ANATOMY FOR NURSES

A TEXTBOOK OF ANATOMY FOR NURSES

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WITH THIRTY-FOUR ORIGINAL ILLUSTRATIONS, FIVE OF WHICH ARE IN COLORS

ST. LOUIS

C. V. MOSBY COMPANY

1917

Press of
C. V. Mosby Company
1917

DEDICATED
TO THE MEMORY OF
EDITH CAVELL
WHO DIED FOR HER FRIENDS

PREFACE

I have written this book because I have found the existing textbooks on the subject unsatisfactory. I believe pupil nurses should be *shown* the various tissues and organs of the body and that this work should be done before they enter hospitals for their professional training. This can be readily accomplished if the medical colleges will offer a brief, practical course in anatomy during the vacation. Such a course should occupy not more than three or four weeks. From two to three hours a day of laboratory instruction, using *prepared* dissections, might be profitably employed.

I fear that I may have made the book too elaborate, but teachers can readily omit descriptions given in too much detail.

The illustrations have been drawn by Miss Helen Lorraine from specially prepared dissections, and appear to me exceptionally well done. They are in many instances designedly diagrammatic.

W. G. C.

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CHAPTER I

INTRODUCTION

The only knowledge of anatomy which is permanently retained is that which is seen or felt. Names are comparatively unimportant, but must be employed to prevent confusion, to enable one to impart what is known and to facilitate such studies as physiology, pathology and surgery. Certain terms, frequently employed, must be explained and comprehended before the study can even be begun.

The entire body is conceived of as a cube, and hence would have six faces which would be directed upward, downward, forward, backward and to either side. The first four are easy of comprehension; but the two lateral confuse us because there are two arms and two legs, distinguished as right and left, each itself having two surfaces which cannot receive these familiar names, because the right side of the left arm has all the peculiarities of the left side of the right; and there must be a name for this symmetrical appearance. Hence, the body may be considered as split by an imaginary plane drawn from the middle of the top of the head down between the feet. Such an imaginary plane or line would add a face which would be directed toward the midline and would be called the

mesial or *inner* face. The mesial or inner faces of the arms or legs are exactly alike, while the parts which are directed away from the midline are the lateral or outer faces and are also alike.

Practically all anatomical names were given when Latin or Greek were the only languages in which learning was concealed. The names which are here employed and which have the great convenience of being intelligible to anatomists all over the world, are of Latin or Greek origin. These names are employed in surgical and medical works, as well as in anatomy. Such terms as front, back, etc., are not usually used, but words of Latin origin with the same significance as follows: Upward is superior, downward is inferior, forward is anterior, backward is posterior, inward is medial, and outward is lateral.

So far only the faces of a cube which have one definite direction have been considered, while some of the cube may be turned to face partly in two directions. These oblique portions are designated by compound words indicative of the two directions involved, thus: Antero-superior would be facing forward and upward; antero-median, forward and inward; antero-lateral, forward and outward, etc.

If a pencil is placed upright on a table, point upward, the pencil will be a line at right angles to the plane of the table, and its point will be in the direction in which the table top faces; i. e., it is the superior surface of the table. The names for many appearances in the body may be determined in just that way. Put the part, above for instance, in its anatomical position, and then place a pencil on the various

parts of the bone just as on the table. If properly placed, the pencil will point in one of the six cardinal directions or to some angle between two or more of them. This will be the direction of that part and probably a portion of its name.

The anatomical position is not the natural position of the body. If one stands at ease he will find that the arms swing at the sides with the thumbs nearly on the thighs, the fingers partly bent and the toes turned out a little. Now turn the hands until the little fingers touch the thighs, thumbs outward, fingers straight, heels and big toes touching, head up and eyes looking straight in front. This is the *anatomical position.* In it every portion of the body must be placed before it can be properly studied, and in it one must, in imagination, place every person and part of a person, until the mind unconsciously perceives them only in that awkward attitude.

Only the broad faces of the cube have thus far been considered. It has, however, narrow lines, or borders, and sharp points, or angles, separating these faces. In anatomical language the faces are surfaces, the lines borders, the points angles, spines or processes. It is chiefly in the study of the bones and viscera that these terms are employed. Other technical terms will be explained as they occur.

CHAPTER II

OSTEOLOGY

The bones form the framework of the body. They are somewhat more than two hundred in number and vary greatly in size and function. Those of the extremities are chiefly a set of levers, actuated by muscles and bound together by ligaments, the entire apparatus being designed for support and to produce motion of some sort. Others serve to more or less perfectly surround cavities which contain important organs, while their exterior faces give firm points of attachment to muscles and ligaments. Roughly bones may be divided into two classes by the presence or absence of marrow cavities: those having such cavities are called long; and those without the cavities, irregular bones. The irregular bones consist more or less completely of two plates or tables bound together by numerous minute bands of bone with spaces between, forming a network not unlike sponge. Both varieties are covered by a delicate membrane, the periosteum, which contains a large number of blood vessels and is the tissue to which ligaments and muscles are really attached. The long bones are found chiefly in the extremities, while most of the irregular bones are in the skull and spinal column, though the hands and feet each contain several bones of this variety.

The term *extremity* is applied to what is usually called arm and leg. In anatomical language the up-

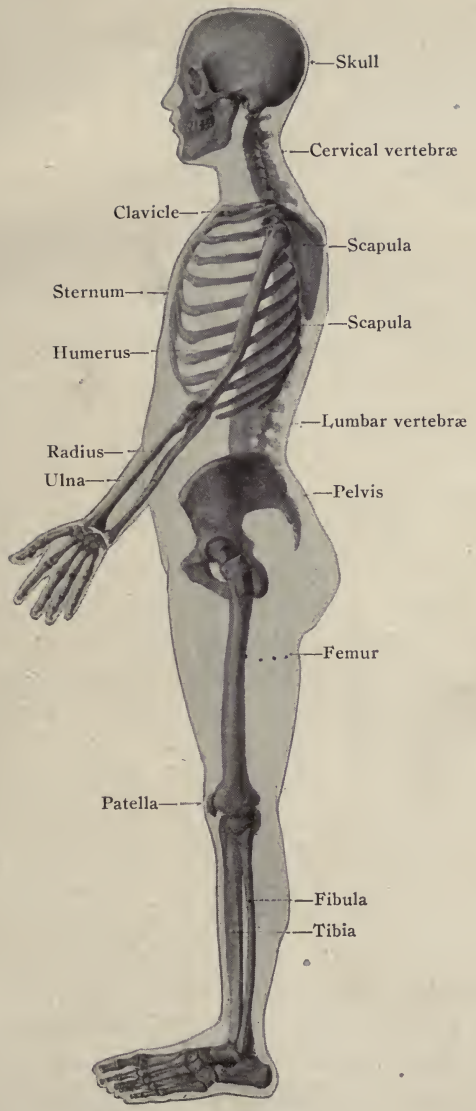

Fig. 1.—Profile of skeleton.

per extremity comprises all the structures from the tips of the fingers to the attachment of the collar bone to the breast bone, while the lower extremity extends from the toes to the pelvis, including the hips. The upper is divided into shoulder, arm, forearm, and hand; the lower into hip, thigh, leg and foot. The term arm, therefore, is correctly used only for that portion of the upper extremity extending from the shoulder to the elbow; while leg is that part from knee to ankle. The remaining portions of the body comprise the head, neck, and trunk, the neck insensibly blending with the upper, and the trunk, or body, with the lower extremity.

THE VERTEBRAL, OR SPINAL, COLUMN

The *spinal, or vertebral column,* binds the head to the neck, forms the middle and posterior part of the latter and of the trunk, and finally binds the trunk to the extremities and the two lower extremities to each other. It contains a central canal for the spinal cord and is so important that it is properly the first object of our study. At an early period of life it consisted of thirty-three pieces of bone called vertebræ (from a Latin word meaning to turn, because turning or twisting the body from side to side is accomplished at the joints between these bones); but, in adult life, nine of these pieces have fused together in such a way as to constitute two pieces, so that the total number of vertebræ is now twenty-six. Of these, seven are found in the neck and are called *cervical;* twelve form the posterior wall of the cavity containing the heart and lungs, thoracic cavity, and are called *thoracic* verte-

bræ for that reason, *dorsal* because they form a large part of the back; five are found in the "small of the back" and are called *lumbar,* or *abdominal* from forming the middle of the posterior wall of the abdominal cavity. The remaining two, sacrum and coccyx, are in the pelvis and are called the *pelvic* vertebræ.

A Typical Vertebra

With certain important exceptions, every vertebra consists of a large central hole (foramen, opening), the vertebral foramen, surrounded by a solid mass of bone in front called the body, two short rounded projections running backward one from either side of the body, the pedicles, which terminate in flattened, broad sheets of bone which run backward and inward until they meet, the laminæ, whose union forms a projection of varying size, shape and direction, the spine, or spinous process. In addition to these appearances there are four projections, two running upward and two downward, by which the vertebræ are joined together, known as *articular* processes, because the joints, or articulations, formed by their union permit movement, and are distinguished as superior and inferior; and two lateral projections, one on either side, forming levers to which muscles can be attached by which the vertebra may be moved. These processes are called transverse from their direction. Above and below each pedicle is a notch, intervertebral, which becomes an intervertebral foramen when two vertebræ are articulated, to transmit the spinal nerves.

In the several regions of the column the component parts of the vertebræ differ sufficiently to enable us

to distinguish a vertebra of one region from that of another.

In the *cervical* region the body is small, has a projecting lip on either side above and a notch in front. Below it has a notch on either side and a lip in front.

In the *thoracic* region the *body* has no lips, is nearly

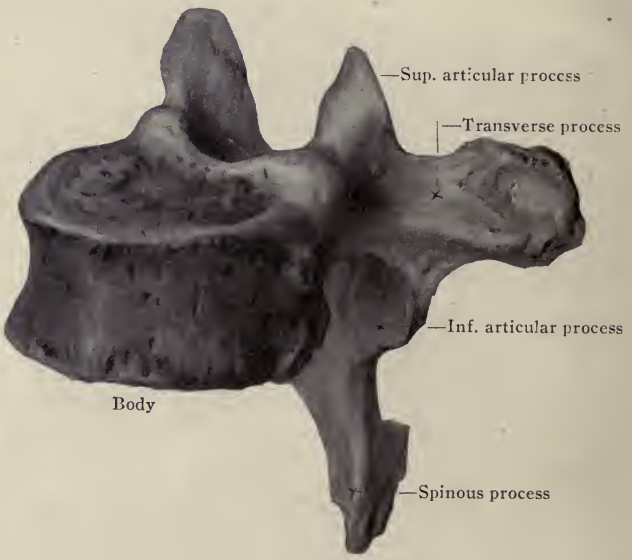

Fig. 2.—Typical vertebra, view from side.

round, and has either a whole or a half facet (articular surface) for the head of a rib.

In the *lumbar* region the *body* has neither facet nor lips. Except that they increase in size from above downward, the *pedicles* have little to distinguish them.

The *laminæ* are large in proportion to the size of the bone in the cervical and thoracic regions and occupy less of the bone in the lumbar.

The *spines* are short and forked (bifurcated) in the cervical region; long, triangular, pointed, and run nearly downward in the thoracic; and short quadrilateral, and very large in the lumbar.

Fig. 3.—Typical vertebra, view from above.

The *superior articular processes* look upward and backward in the cervical, backward in the thoracic, and inward in the lumbar region. The *inferior* look down-

ward and forward in the cervical, forward in the thoracic, and outward in the lumbar.

The *transverse process* is perforated by the vertebral foramen at its base and bifurcated at its extremity in the cervical region; runs outward and backward, is club-shaped and bears an articular facet in the thoracic, and is sharp, curved, and rib-like in the lumbar.

Peculiar Vertebræ

The **first cervical** is called the **atlas** and has no body. Its spinal foramen is very large. It has five articular processes of which the first is on the posterior face of its anterior part, called the anterior arch. The two superior are oval, longer from before backward than from side to side and look upward. They are receiving surfaces for a condyle. The inferior look downward and are flat and circular. The bone has no spine, which would interfere with the movements of the head if present, and is the connecting link between the skull and spinal column.

The **second cervical** is called the **axis.** It is peculiar on its upper and typical on its lower aspect. It is the transition vertebra. On its body above is a sharp pointed process, called *odontoid* because it is like a tooth, whose anterior face is articular for the similar facet on the back of the front part of the atlas. This upright piece is a pivot or axle around which the atlas revolves in turning the head from side to side. The superior articular processes look upward and are round. The spine is very large and bifurcated below.

THE SACRUM AND COCCYX

As the **coccyx** is often ossified to the sacrum and is always articulated with it so that the two act nearly as one bone, they may be described together.

The **sacrum** forms a double wedge whose apex is prolonged downward by the coccyx to a sharp point, while its base is directed upward to the body of the fifth lumbar vertebra whose under surface it exactly resembles. Its *anterior* surface is concave from side to side and from above downward, so as to increase the capacity of the pelvic cavity, whose posterior wall it forms. It has on either side of the midline a vertical row of foramina, which are circular and smooth and terminate laterally in shallow grooves.

The *posterior* surface, much narrower than the anterior, is convex in both directions. It shows a row of tubercles in the midline, the rudiments of spinous processes, and two rows of foramina smaller and less regular than those on the front.

On each side the bone is wide above, narrow and rough below. Near the front above is an articular facet, shaped somewhat like an ear and called *auricular*. This is to articulate with a similar facet on the ilium.

THE RIBS AND THORAX

The bony wall of the **chest** or **thorax** is made up of the breast bone, or sternum, on the midline in front, and the front of the dorsal vertebrae behind with twelve ribs on each side.

The **sternum** consisted at one time of numerous

pieces, as the sacrum did, which have coalesced into three called, from above downward, *manubrium, gladiolus,* and *ensiform* cartilage. It may conveniently be described as a single bone, large above, where it has at each corner, or angle, a saddle-shaped articular facet for the collar bone (clavicle), which is the only bony link between the trunk and the upper extremity, and tapering to an irregular point below. It is slightly convex in front and concave behind. Each lateral border presents pits for the reception of the cartilages which bind the seven true ribs to the sternum.

The **ribs,** twelve on each side, are much curved long bones known by number from above downward. The first seven articulate with the vertebral column and the sternum, and are hence known as *vertebro-sternal.* The next three are indirectly held to the sternum through attachment to the cartilage of the seventh, and have received the name of *vertebro-chondral;* while the last two are attached to the vertebral column alone and are called *vertebral.* A typical rib, like a typical vertebra, possesses certain characteristics common to all though varying in degree. Each has a posterior or vertebral, and an anterior, or sternal, extremity and a shaft with two surfaces and two borders. On the *vertebral extremity* there is a head with two articular facets, separated by a transverse ridge, for the two vertebræ and the intervertebral disk with which a rib articulates, a neck and a tubercle. The latter is also marked by a facet for the transverse process of the lower of the two vertebræ with which it articulates. The posterior part of the rib runs nearly outward, until beyond the tubercle, when it turns abruptly forward and downward, mak-

ing the bone curved in two directions; i. e., it is concave inward and less concave upward, or curved around a vertical and a horizontal axis. The *anterior extremity* is blunt and has a rather deep pit for the cartilage which binds it to the sternum.

The *shaft* has a round upper and a sharp lower border. Its outer surface, which is convex, is rough while the inner is concave, smooth, and marked near the lower border by a groove running three-fourths the length of the bone. Where the double curvature occurs, there is a ridge marking the *angle* of the bone.

The **first rib** is the most peculiar and important. It has only one facet on its head; its surfaces look nearly upward and downward and its borders inward and outward. On its upper surface are two grooves, separated by a slight ridge, for the subclavian artery and vein. Other ribs are also called peculiar, but only the eleventh and twelfth need be noted. They are called false or floating ribs because they are fastened at but one end. Each has a single articular facet and no pit for a sternal cartilage. The twelfth is the guide to the kidney.

The Thorax

The **chest** or **thorax** is a cone opened at the top with its base downward. The projection forward of the thoracic verterbræ makes a cross section of the cone heart-shaped. As the ribs increase in length from the first to the seventh and their anterior extremities are lower than the posterior, while the sternum is shorter than the thoracic part of the column, it follows that the chest is deeper behind than in front, and wider at

the bottom than at the top. The inclination of the ribs has an important bearing on the movements of the chest in breathing. The spaces between the ribs are called intercostal and are filled by soft tissue.

THE EXTREMITIES

The skeleton of the **upper extremity** consists of the *scapula* and *clavicle* forming the shoulder girdle; the *humerus,* the single bone of the arm; the *radius* and *ulna* of the forearm and numerous bones of the hand. That of the **lower extremity** consists of the *os innominatum* (nameless bone) forming the pelvic girdle; the *femur,* the single bone of the thigh; the *tibia* and *fibula* of the leg, and numerous bones of the foot.

The Shoulder Girdle

The **clavicle** or **collar bone** is a long bone and, like all bones of that class, has a shaft and two extremities, inner or sternal and outer or acromial. It runs almost horizontally outward from the upper end of the sternum to the acromion process of the scapula.

The *inner extremity* is rounded and marked by a saddle-shaped (that is concavo-convex) articular facet; the *outer,* flattened from above downward and marked by an oblong facet which faces outward and downward so as to rest on the acromion.

The *shaft* is prismoid for its inner two-thirds and flat for its outer one-third. It is convex forward for its inner two-thirds and concave forward for the outer third. The inferior face is marked by a depression, called rhomboid, where it is fastened to the first rib,

and a shallow groove, running outward, called subclavian. The upper face and anterior border are rounded, slightly rough and can be made out by the finger, except in the very fat, or are *subcutaneous*.

The Scapula.—This is an irregular, flat triangular bone, forming the posterior and bulkier part of the shoulder girdle. It has anterior and posterior faces; external, internal, and superior borders; superior, inferior, and external angles, a spine, acromion and coracoid processes.

The *anterior face* has one large hollow for lodging a muscle, while the posterior has two, the smaller above and the larger below the spine. These hollows are known respectively as the *subscapular, supraspinous* and *infraspinous fossæ*.

The *internal* or *vertebral* border is long, thin, and lipped. The *superior* is short, thin, and has a notch near its outer end. The *anterior* or *axillary* is thick and rough, giving attachment to several muscles.

The superior and inferior angles give attachment to muscles; but the external bears a pear-shaped articular cavity, the *glenoid*, which receives the humerus and with it forms the shoulder joint. The large end of the cavity is below and it is very shallow.

The *spine* starts near the vertebral border and, rising rapidly above the level of the bone, terminates in a triangular projection, the acromion process, which overhangs the glenoid cavity and protects the shoulder joint from violence directed from above and behind. The surfaces of the spine, looking upward and downward, form the floor of the supraspinous and roof

of the infraspinous fossa. The posterior border of the spine is thick, rough, and *subcutaneous.*

The *acromion* process has on its inner border the articular facet for the clavicle.

The *coracoid* process lies under the outer third of the clavicle, projecting like a crooked finger over the glenoid cavity from its upper inner aspect.

The Pelvic Girdle

The Os Innominatum.—The **innominate** or **nameless** bone, consisted, in fetal life, of three bones called *ilium, ischium,* and *pubis,* which are united in the acetabulum.

The *ilium* is the expanded upper part of the bone presenting an external surface which supports the great muscles of the hip and a smaller internal surface, also lodging muscles, and having the important function of forming a large part of the false pelvis. Surmounting the top of the bone is a sinuous *crest* which reaches its highest point about the junction of its anterior and middle thirds. This crest can be felt, except in the very fat, but is not subcutaneous. Many important structures are located by reference to the crest, whose extremities are called *anterior-superior* and *posterior-superior spinous processes.* Below each point is a smaller and less important process designated *inferior* spinous process—anterior and posterior.

The *ischium,* by the greater part of its outer face, forms three-fifths of the acetabulum, while its inner face forms nearly all of the lateral wall of the pelvis, notably its inclined plane. The posterior face is the back of the acetabulum. The lower part of the ischium

is called its tuberosity, upon which the weight of the body rest when one sits straight. The slender anterior piece of bone running up from the tuberosity and forming part of the boundary of the *thyroid* or *obturator* foramen, is called the ramus of the ischium.

The *pubis* forms the most anterior, internal and least massive part of the bone. Its *outer end* is the innermost part of the acetabulum, its inner, which is rough and irregular, forms the union between the two innominate bones *(symphysis pubis)*. The *posterior* face is the anterior wall of the pelvis, while the *anterior,* somewhat rough, gives attachment to several muscles.

Its *superior border* is broad and rounded and marked near the inner end by a prominent *spine* which is one of the most important points of departure in measurements around the hip joint, pelvis and abdomen. The *lower border* is an oblique groove which forms the upper boundary of the thyroid foramen.

The *acetabulum* (a vessel for holding vinegar) is analogous to the glenoid cavity of the scapula, but much deeper. Its bottom is a nonarticular notch and the lower inner part of the prominent rim is wanting. The articular part is the interior of the rim.

The *obturator foramen* is somewhat triangular, more so in women than in men, and is found between the body of the pubis above, that of the ischium externally and the rami of the two internally.

THE PELVIS

The deep cavity formed by the ossa innominate, sacrum and coccyx is the pelvis. The expanded flank

bones, or ilia seem to stop at a prominent ridge or line below which the pelvis, or deep basin, suddenly contracts. This line, extending along the top of the pubis, across the ilium and on to the sacrum, is called the ileo-pectineal. All that lies above it is the false and all below the true pelvis. The true pelvis is deepest behind and on the sides and very shallow in front. The posterior wall is the hollow of the sacrum, the lateral walls the inclined plane or inner face of the ischium, while the front is formed by the union of the pubic bones.

The opening from the abdomen, marked off by the ileo-pectineal line, is called the *inlet;* the lower, irregular opening, is the *outlet,* because the child in being born enters from above and passes out, or is born through the lower opening. It will be seen that the inlet is a dense ring of firmly united bones, while the outlet is made up of three deep notches, anterior and two lateral, with a flexible joint—between sacrum and coccyx—in the middle behind. The female pelvis is much more capacious than the male, is not so deep but wider, and the pubic arch is particularly wide.

The pelvic girdle binds the lower extremities to the trunk as the shoulder girdle does the upper. The former is designed to support the weight of the body, the latter to carry out a great variety of movements. The first is designed primarily for strength, the latter for grace and freedom. Hence it will be observed that the shoulder girdle is given all the strength consistent with perfect freedom of movement, while the pelvic girdle has all the freedom of movement consistent with great strength.

HUMERUS AND FEMUR

These bones have many features in common which should be compared. Both are long bones and, of course, each has a shaft and two extremities.

The Humerus

The *upper extremity* of the **humerus** has a nearly hemispherical head which looks upward, inward and backward, separated from the remainder of the bone by a circular groove called the anatomical neck. External to this are two tuberosities, internal or lesser and external or greater, separated by a deep vertical groove, the *bicipital.* Below the tuberosities the upper extremity diminshes to the circumference of the shaft, this portion being called the *surgical neck.*

The *lower extremity* is flattened and much wider from before backward than from side to side. A little above the termination of the bone a projection on each side, improperly called a condyle, inner and outer, presents strong subcutaneous attachments for muscles of the forearm. The inner of these tuberosities is much larger than the outer, while of the ridges leading upward from the condyles, the outer is the more prominent. The remainder of this extremity shows a rounded articular surface (capitulum humeri) for the radius outwardly and a trochlear surface for the sigmoid cavity of the ulna inwardly. A trochlea is a pulley; i. e., a depression with a ridge on each side, like the grooved wheel in which a sash cord runs. A deep depression behind and a shallow one in front, above the trochlea, receive the olecranon and cora-

noid processes of the ulna in extension and flexion, respectively, and bear the names olecranon and coranoid fossæ.

The *shaft* is somewhat three sided in the middle, circular above, and nearly flat below. The bicipital groove expands into the inner face; the outer has a rough impression for the deltoid muscle about half way down, while both posterior and outer are furrowed by a groove, the musculo-spiral which lodges a nerve of that name. The ridges bounding the bicipital groove are called internal or anterior and external bicipital ridges.

The Femur

The nearly spherical *head* of the **femur** is set on an oblique constricted projection of bone which corresponds to the anatomical neck of the humerus. This is called the neck of the femur and so supports the round head as to make it face upward, inward, and forward. The head has a little nonarticular depression near its center. The neck is shorter above than below and is flattened from before backward. Externally the neck terminates at a quadrilateral tuberosity called the great trochanter (meaning to turn) which projects above the neck, gives attachment to many muscles and is an important landmark about the hip, easily felt though not subcutaneous. Below and internal to the greater is a sharply prominent lesser trochanter. The two are connected by lines or ridges called intertrochanteric.

The *lower extremity* is much larger than the upper. A rough prominence on each side is called a tuberosity,

internal and external, while the bottom is occupied by two oblong, oval, convex articular projections called condyles. These are separated behind by a deep non-articular notch, the intercondyloid, and united in front by a trochlear surface for the patella. The extremity is somewhat flattened.

The *shaft* is bowed so as to be convex forward. It is so nearly cylindrical that borders are nearly indistinguishable except the posterior, called linea aspera (rough line) which gives attachment to a large number of muscles. It breaks up below into two lines which divide to bound a triangle called popliteal. Above the linea aspera runs to the trochanters in three divisions.

The femur is much larger than the humerus, its head more globular, its anatomical neck longer, all points showing it is designed for power and not mobility.

THE RADIUS

The **radius** is the outer and smaller of the two bones of the forearm and increases in size from above downward.

The *upper extremity* has a head consisting of a saucer-like cavity for the radial head of the humerus, surrounded by and continuous with an articular rim for the lesser sigmoid cavity of the ulna. Below this is a constricted neck, the smallest part of the bone and below and internal to this a tuberosity, the bicipital, rough behind and smooth in front.

The *lower extremity* has two articular cavities. The lowest is triangular, base inward, concave in both directions, while that on the inner side is longest from

before backward and is a mere articular strip. The lowest is the *carpal*, the inner the *sigmoid* cavity. Externally the bone terminates in a blunt point, the *styloid process*, easily felt and an important landmark at the wrist. The back of the lower extremity is marked by grooves, separated by ridges, for the passage of tendons.

The shaft is distinctly three sided with one sharp border, the internal or interosseous, where the membrane which binds it to the ulna is attached. The outer surface is rough and convex. The anterior has an oblique line across its upper third.

THE ULNA

The **ulna**, the large internal bone, decreases in size from above downward.

The *upper extremity* is made up of two processes, olecranon above and coranoid below, which form, anteriorly, a receiving surface for a trochlea, the great sigmoid cavity, that is a central ridge with a groove on each side, to fit the trochlea of the humerus. Each process terminates in a point which fits into the corresponding fossa of the humerus. The back of the olecranon is rough and subcutaneous. The outer face of the coranoid has a small cavity, the lesser sigmoid, continuous with the greater, for the rim of the radius.

The *lower extremity* consists of two processes. The one at the inner back part is a blunt point, the styloid process, which is subcutaneous and the most prominent landmark of the wrist. The outer elevation, sep-

arated from the styloid by a groove, is articular below and around its circumference. The rim fits into the sigmoid cavity of the radius, while a cartilage separates the lower face from the carpus.

The *shaft,* for its upper two thirds, is very triangular, showing a prominent posterior border, subcutaneous throughout, a sharp thin external or interosseous and an indistinct anterior border. The anterior and posterior faces are the best marked for muscular attachment.

THE PATELLA

The **patella** is a sesamoid bone developed in the tendor of the triceps extensor of the leg.

Its *posterior surface* corresponds to the anterior of the olecranon process; i. e., is the receiving surface for a trochlea. The large end of the bone is above and it terminates in a blunt point below. The *anterior* face is rough and ridged. The bone is in fact the olecranon process of the tibia.

THE TIBIA

The **tibia,** is the internal, and many times the larger, bone of the leg and the only one entering into the knee joint.

The *upper extremity* presents an inner and an outer tuberosity, the outer showing a facet for the fibula and the inner a groove for a tendon, supporting the glenoid cavities for the condyles of the femur. The inner cavity is oval and deeper than the outer, which is circular. Between the two is a short, thick bifurcated *spine.* Be-

low the cavities in front is the *anterior tubercle* of the tibia, rough below and smooth above.

The *lower extremity* is quadrilateral, but is prolonged downward on its inner face into an irregular process called the *internal malleolus*, whose inner face is rough and subcutaneous and forms an important landmark of the foot and ankle—opposite the malleolus there is a rough triangular depression for the fibula. The summit of the bone, articular and concave, a little wider in front than behind is called the tarsal cavity and receives the astragalus.

The *shaft*, like that of the ulna tapers from above downward and is three sided. Its anterior border, crest or shin, and its internal surface are both subcutaneous and much exposed to injury. The posterior face begins above in a triangle, base up, the popliteal, which is marked off by a ridge of the same name. Below it is narrower and less well marked. This surface is notable for carrying the largest of the nutrient foramina. The outer border is interosseous.

THE FIBULA

The *upper extremity* of the **fibula** is nearly globular, presenting a round articular facet internally and a rough, subcutaneous, nonarticular knob externally. The *lower extremity* has a pear-shaped articular surface, a part of the ankle, internally and externally the subcutaneous rough face of the *external malleolus*, as important a landmark as the internal.

The *shaft*, like the entire bone, is very slender. It fits opposite the tibia and is bound to it at each end

like the pin to a broach. It is so twisted that its borders and surfaces change places from above downward. Its chief function seems to be to support the outer side of the ankle.

THE HAND

The Carpus, Metacarpus, and Phalanges

The **carpus** is made up of eight irregular bones arranged in two rows, the upper of which forms the wrist joint while the lower presents a set of irregular articular facets for the metacarpus: First row, scaphoid, semilunar, cuneiform, pisiform; second row, trapezium, trapezoid, os magnum, unciform. The carpus is convex and rough on its dorsal surface and concave and rough on its palmar face. Above it presents a condyle, long diameter from side to side and convex in both directions. Inferiorly the most external facet is saddle-shaped for the metacarpal bone of the thumb while the facets for the remaining metacarpal bones are less regular in outline and show less freedom of movement.

The **metacarpus** is made up of five long bones known numerically from the outer side. They vary in appearance, the first, that of the thumb being short, thick and marked by a saddle-shaped facet above, that of the index finger, the second, being the longest, the third having a styloid process at its upper outer angle, the fourth none of these appearances, and the fifth being articular on only one side. The lower or distal extremity of each terminates in a rounded head com-

pressed from side to side, which is as large as, or larger than, the upper extremity.

The shaft is concave anteriorly and laterally and convex posteriorly.

The **phalanges** are fourteen long bones arranged in columns of three for each finger except the thumb. The one which articulates with a metacarpal bone is called a first or proximal phalanx, the next the second, and the last the third or distal.

The *upper extremity* of a first phalanx has a cup-like cavity for the head of a metacarpal bone.

The *lower extremity* shows a trochlea. The second phalanges would show a receiving surface for a trochlea above and a trochlea below; while the third has a receiving surface for a trochlea above, and below terminates in an irregular rough surface which supports the nail behind and the pulp of the finger in front. The *shaft* is convex posteriorly and concave anteriorly and decreases in length for each row.

THE FOOT

The Tarsus, Metatarsus, and Phalanges

The **tarsus** consists of seven irregular bones arranged in two rows from behind forward: os calcis and astragalus in the first row; scaphoid, cuboid and three, internal, middle and external, cuneiform bones in the second.

The **os calcis,** or heel bone, longer than the others, projects backward to form a lever on the bottom of which the weight of the body largely rests and which is used for raising that weight in walking. Above it

has two articular facets, separated by a groove, the sulcus calcanei, for the astragalus. Below it and on each side it is rough and nonarticular, the outer side convex, the inner concave and the lower marked by anterior and posterior tubercles. In front there is a concavo-convex articular surface for the cuboid.

The **astragalus,** a nearly square bone, has five articular faces, three of which are continuous. The upper face is convex from before backward, wider in front than behind, continuous with the lateral articular facets which, with it, form a blunt wedge fitting into a sort of mortise formed by the tibia and fibula. The facet for the latter is pear-shaped, large end below, and much larger than that for the tibia. In front of the upper facet is a constricted neck. The *anterior extremity* is an articular head for the scaphoid. The lower surface is divided into a large, posterior, concave, and a small anterior convex facet for the os calcis, separated by a groove called *sulcus tali,* which forms, with the sulcus calcanei, the *sinus tarsi* when the bones are articulated. The thin posterior extremity is marked by an oblique groove.

The **cuboid** is wedged in between other bones, having the os calcis behind, fourth and fifth metatarsals in front, and the scaphoid and external cuneiform to its inner side. Its *lower face* has a deep groove and a prominent ridge, both called peroneal, the outer end of which can be felt about the middle of the outer side of the foot. Its *upper surface* is rough; its *posterior surface projects* partly under the os calcis. There are two articular surfaces on its anterior extremity and usually but one on its inner face.

The **scaphoid,** supposed to be boat-shaped, is concave posteriorly for the astragalus, convex and marked by three wedge-shaped facets in front for the cuneiform bones, and rough and convex on its remaining aspects. Internally it terminates in a blunt tuberosity, forming an important landmark on the inner face of the foot.

The three **cuneiform** bones are known from within outward as first, second, and third; or internal, middle, and external. They are all wedge-shaped but the first, which is the largest and less regularly so than the others. The first also has its large end downward while the others have the longest side upward. The first can be felt on the inner side of the foot and it and the other two on top. Behind they all articulate with the scaphoid while in front each supports a metatarsal bone, the internal the first, the middle the second and the external the third. All touch the second.

The **metatarsal** bones, like the metacarpal, are five in number and are named numerically from the inner side. They resemble the similar bones of the hand but can be distinguished from them by the facts that the shafts taper from back to front and the head or distal end is much smaller than the base. The first metatarsal is much larger than the first metacarpal and has a concave facet instead of concavo-convex on its proximal end.

The **phalanges** are also like those of the hand in number and general arrangement, but differ from them in having shafts so short that they form mere connecting links between the articular extremities.

The foot, as a whole, is concave on its lower or

plantar aspect both from side to side and from before backward, forming an arch which makes the chief weight rest on the posterior tuberosities of the os calcis and the ball of the big toe.

THE HYOID

The **hyoid** is a small but most important bone lying in the neck. The base of the tongue, the larynx, and pharynx are fastened to it. It is shaped something like a horseshoe, but the toe or front of the shoe is thick and strong, forming the body of the bone, while the slender heels stick out behind like horns. If the neck is grasped, just above the Adam's apple, between the thumb and index finger the outline of the body and horns can be easily discerned.

THE SKELETON OF THE HEAD

The head is rather arbitrarily divided into the cranium or upper part, and the face, or front. There is no sharp line of demarcation between the two. There are eight bones in the head and fourteen in the face. Those of the head are occipital at the back, frontal in front, a parietal on each side connecting the first two, a temporal on each side connecting the top and base which is formed by the ethmoid and sphenoid with parts of the frontal and occipital.

In the face two superior maxillary, two malar, two nasal and one inferior maxillary form the visible bones which can be felt in the living being, while a lachrymal in each orbit, a palate, forming the back part of the nose and mouth, an inferior turbinate in each nos-

Fig. 4.—Front view of skull.

tril and a vomer between the nostrils complete the number.

The top of the skull is made up of the frontal, the two parietals, and part of the occipital. Where the occipital and the parietals should meet, an opening is found in the newborn called the posterior fontanelle and a similar space is found at the junction of the parietals and frontal, the anterior fontanelle.

The face shows the sloping frontal bone above and below the eye sockets (orbits) one on each side of the projecting nose, formed by the nasal and nasal processes of the superior maxillary bones. Below the nose comes the opening of the mouth, containing thirty-two teeth, if all are present, whose roof is formed in front by the horizontal part of the upper maxilla and behind by a similar process of the palate, and front and sides by the lower jaw but whose floor is wanting. On each side of the nose, at a little distance from it, is the prominence formed by the cheek or malar bones, leading along a subcutaneous ridge, the zygomatic arch, to the temporal bone just in front of the external auditory meatus, the most important appearance on the lateral aspect of the skull. A large depression in front of this opening is the temporal fossa. The superior maxilla, next to the largest bone of the face, is hollow and its cavity, the antrum of Highmore, communicates with the nasal cavity, so that disease may readily extend from nose to antrum. The nasal cavity has a part of its roof formed by a sieve-like piece of the ethmoid, so there is a very thin wall between the nose and the brain cavity. The inner wall of each nasal cavity is flat and formed chiefly by the vomer.

The outer wall has three projecting shelves of bone (the turbinates) striking into it, so that this wall is very irregular and complex.

The orbits are two four sided pyramids laid flat, whose apices point inward and backward and whose nearly circular bases open on the face. The apex of each is formed by the optic foramen, through which the nerve of sight passes from the cranium to the orbit. The sides of the pyramid are known as roof, floor, inner and outer walls. The inner wall is made of very thin bone separating the orbit from the nasal cavity and skull, with both of which it communicates. The opening into the nose is the canal for the nasal duct, by which the excess of tears is carried into the nose to moisten respired air.

The **inferior maxilla** is the only bone of the face with articular surfaces. It is U-shaped and turned up at the back to form two rami which terminate in a condyle behind, and a coronoid process, for muscular attachment, in front. The body has sockets for sixteen teeth.

If the top of the skull be sawed off so as to expose the interior, the under surface of the vertex, or upper wall, and the upper surface of the base can be seen. The interior of the skull is marked by numerous furrows spreading, like limbs, chiefly from a hole in the sphenoid by which the chief artery for the skull and its membranes enters. There are, besides, broader but shallower depressions, separated by slight ridges, which lodge the convolution and sulci of the brain. A large straight groove runs from the front to a projection called anterior occipital protuberance at the back,

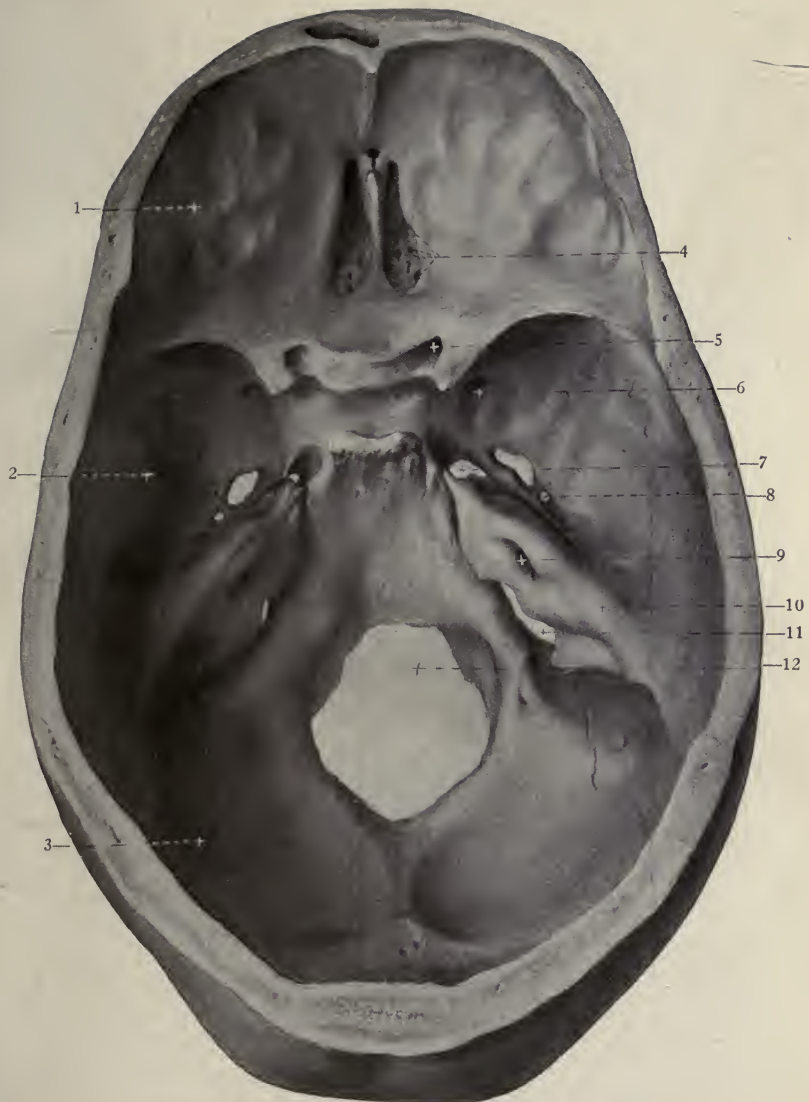

Fig. 5.—Base of skull, upper surface. 1, Anterior fossa; 2, Middle fossa; 3, Posterior fossa; 4, Cribriform plate; 5, Optic foramen; 6, Foramen rotundum; 7, Mid. lacerated foramen and carotid canal; 8, Foramen spinosum; 9, Internal auditory meatus; 10, Eminence of semicircular canal; 11, Jugular foramen; 12, Foramen magnum.

Fig. 6.—Base of skull, lower surface.

which lodges a chief element in the venous circulation. This is joined at right angles on the occipital bone by similar and deeper grooves. These lodge what are called the longitudinal and lateral sinuses.

The *upper surface* of the base of the skull is divided into three spaces, each lower than the preceding, known as anterior, middle and posterior fossæ of the skull. The anterior is formed mainly by the horizontal part of the frontal and the ethmoid, the middle by the body and great wings of the sphenoid and the temporal, while the posterior is chiefly formed by the occipital, but has contributions from the temporal. Each fossa lodges a corresponding part of the brain and each has openings through which the cranial nerves find exit from, and blood vessels entrance to, the skull. In the midde fossa a bulge on the petrous part of the temporal shows the proximity of the ear to the brain, from which it is separated by a thin shell of bone. The anterior fossa shows openings for the first nerve and the *optic foramen* for the second. The middle fossa has the *anterior lacerated* foramen and the *foramen rotundum;* the posterior, the *foramen magnum* and the *jugular foramen.*

The *lower surface* of the base shows the roof of the mouth, ending in the *hard palate* behind, just above which are the *posterior nares.* Behind this is the *basilar* process of the occipital and, behind that, the *foramen magnum* with a condyle on either side. Laterally are seen the *foramen ovale,* the opening for the entrance of the carotid artery and the *jugular foramen* for the transmission of numerous nerves and the jugular vein.

CHAPTER III

ARTHROLOGY

Arthrology is the study of the joints, more particularly of those which are movable.

When bones are united by interlocking processes of bone, as in the skull, the joint is called a *synarthrosis*. These are immovable joints.

When the union is by fibrous tissue separating the bones and permitting movement only by twisting the fibers, it is called *amphiarthrosis* or slightly movable joints, as between the bodies of the vertebræ.

When two smooth articular surfaces are bound together by ligaments, usually exterior to the joint, it is a *diarthrosis* or freely movable joint. Every joint belongs to one of the three classes. Synarthrodial joints are confined to the skull; amphiarthrodial to the vertebral column, pelvis, hand, and foot. The other joints are diarthrodial.

DIARTHRODIAL ARTICULATIONS

Of these there are six varieties:

Arthrodial, formed by flat surfaces with very slight motion often in many directions. Example: That between articular processes of vertebræ.

Ginglymoid, hinge or trochlear, where motion occurs freely but in only two directions. Example: Elbow, knee.

Condyloid, formed by a condyle and a proper receiv-

ing cavity. Example: Wrist, occipital condyles, and cavities of atlas.

Saddle-shaped, or *concavo-convex,* or joints by reciprocal reception. Example: Sternoclavicular.

Pivot, or **trochoid,** when one bone revolves around another. Example: There are but two, atloaxoid and radioulnar.

Ball and **socket,** or **enarthrodial,** when a cup-like cavity receives a rounded head. Example: There are but two, shoulder and hip.

The movements of which joints are capable appear innumerable, but are really limited to eight.

Gliding, most marked in arthrodial joints, where it is the only movement, but present in all diarthrodia.

Flexion, movement usually forward but sometimes backward.

Extension, the reverse of flexion.

Abduction, movement away from a midline, usually that of the body.

Adduction, movement toward a midline.

These are called the four angular movements and when performed in succession, in any order, produce the sixth movement called

Circumduction, which may be inward or outward.

Revolution, where one bone revolves around another. It occurs only in pivot joints.

Rotation occurs only at the shoulder and hip and is made by turning the arm or thigh inward or outward around an axis drawn from the center of the head of the bone to the internal tuberosity at the lower end.

ARTICULATIONS OF THE VERTEBRAL COLUMN

The vertebræ articulate by their bodies and articular processes and have ligaments binding other parts which do not touch. The joint between the bodies is an amphiarthrosis effected by a disk of fibrocartilage which performs the triple function of binding the bones together, lengthening the column and furnishing a cushion between each pair of bones to lessen shock. Movement can take place by twisting the fibers, or by compressing the disk on one side while it is stretched on the other. Running the length of the column both on the front and back of the bodies is a bundle of fibers forming the *anterior* and *posterior common ligaments* of the spine. That on the front is the stronger. That on the back runs in the spinal canal. Ligaments are also found between spines and attached to their points, called interspinous and supraspinous. Capsular ligaments surround the articular processes.

As the **atlas** has no body, there is no intervertebral disk between the first and second cervical vertebræ. A very strong band is attached to the inner face of each lateral mass and encircles the odontoid process, forming the *transverse* ligament. *Capsular* ligaments surround the articular processes and a continuation of the anterior common ligament passes to a tubercle on the front of the atlas.

The *odontoid* process has a diverging bundle running from near its summit to the margin of the foramen magnum on each side. These are the *check* ligaments because they prevent too much turning of the head. A part of the posterior common ligament extends from the body

of the axis over the odontoid process to the anterior margin of the foramen magnum.

The atlas is held to the occipital bone by *capsular* ligaments around the anterior processes, by thin membranes running from the anterior and posterior arches to the corresponding margins of the foramen magnum and by a continuation of the anterior common from the tubercle of the atlas to the occipital in front of the foramen magnum.

Throughout the column the numerous and powerful muscles of the back are powerful means of binding the bones together.

The ligaments binding the last lumbar vertebra to the sacrum are practically identical with those between the lumbar vertebræ.

A capsular ligament is a bag made of white fibrous tissue whose top and bottom are formed by the opposed articular surfaces of the bones. The latter are covered by encrusting cartilage and the whole is lined by a *synovial* membrane furnishing the fluid which lubricates the joint. All synovial membranes are protected by more or less complete capsules; but the fibers in some joints are so much thicker in some parts than in others, that they are spoken of as if they were separate ligaments, though always blended with the capsule.

Movements.—The head rocks backward and forward on the condyles which move in the receiving cavities of the atlas. There is some lateral movement also. Movement forward is flexion, backward, extension. At the atloaxoid joints, the atlas alone moves. It revolves to either side around the odontoid process, the articular

process of the side to which movement is made gliding backward, and the other forward.

Bending the body forward is flexion; backward extension; to either side, right or left lateral flexion. In forward movement the front of the intervertebral disks is compressed and the supraspinous and interspinous ligaments stretched, the inferior articular process of each vertebra gliding upward. The reverse takes place in extension. The corresponding mechanism would produce lateral movement. The performance of each of these movements in succession would be circumduction.

COSTOVERTEBRAL ARTICULATIONS

The ribs are held to the vertebral column by a three pronged bundle running to each of the vertebræ with which the rib articulates, and to the intervertebral disk, from the front of the head; by a small band between the ridge on the head of the rib and the intervertebral disks; by capsular ligaments surrounding the articular facets; and by strong fibers running from the back of the neck of the ribs to the front of the transverse processes and capsular ligaments surrounding these articular facets.

Movements.—The lower anterior end of the ribs moves upward, revolving on an axis formed by the transverse processes. This thrusts the sternum forward and increases the diameters of the chest.

ARTICULATIONS OF THE CLAVICLE

The clavicle articulates with the sternum by a saddle-shaped joint. An *interarticular* plate of cartilage is

interposed between the bones, attached at the top of the clavicle and at the bottom of the receiving cavity. A capsule surrounds the joint. A strong bundle extends from the cartilage of the first rib to the rhomboid impression of the clavicle.

The clavicle articulates with the acromion process of the scapula by an arthrodial joint. Sometimes there is a cartilage between the bones and a capsule always binds them together. This is a very poor security, so the joint is reinforced by powerful fibers which run upward from the coracoid process where the clavicle crosses it to the under surface of that bone. These fibers are described as the conoid and trapezoid ligaments because the shape is different. Viewed from behind they form a cone, from in front, a trapezium.

Movements.—The clavicle can move freely in any direction at either end, though the range of movement is limited. At the inner end the least degree of movement is upward, as in lowering the shoulder. In all movements the shoulder is carried in a direction opposite that in which the head of the clavicle moves. At the outer end the scapula is the more movable bone.

THE ENARTHRODIAL JOINTS

These are but two, the shoulder and hip. In each the receiving cavity is deepened by a fibrocartilage surrounding the margin of the cavity and called the *glenoid* ligament, but the glenoid ligament of the hip is the stronger and deeper and has to bridge the gap at the lower inner acetabular rim. Each has, as almost its only ligament, a strong capsule thickened at certain

points; but the capsule of the shoulder is long and permits a wide separation of the bones, while that at the hip holds the femur in close contact with its cavity.

The **capsule** at the **shoulder** is attached around the anatomical neck of the humerus; that of the hip is fastened just internal to the trochanters, so that all the neck of the femur is in the cavity of the joint. The strengthening bands of the shoulder are unimportant; one of those at the hip, the **Y ligament,** having its tail fastened to the inferior anterior spine of the ilium and its spreading limbs to the anterior intertrochanteric line, is, surgically, of the highest importance. A round bundle, ligamentum teres, running from the head of the femur to the bottom of the acetabulum is peculiar to the hip. Each joint has an extensive synovial membrane which, as elsewhere, lines the interior of the capsule as well as covers the bones. Each is greatly strengthened and protected by surrounding muscles; but the shoulder is more dependent upon this "ligamentous action of muscles" than the hip. Each possesses great number and range of movements, though the range is much greater at the shoulder; and in each the movements can be described in nearly identical words.

Movements.—Flexion in both cases is movement forward. At the shoulder the head of the humerus spins around an axis drawn from the great tuberosity through the center of the head; at the hip the axis is drawn from the great trochanter. *Extension* is the reverse of flexion. *Abduction* is movement of the arm or thigh away from the midline of the body, the head gliding down in either case, pressing on the inferior fibers of the capsule ligament, rupturing it and being dislocated if exaggerated.

Adduction is the reverse. *Circumduction* is the successive performance of these four angular movements. *Axial rotation,* performed at these two joints alone, is movement, inward or outward, causing the whole bone to spin around an axis drawn from the center of the head to the inner tuberosity, or condyle.

THE GINGLYMOID OR HINGE JOINT

The chief hinge joints are the elbow, knee, ankle, and interphalangeal. They are so dissimilar that separate descriptions of each must be given.

The radius and ulna both enter, with the humerus, into the **elbow joint.** These bones of the forearm are held together above by an encircling ligament, the orbicular, attached at each end of the lesser sigmoid cavity and binding the radius firmly to the ulna. Below anterior and posterior fibers extend between the two bones and a triangular cartilage, attached by its base between the two articular cavities and by its apex to a pit between the two processes of the ulna, at once binds these bones together and cuts the ulna out of the wrist joint. The shafts are bound together by a thin but strong membrane attached to their interosseous ridges. This firm binding of the two bones together keeps the radius from independent action at the elbow. In revolving around the ulna it spins on the humerus, but it must follow the ulna in movement of the elbow joint.

The chief ligaments concerned in the elbow joint are the *internal* and *external* lateral. The first is the strongest. It is attached by its apex to the inner condyle and by its base to the olecranon and coronoid processes

where they form the margins of the great sigmoid cavity. The external is fastened above to the outer condyle and below to the orbicular ligament, not touching the radius as it would interfere with it in revolution. The anterior and posterior are hardly more than fibers of the capsular ligament, the work of these ligaments being performed by muscles. The synovial membrane lines the superior radioulnar joint as well as the elbow.

Movements.—Flexion, movement forward, and extension are the only movements. The joint is not a straight line, owing to the greater length of the inner ridge of the trochlea, and the movements are not straight. In extension the foramen is carried away from the midline making an angle open outward.

The **knee joint** is the largest and most complex in the body. The condyles of the femur rest on the glenoid cavities of the tibia and are bound to it by ligaments both inside and outside the joint, and the patella plays on the trochlea connecting the condyles. The cavities of the tibia are deepened by glenoid ligaments, but these rest on the tibia without being directly attached to it and, consequently, participate in the movements and accidents of the joint.

The interior ligaments, called *crucial,* are two in number and are attached, the *anterior* in front of the spine and to the outer side of the condyloid notch, the *posterior* behind the spine and to the inner side of the same notch.

The *external lateral* is fastened to the outer tuberosity above and below, in two bundles, to the styloid process and head of the fibula.

The *internal lateral,* broader and somewhat triangular, seizes the inner tuberosity of the femur above and below

spreads out over the inner tuberosity and upper part of the shaft of the tibia.

The patella is enveloped, except on its posterior face, in the tendon of the great extensor of the leg. The lower part of this tendon runs from the lower end of the patella to the lower part of the anterior tubercle of the tibia, supplying the place of *an anterior* ligament. It is called ligamentum patellæ.

The *posterior ligament* is, in the main, the expanded tendon of the semimembranous muscles, inserted into the tibia below and passing upward to seize the femur between and above the condyles.

The *synovial* membrane is very extensive, lining the interior of all the ligaments except the crucial which it covers and excludes from the synovial cavity, running under the glenoid ligaments and communicating with bursæ around the joint. Bursæ are synovial sacs, like water bags, placed under many tendons around joints. They are very numerous around the shoulder, knee and hip. They contain synovia. Some do not communicate with joints and contain mucus.

Movements.—Movement *backward* is flexion. The leg is carried upward against the thigh, the glenoid cavities moving backward on the condyles and the patella gliding downward on the trochlea. The reverse is extension. The greater length of the internal condyles causes some rotation in these movements, inward in flexion, outward in extension.

The **ankle** is a peculiar form of hinge. The oblong hole a carpenter makes to receive a suitable projection of timber is called a mortise. The projection is called a tenon. In this joint the tibia and fibula furnish the

mortise, the astragalus, the tenon; both are wider in front than behind.

The *internal lateral* or *deltoid* ligament is a thick strong bundle attached above to the inner malleolus and below, by its base, to the astragalus, os cacis and scaphoid. It binds these bones of the foot together in addition to being the strongest ligament of the ankle.

The *external lateral,* arising from the outer malleolus, splits into three fasciculi, or bundles, which are attached in front to the astragalus, in the middle to the os-calcis and behind to the astragalus.

The *anterior* and *posterior* are nearly negligible as ligaments, but the place of a posterior is supplied by the great extensor of the foot, called tendo Achilles. A synovial membrane lines all the structures.

Movement.—Flexion brings the back of the foot up toward the leg and forces the tenon backward in the mortise. Extension is the reverse, pointing the toes downward and, by bringing the narrowest part of the tenon into the broadest part of the mortise, allows slight lateral play and places the joint at great disadvantage as to sprains.

THE CONDYLOID ARTICULATIONS

The joints of this variety are the wrist, temporo-maxillary, occipito-atloid and metacarpo-phalangeal.

The **condyle** of the **wrist** is furnished by these bones of the first row of the carpus, scaphoid, semilunar and cuneiform; the cavity by the lower end of the radius and the cartilage which cuts the ulna out of the joint.

Ligaments called **anterior, posterior, internal** and **external** lateral unite with each other to form a capsule

and are attached to the radius chiefly above and the first row of the carpus below.

Movements.—Condyloid joints have all movements except axial rotation. In every movement the condyle glides in a direction opposite that taken by the part moved; i. e., if the hand moves inward the condyle moves outward, etc.

The **temporo-maxillary** joint is a condyle on each side and a *glenoid* cavity formed on the squamous part of the temporal bone. An interarticular cartilage lies between the bones and moves with the condyles. A *capsular* ligament strengthened particularly on the outer side, where it is called the *external lateral* ligament, binds the bones together. Some bundles of cervical fascia are also classed as ligaments.

Movements.—The jaw moves upward in crushing food, downward in opening the mouth, and alternately to each side in grinding food. In the latter movement the condyles glide alternately backward and forward; i. e., if the jaw is trust to the left, that condyle goes backward and the right forward.

In the **metacarpo-** and **metatarso-phalangeal** joints the long diameter is from before backward while the receiving cavity is almost circular. The chief ligamentous action is exerted by the extensor-tendons on the back and a fibrocartilaginous mass connected with the flexor tendons on the front. This is true also of the interphalangeal joints of both hand and foot. These are trochlear or hinge articulations.

Movements.—At the metacarpo- and metatarso-phalangeal joints some lateral movement is permitted, particularly at the joints on the free (i. e. outer and inner) sides

of the hand and foot. The interphalangeal joints can perform only flexion and extension. Flexion is forward in the hand and downward in the foot.

The **intercarpal** and **carpo-metacarpal** joints are arthrodia bound together by *dorsal* and *palmar* ligaments and, on the free borders, by *lateral* ligaments as well. This is not true of the metacarpal bone of the thumb and the trapezium, which is a *saddle-shaped* joint with a *capsular* ligament.

The **intertarsal** joints are much larger than the intercarpal. The astragalus and os calcis are mainly bound together by fibers filling the sinus tarsi and form the first row of the tarsus. The second row is held together by dorsal and plantar ligaments and is held to the first by very strong plantar ligaments which pass from the os calcis to the cuboid and the scaphoid. These ligaments are very important in maintaining the arch of the foot.

The **tarso-metatarsal** joints are so similar to the corresponding joints of the hand that no separate description is needed.

PELVIC LIGAMENTS

The pubic bones are bound together by a plate of fibrocartilage between their inner ends and by ligaments above, below, behind, and in front. The sacrum is united to the ilia by anterior and posterior fibers, of which the latter are much the more powerful. A very large bundle is attached to the side of the sacrum and coccyx by one end and splits to seize the spine and tuberosity of the ischium at the other, closing the deep

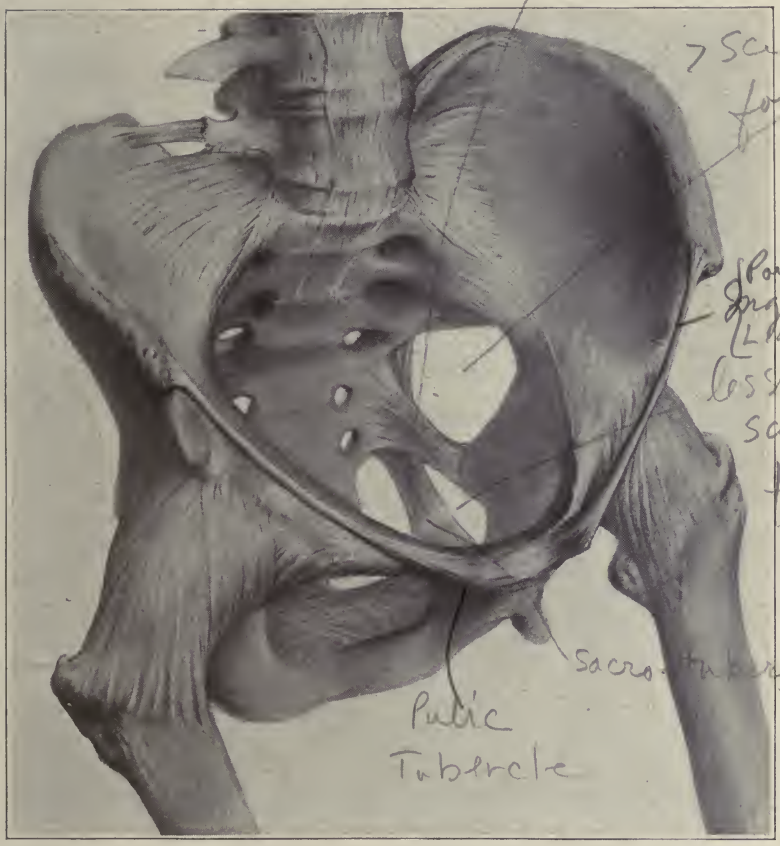

Fig. 7.—Pelvic ligaments and capsule of hip.

gap between sacrum and ischium and converting the sciatic notches into the sciatic foramina, greater and lesser.

A membrane called the triangular ligament fills the space between the ischio-pubic rami while a similar membrane, the thyroid, fills all but the top of that foramen.

CHAPTER IV

MYOLOGY

Muscles are striated or nonstriated. In the study of myology only the striated are considered.

Muscles lie beneath the skin and superficial fascia in all parts of the body and beneath a special membrane called the deep or investing fascia in some parts. These fascias are studied with the muscles. The superficial fascia lies just beneath the skin, which it enables to move freely, and carries the greater part of the body fat and the superficial blood vessels and nerves. As it has no bony attachments, it permits collections of fluid or air to spread widely through or beneath its meshes. The deep fascias, most pronounced in the neck and upper and lower extremities, seek attachment to bone at every opportunity, and hence limit the spread of any accumulation beneath them. They also send down septa between muscles and groups of muscles, by which the area for muscular attachment is greatly increased without adding to the weight of the body, as a corresponding increase of bone would.

Muscles are sometimes spread out in broad sheets, but are more frequently gathered into large bundles of varying shape and direction. As their function is to produce movement of some sort, they run over movable joints and are fastened on either side of one or more such joints. These attachments are spoken of as the origin and insertion, the least movable point usually being the origin. These attachments take place through

long or short masses of white fibrous tissue called tendons. Sometimes the tendinous fibers are imperceptible to the unaided eye, when the attachment is said to be *fleshy;* in other cases some tendinous fibers can be seen and this is called a musculo-tendinous attachment. In still other cases the tendon is spread out in a thin sheet when it is called an aponeurosis.

Muscular nomenclature is very difficult, because there are so many muscles and the names have been derived from such a variety of sources. Those producing angular movements are flexors, extensors, abductors and adductors. Others are named from the direction of their fibers, shape, from points of attachment, etc.

As the physiologist seldom pays attention to the action of individual muscles, the anatomist spends an unusual amount of time on this subject. Muscles act very much as a stretched piece of rubber does; that is, by getting shorter and thicker. If a movable joint is between the attachments, such shortening will bring the two bones nearer together; or, if a cavity is beneath the muscle, and the bones do not move, the size of the cavity will be diminished. If, therefore, the points of attachment are given and the joints are known, the chief function of a muscle may be inferred.

It makes little difference at what point the study of the muscular system is begun. In actual practice it is convenient to begin with the abdominal wall because one can sooner see and study the abdominal viscera.

THE ABDOMINAL MUSCLES

This group consists of three pairs of broad and two of smaller muscles. The broad, and one pair of slender,

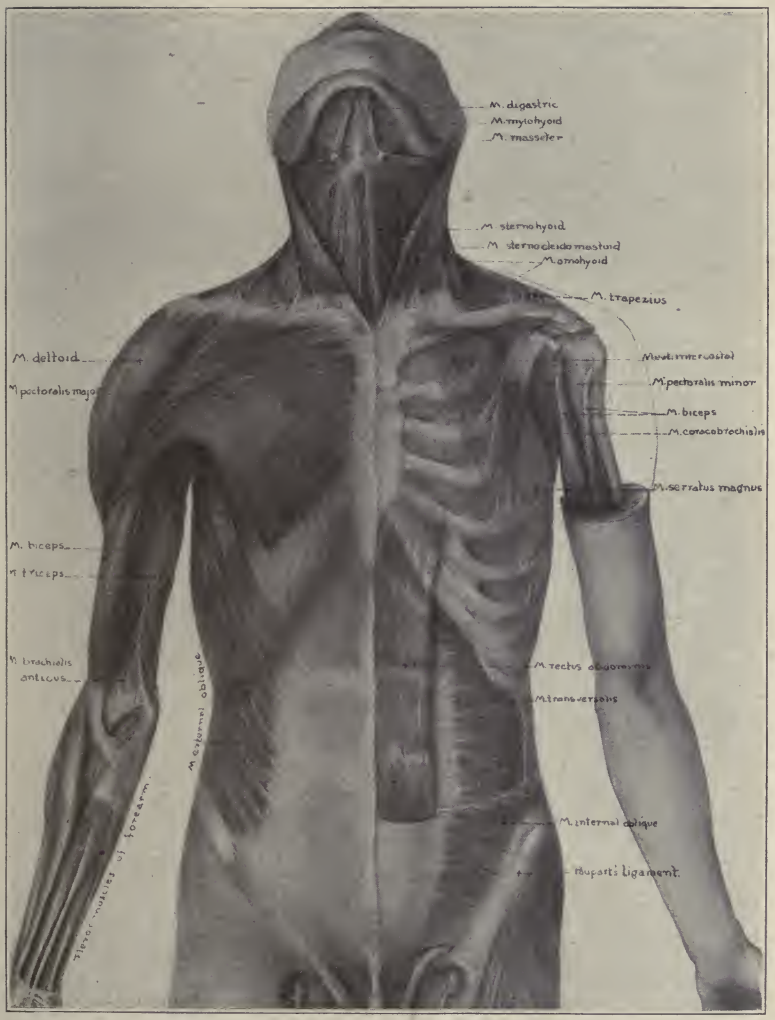

Fig. 8.—Muscles. Front of neck, trunk, and upper extremity.

muscles are named from the direction of their fibers—two oblique, one transverse, and one straight. The remaining pair receive their name from their shape—pyramidal.

The oblique muscles are *external* and *internal* and beneath them is the *transverse*. The fibers of the *external oblique* run downward and inward; of the *internal oblique,* upward and inward, and those of the *transversalis* run around the body from behind forward. It is evident that this arrangement makes a net work of fibers around the abdomen so that, when the muscles shorten, or contract, pressure is made on the contents of the abdomen in various directions.

The **external oblique** arises from the eight lower ribs and is inserted into the crest of the ilium and spine of the os pubis. The part of the tendon stretching from the anterior superior spine of the ilium to the pubis is called Poupart's ligament and is free between its points of attachment. The remaining fibers are inserted into the *linea alba.* This is a thickened mass of fibers stretching from the ensiform cartilage to the symphysis pubis made up of fibers from all the broad muscles of the abdomen.

The **internal oblique** is attached below to the outer part of Poupart's ligament and the crest of the ilium. Above it seizes the four lower ribs and the whole length of the linea alba and the crest of the pubis.

The **transversalis** rises from the outer half of Poupart's ligament, the crest of the ilium, the spines of the lumbar vertebræ and from the inner faces of the six lower ribs, and is inserted into the linea alba and the crest of the pubis.

Rectus abdominalis

The **recti** are flat muscles arising from the front of the symphysis pubis and its crest and inserted into the fifth, sixth, and seventh ribs beside the sternum. These muscles lie on either side of the linea alba and are enclosed in a sheath furnished by the aponeuroses of the broad muscles.

The **pyramidalis** lies in the sheath of the rectus, is sometimes wanting and rather unimportant.

Opposite the spine of the pubis there is a hole in the aponeurosis of the external oblique which transmits the round ligament in the female and the spermatic cord in the male. It is called the superficial abdominal ring.

The abdominal wall is thus seen to consist of skin, superficial fascia which contains much fat, the external oblique, internal oblique, transversalis, a delicate fascia like the superficial, and a sort of internal skin called the peritoneum.

Action.—By contracting, these muscles decrease the size of the abdominal cavity, compressing its contents and expelling parts of them through the openings provided for the purpose—urethra, rectum and vagina. They can also bend the body on the pelvis or the pelvis on the body.

The **diaphragm**, the great respiratory muscle, is a thin dome, when in position, though shaped like a palm-leaf fan when cut out and spread flat, separating the thoracic from the abdominal cavity. The floor of the thorax is, therefore, convex and the roof of the abdomen concave.

The muscle springs from the inner faces of the six lower ribs, where it interlocks with the transversalis, and by two long tendons, which leave a space between

them for the abdominal aorta, from the bodies of the lumbar vertebræ. Between the last rib and the side of the spine two tendinous arches, called ligamenta arcuata interna and externa, give origin to fibers which fill in what would otherwise be a gap in the muscle.

The insertion is into a central tendon, shaped something like a clover leaf, and called trefoil. It follows that the fibers proceed in different directions. Those from the ribs are directed upward and inward, those from the vertebræ, upward and forward, all convex upward and outward or backward.

The diaphragm allows structures to pass from the thorax to the abdomen either through or behind it. The aorta passes with the thoracic duct and other structures through the aortic opening which is behind. The opening for the esophagus is above and in front of the aortic and that for the inferior vena cava is in the central tendon and still higher up.

Action.—If the ribs are fixed when the diaphragm contracts, the whole muscle is pulled downward. At the same time the curved fibers become straight, leaving a greater interval between them and the ribs. All this increases the size of the thorax. The muscle is the great agent of inspiration.

THORACIC MUSCLES

Two muscles, pectoralis major and minor, occupy the front of the chest; the serratus magnus, the sides; and the intercostals, the spaces between the ribs. Except the latter, these are as much muscle of the upper extremity as of the trunk.

The **pectoralis major** occupies the front of the sternum, a part of the clavicle and five of the ribs. It is inserted into the outer bicipital ridge of the humerus.

The **pectoralis minor** springs from the third, fourth and fifth ribs and is inserted into the coracoid process of the scapula.

The **serratus ~~magnus~~** anterior springs from the eight upper ribs and, running between the scapula and the thorax, is inserted into the posterior border of the scapula.

Action.—They all tend to draw the upper extremity toward the midline, i. e., they are adductors, or act from their insertion. They tend to draw the ribs apart and expand the chest.

MUSCLES OF THE CERVICAL REGION

Except the platysma, these muscles are enclosed in a deep or investing fascia, the **cervical,** which fastened to the spines of the vertebræ behind, runs around the entire neck like a high stock, and is fastened behind where it started. Above, it is fastened to the lower jaw, and below, to the clavicle and to structures in the thorax. It not only binds everything in the neck in an envelope, but sends off partitions which form sheaths for muscles and blood vessels.

The **platysma myoides** is a thin muscle spreading over the sides of the neck beneath the superficial and above the deep fascia. Deeper than this muscle, in a sheath of the deep fascia, lies one of the most important muscles of the body, **sterno-cleido-mastoid** whose name indicates its attachment. It arises from the clavicle and sternum and, running upward and backward across the

side of the neck, is inserted into the mastoid process of the temporal and the occipital bones. It can be felt throughout its course.

Action.—The two bow the head, or either, acting alone, can pull the head toward the shoulder and turn the face to the opposite side.

The hyoid bone separates the next layer into two groups distinguished as *suprahyoid,* or *elevators,* and *infrahyoid,* or *depressors* of the hyoid bone.

Two of the depressors, **sterno-hyoid** and **sterno-thyroid,** spring from the back of the sternum and are inserted into the body of the hyoid and wing of the thyroid cartilage respectively. A short muscle called **thyro-hyoid** continues the latter to the hyoid.

The **omo-hyoid** runs nearly inward from the upper border of the scapula, forms a central tendon which plays through a loop of fascia which binds it to the first rib, then turns nearly upward to reach the hyoid.

Two of the *elevators* of the hyoid, **genio-** and **mylo-hyoid,** are attached to the lower jaw and the hyoid bone; one the **digastric,** is double bellied and is pulled down to the hyoid by a loop of fascia, being fastened at one end to the temporal bone and the other to the lower jaw. The stylo-hyoid may be omitted. The mylo- and genio-hyoids aid in forming the floor of the mouth.

Action.—These muscles can either elevate the hyoid bone or depress the lower jaw.

A deeper group, of which the **scaleni** and **recti** are the most prominent, are flexors, anteriorly or laterally, of the vertebral column, or, like the scaleni, elevators of the upper ribs and inspiratory agents.

MUSCLES OF THE HEAD AND FACE

The **muscles of expression** are a group of small muscles usually attached to bone at one end and the skin of the face at the other. Their contraction causes a change of expression.

Among the important muscles of this region are the *muscles of mastication* used in chewing the food.

The **temporal** muscle occupies the fossa of the same name and is, like it, fan-shaped. Below it grasps the coronoid process of the lower jaw.

The **masseter** is attached to the zygomatic arch above and the ramus of the jaw below.

The **pterygoids, internal** and **external,** are attached to the base of the skull and below, to the lower jaw, the inner seizing the ramus, and the outer, the neck of the condyle.

There is a thin flat muscle in the cheek, the **buccinator** which is classed with the masticators because it holds the food between the teeth. Its paralysis causes the food to bulge out the cheek.

Action.—All but the external pterygoid are elevators of the jaw and hence crushers of food. The outer pterygoid causes lateral motion and protrusion forward. It is a grinder of food.

ORBITAL GROUP

The eyeball is moved in its socket by four muscles called *recti* and two called *oblique.* The *recti* are **superior, inferior, internal** and **external.** They are arranged around the eyeball as their names indicate and

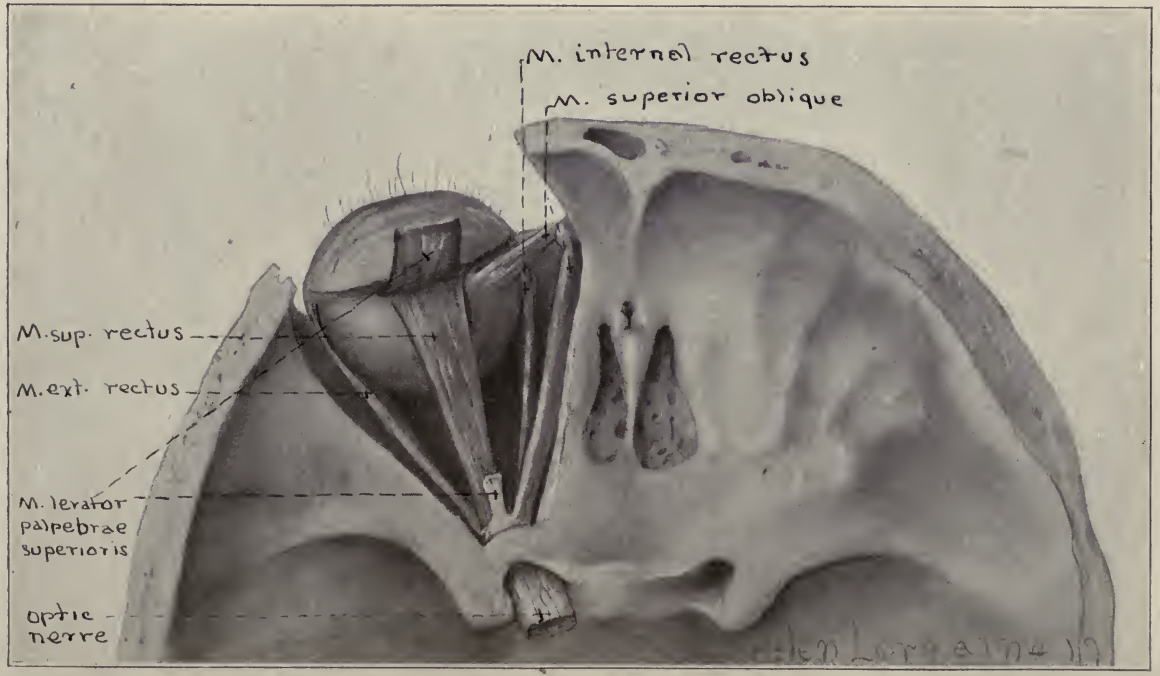

Fig. 9.—Orbital muscles.

each pulls so as to turn the eye upward, downward, inward or outward. All but one of the muscles of the eyeball rise from the corresponding margin of the optic foramen and are insered into the outer (sclerotic) coat of the eye.

The **superior oblique** rises from the margin of the optic foramen, passes through a pulley at the upper inner part of the eye and its tendon then runs downward and outward to the sclerotic.

The **inferior oblique** rises from the upper jaw, within the orbit, and passes outward, beneath the eyeball to reach the same coat on its outer side. Hence it revolves the eye outward, while the superior revolves it inward.

The elevator of the upper lid **(levator palpebrae superioris)** also lies in the orbit, rising from the margin of the optic foramen and being inserted into the upper tarsal cartilage.

MUSCLES OF THE BACK

The superficial fascia of the back, thick and rather coarse, is continuous with that of the axilla, abdomen, neck, and buttock. Beneath it is a broad expanse of aponeurotic fibers, forming the vertebral aponeurosis and giving attachment to many muscles. The muscles of this region are arranged in layers from behind forward. The first layer is made up of two muscles, the *trapezius* above and *latissimus dorsi* below. The two extend from the back of the occiput to the sacrum.

The **trapezius** (the two together are diamond-shaped) arises from the occiput and cervical and dorsal spines and is inserted into the spine of the scapula and the outer third of the clavicle.

Fig. 10.—Muscles. Back of trunk, upper extremity, and hips.

The **latissimus dorsi** starts, underneath the trapezius, from about the sixth dorsal spine, and rises from the dorsal and lumbar spines, the back of the sacrum, the posterior third of the ilium and three or four of the lower ribs. Its tendon passes over the lower angle of the scapula and is inserted into the inner bicipital ridge of the humerus.

Action.—The trapezius draws the scapulæ together and elevates them. The latissimus draws the humerus downward and backward.

The muscles of the next layer are the **rhomboid**, which is attached to the lower cervical and upper dorsal spines and the posterior border of the scapula; and the **levator anguli scapulæ** which rises from the upper cervical transverse processes and is inserted into the upper angle of the scapula. It draws the scapula upward and inward while the rhomboid draws it inward.

A large mass of muscular and tendinous fibers fills the sacral groove and the space on either side of the vertebræ column. It is called **erector spinae** and is continued by a succession of alternate origins and insertions up to the skull. It maintains the body in the erect posture and can restore it to that position after flexion.

MUSCLES OF THE UPPER EXTREMITY

Scapular group

There are five muscles in this group largely concerned in rotation of the humerus. Three are named from the scapular fossæ from which they arise while the other two spring from the axillary border and are called teres (round) muscles from their shape.

The **subscapularis** arises from the fossa of that name on the front of the scapula and is inserted into the small tuberosity of the humerus. It is an inward rotator.

The **supraspinatus** arises from the supraspinous fossa; the **infraspinatus,** from the infraspinous fossa; the **teres minor,** from the axillary border of the scapula; and are inserted in the order given into three impressions on the great tuberosity. The last two are outward rotators; the first an abductor of the humerus.

The **teres major** rises from the lower part of the axillary border of the scapula and is inserted with the latissimus dorsi into the inner bicipital ridge. It acts with that muscle and is an inward rotator.

The rounded outline of the shoulder is largely due to a bulky muscle called **deltoid.** It covers the joint in every aspect except below and internally. It is attached above to the spine and acromion of the scapula and the outer third of the clavicle. Below it seizes the outer face of the humerus about half way down.

The **humeral group** is made up of three muscles in front and one behind. They are enclosed in a strong fibrous envelope which encircles the arm and blends with a strong fascia covering the axillary space and pectoral muscles. Below this fascia seizes the condyles of the humerus and is continued over the muscles of the forearm, forming a special thickening on the front and back of the wrist called *anterior* and *posterior annular* ligaments. It is then continued into the hand as the palmar fascia.

The **triceps** (three heads) is on the back of the humerus. Its long or middle head rises from the scapula

and the other two from the back of the humerus. All are inserted into the olecranon process.

The **biceps** (two heads) rises from the coracoid process and margin of the glenoid cavity of the scapula and is inserted into the bicipital tuberosity of the radius. It and the triceps pass over two joints. An offshoot from the inner head is called the **coraco-brachialis** and is inserted into the inner face of the humerus.

The **brachialis anticus** springs from the lower half of the front of the humerus and is inserted into the coronoid process.

Action.—The triceps extends the forearm; the biceps and brachialis anticus flex it, and the biceps is a supinator. The coraco-brachialis is an adductor and flexor of the arm.

The muscles of the forearm are arranged in anterior and posterior groups, and each of these in two layers. All muscles on the front are either *flexors* or *pronators;* and all on the back are either *extensors* or *supinators.*

On the front a great mass composed of five muscles springs from the inner condyle of the humerus. As this mass passes downward, it gives off first a round muscle, the **pronator radii teres** which is inserted into the middle of the radius; a slender tendon, the **flexor carpi radialis,** inserted into the metacarpal bone of the index finger; a still smaller tendon, the **palmaris longus** inserted into the palmar fascia; a group of four tendons seizing the middle phalanx of each of the four fingers; and a more muscular tendon which is fastened to the metacarpal bone of the little finger. These are the **flexor sublimis digitorum** and the **flexor carpi ulnaris.**

Beneath these are three muscles, the **flexor longus**

pollicis rising from the radius and inserted into the last phalanx of the thumb; the **flexor profundus digitorum,** arising from the ulna and inserted into the last phalanges of the fingers; and the **pronator quadratus** springing from the lower fourth of the ulna and seizing the same amount of the radius.

Action.—Pronation is revolving the radius, carrying the hand so as to turn the palm backward, and supination is the reverse. As movement forward is flexion in this extremity, the flexors have their function indicated by their names. Thus the flexor carpi radialis flexes the wrist but draws it to the radial side; the ulnaris pulls to the ulnar side, while the digital flexors are distinguished as superficial (sublimis) and deep (profundus) and act on the phalanges into which they are inserted. After flexing the fingers, they can act on the joints above.

On the back of the forearm the superficial muscles rise from the external condyle and branch into a short radial extensor **(extensor carpi radialis longior),** a common extensor of the fingers (~~communis~~ extensor **digitorum),** an an extensor of the little finger **(~~Extensor minimi digiti~~)** and an ulnar extensor **(Extensor carpi ulnaris).** Extensors of the fingers are attached to the whole length of the back of the phalanges, furnishing *posterior ligaments* of the joints as they pass over them. The short **radial extensor** is attached to the metacarpal bone of the middle finger, and the ulnar, to that of the little finger.

The deep group comprises five muscles. The first of these, the **supinator ~~brevis~~** runs from the ulna around the upper extremity of the radius, which it seizes. The

next three are attached to one or both bones of the forearm above and, in consecutive order from above downward, to the metacarpal bone, first and second phalanges of the thumb. The last is attached above to the ulna and below to the index finger like all extensor tendons.

Two muscles, **brachio-radialis** and long radial extensor **(Extensor carpi radialis longior)**, are attached above to the ridge above the outer condyle and below the first to the styloid process of the radius and the second to the metacarpal bone of the index finger.

The palm of the hand is covered by a very dense fascia which is attached to the skin and prevents its freedom of movement. This fascia is much thicker centrally than on either side, where it covers two groups of muscles, the *thenar* at the base of the thumb and the *hypothenar* at that of the little finger.

The **thenar** muscles either flex the first phalanx of the thumb, or draw the thumb to or away from the middle of the hand, or approach the thumb to the little finger. Hence the muscles rise from near the middle of the hand.

The **hypothenar** group perform similar functions for the little finger, but their origin is close to the inner side of the hand. Certain small muscles called *interossei* and *lumbricales* occupy the middle of the palm.

MUSCLES OF THE LOWER EXTREMITY

The fascia of the lower extremity envelopes that part in a way similar to that found in the upper extremity. It covers the region of the hip, seizing not only the crest

of the ilium and the os pubis but Poupart's ligament as well. In the thigh it is called *facia lata.* Descending to the knee it forms a strong roof for the *popliteal* space, back of the knee joint, seizes the tuberosities of the tibia and head of the fibula and descends the leg, enveloping the muscles and sending septa between them, as it does in the upper extremity and thigh, forms an anterior and two lateral annular ligaments, and ends by becoming more or less continuous with the plantar fascia.

Here the muscles of the hip correspond to those of the shoulder; those of the thigh, to the arm; of the leg, to the forearm; and of the foot, to the hand.

GLUTEAL GROUP

The hip muscles form a group of nine, arranged in three layers, all having their origin from the innominate and all inserted into some part of the upper end of the femur. These are called *gluteal* and are distinguished as greater, middle, and least, (maximus, medius and minimus). Besides being concerned in rotation, like the shoulder or scapular group, some of these muscles have the important function of sustaining the body in the erect posture by steadying the pelvis on the femur and preventing the falling over which would occur were they paralyzed. The three gluteal muscles are engaged in this way. They are found occupying all the outer surface of the ilium and its crest above and below and are inserted either into or near the great trochanter. Of the remaining muscles of this group two, obturators internus and externus, spring from the obturator membrane; a third, the pyriformis with the obturator internus, rises

within the pelvis and all are inserted into or near the pit on the inner face of the great trochanter. All, except the gluteus minimus, which rotates inward, are outward rotators of the femur.

The muscles of the thigh are arranged in anterior, posterior and internal groups. On the front of the thigh the muscles are either flexors of the thigh on the pelvis or extensors of the leg on the thigh. The posterior muscles are all flexors of the leg and the internal adductors of the thigh.

There are really but two muscles on the front, though they are usually described as five and sometimes seven.

The **biceps flexor femoris** has a long head called *psoas magnus,* which springs from the lumbar vertebræ, and a short, the *iliacus internus,* springing from the iliac fossa. It passes under Poupart's ligament and is inserted into the lesser trochanter.

The **triceps extensor cruris** rises from just above the acetabulum by a long middle head called *rectus;* a short external called *vastus externus,* springs from the outer part of the femur and a shorter, *vastus internus,* from the inner and front part of that bone. They unite to form a strong tendon which encloses the patella and is inserted into the anterior tubercle of the tibia, forming the anterior ligament of the knee joint. The internal and external intermuscular septa give attachment to the two shorter heads.

The **adductor,** or internal group, has four heads called **pectineus** and **adductors longus, brevis,** and **magnus.** Their points of origin can be separated but the insertion can not. They spring from the pectineal triangle and

outer face of the os pubis, and from the tuberosity and ramus of the ischium. They all run outward and downward and are inserted into linea aspera.

Inclosed between layers of the fascia lata are three thin muscles, on the outer, inner, and anterior aspects of the thigh, named **tensor vaginae femoris, sartorius** and **gracilis.** The first rises from just back of, and the second from the anterior superior spine of, the ilium, and the last from the margin of the pubic symphysis. The tensor is inserted into the fascia lata about halfway down. The *sartorius* and *gracilis,* along with the *semitendinosus,* blend together to form what is called the "goose foot" insertion into the inner face of the tibia just below the tuberosity. The gracilis runs straight downward, the sartorius obliquely downward and inward at first and then straight downward. Its course is important because of its relation to the femoral artery. The tensor's action is indicated by its name. The gracilis is an adductor of the leg and thigh; the sartorius draws one leg across the other.

In the posterior region there are three muscles, *biceps flexor cruris semitendinosus* and *semimembranosus.* All of them spring from the tuberosity of the ischium.

The **semitendinosus** and long head of the biceps rise in common and pass down the thigh to below its middle, where the short head of the biceps, which rises from the outer lip of the linea aspera, joins the long and the two muscles diverge to form the upper boundaries of the popliteal space. The biceps is inserted into the head of the fibula while the semitendinosus goes to the "goose foot" insertion.

The **semimembranosus** lies a little in front of the other two but also rises from the tuberosity of the ischium. It passes to the inner side of the popliteal space and is mainly inserted into the groove on the inner tuberosity of the tibia, but a large part goes into the posterior ligament of the knee joint.

Action.—They all flex the leg on the thigh. In standing and walking they act from below, pulling on the tuberosity of the ischium, preventing the tendency to fall forward. They aid in restoring the body to the erect posture after bending forward at the hips.

Two layers of muscles, superficial and deep, are found on the back of the leg and one each on the front and outer side.

The superficial layer at the back is the *triceps surae* whose heads are the *gastrocnemius, plantaris* and *soleus.* The **gastrocnemius** rises from the two condyles of the femur, its outer head springing with the *plantaris.* The two heads form the lower boundaries of the popliteal space.

The **soleus** rises from the tibia and fibula for several inches. The three form the strongest tendon in the body, tendo Achilles, which is inserted into the lower part of the posterior tuberosity of the os calcis.

Action.—By pulling the calcis upward, it turns the toes downward. This raises the body on tiptoes; i. e., it is an extensor of the foot.

The deep group contains the *popliteus, tibialis posticus, flexor longus digitorum* and *flexor longus hallucis.*

The **popliteus** rises from the outer tuberosity of the femur and is inserted into the popliteal triangle of the tibia.

The **tibialis posticus** rises mainly from the interosseous membrane, but from tibia and fibula as well. Its tendon lies on the concave inner face of the calcis to reach the tuberosity of the scaphoid and inner cuneiform.

The **flexor longus hallucis** rises from the fibula and is inserted into the last phalanx of the big toe. It is much larger than the flexor of the toes.

The **flexor longus digitorum** springs from the tibia and is inserted into the last phalanx of the four outer toes, i. e., corresponds to the flexor profundus in the upper extremity. The names explain the action except of the tibialis, which is an extensor of the foot.

The anterior muscles are the *tibialis anticus, extensor longus digitorum* and *extensor proprius hallucis.*

The **tibialis anticus** rises from the tuberosity and upper half of the outer face of the tibia and is inserted into the inner cuneiform and metatarsal bone of the big toe. It flexes the foot and turns it inward; i. e., inverts it.

The **extensor longus digitorum** rises from the head and nearly the whole of the fibula and is inserted into the backs of the phalanges of the four outer toes and into the metatarsal bone of the little toe.

The **extensor proprius hallucis** rises from the middle two-fourths of the fibula and is inserted into the last phalanx of the big toe.

The outer group comprise the **peroneus longus and brevis.** They occupy the whole of the outer aspect of the fibula and, becoming tendinous, the brevis is inserted into the metatarsal bone of the little toe, the longus into that of the big toe, having passed across

the sole of the foot through the peroneal groove on the cuboid.

All of the last five muscles, except the proprius hallucis, spring from the investing fascia.

The peronei extend and *evert* the foot; i. e., turn it so it rests on the inner side.

The **plantar** fascia is much stronger than the palmar, but, like that, the middle division is the strongest. It covers, and gives origin to, three muscles which abduct the great and little toes and flex the four outer toes. These muscles all spring from the under surface of the calcis, as well as the fascia. Above them in the sole lie other layers of muscles which are not important.

The only muscle on the dorsum of the foot is the **extensor brevis digitorum.** It rises from the upper and outer part of the os calcis and, dividing into four tendons, is inserted into the first phalanx of the big toe and the whole length of the backs of the next three like all extensor tendons.

The flexor tendons of the phalanges in both upper and lower extremities are bound to the bones, before insertion, in canals formed partly of bone, but on three sides by very tough fibrous tissue called *thecæ*. These canals are lined by synovial membranes like joints. The extensor tendons of the phalanges all furnish posterior ligaments for the joints over which they pass.

CHAPTER V

SPLANCHNOLOGY

The **alimentary canal** begins at the mouth and terminates at the anus. It consists of the mouth, pharynx, esophagus, stomach, small and large intestines. The pharynx succeeds the mouth and lies in the neck. The esophagus is in the lower neck and thorax while the digestive tract lies in the abdomen.

The **mouth** presents thirty-two teeth set in the gums of the upper and lower jaws and described as four incisor, or cutting, teeth; two canine, or tearing; four premolar and six molar, or grinding teeth, in each jaw. These are the permanent teeth. The milk or deciduous teeth are twenty in number: four incisor, two canine, and four molar teeth in each jaw. Children begin to cut the teeth about the sixth month and the process continues up to about the thirtieth month. The order of eruption is the lower central incisors, upper incisors, lower lateral incisors and first molars, canines and second molars, each successive group appearing from two to six months after its predecessor.

The mouth is lined by mucous membrane, which covers the tongue as well as the cheeks. On the cheeks are the openings of the ducts from the parotid salivary gland while those of the smaller submaxillary and sublingual open together beneath the tongue.

The posterior opening of the mouth (oral cavity) called fauces, is a narrow opening leading into the ex-

panded pharynx. The sides of the fauces are bounded by the tonsils (amygdalæ) so often the subject of disease or the object of surgery.

The upper part of the succeeding cavity is the **nasopharynx** and receives not only the posterior nares, but the openings of the eustachian tubes, by which air is carried into the middle ear. The *oropharynx* is that part into which the mouth opens. Below the pharynx contracts to the esophagus immediately in front of which lies the larynx. The pharynx is, therefore, the space through which food is carried to the esophagus and in which the mouth, nose, ear and voice box communicate. Its walls are partly formed by three muscles, called constrictors, so arranged that they overlap from below upward and each can grasp and force onward a morsel of food before it escapes the one above.

The **esophagus** begins at the cricoid cartilage, and terminates, opposite the tenth or eleventh thoracic vertebra, in the stomach. Its muscular wall is made up of longitudinal and circular muscular fibers which run around the organ or throughout its length with no attachments beyond. In the neck and thorax the esophagus is closely related to important structures, especially the great blood vessels. It lies directly behind the larynx and trachea, the speaking and breathing tubes.

THE ABDOMEN AND ITS VISCERA

The **abdominal cavity** contains the digestive and genito-urinary organs. It is lined by a membrane, the peritoneum, which is a completely closed sac in the male and nearly closed in the female. All the abdom-

inal viscera are in some relation to the peritoneum, which forms a partial or complete coat for them—the visceral peritoneum to distinguish it from the parietal which covers its walls. The viscera are thrust into the sac from behind and, as some are pushed much further than others, there are many cases in which this membrane performs the functions of binding the viscera to each other or the wall of the abdomen or suspending them from one or the other.

The chief ligamentous folds are, one suspending the stomach from the lower surface of the liver, the lesser omentum; a large fold running from the lower border of the stomach nearly to the brim of the pelvis and thence up to the transverse colon, which it invests and, indirectly, suspends from the stomach. This is called the great omentum, and splits into the layers of which the upper follows the abdominal wall and forms the posterior limit of the lesser cavity of the peritoneum, a space behind the stomach, while the lower runs down over the small intestines, forming a ligament, the mesentery, which binds them obliquely from left to right over the three lower lumbar vertebræ. It then runs over the brim of the pelvis, covers the pelvic viscera, forming the ligaments of the bladder and, in the female, the broad ligament, a vertical fold which cuts the pelvis into an anterior and posterior compartment and envelopes the generative organs.

That part of the alimentary canal found in the abdominal cavity is divided into the *stomach, duodenum, jejunum* and *ileum* and the large intestine which is subdivided into *cecum, ascending, transverse,* and *descending colon,* the sigmoid flexure and the *rectum.* Besides these

hollow viscera the abdomen contains the *liver, spleen, pancreas, kidneys,* and *suprarenal capsule,* blood vessels, nerves and lymphatics.

The abdominal alimentary canal is a long hollow tube, expanded at various points, nearly thirty feet in length and made up of an external peritoneal or serous coat, an internal mucous or digesting coat, a submucous coat of fibrous tissue, circular and longitudinal muscular coats. The muscular coats are uniformly distributed until the large intestine is reached, when the longitudinal coat is gathered into bundles situated on the front, back and inner sides. For convenience of description, two imaginary lines may be drawn around the abdomen cutting it into an upper, middle and lower zone. One line is drawn between the anterior superior iliac spines and the other between the ninth costal cartilages. Two other imaginary lines are now projected upward from the middle of Poupart's ligament and the space is divided into nine regions. These are named, from above downward in the middle line *epigastric, umbilical* and *hypogastric.* Those on either side are the *hypochondriac* right and left; *lumbar,* right and left; and the *iliac,* right and left.

The **stomach** lies in the left hypochondriac (beneath the ribs) and the epigastric. Its large end is to the left and its walls look forward and backward. It is just under the liver and has the spleen close to its left end, which is a little below the heart from which it is separated by the diaphragm.

The **duodenum** is the part of the small intestine succeeding the stomach. It first runs upward to the under surface of the liver, then downward, about three inches,

and then upward and to the left. Its course is determined by the head of the pancreas around which it winds. It is nine inches long. The duct of the pancreas and that of the liver empty into the descending part.

The **jejunum** and **ileum,** about twenty feet long, are the names given to the upper two-fifths and the lower three-fifths of the small intestine. They lie coiled up largely in the umbilical region, but some of the convolutions fall into the pelvis and surrounding regions. The mucous coat of the small intestine is thrown into transverse folds, *valvulæ conniventes,* greatly increasing the absorptive area and retarding the flow of semiliquid food.

The small intestine empties into the large in the right iliac fossa two and a half inches above the commencement of the latter. The part below the entrance is called the cecum. The opening is the ileo-cecal and just below it the *vermiform* appendix opens into the cecum. As this appendix has no firm attachment, except to the cecum, its free end may point in any direction and is often attached, as the result of adhesions, to one of the pelvic or adjacent abdominal viscera.

The **ascending colon** begins in the right iliac region, runs up through the right lumbar and terminates in the right hypochondriac, on the under surface of the liver, by becoming the **transverse colon,** which curves downward and to the left to just above the umbilicus, then turns upward and to the left to the spleen where it terminates in the **descending colon,** which runs from the left hypochondriac through the left lumbar to terminate in the left iliac in the **sigmoid flexure** of the colon, which forms a loop whose position varies with that of

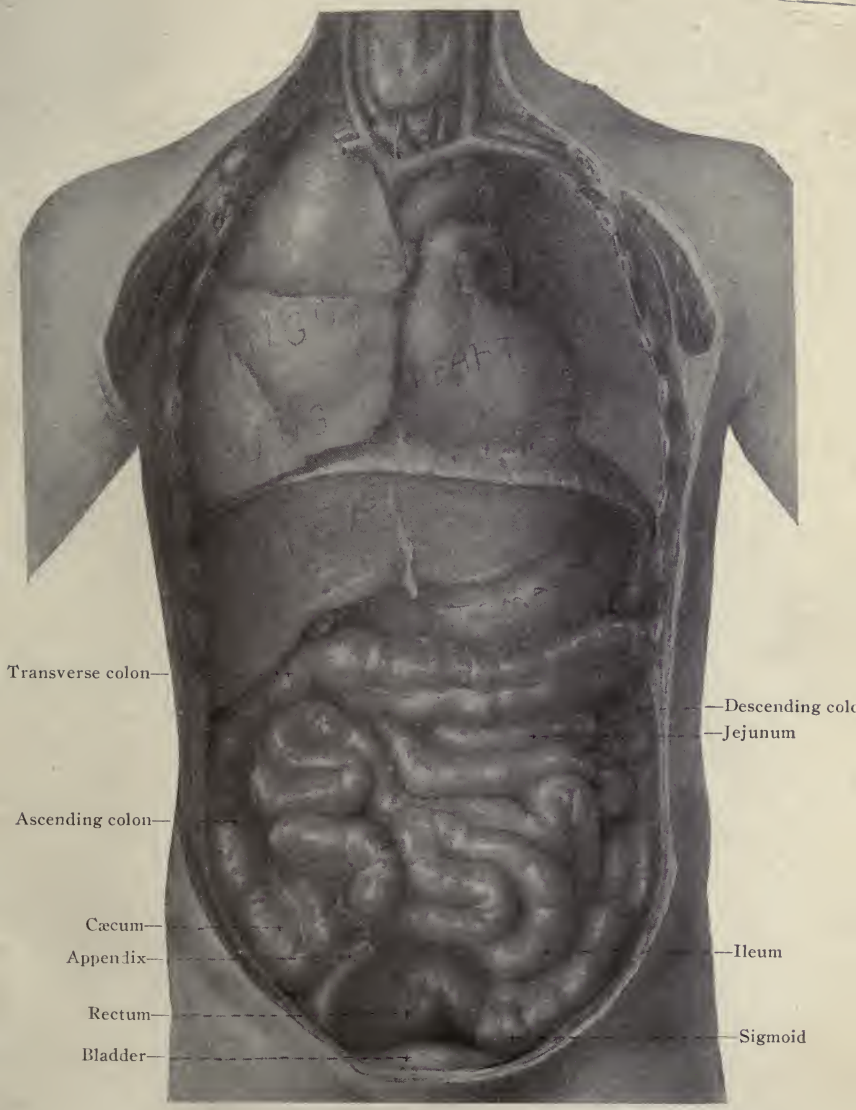

Fig. 11.—Front view of organs. Semi-diagrammatic.

the body but which runs over the brim of the pelvis to the middle of the sacrum when it changes its name to **rectum** which terminates at the anus. The curves in the large intestine made at the liver and spleen are called the hepatic and splenic flexures. The colon lies on the right, above and to the left of the convolutions of the small intestine.

Food enters the stomach, where the pepsin and hydrochloric acid are secreted, begins to be digested there, then passes into the small intestine, where it meets the pancreatic fluid and that of the intestine. Here digestion is continued and absorption goes on, decreasing in amount until finally, in the lower part of the large intestine, there is nothing but the waste matter left.

The **liver,** the largest glandular organ of the body, weighing about four pounds, lies in the right hypochondriac and epigastric regions. It is almost completely covered by peritoneum and overhangs the stomach, ascending duodenum, hepatic flexure of the colon, and the right kidney. It has a deep antero-posterior fissure on its lower surface and, opposite this, a suspensory ligament on the upper surface, which cut it into a large right and small left lobe. Its convex upper surface is in contact with the diaphragm, which separates it from the contents of the thoracic cavity, right lung and heart. On its lower surface is the gall bladder, which holds its secretion, its ducts and the entrance of the artery and vein which are distributed to it.

The branches of the portal vein and the hepatic artery ramify through the liver, conveying to it a large supply of blood, while the branches of the hepatic

duct run together to form a single duct which has a communicating branch, the cystic, by which the *bile* is conveyed to and from the gall bladder on the under surface of the liver. The union of the cystic with the two hepatic ducts forms the common bile duct which usually unites with the pancreatic duct before emptying into the lower part of the perpendicular duodenum.

The Pancreas

The **pancreas** is a compound racemose gland, like the salivary glands. It crosses the body of the first lumbar vertebra, from which it is separated by the abdominal aorta, inferior vena cava and the chief artery and vein of the intestine, and is covered only in front by the peritoneum. The large head is embraced by the duodenum while the tail is in contact with the spleen. The upper border is on a level with that of the stomach, and just below this border the splenic vein lies on the back of the organ. This gland secretes the most important of the digestive juices.

The Spleen

The **spleen,** one of the ductless glands, lies in the left hypochondriac region, completely invested by peritoneum which holds it to the stomach and diaphragm. It corresponds, by its convex outer surface, to the ninth, tenth, and eleventh ribs. The pancreas is bound to its concave inner face. It receives one of the largest of the visceral branches of the aorta and sends a vein, both named splenic, of corresponding size to the portal circulation. It is invested by a strong fibrous capsule and is subject to great variations in size. Normally it is about four inches long by two and a half inches wide.

The Kidneys

The **kidneys** are a pair of small organs, weighing about a quarter of a pound, lying in the lumbar region from the eleventh rib to the iliac crest on the quadratus lumborum muscle, whose outer borders extend a little beyond the twelfth rib. A depression in the back along the outer edge of the erector spinæ muscle, indicates their position. The right kidney is a little lower than the left. The kidneys lie behind the peritoneum, which is usually separated from them by some fat. The right has the ascending colon and descending duodenum in front of it. The left has the descending colon. Each kidney has a deep notch the *hilum* on its inner border leading into a cavity, which lodges the duct and vessels of the organ. These are arranged with the vein in front, duct, or ureter, behind and artery between.

The Urinary Bladder

The **bladder** occupies the anterior part of the pelvic cavity, is a hollow sac made up of an internal mucous, two muscular, and a partial serous coat, having the ureters conveying the excretion of the kidneys into it and the *urethra* conveying it away. The bladder and its appendages rest on the front of the rectum. In the female the internal generative organs lie between bladder and rectum. In both male and female, convolutions of the small intestines fall into the pelvic cavity and come in contact with the bladder and in both the peritoneum covers the posterior half of the organ. The *urethra* in the female is very short, about two inches, and terminates at the upper part of the vaginal cleft. In the male this tube runs the length of the penis. In the male the *pros-*

tate gland surrounds the neck of the bladder and the seminal vesicles with the *vasa deferentia* internal to them, form a triangle between bladder and rectum. In the female these structures are wanting and their place is taken by the upper part of the vagina, the uterus, and its appendages.

The Generative Organs in the Female

These are the *uterus, ovaries, Fallopian tubes* and the *vagina.*

The **uterus** is shaped like a flattened pear with its large end upward in the pelvic cavity and its small end surrounded by the vagina. It is covered by peritoneum, except where the vagina grasps it, and leans forward and upward. Its cavity communicates by a large opening, the os, through a constricted neck, with the vagina, and at each upper angle, through a Fallopian tube, with the peritoneal cavity. There is, therefore, a hole in the female peritoneum which does not exist in the male and a consequent danger of peritonitis. The uterus is held in position by folds of peritoneum behind, in front, and on each side, and by a round ligament which extends from just below the Fallopian tube through the inguinal canal to the labium majus. The lateral ligament (broad ligament) is a vertical band which encloses the tubes, ovaries and round ligament and stretches to the lateral wall of the pelvis. It shuts off a cavity behind, which lies between the rectum and uterus, is known as the *pouch* of Douglas, and can hold a large amount of fluid.

The **ovaries** lie one on each side of the uterus and are held to it by a round ligament developed in the broad

ligament. Its outer end is nearly in contact with the iliac vein and, on the right side, it often touches the appendix. To its outer end, which is the higher, the fimbriated extremity of the Fallopian tube is attached. The function of the ovary is to produce eggs, that of the tube to convey the eggs to the uterus, and of the latter to hatch them. The hatching is called gestation and the act of birth parturition, which takes place through the vagina.

The **vagina** is a tube with anterior and posterior walls the upper inch of which is in the pelvic cavity, covered on its posterior wall by peritoneum. Its anterior wall is in contact with the bladder. Below it terminates in a slit-like aperture, cut vertically, which is surrounded by two thin folds, nymphæ or *labia minora,* which are overlapped and hidden by larger folds, *labia majora,* which unite over the pelvic symphysis in the *mons veneris.* If the labia are separated a triangular space will be seen between the nymphæ in front called the *vestibule.* At the back of the vestibule is the opening of the urethra and just in front of it the clitoris. These appearances are collectively called the *vulva.*

The Generative Organs in the Male

The chief male generative organs lie outside the pelvic cavity and consist of penis and testicles.

The **penis** consists of two parallel bodies, the *corpora cavernosa,* bound together by fibrous tissue, and a longer body opposite the interval between the cavernosa below called *corpus spongiosum,* which carries the *urethra* and turns up in front over the end of the cavernosa to form

the *glans penis* which is pierced by the opening of the urethra, the *meatus urinarius*. Posteriorly the three bodies separate to form the root of the penis; the lateral roots, the origin of the cavernosa, being attached to the rami; and the central body, or bulb, being attached to the triangular ligament.

The **testicle,** originally an abdominal organ which descends through the inguinal canal to the scrotum, is the secreting organ in the male analagous to the ovary in the female. The two testicles lie in a pouch of skin and unstriped muscular fibers, lined by a serous membrane, called the scrotum. The serous membrane covers the testicle and lines the scrotal sac. It is called *tunica vaginalis*. The testicle is suspended by a rounded cord made up of the cremaster muscle, blood vessels, nerves and lymphatic and the duct of the testicle, the *vas deferens*. The vas enters at the hole in the external oblique, passes along the inguinal canal, crosses the external iliac artery and vein to the base of the bladder where it joins a coiled tube, the *seminal vesicle,* a small reservoir for the seminal fluid, forming the *ejaculatory* duct which passes the seminal fluid into the prostatic portion of the urethra.

The passage of the testicle and the presence of the spermatic cord leave a potential canal in the lower abdominal wall along which a portion of the intestine may run in forming an *inguinal hernia*. As the round ligament is the only structure in the female which occupies this canal, the chance of this form of hernia is much lessened in women.

THE THORACIC VISCERA

The **thorax** is divided into two *pleural* and a *cardiac* space, each lined by serous membrane, and a space between, the *mediastinum,* which transmits many important structures.

The cardiac space is surrounded by a membrane, the fibrous *pericardium,* cone-shaped with its large end below, corresponding to the upper face of the central and left leaflets of the trefoil tendon of the diaphragm. Above the cone contracts to blend with the fibrous coat of the great blood vessels attached to the heart. The pericardium lies between the lungs on either side, the sternum and left costal cartilage from the third to the seventh in front, and the vertebral column behind, from which it is separated by the root of the lungs, esophagus, and thoracic aorta. It is lined by a *serous* pericardium which covers its walls and the exterior of the heart and its vessels.

The **heart** has its small end, or apex, directed downward and to the left, corresponding to the space between the fifth and sixth ribs about three inches to the left of the midline. The base, directed backward, upward, and to the right, corresponds to the thoracic vertebræ from the fifth to the eighth inclusive. The exterior of the heart is marked by two furrows at right angles to each other. The upper furrow passes transversely around the organ, lodges a large venous and arterial channel and indicates the position of the septum between auricles and ventricles. The vertical groove passes to the right of the apex, lodges vessels and indicates the position of the interventricular septum.

The interior of the heart is divided into two upper cavities, the right and left auricles, and two lower, the right and left ventricles. The right side of the heart is the venous and the left the arterial.

The **right auricle** receives the inferior vena cava at its lower and the superior vena cava at its upper part. These pour in the blood from all parts of the body except the heart, whose return circulation goes into the same cavity through the *coronary sinus.* The upper front portion is prolonged into a projection like a dog's ear, called the *auricular appendix,* which overlaps the aorta.

The **left auricle,** situated behind and to the left of the right, also has an auricle which overlaps the pulmonary artery. The cavity receives the pulmonary veins, four in number. The two left often unite so as to leave but three openings for their entrance. Each auricle has a large opening through the auriculo-ventricular septum, by which blood is poured into the corresponding ventricle.

The **right ventricle** occupies nearly the whole of the front of the heart. It terminates above in a cone which gives rise to the pulmonary artery, and receives, behind that point, the venous blood through the right auriculo-ventricular opening. The latter is guarded by a valve made up of three flaps, the *tricuspid,* to which are attached small tendons, chordæ tendineæ, the termination of little muscles, the papillary, which are attached to the walls of the ventricle and keep the valves from being forced into the auricle when the ventricle contracts. The opening of the pulmonary artery is guarded by three valves, shaped like half cups, called semilunar.

The **left ventricle** makes up most of the back of the heart, though it forms the front of the apex. It has a left auriculo-ventricular opening guarded by a two flapped valve, the *bicuspid* or *mitral,* which has chordæ tendineæ and columnæ carneæ (papillary) just as on the right side. Behind and to the right of the pulmonary opening of the right, this ventricle gives origin to the aorta, which is guarded by three semilunar valves like those in the pulmonary. The left ventricle has walls about twice as thick as those of the right. The right pumps blood into the lungs only; the left, throughout the body. The left auricle is also thicker than the right, but the difference is not so great.

The two auricles contract to fill the ventricles. Then the bicuspid and tricuspid valves close to prevent flowing back (regurgitation) of blood into the auricles. The contraction of the ventricles drives the blood into the pulmonary artery and the aorta. Then the semilunar valves close to prevent regurgitation into the ventricles. Injury or disease of the valves will cause a leak and the heart has to grow in size and power to compensate the leakage.

The Pleural Cavities and Lungs

Each pleural cavity is the space between the ribs on the sides and behind and the pericardium internally. Each is a closed sac lined by the parietal pleura. The two sacs do not touch, though they are very close together at the level of the second rib. Within these sacs the lungs move freely, covered by the visceral or pulmonary pleura, a reflection of the parietal. The cavities are cone-shaped, with the apices upward and extending

above the clavicle into the root of the neck. The left extends lower down than the right, because the liver pushes the diaphragm up on the right.

The **lungs** correspond in shape to the pleural cavities. The left is slightly larger than the right, but is hollowed out on its inner side by the projection of the heart.

The **bronchi,** two cartilaginous tubes formed by the bifurcation of the trachea, with the pulmonary arteries and veins, form the chief elements of the root of the lungs, which enters at a depression above the middle of the inner surface. These divide and subdivide until small air cells are formed around which the minute vessels are so arranged that the inspired air can exchange its oxygen for the gases contained in the venous blood. The presence of this air causes the lungs to float in water.

The apex of the lung projects into the neck two and a half inches above the first rib and is a blunt point. The base is deeply hollowed out by the dome-shaped diaphragm. The outer surface is broad and convex, to conform to the inner face of the ribs. The anterior border is thin and sharp, to fit into the interval between the front of the pericardium and the back of the sternum and ribs. The posterior border is round and thick to fill in the deep groove beside the vertebral column and on the front of the ribs behind the angle. The inner surface is concave to fit the pericardium.

The Mediastinum

The **mediastinum** is the irregular space between the pleuræ. Draw a line from the junction of the first and second pieces of the sternum upward and backward to

the lower border of the fourth thoracic vertebræ. All the space above this line is the *superior mediastinum.* It contains the innominate artery, and its vein, thoracic part of the left corotid and subclavian arteries, parts of the trachea, esophagus, pneumogastric and phrenic nerves and many other structures.

The remainder of the interpleural space is subdivided into anterior, middle, and posterior mediastinal cavities.

The *anterior mediastinum* is the space in front of the pericardium.

The *middle mediastinum* is the pericardium and its contents.

The *posterior mediastinum* is the space between the back of the pericardium and the front of the thoracic vertebræ below the fourth. It contains the esophagus, descending aorta, thoracic duct, part of the pneumogastric nerves, azygos veins, etc.

CHAPTER VI

ARTERIES AND VEINS

The circulation of the blood starts at the heart which is a four chambered pump, having two right and two left chambers. The right side is for venous blood and the left for arterial. Starting from the left lower chamber the great aorta curves upward about two inches, bends abruptly to the left for nearly three inches and then turns sharply downward to finally divides into two branches near the fourth lumbar vertebra, its two branches going to the lower extremities and the pelvis. As it starts it gives two branches to the heart and then, in its transverse part, a large branch which splits into two to supply the right half of the head and neck and the right upper extremity. A second branch of smaller size does the same work for the left side of the head and neck, while a third is for the left upper extremity. The main aorta, between these branches and its bifurcation, (splitting in two) gives off the branches to the remainder of the body.

The venous blood is poured into the upper right chamber of the heart by two vessels called cavæ, superior and inferior. The superior collects blood from the head, neck and both upper extremities; the inferior from the lower extremities, pelvis, and greater part of the abdominal contents and walls. Between these two a

set of veins called azygos take same blood from the abdomen and more from the thorax. Veins are divided into two sets, superficial, such as are seen on the back of the hand, and deep which accompany the arteries of the same name. The course of the circulation is to pass away from the heart through the arteries and to return to the heart through the veins. There is no direct communication between an artery and a vein; but as the arteries get smaller, their coats get thinner until they terminate in very small thin vessels called capillaries through whose wall the gases in the blood can be given off to the tissue and the gases in the tissue can be taken up by the blood forming an exchange of gases just the reverse of that in the lungs. Roughly the lungs, removing injurious gases, take out CO_2 from the blood and replace it with O; while the tissues take out O and give up CO_2. Gradually the capillaries get thicker walls and unite with each other to form veinlets, which again unite to form small veins, which again unite and so the process is repeated until only two veins remain—superior and inferior venæ cavæ. The arteries, therefore, constantly grow smaller by dividing or giving off branches; and the veins grow larger as they approach the heart, by the union of two or more small veins and the reception of tributaries; that is the veins are like tracing a river from sources to mouth and the arteries like tracing the same from mouth to various sources. At two points, lungs and liver, there is a special arrangement of blood vessels so important as to require special study. Only that in the lungs will be now mentioned.

PULMONARY CIRCULATION

All the blood in the body, at one time or another, is poured through the upper right chamber of the heart (the right or venous auricle), and descends from that into the chamber below—right or venous ventricle. From this it is driven, by contraction of the ventricle through the pulmonary artery, which splits into right and left pulmonary arteries, into the lungs, when these arteries divide and subdivide as in other parts of the body, until their capillaries finally are placed in such relation to the air cells of the lungs that the exchange of gases alluded to above can take place. All the blood in the body thus passes through the lungs where it is oxygenated, but does not nourish the lungs, which must have blood like any other tissue, and get it from a set of bronchial branches coming from the aorta. This aerated blood is now returned to the heart through a set of veins called pulmonary which enter the upper left chamber or auricle of the heart, called the arterial auricle. The pulmonary circulation is thus a sort of loop or side track in the general circulation and presents the anomaly of an artery carrying venous and a set of veins carrying arterial blood. From the left auricle the blood is poured into the left or arterial ventricle and thence is pumped through the aorta and its branches to the remotest parts of the body, whence it is returned through capillaries, veinlets and veins to the heart to start over the same process again. As, therefore, the arteries form a continuous set of tubes leading away from the heart, and the veins a continuous set leading back, it is obvious that if one wants to trace

a substance in its course from or to a given part of the body, it is only necessary to know what vessels supply that part. If one could place a tag on a certain blood corpuscle and route it for the big toe, its course would be as definite as if it had a railroad track to guide it, and like that would be capable of interruption or miscarriage at various branch lines. It would leave the heart at the aortic opening, pass through the various parts of the aorta to its bifurcation where it would enter a primitive iliac artery and proceed through an external iliac, femoral and popliteal to the bifurcation of the latter, thence through the anterior tibial and dorsalis pedis to the great toe. Now it would have the choice of two routes for its return. If it went by the deep vein, it would start by a satellite accompanying the dorsal artery of the foot, through an anterior tibial, popliteal, femoral, external and common iliac into the inferior vena cava and thence into the venous auricle, venous ventricle, pulmonary artery, right or left lung as the case might be, back to the arterial auricle through a pulmonary vein, thence to the arterial ventricle and be ready at the mouth of the aorta to start on the same journey or be routed to the little finger, the eye, ear, brain or any other part of the anatomy. Its second route from the big toe would be to choose a veinlet of a long vein called *internal saphenous,* which would conduct it along the inner side of the foot, ankle, leg and thigh until it pierced the fascia lata just below Poupart's ligament to empty into the femoral vein, after which its course would be the same as that just traced. It is, therefore, plain that the study of the arteries and veins is, in no inconsiderable meas-

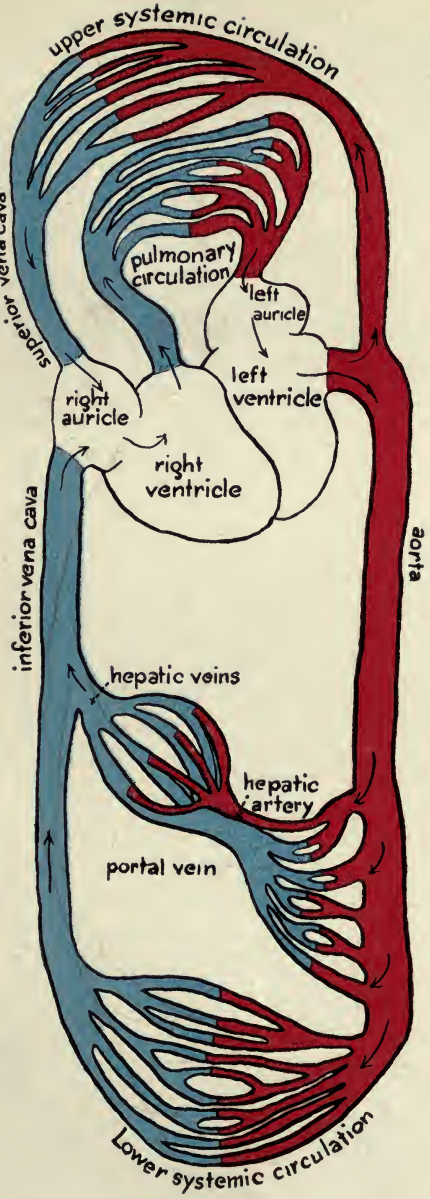

Fig. 12.—Diagram of entire circulation.

ure, merely a learning of names and not of facts; and that a knowledge of the parts formed by the skeleton will, in the main, furnish the student with the names. The two coronary arteries, for the supply of the heart itself, would spring just after the origin of the aorta; then would come the innominate which quickly subdivides into the right common carotid, going upward, and the right subclavian going outward. The left subclavian has a separate origin (the third) from the transverse aorta, and has a thoracic portion similar to the innominate. Getting to the middle of the clavicle, each subclavian becomes the counterpart of the other and the right only will be traced. From the inner end of the collar bone to its outer third the artery and vein are called subclavian; from there to the surgical neck of the humerus, axillary; from there to the bend of the elbow the artery is the brachial, but there are two brachial veins, one on each side. At the bend of the elbow, in other words as soon as there are two bones, the artery bifurcates and the two are known as radial or ulnar according as they are found on the inner or outer bone. They continue under these names into the hand where they communicate, and each has two veins.

From the bifurcation of the aorta the names are to the brim of the pelvis common or primitive iliac which divides into an internal iliac for the pelvis and an external for the lower extremity, which changes its name at Poupart's ligament to become femoral and that becomes popliteal at the lower third of the femur and divides into anterior and posterior tibial just below the knee joint. These pass down on the front and back of the leg respectively, and are distributed to structures

as they descend, the anterior becoming the artery of the back of the foot *(dorsalis pedis)*, while the posterior divides into *internal* and *external plantar* arteries for the sole.

The **right** and **left carotid** arteries, above the clavicle, pass up to the thyroid cartilage and divide into the *internal* and *external* carotids, the internal to enter the skull through an opening in the temporal bone and supply the interior of the skull and its contents; while the external, dividing into *temporal* and *deep facial,* or *internal maxillary,* supplies the interior of the skull and face.

THE AORTA

The **aorta** extends from the base of the heart to the lower border of the fourth lumbar vertebra and is divided into *ascending, transverse* and *descending,* the latter having a *thoracic* and an *abdominal* portion.

The Ascending Aorta

The **ascending aorta,** about two inches long, lies a quarter of an inch behind the sternum, in the pericardium, overlapped by the right auricular appendix and having the pulmonary artery first in front and then to its left. It terminates by becoming the transverse aorta at the upper border of the second right costal cartilage, where the aortic valves may be heard, where the pericardium blends with the outer coat of the vessel.

It gives off the two *coronary* arteries, right or anterior and left or posterior. They descend in the corresponding interventricular grooves and anastomose at the apex of the heart, after giving off lateral

branches at the auriculo-ventricular grooves which embrace the heart transversely and inosculate with each other.

The Transverse Aorta

The **transverse aorta,** starting at the upper second right cartilage, passes backward, downward, and to the left to the lower border of the fourth dorsal vertebra where it becomes the descending aorta. It lies in the superior mediastinum about an inch below the sternal notch and is overlapped greatly by the left pleura and lung. Across its upper front runs the left innominate vein, the left tenth and phrenic nerves, while behind it is in close contact with the trachea, esophagus, thoracic duct and left recurrent laryngeal nerve. The bifurcation of the pulmonary artery is below it.

It gives off, from its upper side, from right to left the *arteria innominata, left common carotid,* and *left subclavian.*

The Thoracic Aorta

The **thoracic aorta** begins at the lower border of the fourth and terminates on the body of the twelfth dorsal vertebra by becoming the abdominal aorta.

It lies in the posterior mediastinum at first on the left side and then on the front of the vertebræ, inclining forward and to the right. The esophagus, bearing the two tenth *(pneumogastric)* nerves, crosses it obliquely in front, as does the root of the left lung. The vena azygos major and thoracic duct are to its inner side. It is nearly covered by the left pleura and lung. In front, below the fifth vertebra, lies the pericardium and heart.

Branches.—These are *bronchial, intercostal, pericardiac, esophageal* and *mediastinal.* The last three are small twigs given the structures whose names they bear.

The *bronchial* arteries pass outward in the root of the lungs and supply the substance of those organs.

The *intercostal* arteries are ten pairs which run in the intercostal spaces, except the upper, to supply the ribs and structures adjacent to them, and to anastomose with branches of the internal mammary in front.

The Abdominal Aorta

The **abdominal aorta** begins on the body of the twelfth thoracic vertebra and terminates, greatly diminished, on the body of the fourth lumbar by dividing into right and left common iliacs.

This artery passes through the aortic opening behind the diaphragm, rests on the bodies of the vertebræ and lies behind the peritoneum and many of the abdominal viscera. It has the stomach in front, but distant, the pancreas and transverse duodenum in immediate contact, and the transverse colon in front and distant. On its right side, throughout, is the inferior vena cava while the mesentery of the small intestine is attached obliquely across it. The left lumbar veins run behind and the left renal in front.

Branches.—The branches, numerous and important, are divided into *parietal* and *visceral.*

The *parietal* branches are *phrenic, lumbar,* and *sacra media.*

The *phrenic* are just muscular branches for the diaphragm. They sometimes come from one of the branches of the aorta, ramify over the diaphragm and inosculate with each other and with the musculo-phrenic of the internal mammary.

The *lumbar* are four pairs which correspond to the intercostals. They have no intercostal spaces in which to run, but spread out in the broad muscles of the abdomen, supplying them and inosculat-

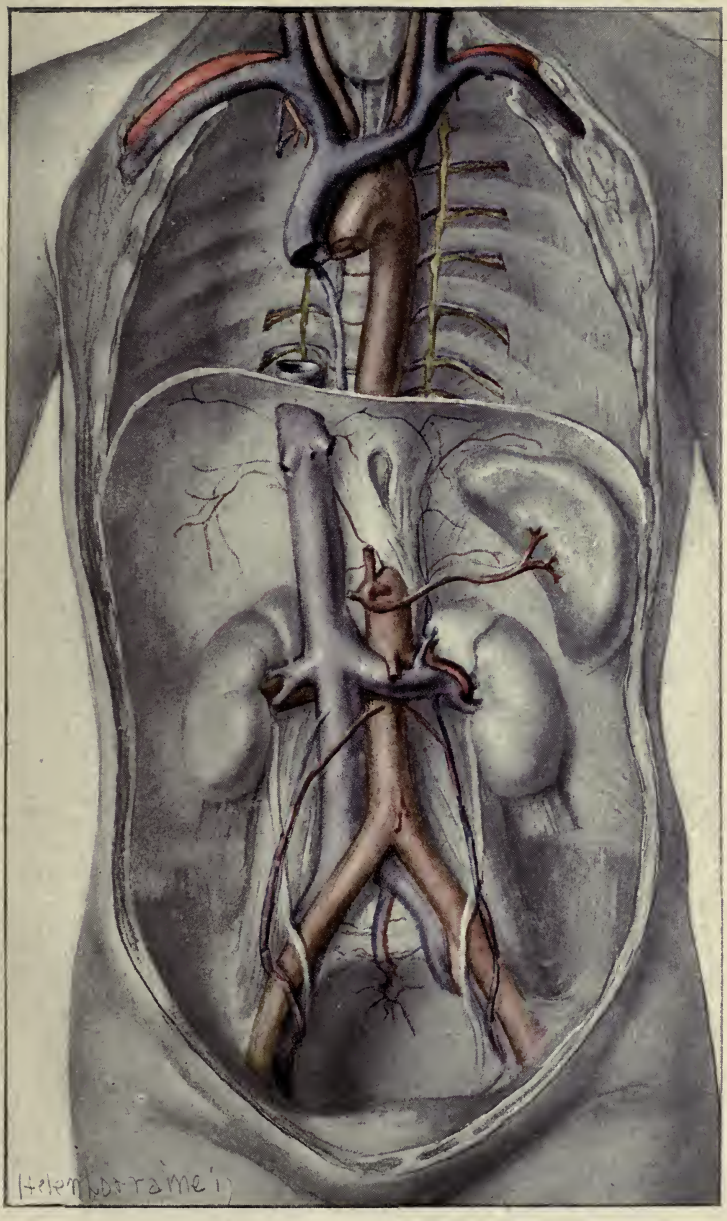

Fig. 13.—The aorta and its branches.

ing with a branch of the external iliac which corresponds to, and anastomoses with, the internal mammary.

The *sacra media* is a small vessel running down the sacrum.

The remaining branches are divided into *digestion* and *genito-urinary.*

In the first set are the *celiac axis, superior* and *inferior mesenteric,* while the second comprises the *renal* and *suprarenal,* the *spermatic* in the male, and *ovarian* in the female.

The Celiac Axis

The **celiac axis** is a short trunk springing from the aorta immediately after it pierces the diaphragm juts forward and breaks up into three branches, *gastric, hepatic,* and *splenic.*

The **gastric** reaches the lesser curvature of the stomach by passing up behind that organ and then runs to the right to meet the pyloric from the hepatic and form a loop along the upper part of the stomach from which small branches run down both its faces.

The **hepatic** runs first to the right and then upward in the lesser omentum to the under surface of the liver where it divides into right and left hepatic arteries for the two lobes of the liver to which it supplies arterial blood. It has the bile duct on its right and the portal vein between and behind duct and artery.

It gives off a branch to the gall bladder and a large branch which, after aiding in the supply of duodenum and pancreas, runs to the left in the great omentum along the great curvature of the stomach to meet a similar branch of the splenic and form a loop which gives ascending branches to both faces of the stomach and descending branches to the omentum. These arteries are called gastro-epiploica dextra and sinistra (arteries of the stomach and omentum, right and left).

The **splenic** is the largest branch of this axis. It runs along the upper border of the pancreas behind the stomach, to the spleen with the splenic vein below it and behind the pancreas. Most of its blood is poured into the spleen (a blood elaborating gland), but it gives large branches to the pancreas and great end of the stomach (vasa brevia) in addition to the gastro-epiploica sinistra.

The Superior Mesenteric

The **superior mesenteric** is a very large vessel which supplies the intestinal canal from the duodenum to the middle of the transverse colon. It arises just below the celiac axis, behind the pancreas, runs between that gland and the transverse duodenum into the mesentery and thence, with a decided curve, convex to the left, passes to the right iliac fossa. It is accompanied by a vein lying to its right and, as the mesentery moves freely, is the most movable artery in the abdomen.

Branches.—This artery is distributed by a number (eight to eighteen) of branches from its convex left side called *vasa intestini tenuis,* and by three branches on the right named, from below up, *ileo-colic, colica dextra* and *colica media,* besides a small branch to the pancreas and duodenum which inosculates with a similar branch derived from the hepatic.

The *vasa intestini tenuis* are all distributed in the same way. Each divides, after a short course, into an upper and a lower branch. The upper of one and the lower of the other run together and form a loop. From these loops branches spring which divide and unite to form a second loop, and from this another loop may be formed. There are usually three series of loops, each smaller than its predecessor, though sometimes more. From the last loop spring branches (vasa recta) which do not divide but run, one in front and the other behind, around the intestine and anastomose with each other in its walls.

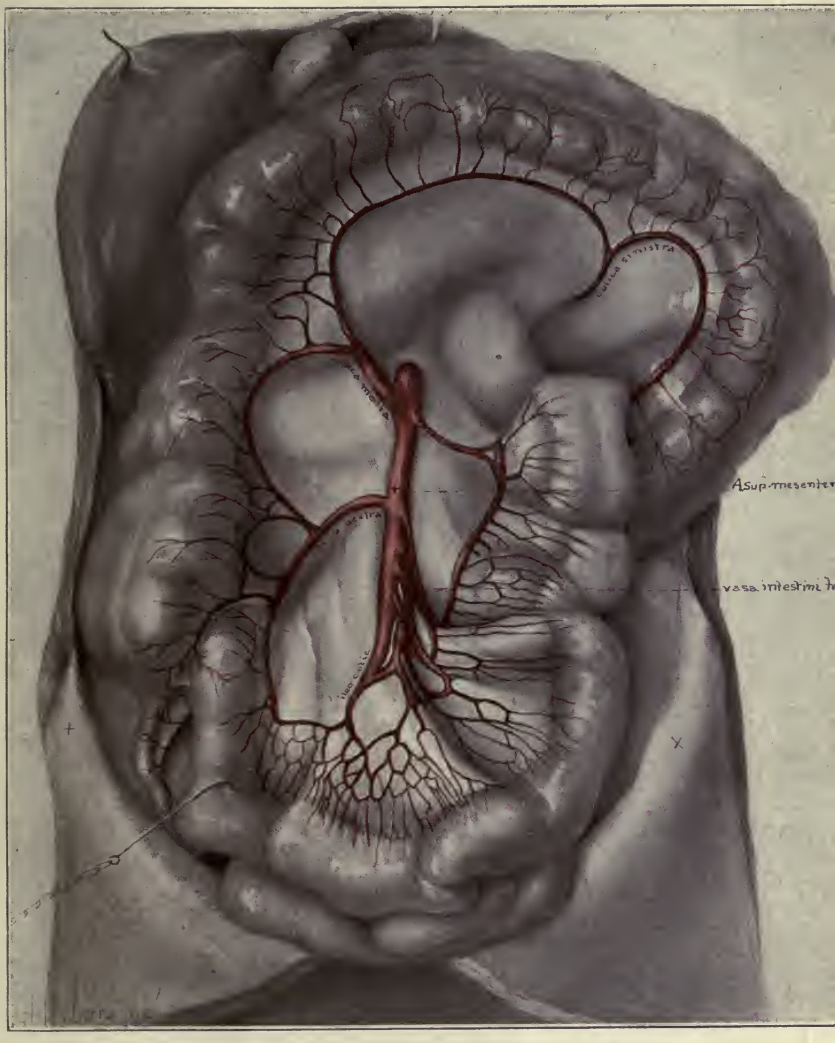

Fig. 14.—Superior mesenteric artery.

On the concave side the distribution is similar but not identical. The *ileo-colic* splits into two of which the lower joins the last of the intestini tenuis and the upper the lower of the two from the *colica dextra* which divides into two, the lower to the *ileo-colic* and the upper the right branch of the *colica media,* whose left branch joins the upper branch of the *colica sinistra,* a branch of the inferior mesenteric. No secondary loops are formed from these anastomoses but straight branches are at once given off to the large intestines.

The Inferior Mesenteric

The **inferior mesenteric,** much smaller than the superior, arises near the termination of the aorta on its left side. It passes to the left, behind the peritoneum, gives off a *colica sinistra* whose upper branch passes to the right to meet the *colica dextra* on the transverse colon, while the lower passes to the descending colon and anastomoses with the highest sigmoid branches. The *sigmoidea* are several branches the highest inosculating with the lower of the sinistra, the lowest with the *superior hemorrhoidal* and supplying the sigmoid flexure.

The superior hemorrhoidal is the termination of the inferior mesenteric and supplies the upper part of the rectum and anastomoses with hemorrhodial branches from the internal iliac.

Summary

The abdominal alimentary canal is supplied with blood as follows: The stomach and duodenum by the gastric and branches from the hepatic and splenic and superior mesenteric; the jejunum and most of the ileum by the vasa intestini tenuis; the lower part of the colon and up to the middle of the transverse colon by the branches from the right side of the superior mesenteric, and

the remainder to the lower part of the rectum, by the inferior mesenteric.

THE PORTAL CIRCULATION

Each of the arteries described above, except the hepatic, is accompanied by a vein of the same name, formed by veinlets which ramify in the corresponding organs. The *inferior mesenteric* vein empties into the superior; the *superior* joins the *splenic* to form the portal; the gastric veins join the splenic before it reaches the superior mesenteric.

The **portal vein,** therefore, receives blood which comes from the abdominal intestinal tract from the beginning of the stomach to the middle of the rectum inclusive. This embraces all the digestive tract, the spleen, and the pancreas. This blood, charged with the products of digestion in addition to the ordinary contents of venous blood, enters the liver with the hepatic artery, breaks up into branches of ever diminishing size to ramify throughout that organ and then form veinlets which collect the blood again until they unite to form the *hepatic* veins which ultimately pour this great volume of blood into the *inferior vena cava* just before it empties into the heart.

THE GENITO-URINARY ARTERIES

These vessels are the *renal, suprarenal* and *spermatic* or *ovarian.*

The **renal** arteries are short large vessels, the right the larger, which pass outward to the hilum of the kidney, one on each side, where they break up into three

branches, one to each third of the organ. They lie behind the peritoneum with the renal vein in front and the ureter behind.

The *suprarenals* are small wigs, often springing from the renal, for the suprarenal gland.

The **spermatic** is a long slender vessel rising just below the renal which leaves the abdomen through the inguinal canal, with other elements of the spermatic cord, and is distributed to the testicle.

The **ovarian** arteries are analogous to the spermatic. They pass over the beginning of the external iliac artry, run in the folds of the broad ligament and are distributed to the ovaries.

ARTERIES OF THE HEAD AND NECK

Three branches spring from the top of the transverse aorta, innominate, left common carotid, and left subclavian. The innominate combines the right common carotid and subclavian.

The Innominate Artery

The vessel springs from the beginning of the transverse aorta and passes upward and to the right through the superior mediastinum to the sterno-clavicular articulation where it divides into the *right common carotid* and *right subclavian* arteries. On its outer side is its own vein, across its front the left innominate vein, internally the left common carotid and, behind and internal, the trachea. The right lung and pleura ovelap it.

The Left Common Carotid

This artery lies with the innominate on its right and left subclavian on its left and slightly behind. It is

crossed by the left innominate vein, has the trachea and esophagus behind and internal, the left pneumogastric and phrenic nerves to its outer side, and the recurrent laryngeal first behind and then internal. Its thoracic portion stops at the sterno-clavicular articulation and the cervical portion, which is like the right, needs no description.

The Left Subclavian

The thoracic portion of the **left subclavian** extends from near the end of the transverse aorta to the inner border of the scalenus anticus muscle. It is nearly invested by the left pleura and lung. The left carotid is internal, the left innominate vein crosses in front high up, the phrenic nerve is in front, the pneumogastric antero-internal and the thoracic duct behind and internal.

The last three vessels are behind the sternum and are in relation with the structures attached to that bone.

The Cervical Carotids

The **common carotids** in the neck lie on the group of muscles covering the transverse processes as high as the fourth, on a level with the upper border of the thyroid cartilage, where they divide into internal and external carotids. They are in a sheath formed by the deep cervical fascia, in which are the internal jugular vein and the pneumogastric nerve. They are deeply seated at the root of the neck where they are covered by the muscles attached to the sternum, but become more superficial as the muscles draw away above. The platysma, deep cervical, fascia, and skin cover them throughout. The sterno-cleido-mastoid covers them below and overlaps them above. Its inner border is the

guide to the vessels. The internal jugular vein is external, the pneumogastric nerve between artery and vein, descendens hypoglossi on the front of the sheath, and the cervical sympathetic behind it. Internally are the larynx, above, and trachea below. No branches arise from these vessels.

The External Carotid

The **external carotid** is the smaller of the terminal branches of the common carotid. Beginning at the upper border of the thyroid cartilage it terminates behind the neck of the lower jaw by dividing into the temporal and internal maxillary. It is covered by the skin, fascia and platysma and overlapped, at first, by the sterno-mastoid. The digastric muscle crosses its front and is used by surgeons to divide it into three parts. It is crossed by the twelfth nerve and has the ninth nerve and superior laryngeal behind it. Its upper part is imbedded in the parotid gland. Internally is the pharynx.

Branches.—These are seven in number, *superior thyroid, lingual, facial, occipital, posterior auricular, ascending pharyngeal,* and *parotidean.* Their names indicate the parts supplied.

The *superior thyroid* goes to structures around the thyroid cartilage and inosculates with its fellow of the opposite side and with an inferior thyroid from the subclavian.

The *lingual* goes to muscles attached to the hyoid bone, but chiefly to the tongue.

The *facial* gives large branches below the lower jaw, runs tortuously across the face from an inch in front of the angle of the jaw, where its pulsation can be felt, to the inner angle of the eye where it inosculates with a branch from the internal carotid. It supplies the chin, lips, cheeks, and nose in part.

The *occipital* winds beneath the mastoid process of the temporal to reach the back of the skull where it inosculates with

its fellow of the opposite side and, in front, with the posterior temporal. It supplies the back part of the scalp and gives one large muscular branch in the neck (princeps cervicis) which runs downward and establishes a communication with a branch of the subclavian.

The *posterior auricular* is distributed to the back of the ear.

The *parotidean* are four or five small branches for the parotid gland.

The *ascending pharyngeal,* coming off near the origin of the carotid, passes up the neck to the pharynx and by one branch, to the membrane of the brain.

The Temporal Artery

The **temporal** is the smaller of the terminal branches of the carotid. It mounts over the zygoma and gives off branches which supply the front of the ear, the side of the face, the temporal muscle and the middle portion of the scalp, inosculating in front with the frontal, derived from the internal carotid, and behind with the occipital.

The Internal Maxillary

The **internal maxillary,** much larger than the temporal, turns inward and forward from the neck of the lower jaw to run finally into the space between the sphenoid and superior maxilla. Its work is to supply the deep structures of the face, including the teeth, and the membranes of the brain.

Branches.—A small branch enters the ear while a much larger, *meningea media,* passes to the middle fossa of the skull through a hole in the sphenoid, and, ramifying between the bone and dura, grooving the bones deeply, is the chief artery of the dura.

The *inferior dental* runs in a tunnel in the lower jaw and gives a branch to every fang of every tooth as it passes, finally emerging on the chin to inosculate with the facial.

The *muscular branches* are distributed to the muscles of mastication.

Superior dental branches supply the teeth of the upper jaw, while an *infraorbital* emerges from a tunnel beneath the floor of the orbit to appear on the face and communicate with the facial. Other branches supply the palate, nose, pharynx and eustachian tube.

The face is very abundantly supplied with blood. Arteries come to it from various sources and inosculate with great freedom. It is nearly impossible to cut off collateral circulation and these tissues will survive injuries which would destroy many others.

The Internal Carotid

The **internal carotid** continues the course of the common carotid upward to the base of the skull where it enters a foramen in the petrous part of the temporal bone, runs forward and inward in a tunnel in that bone, turns upward in the middle fossa of the skull and terminates by dividing into an *anterior* and *middle cerebral, posterior communicating* and *anterior choroid.*

This vessel is deeply seated and in relation with many important structures, very important to the surgeon but of little use to the nurse. The internal jugular vein lies on its outer side, the tenth nerve lies between vein and artery and the ninth, eleventh and twelfth nerves all bear relations to it. The sympathetic is behind.

Branches.—The distribution of these is largely to the brain and can not be comprehended until the brain is studied.

The *ophthalmic* is distributed to structures in and around the orbit. It comes off near the end of the artery, enters the orbit through the optic foramen and breaks up into nearly a dozen branches. These are distributed to the eyeball (*ciliary*), retina, eyelids (*palpebral*), lachrymal gland, nasal cavity and ethmoidal cell while two branches, the *supraorbital* and *frontal* pass out of the orbit to the front of the scalp which they nourish and where

they communicate with the temporal, with each other and with the vessels of the opposite side.

ARTERIES OF THE UPPER EXTREMITY

The Subclavian

The cervical **subclavian** extends on the right from the bifurcation of the innominate at the sterno-clavicular joint to the outer border of the first rib; on the left from the inner edges of the scalenus anticus to the outer border of the left first rib.

The first and second parts of the right subclavian are deeply seated, covered by skin, fascia, platysma, sterno-mastoid, while the outer third of each is superficial, having only skin, fascia and platysma as coverings. The apex of the lung is under the subclavian in its first two parts. The pneumogastric and phrenic nerves cross it in front with the internal jugular vein, which unites with the subclavian to form the right innominate. The artery is bent like a bow; the vein runs straight and only touches the artery at its inner and outer ends. The recurrent laryngeal nerve winds from front to back. The brachial plexus of nerves comes in contact with the artery in its second part and lies above and somewhat posterior.

Branches.—These are the *vertebral, thyroid axis* breaking into the *inferior thyroid, suprascapular* and *transverse cervical;* the *internal mammary, superior intercostal* and *profunda cervicis.*

The *vertebral* enters the foramen in the transverse process of the sixth cervical, passes through these foramina in succession, giving off branches to the spinal canal and its contents, enters the skull through the foramen magnum and joins the opposite vertebral to form the *basilar* whose distribution is taken up with the arteries of the brain.

The *inferior thyroid* is distributed to the thyroid gland and muscles of the neck, inosculating with the superior thyroid and the opposite artery.

The *suprascapular* passes outward across the third part of the subclavian, accompanied by its vein, and is distributed in the supraspinous and infraspinous fossæ.

The *transverse colli* runs across the neck and breaks into two branches, the upper to anastomose with the occipital and the lower to run along the vertebral border of the scapula, communicating with the suprascapular and subscapular.

The *internal mammary* runs down the thorax behind the costal cartilages about half an inch from the sternum to the diaphragm where it divides into the *superior epigastric* and *musculo-phrenic*. It gives off *anterior intercostals* to the intercostal spaces, a branch to the phrenic nerve, *mediastinal* and *pericardiac* and six *anterior perforating* branches which run between the ribs to the muscles of the chest and the mammary gland. They are larger and more important in the female than in the male.

The *superior epigastric* passes down in the rectus muscle to inosculate with an inferior epigastric of the external iliac.

The *musculo-phrenic* gives off intercostal branches to the lower spaces and muscular branches to the diaphragm.

The *superior intercostal* and *profunda cervicis* usually rise by a common trunk, the former supplying the first intercostal space and the latter anastomosing with a branch of the occipital.

The Axillary

The **axillary** begins behind the outer third of the clavicle, on the outer border of the first rib, as a continuation of the subclavian, and passes through the outer angle of the axilla to become the brachial at the lower border of the teres major.

It is covered by the pectoral muscles, rests on the subscapularis and tendons of the latissimus dorsi and teres major, has the serratus magnus internal and the short head of the biceps and the coraco-brachialis external for the lower part. The axillary vein is internal and in front throughout. The brachial plexus lies external

and behind at first, breaks into three cords which lie behind, external and internal behind the pectoralis minor and gives off its terminal branches which surround the artery just below that muscle and then lie on three sides, inner, outer, and posterior.

Branches.—These are very irregular. One, *superior thoracic,* supplies the pectoral muscles; one, *acromial thoracic,* the deltoid and other structures around the acromion. The *long thoracic* goes to the chest wall and the *alar thoracic* to the structures in the axilla.

The *anterior* and *posterior circumflex,* the latter much the larger, surround the surgical neck of the humerus and supply it, the deltoid, and the shoulder.

The *subscapular,* the largest branch, supplies the subscapular fossa, part of the infraspinous and the muscles attached to these and the axillary border of the scapula.

The Axilla

This is a wedge-shaped space between the upper five ribs internally, the bicipital groove of the humerus externally and the scapula behind. Its apex is above. The pectoral muscles form its anterior wall, the serratus magnus the internal and the subscapularis teres major and latissimus dorsi its posterior. The outer angle ends in the bicipital groove between the anterior and posterior walls. The floor is formed by the investing fascia stretching from the anterior to the posterior folds. The outer angle is filled by the axillary vessels, nerves, and lymphatics, which follow the course of the vessels, while the inner and lower part contains a considerable amount of fat.

The Brachial

The **brachial** is a continuation of the axillary and terminates a "fingersbreadth" below the bend of the

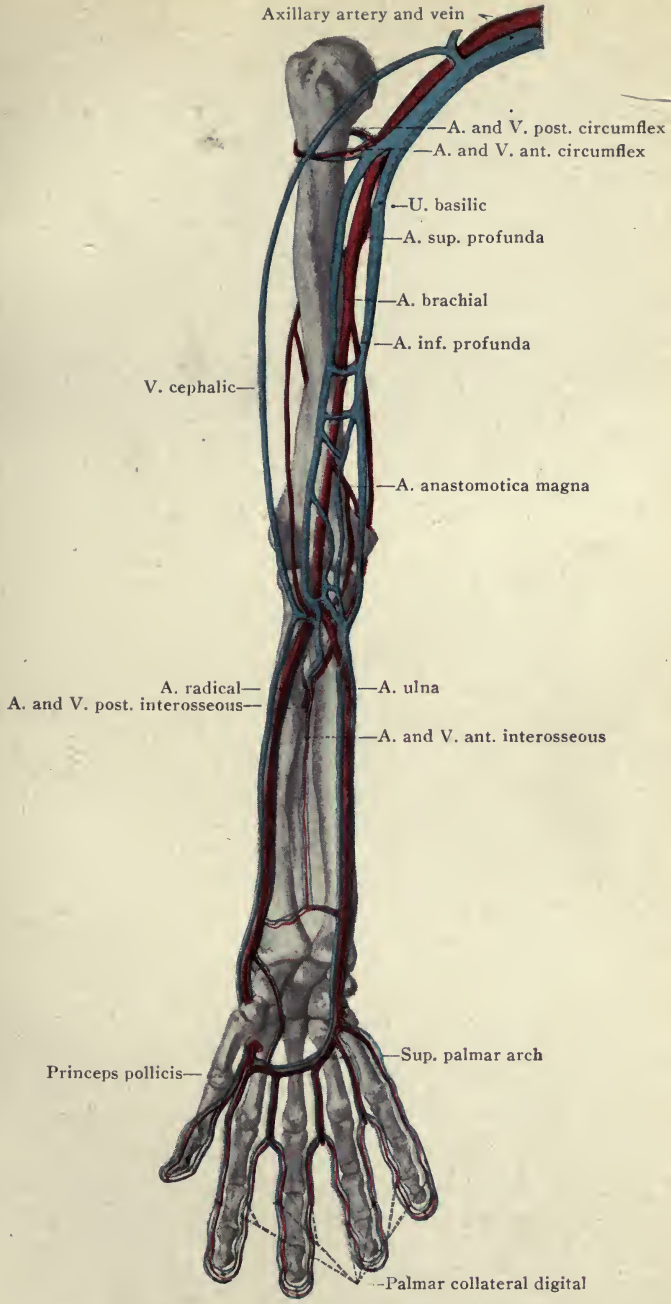

Fig. 15.—Diagram of arteries and veins of upper extremity.

elbow by dividing into radial and ulnar. It is superficial, covered only by skin, superficial and deep fascias, overlapped by the biceps from the outer side and easily compressed against the bone outward and backward above, and backward below. Unlike the corresponding vessel of the lower extremity (popliteal) it has satellite veins, one on each side. The median nerve is first external, then in front and finally internal. The basilic vein and internal cutaneous nerve are in the fascia which covers it antero-internally.

Branches.—The *superior profunda* winds through the musculospinal groove to supply muscles on the back of the arm and aid in the vascular circle around the elbow.

The *inferior profunda* passes to the inner side of the elbow.

The *anastomotica magna* runs transversely around three-quarters of the joint from the inner side, and is the chief agent in forming the anastomoses. Muscular branches are also given off.

The Radial

The **radial** runs down the outer side of the forearm to the styloid process where it turns backward across the carpus to the first interosseous muscle through which it plunges to form the deep palmar arch.

The brachio-radialis muscle lies external to this artery and is the guide to it. Internally the flexor carpi radialis is the chief relation. Between the two the lower part is superficial and is the artery most frequently used to feel the pulse. The artery has satellite veins and the nerve is external in the middle.

Branches.—A recurrent branch aids in the anastomoses around the elbow. Muscular twigs supply the outer side of the forearm.

The Ulnar

The **ulnar** is larger than the radial and more deeply seated. It runs under the muscles of the superficial group, except one, flexor carpi ulnaris, which lies to its inner side, and enters the palm to the outer side of the pisiform to form the superficial palmar arch. It, too, has satellite veins and its nerve internal for its lower two-thirds.

Branches.—Two recurrent branches enter the elbow circle.

The *interosseous* is a short trunk breaking into a large *anterior* and a small *posterior* interosseous. The *anterior* descends on the interosseous membrane, supplying muscles in its course, and, piercing the membrane below, aids in forming the carpal arch. The *posterior* passes above the interosseous membrane and is mainly a muscular vessel for the back of the forearm, but a twig gets to the carpal arch.

Arterial Supply of the Hand

Draw a line from the top of the web between thumb and index finger and the superficial palmer arch is roughly represented. This is formed by the continuation of the ulnar joining a branch of the radial. It lies on the flexor tendons and ulnar and median nerves. From the arch thus formed branches pass to the clefts between the fingers and divide into a branch for the adjacent sides of the fingers. These are called *palmar collateral digital* branches and not only anastomose with the branch of the opposite side of the finger, but with those on the back as well. The branch to the thumb comes entirely from the radial and is called *princeps pollicis.*

The *deep arch* lies higher up on the carpus and under the tendons. It is formed chiefly by the radial with a

communication from the ulnar. Its branches go to the carpus, perforate the spaces to pass to the back of the metacarpus, and give interosseous branches which join the palmar digital.

A *posterior carpal arch* is formed by small branches from the radial and ulnar and this with three branches, dorsales pollicis and dorsalis indicis supply branches to the back of the hand and fingers.

ARTERIES OF THE PELVIS AND LOWER EXTREMITY

Common Iliac

The **common iliac** arteries are terminal branches of the abdominal aorta, beginning on the fourth lumbar vertebra and diverging to reach the disc between the fifth lumbar and sacrum where they bifurcate to form the external and internal iliac arteries.

These vessels lie behind the peritoneum and viscera, and each vein is right of its own artery, but the left vein crosses behind the right artery in order to join the right vein and form the inferior cava.

There are no branches.

The Internal Iliac

The **internal iliac** carries blood to the walls and viscera of the pelvis. It drops over the pelvic brim, runs down on the sacro-iliac joint to the sacro-sciatic notch and divides there into an anterior and posterior trunk. It lies behind the peritoneum with the ureter in front and the lumbosacral cord behind.

Branches.—From the anterior trunk come branches for the bladder (vesical) and rectum (hemorrhoidal) an *obturator* and two terminal branches, *internal pudic* and *ischiatic,* and, in the female, *uterine* and *vaginal* branches.

The *uterine* passes to the neck of the uterus, runs up on the side and joins the ovarian artery. The *vaginal* takes the place of the inferior vesical in the male.

The *obturator* crosses the pelvic wall, with its nerve above and vein below, to the upper part of the obturator foramen through which it leaves the pelvis to be distributed to muscles of the gluteal and adductor groups and to the hip joint.

The *ischiatic* leaves the pelvis through the great sacro-sciatic foramen and runs down the back of the thigh as far as the knee, giving off branches to muscles of that region.

The *internal pudic,* or *pudendal,* artery leaves the pelvis through the great sacro-sciatic foramen to reenter through the lesser, run along the ischio-pubic rami and end in the external genital organs. It gives a branch to the skin of the perineum, one to the back of the penis, one to the carpus spongiosum and one to the cavernosum. In the female these branches are very small and go to analogous parts.

The *posterior trunk* gives off the *ilio-lumbar* which does the work of a lumbar artery and in addition, supplies the iliac fossa; a *lateral sacral,* which gives a branch to each anterior sacral foramen and terminates in the *gluteal,* a large artery which leaves the pelvis above the pyriformis, supplies muscles of the gluteal region and aids in forming the anastomoses around the hip joint.

The External Iliac

The **external iliac** begins at the fifth lumbar disc and terminates under the middle of Poupart's ligament by changing its name to femoral. It is behind the peritoneum, has its vein internal, the psoas magnus external and the ovarian artery in front, in the female, on both sides. The right is overlapped by the cecum and often crossed by the appendix. The left has the sigmoid flexure lying on it.

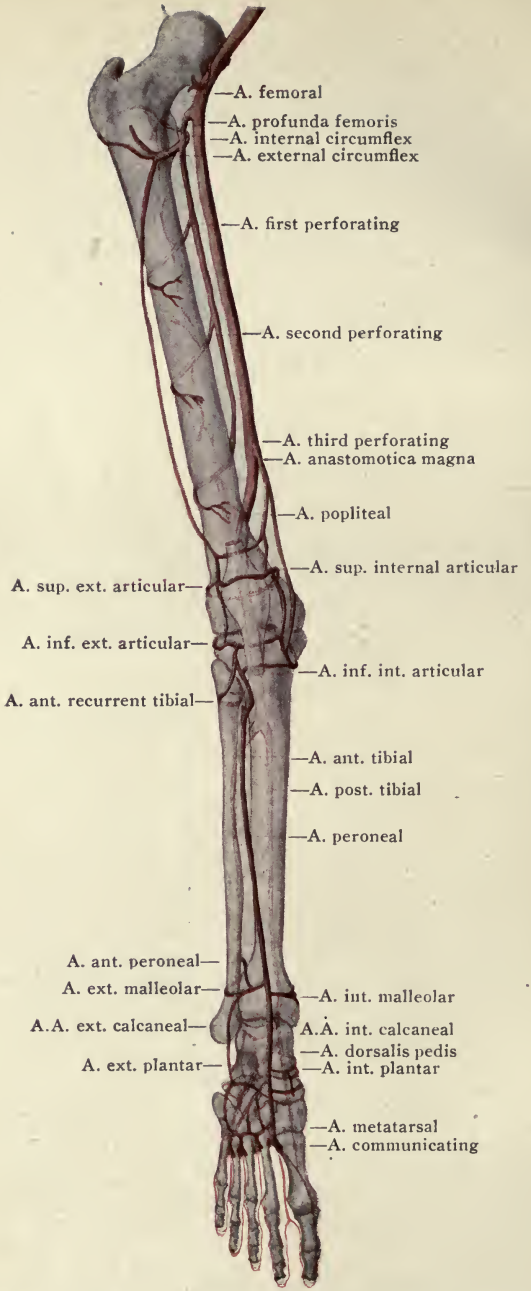

Fig. 16.—Diagram of arterial circulation in lower extremity.

Branches.—These are two, *deep epigastric* and *deep circumflex iliac.*

The *deep epigastric* runs upward in the sheath of the rectus, gives off muscular branches, and anastomoses with the internal mammary.

The *deep circumflex iliac* courses along Poupart's ligament and the crest of the ilium, gives branches to the broad muscles and anastomoses with the lumbar and gluteal arteries.

The Femoral

The **femoral** runs from a point midway between the anterior superior spine of the ilium and the symphysis pubis across the front and inner side of the thigh to its lower third, where it turns to the back and becomes the popliteal. It is superficial above, lying in a space, Scarpa's triangle, bounded above by Poupart's ligament, externally by the sartorius internally by the adductor behind. Its vein is internal and abreast at first but gets longer and then external. The anterior femoral nerve is a quarter of an inch to its outer side. Two inches below its origin it gives off from its outer side, the *profunda femoris* which quickly gets behind with its own vein in front of it. So that femoral artery, femoral vein, profunda vein, profunda artery would be the order from before backward.

Branches.—Besides several superficial branches to the pubic region, lower abdomen, space around the anterior spine of the ilium, and muscular branches, this artery gives off the *anastomotica magna* at its lower portion to partly encircle the femur and form a great portion of the vascular zone around the knee joint.

The **profunda femoris** carries the greater part of the blood of the thigh. It gives off external and internal *circumflex* branches, the external the larger, which en-

circle the upper part of the femur, aid greatly in the anastomoses around the hip joint and supply muscles of the thigh.

The three *perforating arteries* come from the profunda on the adductor muscles, which they perforate to appear at the back of the thigh.

The Popliteal

The **popliteal** extends from the lower third of the femur, across the back of the knee joint, to the upper fifth of the tibia where it divides into anterior and posterior tibial arteries. It lies on the femur, posterior ligament of the knee and popliteus muscle and is surrounded by the muscles bounding the popliteal space. Its vein, which hugs the artery closely, is behind and the internal popliteal nerve is behind the vein. They cross the artery obliquely and are a little external above and a little internal below.

Branches.—Muscular branches, above and below the joint, are given to the hamstring muscles and heads of the gastrocnemius, besides five *articular* arteries, two above, two below, and one in the middle, supplying the joint. They communicate with each other, the anastomotica magna and recurrent branches from the tibia.

The Anterior Tibial

The **anterior tibial** passes between the leg bones and runs down the interosseous membrane, between muscles of the anterior group to the middle of the ankle, beneath the annular ligament, where it changes its name to *dorsalis pedis* which continues the artery to the base of the big toe.

It is accompanied by satellite veins and its nerve which is antero-external.

Branches.—A *recurrent* branch joins the knee circle. Muscular branches supply the tibial group, and *external* and *internal malleolar* form a large part of the ankle circle.

The Posterior Tibial

The **posterior tibial,** larger than the anterior, runs down between the deep and superficial groups on the back of the leg to midway between the inner malleolus and the heel where it divides into the *internal* and *external plantar* arteries. It is accompanied by satellite veins and its nerve which is internal at first but quickly crosses it behind to remain external to the end. At the ankle it lies between the tendon of the flexor longus digitorum internally and the longus pollicis externally.

Branches.—Besides *muscular* and *internal calcanean,* distributed around the inner aspect of the heel and ankle, it gives a large branch high up called *peroneal.*

The *peroneal* corresponds to the posterior interosseous of the ulnar. It descends to the lower part of the leg, gives off a large *anterior peroneal* branch and itself runs to the outer side of the heel as the external calcanean.

Arterial Supply of the Ankle and Foot

The **malleolar** and **calcanean** arteries communicate with each other and with branches of the plantar and dorsalis pedis arteries to form the annular zone around the ankle.

The ~~*external*~~ lateral *plantar* artery corresponds to the superficial palmar arch, supplies the three and a half outer toes and anastomoses with a communicating branch of the dorsalis pedis, which supplies the big toe and inner half of the second.

The ~~*internal*~~ medial *plantar* is chiefly a muscular branch for the inner part of the sole.

The *dorsalis pedis* supplies the back of the great toe and half the second. The remaining toes are supplied dorsally by interosseous branches from the *metatarsal* branch of the dorsalis pedis.

THE VEINS

The veins are divided into *superficial,* lying in the superficial fascia, and *deep,* accompanying the arteries. Some channels in the skull, called *sinuses,* perform the functions of veins.

THE VEINS OF THE LOWER EXTREMITY

The superficial veins of the lower extremity are the long and short saphenous. They are abundantly provided with valves which enable the vertical columns of blood to overcome gravity.

The Long Saphenous

Just back of the web of the toes a venous arch is formed across the dorsum of the foot which receives tributaries from the toes and gives rise to the **long saphenous vein** on the inner side of the foot. It runs across the front of the inner malleolus, up the inner side of the leg to the back of the inner condyle, receives a communication from the short saphenous, continues up the inner face of the thigh, receiving tributaries all the way, reaches the saphenous opening in the fascia lata where it receives the veins accompanying the superficial branches of the femoral artery, and empties into the femoral vein.

The Short Saphenous

The **short saphenous** begins at the outer side of the dorsal arch passes around the outer malleolus to the calf, up the middle of which it runs to the popliteal space, where, after giving a communication to the long saphenous, it empties into the popliteal vein.

Deep Veins of the Lower Extremity

Metatarsal veins unite to form satellite veins for the plantar arteries. The two inner and the two outer plantar veins unite to form the satellites of the posterior tibial, which unite with those of the anterior tibial to form the popliteal. This accompanies the popliteal artery to the lower third of the thigh where it becomes the femoral; follows that artery to two inches below Poupart's ligament, where it receives the deep femoral, then the long saphenous and passes under Poupart's ligament to become the external iliac.

The external iliac receives the epigastric and circumflex iliac veins and joins the internal iliac to form the common iliac. The two common iliacs unite at the fifth lumbar disk on the right side and form the inferior vena cava which passes through the diaphragm opposite the ninth dorsal vertebra and empties into the right auricle of the heart.

THE VEINS OF THE UPPER EXTREMITY

These are also *superficial* and *deep* and are provided with valves. The deep and superficial anastomose frequently.

The Superficial Veins of the Upper Extremity

A network of veins is formed on both surfaces of the hand, though more apparent on the back. Near the wrist a vein called **median** begins and passes up the middle of the front of the forearm until just below the elbow where it divides into the **median cephalic** externally and the **median basilic** internally. The veins on the outer side of the hand give rise to a **superficial radial vein** which courses up the outer side of the forearm to join the median cephalic and form the **cephalic.** This vein passes up the outer side of the arm, runs into the groove between the deltoid and pectoralis major muscles, and empties into the axillary vein just below the clavicle.

There are two **ulnar** veins **anterior** and **posterior** which run up the front and back of the inner part of the forearm. They unite to form the **common ulnar** an inch or more below the elbow joint and this joins the median basilic to form the basilic vein. The **basilic vein** runs up the inner side of the arm, pierces the investing fascia and joins the brachial satellites (the inner usually) to form the axillary.

The **deep veins** begin as satellites of the superficial and deep arches, receive digital and metacarpal veins, form satellites of the radial and ulnar arteries which in turn, after the ulnar receives the interosseous satellites, unite to form the brachial satellites which either unite and join the basilic, or the inner joins the basilic and receives the outer, to form the axillary.

The **axillary** vein accompanies the axillary artery, receives the numerous tributaries which follow

branches of that vessel, is joined by the cephalic just below the clavicle and becomes the subclavian.

The **subclavian** vein touches its artery only at its ends. It receives the external jugular vein in addition to the veins accompanying the branches of the subclavian artery and also the thoracic duct on the left and right lymph duct on the right, just at its junction with internal jugular to form the innominate.

THE VEINS OF THE HEAD AND NECK

The veins of the brain and its membranes empty into channels in the dura called sinuses. The chief sinuses are the **superior** and **inferior longitudinal,** the **straight,** the **occipital, lateral** and **petrosal.** Many of these meet at the anterior occipital protuberance and pour their blood into the straight sinuses which run to the jugular foramen on each side where they meet the inferior petrosal sinuses, one on each side, and their junction forms the internal jugular vein. The ophthalmic veins empty into the **cavernous sinus** and its blood also goes to the jugular.

The **anterior facial vein** is formed by branches from the forehead, nose, lids, lips, and cheeks. It runs across the lower jaw with the facial artery, receives a communication from the posterior facial and empties into the internal jugular below the hyoid.

The **external jugular** is formed by the **posterior auricular** and **posterior facial.** The first comes from the back of the ear; the second is formed by the union of the *superficial temporal* and **internal maxillary** and is often called **temporo-facial.** The vein crosses the

sternor-mastoid, running downward and outward, beneath the platysma and empties into the subclavian vein after crossing the third part of the subclavian artery. It often receives the transverse cervical and suprascapular veins.

The **internal jugular** vein, formed by the lateral and inferior petrosal sinuses, accompanies the internal and common carotid arteries, enclosed in the same sheath, receives tributaries from the branches of the external carotid and unites with the subclavian to form an innominate vein.

The **left innominate, great transverse vein,** is larger than the right lying on the front of the left subclavian, left carotid, and innominate arteries. The two unite at the termination of the ascending aorta to form the superior vena cava which empties into the right auricle.

The **vertebral veins** are a plexus surrounding the vertebral arteries in the foramina in the transverse processes. They empty into the innominate veins, which also receive the inferior thyroid and internal mammary veins.

Most of the intercostal veins empty into the *great azygos,* a vein which begins in the abdominal cavity and passes through the posterior mediastinum to empty into the superior cava. Cardiac blood is collected by veins accompanying the coronary arteries and uniting in the coronary sinus which empties into the right auricle.

THE LYMPHATICS

The **lymphatic system** consists of numerous minute vessels ramifying throughout the body and certain small

glandular bodies at intervals along the vessels. They accompany the veins and are arranged in chains, notably in the groin, axilla, neck, pelvis, and abdomen. Many of them converge to form an irregular sac, the *receptaculum chyli*, on the body of the second lumbar vertebra. This contracts to a tube about the size of a wheat straw which accompanies the aorta through the posterior mediastinum to the fourth ~~dorsal~~ thoracic vertebra where it passes behind the transverse aorta and, bending somewhat forward opposite the interval between the left carotid and subclavian arteries, runs into the root of the neck and, crossing the subclavian, empties into the junction of the left subclavian and internal jugular veins. Just before it terminates it receives the left duct from the left side of the head, neck and upper extremity. A smaller duct collects lymph from the right side of the head, neck and upper extremity and empties into the right subclavian.

See Lymphatics

CHAPTER VII

THE NERVOUS SYSTEM

The nervous system consists of a large mass, *encephalon,* lying in the cranium, the spinal cord, *medulla spinalis,* in the spinal canal and three sets of nerve fibers conveying impulse to and from these centers, *cranial, spinal* and *sympathetic nerves.*

The central mass is enveloped in three membranes. *dura mater* (hard mother), *pia mater* (delicate mother) and *arachnoid.*

THE DURA MATER

The **dura mater** is a dense membrane lining the interior of the skull and spinal canal. Its outer surface, in the skull, corresponds to periosteum while its inner, in both situations, is lined by endothelium. The cranial dura gives off septa which separate or support subdivisions of the brain and lodge some of the venous sinuses.

The **falx major** is attached in front to the junction of the frontal and ethmoid bones, along the middle of the frontal, junction of the parietals and the upper half of the occipital to its anterior protuberance, where it joins the tentorium. In its upper, or attached, border is lodged the *superior longitudinal sinus.* Its lower border, which dips between the hemispheres of the brain, lodges the *inferior longitudinal sinus.*

The **tentorium cerebelli** is attached posteriorly to

the lateral limbs of the occipital cross, anteriorly to the upper border of each petrous bone, leaving a large opening opposite the basilar process for the passage of the midbrain. Along the middle of its upper surface the falx major is attached and forms the straight sinus, which receives blood from the interior of the brain. The lateral sinuses are formed in the posterior attachment of the tentorium. The upper surface of the process supports the occipital lobe of the brain while the lower covers the cerebellum.

THE PIA MATER

The **pia mater** is a thin delicate membrane binding together a network of blood vessels. It covers the entire brain and spinal cord, dips into the fissures found in both and enters the cavity in the interior of the cerebrum. It conducts blood vessels to and from the nerve tissues.

THE ARACHNOID

The **arachnoid** is a very delicate layer investing the pia and not separable from it in many places. It does not dip into the fissures but leaps from one elevation to another, leaving, opposite the depressions, small spaces between itself and the pia called *subarachnoid* spaces.

THE BRAIN

The **brain** may be divided into *cerebrum, cerebellum, pons Varolii* and *medulla oblongata,* or forebrain (prosencephalon), midbrain (mesencephalon) and hindbrain

(rhombencephalon). The forebrain consists of the cerebrum with is commissures; the midbrain comprises the aqueduct of Sylvius, corpora quadrigemina and crura cerebri while the hindbrain embraces the medulla, with the fourth ventricle, pons, and cerebellum.

The **cerebrum** is much the larger part of the brain. It is composed of gray matter externally, which is the active part of the organ, and mainly of white matter internally, the conducting part, though there are masses of gray matter embedded in the white. The longitudinal fissure divides this mass into a right and left hemisphere, the left, in the right-handed, being the more active. The white matter consists of fibers connecting different parts of the same hemisphere—*association fibers;* those running transversely and connecting the two hemispheres—commissural fibers; and of many fibers, as the *corona radiata,* which descend through the crura, pons, and medulla to connect the cerebrum with various parts of the body.

The exterior of each hemisphere is made up of alternate elevations, *convolutions* and depressions, *fissures or sulci.* Some of the latter occur at an early stage of fetal development, or in brains of a low order, and divide the hemisphere into lobes which approximately correspond to some of the cranial bones.

The **fissure of Rolando,** or *central sulcus,* runs from near the middle of the hemisphere downward and forward for two-thirds of its vertical measurement and cuts off the frontal lobe from the parietal.

The **fissure of Sylvius,** projecting in front of the central, and partly on the base of the brain, runs upward and backward and separates the back of the frontal

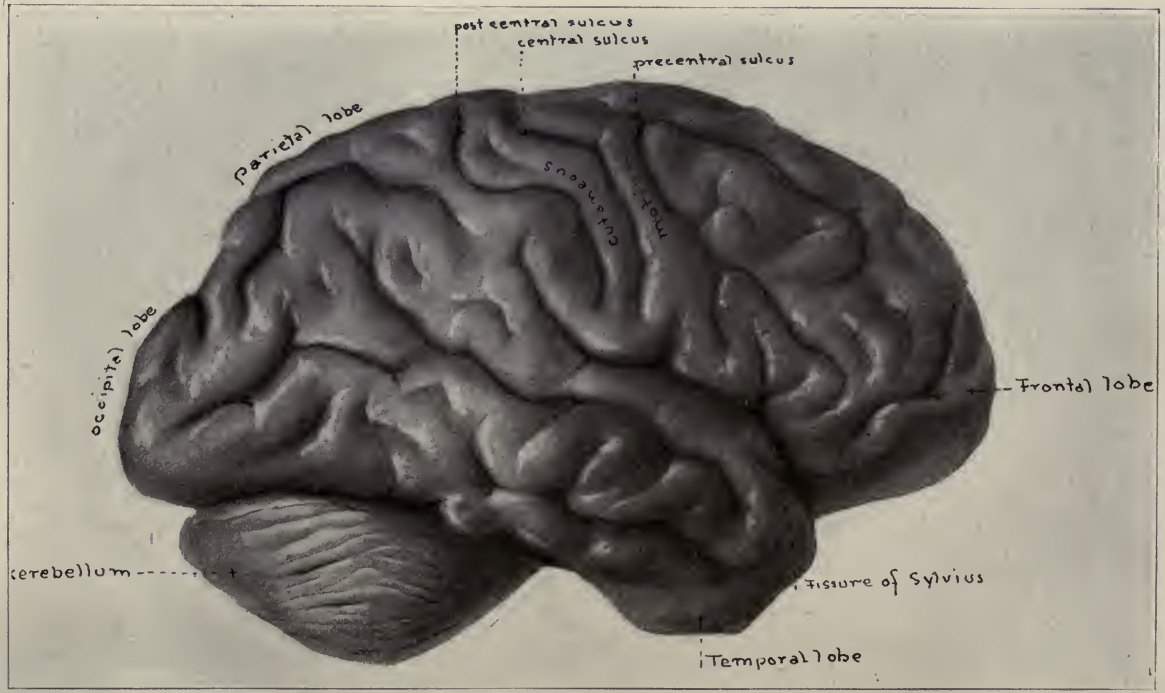

Fig. 17.—Brain, lateral view.

and nearly all of the parietal lobes from the temporo-sphenoidal.

The **parieto-occipital** fissure is almost entirely on the mesial surface at about its posterior fifth and separates the parietal from the occipital lobe.

The *precentral* and *postcentral* sulci run in front of, and behind, the central and cut off the *ascending frontal* and *parietal* convolutions. This area is one of the best known areas in the brain. The frontal furnishes the great *motor* and the parietal the great *sensory* area of the brain. The remainder of the frontal lobe is probably, the area for thought. The occipital, on its inner surface, is marked by a wedge-shaped area, the *cuneus,* which is concerned in vision. Hearing is governed by the temporo-sphenoid lobe just below the Sylvian fissure. Taste is in the anterior part of the same lobe and smell is in a set of fibers connected with this lobe but not forming an integral part of it.

The fibers at the bottom of the longitudinal fissure are called the *corpus callosum,* and bind the hemispheres together so that their action may be coordinated.

The fibers which pass in a general direction from above downward, form the *corona radiata* and connect the surface of the brain with the exterior of the body through the nerves. These fibers pass between two masses of gray matter embedded in the brain and form the *internal capsule.* This brings together the motor and sensory fibers in a very narrow space, so that a very small foreign body can compress a large number of fibers and do great damage.

Under the corpus callosum there is an irregular cavity partly in each hemisphere and partly in the space

between them, called the *ventricular* cavity. This divides into four compartments known as the two lateral, third and fourth ventricles. The fourth is on the pons and medulla.

The inferior surface of the brain corresponds to the steplike arrangement of the upper face of the base of the skull. It shows the origin of the cranial nerves and the arrangement of the blood vessels of the brain.

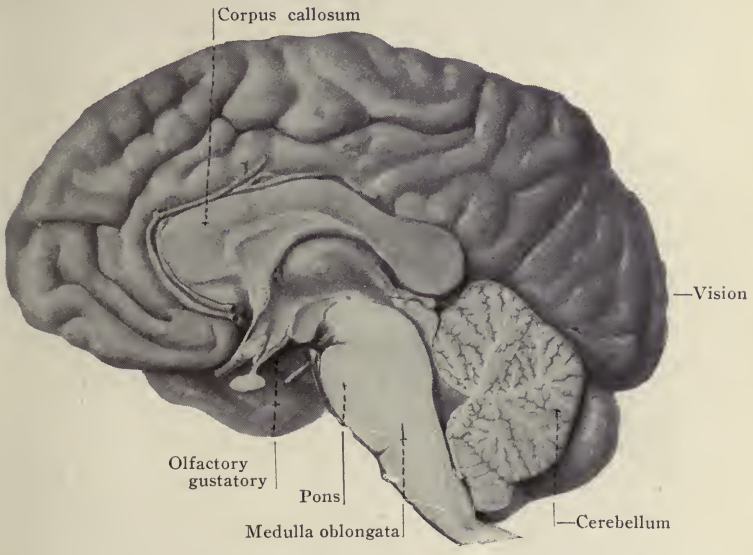

Fig. 18.—Brain, mesial view.

The **crura cerebri** are chiefly made of the fibers of the corona radiata which they are transmitting to the spinal cord. They appear, on the base of the brain, as two round cords, as large as a finger, which converge as they pass downward and backward to the pons, into which they abruptly disappear.

The **pons varolii** appears to consist of two rope-like bundles running from the hemispheres of the cerebellum and blending in a broad mass, grooved longitudinally, on the midline. These superficial fibers are commissural fibers of the cerebellum and cover the longitudinal fibers of the crura.

The **cerebellum** juts into the occipital fossæ between the occipital lobes of the cerebrum above and the medulla below. The fissure separating it from the cerebrum is called the transverse fissure and lodges the tentorium. Between it and the medulla there is a fissure without name and with no process of the dura. The cerebellum consists of two lateral lobes and a middle lobe, the *vermis,* each having upper and lower surfaces. It is not convoluted like the cerebrum but split into thin layers by narrow sulci so that its folds are piled like tiles or shingles.

The **medulla oblongata** is the connecting link between the brain and the spinal cord. It lies just beneath the cerebellum and two bundles of its fibers can be traced directly into that body. They are known as *direct cerebellar* fibers in the cord and become the *restiform* bodies in the medulla from which they pass to the cerebellum, forming its inferior peduncles. Between these diverging bundles is seen the lower half of the diamond-shaped space called *calamus scriptorius,* which forms part of the floor of the fourth ventricle and gives origin to several cranial nerves. The upper half of the diamond is on the pons. The floor of the space is marked by a groove on the midline.

The front of the medulla is also grooved longitudinally and presents a round eminence on either side

called the *anterior pyramid.* They are made up of fibers going to or coming from the crus of that side and descend from the medulla into the cord. The larger part of these fibers, however, cross beneath the floor of the median fissure to the opposite side of the cord, forming the *crossed pyramidal* tract; and this crossing explains the fact that injury to the motor area of one hemisphere of the cerebrum causes paralysis of the opposite side.

THE SPINAL CORD

No line or fissure marks the point of division between the medulla and cord, which corresponds to the upper two-thirds of the vertebral column. It is somewhat flattened from before backward and, unlike the brain, has its gray matter in the middle. It is, apparently, mainly a set of conducting fibers to carry impulses to and from the brain and transmit them to the spinal nerves. It is marked by anterior and posterior fissures and, on either lateral half, by two sets of openings marking the points at which nerves emerged from the cord. Its anterior part is mainly concerned in transmitting motor impulses. If the cord be cut across, the gray matter in the center is seen to be arranged somewhat like a capital H, whose large end is in front and whose posterior horns are longer, as well as smaller, than the anterior. The anterior give attachment to motor and the posterior to sensory nerve fibers.

BLOOD VESSELS OF THE BRAIN

Blood is carried to the brain by branches of the internal carotid and vertebral arteries. From the carotid

the *anterior cerebral* runs in the longitudinal fissure and supplies the mesial face of the hemisphere. The *middle cerebral* lies in the fissure of Sylvius and is the chief supply to the cortex of the frontal, parietal, and temporosphenoidal lobes. The *anterior choroid* enters the apex of that lobe and supplies the choroid plexus in the ventricular cavity.

The two vertebral arteries unite to form the *basilar* which runs to the upper border of the pons and divides into two *posterior cerebral* arteries which pass to the posterior lobe of the cerebrum. Before the formation of the basilar, the vertebral supplies the spinal cord and its membranes and an *inferior cerebellar* to the cerebellum. The basilar gives *anterior* and *superior cerebellar* arteries.

THE CIRCLE OF WILLIS

The two anterior cerebral arteries are united by a short branch, the *anterior communicating*. The *posterior communicating* is a branch of the internal carotid which joins the posterior cerebral. These anastomoses form an irregular circle at the base of the brain. Blood starting at the right internal carotid could pass through the anterior cerebral, anterior communicating, left anterior cerebral, left carotid, posterior communicating and posterior cerebral into the basilar and thence forward through the right posterior cerebral and posterior communicating into the right carotid.

From the circle of Willis branches called *ganglionic* arise which pierce the base of the brain and are distributed to its deep substance. These arteries are called *terminal* because they do not anastomose in the cerebral

substance and, if one of them be destroyed or occluded, the area which it supplies dies from lack of blood; i. e., there is no collateral circulation, as on the surface of the brain or elsewhere in the body.

The return circulation is cared for by cerebral veins formed on the surface and in the interior. The superficial empty into the longitudinal and cavernous sinuses while the deep unite to form the veins of Galen which empty into the straight sinus.

THE NERVES

The nerves are twelve pairs of *cranial* and thirty-one pairs of *spinal* nerves in addition to the *sympathetic.*

The Cranial Nerves

The *cranial nerves* are known by number from before backward and have also names more or less derived from their function. Four are appropriated to the special senses of smell, sight, hearing and taste. Three are concerned in the movements of the eye, one in supplying sensation to the face and motion to the lower jaw; one in supplying motion to the facial muscles, one to those of the tongue, one is almost a spinal nerve and is distributed in the neck, while the tenth scatters fibers from the head to the abdomen.

Nerve fibers conduct impulses to the brain or carry orders from the brain. Sensory nerves, like those recognizing pain, all convey impulses from the periphery to the center, while nerves which give rise to motion, secretion, etc., carry impulses from center to periphery.

The **olfactory,** or **first,** nerve recognizes odors and

conveys that sensation to the brain, and no other. It can be seen at the base of the brain on either side of the longitudinal fissure in the form of an elongated mass of brain tissue which sends numerous filaments through the cribriform plate of the ethmoid to the nose.

The **optic,** or **second,** nerve springs from the *optic chiasum* formed at the junction of the anterior and middle cranial fossæ by the union of two flat bands, the *optic tracts,* which run over the crura cerebri to pass into the midbrain and be connected with the cuneus. The middle fibers in these tracts decussate, i. e., fibers from the right hemisphere pass into the left eye; the outer pass forward in the nerve of the same side; others, the most posterior, run in the tracts entirely and are commissural fibers between the centers, while the most anterior run from retina to retina.

The whole nerve passes through the optic foramen, enters the back of the eyeball and spreads out in the retina.

The **motor oculi,** or **third, patheticus,** or **fourth,** and **abducens,** or **sixth,** are all distributed to muscles of the orbit, the fourth entering the superior oblique, the sixth the external rectus, while the third supplies the remaining muscles of the eyeball and gives the motor filament to the ciliary ganglion which supplies the intrinsic muscles of the eye. These nerves all lie in the outer wall of the cavernous sinus and enter the orbit through the anterior lacerated foramen. Their deep origin is from the floor of the aqueduct of Sylvius or the fourth ventricle.

The **trifacial,** or **fifth,** nerve has, like a spinal nerve, two roots of which the smaller is motor. It furnishes

sensation to all the teeth, the face, front and sides of the head to the vertex, and motion to the muscles of mastication.

It can be seen emerging from the side of the pons while its nucleus of origin is in the floor of the fourth ventricle. An enlargement, the *ganglion* of *Gasser,* is formed on the posterior root while lying on the petrous bone. The nerve now splits into three branches, *ophthalmic, superior maxillary* and *inferior maxillary.*

The *ophthalmic* division passes through the sphenoidal fissure and breaks up into a *lachrymal* branch to the gland of that name and the outer angle of the orbit; a *frontal* which, dividing into *supraorbital* and *supratrochlear,* named from their points of exit from the orbit, supply muscles and integument of the forehead and the upper eyelid; and *nasal* which crosses the orbit, reenters the cranium and descends the nose in a groove on the nasal bone to become superficial at the lower end of that bone and be distributed to its tip. It supplies the sensory twig to the ciliary ganglion.

The *superior maxillary* division leaves the skull through the foramen rotundum and supplies the teeth of the upper jaw, the skin over the cheek bone, sensory fibers to *Meckel's ganglion* and, by an infraorbital nerve, palpebral, nasal and labial branches to the lower lid, nose, and upper lip.

The *inferior maxillary* division carries all the motor fibers. The entire nerve leaves the skull through the foramen ovale and, at the base of the skull breaks up into an anterior trunk, which contains the motor fibers for the temporal, masseter and pterygoid muscles, and a sensory twig to the buccinator, and a posterior trunk

which splits into *inferior dental, gustatory* and *auriculo-temporal.*

The *inferior dental* enters the foramen in the ramus of the lower jaw, runs in the tunnel under the teeth, supplying a branch to every fang of every tooth, and, dividing near the mental foramen, sends one branch forward in the bone to supply the incisor teeth, while the larger division escapes through the mental foramen to give sensation to the lower lip. It gives off a large branch, before entering the dental foramen, to supply the mylo-hyoid and posterior belly of the digastric.

The *gustatory* or *lingual* nerve runs down parallel with the lower jaw to the anterior part of the tongue where it splits into many branches for the numerous papillæ of that organ. It carries with it the *chorda tympani* branch of the seventh whose fibers are mainly distributed to the tongue, but many pass through the submaxillary ganglion to the submaxillary and sublingual glands.

The *auriculo-temporal* passes up over the zygoma, just in front of the ear to the skin of the temporal region.

The **facial** or **seventh** nerve also has two roots. It springs from the side of the medulla, between the restiform and olivary bodies as do the eighth, ninth, tenth, and eleventh, pursues a tortuous course through the petrous bone, emerges through the stylo-mastoid foramen, crosses the carotid artery on a level with the lobe of the ear and breaks up into a whip-lash of branches which supply all the muscles of expression. In addition it furnishes motor fibers to the stapedius, stylo-hyoid and posterior belly of the digastric and, by its cervical branch to the platysma.

The *chorda tympani* branch joins the gustatory and

is the nerve of taste for the anterior two-thirds of the tongue.

The facial also gives a branch to join Mackel's (the sphenopalatine) ganglion through the superficial petrosal.

The **auditory,** or **eighth,** nerve emerges from the side of the medulla just below the seventh. While it seems but one nerve, it really consists of two distinct parts, a *vestibular,* concerned with equilibrium, which has its origin in the superior vermis of the cerebellum and its distribution in the vestibule of the ear; and a *cochlear* division, the nerve of hearing, connected with the cerebrum and distributed to the cochlea of the internal ear.

The **glosso-pharyngeal,** or **ninth,** cranial nerve rises from the medulla just below the eighth. Its deep origin is in the floor of the fourth ventricle. The nerve leaves the skull through the *jugular* foramen, accompanies the internal carotid artery and jugular vein to the stylo-pharyngeus muscle when it turns in across the artery to the side of the tongue, to the posterior third of which it conveys taste.

It gives off branches to the ear (tympanic), pharynx and tonsils.

The **pneumogastric,** or **tenth,** or **vagus,** is both motor and sensory. It rises from the side of the medulla just below the ninth, goes through the jugular foramen, lies in the carotid sheath between artery and vein, passes to the neck and, on the right side, crosses the front of the subclavian artery, runs to the back of the root of the lung where it spreads out into a plexus, forms two cords to run down on the back of the esophagus to the back

of the stomach, where many fibers are distributed, and finally join the celiac plexus.

The left nerve enters the thorax between the carotid and subclavian arteries, behind the innominate vein, crosses the front of the transverse aorta, forms the posterior pulmonary plexus on the root of the left lung, passes to the front of the esophagus, where it forms a plexus with the right, and is distributed to the front of the stomach.

The nerve gives motion and sensation to the pharynx, esophagus and stomach, larynx, trachea and bronchial tubes, sensation to part of the external ear and carries inhibitory and depressor fibers to the heart.

The *pharyngeal* branch joins a similar branch of the ninth and the sympathetic to form the pharyngeal plexus.

The laryngeal branches are superior and inferior, the first sensory and the latter motor.

The *superior laryngeal* is mainly distributed to the mucous membrane of the larynx, but also supplies the crico-thyroid muscle.

The *inferior,* or *recurrent,* laryngeal rises on the right on the subclavian and on the left on the transverse aorta. In each case it curves around the corresponding vessel, runs to the interval between trachea and esophagus and enters the larynx at its lower back part to supply the intrinsic muscles, except the crico-thyroid.

The *cardiac* branches arise high and low in the neck and from the recurrent laryngeal. They join the cardiac plexuses and are distributed from them.

Bronchial branches, anterior and posterior, follow the bronchial tubes into the lungs.

Esophageal and *gastric* branches run to esophagus and stomach, respectively.

The *cardiac* branches join the celiac or solar plexus on the side of the celiac axis. Branches of this plexus follow all the arteries given off from the axis and hence the abdominal viscera receive branches of the tenth nerve.

The **accessory,** or **eleventh,** nerve is made up of a small cranial portion which appears just below the tenth at the side of the medulla, leaves the skull through the jugular foramen and joins the vagus to which it contributes the fibers which are distributed by the pharyngeal and superior laryngeal.

The *spinal portion* arises from the spinal cord as low as the fifth cervical, enters the skull through the foramen magnum, joins the cranial portion and leaves through the jugular foramen. It crosses the jugular vein, usually in front, pierces the sterno-mastoid high up to enter the trapezius and is distributed to those muscles.

The **hypoglossal,** or **twelfth,** springs from the side of the medulla between the olivary body and the pyramid. It leaves the cranium through the hypoglossal (anterior condyloid) foramen, internal to, and behind the jugular vein and internal carotid artery. It passes behind these structures and runs down to a point nearly opposite the angle of the jaw external to the artery. It now crosses the internal carotid, occipital and external carotid arteries, rests on the hypoglossus muscle and runs into the tongue to whose intrinsic muscles it is distributed. It gives additional branches to the stylo-, hyo- and genio-glossus and genio-hyoid muscles.

As the nerve crosses the carotids it gives a large descending branch which joins branches from the second and third cervical nerves and supplies the depressors of the hyoid, except the thyro-hyoid which gets its supply directly from the twelfth.

Many of the cranial nerves communicate with each other, the sympathetic nerves and the spinal nerves, but do not form the intimate associations, called *plexus*, which characterize the spinal nerves.

The Spinal Nerves

These nerves form thirty-one pairs which have their origin in the spinal cord by two roots, emerge through the intervertebral foramina and are distributed to the various parts of the body. There are eight spinal nerves in the cervical, twelve in the thoracic, five in the lumbar and six in the pelvic region.

Each spinal nerve springs by an anterior, motor, and a posterior sensory root. The posterior roots have ganglia formed on them in the intervertebral foramina. After the union of the roots the nerves split into anterior and posterior divisions, but these are now mixed nerves conveying both motor and sensory fibers, efferent and afferent, from and to the brain.

The *posterior divisions*, generally smaller than the anterior, pass to the muscles and integument of the back as individual nerves, not uniting to form plexus as do the anterior roots.

The *anterior divisions* of the cervical nerves form two intercommunications called the *cervical* and *brachial* plexuses. The cervical is formed by the four upper cervical nerves and is distributed to the muscles and

skin of the neck and head. The brachial supplies the upper extremity.

The *thoracic* nerves do not form plexuses, but pass out between the ribs, along with the intercostal arteries, to be distributed to muscles and integument in their course, the skin supply being carried by *lateral cutaneous* branches which rise about midway between the sternum and spine. The lateral cutaneous branch of the second intercostal joins a branch of the brachial plexus and is distributed to the upper extremity. The lower six intercostal nerves are often called *thoracico-abdominal* because they supply structures on both the thorax and abdomen.

The lumbar nerves are distributed, the upper three and a half, by the lumbar plexus. The remaining nerves join the upper sacral nerves and form the sacral plexus.

The spinal nerves carry fibers intended for the sympathetic system and these are also both afferent and efferent. They are described separately.

The Cervical Plexus

The **cervical plexus** is formed by intercommunication between the anterior divisions of the four upper cervical nerves. This is a very loose communication between the nerves whose branches are divided into *superficial* and *deep*.

The *superficial* branches are all cutaneous, that is, they convey common sensations like pain from the skin, and consist of an upper and a lower set. The upper branches have received names indicative of their distribution, *small occipital* (occipitalis minor), *great auricular* (au-

ricularis magnus) and *transverse* or *superficial cervical* (superficialis colli). Together these nerves supply the broad expanse of skin from that covering the occiput to the sternum, omitting the face, the occipital taking that region; the auricular, the scalp back of the ear and over the temporal region; and the cervical, the skin between the jaw and sternum in front of the sternomastoid muscle, around whose posterior border all these nerves wind.

The *descending* superficial branches emerge from beneath the same muscle and are divided into three sets according to their distribution, *sternal, clavicular* and *acromial.*

The *deep* branches are muscular and communicating. The most important of the latter, from the second and third nerves, joins the descending branch of the twelfth cranial for distribution to the infrahyoid muscles.

The *muscular* branches aid the eleventh in supplying the sternomastoid and trapezius. The plexus also supplies deep muscles of the neck.

The **phrenic,** though a muscular branch, is important. It is the motor nerve of the diaphragm and hence the great inspiratory nerve. It is the product of the third and fourth nerves of the plexus and of the fifth from the brachial. Its course is not the same on the two sides. On the right it crosses the subclavian artery in front and behind the vein, runs outside the innominate vein and superior vena cava, in front of the root of the right lung, and descends on the pericardium to the diaphragm. The left nerve crosses the subclavian, lies external to, and in front of, the thoracic part of that vessel, crosses the transverse aorta and runs down the

pericardium to the diaphragm. Both nerves pierce the diaphragm and are distributed to it from its under surface.

The Brachial Plexus

The plexus is formed by the four lower cervical and greater part of the first dorsal. This is a much more intimate communication than the cervical. The plexus lies between the scalene muscles, runs downward and outward to the space between the clavicle, first rib and scapula, is in close relationship to the second and third parts of the subclavian and first and second parts of the axillary artery, on the third part of which it breaks up into seven terminal branches. It is superficial just above the clavicle where only the skin, superficial fascia, platysma and deep fascia cover it. It is partly behind the second part of the subclavian, external to, and behind, the third part of that artery and the first part of the axillary and on three sides, inner, outer and posterior, of the second part of the axillary.

The formation of the plexus varies, but one of the most frequent modes is that the fifth and sixth nerves unite, the seventh passes out alone; the eighth and first dorsal form a cord. The seventh now joins the cord formed by the fifth and sixth, which gives off a large branch to unite with a similar branch from the lower cord and these form the posterior cord of the plexus. These cords do not assume their correct position until they reach the second part of the axillary artery, where they are inner, outer, and posterior cords.

Branches.—These are divided first into *wayside* and *terminal*, and the former into those above and below the clavicle. Above the clavicle branches are given to the supra- and infra-spinait,

rhomboid. serratus, magnus, subclavius, scalene and long cervical muscles. Below the clavicle the branches which supply the pectoral and subscapular muscles arise.

The terminal branches supply all the remaining structures of the upper extremity.

The outer and inner cords contain fibers from all the nerves of the plexus. Each gives a branch to form the *median* nerve on the front of the third part of the axillary.

The Median Nerve

The **median** nerve passes to the middle of the front of the elbow without giving off branches, accompanying the axillary and brachial arteries. It supplies, directly or through its interosseous branch, all the muscles of the front of the forearm except the flexor carpi ulnaris and the inner half of the profundus digitorum.

The nerve then enters the palm and supplies the superficial muscles of the thenar eminence and digital branches to the front of the fingers except the little finger and inner half of the ring finger, and a branch to the skin of the palm.

The Musculo-Cutaneous

The remainder of the outer cord forms the *musculo-cutaneous* nerve which supplies the muscles of the anterior region of the arm, gives a branch to the elbow and, becoming cutaneous, furnishes sensation to the skin of the outer half of the forearm, front and back.

The inner cord carries fibers of the eighth cervical and first dorsal. In addition to giving the inner head of the median, it splits into three branches, *lesser internal cutaneous, internal cutaneous* and *ulnar.*

The Lesser Internal Cutaneous

The **lesser internal cutaneous** receives the lateral cutaneous branch of the second intercostal, which sometimes nearly replaces it, and is distributed to the skin covering the lower third of the postero-internal aspect of the arm.

The Internal Cutaneous

The **internal cutaneous** takes up the supply of the skin of the forearm where the musculo-cutaneous ceases. It supplies about one-half of the forearm, commencing at the middle of the front and continuing, by the inner side, to the middle of the back.

The Ulnar

The **ulnar** nerve is the continuation of the inner cord. It is a musculo-cutaneous nerve, supplying the inner part of the elbow joint, the flexor carpi ulnaris and inner half of the flexor profundus digitorum in the forearm, all the muscles of the hypothenar group and the deep muscles of the thenar in the hand. By a dorsal branch it supplies about half the back of the hand and the palmar aspect of half the ring and all of the little fingers. The nerve passes down the arm diverging from the brachial artery, forms the "funny bone" by lying between the internal condyle and olecranon and lies to the inner side of the ulnar artery in the lower two-thirds of its course.

The posterior cord has fibers from all the nerves. It is a large cord behind the third part of the axillary which is distributed to the neighborhood of the shoul-

der by a branch called *circumflex* and to the back of the arm and forearm by the *musculo-spiral* or radial.

The Circumflex

The **circumflex** is distributed to the teres minor and deltoid muscles, the shoulder, and the skin of the deltoid region. It winds around the shaft of the humerus with the posterior circumflex artery.

The Musculo-Spiral

The **musculo-spiral,** or **radial,** winds around the humerus in the musculo-spinal groove until it reaches the interval between the brachio-radialis and brachialis anticus where it gives off the *posterior interosseous* and continues down the forearm as the radial nerve.

In the arm it furnishes sensation to the skin of the posterior and outer aspects and muscular fibers to the triceps. In the forearm it supplies, directly, or by its interosseous branch, all the muscles on the back and outer side of the forearm.

The *radial* continuation is a nerve of sensation only. Passing to the back of the forearm at its lower fourth, it furnishes branches to the back of the hand on the radial side and the fingers as far as the cleft between the ring and middle fingers.

The Lumbar Plexus

This is a loosely connected plexus behind the psoas magnus muscle formed from the first, second, third, and part of the fourth anterior lumbar divisions.

Ilio-Hypogastric and Ilio-Inguinal

The first branches, called *ilio-hypogastric* and *ilio-inguinal* correspond to intercostal nerves, in that they

wind around the body in the muscular layers and supply the muscles and skin on the lower part of the abdomen, the ilio-inguinal descending to the skin of the upper inner part of the thigh and to the external genitals.

The Genito-Femoral

This is the nerve to the cremaster muscle of the male or round ligament of the female. It also gives a branch which supplies the skin over Scarpa's triangle.

The Lateral Femoral

The **lateral femoral,** *external cutaneous,* supplies the skin over the antero-external and external faces of the thigh as far as the knee.

The Femoral

The **femoral,** *anterior crural,* is the largest branch of the plexus being distributed from within the pelvis as far as the great toe. It is a musculo-cutaneous nerve. It passes under Poupart's ligament, external to the psoas magnus, and lies about a quarter of an inch external to the femoral artery, where it breaks up into superficial and deep branches. The deep branches supply the anterior femoral muscles, except the sartorius, while the superficial under the names *middle* and *internal cutaneous* and *long saphenous* furnish sensation to the skin of the front and inner sides of the thigh, inner side of the leg, and inner side of the great toe. *The middle cutaneous* also supplies the sartorius.

The *long saphenous* is the longest nerve in the body. It accompanies the vein of the same name below the knee joint, its branches fairly corresponding to the tributaries of the vein.

The Obturator

The **obturator** crosses the pelvic wall above the obturator vessels, leaves the pelvis through the obtrurator foramen and breaks up into many branches which supply muscles of the adductor group, including the gracilis, the hip and knee joints and the obturator externus.

The Sacral Plexus

The remainder of the fourth lumbar unites with the fifth to form the *lumbo-sacral* cord which passes over the pelvic brim to unite with the three upper and half of the fourth sacral nerves to form the *sacral plexus.* This plexus lies on the front of the sacrum, separated from it by the pyriformis muscle, with the internal iliac vessels in front of it and covered by the peritoneum and pelvic viscera. It gives branches to the external rotators of the thigh, a gluteal branch to the muscles of that name, an *internal pudic* or *pudendal* nerve to accompany the artery of the same name and be distributed to the genital organs and the perineum, and terminates by dividing into a *lesser sciatic* nerve to the skin of the back of the thigh and the gluteus maximus muscle and a *great sciatic* which supplies the remainder of the lower extremity.

The Great Sciatic

The **great sciatic,** much the largest nerve in the body, leaves the pelvis, below the pyriformis, through the great sacro-sciatic foramen and runs down the middle of the back of the thigh to the popliteal space where it divides into the *tibial* (internal popliteal) and *common peroneal* (external popliteal) nerves. It supplies the hip joint and the posterior femoral muscles.

The **tibial** nerve accompanies the popliteal artery and vein through the popliteal space, lying superficial to both, and then the posterior tibial artery, to which it is external in its lower two-thirds, to the ankle joint between the os calcis and internal malleolus, where, like the artery, it divides into *internal* and *external plantar* nerves.

It supplies three branches of the knee joint, muscular branches for all the muscles on the back of the leg, a cutaneous branch to the short saphenous, formed by this and a branch of the peroneal, which supplies the skin of the back of the leg and inner side of the foot, and cutaneous branches, *calcanean,* to the inner side of the heel and sole.

The Plantar Nerves

The *internal plantar,* larger than the external, gives motor fibers to the muscles of the inner half of the foot and cutaneous branches to the inner three and a half toes.

The *external plantar* gives motor twigs to the superficial muscles of the outer side of the foot, and to most of the deep muscles, and sensory branches to the little toe and outer side of the fourth.

The Common Peroneal

The **common peroneal,** *external popliteal,* nerve supplies two twigs to the knee joint, a cutaneous branch to aid in forming the *short saphenous* and divides into a *deep peroneal* (anterior tibial) and a *superficial peroneal* (musculo-cutaneous).

The *deep peroneal,* or *anterior tibial,* nerve accompanies the anterior tibial artery on the interosseous membrane, supplies the muscles of the front of the leg and dorsum of the foot and terminates in cutaneous branches to the adjoining sides of the great and second toes. It also supplies the ankle and tarsal articulations.

The *superficial peroneal,* or *musculo-cutaneous,* descends with the peroneal muscles, which it supplies, and is distributed to the inner side of the great toe, skips the next cleft and supplies the toes from the outer side of the second to the inner side of the fourth inclusive.

The cutaneous nerves, particularly in the hand and foot, communicate with each other, but by no means so frequently or so intimately as to the arteries and veins.

The Sympathetic Nerves

The **sympathetic nerves** preside over the nonstriated muscular fibers; and, as this is very widely distributed, occurring especially in the viscera and in the vascular system throughout the body, the sympathetic nerves have an equally wide range.

The essential elements of the system are a series of ganglia receiving fibers from cranial or spinal nerves, giving communications to each other and adjacent nerves, and branches of distribution to the viscera and vessels, which usually spring from plexuses formed by intercommunications between various branches of distribution.

Three of these ganglia, the *ciliary, spheno-palatine,* or Meckel's, and the *otic* are connected with the divisions of the fifth nerve and constitute a large part of the cephalic portion of the sympathetic, the remainder of

which follows the internal carotid artery and its branches.

The *ciliary* ganglion, supplying the nonstriated muscle of the eyeball, situated on the outer side of the optic nerve, is the most important. *Meckel's* lies near the spheno-palatine foramen and gives branches to the orbit, nose, soft palate and pharynx.

The Gangliated Cord

Though directly continuous with the cephalic portion, the spinal sympathetic is described as if it were distinct. It consists of a series of ganglia irregularly corresponding to the spinal nerves, lying in the neck, behind the carotid vessels, in the thorax on the head of the ribs, in the abdomen along the inner side of the psoas magnus and in the pelvis on the front of the sacrum. In the neck there are three ganglia, though the superior gives evidence of the coalescence of four, the middle and inferior of two each. In the thorax the number generally corresponds to the number of nerves, though two may coalesce. In the lumbar region there are four and in the pelvic four or five.

Each ganglion consists of ascending branches which run in the cord to the ganglion above, descending to the one below, external, which consist of two sets of fibers, going to and from the spinal nerves, and internal or branches of distribution.

From the *cervical* ganglia come the branches which supply the blood vessels of the region, larynx and pharynx and the cardiac branches, which unite with branches from the pneumogastric to form the great plexus from which the heart is supplied.

The *thoracic* ganglia supply the aorta and its branches and the lungs by branches from the upper five, while the lower seven produce the *splanchnic* nerves which enter the abdominal cavity and are distributed to its viscera and vessels after joining the *celiac* or semilunar ganglia.

The *celiac,* or *solar,* plexus is a great mass of sympathetic fibers surrounding the origin of the celiac axis and the superior mesenteric artery. From it branches are derived which form smaller plexus on all the arteries in this region. We thus have gastric, hepatic, renal, and mesenteric plexus formed from which the ultimate distribution takes place.

The *lumbar* ganglia give branches to form the aortic plexus and others which pass to the iliac vessels and form the hypogastric plexus, from which branches are given to the pelvic viscera.

The *pelvic* ganglia give branches to the pelvic plexus and unite in the *ganglion inpar* on the front of the coccyx.

CHAPTER VIII

ORGANS OF THE SENSES

The special senses are taste, smell, sight, and hearing.

TASTE

The organ of taste is located in the papillæ on the tongue, a muscular organ consisting of bundles of muscle fibers running longitudinally, vertically and horizontally which enable it to change its shape and position, located in the space between the diverging prongs of the lower jaw and attached by its base to the hyoid bone. From the anterior two-thirds of the tongue, taste sensation is conveyed by the chorda tympani nerve, while the glosso-pharyngeal supplies the posterior third.

SMELL

The external organ of smell is the nose, a pyramidal projection, base downward, thrust forward between the eyes on either side above and the mouth below.

The nose is covered by skin and divided into two cavities by a vertical median septum whose anterior third is cartilage and posterior two-thirds bone, made up of the perpendicular plate of the ethmoid and the vomer. This constitutes the inner wall of each nostril, whose outer wall is composed of three shelf-like projections of bone, the *superior, middle,* and *inferior trru-*

binates, with intervening spaces which give this wall a convoluted appearance. The bones and spaces increase in length from above downward. The roof slopes up in front, runs straight back in the middle and downward and backward behind. The whole is covered by mucous membrane, continuous with the skin in front, the lining of the nasopharynx and eustachian tubes leading into the ear behind, the hollow, or antrum, of the upper jaw on the side and the eyes above. This membrane is particularly thick and vascular over the turbinates. The upper part of the nostrils is the olfactory area in which the filaments of the first nerve are distributed. The lower part of each cavity is the respiratory region.

SIGHT

The opening between the eyelids is called the *palpebral fissure.*

The *eyelids,* of which the upper is the more movable, consist of two plates of cartilage, *tarsal plates,* covered by delicate skin and areola tissue with some pale muscular fibers surrounding the fissure. Next the eyeball they are lined by a mucous membrane, the *conjunctiva,* which spreads from lid to eyeball and covers the tarsal glands lying between it and the cartilage. The two lids join internally and externally, but the fissure is enlarged internally and the margins of the lids show each a minute opening, *puncta lachrymalia,* the beginning of the *lachrymal ducts* which unite in the *lachrymal sac,* lodged in the groove on the lachrymal bone, which contracts to form the *naso-larchrymal* duct conveying the tears to the nose.

The *lachrymal gland,* which secretes the tears, is situated in the hollow at the outer angle of the orbit. The ducts pour out the secretion on the conjunctiva whence it is carried into the nose.

The eyelids are studded with hairs, the eyelashes, and a thicker growth of hair along the orbital ridge forms the eyebrow.

THE EYE

The organ of vision is a ball formed of a protecting coat, *sclerotic,* a vascular coat, *choroid* and a visual coat, *retina,* containing three refracting media, *aqueous humor, crystalline lens,* and *vitreous humor.*

The eyeball is not quite globular. Its posterior five-sixths, formed by the sclerotic, is a segment of a large sphere on the front of which is imposed a segment of a small sphere, one-sixth of the whole, formed by the *cornea.* The cornea and sclerotic are continuous, but the cornea is transparent and the sclerotic opaque. A line drawn through the ball from before backward is the *axis* of the eye whose extremities are the *anterior* and *posterior poles.* A line drawn at right angles to the axis through the middle and around the ball is the *equator.* The optic nerve pierces the sclerotic a little to the nasal side of its center and carries the central artery of the retina. It here spreads out in the retina which has a blind spot at the entrance of the artery. The point of most acute vision is a little external to this, at the *fovea centralis,* at the posterior termination of the axis.

The **sclerotic** is a dense fibrous coat pierced behind by the optic nerve and, in front of that point, by numerous openings for the passage of vessels. In front it becomes

continuous with the cornea, *corneo-scleral* junction, which it slightly overlaps, the union being marked by a slight groove.

The **cornea** is the transparent anterior sixth of the outer tunic. It is convex in front and concave behind, its convexity varying in different individuals and at different ages, being more convex in the young.

The **choroid** consists of three parts. The large posterior portion, enveloping five-sixths of the globe, is the vascular tunic of the eye. This is succeeded by the *ciliary* body, which continues the choroid forward, and is itself succeeded by the *iris,* a curtain, hanging down behind the cornea, pierced by a circular opening, the *pupil.*

The *ciliary body* consists of a posterior part, continuous with the choroid, called the *orbicularis ciliaris;* from sixty to eighty infoldings of the choroid, radiating backward from the orbicularis, called *ciliary* processes; and a circular band 3 mm. wide on the anterior part of the choroid, the *ciliary,* or Bowman's muscle. This consists of circular and longitudinal fibers. The latter, the more important, may be described as rising from the choroid and inserting into the ciliary processes which are fastened to the capsule of the lens.

The *iris* contains circular and radiating fibers whose contractions decrease and increase the size of the pupil respectively. It hangs in front of the lens, not in contact with it, and divides the space between cornea and lens and capsule into anterior and posterior chambers, the anterior being limited in front by the cornea and behind by the iris and central part of the lens, the posterior bounded in front by the back of the iris and be-

hind by that part of the lens and capsule beyond the pupillary opening.

The **retina** is the visual coat of the eye and is essentially the spread out fibers of the optic nerve. Its exterior surface is in contact with the choroid while its interior is separated from the vitreous humor by the *hyaloid* membrane. Anteriorly the retina terminates, a little behind the ciliary body, in a jagged edge called the *ora serrata.* About 3 mm. to the outer side of the optic nerve, at the posterior pole of the eye, there is a yellowish oval area, *macula lutea* with a central depression, *fovea centralis,* where the retina is very thin and where vision is most acute.

The refracting media are the *aqueous humor,* filling the anterior and posterior chambers, the *lens* and *capsule* and the *vitreous humor,* filling the posterior and larger segment of the globe.

The *aqueous humor* is an alkaline fluid mainly composed of water.

The *vitreous humor* is a transparent jelly-like substance, albuminous in character, filling the hollow of the retina from which it is separated by the *hyaloid membrane.*

The *hyaloid membrane* becomes thickened at the ciliary body and grooved for the reception of the ciliary processes. It here splits into a very delicate layer which lies in front of a depression in the vitreous, the *hyaloid fossa,* for the reception of the lens, while the other is attached circumferentially to the capsule of the lens and forms its *suspensory ligament.*

The **crystalline lens** lies opposite the ciliary body between the iris in front and the vitreous behind. It is

circular in form, transparent, convex on both surfaces, though more so in front than behind, and is enclosed in structureless transparent membrane called the *capsule* of the lens. The lens is an elastic body which hardens and loses its elasticity with age. It is kept normally slightly flattened by the pull of the suspensory ligament on the capsule. Where it is required to *accommodate* the eye for near vision, the ciliary muscle contracts, draws the choroid forward, relaxes the suspensory ligament and allows the lens to expand. When elasticity is lost with age, the muscle may continue to act, but the lens has lost its power of expansion.

The iris reacts to light. When a strong light is thrown on the eye the circular fibers contract, narrow the pupil and cut off a large portion of the light. When the light becomes dim the circular fibers relax, the radiating contract, the pupil is expanded and a large amount of light is transmitted through the lens to the retina.

THE EAR

The organ of hearing consists of the *external, middle* and *internal* ear.

The *external ear, auricle,* or *pinna,* is an irregular cartilage, covered by skin, situated at the side of the head and prolonged into the canal in the temporal bone. The prominent rim which surrounds the greater part of the circumference is called the *helix;* the depression next it the *scaphoid fossa;* the elevation the *antihelix* and the deep depression in front of this and leading into the skull, the *concha.* The little projection overhanging the auditory canal in front is the *tragus;* the one below and

behind the *anti-tragus;* the space between the *intertragic* notch and the end of the ear below the *lobule.*

There are numerous small muscles attached to the external ear, but, in the human being, they are nearly always powerless and it is a waste of time to study them.

The *external auditory meatus* is the canal leading to the tympanic membrane which guards the middle ear. It is nearly an inch (2.5 cm.) in length, the outer third formed by the cartilage already examined and the inner two-thirds by bone. It is slightly curved with its general direction inward, forward and downward. It is closed by the *tympanic membrane* set obliquely across the canal so that the floor and anterior wall are longer than the roof and posterior.

The *middle ear* is a small slit-like chamber at the bottom of the auditory canal whose essential features are an opening in its anterior wall by which air is conveyed to the cavity from the back of the nose through the *auditory* or eustachian tube; an external wall closed by the *tympanic* membrane; an internal wall pierced by two openings by which this cavity communicates with the inner ear and a chain of small bones, the *auditory ossicles* by which the vibrations of the tympanic membrane are conveyed to the essential organ of hearing in the inner ear. Parallel with the auditory tube there is a small canal which lodges the *tensor tympani* muscles, whose action is to stretch the drum of the ear (tympanic membrane).

The openings on the inner wall are the *oval* (fenestra ovalis) and the *round* (fenestra cochlea or rotunda). The oval opening is above, leads into the *vestibule,* and is

closed by the foot of the stirrup (stapes). The round opening is below, is closed by the *secondary tympanic membrane,* and communicates with the cochlea.

At the upper back part the tympanum is continuous with air cells in the mastoid part of the temporal bone and furnishes a space for a part of the incus.

The three ossicles are the *incus* (anvil), *malleus* (hammer) and *stapes* (stirrup).

The **stapes** is fastened by a long projection to the tympanic membrane. Its head articulates with the incus which is fastened by its short process in the space above the tympanum and by its long process to the stirrup. Hence if the drum is moved it moves the malleus, which moves the incus which, in its turn, moves the stirrup and either presses it more firmly in or draws it away from the fenestra ovalis. The vibrations of the outer membrane are thus communicated across the tympanum to the internal ear.

The *internal ear,* or *labyrinth,* the point of distribution of the auditory nerve, is a very minute and irregular space hollowed out in the petrous portion of the temporal bone and lined by a membrane which is the exact counterpart of the space. Hence it consists of an *osseous* and a *membranous* labyrinth. This is further subdivided into the *cochlea* in front, the three *semicircular canals* behind, and the *vestibule* connecting the two.

The *semicircular canals,* which are concerned in maintaining equilibrium, are three in number. The *superior* and *posterior* are vertical, the superior running at right angles to the bone and the posterior parallel to its long

axis. The *external* is horizontal. They all communicate with the vestibule.

The *cochlea* is like a snail shell, or two and a half turns of a conical screw thrust into a circular box. The flanges of the screw (threads) would form shelf-like projections in the box, ascending to the apex of the cone, which could be prolonged to the walls by a membrane. The attachment of the membrane would split the space into an upper and a lower coiled tunnel each running, like a circular staircase, around a central column. The central column of the cochlea is called the *modiolus,* is hollow and allows the nerve which lies in it to send its branches out through the threads (laminæ) to reach the membrane which completes the two tunnels. The upper of these coiled chambers is called *scala vestibuli* and the lower *scala tympani* indicating the chambers with which they communicate.

The membrane stretching from the spiral laminæ (threads) is called the *basilar membrane* and supports the *organ of Corti* in which the terminals of the eighth nerve are found.

The *membranous labyrinth* follows the bone exactly. The part which fills the vestibule is divided into two sacs, *utricle* for receiving the semicircular canals and saccule communicating with the cochlea. The membranous labyrinth is filled with a fluid called *endolymph* and separated from the bony walls by another fluid, the *perilymph.*

THE LARYNX

About half an inch below the hyoid bone a prominence can be seen on the midline of the neck which is

called the *Adam's apple*. This is the *thyroid cartilage*, the largest single element of the *larynx*, or *voice box*, which is made up of cartilages, ligaments, muscles, nerves, arteries, veins and lymphatics. The chief cartilages are the *thyroid, cricoid* and *arytenoid* (two).

The Thyroid Cartilage

The **thyroid cartilage** is a hollow wedge, base backward, open at both ends and behind. It is composed of two quadrilateral plates called *alæ*, united in a blunt angle in front and expanding above and below into processes called *cornua*. There is a deep notch in front above which gives the superior border a sinuous outline. The inferior border is shorter and thicker than the superior and its cornua are blunt and strong and marked by articular facets internally. The posterior border is rounded. The alæ are marked by oblique ridges for muscular attachment.

The Cricoid Cartilage

The **cricoid cartilage** is a ring, small in front and large behind like a seal. Below it is shaped like a ring of the trachea. Above it slopes rapidly upward from in front and has on either side, a quarter of an inch from the midline, an oblong articular surface for the arytenoid cartilages. On each side, near the lower border, is a circular facet for the horns of the thyroid. In the midline behind is a vertical ridge with a depression for muscles on each side.

The Arytenoid Cartilages

The **arytenoid** cartilages are three sided pyramids, bases downward, facing each other on the upper back

part of the cricoid. The apex of each is surmounted by small corniculate cartilages. The internal face is a plane, the posterior and external are concave. The base presents an angle directed outward and backward which gives attachment to muscles *(the muscular process,)* and a slender projection forward called *vocal process* because the vocal cords are attached to it.

The Epiglottis

The **epiglottis** is a thin leaf-like cartilage projecting upward from the larynx just at the base of the tongue. Its small end is below and is bound to the hyoid bone and thyroid cartilage by bundles of ligamentous fibers. In the natural state it appears to have its base upward, due to the folds of mucous membrane stretching out on either side.

The Ligaments of the Larynx

The various articular surfaces are bound together by capsular ligaments similar to those holding bones in apposition and the joints are lined by synovial membrane. Other bundles of fibers stretch between the cartilages and adjoining structures. A thin membrane, *thyro-hyoid,* thickened at each end into a cord extends from the upper border of the thyroid to the hyoid near its upper border. A similar membrane, the *crico-thyroid,* fills the gap between the lower border of the thyroid and upper border of the cricoid, which is bound to the upper ring of the trachea by a thin membrane.

Stretching from the vocal process of the arytenoid to the back of the thyroid angle is a long band of elastic fibers which has no part in binding the cartilages to-

gether but is intended, by its vibrations, to produce sound. It is called the *thyro-arytenoid* ligament or true *vocal cord* and is connected with the crico-thyroid membrane.

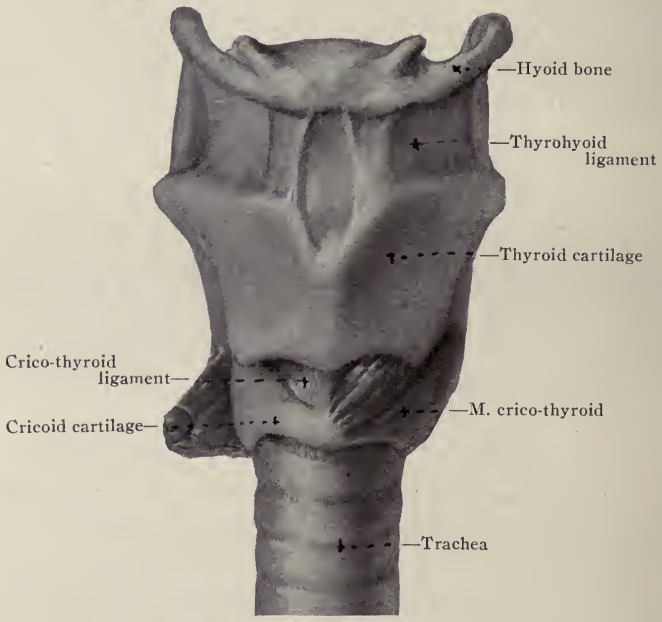

Fig. 19.—Larynx, anterior view.

The Muscles of the Larynx

These are a single muscle, *arytenoideus,* and four pairs of muscles, *crico-thyroid, posterior crico-arytenoid, lateral crico-arytenoid* and *thyro-arytenoid.*

The *arytenoid* fills the concavity on the posterior face of the arytenoid cartilages, stretching from one to the other, so that, when its fibers contract, it brings them in close apposition.

The *crico-thyroid* is fan-shaped and attached near the front of the sides of the cricoid by one end and, by the other, to an ala of the thyroid near its lower border and inferior cornua.

Its fixed point is above. It pulls the front of the cricoid upward, makes it revolve between the inferior cornua, and carries its posterior portion, and the arytenoids with it, backward, tightening the vocal cords.

The *posterior crico-arytenoid* springs form the concave back of the cricoid, passes upward and outward and is inserted into the muscular process of the arytenoid.

Its contraction pulls the vocal process inward, makes the arytenoid revolve on an axis through the center of its base, carrying the anterior (vocal) process outward and widening the interval between the vocal cords.

The *lateral crico-arytenoid* rises from the upper border of the cricoid, in front of the arytenoid, passes backward and is inserted into the front of the vocal process.

It pulls the muscular process forward, rotates the arytenoid inward and narrows the space between the cords, i. e., it is the antagonist of the posterior.

The *thyro-arytenoid* rises from the lower part of the angle of the thyroid, runs backward and is inserted into the base and *vocal* process of the arytenoid. It lies parallel with the vocal cord and is attached to it.

It draws the whole arytenoid forward and relaxes the cord. The fibers inserted into the cord can relax one portion and leave the other tense.

The mucous membrane which leaves the back of the tongue, mounts over the front of the epiglottis, runs down its posterior face and enters the larynx which it lines. It forms *glosso-epiglottic* folds from the tongue

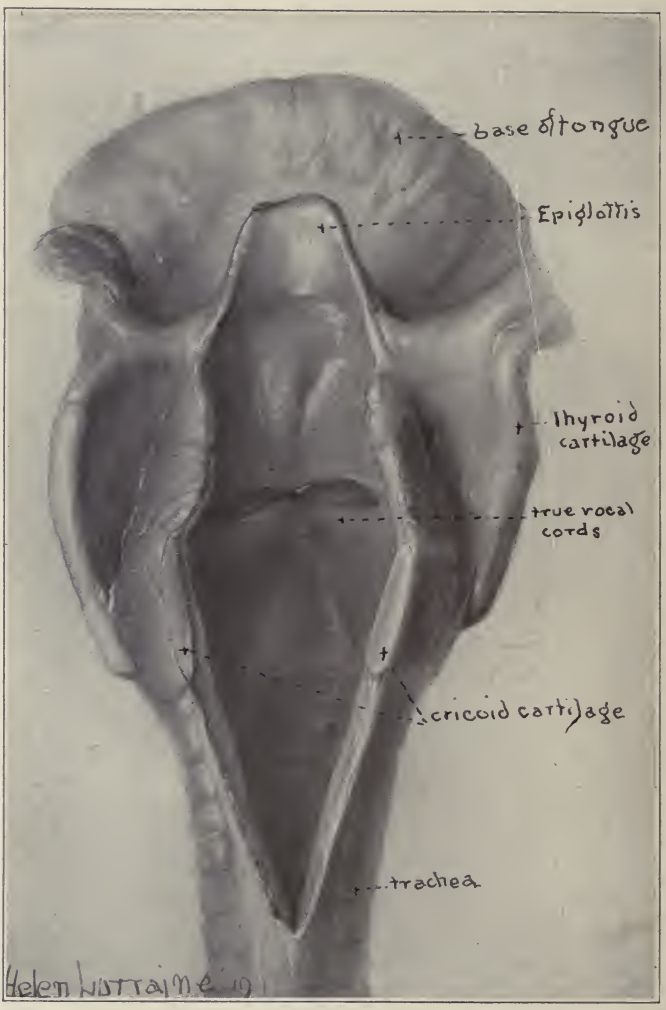

Fig. 20.—Larynx, inside view.

to the epiglottis; a broad fold on either side from the epiglottis to the arytenoids (aryteno-epiglottidean); a similar fold on either side from the thyroid to the arytenoid (thyro-arytenoid), the *false vocal cords* or ventricular folds and descends to cover the true vocal cords.

The superior opening of the larynx slopes downward and backward; the inferior is circular and passes directly to the trachea. The superior communicates with the mouth, nose, and pharynx. The space above the vocal cords is called the *vestibule;* that between the false and true cords and between the former and the thyroid, the *ventricle* and the space between the true cords the *rima glottidis.*

CHAPTER IX

HISTOLOGY

Histology is microscopic anatomy. It is the study of minute cells or of tissues which have grown from cells, and of organs which are composed of tissues and cells.

THE CELL

The **cell** is the simplest form of independent life.

The *ovum* is the name given to the primary cell from which the creature is developed.

A cell is defined as a "nucleated mass of protoplasm endowed with the attributes of life."

Protoplasm—literally *the first thing formed,* is the living matter of which all animals and vegetables are formed. It makes up the mass of all cells and of it all tissues are formed.

The **nucleus** is the somewhat centrally placed active portion of the cell. It seems to preside over cell changes and might be considered as both the brain and the generative part of the cell.

The **nucleolus** bears to the nucleus a relation similar to that which the nucleus bears to the cell.

The **limiting membrane** is the thin and structureless membrane which surrounds the entire mass of protoplasm called the cell.

Intercellular cement is the substance which binds cells together.

Growth and repair are constant phenomena of life. Growth is an increase in the number of cells or in the size of tissue. Repair is the replacement of the worn out or destroyed cells by new cells. Hence it is necessary that cells, like higher organisms, have the power of *reproduction.* This process is accomplished by a division of the cell into two bodies, each of which, at the end of the process, is a complete cell. *Indirect* division, the most common if not the only form, is that method by which the first changes occur in the nucleus and later the cell becomes constricted into a dumb-bell shape and then divides. *Direct* division means the constriction of the whole cell. The change in the nucleus is called *mitosis* or *karyokinesis.* When this process is completed the nucleus has divided into two nuclei, each in its own part of the cell and each possessed of a sort of magnetic power which enables it to draw to itself cell substance sufficient to form a new cell. Constriction of the body of the cell then takes place and two cells are the product of the one old cell. It is said that this process in man requires about half an hour.

THE TISSUES

Cells are either grouped together to form, or are differentiated into masses called, *tissues.* Of these we distinguish **epithelial, connective, muscular** and **nervous** tissues. In addition to these formed tissues the circulating fluids blood and lymph, are to be considered. Numerous *varieties* of these primary tissues are found.

The terms *epi* and *endo* thelial have been employed to distinguish those layers of cells formed on the surface

or in open cavities from those formed in vessels and other closed cavities, as the serous. Endothelium is, however, simply epithelium formed in these places.

Epithelium, therefore, may be said to present varieties distinguished as *endothelium* and *squamous* and *columnar epithelium.*

Connective tissue presents the greatest number of variations. Under this head are embraced *white fibrous, yellow elastic, adipose* (fatty), *retiform* (lymphoid), *mucoid, cartilaginous, osseous* and *dentine.* That is to say that tissues varying as widely as the soft fatty layer just beneath the skin and the solid bone which sustains the weight of the body, are all classed as connective tissues.

Muscular tissue presents three varieties, *striated, unstriated* and *cardiac.*

Nervous tissue is without such subdivisions.

The Distribution of Tissues

Epithelium is the most widely distributed of all tissues. It covers the entire surface of the body, where it is called *epidermis,* enters, through the mouth and nose, the digestive and respiratory tracts which it lines throughout, lines the genito-urinary tract, the ducts and acini of all glands and, as endothelium, lines the interior of all blood and lymph vessels and the great serous cavities of the body.

Connective tissue, almost as widely distributed as epithelium, forms the supporting tissue beneath the skin and serous and mucous membranes, binds muscles to bones and cartilages, forms the framework of the ear (yellow elastic), of the larynx (cartilaginous), sup-

ports glandular organs, enters the walls of blood vessels and hollow viscera and, as bone, forms the framework of the body.

Muscular tissue is formed wherever motion is required. As *striated* muscular tissue it forms the great skeletal muscles distributed over the body; as *nonstriated* it forms part of the walls of blood vessels, of the digestive tract, of the genito-urinary system; and as *cardiac* it forms the great pump which is the primary force of the circulation.

Nervous tissue is found massed in the brain and spinal cord and distributed throughout the body as *cranial, spinal* and *sympathetic* nerves.

The circulating fluids, *blood* and *lymph,* are found in every portion of the body.

Epithelium

Epithelium is either *squamous* or *columnar,* which latter may in its turn be *glandular, cylindrical* or *ciliated.*

Squamous epithelium may be arranged as a single layer of cells, when it is called *simple* or *pavement* epithelium; or in many layers, when it is said to be *stratified.* A subdivision of the latter is called *transitional.*

Endothelium is a simple epithelium consisting of a single layer of cells, united by cement along their edges, lining the closed body cavities. Openings called *stomata* between the cells lead to lymph vessels.

Squamous epithelium consists of flat cells of varying shape, united by cement, never lining closed cavities but occurring in open cavities, as the air sacs of the lungs.

Columnar epithelium consists of rod-like cells resting on a basement membrane, small end toward the mem-

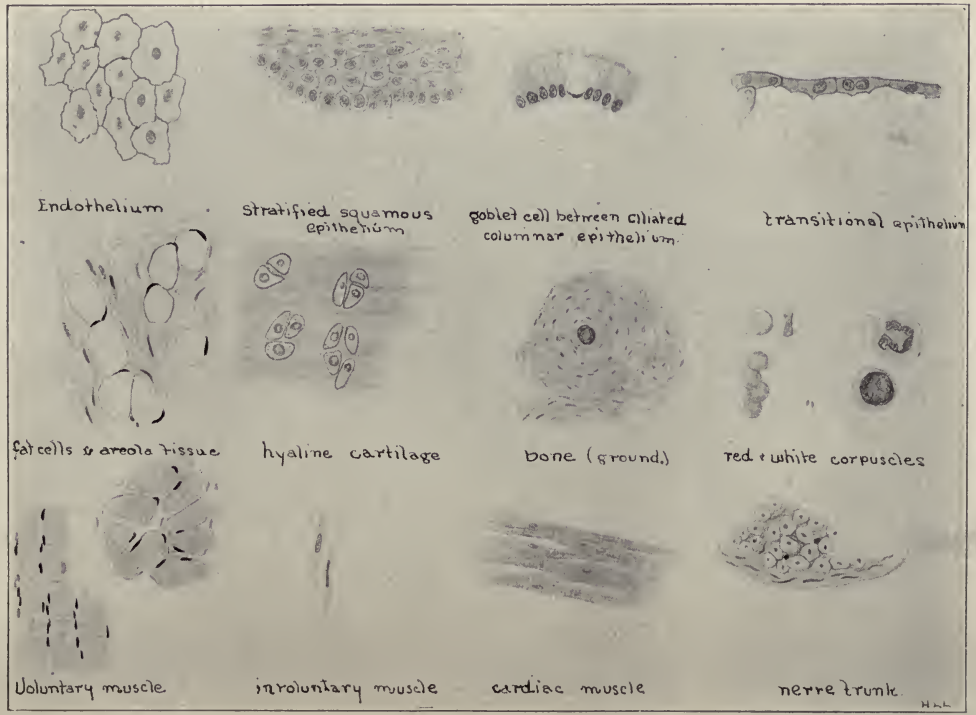

Fig. 21.—Simple tissues.

brane, whose shape is irregular from the pressure of surrounding cells. Columnar epithelium lines the intestinal canal and the glands connected with it.

Goblet cells are columnar cells filled with a substance called *mucin* which is poured out on the mucous surfaces where they are found.

Glandular epithelium is found in the glands. The cells are of many sides from mutual pressure.

Ciliated epithelium is columnar epithelium whose cells are provided with lash-like prolongations, called *cilia,* which produce motion independent of the movement of the part, and can thus extrude foreign bodies. They are especially useful in the respiratory tract and in the uterus and Fallopian tube.

Stratified epithelium consists of many layers of cells which vary greatly in shape and consistency. It is found on the surface of the body where it resists pressure. The cells vary from nearly formless horny scales at the surface to the soft irregular forms of the deeper layers.

Transitional epithelium is a modification of the stratified consisting of fewer layers. It is found in the bladder and ureters. The superficial layers consist of squamous cells while the deeper are elongated with small ends embedded between cells of the third layer. They look like tadpoles.

Connective Tissue

White fibrous tissue, connective tissue proper, consists of parallel bundles composed of minute fibrils, having a wavy appearance, bound together by a transparent cement and having *connective tissue corpuscles*

placed at varying intervals in the bundles. When these bundles are arranged in a broad sheet of loose meshwork, leaving openings (areolæ) which may contain some other substance, it is called *areolar* tissue. Such tissues are the *subcutaneous, subserous* and other areolar tissues. When the areolæ contain fat globules the combination of fat and fibrous tissue is called *adipose* tissue. When the fibrils are gathered into compact bundles with few corpuscles they form *tendons,* or are spread out into *aponeuroses* or the great *investing fascias.*

Retiform, or *lymphoid,* or *adenoid,* tissue is a very fine connective tissue forming the framework of mucous membranes. It has many branched connective tissue cells and the cement has nearly disappeared.

Yellow elastic tissue is composed of coarse branching fibers which anastomose and have a tendency to curl up. They are elastic while white fibrous is not. They are found in the ligamenta subflava of the spinal column and in but few other places in the human body.

CARTILAGE

Cartilage is *permanent* when it remains unossified through life and *temporary* when it is replaced by bone. The latter forms the greater part of fetal skeleton. The subdivisions are *hyaline,* the most widely distributed, *white fibro* and *yellow elastic.*

Hyaline cartilage is found chiefly on the articular surface of bones and in the rings of the trachea. It is surrounded by a fibrous vascular membrane, the *perichondrium,* except in the joints. It consists of a structureless

Fig. 22.—Human cartilage cells.

Fig. 23.—Hyaline cartilage.

or slightly granular ground work with cells embedded and usually arranged in pairs. It has no blood vessels or nerves and derives its nourishment from the perichondrium. Its ground substance was probably white fibrous tissue.

White fibrocartilage is partly cartilage but mainly white fibrous tissue. It is found in the intervertebral disks chiefly.

Yellow elastic cartilage is partly cartilage but is mainly composed of yellow elastic fibers. It is found in the ear, epiglottis, eustachian tube, etc.

BONE

Bone is either *compact,* as in the shafts of long bones, or *spongy,* as in the irregular bones and the extremities of long bones. All bone is modified connective tissue, the fibrils being replaced by minerals, chiefly phosphates.

The shaft of a long bone may be considered as a central large canal, or tunnel, running the length of the shaft, whose surrounding walls are composed of minute tunnels parallel with the central canal arranged in layers (lamellæ) perforated by minute channels (canaliculi) which pierce each lamella making up the system. These small tunnels or tubes are called *Haversian* canals. Each Haversian canal with its surrounding lamellæ and canaliculi constitutes a *Haversian* system.

At intervals the canaliculi are enlarged to form lacunæ, containing bone *corpuscles.* A vast number of Haversian systems, arranged like bunches of small tubes around a large central tube, go to make up a

long bone. The Haversian canals branch and communicate with each other at intervals, so the blood vessels they contain may communicate. Between the

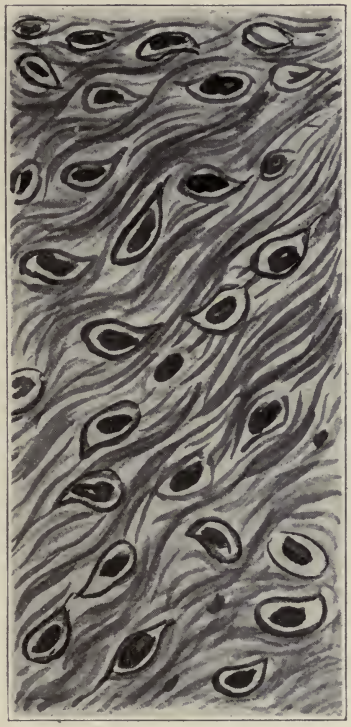

Fig. 24.—White fibrocartilage.

Haversian systems, filling in the irregular intervals, are partial lamellæ with canaliculi.

Each Haversian canal contains an arteriole, venule, lymph channel and a nerve filament. These run through the canaliculi, piercing the lamellæ in every

direction, making free anastomoses in each Haversian system; but two adjacent Haversian systems do not communicate with each other.

Spongy bone has the same arrangement of lacunæ

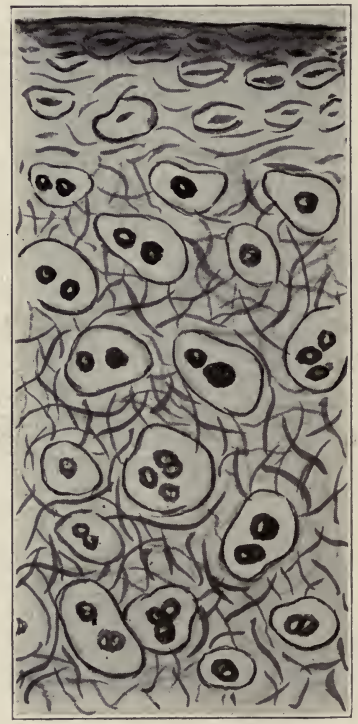

Fig. 25.—Elastic cartilage.

and canaliculi as compact bone, but no Haversian canals.

Development of Bone.—With the exception of the bones of the face and the cranial vault, bones appear in the embryo as cartilage. There follows a process

of enlargement of the cartilage cells and arrangement in rows. Osseous deposits take place in the matrix and processes are pushed in from the perichondrium carrying bone cells and blood vessels. The vessels lie in

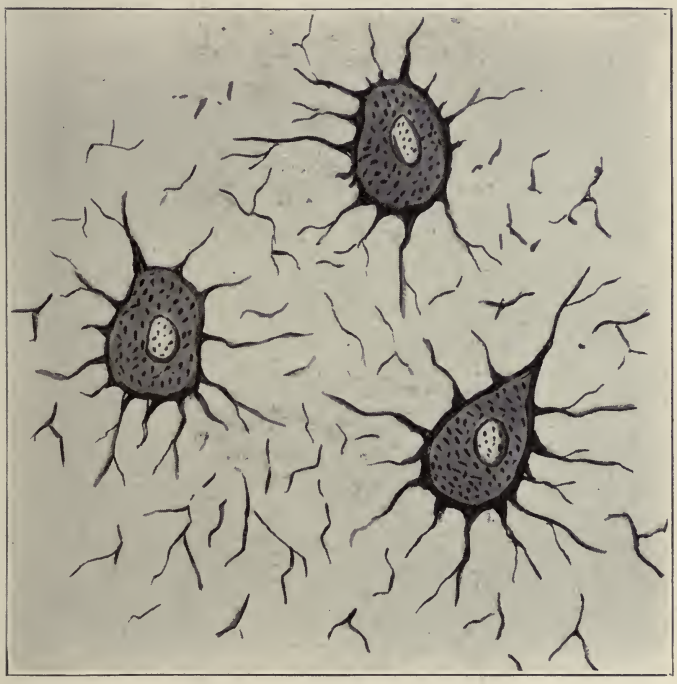

Fig. 26.—Nucleated bone cells, etc.

the future Haversian canals; their branches in the canaliculi, bone deposits are laid down between the canaliculi to constitute the future lamellæ, and this process is continued until the firm bone is formed.

Blood Vessels.—It follows from what has been said of development that blood vessels enter compact bone

from the periosteum, run in the Haversian canals, divide where the canals divide, and give off numerous minute branches to the Haversian systems. The blood to the central marrow usually comes from a single large vessel which enters through a foramen in the shaft, pierces to the marrow cavity and there breaks up into

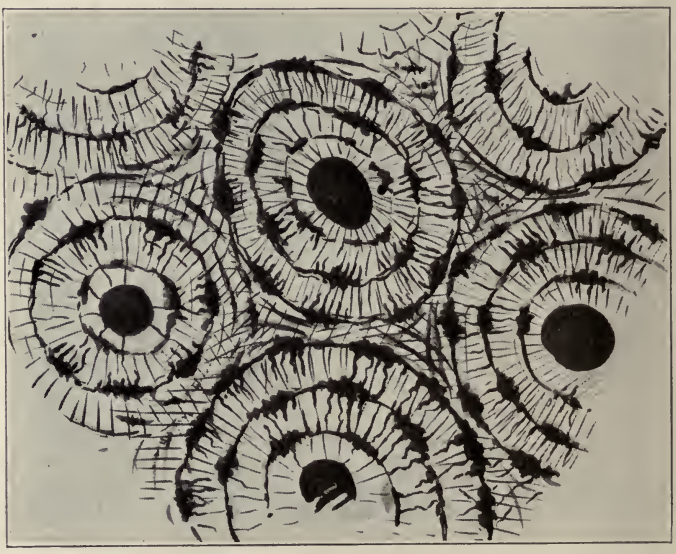

Fig. 27.—Transverse section of compact tissue of bone greatly magnified.

ascending and descending branches. The return circulation comes back through the same foramen and the nerve enters it with the artery.

Marrow.—This substance not only fills the tubes of the long bones but extends into the cancellous tissue of their extremities and into the interstices of the ir-

regular bones. In the long bones it is called *yellow marrow* and contains about 96 per cent fat. In cancellous bone it is called *red marrow* and consists of 25 per cent of all solids, a small proportion of which is fat, and 75 per cent water.

Fig. 28.—Section parallel to the surface from the shaft of the femur.

Periosteum is the membrane which surrounds bone. It is made up of connective and elastic tissue, the latter forming the deep layer, contains some fat and carries the network of blood vessels and nerves which surround the bone.

MUSCLE

Muscle fiber is *striated, nonstriated* or *cardiac,* a variety resembling striated.

Striated muscle fiber is the bulkiest tissue in the body, being the chief constituent of the red skeletal muscles.

Nonstriated muscle fiber is found in all those organs where the contractile power of muscle is required but where its action must not be interfered with by the conscious will. The hollow intestinal canal, the uterus, bladder, blood and lymph channels are its chief seats.

Cardiac muscle fiber, as its name indicates, is found only in the heart. It is striated but branched.

Voluntary, or **striated,** muscle cut parallel to the fibers, is marked by elongated dark lines crossed at regular intervals by light transverse lines. Cross sections show these bundles on end as polygonal areas called Cohnheim's fields.

Each fibril consists of an elongated mass of contractile substance, tapering at either end to join the next mass, contained in a delicate sheath, the sarcolemma. A number of fibrils are bound together by delicate connective tissue, the perimysium, forming *fasciculi;* while a complete muscle is formed by binding together a vast number of fasciculi by a thicker connective tissue covering, called the *epimysium.*

When muscle is united to tendon the contractile element and sarcolemma round off into a blunt point and the sarcolemma is cemented to the tendon.

Blood vessels are very numerous in striated muscle.

Cardiac Muscle

Cardiac muscle fibers are shorter and smaller than those of skeletal muscles, branch and inosculate with each other, and have no distinct sarcolemma.

Nonstriated Muscle

Involuntary or **nonstriated** muscle fibers consist of elongated or spindle-shaped cells, each containing an elongated nucleus, marked by slight longitudinal striations. They are held together by a transparent cement and form broad sheets arranged in various ways, i. e., running both circularly and longitudinally in the intestine, radiating in the stomach, etc., and intimately connected with the fibrous tissue of the various organs in which these muscle fibers occur.

THE NERVOUS SYSTEM

The nervous system consists of *nerve cells, nerve fibers,* connective tissue, and *neuroglia* and *nerve terminals.*

Nerve cells, usually called *ganglion cells,* are of many shapes and sizes. They have large, round nuclei, with nucleoli and their protoplasm contains pigment. These cells have one or many processes springing from them and are described as *uni-, bi-* or multipolar. Each cell has one process called the *axis cylinder process.* The other processes divide and form networks. A ganglion cell with its axis cylinder process is called a *neurone.*

Nerve fibers may be *medullated,* or *white,* or *non-medullated,* or *gray.* Each fiber consists of a central portion, the *axis cylinder,* an enveloping sheath, largely

fatty called the *white substance of Schwann* or *medullary sheath,* and, surrounding this, an envelope of connective tissue, the *neurilemma.* At intervals the neurilemma is constricted so as to reach the axis cylinder. These constrictions are called *nodes* of *Ranvier.*

A collection of a number of parallel nerve fibers bound together by connective tissue called *endoneurium,* forms a *funiculus.* Many parallel funiculi, bound together by another layer of connective tissue, the *perineurium,* form a *nerve trunk,* which is surrounded by a connective tissue sheath called the *epineurium.* The epineurium carries the blood vessels of the nerves and dips in to blend with the perineurium.

Neuroglia is a special form of very delicate connective tissue, connected with the *pia mater,* which furnishes a supporting framework for the brain. Large numbers of fibrils, derived from neuroglia cells interlace and form a network through the brain and cord.

Nerve terminals are of various forms. Some sensory nerves lose their medullary sheaths, divide into many fibrils and have free endings between epithelial cells or in connective tissue. Others end in the *tactile corpuscles* of the skin, in the *Pacinian* bodies, in *end plates* in striated muscle, etc.

The Central Nervous System

The essential function of nerves is to conduct impulses between the brain and the periphery; that of nerve cells to receive or to instigate such impulses or impressions. The nerve cells are, therefore, accumulated in large masses in the brain and spinal cord, which is an intermediate link between brain and periphery.

The Spinal Cord

The **spinal cord** is, on cross section, oval in form and partly divided by *anterior,* and *posterior median fissures* into two similar halves. The exterior is composed of medullated fibers and the interior of a central gray mass arranged like an irregular capital letter H, or like two crescents with their convexities back to back, large in front, small and long behind, and held together by a transverse bar. These elongations are called the *anterior* and *posterior horns* of the gray matter of the cord. From these horns the spinal nerves spring, the *motor* roots from the anterior and the *sensory* from the posterior horns. The exit of these roots through the white matter leaves a chain of minute openings which divides the cord into three columns, *anterior, posterior,* and *lateral,* the first and second bordering on the fissures of the same name and the third between the other two. Further subdivision into columns is made by tracing the fibers into the *medulla,* the next step toward the brain.

Except in arrangement of parts, the gray matter being largely on the surface, brain substance does not differ materially from that of the cord. The nerve fibers are medullated and without neurilemma in the main. There are five layers of the surface gray matter. The pia mater lies next the gray matter and sends blood vessels into the interior of the brain substance.

THE BLOOD

Blood contains solid bodies called *corpuscles,* which are either circular, biconcave disks, the *red blood corpuscles,* or nearly spherical, often granular, colorless bodies called *white blood corpuscles* or *leucocytes.*

Red corpuscles are about 1/3200 inch in diameter, and number about 5,000,000 to the cubic millimeter of blood. They are oxygen carriers.

White corpuscles vary in size up to nearly double the diameter of the red. They vary also in number. Normally there are from five to ten thousand to the cubic millimeter of blood.

White cells are capable of movement by putting out projections called *pseudopodia* into which the remainder of the cell may flow. They are of great importance in inflammation. Pus is largely composed of dead white cells. White cells contain nuclei and are described as *leucocytes* and *lymphocytes.*

There are certain other corpuscular elements in the blood, about one-fourth the size of the red corpuscles, known as *blood plates.*

The coloring matter of the blood is called hemoglobin. It may be crystalized from the blood. It gives the red cells their power of carrying oxygen.

THE SKIN

The **skin** is made of two layers, the *epidermis* or *scarf skin* and the *derma, corium,* or *true skin.*

The **epidermis** is divided into five layers of which the first and second are called the *horny layer* and are made up of more or less worn-out cells, like dandruff, which is derived from the first layer.

The remaining three layers constitute the *Malpighian layer,* or rete mucosum. The cells of these three layers become more distinct in form until, in the deepest layer, they are columnar in shape and carry the pigment of colored races.

The **corium,** *derma* or *true skin* is made up of dense fibrillated connective tissue arranged in minute elevations, *papillæ,* which indent the epidermis and carry the blood vessels and nerves of the skin. The latter often terminate in tortuous structures called *tactile corpuscles.*

Beneath the skin there is a layer of connective tissue and fat in which the superficial bolod vessels and nerves run, called the *subcutaneous* connective tissue.

Connected with the skin are the *hairs, sebaceous* and *sudoriferous glands* and the *nails.* These are called the *appendages* of the skin.

THE CIRCULATORY SYSTEM

The constituents of the circulatory system are the *heart, arteries, arterioles, capillaries, venules,* and *veins.*

The **heart** is a hollow muscle covered on its exterior by a serous membrane, the *pericardium,* which is a single layer of flat endothelial cells on a fibroelastic membrane. Beneath this is a layer of connective tissue and fat, particularly along the blood vessels, similar to the subcutaneous connective tissue and fat.

The connective tissue is continuous with that between the muscle fibers. Next comes the cardiac muscle fibers and then, lining the cavity of the heart, a fibroelastic membrane supporting a single layer of flat endothelial cells, the *endocardium.* The valves of the heart are duplications of the endocardium.

Blood vessels are channels conveying blood from and to the heart. With one exception arteries carry arterial blood away from, and veins carry venous blood to, the heart. *Arterioles* are small arteries and *venules* small

veins. Capillaries form the connecting link between the arterial and venous system.

All blood vessels are lined with flat endothelial cells, cemented by their edges, continuous with the endocardium, and their walls are composed of *nonstriated muscular, yellow elastic* and *white fibrous connective* tissues, which vary in proportion with the size of the vessels. In large arteries the yellow elastic preponderates, while in arterioles the muscular fiber is in excess. Arteries consist of three coats known from within the lumen as *intima, media* and *adventitia.*

The *intima* is mainly endothelium.

The *media* is chiefly of muscular and yellow elastic fibers.

The *adventitia* is nearly all white fibrous tissue with some yellow elastic.

The *capillaries* are made up of flat endothelial cells held together by cement substance. In the *venules* the muscular and elastic elements begin to be apparent and in the veins the adventitia appears. All the coats of veins, except the intima, are thinner than the same coats in the arteries. Valves in the veins are semilunar reduplications of the intima.

Lymph channels are identical in structure with veins, but their walls are much thinner.

THE SPLEEN

The **spleen** is a ductless organ whose essential tissue, the *splenic pulp,* is arranged around the blood vessels.

The organ is surrounded by a fibrous capsule, with a

layer of nonstriated muscle tissue beneath it, which sends bands, or partition walls, throughout the organ, which subdivide to form smaller compartments to contain the pulp. The capillaries do not unite to form venules but empty into sponge-like *venous spaces,*

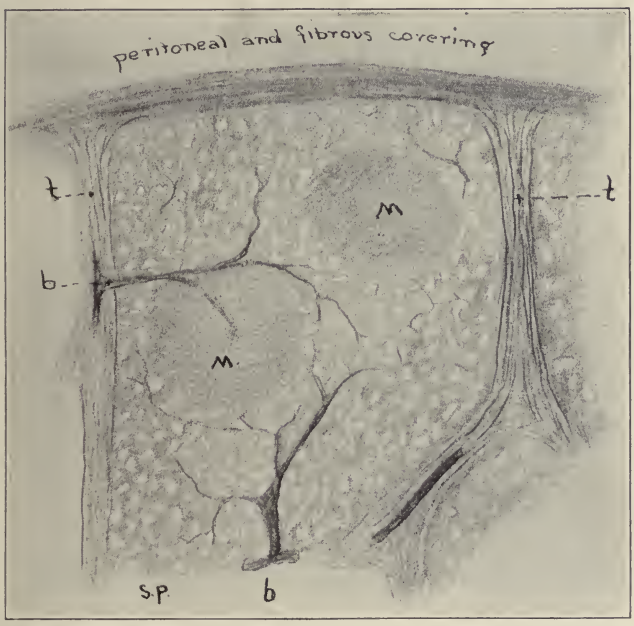

Fig. 29.—Vertical section of human spleen (modified from Kölliker), low power. *t,* trabeculæ; *m,* Malpighian corpuscles; *b,* injected arterial twigs; *s.p.,* spleen pulp. The clear spaces are the venous sinuses.

through which the blood filters to finally enter small veins which unite to form the splenic vein. Many of the arteries are surrounded by nodules of adenoid tissue called *Malpighian bodies.*

GLANDS

A gland is an organ whose cells manufacture, from the blood, something to be utilized in or excreted from the body. The simplest form of gland would, therefore, be a *duct* or *tube* to convey away secretion, the *parenchyma,* or cell to form the secretion, and a nerve and blood supply.

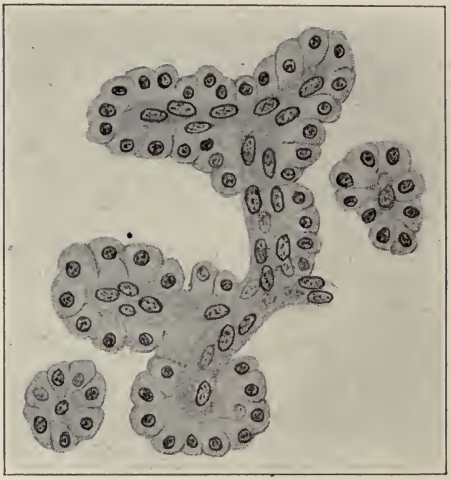

Fig. 30.—Cross section of pancreatic tubule (modified from Sobotta).

Glands may be *simple tubular, coiled tubular,* as in sweat glands, *branched tubular,* or *acinous.*

Acinous glands consist of a single tube which becomes clubbed at its extremity and partially divided into many compartments called *acini* or *alveoli.* A number of acini, held together by delicate connective tissue, form a *lobule;* several lobules may be bound up in the same way to form a *lobe,* and all the lobes, enveloped in a

capsule of connective tissue, form a *compound acinous* gland. This arrangement gives rise to a many-branched duct to convey the secretion from the gland. All the branches from one lobule unite to form an *intralobular* duct, which unites with the ducts of adjacent lobules to form an *interlobular* duct, running between the lobules; and these, in turn, unite to form the main duct of the gland, as in the duct of Wirsung of the pancreas or Stenson's duct of the parotid.

The salivary, buccal and mammary glands and the pancreas are all compound racemose or acinous glands.

Slight differences in structure are found in the sublingual, a mucous gland, and the submaxillary, a mixed gland, which differentiate them from the pure serous glands like the parotid; but the general type is the same. In all the blood vessels and nerves, with which they are abundantly supplied, follow the branches of the duct until it enlarges into alveoli which are surrounded by the vessels, bringing their contents into closest contact with the active cells of the glands. The dividing and supporting bands of connective tissue are all derived from the capsule or envelope.

The Liver

The **liver,** the largest of the glandular organs, is surrounded by a dense connective tissue envelope, the *capsule of Glisson,* covered by peritoneum, which sends branching septa throughout the organ subdividing it into numberless minute subdivisions called *lobules.* Every lobule is made up of *liver cells,* the *parenchyma,* and connected with four channels or vessels, two of which convey something *to* and two something *from* the lobule.

Fig. 31.—Portion of transverse section of human liver. X. 100 *h.a.*, hepatic artery; *v.c.*, intralobular vein; *v.p.*, interlobular vein; *b.d.*, bile duct.

The whole object is to put the liver cells in intimate association with the blood and bile vessels. Hence the structure of the liver can be understood only when the arrangement of these vessels is comprehended. The vessels run in the bands of connective tissue which at once support the lobules and separate them from each other.

The *hepatic artery* and the *portal vein* carry blood into the liver. The *hepatic veins* and the *bile duct* carry blood and bile respectively from the liver.

The artery, portal vein, and bile duct enter the liver through the transverse fissure and at once begin to divide into small and smaller branches until, finally, a very minute branch of each is found in the connective tissues which surround each lobule. From these smallest vessels capillaries are given off which penetrate the lobules between the liver cells. The cell are now in contact with (a) arterial capillaries carrying blood to nourish the liver; (b) portal capillaries carrying blood to be acted on by liver cells; (c) bile duct capillaries to pick up the secretion of the liver cells; and (d) hepatic capillaries to take up the bile free blood and convey it to the center of the lobule where these capillaries empty into, or form an *intralobular* venule which is the beginning of the hepatic veins. The direction of the current in the portal and arterial capillaries is toward the lobule, in the hepatic and bile capillaries, away from the lobule. The portal, arterial and bile vessels lie between the lobules and are *interlobular*. The *interlobular* veins unite beyond the lobules into veins called *sublobular*. Within the lobules, packed between the capillaries, lie the liver cells.

THE DIGESTIVE TRACT

The canal beginning at the mouth and ending at the anus is subdivided into *mouth, pharynx, esophagus, stomach, small* and *large intestines.*

The Mouth, Pharynx, and Esophagus

The **mouth** is lined by a mucous membrane which consists of stratified epithelium.

The **tongue,** which consists chiefly of striated muscle, is marked on its upper surface by a large number of papillæ which are distinguished from each other by being *filiform* or conical in shape, *fungiform,* having a constricted base, or *circumvallate,* which are fungiform in shape but surrounded by a depression with a wall-like elevation. They are located at the back of the tongue *Taste buds* are flask-shaped collections of epithelial cells around the circumvallate papillæ and at other places on the tongue.

The **teeth** are calcareous structures, divided into an exposed part called the *crown,* a constricted portion, the *neck* and a *root* or *roots* embedded in the *alveolus* or socket of the jaw. The crown is covered by the hardest structure in the body, the *enamel.* Beneath this is a layer derived from connective tissue called *dentine,* not so hard as enamel, pierced by radiating canals in which vessels and nerves lie, surrounding a *pulp chamber* which contains the main vessels, nerves and lymphatics of the tooth, bound together by connective tissue and forming the *pulp.*

The **tonsils** are large collections of lymphoid tissue containing many *lymph follicles.* The surface and

crypts of the tonsils are covered by stratified squamous epithelium.

The **pharynx** above the soft palate is covered by ciliated columnar epithelium; below the palate, by stratified squamous epithelium.

The **esophagus** is lined by stratified squamous epithelium resting on connective tissue, the two forming the mucous coat. External to this are the *muscularis mucosa, submucosa* and muscular coats which are striated in the upper third and unstriated in the remainder.

The Stomach and Intestines

The **stomach** and **intestines** are made up of a *mucous coat,* which consists of *epithelial lining, mucosa* and *muscularis mucosa* which is a very thin layer of nonstriated muscular fibers separating the mucous membrane and the *submucosa.* The latter is a layer of loose areolar tissue, corresponding to subcutaneous connective tissue, which connects the muscular and mucous coats and carries the larger vessels, nerves, and lymphatics.

The *muscular* coat is made up of an inner *circular* and an outer *longitudinal* layer of nonstriated muscle. External to this is a *subserous* layer of connective tissue and then the partial or complete *peritoneal* or serous coat.

The mucous coat may be thrown into folds called *rugæ* in the stomach and *valvulæ conniventes* in the small intestines, which greatly increase the extent of its surface.

The mucosa of the stomach is marked by minute de-

pressions, *gastric tubules* or *glands,* which produce the gastric juice. Those in the cardiac end are called *peptic* glands; while the *pyloric* are situated in the small end of the organ.

The *intestines* are formed on the above plan, the

Fig. 32.—Injected lacteal vessels in two villi of human intestine. (Teichmann.) X 100. Lacteals filled with white substance and blood vessels with dark.

longitudinal muscular coat of the large being gathered into three bundles instead of forming a thin layer around the circumference of the canal.

The mucosa, of the small intestine is studded by innumerable elevations, *villi,* separated by depressions of similar minuteness, the *crypts* of Lieberkühn, which

correspond to the tubules of the stomach. Every villus has passing *into* it an arterial capillary and *from* it a venous capillary and a lacteal. The first carries blood to nourish the villus, the second carries the return circulation containing the usual waste products plus the products of digestion, while the third conveys certain blood products, chiefly fat, into the lymph spaces and channels in the submucosa and thence into the larger lymphatics of the mesentery. The cells lining the villi secrete a part of the intestinal fluid—*succus entericus*—while the remainder is formed by *glands of Brunner* located below the crypts of Lieberkühn and opening into the crypts.

Connected with the lymphatic plexus in the submucosa are lymph nodules improperly called *glands*. These are sponge-like bodies through which the lymph filters, its circulation being always in the direction of the venous blood.

THE KIDNEY

The kidney is surrounded by a fibrous capsule which sends delicate septa throughout the organ. Its blood vessels, nerves, and duct enter or leave at the hilum. As its function is to extract the urinary solids, and water to hold them in solution, from the blood, its essential structure is that of a set of capillaries so arranged that they will be surrounded by kidney cells, set in tubes, which can remove the urine from the blood and pour it into the tube. If the kidney be split along its outer border, it will be seen to consist of a dark outer and a lighter inner portion, distinguished

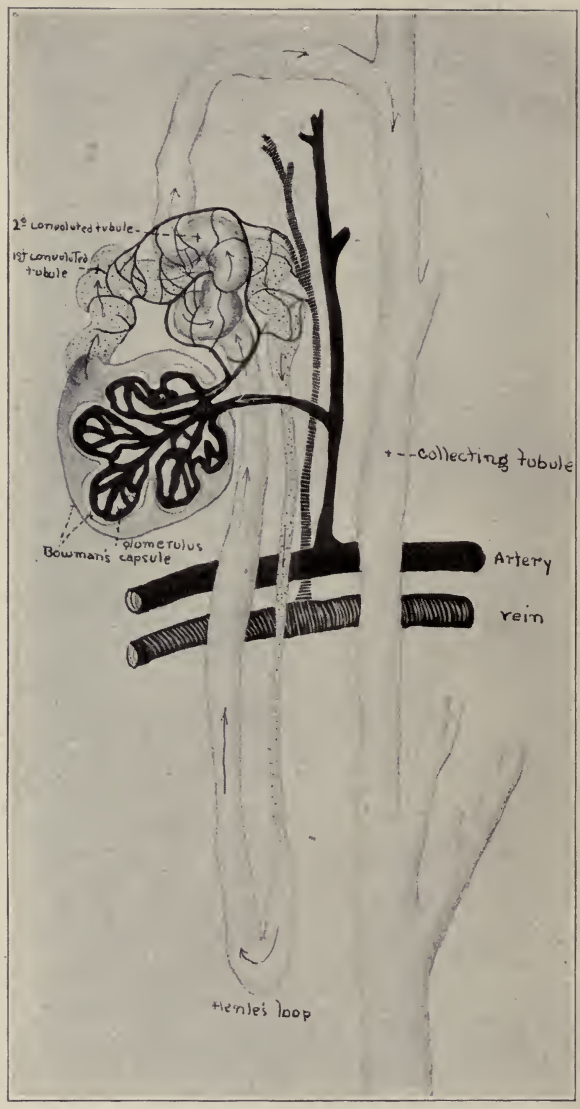

Fig. 33.—Diagrammatic representation of the course of the uriniferous tubules and the kidney vessels.

as *cortical* and *medullary*. In the cortical (outer) portion the work of removing urine from the blood is in the main performed, while the medullary part is largely occupied by minute tubules conveying the urine to the excretory duct—*ureter*.

If the small arterioles be traced to the cortex they will be found to terminate in a curious tuft of capillaries called *Malpighian bodies* or *glomeruli;* and each tuft is surrounded by the expanded end of a tubule, Bowman's capsule, whose lining of flat epithelial cells is reflected over the glomerulus. The small tubule leading from Bowman's capsule, after winding about as the *first convoluted tubule,* runs a short distance into the medullary portion and then turns upward and reenters the cortical area, the U-like loop thus formed being known as *Henle's loop,* while the tortuous part which reenters the cortex is the *second convoluted tubule*. After the formation of the glomeruli from an *afferent* arteriole, these capillaries contract to form an *efferent* arteriole which penetrates Bowman's papsule and breaks up into a second series of capillaries in the region of the convoluted tubules. From these last the venous capillaries are formed and remove the *urine-free* blood from the kidneys. The blood has been brought in contact with the kidney cells at two points, i. e., in Bowman's capsule around the Malpighian tufts and in the convoluted tubules by the second series of capillaries. The second convoluted tubule now runs a nearly direct course into the pyramids from which the urine drops into a *calyx,* the beginning of the ureter. Several calices unite to form an *infundibulum*

and the three infundibula unite to form the *pelvis* of the ureter which contracts to the ureter proper.

ORGANS OF RESPIRATION

The organs of respiration are the *larynx, trachea, bronchi,* and *lungs.* The function of these organs is to effect an exchange of gases in the blood and to produce articulate sound.

The *larynx, trachea,* and *bronchi* have a framework of hyaline cartilage, except the *epiglottis* which is yellow elastic, and each is lined by epithelium which is stratified squamous over the epiglottis and upper third of the larynx and stratified columnar and ciliated elsewhere. Next to the epithelium lies the *mucosa* or internal fibrous coat, containing collections of lymphoid tissue and nutrient vessels. Next to this lies the *muscularis mucosa* followed by the external or *submucous* coat containing the mucous glands and external to this is the cartilage, where it exists.

The two bronchi divide, the right into three and the left into two branches for the corresponding lobes of the lungs. Each of these primary bronchi again divides and these smaller tubes again divide, the process being repeated until the *terminal bronchioles* are reached. As this division proceeds the cartilage is lost, then the mucous coat and its glands disappear and lastly the muscular coat ceases, the cilia disappear, and the epithelium becomes cuboidal in form. Each bronchiole has now apparently dilated into a wide space termed an *infundibulum* whose walls are hollowed out into a number of *air cells* or alveoli lined by a single

Fig. 34.—Diagram of the ending of a bronchial tube.

layer of flat pavement epithelium supported on a fibro-elastic tissue framework carrying a large number of capillaries.

The *bronchial* arteries, which carry nutrient blood to the lungs, with the bronchial veins for the return circulation, follow the bronchi. Entering each lung, near the

middle of its inner surface, is a pulmonary artery. This artery carries *venous* blood. Its subdivisions follow the bronchioles until its capillaries form a rich network around every alveolus and the CO_2 in the blood is thus brought into intimate relationship with the O in the air cells. The capillaries of the pulmonary veins take up the blood after CO_2 has been exchanged for O and unite to form radicles which unite to form the veins which in turn form the pulmonary veins which convey the oxygen-charged blood to the left side of the heart.

The union of many primary air sacs forms a *lobule* and the lobules are combined until a lobe of the lung is formed.

Each lung is lined on its exterior by a serous membrane, the pleura, covered on its superficial surface by endothelium resting on a fibroelastic layer which sends septa into the lungs to divide them into lobes and ultimately into lobules.

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