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Dr. K. K. Swatton

# ANATOMY,

## DESCRIPTIVE AND SURGICAL.


BY

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A REVISED AMERICAN, FROM THE FIFTEENTH ENGLISH EDITION.

WITH 780 ILLUSTRATIONS, MANY OF WHICH ARE NEW.


LEA BROTHERS & CO.,

PHILADELPHIA AND NEW YORK.

1901.

Westcott & Thomson,
Stereotypers and Electrotypers, Philada.

William J. Dornan,
Printer, Philada.

TO

SIR BENJAMIN COLLINS BRODIE, BART.,

F.R.S., D.C.L.,

SERJEANT-SURGEON TO THE QUEEN,

CORRESPONDING MEMBER OF THE INSTITUTE OF FRANCE,

This Work is Dedicated

IN ADMIRATION OF

HIS GREAT TALENTS

AND IN REMEMBRANCE OF

MANY ACTS OF KINDNESS SHOWN TO THE AUTHOR

FROM AN

EARLY PERIOD OF HIS PROFESSIONAL CAREER.

# PUBLISHERS' NOTE TO THE NEW AMERICAN EDITION.

In his masterpiece Henry Gray left undying evidence of his anatomical knowledge and of his comprehension of the best method of imparting it to other minds. It is appropriate that a new and thoroughly revised edition of such a work should appear in the opening of the new century—for forty-five years it has easily held the front place among works on Anatomy, and its merits are only brightened by the numerous works which have endeavored to contest its supremacy. During that time it has had the benefit of the careful scrutiny of many leading anatomists of the English-speaking race. Anatomy is far from stationary, either in its facts or in improvements in the method of their presentation; hence any work which would faithfully reflect the existing position of the science must be revised at comparatively frequent intervals. Fortunately for students and practitioners, *Gray's Anatomy* enjoys a continuous demand rendering frequent revision possible.

The splendid illustrations in *Gray* have long been known as the most effective and intelligible presentations of anatomical structures ever produced. In the present revision this series has been vastly improved, special attention having been given to those for the portion on General Anatomy and Embryology.

The practical application of anatomical facts in medicine and surgery has always been a prominent feature of the work, and this distinctive characteristic has received especial care.

This *new century* edition is presented to the medical public with the absolute confidence that it will be found worthy in every respect to maintain the exalted position which the work has for so many years enjoyed as the most convenient and intelligible exposition of its subject.

# PREFACE TO THE FIFTEENTH ENGLISH EDITION.

In this edition the entire work has undergone a careful revision. The section on Embryology has been somewhat amplified, and its text rendered more intelligible by the introduction of some sixty additional illustrations after His, Kollmann, Duval, and others. Throughout the rest of the work a considerable number of the diagrams have been redrawn and new illustrations here and there added.

The Editors are indebted to Dr. R. Bolam, Lecturer on Physiology and Histology, and to Dr. W. Turnbull, Demonstrator of Anatomy, both of the University of Durham College of Medicine, for their valuable help. The former kindly undertook the revision of the chapter on General Anatomy or Histology; while the latter rendered great assistance in the revision and proof-reading of some of the other portions of the work.

It is hoped that this edition will maintain the reputation which the work has for so many years enjoyed.

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# DESCRIPTIVE AND SURGICAL ANATOMY.

## OSTEOLOGY—THE SKELETON.

THE entire skeleton in the adult consists of 200 distinct bones. These are—

| | |
|---|---|
| The spine or vertebral column (sacrum and coccyx included) | 26 |
| Cranium | 8 |
| Face | 14 |
| Hyoid bone, sternum, and ribs | 26 |
| Upper extremities | 64 |
| Lower extremities | 62 |
| | 200 |

In this enumeration the patellæ are included as separate bones, but the smaller sesamoid bones and the ossicula auditûs are not reckoned. The teeth belong to the tegumentary system.

These bones are divisible into four classes: *Long*, *Short*, *Flat*, and *Irregular*.

The **Long Bones** are found in the limbs, where they form a system of levers, which have to sustain the weight of the trunk and to confer the power of locomotion. A long bone consists of a shaft and two extremities. The *shaft* is a hollow cylinder, contracted and narrowed to afford greater space for the bellies of the muscles; the walls consist of dense, compact tissue of great thickness in the middle, but becoming thinner toward the extremities; the spongy tissue is scanty, and the bone is hollowed out in its interior to form the *medullary canal*. The *extremities* are generally somewhat expanded for greater convenience of mutual connection, for the purposes of articulation, and to afford a broad surface for muscular attachment. Here the bone is made up of spongy tissue with only a thin coating of compact substance. The long bones are not straight, but curved, the curve generally taking place in two directions, thus affording greater strength to the bone. The bones belonging to this class are the *clavicle*, *humerus*, *radius*, *ulna*, *femur*, *tibia*, *fibula*, *metacarpal* and *metatarsal* bones, and the *phalanges*.

**Short Bones.**—Where a part of the skeleton is intended for strength and compactness, and its motion is at the same time slight and limited, it is divided into a number of small pieces united together by ligaments, and the separate bones are short and compressed, such as the bones of the *carpus* and *tarsus*. These bones, in their structure, are spongy throughout, excepting at their surface, where there is a thin crust of compact substance. The *patellæ* also, together with the other sesamoid bones, are by some regarded as short bones.

**Flat Bones.**—Where the principal requirement is either extensive protection or the provision of broad surfaces for muscular attachment, we find the osseous structure expanded into broad, flat plates, as is seen in the bones of the skull and the shoulder-blade. These bones are composed of two thin layers of compact tissue enclosing between them a variable quantity of cancellous tissue. In the cranial bones these layers of compact tissue are familiarly known as the *tables* of the skull; the outer one is thick and tough; the inner one thinner, denser, and more brittle, and hence termed the *vitreous table*. The intervening cancellous tissue is called the *diploë*. The flat bones are: the *occipital, parietal, frontal, nasal, lachrymal, vomer, scapula, os innominatum, sternum, ribs*, and *patella*.

The **Irregular** or **Mixed Bones** are such as, from their peculiar form, cannot be grouped under either of the preceding heads. Their structure is similar to that of other bones, consisting of a layer of compact tissue externally, and of spongy cancellous tissue within. The irregular bones are: the *vertebræ, sacrum, coccyx, temporal, sphenoid, ethmoid, malar, superior maxillary, inferior maxillary, palate, inferior turbinated*, and *hyoid*.

**Surfaces of Bones.**—If the surface of any bone is examined, certain eminences and depressions are seen to which descriptive anatomists have given the following names.

These eminences and depressions are of two kinds: *articular* and *non-articular*. Well-marked examples of articular eminences are found in the heads of the humerus and femur and of articular depressions in the glenoid cavity of the scapula and the acetabulum. Non-articular eminences are designated according to their form. Thus, a broad, rough, uneven elevation is called a *tuberosity*; a small, rough prominence, a *tubercle*; a sharp, slender, pointed eminence, a *spine*; a narrow, rough elevation, running some way along the surface, a *ridge* or *line*.

The non-articular depressions are also of very variable form, and are described as *fossæ, grooves, furrows, fissures, notches*, etc. These non-articular eminences and depressions serve to increase the extent of surface for the attachment of ligaments and muscles, and are usually well marked in proportion to the muscularity of the subject.

A prominent process projecting from the surface of a bone, which it has never been separate from or movable upon is termed an *apophysis* (from ἀπόφυσις, an excrescence); but if such process is developed as a separate piece from the rest of the bone, to which it is afterward joined, it is termed an *epiphysis* (from ἐπίφυσις, an accretion). The main part of the bone, or shaft, which is formed from the primary centre of ossification, is termed the *diaphysis*, and is separated, during growth, from the epiphysis by a layer of cartilage, at which growth in length of the bone takes place.

## THE SPINE.

The **Spine** is a flexuous and flexible column formed of a series of bones called *vertebræ* (from *vertere*, to turn).

The **Vertebræ** are thirty-three in number, and have received the names *cervical, dorsal, lumbar, sacral*, and *coccygeal*, according to the position which they occupy; seven being found in the cervical region, twelve in the dorsal, five in the lumbar, five in the sacral, and four in the coccygeal.

This number is sometimes increased by an additional vertebra in one region, or the number may be diminished in one region, the deficiency being supplied by an additional vertebra in another. These observations do not apply to the cervical portion of the spine, the number of bones forming which is seldom increased or diminished.

The vertebræ in the upper three regions of the spine are separate throughout the whole of life; but those found in the sacral and coccygeal regions are in the adult firmly united, so as to form two bones—*five* entering into the formation of the upper bone or *sacrum*, and *four* into the terminal bone of the spine or *coccyx*.

### General Characters of a Vertebra.

Each **vertebra** consists of two essential parts—an anterior solid segment or *body*, and a posterior segment or *arch*. The arch (*neural*) is formed of two *pedicles* and two *laminæ*, supporting seven *processes*—viz. four *articular*, two *transverse*, and one *spinous*.

The bodies of the vertebræ are piled one upon the other, forming a strong pillar for the support of the cranium and trunk; the arches forming a hollow cylinder behind the bodies for the protection of the spinal cord. The different vertebræ are connected together by means of the articular processes and the intervertebral fibro-cartilages; while the transverse and spinous processes serve as levers for the attachment of muscles which move the different parts of the spine. Lastly, between each pair of vertebræ apertures exist through which the spinal nerves pass from the cord. Each of these constituent parts must now be separately examined.

The **Body** or **Centrum** is the largest part of a vertebra. Above and below, it is flattened; its upper and lower surfaces are rough for the attachment of the intervertebral fibro-cartilages, and present a rim around their circumference. In front, it is convex from side to side, concave from above downward. Behind, it is flat from above downward and slightly concave from side to side. Its anterior surface is perforated by a few small apertures, for the passage of nutrient vessels; whilst on the posterior surface is a single large, irregular aperture, or occasionally more than one, for the exit of veins from the body of the vertebra—the *venæ basis vertebræ*.

The **Pedicles** are two short, thick pieces of bone, which project backward, one on each side, from the upper part of the body of the vertebra, at the line of junction of its posterior and lateral surfaces. The concavities above and below the pedicles are the *intervertebral notches;* they are four in number, two on each side, the inferior ones being generally the deeper. When the vertebræ are articulated the notches of each contiguous pair of bones form the intervertebral foramina, which communicate with the spinal canal and transmit the spinal nerves and blood-vessels.

The **Laminæ** are two broad plates of bone which complete the neural arch by fusing together in the middle line behind. They enclose a foramen, the *spinal foramen*, which serves for the protection of the spinal cord; they are connected to the body by means of the pedicles. Their upper and lower borders are rough, for the attachment of the *ligamenta subflava*.

The **Spinous Process** projects backward from the junction of the two laminæ, and serves for the attachment of muscles and ligaments.

The **Articular Processes**, four in number, two on each side, spring from the junction of the pedicles with the laminæ. The two superior project upward, their articular surfaces being directed more or less backward; the two inferior project downward, their articular surfaces looking more or less forward.[1]

The **Transverse Processes**, two in number, project one at each side from the point where the lamina joins the pedicle, between the superior and inferior articular processes. They also serve for the attachment of muscles and ligaments.

## Character of the Cervical Vertebræ (Fig. 1).

The **Cervical Vertebræ** are smaller than those in any other region of the spine, and may readily be distinguished by the foramen in the transverse process, which does not exist in the transverse process of either the dorsal or lumbar vertebræ.

The **Body** is small, comparatively dense, and broader from side to side than from before backward. The anterior and posterior surfaces are flattened and of equal depth; the former is placed on a lower level than the latter, and its inferior border is prolonged downward, so as to overlap the upper and fore part of the vertebræ below. Its upper surface is concave transversely, and presents a projecting lip on each side; its lower surface is convex from side to side, concave from before backward, and presents laterally a shallow concavity which receives the corresponding projecting lip of the adjacent vertebra. The *pedicles* are directed outward and backward, and are attached to the body midway between the upper and lower borders, so that the superior intervertebral notch is as deep as the inferior, but it is, at the same time, narrower. The *laminæ* are narrow,

[1] It may, perhaps, be as well to remind the reader that the direction of a surface is determined by that of a line drawn at right angles to it.

long, thinner above than below, and overlap each other, enclosing the spinal foramen, which is very large, and of a triangular form. The *spinous process* is short, and bifid at the extremity to afford greater extent of surface for the attachment of muscles, the two divisions being often of unequal size. They increase in length from the fourth to the seventh. The *articular processes* are flat, oblique, and of an oval form: the superior are directed backward and upward; the inferior forward and downward. The *transverse processes* are short, directed downward, outward, and forward, bifid at their extremity, and marked by a groove along their upper surface, which runs downward and outward from the superior intervertebral notch, and serves for the transmission of one of the cervical nerves. They are situated in front of the articular processes and on the outer side of the pedicles. The transverse processes are pierced at their base by a foramen, for the transmission of the vertebral artery, vein, and plexus of nerves.


FIG. 1.—Cervical vertebra.

Each process is formed by two roots: the anterior root, sometimes called the *costal process*, arises from the side of the body, and is the homologue of the rib in the dorsal region of the spine; the posterior root springs from the junction of the pedicle with the lamina, and corresponds with the transverse process in the dorsal region. It is by the junction of the two that the foramen for the vertebral vessels is formed. The extremity of each of these roots forms the *anterior* and *posterior tubercles* of the transverse processes.[1]

The peculiar vertebræ in the cervical region are the first, or *Atlas*; the second, or *Axis*; and the seventh, or *Vertebra prominens*. The great modifications in the form of the atlas and axis are designed to admit of the nodding and rotatory movements of the head.

The **Atlas** (Fig. 2) is so named from supporting the globe of the head. The chief peculiarities of this bone are that it has neither body nor spinous process. The body is detached from the rest of the bone, and forms the odontoid process of the second vertebra; while the parts corresponding to the pedicles join in front to form the anterior arch. The atlas is ring-like, and consists of an anterior arch, a posterior arch, and two lateral masses. The *anterior* arch forms about one-fifth of the ring: its anterior surface is convex, and presents about its centre a *tubercle*, for the attachment of the Longus colli muscle; posteriorly it is concave, and marked by a smooth, oval or circular facet, for articulation with the odontoid process of the axis. The upper and lower borders give attachment to the anterior occipito-atlantal and the anterior atlanto-axial ligaments, which connect it with the occipital bone above and the axis below. The *posterior* arch forms about two-fifths of the circumference of the bone; it terminates behind in a *tubercle*,

[1] The anterior tubercle of the transverse process of the sixth cervical vertebra is of large size, and is sometimes known as "Chassaignac's" or the "carotid tubercle." It is in close relation with the carotid artery, which lies in front and a little external to it so that, as was first pointed out by Chassaignac, the vessel can with ease be compressed against it.

which is the rudiment of a spinous process, and gives origin to the Rectus capitis posticus minor. The diminutive size of this process prevents any interference in the movements between the atlas and the cranium. The posterior part of the arch presents above and behind a rounded edge for the attachment of the posterior occipito-atlantal ligament, while in front, immediately behind each superior articular process, is a groove, sometimes converted into a foramen by a *delicate bony spiculum* which arches backward from the posterior extremity of the superior articular process. These grooves represent the superior intervertebral notches, and are peculiar from being situated behind the articular processes, instead of in front of them, as in the other vertebræ. They serve for the transmission of the vertebral artery, which, ascending through the foramen in the transverse process, winds round the lateral mass in a direction backward and inward. They also transmit the suboccipital (first spinal) nerve. On the under surface of the posterior arch, in the same situation, are two other grooves, placed behind the lateral masses, and representing the inferior intervertebral notches of other vertebræ. They are much less marked than the superior. The lower border also gives attachment to the posterior atlanto-axial ligament, which connects it with the axis. The *lateral masses* are the most bulky and solid parts of the atlas, in order to support the weight of the head; they present two articulating processes above, and two below. The two superior are of large size, oval,

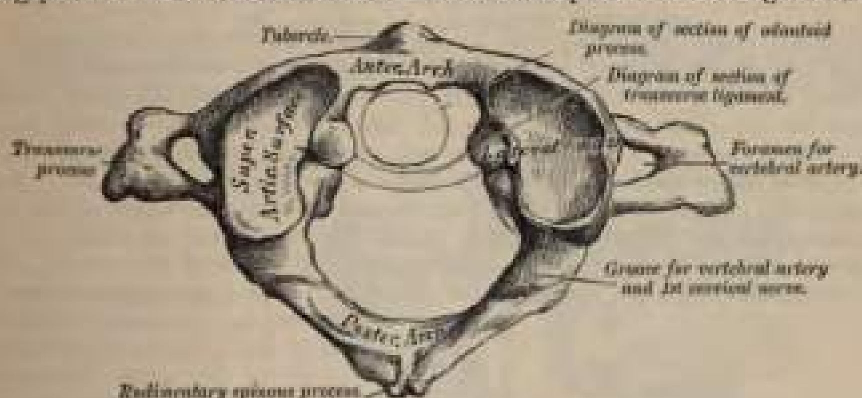



FIG. 2.—First cervical vertebra, or atlas.

concave, and approach each other in front, but diverge behind; they are directed upward, inward, and a little backward, each forming a kind of cup for the corresponding condyle of the occipital bone, and are admirably adapted to the nodding movements of the head. Not infrequently they are partially subdivided by a more or less deep indentation which encroaches upon each lateral margin. The inferior articular processes are circular in form, flattened or slightly concave, and directed downward and inward, articulating with the axis, and permitting the rotatory movements. Just below the inner margin of each superior articular surface is a small tubercle, for the attachment of the transverse ligament, which, stretching across the ring of the atlas, divides it into two unequal parts; the anterior or smaller segment receiving the odontoid process of the axis, the posterior allowing the transmission of the spinal cord and its membranes. This part of the spinal canal is of considerable size, to afford space for the spinal cord; and hence lateral displacement of the atlas may occur without compression of this structure. The *transverse processes* are of large size, project directly outward and downward from the lateral masses, and serve for the attachment of special muscles which assist in rotating the head. They are long, not bifid, and perforated at their base by a canal for the vertebral artery, which is directed from below, upward and backward.

The **Axis** (Fig. 3) is so named from forming the pivot upon which the first vertebra, carrying the head, rotates. The most distinctive character of this bone is the strong, prominent process, tooth-like in form (hence the name *odontoid*), which rises perpendicularly from the upper surface of the body. The *body* is deeper in front than behind, and prolonged downward anteriorly so as to overlap the upper and fore part of the next vertebra. It presents in front a median

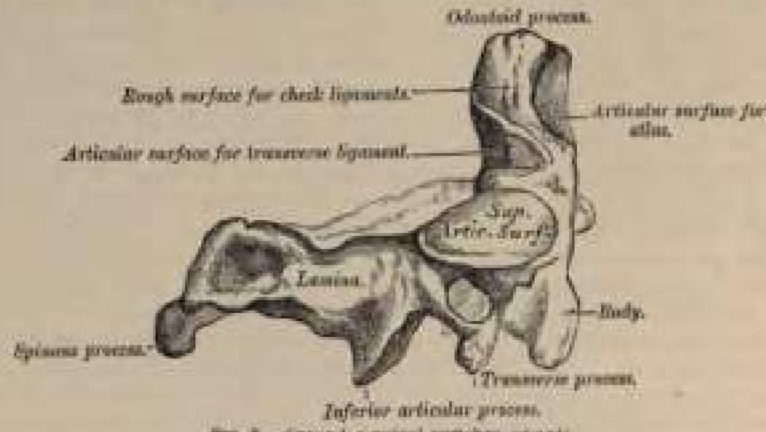



Fig. 3.—Second cervical vertebra, or axis.

longitudinal ridge, separating two lateral depressions for the attachment of the Longus colli muscle of either side. The *odontoid process* presents two articulating surfaces: one in front, of an oval form, for articulation with the atlas; another behind, for the transverse ligament—the latter frequently encroaching on the sides of the process. The apex is pointed, and gives attachment to the middle fasciculus of the odontoid or check ligaments (*ligamentum suspensorium*). Below the apex the process is somewhat enlarged, and presents on either side a rough impression for the attachment of the *lateral* fasciculi of the odontoid or *check* ligaments, which connect it to the occipital bone; the base of the process, where it is attached to the body, is constricted, so as to prevent displacement from the transverse ligament, which binds it in this situation to the anterior arch of the atlas. Sometimes, however, this process does become displaced, especially in children, in whom the ligaments are more relaxed: instant death is the result of this accident. The internal structure of the odontoid process is more compact than that of the body. The *pedicles* are broad and strong, especially their anterior extremities, which coalesce with the sides of the body and the root of the odontoid process. The *laminæ* are thick and strong, and the spinal foramen large, but smaller than that of the atlas. The *transverse processes* are very small, not bifid, and perforated by the foramen for the vertebral artery, which is directed obliquely upward and outward. The *superior articular surfaces* are round, slightly convex, directed upward and outward, and are peculiar in being supported on the body, pedicles, and transverse processes. The *inferior articular surfaces* have the same direction as those of the other cervical vertebræ. The *superior*


Fig. 4.—Seventh cervical vertebra, or vertebra prominens.

*intervertebral notches* are very shallow, and lie behind the articular processes; the *inferior* in front of them, as in the other cervical vertebræ. The *spinous process* is of large size, very strong, deeply channelled on its under surface, and presents a bifid, tubercular extremity for the attachment of muscles which serve to rotate the head upon the spine.

**Seventh Cervical** (Fig. 4).—The most distinctive character of this vertebra is the existence of a very long and prominent spinous process; hence the name "vertebra prominens." This process is thick, nearly horizontal in direction, not bifurcated, and has attached to it the lower end of the ligamentum nuchæ. The *transverse process* is usually of large size, its posterior tubercles are large and prominent, while the anterior are small and faintly marked; its upper surface has usually a shallow groove, and it seldom presents more than a trace of bifurcation at its extremity. The foramen in the transverse process is sometimes as large as in the other cervical vertebræ, but is usually smaller on one or both sides, and sometimes wanting. On the left side it occasionally gives passage to the vertebral artery; more frequently the vertebral vein traverses it on both sides; but the usual arrangement is for both artery and vein to pass in front of the transverse process, and not through the foramen. Occasionally the anterior root of the transverse process exists as a separate bone, and attains a large size. It is then known as a "cervical rib."

## Characters of the Dorsal Vertebræ.

The **Dorsal Vertebræ** are intermediate in size between those in the cervical and those in the lumbar region, and increase in size from above downward, the upper

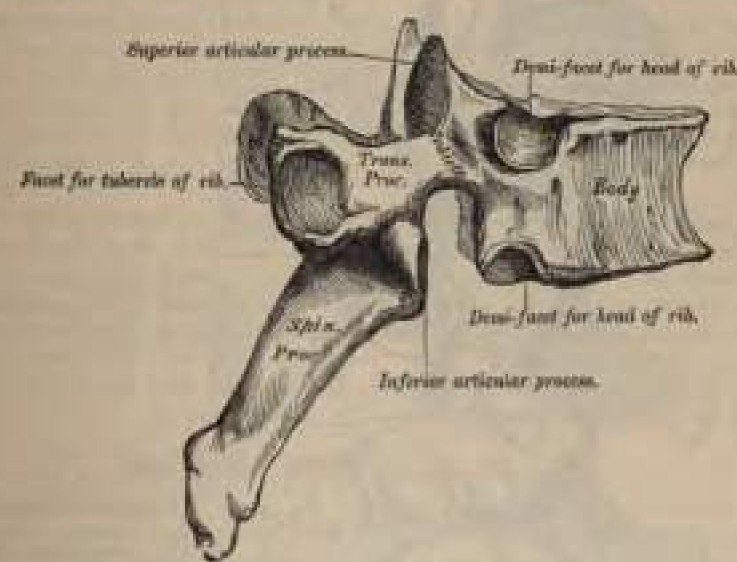



FIG. 5.—A dorsal vertebra.

vertebræ in this segment of the spine being much smaller than those in the lower part of the region. The dorsal vertebræ may be at once recognized by the presence on the sides of the body of one or more facets or half-facets for the heads of the ribs.

The **bodies** of the dorsal vertebræ resemble those in the cervical and lumbar regions at the respective ends of this portion of the spine; but in the middle of the dorsal region their form is very characteristic, being heart-shaped, and as broad in the antero-posterior as in the lateral direction. They are thicker behind than in front, flat above and below, convex and prominent in front, deeply concave behind, slightly constricted in front and at the sides, and marked on each side, near the root of the pedicle, by two demi-facets, one above, the other below. These are covered with cartilage in the recent state, and, when articulated with the adjoining vertebræ, form, with the intervening fibro-cartilage, oval surfaces for the reception of the heads of the corresponding ribs. The *pedicles* are directed backward, and the inferior intervertebral notches are of large size, and deeper than in any other region of the spine. The *laminæ* are broad, thick, and imbricated—that is to say, overlapping one another like tiles on a roof. The spinal foramen is

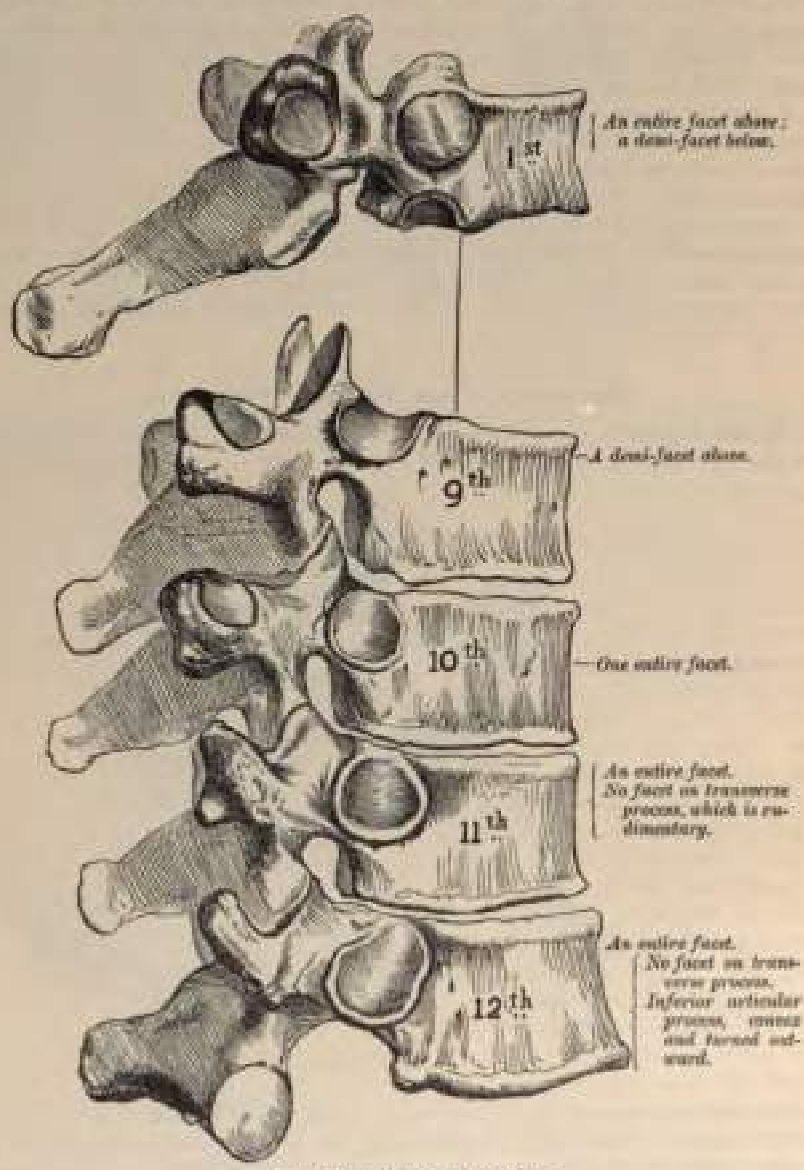



FIG. 6.—Peculiar dorsal vertebræ.

small, and of a circular form. The *spinous processes* are long, triangular on transverse section, directed obliquely downward, and terminate in a tubercular extremity. They overlap one another from the fifth to the eighth, but are less oblique in direction above and below. The *articular processes* are flat, nearly vertical in direction, and project from the upper and lower part of the pedicles; the superior being directed backward and *slightly* outward and upward, the inferior forward and a little inward and downward. The *transverse processes* arise from the same parts of the arch as the posterior roots of the transverse processes in the neck, and are situated behind the articular processes and pedicles; they are thick, strong, and of great length, directed obliquely backward and outward, presenting a clubbed extremity, which is tipped on its anterior part by a small concave surface, for articulation with the tubercle of a rib. Besides the articular facet for the rib, *three indistinct tubercles* may be seen rising from the transverse processes, one at the upper border, one at the lower border, and one externally. In man they are comparatively of small size, and serve only for the attachment of muscles. But in some animals they attain considerable magnitude, either for the purpose of more closely connecting the segments of this portion of the spine or for muscular and ligamentous attachment.

The peculiar dorsal vertebræ are the *first, ninth, tenth, eleventh,* and *twelfth* (Fig. 6).

The **First Dorsal Vertebra** presents, on each side of the *body*, a single entire articular facet for the head of the first rib and a half facet for the upper half of the second. The body is like that of a cervical vertebra, being broad transversely; its upper surface is concave, and lipped on each side. The *articular surfaces* are oblique, and the *spinous process* thick, long, and almost horizontal.

The **Ninth Dorsal** has no demi-facet below. In some subjects, however, the ninth has two demi-facets on each side; when this occurs the tenth has only a demi-facet at the upper part.

The **Tenth Dorsal** has (except in the cases just mentioned) an entire articular facet on each side, above, which is partly placed on the outer surface of the pedicle. It has no demi-facet below.

In the **Eleventh Dorsal** the body approaches in its form and size to the lumbar. The articular facets for the heads of the ribs, one on each side, are of large size, and placed chiefly on the pedicles, which are thicker and stronger in this and the next vertebra than in any other part of the dorsal region. The *spinous* process is short, and nearly horizontal in direction. The *transverse* processes are very short, tubercular at their extremities, and have no articular facets for the tubercles of the ribs.

The **Twelfth Dorsal** has the same general characters as the eleventh, but may be distinguished from it by the inferior articular processes being convex and turned outward, like those of the lumbar vertebræ; by the general form of the body, laminæ, and spinous process, approaching to that of the lumbar vertebræ; and by the transverse processes being shorter, and marked by three elevations, the superior, inferior, and external tubercles, which correspond to the mammillary, accessory, and transverse processes of the lumbar vertebræ. Traces of similar elevations are usually to be found upon the other dorsal vertebræ (*vide ut supra*).

## Characters of the Lumbar Vertebræ.

The **Lumbar Vertebræ** (Fig. 7) are the largest segments of the vertebral column, and can at once be distinguished by the absence of the foramen in the transverse process, the characteristic point of the cervical vertebræ, and by the absence of any articulating facet on the side of the body, the distinguishing mark of the dorsal vertebræ.

The **body** is large, and has a greater diameter from side to side than from before backward, slightly thicker in front than behind, flattened or slightly concave above and below, concave behind, and deeply constricted in front and at the sides, presenting prominent margins, which afford a broad basis for the support of the superincumbent weight. The *pedicles* are very strong, directed backward from the upper part of the bodies; consequently, the inferior intervertebral notches are of considerable depth. The *laminæ* are broad, short, and strong, and the spinal foramen triangular, larger than in the dorsal, smaller than in the cervical, region. The *spinous processes* are thick and broad, somewhat quadrilateral, horizontal in direction, thicker below than above, and terminating by a rough, uneven border.

The *superior articular processes* are concave, and look backward and inward; the *inferior*, convex, look forward and outward; the former are separated by a much wider interval than the latter, embracing the lower articulating processes of the vertebra above. The *transverse processes* are long, slender, directed trans-


FIG. 7.—Lumbar vertebra.

versely outward in the upper three lumbar vertebræ, slanting a little upward in the lower two. They are situated in front of the articular processes, instead of behind them as in the dorsal vertebræ, and are homologous with the ribs. Of the three tubercles noticed in connection with the transverse processes of the twelfth dorsal vertebra, the *superior* ones become connected in this region with the back

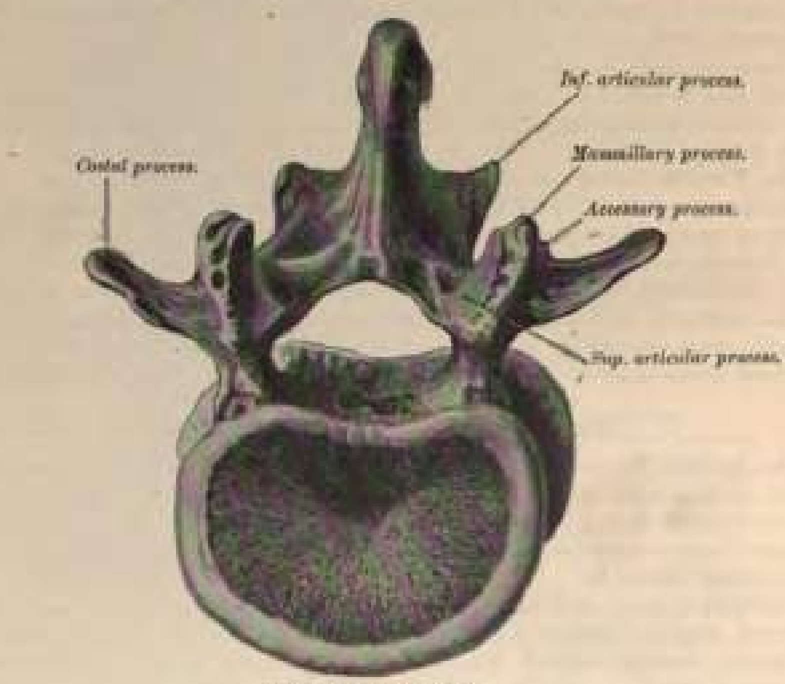



FIG. 8.—Lumbar vertebra.

part of the superior articular processes, and have received the name of *mammillary* processes; the *inferior* are represented by a small process pointing downward, situated at the back part of the base of the transverse process, and called the *accessory* processes: these are the true transverse processes, which are rudimental in this region of the spine; the *external* ones are the so-called transverse processes, the homologue of the rib, and hence sometimes called costal processes (Fig. 8). Although in man these are comparatively small, in some animals they attain considerable size, and serve to lock the vertebræ more closely together.

The **Fifth Lumbar** vertebra is characterized by having the body much thicker in front than behind, which accords with the prominence of the sacro-vertebral articulation; by the smaller size of its spinous process; by the wide interval between the inferior articulating processes; and by the greater size and thickness of its transverse processes, which spring from the body as well as from the pedicles.

**Structure of the Vertebræ.**—The body is composed of light, spongy, cancellous tissue, having a thin coating of compact tissue on its external surface perforated by numerous orifices, some of large size, for the passage of vessels; its interior is traversed by one or two large canals, for the reception of veins, which converge toward a single large, irregular aperture or several small apertures at the posterior part of the body of each bone. The arch and processes projecting from it have, on the contrary, an exceedingly thick covering of compact tissue.

**Development.**—Each vertebra is formed of four primary centres of ossification (Fig. 9), one for each lamina and its processes, and two for the body.[1] Ossifica-

FIG. 9.—Development of a vertebra.

FIG. 10.

FIG. 11.

tion commences in the laminæ about the sixth week of fœtal life, in the situation where the transverse processes afterward project, the ossific granules shooting backward to the spine, forward into the pedicles, and outward into the transverse and articular processes. Ossification in the body commences in the middle of the cartilage about the eighth week by two closely approximated centres, which speedily coalesce to form one central ossific point. According to some authors, ossification commences in the laminæ only in the upper vertebræ—*i. e.*, in the cervical and upper dorsal. The first ossific points in the lower vertebræ are those which are to form the body, the osseous centres for the laminæ appearing at a subsequent period. At birth these three pieces are perfectly separate. During the first year the laminæ become united behind, the union taking place first in the lumbar region and then extending upward through the dorsal and lower cervical regions. About the third year the body is joined to the arch on each side in such a manner that the body is formed from the three original centres of ossification, the amount contributed by the pedicles increasing in extent from below upward. Thus the bodies of the sacral vertebræ are formed almost entirely from the central nuclei; the bodies of the lumbar are formed laterally and behind by the pedicles; in the dorsal region the pedicles advance as far forward as the articular depressions for the head of the ribs, forming these cavities of reception; and in the neck the

[1] By many observers it is asserted that the bodies of the vertebra are developed from a single centre which speedily becomes bilobed, so as to give the appearance of two nuclei; but that there are two centres, at all events sometimes, is evidenced by the fact that the two halves of the body of the vertebra may remain distinct throughout life and be separated by a fissure through which a protrusion of the spinal membrane may take place, constituting an anterior spina bifida.

lateral portions of the bodies are formed entirely by the advance of the pedicles. The line along which union takes place between the body and the neural arch is named the *neuro-central suture*. Before puberty no other changes occur, excepting a gradual increase in the growth of these primary centres; the upper and under surfaces of the bodies and the ends of the transverse and spinous processes being tipped with cartilage, in which ossific granules are not as yet deposited. At sixteen years (Fig. 11) three secondary centres appear, one for the tip of each transverse process, and one for the extremity of the spinous process. In some of the lumbar vertebræ, especially the first, second, and third, a second ossifying centre appears at the base of the spinous process. At twenty-one years (Fig. 10) a thin circular epiphysial plate of bone is formed in the layer of cartilage situated on the upper and under surfaces of the body, the former being the thicker of the two. All these become joined, and the bone is completely formed between the twenty-fifth and thirtieth year of life.

Fig. 12.—Atlas.

Fig. 13.—Axis.

Fig. 14.—Lumbar vertebra.

Exceptions to this mode of development occur in the first, second, and seventh cervical, and in the vertebræ of the lumbar region.

The **Atlas** (Fig. 12).—The number of centres of ossification of the atlas is very variable. It may be developed from two, three, four, or five centres. The most frequent arrangement is by three centres. Two of these are destined for the two lateral or neural masses, the ossification of which commences about the seventh week near the articular processes, and extend backward; these portions of bone are separated from one another behind, at birth, by a narrow interval filled in with cartilage. Between the third and fourth years they unite either directly or through the medium of a separate centre developed in the cartilage in the middle line. The anterior arch, at birth, is altogether cartilaginous, and in this a separate nucleus appears about the end of the first year after birth, and, extending laterally, joins the neural processes in front of the pedicles. Sometimes there are two nuclei developed in the cartilage, one on either side of the median line, which join to form a single mass. And occasionally there is no separate centre, but the anterior arch is formed by the gradual extension forward and ultimate junction of the two neural processes.

The **Axis** (Fig. 13) is developed by *seven* centres. The body and arch of this bone are formed in the same manner as the corresponding parts in the other vertebræ: one centre (or two, which speedily coalesce) for the lower part of the body, and one for each lamina. The centres for the laminæ appear about the seventh or eighth week, that for the body about the fourth month. The odontoid process consists originally of an extension upward of the cartilaginous mass in which the lower part of the body is formed. At about the sixth month of fœtal life two osseous nuclei make their appearance in the base of this process: they are placed laterally, and join before birth to form a conical bilobed mass deeply cleft above; the interval between the cleft and the summit of the process is formed by a wedge-shaped piece of cartilage, the base of the process being separated from the body by a cartilaginous interval, which gradually becomes ossified at its circumference, but remains cartilaginous in its centre until advanced age.[1] Finally, as Humphry has demonstrated, the apex of the odontoid process has a separate nucleus, which appears in the second year and joins about the twelfth year. In addition to these there is a secondary centre for a thin epiphysial plate on the under surface of the body of the bone.

The **Seventh Cervical.**—The anterior or costal part of the transverse process of the seventh cervical is developed from a separate osseous centre at about the sixth month of fœtal life, and joins the body and posterior division of the transverse process between the fifth and sixth years. Sometimes this process continues as a separate piece, and, becoming lengthened outward, constitutes what is known as a cervical rib. This separate ossific centre for the costal process has also been found in the fourth, fifth, and sixth cervical vertebræ.

The **Lumbar Vertebræ** (Fig. 14) have *two additional centres* (besides those peculiar to the vertebræ generally) for the mammillary tubercles, which project from the back part of the superior articular processes. The transverse process of the first lumbar is sometimes developed as a separate piece, which may remain permanently unconnected with the remaining portion of the bone, thus forming a lumbar rib—a peculiarity that is rarely met with.

**Progress of Ossification in the Spine generally.**—Ossification of the laminæ of the vertebræ commences in the cervical region of the spine, and proceeds gradually downward. Ossification of the bodies, on the other hand, commences a little below the centre of the spinal column (about the ninth or tenth dorsal vertebra), and extends both upward and downward. Although, however, the ossific nuclei make their first appearance in the lower dorsal vertebræ, the lumbar and first sacral are those in which these nuclei are largest at birth.

**Attachment of Muscles.**—To the *Atlas* are attached nine pairs: the Longus colli, Rectus capitis anticus minor, Rectus lateralis, Obliquus capitis superior and inferior, Splenius colli, Levator anguli scapulæ, First Intertransverse, and Rectus capitis posticus minor.

To the *Axis* are attached eleven pairs: the Longus colli, Levator anguli scapulæ, Splenius colli, Scalenus medius, Transversalis colli, Intertransversales, Obliquus capitis inferior, Rectus capitis posticus major, Semispinalis colli, Multifidus spinæ, Interspinales.

To the remaining vertebræ, generally, are attached thirty-five pairs and a single muscle: *anteriorly*, the Rectus capitis anticus major, Longus colli, Scalenus anticus medius and posticus, Psoas magnus and parvus, Quadratus lumborum, Diaphragm, Obliquus abdominis internus, and Transversalis abdominis—*posteriorly*, the Trapezius, Latissimus dorsi, Levator anguli scapulæ, Rhomboideus major and minor, Serratus posticus superior and inferior, Splenius, Erector spinæ, Ilio-costalis, Longissimus dorsi, Spinalis dorsi, Cervicalis ascendens, Transversalis colli, Trachelo-mastoid, Complexus, Biventer cervicis, Semispinalis dorsi and colli, Multifidus spinæ, Rotatores spinæ, Interspinales, Supraspinales, Intertransversales, Levatores costarum.

## Sacral and Coccygeal Vertebræ.

The **Sacral** and **Coccygeal Vertebræ** consist, at an early period of life, of nine separate pieces, which are united in the adult so as to form two bones, five entering into the formation of the sacrum, four into that of the coccyx. Occasionally, the coccyx consists of five bones.[2]

The **Sacrum** (sacer, sacred) is a large, triangular bone (Fig. 15), situated at the lower part of the vertebral column, and at the upper and back part of the pelvic cavity, where it is inserted like a wedge between the two innominate bones; its upper part or base articulating with the last lumbar vertebræ, its apex with the coccyx. The sacrum is curved upon itself, and placed very obliquely, its upper

[1] See Cunningham, *Journ. Anat.*, vol. xx. p. 238.

[2] Sir George Humphry describes this as the usual composition of the coccyx.—*On the Skeleton*, p. 456.

extremity projecting forward, and forming, with the last lumbar vertebra, a very prominent angle, called the *promontory* or *sacro-vertebral angle;* whilst its central part is directed backward, so as to give increased capacity to the pelvic cavity. It presents for examination an anterior and posterior surface, two lateral surfaces, a base, an apex, and a central canal.

The **Anterior Surface** is concave from above downward, and slightly so from side to side. In the middle are seen four transverse ridges, indicating the original division of the bone into five separate pieces. The portions of bone intervening between the ridges correspond to the bodies of the vertebræ. The body of the first segment is of large size, and in form resembles that of a lumbar vertebra; the succeeding ones diminish in size from above downward, are flattened from before backward, and curved so as to accommodate themselves to the form of the sacrum, being concave in front, convex behind. At each end of the ridges above mentioned are seen the *anterior sacral foramina*, analogous to the intervertebral foramina,

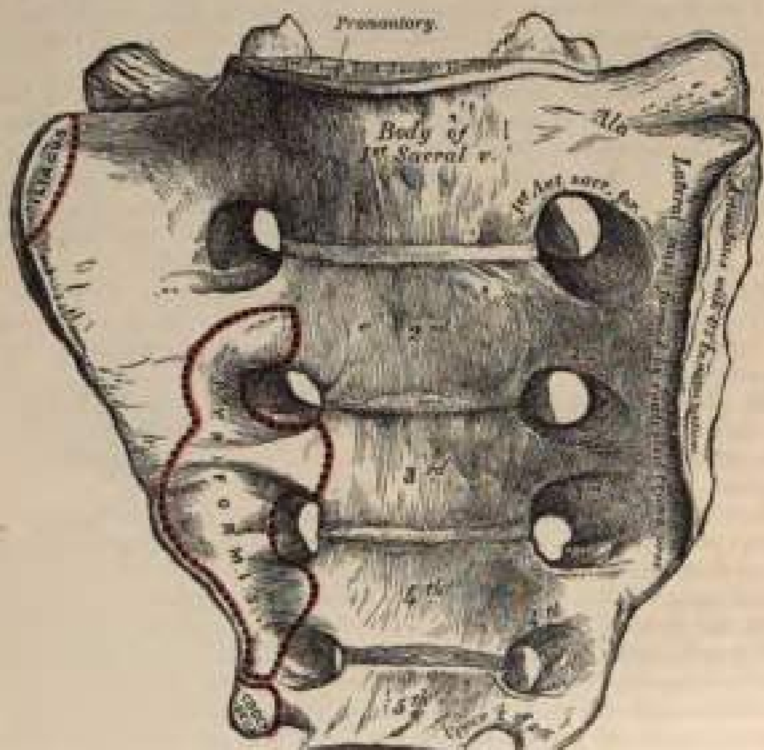



FIG. 15.—Sacrum, anterior surface.

four in number on each side, somewhat rounded in form, diminishing in size from above downward, and directed outward and forward; they transmit the anterior branches of the sacral nerves and the lateral sacral arteries. External to these foramina is the *lateral mass*, consisting at an early period of life of separate segments; these become blended, in the adult, with the bodies, with each other, and with the posterior transverse processes. Each lateral mass is traversed by four broad, shallow grooves, which lodge the anterior sacral nerves as they pass outward, the grooves being separated by prominent ridges of bone, which give attachment to the slips of the Pyriformis muscle.

If a vertical section is made through the centre of the sacrum (Fig. 16), the bodies are seen to be united at their circumference by bone, a wide interval being left centrally, which, in the recent state, is filled by intervertebral substance. In some bones this union is more complete between the lower segments than between the upper ones.

The **Posterior Surface** (Fig. 17) is convex and much narrower than the anterior. In the middle line are three or four tubercles, which represent the rudimentary spinous processes of the sacral vertebræ. Of these tubercles, the first is usually prominent, and perfectly distinct from the rest; the second and third are either separate or united into a tubercular ridge, which diminishes in size from above downward; the fourth usually, and the fifth always, remaining undeveloped. External to the spinous processes on each side are the *laminæ*, broad and well marked in the first three pieces; sometimes the fourth, and generally the fifth, are only partially developed and fail to meet in the middle line. These partially developed laminæ are prolonged downward as rounded processes, the *sacral cornua*, and are connected to the cornua of the coccyx. Between them the bony wall of the lower end of the sacral canal is imperfect, and is liable to be opened in the sloughing of bed-sores. External to the laminæ is a linear series of indistinct tubercles representing the *articular processes;* the upper pair are large, well developed, and correspond in shape and direction to the superior articulating processes of a lumbar vertebra; the second and third are small; the fourth and fifth (usually blended together) are situated on each side of the sacral canal and assist in forming the sacral cornua. External to the articular processes are the four *posterior sacral foramina;* they are smaller in size and less regular in form than the anterior, and transmit the posterior branches of the sacral nerves. On the outer side of the posterior sacral foramina is a series of tubercles, the rudimentary *transverse processes* of the sacral vertebræ. The first pair of transverse tubercles are large, very distinct, and correspond with each *superior angle* of the bone; they together with the second pair, which are of small size, give attachment to the horizontal part of the sacro-iliac ligament; the third give attachment to the oblique fasciculi of the posterior sacro-iliac ligaments; and the fourth and fifth to the great sacro-sciatic ligaments. The interspace between the spinous and transverse processes on the back of the sacrum presents a wide, shallow concavity, called the *sacral groove;* it is continuous above with the vertebral groove, and lodges the origin of the Multifidus spinæ.

FIG. 18.—Vertical section of the sacrum.

The **Lateral Surface**, broad above, becomes narrowed into a thin edge below. Its upper half presents in front a broad, ear-shaped surface for articulation with the ilium. This is called the *auricular* surface, and in the fresh state is coated with fibro-cartilage. It is bounded posteriorly by deep and uneven impressions, for the attachment of the posterior sacro-iliac ligaments. The lower half is thin and sharp, and terminates in a projection called the *inferior lateral angle;* below this angle is a notch, which is converted into a foramen by articulation with the transverse process of the upper piece of the coccyx, and transmits the anterior division of the fifth sacral nerve. This lower, sharp border gives attachment to the greater and lesser sacro-sciatic ligaments, and to some fibres of the Gluteus maximus posteriorly, and to the Coccygeus in front.

The **Base** of the sacrum, which is broad and expanded, is directed upward and forward. In the middle is seen a large oval articular surface, which is connected with the under surface of the body of the last lumbar vertebra by a fibro-cartilaginous disk. It is bounded behind by the large, triangular orifice of the sacral canal. The orifice is formed behind by the laminæ and spinous process of the first sacral vertebra: the superior articular processes project from it on each side; they are oval, concave, directed backward and inward, like the superior articular processes of a lumbar vertebra; and in front of each articular process is an intervertebral notch, which forms the lower part of the foramen between the last lumbar and first sacral vertebra. Lastly, on each side of the large oval articular

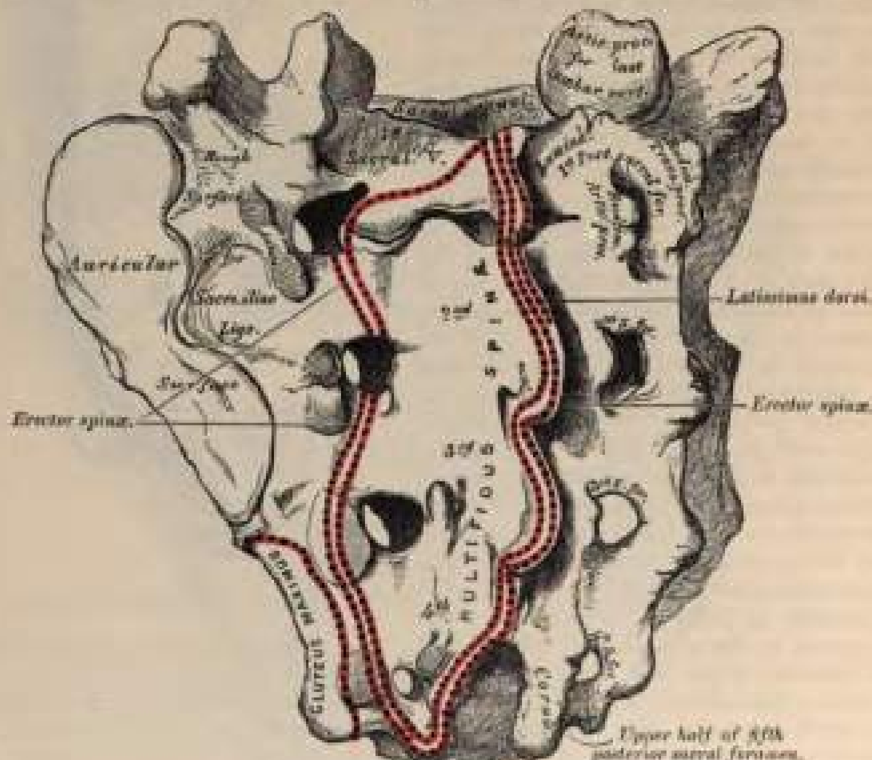



Fig. 17.—Sacrum, posterior surface.

plate is a broad and flat triangular surface of bone, which extends outward, supports the Psoas magnus muscle and lumbo-sacral cord, and is continuous on each side with the iliac fossa. This is called the *ala* of the sacrum, and gives attachment to a few of the fibres of the Iliacus muscle. The posterior part of the ala represents the transverse process of the first sacral segment.

The **Apex,** directed downward and slightly forward, presents a small, oval, concave surface for articulation with the coccyx.

The **Spinal Canal** runs throughout the greater part of the bone; it is large and triangular in form above, small and flattened, from before backward, below. In this situation its posterior wall is incomplete, from the non-development of the laminæ and spinous processes. It lodges the sacral nerves, and is perforated by the anterior and posterior sacral foramina, through which these pass out.

**Structure.**—It consists of much loose, spongy tissue within, invested externally by a thin layer of compact tissue.

**Differences in the Sacrum of the Male and Female.**—The sacrum in the female is shorter and wider than in the male; the lower half forms a greater angle with the upper, the upper half of the bone being nearly straight, the lower half presenting the greatest amount of curvature. The bone is also directed more obliquely backward, which increases the size of the pelvic cavity; but the sacro-vertebral angle projects less. In the male the curvature is more evenly distributed over the whole length of the bone, and is altogether greater than in the female.

**Peculiarities of the Sacrum.**—This bone, in some cases, consists of six pieces; occasionally, the number is reduced to four. Sometimes the bodies of the first and second segments are not joined or the laminæ and spinous processes have not coalesced. Occasionally the upper pair of transverse tubercles are not joined to the rest of the bone on one or both sides; and, lastly, the sacral canal may be open for nearly the lower half of the bone, in consequence of the imperfect development of the laminæ and spinous processes. The sacrum, also, varies considerably with respect to its degree of curvature. From the examination of a large number of skeletons it would appear that in one set of cases the anterior surface of this bone was nearly straight, the curvature, which was very slight, affecting only its lower end. In another set of cases the bone was curved throughout its whole length, but especially toward its middle. In a third set the degree of curvature was less marked, and affected especially the lower third of the bone.

**Development** (Fig. 18).—The sacrum, formed by the union of five vertebræ, has *thirty-five* centres of ossification.

The *bodies* of the sacral vertebræ have each three ossific centres: one for the central part, and one for the epiphysial plates on its upper and under surface. Occasionally the primary centres for the bodies of the first and second piece of the sacrum are double.

The arch of each sacral vertebra is developed by two centres, one for each lamina. These unite with each other behind, and subsequently join the body.

The *lateral masses* have six additional centres, two for each of the first three vertebræ. These centres make their appearance above and to the outer side of the anterior sacral foramina (Fig. 18), and are developed into separate segments


Fig. 18.—Development of the sacrum.


Fig. 19.

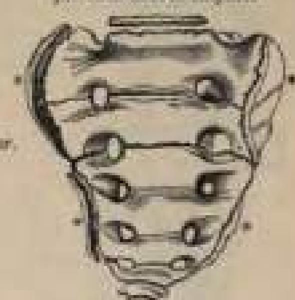



Fig. 20.

(Fig. 19); they are subsequently blended with each other, and with the bodies and transverse processes to form the lateral mass.

Lastly, each *lateral surface* of the sacrum is developed by two epiphysial plates (Fig. 20): one for the auricular surface, and one for the remaining part of the thin lateral edge of the bone.

*Period of Development.*—At about the eighth or ninth week of fœtal life ossification of the central part of the bodies of the first three vertebræ commences, and at a somewhat later period that of the last two. Between the sixth and eighth months ossification of the laminæ takes place; and at about the same period the centres for the lateral masses for the first three sacral vertebræ make their appearance. The period at which the arch becomes completed by the junction of the laminæ with the bodies in front and with each other behind varies in different segments. The junction between the laminæ and the bodies takes place first in the lower vertebræ as early as the second year, but is not effected in the uppermost until the fifth or sixth year. About the sixteenth year the epiphyses for the upper and under surfaces of the bodies are formed, and between the eighteenth and twentieth years those for each lateral surface of the sacrum make their appearance. The bodies of the sacral vertebræ are, during early life, separated from each other by intervertebral disks. But about the eighteenth year the two lowest segments become joined together by ossification extending through the disk. This process gradually extends upward until all the segments become united, and the bone is completely formed from the twenty-fifth to the thirtieth year of life.

**Articulations.**—With four bones: the last lumbar vertebra, coccyx, and the two innominate bones.

**Attachment of Muscles.**—To eight pairs: in front, the Pyriformis and Coccygeus, and a portion of the Iliacus to the base of the bone; behind, the Gluteus maximus, Latissimus dorsi, Multifidus spinæ, and Erector spinæ, and sometimes the Extensor coccygis.

## The Coccyx.

The **Coccyx** (*κόκκυξ*, cuckoo), so called from having been compared to a cuckoo's beak (Fig. 21), is usually formed of four small segments of bone, the most rudimentary parts of the vertebral column. In each of the first three segments may be traced a rudimentary body, articular and transverse processes; the last piece (sometimes the third) is a mere nodule of bone, without distinct processes. All the segments are destitute of pedicles, laminæ, and spinous processes, and, consequently, of intervertebral foramina and spinal canal. The first segment is the largest; it resembles the lowermost sacral vertebra, and often exists as a separate piece; the last three, diminishing in size from above downward, are usually blended together so as to form a single bone. The gradual diminution in the size of the pieces gives this bone a triangular form, the base of the triangle joining the end of the sacrum. It presents for examination an anterior and posterior surface, two borders, a base, and an apex. The *anterior surface* is slightly concave, and marked with three transverse grooves, indicating the points of junction of the different pieces. It has attached to it the anterior sacro-coccygeal ligament and Levator ani muscle, and supports the lower end of the rectum. The *posterior surface* is convex, marked by transverse grooves similar to those on the anterior surface; and presents on each side a lineal row of tubercles, the rudimentary articular processes of the coccygeal vertebræ. Of these, the superior pair are large, and are called the *cornua of the coccyx*; they project upward, and articulate with the cornua of the sacrum, the junction between these two

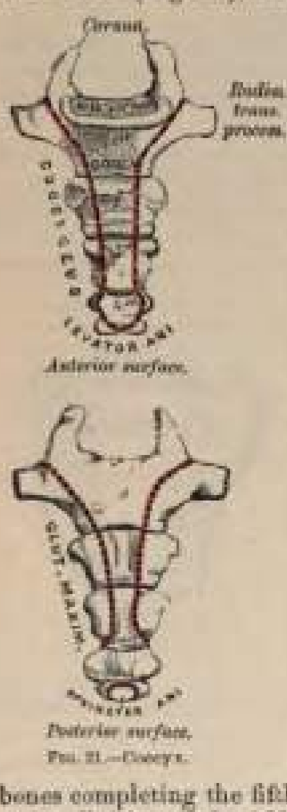


Fig. 21.—Coccyx.

bones completing the fifth posterior sacral foramen for the transmission of the posterior division of the fifth sacral nerve. The *lateral borders* are thin, and present a series of small eminences, which represent the transverse processes of the coccygeal vertebræ. Of these, the first on each side is the largest, flattened from before backward, and often ascends to join the lower part of the thin lateral edge of the sacrum, thus completing the fifth anterior sacral foramen for the transmission of the anterior division of the fifth sacral nerve; the others diminish in size from above downward, and are often wanting. The *borders* of the coccyx are narrow, and give attachment on each side to the sacro-sciatic ligaments, to the Coccygeus muscles in front of the ligaments, and to the Gluteus maximus behind them. The *base* presents an oval surface for articulation with the sacrum. The *apex* is rounded, and has attached to it the tendon of the external Sphincter muscle. It is occasionally bifid, and sometimes deflected to one or other side.

**Development.**—The coccyx is developed by *four* centres, one for each piece. Occasionally one of the first three pieces of this bone is developed by two centres, placed side by side. The ossific nuclei make their appearance in the following order: in the first segment, shortly after birth; in the second piece, at from five to ten years; in the third, from ten to fifteen years; in the fourth, from fifteen to twenty years. As age advances these various segments become united with each other from below upward, the union between the first and second segments being frequently delayed until after the age of twenty-five or thirty. At a late period of life, especially in females, the coccyx often becomes joined to the end of the sacrum.

**Articulation.**—With the sacrum.

**Attachment of Muscles.**—To four pairs and one single muscle: on either side, the Coccygeus; behind, the Gluteus maximus and Extensor coccygis, when present; at the apex, the Sphincter ani; and in front, the Levator ani.

## The Spine in General.

The **Spinal Column,** formed by the junction of the vertebræ, is situated in the median line, at the posterior part of the trunk; its average length is about two feet two or three inches, measuring along the curved anterior surface of the column. Of this length the cervical part measures about five, the dorsal about eleven, the lumbar about seven inches, and the sacrum and coccyx the remainder. The female spine is about one inch less than that of the male.

Viewed in front, it presents two pyramids joined together at their bases, the upper one being formed by all the vertebræ from the second cervical to the last lumbar, the lower one by the sacrum and coccyx. When examined more closely, the upper pyramid is seen to be formed of three smaller pyramids. The uppermost of these consists of the six

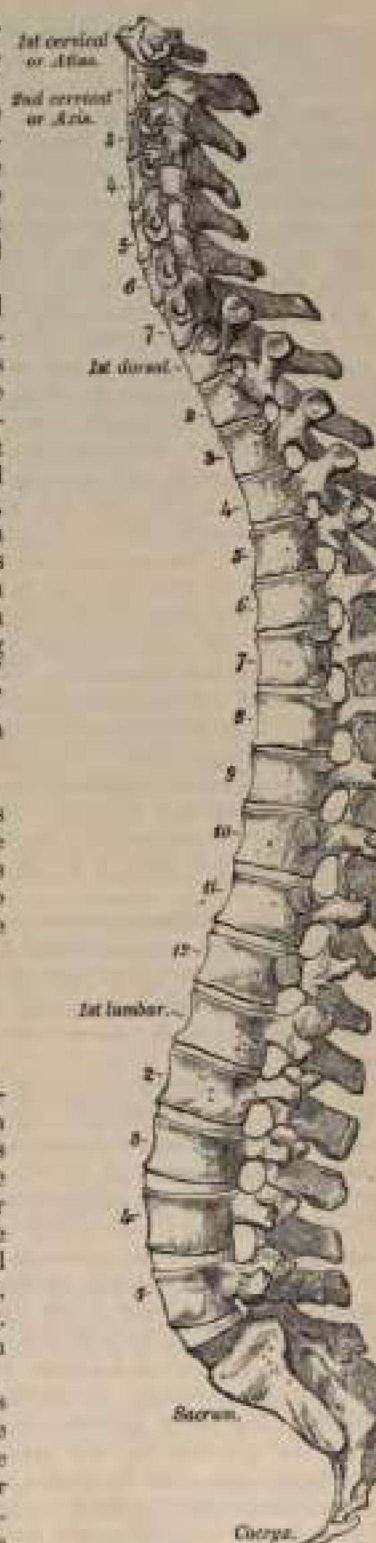



Fig. [illegible].—Lateral view of the spine.

lower cervical vertebræ, its apex being formed by the axis or second cervical, its base by the first dorsal. The second pyramid, which is inverted, is formed by the four upper dorsal vertebræ, the base being at the first dorsal, the smaller end at the fourth. The third pyramid commences at the fourth dorsal, and gradually increases in size to the fifth lumbar.

Viewed laterally (Fig. 22), the spinal column presents several curves, which correspond to the different regions of the column, and are called *cervical*, *dorsal*, *lumbar*, and *pelvic*. The *cervical* curve commences at the apex of the odontoid process, and terminates at the middle of the second dorsal vertebra; it is convex in front, and is the least marked of all the curves. The *dorsal* curve, which is concave forward, commences at the middle of the second, and terminates at the middle of the twelfth dorsal. Its most prominent point behind corresponds to the spine of the seventh dorsal vertebra. The *lumbar* curve commences at the middle of the last dorsal vertebra, and terminates at the sacrö-vertebral angle. It is convex anteriorly; the convexity of the lower three vertebræ being much greater than that of the upper two. The *pelvic* curve commences at the sacro-vertebral articulation and terminates at the point of the coccyx. It is concave anteriorly. The dorsal and pelvic curves are the primary curves, and begin to be formed at an early period of fœtal life, and are due to the shape of the bodies of the vertebræ. The cervical and lumbar curves are compensatory or secondary, and are developed after birth in order to maintain the erect position. They are due mainly to the shape of the intervertebral disks.

The spine has also a slight lateral curvature, the convexity of which is directed toward the right side. This is most probably produced, as Bichat first explained, chiefly by muscular action, most persons using the right arm in preference to the left, especially in making long-continued efforts, when the body is curved to the right side. In support of this explanation it has been found by Béclard that in one or two individuals who were left-handed the lateral curvature was directed to the left side.

The movable part of the spinal column presents for examination an anterior, a posterior, and two lateral surfaces; a base, a summit, and spinal canal.

The **anterior surface** presents the bodies of the vertebræ separated in the recent state by the intervertebral disks. The bodies are broad in the cervical region, narrow in the upper part of the dorsal, and broadest in the lumbar region. The whole of this surface is convex transversely, concave from above downward in the dorsal region, and convex in the same direction in the cervical and lumbar regions.

The **posterior surface** presents in the median line the spinous processes. These are short, horizontal, with bifid extremities, in the cervical region. In the dorsal region they are directed obliquely above, assume almost a vertical direction in the middle, and are horizontal below, as are also the spines of the lumbar vertebræ. They are separated by considerable intervals in the loins, by narrower intervals in the neck, and are closely approximated in the middle of the dorsal region. Occasionally one of these processes deviates a little from the median line—a fact to be remembered in practice, as irregularities of this sort are attendant also on fractures or displacements of the spine. On either side of the spinous processes, extending the whole length of the column, is the vertebral groove formed by the laminæ in the cervical and lumbar regions, where it is shallow, and by the laminæ and transverse processes in the dorsal region, where it is deep and broad. In the recent state these grooves lodge the deep muscles of the back. External to the vertebral grooves are the articular processes, and still more externally the transverse process. In the dorsal region the latter processes stand backward, on a plane considerably posterior to the same processes in the cervical and lumbar regions. In the cervical region the transverse processes are placed in front of the articular processes, and on the outer side of the pedicles, between the intervertebral foramina. In the dorsal region they are posterior to the pedicles, intervertebral foramina, and articular processes. In the lumbar they are placed also in front of the articular processes, but behind the intervertebral foramina.

The **lateral surfaces** are separated from the posterior by the articular processes in the cervical and lumbar regions, and by the transverse processes in the dorsal. These surfaces present in front the sides of the bodies of the vertebræ, marked in the dorsal region by the facets for articulation with the heads of the ribs. More posteriorly are the intervertebral foramina, formed by the juxtaposition of the intervertebral notches, oval in shape, smallest in the cervical and upper part of the dorsal regions, and gradually increasing in size to the last lumbar. They are situated between the transverse processes in the neck, and in front of them in the back and loins, and transmit the spinal nerves.

The **base** of that portion of the vertebral column formed by the twenty-four movable vertebræ is formed by the under surface of the body of the fifth lumbar vertebra; and the **summit** by the upper surface of the atlas.

The **vertebral** or **spinal canal** follows the different curves of the spine; it is largest in those regions in which the spine enjoys the greatest freedom of movement, as in the neck and loins, where it is wide and triangular; and narrow and rounded in the back, where motion is more limited.

*Surface Form.*—The only part of the vertebral column which lies closely under the skin, and so directly influences surface form, is the apices of the spinous processes. These are always distinguishable at the bottom of a median furrow, which, more or less evident, runs down the mesial line of the back from the external occipital protuberance above to the middle of the sacrum below. In the neck the furrow is broad, and terminates in a conspicuous projection, which is caused by the spinous process of the seventh cervical vertebra (vertebra prominens). Above this the spinous process of the sixth cervical vertebra may sometimes be seen to form a projection; the other cervical spines are sunken, and are not visible, though the spine of the axis can be felt, and generally also the spines of the third, fourth, and fifth cervical vertebræ. In the dorsal region the furrow is shallow, and during stooping disappears, and then the spinous processes become more or less visible. The markings produced by these spines are small and close together. In the lumbar region the furrow is deep, and the situation of the lumbar spines is frequently indicated by little pits or depressions, especially if the muscles in the loins are well developed and the spine incurved. They are much larger and farther apart than in the dorsal region. In the sacral region the furrow is shallower, presenting a flattened area which terminates below at the most prominent part of the posterior surface of the sacrum, formed by the spinous process of the third sacral vertebra. At the bottom of the furrow may be felt the irregular posterior surface of the bone. Below this, in the deep groove leading to the anus, the coccyx may be felt. The only other portions of the vertebral column which can be felt from the surface are the transverse processes of three of the cervical vertebræ—viz. the first, the sixth, and the seventh. The transverse process of the atlas can be felt as a rounded nodule of bone just below and in front of the apex of the mastoid process, along the anterior border of the sterno-mastoid. The transverse process of the sixth cervical vertebra is of surgical importance. If deep pressure be made in the neck in the course of the carotid artery, opposite the cricoid cartilage, the prominent anterior tubercle of the transverse process of the sixth cervical vertebra can be felt. This has been named *Chassaignac's tubercle*, and against it the carotid artery may be most conveniently compressed by the finger. The transverse process of the seventh cervical vertebra can also often be felt. Occasionally the anterior root, or costal process, is large and segmented off, forming a cervical rib.

*Surgical Anatomy.*—Occasionally the coalescence of the laminæ is not completed, and consequently a cleft is left in the arches of the vertebræ, through which a protrusion of the spinal membranes (dura mater and arachnoid), and sometimes of the spinal cord itself, takes place, constituting a malformation known as *spina bifida*. This disease is most common in the lumbo-sacral region; but it may occur in the dorsal or cervical region, or the arches throughout the whole length of the canal may remain unapproximated. In some rare cases, in consequence of the non-coalescence of the two primary centres from which the body is formed, a similar condition may occur in front of the canal, the bodies of the vertebræ being found cleft and the tumor projecting into the thorax, abdomen, or pelvis, between the lateral halves of the bodies affected.

The construction of the spinal column of a number of pieces, securely connected together and enjoying only a slight degree of movement between any two individual pieces, though permitting of a very considerable range of movement as a whole, allows a sufficient degree of mobility without any material diminution of strength. The many joints of which the spine is composed, together with the very varied movements to which it is subjected, render it liable to sprains; but so closely are the individual vertebræ articulated that these sprains are rarely or ever severe, and any amount of violence sufficiently great to produce tearing of the ligaments would tend rather to cause a dislocation or fracture. The further safety of the column and its less liability to injury is provided for by its disposition in curves, instead of in one straight line. For it is an elastic column, and must first bend before it breaks: under these circumstances, being made up of three curves, it represents three columns, and greater force is required to produce bending of a short column than of a longer one that is equal to it in breadth and material. Again, the safety of the column is provided for by the interposition of the intervertebral disk between the bodies of the vertebræ, which act as admirable buffers in counteracting the effects of violent jars or shocks. Fracture-dislocation of the spine may be caused by direct or indirect violence, or by a combination of the two, as when a person, falling from a height, strikes against some prominence and is doubled over it. The fractures from indirect violence are the more common, and here the bodies of the vertebræ are compressed, whilst the arches are torn asunder; whilst in fractures from direct violence the arches are compressed and the bodies of the vertebræ separated from each other. It will therefore be seen that in both classes of injury the spinal marrow is the part least likely to be injured, and may escape damage even where there has been considerable lesion of the bony framework. For, as Mr. Jacobson states, "being lodged in the centre of the column, it occupies neutral ground in respect to forces which might cause fracture. For it is a law in mechanics that when a beam, as of timber, is exposed to breakage and the force does not exceed the limits of the strength of the material, one division resists compression, another laceration of the particles, while the third, between the two, is in a negative condition."[1] Applying this principle to the spine, it will be seen that, whether the fracture-dislocation be produced by direct violence or indirect, one segment, either the anterior or posterior, will be exposed to compression, the other to laceration, and the intermediate part, where the cord is situated, will be in a neutral state. When a fracture-dislocation is produced by indirect violence the displacement is almost always the same, the upper segment being driven forward on the lower, so that the cord is compressed between the body of the vertebra below and the arch of the vertebra above.

The parts of the spine most liable to be injured are (1) the dorsi-lumbar region, for this part is near the middle of the column, and there is therefore a greater amount of leverage, and moreover the portion above is comparatively fixed, and the vertebræ which form it, though much smaller, have nevertheless to bear almost as great a weight as those below; (2) the cervico-dorsal region, because here the flexible cervical portion of the spine joins the more fixed dorsal region; and (3) the atlanto-axial region, because it enjoys an extensive range of movement, and, being near the skull, is influenced by violence applied to the head. In fracture-dislocation it has been proposed to trephine the spine and remove portions of the laminæ and spinous processes. The operation can only be of use when the paralysis is due to the pressure of bone or the effusion of blood, and not to cases, which are by far the most common, where the cord is crushed to a pulp. And even in those cases where the cord is compressed by bone the portion of displaced bone which presses on the cord is generally the body of the vertebra below, and is therefore inaccessible to operation. The operative proceeding is one of great severity, involving an extensive and deep wound and great risk of septic meningitis, and, as the advantages to be derived from it are exceedingly problematical and confined to a very few cases, it is not often resorted to. Trephining has also been resorted to in some cases of paraplegia due to Pott's disease of the spine. Here the paralysis is due to the pressure of inflammatory products, and where this is new scar-tissue, formed by the organization of granulation tissue, its removal has been attended with a very considerable amount of success.

## THE SKULL.

The **Skull** is supported on the summit of the vertebral column, and is of an oval shape, wider behind than in front. It is composed of a series of flattened or irregularly shaped bones which, with one exception (the lower jaw), are immovably joined together. It is divided into two parts, the Cranium and the Face, the former of which constitutes a case for the accommodation and protection of the brain, while opening on the face are the orifices of the nose and mouth; between the cranium above and the face below the orbital cavities are situated. The Cranium (κράνος, a helmet) is composed of *eight* bones—viz., the *occipital*, two *parietal*, *frontal*, two *temporal*, *sphenoid*, and *ethmoid*. The Face is composed of *fourteen* bones—viz., the two *nasal*, two *superior maxillary*, two *lachrymal*, two *malar*, two *palate*, two *inferior turbinated*, *vomer*, and *inferior maxillary*. The *ossiculi auditûs*, the *teeth*, and *Wormian bones* are not included in this enumeration.

[1] Holmes's *System of Surgery*, vol. i., p. 529, 1883.

| | | |
|---|---|---|
| *Skull, 22 bones* | *Cranium, 8 bones* . . | Occipital. |
| | | Two Parietal. |
| | | Frontal. |
| | | Two Temporal. |
| | | Sphenoid. |
| | | Ethmoid. |
| | *Face, 14 bones* . . | Two Nasal. |
| | | Two Superior Maxillary. |
| | | Two Lachrymal. |
| | | Two Malar. |
| | | Two Palate. |
| | | Two Inferior Turbinated. |
| | | Vomer. |
| | | Inferior Maxillary. |

The Hyoid Bone, situated at the root of the tongue and attached to the base of the skull by ligaments, has also to be considered in this section.

## THE CRANIUM.

### The Occipital Bone.

The **Occipital Bone** (*ob*, *caput*, against the head) is situated at the back part

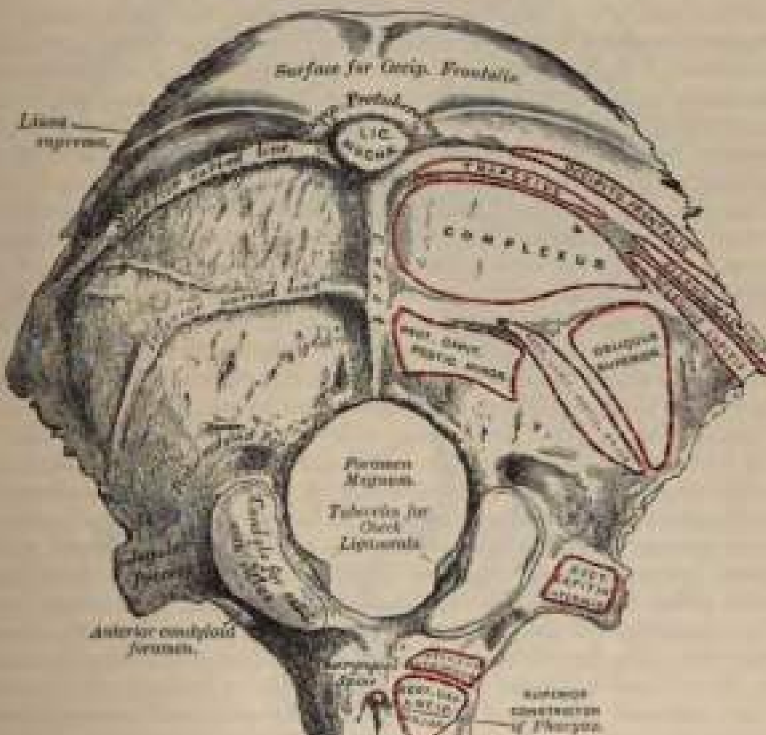



Fig. 23.—Occipital bone. Outer surface.

and base of the cranium, is trapezoid in shape and is much curved on itself (Fig. 23). It presents at its front and lower part a large oval aperture, the *foramen magnum*, by which the cranial cavity communicates with the spinal canal. The portion of bone behind this opening is flat and expanded and forms the *tabula;* the portion in front is a thick, elongated mass of bone, the *basilar process;* while on either side of the foramen are situated processes bearing the condyles, by which the bone articulates with the atlas. These processes are known as the *condylar portions*. It presents for examination two surfaces, four borders, and four angles.

The **external surface** is convex. Midway between the summit of the bone and the posterior margin of the foramen magnum is a prominent tubercle, the *external occipital protuberance*, and, descending from it as far as the foramen, a vertical ridge, the *external occipital crest*. This protuberance and crest give attachment to the Ligamentum nuchæ, and vary in prominence in different skulls. Passing outward from the occipital protuberance is a semicircular ridge on each side, the *superior curved line*. Above this line there is often a second less distinctly marked ridge, called the *highest curved line* (*linea suprema*); to it the epicranial aponeurosis is attached. The bone between these two lines is smoother and denser than the rest of the surface. Running parallel with these from the middle of the crest is another semicircular ridge on each side, the *inferior curved lines*. The surface of the bone above the linea suprema is rough and porous, and in the recent state is covered by the Occipito-frontalis muscle, while the superior and inferior curved lines, together with the surfaces of bone between and below them, serve for the attachment of several muscles. The superior curved line gives attachment internally to the Trapezius, externally to the muscular origin of the Occipito-frontalis, and to the Sterno-cleido-mastoid to the extent shown in Fig. 23; the depressions between the curved lines to the Complexus internally, the Splenius capitis and Obliquus capitis superior externally. The inferior curved line and the depressions below it afford insertion to the Rectus capitis posticus, major and minor.

The **foramen magnum** is a large, oval aperture, its long diameter extending from before backward. It transmits the medulla oblongata and its membranes, the spinal accessory nerves, the vertebral arteries, the anterior and posterior spinal arteries, and the occipito-axial ligaments. Its back part is wide for the transmission of the medulla, and the corresponding margin rough for the attachment of the dura mater enclosing it; the fore part is narrower, being encroached upon by the condyles; it has projecting toward it, from below, the odontoid process, and its margins are smooth and bevelled internally to support the medulla oblongata. On each side of the foramen magnum are the *condyles*, for articulation with the atlas; they are convex, oval, or reniform in shape, and directed downward and outward; they converge in front, and encroach slightly upon the anterior segment of the foramen. On the inner border of each condyle is a rough tubercle for the attachment of the ligaments (*check*) which connect this bone with the odontoid process of the axis; whilst external to them is a rough tubercular prominence, the *transverse* or *jugular process*, channelled in front by a deep notch, which forms part of the jugular foramen or foramen lacerum posterius. The under surface of this process presents an eminence which represents the *paramastoid process* of some mammals. The eminence is occasionally large, and extends as low as the transverse process of the atlas. This surface affords attachment to the Rectus capitis lateralis muscle and to the lateral occipito-atlantal ligament; its upper or cerebral surface presents a deep groove which lodges part of the lateral sinus, whilst its external surface is marked by a quadrilateral rough facet, covered with cartilage in the fresh state, and articulating with a similar surface on the petrous portion of the temporal bone. On the outer side of each condyle, near its fore part, is a foramen, the *anterior condyloid*; it is directed downward, outward, and forward, and transmits the hypoglossal nerve, and occasionally a meningeal branch of the ascending pharyngeal artery. This foramen is sometimes double. Behind each condyle is a fossa,[1] sometimes perforated at the bottom by a foramen, the *posterior condyloid*, for the transmission of a vein to the lateral sinus. In front of the foramen magnum is a strong quadrilateral plate of bone, the *basilar process*, wider behind than in front; its under surface, which is rough, presenting in the median line a tubercular ridge,

[1] This fossa presents many variations in size. It is usually shallow, and the foramen small; occasionally wanting on one or both sides. Sometimes both fossa and foramen are large, but confined to one side only; more rarely, the fossa and foramen are very large on both sides.

the *pharyngeal spine*, for the attachment of the tendinous raphe and Superior constrictor of the pharynx; and on each side of it rough depressions for the attachment of the Rectus capitis anticus, major and minor.

The **Internal** or **Cerebral Surface** (Fig. 24) is deeply concave. The posterior part or tabular is divided by a crucial ridge into four fossæ. The two superior fossæ receive the occipital lobes of the cerebrum, and present slight eminences and depressions corresponding to their convolutions. The two inferior, which receive the hemispheres of the cerebellum, are larger than the former, and comparatively smooth; both are marked by slight grooves for the lodgment of arteries. At the point of meeting of the four divisions of the crucial ridge is an eminence, the *internal occipital protuberance*. It nearly corresponds to that on the outer surface, and is perforated by one or more large vascular foramina. From this eminence the superior division of the crucial ridge runs upward to the superior angle of the bone; it presents a deep groove for the superior longitudinal sinus, the margins of which give attachment to the falx cerebri. The inferior division, the *internal occipital crest*, runs to the posterior margin of the foramen magnum,

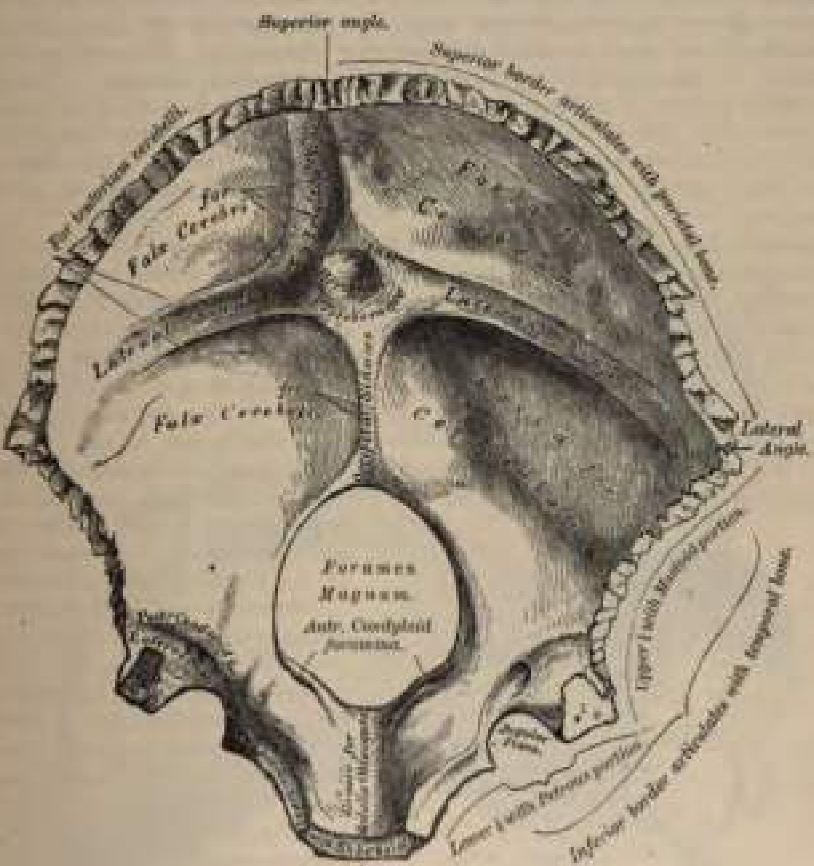



Fig. 24.—Occipital bone. Inner surface.

on the edge of which it becomes gradually lost; this ridge, which is bifurcated below, serves for the attachment of the falx cerebelli. It is usually marked by a single groove, which commences at the back part of the foramen magnum and lodges the occipital sinus. Occasionally the groove is double where two sinuses exist. The transverse grooves pass outward to the lateral angles; they are deeply channelled, for the lodgment of the lateral sinuses, their prominent margins affording attachment to the tentorium cerebelli.[1] At the point of meeting of these grooves is a depression, the *torcular Herophili*,[2] placed a little to one or the other side of the internal occipital protuberance. More anteriorly is the foramen magnum, and on each side of it, but nearer its anterior than its posterior part, the internal openings of the anterior condyloid foramen; the internal openings of the posterior condyloid foramina are a little external and posterior to them, protected by a small arch of bone. At this part of the internal surface there is a very deep groove in which the posterior condyloid foramen, when it exists, has its termination. This groove is continuous, in the complete skull, with the transverse groove on the posterior part of the bone, and lodges the end of the same sinus, the lateral. In front of the foramen magnum is the basilar process, presenting a shallow depression, the *basilar groove*, which slopes from behind, upward and forward, and supports the medulla oblongata and part of the pons Varolii, and on each side of the basilar process is a narrow channel, which, when united with a similar channel on the petrous portion of the temporal bone, forms a groove which lodges the inferior petrosal sinus.

**Angles.**—The *superior* angle is received into the interval between the posterior superior angles of the two parietal bones: it corresponds with that part of the skull in the fœtus which is called the *posterior fontanelle*. The *inferior* angle is represented by the square-shaped surface of the basilar process. At an early period of life a layer of cartilage separates this part of the bone from the sphenoid, but in the adult the union between them is osseous. The *lateral* angles correspond to the outer ends of the transverse grooves, and are received into the interval between the posterior inferior angles of the parietal and the mastoid portion of the temporal.

**Borders.**—The *superior* border extends on each side from the superior to the lateral angle, is deeply serrated for articulation with the parietal bone, and forms, by this union, the lambdoid suture. The *inferior* border extends from the lateral to the inferior angle; its upper half is rough, and articulates with the mastoid portion of the temporal, forming the masto-occipital suture; the inferior half articulates with the petrous portion of the temporal, forming the petro-occipital suture; these two portions are separated from one another by the jugular process. In front of this process is a deep notch, which, with a similar one on the petrous portion of the temporal, forms the *foramen lacerum posterius* or *jugular foramen*. This notch is occasionally subdivided into two parts by a small process of bone, and it generally presents an aperture at its upper part, the internal opening of the posterior condyloid foramen.

Fig. 25.—Development of occipital bone. By seven centres.

**Structure.**—The occipital bone consists of two compact laminæ, called the *outer* and *inner tables*, having between them the diploic tissue; this bone is especially thick at the ridges, protuberances, condyles, and anterior part of the basilar process; while at the bottom of the fossæ, especially the inferior, it is thin, semi-transparent, and destitute of diploë.

**Development** (Fig. 25).—At birth the bone consists of four distinct parts: a *tabular* or expanded portion, which lies behind the foramen magnum; two *condylar* parts, which form the sides of the foramen; and a *basilar* part, which lies in front of the foramen. The number of nuclei for the tabular part vary. As

[1] Usually one of the transverse grooves is deeper and broader than the other; occasionally, both grooves are of equal depth and breadth, or both equally indistinct. The broader of the two transverse grooves is nearly always continuous with the vertical groove for the superior longitudinal sinus.

[2] The columns of blood coming in different directions were supposed to be *pressed* together at this point (*torcular*, a wine-press).

a rule, there are four, but there may be only one (Blandin) or as many as eight (Meckel). They appear about the eighth week of fœtal life, and soon unite to form a single piece, which is, however, fissured in the direction indicated in the figure. The basilar and two condyloid portions are each developed from a single nucleus, which appears a little later. The upper portion of the tabular surface—that is to say, the portion above the transverse fissure—is developed from membrane, and may remain separated from the rest of the bone throughout life, when it constitutes the *interparietal bone;* the rest of the bone is developed from cartilage. At about the fourth year the tabular and the two condyloid pieces join, and about the sixth year the bone consists of a single piece. At a later period, between the eighteenth and twenty-fifth years, the occipital and sphenoid become united, forming a single bone.

**Articulations.**—With six bones: two parietal, two temporal, sphenoid, and atlas.

**Attachment of Muscles.**—To twelve pairs: to the superior curved line are attached the Occipito-frontalis, Trapezius, and Sterno-cleido-mastoid. To the space between the curved lines, the Complexus,[1] Splenius capitis, and Obliquus capitis superior; to the inferior curved line, and the space between it and the foramen magnum, the Rectus capitis posticus, major and minor; to the transverse process, the Rectus capitis lateralis; and to the basilar process, the Rectus capitis anticus, major and minor, and Superior constrictor of the pharynx.

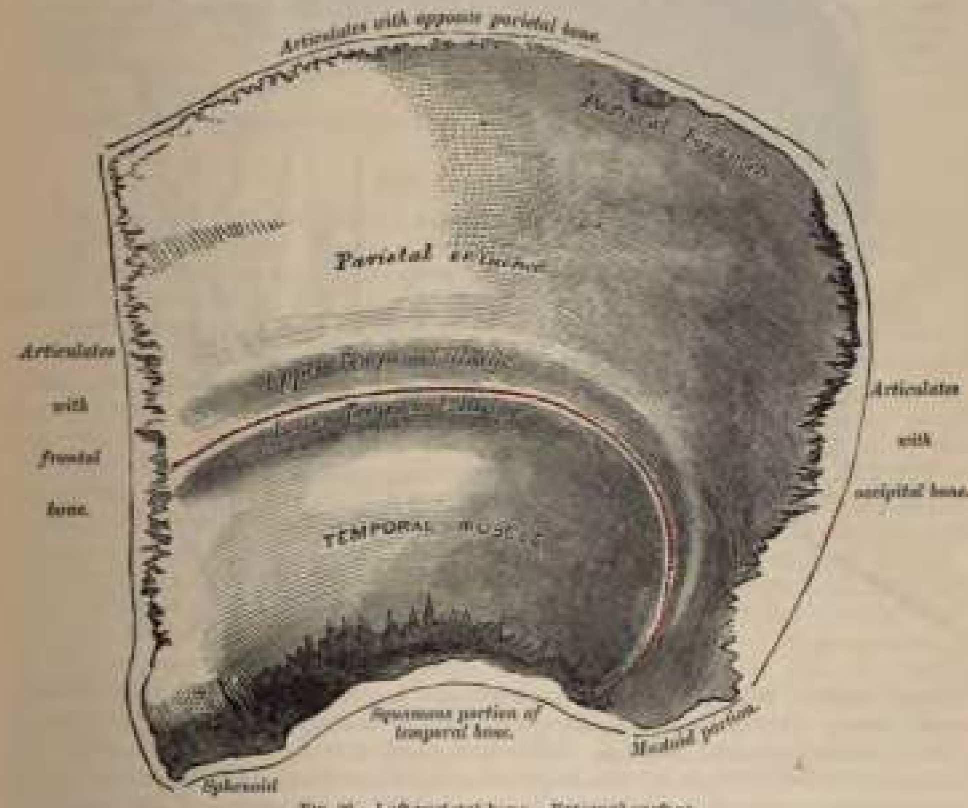



Fig. 26.—Left parietal bone. External surface.

## The Parietal Bones.

The **Parietal Bones** (*paries*, a wall) form, by their union, the sides and roof of the skull. Each bone is of an irregular quadrilateral form, and presents for examination two surfaces, four borders, and four angles.

[1] To these the Biventer cervicis should be added, if it is regarded as a separate muscle.

**Surfaces.**—The *external surface* (Fig. 26) is convex, smooth, and marked about its centre by an eminence called the *parietal eminence*, which indicates the point where ossification commenced. Crossing the middle of the bone in an arched direction are two well-marked curved lines or ridges, the *upper* and *lower temporal ridges;* the former gives attachment to the temporal fascia, while the latter indicates the upper limit of the origin of the temporal muscle. Above these ridges the surface of the bone is rough and porous, and covered by the aponeurosis of the Occipito-frontalis; between them the bone is smoother and more polished than the rest; below them the bone forms part of the temporal fossa, and affords attachment to the temporal muscle. At the back part of the superior border, close to the sagittal suture, is a small foramen, the *parietal foramen*, which transmits a vein to the superior longitudinal sinus, and sometimes a small branch of the occipital artery. Its existence is not constant, and its size varies considerably.

The **internal surface** (Fig. 27), concave, presents depressions for lodging the convolutions of the cerebrum and numerous furrows for the ramifications of the middle meningeal artery; the latter runs upward and backward from the

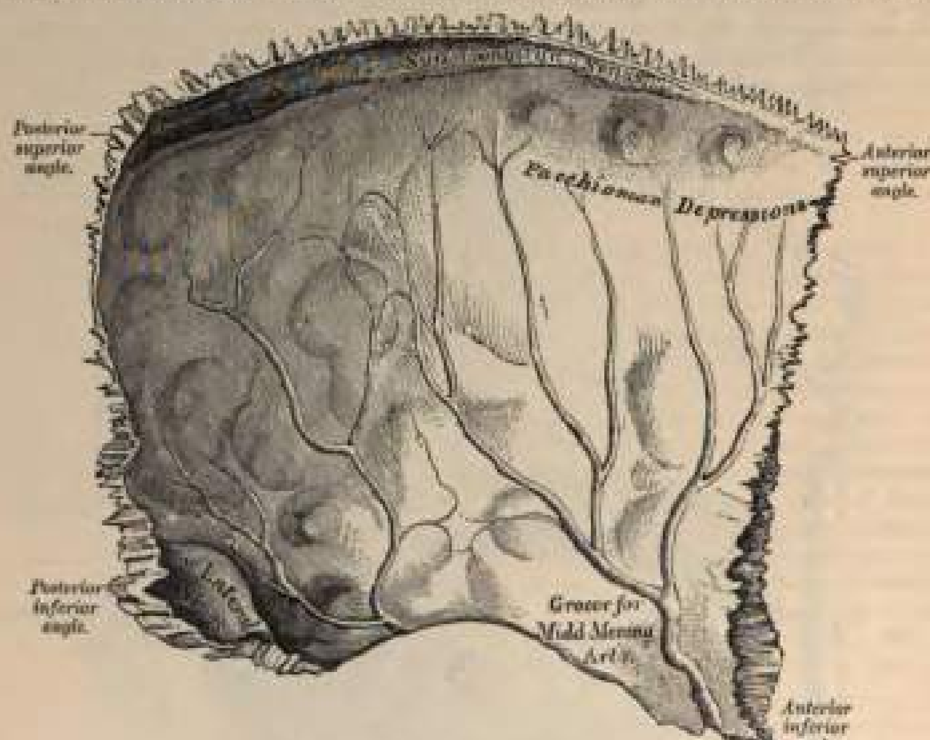



FIG. 27.—Left parietal bone. Internal surface.

anterior inferior angle and from the central and posterior part of the lower border of the bone. Along the upper margin is part of a shallow groove, which, when joined to the opposite parietal, forms a channel for the superior longitudinal sinus, the elevated edges of which afford attachment to the falx cerebri. Near the groove are seen several depressions, especially in the skulls of old persons; they lodge the Pacchionian bodies. The internal opening of the parietal foramen is also seen when that aperture exists.

**Borders.**—The *superior*, the longest and thickest, is dentated to articulate with its fellow of the opposite side, forming the sagittal suture. The *inferior* is divided into three parts: of these, the anterior is thin and pointed, bevelled at the expense of the outer surface, and overlapped by the tip of the great wing of the sphenoid; the middle portion is arched, bevelled at the expense of the outer surface, and overlapped by the squamous portion of the temporal; the posterior portion is thick and serrated for articulation with the mastoid portion of the temporal. The *anterior* border, deeply serrated, is bevelled at the expense of the outer surface above and of the inner below; it articulates with the frontal bone, forming the *coronal suture*. The *posterior* border, deeply denticulated, articulates with the occipital, forming the *lambdoid suture*.

**Angles.**—The *anterior superior* angle, thin and pointed, corresponds with that portion of the skull which in the fœtus is membranous and is called the *anterior fontanelle*. The *anterior inferior* angle is thin and lengthened, being received in the interval between the great wing of the sphenoid and the frontal. Its inner surface is marked by a deep groove, sometimes a canal, for the anterior branch of the middle meningeal artery. The *posterior superior* angle corresponds with the junction of the sagittal and lambdoid sutures. In the fœtus this part of the skull is membranous, and is called the *posterior fontanelle*. The *posterior inferior* angle articulates with the mastoid portion of the temporal bone, and generally presents on its inner surface a broad, shallow groove for lodging part of the lateral sinus.

**Development.**—The parietal bone is formed in membrane, being developed by *one* centre, which corresponds with the parietal eminence, and makes its first appearance about the seventh or eighth week of fœtal life. Ossification gradually extends from the centre to the circumference of the bone: the angles are consequently the parts last formed, and it is in their situation that the fontanelles exist previous to the completion of the growth of the bone. Occasionally the parietal bone is divided into two parts, upper and lower, by an antero-posterior suture.

**Articulations.**—With five bones: the opposite parietal, the occipital, frontal, temporal, and sphenoid.

**Attachment of Muscles.**—One only, the Temporal.

## The Frontal Bone.

The **Frontal Bone** (*frons*, the forehead) resembles a cockle-shell in form, and consists of two portions—a *vertical or frontal* portion situated at the anterior part of the cranium, forming the forehead; and a *horizontal* or *orbito-nasal* portion which enters into the formation of the roof of the orbits and nasal fossæ.

**Vertical Portion.**—*External Surface* (Fig. 28).—In the median line, traversing the bone from the upper to the lower part, is occasionally seen a slightly-elevated ridge, and in young subjects a suture, which represents the line of union of the two lateral halves of which the bone consists at an early period of life; in the adult this suture is usually obliterated and the bone forms one piece; traces of the obliterated suture are, however, generally perceptible at the lower part. On either side of this ridge, a little below the centre of the bone, is a rounded eminence, the *frontal eminence*. These eminences vary in size in different individuals, and are occasionally unsymmetrical in the same subject. They are especially prominent in cases of well-marked cerebral development. The whole surface of the bone above this part is smooth, and covered by the aponeurosis of the Occipito-frontalis muscle. Below the frontal eminence, and separated from it by a slight groove, is the *superciliary ridge*, broad internally, where it is continuous with the nasal eminence, but less distinct as it arches outward. These ridges are caused by the projection outward of the frontal air sinuses,[1] and give attachment to the Orbicularis palpebrarum and Corrugator supercilii. Between the two superciliary ridges is a smooth surface, the *glabella* or *nasal eminence*. Beneath the superciliary ridge is the *supraorbital arch*, a curved and prominent margin, which forms

[1] Some confusion is occasioned to students commencing the study of anatomy by the name "sinuses" having been given to two perfectly different kinds of spaces connected with the skull. It may be as well, therefore, to state here, at the outset, that the "sinuses" in the interior of the cranium which produce the grooves on the inner surface of the bones are venous channels along which the blood runs in its passage back from the brain, while the "sinuses" external to the cranial cavity (the frontal, sphenoidal, ethmoidal, and maxillary) are hollow spaces in the bones themselves which communicate with the nostrils, and contain air.

the upper boundary of the orbit and separates the vertical from the horizontal portion of the bone. The outer part of the arch is sharp and prominent, affording to the eye, in that situation, considerable protection from injury; the inner part is less prominent. At the junction of the internal and middle third of this arch is a notch, sometimes converted into foramen, and called the *supraorbital notch* or *foramen*. It transmits the supraorbital artery, vein, and nerve. A small aperture is seen in the upper part of the notch, which transmits a vein from the diploë to join the supraorbital vein. The supraorbital arch terminates externally in the *external angular process* and internally in the *internal angular process*. The external angular process is strong, prominent, and articulates with the malar bone; running upward and backward from it are two well-marked lines, which, commencing together from the external angular process, soon diverge from each other and run in a curved direction across the bone. These are the *upper* and *lower temporal ridges*; the upper gives attachment to the temporal fascia, the

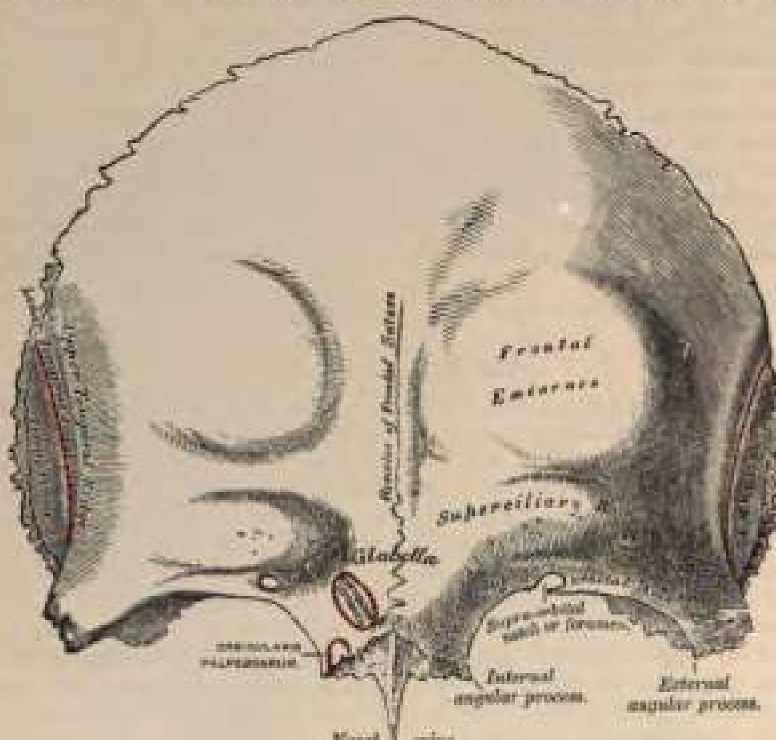



FIG. 28.—Frontal bone. Outer surface.

lower to the temporal muscle. Beneath them is a slight concavity that forms the anterior part of the temporal fossa and gives origin to the Temporal muscle. The internal angular processes are less marked than the external, and articulate with the lachrymal bones. Between the internal angular processes is a rough, uneven interval, the *nasal notch*, which articulates in the middle line with the nasal bone, and on either side with the nasal process of the superior maxillary bone. From the concavity of this notch projects a process, the *nasal process*, which extends beneath the nasal bones and nasal processes of the superior maxillary bones and supports the bridge of the nose. On the under surface of this is a long pointed process, the *nasal spine*, and on either side a small grooved surface enters into the formation of the roof of the nasal fossa. The nasal spine forms part of the septum of the nose, articulating in front with the nasal bones and behind with the perpendicular plate of the ethmoid.

**Internal Surface** (Fig. 29).—Along the middle line is a vertical groove, the edges of which unite below to form a ridge, the *frontal crest;* the groove lodges the superior longitudinal sinus, whilst its margins afford attachment to the falx cerebri. The crest terminates below at a small notch which is converted into a foramen by articulation with the ethmoid. It is called the *foramen cæcum*, and varies in size in different subjects: it is sometimes partially or completely impervious, lodges a process of the falx cerebri, and when open transmits a vein from the lining membrane of the nose to the superior longitudinal sinus. On either side of the groove the bone is deeply concave, presenting depressions for the convolutions of the brain, and numerous small furrows for lodging the ramifications of the anterior meningeal arteries. Several small, irregular fossæ are seen also on either side of the groove, for the reception of the Pacchionian bodies.

**Horizontal Portion.**—This portion of the bone consists of two thin plates, *the orbital plates*, which form the vault of the orbit, separated from one another by a median gap, the ethmoidal notch. The *external surface* of each orbital plate consists of a smooth, concave, triangular lamina of bone, marked at its anterior and external part (immediately beneath the external angular

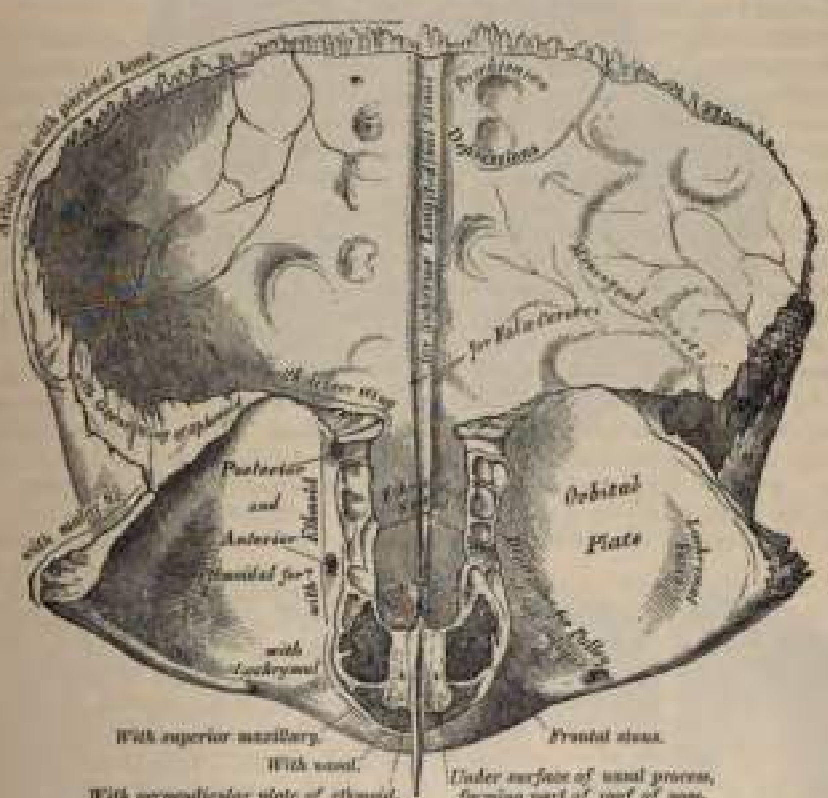



FIG. 29.—Frontal bone. Inner surface.

process) by a shallow depression, the *lachrymal fossa*, for lodging the lachrymal gland; and at its anterior and internal part by a depression (sometimes a small tubercle), the *trochlear fossa*, for the attachment of the cartilaginous pulley of the Superior oblique muscle of the eye. The ethmoidal notch separates the two orbital plates; it is quadrilateral, and filled up, when the bones are united, by the cribriform plate of the ethmoid. The margins of this notch present several half-cells, which, when united with corresponding half-cells on the upper surface of the ethmoid, complete the ethmoidal cells; two grooves are also seen crossing these edges transversely; they are converted into canals by articulation with the ethmoid, and are called the *anterior* and *posterior ethmoidal* canals: they open on the inner wall of the orbit. The anterior one transmits the nasal nerve and anterior ethmoidal vessels, the posterior one the posterior ethmoidal vessels. In front of the ethmoidal notch, on either side of the nasal spine, are the openings of the frontal sinuses. These are two irregular cavities, which extend upward and outward, a variable distance, between the two tables of the skull, and are separated from one another by a thin, bony septum, which is often displaced to one side. They give rise to the prominences above the supraorbital arches called the *superciliary ridges*. In the child they are generally absent, and they become gradually developed as age advances. These cavities vary in size in different persons, are larger in men than in women, and are frequently of unequal size on the two sides, the right being commonly the larger. They are lined by mucous membrane, and communicate with the nose by the infundibulum, and occasionally with each other by apertures in their septum.

The **internal surface of the horizontal portion** presents the convex upper surfaces of the orbital plates, separated from each other in the middle line by the ethmoidal notch, and marked by eminences and depressions for the convolutions of the frontal lobes of the brain.

**Borders.**—The border of the vertical portion is thick, strongly serrated, bevelled at the expense of the internal table above, where it rests upon the parietal bones, and at the expense of the external table at each side, where it receives the lateral pressure of those bones; this border is continued below into a triangular rough surface which articulates with the great wing of the sphenoid. The border of the horizontal portion is thin, serrated, and articulates with the lesser wing of the sphenoid.

**Structure.**—The vertical portion and external angular processes are very thick, consisting of diploic tissue contained between two compact laminæ. The horizontal portion is thin, translucent, and composed entirely of compact tissue; hence the facility with which instruments can penetrate the cranium through this part of the orbit.

**Development** (Fig. 30).—The frontal bone is formed in membrane, being developed by *two* centres, one for each lateral half, which make their appearance about the seventh or eighth week, above the orbital arches. From this point ossification extends, in a radiating manner, upward into the forehead and backward over the orbit. At birth the bone consists of two pieces, which afterward become united, along the middle line, by a suture which runs from the vertex to the root of the nose. This suture usually becomes obliterated within a few years after birth; but it occasionally remains throughout life, constituting the *metopic* suture. Secondary centres of ossification appear for the nasal spine—one on either side at the internal angular process where it articulates with the lachrymal bone; and sometimes there is one on either side at the lower end of the coronal suture. This latter centre sometimes remains ununited, and is known as the pterion ossicle, or it may join with the parietal, sphenoid, or temporal bone.

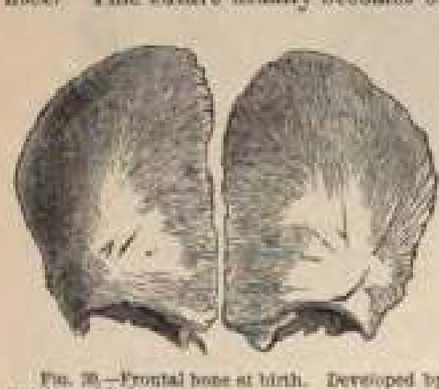


FIG. 30.—Frontal bone at birth. Developed by two lateral halves.

**Articulations.** — With twelve bones: two parietal, the sphenoid, the ethmoid, two nasal, two superior maxillary, two lachrymal, and two malar.

**Attachment of Muscles.**—To three pairs: the Corrugator supercilii, Orbicularis palpebrarum, and Temporal, on each side.

## The Temporal Bones.

The **Temporal Bones** (*tempus*, time) are situated at the sides and base of the skull, and present for examination a *squamous*, *mastoid*, and *petrous* portion.

The **squamous portion** (*squama*, a scale), the anterior and upper part of the bone, is scale-like in form, and thin and translucent in texture (Fig. 31). Its *outer surface* is smooth, convex, and grooved at its back part for the deep temporal arteries; it affords attachment to the Temporal muscle and forms part of the temporal fossa. At its back part may be seen a curved ridge—part of the *temporal ridge*; it serves for the attachment of the temporal fascia and limits the origin of the Temporal muscle. The boundary between the squamous and mastoid portions

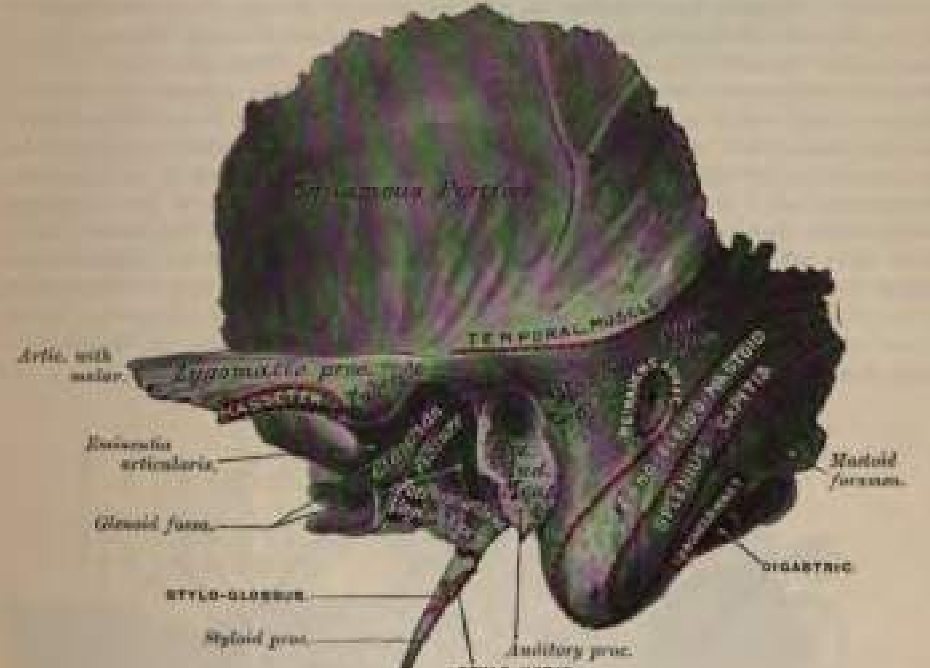



FIG. 31.—Left temporal bone. Outer surface.

of the bone, as indicated by traces of the original suture, lies fully half an inch below this ridge. Projecting from the lower part of the squamous portion is a long, arched process of bone, the *zygoma* or zygomatic process. This process is at first directed outward, its two surfaces looking upward and downward; it then appears as if twisted upon itself, and runs forward, its surfaces now looking inward and outward. The superior border of the process is long, thin, and sharp, and serves for the attachment of the temporal fascia. The inferior, short, thick, and arched, has attached to it some fibres of the Masseter muscle. Its outer surface is convex and subcutaneous; its inner is concave, and also affords attachment to the Masseter. The extremity, broad and deeply serrated, articulates with the malar bone. The zygomatic process is connected to the temporal bone by three divisions, called its *roots*—an anterior, middle, and posterior. The anterior, which is short, but broad and strong, is directed inward, to terminate in a rounded eminence, the *eminentia articularis*. This eminence forms the front boundary of the glenoid fossa, and in the recent state is covered with cartilage. The middle root is known as the *post-glenoid process*, and is very prominent in young bones. It separates the mandibular portion of the glenoid fossa from the external auditory meatus, and terminates at the commencement of a well-marked fissure, the *Glaserian fissure*. The posterior root, which is strongly marked, runs from the upper border of the zygoma backward over the external auditory meatus. It is termed the *supra-mastoid crest*, and forms the posterior part of the lower temporal ridge. At the junction of the anterior root with the zygoma is a projection, called the *tubercle*, for the attachment of the external lateral ligament of the lower jaw; and between the anterior and middle roots is an oval depression, forming part of the glenoid fossa (γλήνη, a socket), for the reception of the condyle of the lower jaw. This fossa is bounded, in front, by the eminentia articularis; behind, by the tympanic plate, which separates it from the external auditory meatus; it is divided into two parts by a narrow slit, the *Glaserian fissure*. The anterior or mandibular part, formed by the squamous portion of the bone, is smooth, covered in the recent state with cartilage, and articulates with the condyle of the lower jaw. This part of the glenoid fossa presents posteriorly a small conical eminence, the *post-glenoid process*, already referred to. This process is the representative of a prominent tubercle which, in some of the mammalia, descends behind the condyle of the jaw, and prevents it being displaced backward during mastication (Humphry). The posterior part of the glenoid fossa, which lodges a portion of the parotid gland, is formed chiefly by the *tympanic plate*, which constitutes the anterior wall of the tympanum and external auditory meatus. The plate of bone terminates above in the Glaserian fissure, and below forms a sharp edge, the *vaginal* process, which gives origin to some of the fibres of the Tensor palati muscle. The Glaserian fissure, which leads into the tympanum, lodges the processus gracilis of the malleus, and transmits the tympanic branch of the internal maxillary artery. The chorda tympani nerve passes through a separate canal, parallel to the Glaserian fissure (*canal of Huguier*), on the outer side of the Eustachian tube, in the retiring angle between the squamous and petrous portions of the temporal bone.[1]

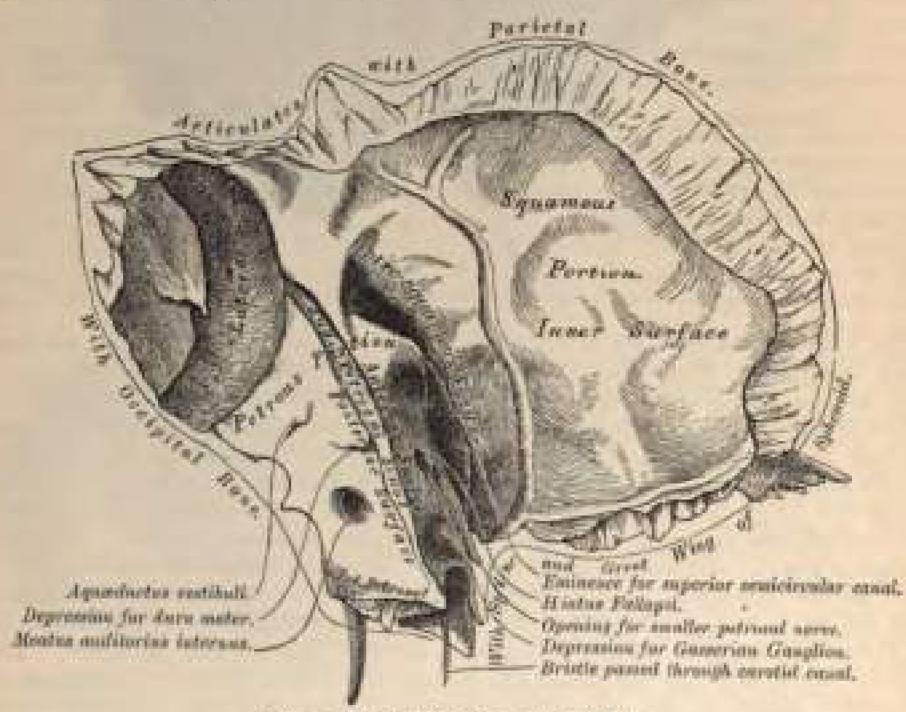



FIG. 32.—Left temporal bone. Inner surface.

The **internal surface** of the squamous portion (Fig. 32) is concave, presents

[1] This small fissure must not be confounded with the large canal which lies above the Eustachian tube and transmits the Tensor tympani muscle.

numerous eminences and depressions for the convolutions of the cerebrum, and two well-marked grooves for the branches of the middle meningeal artery.

**Borders.**—The superior border is thin, bevelled at the expense of the internal surface, so as to overlap the lower border of the parietal bone, forming the squamous suture. The anterior inferior border is thick, serrated, and bevelled, alternately at the expense of the inner and outer surfaces, for articulation with the great wing of the sphenoid.

The **Mastoid Portion** (*μαστός*, a nipple or teat) is situated at the posterior part of the bone; its outer surface is rough, and gives attachment to the Occipito-frontalis and Retrahens aurem muscles. It is perforated by numerous foramina; one of these, of large size, situated at the posterior border of the bone, is termed the *mastoid foramen;* it transmits a vein to the lateral sinus and a small artery from the occipital to supply the dura mater. The position and size of this foramen are very variable. It is not always present; sometimes it is situated in the occipital bone or in the suture between the temporal and the occipital. The mastoid portion is continued below into a conical projection, the *mastoid process,* the size and form of which vary somewhat. This process serves for the attachment of the Sterno-mastoid, Splenius capitis, and Trachelo-mastoid muscles. On the inner side of the mastoid process is a deep groove, the *digastric fossa,* for the attachment of the Digastric muscle; and, running parallel with it, but more internal, the *occipital groove,* which lodges the occipital artery. The internal surface of the mastoid portion presents a deep, curved groove, the *fossa sigmoidea,* which lodges part of the lateral sinus; and into it may be seen opening the mastoid fora-

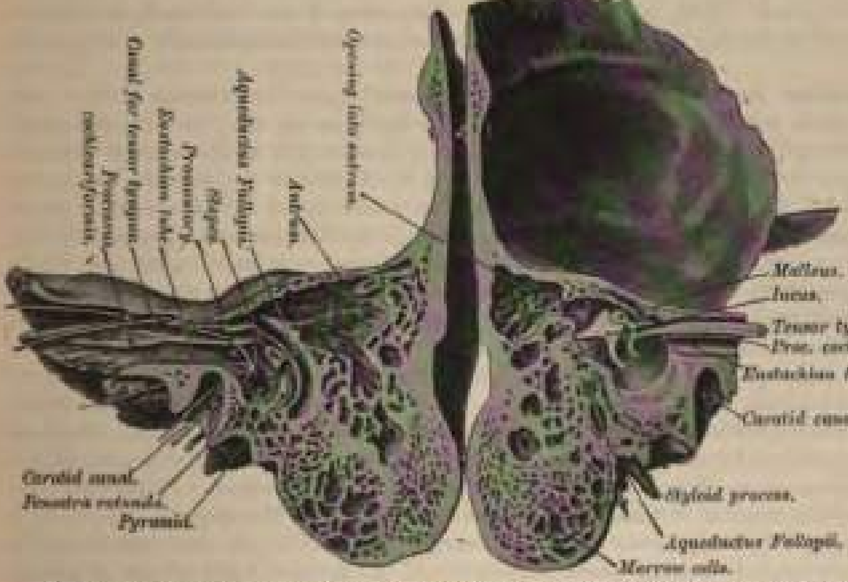



Fig. [illegible].—Section through the petrous and mastoid portions of the temporal bone, showing the communication of the cavity of the tympanum with the mastoid antrum.

men. The groove for the lateral sinus is separated from the innermost of the mastoid air-cells by only a thin lamina of bone, and even this may be partly deficient. A section of the mastoid process shows it to be hollowed out into a number of cellular spaces, communicating with each other, called the *mastoid cells,* which exhibit the greatest possible variety as to their size and number. At the upper and front part of the bone these cells are large and irregular, and contain air. They diminish in size toward the lower part of the bone, those situated at the apex of the mastoid process being quite small and usually containing marrow. Occasionally they are entirely absent, and the mastoid is solid throughout. In addition to these may be seen a large irregular cavity (Fig. 33), situated at the upper and front part of the section. It is called the *mastoid antrum*, and must be distinguished from the mastoid cells, though it communicates with them. It is filled with air, and is lined with a prolongation of the mucous membrane of the tympanum, which extends into it through an opening, by which it communicates with the cavity of the tympanum. The mastoid antrum is bounded above by a thin plate of bone, which separates it from the middle fossa of the base of the skull on the anterior surface of the petrous portion of the temporal bone; below by the mastoid process; externally by the squamous portion of the bone just below the supra-mastoid crest; and internally by the external semicircular canal of the internal ear which projects into its cavity. The opening by which it communicates with the tympanum is situated at the superior internal angle of the posterior wall of that cavity, and opens into that portion of the tympanic cavity which is known as the *attic* or *epitympanic recess;* that is to say, that portion of the tympanum which is above the level of the membrana tympani.

The mastoid cells, like the other sinuses of the cranium, are not developed until after puberty; hence the prominence of this process in the adult: the mastoid antrum, on the other hand, is of large size at birth.

In consequence of the communication which exists between the tympanum and mastoid cells, inflammation of the lining membrane of the former cavity may easily travel backward to that of the antrum, leading to caries and necrosis of their walls and the risk of transference of the inflammation to the lateral sinus or encephalon.

**Borders.**—The superior border of the mastoid portion is broad and rough, its serrated edge sloping outward, for articulation with the posterior inferior angle of the parietal bone. The posterior border, also uneven and serrated, articulates with the inferior border of the occipital bone between its lateral angle and jugular process.

The **Petrous Portion** (πέτρος, a stone), so named from its extreme density and hardness, is a pyramidal process of bone wedged in at the base of the skull between the sphenoid and occipital bones. Its direction from without is inward, forward, and a little downward. It presents for examination a base, an apex, three surfaces, and three borders, and contains, in its interior, the essential parts of the organ of hearing. The *base* is applied against the internal surface of the squamous and mastoid portions, its upper half being concealed; but its lower half is exposed by the divergence of those two portions of the bone, which brings into view the oval expanded orifice of a canal leading into the tympanum, the *meatus auditorius externus*. The curved tympanic plate forms the anterior wall, the floor, and a part of the posterior wall of this meatus, while the squamous temporal completes it above and behind. The entrance to the meatus is bounded throughout the greater part of its circumference by the *auditory process*, which is the name applied to the free rough margin of the tympanic plate, and which gives attachment to the cartilaginous portion of the meatus. Superiorly the entrance to the meatus is limited by the posterior root of the zygoma.

The **apex** of the petrous portion, rough and uneven, is received into the angular interval between the posterior border of the greater wing of the sphenoid and the basilar process of the occipital; it presents the anterior or internal orifice of the carotid canal, and forms the posterior and external boundary of the foramen lacerum medium.

The **anterior surface** of the petrous portion (Fig. 32) forms the posterior part of the middle fossa of the skull. This surface is continuous with the squamous portion, to which it is united by a suture, the *petro-squamous suture*, the remains of which are distinct even at a late period of life. It presents six points for examination: 1, an eminence near the centre, which indicates the situation of the superior semicircular canal; 2, in front and a little to the outer side of this eminence a depression indicating the position of the tympanum; here the layer of bone which separates the tympanum from the cranial cavity is extremely thin, and is known as the *tegmen tympani;* 3, a shallow groove, sometimes double, leading outward and backward to an oblique opening, the *hiatus Fallopii*, for the passage of the greater petrosal nerve and the petrosal branch of the middle meningeal artery; 4, a smaller opening, occasionally seen external to the latter, for the passage of the smaller petrosal nerve; 5, near the apex of the bone, the termination of the carotid canal, the wall of which in this situation is deficient in front; 6, above this canal a shallow depression for the reception of the Gasserian ganglion.

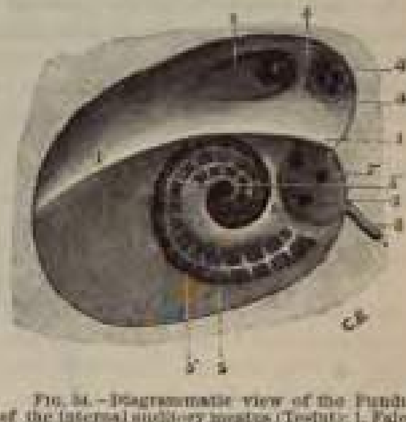


Fig. 34.—Diagrammatic view of the Fundus of the internal auditory meatus (Testut). 1. Falciform crest. 2. Anterior superior cribriform area. 2'. Internal opening of the Aquæductus Fallopii. 3. Vertical crest which separates the anterior and posterior superior cribriform areas. 4. Posterior superior cribriform area, with (4') openings for nerve-filaments. 5. Anterior inferior cribriform area. 5'. Spirally arranged, sieve-like openings for the nerves to the cochlea. 5''. Opening of the central canal of the cochlea. 6. Crest which separates the anterior and posterior inferior cribriform areas. 7. Posterior inferior cribriform area. 7' Orifices for the branches of the nerve to the saccule. 8. Foramen singulare of Morgagni, with the anterior portion of the canal which gives passage to the nerve to the posterior semicircular canal.

The **posterior surface** forms the front part of the posterior fossa of the skull, and is continuous with the inner surface of the mastoid portion of the bone. It presents three points for examination: 1. About its centre, a large orifice, the *meatus auditorius internus*, whose size varies considerably; its margins are smooth and rounded, and it leads into a short canal, about four lines in length, which runs directly outward and is closed by a vertical plate, the *lamina cribrosa*, which is divided by a horizontal crest, the *crista falciformis*, into two unequal portions. Each portion is subdivided by a little vertical crest into two parts, named respectively anterior and posterior. The *lower* portion presents three sets of foramina; one group just below the posterior part of the crest, the *area cribrosa media*, consisting of a number of small openings for the nerves to the saccule; below and posterior to this, the *foramen singulare*, or opening for the nerve to the posterior semicircular canal; in front and below the first, the *tractus spiralis foraminosus*, consisting of a number of small spirally arranged openings which terminate in the canalis centralis cochleæ and transmit the nerve to the cochlea; the upper portion, that above the crista, presents behind a series of small openings, the area cribrosa superior, for the passage of filaments to the utricle and superior and external semicircular canal, and, in front, one large opening, the commencement of the aquæductus Fallopii, for the passage of the facial nerve. 2. Behind the meatus auditorius, a small slit, almost hidden by a thin plate of bone, leading to a canal, the *aquæductus vestibuli*, which transmits the *ductus endolymphaticus* together with a small artery and vein. In the interval between these two openings, but above them, is an angular depression which lodges a process of the dura mater, and transmits a small vein into the cancellous tissue of the bone. In the child this depression is represented by a large fossa, the *floccular fossa*, which extends backward as a blind tunnel under the superior semicircular canal.

The **inferior** or **basilar surface** (Fig. 35) is rough and irregular, and forms part of the base of the skull. Passing from the apex to the base, this surface presents eleven points for examination: 1, a rough surface, quadrilateral in form, which serves partly for the attachment of the Levator palati and Tensor tympani muscles; 2, the large, circular aperture of the carotid canal, which ascends at first vertically, and then, making a bend, runs horizontally forward and inward; it transmits the internal carotid artery and the carotid plexus; 3, the *aquæductus cochleæ*, a small, triangular opening, lying on the inner side of the latter, close to the posterior border of the petrous portion; it transmits a vein from the cochlea which joins the internal jugular; 4, behind these openings a deep depression, the *jugular fossa*, which varies in depth and size in different skulls; it lodges the lateral sinus, and, with a similar depression on the margin of the jugular process of the occipital bone, forms the foramen lacerum posterius or jugular foramen; 5, a small foramen for the passage of Jacobson's nerve (the tympanic branch of the glosso-pharyngeal): this foramen is seen in front of the bony ridge dividing

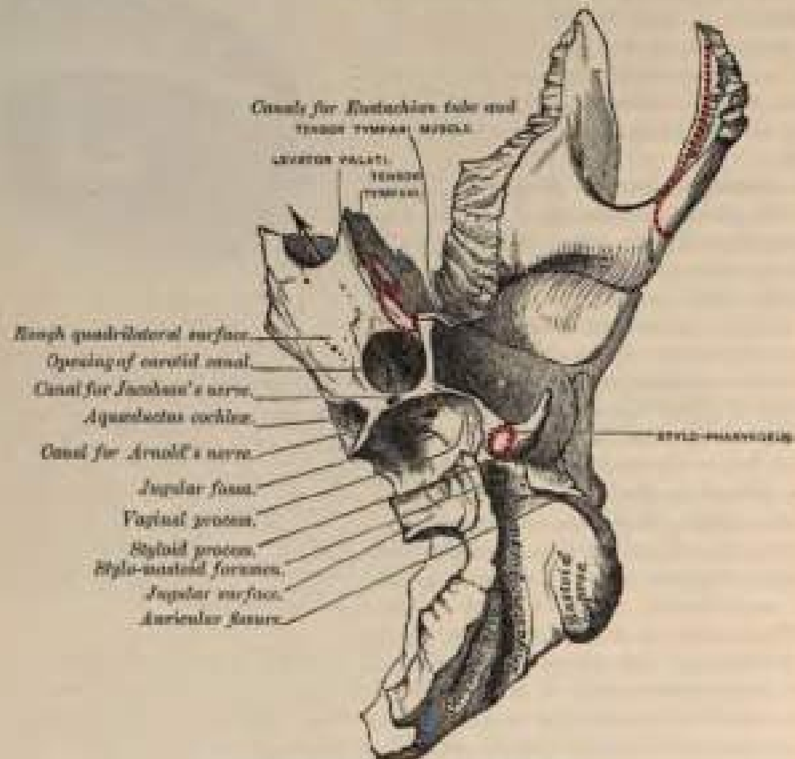



FIG. 55.—Petrous portion. Inferior surface.

the carotid canal from the jugular fossa; 6, a small foramen on the wall of the jugular fossa, for the entrance of the auricular branch of the pneumogastric (Arnold's) nerve; 7, behind the jugular fossa a smooth, square-shaped facet, the *jugular surface;* it is covered with cartilage in the recent state, and articulates with the jugular process of the occipital bone; 8, the *vaginal process*, a very broad, sheath-like plate of bone, which extends backward from the carotid canal and gives attachment to part of the Tensor palati muscle; this plate divides behind into two laminæ, the outer of which is continuous with the tympanic plate, the inner with the jugular process; 9, between these laminæ is the ninth point for examination, the *styloid process*, a sharp spine, about an inch in length: it is directed downward, forward, and inward, varies in size and shape, and sometimes consists of several pieces united by cartilage; it affords attachment to three muscles, the Stylo-pharyngeus, Stylo-hyoideus, and Stylo-glossus, and two ligaments, the stylo-hyoid and stylo-maxillary; 10, the *stylo-mastoid foramen*, a rather large orifice, placed between the styloid and mastoid processes: it is the termination of the aquæductus Fallopii, and transmits the facial nerve and stylo-mastoid artery; 11, the *auricular fissure*, situated between the tympanic plate and mastoid processes, for the exit of the auricular branch of the pneumogastric nerve.

**Borders.**—The *superior*, the longest, is grooved for the superior petrosal sinus, and has attached to it the tentorium cerebelli; at its inner extremity is a semilunar notch, upon which the fifth nerve lies. The *posterior* border is intermediate in length between the superior and the anterior. Its inner half is marked by a groove, which, when completed by its articulation with the occipital, forms the channel for the inferior petrosal sinus. Its outer half presents a deep excavation—the *jugular fossa*—which, with a similar notch on the occipital, forms the foramen lacerum posterius. A projecting eminence of bone occasionally stands out from the centre of the notch, and divides the foramen into two parts. The *anterior* border is divided into two parts—an outer joined to the squamous portion by a suture, the remains of which are distinct; an inner, free, articulating with the spinous process of the sphenoid. At the angle of junction of the petrous and squamous portions are seen two canals, separated from one another by a thin plate of bone, the *processus cochleariformis;* they both lead into the tympanum, the upper one transmitting the Tensor tympani muscle, the lower one forming the bony part of the Eustachian tube.

**Structure.**—The squamous portion is like that of the other cranial bones: the mastoid portion, cellular; and the petrous portion, dense and hard.

**Development** (Fig. 36).—The temporal bone is developed by *ten* centres, exclusive of those for the internal ear and the ossicula—viz., one of the squamous portion including the zygoma, one for the tympanic plate, six for the petrous and mastoid parts, and two for the styloid process. Just before the close of fœtal life the temporal bone consists of four parts: 1. The *squamo-zygomatic*, which is ossified in membrane from a single nucleus, which appears at its lower part about the second month. 2. The *tympanic plate*, an imperfect ring, in the concavity of which is a groove, the *sulcus tympanicus*, for the attachment of the circumference of the tympanic membrane. This is also ossified from a single centre, which appears about the third month. 3. The *petro-mastoid*, which is developed from six centres, which appear about the fifth or sixth month. Four of these are for the petrous portion, and are placed around the labyrinth, and two for the mastoid (Vrolik). According to Huxley, the centres are more numerous, and are disposed so as to form three portions: (1) including most of the labyrinth, with a part of the petrous and mastoid, he has named *prootic;* (2) the rest of the petrous, the *episthotic;* and (3) the remainder of the mastoid, the *epiotic*. The petro-mastoid is ossified in cartilage. 4. The *styloid process* is also ossified in cartilage from two centres: one for the base, which appears before birth, and is termed the *tympano-hyal;* the other, comprising the rest of the process, is named the *stylo-hyal*, and does not appear until after birth. Shortly before birth the tympanic plate joins with the squamous. The petrous and mastoid join with the squamous during the first year, and the tympano-hyal portion of the styloid process about the same time. The stylo-hyal does not join the rest of the bone until after puberty, and in some skulls never becomes united. The subsequent changes in this bone are, that the tympanic plate extends outward and backward, so as to form the meatus auditorius. The extension of the tympanic plate, however, does not take place at an equal rate all round the circumference of the ring, but occurs most rapidly on its anterior and posterior portions, and these outgrowths meet and blend, and thus, for a time, there exists in the floor of the meatus a foramen, the *foramen of Huschke:* this foramen may persist throughout life. The glenoid cavity is at first extremely shallow, and looks outward as well as downward; it becomes deeper and is ultimately directed downward. Its change in direction is accounted for

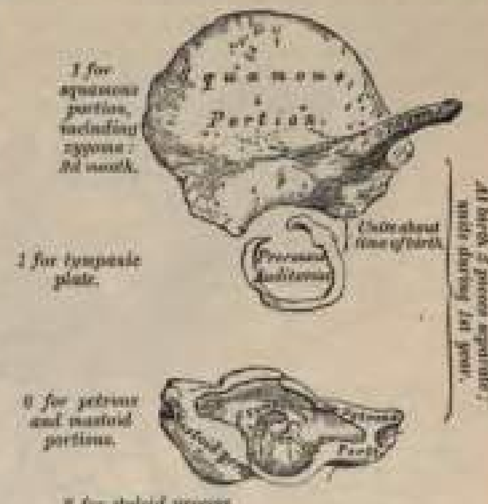



FIG. 36.—Development of the temporal bone. By ten centres.

as follows: the part of the squamous temporal which supports it lies at first *below* the level of the zygoma. As, however, the base of the skull increases in width, this lower part of the squama is directed horizontally inward to contribute to the middle fossa of the skull, and its surfaces therefore come to look upward and downward. The mastoid portion is at first quite flat, and the stylo-mastoid foramen and rudimentary styloid process lie immediately behind the entrance to the auditory meatus. With the development of the air-cells the outer part of the mastoid portion grows downward and forward to form the mastoid process, and the styloid process and stylo-mastoid foramen now come to lie on the under surface. The descent of the foramen is necessarily accompanied by a corresponding lengthening of the aqueduct of Fallopius.

The downward and forward growth of the mastoid process also pushes forward the tympanic plate, so that the portion of it which formed the original floor of the meatus and containing the foramen of Huschke is ultimately found in the anterior wall. With the gradual increase in size of the petrous portion the floccular fossa or tunnel under the superior semicircular canal becomes filled up and almost obliterated.

**Articulations.**—With five bones—occipital, parietal, sphenoid, inferior maxillary, and malar.

**Attachment of Muscles.**—To fifteen: to the squamous portion, the Temporal; to the zygoma, the Masseter; to the mastoid portion, the Occipito-frontalis, Sterno-mastoid, Splenius capitis, Trachelo-mastoid, Digastricus, and Retrahens aurem; to the styloid process, the Stylo-pharyngeus, Stylo-hyoideus, and Stylo-glossus; and to the petrous portion, the Levator palati, Tensor tympani, Tensor palati, and Stapedius.

## The Sphenoid Bone.

The **Sphenoid Bone** (σφήν, a wedge) is situated at the anterior part of the base of the skull, articulating with all the other cranial bones, which it binds firmly and solidly together. In its form it somewhat resembles a bat with its wings extended; and is divided into a central portion or body, two greater and two lesser wings extending outward on each side of the body, and two processes—the pterygoid processes—which project from it below.

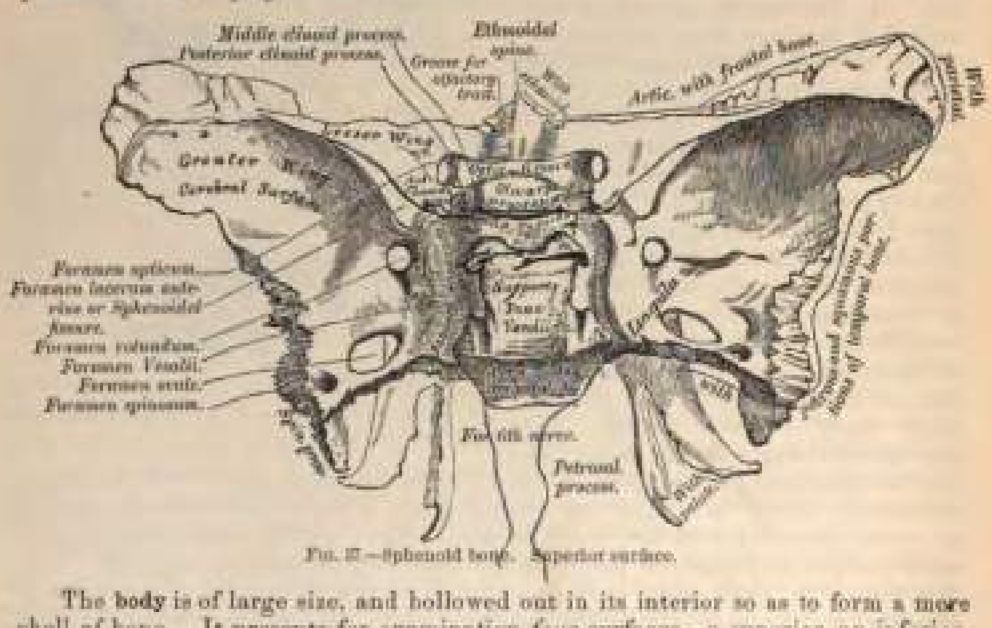



Fig. 37.—Sphenoid bone. Superior surface.

The **body** is of large size, and hollowed out in its interior so as to form a mere shell of bone. It presents for examination *four* surfaces—a superior, an inferior, an anterior, and a posterior.

**The Superior Surface** (Fig. 37).—In front is seen a prominent spine, the *ethmoidal spine*, for articulation with the cribriform plate of the ethmoid; behind this a smooth surface presenting, in the median line, a slight longitudinal eminence, with a depression on each side for lodging the olfactory lobes. This surface is bounded behind by a ridge, which forms the anterior border of a narrow, transverse groove, the *optic groove*, behind which lies the optic commissure; the ridge terminates on either side of the *optic foramen*, for the passage of the optic nerve and ophthalmic artery. Behind the optic groove is a small eminence, olive-like in shape, the *olivary process;* and still more posteriorly, a deep depression, the *pituitary fossa*, or *sella turcica*, which lodges the pituitary body. This fossa is perforated by numerous foramina, for the transmission of nutrient vessels into the substance of the bone. It is bounded in front by two small eminences, one on either side, called the *middle clinoid processes* (κλίνη, a bed), which are sometimes connected by a spiculum of bone to the anterior clinoid processes, and behind by a square-shaped plate of bone, the *dorsum ephippii* or *dorsum sellæ*, terminating at each superior angle in a tubercle, the *posterior clinoid processes*, the size and form of which vary considerably in different individuals. These processes deepen the pituitary fossa, and serve for the attachment of prolongations from the tentorium cerebelli. The sides of the dorsum ephippii are notched for the passage of the sixth pair of nerves, and below present a sharp process, the *petrosal process*, which is joined to the apex of the petrous portion of the temporal bone, forming the inner boundary of the middle lacerated foramen. Behind this plate the bone presents a shallow depression, which slopes obliquely backward, and is continuous with the basilar groove of the occipital bone; it is called the *clivus*, and supports the upper part of the pons Varolii. On either side of the body is a broad groove, curved something like the italic letter *f;* it lodges the internal carotid artery and the cavernous sinus, and is called the *carotid* or *cavernous groove*. Along the outer margin of this groove, at its posterior part, is a ridge of bone in the angle between the body and greater wing, called the *lingula*. The **posterior surface**, quadrilateral

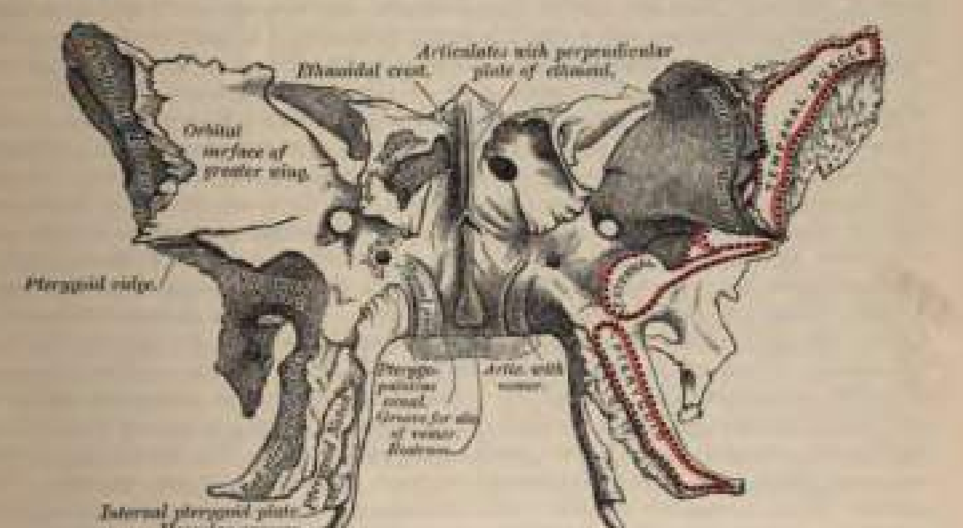



Fig. 38.—Sphenoid bone. Anterior surface.[1]

in form, is joined to the basilar process of the occipital bone. During childhood these bones are separated by a layer of cartilage; but in after-life (between the eighteenth and twenty-fifth years) this becomes ossified, ossification commencing above and extending downward; and the two bones then form one piece. The **anterior surface** (Fig. 38) presents, in the middle line, a vertical ridge of bone, the

[1] In this figure, both the anterior and inferior surfaces of the body of the sphenoid bone are shown, the bone being held with the pterygoid processes almost horizontal.

*ethmoidal crest*, which articulates in front with the perpendicular plate of the ethmoid, forming part of the septum of the nose. On either side of it are irregular openings leading into the *sphenoidal cells or sinuses*. These are two large irregular cavities hollowed out of the interior of the body of the sphenoid bone, and separated from one another by a more or less complete perpendicular bony septum. Their form and size vary considerably; they are seldom symmetrical, and are often partially subdivided by irregular osseous laminæ. Occasionally, they extend into the basilar process of the occipital nearly as far as the foramen magnum. The septum is seldom quite vertical, being commonly bent to one or the other side. These sinuses do not exist in children, but they increase in size as age advances. They are partially closed, in front and below, by two thin, curved plates of bone, the *sphenoidal turbinated* bones, leaving a round opening at their upper parts, by which they communicate with the upper and back part of the nose, and occasionally with the posterior ethmoidal cells or sinuses. The lateral margins of this **surface** present a serrated edge, which articulates with the os planum of the ethmoid, completing the posterior ethmoidal cells; the lower margin, also rough and serrated, articulates with the orbital process of the palate bone, and the upper margin with the orbital plate of the frontal bone. The **inferior surface** presents, in the middle line, a triangular spine, the *rostrum*, which is continuous with the sphenoidal crest on the anterior surface, and is received into a deep fissure between the alæ of the vomer. On each side may be seen a projecting lamina of bone, which runs horizontally inward from near the base of the pterygoid process: these plates, termed the *vaginal processes*, articulate with the edges of the vomer. Close to the root of the pterygoid process is a groove, formed into a complete canal when articulated with the sphenoidal process of the palate bone; it is called the *pterygo-palatine canal*, and transmits the pterygo-palatine vessels and pharyngeal nerve.

The **Greater Wings** are two strong processes of bone which arise from the sides of the body, and are curved in a direction upward, outward, and backward, being prolonged behind into a sharp-pointed extremity, the *spinous process* of the sphenoid. Each wing presents three surfaces and a circumference. The *superior* or *cerebral* surface (Fig. 37) forms part of the middle fossa of the skull; it is deeply concave, and presents eminences and depressions for the convolutions of the brain. At its anterior and internal part is seen a circular aperture, the *foramen rotundum*, for the transmission of the second division of the fifth nerve. Behind and external to this is a large oval foramen, the *foramen ovale*, for the transmission of the third division of the fifth nerve, the small meningeal artery, and sometimes the small petrosal nerve.[1] At the inner side of the foramen ovale a small aperture may occasionally be seen opposite the root of the pterygoid process; it is the *foramen Vesalii*, transmitting a small vein. Lastly, in the posterior angle, near to the spine of the sphenoid, is a short canal, sometimes double, the *foramen spinosum*; it transmits the middle meningeal artery. The *external* surface (Fig. 38) is convex, and divided by a transverse ridge, the *pterygoid ridge* or *infratemporal crest*, into two portions. The superior or larger, convex from above downward, concave from before backward, enters into the formation of the temporal fossa, and gives attachment to part of the Temporal muscle. The inferior portion, smaller in size and concave, enters into the formation of the zygomatic fossa, and affords attachment to the External pterygoid muscle. It presents, at its posterior part, a sharp-pointed eminence of bone, the *spinous process*, to which are connected the internal lateral ligament of the lower jaw and the Tensor palati muscle. The pterygoid ridge, dividing the temporal and zygomatic portions, gives attachment to part of the External pterygoid muscle. At its inner and anterior extremity is a triangular spine of bone which serves to increase the extent of origin of this muscle. The *anterior* or *orbital* surface, smooth and quadrilateral in form, assists in forming the outer wall of the orbit. It is bounded

[1] The small petrosal nerve sometimes passes through a special foramen between the foramen ovale and foramen spinosum.

above by a serrated edge, for articulation with the frontal bone; below, by a rounded border which enters into the formation of the spheno-maxillary fissure. Internally, it presents a sharp border, which forms the lower boundary of the sphenoidal fissure, and has projecting from about its centre a little tubercle of bone, which gives origin to one head of the External rectus muscle of the eye; and at its upper part is a notch for the transmission of a recurrent branch of the lachrymal artery; externally it presents a serrated margin for articulation with the malar bone. One or two small foramina may occasionally be seen for the passage of branches of the deep temporal arteries; they are called the *external orbital foramina*. *Circumference of the great wing* (Fig. 37), commencing from behind, that portion of the circumference from the body of the sphenoid to the spine, is serrated and articulates by its outer half with the petrous portion of the temporal bone, while the inner half forms the anterior boundary of the foramen lacerum medium, and presents the posterior aperture of the Vidian canal for the passage of the Vidian nerve and artery. In front of the spine the circumference of the great wing presents a serrated edge, bevelled at the expense of the inner table below and of the external above, which articulates with the squamous portion of the temporal bone. At the tip of the great wing a triangular portion is seen, bevelled at the expense of the internal surface, for articulation with the anterior inferior angle of the parietal bone. Internal to this is a triangular, serrated surface, for articulation with the frontal bone: this surface is continuous internally with the sharp inner edge of the orbital plate, which assists in the formation of the sphenoidal fissure, and externally with the serrated margin for articulation with the malar bone.

The **Lesser Wings** (*processes of Ingrassias*) are two thin, triangular plates of bone which arise from the upper and lateral parts of the body of the sphenoid, and, projecting transversely outward, terminate in a sharp point (Fig. 37). The superior surface of each is smooth, flat, broader internally than externally, and supports part of the frontal lobe of the brain. The inferior surface forms the back part of the roof of the orbit and the upper boundary of the sphenoidal fissure or foramen lacerum anterius. This fissure is of a triangular form, and leads from the cavity of the cranium into the orbit; it is bounded internally by the body of the sphenoid—above, by the lesser wing; below, by the internal margin of the orbital surface of the great wing—and is converted into a foramen by the articulation of this bone with the frontal. It transmits the third, the fourth, the three branches of the ophthalmic division of the fifth, the sixth nerve, some filaments from the cavernous plexus of the sympathetic, the orbital branch of the middle meningeal artery, a recurrent branch from the lachrymal artery to the dura mater, and the ophthalmic vein. The anterior border of the lesser wing is serrated for articulation with the frontal bone; the posterior, smooth and rounded, is received into the fissure of Sylvius of the brain. The inner extremity of this border forms the *anterior clinoid process*. The lesser wing is connected to the side of the body by two roots, the upper thin and flat, the lower thicker, obliquely directed, and presenting on its outer side, near its junction with the body, a small tubercle, for the attachment of the common tendon of origin of three of the muscles of the eye. Between the two roots is the *optic foramen*, for the transmission of the optic nerve and ophthalmic artery.

The **Pterygoid Processes** (πτέρυξ, a wing; εἶδος, likeness), one on each side, descend perpendicularly from the point where the body and greater wing unite (Fig. 39). Each process consists of an external and an internal plate, which are joined together by their anterior borders above, but are separated below, leaving an angular cleft, the *pterygoid notch*, in which the pterygoid process or tuberosity of the palate bone is received. The two plates diverge from each other from their line of connection in front, so as to form a V-shaped fossa, the *pterygoid fossa*. The *external pterygoid plate* is broad and thin, turned a little outward, and, by its outer surface, forms part of the inner wall of the zygomatic fossa, giving attachment to the External pterygoid; its inner surface forms part of the pterygoid fossa, and gives attachment to the Internal pterygoid. The *internal pterygoid plate* is much narrower and longer, curving outward, at its extremity, into a hook-like process of bone, the *hamular process*, around which turns the tendon of the Tensor palati muscle. The outer surface of this plate forms part of the pterygoid fossa, the inner surface forming the outer boundary of the posterior aperture of the nares. On the posterior surface of the base of the process, above the pterygoid fossa, is a small, oval, shallow depression, the *scaphoid fossa*, from which arises the Tensor palati, and above which is seen the


FIG. 39.—Sphenoid bone. Posterior surface.

posterior orifice of the Vidian canal. Below and to the inner side of the Vidian canal, on the posterior surface of the base of the internal plate, is a little prominence, which is known by the name of the *pterygoid tubercle*. The Superior constrictor of the pharynx is attached to the posterior edge of the internal plate. The anterior surface of the pterygoid process is very broad at its base, and forms the posterior wall of the spheno-maxillary fossa. It supports Meckel's ganglion. It presents, above, the anterior orifice of the Vidian canal; and below, a rough margin, which articulates with the perpendicular plate of the palate bone.

The **Sphenoidal Spongy Bones** are two thin, curved plates of bones, which exist as separate pieces until puberty, and occasionally are not joined to the sphenoid in the adult. They are situated at the anterior and inferior part of the body of the sphenoid, an aperture of variable size being left in their anterior wall, through which the sphenoidal sinuses open into the nasal fossæ. They are irregular in form and taper to a point behind, being broader and thinner in front. Their upper surface, which looks toward the cavity of the sinus, is concave; their under surface convex. Each bone articulates in front with the ethmoid, externally with the palate; its pointed posterior extremity is placed above the vomer, and is received between the root of the pterygoid process on the outer side and the rostrum of the sphenoid on the inner.[1]

**Development.**—Up to about the eighth month of fœtal life the sphenoid bone consists of two distinct parts: posterior or *post-sphenoid* part, which comprises the pituitary fossa, the greater wings, and the pterygoid processes; and an anterior or *pre-sphenoid* part, to which the anterior part of the body and lesser wings belong. It is developed by fourteen centres; eight for the posterior sphenoid division, and six for the anterior sphenoid. The eight centres for the posterior sphenoid are—one for each greater wing and external pterygoid plate, one for each internal pterygoid plate, two for the posterior part of the body, and

[1] A small portion of the sphenoidal turbinated bone sometimes enters into the formation of the inner wall of the orbit, between the os planum of the ethmoid in front, the orbital plate of the palate below, and the frontal above.—Cleland, *Roy. Soc. Trans.*, 1862.

one on each side for the lingula. The six for the anterior sphenoid are one for each lesser wing, two for the anterior part of the body, and one for each sphenoidal turbinated bone.

*Post-sphenoid Division.*—The first nuclei to appear are those for the greater wings (*ali-sphenoids*). They make their appearance between the foramen rotundum and foramen ovale about the eighth week, and from them the external pterygoid plates are also formed. Soon after, the nuclei for the posterior part of the body appear, one on either side of the sella turcica, and become blended together about the middle of fœtal life. About the fourth month the remaining four centres appear, those for the internal pterygoid plates being ossified in membrane and becoming joined to the external pterygoid plate about the sixth month. The centres for the lingulæ speedily become joined to the rest of the bone.

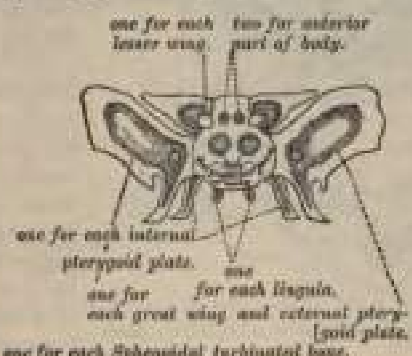



Fig. 40.—Plan of the development of sphenoid. By fourteen centres.

*Pre-sphenoid Division.*—The first nuclei to appear are those for the lesser wings (*orbito-sphenoids*). They make their appearance about the ninth week, at the outer borders of the optic foramina. A second pair of nuclei appear on the inner side of the foramina shortly after, and, becoming united, form the front part of the body of the bone. The remaining two centres for the sphenoidal turbinated bones make their appearance about the fifth month. At birth they consist of small triangular laminæ, and it is not till the third year that they become hollowed out and cone-shaped. About the fourth year they become fused with the lateral masses of the ethmoid, and hence, from an embryological point of view, may be regarded as belonging to the ethmoid.

The pre-sphenoid is united to the body of the post-sphenoid about the eighth month, so that at birth the bone consists of three pieces—viz. the body in the centre, and on each side the great wings with the pterygoid processes. The lesser wings become joined to the body at about the time of birth. At the first year after birth the greater wings and body are united. From the tenth to the twelfth year the spongy bones are partially united to the sphenoid, their junction being complete by the twentieth year. Lastly, the sphenoid joins the occipital from the eighteenth to the twenty-fifth year.

**Articulations.**—The sphenoid articulates with *all* the bones of the cranium, and five of the face—the two malar, two palate, and vomer: the exact extent of articulation with each bone is shown in the accompanying figures.[1]

**Attachment of Muscles.**—To eleven pairs: the Temporal, External pterygoid, Internal pterygoid, Superior constrictor, Tensor palati, Levator palpebræ, Obliquus oculi superior, Superior rectus, Internal rectus, Inferior rectus, External rectus.

## The Ethmoid Bone.

The **Ethmoid** (ἠθμός, a sieve) is an exceedingly light, spongy bone, of a cubical form, situated at the anterior part of the base of the cranium, between the two

[1] It also sometimes articulates with the tuberosity of the superior maxilla.

orbits, at the root of the nose, and contributing to form each of these cavities. It consists of three parts: a horizontal plate, which forms part of the base of the cranium; a perpendicular plate, which forms part of the septum nasi; and two lateral masses of cells.

The **Horizontal** or **Cribriform Plate** (Fig. 41) forms part of the anterior fossa of the base of the skull, and is received into the ethmoid notch of the frontal bone between the two orbital plates. Projecting upward from the middle line of this plate is a thick, smooth, triangular process of bone, the *crista galli*, so called from its resemblance to a cock's comb. Its base joins the cribriform plate. Its posterior border, long, thin, and slightly curved, serves for the attachment of the falx cerebri. Its anterior border, short and thick, articulates with the frontal bone, and presents two small projecting alæ, which are received into corresponding depressions in the frontal, completing the foramen cæcum behind. Its sides are smooth and sometimes bulging; in which case it is found to enclose a small sinus.[1] On each side of the crista galli the cribriform plate is narrow and deeply grooved, to support the bulb of the olfactory tract, and perforated by foramina for the passage of the olfactory nerves. These foramina are arranged in three rows: the innermost, which are the largest and least numerous, are lost in grooves on the upper part of the septum; the foramina of the outer row are continued on to the surface of the upper spongy bone. The foramina of the middle row are the smallest; they perforate the bone and transmit nerves to the roof of the nose. At the front part of the cribriform plate, on each side of the crista galli, is a small fissure, which transmits the nasal branch of the ophthalmic nerve; and at its posterior part a a triangular notch, which receives the ethmoidal spine of the sphenoid.


With inferior turbinated bone.

FIG. 41.—Ethmoid bone. Outer surface of right lateral mass (enlarged).

The **Perpendicular Plate** (Fig. 42) is a thin, flattened lamella of bone, which descends from the under surface of the cribriform plate, and assists in forming the septum of the nose. It is much thinner in the middle than at the circumference, and is generally deflected a little to one side. Its anterior border articulates with the nasal spine of the frontal bone and crest of the nasal bones. Its posterior border, divided into two parts, articulates by its upper half with the sphenoidal crest of the sphenoid, by its lower half with the vomer. The inferior border serves for the attachment of the triangular cartilage of the nose. On each side of the perpendicular plate numerous grooves and canals are seen, leading from foramina on the cribriform plate; they lodge filaments of the olfactory nerves.

The **Lateral Masses** of the ethmoid consist of a number of thin-walled cellular cavities, the *ethmoidal cells*, interposed between two vertical plates of bone, the outer one of which forms part of the orbit, and the inner one part of the nasal fossa of the corresponding side. In the disarticulated bone many of these cells appear to be broken; but when the bones are articulated they are closed in at every part, except where they open into the nasal fossæ. The upper surface of each lateral mass presents a number of apparently half-broken cel-

[1] Sir George Humphry states that the crista galli is commonly inclined to one side, usually the opposite to that toward which the lower part of the perpendicular plate is bent.—*The Human Skeleton*, 1858, p. 277.

lular spaces; these are closed in when articulated by the edges of the ethmoidal notch of the frontal bone. Crossing this surface are two grooves on each side, converted into canals by articulation with the frontal; they are the *anterior* and *posterior ethmoidal* canals, and open on the inner wall of the orbit. The posterior surface also presents large, irregular cellular cavities, which are closed in by articulation with the sphenoidal turbinated bones and orbital process of the palate. The cells at the anterior surface are completed by the lachrymal bone and nasal process of the superior maxillary, and those below also by the superior maxillary. The outer surface of each lateral mass is formed of a thin, smooth, oblong plate of bone, called the *os planum*; it forms part of the inner wall of the orbit, and articulates, above, with the orbital plate of the frontal; below, with the superior maxillary; in front, with the lachrymal; and behind, with the sphenoid and orbital process of the palate.


FIG. 42.—Perpendicular plate of ethmoid (enlarged), shown by removing the right lateral mass.

From the inferior part of each lateral mass, immediately beneath the os planum, there projects downward and backward an irregular lamina of bone, called the *unciform process*, from its hook-like form: it serves to close in the upper part of the orifice of the antrum, and articulates with the ethmoidal process of the inferior turbinated bone. It is often broken in disarticulating the bones.

The inner surface of each lateral mass forms part of the outer wall of the nasal fossa of the corresponding side. It is formed of a thin lamella of bone, which descends from the under surface of the cribriform plate, and terminates below in a free, convoluted margin, the *middle turbinated* bone. The whole of this surface is rough and marked above by numerous grooves, which run nearly vertically downward from the cribriform plate; they lodge branches of the olfactory nerve, which are distributed on the mucous membrane covering the bone. The back part of this surface is subdivided by a narrow oblique fissure, the *superior meatus* of the nose, bounded above by a thin, curved plate of bone, the *superior turbinated* bone. By means of an orifice at the upper part of this fissure the posterior ethmoidal cells open into the nose. Below, and in front of the superior meatus, is seen the convex surface of the middle turbinated bone. It extends along the whole length of the inner surface of each lateral mass; its lower margin is free and thick, and its concavity, directed outward, assists in forming the middle meatus. It is by a large orifice at the upper and front part of the middle meatus that the anterior ethmoidal cells, and through them the frontal sinuses, communicate with the nose by means of a funnel-shaped canal, the *infundibulum*.

FIG. 43.—Ethmoid bone. Inner surface of right lateral mass (enlarged).

The cellular cavities of each lateral mass, thus walled in by the os planum on the outer side and by the other bones already mentioned, are divided by a thin transverse bony partition into two sets, which do not communicate with each other; they are termed the *anterior* and *posterior ethmoidal cells* or *sinuses*. The former, more numerous, communicate with the frontal sinuses above and the middle meatus below by means of a long, flexuous canal, the *infundibulum;* the posterior, less numerous, open into the superior meatus, and communicate (occasionally) with the sphenoidal sinuses.

**Development.**—By *three* centres: one for the perpendicular lamella, and one for each lateral mass.

The lateral masses are first developed, ossific granules making their appearance in the os planum between the fourth and fifth months of fœtal life, and extending into the spongy bones. At birth the bone consists of the two lateral masses, which are small and ill-developed. During the first year after birth the perpendicular plate and crista galli begin to ossify, from a single nucleus, and become joined to the lateral masses about the beginning of the second year. The cribriform plate is ossified partly from the perpendicular plate and partly from the lateral masses. The formation of the ethmoidal cells, which completes the bone, does not commence until about the fourth or fifth year.

**Articulations.**—With fifteen bones: the sphenoid, two sphenoidal turbinated, the frontal, and eleven of the face—the two nasal, two superior maxillary, two lachrymal, two palate, two inferior turbinated, and the vomer. No muscles are attached to this bone.

## DEVELOPMENT OF THE CRANIUM.

The early stages of the development of the cranium have already been described. We have seen that it is formed from a layer of mesoblast, derived from the protovertebral plates of the trunk, which is spread over the whole surface of the rudimentary brain. That portion of this layer from which the bones of the skull are to be developed consists of a thin, membranous capsule.

Ossification commences in the roof, and is preceded by the deposition of a membranous blastema upon the surface of the cerebral capsule, in which the ossifying process extends, the primitive membranous capsule becoming the internal periosteum, and being ultimately blended with the dura mater. The ossification of the bones of the base takes place for the most part in cartilage, and although the bones of the vertex of the skull appear before those at the base, and make considerable progress in their growth, at birth ossification is more advanced in the base, this portion of the skull forming a solid, immovable groundwork.

### The Fontanelles.

Before birth the bones at the vertex and side of the skull are separated from each other by membranous intervals in which bone is deficient. These intervals are principally found at the four angles of the parietal bones. Hence there are six fontanelles. Their formation is due to

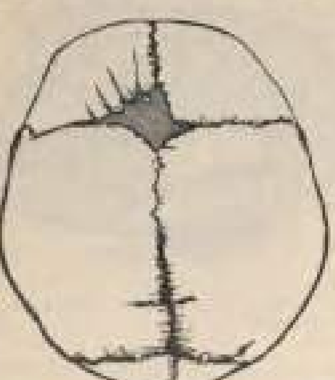


FIG. 44.—Skull at birth, showing the anterior and posterior fontanelles.

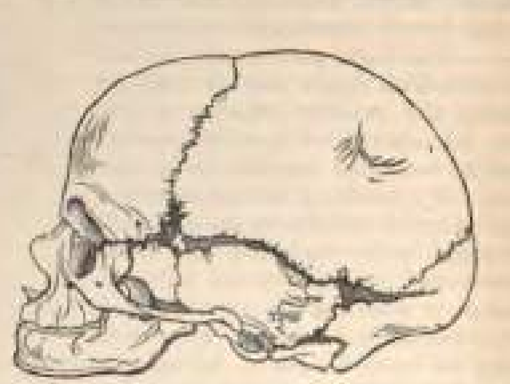


FIG. 45.—The lateral fontanelles.

the wave of ossification being circular and the bones quadrilateral: the ossific matter first meets at the margins of the bones, at the points nearest to their centres of ossification, and vacuities or spaces are left at the angles, which are called *fontanelles*, so named from the pulsations of the brain, which are perceptible at the anterior fontanelle, were likened to the rising of water in a fountain. The anterior fontanelle is the largest; it is lozenge-shaped, and corresponds to the junction of the sagittal and coronal sutures; the posterior fontanelle, of smaller size, is triangular, and is situated at the junction of the sagittal and lambdoid sutures; the remaining ones are situated at the inferior angles of each parietal bone. The latter are closed soon after birth; the two at the two superior angles remain open longer; the posterior being closed in a few months after birth; the anterior remaining open until the first or second year. These spaces are gradually filled in by an extension of the ossifying process or by the development of a Wormian bone. Sometimes the anterior fontanelle remains open beyond two years, and is occasionally persistent throughout life.

### Supernumerary or Wormian[1] Bones.

In addition to the constant centres of ossification of the skull, additional ones are occasionally found in the course of the sutures. These form irregular, isolated bones, interposed between the cranial bones, and have been termed *Wormian bones* or *ossa triquetra*. They are most frequently found in the course of the lambdoid suture, but occasionally also occupy the situation of the fontanelles, especially the posterior and, more rarely, the anterior. Frequently one is found between the anterior inferior angle of the parietal bone and the greater wing of the sphenoid, the *pterion ossicle* (Fig. 45). They have a great tendency to be symmetrical on the two sides of the skull, and they vary much in size, being in some cases not larger than a pin's head, and confined to the outer table; in other cases so large that one pair of these bones may form the whole of the occipital bone above the superior curved lines, as described by Bédard and Ward. Their number is generally limited to two or three, but more than a hundred have been found in the skull of an adult hydrocephalic skeleton. In their development, structure, and mode of articulation they resemble the other cranial bones.

### Congenital Fissures and Gaps.

An arrest in the ossifying process may give rise to deficiencies or gaps; or to fissures, which are of importance in a medico-legal point of view, as they are liable to be mistaken for fractures. The fissures generally extend from the margins toward the centre of the bone, but the gaps may be found in the middle as well as at the edges. In course of time they may become covered with a thin lamina of bone.

## BONES OF THE FACE.

The Facial Bones are fourteen in number—viz. the

| | |
|---|---|
| Two Nasal. | Two Palate. |
| Two Superior Maxillary. | Two Inferior Turbinated. |
| Two Lachrymal. | Vomer. |
| Two Malar. | Inferior Maxillary. |

"Of these, the upper and lower jaws are the fundamental bones for mastication, and the others are accessories; for the chief function of the facial bones is to provide an apparatus for mastication, while subsidiary functions are to provide for the sense-organs (eye, nose, tongue) and a vestibule to the respiratory and vocal organs. Hence the variations in the shape of the face in man and the lower animals depend chiefly on the question of the character of their food and their mode of obtaining it."[2]

### The Nasal Bone.

The **Nasal** (*nasus*, the nose) are two small oblong bones, varying in size and form in different individuals; they are placed side by side at the middle and upper part of the face, forming, by their junction, "the bridge" of the nose (Fig. 46). Each bone presents for examination two surfaces and four borders. The *outer* surface is concave from above downward, convex from side to side; it is covered by the Pyramidalis and Compressor nasi muscles, and gives attachment at its upper part to a few fibres of the Occipito-frontalis muscle (Theile). It is marked by numerous small arterial furrows, and perforated about its centre by a foramen, sometimes double, for the transmission of a small vein. The *inner* surface is concave from side to side, convex from above downward; in which direction

[1] Wormius, a physician in Copenhagen, is said to have given the first detailed description of these bones.

[2] W. W. Keen, American edition p. 185.

it is traversed by a longitudinal groove (sometimes a canal), for the passage of a branch of the nasal nerve. The *superior* border is narrow, thick, and serrated, for articulation with the nasal notch of the frontal bone. The *inferior*

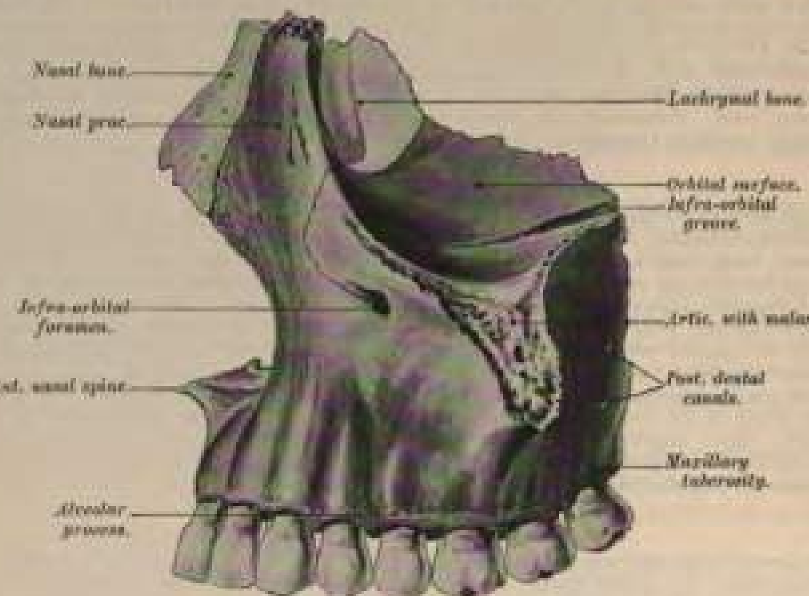



FIG. 46.—Nasal and lachrymal bone *in situ*.

border is broad, thin, sharp, inclined obliquely downward, outward, and backward, and serves for the attachment of the lateral cartilage of the nose. This border presents, about its middle, a notch, through which passes the branch of the nasal nerve above referred to, and is prolonged at its inner extremity into a sharp spine, which, when articulated with the opposite bone, forms the *nasal angle*. The *external* border is serrated, bevelled at the expense of the internal surface above and of the external below, to articulate with the nasal process of the superior maxillary. The *internal* border, thicker above than below, articulates with its fellow of the opposite side, and is prolonged behind into a vertical crest which forms part of the septum of the nose; this crest articulates above downward with the nasal spine of the frontal above, and the perpendicular plate of the ethmoid, and the triangular septal cartilage of the nose.


*Outer Surface.*
FIG. 47.—Right nasal bone.


*Inner Surface.*
FIG. 48.—Left nasal bone.

**Development.**—By *one* centre for each bone, which appears about the eighth week.

**Articulations.**—With four bones: two of the cranium, the frontal and ethmoid, and two of the face, the opposite nasal and the superior maxillary.

**Attachment of Muscles.**—A few fibres of the Occipito-frontalis muscle.

## The Superior Maxillary Bones or Maxillæ.

The **Superior Maxillary** (*maxilla*, the jaw-bone) are the most important bones of the face from a surgical point of view, on account of the number of diseases to which some of their parts are liable. Their careful examination becomes, therefore, a matter of considerable interest. They are the largest bones of the face, excepting the lower jaw, and form, by their union, the whole of the upper jaw. Each bone assists in the formation of three cavities, the roof of the mouth, the floor and outer wall of the nasal fossæ, and the floor of the orbit, and also enters into the formation of two fossæ, the zygomatic and spheno-maxillary, and two fissures, the spheno-maxillary and pterygo-maxillary.

The bone presents for examination a body and four processes—malar, nasal, alveolar, and palate.

The **body** is somewhat cuboid, and is hollowed out in its interior to form a large cavity, the *antrum of Highmore*. Its surfaces are four—an external or facial, a posterior or zygomatic, a superior or orbital, and an internal or nasal.

The **external** or **facial surface** (Fig. 49) is directed forward and outward. It presents at its lower part a series of eminences corresponding to the position of the teeth. Just above those for the incisor teeth is a depression, the *incisive* or *myrtiform fossa*, which gives origin to the Depressor alæ nasi; and below it to the alveolar border is attached a slip of the Orbicularis oris. Above and a little external to it the Compressor nasi arises. More external is another depression, the *canine fossa*, larger and deeper than the incisive fossa, from which

*Outer Surface.*


Fig. 49.—Left superior maxillary bone. Outer surface.

it is separated by a vertical ridge, the *canine eminence*, corresponding to the socket of the canine tooth. The canine fossa gives origin to the Levator anguli oris. Above the canine fossa is the *infraorbital foramen*, the termination of the infraorbital canal; it transmits the infraorbital vessels and nerve. Sometimes the infraorbital canal opens by two, very rarely by three, orifices on the face. Above the infraorbital foramen is the margin of the orbit, which affords partial attachment to the Levator labii superioris proprius. To the sharp margin of bone which bounds this surface in front and separates it from the internal surface is attached the Dilator naris posterior.

The **posterior** or **zygomatic surface** is convex, directed backward and outward, and forms part of the zygomatic fossa. It is separated from the facial surface by a strong ridge of bone, which extends upward from the socket of the second molar tooth. It presents about its centre several apertures leading to canals in the substance of the bone; they are termed the *posterior dental canals*, and transmit the posterior dental vessels and nerves. At the lower part of this surface is a rounded eminence, the *maxillary tuberosity*, especially prominent after the growth of the wisdom-tooth, rough on its inner side for articulation with the tuberosity of the palate bone, and sometimes with the external pterygoid plate. It gives attachment to a few fibres of origin of the Internal pterygoid muscle. Immediately above this is a smooth surface, which forms the anterior boundary of the spheno-maxillary fossa; it presents a groove which, running obliquely downward, is converted into a canal by articulation with the palate-bone, forming the *posterior palatine* canal.

The **superior** or **orbital surface** is thin, smooth, triangular, and forms part of the floor of the orbit. It is bounded internally by an irregular margin which in front presents a notch, the *lachrymal notch*, which receives the lachrymal bone; in the middle articulates with the os planum of the ethmoid, and behind with the orbital process of the palate bone; bounded externally by a smooth, rounded edge which enters into the formation of the spheno-maxillary fissure, and which sometimes articulates at its anterior extremity with the orbital plate of the sphenoid; bounded in front by part of the circumference of the orbit, which is continuous on the inner side with the nasal, on the outer side with the malar, process. Along the middle line of the orbital surface is a deep groove, the *infraorbital*, for the passage of the infraorbital vessels and nerve. The groove commences at the middle of the outer border of this surface, and, passing forward, terminates in a canal, which subdivides into two branches. One of the canals, the *infraorbital*, opens

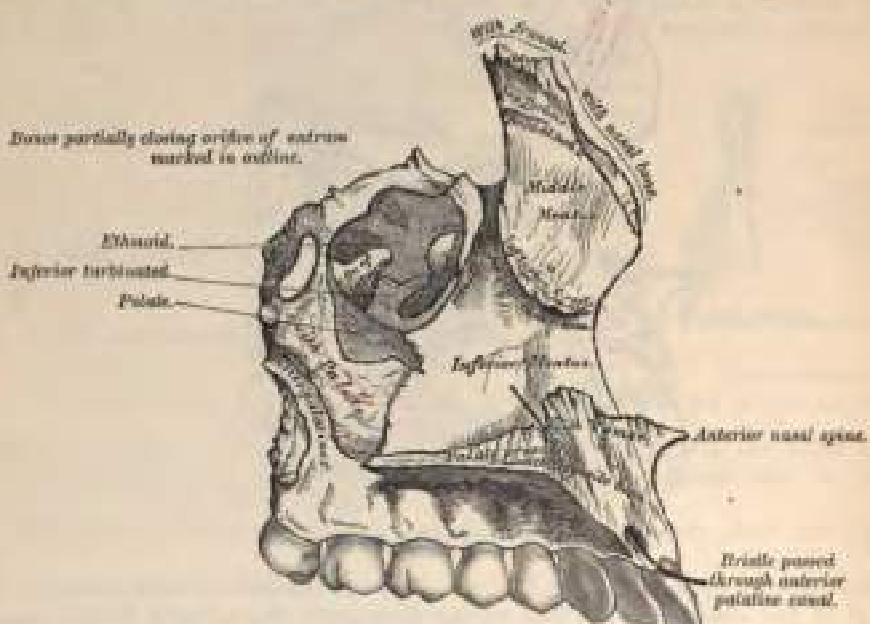



FIG. 50.—Left superior maxillary bone. Internal surface.

just below the margin of the orbit; the other, which is smaller, runs downward in the substance of the anterior wall of the antrum; it is called the *anterior dental* canal, and transmits the anterior dental vessels and nerve to the front teeth of the upper jaw. From the back part of the infraorbital canal a second small canal is sometimes given off, which runs downward in the outer wall of the antrum, and conveys the middle dental nerve to the bicuspid teeth. Occasionally this canal is derived from the anterior dental. At the inner and fore part of the orbital surface, just external to the lachrymal groove for the nasal duct, is a depression which gives origin to the Inferior oblique muscle of the eye.

The **internal surface** (Fig. 50) is unequally divided into two parts by a horizontal projection of bone, the *palate process*: the portion above the palate process forms part of the outer wall of the nasal fossæ; that below it forms part of the cavity of the mouth. The superior division of this surface presents a large, irregular opening leading into the *antrum of Highmore*. At the upper border of this aperture are numerous broken cellular cavities, which in the articulated skull are closed in by the ethmoid and lachrymal bones. Below the aperture is a smooth concavity which forms part of the inferior meatus of the nasal fossæ, and behind it is a rough surface which articulates with the perpendicular plate of the palate bone, traversed by a groove which, commencing near the middle of the posterior border, runs obliquely downward and forward, and forms, when completed by its articulation with the palate bone, the *posterior palatine canal*. In front of the opening of the antrum is a deep groove, converted into a canal by the lachrymal and inferior turbinated bones. It is called the *lachrymal groove*, and lodges the nasal duct. More anteriorly is a well-marked rough ridge, the *inferior turbinated crest*, for articulation with the inferior turbinated bone. The shallow concavity above this ridge forms part of the middle meatus of the nose, while that below it forms part of the inferior meatus. The portion of this surface below the palate process is concave, rough and uneven, and perforated by numerous small foramina for the passage of nutrient vessels. It enters into the formation of the roof of the mouth.

The **Antrum of Highmore**, or **Maxillary Sinus**, is a large, pyramidal cavity hollowed out of the body of the maxillary bone: its apex, directed outward, is formed by the malar process; its base, by the outer wall of the nose. Its walls are everywhere exceedingly thin, and correspond to the orbital, facial, and zygomatic surfaces of the body of the bone. Its inner wall, or base, presents, in the disarticulated bone, a large, irregular aperture, which communicates with the nasal fossa. The margins of this aperture are thin and ragged, and the aperture itself is much contracted by its articulation with the ethmoid above, the inferior turbinated below, and the palate bone behind.[1] In the articulated skull this cavity communicates with the middle meatus of the nasal fossæ, generally by two small apertures left between the above-mentioned bones. In the recent state usually only one small opening exists, near the upper part of the cavity, sufficiently large to admit the end of a probe, the other being closed by the lining membrane of the sinus.

Crossing the cavity of the antrum are often seen several projecting laminæ of bone, similar to those seen in the sinuses of the cranium; and on its posterior wall are the *posterior dental canals*, transmitting the posterior dental vessels and nerves to the teeth. Projecting into the floor are several conical processes, corresponding to the roots of the first and second molar teeth;[2] in some cases the floor is perforated by the teeth in this situation.

It is from the extreme thinness of the walls of this cavity that we are enabled to explain how a tumor growing from the antrum encroaches upon the adjacent parts, pushing up the floor of the orbit, and displacing the eyeball, projecting inward into the nose, protruding forward on to the cheek, and making its way backward into the zygomatic fossa and downward into the mouth.

The **Malar Process** is a rough, triangular eminence, situated at the angle of

[1] In some cases, at any rate, the lachrymal bone encroaches slightly on the anterior superior portion of the opening, and assists in forming the inner wall of the antrum.

[2] The number of teeth whose fangs are in relation with the floor of the antrum is variable. The antrum "may extend so as to be in relation to all the teeth of the true maxilla, from the canine to the *dens sapientiæ*." (See Mr. Salter on Abscess of the Antrum, in a *System of Surgery*, edited by T. Holmes, 2d ed. vol. iv. p. 356.)

separation of the facial from the zygomatic surface. In front it is concave, forming part of the facial surface; behind it is also concave, and forms part of the zygomatic fossa; above it is rough and serrated for articulation with the malar bone; whilst below a prominent ridge marks the division between the facial and zygomatic surfaces. A small part of the Masseter muscle arises from this process.

The **Nasal Process** is a strong, triangular plate of bone, which projects upward, inward, and backward by the side of the nose, forming part of its lateral boundary. Its *external* surface is concave, smooth, perforated by numerous foramina, and gives attachment to the Levator labii superioris alæque nasi, the Orbicularis palpebrarum, and Tendo oculi. Its *internal* surface forms part of the outer wall of the nasal fossæ: at its upper part it presents a rough, uneven surface, which articulates with the ethmoid bone, closing in the anterior ethmoidal cells; below this is a transverse ridge, the *superior turbinated crest*, for articulation with the middle turbinated bone of the ethmoid, bounded below by a shallow smooth concavity which forms part of the middle meatus; below this again is the inferior turbinated crest (already described), where the process joins the body of the bone. Its upper border articulates with the frontal bone. The *anterior* border of the nasal process is thin, directed obliquely downward and forward, and presents a serrated edge for articulation with the nasal bone; its *posterior* border is thick, and hollowed into a groove, the *lachrymal groove*, for the nasal duct: of the two margins of this groove, the inner one articulates with the lachrymal bone, the outer one forms part of the circumference of the orbit. Just where the latter joins the orbital surface is a small tubercle, the *lachrymal tubercle*; this serves as a guide to the position of the lachrymal sac in the operation for fistula lachrymalis. The lachrymal groove in the articulated skull is converted into a canal by the lachrymal bone and lachrymal process of the inferior turbinated; it is directed downward, and a little backward and outward, is about the diameter of a goose-quill, slightly

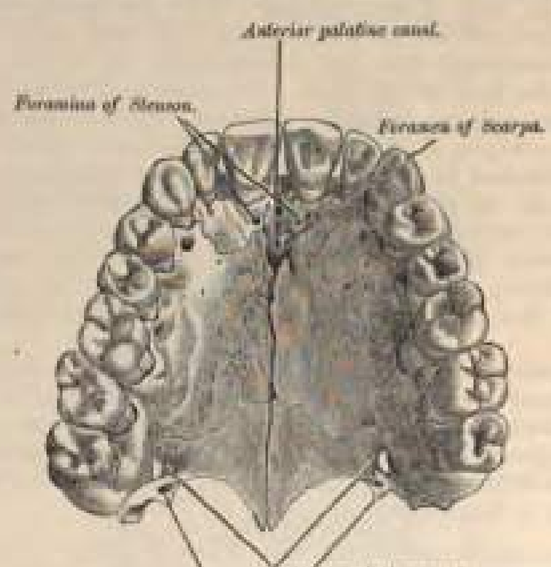



Fig. 51.—The palate and alveolar arch.

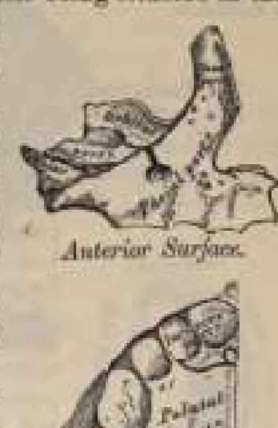
narrower in the middle than at either extremity, and terminates below in the inferior meatus. It lodges the nasal duct.

The **Alveolar Process** is the thickest and most spongy part of the bone, broader behind than in front, and excavated into deep cavities for the reception of the teeth.

These cavities are eight in number, and vary in size and depth according to the teeth they contain. That for the canine tooth is the deepest; those for the molars are the widest, and subdivided into minor cavities; those for the incisors are single, but deep and narrow. The Buccinator muscle arises from the outer surface of this process, as far forward as the first molar tooth.

The **Palate Process**, thick and strong, projects horizontally inward from the inner surface of the bone. It is much thicker in front than behind, and forms a considerable part of the floor of the nostril and the roof of the mouth.

Its *inferior* surface (Fig. 51) is concave, rough and uneven, and forms part of the roof of the mouth. This surface is perforated by numerous foramina for the passage of the nutrient vessels, channelled at the back part of its alveolar border by a longitudinal groove, sometimes a canal, for the transmission of the posterior palatine vessels, and the anterior and external palatine nerves from Meckel's ganglion, and presents little depressions for the lodgement of the palatine glands. When the two superior maxillary bones are articulated together, a large orifice may be seen in the middle line, immediately behind the incisor teeth. This is the *anterior palatine canal* or *fossa*. On examining the bottom of this fossa four canals are seen: two branch off laterally to the right and left nasal fossæ, and two, one in front and one behind, lie in the middle line. The former pair of these canals are named the *foramina of Stenson*, and through them passes the anterior or terminal branch of the descending or posterior palatine arteries, which ascend from the mouth to the nasal fossæ. The canals in the middle line are termed the *foramina of Scarpa*, and transmit the naso-palatine nerves, the left passing through the anterior, and the right through the posterior, canal. On the palatal surface of the process a delicate linear suture may sometimes be seen extending from the anterior palatine fossa to the interval between the lateral incisor and the canine tooth. This marks out the intermaxillary or incisive bone, which in some animals exists permanently as a separate piece. It includes the whole thickness of the alveolus, the corresponding part of the floor of the nose, and the anterior nasal spine, and contains the sockets of the incisor teeth. The *upper* surface is concave from side to side, smooth, and forms part of the floor of the nose. It presents the upper orifices of the foramina of Stenson and Scarpa, the former being on each side of the middle line, the latter being situated in the intermaxillary suture, and therefore not visible unless the two bones are placed in apposition. The *outer* border of the palate process is incorporated with the rest of the bone. The *inner* border is thicker in front than behind, and is raised above into a ridge, the *nasal crest*, which, with the corresponding ridge in the opposite bone, forms a groove for the reception of the vomer. In front this crest rises to a considerable height, and this portion is named the *incisor crest*. The *anterior* margin is bounded by the thin, concave border of the opening of the nose, prolonged forward internally into a sharp process, forming, with a similar process of the opposite bone, the *anterior nasal spine*. The *posterior* border is serrated for articulation with the horizontal plate of the palate bone.



*Anterior Surface.*

*Inferior Surface.*

Fig. 52.—Development of superior maxillary bone. At birth.

**Development.**—This bone commences to ossify at a very early period, and ossification proceeds in it with great rapidity, so that it is difficult to ascertain with certainty its precise number of centres. It appears, however, probable that it is ossified from four centres, which are deposited in membrane. 1. One which forms that portion of the body of the bone which lies internal to the infra-orbital canal, including the floor of the orbit, the outer wall of the nasal fossa, and the nasal process; 2. A second which gives origin to that portion of the bone which lies external to the infra-orbital canal and the malar process; 3. A third from which is developed the palatine process posterior to Stenson's canal and the adjoining part of the nasal wall; 4. And a fourth for the front part of the alveolus which carries the incisor teeth and corresponds to the pre-maxillary bone of the lower animals. These centres appear about the eighth week, and by the tenth week the three first-named centres have become fused together and the bone consists of two portions, one the maxilla proper, and the other the pre-maxillary portion. The suture between these two portions on the palate persists till middle life, but is not to be seen on the facial surface. This is believed by Callender to be due to the fact that the front wall of the sockets of the incisive teeth is not formed by the pre-maxillary bone, but by an outgrowth from the facial part of the superior maxilla. The antrum appears as a shallow groove on the inner surface of the bone at an earlier period than any of the other nasal sinuses, its development commencing about the fourth month of fœtal life. The sockets for the teeth are formed by the growing downward of two plates from the dental groove, which subsequently becomes divided by partitions jutting across from the one to the other.

**Articulations.**—With *nine* bones: two of the cranium, the frontal and ethmoid, and seven of the face—viz. the nasal, malar, lachrymal, inferior turbinated, palate, vomer, and its fellow of the opposite side. Sometimes it articulates with the orbital plate of the sphenoid, and sometimes with its external pterygoid plate.

**Attachment of Muscles.**—To twelve: the Orbicularis palpebrarum, Obliquus oculi inferior, Levator labii superioris alæque nasi, Levator labii superioris proprius, Levator anguli oris, Compressor nasi, Depressor alæ nasi, Dilatator naris posterior, Masseter, Buccinator, Internal pterygoid, and Orbicularis oris.

## CHANGES PRODUCED IN THE UPPER JAW BY AGE.

At birth and during infancy the diameter of the bone is greater in an antero-posterior than in a vertical direction. Its nasal process is long, its orbital surface large, and its tuberosity well marked. In the adult the vertical diameter is the greater, owing to the development of the alveolar process and the increase in size of the antrum. In old age the bone approaches again in character to the infantile condition; its height is diminished, and after the loss of the teeth the alveolar process is absorbed, and the lower part of the bone contracted and diminished in thickness.

## The Lachrymal Bones.

The **Lachrymal** (*lachryma*, a tear) are the smallest and most fragile bones of the face. They are situated at the front part of the inner wall of the orbit (Fig. 46), and resemble somewhat in form, thinness, and size a finger-nail; hence they are termed the *ossa unguis*. Each bone presents for examination two surfaces and four borders. The **external** or **orbital** surface (Fig. 53) is divided by a vertical ridge, the *lachrymal crest*, into two parts. The portion of bone in front of this ridge presents a smooth, concave, longitudinal groove, the free margin of which unites with the nasal process of the superior maxillary bone, completing the lachrymal groove. The upper part of this groove lodges the lachrymal sac; the lower part lodges the nasal duct. The portion of bone behind the ridge is smooth, slightly concave, and forms part of the inner wall of the orbit. The ridge, with a part of the orbital surface immediately behind it, affords attachment to the Tensor tarsi muscle: it terminates below in a small, hook-like projection, the *hamular process*, which articulates with the lachrymal tubercle of the superior maxillary bone, and completes the upper orifice of the lachrymal groove. It sometimes exists as a separate piece, which is then called the *lesser lachrymal bone*. The *internal* or *nasal* surface presents a depressed furrow, corresponding to the


Fig. 53.—Left lachrymal bone. External surface. (Slightly enlarged.)

ridge on its outer surface. The surface of bone in front of this forms part of the middle meatus, and that behind it articulates with the ethmoid bone, filling in the anterior ethmoidal cells. Of the *four borders*, the *anterior* is the longest, and articulates with the nasal process of the superior maxillary bone. The *posterior*, thin and uneven, articulates with the os planum of the ethmoid. The *superior*, the shortest and thickest, articulates with the internal angular process of the frontal bone. The *inferior* is divided by the lower edge of the vertical crest into two parts; the posterior part articulates with the orbital plate of the superior maxillary bone; the anterior portion is prolonged downward into a pointed process, which articulates with the lachrymal process of the inferior turbinated bone and assists in the formation of the lachrymal groove.

**Development.**—By a single centre, which makes its appearance soon after ossification of the vertebræ has commenced.

**Articulations.**—With four bones: two of the cranium, the frontal and ethmoid, and two of the face, the superior maxillary and the inferior turbinated.

**Attachment of Muscles.**—To one muscle, the Tensor tarsi.

## The Malar Bones.

The **Malar** (*mala*, the cheek) are two small, quadrangular bones, situated at the upper and outer part of the face: they form the prominence of the cheek, part of the outer wall and floor of the orbit, and part of the temporal and zygomatic fossæ (Fig. 54). Each bone presents for examination an external and an internal surface; four processes, the frontal, orbital, maxillary, and zygomatic; and four borders. The **external surface** (Fig. 55) is smooth, convex, perforated near its

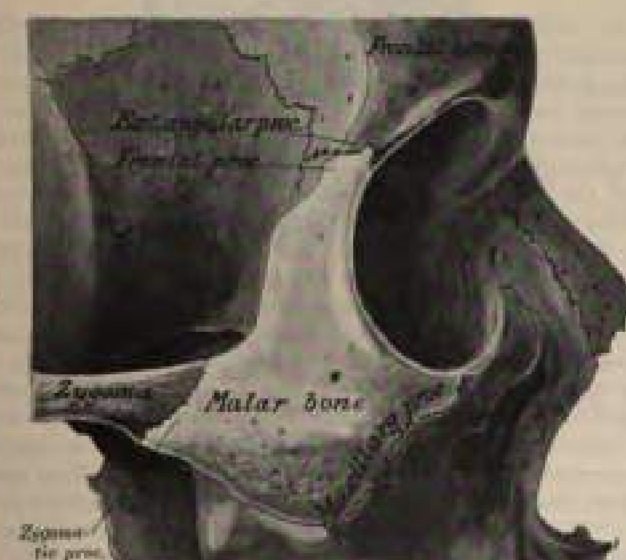



FIG. 54.—Malar bone *in situ*.

centre by one or two small apertures, the *malar foramina*, for the passage of nerves and vessels, covered by the Orbicularis palpebrarum muscle, and affords attachment to the Zygomaticus major and minor muscles.

The **internal surface** (Fig. 56), directed backward and inward, is concave, presenting internally a rough, triangular surface, for articulation with the superior maxillary bone; and externally, a smooth concave surface, which above forms the anterior boundary of the temporal fossa, and below, where it is wider, forms part of the zygomatic fossa. This surface presents, a little above its centre, the aperture of one or two malar canals, and affords attachment to a portion of the

Masseter muscle at its lower part. Of the four processes, the **frontal** is thick and serrated, and articulates with the external angular process of the frontal bone. To its orbital margin is attached the external tarsal ligament. The **orbital** process is a thick and strong plate, which projects backward from the orbital margin of the bone. Its *supero-internal* surface, smooth and concave, forms, by its junction with the orbital surface of the superior maxillary bone and with the great wing of the sphenoid, part of the floor and

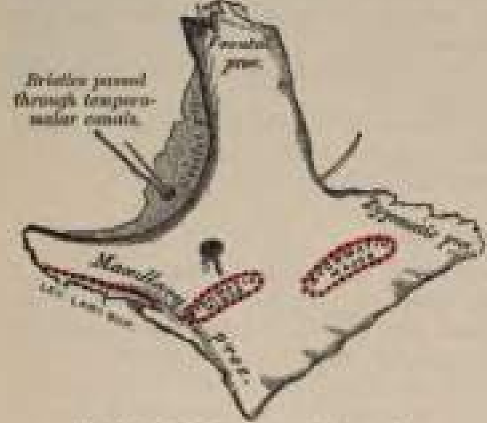



FIG. 55.—Left malar bone. Outer surface.

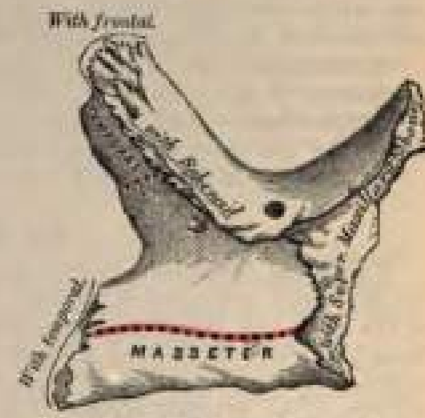



FIG. 56.—Left malar bone. Inner surface.

outer wall of the orbit. Its *infero-external* surface, smooth and convex, forms part of the zygomatic and temporal fossæ. Its *anterior* margin is smooth and rounded, forming part of the circumference of the orbit. Its *superior* margin, rough and directed horizontally, articulates with the frontal bone behind the external angular process. Its *posterior* margin is rough, and serrated for articulation with the sphenoid; *internally* it is also serrated for articulation with the orbital surface of the superior maxillary. At the angle of junction of the sphenoidal and maxillary portions a short, rounded, non-articular margin is generally seen; this forms the anterior boundary of the spheno-maxillary fissure: occasionally, no such non-articular margin exists, the fissure being completed by the direct junction of the maxillary and sphenoid bones or by the interposition of a small Wormian bone in the angular interval between them. On the *upper* surface of the orbital process are seen the orifices of one or two temporo-malar canals; one of these usually opens on the posterior surface, the other (occasionally two) on the facial surface: they transmit filaments (tempero-malar) of the orbital branch of the superior maxillary nerve. The **maxillary** process is a rough, triangular surface which articulates with the superior maxillary bone. The **zygomatic** process, long, narrow, and serrated, articulates with the zygomatic process of the temporal bone. Of the **four borders,** the *antero-superior* or *orbital* is smooth, arched, and forms a considerable part of the circumference of the orbit. The *antero-inferior* or *maxillary* border is rough, and bevelled at the expense of its inner table, to articulate with the superior maxillary bone; affording attachment by its margin to the Levator labii superioris proprius, just at its point of junction with the superior maxillary. The *postero-superior* or *temporal* border, curved like an italic letter *f*, is continuous above with the commencement of the temporal ridge; below, with the upper border of the zygomatic arch: it affords attachment to the temporal fascia. The *postero-inferior* or *zygomatic* border is continuous with the lower border of the zygomatic arch, affording attachment by its rough edge to the Masseter muscle.

**Development.**—The malar bone ossifies generally from three centres, which appear about the eighth week—one for the zygomatic and two for the orbital portion—and fuse about the fifth month of fœtal life. The bone is sometimes, after birth, seen to be divided by a horizontal suture into an upper and larger and a lower and smaller division. In some quadrumana the malar bone consists of two parts, an orbital and a malar, which are ossified by separate centres.

**Articulations.**—With four bones: three of the cranium, frontal, sphenoid, and temporal; and one of the face, the superior maxillary.

**Attachment of Muscles.**—To four: The Levator labii superioris proprius, Zygomaticus major and minor, and Masseter.

## The Palate Bones.

The **Palate Bones** (*palatum*, the palate) are situated at the back part of the nasal fossæ: they are wedged in between the superior maxillary bones and the pterygoid processes of the sphenoid (Fig. 57). Each bone assists in the for-

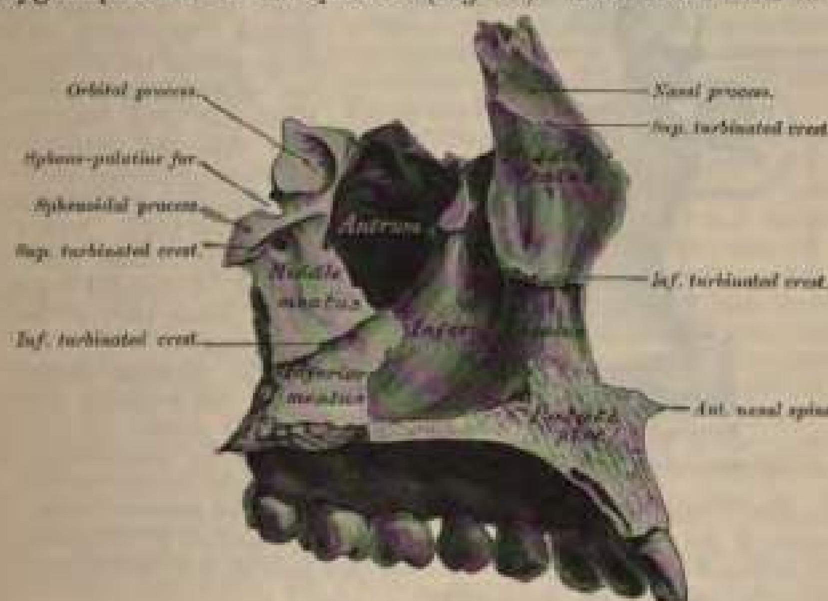



Fig. 57.—Palate bone *in situ*.

mation of three cavities: the floor and outer wall of the nose, the roof of the mouth, and the floor of the orbit, and enters into the formation of two fossæ, the spheno-maxillary and pterygoid; and one fissure, the spheno-maxillary. In form the palate bone somewhat resembles the letter L, and may be divided into an inferior or horizontal plate and a superior or vertical plate.

The **Horizontal Plate** is of a quadrilateral form, and presents two surfaces and four borders. The *superior* surface, concave from side to side, forms the back part of the floor of the nose. The *inferior* surface, slightly concave and rough, forms the back part of the hard palate. At its posterior part may be seen a transverse ridge, more or less marked, for the attachment of part of the aponeurosis of the Tensor palati muscle. At the outer extremity of this ridge is a deep groove converted into a canal by its articulation with the tuberosity of the superior maxillary bone, and forming the *posterior palatine canal.* Near this groove the orifices of one or two small canals, *accessory posterior palatine*, may be seen. The *anterior* border is serrated, bevelled at the expense of its inferior surface, and articulates with the palate process of the superior maxillary bone. The *posterior* border is concave, free, and serves for the attachment of the soft palate. Its inner extremity is sharp and pointed, and, when united with the opposite bone, forms a projecting process, the *posterior nasal spine*, for the attachment of the Azygos uvulæ muscle. The *external* border is united with the lower part of the perpendicular plate almost at right angles. The *internal* border, the thickest, is serrated for articulation with its fellow of the opposite side; its superior edge is raised into a ridge, which, united with the opposite bone, forms a crest in which the vomer is received.

The **Vertical Plate** (Fig. 58) is thin, of an oblong form, and directed upward and a little inward. It presents two surfaces, an external and an internal, and four borders.

The **internal surface** presents at its lower part a broad, shallow depression, which forms part of the inferior meatus of the nose. Immediately above this is a well-marked horizontal ridge, the *inferior turbinated crest*, for articulation with the inferior turbinated bone; above this, a second broad, shallow depression, which forms part of the middle meatus, surmounted above by a horizontal ridge less prominent than the inferior, the *superior turbinated crest*, for articulation with the middle turbinated bone. Above the superior turbinated crest is a narrow, horizontal groove, which forms part of the superior meatus.


Fig. 58.—Left palate bone. Internal view. (Enlarged.)

The **external surface** is rough and irregular throughout the greater part of its extent, for articulation with the inner surface of the superior maxillary bone, its upper and back part being smooth where it enters into the formation of the spheno-maxillary fossa; it is also smooth in front, where it covers the orifice of the antrum. Toward the back part of this surface is a deep groove, converted into a canal, the *posterior palatine*, by its articulation with the superior maxillary bone. It transmits the posterior or descending palatine vessels and one of the descending palatine branches from Meckel's ganglion.

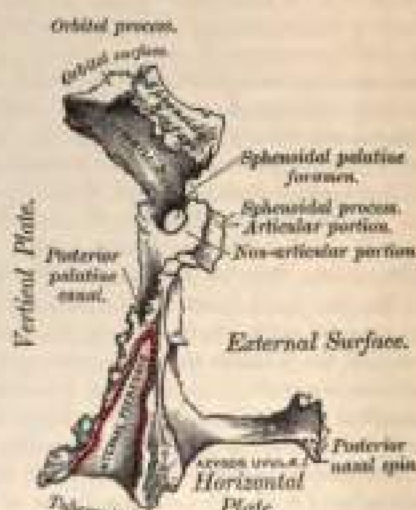



Fig. 59.—Left palate bone. Posterior view. (Enlarged.)

The *anterior* border is thin, irregular, and presents, opposite the inferior turbinated crest, a pointed, projecting lamina, the *maxillary process*, which is directed forward, and closes in the lower and back part of the opening of the antrum. The *posterior* border (Fig. 59) presents a deep groove, the edges of which are serrated for articulation with the pterygoid process of the sphenoid. At the lower part of this border is seen a pyramidal process of bone, the *pterygoid process* or tuberosity of the palate, which is received into the angular interval between the two pterygoid plates of the sphenoid at their inferior extremity. This process presents at its back part a median groove and two lateral surfaces. The groove is smooth, and forms part of the pterygoid fossa, affording attachment to the Internal pterygoid muscle; whilst the lateral surfaces are rough and uneven, for articulation with the anterior border of each pterygoid plate. A few fibres of the Superior constrictor arise from the tuberosity of the palate bone. The base of this process, continuous with the horizontal portion of the bone, presents the apertures of the *accessory descending palatine canals*, through which pass the two smaller descending branches of Meckel's ganglion; whilst its outer surface is rough for articulation with the inner surface of the body of the superior maxillary bone.

The *superior* border of the vertical plate presents two well-marked processes separated by an intervening notch or foramen. The anterior, or larger, is called the *orbital process;* the posterior, the *sphenoidal*.

The **Orbital Process**, directed upward and outward, is placed on a higher level than the sphenoidal. It presents five surfaces, which enclose a hollow cellular cavity, and is connected to the perpendicular plate by a narrow, constricted neck. Of these five surfaces, three are articular, two non-articular or free surfaces. The three articular are the *anterior* or *maxillary* surface, which is directed forward, outward, and downward, is of an oblong form, and rough for articulation with the superior maxillary bone. The *posterior* or *sphenoidal* surface is directed backward, upward, and inward. It ordinarily presents a small, open cell, which communicates with the sphenoidal cells, and the margins of which are serrated for articulation with the vertical part of the sphenoidal turbinated bone. The *internal* or *ethmoidal* surface is directed inward, upward, and forward, and articulates with the lateral mass of the ethmoid bone. In some cases the cellular cavity above mentioned opens on this surface of the bone; it then communicates with the posterior ethmoidal cells. More rarely it opens on both surfaces, and then communicates both with the posterior ethmoidal and the sphenoidal cells. The non-articular or free surfaces are the *superior* or *orbital*, directed upward and outward, of triangular form, concave, smooth, and forming the back part of the floor of the orbit; and the *external* or *zygomatic* surface, directed outward, backward, and downward, of an oblong form, smooth, lying in the spheno-maxillary fossa, and looking into the zygomatic fossa. The latter surface is separated from the orbital by a smooth, rounded border, which enters into the formation of the spheno-maxillary fissure.

The **Sphenoidal Process** of the palate bone is a thin, compressed plate, much smaller than the orbital, and directed upward and inward. It presents three surfaces and two borders. The *superior* surface, the smallest of the three, articulates with the under surface of the sphenoidal turbinated bone; it presents a groove, which contributes to the formation of the pterygo-palatine canal. The *internal* surface is concave, and forms part of the outer wall of the nasal fossa. The *external* surface is divided into an articular and a non-articular portion: the former is rough, for articulation with the inner surface of the internal pterygoid plate of the sphenoid; the latter is smooth, and forms part of the spheno-maxillary fossa. The *anterior* border forms the posterior boundary of the spheno-palatine foramen. The *posterior* border, serrated at the expense of the outer table, articulates with the inner surface of the internal pterygoid plate.

The orbital and sphenoidal processes are separated from one another by a deep notch, which is converted into a foramen, the *spheno-palatine*, by articulation with the sphenoidal turbinated bone. Sometimes the two processes are united above, and form between them a complete foramen, or the notch is crossed by one or more spiculæ of bone, so as to form two or more foramina. In the articulated skull this foramen opens into the back part of the outer wall of the superior meatus, and transmits the spheno-palatine vessels and the superior nasal and naso-palatine nerves.

**Development.**—From a single centre, which makes its appearance about the second month at the angle of junction of the two plates of the bone. From this point ossification spreads inward to the horizontal plate, downward into the tuberosity, and upward into the vertical plate. In the fœtus the horizontal plate is much longer than the vertical, and even after it is fully ossified the whole bone is at first remarkable for its shortness.

**Articulations.**—With six bones: the sphenoid, ethmoid, superior maxillary, inferior turbinated, vomer, and opposite palate.

**Attachment of Muscles.**—To four: the Tensor palati, Azygos uvulæ, Internal pterygoid, and Superior constrictor of the pharynx.

## The Inferior Turbinated Bones.

The **Inferior Turbinated Bones** (*turbo*, a whirl) are situated one on each side of the outer wall of the nasal fossæ. Each consists of a layer of thin, spongy bone, curled upon itself like a scroll—hence its name "turbinated"—and extends horizontally along the outer wall of the nasal fossa, immediately below the orifice of

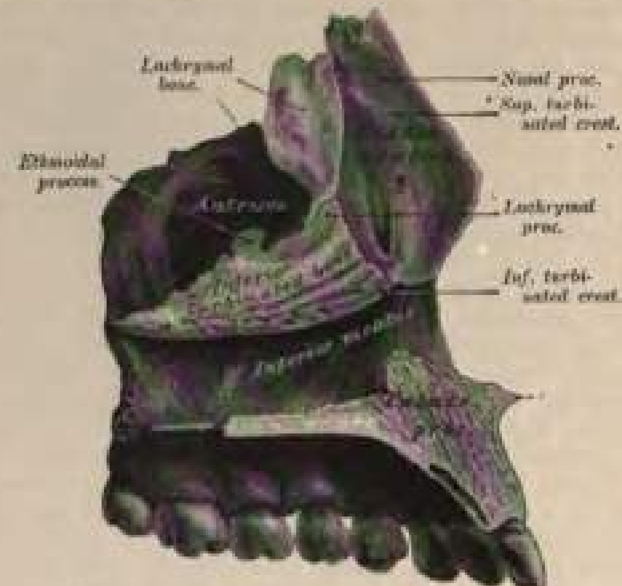



FIG. 60.—Inferior turbinated bone and Lachrymal bone in situ.

the antrum (Fig. 60). Each bone presents two surfaces, two borders, and two extremities.

The **internasal surface** (Fig. 61) is convex, perforated by numerous apertures, and traversed by longitudinal grooves and canals for the lodgement of arteries and


FIG. 61.—Right inferior turbinated bone. Internal surface.


FIG. 62.—Right inferior turbinated bone. External surface.

veins. In the recent state it is covered by the lining membrane of the nose. The **external surface** is concave (Fig. 62), and forms part of the inferior meatus. Its *upper border* is thin, irregular, and connected to various bones along the outer wall of the nose. It may be divided into three portions: of these, the **anterior** articulates with the inferior turbinated crest of the superior maxillary bone; the **posterior** with the inferior turbinated crest of the palate bone; the middle portion of the superior border presents three well-marked processes, which vary much in their size and form. Of these, the anterior and smallest is situated at the junction of the anterior fourth with the posterior three-fourths of the bone: it is small and pointed, and is called the *lachrymal process;* it articulates by its apex with the anterior inferior angle of the lachrymal bone, and by its margins with the groove on the back of the nasal process of the superior maxillary, and thus assists in forming the canal for the nasal duct. At the junction of the two middle fourths of the bone, but encroaching on its posterior fourth, a broad, thin plate, the *ethmoidal process*, ascends to join the unciform process of the ethmoid; from the lower border of this process a thin lamina of bone curves downward and outward, hooking over the lower edge of the orifice of the antrum, which it narrows below: it is called the *maxillary process*, and fixes the bone firmly to the outer wall of the nasal fossa. The *inferior border* is free, thick, and cellular in structure, more especially in the middle of the bone. Bone *extremities* are more or less narrow and pointed, the posterior being the more tapering. If the bone is held so that its outer concave surface is directed backward (*i. e.*, toward the holder), and its superior border, from which the lachrymal and ethmoidal processes project, upward, the lachrymal process will be directed to the side to which the bone belongs.[1]

**Development.**—By a single centre, which makes its appearance about the middle of fœtal life.

**Articulations.**—With four bones: one of the cranium, the ethmoid, and three of the face, the superior maxillary, lachrymal, and palate.

No muscles are attached to this bone.

## The Vomer.

The **Vomer** (*vomer*, a ploughshare) is a single bone, situated vertically at the back part of the nasal fossæ, forming part of the septum of the nose (Fig. 63).

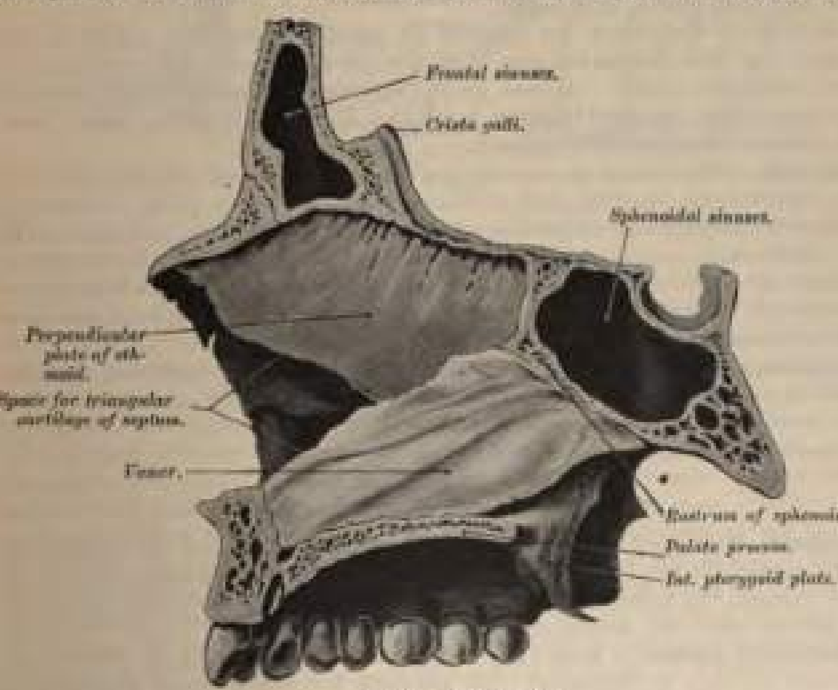



Fig. 63.—Vomer in situ.

It is thin, somewhat like a ploughshare in form; but it varies in different indi-

[1] If the lachrymal process is broken off, as is often the case, the side to which the bone belongs may be known by recollecting that the maxillary process is nearer the back than the front of the bone.

viduals, being frequently bent to one or the other side; it presents for examination two surfaces and four borders. The *lateral surfaces* are smooth, marked by small furrows for the lodgement of blood-vessels, and by a groove on each side, sometimes a canal, the *naso-palatine*, which runs obliquely downward and forward to the intermaxillary suture; it transmits the naso-palatine nerve. The *superior border*, the thickest, presents a deep groove, bounded on each side by a horizontal projecting ala of bone; the groove receives the rostrum of the sphenoid, while the alæ are overlapped and retained by the *vaginal processes* which project from the under surface of the body of the sphenoid at the base of the pterygoid processes. At the front of the groove a fissure is left for the transmission of blood-vessels to the substance of the bone. The *inferior border*, the longest, is broad and uneven in front, where it articulates with the two superior maxillary bones; thin and sharp behind, where it joins with the palate bones. The upper half of the *anterior border* usually consists of two laminæ of bone, between which is received the perpendicular plate of the ethmoid; the lower half, also separated into two lamellæ, receives between them the lower margin of the septal cartilage of the nose. The *posterior border* is free, concave, and separates the nasal fossæ behind. It is thick and bifid above, thin below.

Fig. 64.—The vomer.

The surfaces of the vomer are covered by mucous membrane, which is intimately connected with the periosteum, with the intervention of very little, if any, submucous connective tissue. Hence polypi are rarely found growing from this surface, though they frequently grow from the outer wall of the nasal fossæ, where the submucous tissue is abundant.

**Development.**—The vomer at an early period consists of two laminæ, separated by a very considerable interval, and enclosing between them a plate of cartilage, the *vomerine cartilage*, which is prolonged forward to form the remainder of the septum. Ossification commences in the membrane at the postero-inferior part of this cartilage by two centres, one on each side of the middle line, which extend to form the two laminæ. They begin to coalesce at the lower part, but their union is not complete until after puberty.

**Articulations.**—With six bones: two of the cranium, the sphenoid and ethmoid; and four of the face, the two superior maxillary and the two palate bones; and with the cartilage of the septum.

The vomer has no muscles attached to it.

## The Inferior Maxillary Bone.

The **Inferior Maxillary Bone** (the *Mandible*), the largest and strongest bone of the face, serves for the reception of the lower teeth. It consists of a curved, horizontal portion, the *body*, and two perpendicular portions, the *rami*, which join the back part of the body nearly at right angles.

The **Horizontal Portion** or **Body** (Fig. 65) is convex in its general outline, and curved somewhat like a horseshoe. It presents for examination two surfaces and two borders. The **external surface** is convex from side to side, concave from above downward. In the median line is a vertical ridge, the *symphysis*, which extends from the upper to the lower border of the bone, and indicates the point of junction of the two pieces of which the bone is composed at an early period of life.

The lower part of the ridge terminates in a prominent triangular eminence, the *mental process*. This eminence is rounded below, and often presents a median depression separating two processes, the *mental tubercles*. It forms the chin, a feature peculiar to the human skull. On either side of the symphysis, just below the cavities for the incisor teeth, is a depression, the *incisive fossa*, for the attachment of the Levator menti (or Levator labii inferioris); more externally is attached a portion of the Orbicularis oris (*Accessorii Orbicularis inferioris*), and, still more externally, a foramen, the *mental foramen*, for the passage of the mental vessels and nerve. This foramen is placed just below the interval between the two bicuspid teeth. Running outward from the base of the mental process on each side is a ridge, the *external oblique* line. The ridge is at first nearly horizontal, but afterward inclines upward and backward, and is continuous with the anterior border of the ramus: it affords attachment to the Depressor


FIG. 65.—Inferior maxillary bone. Outer surface. Side view.

labii inferioris and Depressor anguli oris; below it the Platysma myoides is attached.

The **internal surface** (Fig. 66) is concave from side to side, convex from above downward. In the middle line is an indistinct linear depression, corresponding to the symphysis externally; on either side of this depression, just below its centre, are four prominent tubercles, placed in pairs, two above and two below; they are called the *genial tubercles*, and afford attachment, the upper pair to the Genio-hyo-glossi, the lower pair to the Genio-hyoidei, muscles. Sometimes the tubercles on each side are blended into one; at others they all unite into an irregular eminence; or, again, nothing but an irregularity may be seen on the surface of the bone at this part. On either side of the genial tubercles is an oval depression, the *sublingual fossa*, for lodging the sublingual gland; and beneath the fossa a rough depression on each side which gives attachment to the anterior belly of the Digastric muscle. At the back part of the sublingual fossa the *internal oblique line* (*mylo-hyoidean*) commences; it is at first faintly marked, but becomes more distinct as it passes upward and outward, and is especially prominent opposite the last two molar teeth; it affords attachment throughout its whole extent to the Mylo-hyoid muscle: the Superior constrictor of the pharynx with the pterygo-maxillary ligament being attached above its posterior extremity, near the alveolar margin. The portion of the bone above this ridge is smooth, and covered by the mucous membrane of the mouth; the portion below presents an oblong depression, the *submaxillary fossa*, wider behind than in front, for the lodgement of the submaxillary gland. The external oblique line and the internal or mylo-hyoidean line

7

divide the body of the bone into a superior or alveolar and an inferior or basilar portion.

The **superior** or **alveolar** border is wider, and its margins thicker, behind than in front. It is hollowed into numerous cavities, for the reception of the teeth; these cavities are sixteen in number, and vary in depth and size according to the teeth which they contain. To its outer side, the Buccinator muscle is attached as far forward as the first molar tooth. The **inferior** border is rounded, longer than the superior, and thicker in front than behind; it presents a shallow groove, just where the body joins the ramus, over which the facial artery turns.

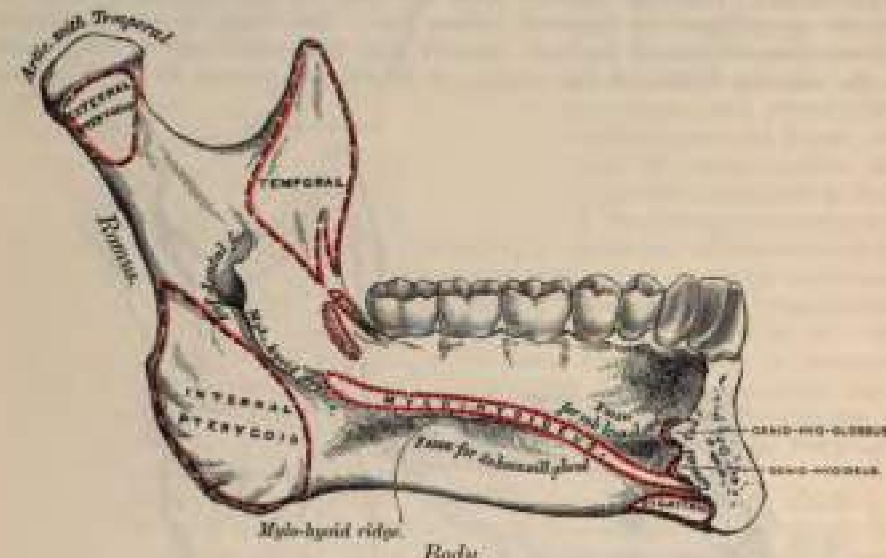



Fig. 86.—Inferior maxillary bone. Inner surface. Side view.

The **Perpendicular Portions**, or **Rami**, are of a quadrilateral form. Each presents for examination two surfaces, four borders, and two processes. The *external surface* is flat, marked with ridges, and gives attachment throughout nearly the whole of its extent to the Masseter muscle. The *internal surface* presents about its centre the oblique aperture of the inferior dental canal, for the passage of the inferior dental vessels and nerve. The margin of this opening is irregular; it presents in front a prominent ridge, surmounted by a sharp spine, the *lingula*, which gives attachment to the internal lateral ligament of the lower jaw, and at its lower and back part a notch leading to a groove, the *mylo-hyoidean*, which runs obliquely downward to the back part of the submaxillary fossa, and lodges the mylo-hyoid vessels and nerve. Behind the groove is a rough surface, for the insertion of the Internal pterygoid muscle. The inferior dental canal runs obliquely downward and forward in the substance of the ramus, and then horizontally forward in the body; it is here placed under the alveoli, with which it communicates by small openings. On arriving at the incisor teeth, it turns back to communicate with the mental foramen, giving off two small canals, which run forward, to be lost in the cancellous tissue of the bone beneath the incisor teeth. This canal, in the posterior two-thirds of the bone, is situated nearer the internal surface of the jaw; and in the anterior third, nearer its external surface. Its walls are composed of compact tissue at either extremity, and of cancellous in the centre. It contains the inferior dental vessels and nerve, from which branches are distributed to the teeth through small apertures at the bases of the alveoli. The *lower border* of the ramus is thick, straight, and continuous with the body of the bone. At its junction with the posterior border is the *angle of the jaw*, which is either inverted or everted, and marked by rough, oblique ridges on each side, for the attachment of the Masseter externally, and the Internal pterygoid internally; the stylo-maxillary ligament is attached to the angle between these muscles. The *anterior border* is thin above, thicker below, and continuous with the external oblique line. The *posterior border* is thick, smooth, rounded, and covered by the parotid gland. The *upper border* of the ramus is thin, and presents two processes, separated by a deep concavity, the *sigmoid notch*. Of these processes, the anterior is the *coronoid*, the posterior the *condyloid*.

The **Coronoid Process** is a thin, flattened, triangular eminence of bone, which varies in shape and size in different subjects, and serves chiefly for the attachment of the Temporal muscle. Its *external surface* is smooth, and affords attachment to the Temporal and Masseter muscles. Its *internal surface* gives attachment to the Temporal muscle and presents the commencement of a longitudinal ridge, which is continued to the posterior part of the alveolar process. On the outer side of this ridge is a deep groove, continued below on the outer side of the alveolar process; this ridge and part of the groove afford attachment, above, to the Temporal; below, to the Buccinator muscle.

The **Condyloid Process**, shorter but thicker than the coronoid, consists of two portions; the *condyle*, and the constricted portion which supports the condyle, the *neck*. The *condyle* is of an oblong form, its long axis being transverse, and set obliquely on the neck in such a manner that its outer end is a little more forward and a little higher than its inner. It is convex from before backward and from side to side, the articular surface extending farther on the posterior than on the anterior aspect. At its outer extremity is a small tubercle for the attachment of the external lateral ligament of the temporo-mandibular joint. The *neck* of the condyle is flattened from before backward, and strengthened by ridges which descend from the fore part and sides of the condyle. Its lateral margins are narrow, the external one giving attachment to part of the external lateral ligament. Its posterior surface is convex; its anterior is hollowed out on its inner side by a depression (the *pterygoid fossa*), for the attachment of the External pterygoid muscle.

The **Sigmoid Notch**, separating the two processes, is a deep semilunar depression, crossed by the masseteric vessels and nerve.

**Development.**—The lower jaw is developed principally from membrane, but partly from cartilage. The process of ossification commences early—earlier than in any other bone except the clavicle. The greater part of the bone is formed from a centre of ossification (dentary), which appears between the fifth and sixth week in the membrane on the outer surface of Meckel's cartilage. A second centre (*splenial*) appears in the membrane on the inner surface of the cartilage, and from this centre the inner wall of the sockets of the teeth is formed; this terminates above in the lingula. The anterior extremity of Meckel's cartilage becomes ossified, forming the body of the bone on each side of the symphysis. Two supplemental patches of cartilage appear at the condyle and at the angle, in each of which a centre of ossification for these parts appears: the coronoid process is also ossified from a separate centre. At birth the bone consists of two halves, united by a fibrous symphysis, in which ossification takes place during the first year.

**Articulation.**—With the glenoid fossæ of the two temporal bones.

**Attachment of Muscles.**—To fifteen pairs: to its external surface, commencing at the symphysis, and proceeding backward: Levator menti, Depressor labii inferioris, Depressor anguli oris, Platysma myoides, Buccinator, Masseter; a portion of the Orbicularis oris (Accessorii orbicularis inferioris) is also attached to this surface. To its internal surface, commencing at the same point: Genio-hyoglossus, Genio-hyoideus, Mylo-hyoideus, Digastric, Superior constrictor, Temporal, Internal pterygoid, External pterygoid.

## CHANGES PRODUCED IN THE LOWER JAW BY AGE.

The changes which the lower jaw undergoes after birth relate (1) to the alterations effected in the body of the bone by the first and second dentitions, the loss of the teeth in the aged, and

SIDE VIEW OF THE LOWER JAW AT DIFFERENT PERIODS OF LIFE.

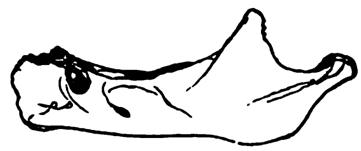


FIG. 67.—At birth.

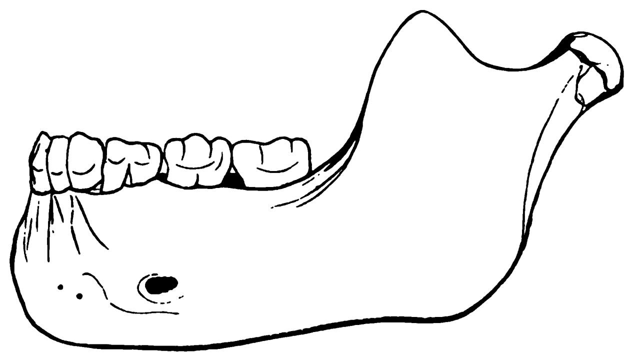


FIG. 68.—At seven years.

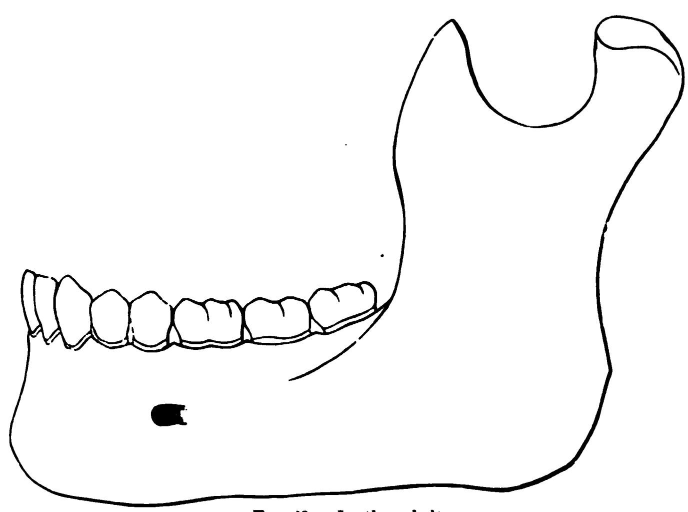


FIG. 69.—In the adult.

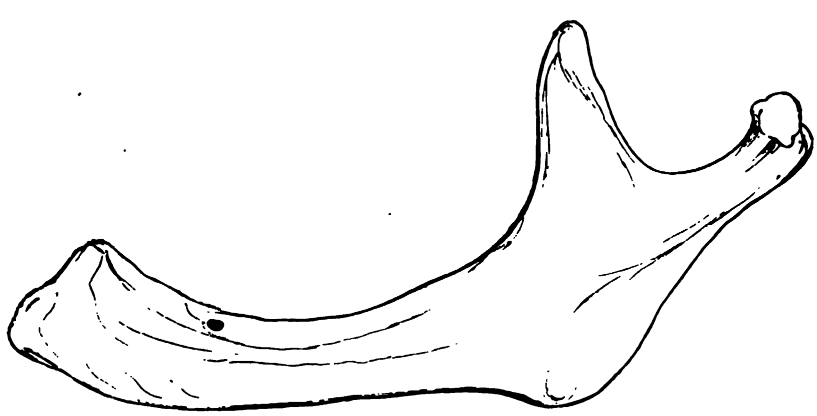


FIG. 70.—In old age.

the subsequent absorption of the alveoli; (2) to the size and situation of the dental canal; and (3) to the angle at which the ramus joins with the body.

*At birth* (Fig. 67) the bone consists of lateral halves, united by fibrous tissue. The body is a mere shell of bone, containing the sockets of the two incisor, the canine, and the two temporary molar teeth, imperfectly partitioned from one another. The dental canal is of large size, and runs near the lower border of the bone, the mental foramen opening beneath the socket of the first molar. The angle is obtuse (175°), and the condyloid portion nearly in the same horizontal line with the body; the neck of the condyle is short, and bent backward. The coronoid process is of comparatively large size, and situated at right angles with the rest of the bone.

*After birth* (Fig. 68) the two segments of the bone become joined at the symphysis, from below upward, in the first year; but a trace of separation may be visible in the beginning of the second year near the alveolar margin. The body becomes elongated in its whole length, but more especially behind the mental foramen, to provide space for the three additional teeth developed in this part. The depth of the body becomes greater, owing to increased growth of the alveolar part, to afford room for the fangs of the teeth, and by thickening of the subdental portion, which enables the jaw to withstand the powerful action of the masticatory muscles; but the alveolar portion is the deeper of the two, and, consequently, the chief part of the body lies above the oblique line. The dental canal after the second dentition is situated just above the level of the mylo-hyoid ridge, and the mental foramen occupies the position usual to it in the adult. The angle becomes less obtuse, owing to the separation of the jaws by the teeth. (About the fourth year it is 140°.)

*In the adult* (Fig. 69) the alveolar and basilar portions of the body are usually of equal depth. The mental foramen opens midway between the upper and lower border of the bone, and the dental canal runs nearly parallel with the mylo-hyoid line. The ramus is almost vertical in direction, and joins the body nearly at right angles.

*In old age* (Fig. 70) the bone becomes greatly reduced in size; for with the loss of the teeth the alveolar process is absorbed, and the basilar part of the bone alone remains; consequently, the chief part of the bone is *below* the oblique line. The dental canal, with the mental foramen opening from it, is close to the alveolar border. The rami are oblique in direction, the angle obtuse, and the neck of the condyle more or less bent backward.

## The Sutures.

The bones of the cranium and face are connected to each other by means of *Sutures*. That is, the articulating surfaces or edges of the bones are more or less roughened or uneven, and are closely adapted to each other, a small amount of intervening fibrous tissue, the *sutural ligament*, fastening them together. The *Cranial Sutures* may be divided into three sets: 1. Those at the vertex of the skull. 2. Those at the side of the skull. 3. Those at the base.

The sutures at the vertex of the skull are three: the *sagittal*, *coronal*, and *lambdoid*.

The **Sagittal Suture** (*interparietal*) is formed by the junction of the two parietal bones, and extends from the middle of the frontal bone backward to the superior angle of the occipital. In childhood, and occasionally in the adult, when the two halves of the frontal bone are not united, it is continued forward to the root of the nose. This suture is sometimes perforated, near its posterior extremity, by the parietal foramen; and in front, where it joins the coronal suture, a space is occasionally left which encloses a large Wormian bone.

The **Coronal Suture** (*fronto-parietal*) extends transversely across the vertex of the skull, and connects the frontal with the parietal bones. It commences at the extremity of the greater wing of the sphenoid on one side, and terminates at the same point on the opposite side. The dentations of the suture are more marked at the sides than at the summit, and are so constructed that the frontal rests on the parietal above, whilst laterally the frontal supports the parietal.

The **Lambdoid Suture** (*occipito-parietal*), so called from its resemblance to the Greek letter Λ, connects the occipital with the parietal bones. It commences on each side at the mastoid portion of the temporal bone, and inclines upward to the end of the sagittal suture. The dentations of this suture are very deep and distinct, and are often interrupted by several small Wormian bones.

The sutures at the side of the skull extend from the external angular process of the frontal bone to the lower end of the lambdoid suture behind. The anterior portion is formed between the lateral part of the frontal bone above and the malar and great wing of the sphenoid below, forming the *fronto-malar* and *fronto* *sphenoidal* sutures. These sutures can also be seen in the orbit, and form part of the so-called *transverse facial* suture. The posterior portion is formed between the parietal bone above and the great wing of the sphenoid, the squamous and mastoid portions of the temporal bone below, forming the *spheno-parietal*, *squamo-parietal*, and *masto-parietal* sutures.

The **Spheno-parietal** is very short; it is formed by the tip of the great wing of the sphenoid, which overlaps the anterior inferior angle of the parietal bone.

The **Squamo-parietal**, or **Squamous Suture**, is arched. It is formed by the squamous portion of the temporal bone overlapping the middle division of the lower border of the parietal.

The **Masto-parietal** is a short suture, deeply dentated, formed by the posterior inferior angle of the parietal and the superior border of the mastoid portion of the temporal.

The sutures at the base of the skull are the *basilar* in the centre, and on each side the *petro-occipital*, the *masto-occipital*, the *petro-sphenoidal*, and the *squamo-sphenoidal*.

The **Basilar Suture** is formed by the junction of the basilar surface of the occipital bone with the posterior surface of the body of the sphenoid. At an early period of life a thin plate of cartilage exists between these bones, but in the adult they become fused into one. Between the outer extremity of the basilar suture and the termination of the lambdoid an irregular suture exists, which is subdivided into two portions. The inner portion, formed by the union of the petrous part of the temporal with the occipital bone, is termed the **petro-occipital**. The outer portion, formed by the junction of the mastoid part of the temporal with the occipital, is called the **masto-occipital**. Between the bones forming the petro-occipital suture a thin plate of cartilage exists; in the masto-occipital is occasionally found the opening of the mastoid foramen. Between the outer extremity of the basilar suture and the spheno-parietal an irregular suture may be seen, formed by the union of the sphenoid with the temporal bone. The inner and smaller portion of this suture is termed the **petro-sphenoidal**; it is formed between the petrous portion of the temporal and the great wing of the sphenoid: the outer portion, of greater length and arched, is formed between the squamous portion of the temporal and the great wing of the sphenoid; it is called the **squamo-sphenoidal**.

The cranial bones are connected with those of the face, and the facial bones with each other, by numerous sutures, which, though distinctly marked, have received no special names. The only remaining suture deserving especial consideration is the **transverse**. This extends across the upper part of the face, and is formed by the junction of the frontal with the facial bones: it extends from the external angular process of one side to the same point on the opposite side, and connects the frontal with the malar, the sphenoid, the ethmoid, the lachrymal, the superior maxillary, and the nasal bones on each side.

The sutures remain separate for a considerable period after the complete formation of the skull. It is probable that they serve the purpose of permitting the growth of the bones at their margins, while their peculiar formation, together with the interposition of the sutural ligament between the bones forming them, prevents the dispersion of blows or jars received upon the skull. Humphry remarks, "that, as a general rule, the sutures are first obliterated at the parts in which the ossification of the skull was last completed—viz. in the neighborhood of the fontanelles; and the cranial bones seem in this respect to observe a similar law to that which regulates the union of the epiphyses to the shafts of the long bones." The same author remarks that the time of their disappearance is extremely variable: they are sometimes found well marked in skulls edentulous with age, while in others which have only just reached maturity they can hardly be traced. The obliteration of the sutures takes place sooner on the inner than on the outer surface of the skull. The sagittal and coronal sutures are as a rule the first to become ossified—the process starting near the posterior extremity of the former and the lower ends of the latter.

## THE SKULL AS A WHOLE.

The Skull, formed by the union of the several cranial and facial bones already described, when considered as a whole is divisible into five regions: a superior region or vertex, an inferior region or base, two lateral regions, and an anterior region, the face.

### The Vertex of the Skull.

The **Superior Region,** or **Vertex,** presents two surfaces, an external and an internal.

The **external surface** is bounded, in front, by the glabella and supraorbital ridges; behind, by the occipital protuberance and superior curved lines of the occipital bone; laterally, by an imaginary line extending from the outer end of the superior curved line, along the temporal ridge, to the external angular process of the frontal. This surface includes the greater part of the vertical portion of the frontal, the greater part of the parietal, and the superior third of the occipital bone; it is smooth, convex, of an elongated oval form, crossed transversely by the coronal suture, and from before backward by the sagittal, which terminates behind in the lambdoid. The point of junction of the coronal and sagittal sutures is named the *bregma*, and is represented by a line drawn vertically upward from the external auditory meatus, the head being in its normal position. The point of junction of the sagittal and lambdoid sutures is called the *lambda*, and is about $2\frac{3}{4}$ inches above the external occipital protuberance. From before backward may be seen the frontal eminences and remains of the suture connecting the two lateral halves of the frontal bone; on each side of the sagittal suture are the parietal foramen and parietal eminence, and still more posteriorly the convex surface of the occipital bone. In the neighborhood of the parietal foramen the skull is often flattened, and the name of *obelion* is sometimes given to that point of the sagittal suture which lies exactly opposite to the parietal foramen.

The **internal surface** is concave, presents depressions for the convolutions of the cerebrum, and numerous furrows for the lodgement of branches of the meningeal arteries. Along the middle line of this surface is a longitudinal groove, narrow in front, where it commences at the frontal crest, but broader behind, where it lodges the superior longitudinal sinus, and by its margin affords attachment to the falx cerebri. On either side of it are several depressions for the Pacchionian bodies, and at its back part the internal openings of the parietal foramina. This surface is crossed, in front, by the coronal suture; from before backward by the sagittal; behind, by the lambdoid.

### The Base of the Skull.

The **Inferior Region,** or **Base of the Skull,** presents two surfaces—an internal or cerebral, and an external or basilar.

The **internal** or **cerebral surface** (Fig. 71) presents three fossæ, called the *anterior*, *middle*, and *posterior* fossæ of the cranium.

The **Anterior Fossa** is formed by the orbital plates of the frontal, the cribriform plate of the ethmoid, the anterior third of the superior surface of the body, and the upper surface of the lesser wings of the sphenoid. It is the most elevated of the three fossæ, convex externally where it corresponds to the roof of the orbit, concave in the median line in the situation of the cribriform plate of the ethmoid. It is traversed by three sutures, the *ethmo-frontal*, *ethmo-sphenoidal*, and *fronto-sphenoidal*, and lodges the frontal lobe of the cerebrum. It presents, in the median line, from before backward, the commencement of the groove for the superior longitudinal sinus and the frontal crest for the attachment of the falx cerebri; the *foramen cæcum*, an aperture formed between the frontal bone and the crista galli of the ethmoid, which, if pervious, transmits a small vein from the nose to the superior longitudinal sinus; behind the foramen cæcum, the *crista galli*, the posterior margin of which affords attachment to the falx cerebri; on either side of the crista galli, the cribriform plate, which supports the olfactory bulb, and presents three rows of foramina for the transmission of its nervous filaments, and in front a slit-like opening for the nasal branch of the ophthalmic division

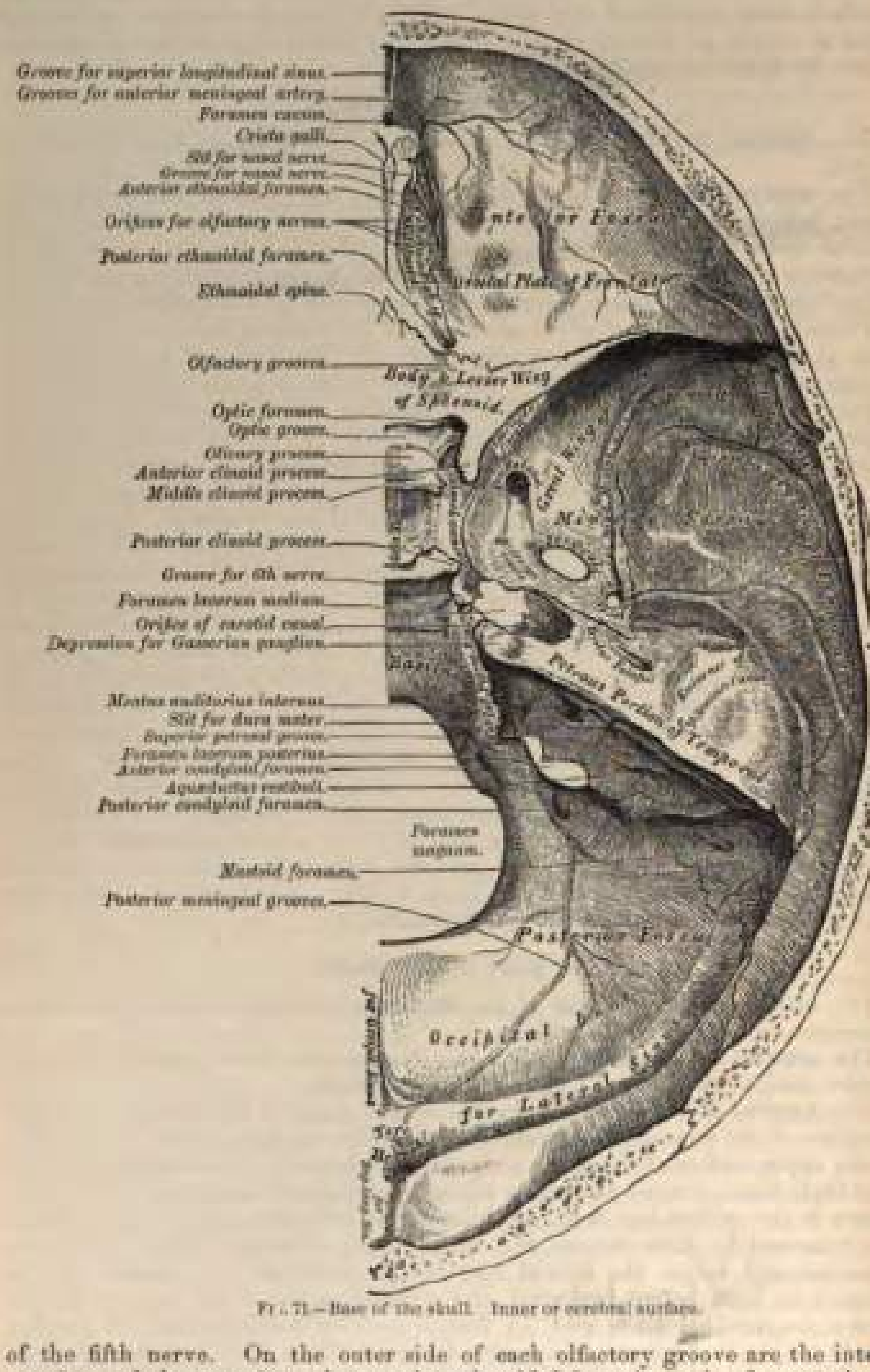



FIG. 71.—Base of the skull. Inner or cerebral surface.

of the fifth nerve. On the outer side of each olfactory groove are the internal openings of the *anterior* and *posterior ethmoidal foramina*; the former, situated about the middle of the outer margin of the olfactory groove, transmits the anterior ethmoidal vessels and the nasal nerve, which latter runs in a depression along the surface of the ethmoid to the slit-like opening above mentioned; while the posterior ethmoidal foramen opens at the back part of this margin under cover of the projecting lamina of the sphenoid, and transmits the posterior ethmoidal vessels. Farther back in the middle line is the *ethmoidal spine*, bounded behind by a slight elevation, separating two shallow longitudinal grooves which support the olfactory lobes. Behind this is a transverse sharp ridge, running outward on either side to the anterior margin of the optic foramen, and separating the anterior from the middle fossa of the base of the skull. The anterior fossa presents, laterally, depressions for the convolutions of the brain and grooves for the lodgement of the anterior meningeal arteries.

The **Middle Fossa**, deeper than the preceding, is narrow in the middle line, but becomes wider at the side of the skull. It is bounded in front by the posterior margin of the lesser wing of the sphenoid, the anterior clinoid process, and the ridge forming the anterior margin of the optic groove; behind, by the superior border of the petrous portion of the temporal and the dorsum ephippi; externally by the squamous portion of the temporal, anterior inferior angle of the parietal bone, and greater wing of the sphenoid. It is traversed by four sutures, the squamo-parietal, spheno-parietal, squamo-sphenoidal, and petro-sphenoidal.

In the middle line, from before backward, is the *optic groove*, behind which lies the optic commissure; the groove terminates on each side in the optic foramen, for the passage of the optic nerve and ophthalmic artery; behind the optic groove is the *olivary process*, and laterally the *anterior clinoid processes*, to which are attached processes of the tentorium cerebelli. Farther back is the *sella turcica*, a deep depression which lodges the pituitary gland, bounded in front by a small eminence on either side, the *middle clinoid process*, and behind by a broad square plate of bone, the *dorsum ephippi*, surmounted at each superior angle by a tubercle, the *posterior clinoid process;* beneath the latter process is a notch, for the sixth nerve. On each side of the sella turcica is the *cavernous groove:* it is broad, shallow, and curved somewhat like the Italic letter *f;* it commences behind at the foramen lacerum medium, and terminates on the inner side of the anterior clinoid process, and presents along its outer margin a ridge of bone. This groove lodges the cavernous sinus, the internal carotid artery, and the nerves of the orbit. The sides of the middle fossa are of considerable depth; they present depressions for the convolutions of the brain and grooves for the branches of the middle meningeal artery; the latter commence on the outer side of the foramen spinosum, and consist of two large branches, an anterior and a posterior; the former passing upward and forward to the anterior inferior angle of the parietal bone, the latter passing upward and backward. The following foramina may also be seen from before backward: Most anteriorly is the *foramen lacerum anterius, or sphenoidal fissure*, formed above by the lesser wing of the sphenoid; below, by the greater wing; internally, by the body of the sphenoid; and sometimes completed externally by the orbital plate of the frontal bone. It transmits the third, the fourth, the three branches of the ophthalmic division of the fifth, the sixth nerve, some filaments from the cavernous plexus of the sympathetic, the orbital branch of the middle meningeal artery, a recurrent branch from the lachrymal artery to the dura mater, and the ophthalmic vein. Behind the inner extremity of the sphenoidal fissure is the *foramen rotundum*, for the passage of the second division of the fifth or superior maxillary nerve; still more posteriorly is seen a small orifice, the *foramen Vesalii*, an opening situated between the foramen rotundum and ovale, a little internal to both: it varies in size in different individuals, and is often absent; when present, it transmits a small vein. It opens below into the pterygoid fossa, just at the outer side of the scaphoid depression. Behind and external to the latter opening is the *foramen ovale*, which transmits the third division of the fifth or inferior maxillary nerve, the small meningeal artery, and the small petrosal nerve.[1] On the outer side of the foramen ovale is the *foramen spinosum*, for the passage of the middle meningeal artery; and

[1] See footnote, p. 74.

on the inner side of the foramen ovale, the *foramen lacerum medium*. The lower part of this aperture is filled with cartilage in the recent state. The Vidian nerve and a meningeal branch from the ascending pharyngeal artery pierce this cartilage. On the anterior surface of the petrous portion of the temporal bone is seen, from without inward, the eminence caused by the projection of the superior semicircular canal; in front of and a little outside this is a depression corresponding to the roof of the tympanum; the groove leading to the hiatus Fallopii, for the transmission of the petrosal branch of the Vidian nerve and the petrosal branch of the middle meningeal artery; beneath it, the smaller groove, for the passage of the lesser petrosal nerve; and, near the apex of the bone, the depression for the Gasserian ganglion; and the orifice of the carotid canal, for the passage of the internal carotid artery and carotid plexus of nerves.

The **Posterior Fossa**, deeply concave, is the largest of the three, and situated on a lower level than either of the preceding. It is formed by the posterior third of the superior surface of the body of the sphenoid, by the occipital, the petrous and mastoid portions of the temporal, and the posterior inferior angle of the parietal bone; it is crossed by four sutures, the petro-occipital, the masto-occipital, the masto-parietal, and the basilar; and lodges the cerebellum, pons Varolii, and medulla oblongata. It is separated from the middle fossa in the median line by the dorsum ephippii, and on each side by the superior border of the petrous portion of the temporal bone. This border serves for the attachment of the tentorium cerebelli, is grooved for the superior petrosal sinus, and at its inner extremity presents a notch, upon which rests the fifth nerve. The circumference of the fossa is bounded posteriorly by the grooves for the lateral sinuses. In the centre of this fossa is the *foramen magnum*, bounded on either side by a rough tubercle, which gives attachment to the odontoid or check ligaments; and a little above these are seen the internal openings of the *anterior condyloid foramina*, through which pass the hypoglossal nerve and a meningeal branch from the ascending pharyngeal artery. In front of the foramen magnum is a grooved surface, formed by the basilar process of the occipital bone and by the posterior third of the superior surface of the body of the sphenoid, which supports the medulla oblongata and pons Varolii, and articulates on each side with the petrous portion of the temporal bone, forming the petro-occipital suture, the anterior half of which is grooved for the inferior petrosal sinus, the posterior half being encroached upon by the *foramen lacerum posterius*, or *jugular foramen*. This foramen presents three compartments: through the anterior passes the inferior petrosal sinus; through the posterior, the lateral sinus and some meningeal branches from the occipital and ascending pharyngeal arteries; and through the middle, the glosso-pharyngeal, pneumogastric, and spinal accessory nerves. Above the jugular foramen is the *internal auditory meatus*, for the facial and auditory nerves and auditory artery; behind and external to this is the slit-like opening leading into the aquæductus vestibuli, which lodges the ductus endolymphaticus; while between the two latter, and near the superior border of the petrous portion, is a small, triangular depression, the remains of the floccular fossa, which lodges a process of the dura mater and occasionally transmits a small vein into the substance of the bone. Behind the foramen magnum are the *inferior occipital fossæ*, which lodge the hemispheres of the cerebellum, separated from one another by the *internal occipital crest*, which serves for the attachment of the falx cerebelli and lodges the occipital sinus. The posterior fossæ are surmounted, above, by the deep transverse grooves for the lodgment of the *lateral sinuses*. These channels, in their passage outward, groove the occipital bone, the posterior inferior angle of the parietal, the mastoid portion of the temporal, and the jugular process of the occipital, and terminate at the back part of the jugular foramen. Where this sinus grooves the mastoid portion of the temporal bone the orifice of the *mastoid foramen* may be seen, and just previous to its termination it has opening into it the *posterior condyloid foramen*. Neither foramen is constant.

The **External Surface** of the Base of the Skull (Fig. 72) is extremely irregular.

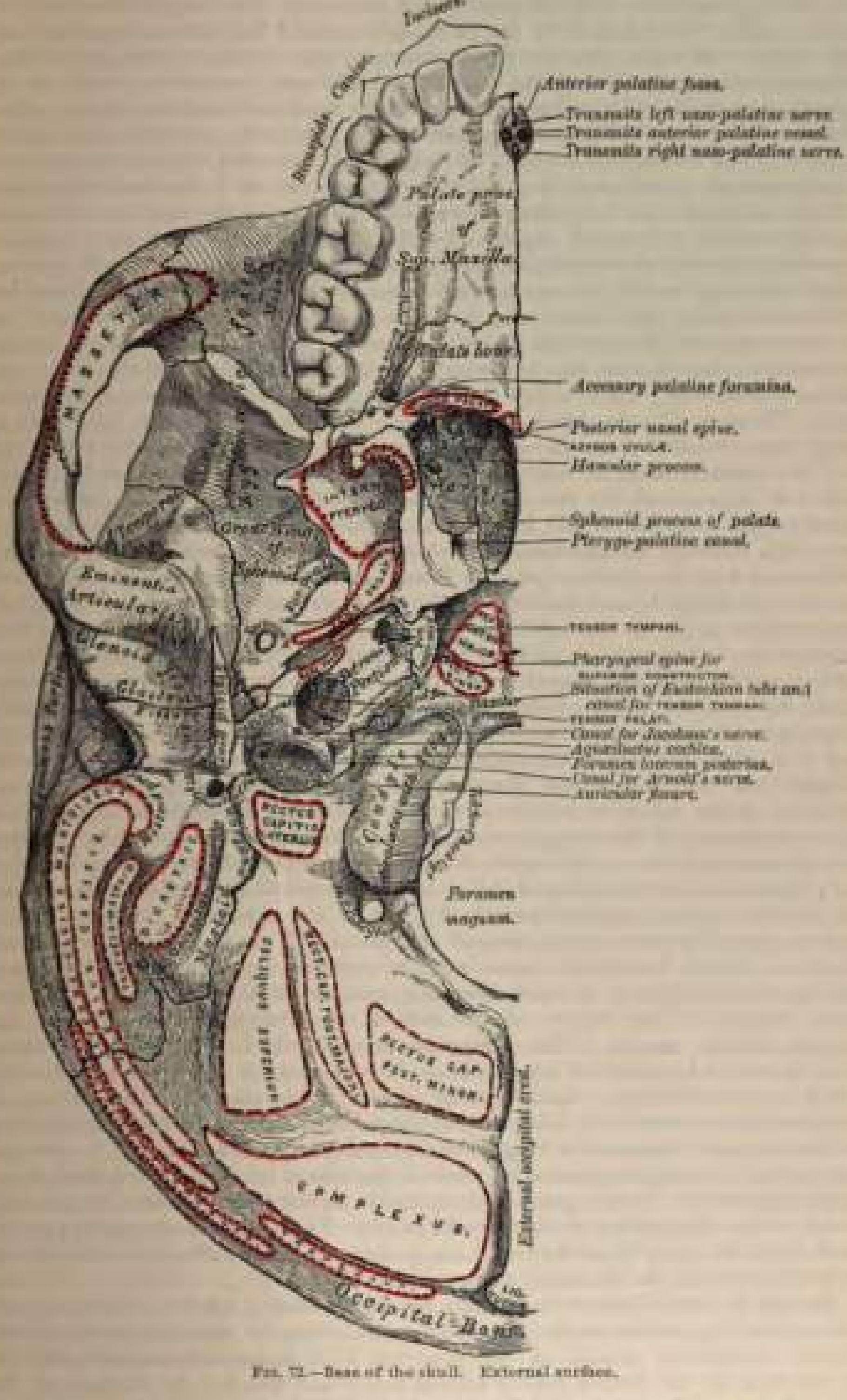



FIG. 72.—Base of the skull. External surface.

It is bounded in front by the incisor teeth in the upper jaw; behind by the superior curved lines of the occipital bone; and laterally by the alveolar arch, the lower border of the malar bone, the zygoma, and an imaginary line extending from the zygoma to the mastoid process and extremity of the superior curved line of the occiput. It is formed by the palate processes of the superior maxillary and palate bones, the vomer, the pterygoid processes, under surface of the great wing, spinous processes and part of the body of the sphenoid, the under surface of the squamous, mastoid, and petrous portions of the temporal, and the under surface of the occipital bone. The anterior part of the base of the skull is raised above the level of the rest of this surface (when the skull is turned over for the purpose of examination), surrounded by the alveolar process, which is thicker behind than in front, and excavated by sixteen depressions for lodging the teeth of the upper jaw, the cavities varying in depth and size according to the teeth they contain. Immediately behind the incisor teeth is the *anterior palatine fossa*. At the bottom of this fossa may usually be seen four apertures: two placed laterally, the *foramina of Stenson*, which open above, one in the floor of each nostril, and transmit the anterior branch of the posterior palatine vessels, and two in the median line in the intermaxillary suture, the *foramina of Scarpa*, one in front of the other, the anterior transmitting the left, and the posterior (the larger) the right, naso-palatine nerve. These two latter canals are sometimes wanting, or they may join to form a single one, or one of them may open into one of the lateral canals above referred to. The palatine vault is concave, uneven, perforated by numerous foramina, marked by depressions for the palatine glands, and crossed by a crucial suture, formed by the junction of the four bones of which it is composed. At the front part of this surface a delicate linear suture may frequently be seen, passing outward and forward from the anterior palatine fossa to the interval between the lateral incisor and canine teeth, and marking off the pre-maxillary portion of the bone. At each posterior angle of the hard palate is the *posterior palatine foramen*, for the transmission of the posterior palatine vessels and large descending palatine nerve; and running forward and inward from it a groove, for the same vessels and nerve. Behind the posterior palatine foramen is the *tuberosity of the palate bone*, perforated by one or more accessory posterior palatine canals, and marked by the commencement of a ridge, which runs transversely inward, and serves for the attachment of the tendinous expansion of the Tensor palati muscle. Projecting backward from the centre of the posterior border of the hard palate is the *posterior nasal spine*, for the attachment of the Azygos uvulæ muscle. Behind and above the hard palate is the posterior aperture of the nares, divided into two parts by the vomer, bounded above by the body of the sphenoid, below by the horizontal plate of the palate bone, and laterally by the internal pterygoid plate of the sphenoid. Each aperture measures about an inch in the vertical and about half an inch in the transverse direction. At the base of the vomer may be seen the expanded alæ of this bone, receiving between them, on each side, the rostrum of the sphenoid. Near the lateral margins of the vomer, at the root of the pterygoid processes, are the *pterygo-palatine canals*. The pterygoid process, which bounds the posterior nares on each side, presents near its base the *pterygoid* or *Vidian canal*, for the Vidian nerve and artery. Each process consists of two plates, which bifurcate at the extremity to receive the tuberosity of the palate bone, and are separated behind by the pterygoid fossa, which lodges the Internal pterygoid muscle. The internal plate is long and narrow, presenting on the outer side of its base the *scaphoid fossa*, for the origin of the Tensor palati muscle, and at its extremity the *hamular process*, around which the tendon of this muscle turns. The external pterygoid plate is broad, forms the inner boundary of the zygomatic fossa, and affords attachment by its outer surface to the External pterygoid muscle.

Behind the nasal fossæ in the middle line is the basilar surface of the occipital bone, presenting in its centre the *pharyngeal spine*, for the attachment of the Superior constrictor muscle of the pharynx, with depressions on each side for the insertion of the Rectus capitis anticus major and minor. At the base of the external pterygoid plate is the *foramen ovale*, for the transmission of the third division of the fifth nerve, the small meningeal artery, and sometimes the small petrosal nerve; behind this, the *foramen spinosum*, which transmits the middle meningeal artery, and the prominent spinous process of the sphenoid, which gives attachment to the internal lateral ligament of the lower jaw and the Tensor palati muscle. External to the spinous process is the *glenoid fossa*, divided into two parts by the Glaserian fissure (page 66), the anterior portion concave, smooth, bounded in front by the eminentia articularis, and serving for the articulation of the condyle of the lower jaw; the posterior portion rough, bounded behind by the tympanic plate, and serving for the reception of part of the parotid gland. Emerging from between the laminæ of the vaginal process of the tympanic plate is the *styloid process*, and at the base of this process is the *stylo-mastoid foramen*, for the exit of the facial nerve and entrance of the stylo-mastoid artery. External to the stylo-mastoid foramen is the *auricular fissure*, for the auricular branch of the pneumogastric, bounded behind by the mastoid process. Upon the inner side of the mastoid process is a deep groove, the *digastric fossa*; and a little more internally the *occipital groove*, for the occipital artery. At the base of the internal pterygoid plate is a large and somewhat triangular aperture, the *foramen lacerum medium*, bounded in front by the great wing of the sphenoid, behind by the apex of the petrous portion of the temporal bone, and internally by the body of the sphenoid and basilar process of the occipital bone: it presents in front the posterior orifice of the Vidian canal; behind, the aperture of the carotid canal. The basilar surface of this opening is filled in the recent state by fibro-cartilaginous substance; across its upper or cerebral aspect passes the internal carotid artery. External to this aperture the *petro-sphenoidal suture* is observed, at the outer termination of which is seen the orifice of the canal for the Eustachian tube and that for the Tensor tympani muscle. Behind this suture is seen the under surface of the petrous portion of the temporal bone, presenting, from within outward, the quadrilateral, rough surface, part of which affords attachment to the Levator palati and Tensor tympani muscles; external to this surface the orifices of the carotid canal and the aquæductus cochleæ, the former transmitting the internal carotid artery and the ascending branches of the superior cervical ganglion of the sympathetic, the latter serving for the passage of a small artery and vein to the cochlea. Behind the carotid canal is a large aperture, the *jugular foramen*, formed in front by the petrous portion of the temporal, and behind by the occipital; it is generally larger on the right than on the left side, and is divided into three compartments by processes of dura mater. The anterior is for the passage of the inferior petrosal sinus; the posterior, for the lateral sinus and some meningeal branches from the occipital and ascending pharyngeal arteries; the central one, for the glosso-pharyngeal, pneumogastric, and spinal accessory nerves. On the ridge of bone dividing the carotid canal from the jugular foramen is the small foramen for the transmission of Jacobson's nerve; and on the wall of the jugular foramen, near the root of the styloid process, is the small aperture for the transmission of Arnold's nerve. Behind the basilar surface of the occipital bone is the *foramen magnum*, bounded on each side by the condyles, rough internally for the attachment of the check or odontoid ligaments, and presenting externally a rough surface, the *jugular process*, which serves for the attachment of the Rectus capitis lateralis muscle and the lateral occipito-atlantal ligament. On either side of each condyle anteriorly is the *anterior condyloid fossa*, perforated by the anterior condyloid foramen, for the passage of the hypoglossal nerve and a meningeal artery. Behind each condyle is the *posterior condyloid fossa*, perforated on one or both sides by the posterior condyloid foramina, for the transmission of a vein to the lateral sinus. Behind the foramen magnum is the *external occipital crest*, terminating above at the *external occipital protuberance*, whilst on each side are seen the *superior* and *inferior curved lines*; these, as well as the surfaces of bone between them, are rough for the attachment of the muscles, which are enumerated on page 59.

## The Lateral Region of the Skull.

The **Lateral Region** of the Skull is of a somewhat triangular form, the base of the triangle being formed by a line extending from the external angular process of the frontal bone along the temporal ridge backward to the outer extremity of the superior curved line of the occiput: and the sides by two lines, the one drawn downward and backward from the external angular process of the frontal bone to the angle of the lower jaw, the other from the angle of the jaw upward and


Fig. 72.—Side view of the skull. (Cryer.)

backward to the outer extremity of the superior curved line. This region is divisible into three portions—temporal fossa, mastoid portion, and zygomatic fossa.

### The Temporal Fossa.

The **Temporal Fossa** is bounded above and behind by the temporal ridges, which extend from the external angular process of the frontal upward and backward across the frontal and parietal bones, curving downward behind to terminate in the posterior root of the zygomatic process (*supra-mastoid crest*). In front it is bounded by the frontal, malar, and great wing of the sphenoid; externally by the zygomatic arch formed conjointly by the malar and temporal bones; below, it is separated from the zygomatic fossa by the pterygoid ridge, seen on the outer surface of the great wing of the sphenoid. This fossa is formed by five bones, part of the frontal, great wing of the sphenoid, parietal, squamous portion of the temporal, and malar bones, and is traversed by six sutures, part of the transverse facial, spheno-malar, coronal, spheno-parietal, squamo-parietal, and squamo-sphenoidal. The point where the coronal suture crosses the superior temporal ridge is sometimes named the *stephanion;* and the region where the four bones, the parietal, the frontal, the squamous, and the greater wing of the sphenoid, meet, at the anterior inferior angle of the parietal bone, is named the *pterion.* This point is about on a level with the external angular process of the frontal bone and about one and a half inches behind it. This fossa is deeply concave in front, convex behind, traversed by grooves which lodge branches of the deep temporal arteries, and filled by the Temporal muscles.

### The Mastoid Portion.

The **Mastoid Portion** of the side of the skull is bounded in front by the tubercle of the zygoma; above, by a line which runs from the posterior root of the zygoma to the end of the mastoid-parietal suture; behind and below by the masto-occipital suture. It is formed by the mastoid and part of the squamous and petrous portions of the temporal bone; its surface is convex and rough for the attachment of muscles, and presents, from behind forward, the mastoid foramen, the mastoid process, the external auditory meatus surrounded by the tympanic plate, and, most anteriorly, the temporo-maxillary articulation.

The point where the posterior inferior angle of the parietal meets the occipital bone and mastoid portion of the temporal is named the *asterion.*

### The Zygomatic Fossa.

The **Zygomatic Fossa** is an irregularly shaped cavity, situated below and on the inner side of the zygoma; bounded, in front, by the zygomatic surface of the superior maxillary bone and the ridge which descends from its malar process; behind, by the posterior border of the external pterygoid plate and the eminentia articularis; above, by the pterygoid ridge on the outer surface of the great wing

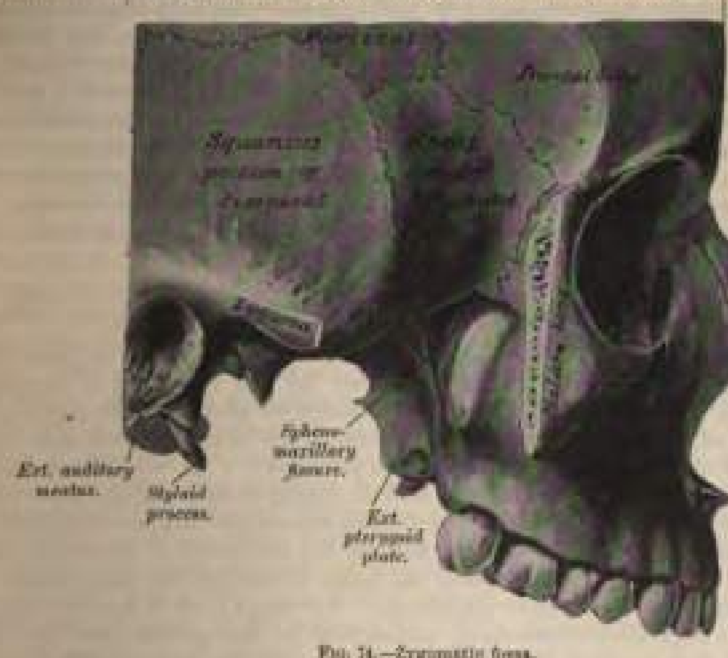



FIG. 74.—Zygomatic fossa.

of the sphenoid and the under part of the squamous portion of the temporal; below, by the alveolar border of the superior maxilla; internally, by the external pterygoid plate; and externally, by the zygomatic arch and ramus of the lower jaw (Fig. 74). It contains the lower part of the Temporal, the External and Internal pterygoid muscles, the internal maxillary artery and vein, and inferior maxillary nerve and their branches. At its upper and inner part may be observed two fissures, the spheno-maxillary and pterygo-maxillary.

The **Spheno-maxillary Fissure,** horizontal in direction, opens into the outer and back part of the orbit. It is formed above by the lower border of the orbital surface of the great wing of the sphenoid; below, by the external border of the orbital surface of the superior maxilla and a small part of the palate bone; externally, by a small part of the malar bone:[1] internally, it joins at right angles with the pterygo-maxillary fissure. This fissure opens a communication from the orbit into three fossæ—the temporal, zygomatic, and spheno-maxillary; it transmits the superior maxillary nerve and its orbital branch, the infraorbital vessels, and ascending branches from the spheno-palatine or Meckel's ganglion.

The **Pterygo-maxillary Fissure** is vertical, and descends at right angles from the inner extremity of the preceding; it is a V-shaped interval, formed by the divergence of the superior maxillary bone from the pterygoid process of the sphenoid. It serves to connect the spheno-maxillary fossa with the zygomatic fossa, and transmits branches of the internal maxillary artery.

### The Spheno-maxillary Fossa.

The **Spheno-maxillary Fossa** is a small, triangular space situated at the angle of junction of the spheno-maxillary and pterygo-maxillary fissures, and placed beneath the apex of the orbit. It is formed above by the under surface of the body of the sphenoid and by the orbital process of the palate bone; in front, by the superior maxillary bone; behind, by the anterior surface of the base of the pterygoid process and lower part of the anterior surface of the great wing of the sphenoid; internally, by the vertical plate of the palate. This fossa has three fissures terminating in it—the *sphenoidal, spheno-maxillary,* and *pterygo-maxillary;* it communicates with the orbit by the spheno-maxillary fissure; with the nasal fossæ by the spheno-palatine foramen, and with the zygomatic fossa by the pterygo-maxillary fissure. It also communicates with the cavity of the cranium, and has opening into it five foramina. Of these, there are three on the posterior wall: the *foramen rotundum* above; below and internal to this, the *Vidian canal;* and still more inferiorly and internally, the *pterygo-palatine canal.* On the inner wall is the *spheno-palatine foramen,* by which the spheno-maxillary communicates with the nasal fossa; and below is the superior orifice of the *posterior palatine canal,* besides occasionally the orifices of the *accessory posterior palatine canals.* The fossa contains the superior maxillary nerve and Meckel's ganglion, and the termination of the internal maxillary artery.

## The Anterior Region of the Skull.

The **Anterior Region** of the Skull, which forms the face, is of an oval form, presents an irregular surface, and is excavated for the reception of two of the organs of sense, the eye and the nose. It is bounded above by the glabella and margins of the orbit; below, by the prominence of the chin; on each side by the malar bone and anterior margin of the ramus of the jaw. In the median line are seen from above downward the glabella, and diverging from it are the *superciliary ridges,* which indicate the situation of the frontal sinuses and support the eyebrows. Beneath the glabella is the fronto-nasal suture, the mid-point of which is termed the *nasion,* and below this is the arch of the nose, formed by the nasal bones, and the nasal processes of the superior maxillary. The nasal arch is convex from side to side, concave from above downward, presenting in the median line the internasal suture formed between the nasal bones, laterally the naso-maxillary suture formed between the nasal bone and the nasal process of the superior maxillary bone. Below the nose is seen the opening of the anterior nares, which is heart-shaped, with the narrow end upward, and presents laterally the thin, sharp

[1] Occasionally the superior maxillary bone and the sphenoid articulate with each other at the anterior extremity of this fissure; the malar is then excluded from entering into its formation.

margins serving for the attachment of the lateral cartilages of the nose, and in the middle line below a prominent process, the *anterior nasal spine*, bounded by two deep notches. Below this is the *intermaxillary suture*, and on each side of it the *incisive fossa*. Beneath this fossa are the alveolar processes of the upper and lower jaws, containing the incisor teeth, and at the lower part of the median line the *symphysis of the chin*, the *mental process*, with its two *mental tubercles*, separated by a median groove, and the *incisive fossa* of the lower jaw.

On each side, proceeding from above downward, is the *supraorbital ridge*, terminating externally in the external angular process at its junction with the malar, and internally in the internal angular process; toward the inner third of this ridge is the *supraorbital notch* or *foramen*, for the passage of the supraorbital vessels and nerve. Beneath the supraorbital ridge is the opening of the orbit, bounded externally by the orbital ridge of the malar bone; below, by the orbital ridge formed by the malar and superior maxillary bones; internally, by the nasal process of the superior maxillary and the internal angular process of the frontal bone. On the outer side of the orbit is the quadrilateral anterior surface of the malar bone, perforated by one or two small malar foramina. Below the inferior margin of the orbit is the *infraorbital foramen*, the termination of the infraorbital canal, and beneath this the *canine fossa*, which gives attachment to the Levator anguli oris; still lower are the alveolar processes, containing the teeth of the upper and lower jaws. Beneath the alveolar arch of the lower jaw is the *mental foramen*, for the passage of the mental vessels and nerve, the *external oblique line*, and at the lower border of the bone, at the point of junction of the body with the ramus, a shallow groove for the passage of the facial artery.

### The Orbits.

The **Orbits** (Fig. 75) are two quadrilateral pyramidal cavities, situated at the upper and anterior part of the face, their bases being directed forward and outward, and their apices backward and inward, so that the axes of the two, if continued backward, would meet over the body of the sphenoid bone. Each orbit is formed of *seven* bones, the frontal, sphenoid, ethmoid, superior maxillary, malar, lachrymal, and palate; but three of these, the frontal, ethmoid, and sphenoid, enter into the formation of *both* orbits, so that the two cavities are formed of *eleven* bones only. Each cavity presents for examination a roof, a floor, an inner and an outer wall, four angles, a circumference or base, and an apex. The roof is concave, directed downward and slightly forward, and formed in front by the orbital plate of the frontal; behind by the lesser wing of the sphenoid. This surface presents internally the depression for the cartilaginous pulley of the Superior oblique muscle; externally, the depression for the lachrymal gland; and posteriorly, the suture connecting the frontal and lesser wing of the sphenoid.

The **floor** is directed upward and outward, and is of less extent than the roof; it is formed chiefly by the orbital process of the superior maxillary; in front, to a small extent, by the orbital process of the malar, and behind, by the superior surface of the orbital process of the palate. This surface presents at its anterior and internal part, just external to the lachrymal groove, a depression for the attachment of the Inferior oblique muscle; externally, the suture between the malar and superior maxillary bones; near its middle, the infraorbital groove; and posteriorly, the suture between the maxillary and palate bones.

The **inner wall** is flattened, nearly vertical, and formed from before backward by the nasal process of the superior maxillary, the lachrymal, os planum of the ethmoid, and a small part of the body of the sphenoid. This surface presents the lachrymal groove and crest of the lachrymal bone, and the sutures connecting the lachrymal with the superior maxillary, the ethmoid with the lachrymal in front, and the ethmoid with the sphenoid behind.

The **outer wall** is directed forward and inward, and is formed in front by the orbital process of the malar bone; behind, by the orbital surface of the greater wing of the sphenoid. On it are seen the orifices of one or two malar canals, and the suture connecting the sphenoid and malar bones.

**Angles.**—The *superior external angle* is formed by the junction of the upper and outer walls; it presents, from before backward, the suture connecting the frontal with the malar in front and with the great wing of the sphenoid behind; quite posteriorly is the foramen lacerum anterius, or sphenoidal fissure, which transmits the third, the fourth, the three branches of the ophthalmic division of the fifth, the sixth nerve, some filaments from the cavernous plexus of the sympathetic, the orbital branch of the middle meningeal artery, a recurrent branch

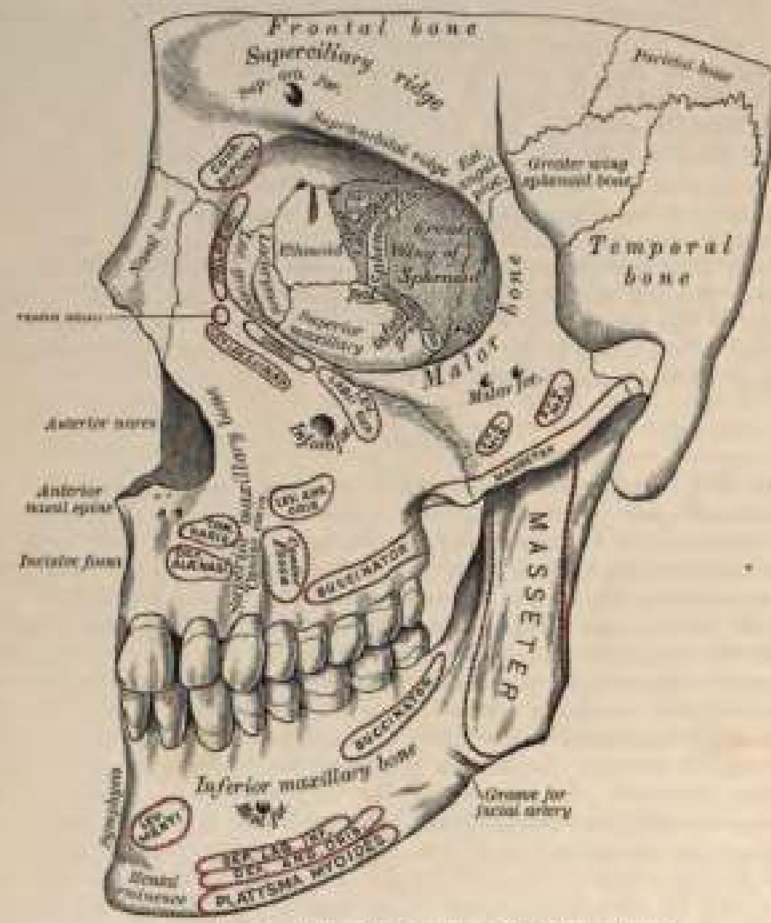



Fig. 75.—Antero-lateral region of the skull. (Cryer.)

from the lachrymal artery to the dura mater, and the ophthalmic vein. The *superior internal angle* is formed by the junction of the upper and inner wall, and presents the suture connecting the frontal bone with the lachrymal in front and with the ethmoid behind. The point of junction of the *anterior* border of the lachrymal with the frontal has been named the *dacryon*. This angle presents two foramina, the anterior and posterior ethmoidal, the former transmitting the anterior ethmoidal vessels and nasal nerve, the latter the posterior ethmoidal vessels. The *inferior external angle*, formed by the junction of the outer wall and floor, presents the spheno-maxillary fissure, which transmits the superior maxillary nerve and its orbital branches, the infraorbital vessels, and the ascending branches from the spheno-palatine or Meckel's ganglion. The *inferior internal angle* is formed by the union of the lachrymal and os planum of the ethmoid with the superior maxillary and palate bones. The *circumference*, or base, of the orbit, quadrilateral in form, is bounded above by the supraorbital ridge; below, by the anterior border of the orbital plate of the malar and superior maxillary bones; externally, by the external angular process of the frontal and malar bones; internally, by the internal angular process of the frontal and the nasal process of the superior maxillary. The circumference is marked by three sutures, the fronto-maxillary internally, the fronto-malar externally, and the malo-maxillary below; it contributes to the formation of the lachrymal groove, and presents, above, the supraorbital notch (or foramen), for the passage of the supraorbital vessels and nerve. The *apex*, situated at the back of the orbit, corresponds to the optic foramen,[1] a short, circular canal which transmits the optic nerve and ophthalmic artery. It will thus be seen that there are *nine* openings communicating with each orbit—viz. the optic foramen, sphenoidal fissure, spheno-maxillary fissure, supraorbital foramen, infraorbital canal, anterior and posterior ethmoidal foramina, malar foramina, and canal for the nasal duct.

### The Nasal Fossæ.

The **Nasal Fossæ** are two large, irregular cavities situated on either side of the middle line of the face, extending from the base of the cranium to the roof of the mouth, and separated from each other by a thin vertical septum. They communicate by two large apertures, the anterior nares, with the front of the face, and by the two posterior nares with the naso-pharynx behind. These fossæ are much

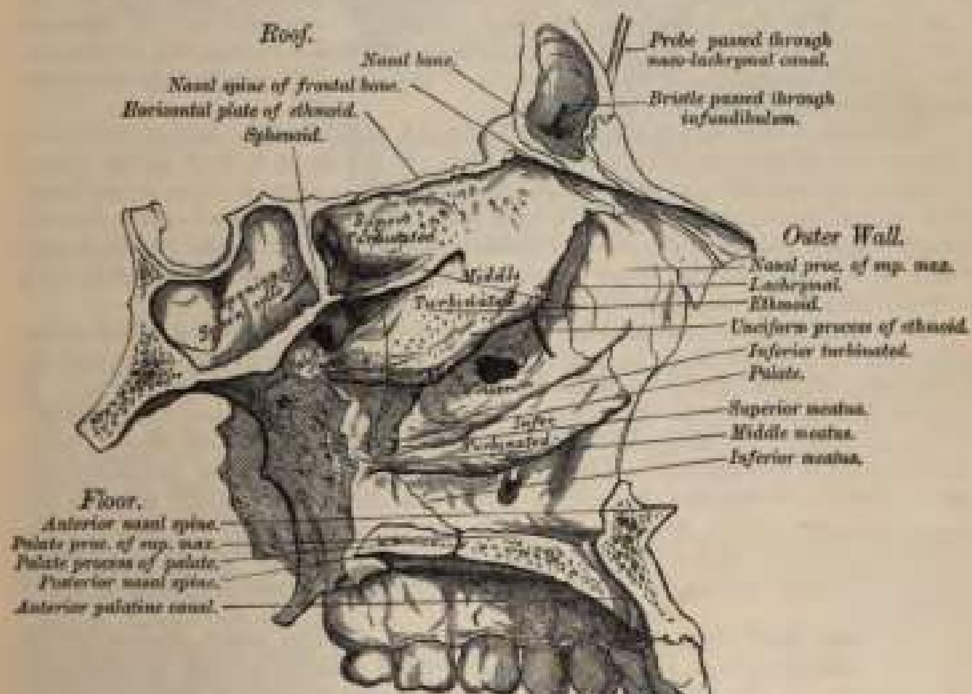



FIG. 76.—Roof, floor, and outer wall of left nasal fossa.

narrower above than below, and in the middle than at the anterior or posterior openings; their depth, which is considerable, is much greater in the middle than at either extremity. Each nasal fossa communicates with four sinuses, the frontal above, the sphenoidal behind, and the maxillary and ethmoidal on the outer wall.

[1] Quain, Testut, and others give the apex of the orbit as corresponding with the inner end of the sphenoidal fissure. It seems better, however, to adopt the statement in the text, since the muscles of the eyeball take origin around the optic foramen, and diverge from it to the globe of the eye.

Each fossa also communicates with four cavities: with the orbit by the lachrymal groove, with the mouth by the anterior palatine canal, with the cranium by the olfactory foramina, and with the spheno-maxillary fossa by the spheno-palatine foramen; and they occasionally communicate with each other by an aperture in the septum. The bones entering into their formation are fourteen in number: three of the cranium, the frontal, sphenoid, and ethmoid, and all the bones of the face, excepting the malar and lower jaw. Each cavity is bounded by a roof, a floor, an inner and an outer wall.

The **upper wall**, or **roof** (Fig. 76), is long, narrow, and horizontal in its centre, but slopes downward at its anterior and posterior extremities; it is formed in front by the nasal bones and nasal spine of the frontal, which are directed downward and forward; in the middle, by the cribriform plate of the ethmoid, which is horizontal; and behind, by the under surface of the body of the sphenoid and sphenoidal turbinated bones, the ala of the vomer and the sphenoidal process of the palate bone, which are directed downward and backward. This surface presents, from before backward, the internal aspect of the nasal bones; on their outer side, the suture formed between the nasal bone and the nasal process of the superior maxillary; on their inner side, the elevated crest which receives the nasal spine of the frontal and the perpendicular plate of the ethmoid, and articulates with its fellow of the opposite side; whilst the surface of the bones is perforated by a few small vascular apertures, and presents the longitudinal groove for the nasal nerve; farther back is the transverse suture, connecting the frontal with the nasal in front, and the ethmoid behind, the olfactory foramina and nasal slit on the under surface of the cribriform plate, and the suture between it and the sphenoid behind: quite posteriorly are seen the sphenoidal turbinated bones, the orifices of the sphenoidal sinuses, and the articulation of the alæ of the vomer with the under surface of the body of the sphenoid.

The **floor** is flattened from before backward, concave from side to side, and wider in the middle than at either extremity. It is formed in front by the palate process of the superior maxillary; behind, by the palate process of the palate bone. This surface presents, from before backward, the anterior nasal spine; behind this, the upper orifices of the anterior palatine canal; internally, the elevated crest which articulates with the vomer; and behind, the suture between the palate and superior maxillary bones, and the posterior nasal spine.

The **inner wall**, or **septum** (Fig. 77), is a thin vertical partition which separates the nasal fossæ from each other; it is occasionally perforated, so that the fossæ communicate, and it is frequently deflected considerably to one side.[1] It is formed, in front, by the crest of the nasal bones and nasal spine of the frontal; in the middle, by the perpendicular plate of the ethmoid; behind, by the vomer and rostrum of the sphenoid; below, by the crests of the superior maxillary and palate bones. It presents, in front, a large, triangular notch, which receives the septal cartilage of the nose; and behind, the grooved edge of the vomer. Its surface is marked by numerous vascular and nervous canals and the groove for the naso-palatine nerve, and is traversed by sutures connecting the bones of which it is formed.

The **outer wall** (Fig. 76) is formed, in front, by the nasal process of the superior maxillary and lachrymal bones; in the middle, by the ethmoid and inner surface of the superior maxillary and inferior turbinated bones; behind, by the vertical plate of the palate bone and the internal pterygoid plate of the sphenoid. This surface presents three irregular longitudinal passages, or *meatuses*, termed the superior, middle, and inferior meatuses of the nose. The *superior meatus*, the smallest of the three, is situated at the upper and back part of each nasal fossa, occupying the posterior third of the outer wall. It is situated between the superior and middle turbinated bones, and has opening into it two foramina, the *spheno-palatine* at the back of its outer wall, and the *posterior ethmoidal cells* at the front part of the outer wall. The sphenoidal sinus opens

[1] See footnote, p. 78.

into a recess, the *spheno-ethmoidal recess*, which is situated above and behind the superior turbinated bone. The *middle meatus* is situated between the middle and inferior turbinated bones, and extends from the anterior end of the inferior turbinated bone to the spheno-palatine foramen of the outer wall of the nasal fossa. It presents in front the orifice of the *infundibulum*, by which the middle meatus communicates with the anterior ethmoidal cells, and through these with the frontal sinuses. The middle ethmoidal cells also open into this meatus, while

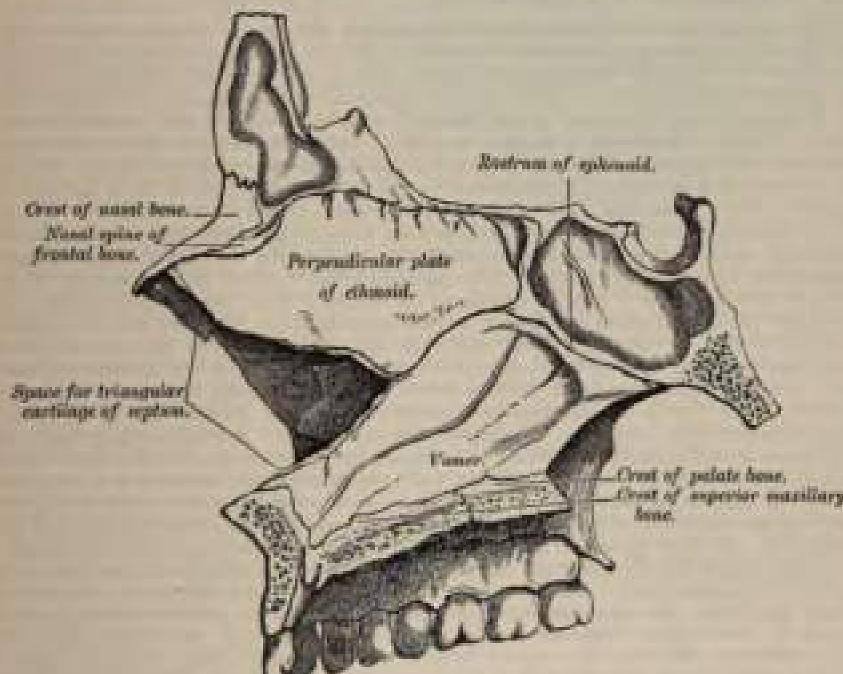



Fig. 77.—Inner wall of nasal fossæ, or septum of nose.

at the centre of the outer wall is the *orifice of the antrum*, which varies somewhat as to its exact position in different skulls. The *inferior meatus*, the largest of the three, is the space between the inferior turbinated bone and the floor of the nasal fossa. It extends along the entire length of the outer wall of the nose, is broader in front than behind, and presents anteriorly the lower *orifice of the canal for the nasal duct*.

The **anterior nares** present a heart-shaped or pyriform opening whose long axis is vertical and narrow extremity upward. This opening in the recent state is much contracted by the cartilages of the nose. It is bounded above by the inferior border of the nasal bone; laterally by the thin, sharp margin which separates the facial from the nasal surface of the superior maxillary bone; and below by the same border, where it slopes inward to join its fellow of the opposite side at the anterior nasal spine.

The **posterior nares**, or **choanæ**, are the two posterior oval openings of the nasal fossæ, by which they communicate with the upper part of the pharynx. They are situated immediately in front of the basilar process, and are bounded above by the under surface of the body of the sphenoid and alæ of the vomer; below, by the posterior border of the horizontal plate of the palate bone; externally, by the inner surface of the internal pterygoid plate; and internally, in the middle line, they are separated from each other by the posterior border of the vomer.

**Surface Form.**—The various bony prominences or landmarks which are to be easily felt and recognized in the head and face, and which afford the means of mapping out the important structures comprised in this region, are as follows:

1. Supraorbital arch.
2. Internal angular process.
3. External angular process.
4. Zygomatic arch.
5. Mastoid process.
6. External occipital protuberance.
7. Superior curved line of occipital bone.
8. Parietal eminences.
9. Temporal ridge.
10. Frontal eminences.
11. Superciliary ridges.
12. Nasal bones.
13. Lower margin of orbit.
14. Lower jaw.

1. The *supraorbital arches* are to be felt throughout their entire extent, covered by the eyebrows. They form the upper boundary of the circumference or base of the orbit, and separate the face from the forehead. They are strong and arched, and terminate internally on each side of the root of the nose in the *internal angular process*, which articulates with the lachrymal bone. Externally they terminate in the *external angular process*, which articulates with the malar bone. This arched ridge is sharper and more defined in its outer than in its inner half, and forms an overhanging process which protects and shields the lachrymal gland. It thus protects the eye in its most exposed situation and in the direction from which blows are most likely to descend. The supraorbital arch varies in prominence in different individuals. It is more marked in the male than in the female, and in some races of mankind than others. In the less civilized races, as the forehead recedes backward, the supraorbital arch becomes more prominent, and approaches more to the characters of the monkey tribe, in which the supraorbital arches are very largely developed, and acquire additional prominence from the oblique direction of the frontal bone. 2. The *internal angular process* is scarcely to be felt. Its position is indicated by the angle formed by the supraorbital arch with the nasal process of the superior maxillary bone and the lachrymal bone at the inner side of the orbit. Between the internal angular processes of the two sides is a broad surface which assists in forming the root of the nose, and immediately above this a broad, smooth, somewhat triangular surface, the *glabella*, situated between the superciliary ridges. 3. The *external angular process* is much more strongly marked than the internal, and is plainly to be felt. It is formed by the junction or confluence of the supraorbital and temporal ridges, and, articulating with the malar bone, it serves to a very considerable extent to support the bones of the face. In carnivorous animals the external angular process does not articulate with the malar, and therefore this lateral support to the bones of the face is not present. 4. The *zygomatic* arch is plainly to be felt throughout its entire length, being situated almost immediately under the skin. It is formed by the malar bone and the zygomatic process of the temporal bone. At its anterior extremity, where it is formed by the malar bone, it is broad and forms the prominence of the cheek; the posterior part is narrower, and terminates just in front and a little above the tragus of the external ear. The lower border is more plainly to be felt than the upper, in consequence of the dense temporal fascia being attached to the latter, which somewhat obscures its outline. Its shape differs very much in individuals and in different races of mankind. In the most degraded type of skull—as, for instance, in the skull of the negro of the Guinea Coast—the malar bones project forward and not outward, and the zygoma at its posterior extremity extends farther outward before it is twisted on itself to be prolonged forward. This makes the zygomatic arch stand out in bold relief, and affords greater space for the Temporal muscle. In skulls which have a more pyramidal shape, as in the Esquimaux or Greenlander, the malar bones do not project forward and downward under the eyes, as in the preceding form, but take a direction outward, forming with the zygoma a large, rounded sweep or segment of a circle. Thus it happens that if two lines are drawn from the zygomatic arches, touching the temporal ridges, they meet above the top of the head, instead of being parallel, or nearly so, as in the European skull, in which the zygomatic arches are not nearly so prominent. This gives to the face a more or less oval type. 5. Behind the ear is the *mastoid portion of the temporal bone*, plainly to be felt, and terminating below in a nipple-shaped process. Its anterior border can be traced immediately behind the concha, and its apex is on about a level with the lobule of the ear. It is rudimentary in infancy, but gradually develops in childhood, and is more marked in the negro than in the European. 6. The *external occipital protuberance* is always plainly to be felt just at the level where the skin of the neck joins that of the head. At this point the skull is thick for the purposes of safety, while radiating from it are numerous curved arches or buttresses of bone which give to this portion of the skull further security. 7. Running outward on either side from the external occipital protuberance is an arched ridge of bone, which can be more or less plainly perceived. This is the *superior curved line* of the occipital bone, and gives attachment to some of the muscles which keep the head erect on the spine; accordingly, we find it more developed in the negro tribes, in whom the jaws are much more massive, and therefore require stronger muscles to prevent their extra weight carrying the head forward. Below this line the surface of bone at the back of the head is obscured by the overlying muscles. Above it, the vault of the cranium is thinly covered with soft structures, so that the form of this part of the head is almost exactly that of the upper portion of the occipital, the parietal, and the frontal bones themselves; and in bald persons even the lines of junction of the bones, especially the junction of the occipital and parietal at the lambdoid suture, may be defined as a slight depression, caused by the thickening of the borders of the bones in this situation. 8. In the line of the greatest transverse diameter of the

head, on each side of the middle line, are generally to be found the *parietal eminences*, one on each side of the middle line, though sometimes these eminences are not situated at the point of the greatest transverse diameter, which is at some other prominent part of the parietal region. They denote the point where ossification of the parietal bone began. They are much more prominent and well-marked in early life, in consequence of the sharper curve of the bone at this period, so that it describes the segment of a smaller circle. Later in life, as the bone grows, the curve spreads out and forms the segment of a larger circle, so that the eminence becomes less distinguishable. In consequence of this sharp curve of the bone in early life, the whole of the vault of the skull has a squarer shape than it has in later life, and this appearance may persist in some rickety skulls. The eminence is more apparent in the negro's skull than in that of the European. This is due to greater flattening of the temporal fossa in the former skull to accommodate the larger Temporal muscle which exists in these races. The parietal eminence is particularly exposed to injury from blows or falls on the head, but fracture is to a certain extent prevented by the shape of the bone, which forms an arch, so that the force of the blow is diffused over the bone in every direction. 9. At the side of the head may be felt the *temporal ridge*. Commencing at the external angular process, it may be felt as a curved ridge, passing upward and then curving backward, on the frontal bone, separating the forehead from the temporal fossa. It may then be traced, passing backward in a curved direction, over the parietal bone, and, though less marked, still generally to be recognized. Finally, the ridge curves downward, and terminates in the posterior root of the zygoma, which separates the squamous from the subcutaneous mastoid portion of the temporal bone. Mr. Victor Horsley has recently shown, in an article on the "Topography of the Cerebral Cortex," that the second temporal ridge (see page 62) can be made out on the living body. 10. The *frontal eminences* vary a good deal in different individuals, being considerably more prominent in some than in others, and they are often not symmetrical on the two sides of the body, the one being much more pronounced than the other. This is often especially noticeable in the skull of the young child or infant, and becomes less marked as age advances. The prominence of the frontal eminences depends more upon the general shape of the whole bone than upon the size of the protuberances themselves. As the skull is more highly developed in consequence of increased intellectual capacity, so the frontal bone becomes more upright and the frontal eminences stand out in bolder relief. Thus they may be considered as affording, to a certain extent, an indication of the development of the hemispheres of the brain beneath, and of the mental powers of the individual. They are not so much exposed to injury as the parietal eminences. In falls forward the upper extremities are involuntarily thrown out, and break the force of the fall, and thus shield the frontal bone from injury. 11. Below the frontal eminences on the forehead are the *superciliary ridges*, which denote the position of the frontal sinuses, and vary according to the size of the sinuses in different individuals, being, as a rule, small in the female, absent in children, and sometimes unusually prominent in the male, when the frontal sinuses are largely developed. They commence on either side of the glabella, and at first present a rounded form, which gradually fades away at their outer ends. 12. The *nasal bones* form the prominence of the nose. They vary much in size and shape, and to them is due the varieties in the contour of this organ and much of the character of the face. Thus, in the Mongolian or Ethiopian they are flat, broad and thick at their base, giving to these tribes the flattened nose by which they are characterized, and differing very decidedly from the Caucasian, in whom the nose, owing to the shape of the nasal bones, is narrow, elevated at the bridge, and elongated downward. Below, the nasal bones are thin and connected with the cartilages of the nose, and the angle or arch formed by their union serves to throw out the bridge of the nose, and is much more marked in some individuals than others. 13. The *lower margin of the orbit*, formed by the superior maxillary bone and the malar bone, is plainly to be felt throughout its entire length. It is continuous internally with the nasal process of the superior maxillary bone, which forms the inner boundary of the orbit. At the point of junction of the lower margin of the orbit with the nasal process is to be felt a little tubercle of bone, which can be plainly perceived by running the finger along the bone in this situation. This tubercle serves as a guide to the position of the lachrymal sac, which is situated above and behind it. 14. The outline of the *lower jaw* is to be felt throughout its entire length. Just in front of the tragus of the external ear, and below the zygomatic arch, the condyle can be made out. When the mouth is opened this prominence of bone can be perceived advancing out of the glenoid fossa on to the eminentia articularis, and receding again when the mouth is closed. From the condyle the posterior border of the ramus can be felt extending down to the angle. A line drawn from the condyle to the angle would indicate the exact position of this border. From the angle to the symphysis of the chin the lower, rounded border of the body of the bone is plainly to be felt. At the point of junction of the two halves of the bone is a well-marked triangular eminence, the *mental process*, which forms the prominence of the chin.

**Surgical Anatomy.**—An arrest in the ossifying process may give rise to deficiencies or gaps; or to fissures, which are of importance in a medico-legal point of view, as they are liable to be mistaken for fractures. The fissures generally extend from the margin toward the centre of the bone, but gaps may be found in the middle as well as at the edges. In course of time they may become covered with a thin lamina of bone.

Occasionally a protrusion of the brain or its membranes may take place through one of these gaps in an imperfectly developed skull. When the protrusion consists of membranes only, and is filled with cerebro-spinal fluid, it is called a *meningocele*; when the protrusion consists of brain as well as membranes, it is termed an *encephalocele*; and when the protruded brain is a prolongation from one of the ventricles, and is distended by a collection of fluid from an accumulation in the ventricle, it is termed an *hydrencephalocele*. This latter condition is frequently found at the root of the nose, where a protrusion of the anterior horn of the lateral ventricle takes place through a deficiency of the fronto-nasal suture. These malformations are usually found in the middle line, and most frequently at the back of the head, the protrusion taking place through the fissures which separate the four centres of ossification from which the tabular portion of the occipital bone is originally developed (see page 61). They most frequently occur through the upper part of the vertical fissure, which is the last to ossify, but not uncommonly through the lower part, when the foramen magnum may be incomplete. More rarely these protrusions have been met with in other situations than those two above mentioned, both through normal fissures, as the sagittal, lambdoid, and other sutures, and also through abnormal gaps and deficiencies at the sides, and even at the base of the skull.

Fractures of the skull may be divided into those of the vault and those of the base. Fractures of the vault are usually produced by direct violence. This portion of the skull varies in thickness and strength in different individuals, but, as a rule, is sufficiently strong to resist a very considerable amount of violence without being fractured. This is due to several causes: the rounded shape of the head and its construction of a number of secondary elastic arches, each made up of a single bone; the fact that it consists of a number of bones, united, at all events in early life, by a sutural ligament, which acts as a sort of buffer and interrupts the continuity of any violence applied to the skull; the presence of arches or ridges, both on the inside and outside of the skull, which materially strengthen it; and the mobility of the head upon the spine which further enables it to withstand violence. The elasticity of the bones of the head is especially marked in the skull of the child, and this fact, together with the wide separation of the individual bones from each other, and the interposition between them of other softer structures renders fracture of the bones of the head a very uncommon event in infants and quite young children; as age advances and the bones become joined, fracture is more common, though still less liable to occur than in the adult. Fractures of the vault may, and generally do, involve the whole thickness of the bone; but sometimes one table may be fractured without any corresponding injury to the other. Thus, the outer table of the skull may be splintered and driven into the diploë, or in the frontal or mastoid regions into the frontal or mastoid cells, without any injury to the internal table. And on the other hand, the internal table has been fractured, and portions of it depressed and driven inward, without any fracture of the outer table. As a rule, in fractures of the skull the inner table is more splintered and comminuted than the outer, and this is due to several causes. It is thinner and more brittle; the force of the violence as it passes inward becomes broken up, and is more diffused by the time it reaches the inner table; the bone, being in the form of an arch, bends as a whole and spreads out, and thus presses the particles together on the convex surface of the arch—*i. e.* the outer table—and forces them asunder on the concave surface or inner table; and, lastly, there is nothing firm under the inner table to support it and oppose the force. Fractures of the vault may be simple fissures or starred and comminuted fractures, and these may be depressed or elevated. These latter cases of fracture with elevation of the fractured portion are uncommon, and can only be produced by direct wound. In comminuted fracture a portion of the skull is broken into several pieces, the lines of fracture radiating from a centre where the chief impact of the blow was felt; if depressed, a fissure circumscribes the radiating line, enclosing a portion of skull. If this area is circular, it is termed a "pond" fracture, and would in all probability have been caused by a round instrument, as a life-preserver or hammer; if elliptical in shape, it is termed a "gutter fracture," and would owe its shape to the instrument which had produced it, as a poker.

Fractures of the base are most frequently produced by the extension of a fissure from the vault, as in falls on the head, where the fissure starts from the part of the vault which first struck the ground. Sometimes, however, they are caused by direct violence, when foreign bodies have been forced through the thin roof of the orbit, through the cribriform plate of the ethmoid from being thrust up the nose, or through the roof of the pharynx. Other cases of fracture of the base occur from indirect violence, as in fracture of the occipital bone from impaction of the spinal column against its condyles in falls on the buttocks, knees, or feet, or in cases where the glenoid cavity has been fractured by the violent impact of the condyle of the lower jaw against it from blows on the chin.

The most common place for fracture of the base to occur is through the middle fossa, and here the fissure usually takes a fairly definite course. Starting from the point struck, which is generally somewhere in the neighborhood of the parietal eminence, it runs downward through the parietal and squamous portion of the temporal bone and across the petrous portion of this bone, frequently traversing and implicating the internal auditory meatus, to the middle lacerated foramen. From this it may pass across the body of the sphenoid, through the pituitary fossa to the middle lacerated foramen of the other side, and may indeed travel round the whole cranium, so as to completely separate the anterior from the posterior part. The course of the fracture should be borne in mind, as it explains the symptoms to which fracture in this region may give rise; thus, if the fissure pass across the internal auditory meatus, injury to the facial and auditory nerves may result, with consequent facial paralysis and deafness; or the tubular prolongation of the arachnoid around these nerves in the meatus may be torn, and thus permit of the escape of the cerebro-spinal fluid should there be a communication between the internal ear and the tympanum and the membrana tympani be ruptured, as is frequently the case; again, if the fissure passes across the pituitary fossa and the muco-periosteum covering the under surface of the body of the sphenoid is torn, blood will find its way into the pharynx and be swallowed, and after a time vomiting of blood will result. Fractures of the anterior fossa, involving the bones forming the roof of the orbit and nasal fossa, are generally the results of blows on the forehead; but fracture of the cribriform plate of the ethmoid may be a complication of fracture of the nasal bone. When the fracture implicates the roof of the orbit, the blood finds its way into this cavity, and, traveling forward, appears as a subconjunctival ecchymosis. If the roof of the nasal fossa be fractured, the blood escapes from the nose. In rare cases there may be also escape of cerebro-spinal fluid from the nose where the dura mater and arachnoid have been torn. In fractures of the posterior fossa extravasation of blood may appear at the nape of the neck.

The bones of the skull are frequently the seat of nodes, and not uncommonly necrosis results from this cause, also from injury. Necrosis may involve the entire thickness of the skull, but is usually confined to the external table. Necrosis of the internal table alone is rarely met with. The bones of the skull are also frequently the seat of sarcomatous tumor.

The skull in rickets is peculiar; the forehead is high, square, and projecting, and the antero-posterior diameter of the skull is long in relation to the transverse diameter. The bones of the face are small and ill-developed, and this gives the appearance of a larger head than actually exists. The bones of the head are often thick, especially in the neighborhood of the sutures, and the anterior fontanelle is late in closing, sometimes remaining unclosed till the fourth year. The condition of *craniotabes* has by some been also believed to be the result of rickets, by others is believed to be due to inherited syphilis. In all probability it is due to both. In these cases the bone undergoes atrophic changes in patches, so that it becomes greatly thinned in places, generally where there is pressure, as from the pillow or nurse's arm. It is, therefore, usually met with in the parietal bone and vertical plate of the occipital bone.

In congenital syphilis deposits of porous bone are often found at the angles of the parietal bones and two halves of the frontal bone which bound the anterior fontanelle. These deposits are separated by the coronal and sagittal sutures, and give to the skull an appearance like a "hot cross bun." They are known as Parrot's nodes, and such a skull has received the name of *natiform*, from its fancied resemblance to the buttocks.

In connection with the bones of the face a common malformation is *cleft palate*, owing to the non-union of the palatal processes of the maxillary or pre-oral arch. This cleft may involve the whole or only a portion of the hard palate, and usually involves the soft palate also. The cleft is in the middle line, except it involves the alveolus in front, when it follows the suture between the main portion of the bone and the pre-maxillary bone. Sometimes the cleft runs on either side of the pre-maxillary bone, so that this bone is quite isolated from the maxillary bones and hangs from the end of the vomer. The malformation is usually associated with hare-lip, which, when single, is almost always on one side, corresponding to the position of the suture between the lateral incisor and canine tooth. Some few cases of median hare-lip have been described. In double hare-lip there is a cleft on each side of the middle line.

The bones of the face are sometimes fractured as the result of direct violence. The two most commonly broken are the nasal bone and the inferior maxilla, and of these the latter is by far the most frequently fractured of all the bones of the face. Fracture of the *nasal* bone is for the most part transverse, and takes place about half an inch from the free margin. The broken portion may be displaced backward or more generally to one side by the force which produced the lesion, as there are no muscles here which can cause displacement. The *malar* bone is probably never broken alone; that is to say, unconnected with a fracture of the other bones of the face. The *zygomatic arch* is occasionally fractured, and when this occurs from direct violence, as is usually the case, the fragments may be displaced inward. This lesion is often attended with great difficulty or even inability to open and shut the mouth, and this has been stated to be due to the depressed fragments perforating the temporal muscle, but would appear rather to be caused by the injury done to the bony origin of the Masseter muscle. Fractures of the *superior maxilla* may vary much in degree, from the chipping off of a portion of the alveolar arch, a frequent accident when the "old key" instrument was used for the extraction of teeth, to an extensive comminution of the whole bone from severe violence, as the kick of a horse. The most common situation for a fracture of the *inferior maxillary bone* is in the neighborhood of the canine tooth, as at this spot the jaw is weakened by the deep socket for the fang of this tooth; it is next most frequently fractured at the angle; then at the symphysis, and finally the neck of the condyle or the coronoid process may be broken. Occasionally a double fracture may occur, one in either half of the bone. The fractures are usually compound, from laceration of the mucous membrane covering the gums. The displacement is mainly the result of the same violence as produced the injury, but may be further increased by the action of the muscles passing from the neighborhood of the symphysis to the hyoid bone.

The superior and inferior maxillary bones are both of them frequently the seat of necrosis, though the disease affects the lower much more frequently than the upper jaw, probably on account of the greater supply of blood to the latter. It may be the result of periostitis, from tooth irritation, injury, or the action of some specific poison, as syphilis, or from salivation by mercury; it not unfrequently occurs in children after attacks of the exanthematous fevers, and a special form occurs from the action of the fumes of phosphorus in persons engaged in the manufacture of matches.

Tumors attack the jaw-bones not infrequently, and these may be either innocent or malignant: in the upper jaw cysts may occur in the antrum, constituting the so-called dropsy of the antrum; or, again, cysts may form in either jaw in connection with the teeth: either cysts connected with the roots of fully-developed teeth, the "dental cyst;" or cysts connected with imperfectly developed teeth, the "dentigerous cyst." Solid innocent tumors include the fibroma, the chondroma, and the osteoma. Of malignant tumors there are two classes, the sarcomata and the epithelioma. The sarcoma are of various kinds, the spindle-celled and round-celled, of a very malignant character, and the myeloid sarcoma, principally affecting the alveolar margin of the bone. Of the epitheliomata we find the squamous variety spreading to the bone from the palate or gum, and the cylindrical epithelioma originating in the antrum or nasal fossæ.

Both superior and inferior maxillary bones occasionally require removal for tumors and in some other conditions. The upper jaw is removed by an incision from the inner canthus of the eye, along the side of the nose, round the ala, and down the middle line of the upper lip. A second incision is carried outward from the inner canthus of the eye along the lower margin of the orbit as far as the prominence of the malar bone. The flap thus formed is reflected outward and the surface of the bone exposed. The connections of the bone to the other bones of the face are then divided with a narrow saw. They are (1) the junction with the malar bone, passing into the spheno-maxillary fissure; (2) the nasal process; a small portion of its upper extremity, connected with the nasal bone in front, the lachrymal bone behind, and the frontal bone above, being left; (3) the connection with the bone on the opposite side and the palate in the roof of the mouth. The bone is now firmly grasped with lion-forceps, and by means of a rocking movement upward and downward the remaining attachments of the orbital plate with the ethmoid, and the back of the bone with the palate, broken through. The soft palate is first separated from the hard with a scalpel, and is not removed. Occasionally in removing the upper jaw it will be found that the orbital plate can be spared, and this should always be done if possible. A horizontal saw-cut is to be made just below the infraorbital foramen and the bone cut through with a chisel and mallet. Removal of one-half of the lower jaw is sometimes required. If possible, the section of the bone should be made to one side of the symphysis, so as to save the genial tubercles and the origin of the genio-hyo-glossus muscle, as otherwise the tongue tends to fall backward and may produce suffocation. Having extracted the central or preferably the lateral incisor tooth, a vertical incision is made down to the bone, commencing at the free margin of the lip, and carried to the lower border of the bone; it is then carried along its lower border to the angle and up the posterior margin of the ramus to a level with the lobule of the ear. The flap thus formed is raised by separating all the structures attached to the outer surface of the bone. The jaw is now sawn through at the point where the tooth has been extracted, and the knife passed along the inner side of the jaw, separating the structures attached to this surface. The jaw is then grasped by the surgeon and strongly depressed, so as to bring down the coronoid process and enable the operator to sever the tendon of the temporal muscle. The jaw can be now further depressed, care being taken not to evert it nor rotate it outward, which would endanger the internal maxillary artery, and the external pterygoid torn through or divided. The capsular ligament is now opened in front and the lateral ligaments divided, and the jaw removed with a few final touches of the knife.

The antrum of Highmore occasionally requires tapping for suppuration. This may be done through the socket of a tooth, preferably the first molar, the fangs of which are most intimately connected with the antrum, or through the facial aspect of the bone above the alveolar process. This latter method does not perhaps afford such efficient drainage, but there is less chance of food finding its way into the cavity. The operation may be performed by incising the mucous membrane above the second molar tooth, and driving a trocar or any sharp-pointed instrument into the cavity.

## THE HYOID BONE.

The **Hyoid bone** is named from its resemblance to the Greek upsilon; it is also called the *lingual bone*, because it supports the tongue and gives attachment to its numerous muscles. It is a bony arch, shaped like a horseshoe, and consisting of five segments, a body, two greater cornua, and two lesser cornua. It is suspended from the tip of the styloid processes of the temporal bone by ligamentous bands, the *stylo-hyoid* ligaments.

The **Body** (*basi-hyal*) forms the central part of the bone, and is of a quadrilateral form; its *anterior surface* (Fig. 78), convex, directed forward and upward, is divided into two parts by a vertical ridge which descends along the median line, and is crossed at right angles by a horizontal ridge, so that this surface is divided into four spaces or depressions. At the point of meeting of these two lines is a prominent elevation, the *tubercle*. The portion above the horizontal ridge is directed upward, and is sometimes described as the superior border. The anterior surface gives attachment to the Genio-hyoid in the greater part of its extent; above, to the Genio-hyo-glossus; below, to the Mylo-hyoid, Styly-hyoid, and aponeurosis of the Digastric (suprahyoid aponeurosis); and between these to part of the Hyo-glossus. The *posterior surface* is smooth, concave, directed backward and downward, and separated from the epiglottis by the thyro-hyoid membrane and by a quantity of loose areolar tissue. The *superior border* is rounded, and gives attachment to the thyro-hyoid membrane, part of the Genio-hyo-glossi and Chondro-glossi muscles. The *inferior border* gives attachment, in front, to the Sterno-hyoid; behind, to the Omo-hyoid and to part of the Thyro-hyoid at its junction with the great cornu. It also gives attachment to the Levatore glandulæ thyroideæ when this muscle is present. The *lateral surfaces* after middle life are joined to the greater cornua. In early life they are connected to the cornua by cartilaginous surfaces, and held together by ligaments, and occasionally a synovial membrane is found between them.

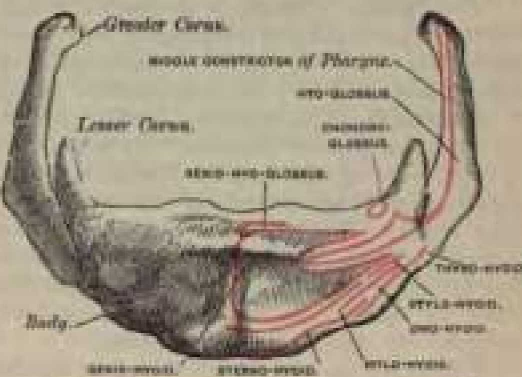



Fig. 78.—Hyoid bone. Anterior surface. (Enlarged.)

The **Greater Cornua** (*thyro-hyal*) project backward from the lateral surfaces of the body; they are flattened from above downward, diminish in size from before backward, and terminate posteriorly in a tubercle for the attachment of the lateral thyro-hyoid ligament. The outer surface gives attachment to the Hyo-glossus, their upper border to the Middle constrictor of the pharynx, their lower border to part of the Thyro-hyoid muscle.

The **Lesser Cornua** (*cerato-hyals*) are two small, conical-shaped eminences attached by their bases to the angles of junction between the body and greater cornua, and giving attachment by their apices to the stylo-hyoid ligaments.[1] The smaller cornua are connected to the body of the bone by a distinct diarthrodial joint, which usually persists throughout life, but occasionally becomes ankylosed.

**Development.**—By *five* centres: one for the body, and one for each cornu. Ossification commences in the body about the eighth month, and in the greater cornua toward the end of fœtal life. Ossification of the lesser cornua commences some years after birth. Sometimes there are two centres for the body.

**Attachment of Muscles.**—Sterno-hyoid, Thyro-hyoid, Omo-hyoid, aponeurosis of the Digastric, Stylo-hyoid, Mylo-hyoid, Genio-hyoid, Genio-hyo-glossus, Chondro-glossus, Hyo-glossus, Middle constrictor of the pharynx, and occasionally a few fibres of the Inferior lingualis. It also gives attachment to the thyro-hyoidean membrane and the stylo-hyoid, thyro-hyoid, and hyo-epiglottic ligaments.

**Surface Form.**—The hyoid bone can be felt in the receding angle below the chin, and the finger can be carried along the whole length of the bone to the greater cornu, which is situated just below the angle of the jaw. This process of bone is best perceived by making pressure on one cornu, and so pushing the bone over to the opposite side, when the cornu of this side will be distinctly felt immediately beneath the skin. This process of bone is an important landmark in ligature of the lingual artery.

**Surgical Anatomy.**—The hyoid bone is occasionally fractured, generally from direct violence, as in the act of garrotting or throttling. The great cornu is the part of the bone most frequently broken, but sometimes the fracture takes place through the body of the bone. In consequence of the muscles of the tongue having important connections with this bone, there is great pain upon any attempt being made to move the tongue, as in speaking or swallowing.

[1] These ligaments in many animals are distinct bones, and in man are occasionally ossified to a certain extent.

## THE THORAX.

The **Thorax**, or **Chest**, is an osseo-cartilaginous cage containing and protecting the principal organs of respiration and circulation. It is conical in shape, being narrow above and broad below, flattened from before backward, and longer behind than in front. It is somewhat reniform on transverse section.

**Boundaries.**—The *posterior* surface is formed by the twelve dorsal vertebræ and the posterior part of the ribs. It is concave from above downward, and presents on each side of the middle line a deep groove in consequence of the direction backward and outward which the ribs take from their vertebral extremities to their angles. The *anterior* surface is flattened or slightly convex, and inclined forward from above downward. It is formed by the sternum and costal cartilages. The *lateral* surfaces are convex; they are formed by the ribs, separated from each other by spaces, the *intercostal spaces*. These are eleven in number, and are occupied by the intercostal muscles.

The *upper opening* of the thorax is reniform in shape, being broader from side to side than from before backward. It is formed by the first dorsal vertebra behind, the upper margin of the sternum in front, and the first rib on each side. It slopes downward and forward, so that the anterior part of the ring is on a lower level than the posterior. The antero-posterior diameter is about two inches, and the transverse about four. The *lower* opening is formed by the twelfth dorsal vertebra behind, by the twelfth rib at the sides, and in front by the cartilages of the eleventh, tenth, ninth, eighth, and seventh ribs, which ascend on either side and form an angle, the *subcostal angle*, from the apex of which the ensiform cartilage projects. It is wider transversely than from before backward. It slopes obliquely downward and backward, so that the cavity of the thorax is much deeper behind than in front. The Diaphragm closes in the opening forming the floor of the thorax.

In the female the thorax differs as follows from the male: 1. Its general capacity is less. 2. The sternum is shorter. 3. The upper margin of the sternum is on a level with the lower part of the body of the third dorsal vertebra, whereas in the male it is on a level with the lower part of the body of the second dorsal vertebra. 4. The upper ribs are more movable, and so allow a greater enlargement of the upper part of the thorax than in the male.

### The Sternum.

The **Sternum** (στέρνον, the chest) (Figs. 79, 80) is a flat, narrow bone, situated in the median line of the front of the chest, and consisting, in the adult, of three portions. It has been likened to an ancient sword; the upper piece, representing the handle, is termed the *manubrium*; the middle and largest piece, which represents the chief part of the blade, is termed the *gladiolus*; and the inferior piece, which is likened to the point of the sword, is termed the *ensiform* or *xiphoid appendix*. In its natural position its inclination is oblique from above downward and forward. It is slightly convex in front, concave behind, broad above, becoming narrowed at the point where the first and second pieces are connected, after which it again widens a little, and is pointed at its extremity. Its average length in the adult is about seven inches, being rather longer in the male than in the female.

The **First Piece** of the sternum, or **Manubrium** (*pre-sternum*), is of a somewhat triangular form, broad and thick above, narrow below at its junction with the middle piece. Its *anterior surface*, convex from side to side, concave from above downward, is smooth, and affords attachment on each side to the Pectoralis major and sternal origin of the Sterno-cleido-mastoid muscle. In well-marked bones the ridges limiting the attachment of these muscles are very distinct. Its *posterior surface*, concave and smooth, affords attachment on each side to the Sterno-hyoid and Sterno-thyroid muscles. The *superior border*, the thickest, presents at its centre the *pre-sternal notch*; and on each side an oval articular surface, directed upward, backward, and outward, for articulation with the sternal end of the clavicle. The *inferior border* presents an oval, rough surface, covered in the recent state with a thin layer of cartilage, for articulation with the second portion of the bone. The *lateral borders* are marked above by a depression for the first costal cartilage, and below by a small facet, which with a similar facet on the upper angle of the middle portion of the bone, forms a notch for the reception of the costal cartilage of the second rib. These articular surfaces are separated by a narrow, curved edge, which slopes from above downward and inward.

The **Second Piece** of the sternum, or **Gladiolus** (*meso-sternum*), considerably longer, narrower, and thinner than the first piece, is broader below than above. Its *anterior surface* is nearly flat, directed upward and forward, and marked by three transverse lines which cross the bone opposite the third, fourth, and fifth articular depressions. These lines are produced by the union of the four separate pieces of which this part of the bone consists at an early period of life. At the junction of the third and fourth pieces is occasionally seen an orifice, the *sternal foramen;* it varies in size and form in different individuals, and pierces the bone from before backward. This surface affords attachment on each side to the sternal origin of the Pectoralis major. The *posterior surface*, slightly concave, is also marked by three transverse lines, but they are less distinct than those in front: this surface affords attachment below, on each side, to the Triangularis sterni muscle, and occasionally presents the posterior opening of the sternal foramen. The *superior border* presents an oval surface for articulation with the manubrium. The *inferior border* is narrow, and articulates with the ensiform appendix. Each *lateral border* presents, at each superior angle, a small facet, which, with a similar facet on the manubrium, forms a cavity for the cartilage of the second rib; the four succeeding angular depressions receive the cartilages of the third, fourth, fifth, and sixth ribs; whilst each inferior angle presents a small facet, which, with a corresponding one on the ensiform appendix, forms a notch for the cartilage of the seventh rib. These articular depressions are separated by a series of curved interarticular intervals, which diminish in length from above downward, and correspond to the intercostal spaces. Most of the cartilages belonging to the true ribs, as will be seen from the foregoing description, articulate with the sternum at the line of junction of two of its primitive component segments. This is well seen in many of the lower animals, where the separate parts of the bone remain ununited longer than in man. In this respect a striking analogy exists between the mode of connection of the ribs with the vertebral column and the connection of the costal cartilages with the sternum.

The **Third Piece** of the sternum, the **Ensiform** or **Xiphoid Appendix** (*meta-sternum*), is the smallest of the three; it is thin and elongated in form, cartilaginous in structure in youth, but more or less ossified at its upper part in the adult. Its *anterior surface* affords attachment to the chondro-xiphoid ligament; its *posterior surface*, to some of the fibres of the Diaphragm and Triangularis sterni muscles; its *lateral borders*, to the aponeurosis of the abdominal muscles. Above it articulates with the lower end of the gladiolus, and at each superior angle presents a facet for the lower half of the cartilage of the seventh rib; below, by its pointed extremity it gives attachment to the linea alba. This portion of the sternum is very various in appearance, being sometimes pointed, broad, and thin, sometimes bifid or perforated by a round hole, occasionally curved or deflected considerably to one or the other side.

**Structure.**—The bone is composed of delicate cancellous structure, covered by a thin layer of compact tissue, which is thickest in the manubrium between the articular facets for the clavicles.

**Development.**—The cartilaginous sternum originally consists of two bars, situated one on either side of the mesial plane and connected with the rib cartilages of its own side. These two bars fuse with each other along the middle line, and the bone, including the ensiform appendix, is developed by *six* centres; one for the first piece or manubrium, four for the second piece or gladiolus, and one for the ensiform

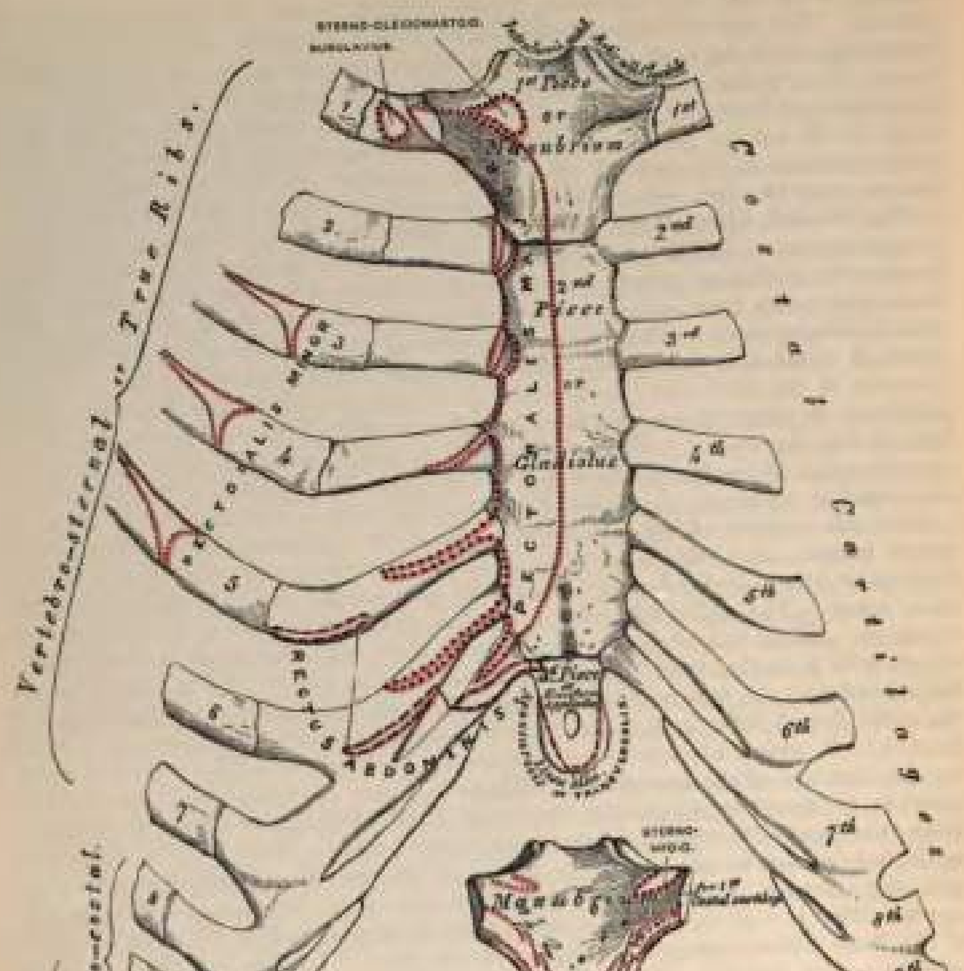



Fig. 79.—Sternum and costal cartilages.

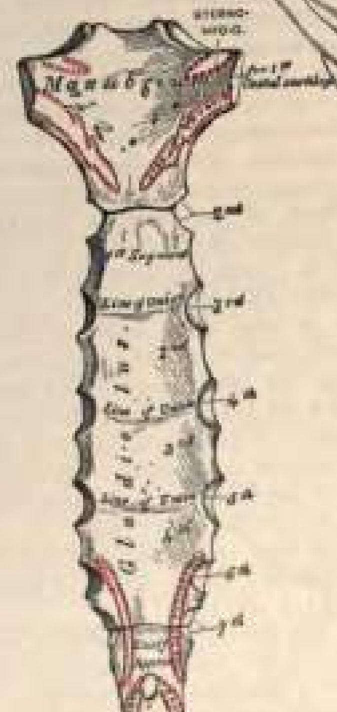



Fig. 80.—Posterior surface of sternum.

appendix. Up to the middle of fœtal life the sternum is entirely cartilaginous, and when ossification takes place the ossific granules are deposited in the middle of the intervals between the articular depressions for the costal cartilages, in the following order (Fig. 81): In the first piece, between the fifth and sixth months; in the second and third, between the sixth and seventh months; in the fourth piece, at the ninth month; in the fifth, within the first year or between the first and second years after birth; and in the ensiform appendix, between the second and the seventeenth or eighteenth years, by a single centre which makes its appearance at the upper part and proceeds gradually downward. To these may be added the

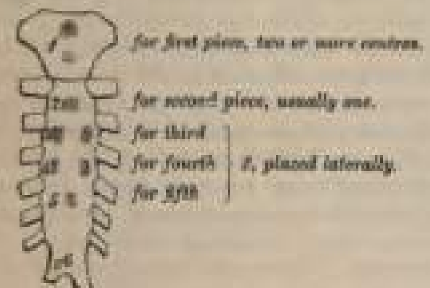



FIG. 81.—Development of the sternum by six centres. Time of appearance.

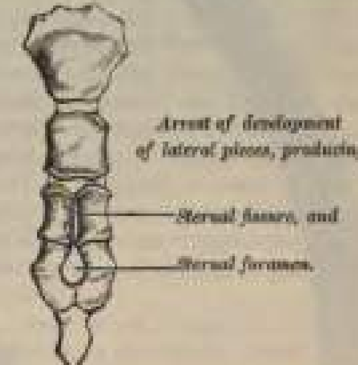



FIG. 82.—Time of union of sternum.

occasional existence, as described by Breschet, of two small episternal centres, which make their appearance one on each side of the presternal notch. They are


FIG. 83.—Peculiarities in number of centres of sternum.


FIG. 84.—Peculiarities in mode of union of sternum.

probably vestiges of the episternal bone of the monotremata and lizards. It occasionally happens that some of the segments are formed from more than one centre, the number and position of which vary (Fig. 83). Thus, the first piece may have two, three, or even six centres. When two are present, they are generally situated one above the other, the upper one being the larger;[1] the second piece has seldom more than one; the third, fourth, and fifth pieces are often formed from two centres placed laterally, the irregular union of which will serve to explain the occasional occurrence of the sternal foramen (Fig. 84), or of the vertical fissure which occasionally intersects this part of the bone, and which is further explained by the manner in which the cartilaginous matrix, in which ossification takes place, is formed. Union of the various centres of the gladiolus commences about puberty, from below, and proceeds upward, so that by the age of twenty-

[1] Sir George Humphry states that this is "probably the more complete condition."


FIG. 83.—A central rib of left side.

five they are all united, and this portion of bone consists of one piece (Fig. 82). The ensiform cartilage becomes joined to the gladiolus about forty. The manubrium is occasionally, but not invariably, joined to the gladiolus in advanced life by bone. When this union takes place, however, it is generally only superficial, a portion of the centre of the sutural cartilage remaining unossified.

**Articulations.**—With the clavicles and seven costal cartilages on each side.

**Attachment of Muscles.**—To nine pairs and one single muscle: the Pectoralis major, Sterno-cleido-mastoid, Sterno-hyoid, Sterno-thyroid, Triangularis sterni, aponeuroses of the Obliquus externus, Obliquus internus, Transversalis, Rectus muscles, and Diaphragm.

## The Ribs.

The **Ribs** are elastic arches of bone, which form the chief part of the thoracic walls. They are twelve in number on each side; but this number may be increased by the development of a cervical or lumbar rib, or may be diminished to eleven. The first seven are connected behind with the spine and in front with the sternum, through the intervention of the costal cartilages; they are called *true* ribs.[1] The remaining five are *false* ribs; of these, the first three have their cartilages attached to the cartilage of the rib above: the last two are free at their anterior extremities; they are termed *floating* ribs. The ribs vary in their direction, the upper ones being less oblique than the lower. The extent of obliquity reaches its maximum at the ninth rib, and gradually decreases from that rib to the twelfth. The ribs are situated one below the other in such a manner that spaces are left between them, which are called *intercostal spaces*. The length of these spaces corresponds to the length of the ribs and their cartilages; their breadth is greater in front than behind, and between the upper than between the lower ribs. The ribs increase in length from the first to the seventh, when

[1] Sometimes the eighth rib cartilage articulates with the sternum; this condition occurs more frequently on the right than on the left side.

they again diminish to the twelfth. In breadth they decrease from above downward; in the upper ten the greatest breadth is at the sternal extremity.

**Common Characters of the Ribs** (Fig. 85).—A rib from the middle of the series should be taken in order to study the common characters of the ribs.

Each rib presents two extremities, a posterior or vertebral, an anterior or sternal, and an intervening portion—the body or shaft.

The **posterior** or **vertebral extremity** presents for examination a head, neck, and tuberosity. The **head** (Fig. 86) is marked by a kidney-shaped articular surface, divided by a horizontal ridge into two facets for articulation with the costal cavity formed by the junction of the bodies of two contiguous dorsal vertebræ; the upper facet is small, the inferior one of larger size; the ridge separating them serves for the attachment of the interarticular ligament. The **neck** is that flattened portion of the rib which extends outward from the head; it is about an inch long, and is placed in front of the transverse process of the lower of the two vertebræ with which the head articulates. Its *anterior surface* is flat and smooth, its *posterior* rough for the attachment of the middle costo-transverse ligament, and perforated by numerous foramina, the direction of which is less constant than those found on the inner surface of the shaft. Of its two borders the *superior* presents a rough crest for the attachment of the anterior costo-transverse ligament; its *inferior border* is rounded. On the posterior surface of the neck, just where it


Fig. 86.—Vertebral extremity of a rib. External surface.

joins the shaft, and nearer the lower than the upper border, is an eminence—the **tuberosity**, or **tubercle**; it consists of an articular and a non-articular portion. The *articular portion*, the more internal and inferior of the two, presents a small, oval surface for articulation with the extremity of the transverse process of the lower of the two vertebræ to which the head is connected. The *non-articular portion* is a rough elevation, which affords attachment to the posterior costo-transverse ligament. The tubercle is much more prominent in the upper than in the lower ribs.

The **shaft** is thin and flat, so as to present two surfaces, an external and an internal, and two borders, a superior and an inferior. The *external surface* is convex, smooth and marked at its back part, a little in front of the tuberosity, by a prominent line, directed obliquely from above downward and outward; this gives attachment to a tendon of the Ilio-costalis muscle or of one of its accessory portions, and is called the *angle*. At this point the rib is bent in two directions. If the rib is laid upon its lower border, it will be seen that the portion of the shaft in front of the angle rests upon this border, while the portion of the shaft behind the angle is bent inward and at the same time tilted upward. The interval between the angle and the tuberosity increases gradually from the second to the tenth rib. The portion of bone between these two parts is rounded, rough, and irregular, and serves for the attachment of the Longissimus dorsi muscle. The portion of bone between the tubercle and sternal extremity is also slightly twisted upon its own axis, the external surface looking downward behind the angle, a little upward in front of it. This surface presents, toward its sternal extremity, an oblique line, the *anterior angle*. The *internal surface* is concave, smooth, directed a little upward behind the angle, a little downward in front of it. This surface is marked by a ridge which commences at the lower extremity of the head; it is strongly marked as far as the inner side of the angle, and gradually becomes lost at the junction of the anterior with the middle third of the bone. The interval between it and the inferior border presents a groove, *subcostal*, for the intercostal vessels and nerve. At the back part of the bone this groove belongs to the inferior border, but just in front of the angle, where it is deepest and broadest, it corresponds to the internal surface. The superior edge of the groove is rounded; it serves for the attachment of the Internal intercostal muscle. The inferior edge corresponds to the lower margin of the rib and gives attachment to the External intercostal. Within the groove are seen the orifices of numerous small foramina which traverse the wall of the shaft obliquely from before backward. The *superior border*, thick and rounded, is marked by an external and an internal lip, more distinct behind than in front; they serve for the attachment of the External and Internal intercostal muscles. The *inferior border*, thin and sharp, has attached to it the External intercostal muscle. The **anterior** or **sternal extremity** is flattened, and presents a porous, oval, concave depression, into which the costal cartilage is received.

## Peculiar Ribs.

The ribs which require especial consideration are five in number—viz. the first, second, tenth, eleventh and twelfth.

The **first rib** (Fig. 87) is one of the shortest and the most curved of all the ribs; it is broad and flat, its surfaces looking upward and downward, and its borders inward and outward. The *head* is of small size, rounded, and presents only a single articular facet for articulation with the body of the first dorsal vertebra. The *neck* is narrow and rounded. The *tuberosity*, thick and prominent, rests on the outer border. There is no angle, but in this situation the rib is slightly bent, with the convexity of the bend upward, so that the head of the bone is directed downward. The *upper surface* of the shaft is marked by two shallow depressions, separated by a small rough surface for the attachment of the Scalenus anticus muscle—the groove in front of it transmitting the subclavian vein, that behind it the subclavian artery. Between the groove for the subclavian artery and the tuberosity is a rough surface, for the attachment of the Scalenus medius muscle. The *under surface* is smooth, and destitute of the groove observed on the other ribs. The *outer border* is convex, thick, and rounded, and at its posterior part gives attachment to the first serration of the Serratus magnus; the *inner* is concave, thin, and sharp, and marked about its centre by the commencement of the rough surface for the Scalenus anticus. The *anterior extremity* is larger and thicker than any of the other ribs.

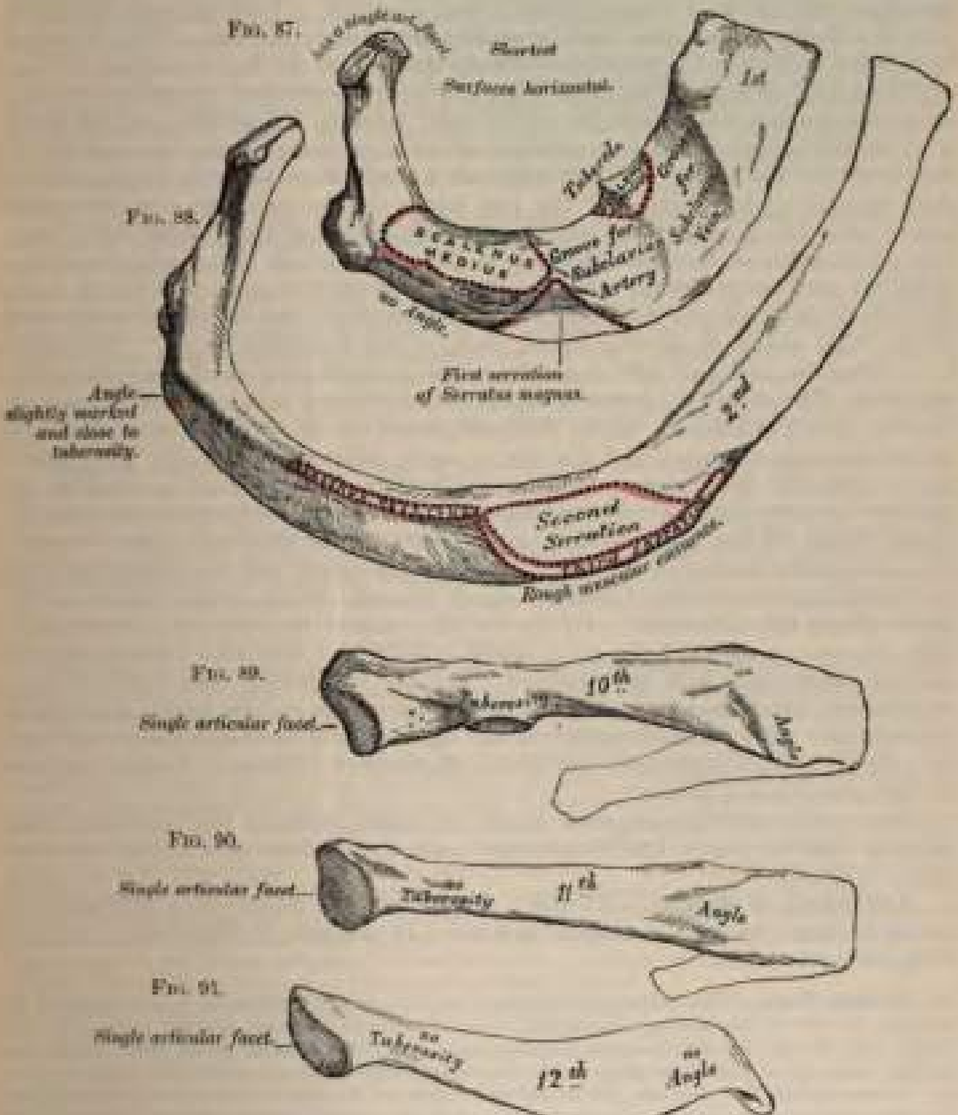
The **second rib** (Fig. 88) is much longer than the first, but bears a very considerable resemblance to it in the direction of its curvature. The non-articular portion of the tuberosity is occasionally only slightly marked. The *angle* is slight and situated close to the tuberosity, and the shaft is not twisted, so that both ends touch any plane surface upon which it may be laid; but there is a similar though slighter bend, with its convexity upward, to that found in the first rib. The shaft is not horizontal, like that of the first rib, its *outer surface*, which is convex, looking upward and a little outward. It presents, near the middle, a rough eminence for the attachment of the second and third digitations of the Serratus magnus; behind and above which is attached the Scalenus posticus. The *inner surface*, smooth and concave, is directed downward and a little inward; it presents a short groove toward its posterior part.

The **tenth rib** (Fig. 89) has only a single articular facet on its head.

The **eleventh** and **twelfth ribs** (Figs. 90 and 91) have each a single articular facet on the head, which is of rather large size; they have no neck or tuberosity, and are pointed at the extremity. The eleventh has a slight angle and a shallow groove on the lower border. The twelfth has neither, and is much shorter than the eleventh, and the head has a slight inclination downward. Sometimes the twelfth rib is even shorter than the first.

**Structure.**—The ribs consist of cancellous tissue enclosed in a thin, compact layer.

**Development.**—Each rib, with the exception of the last two, is developed by *three* centres: one for the shaft, one for the head, and one for the tubercle. The last two have only *two* centres, that for the tubercle being wanting. Ossification commences in the shaft of the ribs at a very early period, before its appearance in the vertebræ. The epiphysis of the head, which is of slightly angular shape, and that for the tubercle, of a lenticular form, make their appearance between the six-




Figs. 87-91.—Peculiar ribs.

teenth and twentieth years, and are not united to the rest of the bone until about the twenty-fifth year.

**Attachment of Muscles.**—To nineteen: The Internal and External intercostals, Scalenus anticus, Scalenus medius, Scalenus posticus, Pectoralis minor, Serratus magnus, Obliquus externus, Quadratus lumborum, Diaphragm, Latissimus dorsi, Serratus posticus superior, Serratus posticus inferior, Ilio-costalis, Musculus accessorius ad ilio-costalem, Longissimus dorsi, Cervicalis ascendens, Levatores costarum, and Infracostales.

## The Costal Cartilages.

The **Costal Cartilages** (Fig. 79, p. 126) are bars of white, hyaline cartilage, which serve to prolong the ribs forward to the front of the chest, and contribute very materially to the elasticity of its walls. The first seven are connected with the sternum, the next three with the lower border of the cartilage of the preceding rib. The cartilages of the last two ribs have pointed extremities, which terminate in free ends in the walls of the abdomen. Like the ribs, the costal cartilages vary in their length, breadth, and direction. They increase in length from the first to the seventh, then gradually diminish to the last. They diminish in breadth, as well as the intervals between them, from the first to the last. They are broad at their attachment to the ribs, and taper toward their sternal extremities, excepting the first two, which are of the same breadth throughout, and the sixth, seventh, and eighth, which are enlarged where their margins are in contact. In direction they also vary: the first descends a little, the second is horizontal, the third ascends slightly, while all the rest follow the course of the ribs for a short extent, and then ascend to the sternum or preceding cartilage. Each costal cartilage presents two surfaces, two borders, and two extremities. The *anterior surface* is convex, and looks forward and upward: that of the first gives attachment to the costo-clavicular ligament and the Subclavius muscle; that of the second, third, fourth, fifth, and sixth, at their sternal ends, to the Pectoralis major.[1] The others are covered by, and give partial attachment to, some of the great flat muscles of the abdomen. The *posterior surface* is concave, and directed backward and downward, the first giving attachment to the Sterno-thyroid, the third to the sixth inclusive to the Triangularis sterni, and the six or seven inferior ones to the Tranversalis muscle and the Diaphragm. Of the two borders, the *superior* is concave, the *inferior* convex; they afford attachment to the internal Intercostal muscles, the upper border of the sixth giving attachment to the Pectoralis major muscle. The contiguous borders of the sixth, seventh, and eighth, and sometimes the ninth and tenth, costal cartilages present small, smooth, oblong-shaped facets at the points where they articulate. Of the two extremities, the *outer* one is continuous with the osseous tissue of the rib to which it belongs. The *inner* extremity of the first is continuous with the sternum; the six succeeding ones have rounded extremities, which are received into shallow concavities on the lateral margins of the sternum. The inner extremities of the eighth, ninth, and tenth costal cartilages are pointed, and are connected with the cartilage above. Those of the eleventh and twelfth are free and pointed.

The costal cartilages are most elastic in youth, those of the false ribs being more so than the true. In old age they become of a deep yellow color, and are prone to calcify.

**Attachment of Muscles.**—To nine: the Subclavius, Sterno-thyroid, Pectoralis major, Internal oblique, Transversalis, Rectus, Diaphragm, Triangularis sterni, and Internal intercostals.

**Surface Form.**—The bones of the chest are to a very considerable extent covered by muscles, so that in the strongly-developed muscular subject they are for the most part concealed. In the emaciated subject, on the other hand, the ribs, especially in the lower and lateral region, stand out as prominent ridges with the sunken, intercostal spaces between them.

In the middle line, in front, the superficial surface of the sternum is to be felt throughout its entire length, at the bottom of a deep median furrow situated between the two great pectoral muscles and called the *sternal furrow*. These muscles overlap the anterior surface somewhat, so that the whole of the sternum in its entire width is not subcutaneous; and this overlapping is greater opposite the centre of the bone than above and below, so that the furrow is wider at its upper and lower parts, but narrower in the middle. The centre of the upper border of the sternum is visible, constituting the pre-sternal notch, but the lateral parts of this border are obscured by the tendinous origins of the Sterno-mastoid muscles, which present themselves as oblique tendinous cords, which narrow and deepen the notch. Lower down on the subcutaneous surface a well-defined transverse ridge, the angle of Ludovic, is always to be felt. This denotes the line of junction of the manubrium and body of the bone, and is a useful guide to the second costal cartilage, and thus to the identity of any given rib. The second rib being found through its

[1] The first and seventh also, occasionally, give origin to the same muscle.

costal cartilage, it is easy to count downward and find any other. From the middle of the sternum the furrow spreads out, and, exposing more of the surface of the body of the bone, terminates below in a sudden depression, the *infrasternal depression* or *pit of the stomach* (*scrobiculus cordis*), which corresponds to the ensiform cartilage. This depression lies between the cartilages of the seventh rib, and in it the ensiform cartilage may be felt. The sternum in its vertical diameter presents a general convexity forward, the most prominent point of which is at the joint between the manubrium and gladiolus.

On each side of the sternum the costal cartilages and ribs on the front of the chest are partially obscured by the great pectoral muscle; through which, however, they are to be felt as ridges, with yielding intervals between them, corresponding to the intercostal spaces. Of these spaces, the one between the second and third ribs is the widest, the next two somewhat narrower, and the remainder, with the exception of the last two, comparatively narrow.

The lower border of the Pectoralis major muscle corresponds to the fifth rib, and below this, on the front of the chest, the broad, flat outline of the ribs, as they begin to ascend, and the more rounded outline of the costal cartilages, are often visible. The lower boundary of the front of the thorax, the *abdomino-thoracic arch*, which is most plainly seen by arching the body backward, is formed by the ensiform cartilage and the cartilages of the seventh, eighth, ninth, and tenth ribs, and the extremities of the eleventh and twelfth ribs or their cartilages.

On each side of the chest, from the axilla downward, the flattened external surfaces of the ribs may be defined in the form of oblique ridges, separated by depressions corresponding to the intercostal spaces. They are, however, covered by muscles, which obscure their outline to a certain extent in the strongly developed. Nevertheless, the ribs, with the exception of the first, can generally be followed over the front and sides of the chest without difficulty. The first rib, being almost completely covered by the clavicle and scapula, can only be distinguished in a small portion of its extent. At the back the angles of the ribs form a slightly-marked oblique line on each side of and some distance from the vertebral spines. This line diverges somewhat as it descends, and external to it is a broad, convex surface caused by the projection of the ribs beyond their angles. Over this surface, except where covered by the scapula, the individual ribs can be distinguished.

**Surgical Anatomy.**—Malformations of the sternum present nothing of surgical importance beyond the fact that abscesses of the mediastinum may sometimes escape through the sternal foramen. Fractures of the sternum are by no means common, owing, no doubt, to the elasticity of the ribs and their cartilages, which support it like so many springs. When broken it is frequently associated with fracture of the spine, and may be caused by forcibly bending the body either backward or forward until the chin becomes impacted against the top of the sternum. It may also be fractured by direct violence or by muscular action. The fracture usually occurs in the upper half of the body of the bone. Dislocation of the gladiolus from the manubrium also takes place, and is sometimes described as a fracture.

The bone, being subcutaneous, is frequently the seat of gummatous tumors, and not uncommonly is affected with caries. Occasionally the bone, and especially its ensiform appendix, becomes altered in shape and driven inward by the pressure, in workmen, of tools against their chest.

The ribs are frequently broken, though from their connections and shape they are able to withstand great force, yielding under the injury and recovering themselves like a spring. The middle of the series are the ones most liable to fracture. The first, and to a less extent the second, being protected by the clavicle, are rarely fractured; and the eleventh and twelfth, on account of their loose and floating condition, enjoy a like immunity. The fracture generally occurs from indirect violence, from forcible compression of the chest-wall, and the bone then gives way at its weakest part—*i. e.* just in front of the angle. But the ribs may also be broken by direct violence, when the bone gives way and is driven inward at the point struck, or they may be broken by muscular action. It seems probable, however, that in these latter cases the bone has undergone some atrophic changes. Fracture of the ribs is frequently complicated with some injury to the viscera contained within the thorax or upper part of the abdominal cavity, and this is most likely to occur in fractures from direct violence.

Fracture of the costal cartilages may also take place, though it is a comparatively rare injury.

The thorax is frequently found to be altered in shape in certain diseases.

The *rickety* thorax is caused chiefly by atmospheric pressure. The balance between the air on the inside of the chest and the outside during some stage of respiration is not equal, the preponderance being in favor of the air outside; and this, acting on the softened ribs, causes them to be forced in at the junction of the cartilages with the bones, which is the weakest part. In consequence of this the sternum projects forward, with a deep depression on either side caused by the sinking in of the softened ribs. The depression is less on the left side, on account of the ribs being supported by the heart. The condition is known as "pigeon-breast." The lower ribs, however, are not involved in this deformity, as they are prevented from falling in by the presence of the stomach, liver, and spleen. And when the liver and spleen are enlarged, as they sometimes are in rickets, the lower ribs may be pushed outward: this causes a transverse constriction just above the costal arch. The anterior extremities of the ribs are usually enlarged in rickets, giving rise to what has been termed the "rickety rosary." The *phthisical chest* is often long and narrow, flattened from before backward, and with great obliquity of the ribs and projection of the scapulæ. In *pulmonary emphysema* the chest is enlarged in all its diameters, and presents on section an almost circular outline. It has received the name of the "barrel-shaped chest." In severe cases of *lateral curvature of the spine* the thorax becomes much distorted. In consequence of the rotation of the bodies of the vertebræ which takes place in this disease the ribs opposite the convexity of the dorsal curve become extremely convex behind, being thrown out and bulging, and at the same time flattened in front, so that the two ends of the same rib are almost parallel. Coincident with this, the ribs on the opposite side, on the concavity of the curve, are sunk and depressed behind and bulging and convex in front. In addition to this the ribs become occasionally welded together by bony material.

The ribs are frequently the seat of necrosis leading to abscesses and sinuses, which may burrow to a considerable extent over the wall of the chest. The only special anatomical point in connection with these is that care must be taken in dealing with them that the intercostal space is not punctured and the pleural cavity opened or the intercostal vessels wounded, as the necrosed portion of bone is generally situated on the internal surface of the rib.

In cases of empyema the chest requires opening to evacuate the pus. There is considerable difference of opinion as to the best position to do this. Probably the best place in most cases will be found to be between the fifth and sixth ribs, in or a little in front of the mid-axillary line. This is the last part of the cavity to be closed by the expansion of the lung; it is not thickly covered by soft parts; the space between the two ribs is sufficiently great to allow of the introduction of a fair-sized drainage-tube, and the opening is in a dependent position, when the patient is confined to bed, as he usually inclines toward the affected side, so as to allow the sound lung the freest possible play, and so permits of efficient drainage.

## THE EXTREMITIES.

The extremities, or limbs, are those long, jointed appendages of the body which are connected to the trunk by one end and free in the rest of their extent. They are *four* in number: an *upper* or *thoracic pair*, connected with the thorax through the intervention of the shoulder, and subservient mainly to prehension; and a *lower pair*, connected with the pelvis, intended for support and locomotion. Both pairs of limbs are constructed after one common type, so that they present numerous analogies, while at the same time certain differences are observed between the upper and lower pair, dependent on the peculiar offices they have to perform.

The bones by which the upper and lower limbs are attached to the trunk are named respectively the *shoulder* and *pelvic girdles*, and they are constructed on the same general type, though presenting certain modifications relating to the different uses to which the upper and lower limbs are respectively applied. The *shoulder girdle* is formed by the scapula and clavicle, and is imperfect in front and behind. In front, however, the girdle is completed by the upper end of the sternum, with which the inner extremities of the clavicle articulate. Behind, the girdle is widely imperfect and the scapula is connected to the trunk by muscles only. The *pelvic girdle* is formed by the innominate bones, and is completed in front through the symphysis pubis, at which the two innominate bones articulate with each other. It is imperfect behind, but the intervening gap is filled in by the upper part of the sacrum. The pelvic girdle, therefore, presents, with the sacrum, a complete ring, comparatively fixed, and presenting an arched form which confers upon it a solidity manifestly intended for the support of the trunk, and in marked contrast to the lightness and mobility of the shoulder girdle.

With regard to the morphology of these girdles, the blade of the scapula is generally believed to correspond to the ilium; but with regard to the clavicles there is some difference of opinion: formerly it was believed that they corresponded to the ossa pubis, meeting at the symphysis, but it is now generally taught that the clavicle has no homologue in the pelvic girdle, and that the os pubis and ischium are represented by the small coracoid process in man and most mammals.

## THE UPPER EXTREMITY.

The bones of the upper extremity consist of those of the shoulder girdle, of the arm, the forearm, and the hand.

### THE SHOULDER GIRDLE.

The shoulder girdle consists of two bones, the clavicle and the scapula.

## The Clavicle.

The **Clavicle** (*clavis*, a key), or collar-bone, forms the anterior portion of the shoulder girdle. It is a long bone, curved somewhat like the italic letter *f*, and placed nearly horizontally at the upper and anterior part of the thorax, immediately above the first rib. It articulates by its inner extremity with the upper border of the sternum, and by its outer extremity with the acromion process of the scapula, serving to sustain the upper extremity in the various positions which it assumes, whilst at the same time it allows of great latitude of motion in the arm.[1] It presents a double curvature when looked at in front, the convexity being forward at the sternal end and the concavity at the scapular end. Its outer third is flattened from above downward, and extends, in the natural position of the bone, from a point opposite the coracoid process to the acromion. Its inner two-thirds are of a prismatic form, and extend from the sternum to a point opposite the coracoid process of the scapula.

**External** or **Flattened Portion.**—The *outer third* is flattened from above downward, so as to present two surfaces, an upper and a lower; and two borders, an anterior and a posterior. The *upper surface* is flattened, rough, marked by impressions for the attachment of the Deltoid in front and the Trapezius behind; between these two impressions, externally, a small portion of the bone is subcutaneous. The *under surface* is flattened. At its posterior border, a little external to the point where the prismatic joins with the flattened portion, is a rough eminence, the *conoid tubercle*; this, in the natural position of the bone, surmounts the coracoid process of the scapula and gives attachment to the conoid ligament. From this tubercle an oblique line, occasionally a depression, passes forward and outward to near the outer end of the anterior border; it is called the *oblique line* or *trapezoid ridge*, and affords attachment to the trapezoid ligament. The *anterior border* is concave, thin, and rough, and gives attachment to the Deltoid; it occasionally presents, at its inner end, at the commencement of the deltoid impression, a tubercle, the *deltoid tubercle*, which is sometimes to be felt in the living subject. The *posterior border* is convex, rough, broader than the anterior, and gives attachment to the Trapezius.

**Internal or Prismatic Portion.**—The prismatic portion forms the *inner two-thirds* of the bone. It is curved so as to be convex in front, concave behind, and is marked by three borders, separating three surfaces. The *anterior border* is continuous with the anterior margin of the flat portion. At its commencement it is smooth, and corresponds to the interval between the attachment of the Pectoralis major and Deltoid muscles; at the inner half of the clavicle it forms the lower boundary of an elliptical space for the attachment of the clavicular portion of the Pectoralis major, and approaches the posterior border of the bone. The *superior border* is continuous with the posterior margin of the flat portion, and separates the anterior from the posterior surface. At its commencement it is smooth and rounded, becomes rough toward the inner third for the attachment of the Sterno-mastoid muscle, and terminates at the upper angle of the sternal extremity. The *posterior* or *subclavian border* separates the posterior from the inferior surface, and extends from the conoid tubercle to the rhomboid impression. It forms the posterior boundary of the groove for the Subclavius muscle, and gives attachment to a layer of cervical fascia covering the Omo-hyoid muscle. The *anterior surface* is included between the superior and anterior borders. It is directed forward and a little upward at the sternal end, outward and still more upward at the acromial extremity, where it becomes continuous with the upper surface of the flat portion. Externally, it is smooth, convex, nearly subcutaneous, being covered only by the

[1] The clavicle acts especially as a fulcrum to enable the muscles to give lateral motion to the arm. It is accordingly absent in those animals whose fore limbs are used only for progression, but is present for the most part in those animals whose anterior extremities are clawed and used for prehension, though in some of them—as, for instance, in a large number of the carnivora—it is merely a rudimentary bone suspended among the muscles, and not articulating either with the scapula or sternum.

Platysma; but, corresponding to the inner half of the bone, it is divided by a more or less prominent line into two parts: a lower portion, elliptical in form, rough, and slightly convex, for the attachment of the Pectoralis major; and an upper part, which is rough, for the attachment of the Sterno-cleido-mastoid. Between the two muscular impressions is a small subcutaneous interval. The *posterior* or *cervical surface* is smooth, flat, and looks backward toward the root of the neck. It is limited, above, by the superior border; below, by the subclavian border; internally, by the margin of the sternal extremity; externally, it is continuous with the posterior border of the flat portion. It is concave from within outward, and is in relation, by its lower part, with the suprascapular vessels. This surface, at about the junction of the inner and outer curves, is also in close relation with the brachial plexus and subclavian vessels. It gives attachment, near the sternal extremity, to part of the Sterno-hyoid muscle; and presents, at or near the middle, a foramen, directed obliquely outward, which transmits the chief nutrient artery of the bone. Sometimes there are two foramina on the posterior surface, or one on the posterior, the other on the inferior surface. The *inferior* or *subclavian*


FIG. 93.—Left clavicle. Superior surface.

*surface* is bounded, in front, by the anterior border; behind, by the subclavian border. It is narrow internally, but gradually increases in width externally, and

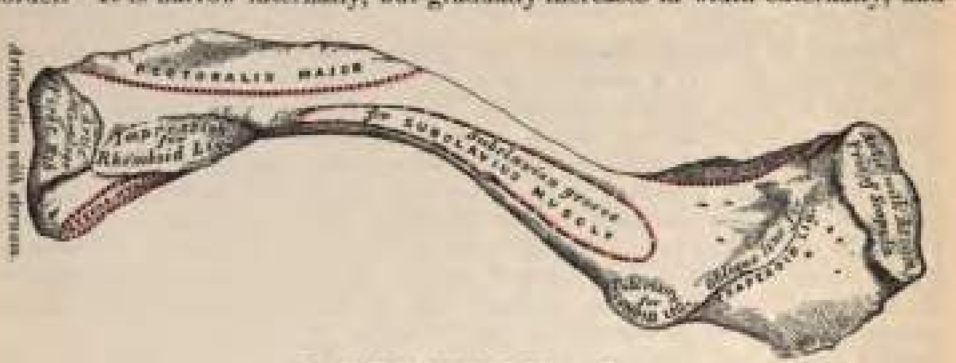



FIG. 94.—Left clavicle. Inferior surface.

is continuous with the under surface of the flat portion. Commencing at the sternal extremity may be seen a small facet for articulation with the cartilage of the first rib. This is continuous with the articular surface at the sternal end of the bone. External to this is a broad, rough surface, the *rhomboid impression*, rather more than an inch in length, for the attachment of the costo-clavicular (rhomboid) ligament. The remaining part of this surface is occupied by a longitudinal groove, the *subclavian groove*, broad and smooth externally, narrow and more uneven internally; it gives attachment to the Subclavius muscle, and by its margins to the costo-coracoid membrane, which splits to enclose a muscle. Not infrequently this groove is subdivided into two parts by a longitudinal line, which gives attachment to the intermuscular septum of the Subclavius muscle.

The **internal** or **sternal extremity** of the clavicle is triangular in form, directed inward and a little downward and forward; and presents an articular facet, concave from before backward, convex from above downward, which articulates with the sternum through the intervention of an interarticular fibro-cartilage; the circumference of the articular surface is rough, for the attachment of numerous ligaments. The posterior border of this surface is prolonged backward, so as to increase the size of the articular facet; the upper border gives attachment to the interarticular fibro-cartilage, and the lower border is continuous with the costal facet on the inner end of the inferior or subclavian surface, which articulates with the cartilage of the first rib.

The **outer** or **acromial extremity**, directed outward and forward, presents a small, flattened, oval facet, which looks obliquely downward, for articulation with the acromion process of the scapula. The circumference of the articular facet is rough, especially above, for the attachment of the acromio-clavicular ligaments.

*Peculiarities of the Bone in the Sexes and in Individuals.*—In the female the clavicle is generally shorter, thinner, less curved, and smoother than in the male. In those persons who perform considerable manual labor, which brings into constant action the muscles connected with this bone, it becomes thicker and more curved, its ridges for muscular attachment become prominently marked. The right clavicle is generally longer, thicker, and rougher than the left.

**Structure.**—The shaft, as well as the extremities, consists of cancellous tissue, invested in a compact layer much thicker in the middle than at either end. The clavicle is highly elastic, by reason of its curves. From the experiments of Mr. Ward it has been shown that it possesses sufficient longitudinal elastic force to project its own weight nearly two feet on a level surface when a smart blow is struck on it; and sufficient transverse elastic force, opposite the centre of its anterior convexity, to throw its own weight about a foot. This extent of elastic power must serve to moderate very considerably the effect of concussions received upon the point of the shoulder.

**Development.**—By *two* centres: one for the shaft and one for the sternal extremity. The centre for the shaft appears very early, before any other bone—according to Béclard, as early as the thirtieth day. The centre for the sternal end makes its appearance about the eighteenth or twentieth year, and unites with the rest of the bone about the twenty-fifth year.

**Articulations.**—With the sternum, scapula, and cartilage of the first rib.

**Attachment of Muscles.**—To six: the Sterno-cleido-mastoid, Trapezius, Pectoralis major, Deltoid, Subclavius, and Sterno-hyoid.

**Surface Form.**—The clavicle can be felt throughout its entire length, even in persons who are very fat. Commencing at the inner end, the enlarged sternal extremity, where the bone projects above the upper margin of the sternum, can be felt, forming with the sternum and the rounded tendon of the Sterno-mastoid a V-shaped notch, the *pre-sternal notch*. Passing outward, the shaft of the bone can be felt immediately under the skin, with its convexity forward in the inner two-thirds, the surface partially obscured above and below by the attachments of the Sterno-mastoid and Pectoralis major muscles. In the outer third it forms a gentle curve backward, and terminates at the outer end in a somewhat enlarged extremity which articulates with the acromial process of the scapula. The direction of the clavicle is almost, if not quite, horizontal when the arm is lying quietly by the side, though in well-developed subjects it may incline a little upward at its outer end. Its direction is, however, very changeable with the varying movements of the shoulder-joint.

**Surgical Anatomy.**—The clavicle is the most frequently broken of any single bone in the body. This is due to the fact that it is much exposed to violence, and is the only bony connection between the upper limb and the trunk. The bone, moreover, is slender, and is very superficial. The bone may be broken by direct or indirect violence or by muscular action. The most common cause is, however, from indirect violence, and the bone then gives way at the junction of the outer with the inner two-thirds of the bone; that is to say at the junction of the two curves, for this is the weakest part of the bone. The fracture is generally oblique, and the displacement of the outer fragments is inward, away from the surface of the body; hence compound fracture of the clavicle is of rare occurrence. The inner fragment as a rule is little displaced. Beneath the bone the main vessels of the upper limb and the great nerve-cords of the brachial plexus lie on the first rib, and are liable to be wounded in fracture, especially in fracture from direct violence, when the force of the blow drives the broken ends inward. Fortunately, the Subclavius muscle is interposed between these structures and the clavicle, and this often protects them from injury.

The clavicle is not uncommonly the seat of sarcomatous tumors, rendering the operation of excision of the entire bone necessary. This is an operation of considerable difficulty and danger. It is best performed by exposing the bone freely, disarticulating at the acromial end, and turning it inward. The removal of the outer part is comparatively easy, but resection of the inner part is fraught with difficulty, the main danger being the risk of wounding the great veins which are in relation with its under surface.

## The Scapula.

The **Scapula** (*σκαπάνη*, a spade) forms the back part of the shoulder girdle. It is a large, flat bone, triangular in shape, situated at the posterior aspect and side of

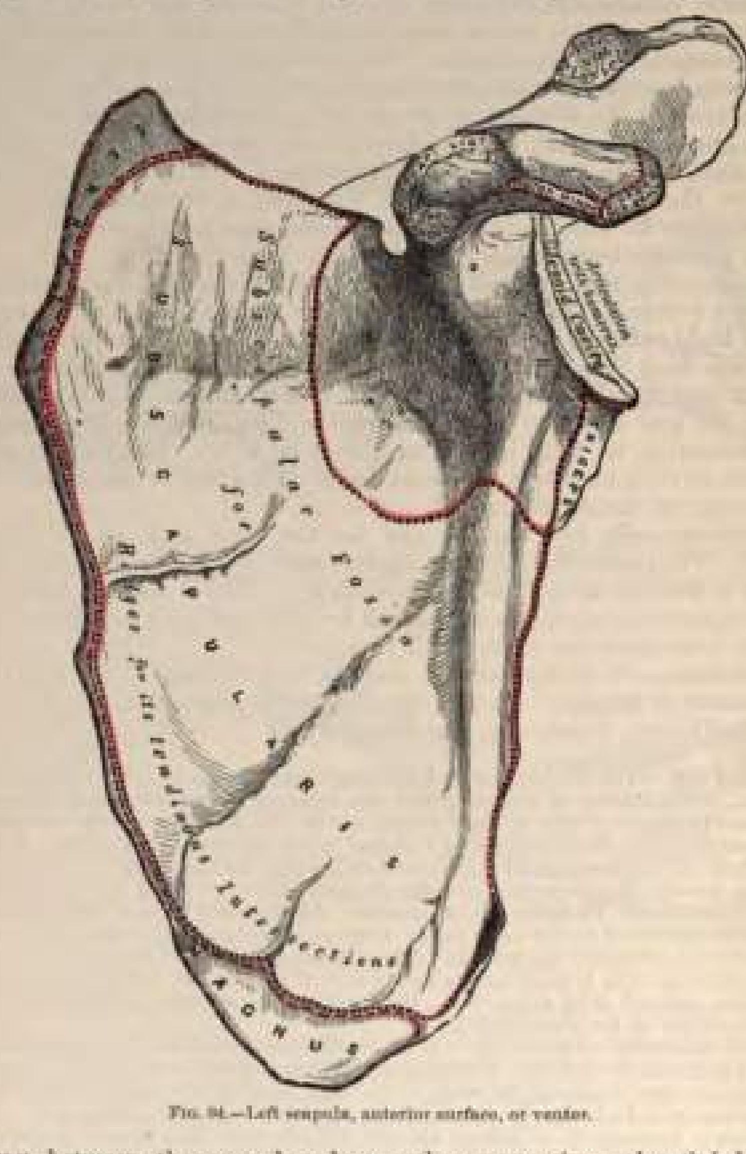


FIG. 94.—Left scapula, anterior surface, or venter.

the thorax, between the second and seventh, or sometimes the eighth, ribs, its internal border or base being about an inch from, and nearly, but not quite parallel with the spinous processes of the vertebræ, so that it is rather closer to them above than below. It presents for examination two surfaces, three borders, and three angles.

The **anterior surface**, or **venter** (Fig. 94), presents a broad concavity, the *sub-*

*scapular fossa.* It is marked, in the inner two-thirds, by several oblique ridges, which pass from behind outward and upward; the outer third is smooth. The oblique ridges give attachment to the tendinous intersections, and the surfaces between them to the fleshy fibres, of the Subscapularis muscle. The anterior third of the fossa, which is smooth, is covered by, but does not afford attachment to, the fibres of this muscle. The venter is separated from the internal border by a smooth, triangular margin at the superior and inferior angles, and in the interval between these by a narrow edge which is often deficient.

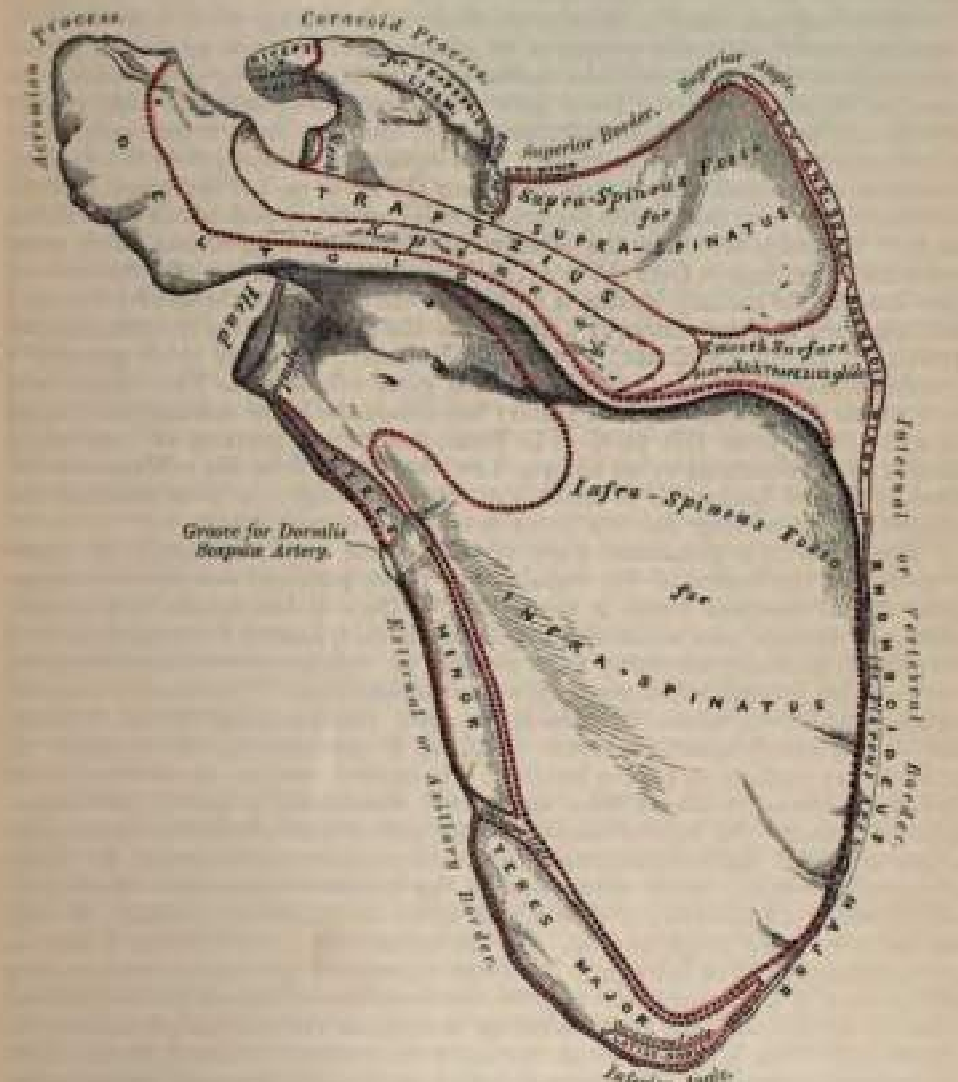



FIG. [illegible].—Left scapula. Posterior surface, or dorsum.

This marginal surface affords attachment throughout its entire extent to the Serratus magnus muscle. The subscapular fossa presents a transverse depression at its upper part, where the bone appears to be bent on itself, forming a considerable angle, called the *subscapular angle,* thus giving greater strength to the body of the bone from its arched form, while the summit of the arch serves to support the spine and acromion process. It is in this situation that the fossa is deepest, so that the thickest part of the Subscapularis muscle lies in a line perpendicular to the plane of the glenoid cavity, and must consequently operate most effectively on the head of the humerus, which is contained in that cavity.

The **posterior surface**, or **dorsum** (Fig. 95), is arched from above downward, alternately concave and convex from side to side. It is subdivided unequally into two parts by the *spine:* the portion above the spine is called the *supraspinous fossa*, and that below it the *infraspinous fossa*.

The **supraspinous fossa**, the smaller of the two, is concave, smooth, and broader at the vertebral than at the humeral extremity. It affords attachment by its inner two-thirds to the Supraspinatus muscle.

The **infraspinous fossa** is much larger than the preceding; toward its vertebral margin a shallow concavity is seen at its upper part; its centre presents a prominent convexity, whilst toward the axillary border is a deep groove which runs from the upper toward the lower part. The inner two-thirds of this surface affords attachment to the Infraspinatus muscle; the outer third is only covered by it, without giving origin to its fibres. This surface is separated from the axillary border by an elevated ridge, which runs from the lower part of the glenoid cavity downward and backward to the posterior border, about an inch above the inferior angle. The ridge serves for the attachment of a strong aponeurosis which separates the Infraspinatus from the two Teres muscles. The surface of bone between this line and the axillary border is narrow in the upper two-thirds of its extent, and traversed near its centre by a groove for the passage of the dorsalis scapulæ vessels; it affords attachment to the Teres minor. Its lower third presents a broader, somewhat triangular surface, which gives origin to the Teres major, and over which the Latissimus dorsi glides; sometimes the latter muscle takes origin by a few fibres from this part. The broad and narrow portions of bone above alluded to are separated by an oblique line which runs from the axillary border, downward and backward, to meet the elevated ridge: to it is attached the aponeurosis separating the two Teres muscles from each other.

The **Spine** is a prominent plate of bone which crosses obliquely the inner four-fifths of the dorsum of the scapula at its upper part, and separates the supra- from the infraspinous fossa: it commences at the vertebral border by a smooth, triangular surface, over which the Trapezius glides, separated from the bone by a bursa, and, gradually becoming more elevated as it passes outward, terminates in the acromion process, which overhangs the shoulder-joint. The spine is triangular and flattened from above downward, its apex corresponding to the vertebral border, its base (which is directed outward) to the neck of the scapula. It presents two surfaces and three borders. Its *superior surface* is concave, assists in forming the supraspinous fossa, and affords attachment to part of the Supraspinatus muscle. Its *inferior surface* forms part of the infraspinous fossa, gives origin to part of the Infraspinatus muscle, and presents near its centre the orifice of a nutrient canal. Of the three borders, the *anterior* is attached to the dorsum of the bone; the *posterior*, or *crest* of the spine, is broad, and presents two lips and an intervening rough interval. To the superior lip is attached the Trapezius to the extent shown in the figure. A rough tubercle is generally seen occupying that portion of the spine which receives the insertion of the middle and inferior fibres of this muscle. To the inferior lip, throughout its whole length, is attached the Deltoid. The interval between the lips is also partly covered by the tendinous fibres of these muscles. The *external border*, or *base*, the shortest of the three, is slightly concave, its edge thick and round, continuous above with the under surface of the acromion process, below with the neck of the scapula. The narrow portion of bone external to this border, and separating it from the glenoid cavity, is called the *great scapular notch*, and serves to connect the supra- and infraspinous fossæ.

The **Acromion Process**, so called from forming the summit of the shoulder (ἄκρον, a summit; ὦμος, the shoulder), is a large and somewhat triangular or oblong process, flattened from behind forward, directed at first a little outward, and then curving forward and upward, so as to overhang the glenoid cavity. Its *upper surface*, directed upward, backward, and outward, is convex, rough, and gives attachment to some fibres of the Deltoid, and in the rest of its extent it is subcutaneous. Its *under surface* is smooth and concave. Its *outer border* is thick and irregular, and presents three or four tubercles for the tendinous origins of the Deltoid muscle. Its *inner margin*, shorter than the outer, is concave, gives attachment to a portion of the Trapezius muscle, and presents about its centre a small oval surface for articulation with the acromial end of the clavicle. Its *apex*, which corresponds to the point of meeting of these two borders in front, is thin, and has attached to it the coraco-acromial ligament.

**Borders.**—Of the three borders of the scapula, the *superior* is the shortest and thinnest; it is concave and extends from the superior angle to the coracoid process. At its outer part is a deep, semicircular notch, the *suprascapular*, formed partly by the base of the coracoid process. This notch is converted into a foramen by the transverse ligament, and serves for the passage of the suprascapular nerve. Sometimes this foramen is entirely surrounded by bone. The adjacent margin of the superior border affords attachment to the Omo-hyoid muscle. The *external, or axillary, border*, is the thickest of the three. It commences above at the lower margin of the glenoid cavity, and inclines obliquely downward and backward to the inferior angle. Immediately below the glenoid cavity is a rough impression (the *infraglenoid tubercle*), about an inch in length, which affords attachment to the long head of the Triceps muscle; in front of this is a longitudinal groove, which extends as far as its lower third and affords origin to part of the Subscapularis muscle. The inferior third of this border, which is thin and sharp, serves for the attachment of a few fibres of the Teres major behind and of the Subscapularis in front. The *internal, or vertebral, border*, also named the *base*, is the longest of the three, and extends from the superior to the inferior angle of the bone. It is arched, intermediate in thickness between the superior and the external borders, and the portion of it above the spine is bent considerably outward, so as to form an obtuse angle with the lower part. The vertebral border presents an anterior lip, a posterior lip, and an intermediate space. The *anterior lip* affords attachment to the Serratus magnus; the *posterior lip*, to the Supraspinatus above the spine, the Infraspinatus below; the interval between the two lips, to the Levator anguli scapulæ above the triangular surface at the commencement of the spine, the Rhomboideus minor to the edge of that surface; the Rhomboideus major being attached by means of a fibrous arch connected above to the lower part of the triangular surface at the base of the spine, and below to the lower part of the posterior border.

**Angles.**—Of the three angles, the *superior*, formed by the junction of the superior and internal borders, is thin, smooth, rounded, somewhat inclined outward, and gives attachment to a few fibres of the Levator anguli scapulæ muscle. The *inferior* angle, thick and rough, is formed by the union of the vertebral and axillary borders, its outer surface affording attachment to the Teres major and frequently to a few fibres of the Latissimus dorsi. The *anterior* angle is the thickest part of the bone, and forms what is called the *head* of the scapula. The head presents a shallow, pyriform, articular surface, the *glenoid cavity* (γλήνη, a socket), whose longest diameter is from above downward, and its direction outward and forward. It is broader below than above; at its apex is a slight impression (*supraglenoid tubercle*), to which is attached the long tendon of the Biceps muscle. It is covered with cartilage in the recent state; and its margins, slightly raised, give attachment to a fibro-cartilaginous structure, the *glenoid ligament*, by which its cavity is deepened. The *neck* of the scapula is the slightly depressed surface which surrounds the head; it is more distinct on the posterior than on the anterior surface, and below than above. In the latter situation it has arising from it a thick prominence, the coracoid process.

The **Coracoid Process**, so called from its fancied resemblance to a crow's beak (κόραξ, a crow), is a thick, curved process of bone which arises by a broad base from the upper part of the neck of the scapula; it is directed at first upward and inward, then, becoming smaller, it changes its direction and passes forward and outward. The ascending portion, flattened from before backward, presents in front a smooth, concave surface over which passes the Subscapularis muscle. The horizontal portion is flattened from above downward, its upper surface is convex and irregular, and gives attachment to the Pectoralis minor; its under surface is smooth; its inner border is rough, and gives attachment to the Pectoralis minor; its outer border is also rough for the coraco-acromial ligament, while the apex is embraced by the conjoined tendon of origin of the short head of the Biceps and of the Coraco-brachialis and gives attachment to the Costo-coracoid ligament. At the inner side of the root of the coracoid process is a rough impression for the attachment of the conoid ligament; and running from it obliquely forward and outward on the upper surface of the horizontal portion, an elevated ridge for the attachment of the trapezoid ligament.

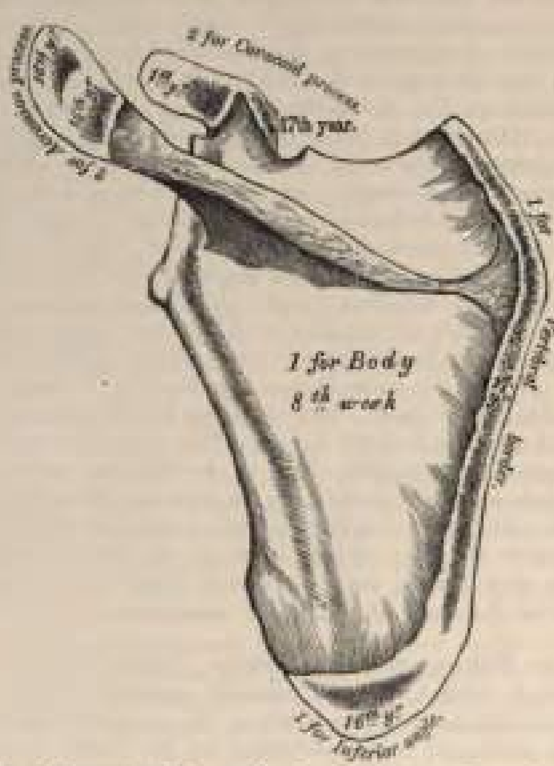



FIG. 96.—Plan of the development of the scapula. By seven centres. The epiphyses (except one for the coracoid process) appear from fifteen to seventeen years, and unite between twenty-two and twenty-five years of age.

**Structure.**—In the head, processes, and all the thickened parts of the bone the scapula is composed of cancellous tissue, while in the rest of its extent it is composed of a thin layer of dense, compact tissue. The centre part of the supra-spinous fossa and the upper part of the infra-spinous fossa, but especially the former, are usually so thin as to be semitransparent; occasionally the bone is found wanting in this situation, and the adjacent muscles come into contact.

**Development** (Fig. 96).—By *seven or more centres*: one for the body, two for the coracoid process, two for the acromion, one for the vertebral border, and one for the inferior angle.

Ossification of the body of the scapula commences about the second month of fœtal life by the formation of an irregular quadrilateral plate of bone immediately behind the glenoid cavity. This plate extends itself so as to form the chief part of the bone, the spine growing up from its posterior surface about the third month.

At birth a large part of the scapula is osseous, but the glenoid cavity, coracoid and acromion processes, the posterior border, and inferior angle are cartilaginous. From the fifteenth to the eighteenth month after birth ossification takes place in the middle of the coracoid process, which usually becomes joined with the rest of the bone at the time when the other centres make their appearance. Between the fourteenth and twentieth years ossification of the remaining centres takes place in quick succession, and in the following order: first, in the root of the coracoid process, in the form of a broad scale; secondly, near the base of the acromion process; thirdly, in the inferior angle and contiguous part of the posterior border; fourthly, near the extremity of the acromion; fifthly, in the posterior border. The acromion process, besides being formed of two separate nuclei, has its base formed by an extension into it of the centre of ossification which belongs to the spine, the extent of which varies in different cases. The two separate nuclei unite, and then join with the extension from the spine. These various epiphyses become joined to the bone between the ages of twenty-two and twenty-five years. Sometimes failure of union between the acromion process and spine occurs, the junction being effected by fibrous tissue or by an imperfect articulation; in some cases of supposed fracture of the acromion with ligamentous union it is probable that the detached segment was never united to the rest of the bone. The upper third of the glenoid cavity is usually ossified from a separate centre (subcoracoid) which makes its appearance between the tenth and eleventh years. Very often, in addition, an epiphysis appears for the lower part of the glenoid cavity.

**Articulations.**—With the humerus and clavicle.

**Attachment of Muscles.**—To seventeen: to the anterior surface, the Subscapularis; posterior surface, Supraspinatus, Infraspinatus; spine, Trapezius, Deltoid; superior border, Omo-hyoid; vertebral border, Serratus magnus, Levator anguli scapulæ, Rhomboideus minor and major; axillary border, Triceps, Teres minor, Teres major; apex of glenoid cavity, long head of the Biceps; coracoid process, short head of the Biceps, Coraco-brachialis, Pectoralis minor; and to the inferior angle occasionally a few fibres of the Latissimus dorsi.

**Surface Form.**—The only parts of the scapula which are truly subcutaneous are the spine and acromion process, but, in addition to these, the coracoid process, the internal or vertebral border and inferior angle, and, to a less extent, the axillary border, may be defined. The acromion process and spine of the scapula are easily felt throughout their entire length, forming, with the clavicle, the arch of the shoulder. The acromion can be ascertained to be connected to the clavicle at the acromio-clavicular joint by running the finger along it, its position being often indicated by an irregularity or bony outgrowth from the clavicle close to the joint. The acromion can be felt forming the point of the shoulder, and from this can be traced backward to join the spine of the scapula. The place of junction is usually denoted by a prominence, which is sometimes called the angle. From here the spine can be felt as a prominent ridge of bone, marked on the surface as an oblique depression, which becomes less and less distinct, and terminates a little external to the spinous processes of the vertebræ. Its termination is usually indicated by a slight dimple in the skin on a level with the interval between the third and fourth dorsal spines. Below this point the vertebral border of the scapula may be traced, running downward and outward, and thus diverging from the vertebral spines, to the inferior angle of the bone, which can be recognized, although covered by the Latissimus dorsi muscle. From this angle the axillary border can usually be traced through this thick muscular covering, forming, with the muscles, the posterior fold of the axilla. The coracoid process may be felt about an inch below the junction of the middle and outer third of the clavicle. Here it is covered by the anterior border of the deltoid and lies a little to the outer side of a slight depression which corresponds to the interval between the Pectoralis major and Deltoid muscles. When the arms are hanging by the side, the upper angle of the scapula corresponds to the upper border of the second rib or the interval between the first and second dorsal spines, the inferior angle to the upper border of the eighth rib or the interval between the seventh and eighth dorsal spines.

**Surgical Anatomy.**—Fractures of the body of the scapula are rare, owing to the mobility of the bone, the thick layer of muscles by which it is encased on both surfaces, and the elasticity of the ribs on which it rests. Fracture of the neck of the bone is also uncommon. The most frequent course of the fracture is from the suprascapular notch to the infraglenoid tubercle, and it derives its principal interest from its simulation to a subglenoid dislocation of the humerus. The diagnosis can be made by noting the alteration in the position of the coracoid process. A fracture of the neck external to, and not including, the coracoid process is said to occur, but it is exceedingly doubtful whether such an accident ever takes place. The acromion process is more frequently broken than any other part of the bone, and there is sometimes, in young subjects, a separation of the epiphysis. It is believed that many of the cases of supposed fracture of the acromion, with fibrous union, which have been found on post-mortem examination are really cases of imperfectly united epiphysis. Sir Astley Cooper believed that most fractures of this bone united by fibrous tissue, and the cause of this mode of union was the difficulty there was in keeping the fractured ends in constant apposition. The coracoid process is occasionally broken off, either from direct violence or perhaps, rarely, from muscular action.

Tumors of various kinds grow from the scapula. Of the innocent form of tumors probably the osteomata are the most common. When it grows from the venter of the scapula, as it sometimes does, it is of the compact variety, such as usually grows from membrane-formed bones, as the bones of the skull. This would appear to afford evidence that this portion of the bone is formed from membrane, and not, like the rest of the bone, from cartilage. Sarcomatous tumors sometimes grow from the scapula, and may necessitate removal of the bone, with or without amputation of the upper limb. The bone may be excised by a T-shaped incision, and, the flaps being reflected, the removal is commenced from the posterior or vertebral border, so that the subscapular vessels which lie along the axillary border are among the last structures divided, and can be at once secured.

## THE ARM.

The **arm** is that portion of the upper extremity which is situated between the shoulder and the elbow. Its skeleton consists of a single bone, the humerus.

### The Humerus.

The **Humerus** is the longest and largest bone of the upper extremity; it presents for examination a shaft and two extremities.

The **Upper Extremity** presents a large, rounded *head*, joined to the shaft by a constricted portion, called the *neck*, and two other eminences, the *greater* and *lesser tuberosities* (Fig. 97).

The **head**, nearly hemispherical in form,[1] is directed upward, inward, and a little backward, and articulates with the glenoid cavity of the scapula; its surface is smooth and coated with cartilage in the recent state. The circumference of its articular surface is slightly constricted, and is termed the *anatomical neck*, in contradistinction to the constriction which exists below the tuberosities. The latter is called the *surgical neck*, from its often being the seat of fracture. It should be remembered, however, that fracture of the *anatomical neck* does sometimes, though rarely, occur.

The **anatomical neck** is obliquely directed, forming an obtuse angle with the shaft. It is more distinctly marked in the lower half of its circumference than in the upper half, where it presents a narrow groove, separating the head from the tuberosities. Its circumference affords attachment to the capsular ligament and is perforated by numerous vascular foramina.

The **greater tuberosity** is situated on the outer side of the head and lesser tuberosity. Its upper surface is rounded and marked by three flat facets, separated by two slight ridges: the highest facet gives attachment to the tendon of the Supraspinatus; the middle one, to the Infraspinatus; the inferior facet and the shaft of the bone below it, to the Teres minor. The outer surface of the great tuberosity is convex, rough, and continuous with the outer side of the shaft.

The **lesser tuberosity** is more prominent, although smaller than the greater: it is situated in front of the head, and is directed inward and forward. Its summit presents a prominent facet for the insertion of the tendon of the Subscapularis muscle. The tuberosities are separated from one another by a deep groove, the *bicipital groove*, so called from its lodging the long tendon of the Biceps muscle, with which runs a branch of the anterior circumflex artery. It commences above between the two tuberosities, passes obliquely downward and a little inward, and terminates at the junction of the upper with the middle third of the bone. It is deep and narrow at the commencement, and becomes shallow and a little broader as it descends. Its borders are called, respectively, the anterior

[1] Though the head is nearly hemispherical in form, its margin, as Sir G. Humphry has shown, is by no means a true circle. Its greatest measurement is from the top of the bicipital groove in a direction downward, inward, and backward. Hence it follows that the greatest elevation of the arm can be obtained by rolling the articular surface in this direction—that is to say, obliquely upward, outward, and forward.

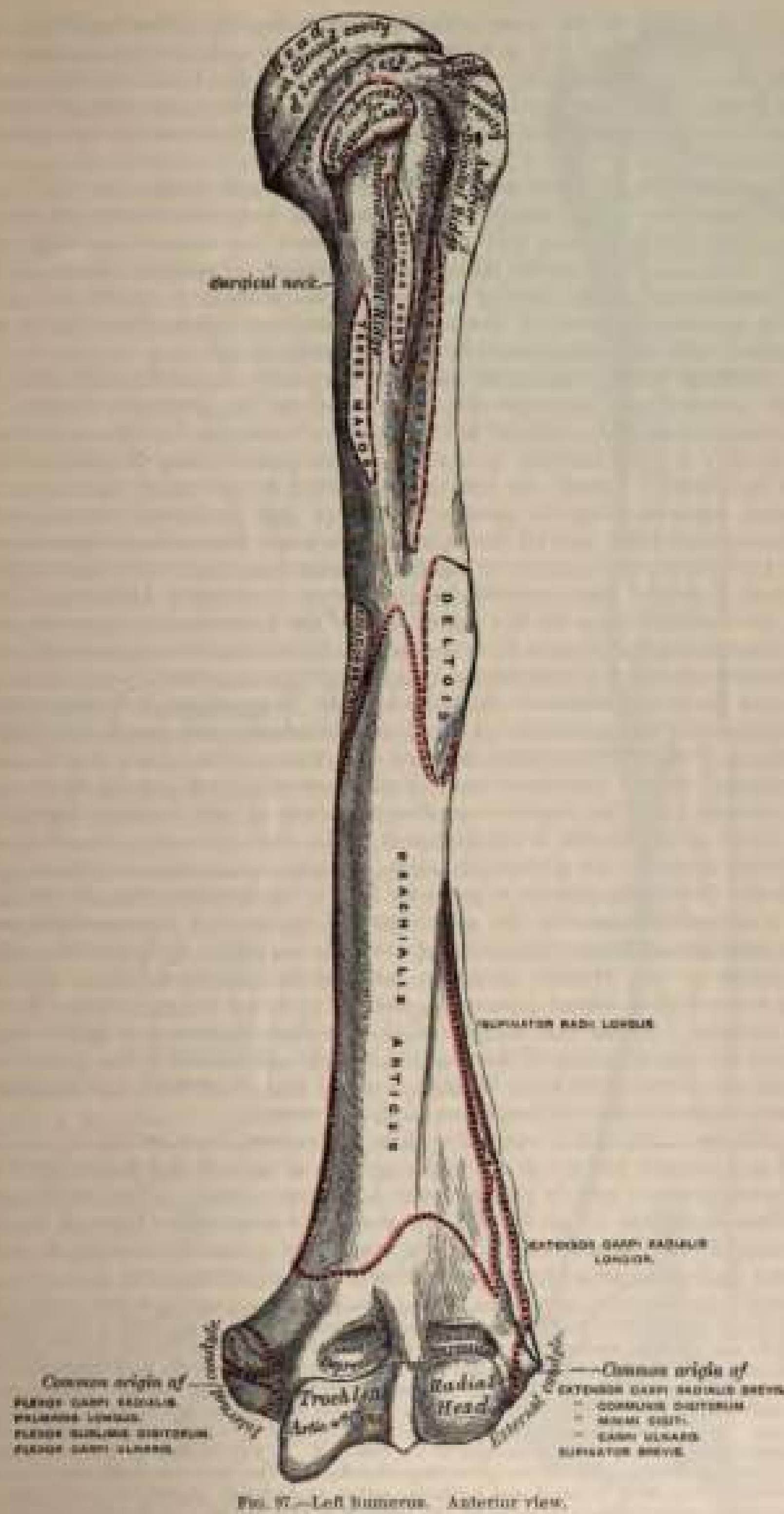



Fig. 97.—Left humerus. Anterior view.

and posterior *bicipital ridges*, and form the upper part of the anterior and internal borders of the shaft of the bone. In the recent state it is covered with a thin layer of cartilage, lined by a prolongation of the synovial membrane of the shoulder-joint, and receives the tendon of insertion of the Latissimus dorsi muscle.

The **Shaft** of the humerus is almost cylindrical in the upper half of its extent, prismatic and flattened below, and presents three borders and three surfaces for examination.

The **anterior border** runs from the front of the great tuberosity above to the coronoid depression below, separating the internal from the external surface. Its upper part is very prominent and rough, and forms the outer lip of the bicipital groove. It is sometimes called the *anterior bicipital* or *pectoral ridge*, and serves for the attachment of the tendon of the Pectoralis major. About its centre it forms the anterior boundary of the rough deltoid impression; below, it is smooth and rounded, affording attachment to the Brachialis anticus.

The **external border** runs from the back part of the greater tuberosity to the external condyle, and separates the external from the posterior surface. It is rounded and indistinctly marked in its upper half, serving for the attachment of the lower part of the insertion of the Teres minor, and below this of the external head of the Triceps muscle; its centre is traversed by a broad but shallow, oblique depression, the *musculo-spiral groove;* its lower part is marked by a prominent, rough margin, a little curved from behind forward, the *external supracondylar ridge*, which presents an anterior lip for the attachment of the Supinator longus above and Extensor carpi radialis longior below, a posterior lip for the Triceps, and an intermediate space for the attachment of the external intermuscular septum.

The **internal border** extends from the lesser tuberosity to the internal condyle. Its upper third is marked by a prominent ridge, forming the posterior lip of the bicipital groove, and gives attachment to the tendon of the Teres major. About its centre is an impression for the attachment of the Coraco-brachialis, and just below this is seen the entrance of the nutrient canal, directed downward. Sometimes there is a second canal, situated at the commencement of the musculo-spiral groove, for a nutrient artery derived from the superior profunda branch of the brachial artery. The inferior third of this border is raised into a slight ridge, the *internal supracondylar ridge*, which becomes very prominent below; it presents an anterior lip for the attachment of the Brachialis anticus, a posterior lip for the internal head of the Triceps, and an intermediate space for the attachment of the internal intermuscular septum.

The **external surface** is directed outward above, where it is smooth, rounded, and covered by the Deltoid muscle; forward and outward below, where it is slightly concave from above downward, and gives origin to part of the Brachialis anticus muscle. About the middle of this surface is seen a rough, triangular impression for the insertion of the Deltoid muscle; and below it the musculo-spiral groove, directed obliquely from behind, forward and downward, and transmitting the musculo-spiral nerve and superior profunda artery.

The **internal surface**, less extensive than the external, is directed inward above, forward and inward below; at its upper part it is narrow and forms the floor of the bicipital groove: to it is attached the Latissimus dorsi. The middle part of this surface is slightly rough for the attachment of some of the fibres of the tendon of insertion of the Coraco-brachialis; its lower part is smooth, concave from above downward, and gives attachment to the Brachialis anticus muscle.[1]

[1] A small, hook-shaped process of bone, the *supracondylar process*, varying from $\frac{1}{10}$ to $\frac{3}{4}$ of an inch in length, is not infrequently found projecting from the inner surface of the shaft of the humerus two inches above the internal condyle. It is curved downward, forward, and inward, and its pointed extremity is connected to the internal border, just above the inner condyle, by a ligament or fibrous band, which gives origin to a portion of the Pronator radii teres; through the arch completed by this fibrous band the median nerve and brachial artery pass when these structures deviate from their usual course. Sometimes the nerve alone is transmitted through it, or the nerve may be accompanied by the ulnar artery in cases of high division of the brachial. A well-marked groove is usually found behind the process in which the nerve and artery are lodged. This space is analogous to the supracondyloid foramen in many animals, and probably serves in them to protect the nerve and artery from compression during the contraction of the muscles in this region. A detailed account of this process is given by Dr. Struthers, in his *Anatomical and Physiological Observations*, p. 202. An accessory portion of the Coracobrachialis muscle is frequently connected with this process, according to Mr. J. Wood (*Journal of Anat. and Phys.*, No. 1, Nov., 1866, p. 47).

The **posterior surface** (Fig. 98) appears somewhat twisted, so that its upper part is directed a little inward, its lower part backward and a little outward. Nearly the whole of this surface is covered by the external and internal heads of the Triceps, the former of which is attached to its upper and outer part, the latter to its inner and back part, the two being separated by the musculo-spiral groove.

The **Lower Extremity** is flattened from before backward, and curved slightly forward; it terminates below in a broad, articular surface which is divided into two parts by a slight ridge. Projecting on either side are the external and internal condyles. The articular surface extends a little lower than the condyles, and is curved slightly forward, so as to occupy the more anterior part of the bone; its greatest breadth is in the transverse diameter, and it is obliquely directed, so that its inner extremity occupies a lower level than the outer. The outer portion of the articular surface presents a smooth, rounded eminence, which has received the name of the *capitellum*, or *radial head* of the humerus; it articulates with the cup-shaped depression on the head of the radius, and is limited to the front and lower part of the bone, not extending as far back as the other portion of the articular surface. On the inner side of this eminence is a shallow groove, in which is received the inner margin of the head of the radius. Above the front part of the capitellum is a slight depression, the *radial fossa*, which receives the anterior border of the head of the radius when the fore-arm is flexed. The inner portion of the articular surface, the *trochlea*, presents a deep depression between two well-marked borders. This surface is convex from before backward, concave from side to side, and occupies the anterior, lower, and posterior parts of the bone. The external border, less prominent than the internal, corresponds to the interval between the radius and the ulna. The internal border is thicker, more prominent, and consequently of greater length, than the external. The grooved portion of the articular surface fits accurately within the greater sigmoid cavity of the ulna: it is broader and deeper on the posterior than on the anterior aspect of the bone, and is inclined obliquely from behind forward and from without inward. Above the front part of the trochlear surface is seen a smaller depression, the *coronoid fossa*, which receives the coronoid process of the ulna during flexion of the forearm. Above the back part of the trochlear surface is a deep, triangular depression, the *olecranon fossa*, in which is received the summit of the olecranon process in extension of

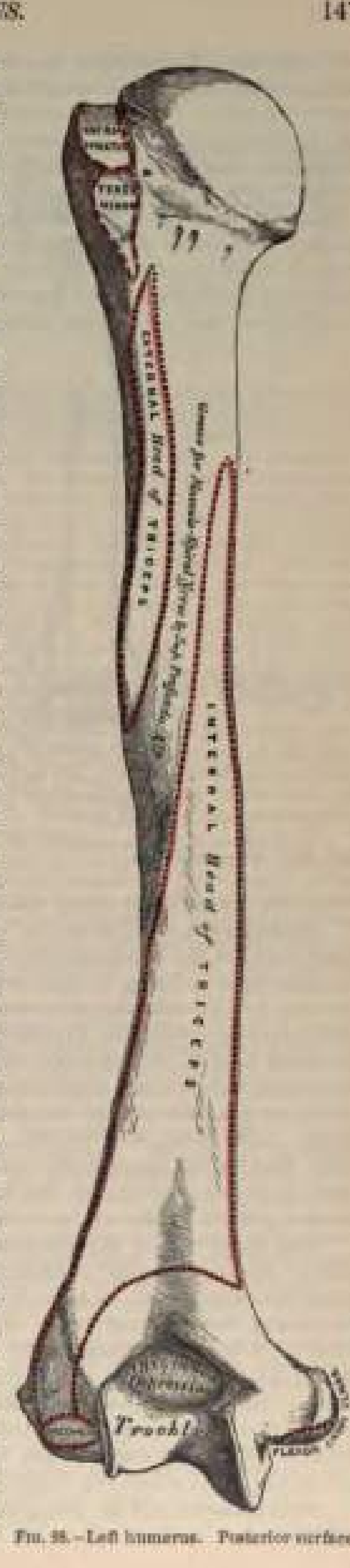



FIG. 98.—Left humerus. Posterior surface.

the forearm. These fossæ are separated from one another by a thin, transparent lamina of bone, which is sometimes perforated, forming the *supratrochlear foramen*; their upper margins afford attachment to the anterior and posterior ligaments of the elbow-joint, and they are lined, in the recent state, by the synovial membrane of this articulation. The articular surfaces, in the recent state, are covered with a thin layer of cartilage. The external condyle (*epicondyle*) is a small, tubercular eminence, less prominent than the internal, curved a little forward, and giving attachment to the external lateral ligament of the elbow-joint, and to a tendon common to the origin of some of the extensor and supinator muscles. The internal condyle (*epitrochlea*), larger and more prominent, and therefore more liable to fracture, than the external, is directed a little backward: it gives attachment to the internal lateral ligament, to the Pronator radii teres, and to a tendon common to the origin of some of the flexor muscles of the forearm. The ulnar nerve runs in a groove at the back of the internal condyle, or between it and the olecranon process. These condyles are directly continuous above with the external and internal supracondylar ridges.

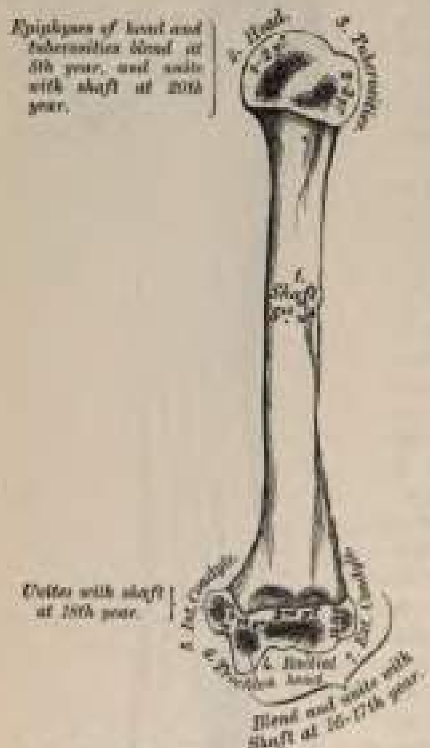



FIG. 99.—Plan of the development of the humerus. By seven centres.

**Structure.**—The extremities consist of cancellous tissue, covered with a thin compact layer; the shaft is composed of a cylinder of compact tissue, thicker at the centre than at the extremities, and hollowed out by a large medullary canal, which extends along its whole length.

**Development.**—By *seven*, or occasionally *eight*, centres (Fig. 99), one for the shaft, one for the head, one for the tuberosities, one for the radial head, one for the trochlear portion of the articular surface, and one for each condyle. The nucleus for the shaft appears near the centre of the bone in the eighth week, and soon extends toward the extremities. At birth the humerus is ossified nearly in its whole length, the extremities remaining cartilaginous. During the first year, sometimes before birth, ossification commences in the head of the bone, and during the third year the centre for the tuberosities makes its appearance, usually by a single ossific point, but sometimes, according to Béclard, by one for each tuberosity, that for the lesser being small and not appearing until the fifth year. By the sixth year the centres for the head and tuberosities have increased in size and become joined, so as to form a single large epiphysis.

The lower end of the humerus is developed in the following manner: At the end of the second year ossification commences in the capitellum, and from this point extends inward, so as to form the chief part of the articular end of the bone, the centre for the inner part of the trochlea not appearing until about the age of twelve. Ossification commences in the internal condyle about the fifth year, and in the external one not until about the thirteenth or fourteenth year. About sixteen or seventeen years the outer condyle and both portions of the articulating surface (having already joined) unite with the shaft: at eighteen years the inner condyle becomes joined; while the upper epiphysis, although the first formed, is not united until about the twentieth year.

**Articulations.**—With the glenoid cavity of the scapula and with the ulna and radius.

**Attachment of Muscles.**—To twenty-four: to the greater tuberosity, the Supraspinatus, Infraspinatus, and Teres minor; to the lesser tuberosity, the Subscapularis; to the anterior bicipital ridge, the Pectoralis major; to the posterior bicipital ridge, the Teres major; to the bicipital groove, the Latissimus dorsi; to the shaft, the Deltoid, Coraco-brachialis, Brachialis anticus, external and internal heads of the Triceps; to the internal condyle, the Pronator radii teres, and common tendon of the Flexor carpi radialis, Palmaris longus, Flexor sublimis digitorum, and Flexor carpi ulnaris; to the external condyloid ridge, the Supinator longus and Extensor carpi radialis longior; to the external condyle, the common tendon of the Extensor carpi radialis brevior, Extensor communis digitorum, Extensor minimi digiti, Extensor carpi ulnaris, and Supinator brevis; to the back of the external condyle, the Anconeus.

**Surface Form.**—The humerus is almost entirely clothed by the muscles which surround it, and the only parts of this bone which are strictly subcutaneous are small portions of the internal and external condyles. In addition to these, the tuberosities and a part of the head of the bone can be felt under the skin and muscles by which they are covered. Of these the greater tuberosity forms the most prominent bony point of the shoulder, extending beyond the acromion process and covered by the Deltoid muscle. It influences materially the surface form of the shoulder. It is best felt while the arm is lying loosely by the side; if the arm be raised, it recedes from under the finger. The lesser tuberosity, directed forward and inward, is to be felt to the inner side of the greater tuberosity, just below the acromio-clavicular joint. Between the two tuberosities lies the bicipital groove. This can be defined by placing the finger and making firm pressure just internal to the greater tuberosity; then, by rotating the humerus, the groove will be felt to pass under the finger as the bone is rotated. With the arm abducted from the side, by pressing deeply in the axilla the lower part of the head of the bone is to be felt. On each side of the elbow-joint, and just above it, the internal and external condyles of the bone are to be felt. Of these the internal is the more prominent, but the ridge passing upward from it, the internal condyloid ridge, is much less marked than the external, and, as a rule, is not to be felt. Occasionally, however, we find along this border the hook-shaped process mentioned above. The external condyle is most plainly to be seen during semiflexion of the forearm, and its position is indicated by a depression between the attachment of the adjacent muscles. From it is to be felt a strong bony ridge running up the outer border of the shaft of the bone. This is the external supracondylar ridge; it is concave forward, and corresponds with the curved direction of the lower extremity of the humerus.

**Surgical Anatomy.**—There are several points of surgical interest connected with the humerus. First, as regards its development. The upper end, though the first to ossify, is the last to join the shaft, and the length of the bone is mainly due to growth from this upper epiphysis. Hence, in cases of amputation of the arm in young subjects the humerus continues to grow considerably, and the end of the bone which immediately after the operation was covered with a thick cushion of soft tissue, begins to project, thinning the soft parts and rendering the stump conical. This may necessitate the removal of a couple of inches or so of the bone, and even after this operation a recurrence of the conical stump may take place.

There are several points of surgical interest in connection with fractures. First, as regard their causation: the bone may be broken by direct or indirect violence like the other long bones, but, in addition to this, it is probably more frequently fractured by muscular action than any other of this class of bone in the body. It is usually the shaft, just below the insertion of the Deltoid, which is thus broken. I have seen the accident happen from throwing a stone, and in an apparently healthy adult from cutting a piece of hard "cake tobacco" on a table. In this latter case there was no disease of the bone that could be discovered. Fractures of the upper end may take place through the anatomical neck, through the surgical neck, or separation of the greater tuberosity may occur. Fracture of the anatomical neck is a very rare accident; in fact, it is doubted by some whether it ever occurs. These fractures are usually considered to be intracapsular, but they are probably partly within and partly without the capsule, as the lower part of the capsule is inserted some little distance below the anatomical neck, while the upper part is attached to it. They may be impacted or non-impacted. In most cases there is little or no displacement on account of the capsule, in whole or in part, remaining attached to the lower fragment. But occasionally a very remarkable alteration in position takes place; the upper fragment turns on its own axis, so that the cartilaginous surface of the head rests against the upper end of the lower fragment. When the fractured end is entirely separated from all its surroundings, its vascular supply must be entirely cut off, and one would expect it, theoretically, to necrose. But this must be exceedingly rare, for Gurlt was unable to find a single authenticated case recorded. Separation of the upper epiphysis of the humerus sometimes occurs in the young subject, and is marked by a characteristic deformity by which the lesion may be at once recognized. This consists in the presence of an abrupt projection at the front of the joint some short distance below the coracoid process, caused by the upper end of the lower fragment. In fractures of the shaft of the humerus the lesion may take place at any point, but appears to be more common in the lower than in the upper part of the bone. The points of interest in con nection with these fractures are—(1) that the musculo-spiral nerve may be injured as it lies in the groove on the bone, or may become involved in the callus which is subsequently thrown out; and (2) the frequency of non-union. This is believed to be more common in the humerus than in any other bone, and various causes have been assigned for it. It would seem most probably to be due to the difficulty that there is in fixing the shoulder-joint and the upper fragment, and possibly the elbow-joint and lower fragment also. Other causes which have been assigned for the non-union are: (1) that in attempting passive motion of the elbow-joint to overcome any rigidity which may exist, the movement does not take place at the articulation, but at the seat of fracture; or that the patient, in consequence of the rigidity of the elbow, in attempting to flex or extend the forearm moves the fragment and not the joint. (2) The presence of small portions of muscular tissue between the broken ends. (3) Want of support to the elbow, so that the weight of the arm tends to drag the lower fragment away from the upper. An important distinction to make in fractures of the lower end of the humerus is between those that involve the joint and those which do not; the former always serious, as they may lead to impairment of the utility of the limb. They include the T-shaped fracture and oblique fractures which involve the articular surface. The fractures which do not involve the joint are the transverse above the condyles and the so-called epitrochlear fracture, when the tip of the internal condyle has broken off, generally from direct violence.

Under the head of separation of the epiphysis two separate injuries have been described. One where the whole of the four ossific centres which form the lower extremity of the bone are separated from the shaft; and secondly, where the articular portion is alone separated, the two condyles remaining attached to the shaft of the bone. The epiphysial line between the shaft and lower end runs across the bone just above the tips of the condyles, a point to be borne in mind in performing the operation of excision.

Tumors originating from the humerus are of frequent occurrence. A not uncommon place for a chondroma to grow from is the shaft of the bone somewhere in the neighborhood of the insertion of the deltoid. Sarcomata frequently grow from this bone.

## THE FOREARM.

The **Forearm** is that portion of the upper extremity which is situated between the elbow and the wrist. Its skeleton is composed of two bones, the ulna and radius.

### The Ulna.

The **Ulna** (Figs. 100, 101), so called from its forming the elbow (ὠλένη), is a long bone, prismatic in form, placed at the inner side of the forearm, parallel with the radius. It is the larger and longer of the two bones. Its upper extremity, of great thickness and strength, forms a large part of the articulation of the elbow-joint; it diminishes in size from above downward, its lower extremity being very small, and excluded from the wrist-joint by the interposition of an interarticular fibro-cartilage. It is divisible into a shaft and two extremities.

The **Upper Extremity**, the strongest part of the bone, presents for examination two large, curved processes, the Olecranon process and the Coronoid process; and two concave, articular cavities, the greater and lesser sigmoid cavities.

The **Olecranon Process** (ὠλένη, elbow; κρανίον, head) is a large, thick, curved eminence situated at the upper and back part of the ulna. It is curved forward at the summit so as to present a prominent tip which is received into the olecranon fossa in extension of the forearm; its base being contracted where it joins the shaft. This is the narrowest part of the upper end of the ulna, and, consequently, the most usual seat of fracture. The posterior surface of the olecranon, directed backward, is triangular, smooth, subcutaneous, and covered by a bursa. Its upper surface is of a quadrilateral form, marked behind by a rough impression for the attachment of the Triceps muscle; and in front, near the margin, by a slight transverse groove for the attachment of part of the posterior ligament of the elbow-joint. Its interior surface is smooth, concave, covered with cartilage in the recent state, and forms the upper and back part of the great sigmoid cavity. The lateral borders present a continuation of the same groove that was seen on the margin of the superior surface; they serve for the attachment of ligaments; viz., the back part of the internal lateral ligament internally, the posterior ligament externally. To the inner border is also attached a part of the Flexor carpi ulnaris, while to the outer border is attached the Anconeus.

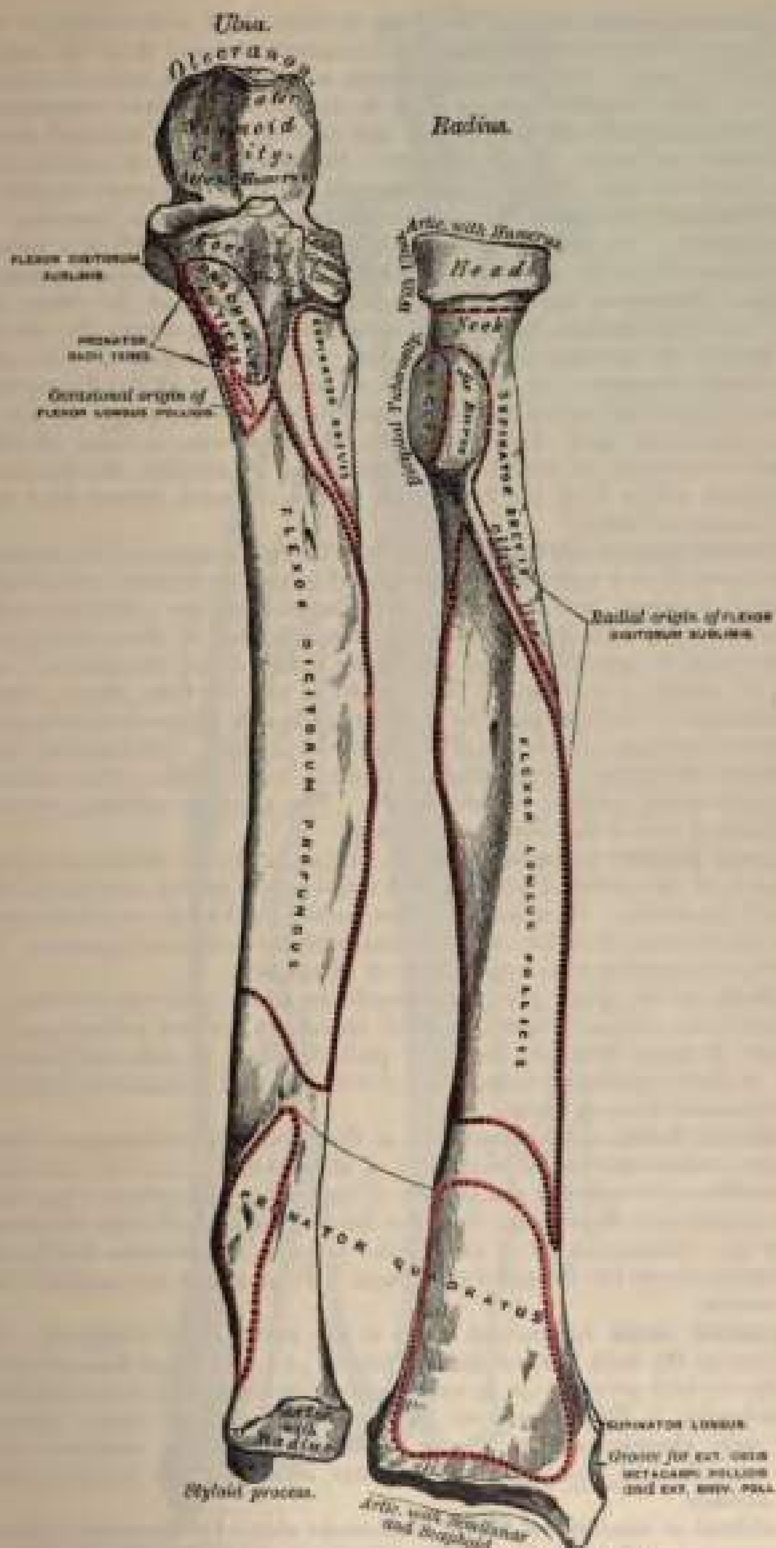



Fig. 100.—Bones of the left forearm. Anterior surface.

The **Coronoid Process** (*κορώνη*, anything hooked like a crow's beak) is a triangular eminence of bone which projects horizontally forward from the upper and front part of the ulna. Its base is continuous with the shaft, and of considerable strength; so much so that fracture of it is an accident of rare occurrence. Its apex is pointed, slightly curved upward, and received into the coronoid depression of the humerus in flexion of the forearm. Its upper surface is smooth, concave, and forms the lower part of the greater sigmoid cavity. The under surface is concave, and marked internally by a rough impression for the insertion of the Brachialis anticus. At the junction of this surface with the shaft is a rough eminence, the *tubercle of the ulna*, for the attachment of the oblique ligament. Its outer surface presents a narrow, oblong, articular depression, the *lesser sigmoid* cavity. The inner surface, by its prominent, free margin, serves for the attachment of part of the internal lateral ligament. At the front part of this surface is a small, rounded eminence for the attachment of one head of the Flexor sublimis digitorum; behind the eminence, a depression for part of the origin of the Flexor profundus digitorum; and, descending from the eminence, a ridge which gives attachment to one head of the Pronator radii teres. Generally, the Flexor longus pollicis has an origin from the lower part of the coronoid process by a rounded bundle of muscular fibres.

The **Greater Sigmoid Cavity**, so called from its resemblance to the old shape of the Greek letter Σ, is a semilunar depression of large size, formed by the olecranon and coronoid processes, and serving for articulation with the trochlear surface of the humerus. About the middle of either lateral border of this cavity is a notch which contracts it somewhat, and serves to indicate the junction of the two processes of which it is formed. The cavity is concave from above downward, and divided into two lateral parts by a smooth, elevated ridge which runs from the summit of the olecranon to the tip of the coronoid process. Of these two portions, the internal is the larger, and is slightly concave transversely; the external portion is convex above, slightly concave below. The articular surface, in the recent state, is covered with a thin layer of cartilage.

The **Lesser Sigmoid Cavity** is a narrow, oblong, articular depression, placed on the outer side of the coronoid process, and receives the lateral articular surface of the head of the radius. It is concave from before backward, and its extremities, which are prominent, serve for the attachment of the orbicular ligament. In the recent state it is covered with a thin layer of cartilage.

The **Shaft**, at its upper part, is prismatic in form, and curved from behind forward and from without inward, so as to be convex behind and externally; its central part is quite straight; its lower part rounded, smooth, and bent a little outward; it tapers gradually from above downward, and presents for examination three borders and three surfaces.

The **anterior border** commences above at the prominent inner angle of the coronoid process, and terminates below in front of the styloid process. It is well marked above, smooth and rounded in the middle of its extent, and affords attachment to the Flexor profundus digitorum: its lower fourth, marked off from the rest of the border by the commencement of an oblique ridge on the anterior surface, serves for the attachment of the Pronator quadratus. It separates the anterior from the internal surface.

The **posterior border** commences above at the apex of the triangular subcutaneous surface at the back part of the olecranon, and terminates below at the back part of the styloid process; it is well marked in the upper three-fourths, and gives attachment to the aponeurosis common to the Flexor carpi ulnaris, the Extensor carpi ulnaris, and the Flexor profundus digitorum muscles; its lower fourth is smooth and rounded. This border separates the internal from the posterior surface.

The **external** or **interosseous border** commences above by the union of two lines, which converge one from each extremity of the lesser sigmoid cavity, enclosing between them a triangular space for the attachment of part of the Supinator brevis,

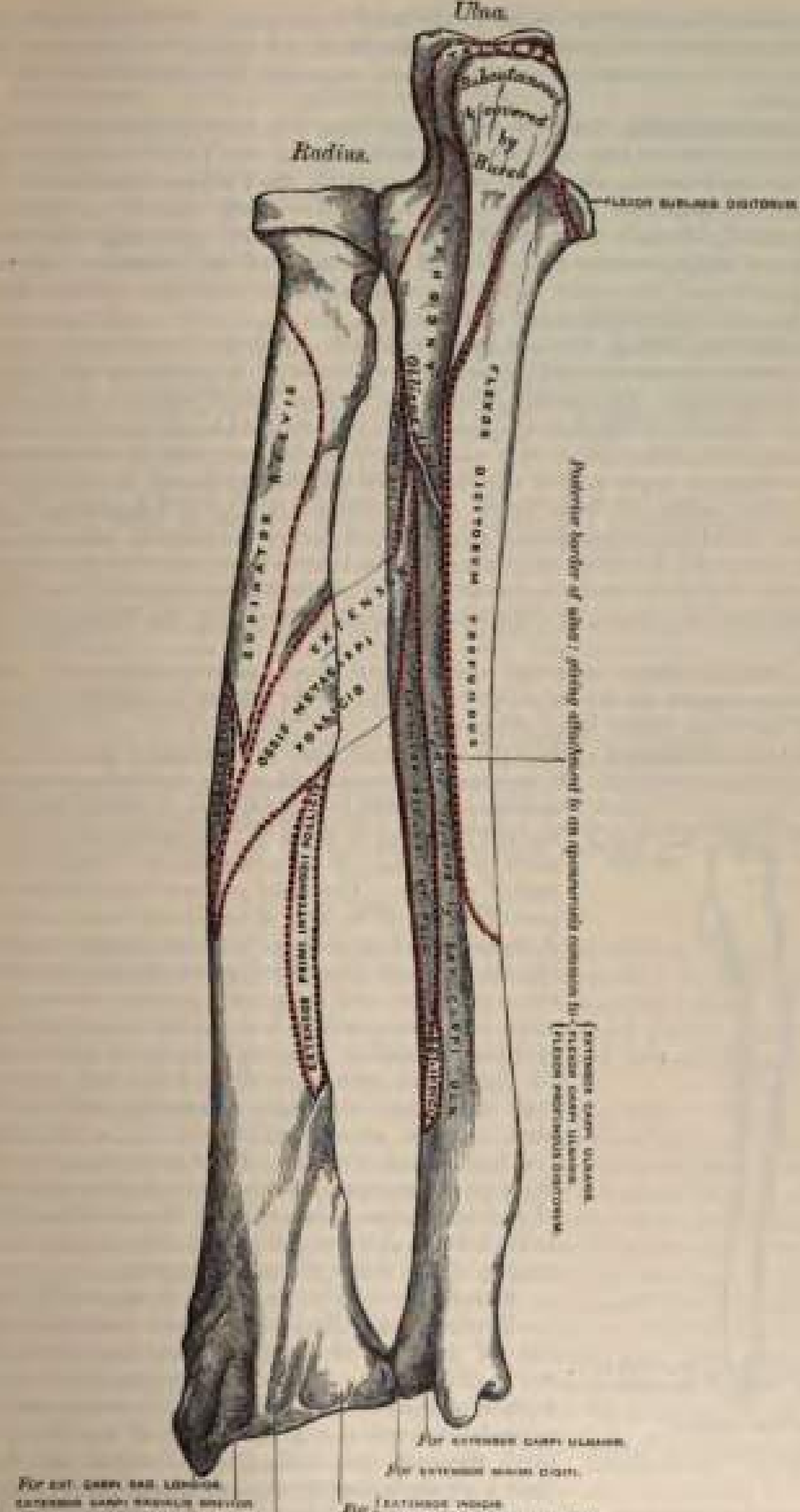



Fig. [illegible].—Bones of the left forearm. Posterior surface.

and terminates below at the middle of the head of the ulna. Its two middle fourths are very prominent; its lower fourth is smooth and rounded. This border gives attachment to the interosseous membrane, and separates the anterior from the posterior surface.

The **anterior surface**, much broader above than below, is concave in the upper three-fourths of its extent, and affords attachment to the Flexor profundus digitorum; its lower fourth, also concave, is covered by the Pronator quadratus. The lower fourth is separated from the remaining portion of the bone by a prominent ridge, directed obliquely from above downward and inward; this ridge (the *oblique* or *Pronator ridge*) marks the extent of attachment of the Pronator quadratus. At the junction of the upper with the middle third of the bone is the nutrient canal, directed obliquely upward and inward.

The **posterior surface**, directed backward and outward, is broad and concave above, somewhat narrower and convex in the middle of its course, narrow, smooth, and rounded below. It presents, above, an oblique ridge, which runs from the posterior extremity of the lesser sigmoid cavity, downward to the posterior border; the triangular surface above this ridge receives the insertion of the Anconeus muscle, whilst the upper part of the ridge itself affords attachment to the Supinator brevis. The surface of bone below this is subdivided by a longitudinal ridge, sometimes called the *perpendicular line*, into two parts: the internal part is smooth, and covered by the Extensor carpi ulnaris; the external portion, wider and rougher, gives attachment from above downward to part of the Supinator brevis, the Extensor ossis metacarpi pollicis, the Extensor longus pollicis, and the Extensor indicis muscles.

The **internal surface** is broad and concave above, narrow and convex below. It gives attachment by its upper three-fourths to the Flexor profundus digitorum muscle: its lower fourth is subcutaneous.

The **Lower Extremity** of the ulna is of small size, and excluded from the articulation of the wrist-joint. It presents for examination two eminences, the outer and larger of which is a rounded, articular eminence, termed the *head* of the ulna, the inner, narrower and more projecting, is a non-articular eminence, the *styloid process*. The *head* presents an articular facet, part of which, of an oval or semilunar form, is directed downward, and articulates with the upper surface of the interarticular fibro-cartilage which separates it from the wrist-joint; the remaining portion, directed outward, is narrow, convex, and received into the sigmoid cavity of the radius. The *styloid process* projects from the inner and back part of the bone, and descends a little lower than the head, terminating in a rounded summit, which affords attachment to the internal lateral ligament of the wrist. The head is separated from the styloid process by a depression for the attachment of the triangular interarticular fibro-cartilage; and behind, by a shallow groove for the passage of the tendon of the Extensor carpi ulnaris.

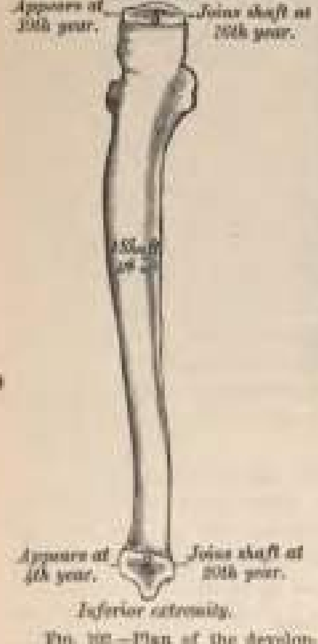



FIG. 102.—Plan of the development of the ulna. By three centres.

**Structure.**—Similar to that of the other long bones.

**Development.**—By *three* centres: one for the shaft, one for the inferior extremity, and one for the olecranon (Fig. 102). Ossification commences near the middle of the shaft about the eighth week, and soon extends through the greater part of the bone. At birth the ends are cartilaginous. About the fourth year a separate osseous nucleus appears in the middle of the head, which soon extends into the styloid process. About the tenth year ossific matter appears in the olecranon near its extremity, the chief part of this process being formed from an extension of the shaft of the bone into it. At about the sixteenth year the upper epiphysis becomes joined, and at about the twentieth year the lower one.

**Articulations.**—With the humerus and radius.

**Attachment of Muscles.**—To sixteen: to the olecranon, the Triceps, Anconeus, and one head of the Flexor carpi ulnaris. To the coronoid process, the Brachialis anticus, Pronator radii teres, Flexor sublimis digitorum, and Flexor profundus digitorum; generally also the Flexor longus pollicis. To the shaft, the Flexor profundus digitorum, Pronator quadratus, Flexor carpi ulnaris, Extensor carpi ulnaris, Anconeus, Supinator brevis, Extensor ossis metacarpi pollicis, Extensor longus pollicis, and Extensor indicis.

**Surface Form.**—The most prominent part of the ulna on the surface of the body is the olecranon process, which can always be felt at the back of the elbow-joint. When the forearm is flexed, the upper quadrilateral surface can be felt, directed backward; during extension it recedes into the olecranon fossa, and the contracting fibres of the triceps prevent its being perceived. At the back of the olecranon is the smooth, triangular, subcutaneous surface, which below is continuous with the posterior border of the shaft of the bone, and felt in every position of the forearm. During extension the upper border of the olecranon is slightly above the level of the internal condyle, and the process itself is nearer to this condyle than the outer one. Running down the back of the forearm, from the apex of the triangular surface which forms the posterior surface of the olecranon, is a prominent ridge of bone, the posterior border of the ulna. This is to be felt throughout the entire length of the shaft of the bone, from the olecranon above to the styloid process below. As it passes down the forearm it pursues a sinuous course and inclines to the inner side, so that, though it is situated in the middle of the back of the limb above, it is on the inner side of the wrist at its termination. It becomes rounded off in its lower third, and may be traced below to the small, subcutaneous surface of the styloid process. Internal to this border the lower fourth of the inner surface is to be felt. The styloid process is to be felt as a prominent tubercle of bone, continuous above with the posterior subcutaneous border of the ulna, and terminating below in a blunt apex, which lies a little internal and behind, but on a level with, the wrist-joint. The styloid process is best felt when the hand is in the same line as the bones of the forearm, and in a position midway between supination and pronation. If the forearm is pronated while the finger is placed on the process, it will be felt to recede, and another prominence of bone will appear just behind and above it. This is the head of the ulna, which articulates with the lower end of the radius and the triangular interarticular fibro-cartilage, and now projects between the tendons of the Extensor carpi ulnaris and the Extensor minimi digiti muscles.

## The Radius.

The **Radius** (*radius*, a ray, or spoke of a wheel) is situated on the outer side of the forearm, lying side by side with the ulna, which exceeds it in length and size. (Figs. 100 and 101.) Its upper end is small, and forms only a small part of the elbow-joint; but its lower end is large, and forms the chief part of the wrist. It is one of the long bones, prismatic in form, slightly curved longitudinally, and, like other long bones, has a shaft and two extremities.

The **Upper Extremity** presents a head, neck, and tuberosity. The *head* is of a cylindrical form, depressed on its upper surface into a shallow cup which articulates with the capitellum or radial head of the humerus. In the recent state it is covered with a layer of cartilage which is thinnest at its centre. Around the circumference of the head is a smooth, articular surface, broad internally where it articulates with the lesser sigmoid cavity of the ulna; narrow in the rest of its circumference, where it rotates within the orbicular ligament. It is coated with cartilage in the recent state. The head is supported on a round, smooth, and constricted portion of bone, called the *neck*, which presents, behind, a slight ridge, for the attachment of part of the Supinator brevis. Beneath the neck, at the inner and front aspect of the bone, is a rough eminence, the *bicipital tuberosity*. Its surface is divided into two parts by a vertical line—a posterior, rough portion, for the insertion of the tendon of the Biceps muscle; and an anterior, smooth portion, on which a bursa is interposed between the tendon and the bone.

The **Shaft** of the bone is prismoid in form, narrower above than below, and slightly curved, so as to be convex outward. It presents three surfaces, separated by three borders.

The **anterior border** extends from the lower part of the tuberosity above to the anterior part of the base of the styloid process below. It separates the anterior from the external surface. Its upper third is very prominent; and from its oblique direction, downward and outward, has received the name of the *oblique line of the radius*. It gives attachment externally to the Supinator brevis, internally to the Flexor longus pollicis, and between these to the Flexor sublimis digitorum. The middle third of the anterior border is indistinct and rounded. Its lower fourth is sharp, prominent, affords attachment to the Pronator quadratus and to the posterior annular ligament of the wrist, and terminates in a small tubercle, into which is inserted the tendon of the Supinator longus.

The **posterior border** commences above at the back part of the neck of the radius, and terminates below at the posterior part of the base of the styloid process; it separates the posterior from the external surface. It is indistinct above and below, but well marked in the middle third of the bone.

The **internal** or **interosseous border** commences above at the back part of the tuberosity, where it is rounded and indistinct, becomes sharp and prominent as it descends, and at its lower part divides into two ridges, which descend to the anterior and posterior margins of the sigmoid cavity. This border separates the anterior from the posterior surface, and has the interosseous membrane attached to it throughout the greater part of its extent.

The **anterior surface** is concave for its upper three-fourths, and gives attachment to the Flexor longus pollicis muscle; it is broad and flat for its lower fourth, and gives attachment to the Pronator quadratus. A prominent ridge limits the attachment of the Pronator quadratus below, and between this and the inferior border is a triangular rough surface for the attachment of the anterior ligament of the wrist-joint. At the junction of the upper and middle third of this surface is the nutrient foramen, which is directed obliquely upward.

The **posterior surface** is rounded, convex, and smooth in the upper third of its extent, and covered by the Supinator brevis muscle. Its middle third is broad, slightly concave, and gives attachment to the Extensor ossis metacarpi pollicis above, the Extensor brevis pollicis below. Its lower third is broad, convex, and covered by the tendons of the muscles, which subsequently run in the grooves on the lower end of the bone.

The **external surface** is rounded and convex throughout its entire extent. Its upper third gives attachment to the Supinator brevis muscle. About its centre is seen a rough ridge, for the insertion of the Pronator radii teres muscle. Its lower part is narrow, and covered by the tendons of the Extensor ossis metacarpi pollicis and Extensor brevis pollicis muscles.

The **Lower Extremity** of the radius is large, of quadrilateral form, and provided with two articular surfaces—one at the extremity, for articulation with the carpus, and one at the inner side of the bone, for articulation with the ulna. The carpal articular surface is of triangular form, concave, smooth, and divided by a slight antero-posterior ridge into two parts. Of these, the external is of a triangular form, and articulates with the scaphoid bone; the inner, quadrilateral, articulates with the semilunar. The articular surface for the ulna is called the *sigmoid cavity* of the radius: it is narrow, concave, smooth, and articulates with the head of the ulna. The circumference of this end of the bone presents three surfaces—an anterior, external, and posterior. The *anterior surface*, rough and irregular, affords attachment to the anterior ligament of the wrist-joint. The *external surface* is prolonged obliquely downward into a strong, conical projection, the *styloid process*, which gives attachment by its base to the tendon of the Supinator longus, and by its apex to the external lateral ligament of the wrist-joint. The outer surface of this process is marked by a flat groove, which runs obliquely downward and forward, and gives passage to the tendons of the Extensor ossis metacarpi pollicis and the Extensor brevis pollicis. The *posterior surface* is convex, affords attachment to the posterior ligament of the wrist, and is marked by three grooves. Proceeding from without inward, the first groove is broad but shallow, and subdivided into two by a slightly elevated ridge: the outer of these two transmits the tendon of the Extensor carpi radialis longior, the inner the tendon of the Extensor carpi radialis brevior. The second, which is near the centre of the bone, is a deep but narrow groove, bounded on its outer side by a sharply-defined ridge; it is directed obliquely from above, downward and outward, and transmits the tendon of the Extensor longus pollicis. The third, lying most internally, is a broad groove, for the passage of the tendons of the Extensor indicis and Extensor communis digitorum.

**Structure.**—Similar to that of the other long bones.

**Development** (Fig. 103).—By *three* centres: one for the shaft and one for each extremity. That for the shaft makes its appearance near the centre of the bone, about the eighth week of fœtal life. About the end of the second year ossification commences in the lower epiphysis, and about the fifth year in the upper end. At the age of seventeen or eighteen the upper epiphysis becomes joined to the shaft, the lower epiphysis becoming united about the twentieth year.

**Articulation.**—With four bones: the humerus, ulna, scaphoid, and semilunar.

**Attachment of Muscles.**—To nine: to the tuberosity, the Biceps; to the oblique ridge, the Supinator brevis, Flexor sublimis digitorum, and Flexor longus pollicis; to the shaft (its anterior surface), the Flexor longus pollicis and Pronator quadratus; (its posterior surface), the Extensor ossis metacarpi pollicis and Extensor brevis pollicis; (its outer surface), the Pronator radii teres; and to the styloid process, the Supinator longus.

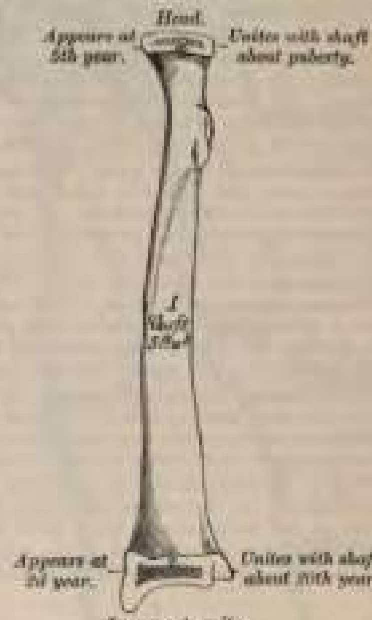



FIG. 103.—Plan of the development of the radius. By three centres.

**Surface Form.**—Just below and a little in front of the posterior surface of the external condyle a part of the head of the radius may be felt, covered by the orbicular and external lateral ligaments. There is in this situation a little dimple in the skin, which is most visible when the arm is extended, and which marks the position of the head of the bone. If the finger is placed on this dimple and the forearm pronated and supinated, the head of the bone will be distinctly perceived rotating in the lesser sigmoid cavity. The upper half of the shaft of the radius cannot be felt, as it is surrounded by the fleshy bellies of the muscles arising from the external condyle. The lower half of the shaft can be readily examined, though covered by tendons and muscles and not strictly subcutaneous. If traced downward, the shaft will be felt to terminate in a lozenge-shaped, convex surface on the outer side of the base of the styloid process. This is the only subcutaneous part of the bone, and from its lower extremity the apex of the styloid process will be felt bending inward toward the wrist. About the middle of the posterior aspect of the lower extremity of the bone is a well-marked ridge, best perceived when the hand is slightly flexed on the wrist. It forms the outer boundary of the oblique groove on the posterior surface of the bone, through which the tendon of the Extensor longus pollicis runs, and serves to keep that tendon in its place.

**Surgical Anatomy.**—The two bones of the forearm are more often broken together than is either the radius or ulna separately. It is therefore convenient to consider the fractures of these two bones together in the first instance, and subsequently to mention the principal fractures which take place in each bone individually. These fractures may be produced by either direct or indirect violence, though more commonly by direct violence. When indirect force is applied to the forearm the radius generally alone gives way, though both bones may suffer. The fracture from indirect force generally takes place somewhere about the middle of the bones; fracture from direct violence may occur at any part, more often, however, in the lower half of the bone. The fracture is usually transverse, but may be more or less oblique. A point of interest in connection with these fractures is the tendency that there is for the two bones to unite across the interosseous membrane; the limb should therefore be put up in a position midway between supination and pronation, which is not only the most comfortable position, but also separates the bones most widely from each other, and therefore diminishes the risk of the bones becoming united across the interosseous membrane. The splints, anterior and posterior, which are applied in these cases should be rather wider than the limb, so as to prevent any lateral pressure on the bones. For in these cases there is a greater liability to gangrene from the pressure of the splints than in other parts of the body. This is no doubt due principally to two causes: (1) the flexion of the forearm compressing to a certain extent the brachial artery and retarding the flow of blood to the limb; and (2) the superficial position of the two main arteries of the forearm in a part of their course, and their liability to be compressed by the splints. The special fractures of the ulna are—(1) Fracture of the olecranon. This may be caused by direct violence, falls on the elbow with the forearm flexed, or by muscular action by the sudden contraction of the triceps. The most common place for the fracture to occur is at the constricted portion where the olecranon joins the shaft of the bone, and the fracture may be either transverse or oblique; but any part may be broken, even a thin shell may be torn off. Fractures from direct violence are occasionally comminuted. The displacement is sometimes very slight, owing to the fibrous structures around the process not being torn. (2) Fracture of the coronoid process sometimes occurs as a complication of dislocation backward of the bones of the forearm, but it is doubtful if it ever occurs as an uncomplicated injury. (3) Fractures of the shaft of the ulna may occur at any part, but usually take place at the middle of the bone or a little below it. They are almost always the result of direct violence. (4) The styloid process may be knocked off by direct violence. Fractures of the radius consist of—(1) Fracture of the head of the bone; this generally occurs in conjunction with some other lesion, but may occur as an uncomplicated injury. (2) Fracture of the neck may also take place, but is generally complicated with other injury. (3) Fractures of the shaft of the radius are very common, and may take place at any part of the bone. They may take place from either direct or indirect violence. In fractures of the upper third of the shaft of the bone, that is to say, above the insertion of the Pronator radii teres, the displacement is very great. The upper fragment is strongly supinated by the Biceps and Supinator brevis, and flexed by the Biceps; while the lower fragment is pronated and drawn toward the ulna by the two pronators. If such a fracture is put up in the ordinary position, midway between supination and pronation, the fracture will unite with the upper fragment in a position of supination, and the lower one in the mid-position, and thus considerable impairment of the movements of the hand will result. The limb should be put up with the forearm supinated. (4) The most important fracture of the radius is that of the lower end (Colles's fracture). The fracture is transverse, and generally takes place about an inch from the lower extremity. It is caused by falls on the palm of the hand, and is an injury of advanced life, occurring more frequently in the female than the male. In consequence of the manner in which the fracture is caused, the upper fragment becomes driven into the lower, and impaction is the result; or else the lower fragment becomes split up into two or more pieces, so that no fixation occurs. Separation of the lower epiphysis of the radius may take place in the young. This injury and Colles's fracture may be distinguished from other injuries in this neighborhood—especially dislocation, with which it is liable to be confounded—by observing the relative positions of the styloid processes of the ulna and radius. In the natural condition of parts, with the arm hanging by the side, the styloid process of the radius is on a lower level than that of the ulna; that is to say, nearer the ground. After fracture or separation of the epiphysis this process is on the same or higher level than that of the ulna, whereas it would be unaltered in position in dislocation.

## THE HAND.

The skeleton of the **Hand** is subdivided into three segments—the Carpus or wrist-bones; the Metacarpus or bones of the palm; and the Phalanges or bones of the digits.

### The Carpus.

The bones of the **Carpus** (καρπός, the wrist), eight in number, are arranged in two rows. Those of the upper row, enumerated from the radial to the ulnar side, are the scaphoid, semilunar, cuneiform, and pisiform; those of the lower row, enumerated in the same order, are the trapezium, trapezoid, os magnum, and unciform.

#### Common Characters of the Carpal Bones.

Each bone (excepting the pisiform) presents six surfaces. Of these the *anterior* or *palmar* and the *posterior* or *dorsal* are rough for ligamentous attachment, the dorsal surface being the broader, except in the scaphoid and semilunar. The *superior* or *proximal* and *inferior* or *distal* are articular, the superior generally convex, the inferior concave; and the *internal* and *external* are also articular when in contact with contiguous bones, otherwise rough and tubercular. The structure in all is similar, consisting of cancellous tissue enclosed in a layer of compact bone. Each bone is also developed from a single centre of ossification.

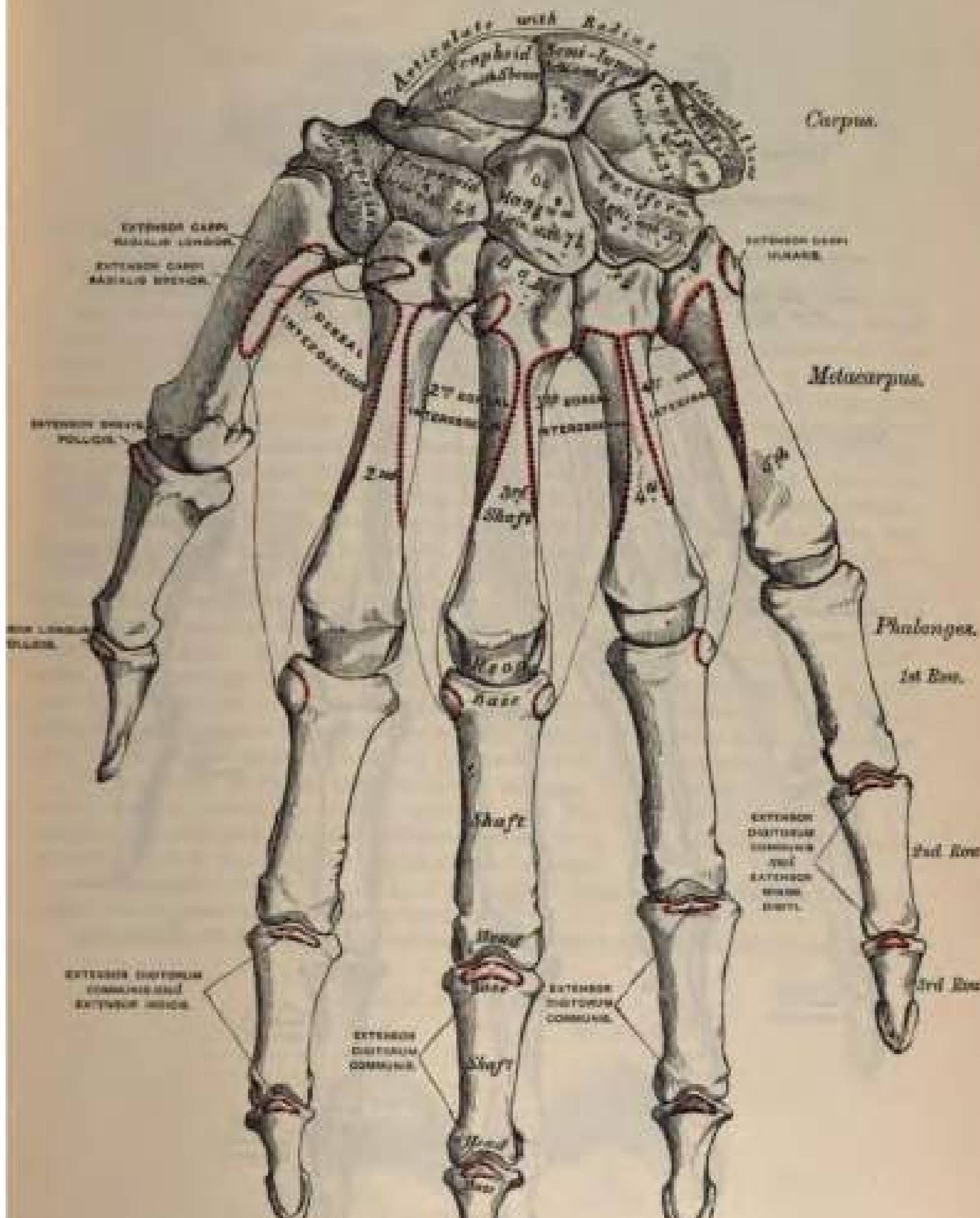



Fig. 104.—Bones of the left hand. Dorsal surface.

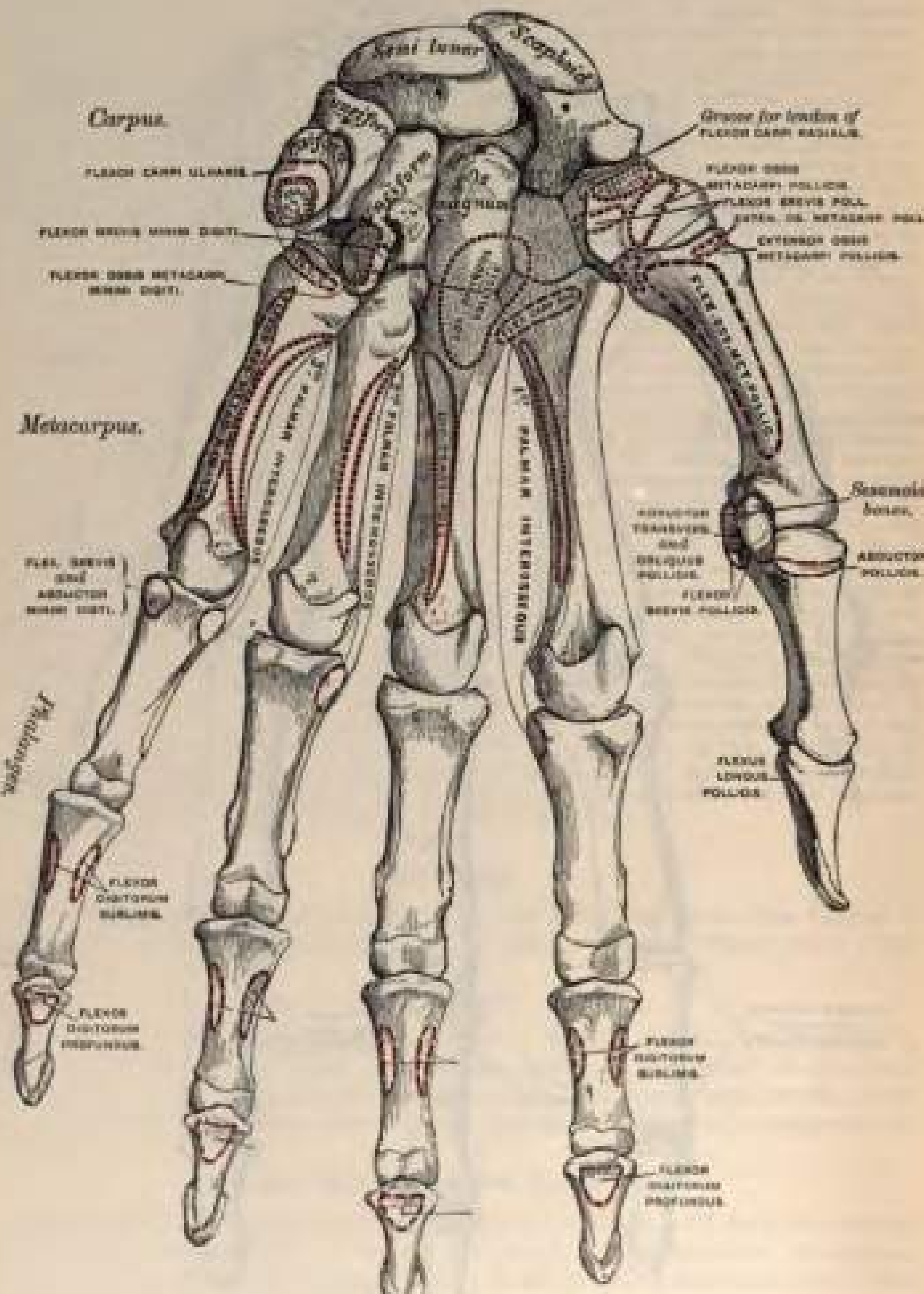



Fig. 1[illegible].—Bones of the left hand. Palmar surface.

### Bones of the Upper Row.

SCAPHOID (Fig. 106).


FIG. 106.—The left scaphoid.

The **Scaphoid** (*σκάφη*, a boat, *εἶδος*, like) is the largest bone of the first row. It has received its name from its fancied resemblance to a boat, being broad at one end and narrowed like a prow at the opposite. It is situated at the upper and outer part of the carpus, its long axis being from above downward, outward, and forward. The *superior surface* is convex, smooth, of triangular shape, and articulates with the lower end of the radius. The *inferior surface*, directed downward, outward, and backward, is smooth, convex, also triangular, and divided by a slight ridge into two parts, the external of which articulates with the trapezium, the inner with the trapezoid. The *posterior* or *dorsal surface* presents a narrow, rough groove which runs the entire length of the bone and serves for the attachment of ligaments. The *anterior* or *palmar surface* is concave above, and elevated at its lower and outer part into a prominent rounded tuberosity, which projects forward from the front of the carpus and gives attachment to the anterior annular ligament of the wrist and sometimes a few fibres of the Abductor pollicis. The *external surface* is rough and narrow, and gives attachment to the external lateral ligament of the wrist. The *internal surface* presents two articular facets: of these, the superior or smaller one is flattened, of semilunar form, and articulates with the semilunar; the inferior or larger is concave, forming, with the semilunar bone, a concavity for the head of the os magnum.

To ascertain to which side the bone belongs, hold it with the superior or radial convex, articular, surface upward, and the posterior surface—*i. e.*, the narrow, non-articular, grooved surface—toward you. The tubercle on the outer surface points to the side to which the bone belongs.[1]

**Articulations.**—With five bones: the radius above, trapezium and trapezoid below, os magnum and semilunar internally.

**Attachment of Muscles.**—Occasionally a few fibres of the Abductor pollicis.

SEMILUNAR (Fig. 107).


FIG. 107.—The left semilunar.

The **Semilunar** (*semi*, half; *luna*, moon) bone may be distinguished by its deep concavity and crescentic outline. It is situated in the centre of the upper

[1] In these directions each bone is supposed to be placed in its natural position—that is, such a position as it would occupy when the arm is hanging by the side, the forearm in a position of supination, the thumb being directed outward, and the palm of the hand looking forward.

row of the carpus, between the scaphoid and cuneiform. The *superior surface*, convex, smooth, and bounded by four edges, articulates with the radius. The *inferior surface* is deeply concave, and of greater extent from before backward than transversely: it articulates with the head of the os magnum and by a long, narrow facet (separated by a ridge from the general surface) with the unciform bone. The *anterior* or *palmar* and *posterior* or *dorsal surfaces* are rough, for the attachment of ligaments, the former being the broader and of a somewhat rounded form. The *external surface* presents a narrow, flattened, semilunar facet for articulation with the scaphoid. The *internal surface* is marked by a smooth, quadrilateral facet, for articulation with the cuneiform.

Hold it with the convex articular surface for the radius upward, and the narrowest non-articular surface toward you. The semilunar facet for the scaphoid will be on the side to which the bone belongs.

**Articulations.**—With five bones: the radius above, os magnum and unciform below, scaphoid and cuneiform on either side.

### Cuneiform (Fig. 108).

The **Cuneiform** (*cuneus*, a wedge; *forma*, likeness) may be distinguished by its pyramidal shape (*os pyramidale*), and by its having an oval, isolated facet for articulation with the pisiform bone. It is situated at the upper and inner side of the carpus. The *superior surface* presents an internal, rough, non-articular portion, and an external or articular portion, which is convex, smooth, and articulates with the triangular interarticular fibro-cartilage of the wrist. The *inferior surface*, directed outward, is concave, sinuously curved, and smooth for articulation with the unciform. The *posterior* or *dorsal surface* is rough, for the attachment of ligaments. The *anterior* or *palmar surface* presents, at its inner side, an oval facet, for articulation with the pisiform; and is rough externally, for ligamentous attachment. The *external surface*, the base of the pyramid, is marked by a flat, quadrilateral, smooth facet, for articulation with the semilunar. The *internal surface*, the summit of the pyramid, is pointed and roughened, for the attachment of the internal lateral ligament of the wrist.

Fig. 108.—The left cuneiform.

Hold the bone with the surface supporting the pisiform facet away from you, and the concavo-convex surface for the unciform downward. The base of the wedge (*i. e.*, the broad end of the bone) will be on the side to which it belongs.

**Articulations.**—With three bones: the semilunar externally, the pisiform in front, the unciform below; and with the triangular, interarticular fibro-cartilage which separates it from the lower end of the ulna.

### Pisiform (Fig. 109).

The **Pisiform** (*pisum*, a pea; *forma*, likeness) may be known by its small size and by its presenting a single articular facet. It is situated on a plane anterior to the other bones of the carpus; it is spheroidal in form, with its long diameter directed vertically. Its *posterior surface* is a smooth, oval facet, for articulation with the cuneiform. This facet approaches the superior, but not the inferior, border of the bone. The *anterior* or *palmar surface* is rounded and rough, and gives attachment to the anterior annular ligament and to the Flexor carpi ulnaris and Abductor minimi digiti muscles. The *outer* and *inner surfaces* are also rough, the former being concave, the latter usually convex.

Fig. 109.—The left pisiform.

Hold the bone with the posterior surface—that which presents the articular facet—toward you, in such a manner that the faceted portion of the surface is uppermost. The outer, concave surface will point to the side to which it belongs.

**Articulations.**—With one bone, the cuneiform.

**Attachment of Muscles.**—To two: the Flexor carpi ulnaris and Abductor minimi digiti; and to the anterior annular ligament.

### Bones of the Lower Row.

Trapezium (Fig. 110).

The **Trapezium** (τράπεζα, a table) is of very irregular form. It may be distin-


Fig. 110.—The left trapezium.

guished by a deep groove, for the tendon of the Flexor carpi radialis muscle. It is situated at the external and inferior part of the carpus, between the scaphoid and first metacarpal bone. The *superior surface*, concave and smooth, is directed upward and inward, and articulates with the scaphoid. The *inferior surface*, directed downward and inward, is oval, concave from side to side, convex from before backward, so as to form a saddle-shaped surface, for articulation with the base of the first metacarpal bone. The *anterior* or *palmar surface* is narrow and rough. At its upper part is a deep groove running from above obliquely downward and inward; it transmits the tendon of the Flexor carpi radialis, and is bounded externally by a prominent ridge, the oblique ridge of the trapezium. This surface gives attachment to the Abductor pollicis, Flexor ossis metacarpi pollicis, and Flexor brevis pollicis muscles, and the anterior annular ligament. The *posterior* or *dorsal surface* is rough. The *external surface* is also broad and rough, for the attachment of ligaments. The *internal surface* presents two articular facets: the upper one, large and concave, articulates with the trapezoid; the lower one, small and oval, with the base of the second metacarpal bone.

Hold the bone with the saddle-shaped surface downward and the grooved surface away from you. The prominent, rough, non-articular surface points to the side to which the bone belongs.

**Articulations.**—With four bones: the scaphoid above, the trapezoid and second metacarpal bones internally, the first metacarpal below.

**Attachment of Muscles.**—Abductor pollicis, Flexor ossis metacarpi pollicis, and part of the Flexor brevis pollicis.

Trapezoid (Fig. 111).

The **Trapezoid** is the smallest bone in the second row. It may be known by its wedge-shaped form, the broad end of the wedge forming the dorsal, the narrow

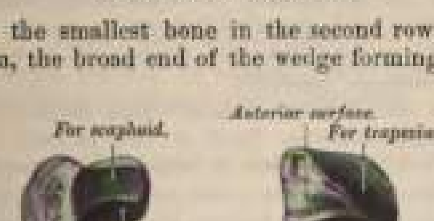



Fig. 111.—The left trapezoid.

end the palmar, surface, and by its having four articular surfaces touching each other and separated by sharp edges. The *superior surface*, quadrilateral in form, smooth, and slightly concave, articulates with the scaphoid. The *inferior surface* articulates with the upper end of the second metacarpal bone; it is convex from side to side, concave from before backward, and subdivided by an elevated ridge into two unequal lateral facets. The *posterior* or *dorsal* and *anterior* or *palmar surfaces* are rough, for the attachment of ligaments, the former being the larger of the two. The *external surface*, convex and smooth, articulates with the trapezium. The *internal surface* is concave and smooth in front, for articulation with the os magnum; rough behind, for the attachment of an interosseous ligament.

Hold the bone with the larger, non-articular surface toward you, and the smooth, quadrilateral articular surface upward. The convex, articular surface will point to the side to which the bone belongs.[1]

**Articulations.**—With four bones: the scaphoid above, second metacarpal bone below, trapezium externally, os magnum internally.

## Os Magnum (Fig. 112).

The **Os Magnum** is the largest bone of the carpus, and occupies the centre of the wrist. It presents, above, a rounded portion or head, which is received into


Fig. 112.—The left os magnum.

the concavity formed by the scaphoid and semilunar bones; a constricted portion or neck; and, below, the body. The *superior surface* is rounded, smooth, and articulates with the semilunar. The *inferior surface* is divided by two ridges into three facets, for articulation with the second, third, and fourth metacarpal bones, that for the third (the middle facet) being the largest of the three. The *posterior* or *dorsal surface* is broad and rough; the *anterior* or *palmar*, narrow, rounded, and also rough, for the attachment of ligaments and a part of the Adductor obliquus pollicis. The *external surface* articulates with the trapezoid by a small facet at its anterior inferior angle, behind which is a rough depression for the attachment of an interosseous ligament. Above this is a deep and rough groove, which forms part of the neck and serves for the attachment of ligaments, bounded superiorly by a smooth, convex surface, for articulation with the scaphoid. The *internal surface* articulates with the unciform by a smooth, concave, oblong facet which occupies its posterior and superior parts, and is rough in front, for the attachment of an interosseous ligament.

Hold the bone with the broader, non-articular surface toward you, and the head upward. The small, articular facet at the anterior inferior angle of the external surface will point to the side to which the bone belongs.

**Articulations.**—With seven bones: the scaphoid and semilunar above; the second, third, and fourth metacarpal below; the trapezoid on the radial side; and the unciform on the ulnar side.

**Attachment of Muscles.**—Part of the Adductor obliquus pollicis.

[1] Occasionally in a badly marked bone there is some difficulty in ascertaining to which side the bone belongs; the following method will sometimes be found useful: Hold the bone with its broader, non-articular surface upward, so that its sloping border is directed toward you. The border will slope to the side to which the bone belongs.

Unciform (Fig. 113).

The **Unciform** (*uncus*, a hook; *forma*, likeness) may be readily distinguished

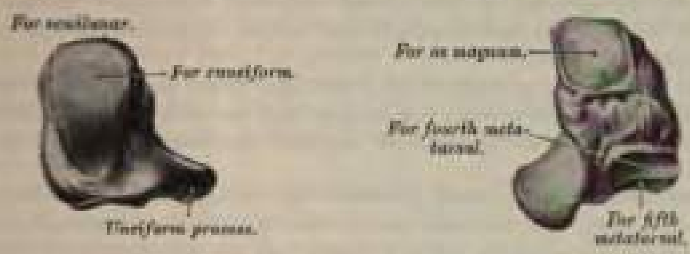



Fig. 113.—The left unciform.

by its wedge-shaped form and the hook-like process that projects from its palmar surface. It is situated at the inner and lower angle of the carpus, with its base downward, resting on the two inner metacarpal bones, and its apex directed upward and outward. The *superior surface*, the apex of the wedge, is narrow, convex, smooth, and articulates with the semilunar. The *inferior surface* articulates with the fourth and fifth metacarpal bones, the concave surface for each being separated by a ridge which runs from before backward. The *posterior* or *dorsal surface* is triangular and rough, for ligamentous attachment. The *anterior* or *palmar surface* presents, at its lower and inner side, a curved, hook-like process of bone, the *unciform process*, directed from the palmar surface forward and outward. It gives attachment by its apex to the annular ligament and Flexor carpi ulnaris; by its inner surface to the Flexor brevis minimi digiti and the Flexor ossis metacarpi minimi digiti; and is grooved on its outer side, for the passage of the Flexor tendons into the palm of the hand. This is one of the four eminences on the front of the carpus to which the anterior annular ligament is attached, the others being the pisiform internally, the oblique ridge of the trapezium and the tuberosity of the scaphoid externally. The *internal surface* articulates with the cuneiform by an oblong facet cut obliquely from above, downward and inward. The *external surface* articulates with the os magnum by its upper and posterior part, the remaining portion being rough, for the attachment of ligaments.

Hold the bone with the hooked process away from you, and the articular surface, divided into two parts, for the metacarpal bones, downward. The concavity of the process will be on the side to which the bone belongs.

**Articulations.**—With five bones: the semilunar above, the fourth and fifth metacarpal below, the cuneiform internally, the os magnum externally.

**Attachment of Muscles.**—To three: the Flexor brevis minimi digiti, the Flexor ossis metacarpi minimi digiti, the Flexor carpi ulnaris.

## The Metacarpus.

The **Metacarpal Bones** are five in number: they are long, cylindrical bones, presenting for examination a shaft and two extremities.

### Common Characters of the Metacarpal Bones.

The **Shaft** is prismoid in form and curved longitudinally, so as to be convex in the longitudinal direction behind, concave in front. It presents three surfaces: two lateral and one posterior. The *lateral surfaces* are concave, for the attachment of the Interossei muscles, and separated from one another by a prominent anterior ridge. The *posterior* or *dorsal surface* presents in its distal half a smooth, triangular, flattened area which is covered, in the recent state, by the tendons of the Extensor muscles. This triangular surface is bounded by two lines, which commence in small tubercles situated on the dorsal aspect on either side of the digital extremity, and, running backward, converge to meet together a little behind the centre of the bone and form a ridge which runs along the rest of the dorsal surface to the carpal extremity. This ridge separates two lateral, sloping surfaces for the attachment of the Dorsal interossei muscles.[1] To the tubercles on the digital extremities are attached the lateral ligaments of the metacarpo-phalangeal joints.

The **carpal extremity,** or **base,** is of a cuboidal form, and broader behind than in front; it articulates above with the carpus, and on each side with the adjoining metacarpal bones; its *dorsal* and *palmar surfaces* are rough, for the attachment of tendons and ligaments.

The **digital extremity,** or **head,** presents an oblong surface, markedly convex from before backward, less so from side to side, and flattened laterally; it articulates with the proximal phalanx; it is broader and extends farther forward on the palmar than on the dorsal aspect. It is longer in the antero-posterior than in the transverse diameter. On either side of the head is a tubercle for the attachment of the lateral ligament of the metacarpo-phalangeal joint. The *posterior surface,* broad and flat, supports the Extensor tendons; the *anterior surface* is grooved in the middle line for the passage of the Flexor tendons, and marked on each side by an articular eminence continuous with the terminal articular surface.

### Peculiar Characters of the Metacarpal Bones.

The **metacarpal bone of the thumb** (Fig. 114) is shorter and wider than the rest, diverges to a greater degree from the carpus, and its *palmar surface* is directed inward toward the palm. The *shaft* is flattened and broad on its dorsal aspect, and does not present the ridge which is found on the other metacarpal bones; it is concave from above downward, on its palmar surface. The *carpal extremity,* or *base,* presents a concavo-convex surface, for articulation with the trapezium; it has no lateral facets, but presents externally a tubercle for the insertion of the Extensor ossis metacarpi pollicis. The *digital extremity* is less convex than that of the other metacarpal bones, broader from side to side than from before backward. It presents on its palmar aspect two distinct articular eminences for the two sesamoid bones in the tendons of the Flexor brevis pollicis, the outer one being the larger of the two.

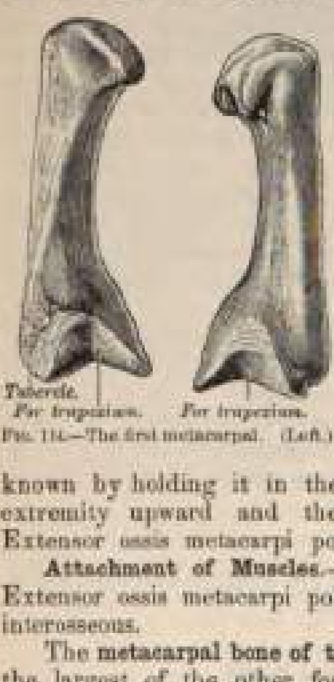


FIG. 114.—The first metacarpal. (Left.)

The side to which this bone belongs may be known by holding it in the position it occupies in the hand, with the carpal extremity upward and the dorsal surface backward; the tubercle for the Extensor ossis metacarpi pollicis will point to the side to which it belongs.

**Attachment of Muscles.**—To four: the Flexor ossis metacarpi pollicis, the Extensor ossis metacarpi pollicis, the Flexor brevis pollicis, and the First dorsal interosseous.

The **metacarpal bone of the index finger** (Fig. 115) is the longest and its base the largest of the other four. Its *carpal extremity* is prolonged upward and inward, forming a prominent ridge. The dorsal and palmar surfaces of this extremity are rough, for the attachment of tendons and ligaments. It presents four articular facets: three on the upper aspect of the base: the middle one of the three is the largest, concave from side to side, convex from before backward, for articulation with the trapezoid; the external one is a small, flat, oval facet, for articulation with the trapezium; the internal one on the summit of the ridge is

[1] By these sloping surfaces the metacarpal bones of the hand may be at once differentiated from the metatarsal bone of the foot.

long and narrow, for articulation with the os magnum. The fourth facet is on the inner or ulnar side of the extremity of the bone, and is for articulation with the third metacarpal bone.

The side to which this bone belongs is indicated by the absence of the lateral facet on the outer (radial) side of its base, so that if the bone is placed with its base toward the student and the palmar surface upward, the side on which there is no lateral facet will be that to which it belongs.

**Attachment of Muscles.**—To six: Flexor carpi radialis, Extensor carpi radialis longior, Adductor obliquus pollicis, First and Second dorsal interosseous, and First palmar interosseous.

The **metacarpal bone of the middle finger** (Fig. 116) is a little smaller than the preceding: it presents a pyramidal eminence (the styloid process) on the radial side of its base (dorsal aspect) which extends upward behind the os magnum; immediately below this, on the dorsal aspect, is a rough surface for the attachment of


FIG. 115.—The second metacarpal. (Left.)


FIG. 116.—The third metacarpal. (Left.)

the Extensor carpi radialis brevior. The carpal, articular facet is concave behind, flat in front, and articulates with the os magnum. On the radial side is a smooth, concave facet, for articulation with the second metacarpal bone, and on the ulnar side two small, oval facets, for articulation with the fourth metacarpal.

The side to which this bone belongs is easily recognized by the styloid process on the radial side of its base. With the palmar surface uppermost and the base toward the student, this process points toward the side to which the bone belongs.

**Attachment of Muscles.**—To six: Extensor carpi radialis brevior, Flexor carpi radialis, Adductor transversus pollicis, Adductor obliquus pollicis, and Second and Third dorsal interosseous.

The **metacarpal bone of the ring finger** (Fig. 117) is shorter and smaller than the preceding, and its base small and quadrilateral: the carpal surface of the base presenting two facets, a large one externally, for articulation with the unciform, and a small one internally, for the os magnum. On the radial side are two oval facets, for articulation with the third metacarpal bone; and on the ulnar side a single concave facet, for the fifth metacarpal.

If this bone is placed with the base toward the student and the palmar surface upward, the radial side of the base, which has two facets for articulation with the third metacarpal bone, will be on the side to which it belongs. If, as sometimes happens in badly marked bones, one of these facets is indistinguishable, the side may be known by selecting the surface on which the larger articular facet is present. This facet is for the fifth metacarpal bone, and would therefore be situated on the ulnar side—that is, the one to which the bone does *not* belong.

**Attachment of Muscles.**—To three: the Third and Fourth dorsal and Second palmar interosseous.

The **metacarpal bone of the little finger** (Fig. 118) presents on its base one facet, which is concavo-convex, and which articulates with the unciform bone, and one


Fig. 117.—The fourth metacarpal. (Left.)


Fig. 118.—The fifth metacarpal. (Left.)

lateral, articular facet, which articulates with the fourth metacarpal bone. On its ulnar side is a prominent tubercle, for the insertion of the tendon of the Extensor carpi ulnaris. The dorsal surface of the shaft is marked by an oblique ridge which extends from near the ulnar side of the upper extremity to the radial side of the lower. The outer division of this surface serves for the attachment of the Fourth dorsal interosseous muscle; the inner division is smooth and covered by the Extensor tendons of the little finger.

If this bone is placed with its base toward the student and its palmar surface upward, the side of the head which has a lateral facet will be that to which the bone belongs.

**Attachment of Muscles.**—To five: the Extensor carpi ulnaris, Flexor carpi ulnaris, Flexor ossis metacarpi minimi digiti, Fourth dorsal, and Third palmar interosseous.

**Articulations.**—Besides the phalangeal articulations, the first metacarpal bone articulates with the trapezium; the second with the trapezium, trapezoid, os magnum, and third metacarpal bones; the third with the os magnum and second and fourth metacarpal bones; the fourth with the os magnum, unciform, and third and fifth metacarpal bones; and the fifth with the unciform and fourth metacarpal.

The *first* has no lateral facets on its carpal extremity; the *second* has no lateral facet on its radial side, but one on its ulnar side; the third has one on its radial and two on its ulnar side; the fourth has two on its radial and one on its ulnar side; and the fifth has only one on its radial side.

## The Phalanges.

The **Phalanges** (*internodia*) are the bones of the fingers; they are fourteen in number, three for each finger, and two for the thumb. They are long bones, and present for examination a shaft and two extremities. The *shaft* tapers from above downward, is convex posteriorly, concave in front from above downward, flat from side to side, and marked laterally by rough ridges, which give attachment to the fibrous sheaths of the Flexor tendons. The *metacarpal extremity*, or *base*, in the first row presents an oval, concave, articular surface, broader from side to side than from before backward; and the same extremity in the other two rows, a double concavity, separated by a longitudinal median ridge, extending from before backward. The *digital extremities* are smaller than the bases, and terminate, in the first and second rows, in two small, lateral condyles, separated by a slight groove; the articular surface being prolonged farther forward on the palmar than on the dorsal surface, especially in the first row.

The **Ungual Phalanges** are convex on their dorsal, flat on their palmar, surfaces; they are recognized by their small size and by a roughened, elevated surface of a horseshoe form on the palmar aspect of their ungual extremity, which serves to support the sensitive pulp of the finger.

**Articulations.**—The first row, with the metacarpal bones and the second row of phalanges; the second row, with the first and third; the third, with the second row.

**Attachment of Muscles.**—To the base of the first phalanx of the thumb, five muscles: the Extensor brevis pollicis, Flexor brevis pollicis, Abductor pollicis, Adductor transversus and obliquus pollicis. To the second phalanx, two: the Flexor longus pollicis and the Extensor longus pollicis. To the base of the first phalanx of the index finger, the First dorsal and the First palmar interosseous; to that of the middle finger, the Second and Third dorsal interosseous; to that of the ring finger, the Fourth dorsal and the Second palmar interosseous; and to that of the little finger, the Third palmar interosseous, the Flexor brevis minimi digiti, and Abductor minimi digiti. To the second phalanges, the Flexor sublimis digitorum, Extensor communis digitorum, and, in addition, the Extensor indicis to the index finger, the Extensor minimi digiti to the little finger. To the third phalanges, the Flexor profundus digitorum and Extensor communis digitorum.

**Surface Form.**—On the front of the wrist are two subcutaneous eminences, one on the radial side, the larger and flatter, due to the tuberosity of the scaphoid and the ridge on the trapezium; the other, on the ulnar side, caused by the pisiform bone. The tubercle of the scaphoid is to be felt just below and in front of the apex of the styloid process of the radius. It is best perceived by extending the hand on the forearm. Immediately below is to be felt another prominence, better marked than the tubercle; this is the ridge on the trapezium which gives attachment to some of the short muscles of the thumb. On the inner side of the front of the wrist the pisiform bone is to be felt, forming a small but prominent projection in this situation. It is some distance below the styloid process of the ulna, and may be said to be just below the level of the styloid process of the radius. The rest of the front of the carpus is covered by tendons and the annular ligament, and entirely concealed, with the exception of the hooked process of the unciform, which can only be made out with difficulty. The back of the carpus is convex and covered by the Extensor tendons, so that none of the posterior surfaces of the bones are to be felt, with the exception of the cuneiform on the inner side. Below the carpus the dorsal surfaces of the metacarpal bones, except the fifth, are covered by tendons, and are scarcely visible except in very thin hands. The dorsal surface of the fifth is, however, subcutaneous throughout almost its whole length, and is plainly to be perceived and felt. In addition to this, slightly external to the middle line of the hand, is a prominence, frequently well marked, but occasionally indistinct, formed by the base of the metacarpal of the middle finger. The heads of the metacarpal bones are plainly to be felt and seen, rounded in contour and standing out in bold relief under the skin, when the fist is clenched. It should be borne in mind that when the fingers are flexed on the hand, the articular surfaces of the first phalanges glide off the heads of the metacarpal bones on to their anterior surfaces, so that the heads of these bones form the prominence of the knuckles and receive the force of any blow which may be given. The head of the third metacarpal bone is the most prominent, and receives the greater part of the shock of the blow. This bone articulates with the os magnum, so that the concussion is carried through this bone to the scaphoid and semilunar, with which the head of the os magnum articulates, and by these bones is transferred to the radius, along which it may be carried to the capitellum of the humerus. The enlarged extremities of the phalanges are to be plainly felt: they form the joints of the fingers. When the digits are bent the proximal phalanges of the joints form prominences, which in the joint between the first and second phalanges is slightly hollowed, in accordance with the grooved shape of their articular surfaces, whilst at the last row the prominence is flattened and square-shaped. In the palm of the hand the four inner metacarpal bones are covered by muscles, tendons, and the palmar fascia, and no part of them but their heads is to be distinguished. With regard to the thumb, on the dorsal aspect the base of the metacarpal bone forms a prominence below the styloid process of the radius; the shaft is to be felt, covered by tendons, terminating at its head in a flattened prominence, in front of which can be felt the sesamoid bones.

**Surgical Anatomy.**—The carpal bones are little liable to fracture, except from extreme violence, when the parts are so comminuted as to necessitate amputation. Occasionally they are the seat of tubercular disease. The metacarpal bone and the phalanges are not unfrequently broken from direct violence. The first metacarpal bone is the one most commonly fractured; then the second, the fourth, and the fifth, the third being the one least frequently broken. There are two diseases of the metacarpal bones and phalanges which require special mention on account of the frequency of their occurrence. One is tubercular dactylitis, consisting in a deposit of tubercular material in the medullary canal, expanding the bone, with subsequent caseation and resulting necrosis. The other is chondroma, which is perhaps more frequently found in connection with the metacarpal bones and phalanges than with any other bones. They are commonly multiple, and may spring either from the medullary canal or from the periosteum.

## Development of the Bones of the Hand.

The **Carpal Bones** are each developed by a *single* centre. At birth they are all cartilaginous. Ossification proceeds in the following order (Fig. 119): In the

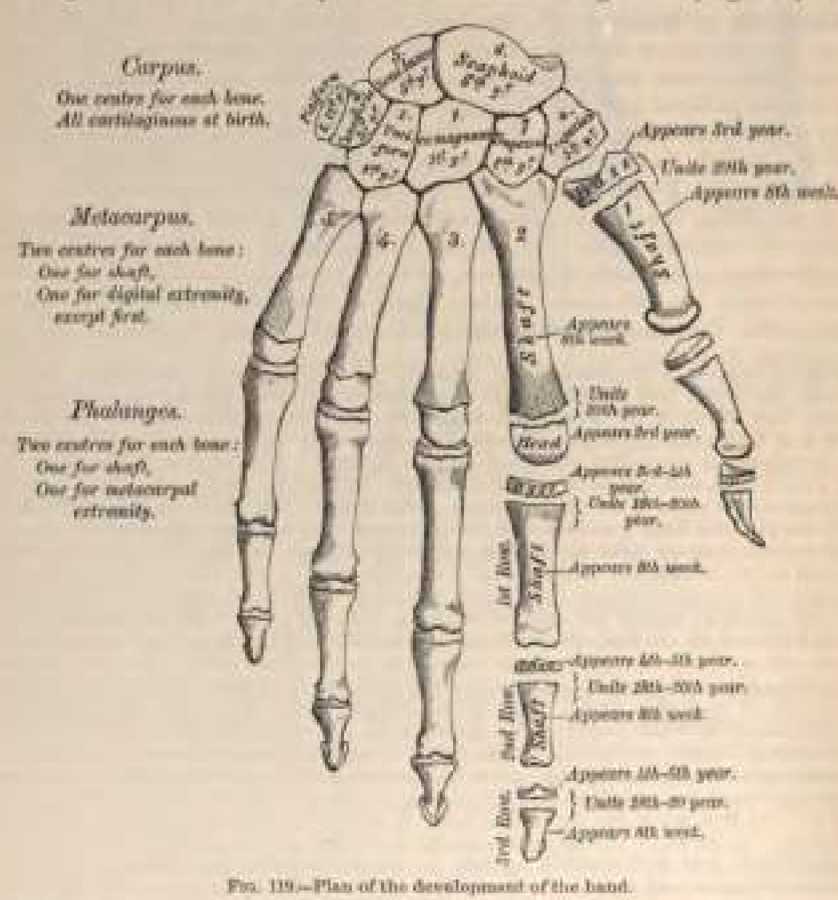



Fig. 119.—Plan of the development of the hand.

os magnum and unciform an ossific point appears during the first year, the former preceding the latter; in the cuneiform, at the third year; in the trapezium and semilunar, at the fifth year, the former preceding the latter; in the scaphoid, at the sixth year; in the trapezoid, during the eighth year; and in the pisiform, about the twelfth year.

Occasionally an additional bone, the *os centrale*, is found in the carpus, lying between the scaphoid, trapezoid, and os magnum. During the second month of fœtal life it is represented by a small cartilaginous nodule, which, however, fuses with the cartilaginous scaphoid about the third month. Sometimes the styloid process of the third metacarpal is detached and forms an additional ossicle.

The **Metacarpal Bones** are each developed by *two* centres: one for the shaft and one for the digital extremity for the four inner metacarpal bones; one for the shaft and one for the base for the metacarpal bone of the thumb, which in this respect resembles the phalanges.[1] Ossification commences in the centre of the shaft about the eighth or ninth week, and gradually proceeds to either end of the bone: about the third year the digital extremities of the four inner metacarpal bones and the base of the first metacarpal begin to ossify, and they unite about the twentieth year.

The **Phalanges** are each developed by *two* centres: one for the shaft and one for the base. Ossification commences in the shaft, in all three rows, at about the eighth week, and gradually involves the whole of the bone excepting the upper extremity. Ossification of the base commences in the first row between the third and fourth years, and a year later in those of the second and third rows. The two centres become united, in each row, between the eighteenth and twentieth years.

In the ungual phalanges the centre for the shaft appears at the distal extremity of the phalanx, instead of at the middle of the shaft, as is the case with the other phalanges.

## THE LOWER EXTREMITY.

The bones of the lower extremity consist of those of the pelvic girdle, of the thigh, of the leg, and of the foot.

### The Pelvic Girdle.

The **Pelvic Girdle** consists of a single bone, the *os innominatum*, by which the thigh is connected to the trunk.

### The Os Innominatum.

The **Os Innominatum** (*in*, not; *nomino*, I name), or *nameless bone*, so called from bearing no resemblance to any known object, is a large, irregularly shaped, flat bone, constricted in the centre and expanded above and below. With its fellow of the opposite side it forms the sides and anterior wall of the pelvic cavity. In young subjects it consists of three separate parts, which meet and form the large, cup-like cavity, the *acetabulum*, situated near the middle of the outer surface of the bone; and, although in the adult these have become united, it is usual to describe the bone as divisible into three portions—the ilium, the ischium, and the os pubis.

The **ilium**, so called from its supporting the flank (*ilia*), is the superior, broad, and expanded portion which runs upward from the acetabulum and forms the prominence of the hip.

The **ischium** (*ἰσχίον*, the hip) is the inferior and strongest portion of the bone; it proceeds downward from the acetabulum, expands into a large tuberosity, and then, curving forward, forms, with the descending ramus of the os pubis, a large aperture, the obturator foramen.

The **os pubis** is that portion which extends inward and downward from the acetabulum to articulate in the middle line with the bone of the opposite side: it

[1] Allen Thomson has demonstrated the fact that the first metacarpal bone is often developed from three centres; that is to say, there is a separate nucleus for the distal end, forming a distinct epiphysis, visible at the age of seven or eight years. He also states that there are traces of a proximal epiphysis in the second metacarpal bone.—*Journal of Anatomy*, 1869.

forms the front of the pelvis, supports the external organs of generation, and has received its name from the skin over it being covered with hair.

The **Ilium** presents for examination two surfaces, an external and an internal; a crest, and two borders, an anterior and a posterior.

**External Surface or Dorsum of the Ilium** (Fig. 120).—The posterior part of this surface is directed backward and outward; its front part, downward and outward.

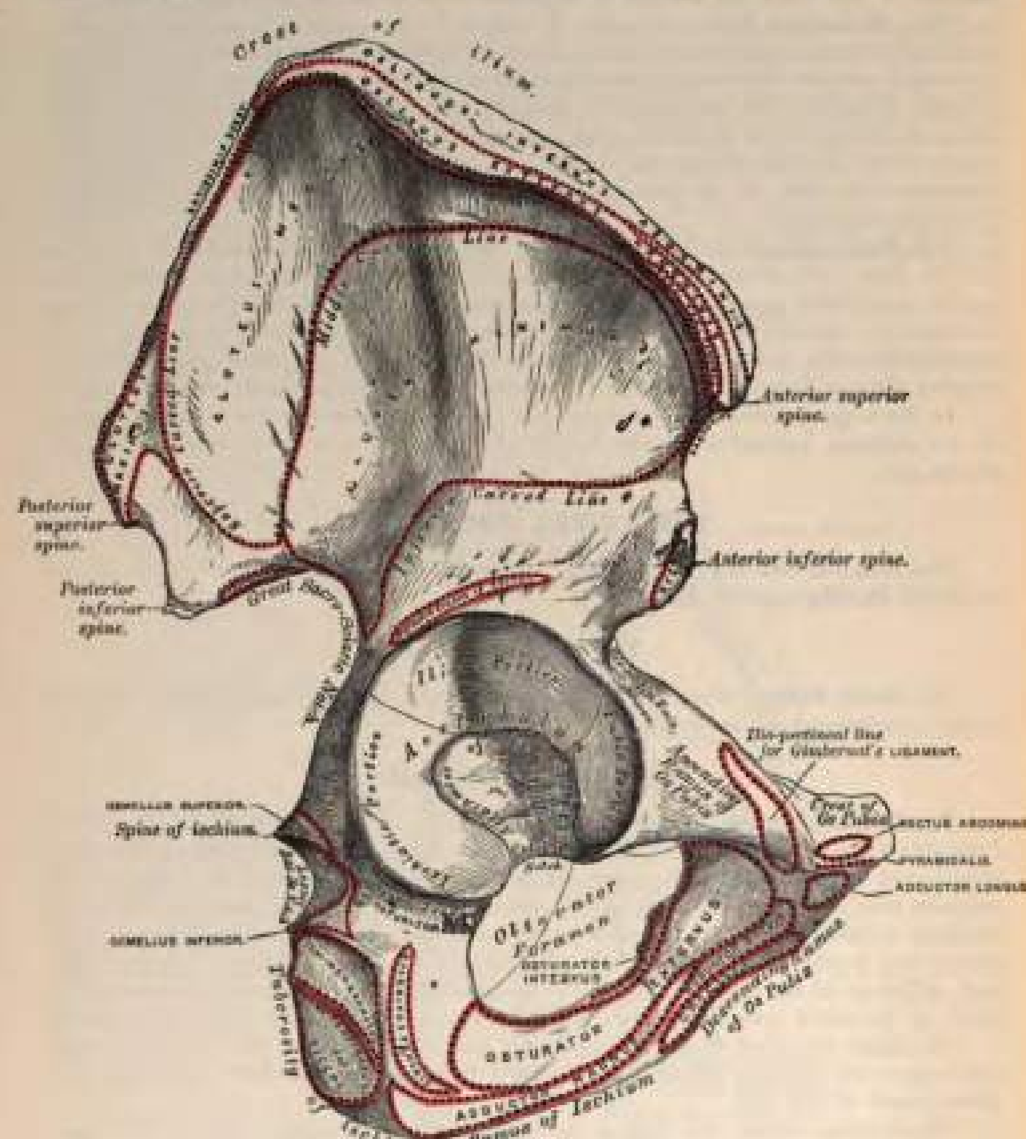



FIG. 120.—Right os innominatum. External surface.

It is smooth, convex in front, deeply concave behind; bounded above by the crest, below by the upper border of the acetabulum; in front and behind by the anterior and posterior borders. This surface is crossed in an arched direction by three semicircular lines—the superior, middle, and inferior curved lines. The *superior curved line*, the shortest of the three, commences at the crest, about two inches in front of its posterior extremity; it is at first distinctly marked, but as it passes downward and backward to the upper part of the great sacro-sciatic notch, where it terminates, it becomes less marked, and is often altogether lost. Behind this line is a narrow semilunar surface, the upper part of which is rough and affords attachment to part of the Gluteus maximus; the lower part is smooth and has no muscular fibres attached to it. The *middle curved line*, the longest of the three, commences at the crest, about an inch behind its anterior extremity, and, taking a curved direction downward and backward, terminates at the upper part of the great sacro-sciatic notch. The space between the superior and middle curved lines and

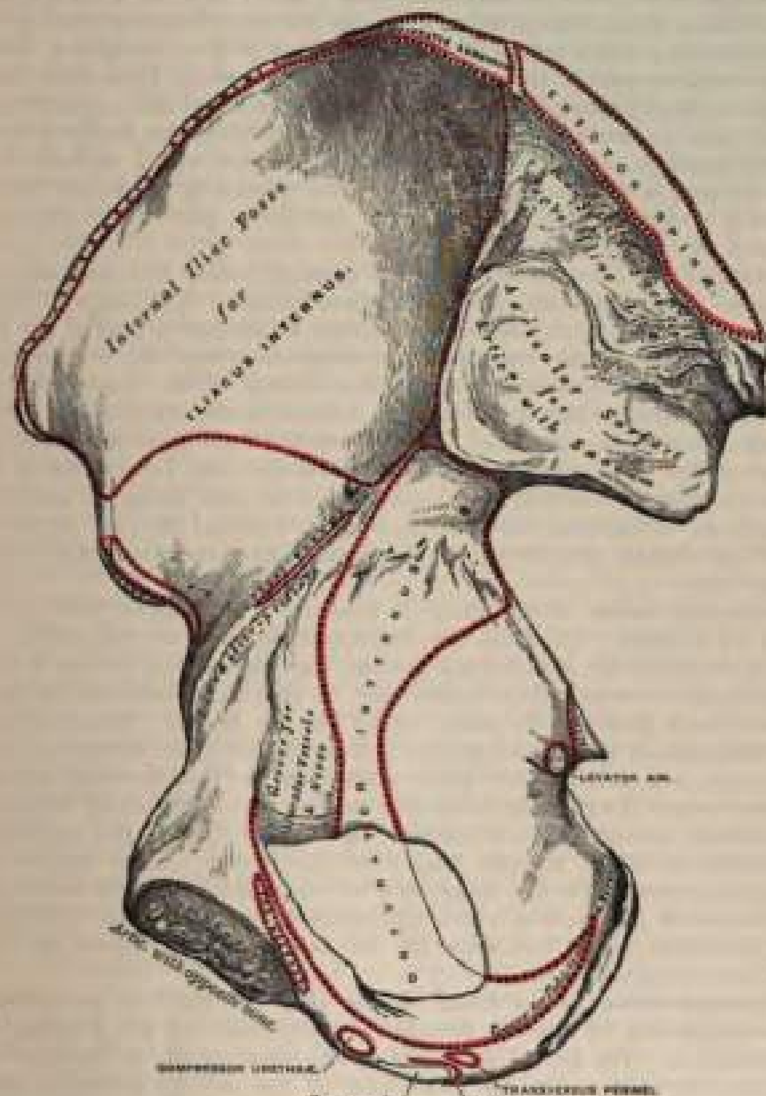



Fig. 121.—Right os innominatum. Internal surface.

the crest is concave, and affords attachment to the Gluteus medius muscle. Near the central part of this line may often be observed the orifice of a nutrient foramen. The *inferior curved line*, the least distinct of the three, commences in front at the notch on the anterior border, and, taking a curved direction backward and downward, terminates at the middle of the great sacro-sciatic notch. The surface of bone included between the middle and inferior curved lines is concave from above downward, convex from before backward, and affords attachment to the Gluteus minimus muscle. Beneath the inferior curved line, and corresponding to the upper part of the acetabulum, is a roughened surface (sometimes a depression), to which is attached the reflected tendon of the Rectus femoris muscle.

The **Internal Surface** (Fig. 121) of the ilium is bounded above by the crest; below it is continuous with the pelvic surface of the os pubis and ischium, a faint line only indicating the place of union; and before and behind it is bounded by the anterior and posterior borders. It presents a large, smooth, concave surface, called the *iliac fossa*, or *venter ilii*, which lodges the Iliacus muscle, and presents at its lower part the orifice of a nutrient canal; and below this a smooth, rounded border (the *linea ilio-pectinea*), which separates the iliac fossa from that portion of the internal surface which enters into the formation of the true pelvis, and which gives attachment to part of the Obturator internus muscle. Behind the iliac fossa is a rough surface divided into two portions, an anterior and a posterior. The anterior or auricular surface, so called from its resemblance in shape to the ear, is coated with cartilage in the recent state, and articulates with a surface of similar shape on the side of the sacrum. The posterior portion is rough, for the attachment of the posterior sacro-iliac ligaments and for a part of the origin of the Erector and Multifidus spinæ.

The **crest** of the ilium is convex in its general outline and sinuously curved, being concave inward in front, concave outward behind. It is longer in the female than in the male, very thick behind, and thinner at the centre than at the extremities. It terminates at either end in a prominent eminence, the *anterior superior* and *posterior superior spinous process*. The surface of the crest is broad, and divided into an external lip, an internal lip, and an intermediate space. About two inches behind the anterior superior spinous process there is a prominent tubercle on the outer lip. To the external lip is attached the Tensor fasciæ femoris, Obliquus externus abdominis, and Latissimus dorsi, and along its whole length, the fascia lata; to the space between the lips, the Internal oblique; to the internal lip, the Transversalis, Quadratus lumborum, and Erector spinæ, the Iliacus, and the fascia iliaca.

The **anterior border** of the ilium is concave. It presents two projections, separated by a notch. Of these, the uppermost, situated at the junction of the crest and anterior border, is called the *anterior superior spinous process* of the ilium, the outer border of which gives attachment to the fascia lata and the origin of the Tensor fasciæ femoris; its inner border, to the Iliacus; while its extremity affords attachment to Poupart's ligament and the origin of the Sartorius. Beneath this eminence is a notch which gives attachment to the Sartorius muscle, and across which passes the external cutaneous nerve. Below the notch is the *anterior inferior spinous process*, which terminates in the upper lip of the acetabulum; it gives attachment to the straight tendon of the Rectus femoris muscle and the ilio-femoral ligament. On the inner side of the anterior inferior spinous process is a broad, shallow groove, over which passes the Ilio-psoas muscle. This groove is bounded internally by an eminence, the *ilio-pectineal*, which marks the point of union of the ilium and os pubis.

The **posterior border** of the ilium, shorter than the anterior, also presents two projections separated by a notch, the *posterior superior* and the *posterior inferior spinous processes*. The former corresponds with that portion of the inner surface of the ilium which serves for the attachment of the oblique portion of the sacro-iliac ligaments and the Multifidus spinæ; the latter, to the auricular portion which articulates with the sacrum. Below the posterior inferior spinous process is a deep notch, the *great sacro-sciatic*.

The **Ischium** forms the lower and back part of the os innominatum. It is divisible into a thick and solid portion—the *body*; a large, rough eminence, on which the trunk rests in sitting—the *tuberosity*; and a thin part which passes forward and slightly upward—the *ramus*.

The **body**, somewhat triangular in form, presents three surfaces, external, internal, and posterior; and three borders, external, internal, and posterior. The *external surface* corresponds to that portion of the acetabulum formed by the ischium; it is smooth and concave, and forms a little more than two-fifths of the acetabular cavity; its outer margin is bounded by a prominent rim or lip, the external border, to which the cotyloid fibro-cartilage is attached. Below the acetabulum, between it and the tuberosity, is a deep groove, along which the tendon of the Obturator externus muscle runs as it passes outward to be inserted into the digital fossa of the femur. The *internal surface* is smooth, concave, and enters into the formation of the lateral boundary of the true pelvic cavity. This surface is perforated by two or three large, vascular foramina, and affords attachment to part of the Obturator internus muscle. The *posterior surface* is quadrilateral in form, broad and smooth. Below, where it joins the tuberosity, it presents a groove continuous with that on the external surface, for the tendon of the Obturator externus muscle. The lower edge of this groove is formed by the tuberosity of the ischium, and affords attachment to the Gemellus inferior muscle. This surface is limited, externally, by the margin of the acetabulum; behind, by the posterior border; it supports the Pyriformis, the two Gemelli, and the Obturator internus muscles in their passage outward to the great trochanter. The *external border* forms the prominent rim of the acetabulum, and separates the posterior from the external surface. To it is attached the cotyloid fibro-cartilage. The *internal border* is thin, and forms the outer circumference of the obturator foramen. The *posterior border* of the body of the ischium presents, a little below the centre, a thin and pointed, triangular eminence, the *spine of the ischium*, more or less elongated in different subjects; its external surface gives attachment to the Gemellus superior, its internal surface to the Coccygeus and Levator ani; whilst to the pointed extremity is connected the lesser sacro-sciatic ligament. Above the spine is a notch of a large size, the *great sacro-sciatic*, converted into a foramen by the lesser sacro-sciatic ligament; it transmits the Pyriformis muscle, the gluteal vessels, and superior and inferior gluteal nerves; the sciatic vessels, the greater and lesser sciatic nerves, the internal pudic vessels and nerve, and the nerves to the Obturator internus and Quadratus femoris. Of these, the gluteal vessels and superior gluteal nerve pass out above the Pyriformis muscle, the other structures, below it. Below the spine is a smaller notch, the *lesser sacro-sciatic*; it is smooth, coated in the recent state with cartilage, the surface of which presents two or three ridges corresponding to the subdivisions of the tendon of the Obturator internus, which winds over it. It is converted into a foramen by the sacro-sciatic ligaments, and transmits the tendon of the Obturator internus, the nerve which supplies that muscle, and the internal pudic vessels and nerve.

The **tuberosity** presents for examination three surfaces: external, internal, and posterior. The *external surface* is quadrilateral in shape, and rough for the attachment of muscles. It is bounded above by the groove for the tendon of the Obturator externus; in front it is limited by the posterior margin of the obturator foramen, and below it is continuous with the ramus of the bone; behind, it is bounded by a prominent margin which separates it from the posterior surface. In front of this margin the surface gives attachment to the Quadratus femoris, and anterior to this to some of the fibres of origin of the Obturator externus. The lower part of the surface gives origin to part of the Adductor magnus. The *internal surface* forms part of the bony wall of the true pelvis. In front it is limited by the posterior margin of the obturator foramen. Behind, it is bounded by a sharp ridge, for the attachment of a falciform prolongation of the great sacro-sciatic ligament; it sometimes presents a groove on the inner side of this ridge for the lodgement of the internal pudic vessels and nerve; and, more anteriorly, has attached the Transversus perinæi and Erector penis muscles. The *posterior surface* is divided into two portions—a lower rough, somewhat triangular part, and an upper smooth, quadrilateral portion. The anterior portion is subdivided by a prominent vertical ridge, passing from base to apex, into two parts: the outer one gives attachment to the Adductor magnus; the inner to the great sacro-sciatic ligament. The upper portion is subdivided into two facets by an oblique ridge which runs downward and outward; from the upper and outer facet arises the Semimembranosus; from the lower and inner, the Biceps and Semitendinosus.

The **ramus** is the thin, flattened part of the ischium which ascends from the tuberosity upward and inward, and joins the descending ramus of the os pubis, their point of junction being indicated in the adult by a rough line. The outer surface of the ramus is rough, for the attachment of the Obturator externus muscle, and also some fibres of the Adductor magnus; its inner surface forms part of the anterior wall of the pelvis. Its inner border is thick, rough, slightly everted, forms part of the outlet of the pelvis, and presents two ridges and an intervening space. The ridges are continuous with similar ones on the descending ramus of the os pubis: to the outer one is attached the deep layer of the superficial perineal fascia, and to the inner, the superficial layer of the triangular ligament of the urethra. If these two ridges are traced downward, they will be found to join with each other just behind the point of origin of the Transversus perinæi muscle; here the two layers of fascia are continuous behind the posterior border of the muscle. To the intervening space, just in front of the point of junction of the ridges, is attached the Transversus perinæi muscle, and in front of this a portion of the crus penis vel clitoridis and the Erector penis vel clitoridis muscle. Its outer border is thin and sharp, and forms part of the inner margin of the obturator foramen.

The **Os Pubis** forms the anterior part of the os innominatum, and, with the bone of the opposite side, forms the front boundary of the true pelvic cavity. It is divisible into a body, an ascending and a descending ramus.

The **body** is somewhat quadrilateral in shape, and presents for examination two surfaces and three borders. The *anterior surface* is rough, directed downward and outward, and serves for the attachment of various muscles. To the upper and inner angle, immediately below the crest, is attached the Adductor longus; lower down, from without inward, are attached the Obturator externus, the Adductor brevis, and the upper part of the Gracilis. The *posterior surface*, convex from above downward, concave from side to side, is smooth, and forms part of the anterior wall of the pelvis. It gives attachment to the Levator ani, Obturator internus, a few muscular fibres prolonged from the bladder, and the pubo-prostatic ligaments. The *upper border* presents for examination a prominent tubercle, which projects forward and is called the *spine*; to it are attached the outer pillar of the external abdominal ring and Poupart's ligament. Passing upward and outward from this is a prominent ridge, forming part of the *ilio-pectineal line*, which marks the brim of the true pelvis: to it are attached a portion of the conjoined tendon of the Internal oblique and Transversalis muscles, Gimbernat's ligament, and the triangular fascia of the abdomen. Internal to the spine of the os pubis is the *crest*, which extends from this process to the inner extremity of the bone. It affords attachment, anteriorly, to the conjoined tendon of the Internal oblique and Transversalis; and posteriorly, to the Rectus and Pyramidalis muscles. The point of junction of the crest with the inner border of the bone is called the *angle*; to it, as well as to the symphysis, is attached the internal pillar of the external abdominal ring. The *internal border* is articular; it is oval, covered by eight or nine transverse ridges, or a series of nipple-like processes arranged in rows, separated by grooves; they serve for the attachment of a thin layer of cartilage, placed between it and the central fibro-cartilage. The *outer border* presents a sharp margin, which forms part of the circumference of the obturator foramen and affords attachment to the obturator membrane.

The **ascending** or **superior ramus** extends from the body to the point of junction of the os pubis with the ilium, and forms the upper part of the circumference of the obturator foramen. It presents for examination a superior, inferior, and posterior surface, and an outer extremity. The *superior surface* presents a continuation of the ilio-pectineal line, already mentioned as commencing at the pubic spine. In front of this ridge the surface of bone is triangular in form, wider externally than internally, smooth, and is covered by the Pectineus muscle.

The surface is bounded externally by a rough eminence, the *ilio-pectineal*, which serves to indicate the point of junction of the ilium and os pubis, and gives attachment to the Psoas parvus, when this muscle is present. The triangular surface is bounded below by a prominent ridge, the *obturator crest*, which extends from the cotyloid notch to the spine of the os pubis. The *inferior surface* forms the upper boundary of the obturator foramen, and presents externally a broad and deep oblique groove, for the passage of the obturator vessels and nerve; and internally a sharp margin which forms part of the circumference of the obturator foramen, and to which the obturator membrane is attached. The *posterior surface* forms part of the anterior boundary of the true pelvis. It is smooth, convex from above downward, and affords attachment to some fibres of the Obturator internus. The *outer extremity*, the thickest part of the ramus, forms one-fifth of the cavity of the acetabulum.

The **descending** or **inferior ramus** of the os pubis is thin and flattened. It passes outward and downward, becoming narrower as it descends, and joins with the ramus of the ischium. Its *anterior surface* is rough, for the attachment of muscles—the Gracilis along its inner border; a portion of the Obturator externus where it enters into the formation of the foramen of that name; and between these two muscles the Adductores brevis and magnus from within outward. The *posterior surface* is smooth, and gives attachment to the Obturator internus, and, close to the inner margin, to the Compressor urethræ. The *inner border* is thick, rough, and everted, especially in females. It presents two ridges, separated by an intervening space. The ridges extend downward, and are continuous with similar ridges on the ascending ramus of the ischium; to the external one is attached the deep layer of the superficial perineal fascia, and to the internal one the superficial layer of the triangular ligament of the urethra. The *outer border* is thin and sharp, forms part of the circumference of the obturator foramen, and gives attachment to the obturator membrane.

The **cotyloid cavity**, or **acetabulum**, is a deep, cup-shaped, hemispherical depression, directed downward, outward, and forward; formed internally by the os pubis, above by the ilium, behind and below by the ischium, a little less than two-fifths being formed by the ilium, a little more than two-fifths by the ischium, and the remaining fifth by the pubic bone. It is bounded by a prominent, uneven rim, which is thick and strong above, and serves for the attachment of the *cotyloid ligament*, which contracts its orifice and deepens the surface for articulation. It presents below a deep notch, the *cotyloid notch*, which is continuous with a circular depression, the *fossa acetabuli*, at the bottom of the cavity; this depression is perforated by numerous apertures, lodges a mass of fat, and its margins, as well as those of the notch, serve for the attachment of the ligamentum teres. The notch is converted, in the natural state, into a foramen by a dense ligamentous band which passes across it. Through this foramen the nutrient vessels and nerves enter the joint.

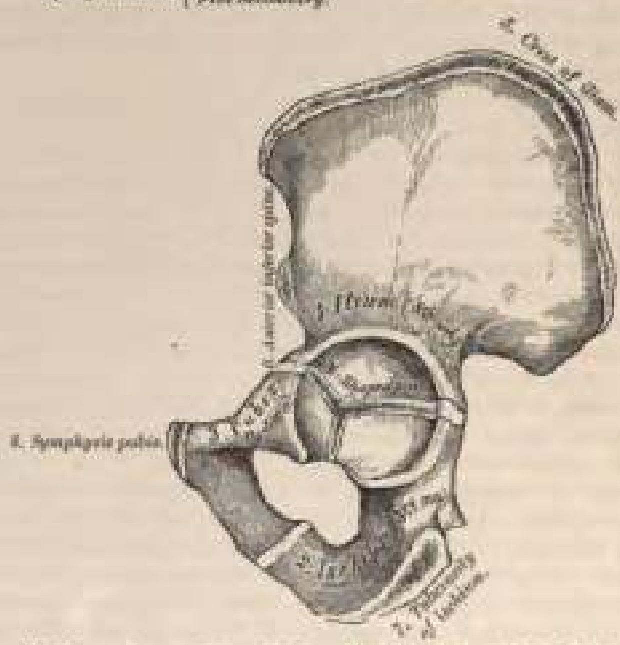
The **obturator** or **thyroid foramen** is a large aperture situated between the ischium and os pubis. In the male it is large, of an oval form, its longest diameter being obliquely from before backward; in the female it is smaller and more triangular. It is bounded by a thin, uneven margin, to which a strong membrane is attached, and presents, anteriorly, a deep groove which runs from the pelvis obliquely inward and downward. This groove is converted into a foramen by the obturator membrane, and transmits the obturator vessels and nerve.

**Structure.**—This bone consists of much cancellous tissue, especially where it is thick, enclosed between two layers of dense, compact tissue. In the thinner parts of the bone, as at the bottom of the acetabulum and centre of the iliac fossa, it is usually semitransparent, and composed entirely of compact tissue.

**Development** (Fig. 122).—By *eight* centres: three primary—one for the ilium, one for the ischium, and one for the os pubis; and *five* secondary—one for the crest of the ilium, one for the anterior inferior spinous process (said to occur more frequently in the male than the female), one for the tuberosity of the ischium, one for the symphysis pubis (more frequent in the female than the male), and one or more for the Y-shaped piece at the bottom of the acetabulum. These various centres appear in the following order: First, in the ilium, at the lower part of the bone, immediately above the sciatic notch, at about the eighth or ninth week; secondly, in the body of the ischium, at about the third month of fœtal life; thirdly, in the body of the os pubis, between the fourth and fifth months. At birth the three primary centres are quite separate, the crest, the bottom of the acetabulum, the ischial tuberosity, and the rami of the ischium and pubes being still cartilaginous. At about the seventh or eighth year the rami of the os pubis and ischium are almost completely united by bone. About the thirteenth or fourteenth year the three divisions of the bone have extended their growth into the bottom of the acetabulum, being separated from each other by a Y-shaped portion of cartilage, which now presents traces of ossification, often by two or more centres. One of these, the *os acetabuli*, appears about the age of twelve, between the ilium and os pubis, and fuses with them about the age of eighteen. It forms the pubic part of the acetabulum. The ilium and ischium then become joined, and lastly the os pubis to the ischium, through the intervention of this Y-shaped portion. At about the age of puberty ossification takes place in each of the remaining portions, and they become joined to the rest of the bone between the twentieth and twenty-fifth years. Separate centres are frequently found for the pubic and ischial spines.

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

*By eight centres* { *Three primary (Ilium, Ischium, and Os Pubis).*
*Five Secondary.*




*The three primary centres unite through Y-shaped piece about puberty.*
*Epiphyses appear about puberty, and unite about 25th year.*

FIG. 122.—Plan of the development of the os innominatum.

**Attachment of Muscles.**—To the *ilium*, sixteen. To the outer lip of the crest, the Tensor vaginæ femoris, Obliquus externus abdominis, and Latissimus dorsi; to the internal lip, the Iliacus, Transversalis, Quadratus lumborum, and Erector spinæ; to the interspace between the lips, the Obliquus internus. To the outer surface of the ilium, the Gluteus maximus, Gluteus medius, Gluteus minimus, reflected tendon of the Rectus; to the upper part of the great sacro-sciatic notch, a portion of the Pyriformis; to the internal surface, the Iliacus; to that portion of the internal surface below the linea ilio-pectinea, the Obturator internus to the internal surface of the posterior superior spine, and the Multifidus spinæ; to the anterior border, the Sartorius and straight tendon of the Rectus. To the *ischium*, thirteen. To the outer surface of the ramus, the Obturator externus and Adductor magnus; to the internal surface, the Obturator internus and Erector penis. To the spine, the Gemellus superior, Levator ani, and Coccygeus. To the tuberosity, the Biceps, Semitendinosus, Semimembranosus, Quadratus femoris, Adductor magnus, Gemellus inferior, Transversus perinæi, Erector penis. To the *os pubis*, sixteen: Obliquus externus, Obliquus internus, Transversalis, Rectus, Pyramidalis, Psoas parvus, Pectineus, Adductor magnus, Adductor longus, Adductor brevis, Gracilis, Obturator externus and internus, Levator ani, Compressor urethræ, and occasionally a few fibres of the Accelerator urinæ.

## The Pelvis (Figs. 123, 124).

The **Pelvis**, so called from its resemblance to a basin (L. *pelvis*), is stronger and more massively constructed than either the cranial or thoracic cavity; it is a bony ring, interposed between the lower end of the spine, which it supports, and the lower extremities, upon which it rests. It is composed of four bones: the two **ossa innominata**, which bound it on either side and in front, and the **sacrum and coccyx**, which complete it behind.

The pelvis is divided by an oblique plane passing through the prominence of the sacrum, the linea ilio-pectinea, and the upper margin of the symphysis pubis into the false and true pelvis.

The **false pelvis** is the expanded portion of the pelvic cavity which is situated above this plane. It is bounded on each side by the ossa ilii; in front it is incomplete, presenting a wide interval between the spinous processes of the ilia on either side, which is filled up in the recent state by the parietes of the abdomen; behind, in the middle line, is a deep notch. This broad, shallow cavity is fitted to support the intestines and to transmit part of their weight to the anterior wall of the abdomen, and is, in fact, really a portion of the abdominal cavity. The term false pelvis is incorrect, and this space ought more properly to be regarded as part of the hypogastric and iliac regions of the abdomen.

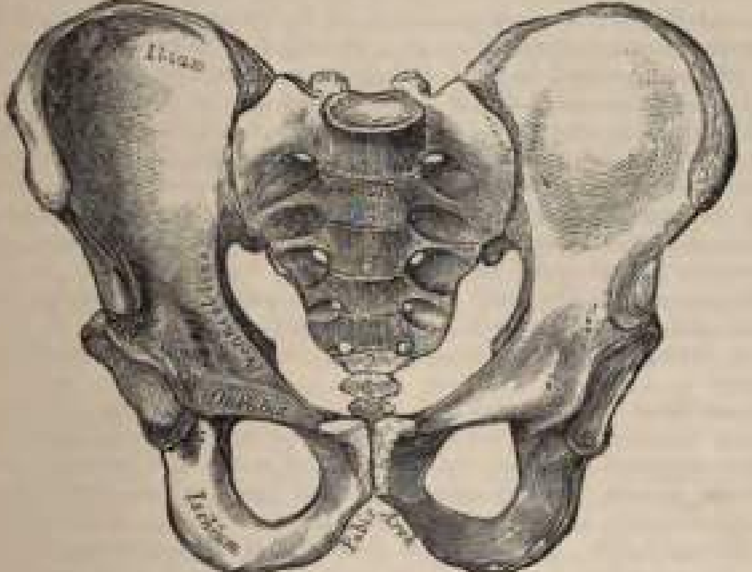



FIG. 123.—Male pelvis (adult).

The **true pelvis** is that part of the pelvic cavity which is situated beneath the plane. It is smaller than the false pelvis, but its walls are more perfect. For convenience of description it is divided into a superior circumference or inlet, an inferior circumference or outlet, and a cavity.

The **superior circumference** forms the brim of the pelvis, the included space being called the *inlet*. It is formed by the linea ilio-pectinea, completed in front

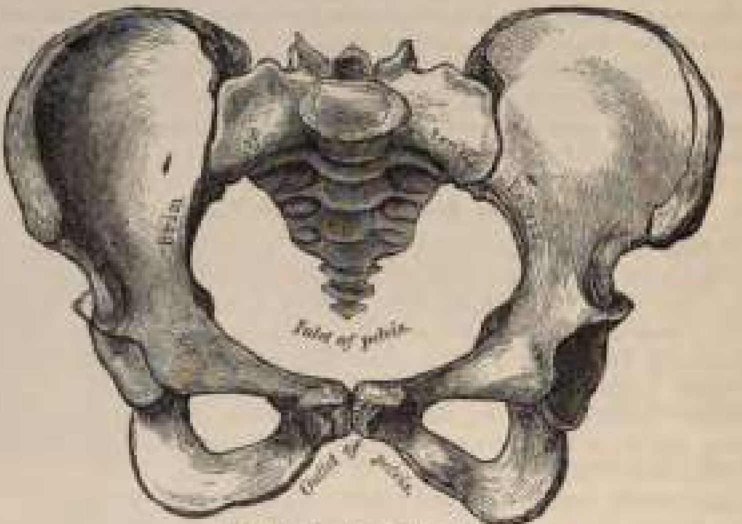



Fig. 124.—Female pelvis (adult).

by the crests of the pubic bones, and behind by the anterior margin of the base of the sacrum and sacro-vertebral angle. The *inlet* of the pelvis is somewhat heart-shaped, obtusely pointed in front, diverging on either side, and encroached upon behind by the projection forward of the promontory of the sacrum. It has three principal diameters: antero-posterior (sacro-pubic), transverse, and oblique. The antero-posterior extends from the sacro-vertebral angle to the symphysis pubis; its average measurement is four inches in the male, four and three-quarters in the female. The transverse extends across the greatest width of the inlet, from the middle of the brim on one side to the same point on the opposite; its average measurement is four and a half in the male, five and a quarter in the female. The oblique extends from the margin of the pelvis, corresponding to the ilio-pectineal eminence on one side, to the sacro-iliac articulation on the opposite side; its average measurement is four and a quarter in the male and five in the female.

The **cavity** of the true pelvis is bounded in front by the symphysis pubis; behind, by the concavity of the sacrum and coccyx, which, curving forward above and below, contracts the inlet and outlet of the canal; and laterally it is bounded by a broad, smooth, quadrangular surface of bone, corresponding to the inner surface of the body of the ischium and that part of the ilium which is below the ilio-pectineal line. The cavity is shallow in front, measuring at the symphysis an inch and a half in depth, three inches and a half in the middle, and four inches and a half posteriorly. From this description it will be seen that the cavity of the pelvis is a short, curved canal, considerably deeper on its posterior than on its anterior wall. This cavity contains, in the recent subject, the rectum, bladder, and part of the organs of generation. The rectum is placed at the back of the pelvis, and corresponds to the curve of the sacro-coccygeal column; the bladder in front, behind the symphysis pubis. In the female the uterus and vagina occupy the interval between these viscera.

The **lower circumference** of the pelvis is very irregular, and forms what is called the *outlet*. It is bounded by three prominent eminences: one posterior, formed by the point of the coccyx; and one on each side, the tuberosities of the ischia. These eminences are separated by three notches; one in front, the *pubic arch*, formed by the convergence of the rami of the ischia and pubic bones on each side. The other notches, one on each side, are formed by the sacrum and coccyx behind, the ischium in front, and the ilium above; they are called the *sacro-sciatic notches;* in the natural state they are converted into foramina by the lesser and greater sacro-sciatic ligaments. In the recent state, when the ligaments are *in situ*, the outlet of the pelvis is lozenge-shaped, bounded in front by the subpubic ligament and the rami of the os pubis and ischium; on each side by the tuberosities of the ischia; and behind by the great sacro-sciatic ligaments and the tip of the coccyx.

The diameters of the outlet of the pelvis are two, antero-posterior and transverse. The *antero-posterior* extends from the tip of the coccyx to the lower part of the symphysis pubis; its average measurement is three and a quarter inches in the male and five in the female. The antero-posterior diameter varies with the length of the coccyx, and is capable of increase or diminution on account of the mobility of that bone. The *transverse* extends from the posterior part of one ischiatic tuberosity to the same point on the opposite side: the average measurement is three and a half inches in the male and four and three-quarters in the female.[1]

**Position of the Pelvis.**—In the erect posture the pelvis is placed obliquely with regard to the trunk of the body: the bony ring, which forms the brim of the true pelvis, is placed so as to form an angle of about 60° to 65° with the ground on which we stand. The pelvic surface of the symphysis pubis looks upward and backward, the concavity of the sacrum and coccyx downward and forward, the base of the sacrum in well-formed female bodies being nearly four inches above the upper border of the symphysis pubis, and the apex of the coccyx a little more than half an inch above its lower border. In consequence of this obliquity of the pelvis the line of gravity of the head, which passes through the middle of the odontoid process of the axis and through the points of junction of the curves of the vertebral column to the sacro-vertebral angle, descends toward the front of the cavity, so that it bisects a line drawn transversely through the middle of the heads of the thigh-bones. And thus the centre of gravity of the head is placed immediately over the heads of the thigh-bones on which the trunk is supported.

**Axes of the Pelvis** (Fig. 125).—The plane of the inlet of the true pelvis will be represented by a line drawn from the base of the sacrum to the upper margin of the symphysis pubis. A line carried at right angles with this at its middle would correspond at one extremity with the umbilicus, and at the other with the middle of the coccyx: the axis of the inlet is therefore directed downward and backward. The axis of the outlet, produced upward, would touch the base of the sacrum, and is therefore directed downward and forward. The axis of the cavity is curved like the cavity itself: this curve corresponds to the concavity of the sacrum and coccyx, the extremities being indicated by the central points of the inlet and outlet. A knowledge of the direction of these axes serves to explain the course of the fœtus in its passage through the pelvis during parturition. It is also important to the surgeon, as indicating the direction of the force required in the removal of calculi from the bladder by the sub-pubic operation, and as determining the direction in which instruments should be used in operations upon the pelvic viscera.

[1] The measurements of the pelvis given above are, I believe, fairly accurate, but different measurements are given by various authors, no doubt due in a great measure to differences in the physique and stature of the population from whom the measurements have been taken. The accompanying chart has been formulated to show the measurements of the pelvis which are adopted by many obstetricians.—Ed.

| | A. P. | Obl. | Tr. |
|---|---|---|---|
| Inlet | 4 | 4½ | 5 |
| Cavity | 4½ | 4½ | 4½ |
| Outlet | 5 | 4½ | 4 |

**Differences between the Male and the Female Pelvis.**—The *female* pelvis, looked at as a whole, is distinguished from the *male* by the bones being more delicate, by its width being greater and its depth smaller. The whole pelvis is less massive, and its bones are lighter and more slender, and its muscular impressions are slightly marked. The iliac fossæ are shallow, and the anterior iliac spines widely separated; hence the greater prominence of the hips. The *inlet* in the female is larger than in the male; it is more nearly circular, and the sacro-vertebral angle projects less forward. The *cavity* is shallower and wider; the sacrum is shorter, wider, and less curved; the obturator foramina are triangular, and smaller in size than in the male. The *outlet* is larger and the coccyx more movable. The spines of the ischia project less inward. The tuberosities of the ischia and the acetabula are wider apart. The *pubic arch* is wider and more rounded than in the male, where it is an angle rather than an arch. In consequence of this the width of the fore part of the pelvic outlet is much increased and the passage of the fœtal head facilitated.


FIG. 128.—Vertical section of the pelvis, with lines indicating the axis of the pelvis.

The size of the pelvis varies, not only in the two sexes, but also in different members of the same sex. This does not appear to be influenced in any way by the height of the individual. Women of short stature, as a rule, have broad pelves. Occasionally the pelvis is equally contracted in all its dimensions, so much so that all its diameters measure an inch less than the average, and this even in women of average height and otherwise well formed. The principal divergences, however, are found at the inlet, and affect the relation of the antero-posterior to the transverse diameter. Thus we may have a pelvis the inlet of which is elliptical either in a transverse or antero-posterior direction; the transverse diameter in the former and the antero-posterior in the latter greatly exceeding the other diameters. Again, the inlet of the pelvis in some instances is seen to be almost circular.

The same differences are found in various races. European women are said to have the most roomy pelves. That of the negress is smaller, circular in shape, and with a narrow pubic arch. The Hottentots and Bushwomen possess the smallest pelves.

In the *fœtus* and for several years after birth the pelvis is small in proportion to that of the adult. The cavity is deep, and the projection of the sacro-vertebral angle less marked. The generally accepted opinion that the female pelvis does not acquire its sexual characters until after puberty has been shown by recent observations[1] to be erroneous, the characteristic differences between the male and female pelvis being distinctly indicated as early as the fourth month of fœtal life.

**Surface Form.**—The pelvic bones are so thickly covered with muscles that it is only at certain points that they approach the surface and can be felt through the skin. In front, the anterior superior spinous process is easily to be recognized; a portion of it is subcutaneous, and in thin subjects may be seen to stand out as a prominence at the outer extremity of the fold of the groin. In fat subjects its position is marked by an oblique depression amongst the surrounding fat, at the bottom of which the bony process may be felt. Proceeding upward and outward from this process, the crest of the ilium may be traced throughout its whole length, sinuously curved. It is represented, in muscular subjects, on the surface, by a groove or furrow, the *iliac furrow*, caused by the projection of fleshy fibres of the External oblique muscle of the abdomen; the iliac furrow lies slightly below the level of the crest. It terminates behind in the posterior superior spinous process, the position of which is indicated by a slight depression on a level with the spinous process of the second sacral vertebra. Between the two posterior superior spinous processes, but at a lower level, is to be felt the spinous process of the third sacral vertebra (see page 53). Another part of the bony pelvis which is easily accessible to the

[1] Fehling, *Zeitschr. für Geburt. u. Gynaek.*, Bd. ix. und x.; and Arthur Thomson, *Journal of Anatomy and Physiology*, vol. xxxiii.

touch is the tuberosity of the ischium, situated beneath the gluteal fold, and, when the hip is flexed, easily to be felt, as it is then to a great extent uncovered by muscle. Finally, the spine of the os pubis can always be readily felt, and constitutes an important surgical guide, especially in connection with the subject of hernia. It is nearly in the same horizontal line with the upper edge of the great trochanter. In thin subjects it is very apparent, but in the obese it is obscured by the pubic fat. It can, however, be detected by following up the tendon of origin of the Adductor longus muscle.

**Surgical Anatomy.**—There is arrest of development in the bones of the pelvis in cases of extroversion of the bladder; the anterior part of the pelvic girdle being deficient, the bodies of the pubic bones imperfectly developed, and the symphysis absent. The pubic bones are separated to the extent of from two to four inches, the superior rami shortened and directed forward, and the obturator foramen diminished in size, narrowed, and turned outward. The iliac bones are straightened out more than normal. The sacrum is very peculiar. The lateral curve, instead of being concave, is flattened out or even convex, with the ilio-sacral facets turned more outward than normal, while the vertical curve is straightened.[1]

Fractures of the pelvis are divided into fractures of the false pelvis and of the true pelvis. Fractures of the false pelvis vary in extent: a small portion of the crest may be broken or one of the spinous processes may be torn off, and this may be the result of muscular action; or the bone may be extensively comminuted. This latter accident is the result of some crushing violence, and may be complicated with fracture of the true pelvis. These cases may be accompanied by injury to the intestine as it lies in the hollow of the bone, or to the iliac vessels as they course along the margin of the true pelvis. Fractures of the true pelvis generally occur through the ascending ramus of the os pubis and the ramus of the ischium, as this is the weakest part of the bony ring, and may be caused either by crushing violence applied in an antero-posterior direction, when the fracture occurs from direct force, or by compression laterally, when the acetabula are pressed together, and the bone gives way in the same place from indirect violence. Occasionally the fracture may be double, occurring on both sides of the body. It is in these cases that injury to the contained viscera is liable to take place: the urethra, the bladder, the rectum, the vagina in the female, the small intestines, and even the uterus, have all been lacerated by a displaced fragment. Fractures of the acetabulum are occasionally met with: either a portion of the rim may be broken off, or a fracture may take place through the bottom of the cavity, and the head of the femur driven inward and project into the pelvic cavity. Separation of the **Y**-shaped cartilage at the bottom of the acetabulum may also occur in the young subject, separating the bone into its three anatomical portions.

The sacrum is occasionally, but rarely, broken by direct violence—*i. e.*, blows, kicks, or falls on the part. The lesion may be complicated with injury to the nerves of the sacral plexus, leading to paralysis and loss of sensation in the lower extremity, or to incontinence of fæces from paralysis of the sphincter ani.

The pelvic bones often undergo important deformity in rickets, the effect of which in the adult woman may interfere seriously with childbearing. The deformity is due mainly to the weight of the spine and trunk, which presses on the sacro-vertebral angle and greatly increases it, so that the antero-posterior diameter of the pelvis is diminished. But, in addition to this, the weight of the viscera on the venter ilii causes them to expand and the tuberosities of the ischia to be incurved. In osteomalacia also great deformity may occur. The weight of the trunk causes an increase in the sacro-vertebral angle and a lessening of the antero-posterior diameter of the inlet, and at the same time the pressure of the acetabula on the heads of the thigh-bones causes these cavities, with the adjacent bone, to be pushed upward and backward, so that the oblique diameters of the pelvis are also diminished, and the cavity of the pelvis assumes a triradiate shape, with the symphysis pubis pushed forward.

## THE THIGH.

The **Thigh** is that portion of the lower extremity which is situated between the pelvis and the knee. It consists in the skeleton of a single bone, the femur.

### The Femur, or Thigh-Bone.

The **Femur** (*femur*, the thigh) is the longest,[2] largest, and strongest bone in the skeleton, and almost perfectly cylindrical in the greater part of its extent. In the erect posture it is not vertical, being separated from its fellow above by a considerable interval, which corresponds to the entire breadth of the pelvis, but inclining gradually downward and inward, so as to approach its fellow toward its lower part, for the purpose of bringing the knee-joint near the line of gravity of the body. The degree of this inclination varies in different persons, and is greater in the female than the male, on account of the greater breadth of the pelvis. The femur, like other long bones, is divisible into a shaft and two extremities.

[1] Wood. Heath's *Dictionary of Practical Surgery*, i., 426.

[2] In a man six feet high it measures eighteen inches—one-fourth of the whole body.

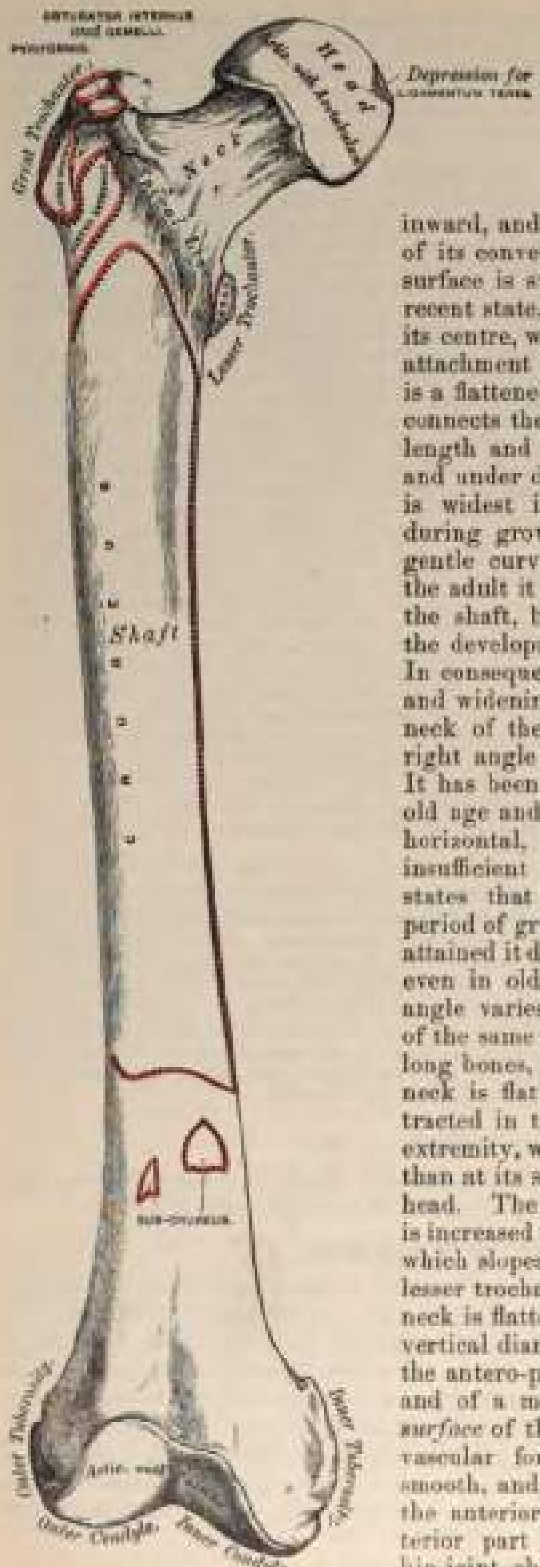



FIG. 126.—Right femur. Anterior surface.

The **Upper Extremity** presents for examination a head, a neck, and a great and lesser trochanters.

The **head**, which is globular, and forms rather more than a hemisphere, is directed upward, inward, and a little forward, the greater part of its convexity being above and in front. Its surface is smooth, coated with cartilage in the recent state, except at a little behind and below its centre, where is an ovoid depression, for the attachment for the ligamentum teres. The **neck** is a flattened pyramidal process of bone which connects the head with the shaft. It varies in length and obliquity at various periods of life and under different circumstances. The angle is widest in infancy, and becomes lessened during growth, so that at puberty it forms a gentle curve from the axis of the shaft. In the adult it forms an angle of about 130° with the shaft, but varies in inverse proportion to the development of the pelvis and the stature. In consequence of the prominence of the hips and widening of the pelvis in the female, the neck of the thigh-bone forms more nearly a right angle with the shaft than it does in man. It has been stated that the angle diminishes in old age and the direction of the neck becomes horizontal, but this statement is founded on insufficient evidence. Sir George Humphry states that the angle decreases during the period of growth, but after full growth has been attained it does not usually undergo any change, even in old age. He further states that the angle varies considerably in different persons of the same age. It is smaller in short than in long bones, and when the pelvis is wide.[1] The neck is flattened from before backward, contracted in the middle, and broader at its outer extremity, where it is connected with the shaft, than at its summit, where it is attached to the head. The vertical diameter of the outer half is increased by the thickening of the lower edge, which slopes downward to join the shaft at the lesser trochanter, so that the outer half of the neck is flattened from before backward, and its vertical diameter measures one-third more than the antero-posterior. The inner half is smaller and of a more circular shape. The *anterior surface* of the neck is perforated by numerous vascular foramina. The *posterior surface* is smooth, and is broader and more concave than the anterior; it gives attachment to the posterior part of the capsular ligament of the hip-joint, about half an inch above the posterior

[1] *Journal of Anatomy and Physiology.*

intertrochanteric line. The *superior border* is short and thick, and terminates externally at the great trochanter; its surface is perforated by large foramina. The *inferior border*, long and narrow, curves a little backward, to terminate at the lesser trochanter.

The **Trochanters** (τροχάω, to run or roll) are prominent processes of bone which afford leverage to the muscles which rotate the thigh on its axis. They are two in number, the great and the lesser.

The **Great Trochanter** is a large, irregular, quadrilateral eminence, situated at the outer side of the neck, at its junction with the upper part of the shaft. It is directed a little outward and backward, and in the adult is about three-quarters of an inch lower than the head. It presents for examination two surfaces and four borders. The *external surface*, quadrilateral in form, is broad, rough, convex, and marked by a prominent diagonal impression, which extends from the posterior superior to the anterior inferior angle, and serves for the attachment of the tendon of the Gluteus medius. Above the impression is a triangular surface, sometimes rough for part of the tendon of the same muscle, sometimes smooth for the interposition of a bursa between that tendon and the bone. Below and behind the diagonal line is a smooth, triangular surface, over which the tendon of the Gluteus maximus muscle plays, a bursa being interposed. The *internal surface* is of much less extent than the external, and presents at its base a deep depression, the *digital* or *trochanteric fossa*, for the attachment of the tendon of the Obturator externus muscle; above and in front of this an impression for the attachment of the Obturator internus and Gemelli. The *superior border* is free; it is thick and irregular, and marked near the centre by an impression for the attachment of the Pyriformis. The *inferior border* corresponds to the point of junction of the base of the trochanter with the outer surface of the shaft; it is marked by a rough, prominent, slightly curved ridge, which gives attachment to the upper part of the Vastus externus muscle. The *anterior border* is prominent, somewhat irregular, as well as the surface of bone immediately below it; it affords attachment at its outer part to the Gluteus minimus. The *posterior border* is very prominent, and appears as a free, rounded edge, which forms the back part of the digital fossa.

The **Lesser Trochanter** is a conical eminence which varies in size in different subjects; it projects from the lower and back part of the base of the neck. Its base is triangular, and connected with the adjacent parts of the bone by three well-marked borders: two of these are above—the *internal* continuous with the lower border of the neck, the *external* with the posterior intertrochanteric line—while the *inferior border* is continuous with the middle division of the linea aspera. Its summit, which is directed inward and backward, is rough, and gives insertion to the tendon of the Ilio-psoas. The Iliacus is also inserted into the shaft below the lesser trochanter between the Vastus internus in front and the Pectineus behind.

A well-marked prominence of variable size, which projects from the upper and front part of the neck at its junction with the great trochanter, is called the *tubercle of the femur;* it is the point of meeting of five muscles: the Gluteus minimus externally, the Vastus externus below, and the tendon of the Obturator internus and Gemelli above. Running obliquely downward and inward from the tubercle is the *spiral line* of the femur, or *anterior intertrochanteric line;* it winds round the inner side of the shaft, below the lesser trochanter, and terminates in the linea aspera, about two inches below this eminence. Its upper half is rough, and affords attachment to the ilio-femoral ligament of the hip-joint; its lower half is less prominent, and gives attachment to the upper part of the Vastus internus. Running obliquely downward and inward from the summit of the great trochanter on the posterior surface of the neck is a very prominent, well-marked ridge, the *posterior intertrochanteric line.* Its upper half forms the posterior border of the great trochanter, and its lower half runs downward and inward to the upper and back part of the lesser trochanter. A slight ridge sometimes commences about the

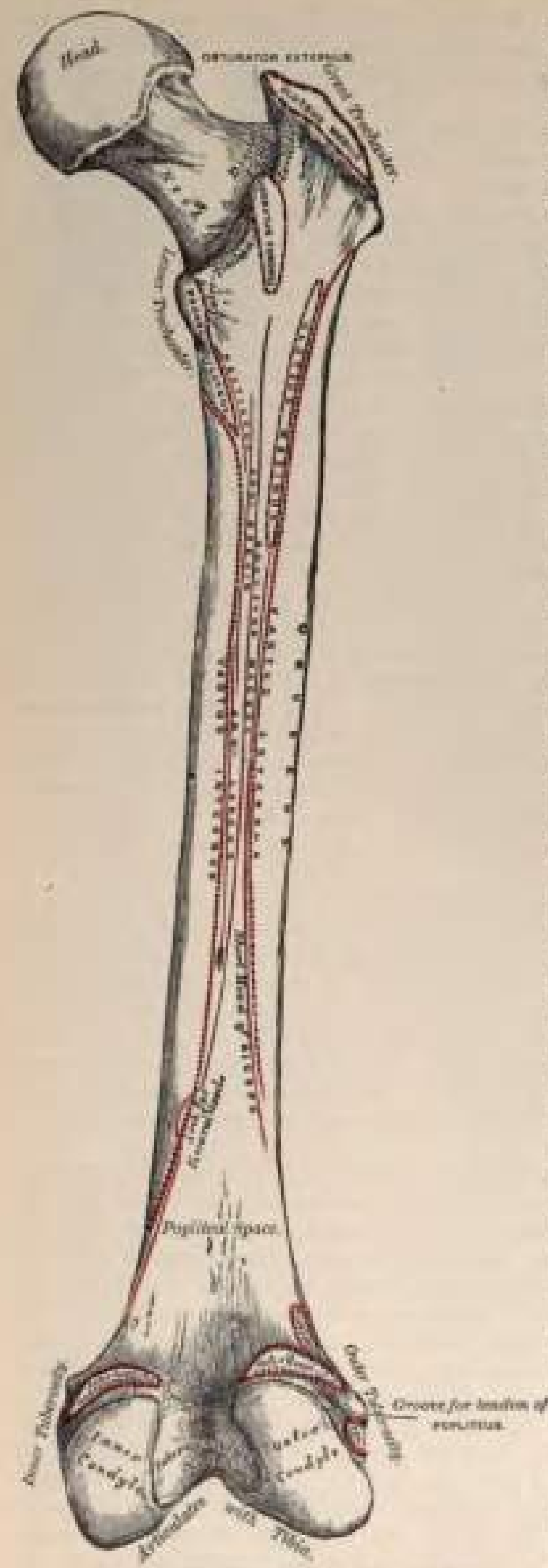



FIG. 127.—Right femur. Posterior surface.

middle of the posterior intertrochanteric line, and passes vertically downward for about two inches along the back part of the shaft: it is called the *linea quadrati*, and gives attachment to the Quadratus femoris and a few fibres of the Adductor magnus muscles.[1]

The **Shaft**, almost cylindrical in form, is a little broader above than in the centre, and somewhat flattened below, from before backward. It is slightly arched, so as to be convex in front and concave behind, where it is strengthened by a prominent longitudinal ridge, the *linea aspera*. It presents for examination three borders, separating three surfaces. Of the three borders, one, the linea aspera, is posterior; the other two are placed laterally.

The **linea aspera** (Fig. 127) is a prominent longitudinal ridge or crest, on the middle third of the bone, presenting an external lip, an internal lip, and a rough intermediate space. Above, this crest is prolonged by three ridges. The most external one is very rough, and is continued almost vertically upward to the base of the great trochanter. It is sometimes termed the *gluteal ridge*, and gives attachment to part of the Gluteus maximus muscle; its upper part is often elongated into a roughened crest, on which is a more or less well-marked, rounded tubercle, a rudimental third trochanter. The middle ridge, the least distinct, is continued to the base of the trochanter minor, and the internal one is lost above in the spiral line of the femur. Below, the linea aspera is prolonged by two ridges, which enclose between them a triangular space, the *popliteal surface*, upon which rests the popliteal artery. Of these two ridges, the outer one is the more prominent, and de-

[1] Generally there is merely a slight thickening about the centre of the intertrochanteric line, marking the point of attachment of the Quadratus femoris. This is termed by some anatomists the *tubercle of the Quadratus*.

scends to the summit of the outer condyle. The inner one is less marked, especially at its upper part, where it is crossed by the femoral artery. It terminates, below, at the summit of the internal condyle, in a small tubercle, the *Adductor tubercle*, which affords attachment to the tendon of the Adductor magnus.

To the inner lip of the linea aspera and its inner prolongation above and below is attached the Vastus internus, and to the outer lip and its outer prolongation above is attached the Vastus externus. The Adductor magnus is attached to the linea aspera, to its outer prolongation above and its inner prolongation below. Between the Vastus externus and the Adductor magnus are attached two muscles—viz. the Gluteus maximus above, and the short head of the Biceps below. Between the Adductor magnus and the Vastus internus four muscles are attached: the Iliacus and Pectineus above, the Adductor brevis and Adductor longus below. The linea aspera is perforated a little below its centre by the nutrient canal, which is directed obliquely upward.

The *two lateral borders* of the femur are only slightly marked, the outer one extending from the anterior inferior angle of the great trochanter to the anterior extremity of the external condyle; the inner one from the spiral line, at a point opposite the trochanter minor, to the anterior extremity of the internal condyle. The internal border marks the limit of attachment of the Crureus muscle internally.

The **anterior surface** includes that portion of the shaft which is situated between the two lateral borders. It is smooth, convex, broader above and below than in the centre, slightly twisted, so that its upper part is directed forward and a little outward, its lower part forward and a little inward. To the upper three-fourths of this surface the Crureus is attached; the lower fourth is separated from the muscle by the intervention of the synovial membrane of the knee-joint and a bursa, and affords attachment to the Subcrureus to a small extent. The *external surface* includes the portion of bone between the external border and the outer lip of the linea aspera: it is continuous above with the outer surface of the great trochanter, below with the outer surface of the external condyle; to its upper three-fourths is attached the outer portion of the Crureus muscle. The *internal surface* includes the portion of bone between the internal border and the inner lip of the linea aspera; it is continuous above with the lower border of the neck, below with the inner side of the internal condyle: it is covered by the Vastus externus muscle.

The **Lower Extremity**, larger than the upper, is of a cuboid form, flattened from before backward, and divided into two large eminences, the *condyles* (κόνδυλος, a knuckle), by an interval which presents a smooth depression in front called the *trochlea*, and a notch of considerable size behind—the *intercondyloid notch*. The *external condyle* is the more prominent anteriorly, and is the broader both in the antero-posterior and transverse diameters. The *internal condyle* is the narrower, longer, and more prominent inferiorly. This difference in the length of the two condyles is only observed when the bone is perpendicular, and depends upon the obliquity of the thigh-bones, in consequence of their separation above at the articulation with the pelvis. If the femur is held obliquely, the surfaces of the two condyles will be seen to be nearly horizontal. The two condyles are directly continuous in front, and form a smooth trochlear surface, which articulates with the patella. It presents a median groove, which extends downward and backward to the intercondyloid notch; and two lateral convexities, of which the external is the broader, more prominent, and prolonged farther upward upon the front of the outer condyle. The external border of this articular surface is also more prominent, and ascends higher than the internal one. The intercondyloid notch lodges the crucial ligaments; it is bounded laterally by the opposed surfaces of the two condyles, and in front by the lower end of the shaft.

**Outer Condyle.**—The *outer surface* of the external condyle presents, a little behind its centre, an eminence, the *outer tuberosity*; it is less prominent than the inner tuberosity, and gives attachment to the external lateral ligaments of the knee. Immediately beneath it is a groove which commences at a depression a little behind the centre of the lower border of this surface: the front part of this depression gives origin to the Popliteus muscle, the tendon of which is lodged in the groove during flexion of the knee. The groove is smooth, covered with cartilage in the recent state, and runs upward and backward to the posterior extremity of the condyle. The *inner surface* of the outer condyle forms one of the lateral boundaries of the intercondyloid notch, and gives attachment, by its posterior part, to the anterior crucial ligament. The *inferior surface* is convex, smooth, and broader than that of the internal condyle. The posterior extremity is convex and smooth: just above and to the outer side of the articular surface is a depression for the tendon of the outer head of the Gastrocnemius, above which is the origin of the Plantaris.

**Inner Condyle.**—The *inner surface* of the inner condyle presents a convex eminence, the *inner tuberosity*, rough for the attachment of the internal lateral ligament. The *outer side* of the inner condyle forms one of the lateral boundaries of the intercondyloid notch, and gives attachment, by its anterior part, to the posterior crucial ligament. Its *inferior* or *articular surface* is convex, and presents a less extensive surface than the external condyle. Just above the articular surface of the condyle, behind, is a depression for the tendon of origin of the inner head of the Gastrocnemius.

**Structure.**—The shaft of the femur is a cylinder of compact tissue, hollowed by a large medullary canal. The cylinder is of great thickness and density in the middle third of the shaft, where the bone is narrowest and the medullary canal well formed; but above and below this the cylinder gradually becomes thinner, owing to a separation of the layers of the bone into cancelli, which project into the medullary canal and finally obliterate it, so that the upper and lower ends of the shaft, and the articular extremities more especially, consist of cancellated tissue invested by a thin, compact layer.

The arrangement of the cancelli in the ends of the femur is remarkable. In the upper end they are arranged in two sets. One, starting from the top of the head, the upper surface of the neck, and the great trochanter, converge to the inner circumference of the shaft (Fig. 128); these are placed in the direction of greatest pressure, and serve to support the vertical weight of the body. The second set are planes of lamellæ intersecting the former nearly at right angles, and are situated in the line of the greatest tension—that is to say, along the lines in which the muscles and ligaments exert their traction. In the head of the bone these

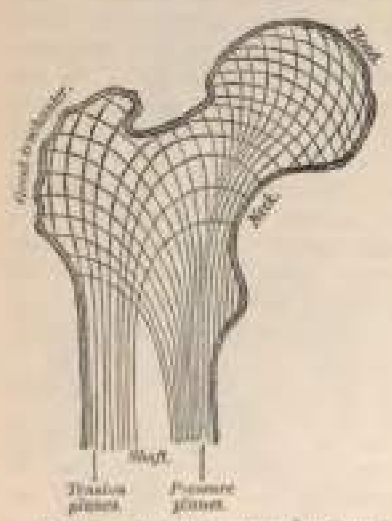



FIG. 128.—Diagram showing the arrangement of the cancelli of the neck of the femur.


FIG. 129.—Calcar femorale.

planes are arranged in a curved form, in order to strengthen the bone when exposed to pressure in all directions. In the midst of the cancellous tissue of the neck is a vertical plane of compact bone, the *femoral spur* (*calcar femorale*) which commences at the point where the neck joins the shaft midway between the lesser trochanter and the internal border of the shaft of the bone, and extends in the direction of the digital fossa (Fig. 129). This materially strengthens this portion of the bone. Another point in connection with the structure of the neck of the femur requires mention, especially on account of its influence on the production of fracture in this situation. It will be noticed that a considerable portion of the great trochanter lies behind the level of the posterior surface of the neck; and if a section be made through the trochanter at this level, it will be seen that the posterior wall of the neck is prolonged into the trochanter. This prolongation is termed by Bigelow the "true neck,"[1] and forms a thin, dense plate of bone, which passes beneath the posterior intertrochanteric ridge toward the outer surface of the bone.

In the lower end the cancelli spring on all sides from the inner surface of the cylinder, and descend in a perpendicular direction to the articular surface, the cancelli being strongest and having a more accurately perpendicular course above the condyles. In addition to this, however, horizontal planes of cancellous tissue are to be seen, so that the spongy tissue in this situation presents an appearance of being mapped out into a series of rectangular areas.

**Articulations.**—With three bones: the os innominatum, tibia, and patella.

**Development** (Fig. 130).—The femur is developed by *five* centres: one for the shaft, one for each extremity, and one for each trochanter. Of all the long bones, except the clavicle, it is the first to show traces of ossification: this commences in the shaft, at about the seventh week of fœtal life, the centres of ossification in the epiphyses appearing in the following order: First, in the lower end of the bone, at the ninth month of fœtal life[2] (from this the condyles and tuberosities are formed); in the head at the end of the first year after birth; in the great trochanter, during the fourth year; and in the lesser trochanter, between the thirteenth and fourteenth. The order in which the epiphyses are joined to the shaft is the reverse of that of their appearance: their junction does not commence until after puberty, the lesser trochanter being first joined, then the great, then the head, and, lastly, the inferior extremity (the first in which ossification commenced), which is not united until the twentieth year.


Fig. 130.—Plan of the development of the femur. By five centres.

**Attachment of Muscles.**—To twenty-three. To the great trochanter: the Gluteus medius, Gluteus minimus, Pyriformis, Obturator internus, Obturator externus, Gemellus superior, Gemellus inferior, and Quadratus femoris. To the lesser trochanter: the Psoas magnus and the Iliacus below it. To the shaft:

[1] *Bigelow on the Hip*, p. 121.

[2] This is said to be the only epiphysis in which ossification begins before birth; though according to some observers, the centre for the upper epiphysis of the tibia also appears before birth.

the Vastus externus, Gluteus maximus, short head of the Biceps, Vastus internus, Adductor magnus, Pectineus, Adductor brevis, Adductor longus, Crureus, and Subcrureus. To the condyles: the Gastrocnemius, Plantaris, and Popliteus.

**Surface Form.**—The femur is covered with muscles, so that in fairly muscular subjects the shaft is not to be detected through its fleshy covering, and the only parts accessible to the touch are the outer surface of the great trochanter and the lower expanded end of the bone. The external surface of the great trochanter is to be felt, especially in certain positions of the limb. Its position is generally indicated by a depression, owing to the thickness of the Gluteus medius and minimus, which project above it. When, however, the thigh is flexed, and especially if crossed over the opposite one, the trochanter produces a blunt eminence on the surface. The upper border is about on a line with the spine of the os pubis, and its exact level is indicated by a line drawn from the anterior superior spinous process of the ilium, over the outer side of the hip, to the most prominent point of the tuberosity of the ischium. This is known as Nélaton's line. The outer and inner condyles of the lower extremity are easily to be felt. The outer one is more subcutaneous than the inner one, and readily felt. The tuberosity on it is comparatively little developed, but can be more or less easily recognized. The inner condyle is more thickly covered, and this gives a general convex outline to this part, especially when the knee is flexed. The tuberosity on it is easily felt, and at the upper part of the condyle the sharp tubercle for the insertion of the tendon of the Adductor magnus can be recognized without difficulty. When the knee is flexed, and the patella situated in the interval between the condyles and the upper end of the tibia, a part of the trochlear surface of the femur can be made out above the patella.

**Surgical Anatomy.**—There are one or two points about the ossification of the femur bearing on practice to which allusion must be made. It has been stated above that the lower end of the femur is the only epiphysis in which ossification has commenced at the time of birth. The presence of this ossific centre is, therefore, a proof, in newly-born children found dead, that the child has arrived at the full period of utero-gestation, and is always relied upon in medico-legal investigations. The position of the epiphysial line should be carefully noted. It is on a level with the adductor tubercle, and the epiphysis does not, therefore, form the whole of the cartilage-clad portion of the lower end of the bone. It is essential to bear this point in mind in performing excision of the knee, since growth in length of the femur takes place chiefly from the lower epiphysis, and any interference with the epiphysial cartilage in a young child would involve such ultimate shortening of the limb, from want of growth, as to render it almost useless. Separation of the lower epiphysis may take place up to the age of twenty, at which time it becomes completely joined to the shaft of the bone; but, as a matter of fact, few cases occur after the age of sixteen or seventeen. The epiphysis of the head of the femur is of interest principally on account of its being the seat of origin of a large number of cases of tuberculous disease of the hip-joint. The disease commences in the majority of cases in the highly vascular and growing tissue in the neighborhood of the epiphysis, and from here extends into the joint.

Fractures of the femur are divided, like those of the other long bones, into fractures of the upper end; of the shaft; and of the lower end. The fractures of the upper end may be classified into (1) fracture of the neck; (2) fracture at the junction of the neck with the great trochanter; (3) fracture of the great trochanter; and (4) separation of the epiphysis, either of the head or of the great trochanter. The first of these, fracture of the neck, is usually termed intracapsular fracture, but this is scarcely a correct designation, as, owing to the attachment of the capsular ligament, the fracture may be partly within and partly without the capsule, when the fracture occurs at the lower part of the neck. It generally occurs in old people, principally women, and usually from a very slight degree of indirect violence. Probably the main cause of the fracture taking place in old people is in consequence of the degenerative changes which the bone has undergone. Merkel believes that it is mainly due to the absorption of the calcar femorale. These fractures are occasionally impacted. As a rule they unite by fibrous tissue, and frequently no union takes place, and the surfaces of the fracture become smooth and eburnated.

Fractures at the junction of the neck with the great trochanter are usually termed extra-capsular, but this designation is also incorrect, as the fracture is partly within the capsule, owing to its attachment in front to the anterior intertrochanteric line, which is situated below the line of fracture. These fractures are produced by direct violence to the great trochanter, as from a blow or fall laterally on the hip. From the manner in which the accident is caused, the neck of the bone is driven into the trochanter, where it may remain impacted, or the trochanter may be split up into two or more fragments, and thus no fixation takes place.

Fractures of the great trochanter may be either "oblique fracture through the trochanter major, without implicating the neck of the bone" (Astley Cooper), or separation of the great trochanter. Most of the recorded cases of this latter injury occurred in young persons, and were probably cases of separation of the epiphysis of the great trochanter. Separation of the epiphysis of the head of the femur has been said to occur, but has probably never been verified by post-mortem examination.

Fractures of the shaft may occur at any part, but the most usual situation is at or near the centre of the bone. They may be caused by direct or indirect violence or by muscular action.

Fractures of the upper third of the shaft are almost always the result of indirect violence, whilst those of the lower third are the result, for the most part, of direct violence. In the middle third fractures occur from both forms of injury in about equal proportions. Fractures of the shaft are generally oblique, but they may be transverse, longitudinal, or spiral. The transverse fracture occurs most frequently in children. The fractures of the lower end of the femur include transverse fracture above the condyles, the most common; and this may be complicated by a vertical fracture between the condyles, constituting the T-shaped fracture. In these cases the popliteal artery is in danger of being wounded. Oblique fracture, separating either the internal or external condyle, and a longitudinal incomplete fracture between the condyles, may also take place.

The femur as well as the other bones of the leg are frequently the seat of acute necrosis in young children. This is no doubt due to their greater exposure to injury, which is often the exciting cause of this disease. Tumors not unfrequently are found growing from the femur: the most common forms being sarcoma, which may grow either from the periosteum or from the medullary tissue within the interior of the bone; and exostosis, which is commonly found originating in the neighborhood of the epiphysial cartilage of the lower end.

## THE LEG.

The skeleton of the Leg consists of three bones: the Patella, a large sesamoid bone, placed in front of the knee; the Tibia; and the Fibula.

### The Patella (Figs. 131, 132).

The **Patella** (*patella*, a small pan) is a flat, triangular bone, situated at the anterior part of the knee-joint. It is usually regarded as a sesamoid bone, developed in the tendon of the Quadriceps extensor. It resembles these bones (1) in its being developed in a tendon; (2) in its centre of ossification presenting a knotty or tuberculated outline; (3) in its structure being composed mainly of dense cancellous tissue, as in the other sesamoid bones. It serves to protect the front of the joint, and increases the leverage of the Quadriceps extensor by making it act at a greater angle. It presents an anterior and a posterior surface, three borders, and an apex.


Fig. 131.—Right patella. Anterior surface.


Fig. 132.—Right patella. Posterior surface.

The **anterior surface** is convex, perforated by small apertures, for the passage of nutrient vessels, and marked by numerous rough, longitudinal striæ. This surface is covered, in the recent state, by an expansion from the tendon of the Quadriceps extensor, which is continuous below with the superficial fibres of the ligamentum patellæ. It is separated from the integument by a bursa. The **posterior surface** presents a smooth, oval-shaped, articular surface, covered with cartilage in the recent state, and divided into two facets by a vertical ridge, which descends from the superior border toward the inferior angle of the bone. The ridge corresponds to the groove on the trochlear surface of the femur, and the two facets to the articular surfaces of the two condyles; the outer facet, for articulation with the outer condyle, being the broader and deeper. This character serves to indicate the side to which the bone belongs. Below the articular surface is a rough, convex, non-articular depression, the lower half of which gives attachment to the ligamentum patellæ, the upper half being separated from the head of the tibia by adipose tissue.

The **superior border** is thick, and sloped from behind, downward and forward: it gives attachment to that portion of the Quadriceps extensor which is derived from the Rectus and Crureus muscles. The **lateral borders** are thinner, converging below. They give attachment to that portion of the Quadriceps extensor derived from the external and internal Vasti muscles.

The **apex** is pointed, and gives attachment to the ligamentum patellæ.

**Structure.**—It consists of a nearly uniform dense cancellous tissue covered by a thin compact lamina. The cancelli immediately beneath the anterior surface are arranged parallel with it. In the rest of the bone they radiate from the posterior articular surface toward the other parts of the bone.

**Development.**—By a single centre, which makes its appearance, according to Béclard, about the third year. In two instances I have seen this bone cartilaginous throughout, at a much later period (six years). More rarely, the bone is developed by two centres, placed side by side. Ossification is completed about the age of puberty.

**Articulations.**—With the two condyles of the femur.

**Attachment of Muscles.**—To four: the Rectus, Crureus, Vastus internus, and Vastus externus. These muscles, joined at their insertion, constitute the Quadriceps extensor cruris.

**Surface Form.**—The external surface of the patella can be seen and felt in front of the knee. In the extended position of the limb the internal border is a little more prominent than the outer, and if the Quadriceps extensor is relaxed, the bone can be moved from side to side and appears to be loosely fixed. If the joint is flexed, the patella recedes into the hollow between the condyles of the femur and the upper end of the tibia, and becomes firmly fixed against the femur.

**Surgical Anatomy.**—The main surgical interest about the patella is in connection with fractures; which are of common occurrence. They may be produced by muscular action; that is to say, by violent contraction of the Quadriceps extensor while the limb is in a position of semi-flexion, so that the bone is snapped across the condyles; or by direct violence, such as falls on the knee. In the former class of cases the fracture is transverse; in the latter it may be oblique, longitudinal, stellate, or the bone variously comminuted. The principal interest in these cases attaches to their treatment. Owing to the wide separation of the fragments, and the difficulty there is in maintaining them in apposition, union takes place by fibrous tissue, and this may subsequently stretch, producing wide separation of the fragments and permanent lameness. Various plans, including opening the joint and suturing the fragments, have been advocated for overcoming this difficulty.

In the larger number of cases of fracture of the patella the knee-joint is involved, the cartilage which covers its posterior surface being also torn. In some cases of fracture from direct violence, however, this need not necessarily happen, the lesion involving only the superficial part of the bone; and, as Morris has pointed out, it is an anatomical possibility, in complete fracture, if the lesion involve only the lower and non-articular part of the bone, for it to take place without injury to the synovial membrane.

## The Tibia (Figs. 133, 134).

The **Tibia** (*tibia*, a flute or pipe) is situated at the front and inner side of the leg, and, excepting the femur, is the longest and largest bone in the skeleton. It is prismoid in form, expanded above, where it enters into the knee-joint, more slightly enlarged below. In the male its direction is vertical and parallel with the bone of the opposite side; but in the female it has a slightly oblique direction downward and outward, to compensate for the oblique direction of the femur inward. It presents for examination a shaft and two extremities.

The **Upper Extremity**, or **Head**, is large, and expanded on each side into two lateral eminences, the *tuberosities*. *Superiorly*, the tuberosities present two smooth, concave surfaces, which articulate with the condyles of the femur; the internal, articular surface is longer, deeper, and narrower than the external, oval from before backward, to articulate with the internal condyle; the external one is broader and more circular, concave from side to side, but slightly convex from before backward, especially at its posterior part, where it is prolonged on to the posterior surface for a short distance, to articulate with the external condyle. Between the two articular surfaces, and nearer the posterior than the anterior aspect of the bone, is an eminence, the *spinous process* of the tibia, surmounted by a prominent tubercle on each side, on to the lateral aspect of which the facets just described are prolonged; in front and behind the spinous process is a rough depression for the attachment of the anterior and posterior crucial ligaments and the semilunar fibro-cartilages. The *anterior surfaces* of the tuberosities are continuous with one another, forming a single large surface, which is somewhat flattened: it is triangular, broad above, and perforated by large vascular foramina; narrow below, where it terminates in a prominent oblong elevation of large size, the *tubercle* of the tibia; the lower half of this tubercle is rough, for the attachment of the ligamentum patellæ; the upper half presents a smooth facet supporting, in the recent state, a bursa which separates the ligament from the bone. *Posteriorly* the tuberosities are separated from each other by a shallow depression, the *popliteal notch*, which gives attachment to part of the posterior crucial ligament and part of the posterior ligament of the knee-joint. The *inner tuberosity* presents posteriorly a deep transverse groove, for the insertion of one of the fasciculi of the tendon of the Semi-membranosus. Its *lateral surface* is convex, rough, and prominent: it gives attachment to the internal lateral ligament. The *outer tuberosity* presents posteriorly a flat articular facet, nearly circular in form, directed downward, backward, and outward, for articulation with the fibula. Its lateral surface is convex and rough, more prominent in front than the internal: it presents a prominent rough eminence, situated on a level with the upper border of the tubercle of the tibia at the junction of its anterior and outer surfaces, for the attachment of the ilio-tibial band. Just below this the Extensor longus digitorum and a slip from the Biceps are attached.

The **Shaft** of the tibia is of a triangular prismoid form, broad above, gradually decreasing in size to its most slender part, at the commencement of its lower fourth, where fracture most frequently occurs; it then enlarges again toward its lower extremity. It presents for examination three borders and three surfaces.

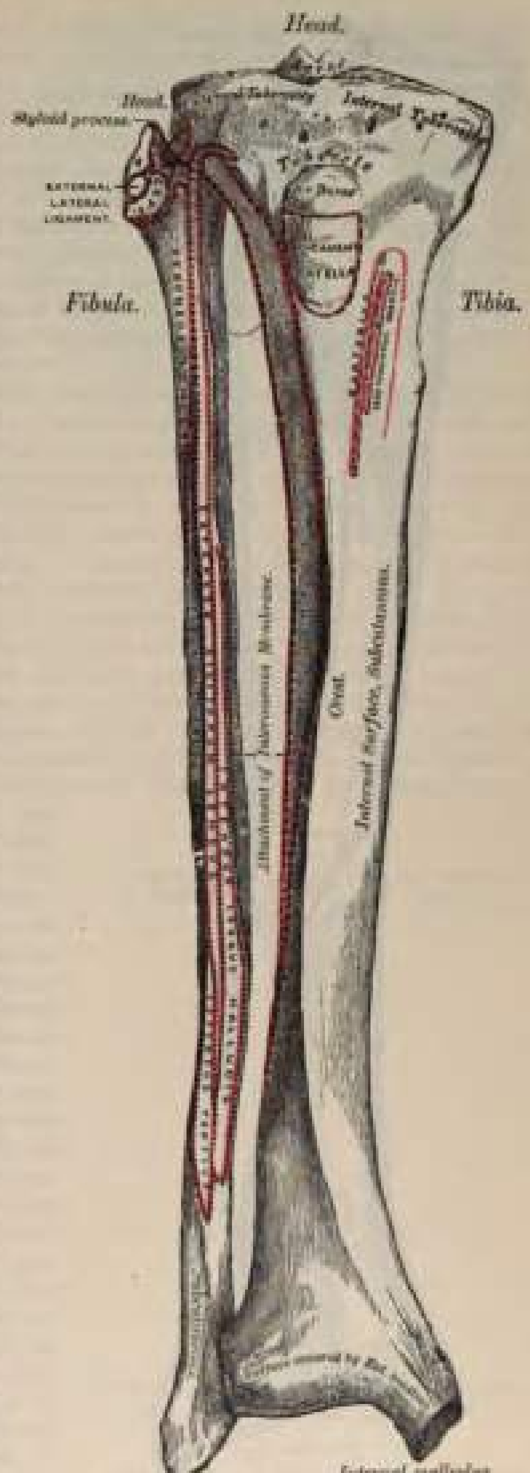



Fig. [illegible].—Bones of the right leg. Anterior surface.

The **anterior border**, the most prominent of the three, is called the *crest of the tibia*, or, in popular language, the *shin;* it commences above at the tubercle, and terminates below

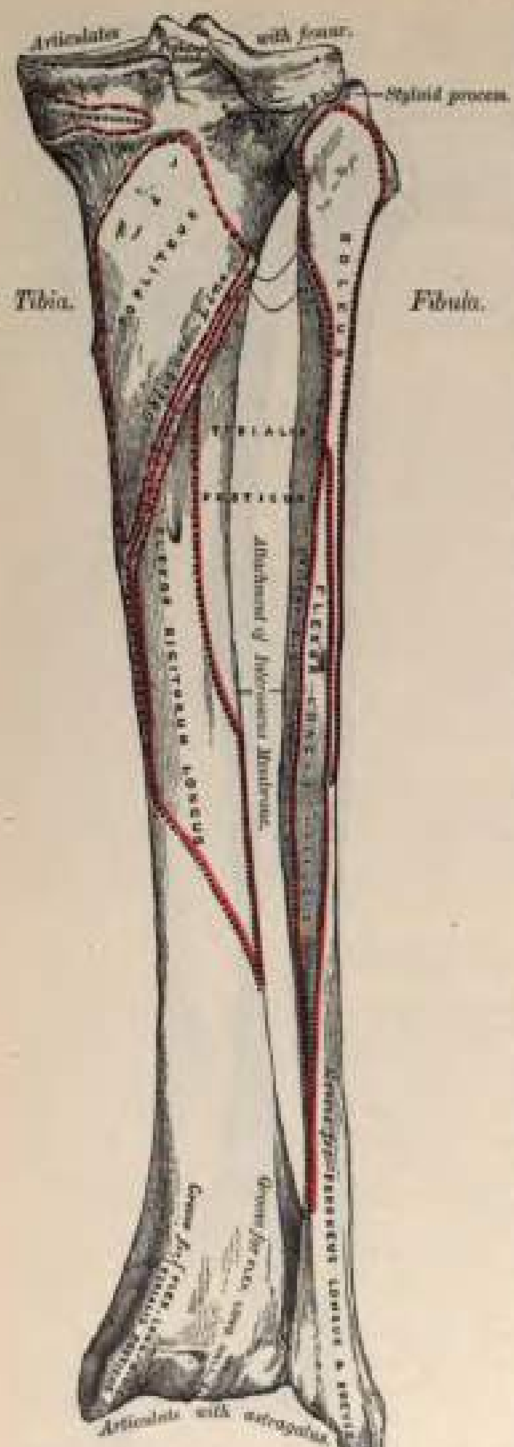



Fig. 134.—Bones of the right leg. Posterior surface.

at the anterior margin of the inner malleolus. This border is very prominent in the upper two-thirds of its extent, smooth and rounded below. It presents a very flexuous course, being usually curved outward above and inward below; it gives attachment to the deep fascia of the leg.

The **internal border** is smooth and rounded above and below, but more prominent in the centre; it commences at the back part of the inner tuberosity, and terminates at the posterior border of the internal malleolus; its upper part gives attachment to the internal lateral ligament of the knee to the extent of about two inches, and to some fibres of the Popliteus muscle; its middle third to some fibres of the Soleus and Flexor longus digitorum muscles.

The **external border,** or **interosseous ridge**, is thin and prominent, especially its central part, and gives attachment to the interosseous membrane; it commences above in front of the fibular articular facet, and bifurcates below, to form the boundaries of a triangular rough surface, for the attachment of the interosseous ligament connecting the tibia and fibula.

The **internal surface** is smooth, convex, and broader above than below; its upper third, directed forward and inward, is covered by the aponeurosis derived from the tendon of the Sartorius, and by the tendons of the Gracilis and Semitendinosus, all of which are inserted nearly as far forward as the anterior border; in the rest of its extent it is subcutaneous.

The **external surface** is narrower than the internal; its upper two-thirds presents a shallow groove for the attachment of the Tibialis anticus muscle; its lower third is smooth, convex, curves gradually forward to the anterior aspect of the bone, and is covered from within outward by the tendons of the following muscles: Tibialis anticus, Extensor proprius hallucis, Extensor longus digitorum.

The **posterior surface** (Fig. 134) presents, at its upper part, a prominent ridge, the *oblique line* of the tibia, which extends from the back part of the **articular** facet for the fibula obliquely downward, to the internal border, at the junction of its upper and middle thirds. It marks the lower limit for the insertion of the Popliteus muscle, and serves for the attachment of the popliteal fascia and part of the Soleus, Flexor longus digitorum, and Tibialis posticus muscles; the triangular concave surface, above and to the inner side of this line, gives attachment to the Popliteus muscle. The middle third of the posterior surface is divided by a vertical ridge into two lateral halves: the ridge is well marked at its commencement at the oblique line, but becomes gradually indistinct below; the inner and broader half gives attachment to the Flexor longus digitorum, the outer and narrower to part of the Tibialis posticus. The remaining part of the bone presents a smooth surface covered by the Tibialis posticus, Flexor longus digitorum, and Flexor longus hallucis muscles. Immediately below the oblique line is the medullary foramen, which is large and directed obliquely downward.

The **Lower Extremity**, much smaller than the upper, presents five surfaces; it is prolonged downward, on its inner side, to a strong process, the *internal malleolus.* The *inferior surface* of the bone is quadrilateral, and smooth for articulation with the astragalus. This surface is concave from before backward, and broader in front than behind. It is traversed from before backward by a slight elevation, separating two lateral depressions. It is narrow internally, where the articular surface becomes continuous with that on the inner malleolus. The *anterior surface* of the lower extremity is smooth and rounded above, and covered by the tendons of the Extensor muscles of the toes; its lower margin presents a rough transverse depression, for the attachment of the anterior ligament of the ankle-joint; the *posterior surface* presents a superficial groove directed obliquely downward and inward, continuous with a similar groove on the posterior surface of the astragalus, and serving for the passage of the tendon of the Flexor longus hallucis; the *external surface* presents a triangular rough depression for the attachment of the inferior interosseous ligament, connecting it with the fibula; the lower part of this depression is smooth, covered with cartilage in the recent state, and articulates with the fibula. This surface is bounded by two prominent borders, continuous above with the interosseous ridge; they afford attachment to the anterior and posterior inferior tibio-fibular ligaments. The *internal surface* of the lower extremity is prolonged downward to form a strong pyramidal process, flattened from without inward—the *internal malleolus.* The *inner surface* of this process is convex and subcutaneous; its *outer surface* is smooth and slightly concave, and articulates with the astragalus; its *anterior border* is rough, for the attachment of the anterior fibres of the internal lateral or Deltoid ligament; its *posterior border* presents a broad and deep groove, directed obliquely downward and inward, which is occasionally double: this groove transmits the tendons of the Tibialis posticus and Flexor longus digitorum muscles. The *summit* of the internal malleolus is marked by a rough depression behind, for the attachment of the internal lateral ligament of the ankle-joint.


FIG. [illegible].—Plan of the development of the tibia. By three centres.

**Structure.**—Like that of the other long bones. At the junction of the middle and lower third, where the bone is smallest, the wall of the shaft is thicker than in other parts, in order to compensate for the smallness of the calibre of the bone.

**Development.**—By *three* centres (Fig. 135): one for the shaft, and one for each extremity. Ossification commences in the centre of the shaft about the seventh week, and gradually extends toward either extremity. The centre for the upper epiphysis appears before or shortly after birth; it is flattened in form, and has a thin, tongue-shaped process in front which forms the tubercle. That for the lower epiphysis appears in the second year. The lower epiphysis joins the shaft at about the eighteenth, and the upper one about the twentieth, year. Two additional centres occasionally exist—one for the tongue-shaped process of the upper epiphysis, which forms the tubercle, and one for the inner malleolus.

**Articulations.**—With three bones: the femur, fibula, and astragalus.

**Attachment of Muscles.**—To twelve: to the inner tuberosity, the Semimembranosus: to the outer tuberosity, the Tibialis anticus and Extensor longus digitorum and Biceps; to the shaft, its internal surface, the Sartorius, Gracilis, and Semitendinosus; to its external surface, the Tibialis anticus; to its posterior surface, the Popliteus, Soleus, Flexor longus digitorum, and Tibialis posticus; to the tubercle, the ligamentum patellæ, by which the Quadriceps extensor muscle is inserted into the tibia. In addition to these muscles, the Tensor fasciæ femoris is inserted indirectly into the tibia, through the ilio-tibial band, and the Peroneus longus occasionally derives a few fibres of origin from the outer tuberosity.

**Surface Form.**—A considerable portion of the tibia is subcutaneous and easily to be felt. At the upper extremity the tuberosities are to be recognized just below the knee. The internal one is broad and smooth, and merges into the subcutaneous surface of the shaft below. The external one is narrower and more prominent, and on it, about midway between the apex of the patella and the head of the fibula, may be felt a prominent tubercle for the insertion of the ilio-tibial band. In front of the upper end of the bone, between the tuberosities, is the tubercle of the tibia, forming an oval eminence which is continuous below with the anterior border or crest of the bone. This border can be felt, forming the prominence of the shin, in the upper two-thirds of its extent as a sharp and flexuous ridge, curved outward above and inward below. In the lower third of the leg the border disappears, and the bone is concealed by the tendons of the muscles on the front of the leg. Internal to the anterior border is to be felt the broad internal surface of the tibia, slightly encroached upon by the muscles in front and behind. It commences above at the wide expanded inner tuberosity, and terminates below at the internal malleolus. The internal malleolus is a broad prominence situated on a higher level and somewhat farther forward than the external malleolus. It overhangs the inner border of the arch of the foot. Its anterior border is nearly straight; its posterior border presents a sharp edge, which forms the inner margin of the groove for the tendon of the Tibialis posticus muscle.

## The Fibula (Figs. 133, 134).

The **Fibula** (*fibula*, a clasp) is situated at the outer side of the leg. It is the smaller of the two bones, and, in proportion to its length, the most slender of all the long bones; it is placed on the outer side of the tibia, with which it is connected above and below. Its upper extremity is small, placed toward the back of the head of the tibia and below the level of the knee-joint, and excluded from its formation: the lower extremity inclines a little forward, so as to be on a plane anterior to that of the upper end, projects below the tibia, and forms the outer ankle. It presents for examination a shaft and two extremities.

The **Upper Extremity,** or **Head,** is of an irregular quadrate form, presenting above a flattened articular facet, directed upward, forward, and inward, for articulation with a corresponding facet on the external tuberosity of the tibia. On the outer side is a thick and rough prominence, continued behind into a pointed eminence, the *styloid process*, which projects upward from the posterior part of the head. The *prominence* gives attachment to the tendon of the Biceps muscle and to the long external lateral ligament of the knee, the ligament dividing the tendon into two parts. The *summit* of the styloid process gives attachment to the short external lateral ligament. The remaining part of the circumference of the head is rough, for the attachment of muscles and ligaments. It presents in front a tubercle for the origin of the upper and anterior part of the Peroneus longus, and the adjacent surface gives attachment to the anterior superior tibio-fibular ligament; and behind, another tubercle for the attachment of the posterior superior tibio-fibular ligament and the upper fibres of the Soleus muscle.

The **shaft** presents four borders—the antero-external, the antero-internal, the postero-external, and the postero-internal; and four surfaces—anterior, posterior, internal, and external.

The **antero-external border** commences above in front of the head, runs vertically downward to a little below the middle of the bone, and then, curving somewhat outward, bifurcates so as to embrace the triangular subcutaneous surface immediately above the outer surface of the external malleolus. This border gives attachment to an intermuscular septum, which separates the extensor muscles on the anterior surface of the leg from the Peroneus longus and brevis muscles on the outer surface.

The **antero-internal border**, or **interosseous ridge**, is situated close to the inner side of the preceding, and runs nearly parallel with it in the upper third of its extent, but diverges from it so as to include a broader space in the lower two-thirds. It commences above, just beneath the head of the bone (sometimes it is quite indistinct for about an inch below the head), and terminates below at the apex of a rough triangular surface immediately above the articular facet of the external malleolus. It serves for the attachment of the interosseous membrane, which separates the extensor muscles in front from the flexor muscles behind.

The **postero-external border** is prominent; it commences above at the base of the styloid process, and terminates below in the posterior border of the outer malleolus. It is directed outward above, backward in the middle of its course, backward and a little inward below, and gives attachment to an aponeurosis which separates the Peronei muscles on the outer surface of the shaft from the flexor muscles on its posterior surface.

The **postero-internal border**, sometimes called the *oblique line*, commences above at the inner side of the head, and terminates by becoming continuous with the antero-internal border or interosseous ridge at the lower fourth of the bone. It is well marked and prominent at the upper and middle parts of the bone. It gives attachment to an aponeurosis which separates the Tibialis posticus from the Soleus above and the Flexor longus hallucis below.

The **anterior surface** is the interval between the antero-external and antero-internal borders. It is extremely narrow and flat in the upper third of its extent; broader and grooved longitudinally in its lower third; it serves for the attachment of three muscles, the Extensor longus digitorum, Peroneus tertius, and Extensor proprius hallucis.

The **external surface** is the space between the antero-external and postero-external borders. It is much broader than the preceding, and often deeply grooved, is directed outward in the upper two-thirds of its course, backward in the lower third, where it is continuous with the posterior border of the external malleolus. This surface is completely occupied by the Peroneus longus and brevis muscles.

The **internal surface** is the interval included between the antero-internal and the postero-internal borders. It is directed inward, and is grooved for the attachment of the Tibialis posticus muscle.

The **posterior surface** is the space included between the postero-external and the postero-internal borders; it is continuous below with the rough triangular surface above the articular facet of the outer malleolus; it is directed backward above, backward and inward at its middle, directly inward below. Its upper third is rough, for the attachment of the Soleus muscle; its lower part presents a triangular rough surface, connected to the tibia by a strong interosseous ligament, and between these two points the entire surface is covered by the fibres of origin of the Flexor longus hallucis muscle. At about the middle of this surface is the nutrient foramen, which is directed downward.

The **Lower Extremity**, or **external malleolus**, is of a pyramidal form, somewhat flattened from without inward, and is longer, and descends lower than the internal malleolus. Its *external surface* is convex, subcutaneous, and continuous with the triangular (also subcutaneous) surface on the outer side of the shaft. The *internal surface* presents in front a smooth triangular facet, broader above than below, and convex from above downward, which articulates with a corresponding surface on the outer side of the astragalus. Behind and beneath the articular surface is a rough depression which gives attachment to the posterior fasciculus of the external lateral ligament of the ankle. The *anterior border* is thick and rough, and marked below by a depression for the attachment of the anterior fasciculus of the external lateral ligament. The *posterior border* is broad and marked by a shallow groove, for the passage of the tendons of the Peroneus longus and brevis muscles. The *summit* is rounded, and gives attachment to the middle fasciculus of the external lateral ligament.

In order to distinguish the side to which the bone belongs, hold it with the lower extremity downward and the broad groove for the Peronei tendons backward—*i. e.* toward the holder: the triangular subcutaneous surface will then be directed to the side to which the bone belongs.

**Articulations.**—With two bones: the tibia and astragalus.

**Development.**—By *three* centres (Fig. 136): one for the shaft, and one for each extremity. Ossification commences in the shaft about the eighth week of fœtal life, a little later than in the tibia, and extends gradually toward the extremities. At birth both ends are cartilaginous. Ossification commences in the lower end in the second year, and in the upper one about the fourth year. The lower epiphysis, the first in which ossification commences, becomes united to the shaft about the twentieth year; the upper epiphysis joins about the twenty-fifth year. Ossification appearing first in the lower epiphysis is contrary to the rule which prevails with regard to the commencement of ossification in epiphyses—viz. that that epiphysis toward which the nutrient artery is directed commences to ossify last; but it follows the rule which prevails with regard to the union of epiphyses, by uniting first.


Fig. 136.—Plan of the development of the fibula. By three centres.

**Attachment of Muscles.**—To nine: to the head, the Biceps, Soleus, and Peroneus longus; to the shaft, its anterior surface, the Extensor longus digitorum, Peroneus tertius, and Extensor proprius hallucis; to the internal surface, the Tibialis posticus; to the posterior surface, the Soleus and Flexor longus hallucis; to the external surface, the Peroneus longus and brevis.

**Surface Form.**—The only parts of the fibula which are to be felt are the head and the lower part of the external surface of the shaft and the external malleolus. The head is to be seen and felt behind and to the outer side of the outer tuberosity of the tibia. It presents a small, prominent triangular eminence slightly above the level of the tubercle of the tibia. The external malleolus presents a narrow elongated prominence, situated on a plane posterior to the internal malleolus and reaching to a lower level. From it may be traced the lower third or half of the external surface of the shaft of the bone in the interval between the Peroneus tertius in front and the other two Peronei tendons behind.

**Surgical Anatomy.**—In fractures of the bones of the leg both bones are usually fractured, but each bone may be broken separately, the fibula more frequently than the tibia. Fracture of both bones may be caused either by direct or indirect violence. When it occurs from indirect force, the fracture in the tibia is at the junction of the middle and lower third of the bone. Many causes conduce to render this the weakest part of the bone. The fracture of the fibula is usually at rather a higher level. These fractures present great variety, both as regards their direction and condition. They may be oblique, transverse, longitudinal, or spiral. When oblique, they are usually the result of indirect violence, and the direction of the fracture is from behind, downward, forward, and inward in many cases, but may be downward and outward or downward and backward. When transverse, the fracture is often at the upper part of the bone, and is the result of direct violence. The spiral fracture usually commences as a vertical fissure, involving the ankle-joint, and is associated with fracture of the fibula higher up. It is the result of torsion, from twisting of the body whilst the foot is fixed.

Fractures of the tibia alone are almost always the result of direct violence, except where the malleolus is broken off by twists of the foot. Fractures of the fibula alone may arise from indirect or direct force, those of the lower end being usually the result of the former, and those higher up being caused by a direct blow on the part.

The tibia and fibula, like the femur, are frequently the seat of acute necrosis. Chronic abscess is more frequently met with in the cancellous tissue of the head and lower end of the tibia than in any other bone of the body. The abscess is of small size, very chronic, and probably the result of tuberculous osteitis in the highly vascular growing tissue at the end of the shaft near the epiphyseal cartilage in the young subject.

The tibia is the bone which is most frequently and most extensively distorted in rickets. It gives way at the junction of the middle and lower third, its weakest part, and presents a curve forward and outward.

## THE FOOT (Figs. 137, 138).

The skeleton of the Foot consists of three divisions: the Tarsus, Metatarsus, and Phalanges.

### The Tarsus.

The bones of the **Tarsus** are seven in number: viz., the calcaneum or os calcis, astragalus, cuboid, navicular, internal, middle, and external cuneiform bones.

#### The Calcaneum (Fig. 139).

The **Calcaneum,** or **Os Calcis** (*calx*, the heel), is the largest and strongest of the tarsal bones. It is irregularly cuboidal in form, having its long axis directed forward and outward. It is situated at the lower and back part of the foot, serving to transmit the weight of the body to the ground, and forming a strong lever for the muscles of the calf. It presents for examination six surfaces: superior, inferior, external, internal, anterior, and posterior.

The **superior surface** is formed behind by the upper aspect of that part of the os calcis which projects backward to form the heel. It varies in length in different individuals; is convex from side to side, concave from before backward, and corresponds above to a mass of adipose substance placed in front of the tendo Achillis. In the middle of the superior surface are two (sometimes three) articular facets, separated by a broad shallow groove, which is directed obliquely forward and outward, and is rough for the attachment of the interosseous ligament connecting the astragalus and os calcis. Of the two articular surfaces, the *external* is the larger, and situated on the body of the bone: it is of an oblong form, wider behind than in front, and convex from before backward. The *internal articular surface* is supported on a projecting process of bone, called the *lesser process* of the calcaneum (*sustentaculum tali*); it is also oblong, concave longitudinally, and sometimes subdivided into two parts, which differ in size and shape. More anteriorly is seen the upper surface of the *greater process*, marked by a rough depression for the attachment of numerous ligaments, and a tubercle for the origin of the Extensor brevis digitorum muscle.

The **inferior surface** is narrow, rough, uneven, wider behind than in front and convex from side to side; it is bounded posteriorly by two tubercles separated by a rough depression: the *external*, small, prominent, and rounded, gives attachment to part of the Abductor minimi digiti: the *internal*, broader and larger, for the support of the heel, gives attachment, by its prominent inner margin, to the Abductor hallucis, and in front to the Flexor brevis digitorum muscles and plantar fascia; the depression between the tubercles gives attachment to the Abductor minimi digiti. The rough surface in front of the tubercles gives attachment to the long plantar ligament and to the outer head of the Flexor accessorius muscle; while to a prominent tubercle nearer the anterior part of this surface, as well as to a transverse groove in front of it, is attached the short plantar ligament.

The **external surface** is broad, flat, and almost subcutaneous; it presents near its centre a tubercle, for the attachment of the middle fasciculus of the external lateral ligament. At its upper and anterior part this surface gives attachment to

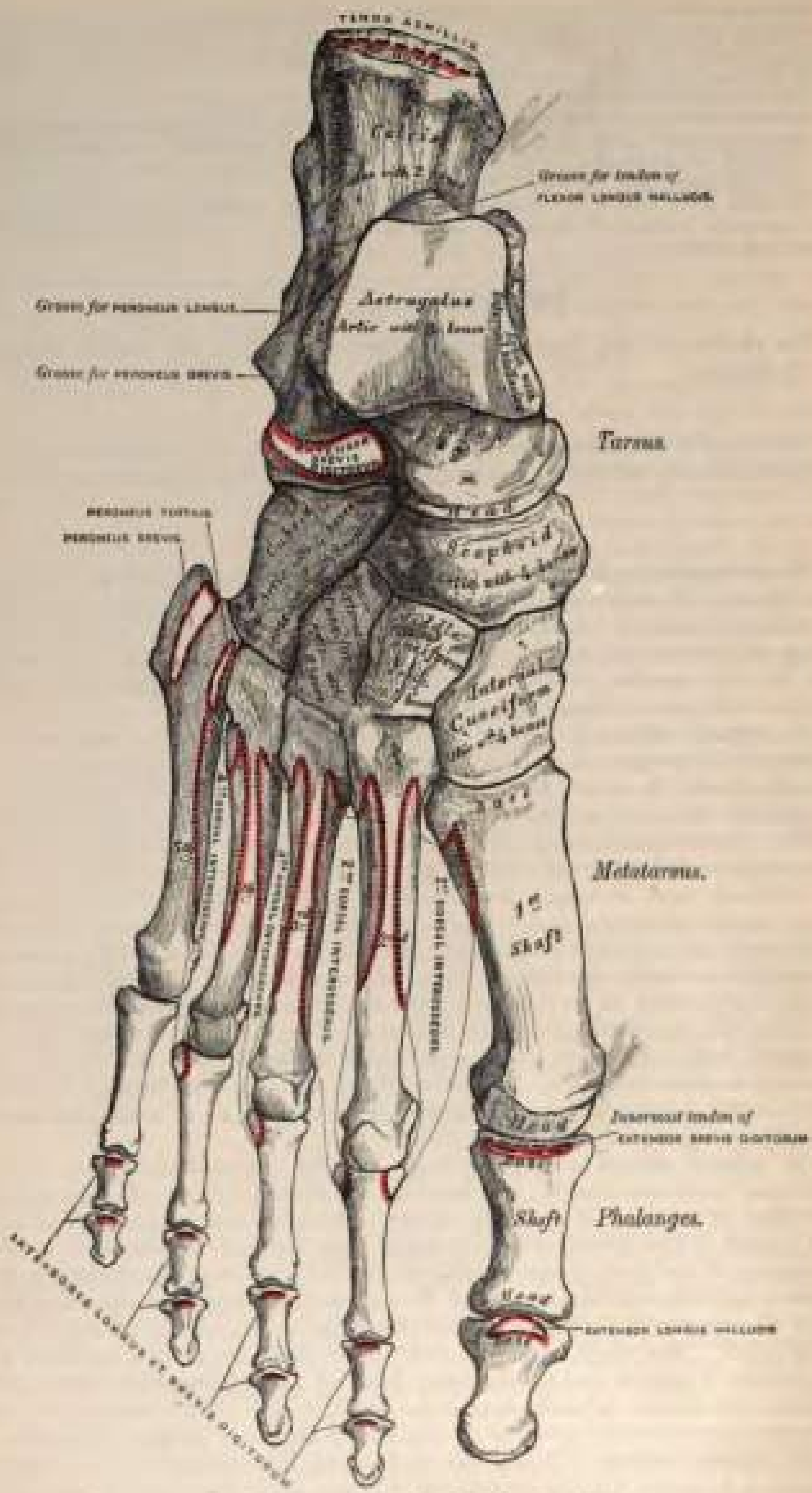



Fig. 177.—Bones of the right foot. Dorsal surface.

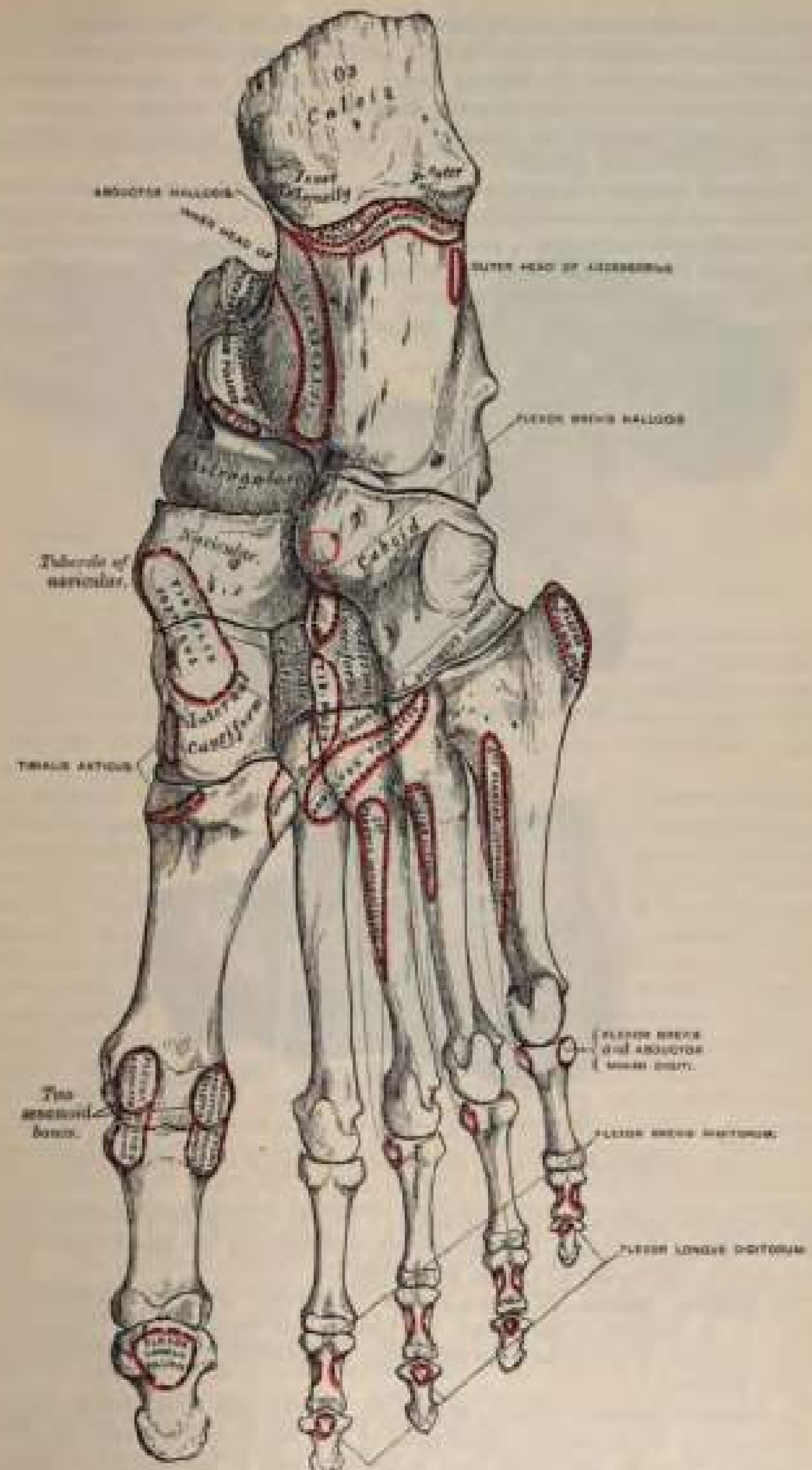



FIG. 138.—Bones of the right foot. Plantar surface.

the external calcaneo-astragaloid ligament; and in front of the tubercle it presents a narrow surface marked by two oblique grooves, separated by an elevated ridge which varies much in size in different bones; it is named the *peroneal tubercle*, and gives attachment to a fibrous process from the external annular ligament. The *superior groove* transmits the tendon of the Peroneus brevis; the *inferior*, the tendon of the Peroneus longus.

The **internal surface** is deeply concave; it is directed obliquely downward and forward, and serves for the transmission of the plantar vessels and nerves into the sole of the foot; it affords attachment to part of the Flexor accessorius muscle. At its upper and fore part it presents an eminence of bone, the *lesser process* or *sustentaculum tali*, which projects horizontally inward, and to it a slip of the tendon of the Tibialis posticus is attached. This process is concave above, and supports the

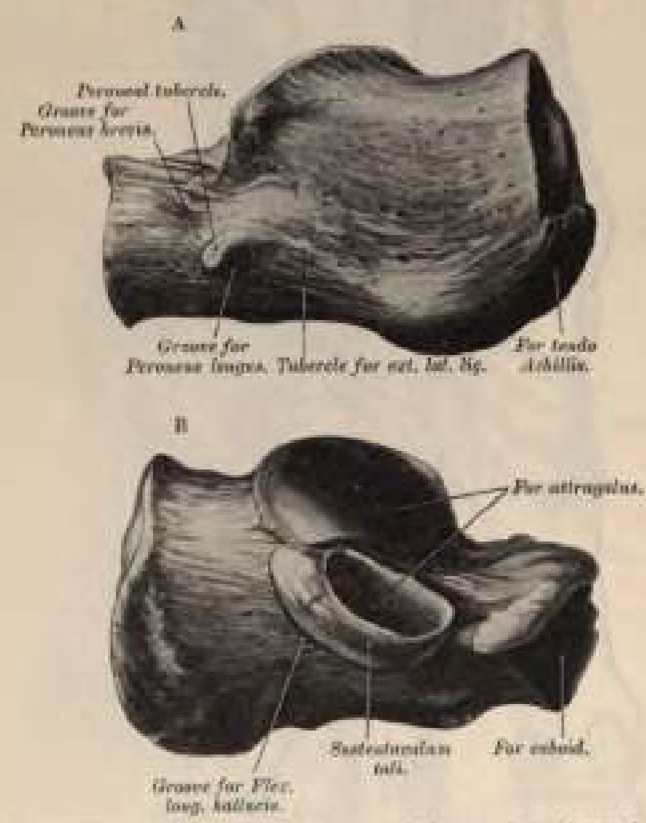



Fig. 138.—The left os calcis. A. Postero-external view. B. Antero-internal view.

anterior articular surface of the astragalus; below, it is grooved for the tendon of the Flexor longus hallucis. Its free margin is rough, for the attachment of part of the internal lateral ligament of the ankle-joint.

The **anterior surface**, of a somewhat triangular form, articulates with the cuboid. It is concave from above downward and outward, and convex in the opposite direction. Its inner border gives attachment to the inferior calcaneo-navicular ligament.

The **posterior surface** is rough, prominent, convex, and wider below than above. Its lower part is rough, for the attachment of the tendo Achillis and the tendon of the Plantaris muscle; its upper part is smooth, and is covered by a bursa which separates the tendons from the bone.

**Articulations.**—With two bones: the astragalus and cuboid.

**Attachment of Muscles.**—To eight: part of the Tibialis posticus, the tendo

Achillis, Plantaris, Abductor hallucis, Abductor minimi digiti, Flexor brevis digitorum, Flexor accessorius, and Extensor brevis digitorum.

### The Astragalus (Fig. 140).

The **Astragalus** (ἀστράγαλος, a die) is the largest of the tarsal bones, next to

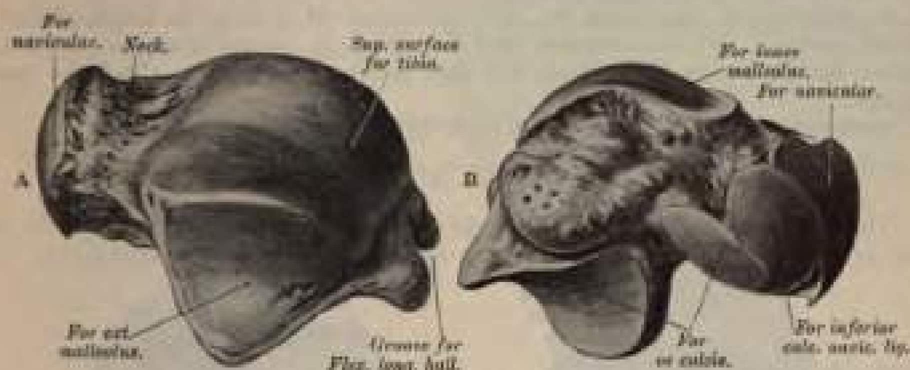



FIG. 140.—The left astragalus. A. Superior and external view. B. Inferior and internal view.

the os calcis. It occupies the middle and upper part of the tarsus, supporting the tibia above, articulating with the malleoli on either side, resting below upon the os calcis, and joined in front to the navicular. This bone may easily be recognized by its large rounded head, by the broad articular facet on its upper convex surface, or by the two articular facets separated by a deep groove on its under concave surface. It presents six surfaces for examination.

The **superior surface** presents, behind, a broad smooth trochlear surface for articulation with the tibia. The trochlea is broader in front than behind, convex from before backward, slightly concave from side to side; in front of it is the upper surface of the neck of the astragalus, rough for the attachment of ligaments. The *inferior surface* presents two articular facets separated by a deep groove. The groove runs obliquely forward and outward, becoming gradually broader and deeper in front: it corresponds with a similar groove upon the upper surface of the os calcis, and forms, when articulated with that bone, a canal, filled up in the recent state by the interosseous calcaneo-astragaloid ligament. Of the two articular facets, the posterior is the larger, of an oblong form and deeply concave from side to side; the anterior is shorter and narrower, of an elongated oval form, convex longitudinally, and often subdivided into two by an elevated ridge; of these, the posterior articulates with the lesser process of the os calcis; the anterior, with the upper surface of the inferior calcaneo-navicular ligament. The *internal surface* presents at its upper part a pear-shaped articular facet for the inner malleolus, continuous above with the trochlear surface; below the articular surface is a rough depression, for the attachment of the deep portion of the internal lateral ligament. The *external surface* presents a large triangular facet, concave from above downward for articulation with the external malleolus; it is continuous above with the trochlear surface; and in front of it is a rough depression for the attachment of the anterior fasciculus of the external lateral ligament of the ankle-joint. The *anterior surface*, convex and rounded, forms the *head* of the astragalus; it is smooth, of an oval form, and directed obliquely inward and downward; it articulates with the navicular. On its under and inner surface is a small facet, continuous in front with the articular surface of the head, and behind with the smaller facet for the os calcis. This rests on the inferior calcaneo-navicular ligament, being separated from it by the synovial membrane, which is prolonged from the anterior calcaneo-astragaloid joint to the astragalo-navicular joint. The head is surrounded by a constricted portion, the *neck* of the astragalus. The *posterior surface* is narrow, and traversed by a groove, which runs obliquely downward and inward, and transmits the tendon of the Flexor longus hallucis, external to which is a prominent tubercle, to which the posterior fasciculus of the external lateral ligament is attached. This tubercle is sometimes separated from the rest of the astragalus, and is then known as the *os trigonum*. To the inner side of the groove is a second, but less marked, tubercle.

To ascertain to which foot the bone belongs, hold it with the broad articular surface upward, and the rounded head forward: the lateral triangular articular surface for the external malleolus will then point to the side to which the bone belongs.

**Articulations.**—With four bones: tibia, fibula, os calcis, and navicular.

### The Cuboid (Fig. 141).

The **Cuboid** (κύβος, a cube; εἶδος, like) bone is placed on the outer side of the foot, in front of the os calcis, and behind the fourth and fifth metatarsal bones. It


Fig. 141.—The left cuboid. A. Antero-internal view. B. Postero-external view.

is of a pyramidal shape, its base being directed inward, its apex outward. It may be distinguished from the other tarsal bones by the existence of a deep groove on its under surface, for the tendon of the Peroneus longus muscle. It presents for examination six surfaces: three articular and three non-articular.

The **non-articular surfaces** are the superior, inferior, and external. The *superior* or *dorsal surface*, directed upward and outward, is rough, for the attachment of numerous ligaments. The *inferior* or *plantar surface* presents in front a deep groove, which runs obliquely from without, forward and inward; it lodges the tendon of the Peroneus longus, and is bounded behind by a prominent ridge, to which is attached the long calcaneo-cuboid ligament. The ridge terminates externally in an eminence, the *tuberosity of the cuboid*, the surface of which presents a convex facet, for articulation with the sesamoid bone of the tendon contained in the groove. The surface of bone behind the groove is rough, for the attachment of the short plantar ligament, a few fibres of the Flexor brevis hallucis, and a fasciculus from the tendon of the Tibialis posticus. The *external surface*, the smallest and narrowest of the three, presents a deep notch formed by the commencement of the peroneal groove.

The **articular surfaces** are the posterior, anterior, and internal. The *posterior surface* is smooth, triangular, and concavo-convex, for articulation with the anterior surface of the os calcis. The *anterior*, of smaller size, but also irregularly triangular, is divided by a vertical ridge into two facets: the inner one, quadrilateral in form, articulates with the fourth metatarsal bone; the outer one, larger and more triangular, articulates with the fifth metatarsal. The *internal surface* is broad, rough, irregularly quadrilateral, presenting at its middle and upper part a smooth oval facet, for articulation with the external cuneiform bone; and behind this (occasionally) a smaller facet, for articulation with the navicular; it is rough in the rest of its extent, for the attachment of strong interosseous ligaments.

To ascertain to which foot the bone belongs, hold it so that its under surface, marked by the peroneal groove, looks downward, and the large concavo-convex articular surface backward toward the holder; the narrow non-articular surface, marked by the commencement of the peroneal groove, will point to the side to which the bone belongs.

**Articulations.**—With four bones: the os calcis, external cuneiform, and the fourth and fifth metatarsal bones; occasionally with the navicular.

**Attachment of Muscles.**—Part of the Flexor brevis hallucis and a slip from the tendon of the Tibialis posticus.

### The Navicular (Fig. 142).

The **Navicular** or **Scaphoid bone** is situated at the inner side of the tarsus,

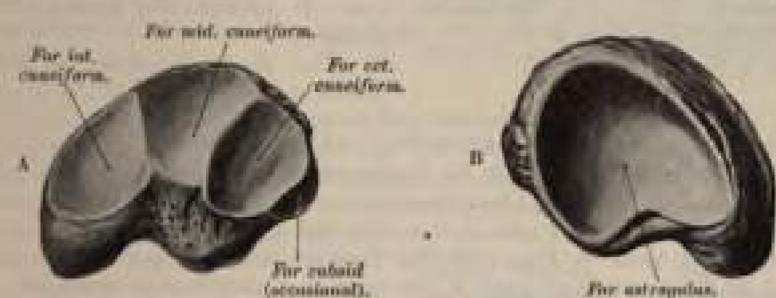



FIG. 142.—The left navicular. A. Antero-external view. B. Postero-internal view.

between the astragalus behind and the three cuneiform bones in front. It may be distinguished by its form, being concave behind, convex and subdivided into three facets in front.

The *anterior surface*, of an oblong form, is convex from side to side, and subdivided by two ridges into three facets, for articulation with the three cuneiform bones. The *posterior surface* is oval, concave, broader externally than internally, and articulates with the rounded head of the astragalus. The *superior surface* is convex from side to side, and rough for the attachment of ligaments. The *inferior* is irregular, and also rough for the attachment of ligaments. The *internal surface* presents a rounded tubercular eminence, the *tuberosity* of the navicular, the lower part of which projects, and gives attachment to part of the tendon of the Tibialis posticus. The *external surface* is rough and irregular, for the attachment of ligamentous fibres, and occasionally presents a small facet for articulation with the cuboid bone.

To ascertain to which foot the bone belongs, hold it with the concave articular surface backward, and the convex dorsal surface upward; the external surface—*i. e.* the surface opposite the tubercle—will point to the side to which the bone belongs.

**Articulations.**—With four bones: astragalus and three cuneiform; occasionally also with the cuboid.

**Attachment of Muscles.**—Part of the Tibialis posticus.

### The Cuneiform Bones.

The **Cuneiform Bones** have received their name from their wedge-like shape (*cuneus*, a wedge; *forma*, likeness). They form, with the cuboid, the anterior row of the tarsus, being placed between the navicular behind, the three innermost metatarsal bones in front, and the cuboid externally. They are called the *first*, *second*, and *third*, counting from the inner to the outer side of the foot, and, from their position, *internal*, *middle*, and *external*.

### The Internal Cuneiform (Fig. 143).

The **Internal Cuneiform** is the largest of the three. It is situated at the inner side of the foot, between the navicular behind and the base of the first metatarsal in front. It may be distinguished from the other two by its large size, and by its not presenting such a distinct wedge-like form. Without the others it may be known by the large, kidney-shaped anterior articulating surface and by the prominence on the inferior or plantar surface for the attachment of the Tibialis posticus. It presents for examination six surfaces.

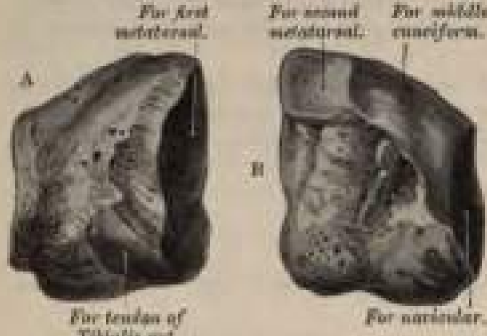



FIG. 143.—The left internal cuneiform. A. Antero-internal view. B. Postero-external view.

The *internal surface* is subcutaneous, and forms part of the inner border of the foot; it is broad, quadrilateral, and presents at its anterior inferior angle a smoot oval facet, into which the tendon of the Tibialis anticus is partially inserted; in the rest of its extent it is rough, for the attachment of ligaments. The *external surface* is concave, presenting, along its superior and posterior borders, a narrow reversed L-shaped surface for articulation with the middle cuneiform behind, and second metatarsal bone in front; in the rest of its extent it is rough for the attachment of ligaments and part of the tendon of the Peroneus longus. The *anterior surface*, kidney-shaped, much larger than the posterior, articulates with the metatarsal bone of the great toe. The *posterior surface* is triangular, concave, and articulates with the innermost and largest of the three facets on the anterior surface of the navicular. The *inferior* or *plantar surface* is rough, and presents a prominent tuberosity at its back part for the attachment of part of the tendon of the Tibialis posticus. It also gives attachment in front to part of the tendon of the the Tibialis anticus. The *superior surface* is the narrow-pointed end of the wedge, which is directed upward and outward; it is rough for the attachment of ligaments.

To ascertain to which side the bone belongs, hold it so that its superior narrow edge looks upward, and the long, kidney-shaped, articular surface forward; the external surface, marked by its vertical and horizontal articular facets, will point to the side to which it belongs.

**Articulations.**—With four bones: navicular, middle cuneiform, first and second metatarsal bones.

**Attachment of Muscles.**—To three: the Tibialis anticus and posticus, and Peroneus longus.

### The Middle Cuneiform (Fig. 144).

The **Middle Cuneiform**, the smallest of the three, is of very regular wedge-like form, the broad extremity being placed upward, the narrow end downward. It is situated between the other two bones of the same name, and articulates with the navicular behind and the second metatarsal in front. It is smaller than the external cuneiform bone, from which it may be further distinguished by the L-shaped articular facet, which runs round the upper and back part of its inner surface.

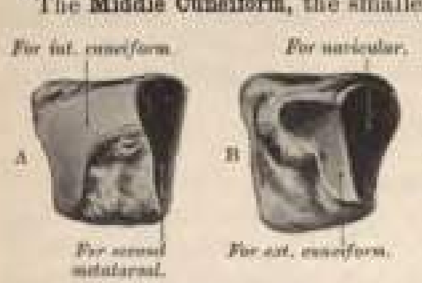



FIG. 144.—The left middle cuneiform. A. Antero-internal view. B. Postero-external view.

The *anterior surface*, triangular in form and narrower than the posterior, articulates with the base of the second metatarsal bone. The *posterior surface*, also triangular, articulates with the navicular.

The *internal surface* presents a reversed L-shaped articular facet, running along the superior and posterior borders, for articulation with the internal cuneiform, and is rough in the rest of its extent for the attachment of ligaments. The *external surface* presents posteriorly a smooth facet for articulation with the external cuneiform bone. The *superior surface* forms the base of the wedge; it is quadrilateral, broader behind than in front, and rough for the attachment of ligaments. The *inferior surface*, pointed and tubercular, is also rough for ligamentous attachment and for the insertion of a slip from the tendon of the Tibialis posticus.

To ascertain to which foot the bone belongs, hold its superior or dorsal surface upward, the broadest edge being toward the holder: the smooth facet (limited to the posterior border) will then point to the side to which it belongs.

**Articulations.**—With four bones: navicular, internal and external cuneiform, and second metatarsal bone.

**Attachment of Muscles.**—A slip from the tendon of the Tibialis posticus is attached to this bone.

## THE EXTERNAL CUNEIFORM (Fig. 145).

The **External Cuneiform**, intermediate in size between the two preceding, is of a very regular wedge-like form, the broad extremity being placed upward, the narrow end downward. It occupies the centre of the front row of the tarsus, between the middle cuneiform internally, the cuboid externally, the navicular behind, and the third metatarsal in front. It is distinguished from the internal cuneiform bone by its more regular wedge-like shape and by the absence of the kidney-shaped articular surface: from the middle cuneiform, by the absence of the reversed L-shaped facet, and by the two articular facets which are present on both its inner and outer surfaces. It has six surfaces for examination.

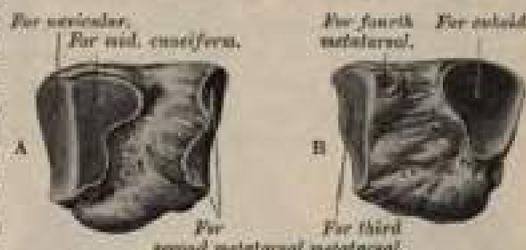


FIG. 145.—The left external cuneiform. A. Postero-internal view. B. Antero-external view.

The *anterior surface*, triangular in form, articulates with the third metatarsal bone. The *posterior surface* articulates with the most external facet of the navicular, and is rough below for the attachment of ligamentous fibres. The *internal surface* presents two articular facets, separated by a rough depression; the anterior one, sometimes divided into two, articulates with the outer side of the base of the second metatarsal bone; the posterior one skirts the posterior border and articulates with the middle cuneiform; the rough depression between the two gives attachment to an interosseous ligament. The *external surface* also presents two articular facets, separated by a rough non-articular surface; the anterior facet, situated at the superior angle of the bone, is small, and articulates with the inner side of the base of the fourth metatarsal; the posterier and larger one articulates with the cuboid; the rough, non-articular surface serves for the attachment of an interosseous ligament. The three facets for articulation with the three metatarsal bones are continuous with one another, and covered by a prolongation of the same cartilage; the facets for articulation with the middle cuneiform and navicular are also continuous, but that for articulation with the cuboid is usually separate. The *superior* or *dorsal surface* is of an oblong square form, its posterior external angle being prolonged backward. The *inferior* or *plantar surface* is an obtuse rounded margin, and serves for the attachment of part of the tendon of the Tibialis posticus, part of the Flexor brevis hallucis, and ligaments.

To ascertain to which side the bone belongs, hold it with the broad dorsal surface upward, the prolonged edge backward; the separate articular facet for the cuboid will point to the proper side.

**Articulations.**—With six bones: the navicular, middle cuneiform, cuboid, and second, third, and fourth metatarsal bones.

**Attachment of Muscles.**—To two: part of the Tibialis posticus, and Flexor brevis hallucis.

The number of tarsal bones may be reduced owing to congenital ankylosis, which may occur between the os calcis and cuboid, the os calcis and navicular, the os calcis and astragalus, or the astragalus and navicular.

## The Metatarsal Bones.

The **Metatarsal Bones** are five in number, and are numbered one to five, in accordance with their position from within outward; they are long bones, and present for examination a shaft and two extremities.

**Common Characters.**—The *shaft* is prismoid in form, tapers gradually from the tarsal to the phalangeal extremity, and is slightly curved longitudinally, so as to be concave below, slightly convex above. The *posterior extremity*, or *base*, is wedge-shaped, articulating by its terminal surface with the tarsal bones, and by its lateral surfaces with the contiguous metatarsal bones, its dorsal and plantar surfaces being rough for the attachment of ligaments. The *anterior extremity*, or *head*, presents a terminal rounded articular surface, oblong from above downward, and extending farther backward below than above. Its sides are flattened and present a depression, surmounted by a tubercle, for ligamentous attachment. Its under surface is grooved in the middle line for the passage of the Flexor tendon, and marked on each side by an articular eminence continuous with the terminal articular surface.

Fig. 146.—The first metatarsal. (Left.)

**Peculiar Characters.**—The **First** (Fig. 146) is remarkable for its great thickness, but is the shortest of all the metatarsal bones. The *shaft* is strong and of well-marked prismoid form. The *posterior extremity* presents, as a rule, no lateral articular facet, but occasionally on the outer side there is an oval facet by which it articulates with the second metatarsal bones. Its terminal articular surface is of large size, kidney-shaped; its circumference is grooved, for the tarso-metatarsal ligaments, and internally gives attachment to part of the tendon of the Tibialis anticus: its inferior angle presents a rough oval prominence for the insertion of the tendon of the Peroneus longus. The *head* is of large size: on its plantar surface are two grooved facets, over which glide sesamoid bones; the facets are separated by a smooth elevated ridge.

This bone is known by the single kidney-shaped articular surface on its base, the deeply grooved appearance of the plantar surface of its head, and its great thickness relatively to its length. When it is placed in its natural position, the concave border of the kidney-shaped articular surface on its base points to the side to which the bone belongs.

**Attachment of Muscles.**—To three: part of the Tibialis anticus, the Peroneus longus, and the First dorsal interosseous.

The **Second** (Fig. 147) is the longest and largest of the remaining metatarsal bones, being prolonged backward into the recess formed between the three cuneiform bones. Its *tarsal extremity* is broad above, narrow and rough below. It presents four articular surfaces: one behind, of a triangular form, for articulation with the middle cuneiform; one at the upper part of its internal lateral surface, for articulation with the internal cuneiform: and two on its external lateral surface—an upper and a lower, separated by a rough non-articular interval. Each of these articular surfaces is divided by a vertical ridge into two facets, thus making four facets; the two anterior of these articulate with the third metatarsal; the two posterior (sometimes continuous) with the external cuneiform. In addition

FIG. 147.—The second metatarsal. (Left.)

FIG. 148.—The third metatarsal. (Left.)

to these articular surfaces there is occasionally a fifth when this bone articulates with the first metatarsal bone. It is oval in shape, and is situated on the inner side of the shaft near the base.

The facets on the tarsal extremity of the second metatarsal bone serve at once to distinguish it from the rest, and to indicate the foot to which it belongs; there being one facet at the upper angle of the internal surface, and two facets, each subdivided into two parts, on the external surface, pointing to the side to which the bone belongs. The fact that the two posterior subdivisions of these external facets sometimes run into one should not be forgotten.

**Attachment of Muscles.**—To four: the Adductor obliquus hallucis, First and Second dorsal interosseous, and a slip from the tendon of the Tibialis posticus; occasionally also a slip from the Peroneus longus.

The **Third** (Fig. 148) articulates behind, by means of a triangular smooth surface, with the external cuneiform; on its inner side, by two facets, with the second metatarsal; and on its outer side, by a single facet, with the fourth metatarsal. The latter facet is of circular form and situated at the upper angle of the base.

The third metatarsal is known by its having at its tarsal end two undivided facets on the inner side, and a single facet on the outer. This distinguishes it from the second metatarsal, in which the two facets, found on one side of its tarsal end, are each subdivided into two. The single facet (when the bone is put in its natural position) is on the side to which the bone belongs.

**Attachment of Muscles.**—To five: Adductor obliquus hallucis, Second and Third dorsal, and First plantar interosseous, and a slip from the tendon of the Tibialis posticus.

The **Fourth** (Fig. 149) is smaller in size than the preceding; its *tarsal extremity* presents a terminal quadrilateral surface, for articulation with the cuboid; a smooth facet on the inner side, divided by a ridge into an anterior portion for articulation with the third metatarsal, and a posterior portion for articulation with the external cuneiform; on the outer side a single facet, for articulation with the fifth metatarsal.

The fourth metatarsal is known by its having a single facet on either side of the tarsal extremity, that on the inner side being divided into two parts. If this subdivision be not recognizable, the fact that its tarsal end is bent somewhat outward will indicate the side to which it belongs.

**Attachment of Muscles.**—To five: Adductor obliquus hallucis, Third and Fourth dorsal, and Second plantar interosseous, and a slip from the tendon of the Tibialis posticus.


Fig. 149.—The fourth metatarsal. (Left.)

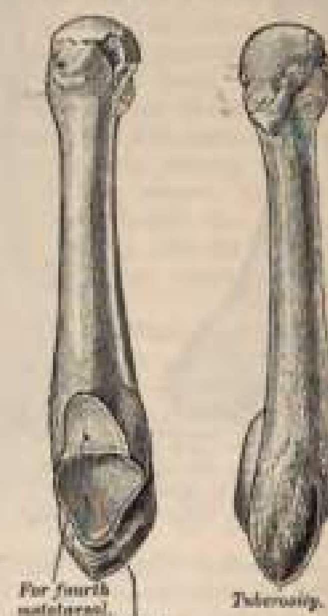



Fig. 150.—The fifth metatarsal. (Left.)

The **Fifth** (Fig. 150) is recognized by the tubercular eminence on the outer side of its base. It articulates behind, by a triangular surface cut obliquely from without inward, with the cuboid, and internally with the fourth metatarsal.

The projection on the outer side of this bone at its tarsal end at once distinguishes it from the others, and points to the side to which it belongs.

**Attachment of Muscles.**—To six: the Peroneus brevis, Peroneus tertius, Flexor brevis minimi digiti, Adductor transversus hallucis, Fourth dorsal, and Third plantar.

**Articulations.**—Each bone articulates with the tarsal bones by one extremity, and by the other with the first row of phalanges. The number of tarsal bones with which each metatarsal articulates is one for the first, three for the second, one for the third, two for the fourth, and one for the fifth.

## The Phalanges.

The **Phalanges** of the foot, both in number and general arrangement, resemble those in the hand; there being two in the great toe and three in each of the other toes.

The phalanges of the *first row* resemble closely those of the hand. The *shaft* is compressed from side to side, convex above, concave below. The *posterior extremity* is concave; and the *anterior extremity* presents a trochlear surface, for articulation with the second phalanges.

The phalanges of the *second row* are remarkably small and short, but rather broader than those of the first row.

The *ungual* phalanges in form resemble those of the fingers; but they are smaller, flattened from above downward, presenting a broad base for articulation with the second row, and an expanded extremity for the support of the nail and end of the toe.

**Articulation.**—The first row, with the metatarsal bones behind and second phalanges in front; the second row of the four outer toes, with the first and third phalanges; of the great toe, with the first phalanx; the third row of the four outer toes, with the second phalanges.

**Attachment of Muscles.**—To the first phalanges. Great toe, five muscles: innermost tendon of Extensor brevis digitorum, Abductor hallucis, Adductor obliquus hallucis, Flexor brevis hallucis, Adductor transversus hallucis. Second toe, three muscles: First and Second dorsal interosseous and First lumbrical. Third toe, three muscles: Third dorsal and First plantar interosseous and Second lumbrical. Fourth toe, three muscles: Fourth dorsal and Second plantar interosseous and Third lumbrical. Fifth toe, four muscles: Flexor brevis minimi digiti, Abductor minimi digiti, and Third plantar interosseous, and Fourth lumbrical.—Second phalanges. Great toe; Extensor longus hallucis, Flexor longus hallucis. Other toes; Flexor brevis digitorum, one slip of the common tendon of the Extensor longus and brevis digitorum.[1]—Third phalanges: two slips from the common tendon of the Extensor longus and Extensor brevis digitorum, and the Flexor longus digitorum.

## Development of the Foot (Fig. 151).

The **Tarsal bones** are each developed by a single centre, excepting the os calcis, which has an epiphysis for its posterior extremity. The centres make their appearance in the following order: os calcis, at the sixth month of fœtal life; astragalus, about the seventh month; cuboid, at the ninth month; external cuneiform, during the first year; internal cuneiform in the third year; middle cuneiform and navicular in the fourth year. The epiphysis for the posterior tuberosity of the os calcis appears at the tenth year, and unites with the rest of the bone soon after puberty.

The **Metatarsal bones** are each developed by *two* centres: one for the shaft and one for the digital extremity in the four outer metatarsal; one for the shaft and one for the base in the metatarsal bone of the great toe.[2] Ossification commences in the centre of the shaft about the ninth week, and extends toward either extremity. The centre in the proximal end of the first metatarsal bone appears about the third year, the centre in the distal end of the other bones between the fifth and eighth years; they become joined between the eighteenth and twentieth years.

The **Phalanges** are developed by *two* centres for each bone: one for the shaft and one for the metatarsal extremity. The centre for the shaft appears about the tenth week, that for the epiphysis between the fourth and tenth years; they join the shaft about the eighteenth year.

## Construction of the Foot as a Whole.

The foot is constructed on the same principles as the hand, but modified to form a firm basis of support for the rest of the body when in the erect position. It

[1] Except the second phalanx of the fifth toe, which receives no slip from the Extensor brevis digitorum.

[2] As was noted in the first metacarpal bone, so in the first metatarsal, there is often to be observed a tendency to the formation of a second epiphysis in the distal extremity. (See footnote, p. 171.)

is more solidly constructed, and its component parts are less movable on each other than in the hand. This is especially the case with the great toe, which has to assist in supporting the body, and is therefore constructed with greater solidity; it lies parallel with the other toes, and has a very limited degree of mobility, whereas the thumb, which is occupied in numerous and varied movements, is constructed in such a manner as to permit of great mobility. Its metacarpal bone is directed away from the others, so as to form an acute angle with the second, and it enjoys a considerable range of motion at its articulation with the carpus. The foot is placed at right angles to the leg—a position which is almost peculiar to man, and has relation to the erect position which he maintains. In order to allow of its supporting the weight of the whole body in this position with the least expenditure of material, it is constructed in the form of an arch. This arch is not, however, made up of two equal limbs. The hinder one, which is made up of the os calcis and the posterior part of the astragalus, is about half the length of the anterior limb, and measures about three inches. The anterior limb consists of the rest of

Fig. 151.—Plan of the development of the foot.

the tarsal and the metatarsal bones, and measures about seven inches. It may be said to consist of two parts, an inner segment made up of the head of the astragalus, the navicular, the three cuneiform, and the three inner metatarsal bones; and an outer segment composed of the os calcis, the cuboid, and the two outer metatarsal bones. The summit of the arch is at the superior articular surface of the astragalus; and its two extremities—that is to say, the two piers on which the arch rests in standing—are the tubercles on the under surface of the os calcis posteriorly, and the heads of the metatarsal bones anteriorly. The weakest part of the arch is the joint between the astragalus and scaphoid, and here it is more liable to yield in those who are overweighted, and in those in whom the ligaments which complete and preserve the arch are relaxed. This weak point in the arch is braced on its concave surface by the inferior calcaneo-navicular ligament, which is more elastic than most other ligaments, and thus allows the arch to yield from jars or shocks applied to the anterior portion of the foot and quickly restores it to its pristine condition. This ligament is supported internally by blending with the Deltoid ligament, and inferiorly by the tendon of the Tibialis posticus muscle, which is spread out into a fan-shaped insertion, and prevents undue tension of the ligament or such an amount of stretching as would permanently elongate it.

In addition to this longitudinal arch the foot presents a transverse arch, at the anterior part of the tarsus and hinder part of the metatarsus. This, however, can scarcely be described as a true arch, but presents more the character of a half-dome. The inner border of the central portion of the longitudinal arch is elevated from the ground, and from this point the bones arch over to the outer border, which is in contact with the ground, and, assisted by the longitudinal arch, produce a sort of rounded niche on the inner side of the foot, which gives the appearance of a transverse as well as a longitudinal arch.

The line of the foot, from the point of the heel to the toes, is not quite straight, but is directed a little outward, so that the inner border is a little convex and the outer border concave. This disposition of the bones becomes more marked when the longitudinal arch of the foot is lost, as in the disease known under the name of "flat-foot."

**Surface Form.**—On the dorsum of the foot the individual bones are not to be distinguished with the exception of the head of the astragalus, which forms a rounded projection in front of the ankle-joint when the foot is forcibly extended. The whole surface forms a smooth convex outline, the summit of which is the ridge formed by the head of the astragalus, the navicular, the middle cuneiform, and the second metatarsal bones; from this it gradually inclines outward and more rapidly inward. On the inner side of the foot, the internal tuberosity of the os calcis and the ridge separating the inner from the posterior surface of the bone may be felt most posteriorly. In front of this, and below the internal malleolus, may be felt the projection of the sustentaculum tali. Passing forward is the well-marked tuberosity of the navicular bone, situated about an inch or an inch and a quarter in front of the internal malleolus. Further toward the front, the ridge formed by the base of the first metatarsal bone can be obscurely felt, and from this the shaft of the bone can be traced to the expanded head articulating with the base of the first phalanx of the great toe. Immediately beneath the base of this phalanx, the internal sesamoid bone is to be felt. Lastly, the expanded ends of the bones forming the last joint of the great toe are to be felt. On the outer side of the foot the most posterior bony point is the outer tuberosity of the os calcis, with the ridge separating the posterior from the outer surface of the bone. In front of this the greater part of the external surface of the os calcis is subcutaneous; on it, below and in front of the external malleolus, may be felt the peroneal ridge, when this process is present. Farther forward, the base of the fifth metatarsal bone forms a prominent and well-defined landmark, and in front of this the shaft of the bone, with its expanded head, and the base of the first phalanx may be defined. The sole of the foot is almost entirely covered by soft parts, so that but few bony parts are to be made out, and these somewhat obscurely. The hinder part of the under surface of the os calcis and the heads of the metatarsal bones, with the exception of the first, which is concealed by the sesamoid bones, may be recognized.

**Surgical Anatomy.**—Considering the injuries to which the foot is subjected, it is surprising how seldom the tarsal bones are fractured. This is no doubt due to the fact that the tarsus is composed of a number of bones, articulated by a considerable extent of surface and joined together by very strong ligaments, which serve to break the force of violence applied to this part of the body. When fracture does occur, these bones, being composed for the most part of a soft cancellous structure, covered only by a thin shell of compact tissue, are often extensively comminuted, especially as most of the fractures are produced by direct violence. And having only a very scanty amount of soft parts over them, the fractures are very often compound, and amputation is frequently necessary.

When fracture occurs in the anterior group of tarsal bones, it is almost invariably the result of direct violence; but fractures of the posterior group, that is, of the calcaneum and astragalus, are most frequently produced by falls from a height on to the feet; though fracture of the os calcis may be caused by direct violence or by muscular action. The posterior part of the bone, that is, the part behind the articular surfaces, is almost always the seat of the fracture, though some few cases of fracture of the sustentaculum tali and of vertical fracture between the two articulating facets have been recorded. The neck of the astragalus, being the weakest part of the bone, is most frequently fractured, though fractures may occur in any part and almost in any direction, either associated or not with fracture of other bones.

In cases of club-foot, especially in congenital cases, the bones of the tarsus become altered in shape and size, and displaced from their proper positions. This is especially the case in congenital equino-varus, in which the astragalus, particularly about the head, becomes twisted and atrophied, and a similar condition may be present in the other bones, more especially the navicular. The tarsal bones are peculiarly liable to become the seat of tuberculous caries from comparatively trivial injuries. There are several reasons to account for this. They are composed of a delicate cancellated structure, surrounded by intricate synovial membranes. They are situated at the farthest point from the central organ of the circulation and exposed to vicissitudes of temperature; and, moreover, on their dorsal surface are thinly clad with soft parts which have but a scanty blood-supply. And finally, after slight injuries, they are not maintained in a condition of rest to the same extent as similar injuries in some other parts of the body. Caries of the calcaneum or astragalus may remain limited to the one bone for a long period, but when one of the other bones is affected, the remainder frequently become involved, in consequence of the disease spreading through the large and complicated synovial membrane which is more or less common to these bones.

Amputation of the whole or a part of the foot is frequently required either for injury or disease. The principal amputations are as follow: (1) Syme's: amputation at the ankle-joint by a heel-flap, with removal of the malleoli and sometimes a thin slice from the lower end of the tibia. (2) Roux's: amputation at the ankle-joint by a large internal flap. (3) Pirogoff's amputation: removal of the whole of the tarsal bones, except the posterior part of the os calcis and a thin slice from the tibia and fibula including the two malleoli. The sawn surface of the os calcis is then turned up and united to the similar surface of the tibia. (4) Subastragaloid amputation: removal of the foot below the astragalus through the joint between it and the os calcis. This operation has been modified by Hancock, who leaves the posterior third of the os calcis and turns it up against the denuded surface of the astragalus. This latter operation is of doubtful utility and is rarely performed. (5) Chopart's or medio-tarsal: removal of the anterior part of the foot with all the tarsal bones except the os calcis and astragalus; disarticulation being effected through the joints between the astragalo-scaphoid and calcaneo-cuboid in joints. (6) Lisfranc's: amputation of the anterior part of the foot through the tarso-metatarsal joints. This has been modified by Hey, who disarticulated through the joints of the four outer metatarsal bones with the tarsus, and sawed off the projecting internal cuneiform; and by Skey, who sawed off the base of the second metatarsal bone and disarticulated the others.

The bones of the tarsus occasionally require removal individually. This is especially the case with the astragalus and os calcis for disease limited to the one bone, or again the astragalus may require excision in cases of subastragaloid dislocation, or, as recommended by Mr. Lund, in cases of inveterate talipes. The cuboid has been removed for the same reason by Mr. Solly. But both these two latter operations have fallen very much into disuse, and have been superseded by resection of a wedge-shaped piece of bone from the outer side of the tarsus. Finally, Mickulicz and Watson have devised operations for the removal of more extensive portions of the tarsus. Mickulicz's operation consists in the removal of the os calcis and astragalus, along with the articular surfaces of the tibia and fibula, and also of the scaphoid and cuboid. The remaining portion of the tarsus is then brought into contact with the sawn surfaces of the tibia and fibula, and fixed there. The result is a position of the shortened foot resembling talipes equinus. Watson's operation is adapted to those cases where the disease is confined to the anterior tarsal bones. By two lateral incisions he saws through the bases of the metatarsal bones in front and opens up the joints between the scaphoid and astragalus, and the cuboid and os calcis, and removes the intervening bones.

The metatarsal bones and phalanges are nearly always broken by direct violence, and in the majority of cases the injury is the result of severe crushing accidents, necessitating amputation. The metatarsal bones, and especially that of the great toe, are frequently diseased, either in tubercular subjects or in perforating ulcer of the foot.

## Sesamoid Bones.

These are small rounded masses, cartilaginous in early life, osseous in the adult, which are developed in those tendons which exert a great amount of pressure upon the parts over which they glide. It is said that they are more commonly found in the male than in the female, and in persons of an active muscular habit than in those who are weak and debilitated. They are invested throughout their whole surface by the fibrous tissue of the tendon in which they are found, excepting upon that side which lies in contact with the part over which they play, where they present a free articular facet. They may be divided into two kinds: those which glide over the articular surfaces of joints, and those which play over the cartilaginous facets found on the surfaces of certain bones.

The sesamoid bones of the joints in the upper extremity, are two on the palmar surface of the metacarpo-phalangeal joint in the thumb, developed in the tendons of the Flexor brevis pollicis; occasionally one or two opposite the metacarpo-phalangeal articulations of the fore and little fingers; and, still more rarely, one opposite the same joints of the third and fourth fingers. In the lower extremity, the patella, which is developed in the tendon of the Quadriceps extensor; two small sesamoid bones, found in the tendons of the Flexor brevis hallucis, opposite the metatarso-phalangeal joint of the great toe; and occasionally one in the metatarso-phalangeal joint of the second toe, the little toe, and, still more rarely, the third and fourth toes.

Those found in the tendons which glide over certain bones occupy the following situations: one sometimes found in the tendon of the Biceps cubiti, opposite the tuberosity of the radius; one in the tendon of the Peroneus longus, where it glides through the groove in the cuboid bone; one appears late in life in the tendon of the Tibialis anticus, opposite the smooth facet of the internal cuneiform bone; one is found in the tendon of the Tibialis posticus, opposite the inner side of the head of the astragalus; one in the outer head of the Gastrocnemius, behind the outer condyle of the femur; and one in the conjoined tendon of the Psoas and Iliacus, where it glides over the os pubis. Sesamoid bones are found occasionally in the tendon of the Gluteus maximus, as it passes over the great trochanter, and in the tendons which wind round the inner and outer malleoli.

# THE ARTICULATIONS.

THE various bones of which the Skeleton consists are connected together at different parts of their surfaces, and such a connection is designated by the name of *Joint* or *Articulation*. If the joint is *immovable*, as between the cranial and most of the facial bones, the adjacent margins of the bones are applied in almost close contact, a thin layer of fibrous membrane, the *sutural ligament*, and, at the base of the skull, in certain situations, a thin layer of cartilage, being interposed. Where slight movement is required, combined with great strength, the osseous surfaces are united by tough and elastic fibro-cartilages, as in the joints between the vertebral bodies and interpubic articulations; but in the *movable* joints the bones forming the articulation are generally expanded for greater convenience of mutual connection, covered by *cartilage*, held together by strong bands or capsules of fibrous tissue called *ligaments*, and partially lined by a membrane, the *synovial membrane*, which secretes a fluid to lubricate the various parts of which the joint is formed; so that the structures which enter into the formation of a joint are bone, cartilage, fibro-cartilage, ligament, and synovial membrane.

**Bone** constitutes the fundamental element of all the joints. In the long bones the extremities are the parts which form the articulations; they are generally somewhat enlarged, consisting of spongy cancellous tissue, with a thin coating of compact substance. In the flat bones the articulations usually take place at the edges, and, in the short bones at various parts of their surface. The layer of compact bone which forms the articular surface, and to which the cartilage is attached, is called the *articular lamella*. It is of a white color, extremely dense, and varies in thickness. Its structure differs from ordinary bone-tissue in this respect, that it contains no Haversian canals, and its lacunæ are much larger than in ordinary bone and have no canaliculi. The vessels of the cancellous tissue, as they approach the articular lamella, turn back in loops, and do not perforate it; this layer is consequently more dense and firmer than ordinary bone, and is evidently designed to form a firm and unyielding support for the articular cartilage.

The **cartilage**, which covers the articular surfaces of bone, and is called the *articular*, will be found described, with the other varieties of cartilage, in the section on General Anatomy.

**Ligaments** consist of bands of various forms, serving to connect together the articular extremities of bones, and composed mainly of bundles of *white fibrous tissue* placed parallel with, or closely interlaced with, one another, and presenting a white, shining, silvery aspect. A ligament is pliant and flexible, so as to allow of the most perfect freedom of movement, but strong, tough, and inextensile, so as not readily to yield under the most severely applied force; it is consequently well adapted to serve as the connecting medium between the bones. Some ligaments consist entirely of *yellow elastic tissue*, as the ligamenta subflava, which connect together the adjacent arches of the vertebræ and the ligamentum nuchæ in the lower animals. In these cases it will be observed that the elasticity of the ligament is intended to act as a substitute for muscular power.

**Synovial membrane** is a thin, delicate membrane of connective tissue, with branched connective-tissue corpuscles. Its secretion is thick, viscid, and glairy, like the white of egg, and is hence termed *synovia*. The synovial membranes found in the body admit of subdivision into three kinds—articular, bursal, and vaginal.

The *articular synovial membranes* are found in all the freely movable joints. In the fœtus this membrane is said, by Toynbee, to be continued over the surface of the cartilages; but in the adult it is wanting, excepting at their circumference, upon which it encroaches for a short distance, and to which it is firmly attached: it then invests the inner surface of the capsular or other ligaments enclosing the joint, and is reflected over the surface of any tendons passing through its cavity, as the tendon of the Popliteus in the knee and the tendon of the Biceps in the shoulder. Hence the articular synovial membrane may be regarded as a short wide tube, attached by its open ends to the margins of the articular cartilages, and covering the inner surface of the various ligaments which connect the articular surfaces, so that along with the cartilages it completely encloses the joint-cavity. In some of the joints the synovial membrane is thrown into folds, which pass across the cavity. They are called *synovial ligaments*, and are especially distinct in the knee. In other joints there are flattened folds, subdivided at their margins into fringe-like processes, the vessels of which have a convoluted arrangement. These latter generally project from the synovial membrane near the margin of the cartilage and lie flat upon its surface. They consist of connective tissue covered with endothelium, and contain fat-cells in variable quantities, and, more rarely, isolated cartilage-cells. The larger folds often contain considerable quantities of fat. They were described by Clopton Havers as *mucilaginous glands*, and as the source of the synovial secretion. Under certain diseased conditions similar processes are found covering the entire surface of the synovial membrane, forming a mass of pedunculated fibro-fatty growths which project into the joint. Similar structures are also found in some of the bursal and vaginal synovial membranes.

The *bursal synovial membranes* are found interposed between surfaces which move upon each other, producing friction, as in the gliding of a tendon or of the integument over projecting bony surfaces. They admit of subdivision into two kinds, the *bursæ mucosæ* and the *bursæ synoviæ*. The *bursæ mucosæ* are large, simple, or irregular cavities in the subcutaneous areolar tissue, enclosing a clear viscid fluid. They are found in various situations, as between the integument and the front of the patella, over the olecranon, the malleoli, and other prominent parts. The *bursæ synoviæ* are found interposed between muscles or tendons as they play over projecting bony surfaces, as between the Glutei muscles and the surface of the great trochanter. They consist of a thin wall of connective tissue, partially covered by patches of cells, and contain a viscid fluid. Where one of these exists in the neighborhood of a joint, it may communicate with its cavity, as in the case of the bursa between the tendon of the Psoas and Iliacus and the capsular ligament of the hip, or the one interposed between the under surface of the Subscapularis and the neck of the scapula.

The *vaginal synovial membranes* (*synovial sheaths*) serve to facilitate the gliding of tendons in the osseo-fibrous canals through which they pass. The membrane is here arranged in the form of a sheath, one layer of which adheres to the wall of the canal, and the other is reflected upon the surface of the contained tendon, the space between the two free surfaces of the membrane containing synovia. These sheaths are chiefly found surrounding the tendons of the flexor and extensor muscles of the fingers and toes as they pass through the osseo-fibrous canals in the hand or foot.

**Synovia** is a transparent, yellowish-white or slightly reddish fluid, viscid like the white of egg, having an alkaline reaction and slightly saline taste. It consists, according to Frerichs, in the ox, of 94.85 water, 0.56 mucus and epithelium, 0.07 fat, 3.51 albumen and extractive matter, and 0.99 salts.

The articulations are divided into three classes: *synarthrosis*, or immovable; *amphiarthrosis*, or mixed; and *diarthrosis*, or movable joints.

### 1. Synarthrosis. Immovable Articulations.

**Synarthrosis** includes all those articulations in which the surfaces of the bones are in almost direct contact, fastened together by an intervening mass of connective tissue, and in which there is no appreciable motion, as the joints between the bones of the cranium and face, excepting those of the lower jaw. The varieties of synarthrosis are four in number: Sutura, Schindylesis, Gomphosis, and Synchondrosis.

**Sutura** (a seam) is that form of articulation where the contiguous margins of flat bones are united by a thin layer of fibrous tissue. It is met with only in the skull. Where the articulating surfaces are connected by a series of processes and indentations interlocked together, it is termed *sutura vera*, of which there are three varieties: sutura dentata, serrata, and limbosa. The surfaces of the bones are not in direct contact, being separated by a layer of membrane continuous externally with the pericranium, internally with the dura mater. The *sutura dentata* (*dens*, a tooth) is so called from the tooth-like form of the projecting articular processes, as in the suture between the parietal bones. In the *sutura serrata* (*serra*, a saw) the edges of the two bones forming the articulation are serrated like the teeth of a fine saw, as between the two portions of the frontal bone. In the *sutura limbosa* (*limbus*, a selvage), besides the dentated processes, there is a certain degree of bevelling of the articular surfaces, so that the bones overlap one another, as in the suture between the parietal and frontal bones. When the articulation is formed by roughened surfaces placed in apposition with one another, it is termed the *false suture* (*sutura notha*), of which there are two kinds: the *sutura squamosa* (*squama*, a scale), formed by the overlapping of two contiguous bones by broad bevelled margins, as in the squamo-parietal (squamous) suture; and the *sutura harmonia* (ἁρμονία, a joining together), where there is simple apposition of two contiguous rough bony surfaces, as in the articulation between the two superior maxillary bones or of the horizontal plates of the palate bones.

**Schindylesis** (σχινδύλησις, a fissure) is that form of articulation in which a thin plate of bone is received into a cleft or fissure formed by the separation of two laminæ in another bone, as in the articulation of the rostrum of the sphenoid and perpendicular plate of the ethmoid with the vomer, or in the reception of the latter in the fissure between the superior maxillary and palate bones.

**Gomphosis** (γόμφος, a nail) is an articulation formed by the insertion of a conical process into a socket, as a nail is driven into a board; this is not illustrated by any articulation between bones, properly so called, but is seen in the articulation of the teeth with the alveoli of the maxillary bones.

**Synchondrosis.**—Where the connecting medium is cartilage the joint is termed a synchondrosis. This is a temporary form of joint, for the cartilage becomes converted into bone before adult life. Such a joint is found between the epiphyses and shafts of long bones.

## 2. Amphiarthrosis. Mixed Articulations.

In this form of articulation the contiguous osseous surfaces are either connected together by broad flattened disks of fibro-cartilage, of a more or less complex structure, which adhere to the end of each bone, as in the articulation between the bodies of the vertebræ and the pubic symphyses. This is termed **Symphysis.** Or, secondly, the bony surfaces are united by an interosseous ligament, as in the inferior tibio-fibular articulation. To this the term **Syndesmosis** is applied.

## 3. Diarthrosis. Movable Articulations.

This form of articulation includes the greater number of the joints in the body, mobility being their distinguishing character. They are formed by the approximation of two contiguous bony surfaces covered with cartilage, connected by ligaments and lined by synovial membrane. The varieties of joints in this class have been determined by the kind of motion permitted in each. There are two varieties in which the movement is uniaxial; that is to say, all movements take place around one axis. In one form, the Ginglymus, this axis is, practically speaking, transverse; in the other, the trochoid or pivot-joint, it is longitudinal. There are two varieties where the movement is biaxial, or around two horizontal axes at right angles to each other or at any intervening axis between the two. These are the condyloid and saddle-joint. There is one form of joint where the movement is polyaxial, the enarthrosis or ball-and-socket joint. And finally there are the Arthrodia or Gliding joints.

**Ginglymus** or **Hinge-joint** (γίγγλυμος, a hinge).—In this form of joint the articular surfaces are moulded to each other in such a manner as to permit motion only in one plane, forward and backward; the extent of motion at the same time being considerable. The direction which the distal bone takes in this motion is never in the same plane as that of the axis of the proximal bone, but there is always a certain amount of alteration from the straight line during flexion. The articular surfaces are connected together by strong lateral ligaments, which form their chief bond of union. The most perfect forms of ginglymus are the inter-phalangeal joints and the joint between the humerus and ulna; the knee and ankle are less perfect, as they allow a slight degree of rotation or lateral movement in certain positions of the limb.

**Trochoides** (pivot-joint).—Where the movement is limited to rotation, the joint is formed by a pivot-like process turning within a ring, or the ring on the pivot, the ring being formed partly of bone, partly of ligament. In the superior radio-ulnar articulation the ring is formed partly by the lesser sigmoid cavity of the ulna; in the rest of its extent, by the orbicular ligament; here the head of the radius rotates within the ring. In the articulation of the odontoid process of the axis with the atlas the ring is formed in front by the anterior arch of the atlas; behind, by the transverse ligament; here the ring rotates round the odontoid process.

**Condyloid Articulations.**—In this form of joint an ovoid articular head, or condyle, is received into an elliptical cavity in such a manner as to permit of flexion and extension, adduction and abduction and circumduction, but no axial rotation. The articular surfaces are connected together by anterior, posterior, and lateral ligaments. An example of this form of joint is found in the wrist.

**Articulations by Reciprocal Reception** (saddle-joint).—In this variety the articular surfaces are concavo-convex; that is to say, they are inversely convex in one direction and concave in the other. The movements are the same as in the preceding form; that is to say, there is flexion, extension, adduction, abduction, and circumduction, but no axial rotation. The articular surfaces are connected by a capsular ligament. The best example of this form of joint is the carpo-meta-carpal joint of the thumb.

**Enarthrosis** is that form of joint in which the distal bone is capable of motion around an indefinite number of axes which have one common centre. It is formed by the reception of a globular head into a deep cup-like cavity (hence the name "ball-and-socket"), the parts being kept in apposition by a capsular ligament strengthened by accessory ligamentous bands. **Examples** of this form of articulation are found in the hip and shoulder.

**Arthrodia** is that form of joint which admits of a gliding movement; it is formed by the approximation of plane surfaces or one slightly concave, the other slightly convex, the amount of motion between them being limited by the ligaments, or osseous processes, surrounding the articulation; as in the articular processes of the vertebræ, the carpal joints, except that of the os magnum with the scaphoid and semilunar bones, and the tarsal joints with the exception of the joint between the astragalus and the navicular.

On the next page, in a tabular form, are the names, distinctive characters, and examples of the different kinds of articulations.

## The Kinds of Movement admitted in Joints.

The movements admissible in joints may be divided into four kinds: gliding, angular movement, circumduction, and rotation. These movements are often, however, more or less combined in the various joints, so as to produce an infinite variety, and it is seldom that we find only one kind of motion in any particular joint.

- *Synarthrosis*, or Immovable Joint. Surfaces separated by fibrous membrane or by line of cartilage, without any intervening synovial cavity, and immovably connected with each other.
  As in joints of cranium and face (except lower jaw).
  - *Sutura*. Articulation by processes and indentations interlocked together.
    - *Sutura vera* (true), articulate by indented borders.
      - *Dentata*, having tooth-like processes.
        As in interparietal suture.
      - *Serrata*, having serrated edges like the teeth of a saw.
        As in interfrontal suture.
      - *Limbosa*, having bevelled margins and dentated processes.
        As in fronto-parietal suture.
    - *Sutura notha* (false), articulate by rough surfaces.
      - *Squamosa*, formed by thin bevelled margins, overlapping each other.
        As in squamo-parietal suture.
      - *Harmonia*, formed by the apposition of contiguous rough surfaces.
        As in intermaxillary suture.
  - *Schindylesis*.—Articulation formed by the reception of a thin plate of one bone into a fissure of another.
    As in articulation of rostrum of sphenoid with vomer.
  - *Gomphosis*.—Articulation formed by the insertion of a conical process into a socket: the teeth.
- *Amphiarthrosis*, Mixed Articulation.
  - *Symphysis*.—Surfaces connected by fibro-cartilage, not separated by synovial membrane, and having limited motion. As in joints between bodies of vertebræ.
  - *Syndesmosis*.—Surfaces united by an interosseous ligament. As in the inferior tibio-fibular articulation.
- *Diarthrosis*, Movable Joint.
  - *Ginglymus*.—Hinge-joint: motion limited to two directions, forward and backward. Articular surfaces fitted together so as to permit of movement in one plane. As in the interphalangeal joints and the joint between the humerus and the ulna.
  - *Trochoides, or Pivot-joint*.—Articulation by a pivot process turning within a ring or ring around a pivot. As in superior radio-ulnar articulation and atlanto-axial joint.
  - *Condyloid*.—Ovoid head received into elliptical cavity. Movements in every direction except axial rotation. As the wrist-joint.
  - *Reciprocal Reception* (saddle-joint).—Articular surfaces inversely convex in one direction and concave in the other. Movement in every direction except axial rotation. As in the carpo-metacarpal joint of the thumb.
  - *Enarthrosis*.—Ball-and-socket joint; capable of motion in all directions. Articulations by a globular head received into a cup-like cavity. As in hip- and shoulder-joints.
  - *Arthrodia*.—Gliding joint; articulations by plane surfaces, which glide upon each other. As in carpal and tarsal articulations.

*Gliding movement* is the most simple kind of motion that can take place in a joint, one surface gliding or moving over another without any angular or rotatory movement. It is common to all movable joints, but in some, as in the articulations of the carpus and tarsus, it is the only motion permitted. This movement is not confined to plane surfaces, but may exist between any two contiguous surfaces, of whatever form, limited by the ligaments which enclose the articulation.

*Angular movement* occurs only between the long bones, and by it the angle between the two bones is increased or diminished. It may take place in four directions: forward and backward, constituting flexion and extension, or inward and outward, from the mesial line of the body (or in the fingers and toes from the middle line of the hand or foot), constituting adduction and abduction. The strictly ginglymoid or hinge-joints admit of flexion and extension only. Abduction and adduction, combined with flexion and extension, are met with in the more movable joints; as in the hip, shoulder, and metacarpal joint of the thumb, and partially in the wrist.

*Circumduction* is that limited degree of motion which takes place between the head of a bone and its articular cavity, whilst the extremity and sides of the limb are made to circumscribe a conical space, the base of which corresponds with the inferior extremity of the limb, the apex with the articular cavity; this kind of motion is best seen in the shoulder- and hip-joints.

*Rotation* is the movement of a bone upon an axis, which is the axis of the pivot on which the bone turns, as in the articulation between the atlas and axis, when the odontoid process serves as a pivot around which the atlas turns; or else is the axis of a pivot-like process which turns within a ring, as in the rotation of the radius upon the humerus.

*Ligamentous Action of Muscles.*—The movements of the different joints of a limb are combined by means of the long muscles which pass over more than one joint, and which, when relaxed and stretched to their greatest extent, act as elastic ligaments in restraining certain movements of one joint, except when combined with corresponding movements of the other, these latter movements being usually in the opposite direction. Thus the shortness of the hamstring muscles prevents complete flexion of the hip, unless the knee-joint is also flexed, so as to bring their attachments nearer together. The uses of this arrangement are threefold: 1. It co-ordinates the kinds of movement which are the most habitual and necessary, and enables them to be performed with the least expenditure of power. "Thus in the usual gesture of the arms, whether in grasping or rejecting, the shoulder and the elbow are flexed simultaneously, and simultaneously extended," in consequence of the passage of the Biceps and Triceps cubiti over both joints. 2. It enables the short muscles which pass over only one joint to act upon more than one. "Thus, if the Rectus femoris remain tonically of such length that, when stretched over the extended hip, it compels extension of the knee, then the Gluteus maximus becomes not only an extensor of the hip, but an extensor of the knee as well." 3. It provides the joints with ligaments which, while they are of very great power in resisting movements to an extent incompatible with the mechanism of the joint, at the same time spontaneously yield when necessary. "Taxed beyond its strength, a ligament will be ruptured, whereas a contracted muscle is easily relaxed; also, if neighboring joints be united by ligaments, the amount of flexion or extension of each must remain in constant proportion to that of the other; while, if the union be by muscles, the separation of the points of attachment of those muscles may vary considerably in different varieties of movement, the muscles adapting themselves tonically to the length required." The quotations are from a very interesting paper by Dr. Cleland in the *Journal of Anatomy and Physiology*, No. 1, 1866, p. 85; by whom I believe this important fact in the mechanism of joints was first clearly pointed out, though it has been independently observed afterward by other anatomists. Dr. W. W. Keen points out how important it is "that the surgeon should remember this ligamentous action of muscles in making passive motion—for instance, at the wrist after Colles's fracture. If the fingers be extended, the wrist can be flexed to a right angle. If, however, they be first flexed, as in "making a fist," flexion at the wrist is quickly limited to from forty to fifty degrees in different persons, and is very painful beyond that point. Hence passive motion here should be made with the fingers extended. In the leg, when flexing the hip, the knee should be flexed." Dr. Keen further points out that "a beautiful illustration of this is seen in the perching of birds, whose toes are forced to clasp the perch by just such a passive ligamentous action so soon as they stoop. Hence they can go to sleep and not fall off the perch."

The articulations may be arranged into those of the trunk, those of the upper extremity, and those of the lower extremity.

## ARTICULATIONS OF THE TRUNK.

These may be divided into the following groups, viz.:

I. Of the vertebral column.
II. Of the atlas with the axis.
III. Of the atlas with the occipital bone.
IV. Of the axis with the occipital bone.
V. Of the lower jaw.
VI. Of the ribs with the vertebræ.
VII. Of the cartilages of the ribs with the sternum and with each other.
VIII. Of the sternum.
IX. Of the vertebral column with the pelvis.
X. Of the pelvis.

### I. Articulations of the Vertebral Column.

The different segments of the spine are connected together by ligaments, which may be divided into five sets: 1. Those connecting the *bodies* of the vertebræ. 2. Those connecting the *laminæ*. 3. Those connecting the *articular processes*. 4. Those connecting the *spinous processes*. 5. Those of the *transverse processes*.

The articulations of the *bodies* of the vertebræ with each other form a series of amphiarthrodial joints; those between the *articular processes* form a series of arthrodial joints.

#### 1. The Ligaments of the Body.

Anterior Common Ligament. Posterior Common Ligament.
Intervertebral Substance.

The **Anterior Common Ligament** (Figs. 152, 153, 160, 164) is a broad and strong band of fibres which extends along the anterior surface of the bodies of the vertebræ from the axis to the sacrum. It is broader below than above, thicker in the dorsal than in the cervical or lumbar regions, and somewhat thicker opposite the front of the body of each vertebra than opposite the intervertebral substance. It is attached, above, to the body of the axis by a pointed process, where it is continuous with the anterior atlanto-axial ligament, and is connected with the tendon of insertion of the Longus colli muscle, and extends down as far as the upper bone of the sacrum. It consists of dense longitudinal fibres, which are intimately adherent to the intervertebral substance and the prominent margins of the vertebræ, but less closely to the middle of the bodies. In the latter situation the fibres are exceedingly thick, and serve to fill up the concavities on their front surface and to make the anterior surface of the spine more even. This ligament is composed of several layers of fibres, which vary in length, but are closely interlaced with each other. The most superficial or longest fibres extend between four or five vertebræ. A second subjacent set extend between two or three vertebræ, whilst a third set, the shortest and deepest, extend from one vertebra to the next. At the side of the bodies the ligament consists of a few short fibres, which pass from one vertebra to the next, separated from the median portion by large oval apertures for the passage of vessels.

The **Posterior Common Ligament** (Figs. 152, 156) is situated within the spinal canal, and extends along the posterior surface of the bodies of the vertebræ from the body of the axis above, where it is continuous with the occipito-axial ligament, to the sacrum below. It is broader above than below, and thicker in the dorsal than in the cervical or lumbar regions. In the situation of the intervertebral substance and contiguous margins of the vertebræ, where the ligament is more intimately adherent, it is broad, and presents a series of dentations with intervening concave margins; but it is narrow and thick over the centre of the bodies, from which it is separated by the *venæ basis vertebræ*. This ligament is composed of smooth, shining, longitudinal fibres, denser and more compact than those of the anterior ligament, and composed of a superficial layer occupying the interval between three or four vertebræ, and of a deeper layer which extends between one vertebra and the next adjacent to it. It is separated from the dura mater of

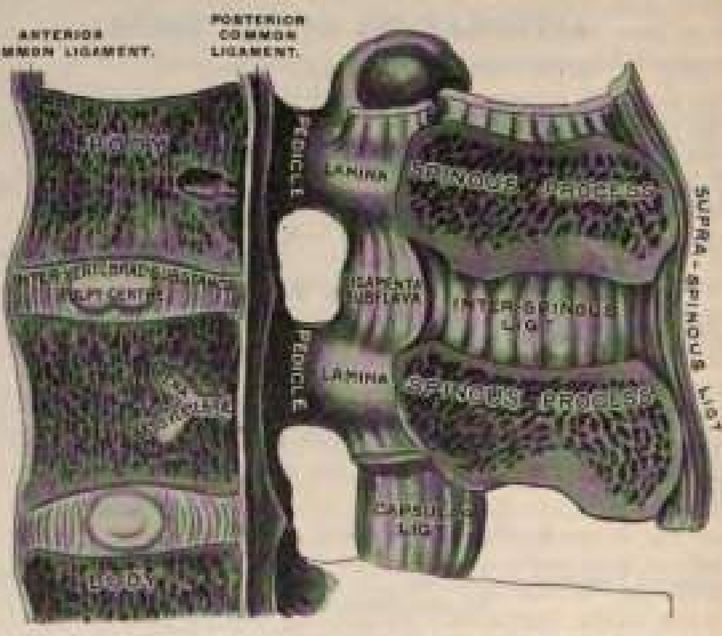



Fig. 152.—Vertical section of two vertebræ and their ligaments, from the lumbar region.

the spinal cord by some loose connective tissue which is very liable to serous infiltration.

The **Intervertebral Substance** (Figs. 152, 161) is a lenticular disk of composite structure interposed between the adjacent surfaces of the bodies of the vertebræ from the axis to the sacrum, and forming the chief bond of connection between those bones. These disks vary in shape, size, and thickness in different parts of the spine. In *shape* they accurately correspond with the surfaces of the bodies between which they are placed, being oval in the cervical and lumbar regions, and circular in the dorsal. Their *size* is greatest in the lumbar region. In *thickness* they vary not only in the different regions of the spine, but in different parts of the same disk: thus, they are thicker in front than behind in the cervical and lumbar regions, while they are uniformly thick in the dorsal region. The intervertebral disks form about one-fourth of the spinal column, exclusive of the first two vertebræ; they are not equally distributed, however, between the various bones; the dorsal portion of the spine having, in proportion to its length, a much smaller quantity than in the cervical and lumbar regions, which necessarily gives to the latter parts greater pliancy and freedom of movement. The intervertebral disks are adherent, by their surfaces, to a thin layer of hyaline cartilage which covers the upper and under surfaces of the bodies of the vertebræ, and in which, in early life, the epiphyseal plate develops, and by their circumference are closely connected in front to the anterior, and behind to the posterior common ligament; whilst in the dorsal region they are connected laterally, by means of the interarticular ligament, to the heads of those ribs which articulate with two vertebræ; they, consequently, form part of the articular cavities in which the heads of these bones are received.

**Structure of the Intervertebral Substance.**—The intervertebral substance is composed, at its circumference, of laminæ of fibrous tissue and fibro-cartilage; and, at its centre, of a soft, pulpy, highly elastic substance, of a yellowish color, which rises up considerably above the surrounding level when the disk is divided horizontally. This pulpy substance, which is especially well developed in the lumbar region, is the remains of the chorda dorsalis, and, according to Luschka, contains a small synovial cavity in its centre. The laminæ are arranged concentrically one within the other, the outermost consisting of ordinary fibrous tissue, but the others and more numerous consisting of white fibro-cartilage. These plates are not quite vertical in their direction, those near the circumference being curved outward and closely approximated; whilst those nearest the centre curve in the opposite direction, and are somewhat more widely separated. The fibres of which each plate is composed are directed, for the most part, obliquely from above downward, the fibres of adjacent plates passing in opposite directions and varying in every layer; so that the fibres of one layer are directed across those of another, like the limbs of the letter X. This laminar arrangement belongs to about the outer half of each disk. The pulpy substance presents no concentric arrangement, and consists of a fine fibrous matrix, containing angular cells, united to form a reticular structure.

### 2. Ligaments connecting the Laminæ.

Ligamenta Subflava.

The **Ligamenta Subflava** (Fig. 152) are interposed between the laminæ of the vertebræ, from the axis to the sacrum. They are most distinct when seen from the interior of the spinal canal; when viewed from the outer surface they appear short, being overlapped by the laminæ. Each ligament consists of two lateral portions, which commence on each side at the root of either articular process, and pass backward to the point where the laminæ converge to form the spinous process, where their margins are in contact and to a certain extent united; slight intervals being left for the passage of small vessels. These ligaments consist of yellow elastic tissue, the fibres of which, almost perpendicular in direction, are attached to the anterior surface of the laminæ above, some distance from its inferior margin, and to the posterior surface, as well as to the margin of the lamina below. In the cervical region they are thin in texture, but very broad and long; they become thicker in the dorsal region, and in the lumbar acquire very considerable thickness. Their highly elastic property serves to preserve the upright posture and to assist in resuming it after the spine has been flexed. These ligaments do not exist between the occiput and atlas or between the atlas and axis.

### 3. Ligaments connecting the Articular Processes.

Capsular.

The **Capsular Ligaments** (Fig. 154) are thin and loose ligamentous sacs, attached to the contiguous margins of the articulating processes of each vertebra through the greater part of their circumference, and completed internally by the ligamenta subflava. They are longer and looser in the cervical than in the dorsal or lumbar regions. The capsular ligaments are lined on their inner surface by synovial membrane.

### 4. Ligaments connecting the Spinous Processes.

Supraspinous. Interspinous.

The **Supraspinous Ligament** (Fig. 152) is a strong fibrous cord, which connects together the apices of the spinous processes from the seventh cervical to the spinous processes of the sacrum. It is thicker and broader in the lumbar than in the dorsal region, and intimately blended, in both situations, with the neighboring aponeurosis. The most superficial fibres of this ligament connect three or four vertebræ; those deeper-seated pass between two or three vertebræ; whilst the deepest connect the contiguous extremities of neighboring vertebræ. It is continued upward to the external occipital protuberance, as the ligamentum nuchæ, which, in the human subject, is thin and forms merely an intermuscular septum.

The **Interspinous Ligaments** (Fig. 152), thin and membranous, are interposed between the spinous processes. Each ligament extends from the root to the summit of each spinous process and connects together their adjacent margins. They meet the ligamenta subflava in front and the supra-spinous ligament behind. They are narrow and elongated in the dorsal region; broader, quadrilateral in form, and thicker in the lumbar region; and only slightly developed in the neck.

### 5. Ligaments connecting the Transverse Processes.

Intertransverse.

The **Intertransverse Ligaments** consist of bundles of fibres interposed between the transverse processes. In the cervical region they consist of a few irregular, scattered fibres; in the dorsal, they are rounded cords intimately connected with the deep muscles of the back; in the lumbar region they are thin and membranous.

**Actions.**—The movements permitted in the spinal column are, Flexion, Extension, Lateral Movement, Circumduction, and Rotation.

In *Flexion*, or movement of the spine forward, the anterior common ligament is relaxed, and the intervertebral substances are compressed in front, while the posterior common ligament, the ligamenta subflava, and the inter- and supra-spinous ligaments are stretched, as well as the posterior fibres of the intervertebral disks. The interspaces between the laminæ are widened, and the inferior articular processes of the vertebræ above glide upward upon the articular processes of the vertebræ below. Flexion is the most extensive of all the movements of the spine.

In *Extension*, or movement of the spine backward, an exactly opposite disposition of the parts takes place. This movement is not extensive, being limited by the anterior common ligament and by the approximation of the spinous processes.

Flexion and extension are free in the lower part of the lumbar region between the third and fourth and fourth and fifth lumbar vertebræ; above the third they are much diminished, and reach their minimum in the middle and upper part of the back. They increase again in the neck, the capability of motion backward from the upright position being in this region greater than that of the motion forward, whereas in the lumbar region the reverse is the case.

In *Lateral Movement*, the sides of the intervertebral disks are compressed, the extent of motion being limited by the resistance offered by the surrounding ligaments and by the approximation of the transverse processes. This movement may take place in any part of the spine, but is most free in the neck and loins.

*Circumduction* is very limited, and is produced merely by a succession of the preceding movements.

*Rotation* is produced by the twisting of the intervertebral substances; this, although only slight between any two vertebræ, produces a considerable extent of movement when it takes place in the whole length of the spine, the front of the upper part of the column being turned to one or the other side. This movement takes place only to a slight extent in the neck, but is freer in the upper part of the dorsal region, and is altogether absent in the lumbar region.

It is thus seen that the *cervical region* enjoys the greatest extent of each variety of movement, flexion and extension especially being very free. In the *dorsal region* the three movements of flexion, extension, and circumduction are permitted only to a slight extent, while rotation is very free in the upper part and ceases below. In the lumbar region there is free flexion, extension, and lateral movement, but no rotation.

As Sir George Humphry has pointed out, the movements permitted are mainly due to the shape and position of the articulating processes. In the loins the inferior articulating processes are turned outward and embraced by the superior; this renders rotation in this region of the spine impossible, while there is nothing to prevent a sliding upward and downward of the surfaces on each other, so as to allow of flexion and extension. In the dorsal region, on the other hand, the articulating processes, by their direction and mutual adaptation, especially at the upper part of the series, permit of rotation, but prevent extension and flexion, while in the cervical region the greater obliquity and lateral slant of the articular processes allow not only flexion and extension, but also rotation.

The principal muscles which produce *flexion* are the Sterno-mastoid, Rectus capitis anticus major, and Longus colli; the Scaleni; the abdominal muscles and the Psoas magnus. *Extension* is produced by the fourth layer of the muscles of the back, assisted in the neck by the Splenius, Semispinalis dorsi et colli, and the Multifidus spinæ. *Lateral* motion is produced by the fourth layer of the muscles of the back, by the Splenius and the Scaleni, the muscles of one side only acting; and *rotation* by the action of the following muscles of one side only—viz. the Sterno-mastoid, the Rectus capitis anticus major, the Scaleni, the Multifidus spinæ, the Complexus, and the abdominal muscles.

## II. Articulation of the Atlas with the Axis.

The articulation of the Atlas with the Axis is of a complicated nature, comprising no fewer than four distinct joints. There is a pivot articulation between the odontoid process of the axis and the ring formed between the anterior arch of the atlas and the transverse ligament (see Fig. 155). Here there are two joints: one in front between the posterior surface of the anterior arch of the atlas and the front of the odontoid process (the *atlanto-odontoid joint of Cruveilhier*); the other between the anterior surface of the transverse ligament and the back of the process (the *syndesmo-odontoid joint*). Between the articular processes of the two bones there is a double arthrodia or gliding joint. The ligaments which connect these bones are the

| | |
|---|---|
| Anterior Atlanto-axial. | Transverse. |
| Posterior Atlanto-axial. | Two Capsular. |

The **Anterior Atlanto-axial Ligament** (Fig. 153) is a strong, membranous layer, attached, above, to the lower border of the anterior arch of the atlas; below, to the base of the odontoid process and to the front of the body of the axis. It is strengthened in the middle line by a rounded cord, which is attached, above, to the tubercle on the anterior arch of the atlas, and below to the body of the axis, being a continuation upward of the anterior common ligament of the spine. These ligaments are in relation, in front, with the Recti antici majores.

The **Posterior Atlanto-axial Ligament** (Fig. 154) is a broad and thin membranous layer, attached, above, to the lower border of the posterior arch of the atlas; below, to the upper edge of the laminæ of the axis. This ligament supplies the place of the ligamenta subflava, and is in relation, behind, with the Inferior oblique muscles.

The **Transverse Ligament**[1] (Figs. 155, 156) is a thick, strong band, which arches across the ring of the atlas, and serves to retain the odontoid process in firm connection with its anterior arch. This ligament is flattened from before backward, broader and thicker in the middle than at either extremity, and firmly attached on

[1] It has been found necessary to describe the transverse ligament with those of the atlas and axis; but the student must remember that it is really a portion of the mechanism by which the movements of the head on the spine are regulated; so that the connections between the atlas and axis ought always to be studied together with those between the latter bones and the skull.

each side to a small tubercle on the inner surface of the lateral mass of the atlas. As it crosses the odontoid process, a small fasciculus is derived from its upper, and another from its lower, border; the former passing upward, to be inserted into the basilar process of the occipital bone; the latter, downward, to be attached to the posterior surface of the body of the axis; hence, the whole ligament has received the name of *cruciform*. The transverse ligament divides the ring of the atlas into two unequal parts: of these, the posterior and larger serves for the transmission of the cord and its membranes and the spinal accessory nerves; the anterior and smaller contains the odontoid process. Since the space between the anterior arch of the atlas and the transverse ligament is smaller at the lower

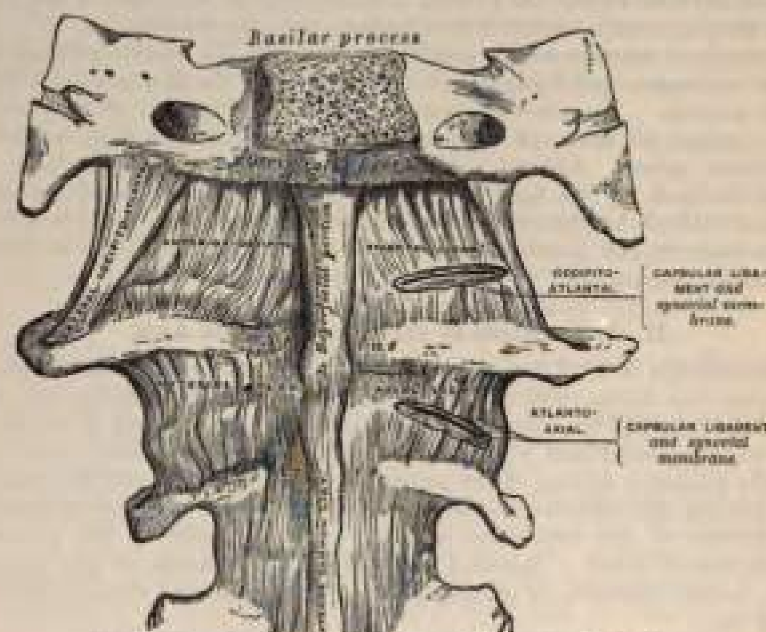



FIG. 153.—Occipito-atlantal and atlanto-axial ligaments. Front view.

part than the upper (because the transverse ligament embraces firmly the narrow neck of the odontoid process), this process is retained in firm connection with the atlas after all the other ligaments have been divided.

The **Capsular Ligaments** are two thin and loose capsules, connecting the lateral masses of the atlas with the superior articular surfaces of the axis, the fibres being strengthened at the posterior and inner part of the articulation by an *accessory ligament*, which is attached below to the body of the axis near the base of the odontoid process.

There are *four* **Synovial Membranes** in this articulation: one lining the inner surface of each of the capsular ligaments; one between the anterior surface of the odontoid process and the anterior arch of the atlas, the *atlanto-odontoid joint*; and one between the posterior surface of the odontoid process and the transverse ligament, the *syndesmo-odontoid joint*. The latter often communicates with those between the condyles of the occipital bone and the articular surfaces of the atlas.

**Actions.**—This joint allows the rotation of the atlas (and, with it, of the cranium) upon the axis, the extent of rotation being limited by the odontoid ligaments.

The principal muscles by which this action is produced are the Sterno-mastoid and Complexus of one side, acting with the Rectus capitis anticus major, Splenius, Trachelo-mastoid, Rectus capitis posticus major, and Inferior oblique of the other side.

## ARTICULATIONS OF THE SPINE WITH THE CRANIUM.

The ligaments connecting the spine with the cranium may be divided into two sets—those connecting the occipital bone with the atlas, and those connecting the occipital bone with the axis.

### III. Articulation of the Atlas with the Occipital Bone.

This articulation is a double condyloid joint. Its ligaments are the

| | |
|---|---|
| Anterior Occipito-atlantal. | Two Lateral Occipito-atlantal. |
| Posterior Occipito-atlantal. | Two Capsular. |

The **Anterior Occipito-atlantal Ligament** (Fig. 153) is a broad membranous layer, composed of densely woven fibres, which passes between the anterior


Fig. 154.—Occipito-atlantal and atlanto-axial ligaments. Posterior view.

margin of the foramen magnum above, and the whole length of the upper border of the anterior arch of the atlas below. Laterally, it is continuous with the capsular ligaments. In the middle line in front it is strengthened by a strong, narrow, rounded cord, which is attached, above, to the basilar process of the occiput, and, below, to the tubercle on the anterior arch of the atlas. This ligament is in relation, in front, with the Recti antici minores; behind, with the odontoid ligaments.

The **Posterior Occipito-atlantal Ligament** (Fig. 154) is a very broad but thin membranous lamina intimately blended with the dura mater. It is connected, above, to the posterior margin of the foramen magnum; below, to the upper border of the posterior arch of the atlas. This ligament is incomplete at each side, and forms, with the superior intervertebral notch, an opening for the passage of the vertebral artery and suboccipital nerve. The fibrous band which arches over the artery and nerve sometimes becomes ossified. It is in relation, behind, with the Recti postici minores and Obliqui superiores; in front, with the dura mater of the spinal canal, to which it is intimately adherent.

The **Lateral Ligaments** are strong fibrous bands, directed obliquely upward and inward, attached above to the jugular process of the occipital bone; below, to the base of the transverse process of the atlas.

The **Capsular Ligaments** surround the condyles of the occipital bone, and connect them with the articular processes of the atlas; they consist of thin and loose capsules, which enclose the synovial membrane of the articulation.

**Synovial Membranes.**—There are two synovial membranes in this articulation, one lining the inner surface of each of the capsular ligaments. These occasionally communicate with that between the posterior surface of the odontoid process and the transverse ligament.

**Actions.**—The movements permitted in this joint are flexion and extension, which give rise to the ordinary forward and backward nodding of the head, besides


FIG. 155.—Articulation between odontoid process and atlas.

slight lateral motion to one or the other side. When either of these actions is carried beyond a slight extent, the whole of the cervical portion of the spine assists in its production. Flexion is mainly produced by the action of the Rectus capitis anticus major et minor and the Sterno-mastoid muscles; extension by the Rectus capitis posticus major et minor, the Superior oblique, the Complexus, Splenius, and upper fibres of the Trapezius. The Recti laterales are concerned in the lateral movement, assisted by the Trapezius, Splenius, Complexus, and the Sterno-mastoid of the same side, all acting together. According to Cruveilhier, there is a slight motion of rotation in this joint.

### IV. Articulation of the Axis with the Occipital Bone.

Occipito-axial. Three Odontoid.

To expose these ligaments the spinal canal should be laid open by removing the posterior arch of the atlas, the laminæ and spinal process of the axis, and the portion of the occipital bone behind the foramen magnum, as seen in Fig. 156.

The **Occipito-axial Ligament** (*apparatus ligamentosus colli*) is situated within the spinal canal. It is a broad, strong band, which covers the odontoid process and its ligaments, and appears to be a prolongation upward of the posterior common ligament of the spine. It is attached, below, to the posterior surface of the body of the axis, and, becoming expanded as it ascends, is inserted into the basilar groove of the occipital bone, in front of the foramen magnum, where it becomes blended with the dura mater of the skull.

**Relations.**—By its anterior surface with the transverse ligament; by its posterior surface with the dura mater.

The **Odontoid** or **Check Ligaments** (*alar ligaments*) are strong, rounded, fibrous cords, which arise one on either side of the upper part of the odontoid process, and, passing obliquely upward and outward, are inserted into the rough depressions on the inner side of the condyles of the occipital bone. In the triangular interval left between these ligaments another strong fibrous cord (*ligamentum suspensorium*, or

**middle odontoid ligament**) may be seen, which passes almost perpendicularly from the apex of the odontoid process to the anterior margin of the foramen magnum, being intimately blended with the deep portion of the anterior occipito-atlantal ligament and upper fasciculus of the transverse ligament of the atlas.

**Actions.**—The odontoid ligaments serve to limit the extent to which rotation

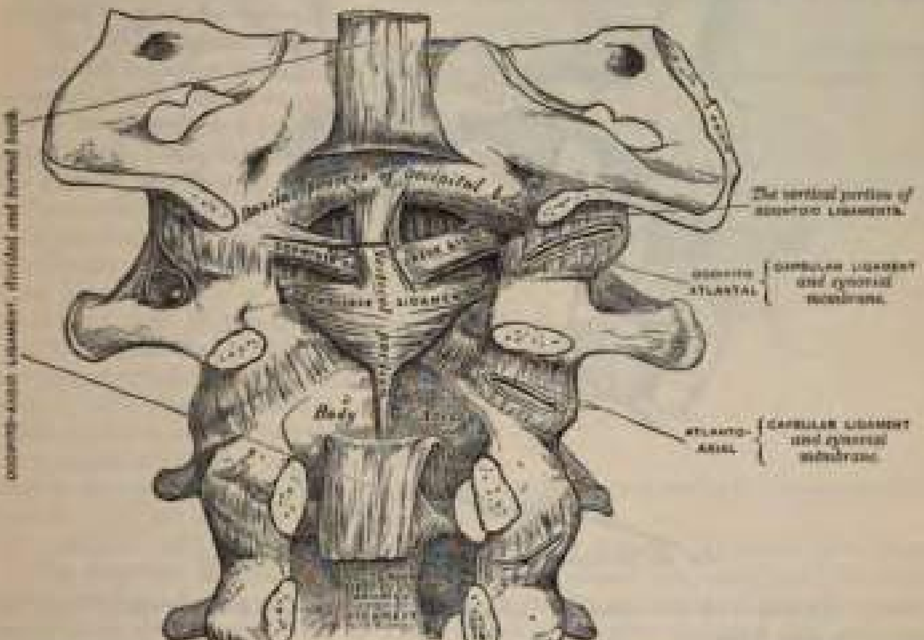



FIG. 156.—Occipito-axial and atlanto-axial ligaments. Posterior view, obtained by removing the arches of the vertebræ and the posterior part of the skull.

of the cranium may be carried; hence they have received the name of *check ligaments*.

In addition to these ligaments, which connect the atlas and axis to the skull, the ligamentum nuchæ must be regarded as one of the ligaments by which the spine is connected with the cranium. It is described on a subsequent page.

**Surgical Anatomy.**—The ligaments which unite the component parts of the vertebræ together are so strong, and these bones are so interlocked by the arrangement of their articulating processes, that dislocation is very uncommon, and, indeed, unless accompanied by fracture, rarely occurs, except in the upper part of the neck. Dislocation of the occiput from the atlas has only been recorded in one or two cases; but dislocation of the atlas from the axis, with rupture of the transverse ligament, is much more common: it is the mode in which death is produced in many cases of execution by hanging. In the lower part of the neck—that is, below the third cervical vertebra—dislocation unattended by fracture occasionally takes place.

## V. Articulation of the Lower Jaw (Temporo-mandibular).

This is a ginglymo-arthrodial joint: the parts entering into its formation on each side are, above, the anterior part of the glenoid cavity of the temporal bone and the eminentia articularis; and, below, the condyle of the lower jaw. The ligaments are the following:

| | |
|---|---|
| External Lateral. | Style-mandibular. |
| Internal Lateral. | Capsular. |
| Interarticular Fibro-cartilage. | |

The **External Lateral Ligament** (Fig. 157) is a short, thin, and narrow fasciculus, attached, above, to the outer surface of the zygoma and to the tubercle on its lower border; below, to the outer surface and posterior border of the neck of the lower jaw. It is broader above than below; its fibres are placed parallel with one another, and directed obliquely downward and backward. Externally, it is covered by the parotid gland and by the integument. Internally,

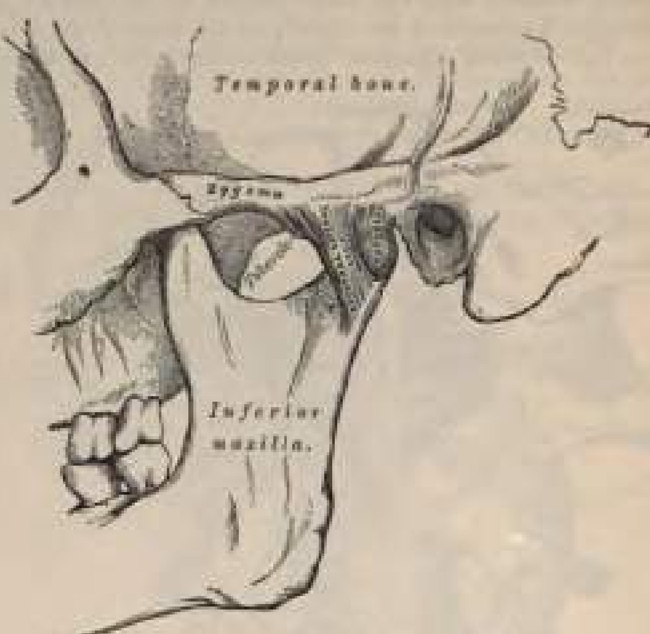



FIG. 157.—Temporo-mandibular articulation. External view.

it is in relation with the capsular ligament, of which it is an accessory band, and not separable from it.

The **Internal Lateral Ligament** (*Spheno-mandibular*) (Fig. 158) is a flat, thin band which is attached above to the spinous process of the sphenoid bone, and, becoming broader as it descends, is inserted into the lingula and margin of the dental foramen. Its outer surface is in relation, above, with the External pterygoid muscle; lower down it is separated from the neck of the condyle by the internal maxillary artery; and still more inferiorly, the inferior dental vessels and nerve separate it from the ramus of the jaw. The inner surface is in relation with the Internal pterygoid. It is really the fibrous covering of a part of Meckel's cartilage.

FIG. 158.—Temporo-mandibular articulation. Internal view.

The **Stylo-mandibular Ligament** is a specialized band of the cervical fascia, which extends from near the apex of the styloid process of the temporal bone to the angle and posterior border of the ramus of the lower jaw, between the Masseter and Internal pterygoid muscles. This ligament separates the parotid from the submaxillary gland, and has attached to its inner side part of the fibres of origin of the Stylo-glossus muscle. Although usually classed among the ligaments of the jaw, it can be considered only as an accessory to the articulation.

The **Capsular Ligament** forms a thin and loose capsule, attached above to the circumference of the glenoid cavity and the articular surface immediately in front; below, to the neck of the condyle of the lower jaw. It consists of a few thin scattered fibres, and can hardly be considered as a distinct ligament; it is thickest at the back part of the articulation.[1]

The **Interarticular Fibro-cartilage** (Fig. 159) is a thin plate of an oval form, placed horizontally between the condyle of the jaw and the glenoid cavity. Its upper surface is concavo-convex from before backward, and a little convex transversely, to accommodate itself to the form of the glenoid cavity. Its under surface, where it is in contact with the condyle, is concave. Its circumference is connected to the capsular ligament, and in front to the tendon of the External pterygoid muscle. It is thicker at its circumference, especially behind, than at its centre. The fibres of which it is composed have a concentric arrangement, more apparent at the circumference than at the centre. Its surfaces are smooth. It divides the joint into two cavities, each of which is furnished with a separate synovial membrane.

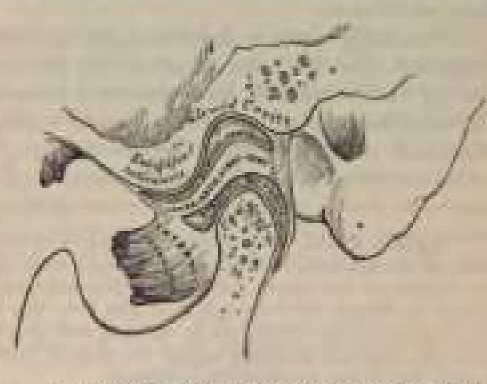


FIG. 159.—Vertical section of temporo-mandibular articulation.

The **Synovial Membranes**, two in number, are placed, one above, and the other below, the fibro-cartilage. The upper one, the larger and looser of the two, is continued from the margin of the cartilage covering the glenoid cavity and eminentia articularis on to the upper surface of the fibro-cartilage. The lower one passes from the under surface of the fibro-cartilage to the neck of the condyle of the jaw, being prolonged downward a little farther behind than in front. The interarticular cartilage is sometimes perforated in its centre; the two synovial sacs then communicate with each other.

The *nerves* of this joint are derived from the auriculo-temporal and masseteric branches of the inferior maxillary. The *arteries* are derived from the temporal branch of the external carotid.

**Actions.**—The movements permitted in this articulation are very extensive. Thus, the jaw may be depressed or elevated, or it may be carried forward or backward. It must be borne in mind that there are two distinct joints in this articulation—that is to say, one between the condyle of the jaw and the interarticular fibro-cartilage, and another between the fibro-cartilage and the glenoid fossa; when the jaw is depressed, as in opening the mouth, the movements which take place in these two joints are not the same. In the lower compartment, that between the condyle and the fibro-cartilage, the movement is of a ginglymoid or hinge-like character, the condyle rotating on a transverse axis on the fibro-cartilage; while in the upper compartment the movement is of a gliding character, the fibro-cartilage, together with the condyle, gliding forward on to the eminentia articularis. These two movements take place simultaneously—the condyle and fibro-cartilage move forward on the eminence, and at the same time the condyle revolves on the fibro-cartilage. In the opposite movement of shutting the mouth the reverse action takes place; the fibro-cartilage glides back, carrying the condyle with it, and this at the same time revolves back to its former position. When the jaw is carried horizontally forward, as in protruding the lower incisors in front of the upper, the move-

[1] Sir G. Humphry describes the internal portion of the capsular ligament separately as the short internal lateral ligament· and it certainly seems as deserving of a separate description as the external lateral ligament is.

ment takes place principally in the upper compartment of the joint: the fibro-cartilage, carrying with it the condyle, glides forward on the glenoid fossa. This is because this movement is mainly effected by the External pterygoid muscles, which are inserted into both condyle and interarticular fibro-cartilage. The grinding or chewing movement is produced by the alternate movement of one condyle, with its fibro-cartilage, forward and backward, while the other condyle moves simultaneously in the opposite direction; at the same time the condyle undergoes a vertical rotation on its own axis on the fibro-cartilage in the lower compartment. One condyle advances and rotates, the other condyle recedes and rotates, in alternate succession.

The lower jaw is *depressed* by its own weight, assisted by the Platysma, the Digastric, the Mylo-hyoid, and the Genio-hyoid. It is *elevated* by the anterior part of the Temporal, Masseter, and Internal pterygoid. It is drawn *forward* by the simultaneous action of the External pterygoid and the superficial fibres of the Masseter; and it is drawn *backward* by the deep fibres of the Masseter and the posterior fibres of the Temporal muscle. The grinding movement is caused by the alternate action of the two External pterygoids.

**Surface Form.**—The temporo-mandibular articulation is quite superficial, situated below the base of the zygoma, in front of the tragus and external auditory meatus, and behind the posterior border of the upper part of the Masseter muscle. Its exact position can be at once ascertained by feeling for the condyle of the jaw, the working of which can be distinctly felt in the movements of the lower jaw in opening and shutting the mouth. When the mouth is opened wide, the condyle advances out of the glenoid fossa on to the eminentia articularis, and a depression is felt in the situation of the joint.

**Surgical Anatomy.**—The lower jaw is dislocated only in one direction—viz. forward. The accident is caused by violence or muscular action. When the mouth is open, the condyle is situated on the eminentia articularis, and any sudden violence, or even a sudden muscular spasm, as during a convulsive yawn, may displace the condyle forward into the zygomatic fossa. The displacement may be unilateral or bilateral, according as one or both of the condyles are displaced. The latter of the two is the more common.

Sir Astley Cooper described a condition which he termed "subluxation." It occurs principally in delicate women, and is believed by some to be due to the relaxation of the ligaments, permitting too free movement of the bone, and possibly some displacement of the fibro-cartilage. Others have believed that it is due to gouty or rheumatic changes in the joint. In close relation to the condyle of the jaw is the external auditory meatus and the tympanum; any force, therefore, applied to the bone is liable to be attended with damage to these parts, or inflammation in the joint may extend to the ear, or on the other hand inflammation of the middle ear may involve the articulation and cause its destruction, thus leading to ankylosis of the joint. In children, arthritis of this joint may follow the exanthemata, and in adults it occurs as the result of some constitutional conditions, as rheumatism or gout. The temporo-mandibular joint is also occasionally the seat of osteo-arthritis, leading to great suffering during efforts of mastication. A peculiar affection sometimes attacks the neck and condyle of the lower jaw, consisting in hypertrophy and elongation of these parts and consequent protrusion of the chin to the opposite side.

## VI. Articulations of the Ribs with the Vertebræ.

The articulations of the ribs with the vertebral column may be divided into two sets: **1.** Those which connect the heads of the ribs with the bodies of the vertebræ, *costo-central*. **2.** Those which connect the necks and tubercles of the ribs with the transverse processes, *costo-transverse*.

### 1. Articulations between the Heads of the Ribs and the Bodies of the Vertebræ (Fig. 160).

These constitute a series of arthrodial joints, formed by the articulation of the heads of the ribs with the cavities on the contiguous margins of the bodies of the dorsal vertebræ and the intervertebral substance between them, except in the case of the first, tenth, eleventh, and twelfth ribs, where the cavity is formed by a single vertebra. The bones are connected by the following ligaments:

Anterior Costo-vertebral or Stellate.
Capsular. Interarticular.

The **Anterior Costo-vertebral** or **Stellate Ligament** connects the anterior part of the head of each rib with the sides of the bodies of two vertebræ and the intervertebral disk between them. It consists of three flat bundles of ligamentous fibres, which are attached to the anterior part of the head of the rib, just beyond the articular surface. The superior fibres pass upward to be connected with the body of the vertebra above; the inferior one descends to the body of the vertebra below; and the middle one, the smallest and least distinct, passes horizontally inward, to be attached to the intervertebral substance.

**Relations.**—In front, with the thoracic ganglia of the sympathetic, the pleura, and, on the right side, with the vena azygos major; behind, with the interarticular ligament and synovial membranes.

In the first rib, which articulates with a single vertebra, this ligament does not present a distinct division into three fasciculi; its fibres, however, radiate, and are attached to the body of the last cervical vertebra, as well as to the body of the vertebra with which the rib articulates. In the tenth, eleventh, and twelfth ribs also, which likewise articulate with a single vertebra, the division does not exist; but the fibres of the ligament in each case radiate and are connected with the vertebra above, as well as that with which the ribs articulate.

The **Capsular Ligament** is a thin and loose ligamentous bag, which surrounds the joint between the head of the rib and the articular cavity formed by the intervertebral disk and the adjacent vertebra. It is very thin, firmly connected with the anterior ligament, and most distinct at the upper and lower parts of the articulation. Behind, some of its fibres pass through the intervertebral foramen to the back of the intervertebral disk. This is the analogue of the *ligamentum conjugale* of some mammals, which unites the heads of opposite ribs across the back of the intervertebral disk.

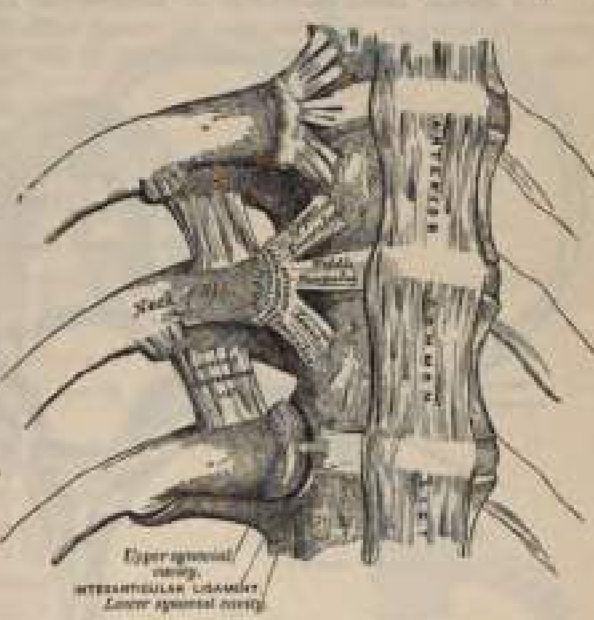



Fig. 160.—Costo-vertebral and costo-transverse articulations. Anterior view.

The **Interarticular Ligament** is situated in the interior of the joint. It consists of a short band of fibres, flattened from above downward, attached by one extremity to the sharp crest which separates the two articular facets on the head of the rib, and by the other to the intervertebral disk. It divides the joint into two cavities, which have no communication with each other. In the first, tenth, eleventh, and twelfth ribs the interarticular ligament does not exist; consequently there is but one synovial membrane.

**The Synovial Membrane.**—There are two synovial membranes in each of the articulations in which there is an interarticular ligament, one on each side of this structure.

2. Articulations of the Necks and Tubercles of the Ribs with the Transverse Processes (Fig. 161).

The articular portion of the tubercle of the rib and adjacent transverse process form an arthrodial joint.

In the *eleventh* and *twelfth ribs* this articulation is wanting.

The ligaments connecting these parts are the—

Anterior Costo-transverse.
Middle Costo-transverse (Interosseous).
Posterior Costo-transverse.
Capsular.

The **Anterior Costo-transverse Ligament** (*superior* or *long*) consists of two sets of fibres: the one (*anterior*) is attached below to the sharp crest on the upper border of the neck of each rib, and passes obliquely upward and outward to the lower border of the transverse process immediately above; the other (*posterior*) is attached below to the neck of the rib, and passes upward and inward to the base of the transverse process and outer border of the lower articular process of the vertebra above. This ligament is in relation, in front, with the intercostal vessels and nerves; behind, with the Longissimus dorsi. Its *internal border* is thickened and free, and bounds an aperture through which pass the posterior branches of the intercostal vessels and nerves. Its *external border* is continuous with a thin aponeurosis which covers the External intercostal muscle.

The *first rib* has no anterior costo-transverse ligament.

The **Middle Costo-transverse** or **Interosseous Ligament** consists of short but strong fibres which pass between the rough surface on the posterior part of the neck of each rib and the anterior surface of the adjacent transverse process. In

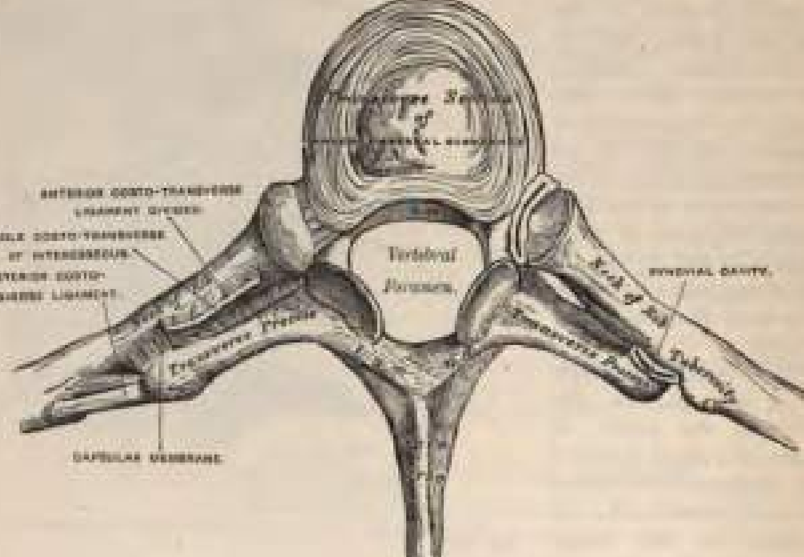



FIG. 161.—Costo-transverse articulation. Seen from above.

order fully to expose this ligament, a horizontal section should be made across the transverse process and corresponding part of the rib; or the rib may be forcibly separated from the transverse process and its fibres put on the stretch.

In the *eleventh* and *twelfth ribs* this ligament is quite rudimentary or wanting.

The **Posterior Costo-transverse Ligament** is a short but thick and strong fasciculus which passes obliquely from the summit of the transverse process to the rough non-articular portion of the tubercle of the rib. This ligament is shorter and more oblique in the upper than in the lower ribs. Those corresponding to the superior ribs ascend, while those of the inferior ribs descend slightly.

In the *eleventh* and *twelfth ribs* this ligament is wanting.

The **Capsular Ligament** is a thin, membranous sac attached to the circumference of the articular surfaces, and enclosing a small synovial membrane.

In the *eleventh* and *twelfth ribs* this ligament is absent.

**Actions.**—The heads of the ribs are so closely connected to the bodies of the vertebræ by the stellate and interarticular ligaments, and the necks and tubercles of the ribs to the transverse processes, that only a slight sliding movement of the articular surfaces on each other can take place in these articulations. The result of this gliding movement with respect to the six upper ribs consists in an elevation of the front and middle portion of the rib, the hinder part being prevented from performing any upward movement by its close connection with the spine. In this gliding movement the rib rotates on an axis corresponding with a line drawn through the two articulations, Costo-central and Costo-transverse, which the rib forms with the spine. With respect to the seventh, eighth, ninth, and tenth ribs, each one, besides rotating in a similar manner to the upper six, also rotates on an axis corresponding with a line drawn from the head of the rib to the sternum. By the first movement—that of rotation of the rib on an axis corresponding with a line drawn through the two articulations which this bone forms with the spine—an elevation of the anterior part of the rib takes place, and a consequent enlargement of the antero-posterior diameter of the chest. None of the ribs lie in a truly horizontal plane; they are all directed more or less obliquely, so that their anterior extremities lie on a lower level than their posterior, and this obliquity increases from the first to the seventh, and then again decreases. If we examine any one rib—say, that in which there is the greatest obliquity—we shall see that it is obvious that as its sternal extremity is carried upward, it must also be thrown forward; so that the rib may be regarded as a radius moving on the vertebral joint as a centre, and causing the sternal attachment to describe an arc of a circle in the vertical plane of the body. Since all the ribs are oblique and connected in front to the sternum by the elastic costal cartilages, they must have a tendency to thrust the sternum forward, and so increase the antero-posterior diameter of the chest. By the *second* movement—that of the rotation of the rib on an axis corresponding with a line drawn from the head of the rib to the sternum—an elevation of the middle portion of the rib takes place, and consequently an increase in the transverse diameter of the chest. For the ribs not only slant downward and forward from their vertebral attachment, but they are also oblique in relation to their transverse plane—that is to say, their middle is on a lower level than either their vertebral or

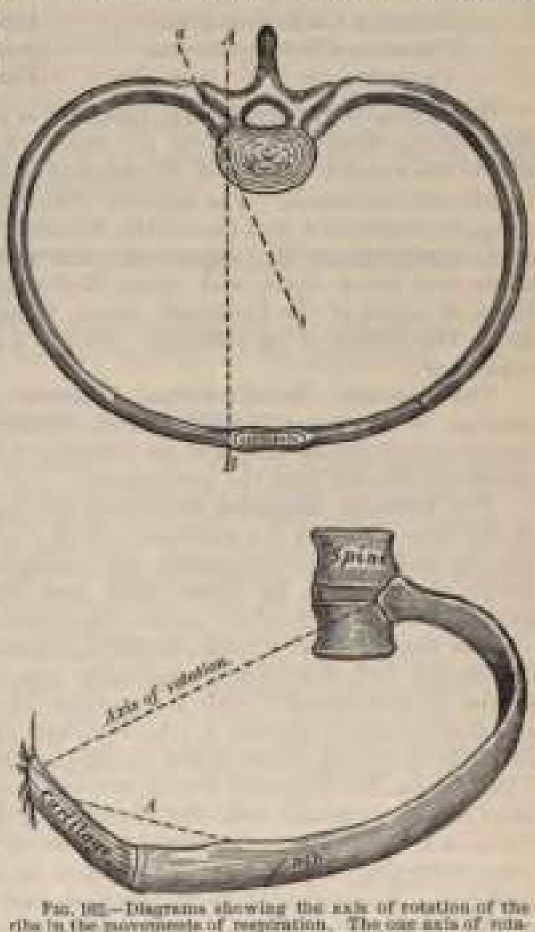



FIG. 182.—Diagrams showing the axis of rotation of the ribs in the movements of respiration. The one axis of rotation corresponds with a line drawn through the two articulations which the rib forms with the spine (a, b), and the other with a line drawn from the head of the rib to the sternum (a, b). (From Kirke's *Handbook of Physiology*.)

sternal extremities. It results from this that when the ribs are raised, the centre portion is thrust outward, somewhat after the fashion in which the handle of a bucket is thrust away from the side when raised to a horizontal position, and the lateral diameter of the chest is increased (see Fig. 162). The mobility of the different ribs varies very much. The first rib is more fixed than the others, on account of the weight of the upper extremity and the strain of the ribs beneath; but on the freshly dissected thorax it moves as freely as the others. From the same causes the movement of the second rib is also not very extensive. In the other ribs this mobility increases successively down to the last two, which are very movable. The ribs are generally more movable in the female than in the male.

### VII. Articulation of the Cartilages of the Ribs with the Sternum, etc. (Fig. 163).

The articulations of the cartilages of the true ribs with the sternum are arthrodial joints, with the exception of the first, in which the cartilage is almost always directly united with the sternum, and which must therefore be regarded as a synarthrodial articulation. The ligaments connecting them are—

| | |
|---|---|
| Anterior Chondro-sternal. | Interarticular Chondro-sternal. |
| Posterior Chondro-sternal. | Anterior Chondro-xiphoid. |
| Capsular. | Posterior Chondro-xiphoid. |

The **Anterior Chondro-sternal Ligament** is a broad and thin membranous band that radiates from the front of the inner extremity of the cartilages of the true ribs to the anterior surface of the sternum. It is composed of fasciculi which pass in different directions. The *superior fasciculi* ascend obliquely, the *inferior* pass obliquely downward, and the *middle fasciculi* horizontally. The superficial fibres of this ligament are the longest; they intermingle with the fibres of the ligaments above and below them, with those of the opposite side, and with the tendinous fibres of origin of the Pectoralis major, forming a thick fibrous membrane which covers the surface of the sternum. This is more distinct at the lower than at the upper part.

The **Posterior Chondro-sternal Ligament**, less thick and distinct than the anterior, is composed of fibres which radiate from the posterior surface of the sternal end of the cartilages of the true ribs to the posterior surface of the sternum, becoming blended with the periosteum.

The **Capsular Ligament** surrounds the joints formed between the cartilages of the true ribs and the sternum. It is very thin, intimately blended with the anterior and posterior ligaments, and strengthened at the upper and lower part of the articulation by a few fibres which pass from the cartilage to the side of the sternum. These ligaments protect the synovial membranes.

**The Interarticular Chondro-sternal Ligaments.**—These are only found between the second and third costal cartilages and the sternum. The cartilage of the *second rib* is connected with the sternum by means of an *interarticular ligament* attached by one extremity to the cartilage of the second rib, and by the other extremity to the cartilage which unites the first and second pieces of the sternum. This articulation is provided with two synovial membranes. The cartilage of the third rib is connected with the sternum by means of an interarticular ligament which is attached by one extremity to the cartilage of the third rib, and by the other extremity to the point of junction of the second and third pieces of the sternum. This articulation is provided with two synovial membranes.

**The Anterior Chondro-xiphoid.**—This is a band of ligamentous fibres which connects the anterior surface of the seventh costal cartilage, and occasionally also that of the sixth, to the anterior surface of the ensiform appendix. It varies in length and breadth in different subjects.

The **Posterior Chondro-xiphoid** is a similar band of fibres on the internal or posterior surface, though less thick and distinct.

**Synovial Membranes.**—There is no synovial membrane between the first costal cartilage and the sternum, as this cartilage is directly continuous with the sternum. There are two synovial membranes, both in the articulation of the second and third costal cartilages to the sternum. There is generally one synovial membrane in each of the joints between the fourth, fifth, sixth, and seventh costal cartilages to the sternum; but it is sometimes absent in the sixth and seventh chondro-sternal joints. Thus there are *eight* synovial cavities on each side in the articulations between the costal cartilages of the true ribs and the sternum. After middle life the articular surfaces lose their polish, become roughened, and the synovial membranes appear to be wanting. In old age the articulations do not exist, the cartilages of most of the ribs becoming continuous with the sternum.

**Actions.**—The movements which are permitted in the chondro-sternal articulations are limited to elevation and depression, and these only to a slight extent.

### Articulations of the Cartilages of the Ribs with each other (Interchondral) (*Fig.* 163).

The contiguous borders of the sixth, seventh, and eighth, and sometimes the ninth and tenth, costal cartilages articulate with each other by small, smooth, oblong-shaped facets. Each articulation is enclosed in a thin *capsular ligament* lined by *synovial membrane*, and strengthened externally and internally by ligamentous fibres (interchondral ligaments) which pass from one cartilage to the other. Sometimes the fifth costal cartilage, more rarely that of the ninth, articulates, by its lower border, with the adjoining cartilage by a small oval facet; more frequently they are connected together by a few ligamentous fibres. Occasionally the articular surfaces above mentioned are wanting.

### Articulations of the Ribs with their Cartilages (Costo-chondral) (*Fig.* 163).

The outer extremity of each costal cartilage is received into a depression in the sternal end of the ribs, and the two are held together by the periosteum.

## VIII. Articulations of the Sternum.

The first piece of the sternum is united to the second either by an amphiarthrodial joint—a single piece of true fibro-cartilage uniting the segments—or by a diarthrodial joint, in which each bone is clothed with a distinct lamina of cartilage, adherent on one side, free and lined with synovial membrane on the other. In the latter case the cartilage covering the gladiolus is continued without interruption on to the cartilages of the second ribs. Mr. Rivington has found the diarthrodial form of joint in about one-third of the specimens examined by him; Mr. Maisonneuve more frequently. It appears to be rare in childhood, and is formed, in Mr. Rivington's opinion, from the amphiarthrodial form by absorption. The diarthrodial joint seems to have no tendency to ossify at any age, while the amphiarthrodial is more liable to do so, and has been found ossified as early as thirty-four years of age. The two segments are further connected by an

Anterior Intersternal Ligament.
Posterior Intersternal Ligament.

The **Anterior Intersternal Ligament** consists of a layer of fibres, having a longitudinal direction; it blends with the fibres of the anterior chondro-sternal ligaments on both sides, and with the tendinous fibres of origin of the Pectoralis major. This ligament is rough, irregular, and much thicker below than above.

The **Posterior Intersternal Ligament** is disposed in a somewhat similar manner on the posterior surface of the articulation.

## IX. Articulation of the Vertebral Column with the Pelvis.

The ligaments connecting the last lumbar vertebra with the sacrum are similar to those which connect the segments of the spine with each other—viz.: 1. The continuation downward of the anterior and posterior common ligaments. 2. The intervertebral substance connecting the flattened oval surfaces of the two bones and forming an amphiarthrodial joint. 3. Ligamenta subflava, connecting the arch of the last lumbar vertebra with the posterior border of the sacral canal. 4. Capsular ligaments connecting the articulating processes and forming a double arthrodia. 5. Inter- and supraspinous ligaments.

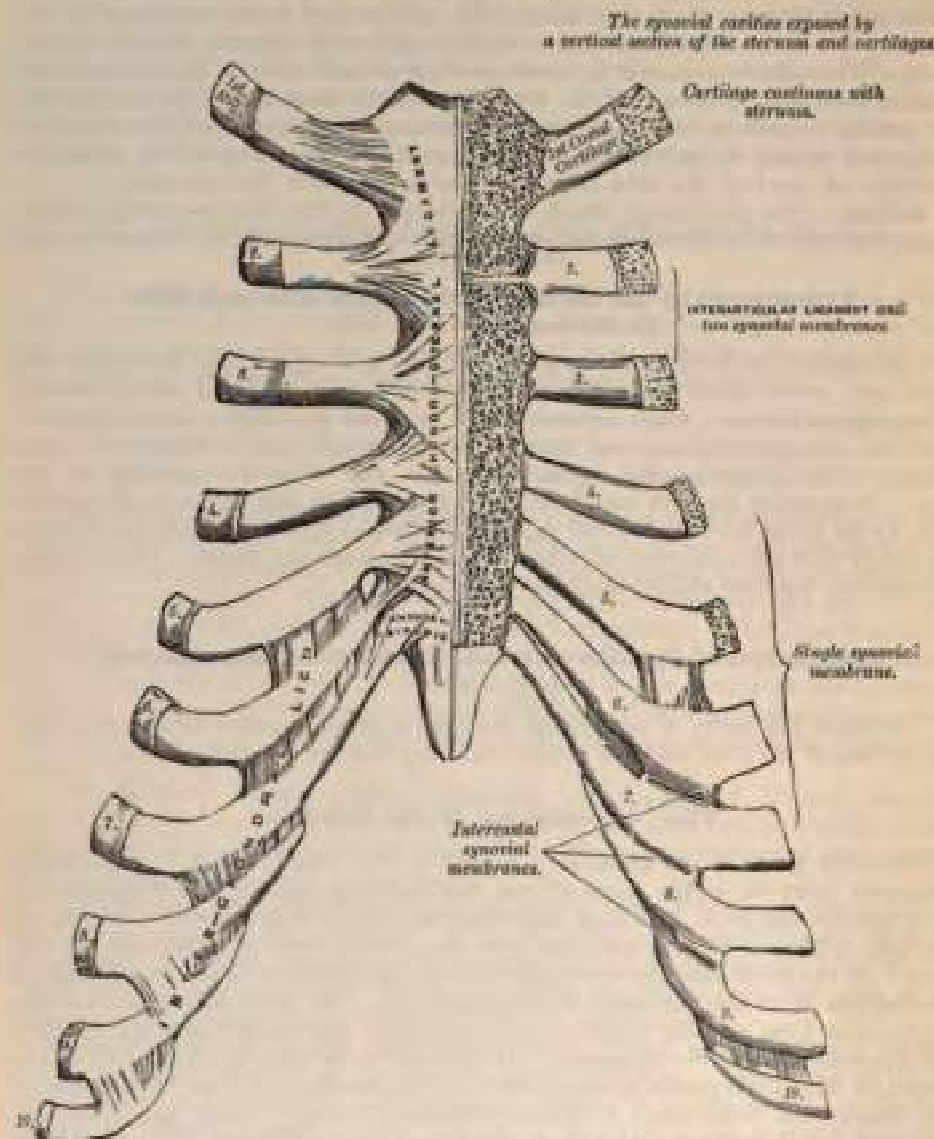



FIG. 163.—Chondro-sternal, chondro-xiphoid, and interchondral articulations. Anterior view.

The two proper ligaments connecting the pelvis with the spine are the lumbo-sacral and ilio-lumbar.

The **Lumbo-sacral Ligament** (Fig. 164) is a short, thick, triangular fasciculus, which is connected above to the lower and front part of the transverse process of the last lumbar vertebra, passes obliquely outward, and is attached below to the lateral surface of the base of the sacrum, becoming blended with the anterior sacro-iliac ligament. This ligament is in relation, in front, with the Psoas muscle.

The **Ilio-lumbar Ligament** (Fig. 164) passes horizontally outward from the

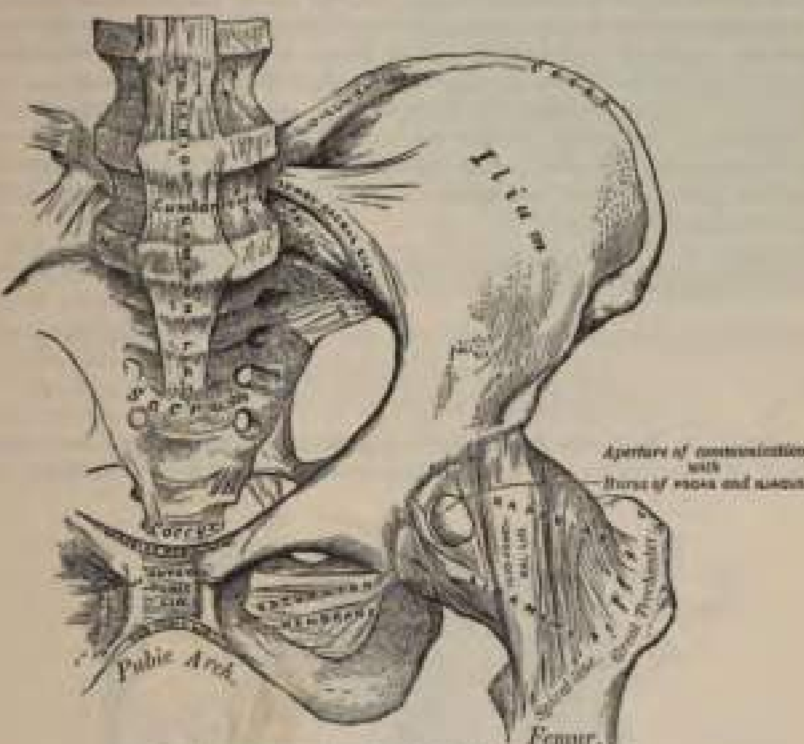



FIG. 164.—Articulations of pelvis and hip. Anterior view.

apex of the transverse process of the last lumbar vertebra to the crest of the ilium immediately in front of the sacro-iliac articulation. It is of a triangular form, thick and narrow internally, broad and thinner externally. It is in relation, in front, with the Psoas muscle; behind, with the muscles occupying the vertebral groove; above, with the Quadratus lumborum.

## X. Articulations of the Pelvis.

The ligaments connecting the bones of the pelvis with each other may be divided into four groups: 1. Those connecting the sacrum and ilium. 2. Those passing between the sacrum and ischium. 3. Those connecting the sacrum and coccyx. 4. Those between the two pubic bones.

### 1. Articulations of the Sacrum and Ilium.

The sacro-iliac articulation is an amphiarthrodial joint, formed between the lateral surfaces of the sacrum and ilium. The anterior or auricular portion of each articular surface is covered with a thin plate of cartilage, thicker on the sacrum than on the ilium. These are in close contact with each other, and to a certain extent united together by irregular patches of softer fibro-cartilage, and at their upper and posterior part by fine fibres of interosseous fibrous tissue. In a considerable part of their extent, especially in advanced life, they are not connected together, but are separated by a space containing a synovial-like fluid, and hence the joint presents the characters of a diarthrosis.

The ligaments connecting these surfaces are the anterior and posterior sacro-iliac.

The **Anterior Sacro-iliac Ligament** (Fig. 164) consists of numerous thin bands which connect the anterior surfaces of the sacrum and ilium.

The **Posterior Sacro-iliac** (Fig. 165) is a strong interosseous ligament, situated in a deep depression between the sacrum and ilium behind, and forming the chief bond of connection between those bones. It consists of numerous strong fasciculi which pass between the bones in various directions. Three of these are of large size: the *two superior*, nearly horizontal in direction, arise from the first and second transverse tubercles on the posterior surface of the sacrum, and are inserted into the rough, uneven surface at the posterior part of the inner surface of the ilium. The third fasciculus, oblique in direction, is attached by one extremity to the third transverse tubercle on the posterior surface of the sacrum, and by the other to the posterior superior spine of the ilium; it is sometimes called the *oblique sacro-iliac ligament*.

The position of the sacro-iliac joint is indicated by the posterior superior spine of the ilium. This process is immediately behind the centre of the articulation.

2. Ligaments passing between the Sacrum and Ischium (Fig. 165).

The Great Sacro-sciatic (Posterior).
The Lesser Sacro-sciatic (Anterior).

The **Great** or **Posterior Sacro-sciatic Ligament** is situated at the lower and back part of the pelvis. It is flat, and triangular in form; narrower in the

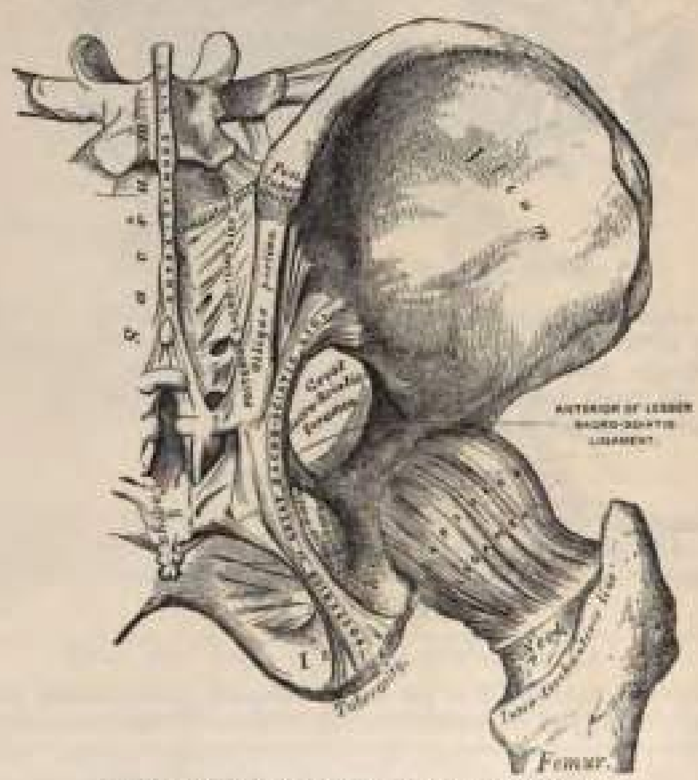



Fig. 165.—Articulations of pelvis and hip. Posterior view

middle than at the extremities; attached by its broad base to the posterior inferior spine of the ilium, to the fourth and fifth transverse tubercles of the sacrum, and to the lower part of the lateral margin of that bone and the coccyx. Passing obliquely downward, outward, and forward, it becomes narrow and thick, and at its insertion into the inner margin of the tuberosity of the ischium it increases in breadth, and is prolonged forward along the inner margin of the ramus, forming what is known as the *falciform ligament.* The free concave edge of this prolongation has attached to it the obturator fascia, with which it forms a kind of groove, protecting the internal pudic vessels and nerve. One of its surfaces is turned toward the perinæum, the other toward the Obturator internus muscle.

The *posterior surface* of this ligament gives origin, by its whole extent, to fibres of the Gluteus maximus. Its *anterior surface* is united to the lesser sacro-sciatic ligament. Its *external border* forms, above, the posterior boundary of the great sacro-sciatic foramen, and, below, the posterior boundary of the lesser sacro-sciatic foramen. Its *lower border* forms part of the boundary of the perinæum. It is pierced by the coccygeal branch of the sciatic artery and coccygeal nerve.

The **Lesser** or **Anterior Sacro-sciatic Ligament,** much shorter and smaller than the preceding, is thin, triangular in form, attached by its apex to the spine of the ischium, and internally, by its broad base, to the lateral margin of the sacrum and coccyx, anterior to the attachment of the great sacro-sciatic ligament, with which its fibres are intermingled.

It is in relation, *anteriorly,* with the Coccygeus muscle; *posteriorly,* it is covered by the great sacro-sciatic ligament and crossed by the internal pudic vessels and nerve. Its *superior border* forms the lower boundary of the great sacro-sciatic foramen; its *inferior border,* part of the lesser sacro-sciatic foramen.

These two ligaments convert the sacro-sciatic notches into foramina. The *superior* or *great* sacro-sciatic foramen is bounded, in front and above, by the

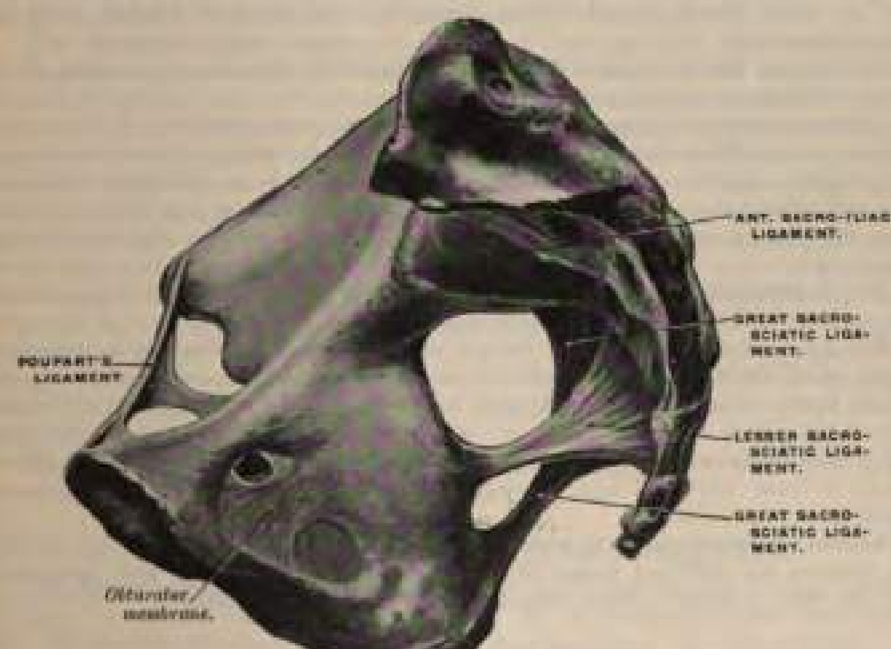



FIG. [illegible].—Side view of pelvis, showing the great and lesser sacro-sciatic ligaments.

posterior border of the os innominatum; behind, by the great sacro-sciatic ligament; and below, by the lesser sacro-sciatic ligament. It is partially filled up, in the recent state, by the Pyriformis muscle, which passes through it. Above this muscle the gluteal vessels and superior gluteal nerve emerge from the pelvis, and, below it, the sciatic vessels and nerves, the internal pudic vessels and nerve, the inferior gluteal nerve, and the nerves to the obturator internus and quadratus femoris. The *inferior* or *lesser* sacro-sciatic foramen is bounded, in front, by the tuber ischii; above, by the spine and lesser sacro-sciatic ligament; behind, by the greater sacro-sciatic ligament. It transmits the tendon of the Obturator internus muscle, its nerve, and the internal pudic vessels and nerve.

### 3. Articulation of the Sacrum and Coccyx.

This articulation is an amphiarthrodial joint, formed between the oval surface at the apex of the sacrum and the base of the coccyx. It is analogous to the joints between the bodies of the vertebræ, and is connected by similar ligaments. They are the

| | |
|---|---|
| Anterior Sacro-coccygeal. | Lateral Sacro-coccygeal. |
| Posterior Sacro-coccygeal. | Interposed Fibro-cartilage. |
| Interarticular. | |

The **Anterior Sacro-coccygeal Ligament** consists of a few irregular fibres which descend from the anterior surface of the sacrum to the front of the coccyx, becoming blended with the periosteum.

The **Posterior Sacro-coccygeal Ligament** is a flat band of a pearly tint, which arises from the margin of the lower orifice of the sacral canal, and descends to be inserted into the posterior surface of the coccyx. This ligament completes the lower and back part of the sacral canal. Its superficial fibres are much longer than the more deeply seated. This ligament is in relation, behind, with the Gluteus maximus.

The **Lateral Sacro-coccygeal Ligaments** connect the transverse processes of the coccyx to the lower lateral angles of the sacrum.

A **Fibro-cartilage** is interposed between the contiguous surfaces of the sacrum and coccyx; it differs from that interposed between the bodies of the vertebræ in being thinner, and its central part firmer in texture. It is somewhat thicker in front and behind than at the sides. Occasionally, a synovial membrane is found when the coccyx is freely movable, which is more especially the case during pregnancy.

The **Interarticular Ligaments** are thin bands of ligamentous tissue which connect the cornua of the two bones together.

The different segments of the coccyx are connected together by an extension downward of the anterior and posterior sacro-coccygeal ligaments, a thin annular disk of fibro-cartilage being interposed between each of the bones. In the adult male all the pieces become ossified, but in the female this does not commonly occur until a later period of life. The separate segments of the coccyx are first united, and at a more advanced age the joint between the sacrum and coccyx is obliterated.

**Actions.**—The movements which take place between the sacrum and coccyx, and between the different pieces of the latter bone, are forward and backward; they are very limited. Their extent increases during pregnancy.

### 4. Articulation of the Ossa Pubis (Symphysis Pubis) (Fig. 167).

The articulation between the pubic bones is an amphiarthrodial joint, formed by the junction of the two oval articular surfaces of the ossa pubis. The ligaments of this articulation are the

| | |
|---|---|
| Anterior Pubic. | Posterior Pubic. |
| Superior Pubic. | Subpubic. |
| Interpubic Disk. | |

The **Anterior Pubic Ligament** consists of several superimposed layers which pass across the front of the articulation. The superficial fibres pass obliquely from one bone to the other, decussating and forming an interlacement with the fibres of the aponeurosis of the External oblique and the tendon of the Rectus muscles. The deep fibres pass transversely across the symphysis, and are blended with the fibro-cartilage.

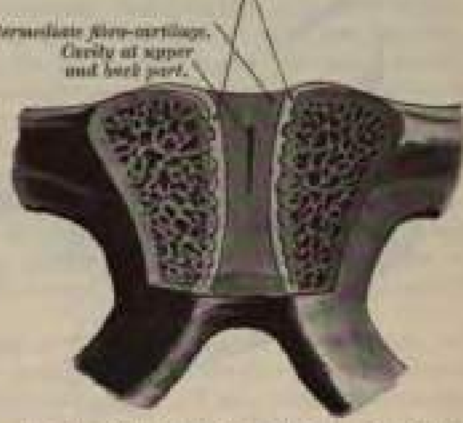



FIG. 167.—Vertical section of the symphysis pubis. Made near its posterior surface.

The **Posterior Pubic Ligament** consists of a few thin, scattered fibres which unite the two pubic bones posteriorly.

The **Superior Pubic Ligament** is a band of fibres which connects together the two pubic bones superiorly.

The **Subpubic Ligament** is a thick, triangular arch of ligamentous fibres, connecting together the two pubic bones below and forming the upper boundary of the pubic arch. Above, it is blended with the interarticular fibro-cartilage; laterally it is united with the descending rami of the os pubis. Its fibres are closely connected and have an arched direction.

The **Interpubic Disk** consists of a disk of cartilage and fibro-cartilage connecting the surfaces of the pubic bones in front. Each of the two surfaces is covered by a thin layer of hyaline cartilage which is firmly connected to the bone by a series of nipple-like processes which accurately fit within corresponding depressions on the osseous surfaces. These opposed cartilaginous surfaces are connected together by an intermediate stratum of fibrous tissue and fibro-cartilage which varies in thickness in different subjects. It often contains a cavity in its centre, probably formed by the softening and absorption of the fibro-cartilage, since it rarely appears before the tenth year of life, and is not lined by synovial membrane. It is larger in the female than in the male, but it is very questionable whether it enlarges, as was formerly supposed, during pregnancy. It is most frequently limited to the upper and back part of the joint, but it occasionally reaches to the front, and may extend the entire length of the cartilage. This cavity may be easily demonstrated by making a vertical section of the symphysis pubis near its posterior surface (Fig. 167).

The **Obturator Ligament** is more properly regarded as analogous to the muscular fasciæ, with which it will be described.

## ARTICULATIONS OF THE UPPER EXTREMITY.

The articulations of the upper extremity may be arranged in the following groups: I. Sterno-clavicular articulation. II. Acromio-clavicular articulation. III. Ligaments of the Scapula. IV. Shoulder-joint. V. Elbow-joint. VI. Radio-ulnar articulations. VII. Wrist-joint. VIII. Articulations of the Carpal Bones. IX. Carpo-metacarpal articulations. X. Metacarpo-phalangeal articulations. XI. Articulations of the Phalanges.

### I. Sterno-clavicular Articulation (Fig. 168).

The **Sterno-clavicular** is regarded by most anatomists as an arthrodial joint, but Cruveilhier considers it to be an articulation by reciprocal reception. Probably the former opinion is the correct one, the varied movement which the joint enjoys being due to the interposition of an interarticular fibro-cartilage between the joint surfaces. The parts entering into its formation are the sternal end of the clavicle, the upper and lateral part of the first piece of the sternum, and the cartilage of the first rib. The articular surface of the clavicle is much larger than


FIG. 168.—Sterno-clavicular articulation. Anterior view.

that of the sternum, and invested with a layer of cartilage[1] which is considerably thicker than that on the latter bone. The ligaments of this joint are the

| | |
|---|---|
| Capsular. | Interclavicular. |
| Anterior Sterno-clavicular. | Costo-clavicular (rhomboid). |
| Posterior Sterno-clavicular. | Interarticular Fibro-cartilage. |

The **Capsular Ligament** completely surrounds the articulation, consisting of fibres of varying degrees of thickness and strength. Those in front and behind are of considerable thickness, and form the anterior and posterior sterno-clavicular ligaments; but those above and below, especially in the latter situation, are thin and scanty, and partake more of the character of connective tissue than true fibrous tissue.

The **Anterior Sterno-clavicular Ligament** is a broad band of fibres which covers the anterior surface of the articulation, being attached, above, to the upper and front part of the inner extremity of the clavicle, and, passing obliquely downward and inward, is attached, below, to the upper and front part of the first piece of the sternum. This ligament is covered, in front, by the sternal portion of the Sterno-cleido-mastoid and the integument; behind, it is in relation with the interarticular fibro-cartilage and the two synovial membranes.

The **Posterior Sterno-clavicular Ligament** is a similar band of fibres which covers the posterior surface of the articulation, being attached, above, to the upper and back part of the inner extremity of the clavicle, and, passing obliquely downward and inward, is attached, below, to the upper and back part of the first piece of the sternum. It is in relation, in front, with the interarticular fibro-cartilage and synovial membranes; behind, with the Sterno-hyoid and Sterno-thyroid muscles.

The **Interclavicular Ligament** is a flattened band which varies considerably in form and size in different individuals; it passes in a curved direction from the upper part of the inner extremity of one clavicle to the other, and is also attached to the upper margin of the sternum. It is in relation, in front, with the integument; behind, with the Sterno-thyroid muscles.

The **Costo-clavicular Ligament** (rhomboid) is short, flat, and strong: it is of a rhomboid form, attached, below, to the upper and inner part of the cartilage of the first rib: it ascends obliquely backward and outward, and is attached, above,

[1] According to Bruch, the sternal end of the clavicle is covered by a tissue which is rather fibrous than cartilaginous in structure.

to the rhomboid depression on the under surface of the clavicle. It is in relation, in front, with the tendon of origin of the Subclavius; behind, with the subclavian vein.

The **Interarticular Fibro-cartilage** is a flat and nearly circular disk, interposed between the articulating surfaces of the sternum and clavicle. It is attached, above, to the upper and posterior border of the articular surface of the clavicle; below, to the cartilage of the first rib, at its junction with the sternum; and by its circumference, to the anterior and posterior sterno-clavicular and interclavicular ligaments. It is thicker at the circumference, especially its upper and back part, than at its centre or below. It divides the joint into two cavities, each of which is furnished with a separate synovial membrane.

Of the two **Synovial Membranes** found in this articulation, one is reflected from the sternal end of the clavicle over the adjacent surface of the fibro-cartilage and cartilage of the first rib; the other is placed between the articular surface of the sternum and adjacent surface of the fibro-cartilage; the latter is the larger of the two.

**Actions.**—This articulation is the centre of the movements of the shoulder, and admits of a limited amount of motion in nearly every direction—upward, downward, backward, forward—as well as circumduction. When these movements take place in the joint, the clavicle in its motion carries the scapula with it, this bone gliding on the outer surface of the chest. This joint therefore forms the centre from which all movements of the supporting arch of the shoulder originate, and is the only point of articulation of this part of the skeleton with the trunk. "The movements attendant on elevation and depression of the shoulder take place between the clavicle and the interarticular fibro-cartilage, the bone rotating upon the ligament on an axis drawn from before backward through its own articular facet. When the shoulder is moved forward and backward, the clavicle, with the interarticular fibro-cartilage, rolls to and fro on the articular surface of the sternum, revolving, with a sliding movement, round an axis drawn nearly vertically through the sternum. In the circumduction of the shoulder, which is compounded of these two movements, the clavicle revolves upon the interarticular fibro-cartilage, and the latter, with the clavicle, rolls upon the sternum."[1] Elevation of the clavicle is principally limited by the costo-clavicular ligament; depression, by the interclavicular. The muscles which *raise* the clavicle, as in shrugging the shoulders, are the upper fibres of the Trapezius, the Levator anguli scapulæ, the clavicular head of the Sterno-mastoid, assisted to a certain extent by the two Rhomboids, which pull the vertebral border of the Scapula backward and upward, and so raise the clavicle. The *depression* of the clavicle is principally effected by gravity, assisted by the Subclavius, Pectoralis minor, and lower fibres of the Trapezius. It is drawn *backward* by the Rhomboids and the middle and lower fibres of the Trapezius, nd *forward* by the Serratus magnus and Pectoralis minor.

**Surface Form.**—The position of the sterno-clavicular joint may be easily ascertained by feeling the enlarged sternal end of the collar-bone just external to the long, cord-like, sternal origin of the Sterno-mastoid muscle. If this muscle is relaxed by bending the head forward, a depression just internal to the end of the clavicle, and between it and the sternum, can be felt, indicating the exact position of the joint, which is subcutaneous. When the arm hangs by the side, the cavity of the joint is V-shaped. If the arm is raised, the bones become more closely approximated, and the cavity becomes a mere slit.

**Surgical Anatomy.**—The strength of this joint mainly depends upon its ligaments, and it is to this, and to the fact that the force of the blow is generally transmitted along the long axis of the clavicle, that dislocation rarely occurs, and that the bone is generally broken rather than displaced. When dislocation does occur, the course which the displaced bone takes depends more upon the direction in which the violence is applied than upon the anatomical construction of the joint; it may be either forward, backward, or upward. The chief point worthy of note, as regards the construction of the joint, in regard to dislocations, is the fact that, owing to the shape of the articular surfaces being so little adapted to each other, and that the strength of the joint mainly depends upon the ligaments, the displacement when reduced is very liable to recur, and hence it is extremely difficult to keep the end of the bone in its proper place.

[1] Humphry, *On the Human Skeleton*, p. 402.

### II. Acromio-clavicular Articulation (Fig. 169).

The **Acromio-clavicular** is an arthrodial joint formed between the outer extremity of the clavicle and the inner margin of the acromion process of the scapula. Its ligaments are the

| | | |
|---|---|---|
| Superior Acromio-clavicular. | | Trapezoid |
| Inferior Acromio-clavicular. | Coraco-clavicular | and |
| Interarticular Fibro-cartilage. | | Conoid. |

The **Superior Acromio-clavicular Ligament** is a quadrilateral band which covers the superior part of the articulation, extending between the upper part of the outer end of the clavicle and the adjoining part of the upper surface of the acromion. It is composed of parallel fibres which interlace with the aponeurosis of the Trapezius and Deltoid muscles; below, it is in contact with the interarticular fibro-cartilage (when it exists) and the synovial membranes.

The **Inferior Acromio-clavicular Ligament**, somewhat thinner than the preceding, covers the under part of the articulation, and is attached to the adjoining surfaces of the two bones. It is in relation, above, with the synovial membranes, and in rare cases with the interarticular fibro-cartilage; below, with the tendon

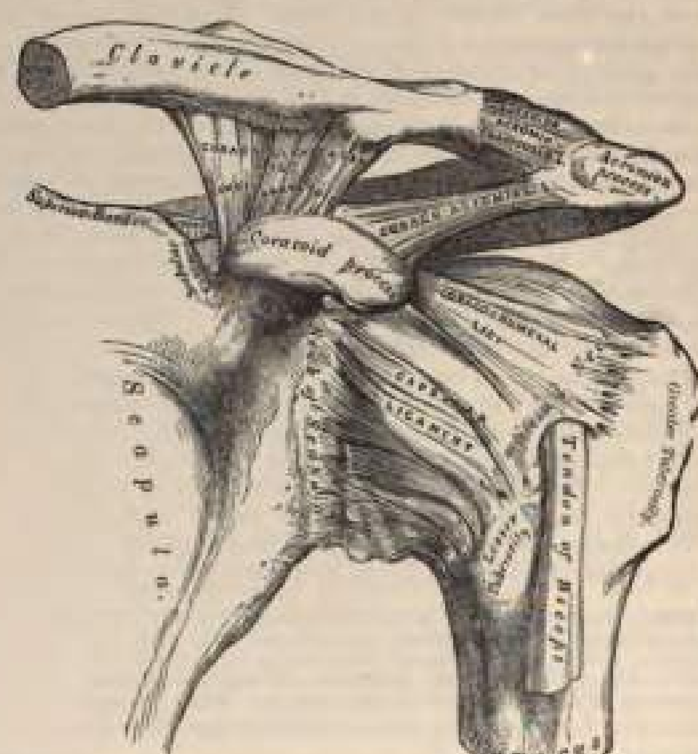



FIG. 169.—The left shoulder-joint, scapulo-clavicular articulations, and proper ligaments of scapula.

of the Supraspinatus. These two ligaments are continuous with each other in front and behind, and form a complete capsule round the joint.

The **Interarticular Fibro-cartilage** is frequently absent in this articulation. When it exists it generally only partially separates the articular surfaces, and occupies the upper part of the articulation. More rarely it completely separates the joint into two cavities.

**The Synovial Membrane.**—There is usually only one synovial membrane in this articulation, but when a complete interarticular fibro-cartilage exists there are two synovial membranes.

The **Coraco-clavicular Ligament** serves to connect the clavicle with the coracoid process of the scapula. It does not properly belong to this articulation, but as it forms a most efficient means in retaining the clavicle in contact with the acromial process, it is usually described with it. It consists of two fasciculi, called the *trapezoid* and *conoid ligaments*.

The *Trapezoid Ligament*, the anterior and external fasciculus, is broad, thin, and quadrilateral; it is placed obliquely between the coracoid process and the clavicle. It is attached, below, to the upper surface of the coracoid process; above, to the oblique line on the under surface of the clavicle. Its anterior border is free; its posterior border is joined with the conoid ligament, the two forming by their junction a projecting angle.

The *Conoid Ligament*, the posterior and internal fasciculus, is a dense band of fibres, conical in form, the base being directed upward, the summit downward. It is attached by its apex to a rough impression at the base of the coracoid process, internal to the preceding; above, by its expanded base, to the conoid tubercle on the under surface of the clavicle, and to a line proceeding internally from it for half an inch. These ligaments are in relation, in front, with the Subclavius and Deltoid; behind, with the Trapezius. They serve to limit rotation of the scapula, the Trapezoid limiting rotation forward, and the Conoid backward.

**Actions.**—The movements of this articulation are of two kinds: 1. A gliding motion of the articular end of the clavicle on the acromion. 2. Rotation of the scapula forward and backward upon the clavicle, the extent of this rotation being limited by the two portions of the coraco-clavicular ligament.

The acromio-clavicular joint has important functions in the movements of the upper extremity. It has been well pointed out by Sir George Humphry that if there had been no joint between the clavicle and scapula the circular movement of the scapula on the ribs (as in throwing both shoulders backward or forward) would have been attended with a greater alteration in the direction of the shoulder than is consistent with the free use of the arm in such position, and it would have been impossible to give a blow straight forward with the full force of the arm; that is to say, with the combined force of the scapula, arm, and forearm. "This joint," as he happily says, "is so adjusted as to enable either bone to turn in a hinge-like manner upon a vertical axis drawn through the other, and it permits the surfaces of the scapula, like the baskets in a roundabout swing, to look the same way in every position or nearly so." Again, when the whole arch formed by the clavicle and scapula rises and falls (in elevation or depression of the shoulders), the joint between these two bones enables the scapula still to maintain its lower part in contact with the ribs.

**Surface Form.**—The position of the acromio-clavicular joint can generally be ascertained by the slightly enlarged extremity of the outer end of the clavicle, which causes it to project above the level of the acromion process of the scapula. Sometimes this enlargement is so considerable as to form a rounded eminence, which is easily to be felt. The joint lies in the plane of a vertical line passing up the middle of the front of the arm.

**Surgical Anatomy.**—Owing to the slanting shape of the articular surfaces of this joint, dislocation generally occurs downward; that is to say, the acromion process of the scapula is dislocated under the outer end of the clavicle; but dislocations in the opposite direction have been described. The displacement is often incomplete, on account of the strong coraco-clavicular ligaments, which remain untorn. The same difficulty exists, as in the sterno-clavicular dislocation, in maintaining the ends of the bone in position after reduction.

## III. Proper Ligaments of the Scapula (Fig. 169).

The proper ligaments of the scapula are the

Coraco-acromial. Transverse.

The **Coraco-acromial Ligament** is a strong triangular band, extending between the coracoid and acromial processes. It is attached, by its apex, to the summit of the acromion just in front of the articular surface for the clavicle, and by its broad base to the whole length of the outer border of the coracoid process. Its posterior fibres are directed inward, its anterior fibres forward and inward. This ligament completes the vault formed by the coracoid and acromion processes for the protection of the head of the humerus. It is in relation, above, with the clavicle and under surface of the Deltoid; below, with the tendon of the Supraspinatus muscle, a bursa being interposed. Its outer border is continuous with a dense lamina that passes beneath the Deltoid upon the tendons of the Supra- and Infraspinatus muscles. This ligament is sometimes described as consisting of two marginal bands and a thinner intervening portion, the two bands being attached respectively to the apex and base of the coracoid process, and joining together at their attachment into the acromion process. When the Pectoralis minor is inserted, as sometimes is the case, into the capsule of the shoulder-joint instead of into the coracoid process, it passes between these two bands, and the intervening portion is then deficient.

The **Transverse** or **Coracoid** (*suprascapular*) **Ligament** converts the suprascapular notch into a foramen. It is a thin and flat fasciculus, narrower at the middle than at the extremities, attached by one end to the base of the coracoid process, and by the other to the inner extremity of the scapular notch. The suprascapular nerve passes through the foramen; the suprascapular vessels pass over the ligament.

An additional ligament (the *spino-glenoid*) is sometimes found on the scapula, stretching from the outer border of the spine to the margin of the glenoid cavity. When present, it forms an arch under which the suprascapular vessels and nerve pass as they enter the infraspinous fossa.

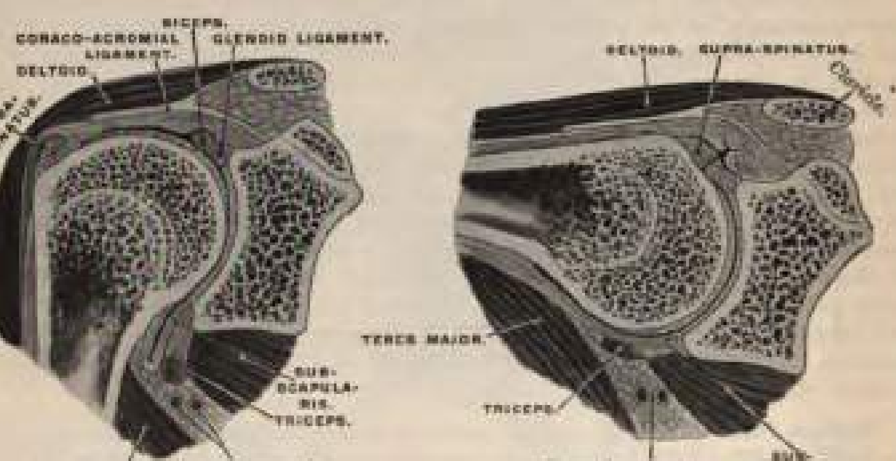



FIG. 170.—Vertical sections through the shoulder-joint, the arm being vertical and horizontal. (After Henle.)

**Movements of Scapula.**—The scapula is capable of being moved upward and downward, forward and backward, or, by a combination of these movements, circumducted on the wall of the chest. The muscles which *raise* the scapula are the upper fibres of the Trapezius, the Levator anguli scapulæ, and the two Rhomboids; those which *depress* it are the lower fibres of the Trapezius, the Pectoralis minor, and, through the clavicle, the Subclavius. The scapula is drawn *backward* by the Rhomboids and the middle and lower fibres of the Trapezius, and *forward* by the Serratus magnus and Pectoralis minor, assisted, when the arm is fixed, by the Pectoralis major. The mobility of the scapula is very considerable, and greatly assists the movements of the arm at the shoulder-joint. Thus, in raising the arm from the side the Deltoid and Supraspinatus can only lift it to a right angle with the trunk, the further elevation of the limb being effected by the Trapezius and Serratus magnus moving the scapula on the wall of the chest. This mobility is of special importance in ankylosis of the shoulder-joint, the movements of this bone compensating to a very great extent for the immobility of the joint.

## IV. Shoulder-joint (Fig. 169).

The **Shoulder** is an enarthrodial or ball-and-socket joint. The bones entering into its formation are the large globular head of the humerus, which is received into the shallow glenoid cavity of the scapula—an arrangement which permits of very considerable movement, whilst the joint itself is protected against displacement by the tendons which surround it and by atmospheric pressure. The ligaments do not maintain the joint surfaces in apposition, because when they alone remain the humerus can be separated to a considerable extent from the glenoid cavity; their use, therefore, is to limit the amount of movement. Above, the joint is protected by an arched vault, formed by the under surface of the coracoid and acromion processes, and the coraco-acromial ligament. The articular surfaces are covered by a layer of cartilage: that on the head of the humerus is thicker at the centre than at the circumference, the reverse being the case in the glenoid cavity. The ligaments of the shoulder are the

| | |
|---|---|
| Capsular. | Transverse humeral. |
| Coraco-humeral. | Glenoid.[1] |

The **Capsular Ligament** completely encircles the articulation, being attached, above, to the circumference of the glenoid cavity beyond the glenoid ligament; below, to the anatomical neck of the humerus, approaching nearer to the articular cartilage above than in the rest of its extent. It is thicker above and below than elsewhere, and is remarkably loose and lax, and much larger and longer than is necessary to keep the bones in contact, allowing them to be separated from each other more than an inch—an evident provision for that extreme freedom of movement which is peculiar to this articulation. Its superficial surface is strengthened, above, by the Supraspinatus; below, by the long head of the Triceps; behind, by the tendons of the Infraspinatus and Teres minor; and in front, by the tendon of the Subscapularis. The capsular ligament usually presents three openings; one anteriorly, below the coracoid process, establishes a communication between the synovial membrane of the joint and a bursa beneath the tendon of the Subscapularis muscle. The second, which is not constant, is at the posterior part, where a communication sometimes exists between the joint and a bursal sac belonging to the Infraspinatus muscle. The third is seen between the two tuberosities, for the passage of the long tendon of the Biceps muscle.

The **Coraco-humeral** is a broad band which strengthens the upper part of the capsular ligament. It arises from the outer border of the coracoid process, and passes obliquely downward and outward to the front of the great tuberosity of the humerus, being blended with the tendon of the Supraspinatus muscle. This ligament is intimately united to the capsular in the greater part of its extent.

**Supplemental Bands of the Capsular Ligament.**—In addition to the coraco-humeral ligament, the capsular ligament is strengthened by supplemental bands in the interior of the joint. One of these bands is situated on the inner side of the joint, and passes from the inner edge of the glenoid cavity to the lower part of the lesser tuberosity of the humerus. This is sometimes known as *Flood's ligament*, and is supposed to correspond with the ligamentum teres of the hip-joint. A second of these bands is situated at the lower part of the joint, and passes from the under edge of the glenoid cavity to the under part of the neck of the humerus, and is known as *Schlemm's ligament*. A third, called the *gleno-humeral ligament*, is situated at the upper part of the joint, and projects into its interior, so that it can

[1] The long tendon of origin of the Biceps muscle also acts as one of the ligaments of this joint. See the observations on p. 222 on the function of the muscles passing over more than one joint.

be seen only when the capsule is opened. It is attached above to the apex of the glenoid cavity, close to the root of the coracoid process, and, passing downward along the inner edge of the tendon of the Biceps, is attached below to the lesser tuberosity of the humerus, where it forms the inner boundary of the upper part of the bicipital groove. It is a thin, ribbon-like band, occasionally quite free from the capsule.

**The Transverse Humeral Ligament.**—This is a broad band of fibrous tissue passing from the lesser to the greater tuberosity of the humerus, and always limited to that portion of the bone which lies above the epiphyseal line. It converts the bicipital groove into an osseo-aponeurotic canal, and is the analogue of the strong process of bone which connects the summits of the two tuberosities in the musk ox.

The **Glenoid Ligament** is a fibro-cartilaginous rim, attached round the margin of the glenoid cavity. It is triangular on section, the thickest portion being fixed to the circumference of the cavity, the free edge being thin and sharp. It is continuous above with the long tendon of the Biceps muscle, which bifurcates at the upper part of the cavity into two fasciculi, and becomes continuous with the fibrous tissue of the glenoid ligament. This ligament deepens the cavity for articulation, and protects the edges of the bone. It is lined by the synovial membrane.

The **Synovial Membrane** is reflected from the margin of the glenoid cavity over the fibro-cartilaginous rim surrounding it: it is then reflected over the internal surface of the capsular ligament, covers the lower part and sides of the anatomical neck of the humerus as far as the cartilage covering the head of the bone. The long tendon of the Biceps muscle which passes through the capsular ligament is enclosed in a tubular sheath of synovial membrane, which is reflected upon it at the point where it perforates the capsule, and is continued around it as far as the summit of the glenoid cavity. The tendon of the Biceps is thus enabled to traverse the articulation, but it is not contained in the interior of the synovial cavity. The synovial membrane communicates with a large bursal sac beneath the tendon of the Subscapularis by an opening at the inner side of the capsular ligament; it also occasionally communicates with another bursal sac, beneath the tendon of the Infraspinatus, through an orifice at its posterior part. A third bursal sac, which does not communicate with the joint, is placed between the under surface of the Deltoid and the outer surface of the capsule.

The *Muscles* in relation with the joint are, above, the Supraspinatus; below, the long head of the Triceps; in front, the Subscapularis; behind, the Infraspinatus and Teres minor; within, the long tendon of the Biceps. The Deltoid is placed most externally, and covers the articulation on its outer side, as well as in front and behind.

The *Arteries* supplying the joint are articular branches of the anterior and posterior circumflex, and suprascapular.

The *Nerves* are derived from the circumflex and suprascapular.

**Actions.**—The shoulder-joint is capable of movement in every direction, forward, backward, abduction, adduction, circumduction, and rotation. The humerus is drawn *forward* by the Pectoralis major, anterior fibres of the Deltoid, Coraco-brachialis, and by the Biceps when the forearm is flexed; *backward*, by the Latissimus dorsi, Teres major, posterior fibres of the Deltoid, and by the Triceps when the forearm is extended; it is *abducted* (elevated) by the Deltoid and Supraspinatus; it is *adducted* (depressed) by the Subscapularis, Pectoralis major, Latissimus dorsi, and Teres major; it is *rotated outward* by the Infraspinatus and Teres minor; and it is *rotated inward* by the Subscapularis, Latissimus dorsi, Teres major, and Pectoralis major.

The most striking peculiarities in this joint are: 1. The large size of the head of the humerus in comparison with the depth of the glenoid cavity, even when supplemented by the glenoid ligament. 2. The looseness of the capsule of the joint. 3. The intimate connection of the capsule with the muscles attached to the head of the humerus. 4. The peculiar relation of the biceps tendon to the joint.

It is in consequence of the relative size of the two articular surfaces that the joint enjoys such free movement in every possible direction. When these movements of the arm are arrested in the shoulder-joint by the contact of the bony surfaces and by the tension of the corresponding fibres of the capsule, together with that of the muscles acting as accessory ligaments, they can be carried considerably farther by the movements of the scapula, involving, of course, motion at the acromio- and sterno-clavicular joints. These joints are therefore to be regarded as accessory structures to the shoulder-joint.[1] The extent of these movements of the scapula is very considerable, especially in extreme elevation of the arm, which movement is best accomplished when the arm is thrown somewhat forward and outward, because the margin of the head of the humerus is by no means a true circle; its greatest diameter is from the bicipital groove downward, inward, and backward, and the greatest elevation of the arm can be obtained by rolling its articular surface in the direction of the measurement. The great width of the central portion of the humeral head also allows of very free horizontal movement when the arm is raised to a right angle, in which movement the arch formed by the acromion, the coracoid process, and the coraco-acromial ligament constitutes a sort of supplemental articular cavity for the head of the bone.

The looseness of the capsule is so great that the arm will fall about an inch from the scapula when the muscles are dissected from the capsular ligament and an opening made in it to remove the atmospheric pressure. The movements of the joint, therefore, are not regulated by the capsule so much as by the surrounding muscles and by the pressure of the atmosphere—an arrangement which "renders the movements of the joint much more easy than they would otherwise have been, and permits a swinging, pendulum-like vibration of the limb when the muscles are at rest" (Humphry). The fact, also, that in all ordinary positions of the joint the capsule is not put on the stretch enables the arm to move freely in all directions. Extreme movements are checked by the tension of appropriate portions of the capsule, as well as by the interlocking of the bones. Thus it is said that "abduction is checked by the contact of the great tuberosity with the upper edge of the glenoid cavity, adduction by the tension of the coraco-humeral ligament" (Beaunis et Bouchard). Cleland[2] maintains that the limitations of movement at the shoulder-joint are due to the structure of the joint itself, the glenoid ligament fitting, in different positions of the elevated arm, into the anatomical neck of the humerus.

Cathcart[3] has pointed out that in abducting the arm and raising it above the head, the scapula rotates throughout the whole movement with the exception of a short space at the beginning and at the end; that the humerus moves on the scapula not only from the hanging to the horizontal position, but also in passing upward as it approaches the vertical above; that the clavicle moves not only during the second half of the movement but in the first as well, though to a less extent—*i. e.*, the scapula and clavicle are concerned in the first stage as well as in the second; and that the humerus is partly involved in the second as well as chiefly in the first.

The intimate union of the tendons of the four short muscles with the capsule converts these muscles into elastic and spontaneously acting ligaments of the joint, and it is regarded as being also intended to prevent the folds into which all portions of the capsule would alternately fall in the varying positions of the joint from being driven between the bones by the pressure of the atmosphere.

The peculiar relations of the Biceps tendon to the shoulder-joint appear to subserve various purposes. In the first place, by its connection with both the shoulder and elbow the muscle harmonizes the action of the two joints, and acts as an elastic ligament in all positions, in the manner previously adverted to.[4] Next, it strengthens the upper part of the articular cavity, and prevents the head of the

[1] See p. 249. [2] *Journal of Anatomy and Physiology*, vol. xviii., 1884. [3] *Ibid.* [4] See p. 222.

humerus from being pressed up against the acromion process, when the Deltoid contracts, instead of forming the centre of motion in the glenoid cavity. By its passage along the bicipital groove it assists in rendering the head of the humerus steady in the various movements of the arm. When the arm is raised from the side it assists the Supra- and Infraspinatus in rotating the head of the humerus in the glenoid cavity. It also holds the head of the bone firmly in contact with the glenoid cavity, and prevents its slipping over its lower edge, or being displaced by the action of the Latissimus dorsi and Pectoralis major, as in climbing and many other movements.

**Surface Form.**—The direction and position of the shoulder-joint may be indicated by a line drawn from the middle of the coraco-acromial ligament, in a curved direction, with its convexity inward, to the innermost part of that portion of the head of the humerus which can be felt in the axilla when the arm is forcibly abducted from the side. When the arm hangs by the side, not more than one-third of the head of the bone is in contact with the glenoid cavity, and three-quarters of its circumference is in front of a vertical line drawn from the anterior border of the acromion process.

**Surgical Anatomy.**—Owing to the construction of the shoulder-joint and the freedom of movement which it enjoys, as well as in consequence of its exposed situation, it is more frequently dislocated than any other joint in the body. Dislocation occurs when the arm is abducted, and when, therefore, the head of the humerus presses against the lower and front part of the capsule, which is the thinnest and least supported part of the ligament. The rent in the capsule almost invariably takes place in this situation, and through it the head of the bone escapes, so that the dislocation in most instances is primarily subglenoid. The head of the bone does not usually remain in this situation, but generally assumes some other position, which varies according to the direction and amount of force producing the dislocation and the relative strength of the muscles in front and behind the joint. In consequence of the muscles at the back being stronger than those in front, and especially on account of the long head of the Triceps preventing the bone passing backward, dislocation forward is much more common than backward. The most frequent position which the head of the humerus ultimately assumes is on the front of the neck of the scapula, beneath the coracoid process, and hence named subcoracoid dislocation. Occasionally, in consequence probably of a greater amount of force being brought to bear on the limb, the head is driven farther inward, and rests on the upper part of the front of the chest, beneath the clavicle (subclavicular). Sometimes it remains in the position in which it was primarily displaced, resting on the axillary border of the scapula (subglenoid), and rarely it passes backward and remains in the infraspinatous fossa, beneath the spine (subspinous).

The shoulder-joint is sometimes the seat of all those inflammatory affections, both acute and chronic, which attack joints, though perhaps less frequently than some other joints of equal size and importance. Acute synovitis may result from injury, rheumatism, or pyæmia, or may follow secondarily on the so-called acute epiphysitis of infants. It is attended with effusion into the joint, and when this occurs the capsule is evenly distended and the contour of the joint rounded. Special projections may occur at the site of the openings in the capsular ligament. Thus a swelling may appear just in front of the joint, internal to the lesser tuberosity, from effusion into the bursa beneath the Subscapularis muscle; or, again, a swelling which is sometimes bilobed may be seen in the interval between the Deltoid and Pectoralis major muscles, from effusion into the diverticulum, which runs down the bicipital groove with the tendon of the biceps. The effusion into the synovial membrane can be best ascertained by examination from the axilla, where a soft, elastic, fluctuating swelling can usually be felt.

Tubercular arthritis not unfrequently attacks the shoulder-joint, and may lead to total destruction of the articulation, when ankylosis may result or long-protracted suppuration may necessitate excision. This joint is also one of those which is most liable to be the seat of osteoarthritis, and may also be affected in gout and rheumatism; or in locomotor ataxy, when it becomes the seat of Charcot's disease.

Excision of the shoulder-joint may be required in cases of arthritis (especially the tubercular form) which have gone on to destruction of the articulation; in compound dislocations and fractures, particularly those arising from gunshot injuries, in which there has been extensive injury to the head of the bone; in some cases of old unreduced dislocation, where there is much pain; and possibly in some few cases of growth connected with the upper end of the bone. The operation is best performed by making an incision from the middle of the coraco-acromial ligament down the arm for about three inches: this will expose the bicipital groove and the tendon of the Biceps, which may be either divided or hooked out of the way, according as to whether it is implicated in the disease or not. The capsule is then freely opened, and the muscles attached to the greater and lesser tuberosities of the humerus divided. The head of the bone can then be thrust out of the wound and sawn off, or divided with a narrow saw *in situ* and subsequently removed. The section should be made, if possible, just below the articular surface, so as to leave the bone as long as possible. The glenoid cavity must then be examined, and gouged if carious.

### V. Elbow-joint (Figs. 171, 172).

The **Elbow** is a *ginglymus* or hinge-joint. The bones entering into its formation are the trochlear of the humerus, which is received into the greater sigmoid cavity of the ulna, and admits of the movements peculiar to this joint—viz. flexion and extension; whilst the lesser, or radial, head of the humerus articulates with the cup-shaped depression on the head of the radius; the circumference of the head of the radius articulates with the lesser sigmoid cavity of the ulna, allowing of the movement of rotation of the radius on the ulna, the chief action of the superior radio-ulnar articulation. The articular surfaces are covered with a thin layer of cartilage, and connected together by a capsular ligament of unequal thickness, being especially thickened on its two sides and, to a less extent, in front and behind. These thickened portions are usually described as distinct ligaments under the following names:

| | |
|---|---|
| Anterior. | Internal Lateral. |
| Posterior. | External Lateral. |

The orbicular ligament of the upper radio-ulnar articulation must also be reckoned among the ligaments of the elbow.

The **Anterior Ligament** (Fig. 171) is a broad and thin fibrous layer which covers the anterior surface of the joint. It is attached to the front of the internal condyle and to the front of the humerus immediately above the coronoid and radial fossæ; below, to the anterior surface of the coronoid process of the ulna and orbicular ligament, being continuous on each side with the lateral ligaments. Its superficial

FIG. 171.—Left elbow-joint, showing anterior and internal ligaments.

FIG. 172.—Left elbow-joint, showing posterior and external ligaments.

fibres pass obliquely from the inner condyle of the humerus outward to the orbicular ligament. The middle fibres, vertical in direction, pass from the upper part of the coronoid depression and become partly blended with the preceding, but mainly inserted into the anterior surface of the coronoid process. The deep or transverse set intersects these at right angles. This ligament is in relation, in front, with the Brachialis anticus, except at its outermost part; behind, with the synovial membrane.

The **Posterior Ligament** (Fig. 172) is a thin and loose membranous fold, attached, above, to the lower end of the humerus, above and at the sides of the olecranon fossa; below, to the groove on the upper and outer surfaces of the olecranon. The superficial or transverse fibres pass between the adjacent margins of the olecranon fossa. The deeper portion consists of vertical fibres, some of which, thin and weak, pass from the upper part of the olecranon fossa to the margin of the olecranon; others, thicker and stronger, pass from the back of the capitellum of the humerus to the posterior border of the lesser sigmoid cavity of the ulna. This ligament is in relation, behind, with the tendon of the Triceps and the Anconeus; in front, with the synovial membrane.

The **Internal Lateral Ligament** (Fig. 171) is a thick triangular band consisting of two portions, an anterior and posterior, united by a thinner intermediate portion. The *anterior portion*, directed obliquely forward, is attached, above, by its apex, to the front part of the internal condyle of the humerus; and, below, by its broad base, to the inner margin of the coronoid process. The *posterior portion*, also of triangular form, is attached, above, by its apex, to the lower and back part of the internal condyle; below, to the inner margin of the olecranon. Between these two bands a few intermediate fibres descend from the internal condyle to blend with a transverse band of ligamentous tissue which bridges across the notch between the olecranon and coronoid processes. This ligament is in relation, internally, with the Triceps and Flexor carpi ulnaris muscles and the ulnar nerve, and gives origin to part of the Flexor sublimis digitorum.

The **External Lateral Ligament** (Fig. 172) is a short and narrow fibrous band less distinct than the internal, attached, above, to a depression below the external condyle of the humerus; below, to the orbicular ligament, some of its most posterior fibres passing over that ligament, to be inserted into the outer margin of the ulna. This ligament is intimately blended with the tendon of origin of the Supinator brevis muscle.

The **Synovial Membrane** is very extensive. It covers the margin of the articular surface of the humerus, and lines the coronoid and olecranon fossæ on that bone; from these points it is reflected over the anterior, posterior, and lateral ligaments, and forms a pouch between the lesser sigmoid cavity, the internal surface of the orbicular ligament, and the circumference of the head of the radius. Projecting into the cavity is a crescentic fold of synovial membrane, between the radius and ulna, suggesting the division of the joint into two: one the humero-radial, the other the humero-ulnar.

Between the capsular ligament and the synovial membrane are three masses of fat; one, the largest, above the olecranon fossa, which is pressed into the fossa by the triceps during flexion; a second, over the coronoid fossa; and a third, over the radial fossa. These are pressed into their respective fossæ during extension.

The *Muscles* in relation with the joint are, in front, the Brachialis anticus; behind, the Triceps and Anconeus; externally, the Supinator brevis and the common tendon of origin of the Extensor muscles; internally, the common tendon of origin of the Flexor muscles, and the Flexor carpi ulnaris, with the ulnar nerve (Fig. 173).

The *Arteries* supplying the joint are derived from the anastomosis between the superior profunda, inferior profunda, and anastomotica magna arteries, branches of the brachial, with the anterior, posterior, and interosseous recurrent branches of the ulnar and the recurrent branch of the radial. These vessels form a complete chain of inosculation around the joint.

The *Nerves* are derived from the ulnar as it passes between the internal condyle and the olecranon; a filament from the musculo-cutaneous (Rüdinger), and two from the median (Macalister).

**Actions.**—The elbow-joint comprises three different portions—viz., the joint between the ulna and humerus, that between the head of the radius and the humerus, and the superior radio-ulnar articulation, described below. All these articular surfaces are invested by a common synovial membrane, and the movements of the whole joint should be studied together. The combination of the movements of flexion and extension of the forearm with those of pronation and supination of the hand, which is ensured by the two being performed at the same joint, is essential to the accuracy of the various minute movements of the hand.

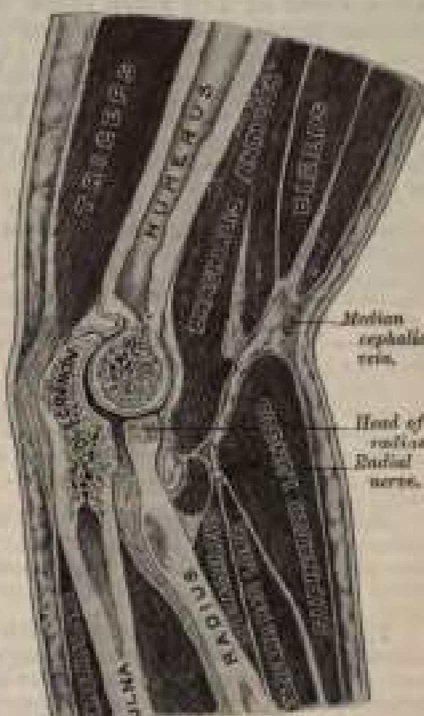


FIG. 173.—Sagittal section of the right elbow-joint, taken somewhat obliquely and seen from the radial aspect. (After Braune.)

The portion of the joint between the ulna and humerus is a simple hinge-joint, and allows of movements of flexion and extension only. Owing to the obliquity of the trochlear surface of the humerus, this movement does not take place in a straight line; so that when the forearm is extended and supinated the axis of the arm and forearm is not in the same line, but the one portion of the limb forms an angle with the others, and the hand, with the forearm, is directed outward. During flexion, on the other hand, the forearm and the hand tend to approach the middle line of the body, and thus enable the hand to be easily carried to the face. The shape of the articular surface of the humerus, with its prominences and depressions accurately adapted to the opposing surfaces of the olecranon, prevents any lateral movement. *Flexion* is produced by the action of the Biceps and Brachialis anticus, assisted by the muscles arising from the internal condyle of the humerus and the Supinator longus; *extension*, by the Triceps and Anconeus, assisted by the extensors of the wrist and by the Extensor communis digitorum and Extensor minimi digiti.

The joint between the head of the radius and the capitellum or radial head of the humerus is an arthrodial joint. The bony surfaces would of themselves constitute an enarthrosis, and allow of movement in all directions were it not for the orbicular ligament by which the head of the radius is bound down firmly to the sigmoid cavity of the ulna, and which prevents any separation of the two bones laterally. It is to the same ligament that the head of the radius owes its security from dislocation, which would otherwise constantly occur as a consequence of the shallowness of the cup-like surface on the head of the radius. In fact, but for this ligament the tendon of the biceps would be liable to pull the head of the radius out of the joint.[1] In complete extension the head of the radius glides so far back on the outer condyle that its edge is plainly felt at the back of the articulation. Flexion and extension of the elbow-joint are limited by the tension of the structures on the front and back of the joint, the limitation of flexion being also aided by the soft structures of the arm and forearm coming in contact.

In combination with any position of flexion or extension the head of the radius

[1] Humphry, *op. cit.*, p. 419.

can be rotated in the upper radio-ulnar joint, carrying the hand with it. The hand is directly articulated to the lower surface of the radius only, and the concave or sigmoid surface on the lower end of the radius travels round the lower end of the ulna. The latter bone is excluded from the wrist-joint (as will be seen in the sequel) by the interarticular fibro-cartilage. Thus, rotation of the head of the radius round an axis which passes through the centre of the radial head of the humerus imparts circular movement to the hand through a very considerable arc.

**Surface Form.**—If the forearm be slightly flexed on the arm, a curved crease or fold with its convexity downward may be seen running across the front of the elbow, extending from one condyle to the other. The centre of this fold is some slight distance above the line of the joint. The position of the radio-humeral portion of the joint can be at once ascertained by feeling for a slight groove or depression between the head of the radius and the capitellum of the humerus at the back of the articulation.

**Surgical Anatomy.**—From the great breadth of the joint, and the manner in which the articular surfaces are interlocked, and also on account of the strong lateral ligaments and the support which the joint derives from the mass of muscles attached to each condyle of the humerus, lateral displacement of the bones is very uncommon, whereas antero-posterior dislocation, on account of the shortness of the antero-posterior diameter, the weakness of the anterior and posterior ligaments, and the want of support of muscles, much more frequently takes place, dislocation backward taking place when the forearm is in a position of extension, and forward when in a position of flexion. For, in the former position, that of extension, the coronoid process is not interlocked into the coronoid fossa, and loses its grip to a certain extent, whereas the olecranon process is in the olecranon fossa, and entirely prevents displacement forward. On the other hand, during flexion, the coronoid process is in the coronoid fossa, and prevents dislocation backward, while the olecranon loses its grip and is not so efficient, as during extension, in preventing a forward displacement. When lateral dislocation does take place, it is generally incomplete.

Dislocation of the elbow-joint is of common occurrence in children, far more common than dislocation of any other articulation, for, as a rule, fracture of a bone more frequently takes place, under the application of any severe violence, in young persons than dislocation. In lesions of this joint there is often very great difficulty in ascertaining the exact nature of the injury.

The elbow-joint is occasionally the seat of acute synovitis. The synovial membrane then becomes distended with fluid, the bulging showing itself principally around the olecranon process; that is to say, on its inner and outer sides and above, in consequence of the laxness of the posterior ligament. Occasionally a well-marked, triangular projection may be seen on the outer side of the olecranon, from bulging of the synovial membrane beneath the Anconeus muscle. Again, there is often some swelling just above the head of the radius, in the line of the radio-humeral joint. There is generally not much swelling at the front of the joint, though sometimes deep-seated fulness beneath the Brachialis anticus may be noted. When suppuration occurs the abscess usually points at one or other border of the Triceps muscle; occasionally the pus discharges itself in front, near the insertion of the Brachialis anticus muscle. Chronic synovitis, usually of tubercular origin, is of common occurrence in the elbow-joint: under these circumstances the forearm tends to assume the position of semi-flexion which is that of greatest ease and relaxation of ligaments. It should be borne in mind that should ankylosis occur in this or the extended position, the limb will not be nearly so useful as if ankylosed in a position of rather less than a right angle. Loose cartilages are sometimes met with in the elbow-joint, not so commonly, however, as in the knee; nor do they, as a rule, give rise to such urgent symptoms, and rarely require operative interference. The elbow-joint is also sometimes affected with osteo-arthritis, but this affection is less common in this articulation than in some other of the larger joints.

Excision of the elbow is principally required for three conditions: viz. tubercular arthritis, injury and its results, and faulty ankylosis; but may be necessary for some other rarer conditions, such as disorganizing arthritis after pyæmia, unreduced dislocations, and osteo-arthritis. The results of the operation are, as a rule, more favorable than those of excision of any other joint, and it is one, therefore, that the surgeon should never hesitate to perform, especially in the first three of the conditions mentioned above. The operation is best performed by a single vertical incision down the back of the joint, a transverse incision, over the outer condyle, being added if the parts are much thickened and fixed. A straight incision is made about four inches long, the mid-point of which is on a level with and a little to the inner side of the tip of the olecranon. This incision is made down to the bone, through the substance of the Triceps muscle. The operator with the point of his knife, and guarding the soft parts with his thumb-nail, separates them from the bone. In doing this there are two structures which he should carefully avoid: the ulnar nerve, which lies parallel to his incision, but a little internal, as it courses down between the internal condyle and the olecranon process, and the prolongation of the Triceps into the deep fascia of the forearm over the Anconeus muscle. Having cleared the bones and divided the lateral and posterior ligaments, the forearm is strongly flexed and the ends of the bone turned out and sawn off. The section of the humerus should be through the base of the condyles, that of the ulna and radius should be just below the level of the lesser sigmoid cavity of the ulna and the neck of the radius. In this operation the object is to obtain such union as shall allow free motion of the bones of the forearm; and, therefore, passive motion must be commenced early, that is to say, about the tenth day.

## VI. Radio-ulnar Articulations.

The articulation of the radius with the ulna is effected by ligaments which connect together both extremities as well as the shafts of these bones. They may, consequently, be subdivided into three sets: 1, the superior radio-ulnar, which is a portion of the elbow-joint; 2, the middle radio-ulnar; and, 3, the inferior radio-ulnar articulations.

### 1. Superior Radio-ulnar Articulation.

This articulation is a trochoid or pivot-joint. The bones entering into its formation are the inner side of the circumference of the head of the radius rotating within the lesser sigmoid cavity of the ulna. Its only ligament is the *annular* or *orbicular*.

The **Orbicular Ligament** (Fig. 172) is a strong, flat band of ligamentous fibres, which surrounds the head of the radius, and retains it in firm connection with the lesser sigmoid cavity of the ulna. It forms about four-fifths of an osseo-fibrous ring, attached by each end to the extremities of the lesser sigmoid cavity, and is smaller at the lower part of its circumference than above, by which means the head of the radius is more securely held in its position. Its *outer surface*, is strengthened by the external lateral ligament of the elbow, and affords origin to part of the Supinator brevis muscle. Its *inner surface* is smooth, and lined by synovial membrane. The synovial membrane is continuous with that which lines the elbow-joint.

**Actions.**—The movement which takes place in this articulation is limited to rotation of the head of the radius within the orbicular ligament, and upon the lesser sigmoid cavity of the ulna, rotation forward being called *pronation*; rotation backward, *supination*. Supination is performed by the Biceps and Supinator brevis, assisted to a slight extent by the Extensor muscles of the thumb and, in certain positions, by the Supinator longus. Pronation is performed by the Pronator radii teres and the Pronator quadratus, assisted, in some positions, by the Supinator longus.

**Surface Form.**—The position of the superior radio-ulnar joint is marked on the surface of the body by the little dimple on the back of the elbow which indicates the position of the head of the radius.

**Surgical Anatomy.**—Dislocation of the head of the radius alone is not an uncommon accident, and occurs most frequently in young persons from falls on the hand when the forearm is extended and supinated, the head of the bone being displaced forward. It is attended by rupture of the orbicular ligament. Occasionally a peculiar injury, which is supposed to be a subluxation, occurs in young children in lifting them from the ground by the hand or forearm. It is believed that the head of the radius is displaced downward in the orbicular ligament, the upper border of which becomes folded over the head of the radius, between it and the capitellum of the humerus.

### 2. Middle Radio-ulnar Union.

The interval between the shafts of the radius and ulna is occupied by two ligaments.

| | |
|---|---|
| Oblique. | Interosseous. |

The **Oblique** or **Round Ligament** (Fig. 171) is a small, flattened fibrous band which extends obliquely downward and outward from the tubercle of the ulna at the base of the coronoid process to the radius a little below the bicipital tuberosity. Its fibres run in the opposite direction to those of the interosseous ligament, and it appears to be placed as a substitute for it in the upper part of the interosseous interval. This ligament is sometimes wanting.

The **Interosseous Membrane** is a broad and thin plane of fibrous tissue descending obliquely downward and inward, from the interosseous ridge on the radius to that

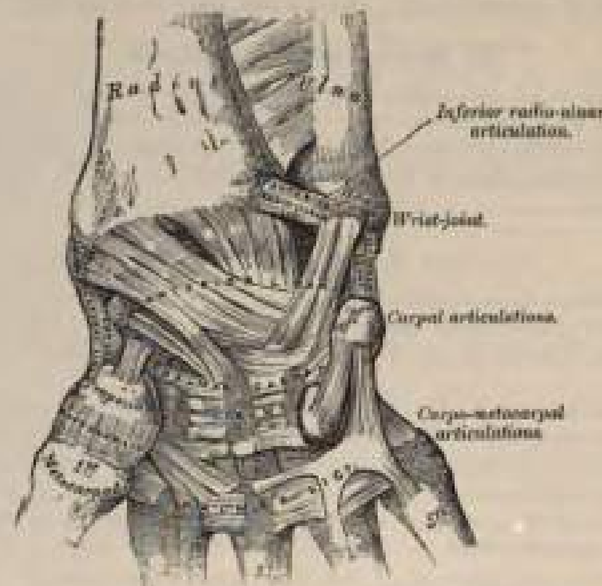



Fig. 174.—Ligaments of wrist and hand. Anterior view.

on the ulna. It is deficient above, commencing about an inch beneath the tubercle of the radius; is broader in the middle than at either extremity; and presents an oval aperture just above its lower margin for the passage of the anterior interosseous vessels to the back of the forearm. This ligament serves to connect the bones and to increase the extent of surface for the attachment of the deep muscles. Between its upper border and the oblique ligament an interval exists through which the posterior interosseous vessels pass. Two or three fibrous bands are occasionally found on the posterior surface of this membrane which descend obliquely from the ulna toward the radius, and which have consequently a direction contrary to that of the other fibres. It is in relation, *in front*, by its upper three-fourths with the Flexor longus pollicis on the outer side, and with the Flexor profundus digitorum on the inner, lying upon the interval between which are the anterior interosseous vessels and nerve; by its lower fourth, with the Pronator quadratus; *behind*, with the Supinator brevis, Extensor ossis metacarpi pollicis, Extensor brevis pollicis, Extensor longus pollicis, Extensor indicis; and, near the wrist, with the anterior interosseous artery and posterior interosseous nerve.

### 3. Inferior Radio-ulnar Articulation.

This is a pivot-joint, formed by the head of the ulna received into the sigmoid cavity at the inner side of the lower end of the radius. The articular surfaces are covered by a thin layer of cartilage, and connected together by the following ligaments:

Anterior Radio-ulnar. Posterior Radio-ulnar.
Interarticular Fibro-cartilage.

The **Anterior Radio-ulnar Ligament** (Fig. 174) is a narrow band of fibres extending from the anterior margin of the sigmoid cavity of the radius to the anterior surface of the head of the ulna.

The **Posterior Radio-ulnar Ligament** (Fig. 175) extends between similar points on the posterior surface of the articulation.

The **Interarticular Fibro-cartilage** (Fig. 177) is triangular in shape, and is placed transversely beneath the head of the ulna, binding the lower end of this bone and the radius firmly together. Its periphery is thicker than its centre, which is thin and occasionally perforated. It is attached by its apex to a depression which separates the styloid process of the ulna from the head of that bone; and by its base, which is thin, to the prominent edge of the radius, which separates the sigmoid cavity from the carpal articulating surface. Its margins are united to the ligaments of the wrist-joint. Its *upper surface*, smooth and concave, articulates with the head of the ulna, forming an arthrodial joint; its *under surface*, also concave and smooth, forms part of the wrist-joint and articulates with the cuneiform and inner part of the semilunar bone. Both surfaces are lined by a synovial membrane—the upper surface, by one peculiar to the radio-ulnar articulation; the under surface, by the synovial membrane of the wrist.

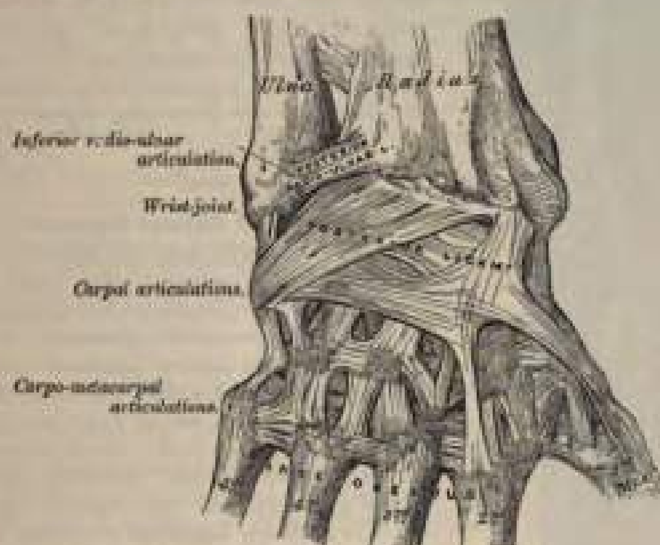



Fig. 176.—Ligaments of wrist and hand. Posterior view.

The **Synovial Membrane** (Fig. 177) of this articulation has been called, from its extreme looseness, the *membrana sacciformis*; it extends horizontally inward between the head of the ulna and the interarticular fibro-cartilage, and upward between the radius and the ulna, forming here a very loose *cul-de-sac*. The quantity of synovia which it contains is usually considerable.

**Actions.**—The movement in the inferior radio-ulnar articulation is just the reverse of that in the superior radio-ulnar joint. It consists of a movement of rotation of the lower end of the radius round an axis which corresponds to the centre of the head of the ulna. When the radius rotates forward, *pronation* of the forearm and hand is the result; and when backward, *supination*. It will thus be seen that in pronation and supination of the forearm and hand the radius describes a segment of a cone, the axis of which extends from the centre of the head of the radius to the middle of the head of the ulna. In this movement, however, the ulna is not quite stationary, but rotates a little in the opposite direction. So that it also describes the segment of a cone, though of smaller size than that described by the radius. The movement which causes this alteration in the position of the head of the ulna takes place principally at the shoulder-joint by a rotation of the humerus, but possibly also to a slight extent at the elbow-joint.[1]

**Surface Form.**—The position of the inferior radio-ulnar joint may be ascertained by feeling for a slight groove at the back of the wrist, between the prominent head of the ulna and the lower end of the radius, when the forearm is in a state of almost complete pronation.

[1] See *Journ. of Anat. and Phys.*, vol. xix., parts ii., iii., and iv.

## VII. Radio-carpal or Wrist-joint.

The **Wrist** is a condyloid articulation. The parts entering into its formation are the lower end of the radius and under surface of the interarticular fibro-cartilage, which form together the receiving cavity, and the scaphoid, semilunar, and cuneiform bones, which form the condyle. The articular surface of the radius and the under surface of the inter-articular fibro-cartilage are the receiving cavity, forming together a transversely elliptical concave surface. The articular surfaces of the scaphoid, semilunar, and cuneiform bones form together a smooth, convex surface, the condyle, which is received into the concavity above mentioned. All the bony surfaces of the articulation are covered with cartilage, and connected together by a capsule, which is divided into the following ligaments:

| | |
|---|---|
| External Lateral. | Anterior. |
| Internal Lateral. | Posterior. |

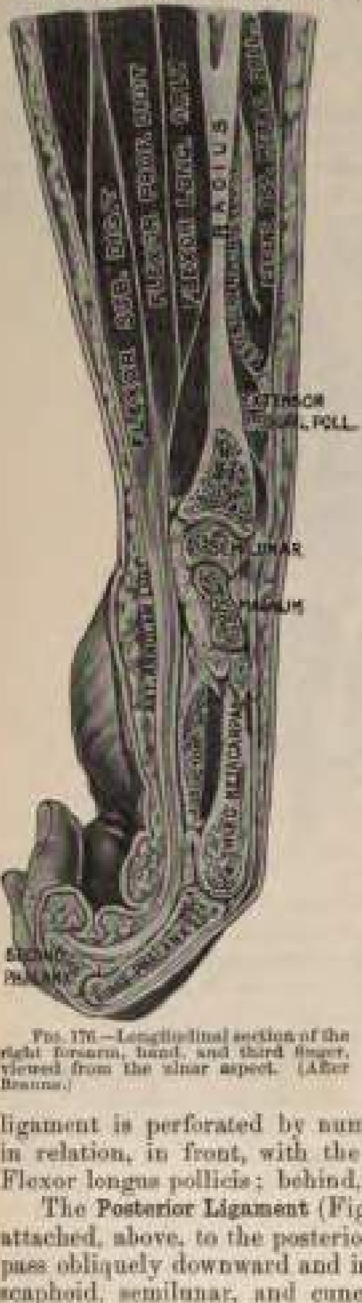


FIG. 176.—Longitudinal section of the right forearm, hand, and third finger, viewed from the ulnar aspect. (After Braune.)

The **External Lateral Ligament** (*radio-carpal*) (Fig. 174) extends from the summit of the styloid process of the radius to the outer side of the scaphoid, some of its fibres being prolonged to the trapezium and annular ligament.

The **Internal Lateral Ligament** (*ulno-carpal*) is a rounded cord, attached, above, to the extremity of the styloid process of the ulna, and dividing below into two fasciculi, which are attached, one to the inner side of the cuneiform bone, the other to the pisiform bone and annular ligament.

The **Anterior Ligament** is a broad membranous band, attached, above, to the anterior margin of the lower end of the radius, its styloid process and the ulna: its fibres pass downward and inward to be inserted into the palmar surface of the scaphoid, semilunar, and cuneiform bones, some of the fibres being continued to the os magnum. In addition to this broad membrane, there is a distinct rounded fasciculus, superficial to the rest, which passes from the base of the styloid process of the ulna to the semilunar and cuneiform bones. This ligament is perforated by numerous apertures for the passage of vessels, and is in relation, in front, with the tendons of the Flexor profundus digitorum and Flexor longus pollicis; behind, with the synovial membrane of the wrist-joint.

The **Posterior Ligament** (Fig. 175), less thick and strong than the anterior, is attached, above, to the posterior border of the lower end of the radius; its fibres pass obliquely downward and inward, to be attached to the dorsal surface of the scaphoid, semilunar, and cuneiform bones, being continuous with those of the dorsal carpal ligaments. This ligament is in relation, behind, with the extensor tendons of the fingers; in front, with the synovial membrane of the wrist.

The **Synovial Membrane** (Fig. 177) lines the inner surface of the ligaments above described, extending from the lower end of the radius and interarticular fibro-cartilage above to the articular surfaces of the carpal bones below. It is loose and lax, and presents numerous folds, especially behind.

**Relations.**—The wrist-joint is covered in front by the flexor and behind by the extensor tendons; it is also in relation with the radial and ulnar arteries.

The *Arteries* supplying the joint are the anterior and posterior carpal branches of the radial and ulnar, the anterior and posterior interosseous, and some ascending branches from the deep palmar arch.

The *Nerves* are derived from the ulnar and posterior interosseous.

**Actions.**—The movements permitted in this joint are flexion, extension, abduction, adduction, and circumduction. Its actions will be further studied with those of the carpus, with which they are combined.

**Surface Form.**—The line of the radio-carpal joint is on a level with the apex of the styloid process of the ulna.

**Surgical Anatomy.**—The wrist-joint is rarely dislocated, its strength depending mainly upon the numerous strong tendons which surround the articulation. Its security is further provided for by the number of small bones of which the carpus is made up, and which are united by very strong ligaments. The slight movement which takes place between the several bones serves to break the jars that result from falls or blows on the hand. Dislocation backward, which is the more common, simulates to a considerable extent Colles' fracture of the radius, and is liable to be mistaken for it. The diagnosis can be easily made out by observing the relative position of the styloid processes of the radius and the ulna. In the natural condition the styloid process of the radius is on a lower level—*i. e.* nearer the ground—when the arm hangs by the side, than that of the ulna, and the same would be the case in dislocation. In Colles' fracture, on the other hand, the styloid process of the radius is on the same, or even a higher level than that of the ulna.

The wrist-joint is occasionally the seat of acute synovitis, the result of traumatism or arising in the rheumatic or pyæmic state. When the synovial sac is distended with fluid, the swelling is greatest on the dorsal aspect of the wrist, showing a general fulness, with some bulging between the tendons. The inflammation is prone to extend to the intercarpal joints and to attack also the sheaths of the tendons in the neighborhood. Chronic inflammation of the wrist is generally tubercular, and often leads to similar disease in the synovial sheaths of adjacent tendons and of the intercarpal joints. The disease, therefore, when progressive, often leads to necrosis of the carpal bones, and the result is often unsatisfactory.

## VIII. Articulations of the Carpus.

These articulations may be subdivided into three sets:

1. The Articulations of the First Row of Carpal Bones.
2. The Articulations of the Second Row of Carpal Bones
3. The Articulations of the Two Rows with each other.

### 1. Articulations of the First Row of Carpal Bones.

These are arthrodial joints. The ligaments connecting the scaphoid, semilunar, and cuneiform bones are—

Dorsal. Palmar.
Two Interosseous.

The **Dorsal Ligaments** are placed transversely behind the bones of the first row; they connect the scaphoid and semilunar and the semilunar and cuneiform.

The **Palmar Ligaments** connect the scaphoid and semilunar and the semilunar and cuneiform bones; they are less strong than the dorsal, and placed very deeply below the anterior ligament of the wrist.

The **Interosseous Ligaments** (Fig. 177) are two narrow bundles of fibrous tissue connecting the semilunar bone on one side with the scaphoid, and on the other with the cuneiform. They are on a level with the superior surfaces of these bones, and close the upper part of the spaces between them. Their upper surfaces are smooth, and form with the bones the convex articular surfaces of the wrist-joint.

The ligaments connecting the pisiform bone are—

Capsular. Two Palmar ligaments.

The **Capsular Ligament** is a thin membrane which connects the pisiform bone to the cuneiform. It is lined with a separate synovial membrane.

The **two Palmar Ligaments** are two strong fibrous bands which connect the pisiform to the unciform, the *piso-uncinate*, and to the base of the fifth metacarpal bone, the *piso-metacarpal ligament* (Fig. 174).

2. Articulations of the Second Row of Carpal Bones.

These are also arthrodial joints. The articular surfaces are covered with cartilage, and connected by the following ligaments:

Dorsal. Palmar.
Three Interosseous.

The **Dorsal Ligaments** extend transversely from one bone to another on the dorsal surface, connecting the trapezium with the trapezoid, the trapezoid with the os magnum, and the os magnum with the unciform.

The **Palmar Ligaments** have a similar arrangement on the palmar surface.

The **three Interosseous Ligaments,** much thicker than those of the first row, are placed one between the os magnum and the unciform, a second between the os magnum and the trapezoid, and a third between the trapezium and trapezoid. The first of these is much the strongest, and the third is sometimes wanting.

3. Articulations of the Two Rows of Carpal Bones with each Other.

The joint between the scaphoid, semilunar, and cuneiform, and the second row of the carpus, or the *mid-carpal joint*, is made up of three distinct portions; in the centre the head of the os magnum and the superior surface of the unciform articulate with the deep, cup-shaped cavity formed by the scaphoid and semilunar bones, and constitute a sort of ball-and-socket joint. On the outer side the trapezium and trapezoid articulate with the scaphoid, and on the inner side the unciform articulates with the cuneiform, forming gliding joints.

The ligaments are—

Anterior or Palmar. External Lateral.
Posterior or Dorsal. Internal Lateral.

The **Anterior** or **Palmar Ligaments** consist of short fibres, which pass, for the most part, from the palmar surface of the bones of the first row to the front of the os magnum.

The **Posterior** or **Dorsal Ligaments** consist of short, irregular bundles of fibres passing between the bones of the first and second row on the dorsal surface of the carpus.

The **Lateral Ligaments** are very short: they are placed, one on the radial, the other on the ulnar side of the carpus; the former, the stronger and more distinct, connecting the scaphoid and trapezium bones, the latter the cuneiform and unciform; they are continuous with the lateral ligaments of the wrist-joint. In addition to these ligaments, a slender interosseous band sometimes connects the os magnum and the scaphoid.

The **Synovial Membrane of the Carpus** is very extensive: it passes from the under surface of the scaphoid, semilunar, and cuneiform bones to the upper surface of the bones of the second row, sending upward two prolongations—between the scaphoid and semilunar and the semilunar and cuneiform; sending downward three prolongations between the four bones of the second row, which are further continued onward into the carpo-metacarpal joints of the four inner metacarpal bones, and also for a short distance between the metacarpal bones. There is a separate synovial membrane between the pisiform and cuneiform bones.

**Actions.**—The articulation of the hand and wrist, considered as a whole, is divided into three parts: (1) the radius and the interarticular fibro-cartilage; (2) the meniscus, formed by the scaphoid, semilunar, and cuneiform, the pisiform bone having no essential part in the movements of the hand; (3) the hand proper, the metacarpal bones with the four carpal bones on which they are supported—viz. the trapezium, trapezoid, os magnum, and unciform. These three elements form two joints: (1) the superior (wrist-joint proper), between the meniscus and bones of the forearm; (2) the inferior, between the hand and meniscus (transverse or mid-carpal joint).

(1) The articulation between the forearm and carpus is a true condyloid articulation, and therefore all movements but rotation are permitted. Flexion and extension are the most free, and of these a greater amount of extension than flexion is permitted on account of the articulating surfaces extending farther on the dorsal than on the palmar aspect of the carpal bones. In this movement the carpal bones rotate on a transverse axis drawn between the tips of the styloid processes of the radius and ulna. A certain amount of adduction (or ulnar flexion) and abduction (or radial flexion) is also permitted. Of these the former is considerably greater in extent than the latter. In this movement the carpus revolves upon an antero-posterior axis drawn through the centre of the wrist. Finally, circumduction is permitted by the consecutive movements of adduction, extension, abduction, and flexion, with intermediate movements between them. There is no rotation, but this is provided for by the supination and pronation of the radius on the ulna. The movement of *flexion* is performed by the Flexor carpi radialis, the Flexor carpi ulnaris, and the Palmaris longus; *extension*, by the Extensor carpi radialis longior et brevior and the Extensor carpi ulnaris; *adduction* (ulnar flexion), by the Flexor carpi ulnaris and the Extensor carpi ulnaris; and *abduction* (radial flexion), by the Extensors of the thumb and the Extensor carpi radialis longior et brevior and the Flexor carpi radialis.

(2) The chief movements permitted in the transverse or mid-carpal joint are flexion and extension and a slight amount of rotation. In flexion and extension, which is the movement most freely enjoyed, the trapezium and trapezoid on the radial side and the unciform on the ulnar side glide forward and backward on the scaphoid and cuneiform respectively, while the head of the os magnum and the superior surface of the unciform rotate in the cup-shaped cavity of the scaphoid and semilunar. Flexion at this joint is freer than extension. A very trifling amount of rotation is also permitted, the head of the os magnum rotating round a vertical axis drawn through its own centre, while at the same time a slight gliding movement takes place in the lateral portions of the joint.

## IX. Carpo-metacarpal Articulations.

### 1. Articulation of the Metacarpal Bone of the Thumb with the Trapezium.

This is a joint of reciprocal reception, and enjoys great freedom of movement, on account of the configuration of its articular surfaces, which are saddle-shaped, so that, on section, each bone appears to be received into a cavity in the other, according to the direction in which they are cut. The joint is surrounded by a capsular ligament.

The **Capsular Ligament** is thick, but loose, and passes from the circumference of the upper extremity of the metacarpal bone to the rough edge bounding the articular surface of the trapezium; it is thickest externally and behind, and lined by a separate *synovial membrane*.

**Movements.**—In the articulation of the metacarpal bone of the thumb with the trapezium the movements permitted are flexion, extension, adduction, abduction, and circumduction. When the joint is flexed the metacarpal bone is brought in front of the palm and the thumb is gradually turned to the fingers. It is by this peculiar movement that the tip of the thumb is opposed to the other digits; for by slightly flexing the fingers the palmar surface of the thumb can be brought in contact with their palmar surfaces one after another.

### 2. Articulations of the Metacarpal Bones of the Four Inner Fingers with the Carpus.

The joints formed between the carpus and four inner metacarpal bones are arthrodial joints. The ligaments are—

Dorsal. Palmar.
Interosseous.

The **Dorsal Ligaments,** the strongest and most distinct, connect the carpal and metacarpal bones on their dorsal surface. The second metacarpal bone receives two fasciculi—one from the trapezium, the other from the trapezoid; the third metacarpal receives two—one from the trapezoid and one from the os magnum; the fourth two—one from the os magnum and one from the unciform; the fifth receives a single fasciculus from the unciform bone, which is continuous with a similar ligament on the palmar surface, forming an incomplete capsule.


Fig. 177.—Vertical section through the articulations at the wrist, showing the five synovial membranes.

The **Palmar Ligaments** have a somewhat similar arrangement on the palmar surface, with the exception of the third metacarpal, which has three ligaments—an external one from the trapezium, situated above the sheath of the tendon of the Flexor carpi radialis; a middle one, from the os magnum; and an internal one, from the unciform.

The **Interosseous Ligaments** consist of short, thick fibres, which are limited to one part of the carpo-metacarpal articulation; they connect the contiguous inferior angles of the os magnum and unciform with the adjacent surfaces of the third and fourth metacarpal bones.

The **Synovial Membrane** is a continuation of that between the two rows of carpal bones. Occasionally, the articulation of the unciform with the fourth and fifth metacarpal bones has a separate synovial membrane.

The synovial membranes of the wrist and carpus (Fig. 177) are thus seen to be five in number. The *first*, the *membrana sacciformis*, passes from the lower end of the ulna to the sigmoid cavity of the radius, and lines the upper surface of the interarticular fibro-cartilage. The *second* passes from the lower end of the radius and interarticular fibro-cartilage above to the bones of the first row below. The *third*, the most extensive, passes between the contiguous margins of the two rows of carpal bones—between the bones of the second row to the carpal extremities of the four inner metacarpal bones. The *fourth*, from the margin of the trapezium to the metacarpal bone of the thumb. The *fifth*, between the adjacent margins of the cuneiform and pisiform bones.

**Actions.**—The movement permitted in the carpo-metacarpal articulations of the four inner fingers is limited to a slight gliding of the articular surfaces upon each other, the extent of which varies in the different joints. Thus the articulation of the metacarpal bone of the little finger is most movable, then that of the ring finger. The metacarpal bones of the index and middle fingers are almost immovable.

3. Articulations of the Metacarpal Bones with each other.

The carpal extremities of the four inner metacarpal bones articulate with one another at each side by small surfaces covered with cartilages, and connected together by dorsal, palmar, and interosseous ligaments.

The **Dorsal** and **Palmar Ligaments** pass transversely from one bone to another on the dorsal and palmar surfaces. The *Interosseous Ligaments* pass between their contiguous surfaces, just beneath their lateral articular facets.

The **Synovial Membrane** between the lateral facets is a reflection from that between the two rows of carpal bones.

The **Transverse Metacarpal Ligaments** (Fig. 178) is a narrow fibrous band which passes transversely across the anterior surfaces of the digital extremities of the four inner metacarpal bones, connecting them together. It is blended anteriorly with the anterior (glenoid) ligament of the metacarpal-phalangeal articulations. To its posterior border is connected the fascia which covers the Interossei muscles. Its anterior surface is concave where the flexor tendons pass over it. Behind it the tendons of the Interossei muscles pass to their insertion.

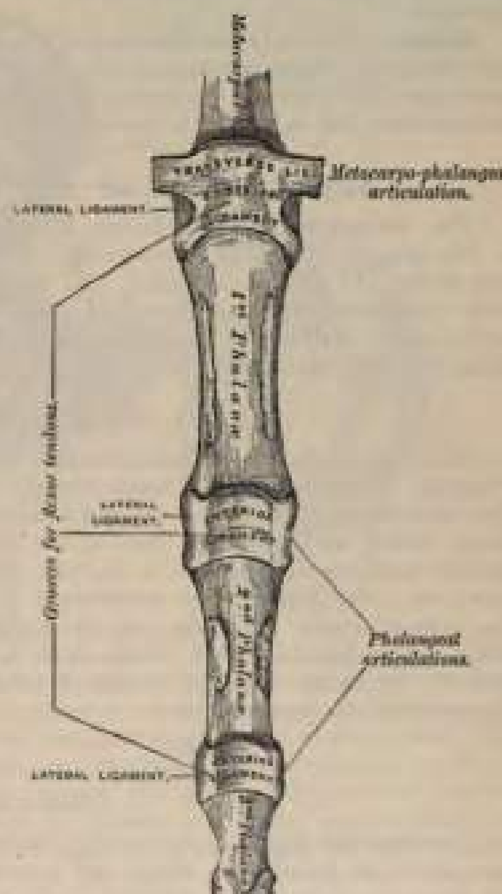


Fig. 178.—Articulations of the phalanges.

## X. Metacarpo-phalangeal Articulations (Fig. 178).

These articulations are of the condyloid kind, formed by the reception of the rounded head of the metacarpal bone into a shallow cavity in the extremity of the first phalanx. The ligaments are—

Anterior.
Two Lateral.

The **Anterior Ligaments** (*Glenoid Ligaments* of Cruveilhier) are thick, dense, fibrous structures, placed on the palmar surface of the joints in the intervals between the lateral ligaments, to which they are connected; they are loosely united to the metacarpal bone, but very firmly to the base of the first phalanges. Their palmar surface is intimately blended with the transverse metacarpal ligament, and presents a groove for the passage of the flexor tendons, the sheath surrounding which is connected to each side of the groove. By their deep surface they form part of the articular surface for the head of the metacarpal bone, and are lined by a synovial membrane.

The **Lateral Ligaments** are strong, rounded cords placed one on each side of the joint, each being attached by one extremity to the posterior tubercle on the side of the head of the metacarpal bone, and by the other to the contiguous extremity of the phalanx.

**Actions.**—The movements which occur in these joints are flexion, extension, adduction, abduction, and circumduction; the lateral movements are very limited.

**Surface Form.**—The prominences of the knuckles do not correspond to the position of the joints either of the metacarpo-phalangeal or interphalangeal articulations. These prominences are invariably formed by the distal ends of the proximal bone of each joint, and the line indicating the position of the joint must be sought considerably in front of the middle of the knuckle. The usual rule for finding these joints is to flex the distal phalanx on the proximal one to a right angle; the position of the joint is then indicated by an imaginary line drawn along the middle of the lateral aspect of the proximal phalanx.

### XI. Articulations of the Phalanges.

These are ginglymus joints. The ligaments are—

| | |
|---|---|
| Anterior. | Two Lateral. |

The arrangement of these ligaments is similar to those in the metacarpo-phalangeal articulations; the extensor tendon supplies the place of a posterior ligament.

**Actions.**—The only movements permitted in the phalangeal joints are flexion and extension; these movements are more extensive between the first and second phalanges than between the second and third. The movement of flexion is very considerable, but extension is limited by the anterior and lateral ligaments.

## ARTICULATIONS OF THE LOWER EXTREMITY.

The articulations of the Lower Extremity comprise the following groups: I. The hip-joint. II. The knee-joint. III. The articulations between the tibia and fibula. IV. The ankle-joint. V. The articulations of the tarsus. VI. The tarso-metatarsal articulations. VII. Articulations of the metatarsal bones with each other. VIII. The metatarso-phalangeal articulations. IX. The articulations of the phalanges.

### I. Hip-joint (Fig. 179).

This articulation is an enarthrodial or ball-and-socket joint, formed by the reception of the head of the femur into the cup-shaped cavity of the acetabulum. The articulating surfaces are covered with cartilage, that on the head of the femur being thicker at the centre than at the circumference, and covering the entire surface, with the exception of a depression just below its centre for the ligamentum teres; that covering the acetabulum is much thinner at the centre than at the circumference. It forms an incomplete cartilaginous ring of a horseshoe shape, being deficient below, where there is a circular depression, which is occupied in the recent state by a mass of fat covered by synovial membrane. The ligaments of the joints are the

| | |
|---|---|
| Capsular. | Teres. |
| Ilio-femoral. | Cotyloid. |
| Transverse. | |

The **Capsular Ligament** is a strong, dense, ligamentous capsule, embracing the margin of the acetabulum above and surrounding the neck of the femur below. Its *upper circumference* is attached to the acetabulum, above and behind, two or three lines external to the cotyloid ligament; but in front it is attached to the outer margin of this ligament, and opposite to the notch where the margin of this cavity is deficient, it is connected to the transverse ligament, and by a few fibres to the edge of the obturator foramen. Its *lower circumference* surrounds the neck of the femur, being attached, in front, to the spiral or anterior intertrochanteric line; above, to the base of the neck; behind, to the neck of the bone, about half an inch above the posterior intertrochanteric line. From this insertion the fibres are reflected upward over the neck of the femur, forming a sort of tubular sheath (the *cervical reflection*), which blends with the periosteum and can be traced as far as the articular cartilage. On the surface of the neck of the femur some of these reflected fibres are raised into longitudinal folds, termed *retinacula*. It is much thicker at the upper and fore part of the joint, where the greatest amount of resistance is required, than below and internally, where it is thin, loose, and longer than in any other part. It consists of two sets of fibres, circular and longitudinal. The circular fibres (*zona orbicularis*) are most abundant at the lower and back part of the capsule, and form a sling or collar around the neck of the femur. Anteriorly they blend with the deep surface of the ilio-femoral ligament, and through its medium reach the anterior inferior spine of the ilium. The longitudinal fibres are greatest in amount at the upper and front part of the cap-

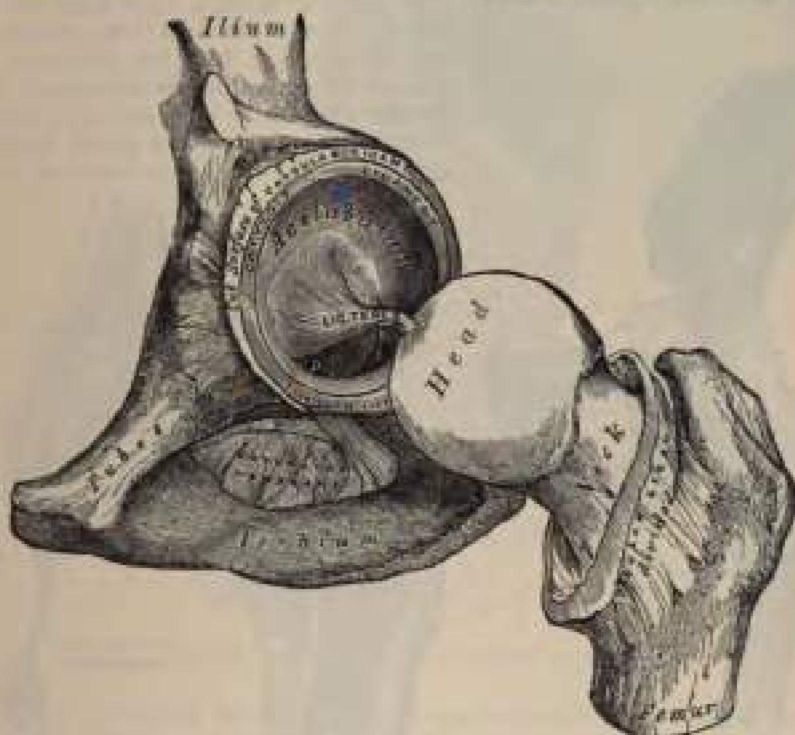



FIG. 179.—Left hip-joint laid open.

sule, where they form distinct bands or accessory ligaments, of which the most important is the *ilio-femoral*. The other accessory bands are known as the *pubo-femoral*, passing from the ilio-pectineal eminence to the front of the capsule; and *ischio-capsular*, passing from the ischium, just below the acetabulum, to blend with the circular fibres at the lower part of the joint. The external surface (Fig. 164, page 241) is rough, covered by numerous muscles, and separated in front from the Psoas and Iliacus by a synovial bursa, which not infrequently communicates, by a circular aperture, with the cavity of the joint. It differs from the capsular ligament of the shoulder in being much less loose and lax, and in not being perforated for the passage of a tendon.

**The Ilio-femoral Ligament** (Figs. 164 and 180) is an accessory band of fibres extending obliquely across the front of the joint; it is intimately connected with the capsular ligament, and serves to strengthen it in this situation. It is attached, above, to the lower part of the anterior inferior spine of the ilium; and, diverging below, forms two bands, of which one passes downward to be inserted into the lower part of the anterior intertrochanteric line; the other passes downward and outward to be inserted into the upper part of the same line and adjacent part of the neck of the femur. Between the two bands is a thinner part of the capsule. Sometimes there is no division, but the ligament spreads out into a flat, triangular band, which is attached below into the whole length of the anterior intertrochanteric line. This ligament is frequently called the Y-shaped ligament of Bigelow;

and the outer or upper of the two bands is sometimes described as a separate ligament, under the name of the *ilio-trochanteric ligament*.

The **Ligamentum Teres** is a triangular band implanted by its apex into the depression a little behind and below the centre of the head of the femur, and by its broad base into the margins of the cotyloid notch, becoming blended with the transverse ligament. It is formed of connective tissue, surrounded by a tubular sheath of synovial membrane. Sometimes only the synovial fold exists, or the ligament may be altogether absent. The ligament is made tense when the hip is semiflexed, and the limb then adducted and rotated outward; it is, on the other hand, relaxed when the limb is abducted. It has, however, but little influence as a ligament, though it may to a certain extent limit movement, and would appear to be merely a modi-

FIG. 190.—Hip-joint, showing the ilio-femoral ligament. (After Bigelow.)

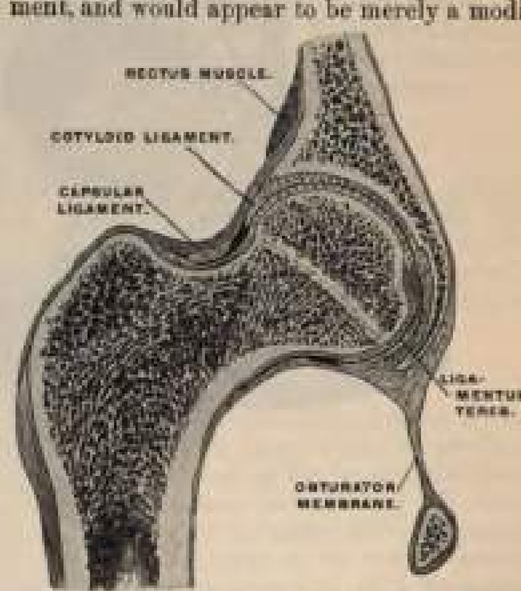



FIG. 191.—Vertical section through hip-joint. (Henle.)

fication of the folds which in other joints fringe the margins of reflection of synovial membranes (see page 218).

The **Cotyloid Ligament** is a fibro-cartilaginous rim attached to the margin of the acetabulum, the cavity of which deepens; at the same time it protects the edges of the bone and fills up the inequalities on its surface. It bridges over the notch as the *transverse ligament*, and thus forms a complete circle, which closely surrounds the head of the femur, and assists in holding it in its place, acting as a sort of valve. It is prismoid on section, its base being attached to the margin of the acetabulum, and its opposite edge being free and sharp; whilst its two surfaces are invested by synovial membrane, the external one being in contact with the capsular ligament, the internal one being inclined inward, so as to narrow the acetabulum and embrace the cartilaginous surface of the head of the femur. It is much thicker above and behind than below and in front, and consists of close, compact fibres, which arise from different points of the circumference of the acetabulum and interlace with each other at very acute angles.

The **Transverse Ligament** is in reality a portion of the cotyloid ligament, though differing from it in having no cartilage-cells amongst its fibres. It consists of strong, flattened fibres, which cross the notch at the lower part of the acetabulum and convert it into a foramen. Thus an interval is left beneath the ligament for the passage of nutrient vessels to the joint.

The **Synovial Membrane** is very extensive. Commencing at the margin of the cartilaginous surface of the head of the femur, it covers all that portion of the neck which is contained within the joint; from the neck it is reflected on the internal surface of the capsular ligament, covers both surfaces of the cotyloid ligament and the mass of fat contained in the depression at the bottom of the acetab-

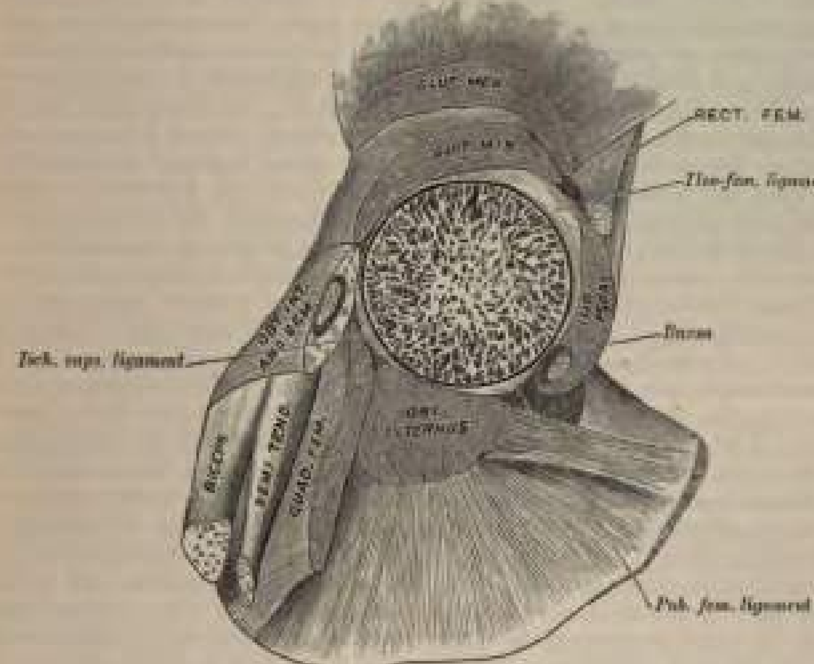



FIG. 182.—Relation of muscles to hip-joint. (Henle.)

ulum, and is prolonged in the form of a tubular sheath around the ligamentum teres, as far as the head of the femur. It sometimes communicates through a hole in the capsular ligament between the inner band of the Y-shaped ligament and the pubo-femoral ligament with a bursa situated on the under surface of the Ilio-psoas muscle.

The muscles in relation with the joint are, in front, the Psoas and Iliacus, separated from the capsular ligament by a synovial bursa; above, the reflected head of the Rectus and Gluteus minimus, the latter being closely adherent to the capsule; internally, the Obturator externus and Pectineus; behind, the Pyriformis, Gemellus superior, Obturator internus, Gemellus inferior, Obturator externus, and Quadratus femoris (Fig. 182).

The arteries supplying the joint are derived from the obturator, sciatic, internal circumflex, and gluteal.

The nerves are articular branches from the sacral plexus, great sciatic, obturator, accessory obturator, and a filament from the branch of the anterior crural supplying the Rectus.

**Actions.**—The movements of the hip are very extensive, and consist of flexion, extension, adduction, abduction, circumduction, and rotation.

The hip-joint presents a very striking contrast to the shoulder-joint in the much more complete mechanical arrangements for its security and for the limitation of its movements. In the shoulder, as we have seen, the head of the humerus is not adapted at all in size to the glenoid cavity, and is hardly restrained in any of its ordinary movements by the capsular ligament. In the hip-joint, on the contrary, the head of the femur is closely fitted to the acetabulum for a distance extending over nearly half a sphere, and at the margin of the bony cup it is still more closely embraced by the cotyloid ligament, so that the head of the femur is held in its place by that ligament even when the fibres of the capsule have been quite divided (Humphry). The anterior portion of the capsule, described as the ilio-femoral ligament, is the strongest of all the ligaments in the body, and is put on the stretch by any attempt to extend the femur beyond a straight line with the trunk. That is to say, this ligament is the chief agent in maintaining the erect position without muscular fatigue; for a vertical line passing through the centre of gravity of the trunk falls behind the centres of rotation in the hip-joints, and therefore the pelvis tends to fall backward, but is prevented by the tension of the ilio-femoral and capsular ligaments. The security of the joint may be also provided for by the two bones being directly united through the ligamentum teres; but it is doubtful whether this so-called ligament can have much influence upon the mechanism of the joint. Flexion of the hip-joint is arrested by the soft parts of the thigh and abdomen being brought into contact when the leg is flexed on the thigh; and by the action of the hamstring muscles when the leg is extended;[1] extension, by the tension of the ilio-femoral ligament and front of the capsule; adduction, by the thighs coming into contact; adduction, with flexion by the outer band of the ilio-femoral ligament, the outer part of the capsular ligament; abduction, by the inner band of the ilio-femoral ligament and the pubo-femoral band; rotation outward, by the outer band of the ilio-femoral ligament; and rotation inward, by the ischio-capsular ligament and the hinder part of the capsule. The muscles which *flex* the femur on the pelvis are the Psoas, Iliacus, Rectus, Sartorius, Pectineus, Adductor longus and brevis, and the anterior fibres of the Gluteus medius and minimus. *Extension* is mainly performed by the Gluteus maximus, assisted by the hamstring muscles. The thigh is *adducted* by the Adductor magnus, longus, and brevis, the Pectineus, the Gracilis, and lower part of the Gluteus maximus, and *abducted* by the Gluteus medius and minimus and upper part of the Gluteus maximus. The muscles which *rotate* the thigh *inward* are the anterior fibres of the Gluteus medius, the Gluteus minimus, and the Tensor fasciæ femoris; while those which rotate it *outward* are the posterior fibres of the Gluteus medius, the Pyriformis, Obturator externus and internus, Gemellus superior and inferior, Quadratus femoris, Iliacus, Gluteus maximus, the three Adductors, the Pectineus, and the Sartorius.

**Surface Form.**—A line drawn from the anterior superior spinous process of the ilium to the most prominent part of the tuberosity of the ischium (Nélaton's line) runs through the centre of the acetabulum, and would, therefore, indicate the level of the hip-joint; or, in other words, the upper border of the great trochanter, which lies on Nélaton's line, is on a level with the centre of the hip-joint.

**Surgical Anatomy.**—In dislocation of the hip "the head of the thigh-bone may rest at any point around its socket" (Bryant); but whatever position the head ultimately assumes, the primary displacement is generally downward and inward, the capsule giving way at its weakest—that is, its lower and inner—part. The situation that the head of the bone subsequently assumes is determined by the degree of flexion or extension, and of outward or inward rotation of the thigh at the moment of luxation, influenced, no doubt, by the ilio-femoral ligament, which is not easily ruptured. When, for instance, the head is forced backward, this ligament forms a fixed axis, round which the head of the bone rotates, and is thus driven on to the dorsum of the ilium. The ilio-femoral ligament also influences the position of the thigh in the various dislocations: in the dislocations backward it is tense, and produces inversion of the limb; in the dislocation on to the pubes it is relaxed, and therefore allows the external rotators to evert the thigh; while in the thyroid dislocation it is tense and produces flexion. The muscles inserted into the upper part of the femur, with the exception of the Obturator internus, have very little direct influence in determining the position of the bone. But Bigelow has endeavored to show that the Obturator internus is the principal agent in determining whether, in the backward dislocations, the head of the bone shall be ultimately lodged on the dorsum of the ilium or in or near the sciatic notch. In both dislocations the head passes, in the first instance, in the same direction; but, as Bigelow asserts, in the displacement on to the dorsum, the head of the bone travels up behind the acetabulum, in front of the muscle; while in the dislocation into the

[1] The hip-joint cannot be completely flexed, in most persons, without at the same time flexing the knee, on account of the shortness of the hamstring muscles.—Cleland, *Journ. of Anat. and Phys.*, No. 1, Old Series, p. 87.

sciatic notch, the head passes behind the muscle, and is therefore prevented from reaching the dorsum, in consequence of the tendon of the muscle arching over the neck of the bone, and so remains in the neighborhood of the sciatic notch. Bigelow, therefore, distinguishes these two forms of dislocation by describing them as dislocations backward, "above and below," the Obturator internus.

The ilio-femoral ligament is rarely torn in dislocations of the hip, and this fact is taken advantage of by the surgeon in reducing these dislocations by manipulation. It is made to act as a fulcrum to a lever, of which the long arm is the shaft of the femur, and the short arm the neck of the bone.

The hip-joint is rarely the seat of acute synovitis from injury, on account of its deep position and its thick covering of soft parts. Acute inflammation may, and does, frequently occur as the result of constitutional conditions, as rheumatism, pyæmia, etc. When, in these cases, effusion takes place, and the joint becomes distended with fluid, the swelling is not very easy to detect on account of the thickness of the capsule and the depth of the articulation. It is principally to be found on the front of the joint, just internal to the ilio-femoral ligament; or behind, at the lower and back part. In these two places the capsule is thinner than elsewhere. Disease of the hip-joint is much more frequently of a chronic character and is usually of a tubercular origin. It begins either in the bones or in the synovial membrane, more frequently in the former, and probably, in most cases, at the growing, highly vascular tissue in the neighborhood of the epiphysial cartilage. In this respect it differs very materially from tubercular arthritis of the knee, where the disease usually commences in the synovial membrane. The reasons why the disease so frequently begins in this situation are twofold; first, this part being the centre of rapid growth, its nutrition is unstable and apt to pass into inflammatory action; and, secondly, great strain is thrown upon it, from the frequency of falls and blows upon the hip, which causes crushing of the epiphyseal cartilage or the cancellous tissue in its neighborhood, with the results likely to follow such an injury. In addition to these, the depth of the joint protects it from the causes of synovitis.

In chronic hip-disease the affected limb assumes an altered position, the cause of which it is important to understand. In the early stage of a typical case the limb is flexed, abducted, and rotated outward. In this position all the ligaments of the joint are relaxed: the front of the capsule by flexion: the outer band of the ilio-femoral ligament by abduction; and the inner band of this ligament and the back of the capsule by rotation outward. It is, therefore, the position of the greatest ease. The condition is not quite obvious at first upon examining a patient. If the patient is laid in the supine position, the affected limb will be found to be extended and parallel with the other. But it will be found that the pelvis is tilted downward on the diseased side and the limb apparently longer than its fellow, and that the lumbar spine is arched forward (lordosis). If now the thigh is abducted and flexed, the tilting downward and the arching forward of the pelvis disappears. The condition is thus explained. A limb which is flexed and abducted is obviously useless for progression, and, in order to overcome the difficulty, the patient depresses the affected side of his pelvis in order to produce parallelism of his limbs, and at the same time rotates his pelvis on its transverse horizontal axis, so as to direct the limb downward instead of forward. In the latter stages of the disease the limb becomes flexed and abducted and inverted. This position probably depends upon muscular action, at all events as regards the adduction. The Adductor muscles are supplied by the obturator nerve, which also largely supplies the joint. These muscles are therefore thrown into reflex action by the irritation of the peripheral terminations of this nerve in the inflamed articulation. Osteo-arthritis is not uncommon in the hip-joint, and it is said to be more common in the male than in the female, in whom the knee-joint is more frequently affected. It is a disease of middle age or more advanced period of life.

Congenital dislocation is more commonly met with in the hip-joint than in any other articulation. The displacement usually takes place on to the dorsum ilii. It gives rise to extreme lordosis, and a waddling gait is noticed as soon as the child commences to walk.

Excision of the hip may be required for disease or for injury, especially gunshot. It may be performed either by an anterior incision or a posterior one. The former one entails less interference with important structures, especially muscles, than the posterior one, but permits of less efficient drainage. In these days, however, when the surgeon aims at securing healing of his wound without suppuration, this second desideratum is not of so much importance. In the operation in front the surgeon makes an incision three to four inches in length, starting immediately below and external to the anterior superior spinous process of the ilium, downward and inward between the Sartorius and Tensor fasciæ femoris, to the neck of the bone, dividing the capsule at its upper part. A narrow-bladed saw now divides the neck of the femur, and the head of the bone is extracted with sequestrum forceps. All diseased tissue is carefully removed with a sharp spoon or scissors, and the cavity thoroughly flushed out with a hot antiseptic fluid.

The posterior method consists in making an incision three or four inches long, commencing midway between the top of the great trochanter and the anterior superior spine, and ending over the shaft, just below the trochanter. The muscles are detached from the great trochanter, and the capsule opened freely. The head and neck are freed from the soft parts and the bone sawn through just below the top of the trochanter with a narrow saw. The head of the bone is then levered out of the acetabulum. In both operations, if the acetabulum is eroded, it must be freely gouged.

## II. Knee-joint.

The knee-joint was formerly described as a ginglymus or hinge-joint, but is really of a much more complicated character. It must be regarded as consisting of three articulations in one: one between each condyle of the femur and the corresponding tuberosity of the tibia, which are condyloid joints, and one between the patella and the femur, which is partly arthrodial, but not completely so, since the articular surfaces are not mutually adapted to each other, so that the movement is not a simple gliding one. This view of the construction of the knee-joint receives confirmation from the study of the articulation in some of the lower mammals, where three synovial membranes are sometimes found, corresponding to these three subdivisions, either entirely distinct or only connected together by small communications. This view is further rendered probable by the existence of the two crucial ligaments within the joint, which must be regarded as the external and internal lateral ligaments of the inner and outer joints respectively. The existence of the ligamentum mucosum would further indicate a tendency to separation of the synovial cavity into two minor sacs, one corresponding to each joint.

The bones entering into the formation of the knee-joint are the condyles of the femur above, the head of the tibia below, and the patella in front. The bones are connected together by ligaments, some of which are placed on the exterior of the joint, while others occupy its interior.

| *External Ligaments.* | *Interior Ligaments.* |
|---|---|
| Anterior, or Ligamentum Patellæ. | Anterior, or External Crucial. |
| Posterior, or Ligamentum Posticum Winslowii. | Posterior, or Internal Crucial. |
| Internal Lateral. | Two Semilunar Fibro-cartilages. |
| Two External Lateral. | Transverse. |
| Capsular. | Coronary. |
| | Ligamentum mucosum. } Processes of Synovial Membrane. |
| | Ligamenta alaria. } Processes of Synovial Membrane. |

The **Anterior Ligament**, or **Ligamentum Patellæ** (Fig. 183), is the central portion of the common tendon of the Extensor muscles of the thigh which is continued from the patella to the tubercle of the tibia, supplying the place of an anterior ligament. It is a strong, flat, ligamentous band about three inches in length, attached, above, to the apex of the patella and the rough depression on its posterior surface; below, to the lower part of the tubercle of the tibia, its superficial fibres being continuous over the front of the patella with those of the tendon of the Quadriceps extensor. The lateral portions of the tendon of the Extensor muscles pass down on either side of the patella, attached to the borders of this bone and its ligament, to be inserted into the upper extremity of the tibia on each side of the tubercle; externally, these portions merge into the capsular ligament. They are termed *lateral patellar ligaments*. The posterior surface of the ligamentum patellæ can usually be easily separated from the front of the capsular ligament.

The **Posterior Ligament (Ligamentum Posticum Winslowii)** (Fig. 184) is a broad, flat, fibrous band, formed of fasciculi separated from one another by apertures for the passage of vessels and nerves. It is attached, above, to the upper margin of the intercondyloid notch of the femur, and below, to the posterior margin of the head of the tibia. Superficial to the main part of the ligament is a strong fasciculus derived from the tendon of the Semimembranosus, and passing from the back part of the inner tuberosity of the tibia obliquely upward and outward to the back part of the outer condyle of the femur. The posterior ligament forms part of the floor of the popliteal space, and the popliteal artery rests upon it.

The **Internal Lateral Ligament** is a broad, flat, membranous band, thicker behind than in front, and situated nearer to the back than the front of the joint. It is attached, above, to the inner tuberosity of the femur; below, to the inner tuberosity and inner surface of the shaft of the tibia to the extent of about two inches. It is crossed, at its lower part, by the tendons of the Sartorius, Gracilis, and Semitendinosus muscles, a synovial bursa being interposed. Its *deep surface* covers the anterior portion of the tendon of the Semimembranosus, with which it is connected by a few fibres, the synovial membrane of the joint, and the inferior internal articular vessels and nerve; it is intimately adherent to the internal semilunar fibro-cartilage.

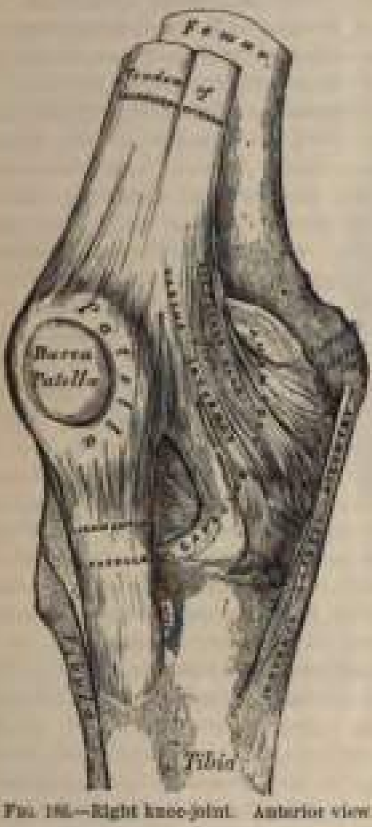



Fig. 1[illegible].—Right knee-joint. Anterior view.


Fig. 1[illegible].—Right knee-joint. Posterior view.

The **Long External Lateral Ligament** is a strong, rounded, fibrous cord situated nearer to the back than the front of the joint. It is attached, above, to the back part of the outer tuberosity of the femur; below, to the outer part [illegible] head of the fibula. Its *outer surface* is covered by the tendon of the Bi[illegible]h divides at its insertion into two parts, separated by the ligament. [illegible]ent has, passing beneath it, the tendon of the Popliteus muscle a[illegible]xternal articular vessels and nerve.

The **Short External Lateral Ligament** is an access[illegible]laced behind and parallel with the preceding, attached [illegible] back part of the outer tuberosity of the femur; be[illegible]loid process of the fibula. This ligament is intim[illegible]lar ligament, and has, passing beneath it, the tendon [illegible] the inferior external articular vessels and nerve.

The **Capsular Ligament** consists of an exceedin[illegible] fibrous membrane which fills in the intervals left between [illegible]nds above described, and is inseparably connected with them. In [illegible]nds with and forms part of the lateral patellar ligaments and fills in th[illegible]al between the anterior and lateral ligaments of the joint, with which latter [illegible]tures it is closely connected. Behind, it is formed chiefly of vertical fibres, which arise above from the condyles and intercondyloid notch of the femur, and is connected below with the back part of the head of the tibia, being closely united with the origins of

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| *External Ligaments.* | *Interior Ligaments.* |
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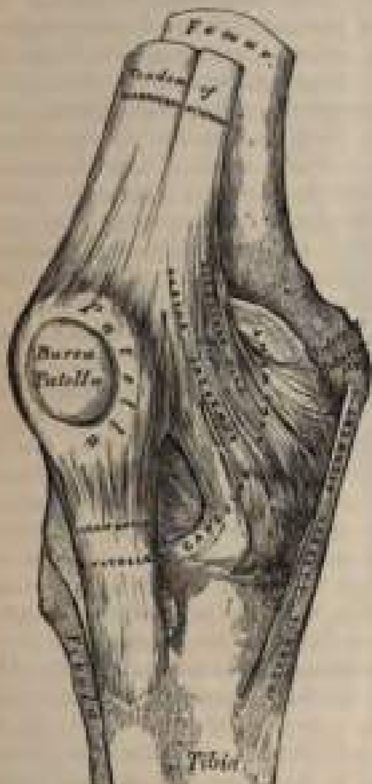


Fig. 183.—Right knee-joint. Anterior view.


Fig. 184.—Right knee-joint. Posterior view.

The **Long External Lateral Ligament** is a strong, rounded, fibrous cord situated nearer to the back than the front of the joint. It is attached, above, to the back part of the outer tuberosity of the femur; below, to the outer part of the head of the fibula. Its *outer surface* is covered by the tendon of the Biceps, which divides at its insertion into two parts, separated by the ligament. The ligament has, passing beneath it, the tendon of the Popliteus muscle and the inferior external articular vessels and nerve.

The **Short External Lateral Ligament** is an accessory bundle of fibres placed behind and parallel with the preceding, attached, above, to the lower and back part of the outer tuberosity of the femur; below, to the summit of the styloid process of the fibula. This ligament is intimately connected with the capsular ligament, and has, passing beneath it, the tendon of the Popliteus muscle and the inferior external articular vessels and nerve.

The **Capsular Ligament** consists of an exceedingly thin but strong, fibrous membrane which fills in the intervals left between the stronger bands above described, and is inseparably connected with them. In front it blends with and forms part of the lateral patellar ligaments and fills in the interval between the anterior and lateral ligaments of the joint, with which latter structures it is closely connected. Behind, it is formed chiefly of vertical fibres, which arise above from the condyles and intercondyloid notch of the femur, and is connected below with the back part of the head of the tibia, being closely united with the origins of the Gastrocnemius, Plantaris, and Popliteus muscles. It passes in front of, but is inseparably connected with, the posterior ligament.

The **Crucial** are two interosseous ligaments of considerable strength situated in the interior of the joint, nearer its posterior than its anterior part. They are called *crucial* because they cross each other somewhat like the lines of the letter X; and have received the names *anterior* and *posterior*, from the position of their attachment to the tibia.

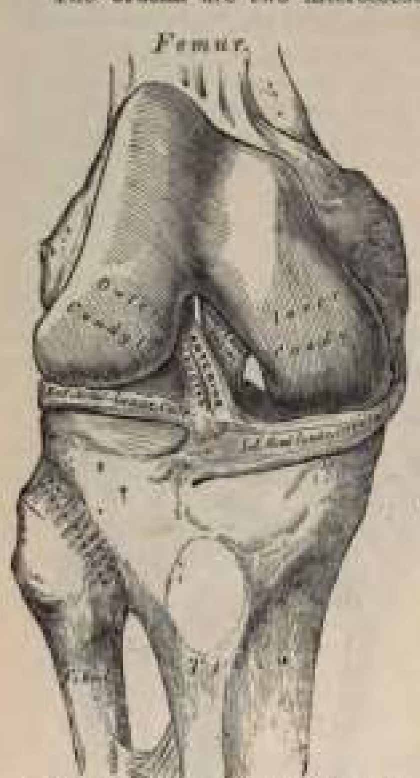


Fig. 185.—Right knee-joint. Showing internal ligaments.

The **Anterior, or External Crucial Ligament** (Fig. 185), is attached to the depression in front of the spine of the tibia, being blended with the anterior extremity of the external semilunar fibro-cartilage, and, passing obliquely upward, backward, and outward, is inserted into the inner and back part of the outer condyle of the femur.

The **Posterior, or Internal Crucial Ligament**, is stronger, but shorter and less oblique in its direction, than the anterior. It is attached to the back part of the depression behind the spine of the tibia, to the popliteal notch, and to the posterior extremity of the external semilunar fibro-cartilage; and passes upward, forward, and inward, to be inserted into the outer and fore part of the inner condyle of the femur. It is in relation, in front, with the anterior crucial ligament; behind, with the capsular ligament.

The **Semilunar Fibro-cartilages** (Fig. 186) are two crescentic lamellæ which serve to deepen the surface of the head of the tibia, for articulation with the condyles of the femur. The circumference of each cartilage is thick, convex, and attached to the inside of the capsule of the knee; the inner border is thin, concave and free. Their upper surfaces are concave, and in relation with the condyles of the femur; their lower surfaces are flat, and rest upon the head of the tibia. Each cartilage covers nearly the outer two-thirds of the corresponding articular surface of the tibia, leaving the inner third uncovered; both surfaces are smooth and invested by synovial membrane.


Fig. 186.—Head of tibia, with semilunar cartilages, etc. Seen from above. Right side.

The **Internal Semilunar Fibro-cartilage** is nearly semicircular in form, a little elongated from before backward, and broader behind than in front; its anterior extremity, thin and pointed, is attached to a depression on the anterior margin of the head of the tibia, in front of the anterior crucial ligament; its posterior extremity is attached to the depression behind the spine, between the attachments of the external **semilunar** fibro-cartilage and the posterior crucial ligaments.

The **External Semilunar Fibro-cartilage** forms nearly an entire circle, covering a larger portion of the articular surface than the internal one. It is grooved on its outer side for the tendon of the Popliteus muscle. Its extremities, at their insertion, are interposed between the two extremities of the internal semilunar fibro-cartilage; the anterior extremity being attached in front of the spine of the tibia to the outer side of, and behind, the anterior crucial ligament, with which it blends; the posterior extremity being attached behind the spine of the tibia, in front of the posterior extremity of the internal semilunar fibro-cartilage. Just before its insertion posteriorly it gives off a strong fasciculus, the *ligament of Wrisberg*, which passes obliquely upward and outward, to be inserted into the inner condyle of the femur, close to the attachment of the posterior crucial ligament. Occasionally a small fasciculus is given off which passes forward to be inserted into the back part of the anterior crucial ligament. The external semilunar fibro-cartilage gives off from its anterior convex margin a fasciculus which forms the transverse ligament.

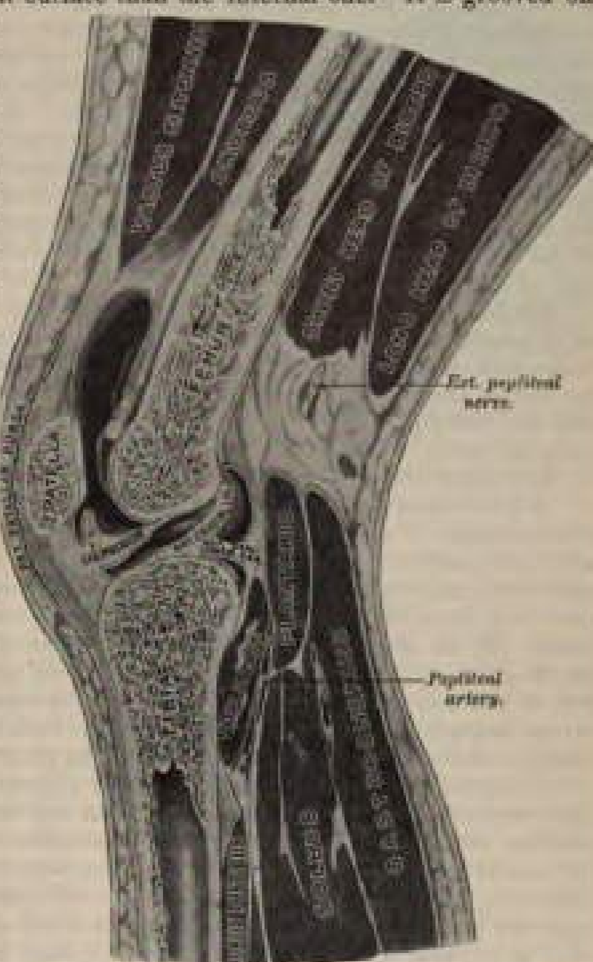


Fig. 187.—Longitudinal section through the middle of the right knee-joint. (After Braune.)

The **Transverse Ligament** is a band of fibres which passes transversely from the anterior convex margin of the external semilunar fibro-cartilage to the anterior convex margin of the internal semilunar fibro-cartilage; its thickness varies considerably in different subjects, and it is sometimes absent altogether.

The **Coronary Ligaments** are merely portions of the capsular ligament, which connect the circumference of each of the semilunar fibro-cartilages with the margin of the head of the tibia.

The **Synovial Membrane** of the knee-joint is the largest and most extensive in the body. Commencing at the upper border of the patella, it forms a short *cul-de-sac* beneath the Quadriceps extensor tendon of the thigh, on the lower part of the front of the shaft of the femur: this communicates with a synovial bursa interposed between the tendon and the front of the femur by an orifice of variable size. On each side of the patella the synovial membrane extends beneath the aponeurosis of the Vasti muscles, and more especially beneath that of the Vastus internus. Below the patella it is separated from the anterior ligament by the anterior part of the capsule and a considerable quantity of adipose tissue. In this situation it sends off a triangular prolongation, containing a few ligamentous fibres, which extends from the anterior part of the joint below the patella to the front of the intercondyloid notch. This fold has been termed the *ligamentum mucosum*. It also sends off two fringe-like folds, called the *ligamenta alaria*, which extend from the sides of the ligamentum mucosum, upward and laterally between the patella and femur. On either side of the joint it passes downward from the femur, lining the capsule to its point of attachment to the semilunar cartilages; it may then be traced over the upper surfaces of these cartilages to their free borders, and from thence along their under surfaces to the tibia. At the back part of the external one it forms a *cul-de-sac* between the groove on its surface and the tendon of the Popliteus; it surrounds the crucial ligaments and lines the inner surface of the ligaments which enclose the joint. The pouch of synovial membrane between the Extensor tendon and front of the femur is supported, during the movements of the knee, by a small muscle, the Subcrureus, which is inserted into the upper part of the capsular ligament.

The folds of synovial membrane and the fatty processes contained in them act, as it seems, mainly as padding to fill up interspaces and obviate concussions. Sometimes the bursa beneath the Quadriceps extensor is completely shut off from the rest of the synovial cavity, thus forming a closed sac between the Quadriceps and the lower part of the front of the femur, or it may communicate with the synovial cavity by a minute aperture.

The bursæ about the knee-joint are the following:

In front there are three bursæ: one is interposed between the patella and the skin; another, of small size, between the upper part of the tuberosity of the tibia and the ligamentum patellæ; and a third between the lower part of the tuberosity of the tibia and the skin. On the outer side there are four bursæ: (1) one beneath the outer head of the Gastrocnemius (which sometimes communicates with the joint); (2) one above the external lateral ligament between it and the tendon of the Biceps; (3) one beneath the external lateral ligament between it and the tendon of the Popliteus (this is sometimes only an expansion from the next bursa); (4) one beneath the tendon of the Popliteus between it and the condyle of the femur, which is almost always an extension from the synovial membrane.

On the inner side there are five bursæ: (1) one beneath the inner head of the Gastrocnemius, which sends a prolongation between the tendons of the Gastrocnemius and Semimembranosus: this bursa often communicates with the joint; (2) one above the internal lateral ligament between it and the tendons of the Sartorius, Gracilis, and Semitendinosus; (3) one beneath the internal lateral ligament between it and the tendon of the Semimembranosus: this is sometimes only an expansion from the next bursa; (4) one beneath the tendon of the Semimembranosus, between it and the head of the tibia; (5) sometimes there is a bursa between the tendons of the Semimembranosus and of the Semitendinosus.

**Structures around the Joint.**—In front and at the sides, the Quadriceps extensor; on the outer side, the tendons of the Biceps and the Popliteus and the external popliteal nerve; on the inner side, the Sartorius, Gracilis, Semitendinosus, and Semimembranosus; behind, an expansion from the tendon of the Semimembranosus, the popliteal vessels, and the internal popliteal nerve, Popliteus, Plantaris, and inner and outer heads of the Gastrocnemius, some lymphatic glands, and fat.

The *Arteries* supplying the joint are derived from the anastomotica magna branch of the femoral, articular branches of the popliteal, anterior and posterior recurrent branches of the anterior tibial, and descending branch from the external circumflex of the Profunda.

The *Nerves* are derived from the obturator, anterior crural, and external and internal popliteal.

**Actions.**—The knee-joint permits of movements of flexion and extension, and, in certain positions, of slight rotation inward and outward. The movement of flexion and extension does not, however, take place in a simple, hinge-like manner, as in other joints, but is a complicated movement, consisting of a certain amount of gliding and rotation; so that the same part of one articular surface is not always applied to the same part of the other articular surface, and the axis of motion is not a fixed one. If the joint is examined while in a condition of extreme flexion, the posterior part of the articular surfaces of the tibia will be found to be in contact with the posterior rounded extremities of the condyles of the femur; and if a simple hinge-like movement were to take place, the axis, round which the revolving movement of the tibia occurs, would be in the back part of the condyle. If the leg is now brought forward into a position of semiflexion, the upper surface of the tibia will be seen to glide over the condyles of the femur, so that the middle part of the articular facets are in contact, and the axis of rotation must therefore have shifted forward to nearer the centre of the condyles. If the leg is now brought into the extended position, a still further gliding takes place and a further shifting forward of the axis of rotation. This is not, however, a simple movement, but is accompanied by a certain amount of rotation outward round a vertical axis drawn through the centre of the head of the tibia. This rotation is due to the greater length of the internal condyle, and to the fact that the anterior portion of its articular surface is inclined obliquely outward. In consequence of this it will be seen that toward the close of the movement of extension—that is to say, just before complete extension is effected—the tibia glides obliquely upward and outward over this oblique surface on the inner condyle, and the leg is therefore necessarily rotated outward. In flexion of the joint the converse of these movements takes place: the tibia glides backward round the end of the femur, and at the commencement of the movement the tibia is directed downward and inward along the oblique curve of the inner condyle, thus causing an inward rotation to the leg.

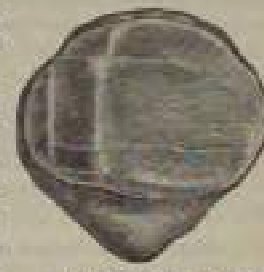

Fig. 188.—View of the posterior surface of the patella, showing diagrammatically the areas of contact with the femur in different positions of the knee.

During flexion and extension the patella moves on the lower end of the femur, but this movement is not a simple gliding one; for if the articular surface of this bone is examined, it will be found to present on each side of the central vertical ridge two less marked transverse ridges, which divide the surface, except a small portion along the inner border, which is cut off by a slight vertical ridge into six facets (see Fig. 188), and therefore does not present a uniform curved surface, as would be the case if a simple gliding movement took place. These six facets—three on each side of the median vertical ridge—correspond to and denote the parts of the bone respectively in contact with the condyles of the femur during flexion, semiflexion, and extension. In flexion only the upper facets on the patella are in contact with the condyles of the femur; the lower two-thirds of the bone rests upon the mass of fat which occupies the space between the femur and tibia. In the semiflexed position of the joint the middle facets on the patella rest upon the most prominent portion of the condyles, and thus afford greater leverage to the Quadriceps by increasing its distance from the centre of motion. In complete extension the patella is drawn up, so that only the lower facets are in contact with the articular surfaces of the condyles. The narrow strip along the inner border is in contact with the outer aspect of the internal condyle when the leg is fully flexed at the knee-joint. As in the elbow, so it is in the knee—the axis of rotation in flexion and extension is not precisely at right angles to the axis of the bone, but during flexion there is a certain amount of alteration of plane; so that, whereas in flexion the femur and tibia are in the same plane, in extension the one bone forms an angle of about ten degrees with the other. There is, however, this difference between the two extremities: that in the upper, during extension, the humeri are parallel and the bones of the forearm diverge; in the lower, the femora converge below and the tibia are parallel.

In addition to the slight rotation during flexion and extension, the tibia enjoys an independent rotation on the condyles of the femur in certain positions of the joint. This movement takes place between the interarticular fibro-cartilages and the tibia, whereas the movement of flexion and extension takes place between the interarticular fibro-cartilages and the femur. So that the knee may be said to consist of two joints, separated by the fibro-cartilages: an upper (menisco-femoral), in which flexion and extension take place; and a lower (menisco-tibial), allowing of a certain amount of rotation. This latter movement can only take place in the semiflexed position of the limb, when all the ligaments are relaxed.

During *flexion* the ligamentum patellæ is put upon the stretch, as is also the posterior crucial ligament in extreme flexion. The other ligaments are all relaxed by flexion of the joint, though the relaxation of the anterior crucial ligament is very trifling. Flexion is only checked during life by the contact of the leg with the thigh. In the act of extending the leg upon the thigh the ligamentum patellæ is tightened by the Quadriceps extensor; but when the leg is fully extended, as in the erect posture, the ligament becomes relaxed, so as to allow free lateral movement to the patella, which then rests on the front of the lower end of the femur. The other ligaments, with the exception of the posterior crucial, which is partly relaxed, are all on the stretch. When the limb has been brought into a straight line, extension is checked mainly by the tension of all the ligaments except the posterior crucial and ligamentum patellæ. The movements of *rotation* of which the knee is capable are permitted in the semiflexed condition by the partial relaxation of both crucial ligaments, as well as the lateral ligaments. Rotation inward appears to be limited by the tension of the anterior crucial ligament, and by the interlocking of the two ligaments; but rotation outward does not appear to be checked by either crucial ligament, since they uncross during the execution of this movement, but by the lateral ligaments, especially the internal. The main function of the crucial ligaments is to act as a direct bond of union between the tibia and femur, preventing the former bone from being carried too far backward or forward. Thus the anterior crucial ligament prevents the tibia being carried too far forward by the extensor tendons, and the posterior crucial checks too great movement backward by the flexors. They also assist the lateral ligaments in resisting any lateral bending of the joint. The interarticular cartilages are intended, as it seems, to adapt the surface of the tibia to the shape of the femur to a certain extent, so as to fill up the intervals which would otherwise be left in the varying positions of the joint, and to interrupt the jars which would be so frequently transmitted up the limb in jumping or falls on the feet; also to permit of the two varieties of motion, flexion and extension, and rotation, as explained above. The patella is a great defence to the knee-joint from any injury inflicted in front, and it distributes upon a large and tolerably even surface during kneeling the pressure which would otherwise fall upon the prominent ridges of the condyles; it also affords leverage to the Quadriceps extensor muscle to act upon the tibia; and Mr. Ward has pointed out [1] how this leverage varies in the various positions of the joint, so that the action of the muscles produces velocity at the expense of force in the commencement of extension, and, on the contrary, at the close of extension tends to diminish velocity, and therefore the shock to the ligaments at the moment tension of the structures takes place.

*Extension* of the leg on the thigh is performed by the Quadriceps extensor; *flexion* by the hamstring muscles, assisted by the Gracilis and Sartorius, and, indirectly, by the Gastrocnemius, Popliteus, and Plantaris; *rotation outward*, by the Biceps; and *rotation inward* by the Popliteus, Semitendinosus, and, to a slight extent, the Semimembranosus, the Sartorius, and the Gracilis.

**Surface Form.**—The interval between the two bones entering into the formation of the knee-joint can always easily be felt. If the limb is extended, it is situated on a slightly higher level than the apex of the patella; but if the limb is slightly flexed, a knife carried horizontally backward immediately below the apex of the patella would pass directly into the joint. When the knee-joint is distended with fluid, the outline of the synovial membrane at the front of the knee may be fairly well mapped out.

**Surgical Anatomy.**—From a consideration of the construction of the knee-joint it would at first sight appear to be one of the least secure of any of the joints in the body. It is formed

[1] *Human Osteology*, p. 405.

between the two longest bones, and therefore the amount of leverage which can be brought to bear upon it is very considerable; the articular surfaces are but ill adapted to each other, and the range and variety of motion which it enjoys is great. All these circumstances tend to render the articulation very insecure; but, nevertheless, on account of the very powerful ligaments which bind the bones together, the joint is one of the strongest in the body, and dislocation from traumatism is of very rare occurrence. When, on the other hand, the ligaments have been softened or destroyed by disease, partial displacement is very liable to occur, and is frequently brought about by the mere action of the muscles displacing the articular surfaces from each other. The tibia may be dislocated in any direction from the femur—forward, backward, inward, or outward; or a combination of two of these dislocations may occur—that is, the tibia may be dislocated forward and laterally, or backward and laterally; and any of these dislocations may be complete or incomplete. As a rule, however, the antero-posterior dislocations are complete, the lateral ones incomplete.

One or other of the semilunar cartilages may become displaced and nipped between the femur and tibia. The accident is produced by a twist of the leg when the knee is flexed, and is accompanied by a sudden pain and fixation of the knee in a flexed position. The cartilage may be displaced either inward or outward: that is to say, either inward toward the tibial spine, so that the cartilage becomes lodged in the intercondyloid notch; or outward, so that the cartilage projects beyond the margin of the two articular surfaces. Acute synovitis, the result of traumatism or exposure to cold, is very common in the knee, on account of its superficial position. When distended with fluid, the swelling shows itself above and at the sides of the patella, reaching about an inch or more above the trochlear surface of the femur, and extending a little higher under the Vastus internus than the Vastus externus. Occasionally the swelling may extend two inches or more. At the sides of the patella the swelling extends lower at the inner side than it does on the outer side. The lower level of the synovial membrane is just above the level of the upper part of the head of the fibula. In the middle line it covers the upper third of the ligamentum patellæ, being separated from it, however, by the capsule and a pad of fat. Chronic synovitis principally shows itself in the form of pulpy degeneration of the synovial membrane, leading to tubercular arthritis. The reasons why tubercular disease of the knee usually commences in the synovial membrane appear to be the complex and extensive nature of this sac; the extensive vascular supply to it; and the fact that injuries are generally diffused and applied to the front of the joint rather than to the ends of the bones. Syphilitic disease not unfrequently attacks the knee-joint. In the hereditary form of the disease it is usually symmetrical, attacking both joints, which become filled with synovial effusion, and is very intractable and difficult of cure. In the tertiary form of the disease gummatous infiltration of the synovial membrane may take place. The knee is one of the joints most commonly affected with osteo-arthritis, and is said to be more frequently the seat of this disease in women than in men. The occurrence of the so-called loose cartilage is almost confined to the knee, though they are occasionally met with in the elbow, and, rarely, in some other joints. Many of them occur in cases of osteo-arthritis, in which calcareous or cartilaginous material is formed in one of the synovial fringes and constitutes the foreign body, and may or may not become detached, in the former case only meriting the usual term, "loose" cartilage. In other cases they have their origin in the exudation of inflammatory lymph, and possibly, in some rare instances, a portion of the articular cartilage or one of the semilunar cartilages becomes detached and constitutes the foreign body.

Genu valgum, or knock-knee, is a common deformity of childhood, in which, owing to changes in and about the joint, the angle between the outer border of the tibia and femur is diminished, so that as the patient stands the two internal condyles of the femora are in contact, but the two internal malleoli of the tibiæ are more or less widely separated from each other. When, however, the knees are flexed to a right angle, the two legs are practically parallel with each other. At the commencement of the disease there is a yielding of the internal lateral ligament and other fibrous structures on the inner side of the joint; as a result of this there is a constant undue pressure of the outer tuberosity of the tibia against the outer condyle of the femur. This extra pressure causes arrest of growth and, possibly, wasting of the outer condyle, and a consequent tendency for the tibia to become separated from the internal condyle. To prevent this the internal condyle becomes depressed; probably, as was first pointed out by Mikulicz, by an increased growth of the lower end of the diaphysis on its inner side, so that the line of the epiphysis becomes oblique instead of transverse to the axis of the bone, with a direction downward and inward.

Excision of the knee-joint is most frequently required for tubercular disease of this articulation, but is also practised in cases of disorganization of the knee after rheumatic fever, pyæmia, etc., in osteo-arthritis, and in ankylosis. It is also occasionally called for in cases of injury, gunshot or otherwise. The operation is best performed either by a horseshoe incision, starting from one condyle, descending as low as the tubercle of the tibia, where it crosses the leg, and is then carried upward to the other condyle; or by a transverse incision across the patella. In this latter incision the patella is either removed or sawn across, and the halves subsequently sutured together. The bones having been cleared, and in those cases where the operation is performed for tubercular disease all pulpy tissue having been carefully removed, the section of the femur is first made. This should never include, in children, more than, at the most, two-thirds of the articular surface, otherwise the epiphyseal cartilage will be involved, with disastrous results as regards the growth of the limb. Afterward a thin slice should be removed from the upper end of the tibia, not more than half an inch. If any diseased tissue still appears to be left in the bones, it should be removed with the gouge rather than that a further section of the bones should be made.

## III. Articulations between the Tibia and Fibula.

The articulations between the tibia and fibula are effected by ligaments which connect both extremities, as well as the shafts of the bones. They may, consequently, be subdivided into three sets: 1. The Superior Tibio-fibular articulation. 2. The Middle Tibio-fibular ligament or interosseous membrane. 3. The Inferior Tibio-fibular articulation.

### 1. Superior Tibio-fibular Articulation.

This articulation is an arthrodial joint. The contiguous surfaces of the bones present two flat, oval facets covered with cartilage, and connected together by the following ligaments:

Capsular.
Anterior Superior Tibio-fibular.
Posterior Superior Tibio-fibular.

The **Capsular Ligament** consists of a membranous bag which surrounds the articulation, being attached around the margins of the articular facets on the tibia and fibula, and is much thicker in front than behind.

The **Anterior Superior Ligament** (Fig. 185) consists of two or three broad and flat bands which pass obliquely upward and inward from the front of the head of the fibula to the front of the outer tuberosity of the tibia.

The **Posterior Superior Ligament** (Fig. 184) is a single thick and broad band which passes upward and inward from the back part of the head of the fibula to the back part of the outer tuberosity of the tibia. It is covered by the tendon of the Popliteus muscle.

A **Synovial Membrane** lines this articulation, which at its upper and back part is occasionally continuous with that of the knee-joint.

### 2. Middle Tibio-fibular Ligament or Interosseous Membrane.

An interosseous membrane extends between the contiguous margins of the tibia and fibula, and separates the muscles on the front from those on the back of the leg. It consists of a thin, aponeurotic lamina composed of oblique fibres which for the most part pass downward and outward between the interosseous ridges on the two bones; some few fibres, however, pass in the opposite direction, downward and inward. It is broader above than below. Its upper margin does not quite reach the superior tibio-fibular joint, but presents a free concave border, above which is a large, oval aperture for the passage of the anterior tibial vessels forward to the anterior aspect of the leg. At its lower part is an opening for the passage of the anterior peroneal vessels. It is continuous below with the inferior interosseous ligament, and is perforated in numerous parts for the passage of small vessels. It is in relation, in front, with the Tibialis anticus, Extensor longus digitorum, Extensor proprius hallucis, Peroneus tertius, and the anterior tibial vessels and nerve; behind, with the Tibialis posticus and Flexor longus hallucis.

### 3. Inferior Tibio-fibular Articulation.

This articulation is formed by the rough, convex surface of the inner side of the lower end of the fibula, connected with a concave rough surface on the outer side of the tibia. Below, to the extent of about two lines, these surfaces are smooth, and covered with cartilage, which is continuous with that of the ankle-joint. The ligaments of this joint are—

Anterior Inferior Tibio-fibular.
Posterior Inferior Tibio-fibular.
Transverse or Inferior.
Inferior Interosseous.

The **Anterior Inferior Ligament** (Fig. 190) is a flat, triangular band of fibres, broader below than above, which extends obliquely downward and outward between the adjacent margins of the tibia and fibula, on the front aspect of the articulation. It is in relation, in front, with the Peroneus tertius, the aponeurosis of the leg, and the integument; behind, with the inferior interosseous ligament; and lies in contact with the cartilage covering the astragalus.

The **Posterior Inferior Ligament,** smaller than the preceding, is disposed in a similar manner on the posterior surface of the articulation.

The **Transverse Ligament** or **Inferior Ligament** lies under cover of the posterior ligament, and is a strong, thick band of yellowish fibres which passes transversely across the back of the joint, from the external malleolus to the posterior border of the articular surface of the tibia, almost as far as its malleolar process. This ligament projects below the margin of the bones, and forms part of the articulating surface for the astragalus.

The **Inferior Interosseous Ligament** consists of numerous short, strong, fibrous bands which pass between the contiguous rough surfaces of the tibia and fibula, and constitute the chief bond of union between the bones. This ligament is continuous above with the interosseous membrane.

The **Synovial Membrane** lining the articular surface is derived from that of the ankle-joint.

**Actions.**—The movement permitted in these articulations is limited to a very slight gliding of the articular surfaces one upon another.

## IV. Ankle-joint.

The **Ankle** is a ginglymus or hinge-joint. The bones entering into its formation are the lower extremity of the tibia and its malleolus and the external malleolus of the fibula, which forms a mortise to receive the upper convex surface of the astragalus and its two lateral facets. The bony surfaces are covered with carti-


FIG. 189.—Ankle-joint: tarsal and tarso-metatarsal articulations. Internal view. Right side.

lage and connected together by a capsule, which in places forms thickened bands constituting the following ligaments:

| | |
|---|---|
| Anterior. | Internal Lateral. |
| Posterior. | External Lateral. |

The **Anterior Ligament** (Fig. 189) is a broad, thin, membranous layer, attached, above, to the anterior margin of the lower extremity of the tibia; below, to the margin of the astragalus, in front of its articular surface. It is in relation, in front, with the Extensor tendons of the toes, with the tendons of the Tibialis anticus and Peroneus tertius, and the anterior tibial vessels and nerve; behind, it lies in contact with the synovial membrane.

The **Posterior Ligament** is very thin, and consists principally of transverse fibres. It is attached, above, to the margin of the articular surface of the tibia, blending with the transverse tibio-fibular ligament; below, to the astragalus, behind its superior articular facet. Externally, where a somewhat thickened band of transverse fibres is attached to the hollow on the inner surface of the external malleolus, it is thicker than internally.

The **Internal Lateral** or **Deltoid Ligament** is a strong, flat, triangular band, attached, above, to the apex and anterior and posterior borders of the inner malleolus. The most anterior fibres pass forward to be inserted into the navicular bone and the inferior calcaneo-navicular ligament; the middle descend almost perpendicularly to be inserted into the sustentaculum tali of the os calcis; and the posterior fibres pass backward and outward to be attached to the inner side of the astragalus. This ligament is covered by the tendons of the Tibialis posticus and Flexor longus digitorum muscles.

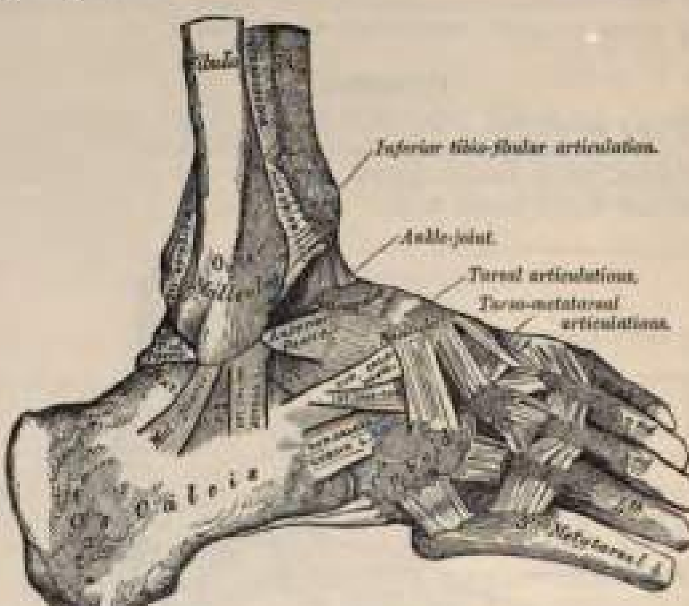


FIG. 190.—Ankle-joint: tarsal and tarso-metatarsal articulations. External view. Right side.

The **External Lateral Ligament** (Fig. 190) consists of three distinctly specialized fasciculi of the capsule, taking different directions and separated by distinct intervals; for which reason it is described by some anatomists as three distinct ligaments.[1]

The *anterior fasciculus* (anterior astragalo-fibular), the shortest of the three, passes from the anterior margin of the external malleolus forward and inward to the astragalus, in front of its external articular facet.

The *posterior fasciculus* (posterior astragalo-fibular), the most deeply seated, passes inward from the depression at the inner and back part of the external malleolus to a prominent tubercle on the posterior surface of the astragalus. Its fibres are almost horizontal in direction.

[1] Humphry, *On the Skeleton*, p. 559.

The *middle fasciculus* (calcaneo-fibular), the longest of the three, is a narrow, rounded cord passing from the apex of the external malleolus downward and slightly backward to a tubercle on the outer surface of the os calcis. It is covered by the tendons of the Peroneus longus and brevis.

The **Synovial Membrane** invests the inner surface of the ligaments, and sends a duplicature upward between the lower extremities of the tibia and fibula for a short distance.

**Relations.**—The tendons, vessels, and nerves in connection with the joint are, in front, from within outward, the Tibialis anticus, Extensor proprius hallucis, anterior tibial vessels, anterior tibial nerve, Extensor longus digitorum, and Peroneus tertius; behind, from within outward, the Tibialis posticus, Flexor longus digitorum, posterior tibial vessels, posterior tibial nerve, Flexor longus hallucis; and, in the groove behind the external malleolus, the tendons of the Peroneus longus and brevis.

The *Arteries* supplying the joint are derived from the malleolar branches of the anterior tibial and the peroneal.

The *Nerves* are derived from the anterior and posterior tibial.

**Actions.**—The movements of the joint are those of flexion and extension. Flexion consists in the approximation of the dorsum of the foot to the front of the leg, while in extension the heel is drawn up and the toes pointed downward. The malleoli tightly embrace the astragalus in all positions of the joint, so that any slight degree of lateral movement which may exist is simply due to stretching of the inferior tibio-fibular ligaments and slight bending of the shaft of the fibula. Of the ligaments, the internal, or deltoid, is of very great power—so much so that it usually resists a force which fractures the process of bone to which it is attached. Its middle portion, together with the middle fasciculus of the external lateral ligament, binds the bones of the leg firmly to the foot and resists displacement in every direction. Its anterior and posterior fibres limit extension and flexion of the foot respectively, and the anterior fibres also limit abduction. The posterior portion of the external lateral ligament assists the middle portion in resisting the displacement of the foot backward, and deepens the cavity for the reception of the astragalus. The anterior fasciculus is a security against the displacement of the foot forward, and limits extension of the joint. The movements of *inversion* and *eversion* of the foot, together with the minute changes in form by which it is applied to the ground or takes hold of an object in climbing, etc., are mainly effected in the tarsal joints, the one which enjoys the greatest amount of motion being that between the astragalus and os calcis behind and the navicular and cuboid in front. This is often called the *transverse* or *medio-tarsal joint*, and it can, with the subordinate joints of the tarsus, replace the ankle-joint in a great measure when the latter has become ankylosed.

*Extension* of the tarsal bones upon the tibia and fibula is produced by the Gastrocnemius, Soleus, Plantaris, Tibialis posticus, Peroneus longus and brevis, Flexor longus digitorum, and Flexor longus hallucis; *flexion*, by the Tibialis anticus, Peroneus tertius, Extensor longus digitorum, and Extensor proprius hallucis;[1] *inversion*, in the extended position, is produced by the Tibialis anticus and posticus; and *eversion* by the Peronei.

**Surface Form.**—The line of the ankle-joint may be indicated by a transverse line drawn across the front of the lower part of the leg, about half an inch above the level of the tip of the internal malleolus.

**Surgical Anatomy.**—Displacement of the trochlear surface of the astragalus from the tibio-fibular mortise is not of common occurrence, as the ankle-joint is a very strong and powerful articulation, and great force is required to produce it. Nevertheless, dislocation does occasionally occur, both in an antero-posterior and a lateral direction. In the latter, which is the most common, fracture is a necessary accompaniment of the injury. The dislocation in these cases is somewhat peculiar, and is not a displacement in a horizontally lateral direction, such as usually

[1] The student must bear in mind that the Extensor longus digitorum and Extensor proprius hallucis are *extensors* of the toes, but *flexors* of the ankle, and that the Flexor longus digitorum and Flexor longus hallucis are *flexors* of the toes, but *extensors* of the ankle.

occurs in lateral dislocations of ginglymoid joints, but the astragalus undergoes a partial rotation round an antero-posterior axis drawn through its own centre, so that the superior surface, instead of being directed upward, is inclined more or less inward or outward according to the variety of the displacement.

The ankle-joint is more frequently sprained than any joint in the body, and this may lead to acute synovitis. In these cases, when the synovial sac is distended with fluid, the bulging appears principally in the front of the joint, beneath the anterior tendons, and on either side, between the Tibialis anticus and the internal lateral ligament on the inner side, and between the Peroneus tertius and the external lateral ligament on the outer side. In addition to this, bulging frequently occurs posteriorly, and a fluctuating swelling may be detected on either side of the tendo Achillis.

Chronic synovitis may result from frequent sprains, and when once this joint has been sprained it is more liable to a recurrence of the injury than it was before; or it may be tuber-


Fig. 191.—Section of the right foot near its inner border, dividing the tibia, astragalus, navicular, internal cuneiform, and first metatarsal bone, and the first phalanx of the great toe. (After Braune.)

cular in its origin, the disease usually commencing in the astragalus and extending to the joint, though it may commence as a synovitis the result probably of some slight strain in a tubercular subject.

Excision of the ankle-joint is not often performed for two reasons. In the first place, disease of the articulation for which this operation is indicated is frequently associated with disease of the tarsal bones, which prevents its performance; and, secondly, the foot after excision is frequently of very little use; far less, in fact, than after a Symes's amputation, which is often, therefore, a preferable operation in these cases. Excision may, however, be attempted in cases of tubercular arthritis, in a young and otherwise healthy subject, where the disease is limited to the bones forming the joint. It may also be required after injury where the vessels and nerves have not been damaged and the patient is young and free from visceral disease. The excision is best performed by two lateral incisions. One commencing two and a half inches above the external malleolus, carried down the posterior border of the fibula, round the end of the bone, and then forward and downward as far as the calcaneo-cuboid joint, midway between the tip of the external malleolus and the tuberosity on the fifth metatarsal bone. Through this incision the fibula is cleared, the external lateral ligament is divided, and the bone sawn through about half an inch above the level of the ankle-joint and removed. A similar curved incision is now made on the inner side of the foot, commencing two and a half inches above the lower end of the tibia, carried down the posterior border of the bone, round the internal malleolus, and forward and downward to the tuberosity of the navicular bone. Through this incision the tibia is cleared in front and behind, the internal lateral, the anterior and posterior ligaments divided, and the end of the tibia protruded through the wound by displacing the foot outward, and sawn off sufficiently high to secure a healthy section of bone. The articular surface of the astragalus is now to be sawn off or the whole bone removed. In cases where the operation is performed for tubercular arthritis the latter course is probably preferable, as the injury done by the saw is frequently the starting point of fresh caries; and after removal of the whole bone the shortening is not appreciably increased, and the result as regards union appears to be as good as when two sawn surfaces of bone are brought into apposition.

## V. Articulations of the Tarsus.

### 1. Articulations of the Os Calcis and Astragalus.

The articulations between the os calcis and astragalus are two in number—anterior and posterior. They are arthrodial joints. The bones are connected together by four ligaments:

| | |
|---|---|
| External Calcaneo-astragaloid. | Posterior Calcaneo-astragaloid. |
| Internal Calcaneo-astragaloid. | Interosseous. |

The **External Calcaneo-astragaloid Ligament** (Fig. 190) is a short, strong, fasciculus passing from the outer surface of the astragalus, immediately beneath its external malleolar facet, to the outer surface of the os calcis. It is placed in front of the middle fasciculus of the external lateral ligament of the ankle-joint, with the fibres of which it is parallel.

The **Internal Calcaneo-astragaloid Ligament** is a band of fibres connecting the internal tubercle of the back of the astragalus with the back of the sustentaculum tali. Its fibres blend with those of the inferior calcaneo-navicular ligament.

The **Posterior Calcaneo-astragaloid Ligament** (Fig. 189) connects the external tubercle of the astragalus with the upper and inner part of the os calcis; it is a short band, the fibres of which radiate from their narrow attachment to the astragalus.

The **Interosseous Ligament** forms the chief bond of union between the bones. It consists of numerous vertical and oblique fibres attached by one extremity to the groove between the articulating facets on the under surface of the astragalus; by the other to a corresponding depression on the upper surface of the os calcis. It is very thick and strong, being at least an inch in breadth from side to side, and serves to unite the os calcis and astragalus solidly together.

The **Synovial Membranes** (Fig. 193) are two in number: one for the posterior calcaneo-astragaloid articulation; a second for the anterior calcaneo-astragaloid joint. The latter synovial membrane is continued forward between the contiguous surfaces of the astragalus and navicular bones.

**Actions.**—The movements permitted between the astragalus and os calcis are limited to a gliding of the one bone on the other in a direction from before backward, and from side to side.

### 2. Articulations of the Os Calcis with the Cuboid.

The ligaments connecting the os calcis with the cuboid are four in number:

| | |
|---|---|
| Dorsal. | Superior Calcaneo-cuboid.<br>Internal Calcaneo-cuboid (Interosseous). |
| Plantar. | Long Calcaneo-cuboid.<br>Short Calcaneo-cuboid. |

The **Superior Calcaneo-cuboid Ligament** (Fig. 190) is a thin and narrow fasciculus which passes between the contiguous surfaces of the os calcis and cuboid on the dorsal surface of the joint.

The **Internal Calcaneo-cuboid (Interosseous) Ligament** (Fig. 190) is a short but thick and strong band of fibres arising from the os calcis, in the deep hollow which intervenes between it and the astragalus, and closely blended, at its origin, with the superior calcaneo-navicular ligament. It is inserted into the inner side of the cuboid bone. This ligament forms one of the chief bonds of union between the first and second rows of the tarsus.

The **Long Calcaneo-cuboid (Long Plantar) Ligament** (Fig. 192), the more superficial of the two plantar ligaments, is the longest of all the ligaments of the tarsus: it is attached to the under surface of the os calcis, from near the tuberosities, as far forward as the anterior tubercle; its fibres pass forward to be attached to the ridge on the under surface of the cuboid bone, the more superficial fibres being continued onward to the bases of the second, third, and fourth metatarsal bones. This ligament crosses the groove on the under surface of the cuboid bone, converting it into a canal for the passage of the tendon of the Peroneus longus.

The **Short Calcaneo-cuboid (Short Plantar) Ligament** lies nearer to the bones than the preceding, from which it is separated by a little areolar tissue. It is exceedingly broad, about an inch in length, and extends from the tubercle and the depression in front of it, on the fore part of the under surface of the os calcis, to the inferior surface of the cuboid bone behind the peroneal groove.

**Synovial Membrane.**—The synovial membrane in this joint is distinct. It lines the inner surface of the ligaments.

**Actions.**—The movements permitted between the os calcis and cuboid are limited to a slight gliding upon each other.

3. THE LIGAMENTS CONNECTING THE OS CALCIS AND NAVICULAR.

Though these two bones do not directly articulate, they are connected together by two ligaments:

Superior or External Calcaneo-navicular.
Inferior or Internal Calcaneo-navicular.

The **Superior or External Calcaneo-navicular** (Fig. 190) arises, as already mentioned, with the internal calcaneo-cuboid in the deep hollow between the astragalus and os calcis; it passes forward from the upper surface of the anterior extremity of the os calcis to the outer side of the navicular bone. These two ligaments resemble the letter Y, being blended together behind, but separated in front.

Fig. 192.—Ligaments of the plantar surface of the foot.

The **Inferior or Internal Calcaneo-navicular** (Fig. 192) is by far the larger and stronger of the two ligaments between these bones; it is a broad and thick band of fibres, which passes forward and inward from the anterior margin of the sustentaculum tali of the os calcis to the under surface of the navicular bone. This ligament not only serves to connect the os calcis and navicular, but supports the head of the astragalus, forming part of the articular cavity in which it is received. The *upper surface* presents a fibro-cartilaginous facet, lined by the synovial membrane continued from the anterior calcaneo-astragaloid articulation, upon which a portion of the head of the astragalus rests. Its *under surface* is in contact with the tendon of the Tibialis posticus muscle;[1] its inner border is blended with the fore part of the Deltoid ligament, thus completing the socket for the head of the astragalus.

**Surgical Anatomy.**—The inferior calcaneo-navicular ligament, by supporting the head of the astragalus, is principally concerned in maintaining the arch of the foot, and when it yields, the head of the astragalus is pressed downward, inward, and forward by the weight of the body, and the foot becomes flattened, expanded, and turned outward, constituting the disease known as *flat-foot*. This ligament contains a considerable amount of elastic fibre, so as to

[1] Mr. Hancock describes an extension of this ligament upward on the inner side of the foot, which completes the socket of the joint in that direction (*Lancet*, 1866 vol. i., p. 618).

give elasticity to the arch and spring to the foot; hence it is sometimes called the "spring" ligament. It is supported, on its under surface, by the tendon of the Tibialis posticus, which spreads out at its insertion into a number of fasciculi which are attached to most of the tarsal and metatarsal bones; this prevents undue stretching of the ligament and is a protection against the occurrence of flat-foot.

### 4. Articulation of the Astragalus with the Navicular Bone.

The articulation between the astragalus and navicular is an arthrodial joint: the rounded head of the astragalus being received into the concavity formed by the posterior surface of the navicular, the anterior articulating surface of the calcaneum, and the upper surface of the inferior calcaneo-navicular ligament, which fills up the triangular interval between these bones. The only ligament of this joint is the **superior astragalo-navicular.** It is a broad band, which passes obliquely forward from the neck of the astragalus to the superior surface of the navicular bone. It is thin, and weak in texture, and covered by the Extensor tendons. The inferior calcaneo-navicular supplies the place of an inferior ligament.

The **Synovial Membrane** which lines the joint is continued forward from the anterior calcaneo-astragaloid articulation.

**Actions.**—This articulation permits of considerable mobility, but its feebleness is such as to allow occasionally of dislocation of the other bones of the tarsus from the astragalus.

The *transverse tarsal* or *medio-tarsal joint* is formed by the articulation of the os calcis with the cuboid, and by the articulation of the astragalus with the navicular. The movement which takes place in this joint is more extensive than that in the other tarsal joints, and consists of a sort of rotation by means of which the sole of the foot may be slightly flexed and extended or carried inward (inverted) and outward (everted).

### 5. The Articulation of the Navicular with the Cuneiform Bones.

The navicular is connected to the three cuneiform bones by

Dorsal and Plantar ligaments.

The **Dorsal Ligaments** are small, longitudinal bands of fibrous tissue arranged as three bundles, one to each of the cuneiform bones. That bundle of fibres which connects the navicular with the internal cuneiform is continued round the inner side of the articulation to be continuous with the plantar ligament which connects these two bones.

The **Plantar Ligaments** have a similar arrangement to those on the dorsum. They are strengthened by processes given off from the tendon of the Tibialis posticus.

**Actions.**—The movements permitted between the navicular and cuneiform bones are limited to a slight gliding upon each other.

The **Synovial Membrane** of these joints is part of the great tarsal synovial membrane.

### 6. The Articulation of the Navicular with the Cuboid.

The navicular bone is connected with the cuboid by

Dorsal, Plantar, and Interosseous ligaments.

The **Dorsal Ligament** consists of a band of fibrous tissue which passes obliquely forward and outward from the navicular to the cuboid bone.

The **Plantar Ligament** consists of a band of fibrous tissue which passes nearly transversely between these two bones.

The **Interosseous Ligament** consists of strong transverse fibres which pass between the rough non-articular portions of the lateral surfaces of these two bones.

**Actions.**—The movements permitted between the navicular and cuboid bones are limited to a slight gliding upon each other.

The **Synovial Membrane** of this joint is part of the great tarsal synovial membrane.

7. The Articulation of the Cuneiform Bones with each other.

These bones are connected together by

Dorsal, Plantar, and Interosseous ligaments.

The **Dorsal Ligaments** consist of two bands of fibrous tissue which pass transversely, one connecting the internal with the middle cuneiform, and the other connecting the middle with the external cuneiform.

The **Plantar Ligaments** have a similar arrangement to those on the dorsum. They are strengthened by the processes given off from the tendon of the Tibialis posticus.

The **Interosseous Ligaments** consist of strong transverse fibres which pass between the rough non-articular portions of the lateral surfaces of the adjacent cuneiform bones.

The **Synovial Membrane** of these joints is part of the great tarsal synovial membrane.

**Actions.**—The movements permitted between the cuneiform bones are limited to a slight gliding upon each other.

8. The Articulation of the External Cuneiform Bone with the Cuboid.

These bones are connected together by

Dorsal, Plantar, and Interosseous ligaments.

The **Dorsal Ligament** consists of a band of fibrous tissue which passes transversely between these two bones.

The **Plantar Ligament** has a similar arrangement. It is strengthened by a process given off from the tendon of the Tibialis posticus.

The **Interosseous Ligament** consists of strong transverse fibres which pass between the rough non-articular portions of the lateral surfaces of the adjacent sides of these two bones.

The **Synovial Membrane** of this joint is part of the great tarsal synovial membrane.

**Actions.**—The movements permitted between the external cuneiform and cuboid are limited to a slight gliding upon each other.

**Nerve-supply.**—All the joints of the tarsus are supplied by the anterior tibial nerve.

**Surgical Anatomy.**—In spite of the great strength of the ligaments which connect the tarsal bones together, dislocation at some of the tarsal joints does occasionally occur; though, on account of the spongy character of the bones, they are more frequently broken than dislocated, as the result of violence. When dislocation does occur, it is most commonly in connection with the astragalus; for not only may this bone be dislocated from the tibia and fibula at the ankle-joint, but the other bones may be dislocated from it, the trochlear surface of the bone remaining *in situ* in the tibio-fibular mortise. This constitutes what is known as the *subastragaloid* dislocation. Or, again, the astragalus may be dislocated from all its connections—from the tibia and fibula above, the os calcis below, and the navicular in front—and may even undergo a rotation, either on a vertical or horizontal axis. In the former case the long axis of the bone becoming directed across the joint, so that the head faces the articular surface on one or other malleolus; or, in the latter, the lateral surfaces becoming directed upward and downward, so that the trochlear surface faces to one or the other side. Finally, dislocation may occur at the medio-tarsal joint, the anterior tarsal bones being luxated from the astragalus and calcaneum. The other tarsal bones are also, occasionally, though rarely, dislocated from their connections.

## VI. Tarso-metatarsal Articulations.

These are arthrodial joints. The bones entering into their formation are four tarsal bones—viz. the internal, middle, and external cuneiform and the cuboid—which articulate with the metatarsal bones of the five toes. The metatarsal bone of the great toe articulates with the internal cuneiform; that of the second is deeply wedged in between the internal and external cuneiform, resting against the middle cuneiform, and being the most strongly articulated of all the metatarsal bones; the third metatarsal articulates with the extremity of the external cuneiform; the fourth with the cuboid and external cuneiform; and the fifth, with the cuboid. The articular surfaces are covered with cartilage, lined by synovial membrane, and connected together by the following ligaments:

Dorsal. Plantar. Interosseous.

The **Dorsal Ligaments** consist of strong, flat, fibrous bands, which connect the tarsal with the metatarsal bones. The first metatarsal is connected to the internal cuneiform by a single broad, thin, fibrous band; the second has three dorsal ligaments, one from each cuneiform bone; the third has one from the external cuneiform; the fourth has two, one from the external cuneiform and one from the cuboid; and the fifth, one from the cuboid.

The **Plantar Ligaments** consist of longitudinal and oblique fibrous bands connecting the tarsal and metatarsal bones, but disposed with less regularity than on the dorsal surface. Those for the first and second metatarsal are the most strongly marked; the second and third metatarsal receive strong fibrous bands which pass obliquely across from the internal cuneiform; the plantar ligaments of the fourth and fifth metatarsal consist of a few scanty fibres derived from the cuboid.

The **Interosseous Ligaments** are three in number—internal, middle, and external. The *internal* one is the strongest of the three, and passes from the outer extremity of the internal cuneiform to the adjacent angle of the second metatarsal. The *middle* one, less strong than the preceding, connects the external cuneiform with the adjacent angle of the second metatarsal. The *external* interosseous ligament connects the outer angle of the external cuneiform with the adjacent side of the third metatarsal.

The **Synovial Membrane** between the internal cuneiform bone and the first metatarsal bone is a distinct sac. The synovial membrane between the middle and external cuneiform behind, and the second and third metatarsal bones in front, is part of the great tarsal synovial membrane. Two prolongations are sent forward from it—one between the adjacent sides of the second and third metatarsal bones, and one between the third and fourth metatarsal bones. The synovial membrane between the cuboid and the fourth and fifth metatarsal bones is a distinct sac. From it a prolongation is sent forward between the fourth and fifth metatarsal bones.

**Actions.**—The movements permitted between the tarsal and metatarsal bones are limited to a slight gliding upon each other.

### VII. Articulations of the Metatarsal Bones with Each Other.

The base of the first metatarsal bone is not connected with the second metatarsal bone by any ligaments; in this respect it resembles the thumb.

The bases of the four outer metatarsal bones are connected together by dorsal, plantar, and interosseous ligaments.

The **Dorsal Ligaments** consist of bands of fibrous tissue which pass transversely between the adjacent metatarsal bones.

The **Plantar Ligaments** have a similar arrangement to those on the dorsum.

The **Interosseous Ligaments** consist of strong transverse fibres which pass between the rough non-articular portions of the lateral surfaces.

The **Synovial Membrane** between the second and third and the third and fourth metatarsal bones is part of the great tarsal synovial membrane.

The synovial membrane between the fourth and fifth metatarsal bones is a prolongation of the synovial membrane of the cubo-metatarsal joint.

**Actions.**—The movement permitted in the tarsal ends of the metatarsal bones is limited to a slight gliding of the articular surfaces upon one another.

### The Synovial Membranes in the Tarsal and Metatarsal Joints.

The **Synovial Membranes** (Fig. 193) found in the articulations of the tarsus and metatarsus are six in number: one for the posterior calcaneo-astragaloid articulation; a second for the anterior calcaneo-astragaloid and astragalo-navicular articulations; a third for the calcaneo-cuboid articulation; and a fourth for the articulations of the navicular with the three cuneiform, the three cuneiform with each other, the external cuneiform with the cuboid, and the middle and external cuneiform with the bases of the second and third metatarsal bones, and the lateral surfaces of the second, third, and fourth metatarsal bones with each other; a fifth for the internal cuneiform with the metatarsal bone of the great toe; and a sixth for the articulation of the cuboid with the fourth and fifth metatarsal bones. A small synovial membrane is sometimes found between the contiguous surfaces of the navicular and cuboid bones.

**Nerve-supply.**—The nerves supplying the tarso-metatarsal joints are derived from the anterior tibial.

The *digital extremities* of all the metatarsal bones are connected together by the *transverse metatarsal ligament.*

The **Transverse Metatarsal Ligament** is a narrow fibrous band which passes transversely across the anterior extremities of all the metatarsal bones, connecting


FIG. 191.—Oblique section of the articulations of the tarsus and metatarsus. Showing the six synovial membranes.

them together. It is blended anteriorly with the plantar (glenoid) ligament of the metatarso-phalangeal articulations. To its posterior border is connected the fascia covering the Interossei muscles. Its inferior surface is concave where the Flexor tendons pass over it. Above it the tendons of the Interossei muscles pass to their insertion. It differs from the transverse metacarpal ligament in that it connects the metatarsal bone of the great toe with the rest of the metatarsal bones.

## VIII. Metatarso-phalangeal Articulations.

The metatarso-phalangeal articulations are of the condyloid kind, formed by the reception of the rounded head of the metatarsal bone into a superficial cavity in the extremity of the first phalanx.

The ligaments are—

Plantar. Two Lateral.

The **Plantar Ligaments** (Glenoid ligaments of Cruveilhier) are thick, dense, fibrous structures. Each is placed on the plantar surface of the joint in the interval between the lateral ligaments, to which they are connected; they are loosely united to the metatarsal bone, but very firmly to the base of the first phalanges. Their plantar surface is intimately blended with the transverse metatarsal ligament, and presents a groove for the passage of the Flexor tendons, the sheath surrounding which is connected to each side of the groove. By their deep surface they form part of the articular surface for the head of the metatarsal bone, and are lined by a synovial membrane.

The **Lateral Ligaments** are strong, rounded cords, placed one on each side of the joint, each being attached, by one extremity, to the posterior tubercle on the side of the head of the metatarsal bone; and, by the other, to the contiguous extremity of the phalanx.

The **Posterior Ligament** is supplied by the extensor tendon placed over the back of the joint.

**Actions.**—The movements permitted in the metatarso-phalangeal articulations are flexion, extension, abduction, and adduction.

## IX. Articulations of the Phalanges.

The articulations of the phalanges are ginglymus joints.

The ligaments are—

Plantar. Two Lateral.

The arrangement of these ligaments is similar to those in the metatarso-phalangeal articulations; the extensor tendon supplies the place of a posterior ligament.

**Actions.**—The only movements permitted in the phalangeal joints are flexion and extension; these movements are more extensive between the first and second phalanges than between the second and third. The movement of flexion is very considerable, but extension is limited by the plantar and lateral ligaments.

**Surface Form.**—The principal joints which it is necessary to distinguish, with regard to the surgery of the foot, are the medio-tarsal and the tarso-metatarsal joints. The joint between the astragalus and the navicular is best found by means of the tubercle of the navicular bone, for the line of the joint is immediately behind this process. If the foot is grasped and forcibly extended, a rounded prominence, the head of the astragalus, will appear on the inner side of the dorsum in front of the ankle-joint, and if a knife is carried downward, just in front of this prominence and behind the line of the navicular tubercle, it will enter the astragalo-navicular joint. The calcaneo-cuboid joint is situated midway between the external malleolus and the prominent end of the fifth metatarsal bone. The plane of the joint is in the same line as that of the astragalo-navicular. The position of the joint between the fifth metatarsal bone and the cuboid is easily found by the projection of the fifth metatarsal bone, which is the guide to it. The direction of the line of the joint is very oblique, so that, if continued onward, it would pass through the head of the first metatarsal bone. The joint between the fourth metatarsal bone and the cuboid and external cuneiform is the direct continuation inward of the previous joint, but its plane is less oblique; it would be represented by a line drawn from the outer side of the articulation to the middle of the first metatarsal bone. The plane of the joint between the third metatarsal bone and the external cuneiform is almost transverse. It would be represented by a line drawn from the outer side of the joint to the base of the first metatarsal bone. The tarso-metatarsal articulation of the great toe corresponds to a groove which can be felt by making firm pressure on the inner side of the foot one inch in front of the tubercle on the navicular bone; and the joint between the second metatarsal bone and the middle cuneiform is to be found on the dorsum of the foot, half an inch behind the level of the tarso-metatarsal joint of the great toe. The line of the joints between the metatarsal bones and the first phalanges is about an inch behind the webs of the corresponding toes.

# THE MUSCLES AND FASCIÆ.[1]

THE Muscles are connected with the bones, cartilages, ligaments, and skin, either directly or through the intervention of fibrous structures called tendons or aponeuroses. Where a muscle is attached to bone or cartilage, the fibres terminate in blunt extremities upon the periosteum or perichondrium, and do not come into direct relation with the osseous or cartilaginous tissue. Where muscles are connected with the skin, they either lie as a flattened layer beneath it, or are connected with its areolar tissue by larger or smaller bundles of fibres, as in the muscles of the face.

The muscles vary extremely in their form. In the limbs, they are of considerable length, especially the more superficial ones, the deep ones being generally broad; they surround the bones and form an important protection to the various joints. In the trunk they are broad, flattened, and expanded, forming the parietes of the cavities which they enclose; hence the reason of the terms, *long, broad, short*, etc., used in the description of a muscle.

There is a considerable variation in the arrangement of the fibres of certain muscles with reference to the tendons to which they are attached. In some, the fibres are parallel and run directly from their origin to their insertion; these are quadrilateral muscles, such as the Thyro-hyoid. A modification of these is found in the fusiform muscles, in which the fibres are not quite parallel, but slightly curved, so that the muscle tapers at each end; in their action, however, they resemble the quadrilateral muscles. Secondly, in other muscles the fibres are convergent; arising by a broad origin, they converge to a narrow or pointed insertion. This arrangement of fibres is found in the triangular muscles—*e. g.* the Temporal. In some muscles, which otherwise would belong to the quadrilateral or triangular type, the origin and insertion are not in the same plane, but the plane of the line of origin intersects that of their insertion; such is the case in the Pectineus muscle. Thirdly, in some muscles the fibres are oblique and converge, like the plumes of a pen, to one side of a tendon, which runs the entire length of the muscle. Such a muscle is rhomboidal or penniform, as the Peronei. A modification of these rhomboidal muscles is found in those cases where oblique fibres converge to both sides of a central tendon which runs down the middle of the muscle; these are called bipenniform, and an example is afforded in the Rectus femoris. Finally, we have muscles in which the fibres are arranged in curved bundles in one or more planes, as in the Sphincter muscles. The arrangement of the muscular fibres is of considerable importance in respect to their relative strength and range of movement. Those muscles where the fibres are long and few in number have great range, but diminished strength; where, on the other hand, the fibres are short and more numerous, there is great power, but lessened range.

Muscles differ much in size: the Gastrocnemius forms the chief bulk of the back of the leg, and the fibres of the Sartorius are nearly two feet in length, whilst

[1] The Muscles and Fasciæ are described conjointly, in order that the student may consider the arrangement of the latter in his dissection of the former. It is rare for the student of anatomy in this country to have the opportunity of dissecting the fasciæ separately; and it is for this reason, as well as from the close connection that exists between the muscles and their investing sheaths, that they are considered together. Some general observations are first made on the anatomy of the muscles and fasciæ, the special description being given in connection with the different regions.

the Stapedius, a small muscle of the internal ear, weighs about a grain, and its fibres are not more than two lines in length.

The names applied to the various muscles have been derived—1, from their situation, as the Tibialis, Radialis, Ulnaris, Peroneus; 2, from their direction, as the Rectus abdominis, Obliqui capitis, Transversalis; 3, from their uses, as Flexors, Extensors, Abductors, etc.; 4, from their shape, as the Deltoid, Trapezius, Rhomboideus; 5, from the number of their divisions, as the Biceps, the Triceps; 6, from their points of attachment, as the Sterno-cleido-mastoid, Sterno-hyoid, Sterno-thyroid.

In the description of a muscle the term *origin* is meant to imply its more fixed or central attachment, and the term *insertion*, the movable point to which the force of the muscle is directed; but the origin is absolutely fixed in only a very small number of muscles, such as those of the face, which are attached by one extremity to the bone and by the other to the movable integument; in the greater number the muscle can be made to act from either extremity.

In the dissection of the muscles the student should pay especial attention to the exact *origin*, *insertion*, and *actions* of each, and its more important *relations* with surrounding parts. An accurate knowledge of the points of attachment of the muscles is of great importance in the determination of their action. By a knowledge of the action of the muscles the surgeon is able to explain the causes of displacement in various forms of fracture and the causes which produce distortion in various deformities, and, consequently, to adopt appropriate treatment in each case. The relations, also, of some of the muscles, especially those in immediate apposition with the larger blood-vessels, and the surface-markings they produce, should be especially remembered, as they form useful guides in the application of a ligature to those vessels.

*Tendons* are white, glistening, fibrous cords, varying in length and thickness, sometimes round, sometimes flattened, of considerable strength, and devoid of elasticity. They consist almost entirely of white fibrous tissue, the fibrils of which have an undulating course parallel with each other and are firmly united together. They are very sparingly supplied with blood-vessels, the smaller tendons presenting in their interior not a trace of them. Nerves also are not present in the smaller tendons, but the larger ones, as the tendo Achillis, receive nerves which accompany the nutrient vessels. The tendons consist principally of a substance which yields gelatin.

*Aponeuroses* are flattened or ribbon-shaped tendons, of a pearly-white color, iridescent, glistening, and similar in structure to the tendons. They are destitute of nerves, and the thicker ones only sparingly supplied with blood-vessels.

The tendons and aponeuroses are connected, on the one hand, with the muscles, and, on the other hand, with the movable structures, as the bones, cartilages, ligaments, fibrous membranes (for instance, the sclerotic). Where the muscular fibres are in a direct line with those of the tendon or aponeurosis, the two are directly continuous, the muscular fibre being distinguishable from that of the tendon only by its striation. But where the muscular fibre joins the tendon or aponeurosis at an oblique angle the former terminates, according to Kölliker, in rounded extremities, which are received into corresponding depressions on the surface of the latter, the connective tissue between the fibres being continuous with that of the tendon. The latter mode of attachment occurs in all the penniform and bipenniform muscles, and in those muscles the tendons of which commence in a membranous form, as the Gastrocnemius and Soleus.

The fasciæ (*fascia*, a bandage) are fibro-areolar or aponeurotic laminæ of variable thickness and strength, found in all regions of the body, investing the softer and more delicate organs. The fasciæ have been subdivided, from the situation in which they are found, into two groups, superficial and deep.

The *superficial fascia* is found immediately beneath the integument over almost the entire surface of the body. It connects the skin with the deep or aponeurotic fascia, and consists of fibro-areolar tissue, containing in its meshes pellicles of fat in varying quantity. In the eyelids and scrotum, where adipose tissue is rarely deposited, this tissue is very liable to serous infiltration. The superficial fascia varies in thickness in different parts of the body: in the groin it is so thick as to be capable of being subdivided in several laminæ. Beneath the fatty layer of the superficial fascia, which is immediately subcutaneous, there is generally another layer of the same structure, comparatively devoid of adipose tissue, in which the trunks of the subcutaneous vessels and nerves are found, as the superficial epigastric vessels in the abdominal region, the radial and ulnar veins in the forearm, the saphenous veins in the leg and thigh, and the superficial lymphatic glands; certain cutaneous muscles also are situated in the superficial fascia, as the Platysma myoides in the neck, and the Orbicularis palpebrarum around the eyelids. This fascia is most distinct at the lower part of the abdomen, the scrotum, perinæum, and extremities; is very thin in those regions where muscular fibres are inserted into the integument, as on the side of the neck, the face, and around the margin of the anus. It is very dense in the scalp, in the palms of the hands and soles of the feet, forming a fibro-fatty layer which binds the integument firmly to the subjacent structure.

The superficial fascia connects the skin to the subjacent parts, facilitates the movement of the skin, serves as a soft medium for the passage of vessels and nerves to the integument, and retains the warmth of the body, since the fat contained in its areolæ is a bad conductor of heat.

The *deep fascia* is a dense, inelastic, unyielding fibrous membrane, forming sheaths for the muscles and affording them broad surfaces for attachment. It consists of shining tendinous fibres, placed parallel with one another, and connected together by other fibres disposed in a rectilinear manner. It is usually exposed on the removal of the superficial fascia, forming a strong investment, which not only binds down collectively the muscles in each region, but gives a separate sheath to each, as well as to the vessels and nerves. The fasciæ are thick in unprotected situations, as on the outer side of a limb, and thinner on the inner side. The deep fasciæ assist the muscles in their action by the degree of tension and pressure they make upon their surface; and in certain situations this is increased and regulated by muscular action; as, for instance, by the Tensor fasciæ femoris and Gluteus maximus in the thigh, by the Biceps in the upper and lower extremities, and Palmaris longus in the hand. In the limbs the fasciæ not only invest the entire limb, but give off septa which separate the various muscles, and are attached beneath to the periosteum: these prolongations of fasciæ are usually spoken of as intermuscular septa.

The Muscles and Fasciæ may be arranged, according to the general division of the body, into those of the cranium, face, and neck; those of the trunk; those of the upper extremity; and those of the lower extremity.

## MUSCLES AND FASCIÆ OF THE CRANIUM AND FACE.

The muscles of the Cranium and Face consist of ten groups, arranged according to the region in which they are situated:

1. Cranial Region.
2. Auricular Region.
3. Palpebral Region.
4. Orbital Region.
5. Nasal Region.
6. Maxillary Region.
7. Mandibular Region.
8. Intermaxillary Region.
9. Temporo-mandibular Region.
10. Pterygo-mandibular Region.

The muscles contained in each of these groups are the following:

1. *Cranial Region.*

Occipito-frontalis.

2. *Auricular Region.*

Attrahens auriculam.
Attollens auriculam.
Retrahens auriculam.

3. *Palpebral Region.*
Orbicularis palpebrarum.
Corrugator supercilii.
Tensor tarsi.

4. *Orbital Region.*
Levator palpebræ.
Rectus superior.
Rectus inferior.
Rectus internus.
Rectus externus.
Obliquus superior.
Obliquus inferior.

5. *Nasal Region.*
Pyramidalis nasi.
Levator labii superioris alæque nasi.
Dilatator naris posterior.
Dilatator naris anterior.
Compressor nasi.
Compressor narium minor.
Depressor alæ nasi.

6. *Maxillary Region.*
Levator labii superioris.
Levator anguli oris.
Zygomaticus major.
Zygomaticus minor.

7. *Mandibular Region.*
Levator labii inferioris.
Depressor labii inferioris.
Depressor anguli oris.

8. *Intermaxillary Region.*
Buccinator.
Risorius.
Orbicularis oris.

9. *Temporo-mandibular Region.*
Masseter.
Temporal.

10. *Pterygo-mandibular Region.*
Pterygoideus externus.
Pterygoideus internus.

### 1. Cranial Region—Occipito-frontalis.

**Dissection** (Fig. 194).—The head being shaved, and a block placed beneath the back of the neck, make a vertical incision through the skin from before backward, commencing at the root of the nose in front, and terminating behind at the occipital protuberance; make

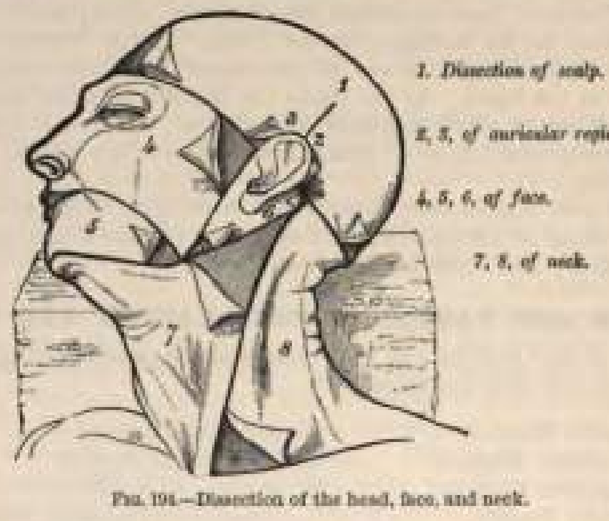


FIG. 194.—Dissection of the head, face, and neck.

a second incision in a horizontal direction along the forehead and round the side of the head, from the anterior to the posterior extremity of the preceding. Raise the skin in front, from the subjacent muscle, from below upward; this must be done with extreme care, removing the integument from the outer surface of the vessels and the nerves which lie immediately beneath the skin.

**The Skin of the Scalp.**—This is thicker than in any other part of the body. It is intimately adherent to the superficial fascia. The hair-follicles are very closely set together, and extend throughout the whole thickness of the skin. It also contains a number of sebaceous glands.

The **superficial fascia** in the cranial region is a firm, dense, fibro-fatty layer, intimately adherent to the integument, and to the Occipito-frontalis and its tendi-

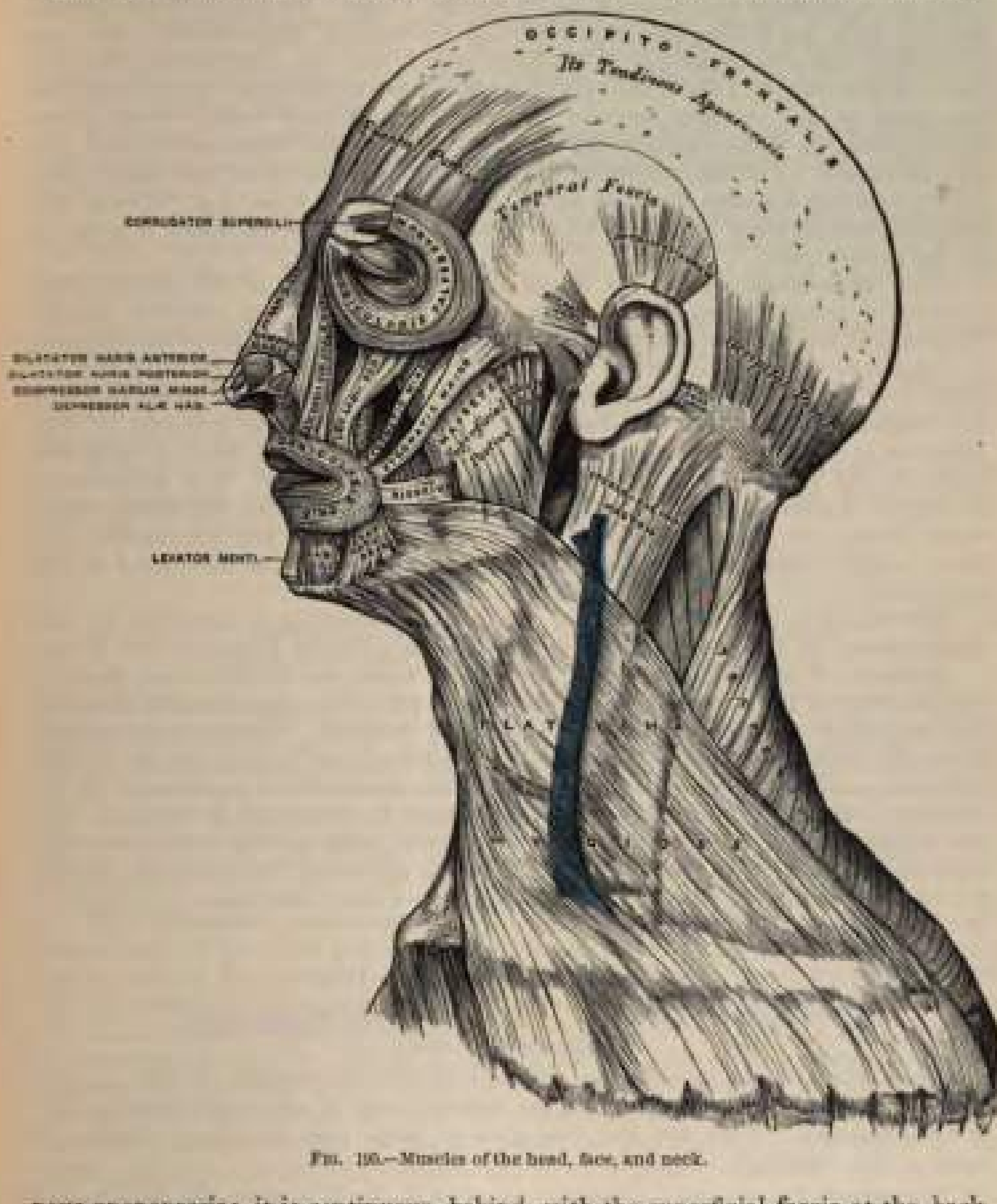


FIG. 195.—Muscles of the head, face, and neck.

nous aponeurosis; it is continuous, behind, with the superficial fascia at the back part of the neck; and, laterally, is continued over the temporal fascia. It contains between its layers the superficial vessels and nerves and much granular fat.

The **Occipito-frontalis** (Fig. 195) is a broad musculo-fibrous layer, which covers the whole of one side of the vertex of the skull, from the occiput to the eyebrow. It consists of two muscular slips, separated by an intervening tendinous aponeurosis. The *occipital portion* (sometimes called the *occipitalis* muscle) is thin, quadrilateral in form, and about an inch and a half in length; it arises from the outer two-thirds of the superior curved line of the occipital bone, and from the mastoid portion of the temporal. Its fibres of origin are tendinous, but they soon become muscular, and ascend in a parallel direction to terminate in a tendinous aponeurosis. The *frontal portion* (sometimes called the *frontalis* muscle) is thin, of a quadrilateral form, and intimately adherent to the superficial fascia. It is broader, its fibres are longer, and their structure paler than the occipital portion. Its internal fibres are continuous with those of the Pyramidalis nasi. Its middle fibres become blended with the Corrugator supercilii and Orbicularis palpebrarum; and the outer fibres are also blended with the latter muscle over the external angular process. According to Theile, the innermost fibres are attached to the nasal bones, the outer to the external angular process of the frontal bone. From these attachments the fibres are directed upward, and join the aponeurosis below the coronal suture. The inner margins of the frontal portions of the two muscles are joined together for some distance above the root of the nose; but between the occipital portions there is a considerable, though variable, interval, which is occupied by the aponeurosis.

The **aponeurosis** covers the upper part of the vertex of the skull, being continuous across the middle line with the aponeurosis of the opposite muscle. Behind, it is attached, in the interval between the occipital origins, to the occipital protuberance and highest curved lines of the occipital bone; in front, it forms a short and narrow prolongation between the frontal portions; and on each side it has connected with it the Attollens and Attrahens auriculam muscles; in this situation it loses its aponeurotic character, and is continued over the temporal fascia to the zygoma as a layer of laminated areolar tissue. This aponeurosis is closely connected to the integument by the firm, dense, fibro-fatty layer which forms the superficial fascia; it is connected with the pericranium by loose cellular tissue, which allows of a considerable degree of movement of the integument.

**Nerves.**—The frontal portion of the Occipito-frontalis is supplied by the facial nerve; its occipital portion by the posterior auricular branch of the facial.

**Actions.**—The frontal portion of the muscle raises the eyebrows and the skin over the root of the nose, and at the same time draws the scalp forward, throwing the integument of the forehead into transverse wrinkles. The posterior portion draws the scalp backward. By bringing alternately into action the frontal and occipital portions the entire scalp may be moved forward and backward. In the ordinary action of the muscles, the eyebrows are elevated, and at the same time the aponeurosis is fixed by the posterior portion, thus giving to the face the expression of surprise: if the action is more exaggerated, the eyebrows are still further raised, and the skin of the forehead thrown into transverse wrinkles, as in the expression of fright or horror.

## 2. Auricular Region (Fig. 195).

Attrahens auriculam. Attollens auriculam.
Retrahens auriculam.

These three small muscles are placed immediately beneath the skin around the external ear. In man, in whom the external ear is almost immovable, they are rudimentary. They are the analogues of large and important muscles in some of the mammalia.

**Dissection.**—This requires considerable care, and should be performed in the following manner: To expose the Attollens auriculam, draw the pinna, or broad part of the ear, downward, when a tense band will be felt beneath the skin, passing from the side of the head to the upper part of the concha; by dividing the skin over this band in a direction from below upward, and then reflecting it on each side, the muscle is exposed. To bring into view the Attrahens auriculam, draw the helix backward by means of a hook, when the muscle will be made tense, and may be exposed in a similar manner to the preceding. To expose the Retrahens auriculam, draw the pinna forward, when the muscle, being made tense, may be felt beneath the skin at its insertion into the back part of the concha, and may be exposed in the same manner as the other muscles.

The **Attrahens auriculam** (*Auricularis anterior*), the smallest of the three, is thin, fan-shaped, and its fibres pale and indistinct; they arise from the lateral edge of the aponeurosis of the Occipito-frontalis, and converge to be inserted into a projection on the front of the helix.

**Relations.**—*Superficially*, with the skin; *deeply*, with the areolar tissue derived from the aponeurosis of the Occipito-frontalis, beneath which are the temporal artery and vein and the temporal fascia.

The **Attollens auriculam** (*Auricularis superior*), the largest of the three, is thin and fan-shaped: its fibres arise from the aponeurosis of the Occipito-frontalis and converge to be inserted by a thin, flattened tendon into the upper part of the cranial surface of the pinna.

**Relations.**—*Superficially*, with the integument; *deeply*, with the areolar tissue derived from the aponeurosis of the Occipito-frontalis, beneath which is the temporal fascia.

The **Retrahens auriculam** (*Auricularis posterior*) consists of two or three fleshy fasciculi, which arise from the mastoid portion of the temporal bone by short aponeurotic fibres. They are inserted into the lower part of the cranial surface of the concha.

**Relations.**—*Superficially*, with the integument: *deeply*, with the mastoid portion of the temporal bone and the posterior auricular artery and nerve.

**Nerves.**—The Attrahens and Attollens auriculam are supplied by the temporal branch of the facial; the Retrahens auriculam is supplied by the posterior auricular branch of the same nerve.

**Actions.**—In man, these muscles possess very little action: the Attrahens auriculam draws the ear forward and upward; the Attollens auriculam slightly raises it; and the Retrahens auriculam draws it backward.

### 3. Palpebral Region (Fig. 195).

| | |
|---|---|
| Orbicularis palpebrarum. | Levator palpebræ. |
| Corrugator supercilii. | Tensor tarsi. |

**Dissection** (Fig. 194).—In order to expose the muscles of the face, continue the longitudinal incision made in the dissection of the Occipito-frontalis down the median line of the face to the tip of the nose, and from this point onward to the upper lip; and carry another incision along the margin of the lip to the angle of the mouth, and transversely across the face to the angle of the jaw. Then make an incision in front of the external ear, from the angle of the jaw upward, to join the transverse incision made in exposing the Occipito-frontalis. These incisions include a square-shaped flap, which should be removed in the direction marked in the figure, with care, as the muscles at some points are intimately adherent to the integument.

The **Orbicularis palpebrarum** is a sphincter muscle, which surrounds the circumference of the orbit and eyelids. It arises from the internal angular process of the frontal bone, from the nasal process of the superior maxillary bone in front of the lachrymal groove for the nasal duct, and from the anterior surface and borders of a short tendon, the *tendo oculi*, or *internal tarsal ligament*, placed at the inner angle of the orbit. From this origin the fibres are directed outward, forming a broad, thin, and flat layer, which covers the eyelids, surrounds the circumference of the orbit, and spreads out over the temple and downward on the cheek. The palpebral portion (ciliaris) of the Orbicularis is thin and pale; it arises from the bifurcation of the tendo palpebrarum, and forms a series of concentric curves, which are on the outer side of the eyelids inserted into the external tarsal ligament. The orbital portion (orbicularis latus) is thicker and of a reddish color: its fibres are well developed, and form complete ellipses. The upper fibres of this portion blend with the Occipito-frontalis and Corrugator supercilii.

**Relations.**—By its *superficial surface*, with the integument. By its *deep surface*, above, with the Occipito-frontalis and Corrugator supercilii, with which it is intimately blended, and with the supra-orbital vessels and nerve; below, it covers the lachrymal sac, and the origin of the Levator labii superioris alæque nasi, the Levator labii superioris, and the Zygomaticus minor muscles. *Internally*, it is occasionally blended with the Pyramidalis nasi. *Externally*, it lies on the temporal fascia. On the eyelids it is separated from the conjunctiva by the **Levator palpebræ**, the tarsal ligaments, the tarsal plates, and the Meibomian glands.

The *tendo oculi* (internal tarsal ligament) is a short tendon, about two lines in length and one in breadth, attached to the nasal process of the superior maxillary bone in front of the lachrymal groove. Crossing the lachrymal sac, it divides into two parts, each division being attached to the inner extremity of the corresponding tarsal plate. As the tendon crosses the lachrymal sac, a strong aponeurotic lamina is given off from the posterior surface, which expands over the sac, and is attached to the ridge on the lachrymal bone. This is the reflected aponeurosis of the tendo oculi.

The *external tarsal ligament* is a much weaker structure than the tendo oculi. It is attached to the margin of the frontal process of the malar bone, and passes inward to the outer commissure of the eyelids; it connects together the outer extremities of the two tarsal cartilages.

**Use of Tendo oculi.**—Besides giving attachment to part of the Orbicularis palpebrarum and to the tarsal plates, it serves to suck the tears into the lachrymal sac, by its attachment to the sac. Thus, each time the eyelids are closed, the tendo oculi becomes tightened, through the action of the Orbicularis, and draws the wall of the lachrymal sac outward and forward, so that a vacuum is made in the sac, and the tears are sucked along the lachrymal canals into it.

The **Corrugator supercilii** is a small, narrow, pyramidal muscle, placed at the inner extremity of the eyebrow, beneath the Occipito-frontalis and Orbicularis palpebrarum muscles. It arises from the inner extremity of the superciliary ridge, from whence its fibres pass upward and outward, and, passing between the palpebral and orbital portions of the Orbicularis palpebrarum, are inserted into the deep surface of the skin, opposite the middle of the orbital arch.


FIG. 196.—Horner's muscle. (From a preparation in the Museum of the Royal College of Surgeons of England.)

**Relations.**—By its *anterior surface* with the Occipito-frontalis and Orbicularis palpebrarum muscles; by its *posterior surface*, with the frontal bone and supratrochlear nerve.

The **Levator palpebræ** will be described with the muscles of the orbital region.

The **Tensor tarsi** (Horner's muscle) (Fig. 196) is a small thin muscle about three lines in breadth and six in length, situated at the inner side of the orbit, behind the tendo oculi. It arises from the crest and adjacent part of the orbital surface of the lachrymal bone, and, passing across the lachrymal sac, divides into two slips, which cover the lachrymal canals and are inserted into the tarsal plates internal to the puncta lachrymalia. Its fibres appear to be continuous with those of the palpebral portion of the Orbicularis palpebrarum; it is occasionally very indistinct.

**Nerves.**—The Orbicularis palpebrarum, Corrugator supercilii, and Tensor tarsi are supplied by the facial nerve. Recent investigations tend to show that the Orbicularis palpebrarum, Corrugator supercilii, and frontal part of the Occipito-frontalis are in reality supplied by fibres of the third nerve, which descend through the pons varolii to join the facial nerve.

**Actions.**—The Orbicularis palpebrarum is the sphincter muscle of the eyelids.

The palpebral portion acts involuntarily, closing the lids gently, as in sleep or in blinking; the orbicular portion is subject to the will. When the entire muscle is brought into action, the skin of the forehead, temple, and cheek is drawn inward toward the inner angle of the orbit, and the eyelids are firmly closed as in photophobia. When the skin of the forehead, temple, and cheek is thus drawn inward by the action of the muscle it is thrown into folds, especially radiating from the outer angle of the eyelids, which give rise in old age to the so-called "crow's feet." The Levator palpebræ is the direct antagonist of this muscle; it raises the upper eyelid and exposes the globe. The Corrugator supercilii draws the eyebrow downward and inward, producing the vertical wrinkles of the forehead. It is the "frowning" muscle, and may be regarded as the principal agent in the expression of suffering. The Tensor tarsi draws the eyelids and the extremities of the lachrymal canals inward and compresses them against the surface of the globe of the eye; thus placing them in the most favorable situation for receiving the tears. It serves, also, to compress the lachrymal sac.

## 4. Orbital Region (Fig. 197).

| | |
|---|---|
| Levator palpebræ superioris. | Rectus internus. |
| Rectus superior. | Rectus externus. |
| Rectus inferior. | Obliquus oculi superior. |

Obliquus oculi inferior.

**Dissection.**—To open the cavity of the orbit, remove the skull-cap and brain; then saw through the frontal bone at the inner extremity of the supraorbital ridge, and externally at its

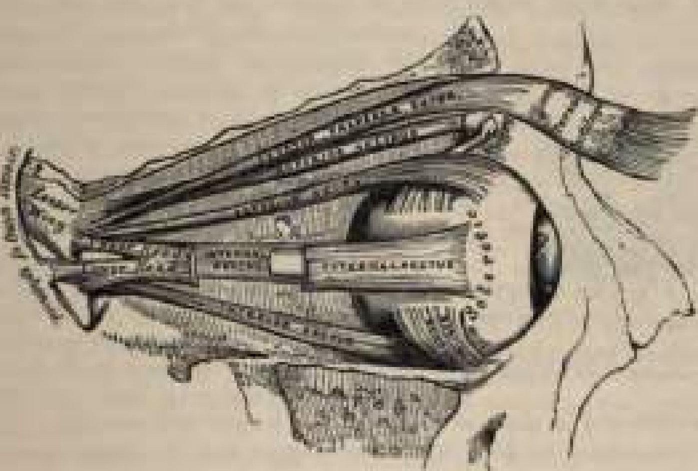

FIG. 197.—Muscles of the right orbit.

junction with the malar. Break in pieces the thin roof of the orbit by a few slight blows of the hammer, and take it away; drive forward the superciliary portion of the frontal bone by a smart stroke, but do not remove it, as that would destroy the pulley of the Obliquus superior. When the fragments are cleared away, the periosteum of the orbit will be exposed; this being removed, together with the fat which fills the cavity of the orbit, the several muscles of this region can be examined. The dissection will be facilitated by distending the globe of the eye. In order to effect this, puncture the optic nerve near the eyeball with a curved needle, and push the needle onward into the globe; insert the point of a blowpipe through this aperture, and force a little air into the cavity of the eyeball; then apply a ligature round the nerve so as to prevent the air escaping. The globe being now drawn forward, the muscles will be put upon the stretch.

The **Levator palpebræ superioris** is thin, flat, and triangular in shape. It arises from the under surface of the lesser wing of the sphenoid, above and in front of the optic foramen, from which it is separated by the origin of the Superior rectus. At its origin it is narrow and tendinous, but soon becomes broad and fleshy, and finally terminates in a wide aponeurosis, which is inserted into the upper margin of the superior tarsal plate. From this aponeurosis a thin expansion is continued onward, passing between the fibres of the Orbicularis to be inserted into the skin of the lid, and some deeper fibres blend with an expansion from the sheath of the Superior rectus muscle, and are with it prolonged into the conjunctiva.

**Relations.**—By its *upper surface*, with the frontal nerve and supraorbital artery, the periosteum of the orbit and lachrymal gland; and, in the lid, with the inner surface of the tarsal ligament; by its *under surface*, with the Superior rectus, and, in the lid, with the conjunctiva. A small branch of the third nerve enters its under surface.

The **Superior rectus**, the thinnest and narrowest of the four Recti, arises from the upper margin of the optic foramen beneath the Levator palpebræ, and from the fibrous sheath of the optic nerve; and is inserted by a tendinous expansion into the sclerotic coat, about three or four lines from the margin of the cornea.

**Relations.**—By its *upper surface*, with the Levator palpebræ; by its *under surface*, with the optic nerve, the ophthalmic artery, the nasal nerve, and the branch of the third nerve which supplies it; and, in front, with the tendon of the Superior oblique and the globe of the eye.

The **Inferior and Internal Recti** arise by a common tendon (the *ligament of Zinn*),[1] which is attached round the circumference of the optic foramen, except at its upper and outer part. The **External rectus** has two heads: the upper one arises from the outer margin of the optic foramen immediately beneath the Superior rectus; the lower head, partly from the ligament of Zinn and partly from a small pointed process of bone on the lower margin of the sphenoidal fissure. Each muscle passes forward in the position implied by its name, to be inserted by a tendinous expansion (the *tunica albuginea*) into the sclerotic coat, about three or four lines from the margin of the cornea. Between the two heads of the External rectus is a narrow interval, through which passes the third, the nasal branch of the ophthalmic division of the fifth and sixth nerves, and the ophthalmic vein. Although nearly all of these muscles present a common origin and are inserted in a similar manner into the sclerotic coat, there are certain differences to be observed in them as regards their length and breadth. The Internal rectus is the broadest, the External is the longest, and the Superior is the thinnest and narrowest.

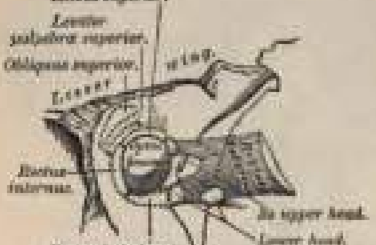


FIG. 198.—The relative position and attachment of the muscles of the left eyeball.

The **Superior oblique** is a fusiform muscle placed at the upper and inner side of the orbit, internal to the Levator palpebræ. It arises about a line above the inner margin of the optic foramen, and, passing forward to the inner angle of the orbit, terminates in a rounded tendon, which plays in a ring or pulley formed by cartilaginous tissue attached to a depression beneath the internal angular process of the frontal bone, the contiguous surfaces of the tendon and ring being lined by a delicate synovial membrane and enclosed in a thin fibrous investment. The tendon is reflected backward, outward, and downward beneath the Superior rectus to the outer part of the globe of the eye, and is inserted into the sclerotic coat,

[1] The ligament of Zinn ought, perhaps more appropriately, to be termed the *aponeurosis or tendon of Zinn*. Mr. C. B. Lockwood has described a somewhat similar structure on the under surface of the Superior rectus muscle, which is attached to the lesser wing of the sphenoid, forming the upper and outer margin of the optic foramen. This *superior tendon* gives origin to the Superior rectus, the superior head of the External rectus, and the upper part of the Internal rectus. (*Journal of Anatomy and Physiology*, vol. xx. part i. p. 1.)

behind the equator of the eyeball, the insertion of the muscle lying between the Superior and External recti.

**Relations.**—By its *upper surface*, with the periosteum covering the roof of the orbit and the fourth nerve: the tendon, where it lies on the globe of the eye, is covered by the Superior rectus; by its *under surface*, with the nasal nerve, ethmoidal arteries, and the upper border of the internal rectus.

The **Inferior oblique** is a thin, narrow muscle placed near the anterior margin of the orbit. It arises from a depression on the orbital plate of the superior maxillary bone, external to the lachrymal groove. Passing outward, backward, and upward between the Inferior rectus and the floor of the orbit, and then between the eyeball and the External rectus, it is inserted into the outer part of the sclerotic coat between the Superior and External recti, near to, but somewhat behind, the tendon of insertion of the Superior oblique.

**Relations.**—By its *ocular surface*, with the globe of the eye and with the Inferior rectus; by its *orbital surface*, with the periosteum covering the floor of the orbit, and with the External rectus. Its borders look forward and backward; the posterior one receives a branch of the third nerve.

**Nerves.**—The Levator palpebræ, Inferior oblique, and all the Recti excepting the External, are supplied by the third nerve; the Superior oblique, by the fourth; the External rectus, by the sixth.

**Actions.**—The Levator palpebræ raises the upper eyelid, and is the direct antagonist of the Orbicularis palpebrarum. The four Recti muscles are attached in such a manner to the globe of the eye that, acting singly, they will turn it either upward, downward, inward, or outward, as expressed by their names. The movement produced by the Superior or Inferior rectus is not quite a simple one, for, inasmuch as they pass obliquely outward and forward to the eyeball, the elevation or depression of the cornea must be accompanied by a certain deviation inward, with a slight amount of rotation, which, however, is corrected by the Oblique muscles, the Inferior oblique correcting the deviation inward of the Superior rectus, and the Superior oblique that of the Inferior rectus. The contraction of the External and Internal recti, on the other hand, produces a purely horizontal movement. If any two contiguous recti of one eye act together, they carry the globe of the eye in the diagonal of these directions—viz. upward and inward, upward and outward, downward and inward, or downward and outward. The movement of circumduction, as in looking round a room, is performed by the alternate action of the four Recti. The Oblique muscles rotate the eyeball on its *antero-posterior axis*, this kind of movement being required for the correct viewing of an object when the head is moved laterally, as from shoulder to shoulder, in order that the picture may fall in all respects on the same part of the retina of each eye.[1]

**Fasciæ of the Orbit.**—The connective tissue of the orbit is in various places condensed into thin membranous layers, which may be conveniently described as (1) the orbital fascia; (2) the sheath of the muscles; and (3) the covering of the eyeball.

(1) The *orbital fascia*. This forms the periosteum of the orbit. It is loosely connected to the bones, from which it can be readily separated. Behind, it is connected with the dura mater by processes which pass through the optic foramen and sphenoidal fissure, and with the sheath of the optic nerve. In front it is connected with the periosteum at the margin of the orbit, and sends off a process which assists in forming the palpebral fascia. From its internal surface two processes are given off—one to enclose the lachrymal gland, the other to hold the pulley of the Superior oblique muscle in position.

(2) The sheaths of the muscles give off expansions to the margins of the orbit which limit the action of the muscles.

[1] "On the Oblique Muscles of the Eye in Man and Vertebrate Animals," by John Struthers, M. D., in *Anatomical and Physiological Observations*. For a fuller account of the various co-ordinate actions of the muscles of a single eye and of both eyes than our space allows, the reader may be referred to Dr. M. Foster's *Text-book of Physiology*.

(3) The fascia covering the eyeball—Tenon's capsule—will be described in the sequel.

**Surgical Anatomy.**—The position and exact point of insertion of the tendons of the Internal and External recti muscles into the globe should be carefully examined from the front of the eyeball, as the surgeon is often required to divide the one or the other muscle for the cure of strabismus. In convergent strabismus, which is the more common form of the disease, the eye is turned inward, requiring the division of the Internal rectus. In the divergent form, which is more rare, the eye is turned outward, the External rectus being especially implicated. The deformity produced in either case is to be remedied by division of one or the other muscle. The operation is thus performed: The lids are to be well separated; the eyeball being rotated outward or inward, the conjunctiva should be raised by a pair of forceps and divided immediately beneath the lower border of the tendon of the muscle to be divided, a little behind its insertion into the sclerotic; the submucous areolar tissue is then divided, and into the small aperture thus made a blunt hook is passed upward between the muscle and the globe, and the tendon of the muscle and conjunctiva covering it divided by a pair of blunt-pointed scissors. Or the tendon may be divided by a subconjunctival incision, one blade of the scissors being passed upward between the tendon and the conjunctiva, and the other between the tendon and the sclerotic. The student, when dissecting these muscles, should remove on one side of the subject the conjunctiva from the front of the eye, in order to see more accurately the position of the tendons, while on the opposite side the operation may be performed.

### 5. Nasal Region (Fig. 195).

| | |
|---|---|
| Pyramidalis nasi. | Dilatator naris anterior. |
| Levator labii superioris alæque nasi. | Compressor nasi. |
| Dilatator naris posterior. | Compressor narium minor. |

Depressor alæ nasi.

The **Pyramidalis nasi** is a small pyramidal slip placed over the nasal bone. Its origin is by tendinous fibres from the fascia covering the lower part of the nasal bone and upper part of the cartilage, where it blends with the Compressor nasi, and it is inserted into the skin over the lower part of the forehead between the two eyebrows, its fibres decussating with those of the Occipito-frontalis.

**Relations.**—By its *upper surface*, with the skin; by its *under surface*, with the frontal and nasal bones.

The **Levator labii superioris alæque nasi** is a thin triangular muscle placed by the side of the nose, and extending between the inner margin of the orbit and upper lip. It arises by a pointed extremity from the upper part of the nasal process of the superior maxillary bone, and, passing obliquely downward and outward, divides into two slips, one of which is inserted into the cartilage of the ala of the nose; the other is prolonged into the upper lip, becoming blended with the Orbicularis oris and Levator labii superioris proprius.

**Relations.**—In front, with the integument, and with a small part of the Orbicularis palpebrarum above.

The **Dilatator naris posterior** is a small muscle which is placed partly beneath the elevator of the nose and lip. It arises from the margin of the nasal notch of the superior maxilla and from the sesamoid cartilages, and is inserted into the skin near the margin of the nostril.

The **Dilatator naris anterior** is a thin delicate fasciculus passing from the cartilage of the ala of the nose to the integument near its margin. This muscle is situated in front of the preceding.

The **Compressor nasi** is a small, thin, triangular muscle arising by its apex from the superior maxillary bone, above and a little external to the incisive fossa; its fibres proceed upward and inward, expanding into a thin aponeurosis which is attached to the fibro-cartilage of the nose and is continuous on the bridge of the nose with that of the muscle of the opposite side and with the aponeurosis of the Pyramidalis nasi.

The **Compressor narium minor** is a small muscle attached by one end to the alar cartilage, and by the other to the integument at the end of the nose.

The **Depressor alæ nasi** is a short radiated muscle arising from the incisive fossa of the superior maxilla; its fibres ascend to be inserted into the septum and back part of the ala of the nose. This muscle lies between the mucous membrane and muscular structure of the lip.

**Nerves.**—All the muscles of this group are supplied by the facial nerve.

**Actions.**—The Pyramidalis nasi draws down the inner angle of the eyebrows and produces transverse wrinkles over the bridge of the nose. The Levator labii superioris alæque nasi draws upward the upper lip and ala of the nose: its most important action is upon the nose, which it dilates to a considerable extent. The action of this muscle produces a marked influence over the countenance, and it is the principal agent in the expression of contempt and disdain. The two Dilatatores nasi enlarge the aperture of the nose. Their action in ordinary breathing is to resist the tendency of the nostrils to close from atmospheric pressure, but in difficult breathing they may be noticed to be in violent action, as well as in some emotions, as anger. The Depressor alæ nasi is a direct antagonist of the other muscles of the nose, drawing the ala of the nose downward, and thereby constricting the aperture of the nares. The Compressor nasi depresses the cartilaginous part of the nose and compresses the alæ together.

### 6. Superior Maxillary Region (Fig. 195).

| | |
|---|---|
| Levator labii superioris. | Zygomaticus major. |
| Levator anguli oris. | Zygomaticus minor. |

The **Levator labii superioris (proprius)** is a thin muscle of a quadrilateral form. It arises from the lower margin of the orbit immediately above the infraorbital foramen, some of its fibres being attached to the superior maxilla, others to the malar bone; its fibres converge to be inserted into the muscular substance of the upper lip.

**Relations.**—By its *superficial surface* above, with the lower segment of the Orbicularis palpebrarum; below, it is subcutaneous. By its *deep surface* it conceals the origin of the Compressor nasi and Levator anguli oris muscles, and the infraorbital vessels and nerve, as they escape from the infraorbital foramen.

The **Levator anguli oris** arises from the canine fossa immediately below the infraorbital foramen; its fibres incline downward and a little outward, to be inserted into the angle of the mouth, intermingling with those of the Zygomaticus major, the Depressor anguli oris, and the Orbicularis.

**Relations.**—By its *superficial surface*, with the Levator labii superioris and the infraorbital vessels and nerves; by its *deep surface*, with the superior maxilla, the Buccinator, and the mucous membrane.

The **Zygomaticus major** is a slender fasciculus which arises from the malar bone, in front of the zygomatic suture, and, descending obliquely downward and inward, is inserted into the angle of the mouth, where it blends with the fibres of the Levator anguli oris, the Orbicularis oris, and the Depressor anguli oris.

**Relations.**—By its *superficial surface*, with the subcutaneous adipose tissue; by its *deep surface*, with the Masseter and Buccinator muscles and the facial artery and vein.

The **Zygomaticus minor** arises from the malar bone immediately behind the maxillary suture, and, passing downward and inward, is continuous with the Orbicularis oris at the outer margin of the Levator labii superioris. It lies in front of the preceding.

**Relations.**—By its *superficial surface*, with the integument and the Orbicularis palpebrarum above; by its *deep surface*, with the Masseter, Buccinator, and Levator anguli oris, and the facial artery and vein.

**Nerves.**—This group of muscles is supplied by the facial nerve.

**Actions.**—The Levator labii superioris is the proper elevator of the upper lip, carrying it at the same time a little forward. It assists in forming the naso-labial ridge, which passes from the side of the nose to the upper lip and gives to the face an expression of sadness. The Levator anguli oris raises the angle of the mouth, and assists the Levator labii superioris in producing the naso-labial ridge. The Zygomaticus major draws the angle of the mouth backward and upward, as in laughing; whilst the Zygomaticus minor, being inserted into the outer part of the upper lip and not into the angle of the mouth, draws it backward, upward, and outward, and thus gives to the face an expression of sadness.

### 7. Inferior Maxillary Region (Fig. 195).

Levator labii inferioris (Levator menti).
Depressor labii inferioris (Quadratus menti).
Depressor anguli oris (Triangularis menti).

**Dissection.**—The muscles in this region may be dissected by making a vertical incision through the integument from the margin of the lower lip to the chin: a second incision should then be carried along the margin of the lower jaw as far as the angle, and the integument carefully removed in the direction shown in Fig. 194.

The **Levator labii inferioris (Levator menti)** is to be dissected by everting the lower lip and raising the mucous membrane. It is a small conical fasciculus placed on the side of the frænum of the lower lip. It arises from the incisive fossa, external to the symphysis of the lower jaw; its fibres descend to be inserted into the integument of the chin.

**Relation.**—On its *inner surface*, with the mucous membrane; in the *median line*, it is blended with the muscle of the opposite side; and on its *outer side*, with the Depressor labii inferioris.

The **Depressor labii inferioris (Quadratus menti)** is a small quadrilateral muscle. It arises from the external oblique line of the lower jaw, between the symphysis and mental foramen, and passes obliquely upward and inward, to be inserted into the integument of the lower lip, its fibres blending with the Orbicularis oris and with those of its fellow of the opposite side. It is continuous with the fibres of the Platysma at its origin. This muscle contains much yellow fat intermingled with its fibres.

**Relations.**—By its *superficial surface*, with part of the Depressor anguli oris and with the integument, to which it is closely connected; by its *deep surface*, with the mental vessels and nerves, the mucous membrane of the lower lip, the labial glands, and the Levator menti, with which it is intimately united.

The **Depressor anguli oris (Triangularis menti)** is triangular in shape, arising, by its broad base, from the external oblique line of the lower jaw, from whence its fibres pass upward, to be inserted, by a narrow fasciculus, into the angle of the mouth. It is continuous with the Platysma at its origin and with the Orbicularis oris and Risorius at its insertion, and some of its fibres are directly continuous with those of the Levator anguli oris.

**Relations.**—By its *superficial surface*, with the integument; by its *deep surface*, with the Depressor labii inferioris and Buccinator.

**Nerves.**—This group of muscles is supplied by the facial nerve.

**Actions.**—The Levator labii inferioris raises the lower lip and protrudes it forward, and at the same time wrinkles the integument of the chin, expressing doubt or disdain. The Depressor labii inferioris draws the lower lip directly downward and a little outward, as in the expression of irony. The Depressor anguli oris depresses the angle of the mouth, being the antagonist to the Levator anguli oris and Zygomaticus major; acting with these muscles, it will draw the angle of the mouth directly backward.

### 8. Intermaxillary Region.

Orbicularis oris. Buccinator. Risorius.

**Dissection.**—The dissection of these muscles may be considerably facilitated by filling the cavity of the mouth with tow, so as to distend the cheeks and lips; the mouth should then be closed by a few stitches and the integument carefully removed from the surface.

The **Orbicularis oris** (Fig. 195) is not a sphincter muscle, like the Orbicularis palpebrarum, but consists of numerous strata of muscular fibres, having different directions, which surround the orifice of the mouth. These fibres are partially derived from the other facial muscles which are inserted into the lips, and are partly fibres proper to the lips themselves. Of the former, a considerable number are derived from the Buccinator and form the deeper stratum of the Orbicularis. Some of them—namely, those near the middle of the muscle—decussate at the angle of the mouth, those arising from the upper jaw passing to the lower lip, and those from the lower jaw to the upper lip. Other fibres of the muscle, situated at its upper and lower part, pass across the lips from side to side without decussation. Superficial to this stratum is a second, formed by the Levator and Depressor anguli oris, which cross each other at the angle of the mouth, those from the Depressor passing to the upper lip, and those from the Levator to the lower lip, along which they run to be inserted into the skin near the median line. In addition to these there are fibres from the other muscles inserted into the lips—the Levator labii superioris, the Levator labii superioris alæque nasi, the Zygomatici, and the Depressor labii inferioris; these intermingle with the transverse fibres above described, and have principally an oblique direction. The proper fibres of the lips are oblique, and pass from the under surface of the skin to the mucous membrane through the thickness of the lip. And in addition to these are fibres by which the muscle is connected directly with the maxillary bones and the septum of the nose. These consist, in the upper lip, of four bands, two of which (*Musculus incisivus superior*) arise from the alveolar border of the superior maxilla, opposite the lateral incisor tooth, and, arching outward on each side, are continuous at the angles of the mouth with the other muscles inserted into this part. The two remaining muscular slips, called the *Naso-labialis*, connect the upper lip to the back of the septum of the nose: as they descend from the septum an interval is left between them. It is this interval which forms the depression seen on the surface of the skin beneath the septum of the nose. The additional fibres for the lower segment (*Musculus incisivus inferior*) arise from the inferior maxilla, externally to the Levator labii inferioris, and arch outward to the angles of the mouth, to join the Buccinator and the other muscles attached to this part.

**Relations.**—By its *superficial surface*, with the integument, to which it is closely connected; by its *deep surface*, with the buccal mucous membrane, the labial glands, and coronary vessels; by its *outer circumference* it is blended with the numerous muscles which converge to the mouth from various parts of the face. Its *inner circumference* is free, and covered by the mucous membrane.

The **Buccinator** (Fig. 208) is a broad, thin muscle, quadrilateral in form, which occupies the interval between the jaws at the side of the face. It arises from the outer surface of the alveolar processes of the upper and lower jaws, corresponding to the three molar teeth, and, behind, from the anterior border of the pterygo-maxillary ligament. The fibres converge toward the angle of the mouth, where the central fibres intersect each other, those from below being continuous with the upper segment of the Orbicularis oris, and those from above with the inferior segment; the highest and lowest fibres continue forward uninterruptedly into the corresponding segment of the lip, without decussation.

**Relations.**—By its *superficial surface*, behind, with a large mass of fat, which separates it from the ramus of the lower jaw, the Masseter, and a small portion of the Temporal muscle; anteriorly, with the Zygomatici, Risorius, Levator anguli oris, Depressor anguli oris, and Stenson's duct, which pierces it opposite the second molar tooth of the upper jaw; the facial artery and vein cross it from below upward; it is also crossed by the branches of the facial and buccal nerves; by its *internal surface*, with the buccal glands and mucous membrane of the mouth.

The *pterygo-maxillary ligament* separates the Buccinator muscle from the Superior constrictor of the pharynx. It is a tendinous band, attached by one extremity to the apex of the internal pterygoid plate, and by the other to the posterior extremity of the internal oblique line of the lower jaw. Its *inner surface* corresponds to the cavity of the mouth, and is lined by mucous membrane. Its *outer surface* is separated from the ramus of the jaw by a quantity of adipose tissue. Its *posterior border* gives attachment to the Superior constrictor of the pharynx; its *anterior border*, to the fibres of the Buccinator (see Fig. 208).

The **Risorius (Santorini)** (Fig. 195) consists of a narrow bundle of fibres which arises in the fascia over the Masseter muscle, and, passing horizontally forward, is inserted into the skin at the angle of the mouth. It is placed superficial to the Platysma, and is broadest at its outer extremity. This muscle varies much in its size and form.

**Nerves.**—The muscles in this group are all supplied by the facial nerve. The buccal branch of the inferior maxillary nerve pierces the Buccinator muscle, and by some anatomists is regarded as partly supplying this muscle. Probably it merely pierces it on its way to the mucous membrane of the cheek.

**Actions.**—The Orbicularis oris in its ordinary action produces the direct closure of the lips; by its deep fibres, assisted by the oblique ones, it closely applies the lips to the alveolar arch. The superficial part, consisting principally of the decussating fibres, brings the lips together and also protrudes them forward. The Buccinators contract and compress the cheeks, so that, during the process of mastication, the food is kept under the immediate pressure of the teeth. When the cheeks have been previously distended with air, the Buccinator muscles expel it from between the lips, as in blowing a trumpet. Hence the name (*buccina*, a trumpet). The Risorius retracts the angles of the mouth, and produces the unpleasant expression which is sometimes seen in tetanus, and is known as "risus sardonicus."

## 9. Temporo-mandibular Region.

Masseter. Temporal.

*Masseteric Fascia.*—Covering the Masseter muscle, and firmly connected with it, is a strong layer of fascia derived from the deep cervical fascia. Above, this fascia is attached to the lower border of the zygoma, and, behind, it covers the parotid gland, constituting the *parotid fascia*.

The **Masseter** is exposed by the removal of this fascia (Fig. 195); it is a short, thick muscle, somewhat quadrilateral in form, consisting of two portions, superficial and deep. The *superficial portion*, the larger, arises by a thick, tendinous aponeurosis from the malar process of the superior maxilla, and from the anterior two-thirds of the lower border of the zygomatic arch: its fibres pass downward and backward, to be inserted into the angle and lower half of the outer surface of the ramus of the jaw. The *deep portion* is much smaller and more muscular in texture; it arises from the posterior third of the lower border and the whole of the inner surface of the zygomatic arch; its fibres pass downward and forward, to be inserted into the upper half of the ramus and outer surface of the coronoid process of the jaw. The deep portion of the muscle is partly concealed, in front by the superficial portion; behind, it is covered by the parotid gland. The fibres of the two portions are united at their insertion.

**Relations.**—By its *superficial surface*, with the Zygomatici, the parotid gland and Socia parotidis, and Stenson's duct; the branches of the facial nerve and the transverse facial vessels, which cross it; the masseteric fascia; the Risorius, Santorini, Platysma myoides, and the integument; by its *deep surface*, with the Temporal muscle at its insertion, the ramus of the jaw, the Buccinator and the long buccal nerve, from which it is separated by a mass of fat. The masseteric nerve and artery enter in on its under surface. Its *posterior margin* is overlapped by the parotid gland. Its *anterior margin* projects over the Buccinator muscle, and the facial vein lies on it below.

The *temporal fascia* is seen, at this stage of the dissection, covering in the Temporal muscle. It is a strong, fibrous investment, covered, on its outer surface, by the Attrahens and Attollens auriculam muscles, the aponeurosis of the Occipito-frontalis, and by part of the Orbicularis palpebrarum. The temporal vessels and the auriculo-temporal nerve cross it from below upward. Above, it is a single layer, attached to the entire extent of the upper temporal ridge; but below, where it is attached to the zygoma, it consists of two layers, one of which is inserted into the outer, and the other into the inner, border of the zygomatic arch. A small quantity of fat, the orbital branch of the temporal artery, and a filament from the orbital, or temporo-malar, branch of the superior maxillary nerve, are contained between these two layers. It affords attachment by its inner surface to the superficial fibres of the Temporal muscle.

**Dissection.**—In order to expose the Temporal muscle, remove the temporal fascia, which may be effected by separating it at its attachment along the upper border of the zygoma, and dissecting it upward from the surface of the muscle. The zygomatic arch should then be divided in front at its junction with the malar bone, and behind near the external auditory meatus, and drawn downward with the Masseter, which should be detached from its insertion into the ramus and angle of the jaw. The whole extent of the Temporal muscle is then exposed.

The **Temporal** (Fig. 199) is a broad, radiating muscle situated at the side of the head and occupying the entire extent of the temporal fossa. It arises from the whole of the temporal fossa except that portion of it that is formed by the malar bone. Its attachment extends from the external angular process of the frontal in front to the mastoid portion of the temporal behind, and from the curved line on the frontal and parietal bones above to the pterygoid ridge on the great wing of the sphenoid below. It is also attached to the inner surface of the temporal fascia. Its fibres converge as they descend, and terminate in an aponeurosis, the fibres of


FIG. 199.—The Temporal muscle, the zygoma and Masseter having been removed.

which, radiated at its commencement, converge into a thick and flat tendon, which is inserted into the inner surface, apex, and anterior border of the coronoid process of the jaw, nearly as far forward as the last molar tooth.

**Relations.**—By its *superficial surface*, with the integument, the Attrahens and Attollens aurieulam muscles, the temporal vessels and nerves, the aponeurosis of the Occipito-frontalis, the temporal fascia, the zygoma, and Masseter; by its *deep surface*, with the temporal fossa, the External pterygoid and part of the Buccinator muscles, the internal maxillary artery, its deep temporal branches, and the deep temporal nerves. Behind the tendon are the masseteric vessels and nerve, and in front of it the buccal vessels and nerve. Its anterior border is separated from the malar bone by a mass of fat.

**Nerves.**—Both muscles are supplied by the inferior maxillary nerve.

### 10. Pterygo-mandibular Region (Fig. 200).

External Pterygoid. Internal Pterygoid.

**Dissection.**—The Temporal muscle having been examined, saw through the base of the coronoid process, and draw it upward, together with the Temporal muscle, which should be detached from the surface of the temporal fossa. Divide the ramus of the jaw just below the condyle, and also, by a transverse incision extending across the middle, just above the dental foramen; remove the fragment, and the Pterygoid muscles will be exposed.

The **External Pterygoid** is a short, thick muscle, somewhat conical in form, which extends almost horizontally between the zygomatic fossa and the condyle of the jaw. It arises by two heads, separated by a slight interval: the *upper* arises from the inferior surface of the greater wing of the sphenoid and from the pterygoid ridge, which separates the zygomatic from the temporal fossa; the *lower* from the outer surface of the external pterygoid plate. Its fibres pass horizontally backward and outward, to be inserted into a depression in front of the neck of the condyle of the lower jaw and into the corresponding part of the interarticular fibro-cartilage.

**Relations.**—By its *external surface*, with the ramus of the lower jaw, the internal maxillary artery, which crosses it,[1] the tendon of the Temporal muscle, and the Masseter; by its *internal surface* it rests against the upper part of the Internal pterygoid, the internal lateral ligament, the middle meningeal artery,

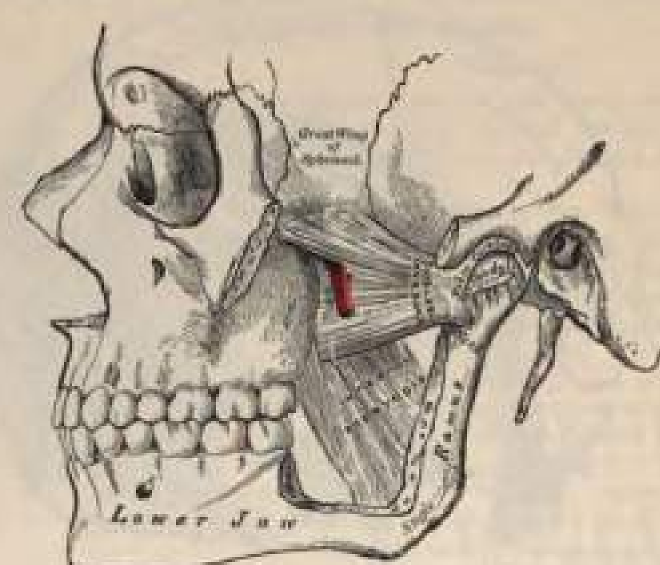


Fig. 200.—The Pterygoid muscles, the zygomatic arch and a portion of the ramus of the jaw having been removed.

and inferior maxillary nerve; by its *upper border* it is in relation with the temporal and masseteric branches of the inferior maxillary nerve; by its *lower border* it is in relation with the inferior dental and gustatory nerves. Through the interval between the two portions of the muscle, the buccal nerve emerges and the internal maxillary artery passes, when the trunk of this vessel lies on the muscle (see Fig. 200).

The **Internal Pterygoid** is a thick, quadrilateral muscle, and resembles the Masseter in form. It arises from the pterygoid fossa, being attached to the inner

[1] This is the usual relation, but in many cases the artery will be found below the muscle.

surface of the external pterygoid plate and to the grooved surface of the tuberosity of the palate bone, and by a second slip from the outer surface of the tuberosities of the palate and superior maxillary bones; its fibres pass downward, outward, and backward, to be inserted, by a strong, tendinous lamina, into the lower and back part of the inner side of the ramus and angle of the lower jaw, as high as the dental foramen.

**Relations.**—By its *external surface*, with the ramus of the lower jaw, from which it is separated, at its upper part, by the External pterygoid, the internal lateral ligament, the internal maxillary artery, the dental vessels and nerves, and the lingual nerve, and a process of the parotid gland. By its *internal surface*, with the Tensor palati, being separated from the Superior constrictor of the pharynx by a cellular interval.

**Nerves.**—These muscles are supplied by the inferior maxillary nerve.

**Actions.**—The Temporal and Masseter and Internal pterygoid raise the lower jaw against the upper with great force. The superficial portion of the Masseter assists the External pterygoid in drawing the lower jaw forward upon the upper, the jaw being drawn back again by the deep fibres of the Masseter and posterior fibres of the Temporal. The External pterygoid muscles are the direct agents in the trituration of the food, drawing the lower jaw directly forward, so as to make the lower teeth project beyond the upper. If the muscle of one side acts, the corresponding side of the jaw is drawn forward, and, the other condyle remaining fixed, the symphysis deviates to the opposite side. The alternation of these movements on the two sides produces trituration.

**Surface Form.**—The outline of the muscles of the head and face cannot be traced on the surface of the body, except in the case of two of the masticatory muscles. Those of the head are thin, so that the outline of the bone is perceptible beneath them. Those in the face are small, covered by soft skin, and often by a considerable layer of fat, so that their outline is concealed, but they serve to round off and smooth prominent borders and to fill up what would be otherwise unsightly angular depressions. Thus, the Orbicularis palpebrarum rounds off the prominent margin of the orbit, and the Pyramidalis nasi fills in the sharp depression beneath the glabella, and thus softens and tones down the abrupt depression which is seen on the unclothed bone. In like manner, the labial muscles, converging to the lips and assisted by the superimposed fat, fill in the sunken hollow of the lower part of the face. Although the muscles of the face are usually described as arising from the bones and inserted into the nose, lips, and corners of the mouth, they have fibres inserted into the skin of the face along their whole extent, so that almost every point of the skin of the face has its muscular fibre to move it; hence it is that when in action the facial muscles produce alterations in the skin-surface, giving rise to the formation of various folds or wrinkles, or otherwise altering the relative position of parts, so as to produce the varied expressions with which the face is endowed; hence these muscles are termed the "muscles of expression." The only two muscles in this region which greatly influence surface form are the Masseter and the Temporal. The Masseter is a quadrilateral muscle, which imparts fulness to the hinder part of the cheek. When the muscle is firmly contracted, as when the teeth are clenched, its outline is plainly visible; the anterior border forms a prominent vertical ridge, behind which is a considerable fulness, especially marked at the lower part of the muscle; this fulness is entirely lost when the mouth is opened and the muscle no longer in a state of contraction. The Temporal muscle is fan-shaped, and fills the Temporal fossa, substituting for it a somewhat convex form, the anterior part of which, on account of the absence of hair over the temple, is more marked than the posterior, and stands out in strong relief when the muscle is in a state of contraction.

## MUSCLES AND FASCIÆ OF THE NECK.

The muscles of the neck may be arranged into groups corresponding with the region in which they are situated.

These groups are nine in number:

1. Superficial cervical region.
2. Depressors of the Os Hyoides and Larynx.
3. Elevators of the Os Hyoides and Larynx.
4. Muscles of the Tongue.
5. Muscles of the Pharynx.
6. Muscles of the Soft Palate.
7. Muscles of the Anterior Vertebral Region.
8. Muscles of the Lateral Vertebral Region.
9. Muscles of the Larynx.