph from the pelvic viscera and the deeper structures of the perineum, buttocks, posterior part of the thigh and urethra. The efferents carry the lymph to the common iliac nodes.

A special group, the **sacral nodes** (*L. sacrales*) lies in the hollow of the sacrum and drain the rectum, prostate and dorsal pelvic wall. The efferent pass to the subaortic and lateral aortic nodes.

3. The **common iliac nodes** are arranged in groups in front, lateral and medial to the common iliac artery. They receive the lymph from the external and internal iliac nodes and send it to the lateral aortic nodes.

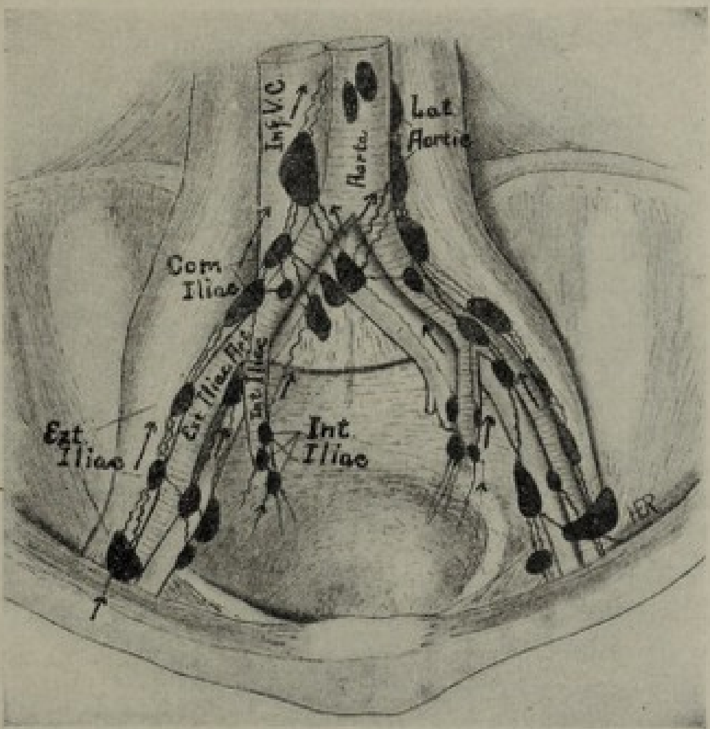


FIG. 190.—Iliac and lateral aortic lymph nodes and lines of drainage.

4. The **subaortic nodes** (*L. subaorticæ*) lie upon the ventral surface of the fifth lumbar vertebra and receive part of the lymph from the sacral and hypogastric nodes and pass the lymph to the lateral aortic nodes.

5. The **lateral aortic** or **lumbar nodes** (*L. lumbales*) comprise two sets *right* and *left*, at the respective sides of the aorta. On each side the nodes receive the lymph from the corresponding common iliac, subaortic and hypogastric nodes; from the testicle, or ovary, oviduct and body of the uterus; from the lateral abdominal muscles; from the kidneys and adrenals. The chief vessels from these nodes are the *right* and *left ascending* (*common*) *lumbar trunks* that empty the lymph into the cisterna chyli.

6. The **retroaortic nodes** lie behind the aorta on the third and fourth lumbar vertebræ. They receive lymph from the lateral and preaortic nodes and the chief vessel from this group is the *retroaortic trunk* that empties into the cisterna chyli.

The **visceral nodes** of the abdomen proper are the *preaortic nodes* consisting of three main groups and a large number of subsidiary groups.

1. The **celiac,** or **middle suprapancreatic group** consists of nodes around the origin of the celiac axis artery. In addition there are several subsidiary groups.

(*a*) The *gastric group* (*L. gastricæ*) comprise the *left ventral gastric nodes* that lie between the layers of the lesser omentum along the left gastric artery; they drain most of the lesser curvature and the neighboring parts of the ventral and dorsal surfaces of the stomach and empty into the left dorsal gastric nodes.

(*b*) The *dorsal paracardial nodes* (*right* and *left*) lie around the cardiac orifice and drain the cardiac end of the stomach and the efferents pass to the left dorsal gastric nodes.

(*c*) The *left dorsal gastric nodes* lie upon the left gastric artery and receive lymph from the cardiac part of the stomach and from the above nodes. The efferents pass to the middle suprapancreatic (celiac) nodes.

(*d*) The *right gastroepiploic nodes* lie along the right part of the greater curvature of the stomach, receive lymph from that part and pass the lymph to the subpyloric nodes.

(*e*) The *subpyloric nodes* are located at the end of the first part of the duodenum and drain the pyloric part of the stomach and receive lymph from the right gastroepiploic nodes. Their efferents pass to the celiac group.

(*f*) The *left suprapancreatic,* or the *pancreaticosplenic nodes* are distributed along the course of the splenic artery and drain the spleen and the left portion of the stomach and empty into the middle suprapancreatic or celiac group.

(*g*) The *right suprapancreatic nodes* lie upon the hepatic artery and drain a part of the liver and the pyloric portion of the stomach. The lymph then passes to the middle suprapancreatic or celiac group.

(*h*) The *biliary nodes* lie along the bile duct and receive lymph from the gall-bladder and liver and pass it to the celiac nodes.

(*i*) The *hepatic nodes* lie at the portal fissure of the liver, receive lymph from the liver and pass it to the celiac nodes.

From the celiac, or middle suprapancreatic nodes the lymph is carried by the *celiac trunk* to the common intestinal trunk and also common lumbar trunks.

2. The **superior mesenteric group** is found around the origin of

the superior mesenteric artery. Its subsidiary groups are: (*a*) mesenteric, (*b*) ileocolic and (*c*) mesocolic nodes.

(*a*) The *mesenteric nodes*, comprising from 100 to 150, lie between the layers of the mesentery. *One group* lies close to the intestinal wall, *another* around the loops and primary branches of the artery and a *third* along the main stem of the artery. The lymph from the small intestine drains through the first group, then into and through the second and then through the third group and is then carried to the superior mesenteric nodes.

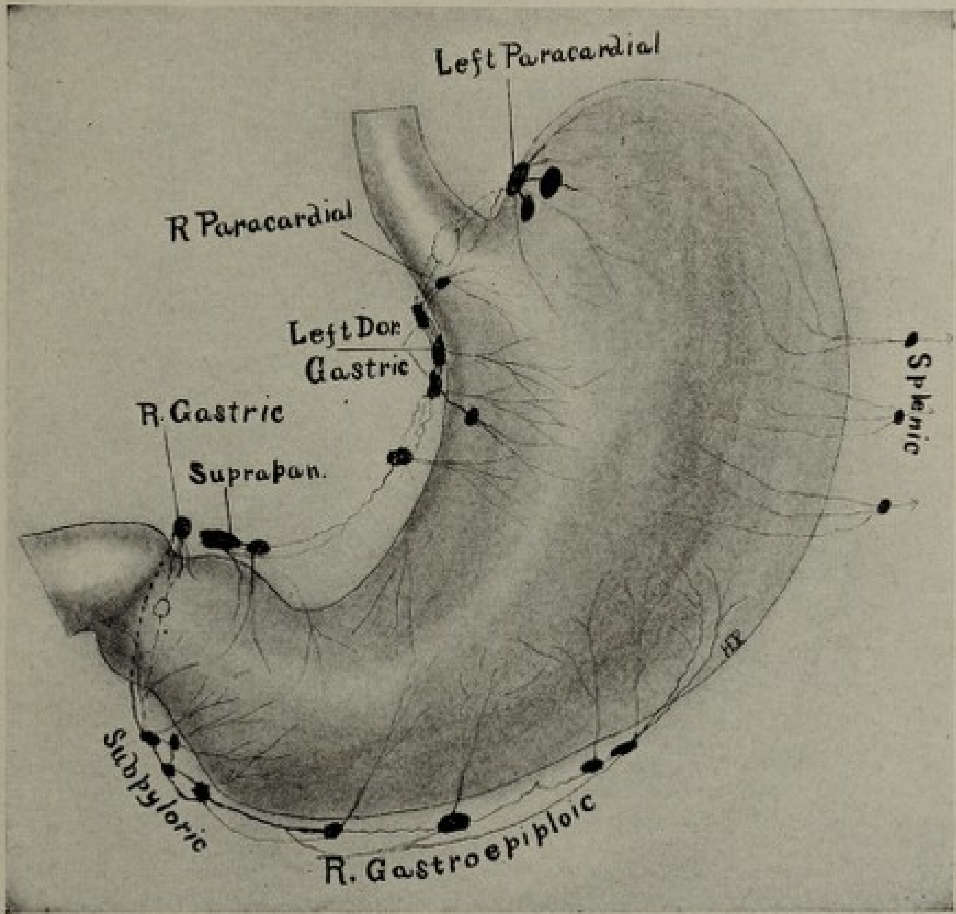


FIG. 191.—Lymph nodes and lymphatic drainage of the stomach.

(*b*) The *ileocolic nodes*, about twenty to thirty, form a chain along the ileocolic artery. The main subgroups are the *ileal*, along the ileal branch of the superior mesenteric artery; the *ventral ileocolic* near the front of the cecum; the *dorsal ileocolic*, in the angle between the ileum and the colon; the *appendicular* along the appendix and *paracolic* along the medial side of the ascending and transverse colons. These nodes drain the lower part of the ileum, cecum, appendix and ascending colon and empty the lymph into the superior mesenteric nodes.

(*c*) The *mesocolic nodes* (part of the paracolic chain) are numerous and lie in relation with the transverse colon. The lymph from the transverse colon passes through these nodes and thence to the superior mesenteric nodes. From the superior mesenteric group the lymph is drained by the *superior mesenteric trunk* that helps to form the common intestinal trunk.

3. The **inferior mesenteric group** lies at the origin of the inferior mesenteric artery. The subsidiary groups are the (*a*) left colic, (*b*) sigmoid, (*c*) pararectal.

(*a*) The *left colic nodes* lie along the branches of the left colic artery and drain the descending colon and empty into the inferior mesenteric group.

(*b*) The *sigmoid nodes* lie along the branches of the sigmoid and superior hemorrhoidal arteries and drain the sigmoid flexure of the colon. The efferents carry the lymph to the inferior mesenteric nodes.

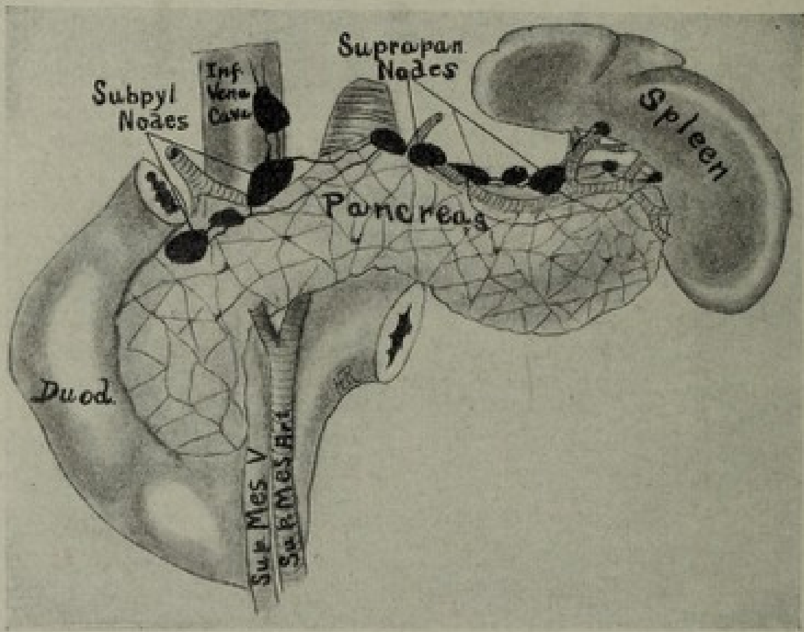


FIG. 192.—Lymph nodes of the pancreas.

(*c*) The *pararectal*, or *superior hemorrhoidal nodes* lie in contact with the muscle coat of the rectum and drain the upper part of the rectum. The lymph then passes to the inferior mesenteric nodes.

From the inferior mesenteric nodes the lymph is carried by the *inferior mesenteric trunk* to the common intestinal trunk.

The *common intestinal trunk* is the main tributary of the cisterna chyli and receives the lymph from the above organs through the celiac, superior and inferior mesenteric nodes and trunks.

The **lymphatic drainage of the liver** is quite complicated and will therefore be given special consideration. There are *two sets* of vessels *superficial* and *deep*. The *superficial vessels of the convex surface* drain in three directions. Those of the *left side* drain into the paracardial nodes of the gastric group; those of the *middle* pass through the caval orifice of the diaphragm and empty into nodes at the termination of the inferior vena cava; from the *right side* the vessels drain into the celiac nodes. In addition some of the lymph passes to the hepatic nodes; some into the inferior diaphragmatic nodes to the internal mammary nodes and some to the dorsal mediastinal nodes.

The **superficial vessels of the visceral surface** carry the lymph chiefly to the hepatic nodes; some of the lymph from the dorsal part of this surface is carried to the caval nodes above mentioned.

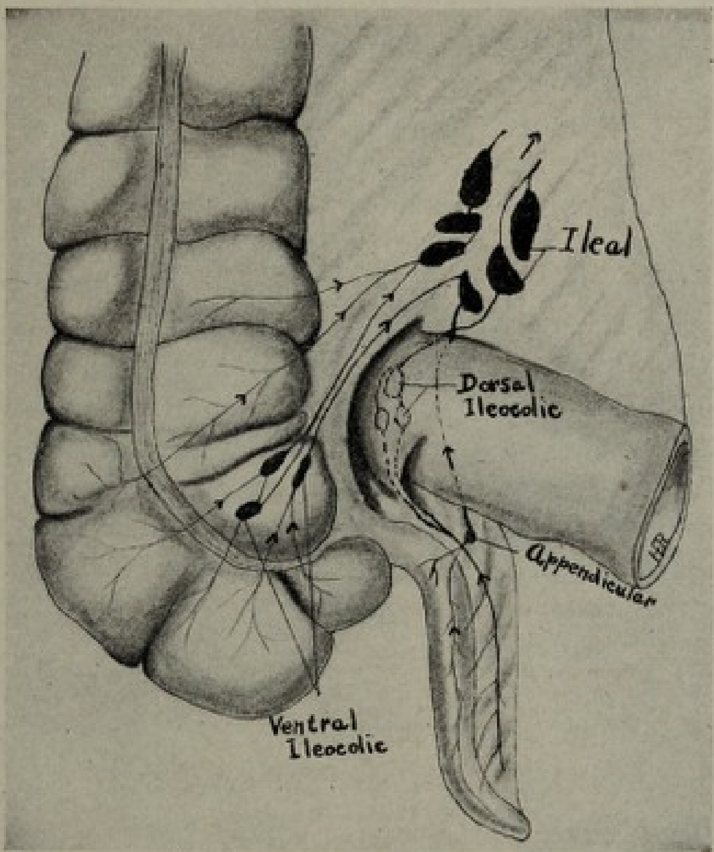


FIG. 193.—Ileal and ileocolic lymph nodes and lymphatic drainage.

The **deep lymphatic vessels** are the *ascending* that accompany the hepatic veins and empty the lymph into the caval nodes, and the *descending* that emerge at the portal fissure and empty the lymph into the hepatic nodes.

THE THORAX

The *lymph nodes of the thorax* comprise *two main sets, parietal* and *visceral.*

Parietal.	Visceral.
1. Internal mammary.	1. Ventral mediastinal.
2. Intercostal	2. Dorsal mediastinal.
3. Diaphragmatic.	3. Tracheobronchial.

Parietal.—1. The **internal mammary, or sternal nodes** (four to eighteen) lie along the course of the internal mammary artery. These receive lymph from mammary gland, the deeper structures of the ventral thoracic and abdominal walls (to umbilicus) and diaphragm, from the liver through the ventral diaphragmatic nodes and from the medial part of the mammary gland. The lymph then passes through the *internal mammary trunk* that empties either into the subclavian-internal jugular vein junction, or upon the right side into the right lymphatic duct, or the right bronchomediastinal trunk, and upon the left side into the thoracic duct.

2. The **intercostal nodes** (*L. intercostales*) lie at the lateral and dorsal part of the intercostal spaces. They receive the lymph from the deeper structures of the dorsal and lateral walls of the thorax. The vessels from the lower four or five intercostal spaces usually form a trunk on each side that descends into the abdomen to empty into the cisterna chyli, or into the first part of the thoracic duct. These are the *descending lumbar trunks*. The lymph of the left upper intercostal spaces drains into the dorsal mediastinal nodes, or into the thoracic duct, while upon the right side the lymph from the corresponding spaces is emptied into the right lymphatic duct.

3. The **diaphragmatic nodes** comprise three groups, (*a*) *ventral*, (*b*) *middle* and (*c*) *dorsal*.

(*a*) The *ventral nodes* lie behind the ensiform cartilage of the sternum and receive lymph from the convex surface of the liver and the ventral part of the diaphragm. The lymph then passes into the internal mammary nodes.

(*b*) The *middle nodes* (*right* and *left*) lie where the phrenic nerves enter the diaphragm. Some of the right nodes lie within the fibrous pericardium. They receive lymph from the middle of the diaphragm and some from the convex surface of the liver (and the right nodes). The lymph then passes to the dorsal mediastinal nodes.

(*c*) The *dorsal nodes* lies at the dorsal part of the diaphragm and receive lymph from the adjacent regions. The lymph then passes partly to the lateral aortic nodes and partly to the dorsal mediastinal nodes.

The **visceral nodes** are (1) *ventral mediastinal*, (2) *dorsal mediastinal* and (3) *tracheobronchial*.

1. The **ventral mediastinal (superior) nodes** lie in front of the arch of the aorta in the superior mediastinum. They receive lymph from the thymus body through the thymic nodes and the lymph vessels passing from these nodes assist in forming the *right* and *left bronchomediastinal trunk*.

2. The **dorsal mediastinal nodes** (eight to twelve) lie behind the pericardium near the esophagus and descending thoracic aorta. They receive lymph from the esophagus, dorsal surface of the peri-

cardium, diaphragm and the convex surface of the liver. Most of the lymph passes to the thoracic duct and the remainder to the tracheobronchial nodes.

3. The **tracheobronchial nodes** comprise *four groups*, the *right* and *left tracheal* and the *intertracheobronchial*, the *bronchopulmonary* and the *pulmonary*.

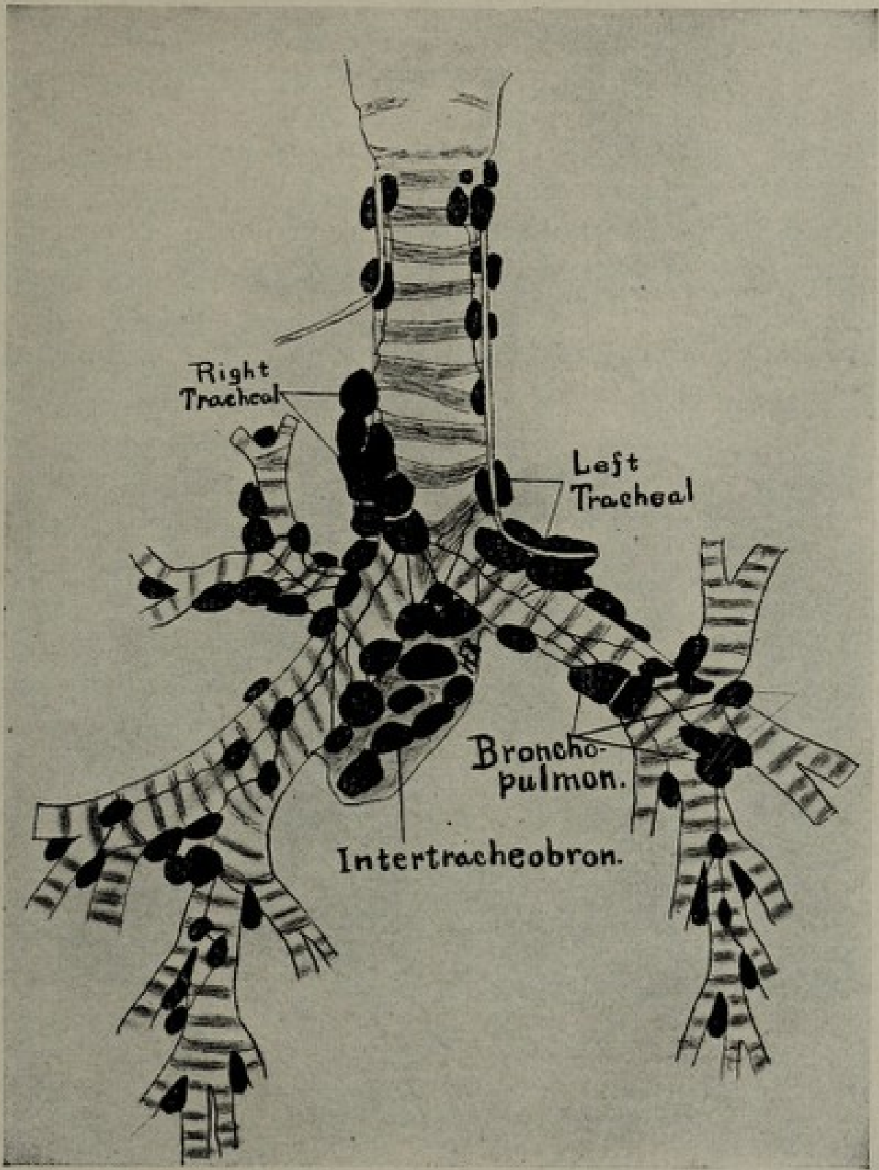


FIG. 194.—Tracheobronchial lymph nodes.

(*a*) The *right* and *left tracheal nodes* lie upon the right and left sides of the trachea.

(*b*) The *intertracheobronchial nodes* are found in the angle of the bifurcation of the trachea.

(*c*) The *bronchopulmonary nodes* lie at the hilus of the lung.

(*d*) The *pulmonary nodes* are in the lungs in the angles where the bronchial tube branches arise.

These nodes receive the lymph from the trachea, bronchi, lungs and heart and some from the dorsal mediastinal nodes. The lymph passes into vessels that unite with the vessels from the internal mammary and ventral mediastinal nodes to form the *right* and *left bronchomediastinal trunks*. These trunks usually empty into the subclavian and internal jugular vein junction, of their respective sides, but may empty into the right lymphatic and thoracic ducts, respectively.

THE SPLEEN AND THYMUS BODY

Although the spleen and thymus are not usually described under the lymphatic system the fact that they consist mainly of lymphoid tissue seems to warrant their description here. They are usually described under ductless glands but they are not of epithelial structure.

The Spleen, Lien.—The spleen, usually called a ductless gland, is located deeply in the left side of the abdominal cavity. It lies

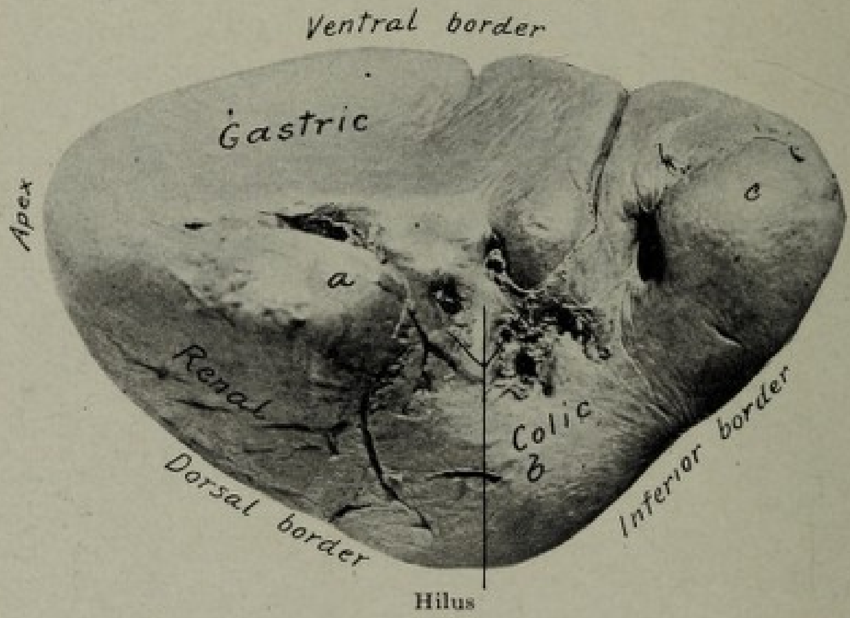


FIG. 195.—The visceral surface of the spleen showing its various areas. (*From a photograph.*) *a*, Intermediate angle; *b*, dorsal angle; *c*, ventral angle.

partly in the epigastric but mainly in the left hypochondriac regions. It is about 5 inches (12.5 cm.) in length, 3 inches (7.5 cm.) wide and 1¼ inches (3 cm.) thick. It weighs about 6½ ounces (195 grams). Its long axis usually conforms to the obliquity of the tenth rib. It is irregular in shape but is said to be tetrahedral in form. It is soft, of a dark brown color and very vascular.

The spleen has an *apex*, a *base*, *two surfaces* and *three borders*. The *apex* is somewhat pointed and is about 1½ inches (3.75 cm.) from the midvertebral line. The *base* corresponds to the colic area of the visceral surface and extends usually to the midaxillary line.

The *parietal*, or *diaphragmatic surface* is smooth and convex and is in contact with the diaphragm. The *visceral surface* is irregular and is divided into three areas by three ridges. The longest ridge starts below the apex and extends nearly to the base. It separates the larger, concave *gastric area* (above) from the smaller and flatter *renal area* (below). On the gastric area is seen the *hilus* where the vessels, nerve and lymph vessels, enter and leave. The *triangular base*, or *colic area*, is the smallest and is bounded by the *medial*, *ventral* and *dorsal angles*.

The *ventral border* is thin and notched and separates the diaphragmatic surface from the gastric area. The *dorsal border* is thin and separates the diaphragmatic surface from the renal area. This border corresponds approximately to the eleventh intercostal space. The *inferior border* separates the diaphragmatic surface from the colic area.

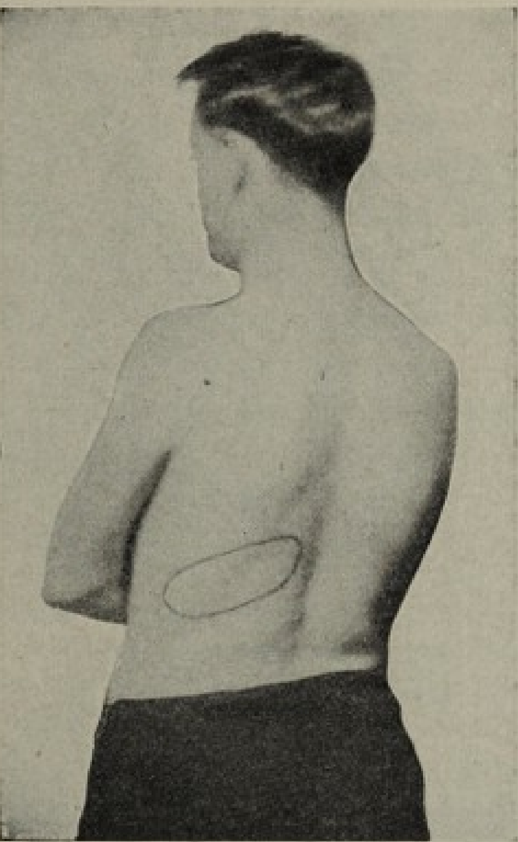


FIG. 196.—Outline of the spleen upon the body wall. (*From a photograph.*)

The spleen is practically completely invested by peritoneum is connected with the stomach by a fold of peritoneum called the *gastrosplenic omentum.* A fold of peritoneum passes from the spleen to the peritoneum ventral to the left kidney; this is the *lienorenal ligament* and through this the splenic artery reaches the organ. Another fold, the *phrenicocolic ligament*, connects it with the diaphragm.

The *spleen is outlined upon the body* as follows: Three points are first determined: (1) $1\frac{1}{2}$ inches to the left of the tenth thoracic spine; (2) in the eleventh intercostal space on a level with the first lumbar spine and 1 inch medial to the level of the center of the crest of the ilium; (3) in the ninth interspace in the midaxillary line. Join the points one and two by a slightly curved line with the convexity downward following the eleventh interspace (renal line); join points two and three by a curved line with the convexity outward (colic line); then continue the curved line from three to the upper border of the ninth rib and follow this to the scapular line, then horizontally across to the upper border of the tenth rib and then in a sharp curve proceed to point one. It must be remembered that this gives the anatomic outline, but this entire area does not give dulness upon percussion as approximately the apical one-fifth is deeply placed.

The *artery* that supplies the spleen is the *splenic artery*. The *splenic vein* returns the blood to the portal vein. The *nerves* are from the splenic plexus derived from the solar plexus of the sympathetic system.

The Thymus Body.—The thymus body, or gland is essentially an organ of fetal life and early childhood. It is located in the lower cervical and upper thoracic regions and in the latter place lies upon the pericardium and great vessels. It weighs about 1 ounce (28

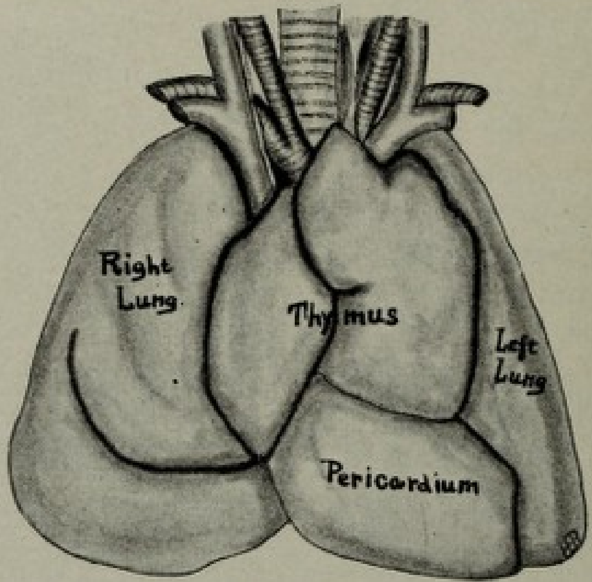


FIG. 197.—Ventral view of the thymus gland and neighboring organs in a child at birth.

grams) at birth but this is quite variable; it measures at that time about 2 inches (5 cm.) in length, 1½ inches (3.75 cm.) in breadth and 1¼ inches (30 mm.) in thickness. It is pinkish in color and consists of two unequal lobes. After the second year it does not grow in proportion to the other organs of the body and gradually loses its lymphoid structure and becomes more adipose in character. Usually at puberty it is very small though it may be very large.

The *arteries* are usually from the *inferior thyroid* and *internal mammary arteries* and its *veins* join the corresponding veins. The *nerves* are derived from the sympathetic and vagal nerves.

CHAPTER VI

THE RESPIRATORY SYSTEM

The respiratory system comprises the *nasal cavities*, the *pharynx*, *larynx*, *trachea*, *bronchi*, *lungs* and *pleuræ*.

THE NASAL CAVITIES

The nasal cavities (Fig. 198), two in number, extend from the *anterior nares* to the *posterior nares*, or *choanæ*. The *anterior nares*, or *nostrils*, lead into the *vestibule*. The lower part of the vestibule is lined with heavy hairs, the *vibrisæ*, that protect the entrance. The upper part of the vestibule is smooth and represents that part of the nasal fossæ lined by an extension of the skin, beyond this area a mucous membrane exists. That part of the nasal cavity above the vestibule is the *olfactory portion* as it is concerned with the sense of smell. This portion is narrow and slit-like. The remainder is expanded and constitutes the *respiratory portion*.

The *floor* of each cavity is formed by the palatal process of the maxilla and palate bone and the soft palate. The *lateral wall* is formed by the nasal bone, frontal process of the maxilla, lacrimal bone, labyrinth of the ethmoid with its superior and middle conchal processes, the vertical plate of the palate bone and the medial surface of the medial pterygoid plate. The *roof* consists of the nasal and frontal bones, the cribriform plate of the ethmoid, the body of the sphenoid and the sphenoidal conchæ, the sphenoidal process of the palate bone and the ala of the vomer. The *medial wall*, or *septum*, consists of the crests of the palate bones, below, the vomer, the perpendicular plate of the ethmoid, the nasal spine of the frontal bone, and the cartilaginous septum, in front. The cavity is deepest in the middle (going from front to back).

Upon the **outer** or **lateral wall** are three projections; the inferior concha (the largest), the middle and superior (smallest) conchal processes. The space between the floor and the inferior concha constitutes the *inferior meatus* and has the nasal duct opening into it. The space between the inferior concha and the middle conchal processes is the *middle meatus*. As its front extremity is the *infundibulum* that leads into the frontal sinus and anterior ethmoidal cells. In the middle of the outer wall is an opening that leads into the maxillary sinus. Between the middle and superior conchal processes lies the *superior meatus* that communicates with the posterior ethmoidal cells. Above the superior conchal process is a small space called the *sphenoethmoidal recess* that communicates with the sphenoidal sinus.

The **choanæ,** or **posterior nares,** are the openings by which the nasal cavities communicate with the pharynx. They are larger than the nostrils.

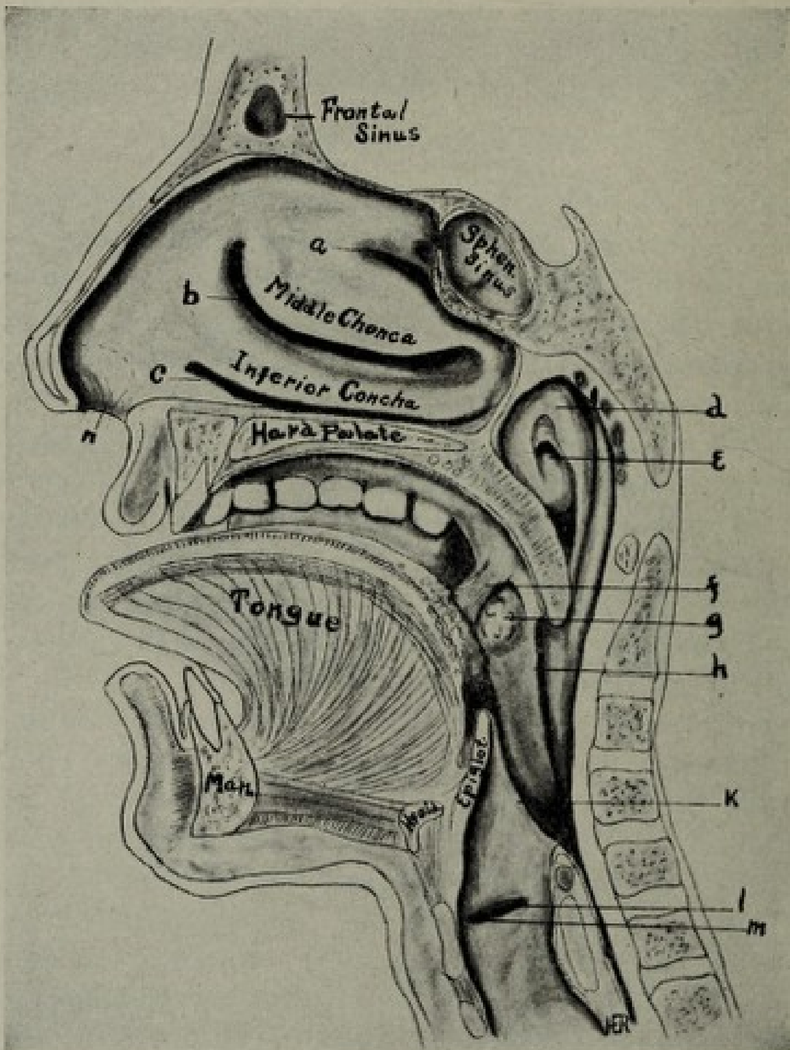


Fig. 198.—Median sagittal section through the head and neck. *a*, Superior meatus of the nose; *b*, middle meatus of the nose; *c*, inferior meatus of the nose; *d*, Eustachian (torus tubarius) cushion; *e*, orifice of auditory tube; *f*, palatoglossal fold; *g*, tonsil; *h*, palatopharyngeal fold; *k*, aryepiglottic fold; *l*, ventricle of the larynx; in, vocal cord; *n*, vestibule of nose.

The pharynx connects the nasal and oral cavities with the larynx. For a description see page 290.

THE LARYNX

The larynx, or organ of voice is situated at the lower part of the pharynx between the trachea, below, and the base of the tongue, above. It lies in the upper and front part of the neck where it causes a projection in the midline that will be described later. It extends from the lower border of the third cervical vertebra to the lower border of the sixth cervical vertebra separated therefrom by the pharynx. Its position depends upon the movements of the head and neck during deglutition and singing. In the fetus it lies at a higher level than in the adult. Up to puberty the larynx of the male is similar to that of the female. After this time the increase in the male is greater, the cartilages enlarging, the thyreoid cartilage becoming more prominent and the glottis nearly doubling its length. At this time the voice of the male is uncertain and likely to break at unexpected moments. The dimensions of the larynx are as follows:

	Male	Female
Vertical	44 mm.	36 mm.
Transverse	43 mm.	41 mm.
Dorsoventral	36 mm.	26 mm.
Circumference	136 mm.	112 mm.

The larynx at its upper extremity is somewhat triangular in outline (base dorsally directed) and below, almost cylindric. It consists of nine cartilages connected by ligaments and intrinsic and extrinsic muscles. The cartilages are:

Single	*Paired*
Thyreoid	Arytenoid
Cricoid	Cuneiform
Epiglottis	Cornicula laryngis

The **thyreoid cartilage** (*cartilage thyreoidea*) is the largest and consists of two lamellæ, or alæ. The *ventral borders* of the alæ meet, in their lower portions in front, at an angle of about 90°, in the male and 120° in the female. This junction produces a prominence in the midline called the *prominentia laryngea*, or *Adam's apple*, which is more noticeable in the male then in the female. Above, these borders are separated by a V-shaped notch, the *incisura thyreoidea*. The *dorsal borders* are thick and each extends upward as a long cylindrical process, the *superior cornu*, and downward in a shorter, heavier process, the *inferior cornu*. The superior cornua are connected to the greater cornua of the hyoid bone, while the inferior cornua articulate with the lateral surface of the cricoid cartilage. Upon the *outer surface* of each ala is an oblique line that divides this surface into two unequal portions. The *inner surface* of each is smooth and to it is attached the mucous membrane of the larynx. At the angle, on this medial surface, are attached, from above downward, the *epiglottis*, the *thyreoepiglottis ligament*, the *plica ventricularis*, *plica vocalis* and lastly the *thyreoepiglottic* and *thyreoarytenoideus muscles*. To the curved *upper border* is attached the *thyreohyoid membrane* and to the slightly curved *lower border* the *cricothyreoid membrane.*

The **cricoid cartilage,** or *signet ring* (*cartilago cricoidea*), is smaller but heavier and stronger than the thyreoid cartilage. It consists of the *lamina* and *arch.* The *lamina,* nearly 2.5 cm. in height, is dorsally placed and lies between the two alæ of the thyreoid cartilage; it exhibits a ridge in the midline that gives attachment to the esophagus. On each side of this line is a shallow depression for attachment of the cricoarytenoideus posterior muscle.

The *arch* constitutes the sides and front of the cartilage and is about 5 to 6 mm. in height. It gives attachment to the cricothyreoideus muscle, in front, and the inferior constrictor of the pharynx, behind. At the junction of the arch portion with the lamina on each side is a facet for articulation with the inferior cornua of the thyreoid cartilage.

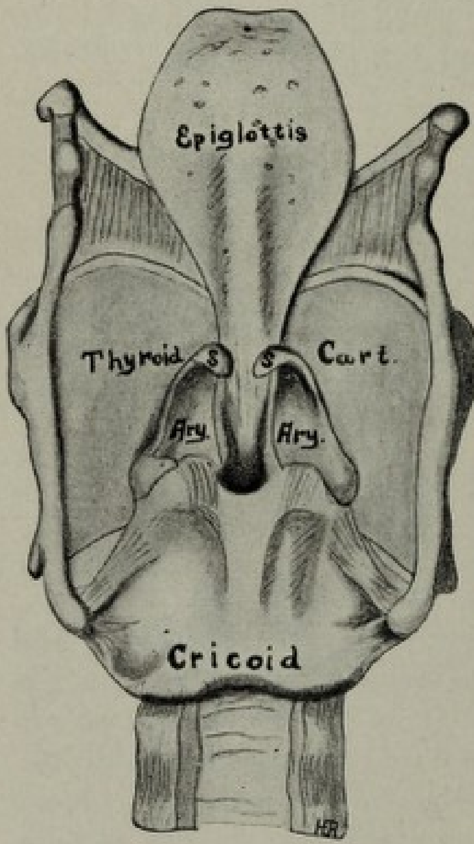


FIG. 199.—The cartilages of the larynx from a dorsal view.

The *upper border* of the cricoid cartilages gives attachment to the cricothyreoid membrane, n front and at the sides and at the side also to the cricoarytenoideus lateralis muscle. The back part presents a facet on each side of the midline for articulation with the arytenoid cartilages. The *lower border* of the cricoid cartilage is connected with the first ring of the trachea.

The **epiglottic cartilage** (*cartilago epiglottica*) is somewhat leafshaped and is attached by its lower smaller end to the alar angle (upper part) by the *thyreoepiglottic ligament.* The ventral surface is attached to the base of the tongue by the *medial* and *two lateral glossoepiglottic folds.* Two little depressions are thus produced one on each side of the medial fold and these are the *valleculæ.* The epiglottis protects the glottis of the larynx during deglutition. From the side of the epiglottis the *aryepiglottic folds* extend backward, on each side, to the arytenoid cartilage.

The **arytenoid cartilages** (*cartilagines arytenoideæ*), two in number, are small and articulate with the upper part of the cricoid cartilage. Each has the form of a three-sided pyramid, having an *apex, base* and *three small surfaces.* The *apex* is pointed and is in relation with, or may be articulated with, the corniculum laryngis. The *base* articulates with the cricoid cartilage. Two of the basal angles are important. The *lateral angle*, or *muscular process*, gives attachment to the cricoartenoideus posterior muscle. The *ventral angle*, or *vocal process*, gives attachment to the inferior thyreoarytenoid ligament, or the true vocal band. The *dorsal surface* gives attachment to the arytenoideus muscle. Upon the *ventrolateral surface* are attached the superior thyreoarytenoid ligament, or the false vocal bands and the thyreoartenoideus muscle. The *medial surface* forms the lateral boundary of the respiratory glottis.

The **cornicula larynges** (*cartilagines corniculatæ*) are two small cone-shaped cartilages that surmount the arytenoid cartilages at the dorsal end of the aryepiglottic folds.

The **cuneiform cartilages** (*cartilagines cuneiformes*) are two, long, flat structures located in the aryepiglottic fold.

Ligaments.—The larynx is connected to the hyoid bone and the trachea by the *extrinsic ligaments*. The cartilages are connected to one another by the *intrinsic ligaments*. The most important of the former is the *thyreohyoid membrane* that extends between the thyreoid cartilage and the hyoid bone. Its variation in thickness gives rise to several subsidiary ligaments. Of the *intrinsic ligaments* the most important, from a surgical standpoint, is the *cricothyreoid membrane*. This extends between the medial portion of the arch of the cricoid and the thyreoid cartilages. It is not of the same thickness throughout, thus giving rise to subsidiary ligaments. It is here that the larynx is opened in cases of obstruction of the glottis.

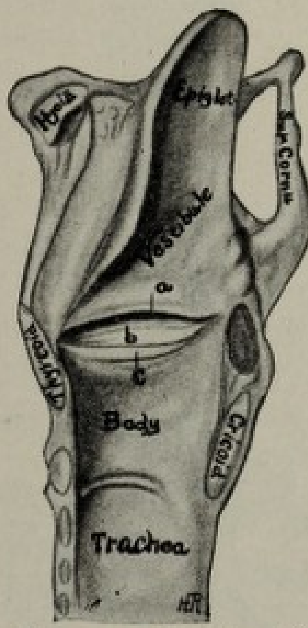


Fig. 200.—Interior of the larynx as seen from the left. *a*, Plica ventricularis; *b*, ventricle; *c*, plica vocalis.

The **interior of the larynx** (*cavum laryngis*) is lined by a mucous membrane. At the upper end of the larynx is located the *superior aperture* (*aditus laryngis*) which is triangular in outline with its base at the epiglottis and its apex at the apices of the arytenoid cartilages. The aperture extends dorsally and downward and is bounded laterally by the aryepiglottis folds. A short distance beneath the aperture are seen the vocal bands. There are two on each side; the *superior fold* is called the *false vocal band*, or *plica ventricularis* and contains the *superior thyreoarytenoid ligament*. The *inferior fold* is the *true vocal band*, or *plica vocalis* and contains the *inferior thyreoarytenoid ligament*. On each side of the larynx between each pair of folds is a depression or pouch called the *ventricle of the larynx* (*ventriculus laryngis*). An extension upward and forward from each ventricle, between the false vocal band and the thyreoid cartilage constitutes the *saccule* (*appendix ventriculi laryngis*). That part of the cavity between the true bands and the aperture is the *vestibule* of the larynx.

The **rima glottidis** is the narrow dorsoventral slit between the true vocal folds. In the male this measures about 23 mm. in length and in the female about 16 to 20 mm. The ventral three-fifths constitutes the *vocal portion* (*pars intermembranacea*) and the dorsal two-fifths is the *respiratory part* (*pars intercartilaginea*). The shape of each portion depends upon the movements of the vocal folds during respiration and phonation. The lower portion of the cavity of the larynx constitutes the *body* and this is nearly cylindrical in shape.

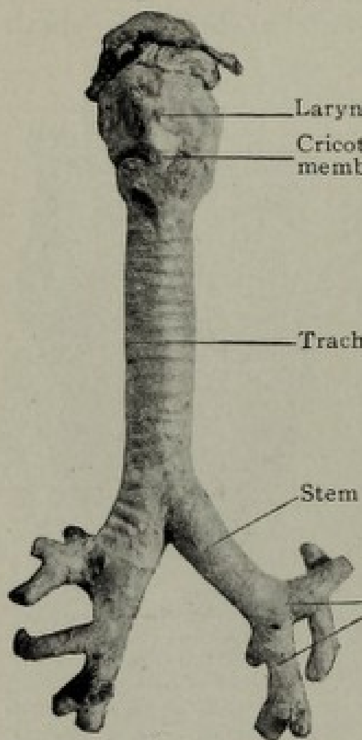


FIG. 201.—Ventral view of the larynx, trachea and bronchi. (*From a photograph.*)

The **muscles** of the larynx are *intrinsic* and *extrinsic*. The *former* serve to move the larynx up and down while the *latter* are connected with the processes of *phonation* and *respiration*. The *intrinsic muscles* are as follows:

Mm. cricothyreoidei (two) render the cords tense.
Mm. thyreoarytenoidei (two) relax the cords.
Mm. cricoarytenoidei posticus (two) open the glottis.
Mm. cricoarytenoidei lateralis (two) close the glottis.
M. arytenoideus (one).

THE TRACHEA AND BRONCHI

The trachea or windpipe, extends from the lower border of the sixth cervical vertebra to the upper border of the fifth thoracic vertebra where it divides into right and left stem bronchi. It is about 4½ inches (11 cm.) long in the male and from 3½ to 4 inches (8.75 cm.) in length in the female. It consists of two portions, *cervical* and *thoracic*. It is nearly cylindrical in shape with the dorsal part flattened. Its caliber in the living is 12.5 mm. transversely and 11 mm. dorsoventrally; in the cadaver it measures from 19 to 25 mm. transversely. Its caliber is slightly greater in the middle than at either end. It is composed of fifteen to twenty C-shaped plates of cartilage separated from one another by white fibrous tissue and mucous membrane.

The **bronchi** are two in number, *right* and *left*. That part to the first branch constitutes the *stem bronchus* and the divisions are the *branch bronchi*.

The *right stem bronchus* is about 1 inch (2.5 cm.) in length, makes an angle of about 25° with the midline of bifurcation and enters the right lung at the level of the fifth thoracic vertebra. It has a greater diameter than the left and gives off *three branches*, one for each lobe of the right lung. The first branch is called the *eparterial bronchus*.

The *left bronchus* is about 2 inches (5 cm.) in length and makes an angle of about 46° with the midline of bifurcation. It enters the lung at the level of the sixth thoracic vertebra. It gives off but *two branch bronchi*, one for each of the two lobes of the left lung. The first branch is called the *hyparterial bronchus*.

THE LUNGS AND PLEURÆ

The lungs (*pulmones*) two in number, are the real organs of respiration. They occupy the bulk of the thoracic cavity and extend into the neck; each lies in a completely closed serous sac, or space. The right lung weighs about 22 ounces and the left lung about 20 ounces in the cadaver. In the bloodless condition, after electrocution, the weights are 8½ ounces and 7½ ounces, respectively. Each lung is smooth and glistening and, at birth, of a pinkish color. In adult life it is usually mottled, becoming darker as age advances. Each lung is somewhat conical in shape and presents an *apex*, a *base*, *two surfaces* and *three borders*.

The **apex** is blunt and projects out of the thoracic cavity into the root of the neck to the extent of about 1 inch above the first rib. The medial and ventral part is grooved by the subclavian artery.

The **base,** or *diaphragmatic surface* is smooth, semilunar in shape and concave fitting upon the dome of the diaphragm on each side. The right dome of the diaphragm ascends higher than does the left so that the concavity is deeper in the right lung.

The **costal surface** is smooth and convex and may show grooves, corresponding to the ribs, in specimens hardened *in situ*. It is the most extensive surface.

The **mediastinal surface** is triangular in shape and concave for the accommodation of the heart and pericardium. A special part where the vessels, nerves, lymph vessels and bronchi enter and leave is noted and this is the *root*, or *hilus*. This surface differs in the two lungs.

In the *left lung* the concavity is deeper. The *root* (*radix pulmonis*) occupies a position a little behind and above the middle of the surface. It is outlined by the reflections of the pleura and consists of the bronchus and its branches, the pulmonary artery and veins, the bronchial artery and vein, nerves and lymphatics. In the root the order of the chief structures is, from above downward, artery, bronchus, vein. At the lower part of the root the two layers of pleura that bound the root come together, continue to the base and extend from the lung to the mediastinal pleura as a band called *ligamentum latum pulmonis*. Above the root is seen the aortic groove caused by the arch of the aorta; from this groove the subclavian groove extends upon the apex; ventral to this groove is seen another made by the left innominate vein. The aortic groove is seen extending downward along the dorsal part of this surface.

In the *right lung* the root has the same general position, appearance and structures. The order, however is different; from above

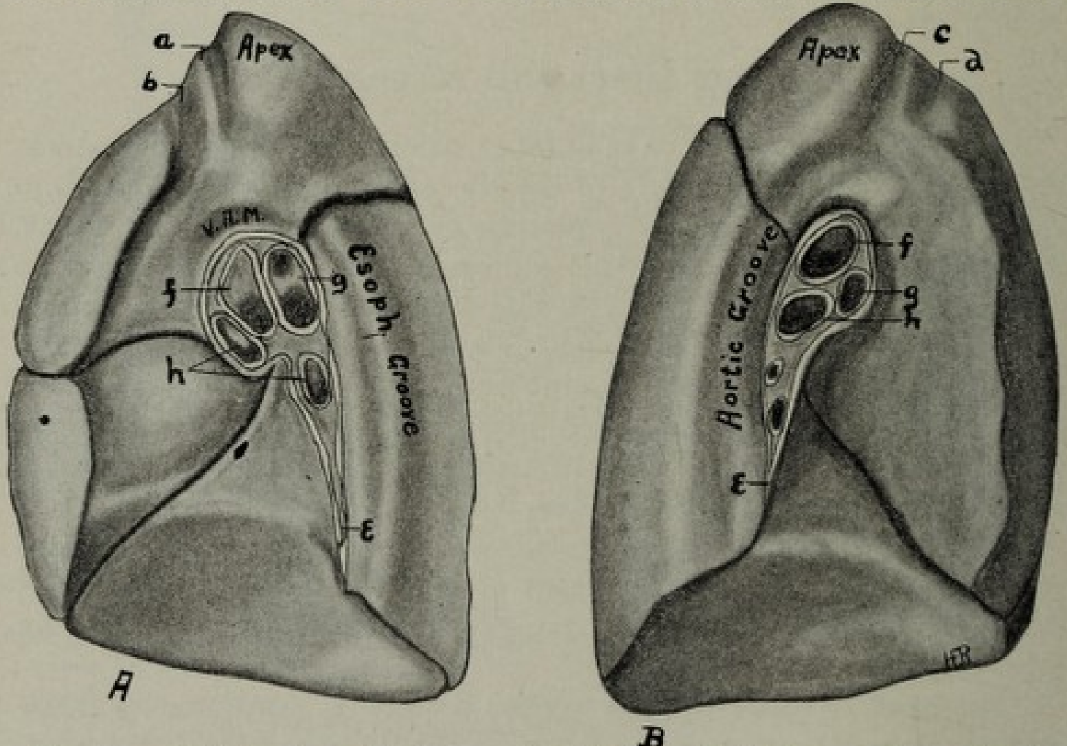


FIG. 202.—Medial surface of the lungs. *A*, Right lung; *B*, left lung. *a*, Groove for the right innominate vein; *b*, groove for the innominate artery; *c* groove for left subclavian artery; *d*, groove for left innominate vein; *e*, *e*, lig. latum pulmonis; *f*, *f*, pulmonary arteries; *g*, *g*, bronchi; *h*, *h*, pulmonary veins.

downward we find bronchus, artery and vein. The ligamentum latum pulmonis is present. Above the root is a deep groove that is formed by the vena azygos major as it hooks over the root to empty into the superior vena cava; above and passing outward is a deep groove for the superior vena cava and right innominate vein; behind the latter the innominate artery may form a groove. At the dorsal part of this surface may be a long groove formed by the esophagus.

The *borders* are *ventral*, *dorsal* and *inferior*, or *basal*. The *ventral border* is thin and sharp and upon the left lung presents a notch called the *incisura cardiaca*. The *dorsal border* is rounded, thick and rests in the deep concavity at the side of the vertebral column. The *basal border* is sharp and thin, separates the base from the other surfaces and extends into the costophrenic sinus.

The *right lung* contains *three lobes*, the upper, middle and lower and *two fissures* while the *left lung* presents *two lobes*, upper and lower separated by the *one fissure*. The lines for the fissures will be given later.

As previously mentioned each lung is in a closed serous cavity the **pleural cavity.** The serous membrane bounding this space is called the **pleura.** The pleura is divided into portions according to parts invested, as *visceral*, that investing the lung, and *parietal*, that attached to the ribs, diaphragm and pericardium, thus bounding each pleural cavity. The *visceral pleura* invests the lungs except at the root where the layers are separated by the structures entering and leaving the lung. At the lower limit of the root the layers approximate and constitute the ligamentum latum pulmonis. The visceral pleura extends into the fissures and completely separates the lobes from each other.

The *parietal pleura* consists of several subdivisions: that covering the inner surfaces of the ribs, cartilages and intercostal muscles and membranes constitutes the *costal pleura;* that upon the diaphragm is the *diaphragmatic pleura;* that toward the midline upon the pericardium constitutes the *mediastinal pleura*, while that portion that covers the apex of the lung in the neck is the *cervical pleura*. These pleural reflections forming a closed sac constitute a continuous layer of endothelium and it is possible to start at any point and return after passing over the various divisions without an interruption in the serous membrane. The surface is constantly kept moist with lymph so as to prevent friction.

As will be seen later the lungs do not extend down completely into the cleft between the diaphragm and body wall; this serous space unoccupied by lung is called the *costophrenic sinus*. It is deepest in the midaxillary line.

The **outline of the pleura** upon the body wall is as follows: From a point ½ to 1 inch (1 to 2.5 cm.) above the clavicle over the sternal end of the first rib, draw a line to the midsternal line to pass under the sternoclavicular articulation. On the *right side* continue this line down to the level of the sixth chondrosternal junction, then obliquely outward to the tenth rib, or interspace on the midaxillary line and then horizontally across to a point between the spine of the twelfth thoracic vertebra and the transverse process of the first lumbar vertebra. From this point carry a line vertically to the upper border of the third thoracic vertebra and then arch across to the apex point. The right apex is about ½ inch higher than the left apex.

On the *left side* where the apex line reaches the midsternal line continue down to the level of the junction of the fourth cartilage

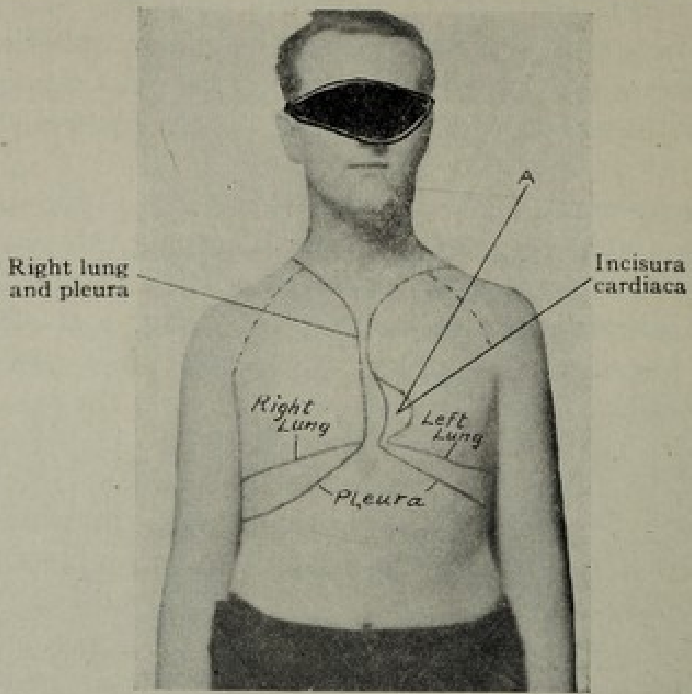


FIG. 203.—Outline of pleuræ and lungs upon the ventral thoracic wall. (*From a photograph.*) *A*, Area of superficial cardiac dullness.

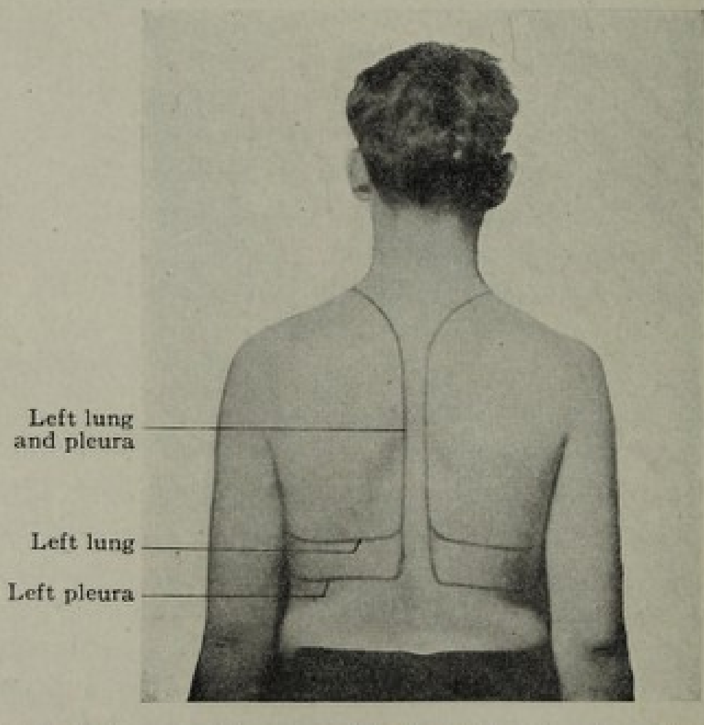


FIG. 204.—Outline of pleuræ and lungs upon the dorsal thoracic wall. (*From a photograph.*)

with the sternum then turn out to the edge of the sternum and down to the level of the sixth chondrosternal junction, then outward to the upper border of the tenth rib in the midaxillary line, thence across to a point midway between the twelfth thoracic spine and the transverse process of the first lumbar vertebra. Then continue vertically upward to the level of the upper border of the third thoracic vertebra and then arch across to the apex point.

To **outline the lungs** draw a line from the apex point to the midsternal line passing beneath the sternoclavicular articulation and just within the pleural line. On the *right side* the edge of the lung follows the pleural line to the sixth chondrosternal junction, then passes obliquely downward and outward to cross the eighth rib on the midaxillary line, then horizontally across to the level of the tenth thoracic spine and up along the vertical pleural line to the apex point. On the *left side* follow the pleural line from the apex point to the midsternal line, then down parallel to the pleural reflection to the level of the fourth chondrosternal junction, then outward in a curved line so that the deviation is about 5 cm. from the midsternal line in the fourth interspace; then curve toward the sternum for about 2.5 cm. thence downward and outward to cross the eighth rib in the midaxillary line, across to the level of the tenth thoracic spine, up parallel to the pleural line to the apex point.

To *outline the main fissure* start on the back at the level of the transverse process of the third thoracic vertebra, pass obliquely down so as to reach the lower border of the lung at the parasternal line. This separates the upper from the lower lobe. On the right side the intermediate fissure starts from the main fissure at the midaxillary line and crosses the front of the thorax practically horizontally to the junction of the fourth cartilage with the sternum. This fissure separates the upper from the middle lobe.

CHAPTER VII

THE ALIMENTARY TRACT (APPARATUS DIGESTORIUS)

The alimentary tract is a tube-like structure about 30 feet in length extending from the lips to the anus. Here the food is mechanically and chemically treated (digested) so that it is capable of absorption. The caudal portion of the apparatus receives and expels the undigestible portions of the food. In addition to the tube are various organs that lie in the wall of the tube or lie outside and are connected to the tract; these are the *accessory organs*. All of the tract caudal to the pharynx is called the *tubus digestorius*. The parts of the alimentary tract are as follows:

			Accessory organs
Mouth	Aperture		Teeth
	Vestibule		Gums
	Oral cavity proper		Tongue
			Salivary glands
			Tonsils (?)
Pharynx			
Esophagus			
Stomach			
Small intestine	Duodenum		Liver
	Jejunum		Pancreas
	Ileum		
Large intestine	Cecum and appendix		
	Colon	ascending	
		transverse	
		descending	
		sigmoid	
	Rectum		
	Anal canal		
	Anus		

THE MOUTH

The mouth comprises the *aperture, vestibule* and *oral cavity proper* and here are found the *accessory organs*, the *teeth, tongue, gums* and *oral salivary glands*.

The **aperture** (*rima oris*) is the narrow slit between the lips (labia oris). It is placed transversely and is bow-shaped. It is about 2 inches (5 cm.) in length and extends from the first premolar of one side to the corresponding premolar of the opposite side.

The **vestibule** (*vestibulum oris*) in a state of rest is a narrow, slit-like cavity that lies between the lips and cheeks (buccæ) externally,

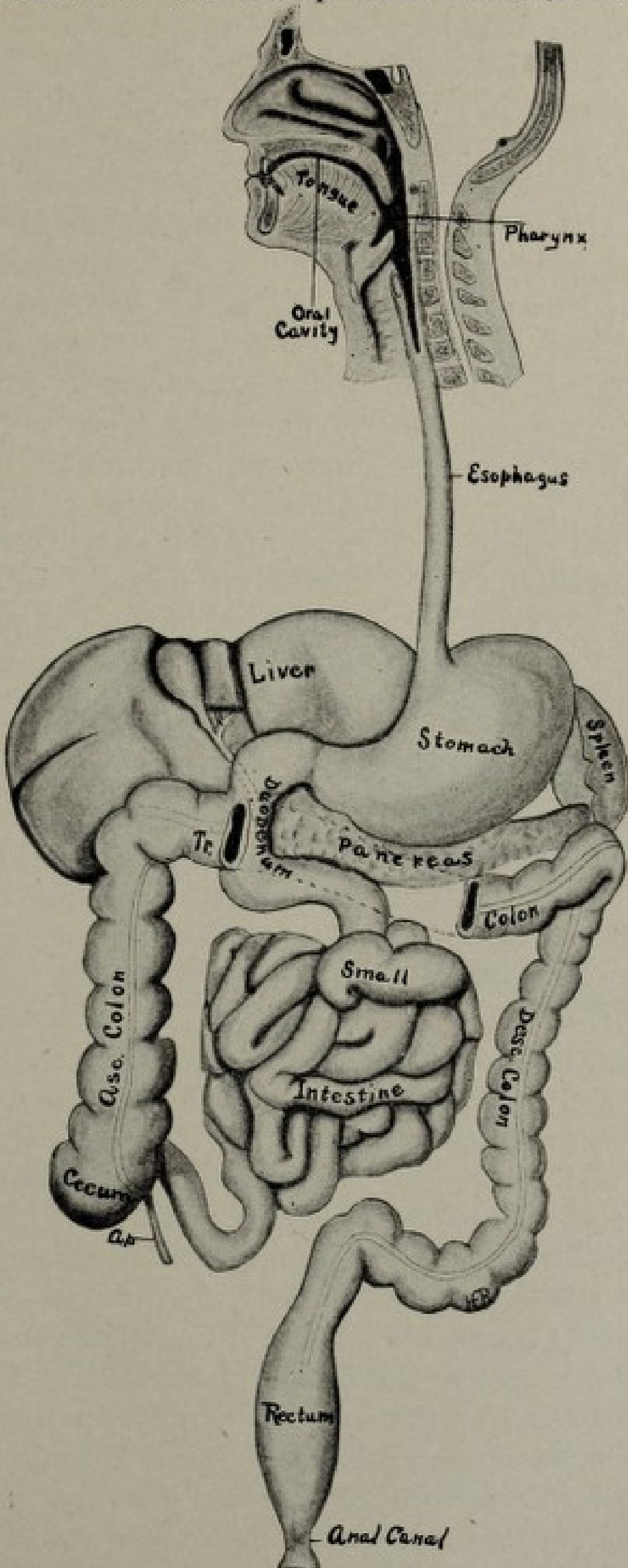


FIG. 205.—A diagram of the alimentary tract.

and the teeth and gums, internally. The **lips** bounding the aperture and vestibule consist of skin externally and mucous membrane internally. Between these lie the muscles, fat and white fibrous tissue supporting blood-vessels, nerves and lymphatics. In the mucous-membrane side lie numerous small labial salivary glands. Internally, each lip is connected to the gum by a delicate fold of mucous membrane, the *frenum;* that of the upper lip is the larger.

The **cheeks** (buccæ) consist of skin externally and mucous membrane internally. Between these lie the muscles, fat and white fibrous tissue and the buccal salivary glands, besides blood-vessels, nerves and lymphatics. In the infant, in the superficial fascia, is an encapsulated mass of fat called the *corpus adiposum buccæ,* or sucking pad. It is of great importance as it strengthens the cheek during nursing. In the adult it is less prominent.

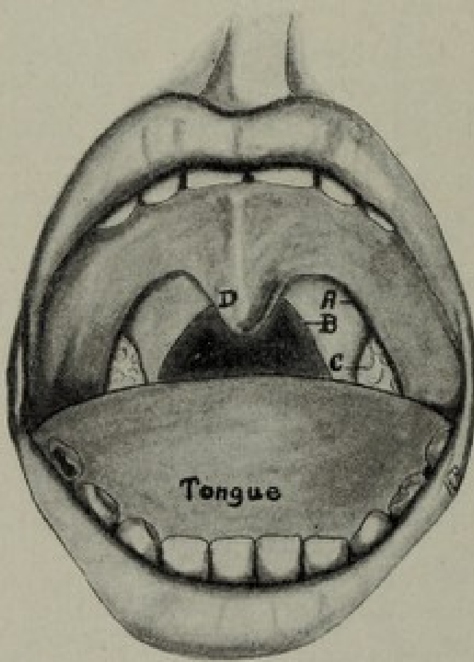


FIG. 206.—Mouth opened. *A*, Palatoglossal fold; *B*, palatopharyngeal fold; *c*, tonsil; *D*, uvula.

The **gums** (*gingivæ*) constitute the mucous membrane covering the alveolar portions of the maxillæ and mandible. They consist of a firm red tissue about 1 or 2 mm. thick. They are quite vascular, are firmly attached to the periosteum and extend about the base of the crown of each tooth in the form of a collar.

The vestibule communicates with the mouth cavity by the small spaces between the teeth and a large space behind the last molar teeth. On the inside of the cheek, opposite to the second upper molar tooth, is a papilla where the parotid duct empties its secretion into this vestibule.

The **oral cavity proper** is bounded *above* by the palate, *below* by the tongue and floor, or sublingual region and *laterally* and in *front* by the teeth and gums. The dorsal wall is wanting, constituting the communication with the pharynx.

The **palate** (*palatum*) consists of two portions, *hard* and *soft.* The *hard palate* (*palatum durum*) constitutes the ventral two-thirds of the roof and is nearly horizontal in direction. It is formed by the palatal processes of the maxillæ and the palate bones and is covered by a mucous membrane and shows a ridge in the midline called the *raphé;* some transverse folds, the *rugæ* (*plicæ palatinæ*) are seen. The soft tissues contain the palatal salivary glands.

The *soft palate* (*palatum molle*) constitutes the dorsal one-third of the roof and it slopes downward (caudad) and backward. The dorsal free edge consists of two lateral arches produced by the downward projecting, cone-like process of the middle of the soft palate called the *uvula*. This part varies in length in different individuals. The ventral edge of the soft palate is attached to the hard palate the upper and lower surfaces are covered by mucous membranes that become continuous at the free edge. Between these mucous membranes lie the *palatal aponeurosis* (attached to the hard palate) and the *muscles* of the palate (in the posterior two-thirds of the soft palate). Extending downward from the palate, are two folds on each side, the *arches*, that will be described later.

The *muscles* of the soft palate are the *mm. tensor veli palatini, levator veli palatini, glossopalatinus, pharyngopalatinus* and *uvulæ*, all paired.

The *blood supply* of the palate is from the descending palatine branch of the internal maxillary artery, the ascending palatine artery and branches from the ascending pharyngeal and dorsalis linguæ arteries.

The *sensor nerves* are from the sphenopalatine ganglion. These are the anterior, middle and posterior palatine nerves; the *motor nerves* for all muscles, except the tensor veli palatini, come from the spinal accessory nerve through the pharyngeal plexus. The tensor veli palatini is supplied by the motor portion of the trigeminal nerve through the otic ganglion.

The **floor of the mouth** consists of the tongue and the sublingual region. The *sublingual region*, or true floor, consists of the tissues between the anterior part of the base of the tongue and the mandible. Connecting the tongue to the floor in the midline is a small fold of mucous membrane, the *frenulum linguæ*. On each side of this fold is a little papilla (*caruncula sublingualis*) in which is the orifice of the submaxillary duct.

Extending from the papilla on each side is a fold of mucous membrane, the *plica sublingualis*, in which are seen numerous openings representing the orifices of the sublingual ducts.

The **teeth** (*dentes*) are the organs of mastication. During life there are two sets, *temporary* and *permanent*. The *temporary*, or *deciduous* teeth (*dentes decidui*), are twenty in number and begin to erupt about the sixth or seventh month and are all present at about the twenty-fourth to the thirtieth month. In each jaw are found *central incisors* (two), *lateral incisors* (two), *canines* (two) and *molars* (four). In the *permanent set* (*dentes permanentes*) there are thirty-two teeth. In each jaw are found *two central incisors, two lateral incisors, two canines, four premolars* and *six molars*. These teeth begin to erupt at about the sixth year and all are present at about the twenty-first to the twenty-fifth year.

Each **tooth** consists of a *central cavity* (*cavum dentis*) surrounded by the *dentin* (*substantia eburnea*) that gives the form to and constitutes the bulk of the tooth. That portion of the tooth projecting beyond the line of the alveolar socket of the jaw is the *crown* (*corona dentis*) and is covered by the *enamel* (*substantia adamantina*); that portion covered by the gum is the *neck* (*collum dentis*) while that part

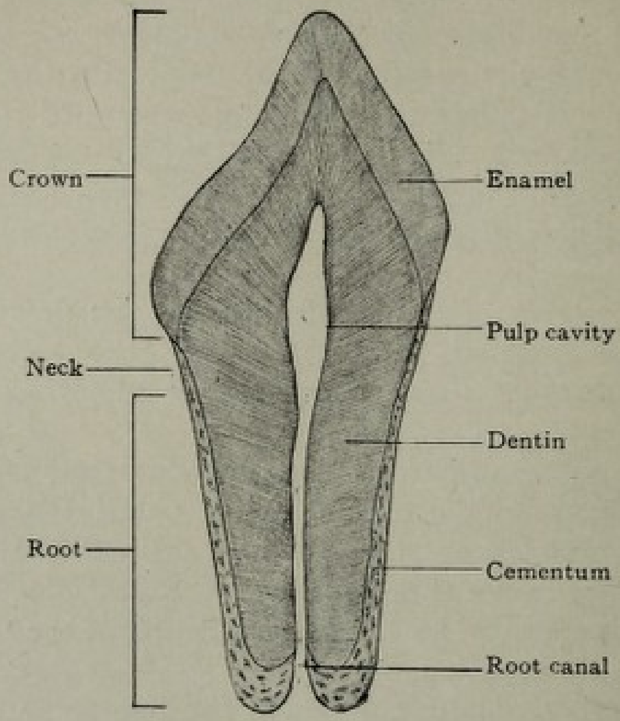


FIG. 207.—Vertical section of a canine tooth.

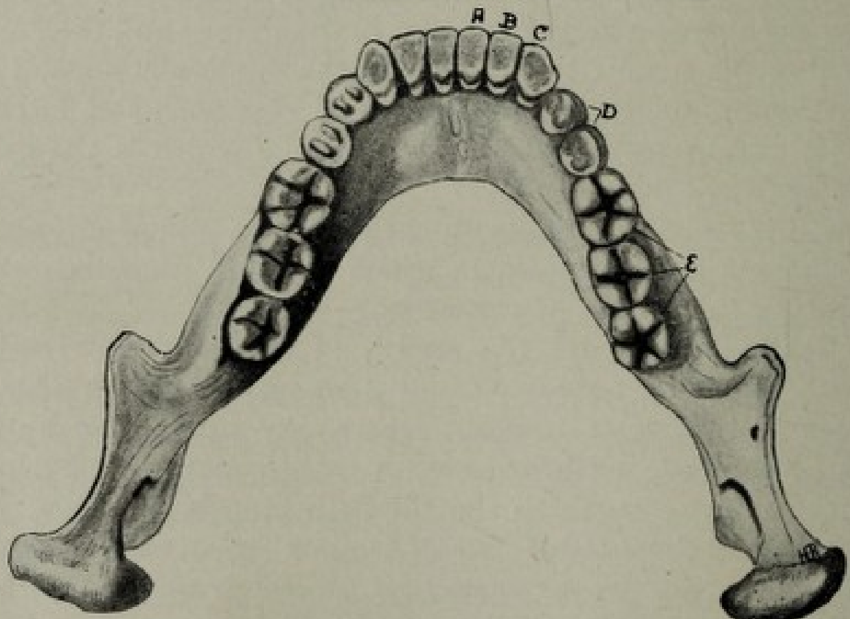


FIG. 208.—Mandible with the permanent teeth. *A*, Central incisor; *B*, lateral incisor. *C*, canine; *D*, premolar; *E*, molar teeth.

within the alveolar process constitutes the *root* (*radix dentis*). The root is held in the alveolar socket by the *peridental membrane* (*periosteum alveolare*). At the apex of the root is an opening (*foramen apicis*) that leads into the *root canal* (*canalis radicis*) that terminates in the pulp cavity (*cavum dentis*). The latter is occupied by the *tooth pulp* (*pulpa dentis*). The part of the tooth that opposes that of the other jaw is called the *facies masticatoria*.

The *incisors* (*dentes incisivi*) are chisel-like teeth and those of the upper jaw are larger and stronger than those of the mandible. The root of each tooth is flattened laterally.

The *canines* (*dentes canini*) are pointed, or conical in shape and are stronger than the incisors. They represent the holding and tearing teeth of the lower animals. The root of each is nearly conical and longer than that of the incisor tooth.

The *premolars* (*dentes premolares*) exhibit two little projections or *cusps* upon the crown the latter being more massive than in the preceding teeth. The root of each tooth is usually single and flattened from side to side.

The *molars* (*dentes molares*) are the most massive teeth; the crowns are cuboidal and the cusps three to five in number. Each upper tooth possesses three roots while each lower but two roots. The third molar, or wisdom tooth, is called the *dens serotinus*.

In the normal condition the teeth form an arch in each jaw the *dental arch* (*arcus dentalis*). The upper is slightly the larger and therefore slightly overlaps the lower arch.

The **tongue** (*lingua*) is the most mobile organ in the body. It has the following important functions: *Mastication*, *insalivation*, *deglutition*, *taste* and *speech*. In order to get the proper shape and dimensions of the tongue it must be hardened *in situ*. It is about 9 cm. (3½ inches) in length and lies in the oral cavity proper and oropharynx. It consists of *apex*, *base*, *dorsum*, *inferior surface* and *margin*.

The *apex*, or *tip* (*apex linguæ*) is the free extremity and is usually narrow and thin, resting against the incisor teeth.

The *base*, or *root* (*radix linguæ*) is the attached portion and is broad and massive. It is directed downward (caudad) and backward and is attached to the hyoid bone, mandible and floor of the mouth.

The *dorsum* (*dorsum linguæ*) consists of two parts, the anterior, or apical two-thirds and posterior, or basal one-third. The *apical* two-thirds, or *oral part*, is nearly horizontal and slightly arched from before backward and from side to side. It may show a slight median, longitudinal groove (*sulcus medianis*) that ends posteriorly in the *foramen cecum*. The apical two-thirds is separated from the basal one-third by a slight V-shaped groove, the *sulcus terminalis*, the apex of which is the foramen cecum. In front of the sulcus is a V-shaped collection of papillæ, eight to ten in number, below the surface, called the *vallate papillæ*. These contain the *taste-buds*. Scattered over the dorsum are smaller, conical projections, the *filliform papillæ;* a third variety, the *fungiform papillæ* are less numerous than the filliform and are found chiefly at the sides and apex.

The *basal one-third*, or *pharyngeal part* of the tongue, is nearly vertical in direction. Papillæ are not found here but rounded elevations, that represent masses of lymphoid tissue below the mucosa, are present. These constitute the *lingual tonsil* (*tonsilla lingualis*).

The dorsum of the base is connected to the epiglottis by three folds, *two lateral* (*plicæ pharyngoepiglotticæ*) and *one median* (*plica glossoepiglottica*), the *glossoepiglottic folds*. Between the median and each lateral fold a little fossa is formed, the *vallecula*.

The *inferior surface* (*fascies inferior*) of the tongue is not extensive. Here is seen a part of the frenulum linguæ and upon each side of

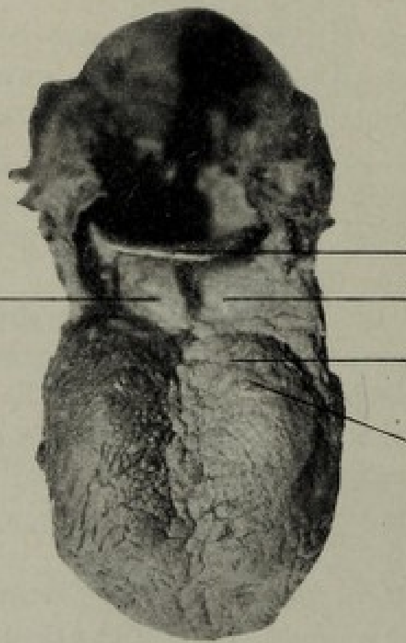


FIG. 209.—Dorsum of the tongue and its connection with the epiglottis. (*From a photograph.*)

this a slight fold of mucous membrane, the *plica fimbriata*. Near the tip there may be a slight elevation that indicates the presence of the *apical gland*.

The *margin* (*margo lateralis*) of the tongue is free in front of the anterior arches of the fauces and separates the dorsum from the inferior surface. The tongue is covered by a mucous membrane. The bulk of the organ consists of voluntary striated muscle tissue. The muscles comprise two sets, the *intrinsic* and the *extrinsic*. The *intrinsic muscles* are the *superior* and *inferior longitudinal*, the *transverse* and the *vertical lingual muscles*. The *extrinsic* are the *hyoglossus*, *genioglossus*, *glossopalatinus*, *styloglossus* and *chondroglossus*. In the tongue are numerous small glands, the *lingual salivary glands* (*glandulæ linguales*).

The *arteries* are the lingual, external maxillary and ascending pharyngeal. The *nerves* are the hypoglossal, glossopharyngeal, chorda tympani, the lingual branch of the mandibular division of the trigeminal and the internal laryngeal branch of the vagus.

The **principal oral salivary glands** (*glandulæ salivares*) are *six* in number, *two parotid*, *two submaxillary* and *two sublingual*.

The **parotid gland** (*glandula parotis*) is the largest and weighs from 20 to 30 grams. It lies upon the side of the face and chiefly in front of the ear. It is bounded *above* by the zygomatic arch, *below* by the angle of the mandible and a line extending back to the mastoid

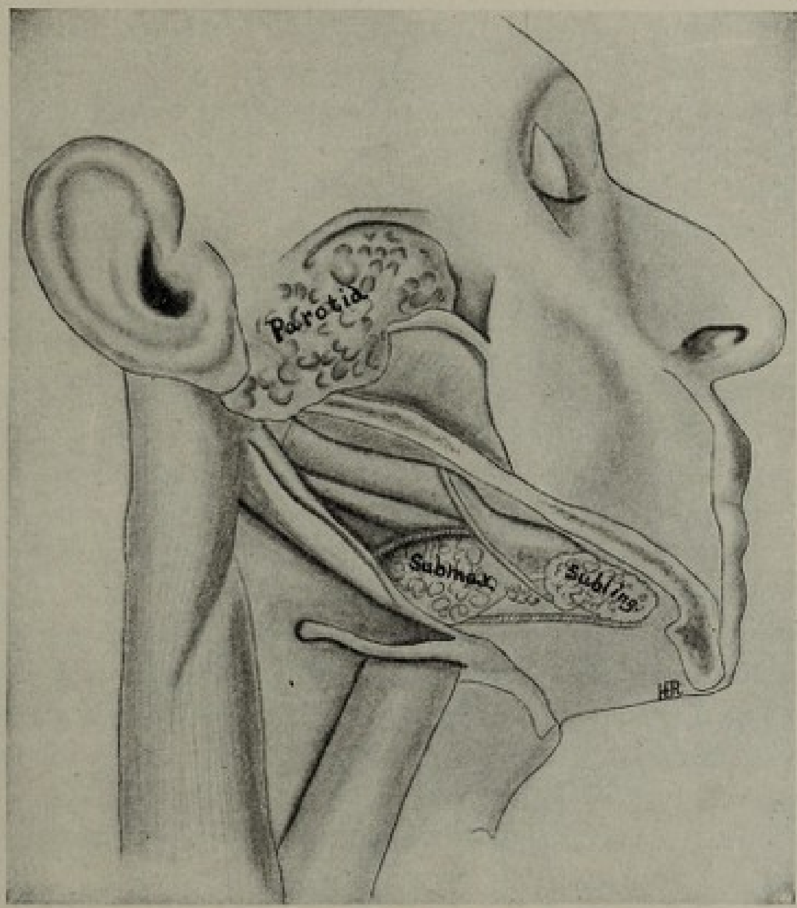


FIG. 210.—The oral salivary glands in their normal positions.

process. In *front* it extends a little distance over the masseter muscle, *behind* to the external auditory canal and sternomastoid muscle. The deepest and thickest part is wedge-shaped and in close relation with the great vessels of the neck. This constitutes the *processus retromandibularis* and occupies the so-called parotid fossa. Within the gland are important vessels and the facial nerve and its branches.

The **parotid duct** (*ductus parotideus*) extends from the upper anterior part of the gland, is 5 to 6 cm. in length and empties into the vestibule opposite the second upper molar tooth. This duct corresponds approximately to the middle third of a line drawn from the lower margin of the external auditory meatus to the middle of the upper lip.

The *blood supply* of the *parotid gland* consists of branches from the external carotid artery and other arteries in relation with the gland.

The *nerves* are from the great auricular, facial, auriculotemporal (from otic ganglion) nerves and the external carotid plexus of the sympathetic system (the latter are chiefly vasomotor).

The **submaxillary gland** (*glandula submaxillaris*) weighs 8 to 10 grams and is located under the middle of the body of the mandible in the submaxillary triangle. A process of the gland usually extend forward and medially.

The *submaxillary duct* (*ductus submaxillaris*) is about 5 cm. long and empties into the oral cavity at the side of the frenum linguæ at the apex of the caruncula sublingualis.

The submaxillary gland receives its *blood supply* from the external maxillary artery. The *nerves* are from the chorda tympani and the lingual nerves, from the submaxillary ganglion and the external maxillary plexus.

The **sublingual gland** (*glandula sublingualis,*) 3 to 4 grams in weight, is a collection of glands in the floor of the oral cavity upon each side of the frenum. They form a mass from 35 to 45 mm. in length. The *ducts* (*ducti sublinguales minores*) may be fifteen to twenty in number upon each side and empty into the oral cavity on the plica sublingualis.

The *blood supply* of the *sublingual glands* consists of the sublingual (from the lingual), the submental (from the external maxillary) arteries. The *nerves* are derived from the lingual and chorda tympani nerves through the submaxillary ganglion and from the external maxillary plexus.

In the mouth cavity the processes of digestion that take place are mastication and insalivation.

The **pharynx** is somewhat funnel-shaped but flattened from before backward. It extends from the base of the skull to the sixth cervical vertebra, behind, and the cricoid cartilage, in front. It is 5 to 5½ inches (12.5 to 14 cm.) in length and widest in the upper part behind the orifices of the auditory tubes. The *nasopharynx* is about 3 cm. long, the *oropharynx* 5 cm. and the *laryngopharynx* about 7 cm. long. From the incisor teeth to the esophagus is about 5½ to 6½ inches. Dorsoventrally the nasopharynx is 15 to 18 mm., from the septum of the nose to the dorsal wall; from the glossopalatal arches to the dorsal wall about 10 mm.; below this the wall approach each other. The transverse dimension at the lateral recesses is 35 mm.; opposite the middle of the soft palate 25 mm.; opposite the inferior margin of the laryngeal opening 45 mm.; below this it narrows to the esophagus.

The pharynx is attached from above downward to the pharyngeal spine, basioccipital, petrous portion of the temporal bone, auditory tube, internal pterygoid plate, pterygomaxillary ligament, mylohyoid ridge, mucous membrane of the mouth, base of the tongue, hyoid

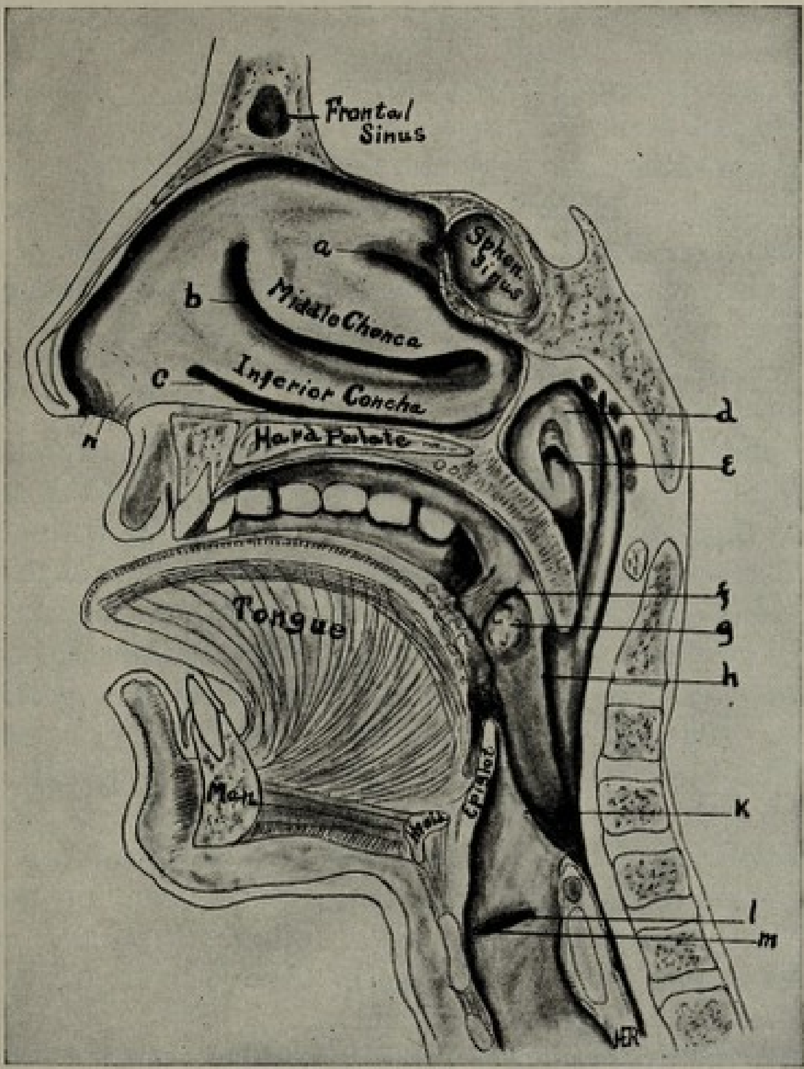


FIG. 211.—Median sagittal section through the head and neck. *a*, Superior meatus of the nose; *b*, middle meatus of the nose; *c*, inferior meatus of the nose; *d*, torus tubarius (eustachian cushion); *e*, orifice of auditory tube; *f*, palatoglossal fold; *g*, tonsil; *h*, palatopharyngeal fold; *k*, aryepiglottic fold; *e*, ventricle of the larynx; *m*, vocal cord; *n*, vestibule of nose.

bone and thyreoid and cricoid cartilages of the larynx and below it becomes continuous with the esophagus.

The *pharynx* is divided into the *nasopharynx*, *oropharynx* and *laryngopharynx*.

The **nasopharynx** (*pars nasalis*) extends from the base of the skull to the dorsal border of the soft palate. It lies behind the nasal cavities and is an accessory portion of the respiratory system. Its *ventral wall* is wanting and here are seen the two choanæ. Upon each *lateral wall* are several points of interest. Here is seen the pharyngeal orifice of the *auditory tube* (*tuba auditiva*) bounded by a hook-shaped prominence, the *torus tubarius*, which is open below. The anterior limb of the cushion continues to the soft palate and is called the *salpingopalatal fold* (*plica salpingopalatina*). The posterior limb is the longer and continues down the pharynx wall and constitutes the *salpingopharyngeal fold* (*plica salpingopharyngea*). Behind the cushion is quite a deep recess called the *lateral recess of the pharynx* (*recessus pharyngeus*). In the middle of the roof is a small recess called the *pharyngeal bursa* (*bursa pharyngea*). In the dorsal wall are collections of lymphoid tissue, the *pharyngeal tonsils*. In infancy and childhood these masses frequently hypertrophy constituting adenoids.

The *floor* is formed by the sloping soft palate the dorsal border of which almost touches the dorsal wall of the pharynx. The narrow space intervening is called the *isthmus of the pharynx* (*isthmus pharyngonasalis*).

The **oropharynx** (*pars oralis*) extends from the lower border of the soft palate to the level of the hyoid bone. The *ventral wall* is partly wanting representing the communication with the oral cavity. The remainder of the wall is made by the base of the tongue. Here are seen the glossoepiglottic folds and the valleculæ. Upon each *lateral wall* are seen two folds that start at the soft palate and diverge, the *anterior* passing to the tongue as the *glossopalatine fold* (*arcus glossopalatinus*) which contains the *glossopalatinus muscle*. The *posterior* extends for some distance upon the lateral pharyngeal wall and is called the *pharyngopalatine fold* (*arcus pharyngopalatinus*) which contains the *pharyngopalatinus muscle*. The wedge-shaped area between these folds extending across the cavity constitutes the *isthmus of the fauces* (*isthmus faucium*). In this area is seen the *tonsil* (*palatal*). Above the tonsil is the *supratonsillar fossa* (*fossa supratonsillaris*).

The **tonsils** (*tonsillæ palatinæ*) are situated between the above folds. Each is about 1 inch (2 to 2.5 cm.) long, ¾ inch (18mm.) wide and ½ inch (12 to 15 mm.) thick. Its pharyngeal surface is covered by mucous membrane and exhibits a number of pits, or crypts (twelve to fifteen in number).

The tonsil is not concerned in the process of digestion but belongs to the great group of lymphatic organs. Its *arteries* are derived from the ascending palatine and tonsillar branches of the external maxillary artery; the dorsalis linguæ of the lingual and the ascending pharyngeal of the external carotid artery. Its *nerves* are from the glossopharyngeal and the pharyngeal plexus.

The **laryngopharynx** (*pars laryngea*) extends from the hyoid bone to the cricoid cartilage, or to the level of the sixth cervical vertebra, behind. Here are seen the opening into the larynx, in *front*, and the opening into the esophagus, *behind*. The epiglottis is seen here as well as the *recessus pyriformis*. Each *recess* lies at the side of the laryngeal aperture and is bounded laterally by the thyreoid cartilage and medially by the aryepiglottic fold.

The pharynx has *seven communications;* two nasal, two auditory tubes, one oral, one laryngeal and one esophageal.

The *muscles of the pharynx* are the *superior*, *middle* and *inferior constrictors*, the *stylopharyngeus* and the *pharyngopalatinus*.

The *blood supply* of the *pharynx* is from the ascending pharyngeal, the ascending palatine (from the external maxillary) descending palatine (from the internal maxillary) dorsalis linguæ and pterygopalatine (from the internal maxillary). The *nerves* are from the pharyngeal plexus of the vagæ, glossopharyngeal and sympathetic nerves.

THE ESOPHAGUS

The esophagus (Fig. 205) is the narrowest part of the alimentary tract and extends from the sixth cervical vertebra to the eleventh thoracic vertebra. It is about 10 inches (25 cm.) long and consists of cervical, thoracic and abdominal portions. Its diameter varies, its widest part being about ½ inch (12 mm.), in the resting condition, and then its ventral and dorsal walls are in contact. Distended, it measures 25 to 30 mm. It is not quite vertical, deviating in certain regions from the midline.

The *blood supply of the esophagus* is derived from the inferior thyroid, descending thoracic aorta, bronchial, left gastric and inferior phrenic arteries. The *nerves* are derived from the vagi and the sympathetic system.

THE ABDOMEN

The abdomen comprises the largest portion of the trunk. In the *male* it is somewhat barrel-shaped and flattened from before backward. In the *female* it has the shape of a flattened, truncated cone. In the midline the ventral wall is only 2½ to 3 inches from the vertebral column.

The abdomen represents the largest serous cavity of the body and consists of *two divisions*, the *abdominal cavity proper* and the *pelvic cavity*. The abdominal cavity proper is bounded *above* by the diaphragm and *below* is continuous with pelvic cavity. *Dorsally* it is bounded by the lumbar vertebræ and iliac bones, *laterally* by the muscles, fasciæ and skin and *ventrally* by muscles, fasciæ and skin. The upper part of the abdominal cavity is under cover of the ribs due to the doming of the diaphragm.

The **pelvic cavity** is bounded *dorsally* by the sacrum and coccyx, *laterally* by the body of the ischium and part of the ilium, *ventrally* by the symphysis pubis. It has an *inlet* that gives communication with the thoracic cavity and its boundaries are as follows: *Dorsally* the margin of the base of the sacrum, *laterally* the iliopectineal lines, *ventrally* the crests of the pubic bones. It slants downward and forward and is heart-shaped. The *outlet* is irregular and is bounded *dorsally* by the tip of the coccyx, *laterally* by the tuberosities of the ischia and *ventrally* by the pubic arches and symphysis. It slants slightly downward and forward. This is not a true aperture but is closed in by the pelvic diaphragm consisting mainly of the levatores ani and the ischiococcygei muscles and pelvic fascia. This diaphragm is pierced by the anal canal, in the male, and the anal canal and the vagina in the female.

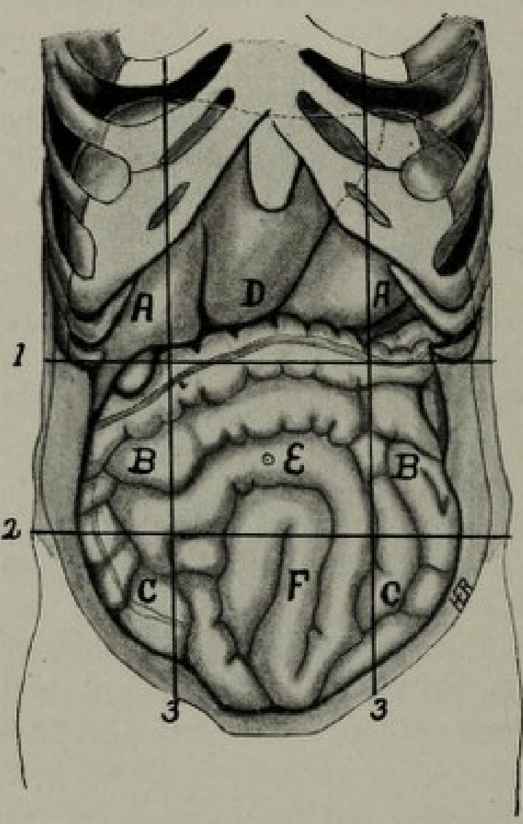


FIG. 212.—Lines and regions of the abdomen and the viscera in each. 1, Subcostal line; 2, intertubercular line; 3, 3, midinguinal lines; *A*, *A*, right and left hypochondriac regions; *B*, *B*, right and left lumbar regions; *C*, *C*, right and left inguinal regions; *D*, epigastric region; *E*, umbilical region; *F*, hypogastric region.

In the female the pelvis is more delicate, wider and shallower than in the male. The inlet is larger, the sacrum shorter and less curved, the outlet larger and the coccyx more movable, the pubic arch larger and less angular.

The **apertures of the abdominal** walls are the three openings in the diaphragm, the openings in the pelvic floor for the rectum the urethra and in the female the vagina; the inguinal canal for the spermatic cord in the male, or the round ligament in the female, and the crural or femoral canal that leads into the thigh.

The abdomen is divided into **nine regions** by four lines or planes, *two horizontal* and *two vertical*. A line drawn about the trunk at the lower border of the tenth costal cartilage and the superior part of third lumbar vertebra is called the *subcostal line*. A second line drawn at the level of the highest points of the iliac crests and through the middle of the fifth lumbar vertebra is the *intertubercular line*. The *two vertical lines* are drawn parallel to the long axis of the body from the midpoint of the inguinal ligament (one on each side). The three transverse zones formed by the horizontal lines are the costal, the umbilical and the hypogastric. The two vertical lines divide these zones into nine regions. In the costal zone the regions are *right hypochondriac*, *epigastric* and *left hypochondriac*. In the umbilical zone they are *right lumbar*, *umbilical* and *left lumbar regions*. In the hypogastric zone lie the *right iliac*, *hypogastric* and *left iliac regions*.

A horizontal line drawn about the trunk at a point midway between the superior border of the crest of the pubis and the inferior margin of the sternum and at the level of the first lumbar vertebra, behind, is the *transpyloric line*.

The **contents** of the abdomen are the stomach, intestines, liver, pancreas, spleen, kidneys, ureters, bladder, adrenals, seminal vesicles, prostate and vasa deferentia (in the male) and the ovaries, oviducts,

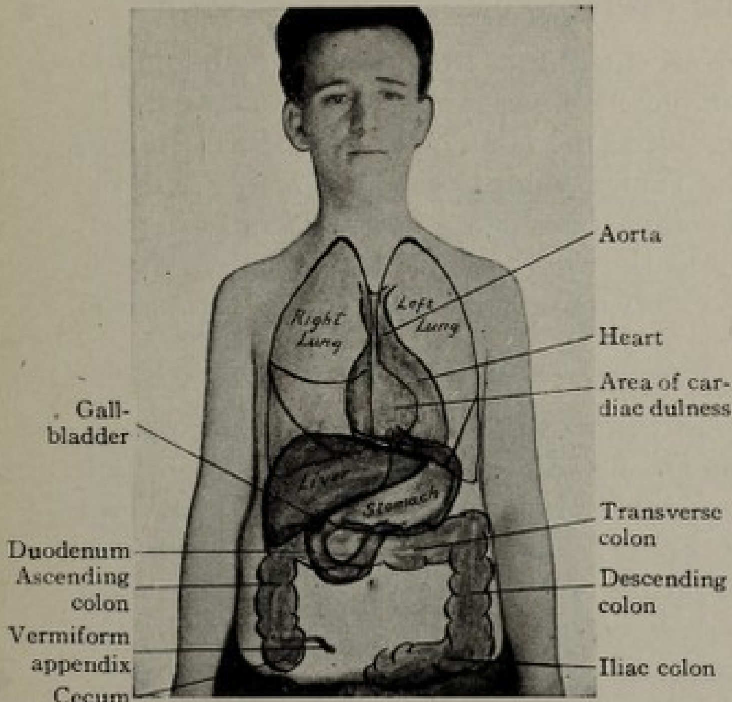


FIG. 213.—Outline of some of the organsof the thorax and abdomen, on the ventral body wall. (*From a photograph.*)

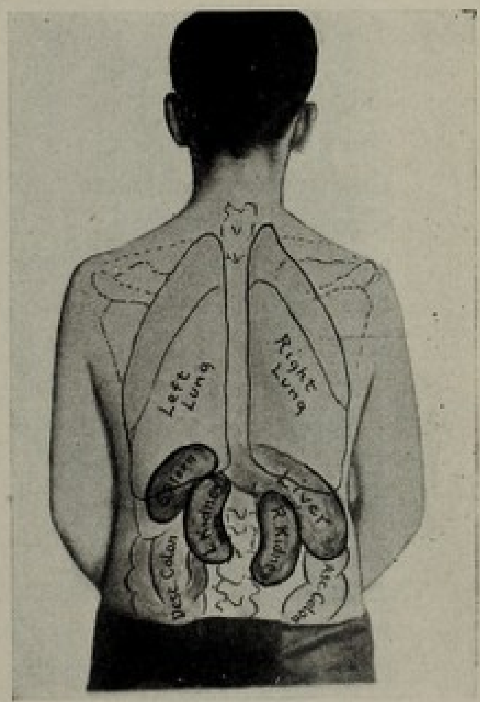


FIG. 214.—Outline of some of the organs of the thorax and abdomen, on the dorsal body wall. (*From a photograph.*)

uterus and vagina (in the female) nerves, sympathetic ganglia, blood-vessels, lymph channels and lymph nodes. These are located in the various regions as follows:

Right Hypochondrium.—Right lobe of the liver, gall-bladder, duodenum, hepatic flexure of the colon and the upper part of the right kidney.

Epigastrium.—Part of right and left lobes of the liver, the pylorus and bulk of the stomach, aorta, celiac axis, celiac ganglia and pancreas.

Left Hypochondrium.—Spleen, tail of the pancreas, splenic flexure of the colon, upper part of left kidney and the left portion of the greater curvature of the stomach.

Right Lumbar Region.—Liver, part of the right kidney, coils of the small intestine and ascending colon.

Umbilical Region.—The transverse colon, the greater curvature of the stomach, coils of the small intestine, the mesentery and great omentum.

Left Lumbar Region.—Lower part of the left kidney, descending colon and coils of the small intestine.

Right Iliac Region.—Cecum, appendix, ileocecal junction and right ureter.

Hypogastric Region.—Coils of the small intestine, fundus of bladder (when distended) uterus (during pregnancy).

Left Iliac Region.—Descending colon and left ureter.

THE PERITONEUM

The peritoneum is a serous membrane that lines the abdominal cavity and more or less completely invests the various organs. In the male this is a closed sac, but in the female the oviducts open into the peritoneal cavity. The tunica vaginalis of the testes and the serous lining of the scrotal compartments are derived from the peritoneum. That portion lining the walls of the peritoneal cavity is the *peritoneum parietale* and that upon the organs is the *peritoneum viscerale.*

Peritoneal folds are of three kinds:

1. **Omenta,** those folds that connect the stomach to other organs. These are the *gastrocolic,* or *great omentum* (*omentum majus*), which extends from the greater curvature of the stomach to the transverse colon. The *gastrohepatic,* or *lesser omentum* (*omentum minus*), extends from the lesser curvature of the stomach to the transverse fissure of the liver. The *gastrosplenic omentum* extends from the greater curvature of the stomach to the spleen.

2. **Mesenteries** that connect parts of the intestine to the dorsal body wall. These are the *mesentery proper* (*mesenterium*) comprising the mesojejunum and mesoileum, the transverse mesocolon (*mesocolon transversum*) mesosigmoid (*mesocolon pelvinum*) and mesoappendix.

3. **Ligaments,** folds of peritoneum that connect organs other than the gastrointestinal tract to the body wall. These are the falciform, the right and left lateral ligaments of the liver, broad ligament of the uterus, false ligaments of the bladder, etc.

Owing to the peculiarity in development of the greater and lesser omenta of the stomach a portion of the general peritoneal cavity, the *lesser sac* (*bursa omentalis*) is cut off from the remainder which then constitutes the greater sac. These two sacs communicate with each other underneath the liver through the *foramen of Winslow* (*foramen epiploicum*).

The **lesser sac** is bounded by two layers of peritoneum, *ventral* and *dorsal*. The *ventral layer* invests the caudate lobe of the liver and continues to the dorsal edge of the portal fissure and from here, and from the fissure for the ligamentum venosum it passes to the lesser curvature of the stomach as the dorsal layer of the gastrohepatic omentum. It invests about the entire dorsoinferior surface of the stomach, being continued as the dorsal layer of the great omentum to the lower border of this fold where it becomes continuous with the dorsal layer of the lesser sac. From the upper part of the greater curvature of the stomach it continues to the spleen as the dorsal layer of the gastrosplenic omentum.

The *dorsal layer* of the lesser sac passes from the foramen of Winslow over the inferior vena cava and the celiac axis, covers a small area of the diaphragm behind the caudate lobe, thence passing to the left, it covers the upper surface of the pancreas, the left adrenal and superior pole of the left kidney and part of the gastric area of the spleen. From the pancreas it continues as the ventral layer of the transverse mesocolon, over the colon and from this region it continues as the ventral layer of the dorsal fold of the great omentum to its lower border, where it becomes continuous with the dorsal layer of the ventral fold previously described.

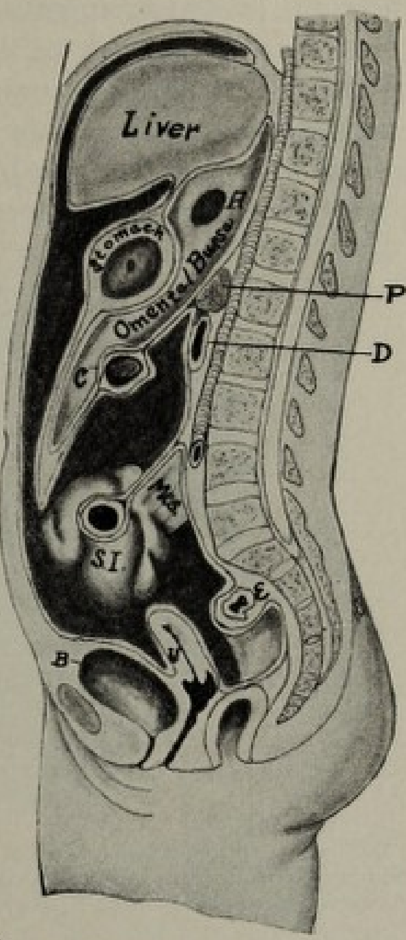


FIG. 215.—Medial sagittal section of female showing the reflections of the peritoneum (digrammatic). *A*, Foramen epiploicum; *B*, bladder; *C*, transverse colon; *D*, duodenum; *E*, rectum; *Mes*, mesentery; *P*, pancreas; *SI*, small intestine; *U*, uterus.

The **greater sac** constitutes the bulk of the peritoneal cavity. The *ventral layer* starts at the uncovered area of the liver (upper margin) and continues on to the under surface of the diaphragm down the ventral body wall to the pelvis. From the umbilical region a fold attached to the ventral body wall and the under surface of the diaphragm is reflected upon the ventral and superior surface of the liver as the falciform ligament of the liver. In the free edge of this fold is the round ligament of the liver.

The *dorsal layer* starts at the upper margin of the uncovered area of the liver, forming here the upper leaflet of the coronary ligament; it invests the superior, right and ventral surfaces of the right and left lobes and passes to the inferior surface at the ventral margin of the liver. Here it passes backward and upward over the right and left lobes to the portal fissure while lateral to this fissure the peritoneum spreads upon the remainder of the inferior surface (except the caudate lobe and the inferior vena cava) to the lower margin of the uncovered area forming here the lower leaflet of the coronary ligament; upon the left it continues to the diaphragm as part of the left lateral ligament and upon the right side as part of the right lateral ligament. The portion extending to the left covers the dorsal abdominal wall lying ventral to the outer and upper part of the left kidney and extending from here to the spleen as the lienorenal ligament. This layer then passes around and invests the spleen covering the renal, colic and part of the gastric areas continues to the greater curvature of the stomach as the ventral layer

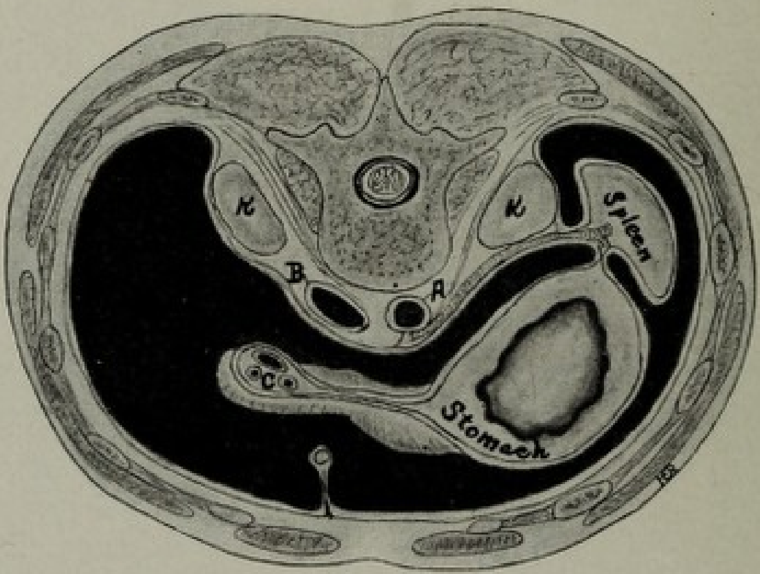


FIG. 216.—Transverse section of the abdomen, at the level of the foramen epiploicum, showing the reflections of the peritoneum (diagrammatic). *A*, Aorta; *B*, inferior vena cava; *C*, gastrohepatic omentum; *K*, *K*, kidneys.

of the gastrosplenic omentum. Upon the right side the peritoneum passes upon the diaphragm as far to the left as the esophagus, forming here the fold called the gastrophrenic ligament. It also continues downward over the right adrenal and kidney, to the duodenum and hepatic flexure of the colon, both of which it partially invests. From the portal fissure the dorsal layer of the greater sac continues down to the lesser curvature of the stomach as the ventral layer of the gastrohepatic omentum; from the lesser curvature it invests the superior surface of the stomach and the greater curvature, from which it is continuous with the ventral layer of the ventral fold of the great omentum to the lower border of that fold. From the lower border of the great omentum it continues upward to the transverse colon as the dorsal layer of the dorsal fold of the great omentum and from the colon up to the dorsal body wall it forms the dorsal layer of the transverse mesocolon to the pancreas. At the pancreas the peritoneum passes downward over the third part of the duodenum to the oblique mesentery of the small intestines. Here it forms the right layer of the mesentery, invests the bowel and then passes to the dorsal body wall as the left layer of the mesentery; it then continues down along the dorsal body wall to the left and right, investing the sides and ventral walls of the ascending and descending colons (with cecum and appendix). In the left iliac fossa it completely invests the sigmoid colon forming for it a mesentery that shortens as the pelvic cavity is reached and ending at the beginning of the rectum. In the pelvic cavity the dorsal layer descends upon the front and sides of the rectum lessening at the sides so that at about the middle of this organ the entire peritoneum leaves the rectum to be carried forward, in the male, to the back of

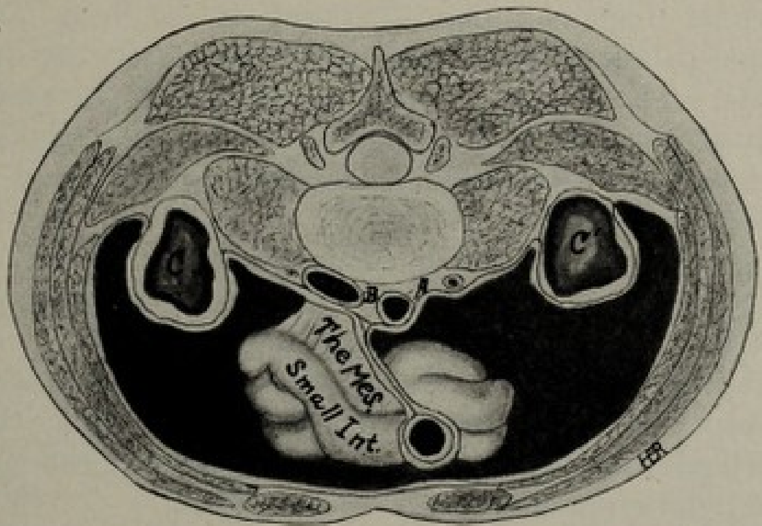


FIG. 217.—Transverse section of the abdomen at a more caudal level (diagrammatic). *A*, Aorta; *B*, inferior vena cava; *C*, ascending colon; *C'*, descending colon.

the bladder and sides of the pelvis, forming the rectovesical pouch. It then continues over the superior part and lateral surfaces of the bladder to the ventral abdominal wall, becoming here continuous with the ventral layer.

In the female the peritoneum is reflected from the rectum to the upper part of the dorsal wall of the vagina and then to the dorsal wall of the uterus and broad ligament, over the fundus and the oviducts to the ventral surface of fundus and body of the uterus and the broad ligament; it then continues to the back of the bladder, up over the superior part of the lateral surfaces of this organ to the ventral body wall. In the female the fossa between the rectum, behind, and uterus and vagina, in front, is the *pouch of Douglas* (*rectouterine*) and between the uterus, behind, and the bladder, *in front,* the space is called the *uterovesical pouch.*

At the sides of the body wall the ventral and dorsal layers of the greater sac are continuous with each other.

The *organs completely invested* by the peritoneum are as follows: Spleen, jejunum, ileum, cecum, appendix, transverse colon, sigmoid colon and the oviducts (in the female).

Those *partially invested* are: Liver, stomach, duodenum, ascending and descending colons, rectum (upper part), bladder, uterus and vagina (in the female).

Those *uninvested* are: Kidneys, adrenals, ureters, rectum (lower part), anal canal, pancreas, seminal vesicles, vas and prostate (in the male), and the urethra.

THE STOMACH (VENTRICULUS)

The stomach (*ventriculus*) lies in the epigastric, umbilical and left hypochondriac regions. The direction of its long axis varies from oblique to nearly horizontal, depending upon the quantity of its contents. The space occupied is called the *stomach-chamber*. When viewed from the side this space is somewhat triangular with curved sides. The *floor* slants downward (caudad) and ventrally; it is formed by the upper surface of the pancreas, the transverse mesocolon, transverse colon, spleen, right adrenal, and the upper pole of the left kidney. The *roof* is formed by the inferior surface of the left lobe of the liver and the diaphragm. The *ventral wall* is formed by the ventral abdominal wall and the diaphragm.

When empty and contracted the stomach is sausage-shaped and almost vertical. As the stomach fills it dilates at the fundus first and at the pyloric portion last.

The stomach presents *two orifices*, *cardia* and *pylorus*, *two surfaces*, *ventral* and *dorsal*, and *two borders*, the *greater* and *lesser curvatures*. It is divided into *fundus*, *body* and *pyloric portion*.

The **cardiac orifice** (*cardia*) is situated about 2 inches (5 cm.) to the left of the midline at the level of the eleventh thoracic vertebra, behind, or 1 inch to the left of the seventh sternochondral junction, in front. It is fixed in position.

The **pyloric orifice** (*pylorus*) is situated about ½ to 1 inch (1¼ to 2.5 cm.) to the right of the midline at the level of the first lumbar vertebra. In the distended stomach the pylorus moves an inch or so to the right. It opens into the duodenum.

The **ventral surface** (*paries anterior*) is convex and is in contact with the roof and ventral wall of the stomach chamber when the organ is distended. When empty, the transverse colon lies ventral to it. It is more extensive than the dorsal surface.

The **dorsal surface** (*paries posterior*) is more flattened and less extensive than the preceding and is in contact with the floor of the stomach chamber. This surface may be divided by a slight ridge into an upper and a lower area.

The **greater curvature** (*curvatura ventriculus major*) is convex and starts to the left of the esophagus in the *incisura cardiaca* and extends to the pylorus. This margin is 12 to 16 inches long in the distended stomach (three to four times that of the lesser curvature) and has the great omentum attached along the greater part of its extent.

The **lesser curvature** (*curvatura ventriculus minor*) is somewhat concave, extends from the cardiac region to the pylorus; it is only 3 to 4 inches in length and has the gastrohepatic omentum attached to it. Near the pylorus is the *incisura angularis*.

The **fundus** (*fundus ventriculi*) is the dilatation to the left of the esophagus and it extends 1 to 2 inches (2.5 to 5 cm.) above the level of the cardiac orifice. It constitutes a little less than one-third of the stomach. The *body* (*corpus ventriculi*) is the next portion and

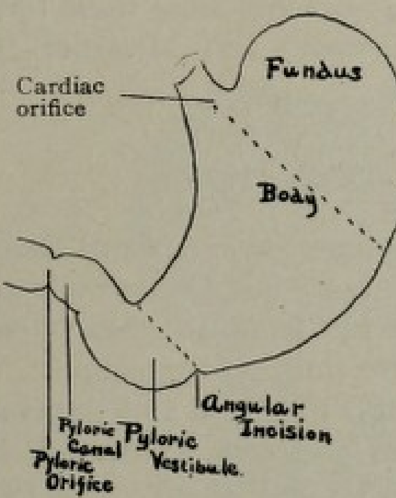


FIG. 218.—The parts of the stomach shown in the distended organ.

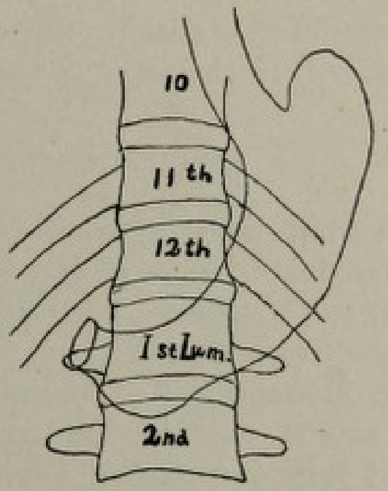


FIG. 219.—Form and position of the empty contracted stomach.

connects the fundus and pyloric portions. It constitutes a little over one-third of the stomach. The *pyloric end* (*pars pylorica*) constitutes about one-third and is separated from the body by the *incisura angularis*. It is sometimes separated into a dilated first part, the *pyloric vestibule* (*antrum pyloricum*) and a second tubular portion, the *pyloric canal*.

The **measurements** of the distended stomach are, length 10 to 12 inches (25 to 30 cm.), lateral 4 to 5 inches (10 to 12.5 cm.), and dorso-ventral 3 to 4 inches (7.5 to 10 cm.). Its *capacity* is usually 1 quart (40 ounces) though some give 4 to 5 pints as the capacity. Its *weight* is 4½ ounces (135 grams).

The stomach is almost completely invested with peritoneum, the uncovered area being just behind and to the left of the cardia. It is triangular in shape, measures about 2 inches along the base and 1½ inches high. The stomach is connected to the liver by the gastrohepatic omentum; to the colon by the gastrocolic omentum and to the diaphragm by a small fold, the gastrophrenic ligament.

The **interior of the stomach** exhibits many folds chiefly longitudinal in direction, consisting of mucous and submucous coats. These folds are the *rugæ*. Minute orifices representing the *gastric pits*, or *crypts*, are seen throughout the entire surface. At the pyloric orifice a distinct fold is seen, constituting the *pyloric valve*. Within this fold is a strong ring of circularly disposed smooth muscle tissue, the *sphincter pylori muscle*.

The stomach is supplied by the following *arteries* (branches of the celiac axis): The gastric (from celiac axis direct), pyloric (from the hepatic), right gastroepiploic (gastroduodenale), left gastroepiploic (splenic), vasa brevia (splenic). The *veins* empty into the superior mesenteric and splenic veins.

The *nerves* are derived from the vagals and the solar plexus (ganglion celiaca) of the sympathetic; branches from these form the plexuses of Auerbach (*plexus myentericus*) and Meissner (*plexus submucosæ*) in the walls of the organ.

SMALL INTESTINE (INTESTINI TENUE)

The small intestine consists of *duodenum*, *jejunum* and *ileum* and is, after death, 20 to 22 feet in length (22.5 feet in the male and 23 feet in the female). The diameter varies from 2 inches (5 cm.) at the duodenum, to a little over 1 inch (27 mm.) at the ileum.

The **duodenum** is 11 inches (27.5 cm.) in length and starts at the right side of the first lumbar vertebra and ends at the left of the second lumbar vertebra having a C-, U- or V-shape. Its two extremities are only about 2 inches (5 cm.) apart. It is the largest part of the small intestine. It consists of *superior* (*pars superior*), *descending* (*pars descendens*), *transverse* (*pars horizontalis*) and *ascending* (*pars ascendens*) *portions*. In the cavity of the duodenal loop is placed the head of the pancreas. All parts do not lie in the same plane. The first part is slightly movable being almost invested by peritoneum while the remainder is fixed being only partially invested. In this it is readily distinguished from the remainder of the intestine. At its termination as it turns ventrally to continue as jejunum (duodenojejunal junction) it is bound to the body wall by a fold, the *suspensory ligament of Treitz*, containing some smooth muscle tissue, the *suspensory muscle* (*m. suspensorius duodeni*). As a whole the duodenum is incompletely invested with peritoneum.

The *interior of the duodenum* varies in appearance. The first part is smooth but this condition is soon changed by the appearance of circular folds, the *plicæ circulares*, or *valvulæ conniventes*. In the descending portion is a longitudinal fold representing the course of the bile and pancreatic ducts. At the lower end of this fold is a papilla (*papilla duodeni*) at which the above ducts empty into the

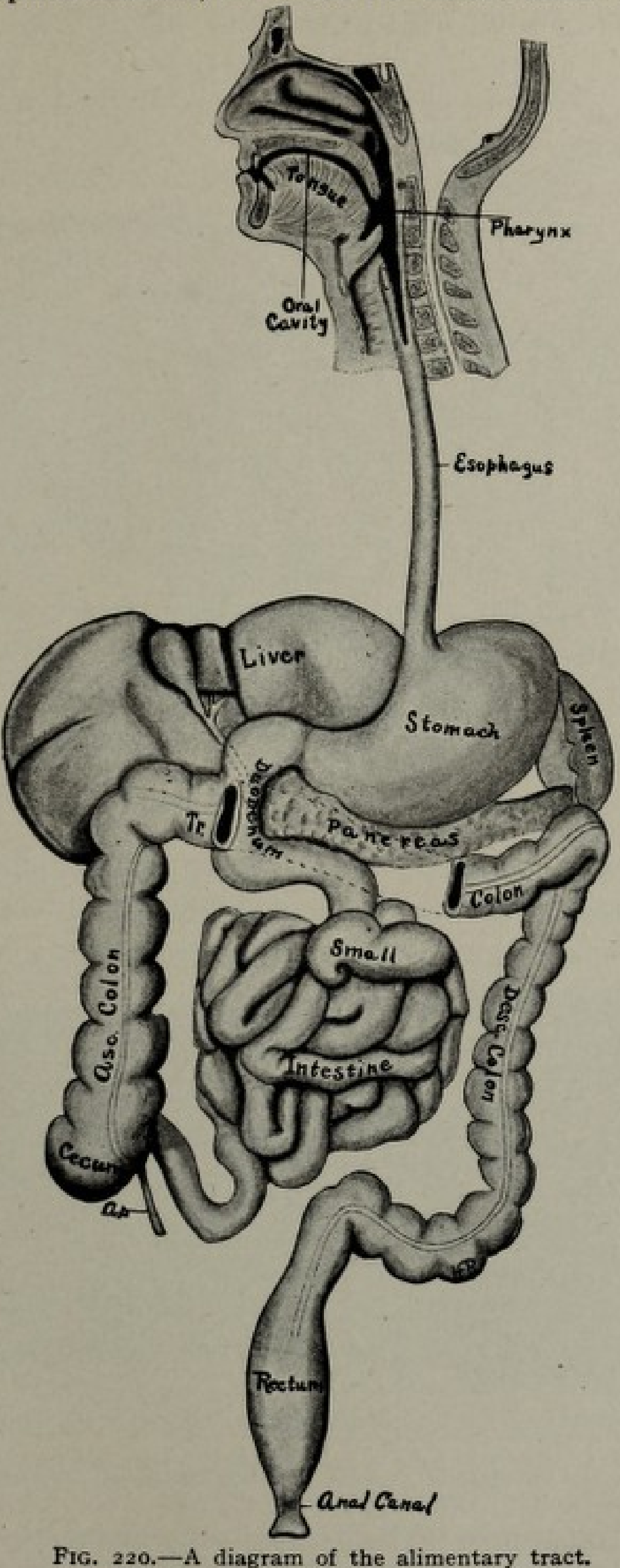


FIG. 220.—A diagram of the alimentary tract.

duodenum. This papilla is usually 3½ to 4 inches from the pyloric orifice.

The **jejunum** (*intestinum jejunum*) represents about two-fifths (8 feet) of the small intestine. It has a greater diameter, 1½ to 1¼ inches (3.75 to 3 cm.) than the ileum, its walls are thicker and

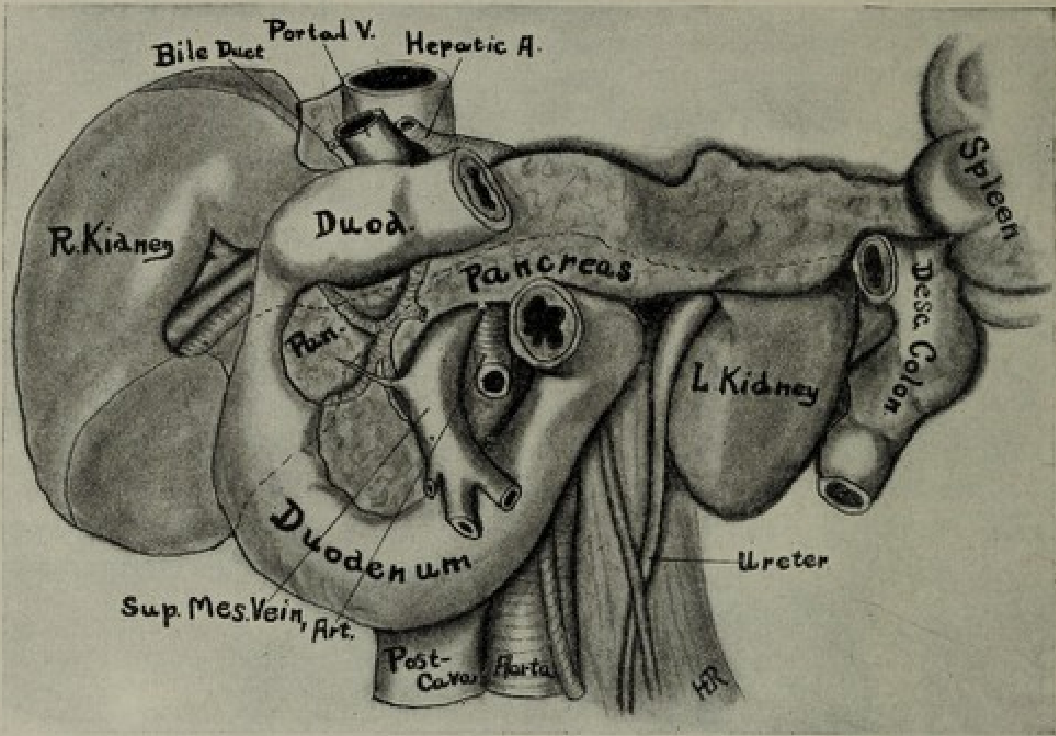


FIG. 221.—Ventral view of the duodenum, pancreas and the neighboring organs.

redder, the plicæ circulares are larger and more numerous than in the ileum and the villi are more numerous and broader.

FIG. 222.—Interior of the jejunum showing the plicæ circulares. (*From a photograph.*)

The **ileum** (*intestinum ileum*) constitutes about three-fifths (12 feet) of the small intestine. It is about 1 inch (2.5 cm.) in diameter, its walls are thin and pale, the plicæ circulares are few and small and the villi few and slender. Both of these portions of the small intestine are completely invested with peritoneum and are suspended from the dorsal body wall by the mesentery. The coils of the jejunum lie chiefly in the upper and left part of the abdominal cavity, the first third of the ileum in the left iliac fossa, and the remainder in the lower right portion of the abdominal cavity and even in the pelvic cavity.

The *small intestine* receives its *blood supply* from the following vessels: *Duodenum* from the pyloric and superior pancreatico-duodenale (branches of the hepatic artery) and inferior pancreatico-duodenale (from the superior mesenteric artery). The *veins* return the blood to the superior mesenteric and portal veins.

The *jejunum* and *bulk of the ileum* receive their *blood* from the vasa intestini tenuis (from the superior mesenteric artery) and the remainder of the ileum from the ileal vessels (ileocolic branch of the superior mesenteric artery). The *veins* return the blood to the superior mesenteric vein.

The *nerves* are derived from the celiac plexus of the sympathetic system. Branches from this plexus form the *plexuses of Auerbach* (*plexus myentericus*) and *Meissner* (*pl. submucosa*) in the walls of the intestine. Some branches of the right vagus join the latter plexuses.

THE LARGE INTESTINE (INTESTINUM CRASSUM)

The large intestine consists of *cecum*, *colon*, *rectum*, *anal canal* and *anus* (Fig. 220).

The large bowel presents a sacculated appearance. This condition is due to the three longitudinal bands, or *teniæ coli*. These bands represent the longitudinal muscle tissue of the large intestine and as these bands are about one-sixth shorter than the intestine they cause the sacculations. They arise at the base of the appendix and are nearly equidistant from one another. They extend to the rectum where they end by spreading out to form a complete longitudinal layer. If the teniæ be removed the sacculations disappear and the bowel is of a cylindrical form. All along the large intestine are seen little tabs of fat surrounded by peritoneum called the *appendices epiploicæ*.

The **cecum** (*intestinum cecum*) is the blind portion of the large intestine. It is about 2.5 inches (6.5 cm.) long and 3 inches (7.5 cm.) wide. It lies in the right iliac fossa and extends as high as the intertubercular plane. The *interior of the cecum* shows some folds of the mucosa and submucosa. The superior end is continuous with the colon. The opening of the ileum is guarded by the *ileocecal valve* (*valvula coli*) that consists of two segments, upper (*labium superius*) and lower (*labium inferius*). About 1¼ inches below the ileocecal orifice is the appendiculer orifice and this may be guarded by a valve.

20

The cecum is usually entirely invested with peritoneum but it has no mesentery.

The **appendix** (*processus vermiformis*) is the smallest part of the intestine. It has been known to be absent and in other cases as long as 9 inches (22.5 cm.). Its average is about 3 inches (7.5 cm.) in length and ¼ inch (6 mm.) in diameter. Its orifice, guarded by a valve (*valvula processus vermiformis*) usually is considered half way on a line between the anterior superior spine of the ilium and the umbilicus; this is called *McBurney's point*. The appendix is completely surrounded by peritoneum and possesses a mesentery, the mesoappendix.

The **colon** (Figs. 213 and 220) consists of four parts, *ascending, transverse, descending* and *sigmoid flexure*.

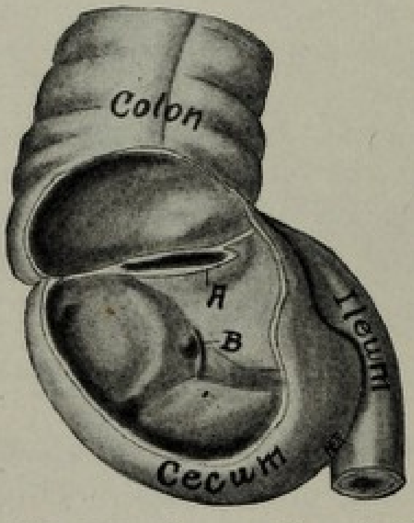


FIG. 223.—Cecum with part of the ventral wall removed. *A*, Ileocecal valve and orifice; *B*, appendicular orifice.

The **ascending colon** (*colon ascendens*) is 5 to 8 inches (12.5 to 20 cm.) long and extends from the intertubercular plane to the under surface of the liver, where it turns ventrally and to the left as the hepatic flexure. It is wider and more prominent than the descending colon; it is usually invested upon its ventral and two lateral surfaces with peritoneum and is, therefore, fixed in position. It lies in the right lumbar and partly in the right hypochondriac regions.

At the liver the colon bends sharply to the left and ventrally and this part is called the *right* (*hepatic*) *flexure* (*flexura coli dextra*) and produces the colic impressions upon the visceral surface of the liver.

The **transverse colon** (*colon transversum*) is from 15 to 20 inches (37.5 to 50 cm.) long; it begins at the hepatic flexure and extends across the body in an arched manner (convexity downward) to the spleen where it ends at the splenic flexure. The first and last portions are fixed in position, but the intervening portion is freely movable possessing a long mesentery, the *transverse mesocolon*. Its extremities lie in the right and left hypochondriac regions while the middle portion lies in the umbilical and even in the hypogastric region.

At the spleen the transverse colon turns sharply downward (caudad), forming the *left* (*splenic*) *flexure* (*flexura coli sinistra*). This lies at a higher level than the right flexure.

The **descending colon** (*colon descendens*) is about 4 to 6 inches (10 to 15 cm.) long and starts at the splenic flexure and extends to the left iliac crest. It is about 1½ inches (3.75 cm.) in diameter and is partly invested with peritoneum; it is fixed in position. It lies in the left hypochondriac and lumbar regions and bends slightly toward the midline at the level of the left kidney.

The **sigmoid flexure,** 17 to 20 inches (42.5 to 50 cm.) in length, consists of two parts, the *iliac* and *pelvic colons*. The *iliac colon,* about 5 to 6 inches (12.5 to 15 cm.) long, extends from the crest of the ilium to the brim of the pelvis. It is completely invested with peritoneum but has no mesentery. It lies in the left iliac and the hypogastric regions. The *pelvic colon,* about 12 to 17 inches (30 to 42.5 cm.) in length, extends from the brim of the pelvis to the third sacral segment in an irregular loop. This constitutes a large coil that is completely invested with peritoneum and has a well-developed mesentery that shortens as the end of this portion of the bowel is reached. This mesentery is referred to as the *mesosigmoid* for both parts as a whole, or *pelvic mesocolon.*

The **rectum** (*intestinum rectum*) about 5 to 6 inches (12.5 to 15 mm.), extends from the third segment of the sacrum to a point about 1½ inches (3.75 cm.) in front of the tip of the coccyx. The first part is only partially invested by peritoneum and the last portion not at all. Its diameter varies, being smallest at the beginning and largest nearest the anal canal. This dilated portion is called the *ampulla* (*ampulla recti*). When empty the diameter is about 1 inch (2.5 cm.) but when distended it may be 3 inches (7.5 cm.).

The rectum is not straight, as its name indicates, but shows a curve from before backward as it follows the curve of the sacrum. Viewed from the front it shows usually three curves; the upper and the lower have the concavity to the left and the middle curve to the right. These are not sacculations but are due to the projection of the coats into the lumen of the organ forming, thus, three well-marked shelves, the *rectal valves* (*plicæ transversales recti*). These valves extend from a half to two-thirds of the way across the lumen and serve to support the weight of the fecal matter.

The **anal canal** (*pars analis recti*) is the slit-like continuation of the bowel. It is from 1 to 1½ inches (2.5 to 3.75 cm.) in length and ½ to ¾ inch (12 to 18 mm.) dorsoventrally. It lies between the levatores ani muscles and extends backward and downward at an angle of about 45° to the horizontal plane, from the end of the rectum to the anal orifice. The circularly disposed smooth muscle fibers extend from the beginning to about ¼ inch from its end and constitute the *internal sphincter muscle.* Around the lower two-thirds is a strong band of circularly arranged voluntary striated muscle called the *external sph ncter.*

The *interior of the anal canal* shows, in its upper and middle thirds, a number (five to ten) of vertical folds called the *columns of*

Morgagni (*columnæ rectales*). Between these are little depressions (*sinuses rectales*) bounded below by crescentic folds called the *anal valves*.

The **anal orifice** is the lower aperture of the alimentary tract. This orifice is irregular and is usually surrounded by hairs, sebaceous and modified sweat glands (*glandulæ circumanales*). At the orifice the mucous membrane of the rectum passes into the skin without any sharp line of demarcation.

The *blood-vessels* that supply the *large bowel* are as follows: *Cecum* and *appendix* by the ileocecal artery (from the ileocolic branch of the superior mesenteric artery); the *ascending colon* by the *right colic* (from the superior mesenteric); the *transverse colon* by the middle colic (from the superior mesenteric) and the left colic (from the inferior mesenteric); *sigmoid colon* by the sigmoid branches of the

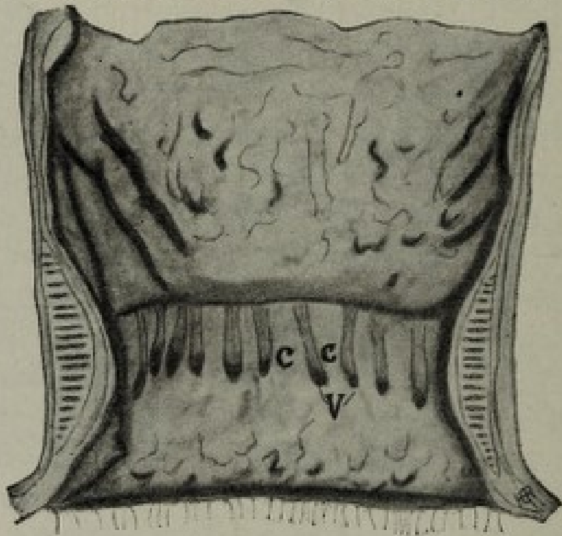


FIG. 224.—Lower part of the rectum and the anal canal. *C, C*, columns of Morgagni; *V*, anal valves.

inferior mesenteric artery; the *rectum* by the superior hemorrhoidal (from the superior mesenteric), the middle hemorrhoidal (from the internal iliac) and the inferior hemorrhoidal (from the internal pudic).

The *venous blood* of the *rectum* passes in two directions. There are two venous plexuses in the rectum, internal and external. The *internal hemorrhoidal plexus* gives rise to the inferior hemorrhoidal veins that empty into the internal pudic vein which is a tributary to the inferior vena cava through the internal and common iliac veins. The *external hemorrhoidal plexus* gives rise to the superior hemorrhoidal vein that empties into the inferior mesenteric vein which is a tributary to the portal vein. The blood that is distributed by the inferior mesenteric artery is returned by venous channels that correspond to the arterial branches; these ultimately form the inferior mesenteric vein that empties into the splenic vein, a tributary to the portal vein. Corresponding venous channels return the blood from the distribution of the superior mesenteric artery to form the superior mesenteric vein. This vein unites with the splenic vein to form the portal vein that enters the portal fissure of the liver.

The *nerves* of the great bowel to the rectum are derived from the sympathetic plexuses around the roots of the superior and inferior mesenteric arteries. Their distribution is similar to that of the small intestine. The rectum receives its sympathetic fibers from the inferior and hypogastric plexuses. Its cerebrospinal nerves are derived from the second, third and fourth sacral segments of the spinal cord.

THE LIVER (HEPAR)

The liver is the largest gland in the body, weighing from 50 to 55 ounces (1500 to 1650 grams) in the male, and from 43 to 48 ounces (1290 to 1440 grams) in the female. It represents one-eighteenth to one-twentieth of the body weight at birth and about one-fortieth in the adult. The bulk of the liver lies in the right hypochondriac region, the remainder extending across the epigastric into the left hypochondriac region. It is soft, of a reddish-brown color and quite friable. It is not completely invested with peritoneum, having a large area, the uncovered area, uninvested. Its shape is irregular and inconstant in the same body varying under different conditions. It is usually described as a "right angle triangular prism with the basal angles rounded." Its *measurements* are as follows: greatest transverse 7 to 8 inches (17.5 to 20 cm.); vertical (near the right side) 6 to 7 inches (15 to 17.5 cm.); dorsoventral (in the thickest part) 4 to 5 inches (10 to 12.5 cm.).

It presents *five surfaces*, *superior*, *ventral*, *right*, *dorsal* (these four constituting the *parietal surface*) and *inferior* (*visceral*) *surface* and an *inferior border*.

The **superior surface** (*facies superior*) is convex from before backward and slightly concave, to the left of the midline, from side to side. This depressed area is the *cardiac impression*, for here the heart rests upon the liver separated therefrom by the central tendon of the diaphragm. The convexity of the two sides is due to the doming of the diaphragm. This surface is divided by the suspensory ligament into a greater, right, and a lesser, left portion.

The **ventral surface** is extensive and of a triangular shape; it is slightly convex, or flattened, resting against the diaphragm and the ventral abdominal wall. It is divided by the suspensory ligament as above stated. The *right lateral surface* is convex and triangular in shape and rests against the diaphragm.

The **dorsal surface** (*facies posterior*) is convex, the greater right portion being broad while the lesser left portion is narrow and comes to a point. To the left of the midline of the liver is the deep *vertebral groove* where the liver is moulded around the protruding vertebra column. The greater portion of this surface is uninvested with peritoneum and is called the *uncovered area.* This area is from 2 to 3 inches (5 to 7.5 cm.) from above downward to 4 to 5 inches (10 to 12.5 cm.) from side to side. This surface presents from right to left, the *uncovered area* with the *adrenal impression* (*impressio suprarenalis*), the *fossa for the inferior vena cava* (*fossa venæ cavæ*), the *base of the caudate lobe,* the *fissure for the ligamentum venosum* and the *esophageal groove* (*impressio esophagea*).

The **inferior,** or **visceral surface** (*facies inferior*), presents from right to left the following: Starting across the upper part is seen first

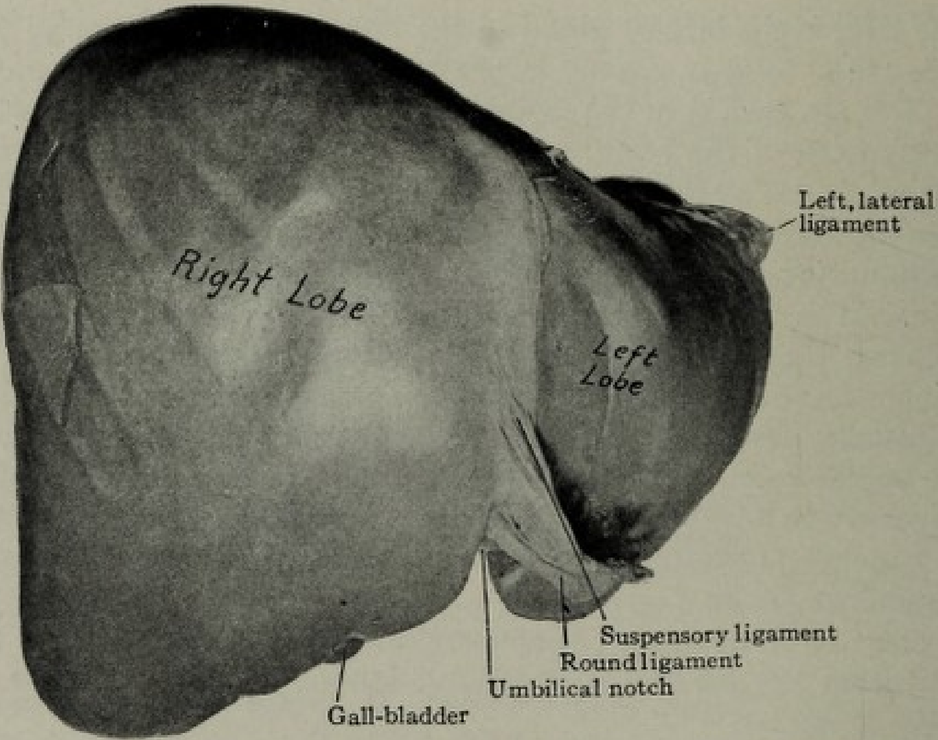


FIG. 225.—Ventral and right surfaces of the liver. (*From a photograph.*)

the *large renal impression* (*impressio renalis*), then the *transverse,* or *portal fissure* with the *processus caudatus* of the caudate lobe above it; then the *fissure for the ligamentum venosum* (*fossa ductus venosi*); next the *omental tuberosity* (*tuber omentale*) that fits into the lesser curvature of the stomach; lastly, the *gastric impression* (*impressio gastrica*) that accommodates the ventral surface of the stomach. Across the lower part of this surface (right to left) are seen: first, the *colic depression* (*impressio colica*) below the renal impression; the *duodenal depression* (*impressio duodenalis*) above and to the left; next, the *gall-bladder* in its *fossa* (*fossa vesicæ felleæ*); then, the *quadrate lobe* with the *pyloric depression* (*impressio pyloris*); the *umbilical fissure* for the round ligament; and lastly, the *end of the gastric impression.*

The **inferior border,** or **margin** of the liver is sharp and thin. Where the falciform ligament reaches it there is a deep notch called the *umbilical notch* (*incisura umbilicalis*) which represents the beginning of the umbilical fissure. A little to the right of the notch is seen the base of the gall-bladder.

The **lobes** of the liver are *four* in number, *right* (*lobus dexter*) with its subdivisions the *quadrate* (*lobus quadratus*), *caudate* (*lobus caudatus*) and lastly the *left lobe* (*lobus sinister*). The **fissures** are *five* in number and form a broken letter H. Upon the left are the continuous *umbilical* (*fossa umbilicalis*) and *ligamentum venosum* (*fossa ligamentum venosum*) *fissures* that constitute the *great longitudinal fissure.* On the right are the *fissure* (*fossa*) *for the gall bladder*

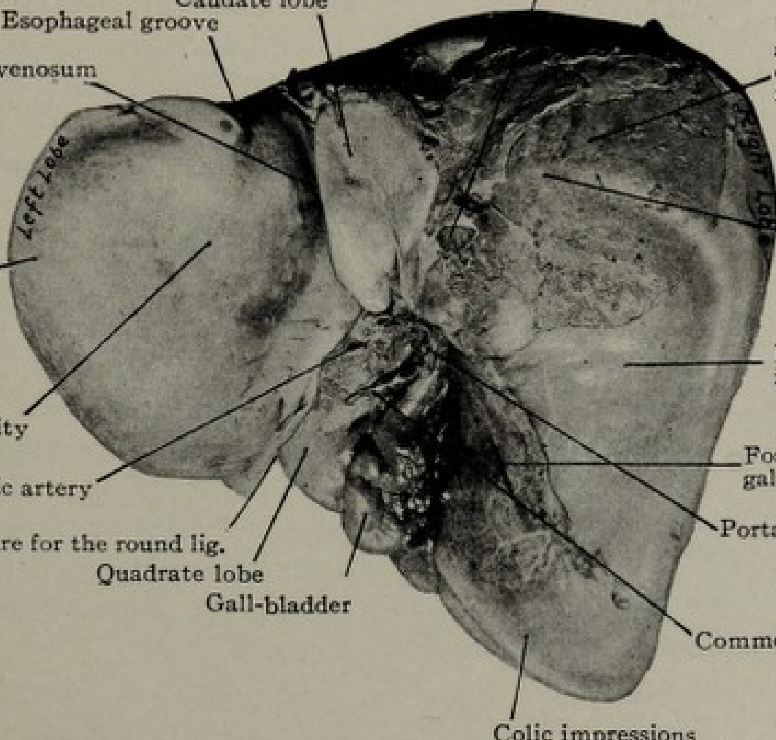


FIG. 226.—Dorsal and inferior surfaces of the liver. (*From a photograph.*)

(*fossa vesicæ felleæ*) and the *fissure for the inferior vena cava* (*fossa venæ cavæ*) interrupted by the caudate process; connecting the longitudinal fissure with the fossa for the gall-bladder is the *transverse,* or *portal fissure* (*porta hepatica*). At the portal fissure the hepatic artery, nerves and portal vein enter and the hepatic ducts and lymph channels pass out.

The **ligaments** are the *suspensory*, *coronary*, *right* and *left lateral*, *umbilical* and *ligamentum venosum.* The *falciform*, or *suspensory ligament* (*ligamentum falciforme hepatis*), is a sickle-shaped fold of peritoneum that connects the liver to the diaphragm and ventral abdominal wall. It starts at the umbilicus, passes upward to the diaphragm and liver and then back to the dorsal surface where its two layers separate, one going to the right and the other to the left as the upper leaflets of the coronary ligament. It passes over the ventral surfaces and superior wall to the left of the midline of the liver and separated the right from the left lobes here.

The **coronary ligament** (*lig. corinarium hepatis*) consists of *upper* and *lower leaflets*. The *upper* have been mentioned above. The *lower leaflet* represents the peritoneum from the visceral surface of the liver and it bounds the inferior margin of the uncovered area. At the right edge of the uncovered area the two leaflets unite and pass to the diaphragm as the *right triangular ligament* (*lig. triangulare dextrum*). To the left of the caudate lobe the two leaflets unite and extend along the dorsal edge of the left lobe to its end and then to the diaphragm as the *left triangular ligament* (*lig. triangulare sinistrum*).

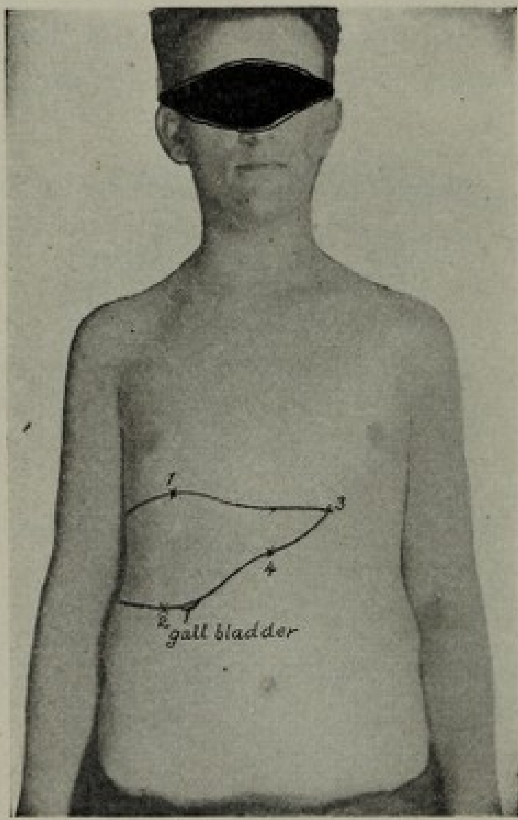


Fig. 227.—Outline of the liver upon the ventral abdominal wall. (*From a photograph.*)

The **round ligament** (*lig. teres hepatis*) represents the impervious umbilical vein of the fetus and it lies in the free edge of the falciform ligament and enters and lies in the fissure for the round ligament in the inferior surface.

The **ligamentum venosum** lies in the fissure of that name and extends from the portal fissure dorsally to the inferior vena cava. It represents the impervious ductus venosus.

The *blood-vessels* entering the liver are the hepatic artery and the portal vein. The latter is the real nutrient vessel of the liver as it is laden with the nutritious substances absorbed from the gastrointestinal tract and comes into very intimate relation with the hepatic cells.

The *several hepatic veins* drain the liver and empty the blood into the inferior vena cava at the dorsal surface of the liver. Two of these veins are usually of considerable size.

The *nerves* are chiefly sympathetic from the celiac plexus; the cerebrospinal nerve assisting is the left vagus.

To **outline the liver** upon the ventral abdominal wall four points are taken: (1) in the middle of the fifth interspace on the right midclavicular line; (3) the upper margin of the sixth left rib ½ inch (1 cm.) medially from the midclavicular line; (2) ½ inch (12.5 mm.)

below the tip of the tenth right rib; (4) a point midway be-between the lower end of the gladiolus sterni and the umbilicus in the midsternal line. The line connecting (1) and (3) should be depressed in the midsternal area representing the cardiac depression. The line connecting (1) and (2) should describe a curve to the right. The line connecting (3) and (2) is concavoconvex, passes through the midsternal point (4) and is like a reversed italic *f*. The position of the liver varies with the movements of respiration, ascending during expiration and descending during inspiration.

THE GALL-BLADDER AND DUCTS

The gall-bladder (*vesica fellea*) lies in a fossa on the visceral surface of the right lobe of the liver. It is pear-shaped, measures about 3

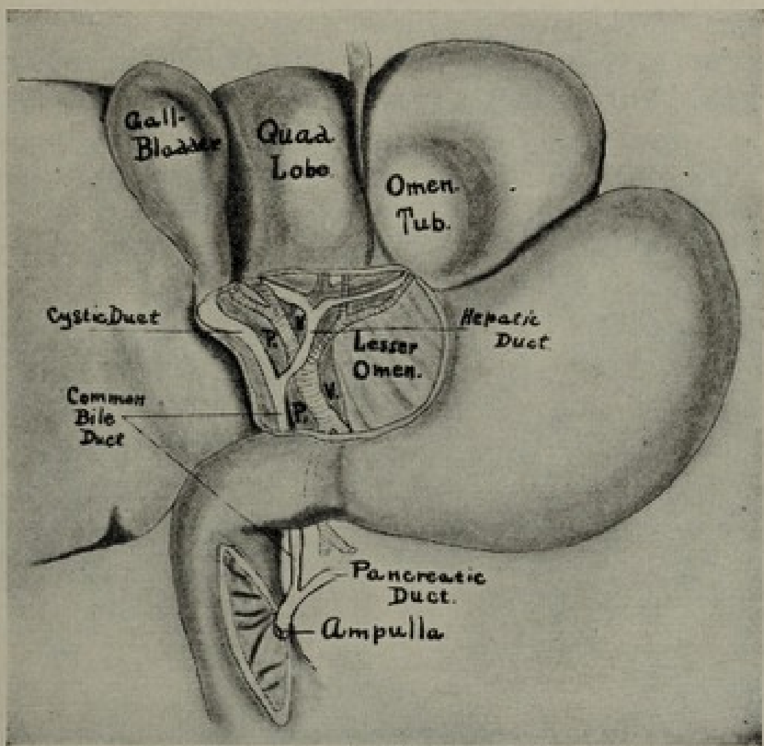


FIG. 228.—Structures in the lesser omentum (liver raised). The duodenum is laid open to show where the conjoined ducts empty. *PV*, Portal vein.

inches (7.5 cm.) in length and 1 to 1½ inches (2.5 to 3.5 cm.) in diameter. Its capacity is from 1 to 1½ ounces (30 to 45 c.c.). It consists of a *fundus*, *body* (*corpus*) and *neck* (*collum*). The *neck* presents a peculiar curve with the convexity directed toward the right.

The **hepatic duct** (*ductus hepaticus*) is made up of the right and smaller left lobar ducts. It measures usually 1 to 1¼ inches (2.5 to 3 cm.) in length and 3 to 4 mm. in diameter and joins the cystic duct.

The **cystic duct** (*ductus cysticus*) begins at the neck of the gall-bladder and is from 1¼ to 1½ inches (3 to 3.75 cm.) in length and

3 to 4 mm. in diameter. It joins the hepatic duct to form the common bile duct.

The **common bile duct** (*ductus cholidochus*) is about 3½ to 4 inches (8.5 to 10 cm.) in length, 6 to 7 mm. in diameter and passes into the duodenal wall where it joins the pancreatic duct. These ducts pass obliquely through the coats of the duodenum and before opening into the lumen of this organ there is a dilatation of this combined duct called the *ampulla of Vater*. The orifice of the common duct is 3½ to 4 inches from the pylorus along the dorsomedial wall.

The *gall-bladder* receives its *blood* from the cystic artery, a branch of the hepatic artery. Its *veins* empty directly into the portal vein. The *nerves* are derived from the sympathetic plexus upon the hepatic artery.

THE PANCREAS

The pancreas is often referred to as the abdominal salivary gland. When fixed *in situ* it measures from 5 to 6 inches (12.5 to 15 cm.) in

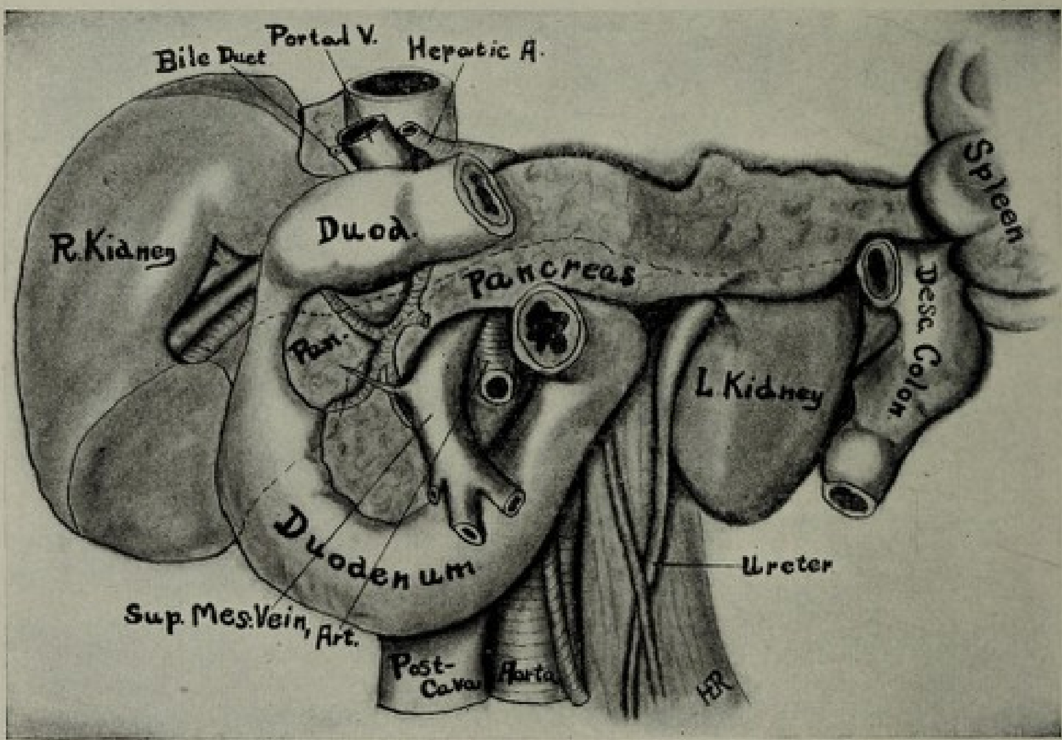


Fig. 229.—Ventral view of the duodenum, pancreas and the neighboring organs.

length. Its *weight* is from 85 to 90 grams. Most of the organ lies in the epigastrium and the remainder in the left hypochondrium. It consists of *head*, *neck*, *body* and *tail*.

The **head** (*caput*) is the largest portion, measures about 2 inches (5 cm.) across. It lies in the concavity of the duodenum. The *neck* (*collum*) is the narrow, constricted portion between the head and the body. It is about 1 inch (2.5 cm.) long and ½ inch (12 mm.) thick.

The *body* (*corpus*) is the longest and thickest division and is somewhat wedge-shaped. It presents *three surfaces*, *ventral*, *inferior* and *dorsal*, and *three borders*, *ventral*, *superior* and *inferior*. The *tail* (*cauda*) is the pointed extremity that extends to the spleen. The pancreas is classed as a retroperitoneal organ.

The **pancreatic duct** (*ductus pancreaticus*) begins near the tip of the tail and continues in a zigzag manner through the long axis of the organ; near the head it bends downward to join the common bile duct.

Occasionally an **accessory duct** (*ductus pancreaticus accessorius*) is found. This is small and opens independently into the duodenum about ¾ inch above and a little ventral to the preceding duct.

The *arteries* are the superior pancreaticoduodenale (from the gastroduodenale of the hepatic artery), the inferior pancreaticoduodenale (from the superior mesenteric artery) and pancreatic branches from the splenic and hepatic arteries. The *veins* empty into the superior mesenteric, splenic and portal veins. The *nerves* are mainly sympathetic from the solar plexus by way of the celiac, splenic and superior mesenteric plexuses.

CHAPTER VIII

THE URINARY SYSTEM

The urinary system comprises the *two kidneys*, *two ureters*, the *bladder* and the *urethra*.

THE KIDNEYS

Each kidney (*ren*) is a large, bean-shaped organ, measuring 4½ inches (11.5 cm.) in length, 2 inches (5 cm.) in width and about 1½ inches (3 cm.) in thickness. In the male the kidney weighs from 4½ to 6 ounces (135 to 180 grams) and in the female from 4 to 5½ ounces (120 to 165 grams). It is rather solid in texture and of a reddish-brown color.

Surfaces.—The kidney presents *ventral* and *dorsal surfaces*, *medial* and *lateral borders* and *superior* and *inferior poles*.

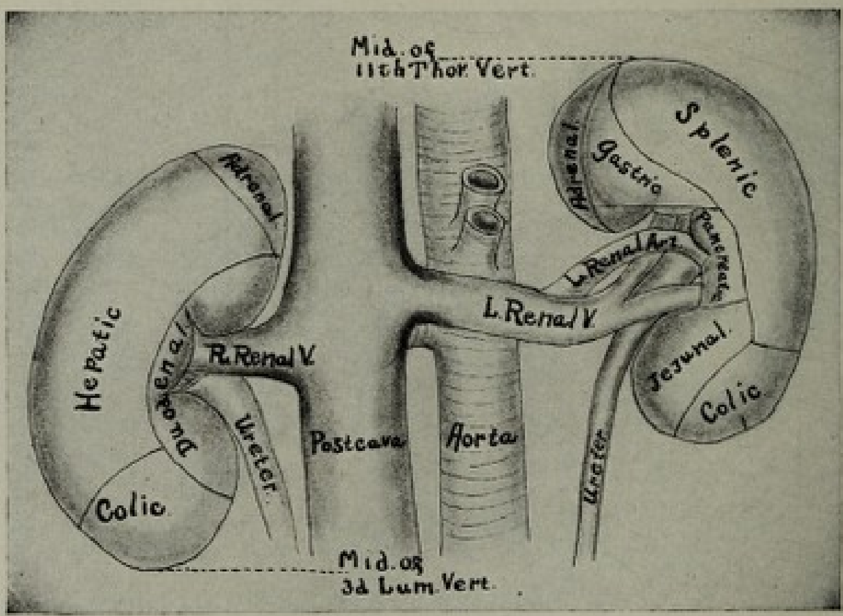


FIG. 230.—Ventral surfaces of the kidneys showing the areas of each.

The *ventral*, or *visceral surface* (*facies ventralis*), is convex and looks forward (ventrally) and outward. Upon each kidney are areas as follows: *Right kidney:* adrenal, duodenal, hepatic and colic. *Left kidney:* adrenal, gastric, pancreatic, splenic, jejunal and colic.

The *dorsal*, or *parietal surface* (*facies dorsalis*) is directed backward (dorsally) and inward and is flatter than the ventral surface. The dorsal surface is in contact with muscles. The areas are diaphragmatic, transversalis, quadratus lumborum and psoas; these are on both kidneys but not to the same extent. In addition to these, upon the left kidney may be seen two grooves formed by the eleventh and twelfth ribs and two little depressions near the medial border formed by the transverse processes of the first and second lumbar vertebræ, respectively. On the right kidney there is one groove formed by the twelfth rib and one depression formed by the transverse process of the first lumbar vertebra.

The *lateral border* (*margo lateralis*) is convex in both directions and belongs more to the dorsal surface. The *medial border* (*margo medialis*) is concave presenting a deep notch, the *hilus*, seen mainly from the front. The vessels here are the renal vein, in front, the renal artery, above and in the middle, and the ureter behind and below.

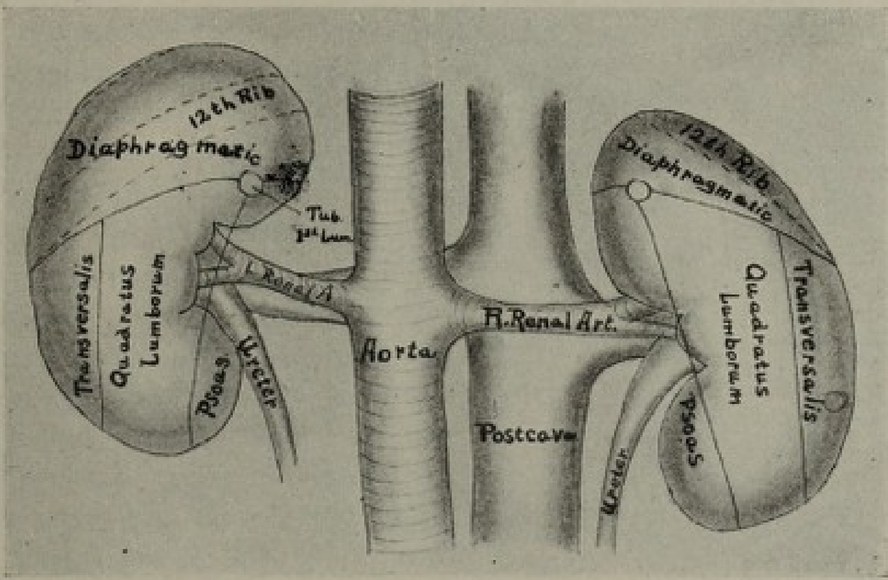


FIG. 231.—Dorsal surfaces of the kidneys showing the areas of each.

The *superior pole*, or *extremity* is thick and broad and about 4 cm. from the midline. It is capped by the adrenal. The *inferior pole*, or *extremity* is usually thinner and more pointed than the preceding and is about 5½ cm. from the midline of the body.

If the kidney be sectioned longitudinally, and parallel to the surfaces, a number of important points are noted. The peripheral one-third is distinctly demarcated from the inner two-thirds and these constitute the *cortex* and *medulla*, respectively. The **cortex** (*substantia* (*corticalis*) shows striations perpendicular to the surface. These alternating dark and light stripes are due to the difference in vascularity of these two parts: the *dark ones* constitute the *labyrinth* (*pars convoluta*) and are the more vascular; the *lighter ones* are the *medullary rays* (*pars radiata*). The rays are continuous with the medullary portion of the kidney while the labyrinth extends a distance into the medulla between the medullary pyramids, forming here the cortical ends of the *columns of Bertin* or *columnæ renales.*

The **medulla** (*substantia medullaris*) is seen to consist of a number of *pyramids* (*pyramides renales*) the apices of which are directed toward the sinus and the bases (*bases pyramides*) toward the cortex. The basal areas constitute the *boundary zone* of the kidney. Between the pyramids are the incomplete fibrous *columns of Bertin* (*columnæ renales*) the pathways of the vessels to and from the boundary zone.

Just within the hilus is seen an area called the **sinus.** This is occupied by the pelvis of the ureter and the branches of the renal artery, the tributaries of the renal vein and some adipose tissue. Here are also seen the apices of the medullary pyramids that project into the sinus a short distance constituting the *papillæ renales.*

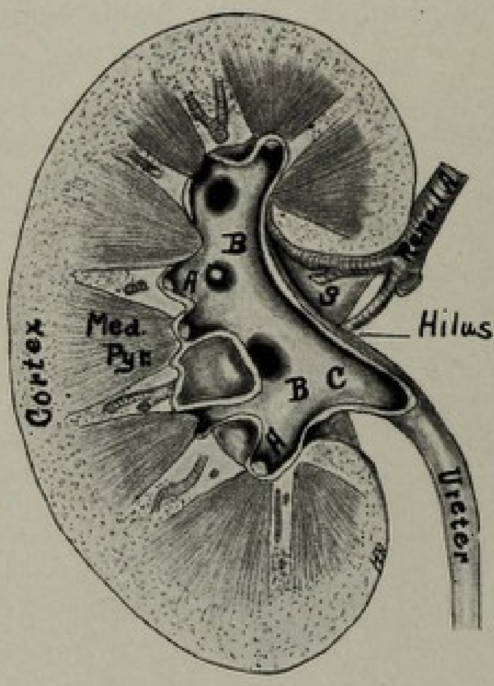


FIG. 232.—Median longitudinal section of the right kidney. *A*, *A*, Calyces minores; *B*, *B*, calyces majores; *C*, pelvis of the ureter; *S*, hilus of the kidney.

The kidneys are retroperitoneal, that is, not in any way or part invested with peritoneum. Each is usually imbedded in considerable fat, the **fatty capsule** (*capsula adiposa*) wihch is usually thicker at the margins of the organ. In this fatty tissue is seen the *fascia renalis,* a sheet of white fibrous tissue with some fat interposed between it and the kidney (the *perirenal fat*). That portion of the fatty capsule outside of the renal fascia is the *pararenal fat.* The organ is held in position by the surrounding organs, chiefly, and somewhat by the renal fascia.

The *vessels of the kidney* are the renal artery and the renal vein. The *nerves* are about fifteen in number and are derived from the renal plexus. This plexus is formed by branches from the solar plexus, celiac ganglion, aortic plexus and lesser and least splanchnic nerves. Branches from the tenth, eleventh and twelfth thoracic nerves also reach the kidneys.

The kidneys lie mainly in the epigastric and umbilical regions but extend somewhat into the lumbar and hypochondriac regions. The left is usually higher than the right. The left kidney extends from the middle of the eleventh thoracic vertebra to the upper border of the third lumbar vertebra. The right kidney extends from the lower border of the eleventh thoracic vertebra to the middle of the third lumbar vertebra. In the female they are somewhat lower than in the male. The inferior poles are 1½ to 2 inches (3.75 to 5 cm.) above the crests of the ilium. The upper pole of each is 4 cm. from the midline while the lower pole is 5½ cm. from the midline.

THE URETERS

The ureters are the tubes by means of which the urine is conveyed from the kidneys to the bladder. Each consists of a *pelvis* and *ureter proper*. The **pelvis** lies in the sinus and consists of a number of small divisions, the *calyces minores* eight to ten in number.

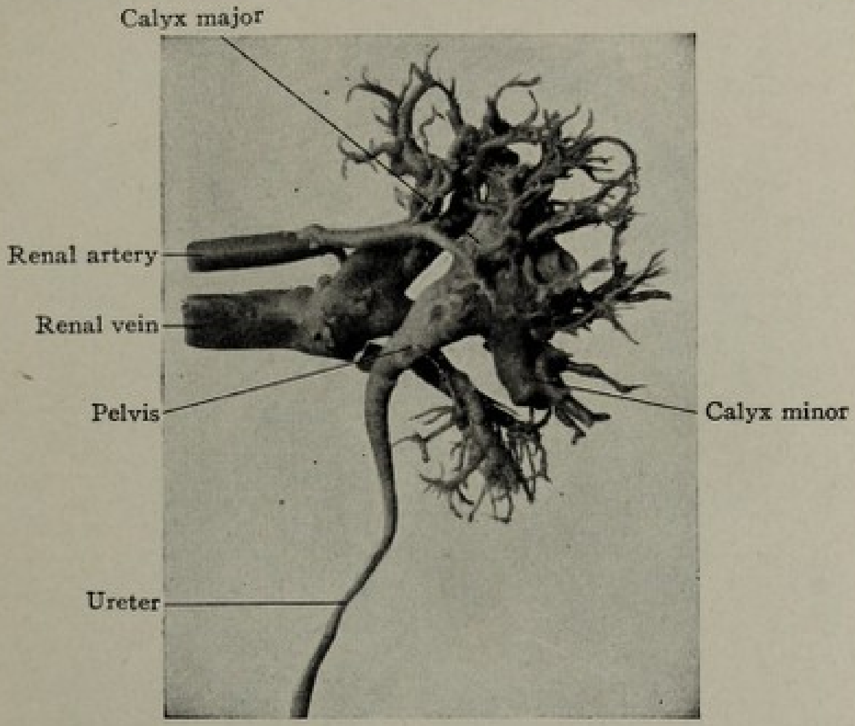


Fig. 233.—Dorsal view of a corrosion preparation of the vessels and ureter of the kidney. (*From a photograph.*)

These calyces minores surround and are completely attached to two or three pyramid apices and join to form two or three tubular structures, the *calyces majores*. The junction is somewhat enlarged and constitutes the *pelvis*. At the level of the disc between first and second lumbar vertebræ it continues as the ureter proper.

The **ureter proper** is a small tube about 4 mm. thick and 10 to 12 inches (25 to 30 cm.) in length. It extends from the upper border of the second lumbar vertebra to the bladder. The first part (*pars abdominalis*) lies in the abdominal cavity and corresponds nearly to the midinguinal line. The second half (*pars pelvina*) lies in the pelvic cavity. When it reaches the bladder, it enters that structure obliquely and proceeds for nearly an inch (2.5 cm.) between the muscular and mucous coats. Its opening in the bladder is guarded by mucous folds.

Its *blood supply* is from the renal, spermatic, ovarian, middle hemorrhoidal and superior vesical arteries. Its *nerves* are derived from the renal, spermatic and hypogastric plexuses of the sympathetic system.

THE BLADDER

The bladder (*vesica urinaria*), located in the pelvic cavity just behind the symphysis pubis, is the reservoir for the urine. When

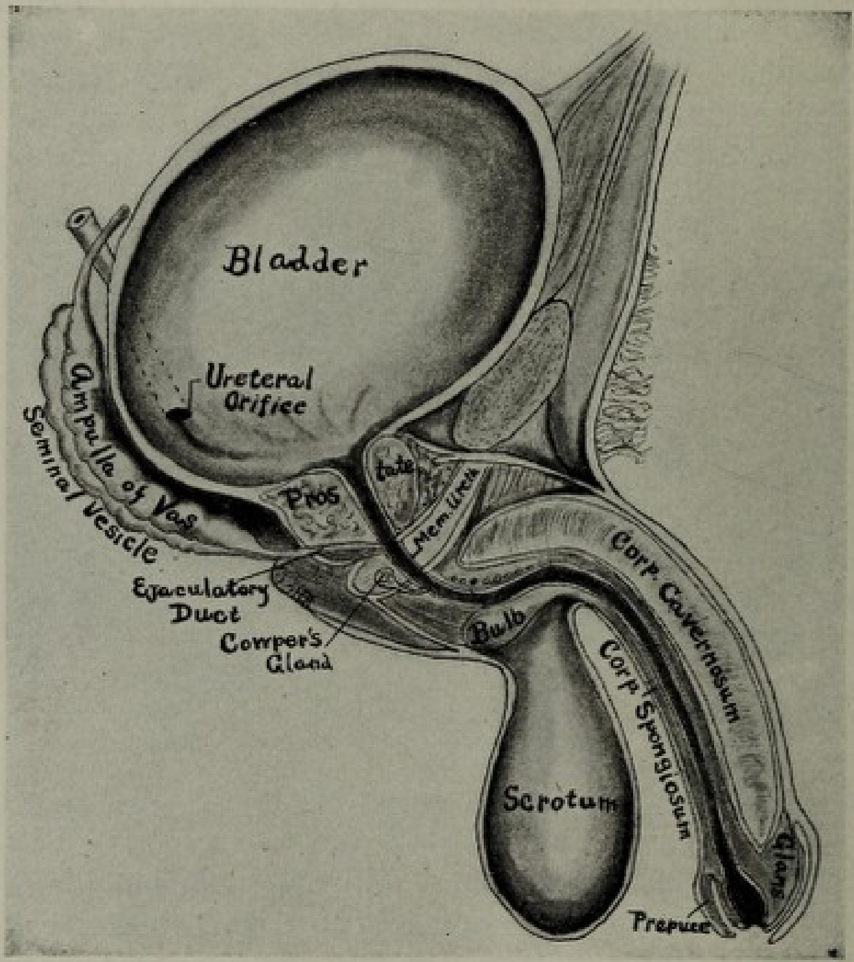


FIG. 234.—Median sagittal section through the bladder, prostate, urethra and penis of the male.

empty and contracted the bladder is almost spherical in shape. Its shape in the infant is somewhat conical. In the empty collapsed state, as in the cadaver, it is somewhat cup-shaped. When distended, it is about 5½ inches (14 cm.) in height, 4½ inches (11.5 cm.) in width and nearly 4 inches (10 cm.) dorsoventrally, and then extends into the abdominal cavity. In the female the width is greater and the dorsoventral dimension less. Its *capacity* is about 1 pint (500 to 700 c.c.) but is usually emptied when it contains 8 to 10 ounces (about 300 c.c.).

The bladder presents an *apex*, a *base*, a *superior* and *ventroinferior* and *two lateral surfaces* and illy defined *borders*.

The **apex** (*vertex vesicæ*) is best seen in the nearly empty bladder and lies just behind the symphysis pubis. From this the *urachus* extends to the umbilicus. The base (*fundus vesicæ*) is directed downward and backward (dorsally) and is partly in relation with rectum and seminal vesicles of the male and vagina of the female. It is partially invested by peritoneum. The *superior surface* is directed toward the abdominal cavity and its shape varies with the state of distention. It is invested with peritoneum. The *ventroinferior surface* is directed downward and forward (ventrally) and

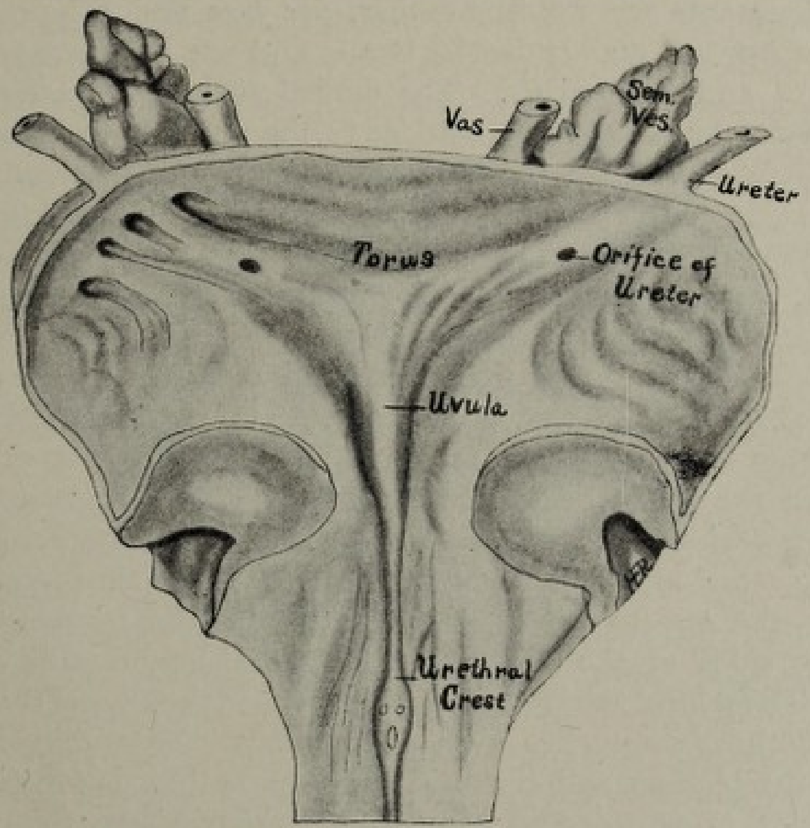


FIG. 235.—Bladder laid open showing the trigone.

when the bladder is distended it is partially invested with peritoneum. The so-called *neck* of the bladder is at the lowest part of the organ, at the junction of the base and ventroinferior surface. Here the urethra begins and it represents the most fixed part of the bladder. The lateral surfaces are directed downward and outward and meet in front at the urethral orifice. Each is partially invested with peritoneum.

When the empty contracted bladder is opened the mucosa exhibits **folds,** or **rugæ** except at the trigone. In the distended bladder these folds disappear. The **trigone** (*trigonum vesicæ*) is a triangular area at the neck; at the basal angles are the two ureteral orifices and at the apical angle is the urethral orifice. The sides are of equal length and measure about 1¼ inches (3 cm.) in the empty bladder and 1½ inches (3.75 cm.) in the distended condition. The **ureteral orifices** are usually guarded by small folds of the mucosa. Extending upward and outward from each ureteral orifice is seen a short ridge the *ureteral fold* (*plica ureterica*) formed by the ureter in its oblique course through the bladder wall. Connecting the ureteral orifices is another fold (basal side of the trigone) the *interureteral fold* (*torus ureterica*), extending from the middle of the fold across the trigone, and on into the urethra, is a ridge the *uvula of the bladder* (*uvula vesicæ*).

The **ligaments** are *ten* in number, *five true* and *five false*. The *true ligaments* are mainly fascial bands and are the *two ventral*, the *two lateral* and the *middle*. The *ventral ligaments* (*puboprostatic*) extend from the neck of the bladder to the prostate gland and then to each side of the symphysis pubis. The *lateral ligaments* extend from the side of the bladder and prostate gland to the lateral walls of the pelvis. The *middle*, or *umbilical ligament* (*lig. umbilicales medium*), consists of the impervious *urachus* and extends from the summit of the bladder to the umbilicus.

The *false ligaments* are peritoneal folds and are *five* in number, *two dorsal*, *two lateral* and *one ventral*. The *dorsal false ligaments* extend from the dorsolateral region of the bladder to the side of the rectum in the male; between the two there is a depression called the *rectovesical pouch*. In the female these ligaments extend from the dorsolateral region of the bladder to the sides of the uterus bounding thus, the *uterovesical pouch*. The *lateral false ligaments* extend from the sides of the bladder to the lateral pelvic walls and iliac fossæ. The *ventral false ligament* extends from the apex of the bladder to the umbilicus and lies over the urachus. Extending from the sides of the bladder and converging at the umbilicus are two additional folds of peritoneum that cover the two impervious hypogastric, or umbilical arteries. These folds are the *plicæ umbilicales laterales* and the impervious arteries are sometimes referred to as the *round ligaments* of the bladder.

The *arterial supply* of the bladder is from the superior, middle and inferior vesical arteries in the male; in the female other branches are received from the uterine and vaginal arteries. The *veins* carry the blood to the tributaries of the hypogastric veins and anastomose with the pudendal venous plexus.

The *lymphatics* are few and empty into the intern aliliac, hypogastric and sacral nodes.

The *nerves* are from the third and fourth sacral cerebrospinal nerves through the vesical plexus and from the upper lumbar nerves through the hypogastric plexus.

THE URETHRA

The urethra varies in the male and female. The **female urethra** (*urethra muliebris*) is about 1½ inches (3.75 cm.) in length extending from the neck of the bladder (*orificium urethræ internum*) to the *external urinary meatus* (*orificium urethræ externum*) in the vestibule. It may be dilated to about ¼ inch (6 mm.) and lies imbedded in the ventral wall of the vagina. It is directed downward and forward.

The **male urethra** (*urethra virilis*), 7 to 8 inches (17.5 to 20 cm.) in length, extends from the neck of the bladder to the end of the penis. It consists of *three parts*, *prostatic*, *membranous* and *penile* portions. The *prostatic portion* (*pars prostatica*) is about 1 inch (2.5 cm.) in length and courses through the prostate from its base to its apex. It presents the most dilated part of the urethra; its greatest caliber is 12 mm. Upon its dorsal wall or floor is seen a ridge the *urethral crest* (*crista urethralis*) which represents a continuation of the uvula of the bladder. The middle part of this ridge is slightly thickened and shows a depression in the center, the *sinus pocularis* (*utriculus prostaticus*) upon each side of which is to be seen the opening of the *ejaculatory duct*. At each side of the crest is a linear depression, the *prostatic sinuses*, into which open the prostatic ducts.

The *membranous portion* (*pars membranacea*) is about ½ inch (12 mm.) in length and lies beneath the symphysis pubis. It is firmly fixed in position and not easily dilated. Its caliber is about 8 mm.; its distal part has thin walls and is the part that is most liable to rupture.

The *spongy*, or *penile portion*, is about 6 inches (15 cm.) in length and lies in the spongy portion of the penis and glans penis. Its caliber is about 9 mm. except near the end where it is dilated to from 12 to 14 mm., the *fossa navicularis*. Its termination is called the *external urinary meatus* (*orificium urethræ externum*) and represents a vertical slit about ¼ inch (6 mm.) in extent.

CHAPTER IX

THE MALE ORGANS OF REPRODUCTION

The male organs of reproduction comprise the **two testes, two vasa deferentia, two seminal vesicles, two ejaculatory ducts, a prostate, two glands of Cowper,** the **penis** and the **scrotum.**

TESTES

The testes, two in number, lie in the scrotum. The **scrotum** is a pouch-like structure of skin at the dorsal side of the root of the penis.

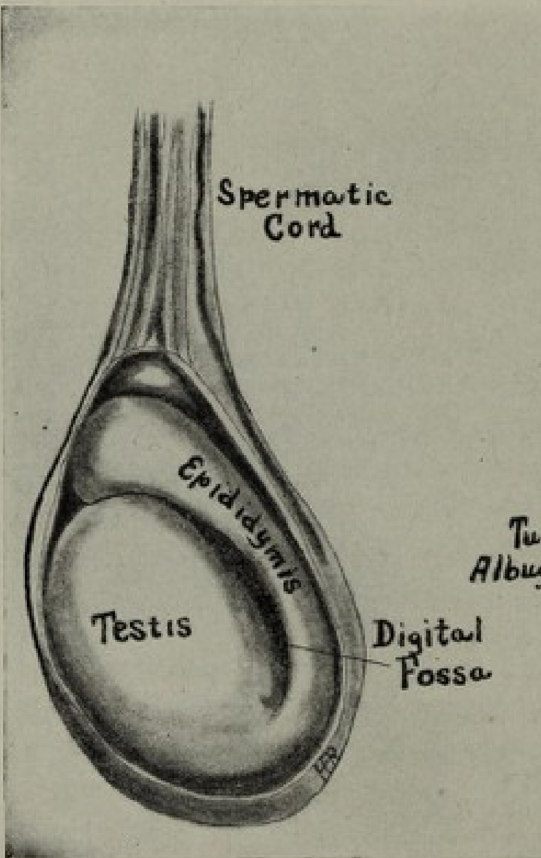


FIG. 236.—The left testis in situ with the tunica vaginalis partly removed.

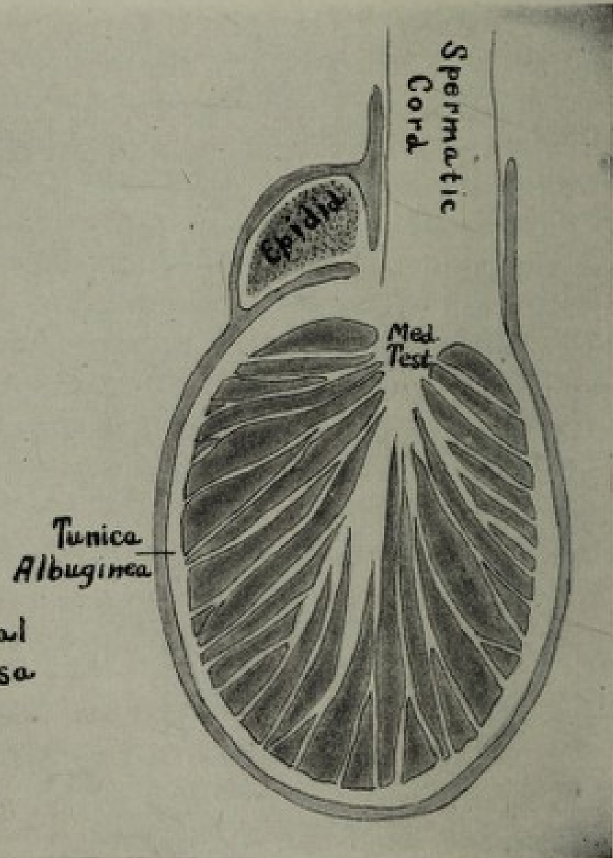


FIG. 237.—Frontal section of testis, epididymis and spermatic cord.

It is divided into *two compartments* by a *septum* (*septum scroti*) which corresponds to the ridge, or *raphé* upon the outside. Internally each compartment is lined by a serous membrane, the *parietal layer of the tunica vaginalis testis*. This was derived from the peritoneum during intrauterine life. Between the serous membrane and skin is the *dartos* (*tunica dartos*) which contains some smooth muscle tissue.

Each **testis** occupies a compartment and is suspended by the spermatic cord. Each organ is about 1½ to 2 inches (4 to 5 cm.) in length, 1¼ inches (3 cm.) dorsoventrally and 1 inch (2.5 cm.) in width. It weighs about 1 ounce (30 grams) and its parenchyma is yellowish in color. The long axis is directed forward, upward and outward.

The testis presents *two surfaces*, *two borders* and *two poles*. The *lateral* (*fascies lateralis*) and the *medial* (*facies medialis*) *surfaces* are convex and smooth. The *ventral border* (*margo ventralis*) is convex and free. The *dorsal border* (*margo dorsalis*) is somewhat flattened and has the epididymis attached to it. The *superior pole*, or *extremity* is rounded and to it is attached the head of the epididymis; to the *inferior pole*, or *extremity* and lower part of the dorsal border is attached the *gubernaculum* that connects the testis to the scrotum. The testis is invested by the *tunica vaginalis testis* except along the dorsal border where the epididymis is attached. Along the outer side of the organ the serous tunic passes in between the testis and epididymis forming the *digital fossa* (*sinus epididymi*).

The **epididymis** consists of the *head* (*caput epididymis*), the *body* (*corpus epididymis*) and the *tail* (*cauda epididymis*). The *head* and *tail* are attached to the testis by the *superior* and *inferior epididymal ligaments*. At the head the excretory ducts of the testicle enter and form that portion of the epididymis. The *body* and *tail* portions consist of the convolutions of one tubule; if this tubule be straightened it would measure about 20 feet in length.

The **spermatic cord** (*funiculus spermaticus*) suspends the testicle in the scrotum and serves as pathway for vessels, nerves, lymphatics and the vas. It consists of numerous vessels, white fibrous tissue and some muscle tissue, the *cremaster muscle*. It contains the vas, the spermatic, cremasteric and deferential arteries, the pampiniform plexus of veins, nerves and lymphatics. It extends from the back of the testis through the so-called inguinal canal to the internal abdominal ring, measuring about 5 inches (12.5 cm.) in length.

The *artery of the testicle* is the spermatic artery, that is, a branch of the abdominal aorta. The *venous channels* form the internal spermatic vein which then forms a complicated plexus upon the spermatic cord, the *pampiniform plexus*. This plexus reforms the spermatic vein that enters the abdomial cavity at the internal abdominal ring; the right one empties directly into the inferior vena cava while that of the left side empties into the left renal vein.

The *nerves* are derived chiefly from the tenth thoracic nerve through the spermatic plexus of the sympathetic system.

THE VAS DEFERENS

The vas deferens (*ductus deferens*) the continuation of the epididymis, is about 18 inches (45 cm.) in length, but the first 6 inches are coiled in a small area at the end of the epididymis. The vas, one on each side, joins the spermatic cord and continues in this through the inguinal canal to the internal abdominal ring; here it enters the abdominal cavity and continues into the pelvic cavity, passes to the under surface of the bladder and near the prostate gland is it joined by the seminal duct. Near its end it dilates constituting the *ampulla* (*ampulla ductus deferens*). It then becomes smaller and joining the seminal duct forms the ejaculatory duct.

THE SEMINAL VESICLES

The seminal vesicles (*vesciculæ seminales*) are two rather wide, convoluted tubes beneath the base of the bladder. Each is about

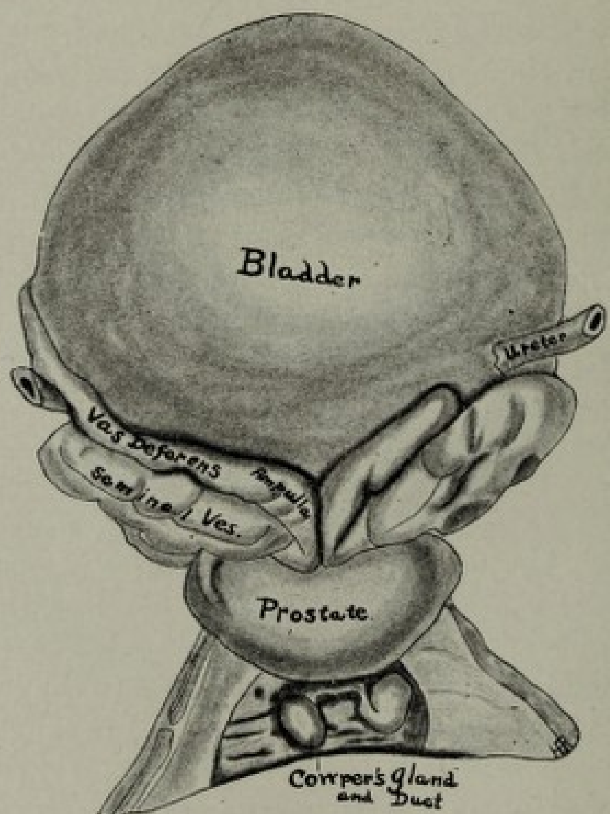


FIG. 238.—Dorsal view of distended bladder and neighboring organs of reproduction of the male.

2½ inches (6 cm.) in length, 10 mm. in breadth and 5 mm. in thickness. If straightened each would measure about 5 inches (12.5 cm.) in length. The **duct** (*ductus excretorius*) is short and joins the vas to form the ejaculatory duct.

The **ejaculatory duct** (*ductus ejaculatorius*) is about ¾ inch (18 mm.) in length and enters the prostate gland near the inferior basal angle, converges with its fellow of the opposite side to the dorsal wall of the urethra where each empties upon the urethral crest.

THE PROSTATE

The prostate gland (*prostata*) is a pyramidal-shaped organ situated at the so-called neck of the bladder. It is of a dark red color and

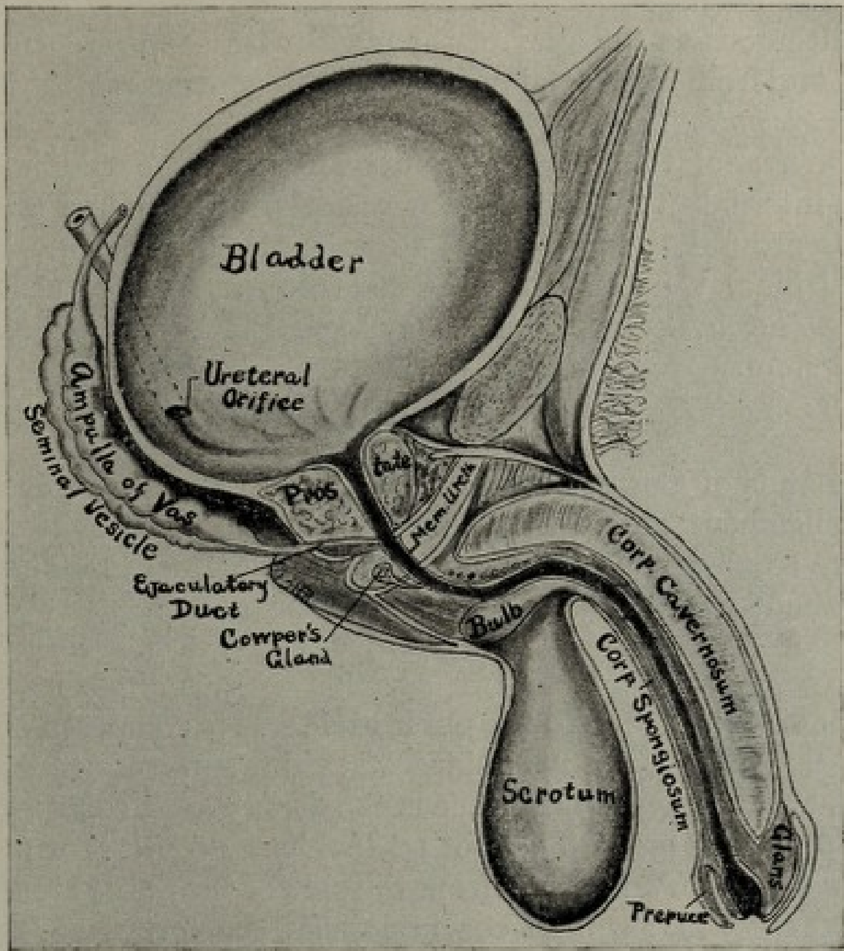


FIG. 239.—Median sagittal section through the bladder, prostate, urethra and penis of the male.

musculoglandular in structure. It is about 1½ inches (3.5 cm.) wide, 1 inch (2.5 cm.) thick and 1¼ inches (3.5 cm.) high. It weighs about ½ ounce (15 grams.)

It consists of *apex, base, ventral, dorsal* and *lateral surfaces*. The *apex* (*apex prostatæ*) is directed downward and forward and rests upon the deep layer of the urinogenital diaphragm. The *base* (*basis prostatæ*) is directed upward and backward and is in contact with the bladder. Near the middle of the base the urethra enters the organ and courses through it to the apex. At the inferior angles of the base the ejaculatory ducts enter the organ and converge at the urethra. That portion of the prostate between these ducts and the urethra constitutes the *so-called middle lobe of the prostate.*

The *dorsal surface* (*facies posterior*) is in contact with the rectum. *The ventral surface* (*facies anterior*) is directed toward the symphysis pubis and is connected to it by the two puboprostatic ligaments. The *lateral surfaces* (*facies laterales*) are in contact with the levatores ani muscles with only a venous plexus intervening.

The visceral layer of the pelvic fascia invests the prostate upon its lateral and dorsal surfaces; this is called the *sheath of the prostate.* It is continuous at the apex of the gland with the urinogenital diaphragm and from its ventral part two bands continue to the pubis as the *puboprostatic ligaments.*

The *arteries* of the prostate are derived from the middle hemorrhoidal, internal pudic and inferior vesical arteries. The *veins* form a plexus around the gland and then empty into the hypogastric (internal iliac) veins. In elderly male these veins are usually enlarged. The *nerves* are from the hypogastric plexus of the sympathetic system.

COWPER'S GLANDS

The glands of Cowper are located between the layers of the triangular ligament and their ducts empty into the penile urethra. They are small organs about 6 to 8 mm. in diameter. The *duct* of each is about 1 inch (2.5 cm.) in length.

THE PENIS

The penis is attached to the pubic arch. It is composed chiefly of erectile tissue. In the pendulous state the surfaces are *under*, or *urethral*, and the opposite surface is the *dorsum.* It consists of *root, body* and *glans penis.* The **root** (*radix penis*) consists of *two crura* and a *bulb.* Each *crus* arises from the side of the pubic arch, gradually increasing in size and continuing as the corpus cavernosum. Each crus is surrounded by the ischiocavernosus muscle and converges to meet its fellow at the midline. The *bulb* (*bulbus urethræ*) is the beginning of the corpus spongiosum and lies behind the point at which the urethra enters the corpus spongiosum.

The **body** (*corpus penis*) of the penis consists of *two corpora cavernosa* (*corpora cavernosa penis*) and the *corpus spongiosum* (*corpus cavernosum urethræ*). Each **corpus cavernosum** lies to the side of the midline of the organ in the dorsal part of the penis and consists of erectile tissue. The **corpus spongiosum** lies in a groove upon the under surface of the corpora cavernosa. It is traversed by the urethra and consists of erectile tissue. These three structures are surrounded by white fibrous tissue and the loose skin.

The **glans penis** is the continuation of the corpus spongiosum and is an expanded, cap-like structure that covers the ends of the corpora cavernosa, where its edge is raised forming the *corona glandis*. At its end is a slit-like orifice the *external urinary meatus*. On the glans the skin forms a free covering, or hood, the *prepuce* (*preputium*) that is attached to the glands beneath the urinary meatus by a delicate fold, the *frenulum* (*frenulum preputii*). From the fibrous capsule of

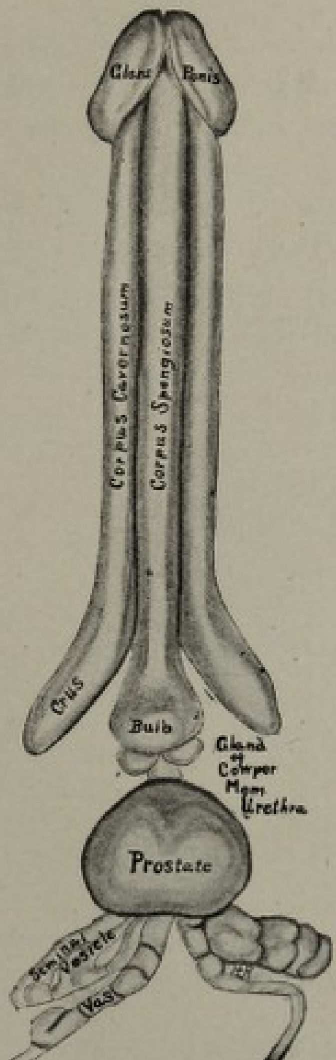


FIG. 240.—Male organs of reproduction (except testes).

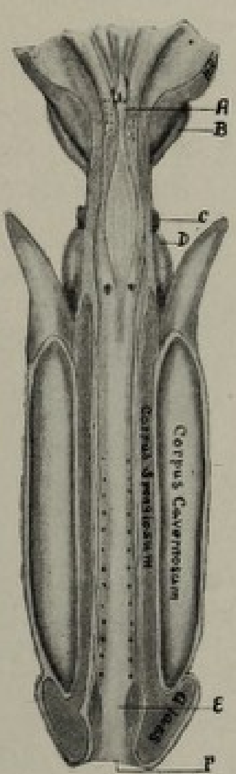


FIG. 241.—Male urethra laid open. *A*, Urethral crest; *B*, prostate; *C*, glands of Cowper; *D*, bulb; *E*, fossa navicularis; *F*, external urinary meatus.

the penis a triangular fold of fibrous tissue is attached to the symphysis pubis; it is the *suspensory ligament* (*ligamentum suspensorium penis*) of the penis. Between the capsule and the corpora cavernosa lie the dorsal vein and dorsal arteries of the penis.

The *arteries* that supply the penis are deep dorsal arteries and the artery to the bulb. The *veins* empty into the prostatic plexus or into the dorsal vein.

The *nerves* are from the pudenal nerve and hypogastric and pelvic plexuses of the sympathetic system.

CHAPTER X

THE FEMALE ORGANS OF REPRODUCTION

The female organs consist of the *two ovaries*, *two oviducts*, *uterus*, *vagina*, *internally*, and the *two glands of Bartholin*, the *vestibule*, *clitoris*, *hymen*, *two labia minora* and *two labia majora* and *mons veneris*, *externally*.

The **ovaries** lie at the side of the pelvic cavity in a little depression called the *ovarian fossa* (*fossa ovarica*). They lie behind the broad ligament of the uterus and are attached thereto. Each organ is about 1½ inches (3.75 cm.) long, ¾ inch (18 mm.) wide and ⅓ inch

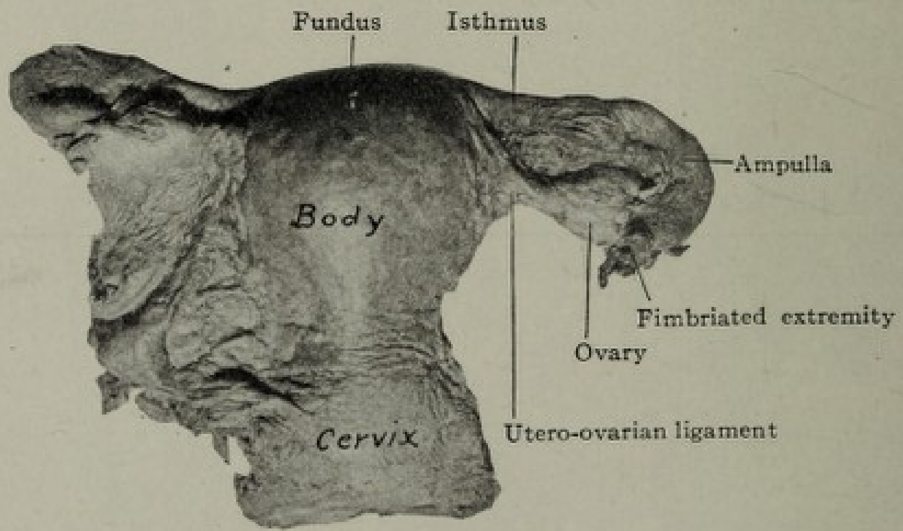


FIG. 242.—Dorsal view of the uterus and broad ligament showing oviducts and ovary. (*From a photograph.*)

(8 mm.) thick. It weighs about 4 to 8 grams. Each presents *two surfaces*, *two borders* and *two poles*. The long axis is directed downward (caudad) and medially.

The *pelvic*, or *lateral* (*facies lateralis*) and *visceral*, or *medial surfaces* (*facies medialis*) are convex and nodular; the latter condition is due to the projecting Graafian follicles, between the age of puberty and the menopause. The *dorsal border* (*margo liber*) is convex and free. The *ventral border* (*margo mesovaricus*) is not free and represents the attached border; it is connected to the broad ligament by a double sheet of peritoneum, the *mesovarium*. The *superior*, or *tubal pole* (*extremitas tubaria*) is rounded and covered by the fimbriated extremity of the oviduct; one of the largest fimbriæ is attached to the ovary and is called the *ovarian fimbria* (*fimbria ovarica*). The *inferior*, or *uterine pole* (*extremitas uterina*) is directed toward the uterus and is connected to it by a cylindric band of fibrous tissue, the *uteroovarian ligament* (*ligamentum ovarii proprium*). The ovary is connected to the lateral pelvic wall by a triangular fold of peritoneum, the *suspensory ligament* (*ligament suspensorium ovarii*) through which the vessels gain access to the ovary.

The **ligaments of the ovary** are the *mesovarium*, *suspensory*, *uteroovarian* and the *fimbria ovarica*.

The *arteries* of the ovaries are the ovarian from the abdominal aorta. These enter at the hilus with the branches of the uterine artery. The *veins* form first a plexus similar to the pampiniform plexus of the male, near the ovary, and then form the ovarian vein upon each side. The right one empties into the inferior vena cava while the left one empties into the left renal vein.

The *nerves* are from the ovarian plexus continuous with the renal and aortic plexuses of the sympathetic system; sensor fibers from the ovary pass through the dorsal root of the tenth thoracic nerve.

THE OVIDUCTS

Each oviduct (*tuba uterina*) is about 4 inches (10 cm.) long and extends from the ovary to the uterus. It is situated at the upper border of the broad ligament in the pelvic cavity and is not straight in course. Each consists of an *infundibulum*, the *ampulla* and *isthmus*.

The *infundibulum* (*infundibulum tubæ uterinæ*) or *fimbriated extremity* is funnel-shaped and fringed; this fringe constitutes the fimbriæ and one of these fimbriæ is attached to the ovary. Its opening (*ostium abdominale*) is about 2 mm. in diameter. The *ampulla* (*ampulla tubæ uterinæ*) is the longest, widest and most tortuous portion; its first part is hooked over the superior pole of the ovary. The *isthmus* (*isthmus tubæ uterinæ*), the narrowest part, is straight and horizontal in its course and ends at the lateral angle of the uterus. Its opening (*ostium uterinum tubæ*) is 1 mm. in diameter. It has a thick wall.

The oviduct is connected to the upper part of the broad ligament of the uterus by a thin band of peritoneum, the *mesosalpinx*. The tube is entirely invested with peritoneum.

The *blood supply* is from the ovarian and mainly the uterine arteries. The *veins* empty into the uterine and ovarian veins. The *nerves* are from the ovarian and uterine plexuses of the sympathetic system. Its sensor fibers enter the dorsal roots of the eleventh and twelfth thoracic and first lumbar nerves.

THE UTERUS

The uterus, or womb, is a muscular organ with a very small cavity. It is situated in the pelvic cavity. It is of a flattened pear-shape and its walls are very thick. Its position varies with the position of the body and the state of the bladder and the rectum. It measures (in the virgin) 3 inches (7.5 cm.) in length, 2 inches (5 cm.) in width and 1 inch (2.5 cm.) in thickness. In the virgin it weighs about 1½ ounces (45 grams) and in those that have borne children about 2½ ounces (75 grams). It consists of *fundus, body, cervix* and *lateral border.*

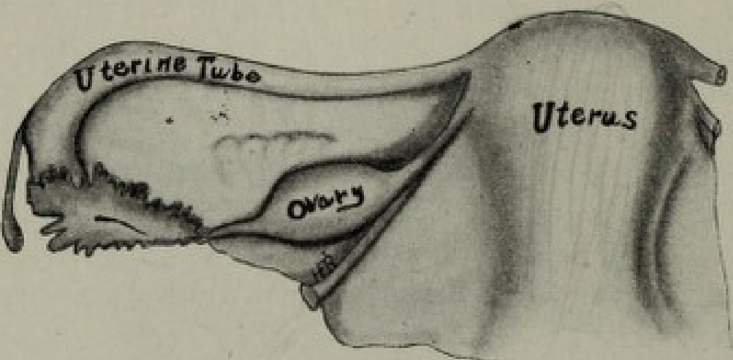


FIG. 243.—Dorsal view of the uterus and left half of the broad ligament.

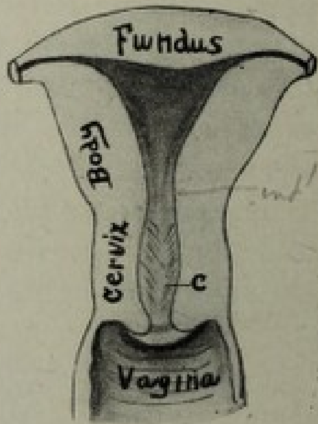


FIG. 244.—Frontal section through the uterus showing its cavity (diagrammatic). *C,* Plicæ palmatæ.

The **fundus** (*fundus uteri*) is the upper, broad and convex extremity above the level of the openings of the oviducts and represents about ½ inch of the length. The **body** (*corpus uteri*) is somewhat triangular in shape, broad above and narrower below. Its *ventral surface* (*facies vesicalis*) is flattened while the *dorsal surface* (*facies intestinalis*) is convex. At the sides the broad ligaments of the uterus are attached. It represents about 1½ inches of the length of the uterus. The **cervix,** or *neck* (*cervix uteri*) about 1 inch in length, is cylindrical in shape. It connects the body of the uterus with the vagina. The lower end projects into the vagina and constitutes the *vaginal portion* (*portio vaginalis*), while the upper end is called the *supravaginal part* (*portio supravaginalis*).

The **cavity** of the uterus when seen from the side represents a mere slit. Viewed from the front, that part in the body is triangular in outline and the cervical portion (canal) is spindle-shaped. The upper end of the *cervical canal* (*canalis cervicis uteri*) represents the *internal os* (*orificium internum uteri*) while the vaginal end represents the *external os* (*orificium externum uteri*). The mucosa of the cervical canal shows a large number of oblique folds, the *plicæ* *palmatæ*, while the mucosa in the body is smooth. The mucosa at the external os is usually pouched forming the *ventral* and *dorsal lips* (*labium anterius et labium posterius*. The fundus, the ventral surface of the cervix and the entire dorsal surface and cervix are invested with peritoneum.

The *lateral border* (*margo lateralis*) separates the two surfaces and here the broad ligament is attached.

The uterus is supported by a number of **ligaments.** The *two broad ligaments* (*ligamenta lata uteri*) extend from the side of the uterus to the lateral pelvic wall and are covered by the peritoneum. From the free edge of each extends the mesosalpinx. Each *round ligament* (*ligamentum teres uteri*) extends from the junction of the oviduct and the fundus, under the peritoneum, to the internal abdominal ring; from here it passes through the inguinal canal and is lost in the tissues of the labium majus. The *two ventral*, or *uterovesical ligaments*, extend from the uterus to the bladder. The *two dorsal ligaments*, or *rectovaginal folds*, extends from the uterus and vagina to the rectum. The *uterorectal folds* (*plicæ rectouterinæ*) extend from the uterus to the rectum and contain the *uterosacral ligaments*.

The position of the uterus varies with the position of the body and the condition of the neighboring organs. In a ventral view it is seen bent usually toward the right side; in the erect position, when the bladder is empty, the uterus usually rests upon the bladder and is then bent forward and downward on the cervix so that the axis of the organ is not a straight line. This is called *anteflexion*. If the uterus as a whole is tilted forward it constitutes *anteversion;* as the bladder fills the uterus becomes more erect. When the bladder is full and the rectum empty the organ may be bent backward and be either *retroverted*, or *retroflexed*.

The **parametrium** is that rather thick layer of loose tissue between the two layers of peritoneum of the broad ligament, below the level of the mesosalpinx. Where the broad ligament joins the pelvic diaphragm will be found the ureter and the uterine vessels. Below these vessels the fibrous and muscle tissue form the *lateral cervical ligament*, on each side.

In the female *at birth* the cervical portion of the uterus predominates and the plicæ extend through the cavity. The organ grows slowly until just before puberty when it rapidly increases in size and the plicæ in the body disappear. In old age the uterus becomes harder and paler.

During the child-bearing period the uterus undergoes periodic changes, called *menstrual changes*. The menstrual flow recurs every twenty-eight days.

The *arteries* of the uterus are the uterine and ovarian arteries, the branches of which form an extensive anastomosis.

The *veins* form a plexus that empties into the tributaries of the internal iliac veins.

The *nerves* are derived from the uterovaginal plexus connected with the hypogastric and vesical plexuses of the sympathetic system and branches are received from the third and fourth sacral nerves.

THE VAGINA

The vagina is a flattened, musculomembranous tube that connects the external genitalia with the uterus. Its ventral and dorsal walls are in contact and the cavity is a transverse or H-shaped slit that extends ventrodorsally. The *ventral wall* is about 3 inches (7.5 cm.) in length, while the *dorsal wall* is about 3½ inches (8.75 cm.) long.

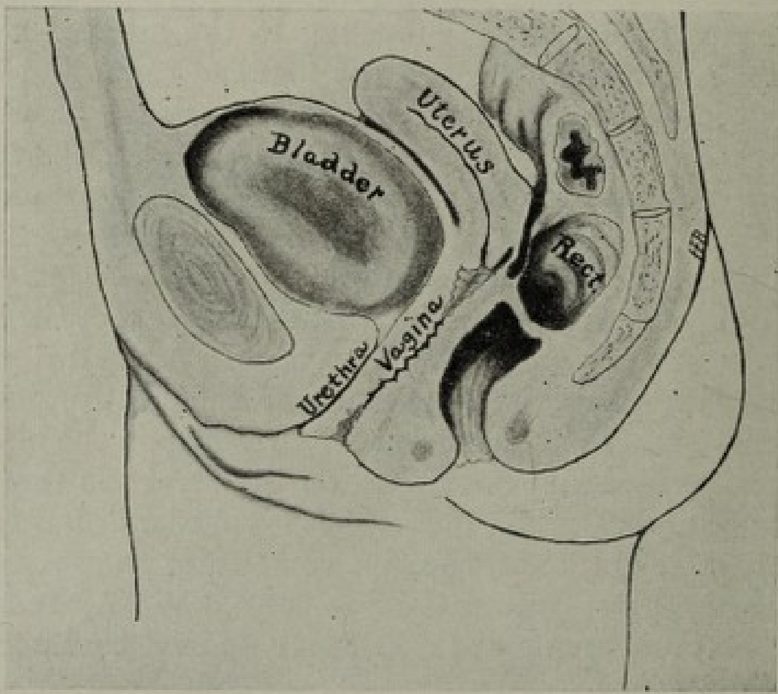


Fig. 245.—Median sagittal section of the female pelvis.

The cervix projects into the vagina and as a result the vaginal cavity projects around the end of the cervix, constituting the *ventral* and *dorsal fornices*, respectively; at the sides of the cervix are the *lateral fornices*. In the ventral wall lies the urethra.

The *arteries* are derived from the uterine, vaginal branches of the hypogastric (internal iliac) and branches from the internal pudendal and middle hemorrhoidal arteries. The *veins* form a dense plexus and empty into the hypogastric veins. The *nerves* are derived from the uterovaginal and vesical plexuses of the sympathetic system and from the third and fourth sacral nerves.

THE EXTERNAL GENITALIA

The external genitalia (*pudendum muliebre*) comprise the *mons veneris*, the *labia majora*, the *labia minora*, the *vestibule*, *clitoris*, *glands of Bartholin* and the *hymen*.

The **mons veneris** (*commissura labiorum anterior*) is the pad of fat covered with skin and hairs over the symphysis pubis.

The **labia majora** are two linear folds of skin extending from the mons veneris toward the anus. In the midline they lie in contact and this line of contact constitutes the *pudendal slit* (*rima pudendi*). The adjacent surfaces of the labia are covered by mucous membrane. Just in front of the anal region the folds are quite low and are connected by a transverse fold called the *posterior commissure* (*commissura labiorum posterior*).

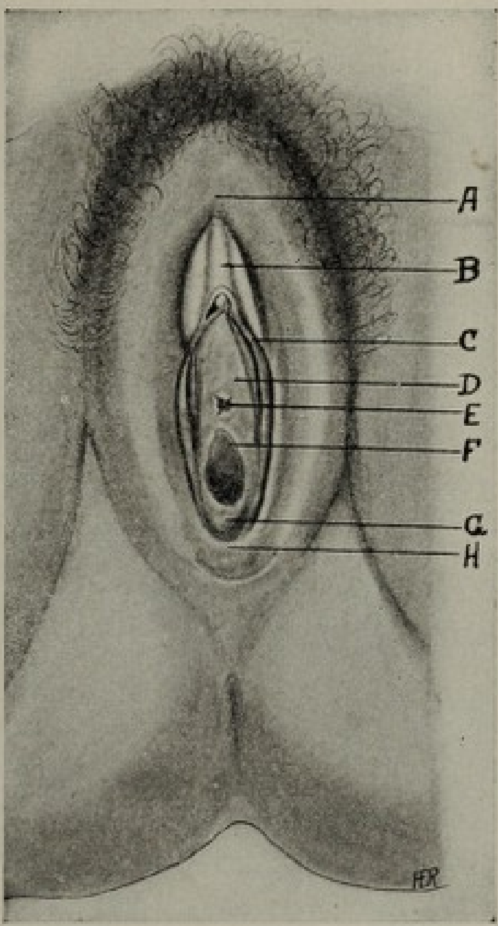


FIG. 246.—External organs of reproduction of the female. *A*, Anterior commissure; *B*, clitoris; *C*, labium minus; *D*, vestibule; *E*, urethral orifice; *F*, vaginal orifice; *G*, hymen; *H*, fourchette.

When the labia majora are separated two smaller folds, the **labia minora** are exposed. At their pubic extremities they are united and surround the clitoris, forming its *prepuce* (*preputium clitoridis*) and *frenulum* (*frenulum clitoridis*); anally they diverge and fuse with labia majora. Near this region a transverse fold, the *fourchette* (*frenulum labiorum pudendi*) connects the labia minora and forms the posterior boundary of the vaginal orifice. The depression between the fourchette and dorsal commissure is the *fossa navicularis*. The long triangular area between the labia minora is the **vestibule** (*vestibulum vaginæ*). Here are seen the vaginal and urethral orifices and the opening of the ducts of the vestibular glands.

The **vaginal orifice** (*orificium vaginæ*) is the larger and occupies the dorsal part of the vestibule or basal part of the triangle. Between the orifice of the vagina and the converged labia minora (pubically) is a triangular area near the middle of which is seen the *urethral orifice* (*orificum urethræ externum*). Upon each side of the vaginal orifice, beneath the mucous membrane and extending to the clitoris region, is a bulb-like mass of erectile tissue, the *bulbus vestibuli*.

The **hymen** is a variable fold of tissue which tends to cover the vaginal orifice. It is usually crescentic in shape but may be absent.

The **glands of Bartholin** (*glandulæ vestibularis majores*) are in relation with the triangular ligament and their ducts empty into the space between the vaginal orifice and the labia minora. Each is elongated and about the size of a bean. They represent the glands of Cowper of the male.

The **clitoris** is the analog of the penis minus a corpus spongiosum. It arises by *two crura* from the sides of the pubic arch and these continue as the *corpora cavernosa clitoridis* that meet and form the *body of the clitoris* (*corpus clitoridis*); this is connected to the symphysis

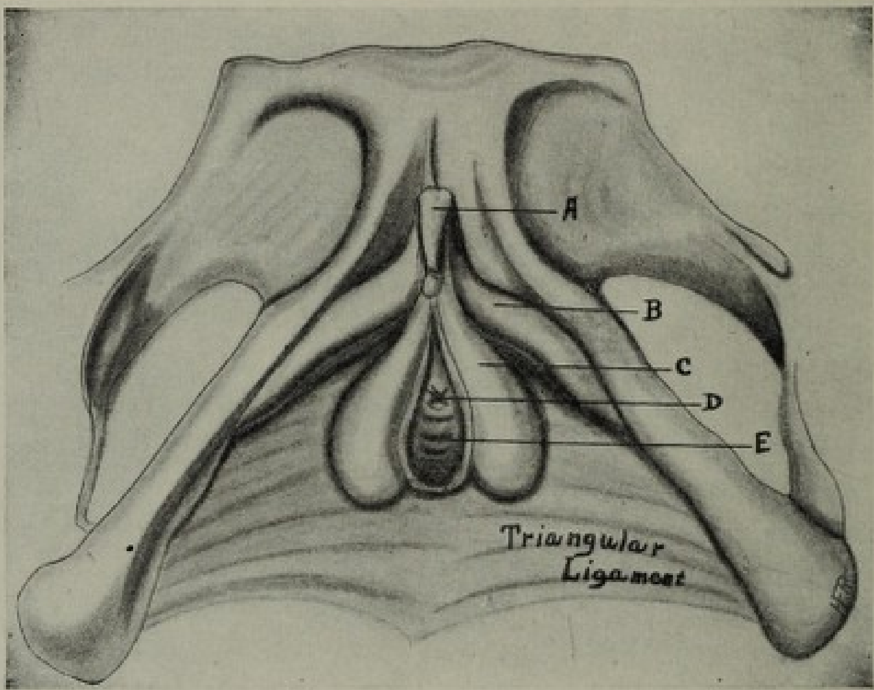


FIG. 247.—Female perineum dissected. *A*, Clitoris; *B*, crus of the clitoris; *C*, bulb of the vestibule; *D*, urethral orifice; *E*, vagina.

by a *suspensory ligament* (*ligament suspensorium clitoridis*). At the end of the body is a small rounded mass of erectile tissue the *glans clitoridis*, that is very sensitive. The glans is covered by, the *prepuce* (*preputium clitoridis*) derived from the labia minora. The body of the clitoris is about 1⅛ inches (3 cm.) long.

Arteries—The artery of the *clitoris* is the deep artery of the clitoris from the internal pudendal. Its *nerves* are derived from the hypogastric plexus of the sympathetic system and the internal pudic nerve. The *glans* is supplied by the dorsal artery of the clitoris. The *bulbus vestibuli* is supplied by the artery of the bulb from the internal pudendal artery. The *nerves* are from the hypogastric plexus and branches from the pudendal nerves.

THE MAMMARY GLANDS

The **mammary glands** (*mammæ*) although not directly connected with the reproductive organs are best considered here as they are accessories. Each is a hemispherical mass in the superficial fascial of the upper, ventral thoracic wall, extending, usually, from the second to the sixth rib. Each is surmounted by a *nipple* (*papillæ mammæ*) which is of variable size and shape; it is usually in the lower, outer quadrant of the gland. The nipple is darker in color than the gland proper and is surrounded by a circular area of darkened skin. This area is the *areola*. The amount of pigment in the areola and nipple varies. On the summit of the nipple are seen small depressions into which the milk ducts empty. During lactation the organ consists mainly of glandular tissue and is firmer and larger than in the non-

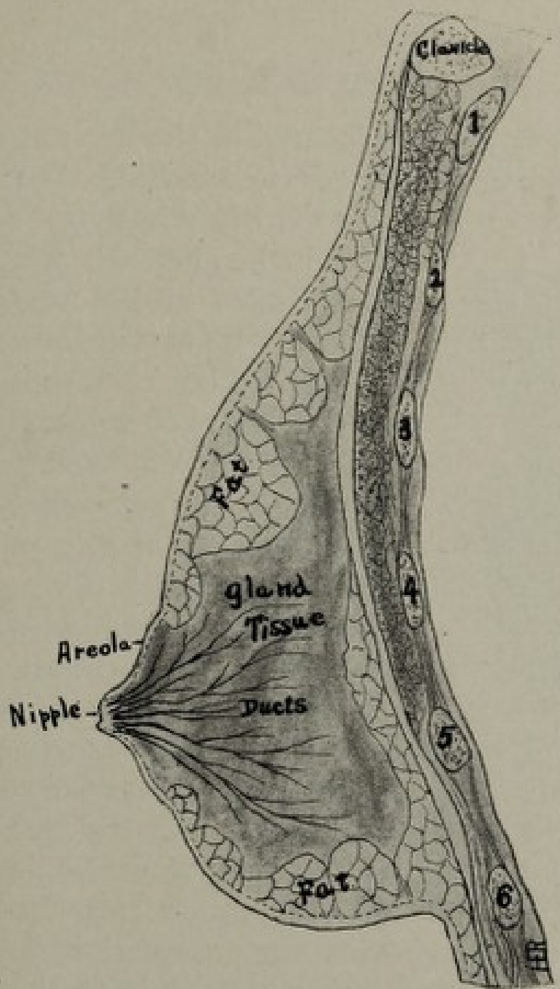


FIG. 248.—Sagittal section of the mammary gland through the nipple.

lactating period. During this latter period the glandular tissue is reduced to a minimum and the organ consists chiefly of adipose and white fibrous tissues and gland ducts. In early childhood there is very little or no difference between the mammæ of the male and female. Toward the age of puberty, in the female, the mammæ begin to grow rapidly.

The *arteries* of the mammary gland are the internal mammary artery and branches from the lateral thoracic and intercostal arteries. The *veins* empty the blood into the internal mammary and axillary veins. The *nerves* are from the thoracic sympathetics and from the fourth, fifth and sixth intercostal nerves.

CHAPTER XI

THE DUCTLESS GLANDS

The ductless glands comprise the *spleen*, *thymus*, *thyreoid*, *parathyreoids*, *adrenals*, *carotid bodies*, *coccygeal body*, *parasympathetic bodies*, *pituitary* and *pineal bodies*.

THE THYREOID BODY

The thyreoid body, or gland is located in the neck at the sides of the larynx and over the upper part of the trachea. It weighs about 25 grams and measures 2 inches (5 cm.) in width and 2.4 inches (6 cm.) in height. It consists of *two lateral lobes* and a *middle lobe*, or *isthmus*. This is not always the case as it may be horseshoe-shaped, or have the form of a notched sphere, or may be in two distinct parts. Each *lateral lobe* is somewhat conical in shape, its apex resting upon the side of the ala of the thyreoid cartilage and the base extending down to the fifth or sixth tracheal ring. The *isthmus* is a narrow band of glandular tissue that connects the two lateral lobes across the second, third and fourth of the trachea rings. Occasionally a *pyramidal lobe* (said to occur in 40 per cent.) is seen extending upward from the upper margin of the isthmus. Being firmly attached to the underlying structures the thyreoid follows the larynx in its movements.

FIG. 249.—Thyreoid gland, ventral view. (*From a photograph.*)

The **arteries** are the superior and inferior thyreoid arteries. The superior and middle thyreoid *veins* empty into the internal jugular vein of each side; the inferior thyreoid vein joins its fellow of the opposite side to empty into the left innominate vein.

The **nerves** are derived from the middle and inferior cervical ganglia of the sympathetic system.

THE PARATHYREOIDS

The parathyreoids are usually four in number, *two superior* and *two inferior*, although as many as twelve may be present. Each weighs from 0.01 gram to 3 grams and is about ¼ inch (6 mm.) in length and about ⅛ inch (3 mm.) in diameter. They are yellowish brown in color and may be lenticular, or nearly spherical in shape. The *superior* are behind the lateral lobes of the thyreoid body at the level of the lower border of the cricoid cartilage. The *inferior* are variable in position and may be found behind the lower part of the lateral lobes and at a distance below. Each is supplied by a branch from the inferior thyreoid artery.

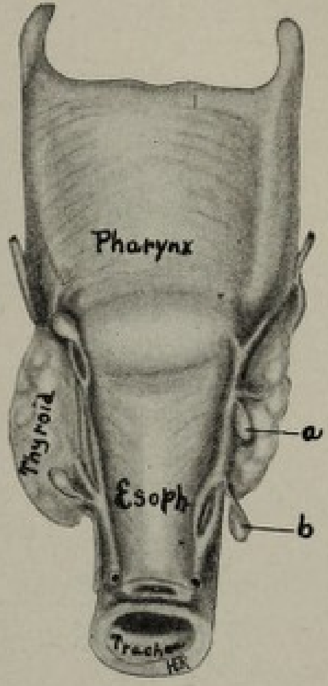


FIG. 250.—Dorsal view of the parathyreoids and the neighboring organs. *a*, *b*, right superior and inferior parathyreoids, respectively.

CHROMAPHYL SYSTEM

A number of small organs in the body stain peculiarly when treated with chromium salts; they secrete adrenalin and are classed under the *chromaphyl system*. The *adrenals* are the largest and the others comprise the *carotid bodies*, *aortic bodies* and *paraganglia;* all are closely associated with the sympathetic system.

THE ADRENALS

The adrenals, or suprarenal glands (*glandulæ suprarenales*) are two in number. Each is of a yellowish color externally, and darkish brown (chromaphyl tissue) internally. Each lies in the epigastric region and is in relation with the upper part of the kidney. Each organ weighs about 6 to 7 grams and measures 2 inches (5 cm.) in height, 1½ inches (3.75 cm.) in width and about ¼ to ½ inch (6 to 12 mm.) in thickness.

The **right adrenal** is *triangular* in outline and its base rests upon the superior extremity of the right kidney. Upon its ventral surface is seen a furrow, the *hilus*, at which the suprarenal vein emerges.

The **left adrenal** is *semilunar* in shape and its base rests upon the upper part of the medial border and a part of the superior extremity of the kidney. Upon its ventral surface is seen the *hilus*.

The adrenals are retroperitoneal.

The **arteries** are the suprarenal arteries from the aorta, and branches from the renal and inferior phrenic arteries. The *right suprarenal vein* empties into the inferior vena cava while the *left* empties into the left renal vein.

The **nerves** are derived from the suprarenal plexus and branches from the solar and renal plexuses of the sympathetic system and from the greater splanchnic, vagal and phrenic nerves.

CAROTID BODIES

The intercarotid bodies (*glomus caroticum*) are two small bodies structures situated at the bifurcation of each common carotid artery. Each is about the size of a grain of wheat (3 mm. by 1 mm.). Each is closely connected with the carotid sympathetics and is grayish-reddish brown, or yellowish in color.

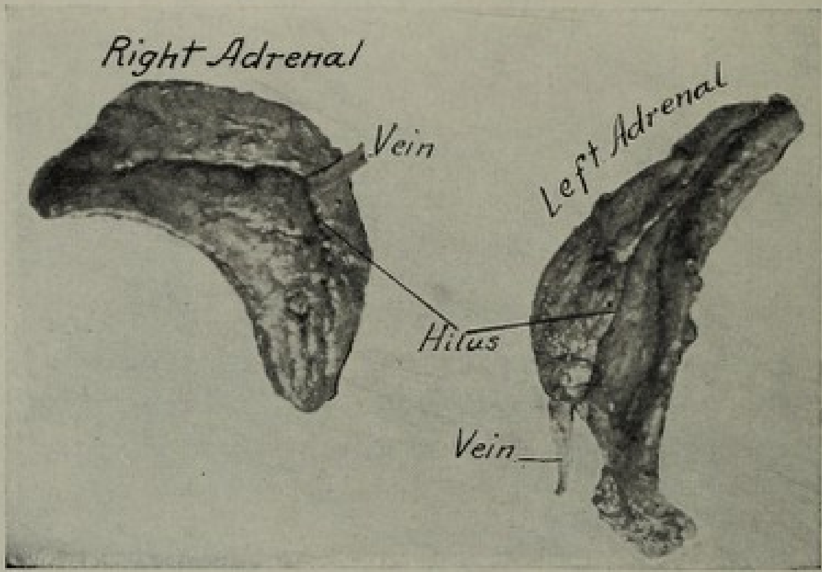


FIG. 251.—The adrenals, ventral view. (*From a photograph.*)

COCCYGEAL GLAND

The coccygeal gland is located in front of the tip of the coccyx and is smaller than the preceding gland. It is in close relation with the middle sacral artery.

PARASYMPATHETIC BODIES

The parasympathetic bodies (*aortic bodies*) are two to three in number and are seen in the fetus and in early childhood. They are retroperitoneal and are found in front of the aorta in the neighborhood of the third and fourth lumbar vertebræ at the origin of the inferior mesenteric artery. Their *blood supply* is from the aorta. Each is brownish in color, about 8 to 11 mm. long and 3 mm. in diameter.

The *pituitary body*, or *hypophysis* and the *pineal body*, or *epiphysis* will be described under the "*Nerve System.*" The *spleen* and *thymus* have already been described under the "*Lymphatic System.*"

CHAPTER XII

THE EYEBALL AND LACRIMAL APPARATUS

The eyeball and part of the lacrimal apparatus lie in each orbital fossa.

The **orbital fossæ** are pyramidal cavities on each side of the bridge of the nose and below the frontal bone, in the upper part of the face region. Each is about 2 inches (5 cm.) deep. The base, or orbital aperture is forward on the face while the apex is directed backward and medially and is represented by the optic foramen. It has a *roof*, *floor*, and *two walls*, a *lateral* and a *medial*. The bones that form the boundaries of each fossa are the frontal, lacrimal, ethmoid, sphenoid, malar, maxilla and palate bones. At the front of the orbit at the junction of the floor and medial wall is seen a groove, the *lacrimal fossa* (*fossa sacci lacrimalis*) and an opening extending into a bony canal. The fossa and opening lodge the *lacrimal sac*, while the bony canal is for the *nasal duct*. At the upper and inner portion of the front of the orbit is a spine, or a depression (*spina vel fovea trochlearis*) for the attachment of the pulley of the superior oblique muscle. In the temporal portion of the orbit is a depression wherein is lodged the *lacrimal gland*.

Within the orbit is lodged the eyeball, the muscles that operate it, the capsule of Tenon and the orbital fat, vessels and nerves.

The **capsule of Tenon** (*fascia bulbi*) is a lymph space of bursa wherein the eyeball moves as free from friction as possible. This is a double layer of serous membrane that covers the posterior portion of the eyeball and extends as far forward as the reflection of the conjunctiva. The layers are practically in apposition. It is pierced posteriorly by the optic nerve and continues thereon. It is likewise pierced further forward by the tendons of the ocular muscles and prolonged upon each in the form of a tubular sheath. That portion of the fascia under the eyeball is formed like a sling, or hammock and seems to support the eyeball and has, therefore, been called the *suspensory ligament*.

The **extrinsic muscles** are the *rectus superior*, *rectus inferior*, *rectus lateralis*, *rectus medialis*, *obliquus superior* and *obliquus inferior*. The *four recti muscles arise* from a tendinous ring around the optic foramen, the lateralis having two heads. These muscles pass forward and are *inserted* into the sclera at about 8 mm. from the corneoscleral junction. The superior and inferior recti are *inserted* into the vertical plane a little medial to the axis of the eyeball while the lateral and medial recti are *inserted* in the horizontal plane. The superior oblique, a digastric muscle, *arises* a little above and medial to the ring and passes forward to the upper and inner angle of the orbit to pass through the pulley and then turns outward between the superior rectus and the eyeball to be *inserted* into the sclera between the superior and lateral recti muscle midway between the cornea and optic nerve area, behind the equator of the eyeball.

The inferior oblique *arises* at the front of the orbit just lateral to the lacrimal fossa. It passes outward between the eyeball and the floor of the orbit, then upward between the lateral rectus and the eyeball to be *inserted* into the sclera between the lateral and superior recti muscles, a little further back than the superior oblique.

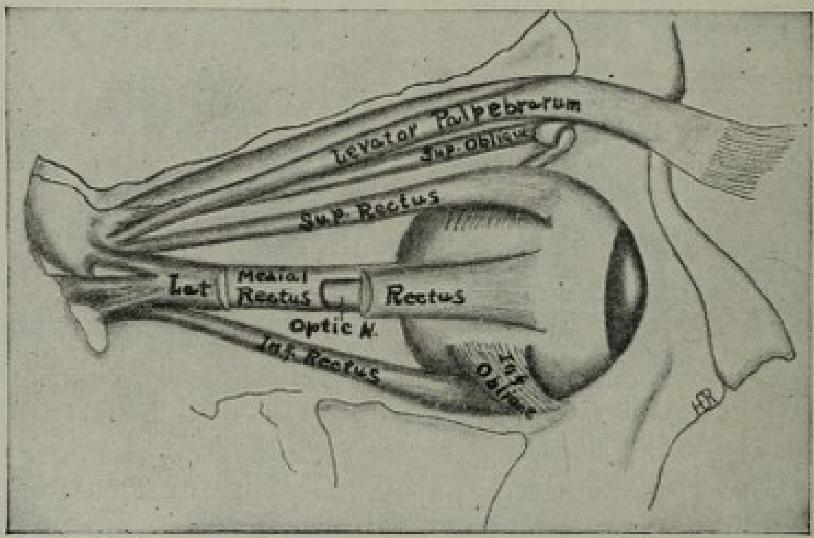


FIG. 252.—Muscles of the right orbit.

The lateral and medial recti muscles move the eyeball horizontally outward and inward. The superior rectus moves the eyeball vertically upward when assisted by the inferior oblique, while the inferior rectus moves the eyeball vertically downward when assisted by the superior oblique. The inferior oblique rotates the eyeball laterally, while the superior oblique rotates the eyeball medially.

The **orbital fat,** usually considerable, serves as a cushion for the eyeball. It varies in quantity in different individuals and in health and sickness. It fills in the orbital fossa around the eyeball and is most abundant behind that organ.

THE EYEBALL

The eyeball (*bulbus oculi*) occupies the anterior portion of the orbit being protected by the orbital margins and the eyelids. The antero-posterior and the transverse diameters are 24 mm. while the vertical diameter is 23.5 mm. so that the eyeball is not quite a sphere at the equator. At birth the eyeball is about 17.5 mm. in diameter and is nearly spherical in shape. It increases about 3 mm. between birth and puberty and soon thereafter attains its adult size and shape.

The apparent difference in the size of the eyeballs of different individuals is not due to a real difference in size but to a difference in the prominence of the eyeball and width of the palpebral fissure. When viewed from the side the eyeball is seen to consist of parts of two spheres. The smaller, anterior, corneal portion (about one-sixth) represents part of a sphere of 14 mm. diameter, while the larger, posterior portion (five-sixths), represents the greater part of

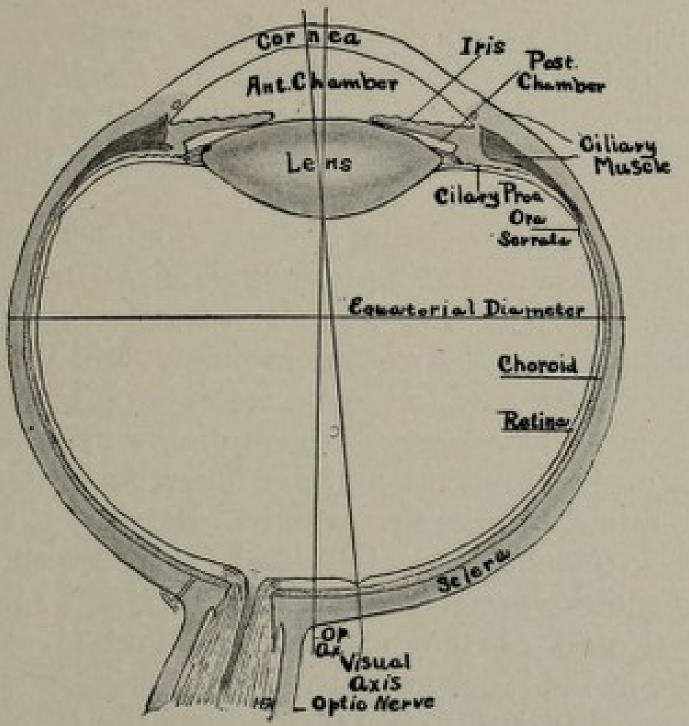


FIG. 253.—Horizontal section of the right eyeball.

a sphere of 24 mm. diameter. The *optic axis* is represented by a line connecting the anterior and posterior poles, that is the central points of anterior and posterior curvatures, respectively. The *equator* is the line around the eyeball midway between the poles. The *visual axis* is a line that passes from the first nodal point of the cornea to the fovea centralis of the retina.

The eyeball is called the organ of vision (*organon visus*). In reality it makes an image like a camera, while nerve impulses that are generated by the cells of the retina travel to the brain and these impulses are then translated into photic impressions.

The eyeball consists of *three coats*, or *tunics:* (1) the *corneoscleral* (*tunica fibrosa oculi*); (2) the *choroid*, *ciliary body* and *iris*, or the *uveal tract;* (3) the *retina*.

1. The **cornea** constitutes about one-sixth of the circumference of the eyeball and is transparent. It represents one of the important

refractive media of the eyeball. It is composed mainly of white fibrous tissue arranged in layers, covered externally by epithelium and internally by endothelium. It is thinner in the axial region (0.9 mm.) and at the corneoscleral region is about 1.2 mm. thick. The curvature is greater in youth than in old age.

The **sclera,** or white of the eyeball consists of about five-sixths of the circumference and is composed of dense white fibrous tissue. It is the protective coat and serves for the attachment of the ocular muscles. That portion of the sclera where the optic nerve passes out is sieve-like and is called the *lamina cribrosa*. Between the sclera and the capsule of Tenon is the *episcleral lymph space*. Between the sclera and the choroid is the *subscleral lymph space*. Besides being pierced by the optic nerve fila it is perforated by the posterior ciliary arteries and the venæ vorticosæ. It is thinnest at the equator.

2. The **uveal tract,** consisting of *choroid*, *ciliary body* and *iris*, is also called the *vascular coat* (*tunica vasculosa oculi*).

The **choroid** (*chorioidea*) is the most extensive of the three divisions. It lies between the sclera, externally, and the retina, internally and extends forward to the ora serrata. It is a loose coat and contains the large blood-vessel trunks of the eyeball, in its outer part, and a capillary plexus near its inner border. The pigment layer of the retina adheres firmly to it. Between it and the sclera is a meshwork (*lamina suprachorioidea*) covered with endothelium, constituting the *suprachoroidal*, or *subscleral lymph space*. It is the posterolateral part of the choroid coat that gives the peculiar *metallic reflex* of the lower animals.

The **ciliary body** (*corpus ciliare*) comprises the *ciliary ring*, *ciliary muscle* and the *ciliary processes*. The *ciliary ring* is indicated upon the outside of the eyeball by a 4-mm. area encircling the eyeball at the edge of the cornea. It is mainly fibrous tissue supporting the blood-vessels of that region.

The *ciliary processes* (*processes ciliares*) are sixty to seventy radially placed ridges that start at the end of the choroid and extend to the base of the iris where they end abruptly at about 1 mm. in height, They vary in length from 2 to 5 mm. and they are not all of the same height. They contain blood-vessels and are covered by the pigmented layer of the retina (*pars ciliaris retinæ*).

The *ciliary muscle* (*m. ciliaris*) consists of smooth muscle and is arranged chiefly in two sets, *radial* and *circular*. The *radial fibers arise* at the corneoscleral junction, radiate backward to be *attached* to the processes and ciliary ring. They constitute the *tensor chorioideæ muscle*. These fibers are usually the more numerous. The *circular fibers* lie under the radial fibers near the base of the iris. These muscles are part of the intrinsic muscles of the eyeball.

The **iris** is the *automatic curtain* of the eyeball regulating the amount of light that enters the organ. In its center is the *pupillary aperture* which varies in size under varying amounts of light. The iris consists mainly of white fibrous tissue, covered anteriorly by endothelium and posteriorly by the pigmented layer of the retina (*pars iridica retinæ*). It contains two sets of smooth muscle, one, the *circular fibers*, arranged circularly near the pupillary aperture. This is called the *sphincter pupillæ muscle*, for by contraction it diminishes the pupillary aperture. The second set or *radial fibers* extend outward from the circular fibers to the base of the iris and constitute the *dilatator pupillæ muscle*, for by contraction they increase the size of the pupillary aperture. In the center of the iris are found also the blood-vessels (to be described later) and varying quantities of pigmented connective-tissue cells that give the color to the eyeball.

The **retina** is the *neural*, or *image-making coat* of the eyeball, *i.e.*, concerned with the formation of an image. It is usually called the expanded portion of the optic nerve but it is more than that and very complex in structure. It consists of *two main parts*, the *pigmented layer* and the *true neural portion* (consisting of nine complete layers). The *pigmented layer* is composed of pigmented columnar epithelial cells that are firmly attached to the glassy membrane of the choroid and continue over the ciliary region and iris as *pars ciliaris* and *pars iridica retinæ*, respectively. The *neural portion* extends only to the end of the choroid where it ends in a serrated edge, the *ora serrata*. This part of the retina constitutes the *pars optica retinæ*. . Its cellular elements are the layer of rods and cones, the outer and inner ganglionic layers. The layer of nerve fibers ultimately forms the optic nerve. The important regions of the retina are the *blind spot*, *yellow spot* and the *ora serrata*.

The **blind spot** (*optic disc*) is so-called because no image can be formed there. It is whitish in color. It represents the area of convergence of nerve fibers that constitute the optic nerve. It is situated about 3 mm. to the nasal side and about 2 mm. below the posterior pole of the eyeball. It is about 1.5 mm. in diameter and is usually slightly depressed in the center, the *excavatio papillæ nervi optici*.

The **macula lutea,** or *yellow spot* is oval in shape and 2 by 3 mm. in its diameters and lies in the visual axis. Its central part is slightly depressed and is called the *fovea centralis*.

The **ora serrata** is the region at which the pars optica retinæ ends. Here the retina is about 0.1 mm. thick while at the optic nerve region it is about 0.4 mm. in thickness.

In the eyeball are the *crystalline lens*, *aqueous* and *vitreous humors*, the *anterior*, *posterior* and *vitreous chambers*.

The **crystalline lens** (*lens crystallina*) is a transparent, biconvex lens in which the posterior curvature is greater than the anterior. The posterior curvature, however, is practically fixed while the anterior curvature is variable. It lies just behind and in contact with the iris (at the pupillary region) and rests in a depression in the vitreous humor called the *patellar fossa* (*fossa patellaris*). It is about 4 mm. in thickness and 9 to 10 mm. in its transverse diameter. It is surrounded by a *capsule* the anterior layer of which, at the edge or equator of the lens, is continuous with the anterior layer of the zonule of Zinn. This zonule represents a thick and plicated portion of the hyaloid membrane of the vitreous humor that is moulded around the ciliary processes and intervening depressions. This anterior layer is called the *suspensory ligament of the lens*. The bulk of the lens consists of lens fibers. The lens represents the most important refractive medium of the eyeball.

The **vitreous humor** (*corpus vitreum*) is the largest structure of the eyeball and occupies the *vitreous chamber*, or *optic cup*, that represents the posterior four-fifths of the eyeball. The jelly-like substance is surrounded by the *hyaloid membrane* (*membrana hyaloidea*). On the anterior surface is the patellar fossa for the posterior surface of the lens. At the ora serrata region the hyaloid membrane becomes thickened and strengthened by radial fibers and this constitutes the *zonule of Zinn* (*zonula ciliaris*). As the *zonule* advances over the ciliary processes toward the lens, it is moulded over and attached to the processes and invaginated into but not attached to the depressions. As the equator of the lens is approached, the zonule splits into two layers, the anterior and thicker blending mainly with the anterior layer of the lens capsule and sending fibers to the posterior layer (that lines the patellar fossa). The vitreous humor represents one of the refractive media but is usually disregarded in ophthalmology.

The **aqueous humor** is merely lymph that occupies the anterior and posterior chambers.

The **anterior chamber** (*camera oculi anterior*) is the space between the back of the cornea and the front of the iris and is filled with aqueous humor. The angle formed at the junction of iris and cornea is the *infiltration angle*.

The **posterior chamber** (*camera oculi posterior*) is the space between the back of the iris and the front of the lens and suspensory ligament. It is filled with aqueous humor and communicates with the anterior chamber through the pupillary aperture.

The **optic nerve** (*nervus opticus*) is 1½ to 2 inches (3.75 to 5 cm.) in length, from the eyeball to the chiasm. It begins as the nerve-fiber layer of the retina, mainly, but also contains fibers that have a centrifugal course. It traverses the orbital fat and leaves the orbit through the optic foramen.

The **blood-vessels** *of the eyeball* are the central retinal artery (*arteria centralis retinæ*) the short and long posterior ciliary arteries and the anterior ciliary arteries. The *central retinal artery* enters the optic nerve near the eyeball and passes into the eyeball to supply the retina. Its blood is returned by the central vein that has a corresponding course.

The *short posterior ciliary arteries*, about six to twelve in number, pierce the sclera near the optic nerve region to enter the choroid. In the choroid they form the layer of large vessels and then the choroidal capillaries and these branches anastomose with those of the other arteries. They supply a part of the sclera.

The *long posterior ciliary arteries*, two in number, pierce the sclera at some distance from the optic nerve and pass between the sclera and choroid to the ciliary muscle where they form the *circulus arteriosus major*, at the base of the iris, by anastomosis. From this circle vessels pass to the pupillary margin to form the *circulus arteriosus minor*.

The *anterior ciliary arteries*, four in number, form a plexus at the edge of the cornea. Branches pierce the sclera and connect with the circulus iridicus major.

The blood from the long and short ciliary arteries is carried to the *venæ vorticosæ* and then to the ophthalmic vein. Most of the blood from the anterior ciliary arteries is returned by the *anterior ciliary veins*.

The **lymphatic spaces** of the eyeball are intercommunicating. The anterior chamber communicates with the posterior and with the spaces in the sclera and cornea and with the venous canal of Schlemm, by means of the spaces of Fontana. The posterior chamber communicates with the spaces in the choroid and retina and through these with the subarachnoidean space around the optic nerve. The capsule of Tenon receives lymph from the subscleral space and from the choroid by means of the vessels around the venæ vorticosæ and the lymph is then transmitted to the subarachnoidean space around the optic nerve.

The **nerves** comprise the long and short ciliary nerves and ciliary ganglion.

THE EYELIDS AND CONJUNCTIVA

The eyelids (*palpebræ*) are two transverse folds of skin, attached to the upper and lower orbital regions, that protect the eyeball. The cleft between the two eyelids is called the *palpebral fissure* and measures about 30 mm. though this varies in the different races. The outer surface is covered with skin while the inner surface is a mucous membrane called the *conjunctiva*. Between these two layers are fibrous and muscle tissues and the *tarsal plate* containing the *tarsal glands*. At the margin are seen two rows of heavy hairs the *eyelashes*, or *cilia*. The medial and lateral angles at which the lids meet are called the *medial* and *lateral canthi*, or *commissures*, respectively. Near the medial canthus of each lid is a minute elevation, the *papilla lacrimalis;* the minute orifice, or *punctum*, found therein is the beginning of the lacrimal duct system. Medial to the papilla is seen the *caruncula lacrimalis*.

The **conjunctiva** (*tunica conjunctiva palpebræ*) is a mucous membrane that lines the inner surface of each lid and is reflected onto the sclera of the eyeball (*tunica conjunctiva bulbi*) just in front of the insertion of the ocular muscles. It continues to the edge of the cornea where its epithelium only passes onto that part of the eyeball. The region where the conjunctiva is reflected from the lid to the sclera is called the *fornix conjunctivæ* (*superior* and *inferior*). When the lids are in apposition the conjunctiva represents a closed sac.

THE LACRIMAL APPARATUS

The lacrimal apparatus comprises the *lacrimal glands*, the *puncta, canaliculi, lacrimal sacs* and *nasal ducts*.

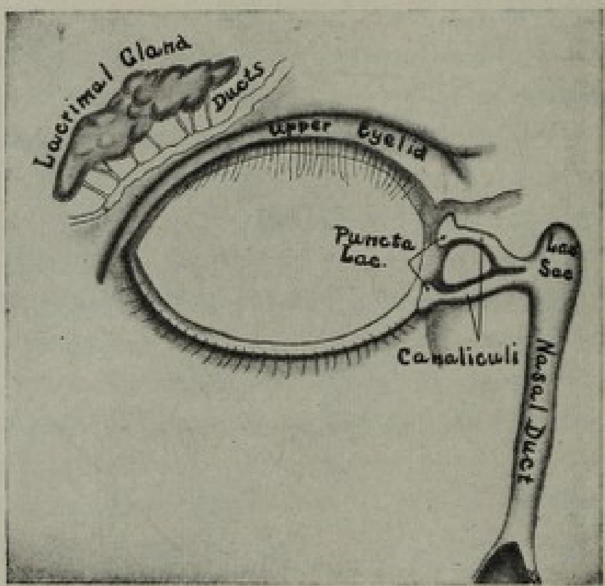


FIG. 254.—The lacrimal apparatus of the right side.

The **lacrimal glands** (*glandulæ lacrimales*) one in each orbital fossa, is located in the upper and lateral (temporal) part of the orbit in the lacrimal fossa. It is flattened and the main portion measures about 12 by 20 mm. The *ducts*, three to nine in number, empty into the conjunctival sac between the upper edge of the eyelid and the fornix.

The **punctum,** one in each eyelid, is located near the inner canthus upon the summit of a little papilla. It leads into a canaliculus. The **canaliculus** (*ductus lacrimalis*) one in each eyelid, of which that in the upper eyelid is the shorter, connects each punctum with the lacrimal sac.

The **lacrimal sac** (*sacus lacrimalis*) represents the dilated upper extremity of the nasal duct. It is about 12 to 15 mm. long, 4 to 5 mm. wide and 7 mm. thick. It lies in the lacrimal groove and receives the canaliculi.

The **nasal duct** (*ductus nasolacrimalis*) is about 18 mm. long and 3 to 4 mm. in diameter. It passes inward and backward and opens into the inferior meatus of the nasal cavity under cover of the inferior conchal bone.

CHAPTER XIII

THE EAR (ORGANON AUDITUS)

The car, or auditory apparatus consists of three parts the *external, middle,* or *tympanum* and *internal* or *labyrinth portions.*

THE EXTERNAL EAR

The *external portion* comprises the *pinna* and *external auditory canal.* The **pinna,** or **auricle,** is a peculiarly moulded mass of elastic cartilage covered with skin and adapted to catch the sound waves and conduct them into the external auditory canal. It is of an oval form and is located midway between the forehead and the occiput. It is attached to the side of the head and its cartilage continues as a tube that forms a part of the external auditory canal. Its parts are the *helix* and *antihelix,* the *tragus* and *antitragus* and the *lobule.* The latter contains no cartilage and is very vascular. The *muscles* of the pinna are *intrinsic* and *extrinsic.* The *extrinsic muscles* are the *attrahens aurem* (*m. auricularis anterior*) which is the smallest and is in front; the *atolens aurem* (*m. auricularis superior*) which is the largest and is above; the *retrahens aurem* (*m. auricularis posterior*) which is behind the pinna. These muscles are of very little importance in man. The *intrinsic muscles* are the *mm. helicis major, helicis minor, tragicus, antitragicus* and the *transversus* and *obliquus auricularæ.*

The **external auditory canal** (*canalis auditorius externus*) is about 1 inch (2.5 cm.) in length when measured, as it should be, from the bottom of the concha. It is like an elongated S in shape and its general direction is forward and inward. It makes an angle of about 45° with the sagittal plane and its diameter varies in the different parts. Its anterior and inferior walls are longer than the posterior and superior walls on account of the slope of the tympanic membrane. The lateral one-third is called the *cartilaginous portion* (*pars cartilaginea*) and is formed by the tube-like continuation of the pinna; the *medial two-thirds* is called the *osseous portion* (*pars ossea*) because its walls are formed by bone (temporal). This canal is lined by skin continued from the pinna and in it are found the ceruminous, or wax glands (*glandulæ ceruminosæ*) and many hairs (*barbula hirci*).

THE MIDDLE EAR

The *middle portion,* or *tympanum* (*cavum tympani*) consists of the *tympanic cavity* proper, the *attic,* the *membrana tympani,* the *ossicles* and its connection with the pharynx, the *auditory tube.*

The **tympanic cavity proper,** or **atrium** lies just medial to the tympanic membrane and is a narrow space, quadrilateral in shape. It is placed practically parallel to the sagittal plane of the body. Its length and height are 15 mm. each. The distance between the lateral and medial walls varies; at the top it is 6 mm., in the middle about 2 mm. and at the bottom about 4 mm. Above the level of the tympanic membrane the tympanic cavity forms a recess called the *attic* (*recessus epitympanicus*), or *epitympanum.* This recess contains most of the incus and half of the handle of the malleus and communicates with the mastoid antrum. In the *anterior*

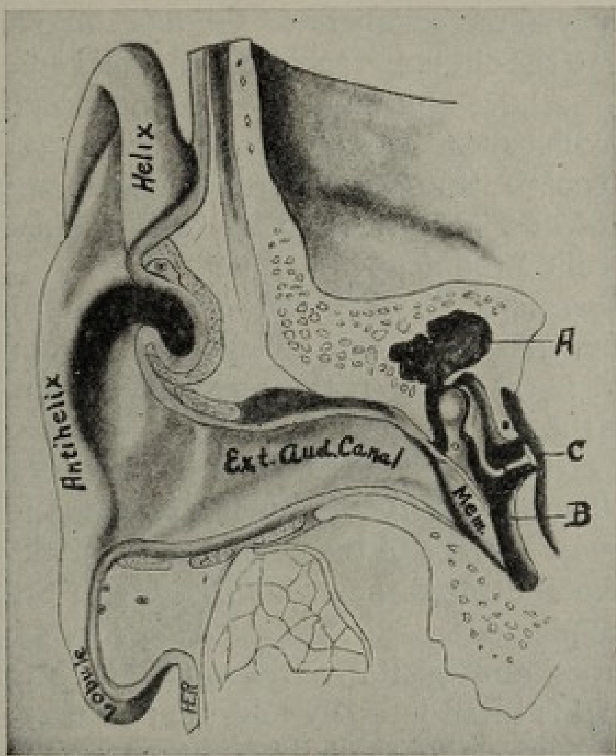


FIG. 255.—Vertical section through the external auditory canal and tympanum. *A*, Epitympanic recess; *B*, tympanum; *C*, fenestra ovalis closed by foot of the stapes; *Mem.*, tympanic membrane.

wall (*paries carotica*) of this cavity are *two openings;* the *upper* represents the orifice of the canal that transmits the tensor tympani muscle (*semicanalis m. tensoris tympani*) while the *lower* represents the orifice of the *auditory tube.* The *medial wall* (*paries labyrinthica*) has an oval opening, the *fenestra vestibuli;* its long axis, 3 mm., is directed horizontally while its shorter axis is directed vertically and measures about 1.5 mm. In the recent state this opening is closed by the foot of the stapes held in position by the annular ligament (*ligamentum annulare*). In the dried bone this opening leads into the vestibule of the internal portion of the ear. Below the fenestra vestibuli is another opening (in the dried bone) that leads into the cochlea and is termed the *fenestra cochleæ.* In the recent state it is closed by the *membrana tympani secundaria.*

The **tympanic antrum** (*antrum tympanicum*) is a cavity in the temporal bone that is about 8 by 10 mm. and connects the epitympanum with the mastoid cells. The *mastoid cells* (*cellulæ mastoideæ*) vary in number and size and are said not to be developed until the sixth year. In the adult they are usually quite numerous.

The **tympanic membrane** (*membrana tympani*) is an elliptical, disc-shaped membrane that slopes downward, medially and backward, thus accounting for the difference in the length of the walls of the external auditory canal. It is about 10 mm. in its vertical dimension and 9 mm. from side to side. Its circumference is thickened by circularly directed fibers of the *annulus fibrocartilagineus*, that attaches it to the circumference of the medial end of the external auditory canal. Above the malleolar prominence (formed by the handle of the malleus) is the *pars flaccida*. The bulk of the membrane is tense, constituting the *pars tensa*. The central part of the membrane is drawn slightly inward by the attached handle of the malleus and is called the *umbo*.

The *lateral surface* of the membrane is covered by a thin skin and the *medial surface* by a delicate mucous membrane. The circular and radial fibers between these two layers are thinner in the middle than at the circumference.

The **muscles** of the middle ear are the *m. tensor tympani* and the *m. stapedius*. The *insertion* of the *tensor tympani* upon the medial edge of the anterior surface of the handle of the malleus is such that when the muscle contracts the handle is drawn medially and the membrane is rendered tense. The *stapedius* is *inserted* into the neck of the stapes and by its contraction the anterior end of the base of the stapes is tilted laterally and the posterior end medially, thus, probably, compressing the lymph in the vestibule.

The **tympanic ossicles** (*ossicula auditus*) or *ear bones* (Fig. 255) are three in number upon each side. These are the *malleus*, *incus* and *stapes*.

The *malleus* is the largest having a length of 8 to 9 mm. It is composed of *head*, *neck*, *handle*, *long* and *short processes*. The *head* (*caput*) articulates with the body of the incus. The *handle* (*manubrium*) is directed downward, medially and backward and is attached along its entire length to the tympanic membrane.

The *incus* consists of a *body* and *two processes*. The *body* (*corpus*) has a facet for articulation with the head of the malleus. The *long process* (*crus longum*) is directed almost perpendicularly downward and at its low extremity it articulates with the head of the stapes.

The *stapes* consists of the *head*, *neck*, *two crura* and a *base*. The *head* (*caput*) articulates with the long process of the incus. The oval *base* (*basis*) rests in the fenestra vestibuli and is held in position by the *ligamentum annulare*.

The **auditory tube** (*tuba auditiva*) connects the tympanic cavity with the pharynx. The air which it transmits to the tympanic cavity serves to maintain an equilibrium of pressure upon both sides of the tympanic membrane. The lateral end opens upon the anterior wall of the tympanic cavity. The tube is about 1½ inches (36 mm.) in length and is directed downward at an angle of about 30° to 40° to the horizontal plane and forward and medially at an angle of about 45° to the sagittal plane. It opens into the nasopharynx. Its lateral one-third is the *osseous portion* (*pars ossea*) and the medial two-thirds the *cartilaginous portion* (*pars cartilaginea*). The cartilage is in the form of a ˥-shaped hook in which the anterior wall is completed by fibrous tissue. The cartilage projects into the nasopharynx (covered by mucosa) constituting the *eustachian cushion* (*torus tubarius*). Some of the fibers of the tensor veli palatini muscle take origin from the upper end of the hook and have been called the *dilatator tubæ muscle*.

THE INTERNAL EAR

The internal portion of the ear, or **labyrinth** is the most important portion of the auditory apparatus. It is located in the petrous portion of the temporal bone and comprises the *osseous* and *membranous labyrinths*.

The **bony labyrinth** (*labyrinthus osseus*) consists of the *vestibule*, the *semicircular canals* and the *cochlea*.

The **vestibule** (*vestibulum*) lies between the semicircular canals, behind, and the cochlea, in front. It is about 6 mm. anteroposteriorly and 4 to 5 mm. from above downward and 3 mm. from without inward. In its *lateral wall* is seen the *fenestra vestibuli* closed by the base of the stapes and its ligament. It lodges the *sacculus* (*recessus sphericus*) and the *utriculus* (*recessus ellipticus*) and numerous foramina that transmit nerve fibers from the sacculus and utriculus and lower end of the cochlear duct, are noted here.

The **semicircular canals** (*canales semicirculares ossei*) are behind and above the vestibule. They are three in number in each ear and are called *superior*, *lateral* and *posterior*. Each forms about two-thirds of a circle and is about 1 to 1.5 mm. in diameter. One extremity of each is dilated and this is the *ampulla* which is 2 mm. in diameter. These canals communicate with the vestibule by five openings. The *superior canal* is vertical and is placed transversely to the long axis of the petrous portion of the temporal bone. Its length is about 18 mm. The *lateral canal* is placed almost horizontally and measures 12 to 15 mm. in length. The *posterior canal* is about 20 mm. in length. The opposite lateral canals lie in the same plane while the superior canal of one ear is parallel to the posterior canal of the other ear.

The **cochlea** represents a tapering tube, of 28 to 30 mm. length, spirally wound for nearly 2¾ turns about a bony axis, the *modiolus*. The broad portion is the base that measures about 9 mm. across and is in relation with inferior fossula of the internal auditory meatus. The end of the coil is the *apex*, or *cupola;* it is about 5 mm. above the base and about 2 mm. above the apex of the modiolus. The basal portion of the tube is about 2 mm. in diameter.

The *modiolus*, or *axis* is a conical mass about 3 mm. high and is pierced by many foramina for the transmission of nerve fibers. Upon the tube side the modiolus sends out a bony shelf that extends

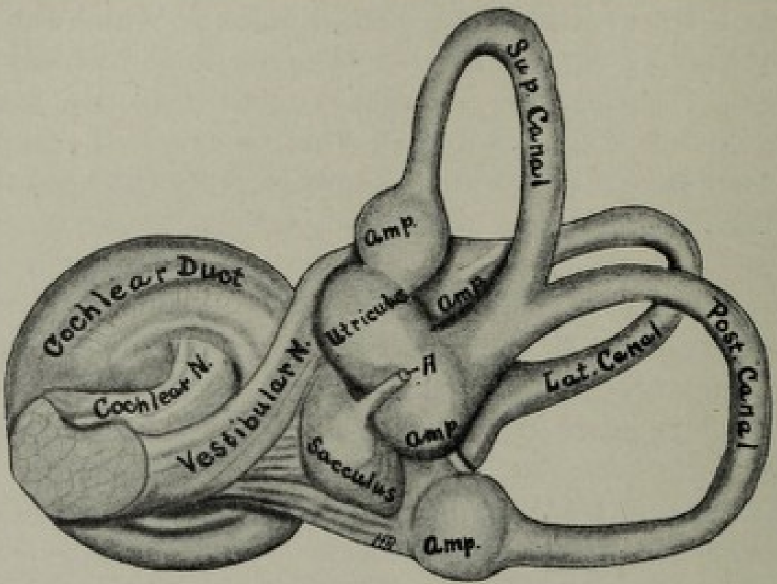


FIG. 256.—Isolated membranous labyrinth of the right side. *A*, ductus endolymphaticus.

about halfway across the tube and is called the *lamina spiralis* (*ossea*). The division of the tube is completed by the *basilar membrane* that extends from the spiral lamina to the lateral wall of the osseous tube. As a result two passage-ways are formed, the *upper* the *scala vestibuli* and the *lower* the *scala tympani*. At the modiolus end of the spiral lamina is a canal that extends the length of the shelf and in this spiral canal is lodged the *spiral ganglion of Corti* (*ganglion spirale*). The spiral lamina and basilar membrane extends to within a short distance of the end of the tube and here the two scalæ communicate with each other. This communication is called the *helicotrema*.

Within the bony labyrinth is a *membranous cast* called the **membranous labyrinth** (*labyrinthicus membranaceous*). This cast is separated from the bony walls by the *perilymph*. Within the membranous labyrinth is the *endolymph*. The parts are the *sacculus*, *utriculus*, the *semicircular canals* and the *cochlear duct*.

The *sacculus* and *utriculus* lie in the osseous vestibule. The sacculus lies in the lower and front part, is oval in shape and measures

2 by 3 mm. It is smaller than the utriculus. It presents a thickened neuroepithelial area, the *macula acustica sacculi*. The saccule communicates with the cochlear duct by means of a small canal, the *ductus reuniens*. Another canal, the *ductus endolymphaticus*, passes through the aqueductus vestibuli to end in a small sac under the dura, in the cranial cavity. This duct is met by a canal from the utriculus, the *ductus utriculosaccularis*, thereby giving an indirect communication between these two structures.

The **utriculus** lies in the posterior and superior part of the bony vestibule. It is larger than the preceding and its highest part communicates with the ampullæ of the superior and lateral membranous

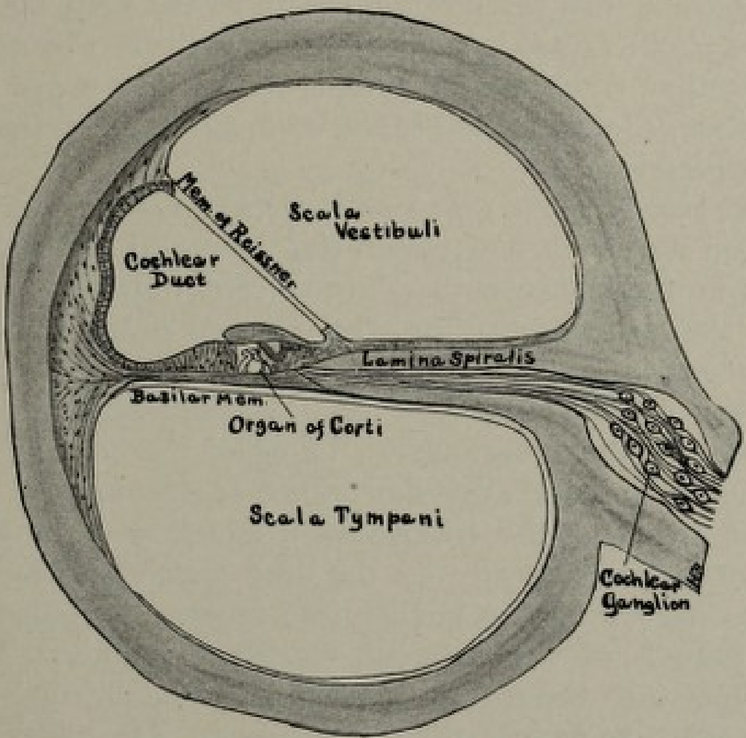


FIG. 257.—Transverse section of the cochlea.

semicircular canals. The lower medial part communicates with the ampulla of the posterior canal. The central part communicates with the lateral canal and above this with the common opening of the posterior and superior canals. The utriculus possesses a whitish, neuroepithelial area, the *macula acustica utriculi*. From the utriculus the ductus utriculosaccularis passes to the ductus endolymphaticus.

The **membranous semicircular canals** (*ducti circulares*) represent casts of the osseous canals, but are only one-fourth the diameter of the latter. In the ampullæ are found neuroepithelial areas, the *crista acusticæ*. The semicircular canals seem to be the organs of equilibrium, the canals being arranged, apparently, in the three dimensions of space.

The **membranous cochlea** (*ductus cochlearis*) *cochlear duct*, or *scala media* is a limited portion of the scala vestibuli. From the spiral lamina the thin *membrane of Reissner* (*membrana vestibularis*) passes upward and laterally at an angle of about 45° to be attached to the lateral wall of the scala vestibuli. This forms a tube, triangular in section, the *scala media*, or *cochlear duct*, which is closed at its apical end, constituting the *lagena*. The *basal end* of the cochlear duct lies in the vestibule and communicates by means of the ductus reuniens with the saccule. Upon the medial end of the basilar membrane is the important part of the auditory apparatus, *the organ of Corti* (*organum spirale*). This consists of supporting and neuroepithelial (hair) cells that form a mass that has a spiral course upon the basilar membrane and extends the length of the scala media. The *hair cells* are about 15,000 in number and constitute the *neuroepithelial elements* that translate the lymph waves into nerve impulses. These impulses are transmitted to the brain and there translated into auditory impressions.

The **blood supply** *of the pinna and external auditory canal* is from the posterior auricular and superficial temporal arteries, chiefly; the veins from the former empty into corresponding veins while the veins from the latter empty into the external jugular and external maxillary veins.

The **nerves** *of the pinna* are the auriculotemporal, the small occipital and the great auricular. Those of the *external canal* are the auriculotemporal and auricular branch of the vagus.

The **blood supply of the tympanum** is as follows: The membrana tympani is supplied laterally by the deep auricular branch of the internal maxillary while the medial side receives its blood from the tympanic branch of the internal maxillary mainly. The veins laterally empty into the external jugular and medially into the plexus of the auditory tube or into the lateral sinus. The *nerves* are laterally from the trigeminus and medially from the glossopharyngeus.

The *arteries that supply the tympanic cavity* are branches of the posterior auricular, internal maxillary, middle meningeal, internal carotid and ascending pharyngeal arteries. The *veins* empty into the superior petrosal sinus, the pterygoid plexus and the middle meningeal vein. The *nerves* are from the pharyngeal plexus. The *tensor tympani muscle* is supplied by the trigeminus (through the otic ganglion) and the *stapedius* by the facial nerve.

The **blood supply of the labyrinth** is the auditory artery from the basilar artery. This gives rise to three branches, the anterior vestibular, the cochlear and the vestibulocochlear arteries. The *auditory veins* return the blood to the inferior petrosal sinus, or to the lateral sinus.

The **nerve of the labyrinth** is the auditory nerve. This consists of *two portions*, *vestibular* and *cochlear*. The *vestibular division* consists of three portions, one from the utriculus, one each from the ampullæ of the superior and lateral semicircular canals. The *cochlear division* consists of three parts, one from the sacculus, one from the posterior semicircular canal and the third, the bulk of this division, from the organ of Corti.

CHAPTER XIV

THE NERVE SYSTEM

The nerve system (*systema nervorum*) is the most important and most complicated apparatus in the body. It serves, through various sensations and impressions, to make us cognizant of our surroundings and give us the power to adapt ourselves to our environments. It presides over motion and sensation and the functions of the various organs are subjected to its control. It is most highly developed in man and consists of two kinds of nerve tissue, *gray* and *white*.

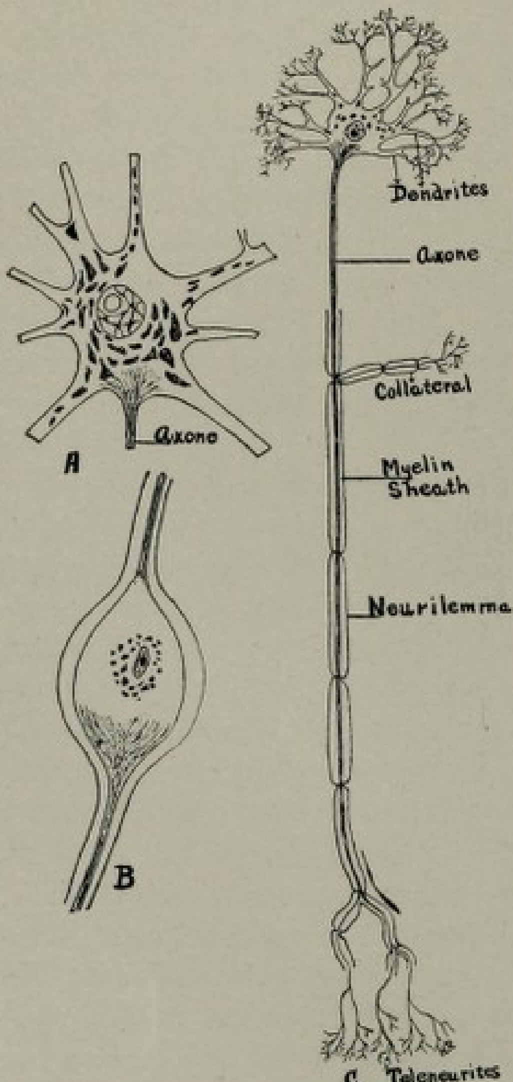


FIG. 258.—Nerve cells. *A*, Multipolar; *B*, bipolar; *C*, diagram of a neuron.

It is composed of units called *neurons* that are linked together in such a manner so as to give direct and indirect connections between the central system and the periphery of the body. Each neuron consists of a *cell* and its *processes*.

Gray nerve tissue is composed of *nerve cells*, *their processes*, *nerve fibers* and a distinctive supportive tissue, the *neuroglia*. A **neuron** is a *nerve cell and its processes*. The *cell body*, or *cytom*, comprises a mass of protoplasm varying from 4μ to 120μ in diameter and exhibits a granular and fibrilar structure. The basophilic granules are large but inconstant depending upon the state of the cell. These granules are called the *corpuscles of Nissl*, or *tigroid bodies*. Their position, size and number depends upon the functional activity of the cell; they may be diffusely scattered and small, or arranged in groups around the nucleus, or near the periphery and extend into the minor processes, or dendrites. In fatigued cells they disintegrate and disappear. The fibrillar character is due to the neurofibrils that extend throughout the protoplasm forming an apparent network but the fibrils do not really form junctions with one another. These fibrils pass into all of the processes and form the most important part thereof. They are brought out by intravitam, or silver nitrate staining.

The *nucleus* is usually large, spherical and pale in appearance as it contains but little chromatin. It is usually eccentrically placed. The *nucleolus* is large and stains darkly.

If but one *process* is present it is the *axone*, the other processes, when present, being called *dendrites*. The *axone* is the main process and consists of a number of neurofibrils embedded in neuroplasm and surrounded by a delicate sheath called the *axilemma*. This process may go but a short distance in the gray substance and terminate in a brush-like manner near the processes of another cell (*second type cell*). When the axone leaves the gray substance and becomes surrounded by a myelin sheath and a neurilemma it constitutes a *myelinated fiber* and the cell is called a *Dieter's cell*, or *cell of the first type*.

The *dendrites* are the minor processes and consist mainly of neurofibrils that extend but a short distance from the cell before they branch and form a large number of twigs that terminate in a brush-like manner near the processes of another cell. These are the *telodendrites* and these processes serve an associative function. Some dendrites are quite long, leave the gray substance and become invested with a myelin sheath and a neurilemma and serve as a nerve fiber.

The cells that possess but *one process*, as those of the ganglia of the dorsal roots of the spinal nerves and certain of the cerebral nerves, are called *unipolar*. When *two processes* are present, as in the cochlear and vestibular ganglia and the Purkinjé cells of the cerebellum, they are called *bipolar cells*. When *more than two processes* are present, they are called *multipolar cells*, as are seen in the cerebral cortex and the ventral horns of the spinal cord especially. The latter are the largest cells of the nerve system.

The **neuroglia** is the special supportive tissue of the nerve system and comprises glial cells and glial fibers. The cells are chiefly stellate, possessing many processes that may be short and thick, or long and slender. The fibers form a meshwork that supports the functionating nerve cells.

Nerve fibers may be *myelinated*, as seen in the cerebrospinal system, or *amyelinated*, as seen in the sympathetic system. A *myelinated nerve fiber*, on cross-section, is seen to consist of a central axis, the *axis-cylinder*, or *axons;* this consists of neurofibrils embedded in *neuroplasm* and surrounded by an *axilemma*. This is surrounded by the *myelin sheath* that is composed of a framework of *neurokeratin* containing the *myelin substance* (*phosphorized fat*) in its meshwork. It is apparently an insulating sheath and is surrounded by the *neurilemma*, a delicate connective-tissue sheath. Upon longitudinal section a nerve fiber shows constrictions (*nodes of Ranvier*) at regular intervals; here the myelin substance is wanting and the neurilemma dips in and touches the axilemma. Here only may collaterals arise. Nerve fibers vary from 2μ to 20μ in diameter.

A **nerve** consists of a number of nerve fibers in one mass of variable size. The number of nerve fibers varies from a few to 450,000 to 800,000, as in the optic nerve. The nerve is surrounded by a connective-tissue sheath called the *epineurium*. This sends in septa that divides the nerve into large secondary bundles and these septa send in others that form sheaths for the primary bundles, or fasciculi. These latter sheaths are the *perineural sheaths*. Fibers of the perineurium pass into the bundles and form a meshwork, the *endoneurium*, that supports the nerve fibers, blood-vessels and nerves of the nerve.

Nerve fibers are *sensor* and *motor* and an entire nerve as the hypoglossal, accessory, oculomotor, trochlearis and abducens may be composed entirely of motor fibers and each is then called a *motor nerve*. A nerve may be composed entirely of sensor fibers, as the acoustic, olfactory and optic nerves and are then called *sensor*. Some nerves, *mixed*, have both sensor and motor fibers as the spinal, vagal, glossopharyngeal, trigeminal and facial nerves. Each main division of such a nerve is distinguished as the *motor root* and the *sensor root*.

Although there are two divisions, the *cerebrospinal* and the *sympathetic*, they are not isolated from each other, but are intimately connected by intercommunicating fibers, the *rami communicantes*.

The **cerebrospinal system** comprises the *central portion, i.e., brain, spinal cord* and their *meninges*, and a *peripheral portion*, the *cerebral* and *spinal nerves* and their *ganglia*.

The **central nerve system** is surrounded and protected by the bones of the skull and the vertebral column. The *cranial part* fits rather snugly into the cranium and the bones surrounding it are immovable, thus affording greater protection. The *spinal portion* is situated in the jointed vertebral column but the vertebral canal is of sufficient diameter to admit of all normal movements without injuring the spinal cord. The central nerve system is not solid but possesses a central cavity system throughout, the cavity varying in the different parts. This canal system is a characteristic of the nerve system of the vertebrates only. It comprises the *ventricles* and *spinal canal* and contains the *cerebrospinal fluid*. It communicates at several points with the subarachnoid lymph spaces around the central system and by means of these communications the intraneural and the extraneural pressure are balanced. Interference with these openings, as in certain diseases, causes a disturbance of the balance with certain attendant symptoms.

The **meninges** comprise three membranes the **dura, arachnoid** and the **pia**. The **dura** (*dura mater*) is a thick and tough white fibrous tissue membrane. In the cranial cavity it is attached to the bones and acts as the inner periosteum thereof as well as a protection to the brain. It also forms the *falx cerebri* which is a vertical, sickle-shaped membrane that separates the cerebral hemispheres from each other in the sagittal plane. The dura forms the walls of the *venous sinuses* and the *tentorium cerebelli*. The latter lies above the cere-

FIG. 259.—Dried specimen showing the falx cerebri and the tentorium cerebelli. (*From a photograph.*)

bellum, serves to support the weight of the occipital portion of the cerebrum and joins the falx cerebri and the falx cerebelli. The dura also forms a sheath about the cerebral nerves for a short distance. The *falx cerebelli* is a vertical septum of dura that lies between the two cerebellar hemispheres. The *diaphragma sellæ* is a portion of the dura that stretches over the top of the sella turcica of the sphenoid bone and thus converts that depression into a fossa in which the hypophysis is situated. The diaphragm is pierced by a small opening through which the stalk of the hypophysis passes.

In the *vertebral canal* the dura does not serve as a periosteum but is suspended as a loose bag that extends from the foramen magnum to the third division of the sacrum. Within this bag is the spinal cord. Between the dura and the arachnoid is a lymph space called the *subdural lymph space.*

The **arachnoid** (*arachnoidea*) is a delicate, web-like membrane that lies between the dura and pia, and though closely applied to the latter does not follow it into the fissures and sulci except in the case of the longitudinal and lateral cerebral fissures. Between the arachnoid and the pia is the *subarachnoid lymph space* (*cavum subarachnoideale*) which does not communicate with the subdural space. The arachnoid forms a number of reddish bodies that project into the venous sinuses. These are the *Pacchionian bodies* (*granulationes arachnoideales*) and although they may appear to lie within the sinuses they are covered by a thin layer of the dura. In certain regions the arachnoid and pia are separated from each other forming spaces, the *cisternæ subarachnoideales.* The *cisterna cerebellomedularis* is the largest and is situated between the cerebellum and the roof of the oblongatal portion of the fourth ventricle. The *cisterna pontis* is in relation with the pons. The *cisterna interpeduncularis* is in the interpeduncular space. The *cisterna chiasmatis* is an extension of the preceding in front of the optic chiasm.

The **pia** (*pia mater*) is the *vascular membrane* of the brain and spinal cord. It is closely applied to the surface of these and enters all of the fissures and sulci, more so in the cerebrum than in the cerebellum. The larger vessels project into the subarachnoid space while the smaller ones ramify the pia and then pierce the nerve tissue.

THE SPINAL CORD

The spinal cord (*medulla spinalis*) is that portion of the central nerve system located in the vertebral canal. It is somewhat cylindrical in shape and extends from the margin of the foramen magnum to the lower border of the first or upper border of the second lumbar vertebra. In the male it measures about 18 inches (45 cm.) and in the female about 17 inches (43 cm.). Its weight, when stripped, is about 30 grams and with the nerve roots about 45 grams. **Two enlargements** are present, one in the cervical portion and the other in the lumbar portion of the cord. The *former* (*intumescentia cervicalis*) is at its maximum at the sixth cervical vertebra (12 to 14 mm.) and the *latter* (*intumescentia lumbalis*) reaches its maximum at the twelfth thoracic vertebra (11 to 13 mm.). This increase is due to the added cells and fibers for the appendages. These enlargements vary in size according to the use of the appendages; in man, ourang and gibbon the cervical enlargement is the larger. In the kangaroo and ostrich the lumbar enlargement is the larger. In animals without appendages these enlargements are barely perceptible.

The terminal portion of the spinal cord is cone-shaped and is called the **conus medullaris.** This includes the three lower sacral and the coccygeal segments. Its formation is due to the reduction in quantity of the gray and white substances.

Extending from the conus is a thread, the **filum terminale**, that

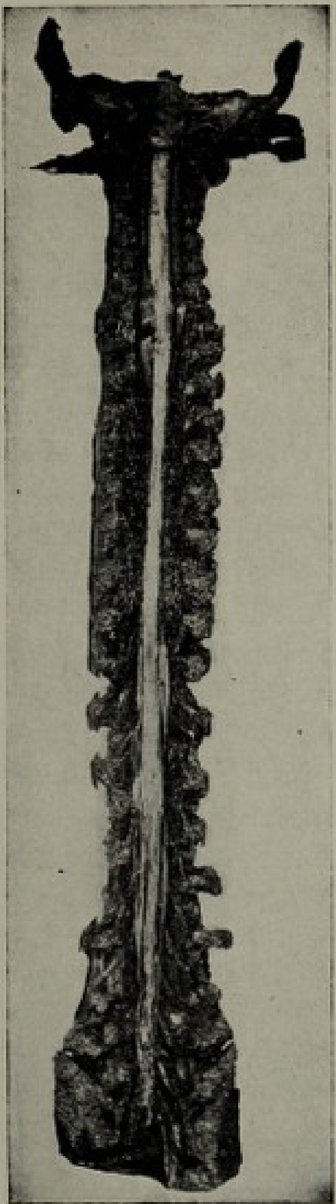


FIG. 260.—Dorsal view of the spinal cord and membranes in situ. The vertebral arches have been removed. (*From a photograph.*)

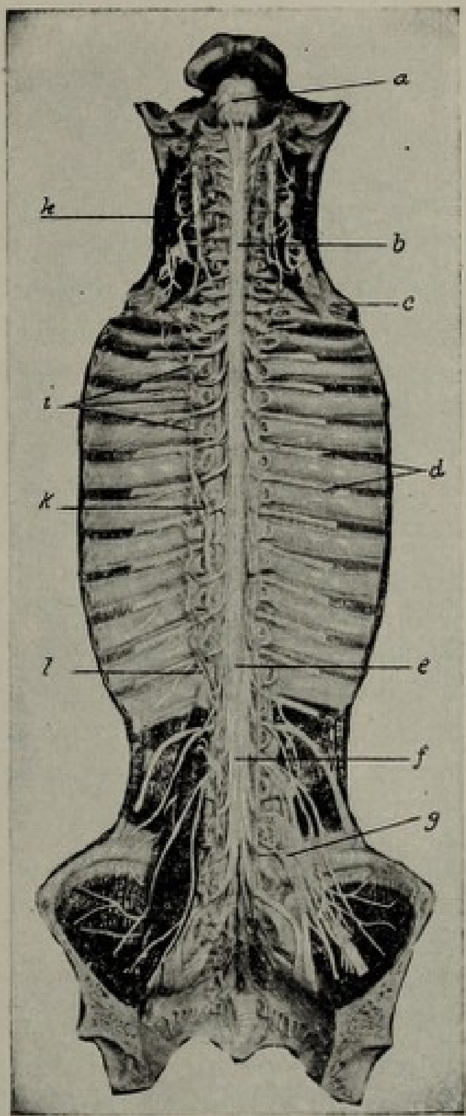


FIG. 261.—Model of the pons, oblongata and spinal cord in situ (ventral view). *a*, Pons; *b*, cervical enlargement; *c*, brachial plexus, *d*, thoracic nerves (ventral divisions); *e*, lumbar enlargement and conus; *f*, cauda equina; *g*, lumbosacral plexus; *h*, cervical sympathetic ganglia; *i*, thoracic sympathetic ganglia; *k*, *l*, splanchnic nerves.

is nearly 10 inches (25 cm.) in length. It consists chiefly of the pia and about one-half lies within the dural sac and its remainder external to the sac. Its peripheral end is attached to the coccyx. In the early months of fetal life, the spinal cord is as long as the vertebral canal. As the cord grows less rapidly than does the vertebral column, it recedes from the bottom so that at birth it extends to the lower border of the fourth lumbar vertebra and in the adult to the upper border of the second lumbar vertebra. In the earliest condition the nerves pass out at right angles to the cord while in the adult, in order to continue out of the proper foramen of exit, each of the lower nerves lengthens as the cord recedes and forms a more acute angle. As a result the lower end of the cord is surrounded by bundles of nerve fibers resembling, thus, a horse's tail; this constitutes the **cauda equina.**

The spinal cord presents a number of **fissures** and **grooves.** Ventrally in the midline is the *ventromedian fissure* (*fissura mediana anterior*) the depth of which is about one-third the dorsoventral diameter of the cord. Dorsally in the midline is the *dorsomedian groove* (*sulcus mediana posterior*). Where the dorsal roots of the spinal nerves enter there is a groove, upon each side of the cord called the *dorsolateral groove* (*sulcus lateralis posterior*); midway between this and the dorsomedian groove lies the *dorsoparamedian groove* (*sulcus intermedius posterior*) upon each side of the cord. The cord is divided into halves, longitudinally, by the ventromedian fissure and the dorsomedian septum. The latter extends all of the way from the surface to the gray commissure.

Upon transverse section, the spinal cord is seen to consist of *internal gray* and *external white nerve tissues.*

The **gray substance** is arranged in the form of an H-shaped column, the dorsoventral bars representing the *horns*, or *cornua* and the transverse bar the *gray commissure* (*commissura grisea*). In the gray commissure is the *central canal* (*canalis centralis*). That portion of each horn ventral to the level of the canal is the *ventral horn* (*columna anterior*) and that behind is the *dorsal horn* (*columna posterior*). The *ventral horns* are the larger, are blunt and do not extend to the periphery of the cord; the *dorsal horns* are more slender and usually extend to the periphery of the cord. The cornua contain the functionating cells of the spinal cord.

The *gray nerve tissue* consists of nerve cells their processes, neuroglia and nerve fibers. The *nerve cells* are arranged in groups in the ventral horns but these groups vary in size and number of cells in the various segments of the cord. The ventral horn cells are the largest nerve cells in the body. The various groups are as follows:

1. The *ventromedian group* is found in nearly all segments of the cord (except the fifth lumbar and the first sacral). This apparently represents the nuclei of origin of the fibers of the nerves that supply the long trunk muscles.

2. The *dorsomedian group* is found in the upper cervical segments, the thoracic and first lumbar segments, in other words where no limb muscles are represented.

3, 4. The *ventrolateral* and *dorsolateral groups* are the largest and represent the nuclei of origin of the nerves to the muscles of the limbs. These groups are not continuous throughout the cord but are found in the cervical and lumbar enlargements and the upper sacral segments.

5. The *central group* is found chiefly in the lumbar and sacral segments.

6. The *intermediate*, or *lateral group*, is a thin, continuous column of cells in the thoracic and first two lumbar segments with recrudescences in the upper cervical and third and fourth sacral segments. The axones from these cells pass to the sympathetic ganglia and represent the *white rami communicantes;* they are *splanchnic efferent* fibers representing motor connections between cerebrospinal and sympathetic systems.

Although many axones of the above cells form the nerve fibers of the ventral roots of the spinal nerves, the axones of the other cells have a different course and function. Some of these axones as well as myelinated dendrites pass to the medial and lateral sides of the ventral horns and form the medial and lateral ground bundles. Upon entering these bundles the fibers branch T-like and the divisions pass up and down for one or two, and occasionally more, segments and then turn into the gray substance and end around the cells of the ventral horns of those segments. These fibers represent *intersegmental association fibers* and serve to connect several segments together for coördination of action of several muscles, or muscle groups. Other cells, especially those along the medial side of the ventral horns, send their axones and dendrites through the gray commissure to the other side of the cord as commissural fibers. The dendrites pass to the ventral horn cells of the same level and they do not leave the gray substance. The axones enter the white substance of the ground bundle of the opposite side, branch T-like and the ascending and descending branches ultimately end in the gray a few segments above and below to terminate around the cells of the ventral horn.

These cells ventral to the intermediate group represent *somatomotor cells* while those of the intermediate group region to the transverse line through the canal represent the *visceromotor cells*.

In the *dorsal horn* there is only one distinct group of large cells, the other cells being somewhat scattered and small. This main group is the *nucleus of Clarke* (*nucleus thoracis*) and is an unbroken column from the eighth cervical segment to the second lumbar segment; it lies at the dorsal side of the cervix of the dorsal horn (the junction of this horn with the gray commissure). Most of the axones of these cells pass to the dorsolateral columns of the same side forming the superficial dorsolateral spinocerebellar tract. The other axones pass through the gray commissure to the opposite side (possibly to the white substance) constituting axones of commissural cells.

The other cells of the dorsal horn are classified as *marginal, stellate* and *spindle cells*. The *marginal cells* are near the extremity of the dorsal horn and the axones enter the lateral columns as intersegmental association and other fibers. The *stellate cells* send their myelinated dendrites to the funiculus cuneatus of the dorsal column. The *spindle cells*, the smallest, send their axones to the dorsal columns. Some of these cells also send their myelinated axones through the dorsal portion of the gray commissure to the opposite side to form there the two spinothalamic tracts, the spinotectal and superficial ventrolateral spinocerebellar tracts.

These cells near the transverse midline of the dorsal horns represent *viscerosensor cells* while those farther dorsad represent *somatosensor cells*.

The **neuroglia** consists of spider-like cells that possess a small, flat body and many, long, slender processes. In addition there are many glial fibers that form a meshwork for the support of the nerve cells and vessels. In the region of the spinal canal there is an especially dense meshwork of these fibers called the *substantia grisea centralis;* around the peripheral end of each dorsal horn is a cap of neuroglia called the *substantia gelatinosa*, or *caput cornualis*. This contains a few nerve cells that send their axones into the marginal tract.

The **white nerve tissue** consists mainly of myelinated nerve fibers supported by neuroglia and a little white fibrous tissue. These are divided into *columns* and *tracts*. In each half of the cord there are *three columns, ventral, lateral* and *dorsal*. The *ventral column* lies between the ventral median fissure and the ventral nerve roots; the *lateral column* lies between the ventral and dorsal nerve roots; the *dorsal column* lies between the dorsal nerve root and the dorsomedian septum. Connecting the ventral columns across the midline is the *white commissure* (*commissura alba*) that lies between the ventral median fissure (ventrally) and the gray commissure (dorsally).

Each column consists of **tracts,** some of which, however, do not extend the full length of the spinal cord. The **ventral columns** are the following:

1. The *sulcomarginal tract* (*fasciculus tectospinalis*) borders the ventromedian fissure, consists of *descending* fibers from the corpora quadrigemina of the opposite side and is seen in the cervical part of the cord.

2. The *direct pyramidal tract* (*fasciculus cerebrospinalis anterior*) lies lateral to the preceding and consists of *descending* fibers from the motor cells of the cerebral cortex. It represents undecussated fibers (10 to 15 per cent.) of the oblongata but they ultimately cross to the opposite ventral horn through the white commissure at vari-

ous levels. It does not extend below the midthoracic segments of the cord.

3. The *vestibulospinal tract* (*fas. vestibulospinalis*) consists of *descending* fibers from the vestibular nuclei of the brain stem, that end in the ventral horn of the cord as far as the sacral region.

4. The *ventral ground bundle* (*fasc. anterior proprius*) lies at the medial side of the ventral horn. It consists of intersegmental association fibers of the ventral cells of the same and opposite sides (*ascending and descending*).

5. The *ventral spinothalamic tract* (*fasc. spinothalamicus anterior*) lies in the intermediate zone of the ventral columns, consists of

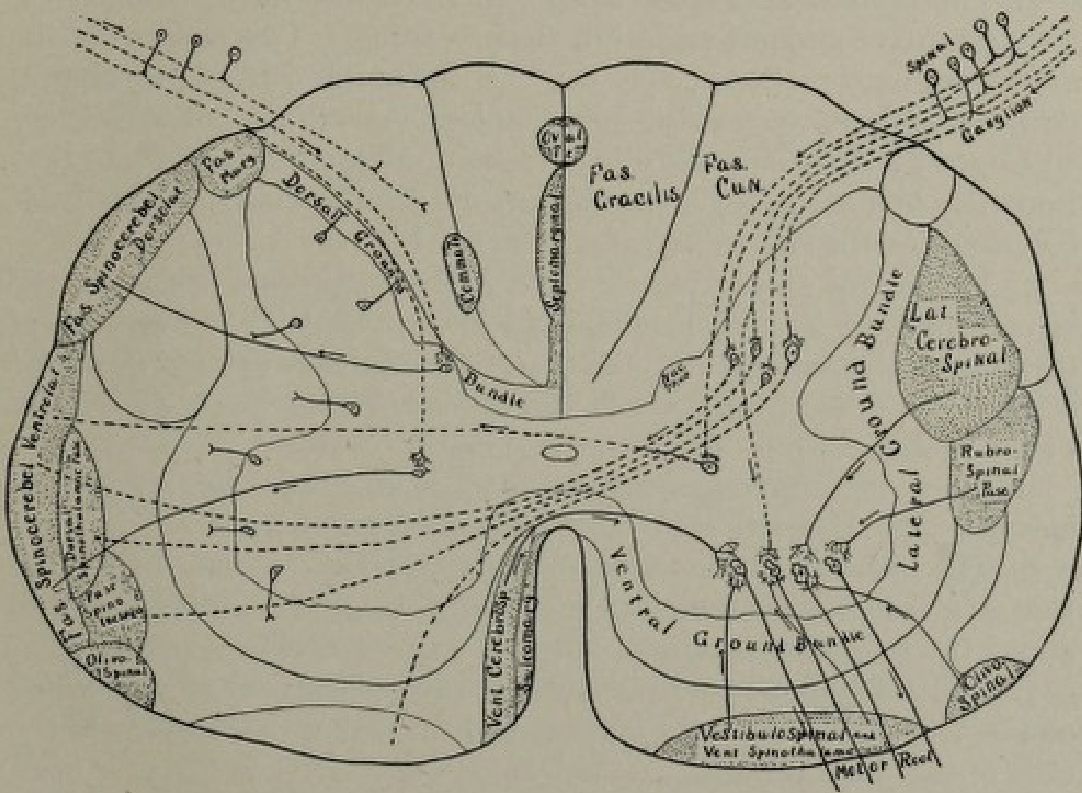


FIG. 262.—Diagram of the various tracts of the spinal cord and their origin or termination.

ascending axones of the cells of the opposite dorsal horn that pass through the white commissure and ascend to end in the thalamus. These fibers convey *touch* and *pressure impressions* from the opposite side of the body.

The **lateral column** is more extensive and contains more tracts.

1. The *olivospinal tract* (*fasc. olivospinalis*) lies at the side of, or in the ventral root region and consists of *descending* axones from the cells of the olivary nucleus (in the oblongata); they end around the ventral horn cells. This tract is found in the cervical segments.

2. The *superficial ventrolateral spinocerebellar tract* (*of Gowers'*) (*fasc. spinocerebellaris anterior*) is at the periphery of the cord and consists of axones from the cells of the dorsal horn of the opposite

side that cross through the white commissure and ventral horn to form this tract. These fibers *ascend* to the cerebellum through its brachium conjunctivum and constitute ascending fibers that convey *muscle sense impressions*, chiefly from the opposite side of the body; they are concerned with *reflex actions*.

3. The *superficial dorsolateral spinocerebellar tract* (*fasc. spinocerebellaris posterior*) extends from the preceding to the dorsal root zone. It consists of the axones of the nucleus of Clarke from the same and opposite sides. These *ascend* and enter the cerebellum through the restiform body and convey also *muscle sense impressions* and are concerned with reflexes.

4. The *crossed pyramidal tract* (*fasc. cerebrospinalis lateralis*) is very extensive and lies medial to the preceding. This consists of the *descending* axones (85 to 90 per cent.) of the motor cells of the cerebral cortex that have decussated in the oblongata. They enter the ventral horn at various levels and terminate about the cells there that form the ventral roots of the spinal nerves especially. This tract continues to the fourth sacral segment.

5. The *lateral ground bundle* (*fasc. lateralis propius*) lies along the lateral margin of the ventral and dorsal horns. It consists of intersegmental association fibers (*ascending and descending*) that arise in the cells of both horns and end at various levels above and below their origin.

Between the above-mentioned tracts is an area called the *mixed lateral tract*. Here several tracts have been isolated.

6. The *rubrospinal tract* (*fasc. rubrospinalis*) consists of axones that *descend* from the cells of the red nucleus of the midbrain to end about the cells of the ventral horn.

7. The *tectospinal tract* (*fasc. tectospinalis*) consists of *descending* axones from the cells of the corpora quadrigemina that end about the cells of the ventral horn.

8. The *fasciculus spinotectalis* consists of *ascending* axones of the cells of the dorsal horn and ends in the corpora quadrigemina.

9. *Ventral* and *dorsal spinothalamic tracts* (*fasciculi spinothalamici anterior et posterior*) comprise *ascending* axones of cells of the dorsal horn of the opposite side that end in the thalamus. The ventral one conveys *impressions of touch* and *pressure* from the opposite side while the dorsal ones (mixed with the fibers of Gowers' tract) convey *impressions of heat*, *cold* and *pain* from the opposite side.

The **tracts** of the **dorsal column** are as follows:

1. The *fasciculus gracilis* (*Golli*) occupies the medial portion of the column along the dorsal septum. It consists almost entirely of the axones of the cells in the ganglia of the dorsal roots of the spinal nerves. It comprises those fibers representing the sacral, the lumbar and last eight thoracic nerves. The sacral fibers are nearest

the dorsal septum and the highest thoracic are nearest fasciculus cuneatus. There is really no functional difference between the fibers of this tract and the fasciculus cuneatus, the latter representing fibers that enter the cord merely at a higher level. Most of these fibers ascend some of them terminating in the gray substance of the dorsal horn at various levels; others, representing fibers from all the spinal nerve roots of this tract, extend the length of the cord and end in the nucleus gracilis of the oblongata. The descending fibers will be considered under the tracts of Schultze, Flechsig and septomarginal of Bruce.

2. The *fasciculus cuneatus* (*Burdachi*) lies lateral to the preceding and represents axones of the cells in the ganglia of the upper thoracic and cervical nerves. They correspond to the preceding and are merely of a higher level.

3. The *dorsal ground bundle* (*fasc. posterior proprius*) is another intersegmental association tract. It consists of the axones of some of the cells in the dorsal horn that pass to the tract and branch T-like and so ascend and descend for a short distance and reënter the gray substance.

4. The *comma tract of Schultze* (*fasc. interfascicularis*) lies deep between the fasciculis gracilis and cuneatus. It consists of the short descending branches of the fibers that form the two above fasciculi. These descend for a short distance and enter the gray of the dorsal horn.

5. The *oval tract of Flechsig* (*tractus cervicolumbalis of Edinger*) is another such tract situated in the fasciculus gracilis at the dorsal median septum. This is best seen in the lumbar region of the cord.

6. The *septomarginal tract* (*fasc. septomarginalis of Bruce*) is another group of descending fibers along the dorsal septum but close to the gray commissure. These tracts, *four*, *five* and *six*, are considered to be of an associative nature.

7. The *marginal tract* (*fasc. posterolateralis of Spitzka and Lissauer*) is a small bundle of fibers among the dorsal root fibers just after they enter the cord. It consists of the axones of some of the cells of the ganglia, that do not enter the dorsal fasciculi proper but continue up the spinal cord as the *marginal tract* to end around the cells of the substantia gelatinosa after a course of only three or four segments; some of these fibers may possibly end around the cells of the ventral and dorsal horns.

The *dorsal columns* are the most complex of the cord. It will simplify them to consider the course of the fibers that enter the dorsal roots of the spinal nerves.

1. Most of these latter fibers form the fasciculi cuneatus and gracilis; these fibers divide into ascending and descending branches. The ascending branches are of variable length some ending soon in

the gray of the dorsal horn and others ending in the same way at higher levels. Some ascending fibers of each spinal nerve continue to the oblongata and end in the nuclei cuneatus and gracilis. The descending branches that form the oval, comma and septomarginal tracts end in the gray substance of the dorsal horn.

2. Many fibers after entering the dorsal root zone course along the medial side of the gray of the dorsal horn and enter it to terminate around the cells of the same level. These latter cells represent neurons that form various tracts of the lateral column and are also concerned in the *reflex arc*.

3. Some fibers of the dorsal roots enter into the formation of the marginal tract and terminate about the cells of the substantia gelatinosa and perhaps around other cells of the ventral and dorsal horns.

The various cell groups and the formation of the various tracts of the spinal cord are diagrammatically represented in Fig. 262.

The **fiber tracts** consist of *extrinsic fibers:* (*a*) that arise outside of the cord and traverse it or end in it; (*b*) fibers that arise in the cord and pass out of it. Under (*a*) are the tracts of Goll and Burdach, the crossed and direct pyramidal tracts, vestibulospinal, olivospinal, some of the mixed lateral and marginal tracts; the direct cerebellar and Gowers' tracts, and parts of the mixed lateral tracts come under (*b*).

The *intrinsic fibers* are those that arise and end in the cord as the three ground bundles.

THE BRAIN

The **brain,** or **encephalon,** is an ovoid mass of gray and white nerve tissues that occupies the cranial cavity. It reaches its highest development in man. It is the seat of the intellect and special senses and presides over motion, respiration, circulation, etc. Its measurements are as follows: Frontooccipitally 6.4 to 6.8 inches (16 to 17 cm.), laterally 5.2 to 5.6 inches (13 to 14 cm.); height 5 inches (12.5 cm.). The average weight of the adult male brain is 1400 grams and of the female 1250 grams. At birth the weight in the male is 400 grams and in the female 380 grams. It usually doubles by the end of the first year and trebles by the end of the fourth or fifth year; it almost reaches its maximum by the end of the eighth or ninth year. From that time the growth in weight is slow and ceases about the eighteenth or twentieth year. The brain begins to lose weight after the sixtieth year and very rapidly from seventy to eighty years. The important *factors* that affect brain weight are *age, sex, race, intelligence, skull form* and *body weight.*

In regard to *race* the Caucasians have the heaviest and the Australians the lightest. There is considerable variation in the Caucasian race. In regard to *intelligence*, the brains of the highly intellectual individuals will weigh on the average 100 grams more. Brains weighing under 1000 grams in the male and 900 grams in the female are usually considered too low for mental integrity.

The brain consists of a number of divisions: (1) the *cerebrum*, comprising the *cerebral hemispheres* and a number of lesser structures; second, the *cerebellum;* third, the *brain stem*, comprising the *midbrain*, the *pons* and *tegmental portion* and the *oblongata*. The brain as a whole when viewed from above, exhibits two lateral masses, the **hemi-**

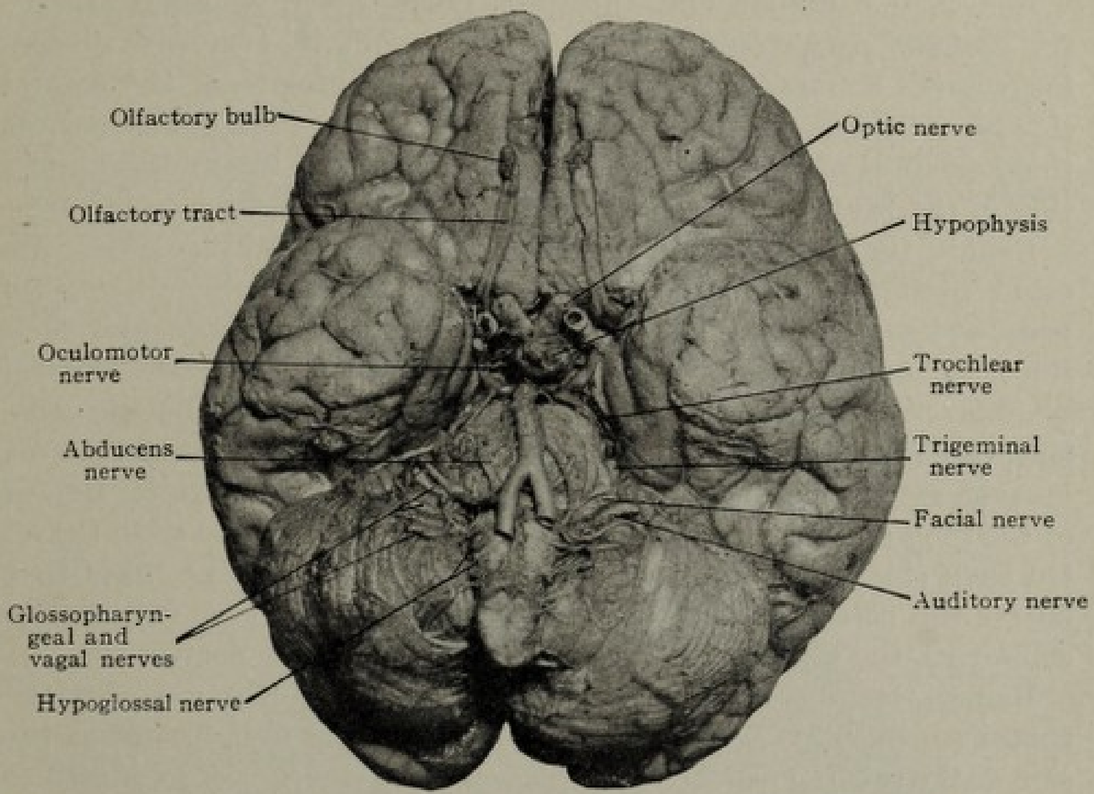


FIG. 263.—Ventral aspect of the brain showing the attachment of the cerebral nerves. (*From a photograph.*)

spheres, separated by a deep cleft, the *longitudinal fissure* (*fissura longitudinalis cerebri*). The *frontal pole* is rather narrow but not pointed. The *parietooccipital* region in the broadest and most massive, while the *occipital pole* is rather sharply pointed. The *superior* and *lateral surfaces* show several rather deep clefts or **fissures** and a number of smaller clefts or **sulci**; these separate the various lobes and convolutions from one another. The size and number of these convolutions depends upon the degree of intelligence. When the hemispheres are separated a whitish band, quite extensive fronto-occipitally, is seen at the bottom of the fissure connecting the two hemispheres; this is the **corpus callosum,** or *intercerebral commissure.* The cerebellum is not visible in this view.

The **under,** or **ventral surface** (*basis cerebri*), is also called the *base*. Going from before backward the following parts are seen: the *frontal lobes* separated by the longitudinal fissure and upon each side of the fissure an *olfactory bulb* and *tract*. Just behind the tracts, across the midline, lies the *optic chiasm* and farther to the side the *temporal lobes* which are separated from the frontal lobes by the *sylvian fissure*. Just behind the *chiasm* is the *tuber* and *stalk of the pituitary body;* to the rear of the tuber lie the *two corpora albicantia*, one upon each side of the midline. This represents the extent of the cerebrum upon the basal surface.

Behind the corpora albicantia is a rather deep, triangular space, the *posterior perforated space*, bounded laterally by two large diverging whitish masses, the *crura cerebri*. Appearing from the medial side of each crus (in the above space) is a nerve, the *oculomotor*, or third cerebral nerve. These structures constitute the midbrain portion of the brain stem.

Behind the posterior perforated space and partially covering the crura cerebri is a broad mass of transversely coursing fibers, the *pons;* at its lateral boundaries in front is seen a large nerve upon each side, the *trigeminus*, or fifth cerebral nerve; at its posterolateral boundary are noted two nerves, the *facial*, or seventh and the *auditory*, or eighth nerves. Coming out between the pons and the crus on each side is the *trochlearis*, or fourth nerve; at the inferior border of the pons and near the midline is seen the *abducens*, or sixth nerve. On each side, the pons continues as a thick rope-like mass that enters the corresponding cerebellar hemisphere; these two masses constitute the *middle cerebellar peduncles* or *brachia pontis*.

Behind the pons is a tapering structure that is continuous with the spinal cord. This is the *oblongata*. Out of the first fissure to the side of the median groove the *hypoglossus*, or twelfth nerve, is seen to emerge, while farther to the side are seen the roots of the *glossopharyngeus* (ninth), *vagus* (tenth)and *accessorius* (eleventh) *nerves*.

At the sides of the oblongata and completely covered by the occipital pole of the cerebrum are the two hemispheres of the *cerebellum*, separated from each other in the midline by a fissure.

The **dorsal surface** of the midbrain, pons and oblongata region are completely hidden by the cerebrum and cerebellum.

When the cerebellum is raised and the pia removed a shallow, diamond-shaped fossa, *the fourth ventricle* is exposed. This is bounded below by the diverging inferior cerebellar peduncles and above by the converging superior cerebellar peduncles.

When the cerebral hemispheres are raised from the cerebellum the *pineal body* and the *corpora quadrigemina* are exposed. The *pineal body* lies in front of and between the two anterior quadrigeminal bodies. These will all be considered under the midbrain.

It is customary to give the external anatomy of each part with its

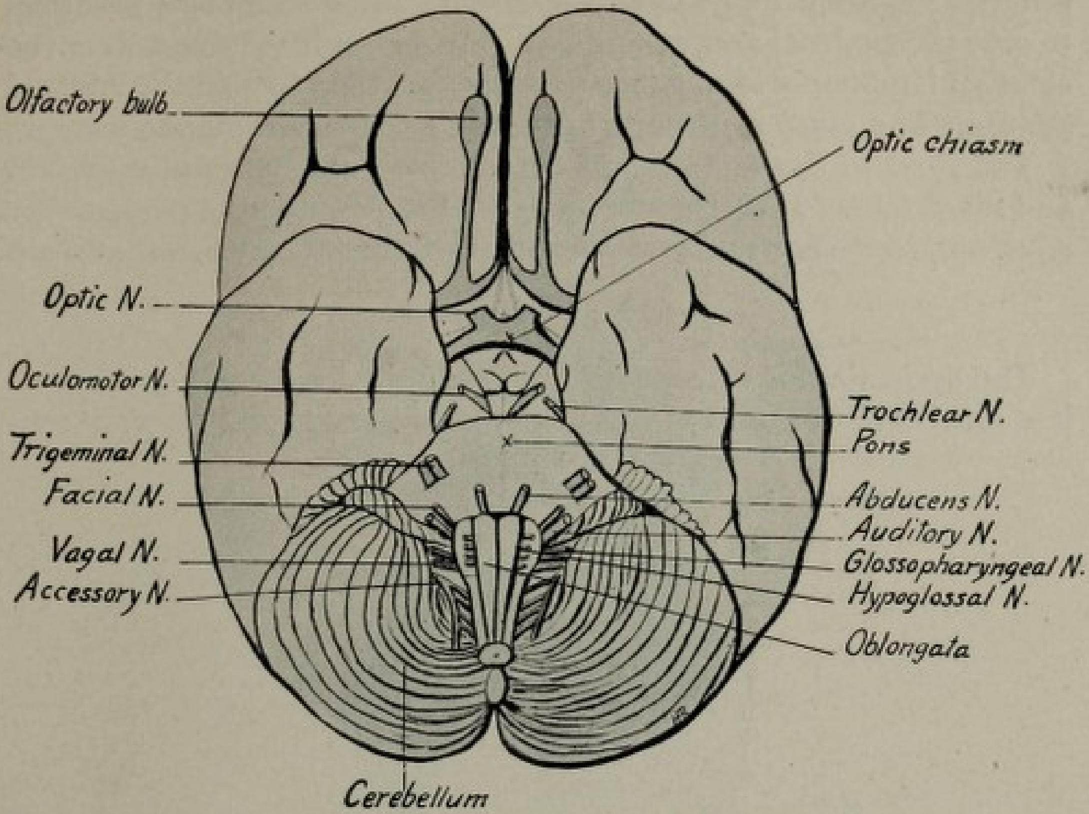


FIG. 264.—Diagram of the ventral surface of brain showing the attachments of the cerebral nerves.

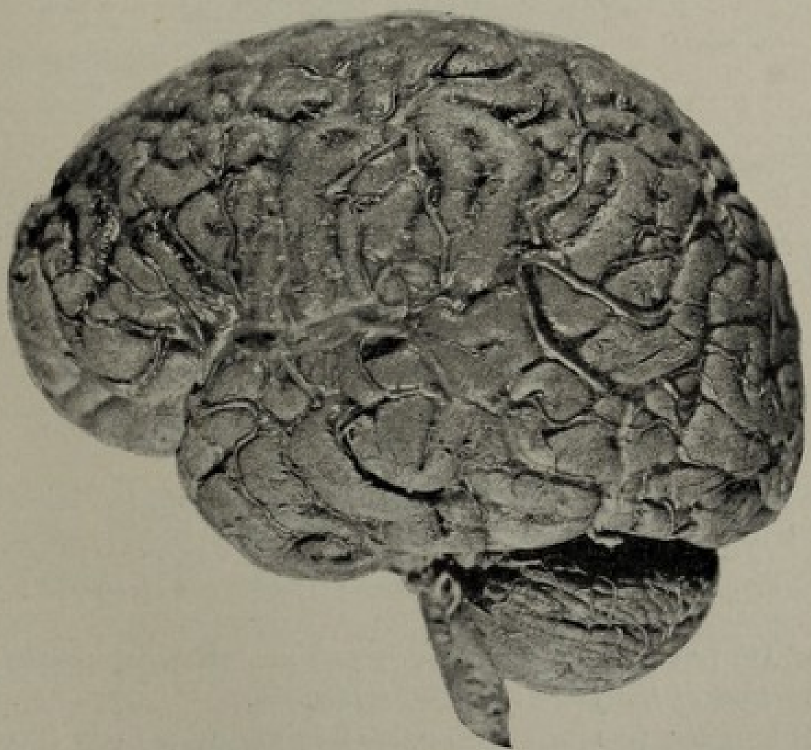


FIG. 265.—Left lateral aspect of the brain with the arachnoid, pia and vessels intact. (*From a photograph*).

internal anatomy immediately following. It seems more practical to give the external anatomy of each part in sequence connecting the external landmarks as much as possible, and then to give the internal anatomy and carry it through in the same connected manner.

The parts of the brain are often described as forebrain, midbrain and hindbrain. It seems more practical to describe the parts under *cerebrum*, *cerebellum* and *brain stem* and will be taken up in that way.

THE BRAIN STEM

The brain stem is continuous with the spinal cord and as it shows less differentiation and is the next direct part it will be first con-

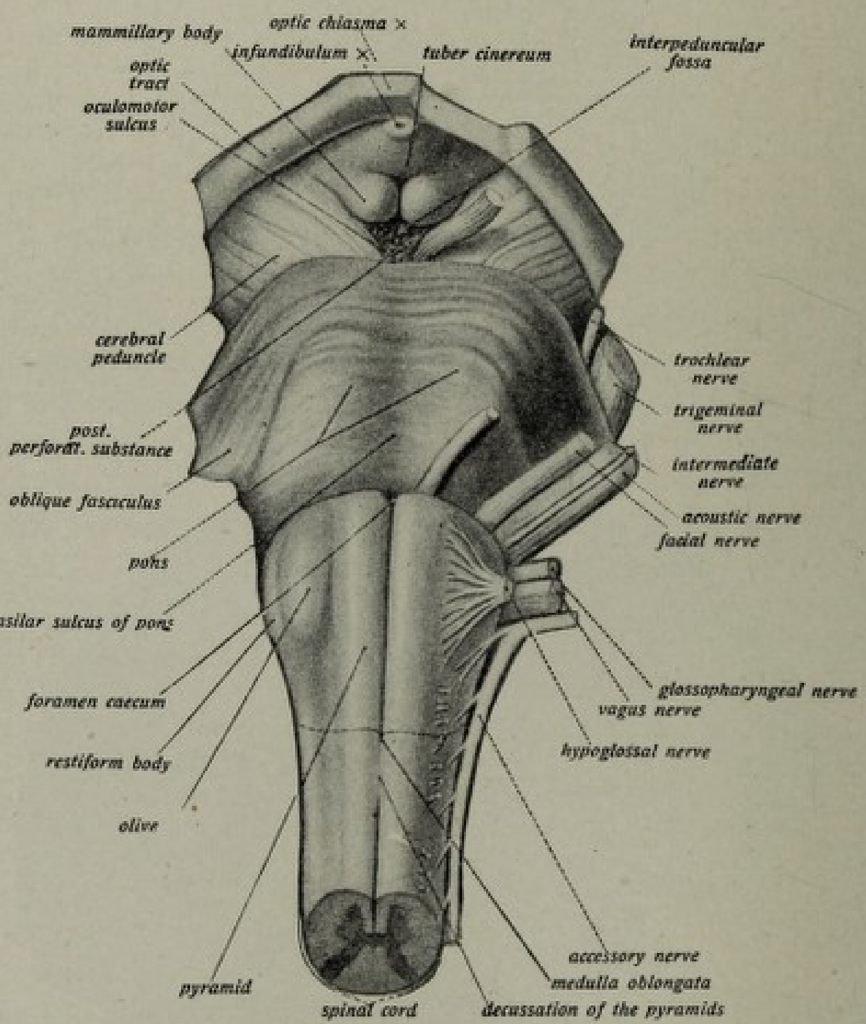


FIG. 266.—Brain stem, ventral view. (*Sobotta and McMurrich.*)

sidered. Its parts from below, upward are *oblongata*, *pons* and *tegmental portion of the pons* and the *midbrain*.

The **oblongata** (*medulla oblongata*) is about 1 inch (2.5 cm.) in length and is a connecting link between the spinal cord and higher centers. It is smallest at the spinal cord end and gradually increases in its dimensions toward its base. At the spinal cord end it measures about 10 mm. in both dimensions; at the pontile end it measures 17 to 18 mm., transversely, and about 15 mm. dorsoventrally. It is flattened from before backward and is directed nearly vertically, resembling an inverted, flattened, truncated cone. It presents *ventral*, *lateral* and *dorsal areas* and certain *grooves*.

The **ventral area** contains only the *pyramid* (*pyramis*, or *fasciculus cerebrospinalis anterior*) and is divided longitudinally by the *ventro-*

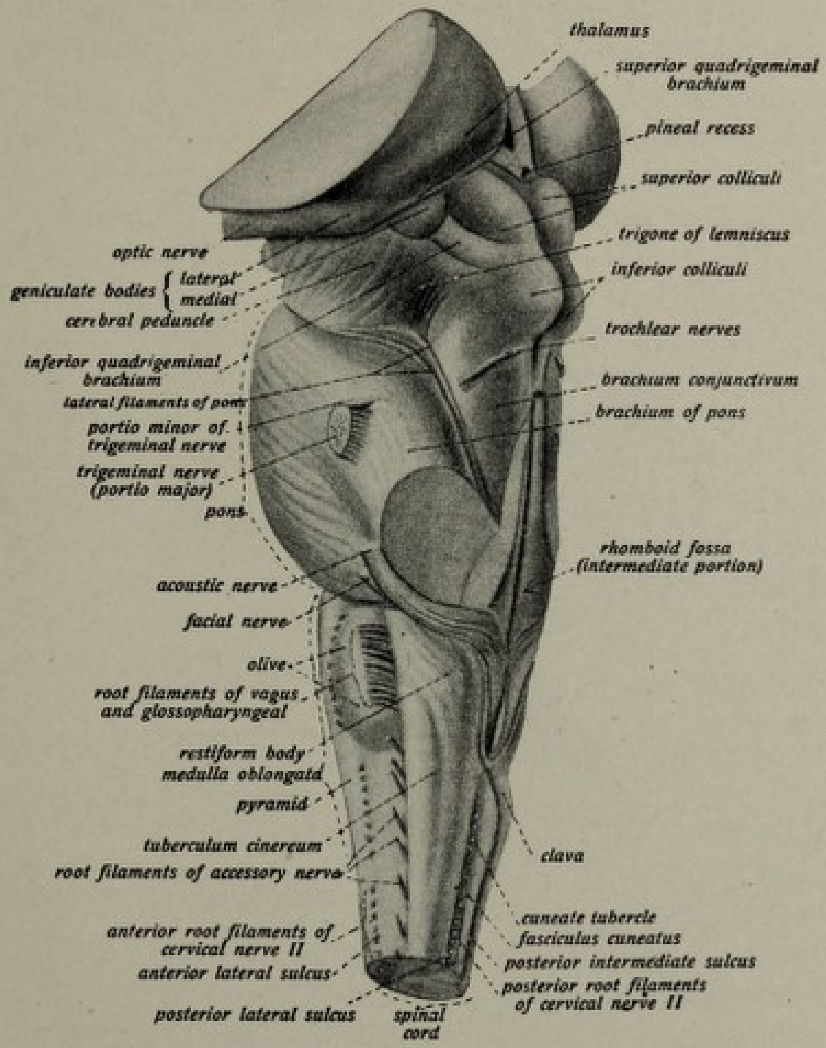


FIG. 267.—Brain stem, lateral view. (*Sobotta and McMurrich.*)

median groove (*fissura mediana anterior*) that terminates at the *foramen cecum*. This groove is not continuous as it is crossed and interrupted by bundles of fibers passing from one side to the other constituting the *pyramidal decussation* (*decussatio pyramidum*). At a little distance to the side of the ventromedian groove is another, the *ventrolateral sulcus* (*sulcus lateralis anterior*). The mass of fibers between these two grooves is the *pyramid*. Those fibers of the pyramid that cross, or decussate (85 to 90 per cent.) constitute the crossed pyramidal tract of the spinal cord. The remaining fibers continue down the same side to the appropriate levels, then cross to the opposite side through the white commissure of the cord; these fibers constitute the direct pyramidal tract of the spinal cord. Between the pons and the upper end of the pyramid the *abducens nerve* is seen to emerge.

The **lateral area** of the oblongata contains the *olivary body*, the *lateral column* and *certain nerve roots*. The *olivary body* (*oliva*) is about the size and shape of an olive pit, that is, about ½ inch (12 mm.) long; it is situated at the upper end of the lateral area and represents the position of the inferior olivary nucleus.

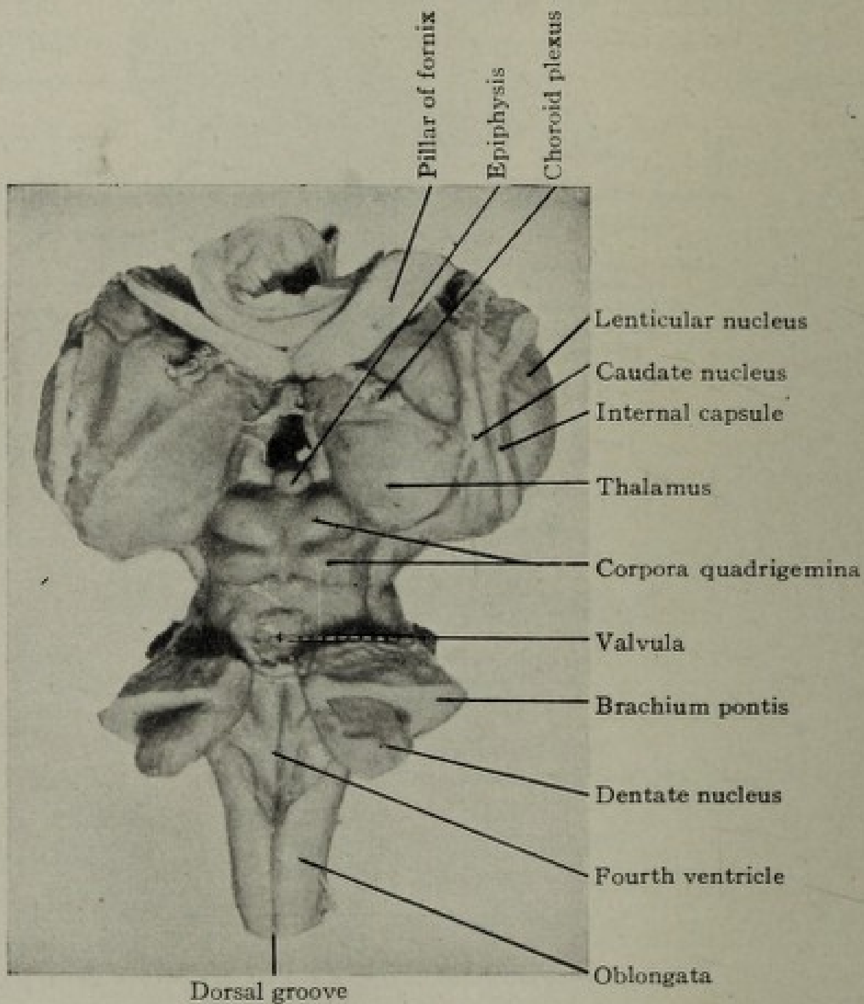


FIG. 268.—Dissection showing the dorsal aspect of the brain stem with the corpora striata and dentate nuclei intact. (*From a photograph.*)

The *lateral column* is in part the continuation of some of the lateral tracts of the spinal cord, *i.e.*, the direct cerebellar, Gowers' and the lateral ground bundle. Below (caudad) the olive it is well marked, being located between the ventrolateral and dorsolateral grooves. Near the olive it is crossed and hidden by the *external arcuate fibers* that pass to the dorsal area.

Between the olive and the pyramid are seen the *roots of the hypoglossal nerve* emerging from the ventrolateral groove. In the dorsolateral groove are seen the *roots of the vagal* and *glossopharyngeal nerves*, above, and the *roots of the accessory nerve*, below.

The **dorsal area** is more complicated. In its lower (caudal) two-thirds in the midline, is the *dorsomedian groove* (*fissura mediana posterior*), which ends above at the lower angle of the fourth ventricle. This is bounded upon each side by a club-shaped elevation, the *nucleus gracilis;* the upper end of this is expanded and is called the *clava.* The nucleus gracilis is bounded laterally by the *dorsal paramedian groove* (*sulcus intermedius*) to the outside of which is the *nucleus cuneatus;* this is bounded laterally by the *dorsolateral groove* (*sulcus lateralis posterior*). These two nuclei occupy the lower two-thirds of the dorsal area. Between the upper end of the nucleus cuneatus and the lateral area lies an eminence the *tuberculum rolandi* (*tuberculum cinereum*); this eminence lies in the dorsolateral groove and causes it to fork at this point. The upper part of the dorsal area in the midline is the lower part of the fourth ventricle, while the lateral part of the area is represented by quite a mass of fibers called the *restiform body*, or *inferiör cerebellar peduncle* (*corpus restiforme*); these two peduncles constitute the lateral boundaries of the lower half of the fourth ventricle. This peduncle consists of the *direct cerebellar tract* of the spinal cord and the *superficial* and *deep arcuate fibers* of the oblongata. The *superficial arcuate fibers* appear from the ventromedian groove and sweep laterally and dorsally over the olive in a sheet-like manner occasionally covering the entire olive. They continue dorsally and assist in the formation of the restiform body.

THE PONS AND THE TEGMENTAL PART OF THE PONS

The pons, or bridge (Fig. 266), represents the broad band of fibers on the ventral surface of the middle part of the brain stem. It is not sharply demarcated from the tegmental part upon section. It represents the transverse fibers that connect the cerebellar hemispheres with each other through the nuclei pontis and constitutes a cerebellar commissure. It is about 1 inch (2.5 cm.) from side to side and also from above downward; it extends laterally to the root of the trigeminus nerve on each side. Along the midline its presents the *basilar groove* (*sulcus basilaris*) in which lies the basilar artery. Along the lower border of the pons three cerebral nerves are seen; near the midline is the *abducens* and at the side the *facial* and *auditory nerves*, at the upper edge of the restiform body. At the sides the pons fibers become massed into a cylindrical band that passes into each cerebellar hemisphere; these are the *middle cerebellar peduncles* (*brachia pontis*). Emerging through the lateral border of the pons is the *trigeminal nerve* constituting the arbitrary lateral boundary of the pons and the beginning of the brachium pontis.

The *tegmental part of the pons*, or *pars dorsalis pontis*, cannot be seen from the ventral surface. If a knife be passed frontally, dorsal to the pons and this structure lifted off, the tegmental part approximately, will be exposed; it seems to be a continuation of the oblongata and by some is well called the *preoblongata*. The dorsal part of this portion of the brain stem shows the *upper half of the fourth ventricle.* At the lateral angles of this space are seen the massive middle cerebellar peduncles; the lateral boundaries, above, are the *converging superior cerebellar peduncles* (*brachia conjunctiva*) that also overhang and form a part of the roof of the fourth ventricle.

The **fourth ventricle,** or **rhomboidal fossa** (*ventriculus quartus*), represents the canal of the spinal cord laid open and the walls at the sides stretched so as to form a diamond-shaped fossa. It is nearly vertical in direction. The *roof* is very thin, possessing practically no nerve tissue, and is reinforced by the pia; that portion over the lower half of the ventricle is called the *inferior medullary velum* (*velum medullare inferius*), while that over the upper half constitutes the *superior medullary velum,* or *valvula* (*velum medullare superius*). Ordinarily the cerebellum hides the fourth ventricle completely.

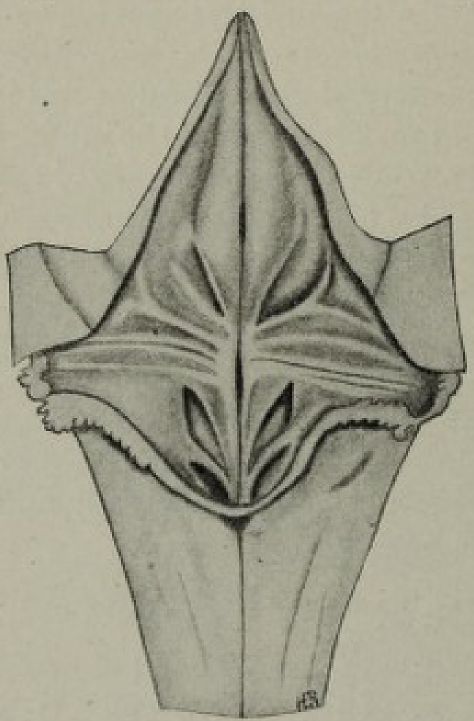


FIG. 269.—The so-called "floor" of the fourth ventricle.

The *so-called floor* is nearly vertical in direction and represents the dorsal surface of the pars dorsalis pontis and oblongata; it consists of gray nerve tissue. It shows a *median longitudinal furrow* and is divided into upper and lower triangles by some nerve fibers that cross the middle of the space transversely to pass into the median furrow; these fibers, the *acoustic striæ* (*striæ medullaris*) may be absent, but when present approximately separate the oblongatal part of the ventricle from the tegmental, or pontile potion.

In the upper triangle near the midline and the acoustic striæ is an eminence, the *colliculus facialis* (*eminentia mediana*); just below and lateral is a depressed area, the *superior fovea.* Above the eminence, toward the apex of the triangle, is a slate-colored, slightly depressed area, the *locus cœruleus;* the cells in this area are pigmented by the *substantia ferruginea.*

In the lower triangle just below the acoustic striæ is the *area acustica* (better *area vestibularis*). Medially and below this is a triangular depression, the *trigonum vagi* (*ala cinerea*) and between this and the median groove is seen a tapering elevation, the *trigonum hypo-*

glossi. These tapering elevations, at the lower angle of the ventricle, constitute the *calamus scriptorius* (point of a pen).

Between the lower margin of the trigonum vagi and the lower boundary of the ventricle is a narrow space, the *area postrema;* this is separated from the trigonum vagi by the *funiculus separans,* a clear ridge.

The lower lateral boundaries of the **fourth ventricle** are the diverging restiform bodies; at the lateral angles are the two middle peduncles; the upper lateral boundaries are the converging superior peduncles that also form a small part of the roof in this region.

The fourth ventricle communicates caudally with the spinal canal and above it is continuous with the aqueduct of Sylvius, or iter. It represents a lymph space and communicates with the subarachnoid space by means of an opening in the roof of the lower triangle, the *foramen of Majendie.* The roof at the lateral angles possesses small openings called the *foramina of Luschka.* At the sides of the ventricle are the *lateral recesses* (*reçessi laterales*) that communicate with the subarachnoid space upon the ventral surface (at the sides) between the acoustic and hypoglossal nerves by means of the *apertura lateralis ventriculi quarti.*

THE MIDBRAIN

The midbrain, the upper part of the brain stem, comprises the *crura cerebri*, the *posterior perforated space*, the *corpora quadrigemina*, the *medial geniculate bodies*, the *brachia* and the *aqueduct of Sylvius*. It is about ¾ inch (18 mm.) in length.

The **crura cerebri** (*pedunculi cerebri*) are seen upon the ventral surface; each crus is a large, whitish, cylindric mass of nerve fibers which starts at the upper border of the pons, but at a more dorsal level, and passes upward (frontally) and laterally into the cerebrum. It represents the chief bulk of the midbrain. Between the diverging crura is a triangular depressed area called the **posterior perforated space** (*interpeduncular space*). This is so called because of the large number of small openings that transmit vessels into the interior of the brain of this region. Along the medial side of each crus is the *oculomotor sulcus* (*sulcus oculomotorius*) from which emerges the oculomotor nerve. Near the pontile border of the lateral margin of each crus is the trochlear nerve.

Upon each side of the midbrain are seen the **crus,** the **medial geniculate body,** and the **superior** and **inferior brachia.**

The **internal geniculate body** (**corpus geniculatum mediale**) is a small oval eminence on the side of the midbrain. It is connected with its fellow of the opposite side by the commissure of Gudden. It also represents an intermediate nucleus in the auditory pathway.

The **superior brachium** (*brachium quadrigeminum superius*) is a band of fibers at the upper, medial part of the midbrain. It consists of fibers of the optic tract that terminate in the superior quad-rigeminal body and also of fibers that pass to the lateral geniculate body.

The **inferior brachium** (*brachium quadrigeminum inferius*) lies at the side of the upper quadrigeminal body and disappears under the medial geniculate body. It represents fibers of the auditory pathway from the inferior quadrigeminal body.

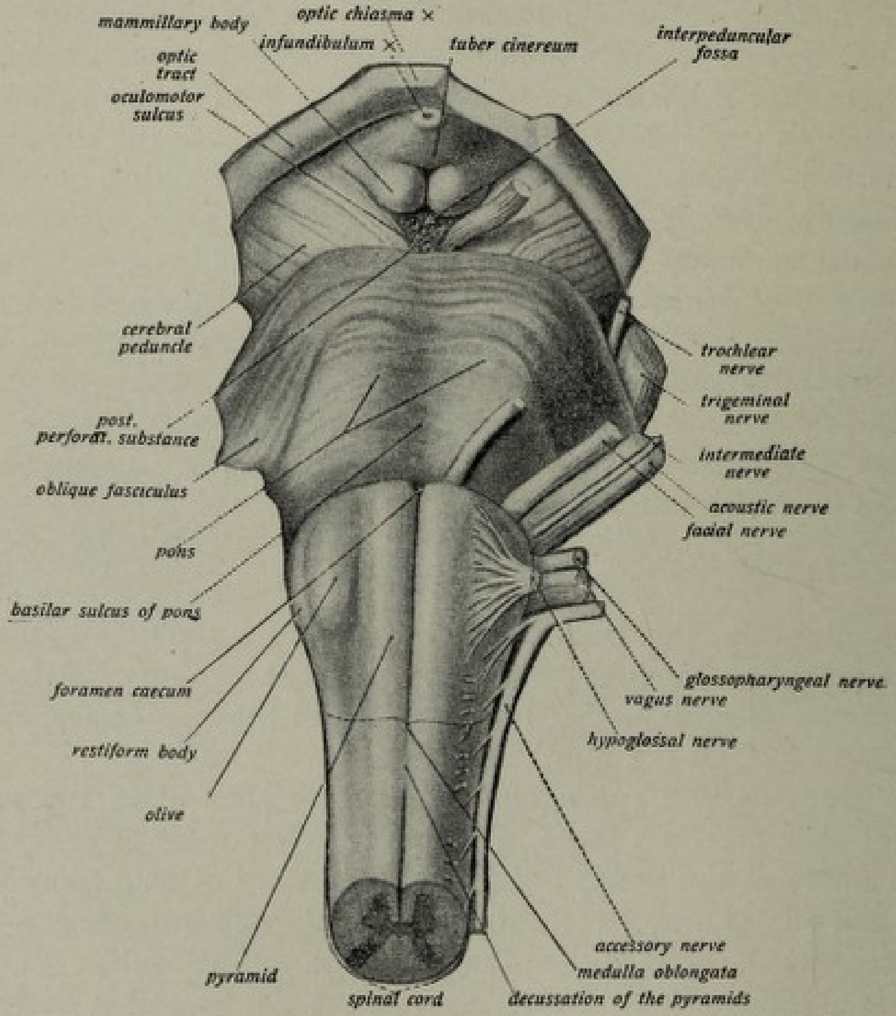


FIG. 270.—Brain stem, ventral view. (*Sobotta and McMurrich.*)

The *dorsal surface of the midbrain exhibits* the **corpora quadrigemina,** or **colliculi;** of these there are *four, two superior* and *two inferior,* and they are separated from one another by a transverse and a longitudinal furrow. The latter is in the midline.

The **superior quadrigemina** are oval in shape, yellowish gray in color and are the larger. Above, in the median groove that separates them, lies the pineal body. They are centers connected with eye-muscle reflexes, resulting from optic and auditory impulses.

The **inferior quadrigemina** are nearly hemispherical in shape and lighter in color than the preceding. They are nuclei in the pathway of auditory impulses.

The superior and inferior quadrigemina rest upon the *lamina quadrigemina* which really constitutes the dorsal wall of the midbrain.

The **iter, or aqueduct** (*aqueductus cerebri*), is a narrow canal connecting the third and fourth ventricles. Its shape varies somewhat in different parts and it lies nearer the dorsal than the ventral surface of the midbrain.

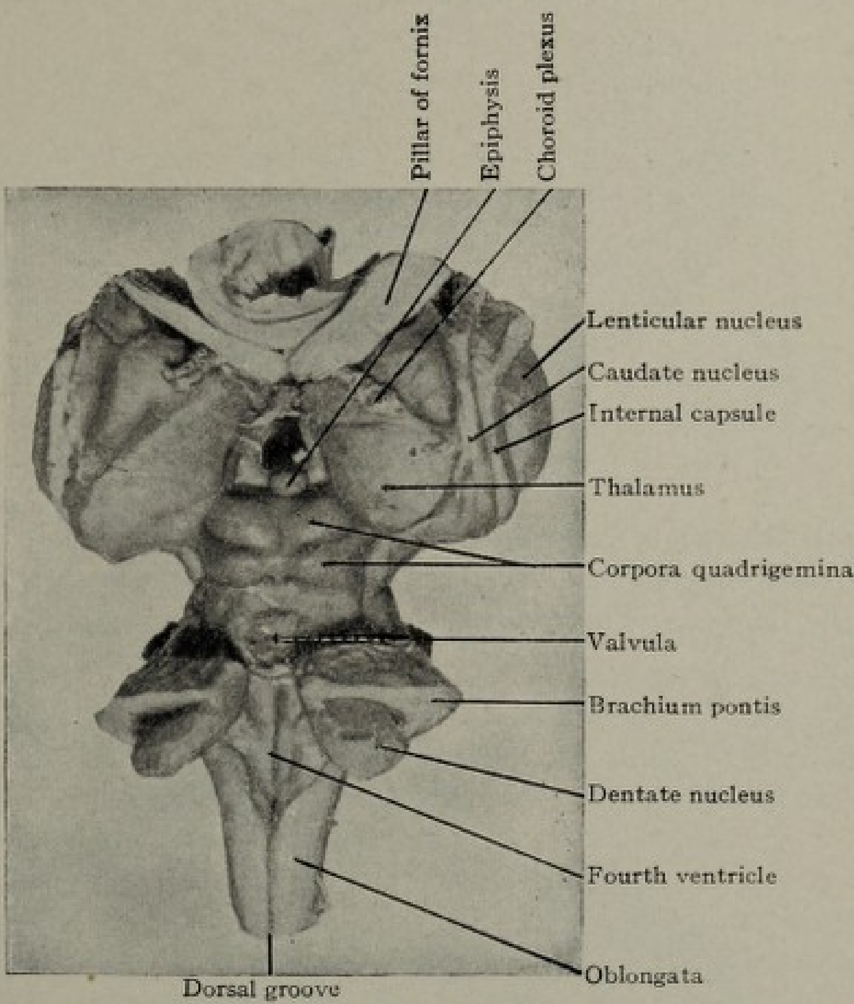


FIG. 271.—Dissection showing the dorsal aspect of the brain stem with the copora striata and dentate nuclei intact. (*From a photograph.*)

THE CEREBELLUM

The cerebellum lies in the posterior fossa of the skull under cover of the occipital pole of the cerebrum from which it is separated by the shelf of dura called the *tentorium cerebelli*. It averages 165 grams in the male and 155 grams in the female, reaching its greatest weight between the twenty-fifth and thirty-fifth years. It represents a coördinating center and might well be called the balancing brain.

The cerebellum consists of *two lateral lobes*, or **hemispheres**, and a *middle lobe*, or **vermis**. The two hemispheres are separated from each other ventrally by a *groove*, the *vallecula*, into which the oblongata, tegmental portion of the pons and the midbrain fit. Dorsally the hemispheres are less widely separated.

The **vermis** and each **hemisphere** present a *superior* and an *inferior surface.* The *superior surface* of the vermis consists of the following lobes, from before backward: (*a*) *lingula cerebelli;* (*b*) *lobus centralis;*

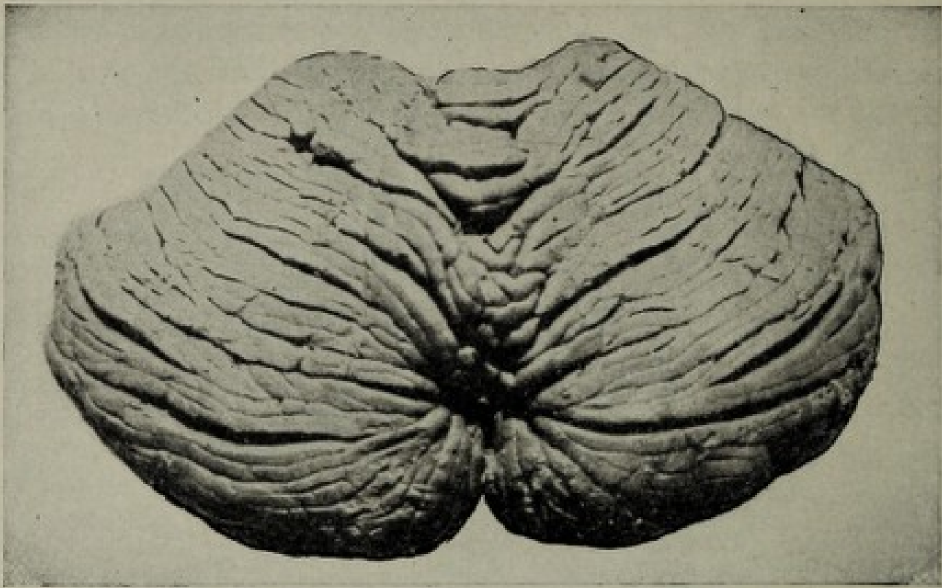


FIG. 272.—Superior surface of the cerebellum. (*From a photograph.*)

(*c*) *culmen;* (*d*) *declive.* The lobes of the superior surface of each hemisphere represents a continuation of these with the exception of the lingula. The *central lobe* is continued into each hemisphere as

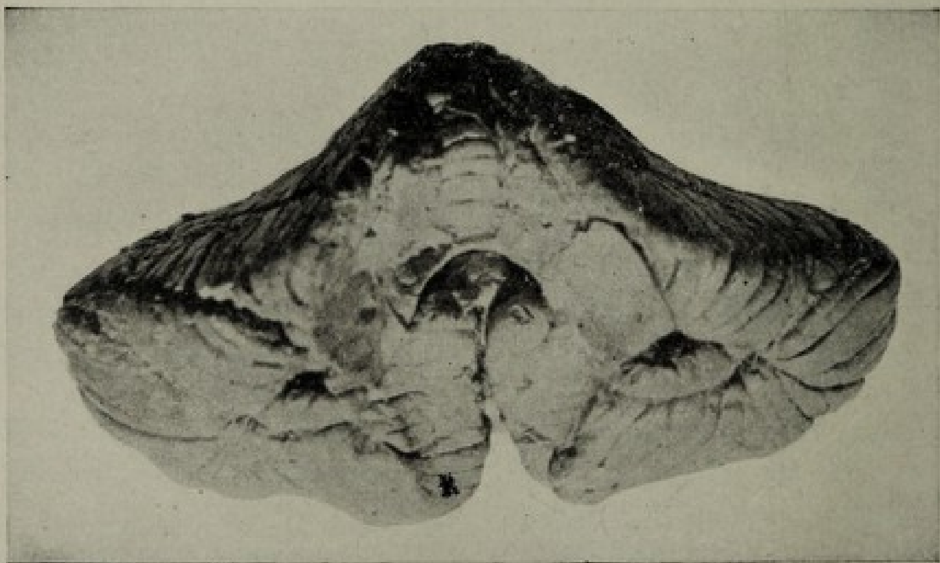


FIG. 273.—Frontal view of the cerebellum. (*From a photograph.*)

the *ali lobuli centralis.* The *culmen* continues as the *lobus culminis.* The *declive* continues as the *lobus lunatus.* In addition to these lobes the last of those of the superior surface is the *posteroinferior lobe.*

Upon the *inferior surface* of the vermis the following lobes are noted from behind forward: (*a*) *tuber;* (*b*) *pyramis;* (*c*) *uvula;* (*d*) *nodulus.* Upon each hemisphere in the same order are the (*a*) *posteroinferior lobule;* (*b*) *biventral lobule;* (*c*) *tonsilla;* (*d*) *flocculus.*

The **fissures** of the cerebellum all run, in general, transversely and are eight in number forming, thus, nine lobes.

The cerebellum is connected to the rest of the nerve system by its *three pairs of peduncles.* The *inferior peduncles* (*corpora restiforme*) connect the *cerebellum* with the spinal cord, the oblongata and the cerebral nerve nuclei. The *middle peduncles* (*brachia pontis*) the largest, consist mainly of fibers that connect one cerebellar hemisphere with the other through the nuclei pontis. The *superior peduncles* (*brachia conjunctiva*) are the smallest and consist chiefly of fibers that connect the cerebellar cortex with the midbrain, especially.

THE CEREBRUM

The cerebrum comprises the *cerebral hemispheres*, the *corpora striata*, the *callosum*, *olfactory tracts* and *bulbs* and the following structures usually classified as *diencephalon:* the *thalami*, the *epiphysis*, the *corpora albicantia*, *tuber*, *hypophysis*, *optic chiasm* and *tracts* and the *lateral geniculate bodies.*

Viewed dorsally only the cerebral hemispheres are seen. When these are separated in the midline, the callosum is exposed. If the cerebral hemispheres are raised, then the epiphysis and velum interpositum are shown covering the thalami and third ventricle. The lateral geniculate bodies are also seen laterally placed. Ventrally are seen from behind forward, the corpora albicantia, the tuber cinereum and hypophysis, the optic chiasm and tracts, and the olfactory tracts and bulbs.

The ventral structures will be considered first.

The **corpora albicantia** are two small, whitish bodies situated close together, one on each side of the midline in the interpeduncular space. These are nuclei in the olfactory pathway.

The **tuber cinereum** is a hollow, conical structure lying just in front of the corpora albicantia. Its cavity constitutes the *infundibular recess* of the third ventricle. Connected with the lower end of the tuber is the hypophysis.

The **hypophysis, or pituitary body,** is a small glandular structure suspended from the lower end of the tuber by means of a small *stalk.* It consists of two divisions the, *anterior lobe*, or *prehypophysis*, and a *posterior portion*, the *posthypophysis.* The *former* is epithelial in structure and is derived from the oral epithelium; the *posthypophysis* is a direct derivative of the nerve system. These two parts are bound together by a common *capsule.*

The **optic chiasm** lies just in front of the tuber and is formed by the convergence of the optic nerves here, attended by a decussation of some of their fibers. The nerve fibers from the nasal portion of each retina cross to the opposite side of the brain while those from the temporal side of the retina continue on the same side. This produces the chiasm and decussation. The fibers on each side then continue as a flattened band called the *optic tract* of which *some* of the fibers pass to the *lateral geniculate* body, *others* to the *pulvinar* of the thalamus and the *remainder* to the *superior quadrigemina*. These fibers constitute the *lateral root* of the optic nerve. The

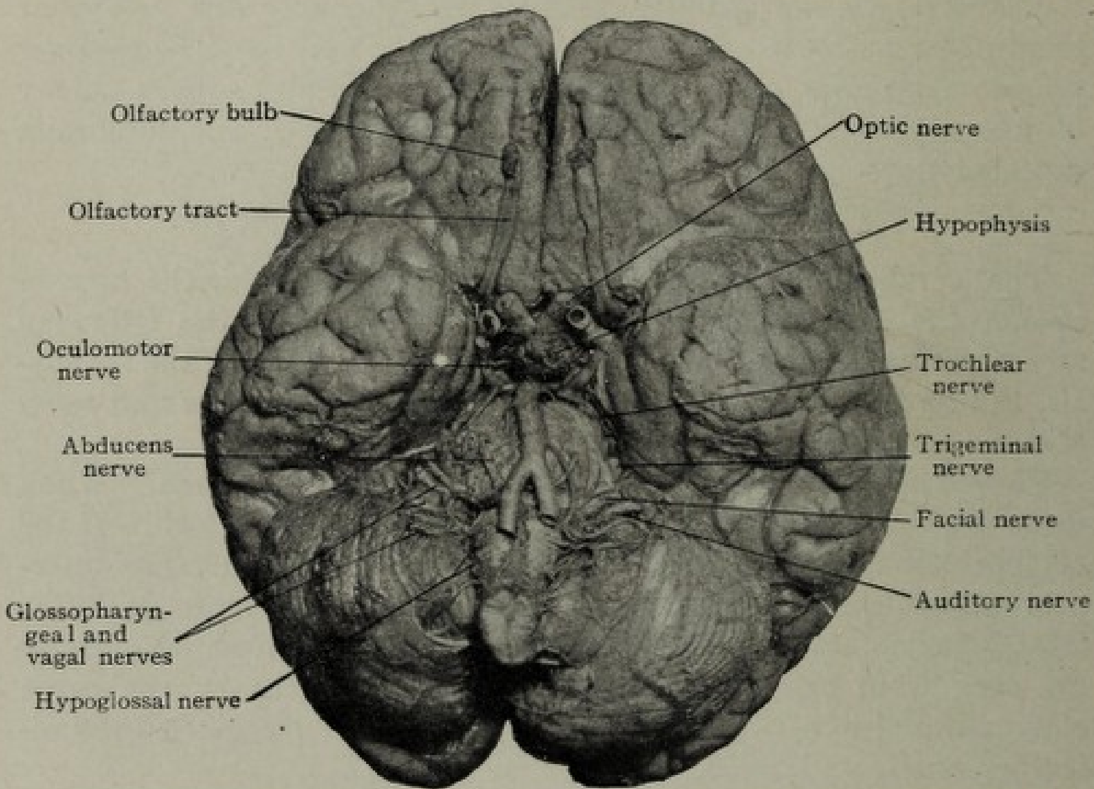


FIG. 274.—Ventral aspect of the brain showing the attachment of the cerebral nerves. (*From a photograph.*)

medial root, or *infracommissure of Gudden*, are independent of these fibers and connect one medial geniculate body with the other through the chiasm but constitute no part of the true optic pathway.

The **lamine terminalis** is a thin layer of gray nerve tissue just behind the optic chiasm, extending upward into the cerebrum in front of the optic thalami and anterior commissure; it separates these from the cerebral hemisphere in front. It represents the frontal end of the original neural tube. The preceding structures constitute the *hypothalamus*.

The **lateral geniculate body** (*corpus geniculatum laterale*) is seen in a lateral view and lies just in front of the medial geniculate body of the midbrain and represents a way-station of visual impulses in the optic pathway. It represents a part of the thalamus. These bodies constitute the *metathalamus*.

The **thalami** lie under cover of the cerebral hemispheres and velum interpositum. When exposed each is a large, ovoid mass of gray nerve tissue separated from its fellow, in the midline, by a vertical cleft, the *third ventricle*. The posteromedial part constitutes the *pulvinar*. The ventricular surface is smooth and shows an area where the two thalami are united across the midline, making the *middle commissure* (*massa intermedia*). Above this and arching over the entire surface is a narrow ridge showing where the dorsal and

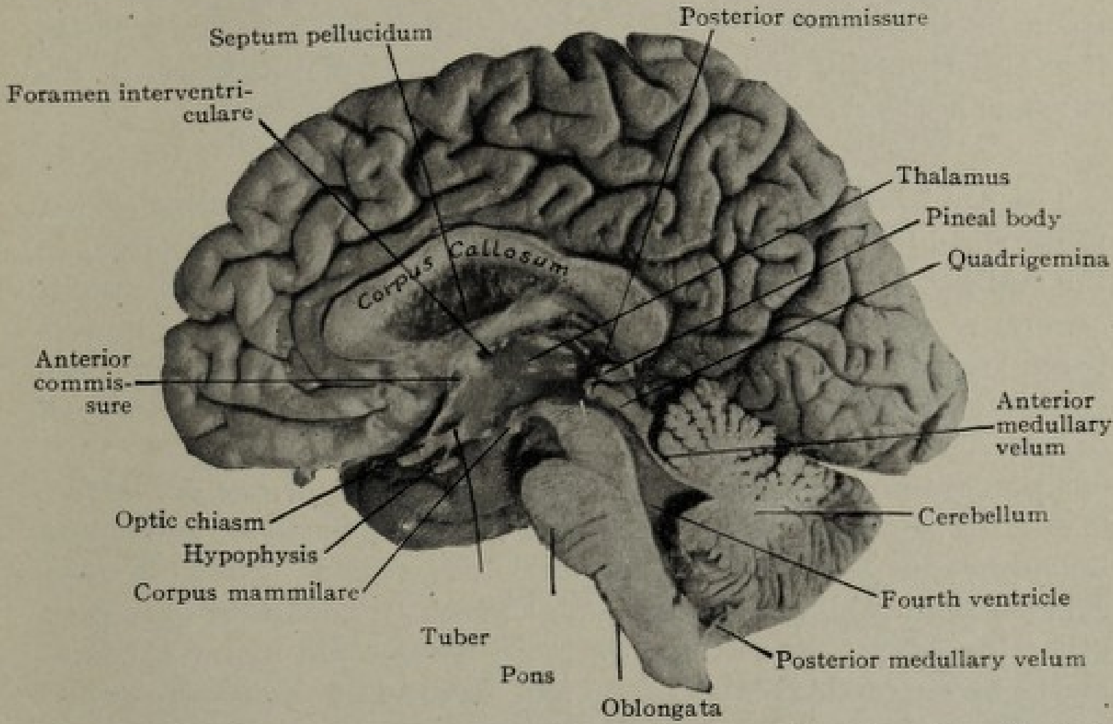


FIG. 275.—Median sagittal section of the brain showing the medial surface of the right half. (*From a photograph.*)

medial surfaces meet and where the velum interpositum is attached. The thalamus is a nucleus in the optic pathway as well as in the general sensor pathway, from the tegmentum to the cerebral cortex (touch pain, temperature, muscle sense and emotional).

The **epiphysis,** or **pineal body,** is a small, reddish body lying between the superior quadrigeminal bodies at the caudal end of the roof of the third ventricle. Its cavity is called the *epiphyseal recess* and is an extension of the third ventricle.

The **velum interpositum** is a thin membrane roofing the third ventricle and covering the dorsal surface of the thalami. This represents the bulk of the roof of the third ventricle and no nerve tissue develops here. It is a thin epithelial layer and is reinforced by pia with its blood-vessels called the *tela chorioidea*. The tela forces this epithelial layer in as two ridges with blood-vessels and these constitute a part of the *chorioidal plexuses*.

Just in front of the superior quadrigemina and between the caudal ends of the thalami is a small triangular area called the *trigonum habenulæ*. This contains some nerve cells, the *ganglion habenulæ*. The axones from these cells form the *fasciculus retroflexus* and terminate in the *ganglion interpedunculare* of the interpeduncular space. The ganglion habenulæ is a way-station in the olfactory pathway.

The epiphysis, velum and trigonum habenulæ constitute the *epithalamus*.

The **third ventricle** (*ventriculus tertius*) is a vertical, cleft-like space between the two thalami. It communicates caudally with the iter and frontally and laterally with the lateral ventricles, in the cerebral hemispheres, by means of the *foramina of Monro*.

CEREBRAL HEMISPHERES

The cerebral hemispheres constitute about six-sevenths of the brain weight. The hemicerebri are separated from each other, in the midline, by the *median longitudinal fissure* (*fissura longitudinalis cerebri*) at the bottom of which is seen the *callosum* which connects these hemispheres with each other. The cerebral hemispheres are connected with the rest of the brain mass by means of the *internal capsule*.

Upon examining each hemicerebrum the *lateral*, or *external surface* is seen to be convex while the *medial surface* is flattened above and hollowed out below in the temporal lobe region. Each of these exhibits little folds called *convolutions* which are separated form each other by *fissures*, or *sulci*. The main fissures are important land marks in the cerebral topography and serve to separate more or less completely the various lobes from one another.

The lobes are *frontal*, *parietal*, *occipital*, *temporal* and *central* in each hemisphere. The interlobar fissures bound these lobes fairly well.

Fissures.—Upon the *lateral surface* are seen the following interlobar fissures:

1. The *Sylvian fissure* (*fissura cerebri lateralis*) is about 2¼ inches (6 cm.) long and is seen at the base and side of the frontal end of the cerebrum. It is the deepest fissure and varies from 15 mm. at its beginning to 25 to 30 mm., at its deepest part. It extends backward and upward and serves to separate the frontal and parietal lobes, above, from the temporal lobe, below. It consists of *stem*, *posterior*, *ascending* and *anterior horizontal rami*. When its lips are separated, the *insula*, or *island of Reil* (*central lobe*) is exposed. The insula is surrounded by the *circuminsular fissure* (*sulcus circulares*).

2. The *central fissure* (*fissura centralis*) starts upon the medial surface and then extends obliquely downward and forward on the lateral surface, in a sinuous manner, for about 4 inches (10 cm). It makes an angle of about 71° with the midline and separates the frontal from the parietal lobe.

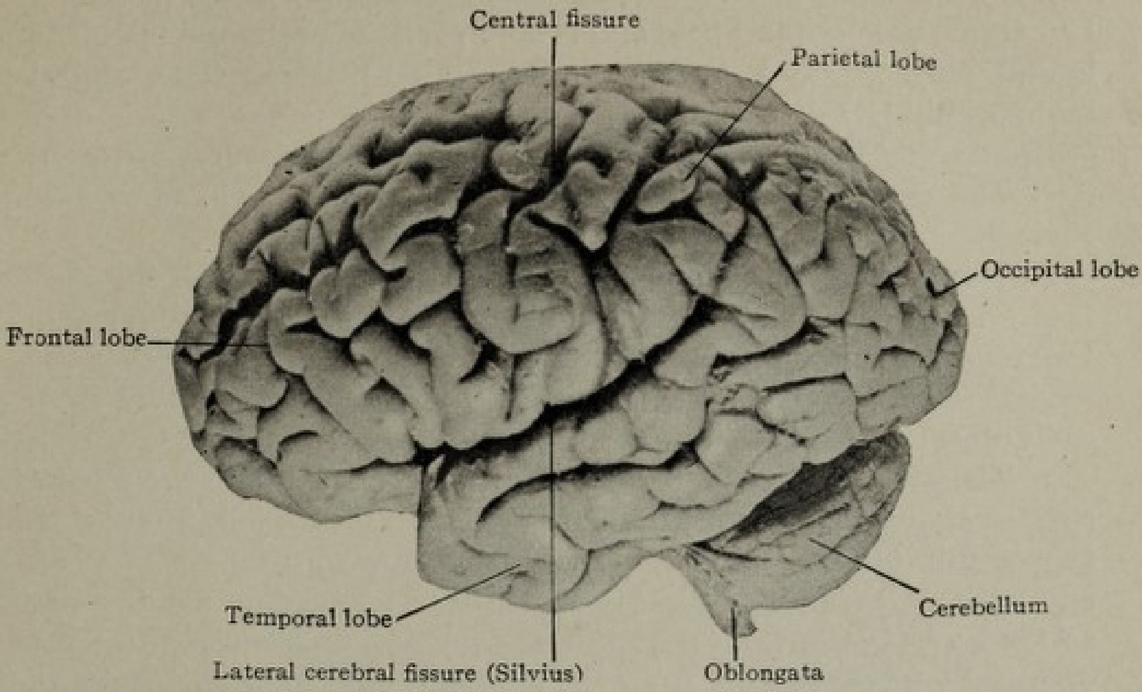


FIG. 276.—Left lateral aspect of the brain with the membranes removed. (*From a photograph.*)

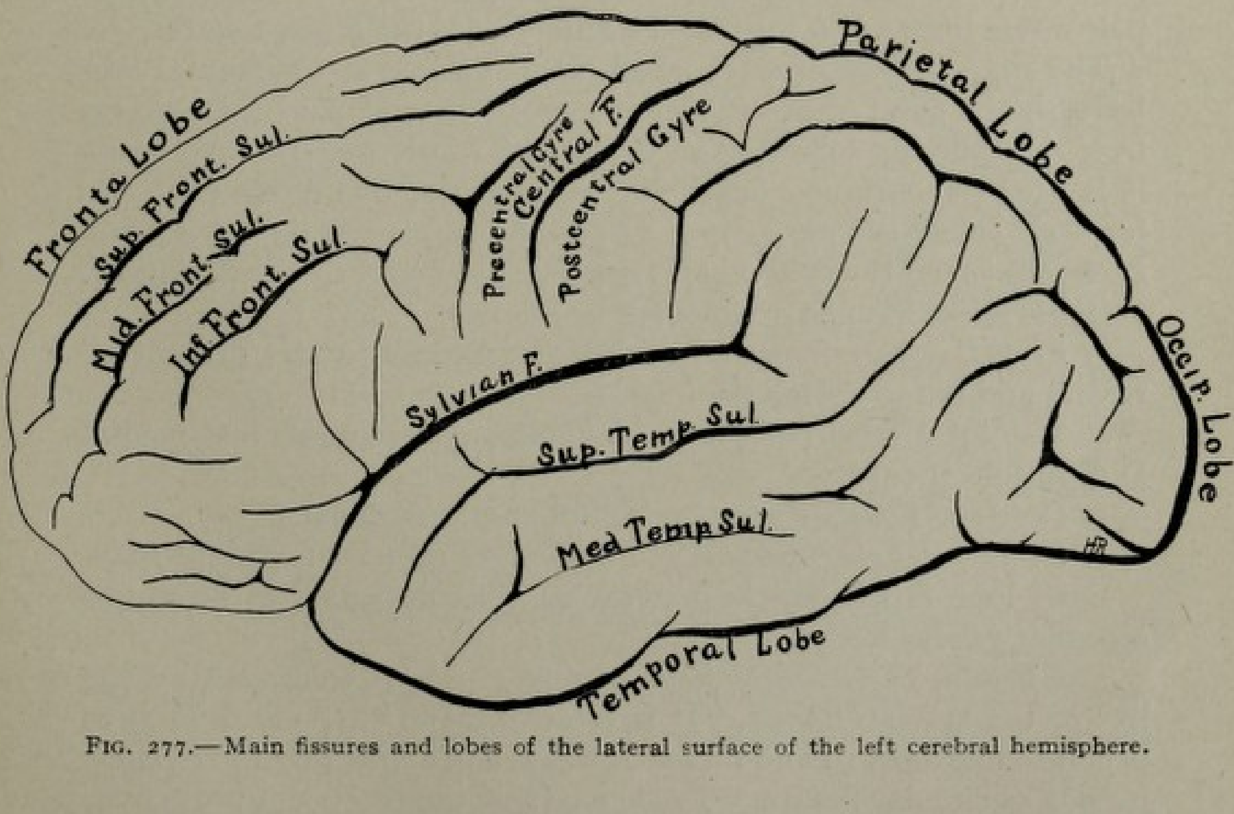


FIG. 277.—Main fissures and lobes of the lateral surface of the left cerebral hemisphere.

3. The *occipital fissure* (*sulcus parietooccipitalis*) is seen about 5 cm. above the occipital pole and is only partly represented upon the lateral surface. It indicates the separation between the occipital and parietal lobes.

Upon the *medial surface* the following interlobar fissures are seen:

1. The *central fissure* which extends for about 1 cm. upon this surface.

2. The *occipital fissure*, or *fossa*, has its main portion on this surface. It extends downward and forward for 3 to 3.5 cm. and meets the following fissure. It is usually quite deep and separates the medial surface of the parietal and occipital lobes completely from each other.

3. The *calcarine fissure* (*sulcus calcarinus*) arises upon the medial surface about 1 cm. above the base of the cerebrum just internal to the occipital pole. It passes upward and inward from 3.5 to 4 cm. and joins the occipital fissure; these continue forward for about 3 cm. as the *occipitocalcarine fissure.* The calcarine fissure separates the occipital lobe completely from the temporal lobe while the occipito-calcarine fissure separates parietal and temporal lobes incompletely. The occipital lobe, or *cuneus* is embraced by the occipital and calcarine fissures.

4. The *collateral fissure* (*sulcus collateralis*) starts near the occipital pole on the temporal lobe and continues frontally into the temporal pole where it may join the rhinal fissure, one of the minor fissures.

The *supercallosal fissure* (*sulcus cinguli*) starts in the frontal lobe beneath the genu of the callosum a short distance and then curves over the callosum following its curvature to the parietal lobe where it is usually continued under the same name; this latter part was formerly called the *paracentral fissure* and surrounds the *paracentral gyre.* Between the collosal and cingular fissures is the *gyrus cinguli.*

Other lesser fissures or sulci are as follows:

1. *Frontal Lobe.*—Superior, middle and inferior frontal, precentral, rostral and paracingular sulci.

2. *Parietal Lobe.*—Postcentral, angular, paroccipital, intermedial and precuneal sulci.

3. *Occipital Lobe.*—Lateral occipital and lunatal sulci.

4. *Temporal Lobe.*—Superior, middle and inferior temporal sulci.

Each lobe is divided into gyres or convolutions by the above secondary fissures.

The **insula,** or *island of Reil*, or *central lobe* is concealed by the lips of the sylvian fissure. It is tetrahedral in shape and its apex is pointed downward and forward. It is surrounded by the circum-insular or circular fissure. Those parts of the cerebrum that cover in the insula are called *opercula*, as *temporal operculum, superior operculum* (frontal and parietal) and *orbital operculum.*

The **olfactory lobes** are located upon the ventral surface of each frontal lobe. Each consists of the **olfactory bulb** and **tract.** The **olfactory bulb** (*bulbus olfactorius*) is a flattened, oval mass of a red-

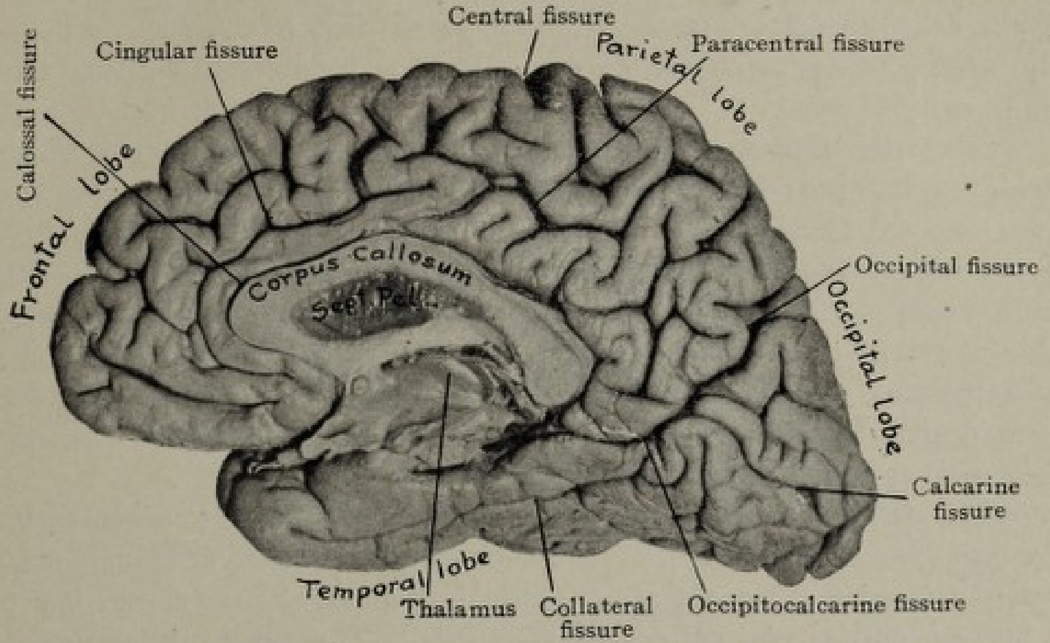


FIG. 278.—Medial aspect of the right cerebral hemisphere showing the lobes and main fissures. (*From a photograph.*)

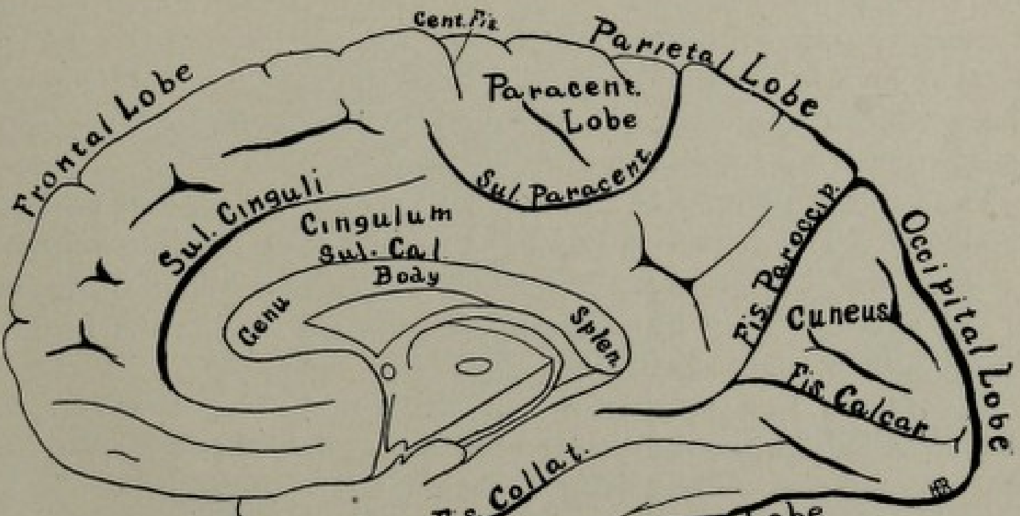


FIG. 279.—Lobes and main fissures of the medial surface of the right cerebral hemisphere.

dish-gray color in relation with the cribriform plate of the ethmoid bone. Through the latter pass the various olfactory fila from the nasal mucosa to end in the bulb.

Each **olfactory tract** (*tractus olfactorius*) is a flattened band of nerve fibers extending backward from the bulb toward the optic chiasm and then separating into a *medial*, an *intermediate* and a *lateral root*. The area at which these arise is called the *trigonum*. The *intermediate root* is short and passes to the anterior perforated substance. The *lateral root* passes to the uncus, gyrus ambiens and gyrus semilunaris. The *medial root* passes but a short distance to the area parolfactoria and subcallosal gyre, fornix and fimbria and hippocampal gyre.

The **corpus callosum** (Fig. 278) is the broad mass of nerve fibers bridging the bottom of the intercerebral cleft and connecting the two cerebral hemispheres together. This represents a commissure. It serves to connect areas of the opposite sides of the cerebrum with each other. Upon the dorsal surface of the callosum lies a very thin layer of gray nerve tissue continuous with the cortex of the hemispheres. In this are some longitudinal fiber bands called the *stria longitudinalis* and *stria medialis*. The gray tissue and fibers represent a poorly developed supercallosal gyre.

When the callosum is cut parallel to the longitudinal fissure, its flattened arch is noted. It consists of the thickened frontal end called the *genu*, next a thinner, band-like part, the *body*, and lastly a large occipital end called the *splenium*. The genu curves downward and then sharply backward, tapering rapidly to form the *rostrum* that joins the lamina terminalis. The genu contains frontal fibers. The body is much longer and narrower than either extremity and contains the parietal fibers. The splenium is the thickest portion and forms the occipital end of the callosum. It contains the occipitotemporal fibers. It overlaps the midbrain but is separated from it by the velum interpositum.

The callosum measures from 7 to 10 cm. in length and varies in thickness. The genu is 9 mm., the body 5 mm. and the splenium 13 to 15 mm. in thickness. The square surface is about 5.5 sq. cm. in the average brain but runs up to 10.5 sq. cm. in the brain of highly intellectual individuals.

The **fornix** lies underneath the callosum. This consists of a bundle of longitudinally directed fibers that describes a longitudinal arch on each side of the midline. At the top of the arch the bundles are side by side and constitute the *body of the fornix*. As they proceed frontally the bundles diverge and descend, each terminating in the corpus albicans of the same side. Occipitally the bundles diverge more widely and descend and then bend frontally continuing to the uncus of the same side as the *fimbria*. These separated bundles constitute the *anterior* and *posterior pillars*, respectively, of the fornix. This structure is a part of the olfactory pathway. The fibers of the fornix originate in the hippocampus, form the fimbria which continue as the posterior pillars, then the body and then the anterior pillars to finally terminate in the corpus albicans of that side.

The **septum lucidum** (*septum pellucidum*) lies between the callosum, above, and the body of the fornix, below. It consists of two layers that enclose a space called the fifth ventricle, or pseudocele. This represents a part of the original longitudinal fissure that lies subcallosal and the thin walls of the septum constitute the medial walls of the hemispheres of this area where nerve tissues fail to develop in any great quantity.

The **hippocampus** is an elevation in the lateral ventricle and is in relation with the fimbria as above described. It constitutes a part of the rhinencephalon.

Within each hemicerebrum is an extensive and irregular cavity called the **lateral ventricle** (*ventriculus lateralis*). Each consists of a *body*, *frontal*, *occipital* and *temporal extensions*, or *horns*. Each ventricle is in connection with the third ventricle by an opening situated between the frontal end of the thalamus and the under-surface of the anterior pillar of the fornix. The opening is called the *foramen of Monro* (*foramen interventriculus*). The ventricles are reservoirs for the cerebrospinal fluid.

CORTICAL LOCALIZATION

The various areas of cortical representation of the special senses and other functional areas are indicated in Figs. 280 and 281.

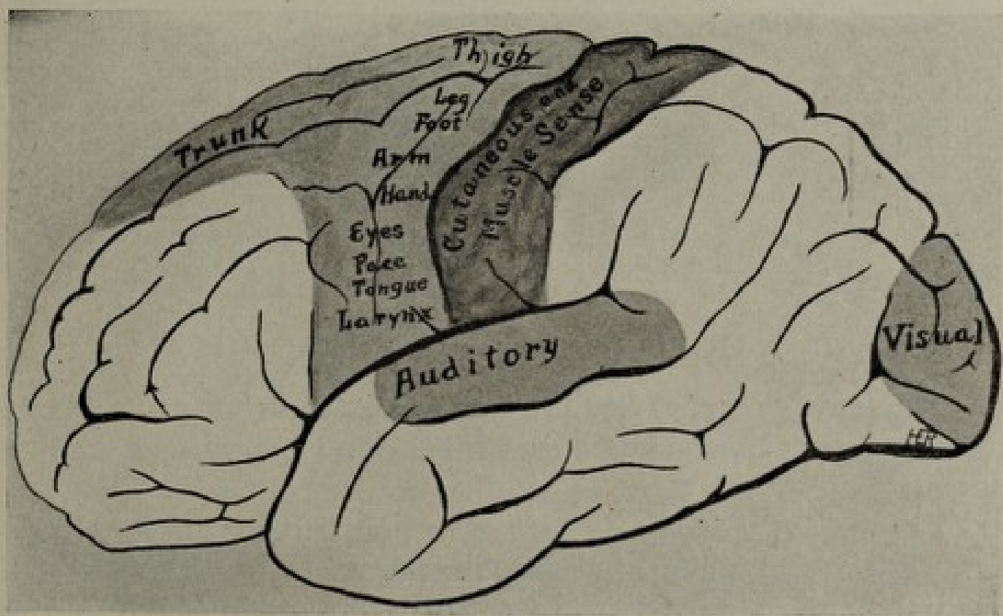


FIG. 280.—Lateral surface of the left cerebral hemisphere showing cortical localization of functions.

1. The **motor area** occupies the posterior portion of the lateral surface of the frontal lobe just in front of the central fissure; it extends over upon the medial surface as indicated.

2. The **general sensor area** (*tactile*, *temperature* and *pain*) lies in frontal portion of the lateral surface of the parietal lobe just behind

the central fissure. It has a marked extension upon the medial surface also.

3. The **auditory area** is located in the upper part of the lateral surface of the temporal lobe just below the sylvian fissure.

4. The **visual area** is located in the occipital lobe partially upon the lateral surface but mainly upon the medial surface, occupying the entire lobe (*cuneus*) here.

5. The **olfactory area** is upon the medial surface surrounding the callosum, including the fornix, fimbria and hippocampal portion of the temporal lobe.

6. The **gustatory area** is located upon the medial surface of the temporal lobe just beneath the olfactory area.

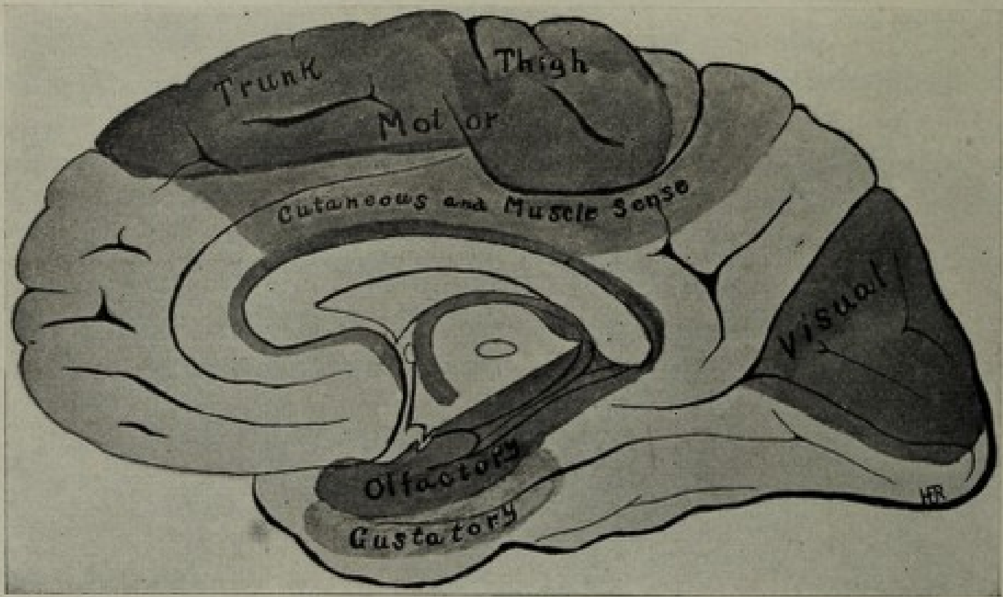


FIG. 281.—Medial surface of the right cerebral hemisphere showing cortical localization of functions.

TOPOGRAPHY OF THE BRAIN

1. The *longitudinal fissure* is indicated by drawing a line from the external occipital protuberance (inion) to the root of the nose (glabella).

2. *The Central Fissure.*—Start at a point upon the longitudinal fissure line 1 cm. behind its midpoint; from this point draw a line downward and forward for 9 to 10 cm. at an angle of 70° to 71°.

3. The *lateral* (*sylvian*) *fissure* starts 1⅕ inches (3 cm.) behind the external angular process of the frontal bone and extends upward and backward to a point ⅘ inch (2 cm.) below the most prominent part of the parietal eminence.

4. *Transverse Fissure.*—Draw a line from the inion to the external auditory meatus.

Kronlein's Method.—(1) The *base line* is a horizontal line from the lower border of the orbit to the upper border of the external auditory meatus. (2) Draw a *horizontal line* parallel to (1) at the level of the supraorbital ridge. (3) Erect a *vertical line AB*, at the middle of the zygoma. (4) Draw a *vertical line CD*, from the posterior border of the mastoid process to the midline of the skull. (5) Connect *B* and *D*. (6) Draw a *vertical line E, G*, from the articulation of the mandible to *BD*. (7) *Bisect* the angle *DBH* with the line *BI*.

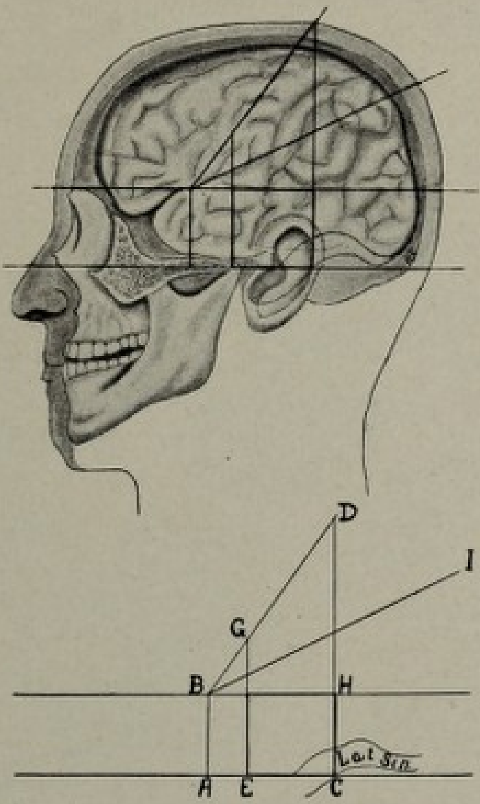


FIG. 282.—Diagram of Krönlein's method of cranial fissure topography.

The line *DB* represents the *central fissure*. *BI* represents the *sylvian fissure*. At *B* the *anterior branch of the middle meningeal artery* may be reached and at *H* the *posterior branch*. In abscess of the temporal lobe trephine in the square *E, C, H*.

THE INTERNAL ANATOMY OF THE BRAIN

Having considered the external anatomy of the parts of the brain consecutively the internal anatomy will now be considered in the same manner by means of trans-sections at certain levels.

In the **spinal cord** the *gray nerve tissue* is placed internally in the form of a *fluted H-shaped column* and the white nerve tissue surrounds it. At the lower part of the oblongata the relation is about the same but certain alterations are noticeable due to the presence of the motor and sensor decussations, etc. The gray nerve tissue continues in relation with the canal and as the canal opens out dorsally to become the fourth ventricle, the gray of the roof fails to develop, so that we find only the floor composed of gray nerve tissue called the *ventricular gray*. It is as though the cord had been split along the dorsal median septum and the two halves spread out and the canal exposed as a diamond-shaped fossa. As a result of this the motor cells are still ventrally placed but mainly near the midline and the dorsal sensor

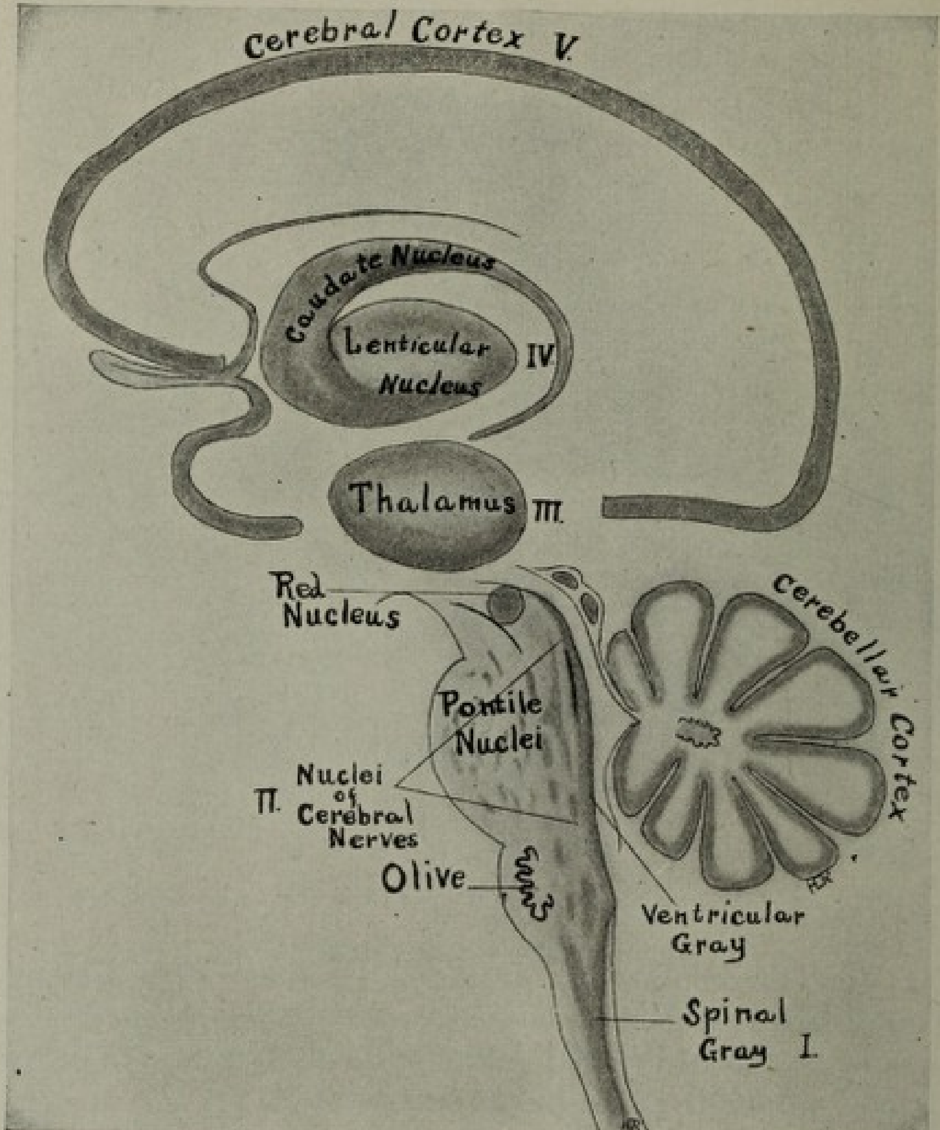


FIG. 283.—Diagram of the main ganglionic categories.

cells have been moved to the side. This will be noticed when the cerebral nerve nuclei are considered. This peculiar condition of the fourth ventricle being at the dorsal surface of the pons-oblongata is due to the failure of development of nerve tissue in the dorsal wall of the neural tube at this region. Hence all nuclei of this part and the fiber tracts that pass centrifugally and centripetally must pass ventral to the cavity, thus placing this ventricle at the dorsal surface.

It is to be remembered that the nerve cells ventral to a line drawn through the spinal canal from side to side are motor and those dorsal are sensor. As the fourth ventricle passes frontal into the aqueduct it is as though the slit cord had been returned to its original condition and gray nerve tissue surrounds the entire aqueduct. The ventral, or floor part represents the seat of the cerebral nerve nuclei.

The *motor nerve cells* do not form continuous columns as in the spinal cord but are grouped forming three interrupted columns, constituting the nuclei of the cerebral nerves. One column (*medial somatic column*) is along the median groove of the fourth ventricle and aqueduct and comprises the *hypoglossal*, and *abducens nuclei*. Another column (*lateral somatic column*) slightly lateral to the preceding, comprises the *accessory*, *part of the vagal*, *the facial*, and *trigeminal nuclei*. These two go to voluntary, or skeletal muscle, including tongue, pharynx and larynx. A third column (*splanchnic* or *visceromotor*) is located further from the midline and comprises part of the *vagal*, *glossopharyngeal* and *facial* nuclei. These cells are concerned with the movements of involuntary nonstriated muscles of the viscera and their axones go to sympathetic ganglia. These cells represent the intermedio-lateral group of the spinal cord.

The *sensor cells* do not form a continuous column either but form isolated groups of nuclei that lie furthest from the midline. These nuclei of termination are for both ordinary and special senses. The olivary, pontile and arcuate nuclei are connecting links between the cerebellum and the rest of the nerve system.

In the **third ventricle** that lies frontad of and is continuous with the aqueduct, the gray substance is practically lacking so that this part of the brain lies beyond the region of the cerebral nerve nuclei. In addition to this central gray there are numerous nuclei scattered in the white nerve tissue, giving thus a mixed character that does not exist in the cord. In the *cerebellum* and the *cerebrum* the relation is again more distinct, but the gray here is superficial or cortical while the white is central or medullary.

THE BRAIN STEM

Oblongata.—In studying the internal structure of the oblongata sections at the **motor decussation, sensor decussation** and **midolivary** levels will be utilized. These sections are from ascending levels in the order named.

Motor Decussation (Figs. 284 and 285).—In the upper or pontile part of the oblongata the motor fibers all lie in a compact bundle in the ventral area constituting the *pyramid*. At the lower (spinal cord) part of the oblongata these fibers are seen crossing the ventral median groove in bundles constituting the *pyramidal*, or *motor decussation*. Upon examining a section at this level these fibers are

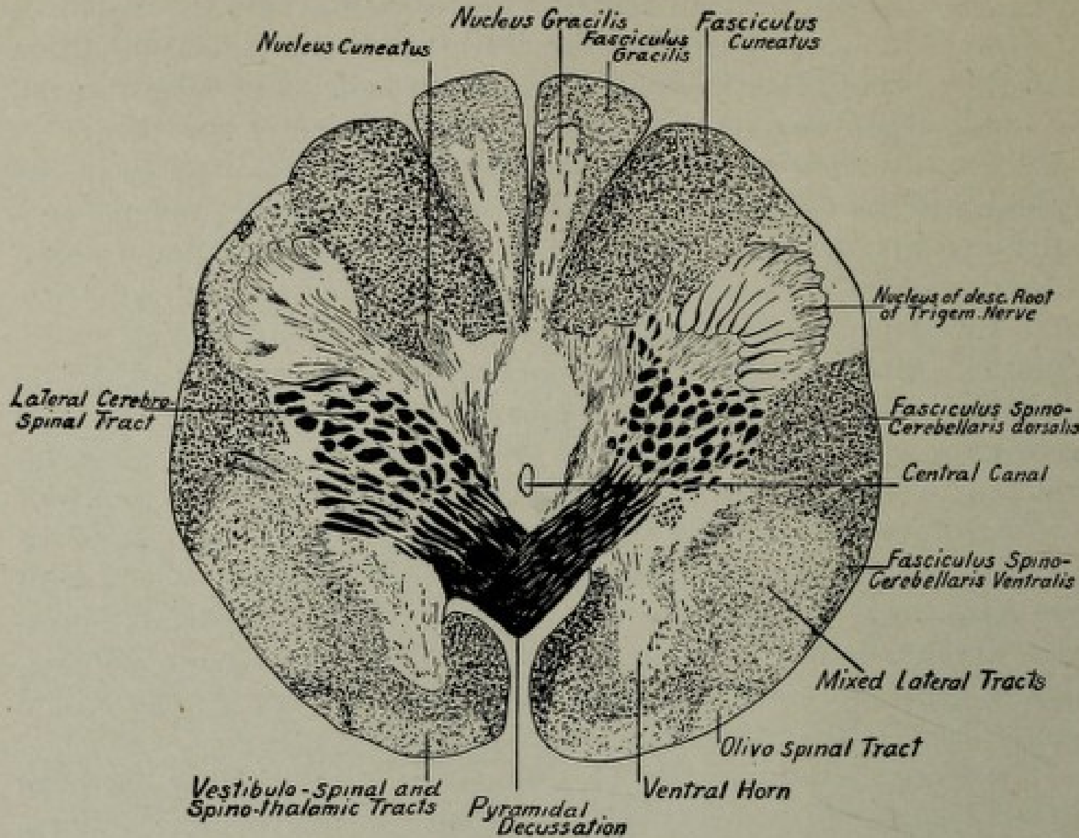


FIG. 284.—Section of the oblongata at the level of the motor or pyramidal decussation.

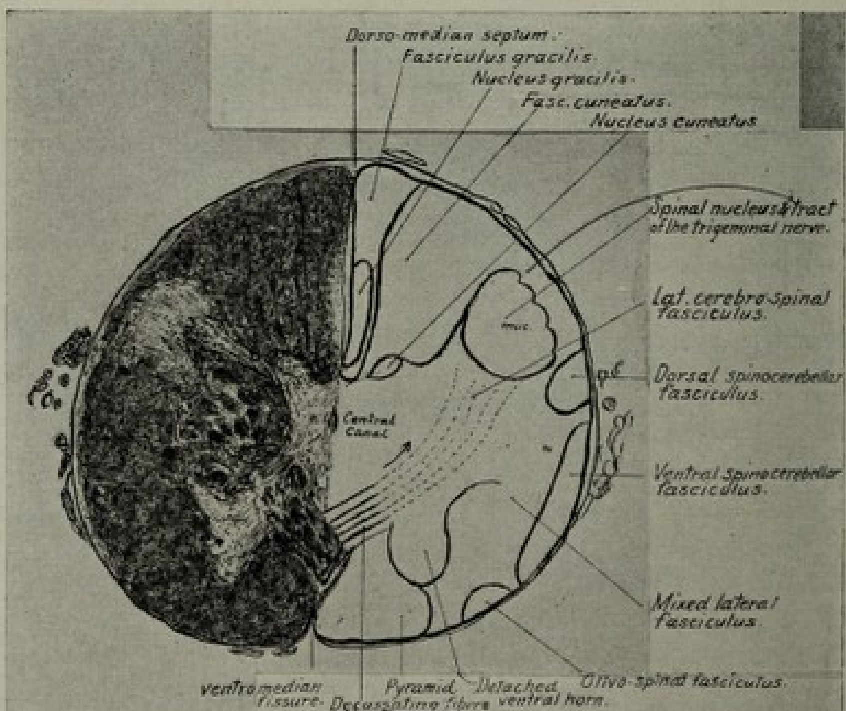


FIG. 285.—Section of the oblongata at the level of the motor decussation (Weigert's stain). The right half shows the various fasciculi and nuclei in outline.

seen sweeping, obliquely dorsolaterally, from one side of the ventral fissure to the opposite side of the oblongata, cutting through the ventral horn of gray tissue to the dorsolateral region. These fibers constitute here the crossed pyramidal tract of the spinal cord and comprise 85 to 90 per cent. of the motor fibers. The remaining 15 to 10 per cent. continue down on the same side as the direct pyramidal tract in the cervical and upper portion of the thoracic part of the spinal cord, where they cross at various levels in the white commissure so that all fibers ultimately end in the opposite of the cord from which they originate in the cerebrum. The motor area of gray represented by the ventral horn of the spinal cord is thus cut into two parts: (1) the *isolated ventral mass* that is gradually pushed more laterally and is diminished in size at higher levels; (2) the *basal portion* (that near the canal) which represents the motor gray of the floor of the fourth ventricle higher up.

Dorsally a change is also noticeable on the peripheral part of the dorsal horn—the *substantia gelatinosa* has become much increased and forms a projection on the lateral surface of the oblongata called the *tuberculum cinereum*. The remainder of the dorsal gray also shows alterations. Near the dorsal median septum an elongated aggregation of cells, the *nucleus gracilis*, appears among the fibers of the *fasciculus gracilis*. This ultimately produces an elevation upon the dorsal surface of the oblongata called the *nucleus gracilis*. A little lateral to this another aggregation, the *nucleus cuneatus*, appears; this also forms an elevation upon the dorsal surface. It will be remembered that the fasciculi gracilis and cuneatus (the tracts of Goll and Burdach) occupy the dorsomedian area in the spinal cord but at this level of the oblongata they are quite a bit smaller as their fibers are terminating in their respective nuclei; in the next level these tracts will have ceased to exist being replaced by these nuclei. The bulk of the fiber tracts of the lateral area of the oblongata pass upward uninterruptedly into the cerebellum, quadrigemina or thalamus as the case may be. These tracts comprise the several spinocerebellar, spinothalamic, rubrospinal, vestibulospinal, spinotectalis and converse tracts. They will be considered later.

Sensor Decussation (Fig. 286).—Just above the motor decussation lies the *sensor decussation*. In the ventral part of the section are seen all of the motor fibers in two compact bundles, the *pyramid*, one upon each side of the ventromedian groove. Just dorsal to these are seen first, a thin flattened bundle, the beginning *lemniscus*, or *fillet* (*lemniscus medialis*) and dorsal to that the *decussating sensor fibers* arising from the nuclei gracilis and cuneatus of the opposite sides. These added fibers here have raised the canal to a slightly higher (dorsal) level; between the decussating fibers and the canal lie the wedge-shaped remains of the filaments of the *hypoglossal* *nerve* sweeping ventrally close to the pyramid. Lateral to these nerve fibers are seen the remains of the isolated portion of the ventral horns somewhat smaller than in the preceding section. In the dorsal half of the section the gray has a peculiar arrangement. Near the midline is the slender nucleus *gracilis* and just lateral the more massive *nucleus cuneatus* and then the *tuberculum cinereum.* Here the nuclei form elevations upon the dorsal surface and the tracts of Goll and Burdach are almost ended. Superficial to the tuberculum cinereum, in both sections, are seen some nerve cells and nerve fibers constituting the *descending nucleus* and *root of the trigeminal nerve*

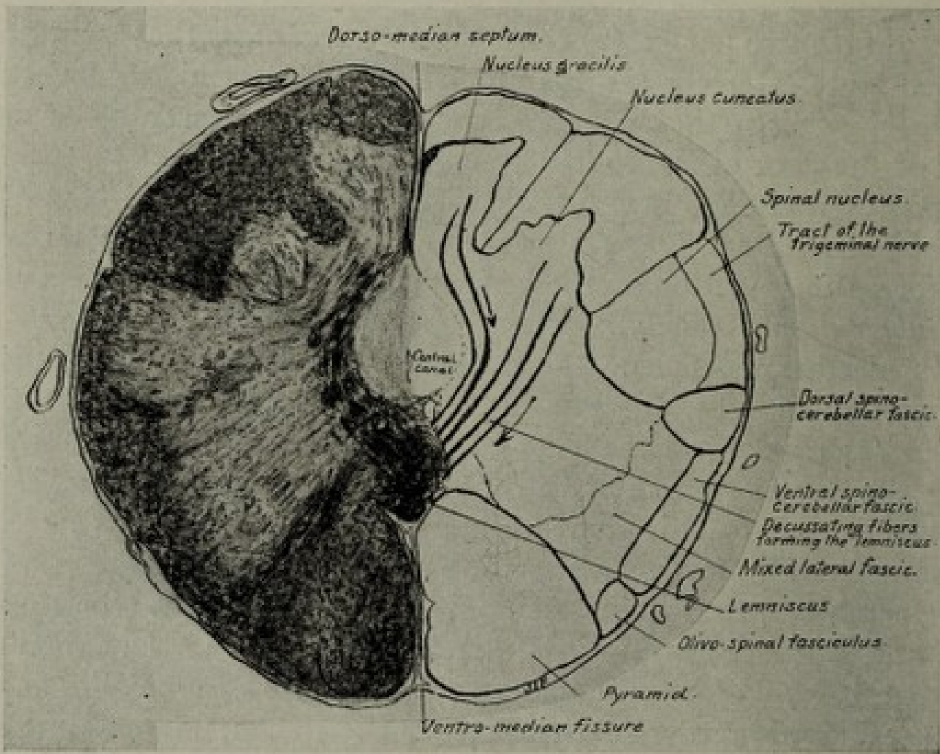


FIG. 286.—Section of the oblongata at the level of the sensor decussation (Weigert's stain). The right half shows the various fasciculi and nuclei in outline.

(*nucleus tractus spinalis nervi trigemini* and *tractus spinalis nervi trigemini*).

Between this and the next section the nuclei gracilis and cuneatus disappear, several new nuclear masses, *olivary nuclei,* appear and the addition of a great mass of nerve fibers (*formatio reticularis*) between the canal and the lemnisci raises the canal to such a level dorsally that it is practically exposed and constitutes the fourth ventricle. This is due to the fact that the dorsal wall of this part of the neural tube develops no nerve tissue and that nerve tissue which does form is ventrally placed.

The Midolivary Region (Fig. 287).—This section shows a marked change. The *ventral median groove* is broad but shallow and is flanked by the large motor tracts, the *pyramids;* these are covered externally (superficially) by some gray nerve tissue, the *arcuate* *nucleus* and some nerve fibers, the *external*, or *superficial arcuate fibers*. Of these arcuate fibers some arise in the nuclei gracilis and cuneatus of the same side and pass to the cerebellum; others arise from the nuclei of the opposite side, decussate in the raphé, course ventrally and pass over the surface of the pyramid. Many of these fibers are interrupted in the arcuate nuclei and then pass on to the cerebellum by way of the restiform body. Just dorsal to the pyramids lie the *medial lemnisci* forming quite a thick bundle of longitudinally coursing fibers. These are separated from each other in the

FIG. 287.—Section of the oblongata at the level of the midolivary region (Weigert's stain). The right half shows the various fasciculi, nuclei and nerves in outline.

midline by the median raphé that extends dorsally to the ventricular gray. The raphé consists of a few nerve cells and fibers. Some of the fibers run longitudinally, others obliquely (*internal arcuate fibers*) and still others run dorsoventrally (belonging to the external arcuate fibers).

Between each lemniscus and the floor of the fourth ventricle on each side of the raphé are seen bundles of fibers running longitudinally, transversely and some gray nerve tissue; this constitutes the mass mentioned above as the *formatio reticularis*. This field is divided by the hypoglossal nerve roots into a median area (*formatio reticularis alba*) as it contains little gray nerve tissue; the lateral part is the *formation reticularis grisea* as it contains considerable gray nerve tissue. The transverse fibers are chiefly *internal* arcuate and *olivocerebellar*, while the longitudinal are chiefly *association fibers* (short course) of the centers of respiration (nuclei of the facial, phrenic and vagal nerves) derived from the cells of the grisea. One especial group of longitudinal fibers just beneath the ventricular gray is called the *median longitudinal bundle* (*fasciculus longitudinalis medialis*). This is a set of longer association fibers that serves to connect the various cerebral nerve nuclei together and corresponds to the ventral and ventrolateral ground bundles of the spinal cord. The fibers just ventral to this bundle constitute the *fasciculus tecto-spinalis.*

Just dorsal to and a little to the side of the pyramid lies a crinkled mass of gray containing white fibers and surrounded by white fibers. This is the *inferior olivary nucleus* (*nucleus olivius inferior*) which produces the elevation upon the lateral surface of the oblongata called the *olive.* Its opening, or *hilus*, is directed toward the raphé and of the fibers seen entering and leaving some pass to the olive of the other side while others pass to the cerebellum of the opposite side through the restiform body and *vice versa.* In addition, fibers pass to and from the olive to the spinal cord and thalami. The *dorsal* and *medial olivary nuclei* are detached parts of the main nucleus.

In the dorsal region of this section is seen the lower end of the *fourth ventricle.* The *roof* is thin and devoid of nerve tissue and constitutes the *tela choroidea inferior.* The *floor* of the ventricle consists of gray nerve tissue showing several aggregations of cells, or cerebral nerve nuclei. On each side of the midline lies the *nucleus of the hypoglossal nerve;* just lateral lies a small group of cells, the *nucleus intercalatus* (function not known). At the side of this lies one of the *nuclei of the vagal nerve.* That part of the vagal nucleus near the midline is *motor* (to the heart) and the lateral portion is *sensor.* In the lateral dorsal mass is seen a large group of fibers, the *descending root of the auditory nerve;* just beneath this are the *nucleus* and *fasciculus solitarius;* at the extreme dorsal portion is seen the *restiform body.* The latter structure contains the fibers of the direct spinocerebellar and cerebellospinal tracts of the spinal cord and the internal and external arcuate fibers of the oblongata region. Beneath these structures is seen another *nucleus of the vagus*, the *nucleus ambiguus* and the *fibers of the vagus.* This nucleus probably represents the remains of the isolated portion of the ventral horn of the cord from lower sections. Near the side are seen the *nucleus* and *fibers of the spinal root of the trigeminal nerve.*

Pons and Pars Dorsalis Pontis.—This portion of the brain stem is equivalent to the oblongatal part plus a broad and thick band of transverse fibers ventrally placed; the latter fibers constitute the *pons*. This part of the brain will be considered in three sections: (1) *lower*, (2) *middle* and (3) *upper*.

1. If a section at the *lower end* be examined the ventral part will be seen to consist of a rather thick mass (*pars basalis pontis*) of transversely coursing fibers, the pons, and two large bundles of longitudinal fibers, the *pyramids*. In among these fibers are seen collections of nerve cells called the *nuclei pontis*. The transverse fibers are more abundant in man than in any other animal. Most of them lie ventral to the pyramidal tracts and serve to connect the cerebellar hemispheres with each other. At the lateral boundaries

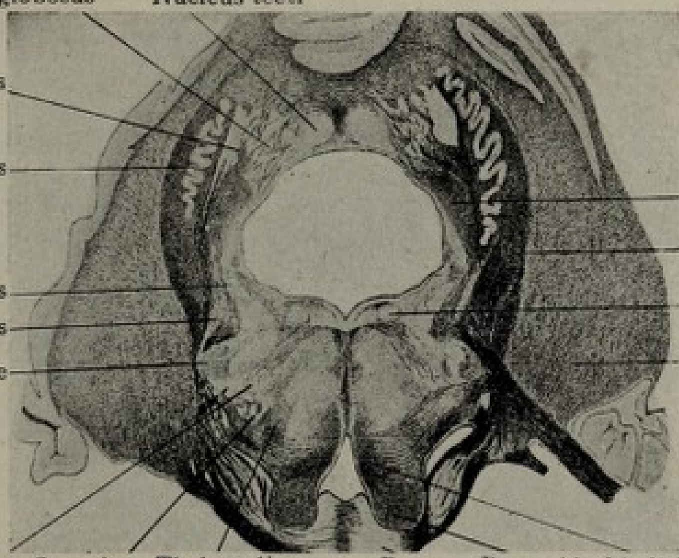


FIG. 288.—Section of the lower part of the pons region.

of the pons these fibers are collected into a compact bundle that enters the corresponding cerebellar hemisphere as the *middle peduncle* (*brachium pontis*). Some of the pons fibers end around the cells of the pontile nuclei of the same side and some go to the opposite side; new fibers then arise from these cells and continue to the cerebellar hemisphere. Some of the cells of the nuclei pontis are also way-stations in the pathway of cerebropontile fibers and new fibers arising here pass to the cerebellar hemispheres. These *cerebropontile fibers* have a longitudinal course.

In the area just dorsal to the pons fibers are the pyramids, two large compact bundles of longitudinal fibers on their way to the oblongata. Some of these fibers terminate in the nuclei pontis representing *cerebropontile fibers*. Dorsal to the pyramids are seen a variable number of *deeper transverse pontile fibers*. The arcuate fibers and nuclei of the oblongata are analogous to the pons fibers and pontile nuclei.

Dorsal to the pons lie the fibers of the *medial lemniscus* forming a

26

rather compact bundle upon each side of the raphé. In higher sections these lemnisci diverge from the midline to make room for the trapezium.

Pars Dorsalis Pontis.—The *lemnisci* separate the pons proper from the pars dorsalis pontis (preoblongata). Dorsal to the outer side of the lemniscus is seen the *central tegmental tract* and the *superior olivary nucleus* connected with the fibers of the trapezium (acoustic fibers). Between the superior olivary nucleus and the formatio

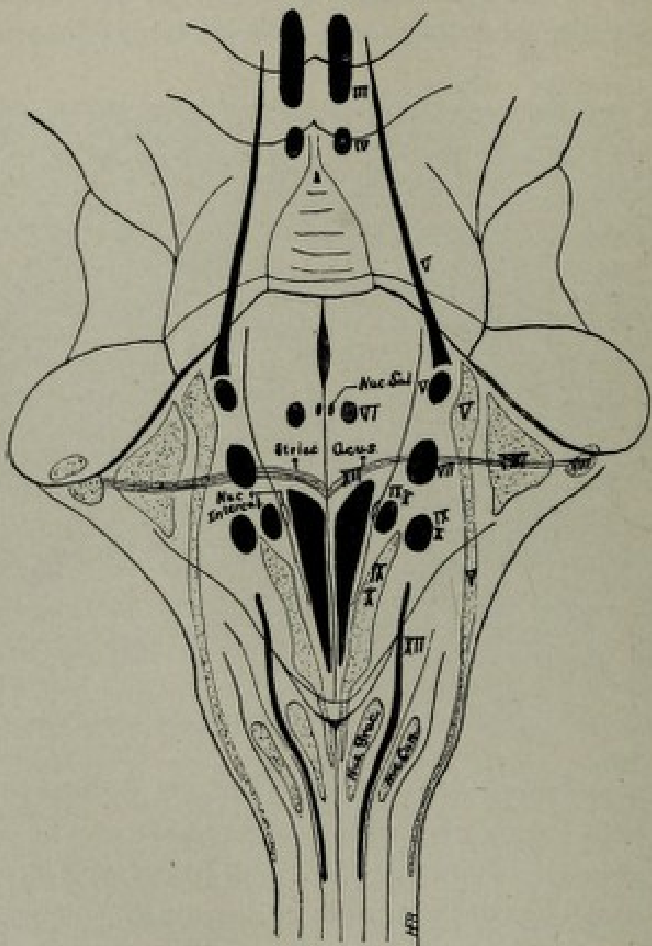


FIG. 289.—Diagram of the nuclei of the cerebral nerves in the brain stem (dorsal view). Motor nuclei in solid black, sensor nuclei dotted.

reticularis lies a bundle of fibers (*trapezial*) that form the trapezium of the next level. This portion shows also the *formatio reticularis* on each side of the raphé with the *median longitudinal bundle* in its dorsal area; between the formatio reticularis and the cavity of the ventricle is the *ventricular gray substance* in which are seen certain cerebral nerve nuclei.

Near the midline is seen the *nucleus insertus* (*Streeter*) that continues up to the aqueduct. To the side of this lies the *nucleus of the abducens nerve;* lateral to this the *principal vestibular nucleus* is noted and beneath the gray the *descending root of the vestibular nerve;* at the dorsal margin lies the upper end of the *restiform body*. Deeper ventrad and over the superior olivary nucleus is the *nucleus of the facial nerve*, while lateral thereto are some of the fibers of this nerve. Between the facial nerve and the restiform body are found the *substantia rolandi* and the *descending root of the trigeminal nerve*.

2. Upon examining a **section through the trigeminal nerve (middle section)** the ventral part of the section exhibits superficial and deep fibers of the pons embracing the two pyramids. At the sides the *brachia pontis* are still present. At the junction of the pons with the

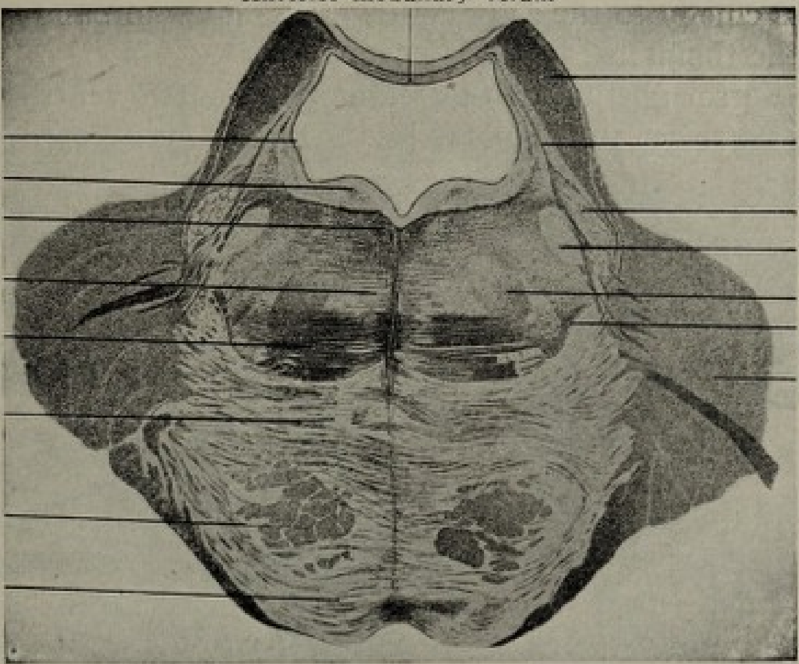


FIG. 290.—Section of the pons at the level of the origin of the trigeminal nerve.

tegmental part the medial lemnisci have been pushed to the side and replaced by the *trapezium*, a set of transversely directed fibers (decussating) intersperced with nerve cells (the *trapezial nucleus*). These fibers arise from the ventral and some from the dorsal cochlear nuclei of the fourth ventricle and pass to the trapezium where some end in the nucleus trapezoideus of the same, or opposite side while others end in the olivary nucleus of the same, or opposite side. The new fibers from the cells of these nuclei then cross to the opposite side (if the preceding have not) making the decussation complete; they are then joined by the new fibers from the cells of the opposite side and constitute the *lateral lemniscus*, which will be described later. The trapezium is a part of the auditory pathway. Between the trapezium and the lateral surface of the section are seen the *superior olivary nucleus*, the fibers of the *motor root of the trigeminal nerve*, while more ventrally are the brachia pontis and the *sensor root of the trigeminal nerve;* near the surface lies the sensor nucleus of the latter nerve.

Dorsal to the trapezium and in the midline is the raphé with the *formatio reticularis* forming a large field on each side. Lateral to the formatio is the *motor nucleus of the trigeminal nerve*, next the *mesencephalic root of the same nerve* and upon the surface the *superior cerebellar peduncle* (*brachium conjunctivum*) forming also the dorsal wall of the section in this area. The peduncle is semilunar in shape and consists chiefly of fibers from the cells of the dentate nucleus of the cerebellum, while the remainder are probably from the cerebellar cortex of the opposite side, decussating to reach this side. These fibers pass chiefly to the red nucleus of the midbrain and some continue to the thalamus.

In the dorsal portion of the section the fourth ventricle is seen becoming narrower and is roofed by the *valvula*, or *anterior medullary*

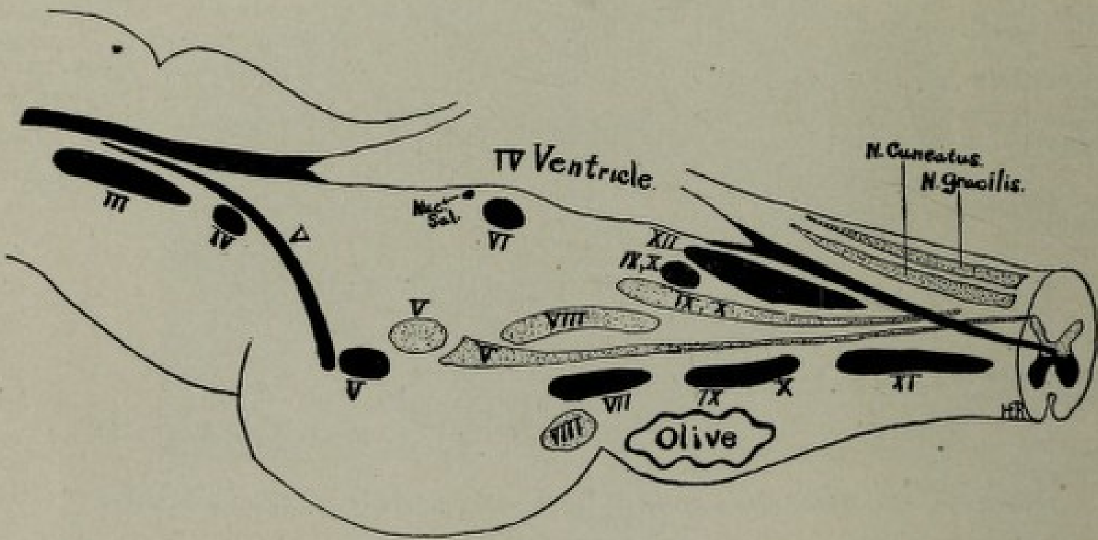


FIG. 291.—Diagram of the nuclei of the cerebral nerves in the brain stem (lateral view). Motor nuclei in solid block, sensor nuclei dotted.

velum. Beneath the ventricular gray and near the midline is the *median longitudinal fasciculus*.

3. A section through the **upper part of the pons** is more compact and smaller. In the ventral area the *pyramids* are separated into many small bundles by the transverse pontile fibers. At the side of the field is seen the *trigeminal nerve*. In the tegmental portion changes have occurred. In the midline just dorsal to the pons fibers the trapezium has been replaced by the *decussating fibers of the brachia conjunctiva* while the *medial lemniscus* is now seen at the side and somewhat flattened. Dorsal to the decussating fibers is seen the *formatio reticularis*, lateral to which is placed the *brachium conjunctivum* no longer superficial, as in the preceding section, but rather deeply placed and covered by the flattened band, the *lateral lemniscus*. The lateral lemniscus previously mentioned consists of the ventral cochlear fibers and nerve cells comprising the *nucleus of*

the lateral lemniscus, apparently a continuation of the superior olive. Here some of the fibers of the lemniscus end and new ones arise from the cells of the nucleus and continue, to end in the inferior quadrigeminum and medial geniculate body and possibly in the superior quadrigeminum. The dorsal median area of the formatio reticularis is occupied by the *median longitudinal fasciculus.* Dorsal to this area is the *ventricular gray substance.* In this section the fourth ventricle is small and entirely roofed over by the valvula that contains a little nerve tissue. At the lateral boundary of the ventricular gray is noted the *mesencephalic root of the trigeminal nerve.*

THE MIDBRAIN

In this portion of the brain stem two sections will be described, one through the *inferior quadrigeminal bodies* and the other at the level of the *superior quadrigeminal bodies.*

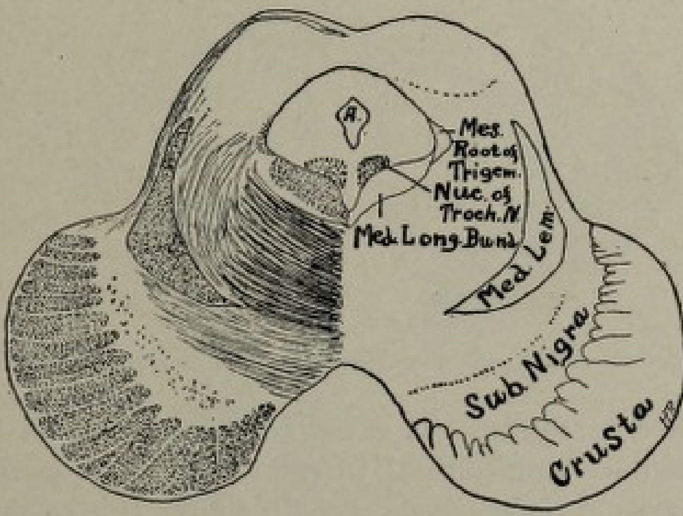


FIG. 292.—Transverse section of the midbrain through the inferior quadrigeminal bodies.

The section through the **inferior bodies** shows a marked change over the preceding sections. Ventrally are seen the *two crura cerebri* (*pedunculi cerebri*) separated from each other by the *interpeduncular space.* Each *crus* consists of a ventral area called the *crusta* (*basis pedunculi*) containing only motor fibers in three groups: (1) the *lateral* one-fifth consisting of fibers from the cortex of the temporal lobe of the cerebrum to the nuclei pontis and called the temporopontile tract; (2) the middle three-fifths consists of the fibers from the pyramidal cells of the motor area of the frontal lobe passing to the cerebral nerve nuclei and to the spinal cord constituting the pyramidal tract previously mentioned; (3) the medial one-fifth consist of fibers from the cells of the frontal lobe passing to the nuclei pontis and called the frontopontile tract. Dorsally the crusta is bounded by a crescentic mass of pigmented gray substance called the *substantia nigra.* This separates the tegmentum from the crusta and its cells send their axones in various directions but their function is unknown. The *substantia nigra* extends throughout the midbrain.

The *tegmentum* consists of transverse and longitudinal fibers with collections of nerve cells here and there. It represents a continuation of the tegmental portion of the pons. In the midline is seen the raphé and at the side, above the substantia nigra, lies each brachium conjunctivum completing its decussation. Lateral to this is the *medial lemniscus*. Dorsal to the superior cerebellar peduncle, near the midline, is seen the *median longitudinal fasciculus*, while near the surface is located the *lateral lemniscus* covered by the *inferior brachium*. Dorsal to the raphé is the *aqueduct gray substance*, containing a small canal, the *iter*, or *aqueduct* (*aqueductus cerebri*). The

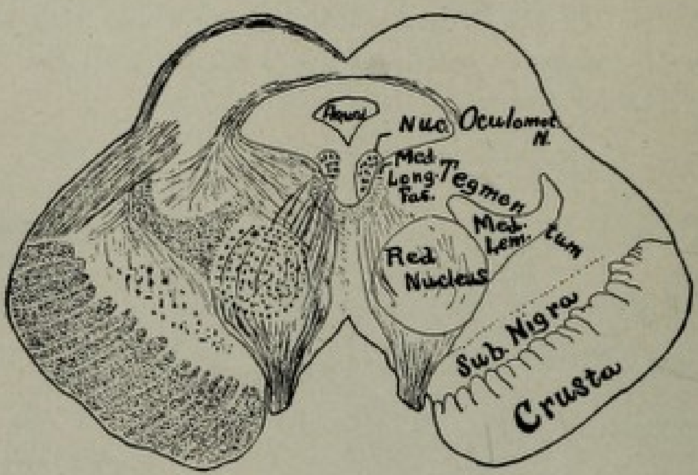


FIG. 293.—Transverse section of the midbrain through the superior quadrigeminal bodies.

gray substance surrounds the canal completely; in its floor, resting upon the median longitudinal fasciculus, is a collection of nerve cells, the *nucleus of the trochlear nerve*. At the side of the gray is the *mesencephalis root of the trigeminal nerve*. Dorsal to the aqueduct gray, on each side of the midline, is a rounded mass of gray nerve tissue covered by white fibers, the *inferior quadrigeminal body* (*colliculus inferior*). The *nucleus of each body* is separated from the aqueduct gray by the *stratum lemnisci*. The nucleus receives fibers chiefly from the lateral lemniscus. Its cells send fibers to the thalamus and the nucleus represents a way-station in the auditory pathway.

In the **pregeminal region** the *crusta* and *substantia nigra* are substantially the same. Medially, at the junction of the tegmentum and crusta, is a *groove* (*sulcus oculomotorius*) from which the *oculomotor nerve* emerges. In the tegmentum an important change has occurred. Near the midline is a large, reddish, circular collection of nerve cells called the *red nucleus*. The fibers of the oculomotor nerve course around and through it. This nucleus receives fibers from the cerebral cortex, the corpus striatum and from the cerebellum through its brachia conjunctiva; most of the fibers of the latter end here. From its cells fibers extend: (1) to the thalamus and the cerebral cortex; (2) to the spinal cord as the rubrospinal tract. These latter fibers decussate almost immediately and pass down the opposite tegmentum.

To the side of the red nucleus lies the *medial lemniscus* and it is smaller as many of its fibers terminate in the superior quadrigeminal

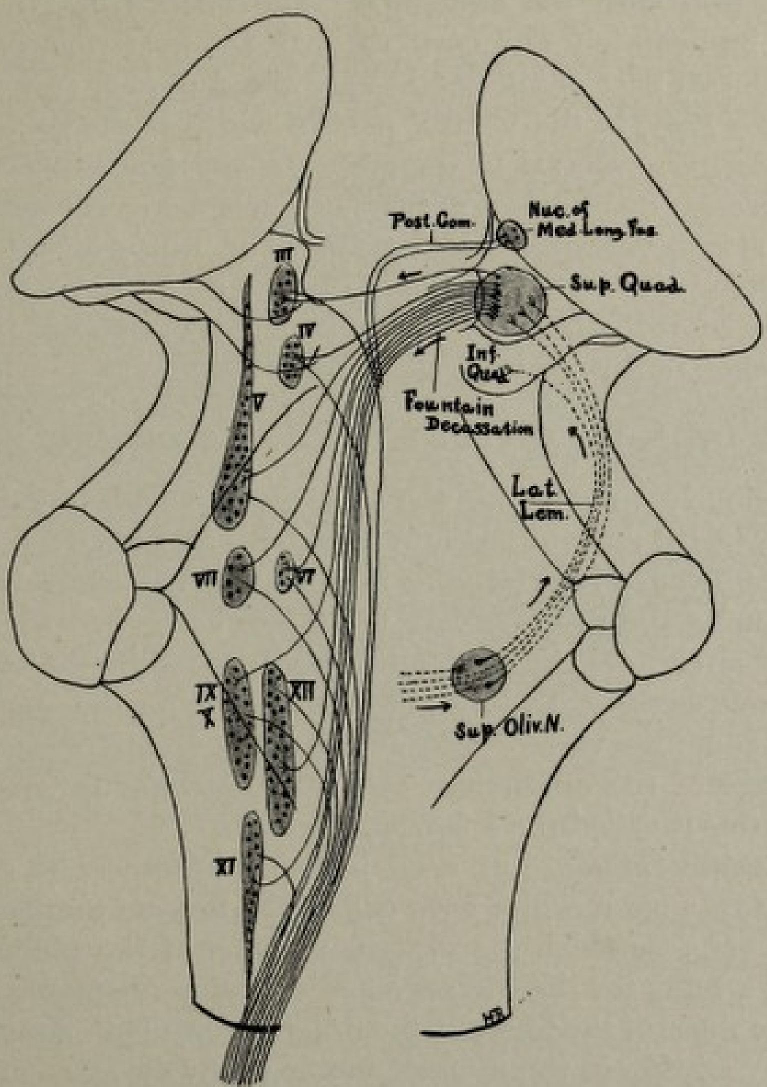


FIG. 294.—Diagram of the formation and components of the median longitudinal fasciculus of the brain stem.

body and the remainder pass to the thalamus (general sensor pathway); at the side of the lemniscus lies the *inferior brachium*. Between the two red nuclei is seen a mass of decussating fibers called the *fountain decussation*. These fibers are derived from the superior quadrigeminal bodies and the cells in the aqueduct gray, cross the midline and join the median longitudinal fasciculus and pass to the nuclei for the nerves of the eye muscles and to the spinal centers for movements of the head and neck.

The *median longitudinal fasciculus* (Fig. 294) occupies, relatively, the same position as in previous sections. It corresponds to the ventral ground bundle of the spinal cord. Its fibers are associative with regard to many cerebral and spinal nerve centers. It connects especially the quadrigeminal bodies and the sensor cerebral nerve nuclei with the oculomotor, trochlear, abducens and facial cerebral nerves. A *special nucleus* is located in the floor of the third ventricle at its junction with the aqueduct. The fibers from this nucleus decussate immediately and cross through the posterior commissure.

In the dorsal part of the section are the *aqueduct*, surrounded by the *aqueduct gray*, in the ventral part of which is the *nucleus for the oculomotor nerve*. Dorsal to the gray are the *two superior quadrigeminal bodies* (*colliculi superiores*). Each body consists of four layers of alternating white and gray. The white layers represent fibers of the optic tract and some from the occipital cortex. Other fibers enter from the lateral and medial lemnisci (part of the optico-acoustic reflex pathway).

INTERNAL ANATOMY OF THE CEREBELLUM

As previously mentioned, the *cerebellum* consists of *two lateral hemispheres* with an intermediate *vermiform lobe* (*vermis*). Most of the gray substance is externally located and the white is internal. The remaining gray is found in the white as certain *nuclei*, to be mentioned later. In the vermis the gray predominates while in the lateral hemispheres the white predominates. As the main fissures and sulci run transversely and as the gray is comparatively thin the cut edge of the cerebellum exhibits a peculiar arborescent appearance; this is called the *arbor vitæ cerebelli*.

In the *white substance* of each lateral hemisphere is a crinkled layer of gray with a white core called the *dentate nucleus* (*nucleus dentatus*). It resembles the olivary nucleus of the oblongata and like it has a *hilus* for the entrance and exit of nerve fibers. Its cells give rise to most of the fibers of the brachia conjunctiva and it represents a way-station in the indirect motor pathway.

The *nucleus embolis* is small, lies just medial to the preceding and is analogous to the accessory olivary nucleus.

The *nucleus globosus* lies a little medial and ventral to the embolis while the *nucleus fastigii* lies in the white substance of the vermis close to the midline.

There are *three pairs of* **cerebellar peduncles,** *inferior*, *middle* and *superior*. The **inferior peduncles,** or **restiform bodies,** enter the cerebellum beneath the other two. Each consists of afferent and efferent fibers; the *afferent* fibers comprise: (1) the dorsolateral superficial spinocerebellar tract (direct cerebellar) derived from the column of Clark (nucleus thoracis) of the spinal cord and ending in the gray of the vermis of both (but chiefly the opposite) sides; (2) the olivocerebellar fibers (internal arcuate of oblongata) that arise in the olivary nucleus and end in the cortex of the vermis and hemispheres and also in the dentate nucleus; (3) the external arcuate fibers from the nuclei gracilis and cuneatus of both sides; (4) fibers from the vestibular and trigeminal nuclei; (5) cerebellospinal fibers arising in the cerebellum and ending in the ventral horns of the spinal cord (*efferent*).

The **middle peduncle** (*brachium pontis*) the largest consists of fibers running in opposite directions across the midline and consti-

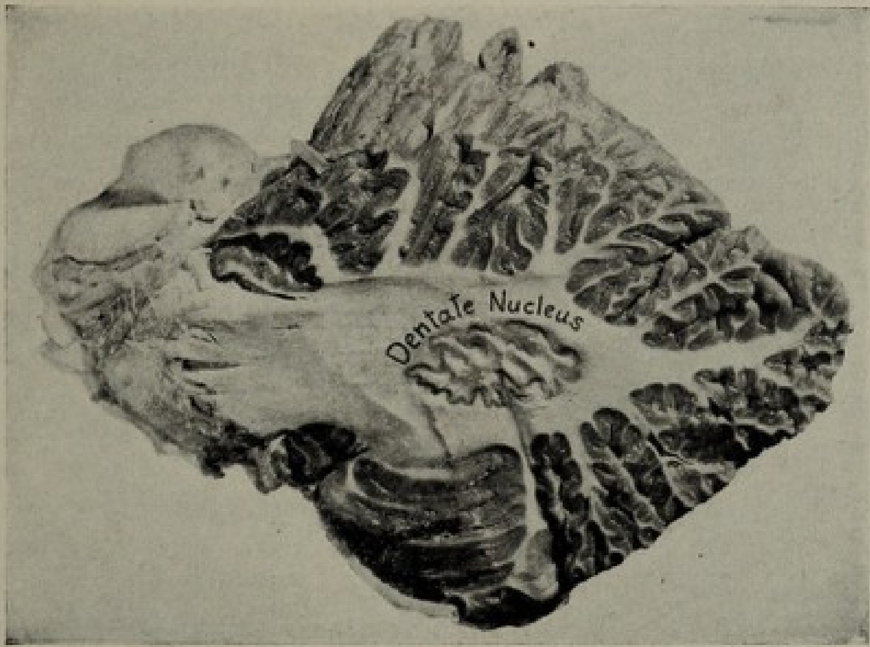


FIG. 295.—Section of the right cerebellar hemisphere showing the dentate nucleus. (*From a photograph.*)

tuting a commissure connecting the two lateral cerebellar hemispheres with each other. Most of these fibers end in the nuclei pontis of the same or opposite side and new fibers from these cells complete the circuit. In addition, some of the fibers connect the cerebellar hemispheres with certain cerebral nerve nuclei, especially the oculomotor, trochlear and abducens nuclei.

The **superior peduncles** (*brachia conjunctiva*) the smallest, form an oval or concavoconvex band; the fibers arise in the dentate nucleus of the same side, chiefly, with additional fibers from the nuclei fastigii of both sides. The fibers decussate in the midbrain where most of them end in the red nucleus, while a few continue to the thalamus. This peduncle also contains the ventrolateral superficial spinocerebellar tract (Gowers'). Its fibers instead of entering the cerebellum through the inferior peduncles continue into the pars dorsalis pontis and enter the cerebellum through the superior-peduncles.

The **cerebellum** contains other fibers than the above, called the *fibræ propræ*. These are *commissural* and *association* fibers; the *commissural fibers* connect the hemispheres with each other across the midline and pass through the vermis. The *association fibers* do not cross the midline but connect adjacent laminæ with one another.

THE INTERNAL ANATOMY OF THE CEREBRUM

A section of the cerebrum shows that like the cerebellum it consists chiefly of gray nerve substance externally (*cortex*) and white nerve tissue internally (*medulla*). In addition, masses of gray tissue are seen near the ventral part of the cerebral hemispheres and are therefore called *basal ganglia*. The internal anatomy is best represented with two sections *one horizontal*, or *flatwise* (side to side) about midway between dorsal and ventral surfaces; the other a *frontal* (*vertical*) *section* at the level of the anterior commissure.

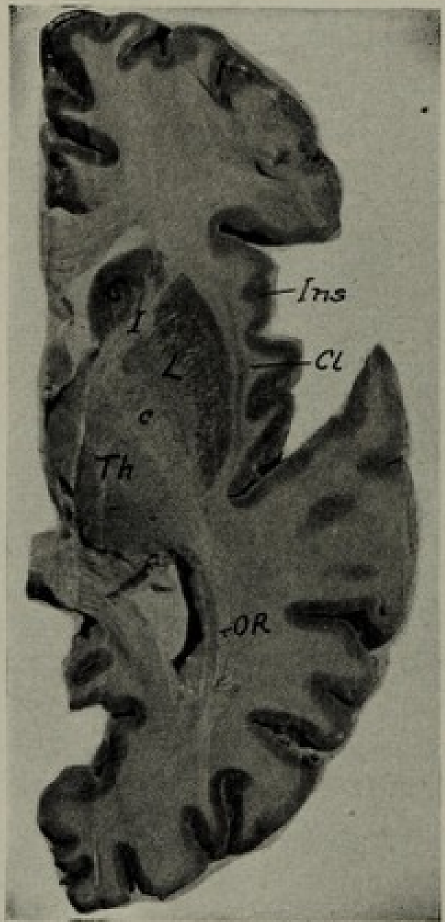


FIG. 296.—Horizontal section of the right cerebral hemisphere through the corpus striatum. (*From a photograph.*) C, Caudate nucleus; *I*, internal capsule (anterior limb); *c*, posterior limb; *Ins*, insula; *Cl*, claustrum; *OR*, optic radiation; *Th*, thalamus.

The **horizontal section** shows the bulk of the gray externally and the white internally placed, while toward the center are seen various basal ganglia. Just within the lateral margin, near the frontal end, is the *island of Reil*, or *central lobe* (*insula*). Medial to this is the *periclaustral* (*white*) *lamina* covering the irregular strip of gray, the *claustrum*. This is one of the basal ganglia and probably represents an isolated portion of the cortex of the insula. Medial to the claustrum lies a narrow strip of white nerve tissue the *external capsule* and frontally, caudally, and dorsally it connects with the internal capsule and represents fibers of an associative nature for the cortical regions around the insula. It contains a few fibers that pass to and from the thalamus.

The next medially placed structure is the *corpus striatum* consisting of two masses of gray, the *lenticular* and *caudate nuclei*, separated from each other by the frontal limb of the internal capsule. The caudal limb of the internal capsule separates the lenticular nucleus from the thalamus.

The *lenticular nucleus* (*nucleus lentiformis*) is surrounded by white substance and is shaped like a triangular pyramid, or on section it resembles a biconvex lens, hence the name. It is divided into *three main masses* and each of these has fine bands of white giving a striated appearance to the mass. The largest and lateral segment is called the *putamen* while the other two constitute the *globus pallidus*.

The *caudate nucleus* (*nucleus caudatus*) as the diagram shows, is a

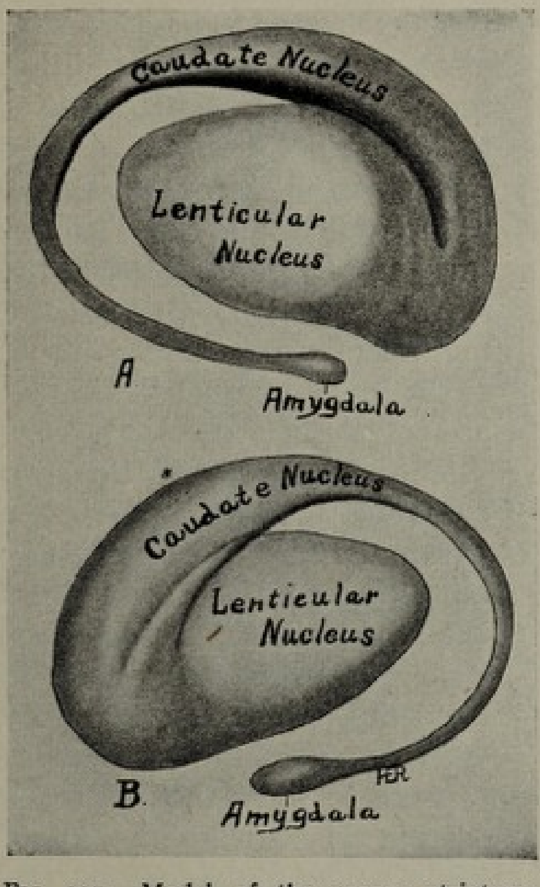


FIG. 297.—Model of the corpus striatum. *A*, Lateral view; *B*, medial view.

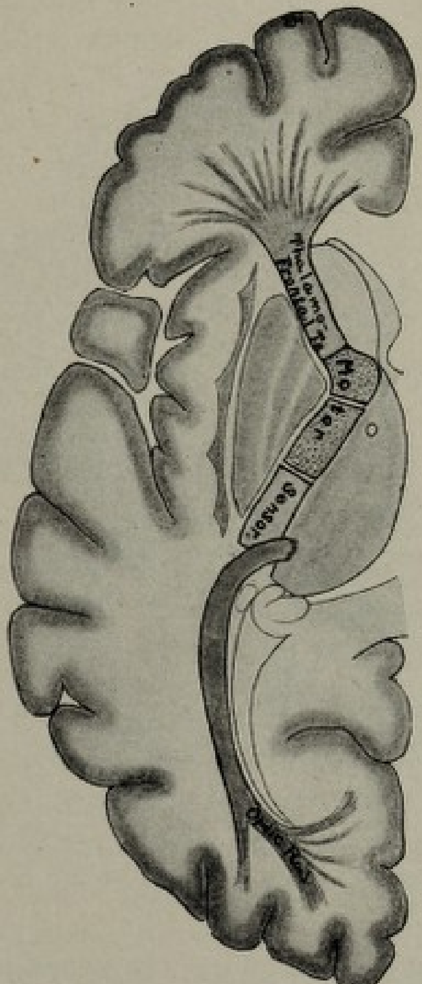


FIG. 298.—Drawing of the left internal capsule, viewed from above, showing its component fibers.

tail-shaped mass of gray nerve tissue. Owing to its arched course its sections present different appearances at different levels.

The *amygdaloid nucleus* (*nucleus amygdala*) represents an isolated part of the temporal cortical gray substance connected with the end of the caudate nucleus. It is not shown at this level.

The *internal capsule* in this section represents a knee-bent mass of white nerve tissue situated between the lenticular nucleus, laterally and the caudate nucleus and thalamus, medially. It represents the only pathway for fibers from the cerebral cortex to brain stem and cerebellum and *vice versa*. In the early stage of development of the nerve system the cerebral vesicles are connected to the primitive forebrain vesicle around the future foramen of Monro which later becomes unimportant functionally. Soon the ventromedial surface of each cerebral vesicle rests upon the dorsolateral surface of each thalamus and a fusion takes place, the *striatothalamic fusion.* This fusion area is the later *internal capsule.* The frontal limb contains the thalamofrontal and striatofrontal fibers. These fibers arise from the cells of the thalamus and end in the lenticular and caudate nuclei of the corpus striatum and frontal lobes of the cerebrum. These are the *corticipetal fibers.* In addition there are the fibers running in the opposite direction as the frontopontile (frontal cortex to pontile nuclei); frontothalamic (frontal cortex to the thalamic nuclei); striatothalamic fibers (from striate nuclei to the thalamic nuclei). These are corticifugal fibers.

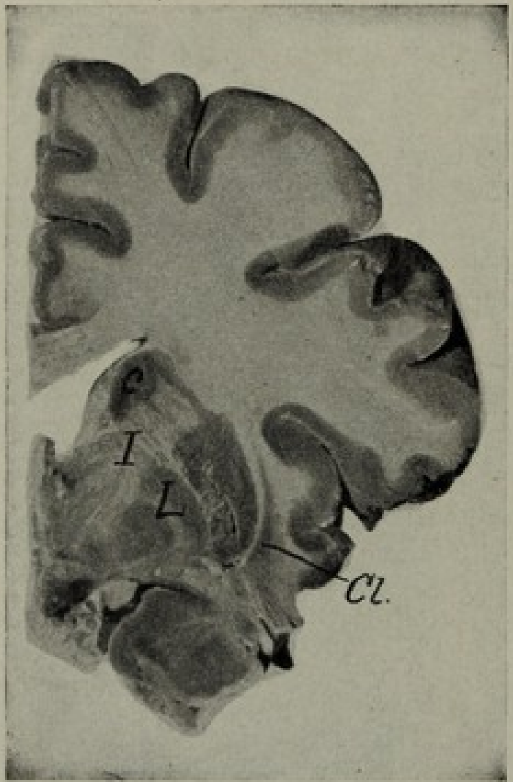


FIG. 299.—Frontal section of the right cerebral hemisphere through the corpus striatum and internal capsule. (*From a photograph.*) *C*, Caudate nucleus; *Cl*, claustrum; *I*, internal capsule; *L*, lenticular nucleus.

The *knee portion*, or *genu* contains the fibers of the pyramidal tract, voluntary motor fibers that arise from the pyramidal cells of the cortex of the frontal lobe in front of the central fissure and pass through the internal capsule to form the pyramids previously mentioned. The motor portion takes in about half of the occipital limb of the internal capsule. The remainder of this limb contains the sensor fibers that pass from the thalamus to the cortex of the parietal lobe, to the general somatic sensor area. At the extreme occipital part of this limb are: (1) fibers of the optic radiation that course in both directions between the pulvinar of the thalamus, the lateral geniculate body and the superior quadrigeminal bodies (on the one hand) and the occipital cortex (visual area) on the other; (2) fibers of the auditory radiation passing both ways between the medial geniculate and inferior quadrigeminal body, on the one hand, and the cortex of the temporal lobe (auditory area) on the other; (3) occipitopontile and temporopontile fibers from the cortex of these lobes to the nuclei pontis.

The *thalamus* (Fig. 296) is an important way-station in the sensor and optic pathways. It receives impulses of muscle sense, pain, temperature and touch and transmits them to the cerebral cortex and receives in return impulses from the various parts of the cerebral cortex. It is an *emotional center* under control of the cerebral cortex. Its fibers constitute the thalamocortical and corticothalamal groups. These represent fibers to and from the frontal, parietal and occipital lobes and ventral fibers to and from the temporal lobe, island of Reil, and lenticular nucleus.

The thalamus lies between the occipital limb of the internal capsule and the midline. It consists of three chief nuclei separated from one another by white nerve tissue; these are the *nucleus anterior*, *nucleus medialis* and the *nucleus lateralis* (largest).

A **vertical** or **frontal section** shows the above structures, but in a slightly different relation. The *internal capsule* shows no bend but has a regular course that is oblique in direction, converging toward the midline. Beneath the lenticular nucleus is seen the *corpus callosum* that represents a commissure connecting the cerebral hemispheres with each other.

THE VENTRICULAR SYSTEM

The ventricular system comprises the *two lateral ventricles*, the *foramina of Monro*, the *third ventricle*, the *aqueduct*, the *fourth ventricle*, the *foramen of Magendie* and the *spinal canal*.

Each **lateral ventricle** (*ventriculus lateralis*) lies in a cerebral hemisphere and comprises a *body*, and *three horns*, *anterior*, *middle* and *posterior*. The *body* (*pars centralis*) is situated underneath the body of the corpus callosum and over the caudate nucleus and part of the thalamus; it communicates at its frontal end with the third ventricle by means of the **foramen of Monro** (*foramen interventriculare*). The *anterior*, or *frontal horn* (*pars anterior*) is short and extends from the foramen of Monro, forward and outward into the frontal lobe. The *middle*, *descending*, or *temporal horn* (*pars inferior*) is the largest and passes backward, outward, downward, forward and inward in the temporal lobe. The *posterior*, or *occipital horn* (*pars posterior*) passes backward and inward from the body of the ventricle into the occipital lobe.

The **third ventricle** (*ventriculus tertius*) is a vertical cleft in the midline between the two thalami and dorsal to the chiasm, tuber cinereum, corpora albicantia and part of the tegmentum of the crura cerebri. It is covered, or roofed by the velum interpositum. It continues frontally as a slight evagination, the *optic recess;* ventrally, it gives rise to the *infundibular recess* and dorsally, to the *epiphyseal*, or *pineal recess*. It communicates with each lateral ventricle by a foramen of Monro and caudally with the fourth ventricle by means of the aqueduct.

The **aqueduct** or **iter** (*aqueductus cerebri*) lies in the midbrain; its roof is the lamina quadrigemina and its floor the tegmental part of the crura cerebri. It is a short, narrow canal that communicates caudally with the fourth ventricle and frontally with the third ventricle.

The **fourth ventricle** (*ventriculus quartus*) is a shallow, diamond-shaped fossa in the pons oblongata region. Its floor (better ventral

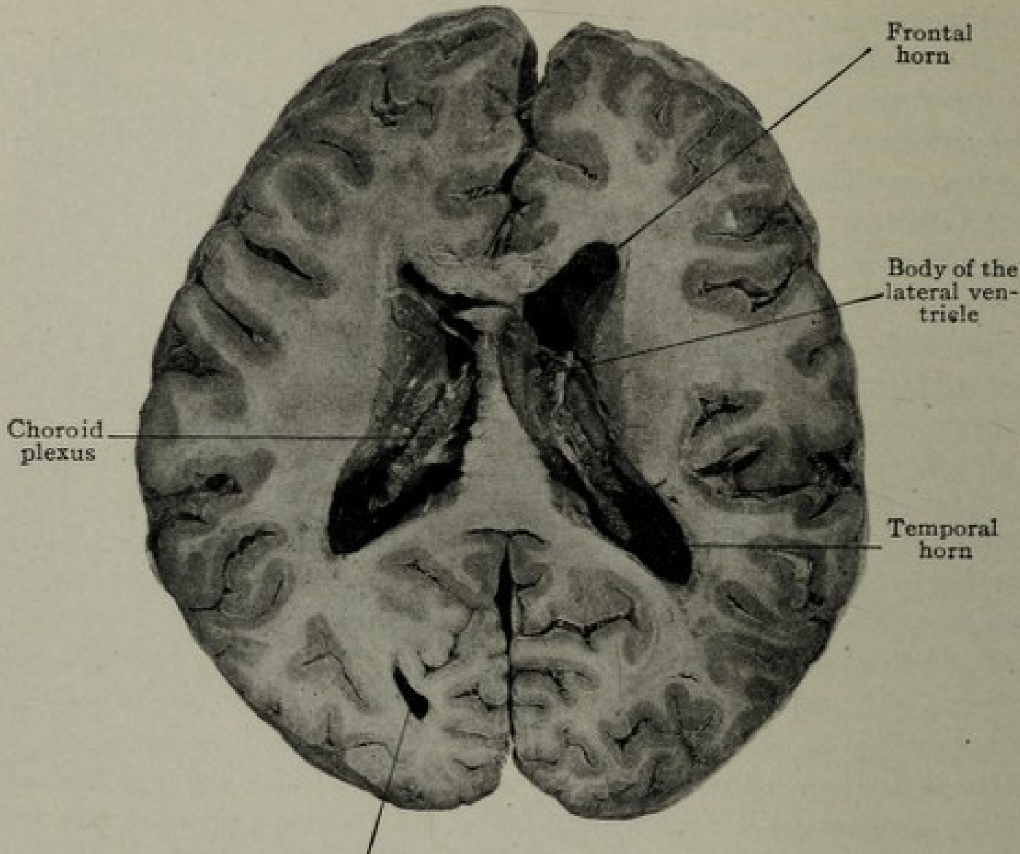


FIG. 300.—Horizontal section of the brain through the lateral ventricles.

wall) is the tegmental part of the pons and oblongata; in the oblongata region it is roofed by the tela chorioidea inferior and in the pons region by the valvula and the brachia conjunctiva. At the frontal and caudal angles the fossa becomes canal-like to continue as the aqueduct and spinal canal, respectively. At the lateral angles the cavity continues as a narrow recess over each corresponding restiform body and these prolongations are called the *lateral recesses.* Openings here lead into the subarachnoid lymph space and these are the *foramina Luschkæ* (*aperturæ laterales*). The upper and lower parts of the roof do not form a flat structure but a gable, or peak under the cerebellum, so that the ventricle has the greatest depth here. The tela chorioidea inferior has an opening near its spinal cord end called the **foramen of Magendie,** which communicates with the subarachnoid space. This with the foramina of Luschka permits an interchange of cerebrospinal fluid between the ventricular system and the lymph spaces of the membranes covering the brain. By this means an equilibrium of pressure is established inside and outside of the brain and spinal cord.

The **spinal canal** is a narrow, tube-like space extending the length of the spinal cord; it is located in the gray commissure. It tends to become obliterated more or less after the prime of life.

The entire ventricular system is lined with *ependymal cells* that in the spinal cord are chiefly simple ciliated cells and in the ventricles simple squamous, or simple ciliated elements.

The **white substance of the cerebrum (medulla)** consists of *myelinated nerve fibers* that are classified according to their connections, into three groups: (1) *projection*, (2) *association*, (3) *commissural*.

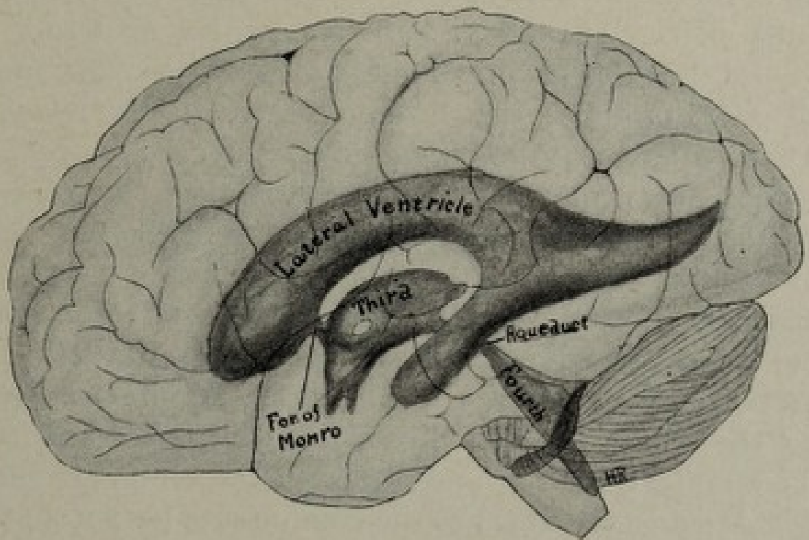


FIG. 301.—The ventricular system of the brain represented in situ.

1. The **projection fibers** are those that pass from the cortex to lower centers (thalamus, midbrain, pons, oblongata) and are *centrifugal* in direction; to these are added the fibers from the lower centers to the cerebral cortex, the *corticipetal fibers*. These fibers form the bulk of the *corona radiata*. This is nothing more nor less than the fan-shaped form assumed by the fibers from the various cerebral convolutions as they pass to, or ascend from, the internal capsule. It is the fan-shaped collection of fibers dorsal to the internal capsule that at a more ventral level constitute the internal capsule.

The *corticifugal fibers* are the pyramidal, or great voluntary motor pathway, the corticothalamic, frontopontile, temporopontile, and the corticifugal fibers of the optic radiation. All of these indicate by the name the origin and termination, and their respective positions have been discussed in the internal capsule and the crura cerebri; the pyramidal tract has been discussed in the pons, oblongata and spinal cord.

The *corticipetal fibers* comprise the thalamocortical, the auditory radiation and the optic radiation.

2. The **association fibers** are *short* and *long*. The *short* ones connect areas in adjacent convolutions with one another, or gyri rather close together (arcuate and tangential fibers). The *long association fibers* connect areas remote from one another in the same cerebral hemisphere as the cingulum, uncinate, superior longitudinal and fasciculus rectus.

3. The **commissural fibers** are those that pass across the midline to connect areas of the opposite sides together. Under this head are found the corpus callosum, the hippocampal commissure and the anterior commissure.

The **corpus callosum** is the largest commissure and consists of fibers that cross the midline in both directions at the bottom of the intercerebral cleft. The fibers form a compact structure already considered and these fibers spread out in all directions, but unequally, so that all parts of the cortex do not receive the same number of fibers. These fibers may be direct axones of cells, or collateral of the association, or projection fibers. It connects all parts of the cerebral cortex with one another, except parts of the temporal lobes and the olfactory bulbs.

The **hippocampal commissure** is part of the olfactory pathway. It connects the cornu ammonis of the two sides together.

The **anterior commissure** is also a part of the olfactory pathway, connecting the two olfactory bulbs with each other and also connecting the olfactory bulb of one side with the temporal lobe of the other side. Most of the fibers of the commissure pass from one temporal lobe to the other, but the exact point of termination is not known.

The various **pathways** will now be considered.

The **Direct Motor Pathway.**—This comprises but *two neurons*. The parts concerned are the *two pyramidal tracts* and the *motor portions of the cerebral and spinal nerves*.

The *pyramidal tract* of each side consists of afferent fibers that arise from the large and small pyramidal cells of the motor area of the cerebral cortex. They pass down through the corona radiata into the internal capsule occupying the middle portion thereof; they enter the crusta of the crus cerebri, then the tegmentum of the pons and the ventral area of the oblongata; in these three regions some of its fibers pass to the cerebral nerve nuclei of origin. At the caudal end of the oblongata 85 to 90 per cent. of the fibers *decussate* to the opposite side of the spinal cord as the *crossed pyramidal tract* and then end at various levels around the cells of the ventral horn. The remaining fibers continue down the same side of the spinal cord, as the *direct pyramidal tract,* to various levels in the cervical and upper thoracic region and then pass through the ventral, or white commissure, to end in the ventral horn of the opposite side. Ultimately all fibers decussate before they end. *This ends the first neuron.* The *second neuron* comprises the cells of the ventral horn and their processes that form the motor root of the spinal nerves, on the one

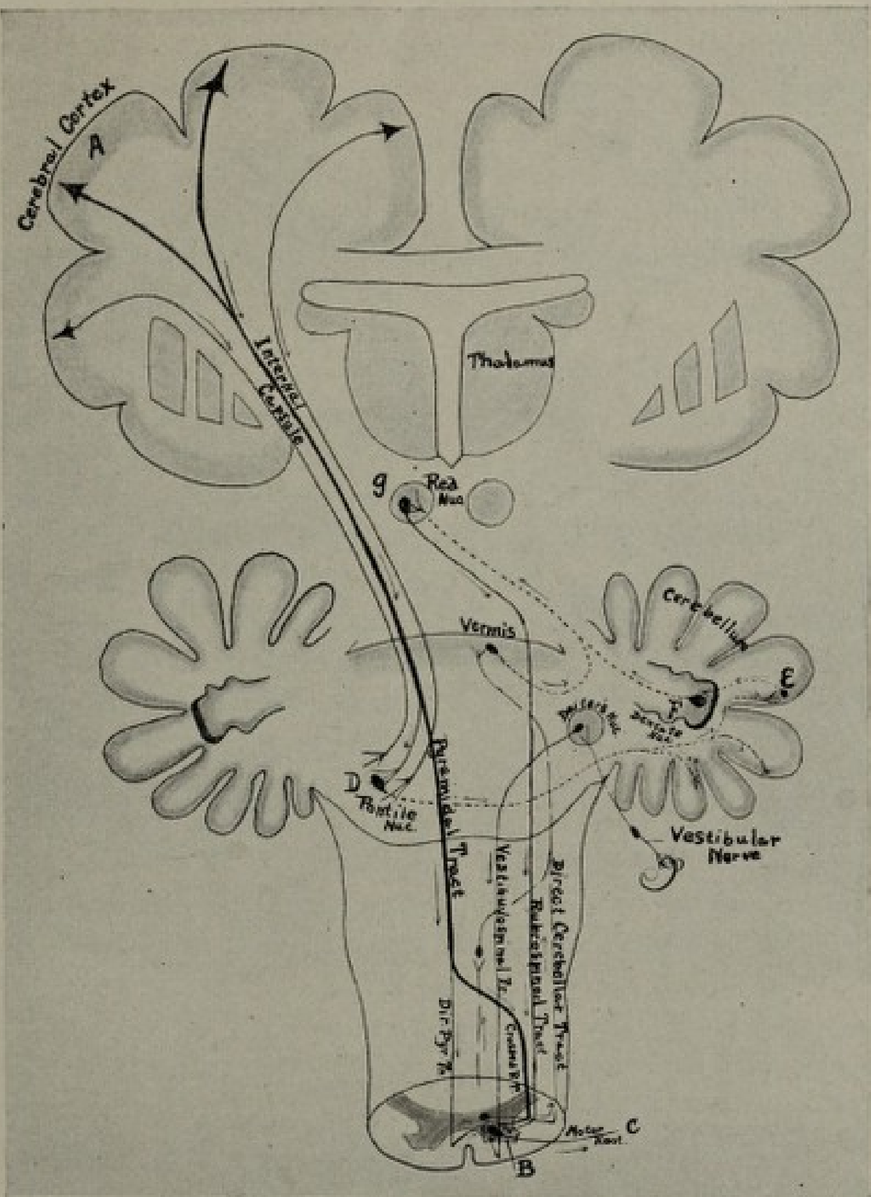


FIG. 302.—Diagram of the neurons in the direct and indirect motor pathways and the connections of the cerebellum with the brain stem and the spinal cord. Direct.—Neuron 1, *A* to *B*; neuron 2, *B* to *C*. Indirect.—Neuron 1, *A* (cerebral cortex) to *D*; 2, *D* to *E*; 3, *E* to *F*; 4, *F* to *g*; 5, *g* to *B*; 6, *B* to *C*.

hand, and in the case of the cerebral nerves comprises the cells of the various nuclei of origin and their processes that form the motor portion of the cerebral nerves. These axones pass out of the gray substance, become myelinated and ultimately end directly in a voluntary striated muscle fiber. *This is the end of the second neuron.*

First neuron, a pyramidal cell in the motor cortex of the cerebrum and its axone that forms a part of the pyramidal tract and that ends in a cerebral nerve nucleus, or the ventral gray of the spinal cord.

Second neuron, the cell in the nucleus of origin or in the ventral

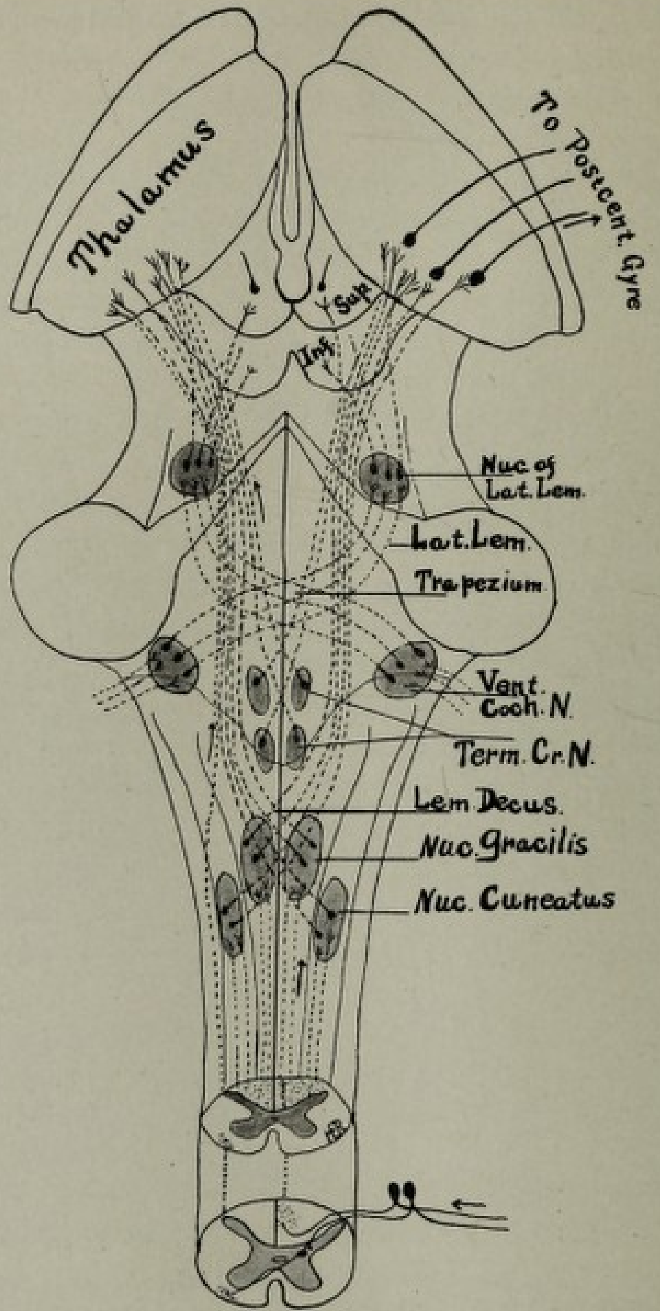


FIG. 303.—The origins, decussations and courses of the fibers forming the medial and lateral lemnisci. Direct sensor pathway.

gray of the spinal cord, and its axone that ends in a voluntary striated muscle fiber.

The Indirect Motor Pathway.—This is more complex and comprises *six neurons. First,* from the motor area of the cerebrum (say right side) through the pyramidal tract, as above, to the *nuclei pontis* of the *same side* (right); *second,* from the nuclei pontis through the brachium pontis to the *cerebellar cortex* of the *opposite* (left) *side; third*, from the cerebellar cortex to the *dentate nucleus* of the cerebellum of the *same* (left) *side; fourth*, from the dentate nucleus through the brachium conjunctivum to the *red nucleus* of the *opposite* (right) *side; fifth*, from the red nucleus of that side through the *rubrospinal tract* to the cerebral nerve nucleus, or ventral horn of the spinal cord of the *opposite* (left) *side*. (The fibers of the rubrospinal tract cross to the opposite side almost immediately after leaving the red nucleus.) *Sixth*, from the cerebral nerve nucleus, or the ventral horn gray to the voluntary striated muscle fiber. As seen above there are *three crossings*, or *decussations*, the next to the last neuron terminating upon the opposite side of the body.

The Direct Sensor Pathway.—*In the trunk* the impulses arise at the periphery and are conveyed by the sensor spinal nerves to the *ganglia on the dorsal roots*. From there they are conveyed into the dorsal column of the spinal cord to end in the *nuclei gracilis* and *cuneatus* of the oblongata of the *same side*. Some collaterals are sent into the dorsal horn gray. *New fibers* arise in the nuclei cuneatus and gracilis and immediately cross, or *decussate* to the opposite side, forming the *sensor decussation*, that lies just above, or cephalad of the motor (pyramidal) decussation. These decussated fibers form the medial lemniscus that continue through the oblongata, pons and midbrain to end in the *thalamus of that side*. From the thalamus *new fibers* convey the impulses through the internal capsule (posterior limb) to the *somatic sensor area of the cerebral cortex* (postcentral gyre). In this pathway *three neurons* are required, the *first*, from the surface to the nuclei gracilis, or cuneatus (the cell body lying in the dorsal ganglion); the *second*, from these nuclei to the thalamus; and the *third*, from the thalamus to the cerebral cortex.

Reflex conduction may occur in two ways:

(1) *Direct.*—The impulse is conveyed into the cord in the above manner but the fiber as it enters the cord gives off collaterals of *two kinds:*

(*a*) A collateral that passes to the ventral horn of the same and opposite sides where it ends. The impulse then originates from the motor cells in that area and is conveyed to the muscle which moves unconsciously.

(*b*) As the sensor fibers enter the spinal cord they divide into ascending and descending fibers. The ascending pass to the nuclei gracilis and cuneatus and give off collaterals at various levels. The descending fibers end at various segments in the dorsal horn and new fibers arise from the cells here to pass to the ventral horn of the same and opposite sides. New impulses arise from the motor cells here and are conveyed to the muscles.

(2) An *indirect reflex path* is as follows: *First neuron*, from the peri-

phery to the nuclei cuneatus and gracilis through the dorsal column of the spinal cord. *Second neuron*, from these nuclei to the cerebellar cortex through the restiform body. *Third neuron*, from the cerebellar cortex to the dentate nucleus of the cerebellum (same side). *Fourth neuron*, from the dentate nucleus to the red nucleus through the brachium conjunctivum. *Fifth neuron*, from the red nucleus through the rubrospinal tract to the ventral horn of the spinal cord. *Sixth neuron*, through the ventral motor roots to the muscle. In

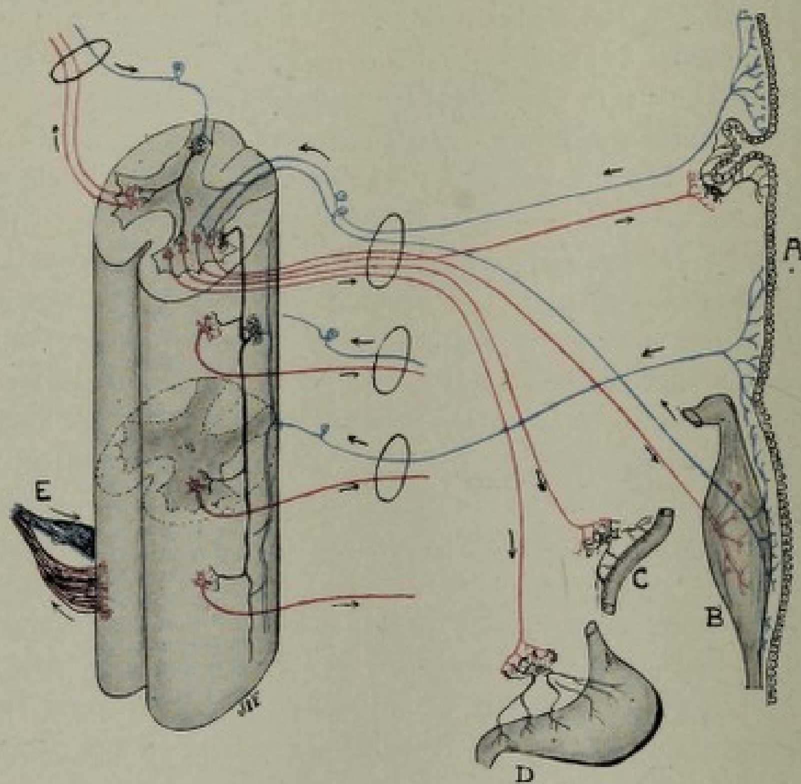


FIG. 304.—Diagram of the structures involved in a reflex action. *A*, receptive surface; *B*, skeletal muscle; *C*, blood-vessel and sympathetic ganglion; *D*, a viscus and sympathetic ganglion; *E*, spinal nerve attached to spinal cord. Red indicates motor and blue sensor impulses.

both varieties of reflex action the cerebral cortex is not brought into the action.

The neurons involved in the movements of the involuntary musculature of the body and secretions of glands are complicated by connection with the sympathetic system.

Optic Pathway (Fig. 305).—The axones of the *first neuron* arise from the inner ganglion cells of the retina and form the optic nerve; at the chiasm those fibers from the temporal half of the retina continue on the same side and those from the nasal half cross to the opposite side through the chiasm. These crossed and uncrossed fibers of each side form the optic tracts that curve over the ventral surface of each cerebral peduncle to end as follows: (1) in the pulvinar of the thalamus; (2) in the lateral geniculate body; (3) a few fibers pass to the superior quadrigeminal body (eye muscle movements). The axones of the *second neurons* start from the pulvinar and lateral geniculate body, form the optic radiation at the caudal and most ventral part of the internal capsule and end in the occipital cortex (visual area).

The neuron that ends in the superior quadrigeminal body is concerned in the action of the sphincter pupillæ muscle of the iris; it is

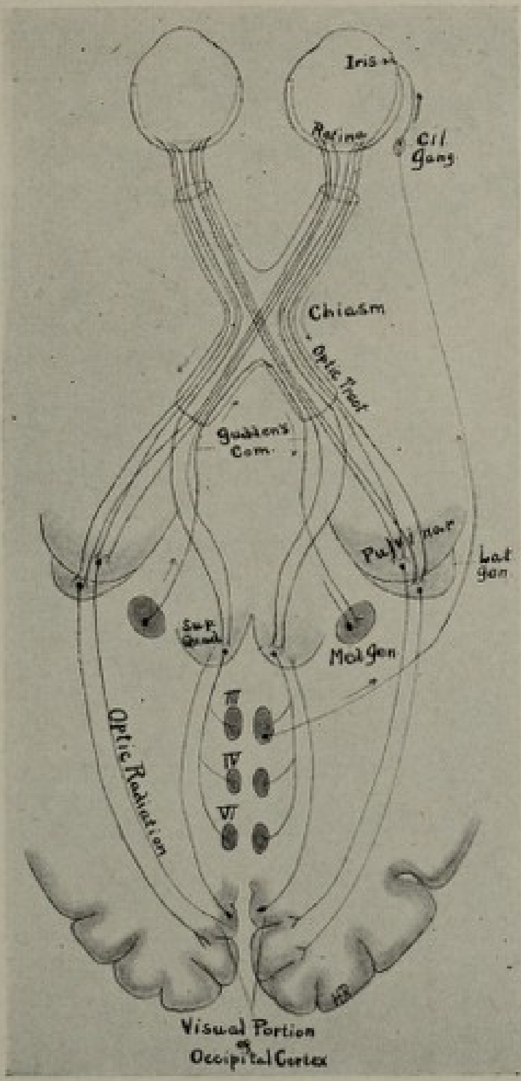


FIG. 305.—Diagram of the optic pathway.

succeeded by a *second neuron* that connects the superior quadrigeminal body with the nucleus of the oculomotor nerve. A *third neuron* connects this nucleus with the ciliary ganglion and a *fourth neuron* connects this ganglion with the sphincter pupillæ muscle.

Gustatory Pathway.—This pathway comprises *two nerves*, the *nervi intermedius* and the *glossopharyngeus*. The *first neuron cell of the nervi intermedius* lies in the geniculate ganglion (of the facial nerve, so called) and the peripheral fiber (dendrite) ends within the tongue; the central fiber (axone) ends in the nucleus solitarius of the

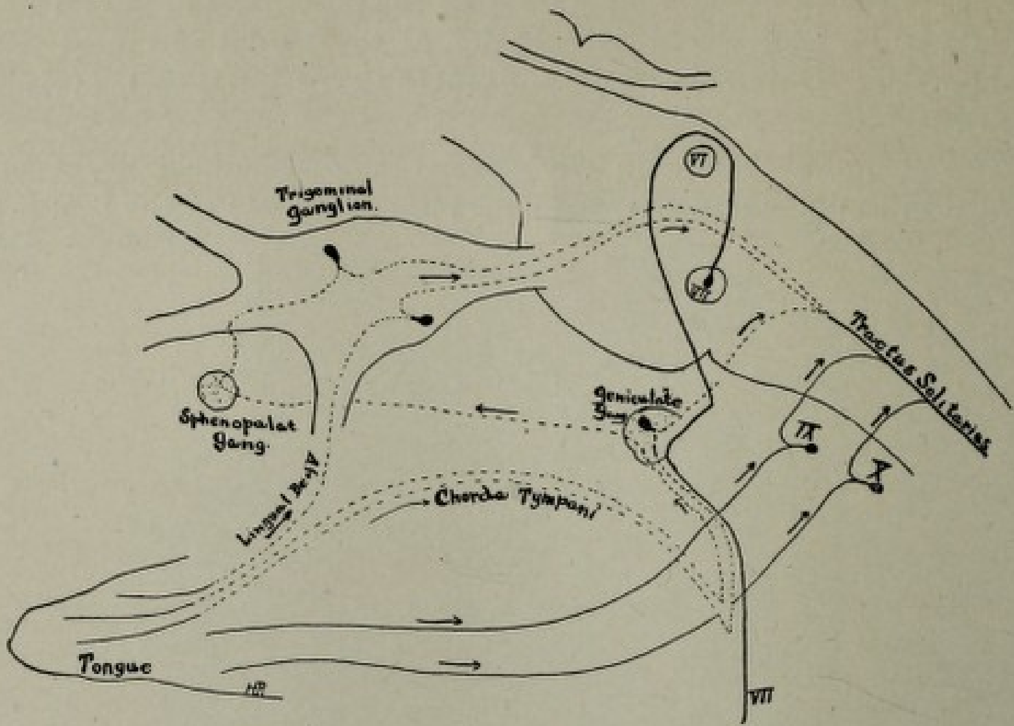


FIG. 306.—A diagram of the probable pathways of gustatory impulses.

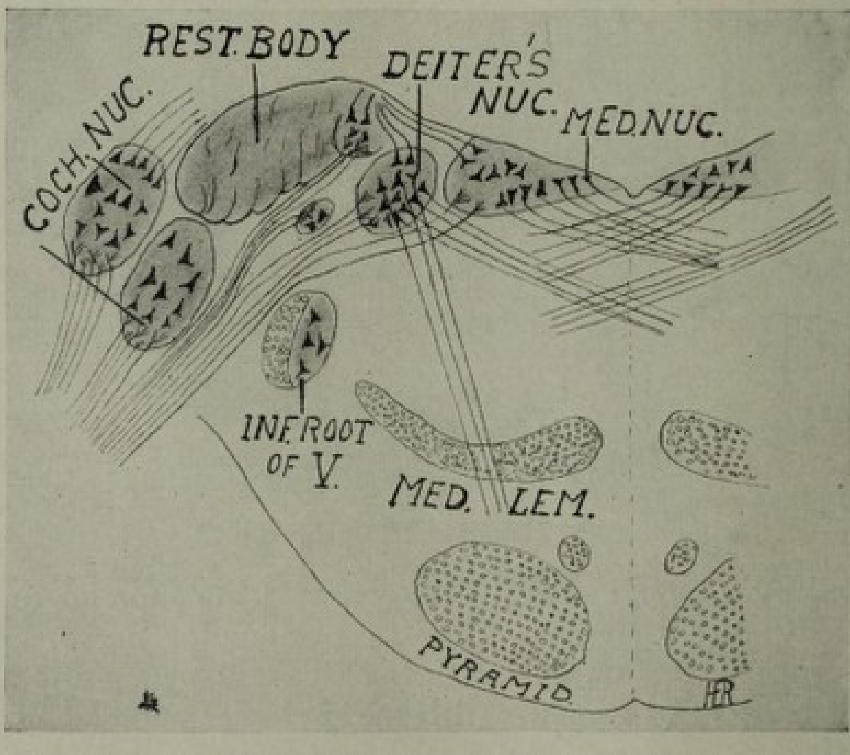


FIG. 307.—Diagram of the nuclei of termination of the vestibular nerve, and their higher connections.

glossopharyngeal and vagal nerves. The *first neuron of the glossopharyngeal nerve* lies in the ganglia jugulare and nodosum and the peripheral fiber (dendrite) ends in the tongue; the central fiber (axone) ends in the nucleus solitarius of the oblongata (as in the preceding). The *second neuron* lies in this nucleus and the axon ends in the thalamus. The *third neuron* starts in the thalamus and ends in the gustatory area of the temporal lobe of the cerebral cortex (medial surface).

Auditory Pathway.—The auditory nerve consists of the cochlear and vestibular divisions. The *first neuron cells* of the *cochlear nerve* lie in the ganglion spirale of the organ of Corti. The peripheral fibers

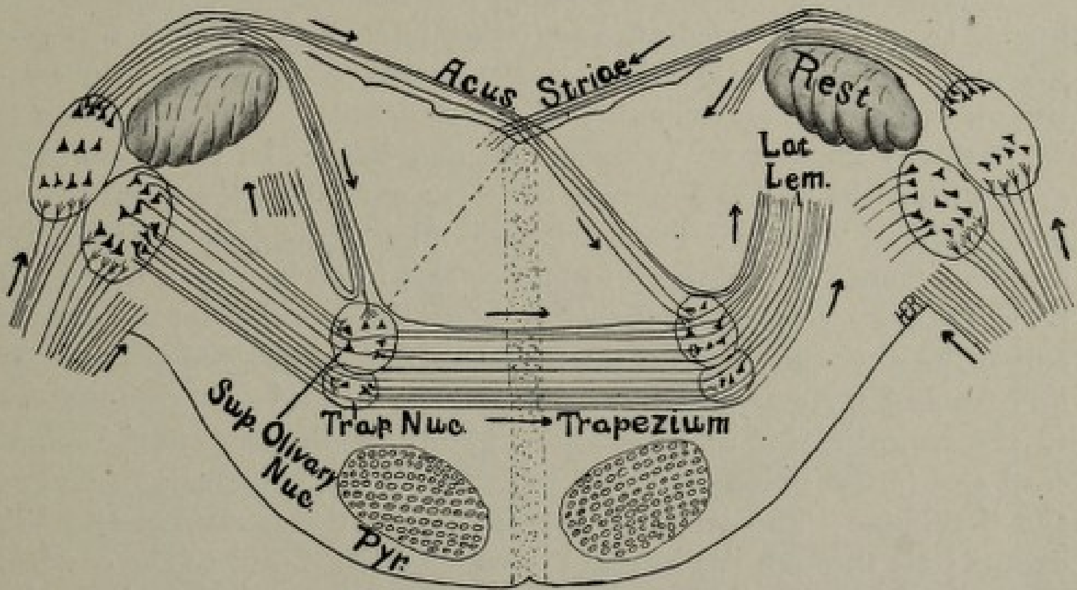


Fig. 308.—Diagram of the cochlear nuclei of termination and their higher connections.

(dendrites) end in relation with the hair cells of the organ of Corti while the central fibers (axones) pass to the dorsal and ventral cochlear nuclei of the oblongata (floor of the fourth ventricle). The *second neuron cells* lie in these nuclei; the axones from the dorsal cochlear nucleus pass over the floor of the ventricle (as the acoustic striæ) to the median sulcus, then pass ventrally into the oblongata cross the midline and most of the fibers pass obliquely to join the lateral lemniscus to end in the medial geniculate body.

The fibers from the ventral cochlear nucleus pass toward the midline, just dorsal to the pyramids, and form here the trapezium. They continue across the midline and sweep dorsally to join the lateral lemniscus and end in the medial geniculate body and the inferior quadrigeminal body. Fibers pass to and end in the superior olivary nucleus. Some fibers end in the nucleus of the lateral lemniscus and are replaced by new fibers. Others may end in the nucleus of the trapezium to be succeeded by new fibers from the cells here.

The *third neuron cells* lie in the medial geniculate body and their axones then pass to the auditory center which is in the superior portion of the cortex of the temporal lobe.

The *first neuron cells of the vestibular nerve* (the nerve of equilibration) lie in the vestibular ganglion in the internal auditory canal. The peripheral fibers (dendrites) end in the neuroepithelial areas of the utriculus, sacculus and semicircular canals of the internal ear. The central fibers (axones) pass to the brain stem where they divide into ascending and descending branches. These branches end in the various vestibular nuclei. The *second neuron cells* lie in these nuclei and the axones of these cells pass to the vermis of the cerebellum, to the nucleus fastigii of the cerebellum, to the various cerebral nerve nuclei through the median longitudinal fasciculus (from Deiter's nucleus), to the superior olive, to the spinal cord (through the vestibulospinal tract) and possibly to the thalamus. *Third* to cortex.

Pathway for Touch, Temperature and Pain.—In the trunk and extremities, the *first neuron cells* lie in the ganglia of the dorsal roots of the spinal nerves. The peripheral fibers (dendrites) bring the impulses from the periphery (organ or skin) and it is then conveyed by the axone into the spinal cord through the dorsal root; the axones end in the gray substance of the dorsal horn. The *second neuron cells* lie here and their axones cross through the ventral gray commissure to the opposite side and form the spinothalamic tracts in the spinal cord and in the oblongata they join the medial lemniscus to end in the thalamus. The *third neuron cells* lie in the thalamus and the axones pass through the internal capsule (sensor limb) to the cortical area of somatic sensibility (postcentral gyre). Some of the impulses of touch and contact sensibility are conveyed through the dorsal column of the spinal cord (same side) to the nucleus cuneatus and gracilis. The new fibers from these nuclei decussate and join the opposite medial lemniscus to end in the thalamus of that side; thus some of the sensibility fibers cross in the spinal cord at their entrance and others do not cross until the above nuclei have been reached.

In the head most of the impulses are conducted to the nuclei of the trigeminus, glossopharyngeal and vagal nerves of each side to the ganglia of the sensor divisions; then they are conducted to the nuclei of termination of these nerves, in the fourth ventricle. This course constitutes the *first neuron*. The *second neurons* connect these nuclei with the thalamus by way of the medial lemniscus. The *third neurons* connect the thalamus with the cerebral cortex as above.

The **muscle sense (deep sensibility)** *impulses* of the trunk and extremities are conveyed as follows: The *first neuron* connects the periphery with the spinal cord where some of the fibers continue on the same side through the dorsal column to the nuclei cuneatus and gracilis. From here the fibers of the *second neuron* convey the impulses by way of the opposite medial lemniscus to the thalamus. The *third neuron* connects the thalamus with the cortical area. Some fibers pass from the nuclei gracilis and cuneatus to the cerebellar cortex; new fibers pass from here to the dentate nucleus of the cerebellum from which new fibers pass to the thalamus through the brachia conjunctiva.

Some of the fibers, only, of the first neuron, have the above course. Others, after entering the dorsal roots of the spinal nerves, do not enter the dorsal column but join the spinocerebellar tracts (ventral and dorsal superficial) to end in the cerebellar cortex of the same side. The impulses are then carried to the dentate nucleus and from here through the brachium conjunctivum to the thalamus; from the thalamus the impulses are conveyed to the cerebral cortex.

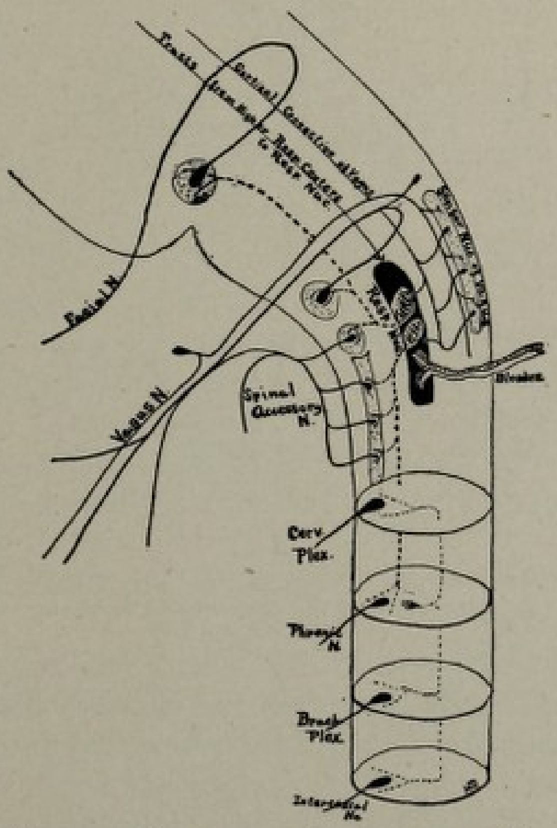


FIG. 309.—Diagram of the nerves and tracts concerned in respiration.

Respiration.—Although respiration is apparently controlled by the respiratory nucleus that lies in the formatio reticularis of the oblongata, it is maintained by stimuli carried to this center by the blood vascular system and reflex impulses from the sensor portion of the vagus through cells in the nucleus of termination of the vagal nerve and by impulses from the higher respiratory centers. The *respiratory nucleus* is connected with the following motor nuclei: Facial, vagal, accessory, cervical plexus, phrenic, brachial plexus and thoracic nerves. Axones from the higher centers and from the sensor vagal nucleus end in the respiratory nucleus. The cells of the respiratory nucleus send their axones directly, or by means of collaterals, in the formatio reticularis, to the nuclei of the abovementioned motor nerves so that through this connection a number of cerebral and spinal nerves are caused to act.

Olfactory Nerves and Pathway.—Each so-called olfactory nerve consists of about *twelve separate nerves* called the *olfactory fila.* These arise in the olfactory mucosa of the nose, pass through the openings in the cribriform plate of the ethmoid bone and terminate in the olfactory bulb.

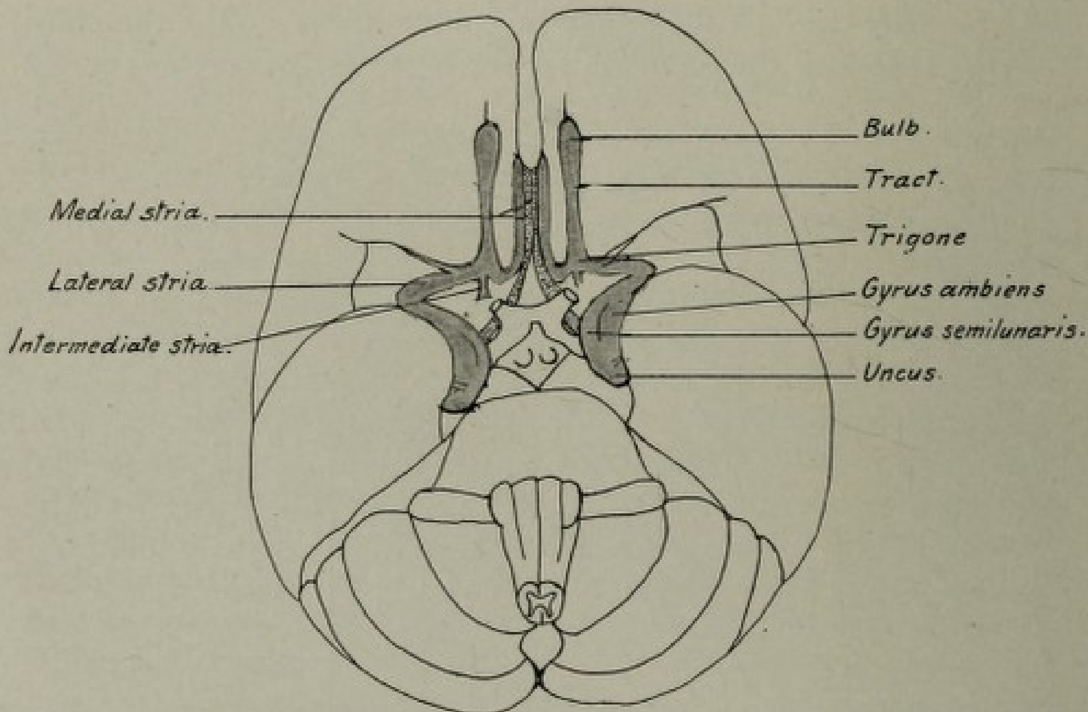


FIG. 310.—Schematic representation of the olfactory pathway upon the ventral surface of the brain.

The *olfactory pathway* comprises the *olfactory fila* and the *rhinencephalon*, the parts of which will be considered under *peripheral* and *central*, or *cortical portions.*

The *peripheral portion* comprises the following:

The **olfactory bulb** (*bulbus olfactorius*) that receives the olfactory fila. Each lies upon the cribriform plate of the ethmoid bone. It is oval in outline, flattened and of a reddish color. It is continued toward the cerebrum as the olfactory tract.

The **olfactory tract** (*tractus olfactorius*) is a wedge-shaped band of nerve fibers and passes from the bulb toward the cerebrum. After a course of about 3.5 cm. it forms the **olfactory tubercle** (*tuberculum olfactorium*) the base of which is seen in the ventral surface of this region and is called the **trigonum olfactorium** (gray nerve tissue).

From the trigonum *three tracts*, or *striæ*, continue, called the *lateral,* *intermediate* and *medial roots*, or *striæ*, of which each has a different course and termination. Each *lateral root* (*stria olfactoria lateralis*) passes to the sylvian fissure where it is continuous with the *limen insula* and then continues to the gyri ambiens and semilunaris.

The *intermediate root* (*stria olfactoria intermedius*) extends from the olfactory tract over the trigonum to the gray substance of the anterior perforated substance.

The *medial root* (*stria olfactoria medialis*) passes to and merges with the area parolfactoria.

Broca's diagonal band is seen ventrally in the anterior perforated space. This comes from the uncus and courses obliquely along the outer side of the optic tract, converging with its fellow of the opposite side to the base of the intercerebral cleft where they pass dorsally into the gyrus subcallosus under the genu of the corpus callosum. From here each continues in the indusium of that side forming the medial and lateral longitudinal striæ.

The *anterior perforated substance* lies just behind (caudad of) the trigonum between this and the optic chiasm. It is somewhat quadrilateral in shape. In the lateral and caudal part of this area is Broca's diagonal line.

The *area parolfactoria* lies in the base of the intercerebral cleft under the genu of the corpus callosum.

The *gyrus ambiens* and *gyrus semilunaris* are seen upon the ventral surface to the side of the corpora albicantia, bounding the anterior perforated space caudolaterally. They represent, apparently, a portion of the uncus separated therefrom by the end of the dentate gyre, called the *frenulum Giacomini*. They are a part of the hippocampal gyre.

The **central portions** are sometimes called the *limbic lobe* and are as follows:

The *gyrus subcallosum* lies just behind the area parolfactoria under the genu of the corpus callosum continuing as the indusium.

The *indusium* (*gyrus epicallosus*) is a thin band of gray nerve tissue extending over the dorsal surface of the corpus callosum. Through it ran the *medial* and *lateral longitudinal striæ*, or *roots*, forming two ridges. The indusium continues ventrally as the *gyrus dentatus*. The *medial* and *lateral longitudinal striæ* are continuations of Broca's diagonal band.

The *hippocampus* is a portion of the temporal lobe that projects into the middle horn of the lateral ventricle. Upon it lies a white band, the *fimbria*, a portion of the fornix.

The *uncus* is a hook-like, isolated portion of the hippocampal gyre just behind the gyrus ambiens upon the ventral surface of the brain just lateral to the frontal portion of the pons.

The *dentate gyre* is a notched band of gray nerve tissue in the depths of the hippochampal fissure that separates it from the hippocampal gyre. On the other side is a fissure that separates it from the fimbria, in the depths of which is a narrow band, the *fasciola cinerea;* this is a narrow extension of the uncus to the splenial portion of the callosum, where it fuses with the dentate gyre. The dentate gyre seems to be a continuation of the indusium that extends ventrally around the uncus as the frenulum Giacomini.

The *gyrus Andræ Retzii* is a small, oval, corrugated portion of the hippochampal gyre just behind the splenium of the corpus callosum.

The *corpora albicantia* are two, small, rounded, white structures, on the ventral surface of the brain just caudad of the optic chiasm

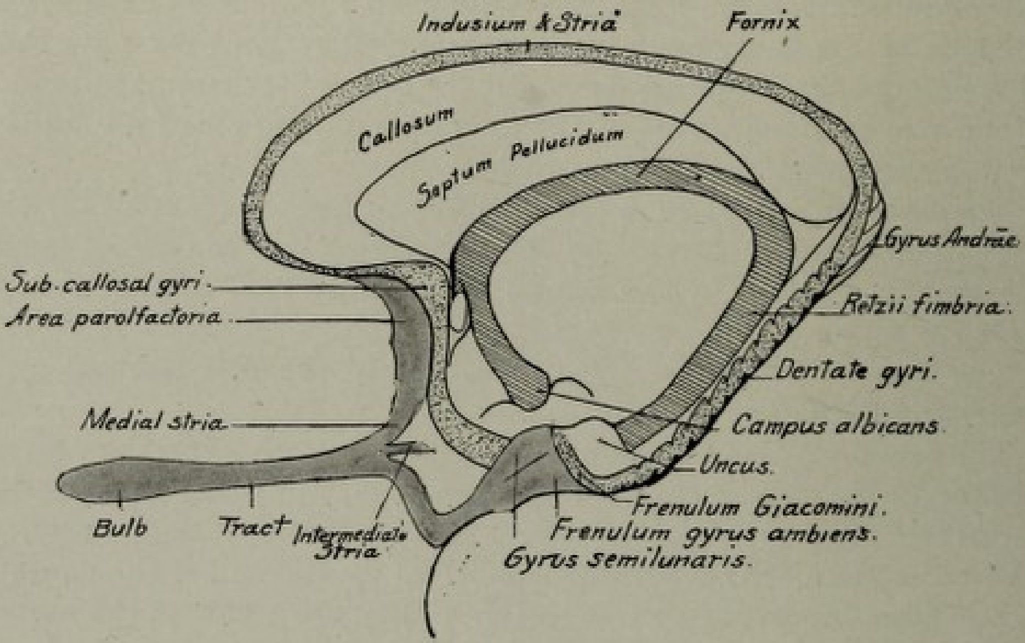


FIG. 311.—Schematic representation of the olfactory pathway.

(intercrural space) and near the midline. Their white color is due to the myelinated nerve fibers of the fornix that end here in the central gray nerve tissue. This gray tissue is usually arranged as two nuclear masses in each body.

The *anterior commissure* is seen in the frontal wall of the third ventricle, as it courses from side to side. It is usually a small bundle of nerve fibers of which the frontal portion belongs to the olfactory pathway. It connects the uncus of the two sides with each other in addition to containing the pathway fibers from the bulb.

The *septum pellucidum* consists of two layers enclosing a portion of the early intercerebral cleft, during the formation of the callosum. This space is the so-called fifth ventricle but is not a part of the true ventricular system of the brain. The septum is enclosed in the arch of the corpus callosum and extends from it to the fornix. Its frontal part contains some gray nerve tissue that is a part of the olfactory pathway. Occasionally an opening is seen in the septum permitting communication between the two lateral ventricles. Also, in two instances the writer has noticed that the septum extended all the way from the genu to the splenium and was twice as long as in the usual specimens.

The *fornix* is a paired structure consisting of longitudinally coursing fibers connecting the uncus and corpus albicans of each side. It consists of a *body* and a pair of *anterior* (frontal) and a pair of *posterior* (occipital) *pillars*. The *body* is that portion ventral of the body of the callosum where the two tracts lie side by side. Frontally, at the region of the anterior commissure, the two tracts diverge and course ventrally, as the *anterior pillars*, to end in the corpus albicans of each side. Occipitally, at the splenium of the callosum, these tracts diverge as the *posterior pillars* and pass first ventrally and then frontally in a hook-like manner to end in the uncus of each side. As the pillars pass ventrally they project into the inferior (temporal) horn of the lateral ventricle and lie upon the hippocampus, here constituting a band of fibers called the *fimbria;* this dwindles in size as the uncus is approached.

Impulses arising in the olfactory portion of the nasal mucosa pass to the olfactory bulb by way of the olfactory fila. This constitutes the peripheral tract (*first neuron*). From the bulb the impulses are conducted by another neuron system, by way of the olfactory tract, to the primary centers, *i.e.*, the gray substance of the tractus olfactorium, trigonum, anterior perforated substance and the gray substance of the septum lucidum. The impulses are then conducted to the cortical centers by a *third neuron*.

The *lateral olfactory stria* carries the impulses to the gyrus ambiens and gyrus semilunaris from the trigonum. The *intermediate stria* carries the impulses to the gray substance of the anterior perforated space; from the trigonum, the anterior perforated substance and the septum lucidum impulses pass to the hippocampus by way of the fornix.

The *medial olfactory stria* consists of fibers from the trigonum that pass toward the gyrus subcallosus and then over the corpus callosum through the dentate gyre to end in the hippocampus.

Other fibers pass from the anterior perforated substance and the septum pellucidum to the nucleus amygdala and the thalamus.

The *hippochampus* is connected with the corpus albicans of each side by the fornix fibers that arise from the cells of the hippocampus and the dentate gyre. As the fornix passes ventral to the corpus callosum it receives fibers from the medial longitudinal striæ, dorsal to the callosum, that pass to this body and constitute the *fibræ perforantes*. While most of the fornix fibers pass to the corpus albicans some pass to the *ganglion habenulæ* (a small nucleus between the epiphysis and the caudal end of the thalamus).

The *corpus albicans* of each side is further connected with the thalamus and the tegmentum of the crus cerebri, where there is a small ganglion, the *ganglion profundum tegmenti.*

THE CIRCULATION OF THE BRAIN

The **arteries** (Fig. 312) that supply the brain are the *two vertebral* (*arteriæ vertebrales*) and the *two internal carotid arteries* (*arteriæ carotides internæ*). The *latter* enter the cranial cavity through the

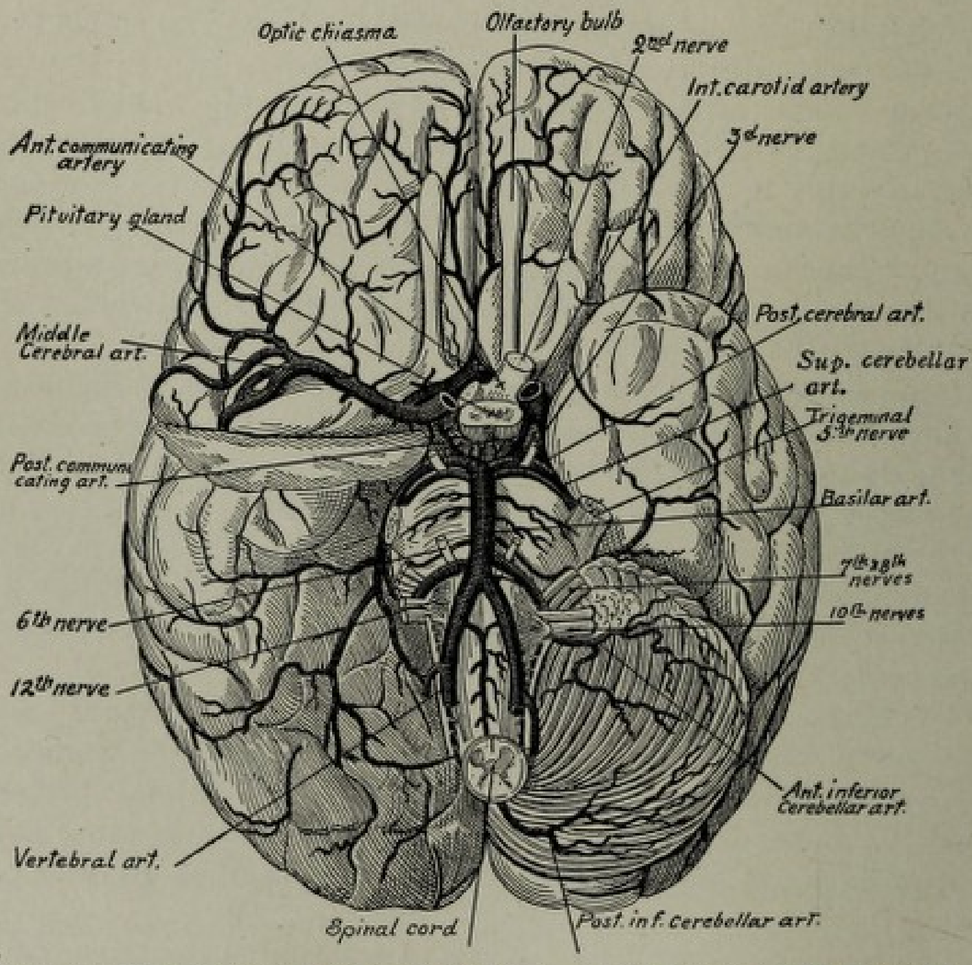


FIG. 312.—The arteries of the base of the brain. (*After Sobotta and McMurrich.*)

carotid canals while the *former* enter through the foramen magnum. The vertebral arteries join to form the *basilar artery* (*arteria basilaris*) the largest branches of which are the two posterior cerebral arteries (*arteriæ cerebri posteriores*). The internal carotid arteries give rise to a branch, the posterior communicating artery, that passes back and anastomoses with the posterior cerebral artery on each side. In front each internal carotid artery gives rise to an anterior cerebral artery (*arteria cerebri anterior*) which is connected to its fellow on the opposite side across the midline by the anterior communicating artery. Thus a so-called circle is formed at the base of the brain called the *circle of Willis* (*circulus arteriosis*).

The other branches of each vertebral artery are the following:

The posterior meningeal.

The ventral spinal, one on each side, which unite to form a single vessel that lies at the front of the ventral median fissure of the spinal cord.

The dorsal spinal artery, one descending upon each side behind the dorsal roots of the spinal nerves.

The posterior inferior cerebellar.

Bulbar.

The basilar artery gives the following branches:

Internal auditory.

Anterior inferior cerebellar.

Superior cerebellar.

Posterior cerebral.

The internal carotid gives rise to the following branches:

Posterior communicating.

Middle cerebral (in the sylvian fissure).

The anterior cerebral that winds over the callosum and lies in the longitudinal fissure.

The *central ganglionic masses* are supplied by branches of the circle of Willis, or trunks close to it.

Veins.—The blood is returned from the cerebrum by the *superficial* and the *deep cerebral veins* (*venæ cerebri*). The *superficial veins* receive the blood from the convolutions and deeper parts and empty into the sinuses. The *deep veins*, or *internal cerebral veins* (Galen) unite to form a short trunk, the *vena magna* Galeni, that ends in the straight sinus.

The *blood from the cerebellum* is returned by the *superficial* and *deep cerebellar veins* which return the blood to the transverse, superior and inferior petrosal and the occipital sinuses.

The *blood from the pons* is returned to the cerebellar veins, or the superior petrosal sinus.

From the *oblongata* the blood is returned to the inferior petrosal sinus, or the basilar plexus.

The *sinuses* in the dura that receive the blood from the brain are the following:

Single:

Superior sagittal sinus.

Inferior sagittal sinus.

Straight sinus.

Occipital sinus.

Circular sinus.

Basilar sinus.

Paired:

Lateral sinuses.

Sphenoparietal sinuses.
Superior petrosal sinuses.
Inferior petrosal.
Cavernous.

The *superior sagittal sinus* (*sinus sagittalis superior*) lies in the upper edge of the falx cerebri and extends from the foramen cecum, in front, to the torcular Herophili (*confluens sinuum*), behind.

The *inferior sagittal sinus* (*sinus sagittalis inferior*) lies in the lower edge of the falx cerebri and extends backward to the frontal edge of the tentorium cerebelli to end by joining the deep cerebral vein (Galen) to form the straight sinus.

The *straight sinus* (*sinus rectus*) extends along the upper surface of the tentorium cerebelli, from the end of the inferior sagittal sinus to the torcular Herophili.

The *occipital sinus*, the smallest, is formed from veins around the margin of the foramen magnum and terminates in the torcular Herophili.

The *circular sinus* (*anterior* and *posterior intercavernous sinuses*) is situated in the pituitary fossa and surrounds the pituitary body and is connected on each side with the cavernous sinus.

The *basilar sinus* (*plexus basilaris*) extends across the basilar portion of the occipital bone and connects the ends of the cavernous, or the ends of the superior petrosal sinuses to each other.

The *lateral sinuses* (*sinus transversi*) begin at the torcular and pass outward and then downward to the jugular foramen of the skull; here each ends in the internal jugular vein of that side. They are the largest sinuses and carry most of the blood out of the skull.

The *sphenoparietal sinuses* (*sinus sphenoparietales*) lie under the lesser wings of the sphenoid bone and each terminates in the anterior end of the corresponding cavernous sinus.

The *cavernous sinus* (*sinus cavernosi*) lie upon the side of the body of the sphenoid bone and extend from the sphenoidal fissure to the apex of the petrous portion of the temporal bone. These communicate with each other through the circular sinus and receive the blood from the sphenoparietal sinuses and send the blood into the superior and inferior petrosal sinuses.

The *superior petrosal sinuses* (*sinus petrosi superiores*) start at the same regions, pass downward and outward along the lower margin of the petrous portion of the temporal bone; each ends in the lateral sinus of that side.

The *inferior petrosal sinuses* (*sinus petrosi inferiores*) begin at the posterior end of the cavernous sinus of each side and pass downward, backward and laterally in the posterior fossa of the skull and empty into the internal jugular vein of that side.

The *veins of the spinal cord* form a plexus in the pia and from this plexus *six main longitudinal* and *radicular veins* are formed. The *longitudinal veins* are *one ventromedian, two ventrolateral, two dorsolateral* and *one dorsomedian.*

The *radicular veins* pass around the nerve roots to terminate in the ventral and dorsal spinal veins.

The *ventromedian* and *dorsomedian veins* empty into veins of the oblongata; the lateral veins empty partly into the preceding but chiefly into the two radicular veins that carry their blood to the ventral and dorsal spinal veins of the vertebral column.

The *intracranial lymphatics* are *meningeal* and *cerebral.* The *meningeal lymphatics* start in the spaces of the dura, follow the blood-vessels and empty into the internal maxillary and upper deep cervical lymph nodes.

The Peripheral Nerve System

The **peripheral nerve system** comprises the *cerebral* and *spinal nerves* and their associated *ganglia.*

THE CEREBRAL OR ENCEPHALIC NERVES

The term **cerebral nerves** is poorly chosen as the first two pairs, only, are connected with the cerebrum and these are not considered true nerves but outgrowths of the cerebral vesicles; the others are connected with the brain stem. The term **encephalic nerves** would be more satisfactory as the distinction from spinal nerves would be maintained and the origin from the brain, as a whole, would be expressed.

The **cerebral nerves** are *twelve pairs* in number and ten pairs are directly connected with the brain stem in which lie their nuclei of origin, or termination. These nerves vary, some are *purely motor*, others *purely sensor* (*special senses*) and others are *mixed.*

These nerves are classified as follows:

1. Olfactory. Pure sensor, special sense (smell).
2. Optic. Pure sensor, special sense (vision).
3. Oculomotor. Pure motor.
4. Trochlear. Pure motor.
5. Trigeminus. Mixed.
6. Abducens. Pure motor.
7. Facial. Mixed. Special sense (taste).
8. Auditory. Pure sensor, special sense (hearing).
9. Glossopharyngeal. Mixed. General and special sense (taste).
10. Vagus. Mixed.
11. Spinal accessory. Pure motor.
12. Hypoglossal. Pure motor.

For the sake of convenience these will be taken up in reverse order just as the brain was considered from the oblongata to the cerebrum.

Hypoglossal Nerve (*Nervus Hypoglossus*).—This is the motor nerve of the tongue and its nucleus lies in the lower, or caudal end of the gray substance of the fourth ventricle. This nucleus is about 18 mm. long and quite narrow; it extends from the upper level of the pyramidal decussation to the striæ acusticæ and close to the mid-line. It represents a continuation of the motor gray of the spinal cord. The upper end of the nucleus lies beneath the trigonum

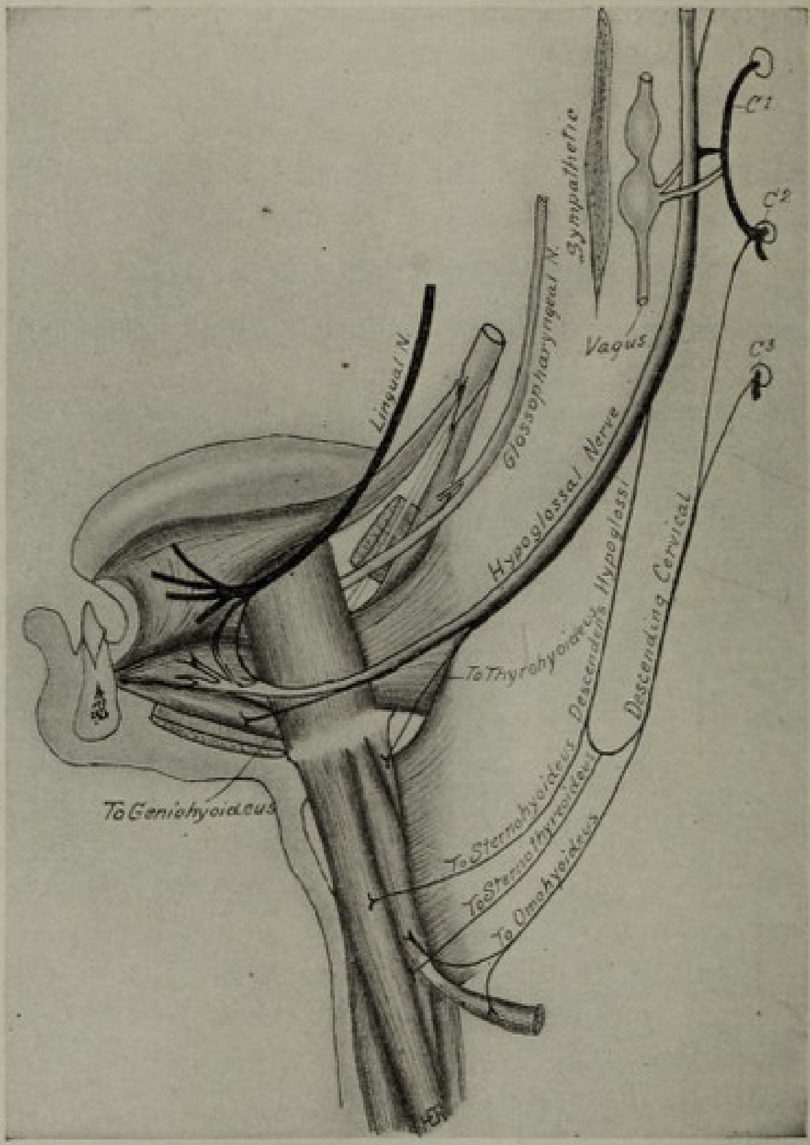


Fig. 313.—The hypoglossal nerve, its connections and distribution.

hypoglossi of the fourth ventricle. The two nuclei are connected across the midline by commissural fibers and fibers from the opposite pyramid end in each nucleus, completing thus the connection with the cerebral cortex. The nerve cells are large and their myelinated axis-cylinders pass ventrally through the formatio reticularis, between the olivary nucleus and the pyramid, to *emerge* (*superficial origin*) in the groove between these two structures on the ventral surface of the oblongata.

The **hypoglossal nerve** leaves the cranial cavity through the hypoglossal canal, enters the neck, passes downward, ventrally and medially to the tongue. It gives off the **recurrent, descending, thyreohyoid** and **lingual** branches.

The **recurrent branch** (*ramus recurrens*) is given off in the cranial cavity and supplies the dura of the posterior fossa. The **descending branch** (*ramus descendens*) forms the *hypoglossal loop* with a branch from the second and third cervical nerves and supplies the mm. omohyoideus, sternohyoideus and sternothyreoideus. The **thyreoid branch** (*ramus thyreoideus*) supplies the m. thyreohyoideus. The **lingual branches** (*rami linguales*) supply the mm. hyoglossus, genioglossus, geniohyoideus and the intrinsic muscles of the tongue.

The hypoglossal nerve *communicates* with the superior cervical ganglion (sympathetic), the ganglion nodosum of the vagal nerve, the upper cervical nerves, the pharyngeal plexus and the lingual branch of the mandibular nerve (trigeminal).

The **Spinal Accessory Nerve** (*Nervus Accessorius*).—This is a pure motor nerve consisting of a *spinal division* (representing a spinal nerve) and an *accessory portion* arising from the oblongata (*bulbar part*). The spinal part arises from the dorsolateral nerve cells in the ventral horn of the first four cervical segments of the spinal cord. These myelinated axones pass ultimately to the surface of the spinal cord, emerge at the lateral column and pass up through the foramen magnum to join the bulbar portion. The *accessory*, or *bulbar root*, arises from nerve cells in the ventricular gray at the upper (cephalic) end of the spinal nucleus and is practically a continuation of the lower, or caudal end of the nucleus ambiguus of the vagal and glossopharyngeal nerves. It is lateral to the lower end of the hypoglossal nucleus and is called the *nidus laryngei*, because its fibers later join the vagus and though this nerve pass to the intrinsic muscles of the larynx, except the cricothyreoid muscle. The spinal root supplies the trapezius and sternomastoid muscles.

Fibers from the opposite pyramids end in each nucleus (cortical connections) as do also fibers from the dorsal (sensor) roots of the spinal nerves (establishing a reflex arc).

The *superficial origin* of the **bulbar portion of the accessory nerve** is the side of the oblongata, at the head end of the restiform body. The **spinal portion** *arises* from the side of the spinal cord as low as the sixth cervical nerves. These two portions join and leave the cranial cavity through the jugular foramen. The **bulbar root** sends a branch to the ganglion nodosum of the vagal nerve and the remainder joins the vagal nerve and ultimately supplies the intrinsic muscles of the larynx (except the m. cricothyreoideus), and furnishes cardioinhibitory nerves to the vagus. The *spinal portion* (*ramus externus*) passes into the neck and supplies the mm. sternomastoideus and trapezius.

The spinal portion communicates with the cervical plexus.

Vagal and Glossopharyngeal Nerves (*Nervus Vagus et Nervus Glossopharyngeus*).—These nerves, though *mixed*, are mainly sensor and as their nuclei of origin and termination are so close together and so intimately associated they will be considered together. It is

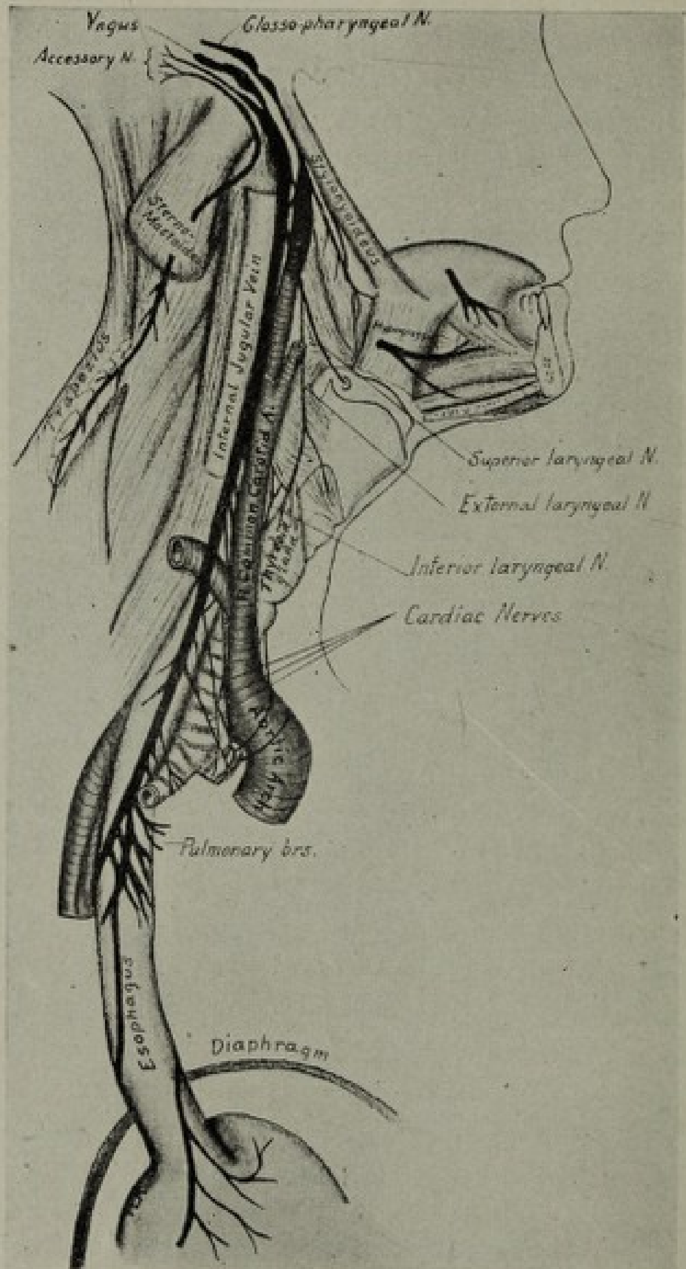


FIG. 314.—Course and distribution of the glossopharyngeal, vagal and accessory nerves.

highly probable that the glossopharyngeal nerve is purely sensor. The nuclei are the dorsal (mixed) nucleus, *nucleus ambiguus* and *nucleus of the fasciculus solitarius*.

The *dorsal* (*mixed*) *nucleus*, long and rod-shaped, lies at the upper end of the hypoglossal nucleus and the motor part comprises that portion nearest the midline. The axones of the cells in this portion pass obliquely ventrolateral between the olivary nucleus and the restiform body, emerging from the oblongata between the olive and the end of the lateral column. The fibers belong to the vagus and pass to the esophagus, stomach, trachea and bronchi. This is a *nucleus of origin* and the sensor part will be discussed later.

The *nucleus ambiguus* is deeply placed in the formatio reticularis and the substantia gelatinosa; it seems to be a continuation of the bulbar part of the accessory nerve. The axones pass first dorsally, then bend ventrally and join the preceding, supplying the esophagus,

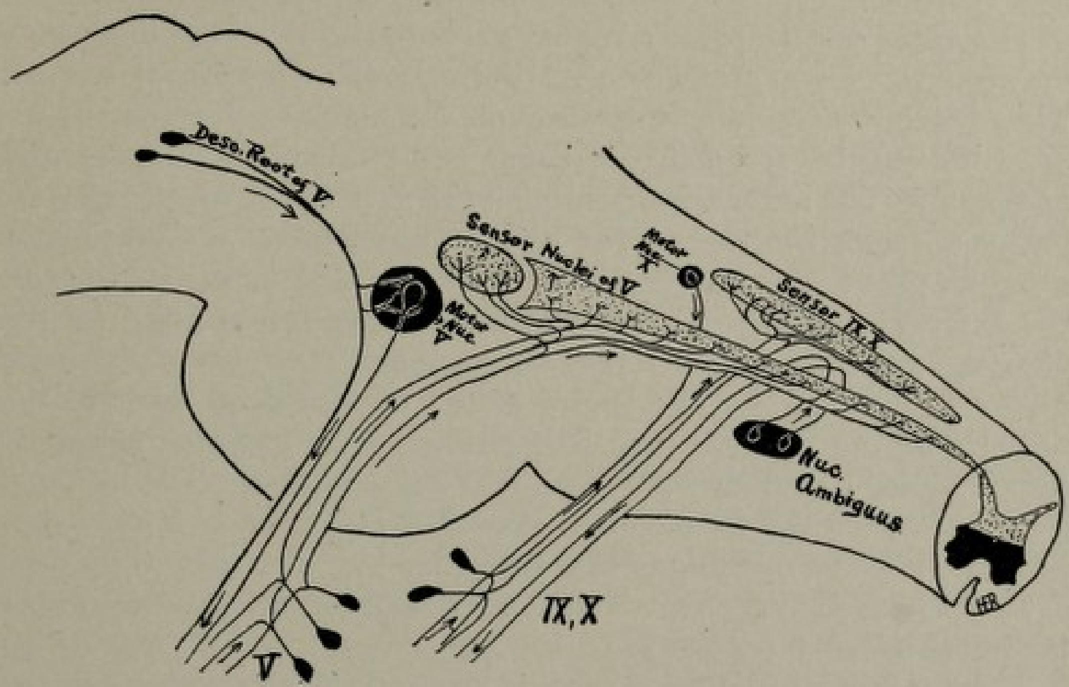


FIG. 315.—Diagram of the course of the trigeminal, glossopharyngeal and vagal nerves in the brain stem. Motor nuclei solid black, sensor nuclei dotted.

pharynx and the m. cricothyreoideus of the larynx. Apparently a portion of this nucleus is *cardio-inhibitory*. This is also a *nucleus of origin*.

The *sensor fibers* arise from cells in the ganglia. Connected with the vagus are the *jugular ganglion* (*ganglion jugulare*) and the *ganglion nodosum*. Connected with the glossopharyngeus are the *ganglion superior* and the *ganglion petrosum*. These ganglia are comparable to the ganglia connected with the dorsal (sensor) roots of the spinal nerves. The axones of the cells in these ganglia enter the oblongata, branch into ascending and descending fibers that terminate in the nucleus *ala cinerea* and the *nucleus of the tractus solitarius*, or *trineural fasciculus*, respectively. These are the *nuclei of termination*.

The *nucleus ala cinerea* is the *sensor part* of the previously mentioned dorsal nucleus and it receives ascending branches, abovementioned; these are chiefly vagal so that the bulk of this nucleus belongs to the vagus.

The *nucleus* and *tractus solitarius* form a spindle-shaped column in the dorsal area of the oblongata between the descending root of the trigeminal nerve and the fibers are mainly of the glossopharyngeal nerve. Only a few vagal fibers enter this nucleus and there are reasons to believe that all of the glossopharyngeal fibers terminate here. This nucleus and tract extend from the upper limit of oblongata into the spinal cord as far as the fourth cervical segment. From the cells of all of these sensor nuclei axones pass to the opposite side of the oblongata, join the lemniscus and pass to the thalamus and ultimately establish a connection with the cerebral cortex.

The **vagal** and **glossopharyngeal nerves** arise from the oblongata between the olivary and the restiform bodies (*superficial origin*). They leave the cranial cavity through the jugular foramen.

In the jugular foramen the vagus has **two ganglia, jugular and nodosum.** The nerve passes through the neck in the carotid sheath, passes through the thorax and enters the abdomen. The **jugular ganglion** gives off branches to the meninges and to the auricle and the external auditory canal. The **ganglion nodosum** gives off the **pharyngeal** and **superior laryngeal nerves.** The *pharyngeal nerve assists* in forming the *pharyngeal plexus* that supplies most of the muscles of the pharynx and soft palate. The **superior laryngeal nerve** divides into *external* and *internal branches.* The *external branch* supplies the m. cricothyreoideus. The *internal branch* supplies the mucous membrane of the larynx.

In the *neck* the vagus gives off the **cardiac branches,** and **recurrent laryngeal nerves.**

The **superior** and **inferior cardiac nerves** *of the right side* join the *deep cardiac plexus* of the thorax. The **left superior cardiac nerve** joins the *deep cardiac plexus* while the **left inferior cardiac nerve** joins the *superficial cardiac plexus.* The **recurrent laryngeal nerve** gives off muscular branches to the trachea and esophagus and then ends in the larynx to supply all of the muscles except the m. cricothyreoideus. *This is the bulbar portion of the accessory nerve.*

In the thorax the vagus assist in forming the **cardiac, pulmonary and coronary plexuses.** These are described on page 470.

In the abdomen the vagi give branches to the stomach and to the celiac, splenic, renal and hepatic plexuses.

The **glossopharyngeal nerve** *arises* just behind the vagus. As it passes through the jugular foramen it exhibits two ganglia, the **superior** and **petrous ganglia.** The **superior** gives off no branches. The **petrous ganglion** gives off the **tympanic branch** that assists in forming the *tympanic plexus* that supplies the mucosa of the tympanum, mastoid cells and auditory tube. It also forms a part of the *superficial petrosal nerve.*

In the *neck* the glossopharyngeal nerve gives a branch to the m.

stylopharyngeus and branches that pass to the mucosa of the pharynx directly and others indirectly (through the pharyngeal plexus). *Terminal branches* pass to the tonsil and mucosa of the dorsal one-third of the tongue.

Auditory Nerve (*Nervus Acusticus*).—This nerve comprises really *two distinct nerves* called *cochlear* and *vestibular divisions* of the auditory nerve; these are both connected with special sense, the former *hearing*, and the latter, the sense of *equilibrium*, if this term might be used. As in the case with all of the real cerebral sensor nerves there is a ganglion connected with each division comparable to the ganglion on the sensor divisions of the spinal nerves. The fibers of the *cochlear division*, the real nerve of hearing, arise from the bipolar cells of the *ganglion spirale* located in the internal ear. These myelinated axones pass into the ventral surface of the brain stem, in connection with the vestibular division, at the lower (caudal) border of the pons at its junction with the brachium pontis. After a short course the fibers terminate in the ventral and dorsal cochlear nuclei. These nuclei lie upon the lateral and ventral aspect of the restiform body, respectively.

The fibers arising from the cells of the ventral cochlear nucleus pass transversely through the ventral part of the tegmentum, just dorsal to the pons fibers, and form here the *trapezium;* here fibers are added from the superior olive of both sides and from the cells of the trapezial nuclei. All of these fibers cross the midline and form the *lateral lemniscus* that ends in the inferior quadrigeminal and medial geniculate bodies. From these structures new fibers continue to the auditory center in the cortex of the temporal lobe.

In the *lateral lemniscus* are cells constituting the *nucleus of the lateral lemniscus* (a way-station in the auditory pathway). Here some of the lemniscal fibers may end and then new ones replace them.

The fibers from the *dorsal*, or *lateral cochlear nucleus* have a different course. They pass over the restiform body to the floor of the fourth ventricle, where most of them continue superficially as the *striæ acusticæ*, to the median sulcus, cross the midline, pass ventrally in an oblique manner and join the lateral lemniscus of the opposite side. Some of the fibers pass to the lemniscal nucleus of the same side from which new fibers join the trapezium and pass to the lemniscus of the opposite side. All of the fibers terminate as those of the ventral nucleus do.

The fibers of the *vestibular division* arise from the bipolar cells of the *ganglion vestibulare* that lies in the internal auditory meatus. They enter the brain stem with the cochlear division. Some of the fibers ascending end in the *medial vestibular nucleus;* others descending end in the *spinal vestibular nucleus;* still others terminate within the *lateral vestibular nucleus* (*Deiter's*) and the remainder pass to the *superior nucleus of Bechterew.* From these nuclei fibers pass in various directions to the dentate nucleus and nucleus fastigii of the

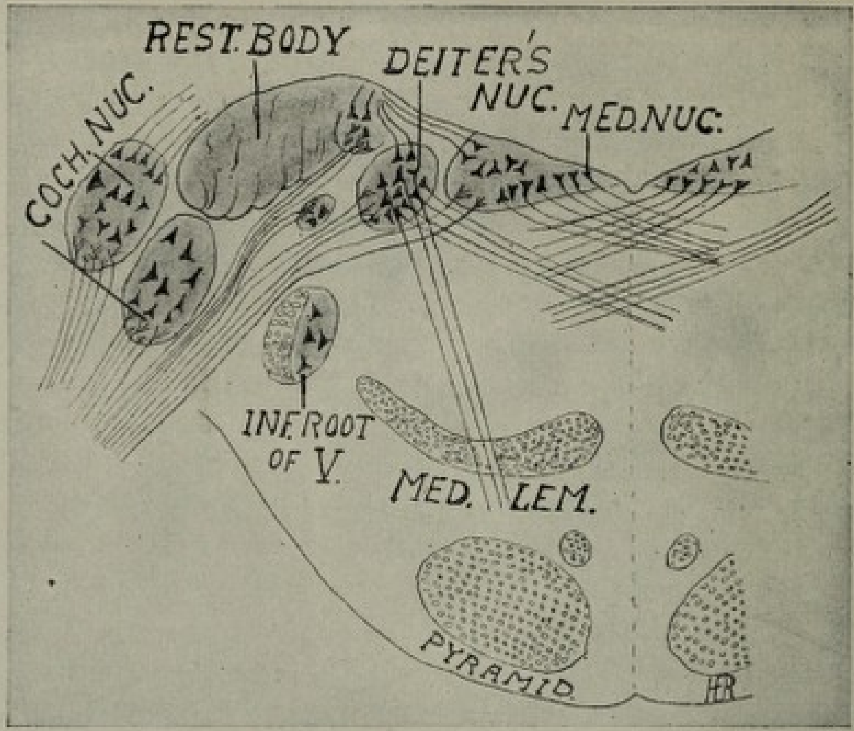


FIG. 316.—Diagram of the nuclei of termination of the vestibular nerve, and their higher connections.

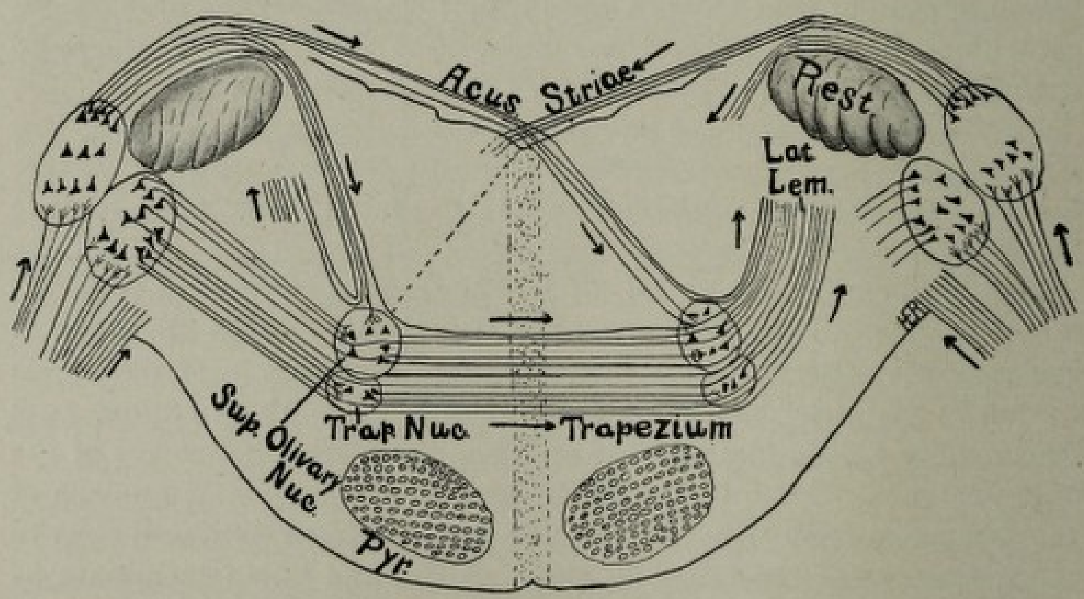


FIG. 317.—Diagram of the cochlear nuclei of termination and their higher connections.

cerebellum, to the nuclei of the oculomotor, trochlear, trigeminus and abducens nerve, to the temporal lobe of the cerebral cortex, to the thalamus and to the ventral horns of the spinal cord (cervical portion).

The *lateral lemniscus* contains all of the auditory fibers but they reach this tract by different routes as shown above.

The auditory nerve is attached to the brain at the inferolateral margin of the pons lateral to the facial nerve. It consists of *vestibular* and *cochlear roots*. It passes into the internal acoustic meatus. The *vestibular root*, or *nerve* communicates with the nervus intermedius and the geniculate ganglion of the facial nerve and sends its *three branches* to the utriculus and ampullæ of the superior and lateral semicircular canals. The *cochlear root*, or *nerve* sends branches to ampulla of the posterior semicircular canal, to the sacculus and the cochlea. The vestibular nerve has the *vestibular ganglion* and the cochlear nerve the *spiral*, or *cochlear ganglion*.

The Facial Nerve (*Nervus Facialis*).—The facial nerve consists of *two distinct nerves*, the *facial proper* (*motor*) and the *nervus intermedius* (*sensor*).

The *nucleus of origin* of the motor portion is deeply placed and lies in the ventral part of the tegmental part of the pons well to the side of the midline. It is just above (cephalad of) the boundary between the oblongata and pons. The axones of these cells have a decidedly peculiar course. They pass first dorsally almost to the ventricular surface, then arch over the nucleus of the abducens nerve (toward the midline), then pass ventrally and emerge from the brain stem at the lower border of the pons at the medial side of the auditory nerve.

The **fibers of the nervus intermedius** are both motor and sensor fibers; the *sensor* portion arises from the unipolar cells of the *geniculate ganglion* in the facial canal. The dendrites, that pass peripherally, constitute the *chorda tympani nerve* (*taste*) and the central fibers (axones) constitute the *intermediate nerve*. They enter the brain stem between the facial and auditory nerves and terminate in the upper end of the *nucleus of the fasciculus solitarius* (*glossopharyngeus*). The *motor* fibers are said to arise from the cells in a nucleus near the midline and beneath the ventricular gray substance (*nucleus salivatorius*). This is said to extend from the level of the facial nerve to the level of the lower end of the motor nucleus of the trigeminal nerve. These represent *excitoglandular fibers*.

The **facial nerve** *arises* from the brain at the inferolateral margin of the pons just medial to the auditory nerve. It passes into the internal acoustic meatus with the acoustic nerve, then through the facial canal of the petrous portion of the temporal bone and appears upon the base of the skull through the stylomastoid foramen. It then passes through the parotid gland (branching here) to supply the muscles of the face. The **geniculate ganglion** is situated upon the facial nerve in the facial canal and gives off the *greater superficial petrosal*, *deep petrosal* and *external superficial petrosal nerves;* the *deep nerve* passes to the sphenopalatine ganglion.

In the *facial canal* the nerve gives off a *branch* to the m. stapedius and the **chorda tympani nerve.** The *latter* passes through the tympanic cavity and petrotympanic fissure to join the lingual branch of the mandibular nerve.

In the *neck* the facial nerve gives *branches* to the mm. stylohyoideus and digastricus (posterior belly), auricularis posterior and occipitalis and the intrinsic muscles of the auricle.

In the *parotid gland* the facial nerve forms the *parotid plexus* constituting *cervicofacial* and *temporofacial divisions*. The **cervicofacial**

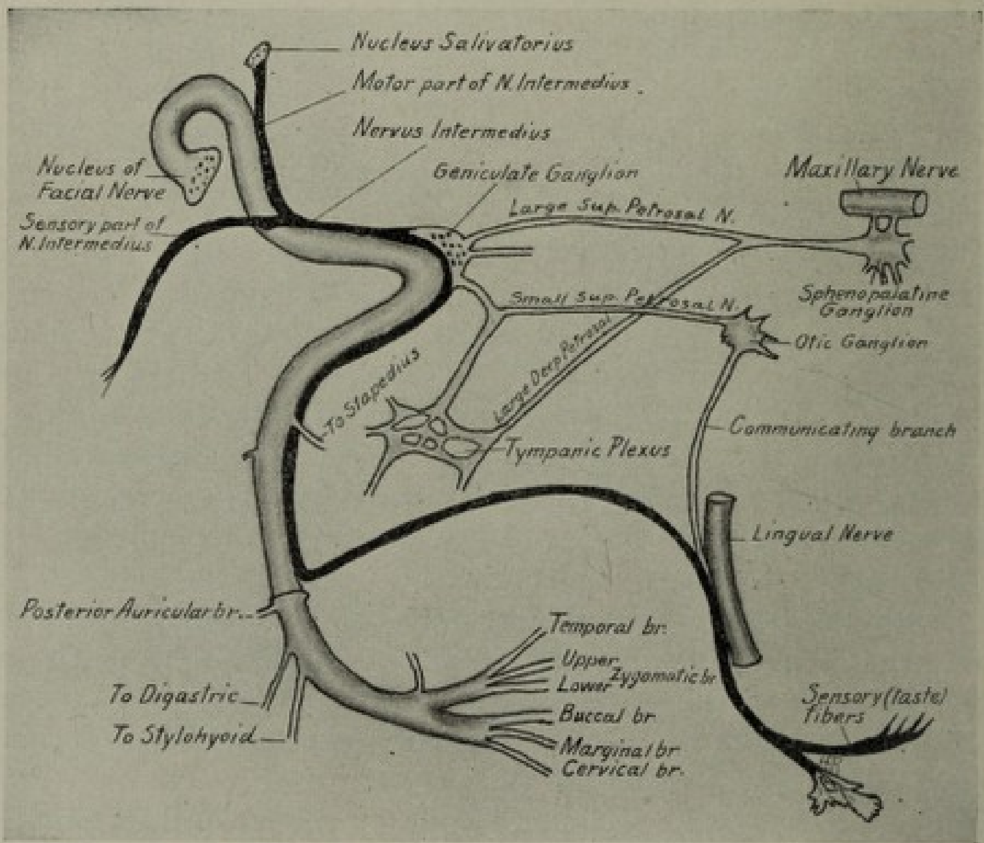


FIG. 318.—Diagram of the facial and intermediate nerves and their connections.

division gives off the following branches: *Buccal branches* to the m. buccinator and muscles at the angle of the mouth; the *marginal*, or *supramandibular, branch* of the mandible that supplies the mm. orbicularis oris and the quadratus labii inferioris. The *cervical*, or *inframandibular, branch* supplies the m. platysma.

The **temporofacial division** gives off the *temporal branches* that supply the mm. orbicularis oculi, corrugator supercilii, frontalis and auricularis anterior and posterior. The *zygomatic branches* supply the mm. orbicularis oculi and zygomaticus.

The Abducens Nerve (*Nervus Abducens*).—This is a small *motor* nerve the fibers of which arise from the cells of the nucleus located under the dorsal part of the tegmental portion of the pons near the midline. The axones pass ventrally and laterally and emerge from the brain stem along the lower border of the pons near the midline (superficial origin).

The **abducent nerve** passes through the middle fossa along the carotid artery and enters the orbital fossa through the superior orbital fissure to supply the m. rectus lateralis.

The Trigeminal Nerve (*Nervus Trigeminus*).—This represents a *mixed* nerve and is the largest of the cerebral nerves. Its nuclei of origin and termination are the most widely distributed and longest of all the nerves, extending from the midbrain through the pars dorsalis pontis and the oblongata into the spinal cord.

The *nucleus of origin of the motor portion* consists of *two parts*, *a principal nucleus* that lies close to the sensor nucleus, though dorsal thereto, near the lateral aspect of the pars dorsalis pontis. The *mesencephalic nucleus* starts just a little above (cephalad of) the preceding and extends throughout the midbrain and is seen at the extreme lateral limit of the gray substance of the aqueduct. Where it starts it is quite large but the midbrain portion gradually tapers. The fibers arising from these two nuclei pass ventrally and emerge from the brain stem at the junction of the pons and brachium pontis of each side serving, thus, as an arbitrary boundary between these two structures. The greater part of the motor root consists of the axones of the principal nucleus. The two nuclei are connected to each other by collateral fibers. These nuclei receive fibers from the motor area of the cerebral cortex through the opposite pyramid.

The *sensor portion* consists of the axones of the cells in the *semilunar ganglion* (*ganglion semilunare*) located upon the apex of the petrous portion of the temporal bone. It is larger than the motor root and enters the brain stem where the motor root emerges. In the brain stem the fibers bifurcate, one branch ascending and ending in the *main sensor nucleus* that lies near the surface of the tegmental part of the pons, ventral to the brachium conjunctivum. This nucleus, like the corresponding motor nucleus, extends into the midbrain, tapering as it ascends. The descending branches form a large tract called the *descending root of the trigeminal nerve.* The tract lies just lateral to the substantia gelatinosa; at intervals the fibers end around the cells of the substantia gelatinosa and they represent the nucleus of termination of the descending root. This descending root decreases in size as it approaches the spinal cord and ends at the level of the first or second cervical nerve. From these *terminal nuclei* fibers (arcuata) pass through the raphé to the opposite side and proceed upward to the thalamus where new fibers arise and pass to the sensor area of the cerebral cortex. Some fibers pass from the sensor to the motor nucleus thus establishing a simple reflex arc.

The **trigeminal nerve** is attached to the brain at the middle of the lateral border of the pons. It consists of *two roots*, the *larger, sensor* and the *smaller, motor.* As these two roots pass forward and reach the apex of the petrous portion of the temporal bone the sensor root exhibits an enlargement, the **semilunar,** or **Gasserian ganglion.** From this ganglion *three roots*, or *nerves*, are seen to arise, the *ophthalmic, maxillary* and *mandibular nerves.* The motor root is hidden by the ganglion and it joins the mandibular nerve.

The **ophthalmic nerve** passes through the middle fossa to enter the orbital fossa through the superior orbital fissure It gives rise

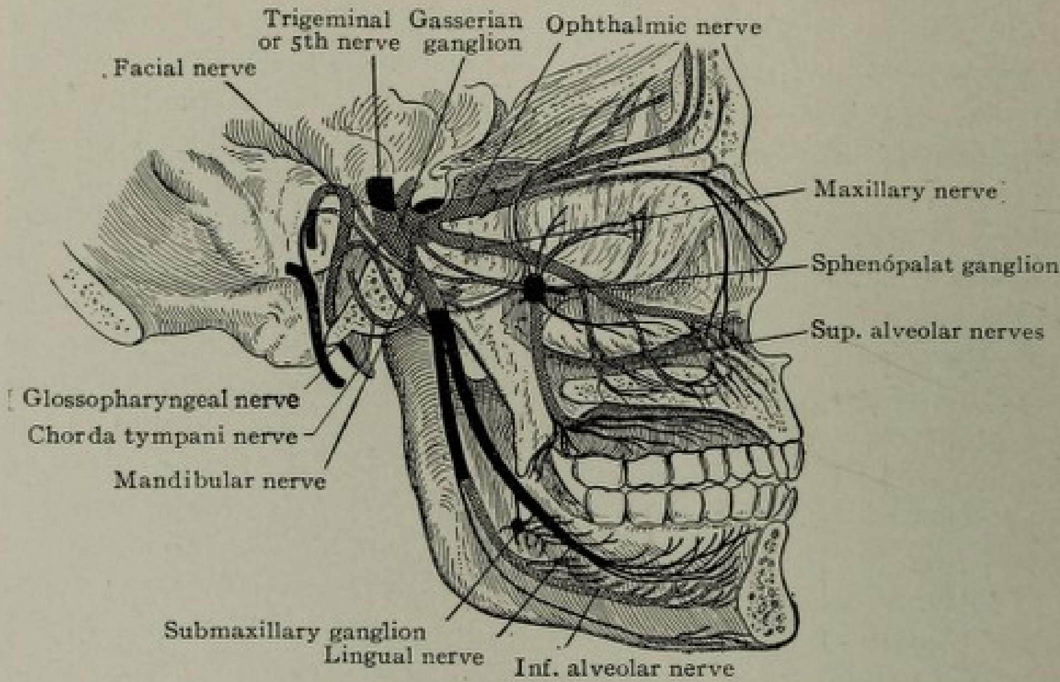


FIG. 319.—The trigeminal nerve and its communications with the facial and glossopharyngeal nerves. (*After Sobotta and McMurrich.*) The exposed nerves are black, the concealed ones shaded.

to *three main branches.* The *lacrimal nerve* gives branches to the lacrimal gland, the conjunctiva and skin at the lateral commissure of the eyelids. The *frontal nerve*, through its *supratrochlear* branch, supplies the skin of the root of the nose, the medial commissure of the eyelids and the medial part of the forehead. Through its larger *supraorbital branch* it supplies the frontal sinus, the skin of the upper eyelid and of the forehead and scalp to the vertex. The *nasociliary nerve*, in the *orbit*, gives a branch to the ciliary ganglion, gives off the *infratrochlear nerve*, that supplies the skin of the root of the nose and the eyelids. In the *nose* it gives off the *lateral* and *medial nasal branches* that supply the mucosa of the lateral wall and septum of the nose. On the *face* the *external nasal branch* supplies the skin of the lower half of the tip of the nose.

The **ciliary ganglion,** connected with this division of the trigeminal nerve, is a small reddish ganglion in the orbit. It has *three roots;*

the *long*, or *sensory root*, is derived from the nasociliary nerve; the *short*, or *motor root* is derived from the oculomotor nerve; the *sympathetic root* is derived from the cavernous plexus of the sympathetic system upon the internal carotid artery. This ganglion gives rise to about *fifteen short ciliary nerves* that supply the coats of the eyeball and the muscles of the ciliary body and iris.

The **maxillary nerve**, the largest division, leaves the middle fossa of the skull through the foramen rotundum, passes through the pterygopalatine fossa where it gives off a number of branches. The remainder of the nerve enters the orbit as the **infraorbital nerve,** passes through the infraorbital canal (giving off branches) and appears upon the face through the infraorbital foramen.

In the *pterygopalatine fossa* it gives off the following branches: *Two branches* to the sphenopalatine ganglion; *posterior superior alveolar nerves*, for the molar teeth and the neighboring parts of the gum. The *zygomatic*, or *orbital branch*, that divides into *zygomaticotemporal* or *temporal nerve* (for the skin of the temple) and the *zygomaticofacial*, or *malar nerve* (for the skin over the zygomatic bone).

In the *infraorbital canal* the **infraorbital nerve** gives off the *middle* and *anterior superior alveolar nerves* that supply the premolar, canine and incisor teeth, the gum and the mucosa of the maxillary sinus.

Upon the *face* the infraorbital nerve gives off the *inferior palpebral branches*, for the lower eyelid; the *external nasal*, for the skin of the side of the nose; the *superior labial*, for cheek and upper lip.

The **sphenopalatine ganglion** is connected with this division of the trigeminal nerve, in the pterygopalatine fossa, by the *two sphenopalatine* (*sensor*) *roots*. The *motor root* comes from the geniculate ganglion of the facial nerve (through the greater superficial petrosal nerve) and the *sympathetic root* comes from the cavernous plexus (through the deep petrosal nerve). These last two named nerves form the *nerve of the pterygoid canal*. This ganglion gives off the following branches: *Pharyngeal branches*, to the mucosa of the roof of the pharynx. The *anterior palatine nerves*, for the mucous membrane of the mucosa of the soft and hard palate and a part of the lateral wall of the nasal fossa. The *middle palatine nerve*, for the mucosa of the uvula, soft palate and palatal tonsil. The *posterior palatine nerve* supplies the mucosa of the same region. The *posterior superior nasal nerve*, for that portion of the lateral wall of the nasal fossa. The *nasopalatine nerve*, for the mucous membrane of the roof and nasal septum and the hard palate. *Orbital branches*, to the periosteum of the orbit.

The **mandibular nerve** contains all of the motor fibers and some sensor fibers. These two parts are separate and leave the middle fossa of the skull through the foramen ovale, enter the infratemporal fossa, fuse and divide into *anterior* and *posterior divisions*.

The branches of the *undivided nerve* are the *spinous*, or *recurrent nerve*, that supplies the dura and a branch to the m. pterygoideus internus.

The **masticator nerve,** or **anterior branch,** gives off a branch to the m. pterygoideus externus; *one*, to the m. masseter; two, to the m. temporalis; a *buccinator branch* (*sensor*) that supplies the skin and mucosa of the cheek.

The **larger posterior branch** gives off the following branches: The *auriculotemporal nerve* (by two roots) that supplies the skin and scalp of the temporal region, the mandibular articulation, the parotid gland, the skin of the external auditory canal and the tympanic membrane.

The **lingual nerve** is one of the terminal branches of the mandibular nerve. It supplies the mucosa of the apical two-thirds of the tongue, the floor and lateral walls of the mouth and sends a branch to the submaxillary ganglion. It is joined by the chorda tympani and branches from the hypoglossal nerve.

The **inferior alveolar,** or **dental nerve,** is the larger terminal branch of the mandibular nerve. This gives off the *mylohyoid nerve*, for the muscle of the same name and the anterior belly of the digastricus. It then enters the mandibular canal, through the mandibular foramen. Here it gives off *branches* to *the molar and premolar teeth* and the *mental nerve* and then terminates in *branches for the canine and incisor teeth.* The *mental nerve* leaves the mandibular canal through the mental foramen and supplies the chin and lower lip.

The **submaxillary ganglion** is connected with the lingual nerve. Its *motor root* is derived from the chorda tympani; its *sensor root* is derived from the lingual nerve; its *sympathetic root* is derived from the sympathetic plexus of the external maxillary artery. Its *branches* are distributed to the submaxillary gland and duct.

The **otic ganglion** is situated near the mandibular nerve as it emerges from the foramen ovale. Its *motor root* is derived from the nerve to the m. pterygoideus internus; its *sensor root* is derived from the tympanic plexus (through the smaller superficial petrosal nerve); the *sympathetic root* is derived from the sympathetic plexus upon the middle meningeal artery. It sends *branches* to the nerve of the pterygoid canal, the chorda tympani and roots of the auriculotemporal nerves; its *two motor branches* supply the mm. tensor veli palatini and tensor tympani.

The Trochlear Nerve (*Nervus Trochlearis*).—This is a *pure motor nerve* that has its nucleus of origin in the midbrain. This nucleus is small and oval and lies in the gray substance of the floor of the aqueduct beneath the inferior quadrigeminal body of each side. It rests upon the median longitudinal fasciculus and lies close to the midline. The axones arising from these cells pass downward (caudally) and laterally along the edge of the aqueduct gray which they follow to the midline; here the nerves decussate at the upper edge of the superior medullary velum and emerge at the medial border of the brachia conjunctiva. They are the smallest of the cerebral nerves. These nuclei receive fibers from the motor area of the opposite cerebral cortex through the pyramid. Fibers of the median longitudinal fasciculus also end here.

The *trochlear nerve arises* from the midbrain just behind the corpora quadrigemina. It passes to the ventral surface of the brain stem and through the middle fossa of the skull to enter the orbital fossa through the superior orbital fissure. It supplies the m. obliquus superior.

The Oculomotor Nerve (*Nervus Oculomotorius*).—This is also a *pure motor nerve* and its nucleus of origin is also in the midbrain.

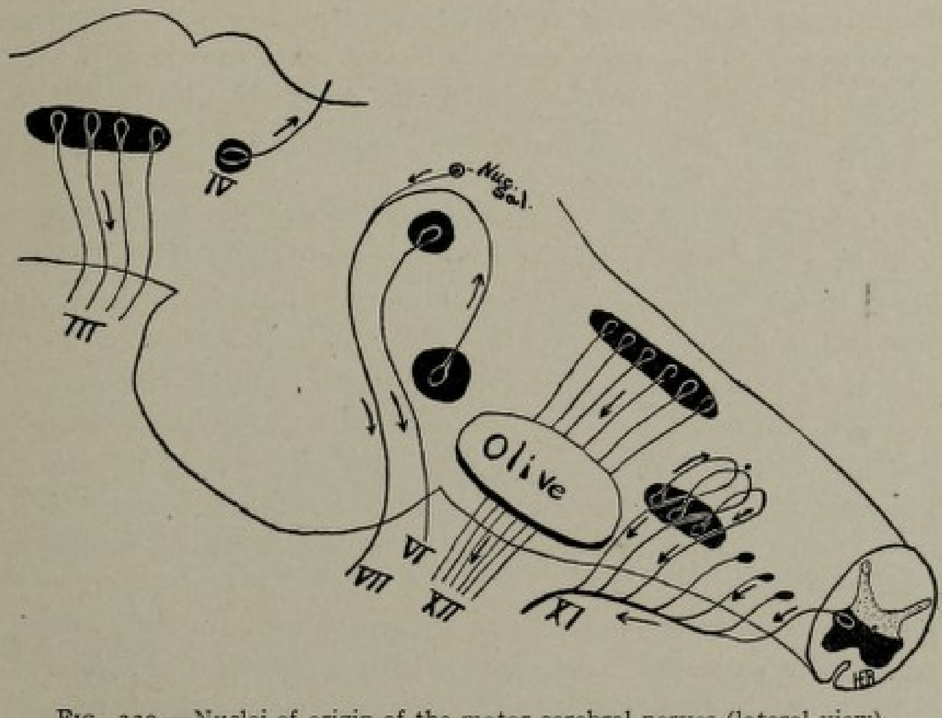


FIG. 320.—Nuclei of origin of the motor cerebral nerves (lateral view).

The nucleus is quite large, 5 to 6 mm. long and lies in the floor of the aqueduct gray substance under the superior quadrigeminal bodies just ahead of the preceding nucleus; it rests upon the median longitudinal fasciculus. The cells do not form a single mass but are arranged into a number of fairly distinct groups (at least seven) in each nucleus and a common small nucleus in the midline, the *central nucleus*. Most of the fibers of each nerve arise from the nucleus of the same side and pass ventrally in bundles; when the red nucleus is reached they spread out and pass through it, to be gathered into compact bundles at its ventral limit. These bundles are then collected into a single mass that emerges upon the medial aspect of each cerebral peduncle (intercrural space) in the oculomotor sulcus (the groove between the crusta and tegmentum of the crus).

The *fibers from the central nucleus*, and possibly other nuclei, *decussate* immediately and join the opposite nerve. These fibers are probably those that innervate the medial rectus muscle.

The oculomotor nucleus is connected to the occipital cortex (visual area) through the optic radiation; with other cerebral nerves through the median longitudinal fasciculus; with the motor area of the cerebral cortex through the pyramid; with the visual apparatus through fibers from the superior quadrigeminal body.

The **oculomotor nerve** emerges from the ventral surface of the midbrain in the oculomotor sulcus and passes forward to enter the orbital fossa through the superior orbital fissure. It supplies the mm. recti superior, inferior, medialis, the levator palpebræ and obliquus inferior; it also sends a branch to the ciliary ganglion.

The Optic Nerve (*Nervus Opticus*).—As previously mentioned this is not considered as a true cerebral nerve and is best considered as the *optic tract.* This tract comprises the *optic nerves* and the *optic chiasm* as the *peripheral parts* and the *pulvinar* (of thalamus) the *lateral geniculate body*, the *superior quadrigeminal body* and the *occipital cortex* as the *central parts.*

The **optic nerve** arises in the retina of the eyeball. The fibers proceed in a peculiar manner. Upon reaching the ventral part of the brain in the region of the thalamus, the fibers from the nasal side of each retina (about two-thirds) cross the midline, *decussate*, forming the *optic chiasm* and those parts usually called the *optic tracts.* In addition the caudal side of the chiasm contains added fibers the *commissure of Gudden*, a group of fibers that connect one medial geniculate body with the other; so far as is known these fibers have no part in the visual pathway but form the *so-called medial root* of the optic tract.

The *optic tract* after leaving the chiasm bends dorsally around the crus cerebri of each side and divides into a *medial* and a *lateral root.* The *medial root* ends in the *medial geniculate body* and represents, the *commissure of Gudden* above mentioned. The *lateral root* is the *real continuation of the visual portion of the chiasm* and ends in the lower, or primary optic centers, *i.e.*, the lateral geniculate body, the pulvinar and the superior quadrigeminal body of that side. The first named receives the most of the fibers and the last the least, as it is concerned only with muscle reflexes and not with light, or color perception. From its cells fibers join the optic nerve and *end in the retina.*

The *lateral geniculate body* and *pulvinar* of the thalamus are important subcenters for vision. From these centers new fibers arise and pass in a compact bundle toward the occipital cortex (*cuneus*) where they end around the occipital cells. In addition, fibers pass from these occipital cells and end in the superior quadrigeminal body and pulvinar of the same side. All of these fibers and the caudal part of the internal capsule constitute the *optic radiation.*

The *superior quadrigeminal body* is connected with the nuclei of the motor nerves of the eyeball by means of fibers that arise from its cells and enter the median longitudinal fasciculus. This body is also connected with the oblongata and the spinal cord through the medial lemniscus.

From the optic chiasm the optic nerve may be followed through the optic foramen to the dorsal portion of the eyeball. Its connection with the eyeball is described under that organ.

Olfactory Nerve (*Nervus Olfactorius*).—This is not a single nerve upon each side but about *twenty nerves*, or *fila;* these arise from the cells of the nasal mucosa, pass through the cribriform plate of the ethmoid bone and terminate in the olfactory bulb. The details of the remainder of the tract have been considered under the "Olfactory Pathway."

THE SPINAL NERVES

The **spinal nerves** are arranged in pairs of which there are usually thirty-one. Each nerve consists of *two portions*, or *roots* called *ventral*, or *motor* and *sensor*, or *dorsal*. These nerves pass from the vertebral canal through the intervertebral foramina. Within the vertebral canal the roots are distinct and separate, but peripheral to the foramina the roots are united together into a single mass, the *nerve proper*. These nerves are named according to the vertebra between which they pass. Each nerve passes beneath its corresponding vertebra except the first cervical pair that emerges between the occipital bone and the atlas and should really be called the *suboccipital nerve*. Occasionally the thirty-first pair is absent, or two additional pairs may be present. These latter are small and do not emerge from the vertebral canal; they represent rudimentary caudal nerves.

The nerves are as follows:

Cervical	8 pairs.
Thoracic	12 pairs.
Lumbar	5 pairs.
Sacral	5 pairs.
Coccygeal	1 pair.

Each **spinal nerve** consists of a *ventral* and a *dorsal root*. The *ventral*, or *motor root* consists of myelinated axones of the cells in the ventral horns of the spinal gray substance. The roots emerge from the ventrolateral region in a linear formation, indicating a segmentation of the cord. The ventral roots are smaller than the dorsal but the individual fibers are larger. These fibers are both *somatomotor* and *visceromotor*.

Within each intervertebral foramen lies a *ganglion* connected with each dorsal root. The *central end* of the root (that which enters the cord) is made up of the myelinated axones of the ganglion cells in these ganglia; the *peripheral part* of the root (that which joins the motor root to form the nerve proper) consists of the myelinated dendrites of the cells in the ganglia.

Each spinal nerve, after the junction of its two roots, is a *mixed nerve;* a short *distance* from this junction each nerve divides into a *dorsal* and a *ventral primary division*, or *ramus*, each of which consists of motor and sensor fibers. Each **dorsal ramus** divides into a *medial* and a *lateral trunk*. The *medial branches*, in the upper half of the body contain the cutaneous nerves while the *lateral branches* contain the muscular nerves; in the lower half of the body the reverse condition prevails. Certain spinal nerves send branches to the sympathetic system and these constitute the *white rami communicantes*.

Those spinal nerves that are intended for the appendages are the largest, as the lower cervical and first thoracic for the pectoral appendage and the lower lumbar and upper sacral for the pelvic appendage. These nerves form the *great brachial* and *lumbar plexuses* upon each side, for the pectoral and pelvic appendages, respectively.

THE DORSAL RAMI OF THE SPINAL NERVES

THE CERVICAL NERVES

The **first cervical,** or **suboccipital nerve** has a rudimentary dorsal root usually. Its *dorsal ramus* is large. The nerve passes into the neck and gives off *muscular branches* to the mm. semispinalis capitis, recti capitis posterior major and minor and the obliqui capitis superior and inferior. It sends a *communicating branch* to the second cervical nerve.

The **dorsal ramus** of the **second cervical nerve** is larger than its ventral ramus and passes into the neck. It distributes *muscular branches* to the mm. semispinales capitis and cervicis, the obliquus inferior and the multifidus. It sends *communicating branches* to help form the dorsal cervical plexus. A large part of this ramus accompanies the occipital artery as the *great occipital nerve* which is the chief cutaneous nerve of the back of the scalp.

The **third cervical nerve** is small and its dorsal ramus divides into medial branch that becomes the *third occipital nerve* and supplies the skin of the scalp and neck. The *lateral*, or *muscular branch*, supplies contiguous muscles.

The **dorsal rami** *of the rest of the cervical nerves* are quite small. Their *medial branches* are cutaneous for the skin of the back of the neck and their *lateral branches* supply the surrounding muscles.

THE THORACIC REGION

Each *dorsal ramus* divides into *medial* and *lateral branches*. The **medial branches** of the first seven thoracic nerves are chiefly cutaneous for the scapular region. The **lateral branches** supply branches to the longitudinal muscles of the back. In the lower thoracic region the lateral branches are cutaneous, supplying the skin of the back as low as the buttock. The medial branches, here, supply branches to the longitudinal muscles of the back.

THE LUMBAR REGION

The *dorsal rami* of the *first, second* and *third lumbar nerves* divide into *medial* and *lateral branches.* The **medial branches** innervate the deep muscles of the back while the **lateral branches** are chiefly cutaneous and supply the skin of the buttock.

The *dorsal rami* of the *fourth* and *fifth lumbar nerves* are chiefly *muscular* and send branches to the longitudinal muscles of the back.

THE SACRAL AND COCCYGEAL REGIONS

The *dorsal rami* of the *first, second* and *third sacral nerves* supply the m. multifidus through their *medial muscular branches*, and the skin of the sacral and adjoining buttock region, through their *lateral cutaneous branches.*

The *dorsal rami* of the *fourth* and *fifth sacral nerves* and that of the *coccygeal nerve* form the *posterior anococcygeal nerve*, which is a cutaneous nerve for the skin of the coccyx region.

THE VENTRAL RAMI OF THE SPINAL NERVES

The *ventral rami of the spinal nerves* are, with the exception of those of the thoracic region, concerned in the formation of extensive plexuses. Each usually receives a *gray ramus communicans* from the sympathetic system and many give off a delicate *white ramus communicans* to the sympathetic system.

Each thoracic nerve passes ventrally between the intercostal muscles, supplying branches to these muscles. At the side of the thorax each gives off a **lateral branch** that passes to the subcutaneous tissues and branches into *ventral* and *dorsal divisions*, for the supply of the skin of the side of the thorax. The *remainder* of the ventral ramus continues ventrally between the intercostal muscles to the margin of the sternum where it passes to the subcutaneous tissues to be distributed to the skin of the ventral thoracic region.

THE CERVICAL PLEXUS (PLEXUS CERVICALIS)

The *ventral rami of the first four cervical nerves* form the **cervical plexus,** under cover of the m. sternomastoideus. These nerves form irregular *loops* with one another and from these loops *superficial* (*cutaneous*) *ascending* and *descending* and *deep* (*muscular* and *communicating*) *branches* are given off.

The Superficial Cutaneous Branches.—*Ascending Branches.*—The *smaller occipital nerve* (C. 2, 3) passes toward the occiput and gives off the *mastoid*, *auricular* and *occipital branches* for the skin of the ear and mastoid and occipital regions.

The **great auricular nerve** (C. 2, 3) passes toward the ear and gives off *mastoid*, *auricular* and *facial branches* to the skin of those regions; the *facial branch* supplies the skin of the cheek and over the masseter muscle and parotid gland.

The **cutaneous cervical nerve** (C. 2, 3) supplies the skin of the anterior triangle of the neck.

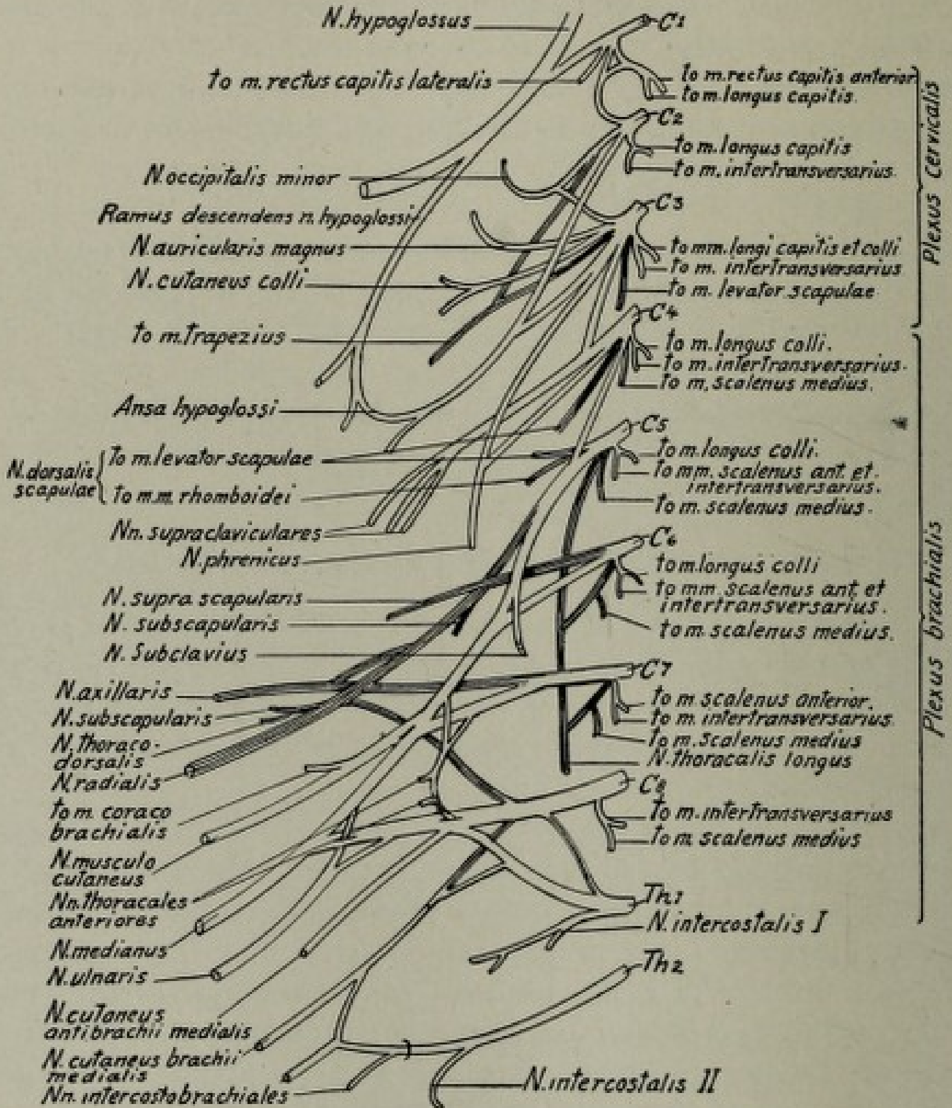


FIG. 321.—Cervicobrachial plexus. (*After P. Eisler.*)

Descending Branches.—The descending roots of the second and third cervical nerves unite to form a *single trunk* that divides into *ventral*, *middle* and *dorsal branches*. The *ventral*, or *suprasternal branches* supply the skin of the neck and upper sternal region. The *middle*, or *suprascapular branches* supply the skin of the over the middle third of the clavicle to the nipple. The *dorsal*, or *supra-acromial*, *branches* supply the skin over the lateral third of the clavicle and the deltoid region.

The Deep Branches.—These are *lateral* and *medial*. The *muscular branches* of the *lateral division* are to the mm. sternomastoideus (C. 2), trapezius (C. 3, 4), levator scapulæ (C. 3, 4), scaleni medius and posterior (C. 3, 4). The *communicating branches* are given to the accessory nerve.

The *medial division* gives *muscular branches* to the prevertebral muscles as follows: mm. rectus capitis lateralis, longus capitis, rectus capitis anterior (C. 1, 2), the mm. intertransversarium, longus colli and longus capitis (C. 2, 3, 4), the m. scalenius anterior (C. 4).

The **descending cervical nerve** is formed by small branches from the second and third cervical nerves. With the *descendens* or *communicans hypoglossi* (derived from the first and second cervical nerves) the descending cervical nerve forms the *ansi hypoglossi*, which sends branches to the mm. sternohyoideus, sternothyreoideus and omohyoideus. The mm. thyreoihyoideus and geniohyoideus are also supplied by the first and second cervical nerves by a branch that accompanies the hypoglossal nerve.

The **phrenic nerve** (*n. phrenicus*) is also derived from the descending branches of the third, fourth (mainly) and fifth cervical nerves. This nerve passes down through the neck and thorax and at the diaphragm supplies this organ with *muscular branches*. It also gives branches to the pleura, pericardium, inferior vena cava, suprarenal gland and liver. The last two are not direct, however, but through the diaphragmatic sympathetic plexus.

The *communications* of the descending cervical branches are with the superior cervical sympathetic ganglia, the vagal and the hypoglossal nerves. The communications of the phrenic nerve are with the cervical sympathetics and the celiac and diaphragmatic plexuses.

THE BRACHIAL PLEXUS (PLEXUS BRACHIALIS)

The brachial plexus is the extensive plexus from which are derived the nerves for the superior extremity. It is formed by the *ventral rami of the fifth, sixth, seventh cervical* and *first thoracic nerves*. This plexus lies in the neck and axillary space and gives rise to a large number of branches.

The brachial plexus *communicates* with the cervical sympathetic ganglia.

The **second thoracic nerve** sends a branch, the *intercostohumeral*, or *intercostobrachial nerve*, directly to the arm.

The **primary cords of the plexus** are formed as follows: The fifth and sixth nerves form the *first cord;* the seventh constitutes the *second cord;* the eighth cervical and first thoracic nerves form the *third cord*. At the same time each of the nerves divides into ventral and dorsal trunks.

The **secondary cords** of the plexus are formed as follows: The *ventral trunks* of the fifth, sixth and seventh nerves form the *lateral cord;* the *ventral trunks* of the eighth cervical and first thoracic form the *medial cord;* the *dorsal cord* is formed by the union of all of the dorsal trunks of the nerves of the plexus. These cords are lateral, medial and dorsal to the axillary artery and from this relation receive their names.

The branches of the brachial plexus are usually described under *supraclavicular* and *infraclavicular branches.*

The **supraclavicular portion** (*pars supraclavicularis*) represents the branches given off above the level of the clavicle and these are anterior and posterior.

The *Anterior Branches.—Muscular branches* to the mm. scalenus anterior and longus colli (C. 5, 6, 7, 8).

The *communicating branch* to the phrenic nerve (C. 5).

The *nerve* to the m. subclavius (C. 5, 6).

The **posterior branches** are as follows: Branches to the mm. scaleni medius and posterior (C. 5, 6, 7, 8).

The *dorsal*, or *posterior scapular nerve* (*n. dorsalis scapulæ*) is distributed to the mm. levator scapulæ, rhomboidei major and minor (C. 5).

The *long*, or *posterior thoracic nerve* (*n. thoracalis longus*) passes through the neck into the axilla to the m. serratus anterior (C. 5, 6, 7).

The **suprascapular nerve** (*n. suprascapularis*) passes from the neck to the superior margin of the scapula, through the scapular notch and supplies the mm. supraspinatus and infraspinatus (C. 5, 6).

The **infraclavicular portion** (*pars infraclavicularis*) is distributed to the shoulder, ventral part of the thorax and the extremity proper. It has *ventral* and *dorsal branches.* Some of the ventral branches are from the lateral cord and some from the medial cord. The dorsal branches are all from the dorsal cord.

The **Ventral Branches.**—The *ventral*, or *anterior thoracic nerves*, are *lateral* and *medial* and arise from the corresponding cords. The *lateral nerve* is derived from the fifth, sixth and seventh cervical nerves and the *medial nerve* from the eighth cervical and first thoracic nerves. These supply the mm. pectorales major and minor.

The **musculocutaneous nerve** (*n. musculocutaneus*) is derived from the lateral cord (C. 5, 6) and is usually accompanied by the nerve to the m. coracobrachialis (C. 6, 7). This nerve passes through the axilla into the arm (between the biceps and brachialis muscles) to elbow where it continues as the *lateral cutaneous nerve of the forearm;* this divides into *ventral* and *dorsal branches.* The *ventral branch* supplies the skin of the lateral half of the ventral surface of the forearm to the ball of the thumb. The *dorsal branch* supplies the skin of the first three-fourths of the lateral half of the dorsal surface of the forearm. The only *muscular branches* are to the biceps and brachialis muscles.

The **medial, or internal cutaneous nerve** (*n. cutaneous antibrachii medialis*), is derived from the medial cord of the brachial plexus (C. 8, Th. 1). It passes from the axilla into the arm, in the distal part of which it divides into *ventral* and *ulnar branches*. The *ventral branch* supplies the medial half of the ventral surface of the forearm to the wrist. The *ulnar branch* supplies the first three-fourths of the medial half of the dorsal surface of the forearm.

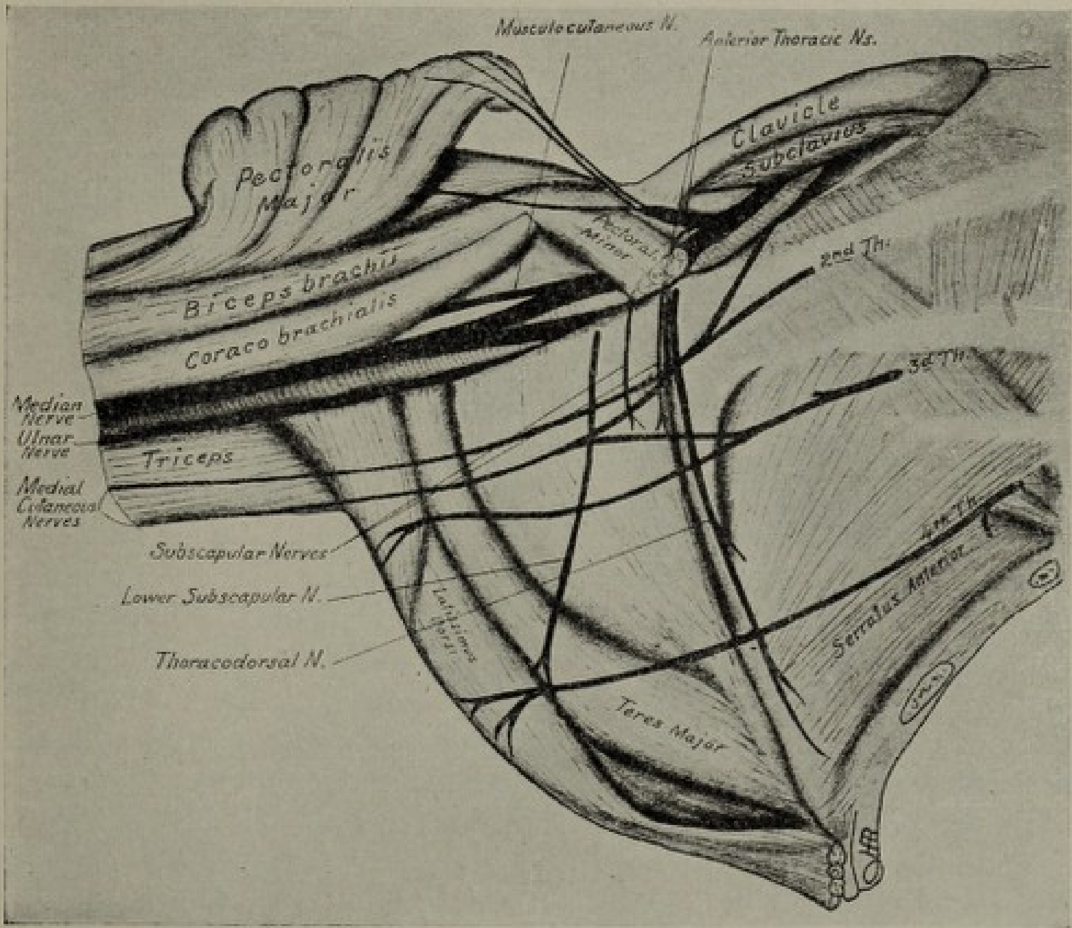


FIG. 322.—Infraclavicular portion of the brachial plexus after removal of most of the pectoralis major and minor muscles.

The **medial cutaneous, or lesser internal cutaneous nerve** of the arm is derived from the median cord of the brachial plexus (Th. 1). It supplies the first half of the skin of the medial surface of the arm.

The **median nerve** (*n. medianus*) is derived from the medial (C. 8, Th. 1) and lateral (C. 5, 6, 7) cords by two heads. It passes from the axilla through the arm and forearm (between the superficial and deep muscles) to the wrist and enters the palm.

Its *first branches* are given off in the forearm to the elbow joint. The next branches are **muscular** for the mm. pronator teres, flexor carpi radialis, palmaris longus, flexor digitorum sublimis. The

ventral, or **volar interosseous nerve,** accompanies the ventral interosseous artery and gives off *muscular branches* to the mm. flexor longus pollicis, pronator quadratus and lateral half of the flexor digitorum sublimis; it gives branches to the radiocarpal articulation.

In the *palm* the median nerve supplies the skin.

In the *hand* it gives off its **terminal branches** which are *muscular* and *cutaneous.* The *muscular branches* are for the mm. abductor pollicis brevis, the opponens pollicis and the flexor pollicis brevis. The *cutaneous branches* are five in number; the *first three* supply successively the lateral and medial sides of the thumb and the lateral side of the index finger; the *other two branches* divide into two each for the adjacent sides of the index and middle and the middle and ring fingers, respectively.

The **ulnar nerve** (*nervus ulnaris*) is derived from the medial cord of the brachial plexus (C. 8, Th. 1). It passes from the axilla through the arm, behind the medial epicondyle into the forearm where it lies between the superficial and deep muscles of the ulnar side. It accompanies the ulnar artery into the palm and there divides into its terminal branches.

Its *first branches* are in the forearm. The *articular branch* supplies the elbow joint. The *muscular branches* are for the mm. flexor carpi ulnaris and medial half of the flexor digitorum profundus. It gives off *cutaneous branches* that extend into the hand. The *ventral* or *palmar cutaneous branch* supplies the distal third of the ventral surface of the forearm (medial half) and the skin of the hypothenar eminence. The *dorsal cutaneous branch* supplies the skin of the distal third of the dorsal surface of the forearm (medial half) and the back of the palm and also gives off the *dorsal digital branches* for the little finger and the adjacent sides of little and ring fingers.

In the *palm* the ulnar nerve supplies the palmaris brevis muscle and divides into a *superficial* and a *deep branch.* The *superficial branch* (cutaneous) divides into *two digital branches* for the medial side of the little finger and the adjacent sides of the little and ring fingers. The *deep branch* supplies the mm. flexor brevis and abductor quinti digiti, opponens quinti digiti, interossei, lumbricales (third and fourth), adductor pollicis and flexor pollicis brevis (deep part).

The **axillary,** or **circumflex nerve** (*n. axillaris*), is derived from the dorsal cord (C. 5, 6). It is large and passes from the axilla, winds around the surgical neck of the humerus and ends by giving branches to the m. deltoideus. It also gives *muscular branches* to the m. teres minor, *articular branches* to the shoulder joint and a large *cutaneous branch* to the skin of the proximal half of the lateral surface of the arm.

The **radial,** or **musculospiral nerve** (*n. radialis*), is derived from all of the nerves of the dorsal cord. It leaves the axilla and passes to the bend of the elbow along the radial groove on the dorsal surface of the humerus. It divides into superficial and deep terminal branches. In its course through the arm it gives off a number of branches. The **muscular branches** are distributed to the mm. triceps,

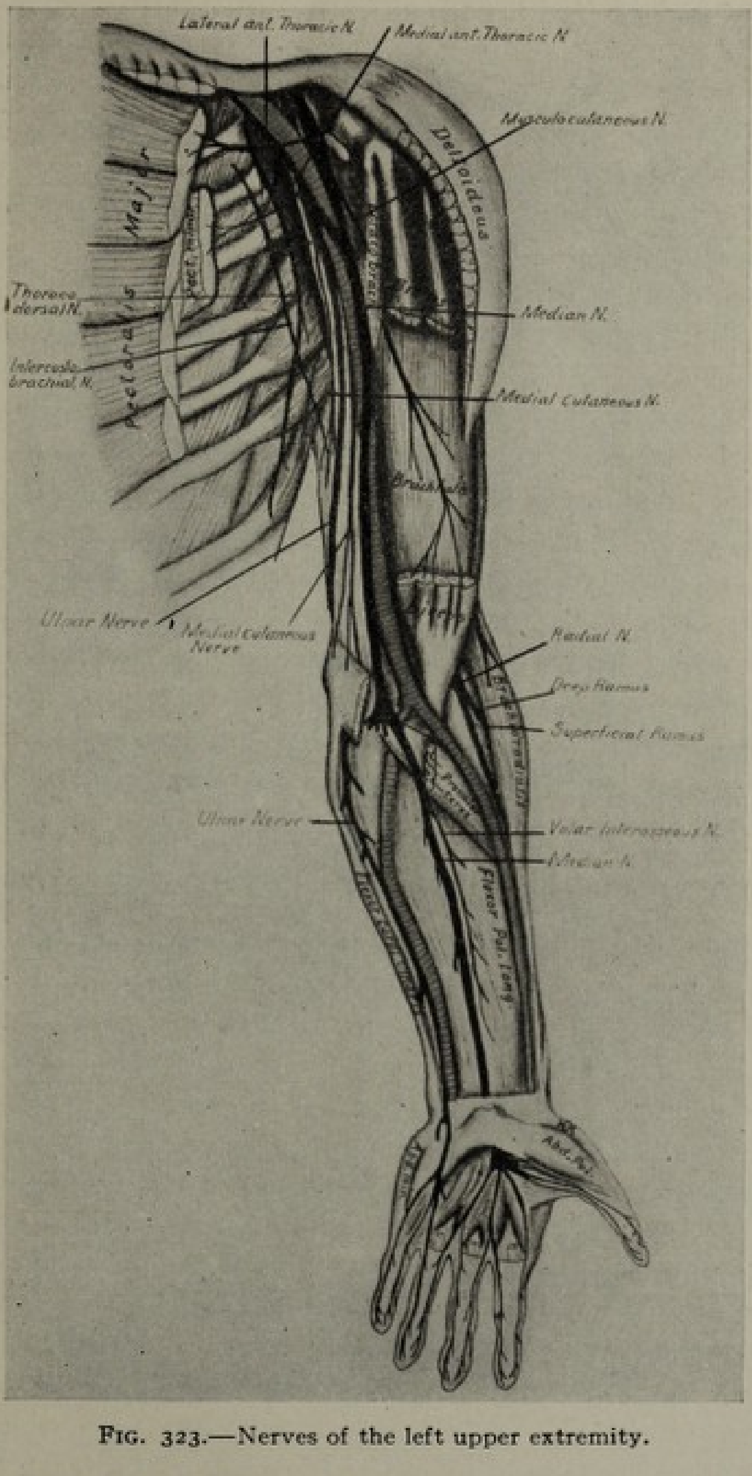


FIG. 323.—Nerves of the left upper extremity.

anconeus, brachialis, brachioradialis, extensor carpi radialis longus and at times the brevis. The **posterior cutaneous brachial** nerve (*the upper internal cutaneous branch of the musculospiral*) supplies the skin of the first third of the medial surface of the arm. The **dorsal**

cutaneous nerve of the forearm supplies the skin of the dorsal surface of the arm (last third) and of the first two-thirds of the forearm.

The **terminal branches** are the **superficial** and **deep rami.** The **superficial ramus,** or *old radial nerve* arises near the elbow, passes along the lateral part of the forearm and in the lower third it passes to the dorsal surface to end in branches that supply the skin of the back of the wrist and some of the fingers. Its *digital branches* are five in number; the *first three* supply both sides of the thumb and the radial side of the index finger. The *other two branches* divide into two each for the contiguous sides of the index and middle and the middle and ring fingers.

The **deep ramus,** or **posterior interosseous nerve,** supplies the muscles of the forearm and the carpal articulations. The nerve lies between the superficial and deep muscles and supplies the following: mm. carpi radialis brevis, supinator, extensores digitorum communis, digiti quinti proprius, carpi ulnaris, the abductor pollicis longus, extensores pollicis longus and brevis and extensor indicis proprius.

The **first,** or **short subscapular nerve** (*n. subscapularis*), is derived from the fifth and sixth cervical nerves (dorsal cord) and supplies the subscapularis muscle.

The **second,** or **lower subscapular nerve,** has the same origin and passes to the teres major and subscapularis muscles.

The **thoracodorsal,** or **long subscapular, nerve** arises from the sixth and seventh and eighth cervical nerves (dorsal cord). It supplies the latissimus dorsi muscle.

THE LUMBOSACRAL PLEXUS (PLEXUS LUMBOSACRALIS)

The lumbosacral plexus is formed by the ventral rami of the five lumbar, the five sacral and one coccygeal nerves. It is usually divided into lumbar, sacral and pudendal plexuses.

The lumbar plexus is formed by the ventral rami of the first, second, third and a branch of the fourth lumbar nerves. It is formed within the substance of the psoas muscles and also divides into its branches here. The first two nerves divide into superior and inferior branches. The superior branch of the first lumbar nerve divides into the **iliohypogastric** and **ilioinguinal nerves.** The *inferior branch* of the first and the superior branch of the second nerve form the **genitofemoral nerve.** The inferior branch of the second, the whole third and the branch of the fourth lumbar nerves divide into smaller ventral and larger dorsal divisions. The ventral divisions form the **obturator nerve**; the dorsal divisions form the **femoral,** and **lateral,** or **external cutaneous,** or **anterior crural nerves.** In addition independent muscular branches are given off. The branches are as follows:

Muscular branches pass to the m. quadratus lumborum (L. 1, 2, 3, 4), psoas major (L. 2, 3), psoas minor (L. 1).

The **iliohypogastric nerve** (*n. iliohypogastricus*) passes into the loin along the crest of the ilium into the groin and gives off *muscular branches* (to the muscles of the abdominal wall) and the *lateral* and *ventral cutaneous branches*. These *cutaneous branches* supply the

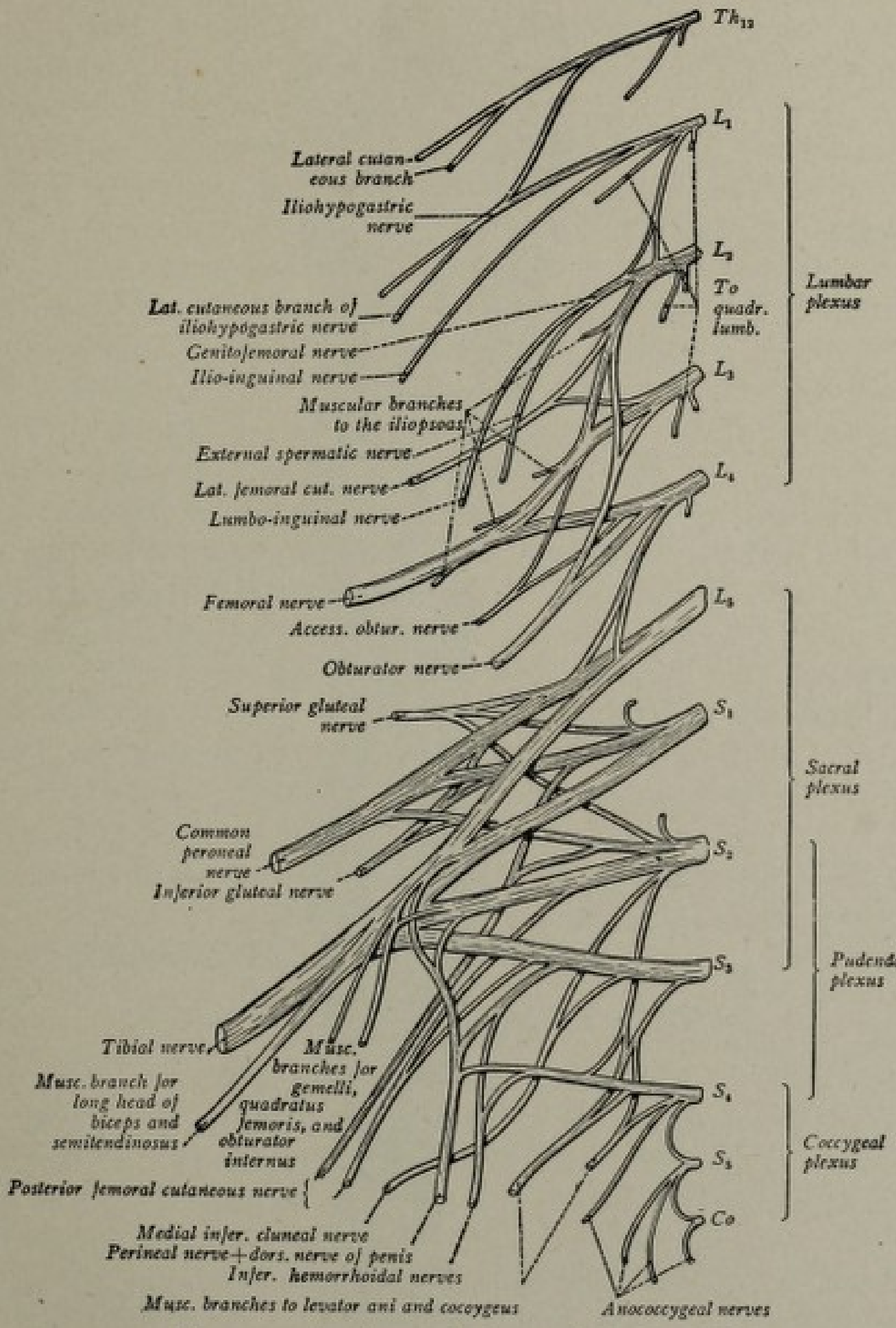


FIG. 324.—Lumbosacral plexus. (*After P. Eisler.*)

skin of the superolateral part of the buttock and the ventral abdominal wall.

The **ilioinguinal nerve** (*n. ilioinguinalis*) passes along the iliac fossa to the external abdominal ring and supplies branches to the skin of the pubic region, scrotum and root of the penis (or mons veneris and labia majora) and the superomedial portion of the thigh.

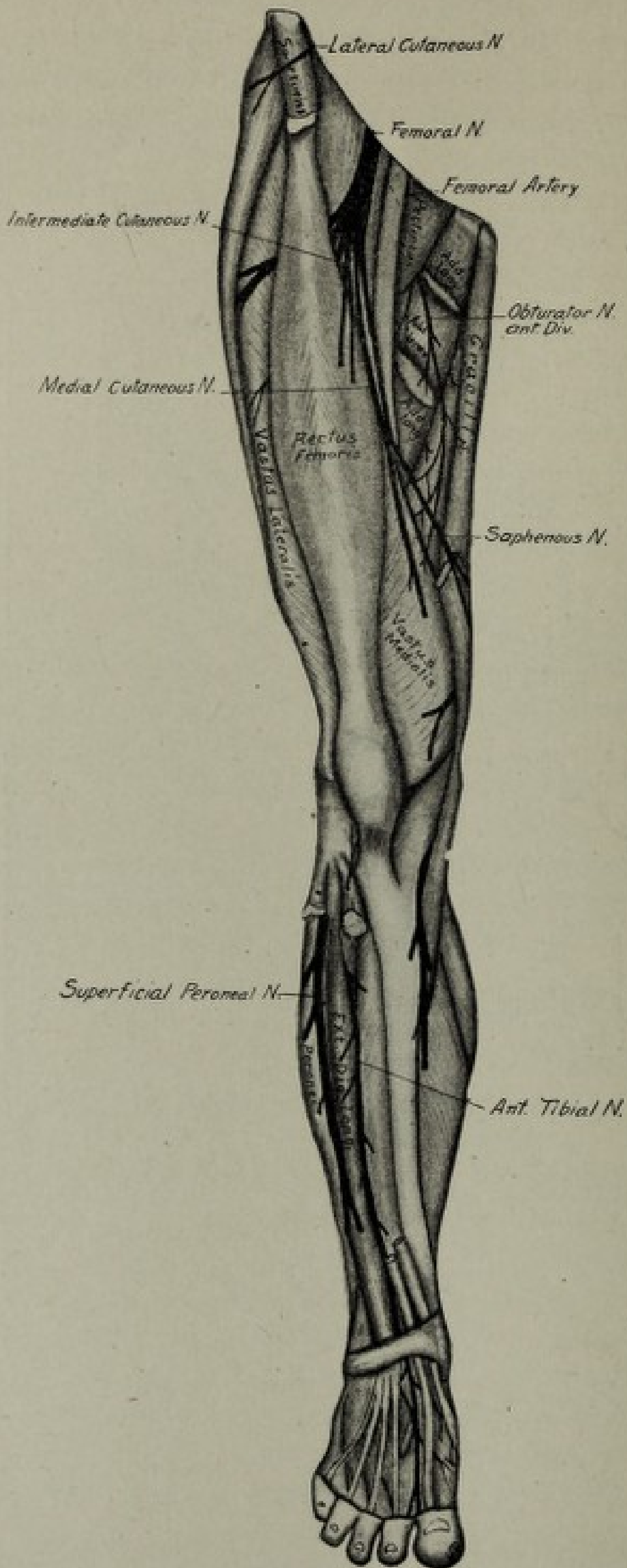


FIG. 325.—Nerves of the ventral part of the right lower extremity.

The **genitofemoral nerve** (*n. genitofemoralis*) passes across the iliac fossa and gives off an *external spermatic branch* that supplies a part of the scrotum and thigh; the remainder passes into the thigh along side of the femoral artery and supplies the skin of the ventral and proximal part of the thigh.

The **lateral cutaneous nerve** (*n. cutaneous femoralis lateralis*) passes into the thigh and supplies the skin of the ventrolateral and lateral aspects of the thigh and buttocks.

The **obturator nerve** (*n. obturatorius*) (L. 2, 3, 4) passes into the thigh through the obturator groove. Its *ventral*, or *superficial branch* supplies *muscular branches* to the adductores longus and brevis, the gracilis and occasionally the pectineus; an *articular branch* to the hip joint; a *cutaneous branch* to the skin of the medial surface of the thigh (distal two-thirds); a branch to the femoral artery. The *dorsal*, or *deep branches* pass into the thigh and give *muscular branches* to the obturator externus, adductores magnus and brevis; an *articular branch* to the knee joint.

The **femoral,** or **anterior crural, nerve** (*n. femoralis*) is a large nerve derived from the second, third and fourth lumbar nerves. It passes through the iliac fossa and into the thigh at the side of the femoral sheath and in the femoral triangle gives off a number of branches. The **muscular branches** are distributed to the mm. pectineus, sartorius, rectus femoris, vasti lateralis, medialis and intermedius; *articular branches* to the hip and knee joints; *cutaneous branches*, the *intermediate* and *medial cutaneous branches*, that supply the skin of the ventral part of the thigh to the knee.

The **saphenous nerve** (*n. saphenus*) is the terminal part of the femoral nerve. It passes into the leg and supplies the medial side of the knee and patellar regions, the medial side of the leg and foot.

THE SACRAL PLEXUS (PLEXUS SACRALIS)

The sacral plexus is formed by the remainder of the fourth, all of the fifth lumbar and all of the first and part of the second and third sacral nerves. The fourth and fifth lumbar and the first and second sacral nerves divide into ventral and dorsal divisions. The third sacral nerve divides into superior and inferior divisions, the latter forming the **pudendal plexus.** The ventral divisions of the fourth and fifth lumbar and first, second and the superior part of the third sacral nerves form the **tibial nerve.** The dorsal divisions form the **common peroneal nerve.** The branches of distribution are dorsal and ventral.

The **sciatic nerve** is really the tibial and common peroneal nerves with extra nerves for the hamstring muscles. This large nerve passes through the greater sciatic foramen into the buttock and then into the thigh where it divides into the tibial and common peroneal

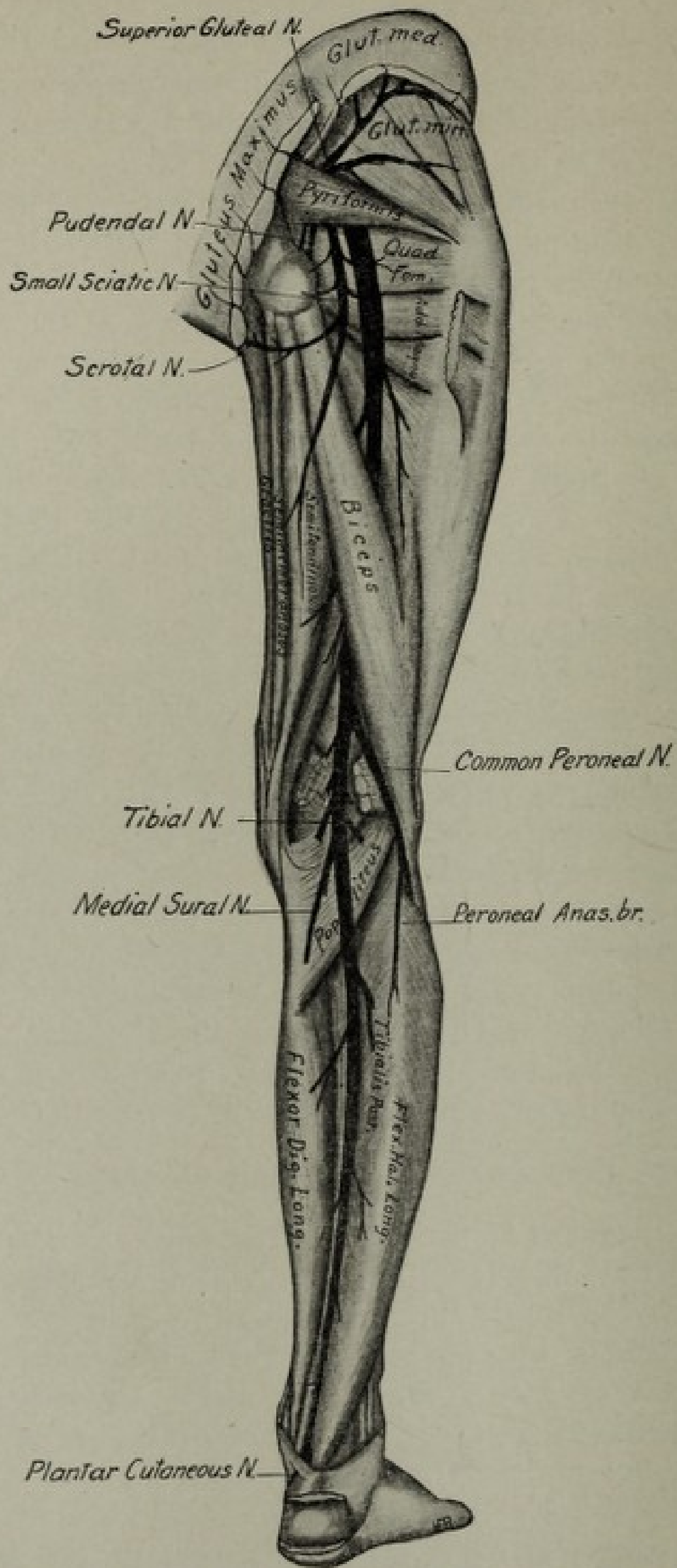


FIG. 326.—Nerves of the dorsal part of the right lower extremity.

nerves at almost any level. In its course the sciatic nerve gives *branches* to the mm. biceps, semitendinosus, semimembranosus and the adductor magnus.

Collateral branches of the sacral plexus are given off as follows: *muscular branches* to the mm. quadratus femoris, obturator internus, gemelli superior and inferior, pyriformis, glutei maximus, medius, minimus; *articular branches* to the hip joint.

The **tibial,** or **internal popliteal, nerve** (*n. tibialis*) is derived from the fourth and fifth lumbar and first three sacral nerves. It is a part of the sciatic nerve to various levels of the thigh but is usually individual before the popliteal space is reached. It continues through the back of the leg to the back of the ankle and passes into the foot where it divides into **medial** and **lateral plantar nerves.**

In the *popliteal space* it gives branches to the knee and proximal tibiofibular joints; *muscular branches* to the mm. plantaris, gastrocnemius (both heads) popliteus; the *medial cutaneous sural nerve* (*tibial communicating nerve*) is joined by the peroneal anastomotic branch of the common peroneal nerve and these form the *sural nerve* that accompanies the small saphenous vein and supplies the skin of the lateral and back parts of the calf, ankle and heel and the side of the foot; it also gives branches to the ankle and tarsal joints. In the *back of the leg* the tibial nerve distributes *muscular branches* to the mm. tibialis posterior, flexor digitorum longus, flexor hallucis longus; *cutaneous branches* to the skin of the medial malleolus and the heel and posterior part of the sole of the foot; *articular branches* to the ankle joint.

The **medial plantar nerve** is the larger of the two terminal branches and accompanies the medial plantar artery. Its *collateral branches* are *muscular* to the mm. abductor hallucis and flexor digitorum brevis; *cutaneous* to the skin of the medial part of the sole of the foot; *articular branches* to the tarsal and metatarsal joints.

The **common digital plantar nerves** are four in number. The *first* (medial) supplies the m. flexor hallucis brevis, and the skin of the medial side of the foot and great toe. The *second* supplies the first lumbricale muscle and then divides into *two proper digital nerves* for the adjacent sides of the great and second toes. The *third* and *fourth* divide into *proper digital branches* for the skin of the adjacent sides of the second and third and the third and fourth toes.

The **lateral plantar nerve** accompanies the lateral plantar artery. It distributes *collateral branches* to the quadratus plantæ and abductor digiti quinti muscles; *cutaneous branches* to the sides of the foot. Its *terminal branches* are the *superficial* and *deep rami.* The *superficial ramus* (*lateral branch*) supplies the flexor digiti quinti brevis and the two interossei of the fourth space and the skin of the sole and of the lateral surface of the little toe. The medial branch divides into *proper digital nerves* for the adjacent sides of the little and fourth toes. The *deep ramus* gives off *muscular branches* to the interossei muscles (except those of the fourth space) to the adductor hallucis and the three lateral lumbricale muscles; *articular branches* to the tarsal and metatarsal joints.

The **common peroneal, or external popliteal nerve** (*n. peroneus communis*), passes through the popliteal space to the back of the head of the fibula. It gives off *collateral branches* as follows: a *muscular branch* to the short head of the biceps; *articular* to the knee

FIG. 327.—The plantar nerves.

joint; *two cutaneous branches*, the *lateral sural branch* and the *anastomotic branch.* The *lateral sural branch* arises in the popliteal space and supplies the skin of the lateral surface and back of the leg in the first two-thirds. The *peroneal anastomotic nerve* (*fibular communicating nerve*) joins the corresponding branch of the tibial nerve the distribution of which has been given.

The *terminal branches* of the common peroneal nerve are the following:

The *tibial recurrent nerve* supplies the proximal part of the tibialis anterior muscle, the knee and tibiofibular joints.

The **deep peroneal,** or **anterior tibial, nerve** (*n. peroneus profundus*) passes to the front of the leg and accompanies the anterior tibial artery to the dorsum of the foot. In the *leg* it gives off *muscular branches* to the mm. tibialis anterior, extensores hallucis longus, digitorum longus and peroneus tertius; a *branch* to the ankle joint. Its *terminal branches* in the foot are *medial* and *lateral*. The *medial branch* that accompanies the dorsalis pedis artery and supplies the first dorsal interosseous muscle and the skin of the medial side of the great toe and the adjacent sides of the great and second toes, also the adjacent joints. The *lateral branch* gives off *muscular branches* to the extensor digitorum brevis muscle, the tarsal and metatarsal joints and branches (sensor probably) to the second and third dorsal interossei.

The **superficial peroneal,** or **musculocutaneous nerve** is the last branch of the common peroneal nerve and lies between the peroneus longus and extensor digitorum longus muscles. It gives *collateral muscular branches* to the peronei longus and brevis muscles and divides into *dorsal medial* and *intermediate cutaneous nerves*. The *former* ultimately divides into two branches that supply the adjacent sides of the second and third toes. The *latter* divides into two branches each of which divides into two for the supply of the skin of the adjacent sides of the third and fourth and the fourth and fifth toes.

THE PUDENDAL PLEXUS (PLEXUS PUDENDUS)

The **pudendal plexus** is formed by fibers from the first three sacral nerves and by the anterior rami of the fourth and fifth sacral and first coccygeal nerves. It receives gray rami communicantes from the sympathetic system. It gives rise to a number of branches.

The **posterior cutaneous nerve of the thigh** (small sciatic nerve) is derived from the first three sacral nerves. It is a *cutaneous nerve* and its branches are as follows: *Perineal branches* supply the scrotum and root of the penis, or the labium majus and clitoris and part of the skin of the perineum. The *inferior gluteal branches* supply the skin of the lower half of the buttock and back of the thigh. The *perforating cutaneous nerve* supplies the skin of the lower part of the buttock and the medial surface of the nates.

The *muscular branches* pass to the levator ani, coccygeus and external sphincter muscles. The nerve to the external sphincter muscle also supplies *cutaneous branches* to the skin of the ischiorectal fossa and the fold of the nates behind the anus.

The **anococcygeal nerve** is derived from a plexus formed by the remainder of the fourth and fifth sacral and coccygeal nerves; it supplies the skin of the coccyx region and that back of the anus.

The **pudendal,** or **pudic nerve** arises in the pelvis from the second, third and fourth sacral nerves. It passes to the buttock through the greater sacrosciatic foramen and in the ischiorectal fossa divides into its terminal branches. The *inferior hemorrhoidal nerve* accompanies the inferior hemorrhoidal artery and gives off *muscular branches* to the external sphincter ani muscle; *cutaneous branches* to the skin around the anus; *communicating nerves* to the surrounding nerves. The *perineal nerve* consists of *superficial* and *deep portions*. The *superficial portion* is *cutaneous* and as its lateral and medial divisions supplies the skin of the scrotum, or labium majus. The *deep branch* gives off *muscular branches* to the anterior portion of the mm. levator ani, and external sphincter, the transversus perinei (superficialis et profundus), ischiocavernosus (or sphincter vaginæ), ischiobulbosus, sphincter urethræ membranaceæ. It also supplies the erectile tissue of the bulb and corpus cavernosum and the mucosa of the urethra as far as the glans.

The **dorsal nerve of the penis,** or **clitoris** accompanies the internal pudendal artery. It passes under the pubic arch and along the dorsum of the penis or clitoris. It sends branches into and around the corpus cavernosum.

THE SYMPATHETIC NERVE SYSTEM

The sympathetic nerve system (*systema nervorum sympathicum*), although seemingly an independent structure, is intimately connected with the cerebrospinal system. Owing to its peculiar arrangement and appearance it is called the *ganglionated cord* and extends from the base of the skull to the coccyx. It rearranges and distributes fibers of the cerebrospinal system to the viscera; it transmits sensor impulses from the viscera to the cerebrospinal system; it sends motor fibers to vessels and organs through the cerebrospinal nerves.

This system consists of a series of *central ganglia*, *collateral ganglia* and *terminal ganglia*. The **central ganglia** (*ganglia trunci sympathici*) are arranged in pairs on each side of the midline from the base of the skull to the coccyx; they are connected with one another up and down (on the same side only). The fibers are gray in color and constitute the *gray rami communicantes;* these are connecting and distributory in function.

Each *ganglion* consists of a variable number of large, multipolar nerve cells surrounded by a capsule of white fibrous tissue. In addition neuroglia, myelinated and amyelinated nerve fibers are present. Each cell possesses a main process, the axone, that may be associative in function, or may pass to the cerebrospinal system as the gray ramus communicans, or it may pass to the periphery, or to ganglia farther out. The dendrites are usually numerous and serve an associative function in the immediate neighborhood. The *white* *rami communicantes* are from two main sections of the spinal cord, the thoracicolumbar (from the second thoracic to the second lumbar nerve levels) and the pelvic, or sacral (from the second to the fourth sacral nerve levels). Both ventral and dorsal roots of the spinal nerves are concerned.

The small fibers (*white rami communicantes*) from the ventral roots of the spinal nerves may end in the central ganglia of that level; they may pass through that ganglion and up or down to another one of the central ganglia; they may pass through the central ganglion and terminate in a collateral ganglion. All of these fibers are the *splanchnic efferent fibers.* The *sensor fibers* are the *splanchnic afferents* and the cells lie in the dorsal root.

Although in early fetal life there are as many pairs of ganglia as vertebral segments, at birth this condition does not prevail. The **central ganglia** are arranged as follows:

Cervical	3 pairs.
Thoracic	10 to 12 pairs.
Lumbar	4 pairs.
Sacral	4 to 5 pairs.
Coccygeal a single one.	

These communicate with one another up and down.

Fibers from the spinal nerves that pass to the sympathetic ganglia are *white* and constitute the *white rami communicantes.* Those from the sympathetic system to the spinal cord are *gray* and constitute the *gray rami communicantes.* These are the *communicating fibers.*

The *fibers of distribution* are chiefly gray and pass from the various sympathetic ganglia to vessels and organs of the thoracic and abdominal cavities, that is, the muscles and epithelium thereof representing both *motor* and *sensor* fibers.

The **collateral ganglia,** or **ganglionated plexuses** are the *cardiac, solar* and *hypogastric plexuses.*

The **terminal ganglia** are in the various organs, as in the *plexuses of Auerbach* and *Meissner* of the gastrointestinal tract.

The **cervical portion** (*pars cephalica et cervicalis*) of the central system comprises three pairs of ganglia, the *superior*, *middle* and *inferior cervical ganglia.* No white rami communicantes are found here.

The branches of these ganglia are either central communicating branches for the other nerves, or peripheral branches that pass directly, or through plexuses to the viscera and vessels of the head, neck and thorax.

The *superior cervical ganglia* (*ganglia cervicales superiores*) are the largest; each lies opposite the second and third cervical vertebræ. Each is broad, flat and spindle-shaped, of a reddish color and represents a fusion of the first four cervical ganglia. From its superior (cephalic) end a branch ascends along the internal carotid artery and in the skull its two branches form the *internal carotid* and *cavern-*

ous plexuses. The *carotid plexus* communicates with the semilunar (Gasserian) and sphenopalatine ganglia and the abducens and glossopharyngeal nerves. The *cavernous plexus,* in the *cavernous* sinus, communicates with the oculomotor, trochlear, the ophthalmic division of the trigeminus and abducens nerves and the ciliary ganglion. Other branches of these plexuses follow the anterior, middle cerebral and ophthalmic arteries.

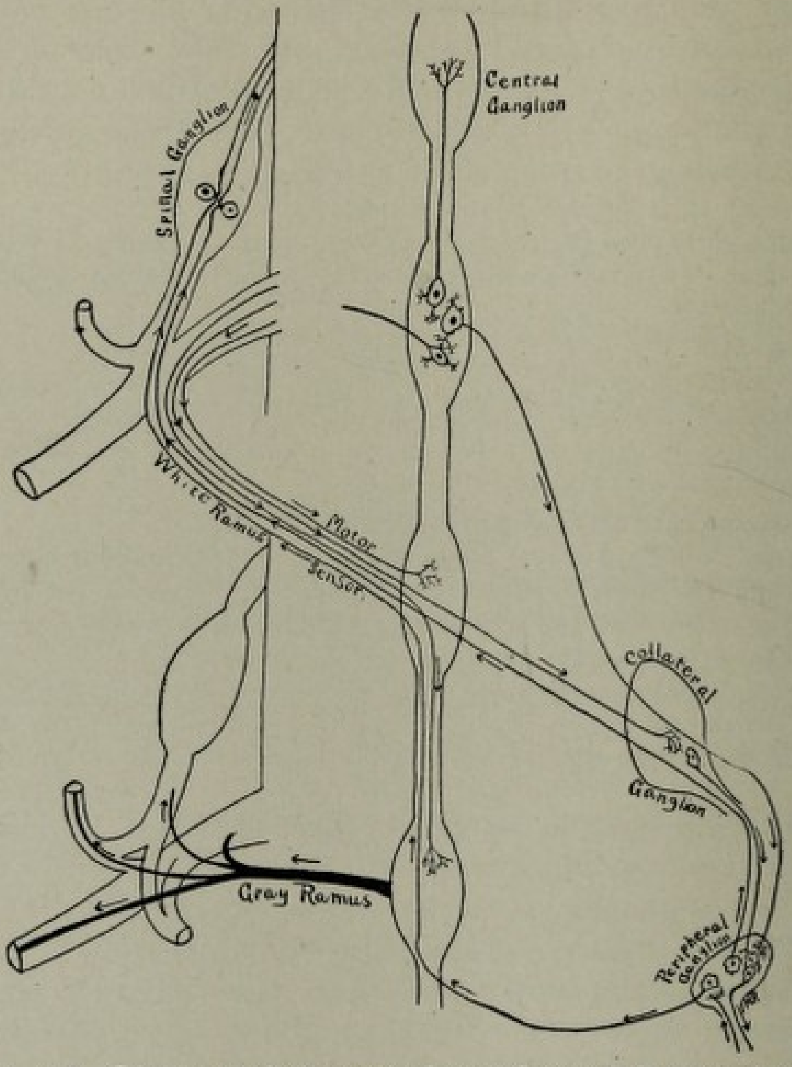


FIG. 328.—Diagram of the sympathetic ganglia and their connections.

Other branches of the superior cervical ganglion communicate with the middle ganglion, the first four cervical nerves (ventral roots) vagal, glossopharyngeal (forming the pharyngeal plexus), and hypoglossal nerves, while others pass to the larynx, pharynx and heart; the *latter* form the *superficial cardiac nerve,* the right one joining the deep cardiac plexus and the left the superior cardiac plexus.

The *middle cervical ganglia* (*ganglia cervicales mediales*) are the smallest and lie in front of the sixth cervical vertebra and represent the fifth and sixth ganglia fused.

Each sends branches, gray rami communicantes, to the fifth and sixth cervical nerves and to the subclavian artery. Peripheral branches pass to the thyreoid gland and heart, as the *middle cardiac nerve* to the deep cardiac plexus. This ganglion may be absent and when this occurs these branches arise direct from the cord in that region.

The *inferior cervical ganglia* (*ganglia cervicales inferiores*) lie upon a level with the seventh cervical vertebra and are irregular in shape. Each usually represents a fusion of the seventh cervical and the first thoracic ganglia and each sends branches, gray rami, to the seventh and eighth cervical nerves and the subclavian artery; it also gives off the *inferior cardiac nerve* that joins the deep cardiac plexus. Other branches follow the vertebral artery into the skull and these continue along the cerebral and cerebellar arteries.

The *thoracic ganglia* (*pars thoracalis*) are ten to twelve pairs in number. They rest against the heads of the ribs, behind the pleura. The first often fuses with the last cervical and the eleventh and twelfth are usually fused. All of the spinal thoracic nerves (except the first) send white rami to these ganglia. Branches from the first five pairs of thoracic ganglia go to the aorta and its branches and from the second, third and fourth others go to the posterior pulmonary plexus. From the lower ganglia branches go to the aorta and others form the splanchnic nerves.

The *great splanchnic nerve* (*n. splanchnicus major*), on each side, is formed by branches from the fifth, sixth, seventh, eighth and ninth ganglia and is whitish in color. It passes through the crus of the diaphragm and joins the celiac ganglion of the solar plexus and ultimately the renal and adrenal plexuses. In the thorax branches pass to the aorta and esophagus.

The *lesser splanchnic nerve* (*n. splanchnicus minor*) is formed by branches from the ninth and tenth ganglia, passes through the diaphragm to join the aorticorenal ganglion of the solar plexus.

The *least splanchnic nerve* (*n. splanchnicus imus*) is made up of fibers from the eleventh thoracic ganglion, pierces the diaphragm and ends in the renal plexus.

The *lumbar ganglia* are usually four in number upon each side, small and placed near the midline. They receive white rami from the first two lumbar nerves. They send branches to the lumbar nerves and to the abdominal aorta and aortic plexus.

The *sacral ganglia* (*pars pelvina*) are four or five in number on each side on the front of the sacrum; branches pass to the sacral nerves. Some of the sacral nerves send branches through the ganglia. Other branches pass to the pelvic plexus and the vessels and pelvic organs, as bladder, rectum, uterus (motor and inhibitor fibers) prostate (secretor fibers) and vasodilatator fibers to the genital organs.

In front of the coccyx the two cords join to form a single *coccygeal ganglion*, or *ganglion impar*.

PLEXUSES

The **cardiac plexus** (*plexus cardiacus*) comprises the *superficial and deep portions* and lies at the base of the heart. The *superficial plexus*, under the arch of the aorta, is formed by the left superior cardiac nerve, the left inferior cervical cardiac, a branch from the vagus and some fibers from the deep plexus. The *ganglion of Wrisberg* may be present. From this plexus branches pass to the left half of the deep plexus and to the anterior coronary and left anterior pulmonary plexuses.

The *deep portion* (*plexus cardiacus profundus*) is situated in front of the tracheal bifurcation. It is the larger and is formed by the cardiac branches of the cervical ganglia (except left superior) branches of the recurrent laryngeal and vagal nerves. Branches pass to the anterior and posterior coronary plexuses. The left coronary plexus sends branches to the left atrium and ventricle and the right coronary plexus to the right atrium and ventricle. Branches also pass to the pulmonary plexuses.

The **pulmonary plexuses** (*plexus pulmonales*) are *ventral* and *dorsal*. The *ventral plexus* on each side lies upon the structures at the ventral part of the root of the lung, which structures it supplies. Each receives fibers from the deep cardiac plexus and the left from the superficial cardiac plexus also. The *dorsal plexus* lies behind the root of the lung and is formed by branches from the second, third and fourth thoracic sympathetic ganglia, but chiefly branches from the vagal nerve. Branches therefrom pass along the vessels and bronchi.

The **esophageal plexuses** (*plexus esophagei*) are *ventral* and *dorsal* and are formed, chiefly, by the vagal nerves through the pulmonary plexuses; branches from these plexuses pass into the esophagus and pericardium. The lower part of the esophagus also receives fibers from the greater splanchnic nerve.

The **solar,** or **celiac plexus** (*plexus celiacus*) is a great network of sympathetic nerves and ganglia situated in front (ventrad) of the aorta and crura of the diaphragm and behind the pancreas; it is in relation with the celiac axis and superior mesenteric arteries. To this plexus pass all of the splanchnic nerves and branches from the right vagus. From it pass branches to the viscera of the abdomen and along the branches of the aorta. It consists of *the celiac plexus* and *two main ganglionic masses*, the *celiac ganglia*. This plexus is connected with the renal, diaphragmatic, adrenal, aortic and superior mesenteric plexuses and others lower down.

The most important ganglia are the *celiac;* these are the largest in the body. Each is large and irregular, situated in front of the crus of the diaphragm and consists of a collection of smaller ganglia. The upper end of each receives the great splanchnic nerve while the lower part constitutes the aorticorenal ganglion that receives the lesser splanchnic nerves.

The solar plexus gives rise to a number of plexuses.

1. The *phrenic plexuses* receive branches from the phrenic nerves. The right is the larger and may possess a ganglion. From each branches pass to the diaphragm and (on the right side) to the inferior vena cava and to the suprarenal and hepatic plexuses.

2. The *coronary plexus* sends branches to the esophagus and along the lesser curvature of the stomach that join branches of the vagus.

3. The *splenic plexus*, chiefly from the left celiac ganglion, accompanies the splenic artery to the spleen, likewise giving branches to the pancreas and the greater curvature of the stomach. Branches of the right vagus join the plexus.

4. The *hepatic plexus* is the largest and receives branches from the left vagal and phrenic nerves. Its branches go to the liver and pyloric portion of the stomach, duodenum, pancreas, greater curvature of the stomach and to the gall-bladder. These branches form plexuses along the arteries and take their names therefrom.

5. The *suprarenal plexus*, on each side, contains a ganglion at the junction of branches of the celiac ganglion, great splanchnic and phrenic nerves and renal plexus that form this plexus. It sends branches to the adrenal, or suprarenal glands.

6. The *superior mesenteric plexus* surrounds the superior mesenteric artery and receives branches from the right vagal nerve, the celiac and aorticorenal ganglia. As it passes into the mesentery it gives rise to subplexuses that follow the branches of this artery, as the *pancreatic*, *intestinal*, *iliocolic*, *right colic* and *middle colic*. It has a ganglion at the root of the artery.

7. The *renal plexuses* consist of branches of the solar plexus, aorticorenal, adrenal and aortic plexuses and the least splanchnic nerves; branches pass to the kidneys and to the spermatic plexuses.

8. (*a*) The *spermatic plexuses* are formed by branches from the renal and aortic plexuses; branches pass to the testes.

(*b*) The *ovarian plexuses* are formed in the same manner and send branches to the ovaries, oviducts and borders of the uterus. They communicate with the uterine plexus.

9. The *aortic plexus* is situated upon the front and sides of the abdominal aorta between the superior and inferior mesenteric arteries. It is made up of branches from the solar plexus and the lumbar sympathetic ganglia. It distributes branches to the spermatic, inferior mesenteric, suprarenal, renal, and hypogastric plexuses and to the inferior vena cava.

The *inferior mesenteric plexuses* is situated at the root of the inferior mesenteric artery where a ganglion is found. It is derived, chiefly, from the left side of the aortic plexus and gives rise to subplexuses that follow the branches of the artery, as the *left colic* and

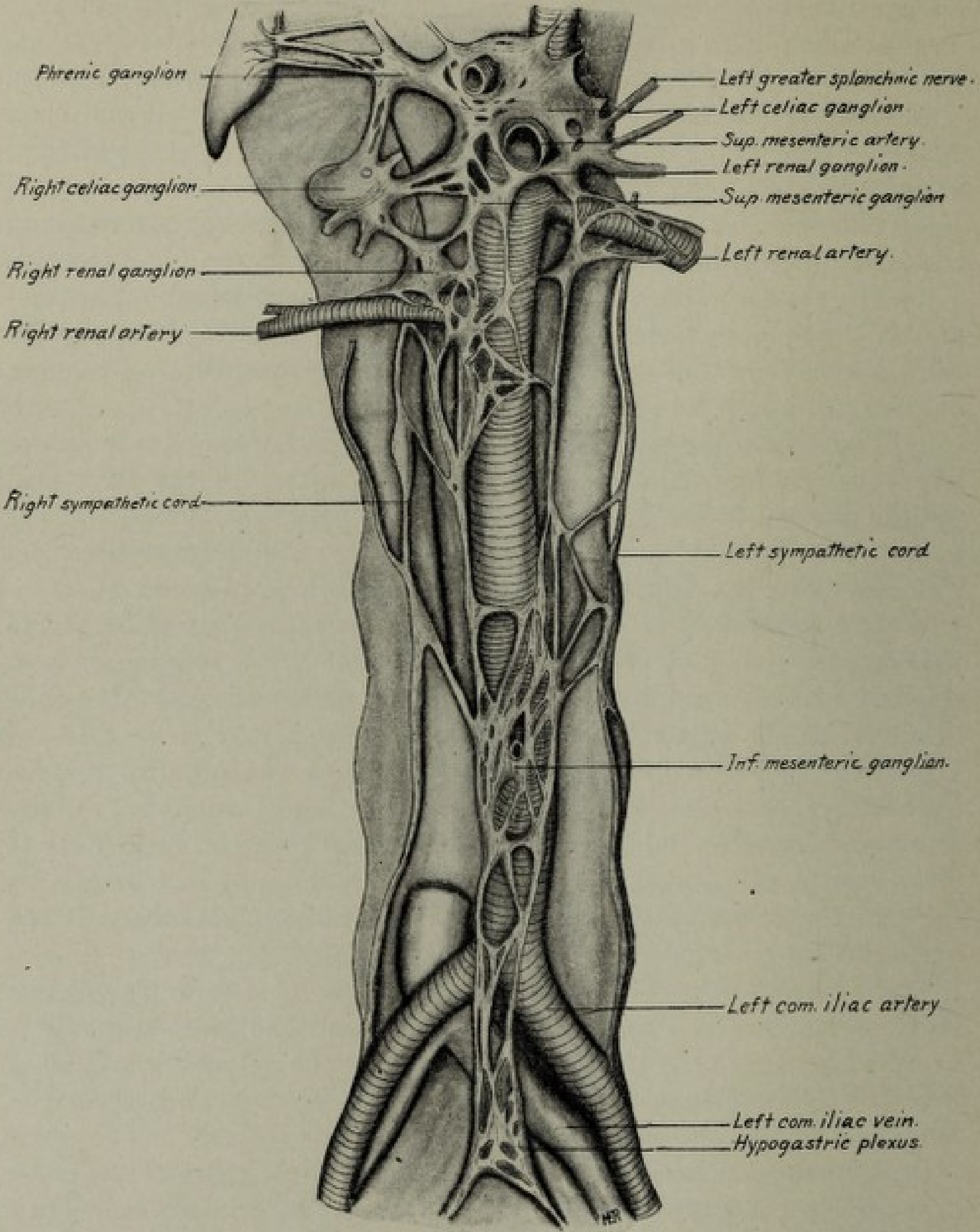


Fig. 329.—Abdominal portion of the sympathetic trunk.

sigmoid plexuses that distribute branches to the corresponding parts of the large intestine (descending, iliac, pelvic colons and the upper part of the rectum).

The **hypogastric plexus** is located in front of the promontory of the sacrum and is composed of branches of the aortic plexus (the hypogastric nerves) and the lumbar ganglia. Below it divides into right and left pelvic plexuses to supply the pelvic viscera.

The *pelvic plexuses* receive branches from the second, third, and fourth sacral nerves and a few from the first two sacral sympathetic ganglia. Small ganglia are present. Subplexuses follow the branches of the internal iliac artery (hypogastric). The subdivisions are as follows:

1. The *vesical plexus* contains a large number of spinal nerve fibers and accompanies the branches of the vesical arteries. Its branches pass to the bladder and ureter and, in the male, to the seminal vesicles and vasa deferentia and some branches join the spermatic plexus on the spermatic cord.

2. (*a*) The *prostatic plexus* is large and sends branches to the prostate, neck of the bladder, seminal vesicles and penis of the male. In the latter they constitute the small and large cavernous nerves that accompany branches of the internal pudic (pudendal) artery.

(*b*) The *uterovaginal plexus* sends branches to the uterus along the uterine artery and these join those of the ovarian plexus. The branches to the vagina, vestibule and clitoris contain quite a few spinal nerve fibers.

3. The *inferior hemorrhoidal plexus* sends branches to the lower part of the rectum and these join the branches from the superior hemorrhoidal plexus.

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