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HAND-ATLAS

OF

HUMAN ANATOMY

BY

WERNER SPALTEHOLZ

PROFESSOR OF ANATOMY IN THE UNIVERSITY AT LEIPZIG

EDITED AND TRANSLATED FROM THE SEVENTH GERMAN EDITION

BY

LEWELLYS F. BARKER

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WITH A PREFACE

BY

FRANKLIN P. MALL

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FOURTH EDITION IN ENGLISH

VOL. I

BONES, JOINTS, LIGAMENTS

PHILADELPHIA AND LONDON

J. B. LIPPINCOTT COMPANY

1923.

TRANSLATIONS OF SPALTEHOLZ' HAND-ATLAS OF HUMAN ANATOMY,
HAVE APPEARED IN ENGLISH, ITALIAN, AND RUSSIAN,
AND A SPANISH EDITION IS IN PREPARATION

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PRINTED IN GERMANY

From the Preface to the First English Edition.

The appearance of Spalteholz's Atlas a few years ago was welcomed alike by teachers and students of anatomy. So useful is this book to students who desire to study anatomy in the dissecting room that without any effort on my part it has become the favorite aid to the students of anatomy at the Johns Hopkins University. Its value to English and American students not acquainted with the German language is now greatly increased through the admirable translation of the text into English by Professor Barker.

The main object of studying anatomy is to obtain a mental image of the human body rather than to memorize numerous terms as is too often the aim in our medical schools, especially in America. When the study of anatomy is transferred from the lecture room, text book and quiz-compend to the dissecting room it becomes one of the best disciplinary studies for medical students and at the same time gives them most useful knowledge by the inductive method of study. In the dissecting room the student obtains the greatest aid from the instructor who teaches him the art of dissection and guides him in methodical study. Next in importance is a good text book which should always be at the student's side in order that he may study the dissection of the body as it proceeds.

The study of anatomy would be relatively easy were the student familiar with the subject before he begins it. The rule that the student should acquire as much knowledge as possible of a region before he begins to dissect it is good but has limitations because it is only through the work itself that the interest of the student, and thereby his instruction, can be kept up. Just at this time an Atlas proves to be of the greatest value. Pictures of dissections, true to nature, aid the imagination of the student enormously and thus guide his work from the known to the unknown. It follows that the illustrations of an anatomical atlas must be typical, giving all stages of the dissection of the body from its beginning to its completion. The Atlas of Spalteholz meets this requirement. In addition to the superior quality of the illustrations it may be stated that they are all carefully marked with the new anatomical nomenclature.

Making the anatomical terms uniform means much more than simply changing some of the names, for it brings us one step nearer to a knowledge of the normal. In casting the new nomenclature the leading anatomists of the world occupied much of their time in determining the normal and for this reason if for no other the BNA should be adopted. In the translation where the terms used are very different from the old nomenclature the latter are inserted in brackets.

The Atlas speaks for itself. If its reception is as favorable generally as it has been at the Johns Hopkins University it will soon become the standard aid to our students of practical anatomy.

Franklin P. Mall.

Author's Preface to the First English Edition.

Soon after the appearance of the first part of this atlas, from various sides the wish was repeatedly expressed, among others by my friend Prof. F. P. Mall, that an English edition be published. The publishers at first hesitated, but when so distinguished a specialist as Professor Barker was found ready to translate the work and edit it, they acquiesced. In order to secure the utmost conformity with the German work, the illustrations have been printed from the original plates, and for the translation, the text of the fourth German edition, under preparation, was submitted. I myself, moreover, have superintended the proof reading.

In accordance with the plan which I had laid as a foundation for the work, the atlas is intended to embrace the whole of descriptive anatomy with the exception of histology; it includes also, as far as possible, the relations which are brought out by magnification with strong hand lenses. It is intended thus to have due regard also for the field which lies between macroscopic anatomy and microscopic anatomy proper. The topographic relations of the organs and especially of the vessels and nerves have been given the utmost consideration attainable within the compass of a book which treats primarily of descriptive anatomy.

In order to increase the clearness of the illustrations, a large portion of them have been done in colors, so that the parts whose portrayal in the sections is of importance, are brought into prominence by the colors.

The number of drawings necessary is provisionally roughly estimated at about 800, but if necessary this number will be increased.

It is intended, if possible, that the second volume, containing muscles and blood vessels, shall appear in the course of the winter, the third volume containing the viscera, brain, nerves, and sense organs, immediately after its completion in the German edition.

At the end of the atlas a complete index will be printed.

For all the illustrations, with unimportant exceptions, new original drawings were made. To the choice of the objects and the production of the drawings the most thoughtful attention was devoted. With regard to the admission and manner of representation of an object, pedagogic principles have been, first and foremost, determining; where an object appeared difficult a greater number of drawings were made, and vice versa. The illustrations, in all cases, have been faithfully drawn from original preparations, but at the same time no copy of a definite individual case, but always a composite from several sections, has been made.

The preparations were made for the most part especially for this purpose and accepted only after many repetitions if the relations did not appear to me clear enough. In those cases in which I have given new delineations which depart somewhat from the customary, I introduced them with full consciousness, on the strength of new preparations.

All illustrations have been made from dissections of the right half of the body.

As the basis for the technical terms, I have, throughout, made use of the new anatomical nomenclature, BNA, as unanimously adopted by the anatomical association at its IX. meeting in Basel on April 19, 1895 and published with introduction and explanations by W. His. I have held myself strictly to the terms there given and only in a few isolated cases added terms according to my own judgment. Also for the mass of quoted terms, the compilation just referred to has served me as a standard; only a few terms will be found missing.

As to the process of reproduction, with a few exceptions the Half-tone has been chosen, because this mechanical method reproduces the original drawing far more accurately than does the woodcut.

The drawings of the attachments of muscles were completed from preparations which were made by the late Prof. W. Braune himself.

As far as the text is concerned, I undertook only unwillingly the writing thereof, since it may permit the student to think, that this text will suffice for the study of anatomy in general. I have decided to write ultimately a supplement to the same if it be much desired, and shall then devote to it the greatest care. My effort has been, to give a clear description of the figures, and at the same time to explain all the descriptive terms made use of in the figure. In so doing the manuscript unintentionally turned out to be much more detailed than was really necessary in the text accompanying an atlas, in which, indeed, the illustrations are the essentials; thus it resembles many text books in completeness. And yet again it is more incomplete than a full text book should be in as much as I found it necessary to omit entirely all general matter, and occasionally, if room for the text was wanting, it was necessary that the illustration alone should speak for itself. Consequently the text remains, for the most part, a guide; it ought not to, and can in no way, render a text book of anatomy unnecessary.

In the part on articulations, I have provided a description of the pure anatomic relations only, and except in the case of the mandibular articulation,

have intentionally, nowhere entered into the function of the same; for while the old classification of joints according to the form of the articulating surfaces has now only partial value, nevertheless a new classification according to the amount of motion possible during life is not yet applicable to all joints.

For showing the soft parts, especially the muscles and viscera, material carefully hardened in formalin has been largely used.

The data regarding the action of the individual muscles take into account only the influence which the muscles exert on the joints over which they pass.

Werner Spalteholz.

Preface to the Third American Edition.

The Hand-Atlas of Professor Spalteholz has been most favorably received, not only in Germany, but also in the United States, and in other countries. In Germany, it has now reached the seventh edition, and from this seventh edition this third English edition has been translated. Each succeeding edition in the original has contained improvements in the Atlas over those preceding it. A number of new illustrations have been added, and many of the old illustrations have been improved.

In the latest edition, a section dealing with the development of the bones has been added, the figures having been drawn from preparations stained and made transparent by the method of Professor Spalteholz. The success achieved in the representation of the delicate structures of the fetal skulls is remarkable.

In this new English edition, all the changes in the text and figures of the several German editions, up to and including the latest one, have been incorporated. In making the revision, I have had the help of Dr. D. I. Macht of the Johns Hopkins University Medical School.

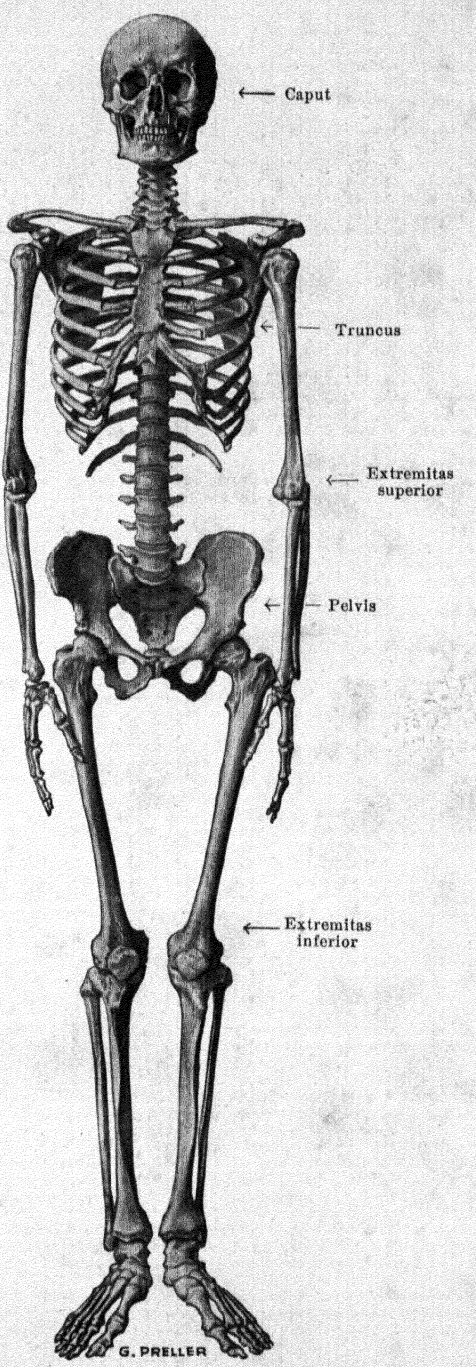
I feel sure that the Hand-Atlas, in its new form, will appeal to its old friends, and will also, I trusts, gain many new ones.

Baltimore, Md., October 1st, 1914.

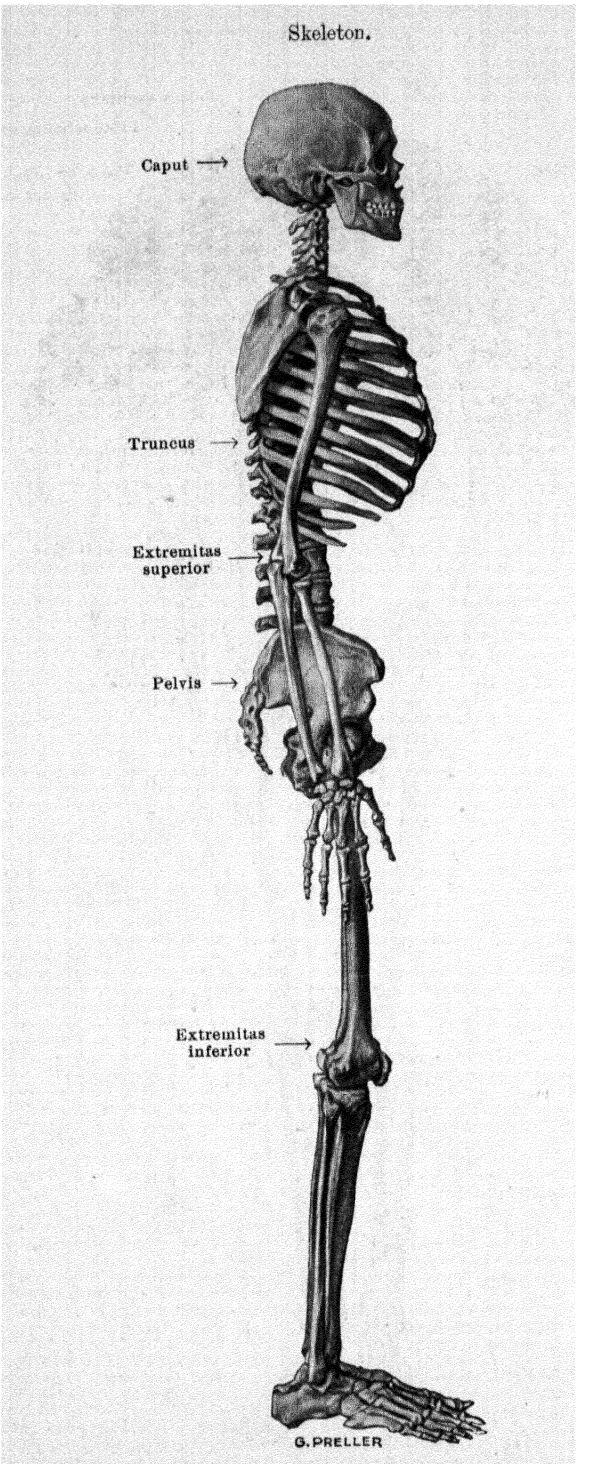
Lewellys F. Barker.

I.

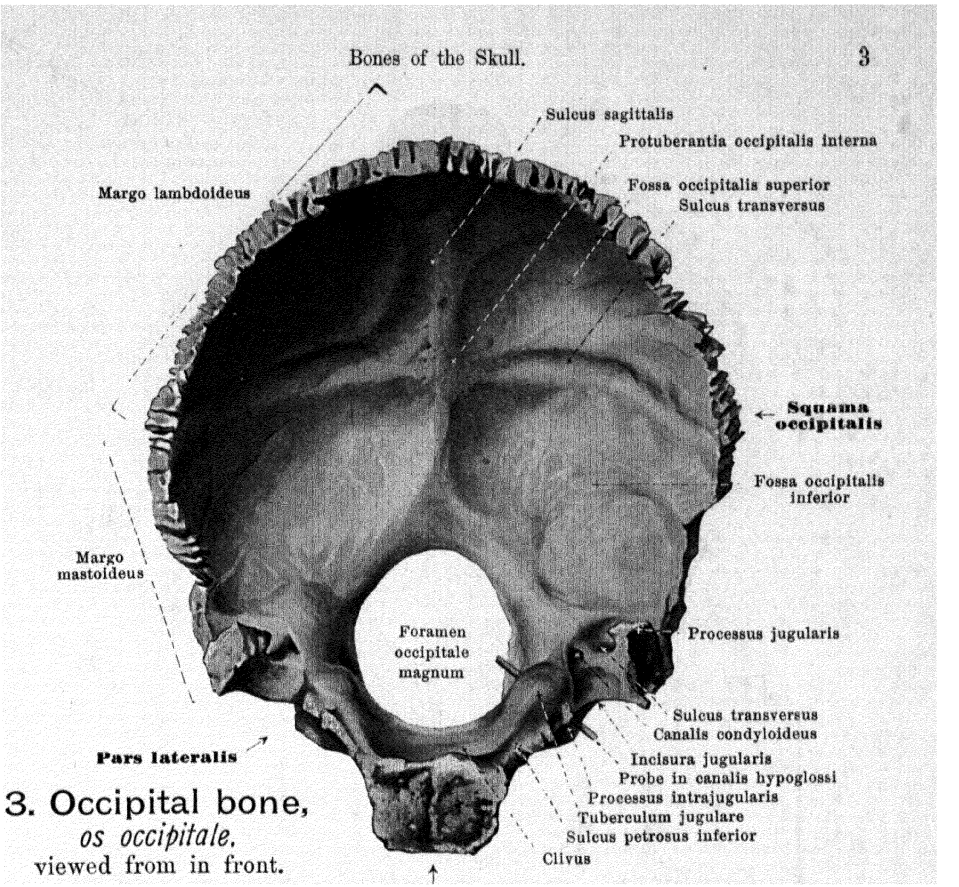
BONES, JOINTS, LIGAMENTS.



1. Skeleton, *sceleton*, anterior view.



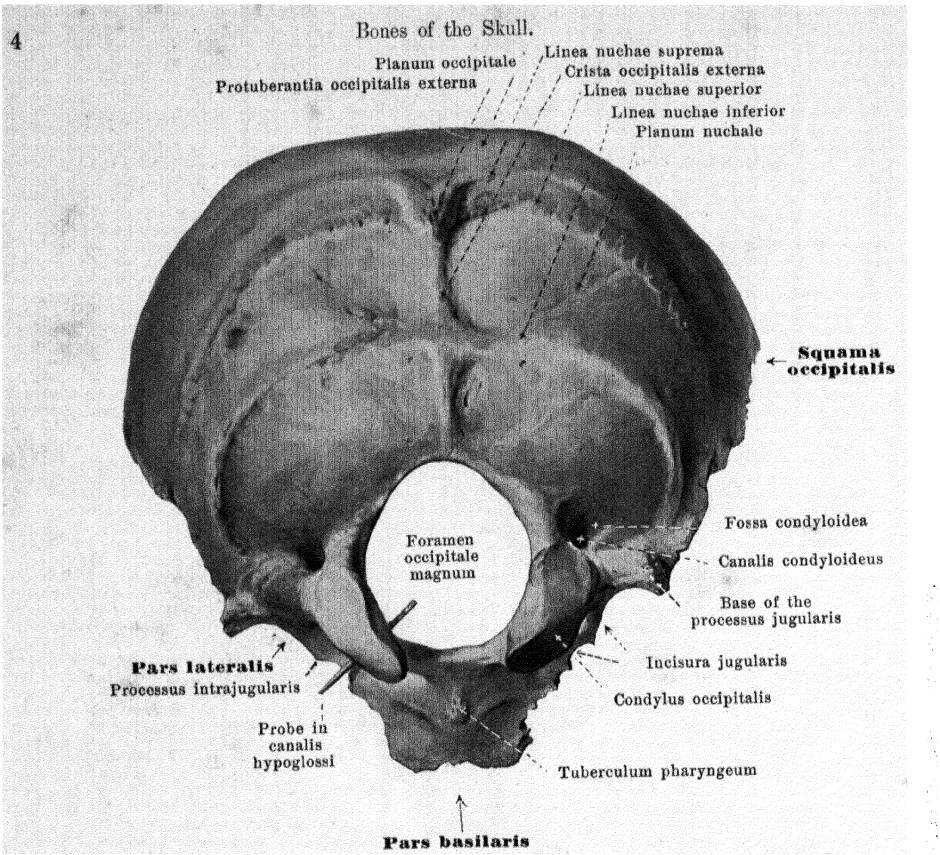
2. Skeleton, *sceleton,* viewed from the right.



3. Occipital bone, *os occipitale,* viewed from in front.

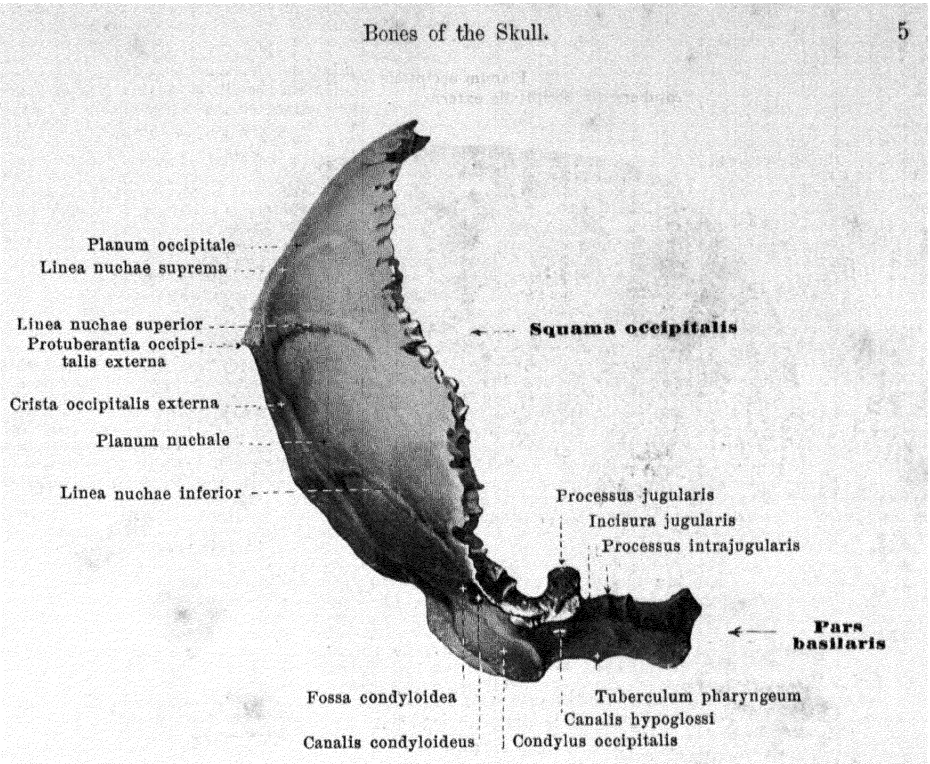
The unpaired **os occipitale** *(occipital bone)* (see also Figs. 4, 5, 57, 58 and 61–68) forms the posterior inferior part of the skull. It is divisible into four parts; (see also p. 67); an unpaired basilar part *(pars basilaris);* an unpaired squama-occipital part *(squama occipitalis)* and the paired lateral parts *(partes laterales).* These parts are so arranged around the large occipital foramen *(foramen occipitale magnum)* that the pars basilaris lies in front of the foramen, the squama occipitalis behind and above it, while the partes laterales lie lateral from it. Through the great occipital foramen pass the meningeal rami of the vertebral arteries, the vertebral arteries themselves, the anterior and posterior spinal arteries, the basilar plexus, the nn. accessorii, the roots of the nn. cervicales 1, and the medulla oblongata. The border-line between *pars basilaris* and *pars lateralis* corresponds to the *canalis hypoglossi;* the border-line between *pars lateralis* and *squama occipitalis* extends from the posterior border of the *foramen occipitale magnum* transversely towards the middle of *margo mastoideus.*

The **pars basilaris** (see also Figs. 4, 5, 61, 62 and 65—68) presents, up to about the twentieth year of life, a rough surface in front corresponding to its attachment to the body of the sphenoid bone; the union is effected by a layer of hyaline cartilage which ossifies later *(fissura* and *synchondrosis sphenooccipitalis).* The two lateral, slightly jagged edges lie upon the posterior angle of the petrous portion of the temporal bone *(fissura* and *synchondrosis petrooccipitalis);* on the upper surface along this edge is situated the groove, formed by the two bones in common, corresponding to the *sulcus petrosus inferior* (for the sinus petros. inf.). The posterior border, sharp in the middle, is smooth and concave, and forms the anterior circumference of the for. occip. mag. The superior surface is smooth and slightly concave in a frontal direction; it helps to form the *clivus* inasmuch as it is directly continuous with the posterior surface of the dorsum sellae of the sphenoid. The clivus gives support to the pons, the vertebral arteries, the basilar artery and their branches. The inferior surface presents in the median line a small projection, the pharyngeal tubercle *(tuberculum pharyngeum)* (for the attachment of the lig. longitud. ant. and the m. constrictor pharyngis sup.), and also alternating ledges for the m. rectus capitis ant. and the m. longus capitis. Laterally and behind on each side comes the condylus occipitalis (see p. 4).



4. Occipital bone, *os occipitale,* viewed from behind.

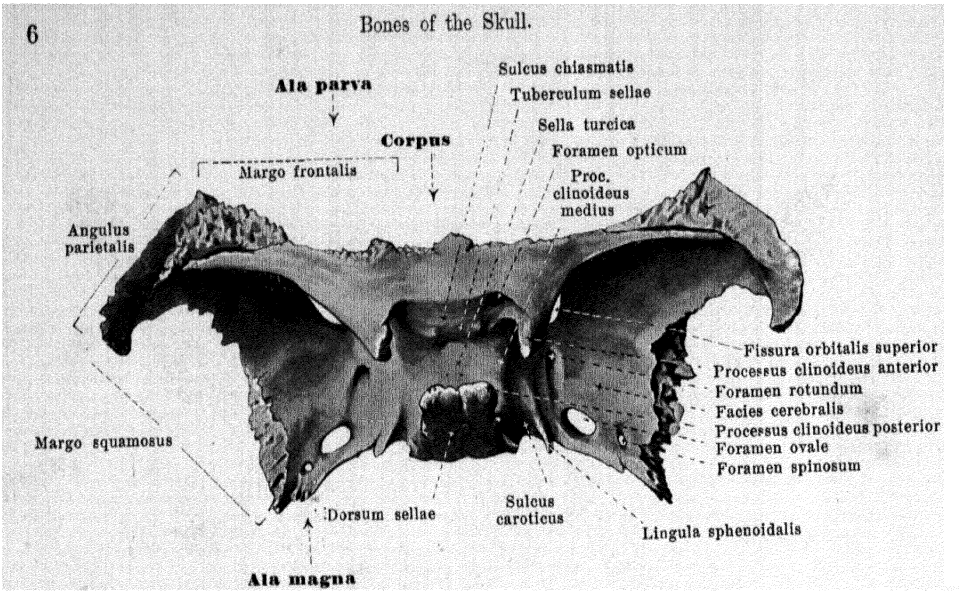
The **partes laterales** (see also Figs. 3, 5, 61, 62 and 65—68) by their medial edges form the lateral borders of the great occipital foramen; the anterior portion of the lateral margin is attached to the posterior angle of the petrous portion of the temporal bone and helps to form the *fissura petrooccipitalis;* it presents a smooth concavity, the *incisura jugularis* which is divided by the small *processus intrajugularis* into a larger lateral, posterior, and a smaller medial, anterior fossa, which, with the corresponding notches of the petrous portion of the temporal bone, help to form the similarly divided *foramen jugulare.* The lateral compartment of the jugular foramen gives passage to the internal jugular vein; the medial compartment to the sinus petrosus inf., the n. glossopharyngeus, n. vagus, n. accessorius, ganglion superius n. glossopharyngei, ganglion jugulare n. vagi, n. glossopharyngeus and the ganglion jugulare n. vagi. The posterior part of the lateral border, *margo mastoideus,* is rough and unites with the occipital margin of the mastoid portion of the temporal bone *(sutura occipitomastoidea).* At the lateral angle between the two divisions of the lateral border, the *processus jugularis* projects upward, being surrounded medianward and behind by the *sulcus transversus* (for the sinus transversus). Median from this lies the oblong, smooth *tuberculum jugulare* and at the corresponding spot on the inferior surface the oval occipital condyle *(condylus occipitalis).* which is covered with cartilage; its anterior portion overlaps the pars basilaris; the condyle is curved so as to be convex in the sagittal and frontal direction. The long diameters of the right and left condyles converge in front. Between the jugular tubercle and the occipital condyle is seen the short *canalis hypoglossi* (O. T. anterior condyloid foramen); it extends from the great occipital foramen obliquely forward and lateralward and gives passage to the rete canal. hypogl. and the n. hypoglossus. Behind the condyle lies the condyloid fossa *(fossa condyloidea)* with an opening (sometimes absent) known as the *canalis condyloideus* (O. T. posterior condyloid foramen); this canal leads to the sulcus transversus and gives passage to the emissarium condyloideum. On the inferior surface corresponding to the base of the jugular process is the site of insertion of the m. rectus capit. lat. and sometimes a blunt projection, the *processus paramastoideus* (not shown in the figure).



5. Occipital bone, *os occipitale,* viewed from the right side.

(The direction does not correspond to that of the bone when the skull is in its ordinary position.)

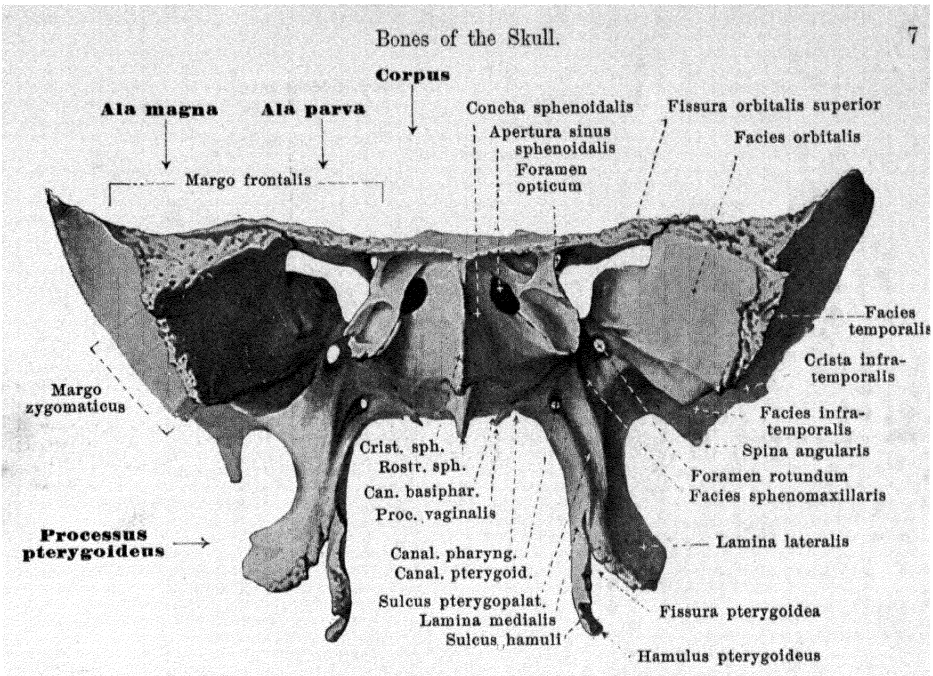
The **squama occipitalis** (see also Figs. 3, 4, 57, 58 and 61—68) is curved so as to be convex backward in the sagittal and transverse direction. Its anterior border forms the posterior periphery of the foramen occipitale magnum; the free lateral and superior borders meet in the median plane, forming on obtuse angle, the lower portion of each lateral border being slightly serrated as the continuation of the *margo mastoideus* (p. 4); the upper portion of this border is deeply and multiply serrated and is known as the *margo lambdoideus*, for union with the occipital margin of the parietal bone *(sutura lambdoidea)*. Projecting from the middle of the posterior surface is seen the external occipital protuberance *(protuberantia occipitalis (externa)*. Extending lateralward from this protuberance on each side are the superior nuchal lines *(lineae nuchae superiores)*, convex upward, and above these the less constant supreme nuchal lines *(lineae nuchae supremae)*. In the median plane, extending toward the foramen magnum, is seen the external occipital crest *(crista occipitalis externa)* which gives attachment to the ligamentum nuchae. From about the middle of the crest extend lateralward the two inferior nuchal lines *(lineae nuchae inferiores)*, also convex upward. The area for the m. occipitalis above the external protuberance and the supreme nuchal lines is called the occipital plain) *(planum occipitale)*, while that below the same is designated the nuchal plain *(planum nuchale)* and gives attachment to the mm. trapezius, sternocleidomastoideus, splenius capitis, semispinalis capitis, obliquus capitis superior, recti capitis posteriores. On the anterior surface of the bone at the middle point of the eminentia cruciata, (as a rule, a little higher than the protuberantia externa), is seen the internal occipital protuberance or *protuberantia occipitalis interna* (for the confluens sinuum; falx cerebri, and tentorium cerebelli). From the internal protuberance arise three well marked grooves: one in the median line passes upward, the *sulcus sagittalis* (O. T. superior longitudinal sulcus) for the sinus sagittalis superior and the falx cerebri: and one lateralward on each side, the *sulcus transversus* (for the sinus transversus; tentorium cerebelli). Of the two transverse sulci the right is usually wider than the left and it alone is continuous with the sulcus sagittalis. A fourth groove or (more often) ridge extends to the foramen magnum and receives the sinus occipitalis. The anterior surface presents variably marked *juga cerebralia* and *cerebellaria* and *impressiones digitatae.*



6. Sphenoid bone, *os sphenoidale,* from above.

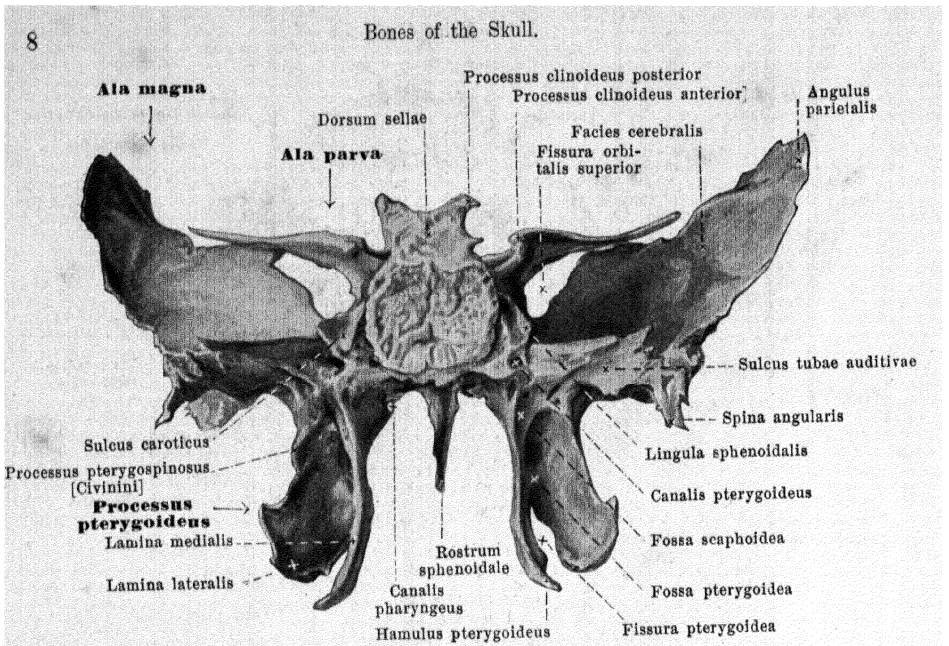
The unpaired **os sphenoidale** (see also Figs. 7, 8, 57, 58, 61, 62, 65—73) lies in the middle of the base of the skull. It is divisible into a middle piece or body *(corpus)* and six processes, known as the two small wings or *alae parvae;* the two large wings or *alae magnae,* and the two pterygoid processes or *processus pterygoidei;* of these the four former are directed lateralward, the two latter, downward. (Development see p. 68.)

The **corpus** *(body)* (see also Figs. 7, 8, 61. 62, 65—68, 70) is approximately cubical, and contains within it two cavities lined by mucous membrane, of very variable size, the *sinus sphenoidales* (O. T. sphenoidal cells) which are separated from one another by the *septum sinuum sphenoidalium* often diverging from the median line. The superior surface presents a deep frontally placed groove, the *sella turcica* (for the sinus circularis; hypophysis) with the *fossa hypophyseos* (O. T. pituitary fossa) in the depth. Posteriorly, the sella is overhung by the *dorsum sellae,* which at the angles of its upper free margin presents on each side a small *processus clinoideus posterior* (for the tentorium cerebelli); the posterior smooth surface of the dorsum sellae, together with the superior surface of the pars basilaris oss. occipitalis, forms the *clivus,* on which lie the *aa. vertebrales,* the *a. basilaris* and its branches, and the pons. In front of the sella lies the small *tuberculum sellae* or pommel; lateralward and dorsally therefrom is situated the middle clinoid process or *processus clinoideus medius* (often absent). In front of the tubercle, extending transversely on each side to the foramen opticum, is the shallow *sulcus chiasmatis* (O. T. optic groove) behind which lies the chiasma opticum. The anterior margin of the superior surface unites with the lamina cribrosa of the ethmoid bone to form the *sutura sphenoethmoidalis.* On the lateral surface extending from behind forward, above the region of origin of the large wing is the *sulcus caroticus* (O. T. cavernous groove) for the a. carotis interna and the plexus caroticus internus. Just lateralward from the posterior extremity of this sulcus projects the *lingula sphenoidalis.* The posterior surface of the body unites with the pars basilaris oss. occipitalis (see p. 3). The anterior, and a part of the inferior, surface are formed by the thin, saucer-shaped, curved *conchae sphenoidales* (O. T. sphenoidal turbinated bones) which, embryologically, properly belong to the ethmoid bone, but which between the 9th—12th year of life grow together with the sphenoid bone. On forcible separation of the bones of the adult skull they usually adhere to the sphenoid bone and are therefore commonly described together with it. Each presents lateralward and above an opening, the *apertura sinus sphenoidalis* and, lateralward from this, small depressions which form the posterior walls of the posterior ethmoidal cells. The borders of these conchae (see Fig. 70) are connected with the *labyrinthus oss. ethmoidal.* (sutura sphenoethmoidalis); below they are in contact with the proc. orb. oss. palat. (sutura sphenoorbitalis. Fig. 70). In the median plane the conchae and the septum in front form the projecting sphenoidal crest or *crista sphenoidalis* (O. T. ethmoidal crest) for contact with the perpendicular plate of the ethmoid bone; this crest runs out below into a projection, the *rostrum sphenoidale* which is directed downward and lies against the vomer.



7. Sphenoid bone, *os sphenoidale,* from in front.

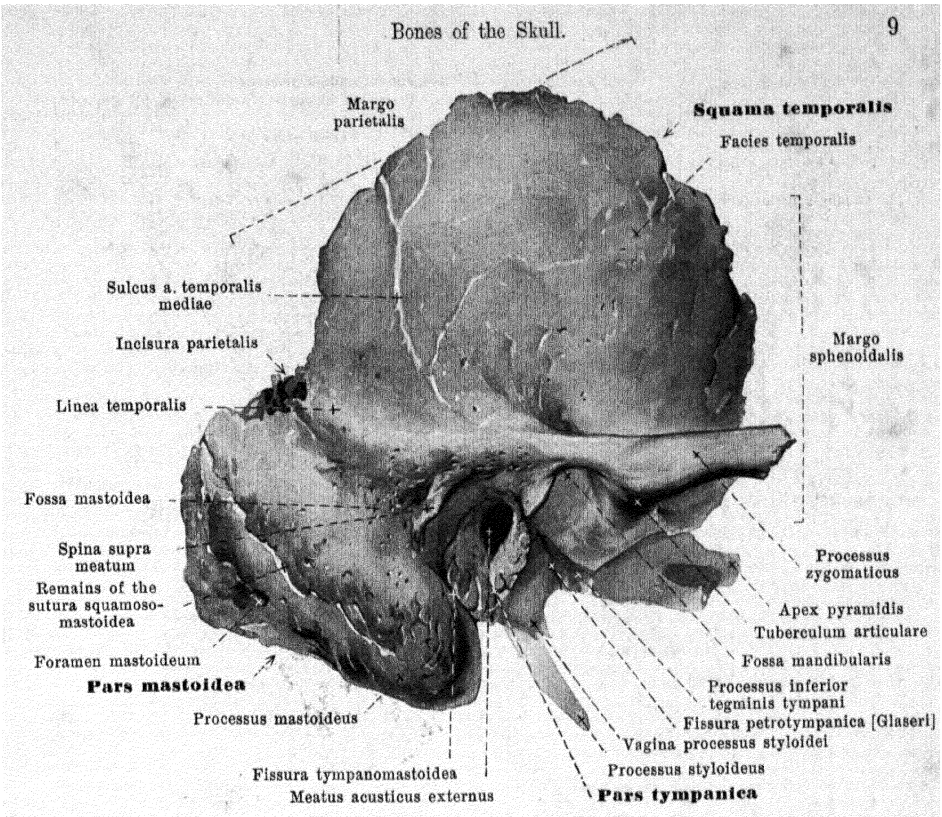
The **alae magnae ossis sphenoidalis** *(large wings of the sphenoid bone)* (see also Figs. 6, 8, 57, 58, 61, 62 and 65—73) arise from the lateral surface of the body of the bone and turn first lateralward, then upward and forward. Each possesses an upper, internal, concave surface or *facies cerebralis* with *juga cerebralia* and *impressiones digitatae*, and a much divided external surface. Of the latter, the quadrangular part which, medianward, is directed forward into the orbit, is called the orbital surface or *facies orbitalis;* its posterior border is smooth and is separated from the ala parva by a fissure wider towards the median line and narrow laterally, the *fissura orbitalis superior* (for the vv. ophthalm. sup. et inf.; nn. oculomot., trochlearis, ophthalm., abducens); the inferior border, also smooth runs nearly parallel with the posterior border of the facies orbitalis maxillae and is separated from it by a fissure spreading laterally, the fissura orbitalis inferior (for the a. infraorbital.; v. ophthalm. inf.; nn. zygomat., infraorbit., rami orbitales ganglii sphenopalatini); the lateral serrated border, *margo zygomaticus,* unites with the frontosphenoidal process of the zygomatic bone to form the *sutura sphenozygomatica* the superior serrated border and its adjoining rough surface, a part of the margo frontalis unites with the orbital portion of the frontal bone and thus helps to form the sutura sphenofrontalis. Below the orbital surface and encroaching upon the pterygoid process lies the triangular *facies sphenomaxillaris* (sphenomaxillary surface) which helps to form the fossa pterygopalatina. The rest of the external surface is divided by the *crista infratemporalis* (O. T. pterygoid ridge), passing from before backward, into an inferior, horizontal field or *facies infratemporalis* (for the m. pterygoid. ext.) which looks into the fossa infratemporalis, and a superior vertical field or *facies temporalis* (for the m. temporalis) which helps to form the fossa tempralis. The posterior border of the latter, *margo squamosus,* is serrated below, somewhat bevelled from without inward above, and serves for apposition with the squama temporalis *(sutura sphenosquamosa).* The uppermost angle *(angulus parietalis),* is bevelled from within and lies upon the angulus sphenoidalis oss. parietalis *(sutura sphenoparietalis).* Passing downward from the most posterior angle of the large wing is a small bony process, the *spina angularis* (O. T. spinous process of the sphenoid) (for the lig. sphenomandibulare; m. tensor veli palatini). In addition, there extends from this point forward and medianward, a short, serrated margin for apposition with the angulus anterior of the petrous portion of the temporal bone *(fissura* and *synchondrosis sphenopetrosa).* Perforating the root of the large wing are three foramina: passing forward from above and behind, to the sphenomaxillary surface is the *foramen rotundum* (for the n. maxillaris); passing downward, from above, to the infratemporal surface is the *foramen ovale* (for the rete foraminis ovalis; n. mandibul.); and the *foramen spinosum* (for the a. mening. med., vv. meningeae mediae; n. spinosus, plexus mening.); the latter foramen lies just in front of the most posterior angle and is sometimes incomplete.



8. Sphenoid bone, *os sphenoidale*, from behind.

The **alae parvae ossis sphenoidalis** *(small wings of the sphenoid bone)* (see also Figs. 6, 7, 65, 68, 71 and 72) arise from the anterior superior part of the lateral surface of the body by two roots which surround the *foramen opticum* (for the a. ophthalmica; n. opticus). They are smooth thin plates of bone which present a superior and an inferior surface; the inferior forms with the orbital surface of the large wing (cf. p. 7) the *fissura orbitalis superior*. The anterior margin, a part of the *margo frontalis*, is serrated and lies upon the posterior margin of the pars orbitalis oss. frontalis *(sutura sphenofrontalis)*; the posterior margin is smooth and runs out medianward and backward into the strong *processus clinoideus anterior;* this may be connected with the proc. clinoideus medius by a bony lamella, which transforms the first part of the sulcus caroticus into a foramen clinoideocaroticum (not shown in the figure).

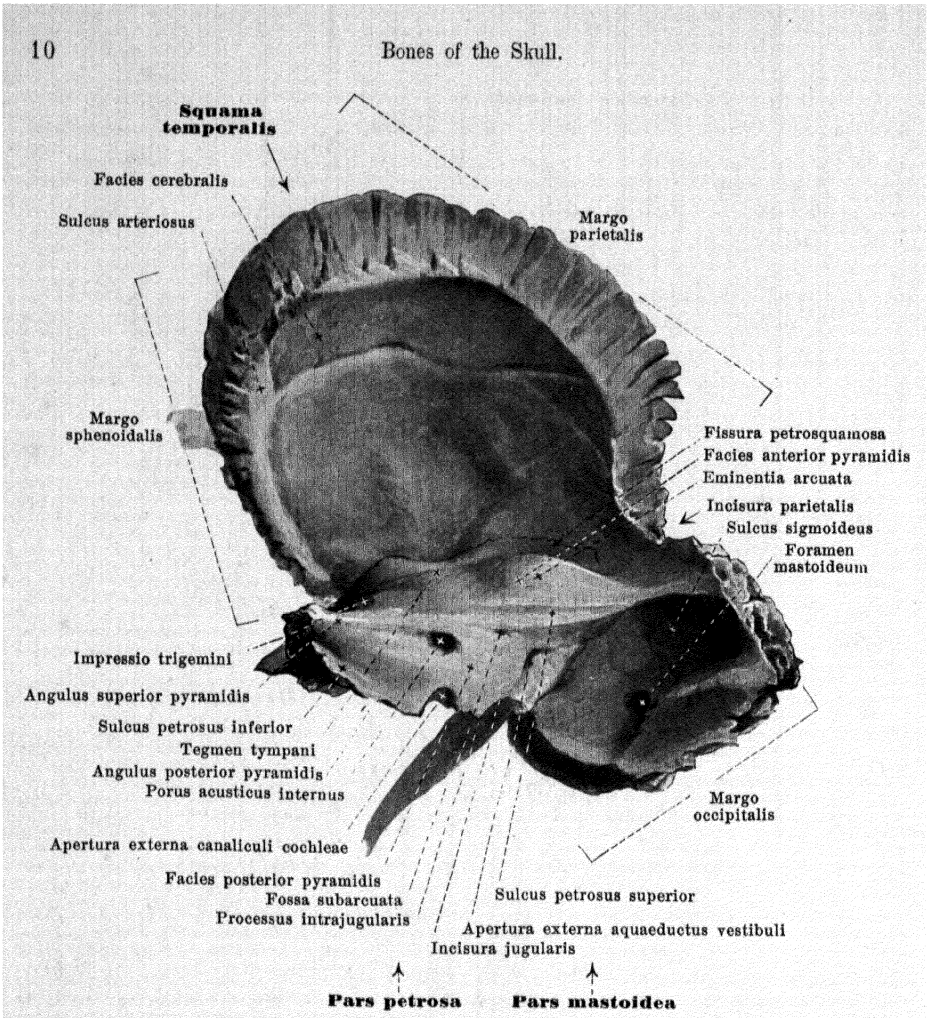
The **processus pterygoidei** *(pterygoid processes)* (see also Figs. 7, 61, 62 and 67—70) extend from the point of union of the body and the large wing downward. They are composed of two plates: the shorter and broader, *lamina lateralis proc. pteryg.* (lateral surface for the m. pterygoideus externus); the other narrower and longer, *lamina medialis proc. pteryg.* The two plates unite anteriorly at an angle, in front of which there extends from above downward the *sulcus pterygopalatinus;* behind, the plates diverge and form the deep *fossa pterygoidea* (for the m. pterygoideus internus); between the two below is a notch with jagged borders, the *fissura pterygoidea,* in which is received the proc. pyramidalis oss. palatini, and over which the proc. pterygoideus sometimes lies against the facies infratemporalis maxillae (see Fig. 69). The lamina medialis runs out below to form the *hamulus pterygoideus* (O. T. hamular process) which is curved lateralward. This process is concave on its lateral surface and is covered with cartilage forming the *sulcus hamuli pterygoidei* (for the tendon of the m. tensor veli palatini). Passing downward over the root of the lamina medialis on the posterior surface is the *fossa scaphoidea* (for the origin of the m. tensor veli palatini). Lateralward and somewhat behind this fossa, encroaching upon the medial surface of the spina angularis lies the *sulcus tubae auditivae* (for the pars cartilaginea tubae auditivae). The lamina medialis gives off from its root the *processus vaginalis,* a small process which extends medianward toward the body; on the inferior surface of this process, either as a closed canal or as a groove which is closed by the proc. sphenoidalis oss. palatini, is the *canalis pharyngeus* (O. T. pterygopalatine canal) (for a small branch of the a. sphenopalatina; rr. nasal. post. sup. lat. gangl. shpenopalat.); between the inferior surface of the body of the bone and the processus vaginalis, a canal is sometimes present, the *canalis basipharyngeus* (for the rr. nasal. post. sup. lat. gangl. sphenopalat.), Constantly present, passing through the root of the pterygoid process in a sagittal direction, is the *canalis pterygoideus [Vidii]* (O. T. Vidian canal) (for the a. et vv. canal. pteryg.; n. canal. pteryg.); its posterior opening lies below the lingula sphenoidalis, its anterior opening upon the sphenomaxillary surface, medianward and below the foramen rotundum.



9. Right temporal bone, *os temporale*, from without.

The paired **os temporale** or temporal bone (cf. also Figs. 10—17, 57, 58, 61, 62 and 65—67) lies between the occipital bone and the phenoid bone, helping to form both the base of the skull and its lateral wall. Each bone is divisible in the adult into four parts; the *squama temporalis, pars mastoidea, pars petrosa* and *pars tympanica.* Around the *meatus acusticus externus* (external auditory canal) which opens lateralward through the oval *porus acusticus externus,* these parts are so arranged that the squam is directed upward, the pars mastoidea backward, the pars tympanica forward and downward an the pars petrosa, medianward and forward. (For the development see p. 69.)

The **squama temporalis** (see also Figs. 10—12, 14, 17, 57, 58, 61, 62 and 65—68) consists essentially of a vertical plate, the free approximately semi-circular border of which is serrated only in its anterior inferior portion, being otherwise bevelled from within; the anterior part of the margin, *margo sphenoidalis,* unites with the large wing of the sphenoid bone to form the *sutura sphenosquamosa,* the posterior, *margo parietalis,* with the margo squamosus oss. parietalis to form the *sutura squamosa.* The lateral surface, *facies temporalis* (for the m. temporalis), is smooth; projecting from the lower part of this surface in front of the external auditory canal is the *processus zygomaticus* (for the lig. temporomandibulare; m. masseter) with two roots of origin; it passes at first horizontally outward, then, turning at a right angle, forward (see also Figs. 11 and 12): it is serrated anteriorly and joins the proc. temporalis ossis zygomatici. Between the two roots, directed downward and covered with cartilage in front, lies the *fossa mandibularis* (O. T. glenoid cavity) with the *facies articularis,* limited in front by the frontally placed *tuberculum articulare,* the latter being covered by cartilage. On the outer surface of the squama temporalis is seen, passing upward in the posterior part, the *sulcus arteriae temporalis mediae* (for the a. tempor. med.). Running out also from the posterior extremity of the zygomatic process is a ridge, the *linea temporalis,* which curves backward to become continuous with the linea temporalis inferior of the parietal bone. The medial surface of the squama, *facies cerebralis* (see Fig. 10) presents well marked juga cerecralia and impressiones digitatae as well as a deep *sulcus arteriosus;* besides, the thin spot corresponding to the fossa mandibularis often presents a bulbous projection.



10. Right temporal bone, *os temporale,* from within and above.

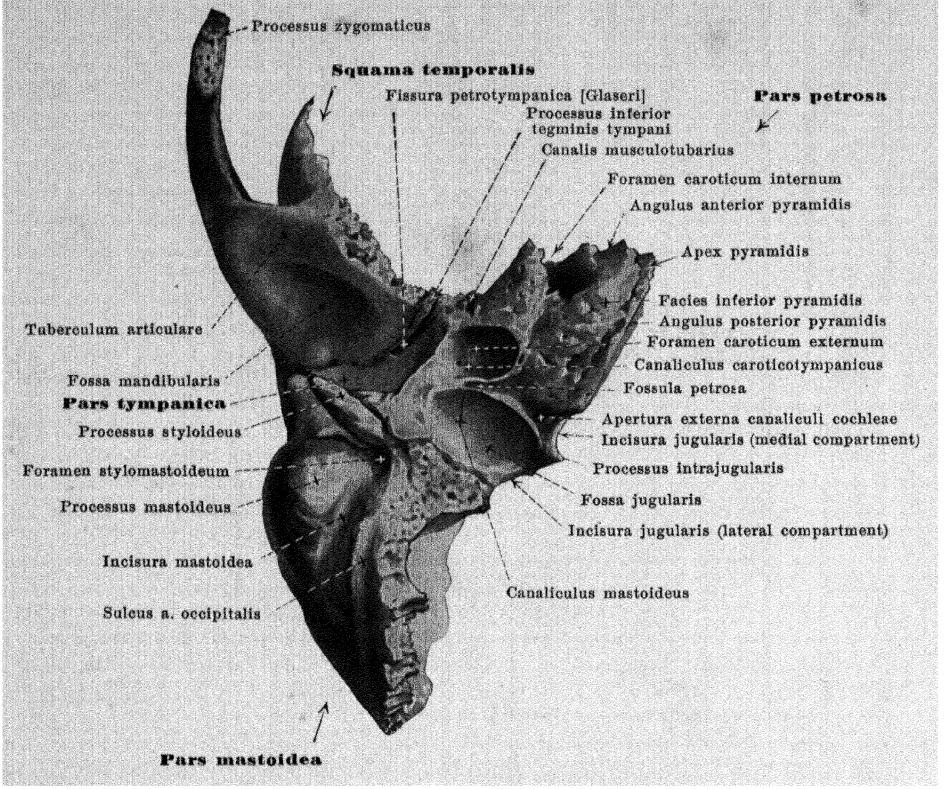
The **pars mastoidea** (see also Figs. 2, 11—17, 57, 58, 61, 62 and 65—68) is a thick conical projection not well developed until adult life. Developmentally it is not an independent part of the bone, but a secondary outgrowth from the lateral and most posterior part of the temporal bone; its superior anterior portion develops from the squama temporalis (see p. 69), its posterior, inferior portion from the pars petrosa (see Figs. 14—16). The site of junction of its two components, is in a third of cases in adults a suture on the lateral surface running downwards and forwards (falsely termed sutura squamosa-mastoidea, and more correctly to be named sutura petrosquamosa). Its posterior, serrated margin, *margo occipitalis,* comes into apposition with the margo mastoideus oss. occipitalis *(sutura occipito-mastoidea);* the short upper serrated margin forms with the margo parietalis of the squama temporalis an angular indentation, the *incisura parietalis,* in which is received the angulus mastoideus oss. parietalis *(sutura parietomastoidea);* above and in front it goes over into the squama temporalis, in front it adjoins the pars tympanica. The lateral surface is convex and slightly roughened (for the attachment of the mm. auricularis posterior et occipitalis), and often presents behind one or several *foramina mastoidea* (for the ramus mastoideus a. occipitalis, emissarium mastoideum) which open on the medial surface in the sulcus sigmoideus. Projecting lateralward from the posterior superior margin of the porus acusticus externus there is frequently found a small spur, the *spina supra meatum;* the surface behind it, often depressed, the *fossa mastoidea,* extends above as far as the linea temporalis and is perforated by numerous foramina for blood vessels.

A thick process extending downward, the ***processus mastoideus*** (for the attachment of the mm. sternocleidomastoideus, splenius capitis, longissimus capitis) (see Figs. 9, 11 and 61) presents on its medial surface, a smooth depression, the ***incisura mastoidea*** (O. T. digastric fossa) for the attachment of the digastric muscle, and, further medianward, a groove, the ***sulcus arteriae occipitalis*** (for the a. occipitalis). The medial surface of the pars mastoidea (see Figs. 10 and 11) is fused in front with the pars petrosa; behind, it is free and there presents a deep groove, curving from above and behind downwards and forwards, the ***sulcus sigmoideus*** (O. T. fossa sigmoidea) (for the sinus transversus). Inside the process are many cavities lined by mucous membrane, the ***cellulae mastoideae*** (cf. Fig. 13), very variable in their development.

The **pars petrosa** ***(pyramis)*** (see Figs. 9—13, 61, 62, 65—68) is a three-sided pyramid, the base of which is directed lateralward, and is united with the pars mastoidea. It completely encloses the internal ear, and together with the squama temporalis and the pars tympanica, the middle ear. It presents for examination three surfaces, a ***facies posterior***, a ***facies inferior***, and a ***facies anterior;*** at the junctions of the surfaces are the angulus posterior, the angulus anterior, and the angulus superior. The tip, or ***apex pyramidis*** is directed medianward and forward, and is inserted in the angle between the occipital bone and the sphenoid bone. Between the anterior border and the sphenoid bone is an irregular chink, the foramen lacerum; it is filled with a mass of connective tissue, the ***fibrocartilago basalis***, which is scooped out on its upper surface into a groove containing the a. carotis interna, the plexus venosus caroticus internus, and the plexus (sympathicus), caroticus internus, and is pierced by the nn. petrosi superficiales.

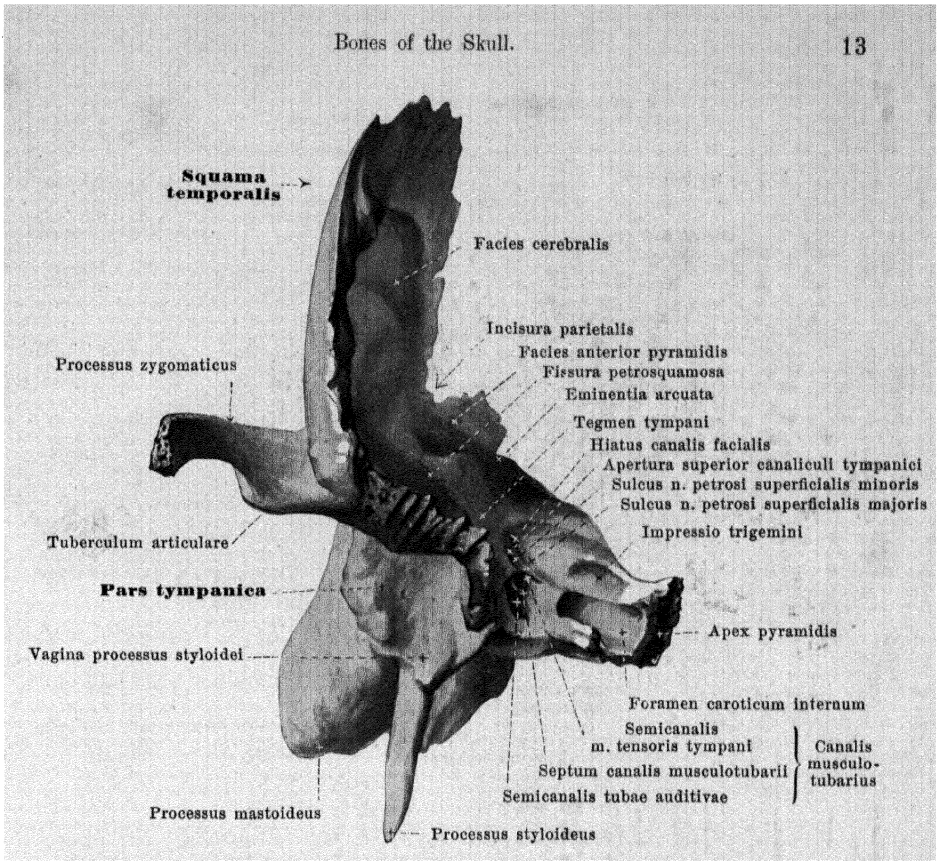
The ***facies posterior pyramidis*** almost vertical, is bounded above by the ***angulus superior*** with the ***sulcus petrosus superior*** (for the sinus petrosus superior; tentorium cerebelli), below by the ***angulus posterior;*** the latter is rough and unites with the lateral margin of the pars basilaris and the pars lateralis of the occipital bone ***(fissura*** and ***synchondrosis petrooccipitalis)***, and contains above at the upper surface of this place of union the ***sulcus petrosus inferior*** (for the sinus petrosus inferior). At about the middle of the posterior surface a circular opening, the ***porus acusticus internus***, leads transversely and frontally into the short ***meatus acusticus internus*** (for the a. and vv. auditivae internae; nn. facialis and acusticus). (See p. 850.) Above lateralward and upwards, close to the superior angle lies the ***fossa subarcuata*** which, running below the superior semicircular canal, receives a process of the dura mater; this fossa, very well marked in the new-born (see Fig. 15), is usually only slightly indicated in the adult. Still further lateralward and downward is seen the ***apertura externa aquaeductus vestibuli*** (for the ductus endolymphaticus); it is usually slit-shaped, opening from a dorsolateral direction, and from it a groove runs downward to the incisura jugularis.

The ***facies inferior pyramidis*** (see Fig. 11) is placed horizontally and is very uneven and rough. In front its boundary is formed laterally by the pars tympanica and medianward therefrom by a free margin, the ***angulus anterior***, which unites with the margin of the large wing of the sphenoid bone situated medianward from the spina angularis, to form the ***fissura*** and ***synchondrosis sphenopetrosa.*** Behind it is bounded by the ***angulus posterior.*** A notch, sometimes scarcely noticeable, the ***incisura jugularis***, close to the small ***processus intrajugularis*** forms with the corresponding ***incisura jugularis***, of the occipital bone (p. 4), the ***foramen jugulare***, (lateral compartment for the v. jugularis interna; medial compartment for the sinus petrosus inferior; nn. glossopharyngeus, vagus, accessorius, gangl. superius n. glossopharyngei, gangl. jugulare n. vagi). Just in front of the lateral compartment of this notch lies the broad ***fossa jugularis*** (for the bulbus v. jugularis superior) with a small hole, one of the openings of the ***canaliculus mastoideus***, and a groove leading to this, the sulcus ***canaliculi mastoidei*** (for the r. auricularis n. vagi). Just medianward from the jugular fossa near the medial compartment of the incisura jugularis, is seen a triangular funnel-shaped depression, with the ***apertura externa canaliculi cochleae*** (for the v. canaliculi cochleae); ductus perilymphaticus deep down.



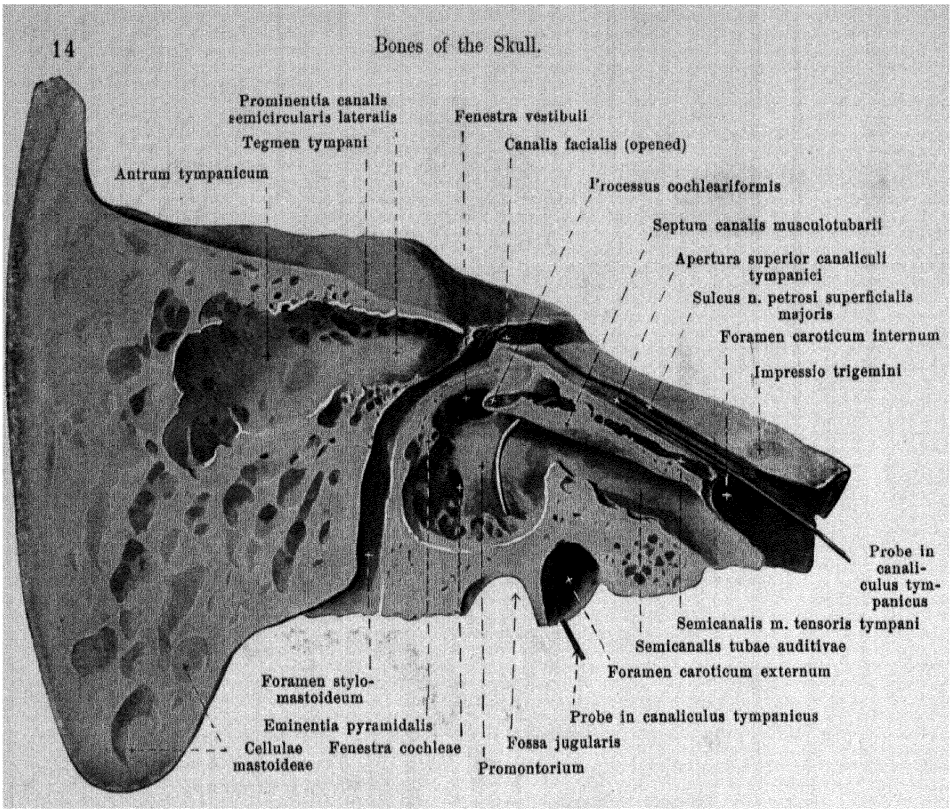
11. Right temporal bone, *os temporale*, from below.

Facies inferior pyramidis (continued). Situated almost exactly in front of the fossa jugularis is a large round opening, the ***foramen caroticum externum***, which forms the entrance to the ***canalis caroticus*** (for the a. carotis interna, plexus venosus caroticus internus; plexus caroticus internus). This canal is curved and passes first perpendicularly, then transversely and obliquely from behind and lateralward, forward and medianward through the pyramid, and emerges near the apex by an irregular opening, the ***foramen caroticum internum***, partly on the inferior and partly on the anterior surface. Near the external carotid foramen can be seen, in the canal, the small openings of the ***canaliculi caroticotympanici*** (for the r. caroticotympanicus a. carotis internae; nn. caroticotympanici), which pass upward to the middle ear. Between the external carotid foramen, the jugular fossa and the apertura externa canaliculi cochleae lies a small depression, the ***fossula petrosa*** (for the gangl. petrosum n. glossopharyngei) with a small opening, the ***apertura inferior canaliculi tympanici*** (for the a. tympanica inferior; n. tympanicus). Situated lateralward and projecting downward and forward is the ***processus styloideus*** (for the lig. stylomandibulare; mm. stylohyoideus, styloglossus, stylopharyngeus), variously developed in different individuals. Just behind it lies the ***foramen stylomastoideum*** (for the a. and v. stylomastoidea; n. facialis). Closely attached to the styloid process in front is seen the *vagina* ***processus styloidei*** (O. T. vaginal process), the lowest portion of the pars tympanica.



12. Right temporal bone, *os temporale,* from in front.

The ***facies anterior pyramidis*** (see also Figs. 10, 13, 65 and 66) is smooth and directed obliquely from behind and above, forward and downward. Laterally it is fused with the squama temporalis through the *fissura petrosquamosa,* where it goes over gradually into the cerebral surface of the squama. The free, rough, anterior margin is the *angulus anterior;* it forms an angle with the margo sphenoidalis of the squama in which fits the posterior angle of the large wing of the sphenoid bone. In this angle lies the opening of the *canalis musculotubarius,* directed forward and medianward; this canal is divided, usually incompletely, by means of a leaflet of bone, projecting from its medial wall, the *septum canalis musculotubarii,* into a smaller upper and median part, the *semicanalis m. tensoris tympani* (O. T. canal for tensor tympani muscle) and a larger inferior part, the *semicanalis tubae auditivae* (O. T. canal for the Eustachian tube) (see Fig. 97). The anterior surface is bounded behind by the *angulus superior* (p. 11). Projecting at a point somewhat lateralward from the middle of the superior surface, near the posterior angle, is the *eminentia arcuata* (O. T. eminence for superior semicircular canal) caused by the canalis semicircularis superior. The smooth region a little lateral from and in front of this is called the *tegmen tympani* since it covers the cavum tympani above. Still further forward two openings can be seen and two grooves running forward from them; the medial opening, *hiatus canalis facialis* (O. T. hiatus Fallopii), leads through a short canal to the geniculum canalis facialis and contains the r. petrosus superficialis a. mening. med. and the n. petrosus superfic. maj., the latter passing further forward in the medial groove called the *sulcus n. petrosi superficialis majoris;* the lateral, smaller, opening, sometimes fused with the medial, is known as the *apertura superior canaliculi tympanici* (O. T. opening for smaller petrosal nerve) through which run the a. tympanica superior and the n. petrosus superfic. min. in order to pass further on in the smaller, lateral, groove, the *sulcus n. petrosi superficialis minoris.* On the upper surface near the apex of the pyramid lies the *impressio trigemini* (O. T. depression for Gasserian ganglion) for the n. trigeminus. In addition the facies anterior presents shallow *juga cerebralia* and *impressiones digitatae.*

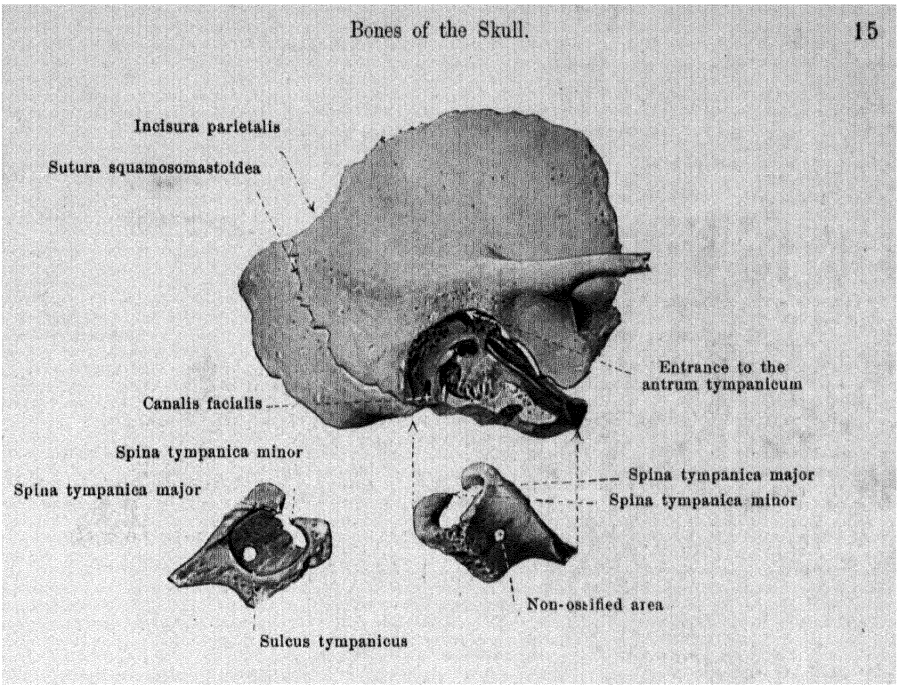


13. Right temporal bone, *os temporale*, cut open, lateral view of medial half bone. Magnification 2:1. (See also Fig. 946.)

(The canalis facialis is opened in its entire length.)

The **canalis facialis (Fallopii)** (O. T. Aqueduct of Fallopius) (for the a. and v. stylomastoidea, r. petrosus superficialis a. meningeae mediae; n. facialis, n. intermedius) begins in the floor of the meatus acusticus internus near the posterior surface of the pyramid (see p. 850), thence passes horizontally lateralward, after a short course bends around at a right angle, forming the *geniculum canalis facialis*, and from this point passes horizontally backward and lateralward and then downward. In doing so it lies close to the mastoid wall of the cavity of the tympanum and there forms the *prominentia canalis facialis* (see Figs. 951, 961, 965 and 966). It runs at first close beneath the facies anterior pyramidis, then between the fenestra vestibuli and the prominentia canalis semicircularis lateralis, then behind the eminentia pyramidalis to terminate in the *foramen stylomastoideum*. From the geniculum canalis facialis which, in the new-born (Fig. 17) lies free upon the anterior surface of the pyramid, a short canal passes medianward and forward to the *hiatus canalis facialis* (O. T. hiatus Fallopii) (for the r. petrosus superfic. a. mening. med.; n. petrosus superficialis major); another very delicate canal runs to the upper part of the canaliculus tympanicus (for the ramus anastom. plexus tympanici); behind the eminentia pyramidalis a little lateral branch is given off to enter this eminence (for the n. stapedicus) and below it arises the *canaliculus chordae tympani* (see Fig. 946) which leads into the middle ear, and receives the canaliculus mastoideus for the ramus auricularis n. vagi (s. Fig. 836).

The *canaliculus tympanicus* (below for the a. tympanica inferior, above for the a. tympanica superior; besides for the n. tympanicus and n. petrosus superficialis minor) begins with an *apertura inferior* in the depth of the *fossula petrosa*, arrives in the cavum tympani on its inferior wall, runs over the promontorium in the *sulcus promontorii*, perforates the root of the processus cochleariformis and then passes in a curved direction in the bone, forward and upward to the *apertura superior canaliculi tympanici* on the upper surface of the pyramid; in this upper part it receives a delicate canal coming from the geniculum canalis facialis. (See above.)



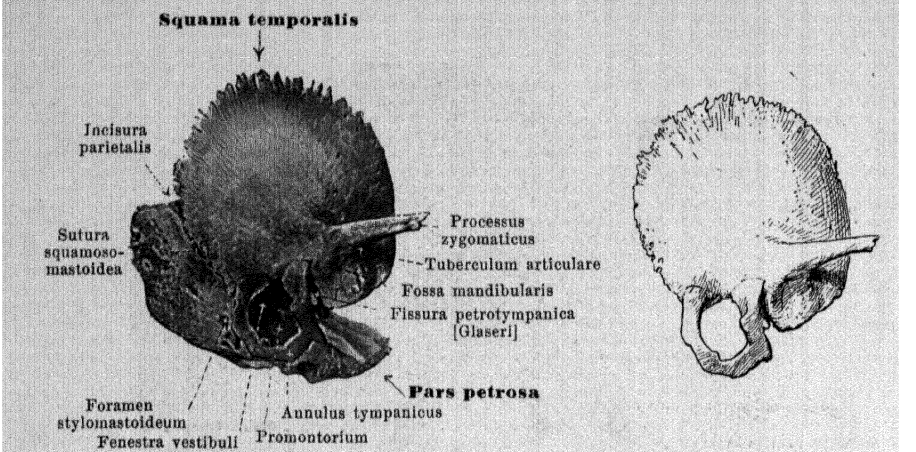
14. Right temporal bone, *os temporale,* at the 7th or 8th year of life, seen from without and somewhat from below.

(The pars tympanica has been shelled out and drawn separately in the lower part of the figure; on the right it is seen from the outside, on the left from within.)

The *canaliculi caroticotympanici* (for the r. caroticotympanicus a. carotis internae; nn. caroticotympanici superior et inferior) usually two in number, are openings or short canals which pass from the posterior wall of the canalis caroticus immediately over the foramen caroticum externum to the cavum tympani and open in the latter on its anterior wall (see Organ of Hearing). See Figs. 11 and 830.

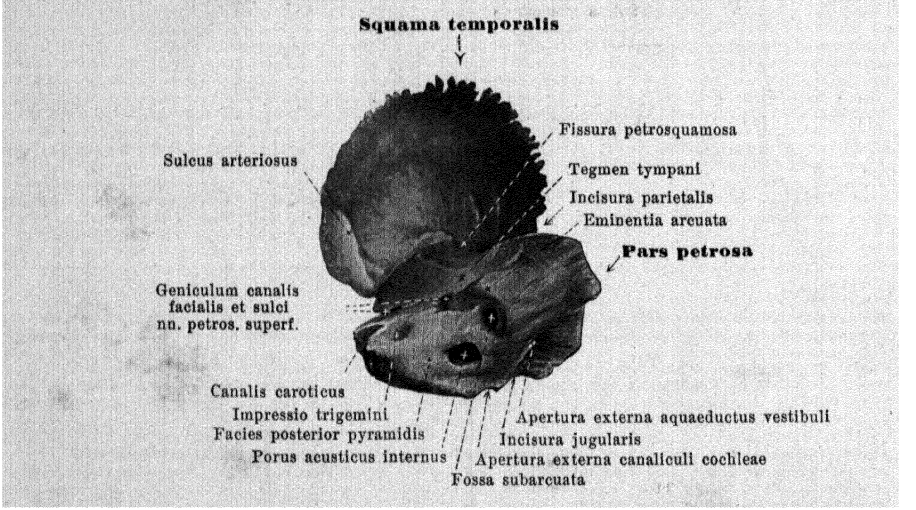
The **pars tympanica** (see also Figs. 9 and 964) a platelet of bone hollowed out behind and above in the form of a groove, a nearly flat plate in front and below, presents normally, during the early years of life, a non-ossified portion. The pars tympanica forms the whole anterior, the inferior and a part of the posterior wall of the *meatus acusticus externus* as well as the *porus acusticus externus.* The posterior limb of the groove lies upon the anterior surface of the proc. mastoideus and often forms there the so-called *fissura tympanomastoidea.* The anterior limb of the groove is attached to the inferior margin of the squama temporalis just behind the fossa mandibularis; lateralward it is fused for a short distance with the squama, but medianward there exists between the two a narrow platelet of bone, *processus inferior tegminis tympani* (Figs. 9 and 11), which proceeds from the anterior margin of the facies anterior pyramidis and which, with the pars tympanica, form the *fissura petrotympanica [Glaseri]* (O. T. Glaserian fissure). The latter presents several small openings for the a. tympanica anterior, vv. tympanicae, chorda tympani and the lig. mallei anterius. Below, surrounding the root of the styloid process from in front like a sheath, is a process of the pars tympanica called the *vagina processus styloidei.* (O. T. vaginal process.)

The superior posterior surface of the pars tympanica is smooth and contains near its anterior medial extremity a groove, bounded by two ridges, the *sulcus tympanicus* (for the membrana tympani), the plane of which looks backward, upward and medianward; at each of the upper angles of the pars tympanica it runs out into a small pointed extremity, the anterior being called the *spina tympanica major,* the posterior, the *spina tympanica minor.* The space between these two spines is not entirely filled up by the attachment of the pars tympanica to the squama temporalis; on the contrary, there remains an indentation called the *incisura tympanica [Rivini]* (see Organ of Hearing). See Figs. 944 and 945.



15 and 16. Right temporal bone, *os temporale,* from the newborn child, seen from without.

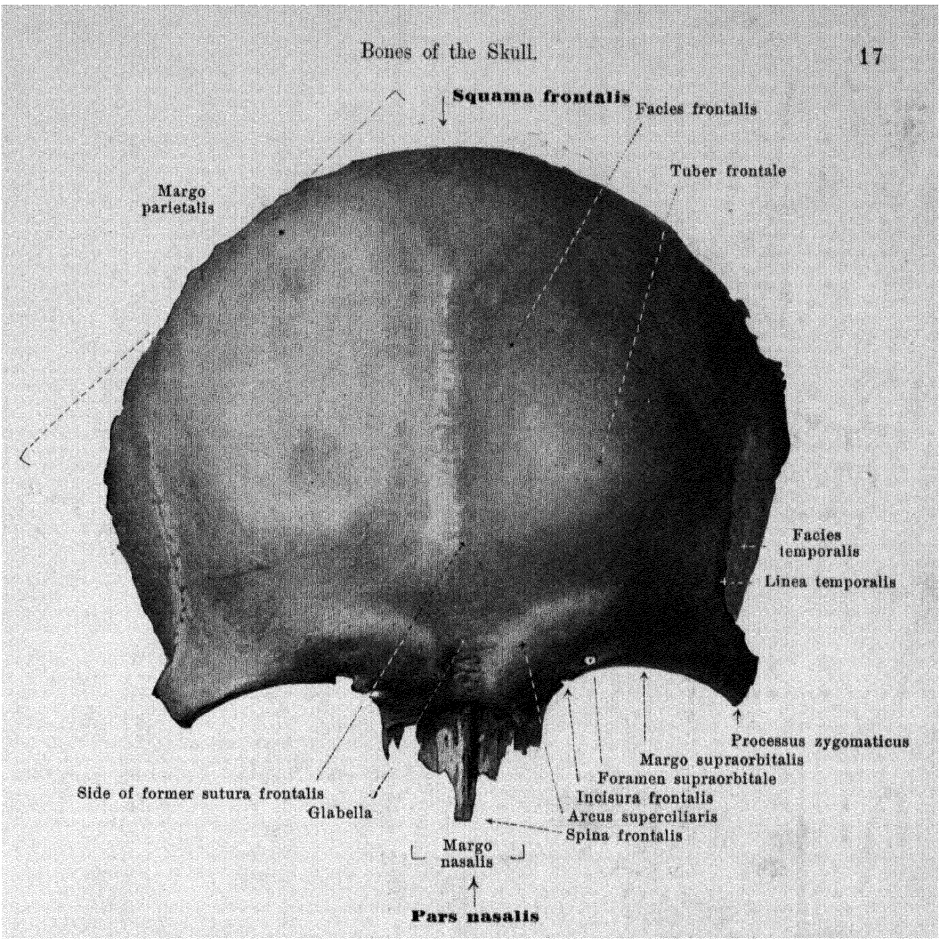
(15: complete, 16: squama temporalis and annulus tympanicus alone.)



17. Right temporal bone, *os temporale,* from newborn child, seen from within.

The **os temporale** consists in the foetus of three parts, pars petrosa, squama temporalis and pars tympanica (see also pp. 10 and 69); in the newborn it is still divided into all three or into only two parts according as the squama temporalis and pars tympanica still remain separated or have united with one another. The pars tympanica in the newborn is a flat semicircle, the *annulus tympanicus;* it is open above and contains in its concavity the *sulcus tympanicus* (see p. 15); out of it the pars tympanica ultimately develops in that it grows out chiefly in a lateral, less in a medial direction to form a groove.

In the newborn no actual *proc. mastoideus* exists. The *foramen stylomastoideum* lies on the lateral surface of what is later to be the pars mastoidea. The *proc. styloideus* is still cartilaginous, entirely or for the most part. On the posterior and anterior surface of the pyramid the size of the *fossa subarcuata* (p. 11) and the site of the *geniculum canalis facialis* (pp. 11—12) not yet bridged over by bone, are striking features; accordingly, a hiatus canalis facialis, in the sense in which it exists in the adult, is absent in the newborn.

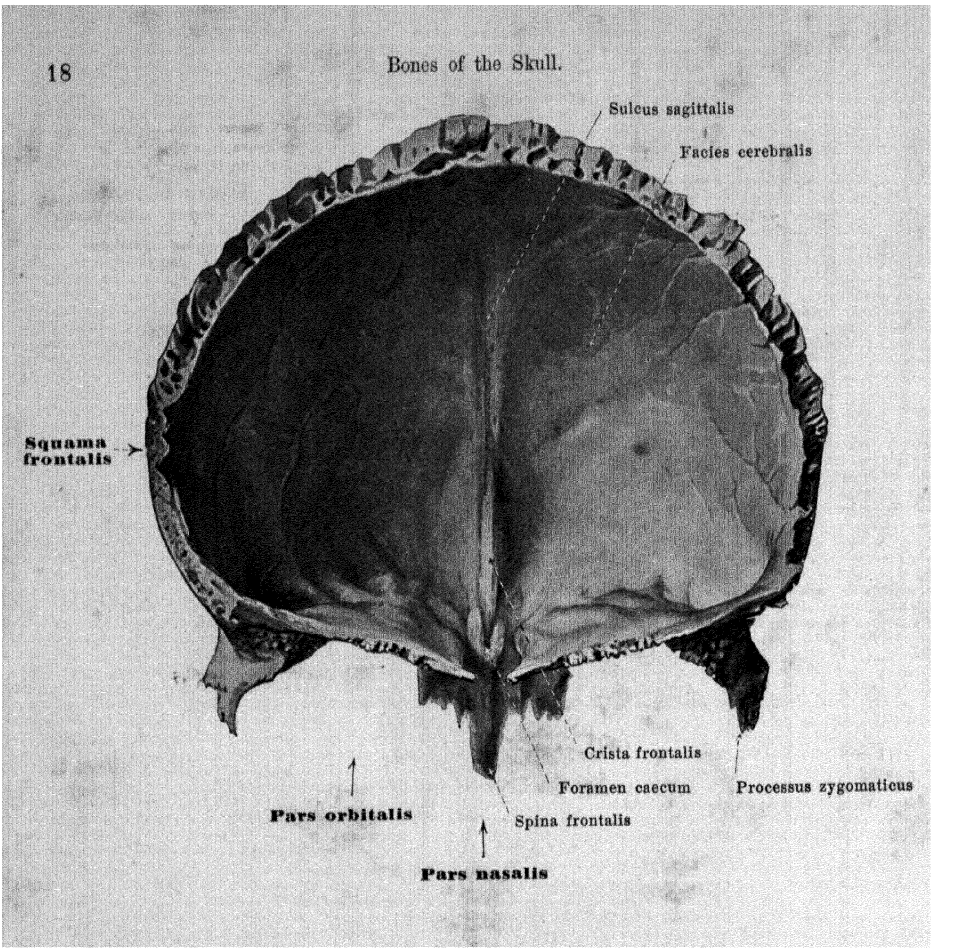


18. Frontal bone, *os frontale*, from in front.

The unpaired **os frontale** *(frontal bone)* (see also Figs. 19, 20, 57—60, 63—68, 70—73, and 76) closes the cerebral skull in front. It has four parts, the unpaired *squama frontalis* and *pars nasalis*, and the paired *partes orbitales*. (For develop. see p. 69.)

The **squama frontalis** (see also Figs. 19, 20, 57—60, and 63—68) is curved sagittally and transversely so as to be convex in front. Its largest posterior serrated margin, *margo parietalis*, unites with the frontal margin of the parietal bone to form the *sutura coronalis*. The inferior boundary is formed in the middle by the pars nasalis, lateral from this on each side by the *margo supraorbitalis;* the latter runs out lateralward into the *proc. zygomaticus*, which unites, by means of a rough surface, with the proc. frontosphen. of the zygomatic bone to form the *sutura zygomaticofrontalis*.

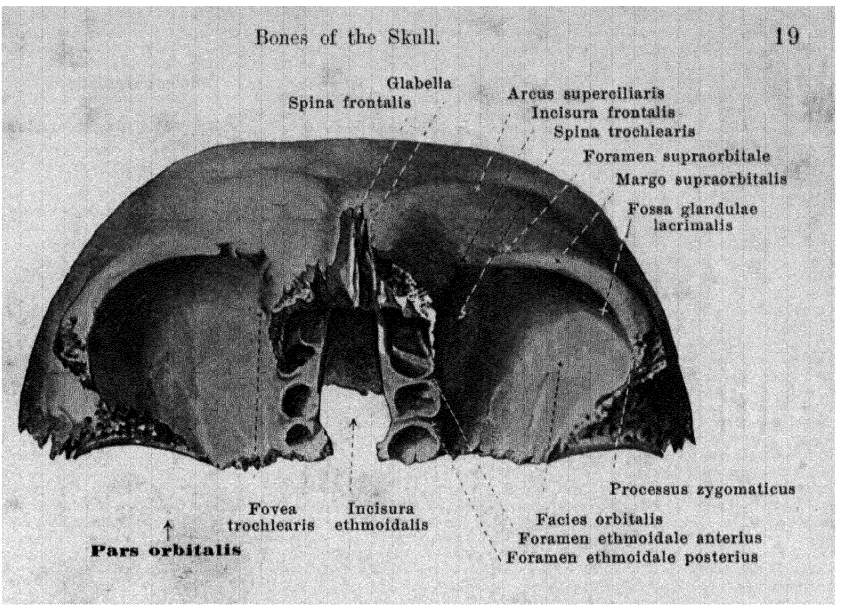
In the medial part of the margo supraorbitalis there is very rarely found a. foramen frontale (for the a. frontalis; r. frontal. n. frontal.); more often there is a shallow notch the incisura frontalis; but just as often it may be absent; lateralward there lies most commonly another flat notch, the incisura supraorbitalis (for the a. supraorbit. n. supraorbit.); more rarely a foramen supraorbitale, and very rarely, neither the one nor the other. The anterior, convex surface, *facies frontalis*, is smooth and sometimes rarely presents, in the median plane, in Europeans at most in 7 % of cases, signs of the *sutura frontalis* which is always present at birth (see page 69); lateralward from this on each side lies the *tuber frontale* (O. T. frontal eminence) and lateralward from this the *linea temporalis*, ascends backward and upward from the zygomatic process, bounding the flat, nearly sagittally placed, *facies temporalis* (for the m. temporal.). Close to the inferior border, near the median plane on each side, begins a ridge, *arcus superciliaris* (O. T. superciliary ridge), which passes upward and lateralward, flattening as it proceeds; the depressed surface lying between the medial ends of these ridges is called the *glabella*.



19. Frontal bone, *os frontale,* from behind.

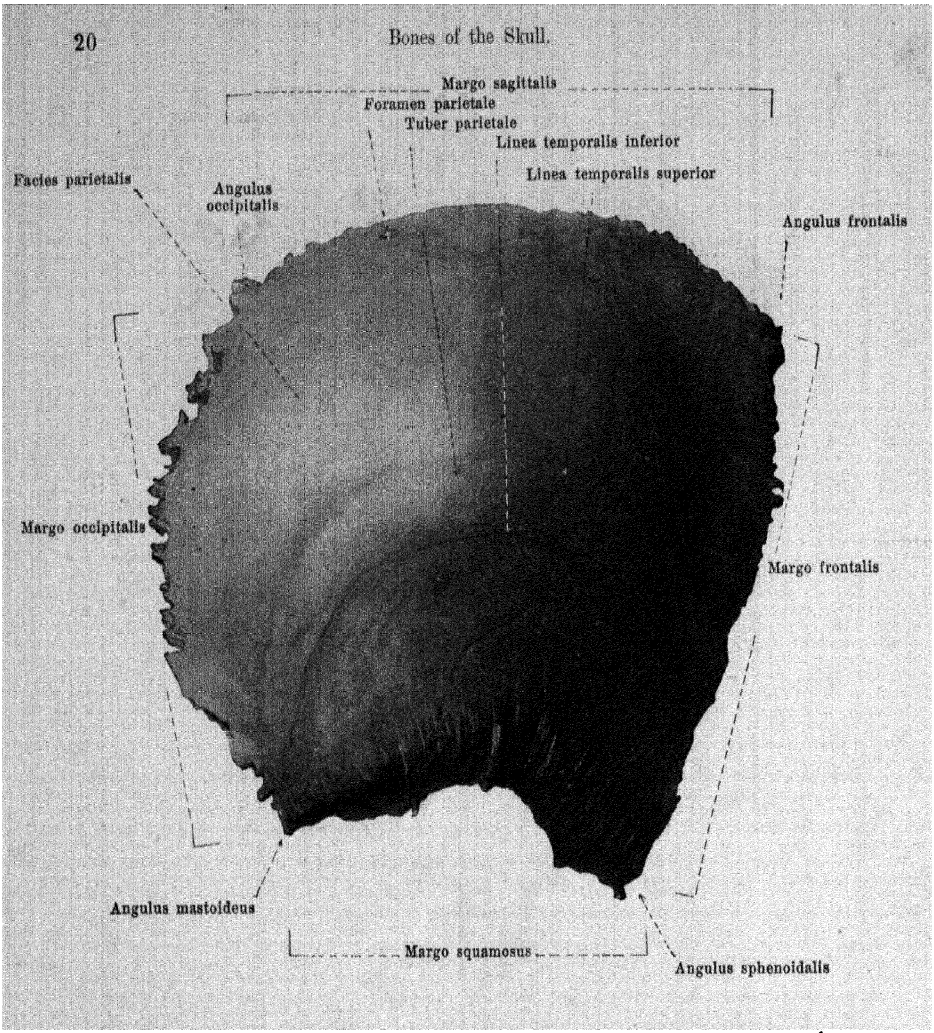
The concave posterior surface of the **squama frontalis** (see also Figs. 64—68) forms a part of the *facies cerebralis* (O. T. internal surface) of the frontal bone. In the median plane in the upper part, is a shallow groove, *sulcus sagittalis* (for the sinus sagittalis superior; falx cerebri); out of its lower end develops a narrow, usually markedly projecting sharp ridge, the frontal crest or *crista frontalis* (for the falx cerebri), which, below, forms the anterior boundary of the foramen caecum. Shallow juga cerebralia and impressiones digitatae are visible, chiefly in front, below and behind.

The term **pars nasalis** (see also Figs. 18, 20, 57—60, and 76—78) is applied to the part projecting somewhat from the inferior margin of the squama frontalis in the middle; it separates the two partes orbitales from one another. In front it is bounded by the slightly serrated *margo nasalis,* to which the nasal bone is attached on each side *(sutura nasofrontalis);* immediately adjacent is attached the proc. frontalis maxillae *(sutura frontomaxillaris).* The posterior free margin is the anterior part of the *incisura ethmoidalis;* it unites with the anterior margin of the lamina cribrosa oss. ethmoidalis and forms a part of the *sutura frontoethmoidalis.* Obliquely downward and forward from the inferior rough surface projects the *spina frontalis* (O. T. nasal spine). It is rough in front for the further attachment of the nasal bones and of the frontal processes of the maxillae; its posterior, partly smooth, partly rough, surface is applied medianward to the crista galli and lamina perpendicularis oss. ethmoidalis, lateralward to the medial wall of the ethmoidal labyrinth; between these the posterior surface helps to form also the anterior wall of the nasal cavity. On the upper surface, close behind the inferior extremity of the crista frontalis, lies the entrance (usually formed by the frontal bone alone) to the *foramen caecum,* a canal which grows smaller as it descend and ends blindly in the apex of the spina frontalis; it contains a process of the dura mater.



20. Frontal bone, *os frontale,* from below.

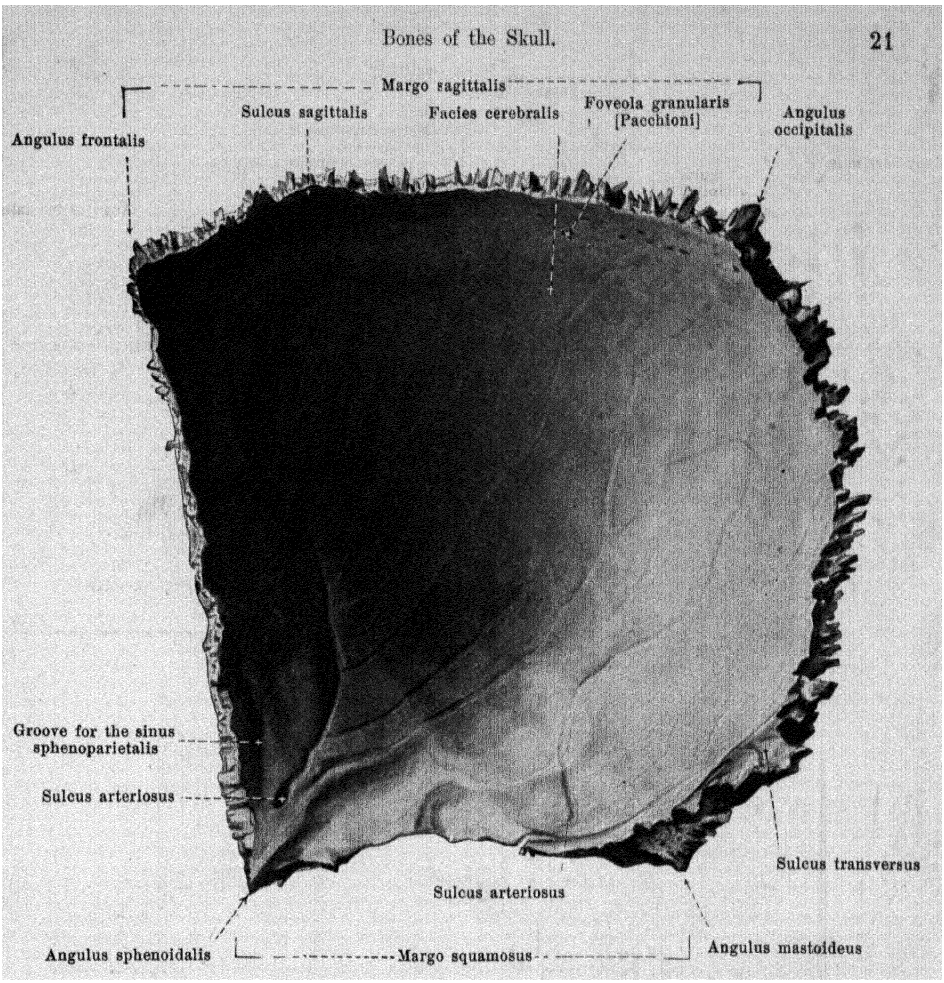
The **partes orbitales** (see also Figs. 19, 65–68, and 70–73) pass at a right angle from the inferior margin of the squama frontalis backward and are separated from one another by the quadrangular ***incisura ethmoidalis*** cutting in from behind. The anterior boundary is formed by the ***margo supraorbitalis;*** the lateral by the ***processus zygomaticus.*** The posterior margin is slightly serrated medianward for union with the **ala parva** oss. sphenoid., and is continuous lateralward toward the proc. zygomat. with a triangular rough surface for contact with the margo frontalis of the ala magna oss. sphenoid. ***(sutura sphenofrontalis);*** behind this surface lies a variable, narrow, sickle-shaped, smooth field, which along which the ala parva oss. sphenoid. helps to form the middle fossa of the skull. The medial border, bounding the incisura ethmoidalis, is only slightly rough and forms with the lateral margin of the lamina cribrosa oss. ethmoid. a part of the ***sutura frontoethmoidalis.*** Parallel to this margin a rough ridge runs lateralward to which are attached in front the os lacrimale by the ***sutura frontolacrimalis,*** behind the lamina papyracea oss. ethmoid. by a part of the ***sutura frontoethmoidalis.*** The oblong field lying between this ridge and the medial border is irregularly divided by thin transverse ridges, lies upon the upper surface of the ethmoidal labyrinth and presents bulgings due to the cellulae ethmoidales which extend into it; two grooves, running frontally, form with corresponding grooves of the ethmoidal labyrinth the ***foramen ethmoidale anterius*** (for the a. ethmoid. ant.; n. ethmoid. ant.) and the ***foramen ethmoidale posterius*** (for the a. ethmoid. poster.; n. ethmoid. poster.; rr. orbital gangl. sphenopalat.). The inferior surface of the pars orbit., ***facies orbitalis,*** is smooth and presents near its medial anterior angle a small depression, the ***fovea trochlearis*** (and occasionally posteriorly near it a small spur, ***spina trochlearis)*** (for the trochlea m. obliqui oculi super.); in the lateral portion, bounded in front by the margo supraorbit., lateralward by the proc. zygomat., lies the ***fossa glandulae lacrimalis*** (for the glandula lacrim. sup.). The upper surface, ***facies cerebralis,*** presents strong juga cerebralia and impressiones digitatae. At the junction of the partes orbitales with the squama frontalis the bone contains within, it, the ***sinus frontales*** or frontal sinuses (see also Fig. 567), cavities between the plates of the partes orbitales and the squama of varying width and lined by mucous membrane. They are subdivided by the ***septum sinuum frontalium,*** which usually diverges somewhat from the median plane; the entrances lie in the anterior medial angles of the partes orbitales; the sinus frontales are occasionally though very rarely absent on one or both sides.



21. Right parietal bone, *os parietale*, from without.

The **os parietale** *(parietal bone)* (see also Figs. 22, 57, 58, 63—68) is paired and helps to form the roof and lateral wall of the skull. It is a quadrangular, flat, saucer-shaped bone with an external, convex *facies parietalis* and an internal, concave *facies cerebralis*. (For the develop. see p. 69.)

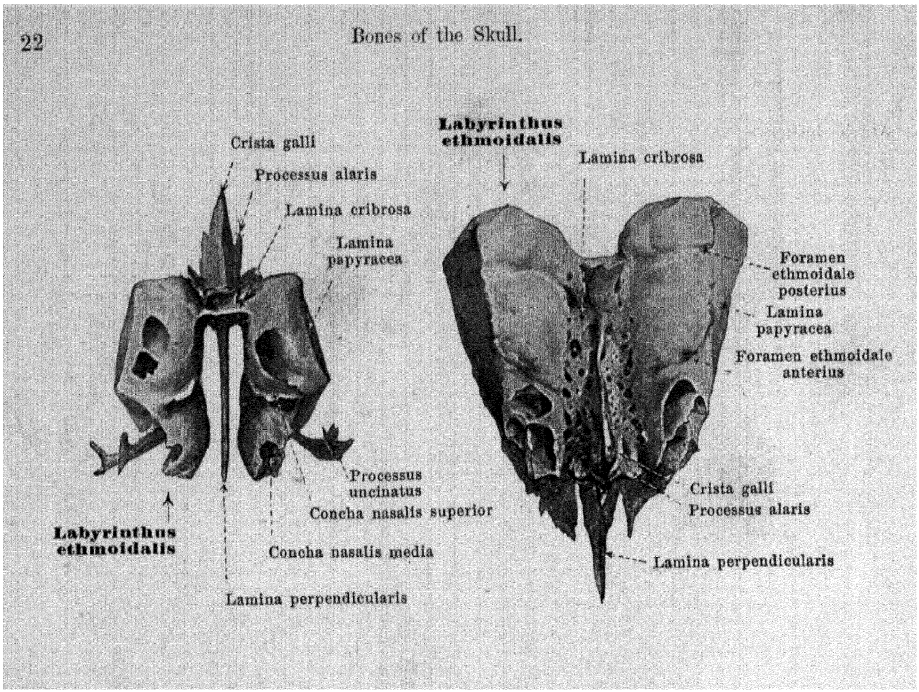
The bone has four margins, and four angles. The posterior convex margin, *margo occipitalis*, is deeply serrated and unites with the margo lambdoideus oss. occip. to form the *sutura lambdoidea*. The inferior margin, *margo squamosus*, is concave and bevelled from without; it is attached to the margo parietal. oss. tempor. *(sutura squamosa)*. The anterior, slightly concave margin, *margo frontalis*, is serrated and unites with the margo parietal. oss. front. to form the *sutura coronalis*, and the upper straight, markedly serrated margin, *margo sagittalis*, forms with the same margin of the opposite parietal bone the *sutura sagittalis*. The anterior superior angle, *angulus frontalis*, lies in the middle of the *sutura coronalis* and adjoins the frontal bone; the posterior superior *angulus occipitalis*, adjoins the upper extremity of the squama occipitalis. The posterior inferior angle, *angulus mastoideus*, is inserted in the incisura parietal. oss. tempor. and forms there with the upper margin of the pars mastoid. oss. tempor., the *sutura parietomastoidea*. The anterior inferior angle, *angulus sphenoidalis*, is bevelled from without, attached to the angul. pariet. of the ala magna oss. sphenoid. and forms with this the *sutura sphenoparietalis*.



22. Right parietal bone, *os parietale,* from within.

The ***facies parietalis*** (see Figs. 21, 57, 58 and 63) is more or less markedly bulged out in the middle; this projection is called the *tuber parietale*. Below it runs the ***linea temporalis inferior,*** convex above, which begins at the margo frontalis as a continuation of the linea temporalis oss. frontalis and goes over at the angulus mastoides into the linea temporalis oss. temporalis; it itself and the field beneath give origin to the m. temporalis. More or less concentric with it runs generally a less marked ***linea temporalis superior,*** which ends at the margo occipitalis; to it is attached the fascia temporalis. Close to the margo sagittalis there is very often, in the posterior third, an opening, the ***foramen parietale*** (for the r. meningeus a. occipitalis, emissarium parietale).

On the **facies cerebralis** (see also Figs. 64—68) along the margo sagittalis runs a groove, completed by apposition with the parietal bone of the other side, the ***sulcus sagittalis*** (for the sinus sagittalis sup.; falx cerebri), into which the foramen parietale usually opens. Over the inner surface of the angulus mastoid. runs a short broad flat groove, the ***sulcus transversus*** (O. T. groove for lateral sinus) (for the sinus transvers.). At the angulus sphenoid. is found a deep sulcus arteriosus which undergoes tree-like branching upward, close in front of the angulus mastoideus is a second less branched; both form sometimes, for a short distance, an actual canal, for branches of the a. mening. med. In addition the facies cerebralis presents *impressiones digitatae* and *juga cerebralia* and also frequently, especially in older people, near the sulcus sagittalis, *foveolae granulares [Pacchioni]* (O. T. Pacchionian depressions) (for the granulationes arachnoideales [Pacchioni]). Corresponding to the tuber parietale there is, on the inner surface, a depression, *fossa parietalis,* in the region of which the bone is thinned.

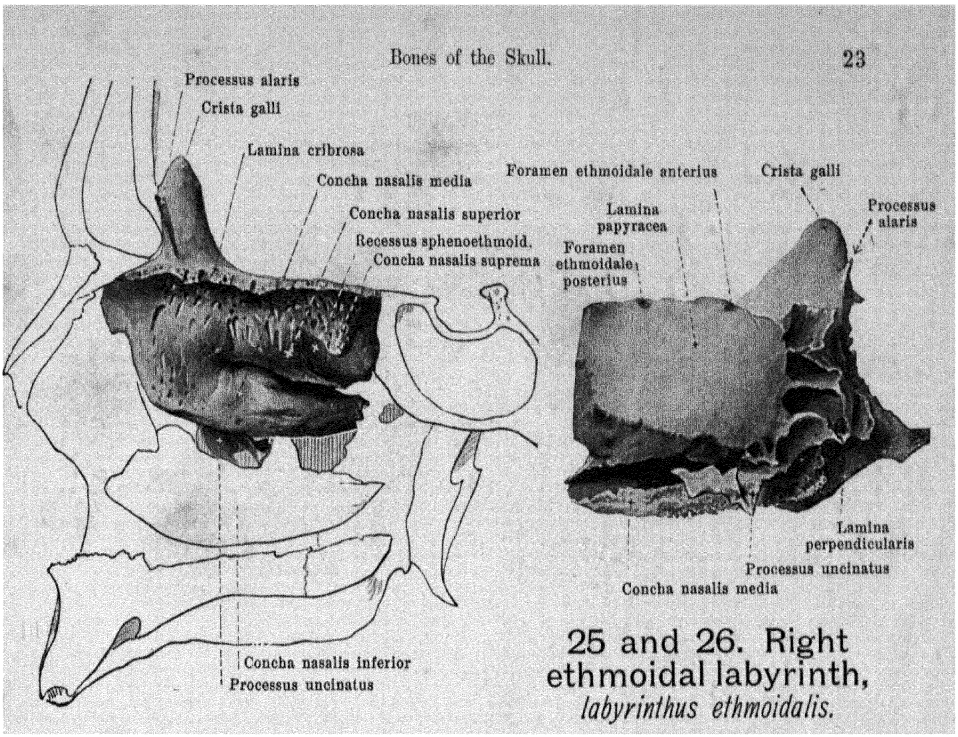


23 and 24. Ethmoid bone, *os ethmoidale.*

From behind, somewhat schematic. From above.

The **os ethmoidale** *(ethmoid bone)* (see also Figs. 25—27, 65, 66, 70—72, 76—78) is unpaired, helps in part to close the most anterior portion of the cerebral skull below, but reaches with its main mass deep down into the facial skull and helps to form the nose and orbit. It consists above of a transversely placed oblong plate, the ***lamina cribrosa;*** from the under surface of this extending downward in the median plane is the ***lamina perpendicularis*** and from each of its two lateral borders hangs the ***labyrinthus ethmoidalis;*** in contact with its posterior surface is the concha sphenoidalis, which apparently seems to be part of the os sphenoidale but in reality belongs embryologically to the os ethmoidale (see p. 61). (Development see p. 70.)

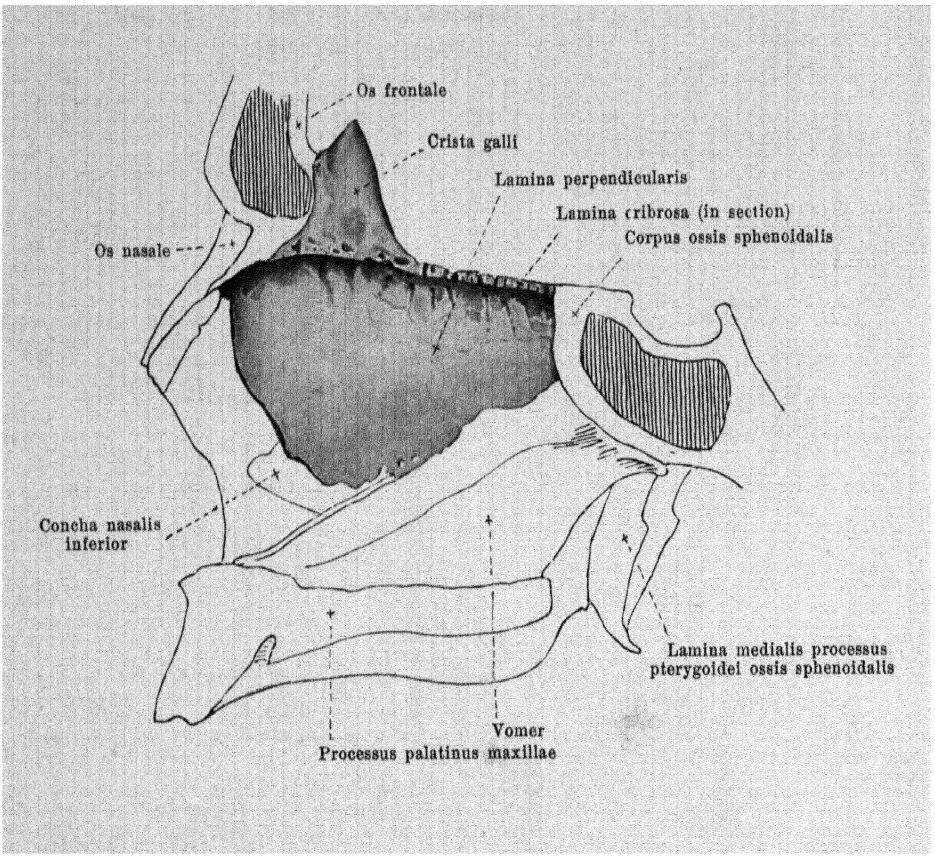
The **lamina cribrosa** *(cribriform plate)* (see also Figs. 25, 65—68, and 74—78) lies horizontally, fills the incisura ethmoidalis oss. frontalis completely and thus forms at the anterior and the two lateral margins a part of the ***sutura frontoethmoidalis;*** the posterior margin lies on the anterior border of the upper surface of the body of the sphenoid bone *(sutura sphenoethmoidalis).* The cribriform plate presents on its upper surface in the median plane a ridge which becomes elevated in front to form the oblong ***crista galli*** or cock's comb (for the falx cerebri); this is higher in front than behind and consists of solid bone tisue or sometimes contains bone-marrow spaces; it is attached to the pars nasalis and crista frontalis oss. frontalis, usually by means of the two small, laterally directed *processus alares,* and completes the entrance to the foramen caecum oss. frontalis when this is incomplete. The cribriform plate is perforated by numerous foramina of different sizes, the larger of which are arranged often in two rows, one medial and one lateral, and which are continued in small grooves on the lamina perpendicularis and on the medial surface of the labyrinth; they give passage to the nn. olfactorii. A small slit lateralward from the anterior part of the crista galli gives passage to the a. and the n. ethmoidalis anterior.



25 and 26. Right ethmoidal labyrinth, *labyrinthus ethmoidalis.*

From within. From without.

Each **labyrinthus ethmoidalis** (O. T. ***lateral mass of ethmoid)*** (see also Figs. 23, 24, 67, 68, 70, 72, 74—78, 567) is oblong and hexagonal in shape, and is connected only above and medianward with the lateral border of the lamina cribrosa. Inside it is divided by delicate platelets of bone into the numerous ***cellulae ethmoidales*** (ethmoid cells) lined by mucous membrane and communicating with each other. These gradually grow larger in the course of development, so that they finally project beyond the limits of the ethmoid bone. They consist of fully formed bone tissue only on the medial surface, and are on the lateral surface for the most part enclosed by the walls of the ethmoid; otherwise they project against neighboring bones, or into them; thus in the isolated bone they partly open and become closed cavities only by the attachment of adjacent bones; in front the pars nasalis oss. frontalis and proc. frontalis maxillae, lateralward by the os lacrimale and corpus maxillae, behind by the proc. orbitalis oss. palatini, corpus oss. sphenoidalis and conchae sphenoidales, above by the pars orbitalis oss. frontalis; spread out on the latter surface of union are the ***foramen ethmoidale anterius*** (for the a. ethmoid. ant.; n. ethmoid. ant.) and the ***foramen ethmoidale posterius*** (for the a. ethmoid. post., n. ethmoid. post., rr. orbit. gangl. sphenopalat.) (see also p. 19). The lateral wall of the labyrinth, ***lamina papyracea*** (O. T. os planum), is oblong, quadrangular, and unites in front with the os lacrimale, below with the corpus maxillae ***(sutura ethmoideo-maxillaris),*** behind with the proc. orbital. oss. palat. ***(sutura palatoethmoidalis)*** and the corpus oss. sphenoid. ***(sutura sphenoethmoidalis),*** above with the pars orbital. oss. front. ***(sutura frontoethmoidalis).*** The medial wall is vertical, is very rough, and much perforated presenting small vertical slits for the nn. olfactorii. Its anterior margin is attached to the posterior surface of the spina frontalis oss. frontalis, its posterior border to the anterior surface of the concha sphenoidalis; the inferior thickened border hangs down free, bends around somewhat lateralward, and thus forms the ***concha nasalis media*** (middle turbinated bone); above this in the posterior part is a deep notch ***(meatus nasi superior,*** upper nasal passage) and above this a similar, concha-like plate of bone, bent so as to be convex medianward, the ***concha nasalis superior*** (superior turbinated bone); further backward and upward lies usually still another turbinated bone, the ***concha nasalis suprema [Santorini],*** separated from the preceding by a groove, the ***recessus sphenoethmoidalis.*** Lateralward from the anterior extremity of the concha media, a sickle-shaped process, the ***processus uncinatus*** (O. T. unciform process), directed backward, becomes separated from the inferior wall; at its extremity it rolls around lateralward, and below or behind this place unites with the proc. ethmoidalis conchae nasalis inferioris (see also Figs. 70 and 77).



27. Ethmoid bone, *os ethmoidale, lamina perpendicularis,* from the left.

The **lamina perdendicularis** or *perpendicular plate* (see also Figs. 23, 67, 68, 78, 567 and 979) is quadrangular with unequal sides; at its upper border in the median plane it is in large part united to the inferior surface of the lamina cribrosa; it hangs down perdendicularly and free between the two labyrinths and thus forms a part of the bony nasal septum. At its upper margin it presents small grooves which are continuations of the medial foramina of the lamina cribrosa for the nn. olfactorii. The upper border is attached in front to the posterior surface of the spina frontalis oss. frontalis *(sutura frontoethmoidalis);* the posterior margin unites with the crista sphenoidalis oss. sphenoidalis *(sutura sphenoethmoidalis),* the inferior with the anterior margin of the vomer, the anterior with the cartilaginous nasal septum.

Deviations of the lamina perpendicularis as a whole or in single spots from the median plane are very frequent.

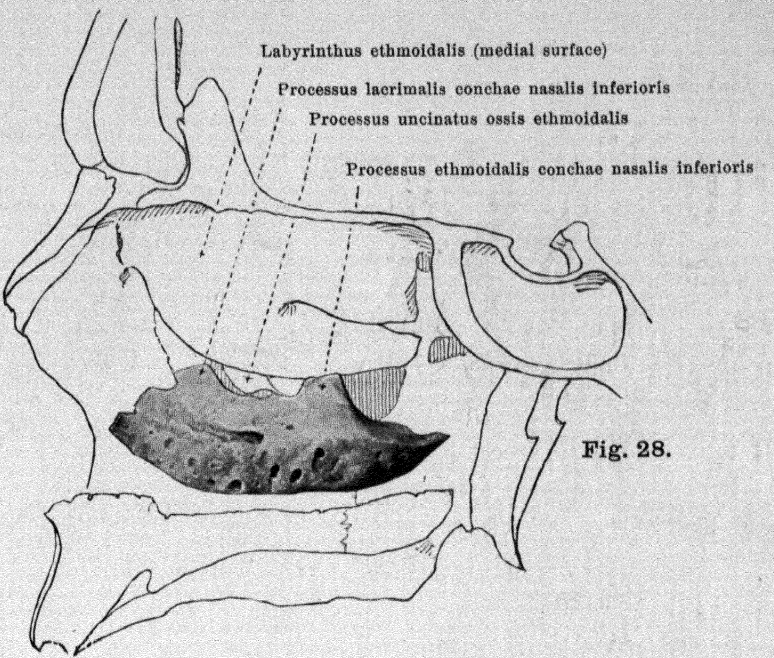


Fig. 28.

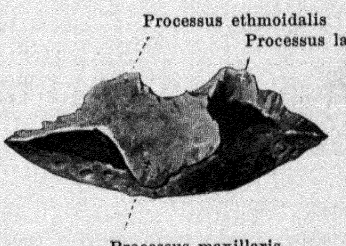
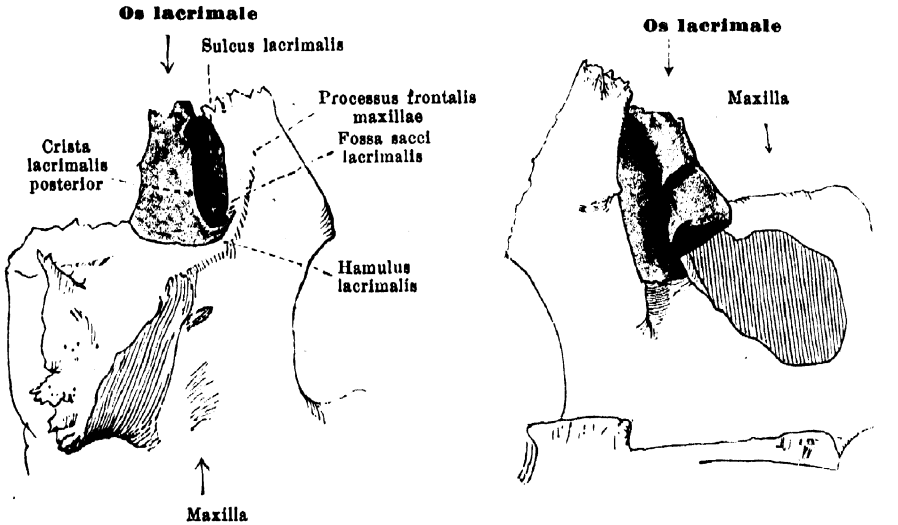


Fig. 29.

28 and 29. Right inferior turbinated bone, *concha nasalis inferior.*

Fig. 28 above, from within. Fig. 29 below, from without.

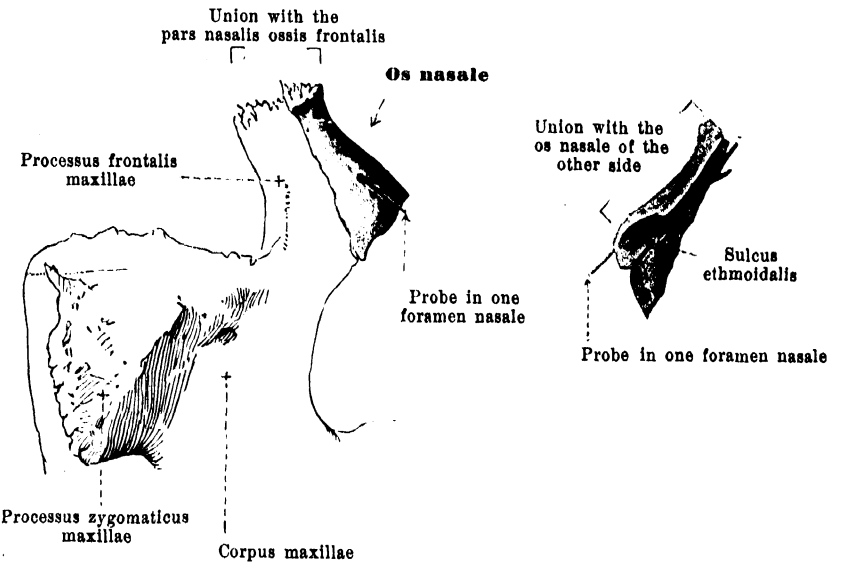
The **concha nasalis inferior** *(inferior turbinated bone)* (see also Fig. 70, 76, 77 and 567) is paired; it lies on each side in the lower part of the lateral wall of the nasal cavity and is placed sagittally in its longest diameter. It is oblong, very porous, bent so as to be convex medianward, and hangs downward as a free mass from its upper attached margin. The inferior border is much thickened and lateralward somewhat rolled. The upper thinner margin is attached in front to the crista conchalis maxillae and gives off close behind this point the *processus lacrimalis,* directed obliquely upward and forward, which unites with the inferior margin of the os lacrimale *(sutura lacrimoconchalis)* and helps the sulcus lacrimalis maxillae (see p. 30) to complete the *canalis nasolacrimalis.* Somewhat further backward the broad *processus maxillaris* projects lateralward and downward, so as to lie on the inferior circumference of the hiatus maxillaris; above this broad process arises the narrower, more irregular *processus ethmoidalis* which passes upward to unite with the processus uncinatus oss. ethmoidalis. The most posterior part of the upper margin is attached to the crista conchalis oss. palatini. (For development see p. 70.)



30 and 31. Right lachrymal bone, *os lacrimale.*

From without. From within.

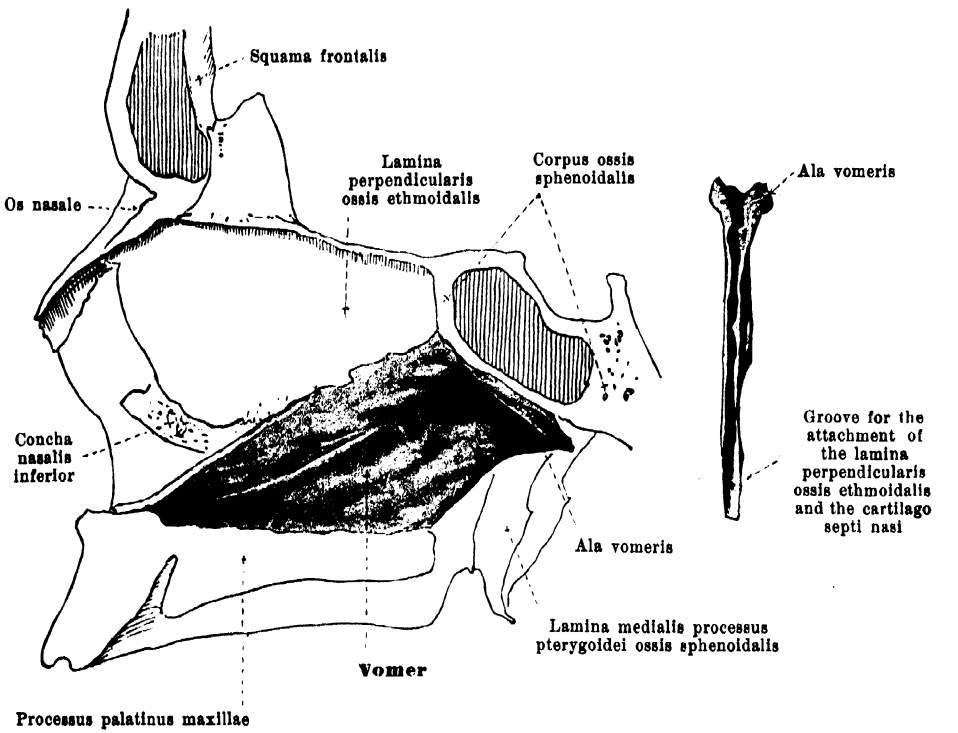
The **os lacrimale** *(lachrymal bone)* (see also Figs. 70—72, 76 and 77) is a paired, oblong, quadrangular, thin platelet of bone, the size of a finger nail, and lies in the anterior part of the medial wall of the orbit. The upper margin unites with the pars orbitalis oss. frontalis *(sutura frontolacrimalis)* (s. p. 19); the posterior margin with the anterior border of the lamina papyracea oss. ethmoidalis; the inferior margin behind with the medial margin of the facies orbitalis of the corpus maxillae *(sutura lacrimomaxillaris)*, in front with the proc. lacrimalis conchae nasalis inferioris *(sutura lacrimoconchalis)*; the anterior margin with the margo lacrimalis of the proc. frontalis maxillae *(sutura lacrimomaxillaris)*. The medial surface is tolerably flat, lies directly on the anterior part of the lateral wall of the ethmoidal labyrinth and forms the lateral wall of the anterior ethmoidal cells; the lateral surface is divided by a crest extending from above downward, the *crista lacrimalis posterior* (O. T. lachrymal crest) (for the origin of the pars lacrimalis m. orbicularis oculi), into a larger posterior level area and a smaller anterior concave area, *sulcus lacrimalis;* the latter forms with the sulcus lacrimalis of the proc. frontalis maxilla, the *fossa sacci lacrimalis* (for the saccus lacrimalis). From the inferior extremity of the crista lacrimalis posterior proceeds the somewhat variable *hamulus lacrimalis* (O. T. hamular process) lateralward, forward and downward; it is inserted in the incisura lacrimalis on the medial anterior margin of the orbital surface of the body of the maxilla. (For development see p. 70.)



32 and 33. Right nasal bone, *os nasale.*

From without. From within.

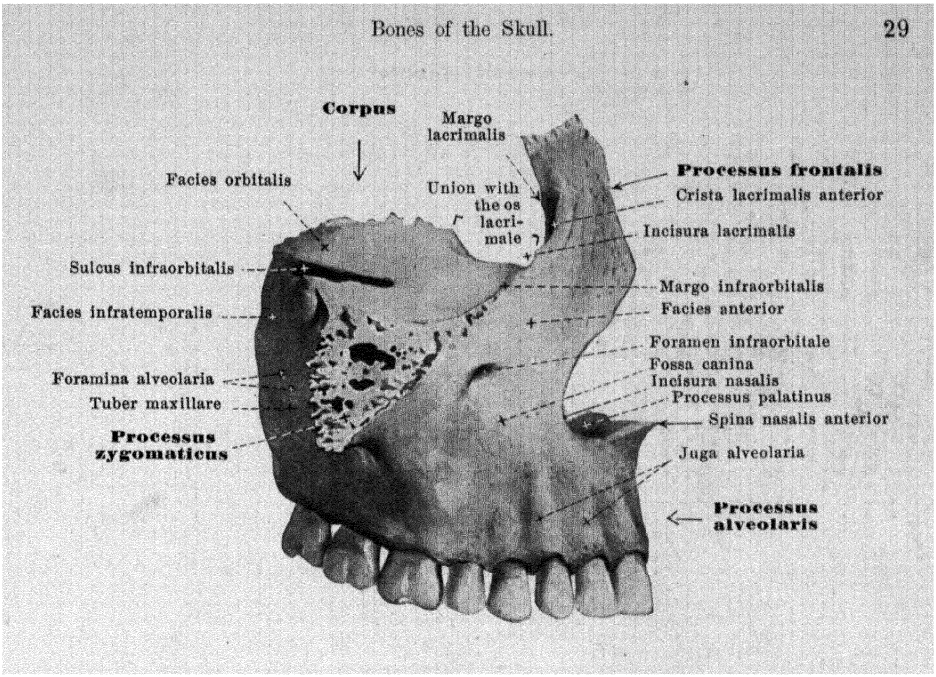
The **os nasale** *(nasal bone)* (see also Figs. 59, 60, 70, 76—78) is paired and forms with that of the other side the root of the nose and the upper part of the back of the nose. It is a small, oblong, quadrangular bone thicker and narrower above, thinner and broader below. The nasal bones of the two sides are attached to one another by their medial, slightly serrated borders to form the *sutura internasalis;* the upper serrated border unites with the margo nasalis of the pars nasalis oss. frontalis to form the *sutura nasofrontalis;* the lateral, somewhat bevelled margin forms with the anterior margin of the processus frontalis maxillae the *sutura nasomaxillaris;* the inferior, bevelled, irregularly serrated margin unites with the lateral nasal cartilage and projects somewhat in front of it, see Figs. 977 and 980; in the macerated skull, however, it lies free and helps to bound the apertura piriformis. The anterior surface is smooth and usually slightly curved like a saddle. The posterior surface in its upper portion is attached from in front to the spina frontalis oss. frontalis; in its lower portion it is smooth and helps to form the bony part of the anterior wall of the nasal cavity; there is seen also the *sulcus ethmoidalis* (O. T. groove for nasal nerve) (for the n. ethmoidalis anterior). The nasal bone is often perforated by one or several small openings *foramina nasalia,* for blood-vessels. (For development see p. 70.)



34 and 35. Plough-share bone, *vomer.*

From the left. From in front.

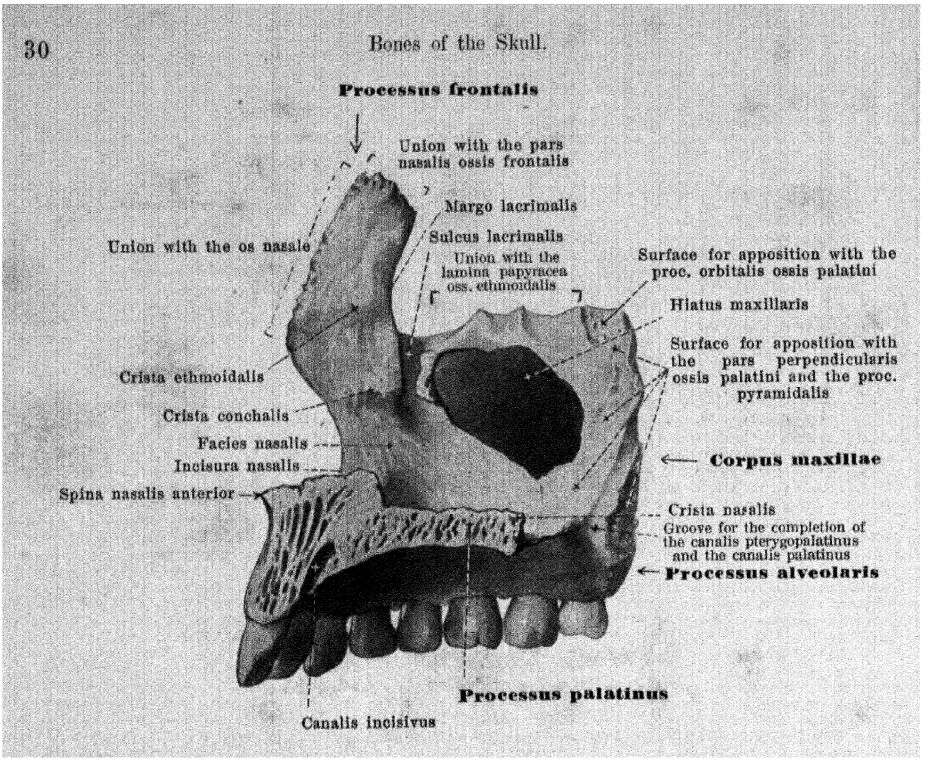
The **vomer** *(plough-share bone)* (see also Figs. 78 and 979) is an unpaired, oblong, quadrangular, flat bone which lies in the median plane and forms the posterior part of the nasal septum. It is usually bent somewhat to one side, but never at its posterior margin. Its upper margin is broad and is split into two thick laterally directed leaves *(alae vomeris)*, each of which is attached by its free margin to the proc. vaginalis of the proc. pterygoideus oss. sphenoidales and to the proc. sphenoidalis oss. palatini. The two wings of the vomer leave a groove between them in which is placed the rostrum sphenoidale. The posterior margin is smooth, thin and lies free. The inferior margin is sharp and serrated, and adjoins the crista nasalis of the united palate bones and upper jaw bones. The anterior margin, which is also the upper, is somewhat thickened and hollowed out to form a groove; it unites behind with the inferior margin of the perpendicular plate of the ethmoid bone, in front with the cartilaginous nasal septum (see Fig. 979). (For development see p. 70.)



36. Right upper jaw bone, *maxilla,* from without.

The **maxilla** (O. T. *superior maxillary bone)* (see also Figs. 37, 38, 57—62, 69—78) is paired, lies in the upper anterior part of the facial skull and is divisible into a ***corpus*** or body and four processes of which two the ***processus frontalis*** and ***processus zygomaticus,*** belong to the upper part, while the two others, the ***processus alveolaris*** and the ***processus palatinus,*** belong to the lower part. (For development see p. 70.)

The **corpus** or ***body*** (see also Figs. 37, 38, 57—60 and 69—75) is quadrangular in shape and contains within it a large cavity, ***sinus maxillaris,*** see Fig. 567 (O. T. antrum of Highmoore) lined by mucous membrane, the entrance to which, ***hiatus maxillaris,*** is situated on the nasal surface. The upper surface, ***facies orbitalis (planum orbitale)*** is smooth, triangular, directed obliquely forward, outward and downward and forms the floor of the orbit; its medial border unites behind with the lamina papyracea oss. ethmoid. ***(sutura ethmoideomaxillaris),*** in front with the lachrymal bone ***(sutura lacrimomaxillaris);*** the anterior border is smooth medianward, lying free as the ***margo infraorbitalis,*** while lateralward it is serrated and goes over into the proc. zygomaticus; the posterior border is for the most part smooth, lies free, and forms with the inferior margin of the orbital surface of the large wing of the sphenoid running parallel to it, the ***fissura orbitalis inferior*** (for the a. infraorbit., v. ophthalm. inf.; nn. zygomat., infraorbit.). From this point forward on the upper surface extends a groove ***(sulcus infraorbitalis)*** closed by periosteum, which gradually becomes deeper and is continued into the ***canalis infraorbitalis*** (both for the a. infraorbit.); n. infraorbit.): branching off from this are the very minute ***canales alveolares*** (for the aa. alveol. sup. ant.; rr. alveol. sup. medius et anteriores n. infraorbit.), which run within the anterior wall of the body of the bone. Upon and beneath the posterior medial angle of the facies orbitalis is attached the proc. orbital. oss. palat. ***(sutura palatomaxillaris).*** The posterior surface ***facies infratemporalis*** (O. T. zygomatic surface), looks into the fossa infratemporalis and pterygopalatina, is slightly rough, often bulged out ***(tuber maxillare)*** and there gives origin to parts of the mm. pterygoidi; it presents from two to three small openings, ***foramina alveolaria,*** which lead into canals passing forward, the ***canales alveolares*** (O. T. posterior dental canals) for the a. alveol. sup. post.; nn. alveol. sup.) which run forward in the lateral wall and are connected with the anterior canales alveolares. The anterior surface, ***facies anterior*** (O. T. external or facial surface), presents above the ***foramen infraorbitale,*** the opening of exit of the canalis infraorbit.; beneath it a variable depression, ***fossa canina*** (for the m. caninus). There arise also in front several muscles, the caput infraorbit. m. quadrat. labii sup., m. nasalis, m. incisivus, m. buccinat. Medianward the facies anterior runs out into a sharp margin, the ***incisura nasalis.***

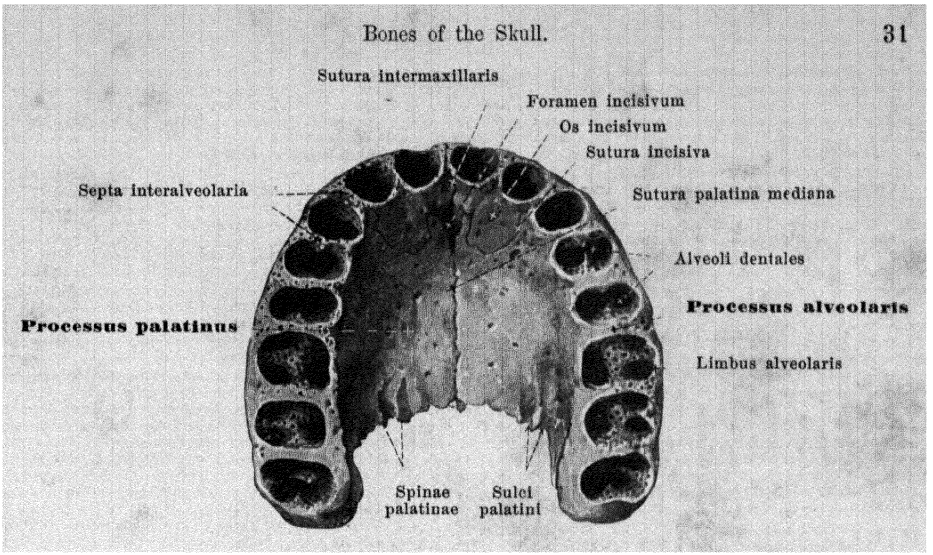


37. Right upper jaw bone, *maxilla,* from within.

The *facies nasalis* of the **corpus maxillae** (see also Figs. 76 and 77) is placed sagittally and helps to form the lateral wall of the nasal cavity. A large opening in it, the *hiatus maxillaris,* leads into the *sinus maxillaris* (O. T. antrum of Highmore). The slightly rough field behind the hiatus has attached to it the facies maxillaris of the pars perpendicularis oss. palatini and presents usually a smooth perpendicular groove for the completion of the canalis pterygopalatinus, occasionally also of the canalis palatinus; the area behind this groove serves for apposition with the proc. pyramidalis oss. palatini. In front of the hiatus in the upper part passing downward from the posterior margin of the proc. frontalis is the *sulcus lacrimalis* which is closed to form the *canalis nasolacrimalis* (O. T. lachrymal groove) by the attachment to it medianward of the os lacrimale above and the proc. lacrimalis conchae nasalis inferioris below. See Figs. 29 and 31. In front of this the *crista conchalis* (for union with the upper border of the concha nasalis inferior) runs approximately horizontally forward. The anterior margin, *incisura nasalis,* helps to bound the *apertura piriformis.*

The **processus frontalis** (O. T. *nasal process)* (see also Figs. 36, 57—60, 69—72, 76 and 77) ascends in front from the upper margin of the facies nasalis and facies anterior. Its upper, thick, serrated margin lies upon the pars nasalis oss. frontalis *(sutura frontomaxillaris);* the anterior, sharp, slightly serrated margin unites with the os nasalis *(sutura nasomaxillaris).* The posterior broad margin presents a groove, *sulcus lacrimalis,* which leads downward on the facies nasalis of the body (vide supra); it is bounded medianward by the *margo lacrimalis,* to which is attached the anterior margin of the lachrymal bone *(sutura lacrimomaxillaris);* lateralward by the slight *crista lacrimalis anterior,* which goes over into the margo infraorbitalis; behind this point of transition is situated the *incisura lacrimalis,* of variable depth, in which is placed the hamulus lacrimalis oss. lacrimalis. The lateral surface is smooth; on the medial, running from behind forward, is the *crista ethmoidalis* (for apposition with the anterior extremity of the medial surface of the labyrinth).

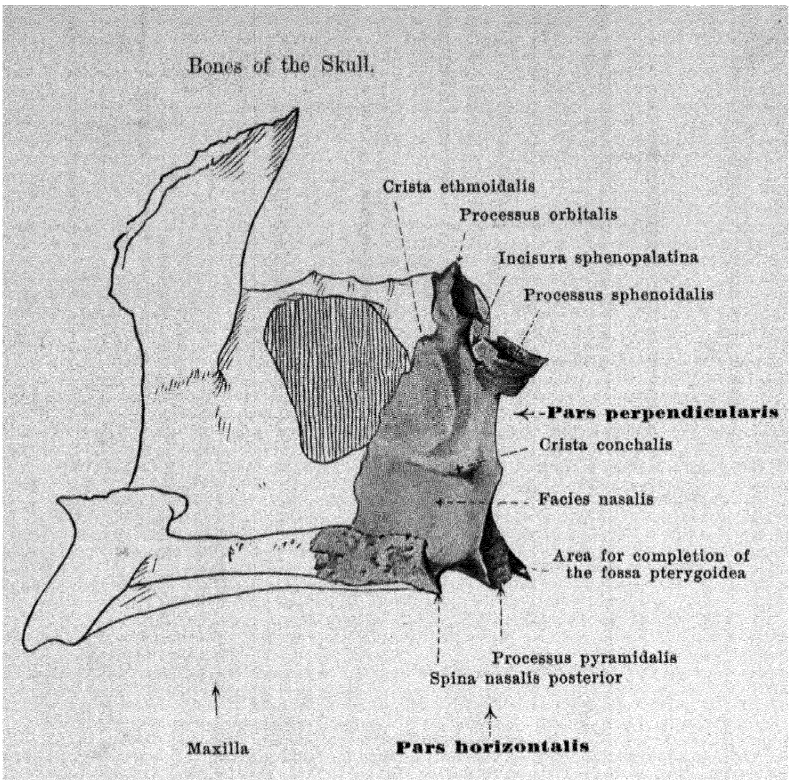
The short, broad **processus zygomaticus** (O. T. *malar process)* (see also Figs. 36, 59, 60 and 71—74) proceeds from the lateral upper angle of the body of the upper jaw and is generally hollowed out inside for a bulging of the sinus maxillaris. Its surface is rough, sometimes incomplete, namely when the sinus maxillaris extends to the os zygomaticum, and unites with the os zygomaticum to form the *sutura zygomatico-maxillaris.*



38. The two upper jaw bones, *maxillae,* united, from below.

The **processus palatinus** (see also Figs. 37, 61, 62, 76—78 and 567 is a transversely placed plate of bone which goes off medianward from the inferior margin of the facies nasalis and helps to form the bony septum between the nasal and the buccal cavity. At the medial rough margin the two maxillae unite with one another to form the *sutura palatina mediana;* above the same on each maxilla runs a ridge, *crista nasalis,* the union of the two ridges serving for the attachment of the vomer and the cartilage of the septum of the nose. (See also Fig. 979.) The posterior margin lies on the anterior border of the pars horizontalis oss. palatini *(sutura palatina transversa).* The upper surface is smooth and slightly concave in frontal direction; the inferior surface is rougher and presents near the posterior extremity usually two *sulci palatini* (for the branches of the a. palatina major) bounded by small ridges, *spinae palatinae.*

The **processus alveolaris** (see also Figs. 36, 37, 57—62, 67—70 and 567) is dependent in its development on that of the teeth and extends downward like an arch convex in front and externally, concave behind and internally, from the lower margin of the body; it forms together with the other maxilla a half elliptical arch. The broader, free, inferior margin, *limbus alveolaris,* contains eight tooth cavities, *alveoli dentales,* which are separated from one another by the *septa interalveolaria;* they have wide mouths and grow narrower in the depth; they are exact impressions of the corresponding roots of the teeth. The anterior surface of the proc. alveolaris presents oblong projections, *juga alveolaria,* corresponding to the anterior five alveoli. The portion of the bone lying most medianward including the most anterior two (incisor-teeth) alveoli represents what is in the foetus a special bone *(os incisivum)* (see also p. 70) which fuses early with the rest of the bone; remains of the suture originally present at the site of union, the *sutura incisiva,* are usually distinct in the newborn, sometimes also in the adult; medianward they extend, arch-like, backward to an unpaired opening, *foramen incisivum,* situated on the inferior surface of the combined proc. palatini; from it proceeds upward the symmetrically forking *canalis incisivus* (for branches of the a. palatina major, branches of the n. nasopalatinus) and ends on the upper surface of each proc. palatinus by an opening on each side. The two processus alveolares unite in the median plane by the *sutura* intermaxillaris, the anterior continuation of the sutura palatina mediana; above this suture there is continued forward on each upper jaw, the *crista nasalis* (nasal crest); it is higher in the region of the sutura intermaxillaris than it is behind and ends behind in the vomer and in front in a projection, the *spina nasalis anterior.*

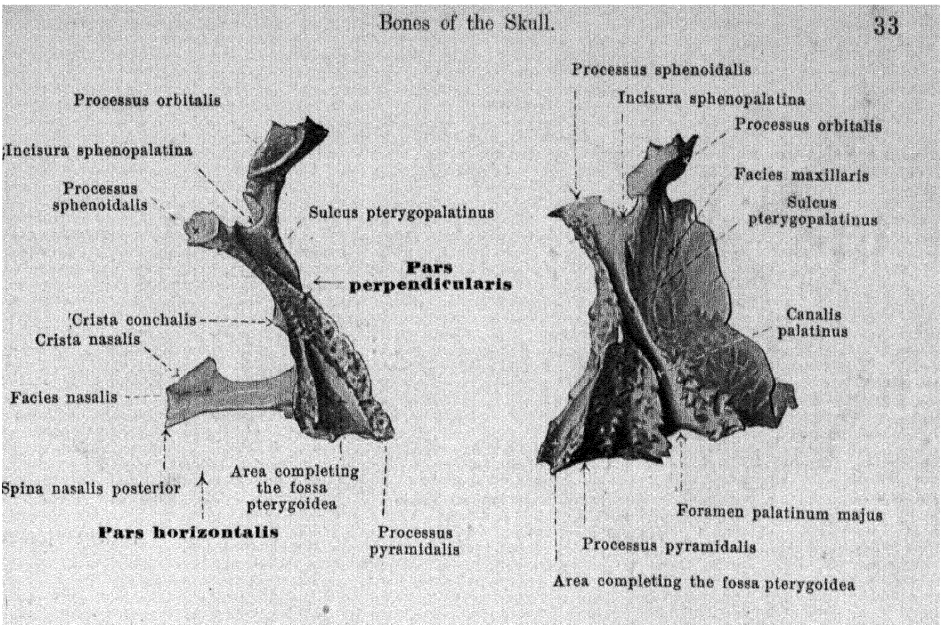


39. Right palate bone, *os palatinum,* from within.

The paired **os palatinum** *(palate bone)* (see also Figs. 40, 41, 61, 62, 70—72 and 74—77) lies in the posterior part of the nasal cavity and there forms a part of the floor of the same (of the hard palate) and of the lateral wall. It presents for examination a *pars horizontalis* and a *pars perpendicularis.* (For development see p. 70.)

The **pars horizontalis** (O. T. *horizontal plate)* (see also Figs. 40, 61, 62 and 76—78) is very similar to the proc. palatinus maxillae, only shorter; the upper surface *(facies nasalis),* is smooth and slightly concave; the lower surface *(facies palatina)* (see Figs. 61 and 62), is somewhat rough and presents near the posterior margin a small sickle-shaped elevated surface for the attachment of the m. tensor veli palatina. The anterior, slightly serrated margin lies on the posterior border of the proc. palatinus maxillae and forms with this the *sutura palatina transversa.* The medial margin unites with the corresponding border of the bone of the other side and forms the posterior part of the *sutura palatina mediana;* on the upper surface of this border the *crista nasalis* (for union with the vomer) projects upward and runs out behind into the *spina nasalis posterior.* The posterior margin is smooth and concave.

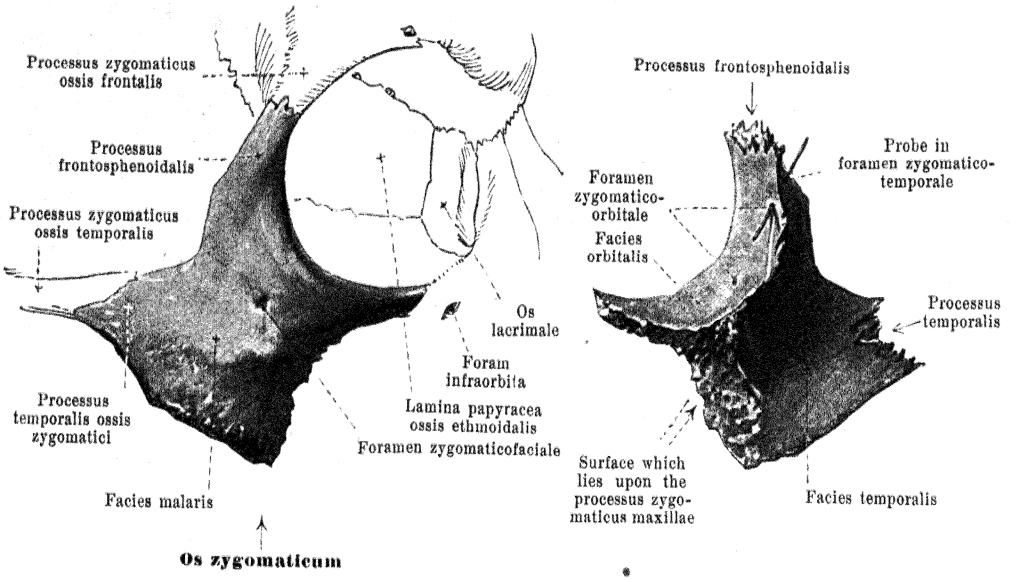
From the lateral part of the posterior margin projects backward the strong *processus pyramidalis* (see also Figs. 40, 41, 61, 62, 69—70). It is more or less inserted in front into the fissura pterygoidea oss. sphenoidalis, so that its posterior surface with a smooth area helps to complete the internal part of the fossa pterygoidea; on each side of this smooth area, the posterior surface is rough and is united with the proc. pterygoideus. The external anterior, rough surface unites with the posterior portion of the corpus maxillae just above the eighth alveolus. The edge between the posterior and the lateral surface sometimes helps, also to form the fossa infratemporalis (see Fig. 70), and then possesses a smooth surface. The medial, smooth surface looks into the nasal cavity. The inferior surface belongs to the lower surface of the hard palate and contains usually three openings, of which the *foramen palatinum majus* lies furthest forward, the others, *foramina palatina minora,* lie further backward (see Fig. 61). These are the outlets of the sulci palatini on the hard palate (see p. 31), and also the openings of the canales palatini (for the aa. palatinae major et minores; nn. palatini); they usually pierce the proc. pyramidalis perpendicularly, but occasionally, especially the longest of them, run between the plate and the upper jaw, so that there is a corresponding groove on each of the bones.



40 and 41. Right palate bone, *os palatinum.*

From behind. From without.

The **pars perpendicularis** (O. T. *(vertical plate)* (see also Fig. 39, 70—72 and 74—77) ascends as a thin leaf of bone vertically upward from the lateral margin of the pars horizontalis. The medial *facies nasalis* is smooth and presents two ridges extending from before backward, an upper, shorter, *crista ethmoidalis* (O. T. superior turbinated crest), for the attachment of the posterior, free end of the concha nasalis media, and a lower, *crista conchalis* (O. T. inferior turbinated crest), for union with the concha nasalis inferior (see Fig. 77). The lateral surface, *facies maxillaris,* is for the most part rough and unites in front with the posterior, rough portion of the facies nasalis corporis maxillae, so that it covers over a portion of the hiatus maxillaris from behind (see Fig. 70); it is attached behind to the anterior margin and the medial surface of the lamina medialis proc. pterygoidei oss. sphenoidalis. Between these two areas, extending from above downwards, is the smooth, shallow *sulcus pterygopalatinus.* Through the attachment of the lateral surface to the two bones mentioned this forms together with the sulcus pterygopalat. of the proc. pteryg. oss. sphenoidalis and a groove on the upper jaw bone, above, the *fossa pterygopalatina,* open lateralward (for the aa. maxill. int., palat. descendens, sphenopalat.; nn. maxillaris zygomat., sphenopalat., alveol. sup., infraorbit.; rr. alveolares superiores posteriores, gangl. sphenopalat.), below, the *canalis pterygopalatinus* (O. T. posterior palatine canal) (for the a. palat. descendens; nn. palat., rr. nasal. post. inf. gangl. sphenopalat.), closed also externally by the proc. pterygoideus oss. sphenoid. and the upper jaw; it is continued below into the *canales palatini* (see p. 32) (for the aa. palatinae major et minores; nn. palat.) which usually run in the proc. pyramidalis alone. From the upper margin of the pars perpendicularis extend two processes, the *processus sphenoidalis* bent somewhat backward and markedly medianward, which lies on the inferior surface of the body of the sphenoid and on the ala vomeris, and the *processus orbitalis* forward and somewhat lateralward. The latter is bulged out and contains a small cavity, the posterior part of a posterior ethmoidal cell which projects into the proc. orbitalis. Its lateral, upper, smooth surface forms the most posterior part of the floor of the orbit (see Fig. 70); in front and below it meets the facies orbitalis corporis maxillae *(sutura palatomaxillaris),* in front and above the lamina papyracea oss. ethmoid. *(sutura palatoethmoidalis),* behind, and above the anterior margin of the lateral surface of the body of the sphenoid *(sutura sphenoorbitalis);* behind and below it lies free and helps in part to form the medial portion of the *fissura orbitalis inferior,* in part it looks into the fossa pterygopalatina. Between the proc. sphenoid. and the proc. orbital. lies the *incisura sphenopalatina,* which is closed by the attachment of the bone to the under surface of the body of the sphenoid forming the *foramen sphenopalatinum* (for the a. sphenopalat.; rr. nasal. poster. super. lateral et medial. gangl. sphenopalat).

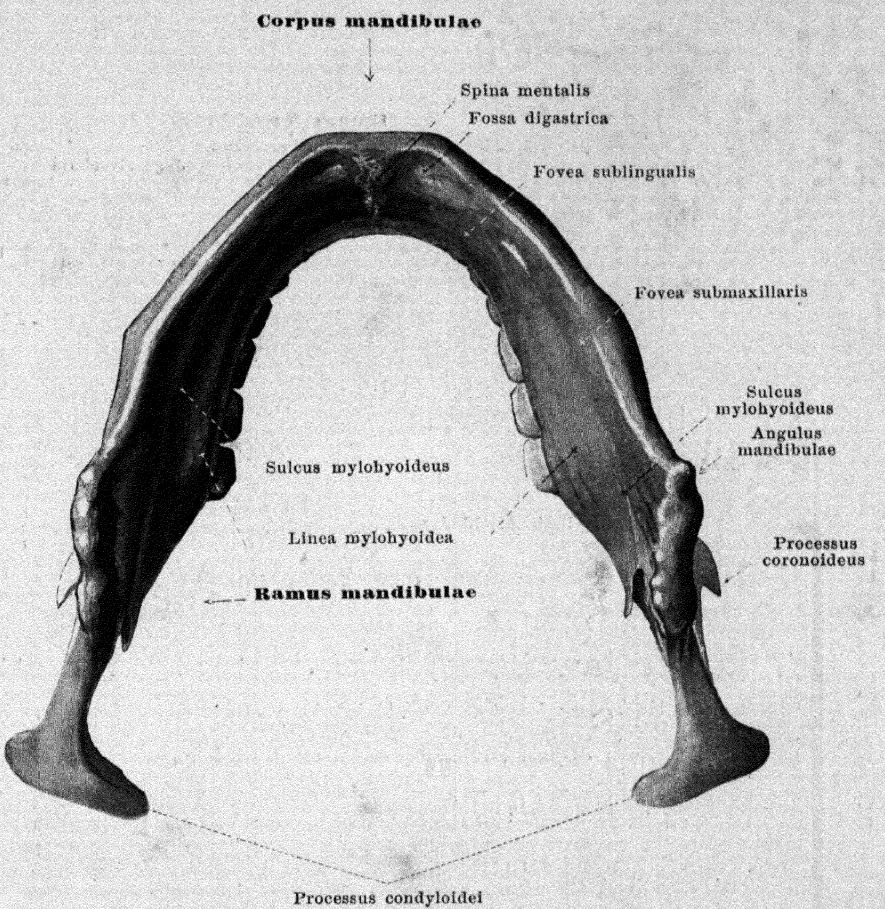


42 and 43. Right yoke bone, *os zygomaticum.*

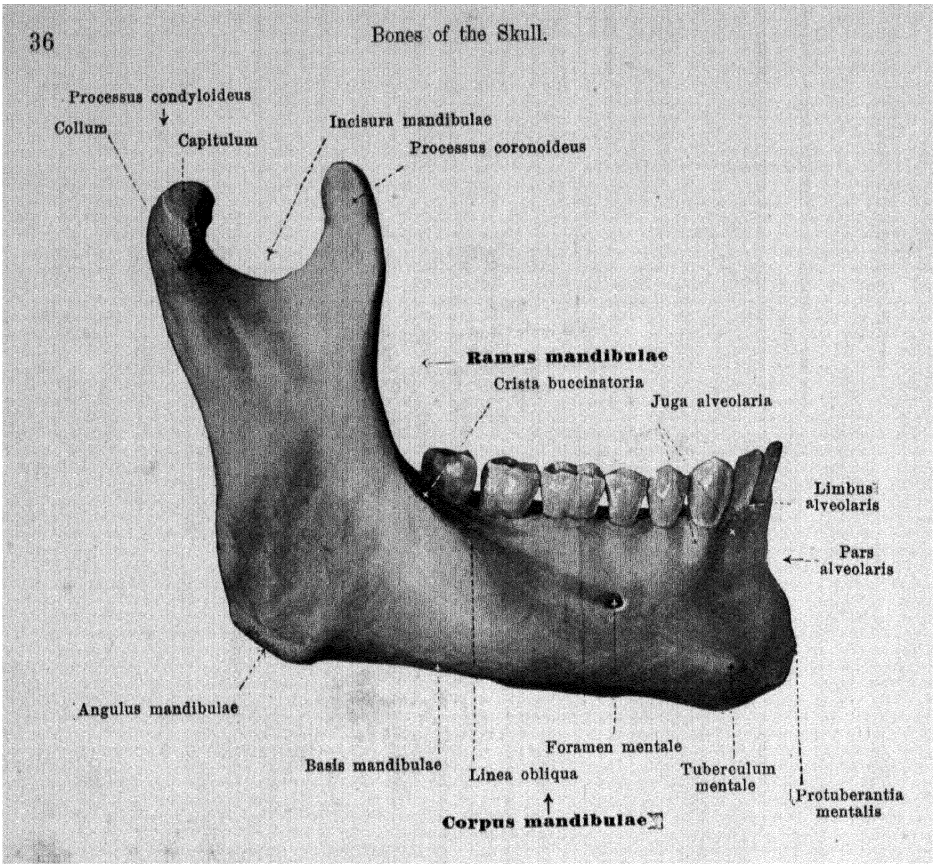
From without. From within.

The **os zygomaticum** or *yoke bone* (O. T. malar bone) (see also Fig. 57—62 and 71—74), is paired and lies in the lateral part of the facial skull. It has three surfaces. The laterally directed *facies malaris* is quadrangular, fairly smooth, markedly convex and presents the *foramen zygomaticofaciale* (O. T. malar foramen). The concave *facies orbitalis*, directed medianward and forward, helps to form the lateral and inferior wall of the orbit and meets the facies malaris, forming a markedly curved concave margin, which below completes the *margo infraorbitalis*, and above forms the lateral margin of the aditus orbitae. The medial inferior margin of the facies orbitalis unites with the lateral angle of the facies orbitalis corporis maxillae *(sutura zygomaticomaxillaris)* and forms in half the cases the lateral boundary of the fissura orbitalis inferior, see Fig. 73; the medial upper margin lies upon the margo zygomaticus of the ala magna oss. sphenoidalis *(sutura sphenozygomatica)*. On the facies orbitalis can be seen the single or double *foramen zygomaticoorbitale* (O. T. temporo-malar canals), the entrance to a canal bifurcating in the bone (sometimes double from the beginning), the divisions of which perforate the bone and end on the facies malaris in the foramen zygomaticofaciale and the facies temporalis in the foramen zygomaticotemporale (for the r. zygomaticofacialis and r. zygomaticotemporalis n. zygomatici). The *facies temporalis* looks downward and medianward, is curved so as to be markedly concave and forms the anterior part of the fossa temporalis. Here the *foramen zygomaticotemporale* is visible medianward; it adjoins a rough surface for broad union with the proc. zygomaticus corporis maxillae *(sutura zygomaticomaxillaris)*. Sometimes the sinus maxillaris extends to this surface; in that case it presents a smooth surface.

At the upper angle of the facies malaris lies the *processus frontosphenoidalis* (O. T. frontal process), in front for union with the proc. zygomaticus oss. frontalis *(sutura zygomaticofrontalis)*, behind with the large wing of the sphenoid (vide supra). From the posterior angle of the bone goes off the slim *processus temporalis* (O. T. zygomatic process), which unites with the proc. zygomaticus oss. temporalis by a serrated suture *(sutura zygomaticotemporalis)* to form the *arcus zygomaticus*. (For development see p. 70.)



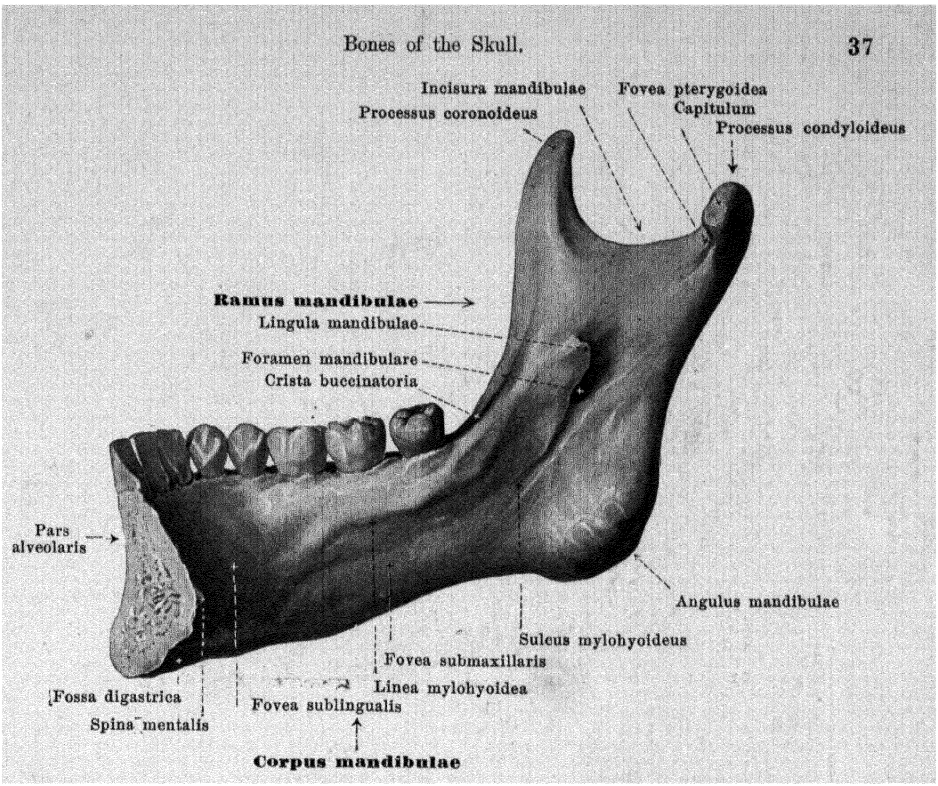
44. Lower jaw bone, *mandibula*, from below.



45. Lower jaw bone, *mandibula,* right half, from without.

The **mandibula** *(lower jaw bone),* (O. T. inferior maxillary) (see also Figs. 44, 46—52, 57—60, 67 and 68) is unpaired and forms the inferior anterior part of the facial skull. It consists of the parabolically curved *corpus,* and two *rami,* which ascend from the ends of the corpus. (For development see p. 71.)

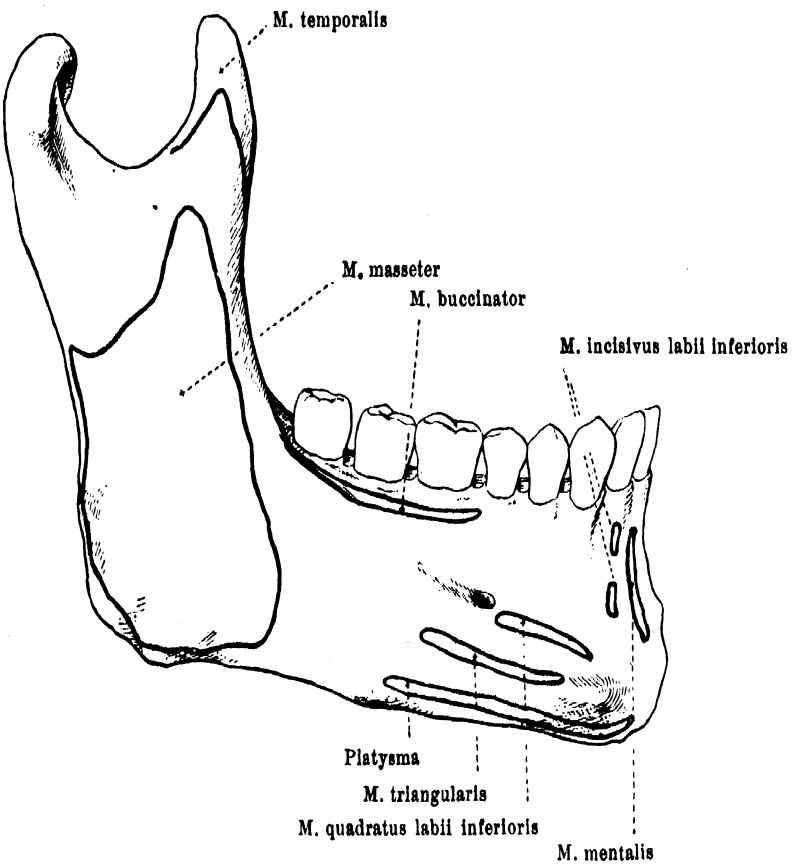
The **corpus mandibulae** *(body of lower jaw)* (see also Figs. 44, 46—52, 57—60, 67 and 68) consists originally of two halves united with one another in the median plane, the union taking place in the first or second year of life. The point of union is often indicated by a groove. Each half represents a mass of bone which is higher than it is thick, and curved in front so as to be markedly convex externally. Its inferior margin, *basis mandibulae,* is somewhat thickened and rounded; close above this, near the median plane, is situated the somewhat roll-shaped, transversely placed *protuberantia mentalis* (O. T. mental process), which, lateralward, runs out into the *tuberculum mentale.* Somewhat lateralward and upward from the latter a round *foramen mentale* (for the a. mentalis; n. mentalis) is visible; it is usually situated below the alveolus of the second praemolar, about half-way between the base and the upper margin. Beneath it, or somewhat further back, begins the *linea obliqua* (O. T. external oblique line) extending obliquely upward to the anterior margin of the ramus. The upper part of the body, *pars alveolaris,* dependent in development upon that of the teeth, is bounded above by a narrow border, the *limbus alveolaris.* It contains on each side eight, altogether then sixteen, *alveoli dentales* which are separated from one another by thin *septa interalveolaria;* the alveoli are wide at the opening and become narrower in the depth, being exact impressions of the roots of the teeth which they hold. Oblong projections, *juga alveolaria,* usually caused by the three anterior alveoli only, are observable on the outer surface. The medial surface of the corpus presents, close to the median plane, the single or double, short *spina mentalis* (O. T. genial tubercles) (for the mm. geniohyoid., geniogloss.) and on each side below it, somewhat lateralward, the *fossa digastrica* (for the m. digastricus).



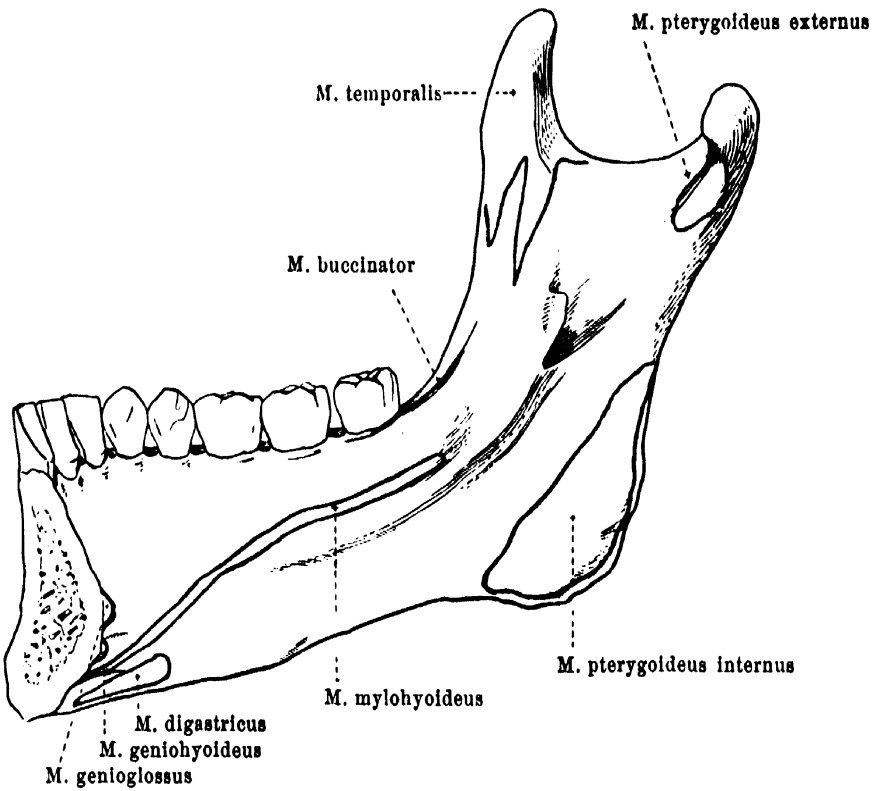
46. Lower jaw bone, *mandibula*, right half, from within.

Above the fossa digastrica on each side begins the ***linea mylohyoidea*** (O. T, internal oblique line) (for the mm. mylohyoid., mylopharyng.), which ascends obliquely backward to the medial surface of the ramus. Above the medial part of the latter lies the ***fovea sublingualis*** (O. T. sublingual fossa) (for the gland. subling.), usually distinctly marked; beneath the lateral portion, often less well indicated, the ***fovea submaxillaris*** (O. T. submaxillary fossa) (for the gland submax.). Extending forward and downward from the foramen mandibulare (see below), below the lateral part of the linea mylohyoidea, is the ***sulcus mylohyoideus*** (for the r. mylohyoid. a. alveol. inf.; n. mylohyoid.).

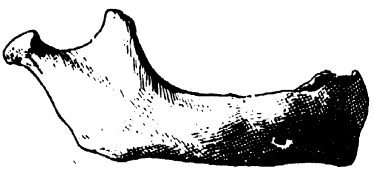
The **ramus mandibulae** (O. T. perpendicular portion) (see also Figs. 44, 45 and 57—60) is a broad plate of bone which extends from the posterior end of the body perpendiculary upward or obliquely backward. Its posterior, thicker margin forms with the basis corporis the ***angulus mandibulae;*** its anterior margin begins laterally at the posterior end of the linea obliqua, medianly at the last alveolus, with a small triangular surface on which is often visible the ***crista buccinatoria*** (for the m. buccinat.). The lateral surface is smooth, the medial presents about its middle an opening, ***foramen mandibulare*** (O. T. inferior dental foramen), which is bounded medianward by a small leaflet of bone, the ***lingula mandibulae.*** In the foramen mandibulare begins the ***canalis mandibulae*** (O. T. inferior dental canal) (for the a. alveol. inf.; n. alveol. inf.) which extends, within the spongiosa of the bone, arch-like, downward and forward as far as the alveolus of the medial incisor; it is wide as far as the foramen mentale through which it opens outwards; from there medianward it is narrow; at the foramen mandibulare the ***sulcus mylohyoideus*** (see above) also begins. The upper end of the ramus supports two processes separated from one another by the ***incisura mandibulae*** (O. T. sigmoid notch); the anterior, ***processus coronoideus,*** (for the insertion of the m. temporal.) is bent backward somewhat hook-like, the posterior, ***processus condyloideus,*** serves for articulation of the lower jaw with the rest of the skull and supports a roller-like ***capitulum mandibulae,*** covered over with cartilage in its anterior division, the long axis of which converges with that of the other side backward toward the anterior circumference of the foramen occipit. magnum. The capitulum sits upon a narrower neck. ***collum (proc. condyloidei) mandibulae,*** and this presents in the medial part of its anterior surface the ***fovea pterygoidea proc. condyloidei*** (for the attachment of the m. pterygoid. ext.).



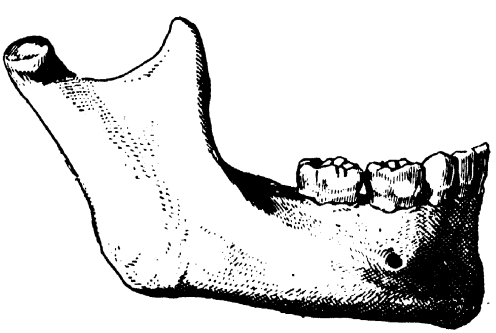
47. Lower jaw bone, *mandibula*, right half, from without, showing muscular attachments.



48. Lower jaw bone, *mandibula*, right half, from within, showing muscular attachments.



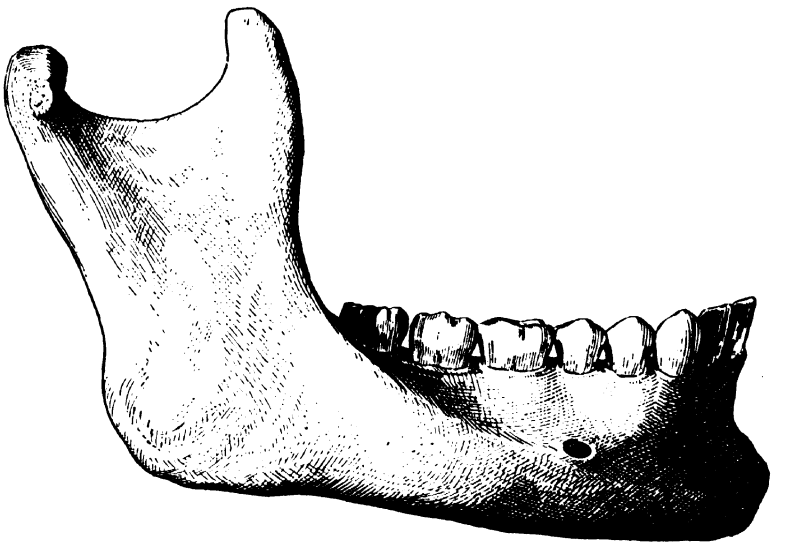
49. Newborn.



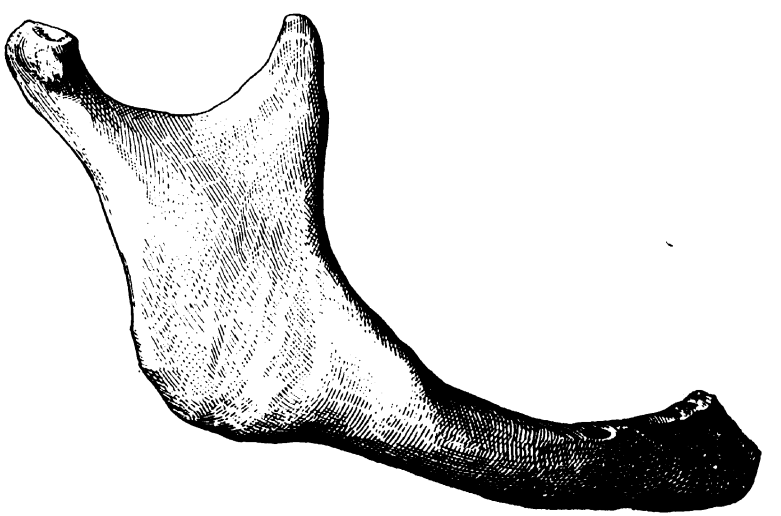
50. 6—7 year old child.

49—52. Lower jaw bones, *mandibulae,*

at different ages of life, figures drawn to uniform scale.



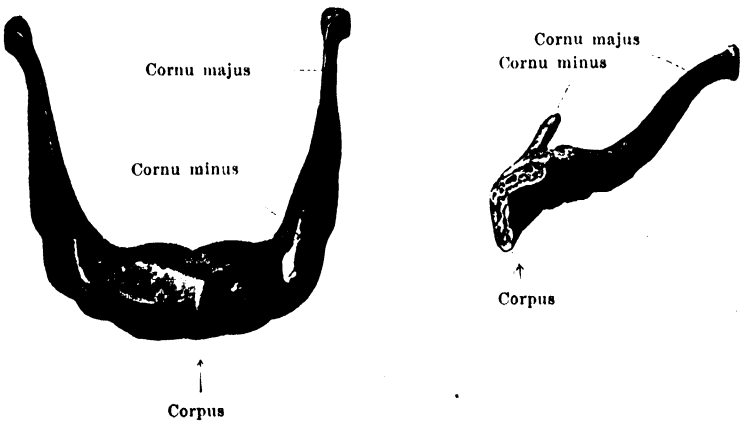
51. Adult.



52. Old age.

49—52. Lower jaw bones, *mandibulae,*

at different ages of life, figures drawn to uniform scale.



53 and 54. Hyoid bone, *os hyoideum.*

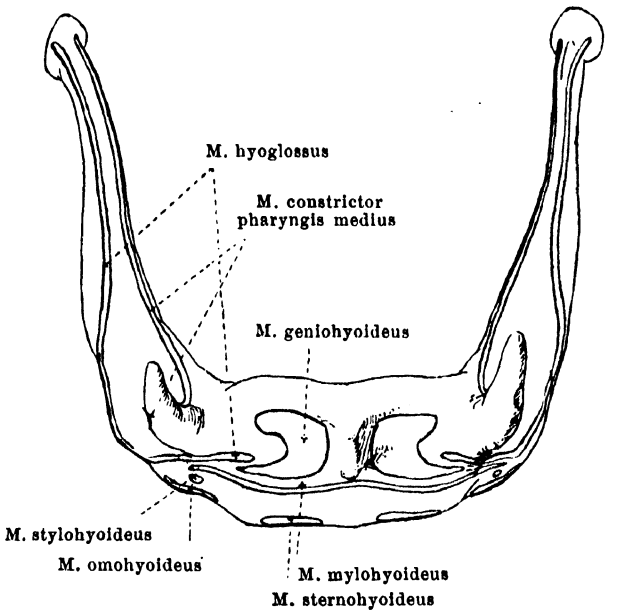
From above. Right half, from the left.

The **os hyoideum** *(hyoid bone)* lies as an unpaired, horse-shoe-shaped bone behind and below the lower jaw between the muscles, without direct connection with the other bones. It is divisible into a middle piece or *corpus,* two *cornua majora* and two *cornua minora.* (For development see p. 71.)

The **corpus** *(body)* is a transversely placed oblong plate with an anterior surface, bent so as to be convex in front and above, and a concave posterior surface. The anterior surface presents variably developed ridges for the muscular attachments, the posterior is smooth. At the lateral ends are small fossae, below for union with the cornua majora, above for the cornua minora.

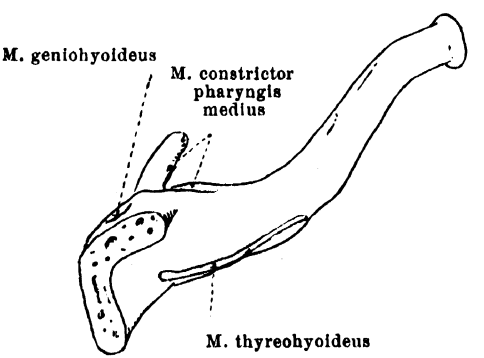
The **cornua majora** are thin, laterally flattened plates of bone, longer than the body. They are placed horizontally or directed obliquely upward, are united in front with the body by means of a narrow plate of cartilage or by a small joint with a joint cavity and a tight capsule. Behind, each ends in a small button-like projection. These merge in middle life with the corpus.

The **cornua minora** are small pieces, sometimes remaining cartilaginous, which are attached above near the point of union of the body and the cornua majora, either by means of a small joint with joint cavity and loose capsule or by ligamentous union only. They are surrounded by the end of the *ligamentum stylohyoideum* (see Fig. 605), a thin round elastic fibrous ligament which extends from the processus styloideus oss. tempor. interwoven in the deep layer of the cervical fascia. Sometimes it contains masses of bone, the single pieces being more or less separated from one another. The processus styloideus, the lig. stylohyoideum and the cornu minus oss. hyoid. arise from the second branchial arch of the embryo.



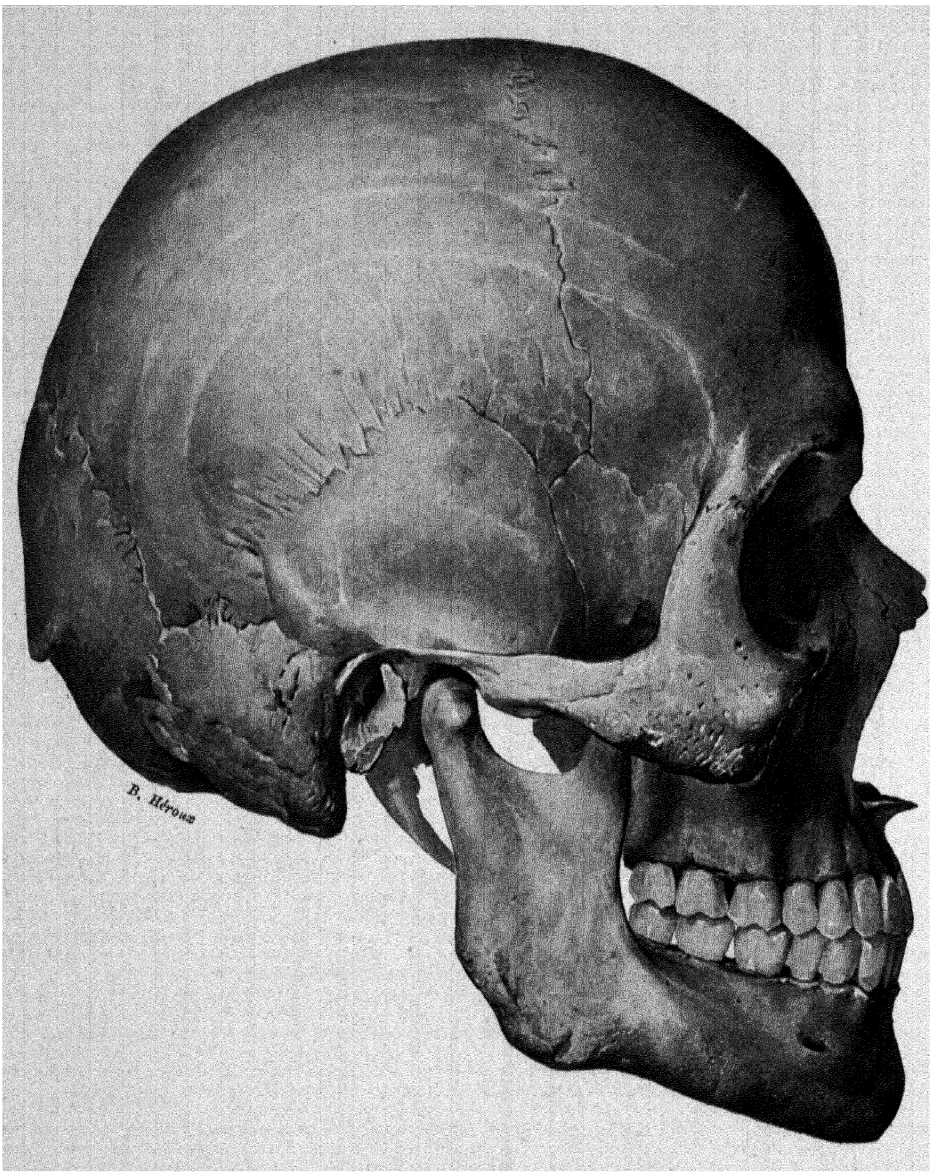
55. Hyoid bone, *os hyoideum,* from above, with muscular attachments.

Magnification 3 : 2.

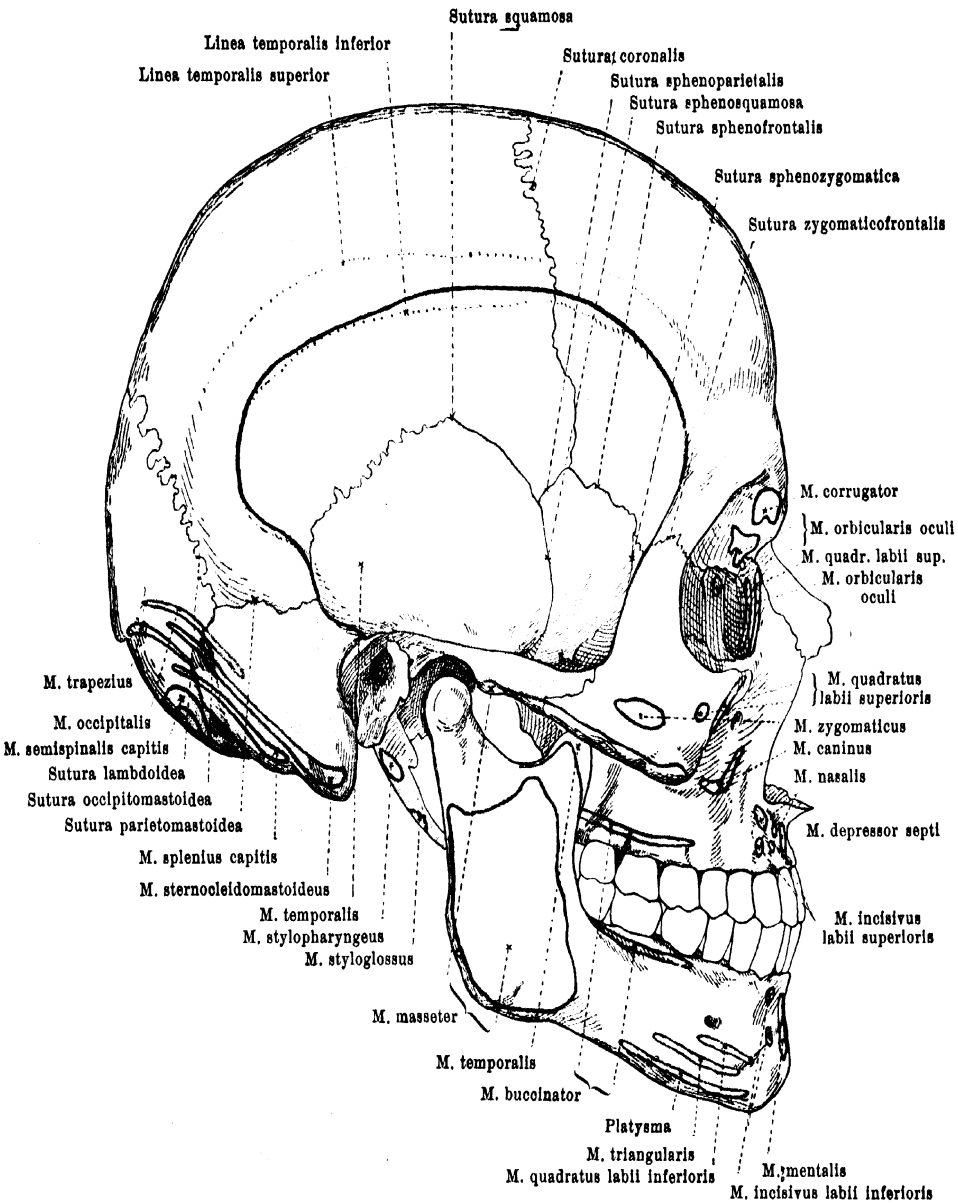


56. Hyoid bone, *os hyoideum,* right half, from the left, with muscular attachments.

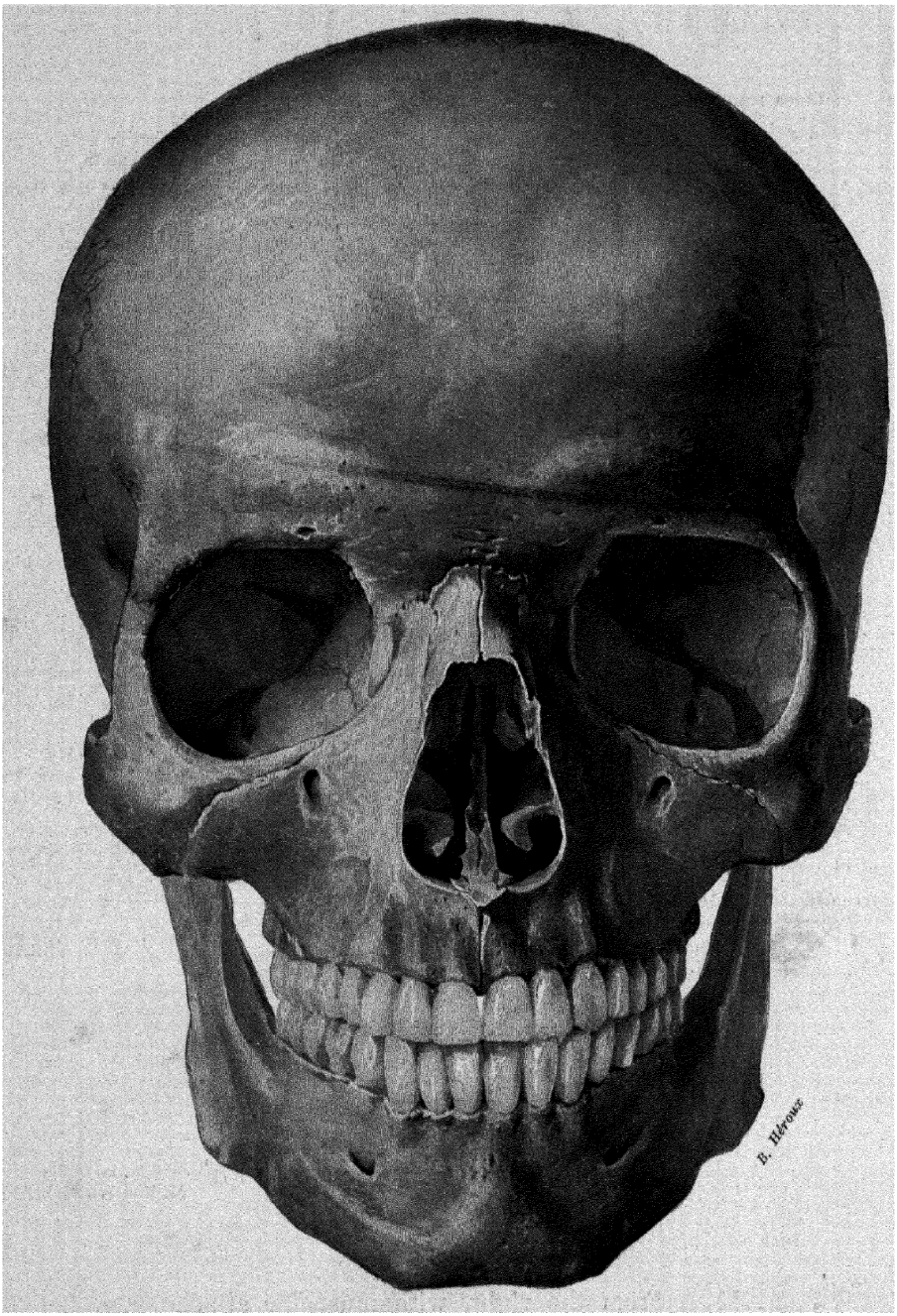
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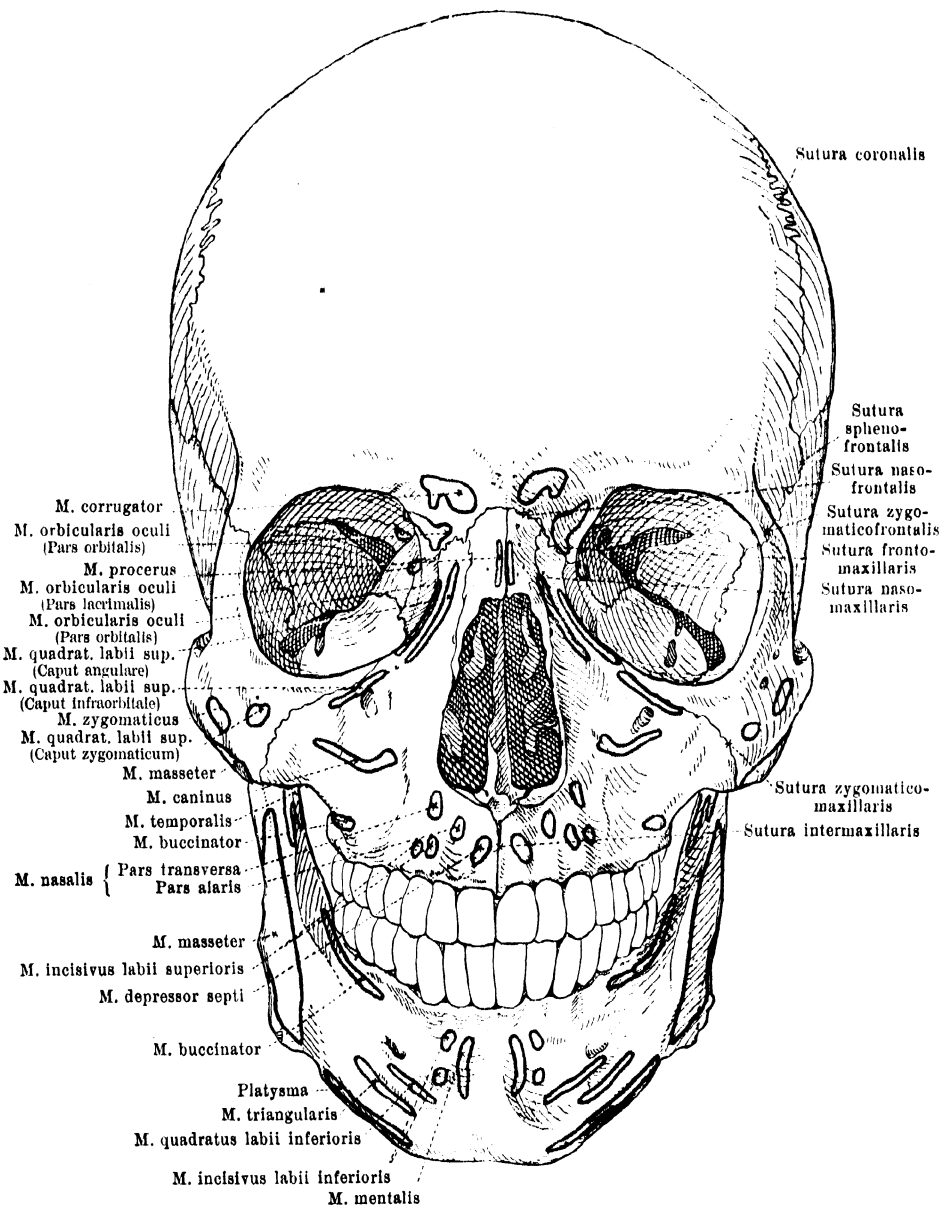
57. Skull, from the right.



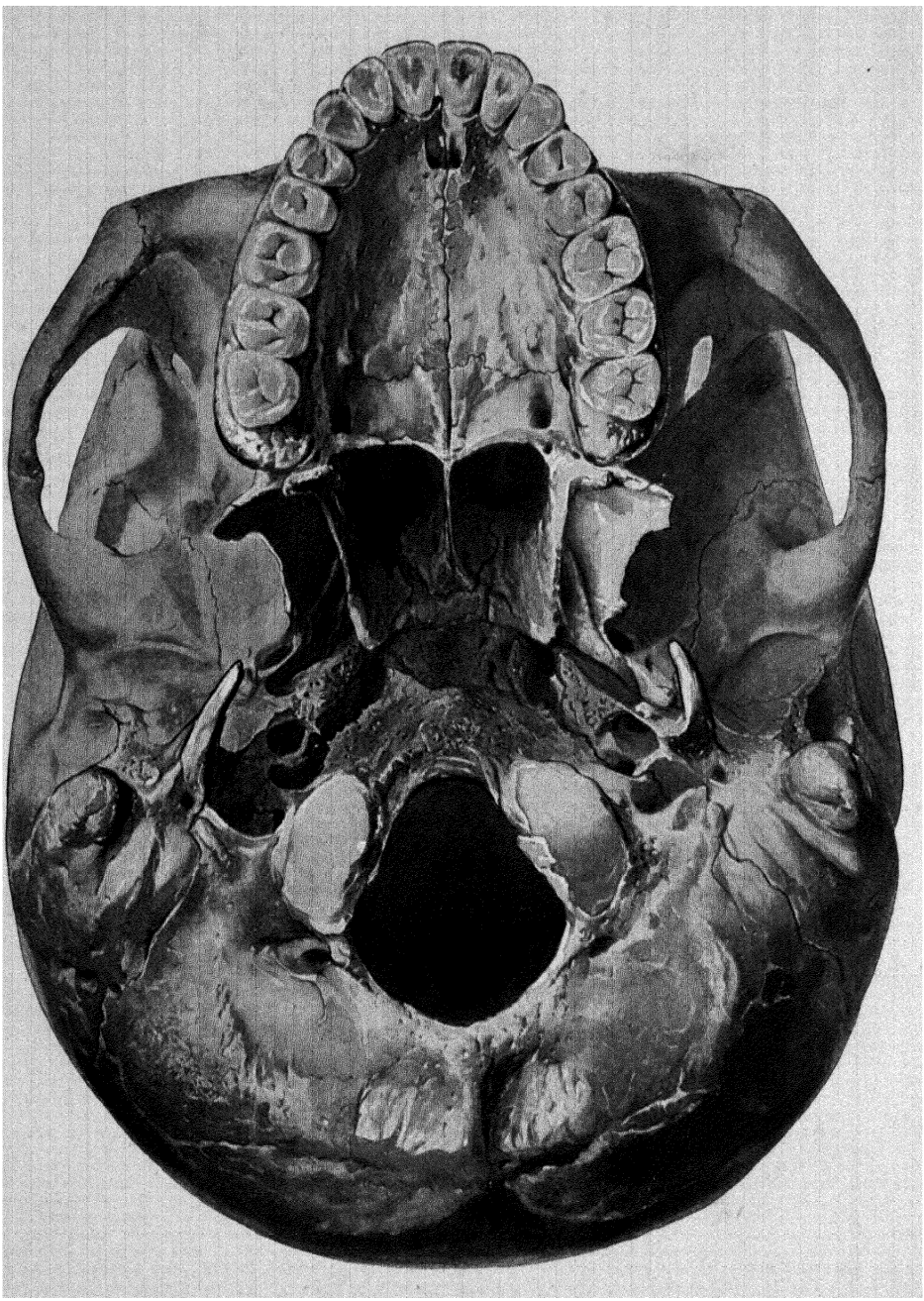
58. Skull, from the right, with muscular attachments.



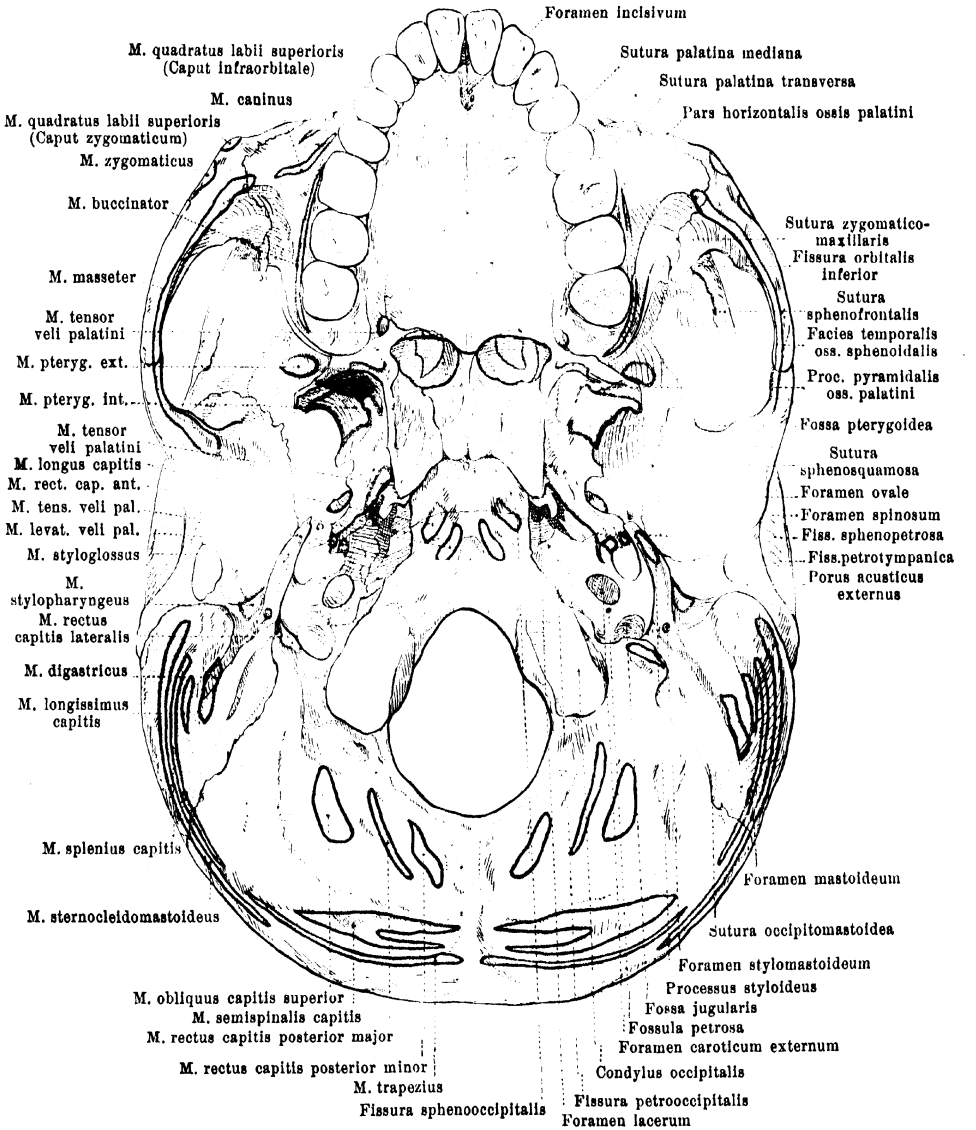
59. Skull, from in front.



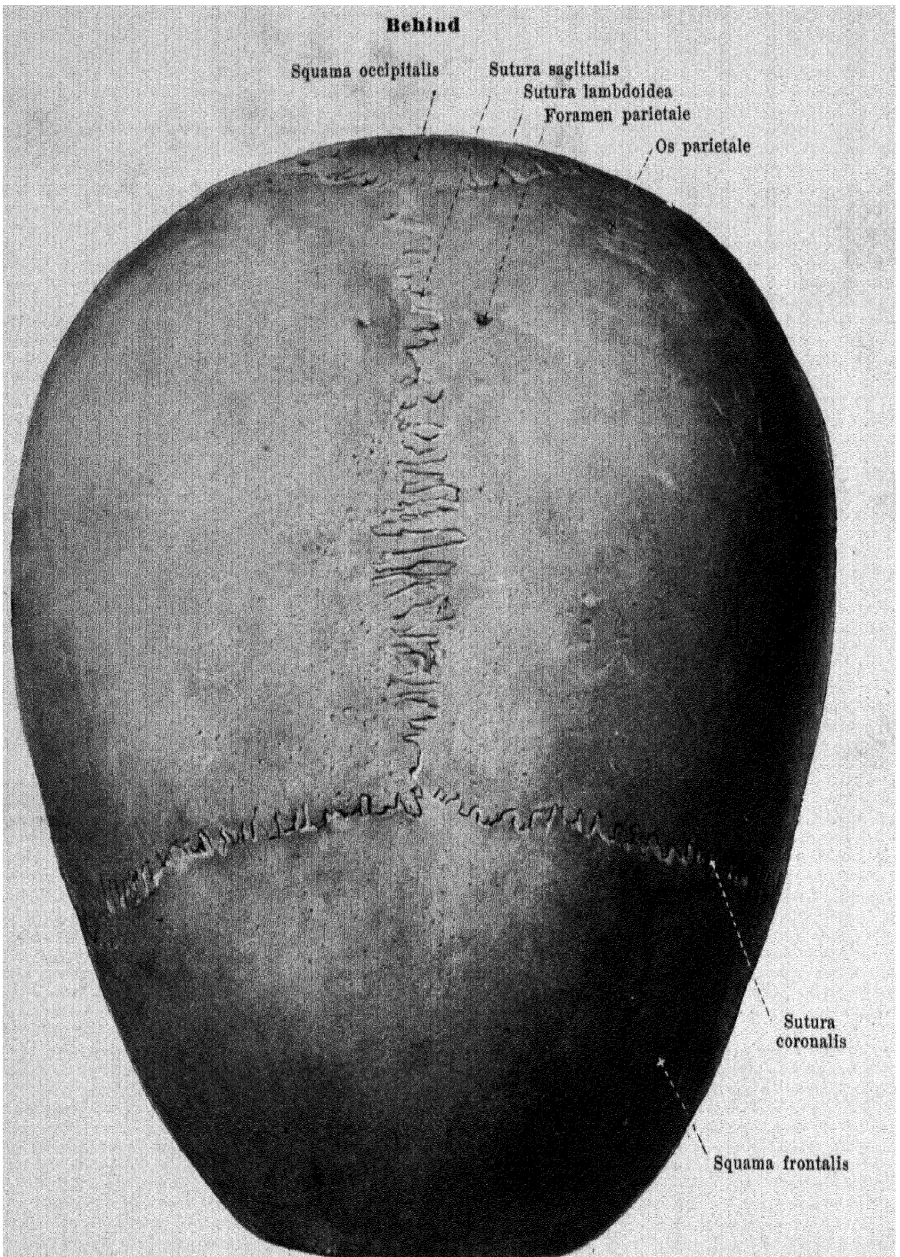
60. Skull, from in front, with muscular attachments.



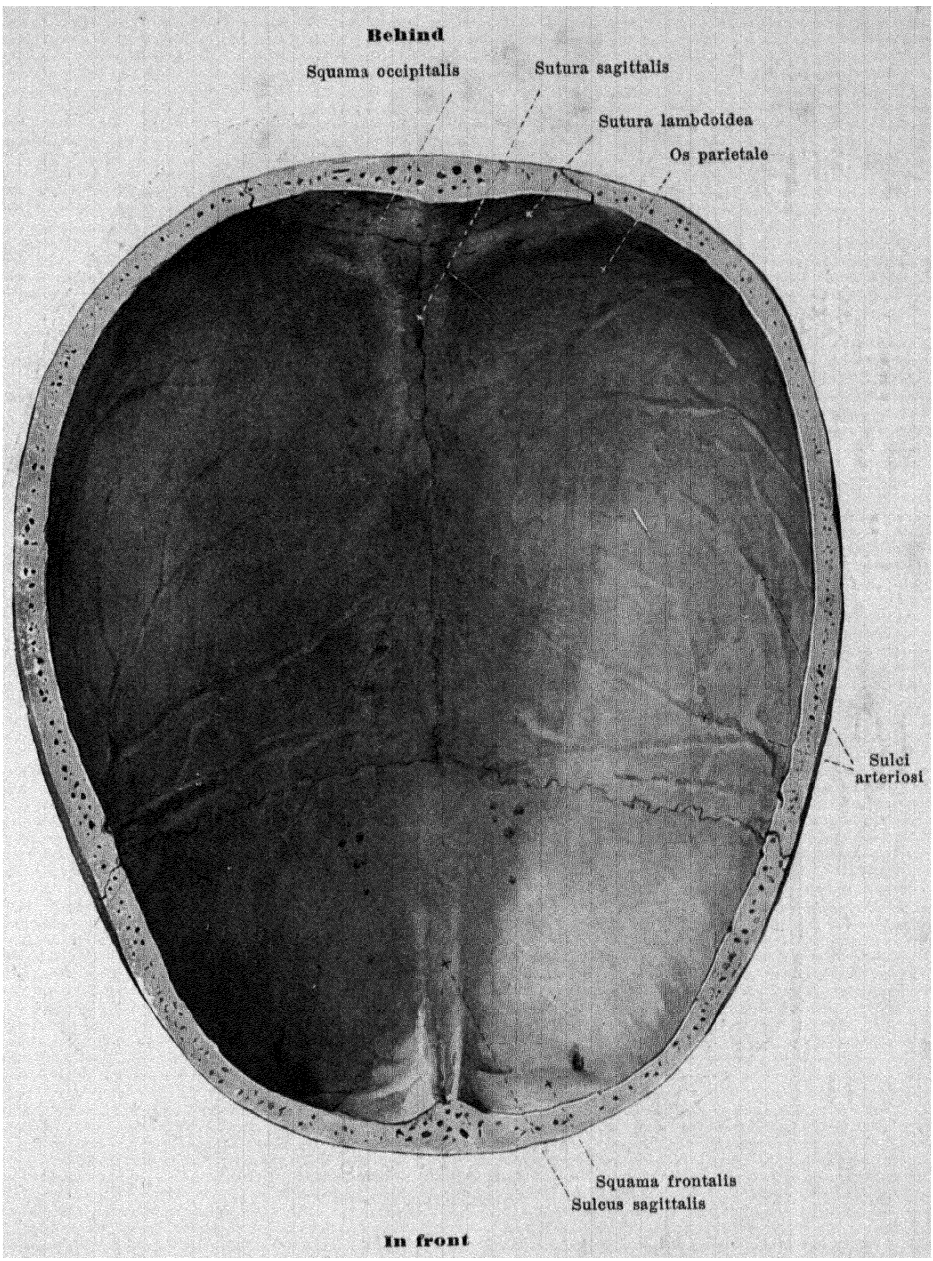
61. Base of the skull, from without, *basis cranii externa.*



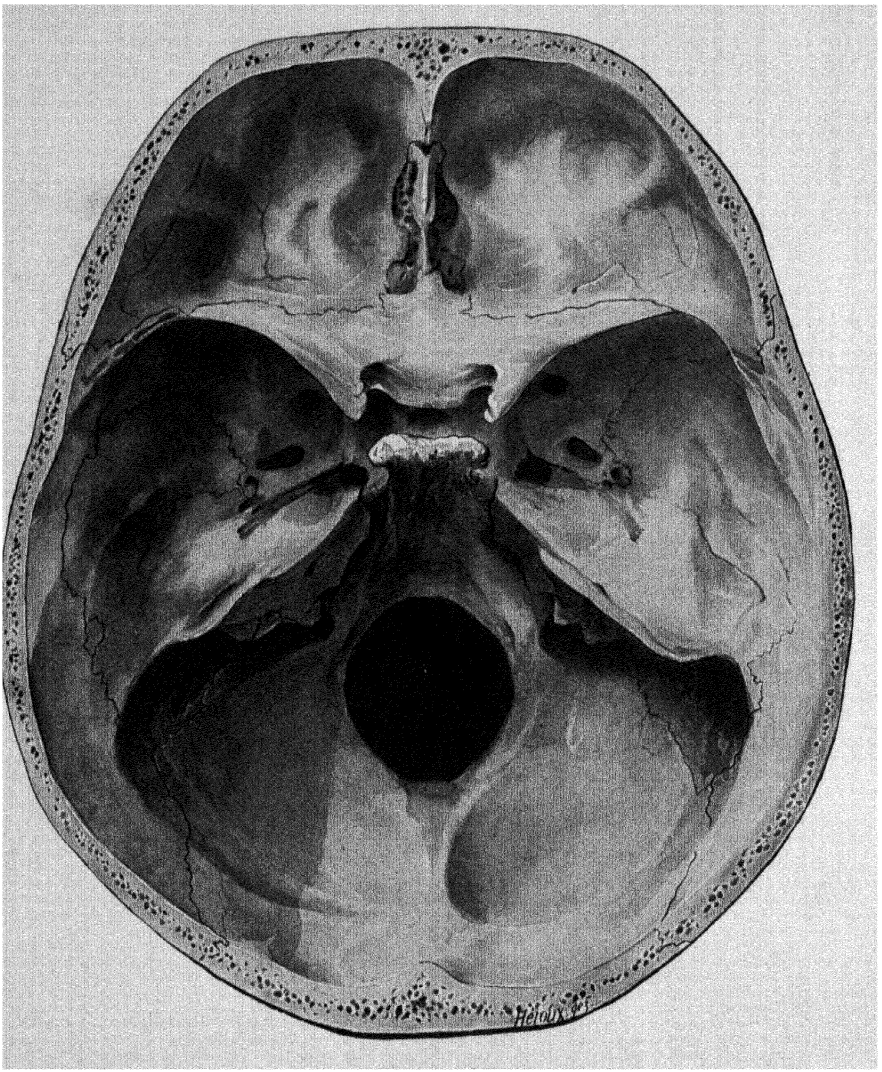
62. Base of the skull, from without, *basis cranii externa,* with muscular attachments.



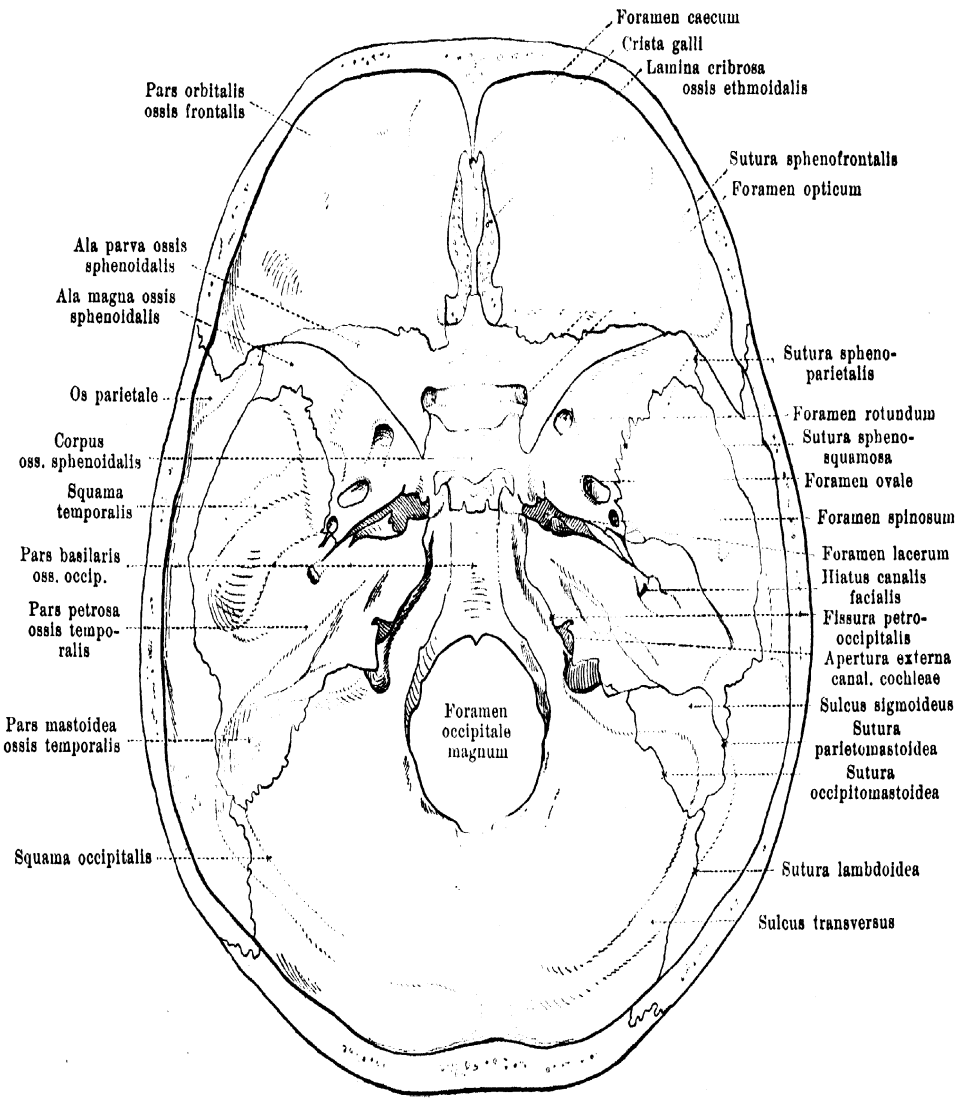
63. Skull, from above.



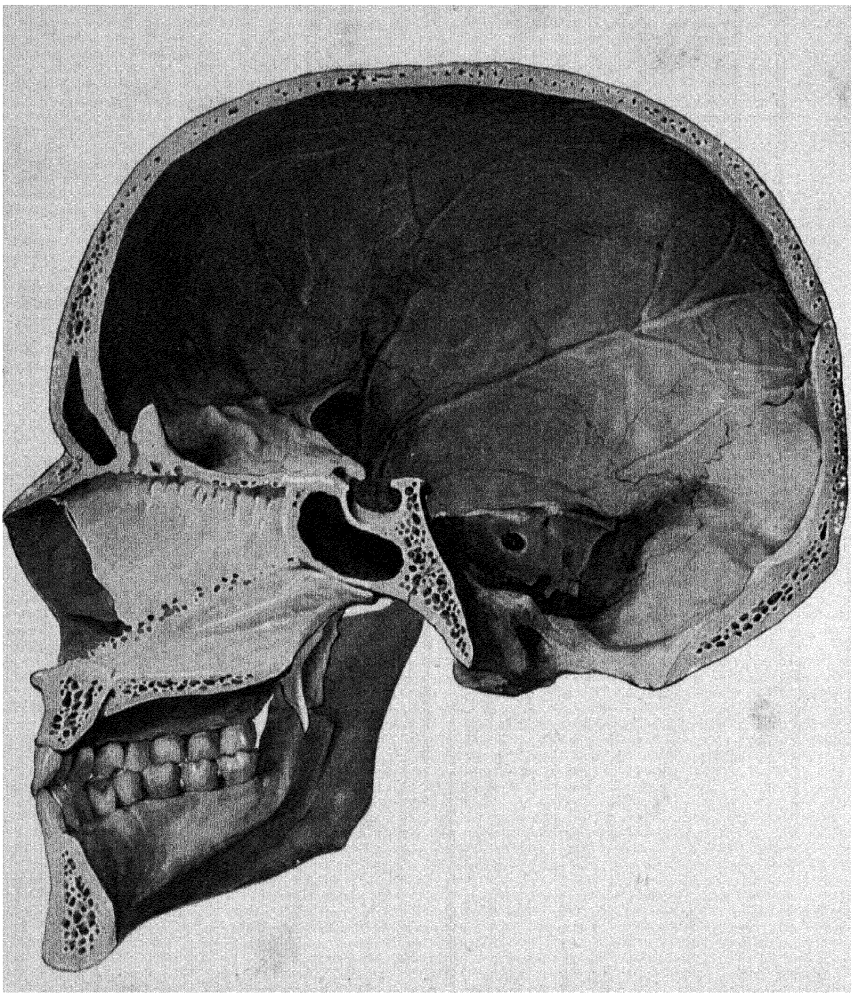
64. Skull cap, from within.



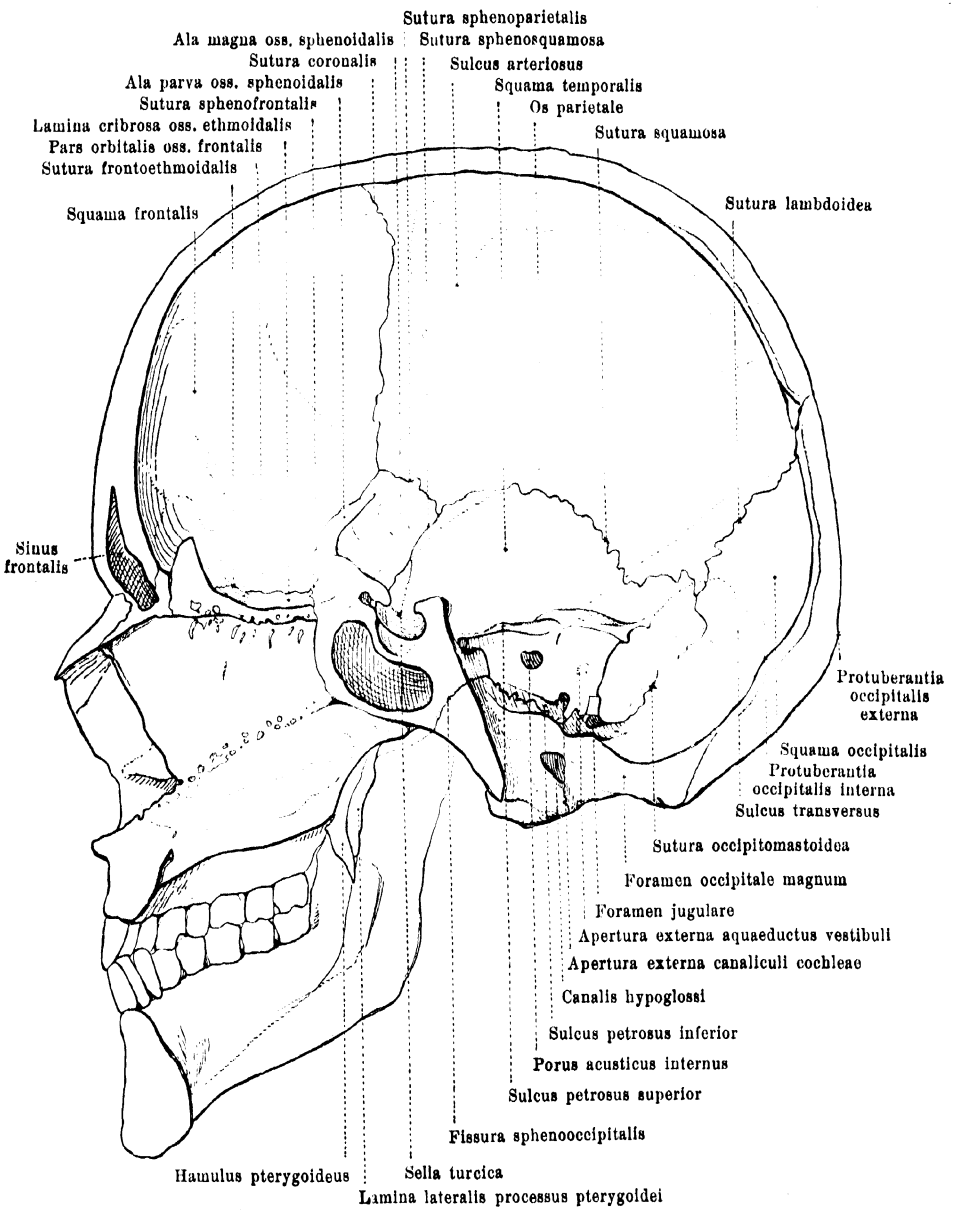
65. Base of the skull, from within, *basis cranii interna.*



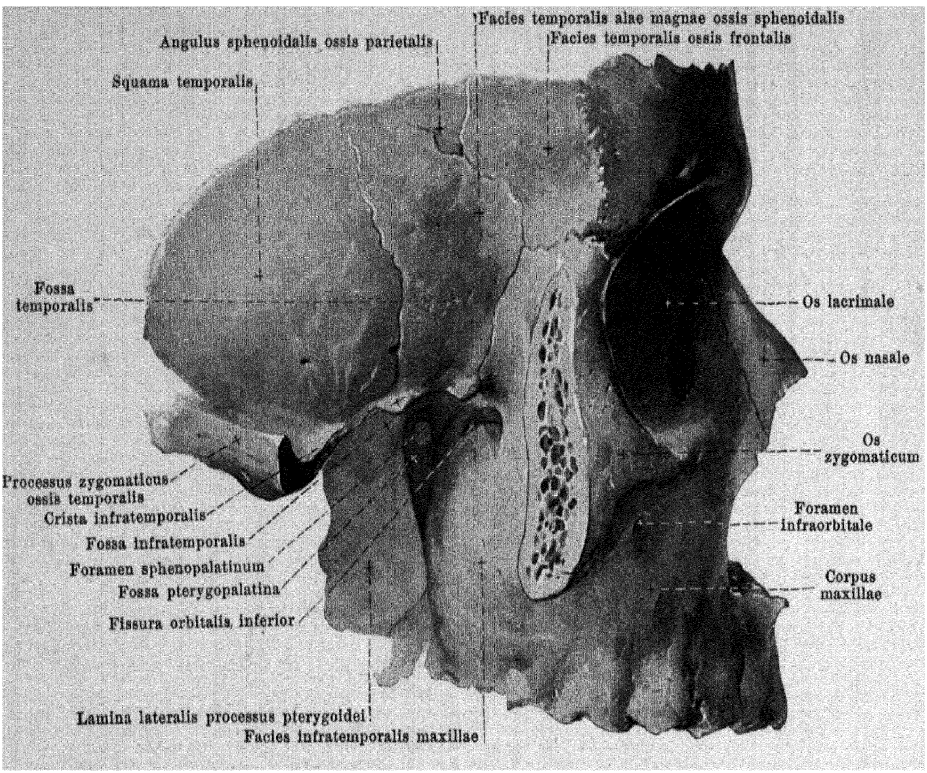
66. Base of the skull, from within, *basis cranii interna*, with names of various parts.



67. Median section of the skull, from the left.



68. Median section of the skull, from the left, with names of various parts.

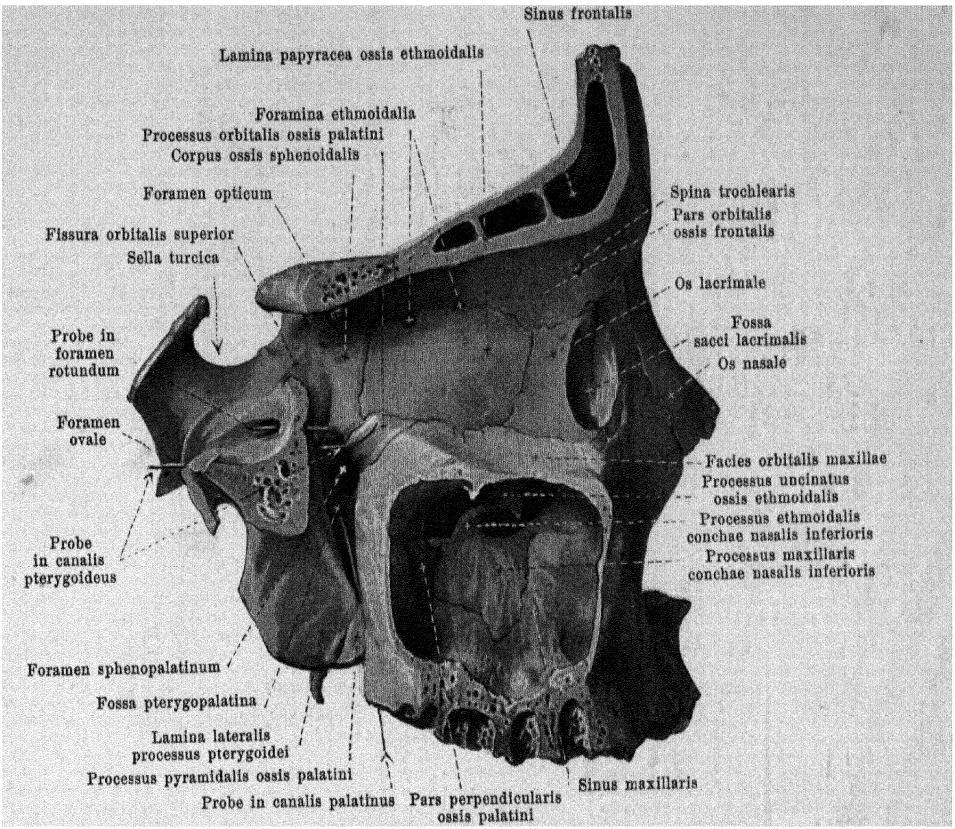


69. Right temporal fossa, *fossa temporalis,* from without.

(The arcus zygomaticus has been partially sawed away.)

The **fossa temporalis** (see also Figs. 57 and 58) lies on each side on the lateral surface of the skull and is, for the most part, open lateralward. Its medial surface is formed by the most inferior part of the facies parietal oss. pariet., by the facies tempor. squamae tempor., the facies tempor. oss. front., and the facies tempor. of the ala magna oss. sphen.; the anterior surface by the facies tempor. oss. front. and the facies tempor. oss. zygom.; the external wall by the arcus zygom.. Below and medianward it goes over into the fossa infratempor.. On the medial surface run the ***sutura squamosa*** (between squama tempor. and margo squamos. oss. pariet.), the ***sutura sphenosquamosa*** (between squama tempor. and margo squamos. alae magnae oss. sphen.), the ***sutura sphenoparietalis*** (between angul. sphen. oss. pariet. and angul. pariet. alae magnae oss. sphen.), the ***sutura coronalis*** (between margo front. oss. pariet. and margo pariet. oss. front.), and the *sutura* ***sphenofrontalis*** (between pars orbital. oss. front, and margo front. alae magnae oss. sphen.); on the anterior surface, the ***sutura zygomaticofrontalis*** (between proc. zygom. oss. front. and proc. frontosphen. oss. zygom.), and the ***sutura sphenozygomatica*** (between os. zygom. and margo zygom. alae magnae oss. phen.); on the lateral surface the ***sutura zygomaticotemporalis*** (between proc. tempor. oss. zygom. and proc. zygom. oss. tempor.). On the anterior wall lies the foramen zygomaticotemporale.

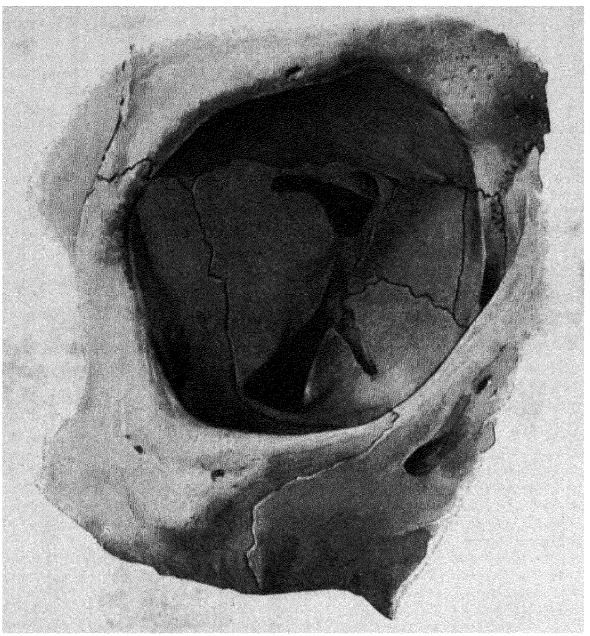
The **fossa infratemporalis** (O. T. zygomatic fossa) (see also Figs. 61 and 62) lies on each side below and medianward from the arcus zygom., and goes over sideways above nto the fossa tempor. and is open behind and below. Its upper wall is formed medianward by the facies infratemp, of the ala magna oss. sphen.. the anterior oblique wall being formed by the facies infratempor. maxillae and the facies tempor. oss. zygom., the lateral wall by the ramus of the lower jaw and the medial by the lamina lat. proc. pteryg.. On the anterior surface the ***sutura zygomaticomaxillaris*** (between os zygom. and proc. zygom. maxillae) is visible. At the junction of the anterior and medial surfaces lies the entrance to the fossa pterygopalatina. On the anterior surface can be seen the foramina alveolaria on the tuber maxillare and above this the lateral extremity of the fissura orbitalis inferior.

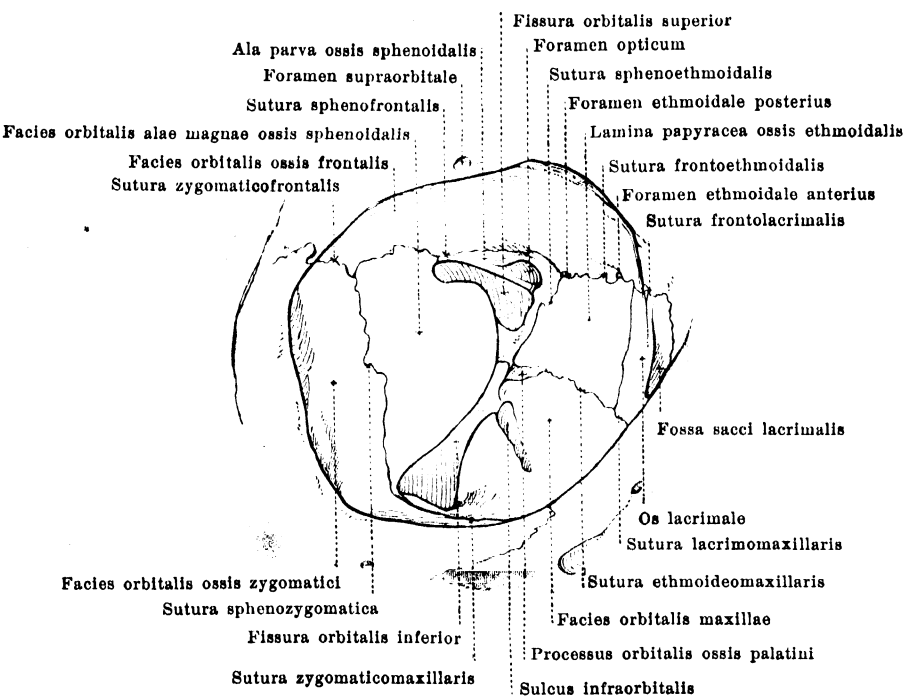


70. Right pterygopalatine fossa, *fossa pterygopalatina*, from without.

(The main portion of the ala magna oss. sphenoid., of the lateral part of the corpus maxillae and of the pars orbit. oss. front. have been removed by a sagittal section, so that the medial wall of the sinus maxillaris and of the orbit is visible.)

The **fossa pterygopalatina** (O. T. sphenomaxillary fossa) (see also Fig. 69) lies, deeply concealed, between the bones medianward from the fossa infratemporalis. It is united with the latter by a sickel-shaped space, broad above, narrow below, which is closed below and lateralward by periosteum. Its medial wall is formed by the lateral surface of the pars perpendicularis oss. palatini, its upper wall by the anterior lateral portion of the inferior surface of the body of the sphenoid, the posterior by the sphenomaxillary surface of the ala magna oss. sphenoidalis and by the anterior surface of the processus pterygoideus, the anterior by the processus orbitalis oss. palatini and by the most posterior margin of the corpus maxillae. Below it narrows to become the *canalis pterygopalatinus* which is continued into the canalis palatini oss. palatini and opens at the foramina palatina majus et minora on the under surface of the hard palate; in addition, delicate canals pass through the pars perpendicularis oss. palatini from the canalis pterygopalatinus into the nose. On the anterior wall connection is made with the orbit by means of the fissura orbitalis inferior, with the anterior surface of the face by the sulcus and canalis infraorbitalis. On the medial surface, the wide foramen sphenopalatinum leads into the nose. From the posterior surface the foramen rotundum goes into the cavity of the skull, the canalis pterygoideus and the canalis pharyngeus to the lower surface of the base of the skull.





71 and 72. Right orbital cavity, *orbita*, from in front.

Magnification 5 : 4.

The **orbita** *(orbital cavity)* (see also Figs. 57—60, 70—75) lies on each side in the upper part of the skull and, above, adjoins the cerebral skull. It opens in front by a wide mouth, *aditus orbitae,* behind this widens suddenly in its lateral half and then narrows gradually from before backward. Its shape, in front, is that of a four-sided, behind, that of a three-sided, pyramid, since the medial and the inferior wall form in front an obtuse angle with one another, while further back, they lie almost in one plane. The axes of the two orbital cavities (from the middle of the anterior opening to the middle of the foramen opticum) converge behind to the region above the sella turcica and are in addition inclined, in front, somewhat downward.

The opening of entrance, **aditus orbitae,** is quadrangular. The upper margin, *margo supraorbitalis,* is formed by the margo supraorbitalis and proc. zygomat. oss. frontalis, the medial by the pars nasalis oss. frontalis and the proc. frontalis maxillae, the inferior, *margo infraorbitalis,* by the corpus maxillae and os zygomaticum, the lateral by the os zygomaticum.

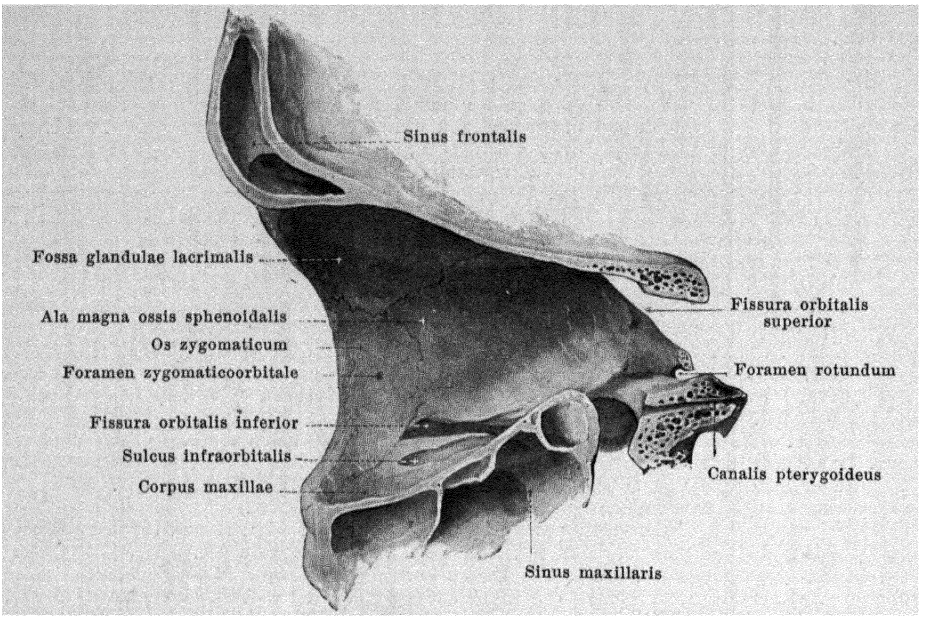
The walls of the orbit go over into one another, usually with rounded angles, and are lined by a thin periosteum, the *periorbita.*

The medial wall, **paries medialis** (see also Fig. 70), is placed nearly sagitally. It is composed of the os lacrimale, the lamina papyracea oss. ethmoidalis and the lateral surface of the corpus oss. sphenoidalis. It presents the *sutura lacrimomaxillaris* (between os lacrimale and proc. frontalis maxillae), the *sutura frontolacrimalis* (between os lacrimale and pars orbitalis oss. frontalis), the *sutura frontoethmoidalis* (between pars orbitalis oss. frontalis and os ethmoidale) as well as the *sutura sphenoethmoidalis* (between os ethmoidale and corpus oss. sphenoidalis). Near the anterior margin lies the fossa sacci lacrimalis. At the junction of the medial with the upper wall go off the foramina ethmoidalia anterius et posterius, of which the anterior leads constantly into the skull cavity upon the lamina cribrosa oss. ethmoidalis, the posterior also to the same place or only as far as the posterior ethmoidal cells. From the most posterior angle the foramen opticum passes to the skull cavity.

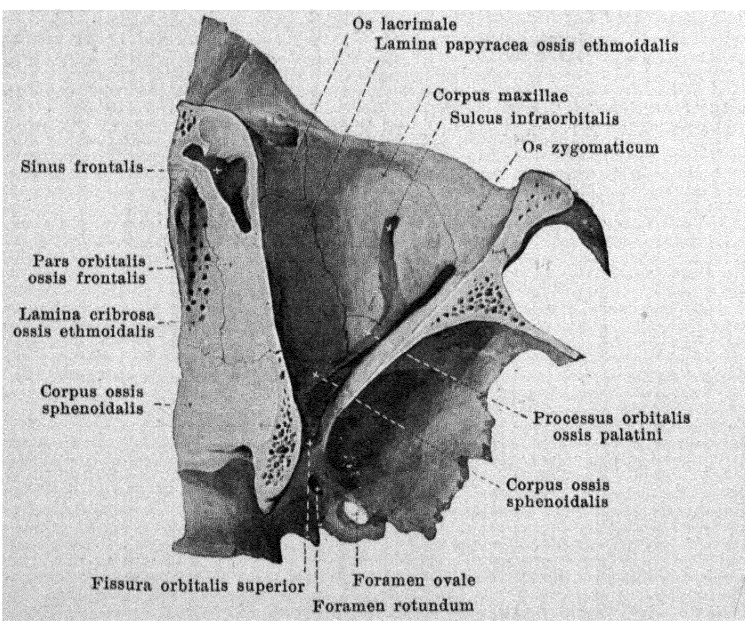
The upper wall of the orbit, **paries superior,** (see also Figs. 71 and 72) is horizontal and is formed by the pars orbitalis oss. frontalis and the ala parva oss. sphenoidalis; it is smooth and slightly concave. A part of the *sutura sphenofrontalis* is visible between these two bones. In addition, it contains in front and lateralward the fossa glandulae lacrimalis, in front and medianward the fovea and occasionally, lateral from this, the spina trochlearis.

The lateral wall, **paris lateralis,** (see also Figs. 71 and 72) is vertical and inclined from in front and lateralward obliquely behind and medianward. It is composed of the facies orbitalis oss. zygomatici, the facies orbitalis of the ala magna oss. sphenoidalis, partly also of the medial surface of the processus zygomaticus oss. frontalis. Between these bones run the *sutura sphenozygomatica,* (between os zygomaticum and ala magna oss. sphenoidalis), the *sutura zygomaticofrontalis* (between processus frontosphenoidalis oss. zygomatici and processus zygomaticus oss. frontalis), as well as the *sutura sphenofrontalis* (between ala magna oss. sphenoidalis and pars orbitalis oss. frontalis). Here can be seen also the single or double foramen zygomaticoorbitale which leads to the facial surface and to the fossa temporalis, and the *fissura orbitalis superior* (O. T. sphenoidal fissure or foramen lacerum anterius). The latter is found on the boundary between the lateral and the superior wall and occupies the whole medial half of the same; it is narrow and acute-angled lateralward and broadens medianward, usually suddenly, to terminate there, rounded off, below the foramen opticum; it leads into the skull cavity, but is, in its larger part, closed by tough connective tissue and periosteum.

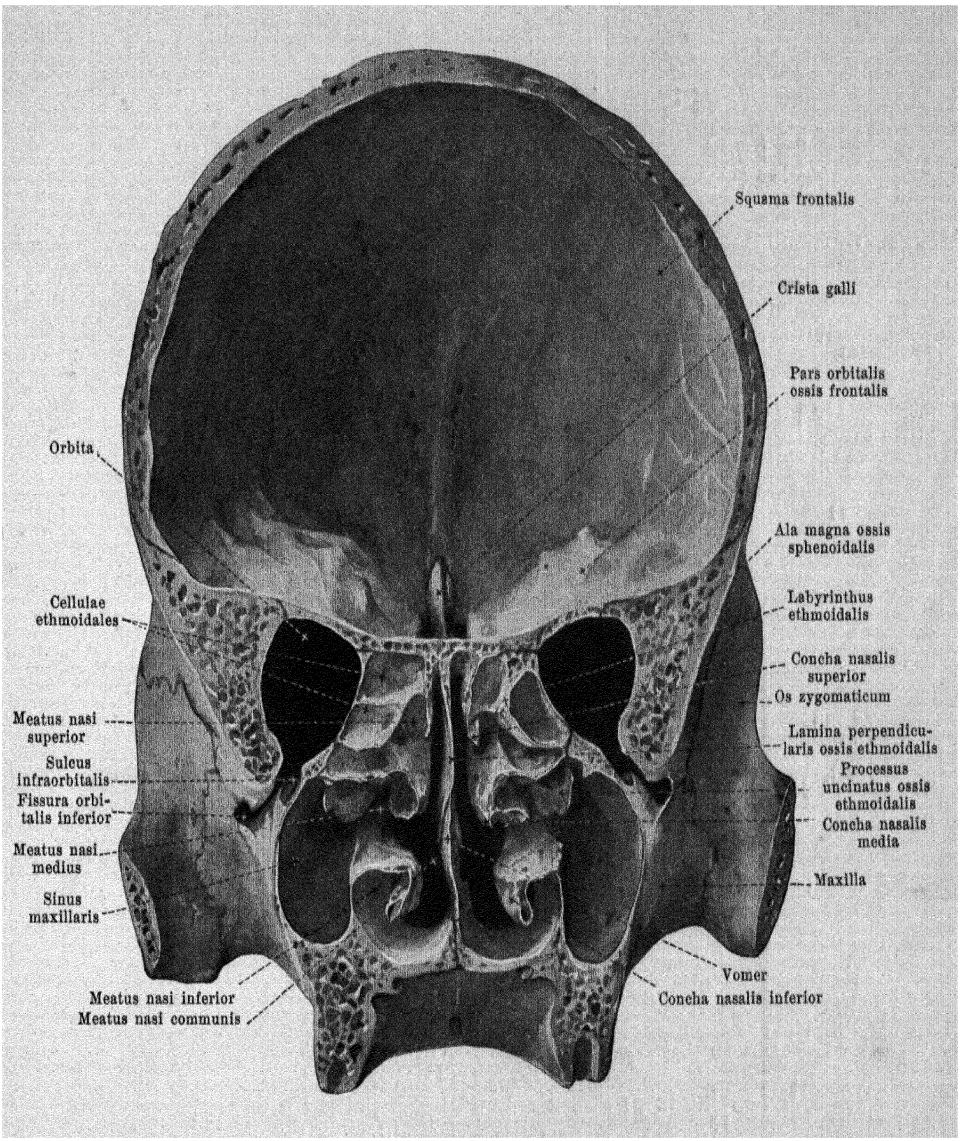
The inferior wall of the orbit, **paries inferior,** (see also Figs. 71 and 72) is inclined somewhat obliquely downward, forward and lateralward. It is formed chiefly by the facies orbitalis corporis maxillae, besides, lateralward, by a part of the facies orbitalis oss. zygomatici, and behind by the processus orbitalis oss. palatini. At the boundary between the inferior and the medial wall one sees the *sutura lacrimomaxillaris* (between os lacrimale and corpus maxillae), the *sutura ethmoideomaxillaris* (between os ethmoidale and corpus maxillae), the *sutura palatoethmoidalis* (between os ethmoidale and proc. orbitalis oss. palatini), the *sutura sphenoorbitalis* (between corpus oss. sphenoidalis and processus orbitalis oss. palatini), besides, near the posterior angle, the *sutura palatomaxillaris* (between corpus maxillae and processus orbitalis oss. palatini) and near the lateral margin the *sutura zygomaticomaxillaris* (between processus zygomaticus maxillae and os zygomaticum). It is united by bone with the lateral wall only in the anterior half, but is separated from it in the posterior half by the *fissura orbitalis inferior* (O. T. sphenomaxillary fissure). This slit, running between the posterior margin of the facies orbitalis corporis maxillae and the inferior margin of the facies orbitalis alae magnae oss. sphenoidalis, is, lateralward, closed either by a small process of one of these two bones (see Figs. 71 and 72) or by the os zygomaticum (see Fig. 73). The slit is often broader lateralward than medianward, leads externally into the fossa infratemporalis, internally into the fossa pterygopalatina and is for the most part closed by tough connective tissue and periosteum. From its medial extremity a groove passes to the fissura orbitalis superior. At about its middle begins the sulcus infraorbitalis; it is shut off from the orbit by the periorbita and after a course of variable length is covered with bony substance thus becoming the canalis infraorbitalis which opens on the facial surface at the foramen infraorbitale.



73. Right orbital cavity, *orbita*, lateral wall, from the left.
(The medial part of the orbit has been removed by an approximately sagittal section.)

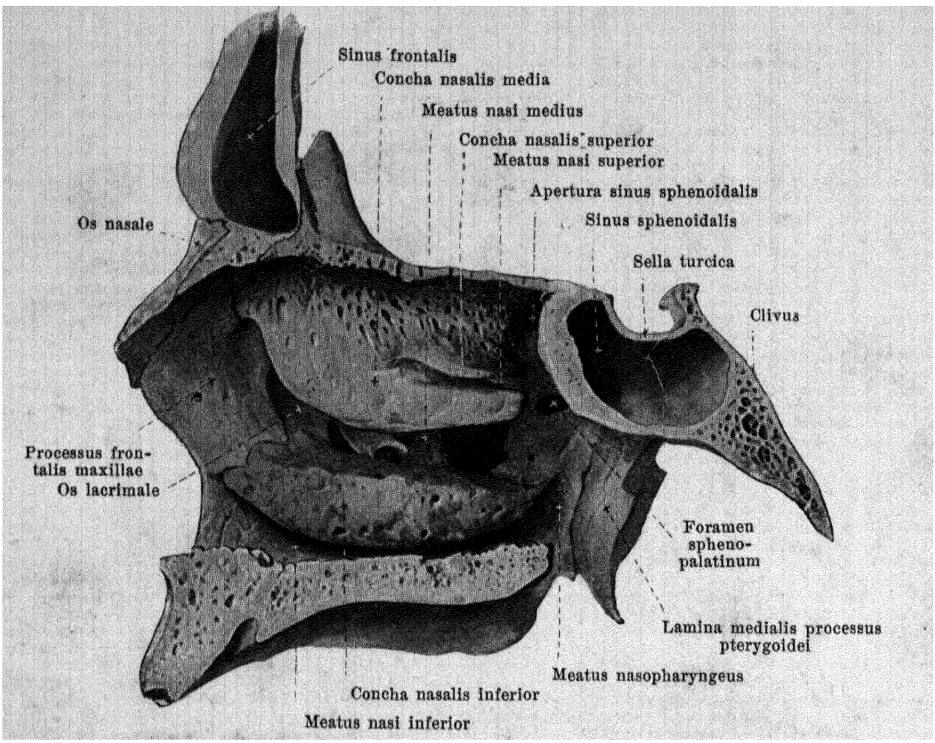


74. Right orbital cavity, *orbita*, inferior wall, from above.



75. Frontal section of the skull, from behind.

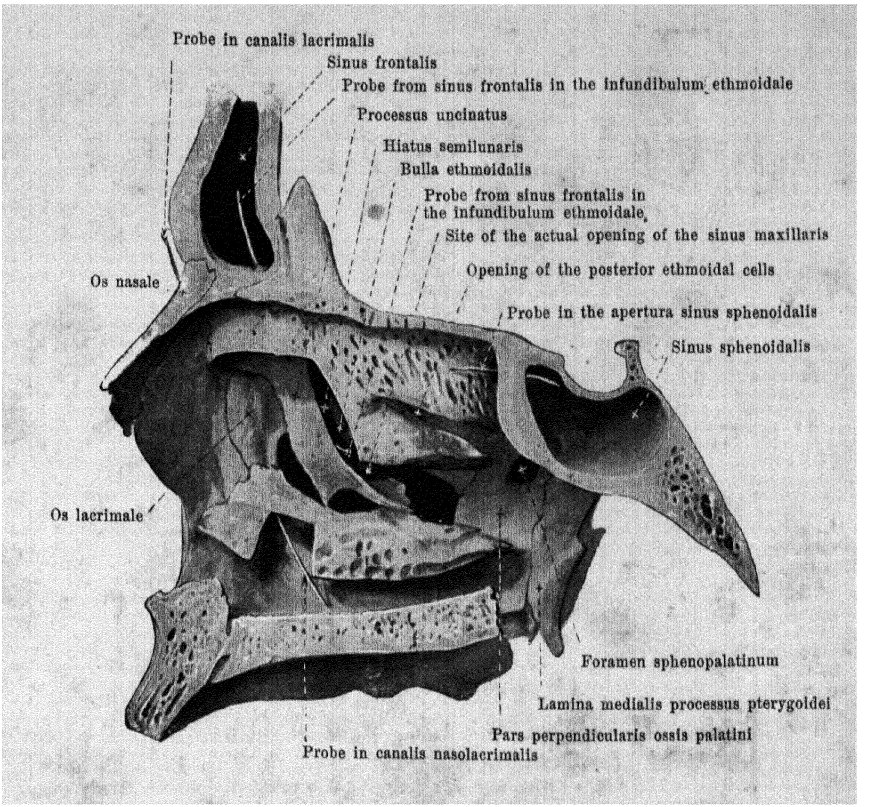
Orbital cavity (continued). The upper wall, *paries superior* (see also Figs. 71—73) is horizontal, and formed by the pars orbitalis oss. frontalis and the ala parva oss. sphenoidalis; it is smooth, and slightly hollowed out. Part of the sutura sphenofrontalis is visible between these two bones. It contains also anteriorly and lateralward the fossa glandulae lacrimalis, medially the fovea, and occasionally laterally from the latter the spina trochlearis.



76. Nasal cavity, *cavum nasi;* right lateral wall, from the left.

The **cavum nasi** *(nasal cavity)* (see also Figs. 59—62, 75, 77 and 78) is unpaired and lies in the middle and upper part of the facial skull. It consists of the nasal cavity proper and the accessory cavities which surround the former in front, above, lateralward and behind; these accessory cavities, *sinus paranasales,* are the *sinus frontales* (in front and above), the *cellulae ethmoidales* (lateralward almost in the whole depth), the *sinus sphenoidales* (behind and above) and the *sinus maxillaris* (lateralward).

The **lateral wall** (see also Figs. 61, 62, 75 and 77) is nearly sagittal, but somewhat inclined from above and medianward downward and lateralward. It is formed in front by the medial surface of the proc. frontalis maxillae, in front and in the middle by the facies nasalis corpor. maxillae further by the os lacrimale, by the medial wall of the labyrinthus ethmoidalis, by the concha nasalis inferior, by the facies nasalis of the pars perpendicularis oss. palatini and by the medial surface of the lamina medialis of the proc. pterygoideus oss. sphenoidalis. From these bones hang down free usually four, sometimes three, conchae nasales (turbinated bones) which cover over partially medianward three oblong fossae, the *nasal passages.* The *meatus nasi superior (upper nasal passage),* between the concha nasalis superior and media of the os ethmoid., is the shortest and narrowest, present only in the posterior half of the nasal cavity; it descends somewhat obliquely toward the upper circumference of the foramen sphenopalatinum. The *meatus nasi medius (middle nasal passage),* between the concha media and the concha inferior, reaches from the anterior margin of the middle concha as far as the region of the foramen sphenopalatinum. The *meatus nasi inferior (inferior nasal passage),* between the concha nasal. inferior and the inferior wall of the nasal cavity, is the longest and at the same time the most capacious. Lateralward from the septum, medianward from the conchae there remains a slit-shaped space between which extends through the whole height of the nasal space, the *meatus nasi communis.* The part of the cavity situated on each side behind the posterior ends of the conchae is called the *meatus nasopharyngeus;* it is bounded above by the inferior surface of the body of the sphenoid, the ala vomeris, the proc. vaginalis of the proc. pteryg. oss. sphenoid. and the proc. sphenoidalis oss. palat., lateralward by the pars perpendicularis oss. palat. and the lamina medialis proc. pteryg., below by the pars horizontalis oss. palat. and medianward by the vomer; behind, it opens by means of the *choana* (O. T. posterior nares) (bounded by the same bones).



77. Nasal cavity, *cavum nasi,* right lateral wall, from the left.

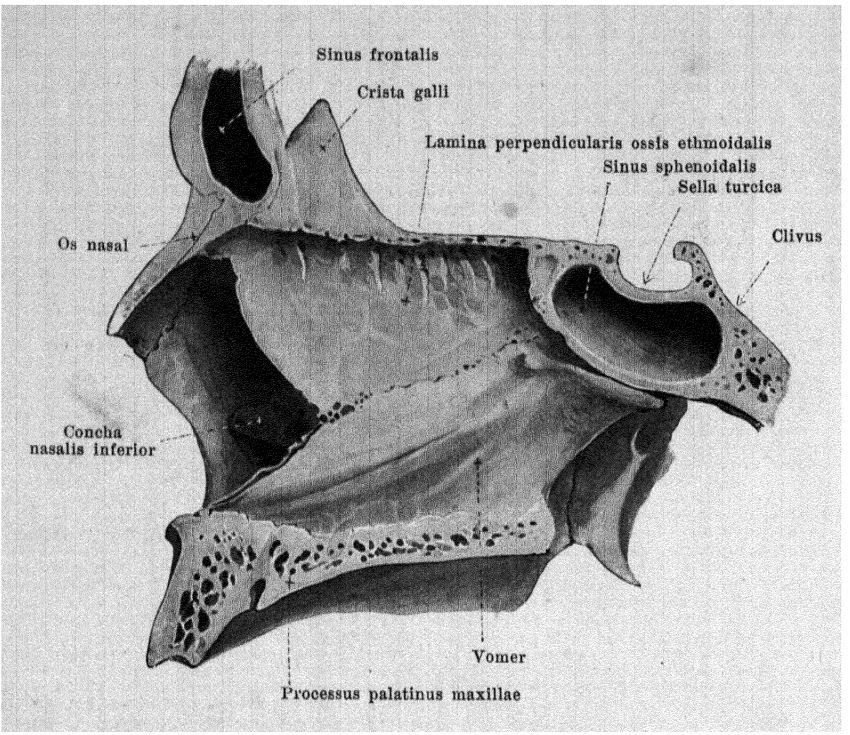
(The middle and inferior turbinated bones have been partially removed.)

In the *meatus nasi inferior,* near the anterior end, lies the lower opening of the *canalis nasolacrimalis.* This goes out from the fossa sacci lacrimalis and is formed lateralward and in front by the sulcus lacrimalis of the corpus and of the proc. frontalis maxillae, medianward and behind by the sulcus lacrimalis oss. lacrimalis and the proc. lacrimalis conchae nasalis inferioris; it is directed from above downward and at the same time somewhat from before backward.

Into the *meatus nasi medius* opens the sinus maxillaris. The opening does not correspond to the whole hiatus maxillaris of the upper jaw bone, for this is essentially narrowed by the overlapping of the neighboring bones, namely, by the pars perpendicularis oss. palatini from behind, the proc. maxillaris conchae nasalis inferioris from below, the proc. ethmoidalis conchae nasalis inferioris and the proc. uncinatus oss. ethmoidalis in the middle. The actual opening lies lateralward from the proc. uncinatus at the bottom of a narrow oblong fossa *(infundibulum ethmoidale),* which extends along the proc. uncinatus upward and forward, widens like a funnel and opens above into the sinus frontalis, but in addition receives the openings from the anterior ethmoidal cells; besides this connection between the frontal and nasal cavities there is also a second just medianward from the processus uncinatus. Projecting downward into the infundibulum ethmoidale from the outside there is usually a vesicular ethmoidal cell, the *bulla ethmoidalis;* the narrow sickle-shaped slit between this and the upper margin of the proc. uncinatus, the entrance to the infundibulum, is called the *hiatus semilunaris.*

Into the *meatus nasi superior* open the middle and posterior ethmoidal cells.

Above the concha superior is situated the *recessus sphenoethmoidalis* (see Fig. 25); the sinus sphenoidalis opens above this from behind by means of the apertura sinus sphenoidalis.



78. Nasal cavity, *cavum nasi,*

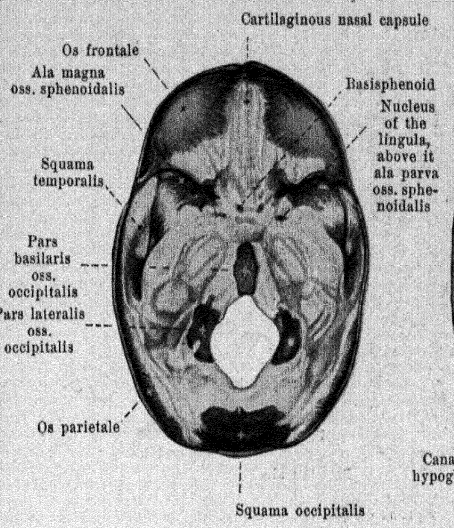
Bony nasal septum, *septum nasi osseum,* from the left.

The **upper,** narrowest **wall of the nasal cavity** (see also Figs. 75—77) is formed by the lamina cribrosa oss. ethmoidalis; the **lower,** broader **wall** by the slightly concave upper surface of the processus palatini maxillae and the partes horizontales oss. palatini.

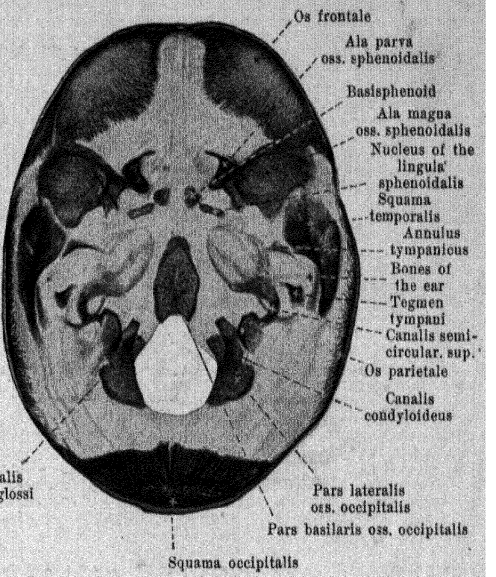
The **anterior wall** (see also Figs. 59, 76 and 77) of the nasal cavity proper is bony above only and is there formed by the spina frontalis of the pars nasalis oss. frontalis and the ossa nasalia; below it presents the *apertura piriformis* (O. T. anterior nares), opening toward the facial surface. This is "pear-shaped", narrow above, broad below and is surrounded above by the free margins of the ossa nasalia, lateralward by the incisurae nasales of the upper jaw bones, below by the ossa incisiva and the spina nasalis anterior.

The **septum nasi osseum** *(bony nasal septum)* (see also Fig. 75), which, within, subdivides the nasal cavity, lies in the median plane and is usually somewhat deflected toward one side or the other. This deviation, however, is never met with at the posterior margin. The septum begins in front, behind the apertura piriformis, by a deep notch which is filled up by the cartilago septi nasi, ends free behind at the posterior boundary of the nasal cavity and otherwise extends without essential interruption from the upper to the lower wall. Its upper part is formed by the lamina perpendicularis oss. ethmoidalis, the lower by the vomer. Above it unites in front with the spina frontalis of the pars nasalis oss. frontalis and with the lamina cribrosa oss. ethmoidalis, behind with the crista sphenoidalis and the rostrum sphenoidale; below it lies on the crista nasalis of the united maxillary and palate bones.

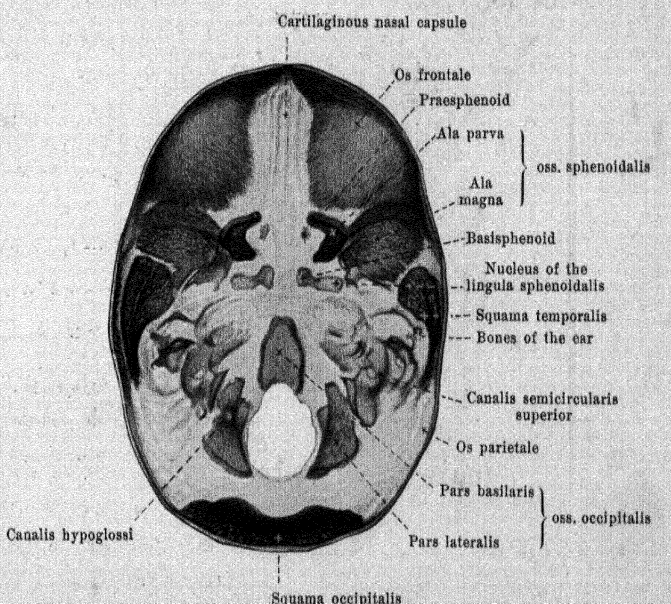
The nasal cavity is connected on its upper wall by the openings of the lamina cribrosa with the skull cavity and by the foramina ethmoidalia with the orbit; on its lateral wall by the canalis nasolacrimalis with the orbit, by the foramen sphenopalatinum with the fossa pterygopalatina; on its anterior wall by the foramina nasalia with the anterior facial surface; on its lower wall by the canalis incisivus with the mouth.



79. **Fetus 14 cm long** (4 months).



80. **Fetus 18 cm long** (4 months).

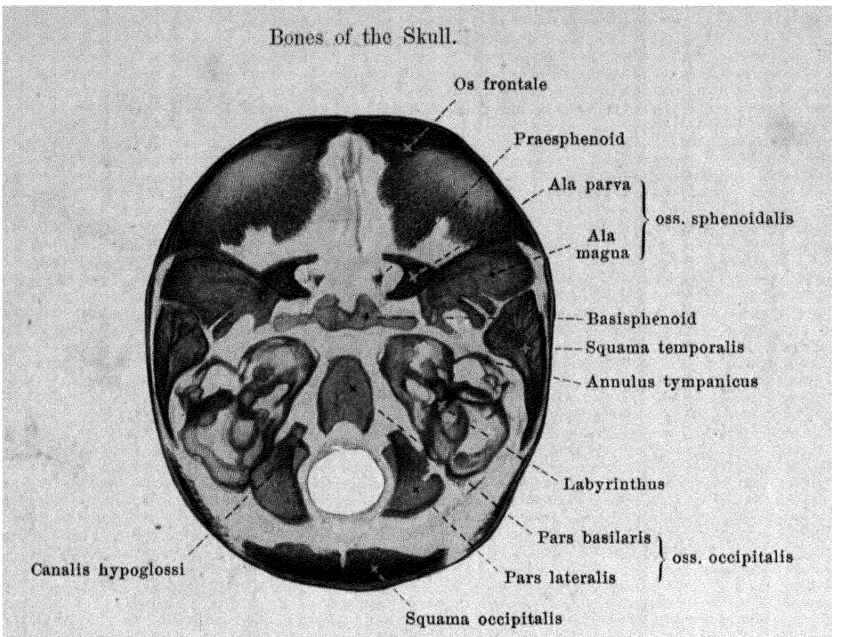


81. **Fetus 12 cm long** (4 months).

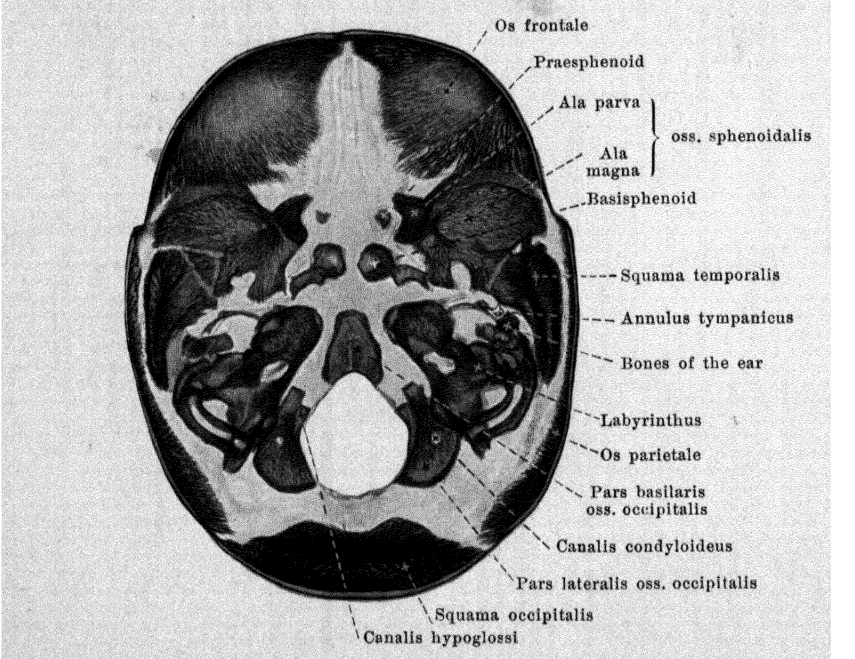
79—84. Base of Fetal Skull,

after removal of the roof of the skull, as seen from above. (Magnification 3:2.)

(The bone substance is colored red, the base transparent.)



82. Fetus 14 cm long (4 months).



83. Fetus 19 cm long (beginning of 5th month).

79—84. Base of Fetal Skull,

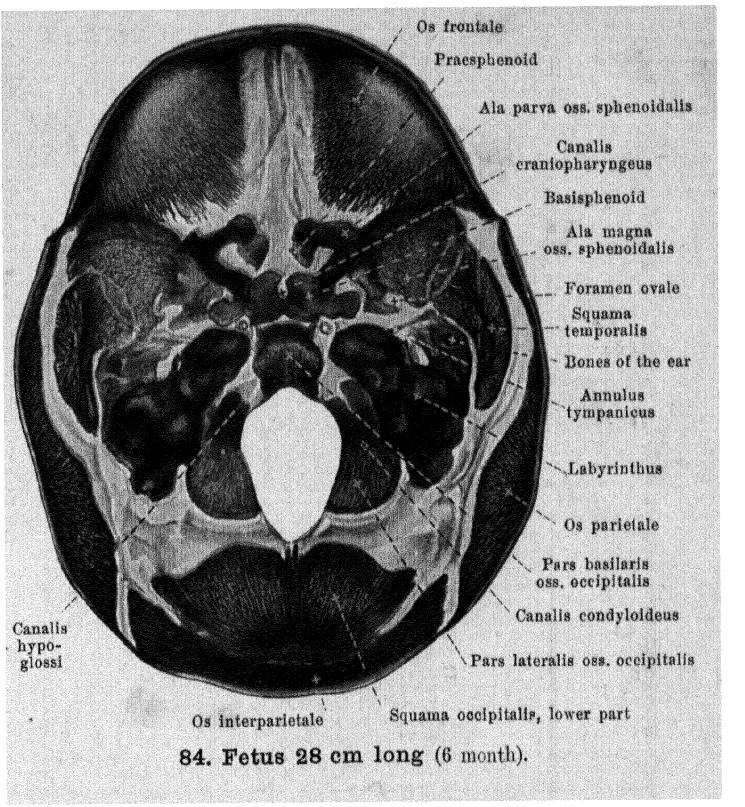
after removal of the roof of the skull, as seen from above. (Magnification 3:3.)

(The bone substance is colored red, the base transparent.)

79—84. Base of Fetal Skull,

after removal of the roof of the skull, as seen from above. Magnif.: 3:2.

(The bone substance is colored red, the base transparent.)



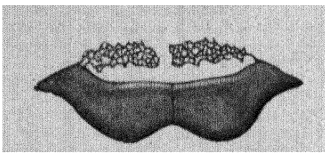
84. Fetus 28 cm long (6 month).

Development of the Bones of the Skull.

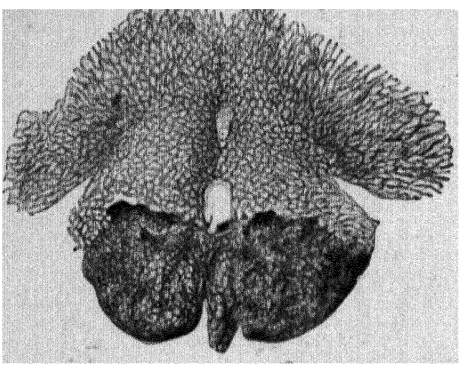
Of the bones of the skull, a part of them is preceeded in their development by the deposition of cartilage (the so-called *cartilage bones,* or *Primordial bones)* and arises from a more or less connected cartilaginous mass, the *Primordial-cranium,* which includes most of the bones of the base of the skull; namely, the os occipitale (without the upper part of the squama), the os sphenoidale (not including the lamina medialis of the processus pterygoideus), the os temporale (without the squama temporalis and the pars tympanica), the os ethmoidale, the concha nasalis inferior, parts of the mandibula, the os hyoideum, and the tympanic ossicles. The upper portion of the squama occipitalis, the lamina medialis of the processus pterygoideus oss. sphenoidalis, the squama temporalis and the pars tympanica oss. temporalis, the greater portion of the mandibula, and all the rest of the skull bones not named above are developed os fibrous-tissue bones or membrane bones, differing from the above cartilage bones in that they are developed by the formation of bone from the connective tissue. This fibrous tissue covers the brain above, in front, behind, and on the sides like a *membranous skull capsule.*

Every bone in the body develops from at least one bone nucleus or center of ossification. The localisation of these bone nuclei is subject to but slight variations, their time of appearance on the other hand does show great individual variations.

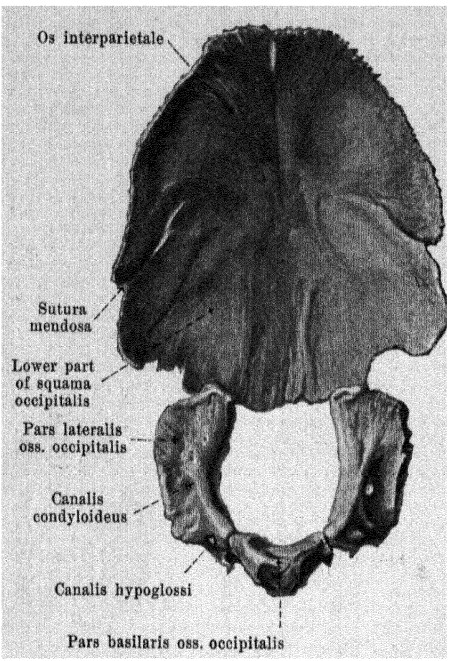
The *os occipitale* (see Figs. 79—87) arises in five parts: the pars basilaris, two partes laterales, and the lower and upper parts of the squama. The latter portion is membranous in origin, the rest are cartilage bones. The pars basilaris develops a bone nucleus or centre of ossification in the 10th week, each pars lateralis one in the eighth week. The lower part of the squama begins to ossify in the eighth week from two nuclei which merge together into a transverse elongated strip. The upper part of the squama *(os interparietale),* is developed from four nuclei, which make their appearance in the ninth week, and of which two partially encroach between the other two; these four nuclei, soon fuse together forming an osseous plate which unites medially with the plate of the lower portion of the squama; on the sides they remain separated by a fissure, and later by a suture *(sutura mendosa)* until the fourth year. The os interparietale may remain separated from the lower portion of the squama throughout life. At the time of birth the os occipitale consists of four pieces. The fusion of the pars basilaris with the partes laterales takes place between the 3rd and 6th yrs.; that of the latter with the squama between 1st and 4th yrs.



85. Occipital Squama of a fetus 5 cm long (about 10 wks.), after Ranke.
Magnif.: 2 : 1.

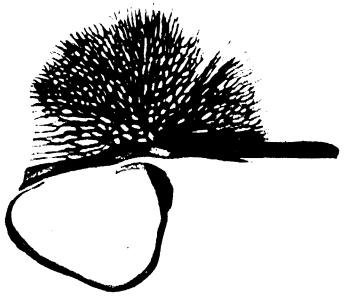


86. Occipital Squama of a fetus 5 cm long (about 13 wks.) viewed from behind, after Ranke. Magnif.: 5 : 1.

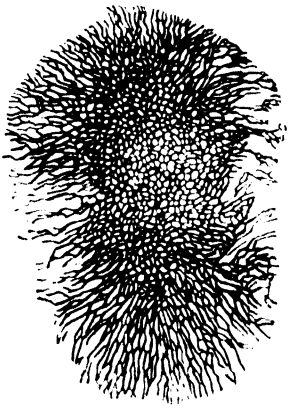


87. Occipital bone of a 7 month fetus, view from the front.
Magnif.: 1 : 1.

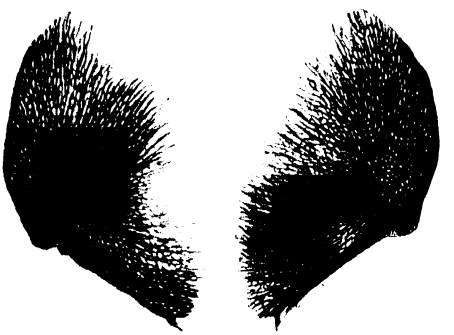
The *os sphenoidale* (see Figs. 79—84), develops from seven pairs of nuclei, at the end of the second month there appears between the foramen rotundum and foramen ovale a nucleus for the greater wing, from which also the lamina lateralis of the proc. pterygoideus ossifies; in the ninth week, there appears at the lateral border of the foramen opticum a nucleus for the lesser wing. The body of the sphenoid ossifies from two pairs of nuclei lying behind each other; the posterior pair forms the *basisphenoid* and appears in the third month in relation to the floor of the sella turcica, the anterior pair forms the *presphenoid* and appears a little later; next to the basisphenoid there arises at the same time a small nucleus for the lingula sphenoidalis and the adjacent part of the sulcus caroticus, which soon fuses with the basisphenoid. The nuclei of the basisphenoid unite in the fourth month; at the same time on each side the nucleus of the lesser wing merges into the presphenoid; the two nuclei of the presphenoid unite in the eighth month with each other and at the same time (at first only laterally) with the basisphenoid. The lamina medialis of the proc. pterygoideus receives a special nucleus in the second month, and in the fourth month fuses with the nucleus of the greater wing. These nuclei of the laminae mediales of the procc. pterygoidei are membranous in origin as are also small distinct nuclei on each side at the tips of the wings; the rest of the nuclei develop in cartilage. At birth the bone consists of three parts; one part on each side formed by the greater wing, and the third consisting of the other nuclei fused with each other; these three parts grow together in the first year. The concha sphenoidalis originates from several nuclei in the Primordialcranium after the fifth month.



88. The right squama temporalis and annulus tympanicus of a fetus 18 cm long (4 months).
Magnif.: 3 : 1.



89. The right parietal bone of a fetus about 9 cm long
(about 12 wks.). Magnif.: 3 : 1.

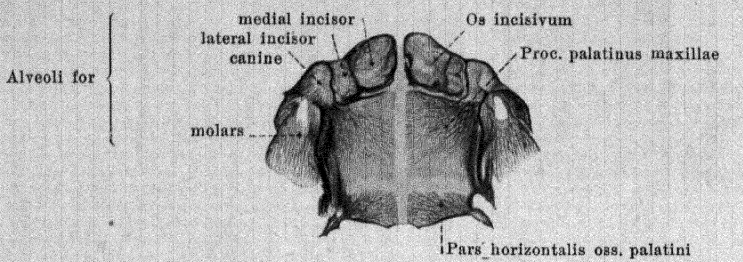


90. Frontal bone of a fetus about 4 months old,
viewed from the front.
Magnif.: 3 : 1.

The *os temporale* (see also Figs. 79—84), shows even at birth its origin from three bones, which correspond to the squama, the pars tympanica, and the pars petrosa; it encloses, moreover, the ossicles of the internal ear, and joins with the processus styloideus which is to be regarded as a separate element. The squama and the pars tympanica are membrane, the other parts are cartilage bones. The squama acquires a nucleus near the root of the proc. zygomaticus about the end of the second month, and this nucleus later on grows down also behind the pars tympanica. The nucleus of the pars tympanica appears in the beginning or middle of the third month in the connective tissue surrounding the border of the tympanum and forms at first a ring almost completely closed, and only open above, the ***annulus tympanicus*** into which the drum membrane is inserted; the free ends of the annulus tympanicus grow together at the time of birth with the squama; (see further p. 16). The pars petrosa originates through the ossification of the cartilaginous labyrinthine capsule; it begins in the fifth month from several nuclei, and at the end of the sixth month the labyrinth is completely enclosed in bone. The proc. styloideus arises from the upper end of the cartilage of the second visceral arch, and ossifies from two centres, of which the upper one appears shortly before, the lower one after birth; the upper nucleus or centre fuses soon with the pars petrosa and the pars tympanica, with the lower centre of ossification it does not unite until middle life. The tympanic ossicles begin to ossify in the second half of the fifth month: the malleus (with the exception of the proc. anterior which is membranous in origin) and the incus are formed each from a nucleus in the upper end of the cartilage of the first visceral arch, the stapes from a nucleus in the upper end of the cartilage of the second visceral arch.

The *os frontale* (see also Figs. 73—84) arises as a membrane bone from a right and a left centre of ossification, each of which about the end of the second month, appears near the margo supraorbitalis; there are moreover several accessory nuclei or centres on each side which appear before birth and which soon fuse into the main centre. The two halves approach each other, but unite only after birth (in the eighth year). See further p. 17. The sinus frontales first appear in the first year.

The ***os parietale*** (see also Figs. 73—84) is a membrane bone originating usually from two centres of ossification, an upper and a lower one which first appear about the end of the second month and very soon fuse together.



91. Palate of a fetus 19 cm long (Beginning of 5th month), seen from below. Magnif.: 2 : 1.



92. Right half of lower jaw of a fetus 6.3 cm long (11th week). Magnif.: 4 : 1.



93. Right half of the lower jaw of a fetus at the end of the 5th month. Magnif.: 2 : 1.

The *os ethmoidale* develops from several centres of ossification arising in the *cartilagenous nasal capsule* which surrounds the nasal cavity above and laterally and shows a division in the median line. About the end of the fifth month there appears a nucleus on each side in the lateral walls of the nasal capsule, from which the lamina papyracea develop and from which the conchae ossify. At the end of the first year a nucleus appears in the upper part of the cartilaginous nasal septum; from this the crista galli and the lamina perpendicularis ossify. In the sixth year the two lateral and the middle parts of the os ethmoidale unite with each other as well as with the accessory centres of ossification which appear in the crista galli and the lamina cribrosa after birth. The ossification of the os ethmoidale is not completed until the sixteenth year.

The *concha nasalis inferior* develops from a nucleus which first appears during the second half of fetal life in the lower portion of the lateral wall of the nasal capsule.

The *os lacrimale* is membranous in origin arising from a nucleus on the outer surface of the cartilaginous nasal capsule in the third month.

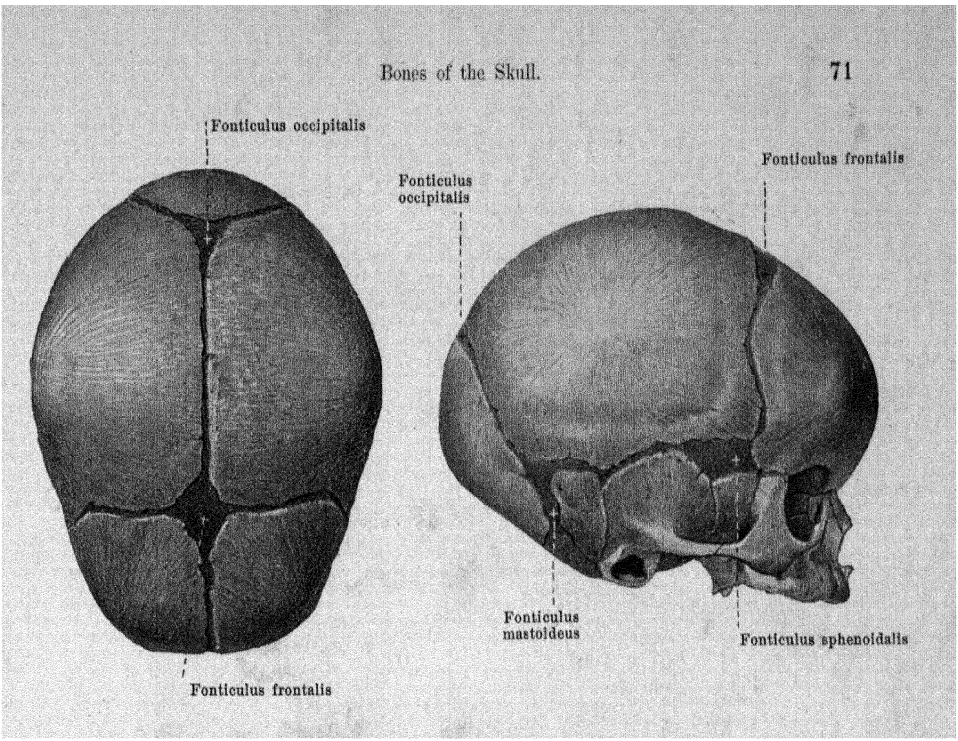
The *os nasale* is a membrane bone which is formed in the anterior part of the cartilaginous nasal capsule, out of a nucleus which first appears at the end of the second month. The cartilaginous substratum of the bone is resorbed after birth.

The *vomer*. In the eighth week there appears a centre of ossification on each side of the cartilaginous nasal septum close to the posterior border; these two centres of ossification unite at the lower margin of the septum and further grow together from behind forwards, while the cartilage between them is gradually resorbed. The vomer is therefore a purely membranous bone. Its development is completed at puberty.

The *maxilla* develops as a membranous bone in two parts, a medial which includes the region of the two incisor alveolae *(os incisivum)*, and a lateral corresponding to the remaining portion. The os incisivum, which helps to delimit the apertura piriformis through a protuberance directed frontally, receives a nucleus at the end of the sixth week; the remaining part, acquires one, or (according to some) more nuclei at the same time; both parts unite about the end of the second month. The sinus maxillaris appears first as a flat groove on the medial surface of the maxilla in the fourth fetal month.

The *os palatinum* is developed as a membrane bone from a nucleus which appears in the eighth week in the angle between the horizontal and vertical parts.

The *os zygomaticum* develops as a membrane bone from a nucleus in the eighth week. Not rarely there are two or three nuclei which for the most part fuse together, but occasionally may remain destinct *(os japonicum)*.



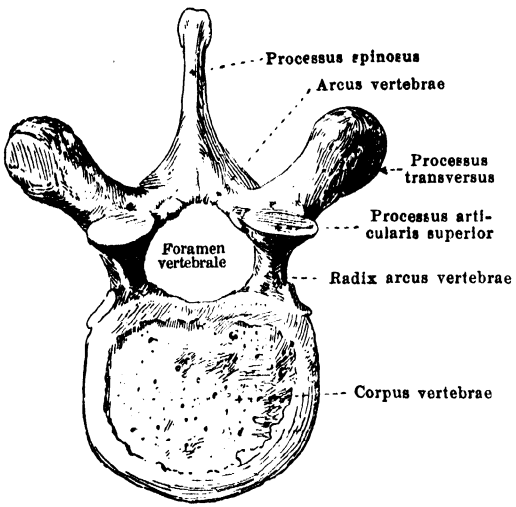
94 and 95. Skull of the new born child, magnification 1 : 2.

View from above. View from the right.

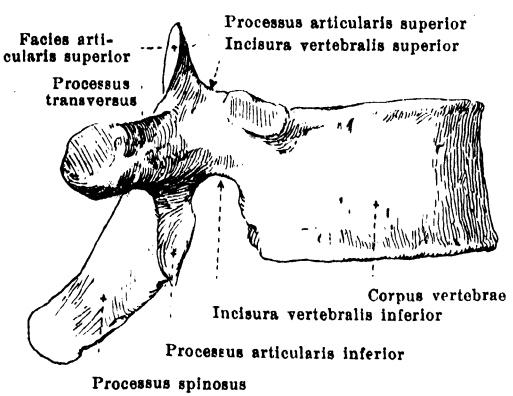
The *mandibula* (see Figs. 92 and 93) develops for the most part as a membrane bone on the lateral side of the *Meckel's cartilage* located in the first embryonic visceral arch, originating from a nucleus on each side, which first makes its appearance in the seventh week, and from which the main portion of the body and of the rami develops. Only the section of Meckel's cartilage in the neighborhood of the incisors is ossified directly into bone. Besides this, there arises also at the tip of the processus coronoideus, of the proc. condyloideus, and at the angle of the embryonic mandibula (independently of Meckel's cartilage), cartilage tissue which is transformed into bone. All these accessory bony formations soon merge into the chief bone. In the connective tissue between the two halves of the jaw there appear shortly before or after birth one or more small ossicles *(ossiculae mentalia)*, which quickly grow together with the corresponding half of the jaw. The two halves of the jaw unite in the first or second year.

The *os hyoideum* develops from cartilage, and ossifies from five centres, of which one is in the body, and one in each of the horns; the centres of ossification of the body and of the great horns appear at the end of fetal life, those of the small horns, only after birth.

Fontanels. In the *membranous skull capsule* (see page 67), there are found at first unossified portions at the places where the bones grow together; and more particularly narrow strips along what are to be later the skull sutures, and large spots where several bones come together. These latter regions are called the **fonticuli** *(fontanelles)* and are six in number; two unpaired and two paired. Of the unpaired the largest, quadrangular, *fonticulus frontalis [major]* lies at the junction of the suturae coronalis, sagittalis and frontalis, the small, triangular *fonticulus occipitalis [minor]* at the apex of the squama occipitalis, where the suturae lambdoideae and the sutura sagittalis meet. Of the paired fontanelles, the anterior, oblong *fonticulus sphenoidalis* lies at the apex of the large wing of the sphenoid, bounded by the angulus parietalis of the ala magna oss. sphenoidalis, by the squama temporalis oss. temporalis, the angulus sphenoidalis oss. parietalis, and the squama frontalis oss. frontalis; the posterior, more irregular *fonticulus mastoideus* is situated below the angulus mastoideus oss. parietalis, enclosed by this, by the pars mastoidea oss. temporalis, and by the squama occipitalis oss. occipitalis. The fontanelles usually close during the first, the fonticulus major not until the second half of the second year of life. The bones of the face with the exception of parts of the mandibula also arise like the roof bones.



from above



from the right

96 and 97. Vertebra, *vertebra*

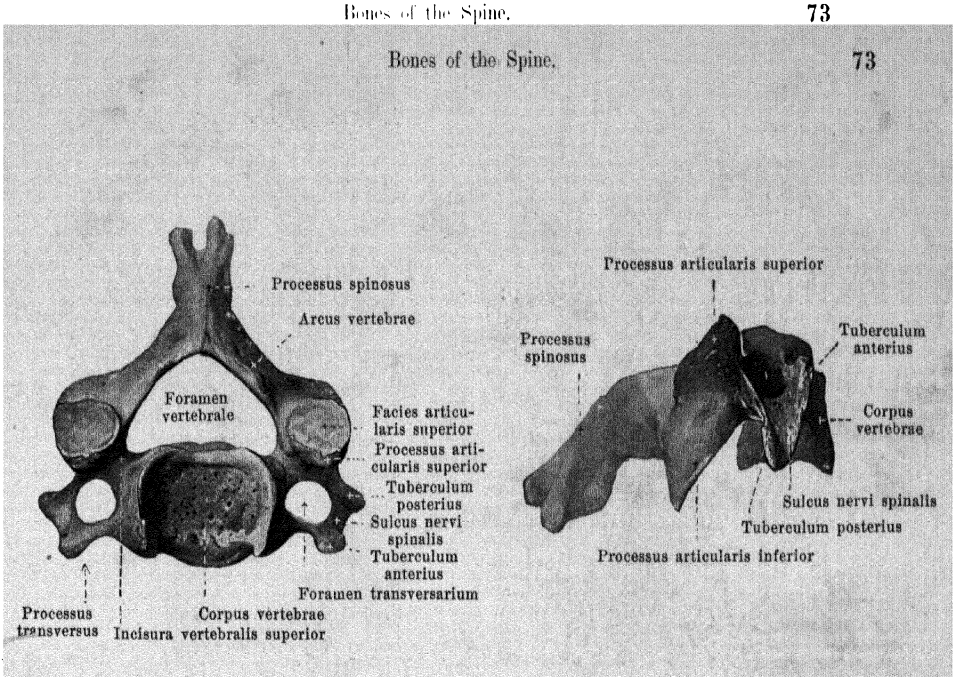
(10th thoracic vertebra, somewhat schematically represented).

The **columna vertebralis** *(vertebral column or spine)* extends from the base of the skull as far as the lower end of the trunk. It consists of the single *vertebrae* superimposed upon one another; these are divisible, according to the regions in which they lie, into *vertebrae cervicales, vertebrae thoracales, vertebrae lumbales, vertebrae sacrales,* and *vertebrae coccygeae.*

Each **vertebra** is approximately ring-shaped and consists of an anterior, thick body, *corpus vertebrae,* and a feebler, flat arch, *arcus vertebrae;* the two include between them a wide opening, the *foramen vertebrale.* The sum of all the vertebral foramina forms the *canalis vertebralis* (spinal canal). (For development see p. 98.)

The **corpus vertebrae** *(vertebral body)* possesses an upper and a lower surface which are nearly parallel and fit into the corresponding surfaces of the neighboring vertebrae; these surfaces are somewhat rough, flat or slightly depressed. The anterior and the lateral surfaces are convex in the horizontal, somewhat concave in the vertical direction; the posterior surface, which forms the anterior boundary of the foramen vertebrale, ih approximately flat and presents especially large foramina nutricia.

The **arcus vertebrae** *(vertebral arch)* begins at the upper part of the posterior surface of the corpus right and left by a narrow root, *radix arcus vertebrae* (O. T. pedicle), above this lies the shallower *incisura vertebralis superior,* below it the deeper *incisura vertebralis inferior;* the intervertebral notches of two adjoining vertebrae unite to form one *foramen intervertebrale* (for the passage of vessels and nerves) (see Fig. 108). Close behind these, passing upward on each side is the *processus articularis superior* with the *facies articularis superior,* which generally looks backward, while passing downward is the *processus articularis inferior* with the *facies articularis inferior* which generally looks forward; between or in front of these, directed lateralward, is the *processus transversus.* From the middle of the arcus, projecting backward, is seen the *processus spinosus.*

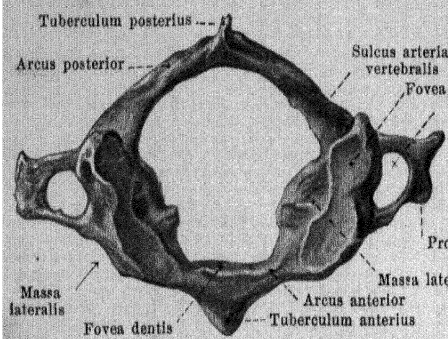


98 and 99. Fourth cervical vertebra,

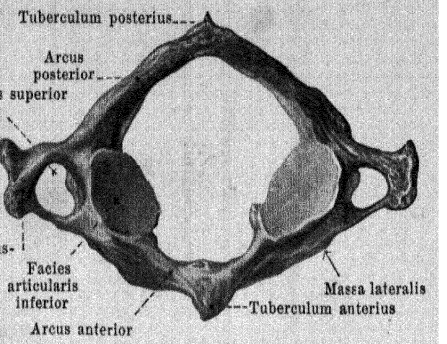
From above. *vertebra cervicalis IV.* From the right.

Each of the *seven* **vertebrae cervicales** *(cervical vertebrae)* (see also Fig. 105) has a low *body* which, as seen from above, is quadrangular with rounded angles. The upper surface is concave in frontal, slightly convex in sagittal direction, the lower exactly the reverse. The ***foramen vertebrale*** is very wide and triangular. The ***processus articulares superiores et inferiores*** are placed very obliquely; their *facies* ***articulares*** are smooth or slightly arched, the ***superiores*** look backward and upward, the ***inferiores*** forward and downward. The ***processus spinosi*** are usually short and split into two spurs. The form of the ***processus transversi*** is especially characteristic for the cervical vertebrae. These arise in front of the processus articulares, from the body and the radix arcus vertebrae, are short and directed lateralward. On the upper surface, each presents a deep **groove**, ***sulcus nervi spinalis*** (for the ramus anterior n. cervicalis) which runs out from the incisura vertebralis superior and separates, at the tip of the transverse process, the *tuberculum* ***anterius*** from the *tuberculum* ***posterius.*** In the region of the groove is situated also the ***foramen transversarium*** (in the upper six cervical vertebrae for the a. and v. vertebralis in the 7th only for the v. vertebralis). The part of the processus transversus situated in front of the foramen transversarium with the tuberculum anterius is partially homologous with a rib and is accordingly also called the ***processus costarius;*** it may be so developed on the seventh cervical vertebra that it actually forms a ***cervical rib*** (see Fig. 117, No. 4). (For development see p. 98).

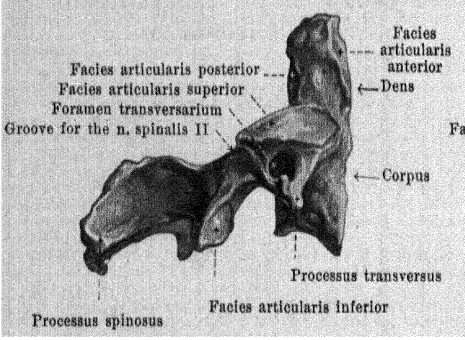
The first cervical vertebra, ***atlas,*** the second, *epistropheus*, and the seventh, ***vertebra prominens,*** differ in some respects markedly from the above description.



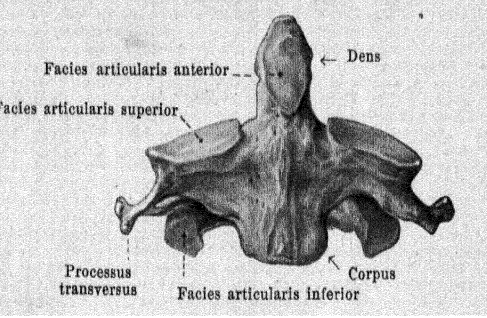
100. Atlas, from above.



101. Atlas, from below.



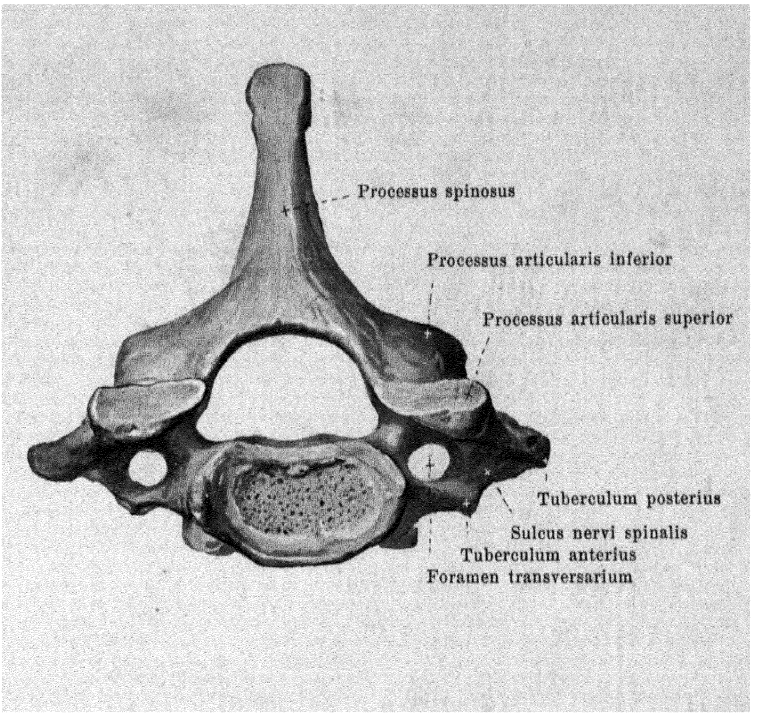
102. Epistropheus, from the right.



103. Epistropheus, from in front.

The **atlas** (see also Fig. 105) is especially characterized by the fact that it lacks the main mass of the body. The only representative of a body is a narrow mass of bone in front, ***arcus anterior,*** which presents, in the middle on its anterior surface, a small ***tuberculum anterius,*** on its posterior surface a flat *fovea dentis,* covered with cartilage. The arch proper, here called *arcus posterior,* is narrow, roundish and presents, in the middle behind, in place of the processus spinosus, a small ***tuberculum posterius.*** Between the two arches lie the *massae laterales;* each lateral mass possesses above an oval, concave articular surface, *fovea articularis superior,* for articulation with the condylus occipitalis (oss. occipitalis), below a flat, rounded *facies articularis inferior* for articulation with the epistropheus. Lateral from each massa lateralis the processus transversus projects far lateralward; it is devoid of sulcus n. spinalis and of tubercles. Running out from the foramen transversarium is a groove which leads behind the massa lateralis on the upper surface of the arcus posterior to the foramen vertebrale, the *sulcus arteriae vertebralis* (for the a. and v. vertebralis; n. suboccipitalis). See also p. 182. Incisurae vertebrales are absent in the form in which they occur in the other cervical vertebrae (vide infra).

The **epistropheus** (O. T. axis) (see also Figs. 102, 103 and 105) is especially characterized by a thick cone, *dens (tooth)* (O. T. odontoid process), which ascends from the upper surface of the body; this presents, both in front and behind, a small, flat surface, covered with cartilage, *facies articularis anterior* and *posterior* and ends above in a blunt tip. Near the toothshaped process on the lateral part of the body lie the slightly convex ***facies articulares superiores*** directed obliquely lateralward and upward. The processus articulares inferiores and spinosus show no especial deviations; the processus transversi lack the tubercula anterius and posterius as well as the sulcus n. spinalis; the foramen transversarium is present below the facies articularis superior as a short canal, curved laterally above. The incisura vertebralis inferior is present and situated as in the other cervical vertebrae, i. e. in front of the processus articularis. An exactly corresponding incisura vertebralis superior is however, absent behind the facies articularis superior, however, is a groove for the n. spinalis II.

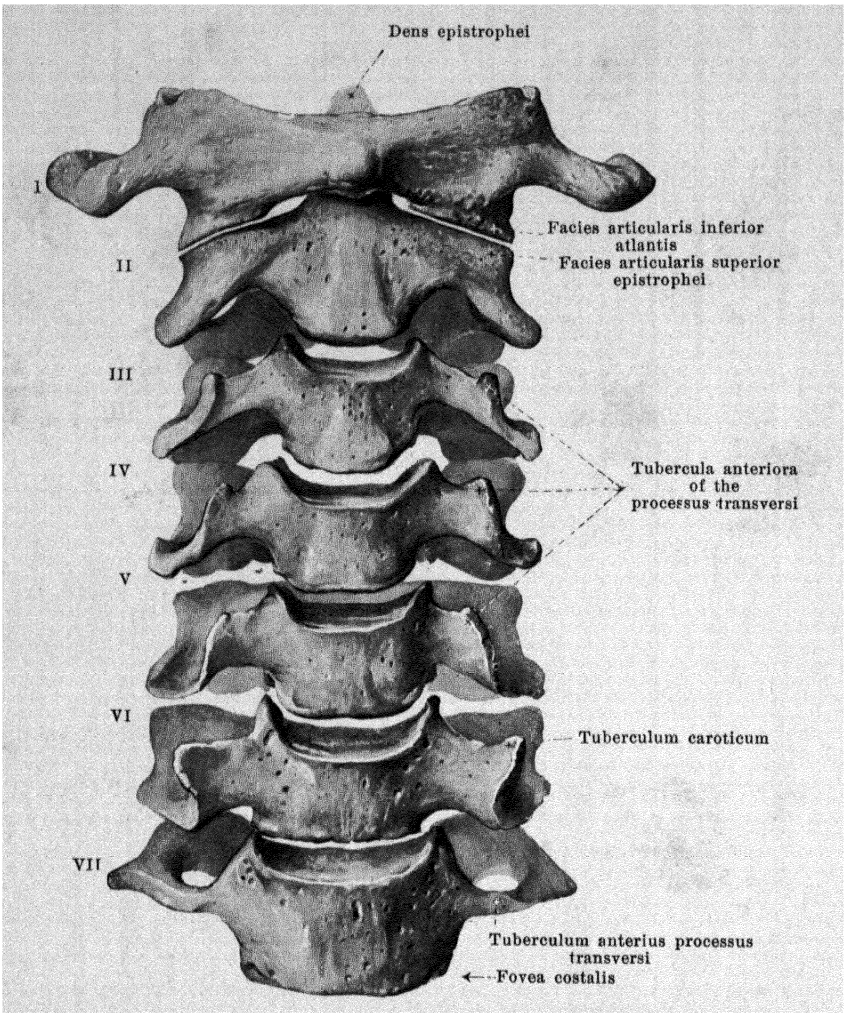


104. Seventh cervical vertebra, *vertebra prominens*, from above.

The **seventh cervical vertebra** (see also Fig. 105) is characterized by an especially long, powerful, non-bifurcated processus spinosus, which on palpation of the spine from above is usually the first to be distinctly felt; the vertebra is accordingly named the **vertebra prominens.** It has in addition longer processus transversi; its foramen transversarium is sometimes absent, it is nearly always small, is sometimes subdivided and often serves for the passage of the v. vertebralis (not the a. vertebralis).

On the lower margin of the lateral surface of the body a *fovea costalis* is usually present for articulation with the head of the first rib.

The part (processus costarius, see p. 73) situated in front of the foramen transversarium, is sometimes slightly movable, forming the so-called *cervical rib,* in which case its length may vary greatly (see Fig. 117, No. 4).

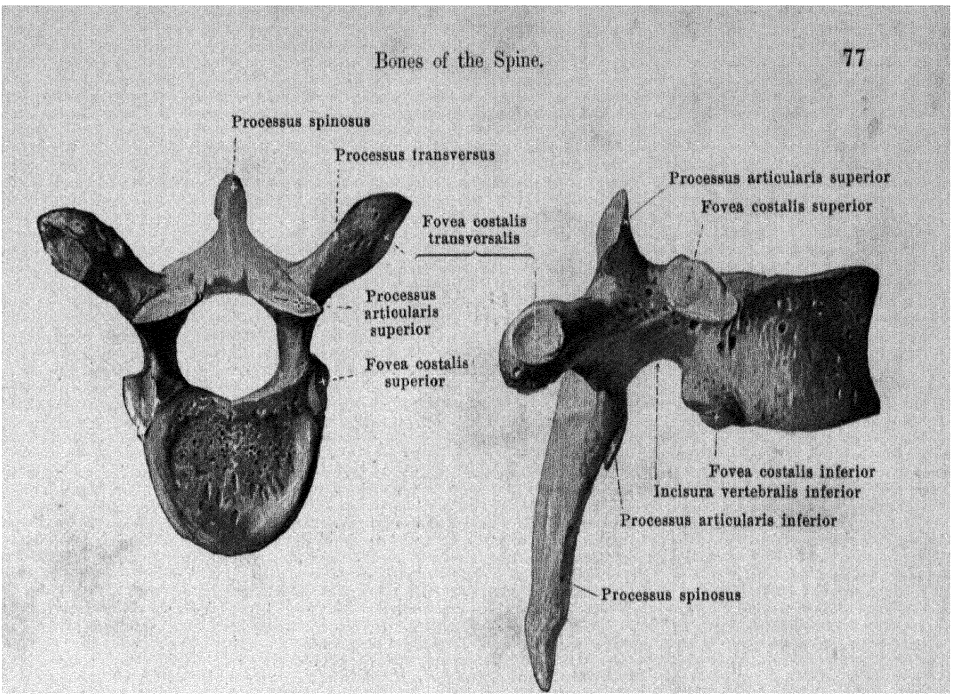


105. Cervical spine, *vertebrae cervicales,* from in front.

The bodies of the *cervical vertebrae* grow gradually broader from the 2nd to the 7th. The adjacent surfaces of the same are so curved that the under surface of each vertebra always fits into the upper surface of the next vertebra below.

The processus transversi on the whole diminish gradually in length from the seventh upward as far as the second vertebra; then follow immediately the widely projecting processus transversi of the atlas. The tubercula anteriora of the processus transversi increase in size from the third to the sixth vertebra; those of the sixth vertebra are called the ***tubercula carotica;*** on the seventh vertebra they are only feebly developed (see also Fig. 104).

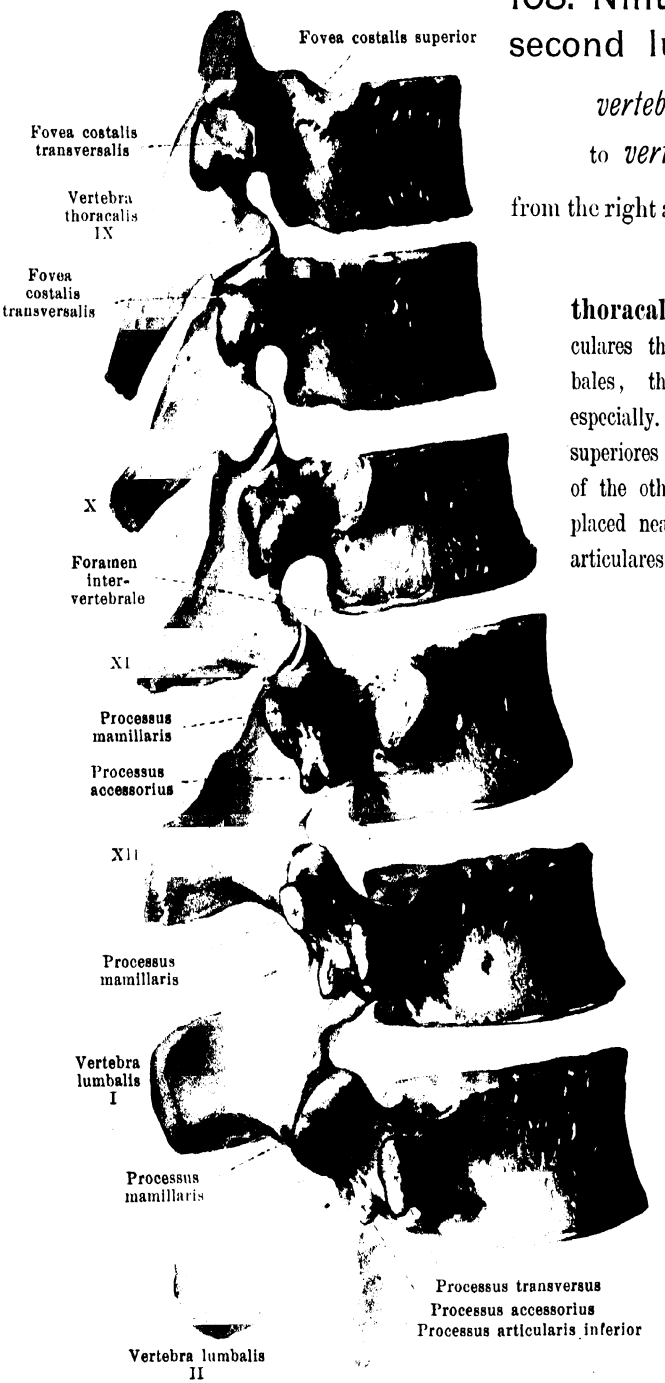
The processus spinosi are short from the second to the (fifth or) sixth cervical vertebrae, usually bifurcated and increase gradually somewhat in length; on the (sixth and) seventh cervical vertebra they are long and not bifurcated.



106 and 107. Sixth thoracic vertebra, *vertebra thoracalis VI.*

From above. From the right.

The *twelve* **vertebrae thoracales** *(thoracic vertebrae,* O. T. dorsal vertebrae) (see also Fig. 108, 127 and 128) possess broad *bodies* which in front are slightly lower than at the back. The connecting surfaces of the bodies are flat and on the upper and lower vertebrae are described as bean-shaped, on the middle vertebrae as more heart-shaped. The ***foramen vertebrale*** is narrow and rounded. The *processus articulares* stand nearly frontally, their ***facies articulares*** are slightly curved and form parts of the mantle of a cylinder, the axis of which is situated in front of the body; the facies articulares superiores look backward, the facies articulares inferiores forward. The *processus transversi* arise between the processus articulares and are very powerful; they are, below more than above, directed obliquely backward and lateralward. On the anterior surface of their lateral extremity they present a small fossa covered with cartilage, the ***fovea costalis transversalis*** (O. T. facet for tubercle of rib) for articulation with the tuberculum costae; they are absent from the eleventh and twelfth (see Fig. 108), sometimes also from the tenth vertebra. The *processus spinosi* are long, triangular, apical and directed more or less markedly downward; the middle ones cover one another like tiles of a roof (see Figs. 127 and 128). The small articular surfaces which lie on the lateral surfaces of the bodies of the vertebrae, just in front of the roots of the vertebral arches, are special peculiarities of the thoracic vertebrae. On the nine upper vertebrae two of these are present on each bone, one larger at the upper margin, *fovea costalis* ***superior*** (O. T. demifacet for head of rib) and one smaller on the lower margin, *fovea costalis* ***inferior;*** each fovea costalis inferior forms with the fovea costalis superior of the next vertebra below and with the intervertebral disc lying between them the articular surface for one capitulum costae. On the tenth to the twelfth vertebra (see Fig. 108) there is only one *fovea costalis;* on the tenth it lies on the upper margin, on the eleventh and twelfth vertebra in the middle of the lateral surface. (For development see p. 98.)



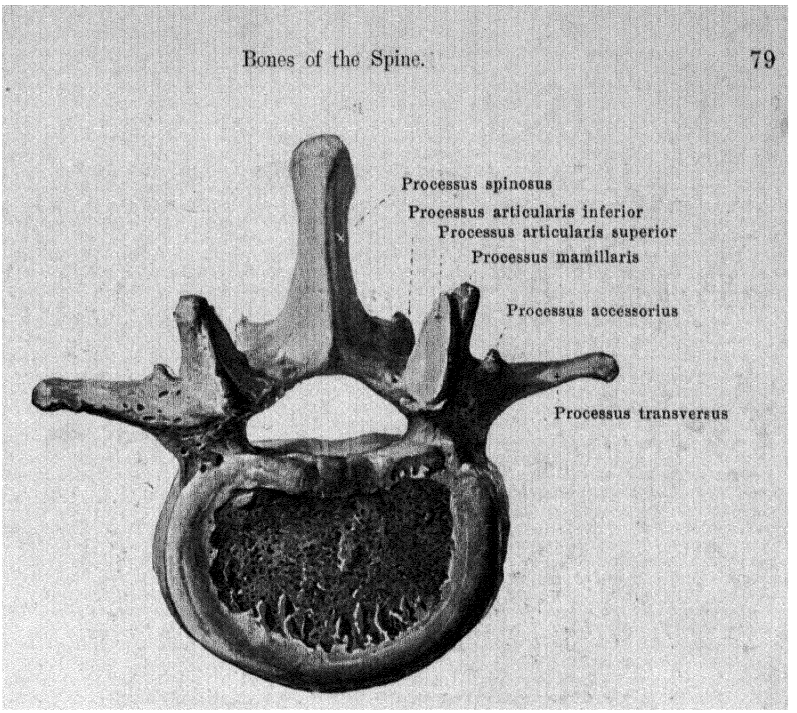
108. Ninth thoracic to the second lumbar vertebra,

vertebra thoracalis IX
to *vertebra lumbalis II*,

from the right and somewhat from behind.

The lower two **vertebrae thoracales** approach in many particulares the form of the vertebrae lumbales, the twelfth thoracic vertebra especially. The processus articulares superiores of the latter are, like those of the other thoracic vertebrae, usually placed nearly frontally; their processus articulares inferiores on the contrary, like those of the lumbar vertebrae, nearly sagittally. This change in the direction of the processus articulares may occur even at the eleventh thoracic vertebra.

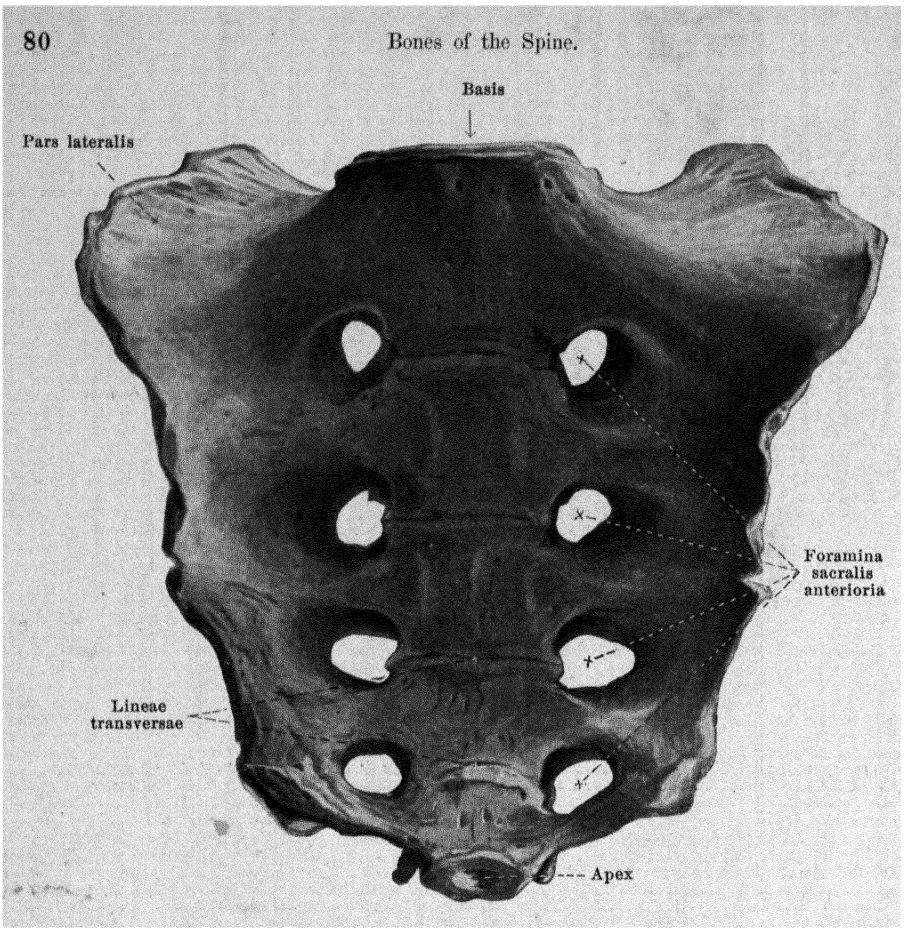
Further, on the posterior surface of the processus transversi and articulares superiores small projections are present which resemble in form and position the *processus accessorii* and *mamillares* of the lumbar vertebrae (see p. 79); these are usually distinctly marked on the twelfth thoracic vertebra, less so on the eleventh and tenth. The processus transversi are short and directed markedly backward.



109. Third lumbar vertebra, *vertebra lumbalis III*, from above.

The *five* **vertebrae lumbales** *(lumbar vertebrae)* (see also Fig. 108) are higher and broader than the cervical and thoracic vertebrae. Their *bodies* have flat connecting surfaces, varying from a bean-shaped to a transversely oval form. The *foramen vertebrale* is narrow and tringular. The *processus articulares* are vertical; their *facies articulares* lie nearly in sagittal planes; the *facies articulares superiores* are concave behind and hollowed out medianward, the *facies articulares inferiores* are convex in front and lateralward, so that the two belong to a cylinder-mantle, the axis of which is situated behind the processus spinosus; every two processus articulares superiores surround the processus articulares inferiores of the next vertebra above as an axle-box does an axle. On the posterior margin of the processus articularis superior a blunt bony mass, the *processus maxillaris*, projects backward. The *processus spinosi* are flat and high, pass straight backward, end in a swollen extremity and are often bent hook-like, downward. The *processus transversi* arise in front of the processus articulares from the region of the radix arcus vertebrae; they are thin, flat and directed only slightly backward. They are considered from their largest part to be homologues of the ribs; the corresponding part is accordingly also designated as the *processus costarius;* this is sometimes especially large on the first lumbar vertebra and united by a joint with the rest of the process; it is then called a *lumbar rib* (see Fig. 117, No. 8). On the posterior surface of the root of the transverse process, lateral from and below the processus mamillaris, a small, variably developed nodule, the *processus accessorius*, projects backward. (For development see p. 98.)

The fifth lumbar vertebra (see Fig. 117, No. 9) is peculiar in that its body exceeds all the others in size; furthermore its body is essentially higher in front than behind; its processus transversi are short, thick and bluntly wedge-shaped, springing with a broad base from the posterior segment of the body and from the root of the arch and directed lateralward and a little backward and upward; the processus articulares superiores are directed more backwards, the processus articulares inferiores more forwards, than those of the other lumbar vertebrae.

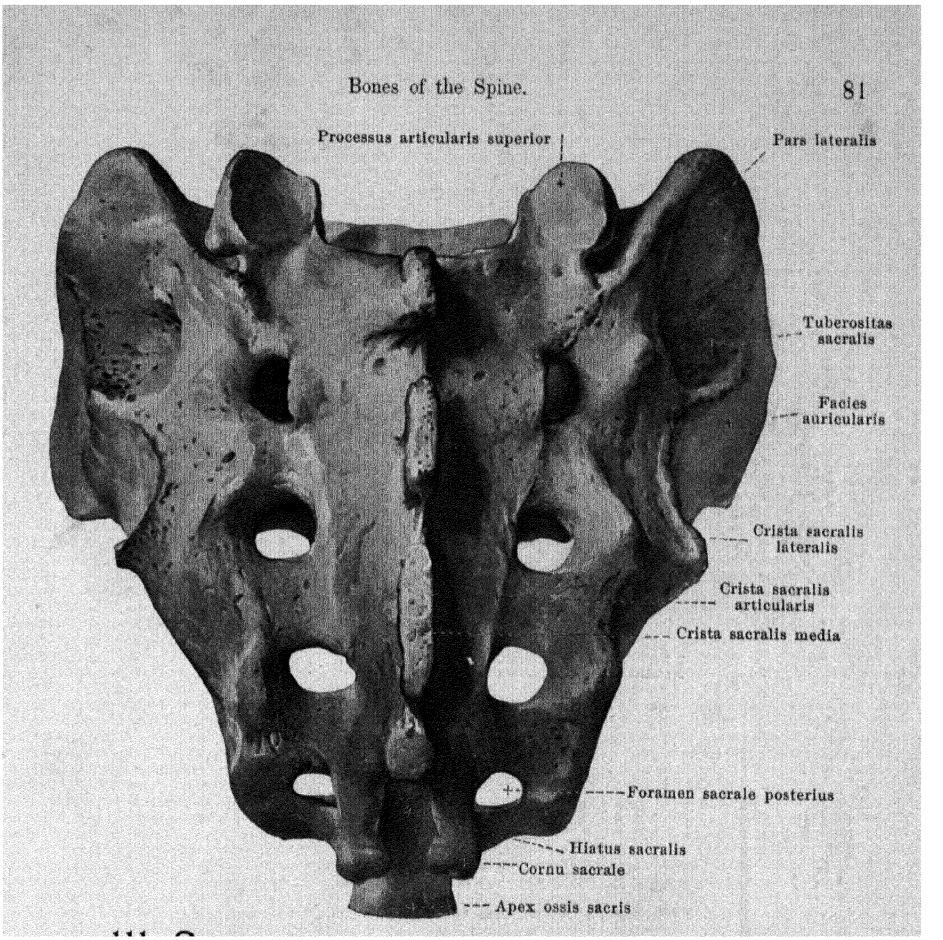


110. Sacrum, *os sacrum,* from in front and below.

The *five vertebrae sacrales* are distinctly separated from one another in youth only; in the adult they are fused to a single bone, the **os sacrum** (see also Figs. 111—114), which is situated below the lumbar vertebra and is the largest and broadest bone of the vertebral column. (For development see p. 98.)

The os sacrum is wedge-shaped, broad above *(basis),* pointed below *(apex)* and often a little more bent about the middle of the third vertebra; it is broadest in the region of the first sacral vertebra, narrows itself somewhat at the second, again usually broadens somewhat at the third vertebra, and from there on constantly diminishes in width; near the tip it possesses an incisura one on each side; its sagittal diameter also diminishes essentially from above downward. Its anterior inferior surface, *facies pelvina,* looking into the pelvis, is concave, its posterior upper surface, *facies dorsalis,* is convex.

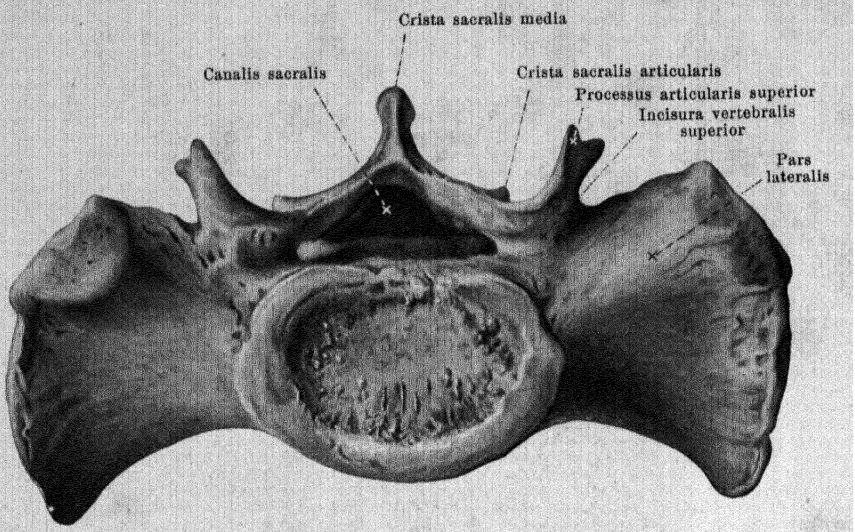
The anterior interior surface, **facies pelvina,** is in general smooth and concave. In the middle, four *lineae transversae* are to be seen, lines corresponding to the places where the five individual bodies of the sacral vertebrae have grown together. Lateral from them on each side lying in a vertical series over one another are the four *foramina sacralia anteriora,* which behind and medianward lead into the *canalis sacralis* (see Fig. 113), but, lateralward, run out into grooves on the anterior surface of the partes laterales. The foramina sacralia anteriora diminish in size from above downward; below the last one, near the apex ossis sacri, is a notch which is closed by the processus transversus ossis coccygis and by the ligamentum sacrococcygeum laterale to form a fifth foramen sacrale. The *apex ossis sacri* presents a small oval, flat surface which is formed by the body of the fifth sacral vertebra only and is united at the *symphysis sacrococcygea* with the upper surface of the coccyx.



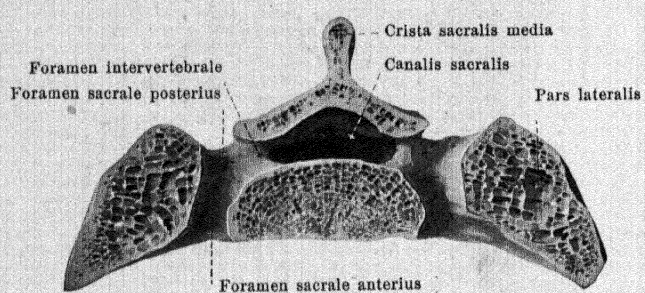
111. Sacrum, *os sacrum,* from behind and above.

The **facies dorsalis ossis sacri** is very rough and convex from above downward and from right to left. On it five rows of processes and projections run downward, almost parallel to one another. The middle row, *crista sacralis media,* has resulted from the fusion of the processus spinosi and is most marked; it presents often an uninterrupted ridge and four tuberosities corresponding to the processus spinosi of the four vertebrae, but is frequently incomplete. Lateralward on each side lies the *crista sacralis articularis;* it is to be considered as the processus articulares fused with one another and usually projects only moderately above the surface and can sometimes be recognized as oblong grooved projections one on each side of the foramina sacralia. Lateralward from this, separated from it by the foramina sacralia posteriora, is the *crista sacralis lateralis;* it arises from the fusion of the processus transversi, consists of a row of tuberosities and is usually more distinctly marked than the crista sacralis articularis. The four *foramina sacralia posteriora* like the anterior, are situated on both sides in nearly parallel rows; they are smaller and more rounded than the anterior ones; they lead (see Fig. 113) forward and medianward into the canalis sacralis, forward and downward to the foramina sacralia anteriora.

Corresponding to the upper end of the cristae sacrales articulares the two completely developed *processus articulares superiores* of the first sacral vertebra pass vertically upward; their facies articulares superiores are directed backward and somewhat medianward and articulate with the processus articulares inferiores of the fifth lumbar vertebra. From the lower end of the cristae sacrales articulares the two small *cornua sacralia* pass downward to meet the cornua coccygea ossis coccygis. Medianward from them lies the lower opening of the canalis sacralis, *hiatus sacralis;* it is usually triangular and varies much in size and arises from the incomplete closure of the arch of the fifth lumbar vertebra and the absence of its processus spinosus.



112. Sacrum, *os sacrum*, from above.

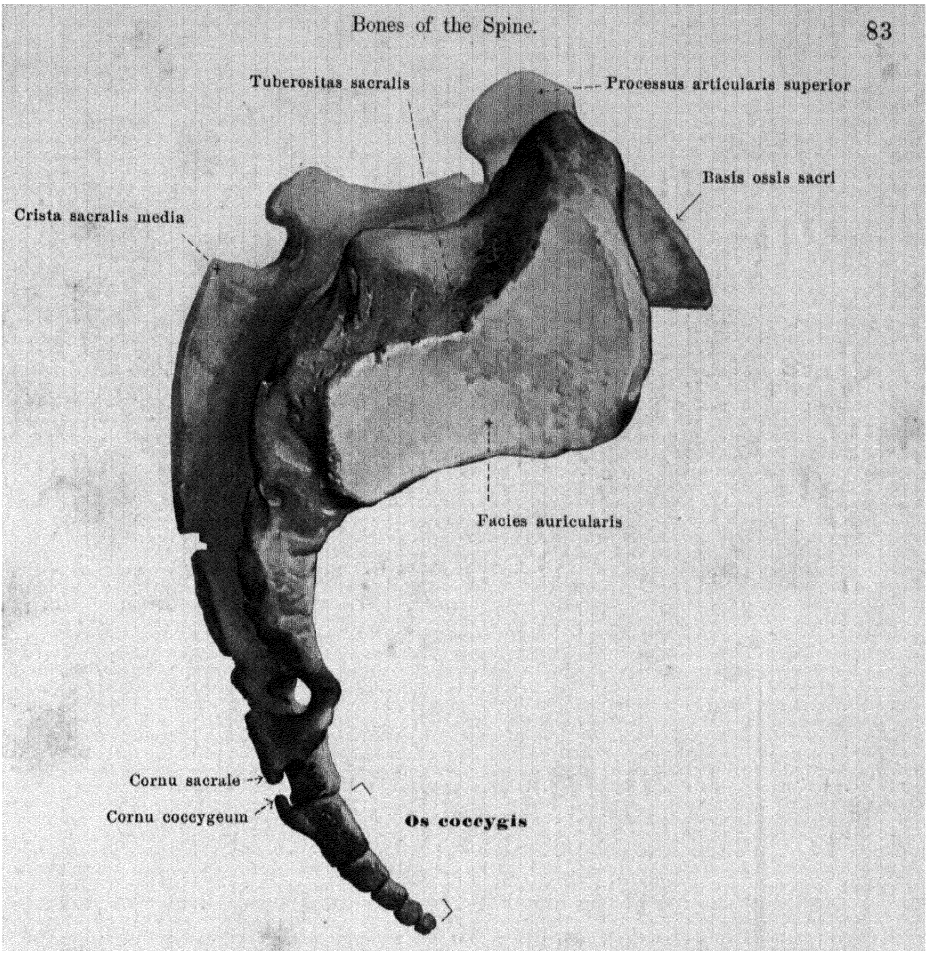


113. Transverse section through the sacrum

at the level of the second pair of foramina sacralia.

The anterior upper surface of the sacrum, **basis ossis sacri** (see also Figs. 110, 111 and 114) contains in the middle a somewhat projecting, transversely oval, flat surface slightly depressed and rough in the middle (the juncture of the 1st sacral vertebra), with which the body of the fifth lumbar vertebra is connected by means of an intervertebral disc. Behind this lies the upper, triangular opening of the *canalis sacralis* which passes through the sacrum as a flattened, triangular canal from above downward and reaches its lower extremity in the hiatus sacralis on the posterior surface, a little above the apex (see Figs. 202 and 203); within the bone at the junctions of the vertebrae sacrales going off from it on each side are four short canals *(foramina intervertebralia)* which are continued H-shaped into the foramina sacralia anteriora and posteriora. Lateralward from the upper opening of the canalis sacralis the *processus articulares superiores* of the 1st sacral vertebra (see p. 81) project upward; in front of them lie the *incisurae vertebrales superiores*. The lateral portions of the basis ossis sacri are smooth, somewhat concave and form the anterior, upper limiting surfaces of the partes laterales ossis sacri.

Through the union of the fifth lumbar vertebra with the sacrum there arises, at the site of junction in front, an angle projecting somewhat downward and forward, the *promontorium* (O. T. sacrovertebral angle) (see Figs. 202 and 203).



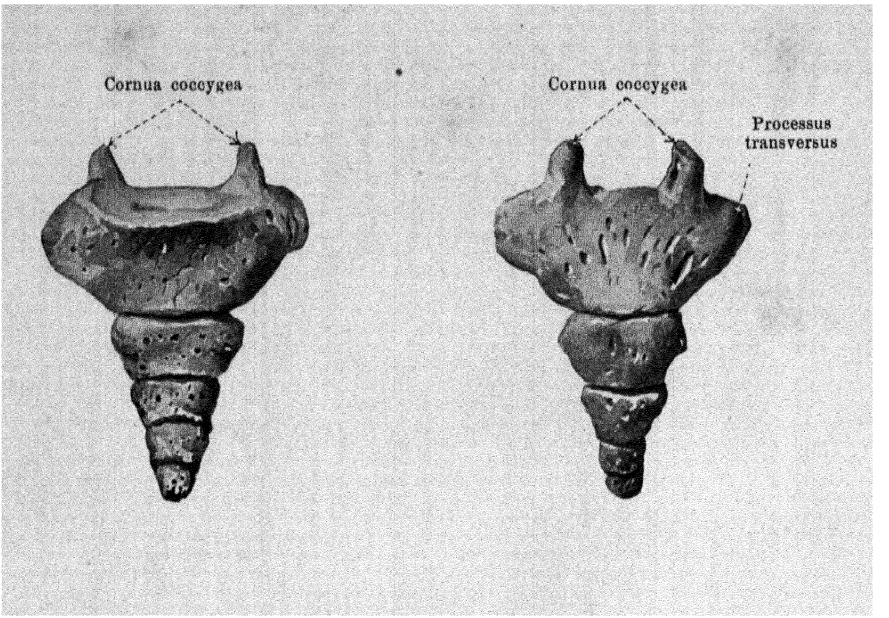
114. Sacrum and coccyx, *os sacrum* and *os coccygis.*

From the right.

The portions which lie lateralward from the foramina sacralia are called the **partes laterales ossis sacri** (see also Figs. 110–113); they have arisen through fusion of the transverse processus and of rudiments of ribs (on the upper three vertebrae). The partes laterales grow much narrower from above downward and present on the upper part of their free lateral surfaces an uneven roughly triangular joint surface, *facies auricularis,* covered with cartilage, for union with the hip bone; it is formed in the main by the first sacral vertebra, less by the second and least by the third. Behind the facies auricularis lies a markedly roughened surface, *tuberositas sacralis,* to which are attached the ligamenta sacroiliaca interossea; medially and dorsally from it runs the crista sacralis lateralis along the facies dorsalis downwards. The part lateralis along its anterior and inferior surface helps to form the facies pelvina.

Sometimes the uppermost vertebra of the sacrum is fused laterally with the pars lateralis only in one-half, while on the other half it has a shape similar to that of a lumbar vertebra; such a transition form is called a *lumbosacral vertebra* (see Fig. 117, No. 11).

The sacrum usually presents certain differences in the two sexes. In man, it is longer, relatively narrower and also more markedly curved; in woman it is shorter, relatively broader and the curve is flatter (see Figs. 196–203).

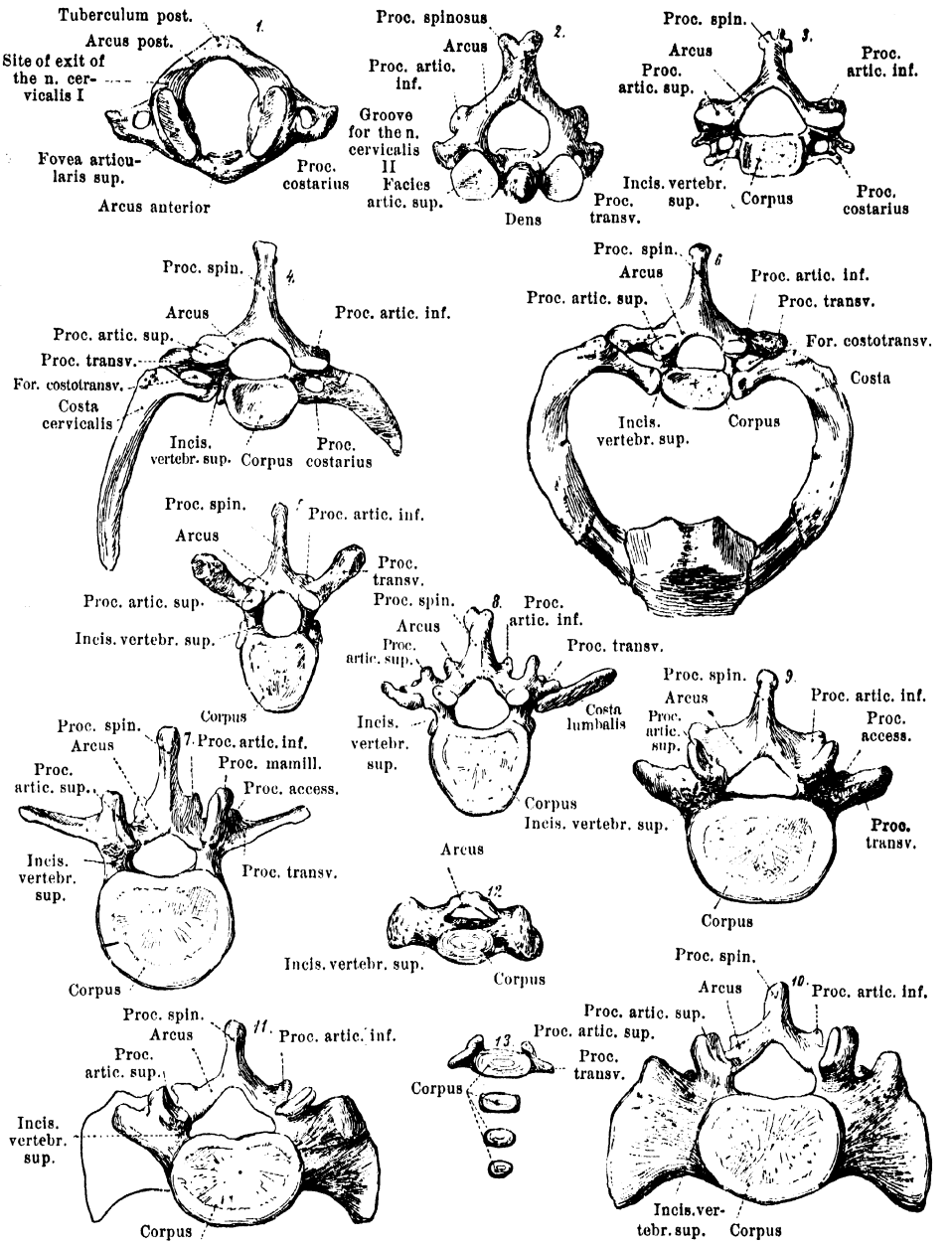


115 and 116. Coccyx, *os coccygis.*

From in front. From behind.

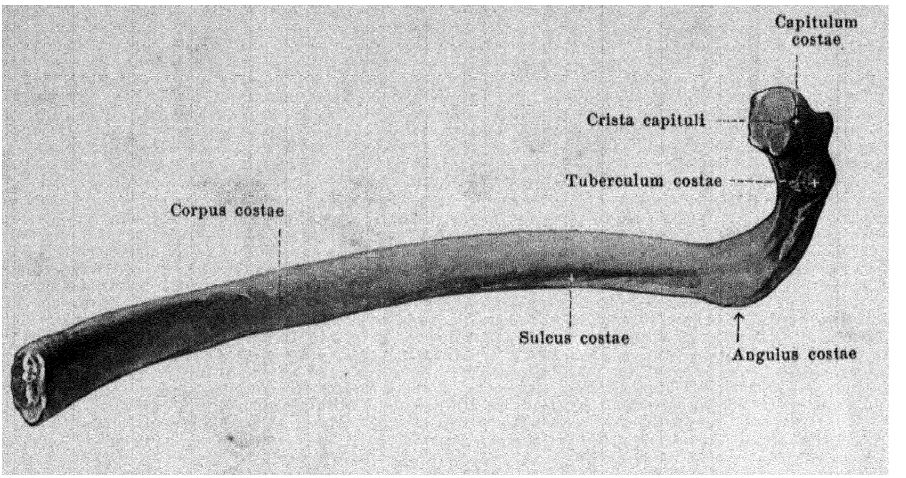
The **os coccygis** (see also Fig. 114) lies as a small, triangular bone at the lower end of the vertebral column below the sacrum. It consists of from four to five rudimentary *vertebrae coccygeae*, of each of which the body only, as a rule, is present. The first possesses still two small, transversely directed *processus transversi* and in place of the processus articulares superiores two flat processes, *cornua coccygea*, directed upward. The succeeding vertebrae diminish in size from above downward and represent actually only small oblong or spherical pieces of bone. (For development see p. 98.)

The upper surface of the coccyx is united with the tip of the sacrum by the *symphysis sacrococcygea* (see p. 180). The first, second and third coccygeal vertebra are usually united with one another by a layer of fibro-cartilage, the third, fourth and fifth by bony substance. Deviations occur very often in that the connections between the first three or that between the coccyx and sacrum ossify.



117. *Collection of different* vertebrae *and* vertebral varieties *to illustrate the morphological value of the single parts* (after Quain).

1. Atlas; 2. epistropheus; 3. fifth cervical vertebra; 4. seventh cervical vertebra with cervical rib; 5. mid-thoracic vertebra; 6. first thoracic vertebra with ribs and a part of the sternum; 7. third lumbar vertebra; 8. first lumbar vertebra with lumbar rib; 9. fifth lumbar vertebra; 10. first sacral vertebra; 11. lumbosacral vertebra; 12. fourth sacral vertebra of a young individual; 13. four coccygeal vertebrae.
All the vertebrae are drawn as seen from above.



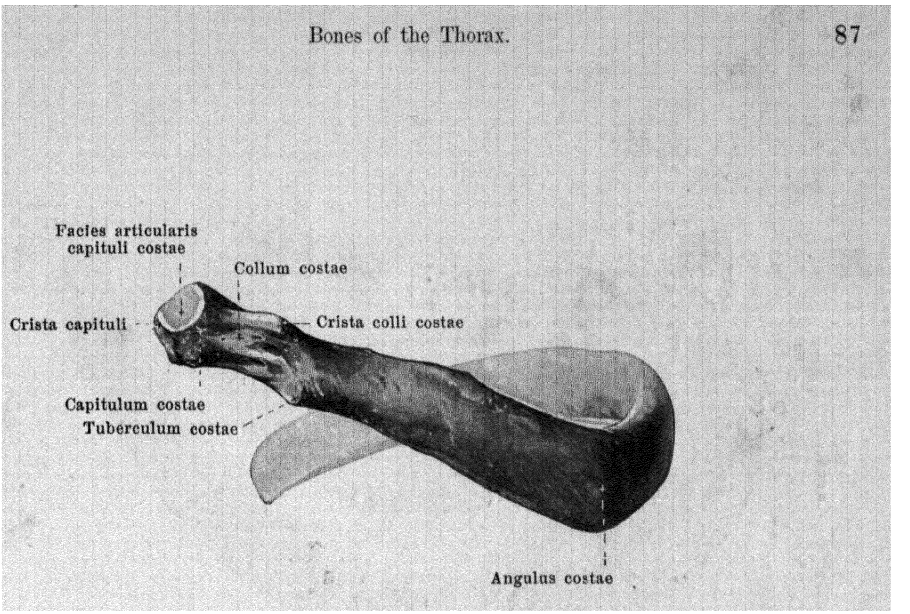
118. Seventh rib of right side, *costa VII,* from within.

The *twelve* **costae** *(ribs)* (see also Figs. 119—123, 126—128) are thin, partly bony, partly cartilaginous masses which go out on each side from the lateral surfaces of the thoracic vertebrae and which, forming an arch which is convex lateralward, help to bound the thoracic cavity. Each thoracic vertebra corresponds to a pair of ribs; they are numbered from above downward. Their length increases from the first to the seventh; and decreases again from the eight down. (For the development see p. 99.)

The upper seven (sometimes eight) pairs of ribs are fastened directly to the sternum in front near the median plane and are distinguished as *costae verae* (true ribs) from the lower five (sometimes four) pairs of ribs, the *costae spuriae* (false ribs), which are indirectly connected with the sternum or else end free. The eleventh and twelfth ribs which are not joined either to the other ribs or with each other, and which float freely in the abdominal muscles are named costae fluctuantes.

Each rib consist of a longer posterior bony portion, *os costale,* and a shorter, anterior, cartilaginous portion, the *cartilago costalis.*

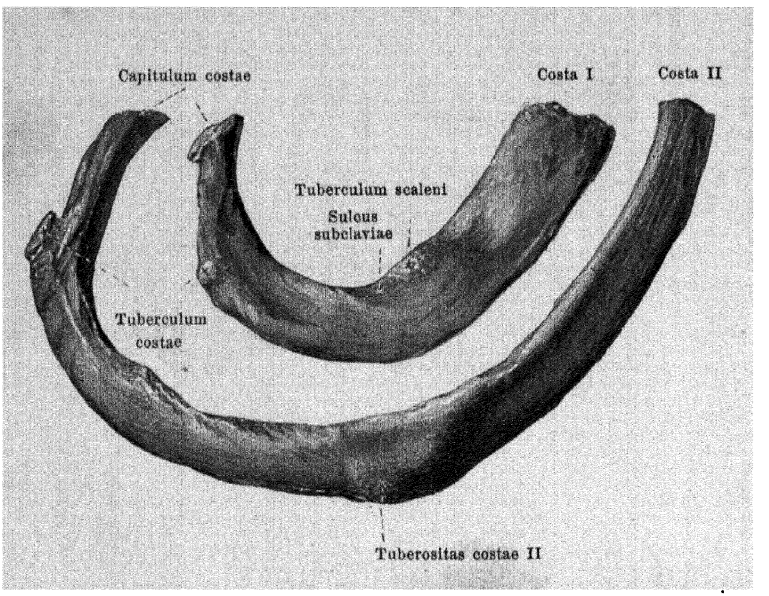
Each ***os costale*** is somewhat expanded at its vertebral end so as to form the ***capitulum costae*** (head of the rib); this possesses a small ***facies articularis capituli costae,*** covered over with cartilage, which is divided, on the ribs from the second to the tenth, by a transverse ridge, *crista capituli,* into an upper smaller and a lower larger surface. By means of these joint surfaces the heads of the ribs articulate with the foveae costales of the bodies of the vertebrae. The portion of the bone adjoining the capitulum is somewhat narrowed, ***collum costae*** (neck of the rib), on the upper ribs more distinctly than on the lower; the neck presents on its upper margin a longitudinal ridge, ***crista colli costae,*** which is continued lateralward upon the shaft and is absent only from the first and the last ribs; at its lateral extremity a small nodule, *tuberculum costae,* projects backward and downward; this possesses a small *facies* ***articularis tuberculi costae,*** covered with cartilage, for articulation with the fovea costalis transversalis of the corresponding vertebra; it is largest on the first ribs and is absent, along with the joint surfaces, on the (tenth) eleventh and twelfth ribs.



119. Eighth rib of right side, *costa VIII*, from behind.

The middle piece or shaft of the rib, ***corpus costae***, forms lateralward from the tuberculum costae an angle which is directed backward and downward, the *angulus costae*. This lies on the first rib close to the tubercle; on succeeding ribs it is situated ever more lateralward; it is most marked on the middle ribs and is absent from the last two ribs. The body of the rib is a flat plate of bone oblong oval in cross section with an internal and an external smooth surface; the external surface is directed vertically in the middle ribs, markedly upward in the uppermost ribs, more downward in the lowermost (see Figs. 126—128). The curvature of a whole rib is double, since in the first place the surface of the shaft is bent so as to be convex lateralward and in the second place, its upper edge is curved so as to be concave or S-shaped. On the internal surface near the lower margin runs the *sulcus costae* (for the v., a. and n. intercostalis); it begins at the tubercle, is most marked behind and becomes lost in front; on the first and last ribs it is absent or only slightly indicated. The anterior extremity is less broadened and ends in a rough depressed surface for the reception of the costal cartilage.

The ***cartilago costalis (costal cartilage)*** (see Fig. 126) has in general the same shape as the rib. It unites in front with the sternum (1^{st}—7^{th}) or is attached to the cartilage of the next rib above (8^{th}—10^{th}), or ends freely (11^{th} and 12^{th} ribs). (See p. 86.) The cartilages increase in length from the first to the seventh; from this on they decrease so that the cartilages of the eleventh ant twelfth ribs are only short pointed pieces. The first two costal cartilages only follow the same direction as the bony parts of their ribs, the others are curved upward at their anterior extremities, the upper ones more than the lower. The costal cartilages often become ossified in old age, the first most frequently.

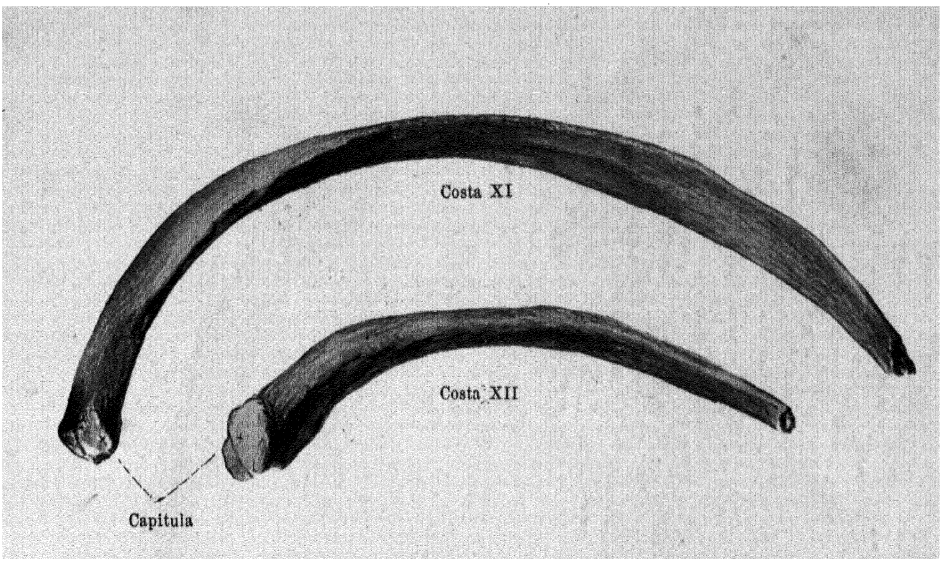


120 and 121. First and second ribs of right side, *costae I et II*, from above and without.

The first two ribs present certain peculiarities.

The **costa I** (see also Figs. 126, 128 and 129) is on the whole directed equally obliquely forward and downward and possesses an upper surface directed somewhat lateralward and a lower directed somewhat medianward. It is broad and flat particularly in front, and its anterior portion is but slightly curved. On the upper surface a little in front of middle, near the medial border is a small nodule (sometimes only a roughening), *tuberculum scaleni [Lisfranci]* (for the attachment of the m. scalenus anterior); a very shallow furrow in front of this serves for the v. subclavia, a curve behind this, the *sulcus subclaviae,* for the a. subclavia is usually somewhat more distinctly marked. Behind the latter lies another roughened area for the m. scalenus medius.

The **costa II** (see also Figs. 126 and 128) is slender and about twice as long as the first and resembles the other ribs in its form much more than it does the first rib. On its lateral surface, somewhat in front of the middle, is a roughened area, the *tuberositas costae II* (for the attachment of prongs of the m. serratus anterior).

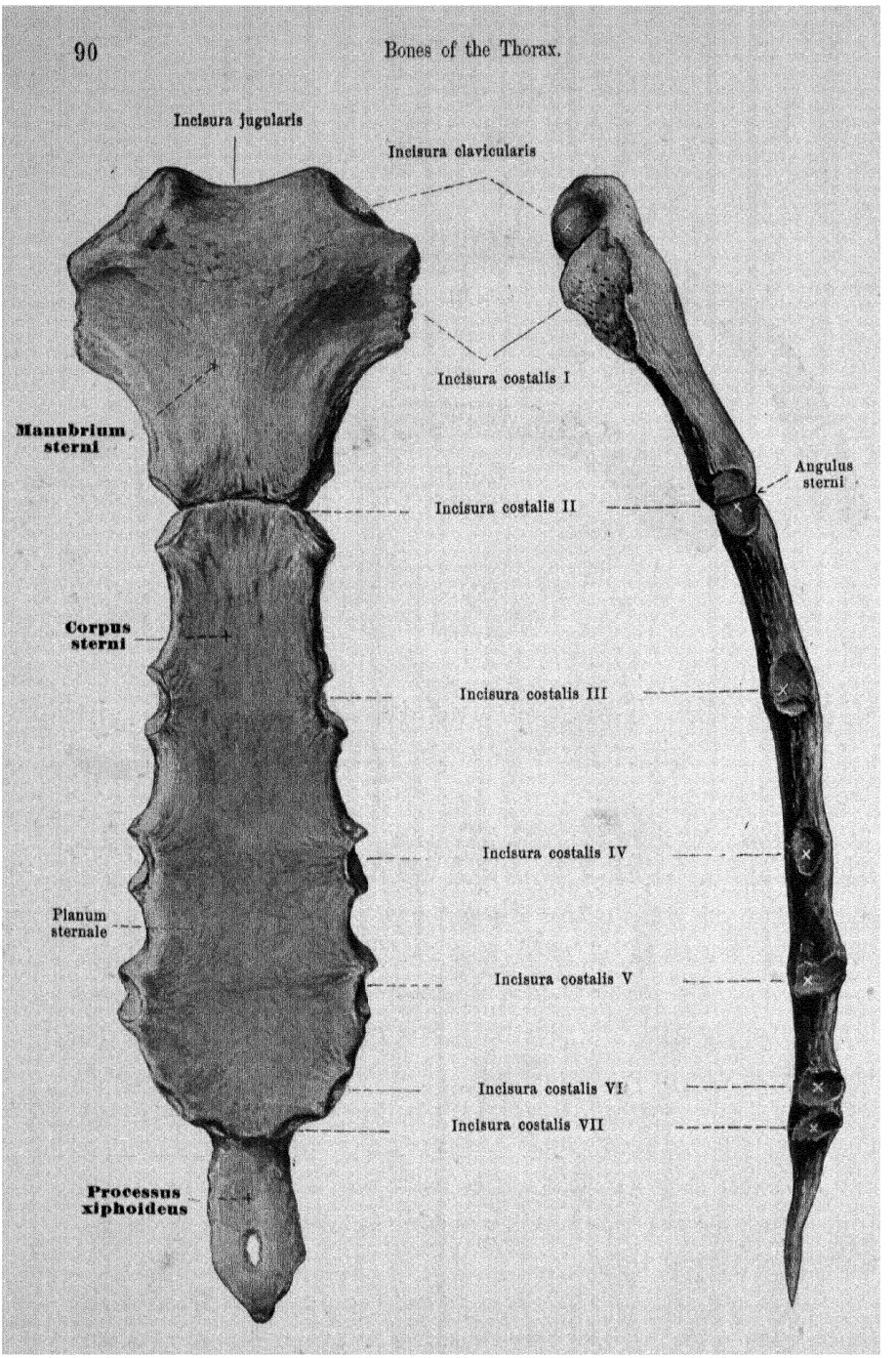


122 and 123. Eleventh and twelfth ribs of right side, *costae XI et XII*, from below.

The **costa XI** is like the **costa XII** (see also Figs. 127 and 128), a delicate bone in which there can be sharply made out only a small *capitulum* behind without crista capituli; the collum costae and tuberculum costae are practically absent as are also the angulus costae and the sulcus costae. The two ribs are, in their whole length, directed nearly evenly obliquely downward and curved so as to be almost evenly convex lateralward and backward. The cross section shows rounded angles; in front the ribs become sharper and possess generally only a small cartilaginous tip. They form no joint union with the other ribs, but end free between the abdominal muscles; the eleventh rib is pretty uniformly turned obliquely downwards through its entire length.

The twelfth rib is very variable in its length; when it is long, it runs parallel to the eleventh rib; when it is short, it runs more transversally and resembles the proc. transversus of a lumbar vertebra.

Between every two adjacent ribs is an intercostal space **spatium intercostale** (see Figs. 126—128). Its form resembles that of the adjacent ribs and varies with their shape and position.



124 and 125. Breast bone, *sternum.*

From in front. From the right.

The **sternum** *(breast bone)* (see also Figs. 126 and 128) lies as an unpaired oblong plate of bone in the median plane and helps to form the anterior wall of the thorax. It extends in general somewhat obliquely from behind and above, forward and downward and corresponds in position to the spine from the second or third to the ninth thoracic vertebra. Three parts are distinguishable: *manubrium sterni*, *corpus sterni* and *processus xiphoideus*, the parts being separated from one another by layers of cartilage which, however, in advanced age may ossify and lead to fusion. (For the development see p. 99.)

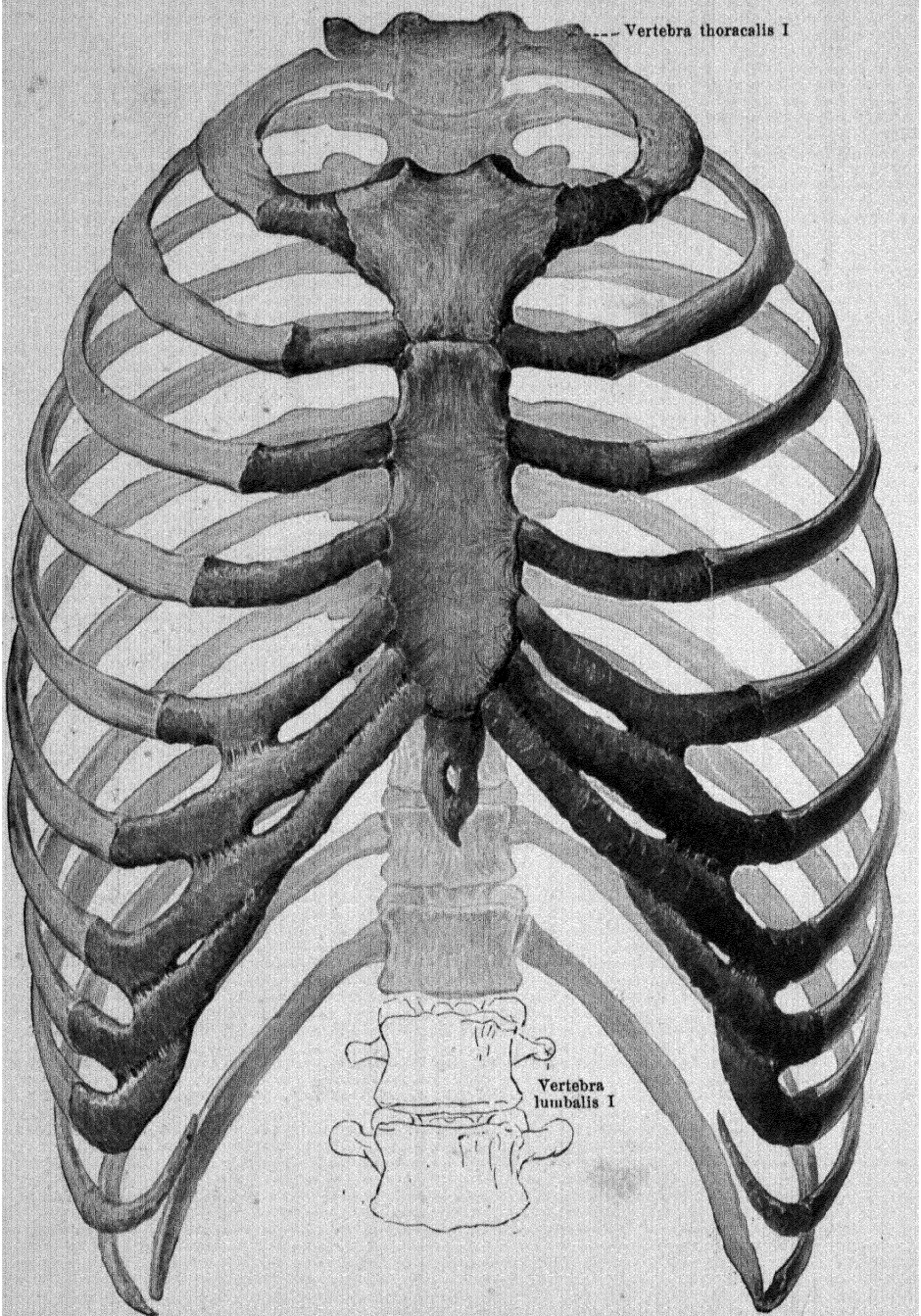
The **manubrium sterni** is the broadest part, especially above; below it becomes somewhat narrower; its anterior surface is slightly convex, its posterior, flat. At the upper margin in the middle is a flat notch, *incisura jugularis* (O. T. presternal notch); near this, at the upper angle on each side, is a somewhat deeper depression covered with cartilage, the *incisura clavicularis*, for articulation with the facies articularis sternalis claviculae; right below it at its widest place is an oblong mostly rough surface, the first incisura costalis (see below).

The **corpus sterni** (O. T. gladiolus) is the longest portion; it is broadest at the juncture of the 5th rib, gradually narrows slowly upwards and sharply downwards; its anterior surface, the planum sternale, and its posterior surface are flat. The manubrium and corpus are somewhat movable upon one another where they are united at the cartilaginous *synchondrosis sternalis* (see Fig. 276); at the point of junction, whether the joint exists or even when it has become ossified, there is an angle, *angulus sterni*, the size of which varies according to age, sex and individual; it changes during respiration.

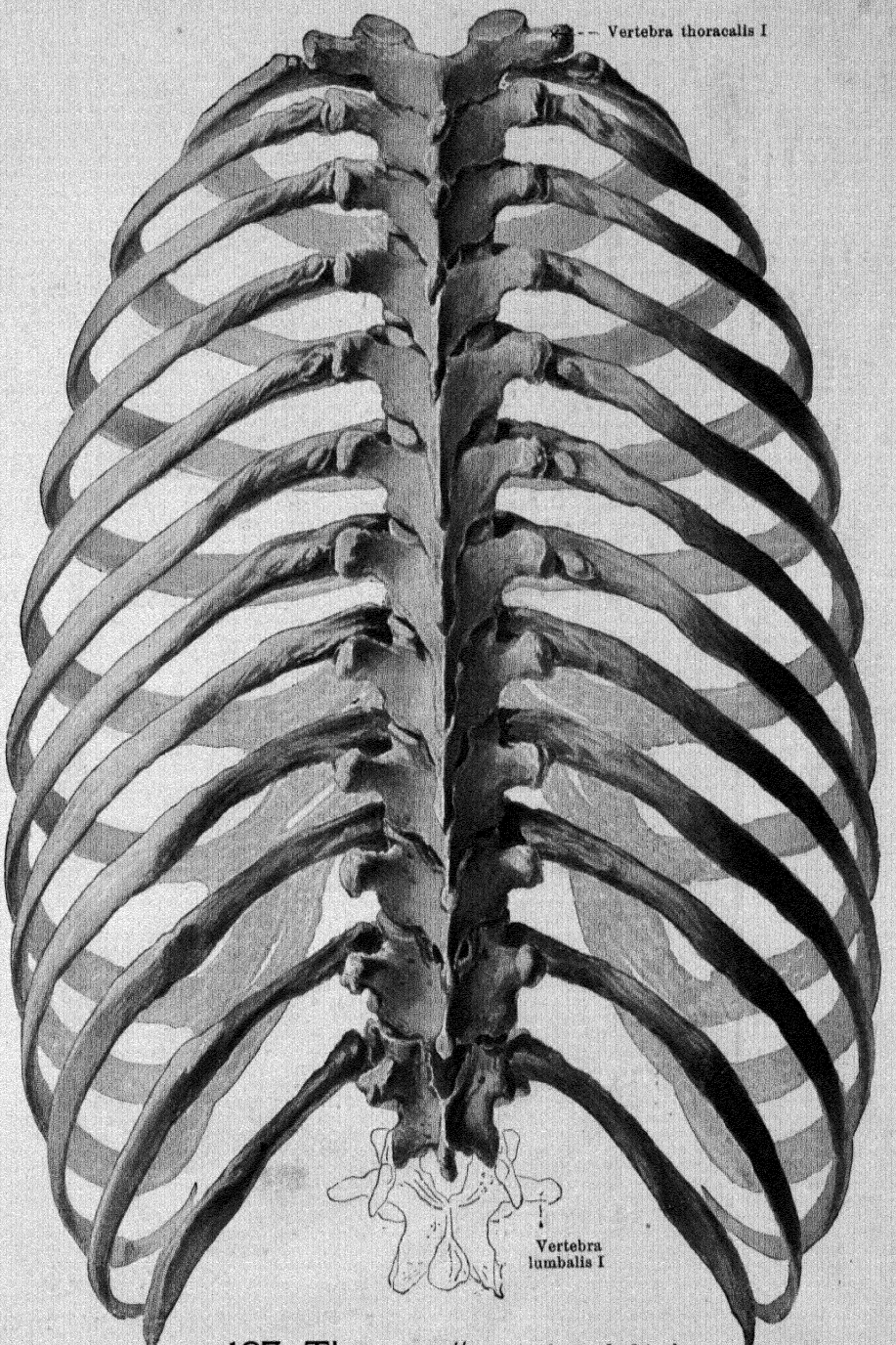
The **processus xiphoideus** (O. T. ensiform process) forms the lower extremity; it is thin, longer than it is broad, very irregular in shape, often bifurcated or perforated by an opening. Late in life it usually fuses with the body.

On each lateral surface of the manubrium and corpus are seven (sometimes eight, see p. 86) notches, *incisurae costales*, for the upper seven (eight) ribs. The uppermost is mostly rough, the others are smoothly covered with cartilage. The uppermost notch is in the manubrium just below the incisura clavicularis (see above); the second at the point of union of manubrium and corpus, each forming a half of it; the third on the corpus nearly in the middle of the whole length of manubrium + corpus; the fourth to the seventh (eighth) in the lower half, so that the inferior notches are closer and closer together, the two lowest often being fused to one; the seventh (and eighth) situated at the junction of the corpus with the processus xiphoideus may be situated partially in front of the latter.

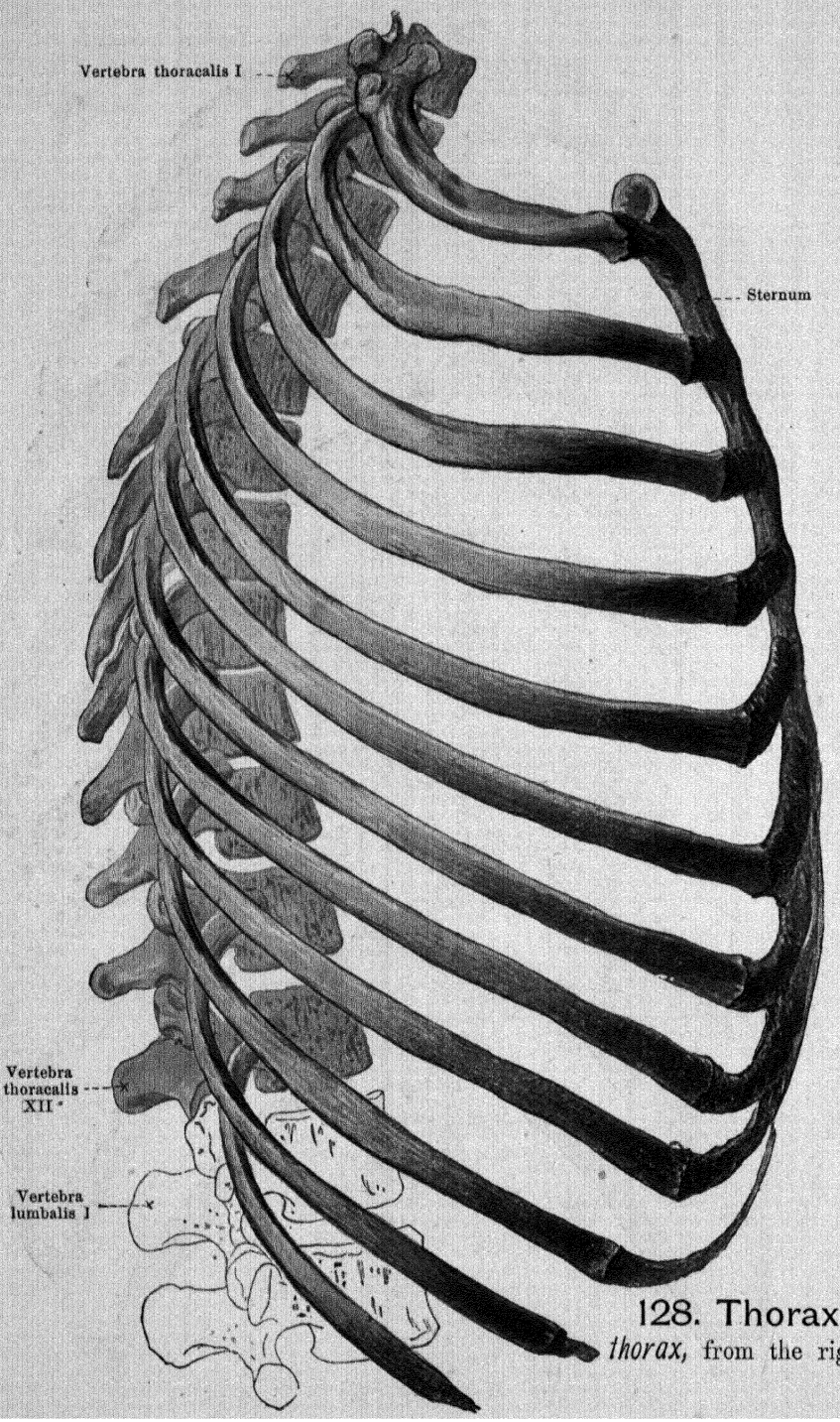
In the female, other things being equal, the corpus sterni is shorter than in the male; accordingly, the female sternum is, on the whole, shorter and looks relatively broader and plumper.



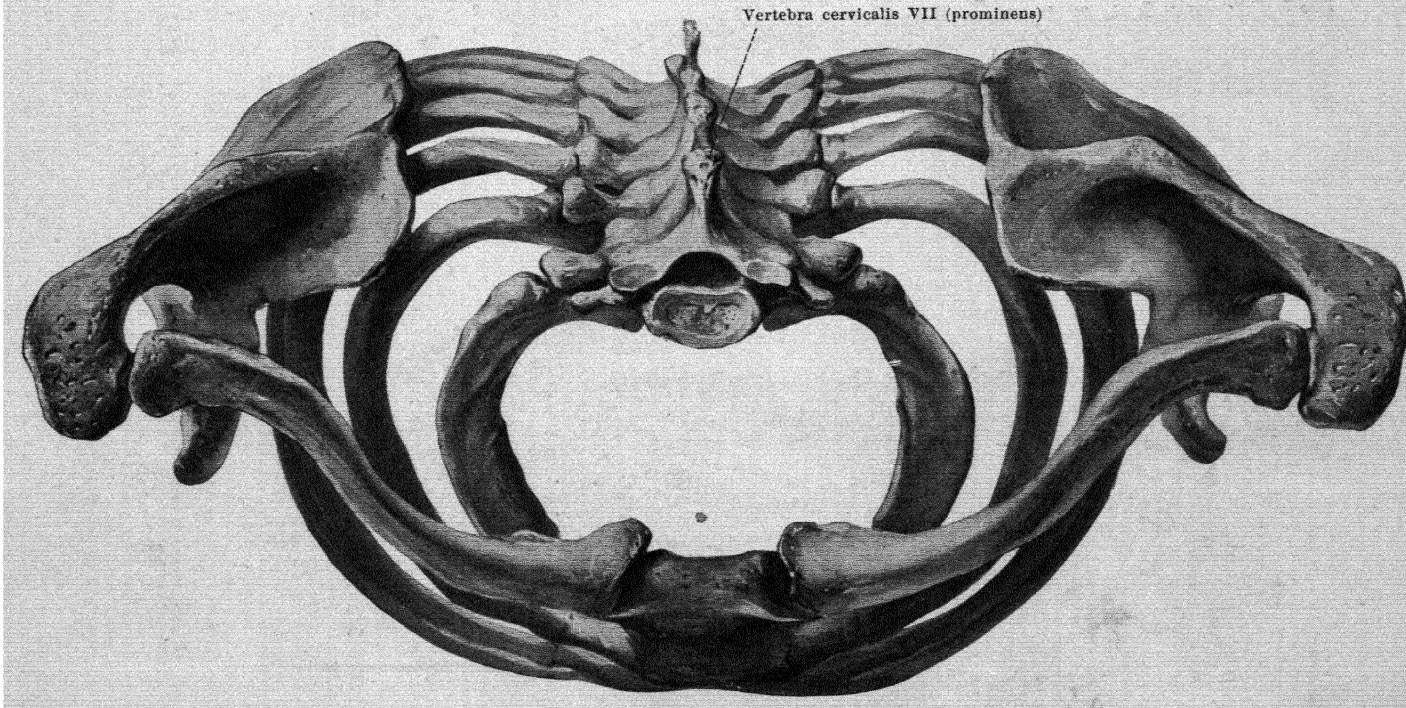
126. Thorax, *thorax*, from in front.



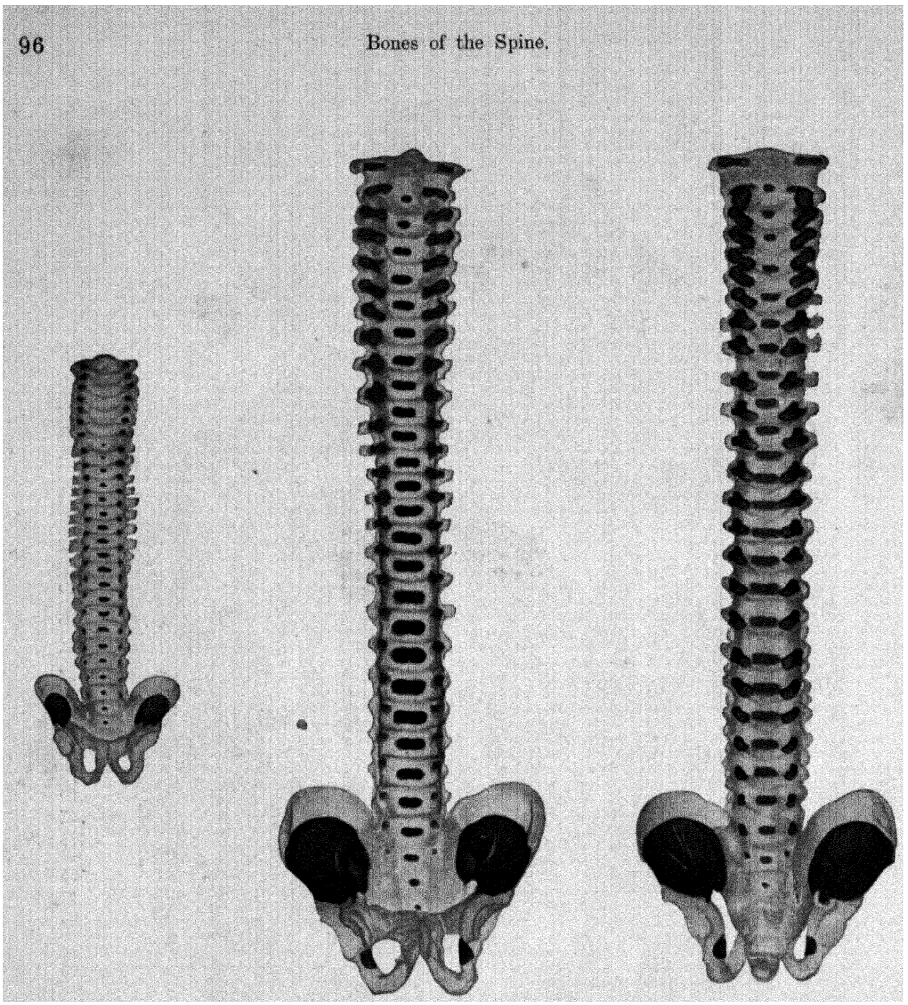
127. Thorax, *thorax*, from behind.



128. Thorax, *thorax,* from the right.



129. Thorax and Shoulder Girdle, viewed from above.

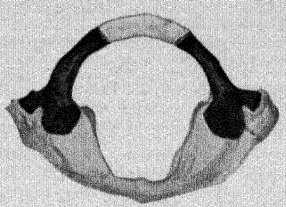


130. Fetus 8,5 cm long (about 12 weeks), from in front.

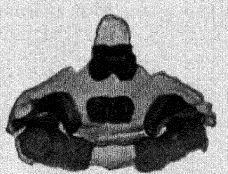
131 and 132. Fetus 18,5 cm long (about 17 weeks), from in front. from behind.

130—132. Spinal Column and Pelvis of human fetus. Magnif.: 3:2.

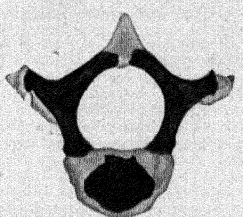
(The bone substance is colored red, the rest of the skeleton is made transparent.)



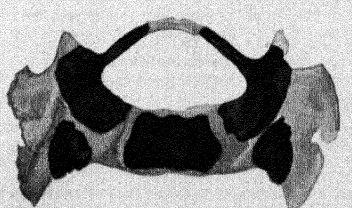
133. Atlas, viewed from above.



134. Epistropheus, from in front.



135. Middle dorsal vertebra,
viewed from above.

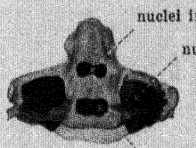


136. First sacral vertebra,
viewed from above.

133—136. Vertebral bones of a newly born.

Magnif.: 3 : 2.

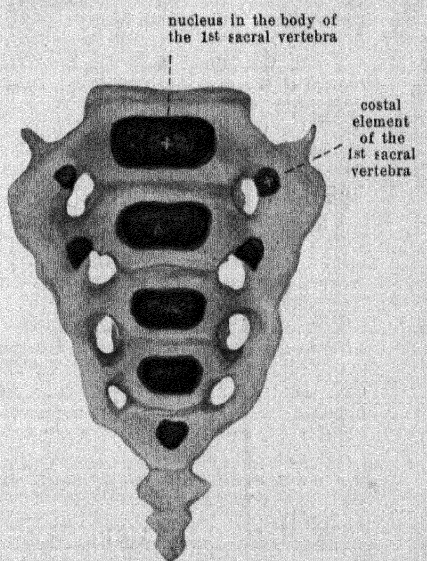
(The bone substance is red, the rest of the vertebra transparent.)



137. Epistropheus of a fetus 6 months old,

from in front. Magnif.: 2 : 1.

(The bone substance is red, the rest of the vertebrae transparent.)



138. Sacrum and Coccyx of an 8 month fetus, from in front.

Magnif.: 1 : 1.

(The bone substance is colored red, the rest is transparent.: The nuclei in the arcus are not visible.)

The **Development of the Bones of the Trunk.**

All the bones of the trunk of the body are cartilaginous in origin.

The ***Vertebrae*** (see Figs. 130—132 and 135). Each vertebra (with the exception of the coccyx), develops from three principal nuclei, one for the body of the vertebra and one for each half of the neural arch. The nuclei of the arches appear first (in the ninth week) and they begin in the cervical vertebrae in the second week, and gradually crop up downwards. The nuclei in the bodies of the vertebrae appear soon after, first in the lower dorsal and first lumbar vertebrae, and from there spreading upwards and downwards. The arch nuclei grow forward anteriorly into the body of the vertebra and form its dorsolateral portion; they also give rise to the main mass of the processes. At birth, the three nuclei are separated only by cartilage. The fusing together of the arch nuclei begins in the first year, and progresses rapidly upwards but slowly downwards. In the 3rd to 6th year there takes place the bony union of the arch-nuclei with the body nuclei, beginning in the thoracic region.

About the time of puberty there appear on the upper and lower surfaces of each vertebra thin bony epiphyseal plates, and at the summits of the processus spinosi and transversi little cup like epiphyses (usually double ones on the proc. spinosi of the cervial vertebrae), which do not fuse with the main nucleus until the twentieth year of life.

Several of the vertebrae exhibit peculiarities.

The *Atlas* (see Figs. 130—133). The arcus posterior and the massae laterales ossify from two symmetrical centres (a right and a left one), which correspond to the centres of the neural arches of the other vertebrae and appear in the ninth week. In the arcus anterior there appears a nucleus (sometimes two) in the first year, which fuses with the two others in the fifth to ninth year. The dorsal nuclei unite in the third to fifth year.

The ***Epistropheus*** (see Figs. 130—132, 134 and 137). The lower part of the body and the two halves of the neural arch each receive a nucleus like in the third cervical vertebra. In the fourth to fifth month there appear in the base of the dens and in the upper part of the body two symmetrical nuclei, which soon fuse with each other. The dens unites with the body and with the lateral parts and these unite with each other in the fourth to sixth year. At the tip of the dens there appears a special nucleus in the second year, which unites with the main mass in the twelfth year. The body receives an epiphysis only at its caudal end.

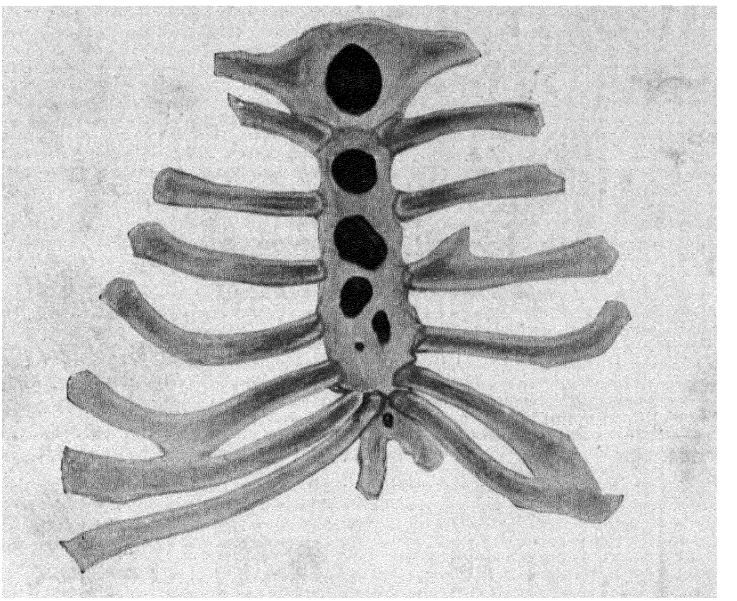
On the *seventh vertebra*, there appears very often in the second to fifth month a special nucleus in the ventral portion of the proc. transversus, which usually unites with the body after birth, but sometimes remains separate, increases in length and may form a movable cervical rib.

The *lumbar vertebrae.* The proc. mamillares of the lumbar vertebrae, of the twelfth dorsal, and of the first sacral vertebra have at their summits special epiphyseal nuclei, which appear about the time of puberty or a little later and which grow together with the rest of the vertebra after the eighteenth year.

The *sacrum* (see Figs. 130—132 and 138). Each sacral vertebra develops (like every other vertebra) from three main centres or nuclei, one for the body and one for each half of the neural arch, which also forms the posterior part of the pars lateralis. The corpus nuclei appear in the first to third vertebra about the end of the third month, in the fourth and fifth, about the fifth to eighth month; the lateral nuclei appear in the upper vertebrae in the fifth and sixth month. Besides these there are formed in the fifth to seventh month, nuclei on the sides of the corpus, in the three, more rarely four or two upper vertebrae, which represent costal elements, and form the section of the pars lateralis which bears the facies auricularis. The latter nuclei fuse with the nuclei of the corpus and arch in the second to fifth year; a little later they unite with each other. The lateral nuclei fuse with each other in the seventh to fifteenth year beginning above and progressing downwards. Besides these main nuclei there appear two epiphyseal plates for each body (about the fifteenth year) and two for each of the lateral borders of the sacrum, one for the facies auricularis and one for the rough caudal part of the border (between the eigteenth and tweentieth year). There are furthermore epiphyses also for the processus spinosi.

The sacral vertebrae are separate from each other until the time of puberty. At that time the lateral portions of the vertebrae begin to grow together; then follows the fusion of the epiphyseal plates and the bodies and the ossification of the intervertebral plates. This process begins at the lower vertebrae and extends upward, so that the sacrum becomes a single bone about the twenty-fifth year; at the same time the lateral epiphyseal plates fuse also with the sacrum.

The *coccyx.* Each coccygeal vertebra ossifies from one nucleus, of which the first one appears in the first year, the others much later, some not before puberty. The three lower ones unite usually about the thirtieth year.

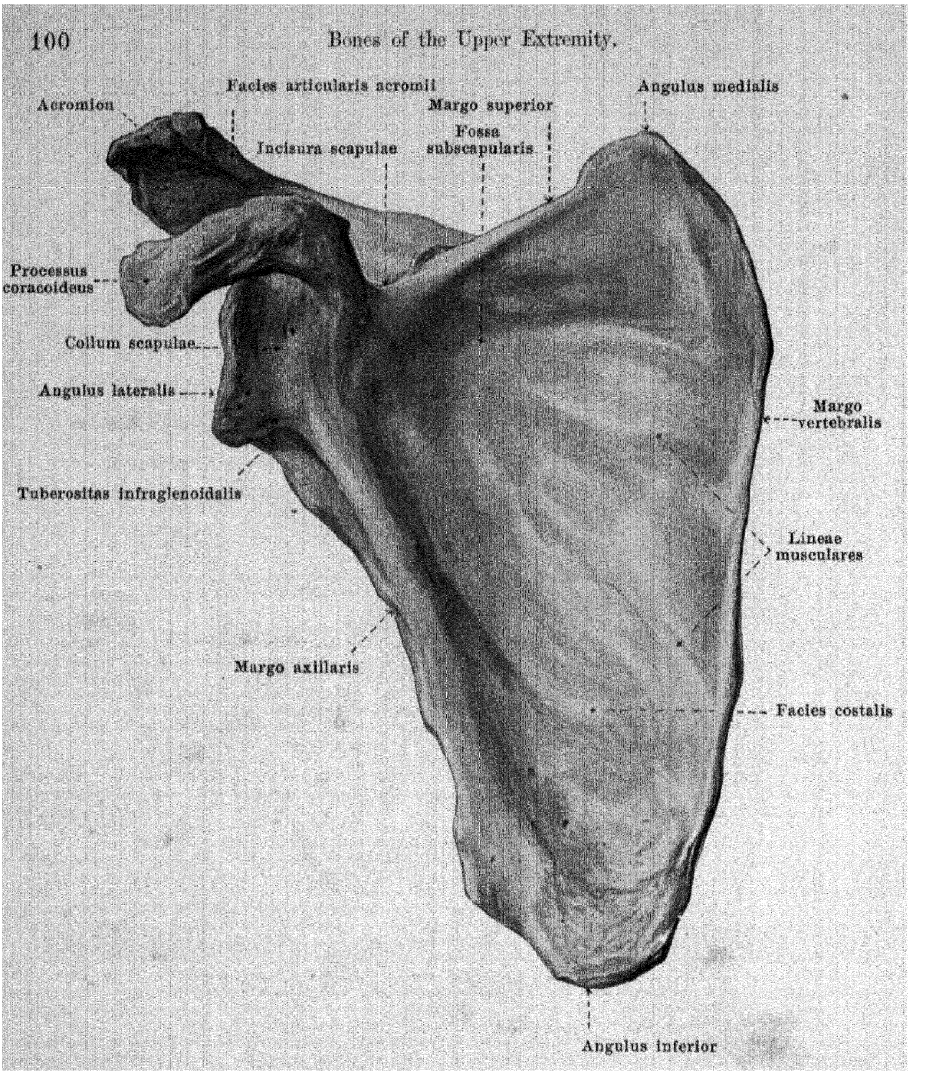


139. The sternum and the rue ribs of a fetus 7 months old. Magnification 1 : 1.

(The bone substance is colored red, the rest is made transparent.)

The *ribs*. The centres of ossification first appear in the sixth and seventh ribs (about the end of the second month), and then extend rapidly to the other ribs, so that most of them have their nuclei at the end of the second month. The ossifying process begins in the region of the angulus costae and extends quickly to the head; the final relation between the costal bones and cartilages is reached in the fourth month. At the time of puberty there appear epiphyseal nuclei, one at each head and two at the tuberculum costae, which fuse with the corpus costae after the twentieth year.

The *Sternum* possesses many centres of ossification, which vary extraordinarily both in regard to their place and time of appearance. The ossifying process usually begins with one nucleus in the manubrium in the third to sixth month; beside this one there often develop a number of accessory nuclei. Soon afterwards there begin to appear in the corpus five to seven partly paired and partly unpaired nuclei; these of the last segment develop only after birth, in the first year of life. The nuclei of the corpus fuse together in irregular order in the sixth to twenty-fifth year. The processus xiphoideus acquires a centre of ossification at its base, which appears in the sixth year or later.

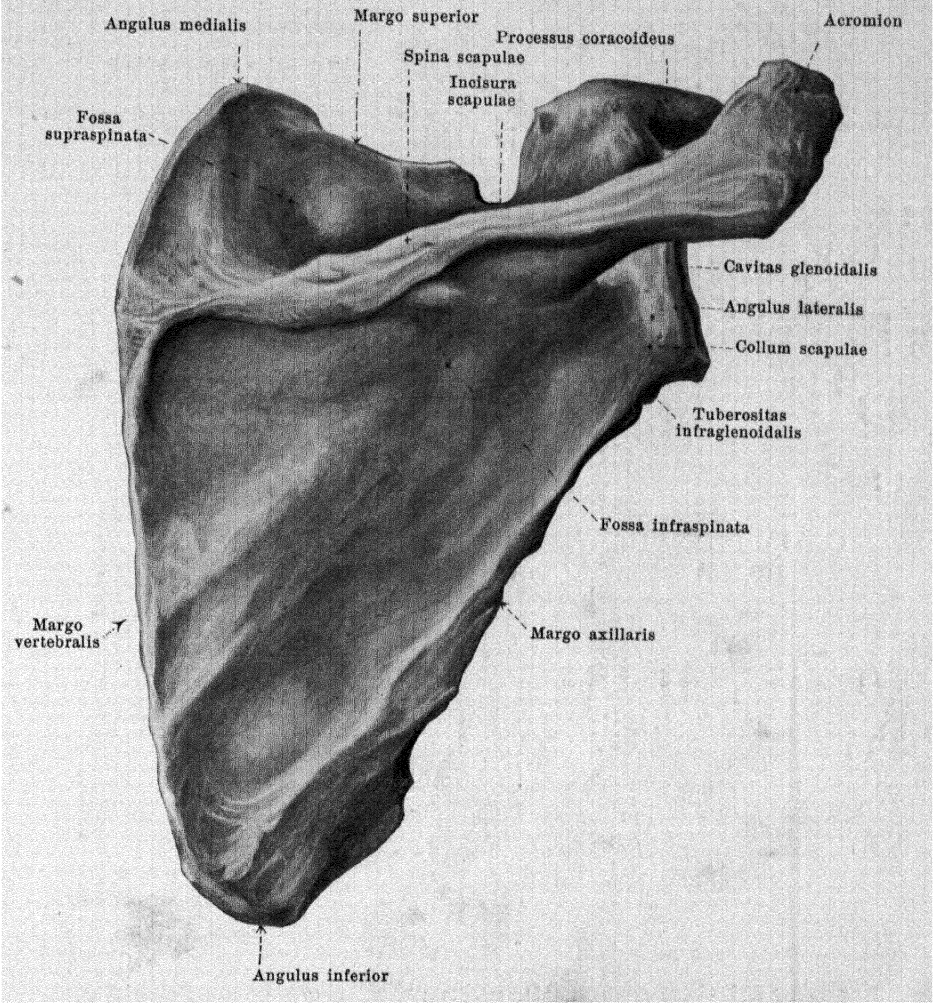


140. Right shoulder blade, *scapula,* from in front.

The **scapula** *(shoulder blade)* (see also figures 129, 141–144) is a broad, flat, thin, triangular bone which lies upon the upper part of the wall of the thorax so that the lateral angle projects lateralward over the thorax; its medial margin, when the arm is hanging down, runs in its lower portion nearly parallel to the median plane and extends from the second or third to the seventh or eighth rib. It lies freely movable between the muscles and is connected by joints lateralward with the clavicle and with the humerus only. (For development see p. 126.)

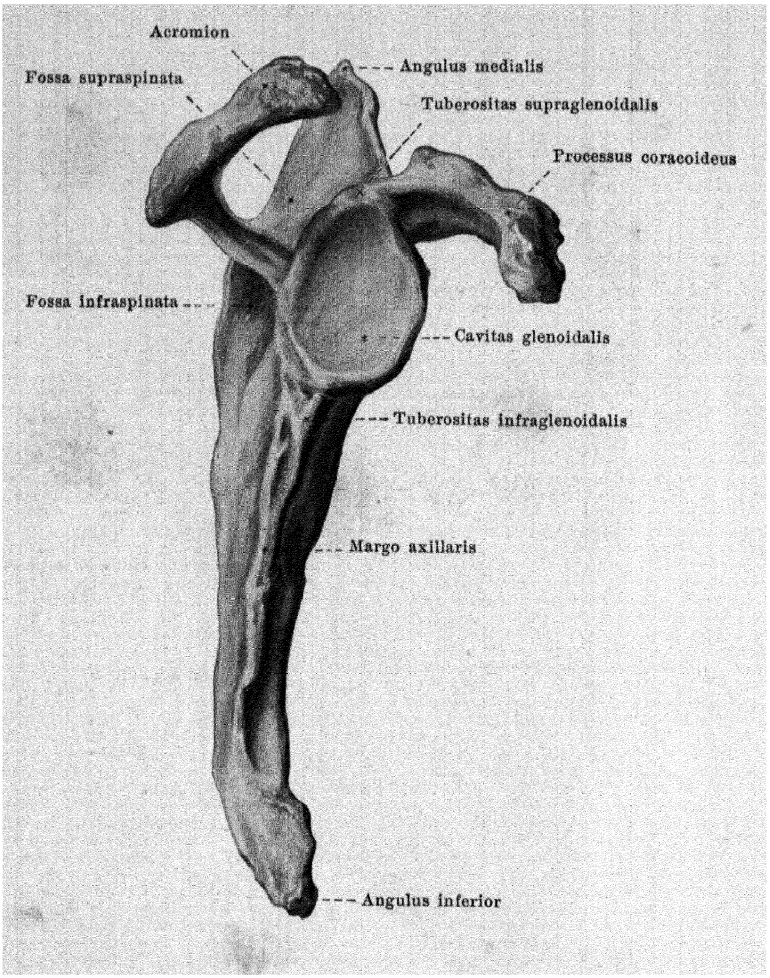
The shoulder blade has three margins: the thin, shortest, upper, *margo superior,* which presents on its lateral extremity a notch, the *incisura scapulae* (O. T. suprascapular notch), the longest, medial margin, *margo vertebralis;* the thick, lateral margin, *margo axillaris.* These margins meet in three angles; the blunt, thick *angulus inferior,* the sharper, thinner *angulus medialis* (O. T. superior angle) and the *angulus lateralis* (O. T. anterior angle); the latter supports the surface for articulation with the humerus (see p. 102).

The anterior surface, **facies costalis,** is markedly concave in its upper lateral part, forming the *fossa subscapularis;* in other parts it looks smooth except for several ridges, *lineae musculares,* directed toward the lateral angle, to which are attached tendinous bands of the m. subscapularis.



141. Right shoulder blade, *scapula,* from behind.

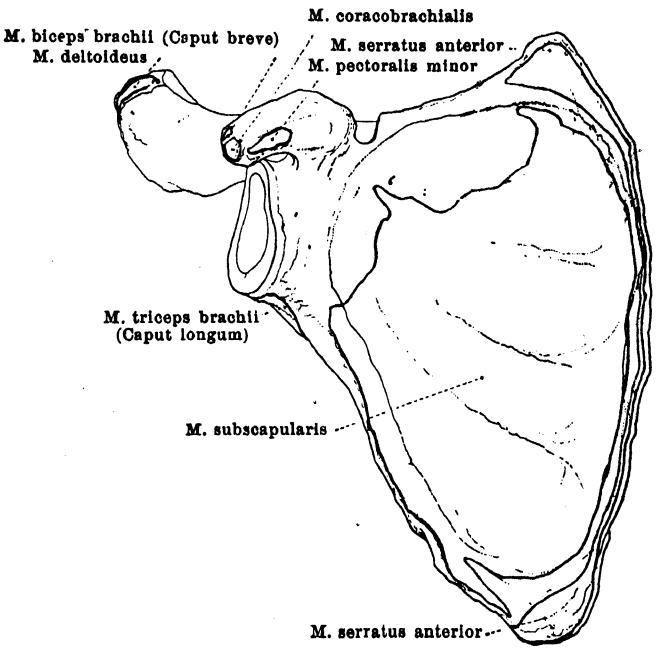
The posterior surface of the shoulder blade, **facies dorsalis scapulae,** is convex and subdivided by a bony projection, *spina scapulae*, which ascends at about the junction of the upper with the middle third, into the upper smaller, deeper *fossa supraspinata* and the lower, larger, flatter *fossa infraspinata.* The spina scapulae is low where it begins at the margo vertebralis and develops gradually to a very powerful high plate of bone which possesses an upper surface, directed also somewhat forward, and a lower surface, looking also somewhat backward. The free margin is broad. A strong process (the *acromion*) goes off from the side of it, first lateralward, then forward; it looks flattened out in its most anterior part and presents an upper and a lower surface; near its apex it presents medianward a small oval *facies articularis acromii* for articulation with the facies articularis acromialis claviculae; the acromion is rarely, in the adult, separated by cartilage from the spina scapulae.

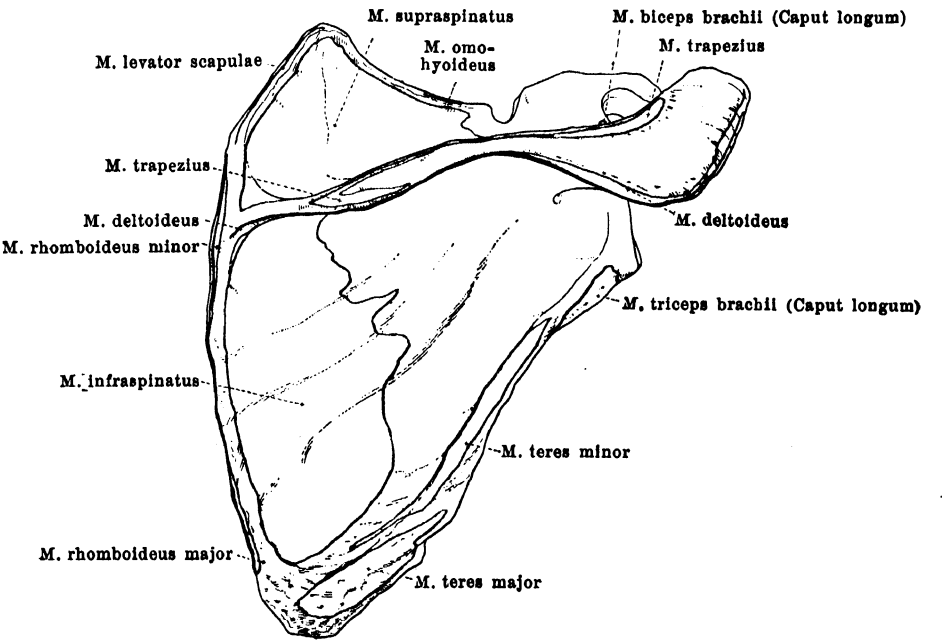


142. Right shoulder blade, *scapula,* from without.

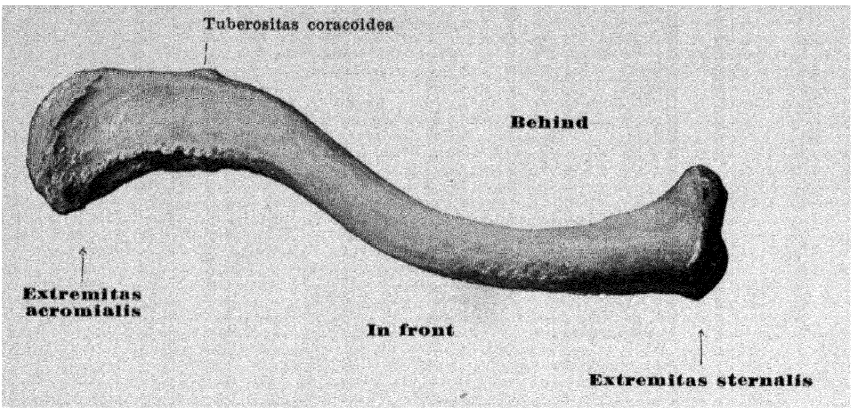
The **angulus lateralis scapulae** becomes markedly broader externally and is marked off from the rest of the shoulder blade by a shallow groove or neck, *collum scapulae.* The surface which is turned lateralward, the *cavitas glenoidalis,* is somewhat concave and is covered with cartilage; it is nearly oval in shape and is broader below than above; there is a slight indentation in the upper part of the anterior margin. A roughness just above this, the *tuberositas supraglenoidalis* (O. T. supraglenoid tubercle), gives origin to the caput longum m. bicipitis; another, larger, below it, at the uppermost end of the margo axillaris, *tuberositas infraglenoidalis* gives origin to the caput longum m. tricipitis.

Between the cavitas glenoidalis and the incisura scapulae, arising from the margo superior, is the *processus coracoideus (crow's beak process);* it is thick, rounded, runs first forward and upward, and then, making a marked hook-like curve forward and lateralward, ends in a blunt tip. Very rarely it is separate from the rest of the bone.

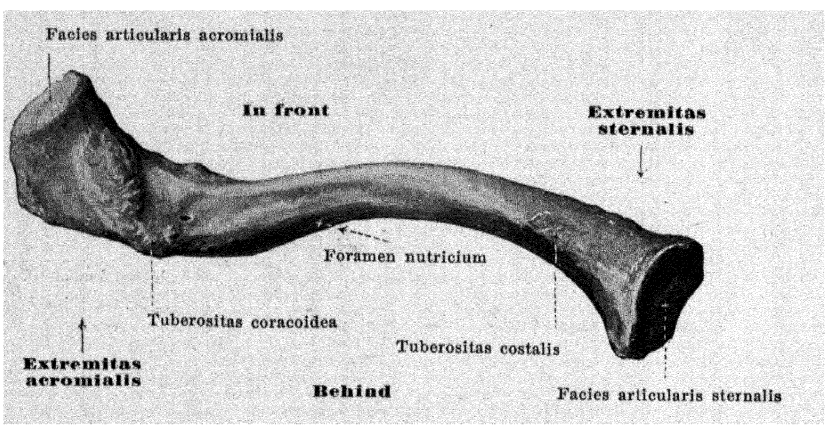




143 and 144. Right shoulder blade, *scapula,* from in front, with the muscular attachments.



145. Right collar bone or clavicle, *clavicula,* from above.

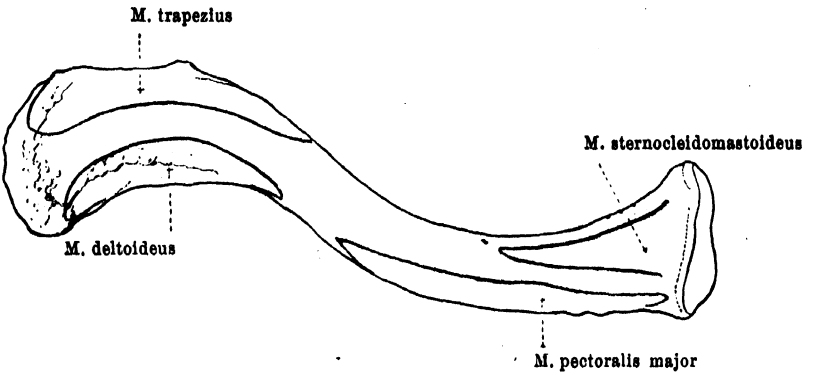


146. Right collar bone or clavicle, *clavicula,* from below.

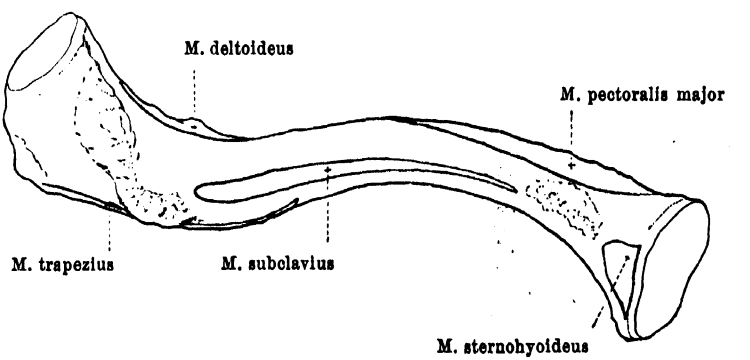
The **clavicula** *(key, clavicle or collar bone)* (see also Fig. 129) is a short, strong, cylindrical bone bent S-like which runs transversely in front of the first rib, going out on each side from the upper end of the sternum, and is attached at its lateral extremity to the acromion scapulae.

It is divisible into a shaft and two extremities: that directed toward the sternum, ***extremitas sternalis,*** and that looking toward the scapula, ***extremitas acromialis.*** (For development see p. 126.)

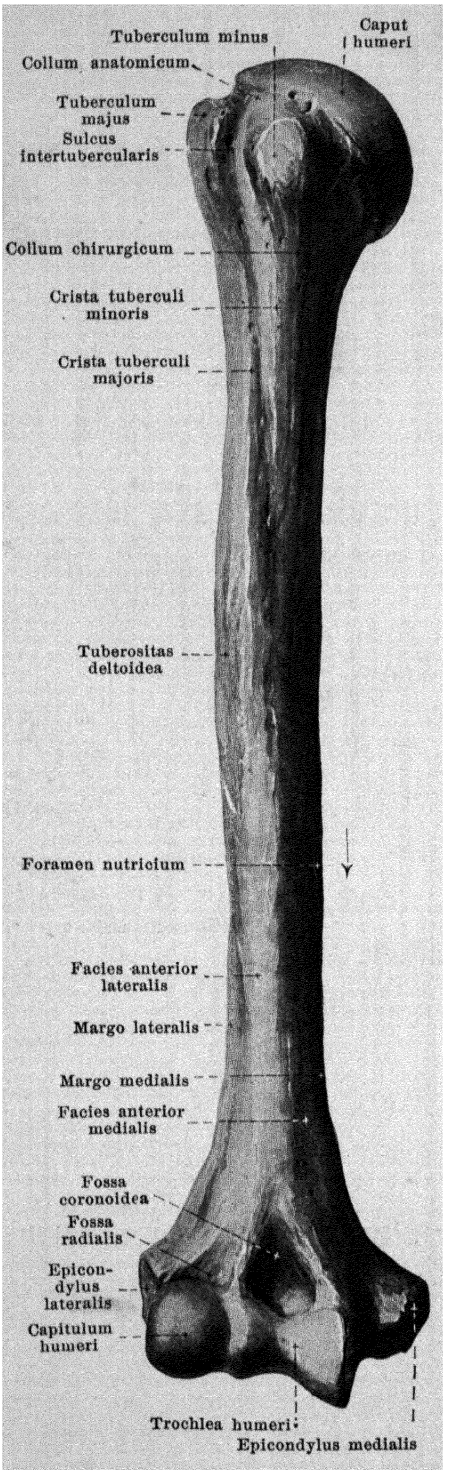
The shaft is bent convexly forward in its medial half; in its lateral half convexly backward. It is triangular with rounded angles especially medianward. The extremitas sternalis is thickened and ends with the approximately triangular, curved *facies* ***articularis sternalis*** covered with cartilage, which lies in the incisura clavicularis sterni. Somewhat lateralward from it, at the junction of the inferior with the posterior surface, the ***tuberositas costalis*** (O. T. Impression for rhomboid ligament) (for the lig. costoclaviculare) is visible. The extremitas acromialis is somewhat broadened and is flattened from above downward; at its extreme end it is turned somewhat forward and supports there the small, oval, flat *facies articularis* ***acromialis*** for articulation with the facies articularis acromii scapulae. Just medianward, near this, on the lower surface lies the oblong, rough *tuberositas coracoidea* (O. T. impression for conoid ligament) (for the lig. coracoclaviculare).



147. Right collar bone or clavicle, *clavicula*, from above, with the muscular attachments.



148. Right collar bone or clavicle, *clavicula*, from below, with the muscular attachments.



149. Right humerus,

humerus, from in front.

The **humerus** *(upper arm bone)* (see also Figs. 150—155) is a long cylindrical bone which articulates above with the shoulder blade, below with the bones of the forearm. It is divisible into a body or shaft, *corpus humeri*, and two extremities. (For development see p. 126.)

The **corpus humeri** *(shaft)* is more cylindrical above, distinctly triangular below; its surfaces are called the *facies posterior*, the *facies anterior medialis* (O. T. internal surface) and the *facies anterior lateralis* (O. T. external surface); the posterior surface is separated from the two anterior surfaces by the *margo medialis* (O. T. internal border) and the *margo lateralis* (O. T. external border) both of these being especially sharp and prominent below. On the facies anterior lateralis somewhat above the middle is a broad rough surface, *tuberositas deltoidea* (for the m. deltoideus); behind this, on the posterior surface lies a shallow groove, the *sulcus nervi radialis* (O. T. musculospiral groove) (for the n. radialis), which begins on the medial margin and descends like a long drawn-out spiral to the lateral margin. A large *foramen nutricium* is often noticeable near the middle on the medial margin; it leads into a *canalis nutricius* directed distalward.

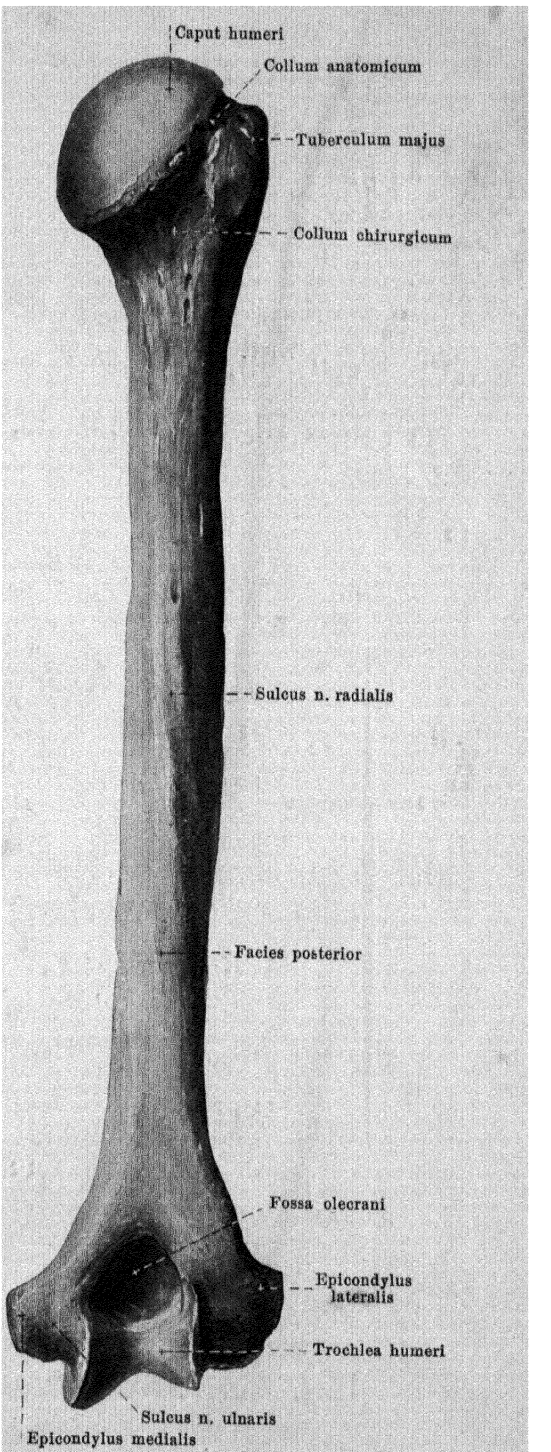
The **upper extremity** is broadened and supports the *caput humeri* which is covered with cartilage; this is nearly hemispherical and directed upward and medianward. It is separated from the rest of the bone by a constriction, the *collum anatomicum* (anatomical neck). Close to this lie two eminences: directed exactly lateralward is the *tuberculum majus* (O. T. greater tuberosity), in front of this directed forward, the *tuberculum minus* (O. T. lesser tuberosity); running forward and downward from both of these are ridges, the *crista tuberculi majoris* (O. T. posterior bicipital ridge) and the *crista tuberculi minoris* (O. T. anterior bicipital ridge). Between the tubercula and the cristae runs the deep *sulcus intertubercularis* (O. T. bicipital groove) (for the tendon of the caput longum m. bicipitis). At the junction of the upper extremity with the corpus humeri lies the *collum chirurgicum* (surgical neck).

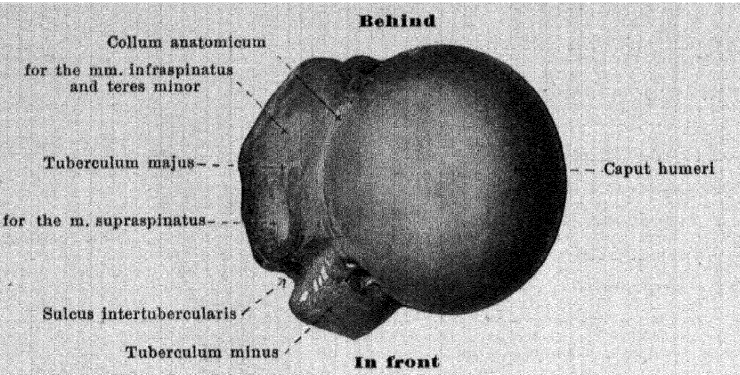
150. Right humerus,

humerus, from behind.

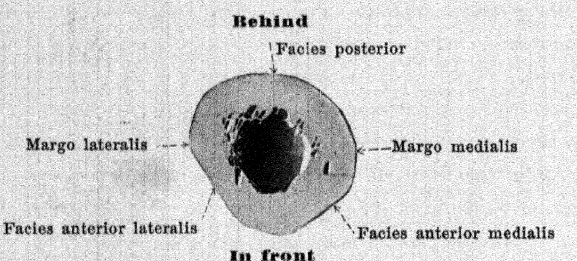
The **lower extremity of the humerus** is somewhat thinner but broader than the shaft. From each side of it projects a rough eminence, the *epicondylus medialis* (O. T. internal condyle) and the *epicondylus lateralis* (O. T. external condyle). These lie in the lines of continuation of the margo medialis and the margo lateralis and give attachment to muscles and ligaments of the elbow joint. The epicondylus medialis is the larger and presents on its posterior surface a shallow groove, *sulcus nervi ulnaris* (for the n. ulnaris).

Between the two epicondyles lies a joint surface, covered with cartilage, for articulation with the bones of the forearm, the axis of which is in oblique relation to the long axis of the corpus humeri. The articular surfaces consist of a medial, rollershaped surface, *trochlea humeri* (for articulation with the ulna), which extends also upon the posterior surface, and of a lateral, smaller *capitulum humeri* (O. T. capitellum or radial head) (for articulation with the radius), shaped like the segment of a sphere, which is not continued upon the posterior surface. Above the trochlea, both in front and behind, is a deep depression; that in front is called the *fossa coronoidea,* that behind, the *fossa olecrani;* between the two the bone is very thin and may be absent. On the anterior surface, above the capitulum humeri, lies the smaller *fossa radialis.* These three depressions are not covered with cartilage.

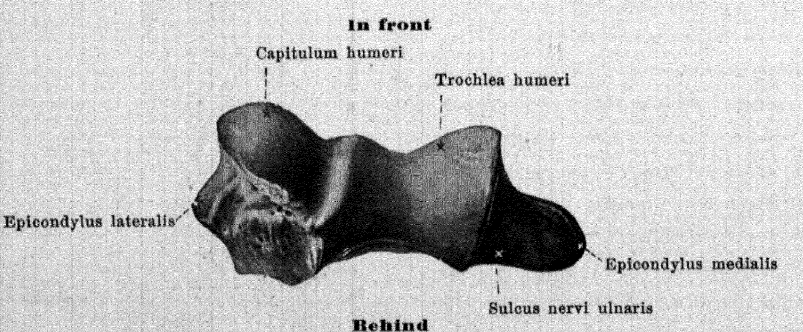




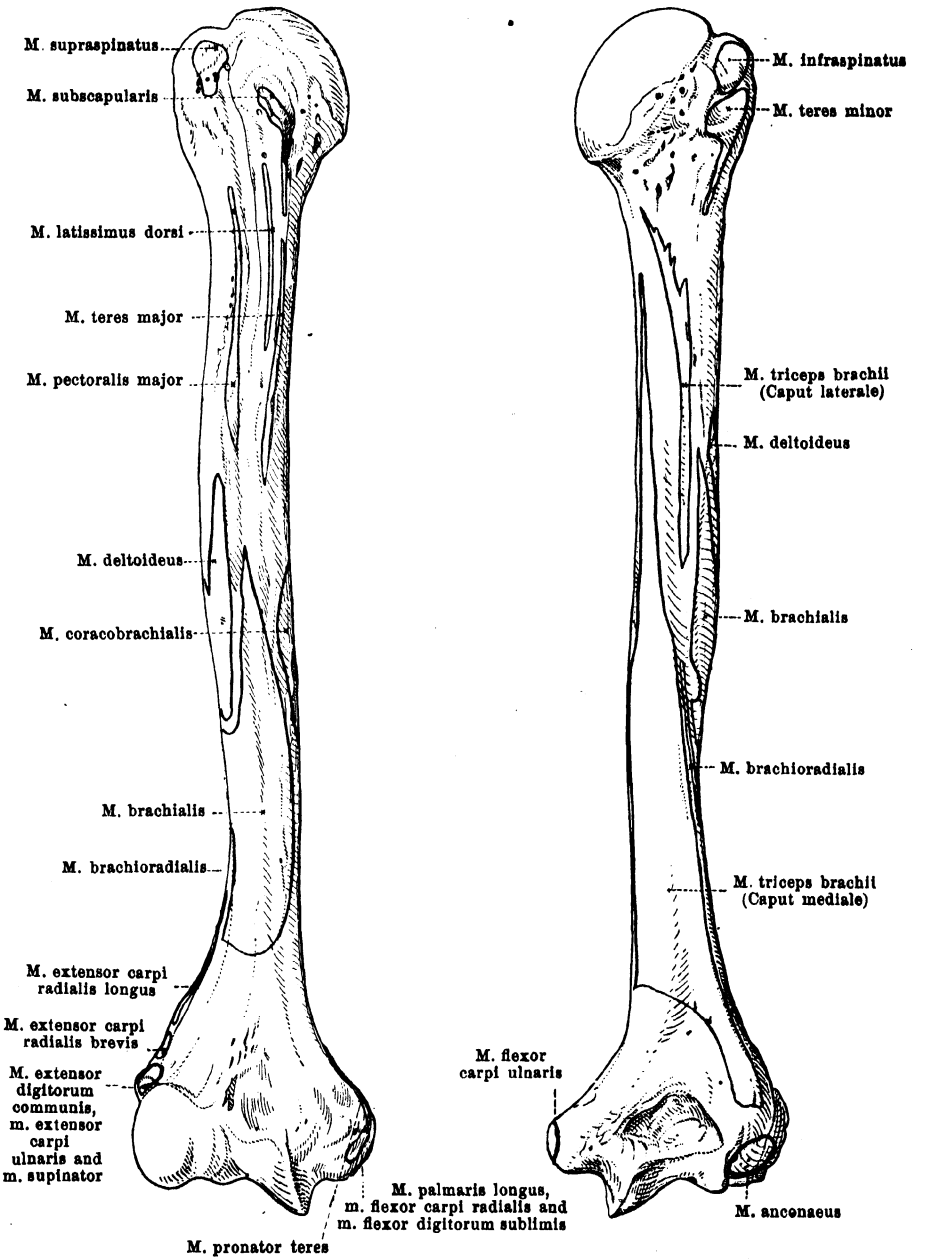
151. Right humerus, *humerus*, upper extremity, from above.



152. Transverse section through the lower half of the right humerus.



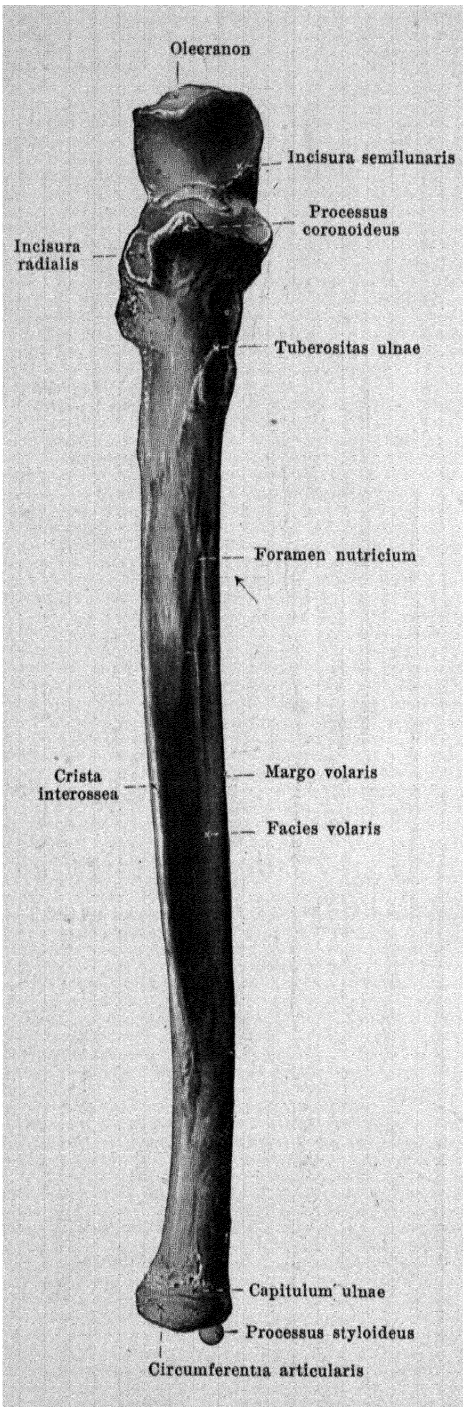
153. Right humerus, *humerus*, lower extremity, from below.



154 and 155. Right humerus, *humerus*,

with muscular attachments.

From in front. From behind.



156. Right ulna, *ulna*, from in front.

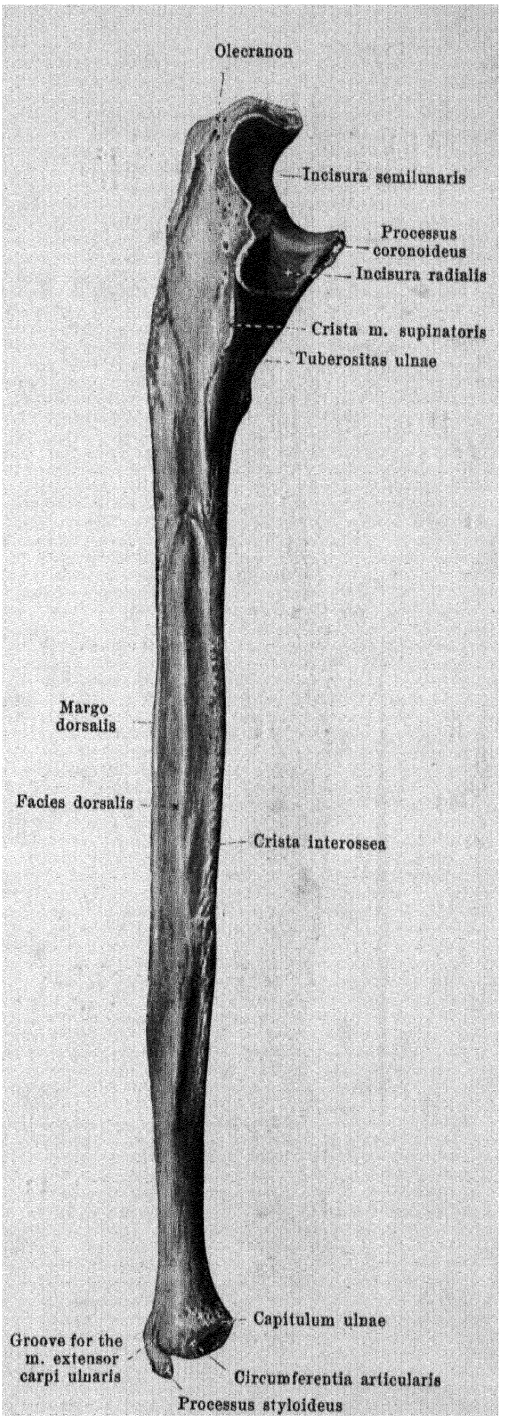
The **ulna** (see also Figs. 157, 161—163, 179) is a long, cylindrical bone which is thicker at its upper than at its lower extremity. It lies on the side of the forearm corresponding to the little finger, is united above by a joint with the upper arm, below, only indirectly, with the carpus; it is united by joints with the radius both above and below. (For development see p. 126).

It is divisible into a shaft or *corpus*, and two extremities.

The shaft, **corpus ulnae**, is bent slightly so as to be convex toward the side of the little finger and is triangularly prismatic. Of its three surfaces, the *facies medialis* (O. T. internal surface) on the side corresponding to the little finger is narrow; it goes over at the rounded *margo volaris* (O. T. anterior border) in front and the *margo dorsalis* (O. T. posterior border) behind, into the broader *facies volaris* (O. T. anterior surface) and *facies dorsalis* (O. T. posterior surface). These meet with their radial borders in the sharply projecting *crista interossea* (O. T. external or interosseous border). A *foramen nutricium* often lies near the crista interossea at the middle of the length of the volar surface and leads into a *canalis nutricius* directed proximalward.

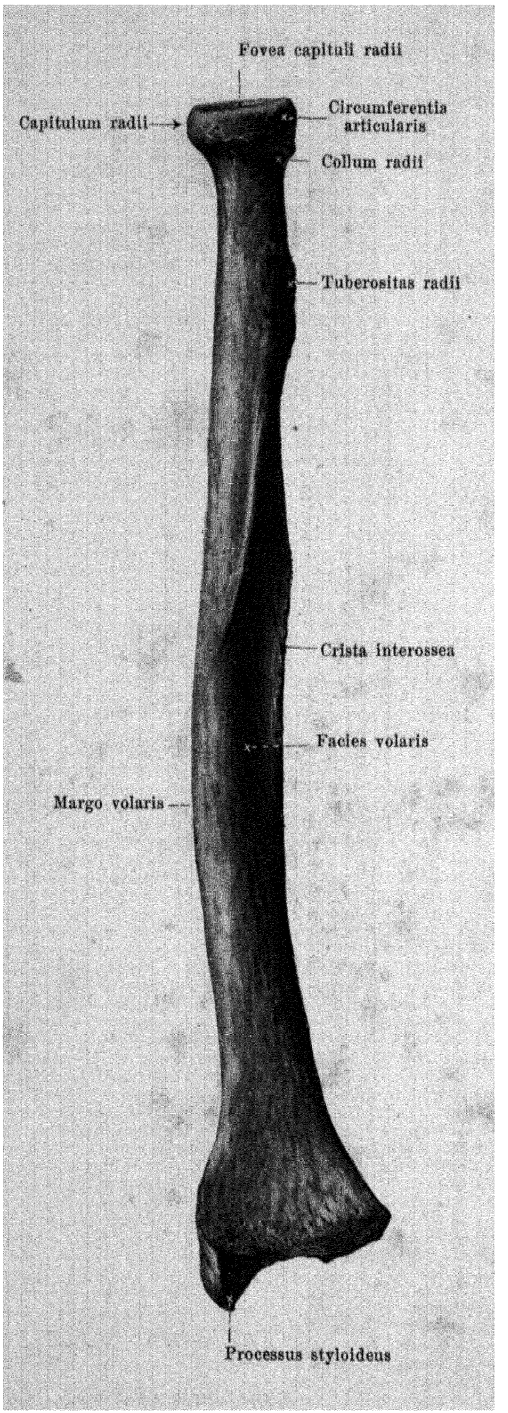
157. Right ulna, *ulna,*

from the radial side.



The **upper extremity of the ulna** is thickened and ends with a rough strong process, the *olecranon;* beneath it, projecting cornice-like from the volar surface, is the strong *processus coronoideus.* Between these two processes lies a deep notch, covered with cartilage, the *incisura semilunaris,* (O. T. greater sigmoid cavity), in which the trochlea humeri is received. On the radial side of the proc. coronoideus the smaller, slightly concave, *incisura radialis* (O. T. lesser sigmoid cavity) (for the capitulum radii) is visible. Passing obliquely backward and downward from this is a sharp bony ridge, the *crista m. supinatoris* (for the origin of the m. supinator). Somewhat below the proc. coronoideus lies a broad rough surface for the attachment of the m. brachialis, the *tuberositas ulnae.*

The **lower extremity** is narrower and forms a small rounded head, *capitulum ulnae.* This is covered with fibro-cartilage not only on its distal surface but also in the largest part of its circumference, the *circumferentia articularis* (for the incisura ulnaris radii). On the side corresponding to the little finger, the small blunt *processus styloideus* projects distalward.



158. Right radius,

radius, from in front.

The **radius** *(spoke)* (see also Figs. 159—163, 179) is a long cylindrical bone, thickened at its lower end which occupies the side of the forearm corresponding to the thumb. It articulates above with the upper arm, below enters into the joint between the bones of the forearm and those of the wrist and rotates above and below on the ulna. (For development see p. 126.)

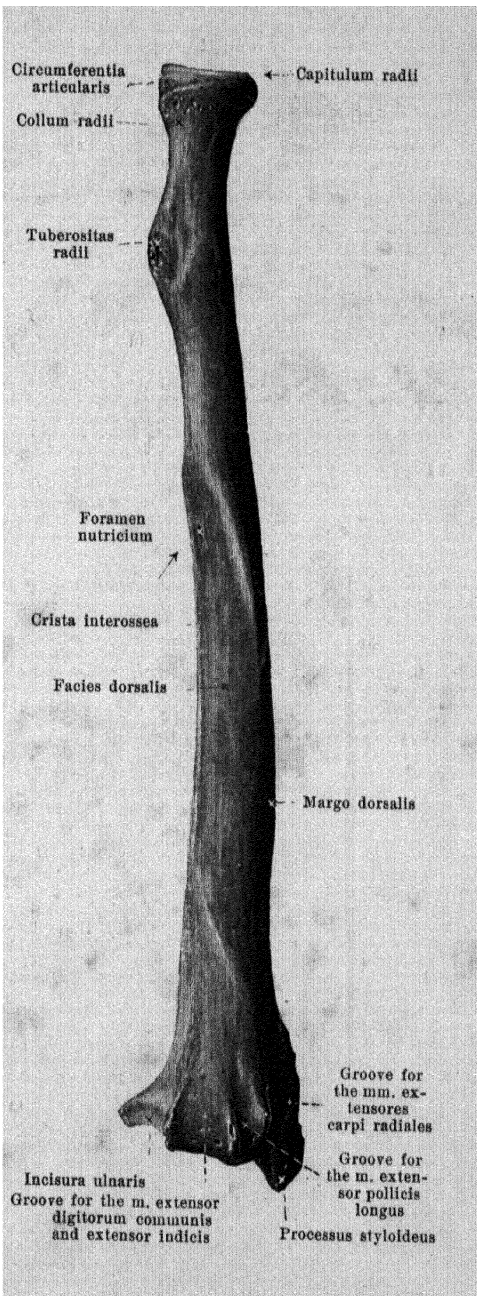
It is divisible into a shaft or *corpus* and two extremities.

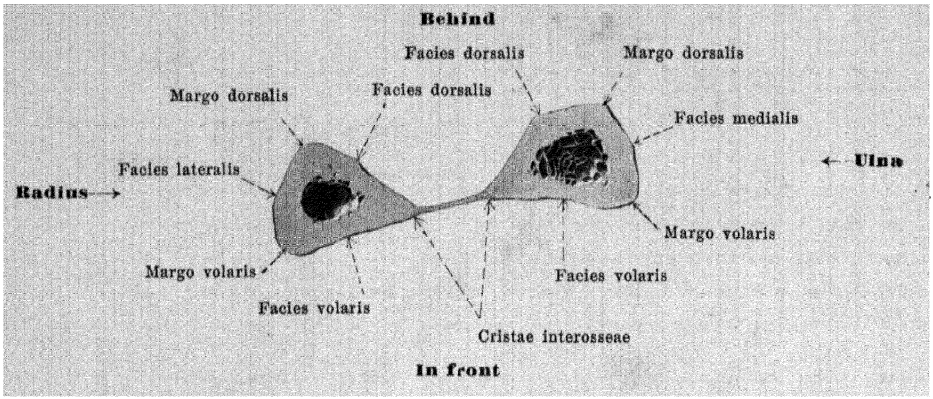
The **corpus radii** or shaft is bent so as to be somewhat convex toward the thumb side and is triangularly prismatic. The narrowest of its three surfaces, *facies lateralis* (O. T. external surface) is directed toward the thumb side; it adjoins at the rounded *margo dorsalis* (O. T. posterior border) behind and the *margo volaris* (O. T. anterior border) in front, the broader *facies dorsalis* (O. T. posterior surface) and *facies volaris* (O. T. anterior surface). The ulnar angle formed by these two surfaces is especially sharp and is called the *crista interossea* (O. T. internal or interosseous border). A *foramen nutricium* is often visible at a spot corresponding to that on the ulna; the *canalis nutricius* is directed proximalward.

159. Right radius, *radius*, from behind.

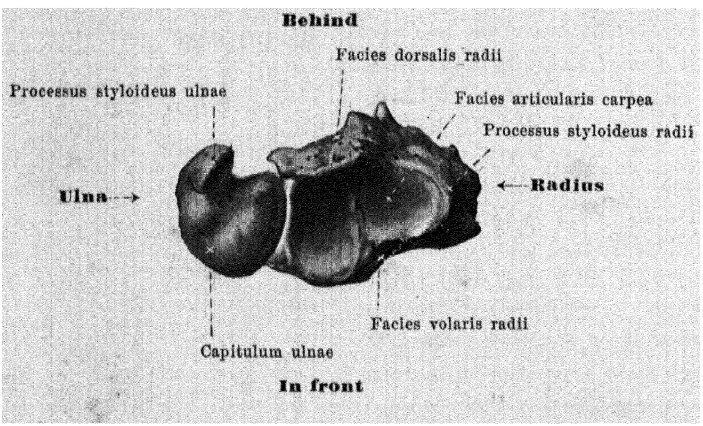
The **upper extremity of the radius** supports the button-shaped *capitulum radii* (head); this is for the most part covered with cartilage and proximalward presents a small flat depression, *fovea capituli radii* (for articulation with the capitulum humeri); its circular periphery covered with cartilage, *circumferentia articularis*, moves in the incisura radialis ulnae. Just below the capitulum the bone is narrowed to form a neck, *collum radii*, and close below this spot, projecting ulnarward and volarward, is the *tuberositas radii* (O. T. bicipital tuberosity) (for the attachment of the m. biceps brachii).

The **lower extremity** is markedly broadened, quadrilateral. Its anterior surface is smooth and slightly concave; its posterior surface is subdivided by several longitudinal ridges into grooves for tendons (see Fig. 163). The distal terminal surface, *facies articularis carpea*, covered with tough fibrocartilage, is slightly concave and triangular; it is subdivided, usually distinctly, into a triangular radial part (for the os naviculare) and a quadrangular ulnar part (for the radial portion of the os lunatum). On the ulnar side is a small notch covered with cartilage, the *incisura ulnaris* (O. T. sigmoid cavity) (for the capitulum ulnae and the discus articularis). Projecting distalward from the angle on the thumb side is the short, blunt, quadrilateral-conical *processus styloideus*.





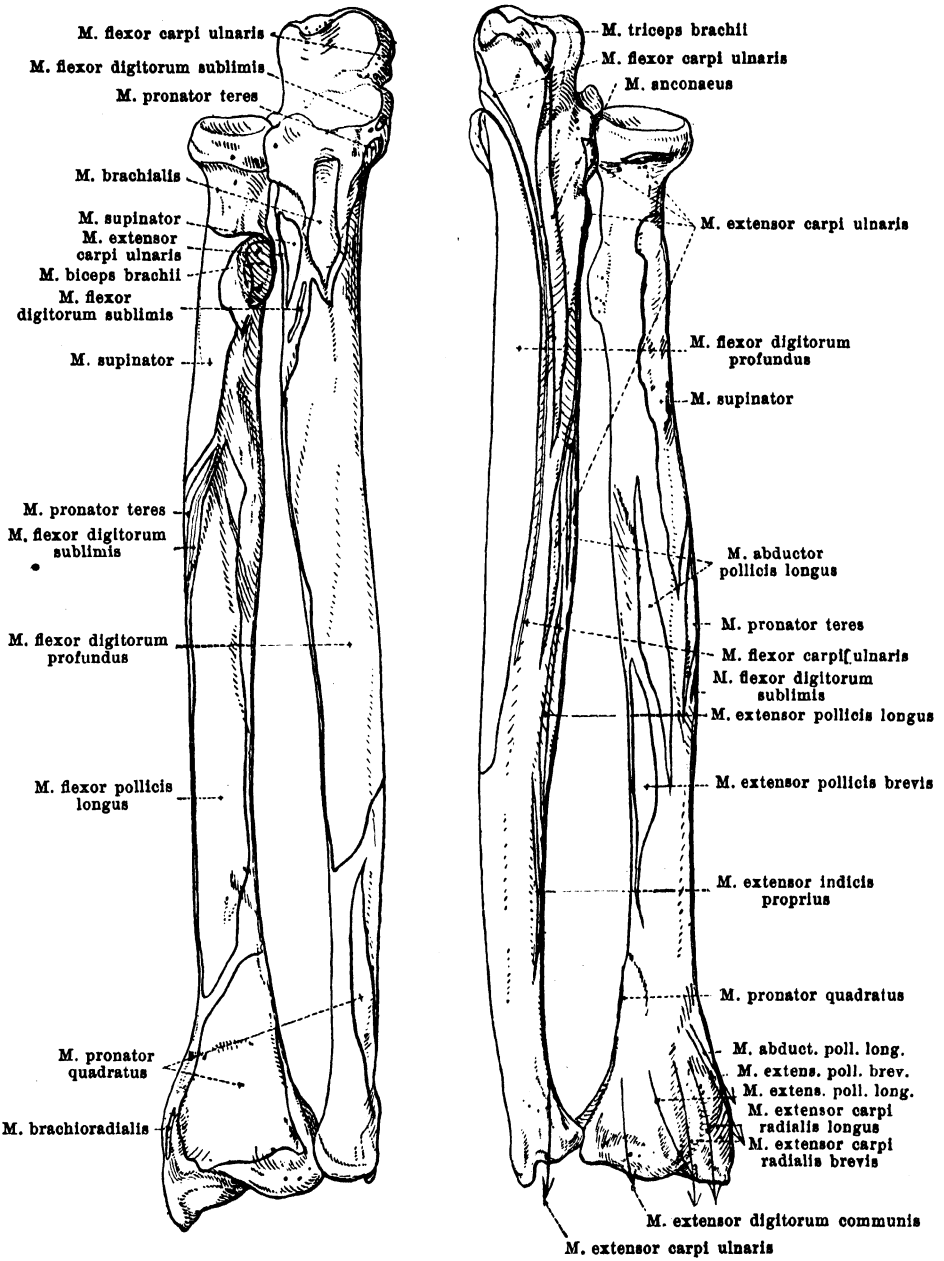
160. Transverse section through the middle of the bones of the right forearm.



161. Lower extremity of the bones of the right forearm, from below.

The **lower extremity of the bones of the forearm** (see also Figs. 180 and 291) which forms the articulation with the carpus, presents on its distal surface the *facies articularis carpea radii* and the *capitulum ulnae.* The former articulates directly with the os naviculare manus and the radial part of the os lunatum. The capitulum ulnae on the contrary does not touch the ulnar part of the os lunatum and the os triquetrum, situated distalward from it, directly, but is separated from them by a discus articularis.

On the sides of this surface the two *processus styloidei* are visible.

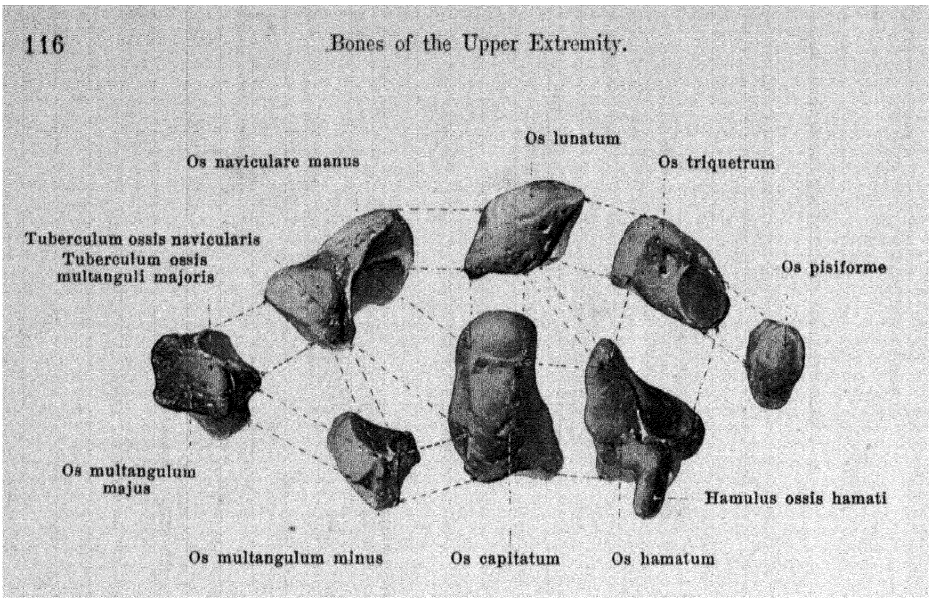


162 and 163. Bones of the right forearm,

with the muscular attachments.

from the surface corresponding the hollow of the hand.

from the side corresponding to the back of the hand.



164—171. Bones of the right carpus, *ossa carpi,* shown singly, from the volar surface.

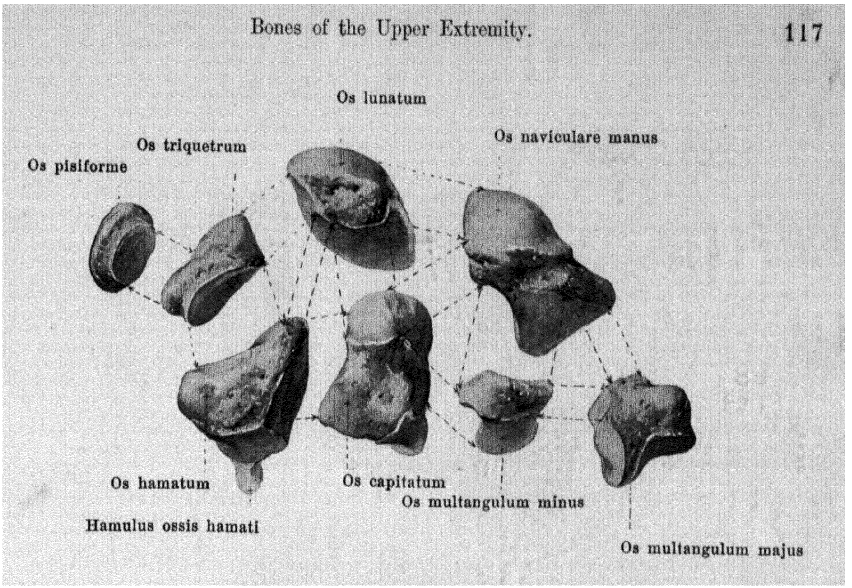
The eight **ossa carpi** *(wrist bones)* (see also Figs. 172—180, 182, 183) are arranged in two transverse rows of four each: the proximal (numbered from the thumb side) consists of the *os naviculare manus, os lunatum, os triquetrum, os pisiforme;* the distal of the *os multangulum majus, os multangulum minus, os capitatum, os hamatum.* (For the development see p. 127.)

The **os naviculare manus** (O. T. scaphoid bone) presents proximally a convex articular surface (for the radius), on its distal surface, a convex articular surface (for the ossa multangula majus et minus), on the ulnar surface proximalward a small crescent shaped, almost flat articular surface (for the os lunatum) and distalward a concave surface (for the os capitatum). On the volar surface lies the *tuberculum ossis navicularis.*

The **os lunatum** (O. T. semilunar bone) presents proximally a markedly convex articular surface (for the radius and for the discus articularis of the joint formed by the forearm with the hand), distally, a markedly concave articular surface (for the os capitatum) and a narrow slightly concave one (for the os hamatum); radialward lies a small crescent shaped, almost flat articular surface for the os naviculare, ulnarward a small square, flat articular surface for the os triquetrum. The volar surface is square, and larger than the dorsal.

The **os triquetrum** (O. T. cuneiform bone) has proximally a small, convex articular surface (for the discus articularis of the joint formed by the forearm with the hand), distally, a large surface curved like the thread of a screw (for the os hamatum), radialward, a small flat one (for the os lunatum) and on the volar surface a small, flat, rounded articular surface (for the os pisiforme).

The **os pisiforme** is a small, egg-shaped bone which dorsalward presents a small, flat, rounded articular surface (for the os triquetrum).



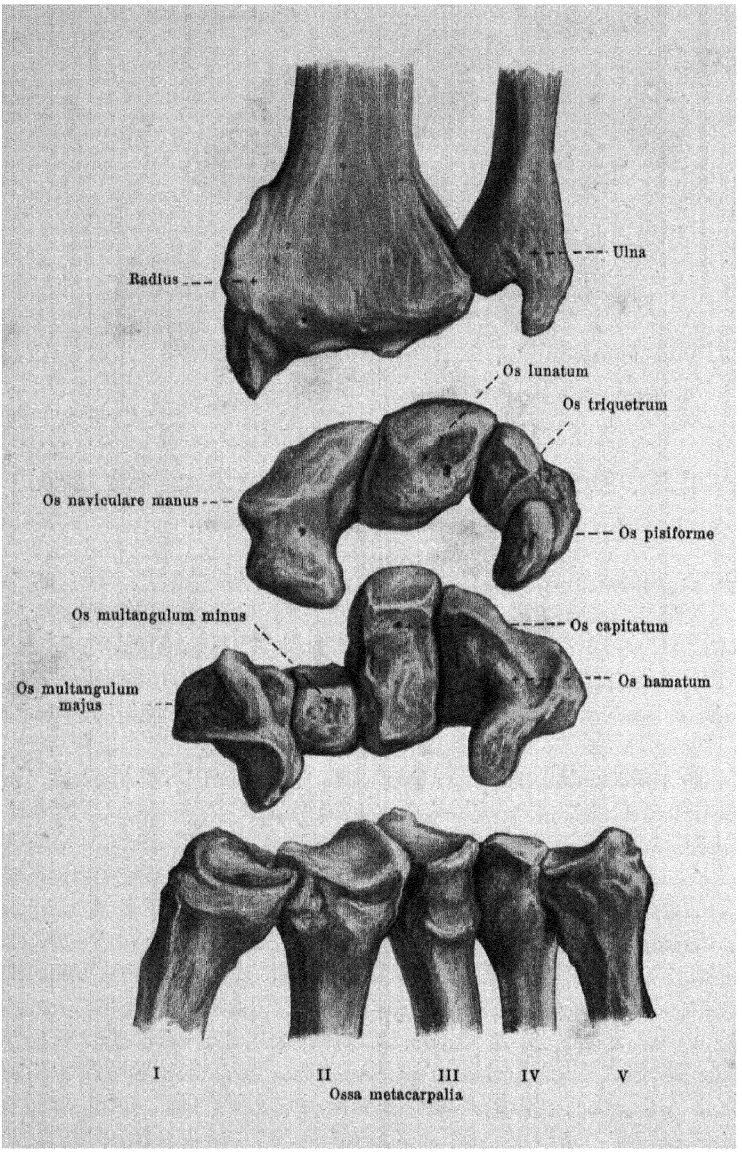
172—179. Bones of the right carpus, *ossa carpi*, shown singly, from the dorsal surface.

The **os multangulum majus** or large multangular bone (O. T. trapezium) has proximally a slightly concave articular surface (for the os naviculare), distalward a saddle-shaped surface (for the os metacarpale I), ulnarward a proximal somewhat larger, concave surface (for the os multangulum minus) and a small distal surface (for the os metacarpale II). On the volar surface is a small projection, ***tuberculum ossi multanguli majoris***, and ulnarward from it a groove (for the tendon of the m. flexor carpi radialis).

The **os multangulum minus** or small multangular bone (O. T. trapezoid bone) presents proximally a slightly concave articular surface (for the os naviculare) distalward a flat saddle-shaped surface (for the os metacarpale II); on the radial surface lies a slightly convex articular surface (for the os multangulum majus), on the ulnar a feebly concave surface (for the os capitatum). The dorsal surface is rough and distinctly larger than the volar one

The **os capitatum** (O. T. os magnum) is inserted in its proximal part into the deep concavity formed by the os naviculare and the os lunatum. It supports there a markedly convex articular surface (for the os lunatum), distalward a tripartite, almost flat, articular surface (for the ossa metacarpalia II, III, IV); radialward are convex articular surfaces for the os naviculare and the os multangulum minus, ulnarward a flat articular sometimes divided surface for the os hamatum. The volar surface is narrower than the dorsal, and shows a long, rough projection.

The **os hamatum** or hook bone (O. T. unciform bone) presents a large, articular surface, curved like the thread of a screw (for the os lunatum and the os triquetrum) directed proximally and at the same time ulnarward; distally is a double more or less flat articular surface (for the ossa metacarpalia IV, V) and radialward a single, flat, sometimes divided articular surface (for the os capitatum). On the volar surface a flat somewhat curved process projects radially upward, the ***hamulus ossis hamati*** (O. T. unciform process).



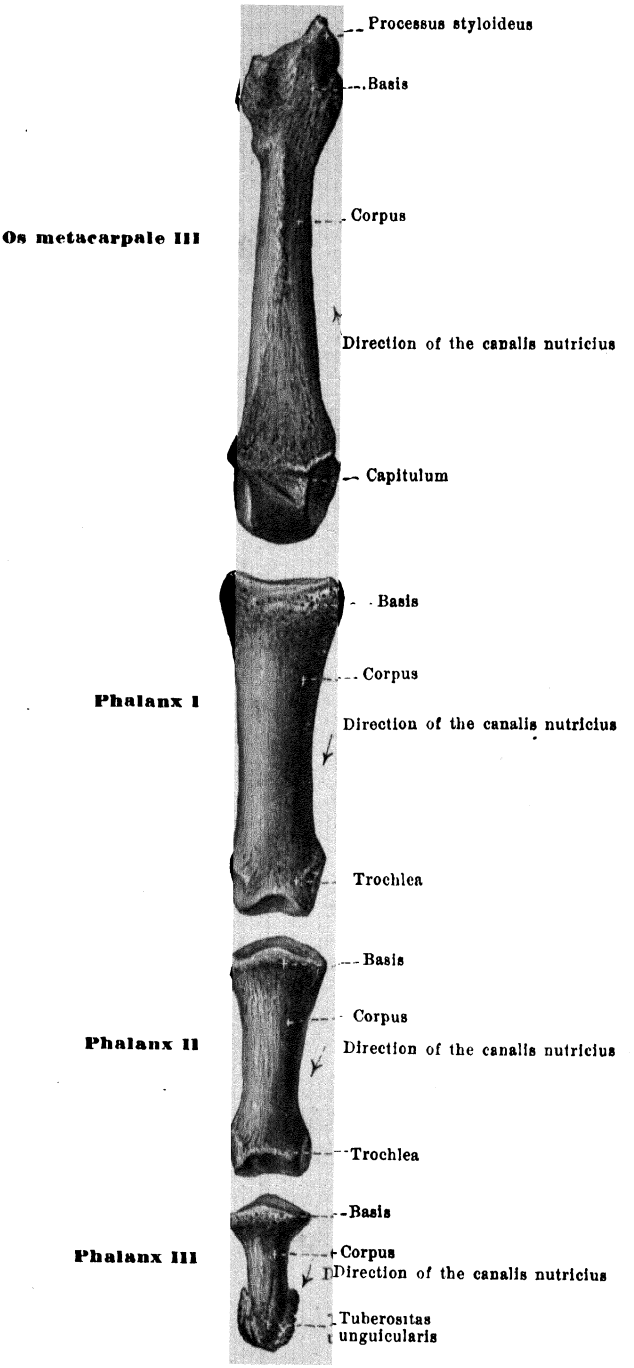
180. Right wrist and neighboring bones,

in transverse rows, separated from one another, from the volar surface.

The **first carpal row** (see also Fig. 291), considered as a whole, has proximalward an elongated oval, markedly convex, articular surface, in the formation of which participate the os naviculare and the os lunatum especially, the os triquetrum to a less extent; the os naviculare and the radial part of the os lunatum articulate with the facies articularis carpea radii, the ulnar part of the os lunatum and the os triquetrum with the discus articularis situated below the capitulum ulnae. The os pisiforme takes no part in the articulation with the bones of the forearm nor in that with the second carpal row, but is simply attached, to the volar surface of the os triquetrum. Distalward the first carpal row is bounded by a surface, the radial portion of which (formed by the os naviculare) is convex and projects markedly distalward, and its ulnar portion (formed by the ossa naviculare, lunatum, triquetrum) represents a markedly hollowed out depression.

The **second carpal row** (see also Fig. 291) ends proximalward in a surface, the radial portion of which (formed by the ossa multangula majus et minus), is concave and its ulnar part (formed by the os capitatum and os hamatum) represents a head projecting markedly proximalward. These proximal surfaces are approximately impressions of the corresponding distal surfaces of the first carpal row. The distal boundary of the second row is formed by a wavy surface in which the ossa metacarpalia are deposited; furthest radialward lies the saddle-shaped surface for the os metacarpale I (formed by the os multangulum majus); after this comes the surface for the os metacarpale II (formed chiefly by the os multangulum majus et minus and partly by the os capitatum); then the surface for the os metacarpale III (formed by the os capitatum), then the surface for the os metacarpale IV (formed chiefly by the os capitatum and partly by the os hamatum) and finally, the surface for the os metacarpale V (formed by the os hamatum).

The **carpus** *(wrist)* (see Figs. 182 and 183) is on the whole almost quadrangular, and narrower proximally than distally. It is besides curved so as to be somewhat convex dorsalward and, accordingly, volarward forms a groove which is made deeper by the fact that the radial and the ulnar sides are somewhat elevated; radialward are the tuberculum ossis navicularis and the tuberculum ossis multanguli majoris which together form the *eminentia carpi radialis;* ulnarward the os pisiforme and the hamulus ossis hamati project upward and form the *eminentia carpi ulnaris.* The groove bounded by the two eminentiae carpi is called the *sulcus carpi;* it is converted into a complete *canalis carpi* by the ligamentum carpi transversum which extends between the eminentiae; through this canal go the tendons, vessels and nerves to and from the fingers.



181. Metacarpal bone and phalanges of the third finger of the right hand, *os metacarpale III et phalanges digiti III,* from the dorsal surface.

The five **ossa metacarpalia** (see also Figs. 180, 182—185) are short cylindrical bones, each of which is divisible into a shaft, or *corpus*, a proximal extremity, *basis*, and a distal extremity, *capitulum*. The whole bone is curved, so as to be slightly convex toward the back of the hand. (For the development see p. 127.)

The *corpus* or shaft is triangular so that one side looks dorsalward, the other two radial- and ulnarward; the latter surfaces meet in an angle directed volarward. On the volar surface is a large *foramen nutricium*, which leads into a *canalis nutricius* directed in the thumb distalward, in the second to the fifth finger, proximalward.

The *basis* is somewhat broadened and presents on its proximal surface an articular surface for connection with the carpus, between the second and the fifth finger also small articular surfaces on the radial and ulnar surface for the neighboring metacarpal bones. The basis ossis metacarpalis I (see Fig. 180), has a proximal saddle-shaped joint surface (for the os multangulum majus) but no lateral articular surfaces. The proximal articular surface of the basis ossis metacarpalis II is divided into three unequal parts (see Fig. 180 and p. 119); and the one for the basis ossis metacarpalis IV into two unequal parts. On the basis ossis metacarpalis III, from the radial part of the dorsal surface, a blunt process, the *processus styloideus ossis metacarpalis III*, (insertion of the m. extensor carpi radialis brevis) projects toward the carpus. The basis ossis metacarpalis V (see Fig. 180) presents proximalward a slightly saddle-shaped articular surface for the os hamatum and a flat articular surface on the radial side.

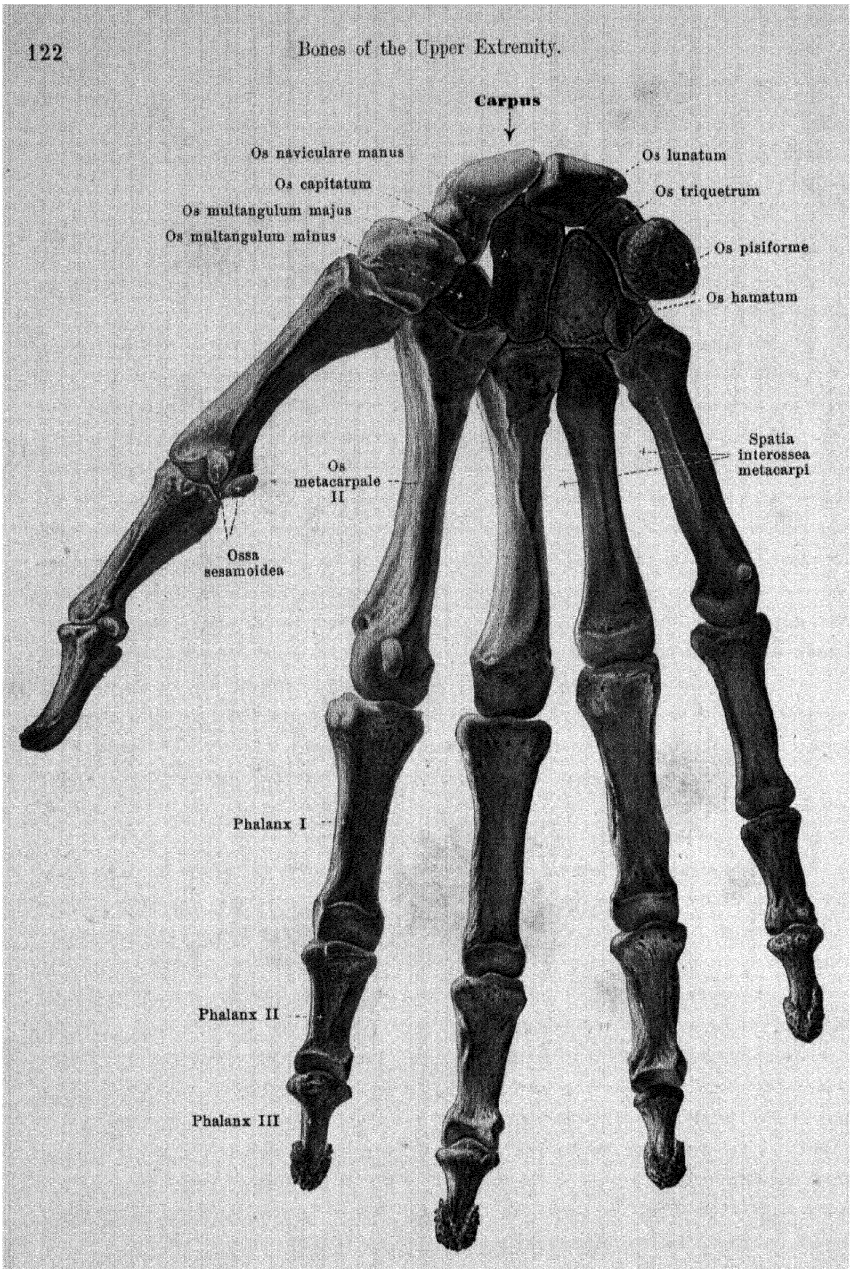
Each *capitulum* possesses a spherical articular surface, covered with cartilage, which extends upon the volar more than upon the dorsal surface. On the two sides there are depressions and roughened areas for the ligaments of the joint.

The four spaces lying between the ossa metacarpalia (see Figs. 182 and 183) are called *spatia interossea metacarpi*. The first, between thumb and index finger is the broadest. They are all filled out by the mm. interossei.

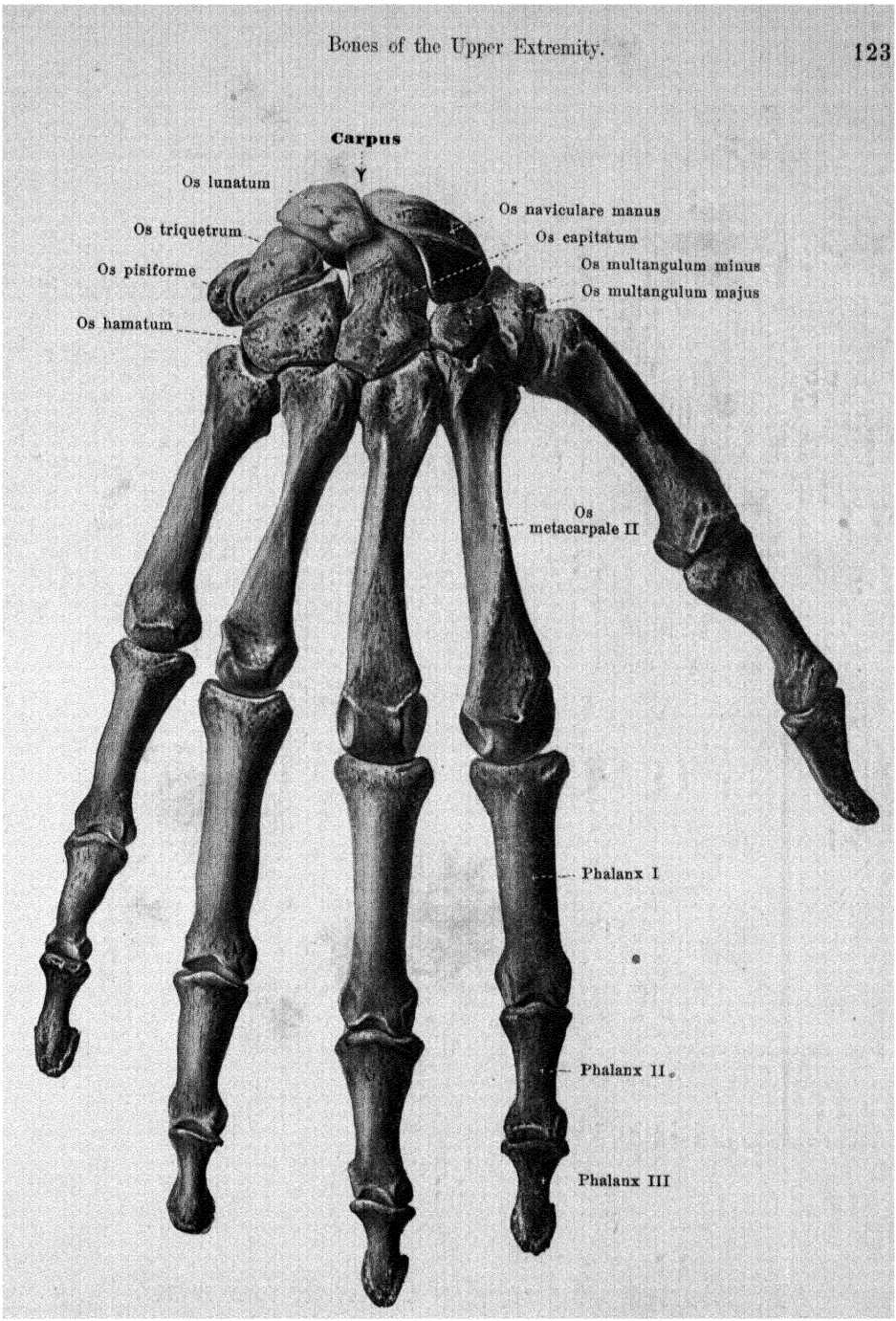
The **phalanges digitorum** (see also Figs. 182 and 183) are three in number from the second to the fifth finger; while on the thumb there are two; they are called *phalanx prima, secunda, tertia*. Each *phalanx* is a short cylindrical bone which is divisible into a shaft or *corpus*, a proximal end, *basis*, and a distal end. (For the development see p. 127.)

The *corpus* is flat volarward and curved dorsalward so as to be convex in transverse direction. A large *foramen nutricium* on its volar surface leads into a *canalis nutricius* directed distalward. The *basis* is somewhat broadened and possesses a deep articular surface, covered with cartilage, which on the first phalanx is simple, on the others is divided by a ridge. The distal end of the first phalanx of the thumb and also of the first and second phalanx of the remaining fingers has a *trochlea*, a small transverse roller surface covered, with cartilage, with a groove in the middle; on the sides lie small depressioms for the attachment of the ligament of the joint. On the terminal phalanx the distal end is transformed to a broad flat rough area, the *tuberositas unguicularis*.

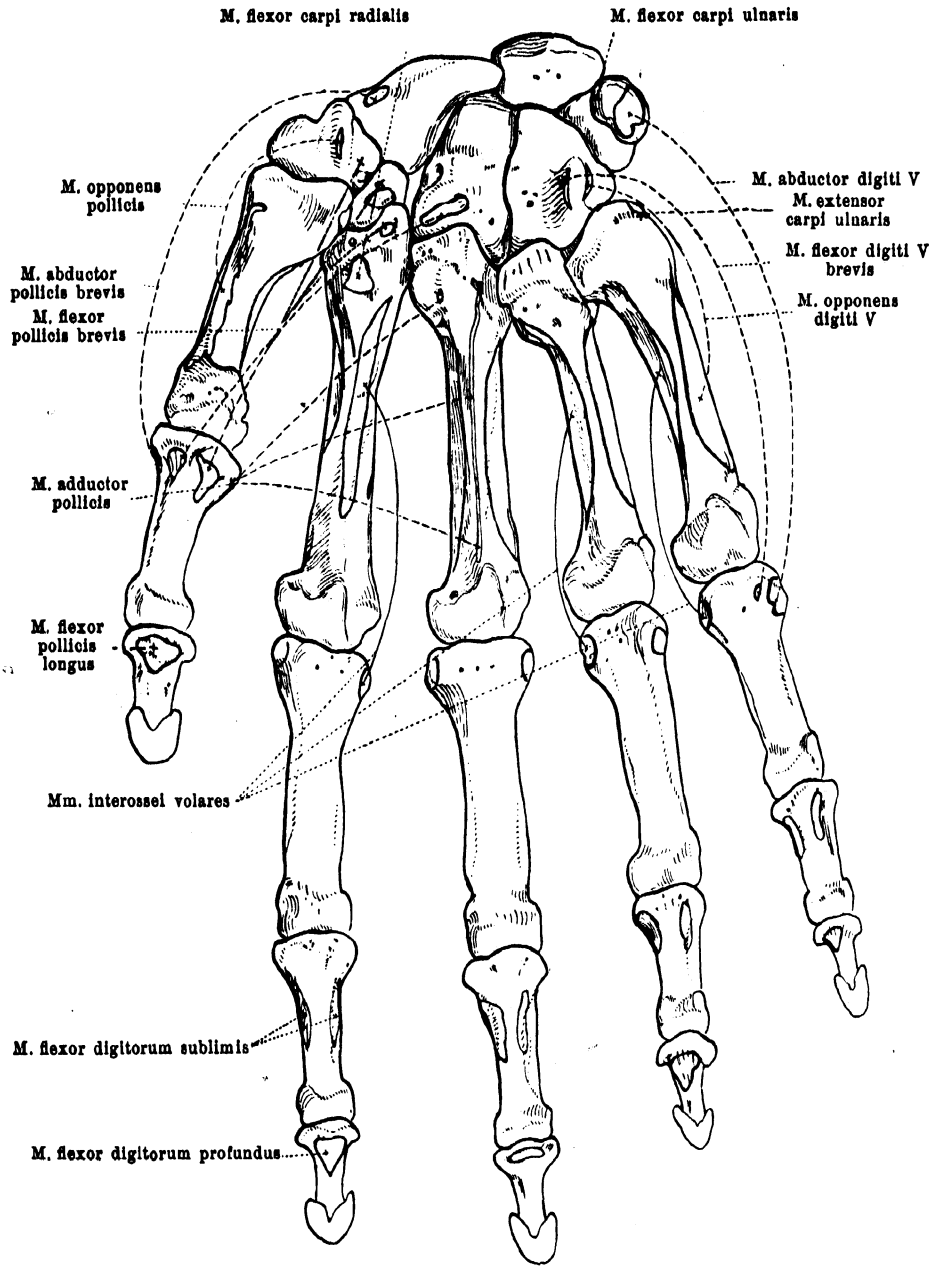
Ossa sesamoidea *(sesamoid bones)* (see Fig. 182) are small masses of bone which, embedded in tendons or ligaments, lie upon the other bones. There are constantly five or almost constantly five such on the volar surface, two at the metacarpophalangeal joint of the thumb, one at the interphalangeal joint of the thumb and one each at the metacarpophalangeal joint of the second and of the fifth finger. (For the development see p. 127.)



182. Bones of the right hand, *ossa manus,*
from the volar surface.

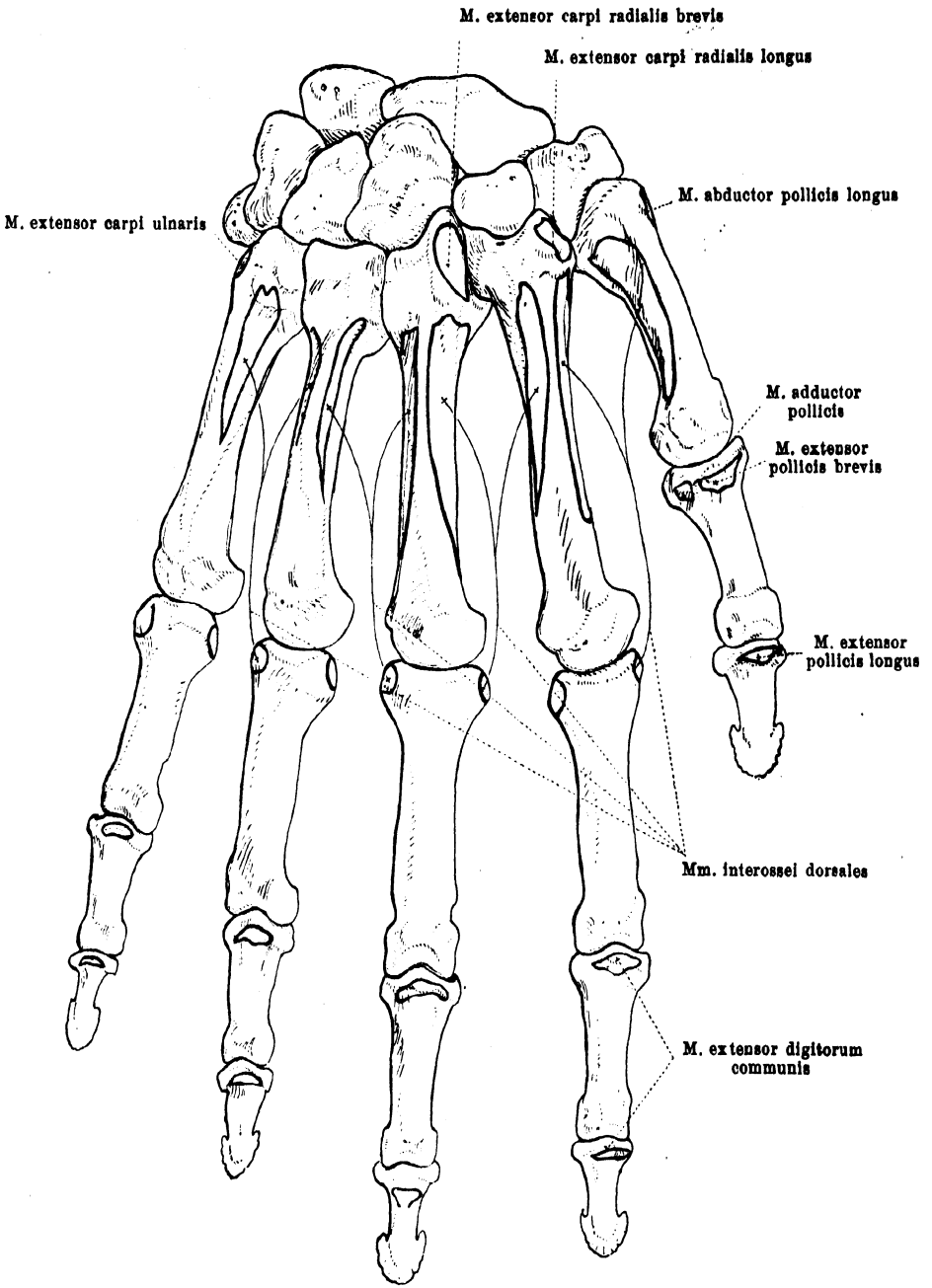


183. Bones of the right hand, *ossa manus,* from the dorsal surface.

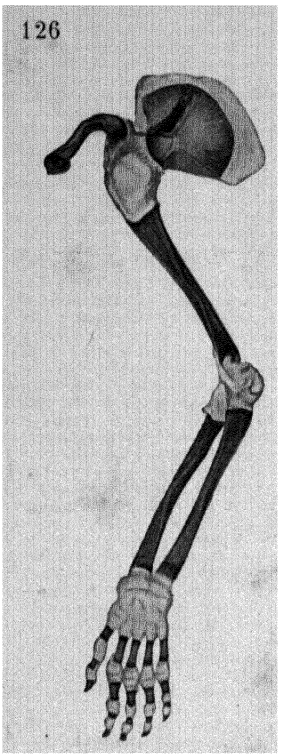


184. Bones of the right hand, *ossa manus,*

from the volar surface, with the muscular attachments.



185. Bones of the right hand, *ossa manus,*
from the dorsal surface, with the muscular attachments.



186. Skeleton of the right upper extremity of a fetus 5 months old, from in front. Magnif.: 1 : 1.

(The bone substance is colored red, the rest is made transparent.)

Development of the bones of the upper extremity. They are all preformed in cartilage. The clavicle is an exception in so far as its primitive centre of development appears prior to the formation of any cartilaginous matrix; the further development, however, takes place in this bone like in all the others from cartilage.

Scapula. The main centre or nucleus appears in the 8th week near the lateral angle and forms the body, the spine, and base of the glenoid cavity. In the first year of life, there appears a nucleus in the proc. coracoideus, which at puberty fuses with the main mass, and in the 10th—12th year there develops a subcoracoid nucleus in the basis of the proc. coracoideus and at the upper edge of the cavitas glenoidalis, which fuses with the main mass about the 18th year. Besides these there appear the following epiphyses: 1. in the acromion (2—3 which quickly fuse into one), appearing in the 15th—18th year, (unite with the spina in the 20th year); 2. at the angulus inferior in the 16th—18th year; 3. in the margo vertebralis in the 18th—20th year; 4. on the upper lateral surface of the proc. coracoideus in the 16th—18th year; and 5. on the upper surface of the cavitas glenoidalis in the 16th—18th year. In the 18th to 20th year there begins a union with the main mass of bone first of the epiphyses of the proc. coracoideus, then of those of the cavitas glenoidalis, then of the angulus inferior, and lastly of the margo vertebralis.

Clavicula. The shaft shows in the 6th week a medial and a lateral nucleus which soon unite. At the sternal end there appears an epiphysis in the 18th—20th year, which unites with the shaft in the 20th—25th year.

Humerus (see also Fig. 187). The nucleus for the shaft first appears in the 6th to 7th week. At the proximal end there develops an epiphyseal nucleus for the caput in the 1st to 2ed year, one for the tuberculum majus in the 1st to 3rd year, and one for the tuberculum minus (not constant) in the 3rd—5th year; these soon coalesce in the 4th—6th year, and unite with the shaft in the 16th—25th year. At the distal end there appear, epiphyseal nuclei in the capitulum in the 1st—3rd year, in the epicondylus medialis in the 5th—9th year, in the trochlea in the 8th—16th year, and in the epicondylus lateralis in the 11th—18th year; of these the three lateral ones first unite with each other and then (in the 16th—17th year) with the shaft, while the epiphyses of the epicondylus medialis unites with the shaft in the 18th year.

Ulna (see also p. 188). The nucleus for the shaft appears in the 7th week. In the distal epiphysis a nucleus is formed in the 6th—9th year (union in the 18th—24th year), and in the proximal epiphysis in the 8th—14th year. (Union in the 17th year.)

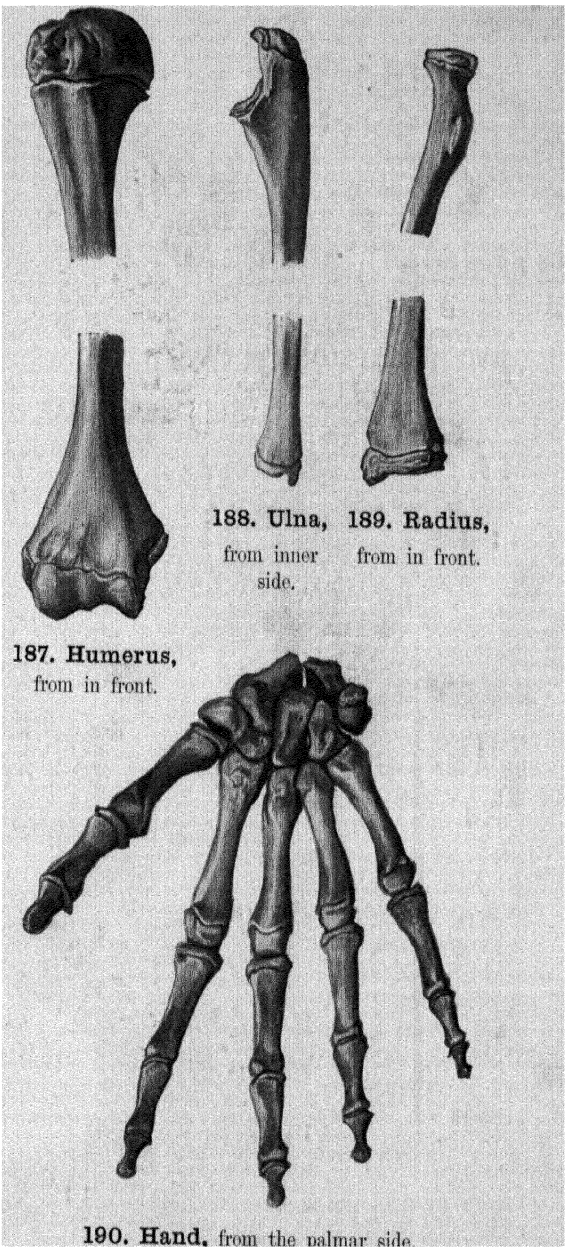
Radius (s. also Fig. 189). The nucleus of the shaft appears in the 7th week. A nucleus in the distal epiphysis appears between the 8th month and the 3rd year; this unites with the shaft in the 21st—25th year. In the proximal epiphysis a nucleus first develops between the 4th and 9th year, and unites with the shaft in the 17th—20th year.

Corpus (see also Fig. 186). A nucleus appears in the os capitulum and the os hamatum in the 1st year; in the os triquetrum in the 2nd—5th year, in the os lunatum in the 3rd—6th year, in the os naviculare, os multangulum majus, and os multangulum minus in the 3rd—6th year, and in the os pisiforme in the 10th—14th year. In each bone there may occur two nuclei or centres of ossification.

Ossa metacarpalia (see also Fig. 186). Each os metacarpale receives a nucleus for its shaft in the 9th week (in the order of II, III, IV, V, I); besides these there is formed an epiphysis for the os metacarpale II—V at the distal end in the 2nd—3rd year, and for the os metacarpale I at the proximal end in the 3rd year. The epiphyses unite with the shafts in the 15th to 20th year.

Phalanges (see also Fig. 186). In the 1st row there appear nuclei for the diaphyses in the 9th week and for the proximal epiphyses in the 1st—2nd year; in the 2nd row nuclei for the diaphyses appear in the 11th—12th week and nuclei for the proximal epiphyses in the 2nd to 3rd year; in the 3rd row nuclei for the diaphyses in the 7th—8th week and nuclei for the proximal epiphyses in the 2nd—3rd year. So that in the hand, the nuclei or centres of ossification for the end phalanges, appear first, then come the ossa metacarpalia, then comes the first row of phalanges, and lastly the second row of phalanges. The union of the epiphyses and diaphyses occurs between the 18th and 20th year.

Ossa sesamoidea. These ossify usually between the 13th and 14th year, sometimes, however, later.



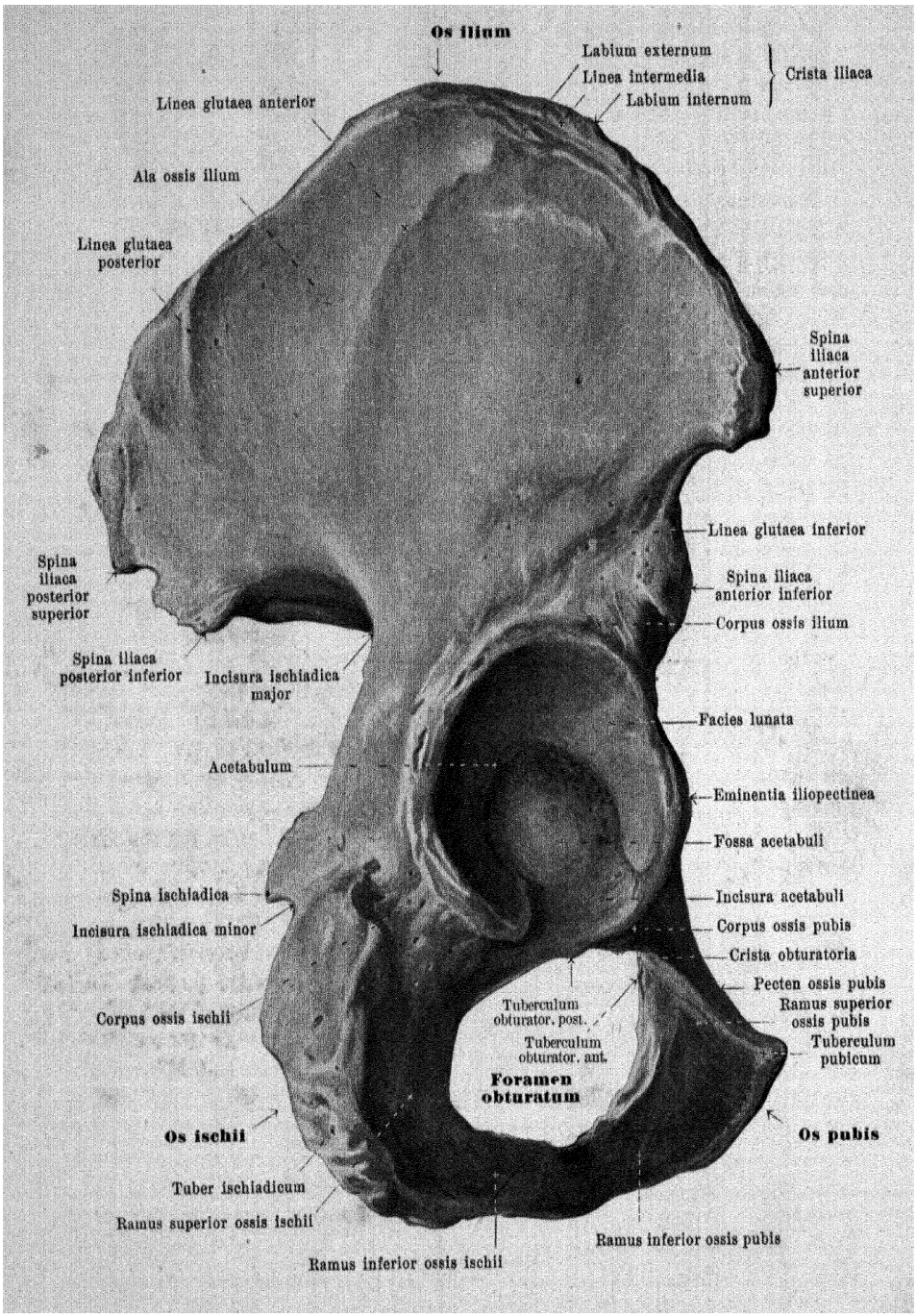
188. Ulna, from inner side. 189. Radius, from in front.

187. Humerus, from in front.

190. Hand, from the palmar side.

187—190. Bones of the right upper extremity of a 10 year girl. Magnification: 1 : 2.

(Of the long bones in each case only the proximal and distal ends are drawn.)

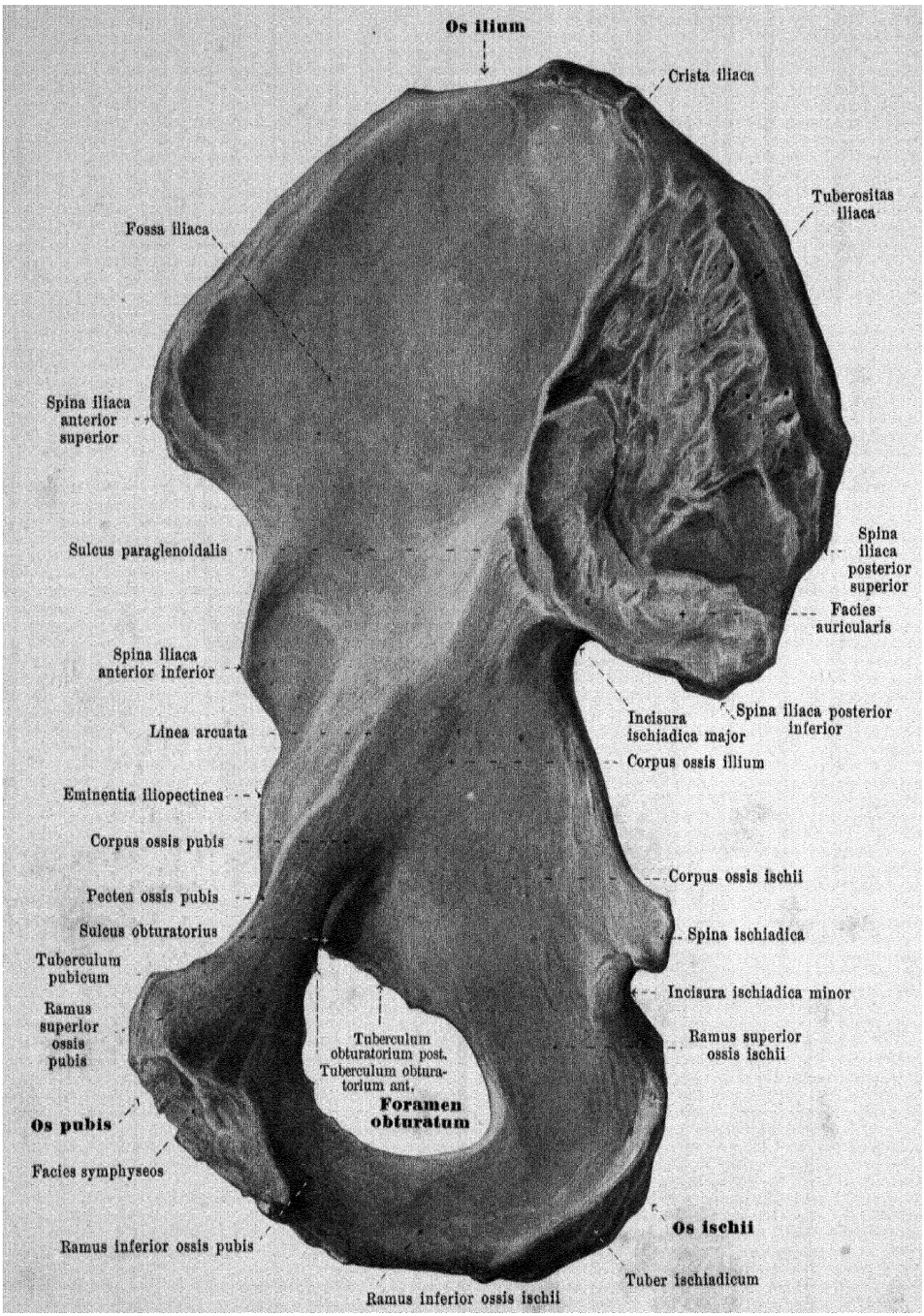


191. Right hip bone, *os coxae*, from without.

The **os coxae** *(hip bone)* (O. T. os innominatum) (see also Figs. 192—206) is paired, lies in the lowermost part of the trunk, and forms there with the same bone of the other side and with the sacrum a firm broad bony ring upon which the vertebral column rests above and with which, externally, the bones of the thigh are connected. (For the development see p. 166.)

Each os coxae is composed of three pieces, separated until about the age of puberty: the *os ilium* which is directed upward and backward, the *os ischii,* which is directed downward and backward and the *os pubis* which is directed forward and downward. These three constituents meet somewhat below the middle of the hip bone. At this spot on the external surface lies a wide deep fossa, the *acetabulum.* This is surrounded by a high bony wall which presents below a broad notch, the *incisura acetabuli*; in the bottom of the acetabulum a large rough spot is visible, the *fossa acetabuli,* which is surrounded in front, above and behind by a horse-shoe-shaped concave surface, the *facies lunata,* covered with cartilage. The acetabulum serves for articulation with the femur. In youth the places where the three bones unite are visible as a Y-shaped seam, the middle point of which is situated in the fossa acetabuli.

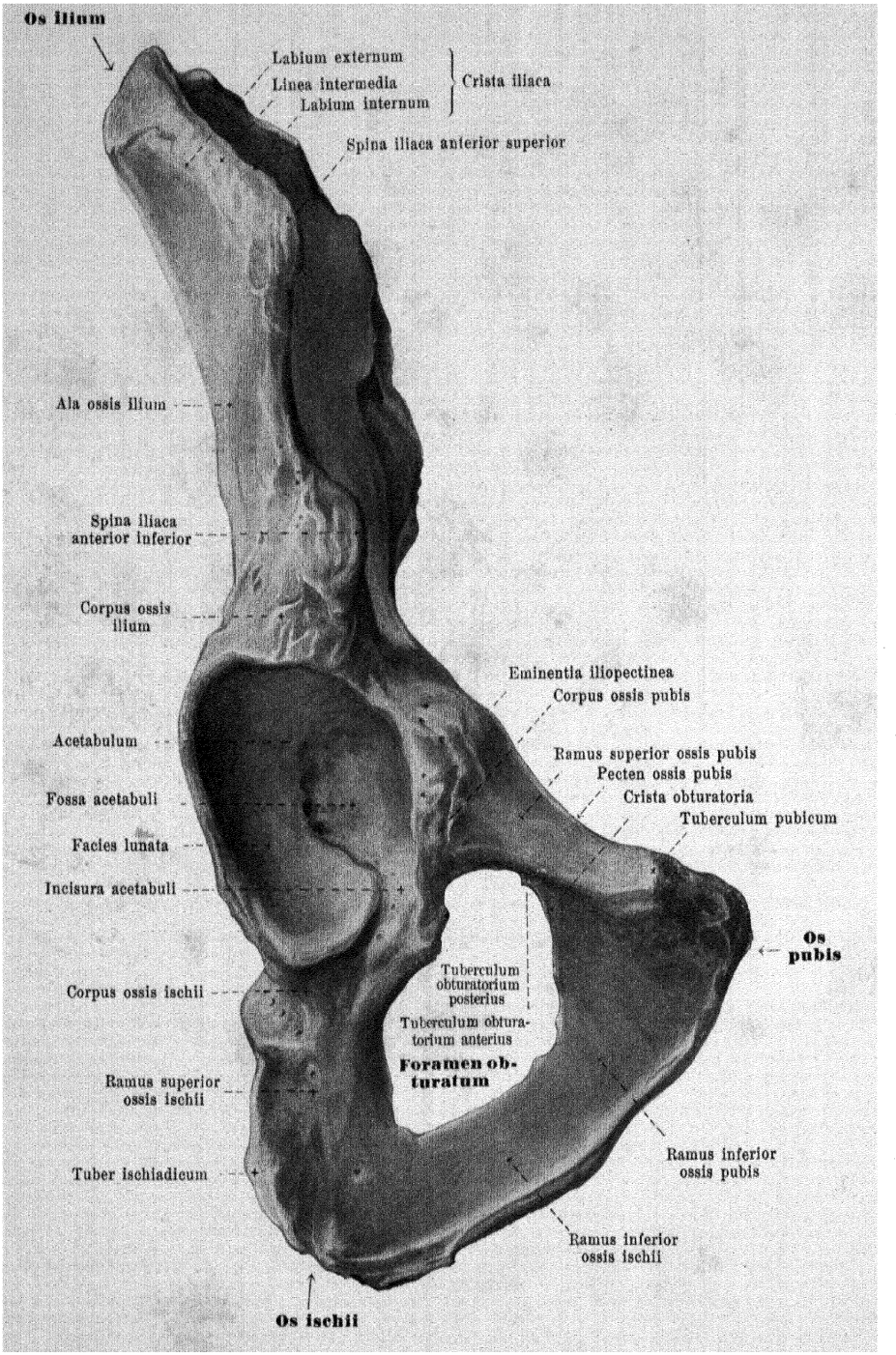
The **os ilium** (see also Figs. 192—194 and 196—206) helps to form the acetabulum by means of its thick and broad lower part, the *corpus ossis ilium* (vide supra); the upper part is a broad, in places very thin, somewhat wavy bony plate which bends backward, upward and lateralward and is called the *ala ossis ilium.* The corpus and ala are separated from one another by the *linea arcuata,* a curved rounded bony ridge descending obliquely from behind and above, forward and downward. The free margin of the ala ossis ilium is curved like the letter S, being concave medianward in front and convex medianward behind; elsewhere it is markedly broadened; it is called the *crista iliaca (iliac crest).* On it the places of attachment of the abdominal muscles are marked as ridges, namely as *labium externum* and *labium internum* on the external and internal angle of the crest and as *linea intermedia* between these two. The crest ends in front in a blunt projection, *spina iliaca anterior superior;* below this the margin is narrower, somewhat concave and presents a second less marked projection, *spina iliaca anterior inferior;* below this it goes over into the corpus ossis pubis and there forms with the latter the *eminentia iliopectinea.* The iliac crest ends behind at the *spina iliaca posterior superior;* below it, separated by a small notch, lies the *spina iliaca posterior inferior* (sometimes indistinct), and still lower is a deep notch involving also the corpus ossis ischii, the *incisura ischiadica major* (O. T. great sacro-sciatic notch). The medial surface of the ala is for the most part, smooth, slightly concave, the *fossa iliaca;* behind it is an uneven surface, the anterior irregularly triangular portion of which, *facies auricularis,* covered with cartilage, articulates with the facies auricularis ossis sacri, while its posterior, very rough portion, *tuberositas iliaca,* serves chiefly for the attachment of the ligamenta sacroiliaca interossea. The facies auricularis is not infrequently partially surrounded in front and behind by a groove, the *sulcus paraglenoidalis,* which serves for the attachment of the deep fibrous bands of the ligamenta sacroiliaca. The external surface of the ala is fairly smooth, and curved so as to be convex in front, concave behind. It presents three rough ridges, convex upward and backward, the shortest of which, the *linea glutaea inferior* (O. T. inferior curved line), lies just above the acetabulum; above and behind this is the *linea glutaea anterior* (O. T. middle curved line) which is the longest of the ridges and extends from the incisura ischiadica major to the spina iliaca anterior superior; and above this the shorter *linea glutaea posterior* (O. T. superior curved line) runs from the spina iliaca posterior inferior to the crista iliaca.



192. Right hip bone, *os coxae*, from within.

The **os ischii** (O. T. ischium) (see also Figs. 191 and 193—206) helps by its thicker upper part or body, the *corpus ossis ischii,* to form the acetabulum. At the anterior margin of this, below the incisura acetabuli, there is not frequently a small projection, *tuberculum obturatorium posterius;* from its posterior margin the strong, sharp *spina ischiadica* (O. T. spine of ischium) projects backward and somewhat medianward. The deep notch between the spina ischiadica and the spina iliaca posterior inferior is called the *incisura ischiadica major* (O. T. great sacro-sciatic notch); a second notch, the *incisura ischiadica minor* (O. T. lesser sacro-sciatic notch), below the spina ischiadica, between this and the tuber ischiadicum, is flatter and covered with cartilage.

Extending backward and downward from the body or corpus is the triangularly prismatic *ramus superior ossis ischii;* its medial surface and the surface directed forward and lateralward is smooth; the surface directed backward and lateralward is rough and much thickened; it forms the *tuber ischiadicum* (O. T. tuberosity of the ischium). From the lower end of the ramus superior in front the thinner flat *ramus inferior ossis ischii* (O. T. ascending ramus) goes off, nearly at a right angle; it extends forward and upward and fuses with the inferior extremity of the ramus inferior ossis pubis.

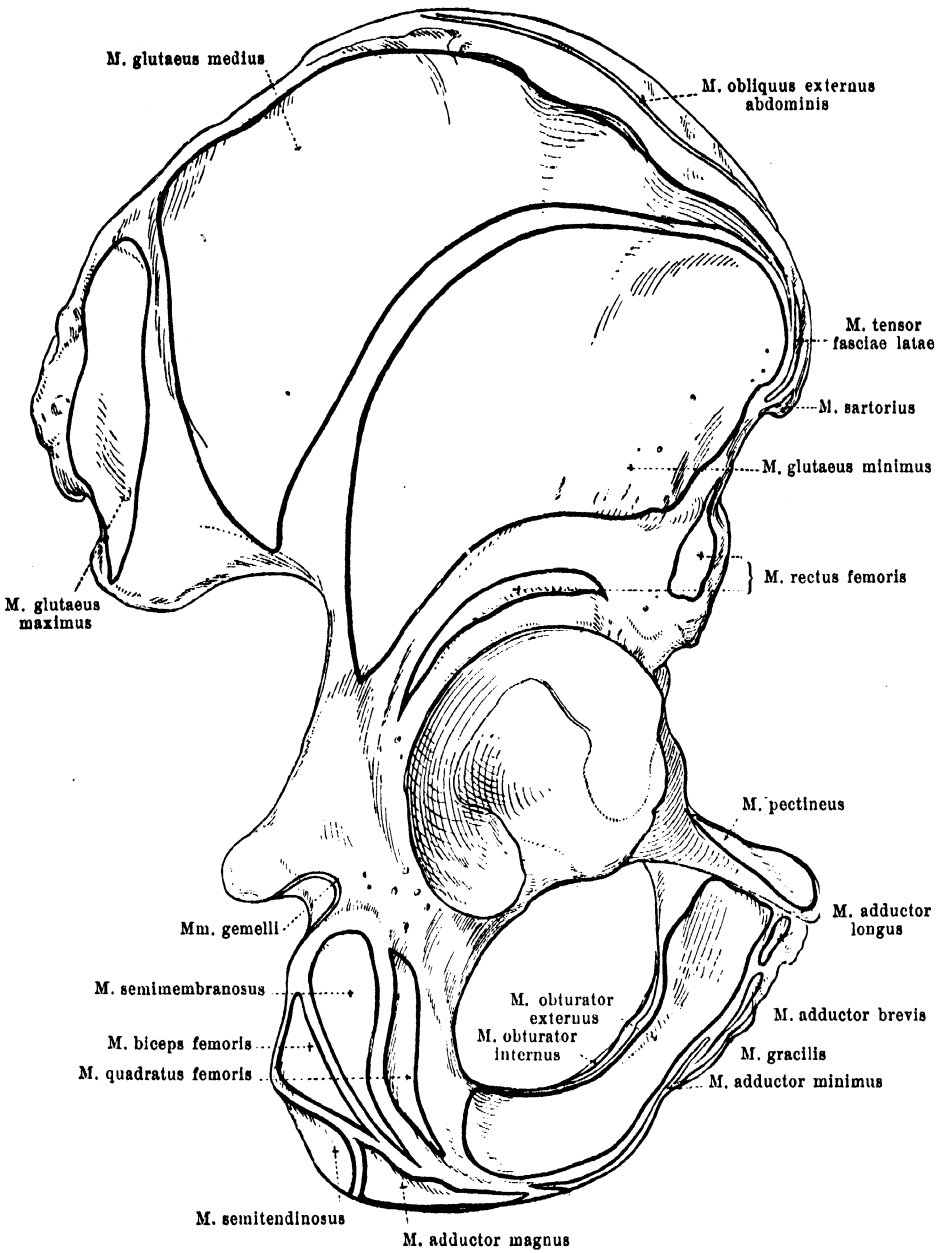


193. Right hip bone, *os coxae*, from in front and below.

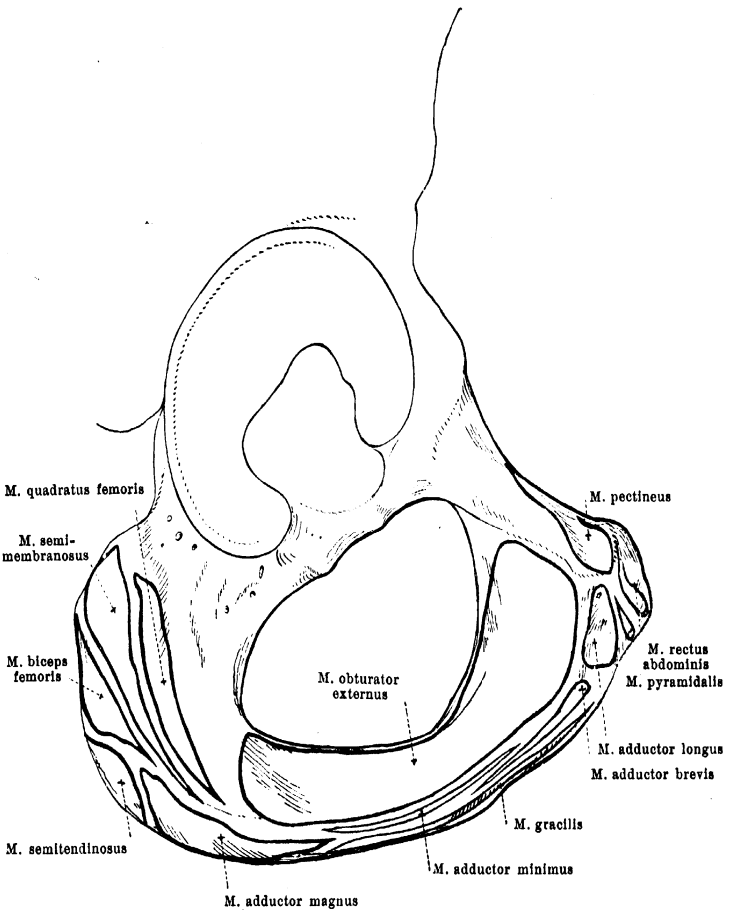
The **os pubis** (see also Figs. 191, 192 and 194—206) helps, with its thicker upper lateral portion, the *corpus ossis pubis,* to complete the acetabulum. Medianward and somewhat in front of this portion lies a rough projection, *eminentia iliopectinea,* formed by the os pubis and the os ilium in common. Extending forward, downward and medianward from the corpus *(body)* is the *ramus superior ossis pubis.* It is triangular and grows narrower from the outside in. Its posterior surface is smooth and somewhat concave. Its superior surface curved so as to be slightly saddle-shaped is directed at the same time obliquely lateralward and forward, is broad at its beginning at the acetabulum and at the eminentia iliopectinea and gradually becomes narrower, medianward; the posterior margin of this surface, *pecten ossis pubis,* projects in part to form a ridge, is continued behind and lateralward into the linea arcuata ossis ilium and forms with it and the projection between the facies pelvina and basis ossis sacri the *linea terminalis* of the pelvis; the anterior border arises from the incisura acetabuli, is rounded, slightly concave and ends near the median plane at a small rough projection, the *tuberculum pubicum* (O. T. spine of os pubis). The lower surface looks medianward at the same time forward and is continued lateralward into a groove, *sulcus obturatorius,* which ascends obliquely lateralward, backward and upward on the lower surface and ends on the inner surface; the sharp bony border, directed downward, by which this surface and groove are bounded medianward is called the *crista obturatoria* and presents a small projection, *tuberculum obturatorium anterius.* The ramus superior ends medianward with an oval rough surface, *facies symphyseos* (O. T. symphysis pubis), for connection with the pubic bone of the other side.

The *ramus inferior ossis pubis* is the narrow, flat piece of bone which extends from the medial end of the ramus superior downward and lateralward and unites with the upper end of the ramus inferior ossis ischii.

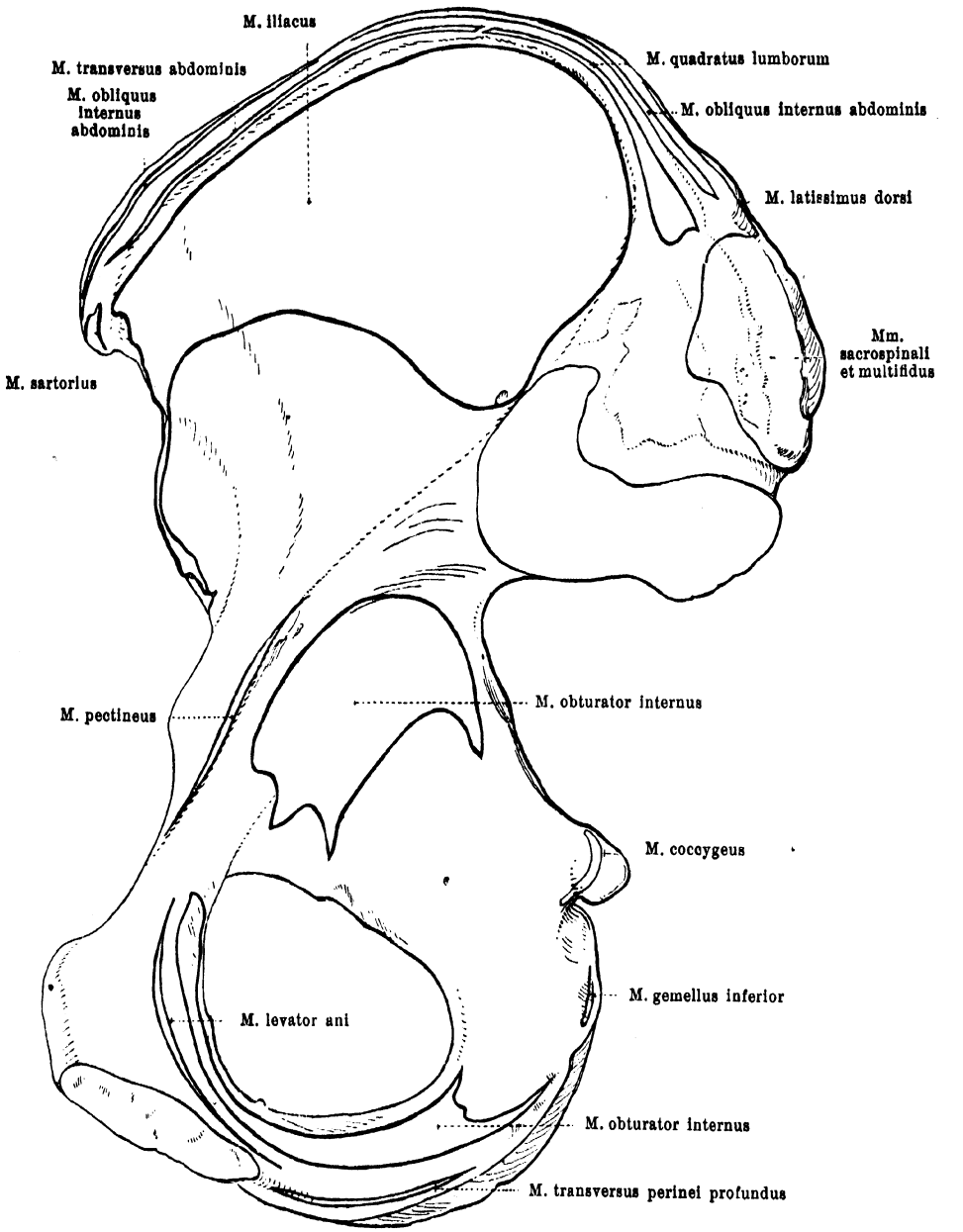
The **foramen obturatum** (see also Figs. 191, 192, 197 and 198) is a large triangular or oval opening which is bounded by the os ischii and the os pubis on all sides. Its margin is everywhere sharp, except in the upper lateral angle where the sulcus obturatorius is situated. The foramen obturatorium is closed in the fresh pelvis by a thin membrane, *membrana obturatoria* (see Fig. 297), whose uppermost transverse bands are stretched out between the two tubercula obturatoria; the space thus left behind corresponds in its course to the sulcus obturatorius and is called the *canalis obturatorius* (for the a. and v. obturatoria; n. obturatorius).



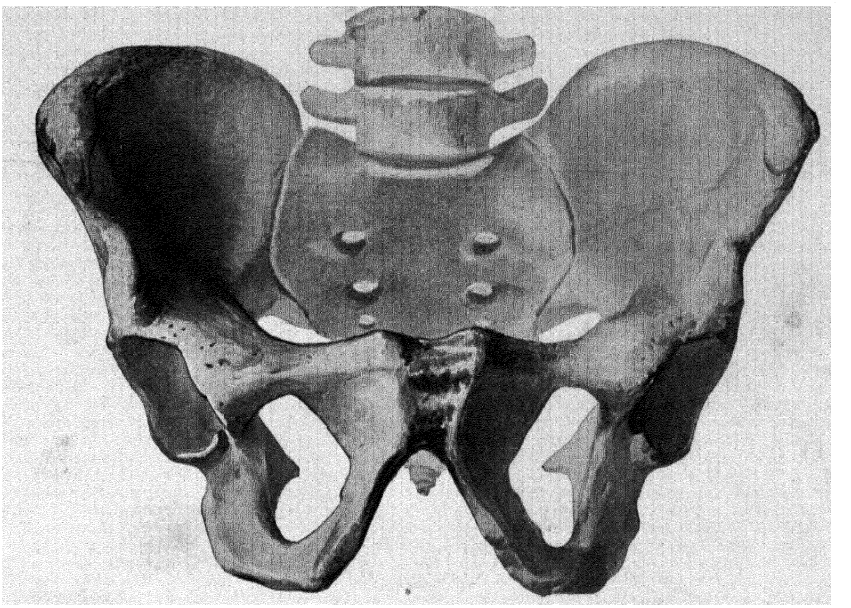
194. Right hip bone, *os coxae,* from behind and without, with the muscular attachments.



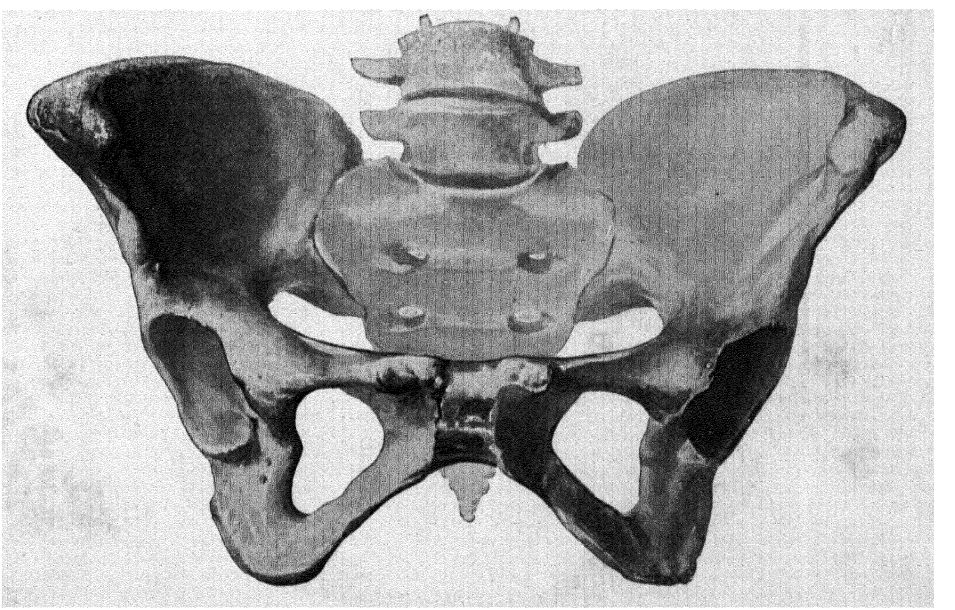
195. Right hip bone, *os coxae,* from in front and without and somewhat from below, with the muscular attachments.



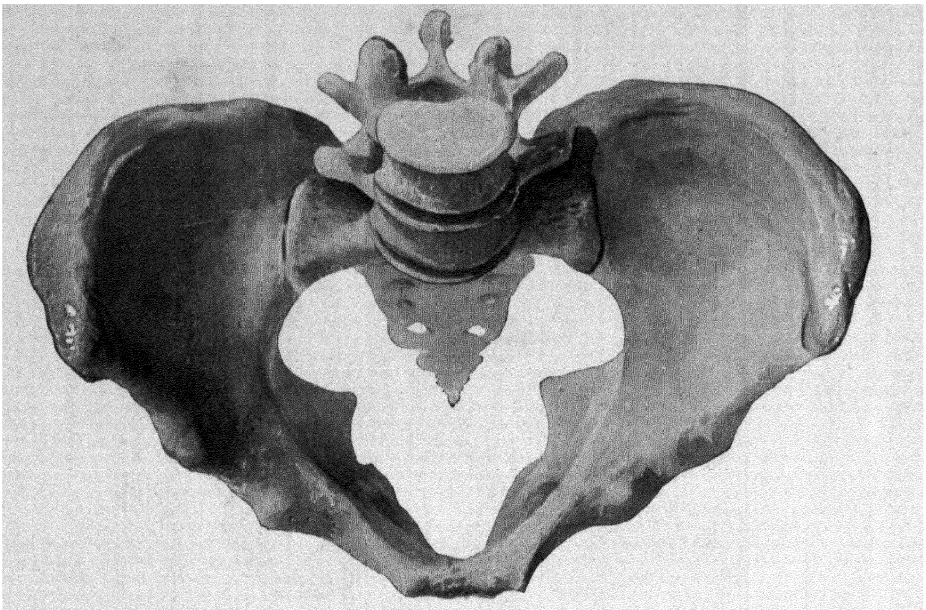
196. Right hip bone, *os coxae,* from within, with the muscular attachments.



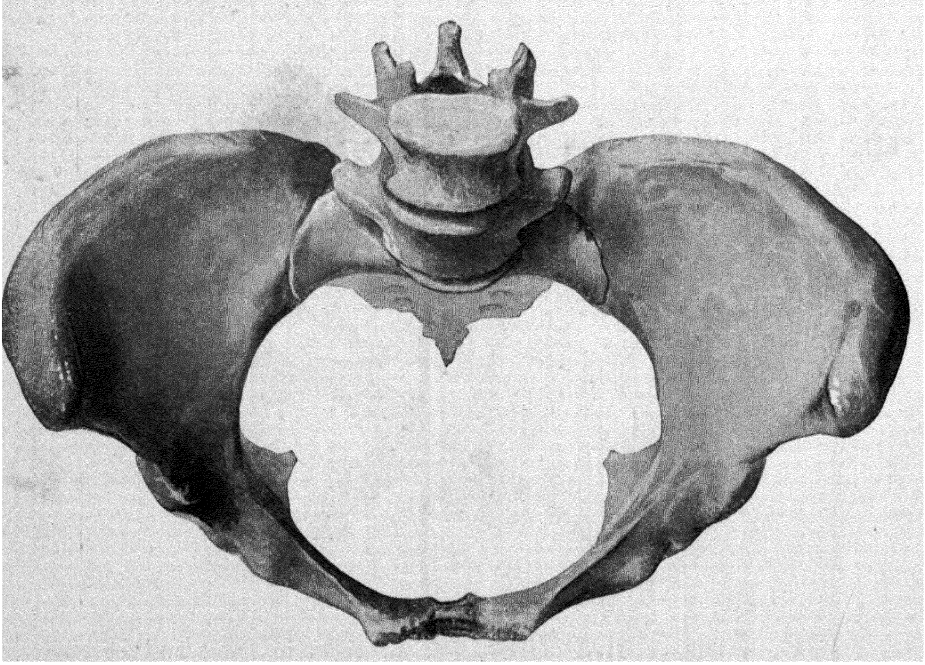
197. Male pelvis, *pelvis*, from in front and below.



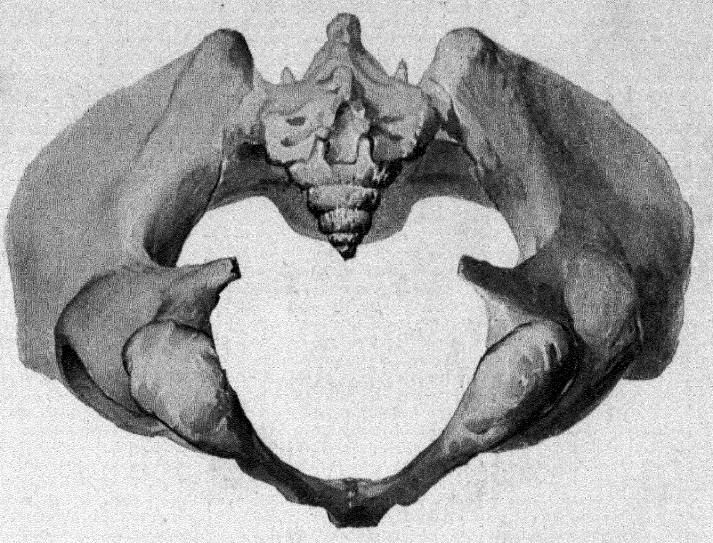
198. Female pelvis, *pelvis*, from in front and below.



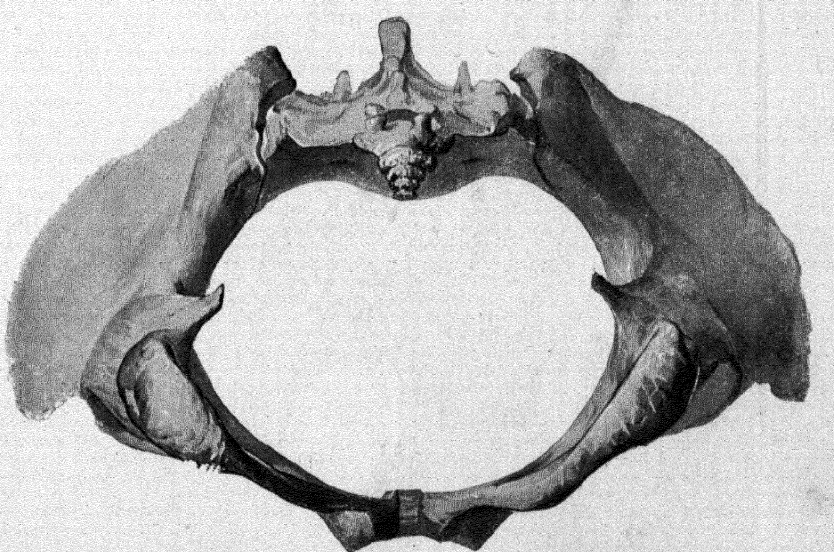
199. Male pelvis, *pelvis,* from in front and above.



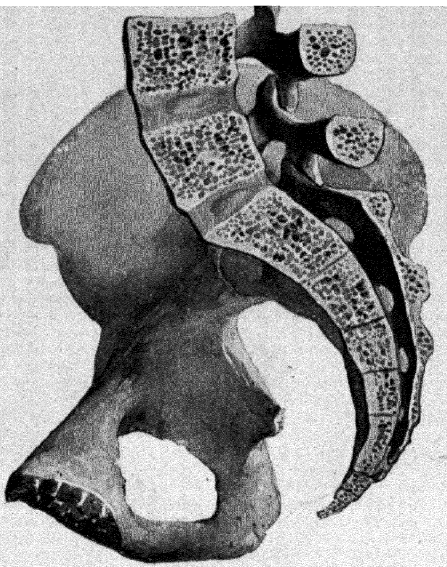
200. Female pelvis, *pelvis,* from in front and above.



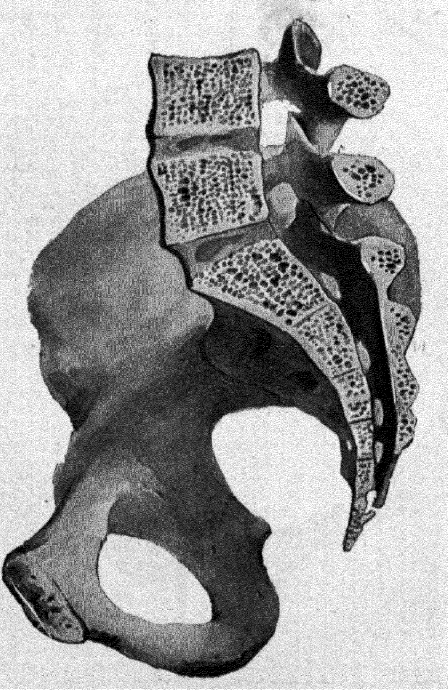
201. Male pelvis, *pelvis*, from below and behind.



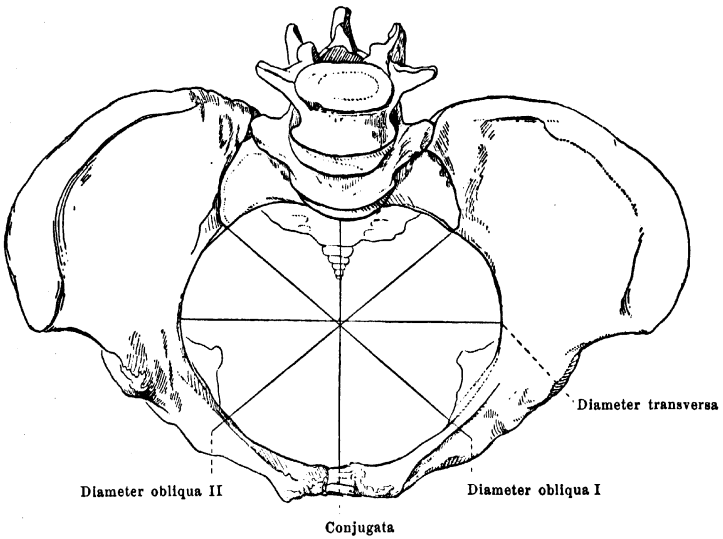
202. Female pelvis, *pelvis*, from below and behind.



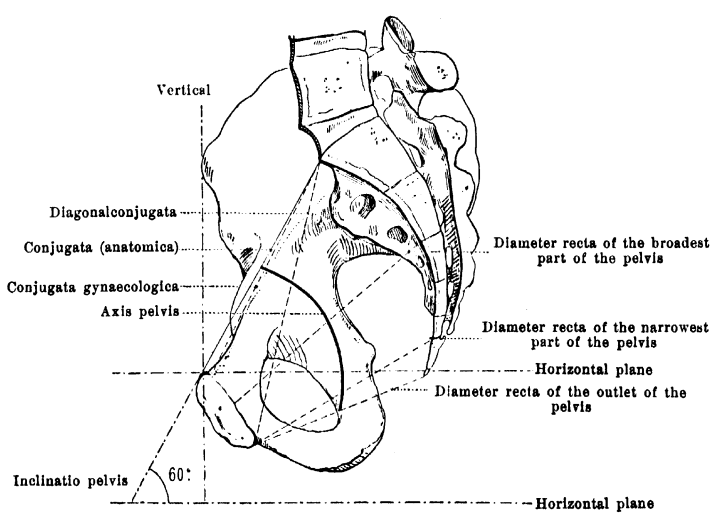
203. Male pelvis, *pelvis,* median section, right half, from the left.



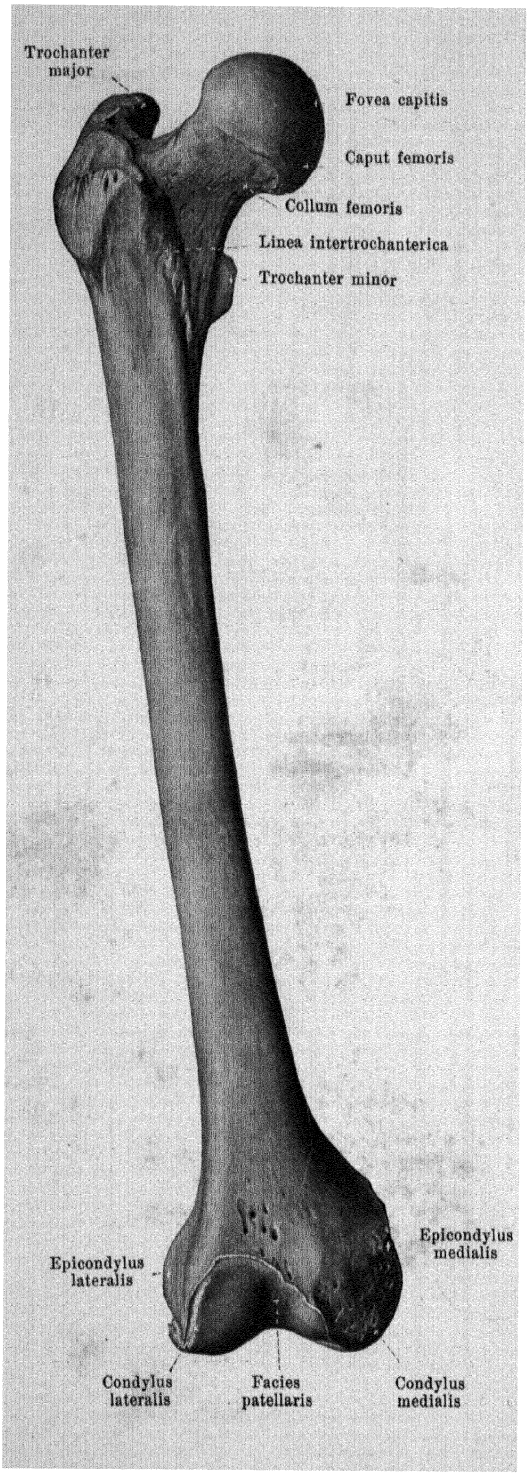
204. Female pelvis, *pelvis,* median section, right half, from the left.



205. Female pelvis, ***pelvis,*** from in front and above, with pelvic diameters.



206. Female pelvis, ***pelvis,*** median section, right half, from the left, with pelvic diameters.



207. Right thigh bone, *femur*, from in front.

The **femur** (see also Figs. 208–217) *(thigh bone)* is the longest cylindrical bone of the human body and lies in the thigh; it articulates above with the acetabulum of the hip bone, below with the tibia and is so situated that its long axis is oblique in that the two thigh bones converge toward one another at their lower extremities. (For the development see p. 168.)

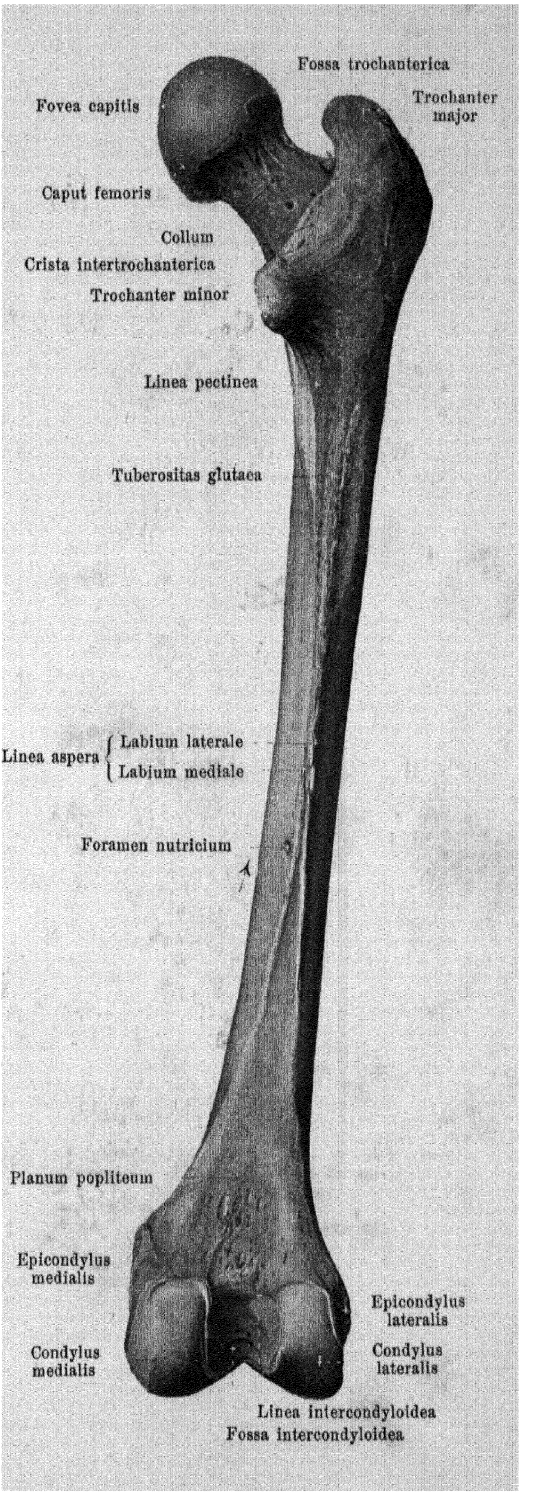
The thigh bone is divisible into a shaft or *corpus*, and two extremities.

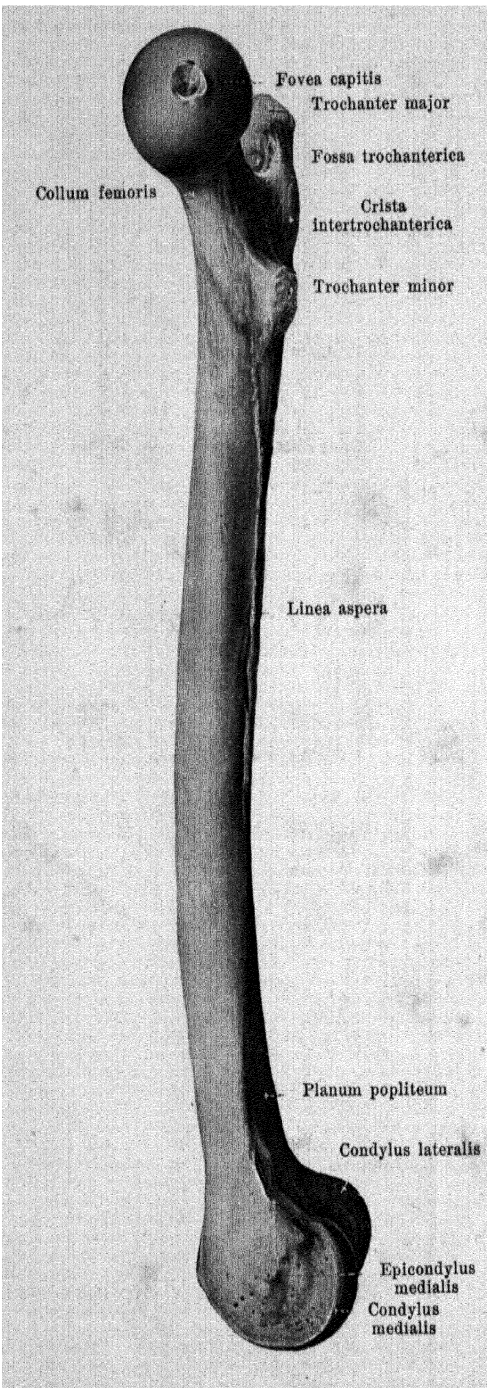
The **corpus femoris** *(shaft)* (see also Figs. 208, 209, 212, 216 and 217) is curved so as to be slightly convex in front and is nearly triangularly prismatic. Its anterior surface is very convexly curved in transverse direction and goes over without sharp limit into the two lateral surfaces which are also directed backward; these latter meet in the middle behind in a rough ridge, *linea aspera*, on which two lips are distinguishable, an external, ***labium laterale***, and an internal, ***labium mediale***. Below and above, these two lips diverge; below they go to the two condyles and leave between them a flat, triangular field, ***planum popliteum*** (O. T. popliteal space). Above, the medial lip extends partly toward the trochanter minor and forms a tolerably distinct ridge, *linea pectinea*, in part it bends below the trochanter minor forward and upward and is continued into the linea intertrochanterica; the lateral lip turns outward and goes over into an oblong rough field, ***tuberositas glutaea***, which sometimes projects like a comb as the so-called *trochanter tertius*.

In the middle of the linea aspera can be seen usually one large or several smaller *foramina nutricia*, which lead into ***canales nutricii***, directed proximalward.

208. Right thigh bone, *femur*, from behind.

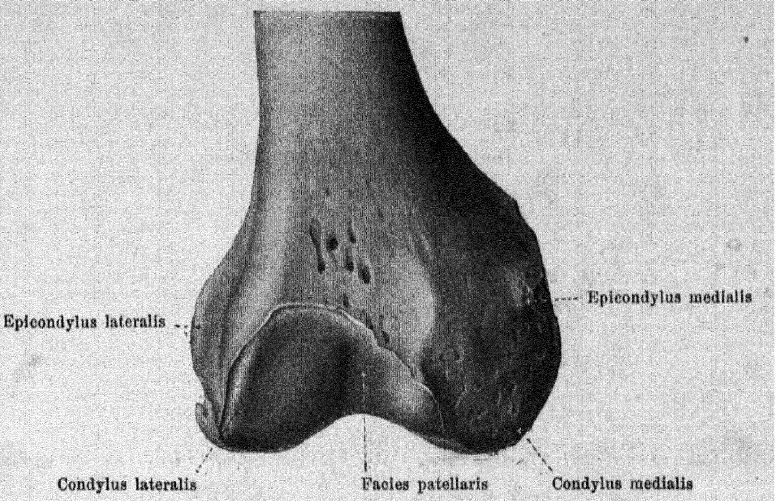
The **upper extremity of the femur** (see also Figs. 207, 209 and 213—217) supports the *caput femoris (head)*, covered with cartilage, which is directed obliquely inward and upward and possesses medianward a small rough depression, the *fovea capitis femoris.* The head includes about three-fourths of the surface of a sphere. It sits upon the *collum femoris (neck)* which looks flattened out from before backward; the long axis of the neck is directed obliquely medianward and upward. At the place where the neck is united with the shaft there are two large projections from the posterior surface, the *trochanter major* and the *trochanter minor.* The trochanter major projects directly backward and upward and possesses on its medial surface, below the blunt tip which is bent medianward, a deep fossa, *fossa trochanterica* (O. T. digital fossa). The trochanter minor is situated lower down and looks also medianward. The *crista intertrochanterica* (O. T. intertrochanteric line), in part very markedly projecting, connects the two trochanters on the posterior surface. The much less prominent *linea intertrochanterica* (O. T. spiral line) runs on the anterior surface of the bone obliquely downward and medianward from the trochanter major, turns backward below the trochanter minor and becomes lost in the labium mediale of the linea aspera.



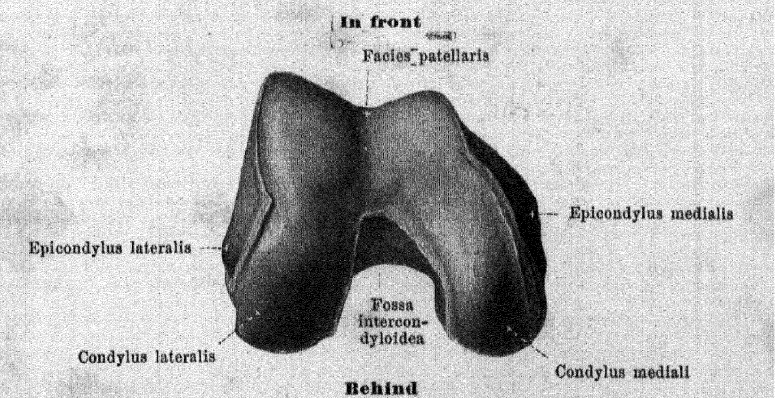


209. Right thigh bone, *femur*, from within.

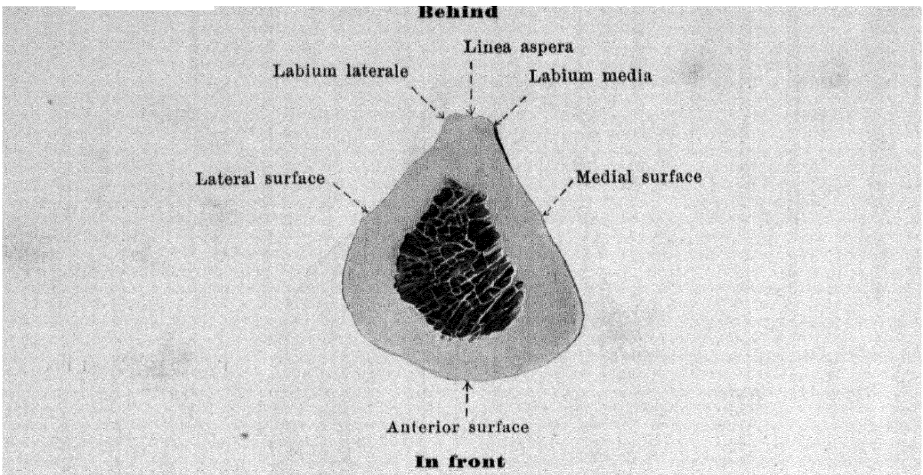
The **inferior extremity of the femur** (see also Figs. 207, 208, 210, 211, 216 and 217) is thickened and runs out into two strong *condyli (condyles),* covered with cartilage, which are especially developed backward, where they are, however, separated from one another by a deep notch, the *fossa intercondyloidea.* The *condylus medialis* (O. T. inner condyle) is larger than the *condylus lateralis* (O. T. outer condyle); both, on account of the oblique position of the thigh bone, are situated in the same horizontal plane in the body; the lateral condyle projects further forward in front than does the medial. Both are covered with cartilage behind, beneath, and in front, run together in front to form a common surface, the uppermost part of which, *facies patellaris,* is hollowed out in the middle like a groove and receives the patella when the knee is extended and slightly flexed. The surface, covered with cartilage, is curved so as to be markedly convex in the sagittal direction. The lateral surfaces of the condyles are rough and each presents a prominent nodule, the *epicondylus medialis* (O. T. inner tuberosity) on the condylus medialis and the *epicondylus lateralis* (O. T. outer tuberosity) on the condylus lateralis. The fossa intercondyloidea is rough and bounded above toward the planum popliteum by the *linea intercondyloidea.*



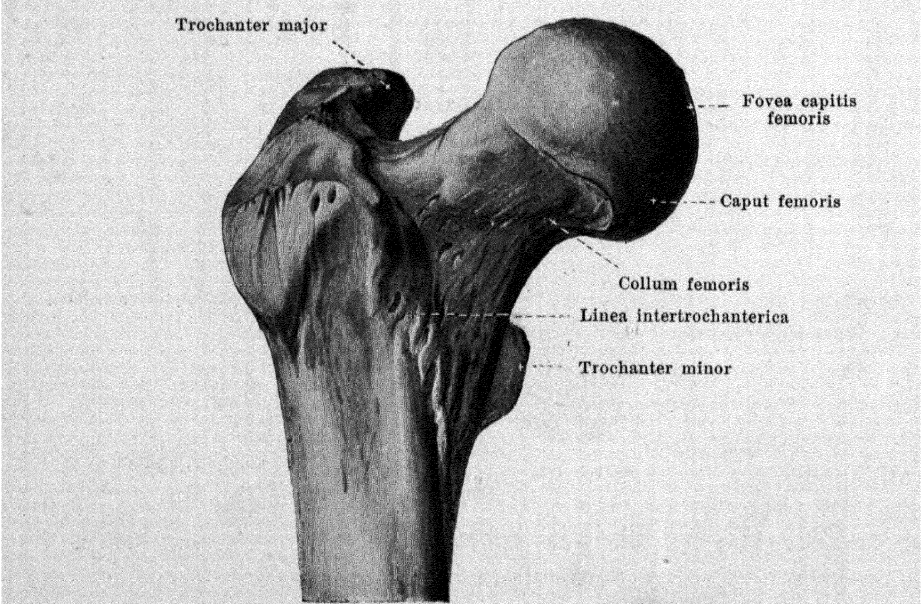
210. Right thigh bone, *femur*, inferior extremity, from in front.



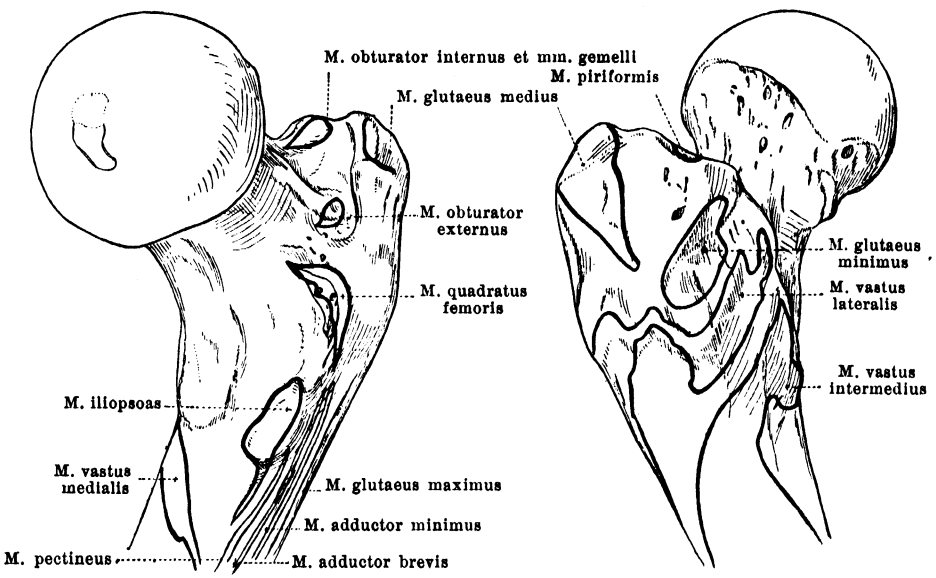
211. Right thigh bone, *femur*, inferior extremity, from below.



212. Transverse section through the middle of the right thigh bone.

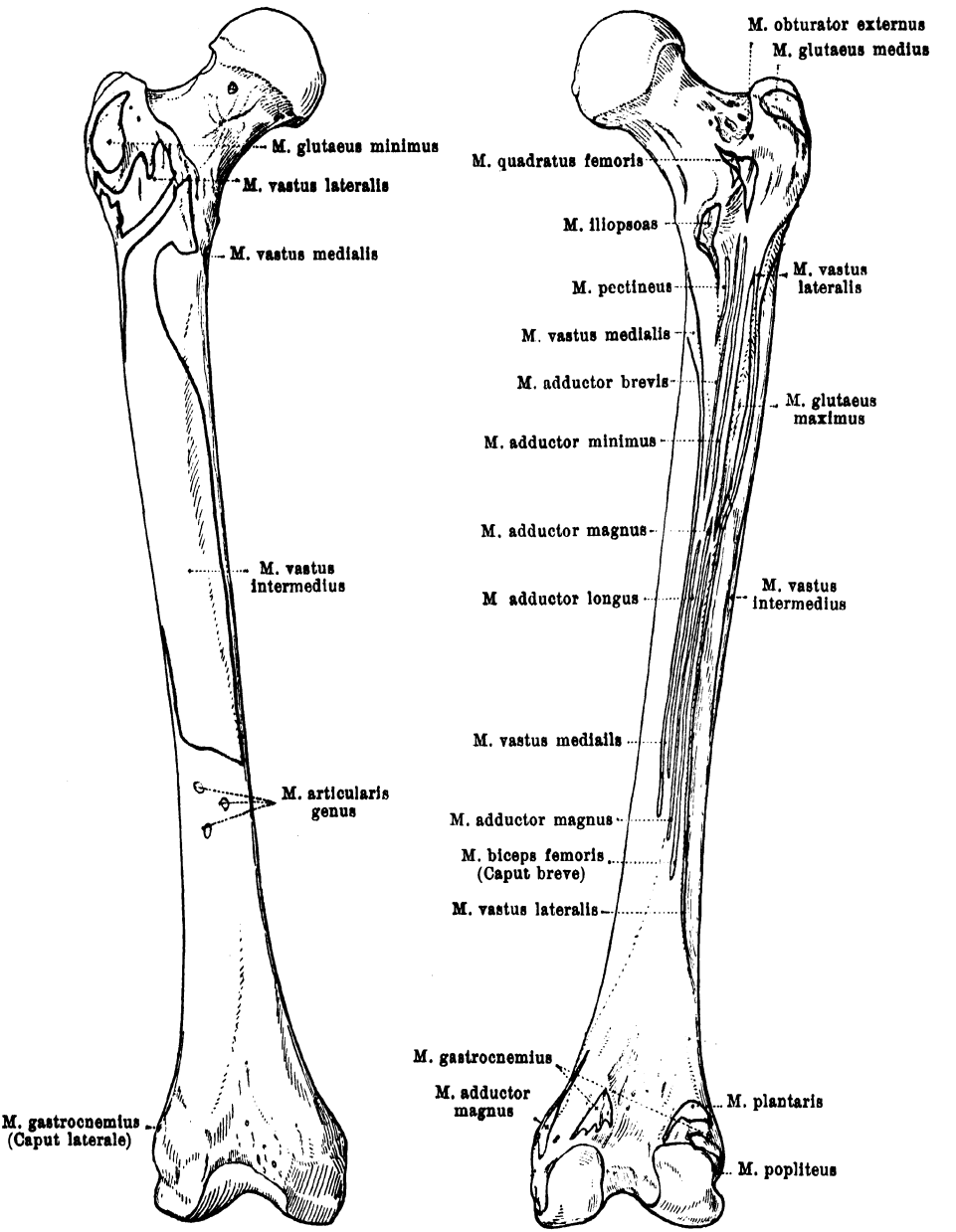


213. Right thigh bone, *femur*, upper extremity, from in front.



214 and 215. Right thigh bone, *femur*, upper extremity, with the muscular attachments.

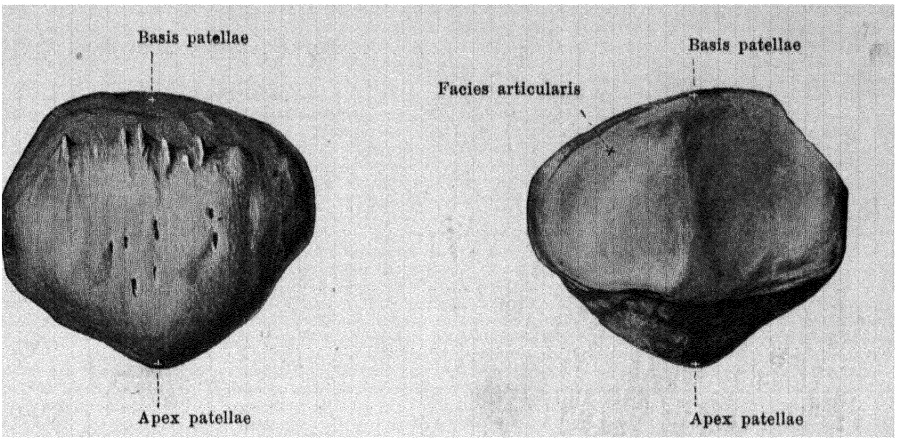
From behind and within. From in front and without.



216 and 217. Right thigh bone, *femur*,

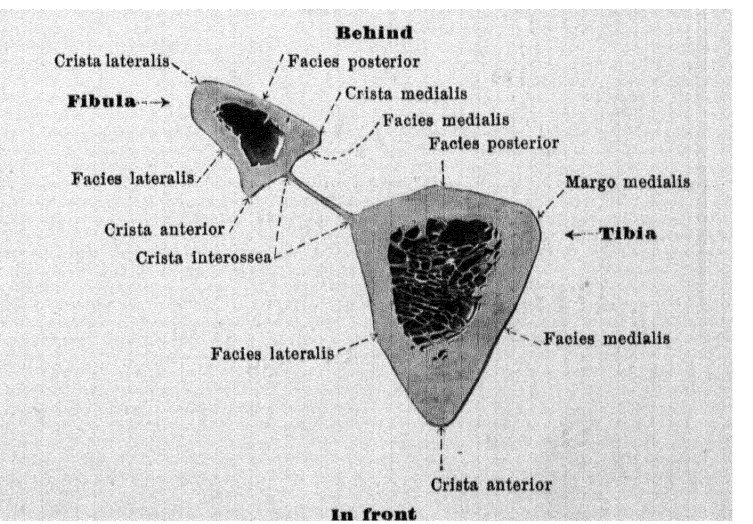
with the muscular attachments.

From in front. From behind.

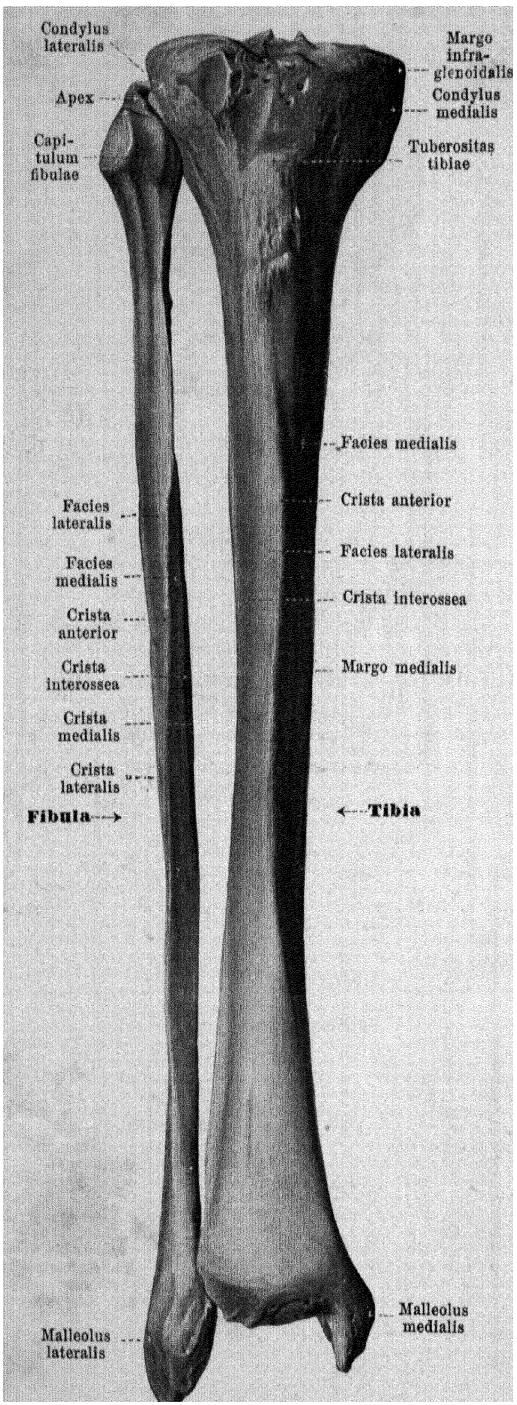


218 and 219. Right patella, *patella.*
From in front. From behind.

The **patella** *(knee-cap)* is a flat, rounded bone, which is intercalated as a large sesamoid bone in the terminal tendon of the m. quadriceps femoris, and is situated in front of the lower extremity of the femur. The upper end is the broader, *basis patellae,* the lower end is somewhat pointed, *apex patellae,* the margins are but little sharpened. The anterior surface is rough. The posterior surface is for the most part covered with cartilage, *facies articularis,* and divided by a longitudinal projection into a somewhat larger lateral and a somewhat smaller medial part; when the knee is extended and the extensor muscles tense it lies with its lower portion on the cartilage covered facies patellaris femoris and its upper portion above the same; and in movements of flexion at the knee joint glides downward and backward and slightly lateralward between the two joint-condyles of the femur in front of the fossa intercondyloidea. (For the development see p. 167.)



220. Transverse section through the middle of the bones of the right leg.



221. Right shin bone and calf bone,

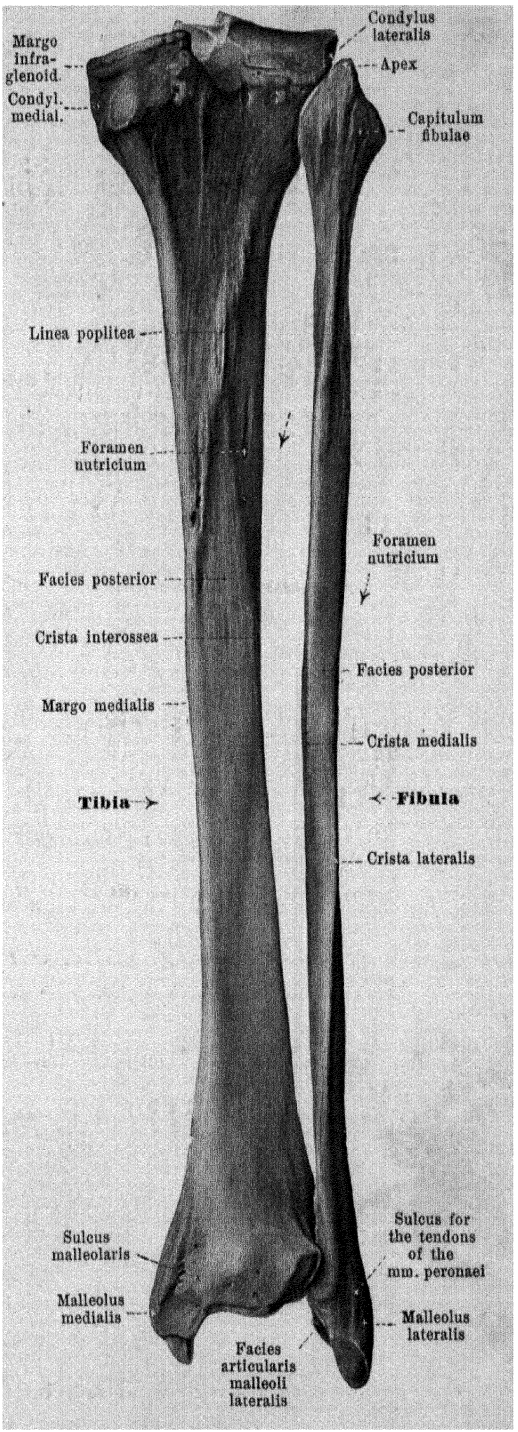
tibia and *fibula,* from in front.

The **tibia** *(shin bone)* (see also Figs. 220, 222—227) is a long, strong cylindrical bone and lies in the medial portion of the leg; it articulates above with the femur, below with the tarsus and also, above and below, with the fibula. It is divisible into a shaft or *corpus* and two extremities. (For the development see p. 167.)

The **corpus tibiae** *(shaft)* (see also Figs. 220, 222, 226 and 227) is triangularly prismatic in its upper two-thirds, quadrilateral below, possesses a posterior, nearly flat surface, *facies posterior,* a smooth, somewhat convex surface looking forward and medianward, *facies medialis,* and a slightly concave surface directed forward and lateralward, *facies lateralis.* Of the three borders where the surfaces meet, the anterior, *crista anterior,* is the sharpest; the laterally directed *crista interossea* is less sharp, while the medial, *margo medialis,* is rounded off. At the uppermost part of the posterior surface a rough ridge, *linea poplitea* (popliteal line), extends obliquely from above and lateralward, downward and medianward. At the junction of the upper and middle thirds there is behind usually a large *foramen nutricium* which leads into a distally directed *canalis nutricius.*

The **upper extremity of the tibia** (see also Figs. 222, 223, 226 and 227) is broadened markedly to form on the two sides the tibial condyles, *condylus medialis* (O. T. internal tuberosity) and *condylus lateralis* (O. T. external tuberosity). Each of these possesses a proximally directed, triangularly oval, somewhat depressed *facies articularis superior,* covered with cartilage; between the two lies a rough surface, broader in front and behind, which is elevated in the middle to form the *eminentia intercondyloidea* (O. T. spinous process) where it ends in two small spurs, the *tuberculum intercondyloideum mediale* and the *tuberculum intercondyloideum laterale.* The area in front of the eminence is called the *fossa intercondyloidea anterior,* that behind it the *fossa intercondyloidea posterior.* The surface covered with cartilage is continued on each side for a certain distance upon the eminence. On the outer circumference of the facies articularis superior the bone falls suddenly as the *margo infraglenoidalis.* Below this, at the upper end of the crista anterior, a rough broad, projecting spur is visible, the *tuberositas tibiae* (O. T. tubercle); at about the same level on the posterior lateral part of the condylus lateralis lies a small, flat, oval articular surface covered with cartilage for the capitulum fibulae, *facies articularis fibularis.*

222. Right shin bone and calf bone, *tibia* and *fibula*, from behind.



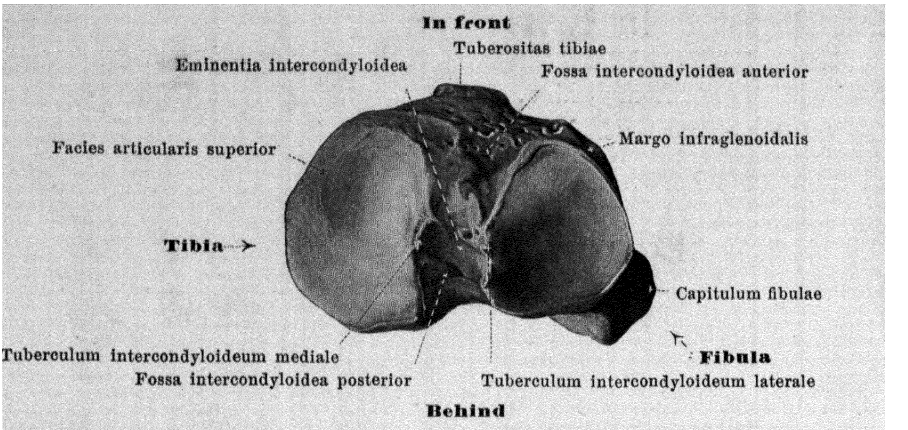
The **inferior extremity of the tibia** (see also Figs. 221 and 225—227) is quadrilateral, but not much broadened; the lateral surface is somewhat concave below, *incisura fibularis*, not covered with cartilage for the attachment of the malleolus lateralis fibulae; medianward a strong blunt process passes downward, *malleolus medialis* (O. T. internal malleolus), which on its medial surface is somewhat rough, on its lateral surface *(facies articularis malleolaris)*, is covered with cartilage; on the posterior surface near the malleolus a shallow furrow extends downward, *sulcus malleolaris* (for the tendon of the m. tibialis posterior). The surface directed distalward, *facies articulais inferior* (for the talus) is slightly concave, quadrangular, and covered with cartilage which runs into that of the malleolus.

The **fibulae** *(calf bone)* (see also Figs. 220, 221, 223—227) is a long, thin cylindrical bone situated in the lateral part of the leg and connected above with the tibia, below with the tibia and the tarsus. It is divisible into a shaft or *corpus*, an upper extremity, *capitulum* and a lower extremity, *malleolus lateralis*. (For the development p. 167.)

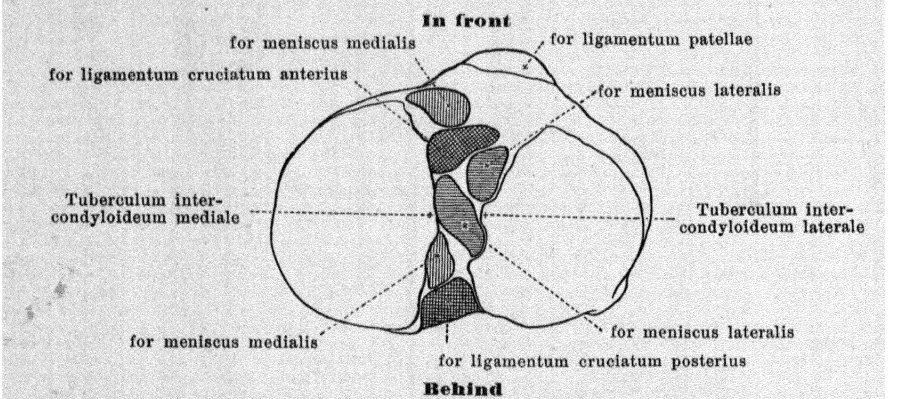
The **corpus fibulae** or *shaft* (see also Figs. 220, 221, 226 and 227) is nearly triangularly prismatic in shape, but appears at the same time twisted on its long axis. We may distinguish a posterior surface, *facies posterior*, an anterior medial, *facies medialis*, and an anterior lateral, *facies lateralis*. They are separated from one another by three borders; the sharpest looks forward, *crista anterior*, the second is directed medianward, *crista medialis* and the third lateralward, *crista lateralis;* further, running down over the medial surface is the *crista interossea*, of markedly variable development. In the middle of the posterior surface a *foramen nutricium* leads into a *canalis nutricius* which runs distalward.

The **capitulum fibulae** *(head)* (see also Figs. 221, 223, 226 and 227) is somewhat thickened, runs out proximally into a blunt tip, *apex capituli fibulae*, and supports on its medial anterior surface a small flat joint surface, *facies articularis capituli*.

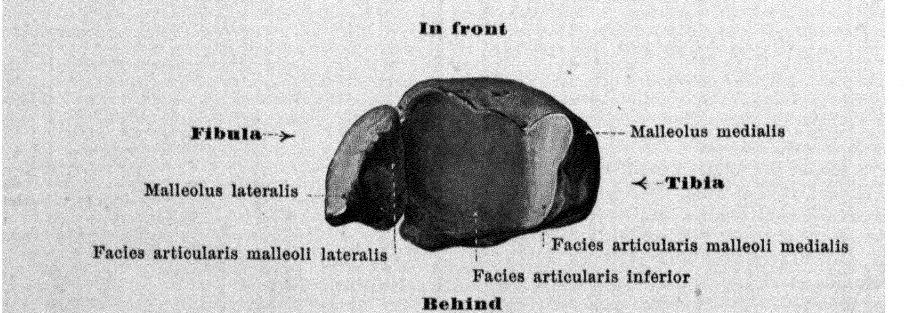
The **malleolus lateralis** (O. T. external malleolus) (see also Figs. 221 and 225—227) is thickened, projects further downward than the malleolus medialis and ends in a blunt tip. On its medial surface it is covered with cartilage, *facies articularis malleoli*, and, above this surface, lies in the incisura fibularis tibiae. The other surfaces are rough; on the posterior surface a shallow furrow for the tendons of the mm. peronaei is visible.



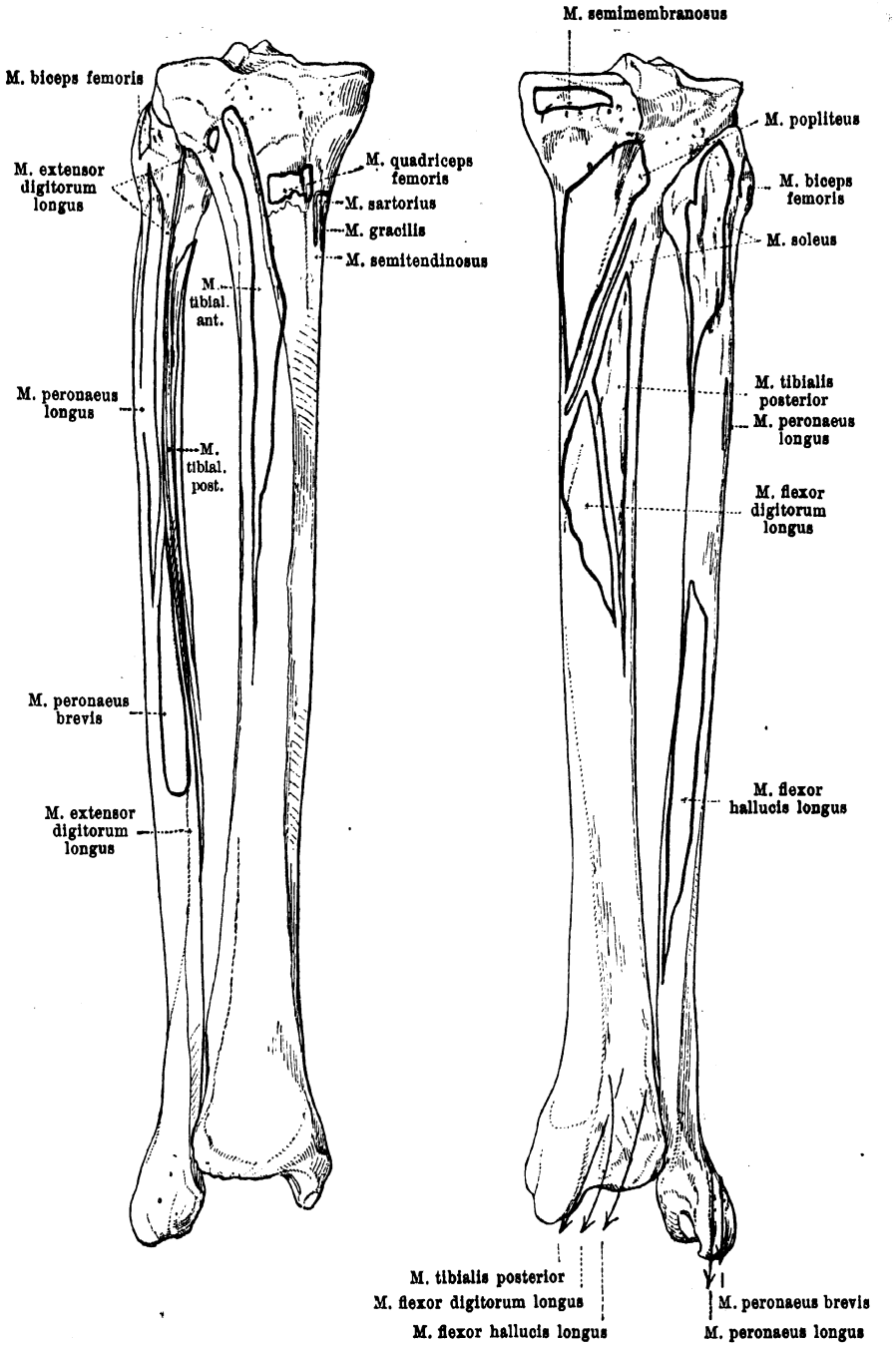
223. Right tibia and fibula, *tibia et fibula*, from above.



224. Right tibia and fibula, *tibia et fibula*, from above, with the places of insertion of the ligaments.

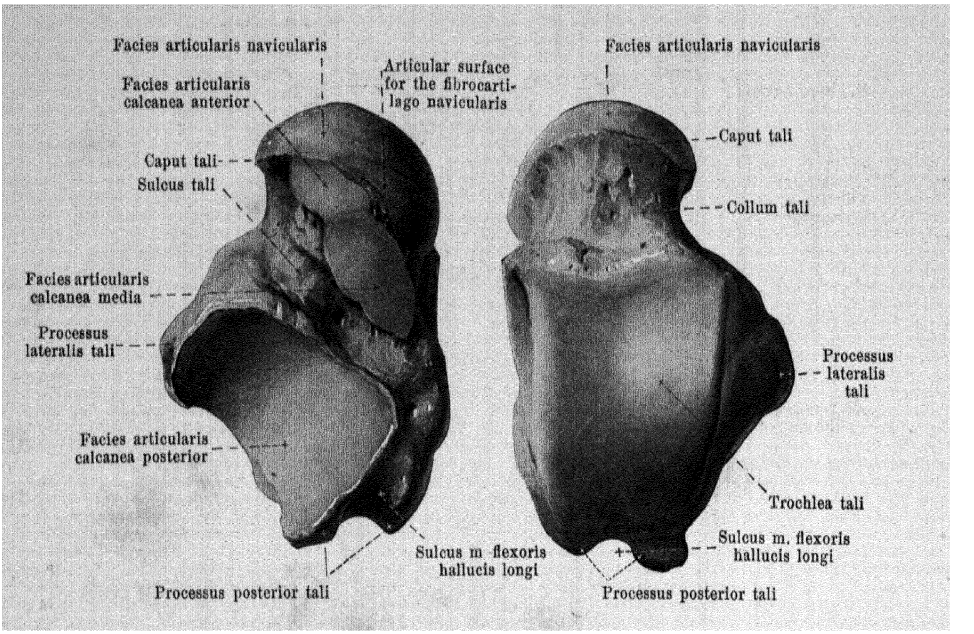


225. Right tibia and fibula, *tibia et fibula*, from below.



226 and 227. Right tibia and fibula, *tibia et fibula,* with the muscular attachments.

From in front. From behind.



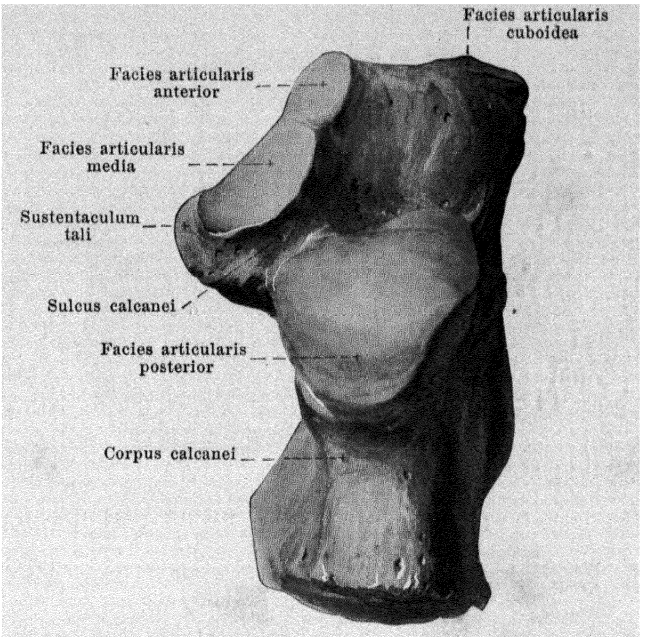
228 and 229. Right ankle bone, *talus* (O. T. astragalus).

From below. From above.

The **tarsus** *(root of the foot)* (see also Figs. 240—245 and 322) is composed of the seven *ossa tarsi: talus calcaneus, os naviculare pedis, ossa cuneiformia primum, secundum, tertium, os cuboideum;* the four last mentioned lie distalward close to one another; the three first mentioned proximalward partly over one another, so that the bones of the leg are not united with several bones of the tarsus, buth only with that situated uppermost, namely, the talus. (For the development see p. 168.)

The **talus** *(ankle bone)* (O. T. astragulus) (see also Figs. 240—245) is divisible into a body, *corpus tali,* and a head, *caput tali,* attached in front; between the two lies a constricted part, the *collum tali.*

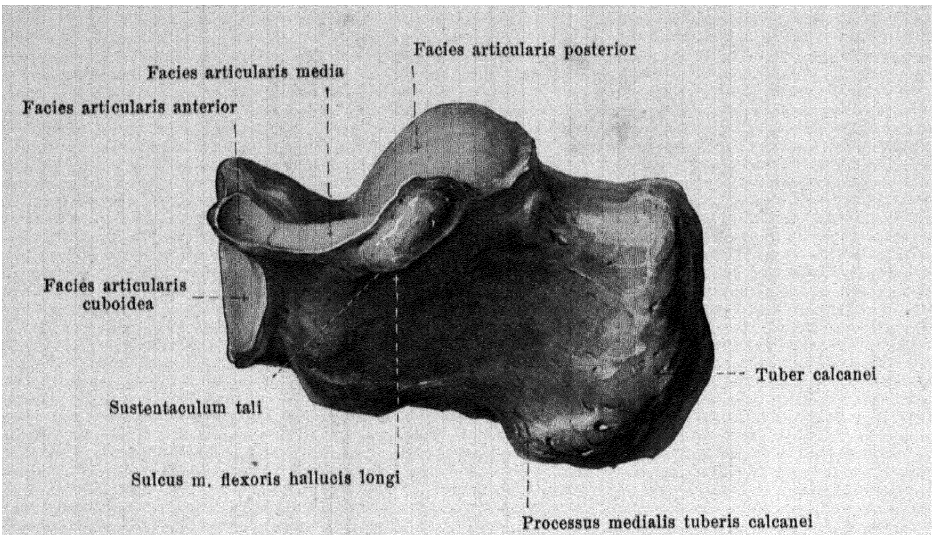
The corpus tali supports on its upper surface the broad *trochlea tali;* this is somewhat broader in front than behind, is covered with cartilage above, *facies superior,* curved so as to be markedly convex from before backward and slightly concave in transverse direction; it possesses a large, triangular, lateral surface, *facies malleolaris lateralis* (see Fig. 240) covered with cartilage, from which a process, *processus lateralis tali,* passes off lateralward and downward; the medial surface of the trochlea has above only a narrow cornua-shaped *facies malleolaris medialis* (see Fig. 241); it is covered with cartilage. The lower surface of the ankle bone possesses three articular surfaces, covered with cartilage, for the calcaneus: a posterior surface which is the largest markedly concave, *facies articularis calcanea posterior,* as well as (separated therefrom by a deep, rough groove, *sulcus tali)* two nearly flat, smaller, *facies articulares calcaneae media et anterior,* which not rarely are grown together, of which the most anterior lies upon the caput tali. On the posterior margin of the body a blunt process, *processus posterior tali,* is visible which is divided by a groove, *sulcus m. flexoris hallucis longi* (for the tendon of the m. flexor hallucis longus), into a smaller, medial and a larger, lateral projection; the latter is sometimes an independent bone *(os trigonum)* and then is connected by connective tissue only with the remaining bone (it is not shown in the figure). The head presents in front an oval, transversely directed, markedly convex articular surface, *facies articularis navicularis* (for the os naviculare); adjacent to this, below and medianward, is another oblong surface for the lig. calcaneonaviculare plantare, or the fibro-cartilago navicularis.



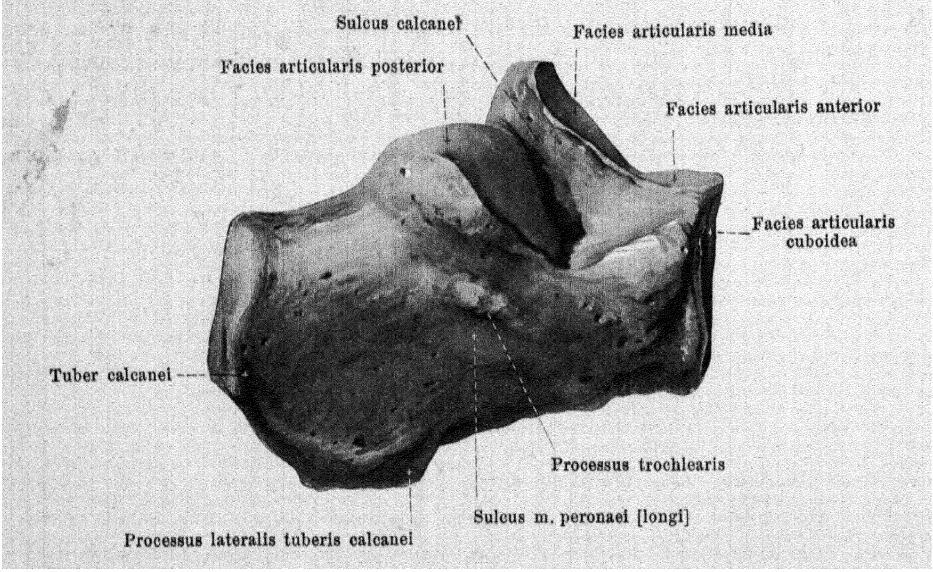
230. Right heel bone, *calcaneus,* from above.

The **calcaneus** *(heel bone,* O. T. os calcis) (see also Figs. **231**, **232**, **240—245**) is the largest tarsal bone, lies below the ankle bone and at the same time projects beyond it behind. It possesses a quadrilaterally prismatic body, *corpus calcanei*, and an anterior extremity.

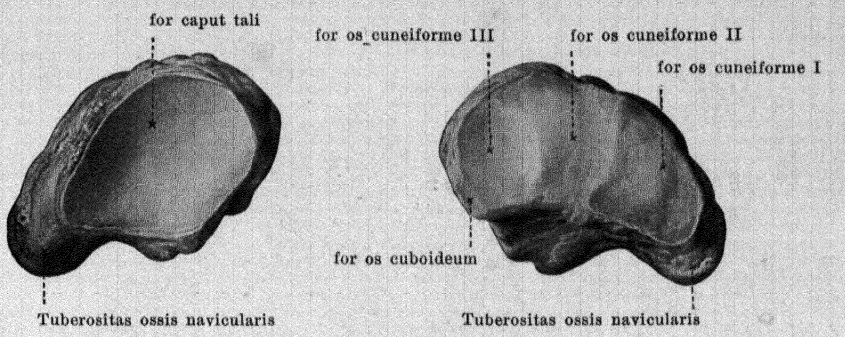
The corpus calcanei becomes thickened behind to form the *tuber calcanei*, from which two rough broad projections pass downward, the *processus medialis tuberis calcanei*, and the *processus lateralis tuberis calcanei* (see Fig. **243**). The posterior surface of the tuber is smooth in its upper part and is there separated by the bursa tendinis calcanei (Achillis), from the tendo calcaneus (Achillis); the rough oven below this smooth surface serves as a place of attachment for the tendo Achillis. The upper surface has three articular surfaces covered with cartilage for the talus; about in its middle an oblong, markedly convex, *facies articularis posterior*, in front and medianward two smaller, almost flat, *facies articulares media et anterior,* which are not sorely grown together, the latter are separated from the posterior by a rough deep groove, *sulcus calcanei;* the middle rests upon a medially projecting piece of bone, *sustentaculum tali,* which presents on its inferior surface a groove, the *sulcus m. flexoris hallucis longi* (for the tendon of the m. flexor hallucis longus). The margin of this projection directed medianward is usually rough, sometimes, however, partly smooth or hollowed out like a groove; on it glides the tendon of the m. flexor digitorum longus on its way to the sole of the foot. On the lateral surface of the heel bone there is often a small projection, *processus trochlearis;* below which runs a groove, the *sulcus m. peronaei [longi]* (for the tendon of the m. peronaeus longus). The anterior surface of the calcaneus is directed also medianward, is quadrilateral with rounded corners, curved so as to be saddle-shaped and covered with cartilage to form the *facies articularis cuboidea* (for the os cuboideum). The sulcus calcanei and sulcus tali form together *sinus tarsi,* a canal which, open lateralward, grows markedly narrower as it extends medianward.



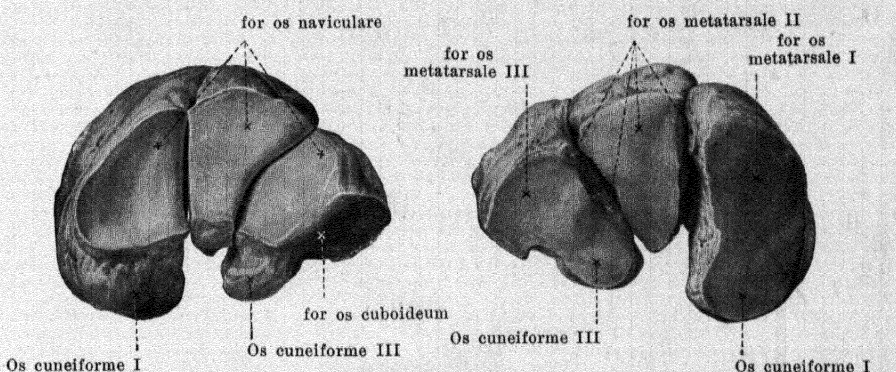
231. Right heel bone, *calcaneus*, from within.



232. Right heel bone, *calcaneus*, from without and somewhat from above.

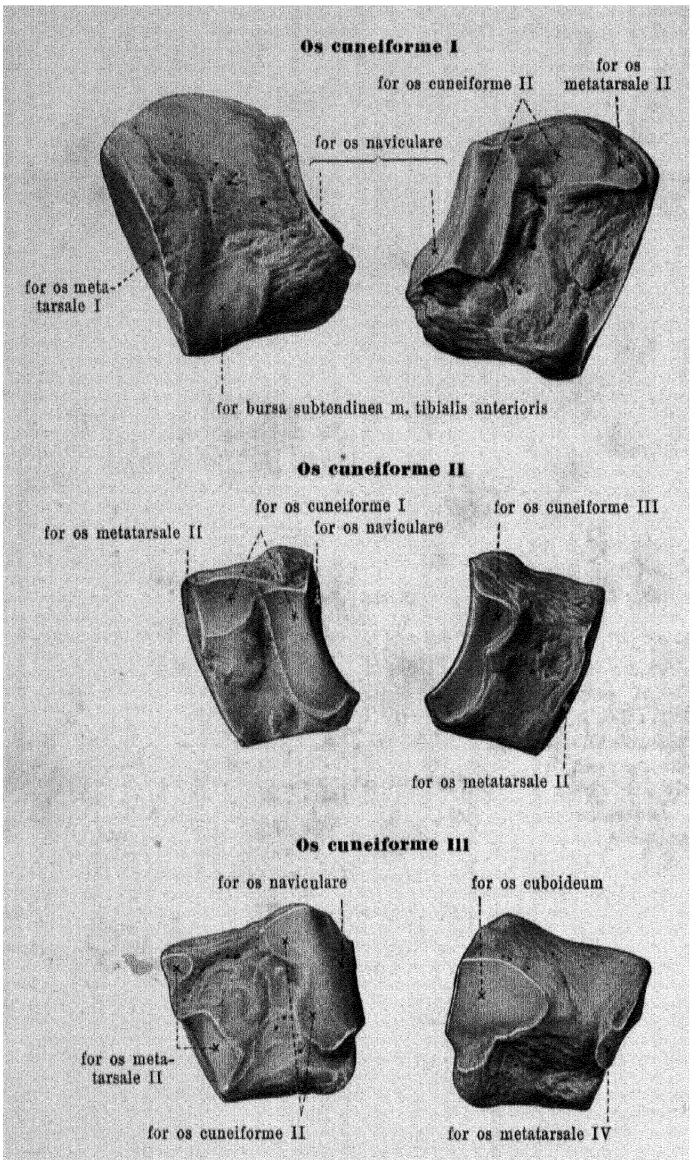


233. Right scaphoid bone, *os naviculare pedis*,
from in front. from behind.



234. The cuneiform bones of the right,
ossa cuneiformia,
from in front. from behind.

The **os naviculare pedis** *(scaphoid bone)* (see also Figs. 240—245 and 322) is oval, flattened from before backward and lies in front of the talus on the medial side of the tarsus. It possesses proximally a markedly concave articular surface covered with cartilage for the caput tali, distalward a convex surface covered with cartilage and divided by two ridges into three parts for the three cuneiforme bones. The lateral surface supports, usually, a small articular surface for the os cuboideum (see Fig. **322**). The upper surface is rough, convex and slopes markedly toward the medial side. Medianward on the lower surface the broad rough *tuberositas ossis* ***navicularis*** projects downward.



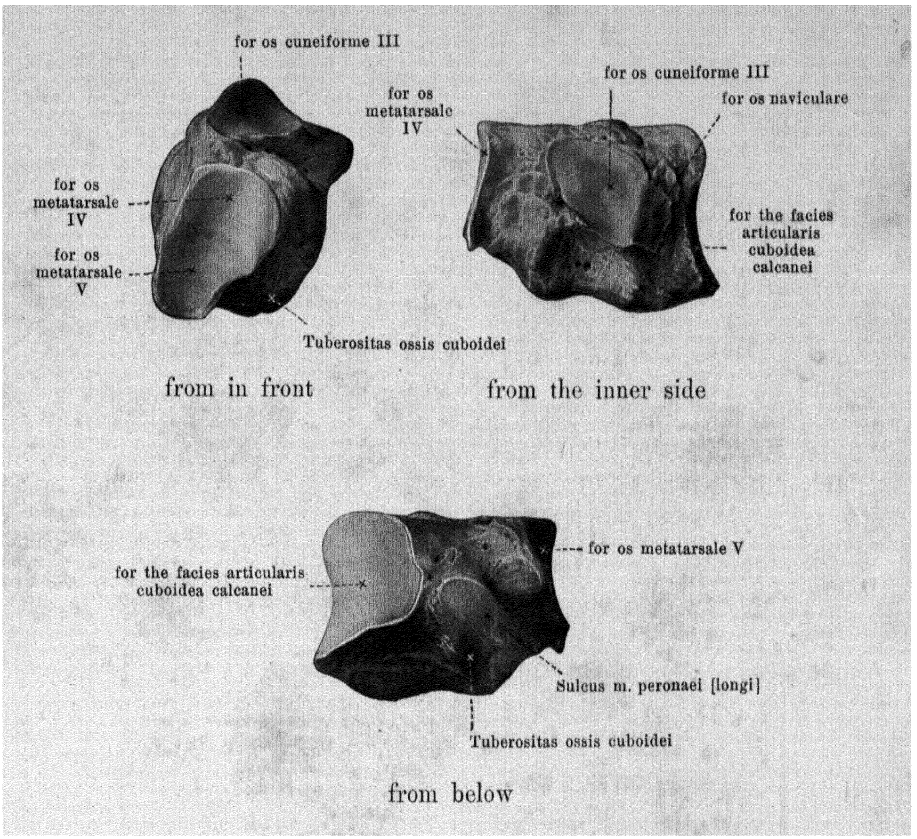
235—237. The cuneiform bones of the right, *ossa cuneiformia*, single, from within. from without.

The **ossa cuneiformia primum, secundum, tertium** *(wedge bones)* (see also Figs. 234, 240—243 and 322) are wedge-shaped; they lie distal from the os naviculare and are numbered beginning at the medial border of the foot.

The **os cuneiforme primum** (O. T. internal cuneiform bone) is the largest with the base of the wedge directed plantarward; it is curved slightly lateralward at is upper extremity. The posterior surface is triangularly rounded, flat and covered with cartilage (for the os naviculare). The medial surface, turned also upward, is rough and possesses in front and below an oblique flat groove in which lies the tendon of the m. tibialis anterior (see Fig. 199) being very often separated from the bone by the bursa subtendinea m. tibialis anterioris. The anterior surface is slightly convex, covered with cartilage, bean-shaped (for the os metatarsale I); the lateral surface has an anterior, small articular surface (for the os metatarsale II) and a posterior (for the os cuneiforme II).

The **os cuneiforme secundum** is the smallest with the base of the wedge directed dorsalward. The posterior triangular slightly concave surface, covered with cartilage, serves for the attachment of the os naviculare, the anterior surface, covered with cartilage, for the os metatarsale II; on the medial side is a divided joint surface for the os cuneiforme I, on the lateral side a plain one for the os cuneiforme III.

The **os cuneiforme tertium** has the base of the wedge looking dorsalward. Its posterior, rounded surface, covered with cartilage, is attached to the os naviculare, the anterior triangular surface covered with cartilage to the os metatarsale III; medianward it possesses a small, anterior articular surface for the os metatarsale II and a larger, posterior for the os cuneiforme II; lateralward it supports a small articular surface for the os cuboideum.



238. Right cuboid bone, *os cuboideum.*

The **os cuboideum** *(cuboid bone)* (see also Figs. 240—245 and 322) is very irregularly cuboid in shape and lies in front of the calcaneus and on the lateral side of the tarsus. Is it longer medianward than lateralward.

Its posterior surface, covered with cartilage, is directed also lateralward, is quadrangularly rounded, curved so as to be saddle-shaped (for the facies articularis cuboidea calcanei); its distal surface supports two rounded quadrangular articular surfaces (for the ossa metatarsalia IV et V) separated by a slight ridge; its medial surface shows a larger articular surface for the os cuneiforme III and usually also a smaller one for the os naviculare (see Fig. 322). The upper and lateral surface is rough. The lower surface presents an oblong bulging, the *tuberositas ossis cuboidei,* above the anterior smooth portion of which, covered lateralward with cartilage *(sulcus m. peronaei [longi])*, the tendon of the m. peronaeus longus glides. In front of the tuberosity is a rough groove extending obliquely medianward and forward.

239. Metatarsal bone and phalanges of the third toe of the right side, *os metatarsale II et phalanges digiti secundi,*

from the plantar aspect.

(The arrows indicate the direction of the canales nutricii.)



The five **ossa metatarsalia** *(metatarsal bones)* (see also Figs. 240—245) are short cylindrical bones in which can be distinguished a shaft or *corpus*, a proximal end, *basis*, and a distal end, *capitulum*. On the whole they are curved so as to be somewhat convex dorsalward. (For the development see p. 169.)

The **corpus** is triangularly prismatic so that one side looks dorsalward, the other two lateral- and medianward; the latter meet in the border directed plantarward. A *foramen nutricium* situated on the plantar side corresponds to the one in the hand (see p. 121).

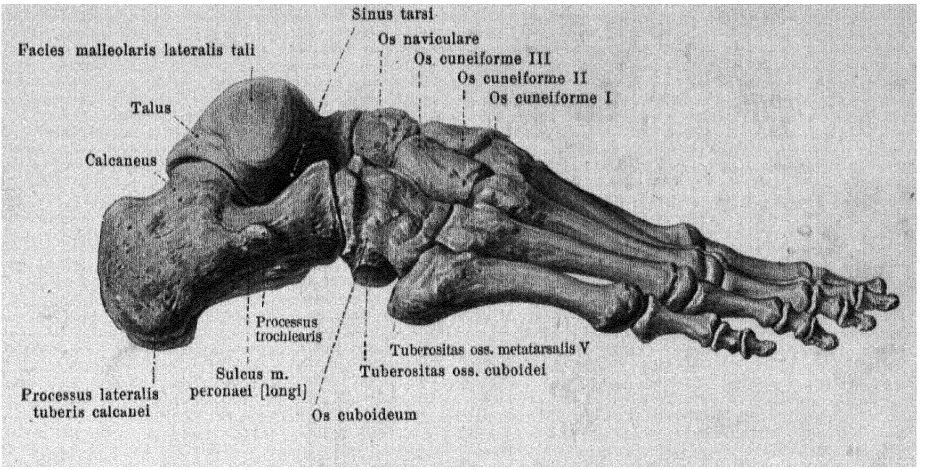
The **basis** is usually somewhat broadened, supports on its proximal side an articular surface for connection with the tarsus and from the second to the fifth toe also small articular surfaces at the sides for the neighboring metatarsal bones. The basis ossis metatarsalis I possesses proximally a large concave, bean-shaped articular surface (for the os cuneiforme I), but no usually articular surfaces on the lateral side; on the plantar surface a blunt nodule, *tuberositas ossis metatarsalis I*, projects lateralward (see Fig. 243). Projecting from the side of the basis ossis metatarsalis V backward is a strong process, the *tuberositas ossis metatarsalis V* (see Figs. 240, 242 and 243).

The **capitulum** is flattened laterally, possesses a spherical articular surface, covered with cartilage, which extends further upon the plantar than upon the dorsal surface. At the sides are rough areas for the articular ligaments.

The four spaces between the ossa metatarsalia, *spatia interossea metatarsi*, (see Fig. 242 and 243) correspond to the spatia interossea metacarpi (see p. 121).

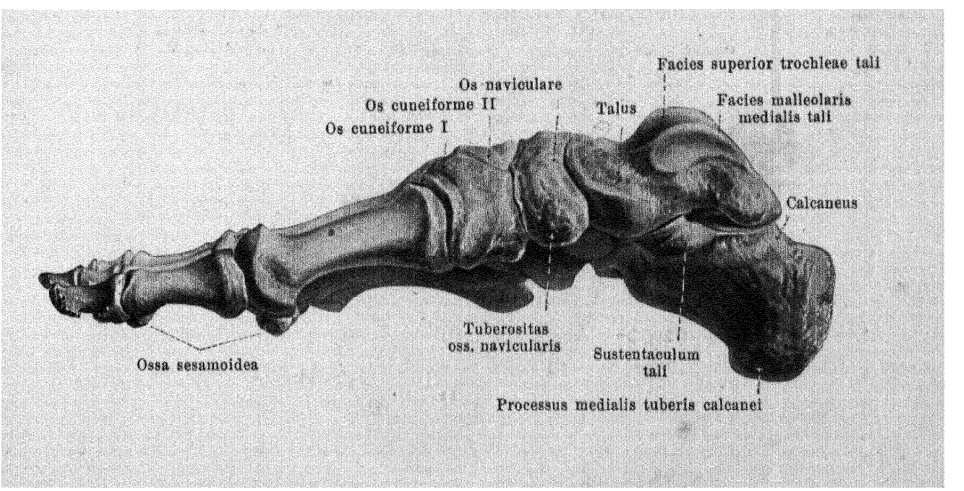
The **phalanges digitorum** correspond in number, arrangement and form as well as in the relations of their foramina nutricia entirely to those of the hand (see p. 121), except that they are all essentially shorter. The 2nd and 3rd phalanx of the 5th toe are often ankylosed. (For the development see p. 169.)

As to **ossa sesamoidea** *(sesamoid bones)* (see Fig. 243), two are constantly found at the metatarsophalangeal joint of the great toe, a third less constant, at the interphalangeal joint of the same toe; a fourth is situated in the tendon of the m. peronaeus longus in front of the lateral angle of the tuberosites ossis cuboidei and a fifth sometimes in the tendon of the m. tibialis posterior below the fibrocartilago navicularis. (For the development see p. 169.)



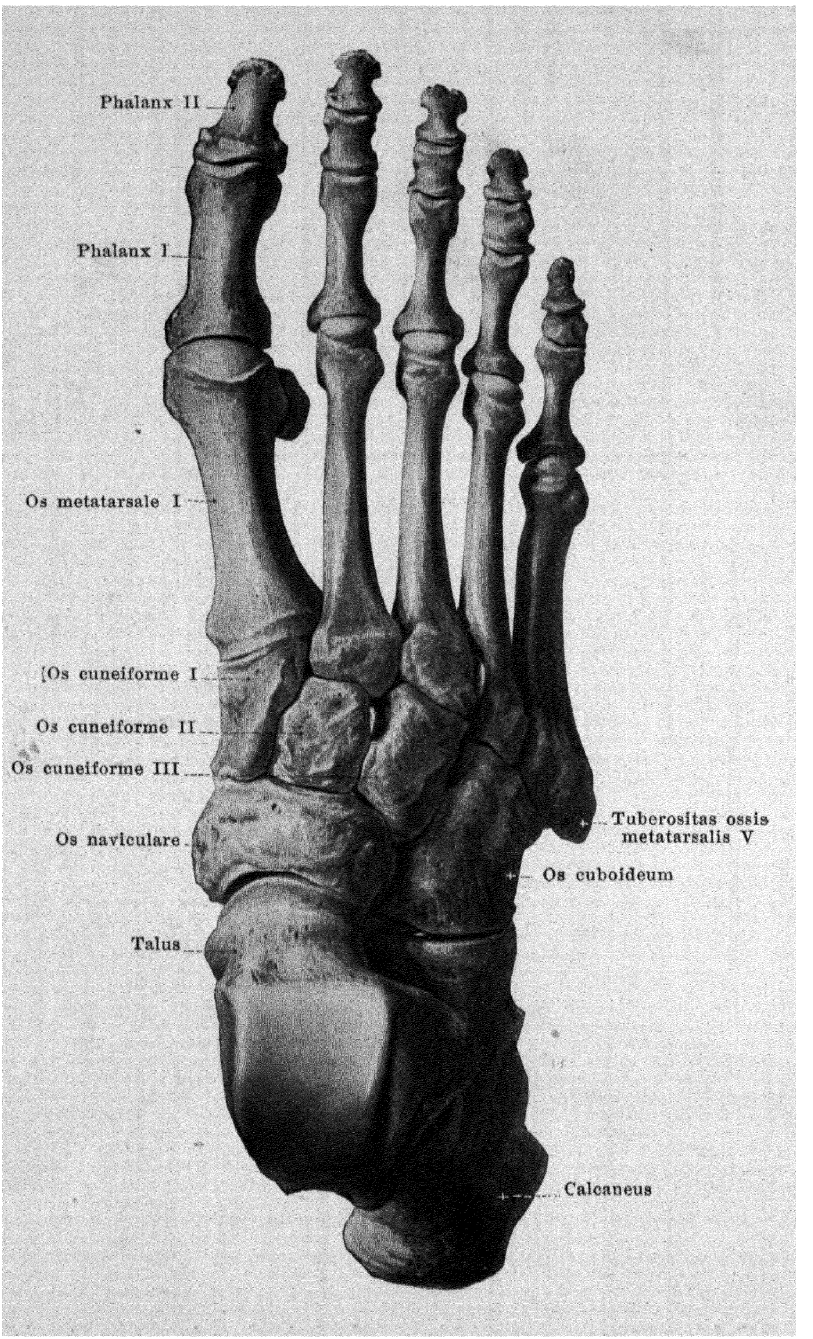
240. Bones of the right foot, *ossa pedis,*

from the lateral aspect.

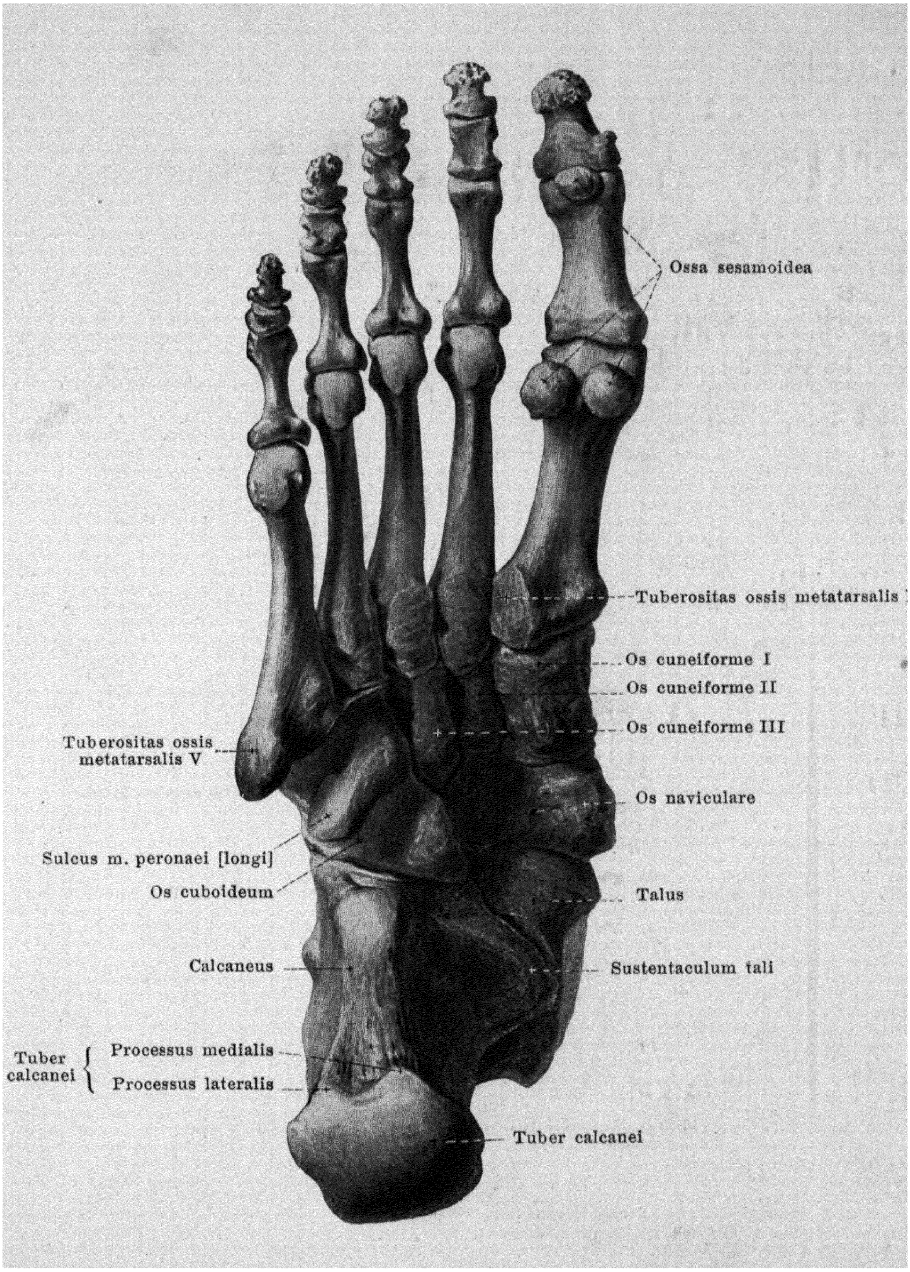


241. Bones of the right foot, *ossa pedis,*

from the medial aspect.

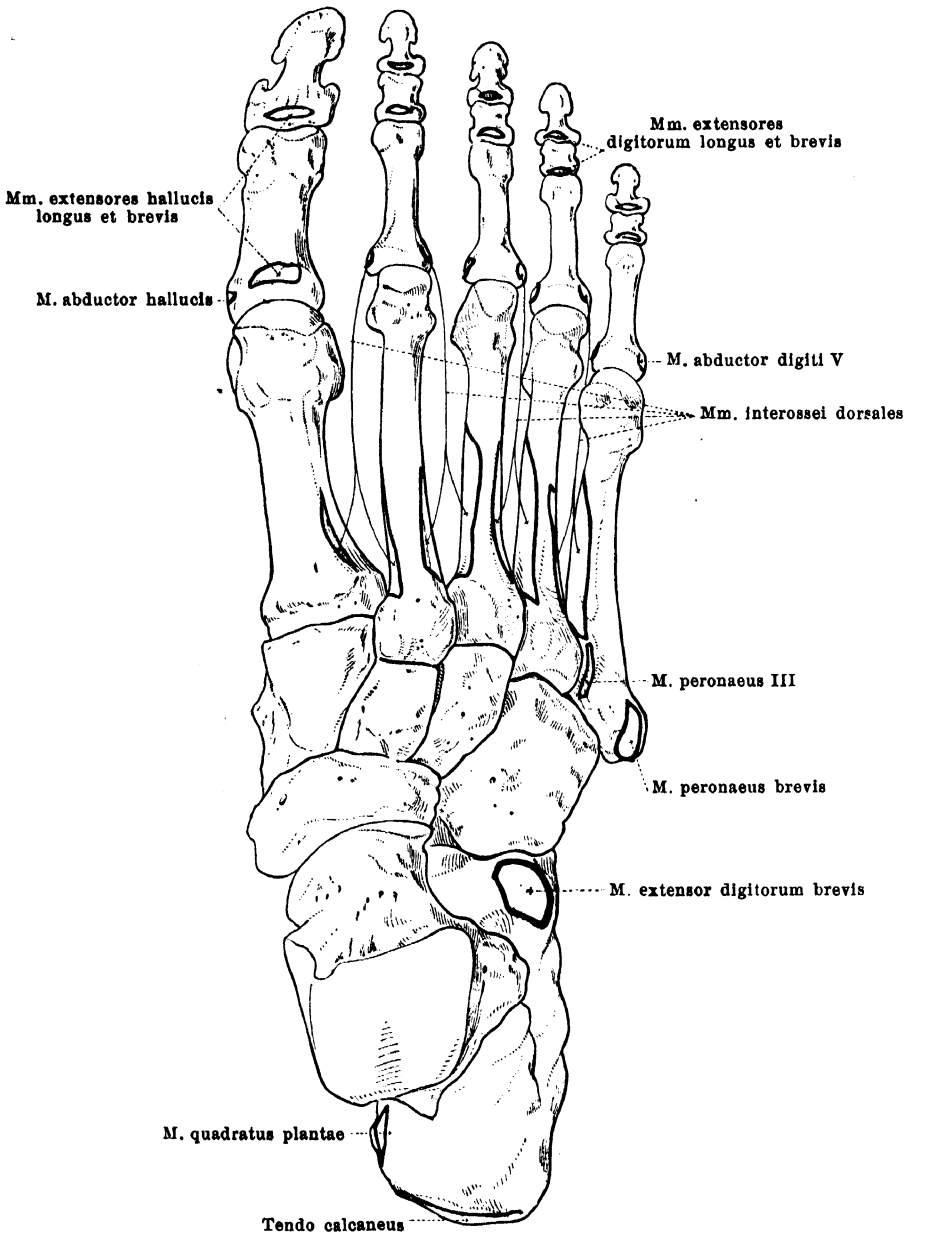


242. Bones of the right foot, *ossa pedis,* viewed from the back of the foot.



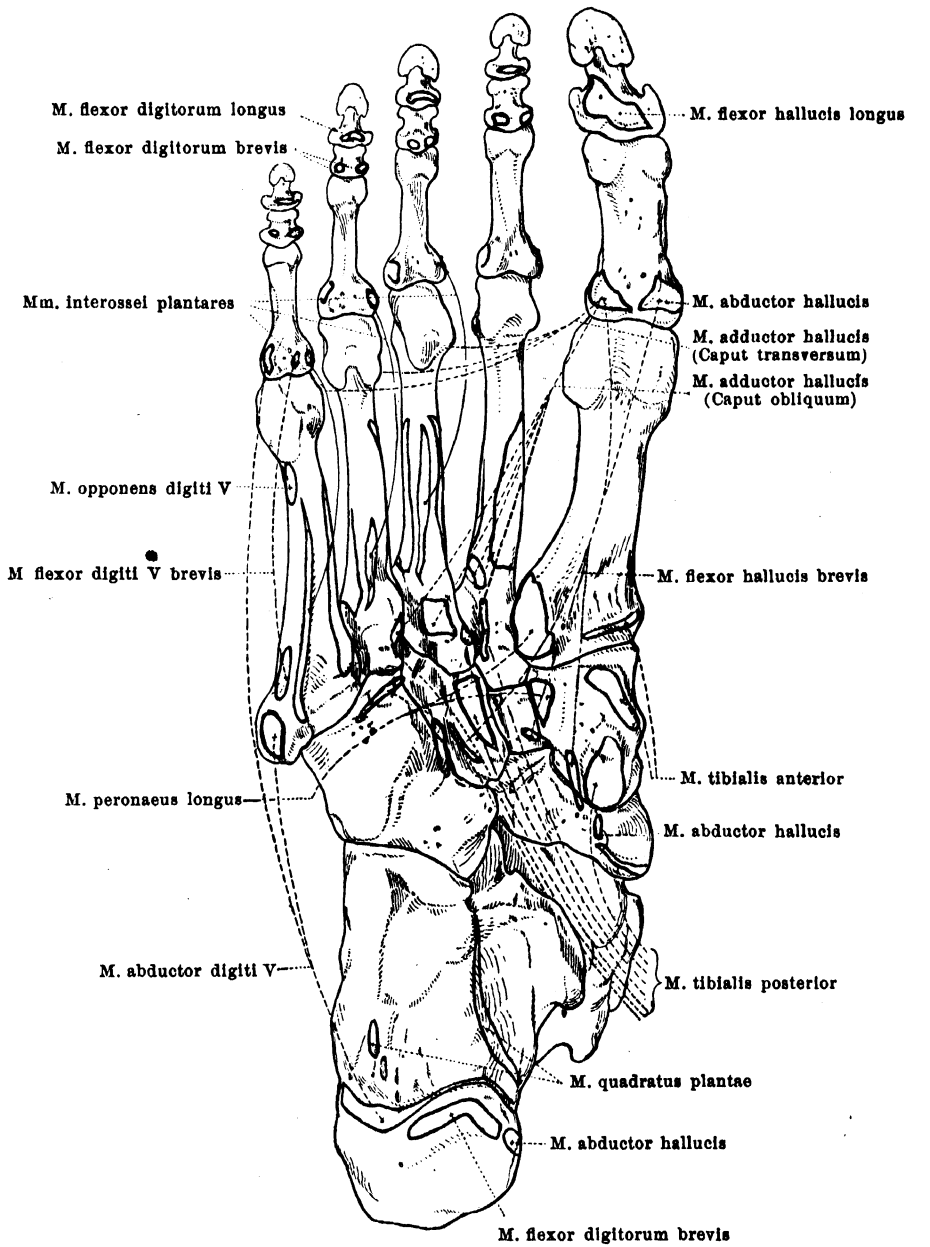
243. Bones of the right foot, *ossa pedis*,

viewed from the sole of the foot.



244. Bones of the right foot, *ossa pedis,*

with the muscular attachments, viewed from the back of the foot.

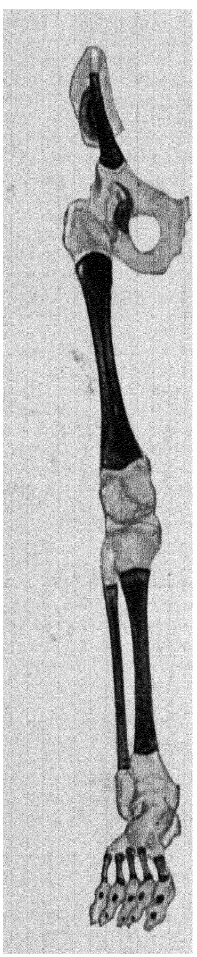


245. Bones of the right foot, *ossa pedis*, with the muscular attachments, viewed from the sole of the foot.

246. Skeleton of the right lower extremity of a 5 month fetus, from in front.

Magnif.: 1 : 1.

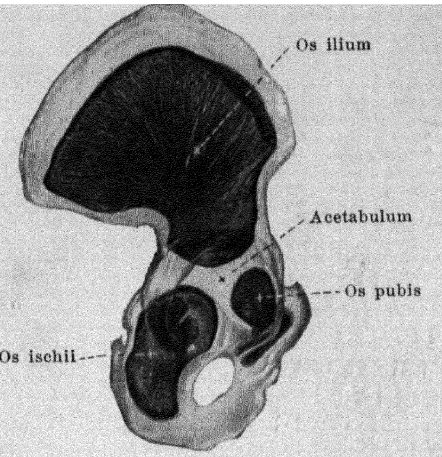
(The bone substance is colored red, the rest of the skeleton is made transparent.)



Development of the bones of the lower extremities.

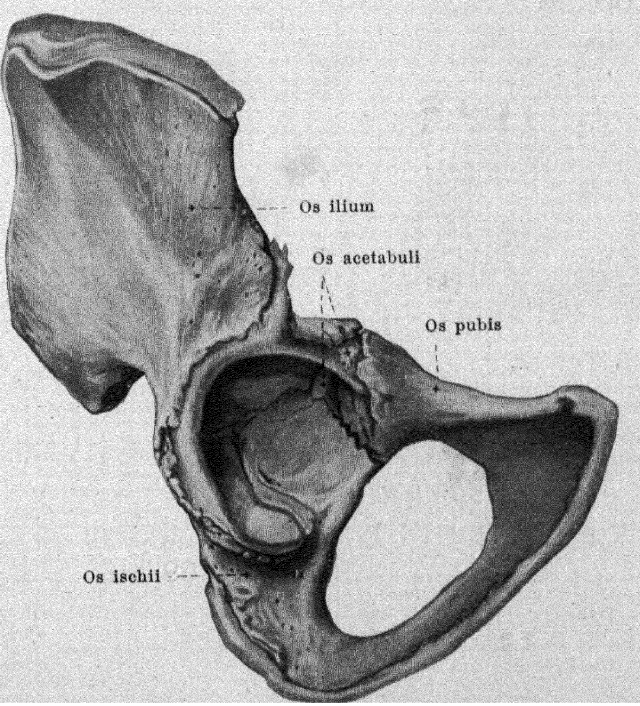
They are all preformed in cartilage.

The ***os coxae*** (see also Figs. 130—132, 247 and 248). It develops from three chief parts: in the os ilium the nucleus appears in the 8th week, in the os ischii, in the 4th month, in the os pubis, in the 4th—5th month. These three nuclei form the acetabulum and are there separated from each other until the time of puberty by a Y-shaped cartilage. In this cartilage there appears in the 9th—12th year, a nucleus between the os ilium and os pubis which forms the os acetabuli of variable size, and furthermore there appear after puberty also some smaller epiphyseal nuclei; the os acetabuli unites about the time of puberty with the os pubis. The rami inferiores of the os pubis and os ischii grow together between the 7th and 8th year; the three main parts unite with each other and with the small nucleus at the bottom of the acetabulum about the 20th year. Soon after puberty epiphyseal nuclei appear: 1st along the crista iliaca. (Union between 20th and 25th year.) 2nd at the tuber ischiadicum (union between 17th and 24th year), 3rd at the spina ischiadica (union between the 18th and 20th year), and 4th at the spina iliaca anterior inferior (union between the 18th and 20th year). In the 18th—20th year there appears at the facies symphyseos oss. pubis an epiphysis with one or two nuclei (union after the 20th year).

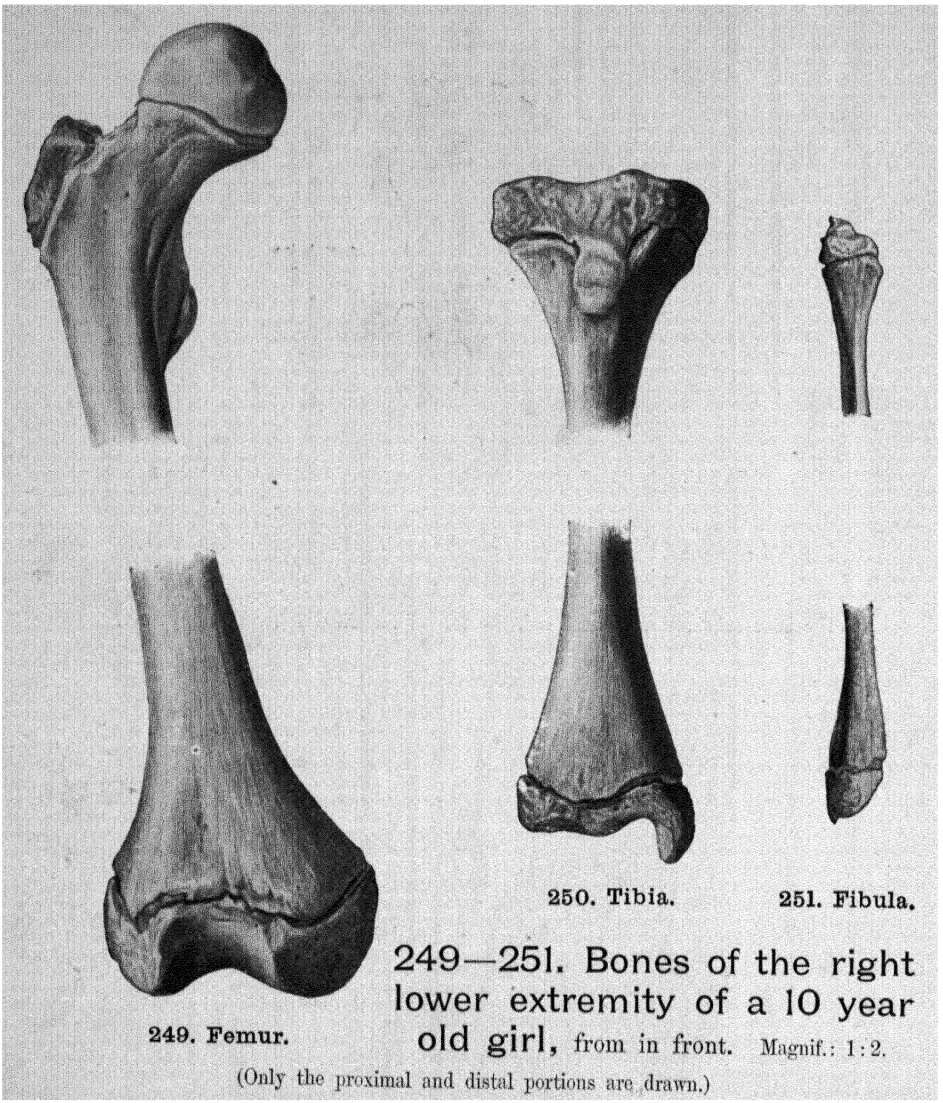


247. Right ilium of an 8 month fetus, viewed from outside. Magnif.: 1:1.

(The bone substance is colored red, the rest of the ilium is made transparent.)



248. Right ilium of a 10 year old girl, from the front and below. Magnif.: 1:2.



250. Tibia. 251. Fibula.

249. Femur.

249—251. Bones of the right lower extremity of a 10 year old girl, from in front. Magnif.: 1:2.

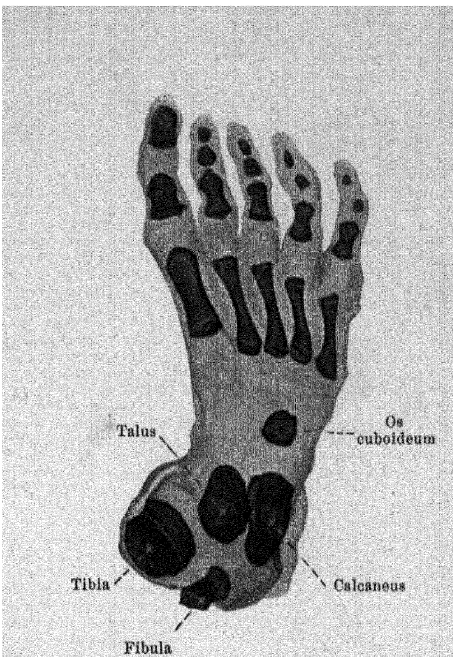
(Only the proximal and distal portions are drawn.)

Femur (see also Fig. 246). The nucleus of the diaphysis appears on the 42nd day. The distal epiphysis receives its nucleus for the most part shortly before birth and unites with the shaft in the 20th—24th year. At the proximal end there appear three epiphyseal nuclei: one for the caput in the 1st year (union in the 18th—19th year), another for the trochanter major in the 3rd—4th year (union in the 18th year), and still another for the trochanter junior in the 11th—14th year. (Union in the 17th year.)

The ***Patella,*** acquires its centre of ossification in the 3rd—5th year.

Tibia (see also Fig. 246). The nucleus for its diaphysis appears on the 44th day. Its proximal epiphysis receives its nucleus at the time of birth; it grows on the anterior side of the body distalwards and forms the tuberositas tibiae (sometimes the latter receives a special nucleus between the 11th and 13th year, which quickly fuses with the epiphysis); the epiphysis unites with the corpus in the 19th—24th year. At the distal epiphysis a nucleus appears in the 2nd year; it fuses with the diaphysis in the 16th—19th year.

Fibula (see also Fig. 246). The nuclei of its diaphysis appear on the 55th day. The distal epiphysis receives its nucleus or centre of ossification in the 2nd year. (Union in the 20th—22nd year.) In the proximal epiphysis a nucleus appears in the 3rd—5th year (union in the 2nd—24th year).



252. Bones of the right foot of a new-born, dorsal view. Magnif.: 1:1.

(The bone substance is colored red, the rest of the skeleton is made transparent.)



253. Bones of the right foot of a 10 year old girl, plantar view. Magnif.: 1:2.

The ***Tarsus*** (see also Fig. 246).

The *Calcaneus.* The main centre or nucleus appears in the 6th fetal month, and an epiphyseal nucleus for its posterior end appears in the 7th—10th year, which unites with the main mass in the 13th—20th year.

Talus: One nucleus in the 6th fetal month.

Os cuboideum: One nucleus shortly before birth.

Os cuneiforme III: One nucleus in the 1st year.

Os cuneiforme I: One nucleus in the 2nd—4th year.

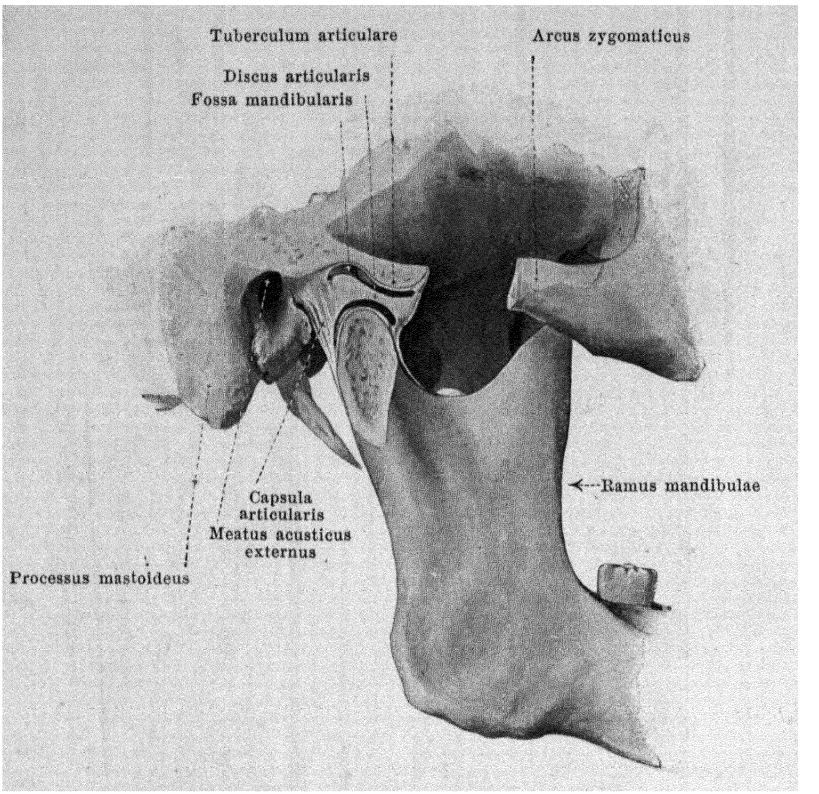
Os cuneiforme II: One nucleus in the 3rd—4th year.

Os naviculare: One nucleus in the 4th—5th year.

Ossa metatarsalia (see also Fig. 246). The nuclei of their diaphyses appear in the 8th—10th week. The epiphyses (at the proximal end in os metatarsale I and at the distal end in ossa metatarsalia II—V) receive their nuclei in the 3rd—8th year and unite with the diaphyses between the 14th and 21st year.

Phalanges (see also Fig. 246). In the 1st row the nuclei for the diaphyses appear in the 3rd fetal month, and those for the proximal epiphyses in the 3rd year; in the 2nd row the nuclei for the diaphyses appear in the 4th—10th fetal month and those for the proximal epiphyses in the 3rd year; in the 3rd row the nuclei for the diaphyses appear on the 58th day, and those for the proximal epiphyses in the 4th year. Union of the epiphyses with the diaphyses occurs between the 14th and 21st year.

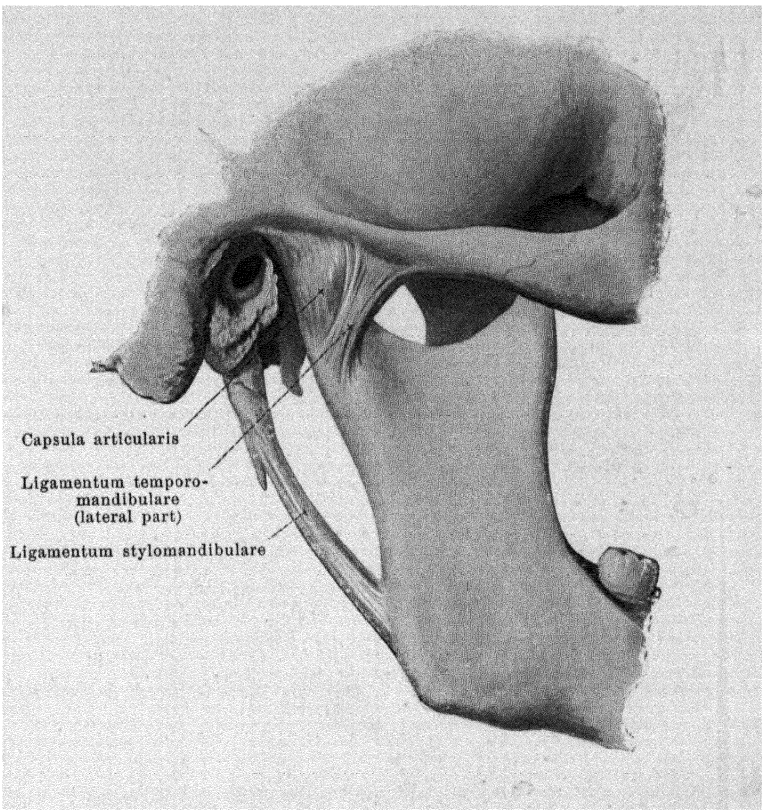
The ***ossa sesamoidea*** of the big toe ossify in the 12th—14th year.



254. Jaw joint of right side, *articulatio mandibularis*, from without.

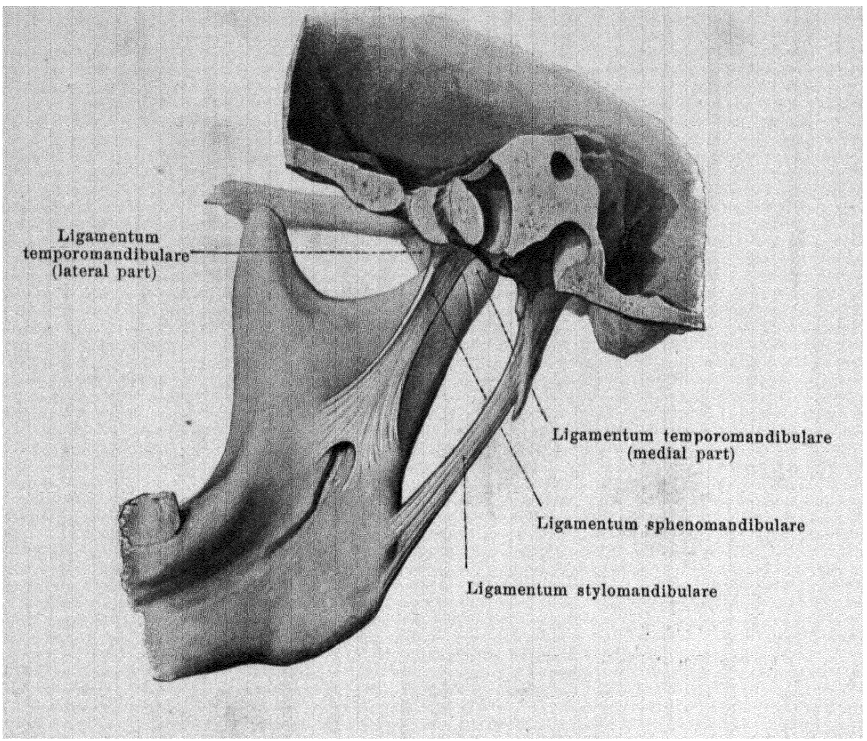
(The arcus zygomaticus and the processus condyloideus mandibulae have been partially removed; the parts have been somewhat separated from one another.)

By means of the **articulatio mandibularis** *(joint of the jaw)* (O. T. temporo-maxillary articulation) (see also Figs. 255—257) the lower jaw is movably connected with the rest of the skull. The capitulum of the processus condyloideus mandibulae on each side rests on the posterior slope of the tuberculum articulare in the fossa mandibularis ossis temporalis. The facies articularis extends into the fossa mandibularis not quite as far as the fissura petrotympanica where it is for the most part covered by connective tissue and only in its most anterior portion covered with cartilage; in front it goes over upon the tuberculum articulare which is covered with cartilage and does not end until its anterior slope is reached. The cartilaginous covering consists of fibrocartilage. Between the processus condyloideus on the one side and the fossa mandibularis and tuberculum articulare on the other is inserted a connective tissue disc, ***discus articularis*** (O. T. interarticular fibrocartilage), which is thinner in the middle, thicker in front and behind and about of the shape of a biconcave transversely placed plate. The ***capsula articularis*** (O. T. capsular ligament) is loose and is stretched from the circumference of the facies articularis of the fossa mandibularis and of the tuberculum articulare to the upper margin of the discus articularis, as well as from the lower border of the latter to the collum (neck) of the processus condyloideus mandibulae covered with fibro-cartilage; it extends further down in the back than in front. In this way two joint cavities, completely separated from one another, are formed, an upper and a lower, which are separated from one another by the articular disc; very rarely they communicate by a cleft in the articular disc.



255. Jaw joint of right side, *articulatio mandibularis*, from without.

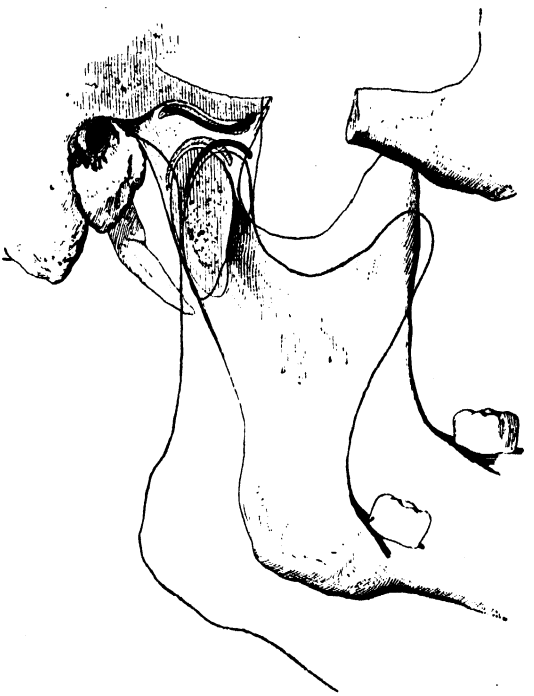
Passing obliquely from in front and above backward and downward, as a strengthening ligament of the capsula articularis, is the *ligamentum temporomandibulare*. It arises on the lateral surface (O. T. external lateral ligament) by a broad base at the root of the processus zygomaticus ossis temporalis and is fastened to the lateral and posterior side of the collum (neck) of the processus condyloideus mandibulae; medianward a weaker fibrous band proceeds from the region of the fissura petrotympanica to the collum processus condyloidei mandibulae (see Fig. 256).



256. Jaw joint of right side, *articulatio mandibularis,* from within.

On the medial side of the jaw joint the *ligamentum sphenomandibulare* proceeds from above and behind, downward and forward. It arises from the spina angularis ossis sphenoidalis and from the fissura petrotympanica ossis temporalis and ends with a broad insertion at the lingula mandibulae the inner surface of the ramus of the lower jaw, and close to the lingula mandibulae, where it bridges over the beginning of the sulcus mylohyoideus. It comes from a part of the embryonal Meckel's cartilage and is separated from the medial fibrous band of the ligamentum temporomandibulare and from the processus condyloideus mandibulae by a space through which runs the a. maxillaris interna with the veins accompanying it (see page 467) and the n. auriculotemporalis.

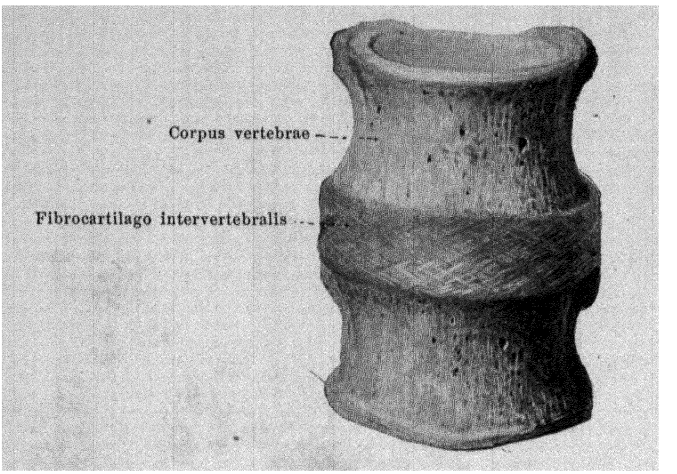
The *ligamentum stylomandibulare* (O. T. stylo-maxillary ligament) arises in common with the ligamentum stylohyoideum (see page 42) from the processus styloideus, runs obliquely forward and downward and is fastened by broad attachment to the inner side of the angulus mandibulae. It is only a band of the fascia buccopharyngea (see page 265) and has nothing to do with the joint of the jaw.



257. Jaw joint of right side, *articulatio mandibularis,* from without; somewhat schematic.

(The position of the lower jaw when the mouth is shut is indicated in black; when the mouth is wide open in red.)

When the mouth is closed the capitulum of the processus condyloideus is in contact with the posterior slope of the tuberculum articulare and the anterior portion of the fossa mandibularis; when the mouth is wide open it stands somewhat in front of the deepest point of the tuberculum articulare; in both cases, however, the capitulum is separated from the points of the temporal bone mentioned by the discus articularis. (See also Fig. 254.)



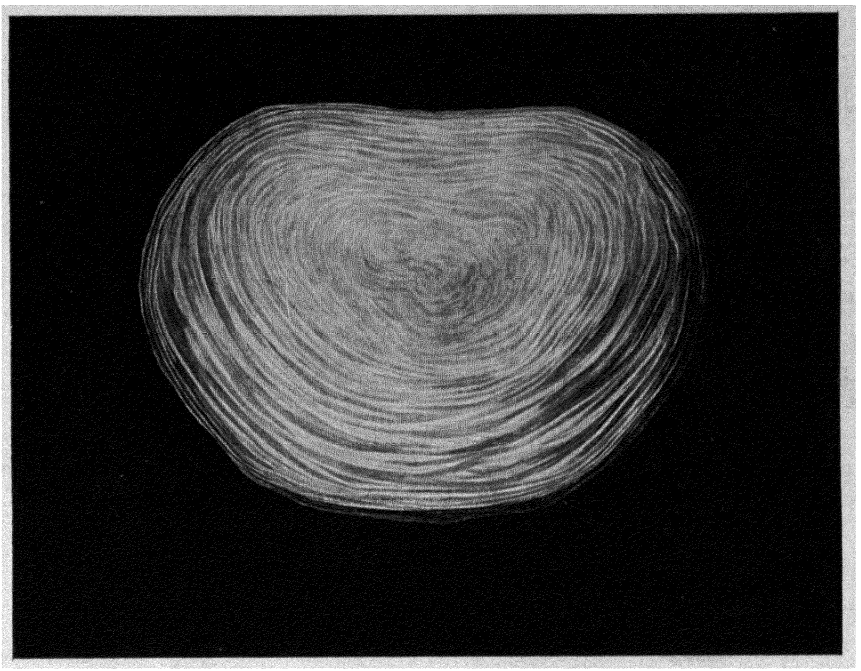
258. Intervertebral disc, *fibrocartilago intervertebralis*, with the adjacent vertebral bodies, from in front.

The **ligamenta columnae vertebralis** *(spinal ligaments)* consist of the *fibrocartilagines intervertebrales* between every two vertebral bodies, of the *capsulae articulares*, which unite the processus articulares inferiores of each vertebra with the processus articulares superiores of the next vertebra below, and of ligaments which are stretched out between the arches and between the processes of the same name of every two adjacent vertebrae, namely: *ligamenta flava, ligamenta intertransversaria, ligamenta interspinalia*; besides the latter there are still a number of ligaments present which extend over the whole spinal collum or at least over the greater part of the same: *ligamentum supraspinale, ligamentum longitudinale anterius* and *ligamentum longitudinale posterius*.

The **fibrocartilagines intervertebrales** *(intervertebral discs)* (see also Figs. 259—260) are flat fibrocartilaginous discs which lie between the adjacent surfaces of every two successive vertebrae; to these surfaces they are very firmly attached by a thin layer of hyaline cartilage. They have the shape of the adjacent vertebral body but are somewhat larger so that at the edges they project somewhat over this.

In the cervical and lumbar part of the vertebral column (see Fig. 260) they are somewhat higher in front than behind, in the dorsal vertebral a little lower in front. The total number of intervertebral discs present down to the sacrum is 23; the uppermost is situated between the second and third cervical vertebrae, the lowermost between the fifth lumbar vertebra and the sacrum (see also page 180); smaller discs also unite the sacrum and coccyx as well as the upper three vertebrae.

On the five lower cervical vertebrae there is usually, on each side, between the bent up lateral part of the upper surface of each vertebral body and the adjoining portion of the intervertebral discs, a small joint cavity with a capsula articularis (see Fig. 233).

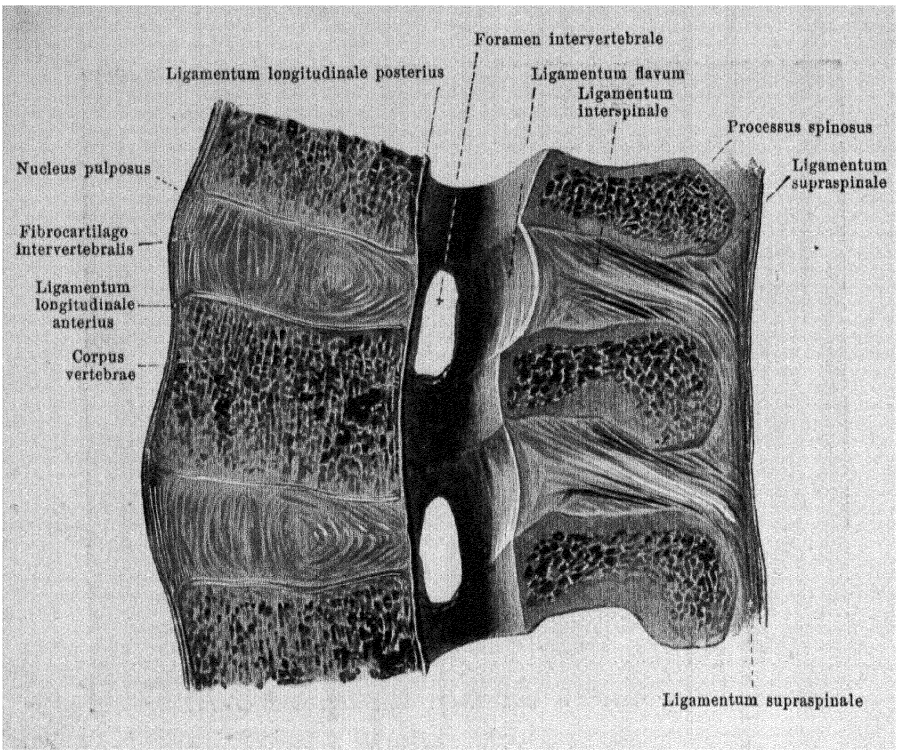


259. Intervertebral disc, *fibrocartilago intervertebralis,* cut through horizontally. Magnification: 3 : 2.

Each **fibrocartilago intervertebralis** consists of a firmer external portion, *annulus fibrosus,* and a softer centre, *nucleus pulposus.*

The **annulus fibrosus** (see also Figs. 258 and 260) is composed of concentric layers of connective tissue fibres which are arranged like the leaves of an onion; inside each layer the fibre bundles cross one another in network-like fashion (see Fig. 208); in the depth the connective tissue layers are less sharply separated from one another and alternate with layers of very soft fibrocartilage. The connective tissue layers (see Fig. 260) are anteriorly slightly convex, posteriorly on the other hand, they are kinked markedly backwards; in the middle of the discs the direction of curvature may change.

The **nucleus pulposus** (see also Fig. 260) consists essentially of a very soft mass of fibrocartilage with irregular connective tissue bands and contains the degenerated remains of the embryonic chorda dorsalis; it is separated but not sharply from its surroundings and lies excentrically nearer the posterior circumference of the intervertebral disc (see Fig. 210). In the uninjured spinal column its constituents are under high pressure so that on cutting through the dics they project markedly.



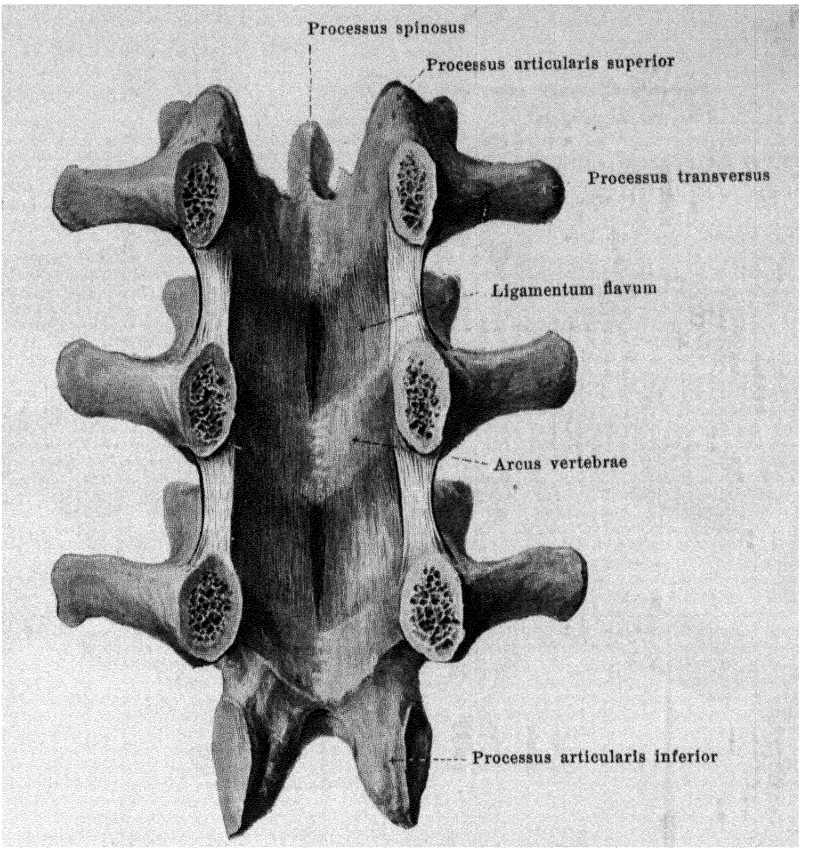
260. Median section of a piece of the lumbar spinal column, right half of section, viewed from the left.

The **capsulae articulares** (see Fig. 271) are stretched out between the borders of each adjacent pair of processus articulares. They are looser on the cervical than on the thoracic and lumbar vertebrae.

The **ligamenta interspinalia** (see Fig. 265) are flat bands of tissue which extend between the borders of each adjacent pair of processus spinosi. They are most strongly developed on the lumbar vertebrae, feeblest on the cervical vertebrae. In general the fibres are directed from above downward and backward. In the cervical vertebrae they are connected with the ligamentum nuchae, in the other vertebrae, with the ligamentum supraspinale.

The **ligamenta intertransversaria** (see Figs. 274 and 275) are rounded, thinner bands which run between the borders of every adjacent pair of processus transversi. They are strongest in the lumbar and thoracic spine, feebler, sometimes doubled on the cervical vertebrae; they may be entirely absent from the latter. The fibres are directed from above downward.

The **ligamentum supraspinale** (see Fig. 268) is a powerful, narrow ligament. It extends downward behind the tips of the spinous processes, becomes narrower between the same and fuses there with the ligamenta interspinalia. At the tips of the processus spinosi it is separated from the bone by a thin layer of fibrocartilage. The ligamentum supraspinale begins at the processus spinosus of the seventh cervical vertebra is a continuation of the ligamentum nuchae, and ends below at the crista sacralis media.

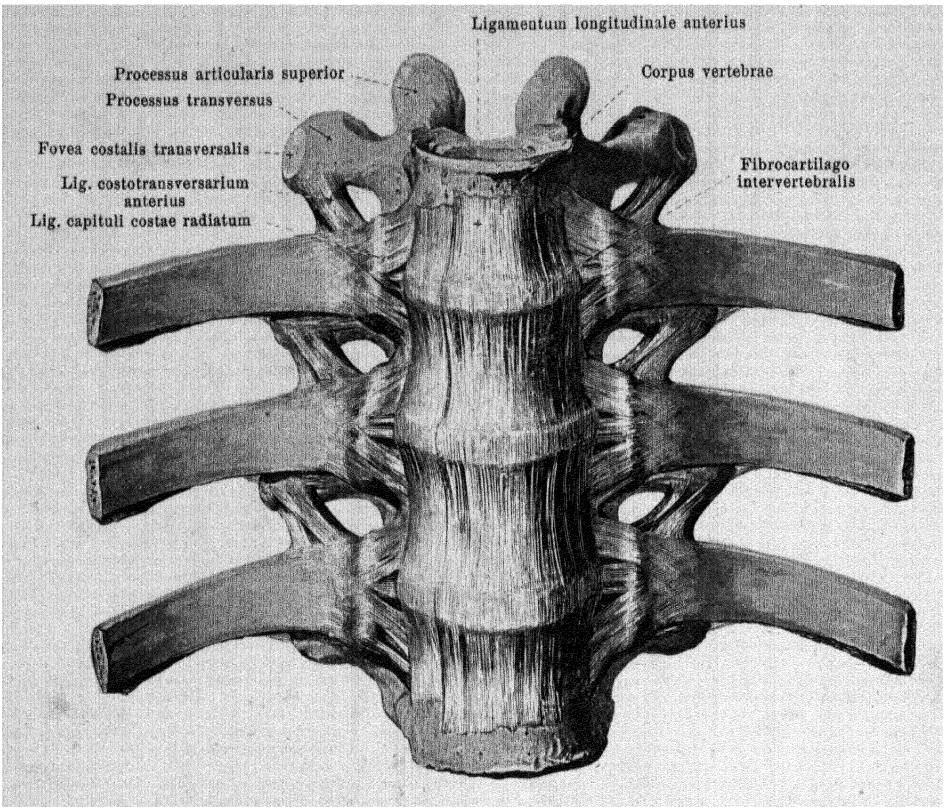


261. Vertebral arches with ligamenta flava,

from in front.

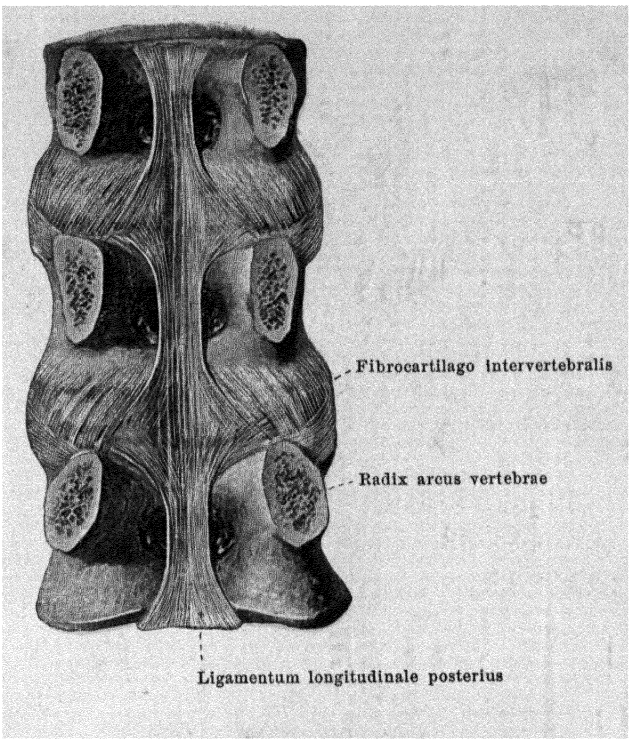
(The vertebral arches have been sawed off at their roots and the vertebral bodies removed.)

The **ligamenta flava** (see also Fig. 260) are broad flat bands stretched out between the arches of every two adjacent vertebrae and always proceed from the front surface of the higher arch to the upper edge of the lower. They are especially strong and long on the lumbar and become feebler towards the cervical vertebrae. Their fibres run in a vertical direction; in the median plane they are divided into two halves by a narrow groove. They consist almost exclusively of elastic fibres and are accordingly of a yellow color; hence the name. The band is not present in this form between the occipital bone and the atlas, nor between atlas and axis; at the former place is the membrana atlantooccipitalis posterior (see page 182), at the latter a thin membrane of connective tissue, which is strengthened only by isolated yellow stripes of elastic fibres (see Fig. 267).



262. Spinal column with ligaments, from in front.

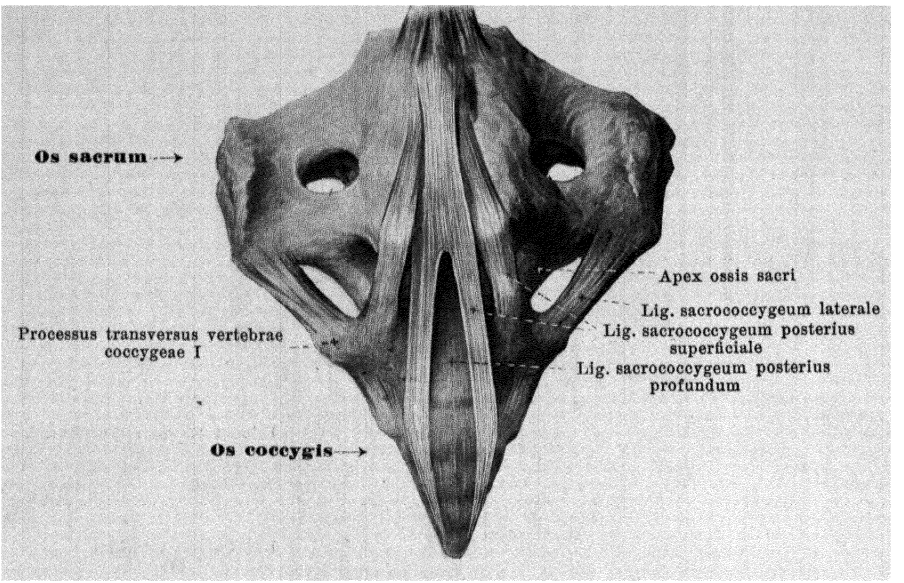
The **ligamentum longitudinale anterius** descends on the anterior and lateral surfaces of the bodies of the vertebrae. It begins as a narrow tough band at the tuberculum pharyngeum ossis occipitalis (see Figs. 266 and 272), is fastened to the tuberculum anterius atlantis, then goes to the anterior surface of the epistropheus and thence to all of the bodies of the vertebrae as far as the upper part of the facies pelvina ossis sacri, where it becomes lost in the periosteum. From the epistropheus on, it becomes ever broader as it passes downward, is intimately connected with the vertebral bodies and with the fibrocartilagines intervertebrales and is divisible more or less distinctly into three stripes, a broader one in the middle and a narrower one on each side. The lateral stripes partially overlap the ligamenta capituli costae radiata. On the lumbar spine there arise from the ligamentum longitudinale anterius, the (tendinous) crura of the pars lumbalis diaphragmatis (lumbar portion of the diaphragm).



263. Vertebral bodies with ligaments, from behind.

(The vertebral arches have been sawed off at their roots.)

The **ligamentum longitudinale posterius** (O. T. posterior common ligament) (see also Figs. 271 and 272) runs on the posterior surface of the vertebral bodies down inside the canalis vertebralis. It begins as an extraordinarily thin, broad layer upon the clivus and at the edge of the foramen occipitale magnum and is united as far as the third cervical vertebra with the membrana tectoria, behind which it descends, and with the dura mater. From the third cervical vertebra on it becomes narrower and stronger behind each vertebral body and is there separated from the bone by a well-developed venous plexus (see page 472); at each fibrocartilago intervertebralis it becomes considerably broader, and is especially firmly attached. It ends in the upper part of the canalis sacralis. In it can be made out deeper bands, lying near the vertebral bodies, which are short and connect the vertebrae which are close to one another, and superficial, long bands which extend over long distances; it is the latter alone which form the uppermost part of the ligament behind the membrana tectoria (see page 186). It is connected with the dura mater spinalis by single fibre-bands (see page 643).



264. Ligaments between the sacrum and the coccyx, from behind.

The connection between the sacrum and the coccyx **(symphysis sacrococcygea)** is mediated by a thin fibrous disc; similar fibrous discs are usually present also between the first, second and third coccygeal vertebrae. These connections can wholly or in part be bony in character. The third, fourth and fifth sacral vertebrae are usually united by bony substance.

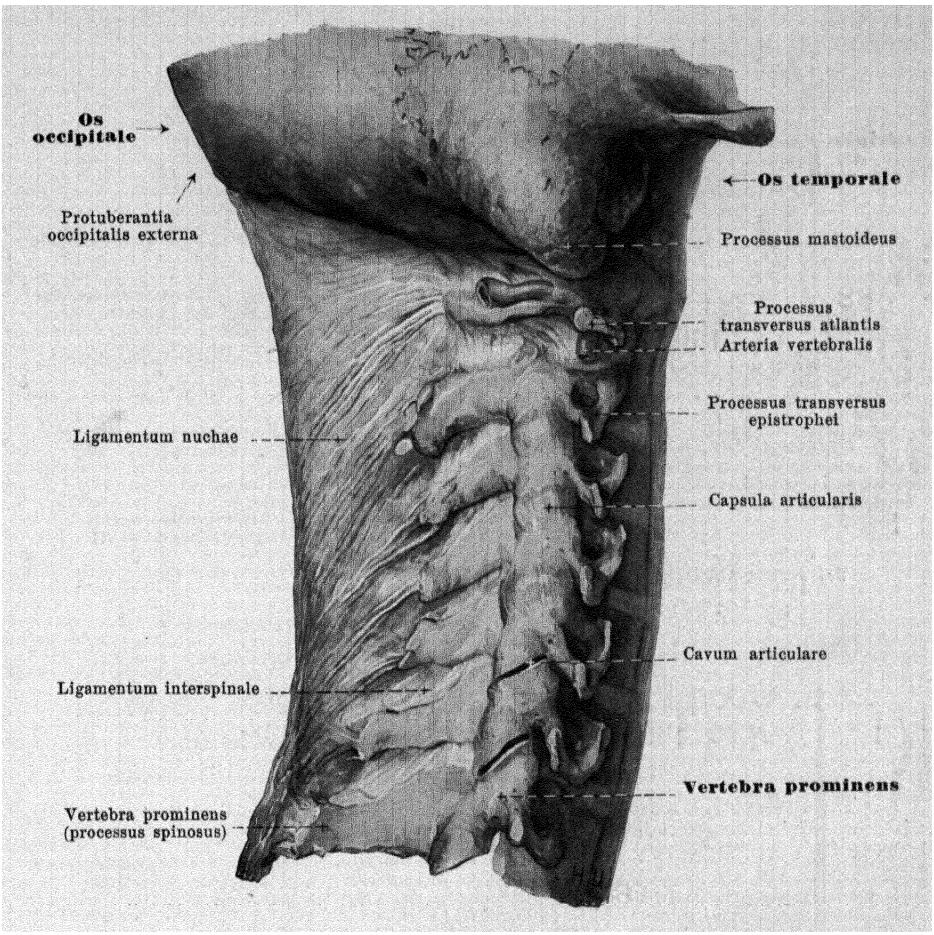
A number of ligaments also are present which are to be considered as modifications of those of the other vertebrae.

The *ligamentum sacrococcygeum anterius* (= lig. longitudinale anterius) (see Figs. 294 and 723) consists of two thin fibrous bands which extend on the anterior surface from the tip of the sacrum to the coccygeal vertebrae, crossing over one another in part; below it is attached to the m. levator ani (see page 628).

The *ligamentum sacrococcygeum laterale* (= lig. intertransversarium) runs on each side from the lower end of the crista sacralis lateralis to the processus transversus of the first coccygeal vertebra, bounds externally the notch situated lateral from the apex of the sacrum and so helps to form a fifth foramen sacrale.

The *ligamentum sacrococcygeum posterius profundum* (= lig. longitudinale posterius), lies as a thin plate immediately upon the posterior surface of the combined bodies of the sacral and coccygeal vertebrae and is connected in part with the following ligament.

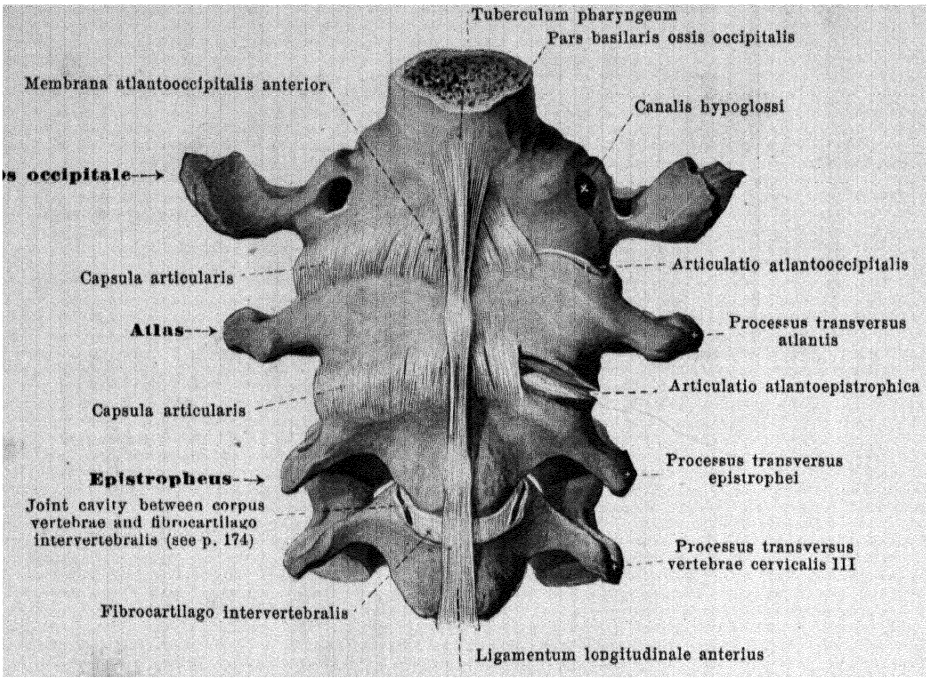
The *ligamentum sacrococcygeum posterius superficiale* consists of several fibre-bands which extend on the one hand from the lower end of the crista sacralis media downward to the posterior surface of the coccyx and at the same time close the hiatus sacralis more or less completely; on the other hand, the fibre-bands extend between the cornua sacralia and the cornua coccygea. Narrow spaces between the single bands serve on both sides for the passage of the n. coccygeus. The ligament corresponds partly to the ligamenta flava, partly to the capsulae articulares.



265. Skull and cervical spine, with ligaments, from the right.

(The joint slits have been partially opened.)

Between the occipital bone and the processus spinosi of the cervical vertebrae is stretched in the median plane the unpaired, triangular **ligamentum nuchae.** It is a membrane of unequal thickness and fastened above to the crista occipitalis externa, in front to the tuberculum posterius atlantis and the tips of the spinous processes from the second to the seventh cervical vertebra (from the second to the sixth vertebra to their dorsal notches). Between the spinous processes it connects with the ligamenta interspinalia, below with the ligamentum supraspinale. Its free, somewhat concave, thickened border lies close beneath the skin, goes from the protuberantia occipitalis externa to the tip of the spinous process of the seventh cervical vertebra and connects with the fascia nuchae. Within the membrane a band of stronger fibrous bundles runs backward and downward from each cervical vertebra.



266. Occipital bone and first three cervical vertebrae with ligaments, from in front.

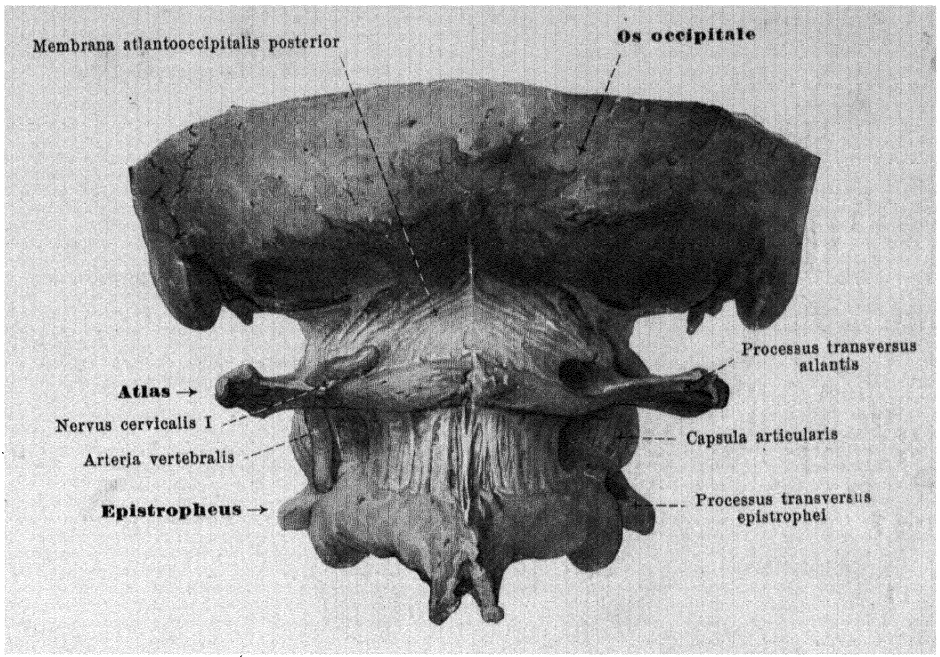
(The joints have been partially opened.)

The **articulatio atlantooccipitalis** *(occipital joint,* O. T. articulation of the atlas with the occipital bone) (see also Figs. 267 and 269) is formed so that the condyli occipitales move in the foveae articulares superiores atlantis. Between the borders of these cartilaginous joint-surfaces are stretched the loose *capsulae articulares* (O. T. capsular ligaments). The interspaces between the arches of the atlas and the occipital bone are filled up by the *membranae atlantooccipitales.*

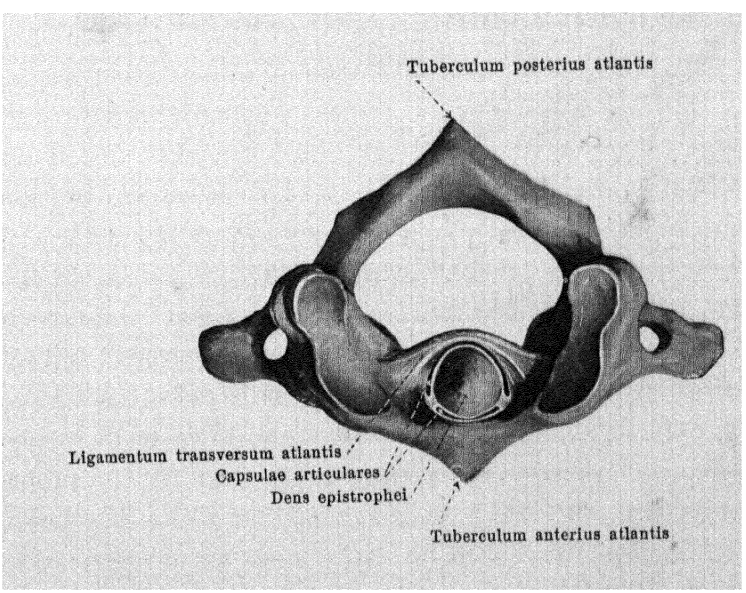
The *membrana atlantooccipitalis anterior* (O. T. anterior occipitoatlantal ligaments) extends as a flat, tough band between the pars basilaris ossis occipitalis and the arcus anterior atlantis; its fibres run essentially vertically. In the middle it is fused with the uppermost part of the ligamentum longitudinale anterius, at the borders with the capsulae articulares.

The *membrana atlantooccipitalis posterior* (O. T. posterior occipitoatlantal ligament) (see Figs. 267 and 272) goes from the posterior circumference of the foramen occipitale magnum to the arcus posterior atlantis. Its lower, medial part is extraordinarily thin and firmly fused with the dura mater. Its upper lateral part consists of stronger fibrous bands; they extend obliquely lateralward and are fastened there to a fibrous arch, sometimes ossified, which bridges over the sulcus a. vertebralis and transforms it into a canal, through which pass the a. and v. vertebralis and the n. cervicalis I.

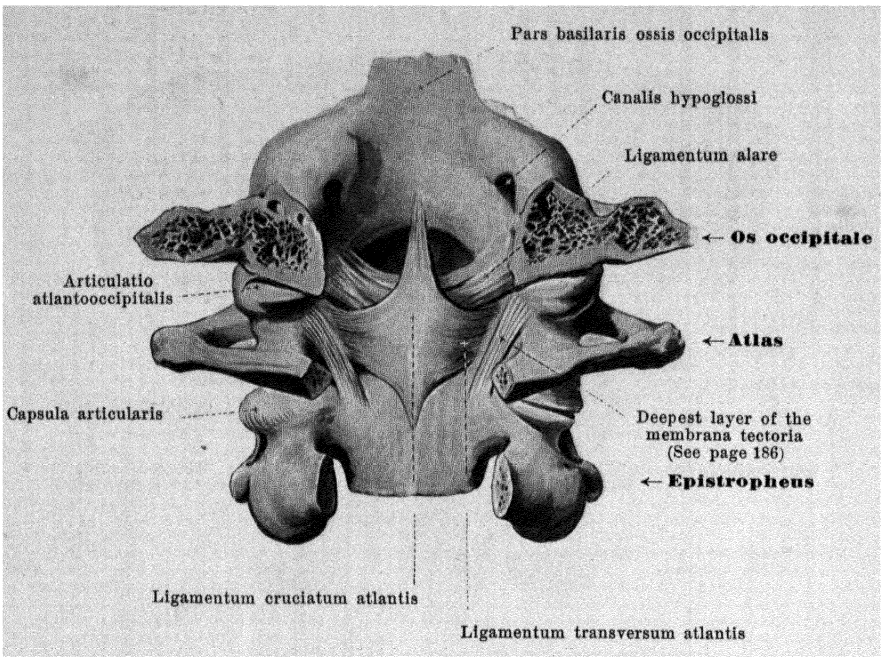
The **articulatio atlantoepistrophica** *(joint for rotation of head),* O. T. articulation of the atlas with the axis) (see also Figs. 268—272) is formed in that the facies articulares inferiores atlantis move upon the facies articulares superiores epistrophei and that, at the same time, the dens epistrophei turns with its two facies articulares, in the cylindrical space which is bounded in front by the arcus anterior atlantis, behind by the ligamentum transversum atlantis (see p. 184). Between the border of each inferior joint-surface of the atlas and the upper joint-surface of the epistropheus are stretched loose *capsulae articulares* (O. T. capsular ligaments); there is also a similar joint-capsule between the border of the fovea dentis of the atlas and the facies articularis anterior epistrophei, as well as between the circumference of the facies articularis posterior epistrophei and the anterior surface of the ligamentum transversum atlantis.



267. Occipital bone, atlas and epistropheus with ligaments, from behind.



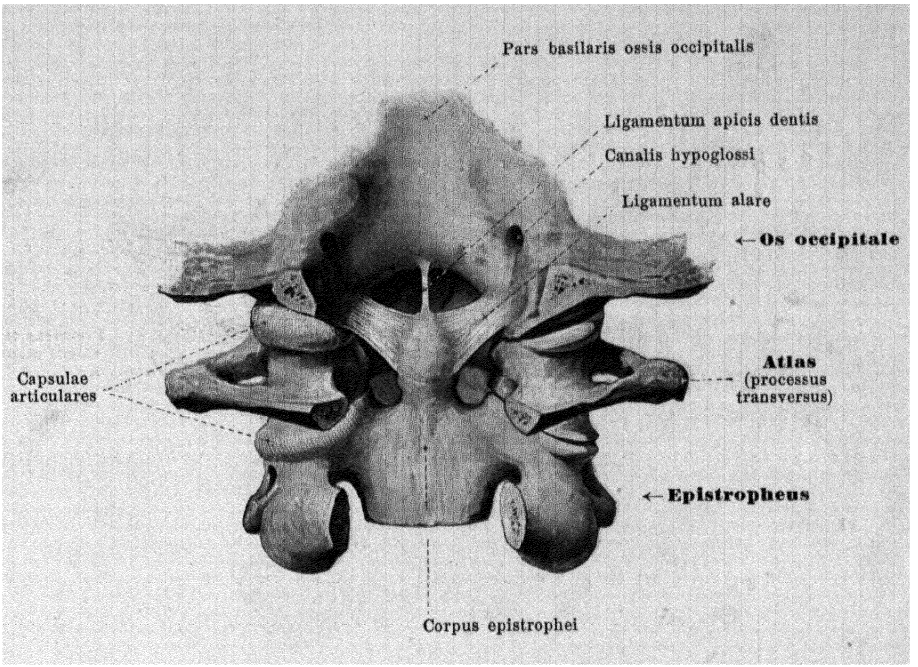
268. Atlas and epistropheus, with ligaments, from above.



269. Occipital bone, first and second cervical vertebrae with ligaments, 3rd layer, from behind.

(The part of the occipital bone situated behind the middle of the foramen occipitale magnum and the arches of the cervical vertebrae have been removed; most of the membrana tectoria has been removed. The joint slits are partly opened.)

Articulatio atlantoepistrophica (continued). Among its essential constituents the *ligamentum transversum atlantis* (O. T. the transverse ligament) may first be mentioned. This tough, flat ligament (see also Figs. 268 und 272) goes behind the dens epistrophei, has a broad origin from the medial surface of one massa lateralis atlantis and is similarly fastened on the other side; it is curved so as to be convex behind and contains in the middle fibrocartilagenous deposits. On its anterior surface it is separated by a small joint-cavity from the odontoid process (see page 182); on its posterior surface it is united loosely with membrana tectoria. From the middle of its upper margin a thinner bundle of fibres runs vertically upward to the anterior circumference of the foramen occipitale magnum and from the inferior margin one runs downward to the posterior surface of the body of the second cervical vertebra. These fibre-bands together with the ligamentum transversum atlantis make up the *ligamentum cruciatum atlantis* (O. T. cruciform ligament).

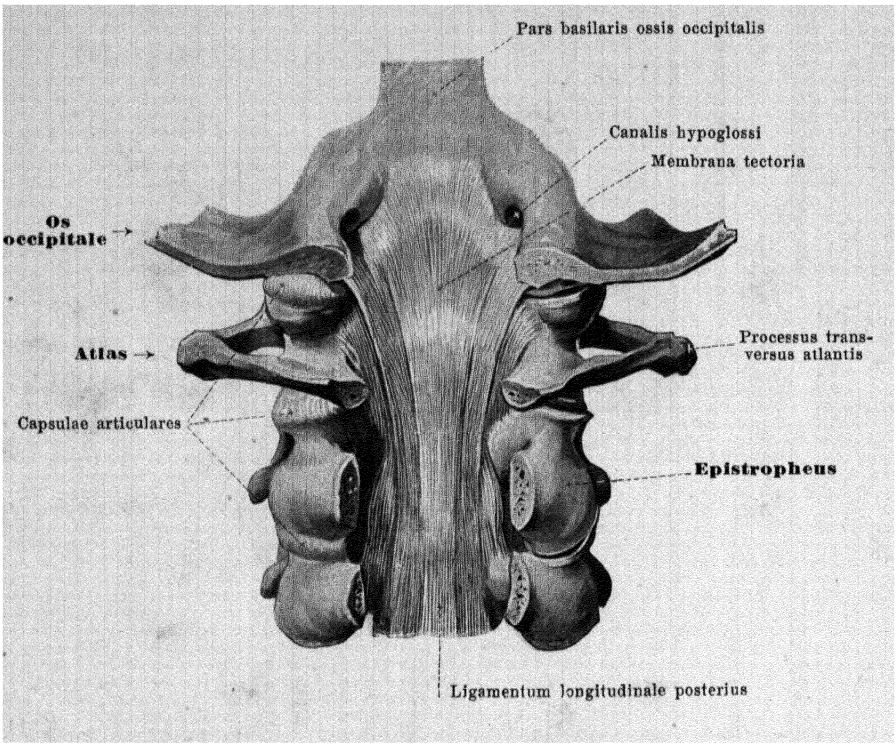


270. Occipital bone, first and second cervical vertebrae with ligaments, 4th layer, from behind.

(The part of the occipital bone situated behind the middle of the foramen occipitale magnum and the arches of the cervical vertebrae have been removed; the membrana tectoria and the ligamentum cruciatum atlantis have been completely removed. The right joint slits are opened.)

Articulatio atlantoepistrophica (continued). It is strengthened by the *ligamenta alaria* (O. T. odontoid or check ligaments) (see also Fig. 269). These are the strongest ligaments of the joint and consist on each side of a strong, flat-rounded fibre bundle which extends from the lateral surface of the dens epistrophei obliquely upward and lateralward to the medial surface of the condylus occipitalis where it is attached. They are situated therefore, in front of the ligamentum cruciatum atlantis.

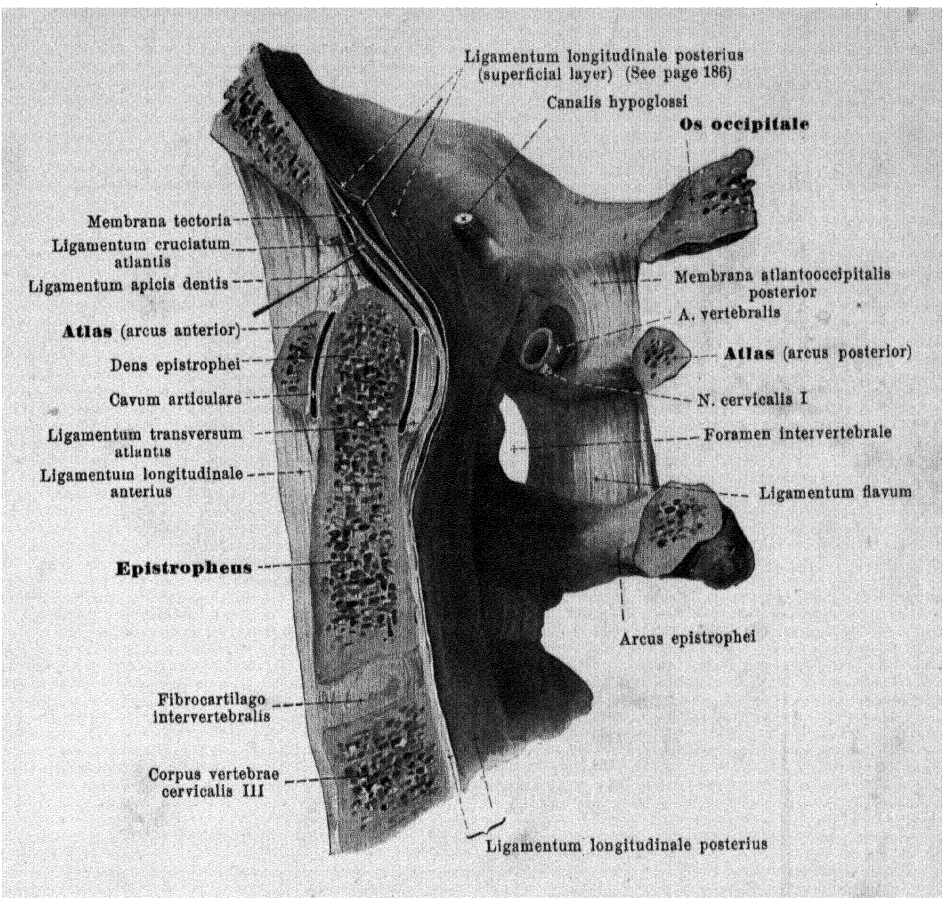
Also in front of the ligamentum cruciatum atlantis, in front of its upper vertical limb, a thin rounded band, *ligamentum apicis dentis,* (O. T. ligamentum suspensorium) extends in the median plane from the tip of the odontoid process to the anterior circumference of the foramen occipitale magnum (see also Fig. 272). It is mechanically insignificant and only important because it arises from the uppermost part of the embryonic chorda dorsalis.



271. Occipital bone and first three cervical vertebrae with ligaments, 2nd layer, from behind.

(The part of the occipital bone situated behind the middle of the foramen occipitale magnum and the arches of the cervical vertebrae have been removed; the most superficial, thin layer of the ligamentum longitudinale posterius has also been removed. The right joint slits are opened.)

The **articulatio atlantoepistrophica** is covered behind by the *membrana tectoria* (O. T. occipital-axial ligament) (see also Fig. 272). This lies as a broad, quadrangular fibrous plate behind the ligamentum cruciatum atlantis, is loosely connected with it and is separated from the dura mater of the canalis vertebralis by a very thin fibrous layer which is considered as a continuation of the superficial long bands of the ligamentum longitudinale posterius, while the membrana tectoria itself is looked upon as the especially strongly developed uppermost part of the deep, short-fibred layer of the ligamentum longitudinale posterius (see page 179). The membrana tectoria arises jointly with the superficial layer of the ligamentum longitudinale posterius from the posterior surface of the clivus, its origin extends on the sides only to the opening of the canalis hypoglossi, and it is broadest above, as well as from the anterior and lateral circumference of the foramen occipitale magnum where it is broadest; its fibres converge downward and become fastened in several strands to the posterior surface of the body of the epistropheus and of the 3rd cervical vertebra. Short bands of fibres between the atlas and the epistropheus are attached in the depth, lateralward, to the membrana tectoria (see Fig. 269).



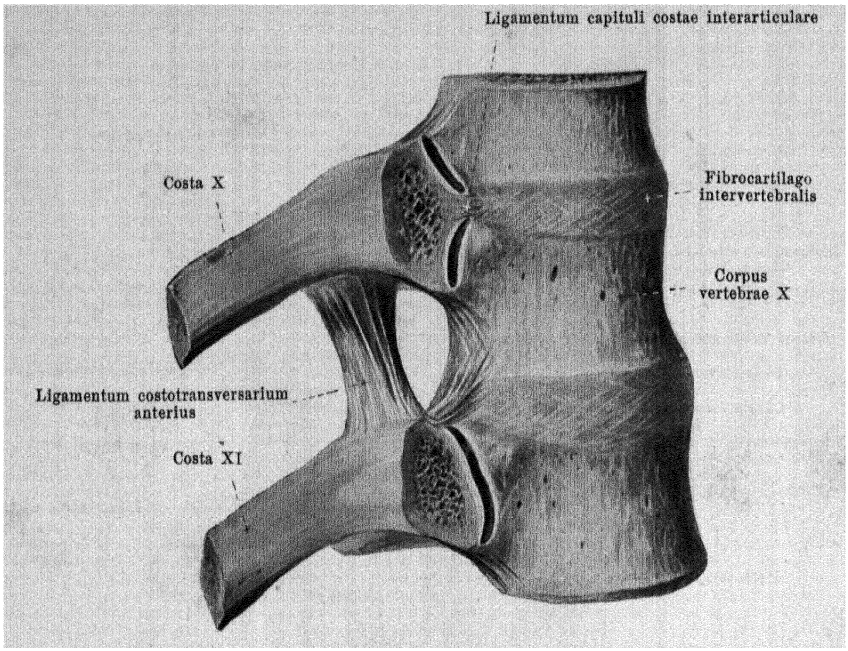
272. Median section through the occipital bone and first three cervical vertebrae with ligaments;

right half of section, viewed from the left, somewhat schematic;

magnification: 1 : 3.

(The ligamentous masses have been partially separated from one another.)

Enumerated from before backward the ligaments of the **articulatio atlantooccipitalis** and the **articulatio atlantoepistrophica** lie behind one another as follows: ligamentum longitudinale anterius with the membrana atlantooccipitalis anterior, ligamentum apicis dentis, ligamenta alaria, ligamentum cruciatum atlantis, membrana tectoria, ligamentum longitudinale posterius (superficial layer), membrana atlantooccipitalis posterior.

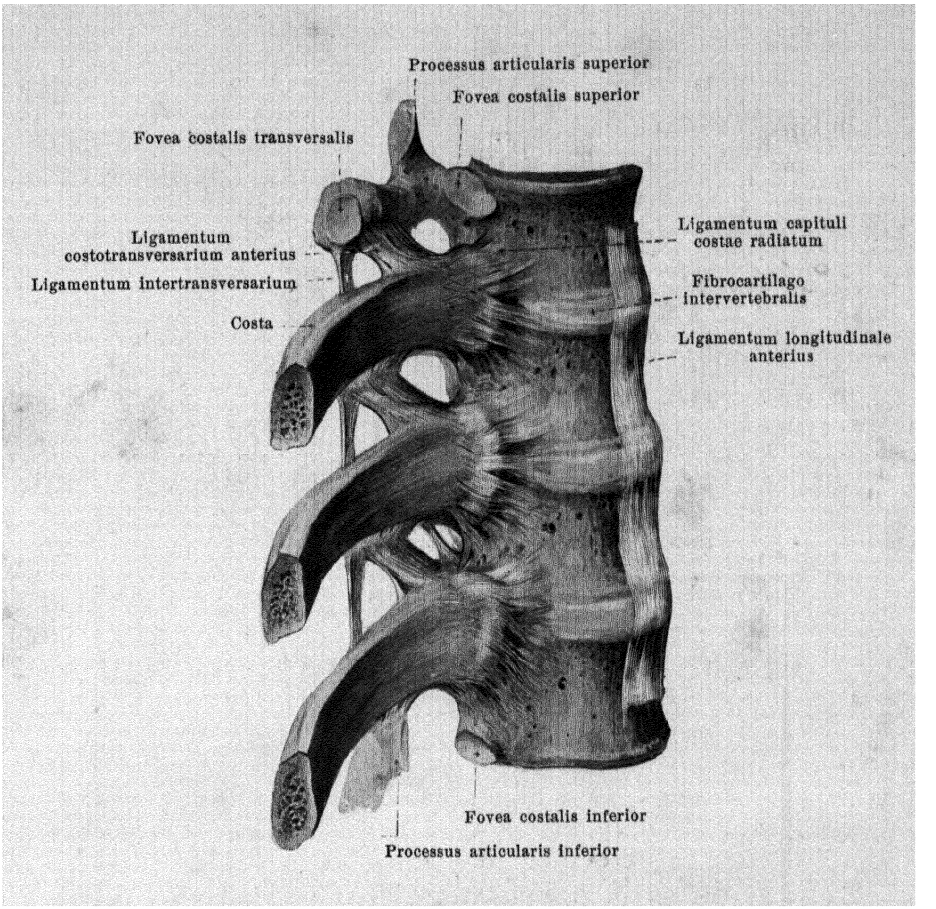


273. The right tenth and eleventh ribs and corresponding vertebral bodies with their ligaments, viewed from the right.

(The most anterior layer has been sawed off from the heads of the ribs; the parts have been somewhat separated from one another. The ligamentum longitudinale anterius has been removed.)

The **articulationes costovertebrales** *(articulations of the ribs with the vertebrae)* (see Fig. 276) are the moveable connections between the ribs and the thoracic vertebrae. Each rib is articulated at two points; the capitulum costae moves in the foveae costales of the bodies of the vertebrae *(articulatio capituli)* and at the same time the tuberculum costae rotates in the fovea costalis transversalis *(articulatio costotransversaria)*. Both together form mechanically one joint.

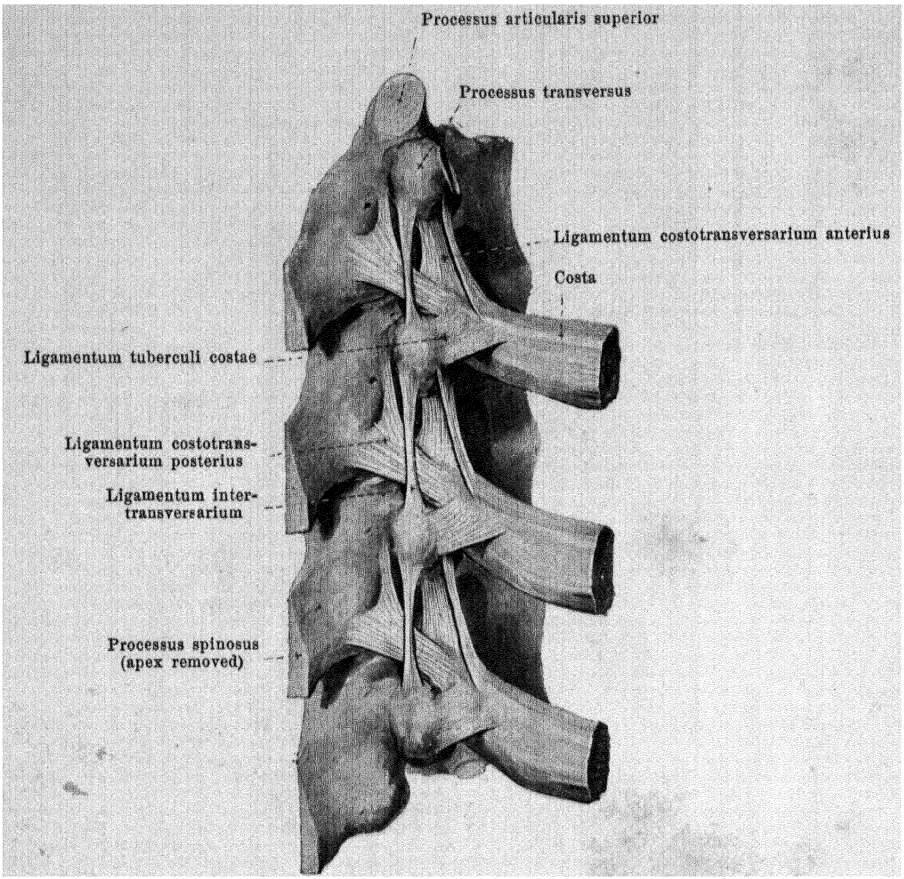
In the ***articulationes capitulorum*** *(articulations between the heads of the ribs and the vertebrae)* (see also Figs. 262, 274 and 276) each capitulum costae lies with its facies articularis in the corresponding foveae costales of the vertebral bodies, so that, for example, the capitulum of the sixth rib rests in the fovea costalis inferior of the fifth thoracic vertebra, in the fovea costalis superior of the sixth thoracic vertebra and in a depression in the intervertebral disc lying between the two. The articular surfaces are for the most part covered by fibrocartilage. On the second to the tenth rib, a *ligamentum capituli costae interarticulare* (O. T. interarticular ligament) extends from each crista capituli to the fibrocartilago intervertebralis, and usually separates two special joint cavities, with their *capsulae articulares* from one another. The first rib is usually, the eleventh and twelfth ribs are occasionally, united each with one vertebral body only and accordingly possess no ligamentum capituli costae interarticulare and also only one capsula articularis each.



274. Ribs and corresponding vertebrae, with ligaments, viewed from the right.

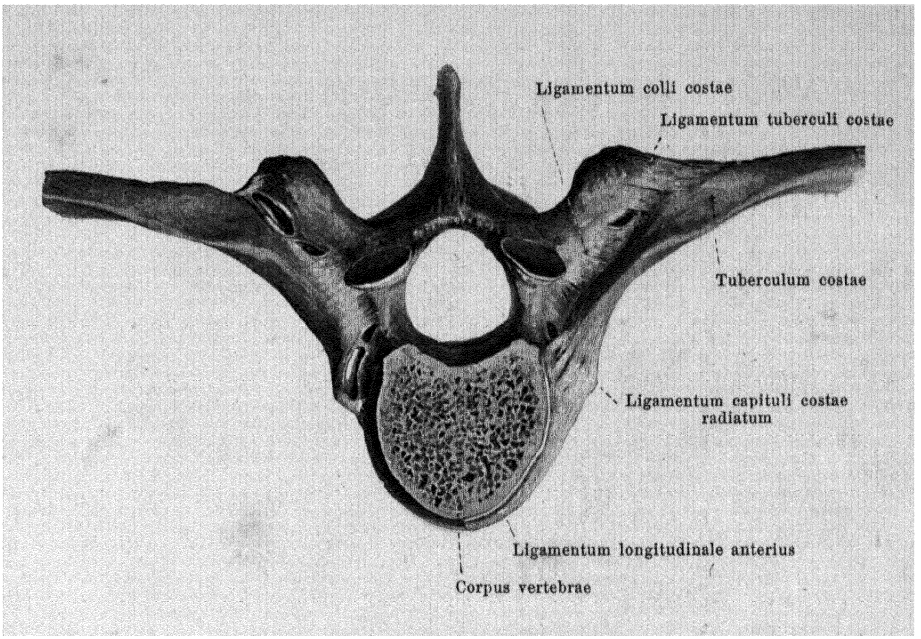
(The right lateral portion of the ligamentum longitudinale anterius has been removed.)

On the anterior surface of each of the **articulationes capitulorum**, the broad flat *ligamentum capituli costae radiatum* (O. T. anterior costovertebral or stellate ligament) (see also Figs. **262** and **276**) extends from the head of the rib to the lateral surfaces of the corresponding vertebral bodies and fibrocartilago intervertebralis; the fibres diverge medianward and are partly covered over by the lateral portions of the ligamentum longitudinale anterius.



275. Ribs and corresponding vertebrae with ligaments, viewed from behind and somewhat from the right.

The **articulationes costotransversariae** (see also Figs. 262, 273, 274 and 276) are formed on the first to the tenth rib by the apposition of each facies articularis tuberculi costae to the fovea costalis transversalis of the vertebra pertaining to the rib, so that, for example, the tubercle of the sixth rib is connected with the transverse process of the sixth thoracic vertebra. The margins of the cartilaginous joint surfaces are connected by *capsulae articulares*. Extending as a strengthening ligament from the under surface of the next transverse process above is the strong, quadrangular *ligamentum costotransversarium anterius*, which passes obliquely downward and medianward to the crista colli; behind this the feebler, triangular *ligamentum costotransversarium posterius* runs from the root of the processus spinosus and from the root of the processus transversus of the next vertebra above obliquely lateralward and downward to the posterior surface of the collum costae and to the region above the tuberculum costae.

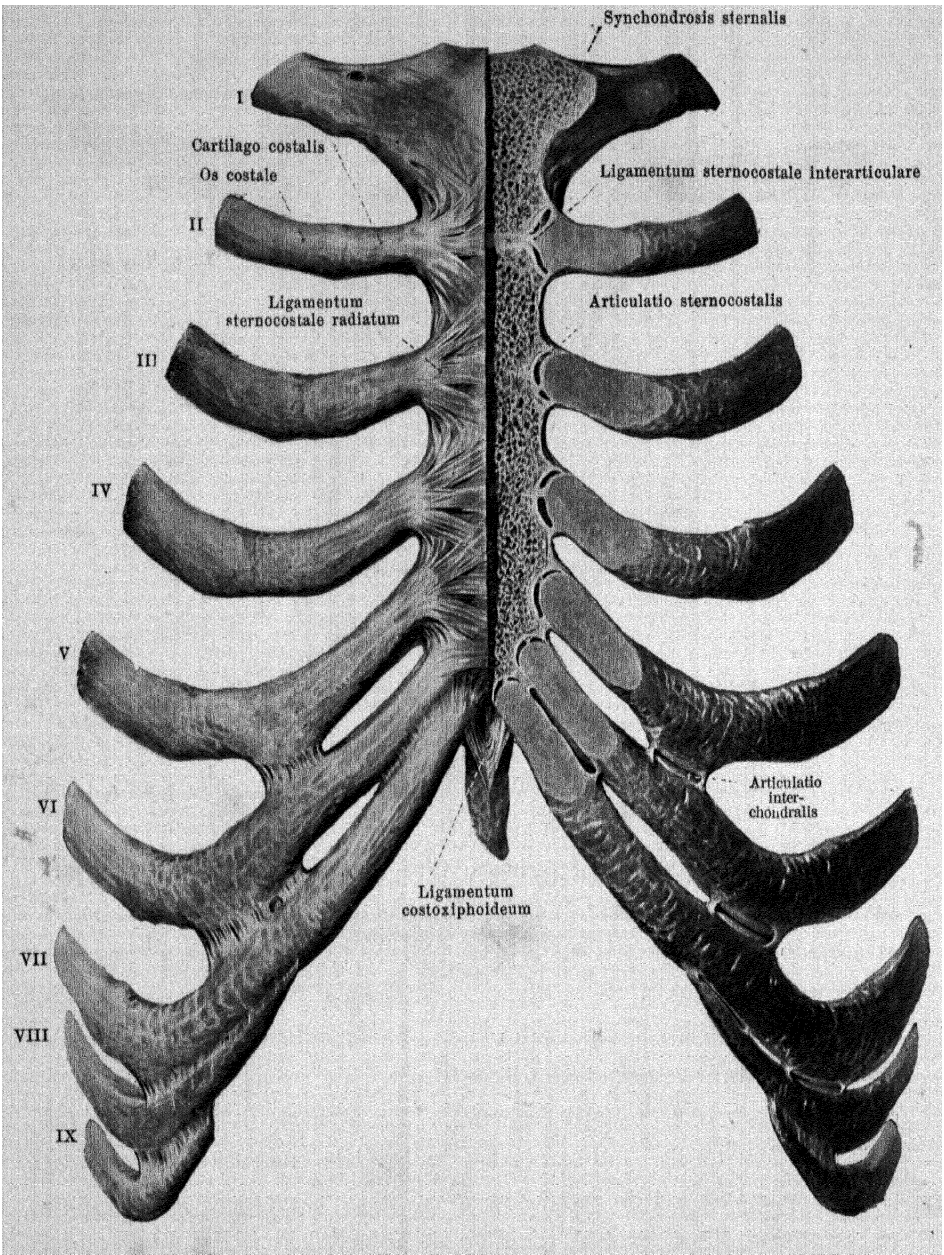


276. Ribs and corresponding vertebra with ligaments, from above.

(The body of the upper of the two vertebrae connected with the rib has been sawed through transversely. On the right side the joint slits have been opened.)

The following strengthening ligaments of the **articulationes costotransversariae** have yet to be considered: — the *ligamentum tuberculi costae,* which extends as a quadrangular ligament behind the joint from the tip of the processus transversus to the posterior surface of the tuberculum costae (see also Fig. 275), as well as the *ligamentum colli costae.* The latter is short, broad, and stretched out horizontally between the posterior surface of the collum costae and the anterior surface of the processus transversus of the corresponding vertebra. The fibres run obliquely backward and medianward from the rib. This ligament fills the space between the anterior surface of the processus transversus and the posterior surface of the collum costae, the *foramen costotransversarium,* almost completely except for chinks in the anterior and posterior part.

The eleventh and twelfth rib do not touch the processus transversus of the vertebrae concerned; they are joined to it only by weak ligaments, and we find here no joint cavities or capsulae articulares; and their articulationes costotransversariae lock joint cavity and capsula articularis; corresponding to this the two ligaments of each of these joints are somewhat modified.



277. Sternum and ribs with ligaments, from in front.

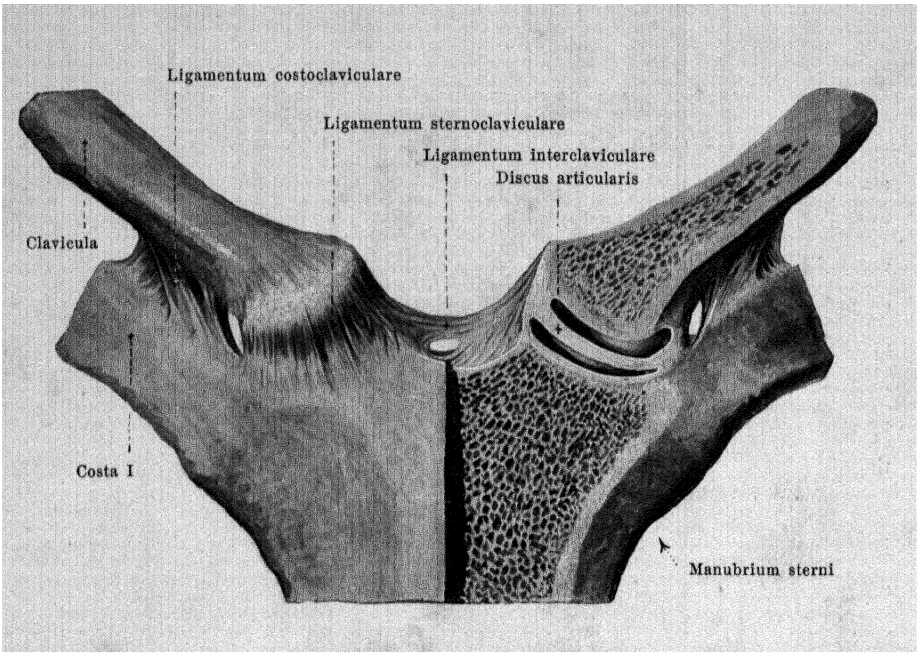
(In the left half of the figure the most anterior layer has been removed and the joint slits have been opened; the parts are separated somewhat from one another on the left side.)

The anterior extremities of the seven (sometimes eight) upper costal cartilages are attached directly to the incisurae costales of the sternum and so form the **articulationes sternocostales** *(articulationes of the cartilages of the ribs with the sternum)*; the cartilage of the first rib fuses usually directly with the sternum, while for the cartilages of the second to the seventh (sometimes eighth) rib there are present slit-shaped joint cavities and *capsulae articulares.* A fibro-cartilaginous layer, the *ligamentum sternocostale interarticulare* (O. T. interarticular chondrosternal ligament), which extends from the medial end of the second costal cartilage to the cartilaginous (or bony) junction of the manubrium with the corpus sterni, there constantly divides this joint into two separate joint cavities. In the other joints there are often similar fibrous strands, which, however, lead usually only to incomplete division of the joint cavities. The joint capsules are strengthened on the anterior surface by strong, on the posterior by weak, *ligamenta sternocostalia radiata* (O. T. anterior and posterior chondrosternal ligaments), which extend from the ends of the costal cartilages, diverging to the sternum; the anterior of these interweave with those of the other side to form a tough layer. This layer, ensheathing the sternum in front and behind, is called the *membrana sterni.*

The eighth and ninth rib are attached usually (see p. 86) each with the anterior end of its cartilage to the cartilage of the next rib above. In these places as well as sometimes at other places on the fifth to the ninth costal cartilage, where contact between the cartilages or cartilaginous processes takes place, small joint slits and joint capsules are present, the *articulationes interchondrales.*

The anterior extremity of the tenth costal cartilage is united by a loose ligamentous band with the ninth; no such connection of the eleventh with the twelfth rib exists. For the synchondrosis sternalis (between the manubrium and the corpus) see p. 105.

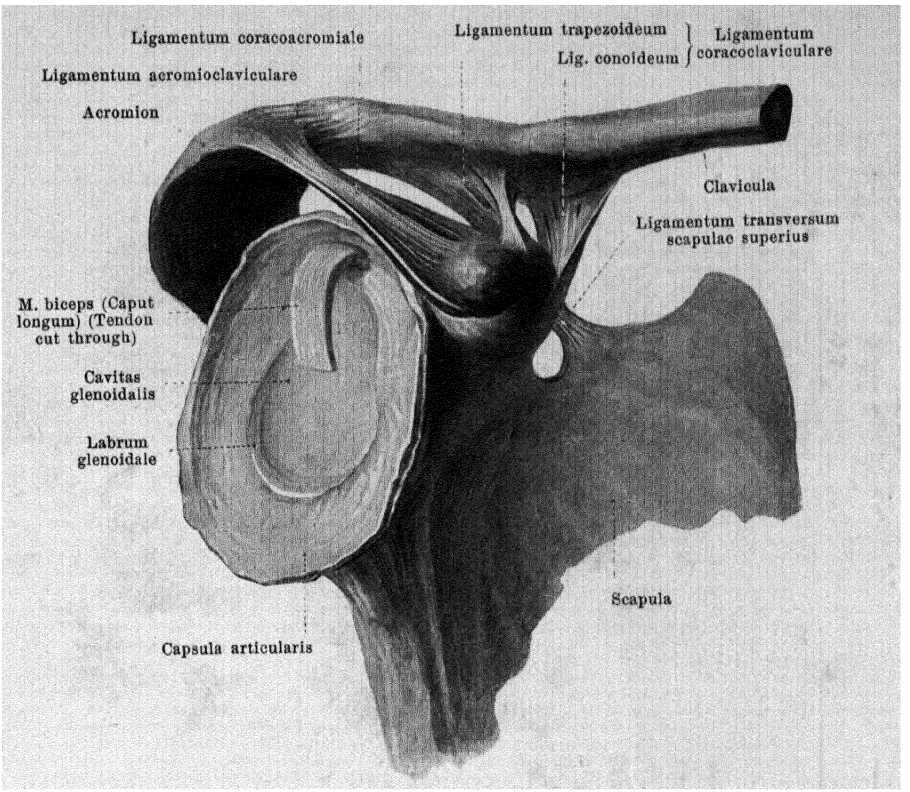
From the lowermost end of the corpus sterni and from the anterior surface of the sixth and seventh costal cartilage strand-like bands go off obliquely medianward to the anterior surface of the processus xiphoideus, the *ligamenta costoxiphoidea* (O. T. chondroxiphoid ligaments). They are connected with the anterior leaf of the vagina musculi recti abdominis.



278. Clavicle, sternum and first rib, with ligaments, from in front.

(On the left half the most anterior layer has been removed; the parts forming the joints are somewhat separated from another.)

The **articulatio sternoclavicularis** *(sternoclavicular joint)* arises from the fact that the extremitas sternalis claviculae with its facies articular sternalis, covered with cartilage, lies in the incisura clavicularis sterni which is also covered with cartilage, the two being separated only by the *discus articularis* (O. T. interarticular fibrocartilage); the latter is thickened above, medianward and behind, and separates two special joint cavities with *capsulae articulares* from one another. The discus articularis and the cartilaginous coverings consist of fibrocartilage. On the anterior surfaces of the joint the broad *ligamentum sternoclaviculare* extends from the clavicle down to the sternum. In addition, the rounded, unpaired *ligamentum interclaviculare,* concave above, stretches out between the medial extremities of the two clavicles over the incisura jugularis sterni. The *ligamentum costoclaviculare* (O. T. rhomboid ligament), a powerful ligament, consisting of several layers, goes from the tuberositas costalis claviculae to the upper margin of the first costal cartilage.



279. Right shoulder girdle with ligaments,

from without and somewhat from in front.

(The medial half of the clavicle has been sawed off. The shoulder joint has been opened and the head of the humerus removed. Of the shoulder blade only the lateral portion has been drawn.)

In the **articulatio acromioclavicularis** the facies articularis acromialis claviculae is united with the facies articularis acromii (rarely with intercalation of a disc of fibro-cartilage, *discus articularis*). From the margins of the joint surfaces stretches out a *capsula articularis*, strengthened on the upper surface by the broad *ligamentum acromioclaviculare*.

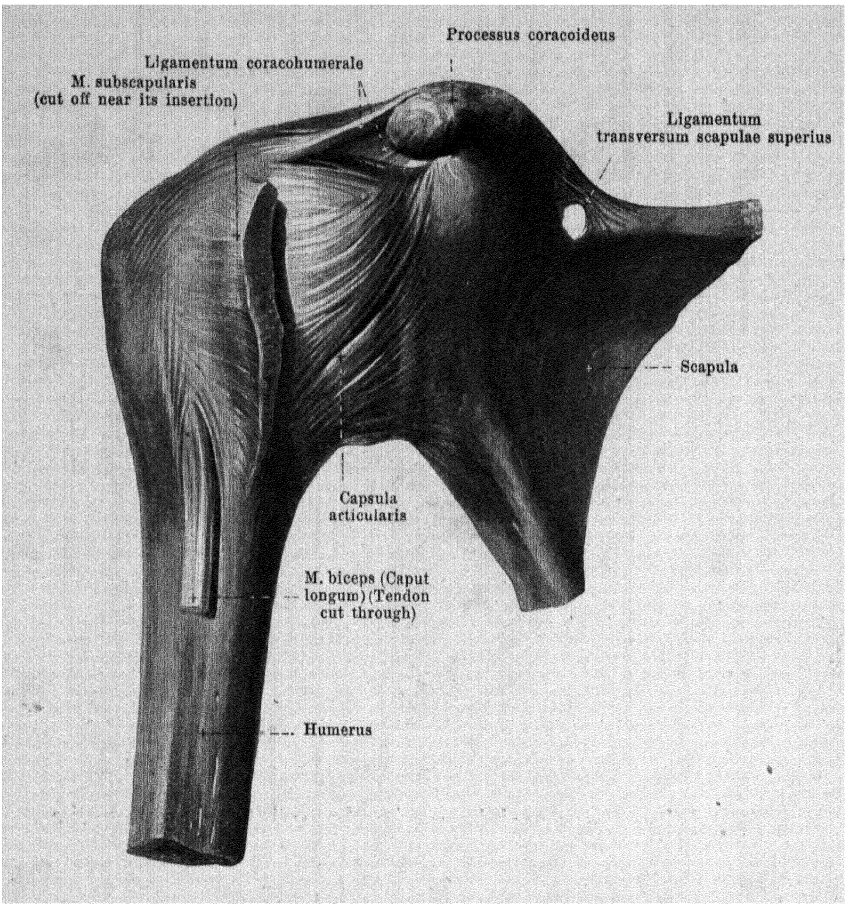
Between the tuberositas coracoidea claviculae and the upper surface of the processus coracoideus scapulae extends the broad, powerful *ligamentum coracoclaviculare;* its anterior, lateral, quadrangular part is called the *ligamentum trapezoideum,* its posterior medial, triangular part, broader above, more apical below, the *ligamentum conoideum;* between the two there is often a bursa, bursa ligamenti coracoclavicularis (see Fig. 318).

The three **ligaments of the shoulder blade** extend between segments of bone which are not moveable upon one another; they accordingly serve only as a supplement of the bony structure.

The *ligamentum coracoacromiale (coracoacromial ligament)* is strong, broad, oblong, quadrangular and extends above the shoulder joint from the anterior surface of the acromion to the posterior surface of the processus coracoideus.

The *ligamentum transversum scapulae superius* (see also Figs. 280 and 282) is thin and flat; it is stretched out over the incisura scapulae and transforms this into a foramen through which pass the v. transversa scapulae and the n. suprascapularis (the a. transversa scapulae generally runs over the ligament).

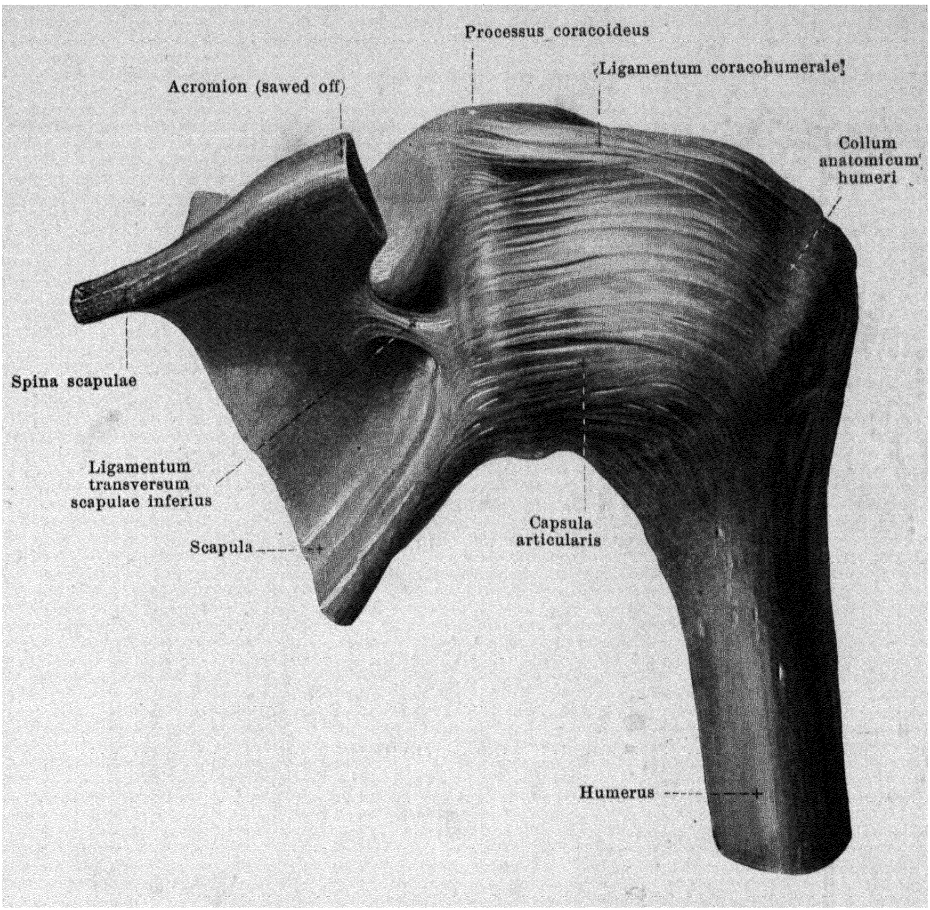
The *ligamentum transversum scapulae inferius* (see Fig. 281) is thin and round; it extends from the root of the acromion to the posterior margin of the cavitas glenoidalis, over the collum scapulae. Through the space between ligament and bone runs the a. transversa scapulae.



280. Right shoulder joint, *articulatio humeri*, from in front.

(The bursa m. subscapularis is not shown. Of the shoulder blade only the lateral part has been drawn in.)

The **articulatio humeri** *(shoulder joint)* (see also Figs. 279, 281 and 282) is formed in that the caput humeri moves upon the cavitas glenoidalis scapulae. The articular surface of the shoulder blade is enlarged by means of a connective tissue ring, ***labrum glenoidale*** (O. T. glenoid ligament), which is attached to the margin of the cavitas glenoidalis. From the outer side of this fibrocartilaginous projection a wide and loose ***capsula articularis*** extends to the collum anatomicum humeri and bridges over the upper end of the sulcus intertubercularis. The **mm. subscapularis**, supraspinatus, infraspinatus, running close by the joint, are firmly attached to the capsule near their insertions to the humerus. The stratum fibrosum of the capsule consists essentially of laterally directed fibre bands which form somewhat thicker layers in front and below.

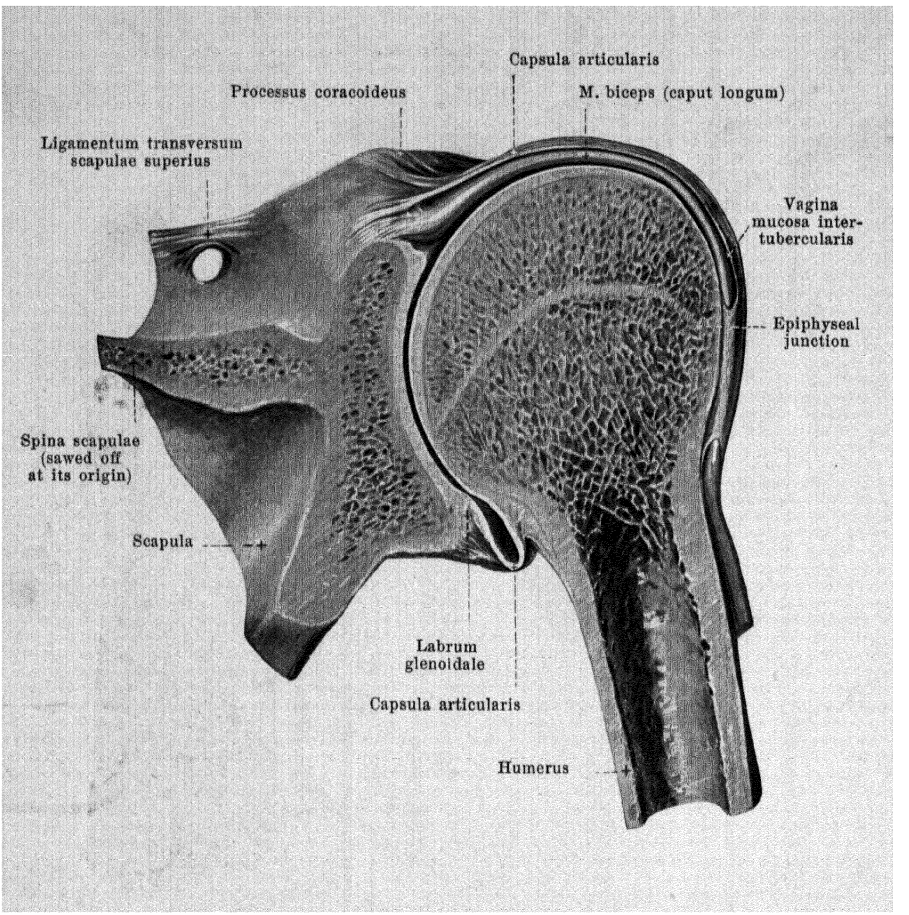


281. Right shoulder joint, *articulatio humeri*, from behind.

(The acromion has been sawed off. Of the shoulder blade only the lateral portion has been drawn in.)

Articulatio humeri (continued) (see also Figs. 280 and 282). The *ligamentum coracohumerale* (see also Fig. 280) is shown as an especial strengthening ligament. This arises from the lateral border of the processus coracoideus below the ligamentum coracoacromiale, is there separated from the capsule by loose tissue, but then sinks into the capsule and radiates out into its upper and posterior wall toward the tuberculum majus.

In the anterior part of the capsular wall there are, in addition, several fibrous bands, markedly variable in development; these are often described as special strengthening ligaments.



282. Right shoulder joint, *articulatio humeri.*

Frontal section through the same, from behind.

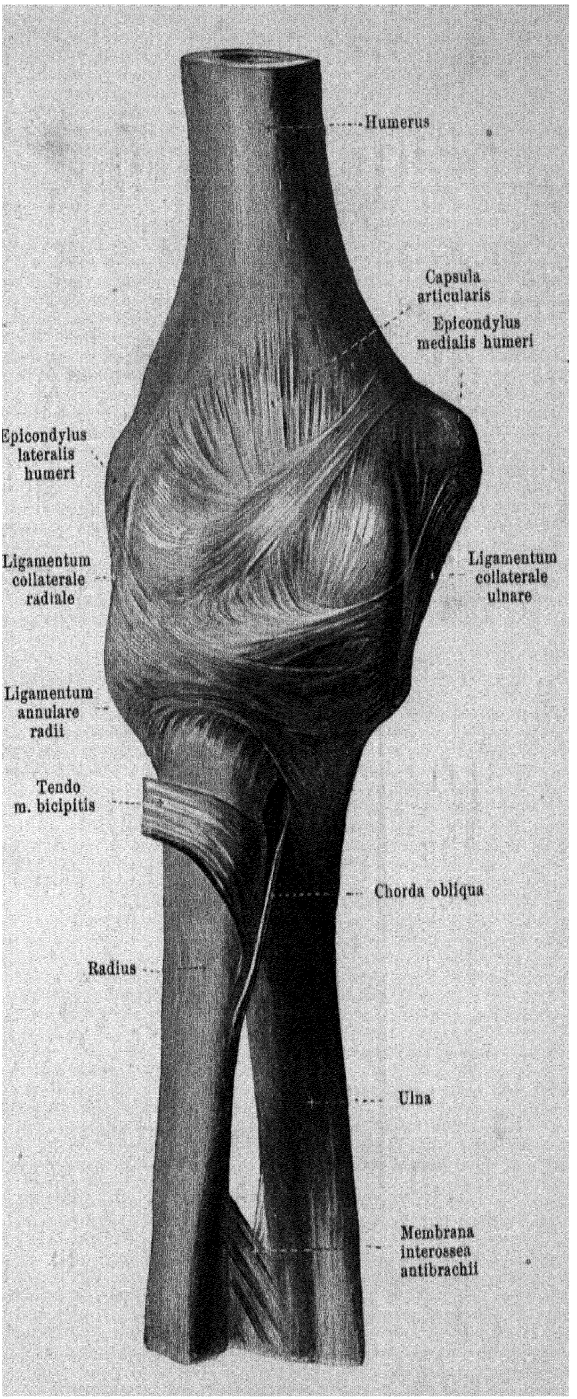
(The vagina mucosa intertubercularis has not been opened in its whole length. Of the shoulder blade only the lateral portion has been drawn.)

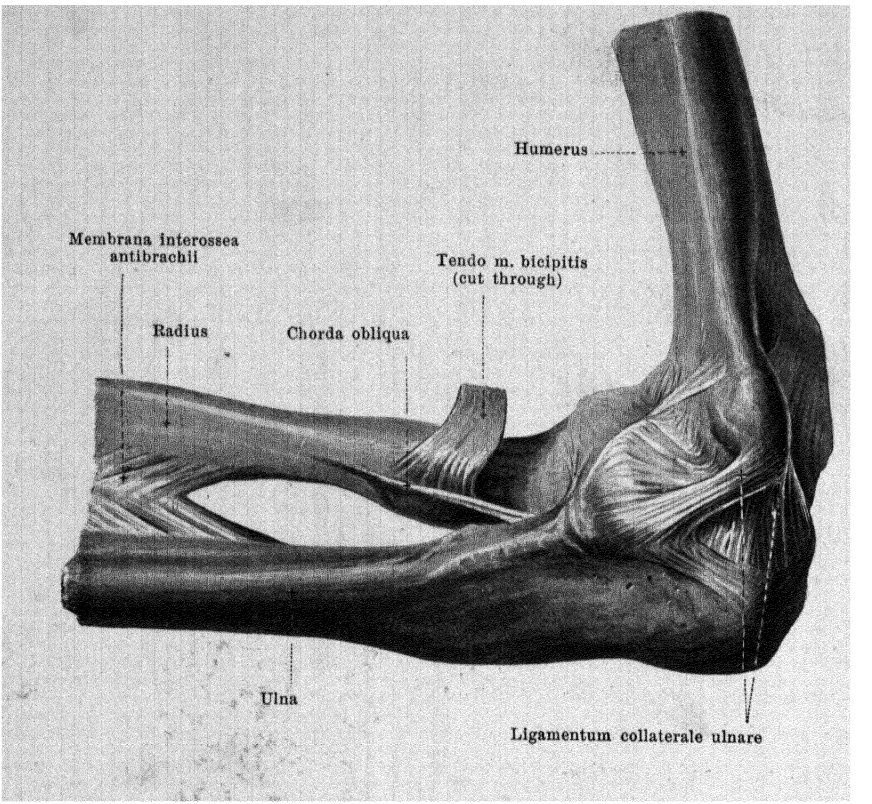
Articulatio humeri (continued) (see also Figs. 280 and 281). It presents regularly two bulgings of its capsula articularis. The one bulging, ***bursa m. subscapularis*** (see also Fig. 397) lies between the upper part of the m. subscapularis and the joint capsule, is ovale and extends to below the root of the processus coracoideus; it is connected with the joint cavity by an opening situated a little below the ligamentum coracohumerale.

The second bulging of the capsula articularis is the *vagina mucosa* ***intertubercularis*** (see also Fig. 397). It surrounds the tendon of the caput longum m. bicipitis as a tubular cylindrical canal, is in free communication at its upper extremity with the joint cavity and lies close to the bone in the region of the sulcus intertubercularis which is covered with cartilage above; it ends in the form of a blind sac in the region of the collum chirurgicum where the stratum synoviale of the capsule is reflected upon the tendon of the m. biceps, covering over part of the same as it runs inside the joint cavity.

283.
Right elbow joint,
articulatio cubiti,
from in front.

The **articulatio cubiti** *(elbow joint)* (see also Figs. 284 to 288) is the articulation between the humerus and the bones of the forearm. Here three different joints are included in one common *capsula articularis*: — (1) the incisura semilunaris ulnae glides upon the trochlea humeri *(articulatio humeroulnaris)*, (2) the fovea capituli radii rotates on the capitulum humeri *(articulatio humeroradialis)*; (3) the circumferentia articularis radii moves in the incisura radialis ulnae *(articulatio radioulnaris proximalis)*. The articulatio humeroulnaris takes part in the movements between the upper arm and the forearm only, while the articulatio radioulnaris proximalis serves exclusively for the movements between the two bones of the forearm; the articulatio humeroradialis on the other hand, takes part in both movements.



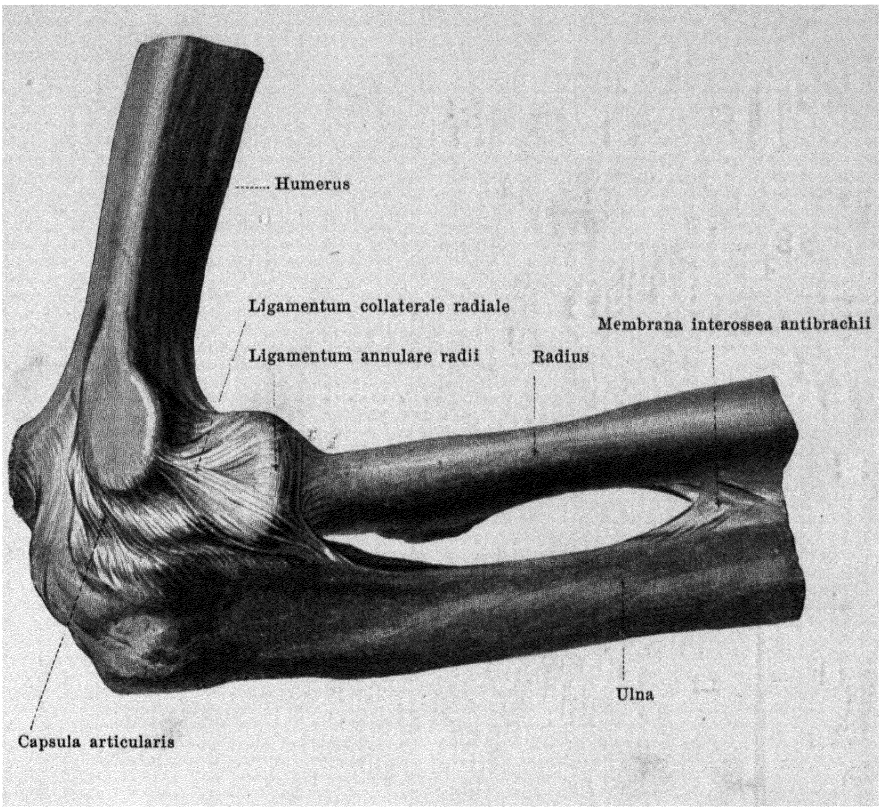


284. Right elbow joint, *articulatio cubiti,*

from the ulnar side.

Articulatio cubiti (continued) (see also Figs. 283, 285—288). The *capsula articularis* is tolerably wide and proceeds from the humerus in front and behind in a line convex above: this place of origin lies in the middle in front close above the fossa coronoidea (see note on Fig. 287) and fossa radialis, behind in the upper part of the fossa olecrani; on the sides it runs distalward from the two epicondyli. On the ulna the capsule is attached in the whole circumference of the incisura semilunaris and incisura radialis beyond the margin of the surface covered with cartilage; to the radius it is fastened around the collum radii, about in the middle between the lower margin of the capitulum and the tuberositas radii. The narrow bulging of the capsule between the incisura radialis ulnae and the circumferentia articularis radii extending distalward is called the ***recessus sacciformis.***

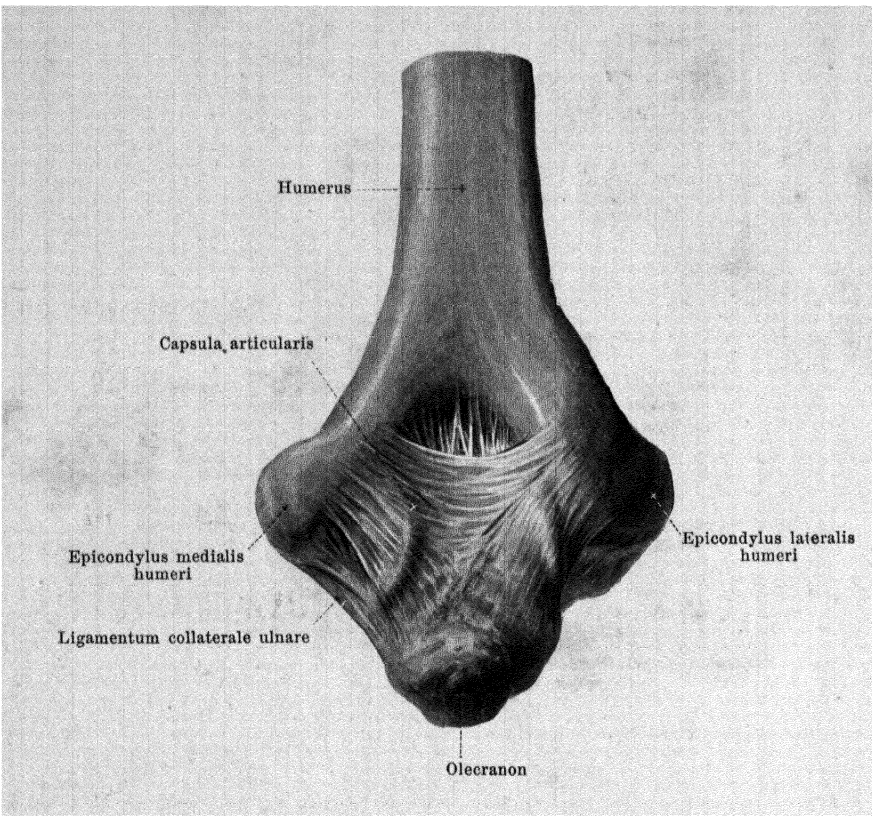
The powerful, flat, triangular ***ligamentum collaterale ulnare*** (O. T. internal lateral ligament) (see also Figs. 283 and 286) is to be mentioned as an especial strengthened ligament on the ulnar side; it extends from the epicondylus medialis humeri, its fibres diverging to the ulnar margin of the incisura semilunaris ulnae; its anterior part is usually in contact with a thick fibrous band, which extends to the basis of the processus coronoideus.



285. Right elbow joint, *articulatio cubiti,*

from the radial side.

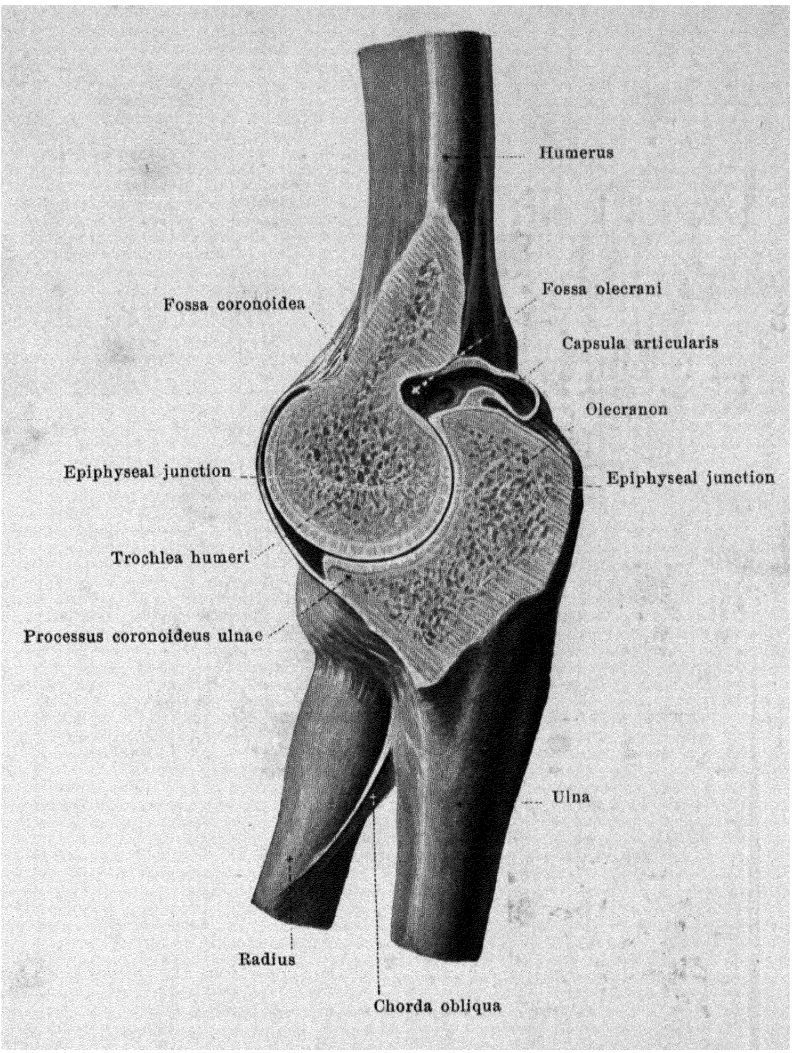
Articulatio cubiti (continued) (see also Figs. 283, 284, 286—288). It possesses as a second strengthening ligament on its radial side the ***ligamentum collaterale radiale*** (O. T. external lateral ligament) (see also Fig. 232). This arises as a strong bundle on the epicondylus lateralis humeri and divides into two diverging fibre bands of which one goes in front of, the other behind the capitulum radii; they are attached to the ulna partly in front of the incisura radialis, partly behind it and to the radial margin of the incisura semilunaris; distalward they reach as far as the level of the collum radii. The space between the diverging limbs of this ligament is filled up by fibres, which come from the epicondylus and are inserted distalward in the ligamentum annulare radii (see below), and also by those which surround the capitulum and collum radii; the latter circular fibre bands which partially unite with the limbs mentioned, and partially are fastened separately to the ulna in front and behind the incisura radialis, are most markedly developed at the distal part and are grouped together there especially, under the name, ***ligamentum annulare radii*** (O. T. orbicular ligament) (see also Fig. 288), but they are only artificially, not sharply, separable from the others.



286. Right elbow joint, *articulatio cubiti,* from behind.

(The forearm is flexed at a right angle on the upper arm.)

The *capsula articularis* of the **articulatio cubiti** (see page 200 and also Figs. 283—285 and 287) reaches on the upper arm behind, in the middle as far as the upper part of the fossa olecrani, on the sides as far as the lower part of the epicondylus medialis and lateralis. Especial strengthening ligaments in the posterior wall of the fibrous capsule will not be described. The upper part of the fossa olecrani contains a thick mass of fat close to the capsule between it and the tendon of the m. triceps brachii.

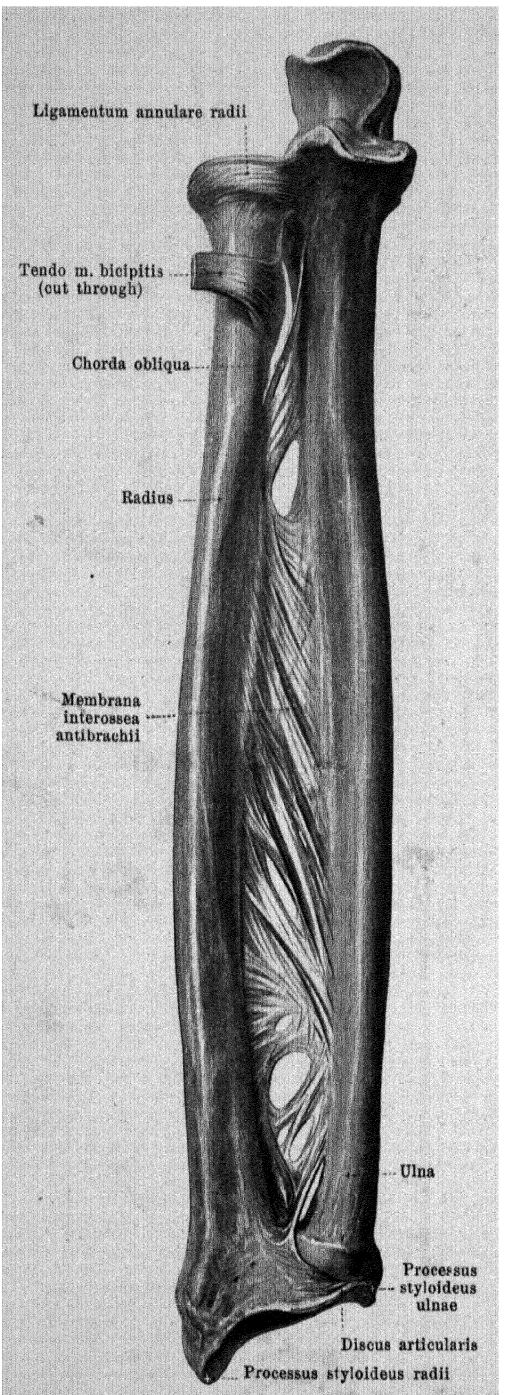


287. Right elbow joint, *articulatio cubiti,*

cut through at right angles to the axis of the trochlea humeri, from the ulnar side.

(The joint cavity on the anterior surface is not struck at the spot in which it extends furthest upward; the latter corresponds about to the place where the dotted line marked "fossa coronoidea" meets the bone.)

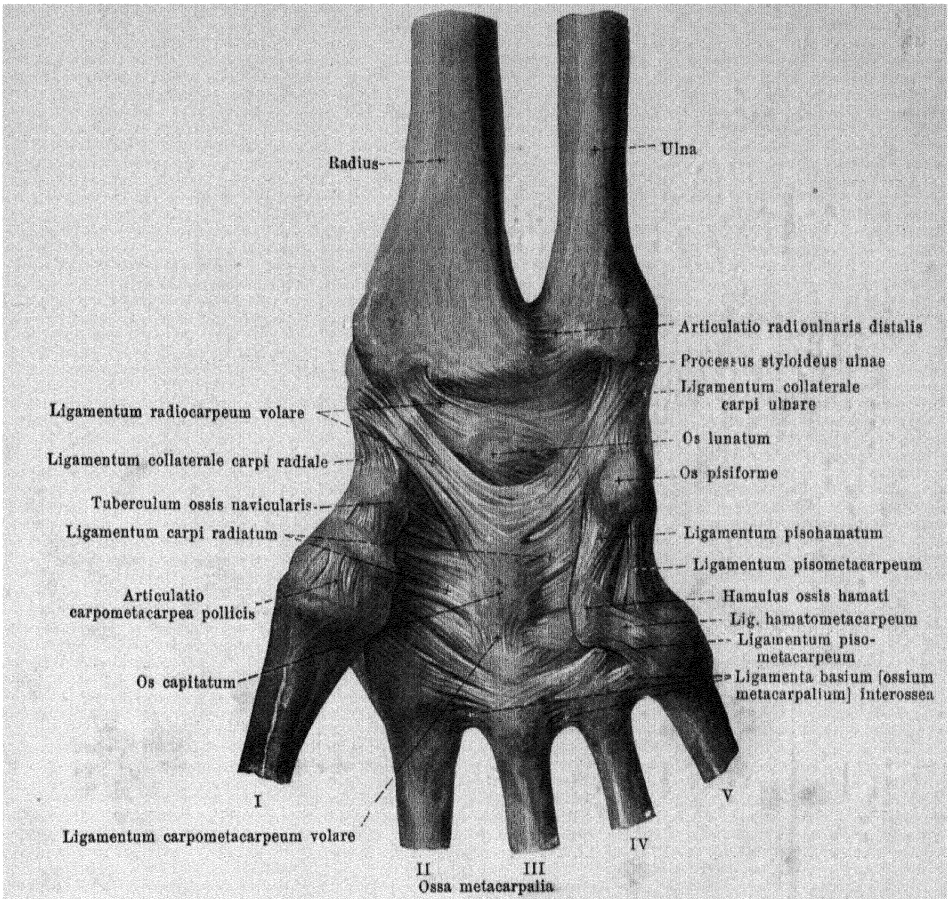
In the **articulatio cubiti** the olecranon ulnae comes to lie in the fossa olecrani humeri when the forearm is extended; when the forearm is flexed, on the contrary, the processus coronoideus ulnae enters the fossa coronoidea humeri and the capitulum radii enters the fossa radialis. The movements of extension and flexion are for the most part checked by the fitting in of the olecranon ulnae or processus coronoideus ulnae respectively into the corresponding depressions of the humerus. During life, however, it is unusual to have the movements of extension and flexion go so far that the projections of the forearm bones mentioned touch the corresponding depressions of the humerus; the movements are checked before this occurs.



288. Bones of the right forearm, with ligaments,

from the volar surface.

The joint union between the two bones of the forearm, the **articulatio radioulnaris** is divisible spatially into two portions; these are the *articulatio radioulnaris proximalis* (O. T. superior radioulnar articulation) between the circumferentia articularis of the capitulum radii and the incisura radialis ulnae (see p. 199) and the *articulatio radioulnaris distalis* (O. T. inferior radioulnar articulation), between the incisura ulnaris radii and the circumferentia articularis of the capitulum ulnae. The latter joint (see also Figs. 289 to 291) is surrounded by a loose *capsula articularis*. This arises on the radius and ulna from the margin of the cartilaginous surfaces and fuses distalward with the margin of the *discus articularis*, a triangular connective tissue plate, often perforated by a slit or hole; this disc has a broad attachment to the ulnar margin of the incisura ulnaris radii and is fastened by means of a short fibrous cord to the tip of the processus styloideus ulnae (see also Fig. 291). The blind-sac-like bulging of the joint capsule extending proximalward between the circumferentia articularis of the capitulum ulnae and the incisura ulnaris radii is called the *recessus sacciformis* (see Fig. 291). The articulationes radioulnares proximalis et distalis, in a mechanical sense, form together one joint. The space between the two bones of the forearm is almost completely filled up by the *membrana interossea antibrachii (interosseous membrane)*. This powerful fibrous sheet is stretched out between the cristae interosseae of the radius and of the ulna, is separated proximalward by a large, distalward by a narrow space from the corresponding joint, and possesses several irregular openings for the passage of vessels and nerves; the fibre bands run in the main obliquely and extend from the radius distalward toward the ulna. In addition the *chorda obliqua* (O. T. oblique ligament) (see also Figs. 283 and 284) extends as a thin rounded fibrous band from the region of the tuberositas ulnae obliquely downward to the region of the tuberositas radii.



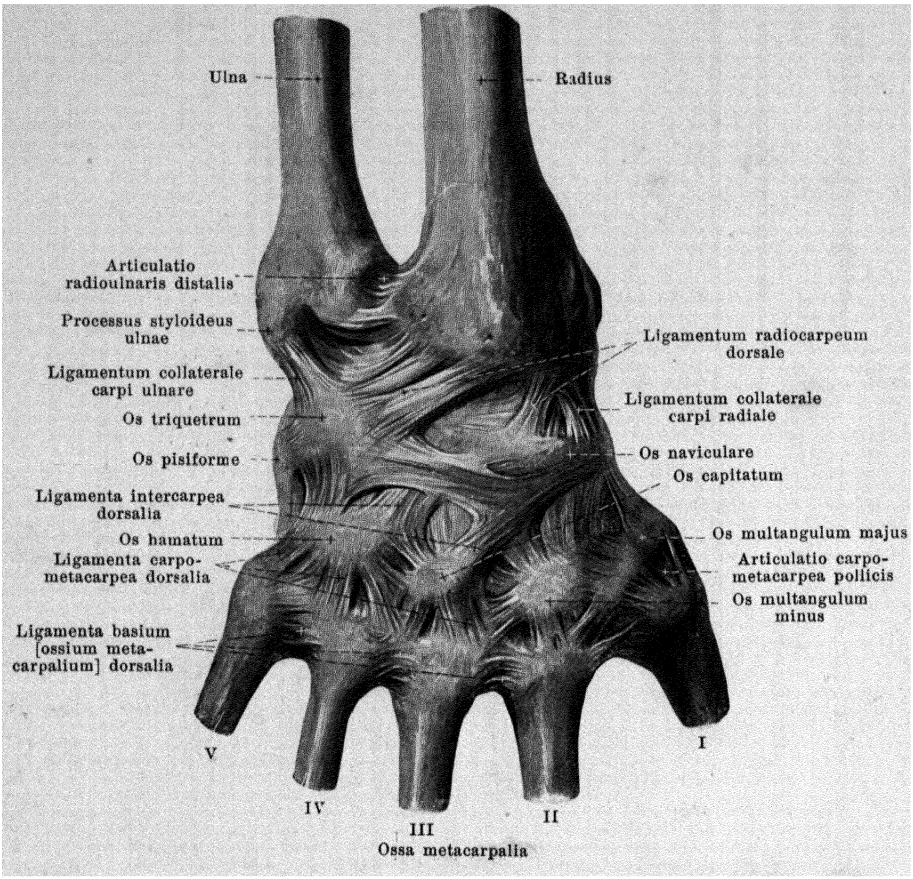
289. Joints of the right hand, *articulatio manus*, from the volar surface.

The **articulatio manus** *(joint of the hand)* (see also Figs. 290 and 291) is divisible into the *articulatio radiocarpea* and the *articulatio intercarpea*.

In the formation of the *articulatio radiocarpea (wrist-joint)* the proximal joint surfaces of the ossa naviculare, lunatum, triquetrum move upon the facies articularis carpea of the radius and upon the distal surface of the discus articularis. Its wide loose *capsula articularis* is attached to the circumference of the articular surfaces. It is strengthened by the powerful *ligamentum collaterale carpi radiale* (O. T. external lateral ligament) which extends from the processus styloideus radii to the os naviculare, and by the longer *ligamentum collaterale carpi ulnare* (O. T. internal lateral ligament) which extends from the processus styloideus ulnae to the os triquetrum. On the volar surface runs also the broad *ligamentum radiocarpeum volare* (O. T. anterior ligament) which arises from the processus styloideus and from the volar margin of the facies articularis carpea of the radius and goes in several bundles to the ossa naviculare, lunatum, triquetrum, capitatum.

The *articulatio intercarpea* connects and permits motion among the bones of the wrist; the individual bones are connected among one another by small *capsulae articulares*. On the volar surface there are several strengthening ligaments, short, flat, almost transversely directed, *ligamenta intercarpea volaria* (O. T. palmarl igaments); of these, those which radiate out from the os capitatum to the adjoining bones are grouped together as the *ligamentum carpi radiatum*.

In the formation of the *articulatio ossis pisiformis*, the dorsal surface of the os pisiforme glides upon the volar surface of the os triquetrum; a small, loose *capsula articularis* connects the borders of these surfaces. From the os pisiform, the powerful *ligamentum pisohamatum* goes to the hamulus ossis hamati; the *ligamentum pisometacarpeum* to the basis ossis metacarpalis III—V both ligaments being really continuations of the tendon of the m. flexor carpi ulnaris.



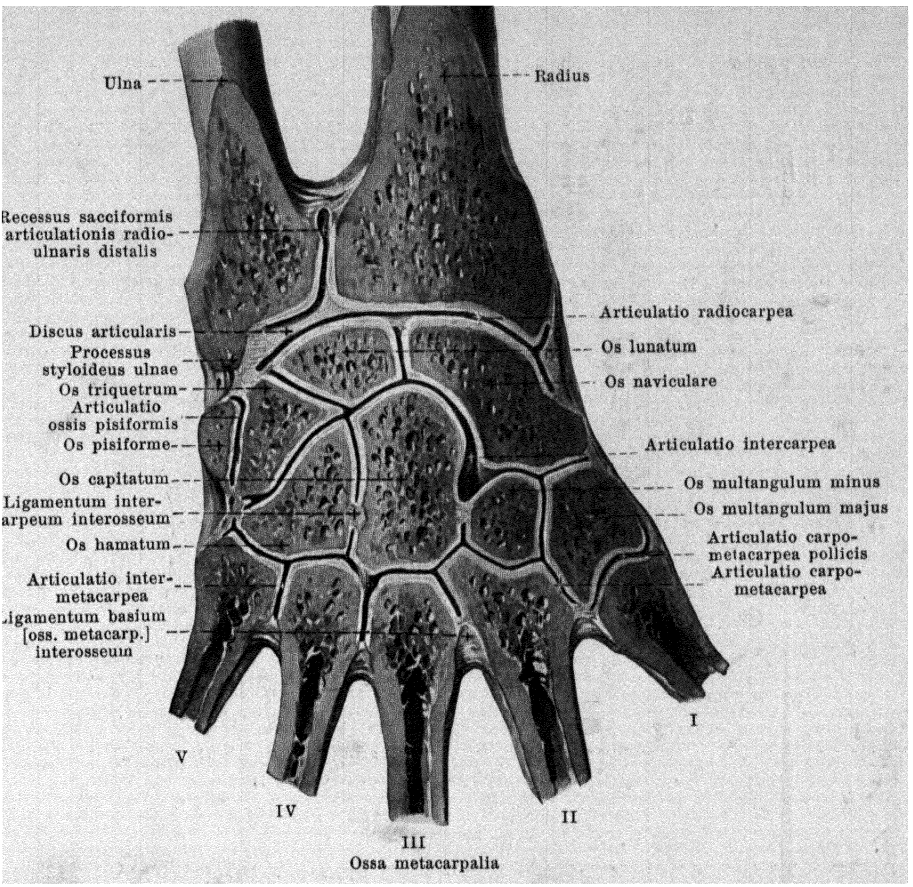
290. Joints of the right hand, *articulatio manus*, viewed from the back of the hand.

Articulatio manus (continued) (see also Figs. 289 and 291). On the dorsal surface, the capsule of the *articulatio radiocarpea* is strengthened by the *ligamentum radiocarpeum dorsale* (O. T. posterior ligament) which goes from the dorsal margin of the facies articularis carpea radii in different divisions to the bones of the first row of the carpus; the band to the os naviculare is often not especially well developed and may be absent altogether.

The *articulatio intercarpea* possesses on the dorsal surface several short strengthening ligaments, *ligamenta intercarpea dorsalia* (O. T. dorsal ligaments), which run usually transversely.

The *articulationes carpometacarpeae (carpometacarpal articulations)* are formed on the one side by the distal surfaces of the bones of the second row of the carpus, on the other side by the proximal surfaces of the ossa metacarpalia. Several short perpendicular and oblique ligaments on the volar and dorsal surfaces, *ligamenta carpometacarpea dorsalia et volaria* (O. T. dorsal and palmar ligaments) serve to their *capsulae articulares* as strengthening ligaments; of the latter, that situated furthest ulnarward extends from the hamulus ossis hamati to the basis ossis metacarpalis V and is called the *ligamentum hamatometacarpeum* (see Fig. 289).

The *articulationes intermetacarpeae (articulations of the metacarpal bones with one another)* have their origin in that the proximal ends of the second to the fifth metacarpal bone can move upon one another by means of their lateral surfaces which are covered with cartilage. Their *capsulae articulares* are strengthened by short transversely directed fibre bands, *ligamenta basium [ossium metacarpalium] dorsalia et volaria* of which there are four on the back of the hand, but only three in the hollow of the hand (the ligament between the os metacarpale I and II is absent) (see also Fig. 289).



291. Joints of the right hand, *articulatio manus*, from the back of the hand.

(The surface of a frozen hand has been filed off until the joint cavities have been opened.)

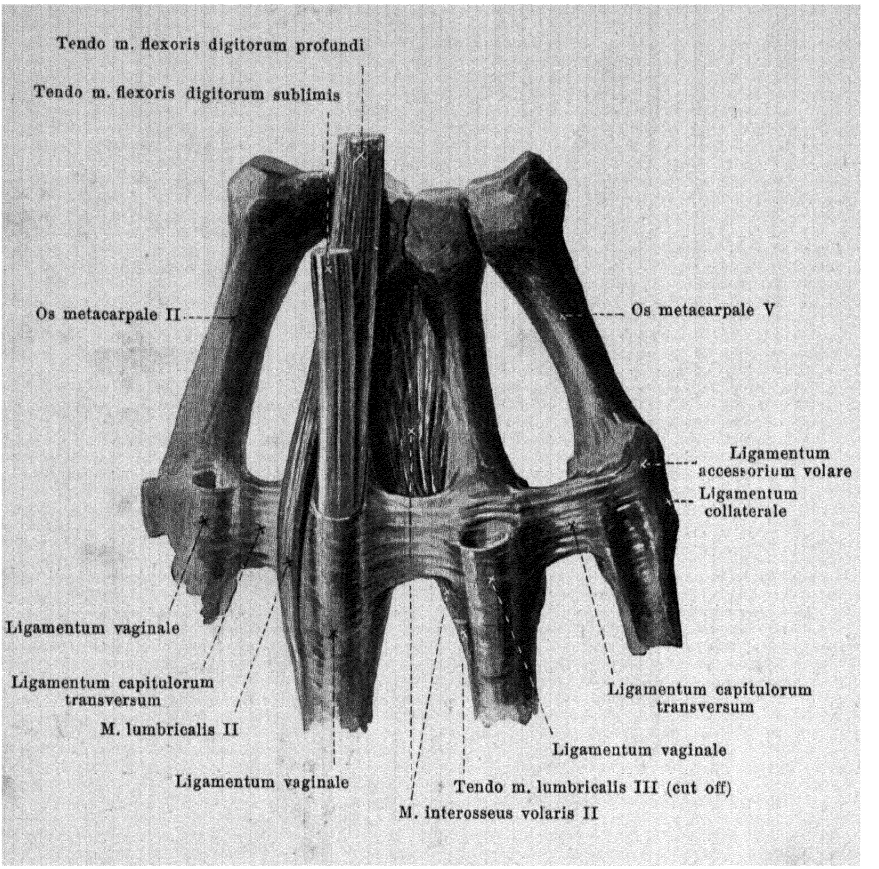
Articulatio manus (continued) (see also Figs. 289 and 290). The joint cavity of the *articulatio radiocarpea* is often connected neither with that of the articulatio radioulnaris distalis nor with that of the articulatio intercarpea (see p. 204).

The slits between the individual joint surfaces of the bones which together form the *articulatio intercarpea* are usually all connected not only with one another, but also between the ossa metacarpea with the joint cavities of the articulationes carpometacarpeae and intermetacarpeae of the second and third fingers. Short, strong *ligamenta metacarpea interossea* extend in the depth in a transverse direction between the neighboring wrist bones of the same row.

The joint cavity of the *articulatio ossis pisiformis* is in about a third of the cases connected with the articulatio radiocarpea.

In the *articulationes carpometacarpeae* of the second and third finger the joint slits are usually connected with those of the articulatio intercarpea, and with those of the *articulationes intermetacarpeae* between the first, second, third and fourth finger; the *articulationes carpometacarpeae* and the *articulatio intermetacarpea* of the fourth and fifth fingers are usually separated from the others, the *articulatio carpometacarpea pollicis* always.

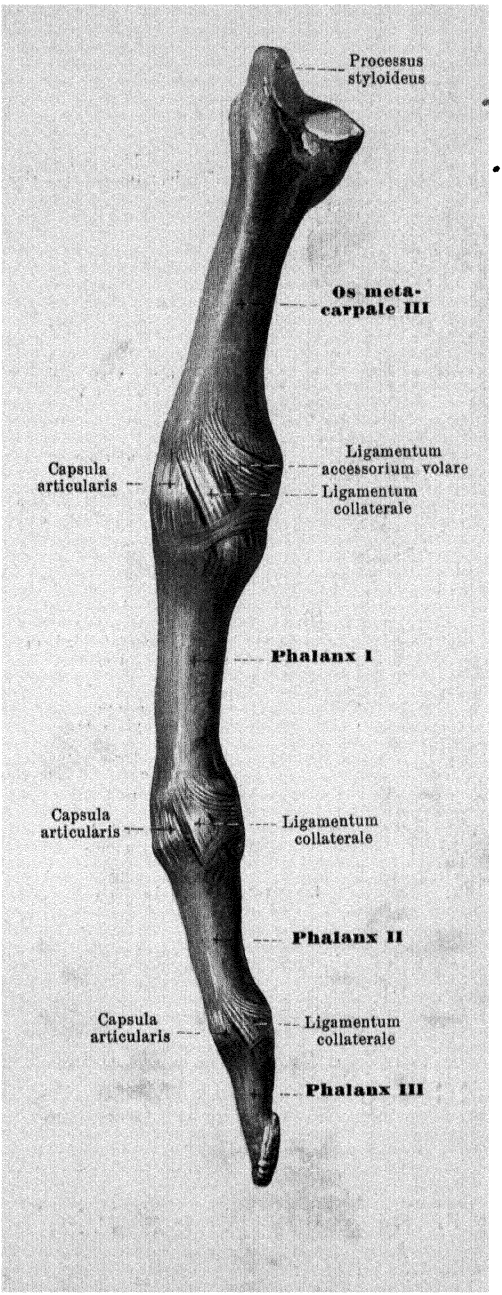
The three *articulationes intermetacarpeae* possess, in the depth, short, transverse *ligamenta basium [ossium metacarpalium] interossea*. The joint capsules go off from the margins of the surfaces covered with cartilage.



292. Metacarpal bones and first phalanges of the second to the fifth finger of the right hand with ligaments, from the volar surface.

In the formation of the **articulationes metacarpophalangeae** (see also Fig. 293) the base of each phalanx I moves upon the capitulum of the os metacarpale. A tolerably loose *capsula articularis* connects the margins of the surfaces covered with cartilage.

Between the heads of the second of the fifth os metacarpale a flat powerful *ligamentum capitulorum [ossium metacarpalium] transversum* (O. T. transverse metacarpal ligament) stretches out transversely over the distal end of the corresponding spatium interosseum metacarpi on the volar surface. It is partially fastened to the lateral surface of the capitulum; in part it goes over into the volar portion of the joint capsule and there connects with the ligamentum accessorium volare and with a small plate of fibrocartilage, which strengthens the joint capsule on the volar side and is connected with the base of the phalanx; in part it helps to form the ligamenta vaginalia for the flexor tendons of the fingers. The ligament separates the distal portions of the mm. interossei from those of the mm. lumbricales in that the former run on the dorsal surface, the latter on the volar surface of it.

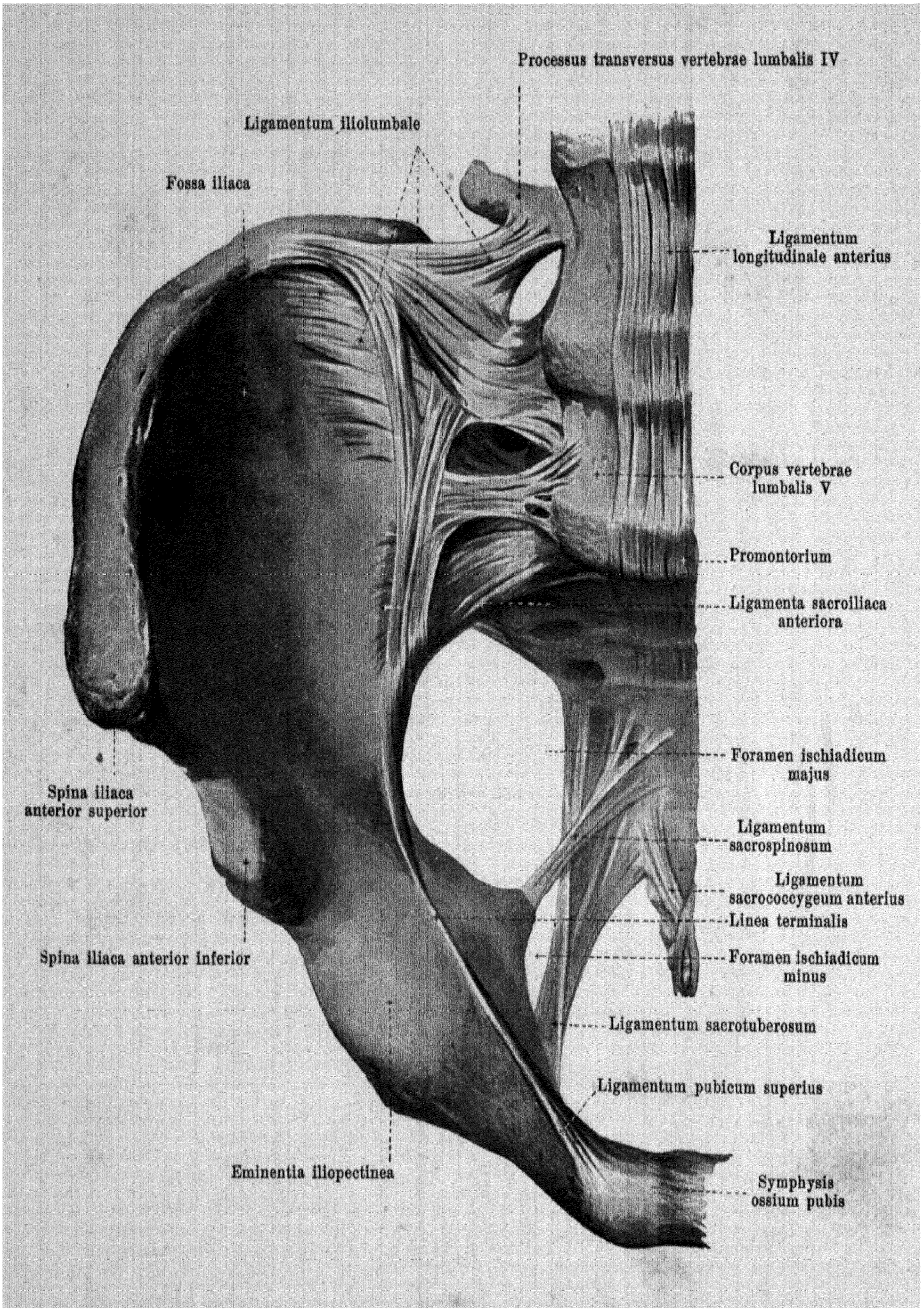


293. Metacarpal bone and phalanges of the third finger of the right hand with ligaments,

from the radial side.

The **articulationes metacarpophalangeae** (continuation. See also Fig. 292) possess a *ligamentum collaterale* (O. T. lateral ligament) as a strengthening ligament, one on the radial and one on the ulnar side which extends from the lateral surface of the capitulum ossis metacarpalis obliquely distalward and volarward to the base of the first phalanx. In addition, a *ligamentum accessorium volare* (O. T. transverse metacarpal ligament) with one limb on each side radial and ulnar, to the capitulum ossis metacarpalis just volarward from the ligamentum collaterale runs arch-like to the volar surface of the joint and touches there the border of the fibrocartilaginous disc (see page 208); on the volar surface it is united with the ligamentum capitulorum transversum (see Fig. 292).

In the formation of the **articulationes digitorum manus** *(finger joints)* the base of each phalanx II is moveably connected with the trochlea of each phalanx I and in the same way the base of each phalanx III with the trochlea of each phalanx II. In the first finger (thumb), only one such joint is present; in the second to the fifth finger always two. Loose *capsulae articulares* connect the margins of the cartilaginous joint surfaces with one another and are strengthened by powerful *ligamenta collateralia* (O. T. lateral ligaments) which run to the radial and ulnar side in a manner entirely analogous to that in the articulationes metacarpophalangeae. Furthermore there are on the volar side of the joints as well as on the metacarpophalangeal joints, small discs of fibrocartilage, inwoven in the joint capsule.



294. Ligaments of the right half of the pelvis,

from in front and somewhat from above.

The **pelvic bones** are connected by means of two joints: — the paired *articulatio sacroiliaca* and the unpaired *symphysis ossium pubis.*

In the **articulatio sacroiliaca** (see also Figs. 295 and 296) the facies auricularis ossis sacri and the facies auricularis ossis ilium of each side are in contact. A short, tight *capsula articularis* connects the margins of the cartilaginous surfaces; it is strengthened on the anterior surface by the *ligamenta sacroiliaca anteriora,* which, considered as a whole, run as broad thin fibre plates from the lateral portion of the basis and facies pelvina of the sacrum transversely to the medial surface of the ilium and are there attached in the periphery of the linea arcuata, eventually also in the sulcus paraglenoidalis.

The *ligamentum iliolumbale* (O. T. iliolumbar ligament) (see also Fig. 295), must also be regarded as a strengthening ligament (in the wider sense) for this joint. This forms a powerful flat fibre band which has its origin from the processus transversus of the fifth (partially also, as in Fig. 294, of the fourth) lumbar vertebra; one part of the fibres extends from there to the posterior portion of the crista iliaca, another larger part broadens out on the inner surface of the ala ossis ilium and on the upper surface of the pars lateralis ossis sacri.

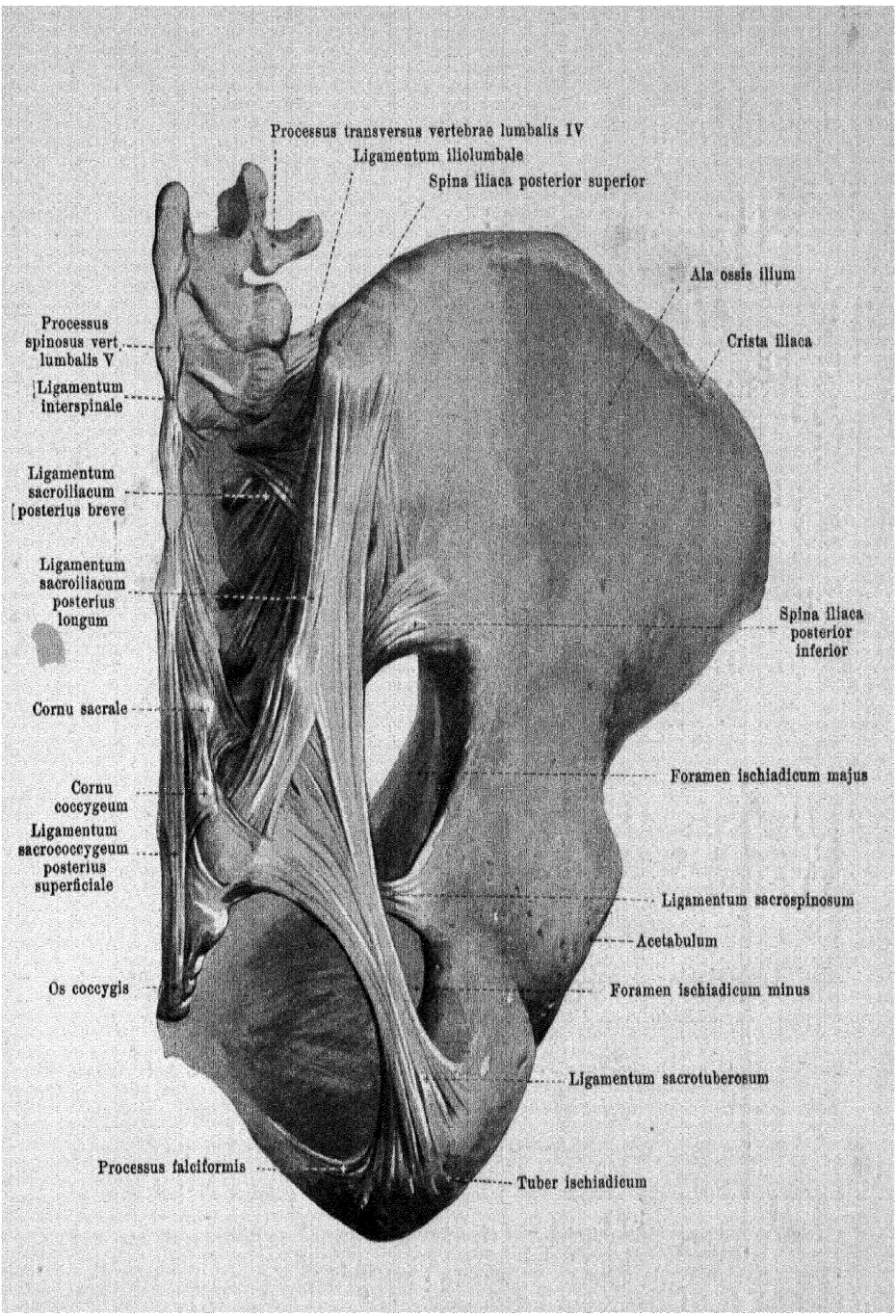
Articulatio sacroiliaca (continued) (see also Figs. 294 and 296). It is strengthened on the posterior surface by the *ligamenta sacroiliaca interossea* (see also p. 214) and the *ligamenta sacroiliaca posteriora breve et longum.* The latter form the broad mass of fibre bands, only indistinctly separated from one another, which ascend obliquely from the region of the crista sacralis lateralis of the sacrum toward the ala ossis ilium where they are attached to the spinae iliacae posteriores and between them, the main mass of them, especially the superficial bands, passing to the spina iliaca posterior superior; of these the fibrous bands which come from the region of the second and third sacral vertebra are called the *ligamentum sacroiliacum posterius breve,* those from the region of the fourth sacral vertebra, the *ligamentum sacroiliacum posterius longum.* These ligaments cover over the ligamenta sacroiliaca interossea completely from behind and lie close upon them.

Of great importance for the form and firmness of the pelvis are also the **ligamentum sacrotuberosum** and the **ligamentum sacrospinosum** (see also Fig. 294).

The *ligamentum sacrotuberosum* (O. T. posterior or great sacrosciatic ligament) arises broad and thin from the spinae iliacae posteriores superior et inferior as well as from the lateral margin of the sacrum and of the two upper coccygeal vertebrae; it is accordingly intimately connected in its upper part with the ligamenta sacroiliaca posteriora. The fibres converge to form a strong flat ligament which extends obliquely forward, downward and lateralward and becomes attached to the medial edge of the tuber ischiadicum where it again broadens out; a narrow band which extends as a continuation of some fibre bundles from this point along the medial margin of the ramus inferior ossis ischii, is called the *processus falciformis* (O. T. falciform ligament).

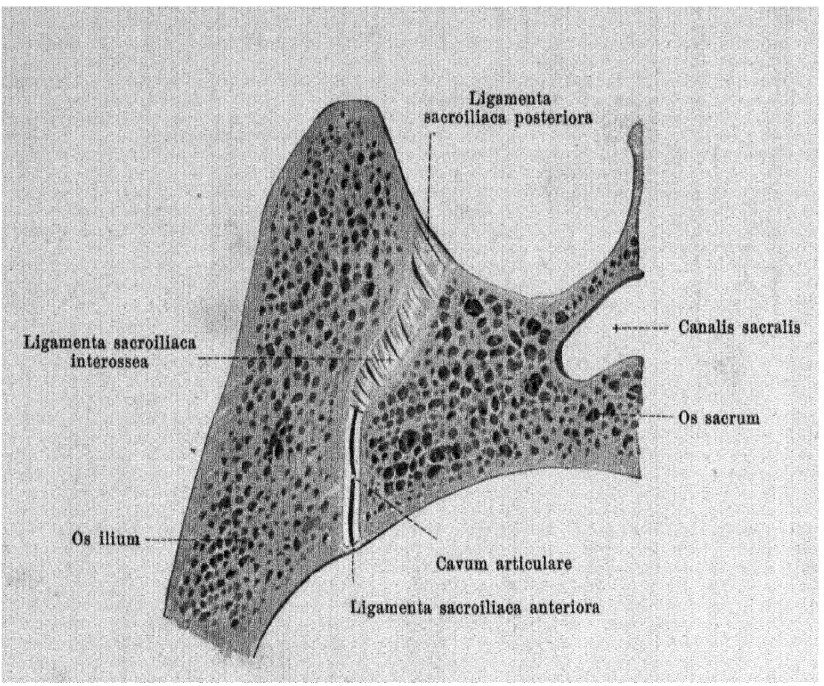
The *ligamentum sacrospinosum* (O. T. anterior or lesser sacrosciatic ligament) is essentially thinner than the preceeding; it arises on the lateral margin of the lower portion of the sacrum and of the upper coccygeal vertebrae, extends past the anterior surface of the ligamentum sacrotuberosum forward and lateralward, narrowing as it goes and is attached to the spina ischiadica; at the point where it crosses the ligamentum sacrotuberosum, it fuses with it. The ligamentum sacrospinosum forms, with the m. coccygeus (see p. 346), a common mass of variable composition; sometimes the connective tissue structures predominate, sometimes the muscle bundles.

The ligamentum sacrotuberosum, as well as the ligamentum sacrospinosum, stretches out medianward from the two incisurae ischiadicae (or between them) so that these notches are transformed into foramina which are surrounded partly by bone, partly by ligaments; the incisura ischiadica major becomes the rounded quadrangular *foramen ischiadicum majus* (O. T. great sacrosciatic foramen), the incisura ischiadica minor the triangular *foramen ischiadicum minus* (O. T. lesser sacrosciatic foramen) (see also Fig. 294).



295. Ligaments of the right half of the pelvis,

from behind.

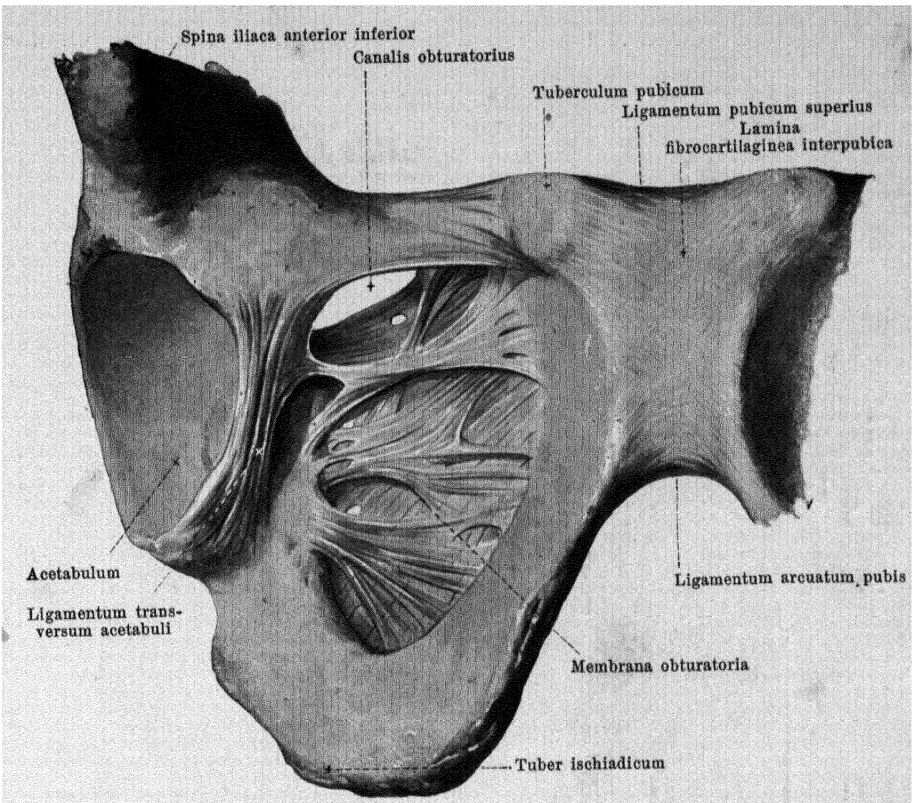


296. Articulatio sacroiliaca dextra, frontal section.

Posterior half of section, from in front.

Articulatio sacroiliaca (continued) (see also Figs. 294 and 295). It possesses an unevenly curved joint slit; the adjoining articular surfaces are completely covered by cartilage and smooth, but they present several irregular projections which fit in to corresponding depressions of the other bone.

On the dorsal surface there are present, as strengthening ligaments, the *ligamenta sacroiliaca interossea.* Under this name are included the mass of short fibre bands which are covered over completely behind by the ligamenta sacroiliaca posteriora and which extend obliquely upward and backward from the tuberositas sacralis [ossis sacri] to the tuberositas iliaca [ossis ilium], eventually, also to the sulcus paraglenoidalis; they fill completely the irregular depression which is situated behind the joint cavity between these two rough surfaces, and are not visible in the uninjured joint.

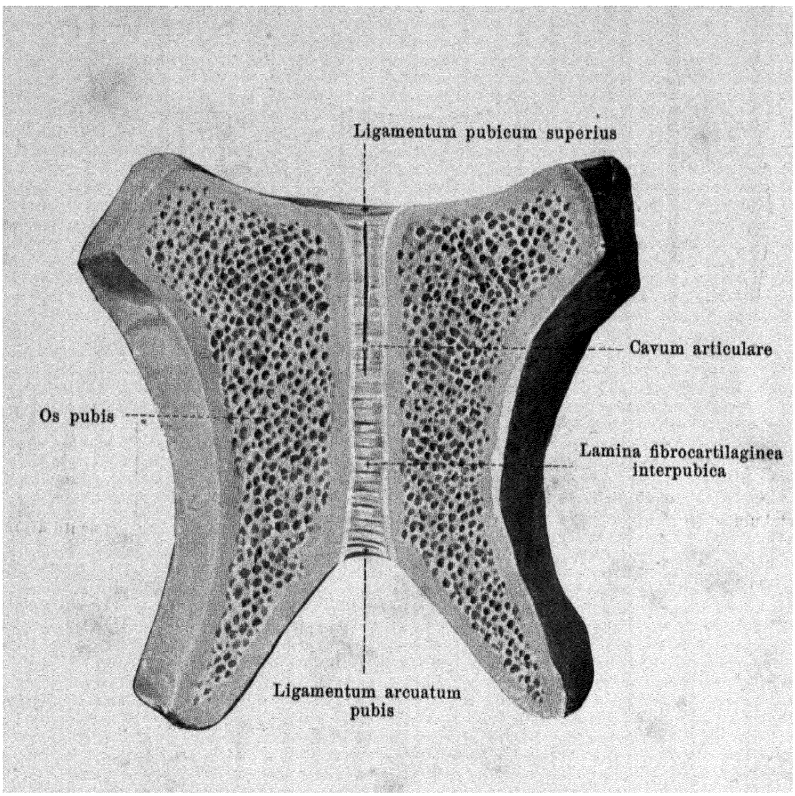


297. Symphysis pubis and right half of pelvis with ligaments, from in front and below.

(Only those fibres of the labrum glenoidale which form the ligamentum transversum acetabuli have been retained.)

The **membrana obturatoria** is usually a thin fibre plate which almost completely closes the foramen obturatum. The fibres arise from the margins of the foramen, coming in the lower and posterior part from the posterior surface of the same. The direction of the fibres is usually transverse. The uppermost bands stretch out below the sulcus obturatorius between the tubercula obturatoria and transform this groove into the short ***canalis obturatorius*** (for the a. and vv. obturatoriae; n. obturatorius). Variably developed bands of fibres, which lie upon the membrane externally, are connected with the capsule of the hip joint and with the ligamentum transversum acetabuli.

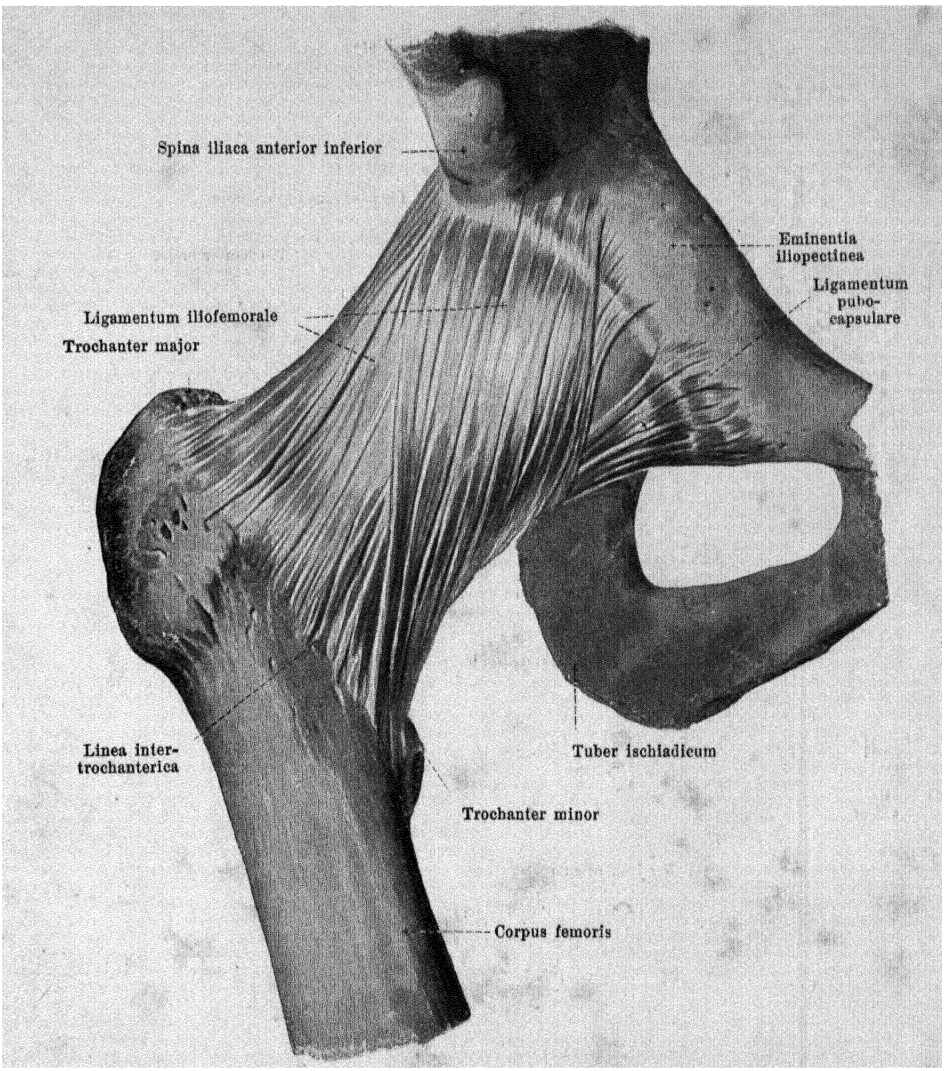
In the unpaired **symphysis ossium pubis** (see also Fig. 298), the two pubic bones are united with one another in the median plane. Between the opposing rough facies symphyseos, which are covered over with a layer of hyaline cartilage, is intercalated a fibrocartilaginous disc ***(lamina fibrocartilaginea interpubica)*** (O. T. interpubic disc). This projects somewhat on the posterior surface as a narrow ridge; in front it broadens essentially and is covered by a layer of decussating fibres which are connected with the tendons of the mm. recti abdominis. The uppermost, transverse fibre layer stretches out between the upper margins of the rami superiores of the pubic bones or rather between the tubercula pubica, and is called the ***ligamentum pubicum superius;*** lateralward it is continued behind the tuberculum pubicum as a ridge upon the pecten ossis pubis (see Fig. 294) and there gives origin to a part of the m. pectineus. The sharp-angled triangular fibrous band which extends from the ramus inferior of one pubic bone to that of the other on the lower margin of the symphysis and which, above, is fused with the fibrocartilaginous disc, is called the ***ligamentum arcuatum pubis*** (O. T. subpubic ligament).



298. Symphysis pubis, opened by a frontal section.

Posterior half, viewed from in front.

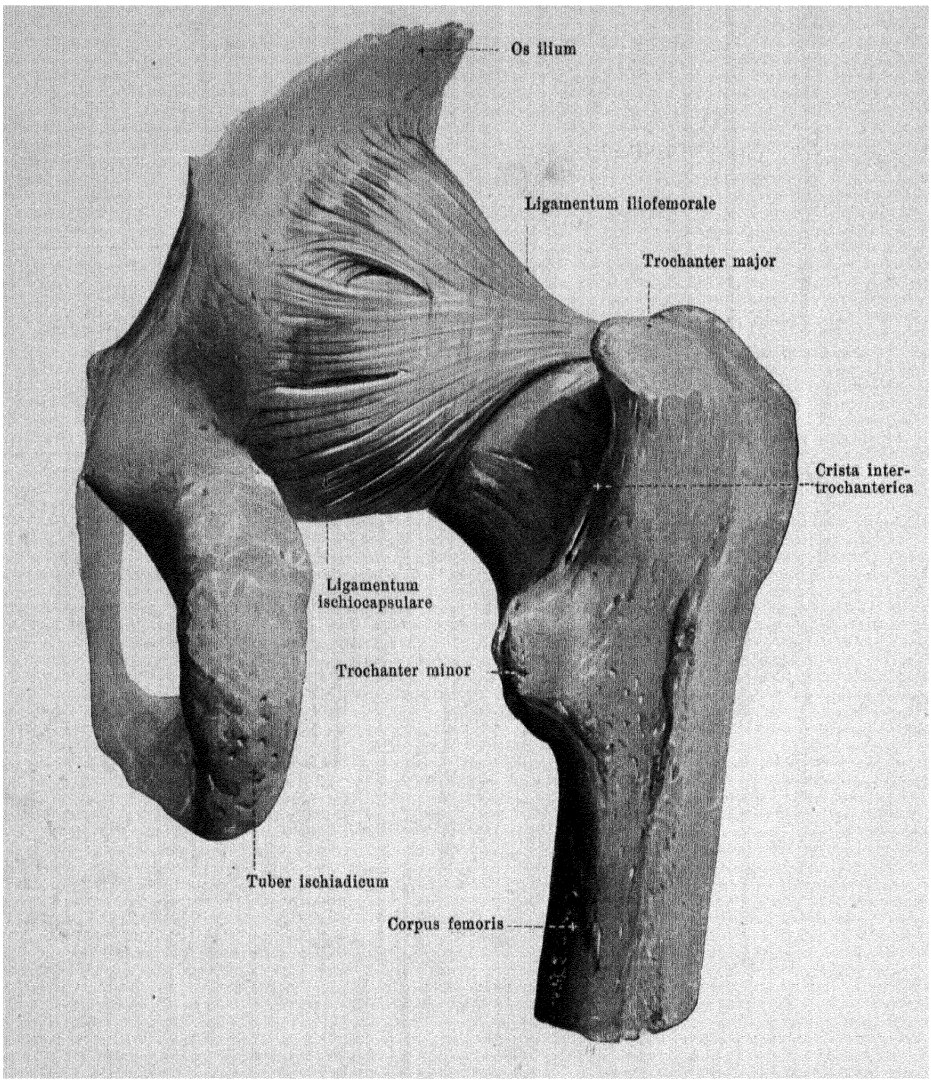
Symphysis ossium pubis (continued) (see also Fig. 297). It contains nearly constantly within its *lamina fibrocartilaginea interpubica* a small medianly situated joint slit which lies nearer the posterior margin than the anterior and extends almost over the upper half of the fibrocartilaginous mass; the joint-slit is larger in the female than in the male. The strands of fibrocartilage run in the depth, mostly transversely, between the two layers of hyaline cartilage and are seen on median section to consist of concentrically arranged circular layers. Cartilage and fibrocartilage are very firmly united with one another.



299. Rigth hip joint, *articulatio coxae*, from in front.

In the formation of the **articulatio coxae** *(hip joint)* (see also Figs. 300—303) the caput femoris moves upon the facies lunata of the acetabulum. The latter is enlarged by means of a high three-cornered connective-tissue ring, ***labrum glenoidale*** (O. T. cotyloid ligament) (see Figs. 301 and 303) which sits with its broad base upon the border of the acetabulum and bridges over the incisura acetabuli as the ***ligamentum transversum acetabuli;*** this has also a broad attachment to the margins of the incisura acetabuli and is connected with the fibres of the membrana obturatoria (see Fig. 297).

The ***capsula articularis*** (see Fig. 303) is strengthened on the anterior surface by the strong triangular ***ligamentum iliofemorale.*** It arises below and near the spina iliaca anterior inferior, broadens gradually and is fastened to the linea intertrochanterica in its whole length. The ***ligamentum pubocapsulare*** (O. T. pubofemoral ligament) lies on the medial, inferior side of the joint, comes from the corpus and ramus superior ossis pubis and runs partly to the upper margin of the trochanter minor, partly to the capsule in the same region.

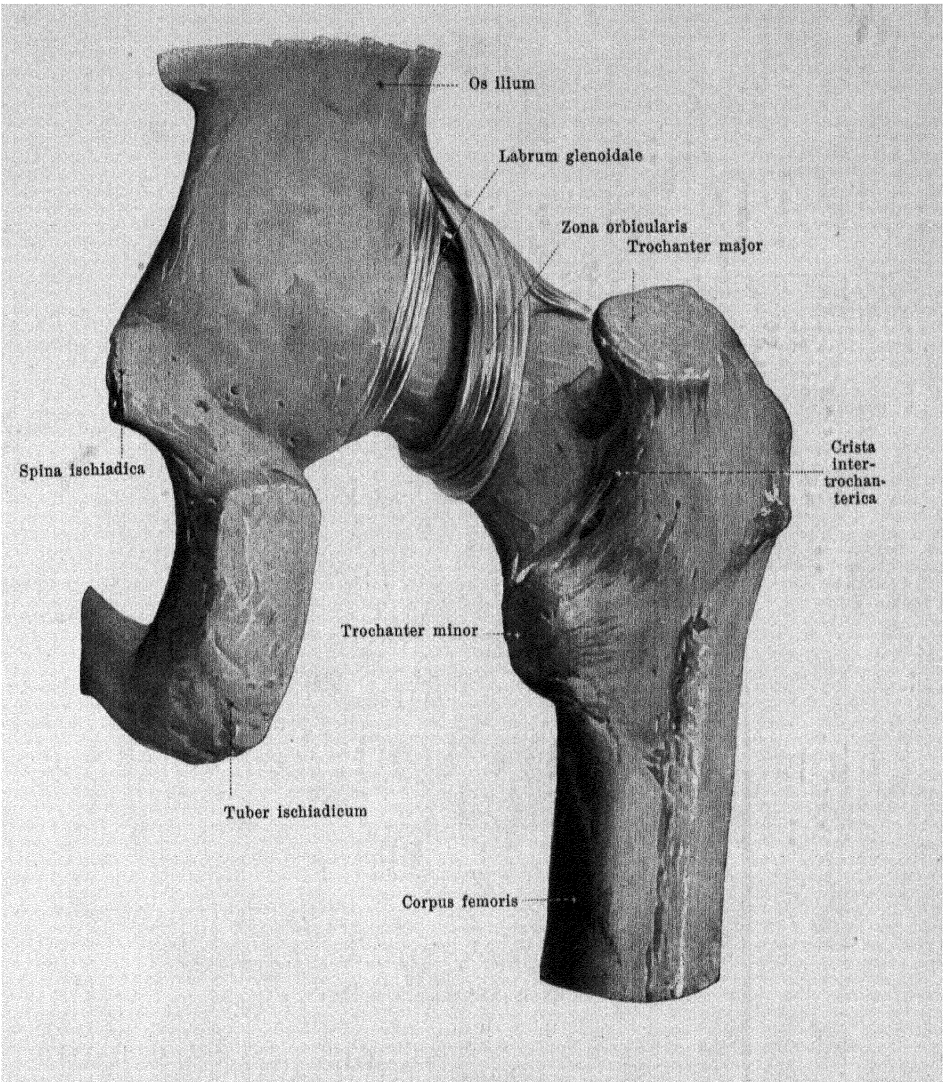


300. Right hip joint, *articulatio coxae*, from behind.

(The joint capsule, except for the strengthening ligaments, has been removed.)

Articulatio coxae (continued) (see also Figs. 299, 301—303). It possesses, as a strengthening ligament of the posterior wall of the capsule, the ***ligamentum ischiocapsulare***. This broad, thick ligament arises externally along the margin of the acetabulum in the whole extent of the corpus ossis ischii; its fibres converge somewhat, run obliquely upward and lateralward and become attached for the most part to the zona orbicularis; part of them reach even to the anterior margin of the trochanter major.

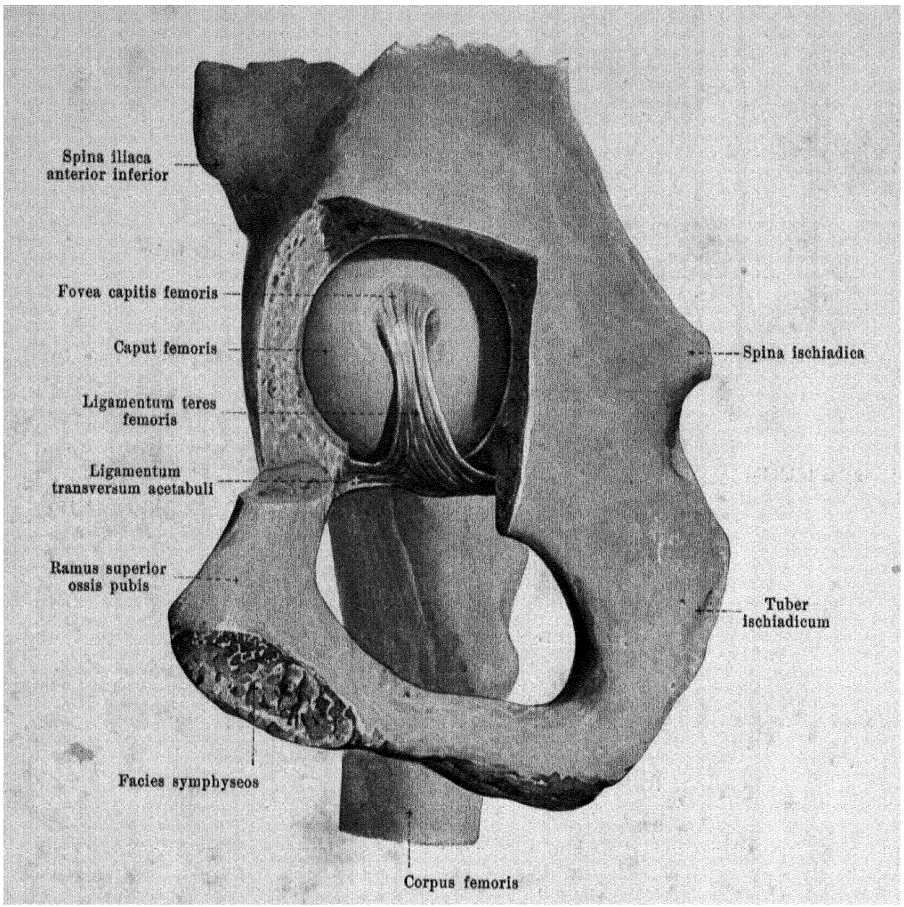
Between the ligamenta iliofemorale, pubocapsulare and ischiocapsulare, the capsule is essentially thinner in three places; these places correspond to the points where the bones forming the acetabulum fuse with one another.



301. Right hip joint, *articulatio coxae*, from behind.

(The superficial layer of the capsule and the ligamentum ischiocapsulare have been removed.)

Articulatio coxae (continued) (see also Figs. 299, 300, 302 and 303). Its capsule is strengthened in the depth by the *zona orbicularis* (see also Fig. 303). This band of fibres, covered over completely by the other ligaments, but connected with them, is strongest and most distinct above, behind and below; it surrounds the neck of the femur like a ring and is connected above with the bone below the spina iliaca anterior inferior. It extends therefore, essentially like a loop, from this point, downward in front of the neck, then behind the same and thence, back again, upward to its starting point; its lateral margin is formed of fibres which run purely circularly.

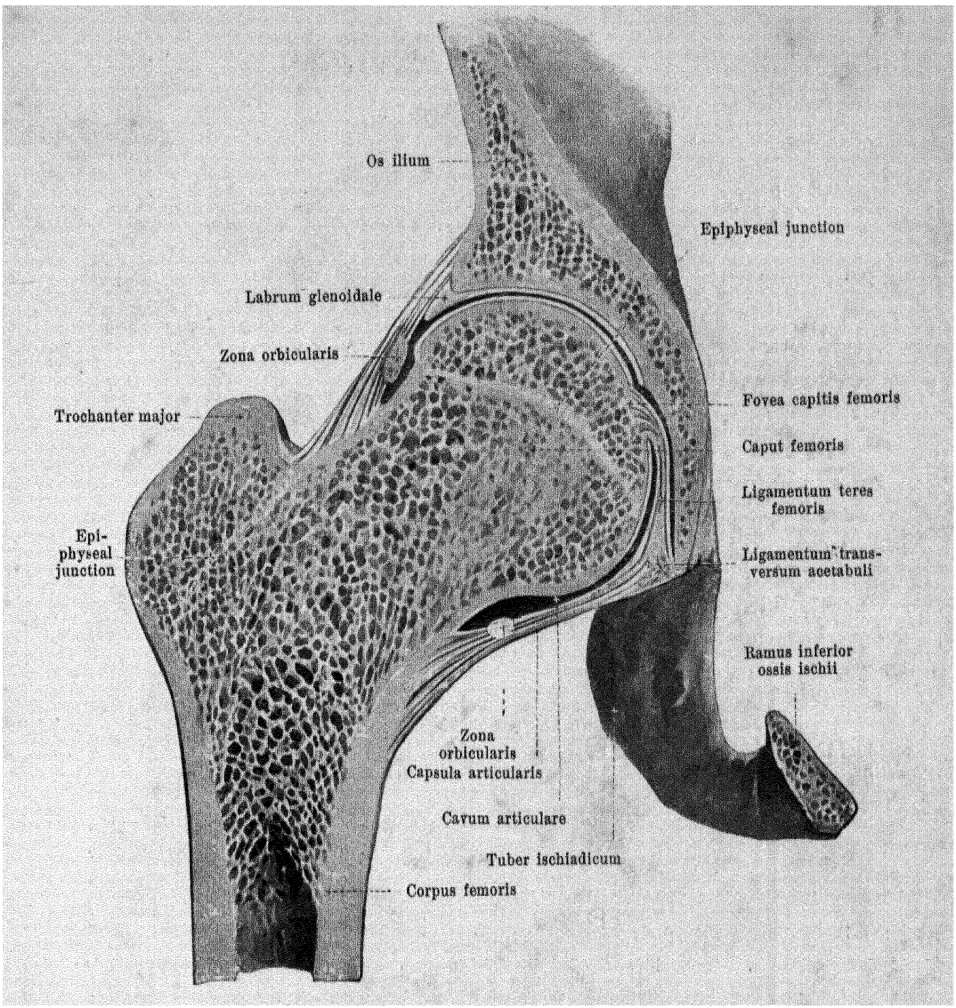


302. Right hip joint, *articulatio coxae,*

from the medial side.

(The bottom of the acetabulum has been chiselled away sufficiently to make the head of the femur visible.)

Articulatio coxae (continued) (see also Figs. 299—301 and 303). Hidden inside it is the *ligamentum teres femoris* (see also Fig. 303). This flatly rounded ligament arises by a broad origin in the neighborhood of the incisura acetabuli and from the ligamentum transversum acetabuli, becomes narrow above and is attached in the fovea capitis femoris. It lies in the fossa acetabuli between its floor and the medial inferior surface of the head of the femur so that the posterior margin of the ligament, when the body is upright, is approximately vertical in direction. The ligamentum teres is covered over by the stratum synoviale of the capsula articularis. Very rarely it may be very thin or may be absent altogether.

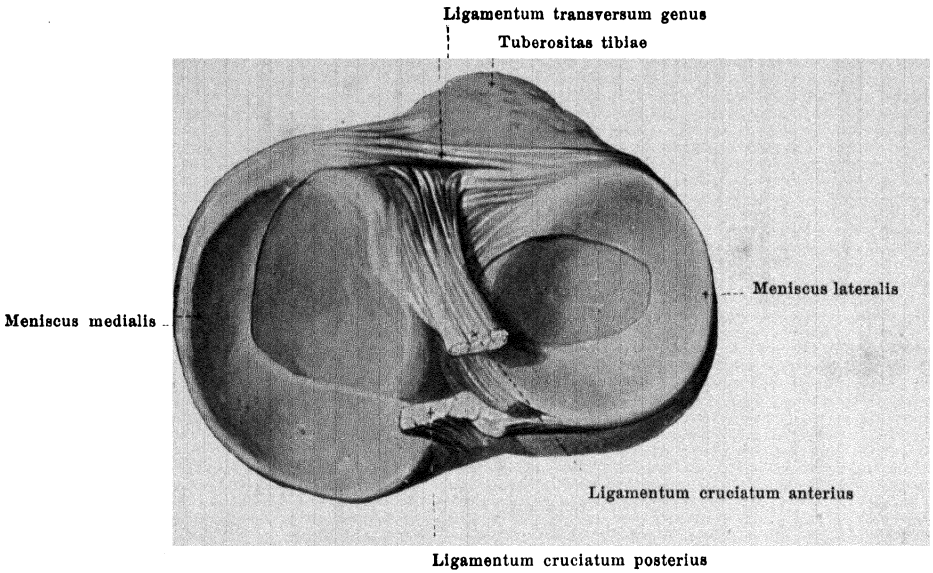


303. Right hip joint, *articulatio coxae.*

Frontal section through the same. Posterior half of section, viewed from in front.

(The joint surfaces have been somewhat pulled apart.)

Articulatio coxae (continued) (see also Figs. 299—302). Its *capsula articularis* arises at the margin of the acetabulum, chiefly outside the labrum glenoidale so that this lies more or less completely within the joint cavity. The capsule is attached to the femur in front close above the linea intertrochanterica, behind to the neck of the femur medianward from the crista intertrochanterica in a line parallel to the latter so that somewhat more than the medial half of the posterior surface of the neck of the femur looks into the joint capsule. The stratum synoviale of the capsule is continued upon the ligamentum teres and encloses this like a sheath. The fossa acetabuli is almost completely filled up by masses of fat, synovial villi and the ligamentum teres.



304. Right knee joint, *articulatio genus.*

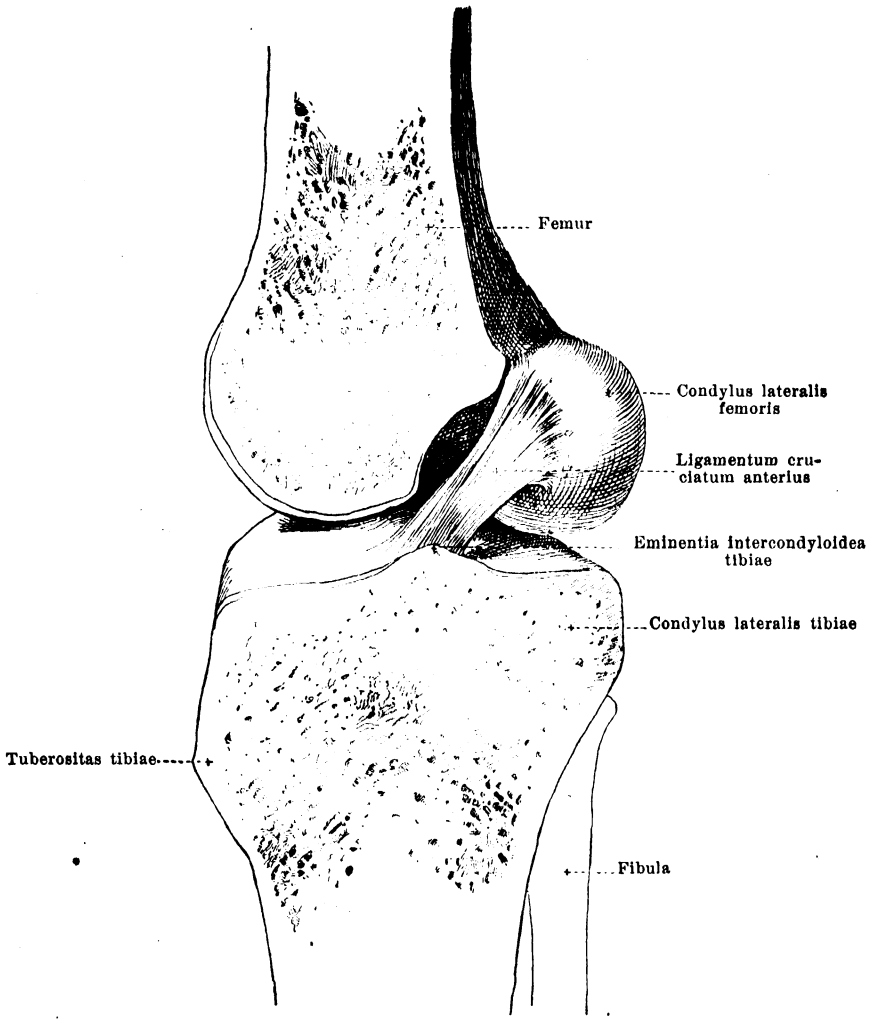
Tibia with cartilaginous discs, from above.

In the formation of the **articulatio genus** *(knee joint)* (see also Figs. 305—312) the two condyli femoris move upon the condyli tibiae. Within the *capsula articularis* enclosing the joint, between the two bones, two sickle-shaped connective-tissue discs are intercalated, the *meniscus lateralis* and the *meniscus medialis* (see also Figs. 306—308 and 311). These are firmly connected at their extremities, by connective tissue strands with the tibia. Each meniscus is triangular on cross section (see Fig. 311); its two smooth sides lie one on the condylus tibiae, the other on the condylus femoris; these two sides meet in a sharp concave margin; its third, narrowest side is directed toward the outer circumference of the joint and is fused with its capsule.

The *meniscus lateralis* (O. T. external semilunar fibrocartilage) is somewhat shorter and more circular; it arises anteriorly (see also Fig. 224) close in front of the eminentia intercondyloidea tibiae, directly in front of the tuberculum intercondyloideum laterale, and is fastened by its posterior extremity to the posterior slope of the eminentia intercondyloidea, chiefly to the tuberculum intercondyloideum laterale, and a part of its bundles of fibres with the tuberculum intercondyloideum mediale.

The *meniscus medialis* (O. T. internal semilunar fibrocartilage) is longer, broader, and more sickle-shaped (see also Fig. 224); it arises anteriorly in front of the fossa intercondyloidea anterior from the margo infraglenoidalis and is attached behind in the fossa intercondyloidea posterior.

Between the most anterior points of the two menisci is stretched out the thin rounded *ligamentum transversum genus* (see also Figs. 306 and 307), which is composed of connective tissue, which pretty frequently is poorly developed and often is absent altogether.

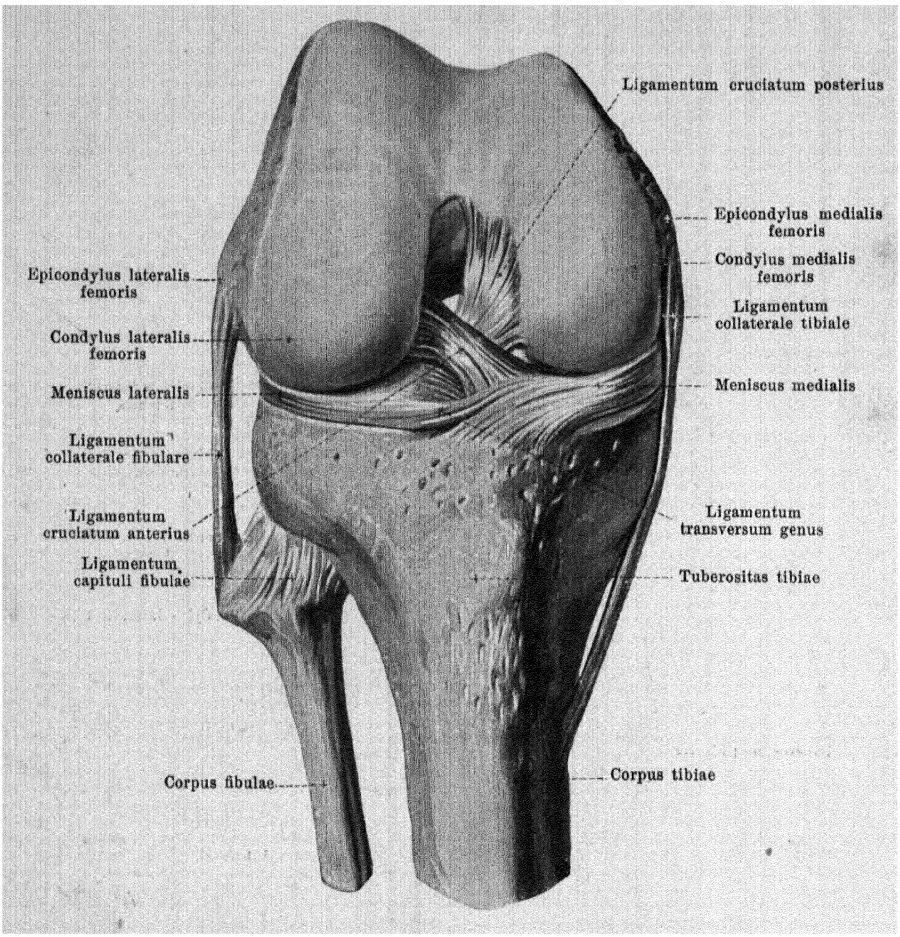


305. Right knee joint, *articulatio genus.*

Sagittal section at about the middle of the joint. Lateral half, viewed from the medial side; somewhat schematic.

(The meniscus lateralis has been removed.)

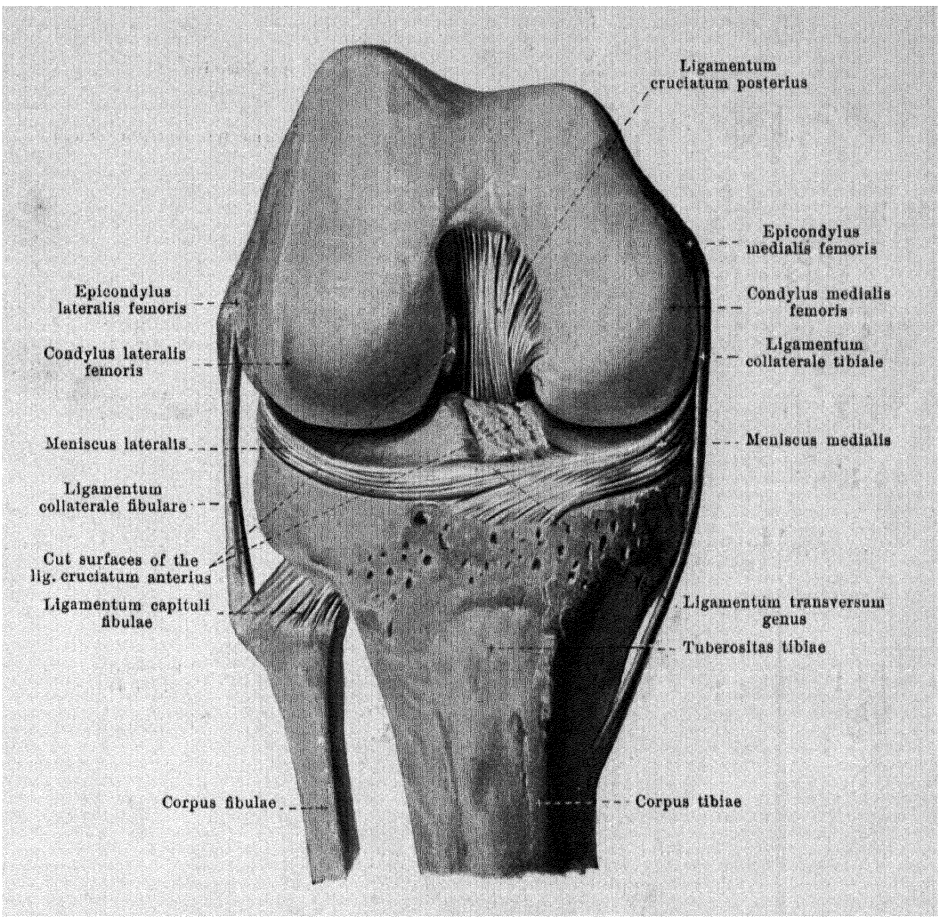
Articulatio genus (continued) (see also Figs. 304, 306—308 and 310). It has inside it the *ligamenta cruciata genus anterius et posterius.* Each of these goes from the surface turned toward the fossa intercondyloidea of one condylus femoris downward to the region of the eminentia intercondyloidea tibiae; in the extended position the anterior ligament is directed obliquely forward, the posterior somewhat obliquely backward. Together they assume the form of an X and are connected by loose connective tissue and fat not only with one another, but also with the posterior wall of the capsula articularis. They are ensheathed by synovial membrane.



306. Right knee joint, *articulatio genus,* from in front.

(The knee is flexed at a right angle; the patella and the capsule of the joint have been removed.)

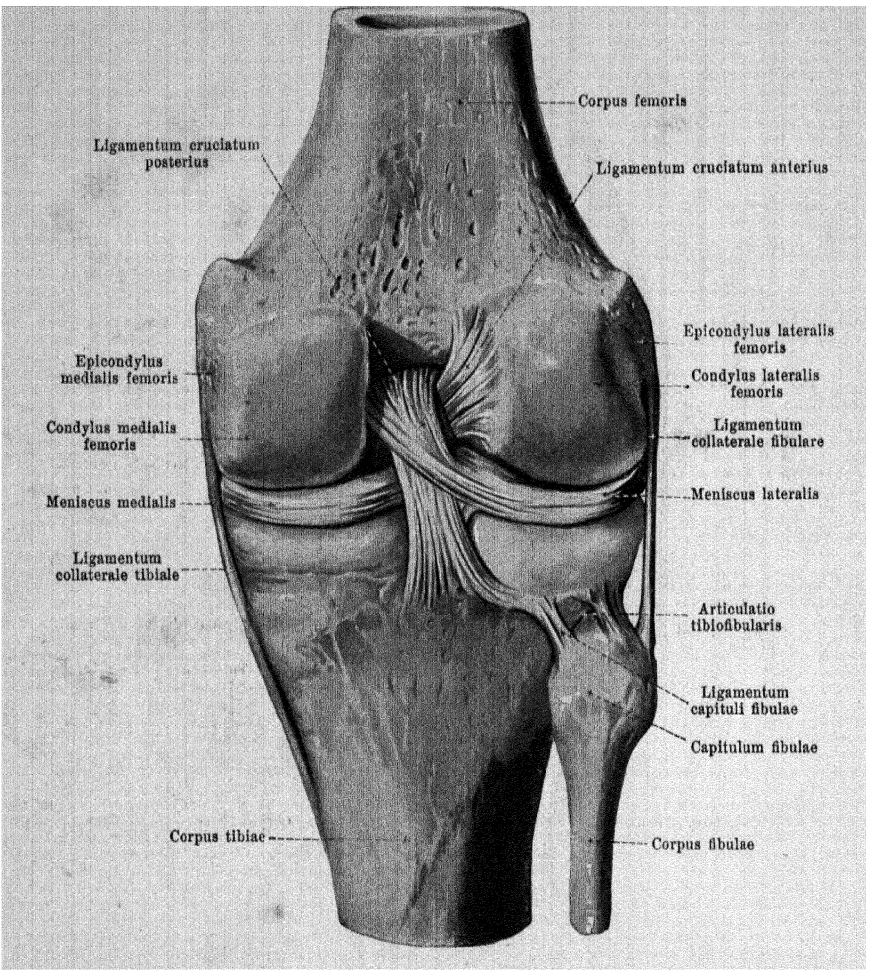
Articulatio genus (continued) (see also Figs. 304, 305 and 308). The ***ligamentum cruciatum anterius*** (O. T. anterior or external crucial ligament) (see also Figs. 304, 305 and 308) has a broad origin on the non-cartilaginous, medial surface of the condylus lateralis femoris, near its posterior margin. From there on it becomes narrower, passes as a flatly rounded bundle obliquely forward, downward, and medianward and is attached especially to the tuberculum intercondyloideum mediale and in the fossa intercondyloidea anterior tibiae (see also Fig. 224).



307. Right knee joint, *articulatio genus*, from in front.

(The knee is flexed at a right angle; the patella and the capsule of the joint have been removed, the ligamentum cruciatum anterius has been cut off short at its points of attachment.)

Articulatio genus (continued) (see also Figs. 304–306, 308–312). The ***ligamentum cruciatum posterius*** (O. T. posterior or internal crucial ligament) lies behind the ligamentum cruciatum anterius, crosses the same and is somewhat stronger. It has a broad origin from the lateral surface of the condylus medialis femoris close to its anterior and inferior margin, narrows to a flatly rounded cord and passes somewhat obliquely downward, backward, and lateralward to the fossa intercondyloidea posterior tibiae and to the posterior surface of the tibia (see also Fig. 224); one band of fibres, arising in the medial portion, runs behind the ligament obliquely lateralward to the posterior part of the meniscus lateralis (see Fig. 308).



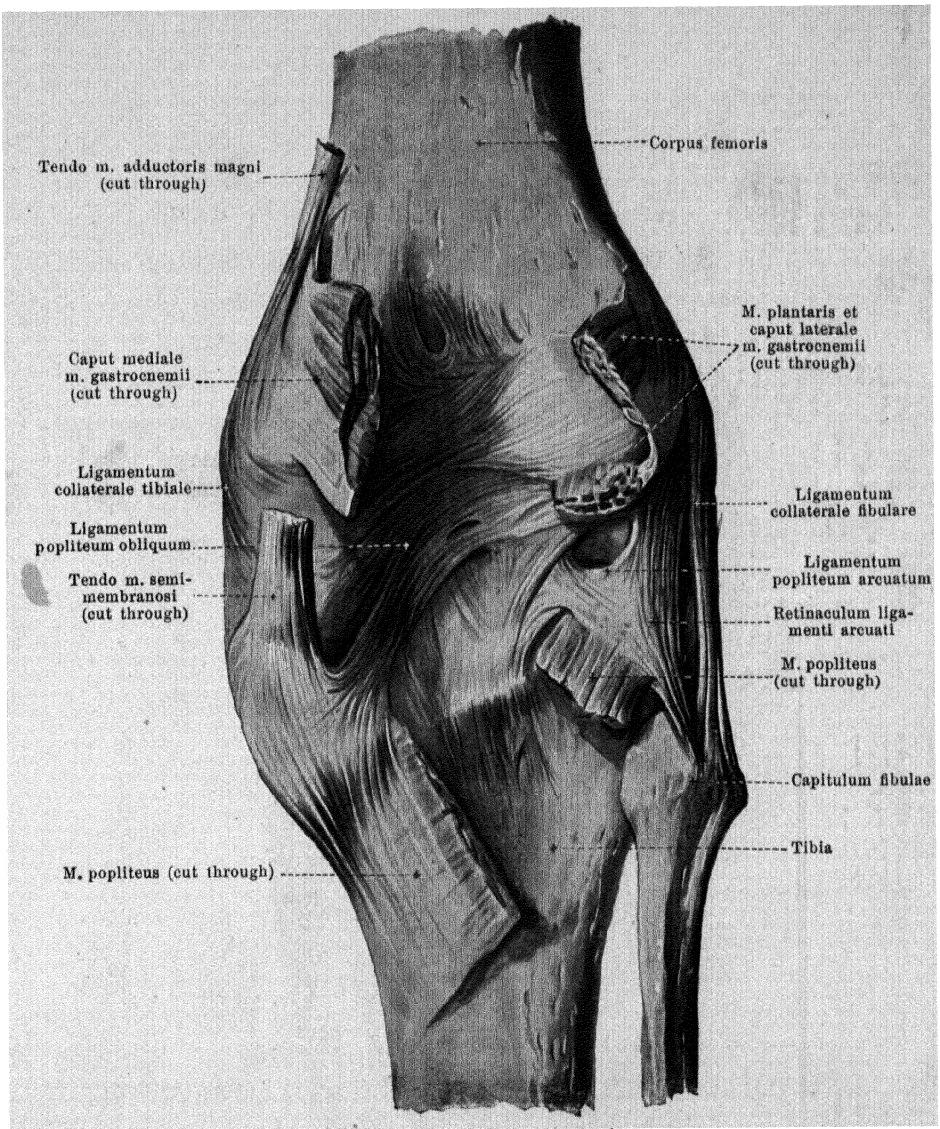
308. Right knee joint, *articulatio genus,* from behind.

(The capsule, except for the strengthening ligaments, has been removed.)

Articulatio genus (continued) (see also Figs. 304—307, 309—312). The ligaments which serve to strengthen the capsule laterally are called the *ligamenta collateralia fibulare et tibiale.*

The *ligamentum collaterale fibulare* (O. T. long external lateral ligament) is a rounded fibrous cord, which, when the knee is extended, is stretched out tight from the epicondylus lateralis femoris to the lateral surface of the capitulum fibulae. It is separated by fatty tissue from the capsule of the joint and by the tendon of the m. popliteus and the bursa m. poplitei from the meniscus lateralis and from the a. genus inferior lateralis which runs upon the meniscus.

The *ligamentum collaterale tibiale* (O. T. internal lateral ligament) is a broader, flat ligament which extends from the epicondylus medialis femoris to the medial portion of the margo infraglenoidalis and thence further downward. It is interwoven in the wall of the capsule and is partly attached also to the meniscus medialis. Below, it covers over the a. genus inferior medialis, which lies directly upon the bone.



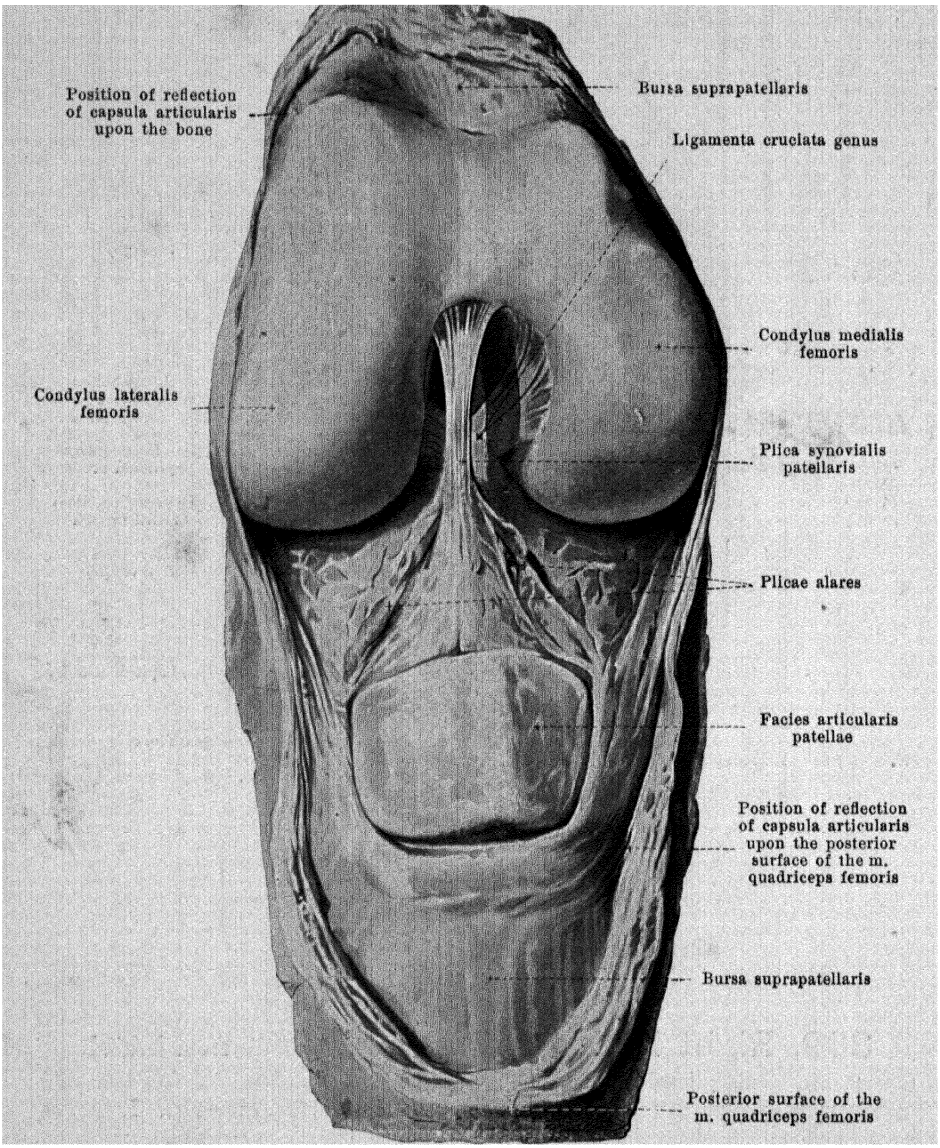
309. Right knee joint, *articulatio genus*, from behind.

(The muscles partially fused with the capsule have been cut off, close to their attachment.)

Articulatio genus (continued) (see also Figs. 304—308, and 310—312). It has, on the posterior surface, the following strengthening ligaments:

The powerful, flat *ligamentum popliteum obliquum* (O. T. posterior ligament) extends from the region of the condylus lateralis femoris obliquely medianward and downward; its fibres become lost, partially descending in the wall of the capsule and in the fascia of the m. popliteus, partially by bending around upward and going over into the tendon of the m. semimembranosus.

The *ligamentum popliteum arcuatum* is a somewhat variable, usually horse-shoe shaped band of fibres, concave above, which arises in the region of the epicondylus lateralis femoris and becomes lost in the middle of the posterior wall of the capsule below the ligamentum popliteum obliquum. From the convex circumference of the ligament the *retinaculum ligamenti arcuati* goes off with two converging limbs; it has a narrow attachment to the capitulum fibulae; from the same place, also a part of the m. popliteus arises.

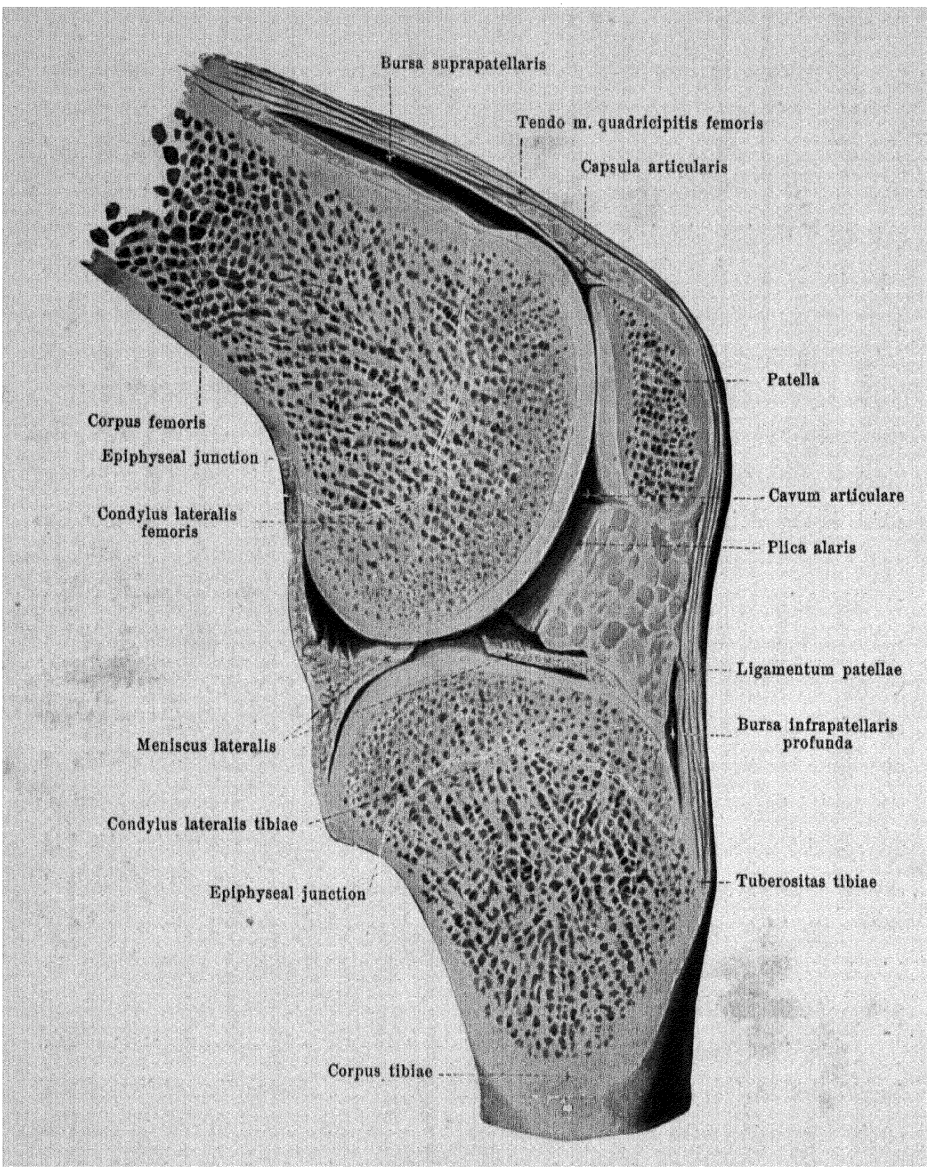


310. Right knee joint, *articulatio genus*, from in front.

(After cutting through the capsula articularis close to the bone the tendinous expansion of the m. quadriceps femoris along with the patella have been turned down in front; the knee is flexed.)

Articulatio genus (continued) (see also Figs. 304—309, 311 and 312). The *capsula articularis* (see also Figs. 311 and 312) extends over the posterior surface of the common tendon of the m. quadriceps femoris in front close above the patella and goes over at the border of the patella upon the latter so that the whole facies articularis patellae looks into the joint cavity. Thence the capsule runs as a loose membrane separated by abundant fatty tissue from the ligamentum patellae and from the adjoining parts of the retinacula patellae to the upper margins of the two menisci and to the inferior attachment of the ligamentum cruciatum anterius. It then encloses the two ligamenta cruciata genus in a common sheath and goes over at the posterior margin of the ligamentum cruciatum posterius into the posterior wall; thus the two ligamenta cruciata genus form with the surrounding synovial membrane a sort of wall of separation which is shoved in from behind into the joint cavity, dividing this, behind, into a medial and a lateral compartment. From the medial and lateral margin of the facies articularis patellae project two prominent, fatty, synovial folds, *plicae alares* (O. T. ligamenta alaria) which converge below; they are often studded with synovial villi. At the angle of union of the same there arises a very variable, simple, larger, often fatty, fold, the *plica synovialis patellaris* (O. T. ligamentum mucosum), which extends backward, in a sagittal direction, free through the joint cavity to become attached at the lowermost margin of the fossa intercondyloidea femoris; it is the anterior margin of a large sagittal fold of the synovial membrane, originally present, ensheathing the ligamenta cruciata; this fold extends from the posterior capsular wall, without interruption, as far as the patella and divides the joint-cavity from behind into two chambers, corresponding to the two pairs of joint-tuberosities, communicating in front of the fold. This original condition may be preserved wholly or in part.

The joint cavity is continued upward in the majority of cases directly into the *bursa [mucosa] suprapatellaris.* This large bursa lies between the anterior surface of the lower end of the femur which has only a slight covering of fat and the posterior surface of the common tendon of the m. quadriceps femoris (see Figs. 311 and 312); it is intimately fused with the latter and separated from the joint cavity, usually only incompletely and indistinctly, by a projecting fold (see Fig. 312). In rarer cases the bursa is completely shut off so that no connection exists between the two cavities, and it then becomes displaced for a variable distance from above downward in front of the capsule of the joint.



311. Right knee joint, *articulatio genus.*

Sagittal section through the condylus lateralis femoris.
Medial half of section, from the lateral side.

(The knee is slightly flexed; the joint surfaces have been pulled a little apart.)

Articulatio genus (continued) (see also Figs. 304—310 and 312). The *capsula articularis* passes in front from the posterior surface of the tendon of the m. quadriceps femoris (see p. 229) to the anterior surface of the femur above the joint tuberosities. The fold of the capsule at the sides runs near the margin of the cartilaginous coating, so that the region of the epicondyli remains free (see Fig. 312); the capsule therefore covers the cartilaginous surfaces and a part of the anterior surface of the femur which is not covered by cartilage.

To the tibia the capsule is attached around the margo infraglenoidalis, a little below the margin of the cartilaginous surfaces; thence it goes to the lower margin of each of the two menisci, lines its lower and upper surfaces and from its upper margin passes in front to the posterior surface of the patella and of the tendon of the m. quadriceps femoris (see p. 229), laterally and behind to the point of reflection on the femur.

The *ligamentum patellae* (see also Fig. 312) is a flat, very strong ligament, which goes off from the lower margin and the anterior surface of the patella and, narrowing slightly, becomes attached to the tuberositas tibiae (see also Fig. 224); it is separated from the capsula articularis by thick masses of fat. The ligament is partially a direct continuation of the tendinous fibres of the m. quadriceps femoris running over the patella and can accordingly be considered as the terminal tendon of this muscle; in this sense the patella itself has to be thought of as a large sesamoid bone intercalated in this tendon.

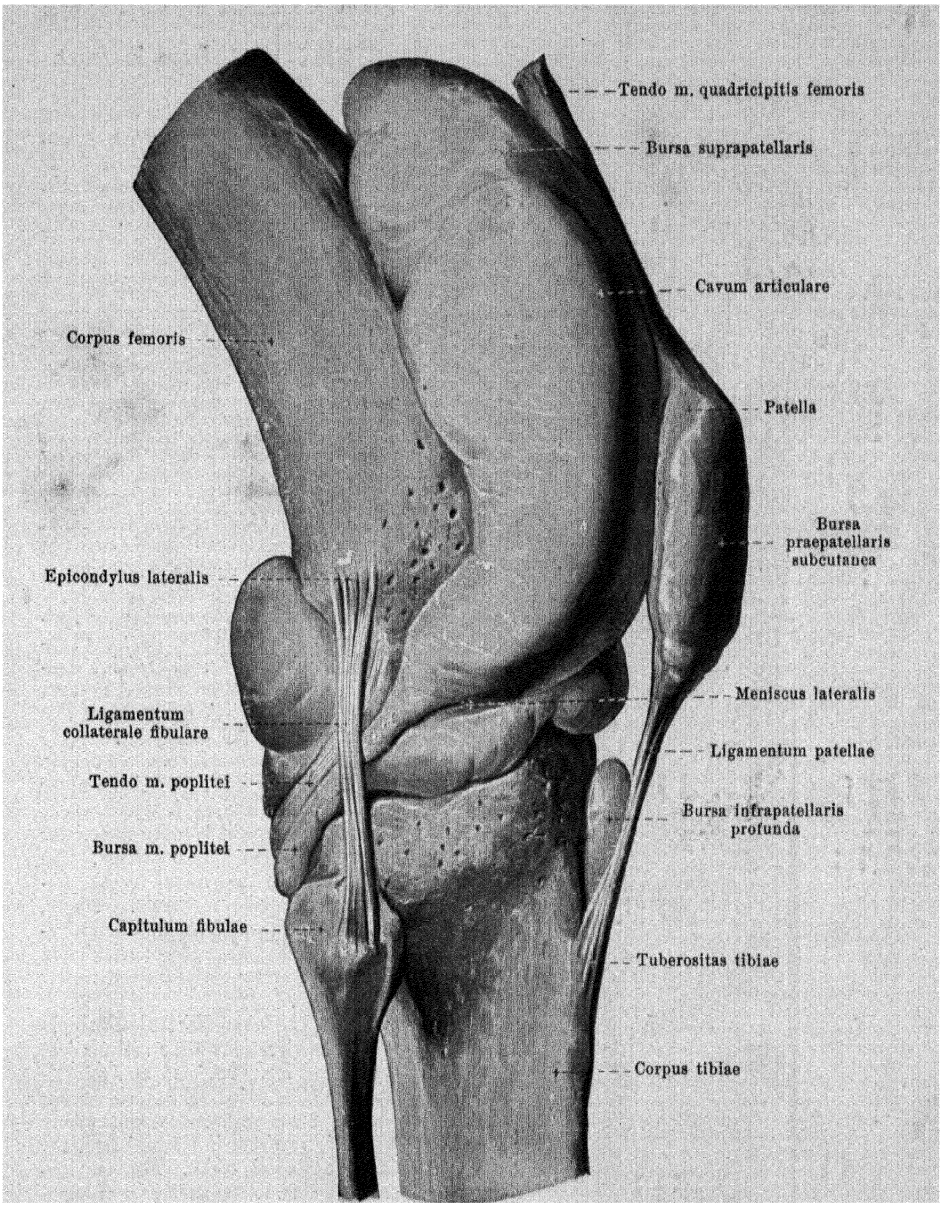
Articulatio genus (continued) (see also Figs. 304—311). The *cavum articulare* is in open communication regularly with the *bursa [mucosa] musculi poplitei* (see also Fig. 447). This tube-like pocket extends downward and backward on the lateral side in front of and below the tendon of origin of the m. popliteus; it opens into the joint by a narrow slit above the meniscus lateralis, between this and the tendon of the m. popliteus, but possesses usually in addition a second communicating opening below the meniscus; it is sometimes connected also with the articulatio tibiofibularis.

In front of the patella are three bursae: the *bursa praepatellaris subcutanea* in the subcutaneous connective tissue in front of the fascia lata (see also Fig. 426), the *bursa praepatellaris subfascialis* behind the fascia lata (not figured), between it and the tendinous expansion of the m. quadriceps femoris, and the *bursa praepatellaris subtendinea* between the tendon of the m. quadriceps and the anterior surface of the patella (not figured). In most cases only one of these three bursae praepatellares occur; sometimes two or three exist over one another in which event they usually communicate freely with one another; the size of these bursae differs much.

The *bursa infrapatellaris profunda* (see also Fig. 311) lies between the posterior surface of the ligamentum patellae and the anterior surface of the tibiae. It is separated from the cavity of the knee joint by masses of fat and communicates with it only very rarely.

The joint-cavity is connected, in addition, in most cases, with the *bursa suprapatellaris* (see p. 229), very often with a *bursa m. semimembranosi* (see p. 366) or with the *bursa m. gastrocnemii medialis* (see p. 367), often also with the *bursa m. gastrocnemii lateralis* (see p. 368).

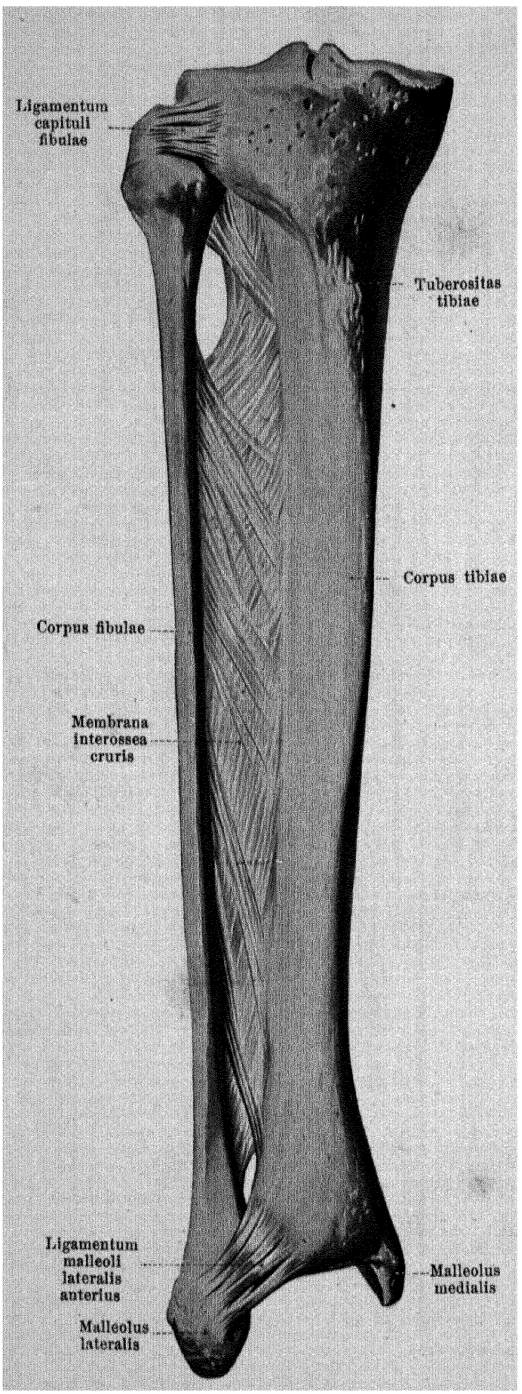
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312. Right knee joint, *articulatio genus*,

from the lateral surface.

(The joint cavity and several bursae have been injected with a stiffening medium and then dissected out.)



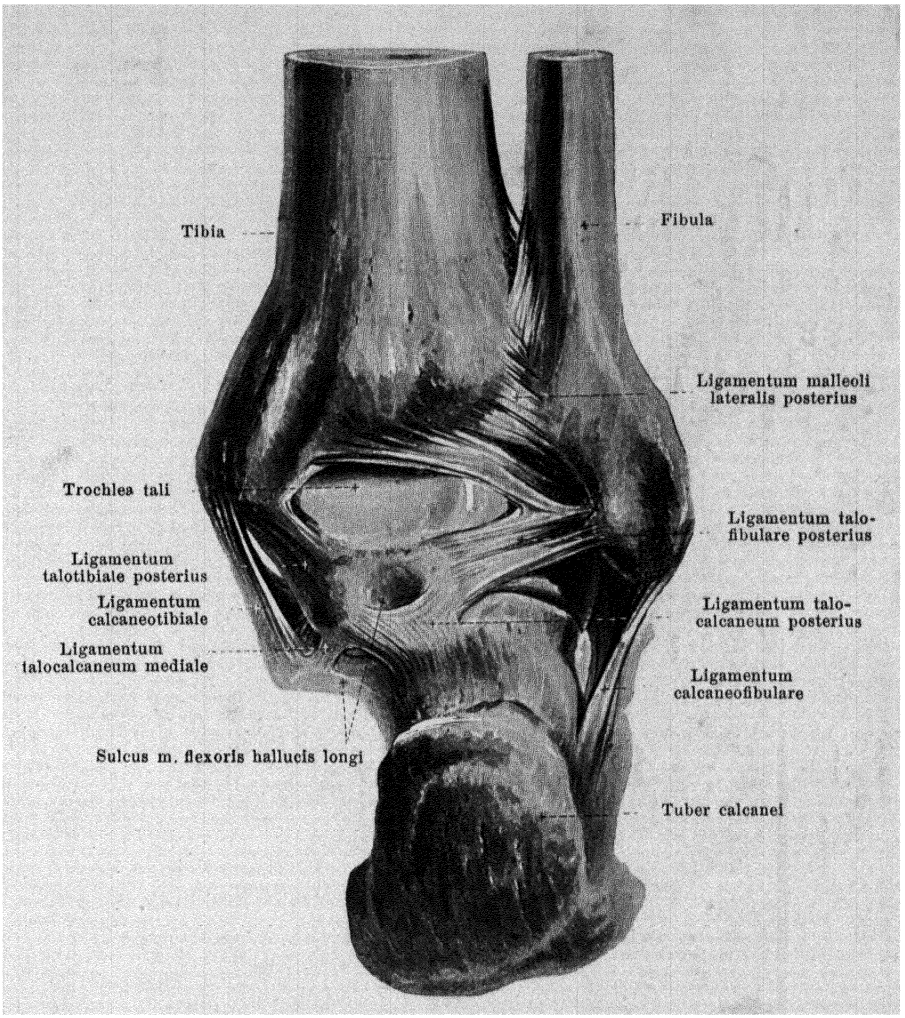
313. Ligaments of the right leg, from in front.

The tibia and fibula are united by two joints, one above and one below, besides throughout nearly their whole length by the membrana interossea cruris.

The **articulatio tibiofibularis** (O. T. superior tibiofibular articulation) (see also Figs. 306—308) arises through the apposition of the facies articularis capituli fibulae and the facies articularis fibularis tibiae. The tight *capsula articularis* arises from both bones generally close to the margin of the cartilaginous surface. On the anterior surface and often also on the posterior, a strengthening ligament, the *ligamentum capituli fibulae* (O. T. anterior and posterior superior tibiofibular ligaments), runs transversely or somewhat obliquely lateralward and downward. In addition the ligamentum collaterale fibulare and the retinaculum ligamenti arcuati of the knee joint are to be regarded as strengthening ligaments (in the wider sense) for the articulatio tibiofibularis. The joint communicates sometimes with the bursa [mucosa] m. poplitei and through this indirectly with the knee joint.

The **membrana interossea cruris** (O. T. middle tibiofibular ligament or interosseous membrane) is stretched out as a broad lamella between the cristae interosseae of the tibia and fibula. The fibres usually assume a course descending toward the fibula. Above, between the membrane and the articulatio tibiofibularis, there remains a large opening for the passage of vessels and nerves.

The **syndesmosis tibiofibularis** (O. T. inferior tibiofibular articulation) (see also Figs. 314, 315 and 322) is the moveable union between the medial surface of the malleolus lateralis (above the facies articularis malleoli) and the incisura fibularis tibiae. The bony surfaces opposed to one another are covered only sometimes in their most anterior portion by hyaline cartilage, otherwise always by periosteum with a fatty substratum in parts; between the two, projecting upward from the articulatio talocruralis is a small slit-shaped pocket. In front and behind strong ligaments run transversely over the joint, the *ligamenta malleoli lateralis*. The *ligamentum malleoli lateralis anterius* extends as a flat cord from the region in front of the incisura fibularis tibiae obliquely downward to the anterior surface of the malleolus lateralis.

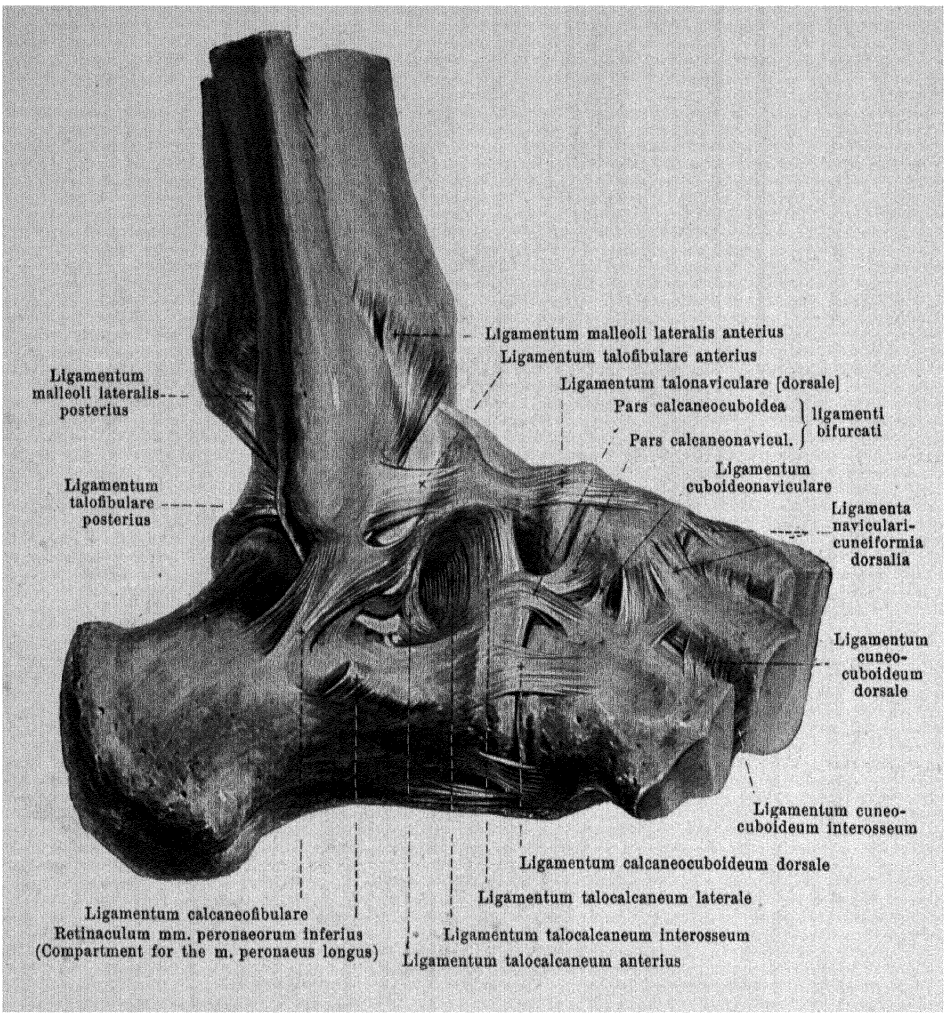


314. Joints of the right foot, *articulationes pedis*, from behind.

(The capsulae articulares have been removed except for the strengthening ligaments.)

Syndesmosis tibiofibularis (continued). The *ligamentum malleoli lateralis posterius* has a broad origin from the region behind the incisura fibularis tibiae and from the posterior margin of the facies articularis inferior tibiae and goes obliquely downward to the posterior surface of the malleolus lateralis; its lower fibres help to enlarge and deepen the joint cavity for the trochlea tali.

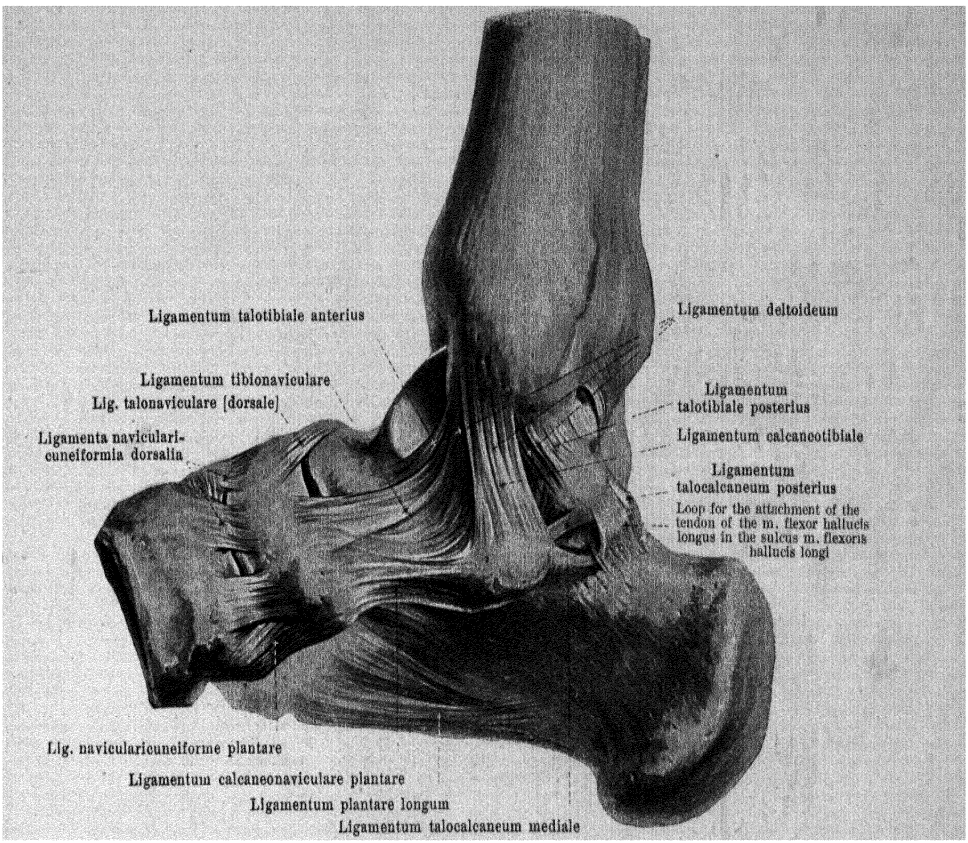
In the formation of the **articulatio talocruralis** *(ankle-joint)* (see also Figs. 315 and 316) the trochlea tali moves in the joint cavity formed by the distal end-pieces of the tibia and fibula; here the facies superior tali glides upon the facies articularis inferior tibiae, the facies malleolaris lateralis tali upon the facies articularis malleoli lateralis [fibulae] and the facies malleolaris medialis tali upon the facies articularis malleoli medialis [tibiae]; the two malleoli thus embrace the trochlea tali from two sides. The *capsula articularis* arises everywhere close to the margin of the cartilaginous surfaces: only in front of the facies articularis superior tali does it cover also a part of the collum tali which is free from cartilage; at the sides the capsule is tight; in front and behind it is looser. Very powerful strengthening ligaments, lateral as *ligamenta talofibularia et calcaneofibulare* (see page 236), medial as *ligamentum deltoideum* (see page 237), go from the two malleoli to the ankle bones.



315. Joints of the right foot, *articulationes pedis*, from the lateral surface.

(The metacarpal bones have been removed as well as the capsulae articulares with the exception of their strengthening ligaments.)

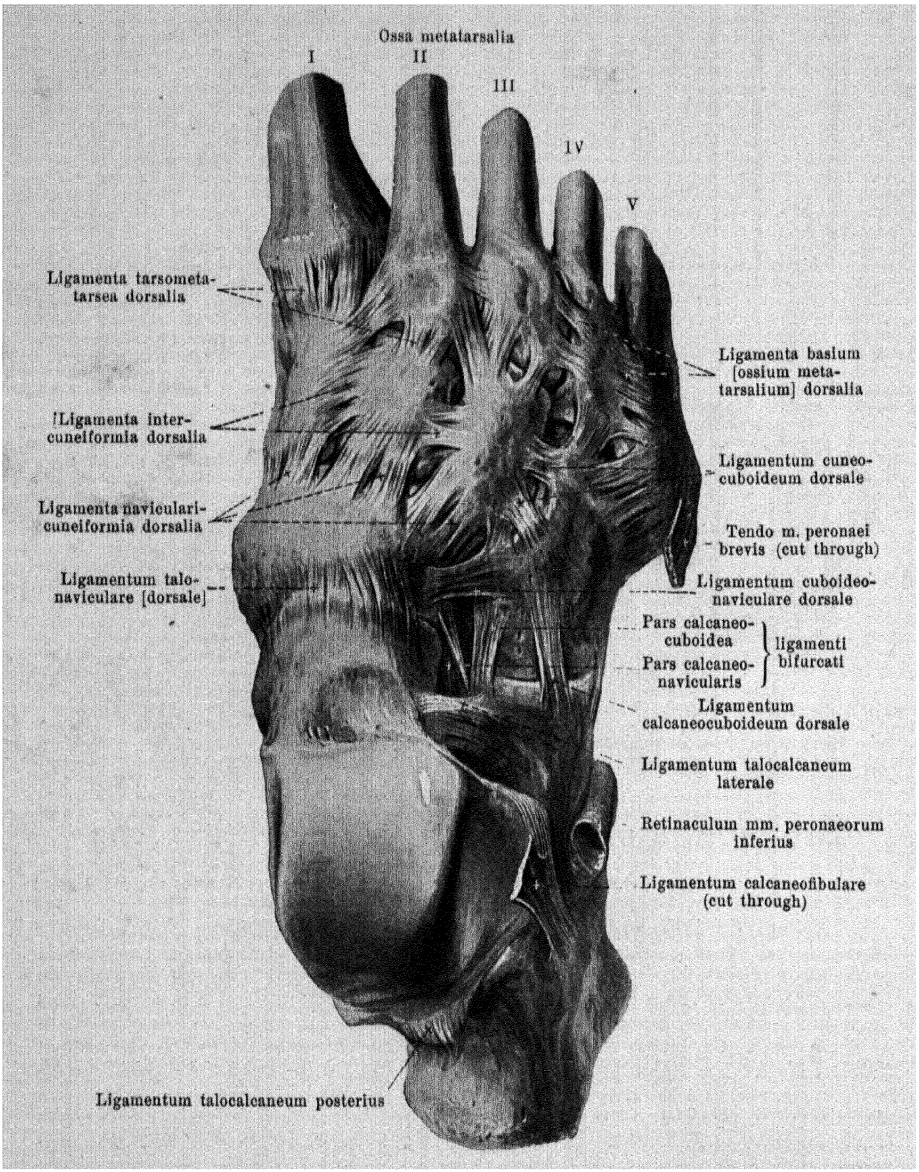
Articulatio talocruralis (continuation). The *ligamentum talofibulare posterius* (O. T. posterior fasciculus of external lateral ligament) (see Fig. 314) arises at the malleolus lateralis [fibulae] behind the facies articularis malleoli lateralis and extends, flat, obliquely medianward and downward to the region of the lateral projection from the processus posterior tali. The *ligamentum talofibulare anterius* (O. T. anterior fasciculus of external lateral ligament) goes from the anterior surface of the malleolus lateralis medianward to the lateral surface of the collum tali. The *ligamentum calcaneofibulare* (O. T. middle fasciculus of external lateral ligament) (see also Figs. 314 and 317) runs as a flat-rounded cord from the tip of the malleolus lateralis obliquely downward and backward to the lateral surface of the calcaneus; its outer surface forms a shallow groove in which glide the tendons of the mm. peronaei.



316. Joints of the right foot, *articulationes pedis*, from the medial surface.

(The specimen has been prepared as for Fig. 315.)

Articulatio talocruralis (continued). The ***ligamentum deltoideum*** (O. T. deltoid or internal lateral ligament + the anterior and posterior tibiotarsal ligaments) is an unequalsided quadrangular ligamentous mass which has its origin on the medial surface of the malleolus medialis [tibiae] and has a broad attachment to the talus, calcaneus and os naviculare. This ligament is composed of several layers and is divisible, according to the lower attachments of its fibres, into the ***ligamenta talotibialia***, the *ligamentum calcaneotibiale* and the ***ligamentum tibionaviculare***. The ***ligamentum talotibiale posterius*** (O. T. posterior tibiotarsal ligament) (see also Fig. 314) is a thick, broad band of fibres which arises behind the tip of the malleolus medialis and is attached to the talus close behind and below the facies malleolaris medialis of the trochlea, in front of the medial projection of the processus posterior tali. The ***ligamentum talotibiale anterius*** (O. T. anterior tibiotarsal ligament) for the most part hidden below the ligamenta calcaneotibiale and tibionaviculare, is short and narrow and goes off from the tip of the malleolus medialis in front of the preceding and has a somewhat broad attachment below the anterior portion of the facies malleolaris medialis of the trochlea tali. The ***ligamentum calcaneotibiale*** (O. T. internal lateral ligament) (see also Fig. 314), the most superficial part of the ligamentum deltoideum, has a broad origin on the medial surface of the malleolus medialis and runs downward to the posterior margin of the sustentaculum tali of the calcaneus. The ***ligamentum tibionaviculare*** has a broad attachment to the medial surface of the malleolus medialis just above the ligamentum talotibiale anterius and, broadening, goes to the dorsal and medial surface of the os naviculare as well as to the medial margin of the ligamentum calcaneonaviculare plantare; at its origin and behind it is partially hidden beneath the ligamentum calcaneotibiale. The medial surfaces of the ligamenta talotibiale posterius and calcaneotibiale form, medianward, a groove for the tendon of the m. tibialis posterior.



317. Joints of the right foot, *articulationes pedis*,

viewed from the back of the foot.

(The ossa metatarsalia have been sawed through in the middle, the capsulae articulares have been removed except for the strengthening ligaments.)

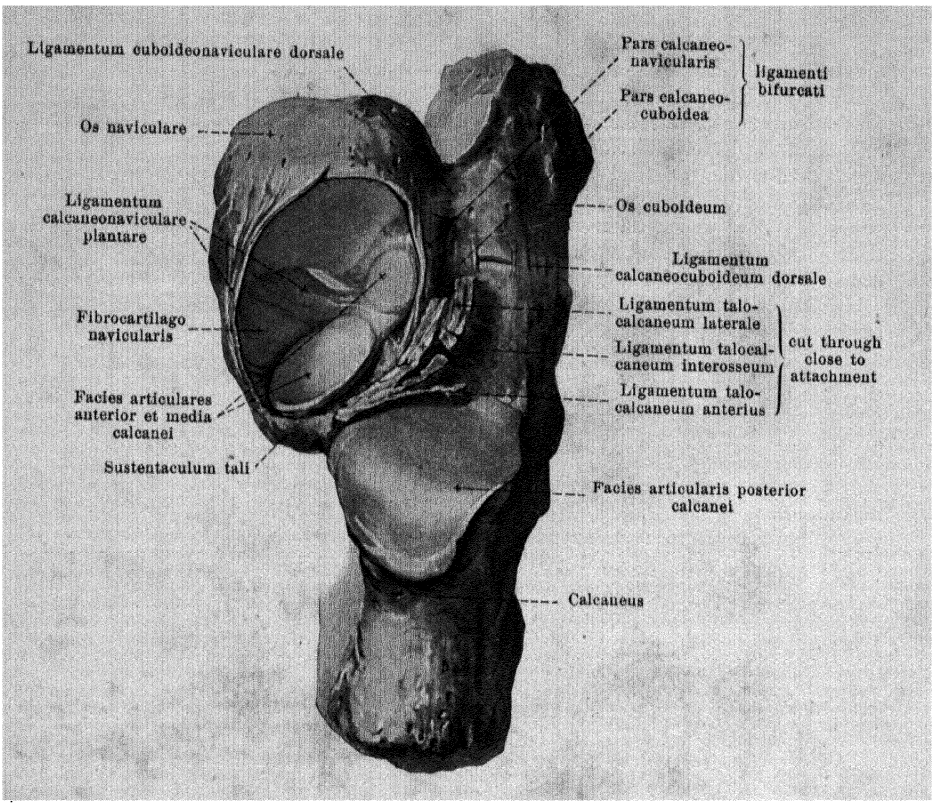
In the formation of the **articulationes intertarseae** (O. T. articulations of the tarsus) each individual ankle bone can move with its cartilaginous joint surface upon the corresponding surfaces of the neighboring tarsal bones. The *capsulae articulares* of the individual joints thus arising (see p. 245) are strengthened usually by short fibrous bands, the *ligamenta talocalcanea* and the *ligamenta tarsi.*

Between the talus and the calcaneus are found five ***ligamenta talocalcanea*** (O. T. ligaments connecting the os calcis and the astragalus): (1) the *ligamentum talocalcaneum posterius* (O. T. posterior calcaneoastragaloid ligament) (see also Figs. 314 and 316), goes from the two projections of the processus posterior tali to the upper surface of the calcaneus immediately behind the facies articularis posterior and bridges over at its origin the sulcus m. flexoris hallucis longi of the talus; (2) the *ligamentum talocalcaneum anterius* (see Figs. 315 and 318) is a broad band of fibres which is stretched out in the sinus tarsi behind the ligamenta talocalcanea laterale et interosseum, on the anterior side of the articulatio talocalcanea (see p. 240 Text), between the lower surface of the talus and the upper surface of the calcaneus, immediately in front of the facies articularis posterior; (3) the *ligamentum talocalcaneum mediale* (O. T. internal calcaneoastragaloid ligament) (see Figs. 314, 316 and 320) is a narrow bundle which extends from the medial tubercle of the processus posterior tali almost horizontally to the posterior margin of the sustentaculum tali of the calcaneus; (4) the *ligamentum talocalcaneum laterale* (O. T. external calcaneoastragaloid ligament) (see also Figs. 315 and 318) has a broad origin from the lateral and inferior surface of the collum tali and runs at the entrance into the sinus tarsi obliquely downward, forward and lateralward to the upper surface of the calcaneus; (5) the *ligamentum talocalcaneum interosseum* (O. T. interosseous ligament) (see Figs. 315 and 318) fills up the sinus tarsi and consists of several broad usually short, bands of fibres which go from the sulcus tali to the sulcus calcanei; in front it is partially covered over and sometimes only indistinctly separable from the ligamentum talocalcaneum laterale. The sinus tarsi contains also masses of fat and in these near the ligamentum talocalcaneum laterale, there is often a bursa, the *bursa sinus tarsi* (not figured).

On the back of the foot are the following ***ligamenta tarsi dorsalia:*** the *ligamentum talonaviculare [dorsale]* (O. T. superior astragalonavicular ligament) (see also Figs. 315 and 316) extends as a broad ligament from the upper surface of the collum tali to the upper surface of the os naviculare; the *ligamentum bifurcatum* (see also Figs. 315, 318 and 322) has a broad origin near the anterior margin of the dorsal surface of the calcaneus in front of the ligamentum talocalcaneum laterale and divides fork-like into the stronger *pars calcaneonavicularis* (O. T. superior or external calcaneonavicular ligament, reaching wide into the depth, which is attached to the posterior lateral angle of the os naviculare, and into the *pars calcaneocuboidea* (O. T. internal calcaneocuboid ligament) which goes to the upper surface of the os cuboideum; the *ligamentum calcaneocuboideum dorsale* (O. T. external calcaneocuboid ligament) (see also Figs. 315 and 318) runs lateralward from the preceding from the upper surface of the calcaneus to the upper surface of the os cuboideum; the *ligamentum cuboideonaviculare dorsale* (see also Figs. 315 and 318) stretches out between the upper surfaces of the os naviculare and the os cuboideum; the *ligamenta navicularicuneiformia dorsalia* (see also Figs. 315 and 318) are from four to five fibrous bands which extend from the dorsal surface of the os naviculare to the upper surfaces of the three cuneiform bones; the two *ligamenta intercuneiformia dorsalia,* sometimes still further subdivided, pass transversely from the dorsal surface of one cuneiform bone to that of the adjoining bone; the *ligamentum cuneocuboideum dorsale* (see also Fig. 315) is a ligament (frequently divided) extending from the upper surface of the third cuneiform bone to that of the cuboid bone.

The **articulationes tarsometatarseae [Lisfranci]** (O. T. tarsometatarsal articulations) (see also pp. 243 and 245) are strengthened by six (or more) short *ligamenta tarsometatarsea dorsalia;* these extend upon the dorsal surface of the ossa cuneiformia and from the os cuboideum straight or obliquely forward to the bases ossium metatarsalium; in this way the second metacarpal bone is connected with all three cuneiform bones.

The **articulationes intermetatarseae** (O. T. articulations of the metatarsal bones with each other) (see also pp. 243 and 245) possess three *ligamenta basium [ossium metatarsalium] dorsalia* which are stretched out transversely between the dorsal surfaces of the proximal ends of the second to the fifth os metatarsale.

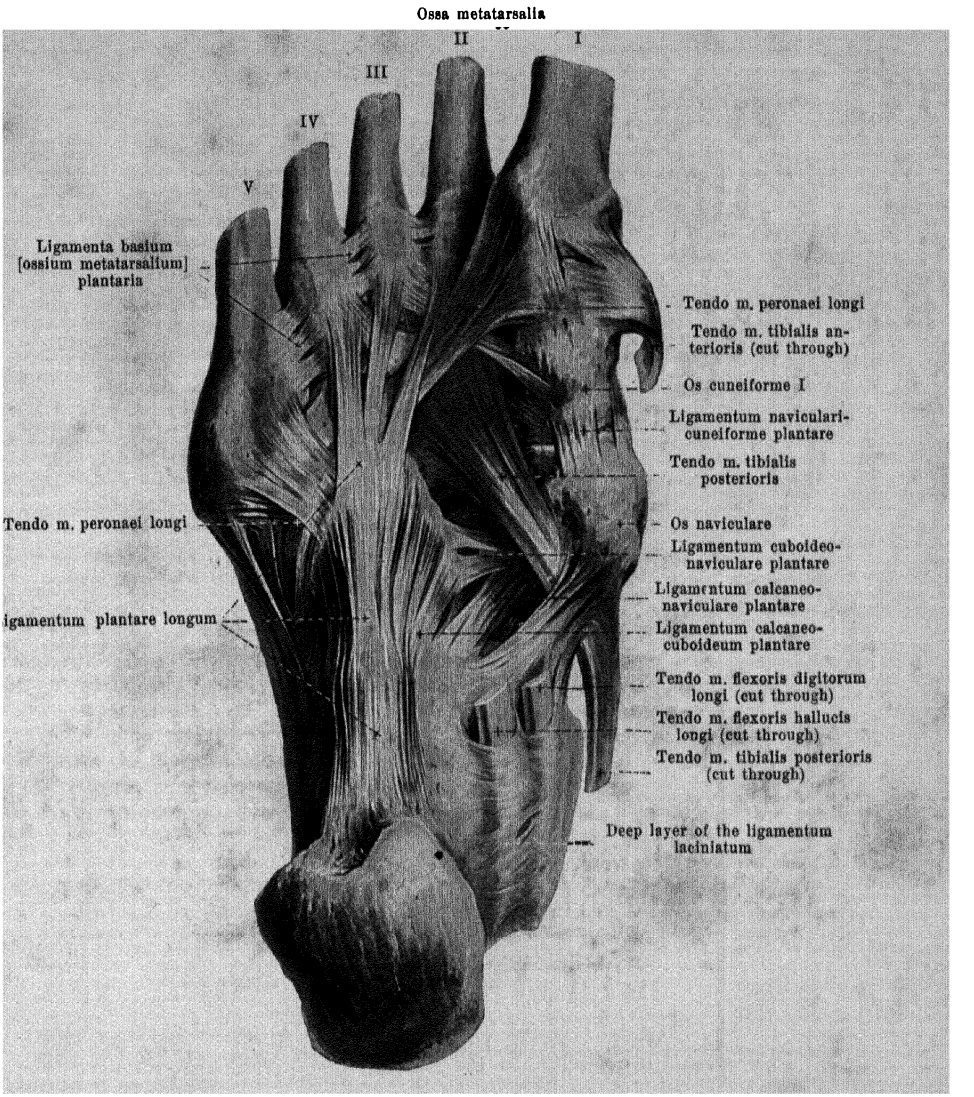


318. Joints of the right foot, *articulationes pedis*, viewed from the back of the foot.

(The talus has been removed as have also the cuneiform bones and the metacarpal bones, the capsulae articulares have been removed except for the strengthening ligaments.)

Articulationes intertarseae (continued).

The talus is moveably united with the calcaneus and with the os naviculare with constant formation of two separate joint cavities (see also Fig. 322). The posterior joint cavity is situated between the facies articularis calcanea posterior of the talus and the facies articularis posterior of the calcaneus; this union is called the **articulatio talocalcanea;** its *capsula articularis* goes off from the bone usually near the margins of the cartilaginous surfaces; the strengthening ligaments belonging here are the ligamenta talocalcanea posterius, anterius et mediale (see p. 239). The anterior joint cavity lies between the facies articulares calcaneae media et anterior of the talus and the facies articulares media et anterior of the calcaneus as well as between the facies articularis navicularis of the talus and the proximal joint surface of the os naviculare; besides, the joint concavity is made still more complete for the caput tali by means of the ligamentum calcaneonaviculare plantare (see p. 242) and the fibrocartilago navicularis enclosed in this, as well as by the pars calcaneonavicularis ligamenti bifurcati (see p. 239); this anterior joint union is known as the **articulatio talocalcaneonavicularis;** its most anterior portion is also known separately as the *articulatio talonavicularis;* its *capsula articularis* leaves the bones for the most part near the margins of the cartilaginous surfaces; lying close upon the capsule, as a strengthening ligament of the same, is the ligamentum talonaviculare [dorsale] (see p. 239) while the ligamenta talocalcanea laterale et interosseum (see p. 239) are separated from it by masses of fat; in addition, the ligamentum calcaneonaviculare plantare and the pars calcaneonavicularis ligamenti bifurcati have to be designated as strengthening ligaments.

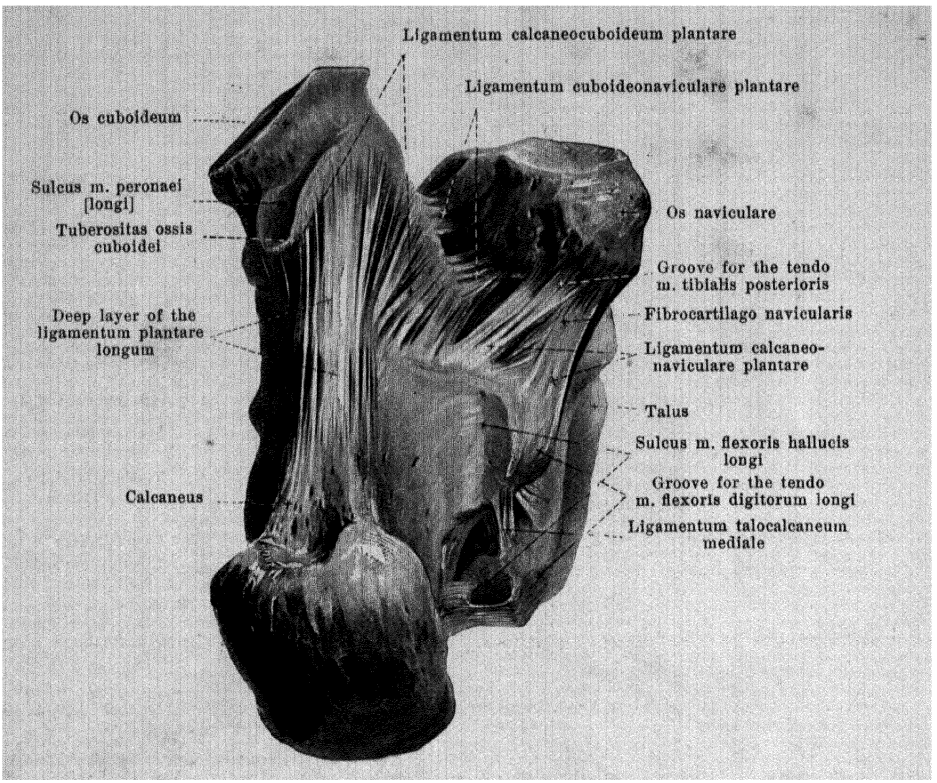


319. Joints of the right foot, *articulationes pedis,*

viewed from the sole of the foot.

(The ossa metatarsalia have been sawed through in the middle, the capsulae articulares with the exception of the strengthening ligaments have been removed.)

Articulationes intertarseae (continued.) Their capsules are strengthened in the sole of the foot by the *ligamenta tarsi plantaria;* the strongest of them is the *ligamentum plantare longum* (O. T. long calcaneocuboid or long plantar ligament) (see also Fig. 320). It is very broad and powerful, arises from the lower surface of the calcaneus in front of the tuber calcanei and extends with its main mass to the tuberositas ossis cuboidei. As a continuation of its most superficial bundles it sends thin diverging fibrous strips to the proximal ends of the ossa metatarsalia which bridges over the groove for the tendon of the m. peronaeus longus.

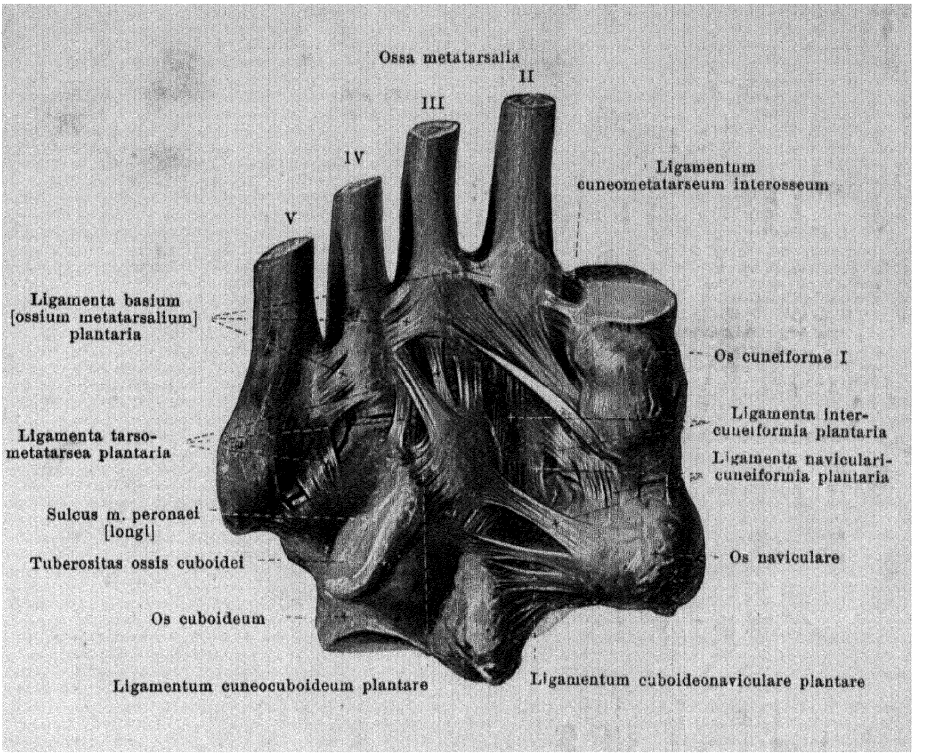


320. Joints of the right foot, *articulationes pedis*, viewed from the sole of the foot.

(The cuneiform bones and the metacarpal bones have been removed, the superficial layer and the most anterior processes of the ligamentum plantare longum have been cut off, the capsulae articulares except the strengthening ligaments have been removed.)

Articulationes intertarseae (continued). *Ligamenta tarsi plantaria* (continued). The *ligamentum calcaneocuboideum plantare* (O. T. short calcaneocuboid or short plantar ligament) (see also Fig. 319) is a broad band of short fibres which go from the anterior end of the lower surface of the calcaneus to the lower surface of the os cuboideum; they are partially covered by the ligamentum plantare longum which lies more superficially and is more or less intimately fused with it.

The *ligamentum calcaneonaviculare plantare* (O. T. inferior calcaneonavicular ligament) (see also Figs. 316, 318 and 319) arises as a thick, broad mass of fibres from the anterior and medial margin of the sustentaculum tali of the calcaneus and is fastened to the posterior end of the inferior and medial surface of the os naviculare. The ligament, the bands of which extend essentially from behind forward and connect dorsalward with the ligamentum tibionaviculare, forms a trough which is concave upward and lateralward (see Fig. 318); its upper concave surface is lined by synovial membrane, belongs to the articulatio talocalcaneonavicularis and forms a part of the socket for the caput tali (see p. 240). At the junction of the inferior with the medial surface a slightly curved fibro-cartilaginous disc, *fibrocartilago navicularis*, is enclosed (see Fig. 318). The medial, inferior surface of the ligament is hollowed out to form a shallow groove and serves for the reception of the tendon of the m. tibialis posterior.



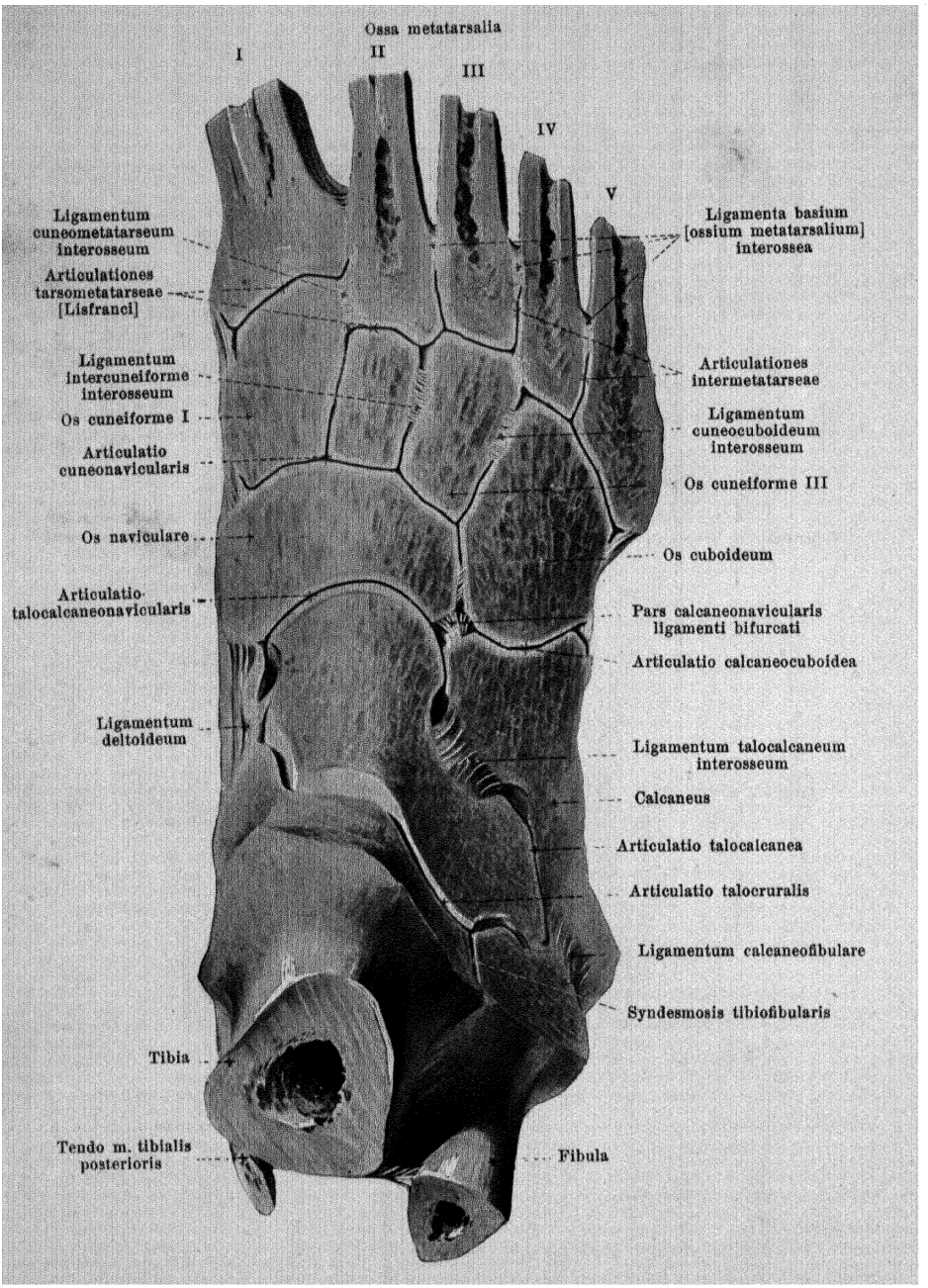
321. Joints of the right foot, *articulationes pedis*, viewed from the sole of the foot.

(The calcaneus and talus have been removed at the so-called articulatio tarsi transversa [Choparti]. The os metatarsale I has been completely excised, the ossa metatarsalia II–V have been sawed through in the middle; the capsulae articulares, with the exception of the strengthening ligaments, have been removed.)

Articulationes intertarseae (continued). ***Ligamenta tarsi plantaria*** (continued). The *ligamentum cuboideonaviculare plantare* (see also Figs. 319 and 320) stretches out between the plantar surfaces of the os cuboideum and the os naviculare. The *ligamenta navicularicuneiformia plantaria* (see also Figs. 316 and 319) are three short bands of fibres passing directly or obliquely forward, which extend from the plantar surface of the os naviculare to the plantar surfaces of the ossa cuneiformia. The two *ligamenta intercuneiformia plantaria* run as short fibre bundles transversely between the plantar surfaces of the ossa cuneiformia. The *ligamentum cuneocuboideum plantare* goes as a broad band from the under surface of the os cuneiforme III obliquely lateralward and backward to the plantar surface of the os cuboideum.

The **articulationes tarsometatarseae [Lisfranci]** (see also pp. 239 and 245) have plantarward a large number of strengthening ligaments, *ligamenta tarsometarsea plantaria*, which, partly shorter, partly longer, run on the plantar surface from the ossa cuneiformia and from the os cuboideum to the bases ossium metatarsalium.

The **articulationes intermetatarseae** (see also pp. 239 and 245) are strengthened plantarward by three *ligamenta basium [ossium metatarsalium] plantaria* (see also Fig. 319) which spread out on the plantar surface transversely between the proximal ends of the second to the fifth metatarsal bone.



322. Joints of the right foot, *articulationes pedis*, from the back of the foot.

(The surface of a frozen foot has been filed off until the joint cavities have been opened.)

Articulationes pedis.

Articulationes intertarseae. The joint slits of the *articulatio talocalcanea* and of the *articulatio talocalcaneonavicularis* (see p. 240) are completely closed off not only from one another, but also from the neighboring joint slits; the *articulatio talonavicularis* is only a part of the articulatio talocalcaneonavicularis (see p. 240).

In the formation of the *articulatio calcaneocuboidea* the facies articularis cuboidea of the calcaneus moves upon the proximal joint surface of the os cuboideum; its *capsula articularis* arises close to the margins of the cartilaginous surfaces; the joint cavity is not connected with adjoining ones. The articulatio calcaneocuboidea and the articulatio talonavicularis are also designated in common by the name *articulatio tarsi transversa [Choparti].*

The *articulatio cuneonavicularis* is the joint between the distal surface of the os naviculare and the proximal surfaces of the ossa cuneiformia; the *capsula articularis* surrounds these joint surfaces but in addition also those by which the ossa cuneiformia articulate with one another and those by which the os cuboideum glides upon the os cuneiforme III and on the os naviculare; the capsule is attached everywhere close to the margin of the cartilaginous surfaces. The joint cavity is connected as a rule, between the first and second cuneiform bones with the cavity of the articulatio tarsometatarsea of the os metatarsale II (and through this also with that of the os metatarsale III); short ligaments extend in the depth between the cuneiform bones and also between the third cuneiform bone and the cuboid bone: two *ligamenta intercuneiformia interossea* and one *ligamentum cuneocuboideum interosseum* (see also Fig. 322).

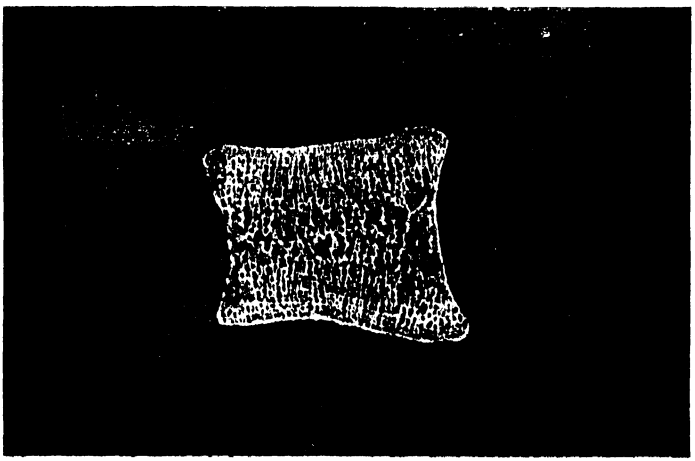
In the formation of the ***articulationes tarsometatarseae [Lisfranci]*** the proximal joint surfaces of the bases ossium metatarsalium are in contact with the distal joint surfaces of the ossa cuneiformia and of the os cuboideum. The places of junction form, in general, a surface convex from the medial toward the lateral side, which suffers interruption at the os cuneiforme II, in that the os metatarsale II reaches further proximalward than the others, there is besides a less abrupt break in surface between the ossa cuneiformia III and the os cuboideum. Usually three separate joint capsules are present: The first between the os cuneiforme I and os metatarsale I (sometimes also os metatarsale II), the second between the ossa cuneiformia II et III and the ossa metatarsalia II et III, the third between the os cuboideum and ossa metatarsalia IV et V; the joint cavity of the second is usually connected with that of the articulatio cuneonavicularis. From the lateral surfaces of the ossa cuneiformia and os cuboideum fibrous strands of variable development run down to the neighboring lateral surfaces of the bases ossium metatarsal. II—IV (see also Fig. 321); they are called *ligamenta cuneometatarsea interossea* (see also Fig. 328), and *ligamentum cuboideometatarseum interosseum,* respectively.

The ***articulationes intermetatarseae*** are formed in that the proximal ends of the first to the fifth os metatarsale are in contact, with the cartilaginous surfaces opposed to one another. The joint slits communicate with those of the corresponding articulatio tarsometatarsea; the *capsulae articulares* arise from the bone close to the margin of the cartilaginous surfaces. Four *ligamenta basium [ossium metatarsalium] interossea* extend, in the depth, between the neighboring surfaces of the bases ossium metatarsalium.

The ***articulationes metatarsophalangeae*** and the ***articulationes digitorum pedis*** (O. T. articulations of the phalanges) present as regards their capsules and ligaments, essentially the same relations as do the corresponding joints in the hand (see pp. 208 and 209).

Above

Behind



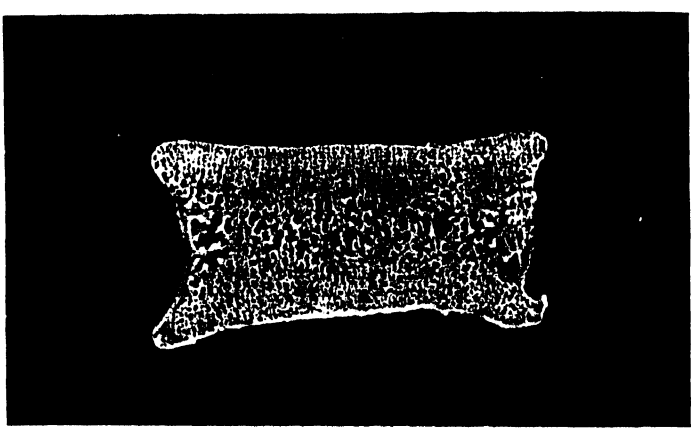
In front

Below

323. Lumbar vertebra, *vertebra lumbalis,*
ground sagittal section, from the side.

Above

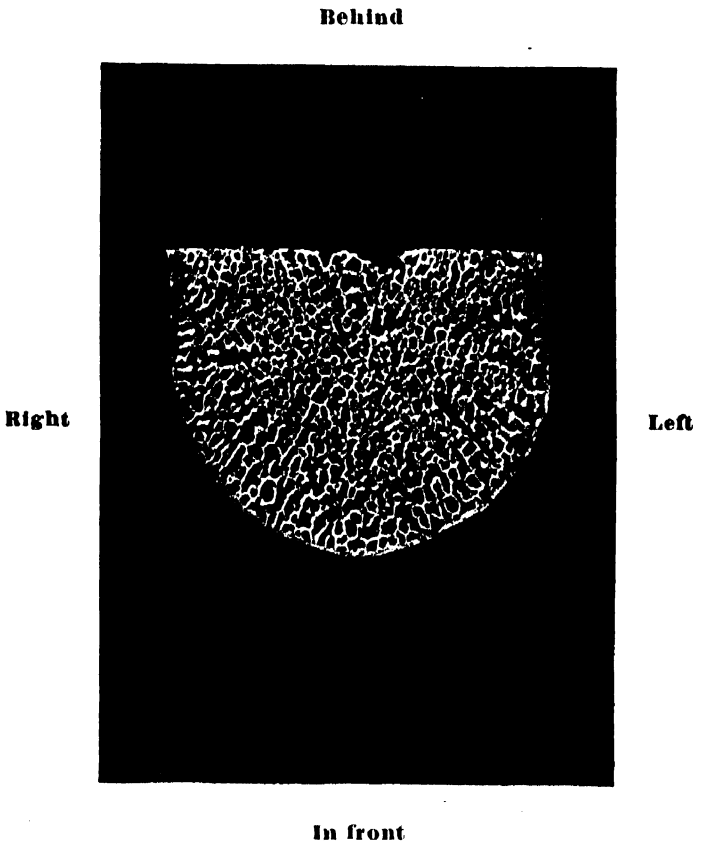
Right



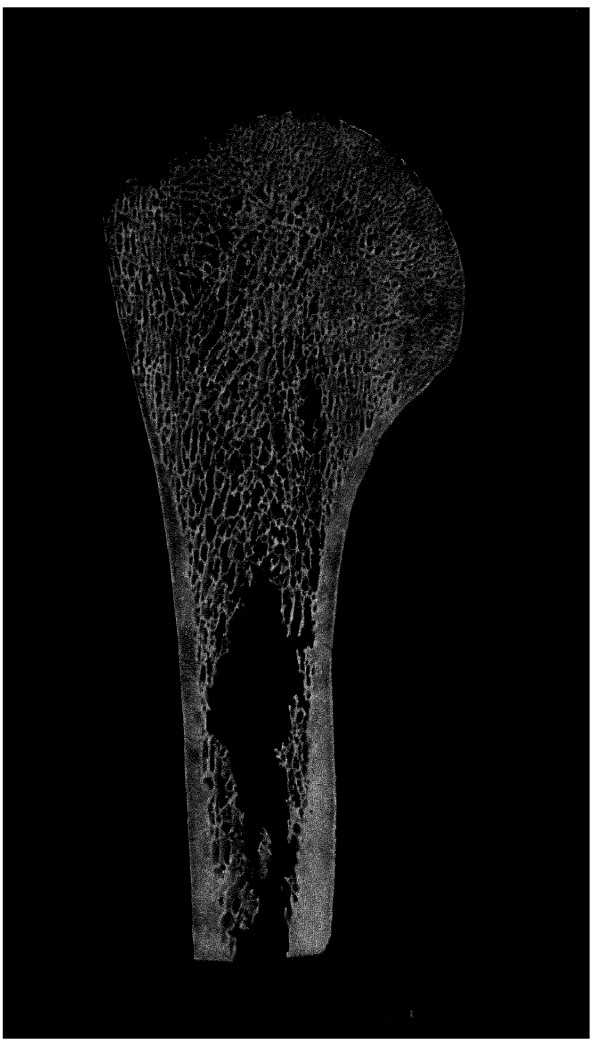
Left

Below

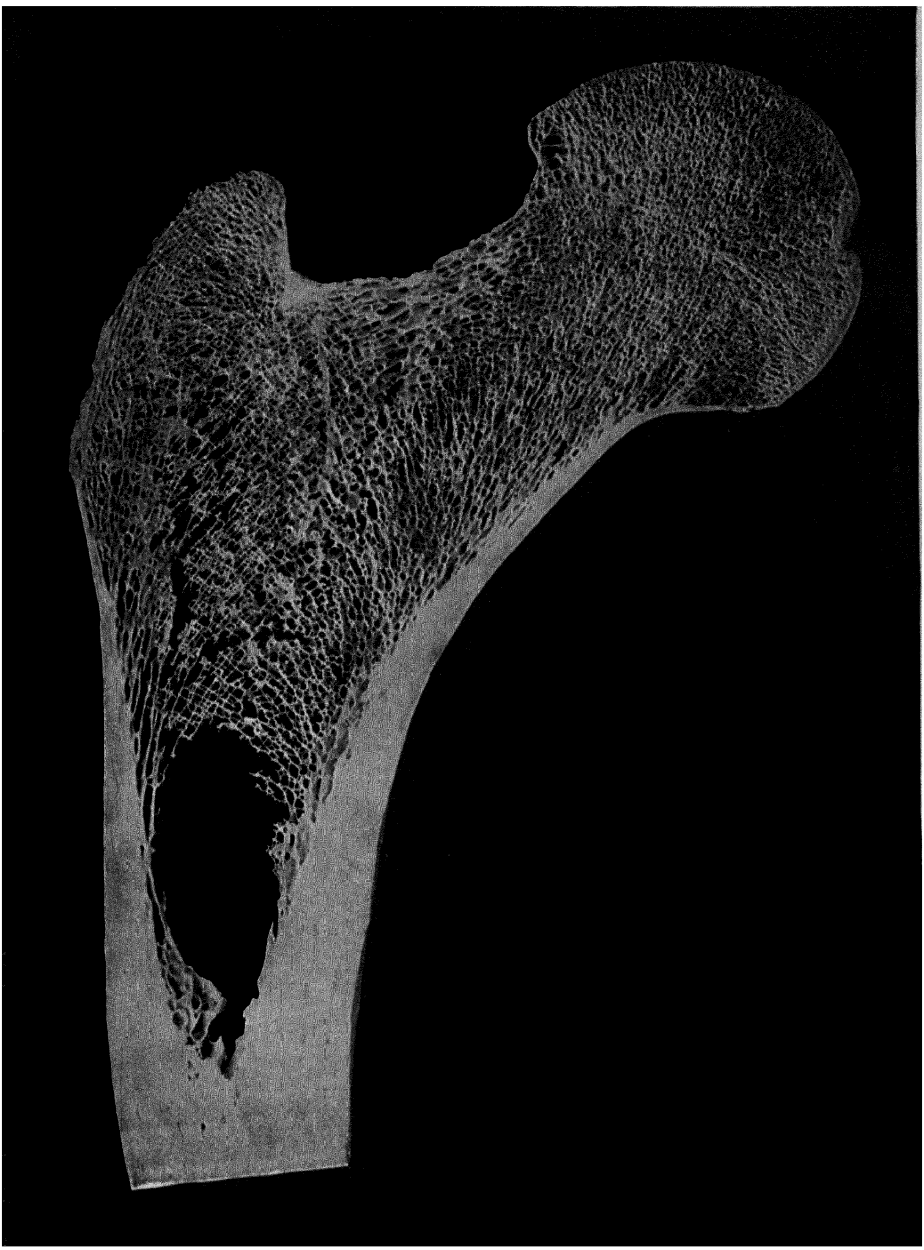
324. Lumbar vertebra, *vertebra lumbalis,*
ground frontal section, from in front.



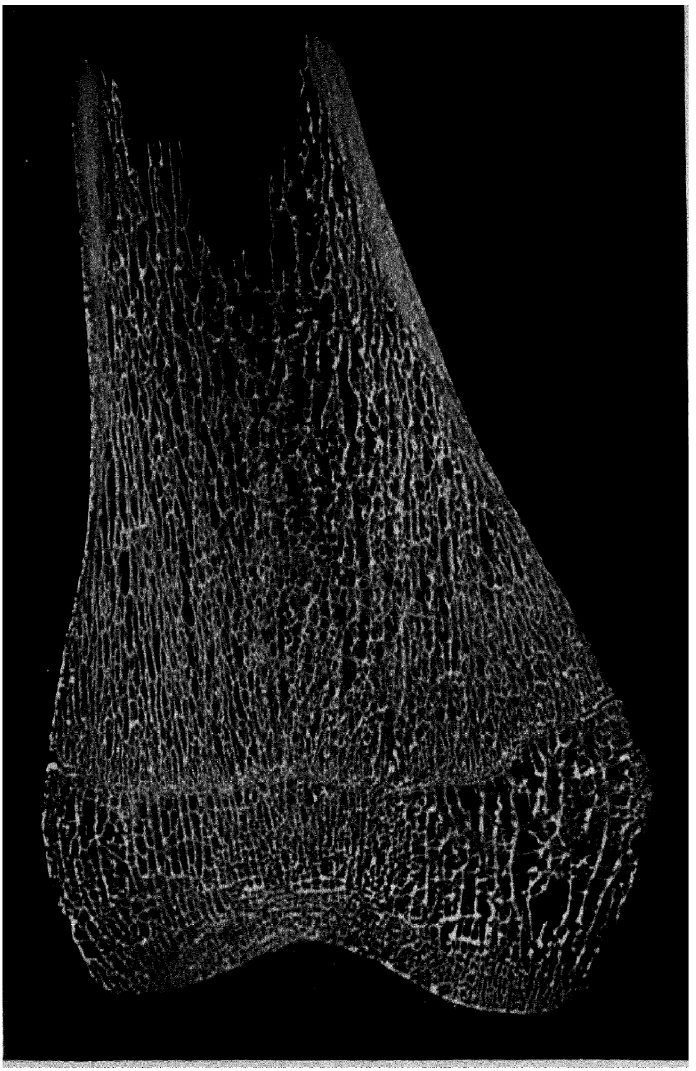
325. Lumbar vertebra, *vertebra lumbalis*, ground horizontal section, from above.



326. Right upper arm bone, *humerus,* upper extremity, ground frontal section, from in front.

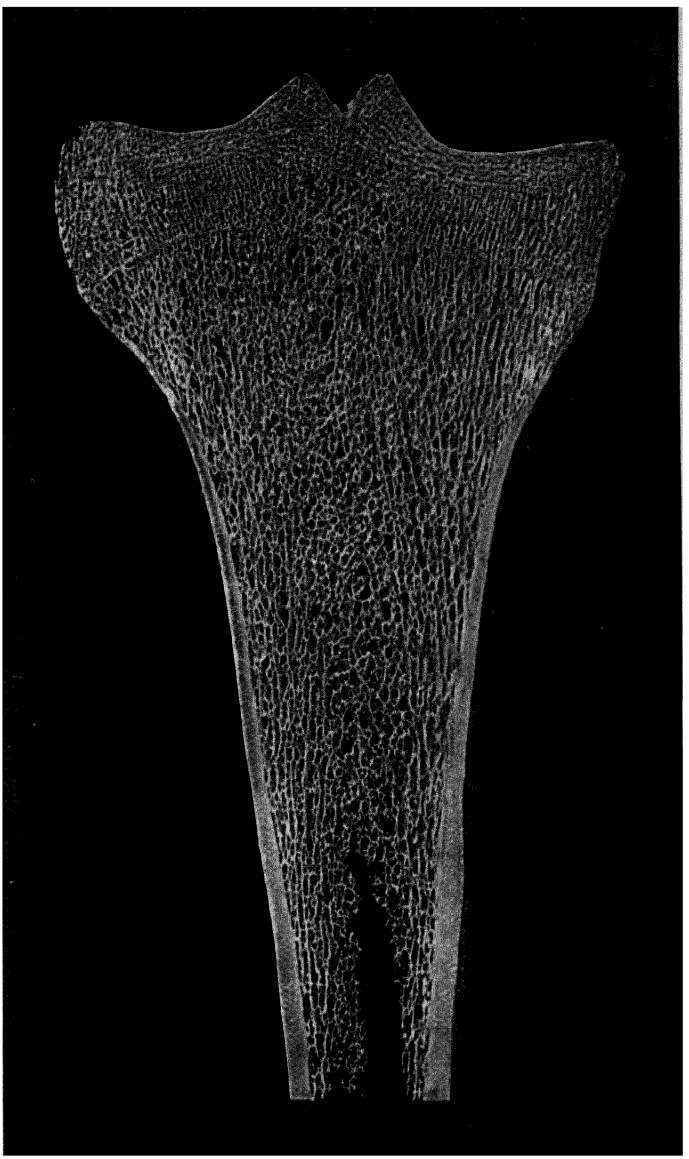


327. Right thigh bone, ***femur,*** upper extremity, ground frontal section, from in front.

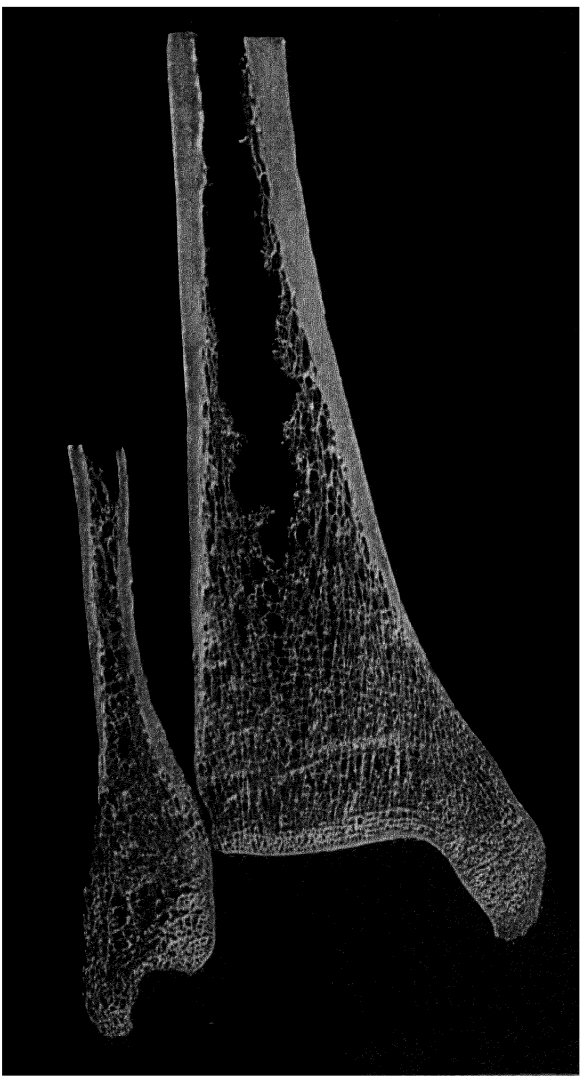


328. Right thigh bone, *femur*,

inferior extremity, ground frontal section, from in front.



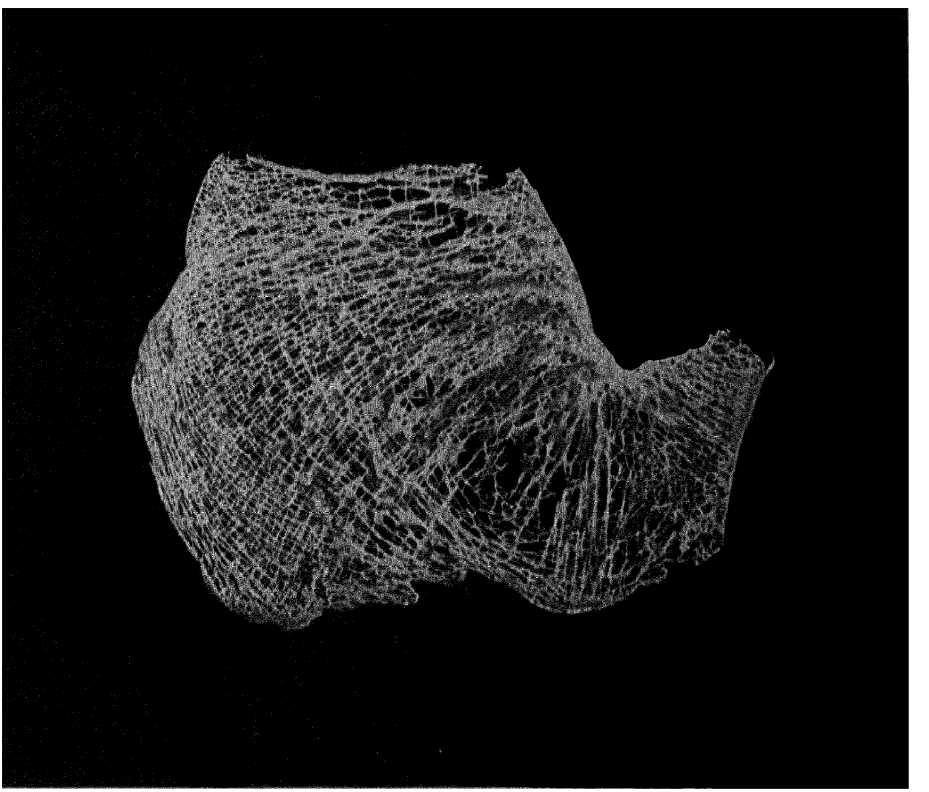
329. Right shin bone, *tibia,* upper extremity, ground frontal section, from in front.



Epiphyseal junction

330. Right shin bone and calf bone,

tibia and *fibula*, inferior extremity,
ground frontal section, from in front.



331. Right heel bone, *calcaneus,*

ground sagittal section, viewed from the side.

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