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WERNER SPALTEHOLZ

HAND ATLAS OF HUMAN ANATOMY

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HAND-ATLAS

OF

HUMAN ANATOMY

BY

WERNER SPALTEHOLZ

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SIXTH EDITION IN ENGLISH

VOL. III

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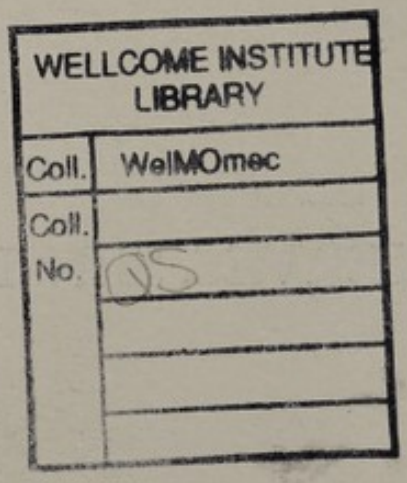

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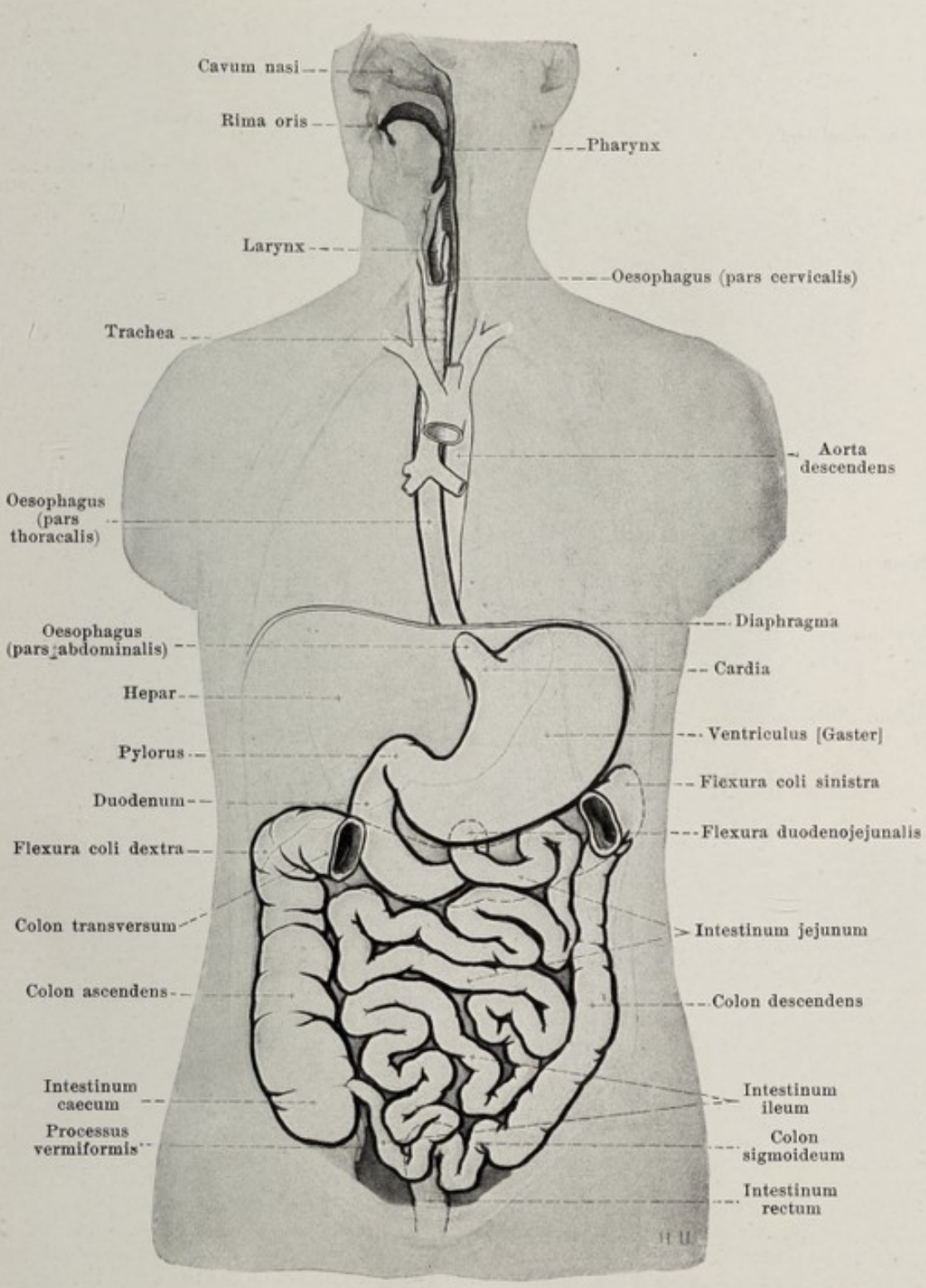
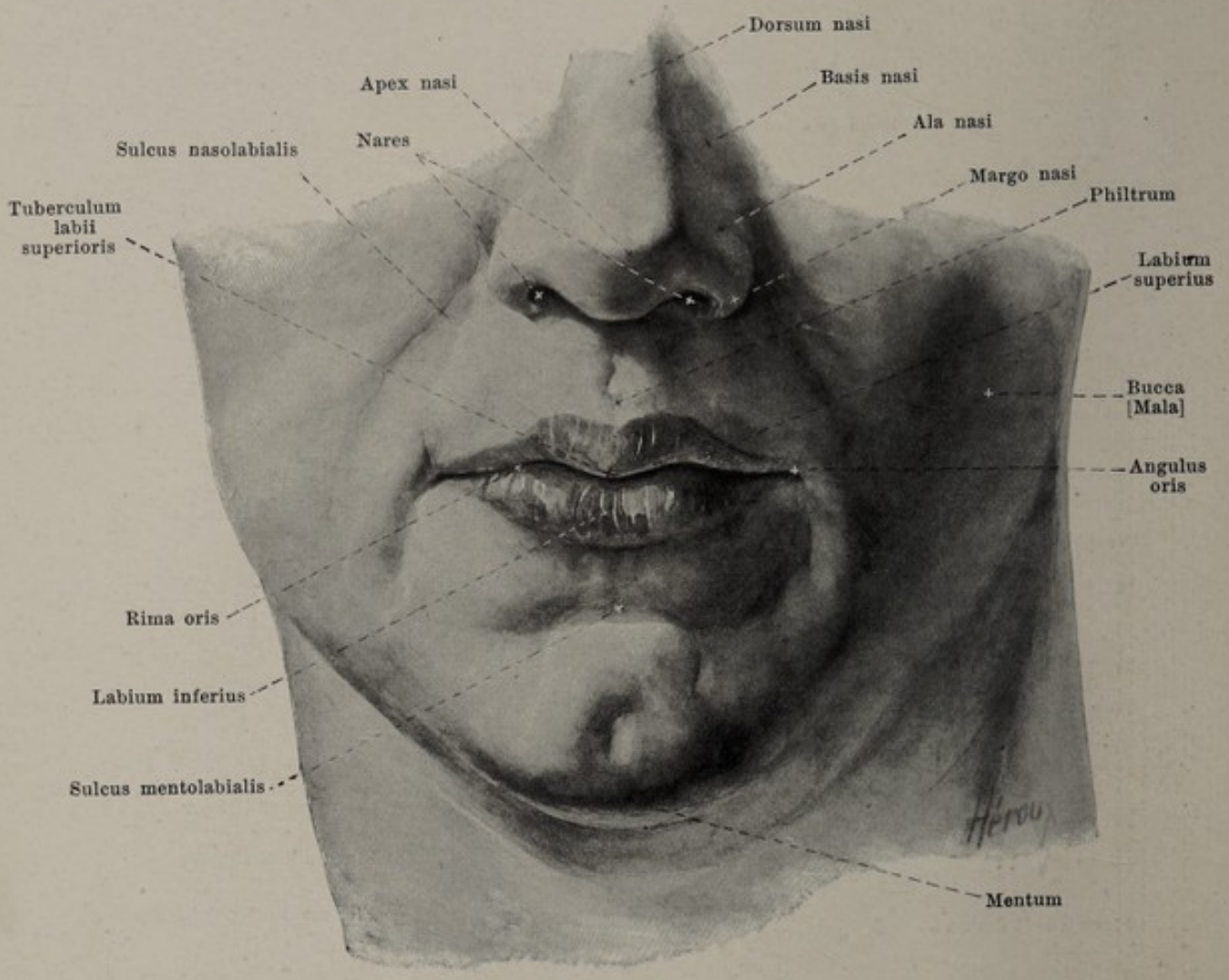


563. General view of the digestive tube,

somewhat schematic.

(A piece has been cut out of the transverse colon, its course being indicated by dotted lines. The inferior margin of the liver is indicated by a fine dotted line.)

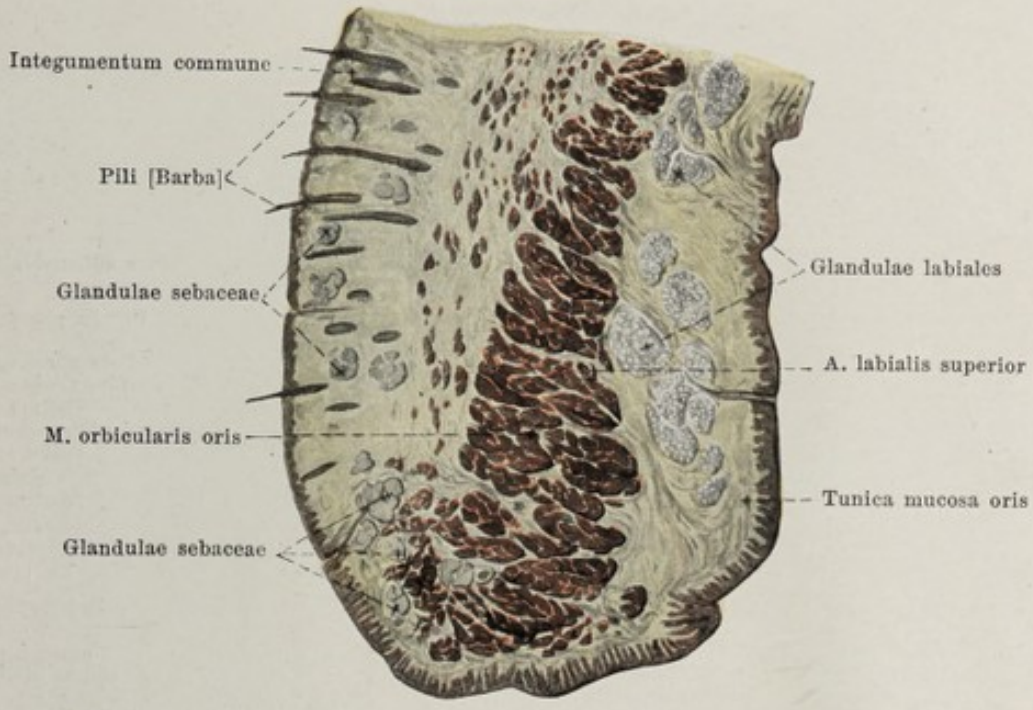


564. The mouth-slit and its surroundings.

The **cavum oris** *(mouth cavity)* (see Figs. 567, 568 and 594) is the beginning of the *apparatus digestorius* (digestive tube) but serves also as a path for the respiratory air and for the formation of sounds of speech. It opens in front through the mouth-slit; in front it is bounded by the mucous membrane of the lips, lateralward by that of the cheeks, above by the palate, below by the tongue and by the mucous membrane which extends from the under surface of the tongue to the gums; behind it is connected by the isthmus faucium with the pharynx. The processus alveolares of the upper jaw-bones and the pars alveolaris of the lower jaw-bone with the teeth fixed in them separate an anterior and lateral, narrow portion *(vestibulum oris)* from the mouth cavity proper *(cavum oris proprium)*.

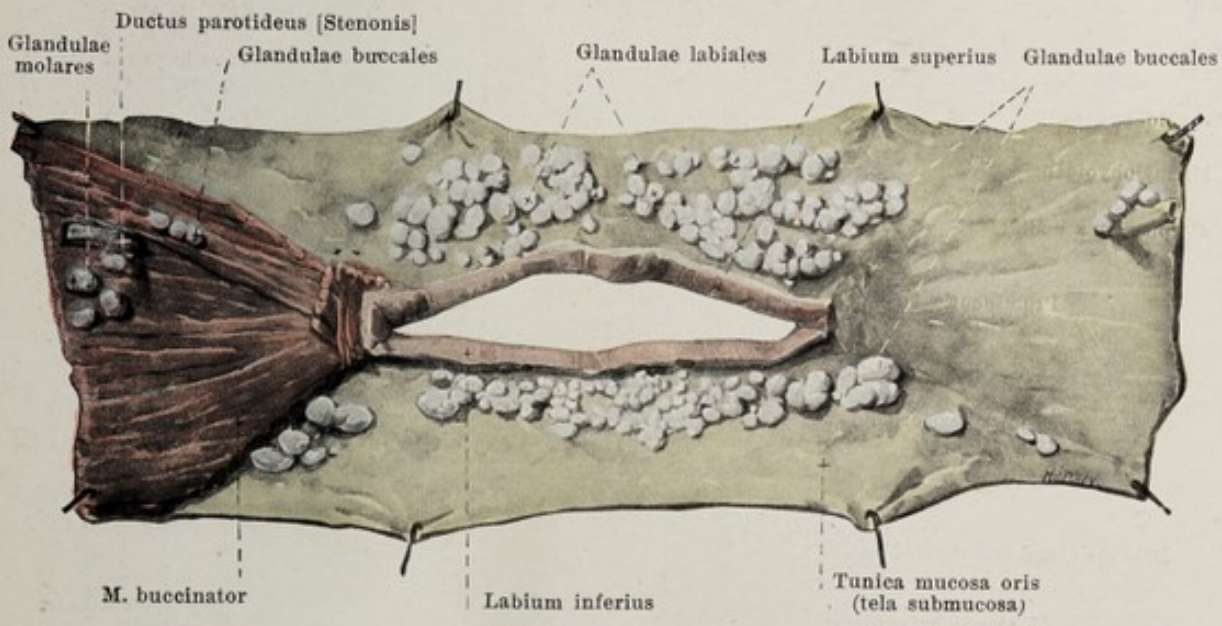
The **vestibulum oris** (see Figs. 567 and 568) when the mouth is closed and lips and teeth in contact, is a vertically placed, horse-shoe-shaped slit, which is connected with the mouth cavity proper only by means of the minute spaces between the teeth and on each side by a somewhat larger space between the hindermost molar teeth and the anterior margin of the ramus of the lower jaw.

The **lips** *(labia oris)* (see also Figs. 565—567, 589 and 594) are folds which are covered on the outer surface by skin, on the inner by the tunica mucosa oris and which contain, between these, the m. orbicularis oris (see p. 263). As *upper* and *lower lip (labium superius, labium inferius)* they bound the *rima oris (mouth-slit)* and go over into one another on each side, lateralward from its extremity *(angulus oris, angle of the mouth)*, by means of the *commissura labiorum*. In the median plane from the posterior surface of each lip a small perpendicular fold of mucous membrane *(frenulum labii superioris, frenulum labii inferioris)* extends to the anterior surface of the jaw-bones. Between the muscular layer and the mucous membrane, in the tela submucosa, lie numerous *labial glands (glandulae labiales)*, some as large as a grain of millet; their ducts open upon the surface of the mucous membrane.



565. Cross-section through the upper lip.

Magnification 4 : 1.

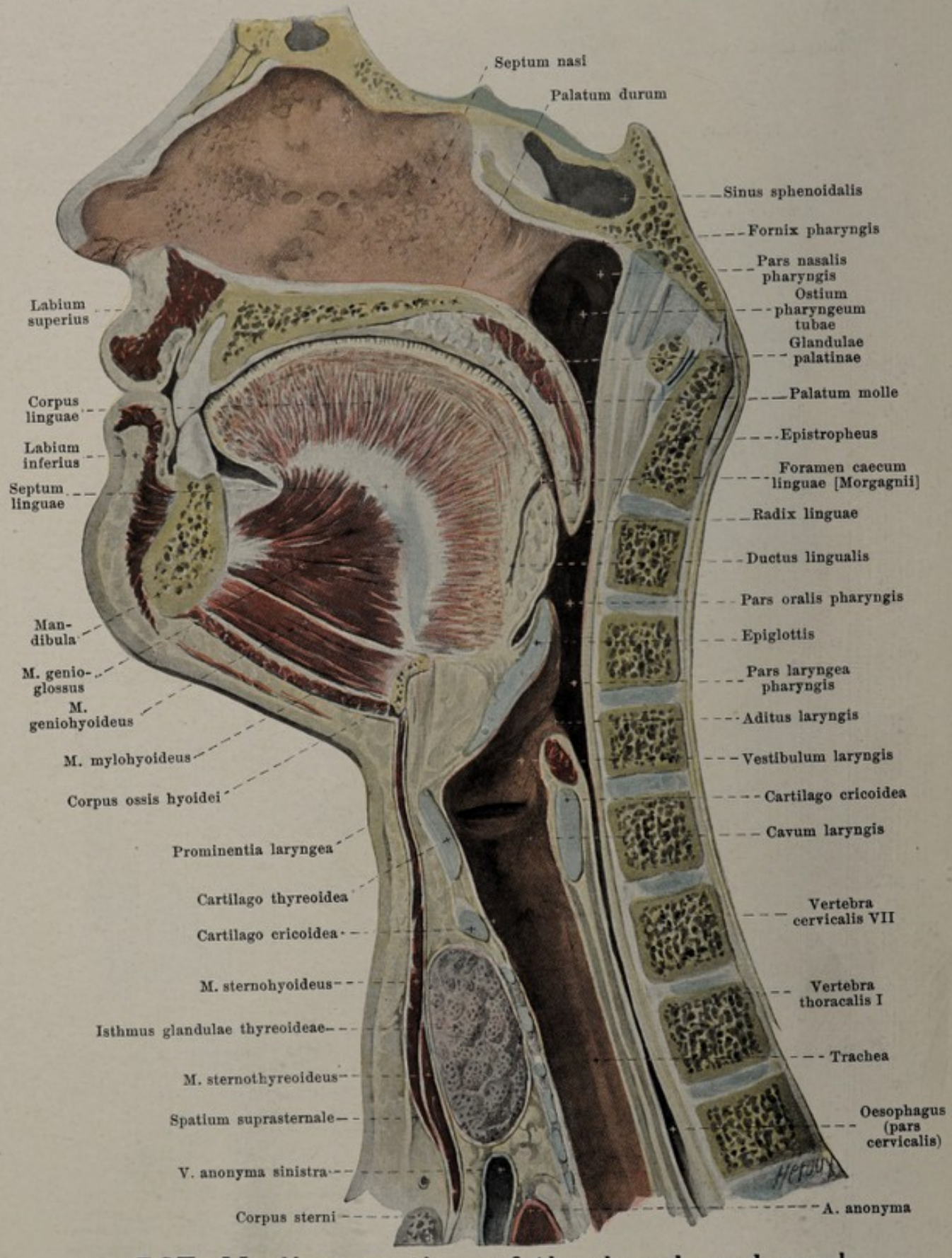


566. Glands of the lips and cheeks,

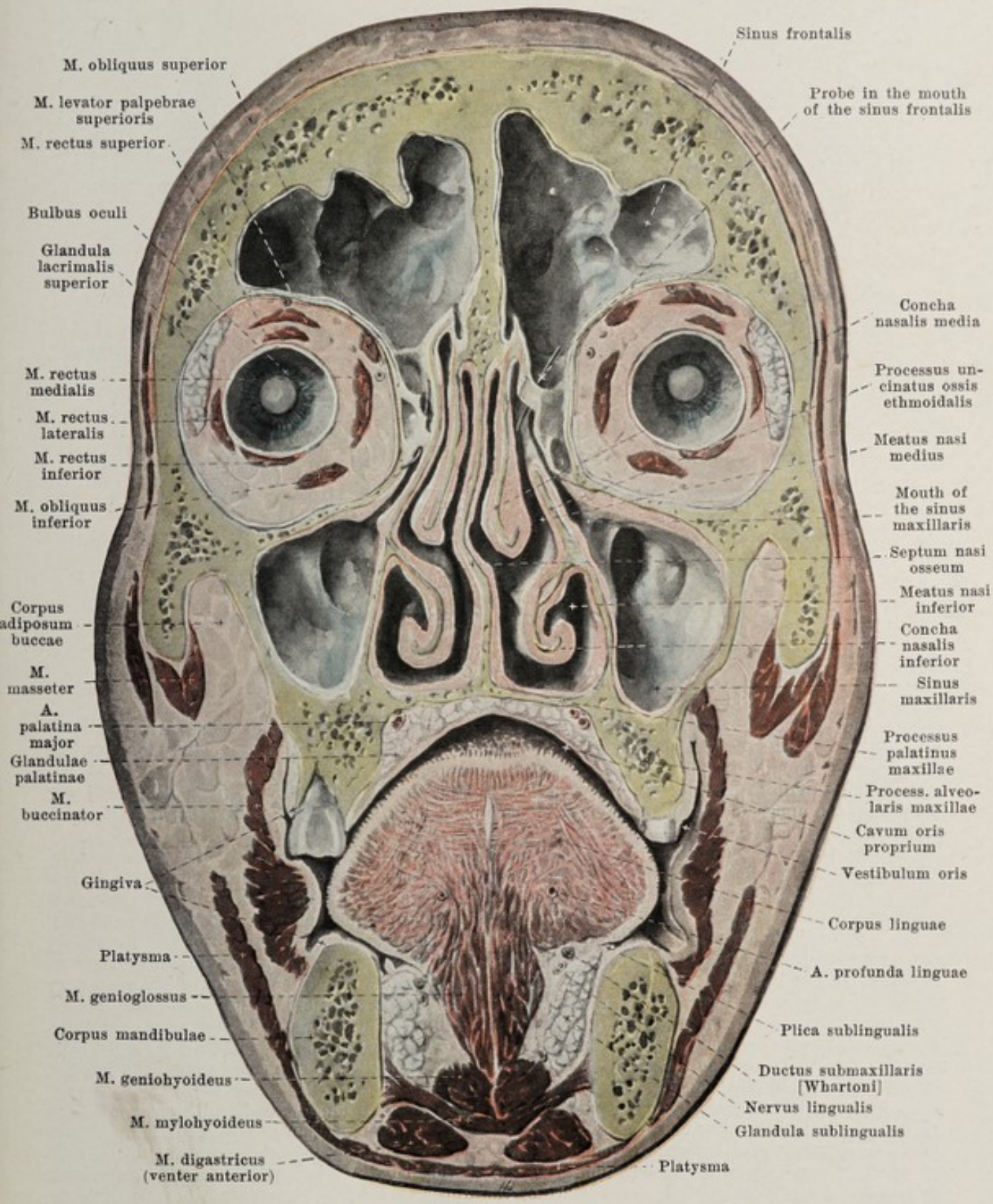
viewed from in front.

(The external skin has been completely, the musculature of the mouth-slit in large part, removed.)

The **cheeks** *(buccae)* are lined internally in the region of the vestibulum oris by the tunica mucosa oris. They contain in an upper and in a lower zone a number of *buccal glands (glandulae buccales)*, which lie usually between the mucous membrane and the m. buccinator. Attached to the latter behind the orifice of the ductus parotideus a group of somewhat larger glands *(glandulae molares)*, is usually situated on the lateral surface of the m. buccinator.



567. Median section of the head and neck,
right half, viewed from the left (partly after W. Braune).

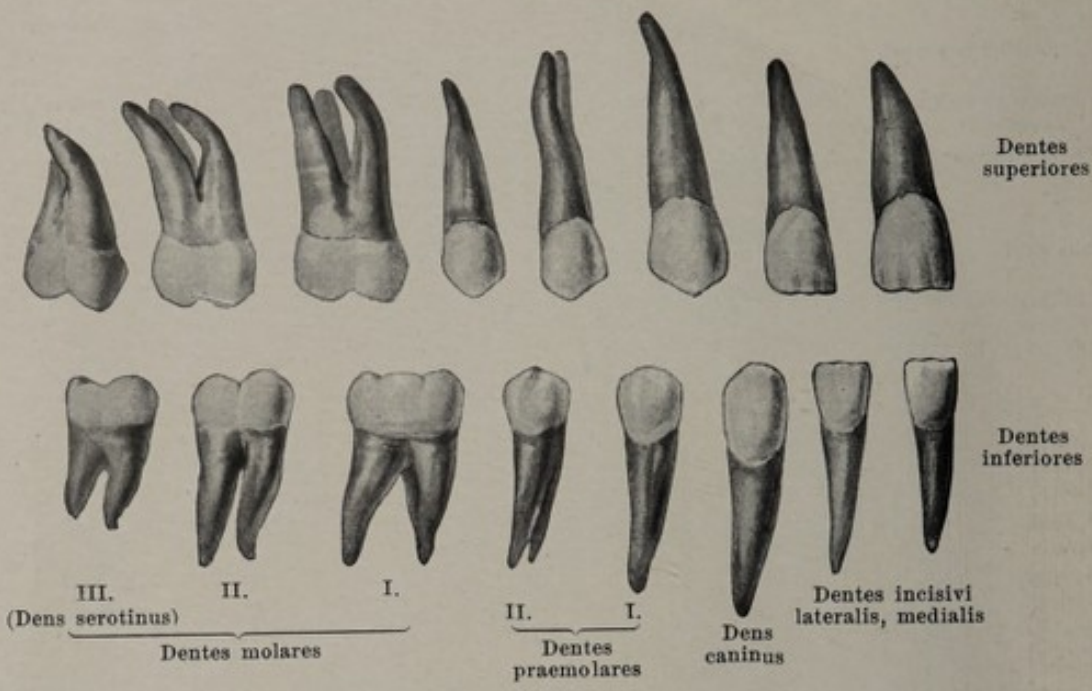


568. Frontal section of the head,

viewed from behind (after W. Braune).

(In the mandibula there are large gaps in the theeth on both sides.)

The **mucous membrane of the mouth cavity** *(tunica mucosa oris)* lines the inner surface of the lips and cheeks and is reflected upon the jaw-bones at about half the height of the roots of the teeth. It there forms the *gums (gingiva)*, is high, dense, immovable and arranged around the neck of the teeth in the form of wall-like elevations (see also Figs. 574 and 594).



569. Permanent teeth, right side,

viewed from the lip or cheek surface.

The **teeth** *(dentes)* appear in two succesive series called *dentitions*. The first dentition consists of 20 *milk teeth*, the second of 32 *permanent teeth*, which appear for the most part in the place of the milk teeth.

The **permanent teeth** *(dentes permanentes)* (see also Figs. 570—572, 578—580) are present in the upper and lower jaws, eight on each side: *2 incisor teeth, 1 canine tooth, 2 premolar teeth* and *3 molar teeth*.

The ***incisor teeth (dentes incisivi)****) possess a crown which in general resembles a chisel so that its free end is formed by a straight edge, the cutting edge. The facies contactus (facies medialis et lateralis) are approximately triangular, the facies labialis et lingualis are somewhat narrowed toward the root. The labial surface is approximately quadrangular and possesses usually three low longitudinal ridges, which correspond, when the teeth have freshly broken through, to three rounded jags on the cutting edge. The lingual surface is more triangular and markedly concave lengthwise; it ends at the neck in a very blunt projection. Each incisor tooth has only o n e root, which is inclined somewhat lateralward ("root characteristic"). The roots are conical, compressed somewhat from right to left (more markedly in the lower teeth) and usually slightly grooved on the medial and lateral surfaces. The root canal (see Figs. 574 and 576) is single. The superior medial incisor tooth is the largest, then follow usually the superior lateral, the inferior lateral and the inferior medial, which is always the smallest.

The ***canine teeth (dentes canini)*** are the strongest and longest teeth with one root. The crown runs out at the free end into an edge, the medial shorter portion of which forms an obtuse angle with the lateral longer portion. The labial surface is approximately pentangular and is broadest between the two terminal points of the cutting edge. It is markedly convex, especially in transverse direction. The lingual surface of the upper canine tooth presents a blunt nodule on its neck, from which a strong longitudinal ridge extends to the medial angle of the chewing edge. Medial and lateral from this ridge lies a shallow groove. The lingual surface of the inferior canine tooth is slightly hollowed; its nodules project only a little or not at all. The crown of the inferior canine is the narrower and longer. The roots are single, flattened and grooved, like those of the incisor teeth; that of the inferior is not seldom bifurcated; they are inclined somewhat backward, specially toward the apex. The root canal is single.

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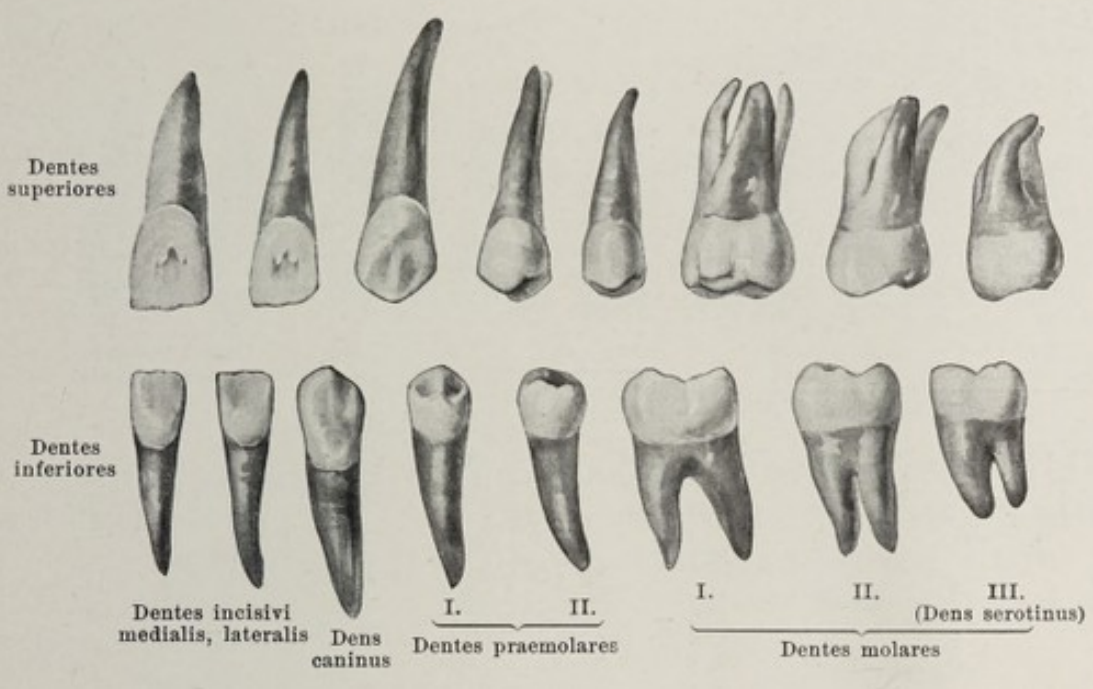
*) For the description of the teeth see also ps. 505 and 506.

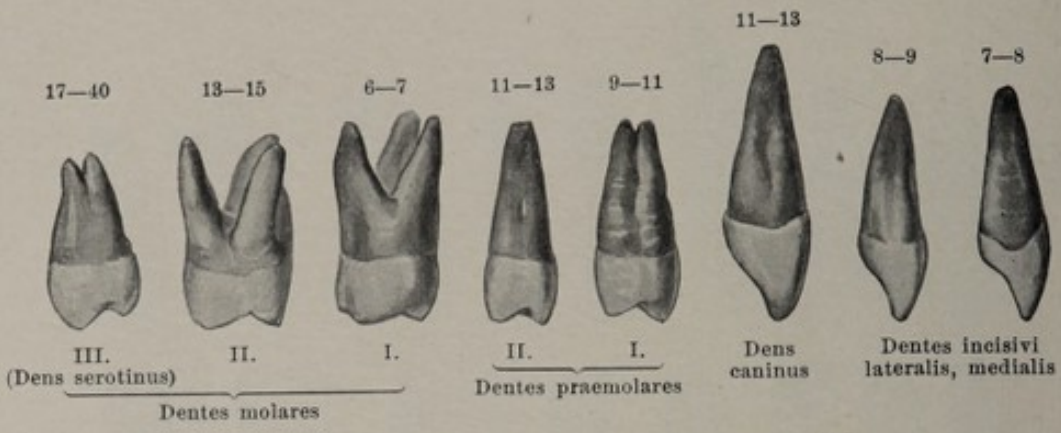


570. Permanent teeth, right side,

viewed from the lingual surface.

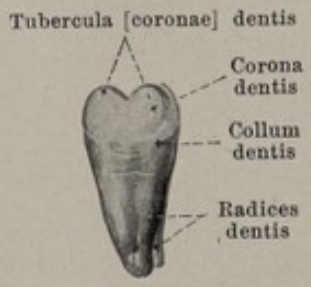
The ***premolar teeth*** *(dentes praemolares)* possess a broad, uneven, rounded-off quadrangular chewing-surface, which is divided by a groove running from before backward into a larger, buccal and a smaller, lingual tubercle; the tubercles are of the same height on the second superior premolar tooth, on the other premolars the lingual tubercle is lower. On the inferior teeth the two tubercles are frequently connected by a ridge of enamel. The buccal and lingual surfaces are convex transversely and longitudinally and each of them helps to form one of the declivities of the tubercles mentioned; thus the buccal surface resembles in its form that of the corresponding canine tooth. The root is single and curved backward; on the upper teeth it is flattened from before backward and presents flat grooves on the anterior and posterior surfaces, the marked development of which leads frequently to a bifurcation of the root of the first superior premolar tooth; the roots of the inferior teeth are more rounded. The pulp-cavity is a narrow slit-like space, compressed from before backward, and possesses two diverticula corresponding to the two tubercles; the first superior premolar tooth has, almost constantly, two root canals, one buccal and one lingual, the other have one slit-like canal (see also p. 505).

The ***molar teeth*** *(dentes molares)* are the strongest teeth and have (especially in the lower jaw) a more cubical crown. On the first superior molar tooth the chewing-surface is rhombic and divided by an H-like asymmetrically arranged groove into four tubercles of unequal size, of which two lie upon the buccal surface and two upon the lingual surface; the anterior lingual tubercle is the largest, the posterior the smallest. The buccal and lingual surfaces are convex and are subdivided by a longitudinal groove; the lingual surface frequently possesses a small (fifth) tubercle in front; it is often merely indicated and only very rarely reaches the chewing-surface. The anterior and posterior surfaces (facies contactus) are convex. The second upper molar tooth has either four tubercles like the first, or only three, in which case the posterior lingual tubercle is merely indicated or entirely absent. The third upper molar tooth *(dens serotinus, wisdom tooth)* varies extremely in form and size. The crown in many ways resembles that of the second; it possesses usually three tubercles, sometimes more, sometimes fewer; it may by very much reduced in size. The upper molar teeth have three roots; the two buccal roots run approximately parallel to one another, are flattened from before backward and bend somewhat backward at the apex; the third, lingual (palatal) root is rounded and diverges from the other two. The buccal roots have usually anterior and posterior longitudinal grooves, the palatal root is often manifoldly grooved on its lingual surface. The roots of the wisdom tooth are more or less fused with one another. The pulp cavity of the upper molar teeth is large, somewhat narrowed from before backward and possesses as many processes as there are nodules present (3—4). Each root has a single canal. The first molar tooth is usually the largest, the third the smallest.

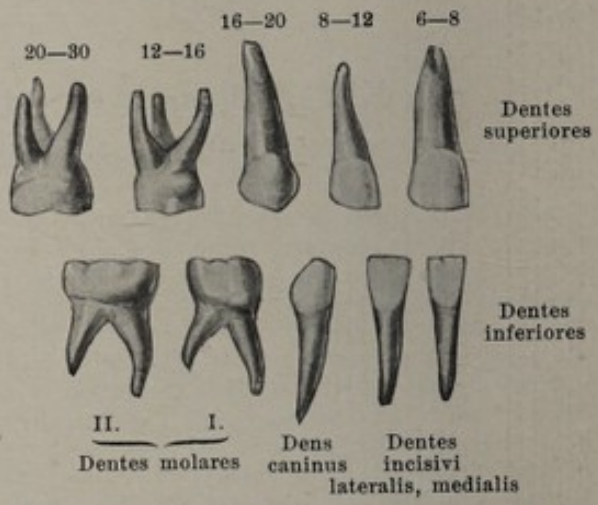


571. Upper permanent teeth, right side, facies contactus; the anterior teeth viewed from the lateral surface, the posterior teeth from the posterior surface.

(The Arabian numerals give the time of eruption of the individual teeth in years [after E. Zuckerkandl].)



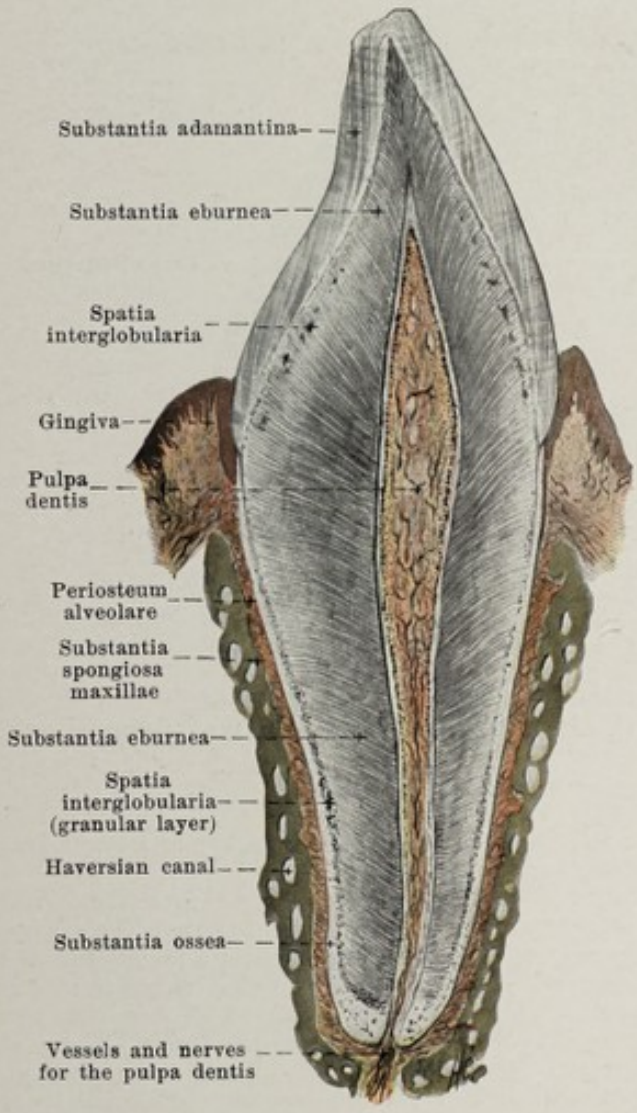
572. First inferior permanent molar tooth, right side, viewed from in front.



573. Milk teeth, right side, viewed from the labial or buccal surface.

(The Arabian numerals give the time of eruption of the individual teeth in months [after Fr. Hesse].)

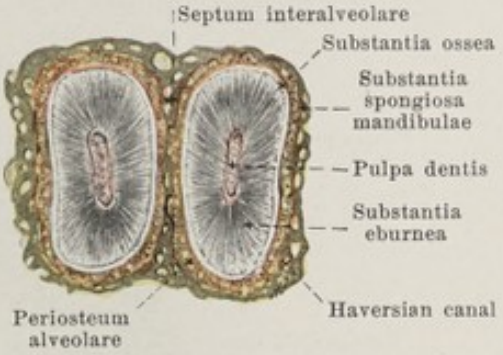
The ***molar teeth*** (continued). The inferior molar teeth are larger and more powerful than the superior. Their chewing-surfaces are rectangular and are somewhat longer from before backward than in the frontal direction. Each surface is divided by a fairly symmetrical +-shaped groove into 4—5 tubercles, namely 2—3 buccal and 2 lingual, of which the latter are a little higher; the anterior tubercles are somewhat larger than the posterior. The buccal surface is more markedly convex than the lingual. The first molar tooth almost always presents five tubercles, the second usually four, often five. The third *(wisdom tooth)* varies very much, but in general is not so rudimentary as in the upper jaw; it has usually 5 or 4 tubercles. The inferior molar teeth possess two roots, an anterior broader and a posterior; both are flattened from before backward and usually present longitudinal grooves on the broad anterior and posterior surfaces. The anterior root is usually directed vertically, the posterior obliquely backward; either of these may be bifurcated. The roots of the wisdom teeth are very different, frequently fused. The pulp cavity (see Fig. 577) resembles in shape that of the crown. The anterior root usually has two canals, a buccal and a lingual, the posterior usually only one (sometimes also two) (see also p. 505). The wisdom tooth presents three or two root canals or even only one. The first molar tooth is usually the largest, the third the smallest.



574. Sagittal section of an upper incisor tooth and its surroundings.

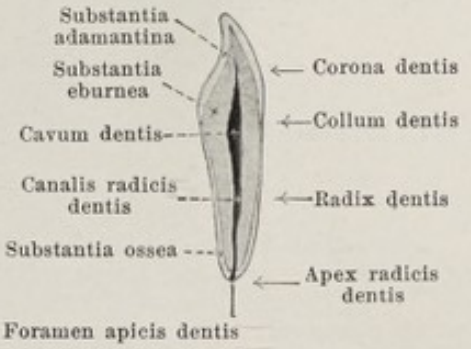
Magnification: 5 : 1.

(In Figs. 574 and 575 the drawings of the teeth have been made from air-containing ground sections.)

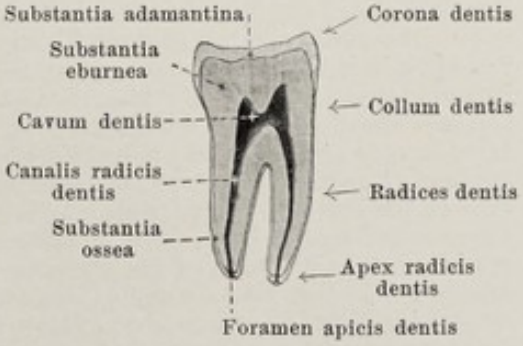


575. Transverse section through the roots of two lower incisor teeth and their surroundings.

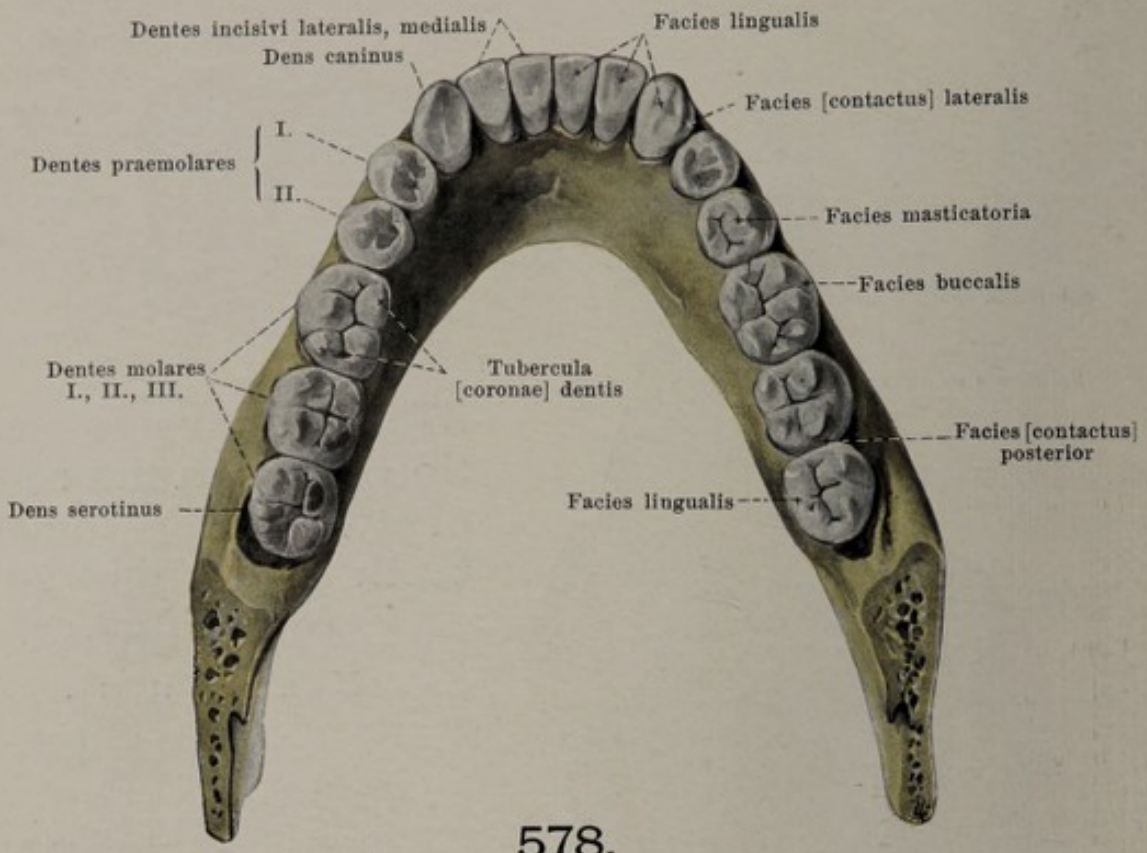
Magnification: 5 : 1.



576. Sagittal section through an upper incisor tooth.



577. Sagittal section through a lower molar tooth.



578.

Permanent teeth of the lower jaw *in situ,* viewed from above.

(The rami mandibulae have been sawed away.)

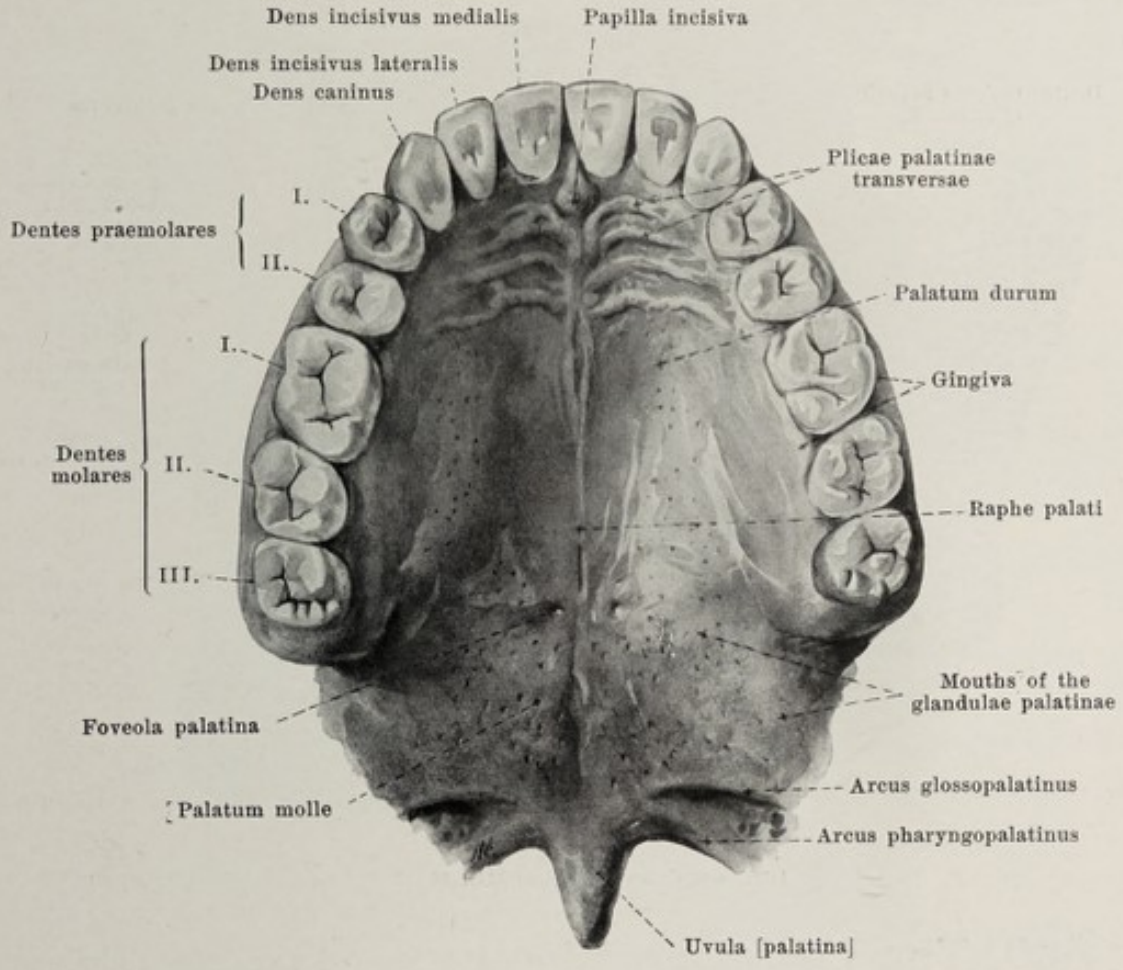
The **milk teeth** *(dentes decidui)* (see Fig. 573) are situated in the upper and lower jaw, five on each side as follows: *2 incisor teeth, 1 canine tooth* and *2 molar teeth.*

With the exception of the first molar teeth, in the main they resemble in form the corresponding permanent teeth, but are, however, in general smaller and more delicate. The crowns of the incisor and canine teeth are relatively broader and shorter, their roots are fairly long and very delicate. The milk teeth stand more perpendiculary in the jaws. Especially characteristic is the markedly developed ridge-like enamel border with which the crown is marked off from the root.

The ***incisor milk teeth*** are in their crowns very similar to the permanent. The root of the upper medial one is somewhat flattened from before backward, that of the others is round. The "root characteristic" (see p. 500) is distinctly marked on the upper teeth, but on the lower it is inconstant.

The ***canine milk teeth*** resemble the permanent very closely; the roots are round and directed toward the first molar tooth.

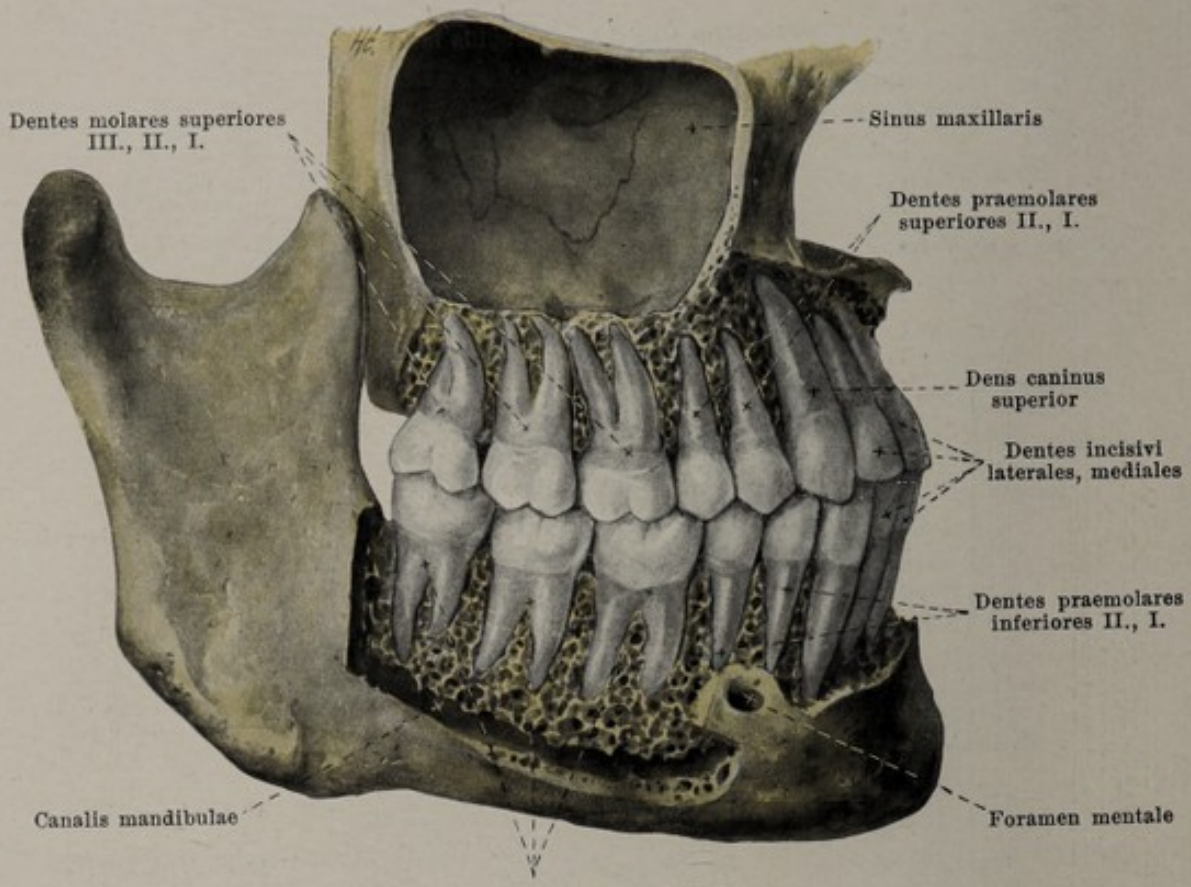
The ***molar milk teeth.*** The first upper molar tooth occurs in two forms. Either it resembles in its crown, especially in its chewing-surface, the first permanent premolar very closely, in which case the chewing-surface is triangular and divided by a sagittal groove into a buccal and a lingual tubercle; or the chewing-surface is broader from before backward, the buccal tubercle runs out more into a cutting edge, and behind the lingual tubercle a second smaller one appears. The buccam surface regularly presents a blunt nodular projection in front just over the neck of the tooth. The upper second molar milk tooth resembles throughout the first permanent upper molar tooth. Both upper molar milk teeth possess three roots, which in position and form are in general like those of the permanent teeth; but at their tips they diverge widely from one another. The first lower molar tooth has a quadrangular chewing-surface, which is drawn out lengthwise from before backward. It presents four or five tubercles, two lingual, sharp, and two or three buccal, lower, separated from the former by a sagittal furrow. The first lower tooth bears on its buccal surface a projection analogous to that seen in the first upper tooth. The second lower molar milk tooth resembles throughout the first permanent lower molar tooth. Each of the two lower molar milk teeth has two broad roots, which diverge markedly from one another, and only at their tips are bent somewhat toward one another; otherwise, however, they resemble those of the permanent teeth.



579. Permanent teeth of the upper jaw *in situ*

with the mucous membrane of the palate, viewed from below.

General statements regarding the teeth (see Figs. 572 and 574—577). Each tooth consists of *dentine (substantia eburnea)*, *enamel (substantia adamantina)* and *cement (substantia ossea)*. The dentine forms the main mass and gives the tooth its form, the enamel covers the free part of the tooth superficially, the cement the parts hidden in the bone and gum. According to form are distinguished the *crown of the tooth (corona dentis)*, the *neck of the tooth (collum dentis)*, and the *root of the tooth (radix dentis)*. The crown of the tooth is the thickest part projecting free into the mouth cavity. The root of the tooth, often multiple, is the longest portion, is situated for the most part in the correspondingly shaped alveolus of the jaw and is there held firmly in place by the fibres of the *root membrane (periosteum alveolare)* which for the most part run transversely; a narrow region of the root, however, projects beyond the free margin of the bone, is covered only by the gum and constricted more markedly in teeth with several roots than in teeth with one root; it is called the *neck of the tooth*. Within the dentine lies a cavity which resembles the external form of the tooth; the larger portion of the cavity situated in the crown and in the neck is called the *pulp cavity (cavum dentis)*; this narrows down to a slender *root canal (canalis radicis dentis)* which runs in every root and opens at the tip of the root *(apex radicis dentis)* by means of a fine opening *(foramen apicis dentis)*. The course, form and number of the root canals especially of the premolar, and of the anterior roots of the two first lower molares are not constant or regular. The canals of the same root are often at different levels connected with each other by fine or coarse anastomoses. Near the tip of the root, the canals may be branched into two or more canaliculi which open apart at the tip. The whole tooth cavity is completely filled by the *tooth pulp (pulpa dentis)*, rich in blood vessels and nerves.

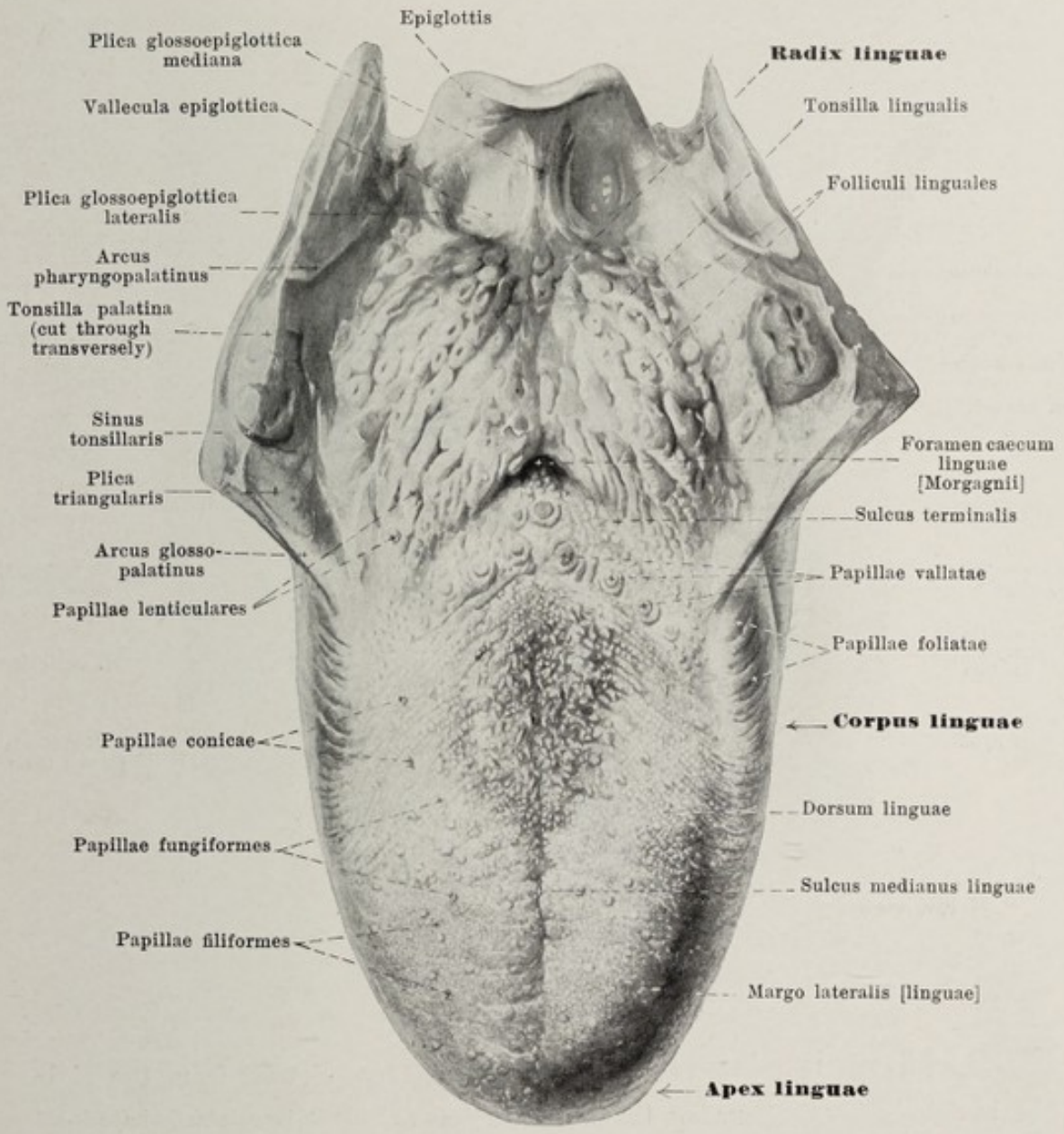


580. The permanent teeth, viewed from the right.

(The external layer of bone has been partly removed and the sinus maxillaris has been opened.)

On the *crown of the tooth* (see Fig. 578) five surfaces can be distinguished. The external surface of the incisor and canine teeth is covered by the lips *(facies labialis)*, of the premolar and molar teeth by the cheeks *(facies buccalis)*. The inner surface belonging to the concave side of the tooth-arch is the *facies lingualis*. The two surfaces, by which the tooth touches its neighbors are called the *facies contactus* and on the incisor and canine teeth are distinguished as the *facies medialis* and *facies lateralis*, on the premolar and molar teeth as the *facies anterior* and *facies posterior*. The fifth surface *(facies masticatoria)* when the jaws are closed is in contact with the corresponding surface of the other row of teeth; on the incisor teeth it is reduced to a cutting edge, but on the other teeth it has one or several tubercles *(tubercula [coronae] dentis)*.

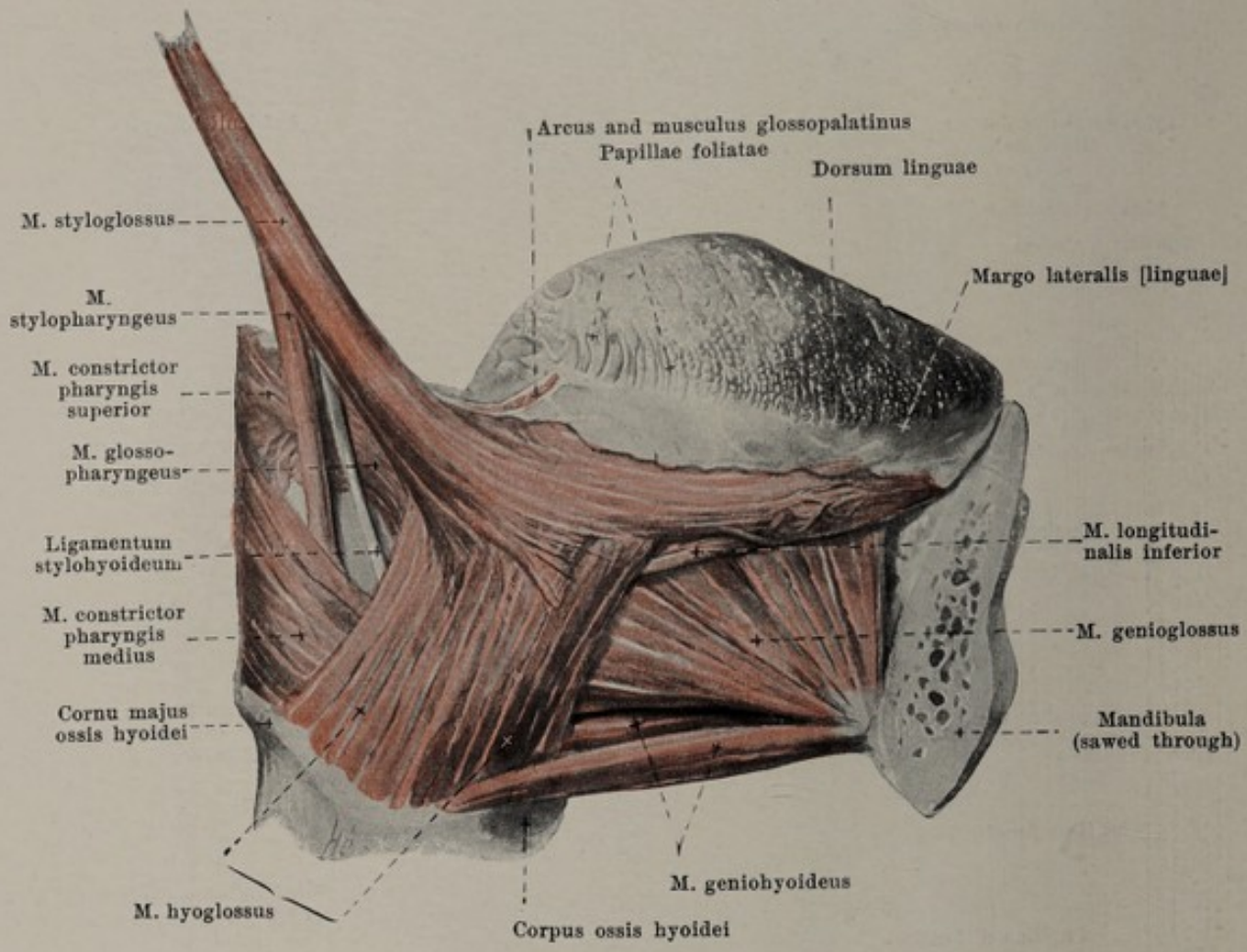
The *lower* **row of teeth** or *tooth-arch (arcus dentalis inferior)* (see Fig. 578) resembles a parabola in its curvature, the *upper row (arcus dentalis superior)* (see Fig. 579) forms half an ellipse. Since the two rows of teeth differ from one another and since, besides, the teeth in the two jaws present differences in form and size, the teeth of the same name in the upper and lower jaws do not come into contact with one another in their corresponding portions. The *articulation of the rows of teeth* occurs rather as follows: The upper teeth which *in toto* are directed with their long axes somewhat obliquely outward and downward, project lateralward somewhat over the lower teeth, the long axes of which run more inward and upward. As a result of this the upper anterior teeth cover somewhat the free ends of the lower teeth from in front (the upper teeth bite o v e r the lower) (see also Fig. 567), while the buccal tubercles of the other upper teeth lie somewhat lateralward as regards the same tubercles of the lower teeth, and the lingual tubercles of the upper teeth lie in the grooves between the buccal and lingual tubercles of the lower teeth. The rows of teeth are also displaced from before backward as regards one another. Especially since the upper incisor teeth are considerably broader than the lower, the upper canine tooth lies between the lower canine and the lower first premolar, touching both; similarly the upper premolar and molar teeth are displaced backward; the upper wisdom tooth, smaller than the lower, is the only one that does not project over behind the lower.



581. Tongue, viewed from above.

(The palatine arches and the palatine tonsils have been cut through transversely.)

The **tongue** *(lingua)* is a flat, oblong body consisting mainly of muscles and is fastened below to the floor of the mouth. It ends in front in a flat rounded tip *(apex linguae)*. Following upon this without being sharply differentiated from it is the body of the tongue, *corpus linguae*. This in turn is bounded behind by the *sulcus terminalis*, the right and left limbs of which run obliquely backward toward the median plane and meet in the *foramen caecum linguae [Morgagnii]*; the latter is represented usually by a small depression and in an early embryonal period is the opening of the ductus thyreoglossus (see p. 592), the terminal portion of which may still be met with in variable length in the adult as the *ductus lingualis* (see Fig. 567). The region behind the sulcus terminalis is called the *radix linguae* (root of the tongue). The upper surface of the tongue *(dorsum linguae)* (see also Figs. 567 and 568) is curved in a sagittal and frontal direction so as to be convex upward and presents in the median plane especially in front a shallow groove, the *sulcus medianus linguae*. At the root of the tongue it goes directly over into the medial surface of the palatine arches and the tonsils (see also Fig. 596). The body of the tongue is bounded lateralward by the blunt *margo lateralis [linguae]*. The inferior surface *(facies inferior [linguae])* lies free only along its lateral margins and below the anterior portion of the tongue (see also Figs. 567, 568 and 589).



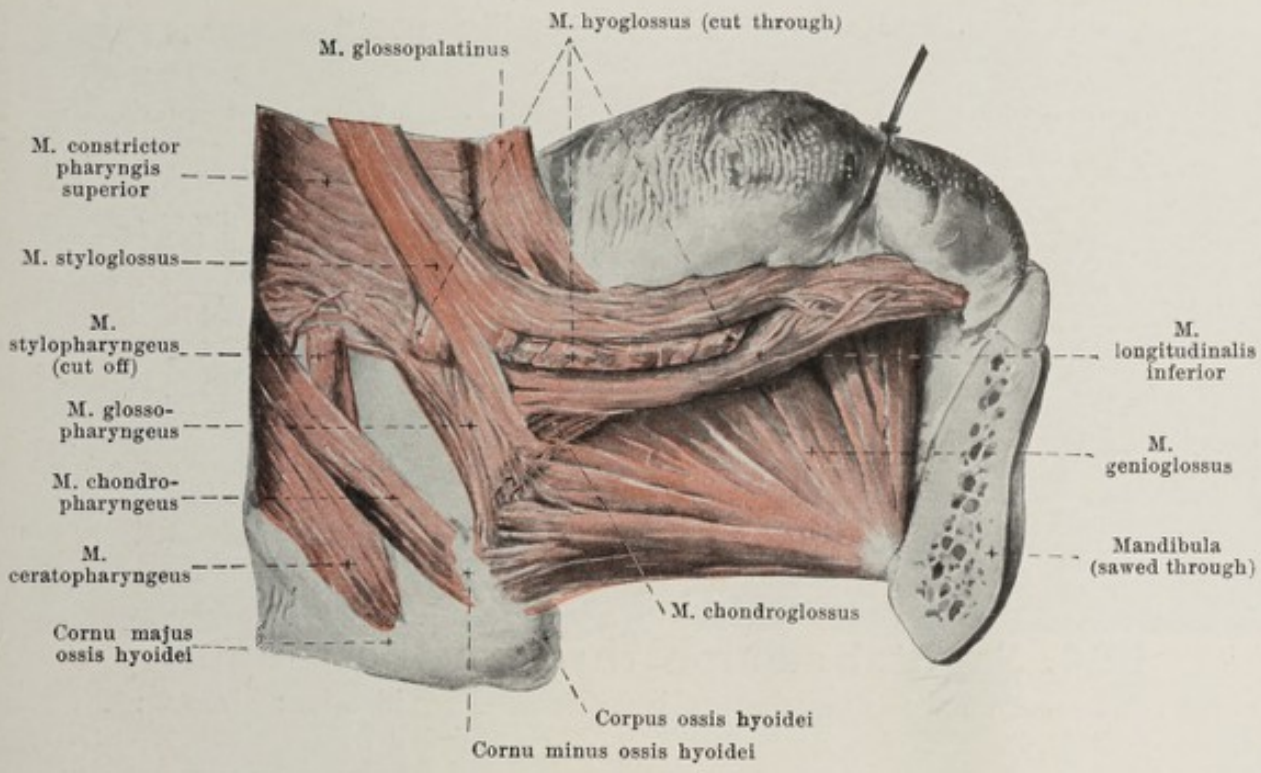
582. Musculature of the tongue, viewed from the right.

(The right half of the lower jaw, the m. mylohyoideus and the salivary glands have been removed.)

Muscles of the tongue *(musculi linguae):*

M. styloglossus (see also Figs. 583, 585, 590 and 606). Form: long, narrow and flat. Position: medianward from and above the m. stylohyoideus, between the a. carotis externa and interna, medianward from the mandibula and m. pterygoideus internus, covered by the glandula parotis. Origin: processus styloideus and ligamentum stylohyoideum. Insertion: it runs obliquely downward, forward and medianward to the lateral surface of the m. hyoglossus. It there divides into two bundles; the larger, lateral, upper bundle goes on the lateral surface of the m. hyoglossus and m. longitudinalis inferior beneath the lateral margin of the tongue toward the tip of the tongue; the smaller, medial, inferior bundle perforates the m. hyoglossus and turns medianward in the posterior part of the tongue. Action: it draws the tongue, especially the radix linguae, upward and backward. Innervation: n. hypoglossus.

M. hyoglossus (see also Fig. 583). Form: flat, quadrangular. Position: medianward from and above the glandula submaxillaris and m. mylohyoideus, medianward from the mandibula. Origin: upper margin of the corpus and cornu majus ossis hyoidei. Insertion: it extends upward and somewhat forward and plunges between the bundles of the m. styloglossus; the fibres then bend around forward between the lateral bundle of the m. styloglossus and the m. longitudinalis inferior and run longitudinally in the tongue toward the apex. Action: it draws the tongue backward and downward. Innervation: n. hypoglossus.



583. Deep musculature of the tongue,

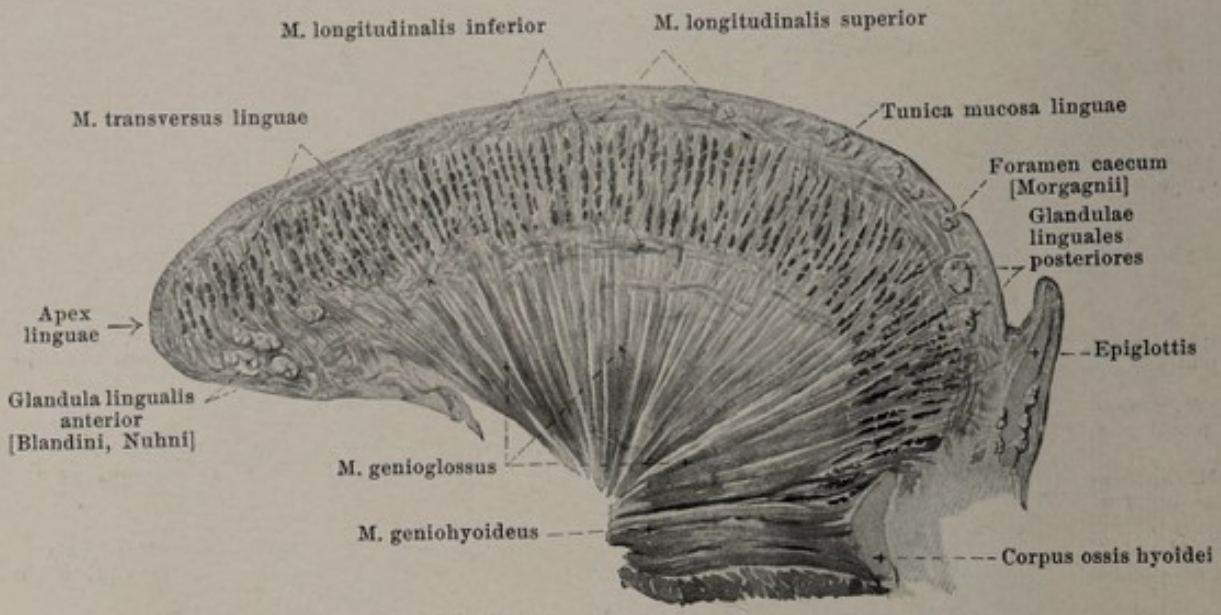
viewed from the right.

(As in Fig. 582; in addition the mm. geniohyoideus and hyoglossus have been removed and the tongue has been drawn upward and to the left.)

M. genioglossus (O. T. geniohyoglossus) (see also Figs. 582, 584, 585 and 590). Form: approximately quadrangular, thick, placed sagittally. Position: in the depth of the tongue, just above the m. geniohyoideus, close to and parallel to the median plane, separated from the muscle of the other side only by loose connective tissue and by the septum linguae (see p. 511); lateralward partly covered directly by the mm. longitudinalis inferior, hyoglossus, styloglossus and the glandula sublingualis. Origin: by a small triangular tendon from the spina mentalis mandibulae, just above the m. geniohyoideus. Insertion: the fibres diverge backward and upward. The lowermost fibres go backward parallel to the m. geniohyoideus and are attached partly to the corpus ossis hyoidei, partly to the epiglottis; the other fibres radiate fan-like toward the dorsum linguae in the whole length of the tongue and accordingly decussate in layers with the fibres of the m. transversus linguae. Action: it draws the tongue forward and downward. Innervation: n. hypoglossus.

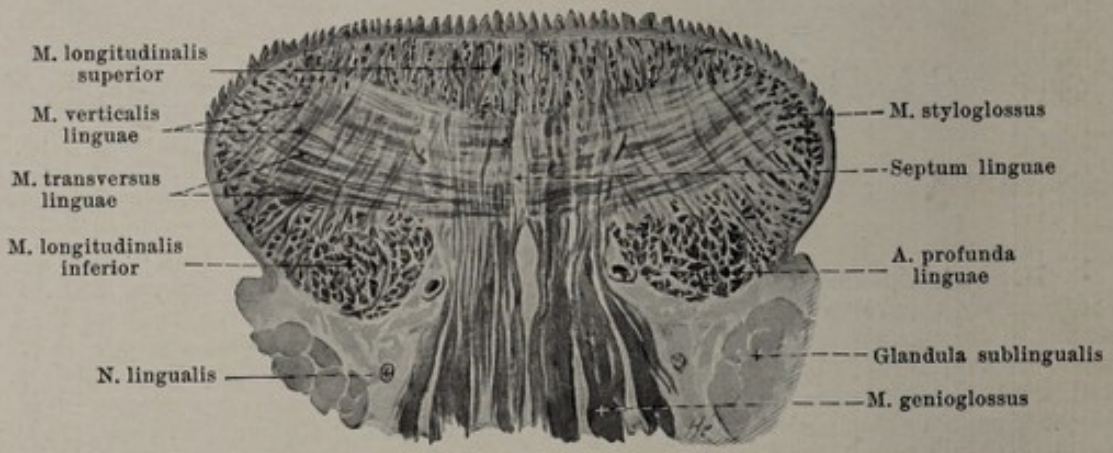
M. longitudinalis inferior (O. T. inferior lingual) (see also Figs. 582, 585 and 590). Form: long and narrow. Position: in the depth of the tongue, in front between the mm. genioglossus and styloglossus, behind between the mm. genioglossus and hyoglossus. Origin: in the mucous membrane of the root of the tongue. Insertion: the fibres pass downward in the form of a curve and collect on the medial surface of the m. hyoglossus in the form of a well isolated muscle-belly. Fibres which arise from the cornu minus oss. hyoidei *(m. chrondoglossus)* partly lie upon this muscle-belly below, partly extend upward and forward between the bundles of the m. genioglossus and join the m. longitudinalis superior. The main mass of the m. longitudinalis inferior runs straight forward and ends in the mucous membrane of the facies inferior linguae; only a small part bends upward to the mucous membrane of the dorsum of the tongue. Action: it shortens the tongue in the longitudinal direction. Innervation: n. hypoglossus.

M. longitudinalis superior (O. T. superior lingual) (see Figs. 584—586), just beneath the mucous membrane of the whole dorsum of the tongue, strengthened behind by a part of the fibres of the m. chondroglossus. The fibres run in the longitudinal direction, are stretched out in bundles in short arches, concave above, between points of the mucous membrane, the different bundles decussating with one another. Action: it bulges the tongue upward in the longitudinal direction. Innervation: n. hypoglossus.



584. Sagittal section through the tongue

of a new-born babe, near the median plane. Magnification: circa 3:1.



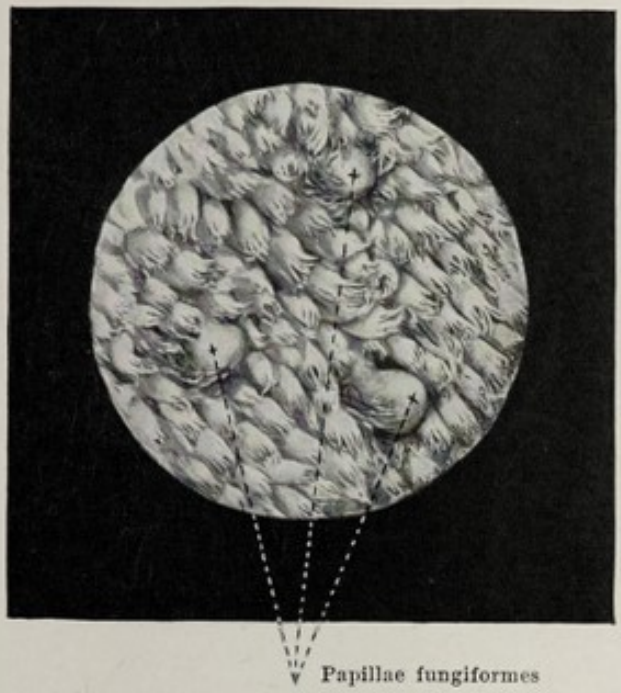
585. Frontal section through the body of the tongue

of a new-born babe. Magnification: circa 3:1.

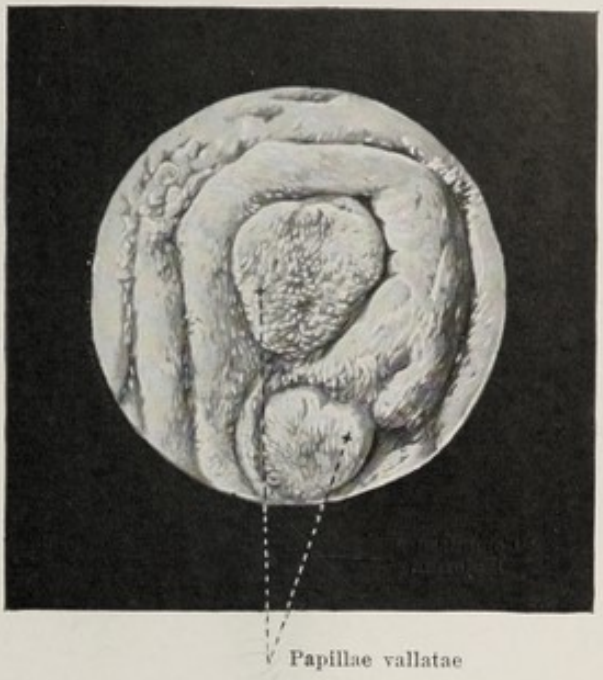
586. Frontal section through the apex of the tongue

of a new-born babe. Magnification: circa 3:1.

(Figs. 584—586 after preparations of Fr. Hesse.)



Papillae fungiformes



Papillae vallatae

587. Papillae filiformes,
viewed from the surface.

588. Papillae vallatae,
viewed from the surface.

Magnification: 7:1.

M. transversus linguae (see Figs. 584—586), in the whole extent of the tongue. It consists of layers placed perpendicularly to the surface alternating with the lamellae of the m. genioglossus; in these layers the fibers run in a frontal direction and in a fan-like distribution to the mucous membrane of the dorsum and lateral margin of the tongue; some of the fibres of the muscle arise from the septum linguae, others perforate it. Action: it bulges the tongue upward in the transverse direction. Innervation: n. hypoglossus.

M. verticalis linguae (see Figs. 585 and 586) is formed of bundles of fibres, which pass directly from the superior to the inferior mucous membrane of the tongue especially in the neighborhood of its lateral margin. Innervation: n. hypoglossus.

Septum linguae (see Figs. 567, 585 and 586) is a small, narrow leaf of connective tissue which runs from before backward in the median plane and is surrounded on all sides by muscles; it is curved in a zigzag fashion to the right and to the left and multiply perforated.

The **tunica mucosa linguae** *(mucous membrane)* (see Fig. 581) is covered on the dorsum of the tongue by small elevations, the *papillae linguales (papillae of the tongue).* These are:

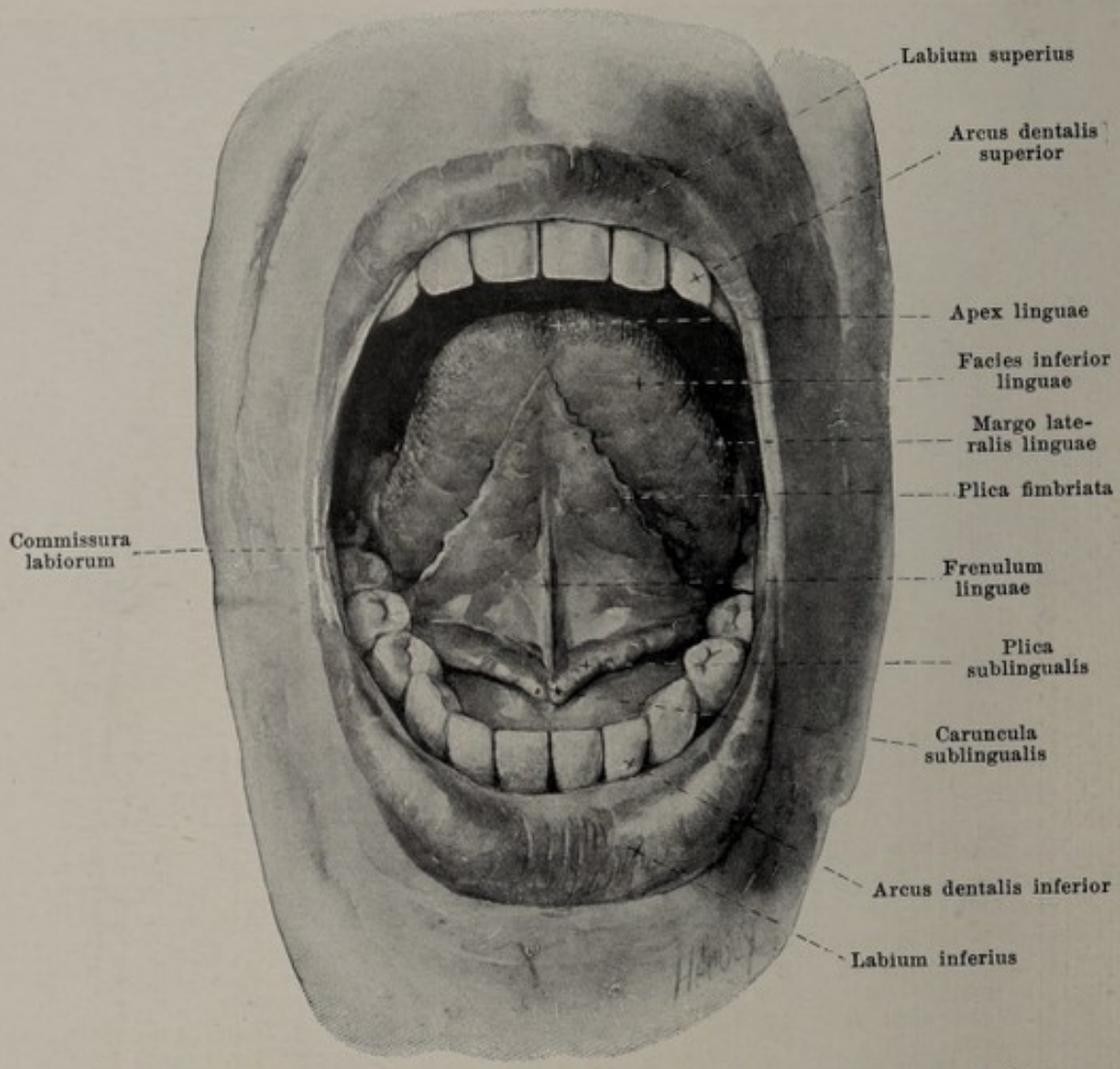
1. *Papillae filiformes*, narrow wedge-shaped elevations, with brush-like epithelial appendages of whitish color, present on the whole of the dorsum of the tongue, on its lateral margins, and at its tip. They are most dense in the middle part of the dorsum a little in front of the papillae vallatae and lie on the dorsum, as a rule, in rows from the median plane forward and lateralward.

2. *Papillae fungiformes*, flask-like projections, of reddish color, larger than the preceding, scattered between them, especially in the anterior half of the tongue; frequently accumulated at the point of the tongue. On the lateral margins of he tongue especially they are often markedly flattened and are then called *papillae lenticulares. Papillae conicae* is the name of papillae fungiformes which, owing to their more pointed shape, resemble the papillae filiformes.

3. *Papillae vallatae* (O. T. circumvallate papillae), the largest of all, 6—16, most often 9, are situated almost parallel to and in front of the sulcus terminalis in the form of a V or Λ, the most posterior is situated a little in front of the foramen caecum. They are short, cylindrical elevations, which are surrounded by a circular groove and a ridge of mucous membrane and project slightly above their surroundings.

4. *Papillae foliatae*, on each side on the margo lateralis linguae, a little in front of the beginning of the arcus glossopalatinus, are very variable and consist of from 4—8 nearly vertically placed folds separated by grooves and projecting but little above the surroundings.

Folliculi linguales are accumulations of lympathic tissue (with nodules) on the root of the tongue which produce variably large lens-shaped elevations in the mucous membrane. They may be partly fused with one another, extend backward as far as the epiglottis, laterally as far as the palate tonsils and are collectively termed *tonsilla lingualis.* Their average number is 66. Each one has a small, crater-shaped depression (see also Fig. 605).



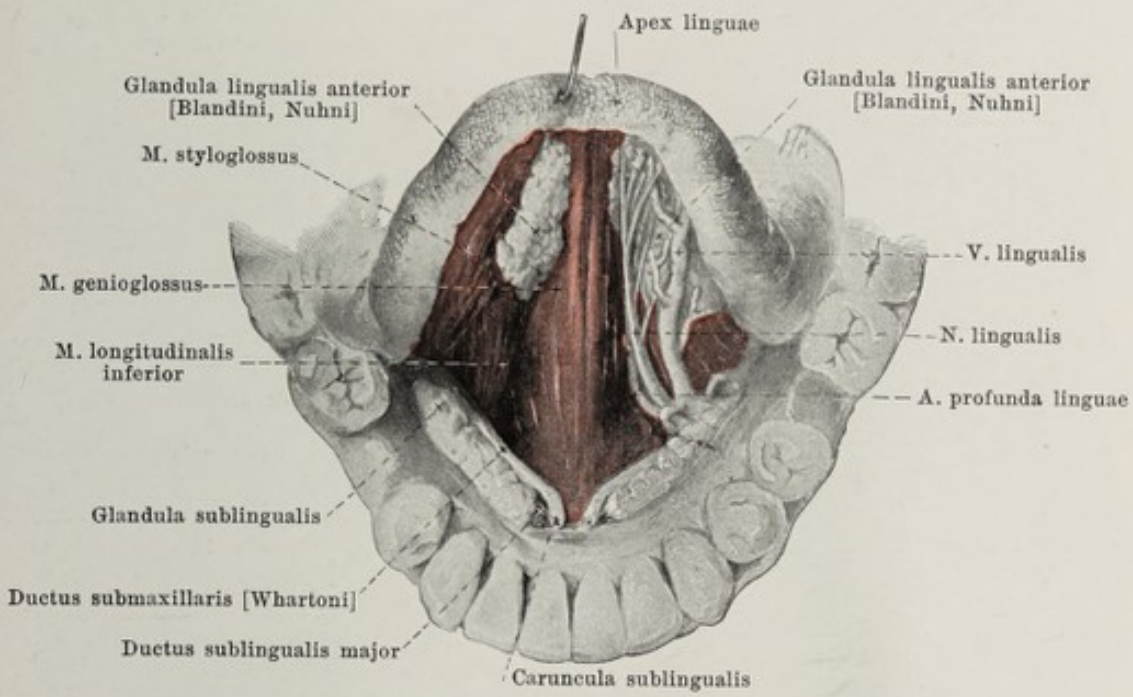
589. Inferior surface of the tongue and its surroundings, the tip of the tongue being elevated.

Mucous membrane of the tongue (continued). Passing out from the root of the tongue (see Fig. 581) in the median plane is a large fold of mucous membrane, *plica glossoepiglottica mediana* (median glosso-epiglottidean fold), and lateralward from it on each side a smaller, *plica glossoepiglottica lateralis;* these folds extend to the anterior surface of the epiglottis. Between them on each side lies a fossa-like depression, *vallecula epiglottica.*

The mucous membrane of the facies inferior linguae is smooth and presents only two symmetrical low, narrow folds, *plicae fimbriatae*, which converge in front; the free margin of each fold is for some distance finely jagged. These folds are more distinct in the new-born and in children than in the adult. In the median plane extending from the inferior surface of the tongue to the gums is a fold of mucous membrane, the *frenulum linguae.* Close to it on each side lies a small round nodule, *caruncula sublingualis*, which contains the opening of the ductus submaxillaris and sometimes also that of the ductus sublingualis major. On the region between the frenulum linguae and the arcus glossopalatinus the mucous membrane goes over in a flat curve upon the gums; at the point where it covers the glandula sublingualis it is elevated to form a long nodular ridge, the *plica sublingualis* (sublingual fold), which runs from the caruncula sublingualis on backward and lateralward; upon this ridge open the ductus sublinguales minores in small wart-like elevations.

The *glandulae linguales posteriores* (see Fig. 584) lie in large numbers just beneath the mucous membrane of the posterior half of the tongue lateralward as far as the palate tonsils.

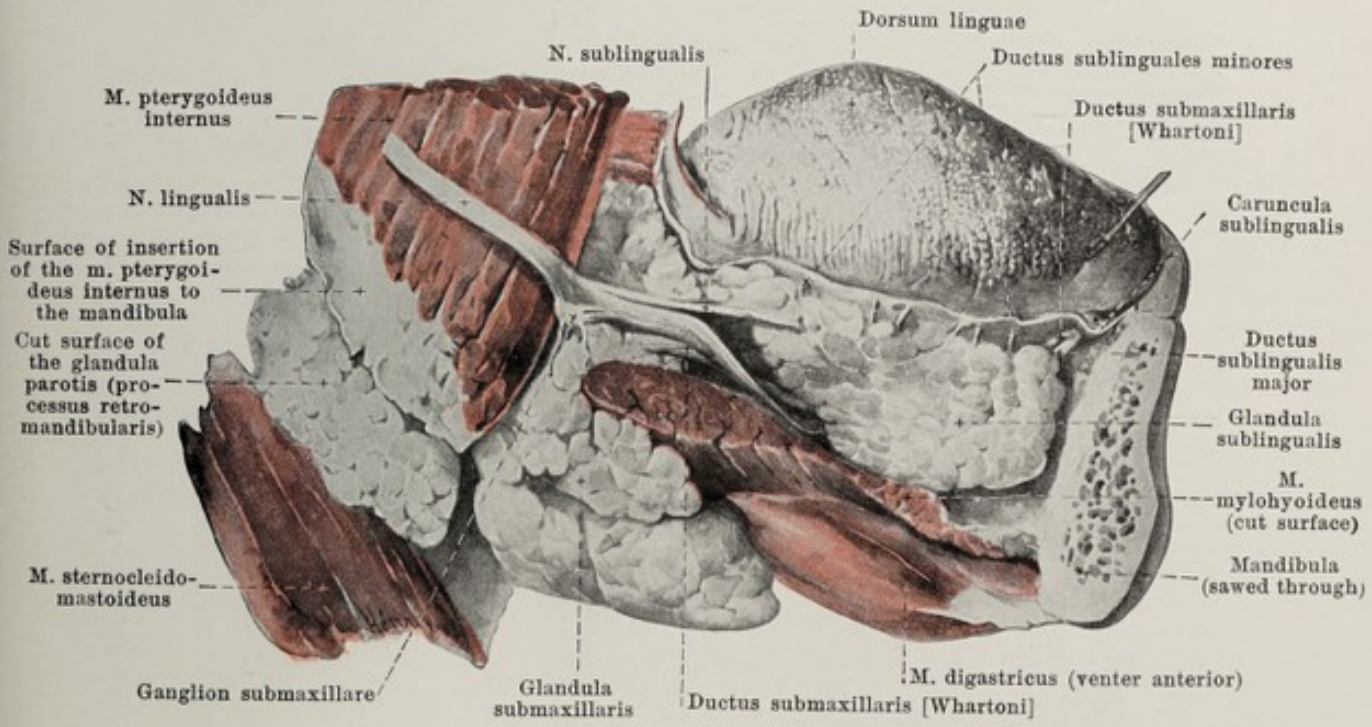
The *glandula lingualis anterior [Blandini, Nuhni]* (O. T. gland of Nuhn) (see Figs. 586 and 590) is an oblong body on each side lying lateralward from the anterior extremity of the m. genioglossus close behind the tip of the tongue; it is covered on its inferior surface by some fibres of the mm. styloglossus and longitudinalis inferior. It becomes thinner in front and combines with the one on the other side in a pointed curve. Its ducts (5—7) open on small protuberances of the mucous membrane medially of the plica fimbriata, sometimes in two rows.



590. Inferior surface of the tongue,

after removal of the mucous membrane, the tip of the tongue being elevated.

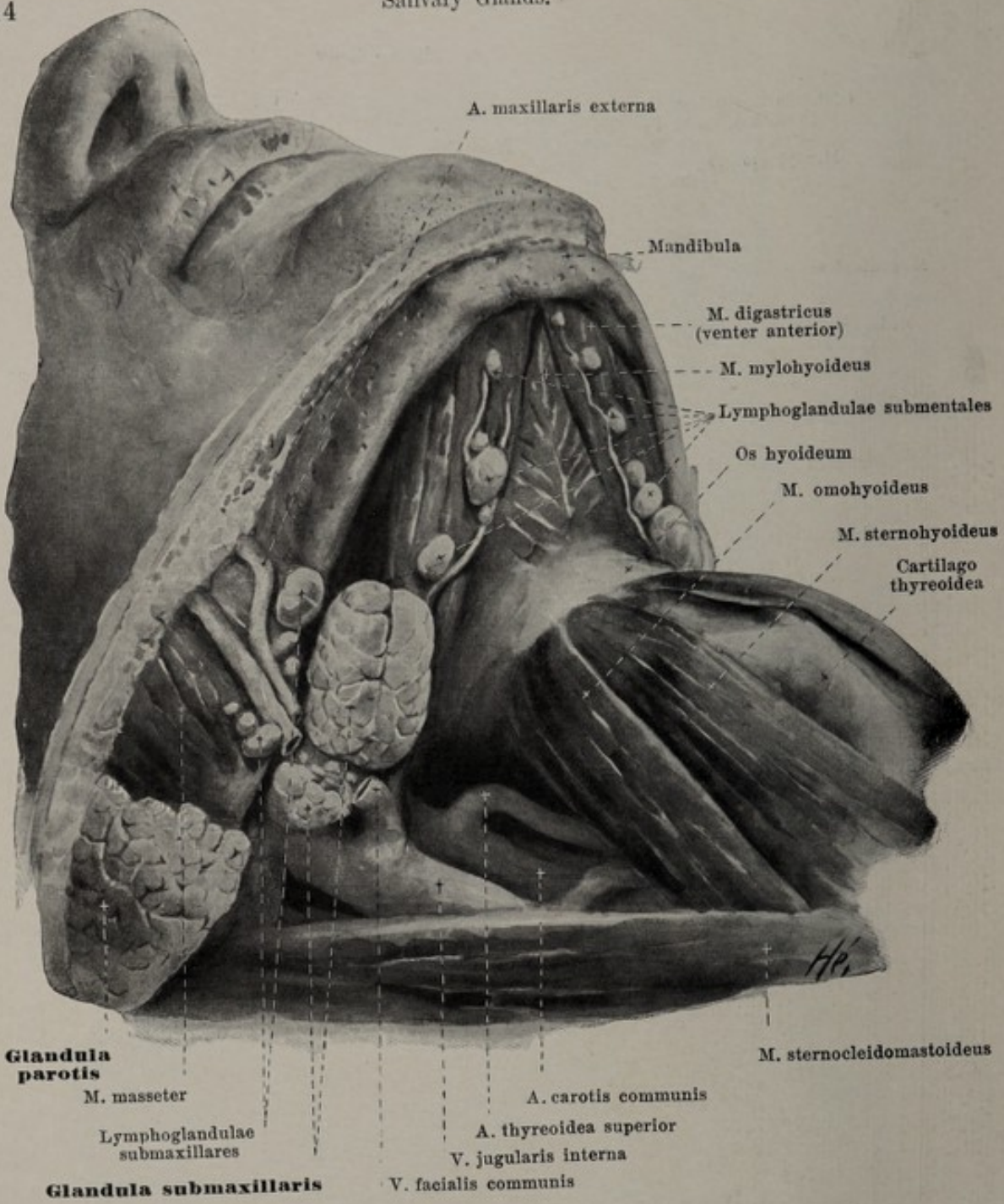
(On the right the blood vessels and nerves have been removed, as have also the superficial fibres of the mm. styloglossus and longitudinalis inferior as far as they cover the glandula lingualis anterior.)



591. Salivary glands of the right side,

after removal of the right half of the lower jaw, viewed from the right.

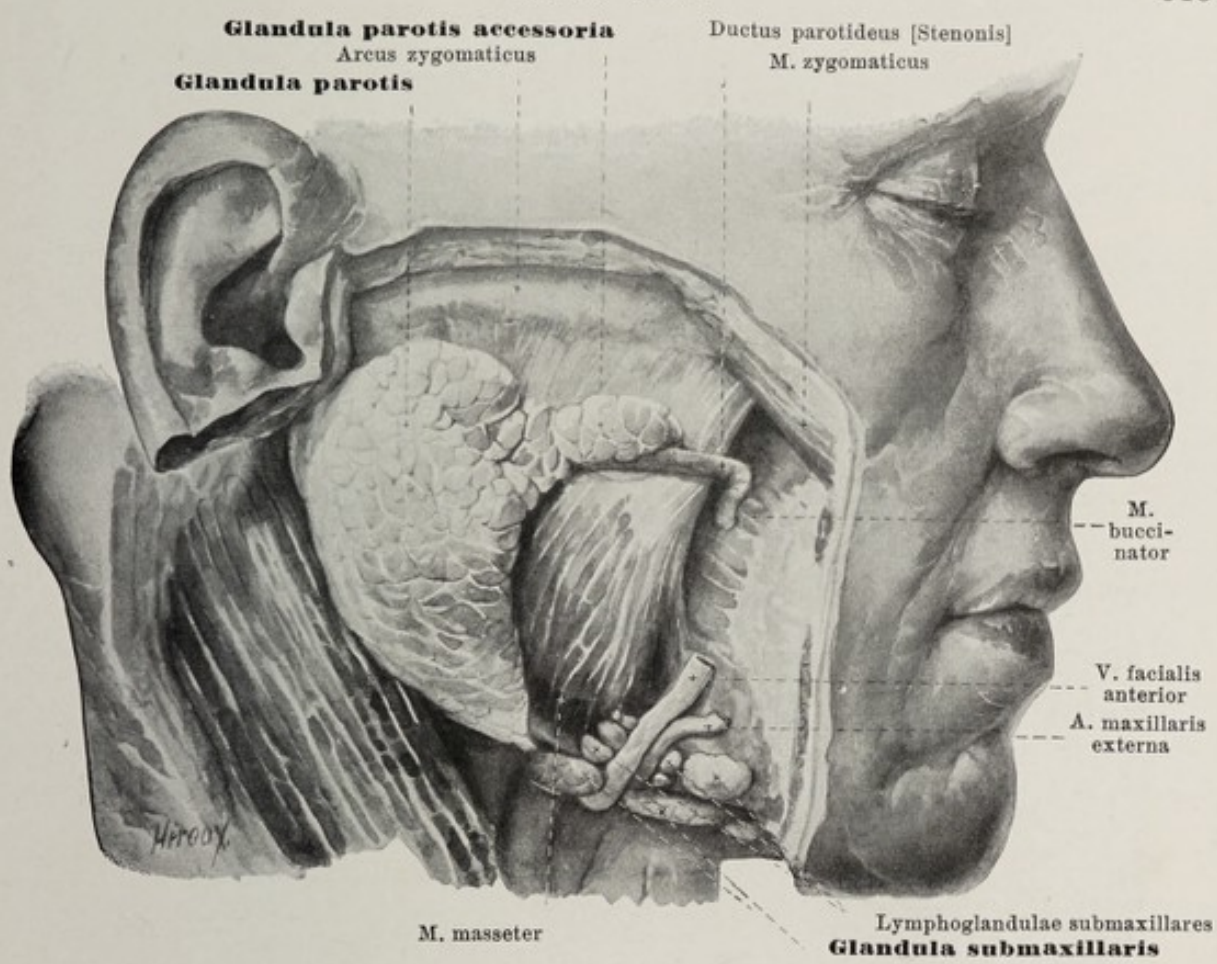
(The glandula parotis has been in large part removed.)



592. Right submaxillary gland and its neighborhood, viewed from the right and below.

(The platysma has been removed.)

The **glandula sublingualis** *(sublingual gland)* (see Figs. 568, 590 and 591) is oblong, narrow, longer from before backward than from above downward. It lies directly upon the m. mylohyoideus between the mm. geniohyoideus, genioglossus and hyoglossus on the one hand and the medial surface of the corpus mandibulae on the other and lies in the fovea sublingualis of the latter; above it is directly covered by the mucous membrane of the mouth and there causes the plica sublingualis to project (see Fig. 589). Behind it is adjacent to the glandula submaxillaris. It is of very varying structure. The main mass of its lobes opens with numerous (5—20 or more) narrow and short ducts, *ductus sublinguales minores*, upon the plica sublingualis; an anterior group of lobes sometimes sends out a larger duct, the *ductus sublingualis major*, which runs forward and upward on the medial surface of the gland beneath the ductus submaxillaris and usually goes into the latter or more seldom opens close to it upon the caruncula sublingualis.

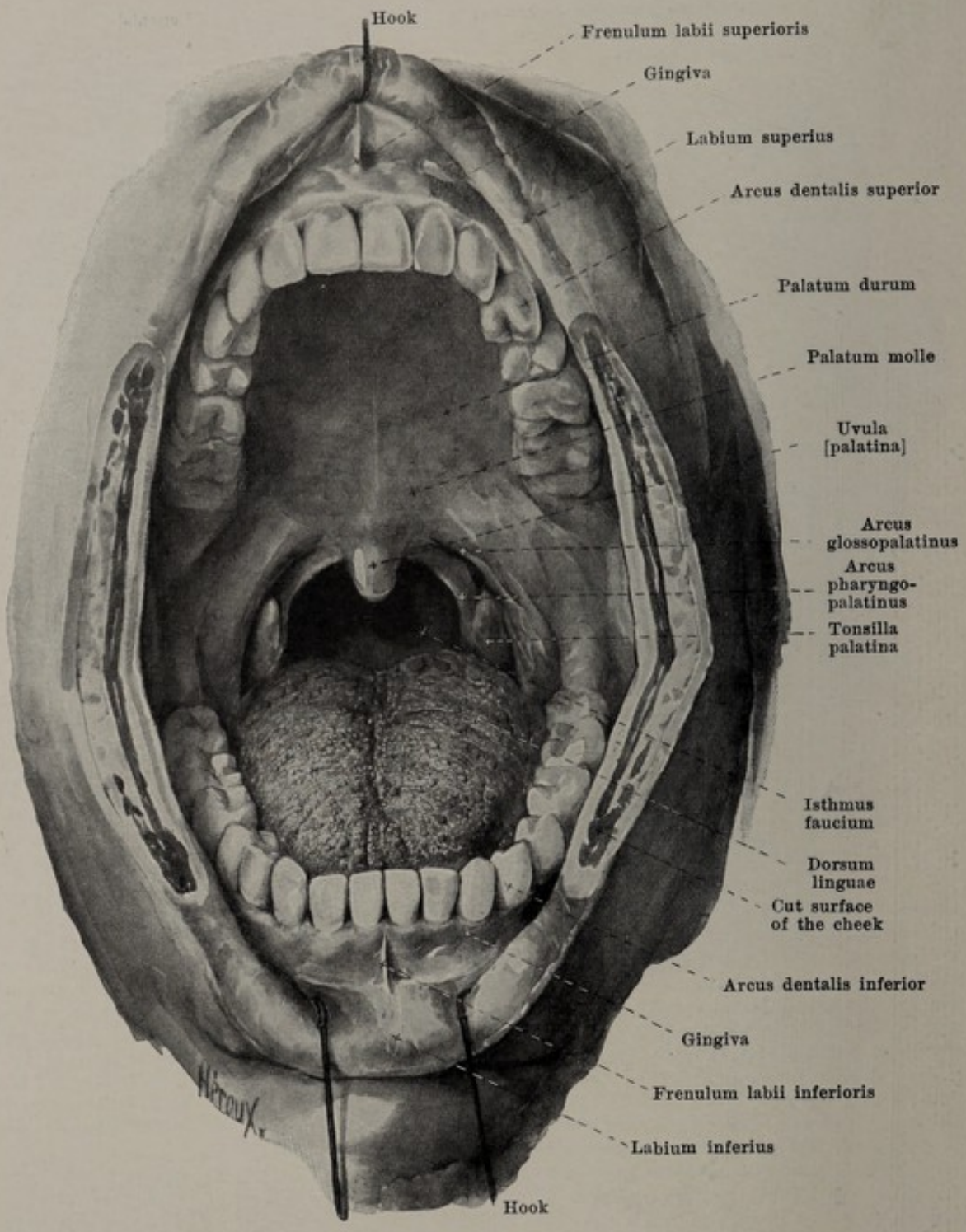


593. Right parotid gland, viewed from the right.

(The platysma and the nerves have been completely removed; the vessels have been partially removed.)

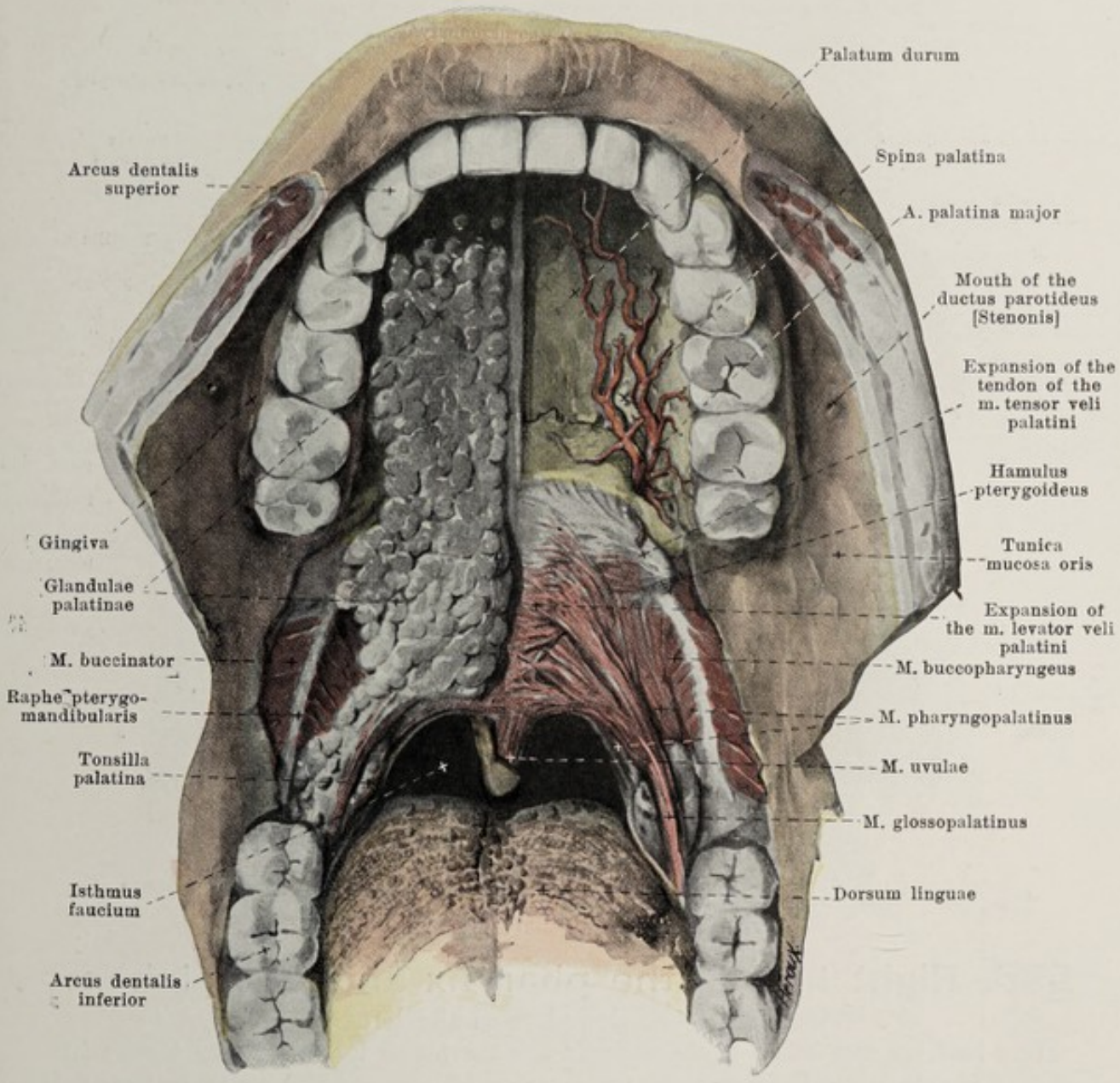
The **glandula submaxillaris** *(submaxillary gland)* (see also Figs. 591 and 592) has the shape of a flattened egg. It lies in the fossa which is bounded above and lateralward by the fovea submaxillaris of the mandibula, elsewhere by the mm. digastricus and stylohyoideus. Above and medially it is in contact with the inferior surface of the m. mylohyoideus and sends (near the ductus submaxillaris) around its posterior margin to its upper surface a process of variable size which reaches the glandula sublingualis or even may accompany it a certain distance of variable length, and comes in contact medianward with the m. hyoglossus. Behind it often reaches as far as the glandula parotis and touches the m. pterygoideus internus. Its free surface is crossed by the v. facialis anterior and covered by the platysma. The excretory duct, *ductus submaxillaris [Whartoni]* (see Figs. 568, 590 and 591), emerges at the posterior margin of the m. mylohyoideus from the inner surfcae of the gland, runs forward and upward on the medial surface of the glandula sublingualis and opens into the caruncula sublingualis.

The **glandula parotis** *(parotid gland)* (see also Fig. 592) is approximately triangular on its lateral slightly convex surface. With its medial, narrowed portion, *processus retromandibularis* (see Fig. 591), it fills up the fossa which is bounded in front by the posterior margin of the ramus mandibulae and the m. pterygoideus internus, behind by the pars tympanica oss. temporalis, by the cartilago meatus acustici as well as by the anterior margin of the proc. mastoideus and of the m. sternocleidomastoideus; in the depth it comes into contact with the proc. styloideus, the mm. stylohyoideus and styloglossus, the a. carotis interna and the v. jugularis interna. Lateralward it passes forward upon the ramus mandibulae and m. masseter and reaches almost as far as the arcus zygomaticus. Below it tapers out and terminates close beneath the angulus mandibulae and often touches the glandula submaxillaris. Inside the gland run for some distance the a. carotis externa and several of its branches, the v. facialis posterior as well as the n. facialis and its peripheral branches. The duct, *ductus parotideus [Stenonis]*, goes off from the upper portion of the anterior margin, runs approximately horizontally forward upon the lateral surface of the m. masseter, then bends medianward, perforates the m. buccinator obliquely and opens in the vestibulum oris opposite the second (or first) upper molar tooth (see Fig. 595); upon the m. masseter there often lies on the duct a *glandula parotis accessoria* which is of variable size.



594. The mouth cavity, viewed from in front, after deep incisions in the cheeks (starting from the angles of the mouth) forced wide open.

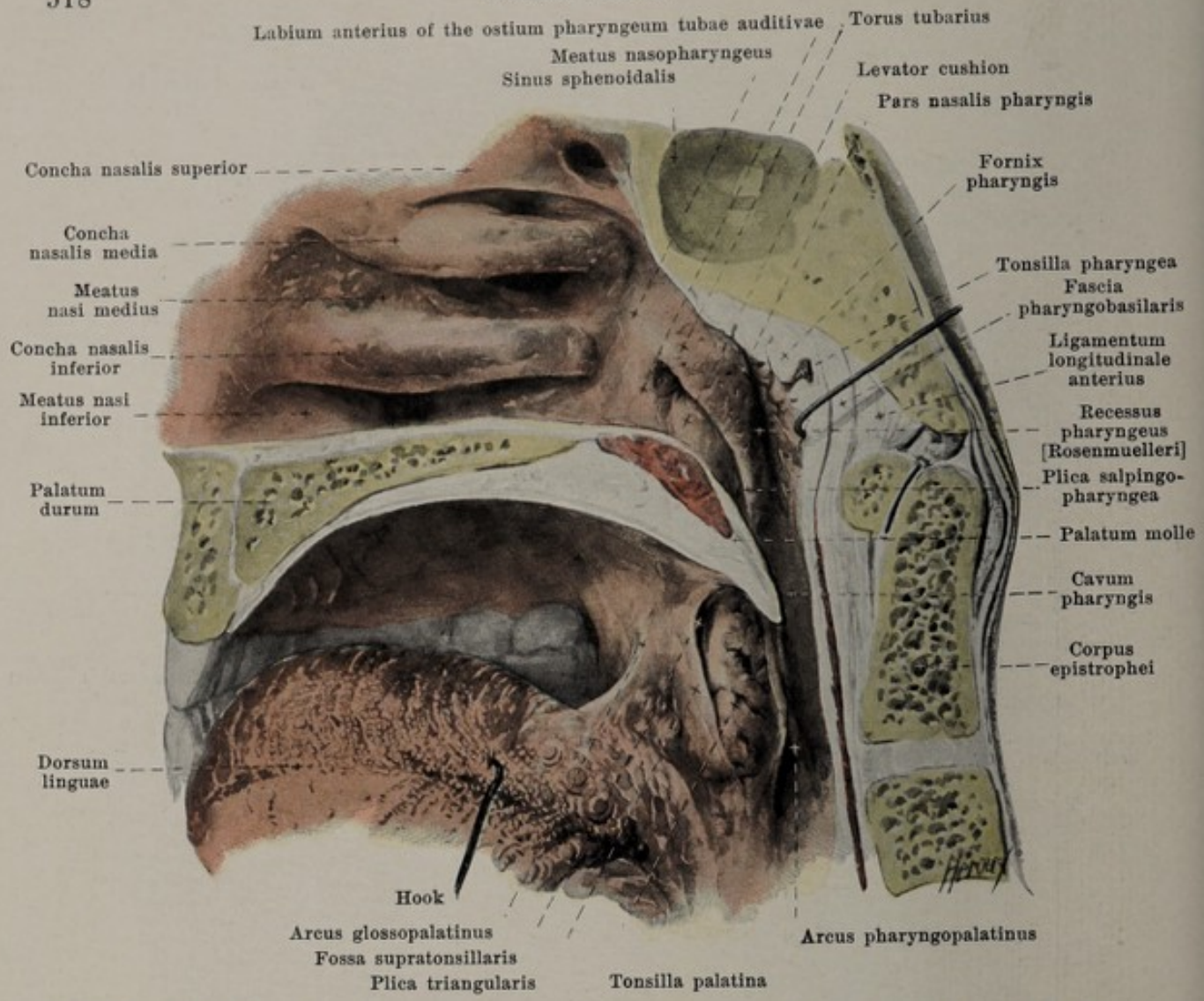
The roof of the mouth cavity is formed by the **palate** *(palatum)* (see also Figs. 567, 568, 579, 595 and 596), which is curved so as to be more concave from the right to the left than from before backward. The substratum of the palate is bony in front *(palatum durum)* and consists there of the processus alveolares and palatini of the upper-jaw-bones and the partes horizontales of the palate bones (see also Figs. 61 and 62); in the posterior part it is muscular *(palatum molle)*. The mucous membrane, very firmly attached to the substratum especially in the hard palate, is in general smooth and goes directly over forward and lateralward into the gums, behind into the uvula and the palatal arches.



595. The palate, after removal of the mucosa, viewed from below.

(On the left side the palatal glands have also been removed; the checks have been drawn away from the teeth.)

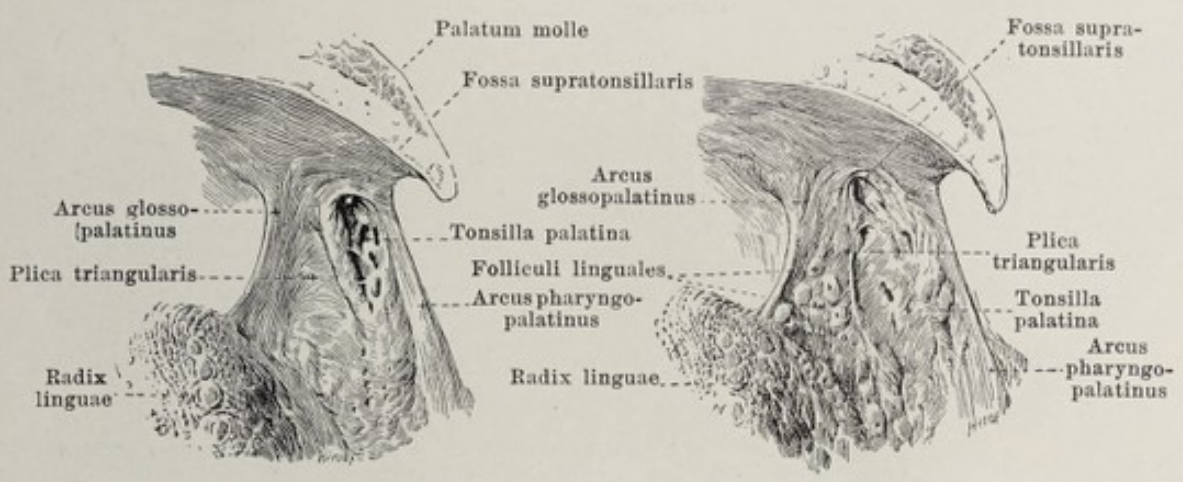
The **mucous membrane of the palate** (see Fig. 579) presents in the median plane a narrow, whitish streack, the *raphe palati*, which in front is often ridge-like in shape, but behind has usually the form of a groove. Running out from it just behind the incisor teeth on each side can be seen one or several low ridges, *plicae palatinae transversae*, straight or curved lateralward. In front of them in the median plane is a small projection, the *papilla incisiva*, which extends partly between the two medial incisor teeth. At the junction of the hard and soft palate there is very frequently visible on each side of the raphe a small depression, *foveola palatina*, into which merge the openings of the excretory ducts of several glands. The mucous membrane is thinnest in the region of the raphe, especially on the hard palate. Lateralward a thick layer of *palatal glands, glandulae palatinae* (see also Fig. 568), fills up on each side the deep groove between the hard palate and the processus alveolaris maxillae. This layer of glands becomes narrower medianward and in front, is especially thick in the anterior part of the soft palate and decreases in thickness again also farther back; the glands are here partly imbedded in the muscles. Larger glands are to be found also on the anterior, smaller glands on the posterior surface of the uvula (see Fig. 567).



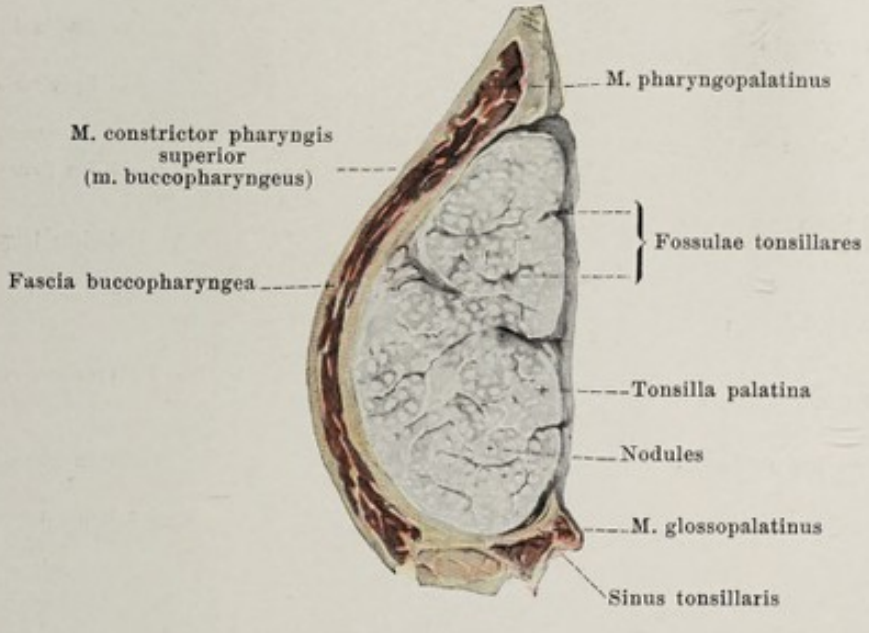
596. Right half of the pharynx and its neighborhood, viewed from the left.

(The head has been halved in the median plane; the tongue has been drawn downward.)

The **soft palate** *(palatum molle)* (see also Figs. 567, 594 and 600) is a thick transversely placed membrane, which contains within it the expansion of several muscles (see p. 524). The anterior portion connected with the hard palate is placed nearly horizontally; the posterior portion, *velum palatinum (palatal sail)*, is directed obliquely backward and downward, terminating (see also Fig. 579) behind and lateralward on each side in a free margin, the *arcus pharyngopalatinus;* in the middle it is drawn out to form the small, conical, very variable, *uvula [palatina]*. The mucous membrane which covers the inferior surface of the soft palate is directly continued at its free margin upon the upper surface into the mucous membrane of the pharynx and of the nasal cavity. The *arcus pharyngopalatinus (posterior palatal arch)* (see also Fig. 600) is thicker above, thinner below where it has almost a sharp edge; from the lateral margin of the uvula it bends so as to be markedly concave downward and a little backward and becomes lost in the lateral wall of the pars laryngea pharyngis. Arising from the lower surface of the velum palatinum on each side a little in front of the base of the uvula (see also Figs. 579 and 594) is a fold of mucous membrane, the *arcus glossopalatinus (anterior palatal arch)*, which, curved so as to be slightly concave, extends downward and lateralward and unites behind the papillae foliatae with the lateral margin of the tongue (see also Fig. 581). From the posterior surface of this anterior palatal arch a thin, very variable triangular fold of mucous membrane, the *plica triangularis*, passes dorsalward; it is narrow at its beginning above but is broad at its attachment to the lateral margin of the tongue. Lateralward from and dorsal to it, reaching behind as far as the arcus pharyngopalatinus, lies, in the embryo, a deep fossa, the *sinus tonsillaris*, from the bottom of which the tonsilla palatina develops.



597 and 598. Right palatine tonsils, unequally developed, viewed from the left (see Fig. 596).

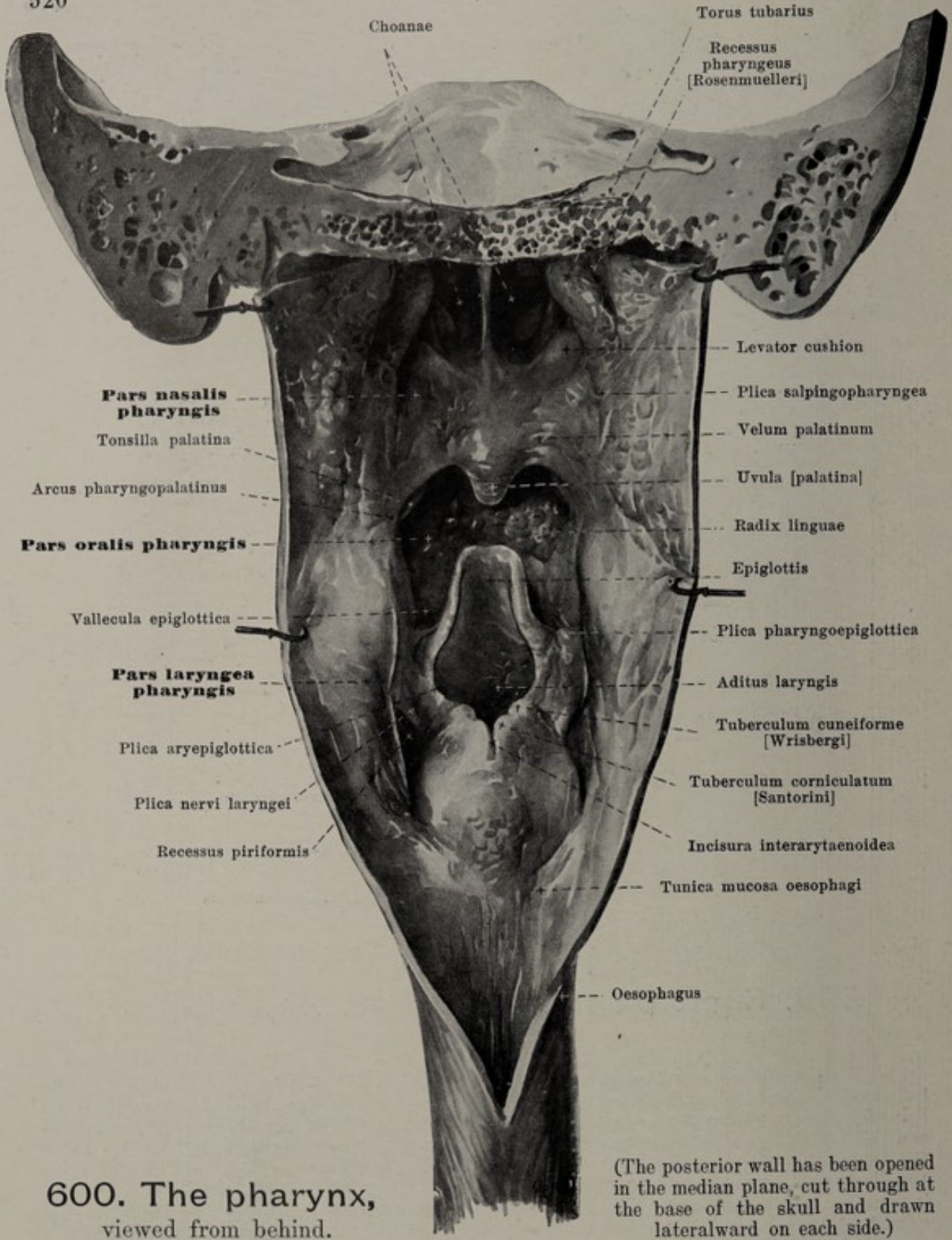


599. Right palatine tonsil, cut through horizontally.

Magnification: 2 : 1.

The *tonsilla palatina (palatine tonsil)* (see also Figs. 594—596) is a very variable oblong body usually shaped like a flattened egg, of the size of an almond or somewhat larger, which lies on each side between the two palatal arches; it is bounded lateralward by the m. buccopharyngeus and looks, with its medial nodular surface, more or less deeply free into the mouth cavity. From this surface 10—20 smaller or larger oblong openings lead into single or forked slits, the *fossulae tonsillares*, which penetrate very deep into the tonsils and are surrounded by a thick layer of lympathic tissue containing nodules. The tonsil is very frequently confined only to the embryonal sinus tonsillaris (see p. 518); but in other cases the tonsil-tissue penetrates the plica triangularis also, so that the latter may vanish more or less entirely. Folliculi linguales may extend as far as the free margin of the plica triangularis or its remainder (see Figs. 596 and 598). In front of the superior pole of the tonsil runs always laterally from the plica triangularis as a remainder of the embryonal sinus tonsillaris a slit-shaped groove, *fossa supratonsillaris* (see Figs. 596—598), to a variable distance upward and forward.

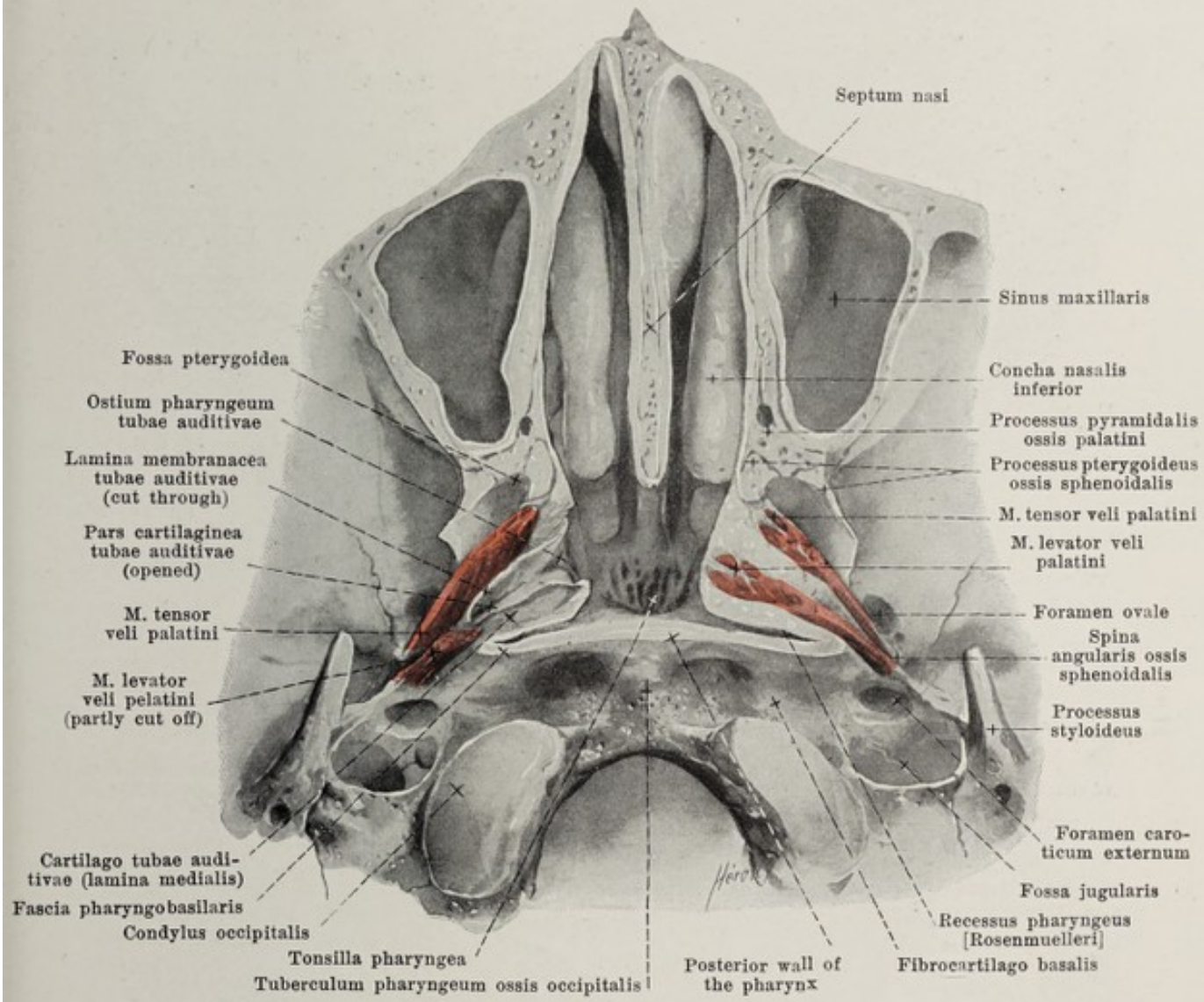
The space enclosed by the soft palate, the palatal arches and the root of the tongue is called the *isthmus faucium* (see Fig. 594).



600. The pharynx, viewed from behind.

(The posterior wall has been opened in the median plane, cut through at the base of the skull and drawn lateralward on each side.)

The **pharynx** (see also Figs. 567 and 596) is an unpaired, tube-like cavity which is situated behind the nose, mouth and larynx; it is correspondingly divided into three portions, which, however, are not sharply separable from one another: *pars nasalis*, *pars oralis* and *pars laryngea*. The cavity surrounded by its walls, *cavum pharyngis*, is connected in front with the three cavities mentioned. Its frontal diameter is everywhere greater than the sagittal but diminishes markedly and suddenly at the inferior end.

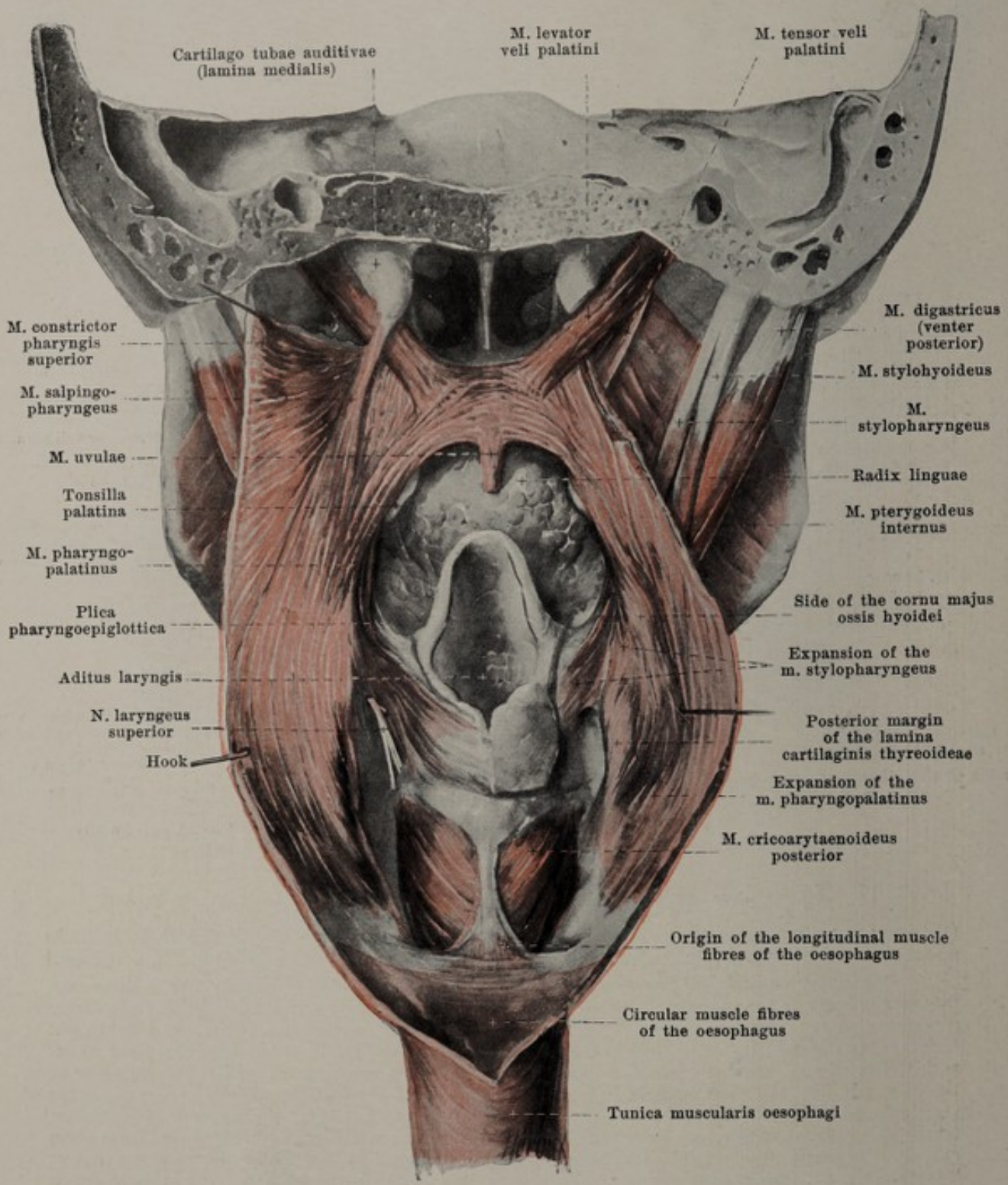


601. Upper end of the pharynx, viewed from below.

(Horizontal section at the level of the nasal surface of the hard palate; in the right half the m. levator veli palatini has been partially removed, the pars cartilaginea tubae has been opened.)

The upper end of the pharynx, *fornix pharyngis*, is bounded chiefly by the inferior surface of the body of the sphenoid bone and of the pars basilaris oss. occipitalis; the line of attachment goes on each side lateralward from the tuberculum pharyngeum oss. occipitalis beneath the fibrocartilago basalis (see also Fig. 953) and the apex of the pyramid of the temporal bone as far as in front of the foramen caroticum externum, turns again medianward behind the cartilage of the tuba auditiva and then extends to the medial surface of the lamina medialis of the processus pterygoideus. Its posterior wall lies directly in front of the bodies of the upper 6 cervical vertebrae and in front of the mm. recti capitis anteriores, longi capitis and colli, separated from them only by the fascia praevertebralis. Lateralward it is bounded by the aa. carotides communes et internae, the vv. jugulares internae, the cornua majora of the hyoid bone and the laminae cartilaginis thyreoidae. Below at the 6th cervical vertebra it goes over into the oesophagus.

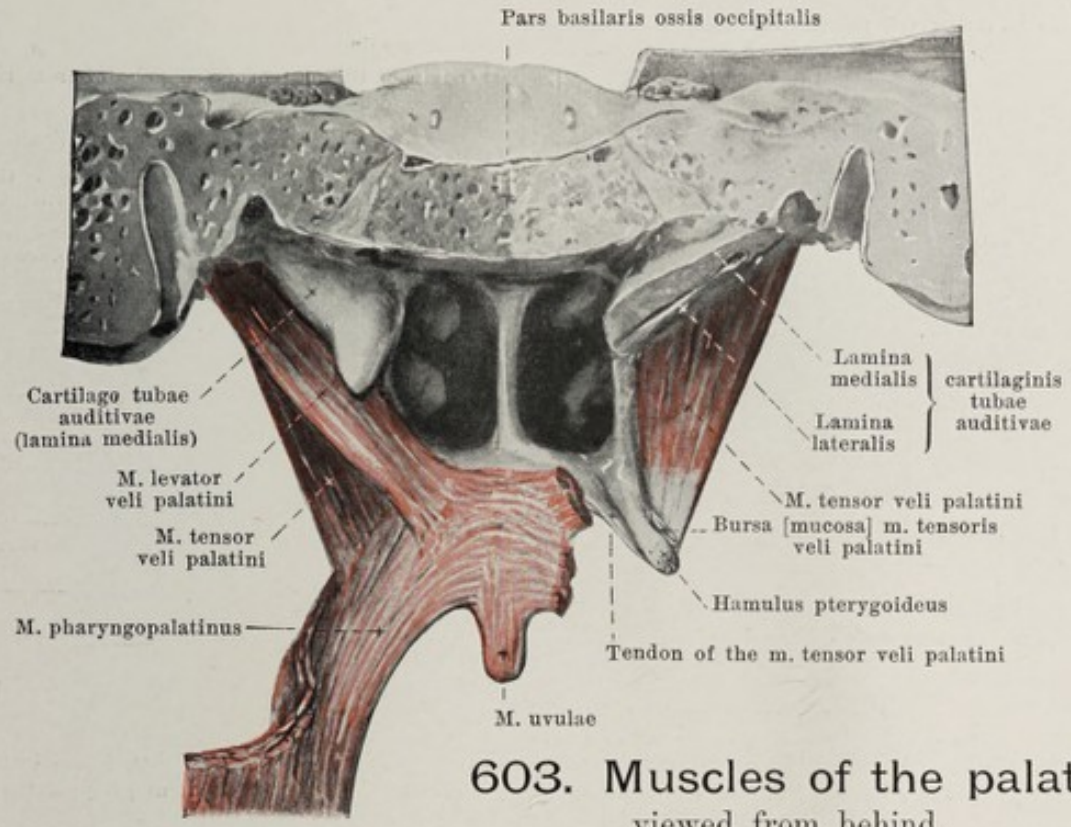
The **wall of the pharynx** consists of the *tunica mucosa (mucous membrane)*, *tela submucosa* and *tunica muscularis pharyngis*. The mucous membrane (see Fig. 600) completely covers the internal surface and is uninterruptedly continuous with that of the neighboring cavities. At the fornix pharyngis and in the uppermost part of the posterior wall, it is thickened by the presence of lymphatic tissue with nodules in a varying manner and subdivided by slits *(fossulae tonsillares)*. This place is called the *tonsilla pharyngea*, *pharyngeal tonsil* (see also Fig. 596), and is much more highly developed in children than in adults. On its inferior boundary there is sometimes found in children in the median plane a small blind-sack-like depression, *bursa pharyngea* (not illustrated), extending as far as the os occipitale.



602. Muscles of the palate and pharynx,

viewed from behind.

(The pharynx has been opened as in Fig. 600; the tunica mucosa and tela submucosa have been dissected away, except for a small area of the pars laryngea. On the right side the m. salpingo-pharyngeus, a part of the m. constrictor pharyngis superior and a corner of the cartilago tubae auditivae have been removed.)



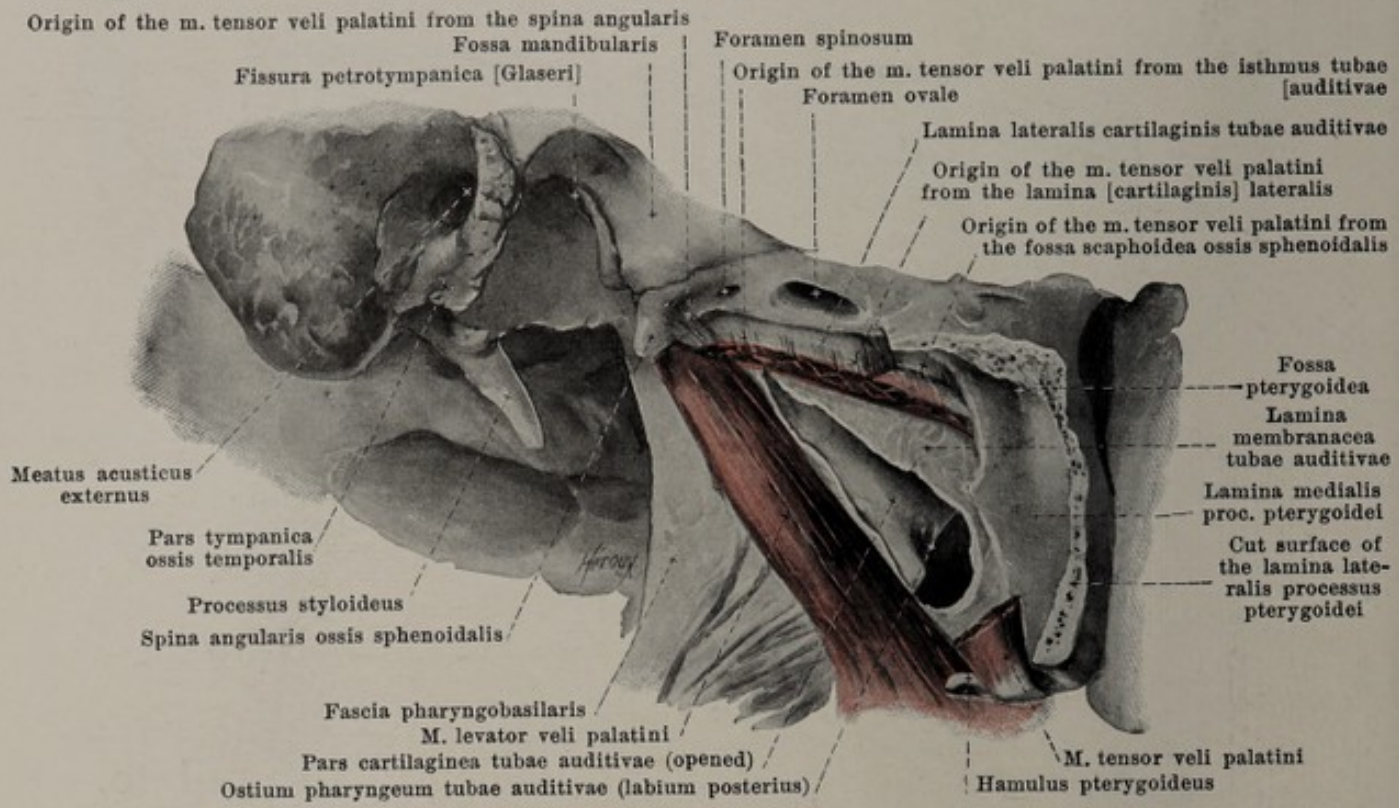
603. Muscles of the palate, viewed from behind.

(On the right side the m. levator veli palatini and the m. pharyngopalatinus have been removed. In addition the lamina medialis of the cartilago tubae auditivae has been partially cut away and the pars cartilaginea of the Eustachian tube has been opened for a corresponding length.)

In the pars nasalis pharyngis (see Figs. 596, 600, 601, 982 and 983) on each side lateralward, behind the insertion of the inferior turbinated bone, is visible the sickle-shaped *ostium pharyngeum tubae auditive;* it is surrounded above and behind by a horse-shoe-shaped ridge. The anterior part of the ridge, *labium anterius*, is the smaller; the upper and posterior part *(labium posterius)* is thicker and harder, being made prominent by the lamina medialis of the cartilago tubae auditivae (see p. 842) whence it is also called the *torus tubarius.* The opening is encroached upon from below by a projection caused by the m. levator veli palatini *(levator cushion).* From the lower end of the labium posterius a fold of mucous membrane, *plica salpingopharyngea,* extends downward for a variabl distance on the lateral wall. Behind the torus tubarius, extending far lateralward, is a pocket, usually slit-shaped, the *recessus pharyngeus [Rosenmuelleri]* (pharyngeal recess of Rosenmueller). The partition between the pars nasalis and the pars oralis, formed by the velum palatinum, is indistinct and incomplete. Lateralward in the pars oralis is the arcus pharyngopalatinus; the pars oralis (see Figs. 567, 596 and 600) is not sharply marked off from the pars laryngea. In the pars laryngea (see Fig. 600), extending lateralward from the lateral margin of the epiglottis, is the low *plica pharyngoepiglottica.* Below and behind it on each side between the plica aryepiglottica and the lamina cartilaginis thyreoideae, which is covered directly by the mucous membrane, lies a deep fossa, the *recessus piriformis* (O. T. sinus pyriformis) which runs downward in the form of a groove; a fold, *plica nervi laryngei* (caused by the r. internus n. laryngei superioris), runs obliquely downward and medianward in its most anterior part. *Glandulae pharyngae* (not illustrated) are to be found in the tunica mucosa of the fornix, particularly behind the tonsilla pharyngea, also in the tela submucosa of the remaining part of the region, especially in the recessus pharyngeus and in the plica salpingopharyngea.

Muscles of the palate *(musculi palati et faucium)* (see also Figs. 595, 602 and 605).

M. pharyngopalatinus (O. T. palatopharyngeus). Form: triangular, thin, long. Position: for the most part in the arcus pharyngopalatinus. Origin: broad in the tela submucosa of the posterior wall of the pars laryngea pharyngis and from the posterior margin of the lamina cartilaginis thyreoideae, in front of the m. constrictor pharyngis inferior. Insertion: the fibres, converging, run in front of the m. constrictor pharyngis medius upward, first lateralward, then medianward, and radiate out transversely into the palate; some fibres go to the hamulus pterygoideus, others as the *m. salpingopharyngeus* (see Fig. 602) in the plica salpingopharyngea to the lower end of the lamina medialis cartilaginis tubae auditivae. Action: both approximate the pharyngopalatine arches, and elevate the inferior part of the pharynx and the larynx. Innervation: rami pharyngei n. vagi.



604. Cartilaginous part of the right Eustachian tube, viewed from the lateral surface and somewhat below and behind.

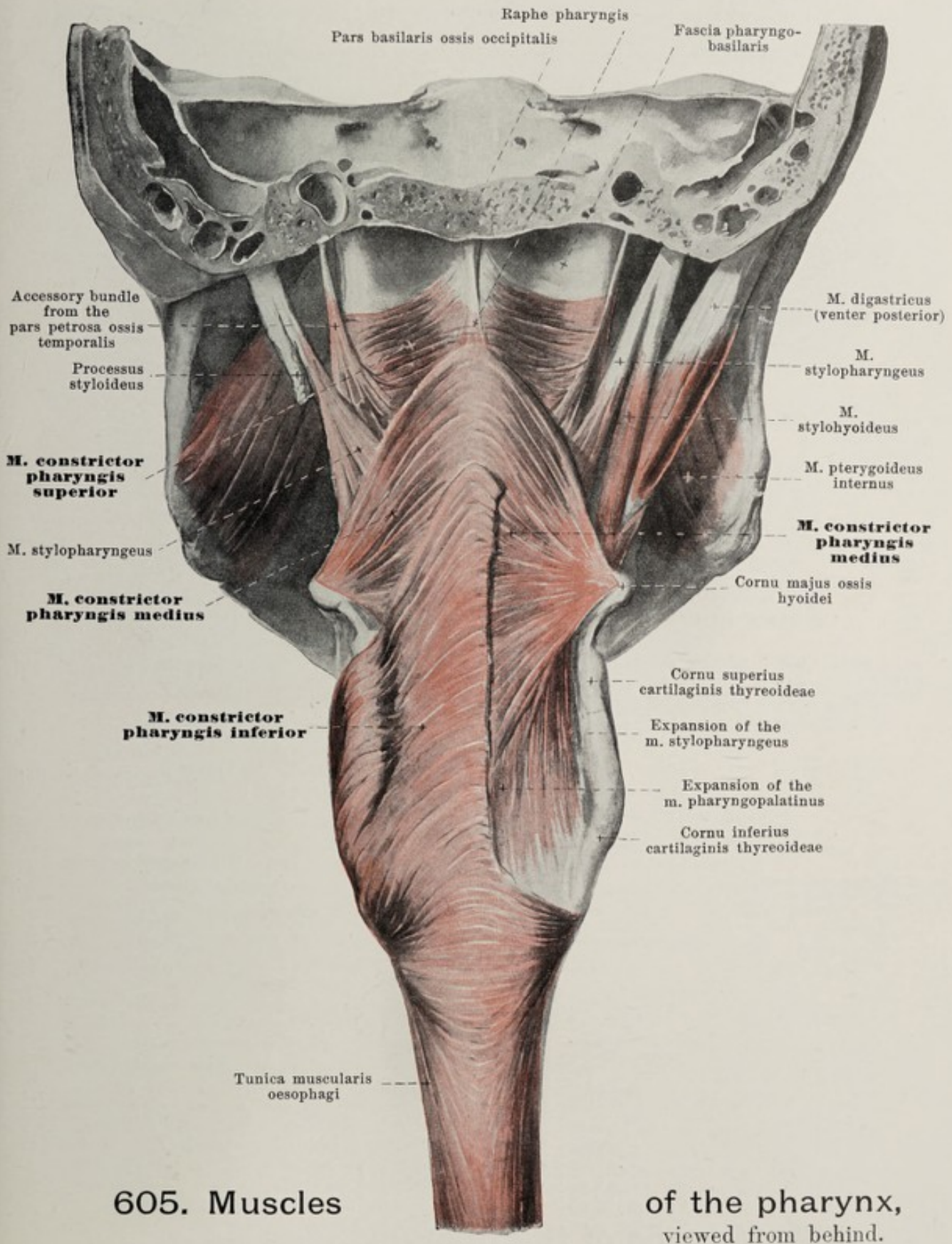
(The lamina lateralis processus pterygoidei, the m. tensor veli palatini and the lamina membranacea of the tuba have been partially, the m. pterygopharyngeus has been completely removed.)

M. glossopalatinus (O. T. palatoglossus) (see Figs. 583 and 595). Form: narrow, long. Position: in the arcus glossopalatinus. Origin: at the lateral margin of the tongue from fibres of the latter which run transversely. Insertion: curving upward it radiates out transversely in the soft palate. Action: the muscle of the two sides together narrow the isthmus faucium. Innervation: rami pharyngei n. vagi.

M. uvulae (O. T. azygos uvulae) (see Figs. 595, 602 and 603). Form: narrow, oblong; frequently paired. Position: in uvula, nearer the upper surface, partly behind other muscles. Origin: tendinous expansions of mm. tensores veli palatini. Insertion: backward and downward to the tip of the uvula. Action: shortens the uvula and draws it backward and upward. Innervation: rami pharyngei n. vagi.

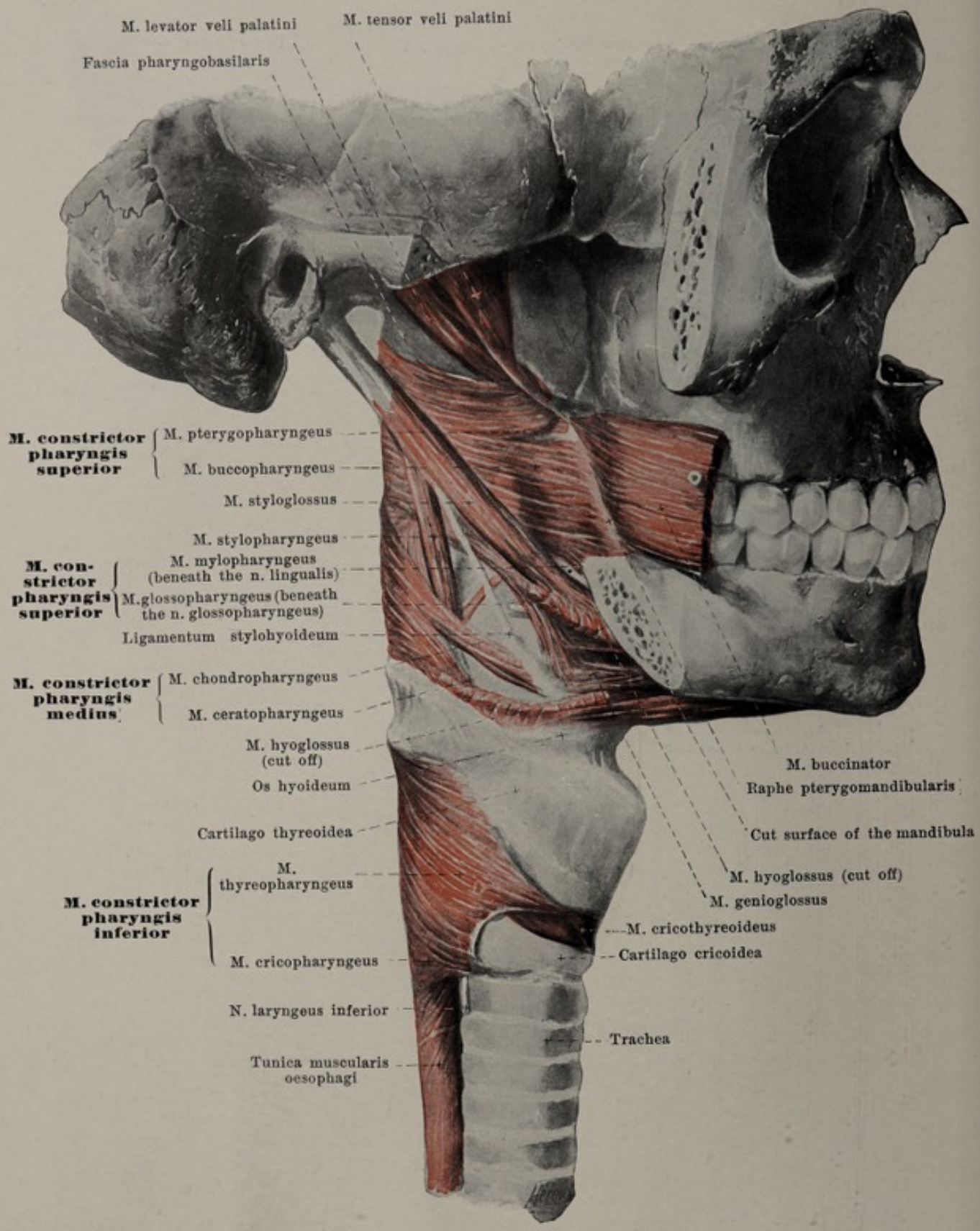
M. levator veli palatini (O. T. levator palati) (see also Figs. 595, 601—603, 606, 954—957). Form: flat-cylindrical. Position: in the uppermost part of the lateral wall of the pharynx, directly in front of the recessus pharyngeus. Origin: facies inferior pyramidis ossis temporalis, just in front of the foramen caroticum externum; some fibres from the lateral end of the lamina medialis of the cartilago tubae and from the adjoining part of the lamina membranacea tubae. Insertion: the fibres are parallel to the inferior margin of the lamina medialis of the cartilago tubae, run downward, medianward and forward (see p. 523) and go to the soft palate. They are there interwoven with the other muscles and unite mainly with the same muscle of the other side. Action: it lifts the velum paaltinum, narrows the ostium pharyngeum and widens the isthmus tubae. Innervation: rami pharyngei n. vagi.

M. tensor veli palatini (see also Figs. 595, 601—603, 606, 954—957). Form: triangular, flat, thin. Position: lateral from the lamina membranacea tubae auditivae and the m. levator veli palatini, medial from the m. pterygoideus internus. Origin: fossa scaphoidea ossis sphenoidalis, lamina [cartilaginis] lateralis and (at the isthmus) lamina membranacea tubae auditivae, spina angularis ossis sphenoidalis. Insertion: the fibres converge and run downward and forward to a small tendon which forms a loop around the sulcus hamuli pterygoidei (here is situated the *bursa m. tensoris veli palatini*, see Fig. 603) and radiates out medianward into the soft palate; there (see Fig. 595) it becomes attached partly to the posterior margin of the pars horizontalis ossis palatini, and becomes connected partly with the fibres of the muscle of the other side. Action: it makes the anterior portion of the soft palate tense and opens the tuba auditiva. Innervation: n. tensoris veli palatini (from the n. mandibularis).



605. Muscles of the pharynx, viewed from behind.

(On the right side most of the m. constrictor pharyngis inferior has been removed, on the left side the mm. digastricus and stylohyoideus have been removed.)



606. Muscles of the pharynx, viewed from the right.

(The arcus zygomaticus and ramus mandibulae have been completely, the m. hyoglossus has been partially removed.)

The **tunica muscularis pharyngis** (see p. 523) consists mainly of the three *mm. constrictores pharyngis (constrictors of the pharynx)*, which surround the posterior and lateral walls, and of which the lower one in each case partly covers the next upper from behind; in addition, this muscular tunic contains the terminal expansions of the *mm. pharyngopalatinus* (see p. 523) and *stylopharyngeus*. The constrictors of the pharynx of the two sides partly fuse behind in the median plane, in part, however, they are connected with a band of connective tissue, the *raphe pharyngis* (see Fig. 605); this raphe is usually distinct in the uppermost part only and is attached to the tuberculum pharyngeum oss. occipitalis. The uppermost constrictor of the pharynx does not reach as far as the base of the skull but leaves an area of variable size free on each side on the posterior and lateral walls in which the tela submucosa pharyngis is visible; this is thicker here and is called the *fascia pharyngobasilaris* (see Figs. 605 and 606).

M. constrictor pharyngis superior (see Figs. 602, 605 and 606) arises from several parts of the head. It is divided into:

1. *M. pterygopharyngeus.* Origin: posterior margin of the lamina medialis of the processus pterygoideus and hamulus pterygoideus.

2. *M. buccopharyngeus.* Origin: raphe pterygomandibularis (see p. 265), partly connected with fibres of the m. buccinator.

3. *M. mylopharyngeus.* Origin: posterior end of the linea mylohyoidea mandibulae in the region of the third molar tooth.

4. *M. glossopharyngeus* (see also Fig. 583). Origin: from fibres running transversely in the root of the tongue, which appear between the posterior bundles of the m. genioglossus, and, covered by the m. hyoglossus, extend obliquely upward.

The fibres run for the most part horizontally backward; the upper ones extend chiefly somewhat upward (see Fig. 605) and becoming tendinous may reach the base of the skull; the lower ones curve behind somewhat downward. The muscle is partly covered behind by the m. constrictor pharyngis medius. Accessory bundles (see Fig. 605) frequently arise at the anterior margin of the foramen caroticum externum, descend behind the muscle at the junction of the lateral and posterior wall and finally turn around into the horizontal direction.

M. constrictor pharyngis medius (see Figs. 582, 583, 605 and 606) arises from the hyoid bone in two parts as the

1. *M. chondropharyngeus.* Origin: cornu minus ossis hyoidei.

2. *M. ceratopharyngeus.* Origin: cornu majus ossis hyoidei.

The fibres arising most anteriorly are covered by the m. hyoglossus; behind the middle fibres run horizontally, the others diverge upward and downward and may, above, even reach the base of the skull. The muscle is covered in its lower larger part by the m. constrictor pharyngis inferior.

M. constrictor pharyngis inferior (see Figs. 605 and 606) arises from the larynx. It is divisible into:

1. *M. thyreopharyngeus.* Origin: lateral surface of the lamina cartilaginis thyreoideae (linea obliqua).

2. *M. cricopharyngeus.* Origin: from a tendinous arch convex backward, which is stretched out between the tuberculum thyreoideum inferius and the lateral surface of the cartilago cricoidea and partially bridges over the m. cricothyreoideus (see p. 572), and from the lateral surface of the cartilago cricoidea.

The upper, larger mass of fibres forms a loop around the posterior margin of the cartilago thyreoidea and runs medianward and upward, diverging somewhat. The inferior bundles of fibres extend more horizontally but so that they mostly form convex arches with the fibres of the other side; these arches are curved partly upward, partly downward; those which are curved downward fuse with the circular muscle layer of the oesophagus between the bundles of origin of the longitudinal muscle fibres of the oesophagus as these converge below.

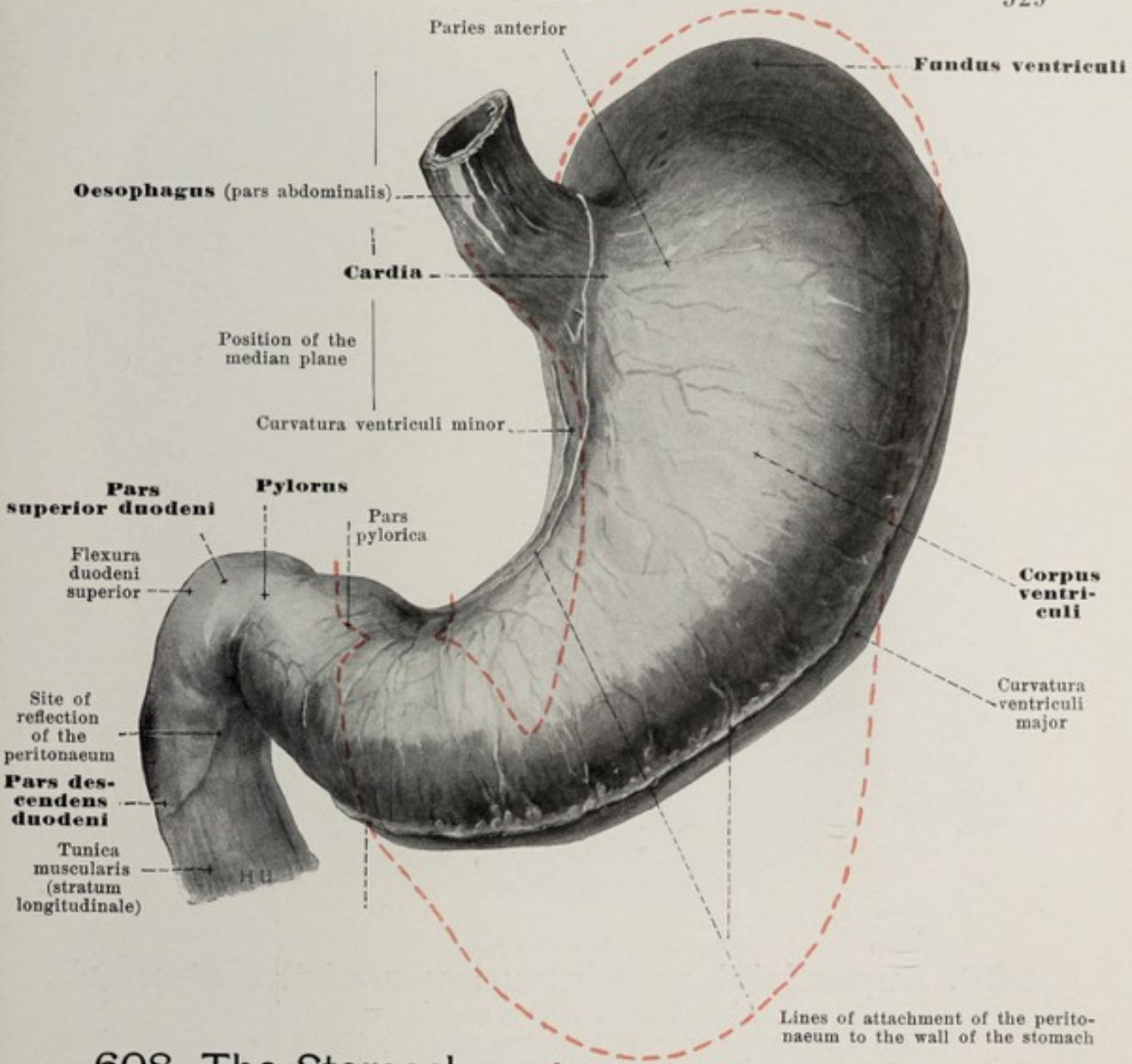
Action of the constrictor muscles of the pharynx: they narrow the pharynx. Innervation: rami pharyngei n. vagi.

M. stylopharyngeus (see Figs. 582, 602, 605 and 606). Form: slender, flattened. Position: above it is situated between the m. constrictor pharyngis superior and the m. stylohyoideus, as well as between the a. carotis interna and externa, below in the wall of the pharynx medianward from the mm. constrictores pharyngis medius et inferior. Origin: root of the processus styloideus. Insertion: it extends downward and medianward and, diverging in front of the upper margin of the m. constrictor pharyngis medius, sinks into the wall of the pharynx. A part of the fibres extends medianward at the posterior wall, the other part runs farther downward and (see Fig. 602) arrives in front of the m. pharyngopalatinus partly in the plica pharyngoepiglottica to the anterior surface of the epiglottis, partly in the plica aryepiglottica to the m. aryepiglotticus (see p. 575) and the thyroid and cricoid cartilage, partly (see Figs. 602 and 605) to the upper margin of the lamina cartilaginis thyreoideae. Action: it widens the pharynx and elevates the pharynx and larynx. Innervation: rami pharyngei n. vagi (see farther p. 733).

607. Oesophagus and trachea with surrounding tissues, viewed from in front.

(The pleura with the exception of its uppermost part has been removed on each side.)

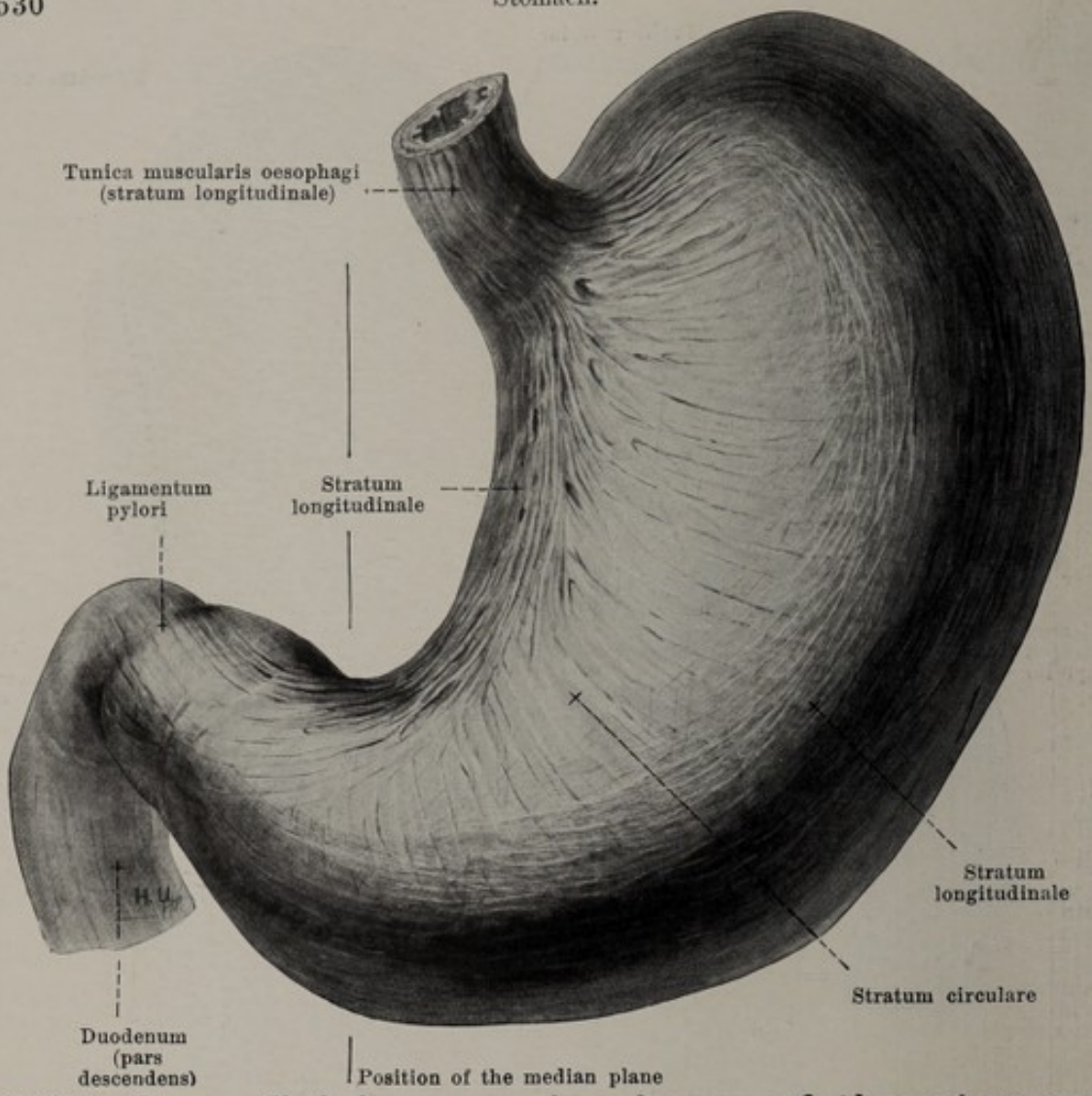
The **oesophagus** *(gullet)* (see also Figs. 358, 563, 567, 600, 608 and 681—683) is a muscular tube and in man averages 25 centimetres in length. It begins as the continuation of the pharynx behind the cartilago cricoidea, in front of the 6th cervical vertebra *(pars cervicalis)*, runs downward through the spatium mediastinale posterius of the thorax *(pars thoracalis)*, passes through the hiatus oesophageus diaphragmatis into the abdominal cavity *(pars abdominalis)* and opens into the cardia of the stomach at the level of the 10th—12th thoracic vertebra.



608. The Stomach, nearly empty, viewed from in front.

(The red line indicates the form and position of the distended stomach. After C. Elze.)

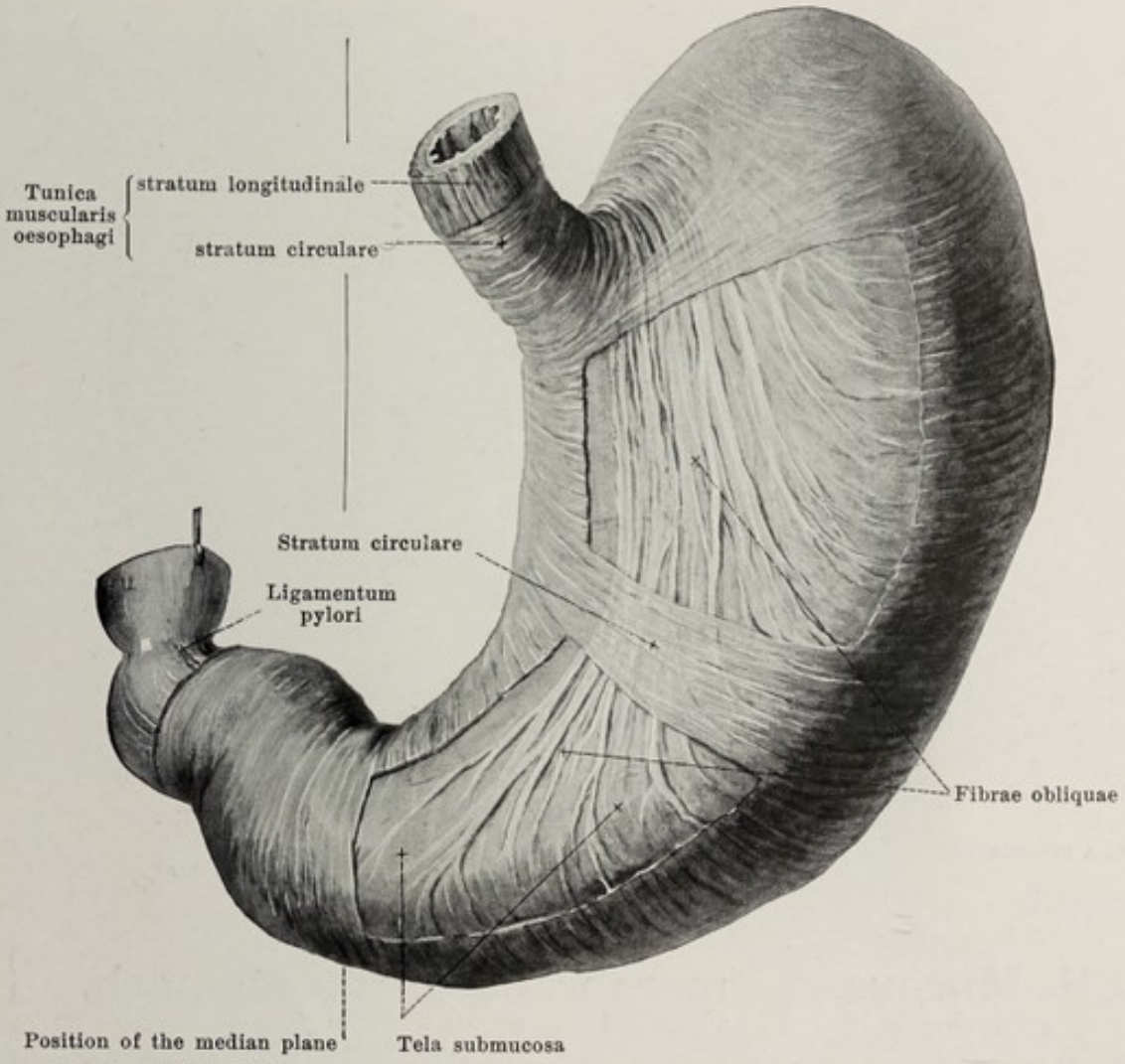
Oesophagus (see also Figs. 358, 563, 567, 600, 607 and 681—683) (continued). In its course it lies, with the exception of its lowermost portion, directly in front of the spinal column, in its upper half also behind the trachea, in the lower part of the pars thoracalis behind the pericardium and the left atrium. It runs nearly straight in front of the middle of the spinal column, deviating above a little to the left, in the middle a little to the right where it passes on the right anterior surface of the aorta thoracalis, and on the left side of the v. azygos; in the lowermost part of the pars thoracalis it extends, turned slightly to the left and forward, on the anterior surface of the aorta and goes in front of this, somewhat to the left of the median plane, obliquely through the diaphragm. In the middle part of the pars thoracalis the oesophagus, especially its posterior wall, lies for a long distance close to the pleura mediastinalis dextra (see Fig. 683), in the lowermost part it approaches for a short distance very close to the pleura mediastinalis sinistra (see Fig. 681). The pars abdominalis is very short and runs to the left and downward in front of the pars lumbalis diaphragmatis, directly behind the impressio oesophagea of the liver. The oesophagus when empty is markedly flattened above from before backward, its lumen being a frontally placed slit; in the whole thoracic portion it is wide open during life. Its diameters increase on the average from above downward; circular constrictions can however be made out, oftenest in three situations: behind the cartilago cricoidea, behind the bifurcatio tracheae and in the hiatus oesophageus of the diaphragm; the uppermost is very frequently the narrowest.



609. Superficial muscular layer of the stomach, viewed from above and in front.

The *wall of the oesophagus* consists of three layers. Inside lies the mucous membrane, *tunica mucosa*, of a grayish-red to a whitish color; beneath it is the connective tissue, *tela submucosa*. Throughout the latter are mucous glands, *glandulae oesophageae*, varying in number and size; at the upper and lower end of the oesophagus however the mucous membrane possesses in addition a variable quantity of glands which agree in their structure with the glands of the stomach. The outermost layer, *tunica muscularis*, is composed of an inner circular and an outer longitudinal layer (see also Figs. 593, 605, 606 and 610). The bundles of the latter arise from the posterior surface of the cartilago cricoidea, surround in part the oesophagus and spread out upon the whole circumference of the latter. On the relation of these layers to the cardia see pp. 532 and 533. The longitudinal layer is connected usually by very variable narrow bands of fibres (not illustrated) with the posterior surface of the trachea, of the left bronchus *(m. bronchooesophageus)*, with the pleura mediastinalis sinistra *(m. pleurooesophageus)* and with the muscle fibres which surround the hiatus oesophageus of the diaphragm.

The **stomach** *(ventriculus, gaster)* (see also Figs. 563, 608 and 611) is an unpaired, saccular dilatation of the alimentary canal connecting above with the oesophagus, below with the duodenum. In it can be distinguished an upper surface directed at the same time forward and to the right *(paries anterior)* and a lower surface directed at the same time backward and to the left *(paries posterior)*; these go over into one another to the right and behind at the shorter *curvatura ventriculi minor*, and to the left and in front at the longer, considerably curved *curvatura ventriculi major*, on which run the main-stems of the gastric vessels. At the upper end of the curvatura minor the oesophagus enters the wall of the stomach *(cardia)*; the blind-sac-like portion projecting higher up and situated to the left of the cardia is called the *fundus (fornix) ventriculi*. The middle and largest part is called *corpus ventriculi*. The corpus is usually continued into the *expulsion canal* or *pars pylorica* very frequently by a right-angled or acute-angled bend, which often causes a distinct furrow at the curvatura minor.



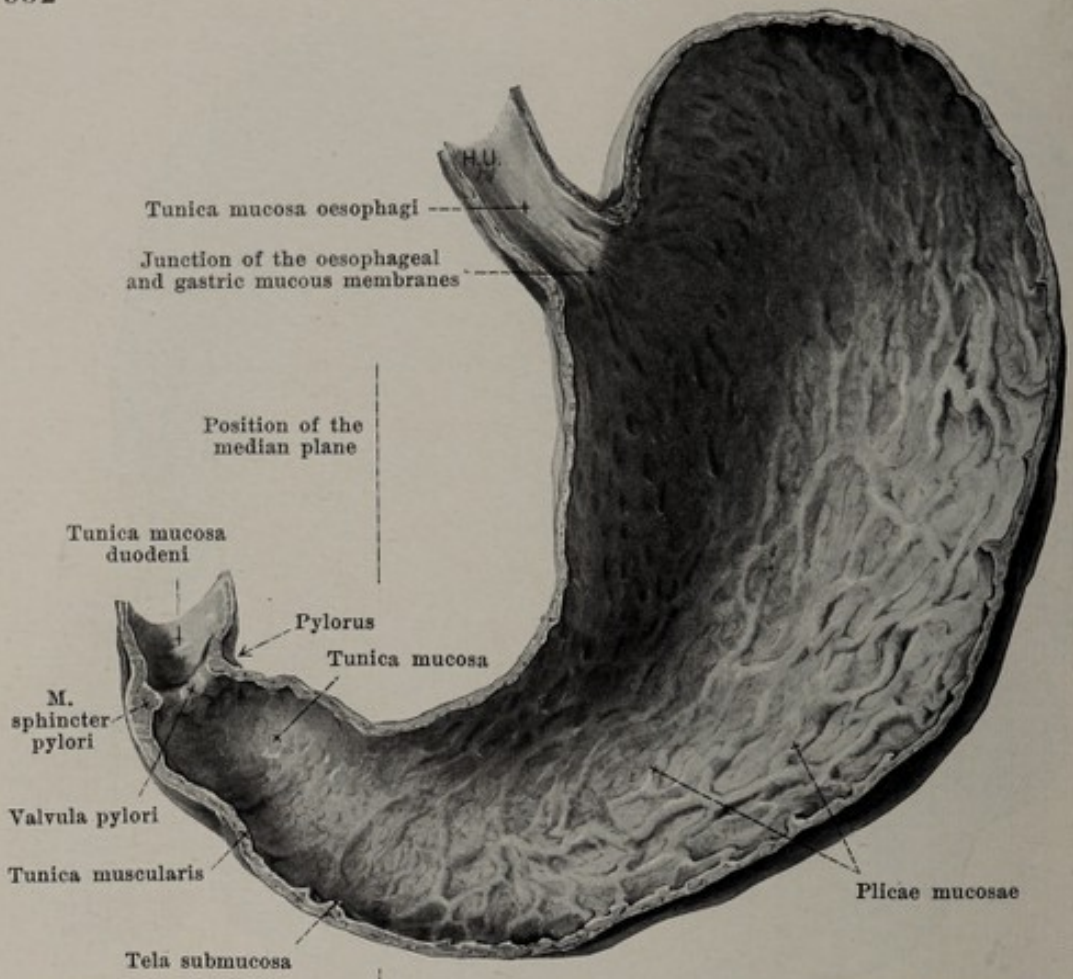
610. Middle and deep muscular layers of the stomach, viewed from above and in front.

(The superficial layer has been completely, the middle partly, cut away.)

Stomach (continued). The pars pylorica is approximately cylindrical in shape and may be separated from the duodenum by a ring-formed constriction, which indicates the position of the *pylorus*.

The form of the stomach (and partly also its position) varies very considerably in the living, and depends particularly on the volume of its contents and on the position of the body. The empty, contracted stomach looks like an intestine, but is somewhat wider above than below. When the stomach is filled the pars pylorica changes only very little in shape; but on the other hand fundus and corpus distend from the curvatura minor both to the left and downward, so that the angular bend of the pars pylorica increases and the stomach assumes the shape of a bow („fish-hook-shape") when the body is in vertical position.

Position of the stomach (s. Figs. 516, 548 and 642—644). The main portion of the stomach lies on the left side of the body. A plane passing through the two curvatures looks forward and slightly to the right and upward. In this plane the stomach lies in the form of a semi-ring or loop, convex to the left, below and in front, curved around the pars lumbalis of the diaphragm, around the tuber omentale of the pancreas and around the tuber omentale and the processus papillaris of the liver. The upper portion of the curvatura minor extends pretty constantly almost vertically to the left crus mediale of the diaphragm. The pars pylorica in the contracted stomach and in recumbent position extends almost transversely to the right and backward; in the distended stomach, and in upright posture, obliquely to the right upward and backward, or upward and backward. The lowest point of the stomach when in the form of a bow (see above) may reach as far as below the navel. The pylorus is always situated above the caudal part; it lies farther forward than the cardia. In recumbent position it lies usully on the right hand side of the 1st lumbar vertebra and in vertical position as a rule at the level of the 3rd—4th lumbar vertebra.



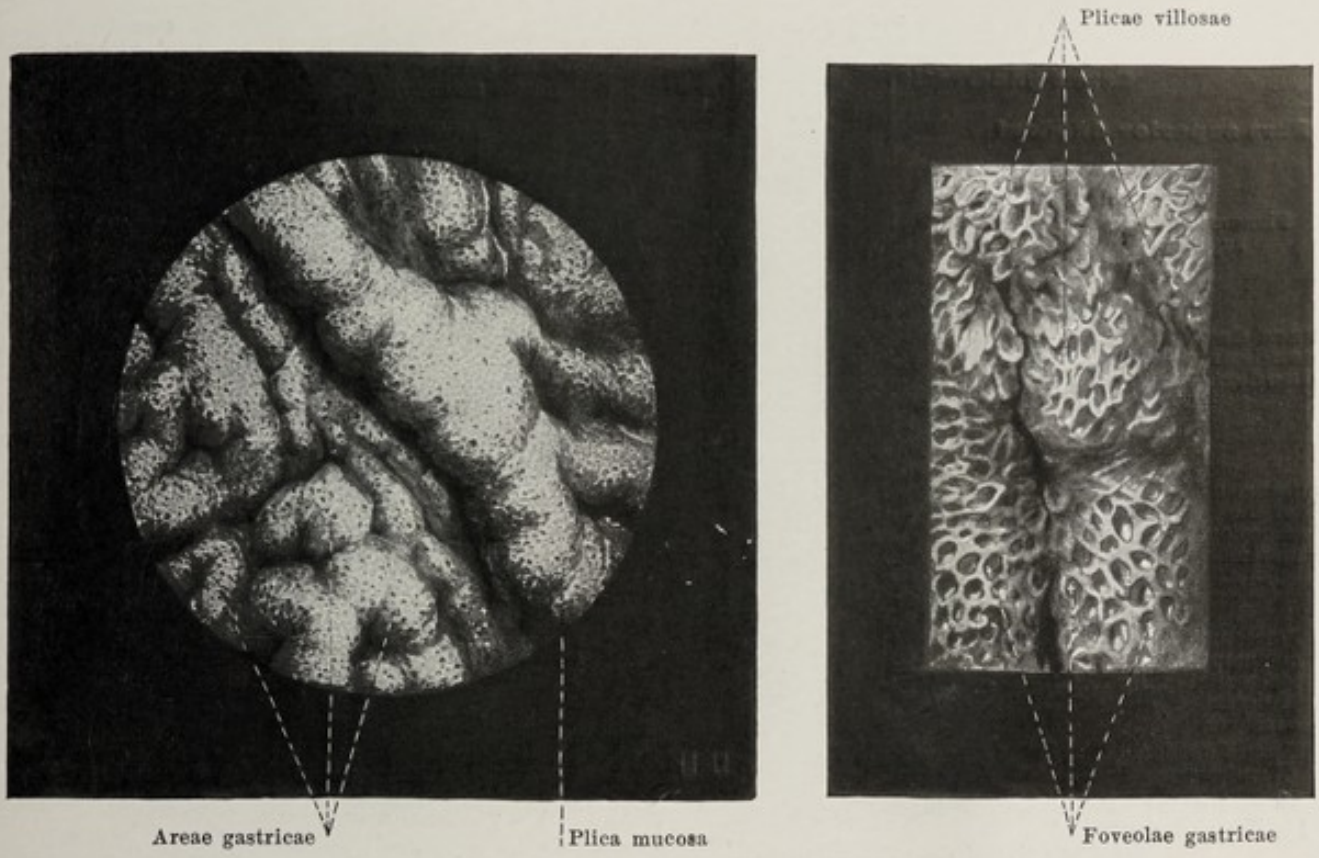
611. Mucous membrane of the stomach, posterior half, viewed from above and in front.

(The moderately distended stomach has been cut through along the greater and lesser curvatures.)

Position of the stomach (continued) (see Figs. 643 and 644). The fundus is bounded directly above by the cupola of the diaphragm, to the left and behind by the facies gastrica of the spleen. The paries posterior is in contact with the facies anterior of the glandula suprarenalis sinistra, with the facies anterior (impressio gastrica) of the left kidney, with the facies anterior of the pancreas and with the mesocolon transversum; it is partly separated from these organs by the bursa omentalis. The paries anterior is in contact with the impressio gastrica of the lobus sinister and of the lobus quadratus as well as with the tuber omentale of the liver and, when the stomach is empty, is almost completely covered by these parts. When the stomach is full the paries anterior is in contact on the left side in still greater extent with the diaphragm; in addition, a triangular area of the corpus and pars pylorica lies directly against the anterior abdominal wall in the regio epigastrica beneath the margo anterior of the left lobe of the liver and to the right of the 8th (and 9th) costal cartilage of the left side (see Fig. 642).

The external surface of the stomach is covered by the ***tunica serosa*** *(peritoneal coat)* (see Fig. 608). Two narrow strips running from the cardia to the pylorus alone remain free from it. One of these extends along the curvatura minor; near it is attached the ligamentum hepatogastricum. The other stretches behind the fundus and along the curvatura major; near it goes off the lig. gastrolienale, the omentum majus and the lig. gastrocolicum.

Beneath the peritoneal covering lies the ***tunica muscularis.*** It consists of three layers. The outermost layer, *stratum longitudinale* (see Fig. 609), is a continuation of the longitudinal muscle fibres of the oesophagus. It forms a narrower, more powerful, complete band of fibres along the curvatura minor, while a broader but feebler band passes over the fundus and the greater curvature; in addition fibres diverge from the cardia to the corpus. The bundle running along the curvatura minor, becomes, after divergence of the fibres to the pars pylorica, very thin. The pars pylorica possesses a closed outer layer of longitudinal muscle fibres, which only to a very slight degree extend over the duodenum; the most of them bend into the depth at the pylorus. The bundles upon the anterior and posterior surfaces of the pars pylorica are especially tense and closely arranged and are designated the *ligamenta pylori.*



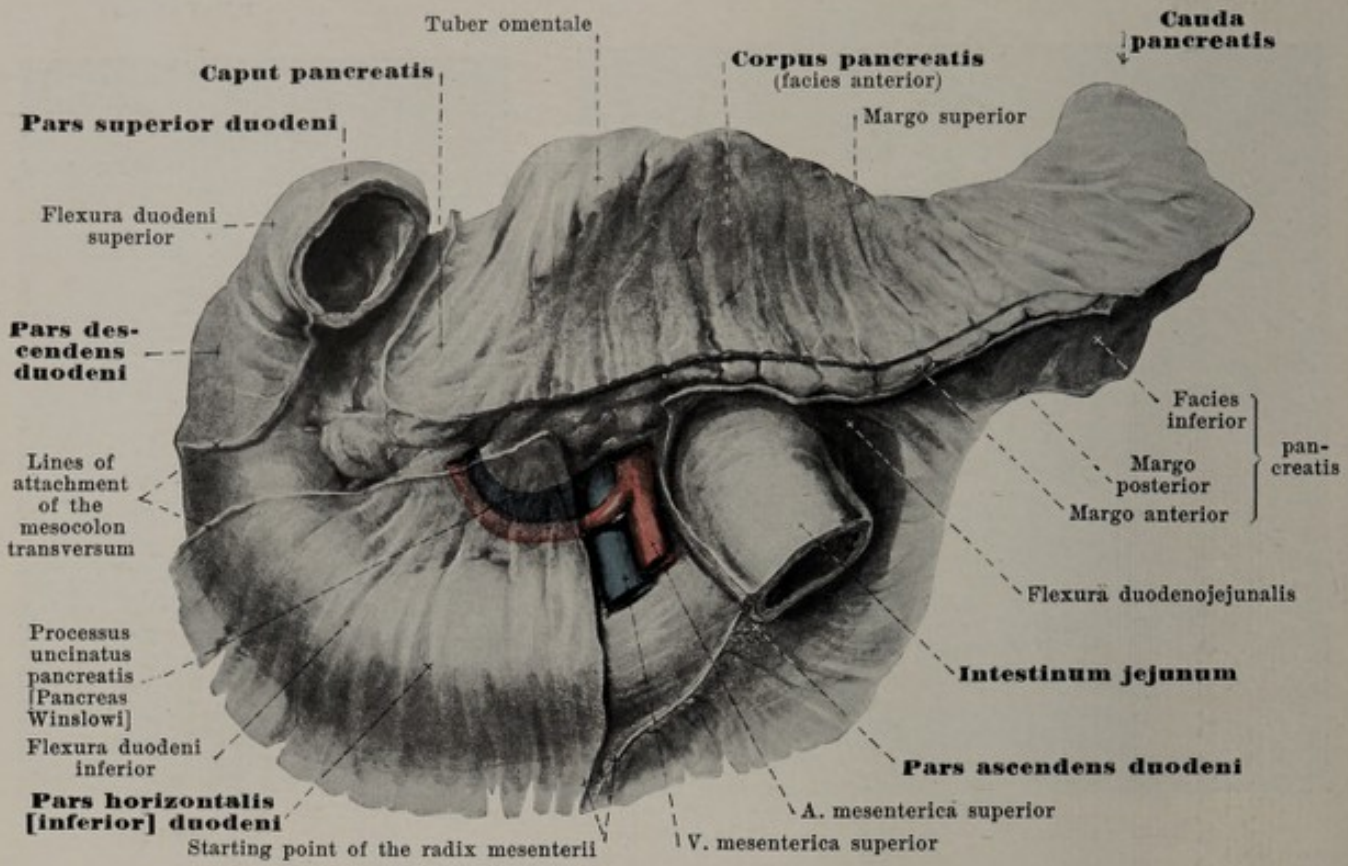
612 and 613. Mucous membrane of the stomach,

from the pars pylorica, viewed from the surface.

Magnification: 5 : 1. Magnification: 16 : 1.

The **stomach.** ***Tunica muscularis*** (continued). The second layer of the same, *stratum circulare* (see Figs. 609 and 610), in the form of even circular bands of fibres covers the whole stomach with the exception of the fundus; the uppermost fibres arising at the right side of the cardia form only incomplete rings. The layer is directly connected with the circular layer of the oesophagus and of the duodenum and projects at the pylorus into the interior of the stomach as an especially thickened ring, *m. sphincter pylori* (see Fig. 611). The third, deepest layer, *fibrae obliquae* (see Fig. 610), is connected at the left side of the cardia with the circular layer of the oesophagus. Thence the fibres diverge upon the paries anterior and posterior so that the first run parallel to the curvatura minor and pass almost as far as the pars pylorica, the last run more transversely to the long axis; all the fibres bend around finally in the direction of the stratum circulare and are partly continued into this. To these fibres are added, on the left side and above, those which encircle the fundus in concentric rings.

The ***tunica mucosa*** *(mucous membrane)* of the stomach (see also Fig. 611) is separated from the tunica muscularis by the *tela submucosa*. It is of a grayish-red or rose color and is marked off at the cardia by a sharp jagged line from the more whitish mucous membrane of the oesophagus. When the stomach is contracted it forms with the tela submucosa numerous folds, the *plicae mucosae* (O. T. rugae). Longitudinal folds are found along the curvatura minor (which may also be free from folds) and in the pars pylorica; in other places the folds are arranged in an irregular network. These folds vanish entirely when the stomach is markedly distended. At the pylorus there is always a fold, usually circular, the *valvula pylori*, which is shoved forward by the m. sphincter pylori and surrounds an opening, which when relaxed is just large enough to receive the tip of the 4th finger. Besides the larger folds of the stomach there are still smaller elevations, *areae gastricae*, incompletely separated from one another by a large number of irregular furrows of varying depth; they differ markedly from one another and each has an area of several square millimeters. Over the whole mucous membrane with the aid of a hand-lens can be seen minute depressions, *foveolae gastricae*, in which open the glands of the stomach, *glandulae gastricae [propriae]* and *glandulae pyloricae*. The thin walls intervening between these depressions present, especially in the pars pylorica, small, oblong, flat villous processes, the *plicae villosae*.

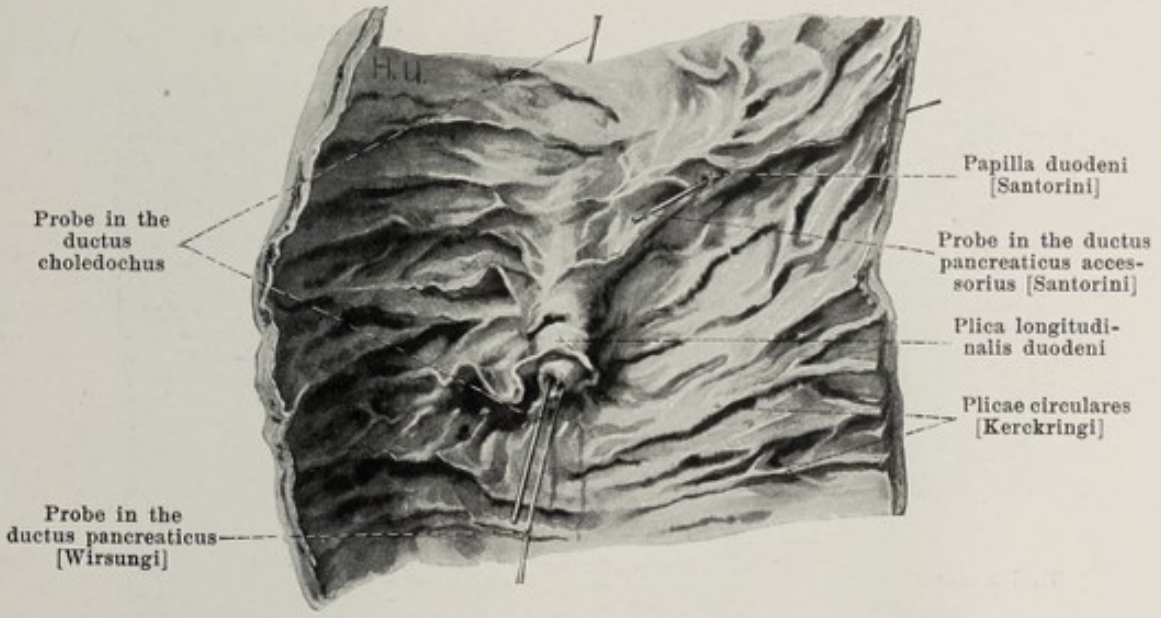


614. Duodenum and pancreas, viewed from in front.

(A piece of the pars superior duodeni has been cut off. The peritonaeum has been cut away exactly at the point where it turns away from the two organs.)

The **small or thin intestine** *(intestinum tenue)* (see Fig. 563) is a cylindrical tube; it begins at the pylorus, fills up a large part of the abdominal and pelvic cavities with its numerous convolutions and ends by opening into the large intestine. Its length is in adults generally 5—7 metres and its diameter gradually diminishes from above downward. The small intestine is divisible into the *duodenum* and the *intestinum tenue mesenteriale.*

The ***duodenum*** (see also Figs. 635, 636 and 642—645) is the name given to the first portion of the small intestine which is directly and firmly attached to the posterior abdominal wall. It forms a spirally curved ring, open to the left and above, in the concavity of which the pancreas is inserted and the terminal points of which lie closer to one another when the stomach is empty than when it is full. It presents for examination a *pars superior*, *pars descendens* and *pars inferior*. The *pars superior* is the shortest portion and runs approximately horizontally and backward in recumbent position, obliquely cranialward and backward in upright posture; it extends at the same time, more or less distinctly, from left to right. It lies to the right and in front of the pars lumbalis of the diaphragm, of the v. portae, a. hepatica and ductus choledochus, behind and below the lobus quadratus of the liver, crosses the porta hepatis and by means of the *flexura duodeni superior* bends around beneath the processus caudatus of the liver into the *pars descendens.* This runs downward and somewhat to the left in front of the medial margin of the right kidney (somewhat nearer the median plane when the colon ascendens is full than when it is empty), to the right of the v. cava inferior, behind the left portion of the right lobe of the liver, behind the gall-bladder and behind the colon transversum and goes over by means of the *flexura duodeni inferior* into the *pars inferior.* The latter extends transversely to the left at first *(pars horizontalis [inferior])* in front of the body of the 3rd or 4th lumbar vertebra and in front of the v. cava inferior and then turns abruptly upward and somewhat to the left *(pars ascendens)* in front of the aorta abdominalis. This last portion runs behind the a. and v. mesenterica superior, crossed by the radix mesenterii, as far as the left side of the body of the 2nd lumbar vertebra and as far as the facies inferior pancreatis and there, covered by the stomach, suddenly bends around markedly to the right and forward *(flexura duodenojejunalis)*, to go over into the intestinum jejunum. Sometimes no marked pars horizontalis inferior is present; the pars descendens then forms a V with the pars ascendens.



615. Mucous membrane of the pars descendens of the duodenum.

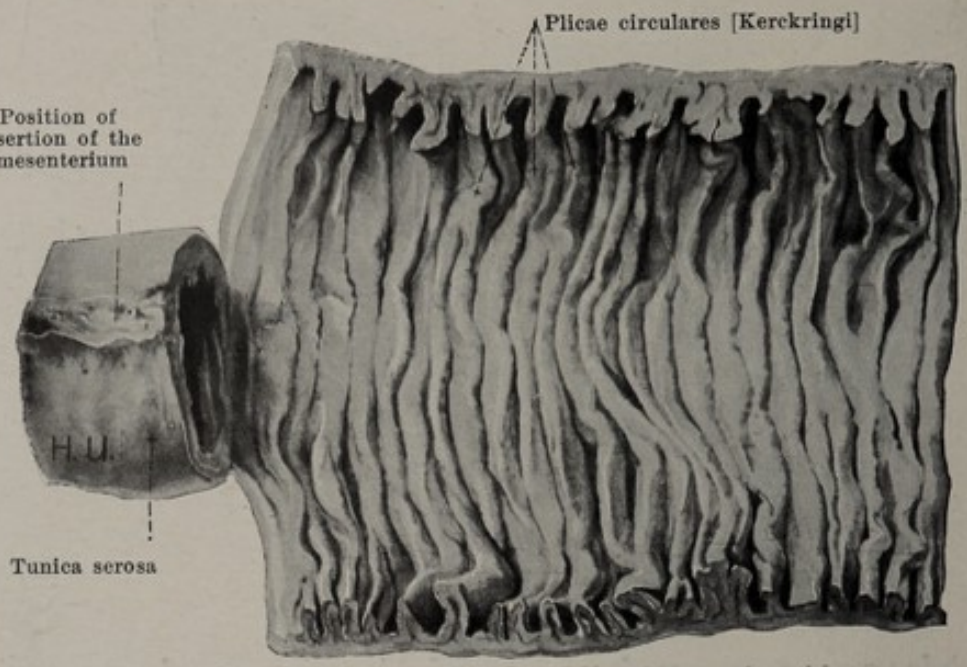
(The piece of intestine has been cut open along its right side and spread out.)

Duodenum (continued). The flexura duodenojejunalis is firmly attached to the diaphragm by means of the *m. suspensorius duodeni* (see Fig. 686). This small, flat, triangular muscle consisting of smooth muscle fibres arises directly above the hiatus aorticus from the bands of fibres of the pars lumbalis diaphragmatis. It runs downward in front of the plexus coeliacus and behind the pancreas, its fibres diverging downward; it lies to the left of the a. coeliaca and a. mesenterica superior and is strengthened by fibres from the neigborhood; at the flexure it radiates out into the longitudinal and circular muscle bands of the intestine.

The *tunica serosa (peritoneal covering)* is present only in part of the duodenum (see Figs. 614, 644 and 645). A part of the left wall of the pars superior looks into the bursa omentalis and is covered by its peritonaeum; the right and upper walls are completely covered by peritonaeum, the latter except for a narrow strip, from which the ligamentum hepatoduodenale goes off. The pars descendens possesses a serous covering on its right and anterior walls, and only the area between the lines of attachment of the mesocolon transversum is free from it. The pars horizontalis [inferior] is covered by peritonaeum in front and below, the pars ascendens in front and to the left, the latter with the exception of the spot where it is crossed by the radix mesenterii.

The *tunica muscularis* in detail, the *tunica mucosa* in general, resembles that of the rest of the small intestine. But the mucous membrane possesses in the pars descendens certain special structures in addition (see also Fig. 635). In that region, at the junction of the posterior with the left wall, it is elevated by the ductus choledochus to a longitudinal fold more distinct below, the *plica longitudinalis duodeni;* in its lower part this presents a small projection upon which open the ductus choledochus and the ductus pancreaticus [Wirsungi] either close to one another with two openings or, when they have previously united, by a common opening. Somewhat above and in front of this spot there is constantly to be found a smaller rounded elevation, *papilla duodeni [Santorini]*, with the opening (sometimes missing) of the ductus pancreaticus accessorius [Santorini].

The ***intestinum tenue mesenteriale*** (see Figs. 563 and 640) by means of numerous convolutions fills up the space which is bounded on the right by the colon ascendens, above by the colon transversum and mesocolon transversum, to the left by the colon descendens; it is shoved into the right and left partly in front of the organs mentioned and extends below into the cavity of the small pelvis. In the posterior wall of this space, covered by the peritonaeum, lie the bodies of the two inferior lumbar vertebrae, the lower part of the pars descendens and the pars inferior duodeni, the processus uncinatus of the pancreas and the large abdominal vessels, as well as, on each side, parts of the mm. iliopsoas et quadratus lumborum, the kidney and the ureter. In front and lateralward the small intestine is covered to a variable extent by the great omentum (see Fig. 639) and is separated by this from the peritoneal covering of the m. transversus abdominis and of the mm. recti abdominis.



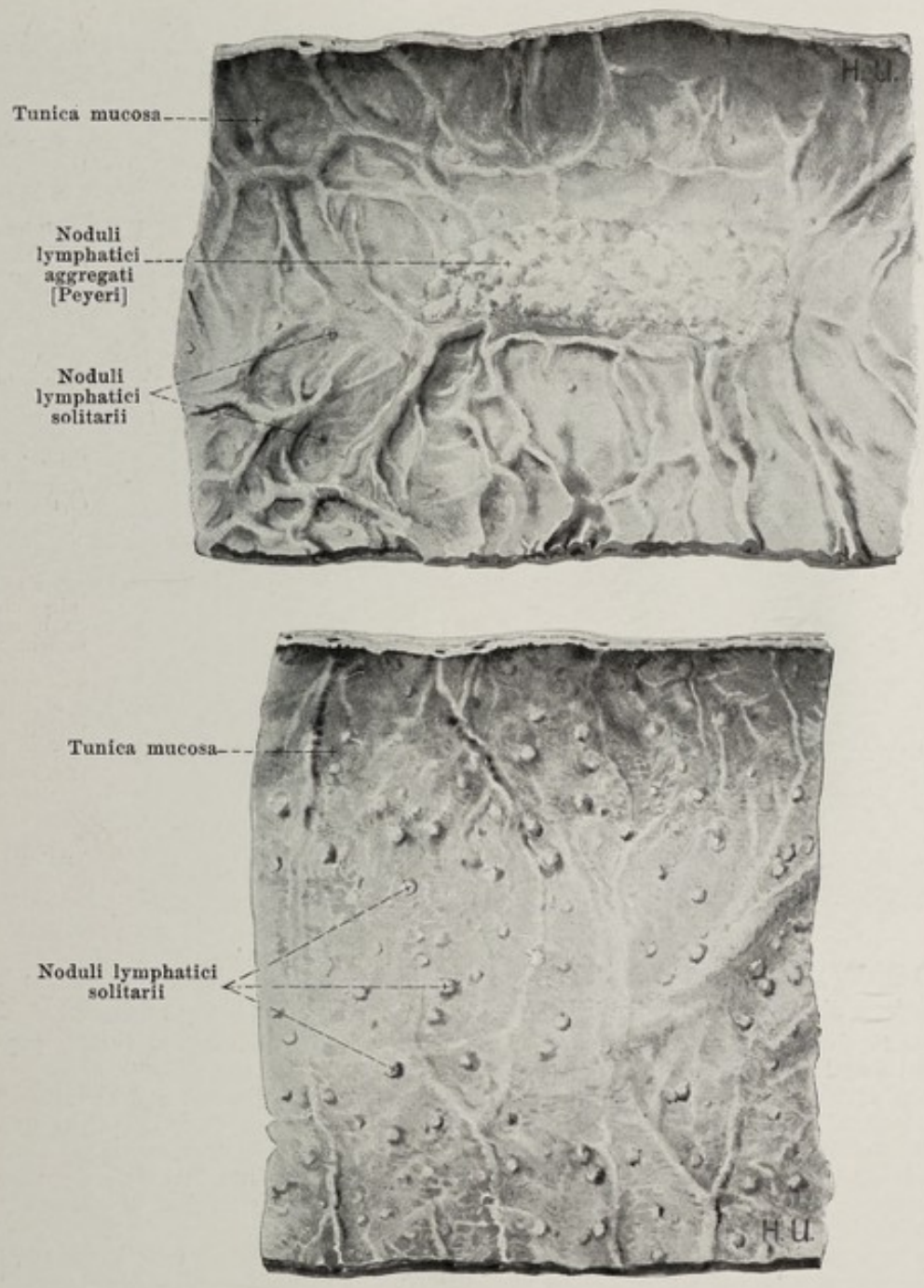
616. Portion of the intestinum jejunum,

in part cut open at the attachment of the mesentery and spread out.

Of the ***intestinum tenue mesenteriale*** about the upper half is called the ***intestinum jejunum*** (empty intestine), the lower is called the ***intestinum ileum*** (convoluted intestine); a sharp limit between the two however exists neither on the external nor on the internal surface. The general arrangement is very frequently as follows (see Figs. 563, 640 and 641): the first portion lies in the regio hypochondriaca sinistra with two groups of loops, which reach above as far as the flexura coli sinistra and are partly covered by the colon transversum; the intestine then passes through the regio umbilicalis turning into the right half of the body, curves around there and runs backward again across the median plane; thereupon it forms several loops in the left fossa iliaca, extends to the right again and finally descends into the small pelvis, where it fills up with its loops the cavity which is lined by the peritonaeum; its terminal portion passes upward again, curves to the right around the margin of the right m. psoas major and passes in the fossa iliaca into the colon ascendens (see also Fig. 624). Deviations from this course are frequent.

The external covering of the intestinum tenue mesenteriale is formed by the delicate *tunica serosa (peritoneal coat)* (see also Fig. 619), which leaves free only a narrow strip where the mesenterium is attached to the intestine. The second layer of the wall consists of the *tunica muscularis;* this is composed of a thinner, external, less complete longitudinal layer, *stratum longitudinale*, and of a thicker, internal, continuous circular layer, *stratum circulare* (see Fig. 619). The innermost layer, *tunica mucosa (mucous membrane)* is separated from the preceding by the *tela submucosa* (see Fig. 619). In the duodenum the latter contains the glandulae duodenales [Brunneri] (not illustrated) and throughout the whole length of the intestine the bodies of the noduli lymphatici; it sends stripe-like continuations into the plicae circulares [Kerckringi]. The mucous membrane is of a reddish color and presents the following special structures:

a) *Plicae circulares [Kerckringi]* (O. T. valvulae conniventes) (see also Fig. 619), are constant folds, which are formed by the mucous membrane and the tela submucosa. They are absent in the pars superior duodeni, appear in the pars descendens duodeni and are especially numerous and large in the pars inferior duodeni and in the upper third of the intestinum jejunum; farther on they diminish again and are usually completely absent in the lowermost portion of the intestinum ileum. They run approximately at right angles to the long axis of the intestine and extend usually over only a part of the circumference; a number of folds forms complete rings and others encircle the intestine in a spiral turn (more rarely in several). In the upper part of the intestine they are longer and higher than in the lower part. The folds are manifoldly forked; neighboring ones are also frequently united with one another by low, slender folds.

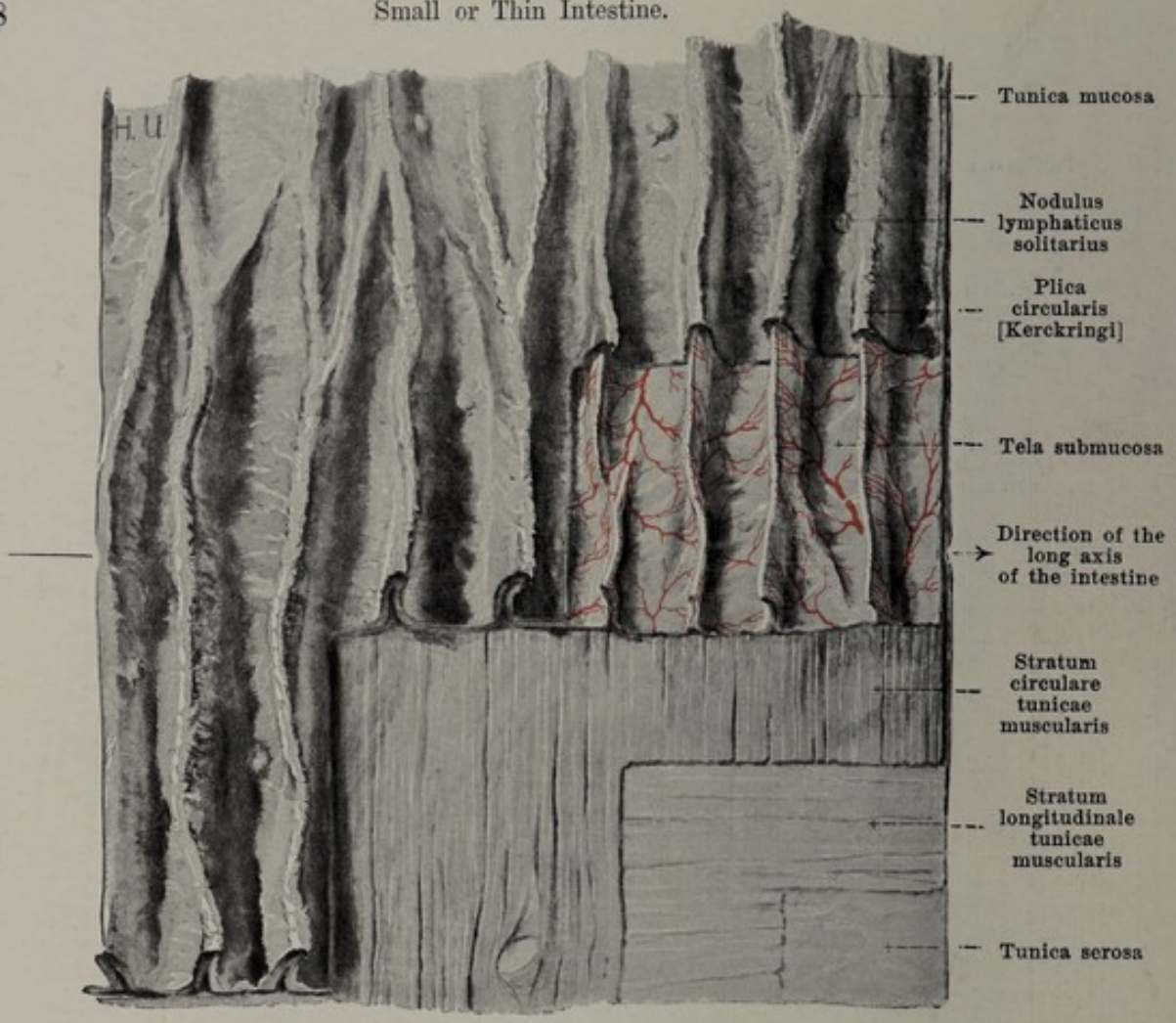


617 and 618. Portions of the intestinum ileum,

cut open at the insertion of the mesenterium and spread out.

(The upper figure shows an intestine with many groups of lymph nodules (Peyer's patches). the lower an intestine in which the groups of lymph nodules are only slightly developed and are replaced by an increased number of solitary nodules.)

b) *Noduli lymphatici (lymph nodules)* (see also Figs. 619—621) are small, usually pear-shaped structures, whose thick bodies are situated in the tela submucosa; the blunt wedge-shaped apex of each lies in the tunica mucosa and forms a (non-villous) dome-like elevation of the surface of the mucous membrane. They are usually single in the intestinum jejunum *(noduli lymphatici solitarii).* In the intestinum ileum they are numerous and much higher and in part are crowded together into oblong *Peyer's patches (noduli lymphatici aggregati [Peyeri]);* these vary in size but generally contain from twenty to thirty nodules; they lie opposite the insertion of the mesenterium; these patches may be replaced in part by an increased number of solitary nodules.



619. The wall of the small intestine. Magnification: 3 : 2.

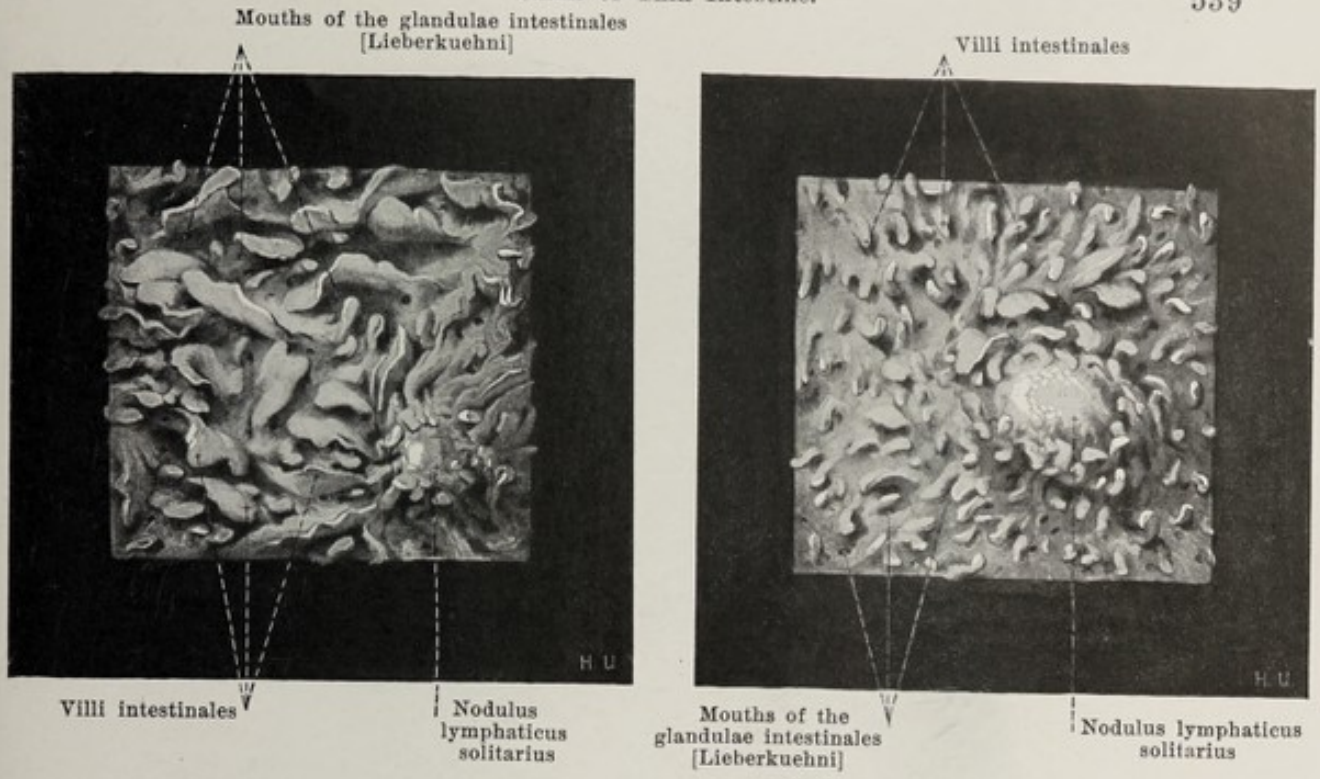
(Passing from above downward the individual layers have been gradually removed.)

c) *Villi intestinales* (villi of the intestine) (see Figs. 620 and 621) are small elevations (the largest being 1 mm long) of the surface of the mucous membrane which are present from the pylorus almost as far as the free margin of the valvula coli and are closely crowded upon the plicae circulares [Kerckringi] and between them. They leave free only the domes of the noduli lymphatici and are somewhat more numerous in the upper than in the lower part of the intestine. In the upper part of the intestine they are also much broader, more leaf-like, in the lower part more slender, cylindrical or flattened; along with these however all possible intermediate forms occur.

d) *Glandulae intestinales [Lieberkuehni]* (O. T. crypts of Lieberkuehn) (not illustrated) are tube-like glands which are studded over the mucous membrane perpendicularly to the surface throughout the whole extent of the small and large intestines. With the hand-lens their mouths are visible as small openings (see Figs. 620, 621 and 628).

e) *Glandulae duodenales [Brunneri]* (Brunner's glands of duodenum) (not illustrated) are glands which are found in the duodenum only; the main bodies of the glands are situated in the tela submucosa while the ducts extend between the glandulae intestinales [Lieberkuehni] through the tunica mucosa to its surface. The glands are largest and most numerous in the pars superior duodeni; farther on they gradually become less numerous and vanish entirely at the level of the flexura duodenojejunalis.

The **large or thick intestine** *(intestinum crassum)* (see Figs. 640—642), following upon the small intestine, is the most variable portion of the digestive tube. It begins as the *intestinum caecum* in the fossa iliaca dextra, surrounds a part of the peritoneal cavity and the small intestine with a large loop, which ends in the fossa iliaca sinistra and in which we distinguish an ascending *(colon ascendens)*, a transverse *(colon transversum)* and a descending limb *(colon descendens)*. Its terminal portion *(colon sigmoideum)* hangs as a loop generally down into the cavity of the small pelvis (see p. 544) and goes over in front of the sacrum into the rectum. It is on an average about 1½ metres long. The portion from the caecum to the rectum is called the *colon (griping intestine)*.



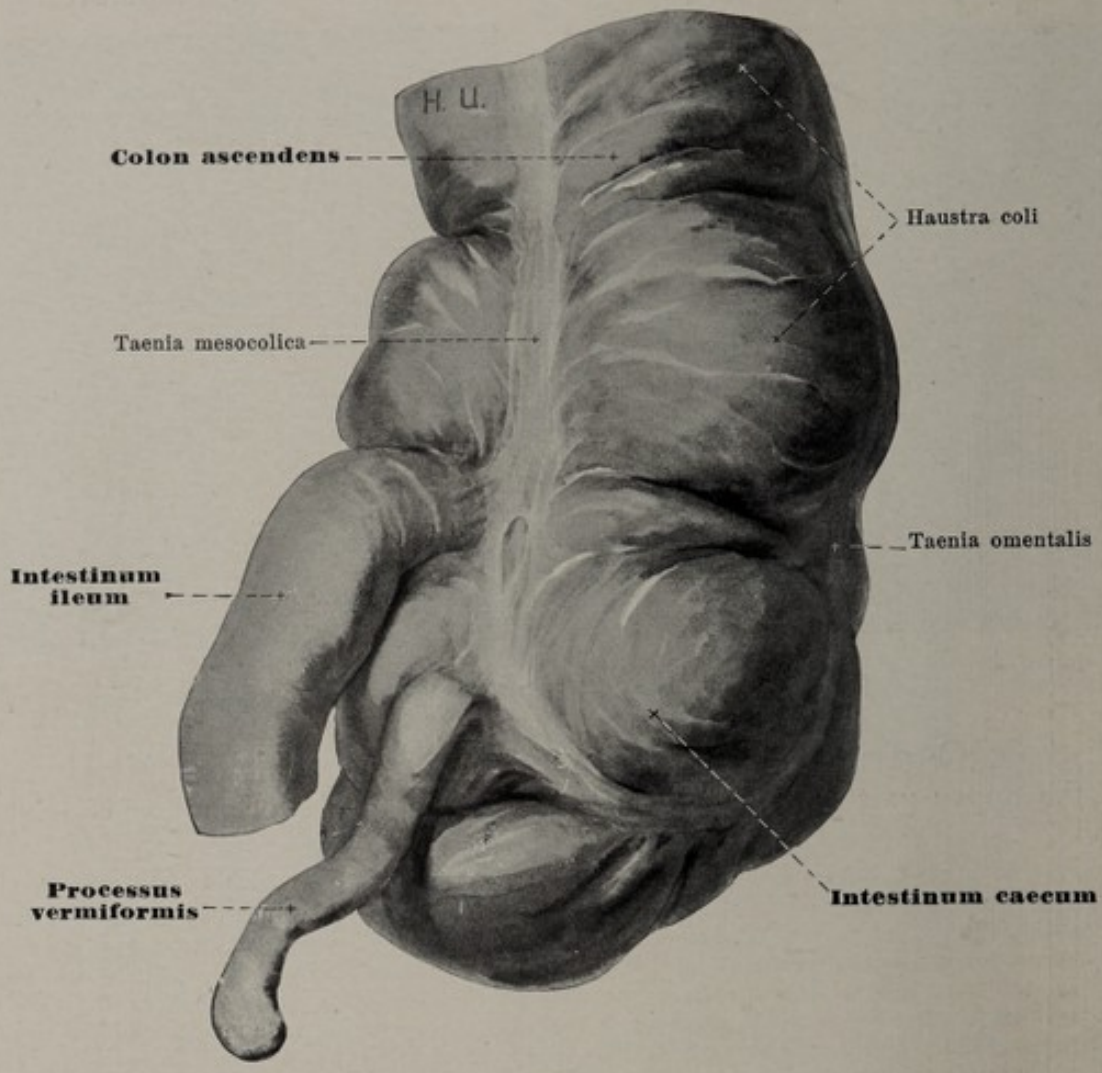
620 and 621. Villi of the small intestine, from the upper part of the intestine. from the lower part of the intestine.

Magnification: 12 : 1.

The large intestine is characterized (see Figs. 622, 623 and 625) by the fact that its surface is not smoothly cylindrical but presents a nodular appearance due to three rows of irregular, flask-like projections, *haustra coli.* These rows of haustra are separated from one another by three band-like strips of the longitudinal muscle (see p. 545), *taeniae coli*, which run in the long axis of the intestine, but they are besides individually further subdivided by furrows of varying depth which correspond to sickle-shaped folds on the surface of the mucous membrane, the *plicae semilunares coli.* The diameter of the large or thick intestine is larger than that of the small intestine, but diminishes gradually toward its termination. The distention of the large intestine with faeces usually diminishes from the caecum toward the rectum, so that the colon descendens is usually empty and collapsed; the colon sigmoideum is, on the contrary, often distended by gas or faeces.

The ***intestinum caecum*** *(blind gut)* (see Figs. 622—625) is the blind-sac-like portion of the large intestine situated below the opening of the intestinum ileum into the large intestine. Its upper boundary is indicated externally by a deep incomplete groove which surrounds the intestine at the level of this opening and to which internally the frenula valvulae coli correspond. The contracted caecum (see Fig. 623) forms a kink in this furrow with the colon ascendens, so that it runs to the left, downward and backward; its haustra are but little marked and it has the shape of a wedge, from the apex of which the processus vermiformis goes off with more or less distinct narrowing, at first in the direction of the main tube. The distended caecum (see Figs. 622, 624, 625 and 647) forms a less marked kink with the colon ascendens and is directed downward and a little to the left. It is approximately hemispherical in shape and has well marked haustra. The processus vermiformis goes off directly from the medial part of the posterior wall. The three taeniae coli extend toward the beginning of the processus vermiformis; in the contracted intestine they converge gradually as they approach, in the distended they meet one another in the form of a T.

The *processus vermiformis* (O. T. *vermiform appendix)* (see Figs. 622—625 and 647) is a narrow, generally cylindrical, hollow, blind-ending appendix of the intestinum caecum, the length, curvature and position of which vary extraordinarily; it is on an average 8½ centimetres long. From its origin behind and beneath the termination of the small intestine it runs straight or tortuous toward the small pelvis or upward behind the caecum or to the left and upward behind the small intestine, or often in some other direction. Its position varies correspondingly; it is covered in its course partly or entirely by the caecum. It is covered externally by a continuous layer of longitudinal muscle. The processus vermiformis often becomes partly or entirely obliterated in the later years of life.



622. Caecum, distended,

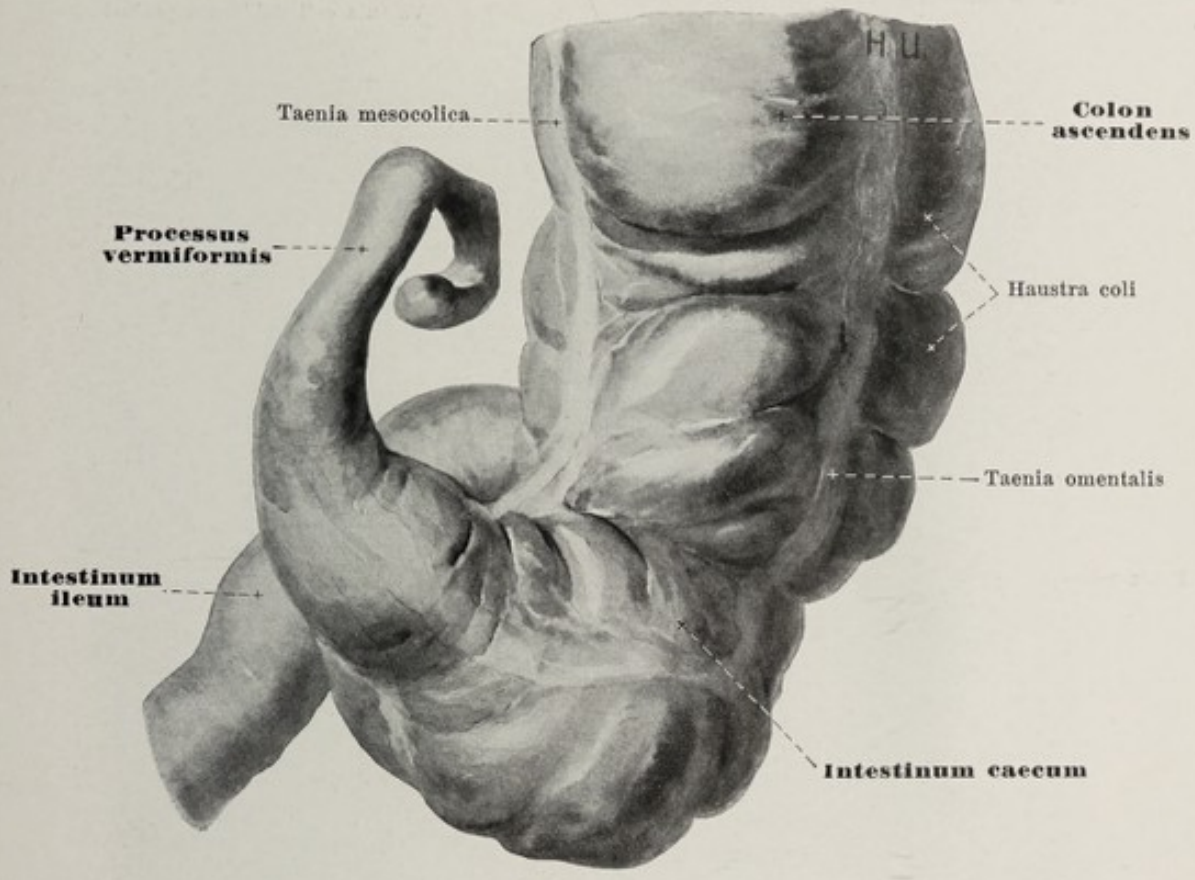
viewed from behind, after removal of the peritoneal coat.

Position of the caecum (see Figs. 640—642). The caecum rests in the fossa iliaca dextra directly upon the fascia iliaca, separated by this from the m. iliopsoas. When it is full its lower end lies just over the lateral half of the right ligamentum inguinale; its right wall is in contact with the lateral wall of the abdominal cavity; its anterior wall is overlapped below and to the left by small intestines and is directly in contact above and to the right with the anterior abdominal wall; its left wall may reach the left margin of the right m. psoas major and the right vasa iliaca externa. In the contracted condition the lower end does not reach so far downward and the anterior wall is completely covered in front by loops of small intestine.

The *wall of the caecum* consists like that of the whole of the large intestine of *tunica serosa, tunica muscularis, tela submucosa* and *tunica mucosa.*

The *tunica serosa (peritoneal coat)* (see Figs. 624 and 647) covers the caecum and the vermiform appendix almost completely in by far the majority of cases; it leaves free only a narrow strip which extends from the orifice of the small intestine to near the tip of the vermiform process (see p. 565) and along this the mesenteriolum processus vermiformis is attached to the intestine. Sometimes only the inferior portion of the posterior wall is covered by the peritonaeum; the upper part then has the same relations as the colon ascendens.

The *tunica muscularis* resembles that of the rest of the large intestine (see p. 545).

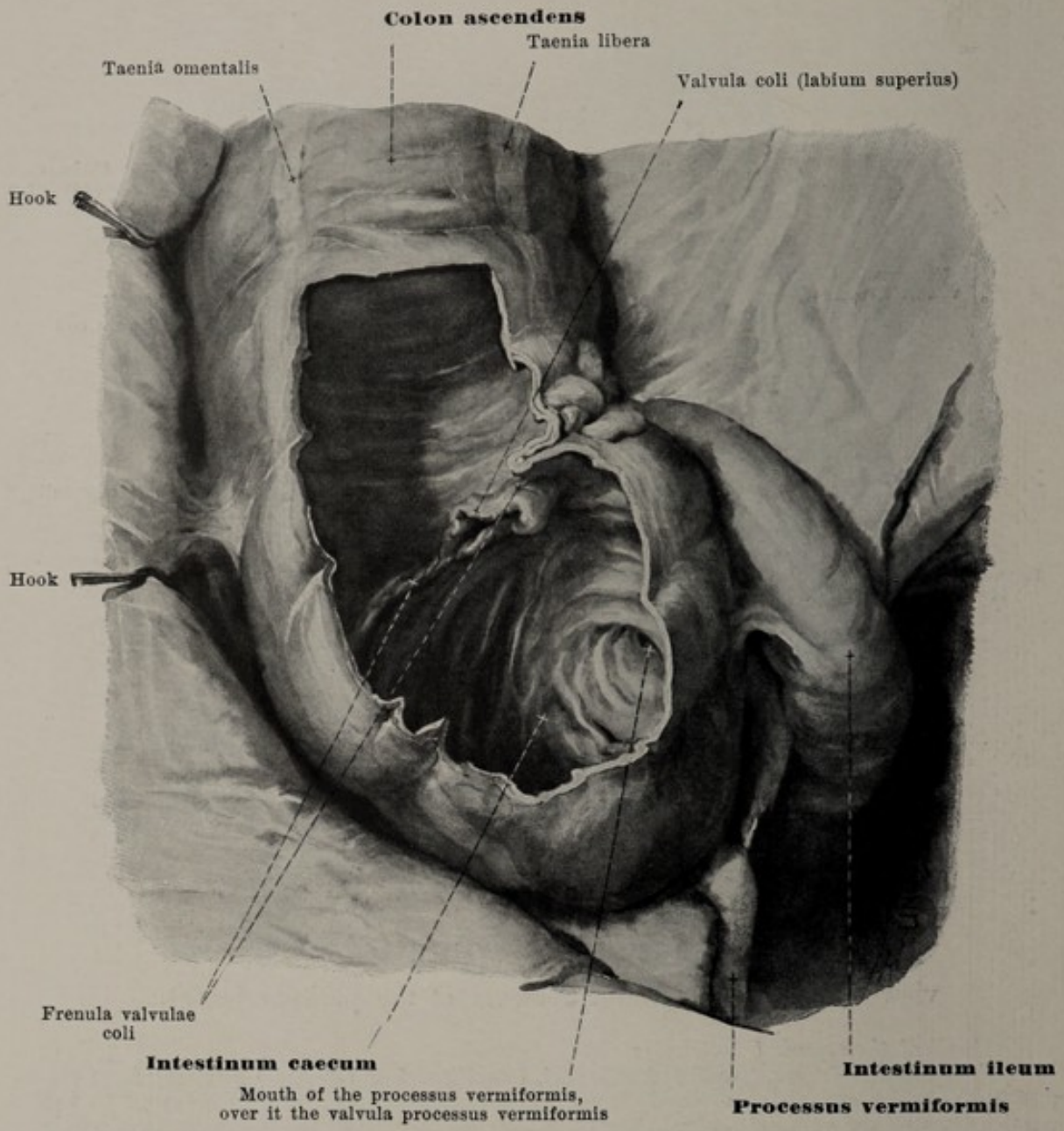


623. Caecum, contracted,

viewed from behind, after removal of the peritoneal coat.

Wall of the caecum (continued):

The *tunica mucosa (mucous membrane)* (see Figs. 624 and 625) presents fossa-like depressions which correspond to the haustra, and plicae semilunares which correspond to the constrictions on the external surface. The funnel-shaped opening of the processus vermiformis is sometimes surrounded on the left and above by a sickle-shaped fold of mucous membrane *(valvula processus vermiformis)*. At the upper limit of the caecum in the posterior part of the left wall lies the opening of the small intestine within the *valvula coli (valve of the large intestine)*. In the formation of this the terminal portion of the small intestine is invaginated into the cavity of the large intestine (see Fig. 625), its external wall being fused for a certain distance with that of the large intestine. There thus arise two high folds formed by the walls of the small and large intestines, the *labium superius* and *labium inferius* of the valvula coli, of which the lower may be shorter than the upper. Both folds go over into one another at their ends and surround the opening of the small intestine proper by their projecting margins. This opening is slit-shaped and its longitudinal diameter is usually directed from the left and above to the right and downward. From the point of union of the two folds there goes off in front and behind a high fold of mucous membrane of the large intestine, the *frenulum valvulae coli;* the two frenula have in common with the labium superius a sickle-like form, run from the left and above to the right and downward and extend over more than half the circumference of the intestine; the posterior frenulum is the longer and broader. They correspond to the deep furrow on the outer surface at the level where the caecum forms a kink with the large intestine (see p. 539). The valve of the large intestine is said to be always insufficient in the newly born, in children and adults it is normally sufficient. Regarding the mucous membrane see farther p. 545.

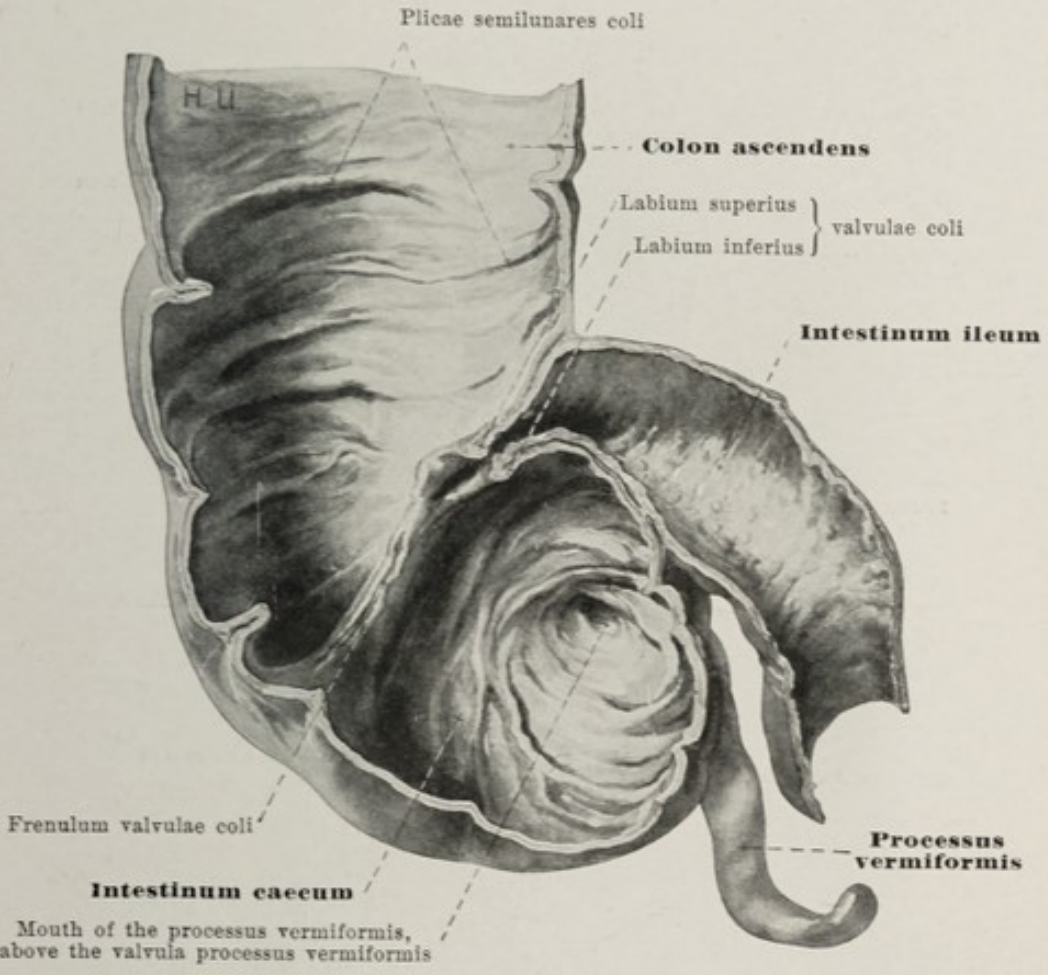


624. Caecum, distended, *in situ,* partly opened from in front.

(The anterior abdominal wall has been reflected to the right and downward; the small intestines have in large part been removed.)

The ***colon ascendens*** (see also Figs. 640—643) begins at the frenula valvulae coli as the direct continuation of the caecum; it passes upward and somewhat backward from the fossa iliaca dextra in front of the posterior part of the crista iliaca to the anterior surface of the m. quadratus lumborum dexter and then turns again somewhat forward to go over at the inferior pole of the right kidney through the flexura coli dextra into the colon transversum. Its right wall touches the lateral wall of the abdomen; its anterior wall in the contracted condition is completely, in the distended condition only partly, covered by loops of the small intestine and elsewhere is in contact with the anterior abdominal wall; its left wall is bounded partly by the m. psoas major, partly by loops of small intestine.

The *flexura coli dextra* (O. T. hepatic flexure of the colon) (see Figs. 642, 643 and 645) reaches either only from below to the inferior pole of the right kidney or covers the latter for some distance and is in contact in front and above with the impressio colica of the liver.



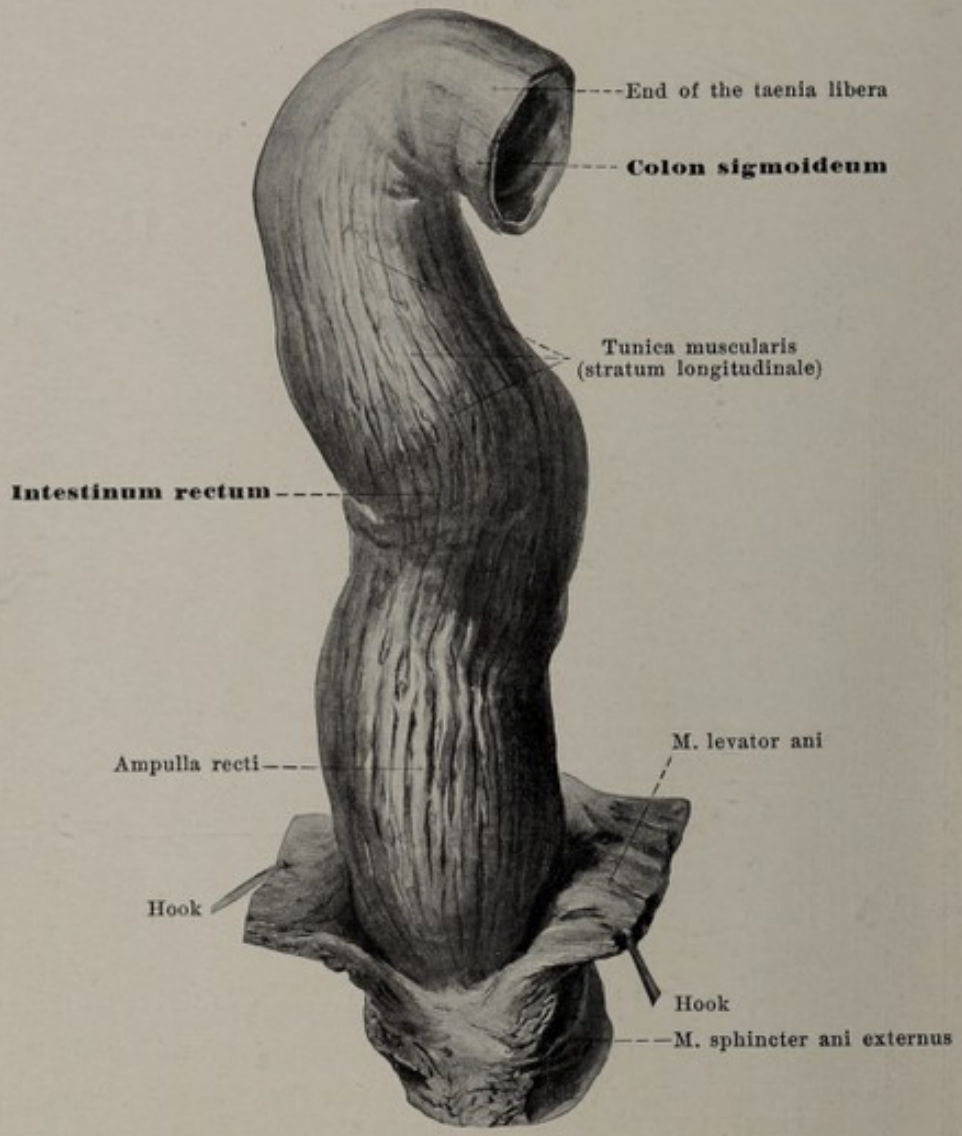
625. Valve of the large intestine *(valvula coli)*

and neighboring pieces of intestine, cut through, viewed from in front.

The ***colon transversum*** *(transverse colon)* (see Figs. 642 and 645) runs out to the left and somewhat upward from the flexura coli dextra over the median plane in a curve convex forward and at the same time somewhat downward and goes over just at the right of the extremitas inferior of the spleen through a sharp curve (flexura coli sinistra) into the colon descendens (see Fig. 644); it is often markedly curved downward. In its course it is bounded above by the impressio colica of the liver, the body of the gall bladder and the curvatura ventriculi major; it lies in front of the pars descendens duodeni, the pancreas, the pars ascendens duodeni and the upper part of the left kidney; on its inferior surface lie loops of the intestinum jejunum, the latter being on the left also shoved upward and partly behind it; its anterior surface (see Figs. 640 and 649) is covered by the omentum majus and by this separated from the anterior abdominal wall and (on the left) from the diaphragm.

The *flexura coli sinistra* (O. T. splenic flexure of the colon) makes a sharper bend than the flexura coli dextra and lies in front of the upper part of the lateral margin of the left kidney, regularly higher and farther dorsalward than the right; it reaches as far as the spleen (see p. 554) and may when the stomach is empty reach as far as the left dome of the diaphragm.

The ***colon descendens*** (see Figs. 641 and 642) runs, in a curve which is slightly convex backward and lateralward, to the inferior pole of the left kidney and then downward and forward on the lateral surface of the m. psoas major in front of the m. quadratus lumborum, the posterior part of the crista iliaca and the m. iliacus to the fossa iliaca sinistra; there it bends around and extends parallel to and above the lig. inguinale sinistrum to the right, downward and forward, in front of the m. iliopsoas until it is in front of the vasa iliaca externa and the left ductus deferens (in the male, the ligamentum teres uteri in the female); in that situation it goes over into the colon sigmoideum (see also Fig. 648). It is bounded above and on the left by the lateral wall of the abdomen; below, its anterior wall may lie partly against the anterior abdominal wall, otherwise it is overlapped by loops of small intestine (see Fig. 640). It is much longer than the colon ascendens.

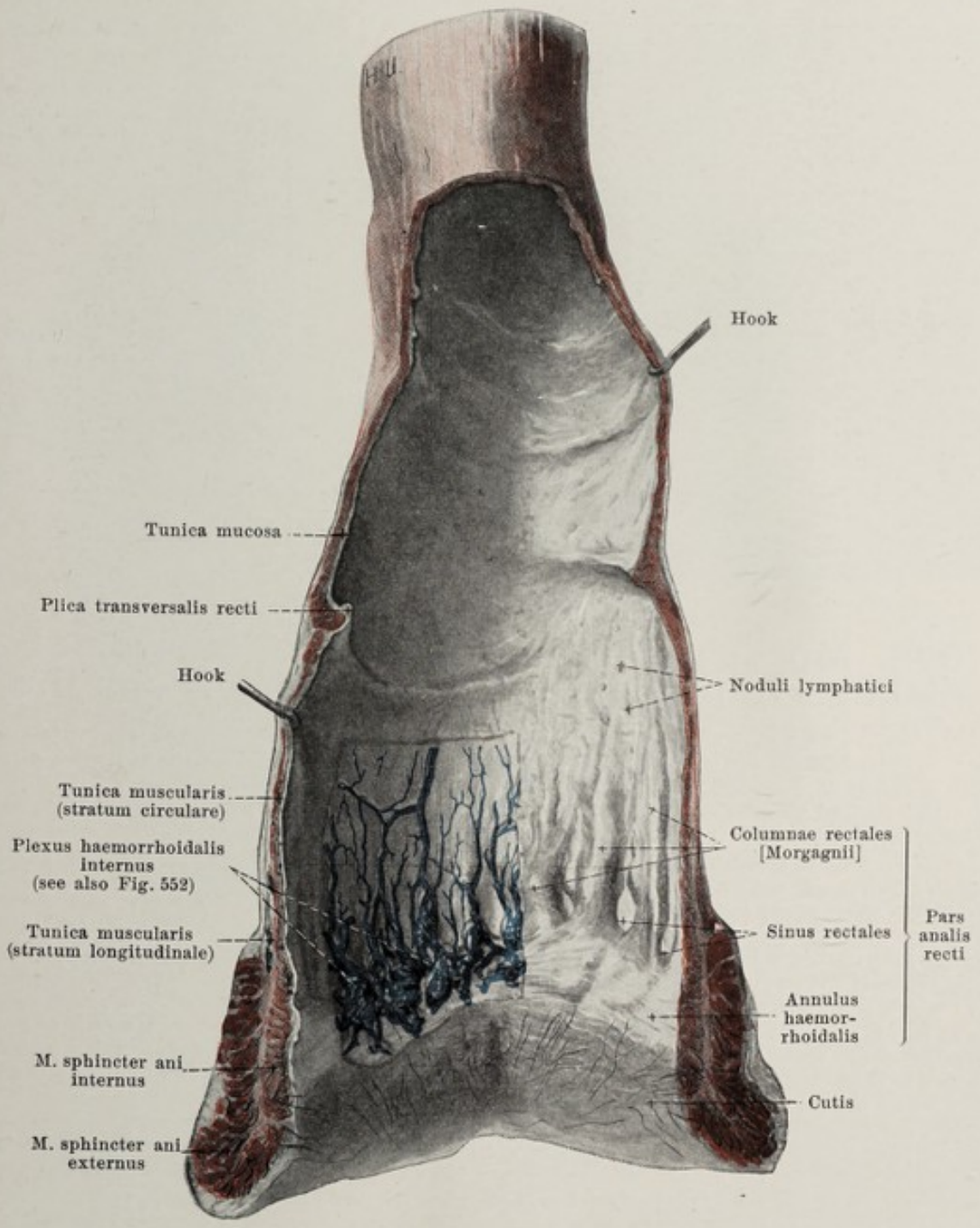


626. Rectum, after removal of the peritonaeum, viewed from in front.

The ***colon sigmoideum*** (O. T. sigmoid flexure of the colon) (see Figs. 642 and 648) forms between the colon descendens and the rectum a movable loop of variable length consisting of two limbs running nearly parallel to one another. This either hangs down into the small pelvis and lies upon the left and posterior wall of the same, or it passes directly upward or obliquely to the right and upward; the latter position is especially frequent in the new born. The colon sigmoideum is usually overlapped by loops of small intestine. At its termination it goes over, in a curve or straight, in front of the 3rd sacral vertebra in the median plane into the rectum. The junction is indistinct and only recognizable by the fact that the haustra which are indistinctly marked but still recognizable in the colon sigmoideum stop altogether, and that, of the three taeniae, the omentalis and the libera unite in order to form the anterior strengthening band of the longitudinal muscle of the rectum while the taenia mesocolica goes over into the posterior band.

Wall of the large or thick intestine.

The *tunica serosa (peritoneal coat)*, after development has been completed, covers only the anterior, lateral and medial walls of the colon ascendens and descendens, the posterior wall being left free to a variable extent. The colon transversum is almost completely covered by it, being free from it only along the taenia mesocolica where the mesocolon transversum is attached, and along the taenia omentalis, where the omentum majus goes off. The colon sigmoideum behaves similarly to a loop of small intestine and there remains only a narrow strip uncovered by peritonaeum where the mesocolon sigmoideum is attached. Along the whole large intestine are found variably developed lobe-like fatty duplicatures of the tunica serosa, *appendices epiploicae;* they are usually situated near the taeniae (see Figs. 647 and 648).



627. Rectum, opened, viewed from in front.

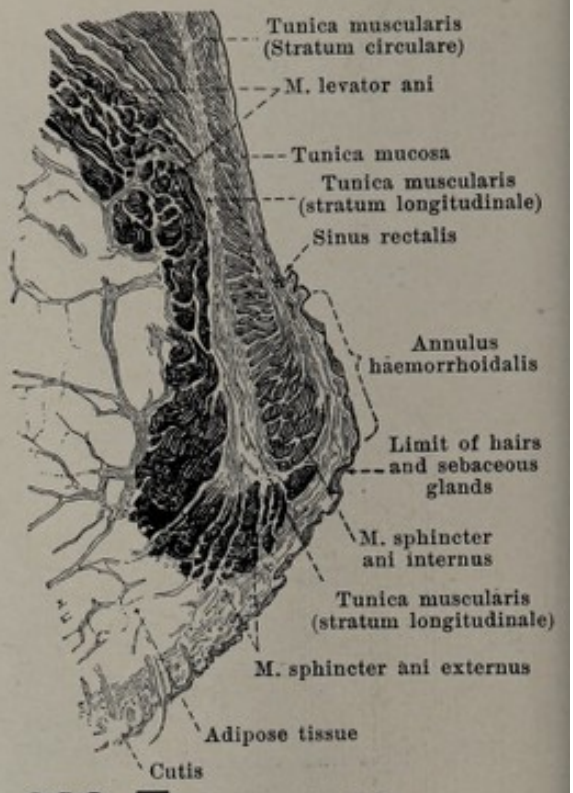
(A strip has been cut out of the anterior wall. The mucous membrane has been partly dissected off.)

Wall of the large or thick intestine (continued):

Tunica muscularis: the *stratum longitudinale* is limited to three strips which are called the *taeniae coli* (see Figs. 622—624, 641 and 642). On the colon ascendens, colon descendens and colon sigmoideum the *taenia libera* is placed anteriorly, the *taenia mesocolica* posteriorly and medianward and the *taenia omentalis* posteriorly and lateralward; on the colon transversum the taenia libera lies below (see Figs. 641 and 646), the taenia mesocolica behind, the taenia omentalis in front and above. The *stratum circulare* is uninterrupted and is somewhat strengthened at the plicae sigmoideae. The thickness of the musculature increases somewhat from above downward.

The *tunica mucosa* is connected with the tunica muscularis by the connective tissue of the *tela submucosa* and is elevated into large sickle-shaped folds, *plicae semilunares coli* (see p. 539). Its finer structure agrees with that of the upper part of the rectum (see p. 547).

628. Mucous membrane of the rectum (upper part), viewed from the surface. Magnification: 12 : 1.

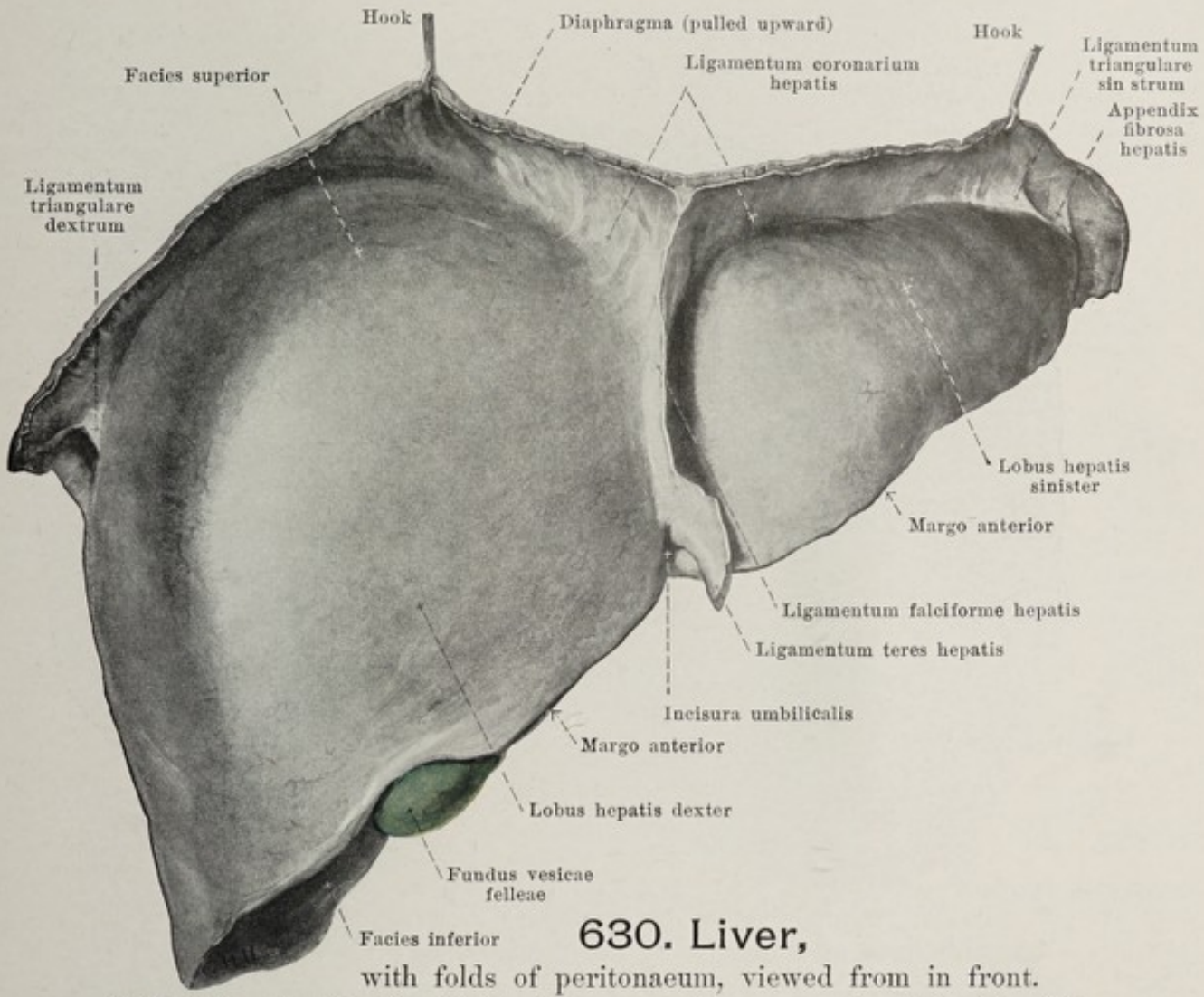


629. Transverse section through the pars analis recti.

Magnification: 2 : 1.

The **rectum** *(intestinum rectum)* (see Figs. 626, 627, 642, 708, 709, 718 and 720) is the terminal portion of the digestive tube which extends from the colon sigmoideum through the inferior wall of the small pelvis to the inferior opening, the *anus*. It is about 16 cm long and runs in the median plane at first downward and backward, and extends forward and downward directly in front of the sacrum and coccyx in a curve which is concave forward and upward, the *flexura sacralis*, as far as the facies posterior of the prostata (in the male, the lower part of the posterior vaginal wall in the female); thence it goes downward and backward in a markedly curved arch convex in front, the *flexura perinealis*. It is covered above in front and laterally by peritonaeum; the lines of reflection of the peritonaeum then gradually turn forward and leave the lateral walls uncovered. From the anterior wall in the region of the right plica transversalis recti (see p. 547), the peritonaeum in the male is reflected upon the bladder at the level of the mouths of the ureters and thus lines a fossa, the *excavatio rectovesicalis* (see p. 615); in the female it turns to the posterior wall of the vagina at the level of the orificium externum uteri and forms the *excavatio rectouterina [cavum Douglasi]* (see p. 623). In this portion of its course the rectum is covered above by loops of small intestine or by the colon sigmoideum; below, its anterior wall lies in the male on the posterior surface of the bladder when the latter is distended, in the female on the uterus. Beneath the site of reflection of the peritonaeum the anterior wall in the male lies against the fundus vesicae, the ductus deferentes and vesiculae seminales as well as the facies posterior prostatae, in the female against the posterior wall of the vagina. The rectum then turns away from these structures backward and downward, and is surrounded a little above the anus by the fibres of the mm. levatores ani and sphincter ani externus. In the frontal direction also it often presents curves, produced by lateral furrows, which correspond to the plicae transversales recti (see p. 547). The middle portion is rarely entirely empty; it is often on the contrary the site of a spindle-shaped distention, the *ampulla recti*. The lowest portion surrounded by the mm. levatores ani and the mm. sphincteres, corresponding to the pars analis recti (see p. 547) is always found empty and contracted, and represents the *canalis analis* the narrow, the slit-like lumen of which lies in the median plane.

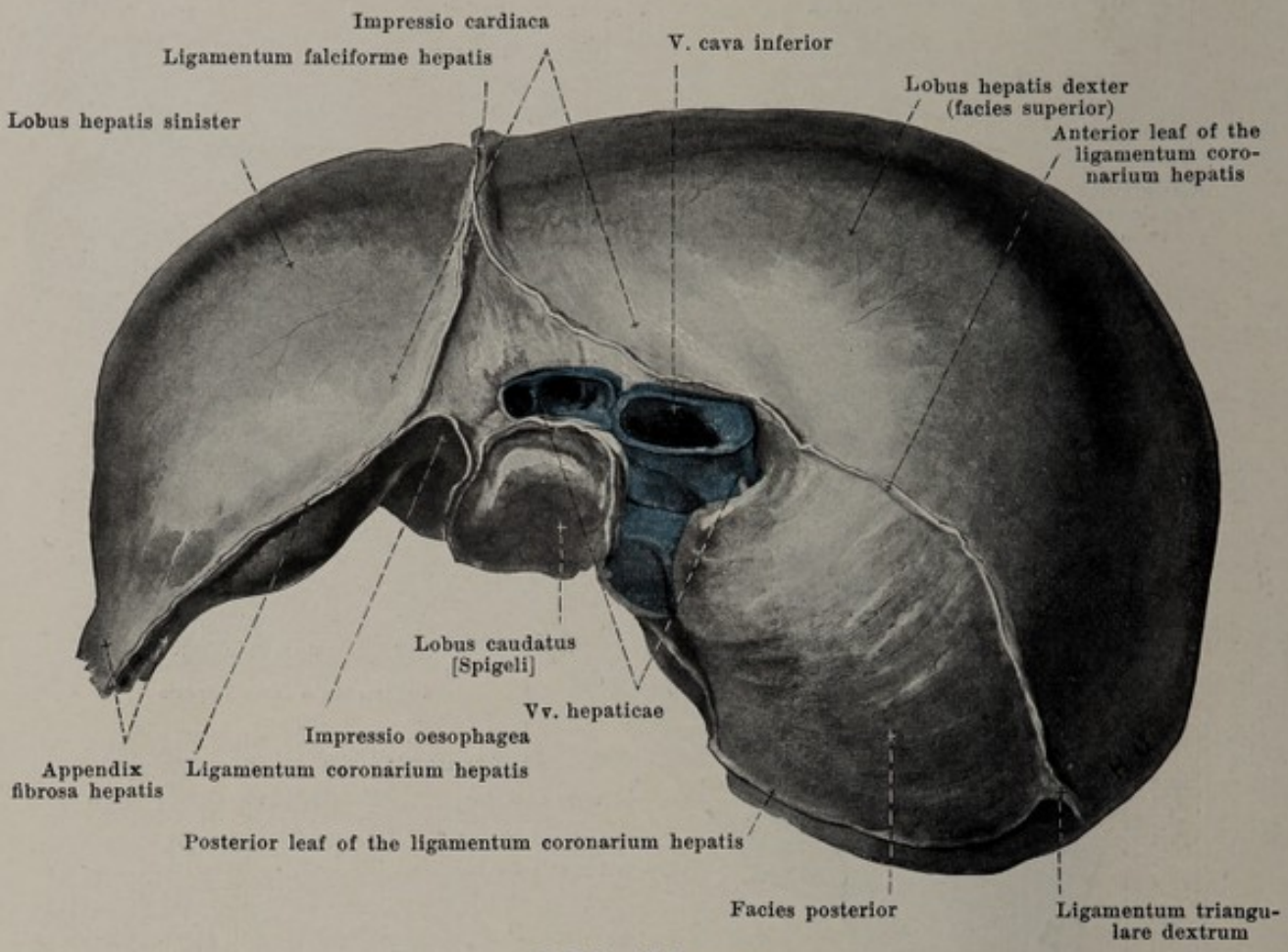
Wall of the rectum. Tunica muscularis (see also Fig. 626). The *stratum longitudinale* covers the whole surface but forms in front and behind a stronger and shorter band of fibres (see p. 544); only in the lower part of the ampulla is the distribution more even. A band of smooth muscle fibres which arise from the lig. sacrococcygeum anterius, *m. rectococcygeus* (see Figs. 723 to 725) is mixed with them on the posterior surface. The longitudinal fibres interweave below with the fibres of the mm. levatores ani and go partly to the skin. The *stratum circulare* is emphasized in the base of each plica transversalis; at the inferior end it is concentrated gradually to form the *m. sphincter ani internus* and reaches as far as the junction with the external skin.



630. Liver,

with folds of peritonaeum, viewed from in front.

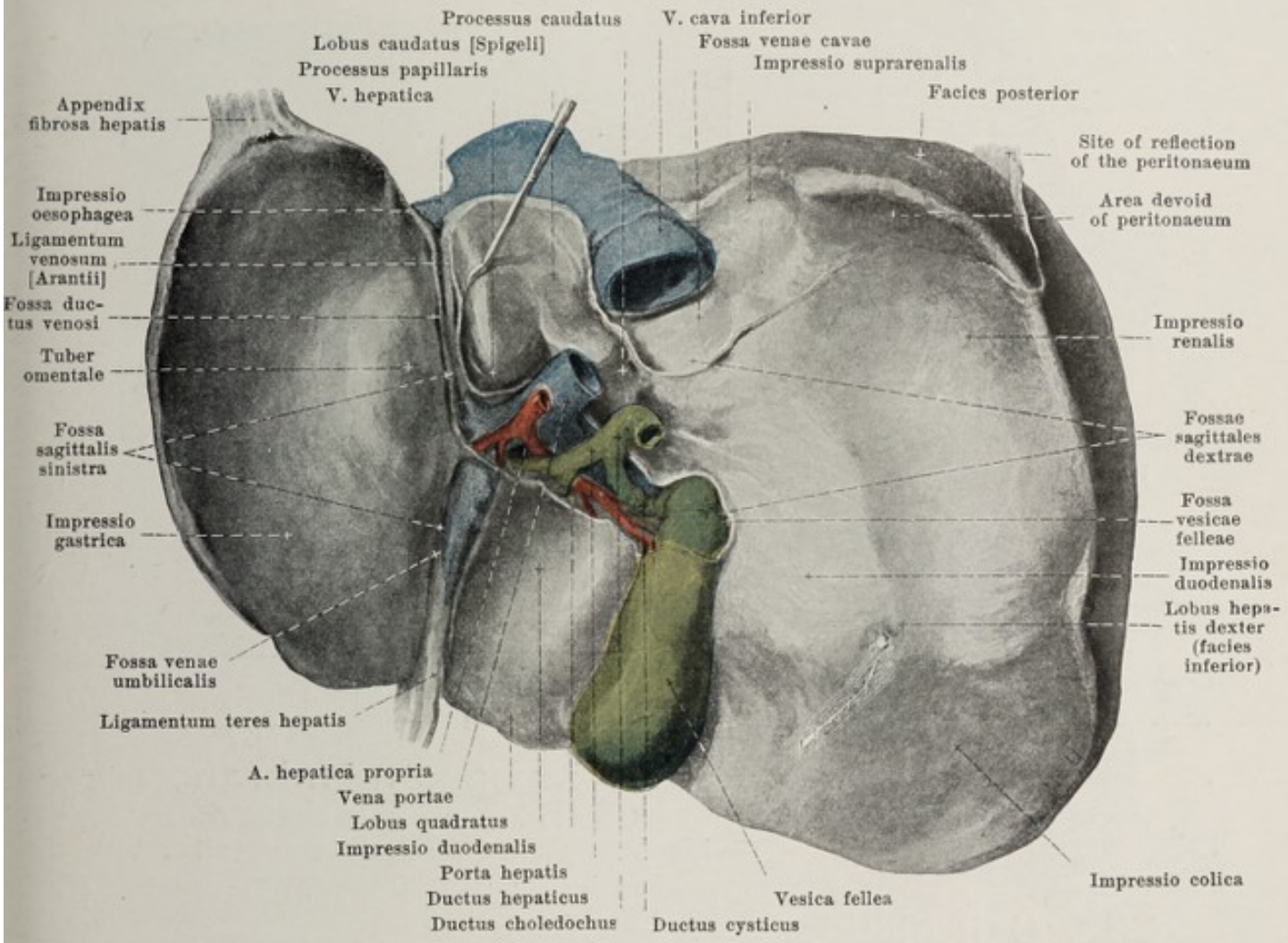
Wall of the rectum (continued). The *tunica mucosa (mucous membrane)* (see Figs. 627 and 628) is separated from the tunica muscularis by the connective tissue of the *tela submucosa.* It forms in the distended rectum in common with this (and a band of the circular muscle layer) usually two sickle-shaped transverse folds, *plicae transversales recti*, which surround more than half the circumference of the tube; of these two folds the lower, larger one, 6—6,5 cm above the anus, lies on the right (see Figs. 709 and 719), the upper one 9—10 cm above the anus on the left; a third is often present on the left below them about 4 cm above the anus. Below the ampulla recti project 5—10 longitudinal folds of the mucous membrane, *colomnae rectales [Morgagnii]*, which contain bundles of longitudinal muscles. They become higher and broader below and each unites with the two neighboring ones by means of arch-like folds which help to bound fossa-like depressions open above, the *sinus rectales.* The next zone, *annulus haemorrhoidalis*, reaches below as far as the line from which on hairs, sebaceous glands and glandulae circumanales appear; it bounds the *anus*, is fairly smooth when distended, but at other times presents a circular ridge due to the bulging of the m. sphincter ani internus and indentations corresponding to radial folds streaming out to the skin (see Fig. 722). At the mucous membrane of the annulus haemorrhoidalis and somewhat above it can often be seen ampulla-like dilatations of the venous plexus haemorrhoidalis internus which may develop into flask-shaped projections, *haemorrhoidal tumors (varices haemorrhoidales).* The region of the columnae rectales, the sinus rectales and the annulus haemorrhoidalis is as whole designated the *pars analis recti.* The mucous membrane in the upper part has the same structure as in the large intestine; it is whitish, contains numerous tube-like *glandulae intestinales [Lieberkuehni]* running perpendicularly to the surface, the openings of which are visible as small holes with the aid of a hand-lens (see Fig. 628) and between them are scattered lymph nodules, *noduli lymphatici*, the domes of which project somewhat above the surface (see Fig. 627). The mucous membrane of the annulus haemorrhoidalis changes somewhat in structure and mediates the gradual transition to the external skin.



631. Liver

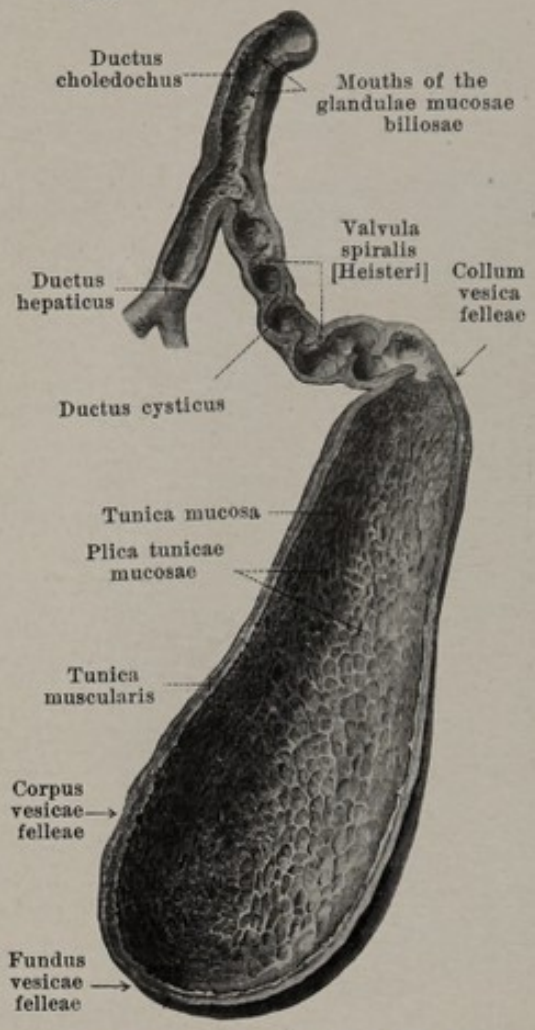
with lines of reflection of the peritonaeum, viewed from above.

The **liver** *(hepar)* (see also Figs. 630 and 632) is a large, reddish-brown gland, almost 2 kilo in weight, approximately wedge-shaped, which is situated for the most part to the right of the median plane in the regio hypochondriaca dextra and in the regio epigastrica, a small part however reaching over into the regio hypochondriaca sinistra. It presents for examination five surfaces, a right, an anterior and a superior which together form the *facies superior*, a posterior, *facies posterior*, and an inferior, *facies inferior*. The facies superior and inferior meet in the sharpened *margo anterior;* on the right side this presents a shallow indentation, in which the fundus of the gall bladder is visible, on the left side a sharper notch, the *incisura umbilicalis*. This notch and a fold of peritonaeum running upward from it on the facies superior separate a larger, right lobe, *lobus hepatis dexter*, from a smaller, left, variable *lobus hepatis sinister*. On the inferior and posterior surfaces, the left lobe is bounded by the correspondingly directed *fossa sagittalis sinistra*, while a medial region is marked off from the right lobe by the *fossae sagittales dextrae*, approximately parallel to it; this medial region is divided by the transversely placed *porta hepatis* into the *lobus quadratus* and the *lobus caudatus [Spigeli]*. The *right surface* is approximately rectangular and everywhere somewhat convex; it goes over gradually into the anterior, superior and posterior surfaces; with the inferior it helps to form the margo anterior. The *anterior surface* is approximately triangular and smooth; it is not sharply limitable from the superior surface and with the inferior surface it forms the margo anterior. The *superior surface*, like the right and (for the most part) the anterior, lies directly against the diaphragm and is curved corresponding to the shape of that structure; it reaches somewhat higher up on the right than on the left and between is slightly depressed *(impressio cardiaca);* it meets the posterior surface in a blunt margin. The *facies posterior* is approximately rectangular-triangular, and is uneven. It is curved so as to be convex on the right side where it is formed by the right lobe of the liver; passing to the left there then follows the superior fossa sagittalis dextra as a flat furrow, *fossa venae cavae*, which is filled up by the v. cava inferior; it helps to bound below the triangular fossa situated to the right, namely the *impressio suprarenalis*, for the glandula suprarenalis dextra.



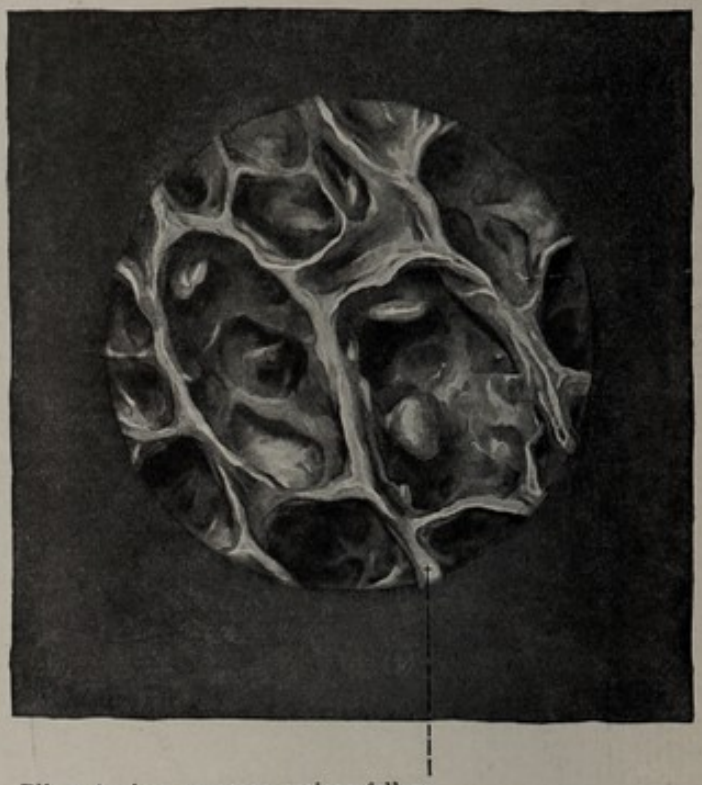
632. Liver with lines of reflection of the peritonaeum, from below and behind.

Liver (continued). To the *facies posterior* belongs farther the quadrangular, oblong lobus caudatus, the long axis of which is placed vertically and lies upon the right crus mediale diaphragmatis. To the left of this follows the upper part of the fossa sagittalis sinistra, the *fossa ductus venosi*, which extends for a variable distance in front of the lobus caudatus and in its depth contains the cord-like *ligamentum venosum [Arantii]*, the obliterated ductus venosus (see p. 491). Near the upper part of this fossa, on the left lobe of the liver, the groove-like *impressio oesophagea* (for the pars abdominalis oesophagi) runs downward and to the left. The *facies inferior* is very irregular and runs obliquely forward, downward and to the right; it is bounded behind on the right at the posterior surface by a blunt margin, on the left at the upper by a sharper margin, the continuation of the margo anterior. The right lobe presents in front a flat depression, *impressio colica*, for the flexura coli dextra and the colon transversum; behind it on the right lies the oblong *impressio renalis* for the right kidney and to the left of it the flatter *impressio duodenalis* for the pars descendens duodeni. Thence, in front of the fossa venae cavae and behind the fossa vesicae felleae, a strip of liver substance, the *processus caudatus*, extends to the left to the inferior margin of the lobus caudatus; to the left of it projects downward a flat process of the latter, the *processus papillaris*. Directly in front of these structures lies the porta hepatis and in front of it the lobus quadratus, which is slightly concave for the pars superior duodeni, *impressio duodenalis*, and the pars pylorica of the stomach. On the right this lobe is bounded by the flat inferior fossa sagittalis dextra, the *fossa vesicae felleae*, which is completely hidden by the gall bladder, on the left by the inferior part of the fossa sagittalis sinistra, the narrow *fossa venae umbilicalis*, in which is situated the cord-like *ligamentum teres hepatis*, the obliterated v. umbilicalis (see p. 491). On the left lobe of the liver near the processus papillaris can be seen a larger projection, the *tuber omentale*, which adjoins the omentum minus; it is surrounded by a deep and broad groove, *impressio gastrica*, in which the stomach comes into contact with the liver.



633. Gall bladder and bile ducts,

cut through.



Plicae tunicae mucosae vesicae felleae

634. Mucous membrane of the gall bladder,

viewed from the surface. Magnific.: 14:1.

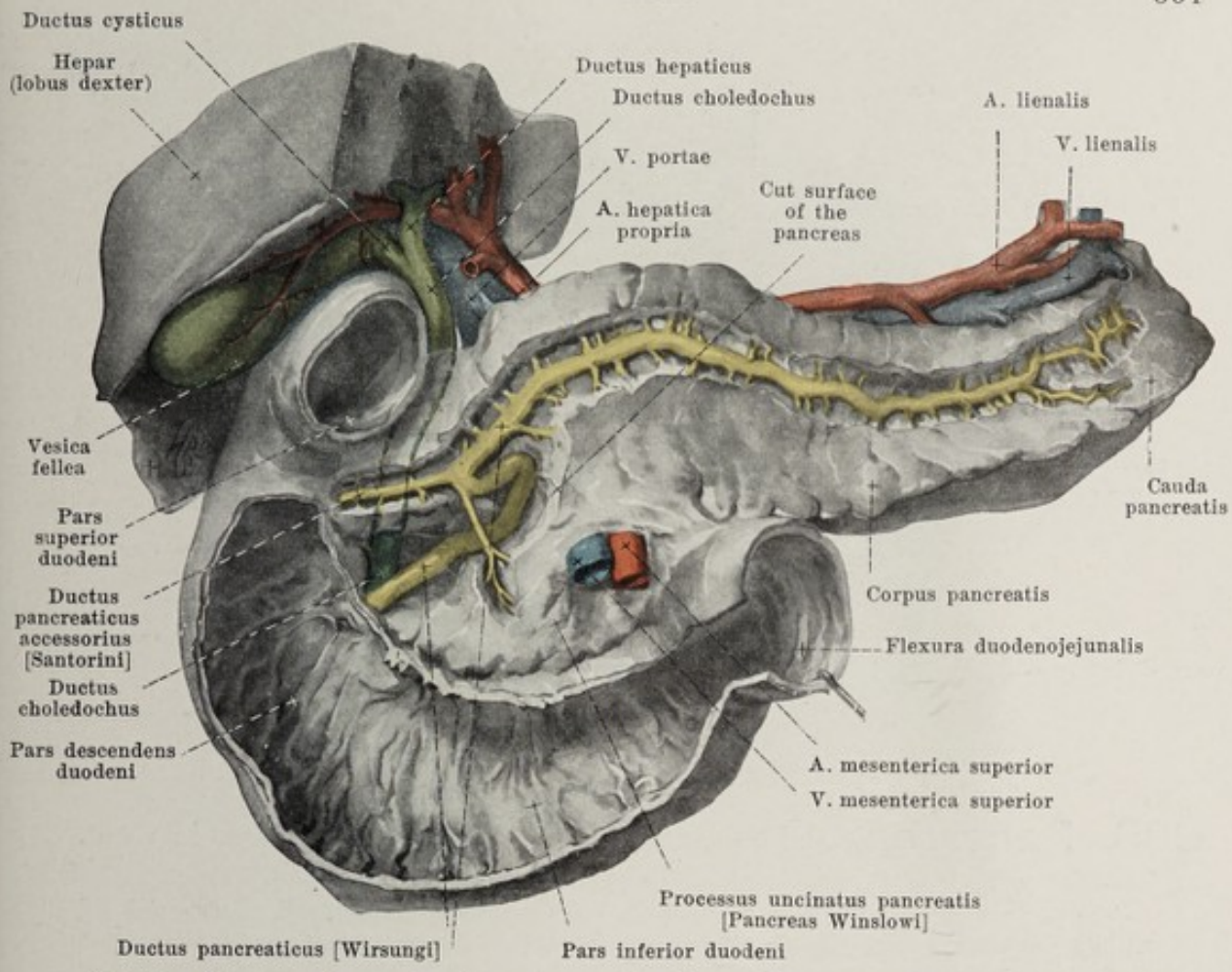
Liver (continued) (see Figs. 630—632). The posterior part of the sharpened edge of the left lobe not infrequently presents a flat appendix of variable size, composed of connective tissue, the *appendix fibrosa hepatis;* it is the remnant of the liver substance present there in the new-born and later still contains parts of the bile ducts, the *vasa aberrantia hepatis* (not illustrated), and blood vessels.

The liver completely fills up the dome of the diaphragm on the right side, only partly on the left, and is in contact with this muscle in the largest part of the facies superior and posterior. It is covered to a large extent by the lower ribs; its anterior surface lies directly in contact with the anterior abdominal wall (see Fig. 642) only in the regio epigastrica above a line which extends between the anterior ends of the right 9^{th} or 10^{th} and the left 8^{th} costal cartilage; the incisura umbilicalis is situated somewhat to the right of the median plane. The facies inferior is in close contact with various abdominal organs all of which leave impressions upon it (see these, p. 549). Beneath the processus caudatus is situated the foramen epiploicum [Winslowi].

The liver is for the most part covered by the *tunica serosa (peritoneal coat).* Only the posterior surface of the right lobe, a triangular field on the upper surface in front of the lobus caudatus, the porta hepatis, the fossae sagittales and two additional narrow strips remain free from it; of the latter one extends from the incisura umbilicalis upward to the triangular area mentioned and is situated at the starting point of the ligamentum falciforme hepatis, while the other runs from the triangular area to the left as far as the appendix fibrosa, and serves as an origin for the left portion of the ligamentum coronarium hepatis and the ligamentum triangulare sinistrum. From the fossa ductus venosi and the porta hepatis the omentum minus goes off.

At the porta hepatis the branches of the v. portae and the a. hepatica enter the liver and the branches of the ductus hepaticus leave it, while the vv. hepaticae leave the liver on the upper surface in the neighborhood of the fossa venae cavae.

A sagittal plane passing through the v. cava inferior and the fundus of the gall bladder divides the liver into two parts of almost equal weight and separates fairly exactly the domains of the right and left branches of the v. portae, of the a. hepatica and of the ductus hepaticus.



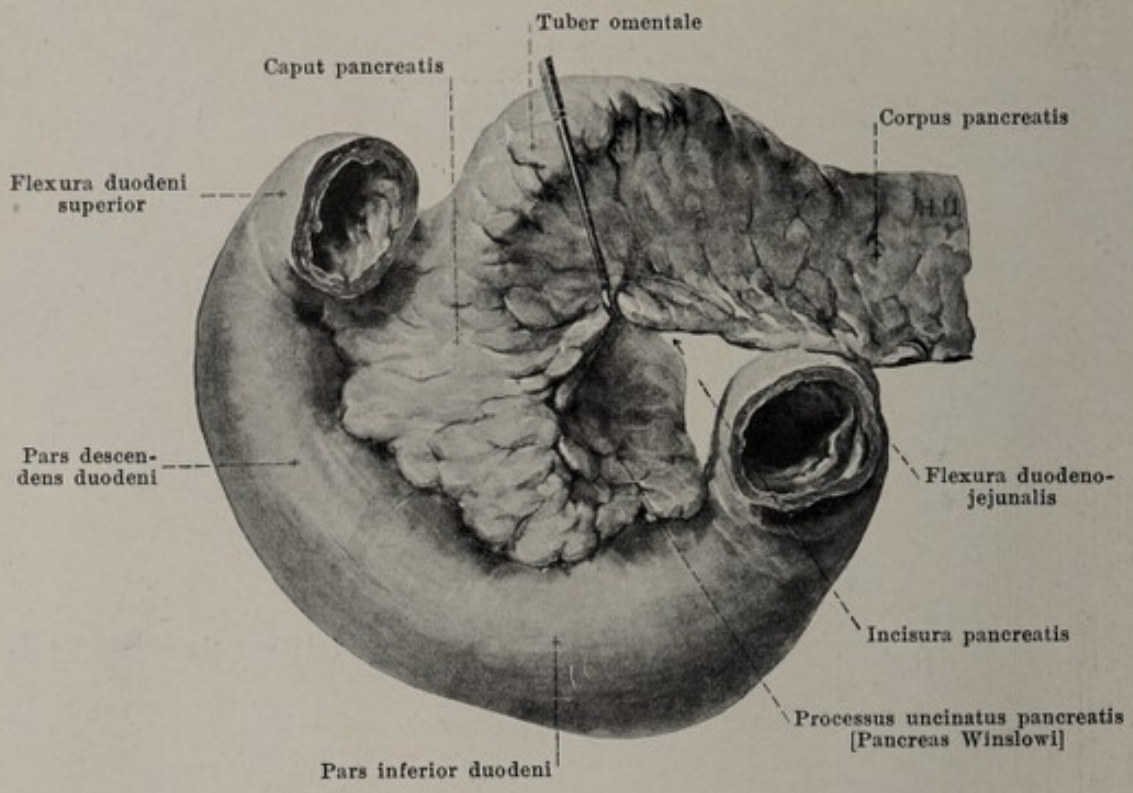
635. Excretory ducts of the liver and pancreas, viewed from in front.

(In the pancreas the ducts have been dissected out; the duodenum has been partly opened; of the liver only the right lobe has been retained and it has been pressed somewhat aside.)

The *ductus hepaticus* (see also Figs. 632 and 633), the excretory duct of the liver, begins in the porta hepatis by the union of a right and a left branch. It runs downward in the ligamentum hepatoduodenale to the right of the a. hepatica propria and in front of the v. portae and soon unites at an acute angle with the ductus cysticus to form the ductus choledochus (vide infra).

The ***gall bladder*** *(vesica fellea)* (see also Figs. 632—634, 642—645) is an oblong, pear-shaped sac, which is fastened by loose connective tissue in the fossa vesicae felleae of the liver. When the bladder is full, its broad, blind and rounded end, *fundus vesicae felleae*, projects somewhat beyond the margo anterior of the liver and comes in contact with the anterior abdominal wall just medianward from the anterior extremity of the 9th costal cartilage of the right side. From the fundus the *corpus vesicae felleae* extends upward, backward and somewhat to the left and narrowing suddenly *(collum vesicae felleae)* goes over at the right side of the porta hepatis into the ductus cysticus. The gall bladder comes into contact below with the colon transversum and behind with the pars descendens duodeni. The fundus and the posterior, inferior surface possess a peritoneal coat, *tunica serosa*. The wall consists of a delicate layer of mostly circular muscle fibres, *tunica muscularis*, and a mucous membrane, *tunica mucosa*, from which project numerous ridges, *plicae tunicae mucosae*, arranged in the form of a network. The *ductus cysticus* leaves the bladder with a marked downward bend, extends downward and to the left and after a short course joins the ductus hepaticus; its mucous membrane presents a series of folds, which are arranged in the form of a spiral *(valvula spiralis [Heisteri])*, and which correspond to grooves on the external surface.

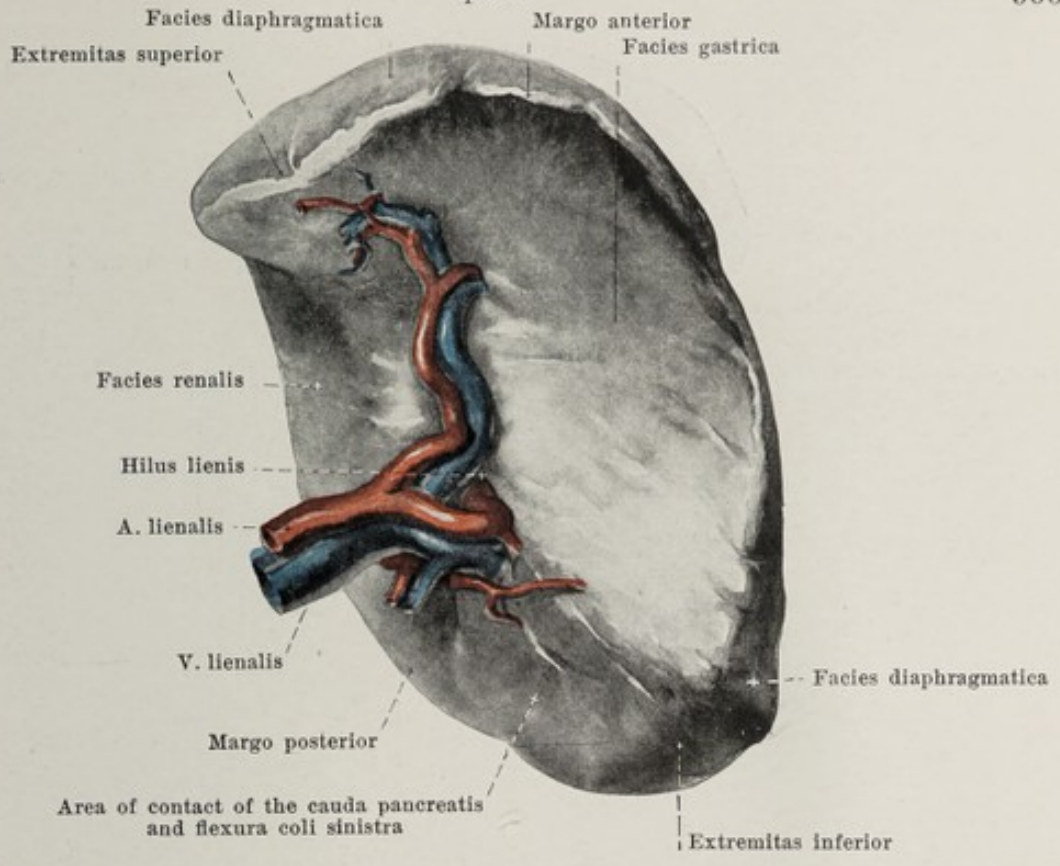
The *ductus choledochus* runs downward, in the direction of the ductus hepaticus, at first in the ligamentum hepatoduodenale to the right of the v. portae, then in the caput pancreatis at the junction of the left and posterior walls of the pars descendens duodeni. It perforates the tunica muscularis of the same, extends downward in the tela submucosa and opens near the ductus pancreaticus or in common with it at the inferior extremity of the plica longitudinalis duodeni.



636. Pancreas, right portion, drawn apart, viewed from in front.

(The peritonaeum has been dissected off.)

The **pancreas** (see also Figs. 614 and 635) is an unpaired, long gland of a grayish-red color which lies transversely in front of the posterior wall of the abdominal cavity. It presents for examination a *caput*, a *corpus* and a *cauda pancreatis*. The *caput pancreatis* fills up the concavity of the pars descendens and pars inferior duodeni and is intimately united with their walls. A notch directed from left to right, *incisura pancreatis*, in which run the a. and v. mesenterica superior, marks off the inferior portion, *processus uncinatus [Winslowi]*; this lies below upon the pars inferior duodeni; above it is shoved up behind the upper portion and is hollowed out in the form of a groove on its anterior surface for the a. and v. mesenterica superior. From its upper part and from the beginning of the corpus a broad, blunt-wedge-shaped mass, the *tuber omentale*, projects forward and upward, its dome covered by peritonaeum coming into contact with the inferior surface of the omentum minus. The anterior surface, *facies anterior*, of the caput, is in contact above with a part of the corpus ventriculi, with the pars pylorica of the stomach and with the pars superior duodeni, below with loops of small intestine; between the two it is crossed by the colon transversum. The posterior surface *(facies posterior)* of the caput is curved so as to be concave from right to left and is in close contact in front of the 1st and 2nd lumbar vertebra with the pars lumbalis diaphragmatis, the aorta abdominalis and the v. cava inferior; above it is in contact with the a. coeliaca, a. and v. mesenterica superior and the beginning of the v. portae as well as the vena lienalis and the v. renalis sinistra, on the right with the ductus choledochus. The *corpus pancreatis (body of the pancreas)* is curved from right to left so as to be somewhat convex behind and has an approximately triangular prismatic shape. Its *facies anterior* is directed forward and upward and curved so as to be concave, corresponding to the bulging curvature of the paries posterior ventriculi, which is in contact with it. The *facies inferior* is narrower and curved slightly in the form of the letter S. It rests to the right upon the flexura duodenojejunalis, to the left upon the end of the colon transversum; between lie upon it the loops of the upper part of the small intestine. With the anterior surface it forms a sharp margin, *margo anterior*, directed toward the root of the mesocolon transversum. The *facies posterior* is in direct contact with the v. lienalis and the v. renalis sinistra, the left suprarenal and kidney and presents a flat depression corresponding to these organs, as well as a groove for the left renal vessels and the v. mesenterica inferior. With the inferior surface it forms the blunter *margo posterior*, with the anterior surface the sharper *margo superior*, which is concave upward. The *cauda pancreatis (tail of the pancreas)* is the blunt end directed to the left and upward; its narrow inferior surface lies upon the flexura coli sinistra and its posterior surface comes into contact with the lower part of the spleen.

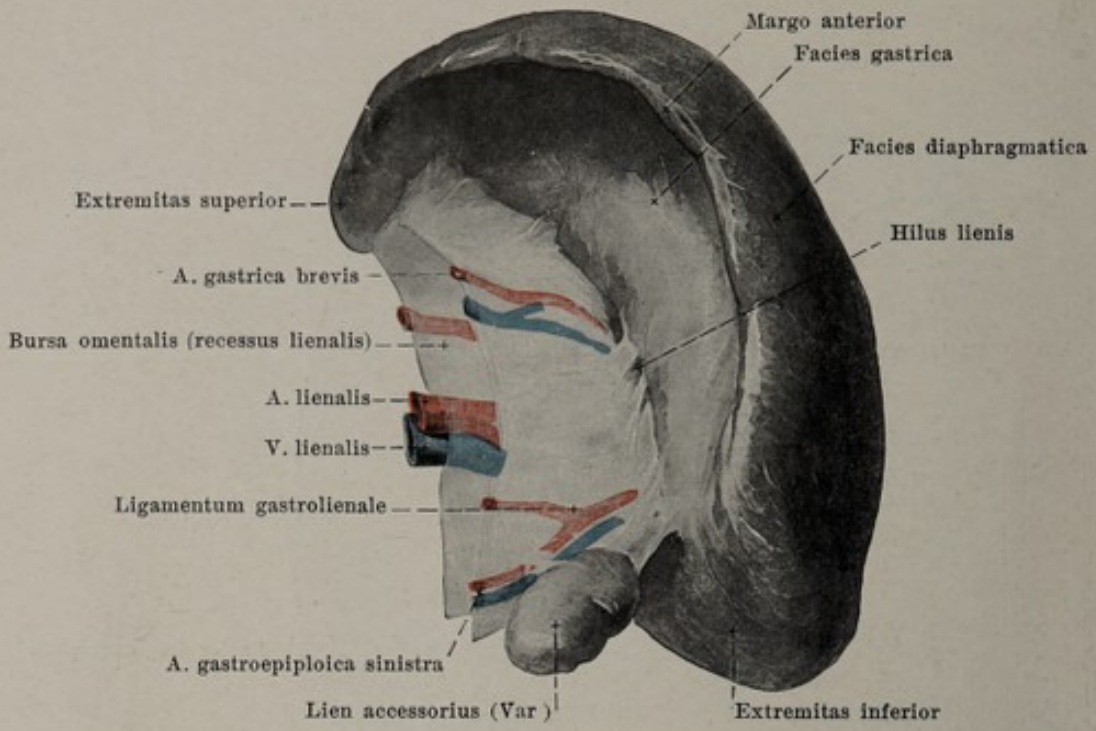


637. Spleen, viewed from in front and somewhat from the right. (The peritonaeum has been dissected off at the hilus lienis.)

Pancreas (continued): The anterior and inferior surfaces are covered by peritonaeum (see Fig. 614). The posterior surface is free from it (see also p. 567); in addition, transversely in front of the caput and along the margo anterior, is a narrow strip which remains uncovered by peritonaeum and to which is turned the root of the mesocolon transversum. The portion lying above this strip belongs to the bursa omentalis. On the portion situated below this strip there is also free from peritonaeum the area, in which the a. and v. mesenterica superior extend to the root of the mesentery.

The *duct (ductus pancreaticus [Wirsungi])* (see Fig. 635) begins as a delicate duct in the cauda, extends within the substance of the gland to the right to the caput and gradually enlarges as it receives numerous narrow branches. In the caput it is markedly tortuous and runs to the right and somewhat downward; near its lower end it lies close to the ductus choledochus and opens at the inferior extremity of the plica longitudinalis duodeni (see also Fig. 615) either after previous union with the former or separately from it. In the upper part of the caput, in front of the ductus choledochus, very often runs in a transversal direction a small duct *(ductus pancreaticus accessorius [Santorini])*, which opens as well in the main duct as in the duodenum (upon the papilla duodeni [Santorini] see also Fig. 615), and which generally a little decreases in its diameter from the left to the right; sometimes the opening in the duodenum is absent; sometimes the upper duct is the larger of the two or opens in common with the ductus choledochus.

The **spleen** *(lien)* (see also Fig. 638) is an unpaired, soft, oblong organ, very variable in size, of a dark bluish-red color. Its largest surface, *facies diaphragmatica*, directed to the left, backward and upward, is smooth and convex. It is separated by a blunt margin, *margo posterior*, from the narrow, flat or slightly concave *facies renalis*, which is directed medianward and downward. The sharper, repeatedly indented *margo anterior* separates the facies diaphragmatica from the markedly concave *facies gastrica*, which looks forward and to the right. Upon this, near the medial margin and parallel with it, lies a series of depressions or a slit, the *hilus lienis*, in which enter or leave the vessels and nerves. The upper pole of the spleen, *extremitas superior*, is curved medianward; the lower pole, *extremitas inferior*, is directed to the left and downward. The medial surface of the latter goes over usually into an approximately triangular area, well marked off from the facies renalis and gastrica; this area serves above (in the immediate neighborhood of the hilus) for contact with the cauda pancreatis and below for contact with the flexura coli sinistra.



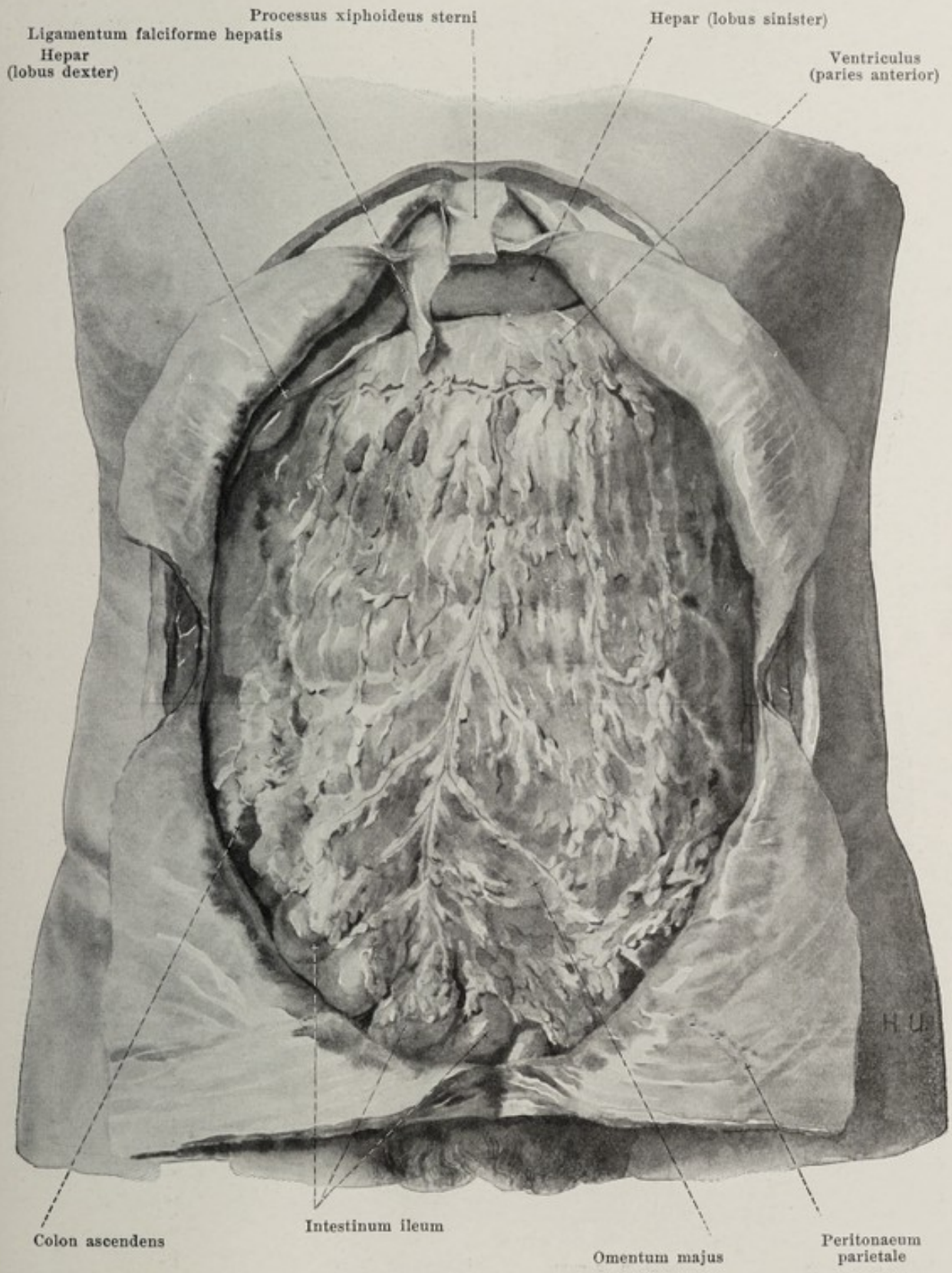
638. Spleen with peritonaeum,

viewed from in front and somewhat from the right.

Spleen (continued): *Position* (see Figs. 643 and 644). It lies in the posterior part of the left regio hypochondriaca so inserted between the posterior circumference of the stomach, left kidney and diaphragm that it is not visible from in front. Its facies diaphragmatica is so closely in contact with the concave surface of the diaphragm that it corresponds approximately to the space between the 9th and 11th rib on the left side, and that its long diameter runs approximately parallel to the 10th rib; it is separated from the ribs not only by the peritonaeum and diaphragma but partly also by the pleural cavity and the lung. The extremitas superior reaches close to the left side of the body of the 10th or 11th thoracic vertebra. The facies renalis is in contact with the margo superior of the left suprarenal gland and with the upper anterior part of the margo lateralis of the left kidney. The facies gastrica is bounded in front and to the right by the fundus and corpus ventriculi; the triangular area beneath it lies in contact with the cauda pancreatis and the flexura coli sinistra. Near the latter is situated also the extremitas inferior; it rests in a pocket *(saccus lienalis, spleen bed)* which is bounded in front by the *ligamentum phrenicocolicum* (O. T. sustentaculum lienis) (see Fig. 644). This stretches out membrane-like from the flexura coli sinistra to the region of the origin of the diaphragm from the 10th or 11th rib and presents a free margin directed upward; originally it is connected with the great omentum.

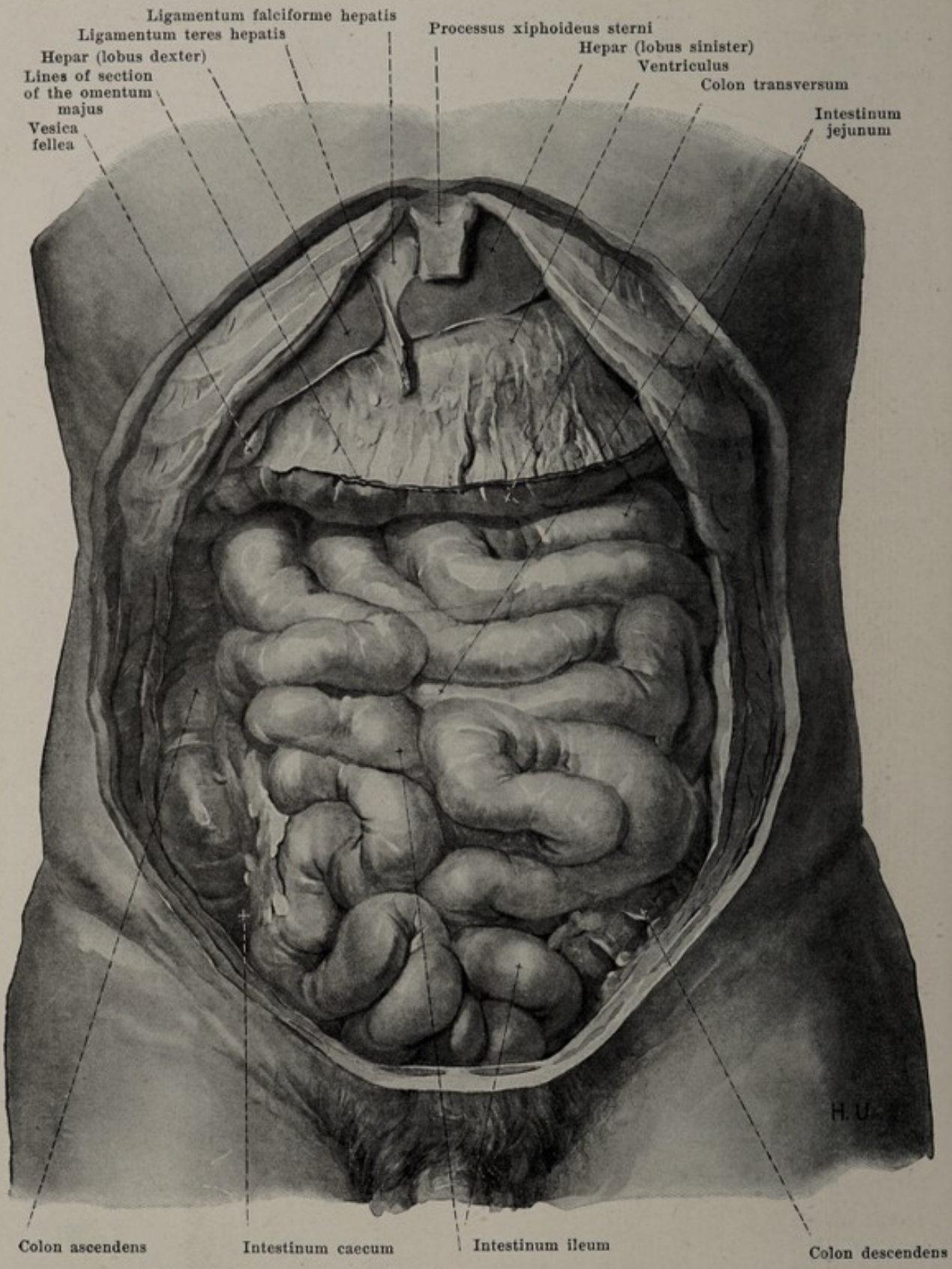
The spleen possesses a complete covering of peritonaeum *(tunica serosa)*, only the hilus being free from it. Starting from the hilus the peritonaeum extends in front as the *ligamentum gastrolienale* to the anterior layer of the great omentum and to the curvatura ventriculi major. Behind starting from the hilus the peritonaeum goes to the kidney and the inferior surface of the diaphragm as the *ligamentum phrenicolienale*.

In the ligamentum gastrolienale, in the omentum majus or in the pancreas a rounded or a long *accessory spleen, lien accessorius*, of variable size is occasionally to be found; there may be two or even many of these.



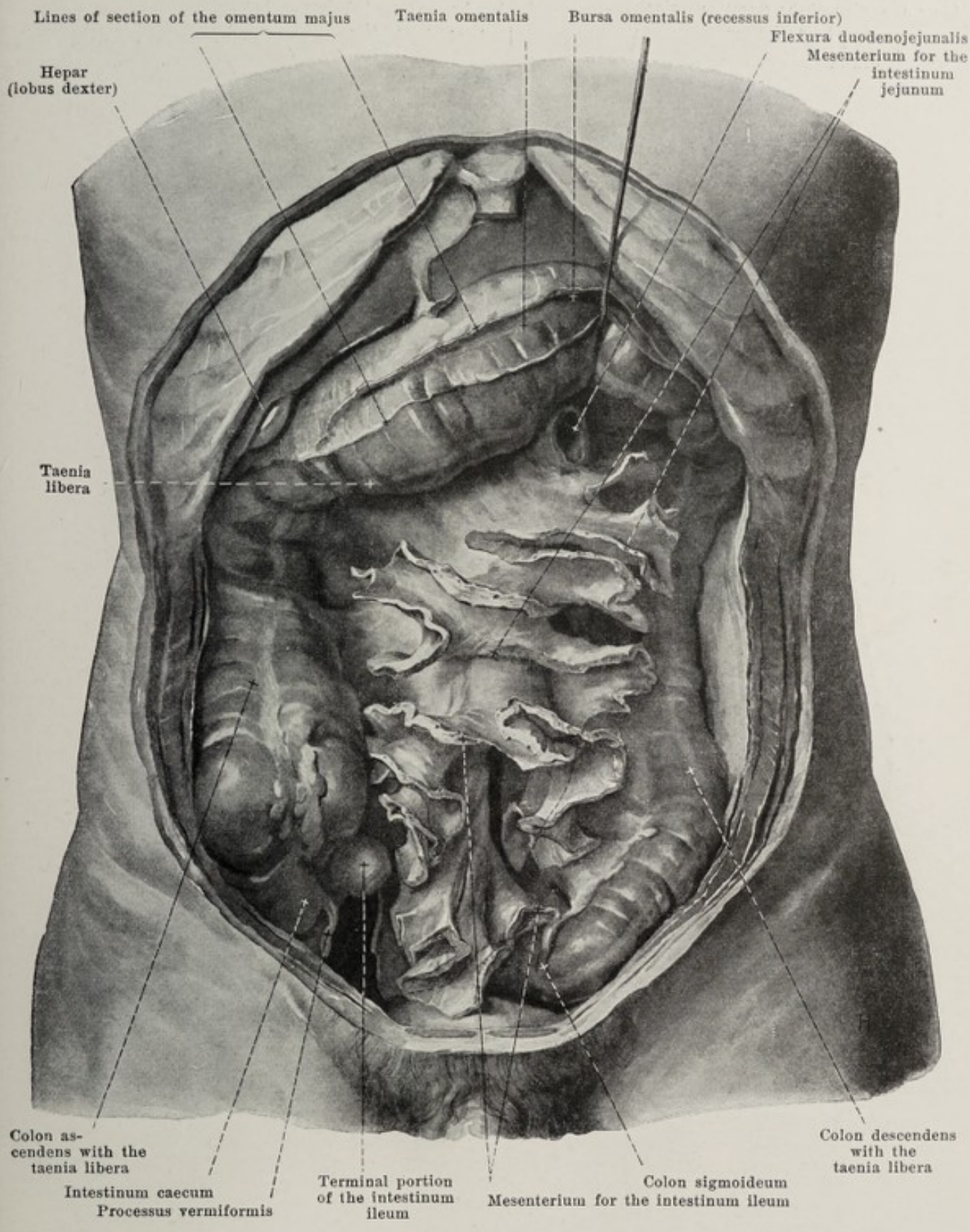
639. Abdominal viscera, viewed from in front.

(Figs. 639—642 are drawn from the same dissection. The skin and muscles of the anterior abdominal wall have been removed; their peritoneal covering has been cut through and reflected backward.)



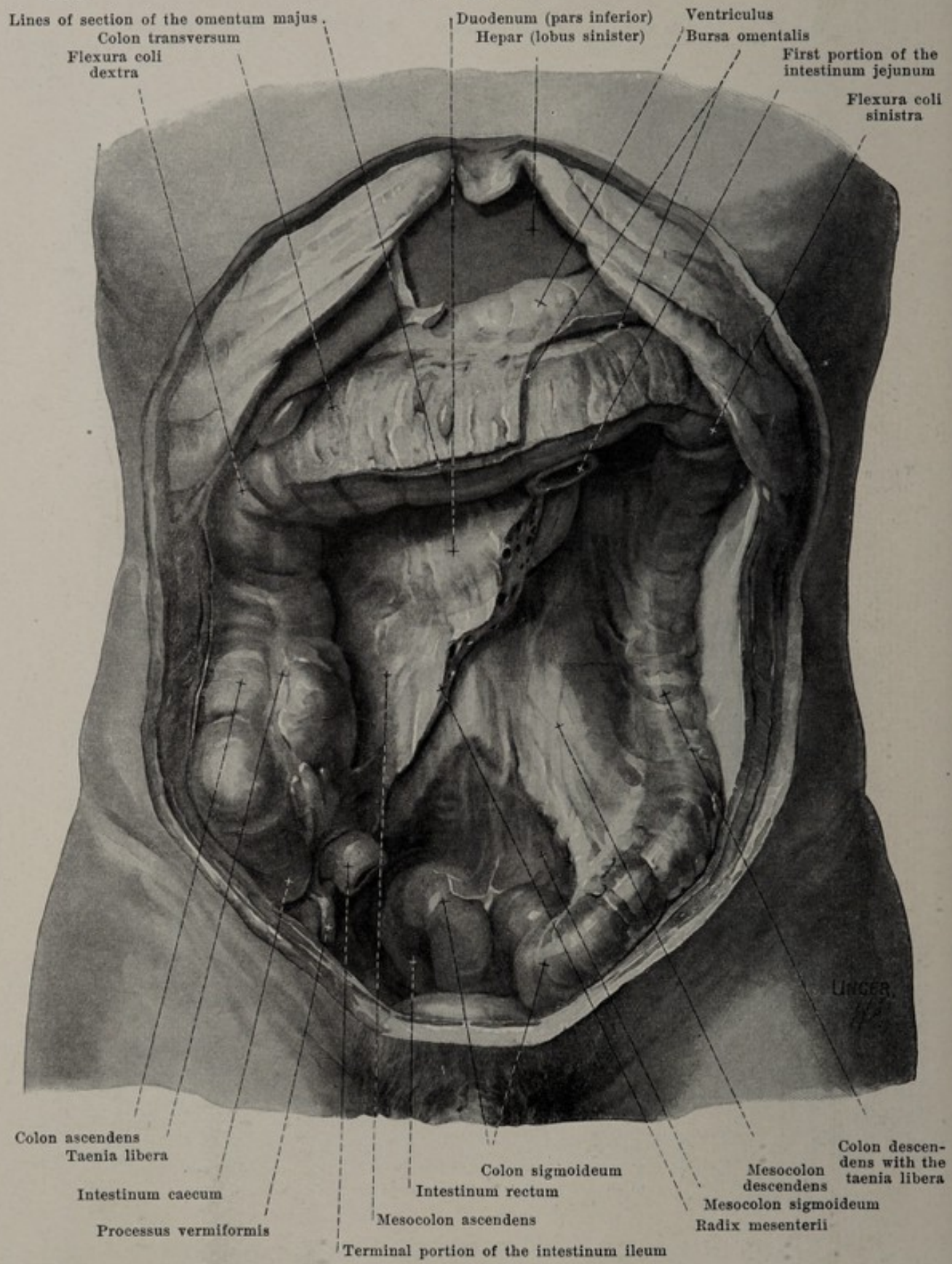
640. Small intestines, viewed from in front.

(Figs. 639—642 have been drawn from the same dissection. The anterior abdominal wall and the great omentum have been removed. In Figs. 640 and 641 the crosses have been placed upon the portions of the small intestine and of the margin of the mesentery which belong to one another. The course of the loops of the intestine is visible in Fig. 641.)



641. Convolutions of the mesentery, viewed from in front.

(Figs. 639—642 have been drawn from the same dissection. The colon transversum has been drawn upward. The small intestine has been cut off close to its mesentery and the course of the invisible parts of the free margin of the mesentery indicated by dotted lines. For further explanation see Fig. 640.)



642. Large intestine and root of the mesentery,

viewed from in front.

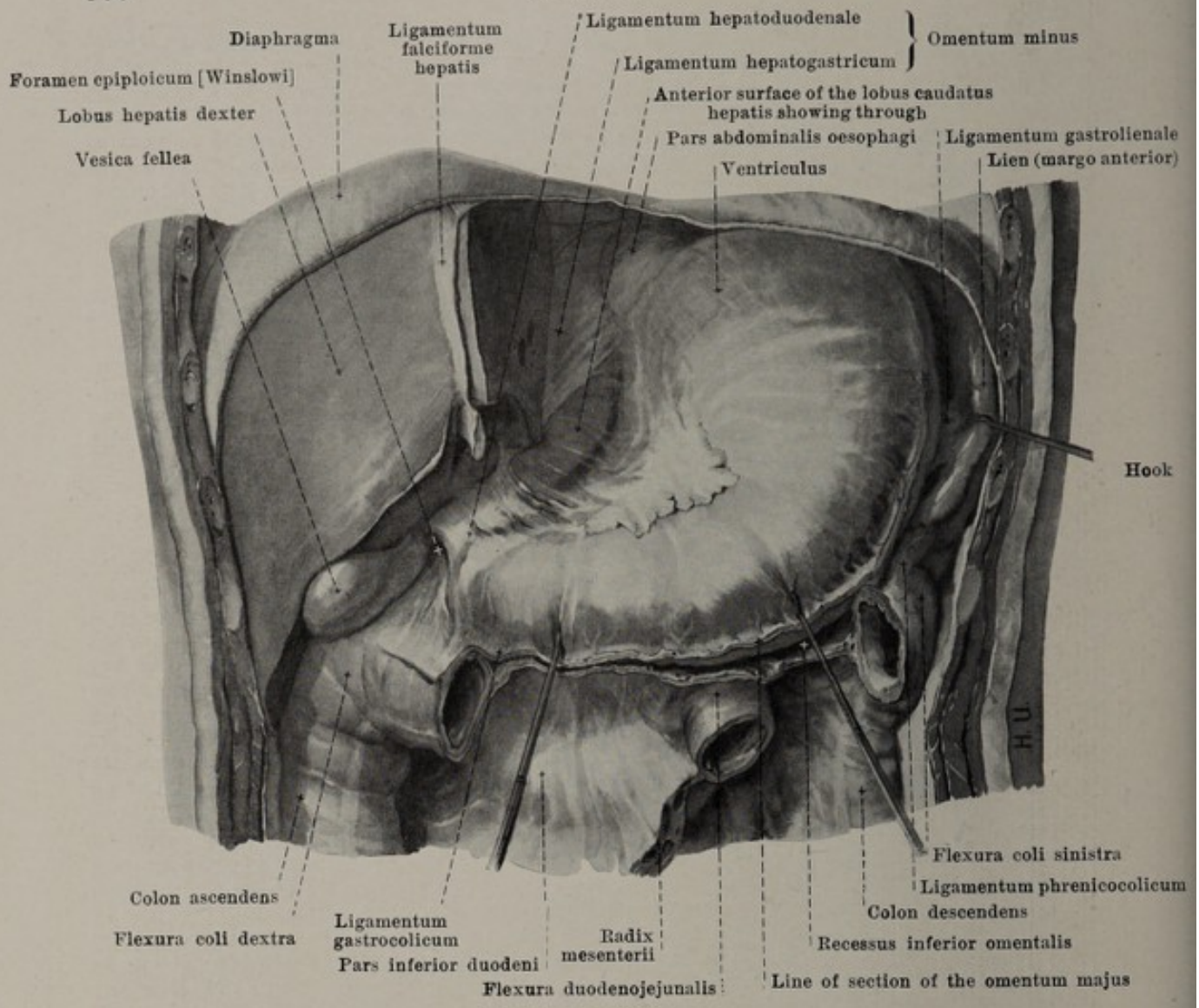
(Figs. 639—642 have been drawn from the same dissection. The mesentery of the small intestine has been cut away at its root.)

The **peritonaeum** (see Fig. 649) is the smooth glistening serous membrane, *tunica serosa*, which covers in varying degrees of completeness the walls and viscera of the abdominal and pelvic cavities; it is fastened to the tissue beneath it by a thin layer of loose connective tissue, *tela subserosa*. That part of it which covers the walls of these cavities and the large vascular and nerve trunks attached to them as well as some parts of the urinary and sexual apparatus is called the *peritonaeum parietale*. That part of it which is firmly attached to the surface of the more freely movable portions of the digestive tube, the pancreas, liver and spleen, as well as to other parts of the urinary and sexual apparatus is called the *peritonaeum viscerale;* under the latter term are also grouped the coverings of the membranes which stretch out between the abdominal wall and individual viscera or stretched out in the embryo, passing free through the abdominal cavity, and in which the vessels and nerves belonging to these viscera run. The parietal and visceral peritonaeum go directly over into one another at their margins and can therefore be grouped together as a great sac, which in the male is completely closed and in the female presents an opening only at the ostium abdominale tubae uterinae on each side. The free surface of the peritonaeum surrounds a cavity, the *peritoneal cavity (cavum peritonaei)*, which is really only a capillary slit, since the viscera lie closely pressed upon one another and upon the walls of the cavity; it contains a very small amount of clear, serous fluid which moistens the surface so that the parts glide easily upon one another. The peritonaeum parietale is in general somewhat thicker than the peritonaeum viscerale and is attached rather loosely by means of the fascia transversalis to the mm. recti abdominis, the posterior layer of the vagina m. recti and to the m. transversus abdominis, more firmly to the diaphragm.

Course of the peritonaeum. From the posterior surface of the upper part of the anterior abdominal wall and from the diaphragm a fold of peritonaeum, *ligamentum falciforme hepatis* (see Figs. 630, 631, 639 and 640), runs off approximately in the median plane; it begins as a low fold at the umbilicus and gradually increasing in height extends backward and somewhat to the right to the incisura umbilicalis and to the facies superior of the liver; between the umbilicus and the incisura umbilicalis it presents a free margin, in which runs the ligamentum teres hepatis. At the impressio cardiaca of the liver the two layers of the fold diverge from one another and go over into the anterior layer of the *ligamentum coronarium hepatis* (see Figs. 630 and 631), which extends from the inferior surface of the diaphragm approximately in a frontal plane to the upper surface of the liver. On the left side this fold consists of an anterior and a posterior plate of peritonaeum which are in contact with one another; it runs as far as the appendix fibrosa hepatis and there ends in a sharp concave margin, the *ligamentum triangulare sinistrum*. On the right, the fold is formed of two plates which are in contact with one another only at its right free end, the *ligamentum triangulare dextrum;* elsewhere the posterior plate is considerably separated from the anterior, leaves the posterior surface of the right lobe of the liver uncovered and follows a course partly upon the posterior surface of the diaphragm, partly upon the anterior surface of the right kidney and suprarenal, to run in front of the same as far as the flexura coli dextra. Between the inferior surface of the liver and the kidney a special fold, the *ligamentum hepatorenale* (see Fig. 645), is often stretched out.

The peritonaeum covers the superior and inferior surfaces of the liver and extends (see Figs. 643 and 644) from the fossa ductus venosi and from the porta hepatis to the inferior surface of the diaphragm, to the right side of the pars abdominalis of the oesophagus, to the curvatura ventriculi minor and to the upper surface of the pars superior duodeni in a duplicature as the ***lesser omentum,*** *omentum minus*, and then covers these organs. The omentum minus is a membrane of variable strength, the anterior layer of which is going to the anterior surfaces of the organs named, the posterior layer belonging to the bursa omentalis (see p. 561); the portion going to the oesophagus and stomach is called the *ligamentum hepatogastricum:* in its upper sickle-shaped portion, which goes to the oesophagus and cardia, it is striped and stout, in its lower part attached to the curvatura minor it is very thin and loose. To the latter on the right side without sharp limit is attached the portion of the omentum minus, which extends from the porta hepatis to the duodenum, *ligamentum hepatoduodenale;* this is thick, ends on the right in a free, slightly concave margin (see also Fig. 645) and contains within it the a. hepatica propria (to the left and in front), the v. portae (in the middle and behind) and the ductus choledochus (to the right and in front) (see Figs. 548 and 635), as well as the plexus hepaticus s. sympathici and lymph vessels. From the anterior surface of this ligament there often arises a fold which runs from the posterior surface of the gall bladder either only as far as the pars descendens duodeni or even *(ligamentum hepatocolicum*, see Fig. 645), to the colon transversum. From the region where the free margin of the lig. hepatoduodenale ends below, a smaller fold, *ligamentum duodenorenale* (see Fig. 645), often extends to the anterior surface of the right kindney.

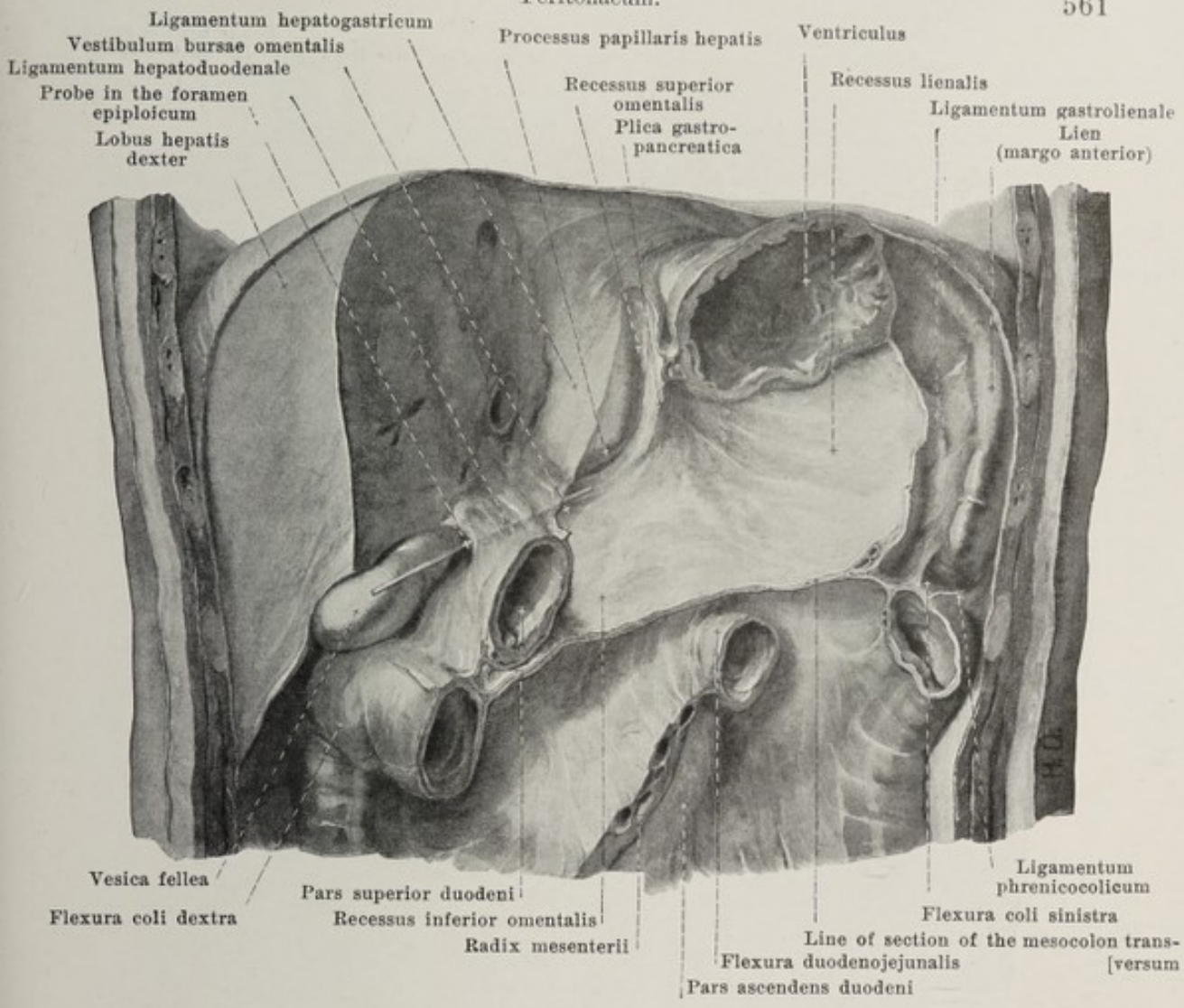
The peritonaeum covers the anterior superior surface of the stomach and on the left side at the curvatura major goes backward as the broad *ligamentum gastrolienale* (see Fig. 643) to the facies gastrica of the spleen, covers the spleen and passes from its facies renalis as the *ligamentum phrenicolienale* (not illustrated) around to the left kidney and the diaphragm.



643. Lesser omentum *(omentum minus)*, viewed from in front.

(The left lobe of the liver has been completely removed, the colon transversum in largest part; the stomach has been drawn somewhat downward, the spleen somewhat to the left.)

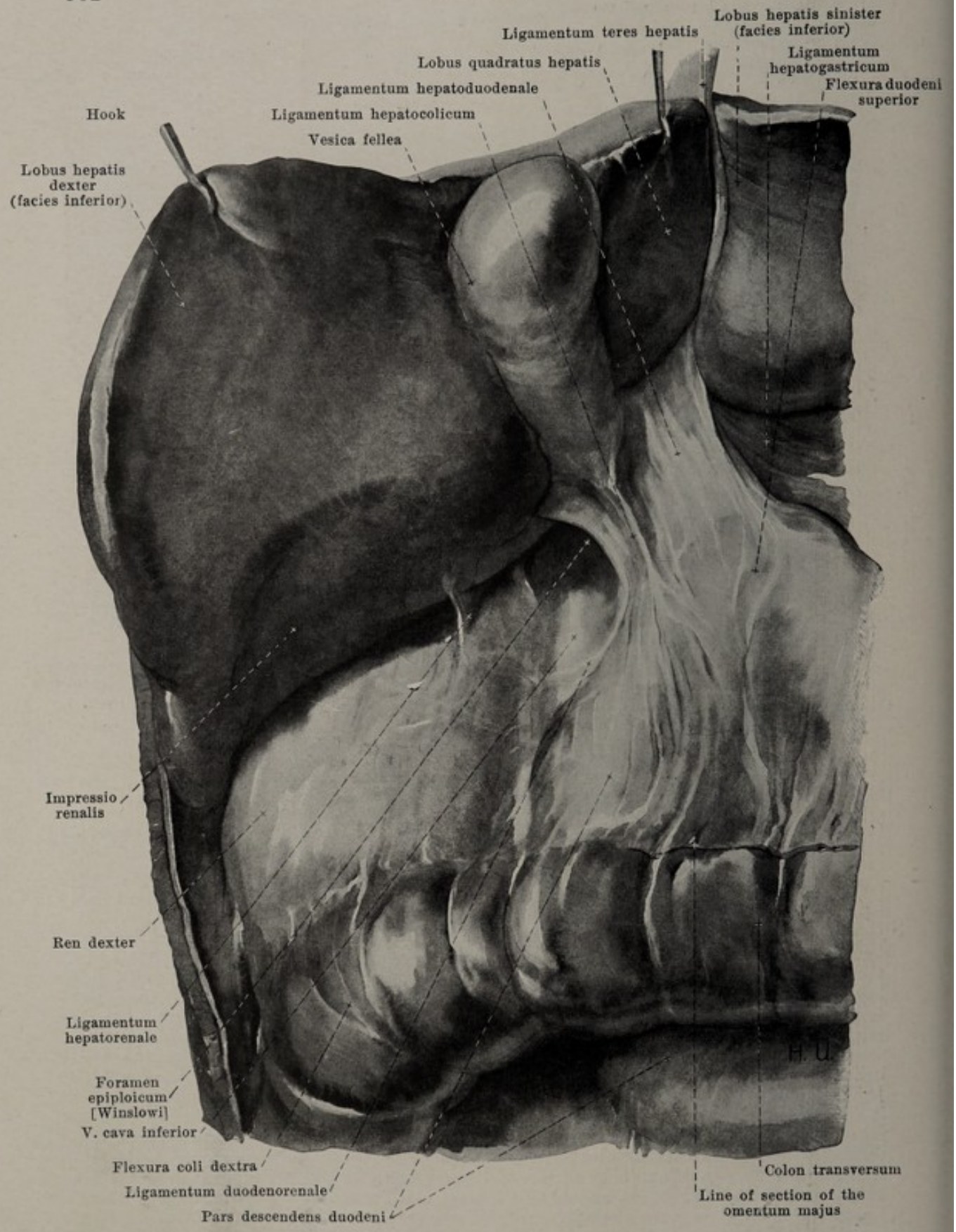
Course of the peritonaeum (continued). Hanging downward from the curvatura major of the stomach like an apron in front of the colon transversum and in front of the small intestine for a variable distance and ending below in a jagged margin is the great omentum, ***omentum majus.*** (see Fig. 639). This broad peritoneal appendage is for the most part thin and transparent, but often contains large accumulations of fat along the vessels. In youth it consists of four layers (see also Fig. 649) of which the two anterior and two posterior ones are grown together; the two anterior proceed at the curvatura ventriculi major directly from the tunica serosa of the paries anterior et posterior ventriculi; the two posterior are continued at the taenia omentalis of the colon transversum into the tunica serosa of the colon transversum and into the mesocolon transversum; at the free margin the two outer layers and the two inner layers go directly over into one another. In the embryonal period (see Fig. 649) the two posterior layers extend above the colon transversum as far as the posterior abdominal wall; later however the mesocolon transversum and its intestine come into contact from below with this portion of the primary great omentum and fuse with it. The recessus inferior omentalis(see p.561) extends originally into the great omentum as far as its free margin, but vanishes in youth or later often more or less completely owing to a fusion of the two middle layers of peritonaeum bounding this space. When this fusion has advanced as far as the colon transversum (which happens earlier on the right side than on the left), the two anterior layers of the great omentum extend from the curvatura ventriculi major wholly or partly directly to the colon transversum and form a ligamentum *gastrocolicum;* from there the omentum majus is hanging down as an uniform plate. On the left side the two anterior layers go over directly into the *ligamentum gastrolienale* (see p. 559) and are connected with the *ligamentum phrenicocolicum* (see p. 554).



644. Bursa omentalis, opened, viewed from in front.

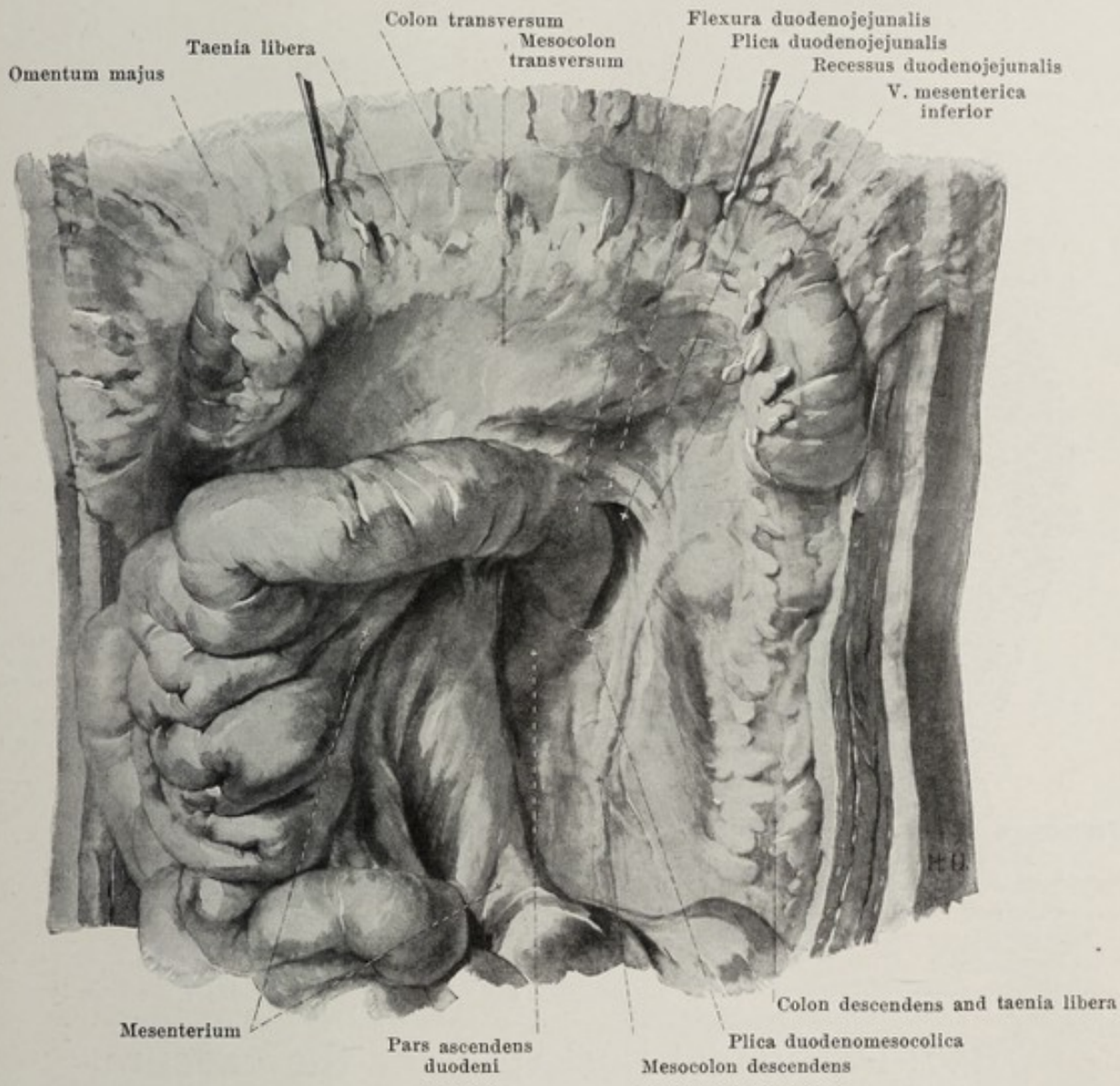
(From the dissection illustrated in Fig. 643 a piece of the right lobe of the liver has been removed and also the stomach in its largest part; the mesocolon transversum has been cut off shorter.)

Course of the peritonaeum (continued). The ***omental bursa***, *bursa omentalis* (O. T. lesser peritoneal cavity) (see also Fig. 649) is a slit-like cavity surrounded on all sides by peritonaeum, which is connected with the general cavum peritonaei at one spot only. This opening, *foramen epiploicum [Winslowi]* (see also Figs. 643 and 645), is bounded in front by the ligamentum hepatoduodenale, above by the processus caudatus of the liver, behind by the v. cava inferior and below by the flexura duodeni superior. A narrow passage, *vestibulum bursae omentalis*, leads out from it under the processus caudatus and over the caput pancreatis to the left as far as the sickle-shaped fold projecting in the median plane, the *plica gastropancreatica*, in which the a. gastrica sinistra and v. coronaria ventriculi run from the tuber omentale pancreatis to the right side of the cardia. Ascending vertically upward from the vestibulum as a narrow prolongation behind the ligamentum hepatogastricum and lobus caudatus [Spigeli] and in front of the pars lumbalis diaphragmatis is the *recessus superior omentalis;* it clothes these parts with its peritonaeum. Near the plica gastropancreatica is the passage into the main portion which as the *recessus inferior omentalis* extends downward from the cardia into the great omentum; its anterior wall is formed by the paries posterior of the stomach, its posterior by the anterior surface of the left suprarenal, of the upper part of the left kidney and of the pancreas, as well as by the mesocolon transversum and the colon transversum; all of these parts possess a peritoneal covering belonging to the bursa omentalis. Concerning the inferior portion of the recessus inferior situated in the omentum majus see p. 560. On the left side the bursa omentalis extends as the *recessus lienalis* behind the ligamentum gastrolienale almost as far as the hilus of the spleen (see also Fig. 638). This bursa omentalis may be diminished in size in old age by partial fusion of its peritoneal walls.



645. Entrance to the omental bursa,

the liver having been drawn upward.

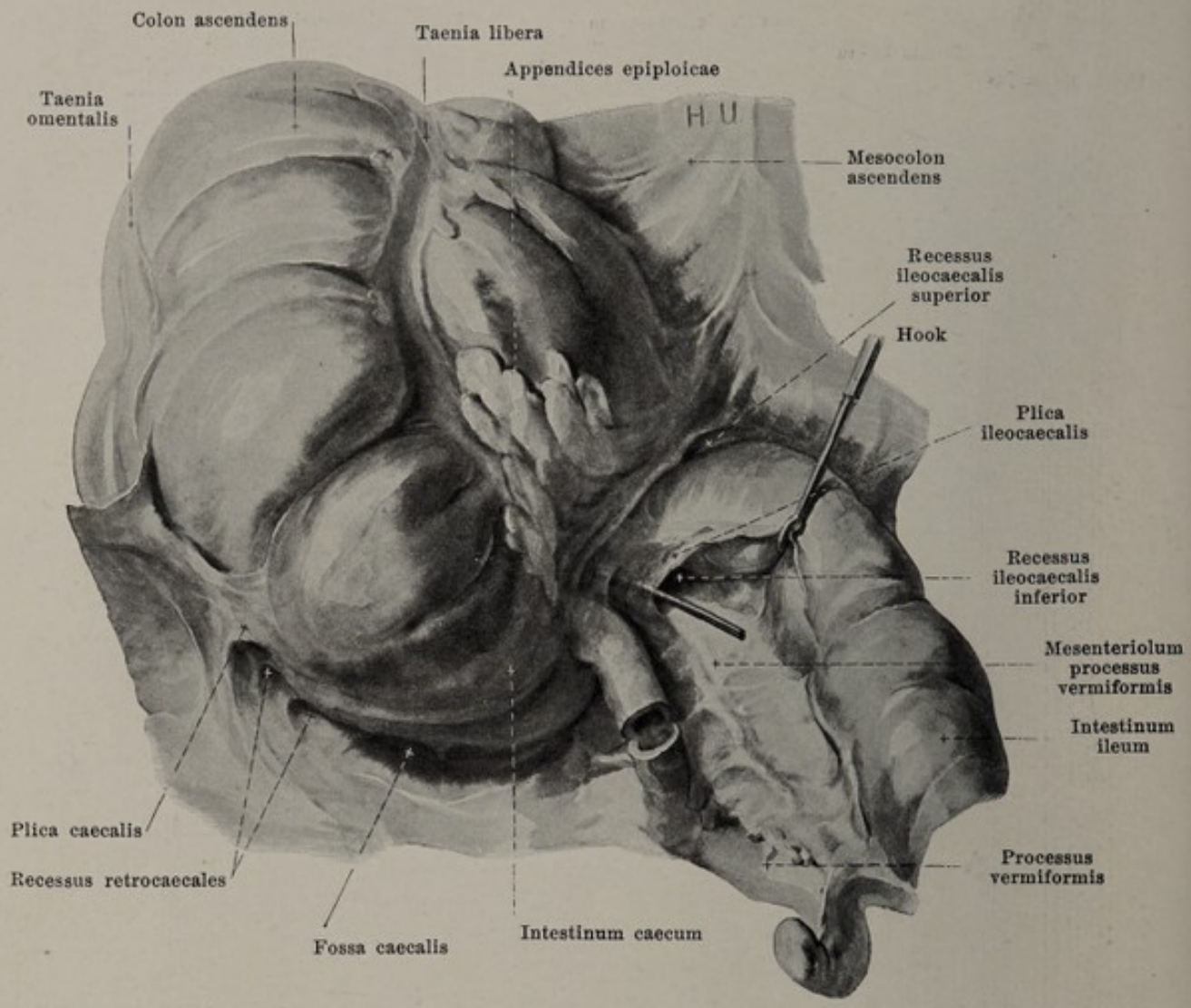


646. Recessus duodenojejunalis, viewed from in front.

(The colon transversum is drawn upward, the small intestine with the mesentery to the right.)

Course of the peritonaeum (continued). From the flexura duodenojejunalis on there arises from the posterior wall of the abdomen a large fold of peritonaeum, the ***mesenterium (mesentery)***, the starting point of which, *radix mesenterii* (root of the mesentery) (see Figs. 642 and 644), extends from the left side of the body of the second lumbar vertebra obliquely downward and somewhat to the right in front of the pars ascendens duodeni, the aorta abdominalis, the v. cava inferior and the right ureter to the right articulatio sacroiliaca. The mesentery consists of a layer of connective tissue, *lamina mesenterii propria*, in which are situated the vessels, lymph glands, nerves and masses of fat and is covered on both sides by the tunica serosa. It is narrow at its starting point, then broadens fairly suddenly and presents many markedly zigzag-shaped tortuous folds (see Fig. 641) and is finally attached to the whole extent of the intestinum tenue mesenteriale; its peritoneal covering goes over into the tunica serosa of the intestine (see Fig. 649). The length of the mesentery measured from its starting point to the intestine increases distalward from the flexura duodenojejunalis on, is longest on those loops which descend into the true pelvis (see p. 536), and then again becomes shorter.

Above, extending to the left from the flexura duodenojejunalis is a variably developed sickle-shaped fold of peritonaeum, the *plica duodenojejunalis*, which may contain the main stem of the v. mesenterica inferior; somewhat deeper there often goes off from the pars ascendens duodeni a narrower fold, *plica duodenomesocolica*. Their free edges are directed toward one another. These folds bound the *recessus duodenojejunalis*.

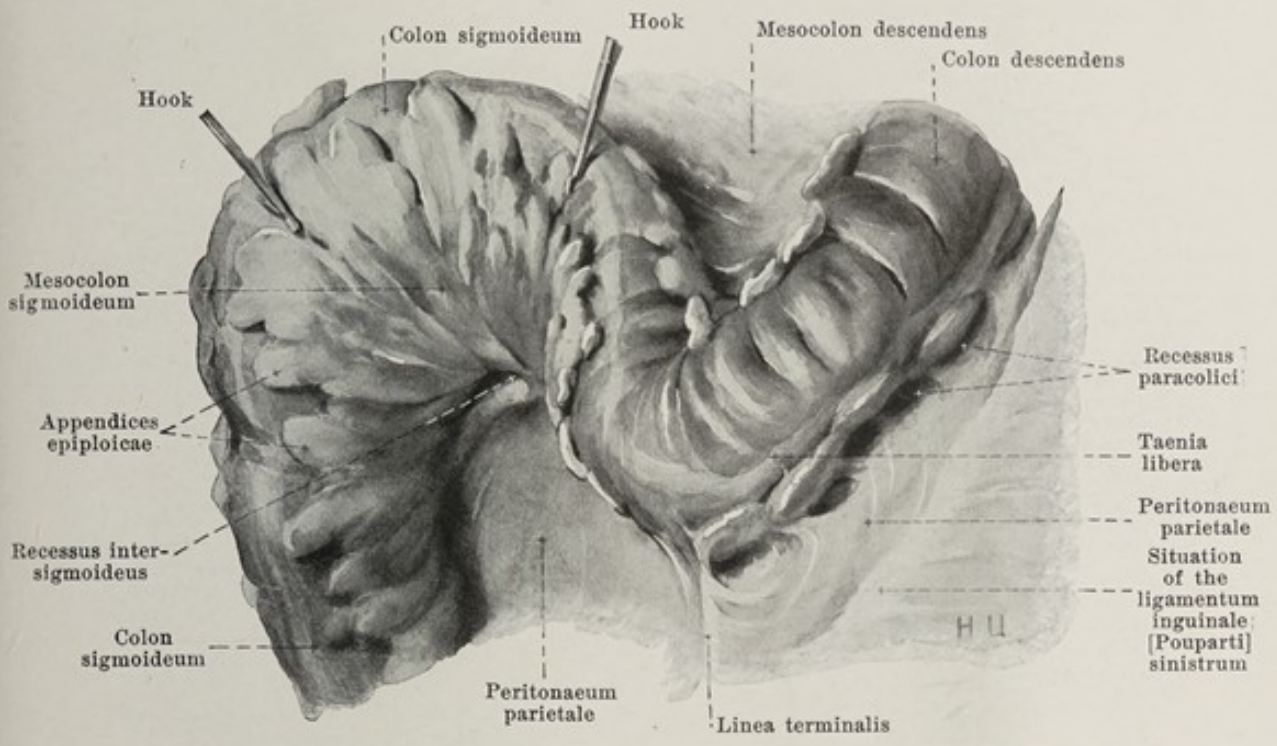


647. Peritoneal pockets near the caecum,

viewed from in front.

(The small intestine has been drawn to the left, the vermiform process has been cut into.)

Course of the peritonaeum (continued). Up to the fourth month of embryonic life the large intestine is movably hung by its ***mesocolon,*** a duplicature of the peritonaeum, exactly in the way that the small intestine is hung by its mesentery; it is connected with the peritonaeum parietale in front of the spinal column only. Originally both kidneys, the ureters and vasa spermatica interna as well as the mm. quadratus lumborum and iliopsoas on each side are also covered by (primary) peritonaeum parietale. Subsequently, however, the movability of the large or thick intestine becomes lost owing to the fact that the mesocolon and large intestine come into relation to neighboring portions of the peritonaeum and fuse with them in variable extent. This happens in the following way: the colon ascendens and its fold of peritonaeum, *mesocolon ascendens*, becomes attached in the fourth month of the embryo to the posterior abdominal wall to the right of the radix mesenterii and the posterior layer of the mesocolon fuses with the peritonaeum parietale originally present there. After this fusion i. e. secondary, the peritonaeum parietale becomes directly continuous with the tunica serosa of the right wall of the colon ascendens, and the posterior wall of the latter no longer possesses a peritoneal covering. The fusion does not extend usually as far as the intestinum caecum (see p. 540). Behind this, therefore, is found a prolongation of the peritoneal cavity open below, the *fossa caecalis;* it is bounded on the right by the *plica caecalis*, which is stretched out downward from the right inferior extremity of the surface of fusion. From the cupula of the fossa caecalis extend upward not infrequently one or several small depressions, *recessus retrocaecales*, the origin of which is to be explained in irregularities in the fusion of the colon to the peritonaeum parietale.



648. Recessus intersigmoideus,

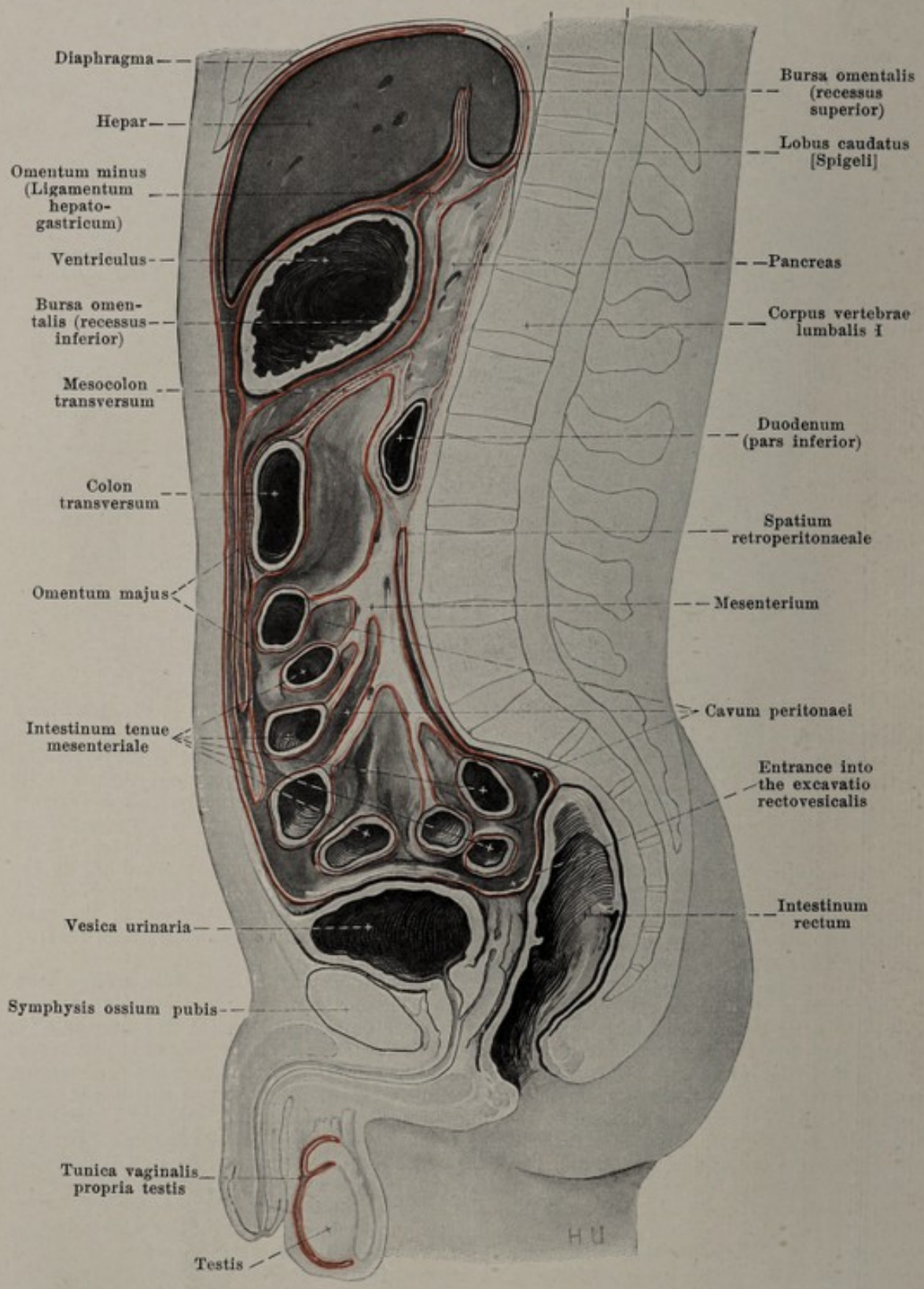
viewed from in front and below.

(The colon sigmoideum has been drawn upward.)

Course of the peritonaeum (continued). Behind the terminal portion of the intestinum ileum there arises from the posterior wall an approximately quadrangular fold of peritonaeum, the *mesenteriolum processus vermiformis* (see Fig. 647). This is attached to the taenia mesocolica of the caecum and to the upper margin of the processus vermiformis, going over there into its tunica serosa. From the anterior wall of the last piece of small intestine extends a variably developed fold of peritonaeum, the *plica ileocaecalis*, to the caecum and to the anterior surface of the mesenteriolum (see Fig. 647). It contains smooth muscle fibres and bounds from in front the *recessus ileocaecalis inferior*, which is very variable in size and open downward and to the left. Above this portion of the small intestine a narrow triangular fold of peritonaeum goes to the right and downward from the anterior surface of the mesentery in front of the small intestine to the large intestine; it forms the anterior wall of the *recessus ileocaecalis superior* (see Fig. 647) which is usually small and open toward the left.

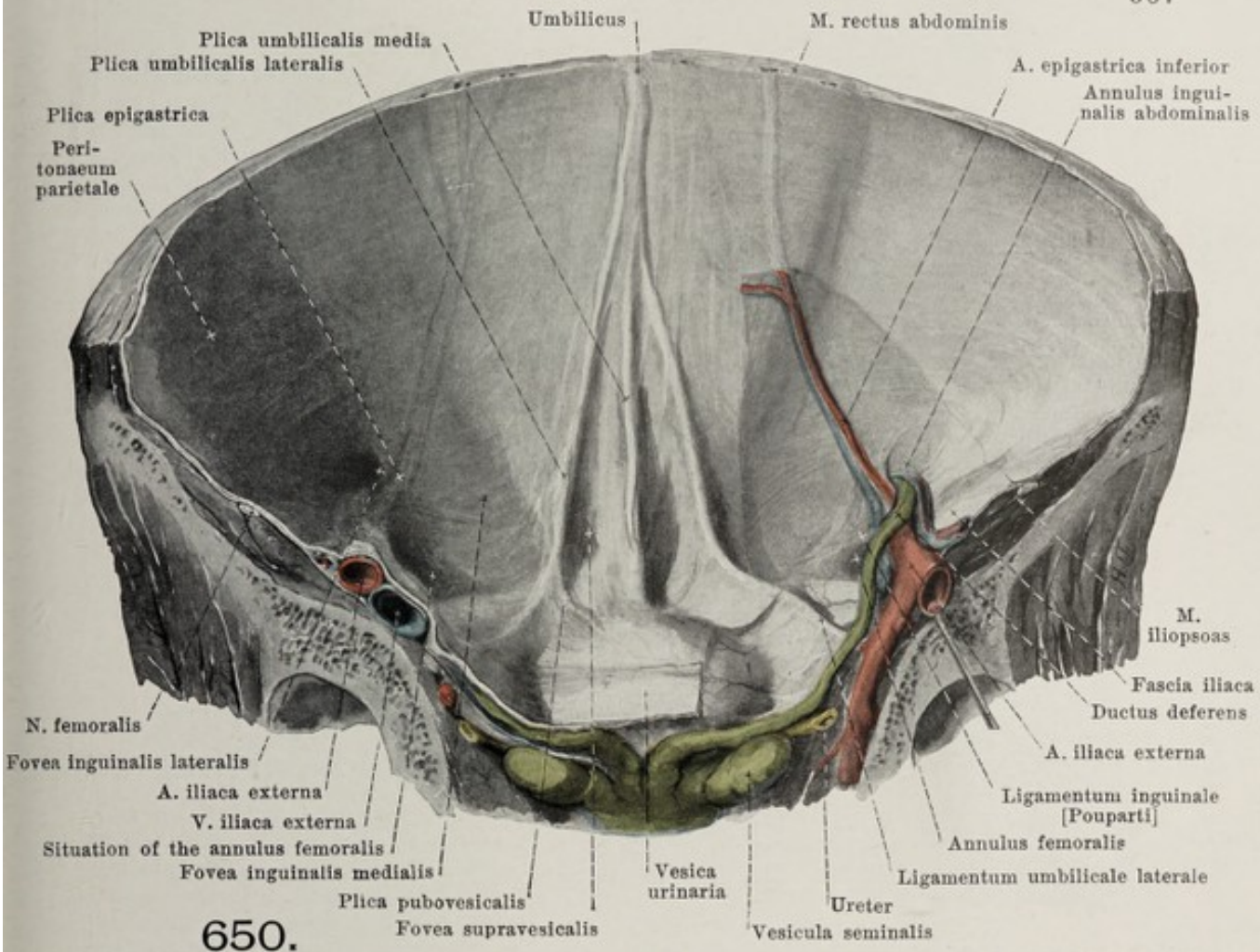
The colon transversum and its duplicature of peritonaeum, the *mesocolon transversum*, in the fourth month of the embryo lies on the right side on the primary peritonaeum parietale in as far as it covers the inferior portion of the pars descendens duodeni, the pars inferior duodeni and the processus uncinatus pancreatis. The posterior layer of the mesocolon transversum then fuses there with the (primary) peritonaeum parietale so that later the peritonaeum goes over (secondarily) directly from the anterior surface of the right kidney and of the upper part of the pars descendens duodeni to the colon transversum (see Fig. 645). On the left the mesocolon transversum becomes attached from below to the two posterior layers of the primary omentum majus (see p. 560 and Fig. 649) which went originally as far as the posterior abdominal wall, and its upper layer, as well as the tunica serosa of the upper surface of the colon transversum, fuses with the most posterior layer of the primary omentum majus. Later, as a result of this, the two posterior layers of the omentum majus are directly attached to the colon transversum so that the latter lies as it were between these layers of the great omentum, and the upper surface of the colon transversum, as well as the upper layer of the mesocolon transversum, looks into the bursa omentalis.

The colon descendens and its fold of peritonaeum, *mesocolon descendens*, lies in the fifth month of the embryo on the left of the spine on the posterior abdominal wall and fuses there with the (primary) peritonaeum parietale exactly as does the mesocolon ascendens on the right; this fusion reaches below usually as far as the medial margin of the left m. psoas major (see also Fig. 686), but it may fail to take place to a variable extent in the fossa iliaca. Small fossae on the left side which lead behind the colon, *recessus paracolici*, arise in very much the same way as do the recessus retrocaecales (see p. 564).



649. Course of the peritonaeum, red, in a median section of a male (after W. Braune), somewhat schematic.

(The dotted red lines refer to the embryonic conditions [see pp. 560 and 565].)



650. Anterior abdominal wall of a male (inferior half), viewed from behind.

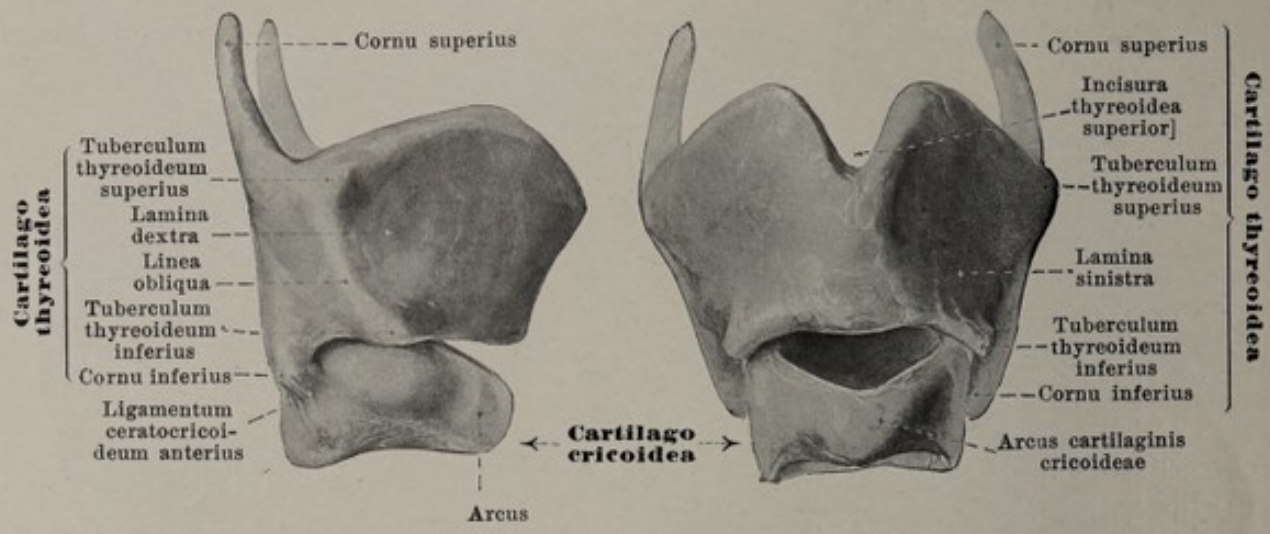
(The posterior part of the pelvis has been removed by a frontal section; the peritonaeum has been partly dissected away on the right side. Cf. Fig. 379. The bladder is empty.)

Course of the peritonaeum (continued). The colon sigmoideum and its duplicature of peritonaeum, *mesocolon sigmoideum*, does not fuse with the peritonaeum parietale but remains always freely movable. The starting point of this mesocolon forms a ∧ (see Fig. 686), the left limb of which corresponds to the inferior extremity of the surface of fusion of the mesocolon descendens (see p. 565), and its right limb extends downward and to the right in front of the promontorium. From the appex of the ∧ a funnel-shaped prolongation, *recessus intersigmoideus*, of varying size extends upward along the aa. sigmoideae (see Figs. 648 and 686).

The duodenum with the pancreas are also originally freely movable by a plate of peritonaeum but later like the colon become firmly attached to the posterior abdominal wall owing to the fact that posterior surface of the peritoneal plate fuses with the peritonaeum parietale.

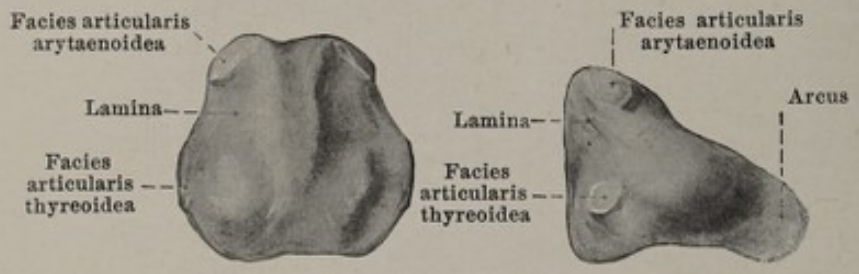
The space situated behind the primary peritonaeum parietale, and which contains the suprarenal glands, the kidneys, the ureters, the large vessels as well as their paired branches and the large nerves, is called the *spatium retroperitonaeale (retroperitoneal space)*.

The posterior surface of the anterior abdominal wall is covered by the *peritonaeum parietale*. From this arise, below the umbilicus, five folds (see also Fig. 379). The *plica umbilicalis media*, which is made to project by the ligamentum umbilicale medium (see p. 601), runs approximately in the median plane; the *plica umbilicalis lateralis*, in which is situated the ligamentum umbilicale laterale (see p. 446), extends downward and lateralward to the pelvic inlet. The plicae umbilicales are sometimes indistinct, usually low above, higher below; they usually fuse somewhat below the navel. Between these folds on each side, above the pubis and behind the m. rectus abdominis, lies the *fovea supravesicalis*. Further lateralward is situated the *plica epigastrica* which is caused to project by the a. and vv. epigastricae inferiores; it is distinct below only. Lateralward from it, behind the annulus inguinalis abdominalis, lies the *fovea inguinalis lateralis*, medianward from it the *fovea inguinalis medialis;* from this, leading in front of the plica umbilicalis lateralis, a pocket very often extends medianward.



651 and 652. Thyroid and cricoid cartilages,

viewed from the right. viewed from in front.



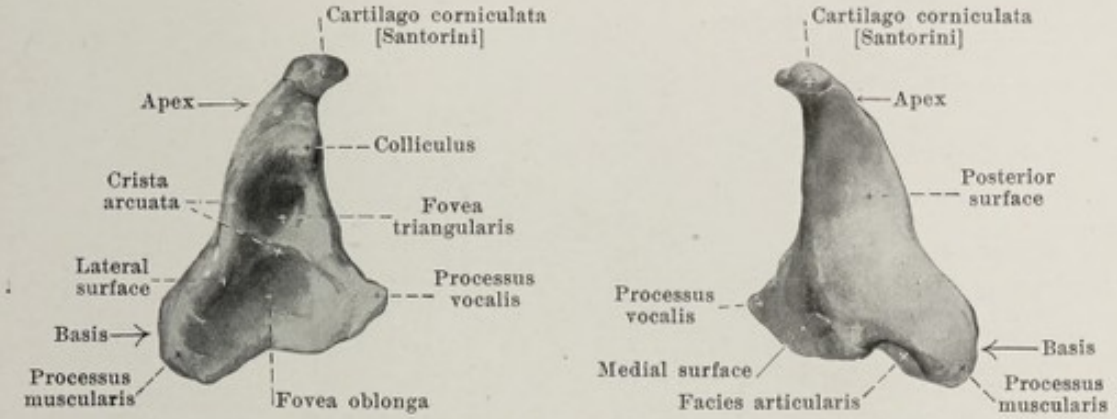
viewed from behind. viewed from the right.

653 and 654. Cricoid cartilage,

The **larynx** (see Figs. 567 and 660) is an oblong hollow body which lies in the middle of the neck, below the hyoid bone, in front of the lower half of the cervical spine. It is bounded in front in the median plane directly by the fascia colli and the skin (bursa [mucosa] subcutanea prominentiae laryngeae see p. 275), is covered lateralward partly by the thyroid gland and the mm. sternohyoidei, sternothyreoidei, thyreohyoidei, omohyoidei and constrictores pharyngis inferiores and is bounded behind by the pars laryngea pharyngis. Above it opens through the aditus laryngis into the pharynx, below it goes over into the trachea. In the male it is absolutely and relatively larger than in the female. It possesses a cartilaginous framework.

Cartilages of the larynx *(cartilagines laryngis).* They ossify almost completely in old age but later in the female than in the male. Ossification occurs in the 15th to 20th year.

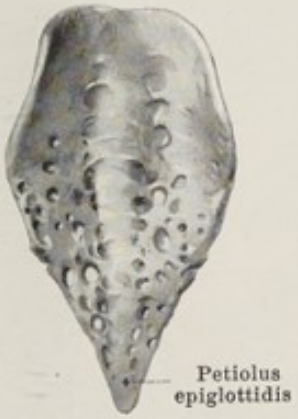
Cartilago thyreoidea *(thyroid cartilage)* (see also Fig. 663), unpaired, is the largest hyaline cartilage and lies in the anterior superior part of the larynx. It is formed of two quadrangular *plates, laminae [dextra et sinistra]*, which converge in front and below and in the male meet at an angle (above about 90°), in the female they go over into one another in the form of an arch. The line of junction in the male runs obliquely backward and downward; its uppermost, most anterior point causes a projecting of the skin, *prominentia laryngea* (see Fig. 567), which is scarcely noticeable in the female. The inner surface is smooth; the outer surface frequently presents a flat ridge behind extending from above and behind downward and forward, the *linea obliqua* (for the mm. sternothyreoideus, thyreohyoideus and thyreopharyngeus); this begins above in a triangular nodule, *tuberculum thyreoideum superius*, and ends below in a smaller ridge-like projection of the inferior margin, *tuberculum thyreoideum inferius*. Below the tuberculum superius there is frequently an opening, *foramen thyreoideum* (see Fig. 660), of variable size. The upper margin is curved so as to be convex on each side; in the middle at the junction of the right and left upper margins is a notch of variable depth, *incisura thyreoidea [superior]*. The inferior margin presents on each side two flat depressions of variable development. From the posterior margin which is almost straight on each side projecting upward and a little backward is the *cornu superius*, projecting downward and a little forward the shorter *cornu inferius*. Both are rounded and curved somewhat medianward; the inferior presents on the median decline of its apex a rounded articular surface (for the facies articularis thyreoidea of the cartilago cricoidea).



655 and 656. Right arytaenoid cartilage,

viewed from in front and lateralward. viewed from behind and medianward.

Magnification: 3:2.



657. Cartilage of the epiglottis,

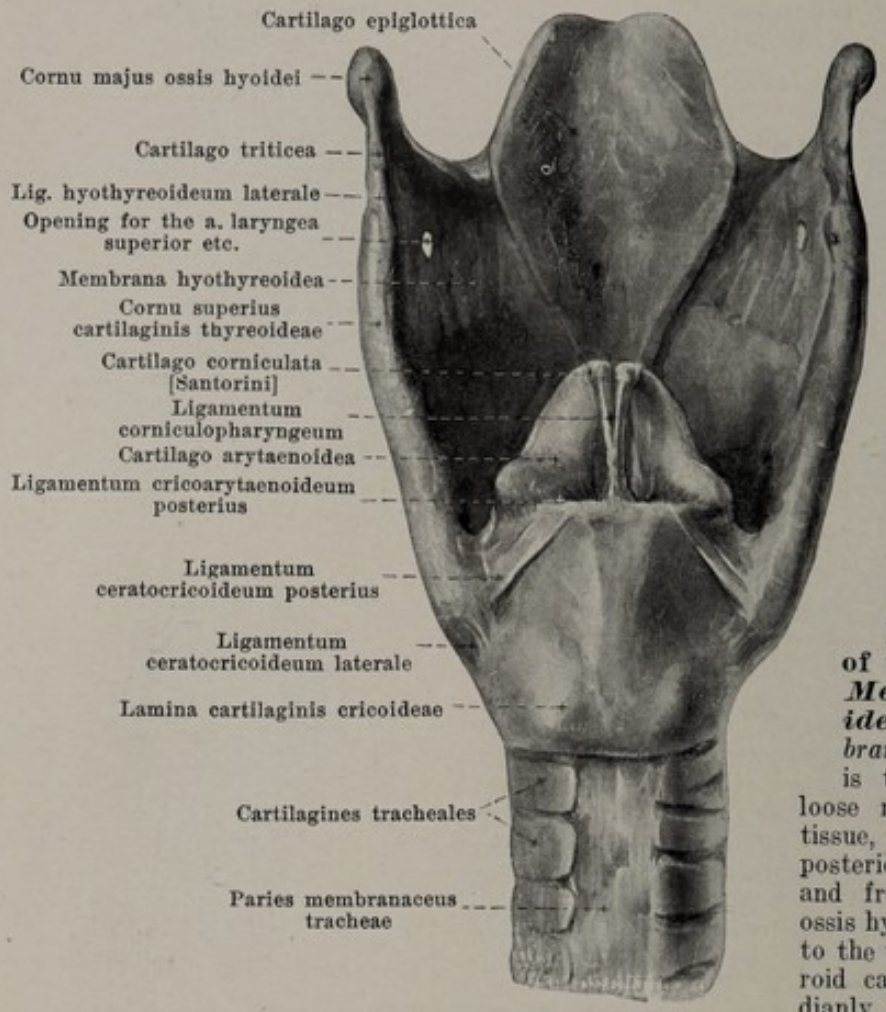
viewed from behind.

Cartilago cricoidea *(ring cartilage or cricoid cartilage)* (see Figs. 651—654), unpaired, consists of hyaline cartilage and lies below the thyroid cartilage. It has the shape of a seal ring. The anterior portion, *arcus*, is low in front and becomes gradually higher behind. The posterior portion, *lamina*, is approximately hexagonal and higher; it lies in a frontal plane and projects upward between the posterior margins of the thyroid cartilage. Its anterior surface is smooth, its posterior presents two flat fossae (for the mm. cricoarytaeniodei posteriores), separated by a median ridge. Each lateral superior angle of the lamina bears a small articular surface looking upward, forward and lateralward, the *facies articularis arytaenoidea* (for the facies articularis of the cartilago arytaenoidea); this surface is cylindrically curved. Each lateral middle angle of the lamina possesses a small rounded articular surface, *facies articularis thyreoidea* (for the cornu inferius of the cartilago thyreoidea).

Cartilago arytaenoidea *(arytaenoid cartilage)* (see also Figs. 658 and 663), paired, lies above the lamina of the cricoid cartilage in the posterior part of the larynx and consists of hyaline cartilage with the exception of the processus vocalis and often the apex which are elastic cartilage. It has approximately the form of a three-sided pyramid. The posterior surface is markedly concave (for the m. arytaenoideus transversus); the medial, narrow surface is flat and stands sagittally. The lateral surface looking at the same time forward presents close below the apex a small nodule, the *colliculus*. From this a ridge, *crista arcuata*, goes first backward then forward and downward to the processus vocalis; it forms the margin of a deep fossa, *fovea triangularis*, and separates it from a larger, flatter depression, *fovea oblonga* (for the m. vocalis). The oblong, somewhat obliquely placed *basis* presents behind a rounded, concave *facies articularis* (for the facies articularis arytaenoidea of the cartilago cricoidea); directly above this lies the lateral blunt angle, *processus muscularis*, for the mm. cricoarytaenoidei. The anterior angle of the basis, *processus vocalis*, is longer and tapered. The tip, *apex*, is blunt and curved backward; it carries a short wedge-shaped appendage, the ***cartilago corniculata [Santorini]***, which consists of elastic cartilage and is directed backward and medianward.

Cartilago cuneiformis [Wrisbergi], paired, consisting of elastic cartilage, often lies as an oblong rod close in front of the cartilago corniculata in the posterior part of the plica aryepiglottica (see Fig. 666 in the projection beneath the tuberculum cuneiforme).

Cartilago epiglottica *(cartilage of the epiglottis)* (see also Figs. 658, 659 and 666), unpaired, consisting of elastic cartilage, is thin, very flexible, shaped like the ace of hearts, multiply perforated and presents numerous small depressions; it is situated above the thyroid cartilage behind the root of the tongue and the hyoid bone and directed obliquely backward and upward. It presents below a thicker tip, *petiolus epiglottidis*, above frequently a notched margin. Its posterior surface is curved so as to be saddle-shaped, being slightly convex backward in the sagittal direction, markedly concave in the transversal direction.



658. Larynx with its ligaments,

viewed from behind.

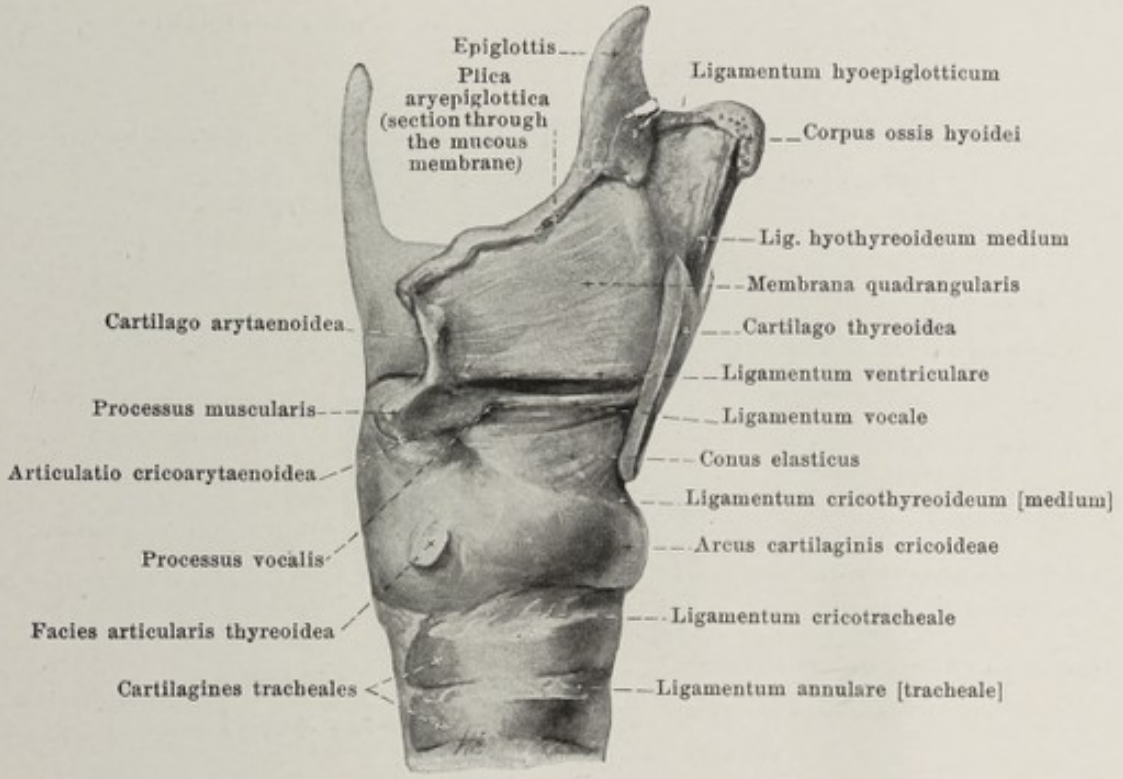
Ligaments and joints of the larynx.

Membrana hyothyreoidea *(hyothyroid membrane)* (see also Fig. 660) is the name given to the loose membrane of connective tissue, which goes from the posterior margin of the corpus and from the cornua majora ossis hyoidei (bursae, see p. 275) to the upper margin of the thyroid cartilage and divides medianly into an anterior and posterior layer. The anterior layer is strengthened in the middle by elastic fibres which form the *ligamentum hyothyreoideum medium* (see also Fig. 666), is laterally very thin and nearly in the middle of the cornu majus joins the posterior layer (see Fig. 660). The posterior layer arises at the lateral margin of the cartilago epiglottica, connects with the lig. hyoepiglotticum and only laterally attaches to the upper margin of the thyroid cartilage, medianly it goes into the depth behind it. The membrane presents an opening for the passage of the a. and v. laryngea superior and the ramus internus n. laryngei superioris and on its lateral extremity is thickened on each side by means of elastic fibres between the tips of the cornu majus ossis hyoidei and the cornu superius cartilaginis thyreoideae to form a rounded cord, *ligamentum hyothyreoideum laterale* (see also Fig. 660); this usually contains a small piece of fibrocartilage, *cartilago triticea* (not infrequently ossified). Between the two layers the posterior extremity of a fat body is shoved in from in front (see p. 571 and Fig. 660).

In the ***articulatio cricothyreoidea*** on each side the facies articularis thyreoidea of the cricoid cartilage glides upon the cornu inferius of the thyroid cartilage. The *capsula articularis cricothyreoidea* is stretched out between the margins of the articular surfaces; it is very thin and loose. It is strengthened by the *ligamenta ceratocricoidea*, which arise at the cornu inferius of the thyroid cartilage, and of which the *anterius* (see Fig. 651) extends forward and downward, the *laterale* downward, while the *posterius* passes medianward from the inner surface of the cornu inferius to the upper margin of the lamina cartilaginis cricoideae.

In the ***articulatio cricoarytaenoidea*** on each side the facies articularis of the arytaenoid cartilage moves upon the facies articularis arytaenoidea of the cricoid cartilage. The *capsula articularis cricoarytaenoidea* goes off just outside the margins of the articular surfaces; it is very thin and loose. It is strengthened on the posterior surface by the elastic *ligamentum cricoarytaenoideum posterius*, which extends from the upper margin of the lamina cartilaginis cricoideae lateralward to the medial part of the dorsal surface of the arytaenoid cartilage.

Synchondrosis arycorniculata is the name given to the movable union formed by loose connective tissue bands between the cartilago corniculata [Santorini] and the apex cartilaginis arytaenoideae.



659. Larynx with its ligaments, viewed from the right.

(The right half of the hyoid bone and of the cartilago thyreoidea have been removed.)

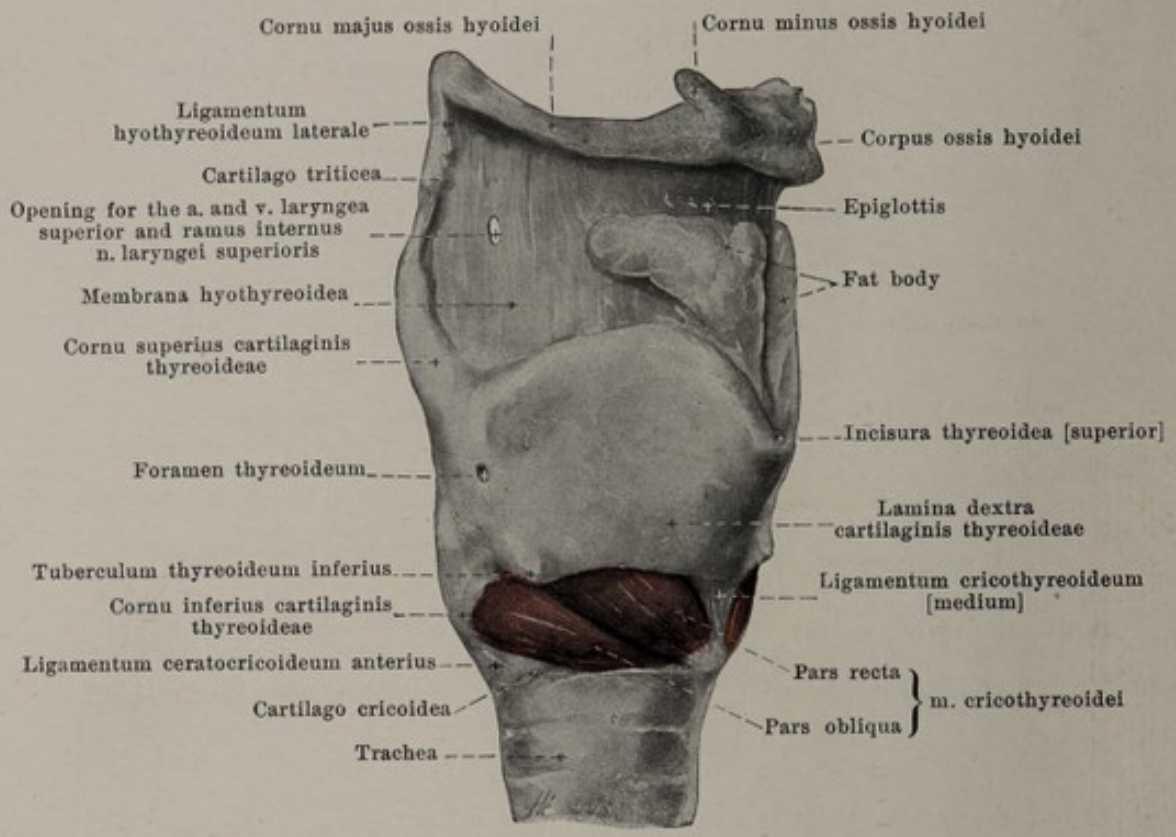
Ligaments and joints of the larynx (continued).

Going downward from the tip of each cartilago corniculata (see Fig. 658) is a thin band of connective tissue, the *ligamentum corniculopharyngeum*, which unites behind the mm. arytaenoidei with that of the other side to form a strip, which extends to the upper margin of the lamina of the cricoid cartilage and to the anterior surface of the mucous membrane of the pharynx; the inferior fibres of this strip are designated the *ligamentum cricopharyngeum* (not illustrated).

The cartilago epiglottica is connected with the other cartilages by loose ligaments only. At the root of the tongue it is fastened by the *ligamentum glossoepiglotticum* (consisting of elastic fibres) (not illustrated), which runs from before backward in the plica glossoepiglottica mediana. The *ligamentum hyoepiglotticum* (see also Fig. 666) extends as a short but broad plate of elastic fibres from the upper margin of the body and the cornua majora of the hyoid bone to the anterior surface of the cartilage of the epiglottis and coalesces laterally with the posterior layer of the membrana hyothyreoidea. The petiolus epiglotticus is fastened behind and below the incisura thyreoidea superior by means of the powerful *ligamentum thyreoepiglotticum* (see Fig. 666) consisting of elastic fibres. The triangular space between the ligamentum hyoepiglotticum, the anterior surface of the cartilage of the epiglottis and the ligamentum hyothyreoideum medium contains on each side a mass of fat (see Figs. 660 and 666), which is shoved in lateral between the two layers of the membrana hyothyreoidea.

The *ligamentum cricotracheale* is the name given to the vertical, short bands of connective tissue which run from the inferior margin of the cricoid cartilage to the superior margin of the first cartilago trachealis.

The ***conus elasticus*** (see also Fig. 668) is a membrane the elastic bands of which radiate fan-like from the lower margin and from the posterior surface of the angle of the cartilago thyreoidea to the upper margin of the arch of the cartilago cricoidea and to the processus vocales of the cartilagines arytaenoideae. The two halves of the membrane converge above and medianward and are slightly concave lateralward. The most anterior thick portion consisting of perpendicular fibres, *ligamentum cricothyreoideum [medium]* (see also Figs. 660, 661 and 666), is stretched out in the middle from the inferior margin of the thyroid cartilage to the upper margin of the arcus cartilaginis cricoideae; it is perforated by vessels and becomes broader below. The uppermost strengthened bands of fibres of the conus arise on each side as the *ligamentum vocale* (see also Figs. 663, 667 and 668) close to the median plane from the middle of the angle of the cartilago thyreoidea and run horizontally to the processus vocalis. They surround in front a small nodule of elastic tissue which may contain cartilage cells, *cartilago sesamoidea* (not illustrated).



660. Larynx with its muscles, viewed from the right.

(The anterior layer of the membrana hyothyreoidea [with the lig. hyothyreoideum medium] has been removed.)

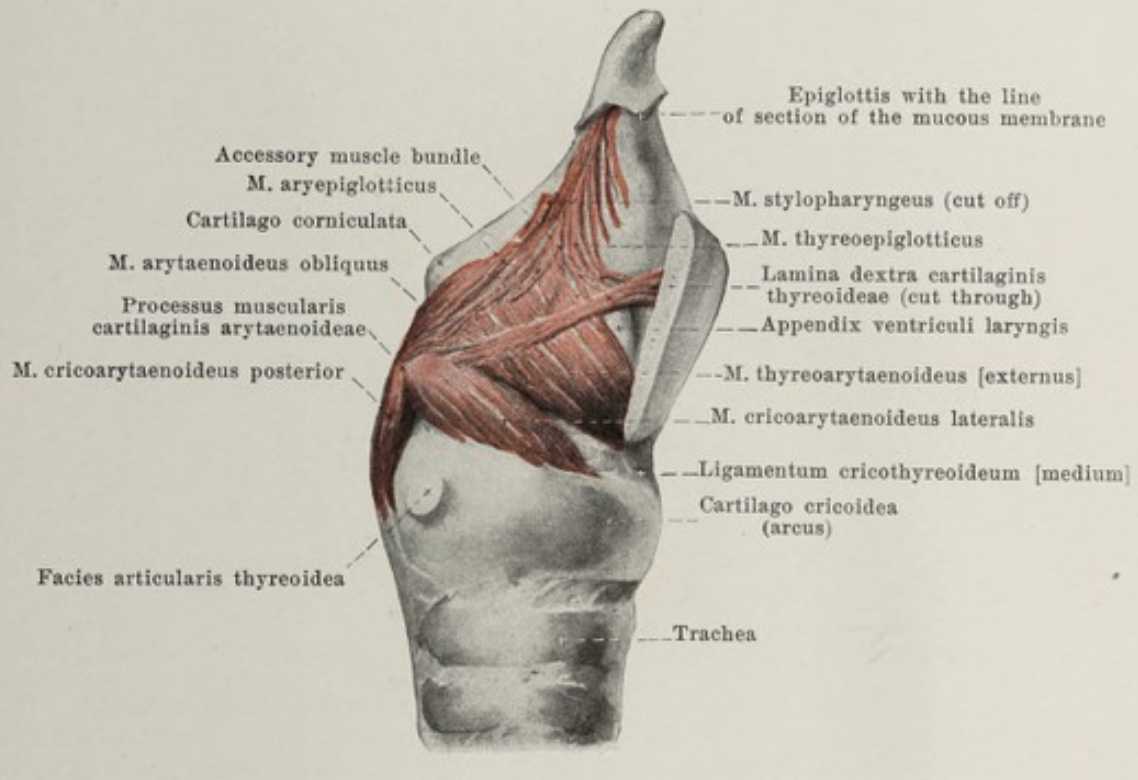
Ligaments and joints of the larynx (continued).

Membrana quadrangularis (see Fig. 659) is a membrane somewhat split up by glands deposited in it; it consists of elastic fibres the bundles of which run in sagittal direction in the main horizontally, partly also backward and downward. It arises on each side in front and above at the lateral margin of the cartilago epiglottica, below at the posterior surface of the angle of the cartilago thyreoidea and becomes attached behind the cartilago corniculata [Santorini] and to the medial margin of the arytaenoid cartilage. The membranes of the two sides converge below and medianward. The inferior end is called the *ligamentum ventriculare* and consists of fibres which go off at the thyroid cartilage somewhat above the ligamentum vocale and extend horizontally near the median plane backward to the medial margin of the fovea triangularis of the arytaenoid cartilage. Its upper margin runs obliquely backward, downward and medianward. The membrane above forms the basis of the plica aryepiglottica and there contains posteriorly the cartilago cuneiformis [Wrisbergi].

Conus elasticus and membranae quadrangulares are grouped together as ***membrana elastica laryngis.***

Muscles of the larynx *(musculi laryngis).*

M. cricothyreoideus (see also Figs. 349, 353, 576 and 668), paired. Form: quadrangular, broader and thicker above. Position: on the external surface of the larynx, covered by the glandula thyreoidea, as well as by the mm. sternothyreoideus and sternohyoideus. Those of the two sides leave free between them in the middle a triangular area broader above, in which the ligamentum cricothyreoideum [medium] is visible. Origin: inferior margin and medial surface of the lamina cartilaginis thyreoideae as far as the apex of the cornu inferius. Insertion: external surface of the arcus cartilaginis cricoideae. The fibres converge downward like a fan so that in the anterior portion, *pars recta*, they extend more vertically, in the posterior portion, *pars obliqua*, more obliquely forward; the two portions are often distinctly separated from one another. Behind, the muscle is usually covered by bundles of origin of the m. cricopharyngeus (see p. 527) and is connected with them. Action: the muscles of both sides elevate the arcus, move the upper margin of the lamina of the cricoid cartilage (and the cartilagines arytaenoideae) dorsalward and thereby make the ligamenta vocalia tense. Innervation: ramus externus n. laryngei superioris (X).



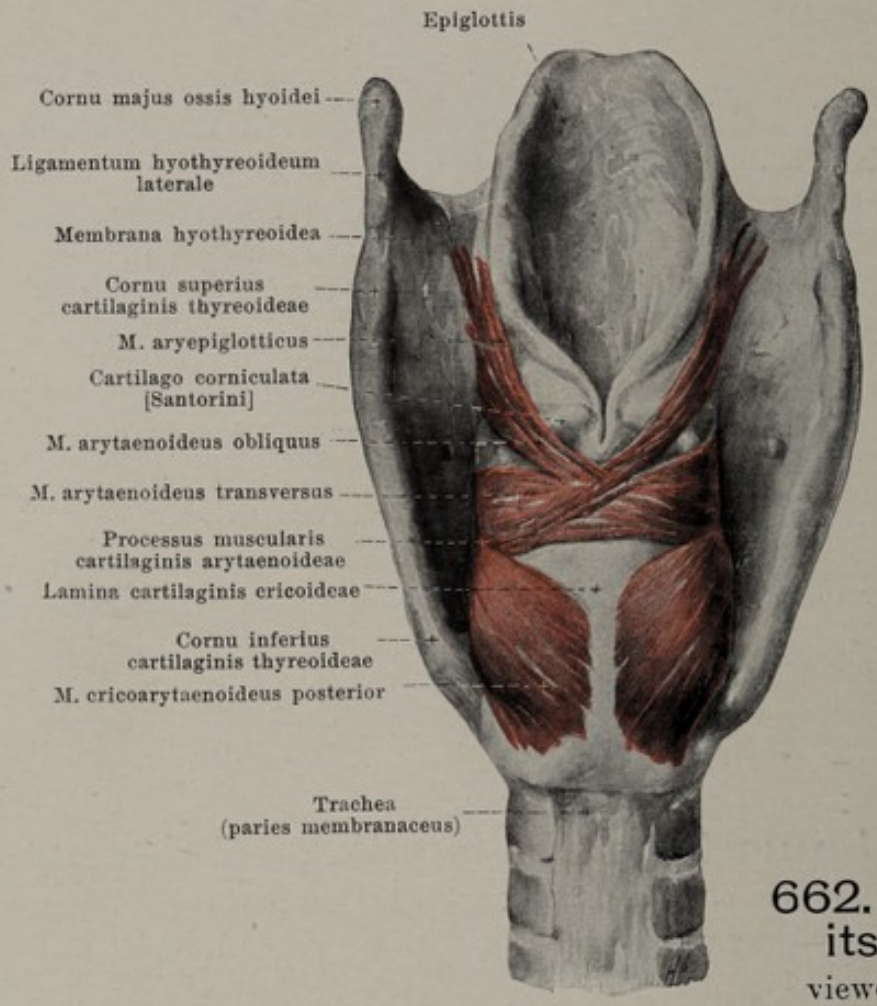
661. Internal muscles of the larynx, viewed from the right.

(The lamina dextra of the cartilago thyreoidea has been removed.)

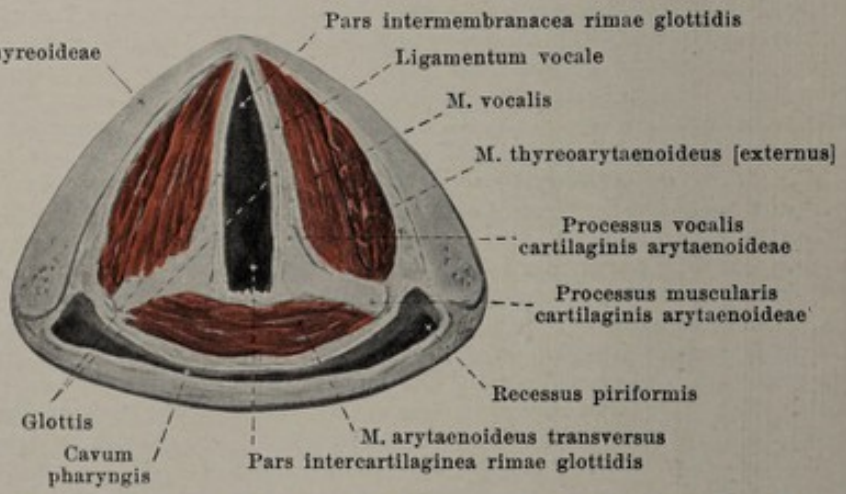
M. cricoarytaenoideus posterior (see also Figs. 602 and 662), paired. Form: triangular. Position: on the posterior surface of the lamina cartilaginis cricoideae, directly covered behind by the tela submucosa of the pharynx. Origin: medial and inferior part of the posterior surface of the lamina cartilaginis cricoideae. Insertion: the fibres converge upward and lateralward to the posterior surface and to the apex of the processus muscularis cartilaginis arytaenoideae; in their course the lateral fibres run nearly vertically, the upper fibres almost horizontally. Action: it draws the processus muscularis backward and downward, rotates the arytaenoid cartilage so that the processus vocalis is turned lateralward and somewhat upward, the rima is opened wider and the ligamentum vocale is put somewhat upon the stretch. Innervation: ramus posterior n. laryngei inferioris (X).

M. cricoarytaenoideus lateralis, paired. Form: triangular. Position: in the lateral wall of the larynx upon the conus elasticus, covered by the lamina cartilaginis thyreoideae, the glandula thyreoidea and the mm. sternothyreoideus, thyreohyoideus, sternohyoideus and thyreopharyngeus. Origin: upper margin and external surface of the arcus cartilaginis cricoideae, as well as the conus elasticus. Insertion: by converging fibres backward and upward to the anterior surface of the processus muscularis cartilaginis arytaenoideae. The muscle is very frequently inseparable from the m. thyreoarytaenoideus [externus]. Action: it draws the processus muscularis forward and downward so that the processus vocalis is turned medianward and a trifle downward, the rima is narrowed and the ligamentum vocale is rendered somewhat flaccid. Innervation: ramus anterior n. laryngei inferioris (X).

M. thyreoarytaenoideus [externus] (see also Figs. 663, 667 and 668), paired, forms with the m. vocalis a common mass of muscle, separable only by artificial means. Form: thin, quadrangular. Position: in the lateral wall of the larynx; medianward it is adjacent above to the appendix ventriculi laryngis, below to the m. vocalis and partly to the conus elasticus; lateralward it is covered by the lamina cartilaginis thyreoideae and the mm. thyreohyoideus and sternohyoideus. Origin: posterior surface of the cartilago thyreoidea, directly lateralward from the m. vocalis, reaching for a variable distance upward. Insertion: the fibres extend backward and upward to the lateral margin of the arytaenoid cartilage; some bundles go over into the m. arytaenoideus obliquus. The upper fibres vary greatly in their development. Action: it draws the cartilago arytaenoidea forward and rotates it, so that the processus vocalis is turned medianward and somewhat downward, the rima is narrowed and the ligamentum vocale is rendered somewhat flaccid. Innervation: ramus anterior n. laryngei inferioris (X).



662. Larynx with its muscles, viewed from behind.



663. Transverse section, through the larynx at the level of the vocal cords, viewed from above.

M. vocalis (see also Figs. 667 and 668), paired, forms with the m. thyreoarytenoideus [externus] one mass of muscle, which can be separated only by dissection. Form: triangularly prismatic. Position in the labium vocale, its median surface lies directly next to the ligamentum vocale and conus elasticus, its upper surface runs along under the upper surface of the labium vocale, and its lateral surface is bounded by the m. thyreoarytaenoideus [externus] (see p. 573). Origin: lower half of the posterior surface of the angle of the cartilago thyreoidea. Insertion: the fibres run parallel and horizontally backward to the processus vocalis and the fovea oblonga of the cartilago arytaenoidea. Action: it draws the processus vocalis forward, and relaxes the ligamentum vocale. Innervation: ramus anterior n. laryngei inferioris (X).

M. ventricularis (see Fig. 668) consists of several bundles of muscle, visible under the microscope, which run between the glands in the plica ventricularis in a sagittal direction from the lateral edge of the arytaenoid cartilage to the lateral margin of the cartilage of the epiglottis. In addition the pocket ligament contains also outrunners of the mm. thyreoarytaenoideus [externus] and aryepiglotticus.

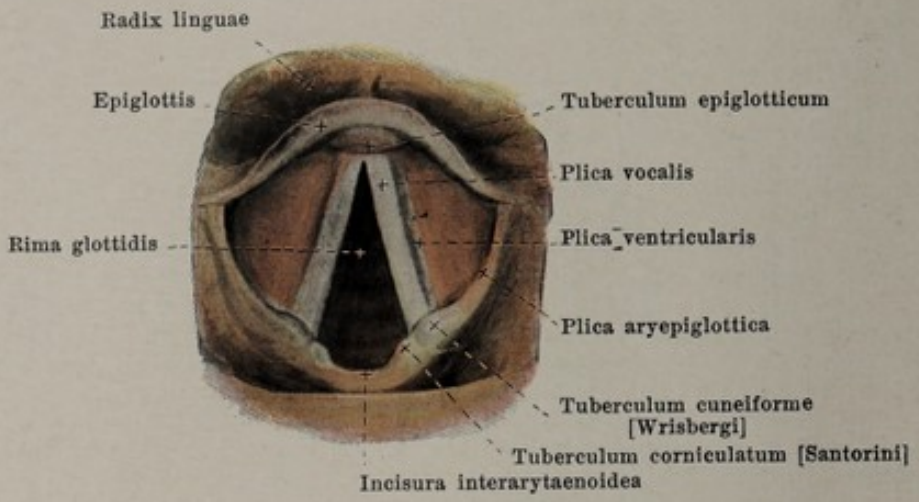
M. thyreoepiglotticus (see Fig. 661), paired and very variable. Form: oblong, thin. Position: in the lateral wall of the larynx; it is bounded below directly by the m. thyreoarytaenoideus [externus], medianward and below lies adjacent to the appendix ventriculi laryngis, above to the membrana quadrangularis and is covered lateralward by the lamina cartilaginis thyreoideae and by the mm. sternothyreoideus and sternohyoideus. Origin: medial surface of the lamina cartilaginis thyreoideae, immediately adjacent to the m. thyreoarytaenoideus [externus]. Insertion: the fibres run in arches upward and backward partly toward the margin of the plica aryepiglottica, partly toward the margin of the cartilago epiglottica, interwoven with the m. aryepiglotticus. Action: it widens the aditus and the vestibulum laryngis. Innervation: ramus anterior n. laryngei inferioris (X).

M. arytaenoideus obliquus (see Figs. 661 and 662), paired. Form: narrow, thin. Position: in the posterior wall of the larynx, bounded in front by the m. arytaenoideus transversus, covered behind by the tela submucosa pharyngis. Origin: posterior surface of the processus muscularis cartilaginis arytaenoideae. Insertion: the fibres run obliquely medianward and upward, decussate in the median plane with those of the other side, arrive at the tip of the arytaenoid cartilage of the other side, and there become partially attached; a part of them, arising there ***(m. aryepiglotticus)***, extend forward and upward in arches in the plica aryepiglottica to terminate in the membrana quadrangularis and at the lateral margin of the cartilago epiglottica. Above, it is connected with fibres of the m. stylopharyngeus (see p. 527). Action: it narrows the aditus and the vestibulum laryngis. Innervation: ramus anterior n. laryngei inferioris (X).

M. arytaenoideus transversus (see also Figs. 662, 663 and 666), unpaired. Form: oblong-quadrangular, thick. Position: in the posterior wall of the larynx; its anterior surface is adjacent to the posterior concave surface of the arytaenoid cartilage and between them is covered by the mucous membrane of the larynx; its posterior surface is covered by the mm. arytaenoidei obliqui and by the tela submucosa pharyngis. It reaches below as far as the lamina cartilaginis cricoideae, above not quite as far as the apex of the arytaenoid cartilages. Origin and insertion: on both sides to the posterior surface of the processus muscularis and to the lateral edge of the cartilago arytaenoidea. The fibres run horizontally in a frontal direction. Action: it draws the processus musculares backward and upward so that the processus vocales approach one another and are somewhat elevated, the rima is narrowed, and the ligamenta vocalia are put somewhat upon the stretch. Innervation: ramus posterior n. laryngei inferioris (X) of both sides.

Cavum laryngis ***(cavity of the larynx)***, (see Figs. 663—668).

The cavity of the larynx is considerably smaller than its outer circumference. It is bounded in front (see Fig. 666) by the posterior surface of the cartilago epiglottica, of the ligamentum thyreoepiglotticum, of the angle of the cartilago thyreoidea, of the ligamentum cricothyreoideum [medium] and of the arcus cartilaginis cricoideae. The lateral wall (see Figs. 666 and 667) is formed on each side by the medial surface of the membrana quadrangularis with the cartilagines cuneiformis [Wrisbergi] et corniculata [Santorini], of the cartilago arytaenoidea, of the conus elasticus and of the arcus cartilaginis cricoideae. The posterior wall (see Fig. 666) is closed by the anterior surface of the m. arytaenoideus transversus and the lamina cartilaginis cricoideae. These walls are all directly covered by the *mucous membrane of the larynx, tunica mucosa laryngis.* It is connected at the *epiglottis* with the mucous membrane of the tongue. At the upper margin of the membrana quadrangularis it is continuous on each side with the tunica mucosa pharyngis and it forms a fold with the latter, *plica aryepiglottica* (see Figs. 664—666), which extends medianward, downward and backward from the lateral margin of the epiglottis to the apex of the arytaenoid cartilage, and which contains processes of the mm. stylopharyngeus, thyreoepiglotticus and aryepiglotticus. This fold in the neighborhood of its posterior end presents two small nodules, an anterior, *tuberculum cuneiforme [Wrisbergi]*, and a posterior, *tuberculum corniculatum [Santorini]*, which are due to the projections of the cartilages of the same name. The anterior wall is broad above (see Fig. 665) and becomes very markedly narrow toward the middle, widening out again below; it presents just above the middle a small transverse projection, *tuberculum epiglotticum* (see Figs. 664 and 665), which covers the petiolus epiglottidis and the ligamentum thyreoepiglotticum. The lateral surface (see Fig. 666) presents above a projection which extends obliquely downward and forward from the tuberculum cuneiforme; this projection contains the cartilago cuneiformis and the glandulae laryngeae mediae. Just below, running horizontally in a sagittal direction, are two folds, *plica ventricularis* and *plica vocalis* (see Figs. 664—668), separated from one another by a deep groove, *ventriculus laryngis [Morgagnii]*.



664. Laryngoscopic view of the larynx

on quiet breathing (after M. Schmidt).

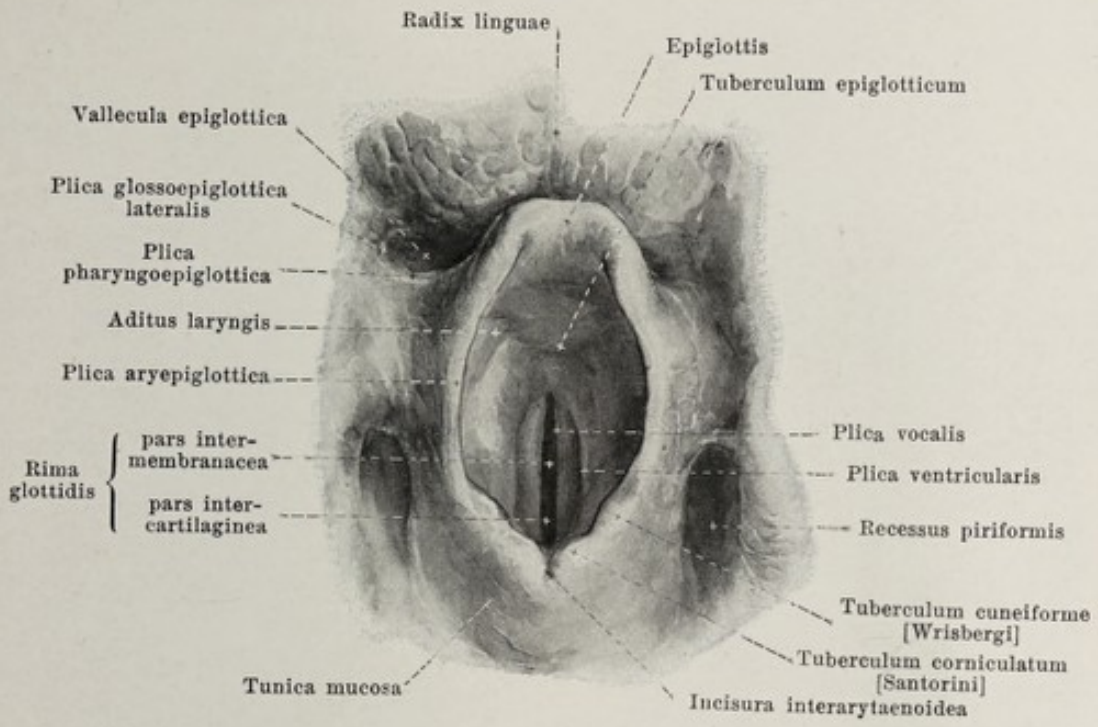
Cavum laryngis (see Figs. 663—668) (continued).

The upper fold, ***plica ventricularis***, *ventricular fold* (O. T. false vocal cord), presents a projecting free margin and forms by its broad inferior surface the upper wall of the ventriculus laryngis; its insertions are the same as those of the ligamentum ventriculare (see p. 527). It contains within it the lower part of the membrana quadrangularis with the ligamentum ventriculare, the m. ventricularis and the glandulae laryngeae mediae.

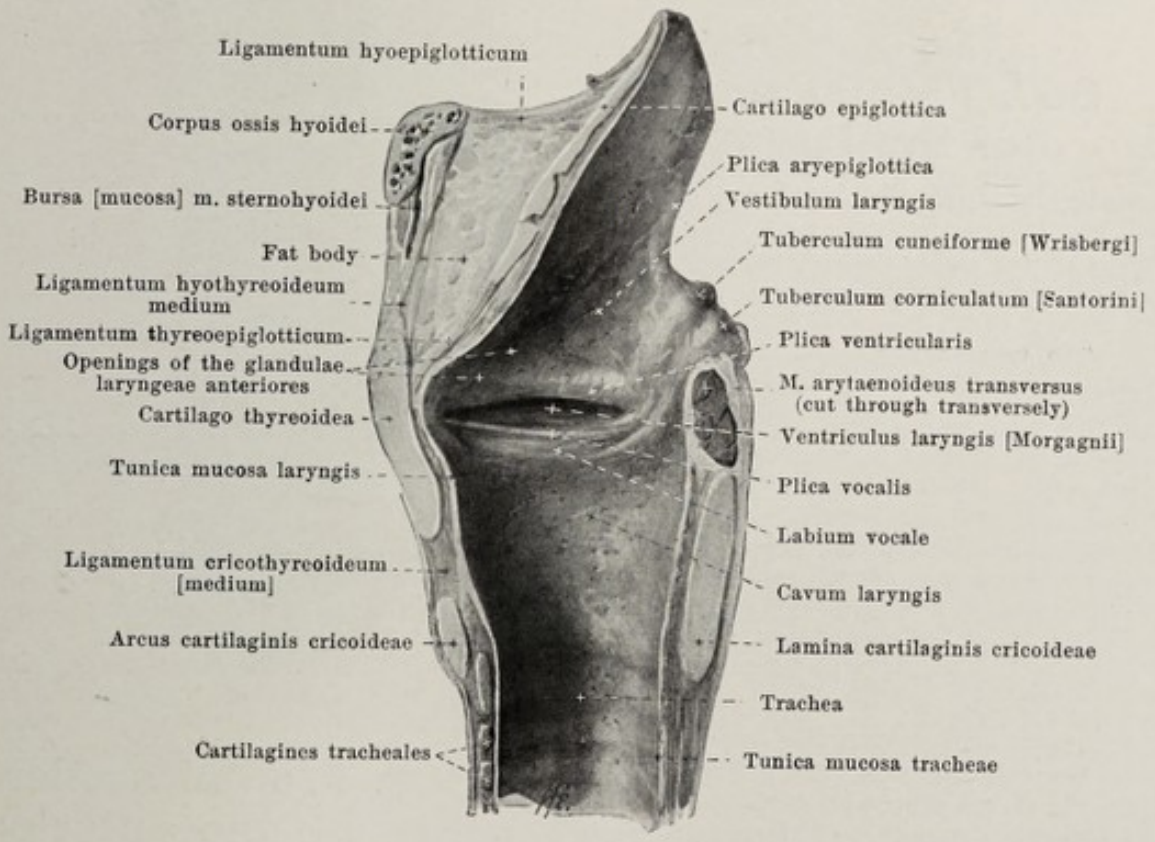
The lower fold, ***plica vocalis***, *vocal fold* (O. T. true vocal cord), is the free margin of the trilateral-prismatic projection, *labium vocale*, the upper free surface of which is horizontal, flat or a little concave and forms the inferior wall of the ventriculus laryngis, while its medial, free surface is turned at the same time downward; the projection contains within it the upper part of the conus elasticus with the ligamentum vocale, as well as the m. vocalis. The vocal fold projects farther medianward than the ventricular fold. It presents a tolerably sharp, free edge which has the same attachment as the ligamentum vocale; near the anterior end the cartilago sesamoidea shows through the mucous membrane as a yellowish spot *(macula flava)*. The tone-producing apparatus formed by the two vocal folds is called the *glottis*.

The ***ventriculus laryngis [Morgagnii]*** is a long drawn out pocket-shaped slit which extends lateralward between the ventricular fold and the vocal fold and is deepest in the middle. It gives off usually from its anterior half vertically upward a very variable slit-like blind sack, *appendix ventriculi laryngis*, which is shoved in upward between the ventricular fold on one hand, the m. thyreoarytaenoideus [externus] and the lamina cartilaginis thyreoideae on the other (see also Fig. 661) and usually ends beneath the upper margin of the latter; its anterior margin is bounded by the epiglottis; its walls are folded. Very rearely the appendix is absent, or it may be enlarged. In the new-born it is larger than in the adult.

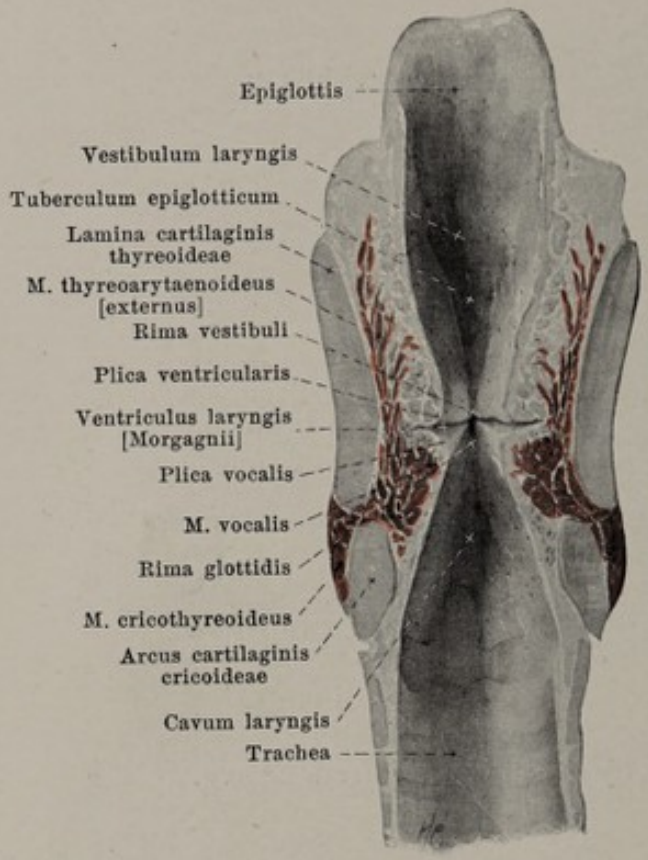
The upper opening of the larynx, *aditus laryngis* (see Fig. 665), looks backward and upward and is triangular and rounded. It is bounded by the posterior surface of the epiglottis and by the plicae aryepiglotticae converging backward; passing for a short distance downward between the cartilagines corniculatae is a small slit, the *incisura interarytaenoidea*. The upper approximately oval part of the cavity, *vestibulum laryngis* (see Figs. 665—667) is higher in front than behind, becomes narrower passing downward and goes over through the *rima vestibuli* (bounded by the two ventricular folds) into the *aditus glottidis superior*, which is bounded lateralward by the ventriculi laryngis. Just beneath it at the level of the 5th cervical vertebra, between the two plicae vocales, lies the *rima glottidis* (see Figs. 663, 665 and 667), the form of which is approximately lancet-shaped in the cadaver, but in life is very variable. In it can be distinguished a longer, anterior portion situated between the plicae vocales and called the *pars intermembranacea*, and a shorter posterior portion, bounded lateralward by the medial surfaces of the arytaenoid cartilages, behind by the anterior surface of the m. arytaenoideus transversus, and called the *pars intercartilaginea*. The space situated just beneath the rima glottidis, the *aditus glottidis inferior*, is oval in cross-section; where it goes over into the trachea, it is round.



665. Cavity of the larynx, viewed from above.



666. Median section of the larynx,
right half, viewed from the left.

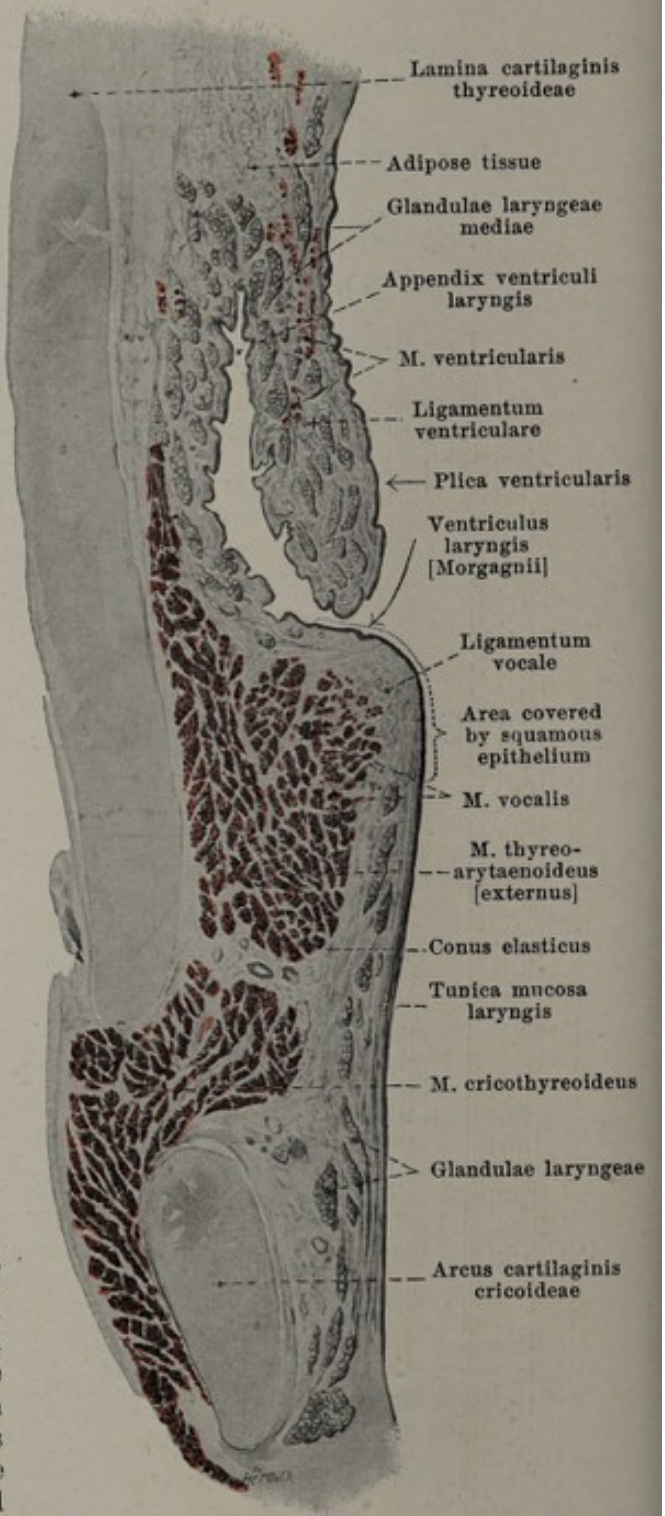


667. Frontal section of the larynx,

anterior half, viewed from behind.

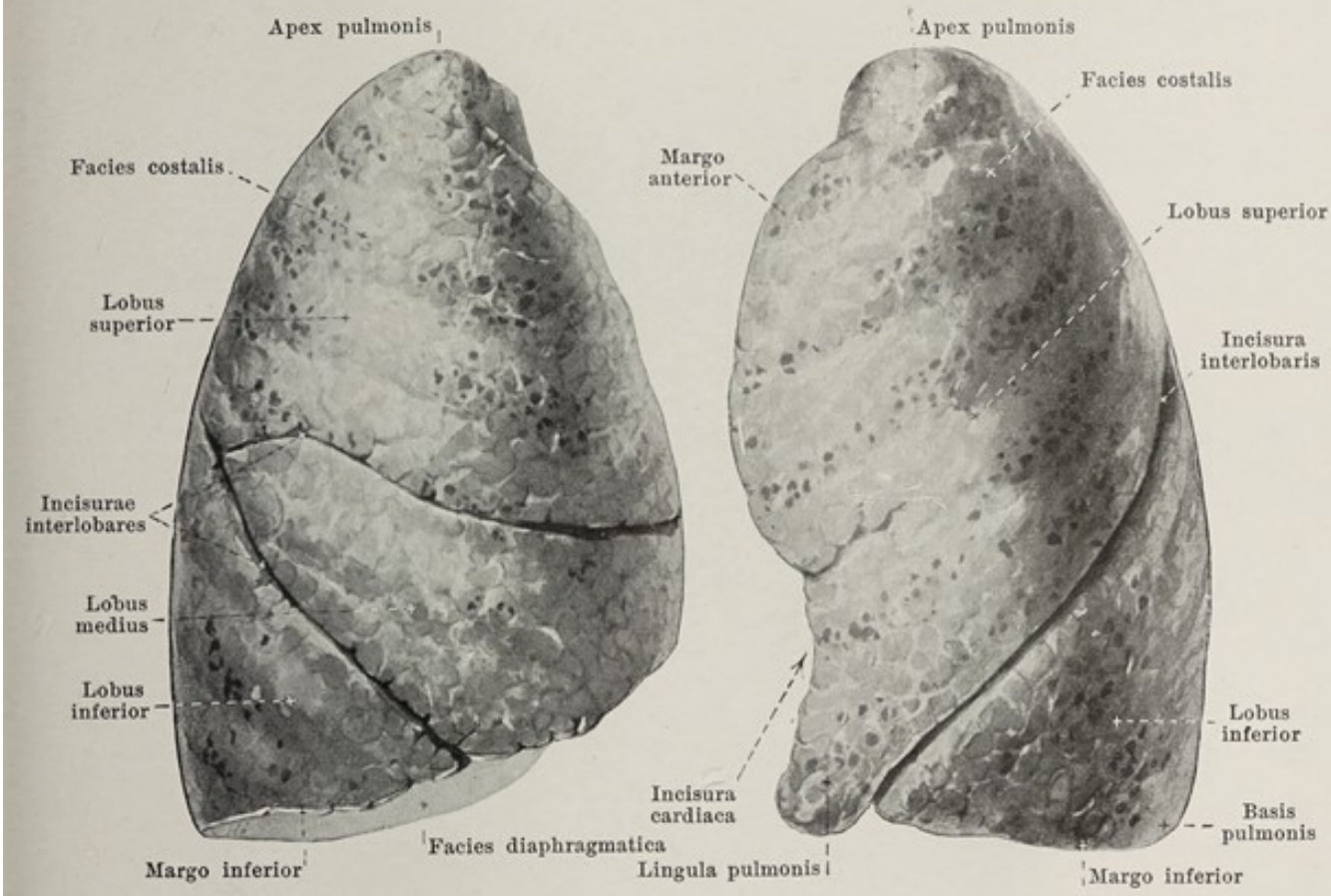
(The section passes through the posterior portion of the vocal fold.)

The *mucous membrane of the larynx* is of a reddish color, that of the vocal folds of a white color; it is firmly connected with the underlying tissue on the posterior surface of the epiglottis and on the ventricular and vocal folds, elsewhere more loosely. It contains lymph nodules, *noduli lymphatici laryngei*, on the posterior surface of the epiglottis and in the ventriculus laryngis; also numerous glands, *glandulae laryngeae*. The latter are found in larger groups in front of and behind the epiglottis, *gl. laryngeae anteriores* (see Fig. 666); in the ventricular fold, as a sheath for the cartilago cuneiformis, in the fovea triangularis of the arytaenoid cartilage and in the ventriculus laryngis, *gl. laryngeae mediae;* as well as before, within and behind the m. arytaenoideus transversus, *gl. laryngeae posteriores.* The glands are entirely absent from the vocal folds.



668. Frontal section through the anterior part of the larynx.

Magnification: 5 : 1.

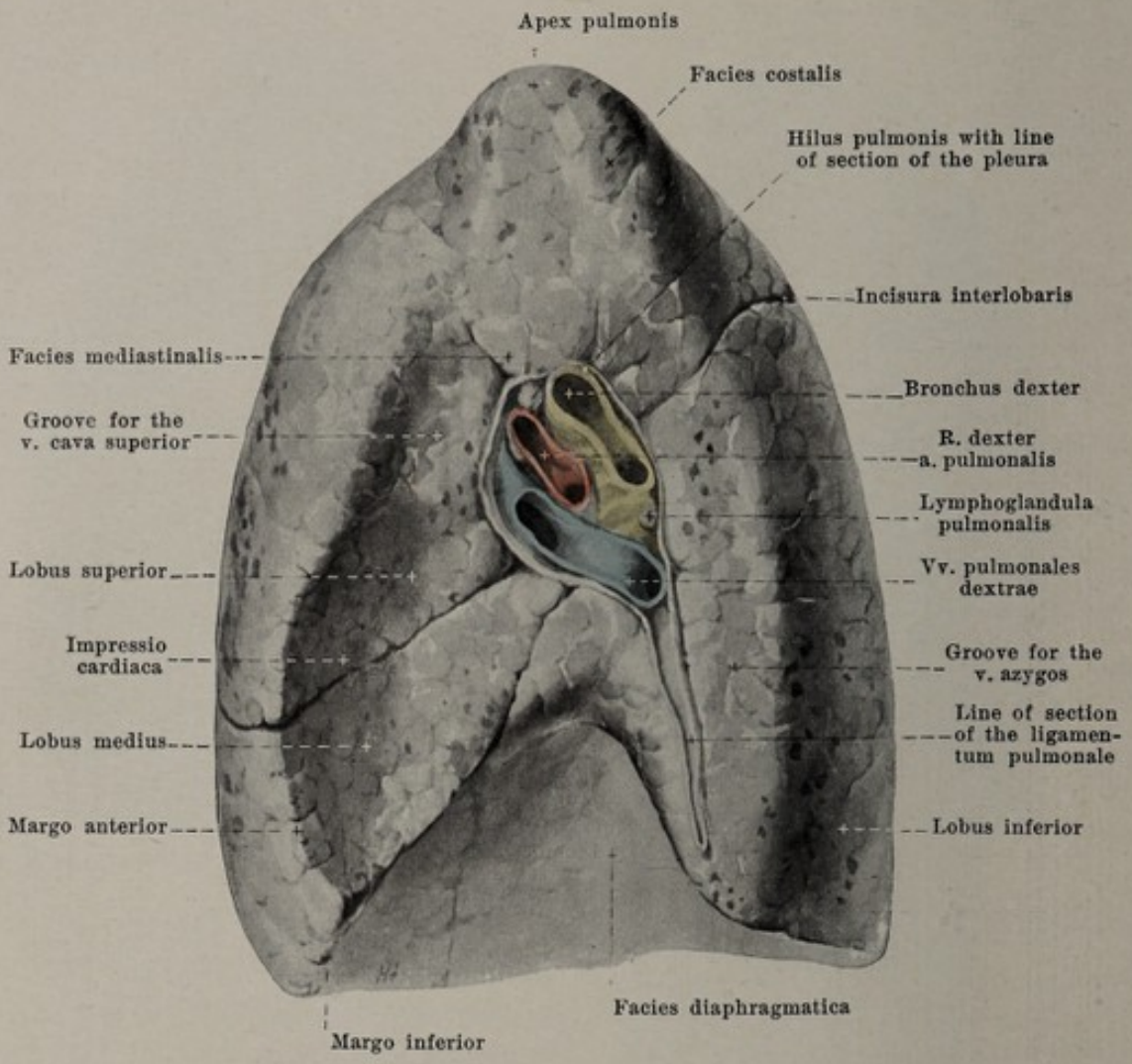


669. Right lung, 670. Left lung,

viewed from in front and lateralward.

The **trachea** (see Figs. 358, 563, 567, 606, 607, 658, 659, 666, 675, 680 and 682) is a cylindrical, hollow, elastic tube. It begins above as the continuation of the larynx in front of the 7th cervical vertebra, passes downward and somewhat backward and divides *(bifurcatio tracheae)* in front of the 4th or 5th thoracic vertebral body, at the level of the processus spinosus of the 4th thoracic vertebra or somewhat below this point, into the two *bronchi;* as it descends it is more deeply situated, lies in the median plane and below only deviates a little to the right. Its posterior wall adjoins the oesophagus. In front it is covered in the neck by the isthmus glandulae thyreoideae and by the v. thyreoidea ima, in the thoracic cavity by the a. anonyma, a. carotis communis sinistra, arcus aortae, v. anonyma sinistra and by the thymus gland situated in front of them. Its lateral surfaces lie in the neck in contact with the lobi glandulae thyreoideae and the nn. recurrentes (X), in the thoracic cavity on the right side with the n. vagus dexter, the v. azygos and the pleura mediastinalis, on the left side with the n. recurrens sinister (X) and the arcus aortae. It is ensheathed in loose connective tissue, which contains especially on the anterior surface numerous lymph nodules, *lymphoglandulae tracheales;* especially constant is a large group of lymph glands beneath the angle of bifurcation, *lymphoglandulae bronchiales.* The cross-section of the trachea is rounded with its posterior wall flattened. The lumen enlarges from above toward the middle and then again diminishes in size.

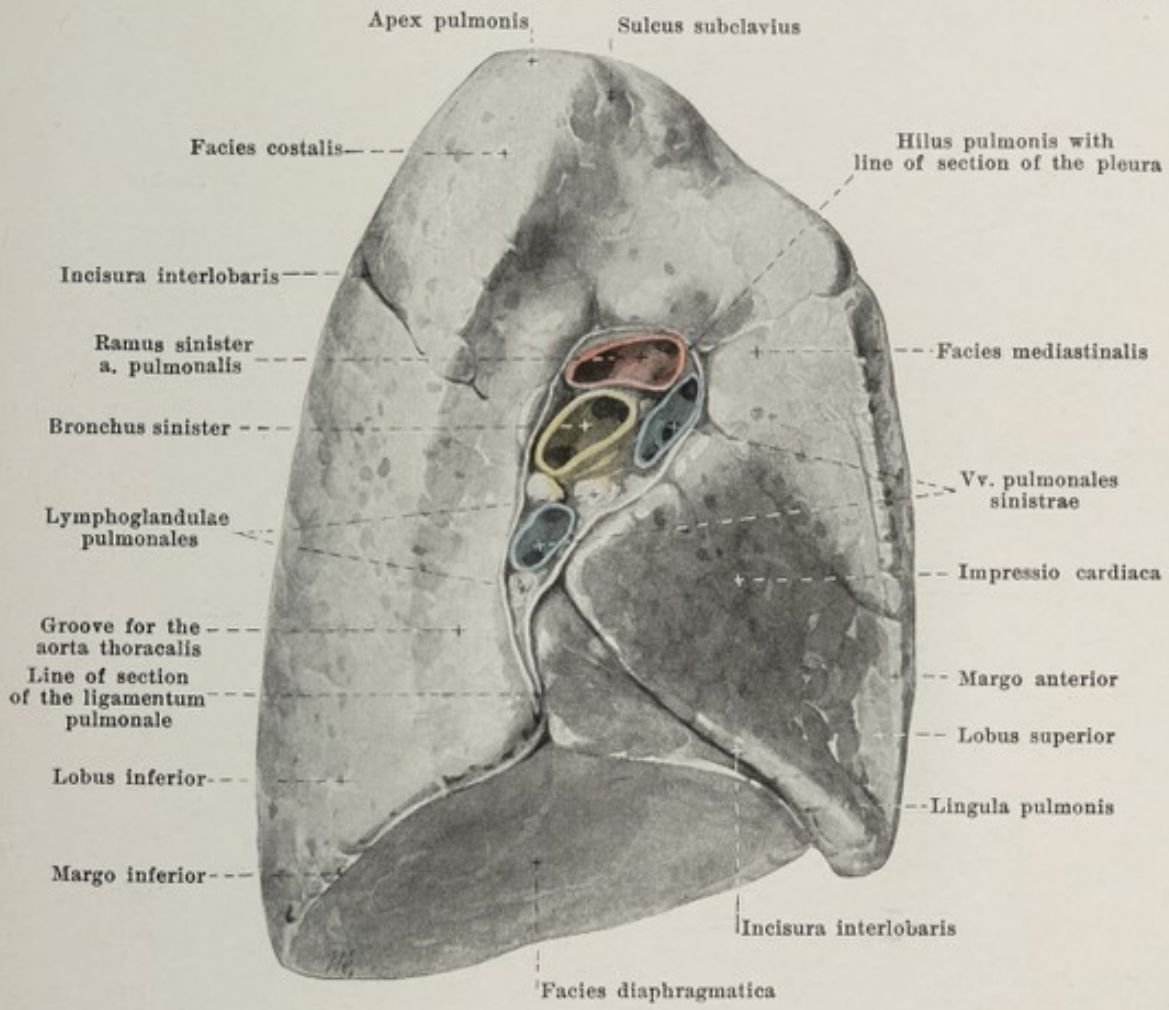
The wall of the trachea contains 16—20 horseshoe-like curved strips of hyaline cartilage, open behind, the *cartilagines tracheales.* They are often split and may be united with their neighbors. The strips of cartilage are connected with one another by means of the *ligamenta annularia [trachealia],* tough membranes, consisting chiefly of elastic and collagenous fibres running longitudinally; these membranes are continous with the perichondrium, and with a similarly built but thinner layer of the posterior wall. The posterior wall, *paries membranaceus,* consists besides internally of the *tunica muscularis,* a layer of smooth muscle fibres which are stretched out, especially transversely, between the ends of the cartilages. The mucous membrane, *tunica mucosa,* is pale, and on the posterior wall is thrown up into longitudinal folds. It is connected with the underlying tissue by the *tela submucosa,* which consists of connective tissue, in which are numerous glands, *glandulae tracheales* (not illustrated), especially in the anterior and posterior wall; posteriorly, the largest are found in part between and behind the muscles.



671. Right lung, viewed from the medial surface.

The **lungs** *(pulmones)* (see also Figs. 670, 672, 678, 679, 682 and 683) are paired, approximately wedge-shaped organs, which fill up the lateral halves of the thorax, are connected with the trachea through its two subdivisions, the bronchi, and contain the terminal branches of these bronchi. They are covered on their outer surface by the pleura pulmonalis (see p. 587). Their color is reddish gray with blue and black spots.

Each lung presents above a blunt tip, *apex pulmonis*, and below a broad base, *basis pulmonis*, with the markedly concave *facies diaphragmatica*, which lies upon the diaphragm and is directed downward and medianward. The markedly convex *facies costalis* which looks forward, lateralward and backward is bounded by the ribs; it presents, corresponding to the intercostal spaces, flat bulgings, which are characterized by the presence of more marked accumulations of pigment. This surface with the facies diaphragmatica helps to form the sharp *margo inferior*. The medial surface, *facies mediastinalis*, is approximately vertical and is directed toward the pericardium and the medianstinal spaces; it forms with the facies costalis in front the sharp *margo anterior*, behind a blunt margin, while with the facies diaphragmatica it forms a part of the sharp margo inferior. The medial surface presents, nearer its posterior margin than its anterior, a club-shaped fossa, the *hilus pulmonis*, in which lie the bronchi and the vessels and nerves entering and leaving the lung and also several lymph nodules, *lymphoglandulae pulmonales*. The structures running to the hilus are grouped together as the *root of the lung, radix pulmonis* (see also Fig. 683). Behind the hilus on the left runs a deeper and broader furrow for the aorta thoracalis, on the right a flatter and narrower one for the v. azygos perpendicularly upward and then bends around forward. Connected with this toward the apex is a flat groove, the *sulcus subclavius*, for the a. subclavia. In front of and below the hilus lies a fossa, for the heart, *impressio cardiaca*, deeper on the left side and going over on the right side above into a groove for the v. cava superior.

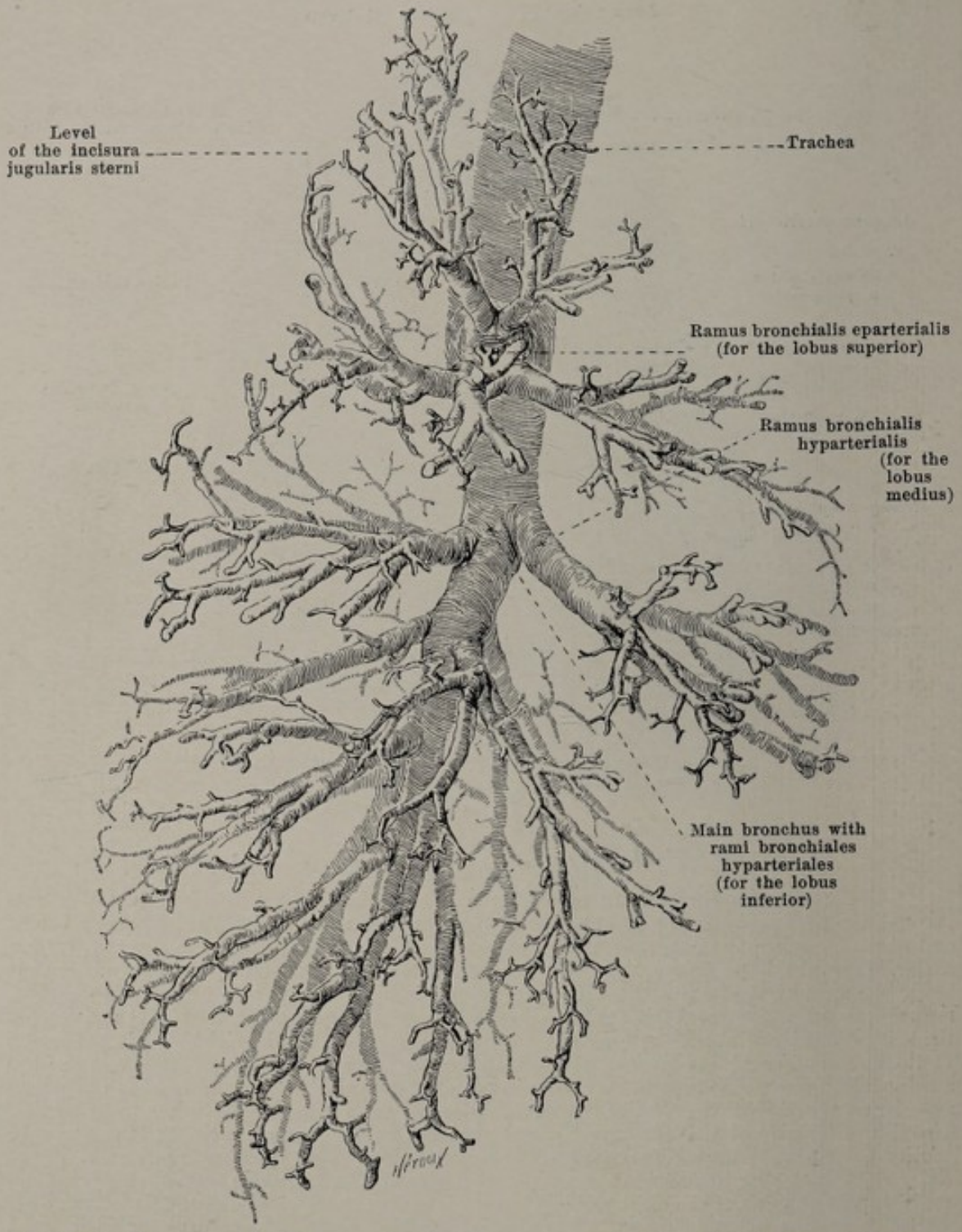


672. Left lung, viewed from the medial surface.

The **lungs** (continued). In each lung a fissure, the *incisura interlobaris*, which cuts through the whole substance almost as far as the hilus (see also Fig. 683) extends from behind and above forward and downward and separates a smaller, upper lobe, *lobus superior*, from a larger, lower lobe, *lobus inferior*. The fissure whose course often varies begins commonly somewhat below the apex at the level between the processus spinosi of the 2nd and 3rd thoracic vertebra, runs downward and forward (on the left somewhat more steeply than on the right) and reaches the margo inferior in about the region of the mammillary line. In the right lung in the region of the axillary line at the level of the 4th intercostal space there goes off from this incisure a second deep one which runs in an approximately horizontal direction and reaches the margo anterior at the level of the 4th rib; it together with the main incisure bounds the *lobus medius*. The margo interior of the left lung is deeply notched below, *incisura cardiaca;* the narrower portion projecting forward beneath it from the upper lobe is called the *lingula pulmonis*.

The right lung is somewhat shorter and broader and on the whole somewhat larger than the left. The volumes of the right and left lungs are in man in the ratio of 10: 9, in woman 8: 7.

Position of the lungs. The apex of the lung projects upward as far as in front of the neck of the first rib (see Figs. 679—681); it is somewhat higher and somewhat farther forward on the right than on the left and in the ordinary, upright position reaches from one to three cm above the extremitas sternalis claviculae. The margo inferior extends in front, on moderate expiration, first along the lower margin of the 6th rib, cuts the upper margin of the 7th rib in the mammillary line, crosses the 8th rib in the axillary line, the 9th and 10th rib in the scapular line, and reaches the spine at the level of the processus spinosus of the 11th thoracic vertebra; it thus runs lateralward and backward almost horizontally. The margo anterior begins above on both sides symmetrically behind the articulatio sternoclavicularis, extends thence on the right in a slightly convex curve toward the insertion of the 6th costal cartilage and goes in the middle of its extent a little beyond the median plane. On the left it runs in a corresponding direction as far as the level of the 4th costal cartilage and then curves at the incisura cardiaca first lateralward, then downward and somewhat medianward.

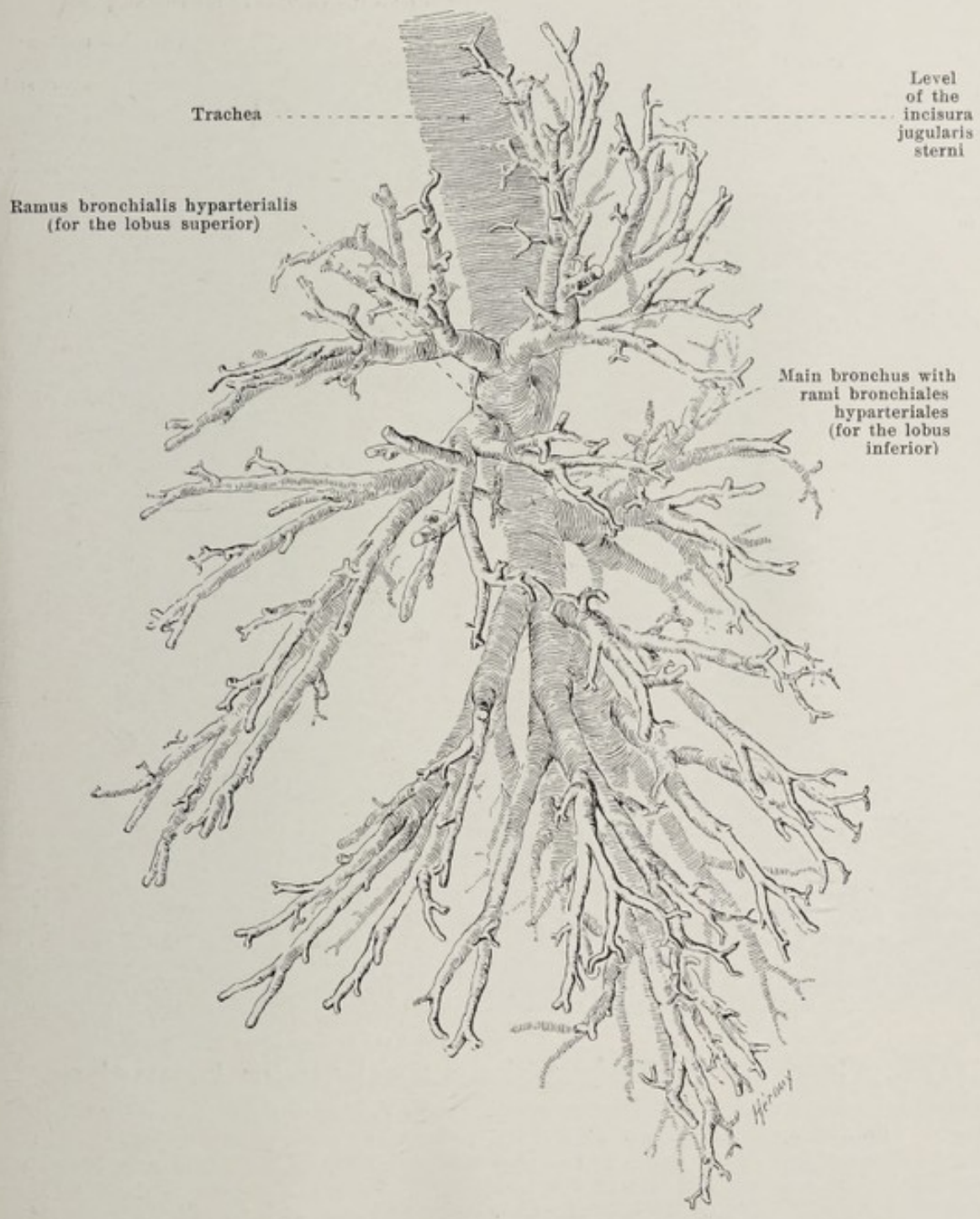


673. Cast of the air tubes and their branches,

viewed from the right, semi-schematic.

(After a preparation of F. V. Birch-Hirschfeld, with the aid of a drawing by Dr. M. Lange. Figs. 673—675 represent the same preparation.)

The two **bronchi**, *bronchus dexter* and *bronchus sinister* (see also Figs. 607, 674 and 675) extend out from the bifurcatio tracheae at an angle, usually less than 90°, and pass downward and lateralward to the hilus pulmonis. The non-branched part is steeper, shorter and a little wider on the right side than on the left. They are constructed exactly as is the trachea and have on the right side 6—8, on the left side 9—12 hyaline rings of cartilage which are open behind; they possess numerous glands, *glandulae bronchiales*, and single lymph follicles, *noduli lymphatici bronchiales*.

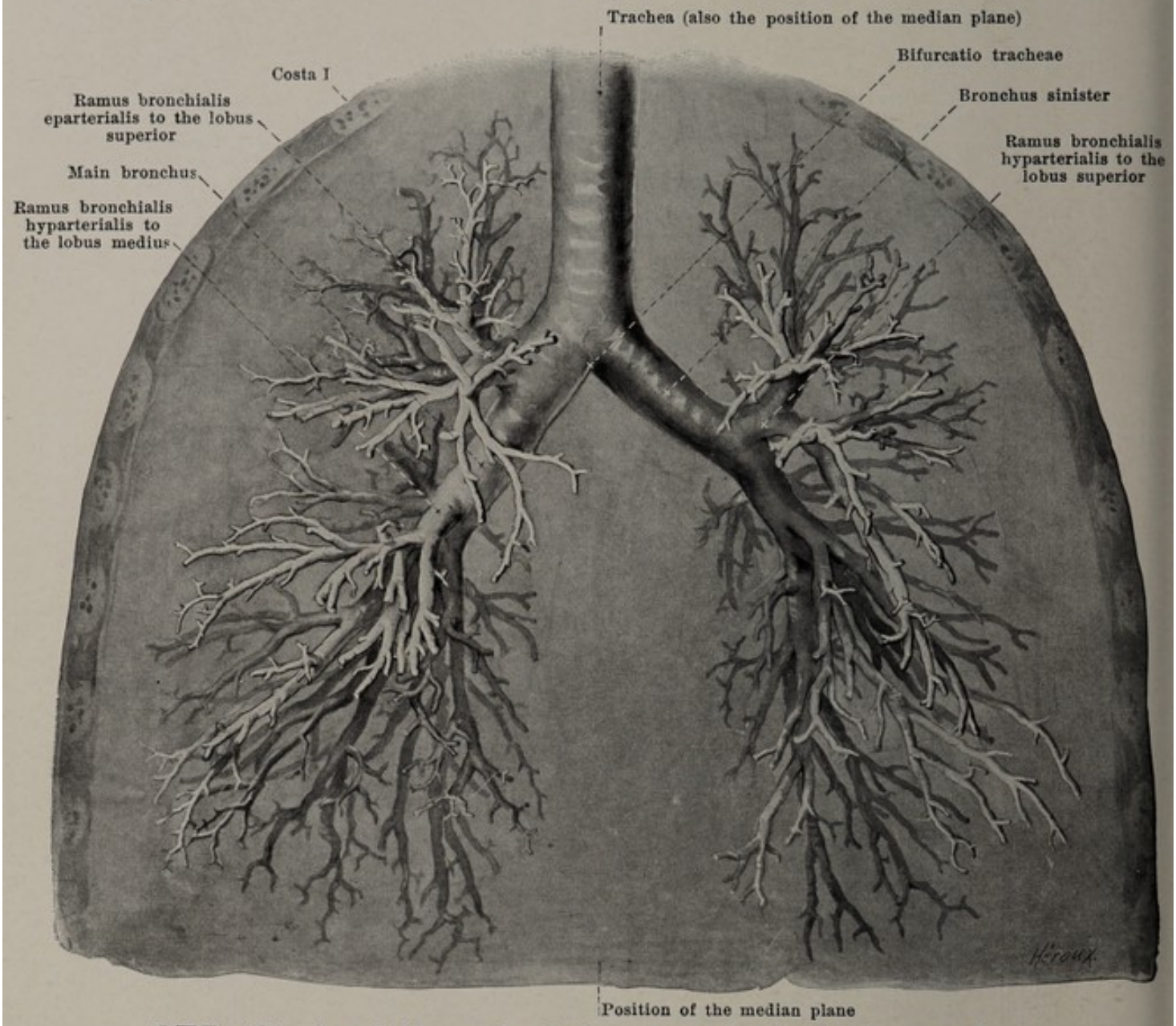


674. Cast of the air tubes and their branches,

viewed from the left, semi-schematic.

(After a preparation of F. V. Birch-Hirschfeld, with the aid of a drawing by Dr. M. Lange. Figs. 673—675 represent the same preparation.)

Position of the bronchus (see Figs. 607, 671, 672, 680 and 681). The branch of the a. pulmonalis runs on each side in front of the bronchus to the hilus, there lies on the anterior and upper surface of the bronchus and then curves around it lateralward to run into the lung along its posterior surface. The vv. pulmonales leave the hilus at the anterior and inferior surfaces of the bronchus. The a. bronchialis is situated in the hilus on the posterior surface of the bronchus. Above and behind the bronchus on the right side runs the v. azygos, on the left side the aorta thoracalis, behind it on both sides the n. vagus.

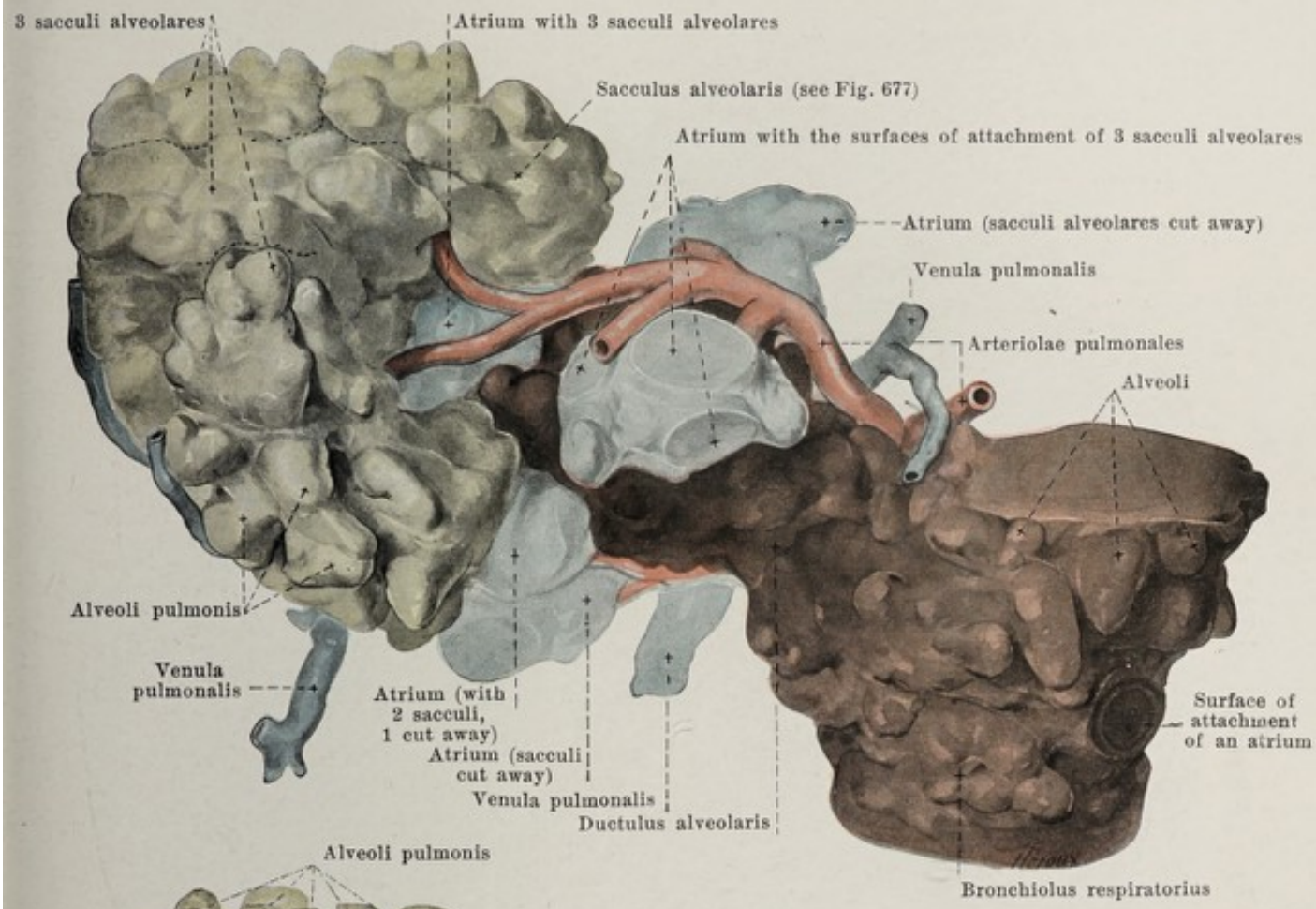


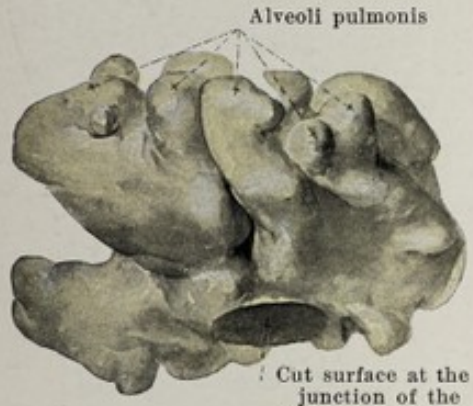
675. Cast of the air tubes and their branches.

viewed from in front. (After a preparation of F. V. Birch-Hirschfeld, with the aid of a drawing by Dr. M. Lange. Figs. 673—675 represent the same preparation.)

Branching of the bronchi (see also Figs. 607, 673 and 674). The main bronchus *(stembronchus)* runs on each side as the continuation of and in the same direction as the corresponding subdivision of the trachea during its whole length as far as the posterior part of the basis pulmonis; the left one is curved slightly like the letter S. From it go off monopodic *lateral bronchi, rami bronchiales,* four ventral and four dorsal arising alternately. The first lateral bronchus supplying the lobus superior goes off on the right side above the place, where the bronchus and the branch of the a. pulmonalis cross one another, as a (single) *ramus bronchialis eparterialis;* on the left it arises below the place of crossing and belongs accordingly like all the other branches to the *rami bronchiales hyparteriales.* The middle lobe on the right side is supplied by the first ventral lateral bronchus. These lateral bronchi give off numerous branches which go on subdividing so that they become finer and finer and form the *bronchioli.*

The main bronchi and their branches present only irregular cartilaginous plates which are distributed about the whole circumference of the tubes. They are larger at the beginning, where they are also closer together; they disappear in the tubes of 1 mm diameter; the larger ones have a hyaline ground-substance, the small tubes one with elastic fibres. Internally from them lies a circular layer of smooth muscle fibres and a mucous membrane. Glands are present on the outer surface of the muscles wherever the cartilages occur; *noduli lymphatici bronchiales* are present down to the finest branches.





677. Air saccule, by itself.

Magnification: 60:1 (see Fig. 676).

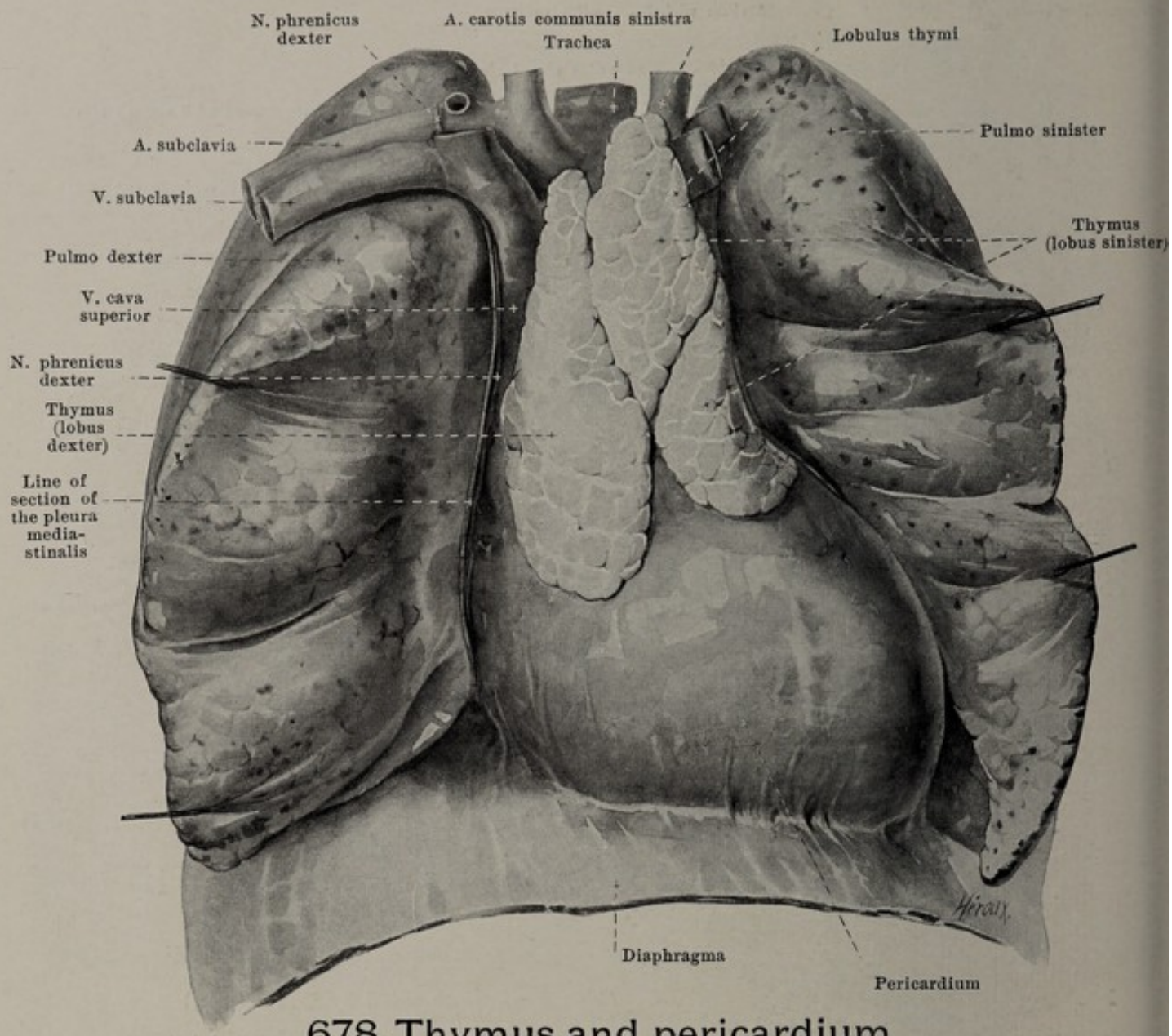
676. Alveolar duct, with branches and blood vessels, from the dog.

Magnification: 60:1

(After a wax-plate model by W. S. Miller.)

Mode of termination of the air spaces. Each bronchiolus divides farther into branches, *bronchioli respiratorii*, the walls of which are no longer smooth but present numerous small bulgings, *alveoli pulmonis*. Out of these bronchioli respiratorii, as terminal branches, pass the *alveolar ducts, ductuli alveolares*, which bear alveoli on all sides and lead through openings in their terminal piece into several approximately spherical spaces, *atria*. Each atrium is connected in turn with a number of larger and more irregular cavities, *air sacs, sacculi alveolares (infundibula)*, the whole surface of which is closely set with small cavities, *alveoli pulmonis*. Each alveolar duct together with its branches forms a *lobule of the lung, lobulus pulmonis*. The bronchioli respiratorii and the ductuli alveolares still possess a circular layer of smooth muscle fibres but this is absent from the atria and sacculi alveolares.

The branches of the a. pulmonis accompany the air-conducting tubes as far as the atria and break up into capillaries on the sacculi alveolares. The smallest veins collect at the periphery of the lobule, receive tributaries from the points of division of the bronchioli and run at first between the lobules, separated as far as possible from the bronchioli and the arteries; only when the larger branches have been reached in the neighborhood of the hilus do they approach the anterior surface of the bronchi.



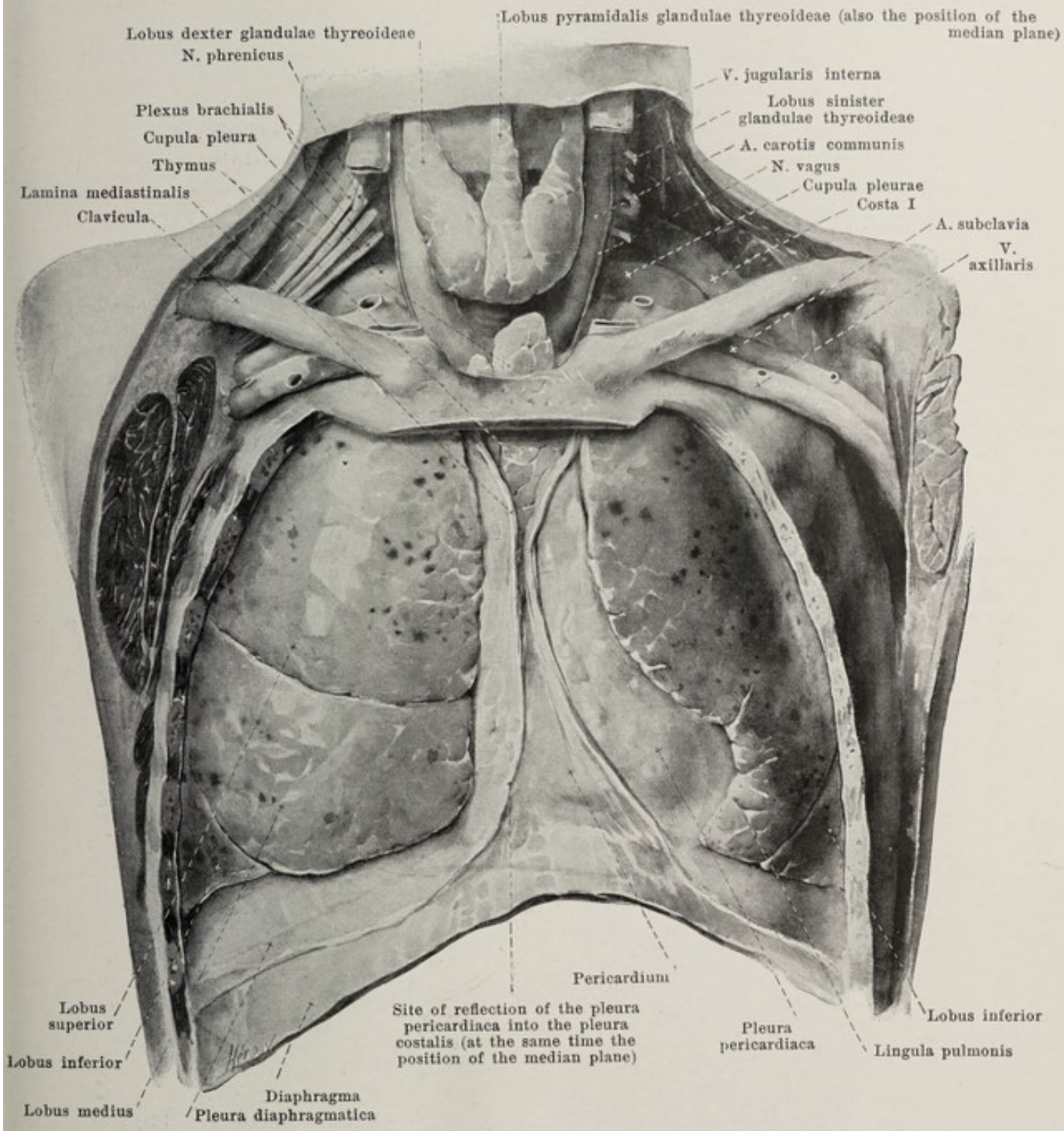
678. Thymus and pericardium

of a 12 year old boy, viewed from in front.

(The lungs have been drawn aside and the thymus and pericardium dissected out after removal of the pleurae mediastinalis.)

The **thymus**, or *thymus gland*, which develops as a paired organ from the ventral diverticula of the 3rd and 4th embryonal pharyngeal pouches, increases in size up to the beginning of puberty, and then in healthy individuals gradually decreases. From the 20th—25th year on the interstitial connective tissue, which in a person of mature age has the character of adipose tissue, exceeds greatly the parenchyma of the gland. The organ from birth shows no sexual differences; but later in life it seems to be lighter in woman than in man. It is of a grayish-red color, has an irregular flat-oblong shape and consists of two usually asymmetrical *lobes*, *lobus dexter* and *lobus sinister*, united only by loose connective tissue. Each of these lobes is composed of a large number of small *lobules*, *lobuli thymi*, which are separable from one another, but all are connected by a *medullary cord*, *tractus centralis* (not illustrated), which follows a tortuous course inside the thymus and penetrates also into the lobules.

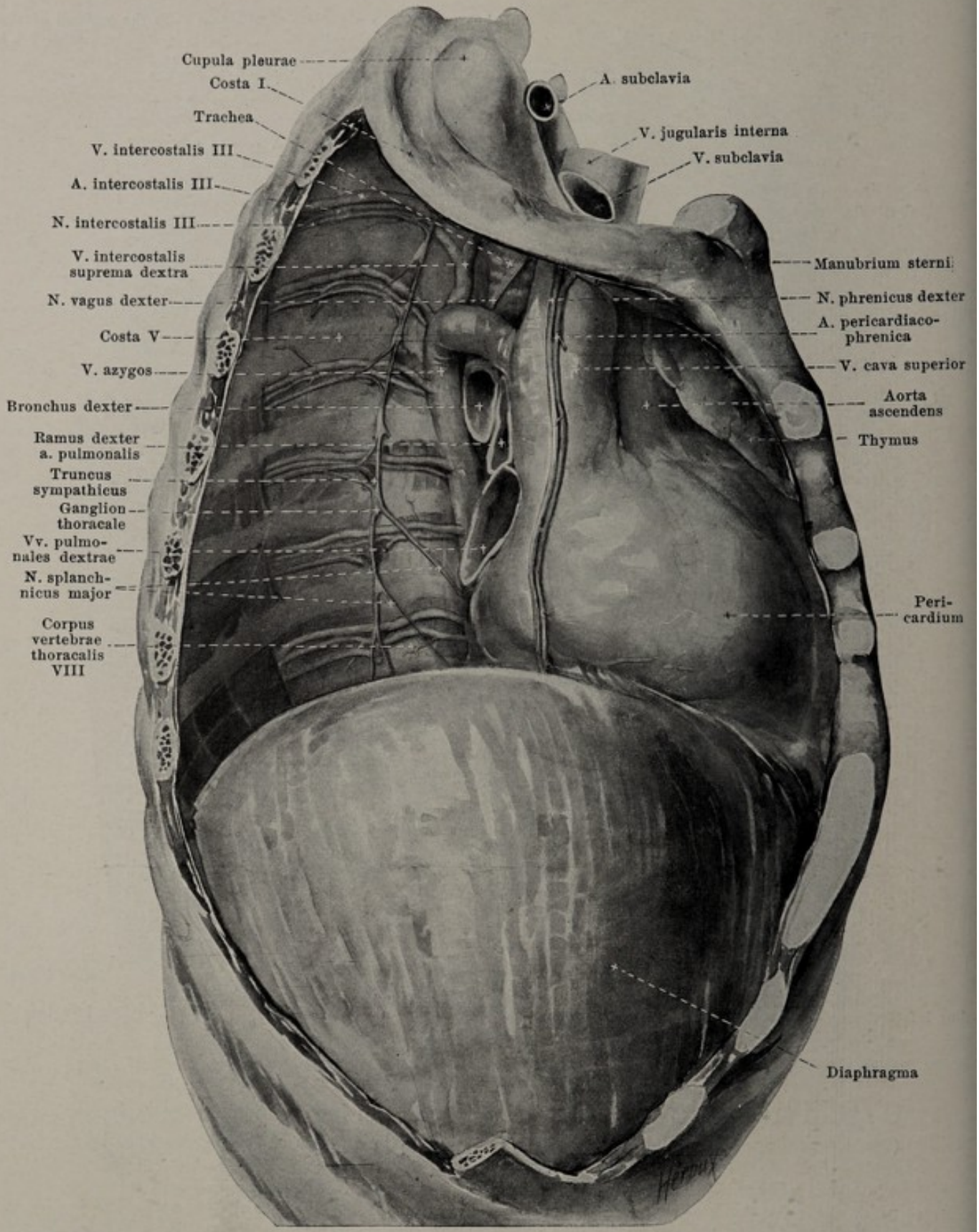
It lies (see also Figs. 679—681) just behind the sternum in the spatium mediastinale anterius, is bounded behind by the upper part of the pericardium, the v. cava superior, vv. anonymae, the arcus aortae and its branches, lateralward and partly in front by the pleura mediastinalis. Above it may reach behind the mm. sternothyreoidei as far as the glandula thyreoidea. Its anterior wall is loosely, the others more firmly connected with the surrounding tissues.



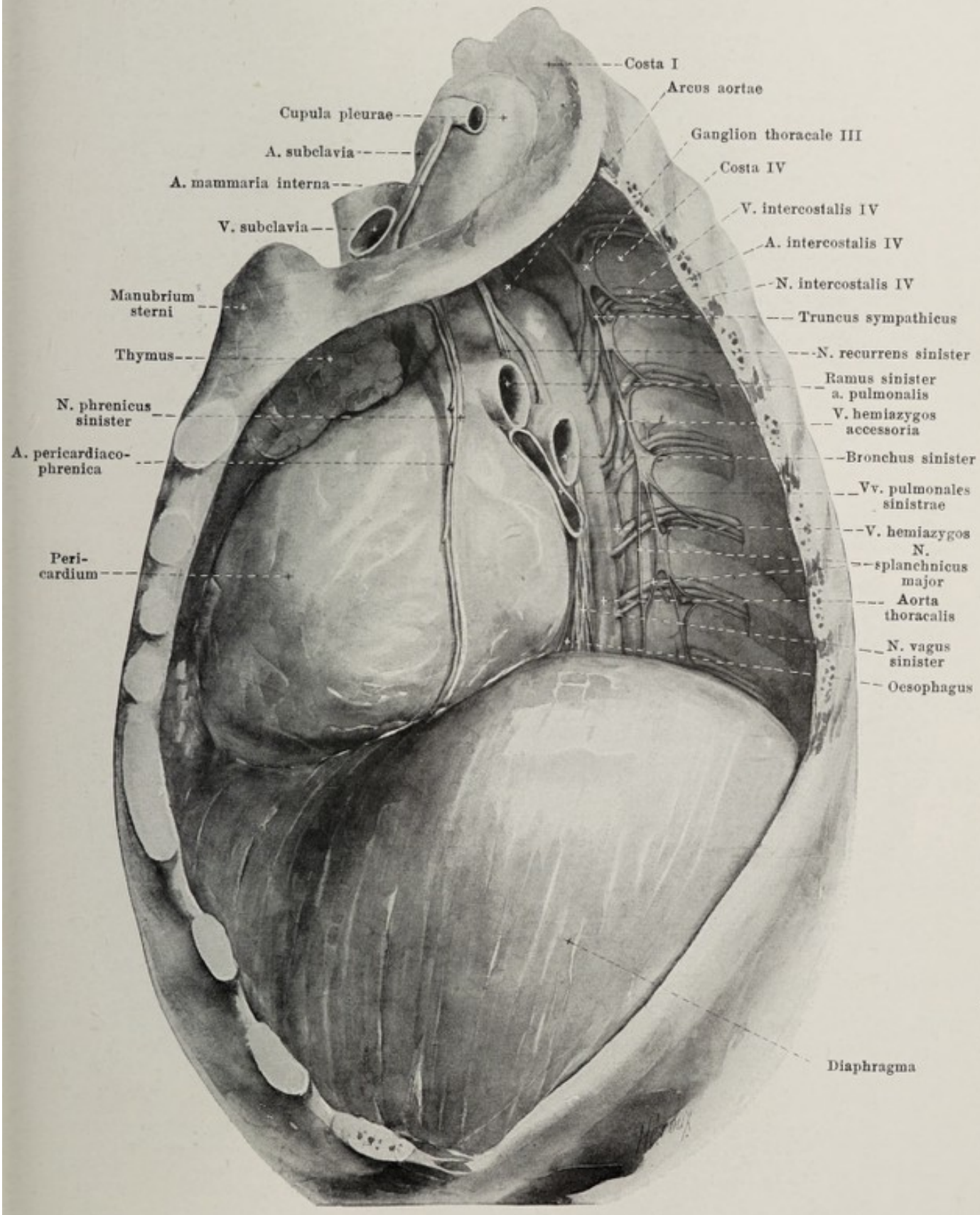
679. Thoracic viscera of a 12 year old boy, viewed from in front.

(The sternum and ribs have been removed. In the neck the cupulae of the pleurae have been exposed. The lungs are somewhat retracted.)

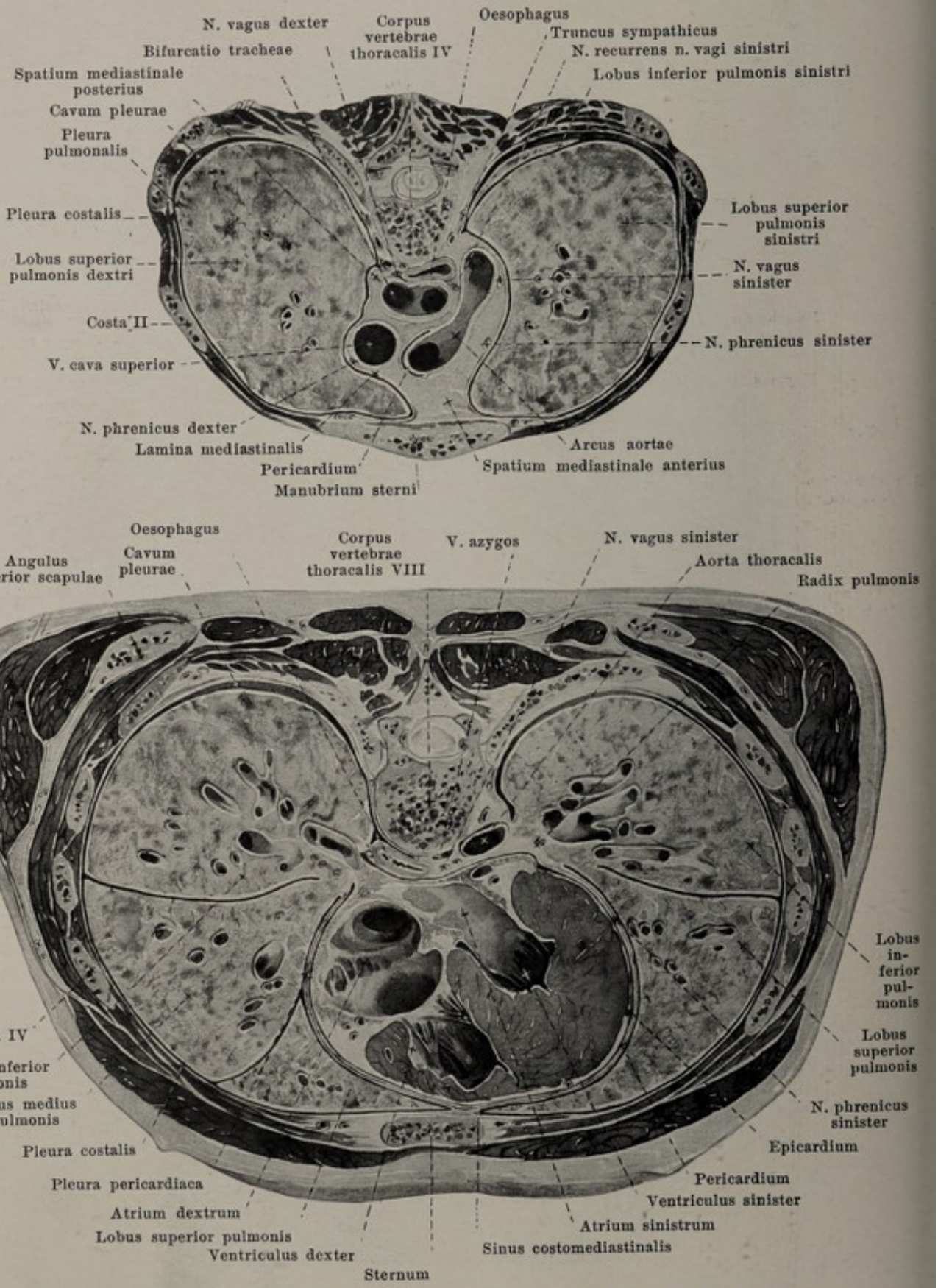
The **pleurae** (see also Figs. 682 and 683) are two smooth, glistening, serous membranes which cover the walls and viscera of the thoracic cavity *(cavum thoracis)*. They form, one in the right and one in the left half of the thoracic cavity, sacs complete in themselves, separated from one another by the septum mediastinale; one portion of each sac, *pleura pulmonalis*, covers the lung, and the other portion, *pleura parietalis*, the walls of the space occupied by the lung; the two portions go over into one another at the hilus pulmonis and inclose a slit-like space, *cavum pleurae*, which contains a very small amount of clear, serous fluid.



680. Right thoracic cavity and septum mediastinale, viewed from the right, after removal of the lungs and pleura.



681. Left thoracic cavity and septum mediastinale,
viewed from the left, after removal of the lungs and pleura.



682 and 683. Cross-sections of the thorax,

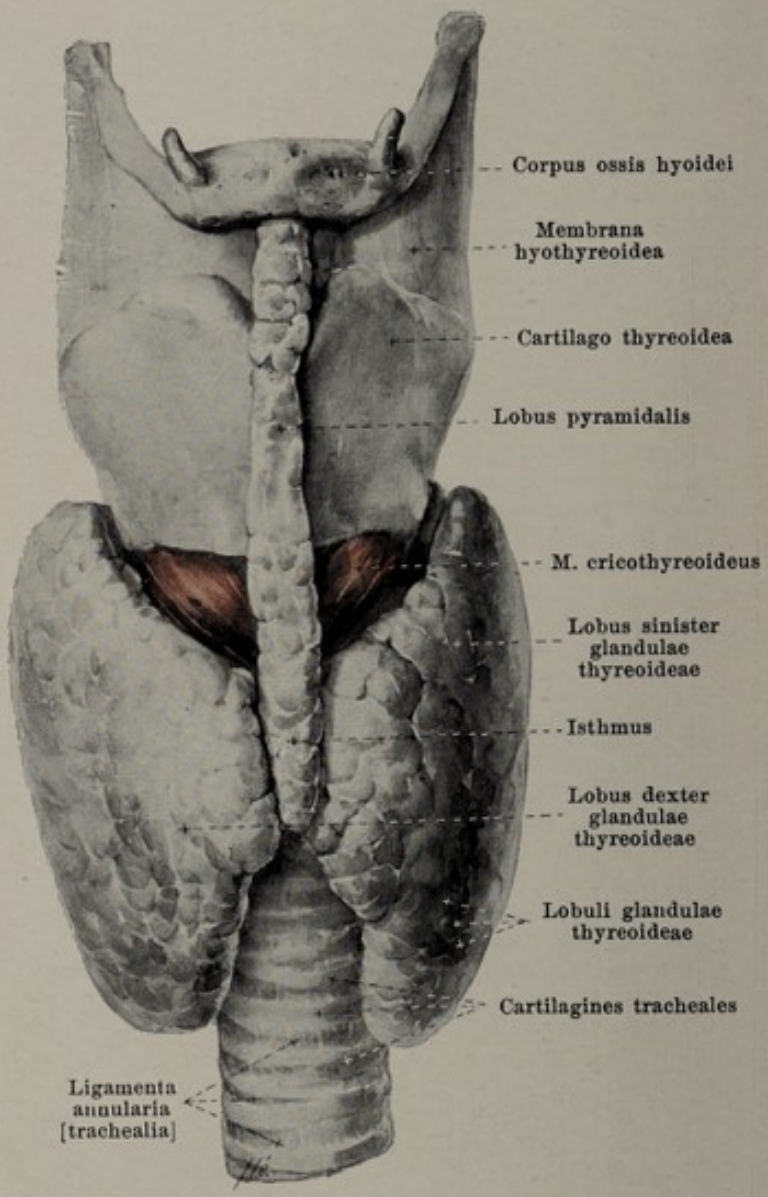
viewed from above (after W. Braune).

Pleura (continued).

The ***pleura pulmonalis*** is intimately fused with the surface of the lung and follows it even into the depth of the incisurae interlobares (see Fig. 683). At the hilus it leaves the surface of the lung, is attached for a short distance to the root of the lung (see Fig. 683) and is then continued into the pleura mediastinalis. In so doing it forms below the hilus between the lung and the pleura mediastinalis a triangular duplicature, *ligamentum pulmonale*, the origin of which on the right lung runs in front of the groove for the v. azygos, on the left in front of the groove for the aorta thoracalis almost as far as the facies diaphragmatica (see Figs. 671 and 672); below it ends with a free margin or is attached to the pleura diaphragmatica.

The ***pleura parietalis*** is divisible into *pleura costalis*, *pleura diaphragmatica* and *pleura mediastinalis*. The *pleura costalis* (costal pleura) (see Figs. 682 and 683) covers the inner surface of the ribs on both sides, the lateral surface of the bodies of the thoracic vertebrae, partly also the posterior surface of the sternum, the mm. intercostales, subcostales and transversus thoracis, as well as the aa., vv. and nn. intercostales, a. and vv. mammariae internae, the truncus sympathicus and its branches. It is connected with these parts by the *fascia endothoracica* (not illustrated), a layer of connective tissue, which is strongest anteriorly behind the cartilages of the ribs and becomes thinner and looser posteriorly. Above the pleura forms a blind-sac-like prolongation, the *cupula pleurae* (see Figs. 679—681), which lies exactly at the apex of the lung and which accordingly projects as this does upward as far as the neck of the first rib (see p. 581). The cupula is related (from behind forward) to the lowermost bundle of origin of the plexus brachialis, to the ganglion cervicale inferius, the m. scalenus minimus, the a. subclavia with the first portions of the a. vertebralis and a. intercostalis suprema, the m. scalenus anterior, the a. mammaria interna and the v. subclavia, on the left also the ductus thoracicus; it is attached by the m. scalenus minimus and different bands of connective tissue upward to the cervical spine and fasciae. The *pleura diaphragmatica* (see Fig. 679) covers the upper surface of the diaphragm very firmly and exactly as far as the neighborhood of its origins from the ribs, where it is reflected into the pleura costalis; this line of reflection begins near the sternum at the lower margin of the 6th rib, cuts the 7th rib at the junction of the cartilage with the bone, the 8th rib behind it and reaches the spine at the lower border of the body of the 12th thoracic vertebra or of the processus transversus of the 1st lumbar vertebra below the attachment of the 12th rib. Between this line of reflection and the lower margin of the lung (see p. 581) the pleura diaphragmatica lies on the pleura costalis for some distance and with it bounds the *sinus phrenicocostalis*. During inspiration the lung passes into this *sinus pleurae* which then becomes smaller, but is not, as a rule, totally obliterated in its most dependent parts, since the lung generally does not pass as far as the line of reflection.

The right and the left cavum pleurae are separated by the ***septum mediastinale*** which is narrower above and broader below and contains chiefly the heart, the great vessels, the trachea, the oesophagus and the thymus gland (see Figs. 680—683). This septum is covered right and left by the ***pleura mediastinalis:*** that portion of this which is very firmly fused with the parietal layer of the pericardium is designated as *pleura pericardiaca*, the rest of it as *lamina mediastinalis*. The pleura mediastinalis is connected in front and behind with the pleura costalis, below with the pleura diaphragmatica. The anterior line of reflection (see Fig. 679) runs on the right as does the anterior margin of the right lung (see p. 581), on the left in a similar curve but so that it usually lies lateralward from the medial end of the 5th left intercostal space; as a result of this the pleurae of the two sides may come into contact with one another between the 2nd and 4th costal cartilages but are usually separated, however, especially in younger individuals by a layer of loose tissue. The starting point of the mediastinal pleura behind lies on the lateral surface of the bodies of the vertebrae. Toward the apex the pleura mediastinalis goes over into the medial wall of the pleural cupula; below this it extends almost directly (see Fig. 682) from before backward and in so doing directly covers on both sides the thymus, nn. phrenicus and vagus, on the right side (see Fig. 680) the vv. cava superior, anonyma dextra and azygos, as well as the trachea, on the left side (see Fig. 681) the aorta thoracalis and the a. subclavia sinistra. The pleura mediastinalis is curved out lateralward below (see Fig. 683), more markedly on the left than on the right side, but in the neighborhood of its posterior portion it is interrupted by the hilus pulmonis and the ligamentum pulmonale, upon which it becomes reflected; it thus directly covers as pleura pericardiaca in front the pericardium, the nn. phrenici and the accompanying vessels, behind the oesophagus with the nn. vagi (on the right in the middle, on the left below) as well as on the right the v. azygos and the vv. intercostales dextrae and on the left the aorta thoracalis. Anteriorly, where the pleura costalis goes over into the pleura mediastinalis, more distinctly visible below than above, is a slit-like space, *sinus costomediastinalis* (see Fig. 683), which on inspiration is, in general, completely filled up by the margo anterior of the lung; only the portion situated in front of the heart and corresponding to the incisura cardiaca (see Fig. 679) remains free from the lung even on deepest inspiration. In the sinus phrenicocostalis and in the groove between the pleura diaphragmatica and the pleura mediastinalis are frequently situated lobe-like adipose appendages of the mediastinum, *plicae adiposae* (not illustrated), which carry small villous projections, *villi pleurales*.



684. Thyroid gland,

in its position to the larynx and to the trachea, viewed from in front.

Pleura (continued).

The ***septum mediastinale*** is divided into two portions of different size, which are separated only indistinctly from one another by the heart with the pericardium, the central part of the large vessels, the roots of the lungs and the trachea. The smaller, anterior portion, *spatium mediastinale anterius*, contains the aa. and vv. mammariae internae, nn. phrenici, thymus gland and lymph glands; the posterior, *spatium mediastinale posterius*, contains the aorta thoracalis, aa. and vv. intercostales dextrae, vv. azygos and hemiazygos, ductus thoracicus, nn. vagi and splanchnici, oesophagus and lymph glands (see also Figs. 682 and 683).

The **thyroid gland** *(glandula thyreoidea)* (see Figs. 358, 567, 679, 684 and 685) is an unpaired very variable, frequently asymmetrical gland, which in the early embryonal period opens to the outside by means of an duct, *ductus thyreoglossus* (see p. 507), but later forms a body completely shut off from the surface. It is of a bluish-red or reddish-yellow color, lies upon the lateral surface of the larynx as well as upon the lateral and anterior surfaces of the upper end of the trachea and surrounds the latter like a horse-shoe. It is covered in front (see Figs. 349 and 353) by the mm. sternothyreoidei, omohyoidei, sternohyoidei and sternocleidomastoidei. It presents for examination two *lateral lobes, lobus dexter* and *lobus sinister*, which are united with one another in front by means of a *middle piece, isthmus glandulae thyreoideae*. The oblong and thick *lateral lobe* lies on each side on the lateral surface of the trachea and oesophagus as well as on each side of the larynx and pharynx. On the thyroid cartilage it reaches only as far as the insertion of the m. sternothyreoideus; from there on it is pressed somewhat backward and becomes drawn out into a pointed process which may extend as far as the hyoid bone. Its medial surface is in contact below also with the n. recurrens (X); its posterior surface is in contact with the a. carotis communis (which usually makes a groove-like impression upon it), the a. thyreoidea inferior and the v. jugularis interna, above also with the fascia praevertebralis; the anterior surface, directed at the same time lateralward, is covered by the above-mentioned muscles. The *middle piece* is essentially shorter and covers the 2nd, 3rd and 4th, very often also the 1st cartilago trachealis; going out from it, usually from the left side, is often a process, variable in from, the *lobus pyramidalis*, which passes in front of the thyroid cartilage upward toward the middle of the hyoid bone, but does not always reach it. The isthmus varies much in its development and may be absent altogether. The gland consists of connective tissue, *stroma glandulae thyreoideae*, in which lie small gland vesicles, which are arranged in larger groups, *lobuli glandulae thyreoideae*.

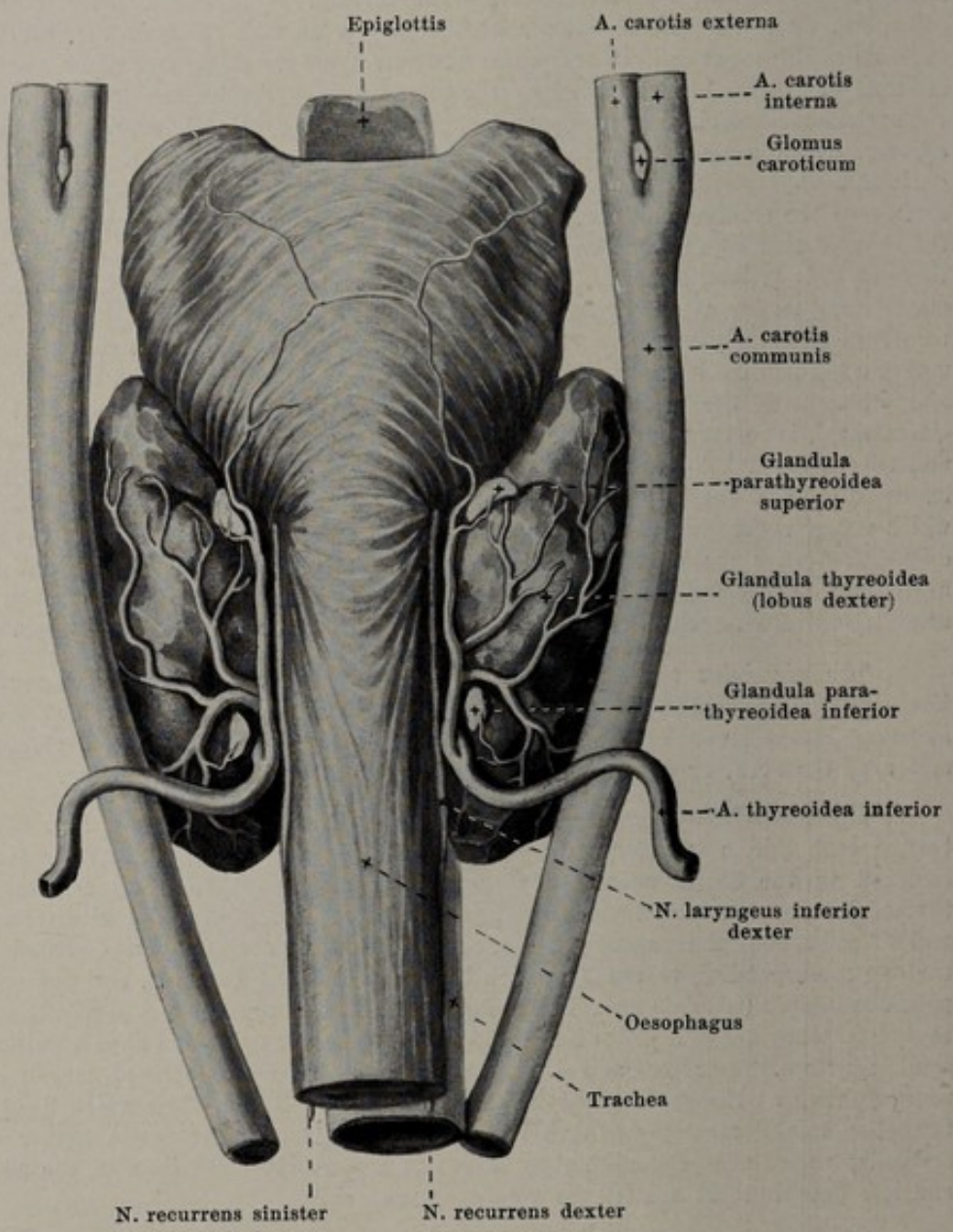
The *glandulae thyreoideae accessoriae* (not illustrated) are small masses of thyroid tissue which may occur close above the hyoid bone *(glandula thyreoidea accessoria suprahyoidea)*, in the course of the lobus pyramidalis or dorsal of the thyroid gland, in the lateral region of the neck, or upon the trachea as far down as the arcus aortae.

The ***glandulae parathyreoideae*** *(epithelial bodies)* (see Fig. 685) are usually two on each side, a *superior* and *inferior* one. They are solid epithelial structures, which are situated on the dorsal surface of the thyroid gland next to small accessory thymus and thyroid lobules and lymph glands. They are developed from the dorsal diverticula of the 3rd and 4th embryonal pharyngeal pouches, and in the course of development become so shifted that the one corresponding to the 3rd pouch becomes the lower (caudal), and the one from the 4th pouch the upper (cranial) one. Their number (both sides together) is in adults often diminished to 3 or 2. They are of a yellowish-red or yellowish-brown color and have a uniform smooth and shining surface. Their form and size is very variable. They are flattened, mostly oval, and sometimes pointed at the ends. Their length is usually 6—8 mm, their width 3—4 mm and their thickness 1,5—2 mm, the length being very variable, the thickness rather constant. The epithelial bodies are proportionately larger in size in the child than in the adult. The right and left parathyroids are seldom placed symmetrically.

The upper parathyroid is situated in the median portion of the posterior surface of the lateral lobe of the thyroid, frequently in a notch of the latter, next to the wall of the pharynx or oesophagus, about the level of the lower border of the cartilago cricoidea, and is usually separated from the thyroid by loose connective tissue. The ascending branch of the a. thyreoidea inferior, which gives off the a. laryngea inferior, and the n. laryngeus inferior run somewhat ventrally and medially to it.

The lower parathyroid is less constant in its position and relations. It lies close to the lower pole of the lateral lobe of the thyroid gland near the 3rd and 4th cartilage ring of the trachea, ventrally to the ascending branch of the a. thyreoidea inferior and n. laryngeus inferior; sometimes it is found nearer to the upper superior parathyroid or more caudally from the thyroid on the trachea.

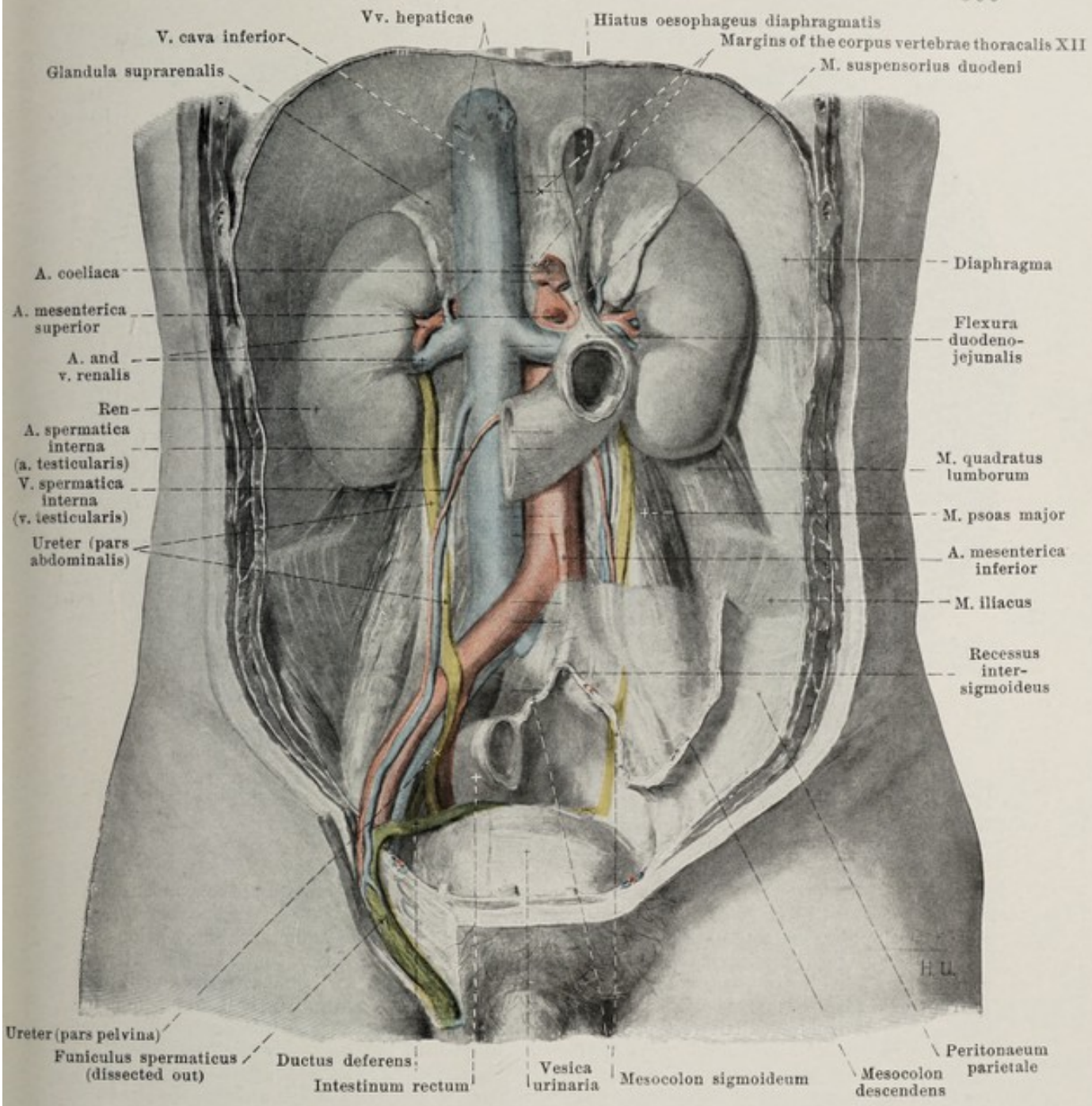
There have also been observed internal epithelial bodies enclosed at all sides from the thyroid tissue.



685. Thyroid gland and its relation to the surrounding organs, from behind.

(The carotid arteries are turned a little outward so that the carotid glands may be seen.)

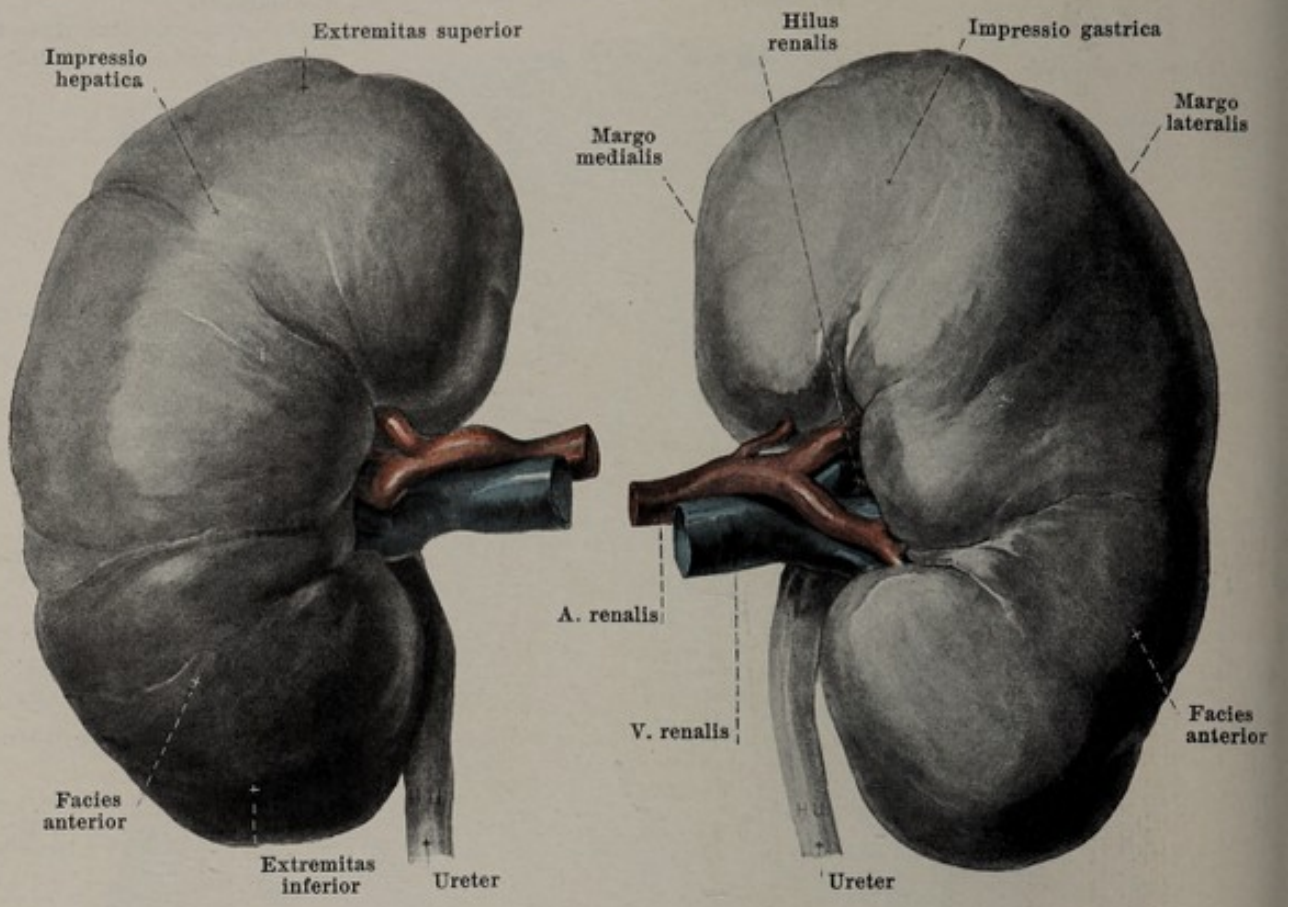
The ***glomus caroticum*** *(Paraganglion intercaroticum, carotid gland)* is an oblong, flattened body about 5 mm long, which is situated immediately above the division of the a. carotis communis directly on the medial surface of this artery and of its both branches. It sometimes consists of 2—5 nodules of hard consistency and of grayish-red or brownish-red color. It consists of chromaffin cells and abundant vascular and nervous elements.



686. Urinary organs in a male, viewed from in front.

(Of the intestine only the termination of the duodenum has been left; the peritonaeum, with the exception of the inferior portion on the left side, has been removed. The margins of the bodies of the vertebrae are indicated by interrupted lines.)

The **kidneys** *(renes)* are two large glands, which are situated, one on each side, in the upper part of the posterior wall of the abdominal cavity near the spine. The posterior surface of the kidney, directed at the same time medianward, lies in front of that portion of the diaphragm which arises from the arcus lumbocostales, as well as in front of the mm. psoas major, quadratus lumborum and transversus abdominis and is separated from them by a layer of loose tissue, rich in fat, the *capsula adiposa*. In the male the left kidney reaches usually from the 11th thoracic vertebra as far as the upper border of the 3rd lumbar vertebra; the right lies usually deeper by the distance of from a half to a whole vertebral level. In the female both kidneys are lower down by about one half a vertebra but do not reach normally the level of the crista iliaca. The twelfth rib runs obliquely downward behind the posterior surface of the kidney. The upper part of the kidney accordingly still remains in the domain of the sinus phrenicocostalis of the pleura.



687. Right kidney, 688. Left kidney,

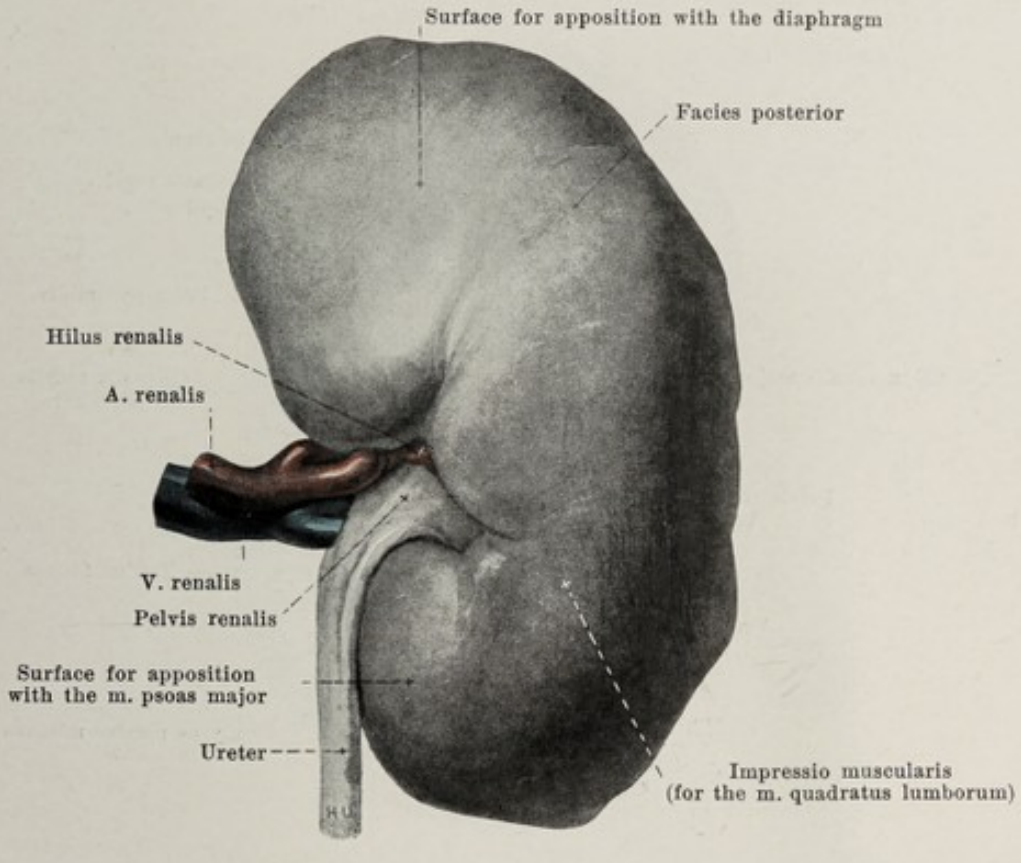
viewed from in front.

Position of the kidneys (continued) (see Fig. 686).

Their largest planes of section cut one another in front of the spine, and their upper poles lie nearer the median plane than their lower poles. The anterior, lateral surface is covered by a feebly developed capsula adiposa (see p. 595) and right and left shows differences in relations as regards the neighboring organs. The right kidney (see Fig. 645) is lateralward almost entirely covered by the liver, its upper pole is closely related medianward to the suprarenal gland, and in front of its medial margin the pars descendens duodeni passes downward; its lower pole is in contact for a variable extent (see p. 542) with the flexura coli dextra. It is covered by peritonaeum parietale to the extent of its surface of contact with the liver, only with the exception of the uppermost end. On the left kidney at the medial margin of its upper pole lies the suprarenal, on the upper part of its anterior surface the paries posterior of the stomach, below this the facies posterior of the pancreas and the vasa lienalia, and at the lowest part lie several loops of the jejunum; on the upper part of its lateral margin lies the facies renalis of the spleen; along the lower part of its lateral margin it is covered by the flexura coli sinistra and by the colon descendens. The peritonaeum covers on the left the portions related to the spleen and the stomach; that covering the latter looks into the bursa omentalis; the peritonaeum also covers the surface situated below the pancreas, with which the mesocolon transversum and descendens is fused.

Form of the kidneys (see also Fig. 689).

Each kidney has the shape of a flattened bean. It presents an upper, broader and thinner end or *pole*, *extremitas superior*, and a lower, narrower and thicker, *extremitas inferior*, as well as a markedly convex lateral border, *margo lateralis*, and a feebly convex medial, *margo medialis*. The latter presents in the middle an oblong fossa which cuts in deep, and is bounded by convex margins, the *hilus renalis*, in which the a. renalis enters and from which the v. renalis and the ureter emerge; it goes over into a deep slit, *sinus renalis*, which runs into the kidney in a longitudinal direction and contains the pelvis of the kidney (see Fig. 691).



689. Right kidney, viewed from behind.

Form of the kidneys (continued).

The anterior surface *(facies anterior)* (see Figs. 687 and 688) is convex. On the right side its upper part is usually somewhat flattened corresponding to its apposition with the liver, *impressio hepatica;* on the left the stomach causes a trough-like depression, often very marked in its upper part, *impressio gastrica.* The posterior surface, *facies posterior*, has a somewhat flatter curve. It presents in its lower part a variable marked impression, *impressio muscularis*, for the m. quadratus lumborum and medianward from it frequently a flattened surface for the m. psoas major; in the upper half the surface for apposition with the diaphragm is often distinctly recognizable.

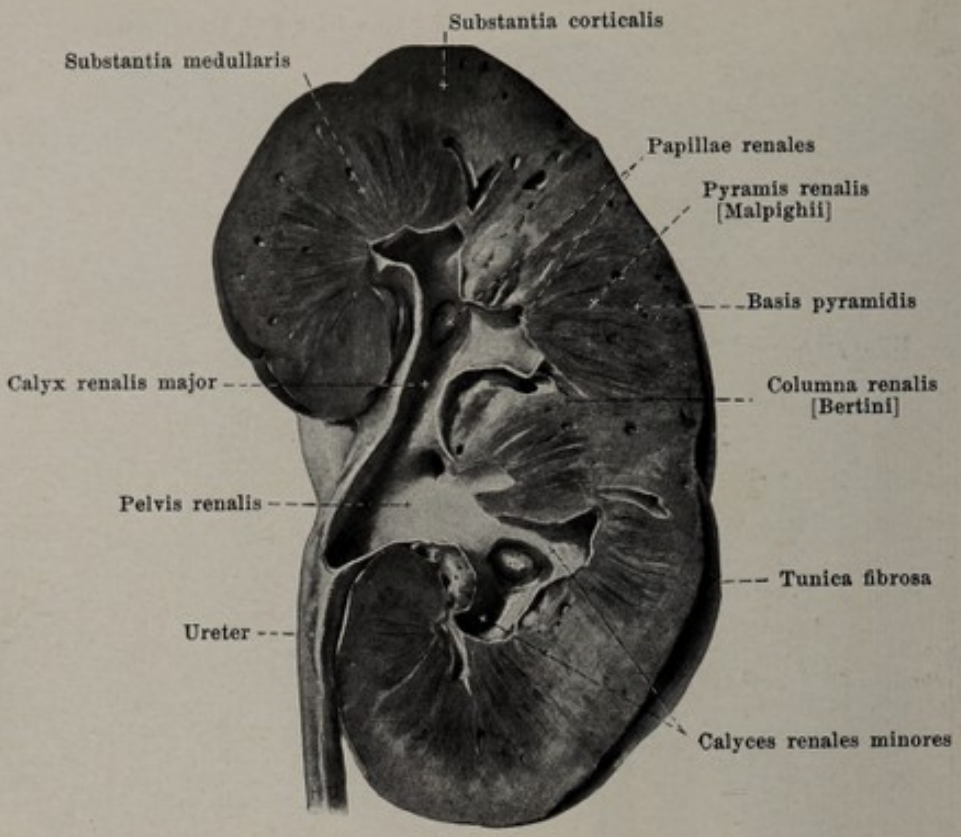
The surface of the kidney is usually smooth and presents notches only at the hilus. In the embryo and the new born (see Fig. 692) it is, on the contrary, subdivided by several deep furrows into a large number of lobes, *lobi renales* (see also p. 598), the margins of which disappear as a rule during the early years of life.

Structure of the kidney (see Fig. 690).

The external covering of the kidney (within the capsula adiposa) is formed by the thin, but firm layer of connective tissue, *tunica fibrosa*, the innermost part of which, *tunica muscularis*, contains a network of smooth muscle bundles; it is easily separable from the underlying tissue. The gland tissue consists of two layers, *substantia medullaris* and *substantia corticalis.*

The *substantia medullaris, medullary substance*, surrounds the sinus renalis and consists of 26 to 46 (averaging 35) wedge-shaped masses, *pyramides renales [Malpighii]*, between which, separating them, are intercalated strips of substantia corticalis, *columnae renales [Bertini].* Each pyramis renalis has its rounded *basis pyramidis* directed toward the substantia corticalis; its apex lies in a small blunt wedge-shaped elevation, *papilla renalis*, which projects from the medullary substance into the beginning of a renal calyx (see p. 598). The pyramids present converging stripes toward their apices, converge toward the hilus and fuse at their apices with their neighbors, so that each papilla renalis contains 2—4 (at the poles 5—9) apices of pyramids. The number of papillae renales varies from 6 to 14 (averaging 9).

The *substantia corticalis (cortical substance)* forms the continuous peripheral layer and extends between the pyramids of the medullary layer as the columnae renales (vide supra).



690. Right kidney, cut through, viewed from behind.

Structure of the kidney (continued).

The cortical substance and the columnae renales are of a reddish-brown color, the pyramids are somewhat lighter toward their apices, but elsewhere more violet and darker.

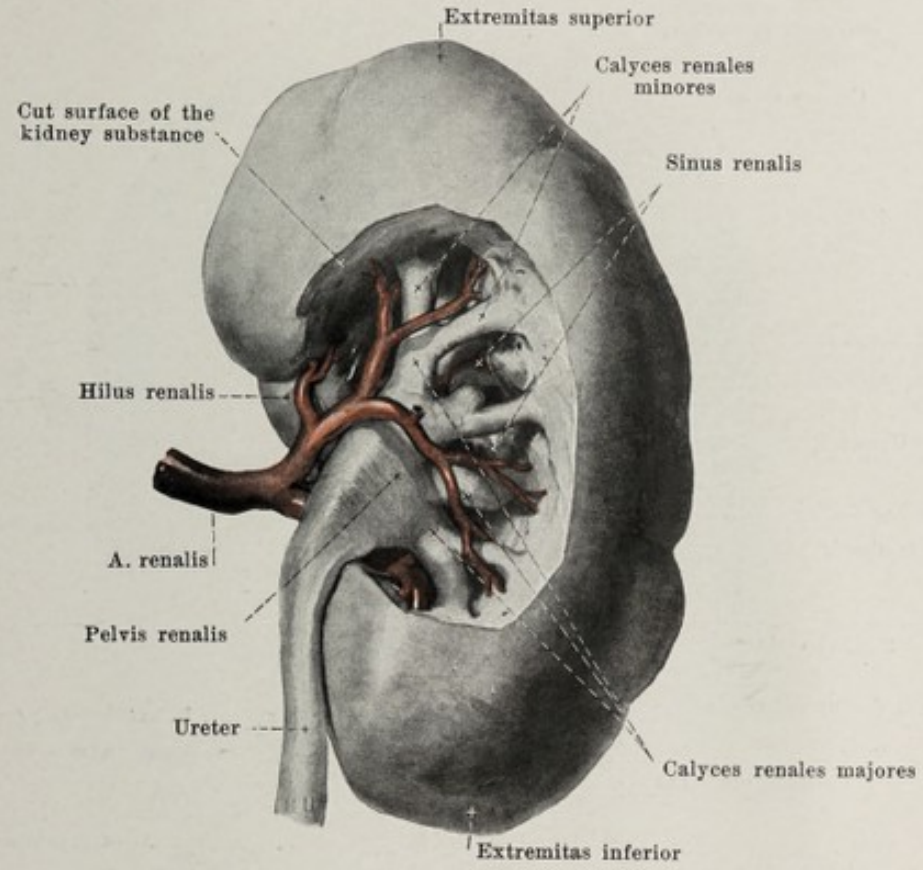
In the fetus and new-born (rarely in the adult) the surface is divided by deep, irregular furrows into 11—21 (averaging 15) areas (see Fig. 692). Each wedge-shaped portion of the cortical and medullary substance reaching as far as the sinus renalis corresponding to one of these areas is called a *lobus renalis;* each renal lobe contains several pyramides renales and is not separable in the depth from its surroundings.

The excretory ducts of the kidney, *urinary tubules, tubuli renales* (not illustrated), in the cortex are in their course partly tortous, *tubuli renales contorti*, partly straight, *tubuli renales recti*, in the pyramids straight only. The cortex consists of an enormous number of very small columnar *cortical lobules, lobuli corticales*, all of which extend from the medullary substance to the periphery, lying closely packed together and only incompletely separable from one another; their margins are indicated by the radially directed aa. and vv. interlobulares renis. In the axis of each lobule extending from the basis pyramidis to the apex is a light strip, *pars radiata [processus Ferreini]*, which is formed of tubuli recti; the rest of the lobule, *pars convoluta*, is of a somewhat darker color and consists of tubuli contorti.

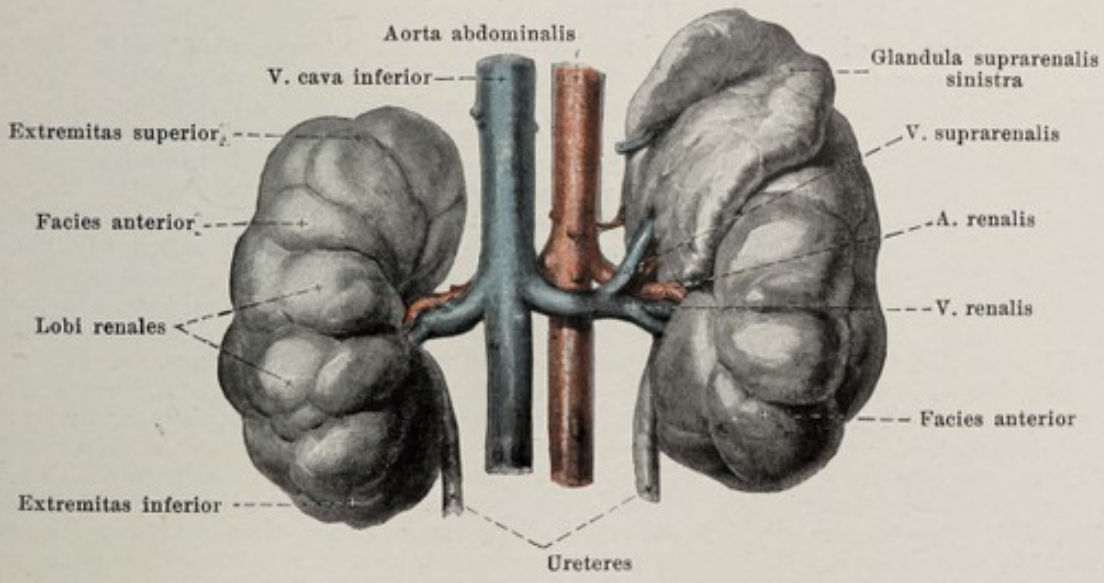
The largest tubuli renales of each pyramid converge toward its apex, open there by *foramina papillaria* into the calyx of the kidney and thus form the *area cribrosa* of the papilla.

Excretory channels of the kidney (see also Fig. 691).

Each papilla renalis projects usually singly into the blind end of a short narrow tube, *calyx of the kidney, calyx renalis minor*, and is covered by its mucous membrane. Several calyces minores unite to form one short, broader *calyx renalis major*, of which there are altogether usually 2 or 3; these again combine and form the *pelvis of the kidney, pelvis renalis*, a flattened tube curved downward and narrowed below, which either gradually or by sudden constriction goes over into the ureter. The calyces renales, with the branches of the blood vessels and some fatty tissue, completely fill up the sinus renalis. The pelvis of the kidney in part projects out of the hilus renalis (see also Fig. 689) and there lies b e h i n d the blood vessels surrounded by fatty tissue.

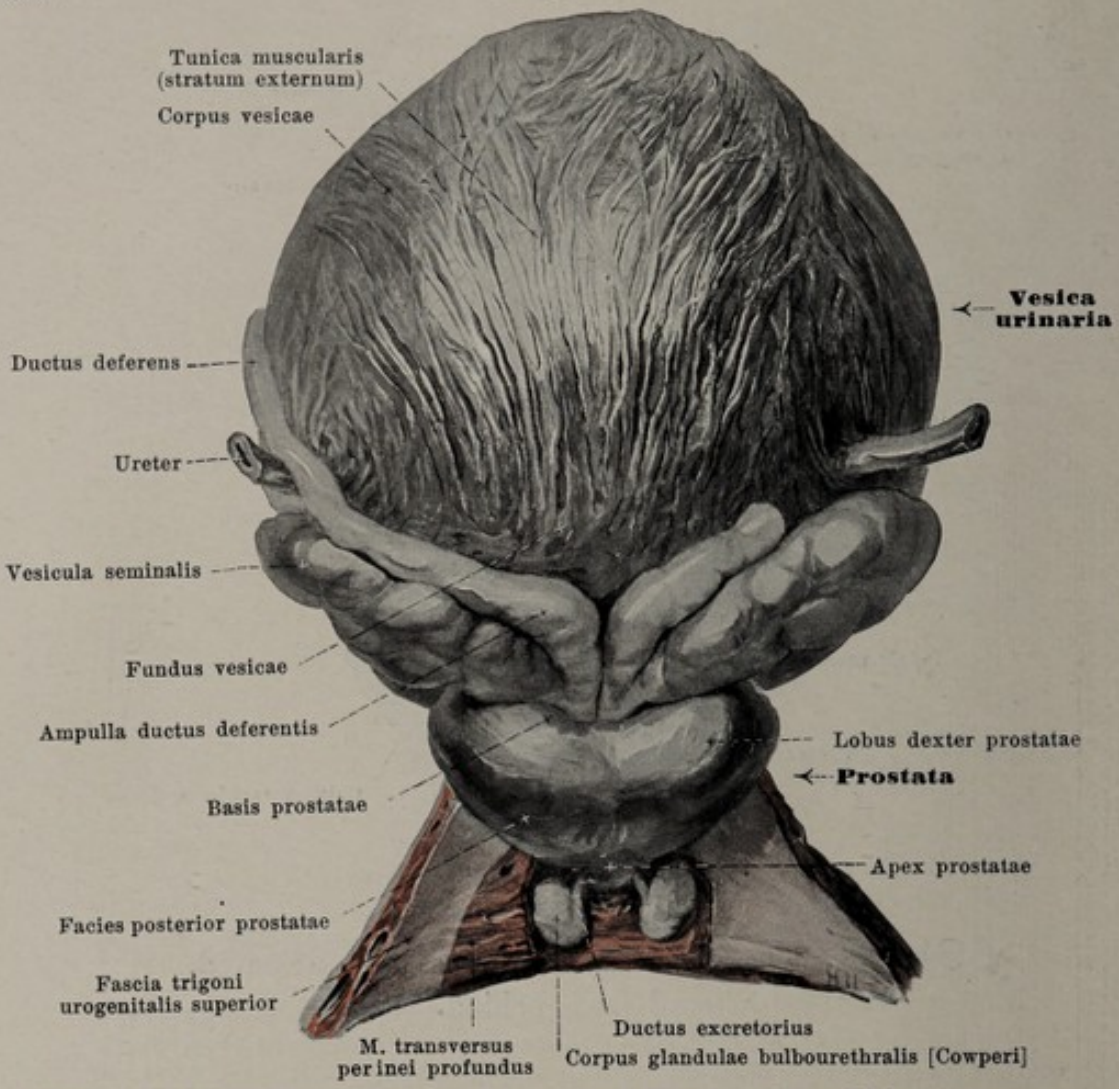


691. Right kidney with its pelvis exposed, viewed from behind.



692. Kidneys of a new-born babe, viewed from in front.

(The left suprarenal gland has been left in position, the right has been removed.)

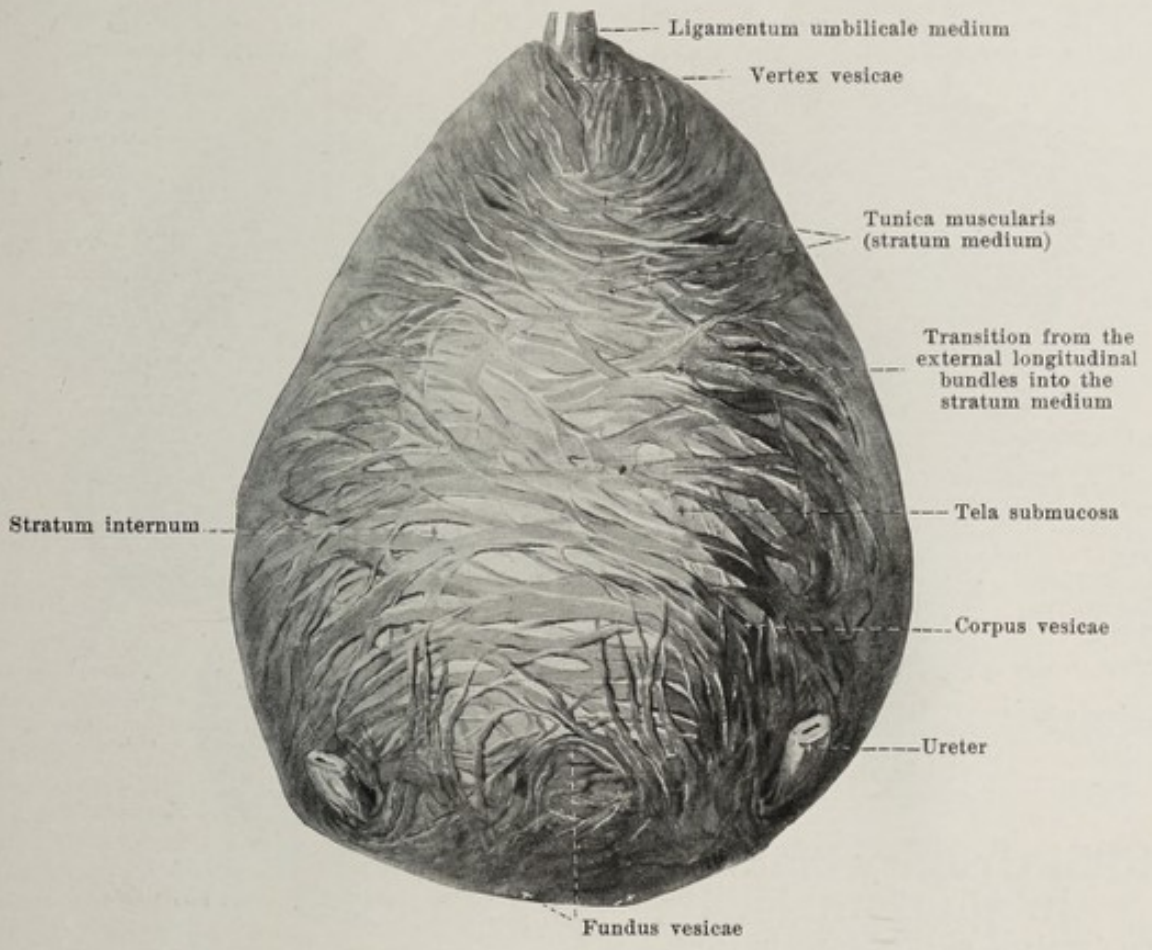


693. Urinary bladder, distended, with surrounding structures, viewed from behind.

(The glandulae bulbourethrales have been exposed in the trigonum urogenitale.)

The **ureter** (see also Figs. 686, 689, 708, 718—720) runs out on each side from the pelvis of the kidney in front of the m. psoas and the fascia iliaca; it is imbedded in loose connective tissue, is curved slightly downward and a little medianward *(pars abdominalis)*, crosses usually on the right side the a. and v. iliaca externa immediately after their origin (see Figs. 521 and 551), on the left side the a. and v. iliaca communis and then *(pars pelvina)* (see Fig. 521) extends on the medial surface of the a. hypogastrica, usually further forward on the right than on the left, medianward from the a. and n. obturatorius and the a. vesicalis superior (a. umbilicalis) (in the female at the same time directly behind the margo liber of the ovary, see Fig. 718 and 719), downward on the lateral wall of the small pelvis; from there on it behaves somewhat differently in the two sexes. The pars abdominalis above lies behind the pars descendens duodeni on the right side, behind the flexura duodenojejunalis on the left side, is then crossed in front by the a. and v. spermatica interna and is everywhere retroperitoneal in position. The pars pelvina is also, for the most part, directly covered by peritonaeum. In the male its terminal portion (see Figs. 686 and 708) extends from the lateral wall of the pelvis, medianward and somewhat forward near the upper end of the vesicula seminalis to the fundus vesicae and in so doing is crossed medianward and in front by the ductus deferens. In the female (see Figs. 522, 523, 553, 718—720), where the terminal portion lies on the medial side of the a. uterina on the pelvic wall, it turns forward and medianward below the posterior layer of the ligamentum latum uteri to the base of the urinary bladder; in so doing, it runs through the parametrium, about 1½ cm lateral from the cervix uteri, then comes into direyt contact with the anterior and lateral wall of the vagina, being crossed in front by the a. uterina at the level of the orificium internum uteri.

The ureter enters the urinary bladder, passing obliquely forward and medianward, runs for some distance in the wall of the same, and then opens at the orificium ureteris (see Figs. 695 and 696).



694. Urinary bladder, distended,

after removal of the superficial muscular layer, viewed from behind and above.

Ureter (continued).

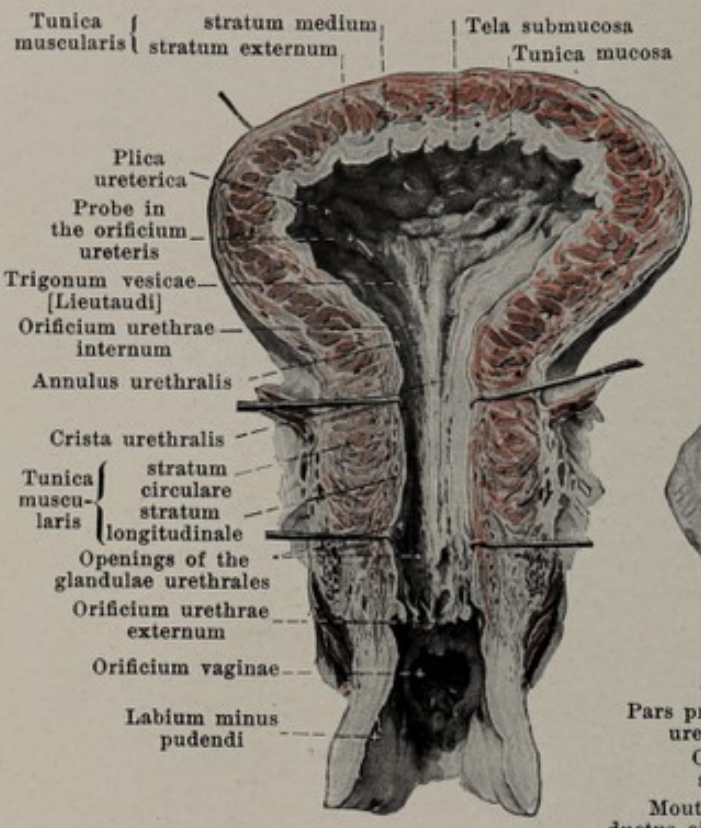
The ureter is a tube, flattened from before backward, which, in the lower part of its pars abdominalis, presents a spindle-shaped dilatation of variable length, the lower boundary of which is situated in front of the a. iliaca. The pars pelvina is of approximately even caliber throughout.

The *wall of the ureter* (not illustrated) consists of a peripheral *tunica adventicia*, composed of connective tissue, a thick muscular layer, *tunica muscularis*, in which are distinguishable a middle circular layer, *stratum medium*, as well as an external, longitudinal layer, *stratum externum* (existing only in the lower half), and an internal longitudinal layer, *stratum internum*, and the mucous membrane, *tunica mucosa*.

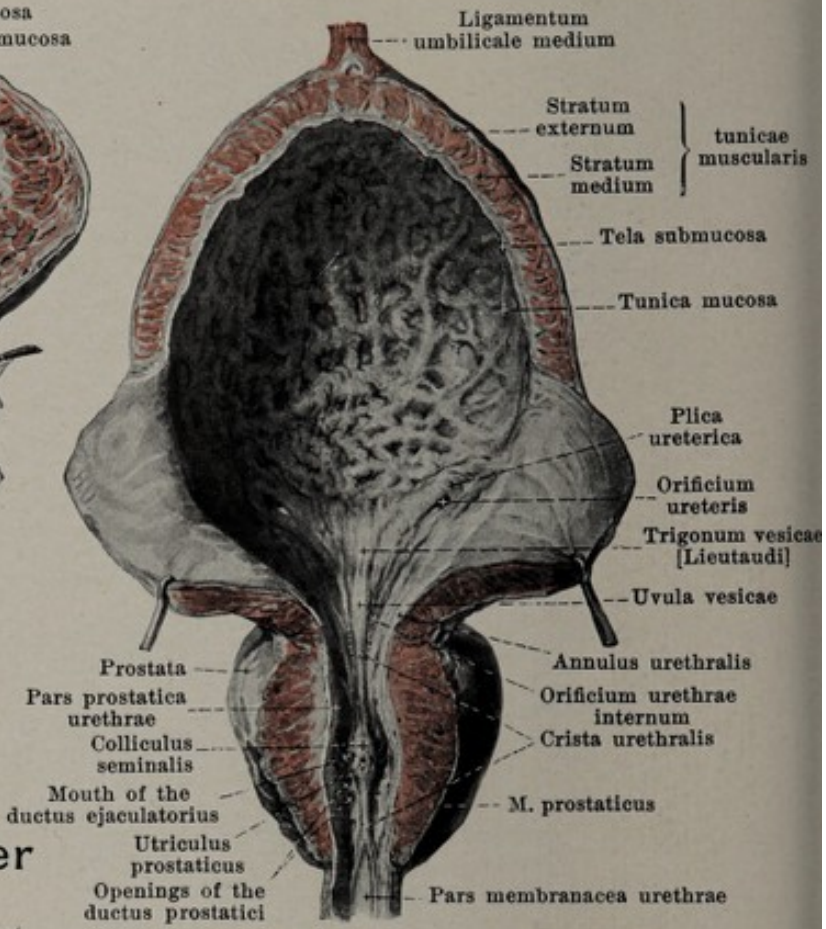
The **urinary bladder,** *vesica urinaria* (see also Figs. 686, 693, 695, 696, 708, 709, 718, 719 and 730), is an unpaired, musculo-membranous sac, situated in the small pelvis, into which open the right and the left ureter; it communicates with the urethra through the orificium urethrae internum.

It presents for examination a *vertex vesicae* or *vault of the bladder* directed forward and upward; in youth this has the shape of a blunt wedge. Extending upward from the vertex to the navel is a cord of connective tissue, *ligamentum umbilicale medium* (see p. 567), the remnant of the obliterated embryonic urachus. The inferior and posterior region turned toward the perineum, containing the orificium urethrae internum, the trigonum vesicae and the plicae uretericae, is the *fundus vesicae*. The rest is called the *body of the bladder, corpus vesicae*.

The ***form*** of the empty bladder (see Figs. 693, 708, 709, 718 and 719) is similar a tetrahedron, the four corners being formed by the beginning of the lig. umbilicale medium, the entries to the ureters in the urinary bladder and by the urethra; the margins are rounded off and the surfaces slightly convex; the bladder when full is egg-shaped or spherical. Deviations in shape are not unusual. The more tube-like or pear-shaped form met with in childhood may be found even in the adult. In all cases the contracted bladder has a thicker wall than the relaxed bladder, and the wall is thicker in the male than in the female.



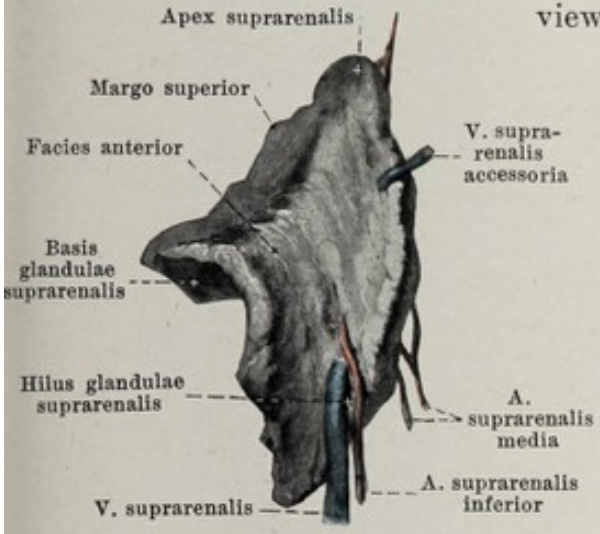
695. Urinary bladder in the female, contracted, opened from in front.



696. Urinary bladder in the male, moderately distended, opened from in front.

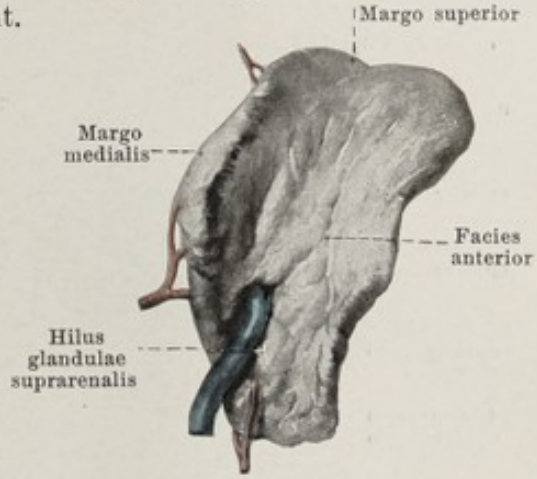
Wall of the urinary bladder (see also Figs. 693, 694, 708, 709, 718, 719, 729 and 730). It is partly covered by a peritoneal coat, *tunica serosa*. This covers the upper wall and the upper part of the lateral surface (in the male also the upper part of the posterior wall, reaching somewhat deeper in the middle); it turns in the female upon the facies vesicalis uteri, in the male upon the anterior surface of the rectum usually somewhat above the basis prostatae. The peritonaeum forms a transverse fold, *plica vesicalis transversa* (see p. 615), over the empty bladder. The second layer, *tunica muscularis*, consists of smooth muscle fibres, which are arranged in the form of a network. Its *stratum externum* (see Fig. 693) is formed of bundles which are very narrow-meshed especially in the middle; the bundles run in a longitudinal direction and diverge somewhat toward the vertex; in front they are connected with the *m. pubovesicalis* (see p. 633), behind with the *m. rectovesicalis* (see p. 615). The *stratum medium* (see Fig. 694) is the strongest; its bundles run especially in the transverse direction, form an uninterrupted layer at the fundus and there go over into fibres which surround the urethra in a ring inclined obliquely forward and downward, the *m. sphincter vesicae*, and are connected in front with the m. prostaticus. The *stratum internum* is thin and consists of wide meshes somewhat drawn out in the longitudinal direction. All three layers are intimately connected with one another, since bundles from one go over into the others. The tunica muscularis is separated by the vascular *tela submucosa* from the mucous membrane, *tunica mucosa*. The latter, of an intense red color, presents, when the bladder is empty or moderately filled, numerous folds which vanish when the organ is distended. Situated at the fundus vesicae is an approximately triangular smooth area (or when the bladder is empty not quite smooth), *trigonum vesicae [Lieutaudi]*. This is bounded behind on each side by the *plica ureterica*, a flat projection which is bulged forward by the ureter on its passage through the wall of the bladder and which in front contains the obliquely situated *orificium ureteris*. In front the trigonum reaches as far as the sickle-shaped *orificium urethrae internum*, which is convex forward forming a small oblong rounded elevation, *uvula vesicae*. The orificium urethrae internum is surrounded by a circular projection, *annulus urethralis*, which is especially distinctly developed in the male and which surrounds also the initial portion of the urethra.

697. Right suprarenal gland,



viewed from in front.

698. Left suprarenal gland,

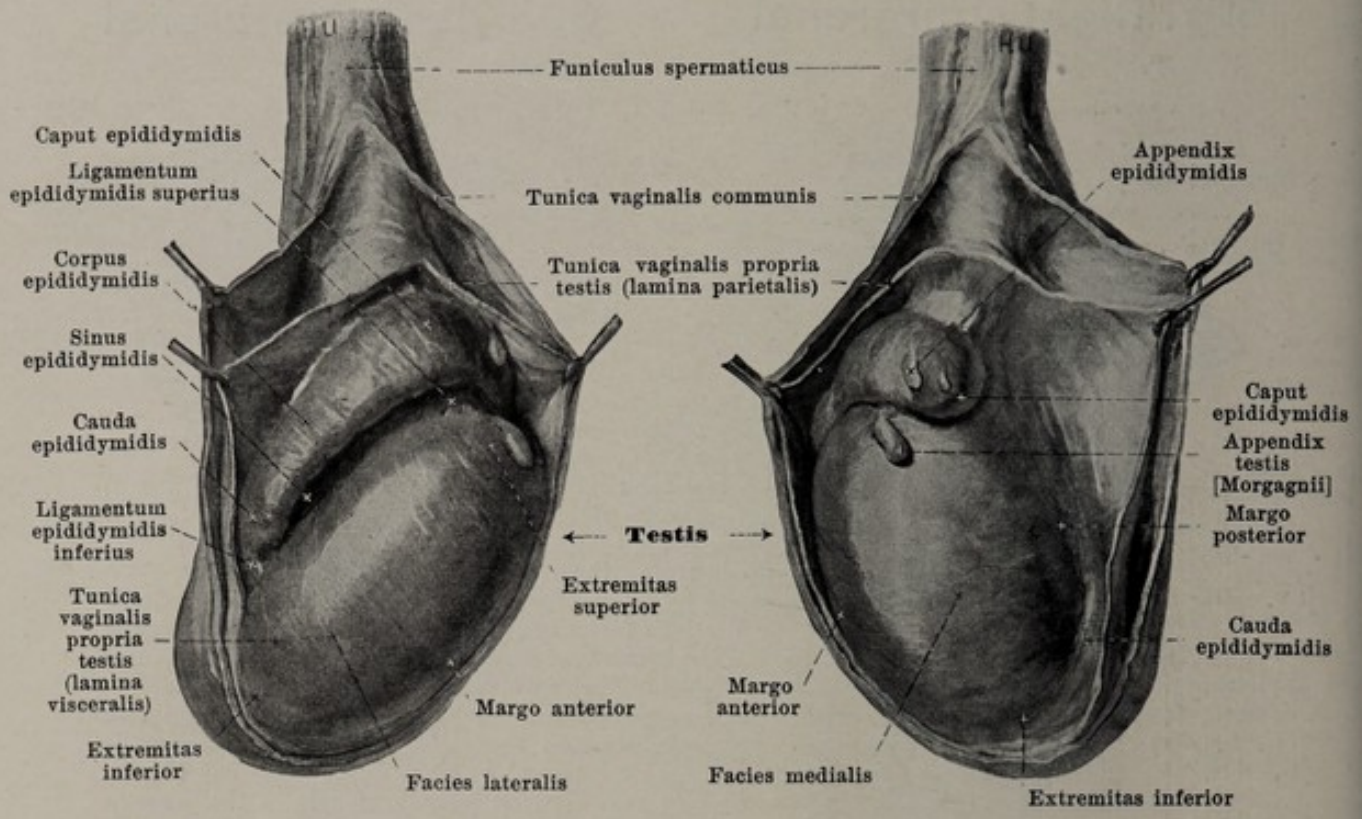


Position of the urinary bladder (see Figs. 686, 708, 709, 718-720 and 730). The anterior wall, looking at the same time downward, lies just behind the symphysis ossium pubis and the neighboring parts of the pubic bone, separated from them above by loose tissue only, below also by the plexus pudendalis (see Figs. 551 and 553). When the bladder is empty the vertex does not project beyond the upper margin of the symphysis; when it is full it projects above it for a variable distance. The lateral wall, turned at the same time downward, is very narrow when the bladder is empty and lies against the m. levator ani (see Fig. 730); when the bladder is full it passes upward on the m. obturator internus and is crossed by the a. umbilicalis (ligamentum umbilicale laterale) and the ductus deferens (in the male, ligamentum teres uteri in the female) (see Fig. 708); it is separated from the muscles by loose tissue, the fascia pelvis and the plexus vesicalis (see Figs. 551, 553 and 730). The inferior wall of the urinary bladder adjoins in the male the basis prostatae, in the female the trigonum urogenitale; its deepest point is usually the orificium urethrae internum, which in the male is situated behind the middle of the symphysis ossium pubis or somewhat higher, in the female is situated somewhat deeper. The posterior wall, directed at the same time somewhat downward, is in relation in the male with the seminal vesicles, with the ampullae of the seminal ducts, as well as, between and above these in variable extent and separated from it by loose tissue, with the rectum; above it is covered by peritonaeum. In the female it rests upon the anterior wall of the vagina and is connected with it and the cervix uteri by loose tissue rich in veins. On the upper wall, covered by peritonaeum, in the male lie intestinal loops; in the female the facies vesicalis of the uterus lies upon it, separated from it only by the slit-like excavatio vesicouterina. The bladder, when full, projects for a variable distance upward into the peritoneal cavity. By distension of the rectum the orificium urethrae internum is pressed forward and upward so that the bladder when it becomes full at the same time lies directly in contact for some distance with the anterior abdominal muscles.

The **suprarenal glands**, *glandulae suprarenales* (see also Figs. 686 and 692), are two small flat bodies, which lie directly medial from and above the kidneys, one on each side. The right is approximately triangular and sits more upon the upper pole of the kidney, the left approximately sickle-shaped and lies more upon the margo medialis of the kidney. Each presents for examination a posterior surface, *facies posterior*, which lies loosely upon the pars lumbalis diaphragmatis, and a *facies anterior*, which is in relation on the right side with the impressio suprarenalis hepatis (there covered below by peritonaeum) and the v. cava inferior, on the left side above with the pars cardiaca of the stomach (thus far covered also by the posterior layer of the bursa omentalis), below with the a. and v. lienalis and the pancreas; on the anterior surface runs a groove, *hilus glandulae suprarenalis*, from which the principal vein, *v. centralis*, emerges. The concave *basis glandulae suprarenalis* looks lateralward and backward and lies upon the kidney. In addition there can be made out a sharpened *margo medialis* and *margo superior*, which form on the right an obtuse angle, *apex suprarenalis*. The left margo superior is in contact with the facies renalis of the spleen. The suprarenal gland consists of a firmer yellowish *substantia corticalis* which develops from coelomic epithelium of the embryo and of a softer brownish *substantia medullaris* which arises from sympathetic elements.

Real **accessory suprarenal glands**, *glandulae suprarenales accessoriae* (not shown), consisting of cortical and medullary substance are very rarely seen in the adult and when present are to be found in the plexus nervosus coeliacus.

Other accessory suprarenals, of cortical substance only, are very common; they are found in varying numbers in the neighborhood of the suprarenal glands, also in the kidneys, liver, pancreas, near the sexual glands and along the vasa spermatica interna.



699 and 700. Right testicle and epididymis

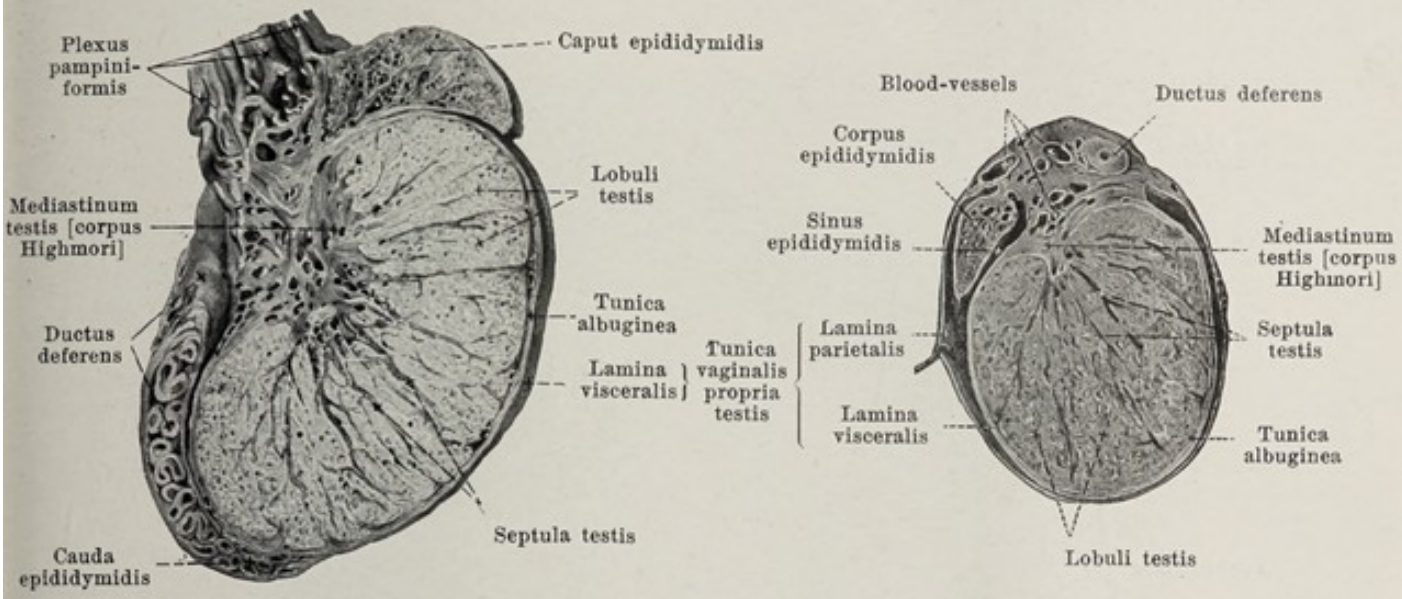
after opening the ensheathing membranes,

viewed from the lateral surface, viewed from the medial surface.

The **testicles**, *testes*, are the two male sexual glands which secrete the *sperma [semen]*; they lie in the lower portion of the scrotum (see Fig. 705) and each possesses an appendage, the *epididymis*.

The ***testicle***, *testis* (see also Figs. 701 and 702), is approximately egg-shaped, flattened somewhat from side to side and presents a convex surface of a bluish-white color. Its upper *pole*, *extremitas superior*, is directed at the same time somewhat forward and lateralward; its lower pole, *extremitas inferior*, is directed at the same time somewhat backward and medianward. It presents also a slightly convex *facies lateralis*, which looks at the same time somewhat backward, and a more flattened *facies medialis*, which is directed at the same time somewhat forward; these surfaces are connected with one another by a free *margo anterior*, which is directed at the same time a little downward, and the hidden *margo posterior* which looks also upward and at which the vessels and nerves enter and leave the testicle.

Structure of the testicle (see also Figs. 701—704). The surface of the testicle with the exception of the margo posterior is smooth and glistening, being formed by the *lamina visceralis* of the *tunica vaginalis propria testis* (see p. 608). Beneath it, fused with it, lies the *tunica albuginea*. This tough membrane of connective tissue completely ensheaths the substance of the testicle and is thickened at the posterior margin to form a triangular projection of loose sponge-like porous structure which extends into the interior of the testicular substance and is called the *mediastinum testis [corpus Highmori]*. Radiating out from this like a fan are thin leaflets of connective tissue, interrupted in spots, *septula testis;* these unite with the peripheral tunica albuginea. In the connective tissue framework lies the *parenchyma testis*. This consists of the approximately wedge-shaped lobules of the testicle, *lobuli testis* (100—200), which are separated from one another by the septula; the lobules converge with their apices toward the mediastinum testis. Each lobule contains two or more long, manifoldly twisted seminal canals which begin in part blind in the periphery and may anastomose with one another, *tubuli seminiferi contorti*. They unite at the apex of the lobule to form short, narrow, straight seminal canals, *tubuli seminiferi recti*, which enter the mediastinum testis and form in it along with the others a fine network, *rete testis [Halleri]*. Out of this network proceed about a dozen (7—15) *ductuli efferentes testis*, which perforate the tunica albuginea at the upper end of the posterior margin and enter the head of the epididymis.



701 and 702. Right testicle and epididymis.

Sagittal section. Transversal section.

The ***epididymis*** (see also Figs. 699, 700, 703 and 704) is long, cordlike, and sits upon the posterior margin of each testicle; it is curved so as to be convex backward and at the same time lateralward. Its upper, somewhat thicker portion, *caput epididymidis*, is directed medianward with its rounded end, rests with its lower concave surface upon the upper pole of the testicle and in largest part is there fused with it. The approximately triangular middle piece, *corpus epididymidis*, lies with its concave anterior surface upon the posterior margin and the posterior portion of the lateral surface of the testicle; it is partly separated from it by the sinus epididymidis, otherwise fused with it. The lower, rounded end, *cauda epididymidis*, goes over below with a sharp bent into the beginning of the ductus deferens, which extends upward and backward.

Structure of the epididymis (see also Figs. 699, 700, 703 and 704). The slightly nodular surface is covered on the convex side of the caput, on the lateral and partly also on the anterior surface of the corpus and on the lateral surface of the cauda by the *lamina visceralis* of the *tunica vaginalis propria testis* (see p. 608). Between the testicle and the corpus epididymidis this membrane therefore gives rise to a slit-shaped prolongation of variable length, *sinus epididymidis*, which is bounded above and below by variably developed folds, *ligamentum epididymidis superius* and *ligamentum epididymidis inferius* respectively. The caput epididymidis consists of about a dozen (7—15) small wedge-shaped lobules, *lobuli epididymidis;* each of these has its base directed toward the free surface and receives at its apex one ductulus efferens testis, which forms a skein and by numerous turns completely fills up the lobule. The ductulus of the uppermost lobule goes from the base of the same, markedly twisted, to the corpus epididymidis, receives the ducts of the other lobules and becomes the *ductus epididymidis*. This completely fills up the corpus and the cauda epididymidis with its numerous short and marked turns and is continued at the end of the cauda directly into the ductus deferens.

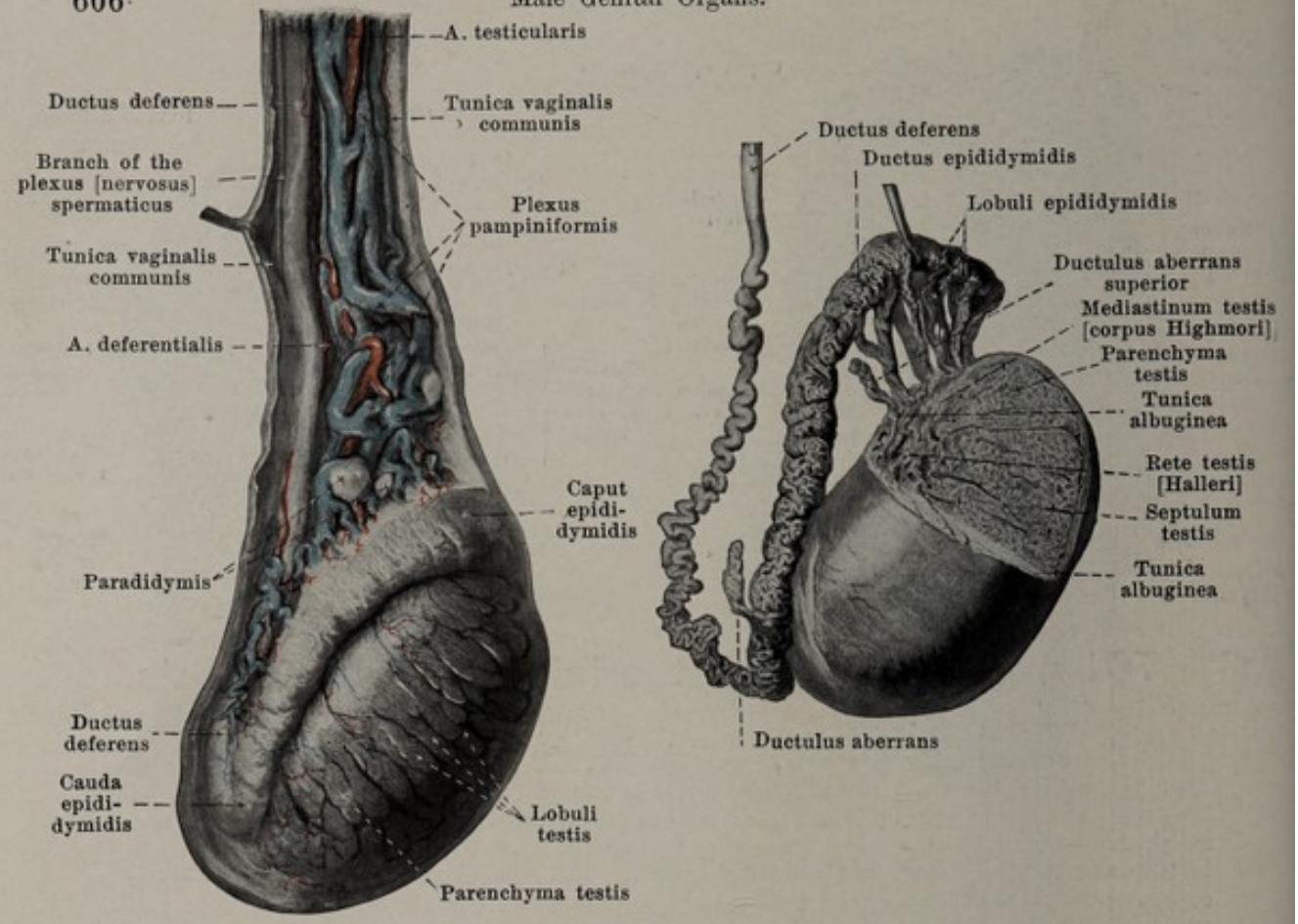
Appendages of the testicle and epididymis, appendices testis (see Figs. 699 and 700).

Appendix testis [Morgagnii], non-pedunculated hydatid, constant, sits as a soft, oblong corpuscle with a broad base upon the upper pole of the testicle, just beneath the caput epididymidis. It is a remnant of the upper end of Müller's duct, homologous with the infundibulum tubae uterinae.

Appendix epididymidis, pedunculated hydatid, single or multiple, connected frequently with the free end of the caput epididymidis as a small pedunculated pear-shaped vesicle. It consists of the stunted abdominal end of the Wolffian duct or of remains of canals of the Wolffian body.

Ductuli aberrantes (see Fig. 704) are tortuous ducts ending blind, in the epididymis. The *ductulus aberrans superior*, in the caput epididymidis, is connected with the rete testis. The other, larger, in the cauda epididymidis, arises from the ductus epididymidis, runs upward for a variable distance; it is a canal of the Wolffian body which has persisted.

Paradidymis (O. T. organ of Giraldés) (see Fig. 703) lies as an oblong body in the lowermost end of the spermatic cord, in front of the vessels. It consists of groups of microscopic vesicles and tubules which are remains of the caudal part of the Wolffian body.



703 and 704. Right testicle and epididymis,

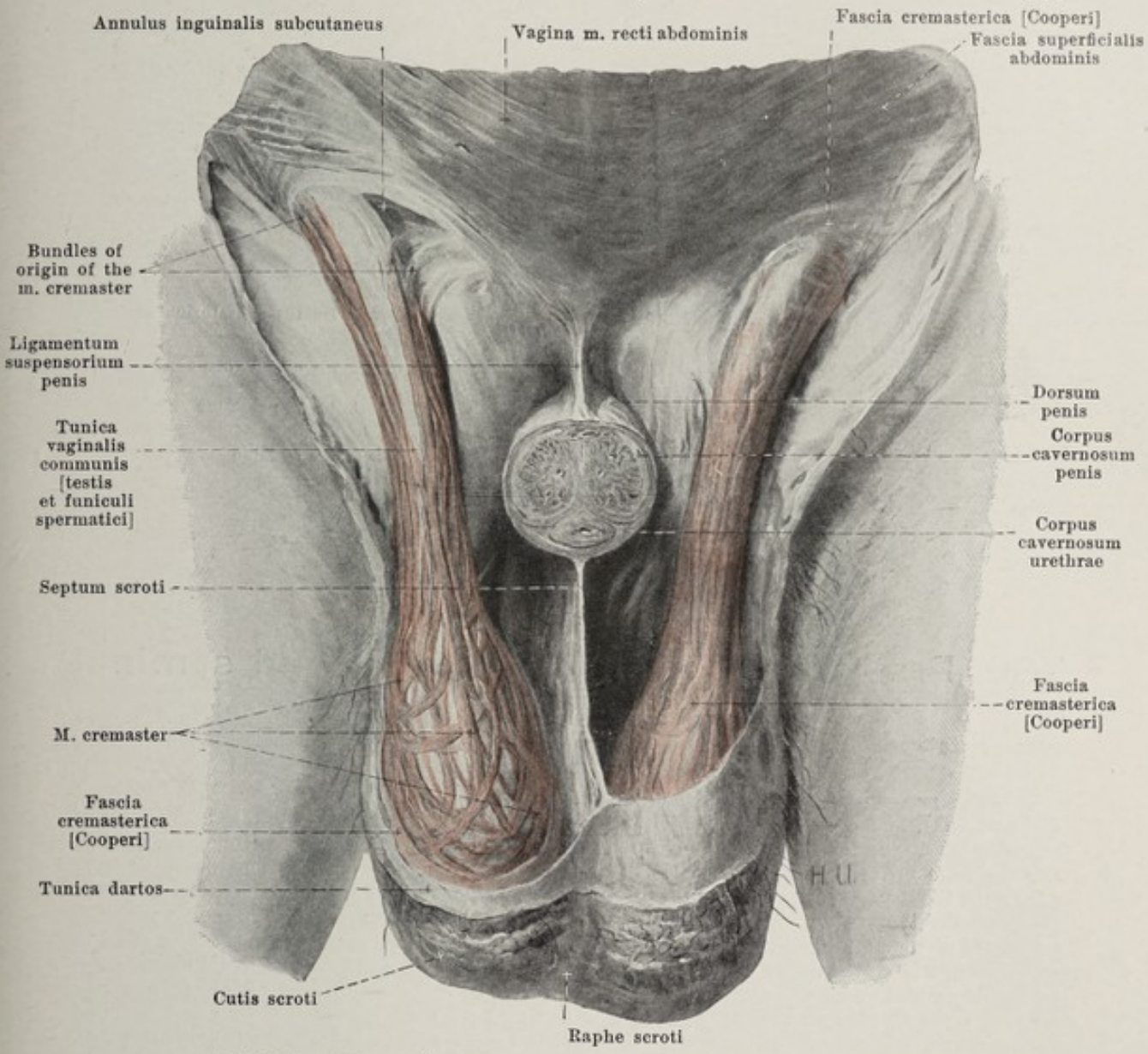
viewed from the lateral surface,

after removal of the tunica albuginea and dissection of the spermatic cord.

after removal of a sector from the testicle and dissection of the epididymis.

The **seminal duct,** *ductus deferens* (see also Figs. 650, 686, 693, 706, 707 and 709), is the excretory duct of the testicle. It begins at the cauda epididymidis as the continuation of the ductus epididymidis and ends by uniting with the ductus excretorius of the seminal vesicle to form the ductus ejaculatorius. It runs upward at first in a markedly tortuous direction, then less tortuously, its wall gradually increasing in thickness, on the posterior margin of the testicle and on the medial surface of the epididymis; it then extends as a rounded, thick-walled, hard cord almost straight upward in the posterior portion of the spermatic cord (turning gradually from its medial to its lateral side) and, passing through the canalis inguinalis lying directly on its inferior wall and arrives in the peritoneal cavity. There it loops over the origin of the a. and v. epigastrica inferior (see Figs. 521, 551, 650 and 686) medianward and runs downward and backward on the lateral wall of the small pelvis; the a. and v. iliaca externa, the ligamentum umbilicale laterale, the vessels and nerves of the neighboring pelvic wall and the ureter lie on its lateral surface in this portion of its course. It then turns medianward to the hind wall of the bladder and extends at first directly over the upper end of the seminal vesicle, then on the medial surface of the same, close behind the wall of the bladder, to the basis prostatae; the ducts of the two sides converge in this part of their course. This last portion situated behind the bladder is markedly curved and presents a spindle-shaped dilatation, *ampulla ductus deferentis*, with a nodular surface; it contains a tortuous main duct and in the interior shows depressions, the *diverticula ampullae*, separated by projecting ridges. From the annulus inguinalis abdominalis as far as the middle of the ampulla, the duct lies directly beneath the peritonaeum.

The wall of the ductus deferens consists of three layers. Externally lies a *tunica adventicia*, which consists of connective tissue. Then follows the *tunica muscularis*, which is composed of a thin, longitudinal *stratum internum*, present only at the beginning, a thick, circular *stratum medium* and a correspondingly thick longitudinal *stratum externum*. Innermost lies the mucous membrane, *tunica mucosa*, partly thrown up in folds.

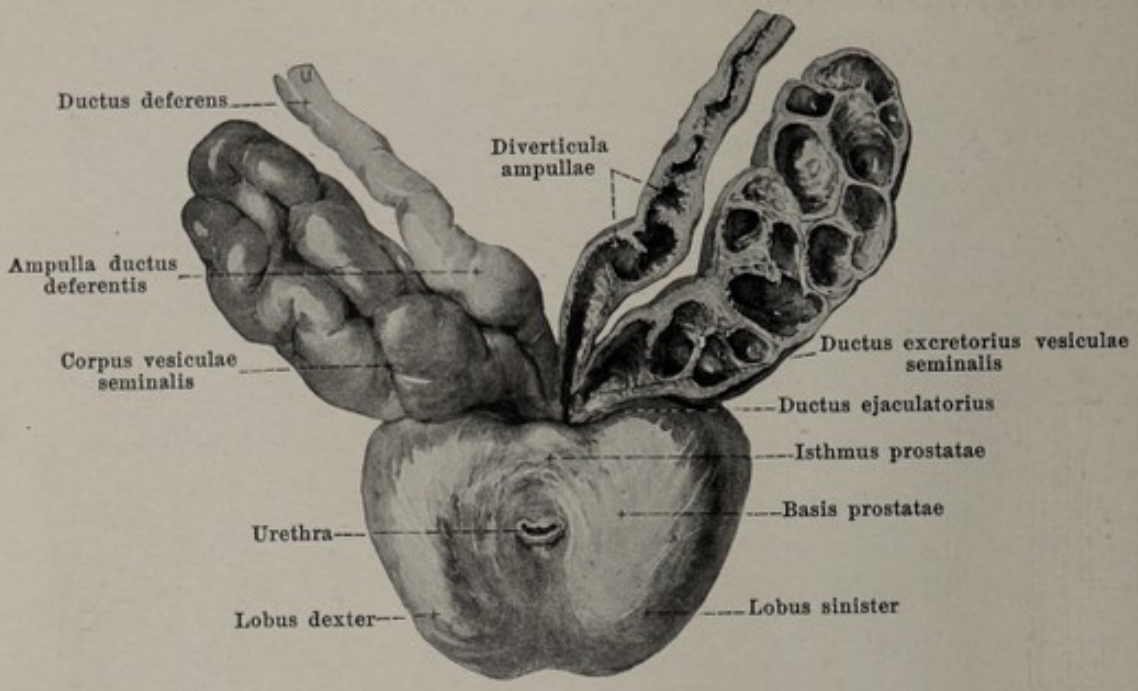


705. Scrotum, opened, viewed from in front.

(On both sides the skin and the tunica dartos have been removed. On the right side the fascia cremasterica [Cooperi] and the fascia superficialis abdominis have also been removed. The penis has been cut through transversely.)

The **spermatic cord,** *funiculus spermaticus* (see also Figs. 686, 697, 703), is a round, smooth, soft cord from the annulus inguinalis abdominalis to the posterior margin of the testicle.

It contains the ductus deferens, the a. and vv. deferentiales, the a. testicularis, the plexus pampiniformis, lymph vessels, the plexus nervosi deferentialis and spermaticus, as well as (when present) the rudimentum processus vaginalis (see p. 608), all united by loose connective tissue. These structures are all ensheathed by the *common sheath*, composed of connective tissue, *tunica vaginalis communis [testis et funiculi spermatici]*, which may be looked upon as a continuation of the fascia transversalis abdominis. It is very loose and cannot be dissected out in the inguinal canal and does not become tougher until the neighborhood of the testicle and epididymis is reached. It also completely encloses the two latter and is firmly fused with the lamina parietalis of the tunica vaginalis propria testis (see p. 608), as well as with the posterior margin of the testicle and epididymis. In the inguinal canal the fibres of the *m. cremaster* (see p. 299) lie upon this sheath and accompany it downward. In the same layer, in the inguinal canal, lie also the a. and v. spermatica externa and the nn. spermaticus externus and ilioinguinalis. Around these parts at the annulus inguinalis subcutaneus is situated a continuation of the fascia superficialis abdominis, the *fascia cremasterica [Cooperi]*, which is usually distinct above only.



706. Prostate with seminal vesicles and seminal ducts, viewed from in front and above.

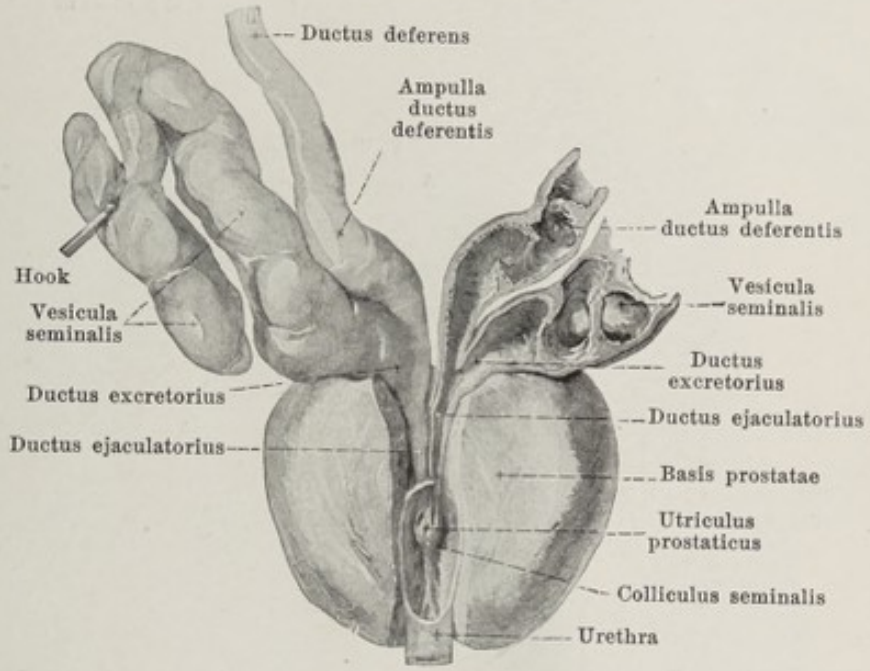
(The prostate has been separated from the urinary bladder; on the left side seminal vesicles and seminal ducts have been cut open.)

The *proper sheath of the testicle, tunica vaginalis propria testis* (see Figs. 649, 699, 700 and 702), is the serous covering of the testicle and epididymis (see pp. 604 and 605) and arises with the descensus testis as a blind-sac-like prolongation of the peritonaeum, *processus vaginalis peritonaei;* it lies before the descensus as a small projection, but develops fully only with the descensus testis. This extends in the fetus in front of the ductus deferens and in front of the testicle as far as the bottom of the scrotum and surrounds a cavity which is connected at the annulus inguinalis abdominalis with the peritoneas cavity. At the time of birth or somewhat later the upper longer part of this cavity from the annulus inguinalis abdominalis as far down almost as the caput epididymidis usually becomes obliterated. (This obliteration may be delayed, may be partial, or may not occur at all.) In its place later there is found only a somewhat firm cord of connective tissue, *rudimentum processus vaginalis* (not illustrated), though this is very often absent. The lower end of this fetal peritoneal sac remains throughout life as the tunica vaginalis propria testis. This membranous sheath with its *lamina visceralis* directly covers the surface of the testicle (see p. 604) and of the epididymis (see p. 605), as well as in part the lowermost end of the ductus deferens and forms between the testicle and the epididymis the *sinus epididymidis* (see p. 605). Beyond these attachments it is continued into the *lamina parietalis*, which surrounds the testicle and epididymis with the exception of the posterior margin as a wide, loose sac and is separated from the lamina visceralis by a slit-like space containing a little serous fluid.

The **testicular sac** or *scrotum* (see Fig. 705) is a wide, loose, unpaired bag formed by the external skin; it incloses the testicles, epididymis and spermatic cords and their sheaths. Its cutis (see also Figs. 708 and 709) is connected above with that of the penis and the mons pubis, lateralward with that of the thigh, behind with that of the perineum; it is thin, of a dark color, wrinkled and possesses only a few hairs but many sebaceous and sweat glands. In the median plane runs a narrow darker strip, *raphe scroti*, from the under surface of the penis to the perineum. In the tela subcutanea of the skin lies the *tunica dartos*, a layer consisting of smooth muscle fibres interwoven in the form of a network, which is connected above with the fascia penis and fascia superficialis of the abdomen, thigh and perineum. It is continued in the median plane as the *septum scroti* (see also Fig. 709) into the interior of the scrotum, and so separates the two spaces filled up on each side by testicle, epididymis and spermatic cord; it is connected with the fascia of the penis and perineum. Beneath the tunica dartos follows a very loose subcutaneous tissue, free from fat, which forms the connection with the fascia cremasterica and the m. cremaster.

707. Ductus ejaculatorii,

viewed from in front and above.

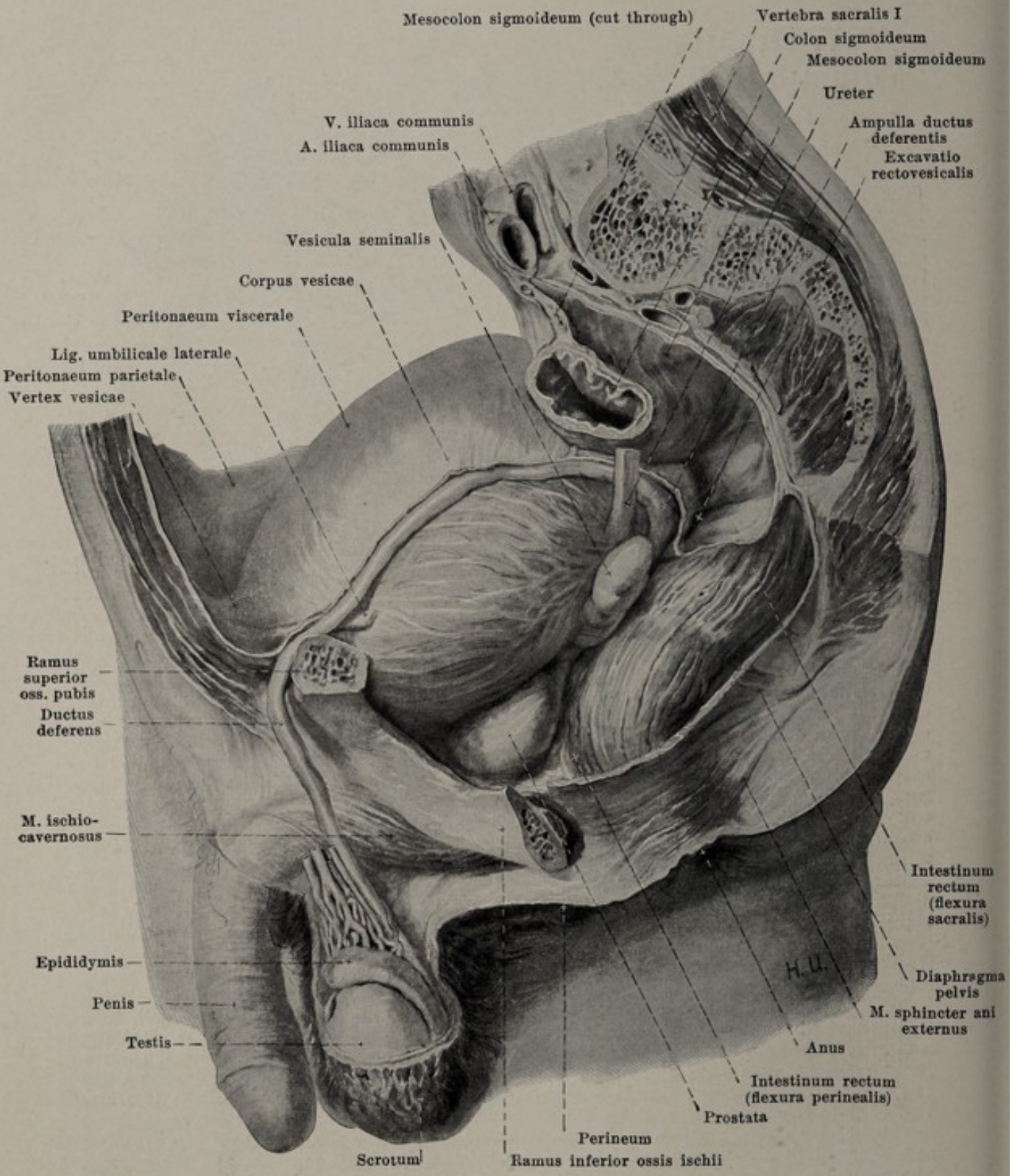


(The same preparation as in Fig. 706. In addition the right seminal vesicle has been further dissected out and a wedge has been cut out of the prostate reaching as far as the ductus ejaculatorii and the urethra.)

The **seminal vesicles**, *vesiculae seminales* (see also Figs. 650, 693, 706 and 708), are paired, oblong, flattened bodies of variable size, with a nodular surface; the upper end of each is broader, the lower end apical and directed toward the basis prostatae. Their long axes run in a plane inclined forward and downward, and at the same time they converge at their lower ends. The seminal vesicles lie above and behind the prostate; they are attached in front, when the bladder is full in their whole extent (when the bladder is empty only in their lower portions) to the posterior wall of the bladder, behind in the lower half to the rectum and are separated from the musculature of these organs by only a little loose, fatty, connective tissue. The medial margin lies on each side in contact with the ampulla ductus deferentis, and in front of its upper end runs the last portion of the ureter. The posterior surface is covered in its upper third or upper half by the peritonaeum of the excavatio rectovesicalis. Each seminal vesicle consists of a large tortuous main duct into which open a variable number of accessory ducts; the main duct is often bent like a hook. In addition all the ducts present inside depressions separated by ridges and are externally united by connective tissue to form a firm continuous mass, *corpus vesiculae seminalis*. The main duct goes over into the *ductus excretorius* at the lower end where it becomes narrower; the excretory duct unites with the lower end of the ampulla ductus deferentis to form the ductus ejaculatorius. The wall of the seminal vesicle consists of an external connective tissue layer, *tunica adventicia*, a middle, well-developed *tunica muscularis* and an internal, secreting mucous membrane, *tunica mucosa*.

The ***ductus ejaculatorius*** (see also Fig. 709) arises on each side at the basis prostatae through the union of the lower end of the ampulla ductus deferentis with the ductus excretorius of the seminal vesicle. It is a very narrow canal which runs downward and forward into the prostate, lies directly upon the wall of the utriculus prostaticus and opens at the colliculus seminalis (see also Fig. 696) by a fine, slit-like opening into the urethra.

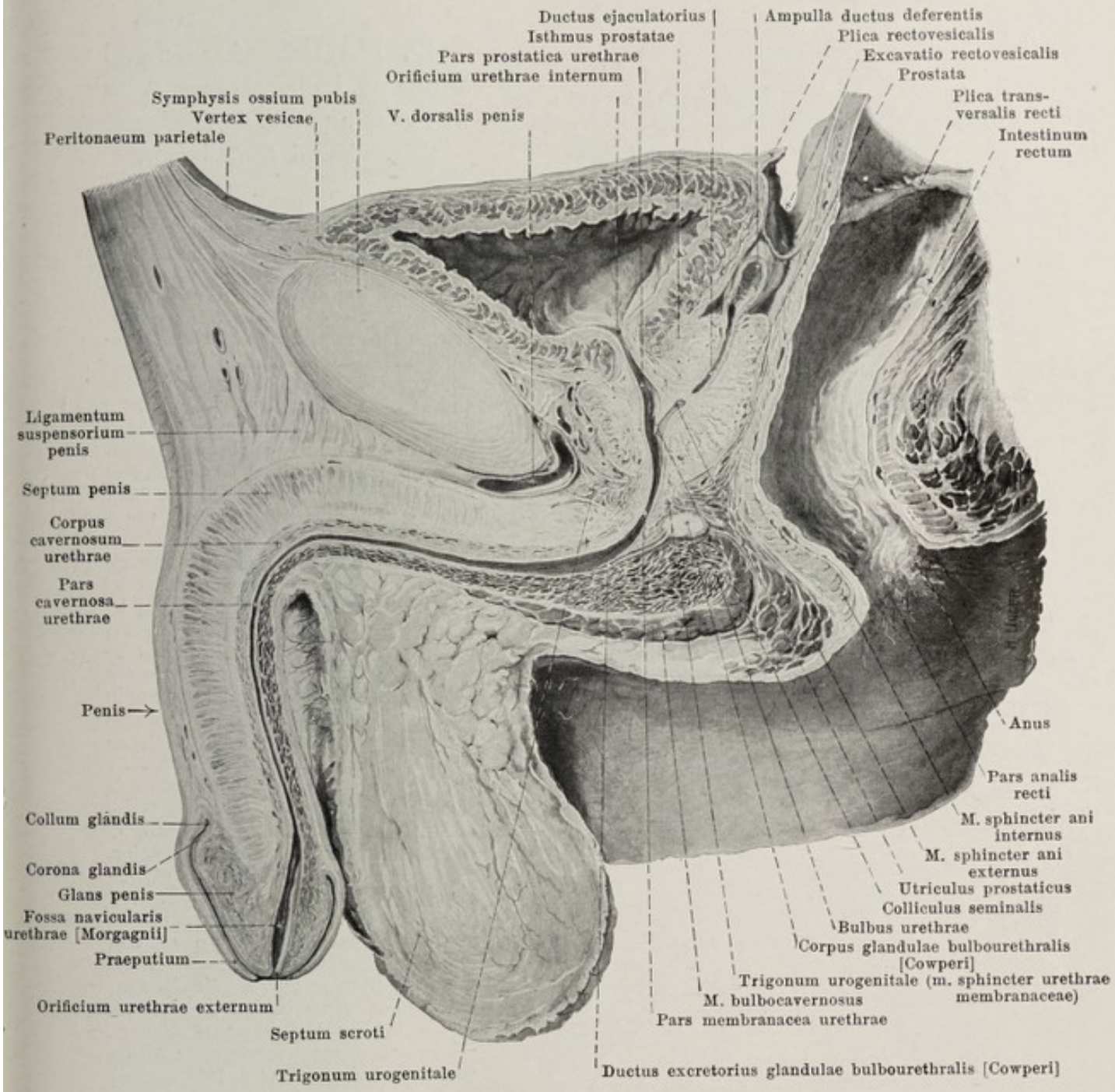
The **prostate gland**, *prostata* (see also Figs. 693, 696, 706, 708, 709 and 730), is an unpaired glandular body of the form of a chestnut, the rounded tip of which, *apex prostatae*, is directed downward and rests upon the trigonum urogenitale. Its anterior, shortest surface, *facies anterior*, which looks at the same time a little downward, lies behind the lower portion of the symphysis ossium pubis; it is separated from it by the plexus pudendalis (see also Fig. 551) and connected with it by the ligamenta puboprostatica. The lateral surfaces are bounded by the medial margins of the mm. levatores ani and the plexus vesicalis (see Figs. 551 and 730), which fills up especially the groove between the basis prostata and the bladder. The posterior surface, *facies posterior*, is in almost direct contact with the anterior wall of the rectum, being separated from it only by a little loose connective tissue, devoid of fat; it frequently presents a median, shallow groove (see Fig. 693) which only imperfectly separates the two lateral halves, *lobus dexter* and *lobus sinister*, from one another. The largest, upper surface, *basis prostatae*, is at the same time directed a little obliquely forward and is concave. That portion of it situated behind the urethra presents in the middle a deep, short transverse groove for the entrance of the ductus ejaculatorii; this groove separates a posterior from an anterior area. The posterior area lies in loose contact with the ampulla of the seminal ducts and the seminal vesicles. (Continuation see p. 611).



708. Pelvic organs in the male,

after removal of the left wall of the pelvis, viewed from the left.

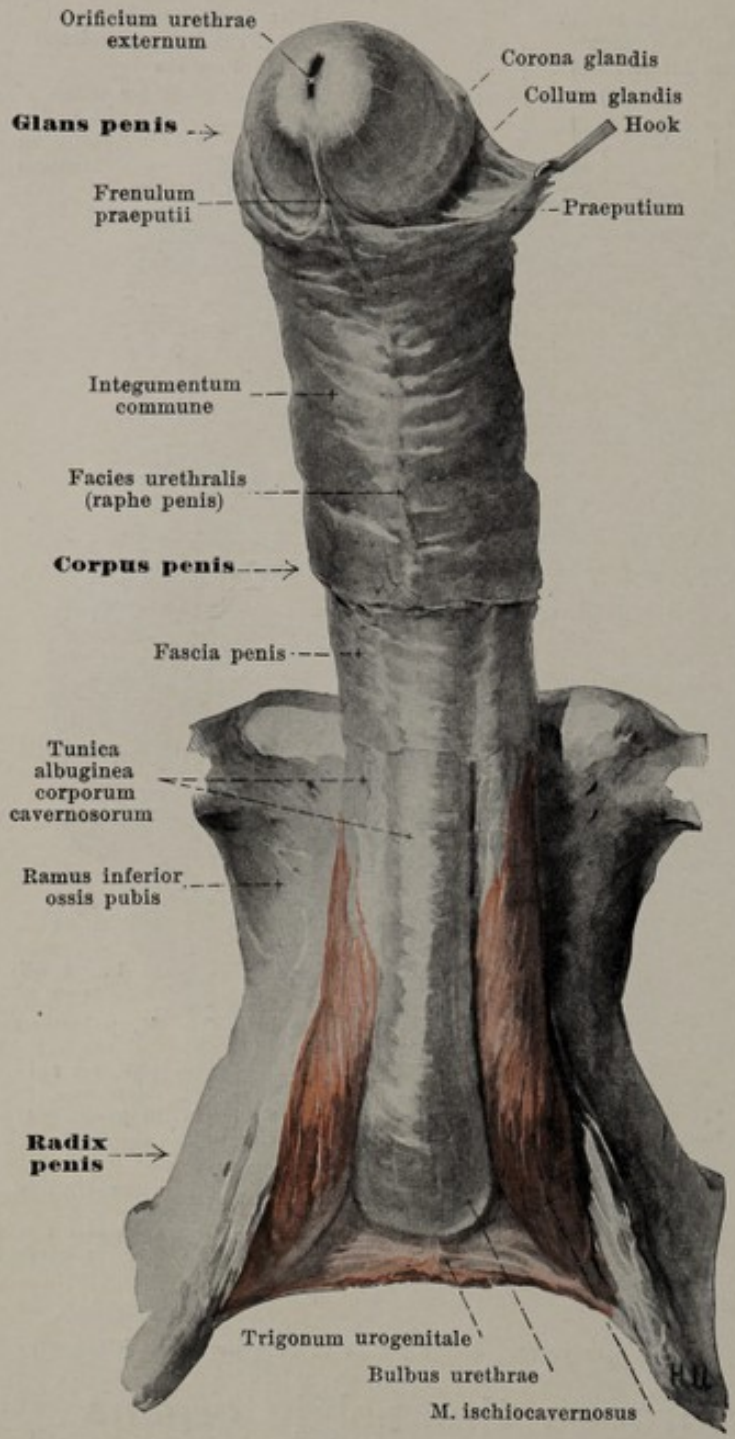
(The urinary bladder is markedly distended.)



709. Median section through the pelvic organs in the male, right half, viewed from the left side (partly after a frozen section by W. Braune).

(The urinary bladder has been only partly filled. The left glandula bulbourethralis [Cowperi] situated laterally from the median plane has been introduced as though projected upon the median plane. The urethra is represented as somewhat dilated.)

Prostata (continued). The area of the basis lying between the urethra and the ductus ejaculatorii, *isthmus prostatae* (see Fig. 706), is with the rest of the basis firmly united to the fundus vesicae; it may in old age project so as to form a rounded nodule, *lobus medius* (not illustrated), which bulges forward the wall of the trigonum vesicae. The prostate is obliquely perforated in its posterior upper part by the ductus ejaculatorii. Through its anterior part from the basis as far as the apex runs the pars prostatica of the urethra; it enters above at the basis and leaves the prostate a little in front and above the apex. (Continuation see p. 612.)



710. Penis, after removal of the m. bulbocavernosus, as well as of a part of the fascia and skin, viewed from below.

Prostata (continued) (see Figs. 696, 709 and 730). It consists in largest part of glandular substance which as *corpus glandulare* surrounds the first portion of the urethra in the form of a broad clasp, open in front. This clasp is closed to form a ring by the *m. prostaticus*. The latter consists, in its upper part, of smooth muscle fibres and is connected with the m. sphincter vesicae; in the lower part it is formed of striped fibres and is inseparably continuous with the m. sphincter urethrae membranaceae (see p. 629). The muscle fibres run especially transversely and radiate out into the glandular substance and upon its surface. The glandular substance consists of many (30—50) small wedge-shaped lobules, the apices of which are directed toward the urethra; each of them contains a small excretory duct, *ductus prostaticus;* of such ducts there are in all from 20 to 30, they mostly open into the urethra in the two grooves lateralward from the colliculus seminalis.

The surface of the prostate is smooth and is covered on its posterior and lateral surfaces by a sheath of connective tissue, the *fascia prostatae.*

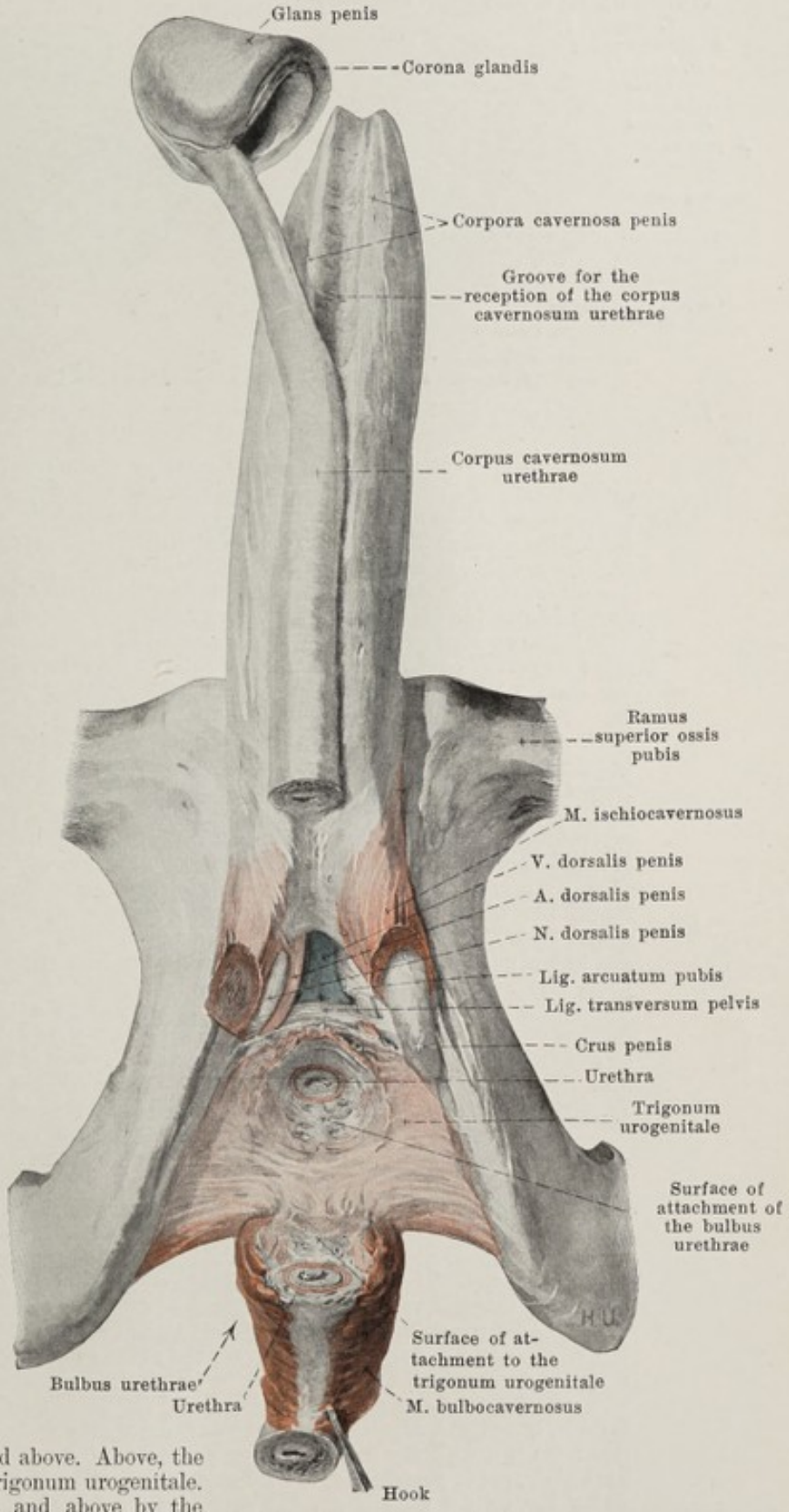
The **glandula bulbourethralis [Cowperi]** (see Figs. 693, 709 and 726) is a paired gland, of the size of a pea; the surface of this gland is nodular. It lies with its *corpus glandulae bulbourethralis* near the median plane behind the urethra, ensheathed by the fibres of the m. sphincter urethrae membranaceae, within the trigonum urogenitale. Its excretory duct, *ductus excretorius* (see Fig. 709), is very thin, runs forward in the bulbus urethrae and opens by a fine slit in the posterior part of the pars cavernosa urethrae.

The **penis** (see also Figs. 708, 709, 711—714) is a long, trilaterally-prismatic body which lies below and in front of the symphysis ossium pubis and surrounds the longest part of the urethra. It presents for examination a posterior, broader end, *radix penis*, and an anterior main portion, *corpus penis*, the free end of which is formed by the *acorn* or *glans penis*. The root and the posterior part of the corpus lie hidden below the skin of the perineum and scrotum and are immovably fastened *(pars fixa)* by fusion with the trigonum urogenitale, the pubic bones and the symphysis; the rest projects free and is easily movable *(pars mobilis);* between these two parts when the organ is relaxed is an angle which vanishes during erection. The corpus penis possesses an upper surface, *dorsum penis*, and a lower surface, *facies urethralis;* these are not sharply separated from one another by the rounded lateral surfaces.

711. Corpora cavernosa penis and trigonum urogenitale,

viewed from below.

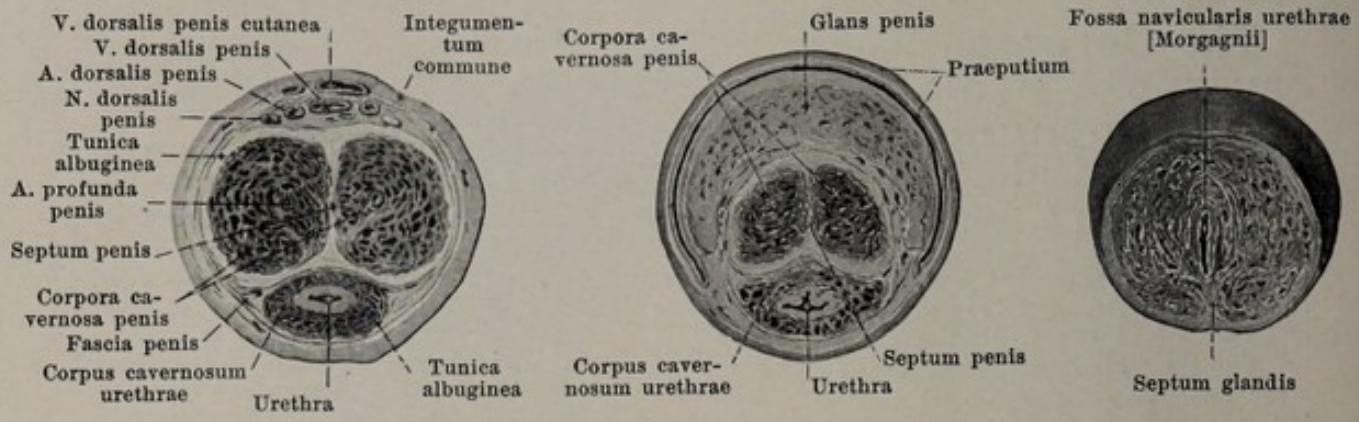
(The bulbus urethrae has been cut off distalward, dissected out and reflected backward. On the left side the m. ischiocavernosus alone has been cut through, on the right side it and also the crus penis have been cut away. The glans penis has been loosened from its position.)



Penis (continued). The penis consists chiefly of the three ***erectile bodies,*** *corpora cavernosa.*

The two *corpora cavernosa penis* are approximately cylindrical, tube-like structures. Their posterior pointed ends, *crura penis,* run converging along the medial margins of the rami inferiores of the ischium and pubis in front of the symphysis pubis and are firmly attached to the bones by fusion of their tunica albuginea with the periosteum. In front of the lower part of the symphysis the two crura unite at an acute angle to form an unpaired, flat-rounded body, which reaches by its anterior pointed end into the posterior excavation of the glans penis; its upper surface possesses a flat median groove for the v., aa. and nn. dorsales penis, its lower surface a deeper groove for the reception of the corpus cavernosum urethrae.

The *corpus cavernosum urethrae* (O. T. corpus spongiosum) is thinner and longer than the two others. It begins behind in a swelling the size of a hazelnut, the *bulbus urethrae,* which may be divided by a shallow constriction of the posterior margin into two *hemisphaeria bulbi urethrae;* this groove corresponds to a thin median *septum bulbi urethrae* in the interior which consists of connective tissue and projects deep down from behind and above. Above, the bulbus is firmly united with the trigonum urogenitale. The bulbus is perforated in front and above by the urethra so that its main mass lies behind the latter. In front becoming gradually narrower it goes over into the longest narrow-cylindrical part, which is attached to the corpora cavernosa penis in a longitudinal groove on their lower surface and surrounds the urethra on all sides.



712—714. Cross-sections of the penis

through the body. through the posterior part of the glans penis. through the anterior part of the glans penis.

Penis (continued). The *glands penis* or *acorn* has the form of a blunt wedge. Its excavated base is firmly united with the anterior end of the combined corpora cavernosa penis and projects lateralward and upward somewhat behind these by a swelling, the *corona glandis;* behind the corona runs a groove, *collum glandis.* The upper surface of the glans is longer and convex, the lower is more flat. The glans consists of a special erectile body which is separated from the others more or less distinctly; it surrounds the anterior, reduced end of the corpus cavernosum urethrae with the urethra, which runs near its lower surface and opens at the apex of the acorn.

The *corpora cavernosa penis* are covered by a thick layer of connective tissue, *tunica albuginea corporum cavernosorum*, which extends also between the combined corpora cavernosa as the *septum penis;* in front and dorsalward the latter possesses numerous slit-like openings through which the vessels of the two corpora cavernosa communicate with one another (see Fig. 709). Numerous leaf-like or thread-like columns, *trabeculae corporum cavernosorum,* containing smooth muscle fibres, go off from the tunica albuginea into the interior, where they form a close network; the meshes of the same are smaller in the periphery than near the septum and surround spaces filled with blood, *cavernae corporum cavernosorum.* Through this network of trabeculae extending forward on each side near the septum is the a. profunda penis. The arterial branches run in the trabeculae and open directly into the cavities by means of precapillary branches. Part of them, especially these in the crura penis, appear to be bent around tendril-like at the end, *arteriae helicinae*, when the organ is relaxed. The veins, *venae cavernosae*, from the posterior, larger part of the corpora from the vv. profundae penis; in front and in the middle they pierce the tunica albuginea at various places, surrounding arch-like the penis (see Fig. 551) and reach the v. dorsalis penis.

The *corpus cavernosum urethrae* is covered by a thin tunica albuginea; with the exception of the bulbus, in it no arteries open directly into venous spaces; it is composed solely of especially well developed submucous venous plexuses; their channels of exit empty partly into the branches of the v. dorsalis penis which surround the penis, partly directly into the vv. pudendae internae. The larger part of the corpus cavernosum lies u n d e r the urethra.

The *glans penis* is covered by a thin tunica albuginea, which sends a median *septum glandis*, composed of connective tissue from the lower surface as far as the urethra. The erectile tissue of the glans has essentially the same construction as that of the urethra.

The penis is attached above by means of two ligaments. The short, triangular, tough *ligamentum suspensorium penis* (see Figs. 705 and 709) goes from the anterior surface of the symphysis ossium pubis on the pars fixa penis to the tunica albuginea of the combined corpora cavernosa penis. The *ligamentum fundiforme penis* (see p. 297) surrounds the penis at the borderline between pars mobilis and pars fixa.

Loose connective tissue, the *fascia penis* (see also Fig. 710), covers the organ, and also the v., aa. and nn. dorsales penis, from the radix as far as the collum glandis; it is connected with the tunica dartos as well as with the fasciae superficiales perinei and abdominis.

The *skin, integumentum commune,* of the penis (see also Fig. 710) covers only the pars mobilis, is delicate, almost devoid of hairs, extensible and united by loose subcutaneous tissue, free from fat, with the fascia penis so as to be easily movable. On its lower surface a narrow dark strip, *raphe penis*, runs forward as a continuation of the raphe scroti as far as the prepuce. From the collum glandis on, the skin forms a folded duplicature, the *prepuce, praeputium* (see also Figs. 709 and 710), in that it goes forward at first over the apex of the glans, is then reflected, runs backward again as far as the collum glandis and finally, becoming very thinned, covers the surface of the glans directly; it is connected with the lower surface of the glans by a median fold, *frenulum praeputii.*

The **male urethra**, *urethra virilis* (see Fig. 709), is the excretory duct of the bladder and (with the exception of its initial portion) also of the genital organs; it begins at the collum vesicae at the *orificium urethrae internum*, and ends at the apex of the glans penis at the *orificium urethrae externum*. When the penis is relaxed the urethra describes in its course an ∾-shaped curve which varies individually, and is divided according to the structures perforated by it into a *pars prostatica*, *pars membranacea* and *pars cavernosa*.

The *pars prostatica* (prostatic portion of the urethra) (see Figs. 696 and 709) perforates the prostate from the base to the apex, surrounded by it on all sides and runs in an almost vertical direction. At the orificium urethrae internum and directly beneath it, it is surrounded by the *annulus urethralis vesicae* (see p. 602). In the middle of its posterior wall projects an oblong, rounded elevation, *colliculus seminalis;* this appears as aswelling on a longitudinal ridge of mucous membrane, *crista urethralis*, which reaches from the uvula vesicae on into the pars membranacea and even somewhat farther and distalward frequently bifurcates. Above the colliculus and in front of it the urethra is markedly bulged out being deepened at its two sides to form grooves. The colliculus contains the openings of the ductus ejaculatorii, of several ductus prostatici and in the median plane an oblong, slit-like blind sac, the *utriculus prostaticus (vagina masculina)*, which is directed obliquely upward toward the basis prostatae and opens, slit-like, at the level of the colliculus. The utriculus is the rudiment of the fused caudal extremities of Müller's ducts.

The *pars membranacea* (see Figs. 709 and 726) perforates the trigonum urogenitale obliquely from behind and above forward and downward and is almost immovably attached in it. It is surrounded by a ring of cavernous tissue and by a layer of cross-striped muscle fibres, *m. sphincter urethrae membranaceae* (see p. 629), which goes over proximalward directly into the m. prostaticus and can be followed distalward as far as the anterior half of the penis.

The *pars cavernosa* (cavernous portion of the urethra) (see Figs. 709, 712—714) runs within the corpus cavernosum urethrae and the glans penis. Behind, it is curved so as to be slightly convex downward, then extends forward and somewhat upward and finally if the penis is flaccid bends downward. In the region of the bulbus it is regularly bulged out somewhat backward. In this region open also the glandulae bulbourethrales [Cowperi]. In the glans penis it presents an oblong dilatation, *fossa navicularis urethrae [Morgagnii];* on its upper wall there is frequently a thin fold of mucous membrane, *valvula fossae navicularis* (not illustrated), which bounds a pocket, open in front.

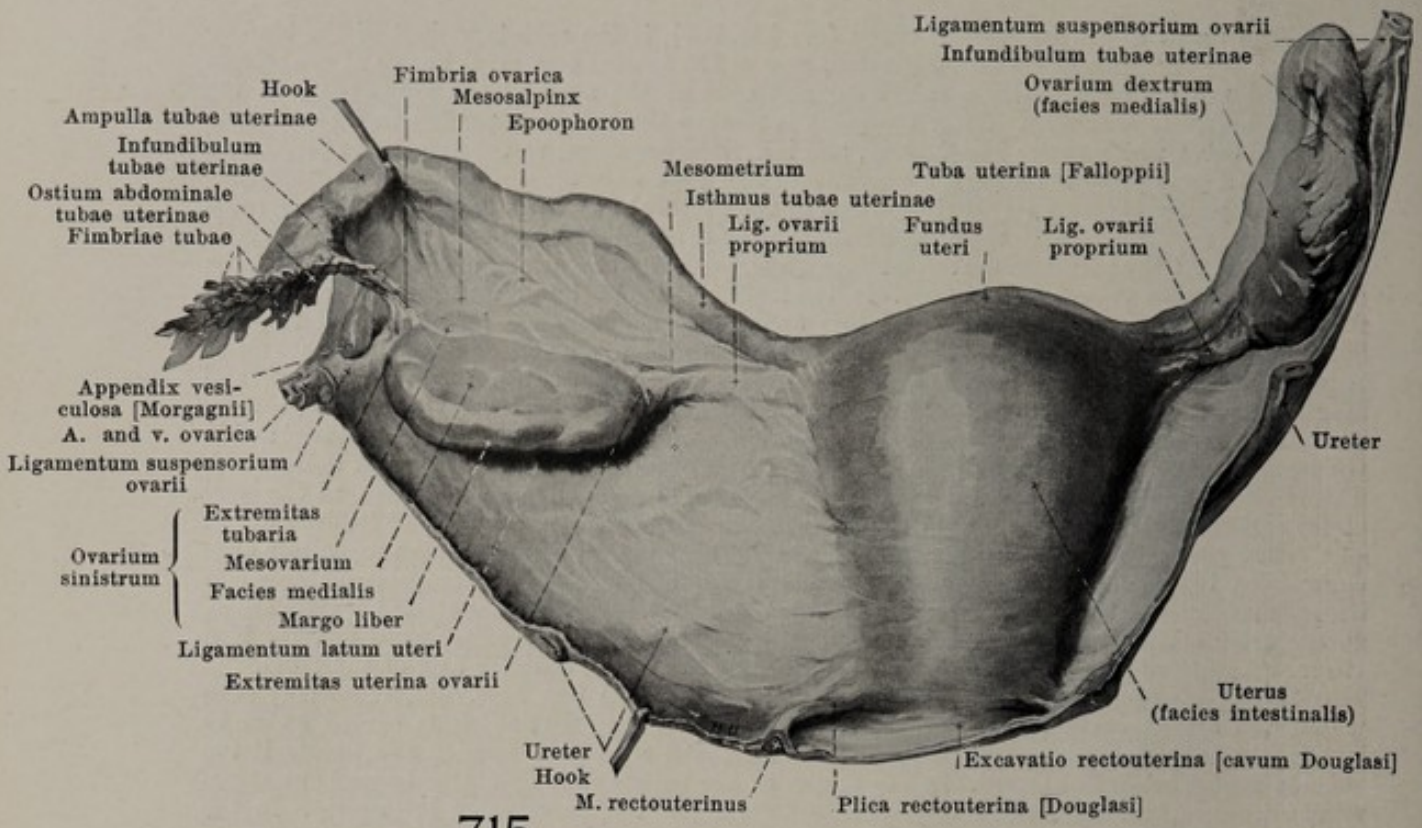
The walls of the empty urethra lie directly in contact with one another. At the orificium urethrae internum, in the pars prostatica and pars membranacea (see Fig. 711) its *lumen* forms a slit which is convex forward, the greatest breadth and depth of which corresponds to the colliculus seminalis; in the most posterior part of the pars cavernosa it is a vertical slit, in the larger anterior portion (see Fig. 712) it is a slit which is slightly concave dorsalward; in the base of the glans it is ⊥-shaped (see Fig. 713), in the fossa navicularis and at the orificium externum it is a vertical slit (see Fig. 714).

The *caliber* of the urethra is narrowest at the orificium externum and becomes dilated in the fossa navicularis; then follows the progressively somewhat narrower, long stretch of the pars cavernosa as far as the second dilatation in the bulbus urethrae; upon this again follows a marked narrowing in the pars membranacea, then a third wider portion in the pars prostatica, and finally again a narrowing at the annulus urethralis. The two narrowest spots (at the orificium externum and in the pars membranacea) are also the least extensible.

The urethra is lined by a thin, whitish mucous membrane. This possesses, except in the most anterior portion, small glands, *glandulae urethrales [Littrei];* they open partly into the *lacunae urethrales [Morgagnii]* (see Fig. 695), which are small pockets of mucous membrane, open forward occurring especially in the upper wall of the pars cavernosa.

Course of the peritonaeum in the male pelvis (see Figs. 649, 650, 708 and 709).

From the posterior surface of the anterior abdominal wall the peritonaeum goes directly over upon the upper surface of the urinary bladder; on the side it covers for a certain distance the lateral surfaces of the small pelvis, that is, the vessels and nerves situated there, the ureters and the seminal ducts, before it is reflected upon the wall of the bladder. This distance is larger when the bladder is empty than when it is full. In addition when the bladder is empty the peritonaeum forms a larger fold, *plica vesicalis transversa* (see also Figs. 719 and 720), which runs transversely over the upper surface of the bladder toward the origin of the annulus inguinalis abdominalis; less constantly present are from two to three smaller folds, *plicae pubovesicales* (see Fig. 650), which extend from the region of the vertex vesicae toward the plica umbilicalis lateralis. Behind the peritonaeum covers a portion of the fundus vesicae, the seminal vesicles and the seminal ducts and then bends around into the tunica serosa of the rectum. Between the bladder and rectum there thus arises a pocket, generally slit-like, *excavatio rectovesicalis*. It is deepest in the middle but as a rule does not reach down to the prostate and is bounded above by two folds, *plicae rectovesicales*, which go from the posterior part of the bladder in the form of an arch to the lateral surface of the rectum; the folds contain smooth muscle fibres in their bases, *mm. rectovesicales*.



715.

Uterus, Falloppian tubes and ovaries, viewed from behind.

(On the right the parts have been left in their natural position, on the left the ligamentum latum has been unfolded.)

The **ovaries,** *ovaria* (see also Figs. 716—720), are the two genital glands in the female; they lie in the small pelvis and are attached by a narrow fold of peritonaeum, *mesovarium,* to the posterior surface of the ligamentum latum uteri.

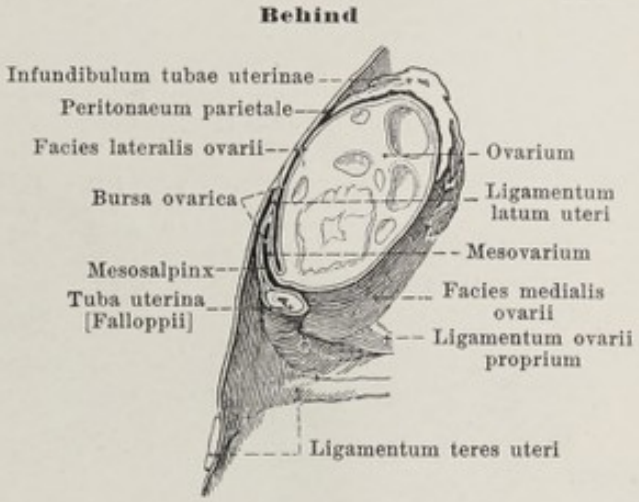
Each ovary has the form of a flattened ellipsoid. It presents for examination a *facies medialis* and a *facies lateralis,* a *pole* directed upward, *extremitas tubaria,* and a somewhat narrower pole looking downward, *extremitas uterina;* its more convex, posterior margin, *margo liber,* is free; its more straight, anterior margin, *margo mesovaricus,* is attached to the mesovarium. The latter margin presents also an oblong groove, *hilus ovarii,* for the entrance and exit of vessels and nerves. From the lower pole goes off the ligamentum ovarii proprium and to the upper pole the fimbria ovarica is attached.

The ovary (see also Figs. 717—720) is placed almost exactly sagittally in its largest plane of hemisection, and nearly vertically in its longest diameter (when the body is in upright position); it is freely movable and can be easily displaced from its position. Its lateral surface lies directly in contact with the peritoneal covering of the lateral wall of the small pelvis. The area of apposition is sometimes depressed so as to form a hollow, lies below and behind the a. and v. iliaca externa and is bounded in front and above by the a. umbilicalis, behind and above by the a. and v. hypogastrica and by the ureter, which in this situation runs on the anterior margin of the a. hypogastrica and before it; lateralward from this area are situated the n. obturatorius, the a. and v. obturatoria and the m. obturator internus. It is rare that the two ovaries lie exactly symmetrically. If the uterus is displaced to the right, then the left ovary sinks somewhat and its lower pole is turned somewhat medianward and vice versa. The ovarium is partly overlain by the tuba uterina, so that only a small part of its medial surface looks free into the pelvic cavity.

The surface of the ovary covered by the germinal epithelium is grayish-red; in childhood it is smooth, later it is uneven on account of nodular projections and scarred depressions. The interior (see Fig. 717) consists of a central medullary layer and a peripheral cortical layer. The latter contains spherical structures, up to the size of a pea, the *egg follicles,* the largest of which project beyond the surface. The smaller are called *primary follicles, folliculi oophori primarii,* the larger contain a clear fluid, *liquor folliculi,* and are called *Graafian follicles, folliculi oophori vesiculosi [Graafi].* Each egg follicle contains one egg, *ovulum;* the follicles are separated from one another by firm connective tissue, *stroma ovarii.* After the extrusion of the egg from the follicle a *corpus luteum* develops from the latter; this changes later into a firm mass of connective tissue, *corpus albicans,* and finally vanishes entirely.

716. Right ovary and Falloppian tube

in their natural position, cut through transversely



The **uterine** or **Falloppian tube**, *tuba uterina [Falloppii]* (see also Figs. 715, 717—720), is a paired, long, thin, tube-like structure, which runs from the ovary to the uterus and is movably attached to the ligamentum latum uteri by means of a thin fold of peritonaeum, the *mesosalpinx*.

The tuba uterina (see Figs. 715 and 717) begins at the ovary by a wide, funnel-shaped portion, *infundibulum tubae uterinae*, the margin of which is split up into numerous narrow, very jagged processes, *fimbriae tubae;* one of these, the *fimbria ovarica*, is as a rule longer than the others, is continued along the free edge of the mesosalpinx as far as the extremitas tubaria of the ovary and forms a groove beside the ovary. The inner surface of the fimbriae is studded with numerous folds of mucous membrane, which are continued directly into the longitudinal folds of the ampulla; between them, in the depth, is situated the narrow opening, *ostium abdominale tubae uterinae*. The longer portion following upon the infundibulum is called the *ampulla tubae uterinae;* it is tortuous and narrows gradually toward the narrowest part, the *isthmus tubae uterinae*, which is immediately adjacent to the uterus. The short terminal portion of the Faloppian tube, *pars uterina*, lies within the wall of the uterus and opens into the cavum uteri by a narrow funnel-shaped opening, *ostium uterinum tubae*.

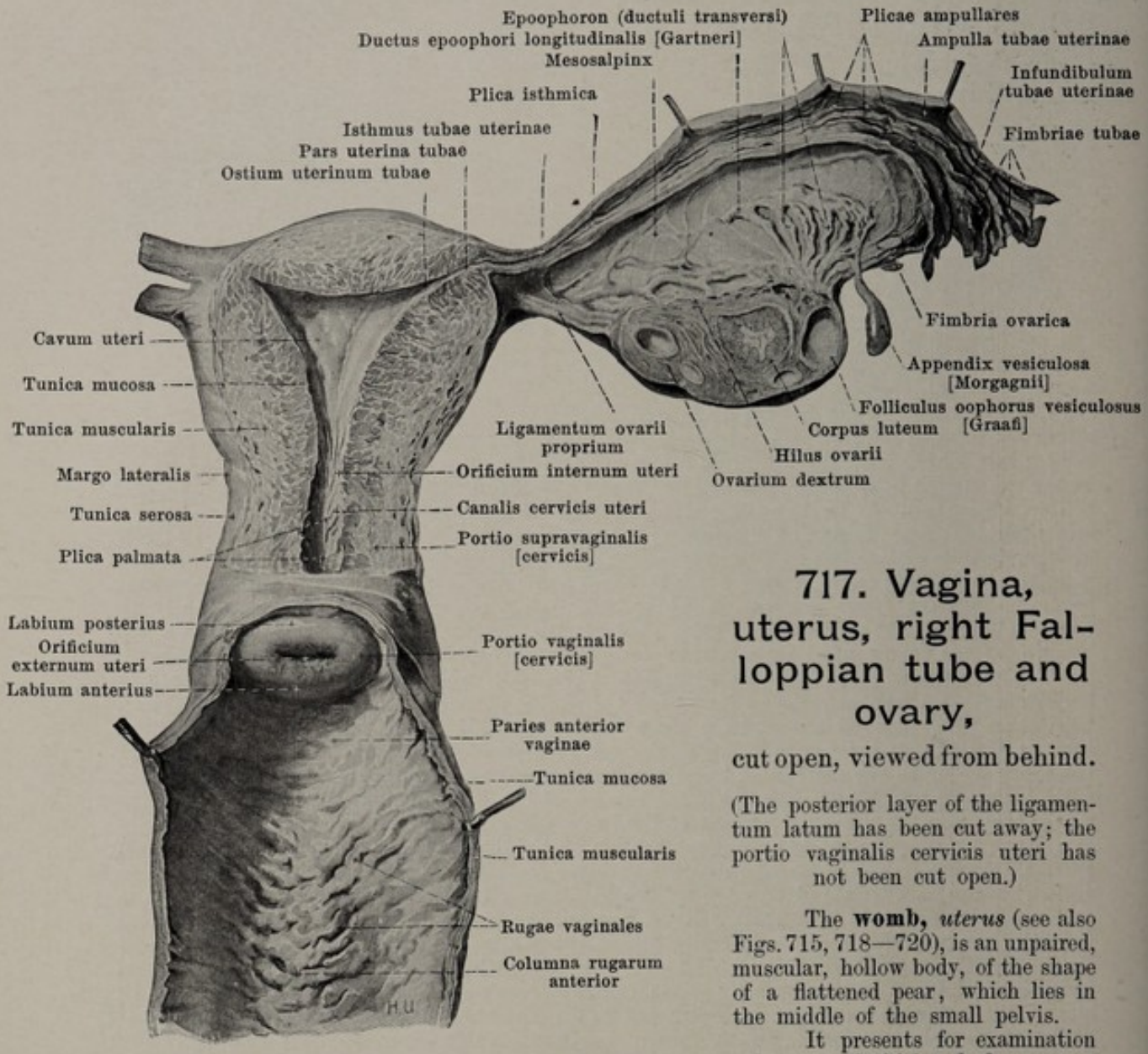
The isthmus runs (see also Figs. 715, 717—720), when the body is upright, nearly horizontally in a frontal plane as far as the extremitas uterina of the ovary. The Falloppian tube there bends around almost at a right angle and, lying close to the wall of the pelvis, ascends straight or tortous in front of the margo mesovaricus or at the medial surface of the ovary as far as the extremitas tubaria. Here it turns again abruptly downward and somewhat backward and along with the inner surface of the infundibulum lies directly upon the margo liber and the posterior portion of the facies medialis; the fimbria ovarica thus ascends in a recurrent direction to the extremitas tubaria. Since the ovary lies against the peritonaeum parietale of the pelvic wall lateralward and since in front, above, behind and partly also medianward it is overlapped directly by the Falloppian tube and by the mesosalpinx, it is enclosed by these parts in a pocket, *bursa ovarica*, the slit-like lumen of which is connected with the cavum peritonaei only laterally behind and medianly in front.

The Falloppian tube is covered on its external surface by peritonaeum, *tunica serosa*, beneath which lies a loose connective tissue, *tunica adventicia*. Then follows a layer of smooth muscle fibres, *tunica muscularis*, in which can be distinguished a thinner external longitudinal layer, *stratum longitudinale*, and a thicker internal circular layer, *stratum circulare*. The inner surface is formed by a grayish-red mucous membrane, *tunica mucosa*. This everywhere presents very delicate folds, *plicae tubariae* (see Fig. 717), which begin in the pars uterina as simple, low, longitudinal folds and become larger in the isthmus, *plicae isthmicae;* in the ampulla they are highest and form the *plicae ampullares*, and here they are studded with accessory folds. At the free jagged margin of the infundibulum the mucous membrane is continued directly into the peritonaeum.

The *epoophoron* (see Figs. 715 and 717) is a small flattened body which lies on each side in the lateral portion of the mesosalpinx between its peritoneal layers. It consists of several short canals, *ductuli transversi*, which converge toward the hilus ovarii and near the the Falloppian tube open almost at a right angle into a main canal, *ductus epoophori longitudinalis [Gartneri]*. The latter represents the remains of the embryonal Wolffian duct, the ductuli transversi being remains of the tubules of the Wolffian body.

Appendices vesiculosae [Morgagnii] (see Figs. 715 and 717). O. T. hydatids of Morgagni.) Hanging down free, almost constantly, from the region of the epoophoron, one or several pedunculated vesicles filled with fluid; they have their origin in the Wolffian duct.

Paroophoron (not illustrated) seen with the naked eye only until the first year, is a flat, roundish, brown or grayish-yellow body, which lies medially from the epoophoron, between the leaves of the mesosalpinx in the vicinity of the angle between the uterus and tube. It contains canaliculi and glomeruli, as the remains of the caudal part of the Wolffian body.



717. Vagina, uterus, right Fallopian tube and ovary,

cut open, viewed from behind.

(The posterior layer of the ligamentum latum has been cut away; the portio vaginalis cervicis uteri has not been cut open.)

The **womb,** *uterus* (see also Figs. 715, 718—720), is an unpaired, muscular, hollow body, of the shape of a flattened pear, which lies in the middle of the small pelvis.

It presents for examination a larger and thicker *body, corpus uteri*, and a *neck, cervix [uteri]*. The body possesses an inferior, fairly smooth surface lying upon the urinary bladder, *facies vesicalis*, and an upper surface, turned at the same time somewhat backward, *facies intestinalis*, which is curved above so as to be convex in the frontal and sagittal directions. The anterior, blind end is broad and convex (more markedly convex in women who have borne children than in nulliparae); that portion of it which projects beyond the line between the openings of the Falloppian tubes is called the *fundus uteri*. The body narrows behind, goes over into the cervix and is usually marked off from the latter by a shallow constriction. Lateralward on each side runs a blunt margin, *margo lateralis*, from which the ligamentum latum uteri goes off. The neck in children and nulliparae is spindle-shaped; in women who have borne children it is of a cylindrical shape. Its posterior, inferior third is surrounded by the upper end of the vagina and projects into the cavity of the latter; it is called the *portio vaginalis [cervicis]*; the remaining part of the cervix is the *portio supravaginalis [cervicis]*. The portio vaginalis is transversely elliptical and divided by the round or transversely oval *orificium uteri externum, external mouth of the womb*, into a *labium posterius*, and a *labium anterius*, both of which are smooth and of almost equal thickness; the anterior lip extends deeper down but is shorter than the posterior; in women who have borne children, the orificium is a transverse slit with irregular margins.

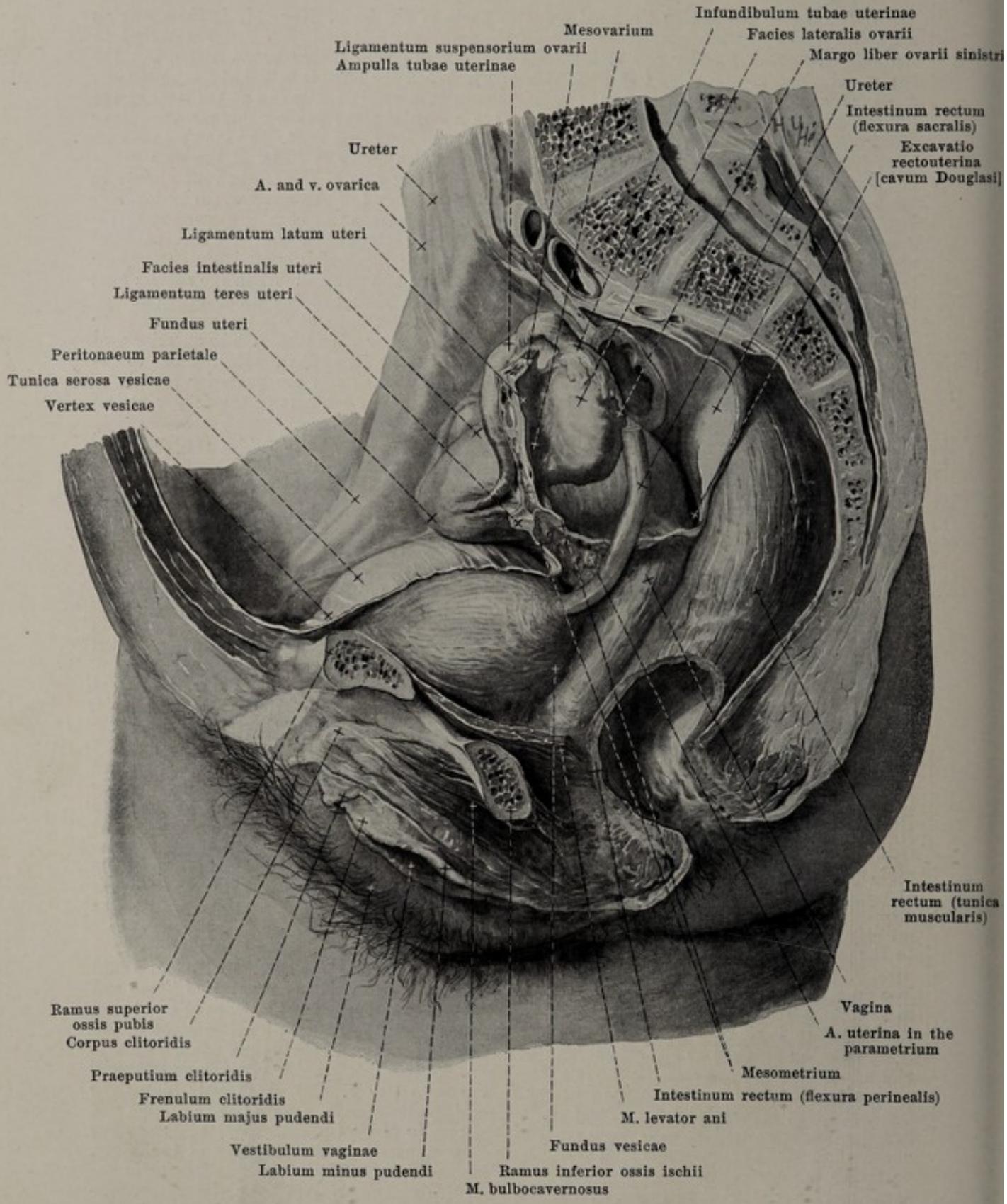
Uterus (continued).

The uterus belongs to the most movable parts of the body. Not only is the organ as a whole movable but the body is movable on the neck, which is relatively firmly attached to the vagina, urinary bladder and vessels. Its position can vary within broad limits, but the typical situation is as follows (see Figs. 718—720). When the body is in the upright position, and the bladder and rectum empty, the orificium externum uteri usually lies at the level of the upper margin of the symphysis ossium pubis and in a frontal plane passing through the spinae ischiadicae; above, the uterus does not reach the plane of the pelvic inlet. The long axis drawn from the fundus to the external orifice of the uterus lies above in front of the axis pelvis (see Fig. 206) *(anteversion* of the whole uterus). The long axis of the cervix runs almost in the axis pelvis, that of the corpus almost horizontally; the two form an angle which varies from 70° to 100° *(anteflexion* of the body of the uterus). The uterus lies usually somewhat asymmetrically; its anterior end especially tends to be displaced somewhat toward the right; it may even be turned toward the left. When the bladder fills, the anteflexion is diminished (its angle becomes larger) and the whole organ is displaced backward and upward. When the rectum fills, the anteflexion becomes larger (its angle is diminished in size) and the whole organ is displaced forward. The facies vesicalis of the corpus uteri lies upon the upper surface of the urinary bladder and causes a saucer-like depression in the latter when empty. The anterior wall of the cervix is connected by loose tissue with the posterior wall of the bladder. Close to the facies intestinalis of the corpus uteri lie loops of the intestine and the posterior surface of the neck helps to form the excavatio rectouterina. The lateral surfaces of the corpus and of the cervix adjoin the parametrium (see p. 623).

The uterus possesses in part a (visceral) peritoneal coat, *tunica serosa (perimetrium)* (see Figs. 717—719). This covers the posterior surface of the portio supravaginalis cervicis as well as the facies intestinalis, the fundus and the facies vesicalis of the body and is reflected in front at the junction between the corpus and cervix, at the level of the orificium internum uteri, upon the urinary bladder. It is attached very firmly to the fundus and the largest part of the body, lateralward more loosely, to the cervix very loosely and at the margo lateralis goes over directly into the ligamentum latum uteri. Beneath the tunica serosa is situated the thick *tunica muscularis (myometrium)*, composed of smooth muscle fibres, and consisting at the body mainly of a middle circular layer. The corresponding layer of the cervix, *tunica muscularis cervicis*, is formed by a thick middle layer of circular fibres as well as of an external and an internal thin layer of longitudinal fibres. The musculature is connected with that of the vagina, of the Falloppian tubes, of the ligamenta teretia and ovarii propria and with the mm. rectouterini. The inner covering is formed by the mucous membrane, *tunica mucosa*. This is of a grayish-red color, is firmly connected with the musculature and contains in the corpus tube-like glands, *glandulae uterinae*, in the cervix markedly dilated, *glandulae cervicales [uteri]*, which secrete mucus. The mucous membrane in the body is smooth and surrounds a cavity (see Figs. 717 and 719). In the corpus this is a triangular slit, *cavum uteri*, the anterior and posterior wall of which usually lie close against one another; the sides project so as to be convex inward in women who have not borne children; the upper two corners go over like funnels into the ostia uterina of the Fallopian tubes, the lower end is separated only imperfectly from the canalis cervicis uteri by a canal-like narrowing, *orificium internum uteri*. The cavity situated in the neck, *canalis cervicis uteri*, has a rounded spindle-shaped, slit-like lumen, is widest in the middle and opens into the vagina through the *orificium externum uteri* (see p. 618). Its mucous membrane presents a fold-formation, *plica palmata*, on its anterior and posterior walls; this consists of a thicker median ridge and finer folds going off obliquely from it lateralward and to the Falloppian tubes; the formation gradually vanishes at the orificium internum uteri.

Ligamentum teres uteri (round ligament of the uterus) (see Figs. 718—720 and 728) is a rounded, smooth cord about the size of a goose quill consisting of connective tissue and smooth muscle fibres; it arises on each side from the margo lateralis uteri in front of and below the Fallopian tube, runs at first horizontally in the ligamentum latum uteri in front of the isthmus tubae uterinae to the lateral wall of the small pelvis and then passes upward on this and forward to the annulus inguinalis abdominalis. In this last portion of its course it runs almost exactly as does the ductus deferens in the male (see p. 606). Finally it enters the inguinal canal, extends with the a. and vv. ligamenti teretis uteri, n. spermaticus externus and n. iloinguinalis as well as with some cross-striped muscle fibres (m. cremaster) as far as the annulus inguinalis subcutaneus and, spreading out, goes partly to the periphery of the latter, partly to the connective tissue and skin of the labium majus. At the annulus inguinalis abdominalis, lying in front and over it, is a small sac-like prolongation of the peritonaeum, *processus vaginalis peritonaei* (not illustrated), which is longer in fetal life and sometimes persists so.

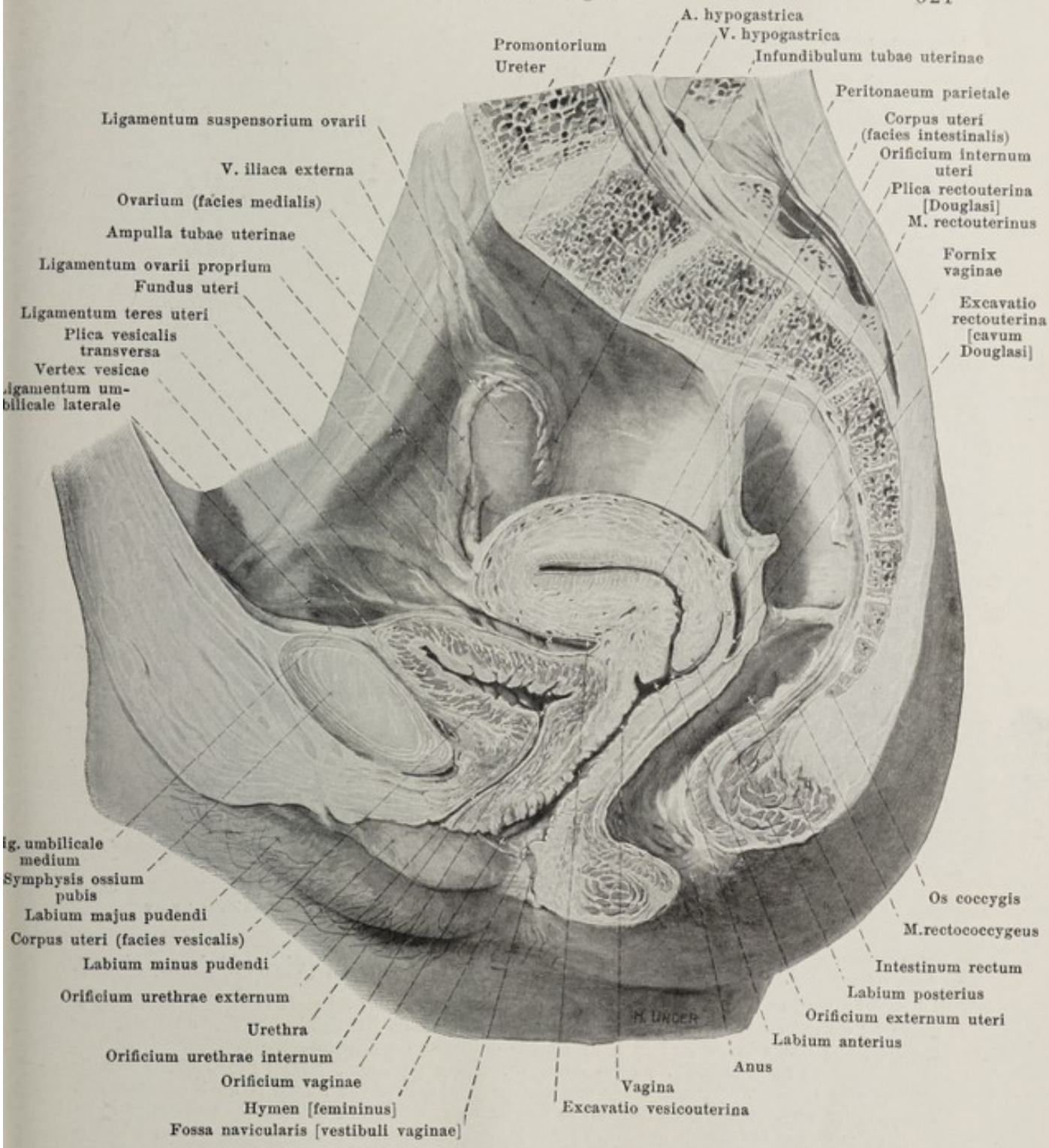
Ligamentum ovarii proprium (O. T. ligament of the ovary) (see Figs. 715, 717, 719 and 720) consists of connective tissue and smooth muscle fibres; it goes off on each side as a rounded cord from the upper end of the margo lateralis uteri, extends in the ligamentum latum to the extremitas uterina of the ovary and becomes lost in the hilus of the latter.



718. Pelvic organs in the female,

after removal of the left pelvic wall, viewed from the left.

(The urinary bladder is only partially filled. A piece has been cut out of the rectum.)

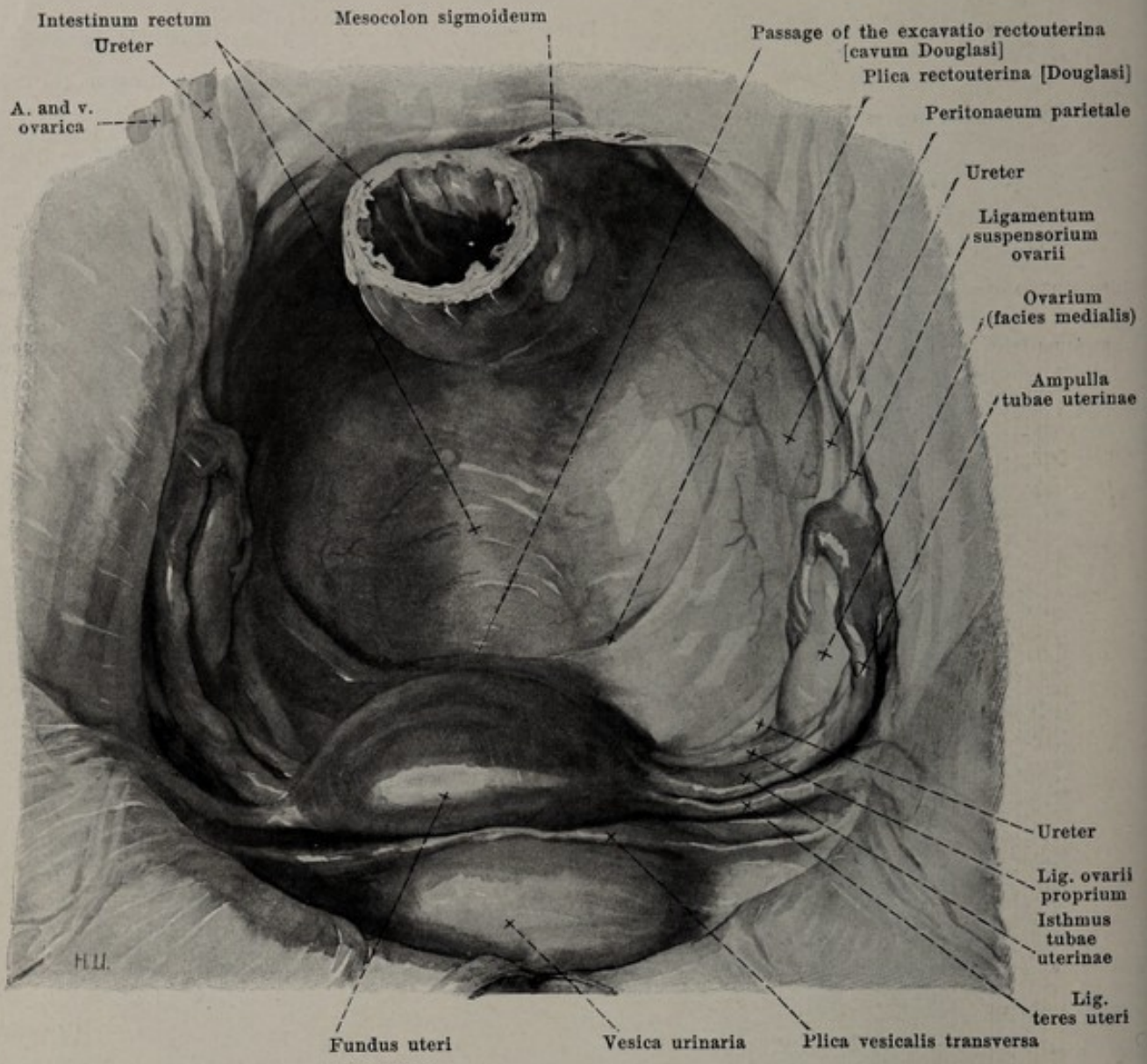


719. Median section through the pelvic organs in the female,

right half, viewed from the left (partly after a frozen section by W. Braune).

(The urinary bladder is empty. The canals lined by mucous membrane and the peritoneal spaces are represented as though somewhat dilated.)

M. rectouterinus (see also Fig. 715) is the name given to the smooth muscle fibres which run in the plica rectouterina [Douglasi] on each side. It arises as a flat, rounded cord from the posterior wall of the neck of the uterus, radiates out near the rectum into the neighborhood of the latter and extends in part to the musculature of the rectum, in part to the anterior surface of the sacrum.



720. Pelvic organs in the female, viewed from above.

The **vagina** (see Figs. 717—719) is a flattened muscular tube. It ends blind behind and above by an extremity which surrounds the portio vaginalis [cervicis] uteri like a ring, *fornix vaginae*, and opens below and in front by the *orificium vaginae* into the vestibulum vaginae. It possesses an anterior wall, *paries anterior*, and a posterior, *paries posterior*, which lie against one another. At the lower end the cross-section of the lumen is an H-shaped slit. The anterior wall, reaching as far as the labium anterius, is shorter than the posterior.

The wall of the vagina (see Fig. 717) is formed externally of a *tunica muscularis*, which is divisible into an external longitudinal and an internal circular layer. It consists above of smooth muscle fibres, in the trigonum urogenitale of cross-striped fibres. It has, lying loosely upon it within, the thick, grayish-red mucous membrane, *tunica mucosa*. In the virgin this presents, especially below, numerous strong transverse folds, *rugae vaginales*, which in the middle of the anterior and posterior walls form a longitudinal projection, *columna rugarum anterior* and *posterior*. The anterior projection is higher below and is continued in the vestibulum vaginae as far as the orificium urethrae externum as the *carina urethralis [vaginae]* (see Fig. 722). In virgins, going off at the orificium vaginae, chiefly from the posterior wall of the vagina, is a fold of mucous membrane, usually sickle-shaped, the *hymen [femininus]* (see Figs. 719 and 722); it extends forward and upward and narrows the opening. Its margin is smooth or slightly jagged By sexual intercourse the hymen is torn into several lobules, which shrivel up after the first child-birth into small lobe-like or wart-like projections, *carunculae hymenales* (see Fig. 721).

Vagina (continued).

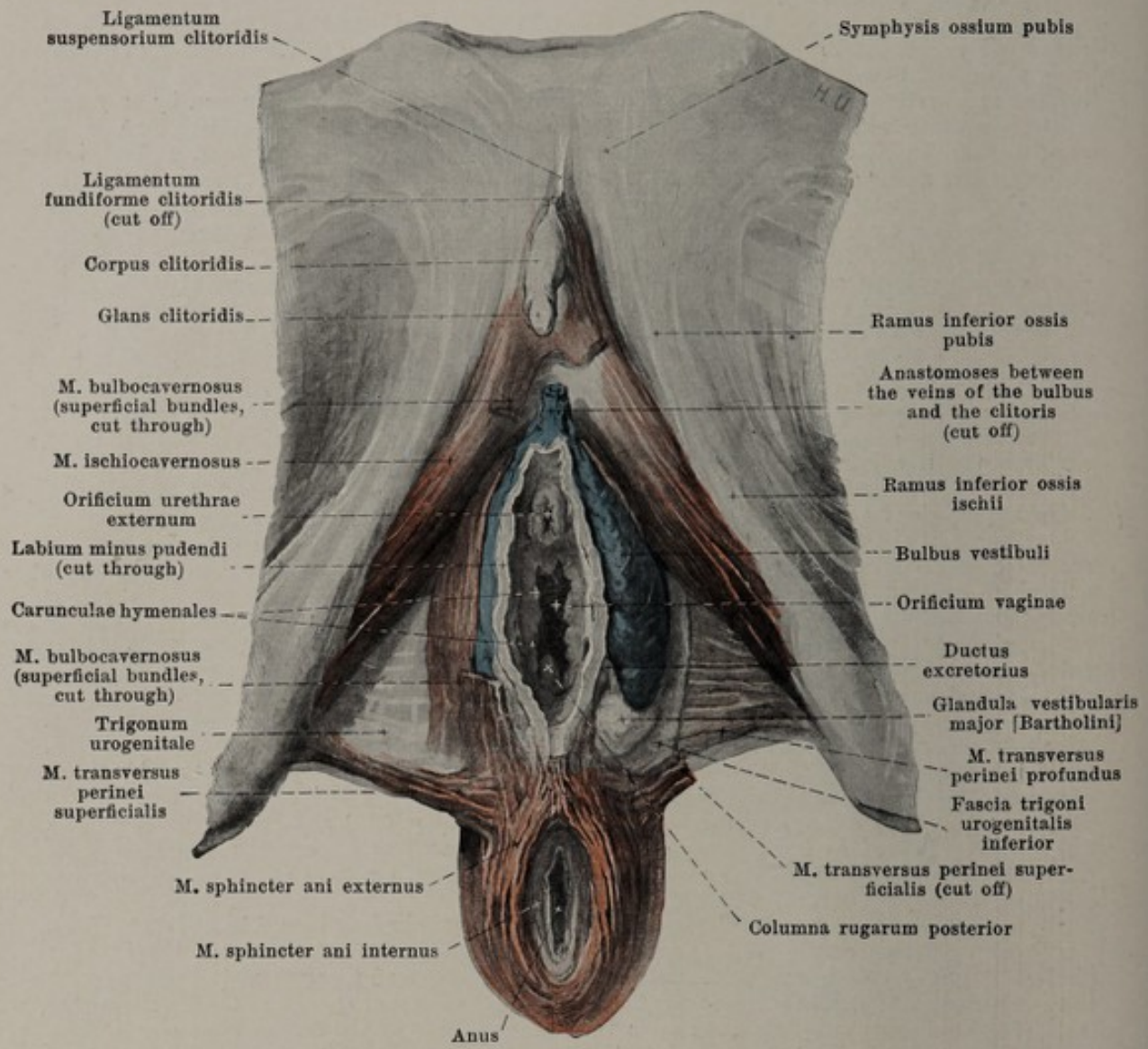
The vagina forms an obtuse angle (see Fig. 719) with the long axis of the cervix uteri and runs below in front of the lower portion of the axis pelvis (see Fig. 206) approximately straight from above and behind, downward and forward. In front it adjoins the fundus of the urinary bladder and urethra and is connected by loose connective tissue with the bladder, by very firm connective tissue with the urethra; above on the lateral portion, the two ureters also lie for some distance on its anterior wall but far more loosely connected (see Fig. 718). Behind, it is covered above as far as the level of the orificium externum uteri by the peritonaeum; it then lies on the anterior surface of the rectum and below goes again away from it; above, it is separated from the rectum by loose connective tissue; below, the musculature of the perineum is shoved in between the two. Laterally on each side above (see also Figs. 522, 523, 553 and 554) the vagina adjoins the parametrium (vide infra), below, it adjoins the medial margin of the m. levator ani; just in front of its opening into the vestibulum it perforates the trigonum urogenitale.

The **female urethra**, *urethra muliebris* (see Figs. 695 and 719), is the channel of exit of the urinary bladder; it begins at the fundus vesicae as the *orificium urethrae internum* (see p. 602) and ends in the vestibulum vaginae upon a small, blunt-wedge-shaped projection as the *orificium urethrae externum*, which as a rule is a sagittal slit. It runs downward and forward in the same way as does the vagina, being curved so as to be a little convex behind. In front and laterally it adjoins the plexus pudendalis, the trigonum urogenitale, which it perforates, and the bulbi vestibuli; behind, it is united with the anterior wall of the vagina immediately below the bladder by means of loose tissue, elsewhere, however, it is very firmly attached.

The wall of the urethra (see Fig. 695) consists externally of a *tunica muscularis*, which is composed of an internal longitudinal layer, *stratum longitudinale*, of smooth muscle fibres and of an external circular layer, *stratum circulare;* the latter is composed internally also by smooth muscle fibres, but externally lie cross-striped muscle fibres, connected with the m. sphincter urethrae membranaceae, which form a closed ring near the bladder only. Internally from this follows a thick, loose *tela submucosa;* it contains large venous networks, which are continued between the layers of muscle and give to them a spongy character, *corpus spongiosum urethrae.* The inner surface is covered by the mucous membrane, *tunica mucosa.* Along the posterior surface, extending from the anterior end of the trigonum vesicae, there is a marked longitudinal fold, *crista urethralis*, which goes as far as the neighborhood of the orificium externum. The lumen is stellate and capable of marked dilatation. The mucous membrane possesses *lacunae urethrales* as in the male (see p. 615) and small tubular glands, which are considered as homologues of the prostatic glands in the male; a large group of these glands opens on each side externally near the orificium urethrae externum through the narrow *ductus paraurethralis* (not drawn).

Course of the peritonaeum in the female pelvis (see Figs. 715 and 718—720).

The relations of the peritonaeum, between the bladder on the one hand, the anterior abdominal wall and the lateral pelvic wall on the other, correspond throughout to those met with in the male (see p. 615). The peritonaeum is reflected from the upper surface of the bladder at the level of the orificium internum uteri upon the facies vesicalis of the corpus uteri (see p. 619), covers this, the fundus and the facies intestinalis of the uterus, then goes over upon the fornix of the vagina, covers its posterior wall as far as the region of the orificium externum uteri and turns to the anterior surface of the rectum. There thus arise two slit-like spaces, the *excavatio vesicouterina* between the bladder and the facies vesicalis uteri and the *excavatio rectouterina [cavum Douglasi]* between the uterus and rectum. The latter space is closed in front by the portio supravaginalis of the cervix uteri and the fornix vaginae, behind by the sacrum and rectum; it ends below in a blind sac in the region of the orificium uteri externum; its upper boundary is formed by two folds of peritonaeum, *plicae rectouterinae [Douglasi]* (see also p. 621), which run from the posterior surface of the cervix uteri near the lateral wall of the rectum to the sacrum; the two go over into one another in front and possess a free concave margin. Arising at the margo lateralis uteri on each side is a duplicature of the peritonaum, *ligamentum latum uteri* (broad ligament of the uterus); it is, when stretched out, quadrangularly-rounded in form (see Fig. 715) and its two layers lie for the most part close to one another. Lateralward and below they deviate from one another and go over into the peritonaeum on the lateral pelvic wall, the bladder and the rectum. They thus bound in front and behind an approximately quadrilateral space (see Fig. 718), which is bounded lateralward by the m. levator ani, medianward by the upper, lateral part of the vagina, as well as by the neck and body of the uterus. This space contains the a. uterina and the ureter, surrounded by the plexus uterovaginalis (see Figs. 553 and 554), all ensheathed in loose, fatty, connective tissue, the *parametrium.* The lateral margin of the ligamentum latum reaches above as far as the v. iliaca externa; going off upward from it in that situation is a fold of peritonaeum, *ligamentum suspensorium ovarii*, which contains the a. and v. ovarica. Passing from the posterior surface is above the short *mesovarium* (see p. 616); the larger, denser portion lying beneath it is called the *mesometrium*, the other, thinner part the *mesosalpinx* (see p. 617). The ligamentum latum turned forward near the bladder lies close to the parietal layer of the peritonaeum.



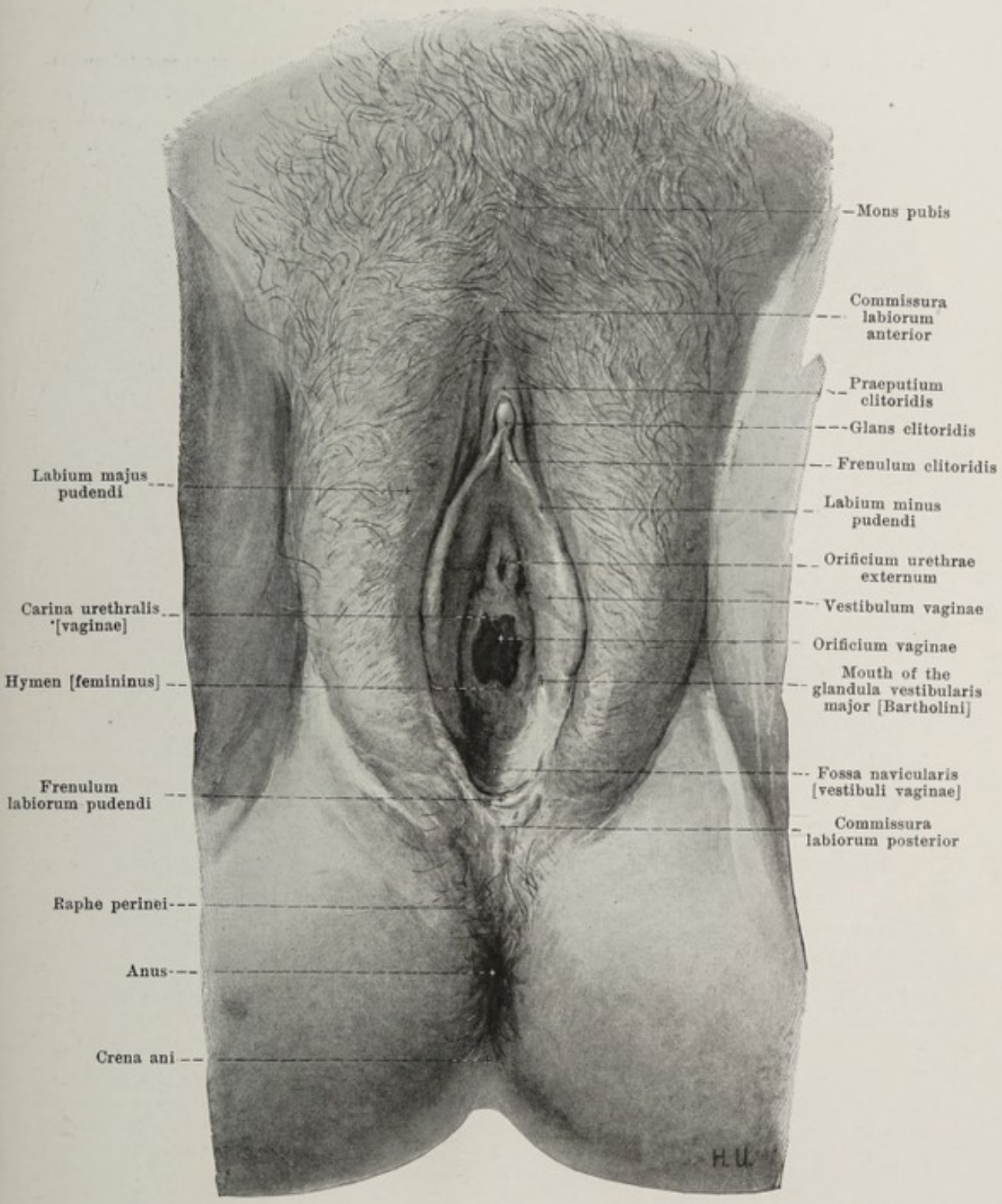
721. Bulbus vestibuli and trigonum urogenitale, viewed from below.

(On the left is the m. transversus perinei superficialis and m. bulbocavernosus, on the right the latter is partly removed. On the left the m. transversus perinei profundus is partly exposed.)

The **pudendum muliebre** (O. T. vulva) (see Figs. 718, 719 and 722) lies beneath the trigonum urogenitale and in front of the symphysis ossium pubis; it consists of the labia majora and of the parts which are visible when the vulvar slit is relaxed (see Fig. 722).

The **clitoris** (see also Figs. 554 and 718) corresponds essentially to the corpora cavernosa penis (see pp. 613 and 614), but is much smaller. It consists of two similarly constructed *corpora cavernosa clitoridis*, which, as the *crura clitoridis*, are separated behind, where they exactly resemble the crura penis in position and attachment; they unite in front to form the unpaired, rounded *corpus clitoridis*, which is divided in the median plane by the *septum corporum cavernosorum* and hangs down, even during erection, in a curve in front of the symphysis ossium pubis. The tip of the corpus, *glans clitoridis*, lies free and is covered by external skin. The clitoris is ensheathed by the *fascia clitoridis* and attached by means of the *ligamentum suspensorium clitoridis;* these parts correspond also to those of the penis.

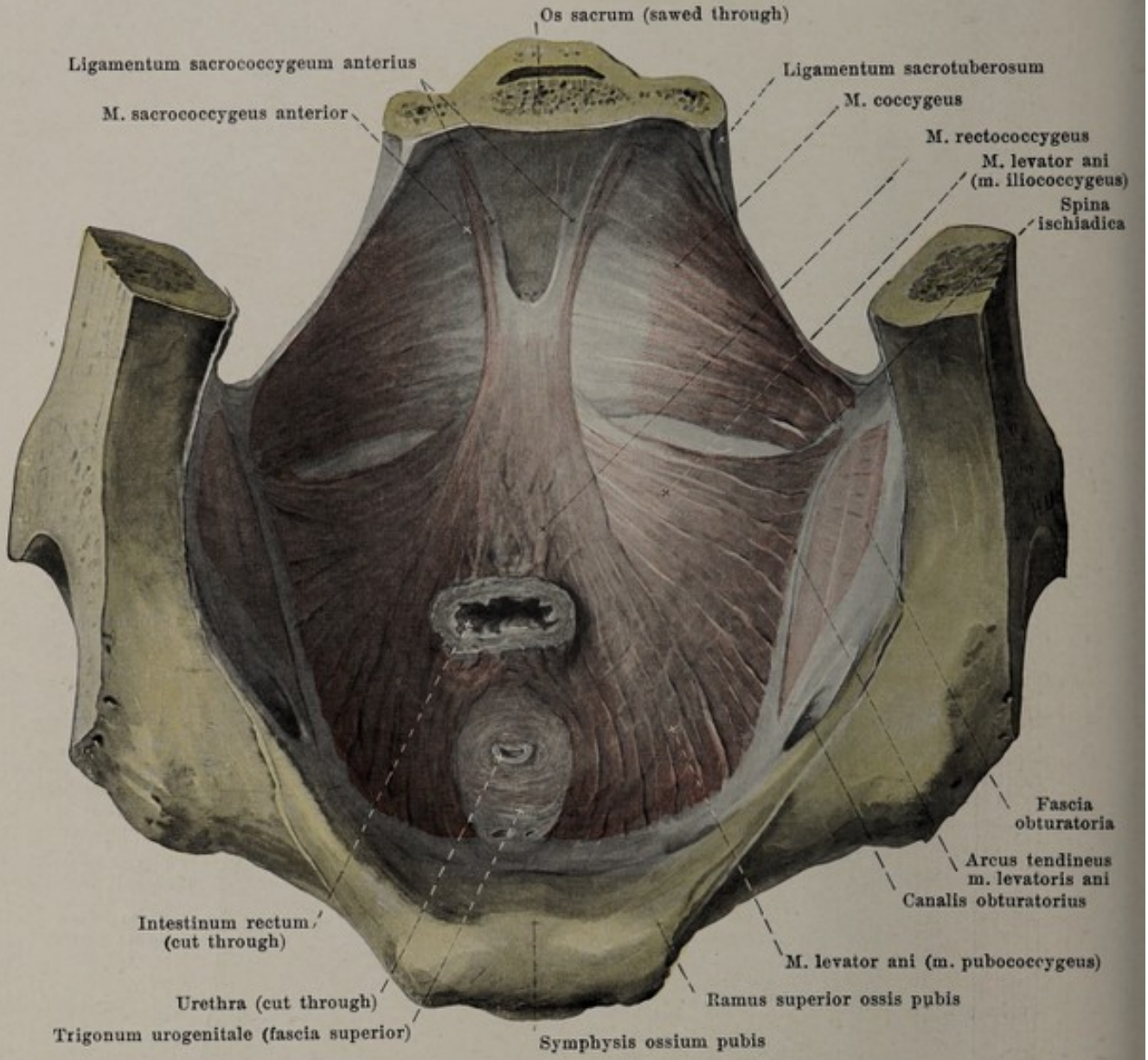
The **bulbus vestibuli** is an oblong body, somewhat pointed in front, somewhat rounded off behind; there is one on each side below the trigonum urogenitale; medianward it adjoins the wall of the vestibulum and introitus vaginae and the glandula vestibularis major; lateralward and below it is covered by the m. bulbocavernosus. It corresponds to the bulbus urethrae of the male (see pp. 613 and 614) and is composed of a plexus of wide, thin-walled veins. Beneath the clitoris the two bulbi are connected with one another and with the veins of the clitoris.



722. External genitals of the female.

(The labia have been drawn apart.)

The ***glandula vestibularis major [Bartholini]*** (see also Fig. 721) corresponds in structure, form and size to the glandula bulbourethralis [Cowperi] of the male (see p. 612). It lies on each side lateralward from the posterior part of the vestibulum vaginae partly in the trigonum urogenitale and is partly covered by the posterior end of the bulbus vestibuli and by the m. bulbocavernosus. Its duct opens just laterally to the hymen at the level of the posterior half of the orificium vaginae.

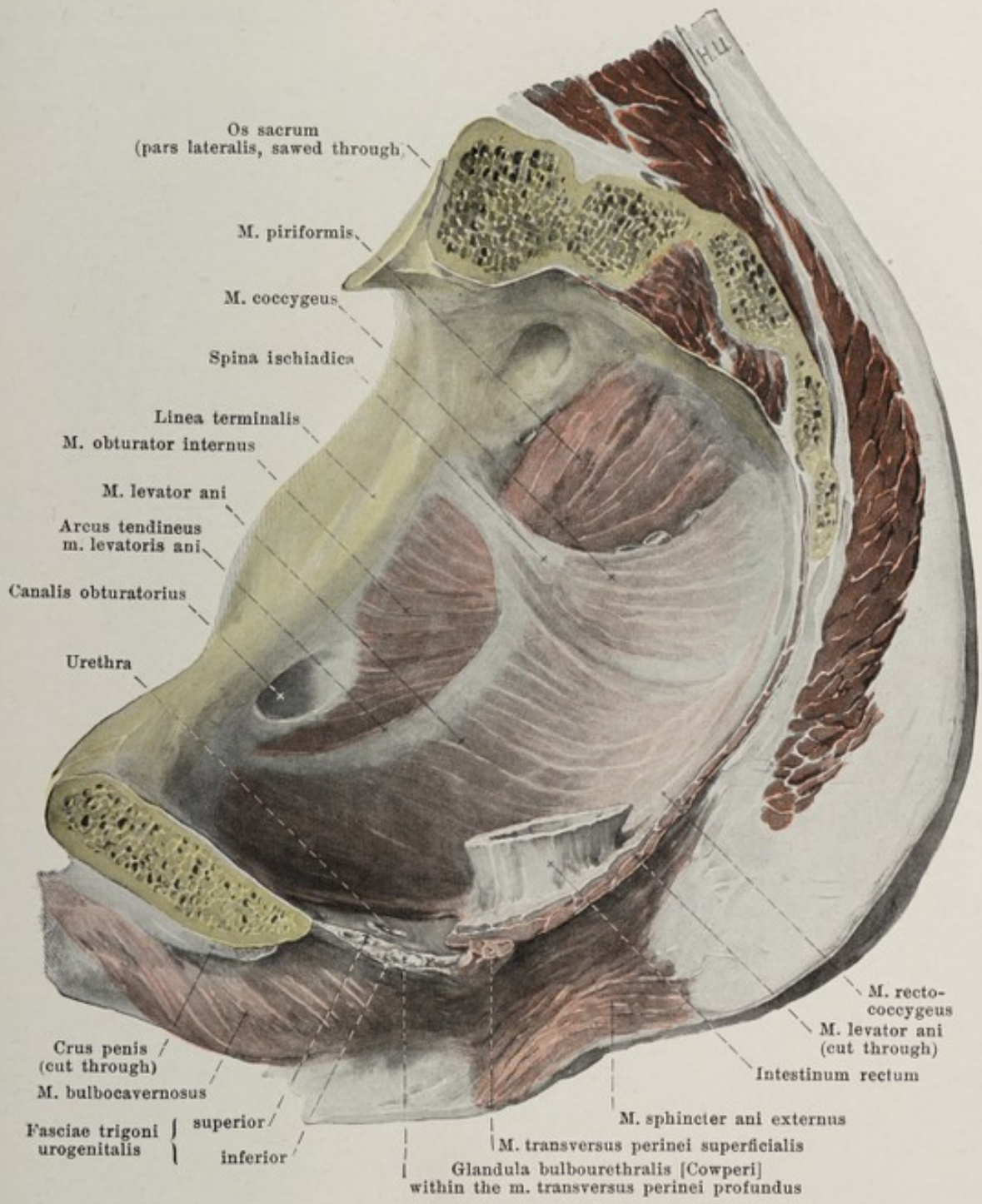


723. Mm. levatores ani of the male, viewed from above.

(The prostate has been removed, the rectum cut off short.)

The ***large lips.*** *labia majora pudendi* (see Fig. 722), are two large folds of skin, rich in fat, which extend from the upper margin of the symphysis to the perineum and include between them the *rima pudendi* or *pudendal slit.* In front these folds go over into one another forming the *commissura labiorum anterior;* behind they are either connected with one another forming the *commissura labiorum posterior*, or they may remain separated by a groove. Lateralward they are bounded by furrows in the skin; their anterior surface is covered with pubic hairs, *pubes.* The skin of the labia majora contains many sweat glands and large sebaceous glands.

The ***small lips,*** *labia minora pudendi* (see Figs. 718, 719 and 722), are two thinner, cockscomb-like, reddish folds which enclose the *vestibulum vaginae* and are ordinarily not visible when the pudendal slit is closed. They are separated from the labia majora by a groove. They unite behind in women who have not borne children, usually forming a delicate fold, *frenulum labiorum pudendi*, behind which lies a fossa, *fossa navicularis [vestibuli vaginae].* In front they divide into two limbs; the external limbs unite over the glans clitoridis to form the gable-like *praeputium clitoridis*, the internal limbs become attached together to the under surface of the glans clitoridis as the *frenulum clitoridis.* In the vestibulum, especially between the urethral and the vaginal opening, small glands, *glandulae vestibulares minores,* occour.



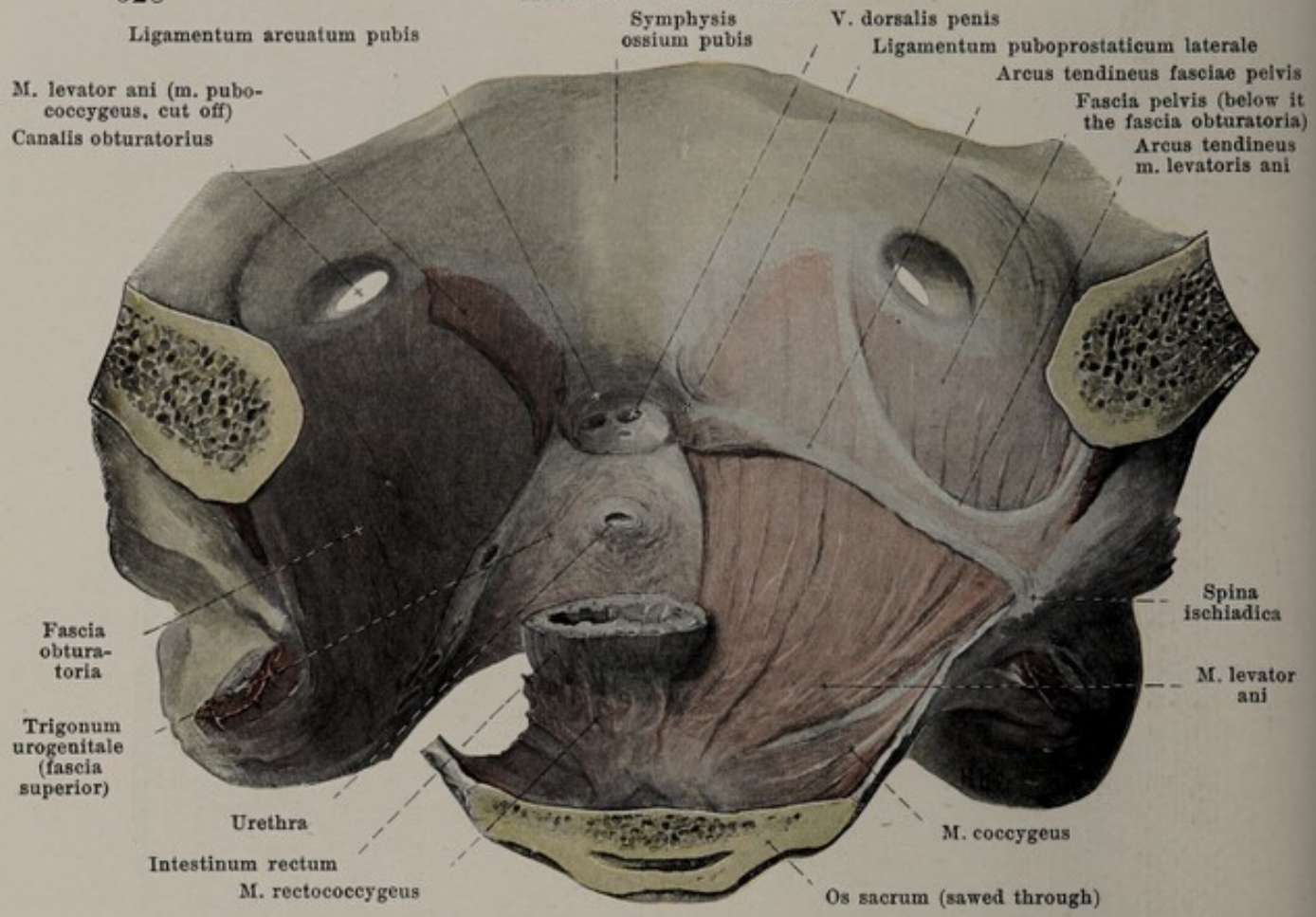
724. Right m. levator ani in the male, viewed from the left.

(The pelvis has been cut through on the left side near the median plane; the prostate is removed, the bowel cut off.)

The floor of the small pelvis is formed chiefly by the **diaphragma pelvis**; this is composed of the two mm. levatores ani and coccygei and has the form of a funnel, the deepest point of which lies below in the pars analis recti.

M. coccygeus (see p. 346).

M. levator ani (see also Figs. 723, 725, 727, 728 and 730), paired. Form: quadrangular, thin, flat, separable in two portions, *m. pubococcygeus* and *m. iliococcygeus*. Innervation: branches of the plexus pudendus ([S_2] S_3, S_4). (Continuation see p. 628.)



725. Right m. levator ani and trigonum urogenitale

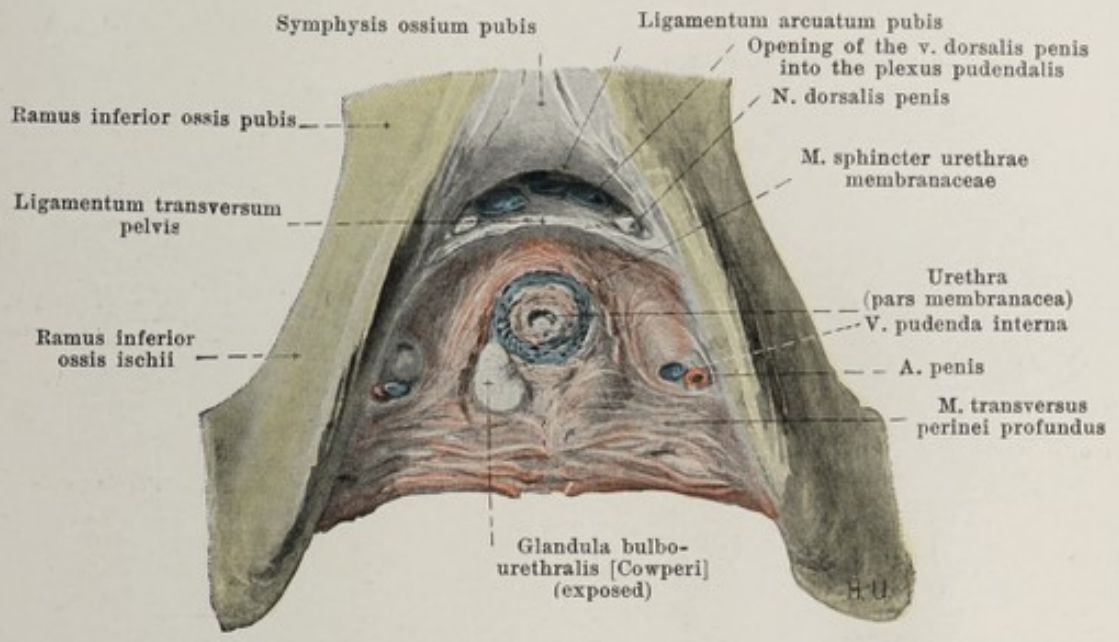
of the male, viewed from behind and above.

M. pubococcygeus. Origin: from the posterior surface of the rami ossis pubis in a narrow curved area (which in front surrounds the origin of the m. obturator internus) and from the most anterior portion of the arcus tendineus m. levatoris ani (vide infra); a few fibres also from the anterior part of the arcus tendineus fasciae pelvis. Insertion: the fibres run backward, downward and medianward near the prostate in the male, near the urethra and vagina in the female and near the rectum; partly they go to a tendinous plate, which goes over into the ligamentum sacrococcygeum anterius; partly they interweave between the rectum and the coccyx with the fibres of the other side; only a few fibres go to the wall of the rectum and run in its anterior, lateral portion to the skin. Behind the rectum the m. rectococcygeus (see p. 546) lies directly above this muscle. Action of the muscles of the two sides together: they narrow the pars analis recti (and in the female the vagina), draw the rectum forward and upward, and elevate the floor of the pelvis.

M. iliococcygeus. Origin: from an arch, *arcus tendineus m. levatoris ani*, convex downward, interwoven in the fascia obturatoria; the anterior end of the arch begins on the posterior surface of the ramus superior ossis pubis, and the posterior end can be followed as far as the linea arcuata of the ilium; between these two points it descends for a variable distance but always leaves free the canalis obturatorius. Insertion: the fibres run medianward and downward, pass beneath the posterior portion of the m. pubococcygeus and also often overlap the m. coccygeus from above; the anterior fibres between the anus and the tip of the coccyx form tendinous connections with the fibres of the other side, the posterior fibres go to the margin of the os coccygis. Action of the muscles of the two sides together: they elevate the floor of the pelvis.

M. sacrococcygeus anterior (see Fig. 723), paired, present very often. Form: narrow, thin. Position: on the upper surface of the m. coccygeus. Origin: anterior surface of the 3rd or 4th sacral vertebra. Insertion: ligamentum sacrococcygeum anterius. Innervation: branches of the plexus coccygeus (S_4, S_5).

M. sacrococcygeus posterior (not illustrated), paired, very variable. Thin muscle bundles upon the posterior surface of the lower sacral and upper coccygeal vertebrae. Innervation: branch of the plexus coccygeus.



726. Muscles of the trigonum urogenitale of the male, viewed from below.

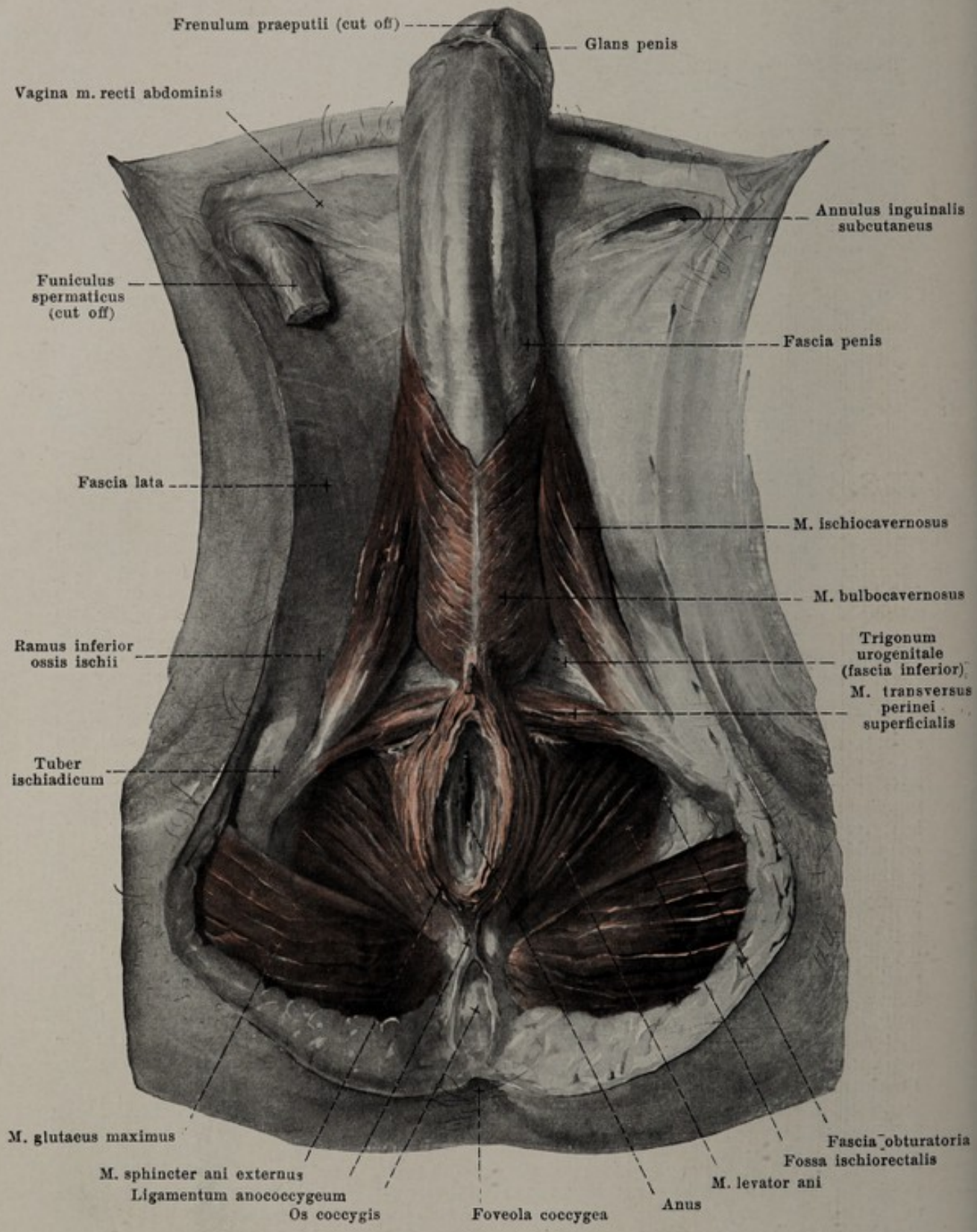
(The fascia inferior has been removed, on the right side the glandula bulbourethralis has been exposed.)

The **trigonum** ***(diaphragma)*** **urogenitale** (O. T. triangular ligament) (see Figs. 693, 709—711, 721, 724, 725, 727, 728 and 730) is a firm, trapezoid, musculo-tendinous plate which fills up the space between the rami inferiores of the ischial and pubic bones, beneath the two mm. pubococcygei, so that only a space is left free in front, just beneath the ligamentum arcuatum pubis for the passage of the v. dorsalis penis (clitoridis). It ends behind in a thin, slightly concave curved margin, in front in a sharp margin and is perforated perpendicularly by the pars membranacea of the urethra in the male, the urethra and the vagina in the female.

The trigonum urogenitale consists of two strong layers, the *fascia trigoni urogenitalis superior* (O. T. posterior layer of triangular ligament, deep or superior triangular ligament), and *fascia trigoni urogenitalis inferior* (O. T. anterior layer of the triangular ligament, superficial or inferior triangular ligament). These are fused with one another at their anterior and posterior margins and enclose a flat slit-like space. Through the fusion of their anterior margins there is formed a firm cord, *ligamentum transversum pelvis*, which is stretched transversely from one pubic bone to the other; the region of fusion of the posterior margins is less pronounced and is covered on its inferior surface by the m. transversus perinei superficialis. The compartment between the two fasciae is filled up by the *m. transversus perinei profundus*, the *m. sphincter urethrae membranaceae*, the glandulae bulbourethrales in the male, a part of the glandulae vestibulares majores in the female; in the grooves at the two sides run the aa. penis (clitoridis), vv. pudendae internae and nn. dorsales penis (clitoridis). The two fasciae arise from the lower rami of the ischium and os pubis, are strongest lateralward and are connected medianward with the wall of the urethra (and vagina); the upper is continued also into the fascia prostatae.

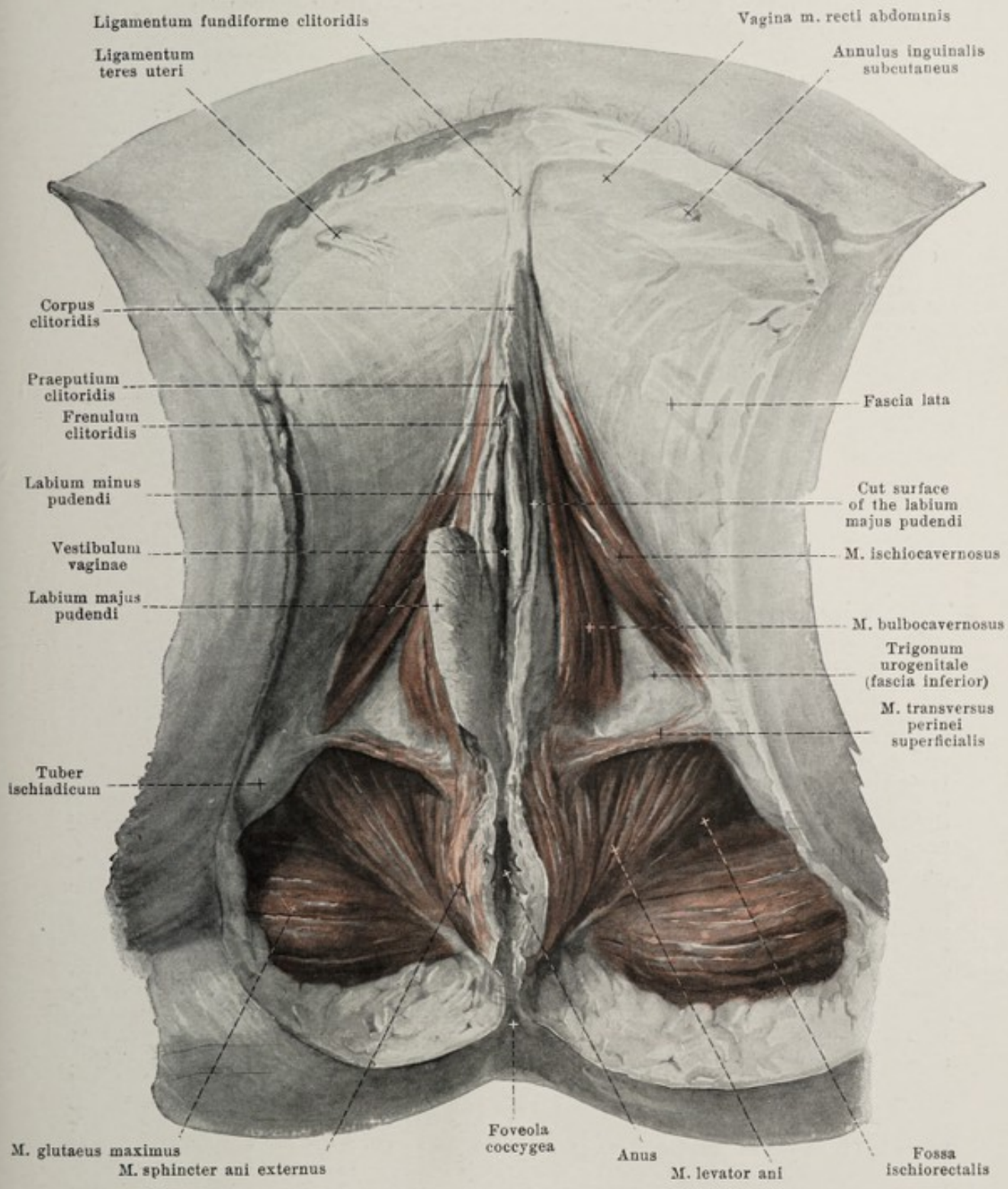
M. transversus perinei profundus. Form: flat. Position: in the posterior part of the trigonum urogenitale. Origin: rami inferiores ossis ischii. Insertion: the fibres run to the median plane and there, becoming tendinous, interweave with one another. Innervation: n. dorsalis penis (clitoridis) (S_3).

M. sphincter urethrae membranaceae. a) In the *male*. Its innermost fibres surround the urethra as an uninterrupted circular layer and are directly connected proximalward with the m. prostaticus, distalward with circular fibres of the pars cavernosa urethrae. The external fibres arise from the angle of junction of the crura penis, from the ligamentum transversum pelvis, from the fasciae trigoni and from the rami inferiores of the pubic bones; they surround the urethra and the glandulae bulbourethrales in arches and, becoming tendinous, unite with one another behind in the median plane. Action: it compresses the urethra and the glandulae bulbourethrales. b) In the *female*. The innermost fibres run similar to those in the male, forming a ring around the urethra. The external fibres arise from the ligamentum transversum pelvis, the fasciae trigoni and the pubic bones and extend in arches or straight to the junction between the urethra and the vagina or become attached to the wall of the vagina; they pass through and partly cover over the glandulae vestibulares majores. Innervation: nn. dorsales penis (clitoridis) (S_3).



727. Muscles of the male perineum,

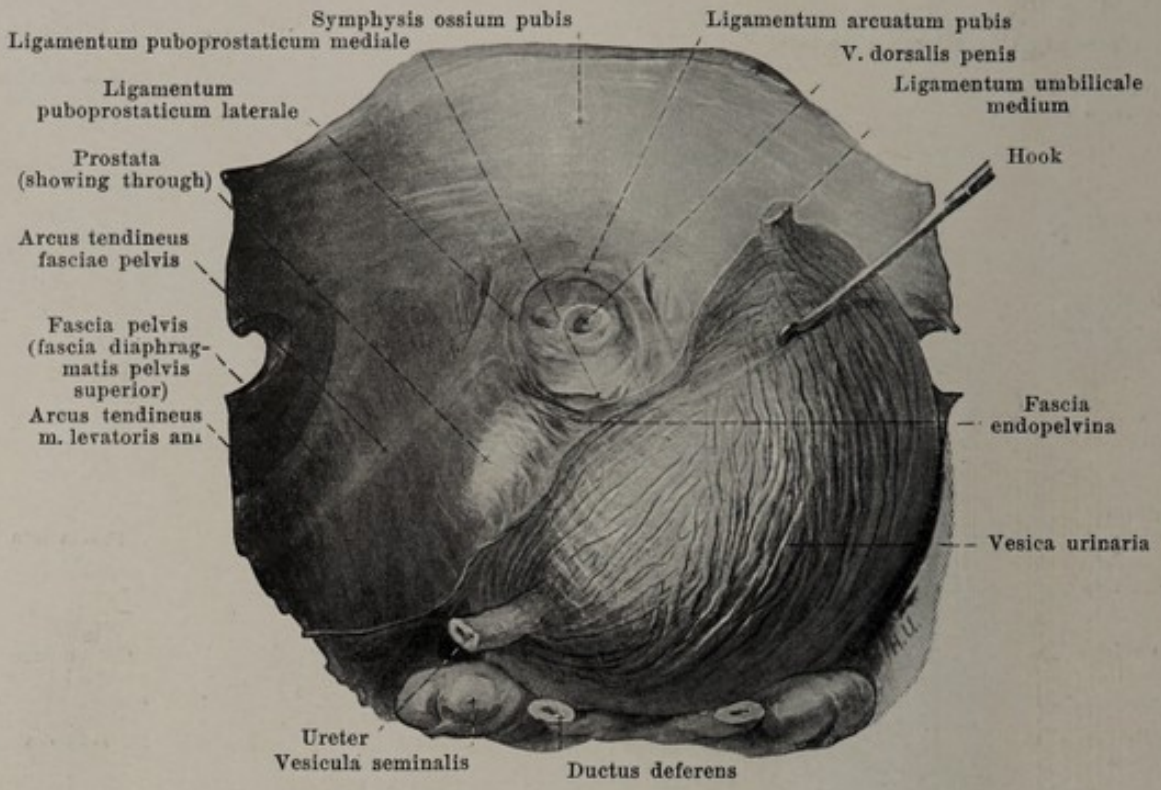
viewed from below.



728. Muscles of the female perineum, viewed from below.

(On the right side the posterior part of the labium majus has been left in situ.)

M. transversus perinei superficialis (see also Figs. 721 and 727), paired, very variable. Form: narrow, rounded or flattened. Position: below the posterior margin of the trigonum urogenitale. Origin: medial margin of the ramus inferior ossis ischii, above or below the origin of the m. ischiocavernosus. Insertion: the fibres run medianward to the region between the anus and the urogenital canal; there, undergoing partial decussation, they run to the raphe of the m. bulbocavernosus, to the trigonum urogenitale and, in the depth, very often also to the m. sphincter ani externus of the other side. Innervation: n. perinei (S_3).



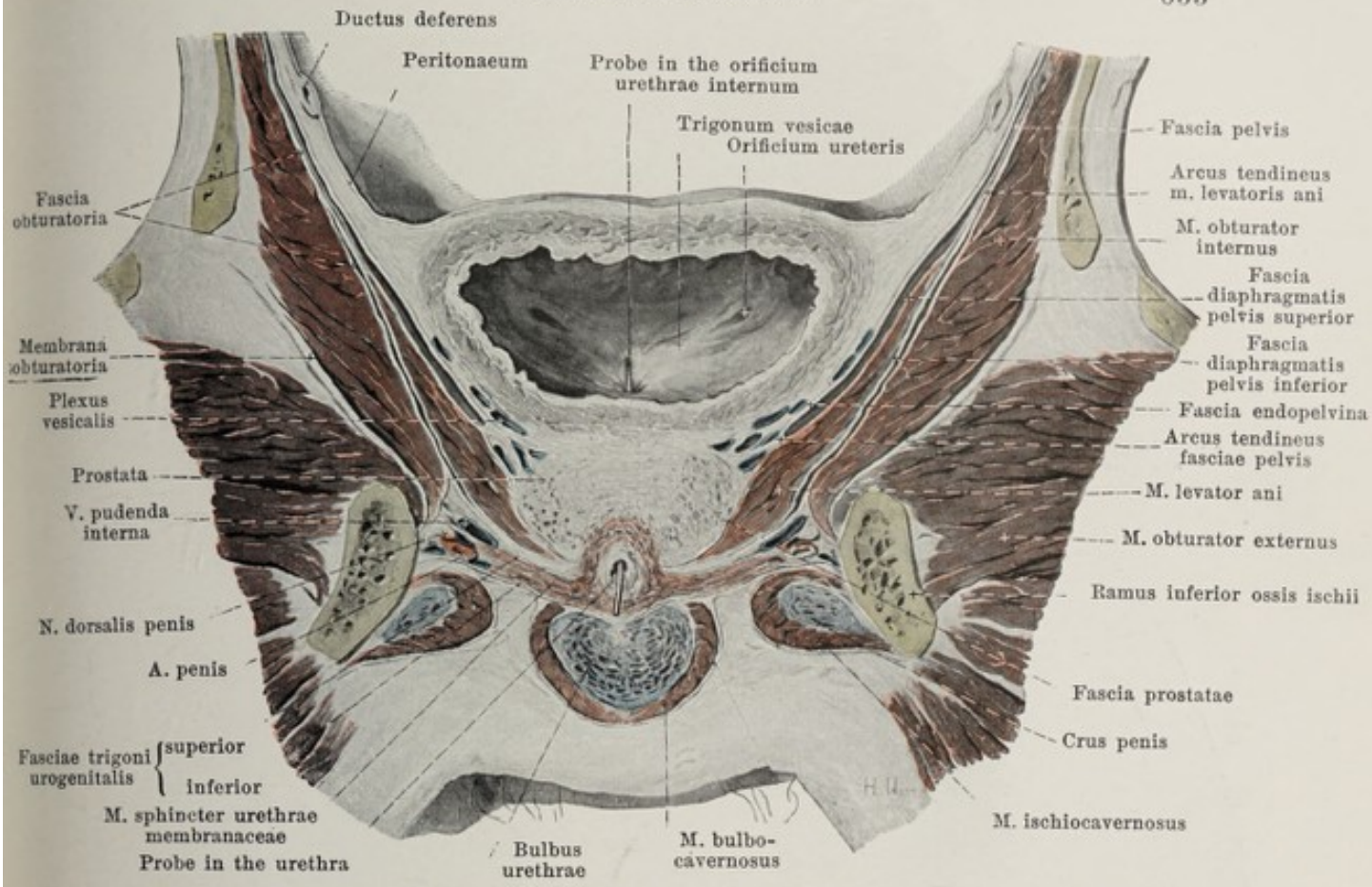
729. Ligamenta puboprostatica, viewed from above and behind.

(The urinary bladder has been drawn to the right, its musculature has for the most part been exposed.)

M. sphincter ani externus (see Figs. 629, 721, 724, 727 and 728), unpaired. Form: oval, thick. Position: external from the m. sphincter ani internus, encircling the anus and the annulus haemorrhoidalis; above it is directly continuous with the mm. pubococcygei. Origin and insertion: the more superficial fibres arise behind the anus, partly crossed, from the skin or, through the mediation of a strand of connective tissue, *ligamentum anococcygeum*, from the posterior surface and the tip of the coccyx, and end in front of the anus, crossed and uncrossed, in the skin and in the raphe of the m. bulbocavernosus. The deep, thicker fibre mass is circular; its fibres partly decussate in front and behind; see also p. 631. Action: it closes the anus. Innervation: nn. haemorrhoidales inferiores (S_3, S_4).

M. ischiocavernosus (O. T. erector penis in the male, ischiocavernosus in the female), paired. a) In the *male* (see Figs. 708, 710, 711, 727 and 730). Form: oblong, groove-like, thicker in the middle, where it is fleshy; tendinous in front and behind. Position: below and medianward it embraces the crus penis; it is adjacent above to the trigonum urogenitale, medianward to the m. bulbocavernosus; behind it reaches as far as the posterior margin of the trigonum urogenitale. Origin: medial surface of the ramus inferior ossis ischii. Insertion: the fibres go forward partly to the medial and inferior surfaces of the crus penis, partly lateralward to the dorsum penis and, becoming tendinous, are attached to the tunica albuginea. Action: it makes the tunica albuginea tense and helps in erection and ejaculation. b) In the *female* (see Figs. 721 and 728) it is feebler, but otherwise resembles that of the male. Innervation: n. perinei (S_3).

M. bulbocavernosus (O. T. accelerator urinae). a) In the *male* (see Figs. 709, 724, 727 and 730), unpaired. Form: groove-like. Position: ensheaths the free surface of the bulbus urethrae, is adjacent above the trigonum urogenitale, lateralward to the mm. ischiocavernosi. Origin: from the median tendinous raphe, which lies on the lower and posterior surface of the bulbus urethrae. Insertion: the fibres run in curves on each side forward and upward; the anterior more superficial fibres embrace the corpus penis and end upon its dorsum in the fascia penis; the deeper fibres go partly to the angle of junction of the crura penis, partly they encircle the bulbus (see Fig. 711). b) In the *female* (see Figs. 718 and 728) divided behind into two symmetrical halves. Position: directly on the lateral surface of the bulbus vestibuli and the glandula vestibularis major; otherwise as in the male. Origin: most posterior portion of the trigonum urogenitale. Insertion: the more superficial fibres go to the dorsum clitoridis, the deeper fibres embrace the bulbus vestibuli and go to the angle of junction of the crura clitoridis (see Fig. 721). The muscle is frequently connected, especially in the female, with the m. sphincter ani externus of the same side. Action: it compresses the bulbi (and glandulae vestibulares majores) and helps in erection and ejaculation. Innervation: nn. perinei (S_3).



730. Frontal section through the male pelvis.

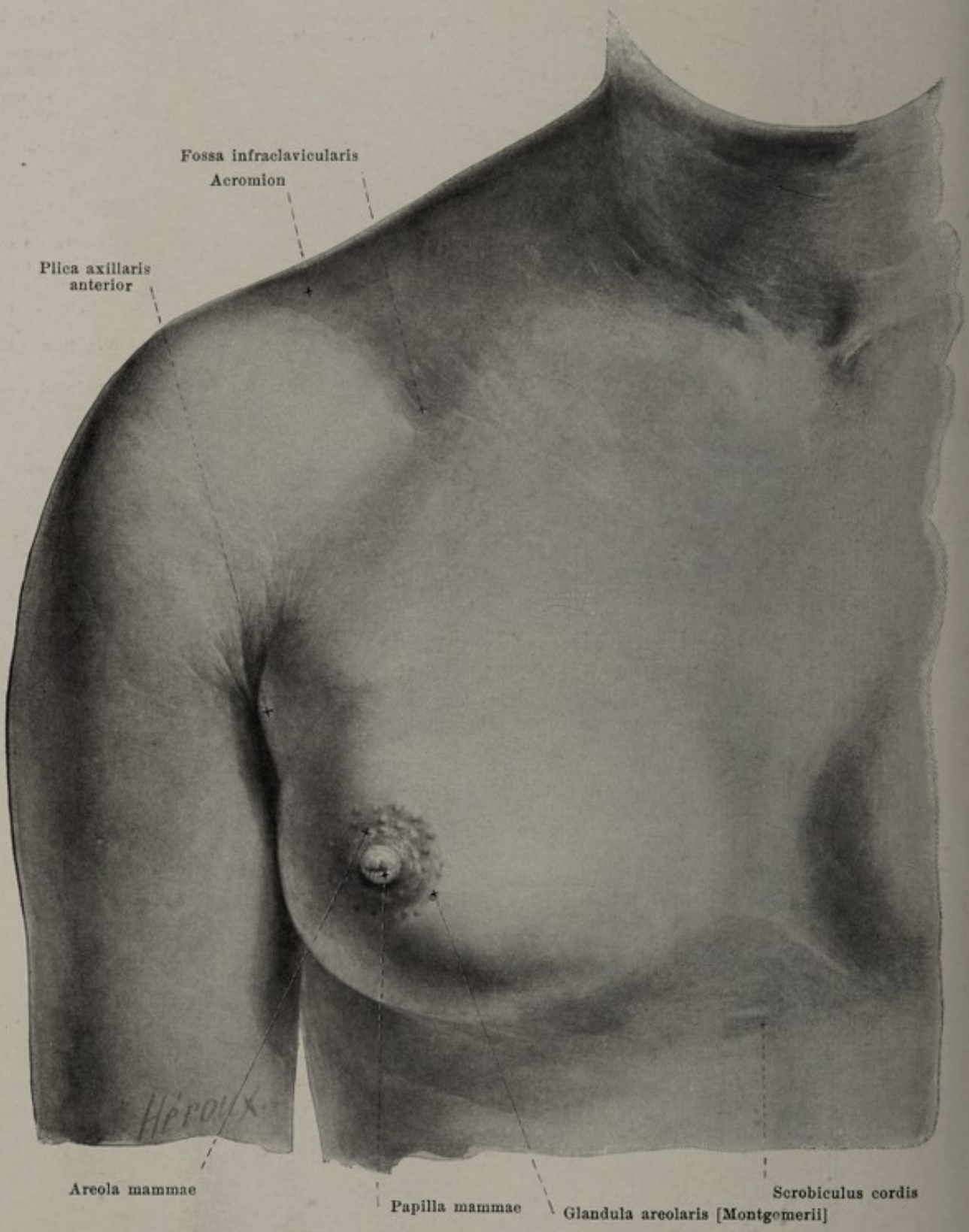
(After a frozen section by W. Braune. The posterior part is viewed from in front.)

Fascia obturatoria (obturator fascia) (see also Figs. 723 and 725) is a very strong fascia which covers the medial surface of the m. obturator internus and is everywhere attached at its border to the bone; interwoven in it is the arcus tendineus m. levatoris ani (see p. 628).

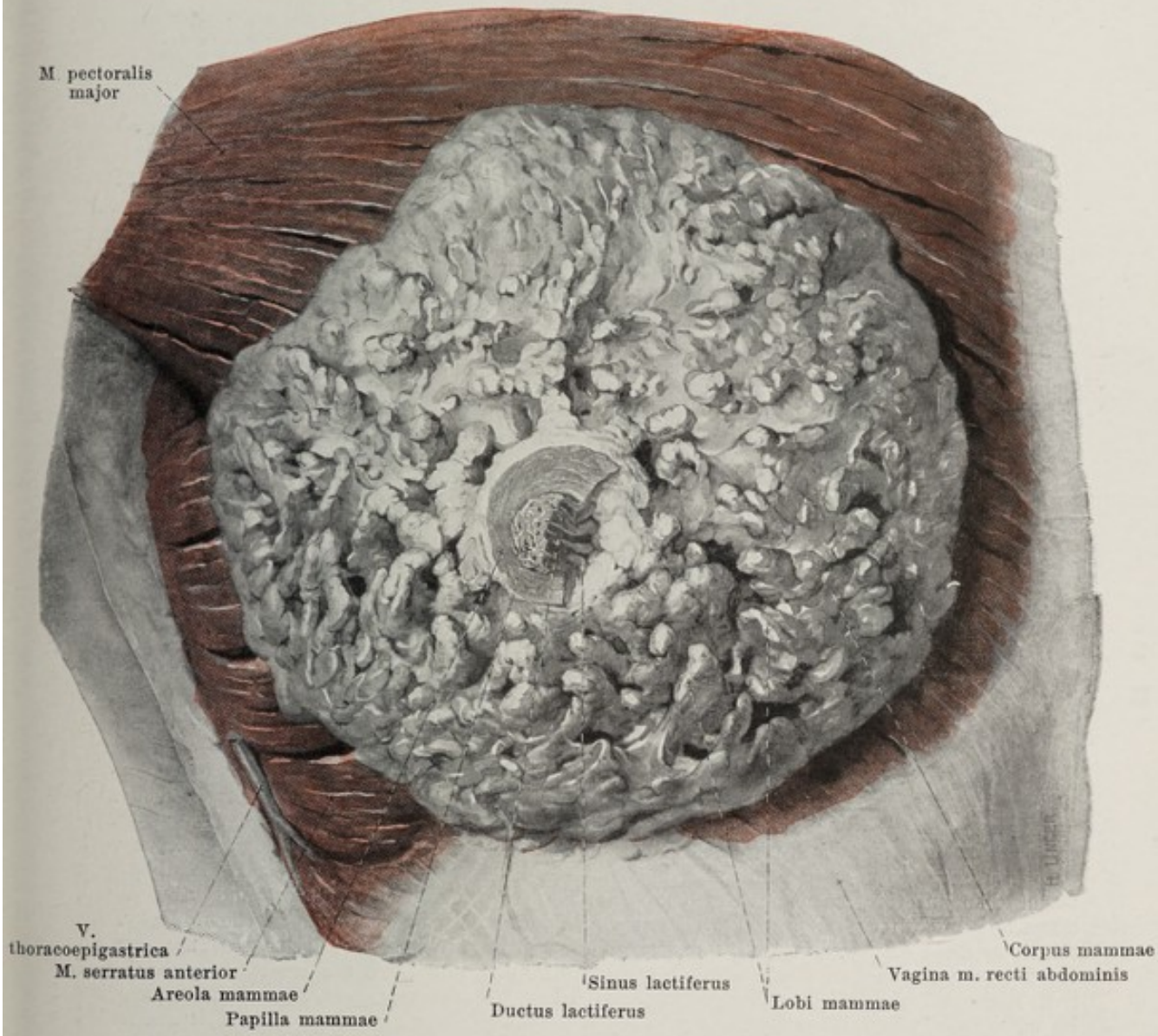
Fascia pelvis (pelvic fascia) (see also Figs. 725 and 729) is connected above at the linea terminalis with the fascia transversalis and the fasciae iliacae. As a thin membrane it covers at first the inner surface of the bones and of the fascia obturatoria, then becomes stronger and as the *fascia diaphragmatis pelvis superior* covers the medial, upper surface of the diaphragma pelvis downward as far as a tough tendinous strip of connective tissue, *arcus tendineus fasciae pelvis* (O. T. white line), which runs in it on each side from the lowermost portion of the symphysis ossium pubis backward and lateralward to the spina ischiadica. At this strip the main mass of the fascia goes over upon the pelvic viscera and, as the *fascia endopelvina*, covers the urinary bladder, the vagina and the rectum, along with their venous plexuses, gradually becoming lost above. Other bands of fascia extend from the arcus tendineus fasciae pelvis on the medial surface of the diaphragma pelvis in the male as far as the tip of the prostate and there go over into the fascia prostatae (in the female they go to the vagina and the urethra). Between the anterior ends of the two arcus tendinei fasciae pelvis, the fascia descends somewhat deeper and thus forms a fossa which is bounded lateralward by two projecting strips, the *ligamenta puboprostatica* (in the female *pubovesicalia) lateralia* (O. T. lateral true ligaments of the bladder) and in its depth runs the *ligamentum puboprostaticum* (in the female *pubovesicale) medium* (O. T. anterior true ligament of the bladder). These ligaments run out from the posterior surface of the lowermost portion of the symphysis in the male to the urinary bladder and prostate, in the female to the urinary bladder and urethra, and contain in their depth bands of smooth muscle fibres, *mm. pubovesicales.*

The lateral, lower surface of the diaphragma pelvis is covered by the thin *fascia diaphragmatis pelvis inferior*, which is connected with the fascia obturatoria above. The wedge-shaped space (see Figs. 727 and 728) situated between it and the fascia obturatoria, filled by fat, vessels and nerves, is called the *fossa ischiorectalis.*

The *fascia superficialis perinei* (O.T.fascia of Colles) (not illustrated) begins at the posterior margin of the trigonum urogenitale, covers the radix penis and its muscles, is connected lateralward with the bone and goes over in front into the tunica dartos and into the fascia penis.



731. Right breast of a girl, eighteen years old.

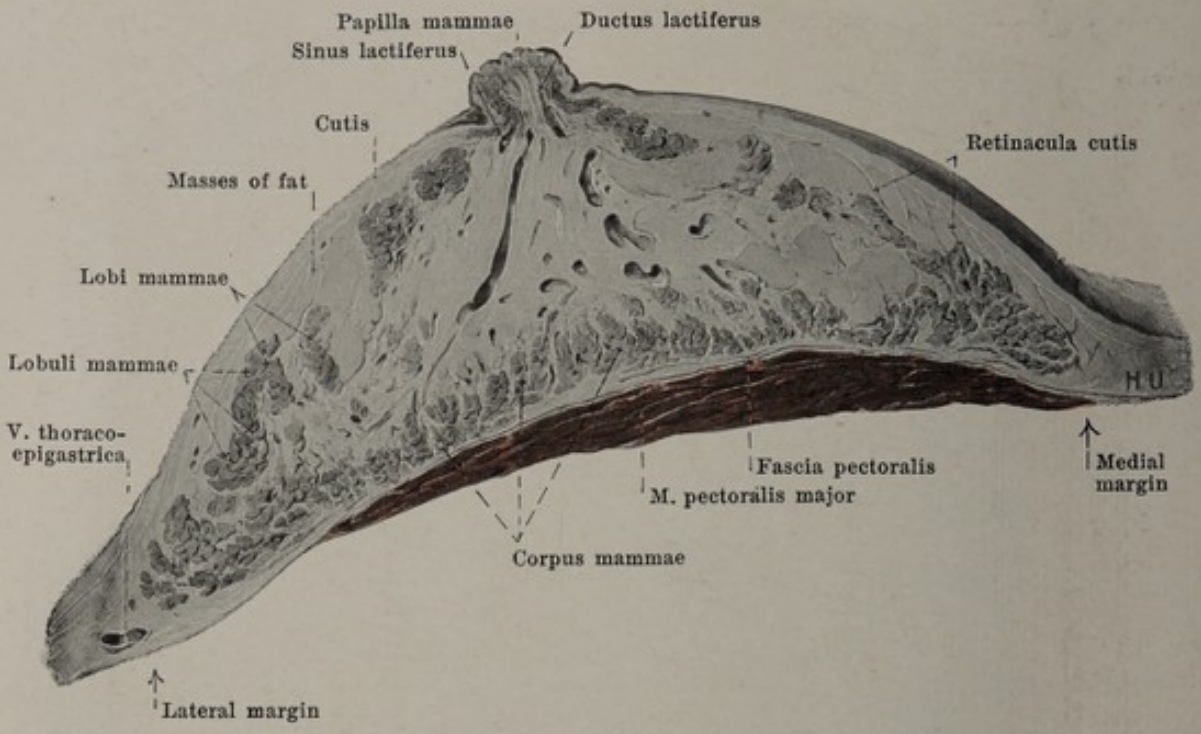


732. Right breast of a woman in advanced pregnancy,

dissected out, in its natural position as regards the thoracic muscles.

The **breasts,** *mammae* (see also Figs. 731 and 733), come to full development in the female only; in the male they remain rudimentary troughout life. They are paired, and are very differently developed and formed according to race, individual and the functional condition of the gland.

A well-formed, firm elastic breast represents a segment of a sphere which projects a little more below than above. At about the height of the convexity projects the *nipple of the breast, papilla mammae*, variable in height; in nulliparae this is wedge-shaped or cylindrical. Its apex is rough and fissured and contains in its depressions the openings of the milk ducts; its circumference is covered with wrinkles. It is surrounded by a circular area, also wrinkled, the *areola mammae;* this presents, especially during pregnancy, several rounded elevations of the size of a head of a pin, which are due to the glandulae areolares. When the breasts are well developed their bases reach from the third to the sixth, rarely as far as the seventh, rib and are separated from one another in the middle by a furrow, the *bosom*, corresponding to the sternum. In nulliparae the breasts are obliquely placed, that is the nipples are directed somewhat lateralward. They project lateralward beyond the margin of the m. pectoralis major and beyond the anterior axillary fold corresponding to it, the *plica axillaris anterior.* The nipple, when the breast is firmly seated, is situated at the level of the 5th rib; the level on the right and left side frequently varies and the two nipples vary in their distance from the median plane.



733. Horizontal section through the right breast of a woman in advanced pregnancy, upper half, viewed from below.

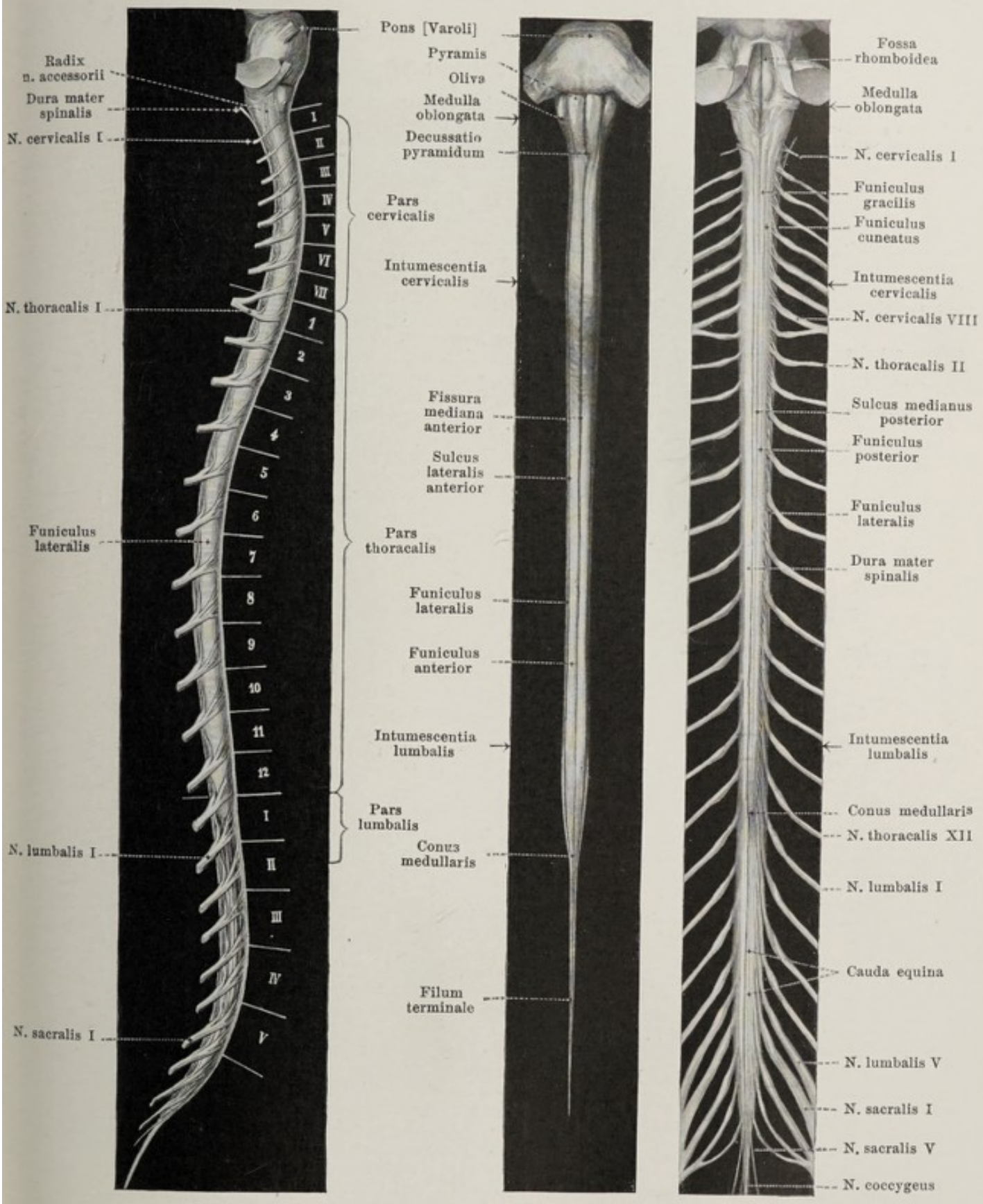
The **glands of the breast**, *corpus mammae*, enclosed by the breast, form a disk with rounded angles, the smooth posterior surface of which lies for the most part upon the m. pectoralis major, in a smaller lateral portion upon the m. serratus anterior; it is connected with these muscles by the loose connective tissue of the fascia pectoralis so as to be movable upon them. The anterior surface is very uneven and presents, especially below and lateralward, numerous comb-like and jagged processes which leave deep spaces between them. From the apices of these elevations go off connective tissue cords, *retinacula cutis*, to the cutis and all the interspaces between the gland substance; retinacula and cutis are filled up by masses of fat. The gland has 15—24 and more irregular *lobes*, *lobi mammae*, separated from one another by connective tissue; these lobes are broader peripheralward and have their apices directed toward the nipple. Each lobe is again subdivided by the penetrating connective tissue into numerous smaller *lobules*, *lobuli mammae*, and possesses o n e excretory duct, *ductus lactiferus*, which extends as a whitish cord in the yellowish-red glandular tissue to the apex of the lobe, and there bends around into the nipple. Before entrance into the nipple each excretory duct presents a spindle-shaped dilatation, *sinus lactiferus*, which may reach half a centimetre in width. In the nipple itself the ductus lactiferi run parallel to one another and open in the depressions at the apex.

In the region of the nipple and of the areola there are well developed sebaceous glands, *glandulae sebaceae*. In the areola sweat glands, *glandulae sudoriferae*, are found in small number as well as several rudimentary milk glands, *glandulae areolares [Montgomerii]*, which latter open each with one small milk duct at the level of the elevation caused by it.

The skin over the breast is soft and delicate and is especially thin on the nipple and areola. Its color in the last two places is light red in nulliparae, while in beginning pregnancy it usually becomes dark brown.

The **male breast**, *mamma virilis* (not illustrated), is a small flat structure which consists essentially of connective tissue and usually contains indications of glandular tissue. It possesses a brown *areola mammae* and a *papilla mammae*, but the latter is smaller than in the female. The nipple lies usually in the 4th intercostal space, more rarely upon the 4th or 5th rib, the level frequently varying on the right and left sides; the nipples of the two sides may vary in distance from the median plane.

Supernumerary nipples and breasts, *mammae accessoriae (muliebres et viriles)*, occur in very variable development in both sexes in the region of two lines which run down from the attachment of the upper extremities, converging over the normal glands, to the genitalia.

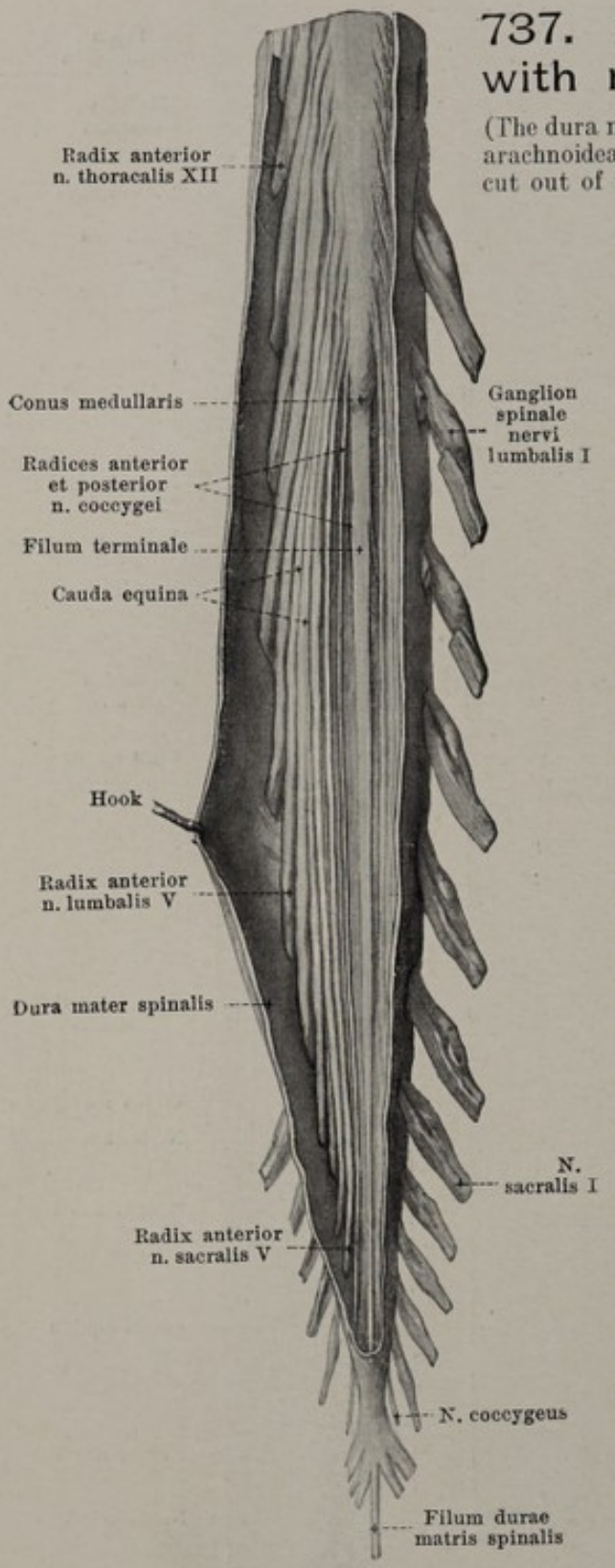


734—735. Spinal Cord.

Viewed from the right. Viewed from in front. (Nerve roots not shown.) Viewed from behind.

737. Lower end of spinal cord with nerve roots, viewed from in front.

(The dura mater has been opened and drawn to the right side; the arachnoidea has been removed. On the left side pieces have been cut out of the anterior roots of the 1st and 2nd lumbar nerves.)



The **central nervous system** *(systema nervorum centrale)* is divisible into the *spinal cord (medulla spinalis)* and the *brain (encephalon)*.

The **spinal cord** *(medulla spinalis)* (see also Figs. 734—736 and 749), an aproximately cylindrical cord more or less flattened from before backward, lies within the vertebral canal and presents curvatures corresponding to those of the canal. Above, it goes over insensibly, between the atlas and the occipital bone, into the medulla oblongata; below, it tapers into a short, wedge-like portion *(conus medullaris)* and, in the adult, goes over at the lower margin of the first, or opposite the upper part of the second, lumbar vertebra into a long, delicate *terminal thread (filum terminale)* which can be followed as far as the posterior surface of the coccyx.

The spinal cord is divisible into three parts: the *pars cervicalis* includes the region of exit of the cervical nerves, the *pars thoracalis* that of the thoracic nerves, the *pars lumbalis* that of the lumbar and sacral nerves. The diameters of the spinal cord are not the same at all levels; those portions of the cord which give off the nerves for the extremities are thickened especially in the frontal direction to form spindle-shaped enlargements. The *cervical enlargement (intumescentia cervicalis)* extends from the 3rd cervical to the 2nd thoracic vertebra, its greatest breadth corresponding to the 5th or 6th cervical vertebra; the *lumbar enlargement (intumescentia lumbalis)* begins at the 9th or 10th thoracic vertebra, is most marked at the 11th or 12th thoracic vertebra, and, at the 1st or 2nd lumbar vertebra, goes over into the conus medullaris.

The ***surface of the spinal cord*** (see Figs. 734—736 and 738—747) is divided into two nearly symmetrical halves by a broad, deep anterior median fissure *(fissura mediana anterior)*, which contains a duplicature of the pia mater spinalis rich in blood vessels, and a median posterior sulcus *(sulcus medianus posterior)*, from which extends a median septum of neuroglia *(septum medianum posterius)* to the interior. On each of these two lateral halves, in the posterior part 2½—3½ mm lateral from the sulcus medianus posterior can be seen a groove, *sulcus lateralis posterior*, along which the posterior roots enter the spinal cord; the anterior root fibres leave the spinal cord on its anterior aspect along a zone about 2 mm broad, situated somewhat lateralward from the fissura mediana anterior, running nearly parallel to it, and called the *sulcus lateralis anterior*. In the cervical region there is still another delicate longitudinal groove on the posterior surface, the *sulcus intermedius posterior* (see Fig. 758); it runs downward from the medulla oblongata about 1 mm lateralward from the sulcus medianus posterior and corresponds to the junction of the fasciculus gracilis with the fasciculus cuneatus. Occasionally an analogous groove, *sulcus intermedius anterior* (not illustrated), can be seen sometimes on the anterior surface of the cervical portion, forming the lateral boundary of the fasciculus cerebrospinalis anterior.

Level of exit of 5th sacral nerve

Level of exit of 3rd sacral nerve

Level of exit of 1st sacral nerve

Level of exit of 3rd lumbar nerve (maximal breadth of lumbar enlargement)

Level of exit of 1st lumbar nerve

Level of exit of 8th thoracic nerve

Level of exit of 2nd thoracic nerve

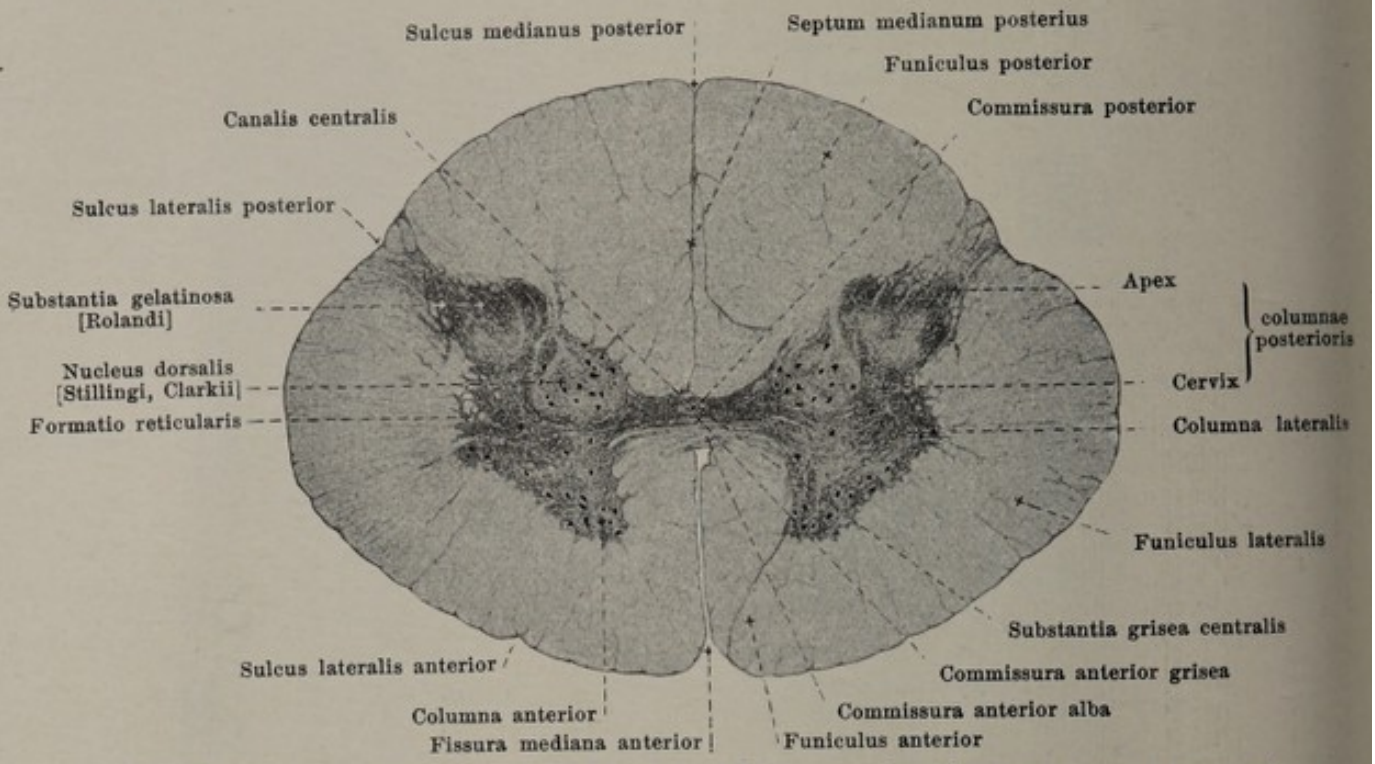
Level of exit of 5th cervical nerve (maximal breadth of cervical enlargement)

738. Transverse sections through the adult spinal cord.

Magnification: 4:1. (Held.)

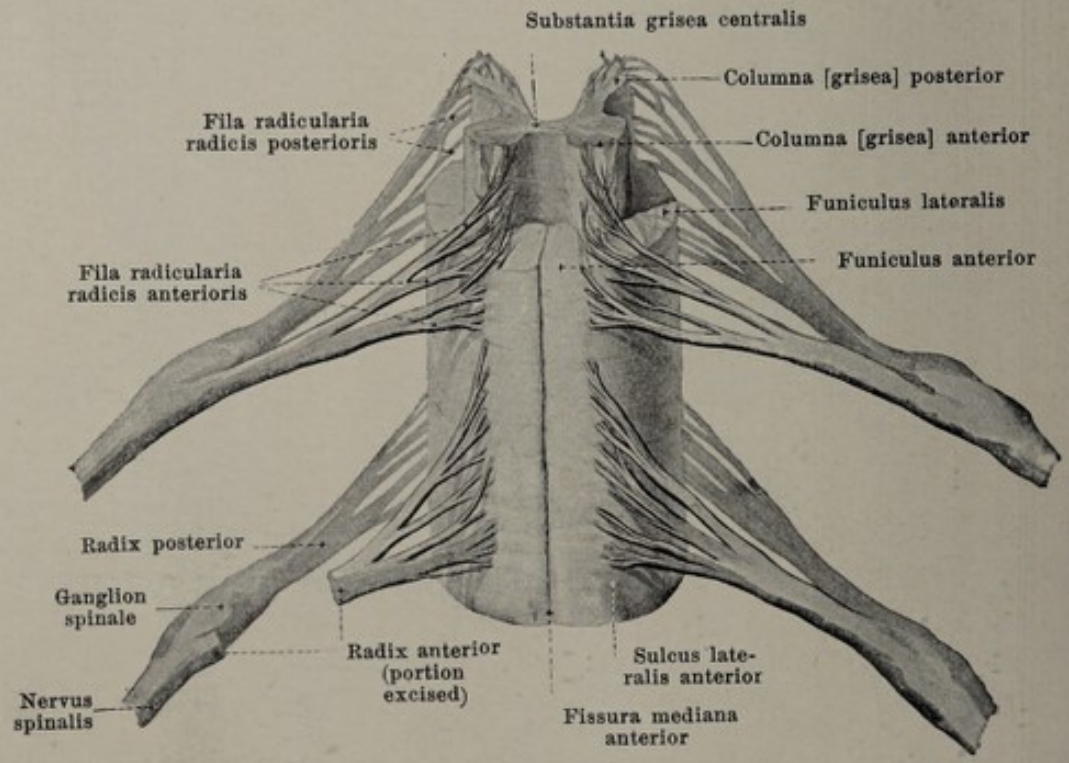
(The sections have all been taken from the same spinal cord and are so arranged that the dorsal margin of the section is uppermost.)

Surface of the spinal cord (continued) (see Figs. 734—736, 739, 740 and 802). The prismatic mass situated on each side between the fissura mediana anterior and the lateral bundles of the anterior root fibres is called the *anterior funiculus (funiculus anterior,* O. T. anterior column); the mass which extends from this to the sulcus lateralis posterior is called the *lateral funiculus (funiculus lateralis)* and that between the sulcus lateralis posterior and the sulcus medianus posterior, the *posterior funiculus (funiculus posterior).*



739. Transverse section through the uppermost part of the lumbar cord of an adult. Magnific.: 10:1. (Held.)

(The section is the same as the fifth one in Fig. 738.)

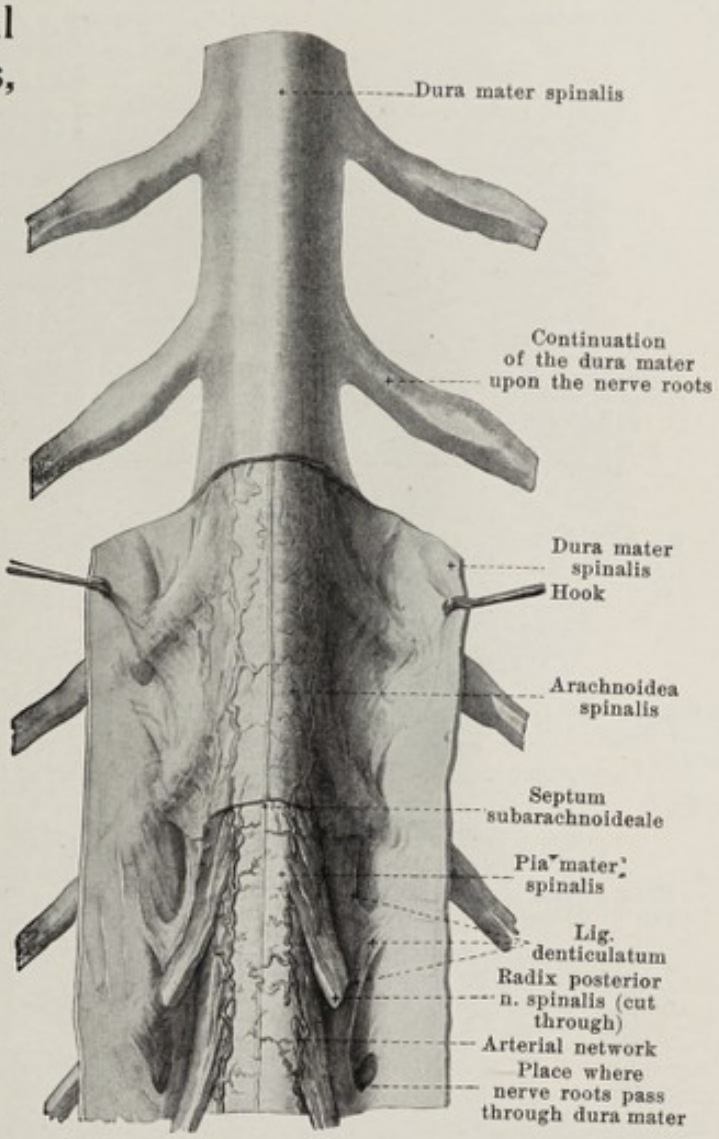


740. Portion of the spinal cord with the roots of two nerves, viewed from in front, partly schematic. Magnific.: ca. 3:1.

(In the uppermost part the white matter has been removed.)

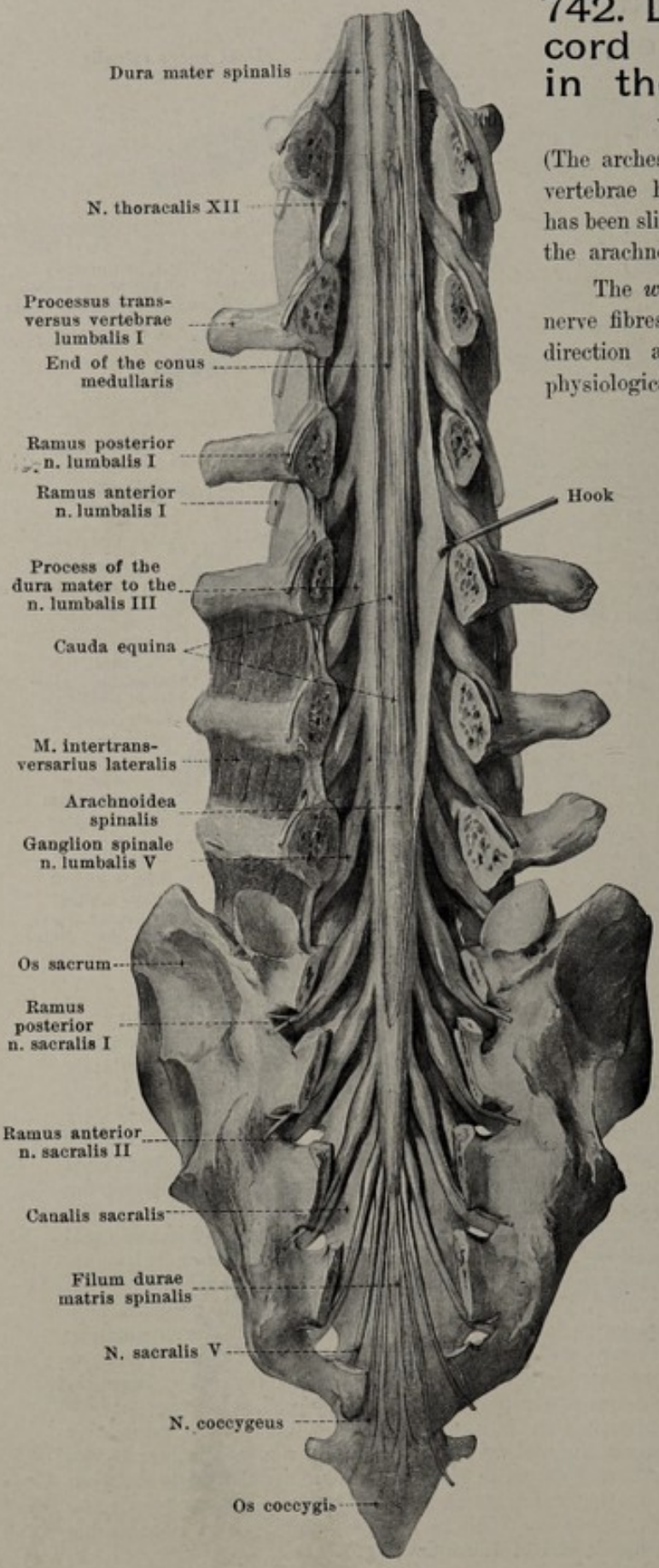
741. Portion of spinal cord with membranes, viewed from behind.

(The dura mater has been slit up below and turned aside; the arachnoidea has been in part removed.)



The ***interior of the spinal cord*** (see Figs. 738—740 and 802—804) consists of *gray matter (substantia grisea)* and *white matter (substantia alba)*, the reciprocal volume-relations of which vary somewhat at different levels (see Fig. 738).

The *gray matter* contains the nerve cells and lies in the interior of the spinal cord, so that it nowhere touches the surface; it consists of two markedly developed lateral parts, one on each side of the cord, and of a bridge connecting the two in the middle so that on cross section an H-like figure is produced. The bridge in the middle usually lies somewhat nearer the anterior surface of the cord than the posterior and surrounds the small rounded or oval *central canal (canalis centralis)*. This canal is continued above into the medulla oblongata and opens at the inferior angle of the rhomboid fossa, in front of the obex (see p. 649), into the fourth ventricle; in the lower part of the conus medullaris it becomes widened to form the elongated, usually three-sided *ventriculus terminalis* (not illustrated) and then runs as an extremely fine canal for a variable distance far into the filum terminale, finally ending blind; it contains a small amount of fluid and is immediately surrounded by the *substantia grisea centralis*. In the adult it is frequently obliterated at intervals. The transverse gray bar behind it is called the *commissura posterior*, the very narrow band in front of it the *commissura anterior grisea*, the latter being immediately adjacent to the *commissura anterior alba* which belongs to the white matter. In the lateral parts of the gray matter, the form of which varies somewhat at different levels, two approximately cylindrical *columnae griseae* can be distinguished on each side. The *columna anterior (anterior column, anterior horn)* is directed forward and a little lateralward and reaches backward as far as the gray bridge mentioned. The *columna posterior (posterior column, posterior horn)* extends from here backward and a little lateralward in places going very close to the surface; it is longer and narrower than the columna anterior, is constricted somewhat ventralward *(cervix columnae posterioris)* and is somewhat pointed dorsalward *(apex columnae posterioris)*; the sickle-shaped area seen in cross section, bounding the posterior horn behind, is called the *substantia gelatinosa [Rolandi]*. The sharply circumscribed group of ganglion cells situated on the medial side of the posterior horn, near the commissura posterior, extending from the 2nd lumbar to the 7th cervical nerve, and most markedly developed in the upper lumbar and lower thoracic cord, is called the *nucleus dorsalis [Stillingi, Clarkii] (Clarke's column)*; it is round or oval in cross section. In the upper part of the thoracic cord, projecting lateralward from the posterior part of the anterior horn into the white substance, is a triangular process, *columna lateralis (lateral column, lateral horn)*; it gradually vanishes below; in the cervical cord it fuses with the anterior horn to form a common mass. In the angle between it and the posterior horn, the gray matter sends strands out lateralward, arranged in the form of a network, *formatio reticularis*; these are indistinct in the lumbar cord but become progressively more marked toward the upper end of the spinal cord.



742. Lower end of spinal cord with membranes in the vertebral canal,

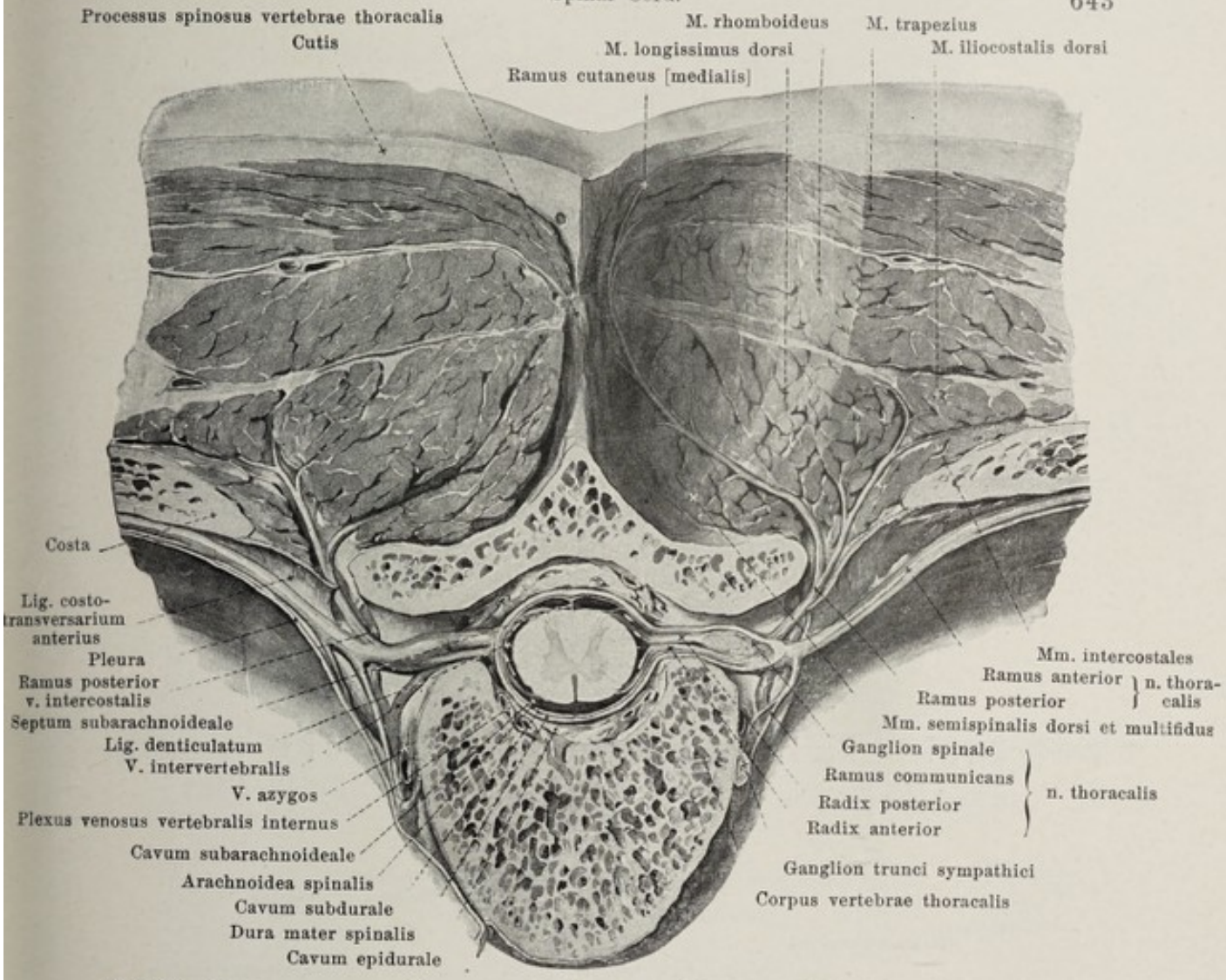
viewed from behind.

(The arches of the thoracic, lumbar and sacral vertebrae have been removed; the dura mater has been slit open lengthwise and partly reflected; the arachnoidea has been in large part removed.)

The *white matter* contains only medullated nerve fibres; they run chiefly in a longitudinal direction and are divisible into a number of physiologically non-equivalent bundles, the size of which varies at different levels and the areas of which partly overlap. Concerning these bundles and the principal groups of cells of the gray matter and their connections, the reader is referred to Figs. 802—804.

In the conus medullaris the white matter is relatively much reduced as compared with the gray; the latter has gradually fused to a common mass in which the differentiation of anterior horn and posterior horn is impossible. In the filum terminale the gray and the white matter are continued in the same arrangement for 6—8 cm further. Further down, the filum terminale consists of connective tissue, vessels and the rudiments of the 2nd and 3rd nervus coccygeus, which then extend caudally.

The spinal cord is surrounded by the ***membranes of the cord*** (see also Figs. 737, 741 and 743), which are continuous above with the *membranes of the brain*, forming with these the *meninges*. The *pia mater spinalis (soft membrane of the cord)* is everywhere closely attached to the spinal cords as a delicate vascular membrane. It sends a duplicature into the fissura mediana anterior and with the blood vessels numerous fine processes into the substance of the spinal cord. Below, it surrounds the portion of the filum terminale situated in the sac of the dura mater and then fusses with the dura mater.

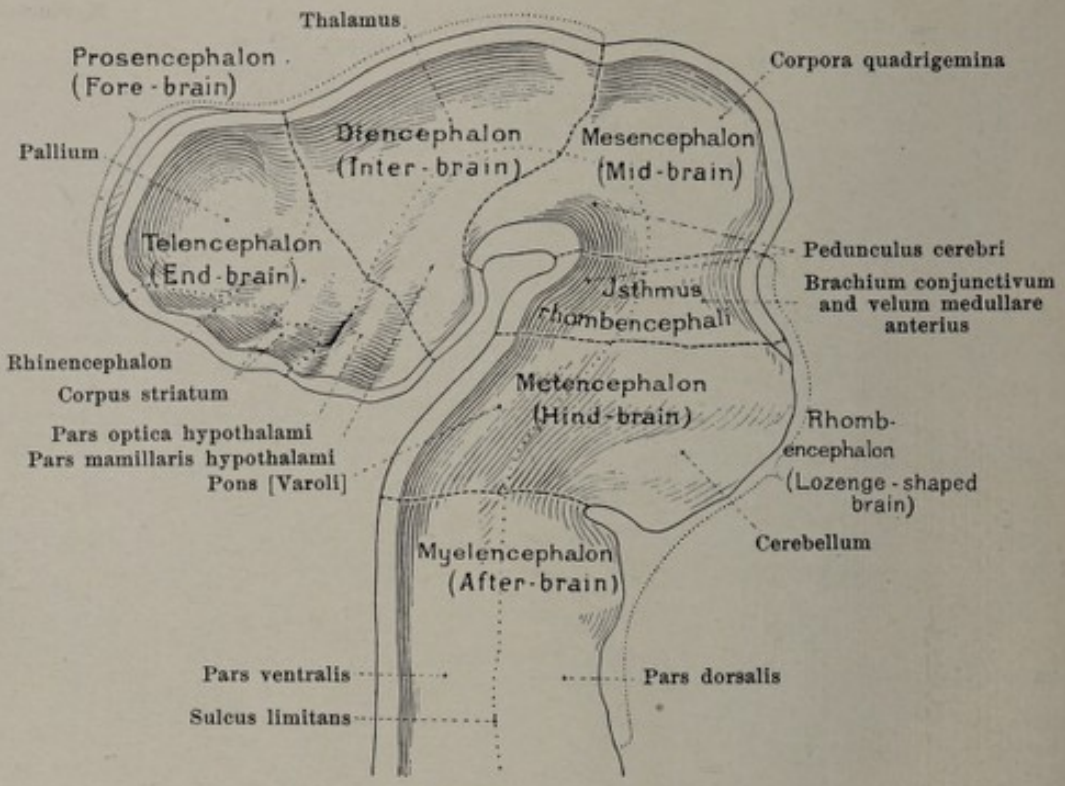


743. Cross-section of the spine with its muscles.

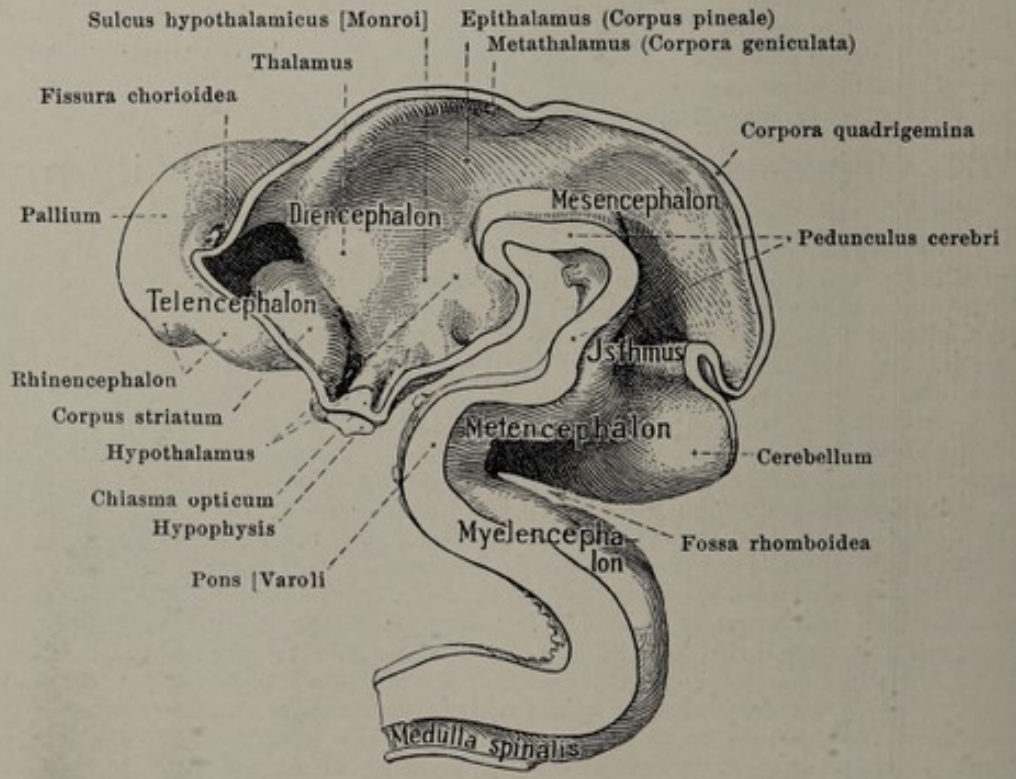
(On the left side the pleura has been drawn aside and a piece of muscle has been cut out.)

Membranes of the spinal cord (continued) (see also Figs. 737, 741 and 742). Going off from the lateral surface of the pia mater spinalis on each side is a frontally placed leaflet of connective tissue, *ligamentum denticulatum,* which runs between the anterior and posterior nerve roots and becomes attached to the inner surface of the dura mater usually by twenty-one jags; the jags are inserted there usually between the points of exit of two nerves, the uppermost one a little above the place where the a. vertebralis passes through the dura mater (see Fig. 833), the lowermost one between the last thoracic and the first lumbar nerve. The *arachnoidea spinalis (cobweb membrane),* a very delicate non-vascular membrane, forms a sac which surrounds the spinal cord only loosely; it is separated from the dura mater merely by a capillary slit, *cavum subdurale,* from the pia mater by a large space. *cavum subarachnoideale,* filled with *liquor cerebrospinalis.* The arachnoidea ensheaths the lig. denticulatum and, especially along the sulcus medianus posterior, sends fine threads to the pia; in the lower cervical region and in the thoracic region these fuse to form lamellae. *septum subarachnoideale.* The *dura mater spinalis (hard membrane of the cord)* is a tough connective tissue tube, poor in blood vessels, which, tapering out, ends blind (with the arachnoidea) below the conus medullaris at the level of the 2nd or 3rd sacral vertebra; from there on it forms a direct covering for the filum terminale known as the *filum durae matris spinalis.* It is separated from the periosteum of the vertebral canal by fat, connective tissue and venous plexuses (see p. 472), among which there exists a system of lymph spaces, *cavum epidurale,* reaching above as for as the foramen occipitale magnum, below as for as the hiatus sacralis; strong bands of connective tissue pass from its anterior surface to the lig. longitudinale posterius, especially in the canalis sacralis.

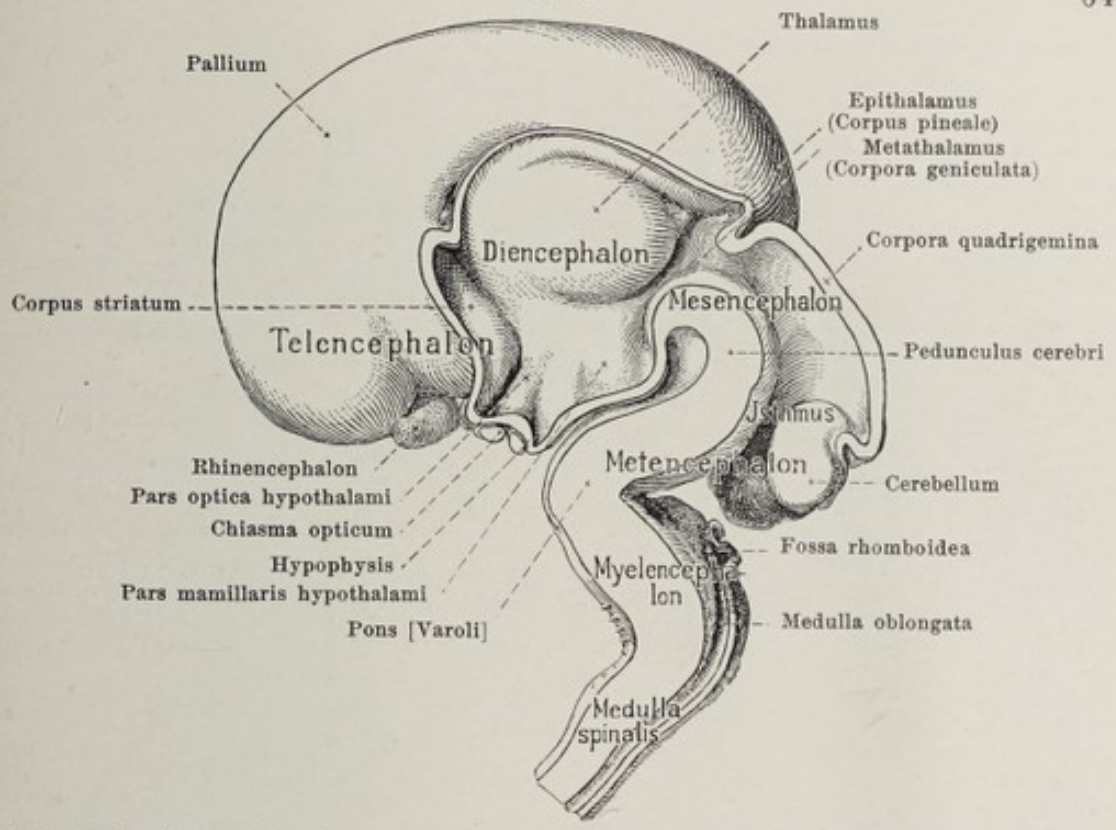
All three membranes are continued upon the nerve roots, fuse near the ganglia, and then go over into the connective tissue sheaths of the nerves.



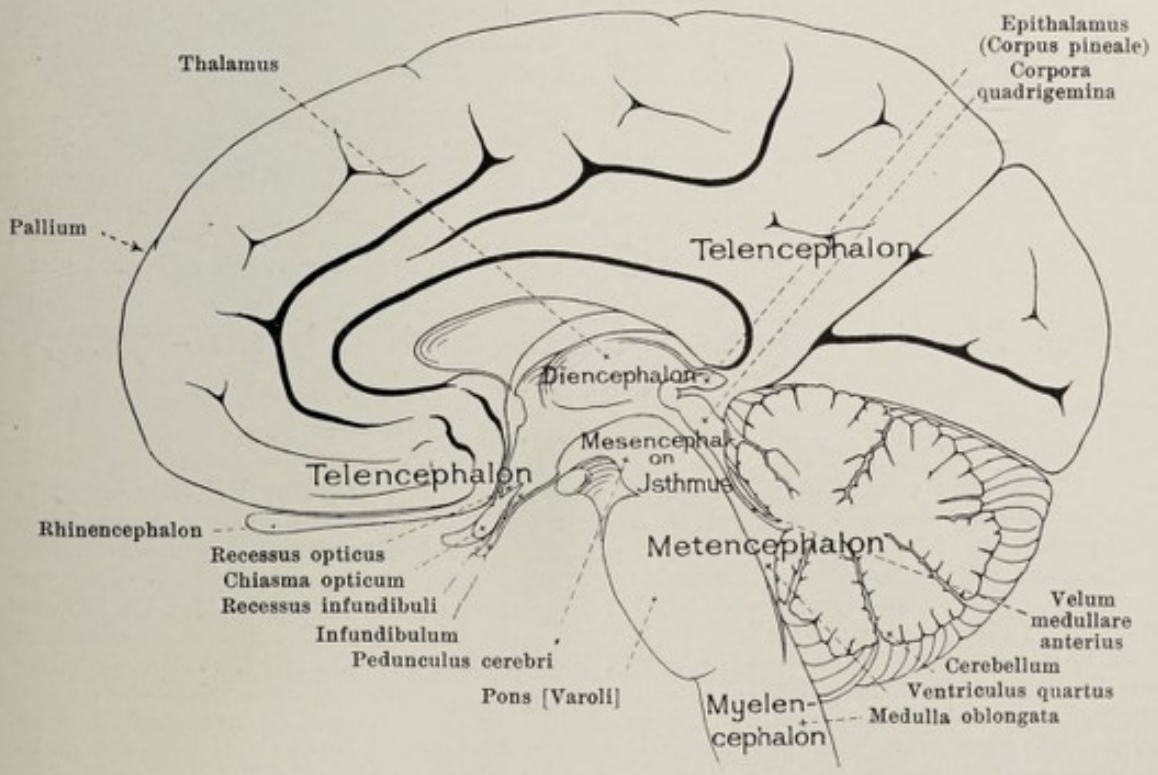
744. Brain of a human embryo at end of 1st month,
right half, viewed from the left. (After a model by W. His.)



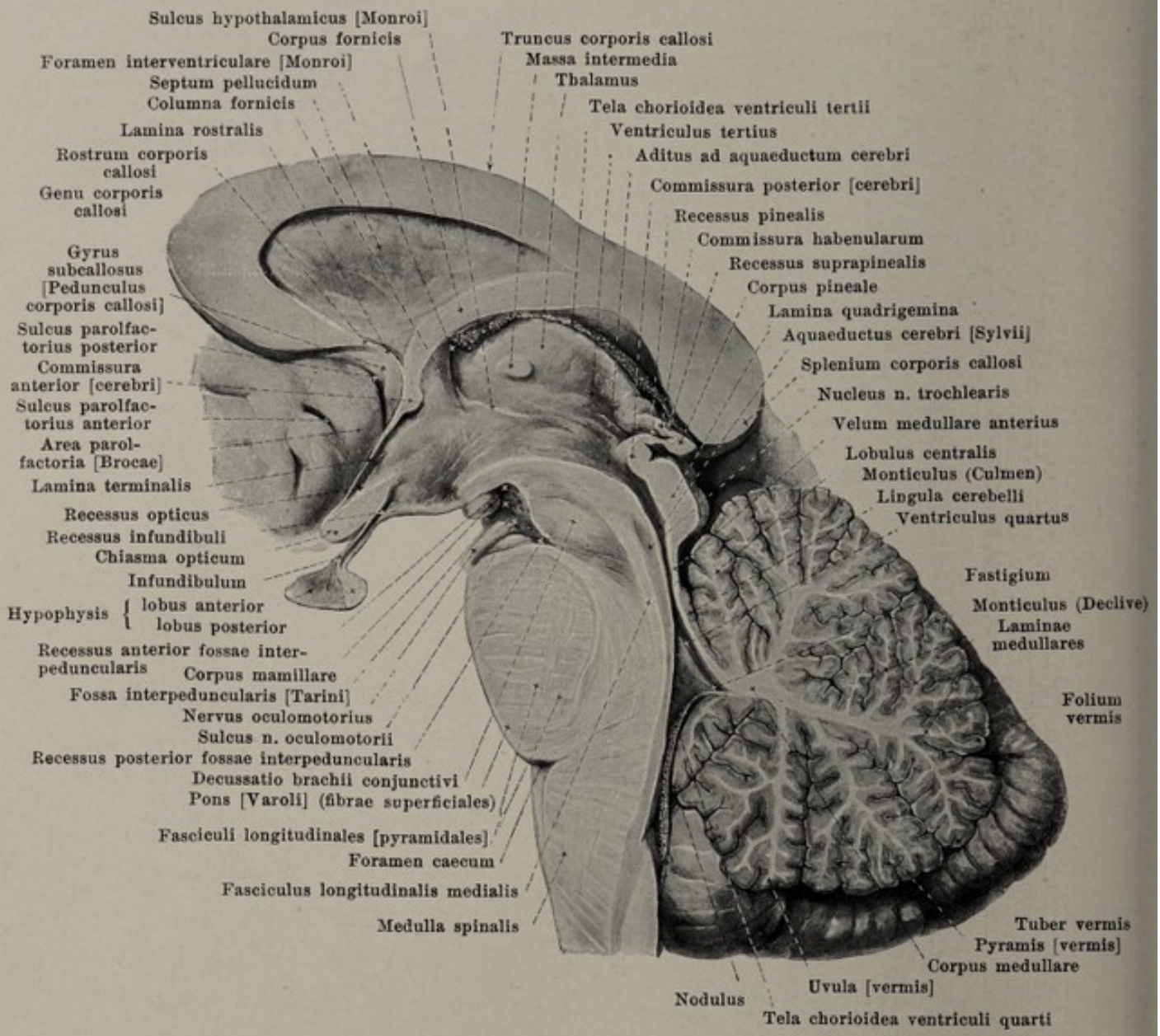
745. Brain of a human embryo five weeks old,
right half, viewed from the left. (After a model by W. His.)



746. Brain of a human embryo in the third month,
right half, viewed from the left.
(After a model by W. His; cerebral hemisphere after F. Hochstetter.)



747. Adult human brain,
right half, viewed from the left, partly schematic.



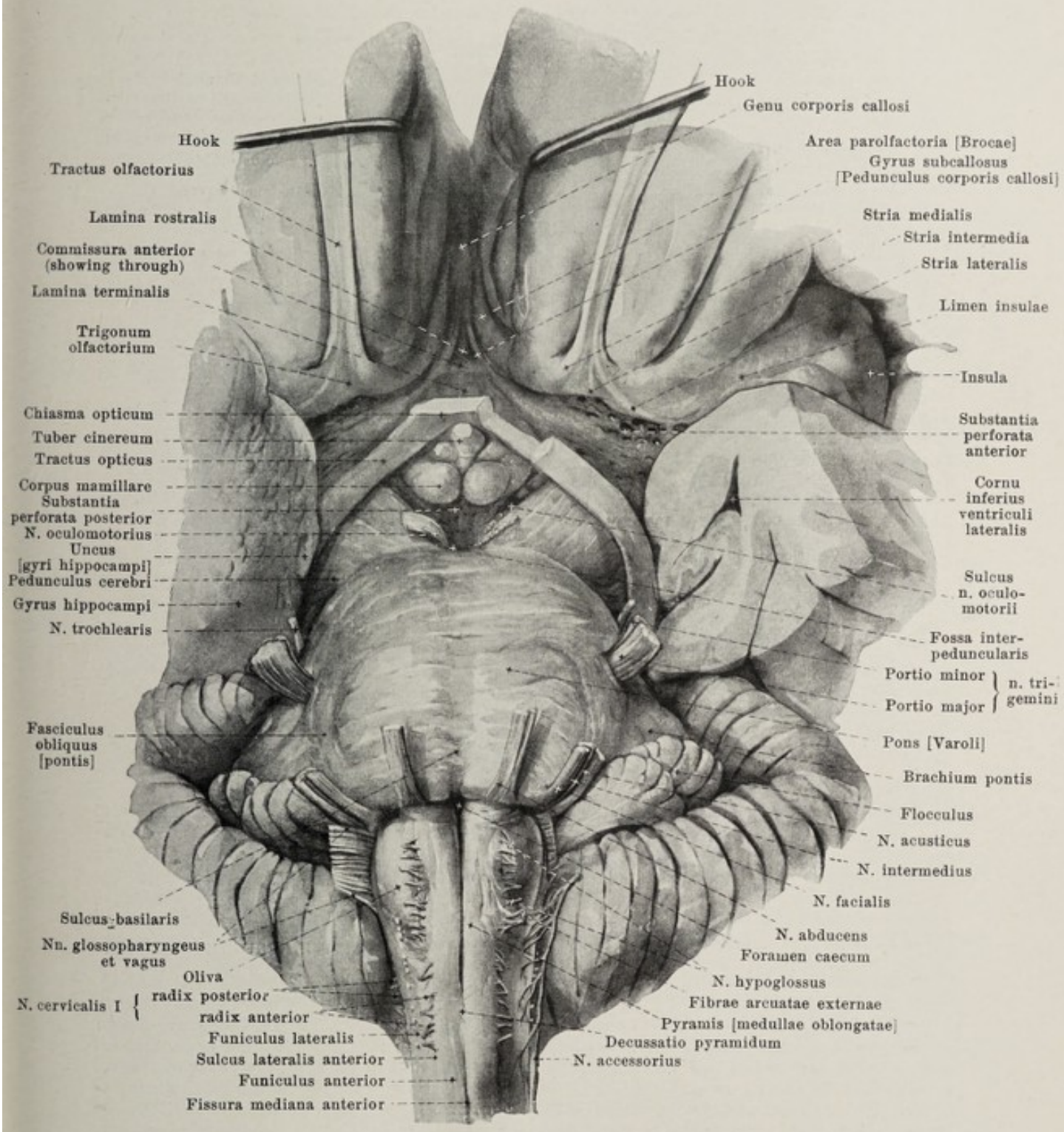
748. Median section through the brain-stem,

right half, viewed from the left.

(Only a very small part of the brain mantle is shown.)

The **brain** *(encephalon)* (see Figs. 744—747) is divisible on embryological grounds into *rhombencephalon (lozenge - shaped brain)*, *mesencephalon (mid-brain)*, and *prosencephalon (fore-brain)*; the two latter together form the *cerebrum (large brain)*. In the *rhombencephalon* are included the *myelencephalon (after-brain)*, which corresponds to the medulla oblongata, the *metencephalon (hind-brain)*, which includes the pons and the cerebellum, and the *isthmus rhombencephali*, that narrow portion of the brain surrounding the upper end of the rhomboid fossa to which parts of the pedunculi cerebri, the brachia conjunctiva and the velum medullare anterius belong. The *mesencephalon* includes parts of the pedunculi cerebri and the corpora quadrigemina. The *prosencephalon* is divisible into the *diencephalon (inter-brain)* to which belong the *pars mamillaris hypothalami* and the *thalamencephalon* (= thalamus + metathalamus + epithalamus) and the *telencephalon (end-brain)* which includes the *pars optica hypothalami* and the *hemisphaerium* (= corpus striatum + rhinencephalon + pallium).

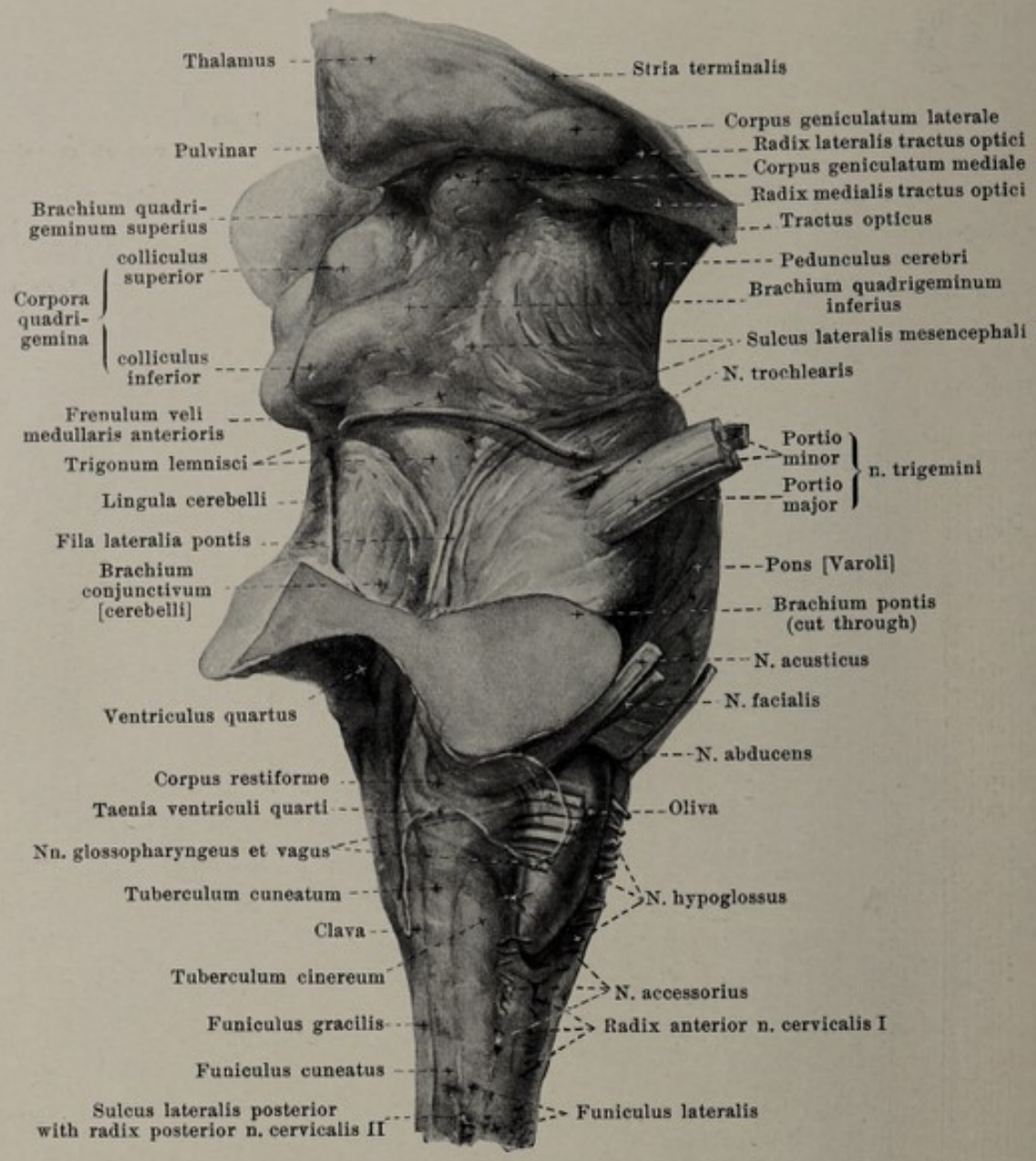
The term *brain-stem* is applied often to the part of the brain left after removal of the pallium.



749. Base of brain, viewed from below.

Magnification: circa 4 : 3.

(The cerebellar and cerebral hemispheres are shown only in part. The frontal lobes have been pulled apart. The anterior and medial portion of the left temporal lobe have been cut away and a piece has been excised from the left tractus opticus. On the right the radicular threads of the n. oculomotorius have been cut off short.)



750. Brain-stem, viewed from the right. Magnification: ca. 3 : 2.

(The cerebellum has been removed by cutting through the brachia pontis and the brachia conjunctiva; the cerebral hemispheres have also been removed.)

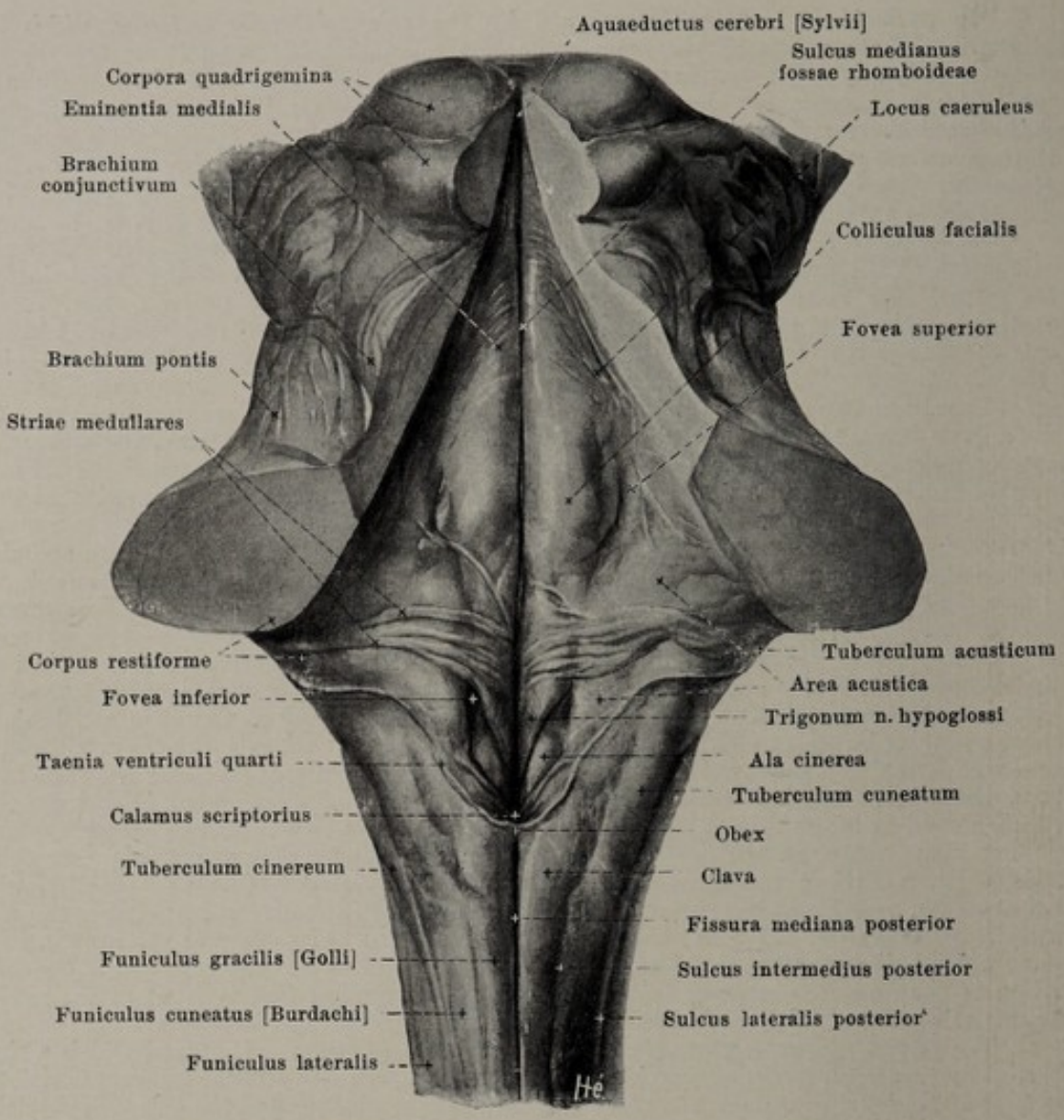
The **medulla oblongata** (see also Figs. 748, 749, 751, 752, 755 and 758) corresponds to the myelencephalon (see p. 646), is continuous without sharp limit with the upper end of the spinal cord; it lies for the most part in the skull and in an almost vertical direction. It extends from the upper root-bundles of the 1st cervical nerve as far as the inferior margin of the pons in front, and as far as the inferior margin of the pars intermedia of the 4th ventricle behind (see p. 649); it becomes expanded above, especially in the frontal direction, somewhat less so in the sagittal direction.

On its anterior surface (see Fig. 749), running in the median plane, is the deep *fissura mediana anterior;* it corresponds to the fissure of the same name in the spinal cord, but is separated from it, about at the level of the root-bundles of the 1st cervical nerve, by decussating bundles of nerve fibres, *decussatio pyramidum (decussation of the pyramids);* it ends above at the pons in a triangular depression, the *foramen caecum* (see also Fig. 748). The mass lying on each side of this fissure, the *pyramis [medullae oblongatae] (pyramid)*, appears to be continuous with the anterior funiculus of the spinal cord, but in reality it sends only a small part of its fibre bundles into it to the „anterior pyramidal tract", while the larger portion of them go to the lateral funiculus of the opposite side to form the „lateral pyramidal tract" (see p. 686).

The pyramid is bounded lateralward by the *sulcus lateralis anterior*, which is a continuation of the sulcus of the same name in the spinal cord; from it emerge the root bundles of the n. hypoglossus. Lateral from this groove in the upper part of the medulla oblongata lies an oblong, egg-shaped elevation, the *oliva (olive);* it is somewhat broadened and thickened above and extends with a blunt pole as far as the pons; its surface is sometimes smooth, sometimes nodular; below, it is frequently crossed by arch-like fibres, *fibrae arcuatae externae*, which go from the surface of the corpus restiforme (vide infra) to the region of the sulcus lateralis anterior, sometimes overlying and obscuring the sulci (see also p. 687).

On the posterior surface (see Figs. 750 and 751) the *fissura mediana posterior* forms the continuation of the sulcus medianus posterior as far as the lower end of the rhomboid fossa (vide infra). The *sulcus lateralis posterior* and *sulcus intermedius posterior* run, as continuations of the sulci of the same names in the spinal cord, upward and somewhat lateralward; the former is frequently indistinct and extends upward as far as the level of the middle of the olive (see Fig. 750), the latter ends at the lower margin of the recessus lateralis fossae rhomboideae. The two *funiculi graciles [Golli]*, ascending from the spinal cord, broaden somewhat a little below the rhomboid fossa and present there a flattened bulging, the *clava;* from this swelling on, the funiculi graciles run along the lower lateral margin of the rhomboid fossa, diverging upward and lateralward; they gradually become narrowed and go over without sharp limit into the medial part of the corpora restiformia (vide infra). The *funiculus cuneatus [Burdachi]* is the continuation of the funiculus of the same name in the spinal cord and above is often bounded very indistinctly lateralward by the sulcus lateralis posterior; the funiculi of the two sides diverge from the clava on, passing upward and lateralward where each presents a variably developed slight projection, the *tuberculum cuneatum;* they become lost above on each side in the corpus restiforme (vide infra). The *funiculus lateralis* (see Fig. 750) is the direct prolongation of the funiculus of the same name in the spinal cord; it becomes somewhat broadened as it passes upward and extends in front as far as the lower end of the olive and behind it almost as far as its upper end. A fine groove in which the root-threads of the nn. accessorius, vagus and glossopharyngeus are situated, runs upward on the lateral funiculus from the upper end of the spinal cord; it is curved slightly forward and, passing somewhat behind the olive, extends almost as far as the pons; below, it separates a broader, anterior area from a narrower, posterior area; above, on the contrary, the posterior area is broader and presents, especially in the child, a distinct club-shaped swelling, *tuberculum cinereum* (see also p. 687), which reaches as far as behind the olive and finally goes over into the corpus restiforme. The name ***corpus restiforme (rope-like body)*** has been given, on account of its external appearance, to the bundle which is the apparent continuation of the funiculi gracilis and cuneatus and of the dorsal portion of the funiculus lateralis just mentioned, passes upward just in front of the recessus lateralis of the rhomboid fossa and bends around dorsalward to the cerebellum.

The ***fossa rhomboidea*** *(lozenge-shaped fossa)* (see Figs. 751, 752 and 805) is a rhombic, slightly depressed, generally grayish area, which lies in a nearly vertical plane; it is visible as the floor of the fourth ventricle after the removed of the cerebellum and the thin tela chorioidea ventriculi quarti; only its lower part, embraced by the corpora restiformia, belongs to the medulla oblongata (the myelencephalon); the middle part lies in the metencephalon, and the uppermost part belongs to the isthmus. The lower part *(pars inferior fossae rhomboideae)* is approximately triangular and contains at its inferior angle the opening of the canalis centralis; it appears much deepened below and is marked there by several furrows which converge downward and medianward; this peculiar configuration of the surface has led to the further name ***calamus scriptorius.*** Along its lateral and inferior margin the tela chorioidea ventriculi quarti (see also Figs. 750, 751 and 756) is attached; when this is forcibly removed it leaves behind it a fine jagged edge, a part of the *taenia ventriculi quarti*, which covers the lowermost apex of the rhomboid fossa from behind as a thin triangular plate, called the *obex.* The taenia, above, bends around sharply lateralward upon the corpus restiforme and there forms the lower boundary of the *pars intermedia fossae rhomboideae;* this pars intermedia on each side, with the *recessus lateralis fossae rhomboideae*, passes far lateralward over the corpus restiforme, but above, between the brachia pontis, becomes considerably narrower and goes over at the upper end of the fovea superior (see p. 650) into the *pars superior fossae rhomboideae.* The pars superior is bounded lateralward by the brachia conjunctiva and covered behind by the velum medullare anterius; it becomes much narrower above and goes over insensibly in front of the lamina quadrigemina into the aquaeductus cerebri. The rhomboid fossa is divided into two symmetrical halves by the *sulcus medianus fossae rhomboideae* which runs in the median plane; the sulcus is deeper below, shallower above. Close to this fossa, on each side, extending through the whole length of the fossa, is a ridge, the *eminentia medialis;* in the pars superior it occupies the whole breadth (produced by the genu [internum] radicis n. facialis and the nucleus n. abducentis); in the upper part of the pars intermedia it presents an elongated projection, the *colliculus facialis;* from this point on, downward, it tapers, at first gradually, but in the pars inferior rather suddenly, so as to form there a right-angled triangular area, *trigonum n. hypoglossi.*

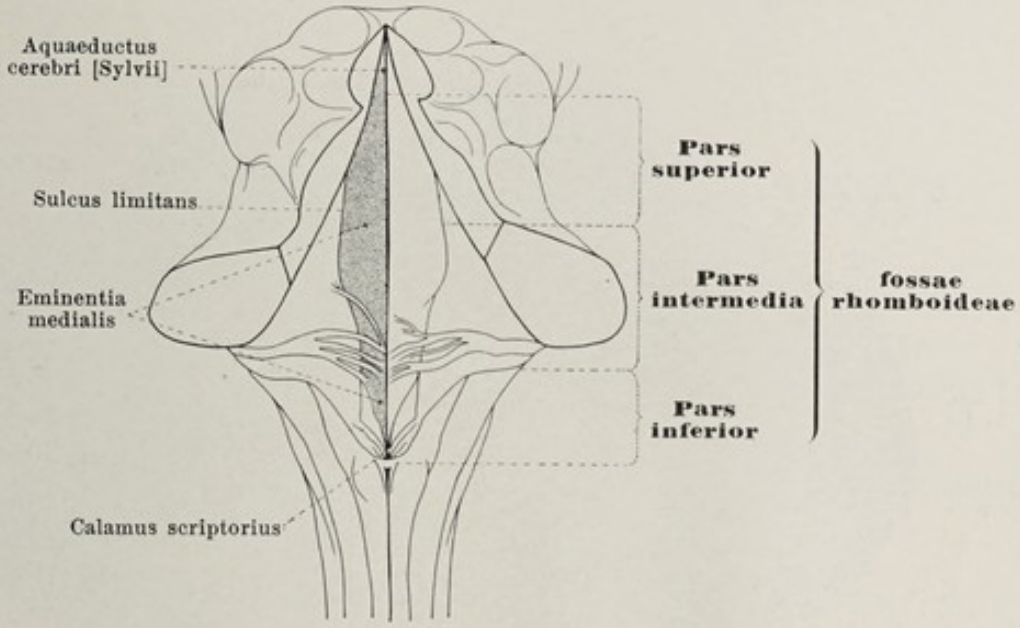


751. Rhomboid fossa, viewed from behind. Magnification: 2:1.

(The cerebellum and the choroid plexus of the fourth ventricle have been completely removed; the brachia conjunctiva with the velum medullare anterius and the lamina quadrigemina have been partly removed.)

Fossa rhomboidea (continued) (see also Figs. 752 and 805).

The eminentia medialis is bounded lateralward by the *sulcus limitans.* This runs, in the pars superior, along the lateral margin and is accompanied there for a considerable distance by a grayish-blue or dark-brown colored area, the *locus caeruleus.* Near the colliculus facialis the sulcus limitans broadens out to form a flat fossa, *fovea superior,* which is usually of a bluish color owing to the presence of a superficial vein; the sulcus ends in the uppermost part of the pars inferior in a sharply marked depression, *fovea inferior.* The narrow, somewhat depressed triangular area beneath the latter which extends not quite so far as the lower margin of the rhomboid fossa, is of a dark gray color and is called the *ala cinerea;* before it lie sensory nuclei of the nn. glossopharyngeus and vagus. Lateral from the sulcus limitans in the pars intermedia and from the ala cinerea of the pars inferior is a flattened elevation, the *area acustica* (here lie nuclei of the n. vestibularis), which, medianward, ends in a convex arch, and lateralward extends into the recessus lateralis to end there in the *tuberculum acusticum* (usually but poorly developed in man); here lies the nucleus of the n. cochlearis dorsalis. Running transversely over the area acustica and over the neighboring part of the eminentia medialis are certain superficial bands of white fibres, *striae medullares* (see also p. 700), which arise on the surface of the tuberculum acusticum and disappear in the depth in the sulcus medianus or before going that far; the striae are very variable in number and size; they run parallel to one another or diverge as they pass medianward.



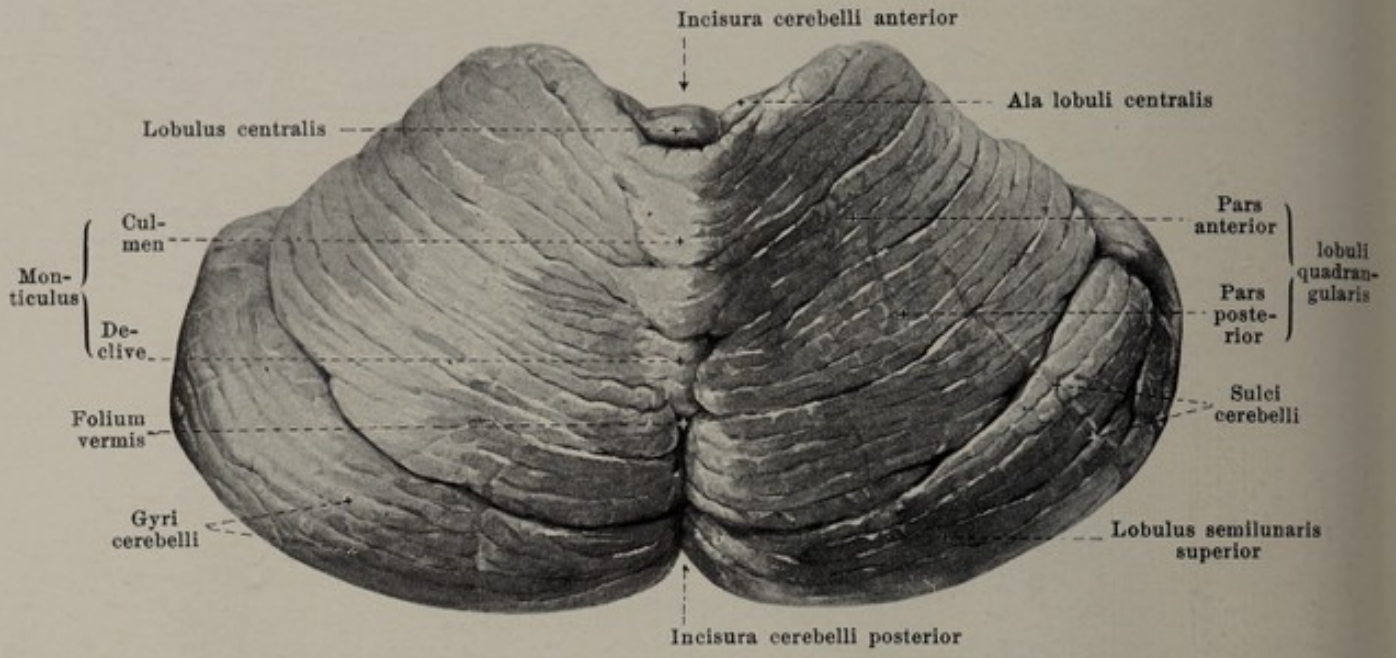
752. Rhomboid fossa,

viewed from behind, partly schematic. Magnification: 11 : 10.

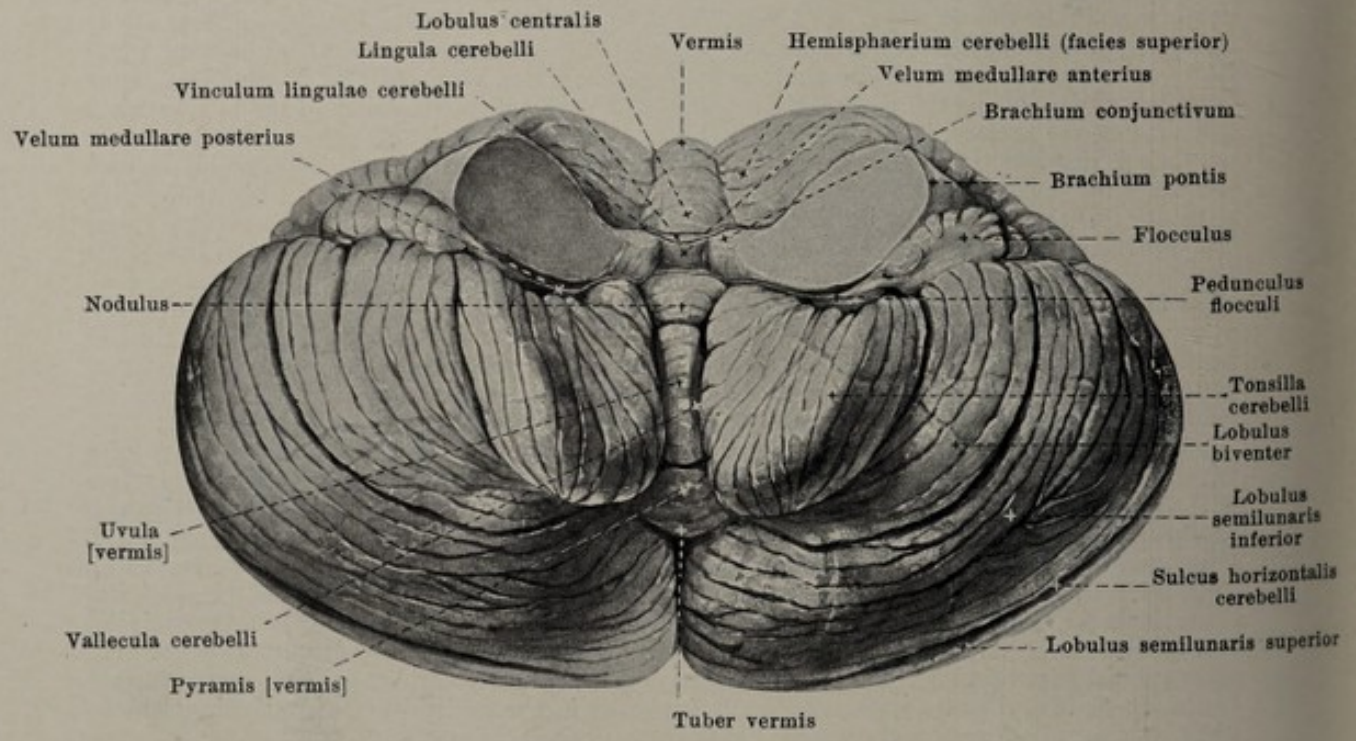
(The left eminentia medialis is shaded.)

The **bridge** *(pons [Varoli])* (see Figs. 748—750, 755 and 758) forms a broad, white mass, running transversely, which is sharply marked off at its lower, posterior margin from the medulla oblongata and at its upper, anterior margin just as distinctly from the cerebral peduncles which pass through it; it lies upon the clivus and reaches upward as far as the upper margin of the dorsum sellae (see Fig. 815). It is convex forward in both sagittal and transversal directions, but presents in the median plane a flat longitudinal groove, the *sulcus basilaris*, which is broader above than below and in which, as a rule, the a. basilaris runs. Broad bundles of fibres can be seen passing in transversal direction on its surface; they converge somewhat lateralward where they become interwoven with one another; usually one broad band of fibres, *fasciculus obliquus [pontis]*, emerges from the general mass medial from the superficial origin of the n. trigeminus and runs on the surface, in a curve convex lateralward, to the region of superficial origin of the nn. facialis and acusticus. Lateralward from this bundle the pons narrows considerably on each side, since the upper, anterior margin curves markedly downward and backward, while the inferior, posterior margin runs further in the transversal direction. Lateralward from a line which connects the superfical origin of the n. trigeminus with that of the n. facialis the mass is designated the *brachium pontis (arm of the pons)* [O. T. middle peduncle of the cerebellum]; it passes lateralward and backward between the flocculus and the lobulus quadrangularis into the substance of the cerebellum. Certain small bundles of nerve fibres, very variable, known as the *fila lateralia pontis* (see Figs. 750 and 757), arise in the groove between the brachium conjunctivum and the brachium pontis, and run medianward along the upper boundary of the brachium pontis and the pons to disappear in the fossa interpeduncularis in the cerebral peduncle.

The **cerebellum** *(small brain)* (see Figs. 748, 753—755 and 758) has the shape of a flattened egg with its longest diameter directed transversely; it lies dorsalward from the upper part of the medulla oblongata, from the rhomboid fossa, and from the brachia conjunctiva and corpora quadrigemina, and with the brachia pontis and the pons forms a ring through which the structures lying in the floor of the rhomboid fossa appear to have been thrust. It fills up completely the fossae occipitales inferiores lying below the sulcus transversus of the occipital bone, extends above as far as the tentorium cerebelli and is separated by this from the occipital lobe of the cerebrum. Below, on each side, the tonsilla cerebelli and the lobulus biventer very often project slightly through the foramen magnum into the vertebral canal. The upper surface of the cerebellum, directed also dorsalward, is curved in the sagittal and frontal directions so as to be convex backward and upward; the lower surface, looking forward and also ventralward is likewise arched in both directions, and presents in the middle a broad groove, formed by the nodulus, the uvula and the tonsillae, called the *vallecula cerebelli*, in which the medulla oblongata is situated. The anterior margin of the upper surface presents in the middle a flat notch, *incisura cerebelli anterior*, which corresponds to the neighboring corpora quadrigemina; on the posterior margin, in the median plane is a deep, narrow notch, *incisura cerebelli posterior*.

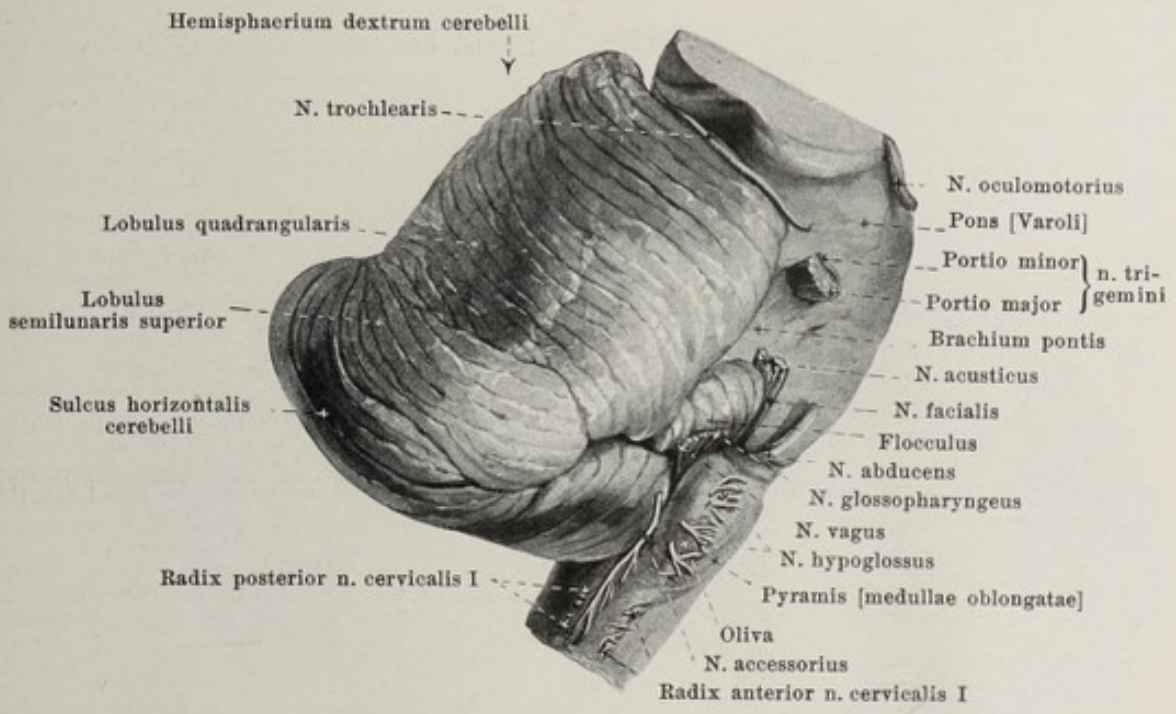


753. Cerebellum, viewed from above and behind.



754. Cerebellum, viewed from below and in front.

(In both figures the cerebellum has been freed by cutting through the brachia pontis, the brachia conjunctiva and the velum medullare anterius.)



755. Rhombencephalon, viewed from the right side.

(The cerebrum has been removed by cutting through the cerebral peduncles and the corpora quadrigemina.)

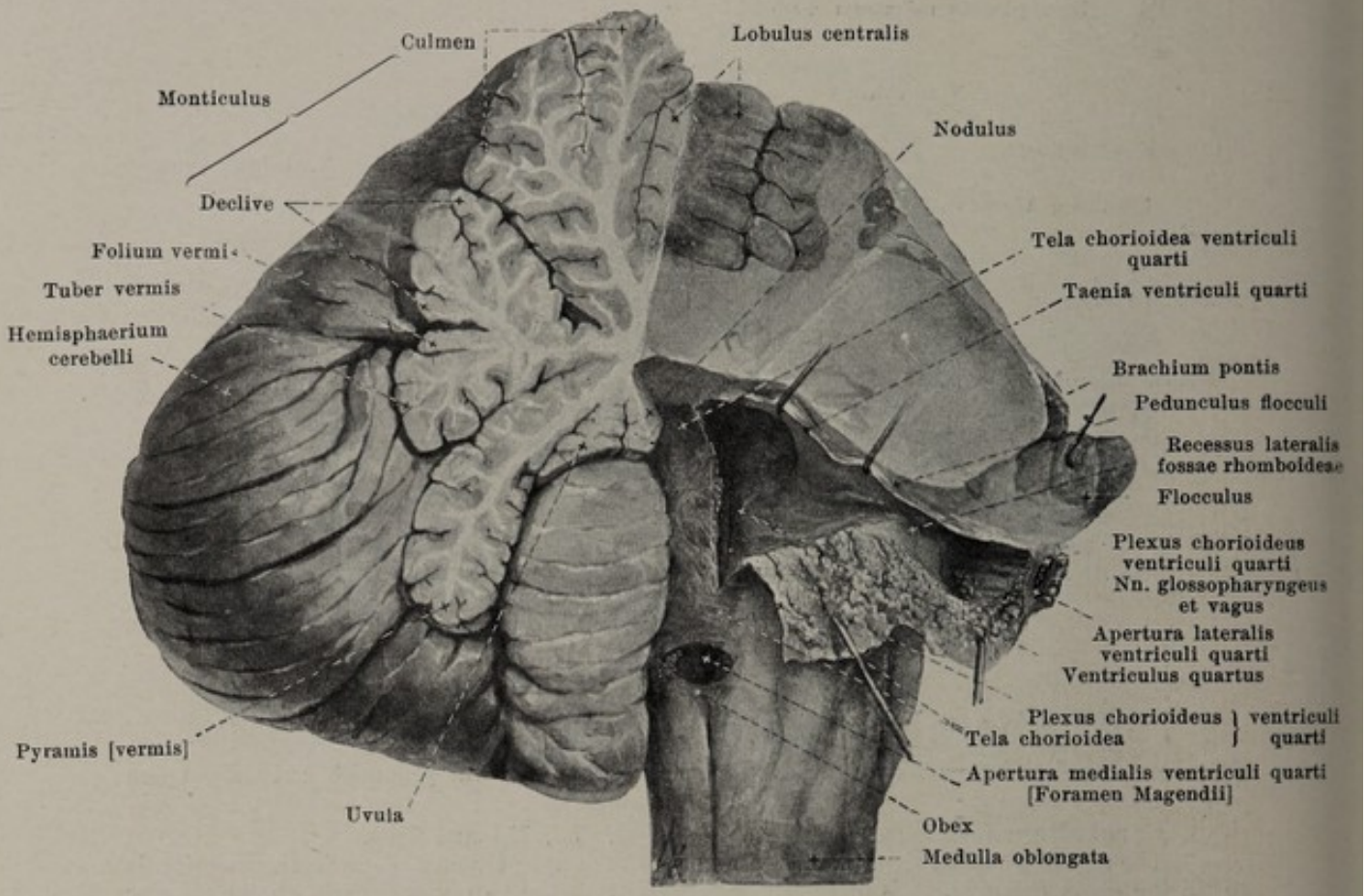
Cerebellum (continued) (see also Figs. 748, 753, 754 and 758).

The medial portion, situated between the incisura anterior and the incisura posterior, is called the *worm (vermis)*. It is distinctly separated from the two lateral parts on the inferior surface but very indistinctly on the superior; each of these lateral portions is called a *cerebellar hemisphere (hemisphaerium cerebelli)*. The *convolutions, gyri cerebelli*, are separated from one another by numerous narrow *grooves, sulci cerebelli*, which extend continuously, especially on the superior surface, over the worm and the hemispheres and run approximately parallel to the posterior margin. A deeper sulcus, *sulcus horizontalis cerebelli*, extends along the posterior margin or rather upon the inferior surface; it divides the surface of the hemispheres into a *facies superior* and a *facies inferior*. Other deep sulci separate individual lobules from one another, each involving both hemispheres and worm so that one lobule of the worm always corresponds to a similar lobule of the hemisphere. On the upper surface of the worm, from before backward, the following structures are met with: *lingula cerebelli* (see p. 655), *lobulus centralis, monticulus*, in which are to be distinguished *culmen* and *declive*, and the narrow *folium vermis;* on the hemispheres: the delicate *vinculum lingulae cerebelli* (see p. 655), the narrow *ala lobuli centralis*, the *lobulus quadrangularis* which consists of a *pars anterior* and a *pars posterior*, and the *lobulus semilunaris superior*. On the inferior surface of the worm, passing from behind forward are to be seen: the *tuber vermis*, the *pyramis [vermis]*, the *uvula [vermis]* and the *nodulus;* on the hemispheres, the *lobulus semilunaris inferior*, the *lobulus biventer*, and surrounded lateralward by it, the *tonsilla cerebelli* and the *flocculus*. The latter is a club-shaped lobule situated in front of the lobulus biventer and the tonsilla cerebelli and just behind the brachium pontis; it tapers out medianward to the *pedunculus flocculi* and then goes over into a thin leaflet, *velum medullare posterius*, which lies in contact with the front of the nodulus; flocculus, pedunculus flocculi and velum medullare posterius are in direct contact with the lamina epithelialis of the tela chorioidea ventriculi quarti (see p. 654).

The cerebellum is united on each side with the medulla oblongata by means of the corpus restiforme, with the pons by means of the brachium pontis, and with the cerebrum by means of the brachium conjunctivum. These connecting bundles are crowded closely together at the anterior part of the cerebellum.

The **fourth ventricle** *(ventriculus quartus)* (see Figs. 748 and 756), situated within the rhombencephalon, is a cavity containing a small amount of fluid, continuous below with the central canal of the spinal cord and going, above, directly over into the aquaeductus cerebri. On the whole, it is a transverse slit of the form of the rhomboid fossa, and is nowhere deep except in the middle of its length.

Its anterior wall *(floor of the 4th ventricle)* is formed by the rhomboid fossa (see p. 649).



756. Fourth ventricle,

partly opened, viewed from behind and from the right.

(The right half of the cerebellum has been in large part removed; the tela chorioidea ventriculi quarti has been cut through on the right side and reflected.)

Fourth ventricle (continued) (see also Fig. 748).

Its posterior wall *(roof of the 4th ventricle)* consists in its upper part of the velum medullare anterius and the brachia conjunctiva (see p. 655); in its lower part it is formed by a thin layer, *tela chorioidea ventriculi quarti* (see p. 674), which extends from the velum medullare posterius, the pedunculus flocculi and the flocculus to the margins of the inferior and middle parts of the rhomboid fossa. This layer is lined on its ventricular surface with epithelium, *lamina chorioidea epithelialis*, which, at the margin, is continuous with the brain substance, and which embryologically is a very thin part of the brain wall, arrested in development early in embryonal life. On forcibly opening the ventricle the epithelial layer goes with the tela, tearing along the line of transition into brain substance; the fine, jagged border visible along the margin of the tear is called the *taenia ventriculi quarti;* it runs (see Figs. 750 and 751) along the margin of the pars inferior fossae rhomboideae (see p. 649), then follows the lower margin of the recessus lateralis as far as the posterior surface of the region of origin of the nn. glossopharyngeus and vagus, and turns, further on, to the anterior surface of the flocculus; finally it passes along the pedunculus flocculi and the velum medullare posterius. The main mass of the tela chorioidea is formed by a lamella of the pia mater encephali, which is united by loose subarachnoideal tissue with the covering (also formed by pia mater) of the under surface of the worm and of the tonsillae cerebelli. The tela chorioidea is provided on its ventricular surface with lobulated, villus-like, reddish, vascular processes, known as the *plexus chorioideus ventriculi quarti;* they run as two parallel bands close to the median plane in the lower part of the ventricle, are united with one another above and then bend around at a right angle into the recessus laterales; the free ends of the plexus project for a variable distance through the three openings of the ventricle (see p. 655) and hang in the subarachnoidal spaces, so that in the undissected brain the lateral end can be seen on each side, in the angle between the flocculus, nn. facialis and acusticus on the one hand, and the tonsilla cerebelli, nn. glossopharyngeus and vagus on the other (see Fig. 758).

The tela chorioidea is completely closed originally, but is regularly broken through later in the 4th embryonal month at three places; these openings (see Figs. 756 and 815) unite the subarachnoideal spaces with the fourth ventricle; they are of variable size. One unpaired opening, *apertura medialis ventriculi quarti [foramen Magendii]*, lies just over the obex at the lower end of the posterior wall of the ventricle; the other paired opening, *apertura lateralis ventriculi quarti*, corresponds approximately to the apex of the recessus lateralis and lies upon the posterior surface of the roots of the nn. glossopharyngeus and vagus.

The angle formed by the meeting of the velum medullare anterius and the velum medullare posterius, very distinct in the median section (see Fig. 748), is called the *fastigium*.

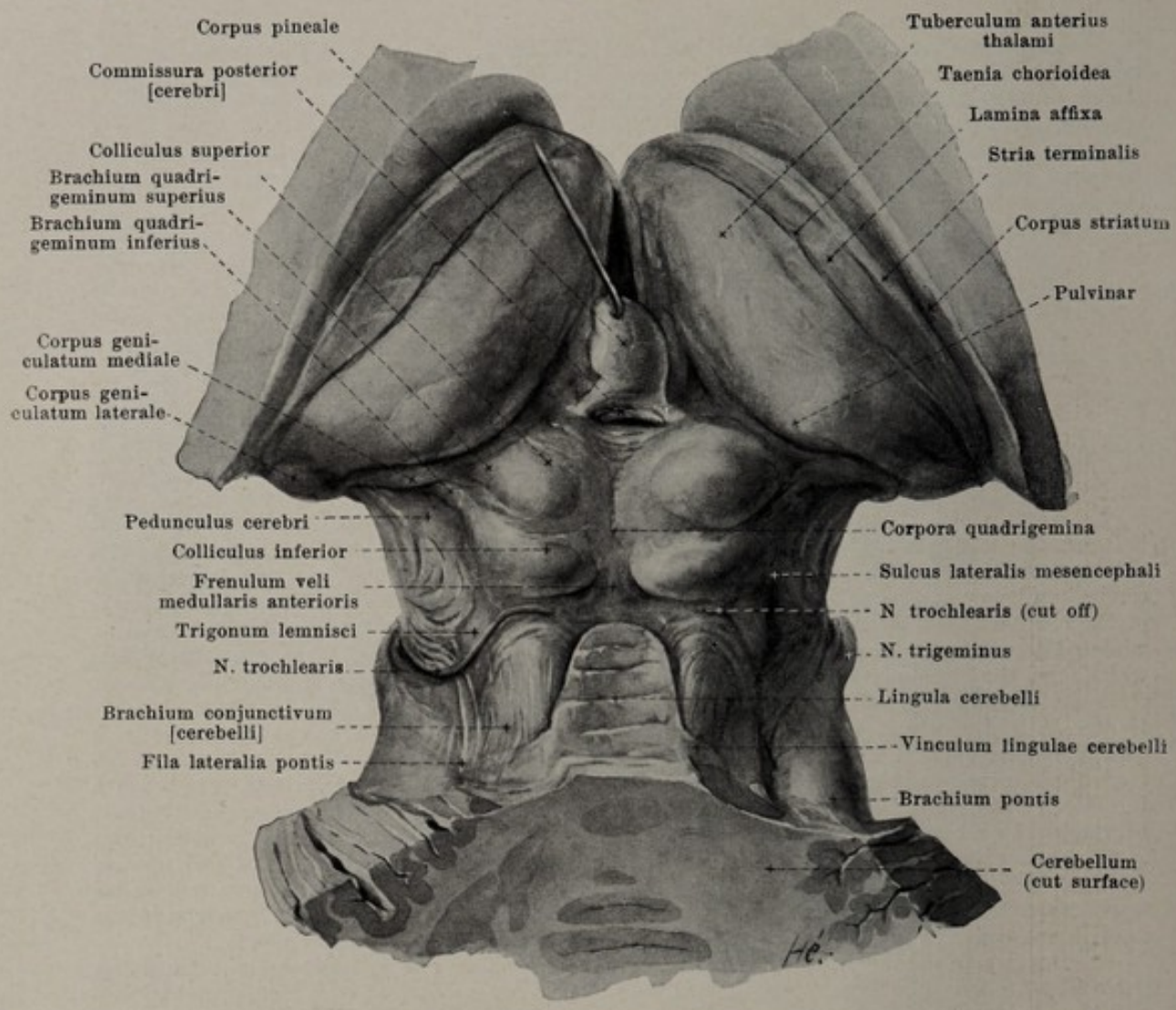
The transverse slit which passes upward between the posterior surface of the medulla oblongata and the anterior surface of the cerebellum is called the *fissura transversa cerebelli*.

Isthmus rhombencephali and mesencephalon.

The ***brachia conjunctiva cerebelli*** (O. T. superior cerebellar peduncles) are two flat, striped, white bundles which pass out of the anterior portion of the cerebellum (see Figs. 750, 754 and 757), converge as they pass upward and disappear beneath the lamina quadrigemina. Laterally each one fuses, below with the brachium pontis, above with the pedunculus cerebri; the junction of these structures is indicated on the surface by a groove, *sulcus lateralis mesencephali*, which is continued upward as far as the medial geniculate body. Stretching out between the medial margins of the brachia conjunctiva is an unpaired, thin, white leaflet, *velum medullare anterius* (see also Figs. 748 and 754), which is directly connected with the cerebellum below and narrows as it passes upward; its anterior surface, with the adjacent parts of the brachia conjunctiva, forms the upper part of the posterior wall of the fourth ventricle, while its posterior surface (see Figs. 748 and 757) is fused with several transverse gray ridges which form the *lingula cerebelli* of the worm; from the latter, on each side, a triangular process, *vinculum lingulae cerebelli*, goes off below and passes lateralward over the brachium conjunctivum. A white strand running from the lower end of the median sulcus of the corpora quadrigemina to the upper end of the velum medullare anterius is called the *frenulum veli medullaris anterioris;* the n. trochlearis emerges lateralward from it on each side, just beneath the inferior colliculus. The upper part of the lateral surface of the brachium conjunctivum is overlapped by a triangular area, *trigonum lemnisci* (see Fig. 750), which projects somewhat but is not always well defined; the fibres directed obliquely medianward, dorsalward and upward belong to the *lemniscus (fillet)* — to the *lemniscus lateralis [acusticus];* this area is bounded lateralward by the sulcus lateralis mesencephali, in front by the brachium quadrigeminum inferius and contains in the depth the *nucleus lemnisci lateralis*.

Directly in contact with the brachia conjunctiva above and in front are the ***corpora quadrigemina*** (see Figs. 748, 750 and 757). These are subdivided by a median flat groove and by a transverse groove passing at right angles to the median groove somewhat behind its middle, sharply marked lateralward, into four, whitish hemispherical elevations, so that a *colliculus inferior* and a *colliculus superior* are formed on each side; the superior colliculi are considerably larger than the inferior, but their convexities are more flattened. In the median groove between the two superior colliculi lies the corpus pineale (see p. 666); it hides them for a variable distance downward (see Fig. 770). The corpora quadrigemina are elevations from a plate, the *lamina quadrigemina* (see Figs. 748 and 787), which goes directly over, on each side, lateralward and in front, into the tegmentum of the pedunculus cerebri; the anterior boundary of this plate corresponds to a plane passing through the aquaeductus cerebri parallel to the posterior surface (see Fig. 787). Each colliculus is continuous lateralward with a *quadrigeminal arm* (see also Fig. 750) directed upward and lateralward, each arm being separated by a groove from its neighbor; the *superior quadrigeminal arm (brachium quadrigeminum superius)* proceeds from the colliculus superior and disappears beneath the medial geniculate body and beneath the pulvinar by which it is partly overlapped; the *inferior quadrigeminal arm (brachium quadrigeminum inferius)*, from the collicus inferior, is longer, passes along the upper margin of the trigonum lemnisci as far as the sulcus lateralis mesencephali, and then disappears beneath the medial geniculate body.

On the anterior inferior surface of the brain-stem (see Figs. 749 and 758) two large, striped white bundles, ***pedunculi cerebri*** (O. T. crura cerebri), are to be seen close to one another; they emerge from the upper margin of the pons and diverging almost at a right angle, pass upward and lateralward to disappear beneath the tractus optici. The ventral surface here visible and the lateral free surface as far as the sulcus lateralis mesencephali (see Fig. 750) belong to the *basis pedunculi (foot of the cerebral peduncle)*, while the area between this sulcus and the lamina quadrigemina overlaid by the trigonum lemnisci and the brachium quadrigeminum inferius belongs to the *tegmentum* (see Fig. 787).



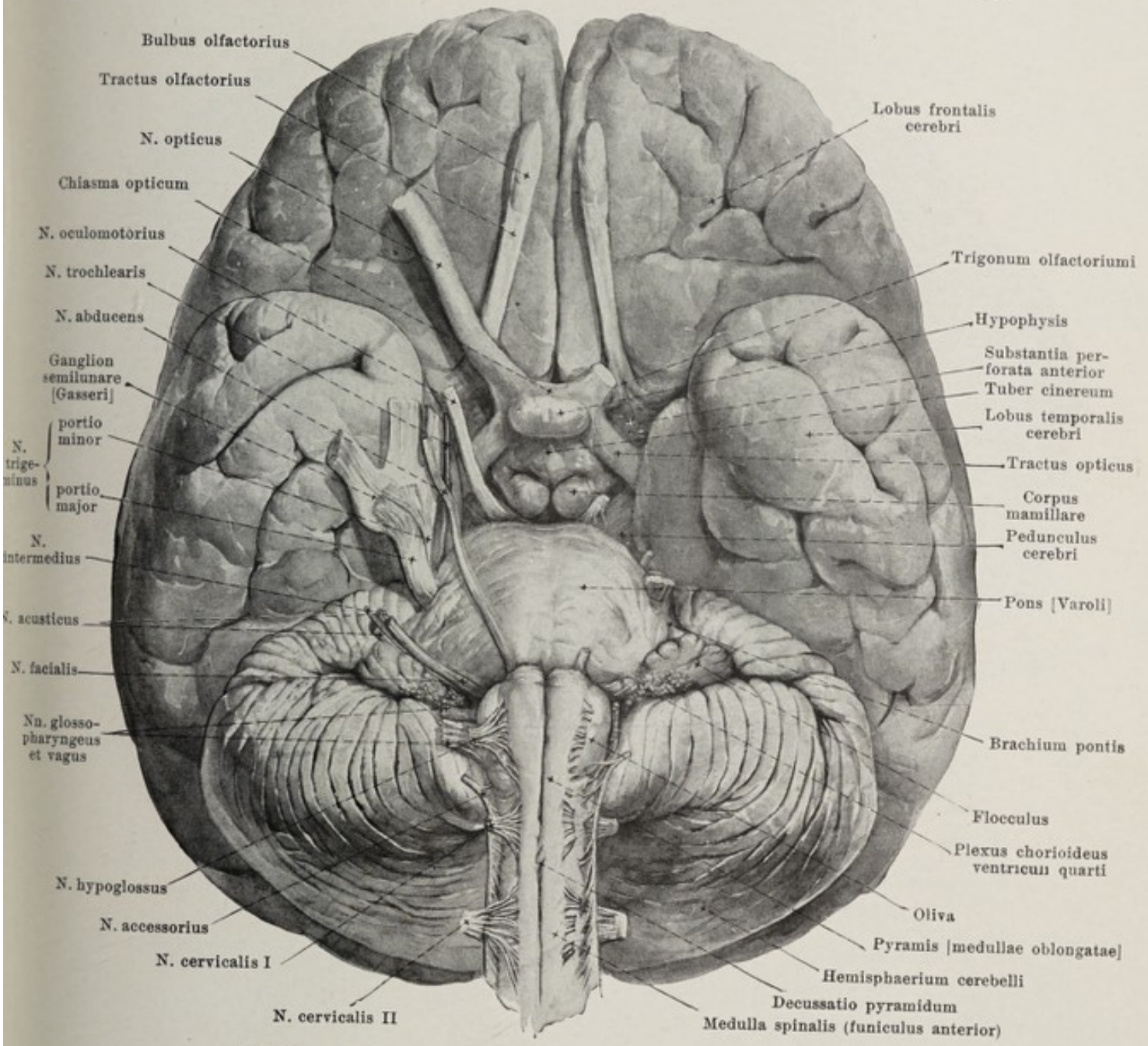
757. Corpora quadrigemina and neighborhood, viewed from behind and above.

(The upper part of the cerebellum has been removed by a cut passing obliquely backward and downward; the cerebral hemispheres have been removed; the corpus pineale has been pulled upward by a hook.)

Between the diverging cerebral peduncles is a deep depression, *fossa interpeduncularis [Tarini]* (see Fig. 749); its *recessus posterior* slightly undermines the upper margin of the pons and its *recessus anterior* passes into the depth between the corpora mamillaria (see Fig. 748). The floor of this approximately triangular fossa, which reaches upward as far as the corpora mamillaria, is formed by the *substantia perforata posterior*. This surface presents numerous openings for blood vessels, is subdivided by a median shallow groove and helps, on each side, to bound the tegmentum medianward (see Fig. 787). It is marked off from the cerebral peduncle by a groove, the *sulcus n. oculomotorii* (see Fig. 749).

The ***aquaeductus cerebri [Sylvii]*** (see Figs. 748, 784—787, 794 and 795) is a narrow canal, 1,5 cm long, which passes from the upper end of the fourth ventricle (see p. 653) through the mesencephalon to the third ventricle. It is covered behind by the lamina quadrigemina and the commissura posterior; it is bounded in front by the tegmentum of the pedunculus cerebri. In cross-section it is triangular or T-shaped in its upper and lower parts, while in the middle it has approximately the shape of an ace of hearts, though it deviates sometimes from this shape.

The **cerebrum** *(large brain)* (see p. 646) is approximately egg-shaped. It presents a surface, markedly convex upward in the sagittal and frontal directions, *facies convexa cerebri* (see also Figs. 759, 760 and 763), which corresponds to the inner surface of the roof of the skull, and an inferior surface, *basis cerebri* (see Figs. 765 and 766); the front part of the latter lies in the anterior and middle fossae of the skull, the back part upon the tentorium cerebelli which separates it from the cerebellum; its bulgings correspond to the surfaces.



758. Brain, viewed from below and in front.

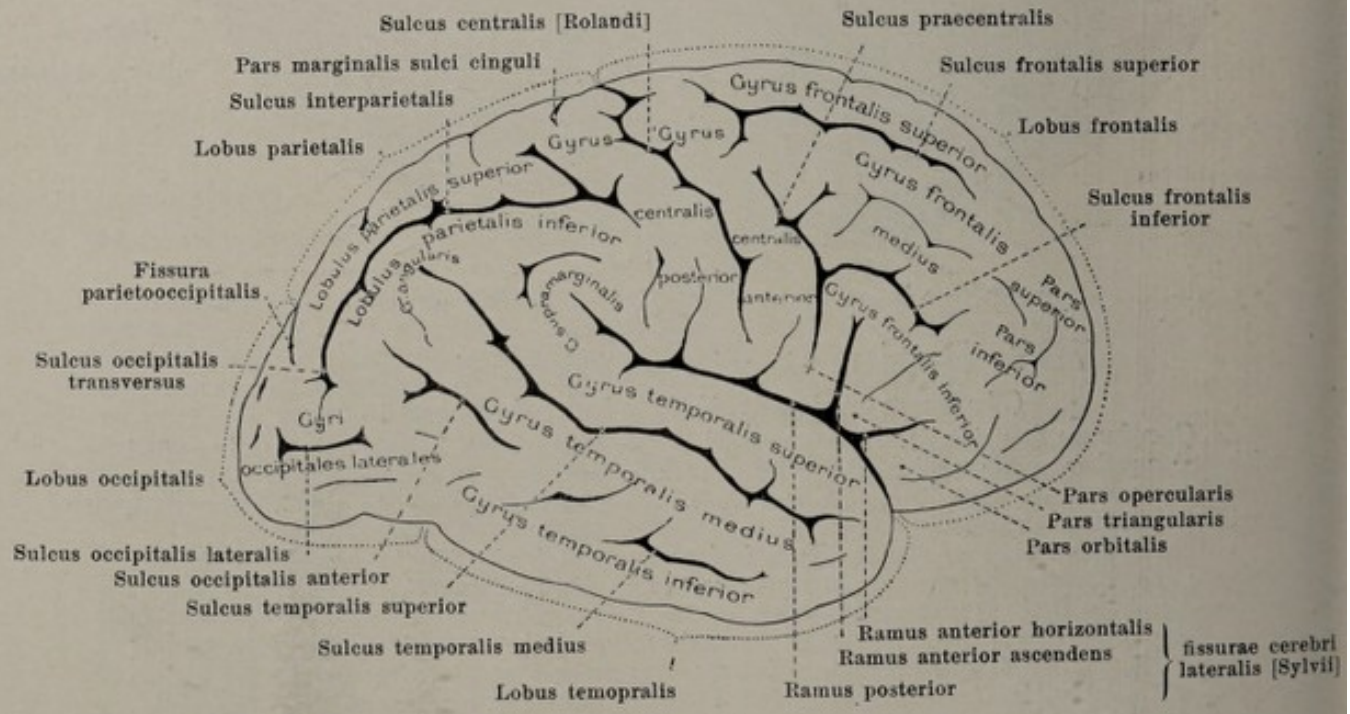
(The nerves on the left side have been cut off short.)

Cerebrum (continued). It is composed of two symmetrical halves, only partly united with one another in the median plane; hence each half presents an approximately flat *facies medialis cerebri* (see Figs. 748, 761 and 762), which belongs partly to the 3rd ventricle, partly to the free surface.

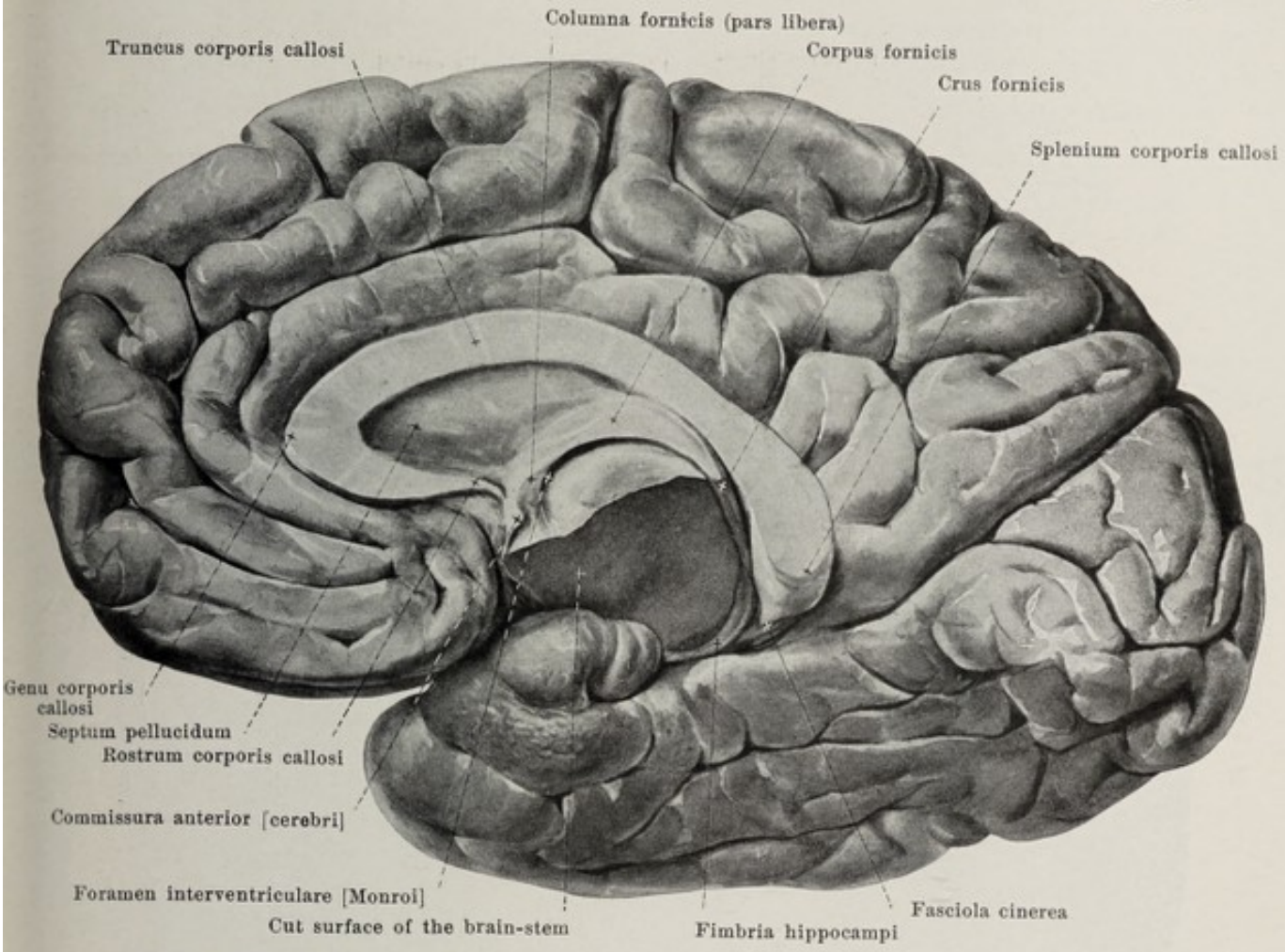
The largest mass of the cerebrum is formed on each side by the ***cerebral hemisphere*** *(hemisphaerium cerebri)*, in which are to be distinguished the *pallium*, the *rhinencephalon* and the (buried) *corpus striatum*.

The ***pallium*** *(brain-mantle)* is the main mass of the hemisphere, markedly fissured on the surface; that of one hemisphere is separated from that of the other side by a deep median slit, *fissura longitudinalis cerebri* (see Figs. 763 and 765), reaching to the corpus callosum. The deep transverse slit, which passes in from behind, between the pallium on the one hand and the upper surface of the cerebellum, the corpora quadrigemina and the corpus pineale on the other, filled up behind by the tentorium cerebelli and in front by a duplicature of the pia mater, is called the *fissura transversa cerebri* (see Fig. 747, not designated) (Continuation see p. 660).

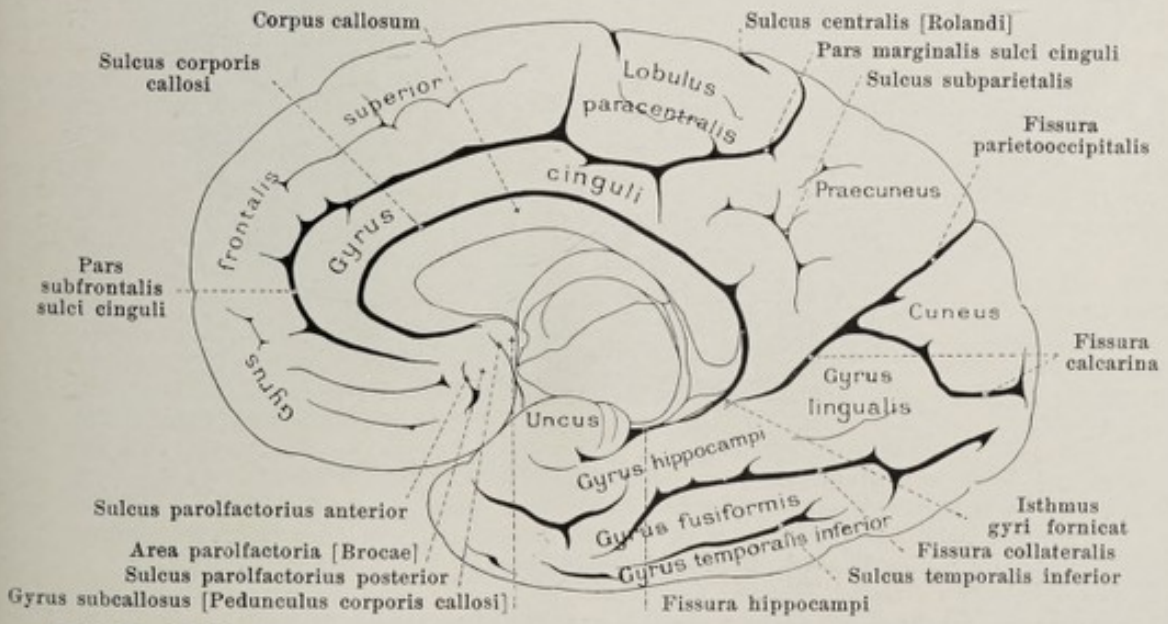
759. Brain, viewed from the right.



760. Cerebral hemisphere, viewed from the right, partly schematic.

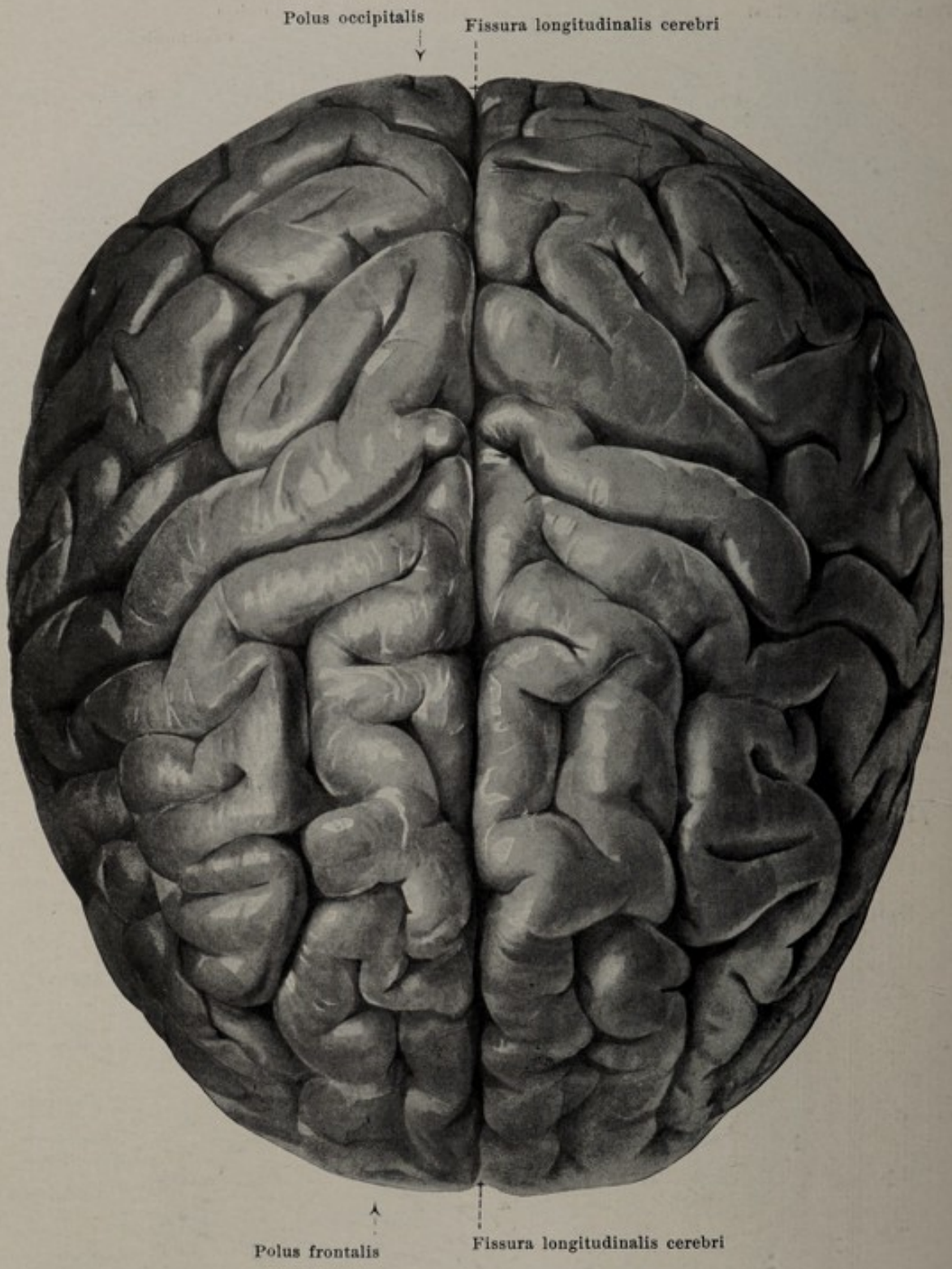


761. Right cerebral hemisphere, viewed from the left.



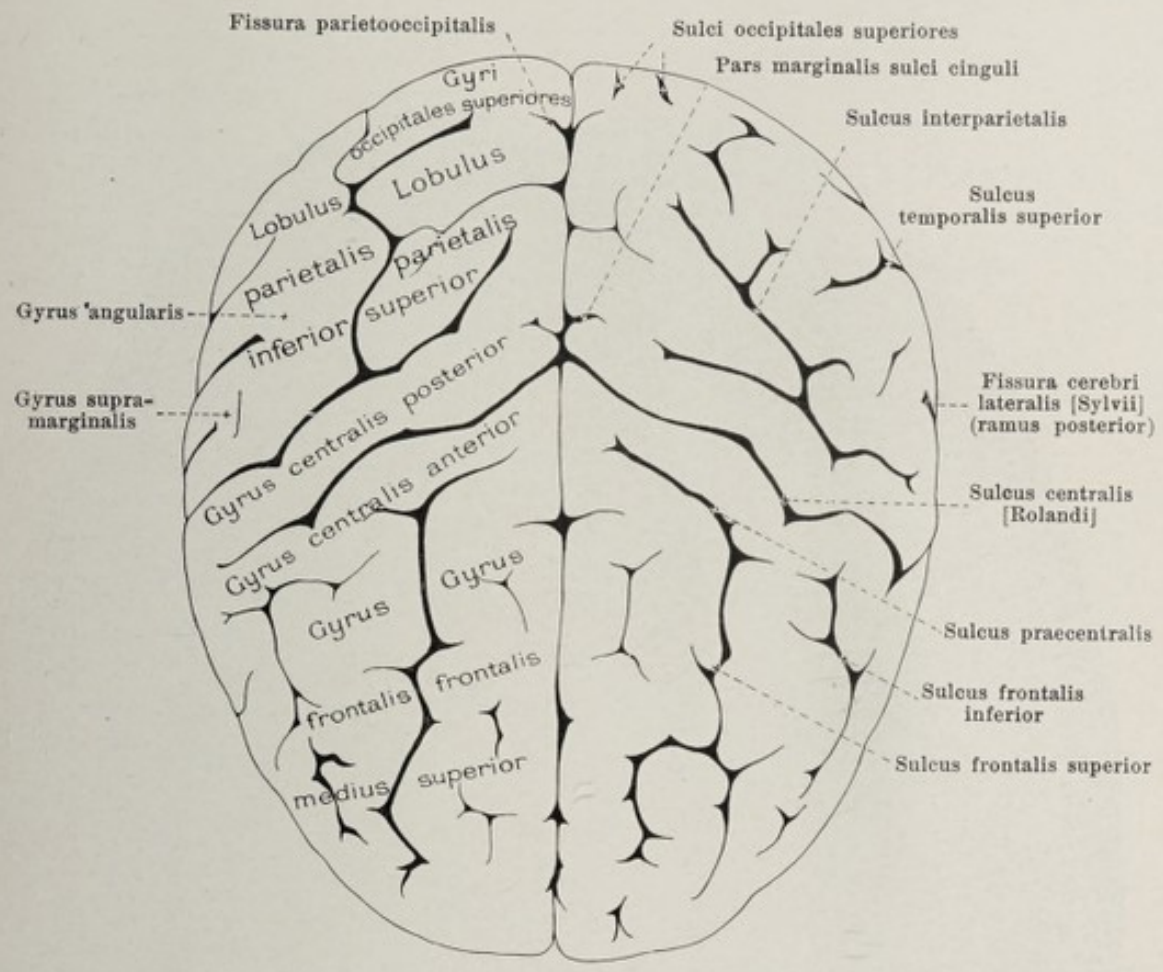
762. Right cerebral hemisphere, viewed from the left, partly schematic.

(The brain has been cut in half; the lower part of the brain-stem has been removed by an oblique cut.)



763. Cerebral hemispheres, viewed from above.

Pallium (continued). What has been said concerning the form of the cerebrum holds for the pallium; on the inferior, basal surface the upper angle of the pyramid of the temporal bone causes a slight depression, *impressio petrosa* (see Fig. 765), which runs obliquely lateralward and dorsalward.

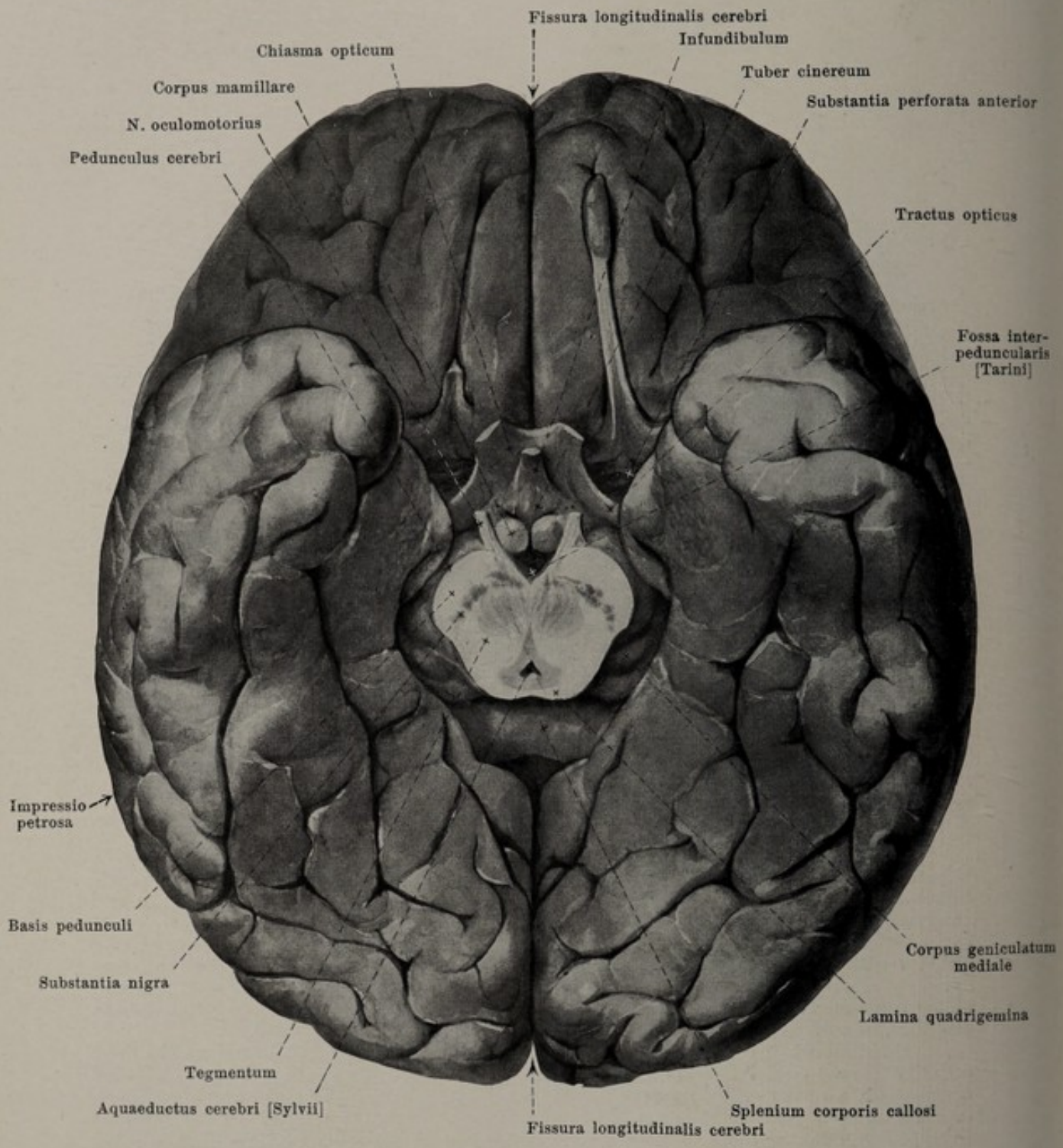


764. Cerebral hemispheres, viewed from above, partly schematic.

Pallium (continued). The surface is studded by numerous *convolutions, gyri cerebri*, in part individually variable; they are shorter or longer, straight or curved elevations, separated from one another by groove-like or slit-like depressions, *sulcus cerebri*. These superficial gyri are manifoldly connected in the depth of the sulci by hidden *deep gyri, gyri profundi*. Short gyri which, lying superficially or in the depth, making a connection between two longer gyri are called *transitional gyri, gyri transitivi* (O. T. annectant gyri). Those sulci which arise as "primary fissures" in the embryo by a total infolding into the ventricular cavity of the wall of the hemisphere, still very thin at this time, are called *fissurae;* each of these corresponds, therefore, to a projection in the wall of the ventricle, usually similarly named.

On the lateral, convex surface of the pallium (see Figs. 759 and 760) runs the deep, arch-like *fissura cerebri lateralis [Sylvii]* (see also p. 664); it divides into a *ramus anterior horizontalis*, a *ramus anterior ascendens*, and a *ramus posterior*. The portion of the pallium over its anterior part, reaching as far as the sulcus centralis, is called the *lobus frontalis (frontal lobe);* that over its posterior part, extending from the sulcus centralis almost to the fissura parietooccipitalis, is the *lobus parietalis (parietal lobe);* the part lying beneath it is the *lobus temporalis (temporal lobe)* which is very indistinctly marked off from the most posterior portion, *lobus occipitalis (occipital lobe)*. The most anterior point of the frontal lobe is called the *polus frontalis*, that of the temporal lobe, the *polus temporalis*, while the most posterior point of the occipital lobe is called the *polus occipitalis* (see also Fig. 766).

Upon the convex surface of the *frontal lobe* (see also Figs. 759, 760 and 763) above runs the *sulcus frontalis superior*, below, the *sulcus frontalis inferior*, which goes over behind into the *sulcus praecentralis;* in this way are formed the *gyrus frontalis superior*, the *gyrus frontalis medius*, which is again subdivisible in front into a *pars superior* and a *pars inferior*, the *gyrus frontalis inferior*, divided by the two anterior rami of the fissura cerebri lateralis into a *pars orbitalis*, a *pars triangularis* and a *pars opercularis*, and the *gyrus centralis anterior*.

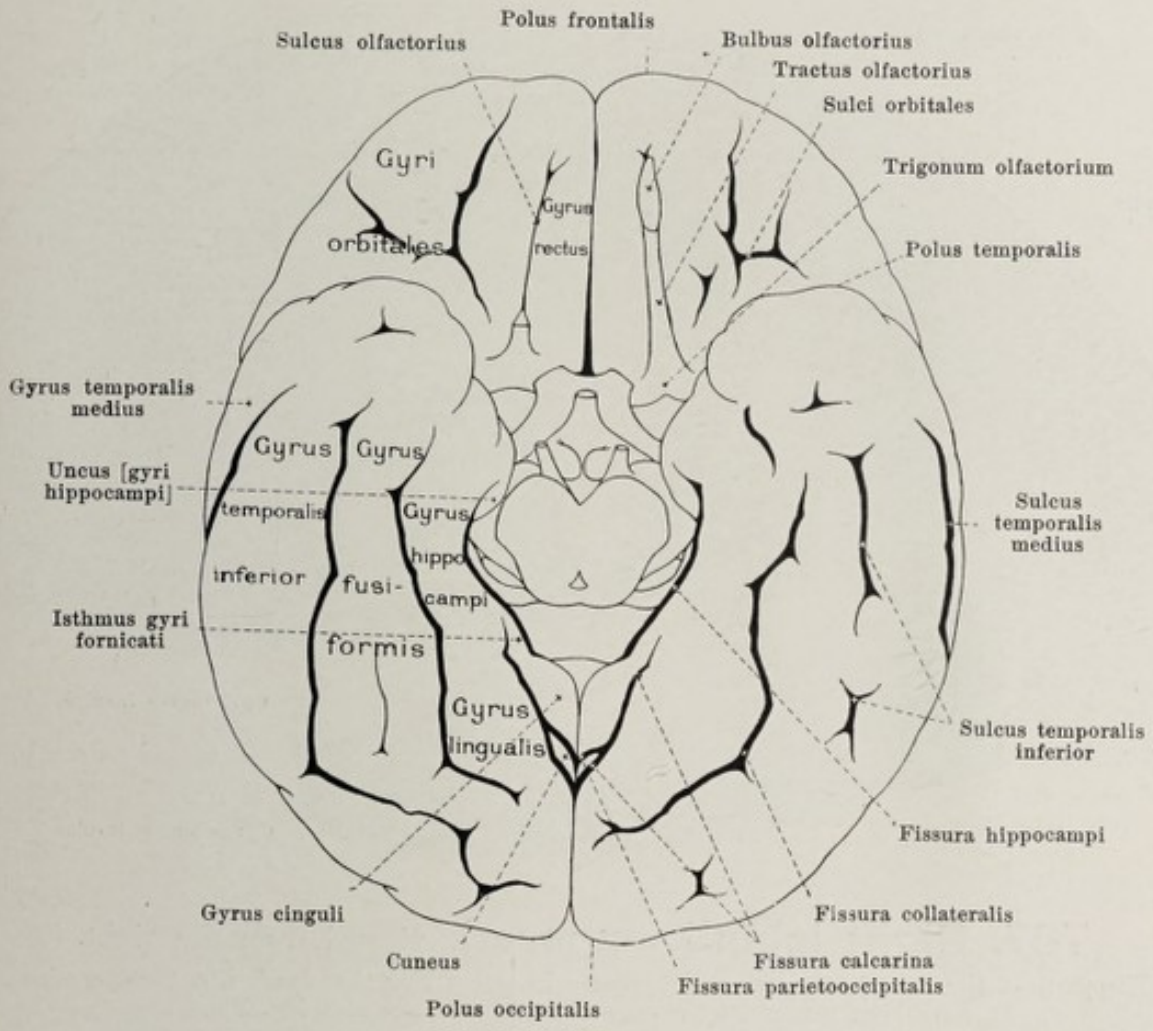


765. Base of cerebrum *(basis cerebri)*, viewed from below.

(The rhombencephalon has been cut off transversely, just above the pons. The hypophysis and the right tractus olfactorius have been removed.)

Pallium (continued).

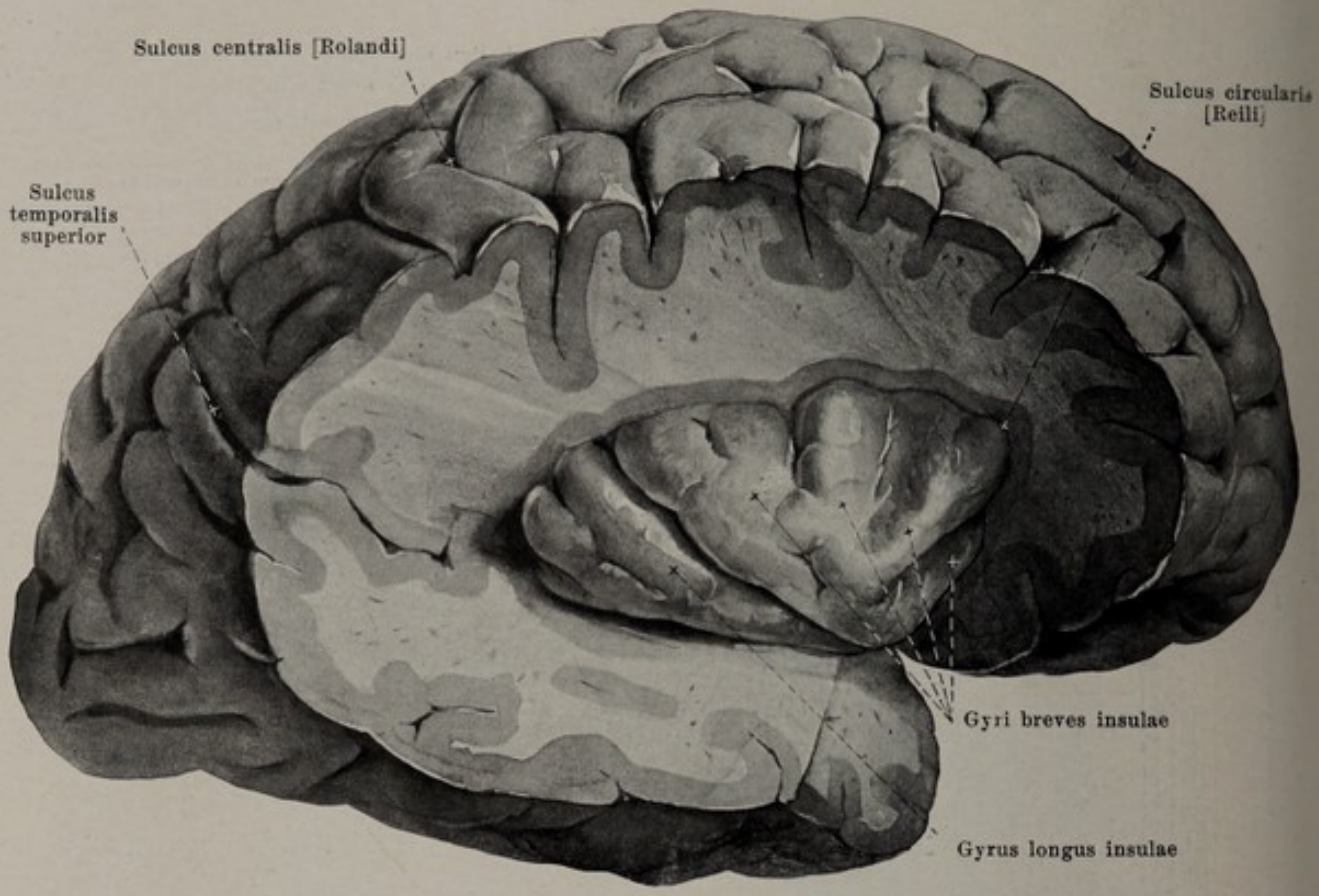
Behind the gyrus centralis anterior, the *sulcus centralis [Rolandi]* (O. T. fissure of Rolando) (see Figs. 759—764) passes obliquely upward and backward, usually as far as the medial surface. On the inferior, basal surface, the *sulci orbitales* and the *sulcus olfactorius* are to be seen; they separate the *gyri orbitales* and the *gyrus rectus* from one another.



766. Base of the cerebrum *(basis cerebri)*,

viewed from below, partly schematic. (See text to Fig. 765.)

Pallium (continued) (see also Figs. 759—765). In the parietal lobe, on the convex surface, the *gyrus centralis posterior* is bounded behind by the *sulcus interparietalis*, which also separates the *lobulus parietalis superior* from the *lobulus parietalis inferior;* in the latter, the curved gyrus surrounding the end of the fissura cerebri lateralis is called the *gyrus supramarginalis*, and the gyrus encompassing the end of the sulcus temporalis superior, the *gyrus angularis*. The *occipital lobe* is divided, on its convex surface, by the *sulcus occipitalis transversus*, as well as by the *sulci occipitales anterior, laterales, superiores* into the *gyri occipitales laterales et superiores*. In the *temporal lobe*, the *sulci temporales transversi* (see Fig. 768) divide the surface, which is turned partly toward the island, into the *gyri temporales transversi:* on the convex and basal surfaces are to be seen the *sulci temporales superior, medius* and *inferior*, situated beneath, or medianward from the *gyri temporales superior, medius* and *inferior;* next to the latter, on the basal surface, is the *gyrus fusiformis*, then the *fissura collateralis*, and then, behind, the *gyrus lingualis*, in front, the *gyrus hippocampi* (see below). On the *facies medialis hemisphaerii* (see Figs. 761 and 762) the *sulcus corporis callosi* runs just above the corpus callosum and goes over behind into the *fissura hippocampi*, which is situated between the gyrus hippocampi and the fascia dentata. Along these two sulci runs the *gyrus fornicatus*, which is divisible into an upper part, *gyrus cinguli*, a lower part, *gyrus hippocampi* with the *uncus [gyri hippocampi]* (see also Figs. 774 and 775 and p. 674), and an intermediate portion, *isthmus gyri fornicati*. By means of the rhinencephalon, which connects through the area parolfactoria with the gyrus cinguli (see also Fig. 749) and through the substantia perforata anterior with the gyrus hippocampi, the two ends of the gyrus fornicatus are united to form a closed ring. The gyrus cinguli is bounded by the *sulcus cinguli*, which in its *pars subfrontalis* belongs to the anterior inferior part of the frontal lobe, and in its *pars marginalis* turns up behind the medial end of the sulcus centralis to the convex surface of the hemisphere.



767. Right island, exposed, viewed from the right.

(The parts of the frontal, parietal, and temporal lobes covering the island, *i. e.* the operculum, have been removed by a cone-like section. See also Fig. 759.)

Pallium (continued). Following upon the sulcus cinguli (see Figs. 761 and 762) can be seen, in front, the gyrus frontalis superior and behind it, as far as the ramus marginalis of the sulcus cinguli, the *lobulus paracentralis;* behind this, again, lies the *praecuneus,* which is bounded, below by the *sulcus subparietalis,* and behind by the *fissura parietooccipitalis;* behind this fissure, extending as far as the *fissura calcarina,* is the *cuneus.*

If the margins of the fissura cerebri lateralis [Sylvii] (see p. 661) be drawn apart, a deep fossa becomes visible, the *fossa cerebri lateralis [Sylvii];* its floor is formed by a special lobe of the cerebral hemisphere, the *island (insula)* (see also Figs. 768 and 769). During embryonic life this is exposed, but later it becomes overlapped in front and above by part of the frontal lobe, behind and above by a part of the parietal lobe, and below by a part of the temporal lobe. These parts of the hemisphere, which hide the island completely, are spoken of, together as the *operculum (lid);* it is divisible into a *pars frontalis,* a *pars parietalis* and a *pars temporalis.* The surface of the island is convex lateralward; it is divided by a crest, gradually rising from behind forward, into an upper lateral, a lower lateral and an anterior surface; a narrow, inferior surface (see Fig. 749) lies approximately horizontal and goes over medianward into the limen insulae (see p. 665). At the junction of the surface of the island with that of the operculum, running between the two, is a slit-like groove, *sulcus circularis [Reili];* it is lacking only at the limen insulae. On the surface of the island are a number of gyri, *gyri insulae.* A deep sulcus running from in front and below, backward and upward, separates a larger, anterior portion of the island from a smaller, posterior portion; in the anterior portion several *gyri breves insulae* can be seen diverging from the apex of the crest; in the posterior, there is a simple, long, arched gyrus, *gyrus longus insulae.*

The ***rhinencephalon*** *(olfactory brain)* (see Figs. 744—749, 761 and 762) is relatively feebly developed in human beings. It belongs chiefly to the base of the brain, but in part helps also to form the medial surface of the cerebrum, where it is separated, by a short, curved sulcus, *sulcus parolfactorius anterior* (see Figs. 748, 761 and 762), from the gyrus frontalis superior and the gyrus cinguli. On embryological grounds a *pars anterior [rhinencephali]* and a *pars posterior [rhinencephali]* can be distinguished.

The pars anterior rhinencephali (see Figs. 749, 758, 765 and 766) at the base of the brain, is formed by the *lobus olfactorius (olfactory lobe)* which, on each side, on the inferior surface of the frontal lobe passes backward and somewhat lateralward to the brain-stem; at its largest anterior part it lies very close to the sulcus olfactorius. It presents, in front, an oval, gray enlargement, *bulbus olfactorius*, which lies upon the lamina cribrosa of the ethmoid bone, and into which the nn. olfactorii enter; connected with the bulb is a whitish, triangular, prismatic band, *tractus olfactorius*, which broadens somewhat behind and goes over into a gray ridge, running transversely and at right angles to it, the *trigonum olfactorium* (see Fig. 749). This is sharply marked off behind from the substantia perforata anterior and presents on its inferior surface three whitish bands of fibres which begin at the tractus and disappear at the anterior boundary of the substantia perforata anterior: the *stria lateralis*, the longest, passes in a curve backward and lateral, the *stria medialis* goes backward and somewhat medial, while the *stria intermedia*, occasionally present between these two, runs almost straight backward. Running out lateralward and somewhat backward from the trigonum, along the substantia perforata anterior, to the gyrus hippocampi is a gyrus which is directly connected lateralward with the island (see p. 664) and is therefore called in that situation the *limen insulae (threshold of the island)*. Medianward, the trigonum goes over into a gyrus, the *area parolfactoria [Brocae]* (see Figs. 748, 749, 761 and 762), which belongs to the medial surface of the cerebrum; it is bounded in front by the sulcus parolfactorius anterior (see p. 664) and is separated behind from the gyrus subcallosus by the deep *sulcus parolfactorius posterior*.

The pars posterior rhinencephali includes, at the base of the brain, the *substantia perforata anterior* (see Fig. 749), thus named on account of the numerous perforations in it, in front particularly, for blood vessels, lies directly behind the trigonum olfactorium; it is an approximately quadrangular, gray area; laterally it adjoins the uncus, medially and behind, the tractus opticus; medially and in front, it goes over into a whitish ridge, *gyrus subcallosus [pedunculus corporis callosi]*, which passes above the chiasma opticum to the medial surface of the cerebrum, runs upward in front of the commissura anterior and the lamina rostralis (see Figs. 748, 749, 761 and 762) and, tapering out, becomes fused with the rostrum corporis callosi (see also p. 668).

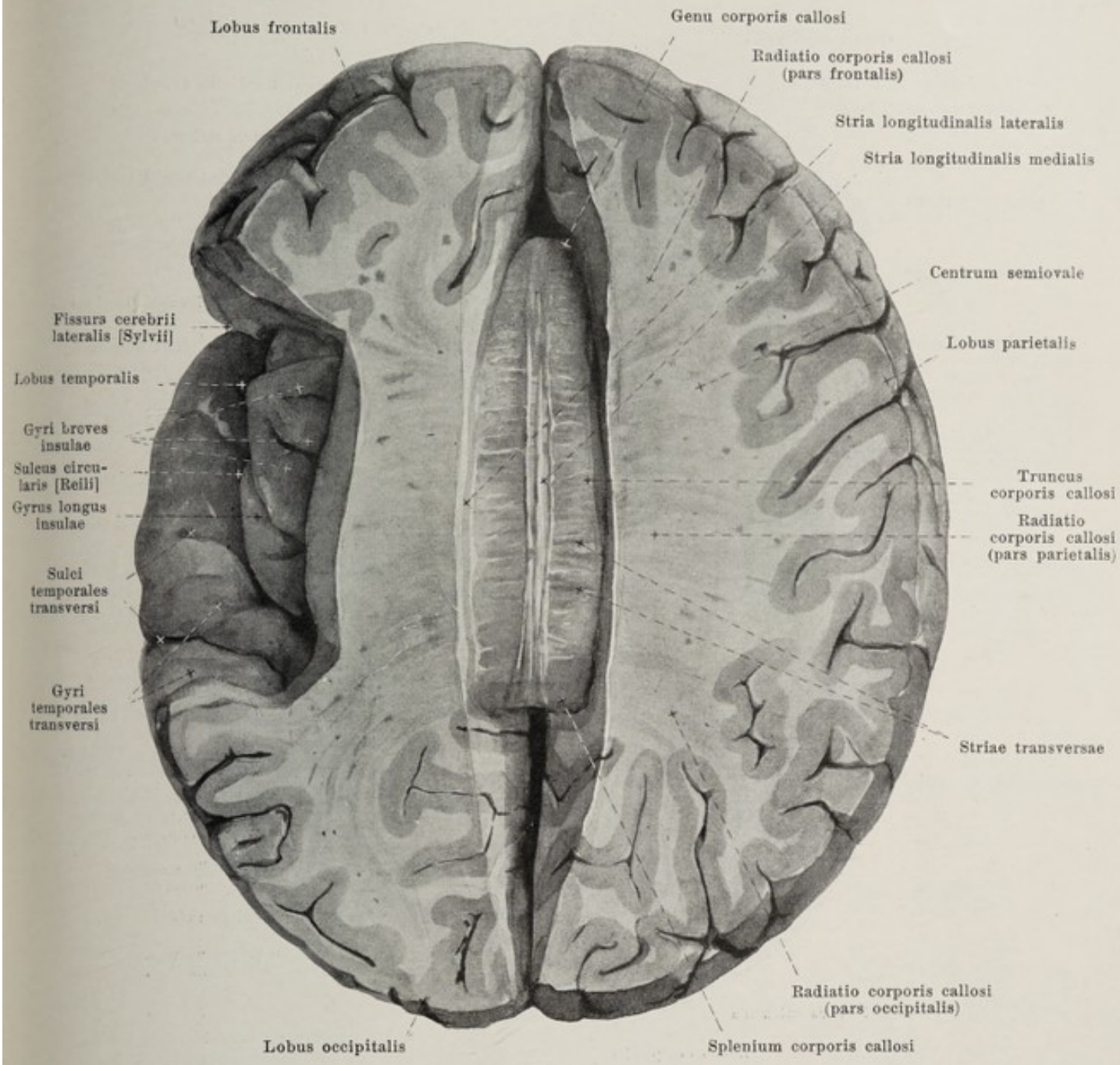
The other portions of the brain, situated at the base in front of the substantia perforata posterior (see Figs. 744—748, 749, 758 and 765), belong to the ***hypothalamus.*** In it, two parts are to be distinguished; its posterior part, *pars mamillaris*, which is formed by the corpora mamillaria, belongs to the diencephalon; its anterior part, *pars optica*, which includes the other parts, belongs to the telencephalon. Just in front of the substantia perforata posterior (see p. 656) project the *corpora mamillaria*, two white, pear-shaped elevations which are crowded close against one another at their thick, medial extremities. In front of them rises an unpaired, gray hillok, *tuber cinerum*, which, in front, tapers off like a cone to form the *infundibulum (funnel)* (see Figs. 748 and 765). Hanging on the latter, as though on a stem, is an egg-shaped gray mass, about the size of a bean, the *hypophysis (pituitary body)* (see Figs. 748 and 758), the largest diameter of which is placed frontally. It is situated in the fossa hypophyseos of the sella turcica, and on section is seen to consist of two parts, a larger anterior, *lobus anterior*, which embryologically, does not belong to the brain (it is developed from the Rathke's pouch of the primitive oral cavity), but only lies in contact with it, and a smaller posterior, *lobus posterior*, which alone is directly continuous with the infundibulum; between both of these lies the small *intermediate lobe*. Directly attached to the tuber cinereum in front and lateralward is the posterior margin of the unpaired *chiasma opticum*, a white, thick, quadrangular plate, with concave margins, situated somewhat behind the sulcus chiasmatis of the sphenoid bone; at its two anterior corners, it receives the nn. optici; from its two posterior corners go off the two *tractus optici*. Passing upward from the upper anterior surface of the chiasm, is a thin layer, *lamina terminalis* (see Figs. 748 and 749), which is in contact above with the anterior surface of the commissura anterior [cerebri] and then goes over into the lamina rostralis; it forms a part of the anterior wall of the third ventricle.

The *tractus opticus* (see Figs. 749, 750, 758 and 765), a flattened band fused with the subjacent tissue, runs at the posterior margin of the lamina perforata anterior, at first along the tuber cinereum; turning then lateralward and backward approximately at right angle to the direction of the pedunculus cerebri, it goes around the latter in the form of an arch, adjoining the gyrus hippocampi lateralward and below, and finally divides into two limbs which form the transition to the ***metathalamus*** (see p. 646). The narrower, medial limb, *radix medialis*, passes into the gray *corpus geniculatum mediale (medial geniculate body)* (see Figs. 750 and 757), an oblong, oval enlargement, situated at the anterior end of the sulcus lateralis mesencephali and of the brachium quadrigeminum inferius (see p. 655), bounded medianward by the brachium quadrigeminum superius as well as by the overhanging pulvinar and separated by a deep groove from the corpus geniculatum laterale. The thicker and shorter, lateral limb, *radix lateralis*, passes to the grayish-white *corpus geniculatum laterale (lateral geniculate*

body), an oblong body projecting only a little from the posterior inferior surface of the thalamus, lateral from the pulvinar.

Just in front of the geniculate bodies and corpora quadrigemina, on each side, lies the ***thalamus*** (see Figs. 748, 750, 757, 770, 773, 798 and 801), which first becomes visible after removal of the corpus callosum, fornix and choroid plexus. It is a large ganglionic mass of approximately oval shape, broadening behind. Only its upper and medial surfaces are free, its lateral and its narrow, inferior surfaces are fused with neighboring parts. The upper approximately triangular surface, covered by a layer of white matter *(stratum zonale)*, lies approximately horizontally and is curved so as to be slightly convex in the frontal direction, markedly convex in the sagittal direction. In front it presents an oval enlargement, *tuberculum anterius thalami;* behind it goes over into a ridge, protruding dorsalward, the medial portion of which, the *pulvinar*, projects for a greater or less distance over the superior quadrigeminal arm and the medial geniculate body, and the lateral portion of which contains the lateral geniculate body (see p. 665). The medial gray surface forms approximately a right angle with the superior surface, is placed sagittally and separated from that of the opposite side only by the third ventricle; below, it is separated from the ventricular surface of the hypothalamus by a shallow groove, *sulcus hypothalamicus [Monroi]* (see Fig. 748), which runs, curved somewhat like the letter S, from the foramen interventriculare to the aditus ad aquaeductum cerebri. Stretching out between the two thalami, somewhat in front of their middle, is a gray bridge, *massa intermedia*, very variable in thickness and form. At the junction of the medial and superior surfaces, runs a band of white matter, *stria medullaris*, which is situated somewhat deeper behind than in front; this gradually broadens behind to form a nearly horizontal, triangular area, *trigonum habenulae*. The stria, at its sharpened margin, is directly continuous with the epithelial lamella, *lamina chorioidea epithelialis*, which covers the *tela chorioidea ventriculi tertii* (see p. 674) below, and which, on being removed at its attachment, leaves behind a fine jagged edge, *taenia thalami;* behind, the taenia, corresponding to the region of departure of the epithelial lamella (vide infra), turns to the upper surface of the habenula and of the corpus pineale to go over at the latter place into that of the opposite side. Running out medianward from the trigonum habenulae is a white band of fibres, *habenula* (see Fig. 770); in its anterior part, it is continuous with that of the opposite side, thus forming the *commissura habenularum;* behind, on the contrary, it goes over into the *corpus pineale* (O. T. pineal gland). The latter (see Figs. 748, 757 and 770) forms a grayish-red, flattened, „pine-cone"-shaped body, usually nodular on the surface and variable in size; it is narrowed somewhat in front and lies in the groove between the two superior colliculi. The pineal body, the habenula and the trigonum habenulae belong to the ***epithalamus*** (see p. 646).

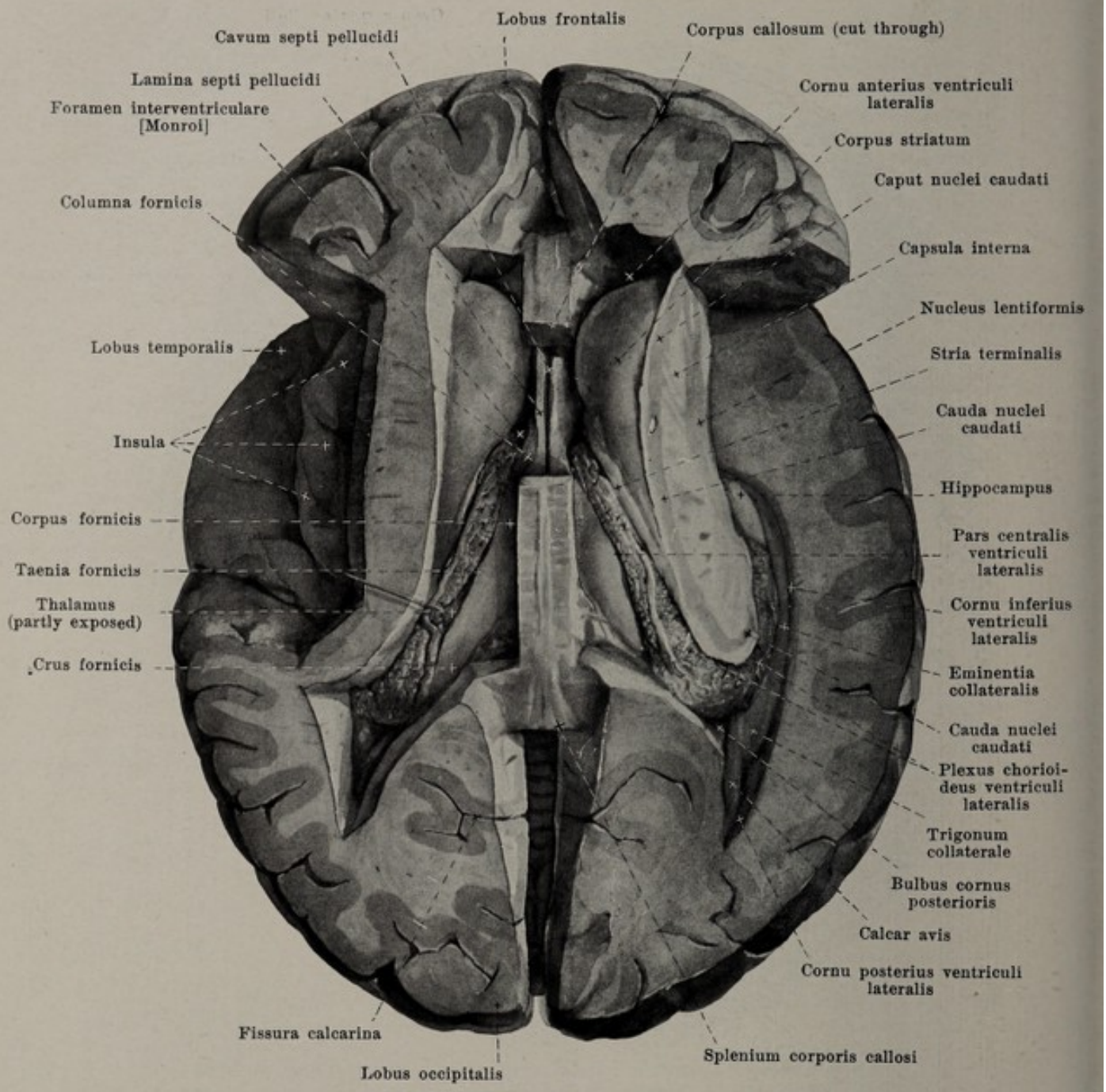
The ***third ventricle*** *(ventriculus tertius)* (see Figs. 748, 770, 773, 798 and 801) is an unpaired, median, slit-like space which is bounded on each side by the medial surface of the thalamus and of the hypothalamus; in that situation are to be seen the massa intermedia and the sulcus hypothalamicus (see above). The posterior wall is formed above by the corpus pineale, which is penetrated in front by a short slit, *recessus pinealis;* just beneath it runs the *commissura posterior [cerebri]*, a white band of fibres which bends around in a transverse direction and bulges into the cavity of the third ventricle; its fibres run partly caudalward to the tegmentum and to the fasciculus longitudinalis medialis, partly through the region of the thalamus lateralward, partly in an unknown direction. It bounds above the *aditus ad aquaeductum cerebri*, a three-sided funnel-shaped opening leading to the fourth ventricle. The narrow inferior wall is bounded behind by the diverging cerebral peduncles and presents two small elevations due to the corpora mamillaria; in front of them it is formed by the thin wall of the tuber cinereum; it becomes narrowed behind the chiasma opticum to form the funnel-like *recessus infundibuli*, from which a fine slit passes into the infundibulum. In front of the chiasma opticum, which projects into the cavity, is situated the *recessus opticus*, bounded in front by the thin *lamina terminalis*. This lamina forms the anterior wall; behind it above lies the *commissura anterior [cerebri]*, a thick band of white fibres which unites the two cerebral hemnispheres with one another and which is visible here, for a short distance, on the surface, but, otherwise, lies hidden in the substance of the brain. Lateral behind this commissure the columnae fornicis (see p. 670) form a part of the lateral wall of the ventricle and, converging, run upward; in this way, with the commissure, they surround the *recessus triangularis* (see Fig. 770). Above, the ventricle is closed by the *lamina chorioidea epithelialis* (vide supra) which is to be regarded as a thin portion of the brain wall, arrested in development. In front, on both sides, this is continued in its greatest extent through the taenia thalami into the stria medullaris, but it is fastened behind to the upper surface of the habenula and of the corpus pineale, and hence forms the upper boundary of the *recessus suprapinealis*, a blind-sac like cavity situated above the corpus pineale; in front it goes over into the posterior surface of the columna fornicis (see Fig. 748) and forms the upper boundary of the *foramen interventriculare [Monroi]*, which is bounded in front by the columnae fornicis, behind by the thalami, and connects the lateral ventricles with each other and with the third ventricle.



768. Corpus callosum, exposed, viewed from above.

(The upper part of the cerebral hemispheres has been removed by a horizontal cut; small pieces in front and behind have been removed by wedge-shaped cuts. On the left side a portion of the hemisphere has been cut away to expose the island.)

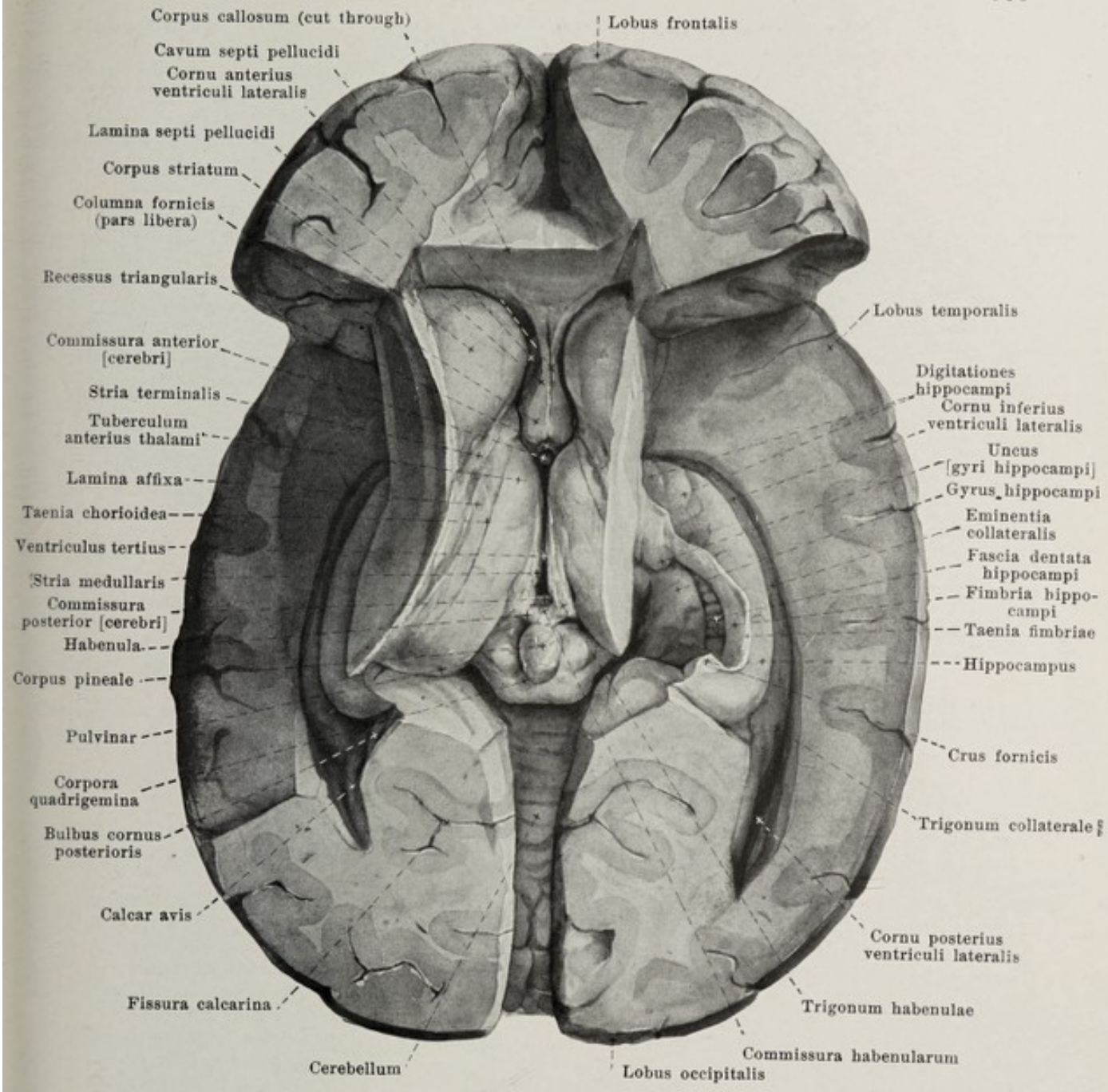
The ***corpus callosum*** (see also Figs. 748, 761, 769—773, 798 and 801) is a large mass of white fibres which unites the two cerebral hemispheres to each other. Only a smaller, medial portion of the mass lies free in the depth of the fissura longitudinalis cerebri; by far the larger part is concealed in the substance of the hemispheres into which it radiates. It begins in front of and above the commissura anterior (see Figs. 748 and 749), in direct contact with the lamina terminalis, by a short, thin layer, *lamina rostralis*, which runs, in a curve, upward and forward; it then thickens suddenly to form the *rostrum corporis callosi*, extends forward and then bends sharply backward, as the *genu corporis callosi*, to pass backward as the arched *truncus corporis callosi* until over the corpora quadrigemina, where it ends in a thickened margin, *splenium corporis callosi* (see also Fig. 765).



769. Lateral ventricle, opened, viewed from above.

(As in Fig. 768. In addition, the corpus callosum, with the exception of a narrow remnant, has been removed; besides, the posterior horn has been opened on both sides, and, on the right side, the inferior horn has been fully exposed by cutting away the island and the upper part of the temporal lobe.)

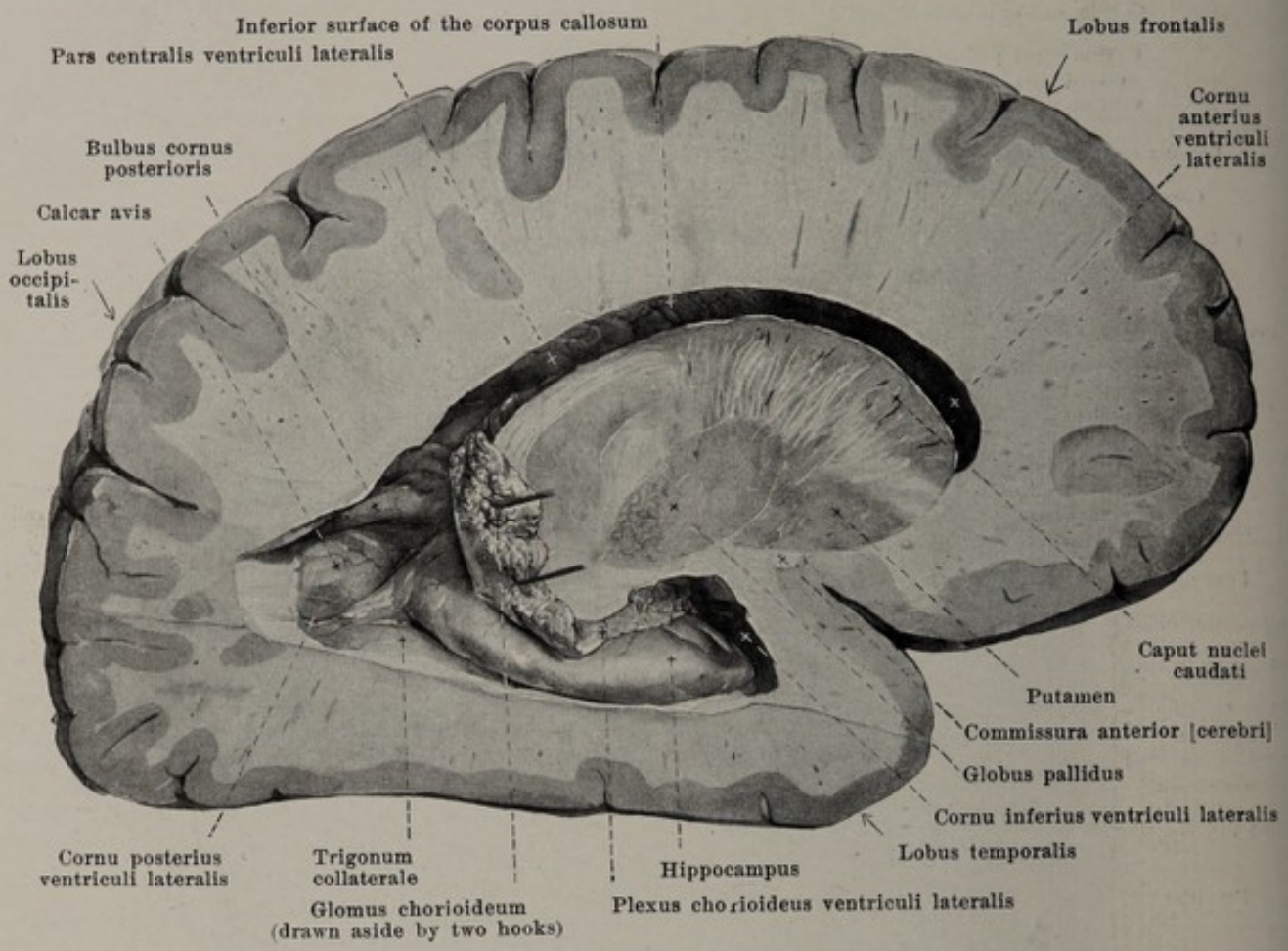
Corpus callosum (continued) (see also Figs. 768 and 773). The surface shows transverse bands, *striae transversae*, due to the fibre bundles. In addition, a delicate, variable, longitudinal band, *stria longitudinalis medialis*, runs, on each side, close to the median plane. This bends around, in front, upon the rostrum and unites with the gyrus subcallosus; behind, it goes over into the *fasciola cinerea* (see Fig. 761), a strip of gray matter which lies directly in contact with the splenium corporis callosi, below and lateralward, and is continued, below and in front, partly into the fascia dentata hippocampi, partly runs pointed between the fascia dentata and the fimbria hippocampi. A second, still more delicate and more irregular longitudinal band, *stria longitudinalis lateralis*, lies lateralward on the surface of the corpus callosum, in the depth of the sulcus corporis callosi.



770. Third ventricle, opened, viewed from above.

(Same as in Fig. 769. In addition, the corpus callosum and a large part of the fornix have been removed. On the left side the inferior horn has been opened. On the right side more of the basal ganglia has been cut away, so as to expose completely the hippocampus and its neighborhood.)

Beneath the corpus callosum lies the ***fornix*** (see also Figs. 748, 761, 769, 773, 798, 799 and 801). It consists of two white strips, a right and a left one, often not entirely symmetrical, each being curved almost in the form of a spiral. These run separately in the most anterior part *(columnae fornicis)*, are closely approximated in their middle portion to the unpaired *corpus fornicis*, which is joined above to the under surface of the corpus callosum; behind they again become separated *(crura fornicis)*, and as they diverge, they pass to the inferior horns of the lateral ventricles, there becoming continuous in the main with the *fimbria hippocampi* (see p. 674). In the triangular space, bounded by the lamina rostralis, rostrum, genu and truncus corporis callosi on the one side, and by the uppermost part of the columnae and of the corpus fornicis on the other side (see Figs. 748 and 761), the *septum pellucidum* is stretched out as a partition between the anterior cornua of the lateral ventricles; it consists (see also Figs. 769, 799 and 800) of two thin layers, *laminae septi pellucidi*, which enclose a narrow, median slit, *cavum septi pellucidi*, closed on all sides.

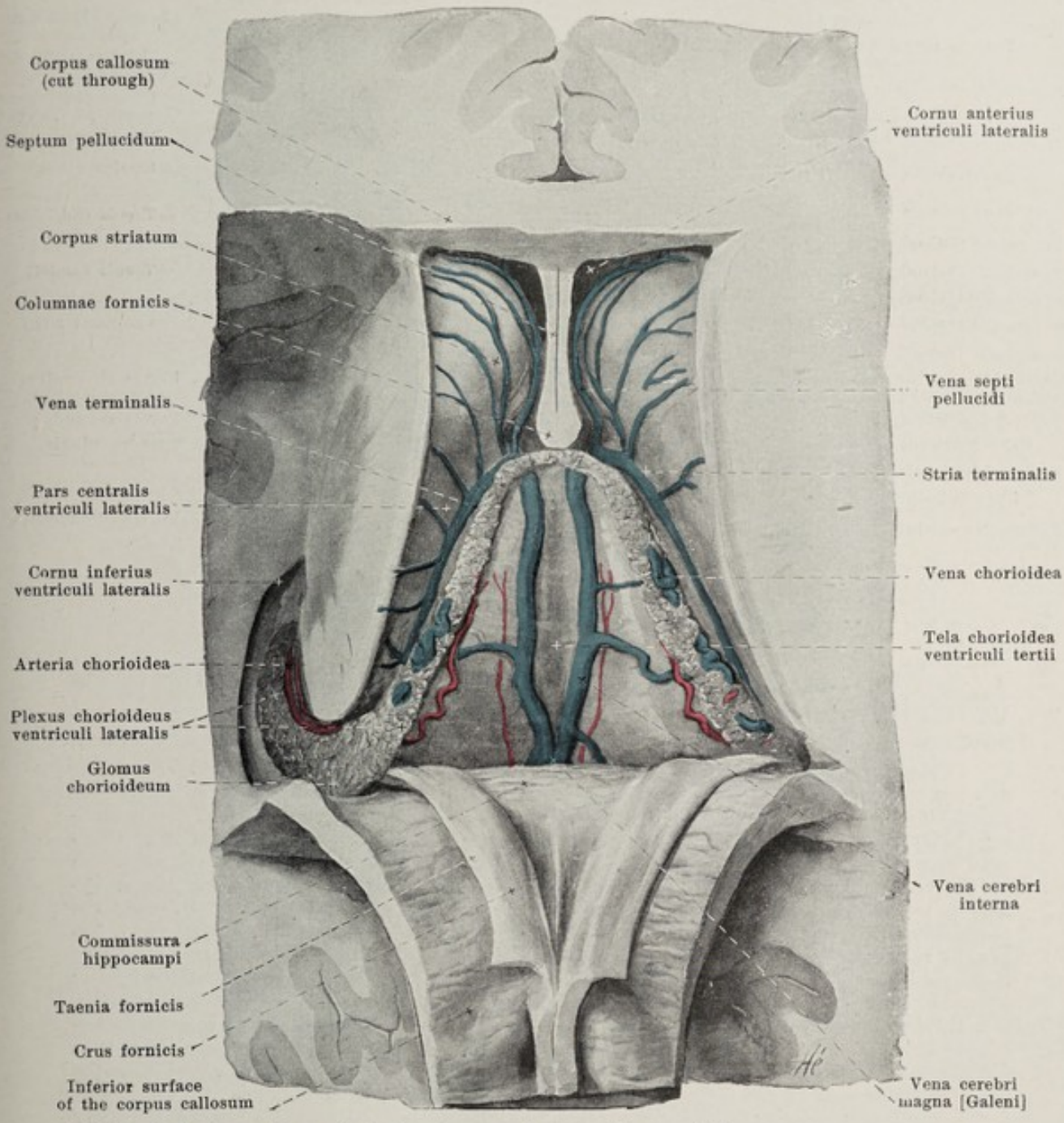


771. Right lateral ventricle, opened, viewed from the right.

(The largest part of the right hemisphere has been removed by two approximately sagittal cuts.)

Fornix (continued) (see Figs. 748, 761, 769, 770, 773, 798, 799 and 801). The *columna fornicis* (bilateral) is a cylindrical bundle of medullated fibres; hidden in the hypothalamus it extends forward and upward from the corpus mamillare as the *pars tecta columnae fornicis*, emerges in part from the lateral wall of the 3rd ventricle just behind the commissura anterior and runs upward and somewhat medianward as the *pars libera columnae fornicis*, soon fusing completely with its fellow of the opposite side; the pars libera forms the anterior boundary of the foramen interventriculare [Monroi] (see p. 666). The *corpus fornicis* reaches from the region of the foramen interventriculare backward and somewhat upward as far as the middle of the thalamus; in this course it is separated from the roof of the 3rd ventricle and from the upper surfaces of the thalami by the tela chorioidea ventriculi tertii. It is fused behind with the inferior surface of the corpus callosum; in front it is united with that body by the septum pellucidum. The inferior surface presents a groove-like depression in the middle. Each half is rather rounded in cross-section in front, more triangular behind, and is drawn out laterally into a fine edge, *taenia fornicis*, from which the lamina epithelialis of the plexus chorioideus ventriculi lateralis extends out; the two taeniae fornicis become continuous with each other in front, over the foramen interventriculare. The *crus fornicis* is markedly flattened and directly attached to the inferior surface of the corpus callosum; it runs obliquely backward, lateralward and downward on each side, over the pulvinar, to the inferior horn (see p. 669). The two crura fornicis bound a triangular area, which is closed behind by the splenium corporis callosi, and the floor of which is formed by the inferior surface of the corpus callosum (see Fig. 772); the transverse fibres visible in this area form the *commissura hippocampi*.

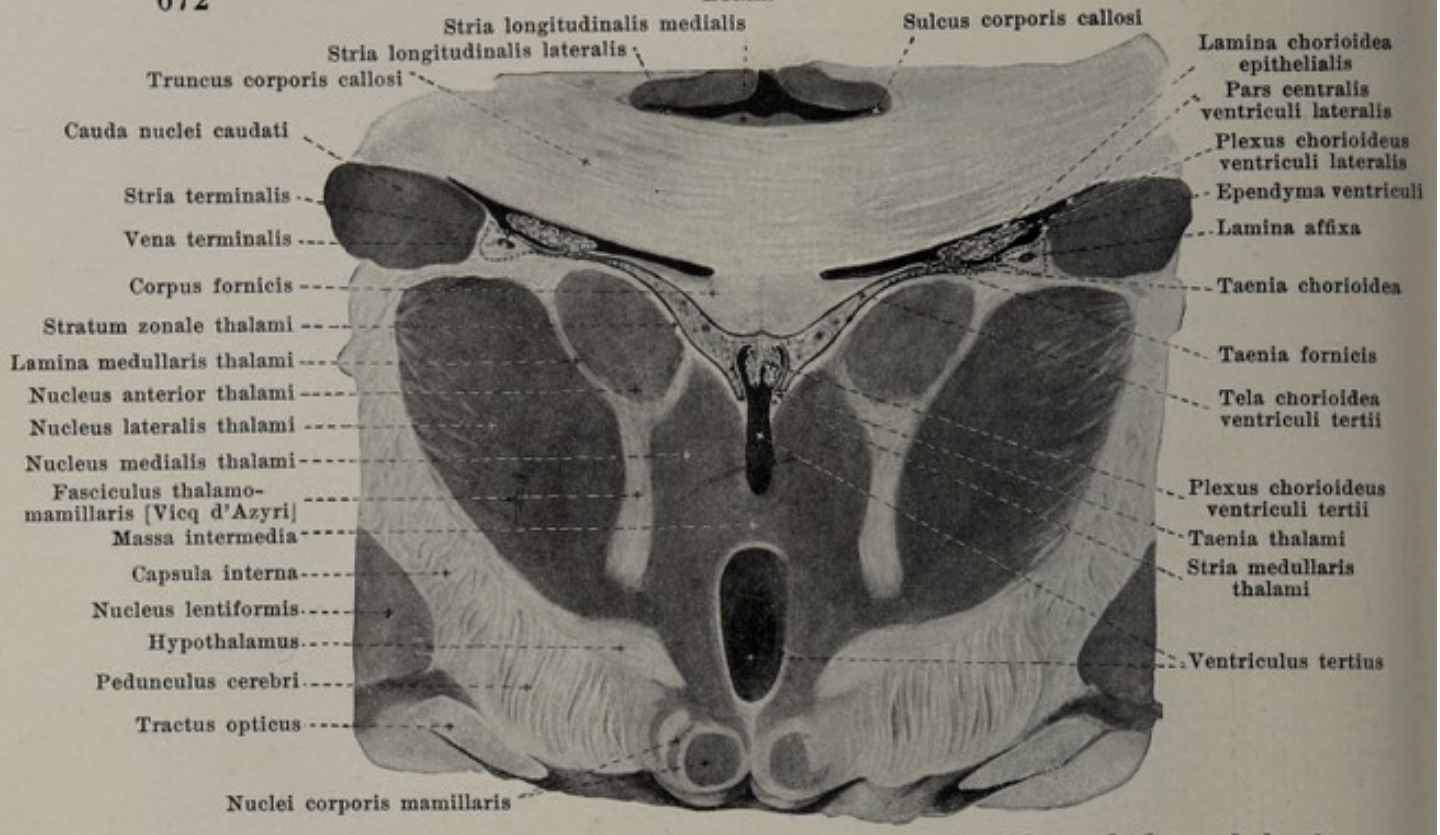
The ***ventriculus lateralis*** *(lateral ventricle)* (see also Figs. 769 and 772—774) is the paired cavity which is situated symmetrically within each cerebral hemisphere; it is connected by the foramen interventriculare [Monroi] with the 3rd ventricle and through this indirectly also with the lateral ventricle of the other side, but is otherwise completely closed; it contains a small amount of liquor cerebrospinalis.



772. Tela chorioidea ventriculi tertii, laid bare from above.

(The specimen has been prepared in a similar way to that in Fig. 769, except that the corpus callosum, along with the fornix, has been cut through and reflected backward. The tela chorioidea ventriculi lateralis has been removed at the taenia fornicis.)

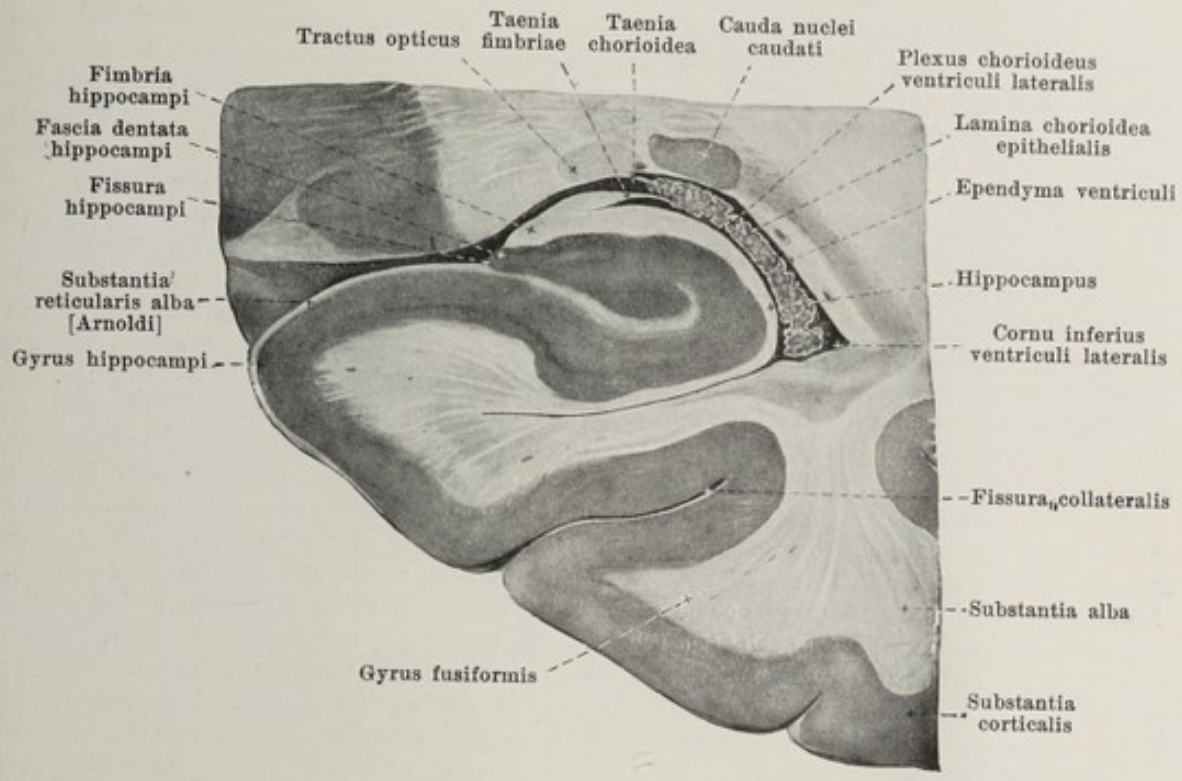
Ventriculus lateralis (continued) (see also Figs. 769, 771, 773 and 774). It resembles on each side, in the main, a horse-shoe, open in front (see Fig. 771), the upper end of which, *cornu anterius,* lies in the frontal lobe and the lower end of which, *cornu inferius,* lies in the temporal lobe; from the posterior convexity, a short process, *cornu posterius,* projects into the occipital lobe; the part between the foramen interventriculare and the cornu posterius is called the *pars centralis.* The lateral ventricle is partly bounded by the gray *corpus striatum (striate body)* (see p. 690), of which the anterior, flask-like, thickened end forms the lateral inferior wall of the cornu anterius; by means of its long, narrow, posterior part it extends through the pars centralis and, thence, markedly curved, into the roof of the cornu inferius. This free surface belongs to that part of the corpus striatum, known as *nucleus caudatus (tailed nucleus)* and has a corresponding form; its anterior portion is called *caput nuclei caudati,* its posterior and lower portion, *cauda nuclei caudati.*



773. Frontal section through the middle of the third ventricle. Magnification: 2:1. (The relations of the chorioid plexus are somewhat schematically represented; the origin of the lamina affixa is indicated by the dotted lines.)

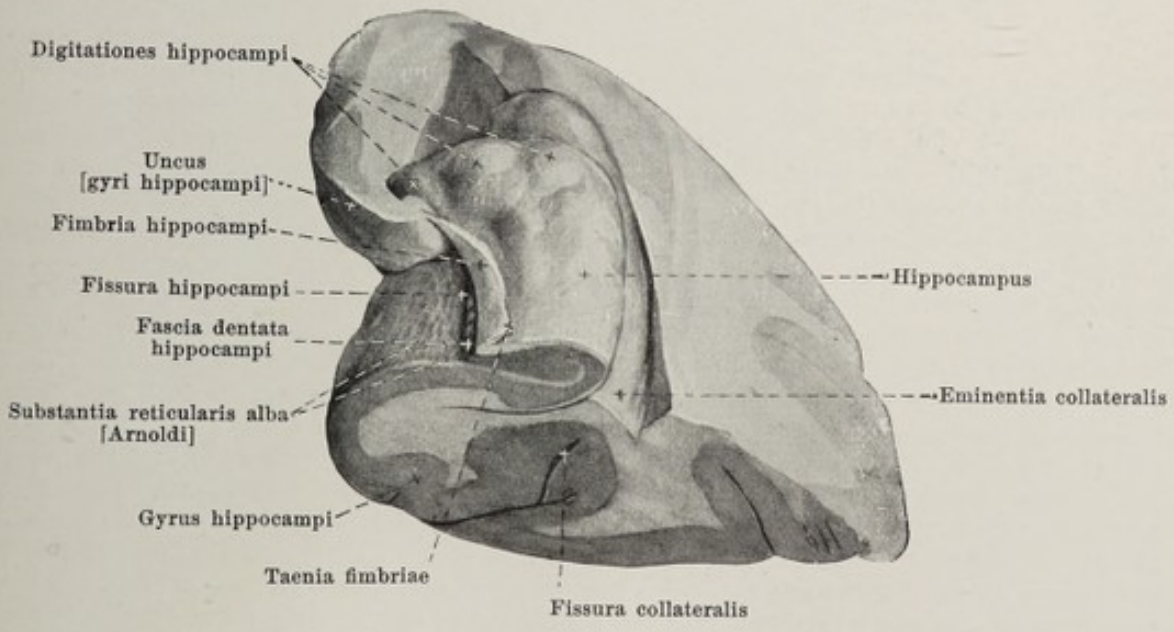
Ventriculus lateralis (continued) (see also Figs. 769, 771, 772 and 774). The anterior part of the nucleus caudatus rises above the thalamus in front; the middle part runs parallel to its lateral margin. In the latter situation, the *stria terminalis* (O. T. taenia semicircularis) runs on the surface between the two, from the region of the foramen interventriculare as far as the inferior horn; it contains a band of medullated fibres and is colored bluish by the v. terminalis which partly covers it. The layer of substance which covers the v. terminalis is continued as a thin layer, *lamina affixa* (see also Figs. 757 and 770), upon the neighboring part of the thalamus and is originally not fused to the thalamus, so that the v. terminalis runs extraventricularly; but it fuses already in the embryo with the thalamus; it at first increases in breadth from before backward, but further on decreases: it is absent in the inferior horn. It is directly continuous with the epithelium of the plexus chorioideus ventriculi lateralis, i. e. the *lamina chorioidea epithelialis*, and on removal of the choroid plexus is seen to terminate in a delicate, torn margin, *taenia chorioidea;* the latter, in the inferior horn, runs directly medianward from the cauda nuclei caudati, is connected at its anterior end with the taenia fimbriae and at the foramen interventriculare with the taenia thalami.

The *cornu anterius (anterior horn)* (see also Figs. 798—801) resembles a part of the cavity of a bowl, convex forward, upward and medianward; the arch of the bowl is formed by the most anterior part of the corpus striatum (see also p. 671). Above in front, and below, it is bounded by the radiations of the knee of the corpus callosum, medianly by the septum pellucidum, laterally by the caput nuclei caudati. The *pars centralis* is an approximately horizontal slit, the roof of which is formed by the inferior surface of the truncus corporis callosi; its inferior surface (see also Fig. 769) is composed of the middle, narrow part of the nucleus caudatus, the stria terminalis, the lamina affixa, the lamina chorioidea epithelialis of the plexus chorioideus ventriculi lateralis, as well as the upper surface of the corpus and crura fornicis. The *cornu posterius (posterior horn)* is a curved slit of variable length, convex lateralward in the horizontal direction, which curves in a hook-like fashion around the deep fissura parietooccipitalis, so that its posterior extremity is turned medianward. Its lateral, superior, limiting surface is formed by that part of the radiation of the corpus callosum known as the *tapetum*. Two variable longitudinal ridges run out backward upon its medial surface from the end of the pars centralis (see Figs. 769—771 and 801). The inferior, thicker ridge, *calcar avis*, corresponds to the anterior part of the fissura calcarina, which here shoves the thin wall of the hemisphere into the ventricle. The superior, irregular ridge, *bulbus cornus posterioris*, is a thickening of the hemispheric wall and is formed by fibres of the corpus callosum.



774. Frontal section through the inferior horn of the right lateral ventricle, viewed from behind. Magnific.: 2:1.

(The choroid plexus is somewhat schematically represented.)

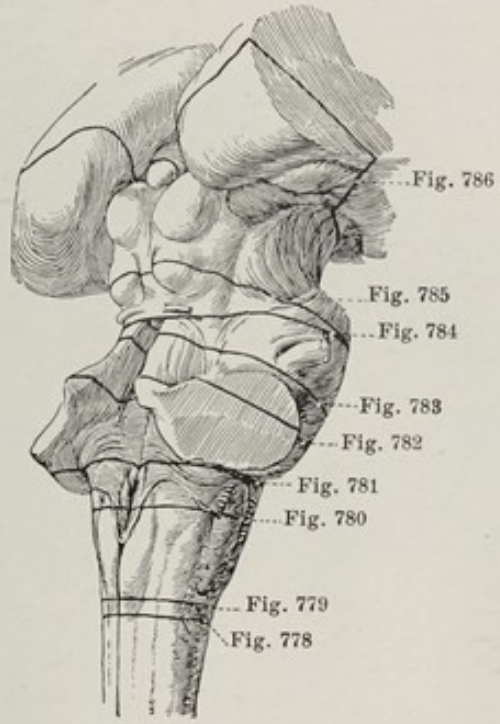


775. Inferior horn of the right lateral ventricle, anterior half, viewed from above and behind.

(The temporal lobe has been removed by a frontal section and the roof of the inferior horn afterwards cut away. See also Figs. 770, 771 and 774.)

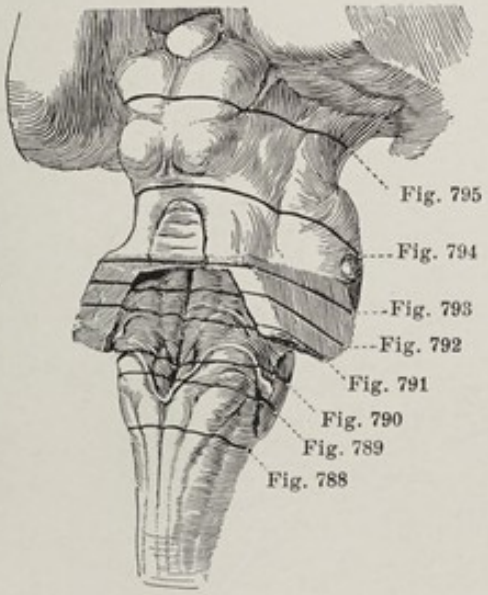
Ventriculus lateralis (continued) (see Figs. 769—775). The *cornu inferius (inferior horn)* is a curved slit which passes forward along the medial margin of the temporal lobe but does not reach its apex. Its narrow, inferior wall is developed behind from a feebly arched triangular area, *trigonum collaterale*, which is situated between the calcar avis and the hippocampus and extends also into the beginning of the posterior horn; it is sometimes elevated in the form of a longitudinal ridge *(eminentia collateralis)*, due to the bulging in of the wall of the hemisphere by the fissura collateralis. The lateral and superior wall is the immediate continuation of the similar surface of the posterior horn and is formed in the same way (see p. 672), but medianward it contains in addition the lowermost end of the cauda nuclei caudati. The medial wall is formed by a thick, white, longitudinal ridge, *hippocampus*, curved, like a sickle, which begins gradually behind at the end of the pars centralis and ends in front, expanded, in the uncus [gyri hippocampi]; its surface is divided, in front, by 2—4 flat, radial grooves, into a number of flattened elevations, *digitationes hippocampi*. The ridge corresponds to the fissura hippocampi and is caused by it. The white covering of the hippocampus is connected at its medial margin with the *fimbria hippocampi*, a triangular white strip which passes forward as far as the uncus and forms the direct continuation of the crus fornicis (see also Fig. 761). It goes over by a lateral, sharpened edge into the epithelium of the plexus chorioideus ventriculi lateralis and, when the choroid plexus is removed, ends in a delicate torn margin, *taenia fimbriae* (see p. 670). The largest part of the fimbria is situated outside of the ventricle and is separated from the fissura hippocampi and the gyrus hippocampi by a narrow, peculiarly notched strip of gray substance, *fascia dentata hippocampi*, which, in front, ends in the uncus and, behind, goes over into the fasciola cinerea (see p. 668). The part of the gyrus hippocampi adjoining this is covered by a delicate reticular layer of white substance, the *substantia reticularis alba [Arnoldi]*, the relations of which are represented in Figs. 774 and 775.

The ***pia mater encephali*** (see p. 642) lies everywhere closely in contact with the external surface of the brain and penetrates also into the depths of the cerebral sulci. In addition it penetrates into the fissura cerebelli transversa, forming there the *tela chorioidea ventriculi quarti* (see p. 654). Farther, it passes into the fissura cerebri transversa as the *tela chorioidea ventriculi tertii* (O. T. velum interpositum) (see Figs. 748, 772 and 773). The latter is a triangular duplicature which ends blind, in front, at the foramen interventriculare. It consists 1. of an upper lamella which is attached to the inferior surface of the corpus callosum and of the fornix, 2. of an inferior lamella which covers the largest part of the superior surface of both thalami and in addition, covered by the lamina chorioidea epithelialis (p. 666), forms, between the two thalami, the roof of the third ventricle, and 3. of loose connective tissue, the continuation of the subarachnoidal connective tissue of the cisterna venae cerebri magnae (see p. 706). Within the latter, running from before backward, close to one another, are the two *venae cerebri internae* (see Fig. 772) which unite in the region of the corpus pineale to form the broad, unpaired *v. cerebri magna [Galeni]*. The latter passes around the splenium corporis callosi upward and to the front and runs from behind at an acute angle into the beginning of the sinus rectus (see Figs. 542 and 815). Each v. cerebri interna receives, in front, the *v. septi pellucidi*, which comes from the septum pellucidum, and the *v. terminalis*, which passes forward in the stria terminalis; one of these two receives the very tortuous *v. chorioidea*, which runs in the plexus chorioideus ventriculi lateralis. Hanging down, on each side, from the inferior lamella into the cavity of the third ventricle, very close to the median plane, is a narrow strip of lobulated, villus-like, reddish processes; those of the two sides together, are called the *plexus chorioideus ventriculi tertii (venous plexus of the third ventricle)* (see Fig. 773); they are covered by the lamina chorioidea epithelialis. A similarly constructed but thicker strip, *plexus chorioideus ventriculi lateralis (venous plexus of the lateral ventricle)* (see Figs. 769 and 771—774), penetrates on each side, between the fornix and fimbria on the one hand, and the stria terminalis on the other hand, into the pars centralis and into the cornu inferius of the lateral ventricle, being especially well developed at the junction between the pars centralis and the inferior horn where it is called the *glomus chorioideum;* the lamina chorioidea epithelialis, which covers it, proceeds from the taenia fornicis and from the taenia fimbriae to the taenia chorioidea. The two strips of the plexus chorioideus ventriculi tertii and the plexus chorioidei of the two lateral ventricles are connected with one another at the foramen interventriculare.



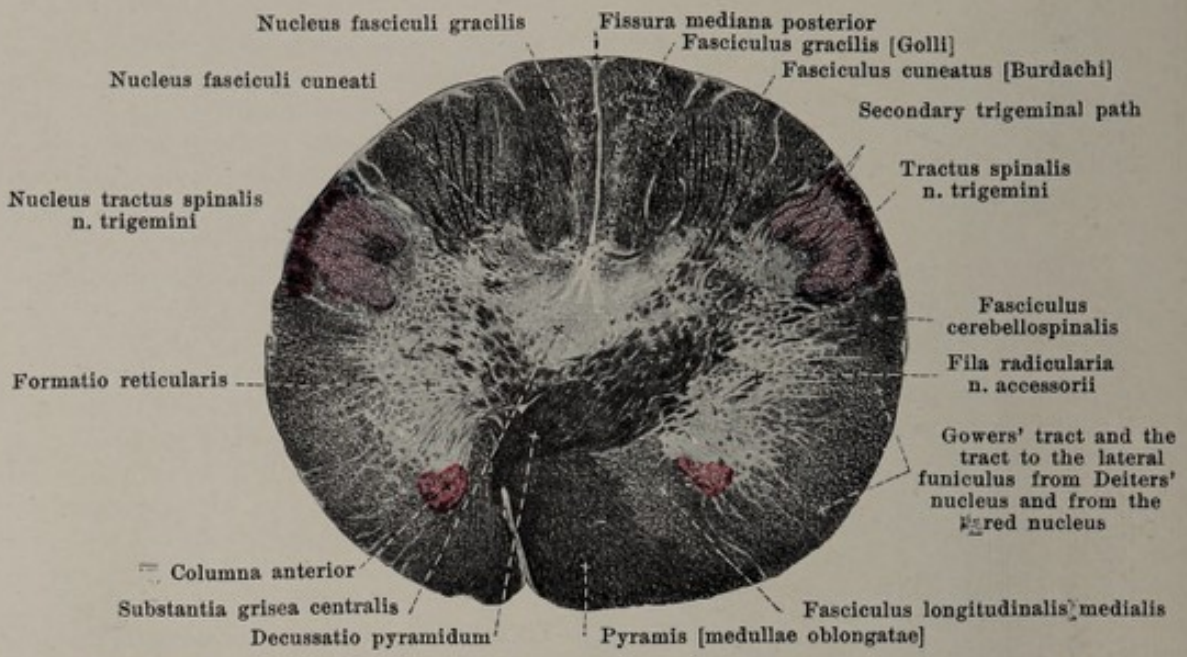
776. Brain-stem of an adult, viewed from behind and from the right and showing the directions of the sections represented in Figs. 778—786.

Magnification: 6:7.

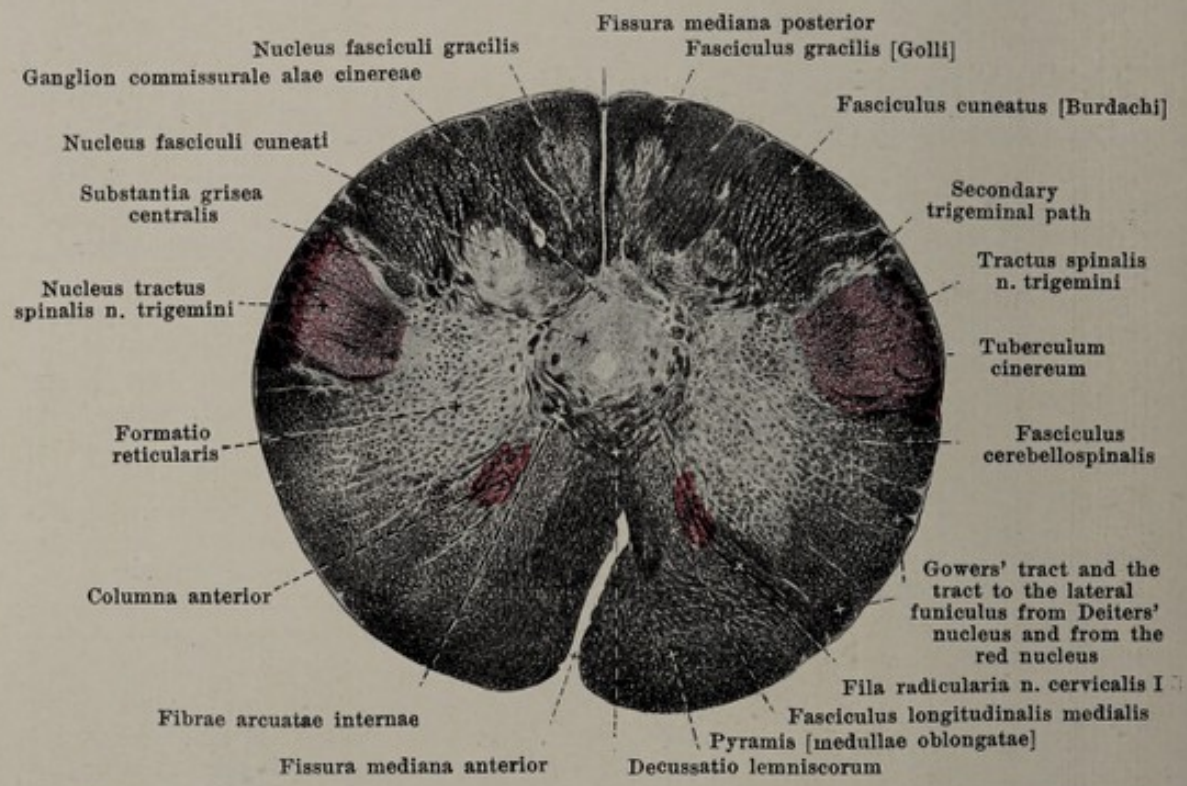


777. Brain-stem of an 8—9 month human fetus, viewed from behind and somewhat from the right, showing the direction of the sections represented in Figs. 788—795.

Magnification: 4:3.



778. Through the decussation of the pyramids. Magnification: 6:1.



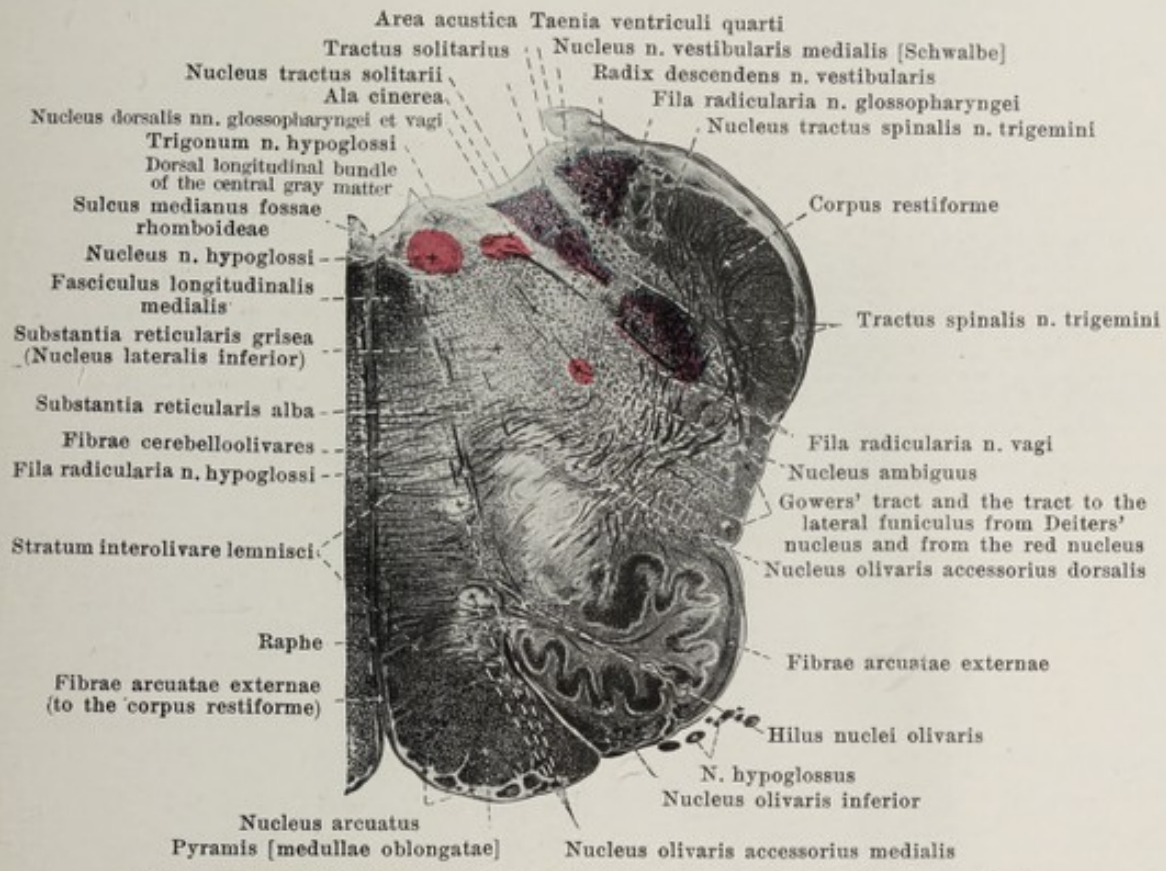
779. Between the decussation of the pyramids and the olives. Magnification: 6:1.

778—786. Transverse sections through the brain-stem of an adult.

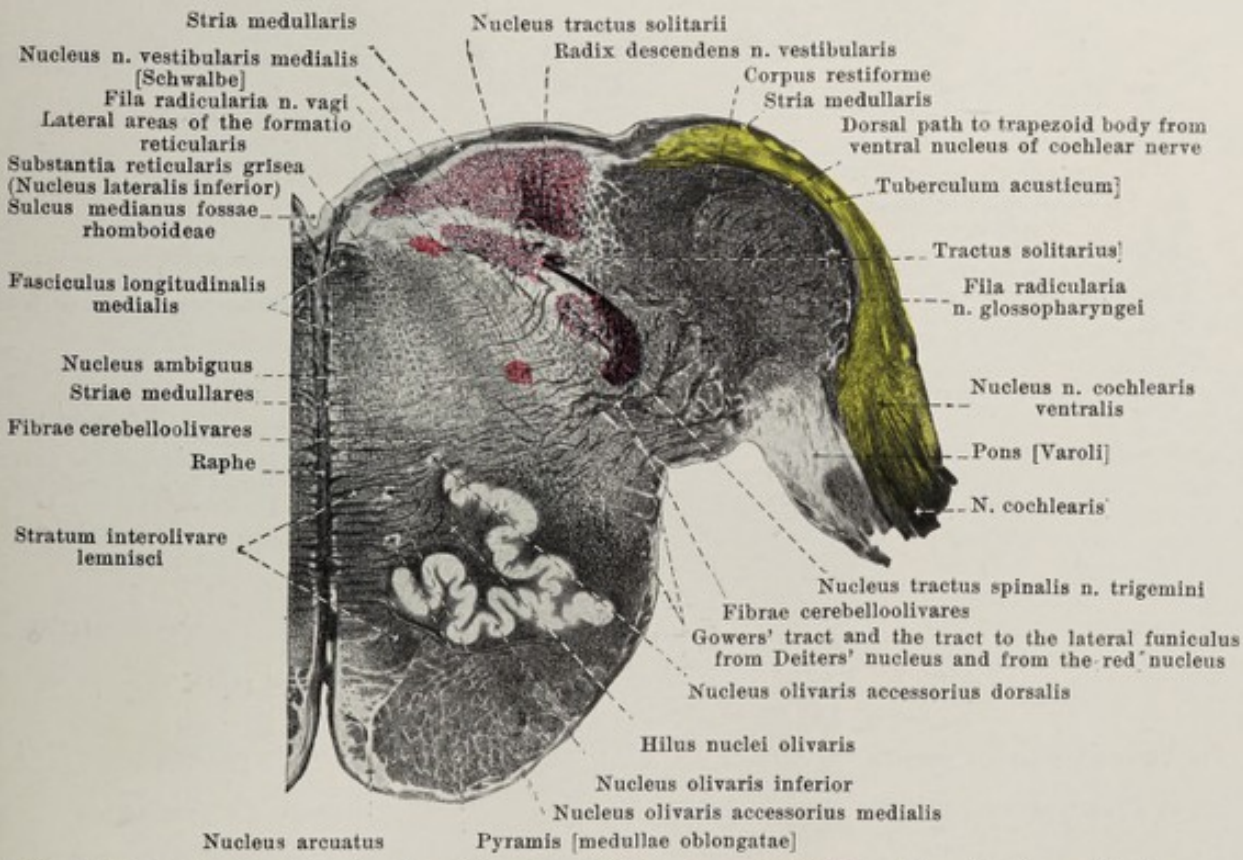
White substance black; gray substance light. Motor nuclei red. Sensory nuclei of termination colored violet (except the nuclei of the n. cochlearis which are colored yellow). (Held.)

Concerning the level and direction of the sections see Fig. 776.

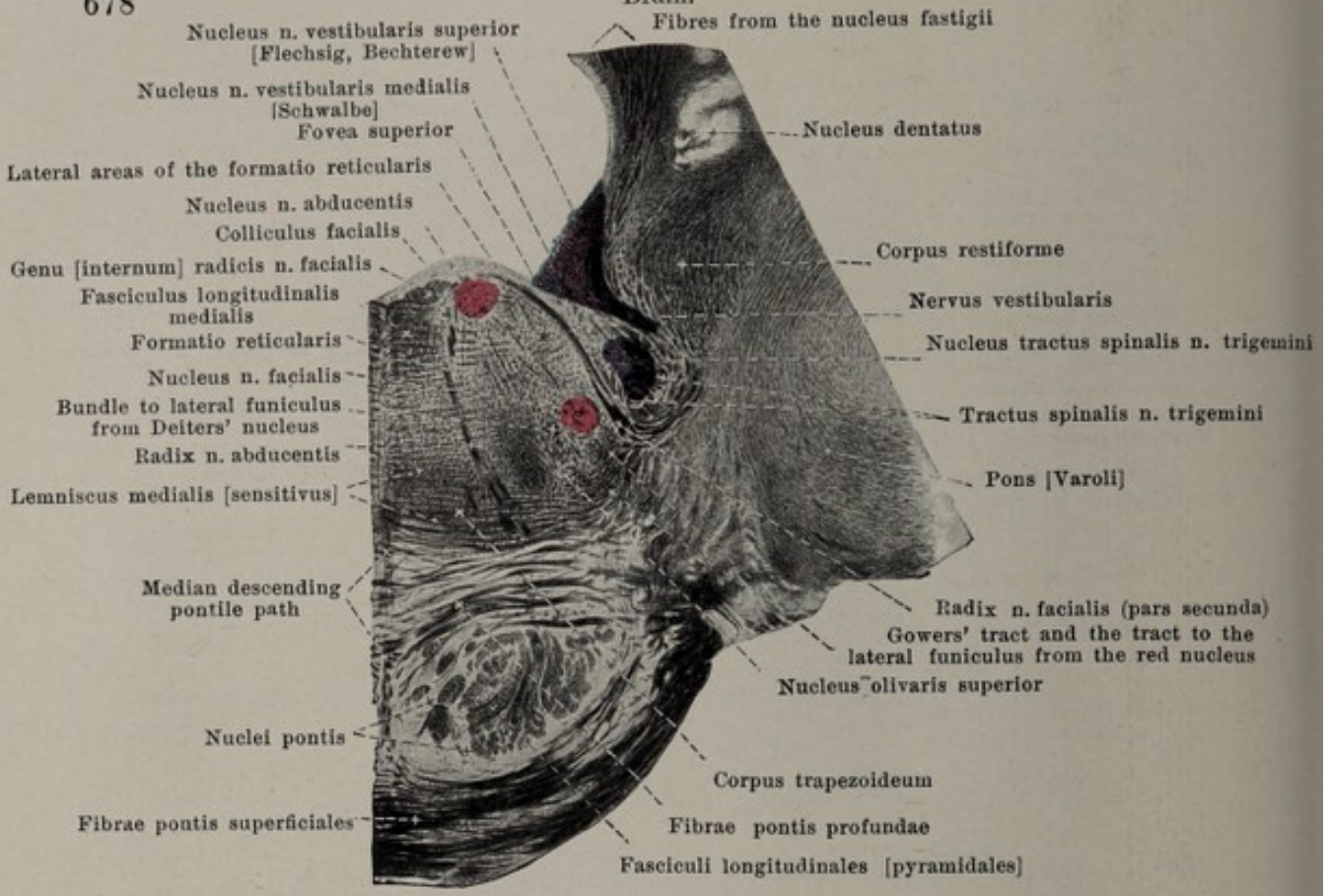
(The sections in Figs. 778—796 have been arranged so that their dorsal margins are upward.)



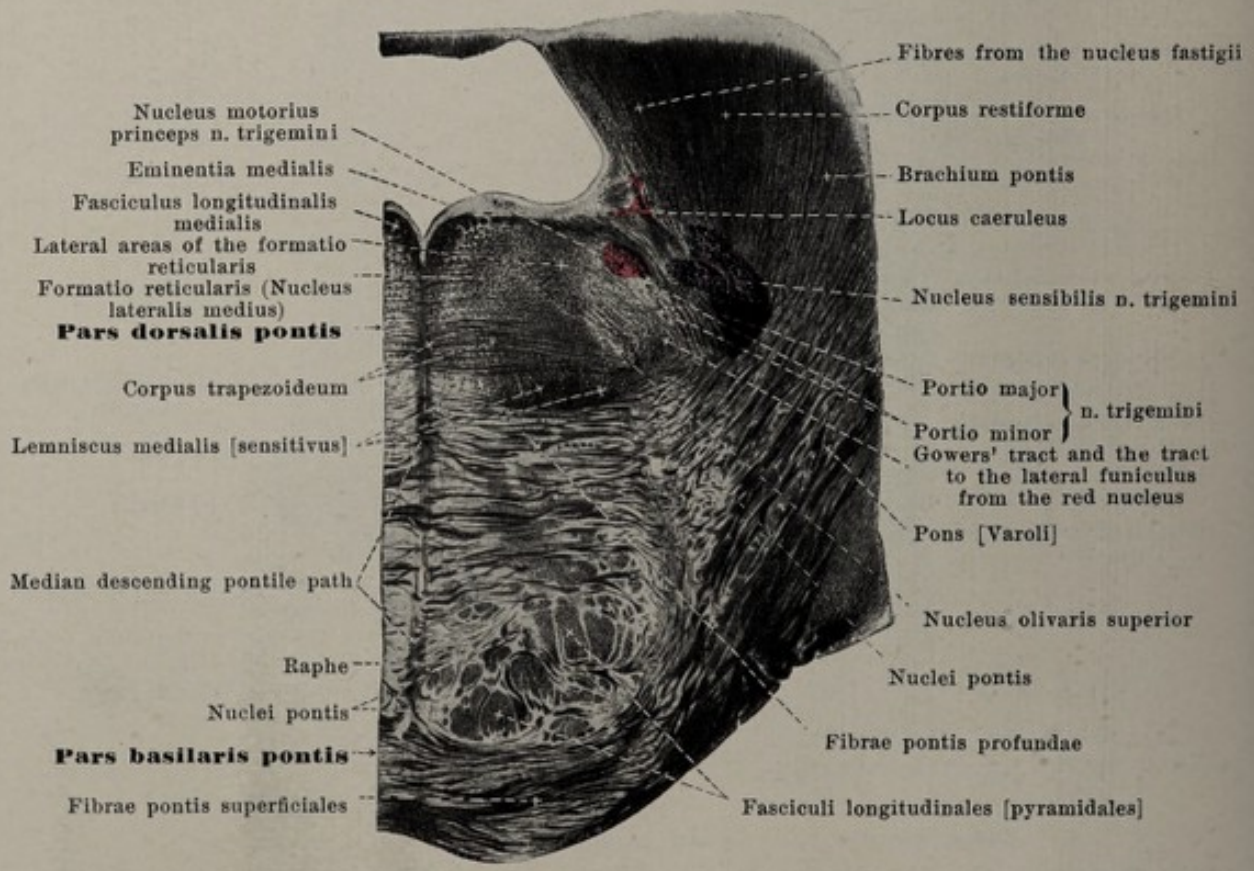
780. Through the middle of the olives. Magnification: 4.5:1.



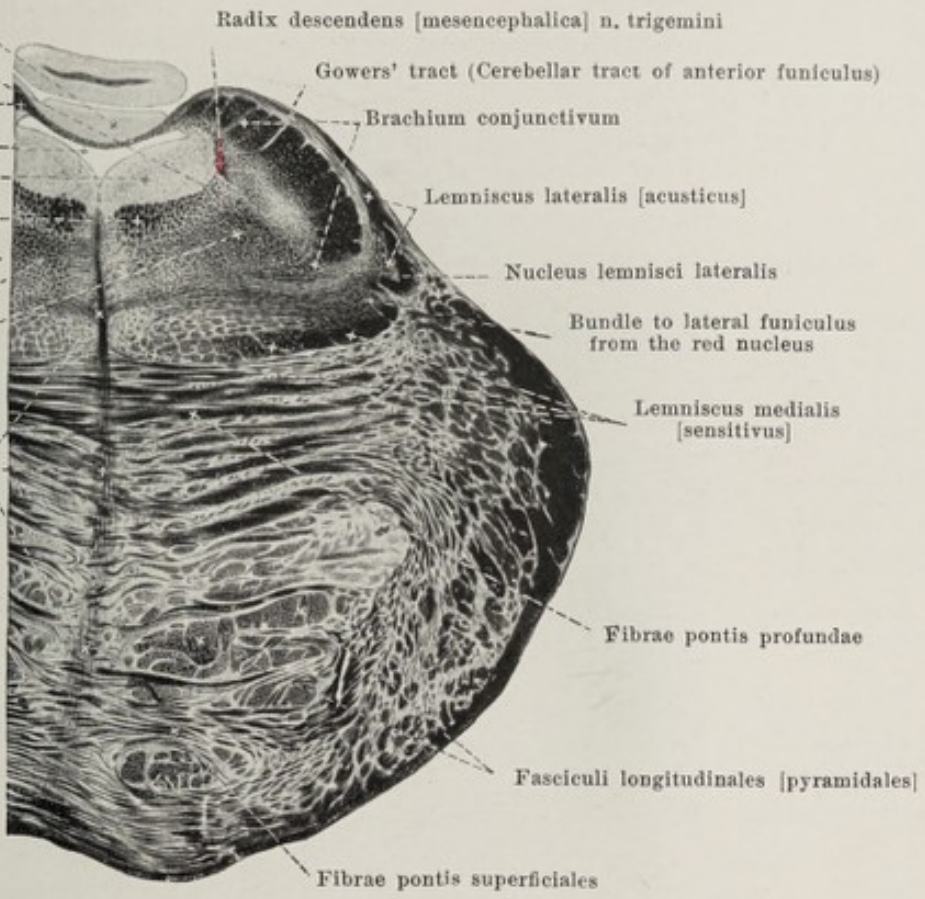
781. Through the level of entrance of the n. acusticus. Magnification: 4.5:1.



782. Level of the roots of the n. facialis and n. abducens. Magnification: 3:1.

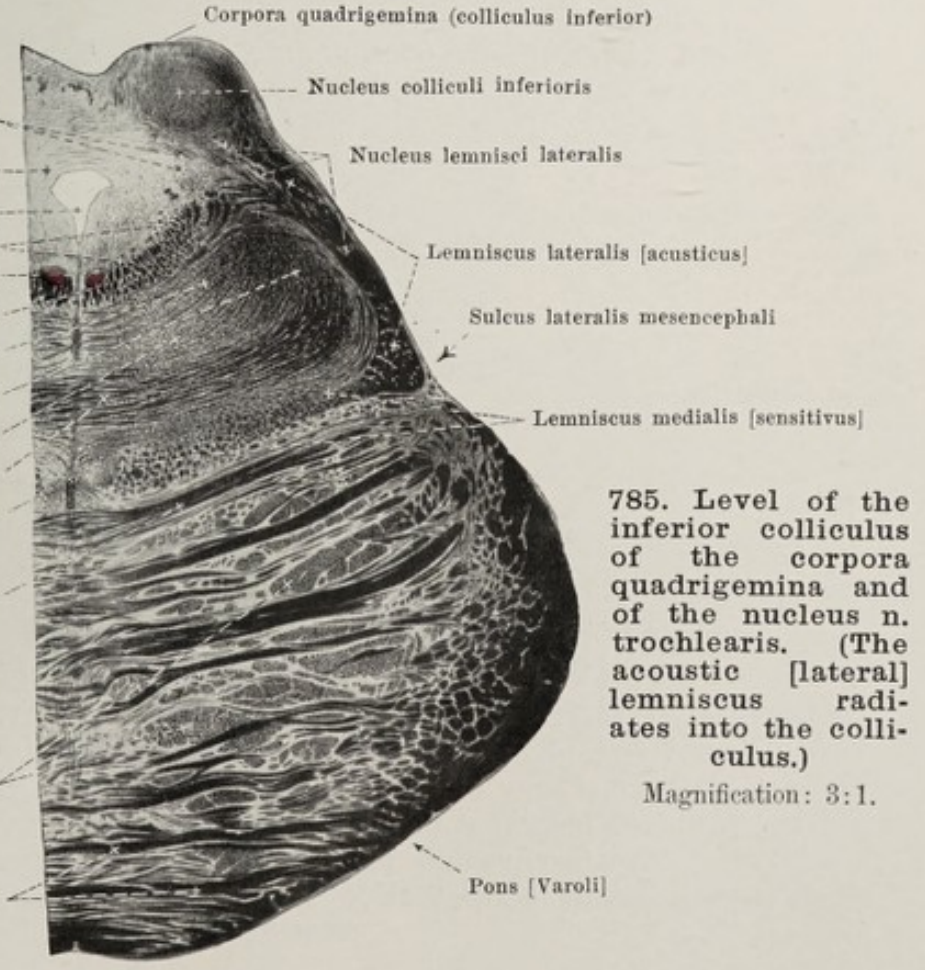


783. Level of the roots of the n. trigeminus. Magnification: 3:1.



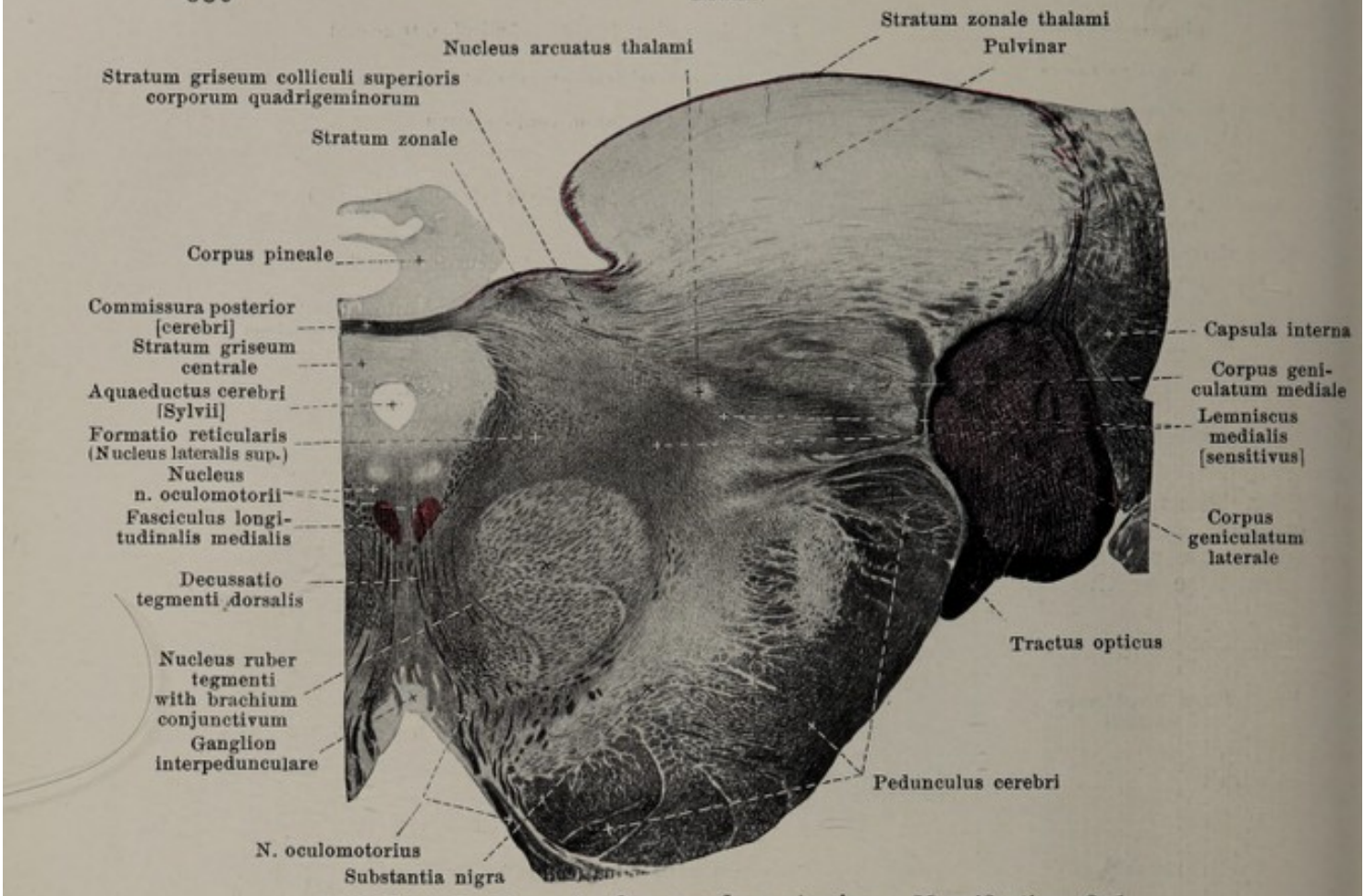
784. Through the velum medullare anterius and the middle of the pons.

Magnification: 3:1.

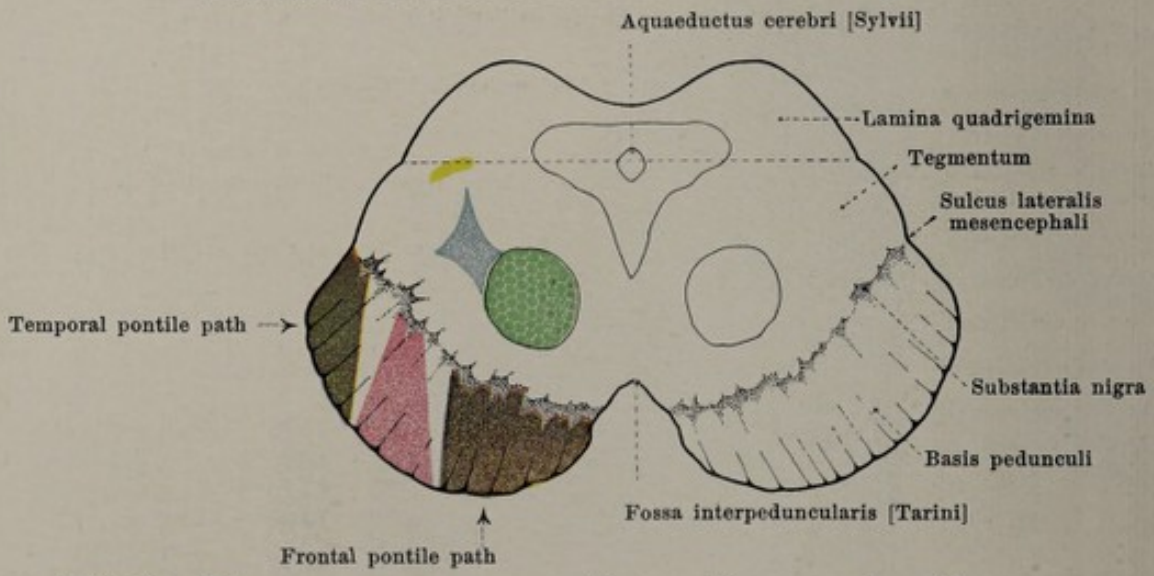


785. Level of the inferior colliculus of the corpora quadrigemina and of the nucleus n. trochlearis. (The acoustic [lateral] lemniscus radiates into the colliculus.)

Magnification: 3:1.

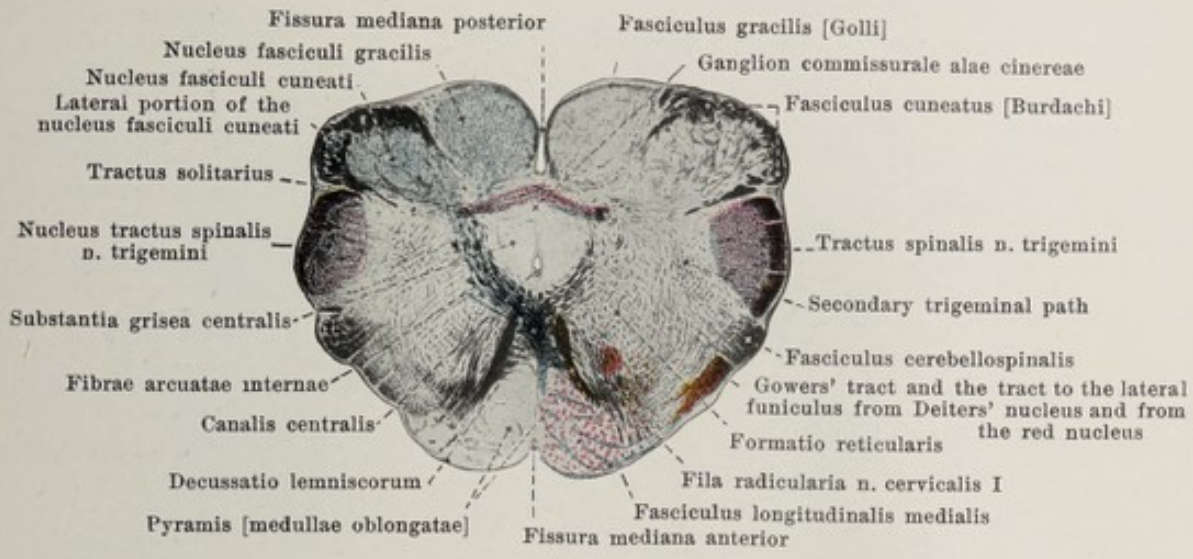


786. Level of root of n. oculomotorius. Magnification: 3:1.

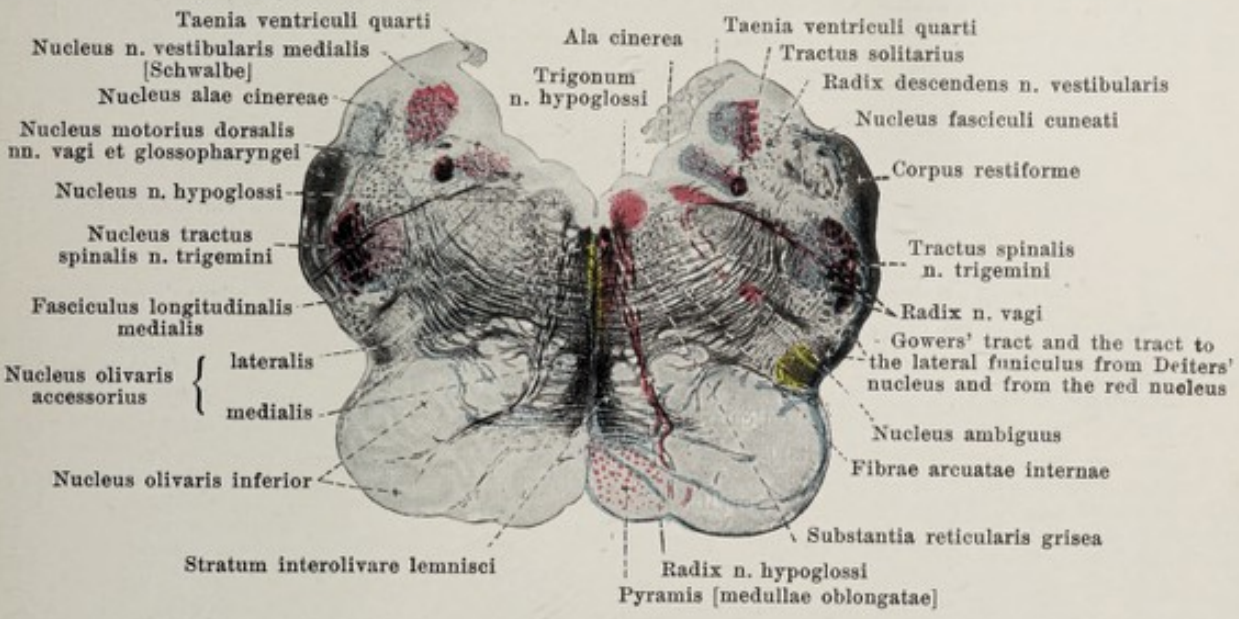


787. Transverse section through the corpora quadrigemina and cerebral peduncles, somewhat schematic. Pyramidal tract red; medial lemniscus to the [ventro]lateral nucleus of the thalamus blue; brachium conjunctivum green; auditory path yellow; temporal pontile path (Türck's bundle) light brown; frontal pontile path (Arnold's bundle) dark brown. (Held.)

(The sections represented by Figs. 778—796 are regularly so arranged that their dorsal margins are upward.)



788. Level of the sensory decussation (Decussatio lemniscorum).



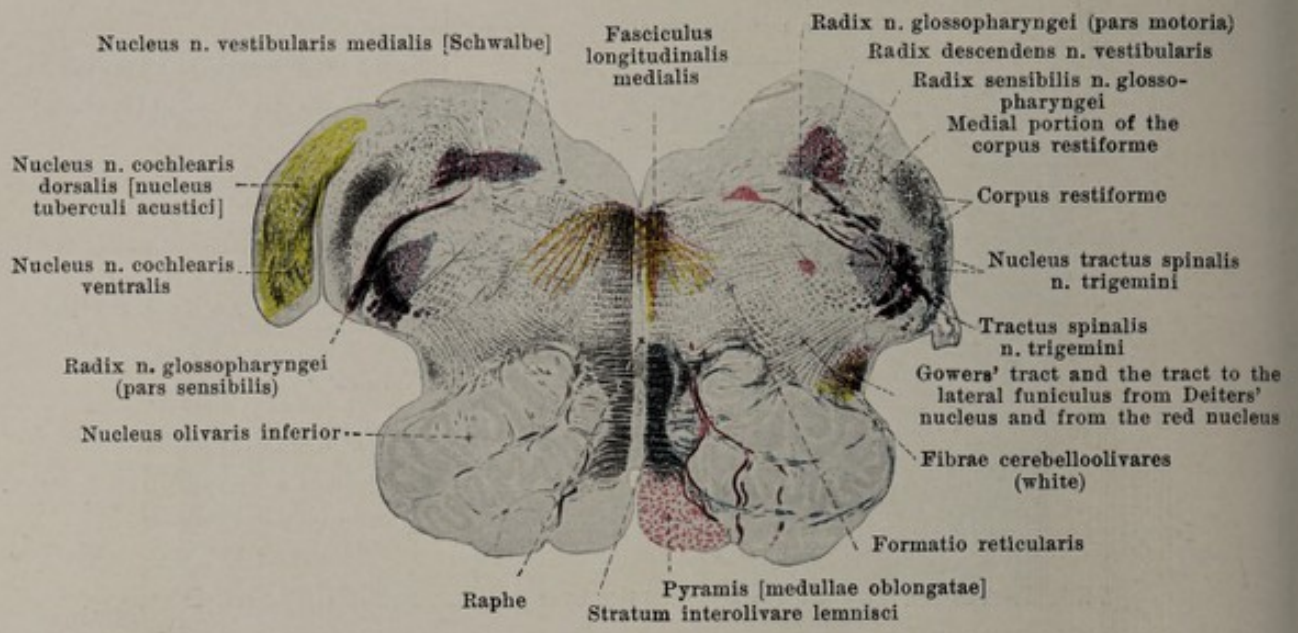
789. Level of radix n. hypoglossi and radix n. vagi.

788–795. Transverse sections through the brain-stem of an 8–9 month fetus; the nerve fibres are not yet completely medullated.

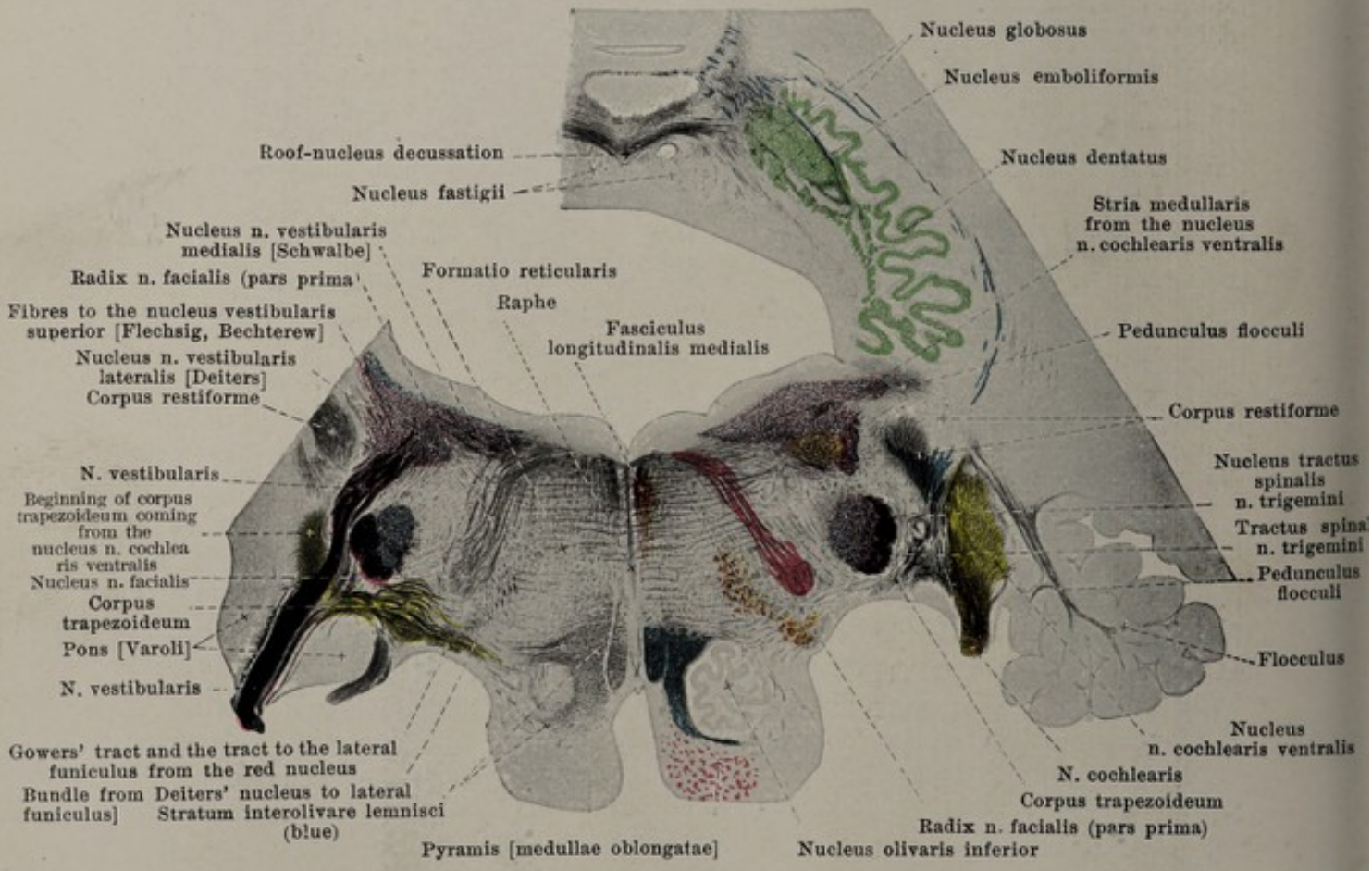
Magnification: 6:1. White matter black; gray matter light. Motor roots and nuclei, as well as the pyramidal tract red; roots and primary terminal nuclei of the sensory cerebral nerves (except the yellow-colored n. cochlearis and its indirect continuations) violet; secondary (ascending) paths from the nuclei of the posterior funiculi blue; brachium conjunctivum green. (Held.)

Concerning the level and direction of the sections see Fig. 777.

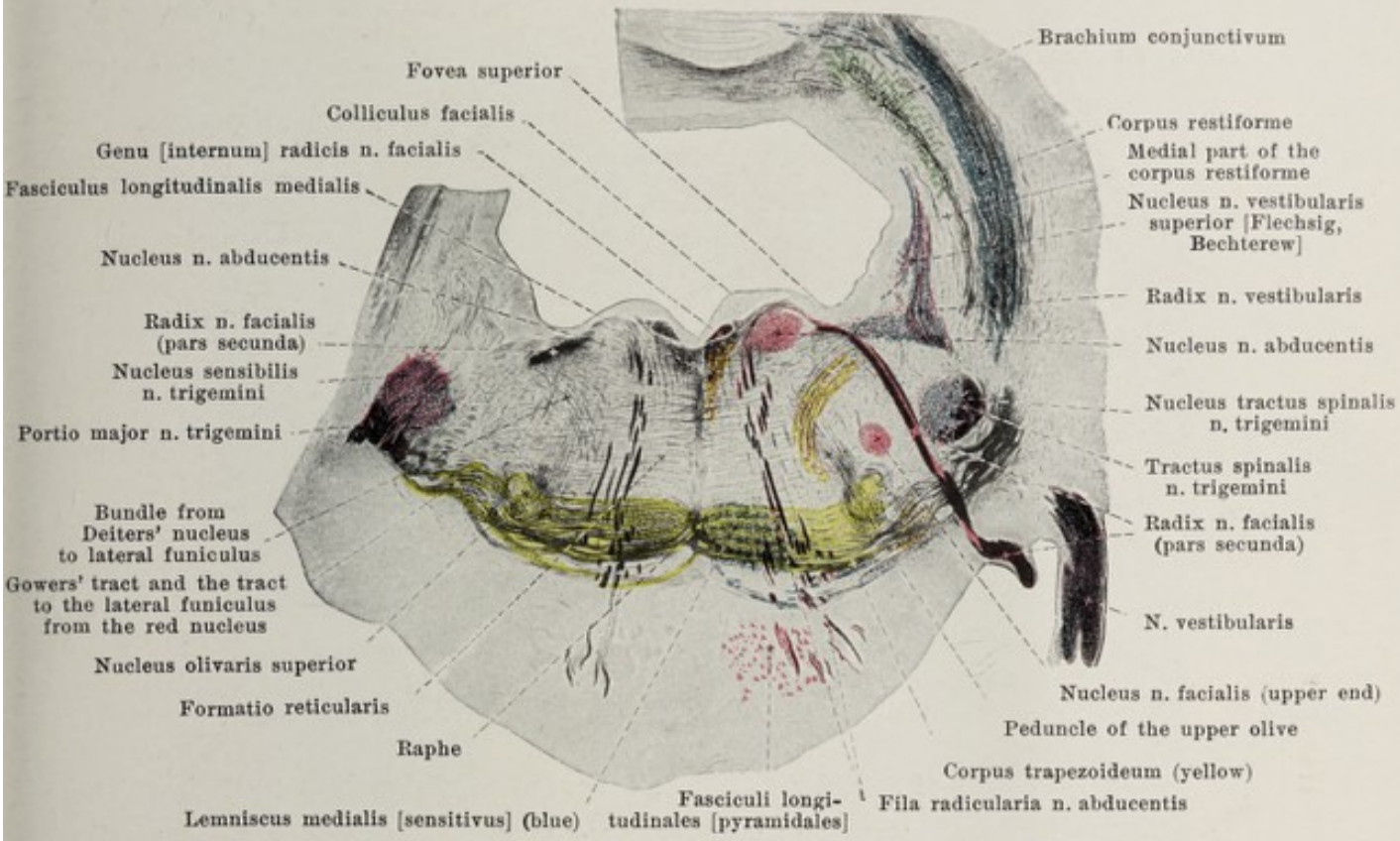
(The sections represented by Figs. 778—796 are so arranged that their dorsal margins are upward.)



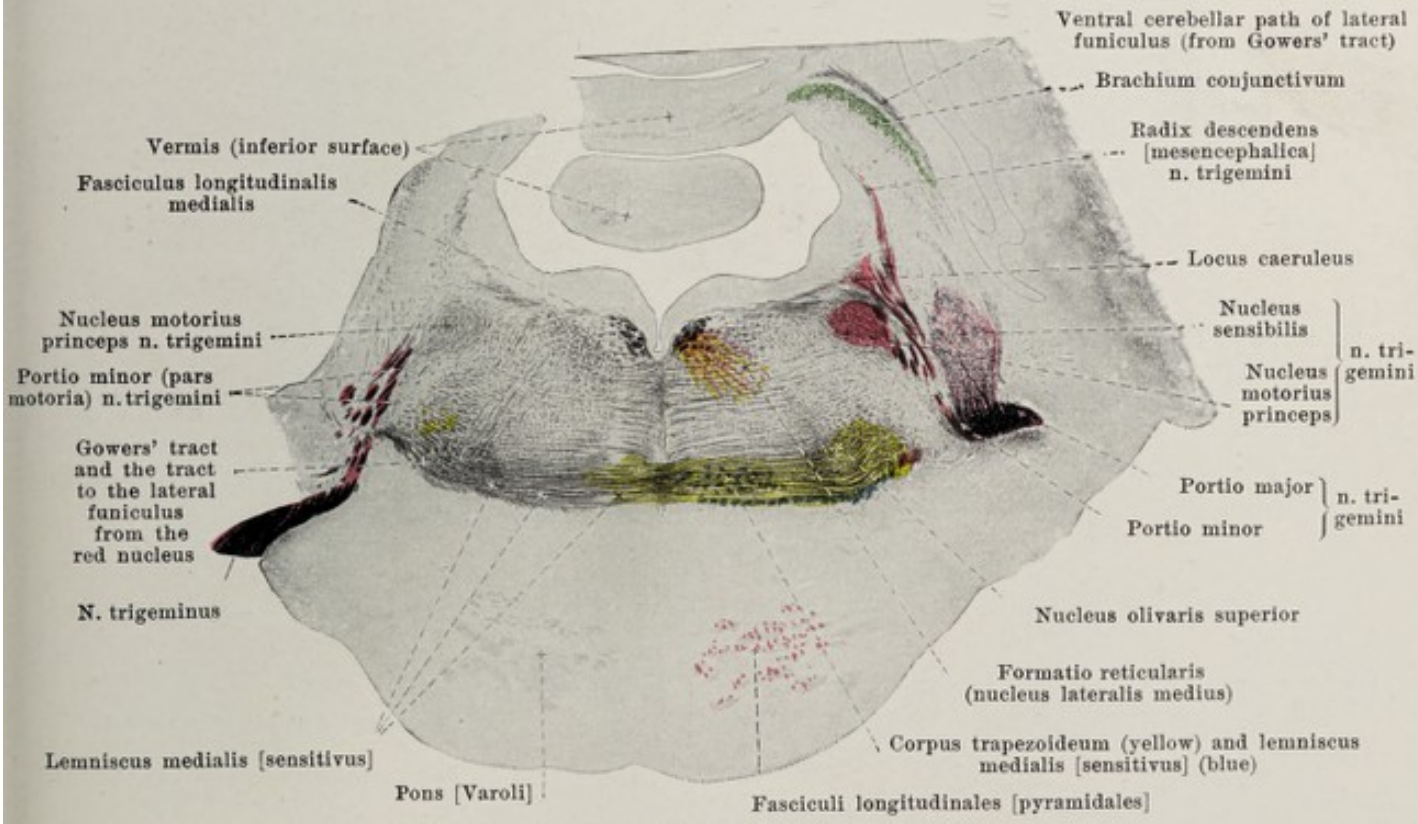
790. Level of the tuberculum acusticum (on the left side) and of the radix n. glossopharyngei.



791. Level of entrance of the n. acusticus (left side: n. vestibularis, right side: n. cochlearis) and, on the left, of the exit of the n. facialis.

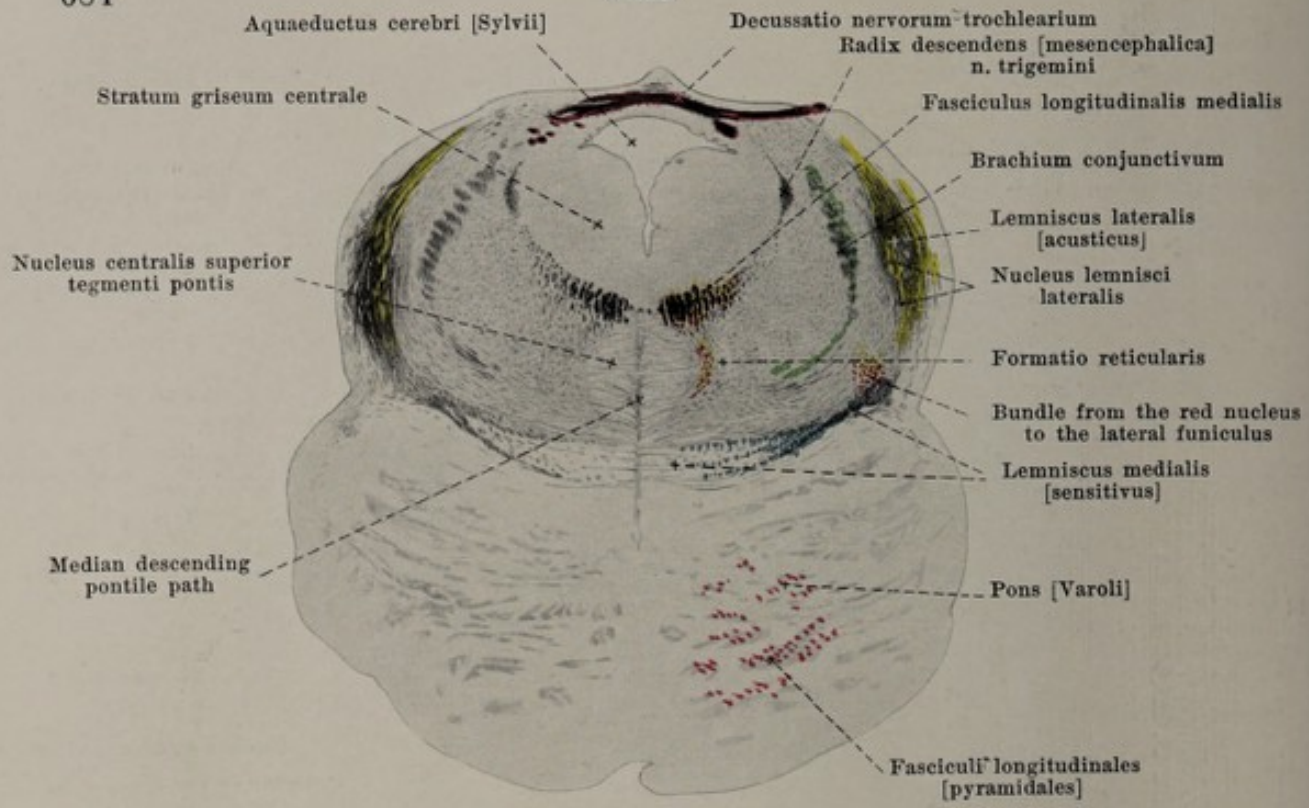


792. Level of exit of the n. facialis and of the nucleus n. abducentis.

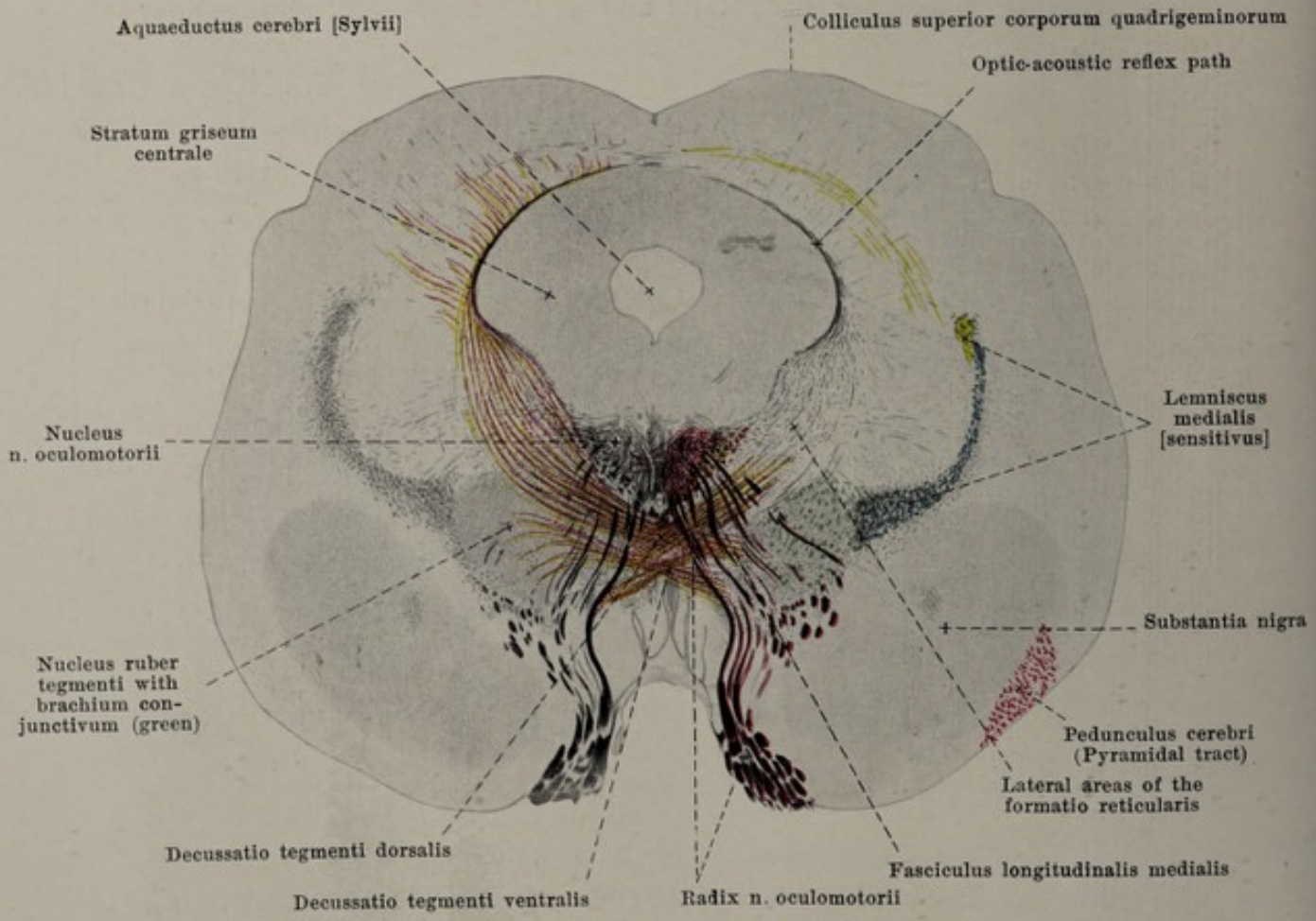


793. Level of roots of the n. trigeminus.

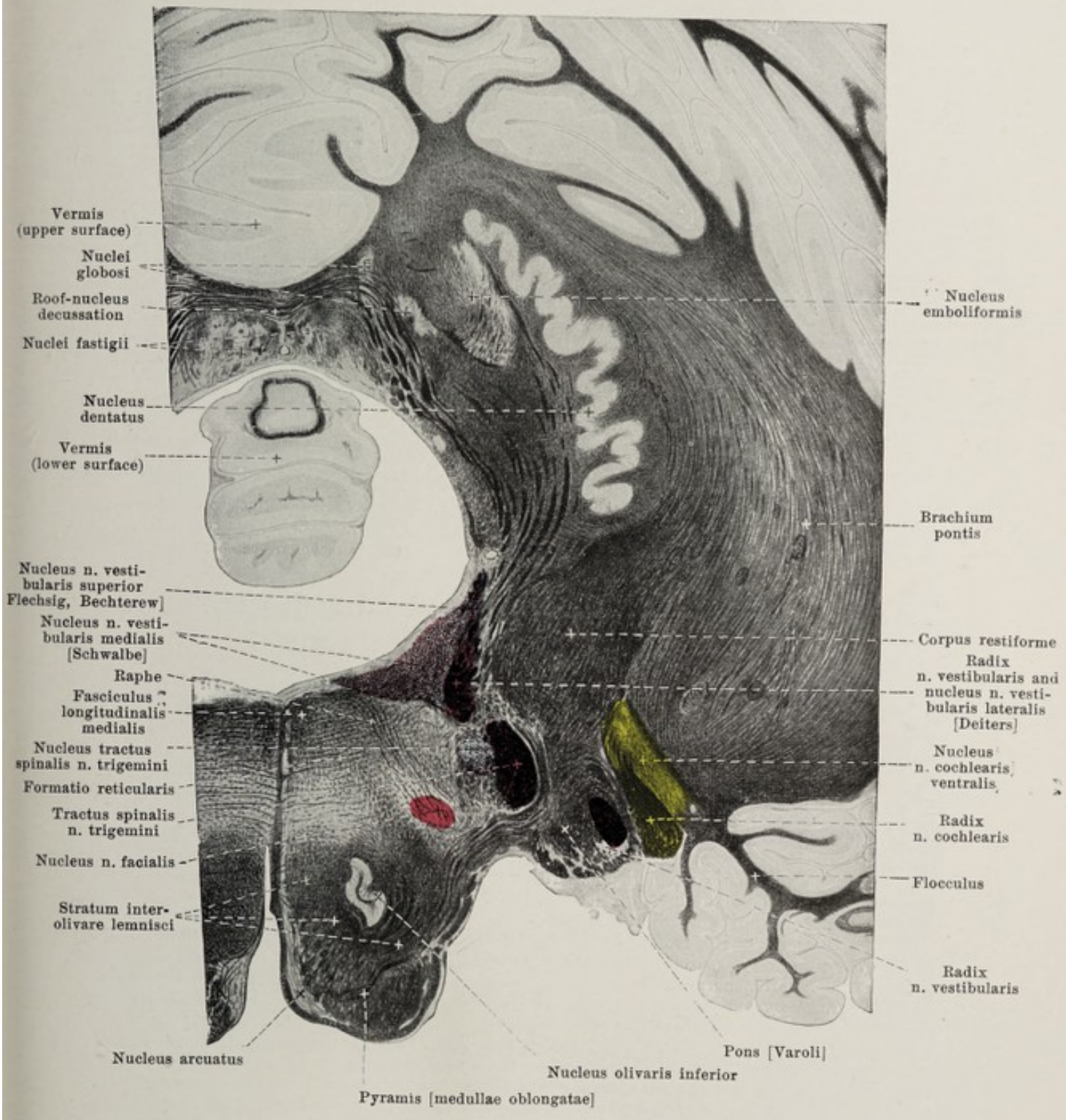
792 and 793. Region of the corpus trapezoideum.



794. Level of the decussatio nervorum trochlearium
(radix n. trochlearis see Fig. 785).



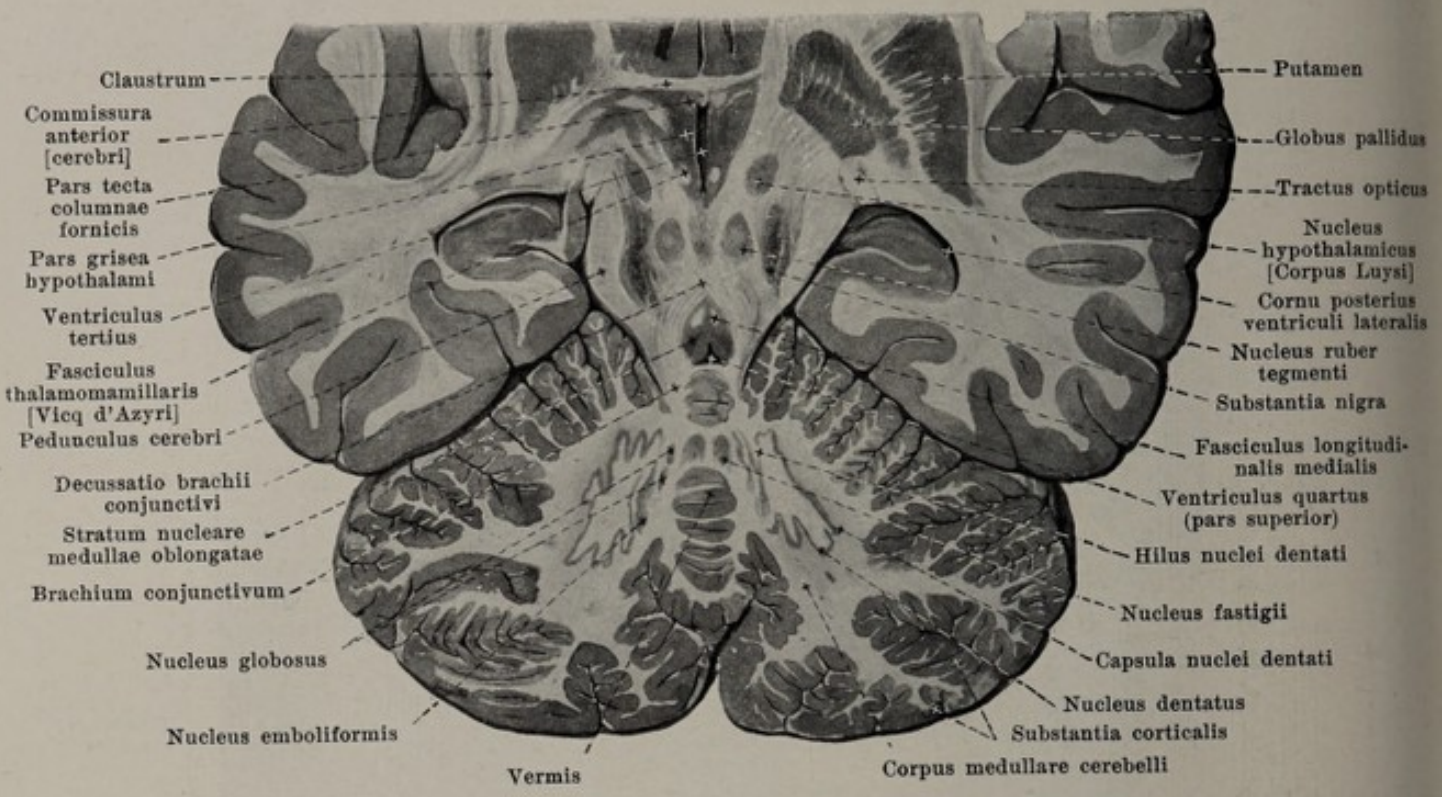
795. Level of exit of the n. oculomotorius.



796. Section through the middle of the cerebellum and through the medulla oblongata.

Approximately in the direction of the radiation of the corpora restiformia (after a preparation by P. Flechsig). Magnification: 4:1. (Held.) White substance black; gray substance light.

Motor nuclei red, sensory blue, acoustic yellow.



797. Section through the brain in the direction of the brachia conjunctiva.

Distribution of the principal masses of gray and white matter in the brain. In the region of transition from the spinal cord to the medulla oblongata the masses of white and gray matter undergo greater or less alterations in character and position; and furthermore new masses of grey matter appear and corresponding to them new tracts of white fibres. A specially marked shifting of individual parts is brought about by the separation of the parts of the spinal cord situated dorsally from the central canal, in such a manner that the dorsal masses of the cord are moved laterally and the central canal opens up as a transversely striated slit. Consequently the form and delineation of the cross-sections is different at different levels.

Even in the cervical region peculiarities are to be noted in that the fibres of the n. accessorius from the anterior horn (see p. 700), in the region of the upper 5—7 cervical segments, run outward through the lateral tract.

At the level of the root fibres of the 1st cervical nerve (see Fig. 778) the fibre bundles of the *fasciculus cerebrospinalis lateralis [pyramidalis lateralis] (lateral pyramidal tract)* run through the anterior horn obliquely medianward, ventralward and upward, cross the middle line *(decussatio pyramidum)* (see also p. 649) and join the *fasciculus cerebrospinalis anterior (anterior pyramidal tract)* of the opposite side forming together the *pyramis [medullae oblongatae]* (see Figs. 778—781, 788—791 and 796), nearly triangular in cross section, which projects from the ventral surface of the medulla oblongata as a prominence directly next to the fissura mediana anterior (see p. 648), and which extends as a close and distinct mass to the lower border of the pons; the bundles forming the pyramis, *fasciculi pyramidales*, are continued cerebralward directly in the fasciculi longitudinales [pyramidales] of the pons (see p. 688), and are separated by the transverse fibres of the latter into bundles of different thicknesses.

In the region of the pyramidal decussation (see Figs. 778, 779 and 788) there appears in the fasciculus gracilis a long wedge-shaped mass of gray matter, the *nucleus fasciculi gracilis*, which produces the clava (see p. 649) on the surface, and a little further up in the fasciculus cuneatus, there appears the *nucleus fasciculi cuneati*, which corresponds superficially to the tuberculum cuneatum (see p. 649); both are connected with the central gray matter. Corresponding to the divergence of the posterior bundles (see p. 649), their so called *posterior nuclei* are also shifted lateralward (see Fig. 789). They extend upward getting smaller as

they go, until about the lower end of the area acustica (see p. 649). The posterior horn corresponding to the decreasing of the lateral pyramidal tract is gradually displaced lateralward and ventralward (see Figs. 778, 779, 788 and 789), and soon disappears altogether; only its substantia gelatinosa [Rolandi] remains, becomes thicker and is continued as a thick, gray mass, the *nucleus tractus spinalis n. trigemini*, which reaches almost to the surface laterally, and is there in contact with the *tractus spinalis n. trigemini* (see also p. 698); it bulges out as the tuberculum cinereum (see p. 649) more noticeably in the child than in the adult.

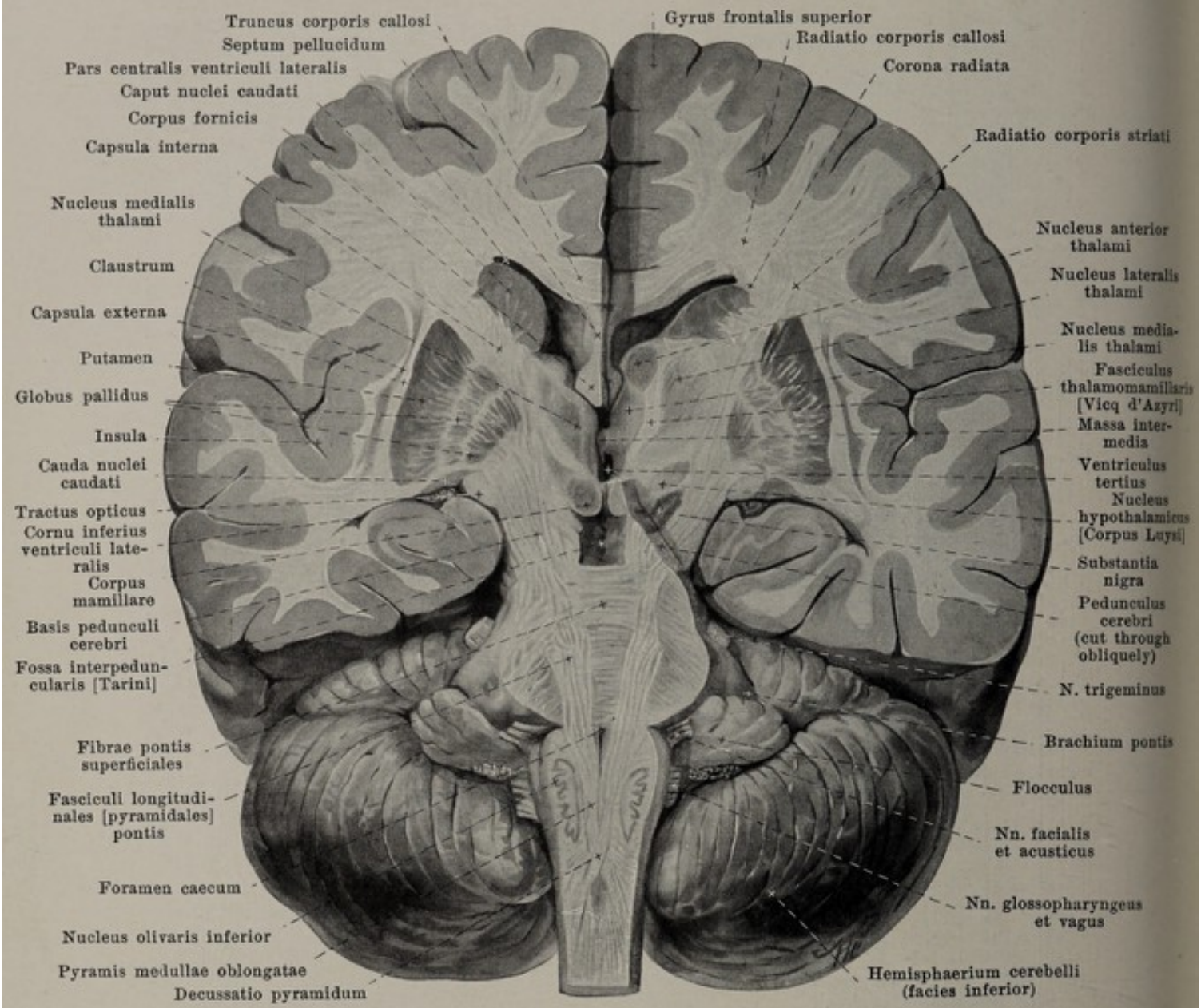
From the cells of the nuclei in the posterior tracts at which all fibres of the posterior tracts terminate, other fibres orginate and run in concentric arches around the central canal medianward, ventralward and cerebralward, *(fibrae arcuatae internae)* (see Figs. 778, 779, 788 and 789). They intersect the fibres of the other side ventrally to the central canal *(decussatio lemniscorum)*, and on crossing the median line bend on the other side into a region which lies close to the medially running *raphe*, between the latter and the nucleus olivaris inferior, and directly dorsal to the pyramid, and is known as *stratum interolivare lemnisci*, (see Figs. 780, 781, 789—791 and 796). Below the decussatio lemniscorum adjoins the cerebral end of the decussation of the pyramids and above it extends to near the region of the hypoglossal nuclei. The stratum interolivare lemnisci is continued dorsally directly into the substantia reticularis alba (see below); its fibres run vertically cerebralwards and pass above the olivary nuclei, directly into the lemniscus medialis [sensitivus] (see p. 688).

In the continuation of the laterally displaced upper ends of the posterior tracts and posterior nuclei one can see on cross-section an area of medullated fibres, the *corpus restiforme* (see Figs. 780—783, 789—792 and 796), which extends almost to the surface (see pp. 649 and 700).

With the separation of the spinal cord matter lying dorsal to the central canal and with the widening out of the central canal into the 4th ventricle, the masses of gray matter which were ventral to it *(stratum nucleare medullae oblongatae)* come directly to the surface of the ventricle, and under the floor of the rhomboid fossa and partly further caudalward are situated most of the nuclei of the motor and the primary terminal nuclei of sensory cerebral nerves (see Figs. 780—783, 789—793, 796 and 805) and the ascending nerve tracts from the spinal cord connected with them. As a special structure there appears the *formatio reticularis* (see Figs. 778—785 and 788—796). This consists of partly longitudinal and partly transverse medullated fibres largely interwoven with each other and containing individual ganglion cells or small masses of gray matter. In the lowermost part of the medulla oblongata, in direct connection with the formatio reticularis of the spinal cord (see p. 641), it begins with those remains of the anterior and lateral funiculi which are to be seen above the pyramidal decussation and with the remains of the anterior horns. Below, it lies between the pyramids and olives on the one hand and the nuclei of the posterior funiculi (see abore) on the other; it then approaches close to the floor of the rhomboid fossa and is continued through the dorsal portion of the pons (see p. 688) as far forward as the level of the inferior colliculi of the corpora quadrigemina. The medial region, bounded lateralward by the root fibres of the n. hypoglossus (see Figs. 780 and 789), is relatively poor in ganglion cells and is called the *substantia reticularis alba* in contrast with the area situated lateralward from it, the *substantia reticularis grisea*.

On the ventral side (see Figs. 780—782, 789—791, 796 and 798) the *nucleus olivaris inferior* appears in the olive; it is a shell-like, much folded gray mass which is open medianward at the *hilus nuclei olivaris;* small detached portions of its gray matter are known as the *nucleus olivaris accessorius medialis* and *dorsalis (medial* and *dorsal accessory olive)*. At the same level the *nuclei arcuati* (see Figs. 780 and 781), flat masses of gray matter, lie in the *fibrae arcuatae externae* (see p. 649 and 700) on the ventral and medial surfaces of the pyramids.

About the level of the lower border of the pons cranialward from the nucleus olivaris inferior lies a poorly defined, small gray mass, the *nucleus olivaris superior*, or *upper olive* (see Figs. 782, 783, 792 and 793), which is separated from the fibres of the pons, by a strong transverse band, the *corpus trapezoideum*, or *trapezoid body* (see Figs. 782, 783, 792 and 793). It is thus termed as in lower animals in which the pons does not extend so far down, it is visible as a trapezoid area, free in the ventral surface of the medulla oblongata, laterally to the pyramids between the pons and the olive. The big ganglion cells which lie among the fibres of the trapezoid body, near the middle line, are known as the *nucleus corporis trapezoidei*. The trapezoid body originates in the cells of the nucleus n. cochlearis ventralis, runs in bundles through the medial lemniscus and continues (see p. 700) directly into the *lemniscus lateralis [acusticus]* (see Figs. 784, 785, 787 and 794), which gradually moves lateralward and dorsalward, comes at the isthmus rhombencephali directly under the surface as the trigonum lemnisci (see p. 655) and ends in the corpora quadrigemina (see p. 700).



798. Section through the brain in the direction of the cerebral peduncles, viewed from in front.

(In the left half of the cerebrum a second cut has been made parallel to the first and a plane situated somewhat further dorsalward represented.)

Lemniscus medialis [sensitivus] (see Figs. 782—787 and 792—795) is the name given to the transversely oval-shaped field of vertically running fibres which lies close to the upper surface of the pons and in which the fibres of the stratum interolivare lemnisci (see p. 687) are directly continued. This band of the medial lemniscus first widens gradually, then moves laterally and dorsalward, close to the lateral lemniscus as far as near the upper surface of the isthmus rhombencephali and can then be followed up (see Figs. 786 and 787) as a poorly defined cross section laterally and dorsally to the nucleus ruber tegmenti (see p. 689), to the ventrolateral nucleus of the thalamus (see also p. 695).

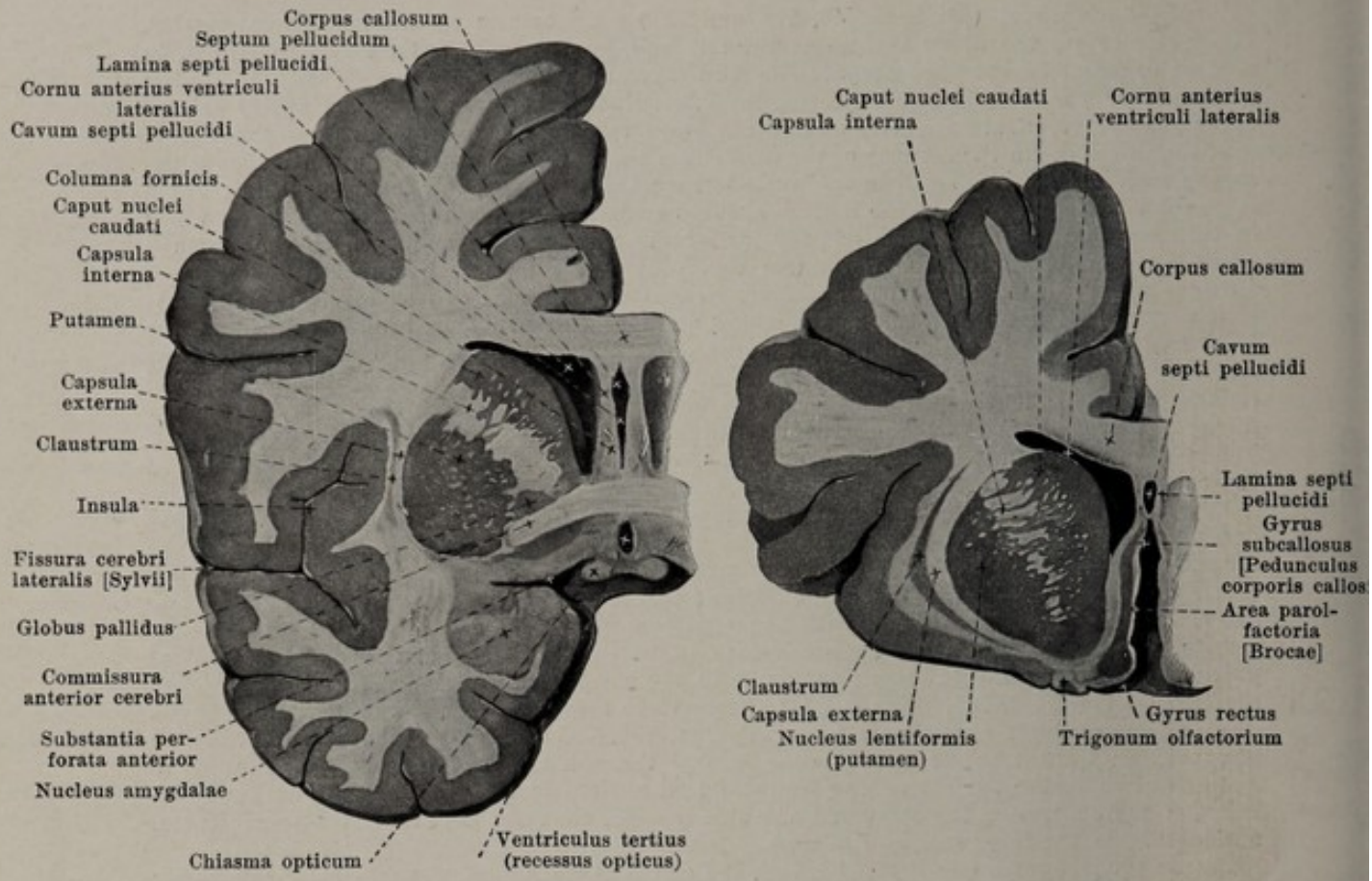
In the region of the *pons* (see Figs. 782—785, 793 and 794) two divisions are to be noted. The larger, ventral one, *pars basilaris pontis,* consists of transverse fibres which run lateralward to the brachia pontis; these fibres contain between them irregular groups of gray matter, *nuclei pontis,* are pierced on each side by the *fasciculi longitudinales [pyramidales],* and thus divided into *fibrae pontis superficiales* and *profundae.* The dorsal division, *pars dorsalis pontis,* extends as far as the rhomboid fossa.

The *cerebellum* (see Figs. 748, 796 and 797) consists also of white and gray matter. The latter covers the whole surface as the *cerebellar cortex (substantia corticalis);* in it, in a fresh or properly hardened preparation, two layers can be made out even with the naked eye, an inner yellowish or reddish-brown layer, *stratum granulosum (granular layer)* and an outer gray layer, *stratum cinereum;* between these two lies the narrow *stratum gangliosum (Purkinje's cells).* In the interior of the cerebellum the white matter forms a continuous mass, *corpus medullare;* this is small in the worm but markedly developed in the hemispheres. From it go off into the interior of the individual lobes *medullary layers, laminae medullares,* which in turn send off secondary and tertiary laminae into the lobules and gyri, so that upon a sagittal median section of the worm (see Fig. 748) a tree-like, much branched figure, *arbor vitae,* is produced. In the corpus medullare lie several gray masses (see Figs. 796 and 797); thus near the worm on each side is the jagged and markedly convoluted *nucleus dentatus,* the *hilus nuclei dentati* of which looks medianward; medial from it is the club-shaped *nucleus emboliformis* (the *cork* or *plug)* and medianward from this one or several *nuclei globosi (spherical nuclei);* in the worm on each side, close to the ventricular cavity, is the *nucleus fastigii (nucleus of the roof)* which is thicker in front and, behind, runs out into several points. The layer of white fibres which passes along the lateral surface of the nucleus dentatus is called the *capsula nuclei dentati.*

A bundle of fibres originating chiefly in the hilus nuclei dentati (see Figs. 797 and 806 and p. 702), the *brachium conjunctivum,* lies at first on the medial side of the fibres of the corpus restiforme which run to the cerebellum (see Figs. 782, 783, 792 and 793) and then (see Figs. 784, 785 and 794) as a bundle bent in cross-section, partly covered by the lemniscus lateralis, runs converging with the one from the other side to the corpora quadrigemina. Both of the brachia approach each other gradually in their medial and ventral portions and their fibres intersect, ventrally to the corpora quadrigemina *(decussatio brachii conjunctivi)* (see Figs. 785, 797 and 806). From there they run on each side as circular tracts inside the tegmentum [pedunculi] (see Figs. 786, 787, 795 and 808) ventrally to its central gray matter, toward the brain, and soon enlarge through the deposition of gray matter to a spherical body, the *nucleus ruber [tementi] (red nucleus of the tegmentum)* (see Figs. 786, 795, 797 and 801), from the upper end of which they for the most part reach the ventrolateral nucleus of the thalamus (see also p. 702).

In the *mid-brain* (see Figs. 785, 786, 794 and 795) the aquaeductus cerebri is completely surrounded by a gray mass, *stratum griseum centrale,* which is the direct continuation of the gray covering of the floor of the rhomboid fossa. In it lie also the nuclei of origin of the nn. trochlearis and oculomotorius and one nucleus of origin of the motor root of the n. trigeminus (see also Fig. 805). In its ventral part, in the interior of the tegmentum [pedunculi] (see p. 655), lies the spherical gray mass called the *nucleus ruber [tegmenti]* and ventral from this (see above), between the medial lemnicus and the base of the cerebral peduncle, is a larger area, *substantia nigra* (see Figs. 786, 797 and 798), dark colored even to the naked eye owing to its markedly pigmented ganglion cells, it extends upward into the hypothalamus. Dorsalward in the centre of the inferior colliculus is a lenticular gray mass, *nucleus colliculi inferioris* (see Fig. 758), and in the superior colliculus covered by a layer of white matter, *stratum zonale,* is a manifoldly lamellated gray mass, *stratum griseum colliculi superioris* (see Fig. 786).

In the *inter-brain* (see p. 646) in the region of the *hypothalamus,* lying within the corpus mamillare (see Figs. 773 and 798), covered by a layer of white matter, are two gray masses, *nuclei corporis mamillaris.* In these ends partly the columna formicis, and from them runs the *fasciculus thalamomamillaris [Vicq d'Azyri]* (see Figs. 773 and 798) to the nucleus anterior thalami. Directly continuous with the stratum griseum centrale of the mid-brain is a layer of gray matter, *pars grisea hypothalami,* which invests the floor of the third ventricle as far forward as the infundibulum, covering also the medial surface of the hypothalamus and thalamus; it also forms the *massa intermedia* (see p. 666). In the depth lies a special lens-shaped, gray mass, the *nucleus hypothalamicus [corpus Luysi]* (see Figs. 797, 798 and 801), directly in contact with the dorso-medial surface of the base of the cerebral peduncle; it begins approximately in the middle of the nucleus ruber and extends farther rostralward than this. The thalamus contains (see p. 666 and Figs. 773, 798 and 810) several gray nuclie which are partly circumscribed by sharply defined layers of white matter, *laminae medullares thalami;* the largest mass which reaches dorsalward as far as the pulvinar is called the *nucleus lateralis thalami* on which in the depth may be distinguished a *nucleus ventrolateralis [posterior]* and a *nucleus ventrolateralis anterior;* besides this there may be distinguished the *nucleus medialis thalami* and, under the tuberculum anterius, the *nucleus anterior thalami;* in addition, another centrally situated mass is especially striking, usually in the posterior part of the thalamus, the *nucleus centralis (centre médian).* The *corpus geniculatum laterale* (see Fig. 786) and *mediale* (see Figs. 786 and 801) each contains a large nucleus, *nucleus corporis geniculati lateralis* and *medialis;* the *trigonum habenulae* (see Fig. 801) contains a small gray mass, *nucleus habenulae.*

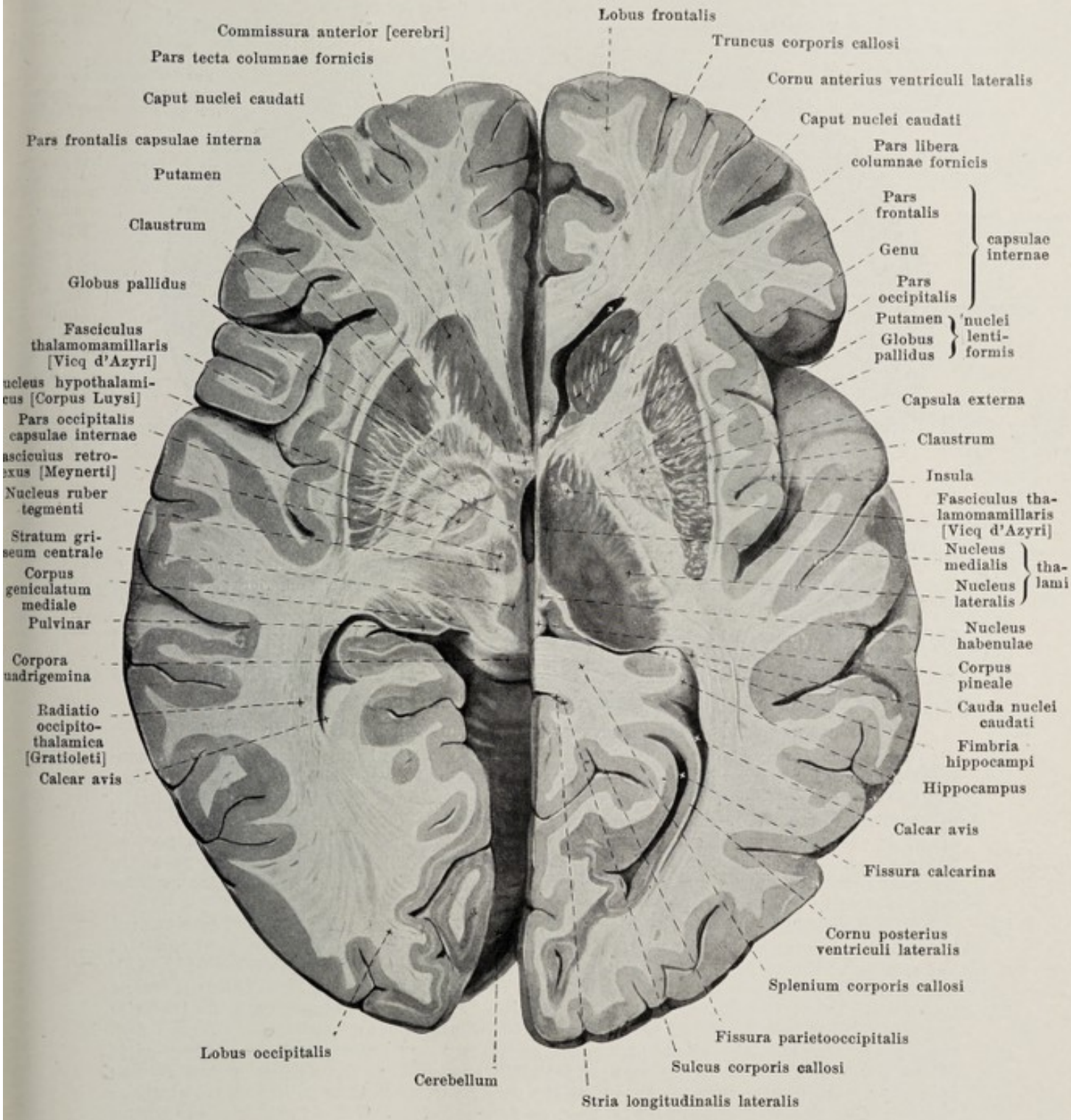


799 and 800. Frontal sections of the brain

left half, viewed from behind,

through the commissura anterior. in front of the commissura anterior.

The *cerebral hemisphere* is covered on its whole surface by a layer of gray matter, the *cerebral cortex (substantia corticalis)* (see Figs. 797—801). In the depth, in the neighborhood of the nuclei of the thalamus, lies the gray *corpus striatum*, separated from these and from the cortex by layers of white matter; it is divided itself by masses of white fibres *(capsula interna*, see below) into a medial part, the *nucleus caudatus* (see p. 671 and Figs. 769, 771, 773 and 798—801), bordering on the cavity of the lateral ventricle, and a lateral part, the *nucleus lentiformis* (see Figs. 769, 771, 773 and 797—801), buried in the interior. The latter lies also laterally of the thalamus and is wedge-shaped. It does not reach so far forward as the nucleus caudatus nor backward nearly so far as the thalamus, it is divided in to three parts by two thin medullary layers, concentric with the convex lateral surface. Of the parts of the nucleus lentiformis, the medial and middle portions together, pale and like the adjacent thalamus, are called the *globus pallidus*, while the lateral largest part, *putamen*, is colored dark-gray like the nucleus caudatus; putamen and nucleus caudatus are partly connected with each other in their frontal portions (see Figs. 771 and 797—801). The medial boundary of the lentiform nucleus (see Figs. 769 and 798—801) is formed by a broad mass of white matter, *capsula interna*. This is bent at an angle (see Fig. 801) and is subdivisible into a *pars frontalis capsulae internae* between the nucleus caudatus and the lentiform nucleus, a *genu capsulae internae*, and a *pars occipitalis capsulae internae* between the thalamus and the nucleus lentiformis. It is separated by a thin medullary layer, *capsula externa*, from a narrow layer of gray matter, *claustrum (bulwark)*; the medial surface of this is smooth but its lateral surface presents small projections corresponding to the gyri of the island. The claustrum is separated from the cortex of the island by a further layer of white matter.



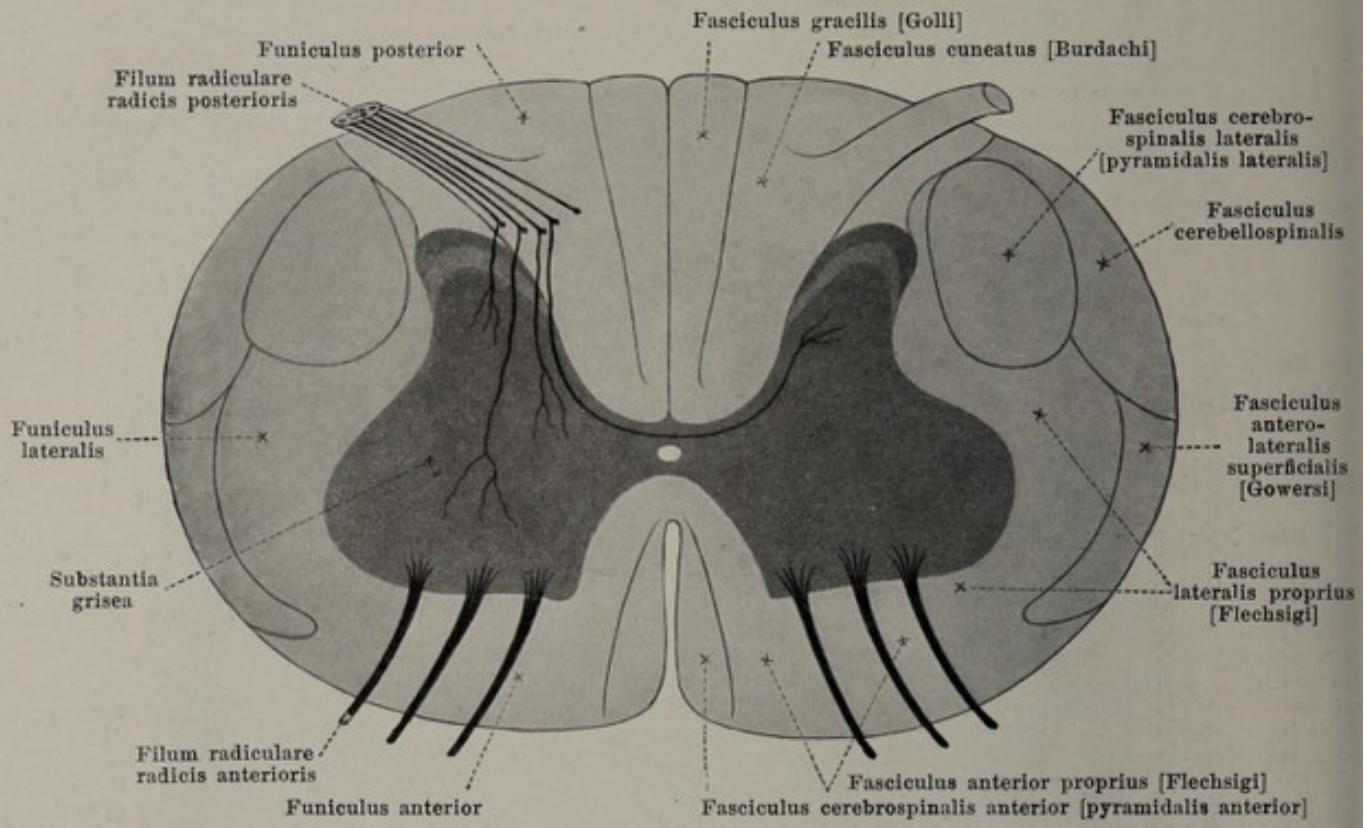
801. Horizontal section through the brain,

viewed from above.

(In the left half of the figure the plane of the section is about 1 cm deeper than in the right.)

In the most anterior part of the temporal lobe lies a large gray mass, *nucleus amygdalae, almond nucleus* (see Fig. 799), which is continuous medianward with the cortex of the gyrus hippocampi and dorsalward with the lentiform nucleus.

The gray masses which surround directly the cavities in the interior of the brain and of the medulla oblongata are collectively called the *central gray matter* (see also p. 689).



802. Schematic transverse section of the spinal cord with the chief conduction paths.

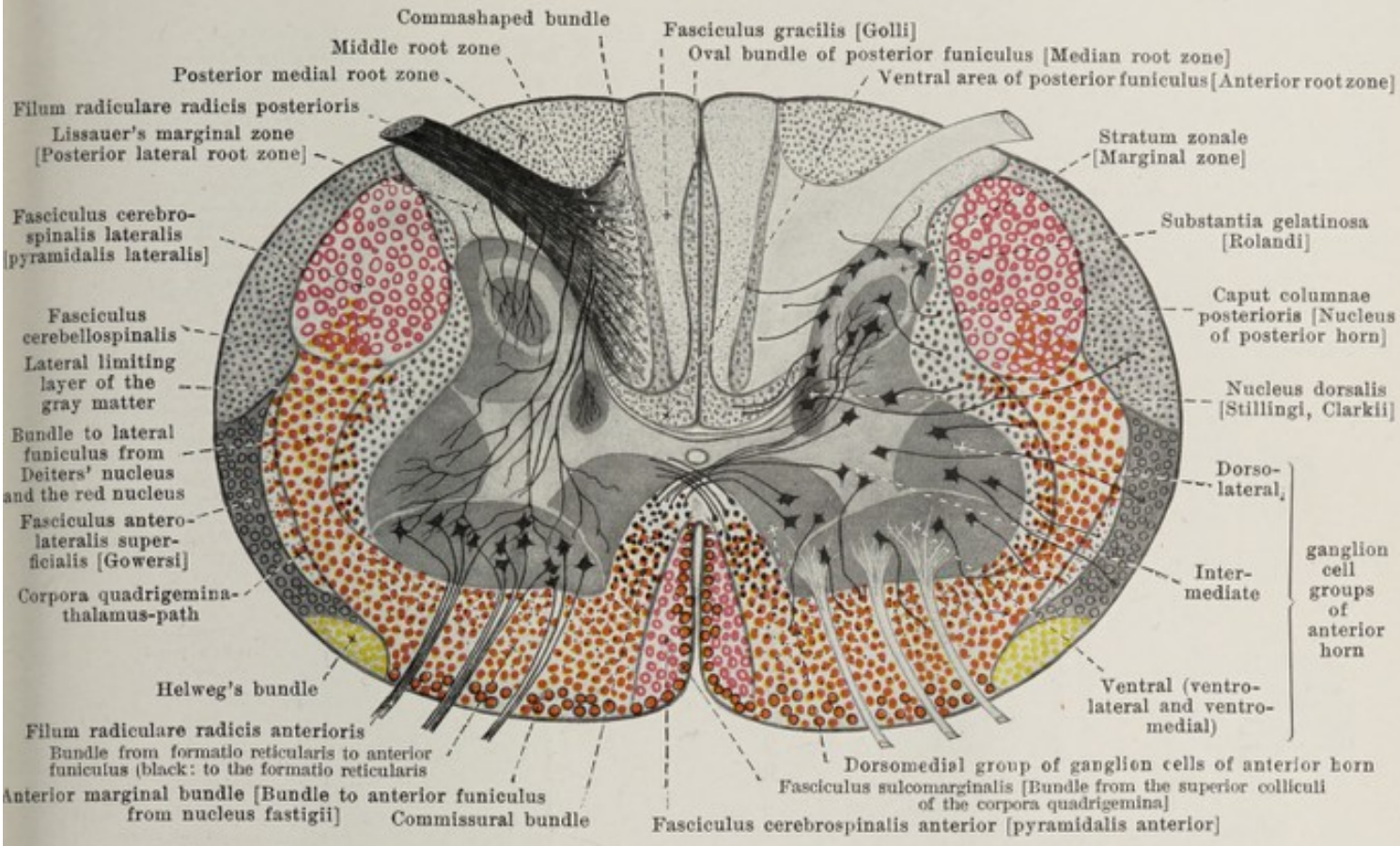
Magnification: ca. 12.5:1.

(The lateral strands are drawn darker than the anterior and posterior strands.)

The sum of the fibres which arise from the cortex of the brain (or end there) and converge fanshaped toward the interbrain forms the so-called *corona radiata* (Fig. 798); they run to the gray matters of the interbrain or further caudalward to the mid-brain, hind-brain, and medulla (see p. 702). According to the relation of the fibres to the various areas of the brain, we distinguish in the corona radiata, a *pars frontalis*, *pars parietalis*, *pars temporalis*, and *pars occipitalis*. The fibres of the capsula interna and capsula externa, which pass into the corona radiata at the upper border of the lenticular nucleus, are designated as *radiatio corporis striati* (see Fig. 798).

The medullary substance of each cerebral hemisphere attains its greatest development above the corpus striatum; on horizontal cross-section at the level of the upper surface of the corpus callosum it appears as a large white field, *centrum semiovale* (see Fig. 768), surrounded on all sides by a coat of gray matter. It contains besides the fibres from the corona radiata and association fibres (see p. 702), also the fibres from the corpus callosum *(radiatio corporis callosi)* (see Figs. 768 and 798). These radiations from the corpus callosum first run horizontally, but later ascend or descend, as the case may be, to the upper or lower parts of the brain. The fibres running forward from the knee of the corpus callosum and arching laterally to the frontal lobe are known as the *pars frontalis* of the *radiatio corporis callosi*, those running sideways to the parietal lobe, as *pars parietalis*. Other fibres from the corpus callosum running backward in a laterally convex arch form the *pars occipitalis;* still others in the temporal region, the *pars temporalis;* these fibres spread over the white layer, or *tapetum*, covering the posterior and inferior horns.

The corpus callosum is the strongest band of fibres, or *commissures*, which connect the two cerebral hemispheres with each other. The *commissura anterior [cerebri]* (see p. 666 and Figs. 748, 761, 771, 797, 799 and 801) runs transversely as a strong fibre bundle over the substantia perforata anterior behind the lamina terminalis and in front of the limbs of the fornix; its chief mass *(pars posterior)* curves downward and backward and runs at the base of the lenticular nucleus to the caudal part of the temporal lobe; a small part *(pars anterior)* runs to the lobus olfactorius. The *commissura hippocampi* (see p. 670) consists chiefly of fibres which run from one hippocampus to the other.



803. Schematic transverse section of spinal cord with conduction paths and groups of ganglion cells. Magnification: circa 12.5 : 1. (Held.)

(All the paths descending from the brain to the spinal cord are in colors, all other paths in the spinal cord, ascending and descending, are indicated in black.)

Brief resumé of the conduction paths of the spinal cord with synonyms. (Held.)

Funiculus posterior.

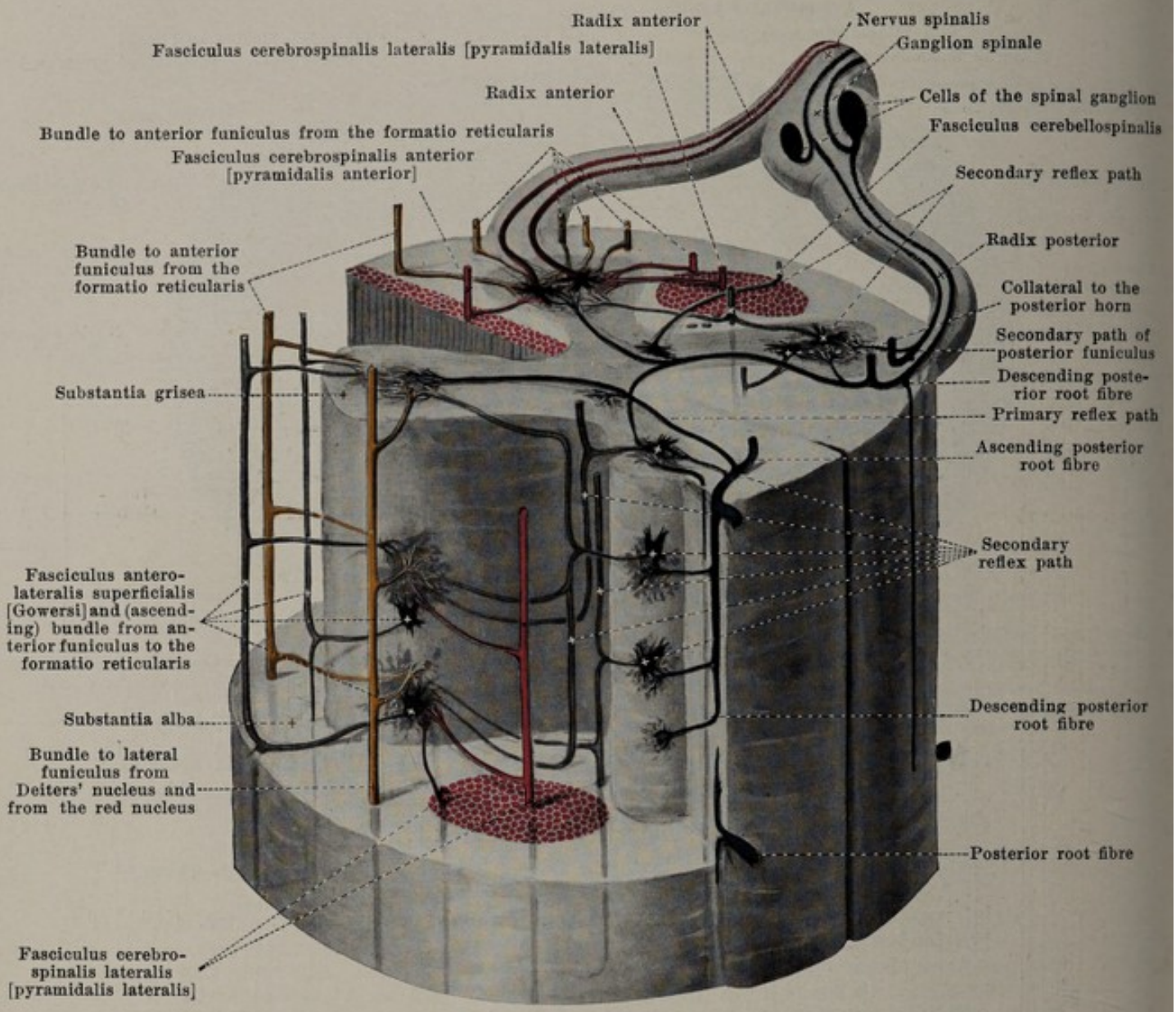
Oval bundle of posterior funiculus = median root zone.
Fasciculus gracilis [Golli] = Goll's tract.
Ventral area of posterior funiculus = anterior root zone
Comma-shaped bundle
Middle root zone
Posterior medial root zone
} Fasciculus cuneatus [Burdachi] = Burdach's fasciculus.
Lissauer's marginal zone = posterior lateral root zone.

Funiculus lateralis.

Fasciculus cerebrospinalis lateralis [pyramidalis lateralis] = lateral pyramidal tract.
Fasciculus cerebellospinalis = direct cerebellar tract.
Fasciculus anterolateralis superficialis [Gowersi] = Gowers' tract = cerebellar tract of anterolateral funiculus.
Lateral limiting layer of the gray matter
Bundle to lateral funiculus from Deiters' nucleus and from the red nucleus
Corpora quadrigemina-thalamus-path
Helwegs' bundle
} Fasciculus lateralis proprius [Flechsigi] = ground bundle of lateral funiculus.

Funiculus anterior.

Bundle to anterior funiculus from formatio reticularis (partly also to the formatio reticularis)
Anterior marginal bundle = bundle to anterior funiculus from the nucleus fastigii (roof-nucleus)
Commissural bundle
} Fasciculus anterior proprius [Flechsigi] = ground bundle of anterior funiculus.
Fasciculus cerebrospinalis anterior [pyramidalis anterior] = anterior pyramidal tract.
Fasciculus sulcomarginalis = path from corpora quadrigemina to anterior funiculus.



804. The most important relations of the nerve-elements of the spinal cord in transverse and longitudinal section, schematic. Magnification: circa 10 : 1. (Held.)

(A part of the gray matter has been exposed on the left side in a piece of spinal cord. The nerve fibres have been drawn in as rigid tubes and the cells have been introduced in the gray matter [supposedly transparent]. The spinal cord is viewed from the left and behind.)

Motor anterior roots red; posterior roots from the spinal ganglion blue; colors otherwise the same as in Fig. 803.)

Conduction paths of the spinal cord (see also Fig. 803). (Held). ***Cross-section relations of the posterior roots:*** to the posterior horn of the same and of the opposite side, to Clarke's column and to the anterior horn *(reflex bundle of the sensory roots of the spinal cord).* The ***funiculi of the spinal cord*** are derived, aside from the areas of the posterior funiculus which come from the limbs of bifurcation of the posterior roots themselves, from the different *funicular cells of the gray matter* (see their arrangement also in Fig. 803), or they are the *continuations of conduction paths,* the origins of which are situated above the spinal cord in the brain-stem, cerebellum or cerebrum.

All funiculi of the spinal cord have, by means of their collaterals, cross-section relations with the gray matter of the spinal cord and its cell-groups.

The **origin of the conduction paths descending to the spinal cord** (indicated in colors in Fig. 803) is as follows: ***the pyramidal tract*** (red) comes from the anterior central gyrus (of the same and of the opposite side, decussation of pyramids see Figs. 778 and 807); the ***anterior marginal bundle*** comes from the roof-nucleus (nucleus fastigii) (see Fig. 796), perhaps also from other gray masses of the cerebellum (of the same and of the opposite side). The ***fasciculus sulcomarginalis*** arises as the *optic-acoustic reflex path* (see also p. 698) in the middle gray matter of the superior colliculus (see Fig. 795), in largest part crosses in the *dorsal decussation of the tegmentum* (see Figs. 786 and 795) and then passes into the brain-stem in the *fasciculus longitudinalis medialis* (O. T. *posterior longitudinal bundle)* (see Figs. 778—785 and 788—794) downward to the spinal cord; individual fibres in the more lateral areas of the anterior and lateral funiculi (not designated) have the same origin. The origin of the orange-colored area is in three places: 1. In Deiters' nucleus (nucleus n. vestibularis lateralis) (see Figs. 791 and 805) of the same side; this system passes as the *bundle of the lateral funiculus from Deiters' nucleus* obliquely through the formatio reticularis (see Figs. 782, 791 and 792) and runs through the medulla oblongata in the area occupied by Gowers' tract (see Figs. 778—781 and 788—790). 2. In the red nucleus of the tegmentum (nucleus ruber tegmenti) of the opposite side; this bundle goes through the *ventral decussation of the tegmentum* (see Fig. 795) into the lateral lemniscus of the opposite side (see Figs. 784 and 794), then perforates the trapezoid body (corpus trapezoideum) (see Figs. 782, 783, 792 and 793) and as the *bundle of the lateral funiculus from the red nucleus* joins that from Deiters' nucleus (see Figs. 781—783 and 790—793). 3. In the three lateral nuclei of the formatio reticularis (nucleus lateralis inferior see Figs. 780 and 781, medius see Fig. 783, superior see Fig. 786); its fibres lie in large part in the *fasciculus longitudinalis medialis* (O. T. posterior longitudinal bundle), in part also in the longitudinal strands of the formatio reticularis (substantia reticularis alba) (see Fig. 778—786 and 788—795).

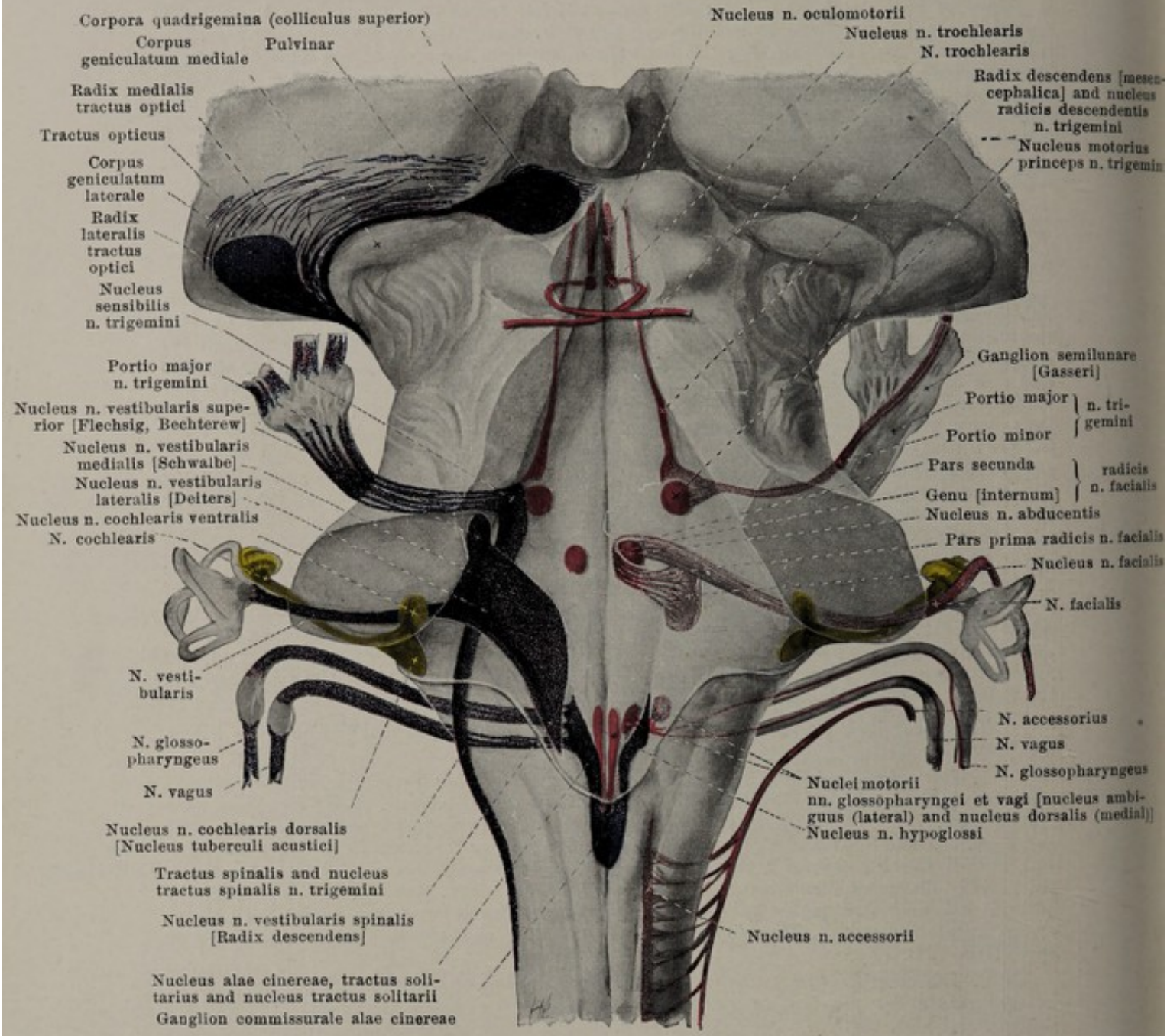
The *other descending conduction paths in the spinal cord* come from three sources: 1. From the posterior roots (origin: spinal ganglia); these lie partly in *Lissauer's marginal zone,* partly in the *middle root zone.* 2. From the cells of the posterior horn (stratum zonale see Fig. 803); these run partly in the *comma-shaped bundle,* in the *ventral area of the posterior funiculus* and in the *lateral limiting layer of the gray matter,* partly also in *Lissauer's marginal zone.* 3. From the cells of the anterior horn; these lie partly in the anterior, partly in the lateral funiculi.

The **ascending systems of the spinal cord** (see Figs. 803 and 804) are the following three:

1. ***Direct continuation of the posterior roots;*** these run in the posterior funiculus to the nucleus fasciculi gracilis and nucleus fasciculi cuneati. Their *secondary path* arising here, crosses in the *sensory (fillet) decussation (decussatio lemniscorum)* (see p. 687 and Figs. 779 and 788) and goes as the *interolivary layer (stratum interolivare lemnisci)* and *medial fillet (lemniscus medialis [sensitivus])* to the ventrolateral nucleus of the thalamus, partly directly to the somaesthetic area (see Figs. 779—786, 789—795 and 806—812) and crossed and uncrossed partly by way of the fibrae arcuatae externae and in the path of the corpus restiforme (see p. 700) to the nucleus dentatus and worm of the cerebellum (see Figs. 789—792).

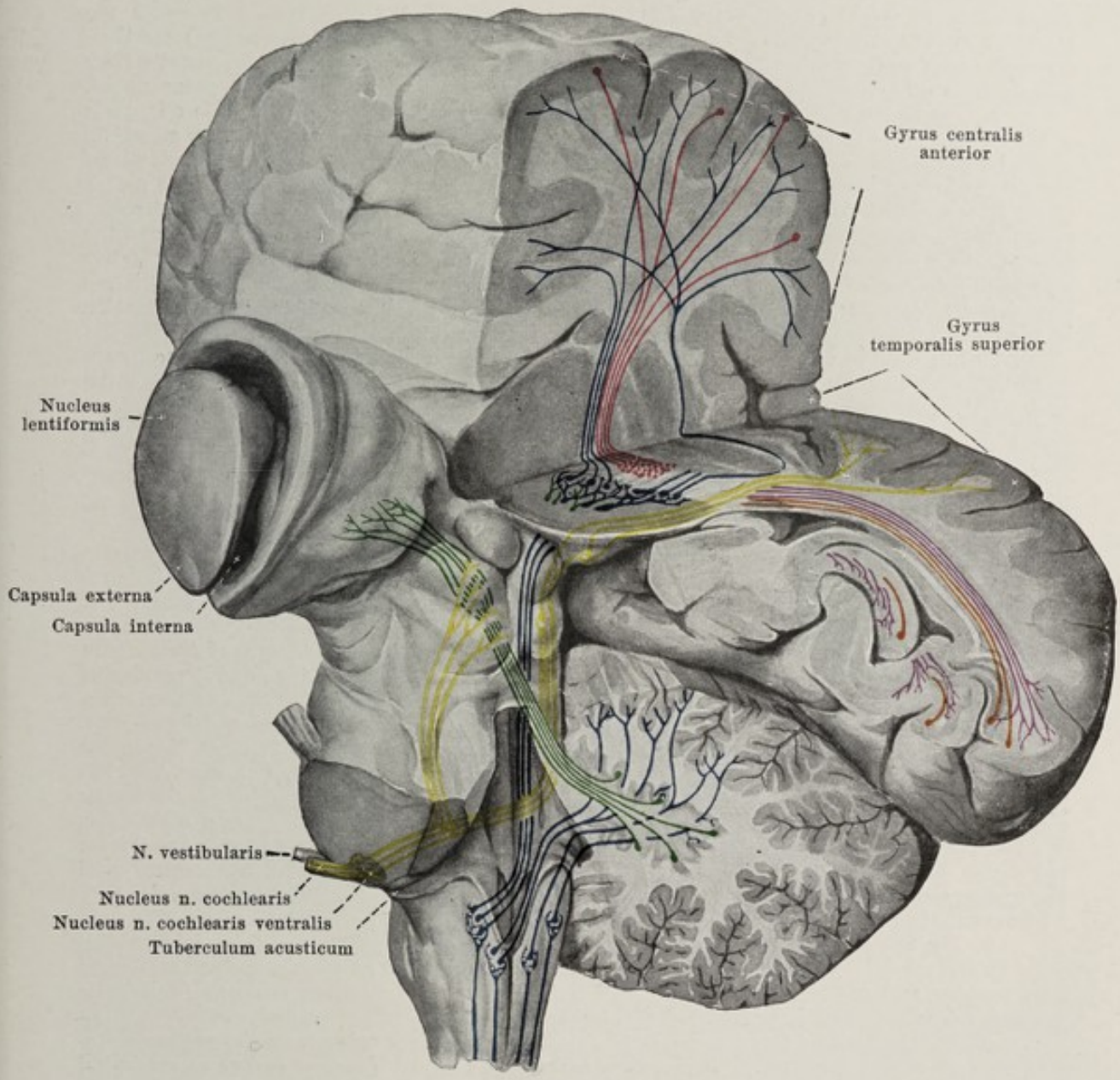
2. The ***conduction paths superimposed upon this primary sensory path of the posterior funiculus*** are derived from the cells of the posterior horn, of Clarke's column, and also, partly, of the anterior horn, around which collaterals of the posterior roots break up. The conduction paths arising from the posterior horn go partly into the posterior funiculus of the same side and into the lateral funiculus of the same side *(lateral limiting layer of the gray matter),* partly also into the opposite anterior funiculus (by way of the *anterior white commissure).* The cells of Clarke's nucleus send their axones by way of the homolateral *direct cerebellar tract, fasciculus cerebellospinalis,* (contained above in the corpus restiforme) (see Figs. 778—783 and 788—792) to the cortex of the upper surface of the worm. The anterior horn cells concerned send their axis-cylinder-processes probably in the area of the homolateral *Gowers' tract (fasciculus anterolateralis superficialis [Gowersi], cerebellar path of anterolateral funiculus)* (see Figs. 778—784 and 788—793) to the inferior surface of the worm and into the *commissural bundle* whence their course and end is unknown.

3. The ***conduction paths arising from the anterior horn cells*** are partly short, running in the ground bundles of the anterior and lateral funiculi and then bend back into the gray matter, partly long, extending upward as far as the formatio reticularis to end in an unknown manner.



805. Nuclei of origin of motor and primary terminal nuclei of sensory cerebral nerves, schematically represented in a supposedly transparent brain-stem, viewed from behind (see also Figs. 751 and 757). Magnification: 2:1. (Held.)

(Nuclei and roots of motor nerves red, of sensory reddish-violet, of the n. cochlearis yellow and of the n. opticus bluish-violet.)



806. Course of some of the greater conduction paths in the brain (see also Figs. 807 and 808). (Held.)

On the left side the cerebellum has been completely removed as well as the cerebrum with the exception of the large ganglia; on the right side the posterior superior part of the cerebral hemisphere has been removed by a vertical (not exactly frontal) and a horizontal section.

The brain is viewed from the left and from behind.

Pyramidal tract red; **path from the ventrolateral nucleus of the thalamus to the somaesthetic area** blue; **posterior funiculi, nuclei of posterior funiculi** and further portions of the same conduction paths, viz.: 1. **medial lemniscus** (crossed) to the ventrolateral nucleus of the thalamus, 2. part of the **corpus restiforme** (of the same and of the opposite side) to the nucleus dentatus and to the cortex of the vermis blue; **cochlear nerve** and **auditory conduction path** yellow; **primary** (corticopetal) **optic radiation** violet, **secondary** (corticofugal) orange; **brachium conjunctivum** green.

Origin and central conduction paths of the cerebral nerves. (Held.)

The **motor cerebral nerves** arise in definite gray masses of the brain-stem, their so-called *nuclei of origin (nuclei originis)*. On the other hand, the gray masses in which the **sensory cerebral nerves** first enter and branch up (nuclei of the sensory nerves) are their *terminal nuclei* or their primary domains of termination, while their origin must be sought in their ganglia situated outside the brain. The *secondary paths* proceed from the primary terminal nuclei.

1. The **nervus olfactorius** arises in the bipolar olfactory cells of the regio olfactoria of the nasal mucous membrane; its primary domain of termination lies in the olfactory glomeruli of the bulbus olfactorius. From this a secondary path proceeds from the mitral cells and forms the nerve fibres of the *tractus olfactorius* (see p. 665). A part of the latter ends in the cortex of the trigonum olfactorium; a second part, the *lateral olfactory root (stria olfactoria lateralis)*, runs to the uncus, whence further paths go to the hippocampus, the gyrus hippocampi and the half of the gyrus fornicatus adjoining the corpus callosum. The *intermediary root (stria olfactoria intermedia)* penetrates into the substantia perforata anterior and the *medial olfactory root (stria olfactoria medialis)* passes to the gyrus subcallosus. These domains of termination in the cortex form together the *olfactory sphere* (see Fig. 801).

2. The sensory cells of the retina are connected by the bipolar nerve cells of the innner granular layer with the large ganglion cells of the retina; from these arises the **nervus opticus**, which undergoes partial decussation with the optic nerve of the other side in the *chiasma opticum*, whereby the largest part (from the nasal half of the retina) passes into the opposite tractus opticus, a smaller part (from the temporal side of the retina) into the tractus of the same side. The tractus opticus, which therefore contains nerve fibres from both retinae, ends in the corpus geniculatum laterale and in the pulvinar thalami as well as in the superficial and middle gray matter of the superior colliculus (see Figs. 786 and 805). The corticopetal *primary optic radiation* runs from the geniculate body and thalamus in the *radiatio occipitothalamica [Gratioleti]* occipitalward along the posterior horn of the lateral ventricle (separated from it by the tapetum) to the visual sphere lying around he fissura calcarina and characterized by the linea Gennari (see Figs. 801, 806 and 808—812). Fibres run also in the opposite direction (corticofugal) from the visual sphere to the superior colliculus of the corpora quadrigemina *(secondary optic radiation)*. In the middle gray matter of the superior colliculus arises the *optic-acoustic reflex path* (see p. 695), innervates the nuclei of the nn. oculomotorius, trochlearis and abducens and descends to the spinal cord (see Figs. 778—786 and 788—795).

3. The **nervus oculomotorius** arises in the *nucleus n. oculomotorii*, which lies in the floor of the substantia grisea centralis at the level of the superior colliculus (see Figs. 786, 795 and 805). The ganglion cell-groups lying in the dorsal trough of the fasciculus longitudinalis medialis form the lateral nucleus, which especially innervates the extrinsic muscles of the eye. A small part of the n. oculomotorius crossing the middle line between the two nuclei arises from the distal portion of the nucleus of the other side. From the cortex of the central gyri the oculomotorius nucleus, like that of the n. trochlearis, in all probobility receives voluntary innervation; the path passes through the base of the cerebral peduncle.

4. The **nervus trochlearis** arises from the *nucleus n. trochlearis* situated just caudalward to the previous nucleus (see Fig. 785); it passes dorsalward at the margin of the central gray matter and undergoes total decussation in the velum medullare anterius *(decussatio nervorum trochlearium)* (see Figs. 794 and 805).

5. **N. trigeminus** (see Fig. 805). The motor *portio minor* arises from the *nucleus motorius princeps n. trigemini*, the *locus caeruleus* and the cell column *(nucleus radicis descendentis)* accompanying the *radix descendens [mesencephalica] n. trigemini*, which reaches upward at the margin of the central gray matter almost as far as the level of the commissura posterior (see Figs. 783—785, 793 and 794). The sensory *portio major* arises from the *ganglion semilunare [Gasseri]*, perforates the pons and, bifurcating, ends partly in the *nucleus sensibilis n. trigemini*, partly descending as the *tractus spinalis n. trigemini* in the gray mass *(nucleus tractus spinalis)* adjacent to it (see Figs. 778—783, 788—792 and 796). From the sensory trigeminus nucleus a reflex path passes to the motor trigeminus nucleus of the same and of the opposite side; upon these also collaterals of the radix descendens influence. Similarly a path to this motor nucleus of origin arises from the nucleus tractus spinalis n. trigemini by way of the fibrae arcuatae internae at the level of the facial nucleus. In addition secondary cortical paths extend from the terminal nucleus of the tractus spinalis partly in the crossed interolivary layer, partly in fields of the formatio reticularis of the same and of the opposite sides; they finally, through intercalation of the ventrolateral nucleus of the thalamus, become connected with the cortex of the somaesthetic area. The voluntary cortical path for the motor nucleus of the n. trigeminus runs in part in the pyramidal tract; it arises in the inferior third of the anterior central gyrus and in the feet of the frontal gyri in front of it (see Fig. 811).

6. **N. abducens.** It arises from the *nucleus n. abducentis*, which lies just in front of the genu [internum] radicis n. facialis on the floor of the fourth ventricle (see Figs. 782, 792 and 805). The cortical path for its voluntary innervation is probably the pyramidal tract.

807. Course of the pyramidal tract (red) **and of the cerebropontile paths** (temporal: light-brown; frontal: dark-brown); **end of auditory conduction path** (yellow) **and indirect continuation of medial lemniscus and brachium conjunctivum from the ventrolateral nucleus of the thalamus** (blue), introduced into Fig. 798. (Held.)

7. **N. facialis** (see Figs. 782, 791, 792 and 805). Its nucleus of origin, *nucleus n. facialis,* lies in the ventral part of the formatio reticularis at about the middle of the dorsoventral diameter of the pons. It is innervated by the lower third of the anterior central gyrus (see Fig. 811) by way of the pyramidal tract, which gives off arcuate fibres, partly to the nucleus of the same side, partly to that of the opposite side, through the raphe of the medulla oblongata. The *radix n. facialis* at first passes *(pars prima)* dorsal- and medianward as far as the floor of the rhomboid fossa, there loops in front of the colliculus facialis with a sharp bent *(genu [internum])* around the nucleus of the n. abducens and then *(pars secunda)* goes ventral- and lateralward to the site of emergence.

The central connections of the *n. intermedius* have been insufficiently worked out in man.

8. **N. acusticus.** It consists of the *n. vestibularis* and the *n. cochlearis* (see Fig. 805).

a) The *n. vestibularis* arises in the *ganglion vestibulare;* its central root ends in the region of the floor of the rhomboid fossa in the *nucleus nervi vestibularis lateralis [Deiters], nucleus medialis [Schwalbe]* and *nucleus superior [Flechsig, Bechterew]* (see Figs. 780—782, 791, 792 and 796). Another part passes downward as the *radix descendens* and ends in the gray mass accompanying it *(nucleus n. vestibularis spinalis)* (see Figs. 780, 781, 789 and 790). Reflex paths pass from Deiters' nucleus to the lateral funiculus of the spinal cord, from the medial and superior nuclei to the fasciculus longitudinalis medialis of both sides,

a part, after innervation of the nucleus n. abducentis of the same side passing to the nucleus n. trochlearis and nucleus n. oculomotorii of the opposite side. Farther, fibrae arcuatae internae extend from the terminus of the n. vestibularis to the lateral areas of the formatio reticularis of both sides; of these a part acts upon the motor trigeminus nucleus and farther up upon the oculomotorius nucleus, arriving finally in the ventrolateral nucleus of the thalamus; hence connection is made with the somaesthetic area. Special paths from the lateral and superior nuclei connect with the nucleus fastigii of the cerebellum, the nucleus dentatus and the cortex of the vermis.

b) The *nervus cochlearis* arises from the *ganglion spirale;* its central root perforates the posterior, lateral margin of the pons and ends in the *nucleus n. cochlearis ventralis* and the *nucleus n. cochlearis dorsalis [nucleus tuberculi acustici]* (see Figs. 781, 790, 791 and 796). From the latter proceed the inconstant striae medullares; from the ventral nucleus arises the corpus trapezoideum, the nerve fibres of which are supplemented by others from the upper olive and the trapezoid nucleus. The upward continuation of the trapezoid body is the *lateral lemniscus (lemniscus lateralis [acusticus]);* it carries fibres from the corpus trapezoideum of both sides, also fibres from the *nucleus lemnisci lateralis* and ends in the nucleus of the inferior colliculus of the same and of the opposite side, as well as in the middle gray matter of the superior colliculus (see also optic-acoustic reflex path p. 695). Another part, supplemented by paths from the inferior colliculi, goes to the corpus geniculatum mediale, or directly over into the higher conduction path, extending from this geniculate body to the cortex of the gyri temporales transversi *(auditory sphere)* (see Figs. 805—811).

9. 10. **N. glossopharyngeus** and **n. vagus** (see Fig. 805). Their motor fibres arise partly in the *nucleus dorsalis nn. glossopharyngei et vagi* (medial from the ala cinerea), partly in the *nucleus ventralis [nucleus ambiguus]*, which lies in the formatio reticularis dorsal from the dorsal accessory olive (see Figs. 780, 781 and 789). Their sensory fibres arise in the *ganglion superius* and *petrosum n. glossopharyngei,* and in the *ganglion jugulare* and *nodosum n. vagi* and pass upward in an oblique direction from the lateral margin of the medulla oblongata to the ala cinerea. Through bifurcation of their nerve fibres the *tractus solitarius* arises. Their primary terminal domain is the *nucleus alae cinereae,* the *nucleus tractus solitarii* and the *ganglion commissurale alae cinereae* (see Figs. 779—781, 788 and 789). Reflex fibres extend to the dorsal vago-glossopharyngeal and to the hypoglossal nucleus. The secondary paths lie in the lateral areas of the formatio reticularis of the same and of the opposite side, as well as in the crossed interolivary layer. Fibres from the pyramidal tract pass to the motor nuclei.

11. **N. accessorius.** Its upper bundles arise along with the motor portion of the vagus, the lower spinal bundles, on the other hand, from the dorsolateral group of anterior horn cells as far down as the 5^{th}—7^{th} cervical segment (see p. 686 and Fig. 805).

12. **N. hypoglossus** arises in the *nucleus n. hypoglossi* in the floor of the rhomboid fossa and in the central gray matter at the end of the central canal (see Figs. 780, 789 and 805). The nuclei receive voluntary innervation from the pars frontalis of the operculum (see Fig. 811) by way of the pyramidal tract through fibres running upward in the raphe which dominate both nuclei.

Connections of the cerebellum. (Held.)

The conduction paths of the cerebellum on each side ending or arising in its gray cortex and its subcortical ganglia lie chiefly in three great bundles, which are distinguished macroscopically as the *restiform body,* the *arm of the pons* and the *connecting arm.* Macroscopically inseparable from the restiform body is a fourth bundle called the *medial part of the corpus restiforme.*

1. The ***corpus restiforme*** (O. T. inferior cerebellar peduncle) unites the *paths from the spinal cord and the medulla oblongata.* These arise

a) from Clarke's column of the same side *(direct cerebellar tract)* (see p. 695). [A path parallel to the direct cerebellar tract is the *cerebellar path of the anterior funiculus (Gowers' tract)* (see also p. 695), which runs on the more ventral surface of the medulla oblongata, is covered later by the pons, then loops around the lateral lemniscus and the brachium conjunctivum, and, passing along the velum medullare anterius, ends in the vermis (see Figs. 778—784, 788—793 and 803)];

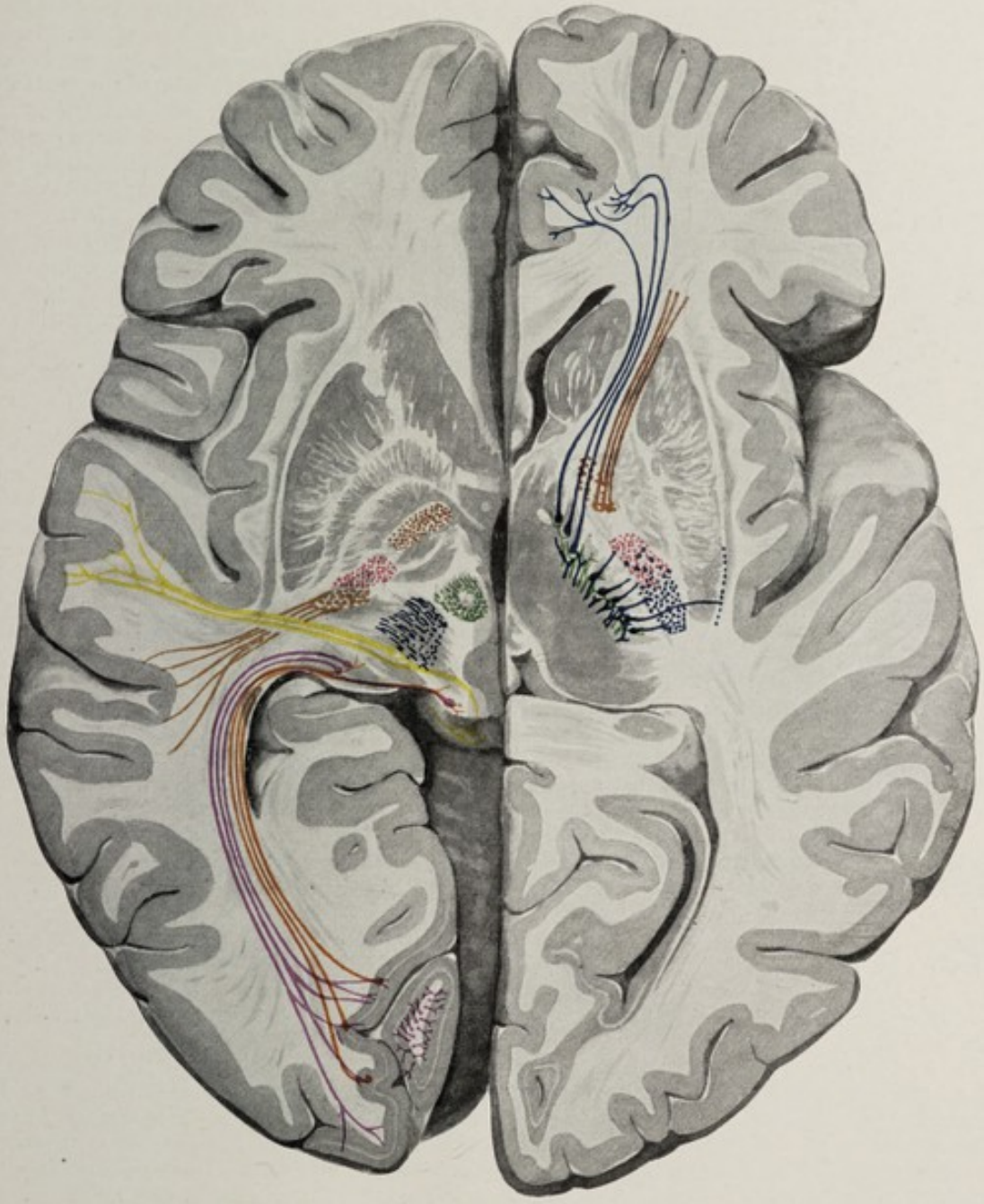
b) from the nuclei of the posterior funiculi of the same and of the opposite side (sensory decussation, *fibrae arcuatae internae* and *externae)* (see Figs. 779 and 788);

c) from the inferior olives of the same and of the opposite side *(fibrae cerebelloolivares)* (descending paths also run in this *olive-worm-path)* (see Figs. 780, 781, 789 and 790);

d) from the nucleus of the lateral funiculus.

The corpus restiforme ends in the nucleus dentatus, nucleus emboliformis and nucleus globosus (chiefly through collaterals), the nucleus of the roof and in the cortex of the vermis (see Figs. 791, 792, 796 and 806).

2. The ***medial part of the corpus restiforme*** (see Fig. 792) consists in large part of the *direct sensory cerebellar path,* which passes from the terminal nuclei of the nn. glossopharyngeus, vagus, vestibularis and trigeminus to the nucleus of the roof and the cortex of the vermis. There are also descending paths which go from here partly directly by way of the formatio reticularis into the anterolateral funiculus of the spinal cord, in large part, however, indirectly, ending in Deiters' nucleus, from which a bundle descends to the lateral funiculus.



808. Position of the pyramidal tract (red), **secondary optic radiation** (orange), **frontal pontile path** (dark-brown), **temporal pontile path** (light-brown), **auditory conduction path** (yellow), **primary optic radiation** (violet), **medial lemniscus** (blue), **brachium conjunctivum** (green), **cortical path from the ventrolateral nucleus of the thalamus** (blue), introduced into Fig. 801. (Held.)

3. The ***arms of the pons,*** *brachia pontis,* (O. T. middle cerebellar peduncles) arise in the cortex of the cerebellar hemispheres and end in the nuclei pontis of the same and of the opposite side; paths in the opposite direction also exist. Farther continuations are a) the *median descending pontile path* (see Figs. 782—785), which penetrates the tegmentum of the pons and hence in part descends to the spinal cord, in part ascends toward the corpora quadrigemina, as well as b) the *corticopetal fibres of the cerebropontile paths* (chiefly of the temporal).

4. The ***connecting arms,*** *brachia conjunctiva,* proceed chiefly from the nucleus dentatus (supplemented by paths from the nucleus fastigii and the cortex of the vermis), decussate in the raphe of the tegmentum, become connected by collaterals with the red nucleus, which, through its bundle to the lateral funiculus, innervates the opposite half of the spinal cord, and end in large part finally, together with the medial lemniscus, in the ventrolateral nucleus of the thalamus, whence the cortical path passes to the somaesthetic area (see Figs. 797, 806 and 808).

Connections of the cerebrum. (Held.) The white substance of the cerebrum contains 1. proper, endogenous conduction paths, the *association fibres,* which unite spatially separated and functionally non-equivalent gyri of the cortex with one another, 2. those which bring the cerebral cortex (or parts homologous with it: nucleus caudatus, putamen) into relation with the thalamus, the so-called *corona radiata of the thalamus (radiation of the thalamus),* 3. paths which connect the cerebral cortex with lower regions of the central nervous system (brain-stem, medulla oblongata, spinal cord) and which are contained in the stem-bundles. The two latter form the system of *projection fibres* and include the sensory conduction paths as well as the motor paths which transfer the voluntary impulses of the cerebral cortex to the lower nuclei of origin of the individual muscle nerves.

I. The ***association fibres*** are intercortical conduction paths, and as such unite either different gyri of the same hemisphere or of the two hemispheres. The latter are contained in the corpus callosum, the anterior commissure and the commissura hippocampi.

II. While the association fibres run more superficially beneath the cortex and follow its surface, the ***radiation of the thalamus*** presents a fan-like arrangement toward the depth. It is arranged in the gross form of the so-called *peduncles of the thalamus,* the anterior, superior, posterior and inferior peduncles, converging from the frontal, parietal, occipital and temporal lobes respectively to the thalamus, and there helping to form, on its outer surface and on that of the nucleus caudatus, the capsula interna. Ascending and descending conduction paths are to be distinguished in this radiation *(Stabkranz).*

1. The *ascending conduction paths* of the radiation carry the different sensory paths to the sense centres of the cerebral cortex (see Figs. 806—812):

a) From the ventrolateral nucleus of the thalamus to the cortex of the *somaesthetic area* (see Figs. 811 and 812); these are the continuations of the medial lemniscus, of the lateral areas of the formatio reticularis and of the brachia conjunctiva (see Fig. 806). (A small part of the first mentioned goes directly through the thalamus without interruption.) They lie in larger part in the posterior third of the capsula interna (see Fig. 808), in smaller part also, after perforating or encircling the nucleus lentiformis from below, in the capsula externa (see Fig. 806).

b) Behind this the *auditory conduction path* emerges from the internal capsule; it runs transversely a little behind the free posterior margin of the nucleus lentiformis and passes directly lateralward to the cortex of the gyrus temporalis superior and gyri temporales transversi (see Fig. 809).

c) The *visual conduction path (primary optic radiation* of Flechsig), emerging lateralward and below the pulvinar and lateral geniculate body, runs straight occipitalward to the cortex about the fissura calcarina *(visual sphere)* (see also p. 698 and Fig. 810).

2. *Descending conduction paths.* They arise in general from the pyramidal cells of the cerebral cortex and end in part in the subcortical ganglia of the cerebrum or in the mid-brain. Here belong, among others:

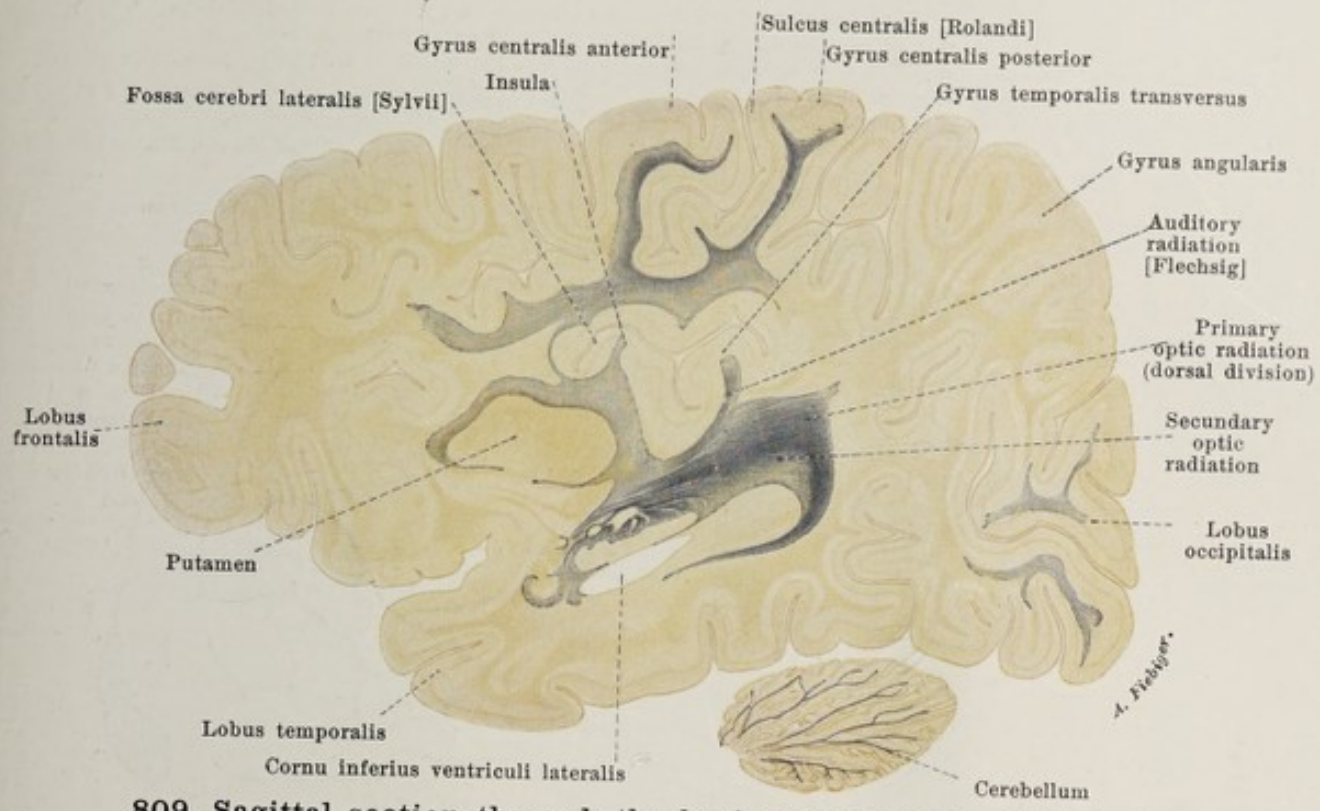
A) The part of the fornix which as the fimbria proceeds from the cortex of the hippocampus, and as the columna fornicis ends in the corpus mamillare of the same and of the opposite sides, whence the path is continued, partly as the *fasciculus thalamomamillaris [Vicq d'Azyri]* to the anterior nucleus of the thalamus (see Figs. 773 and 798), partly as the *fasciculus tegmentomamillaris* to the tegmentum of the base of the cerebral peduncle. Here belongs also the *secondary visual conduction path (secondary optic radiation)* (see also p. 698 and Figs. 806, 808 and 810), which acts upon the superior colliculus.

B) Of the descending conduction paths of the cortex a large part passes through the capsula interna directly into the base of the cerebral peduncle and ends at varying depths (see Figs. 787, 807 and 808):

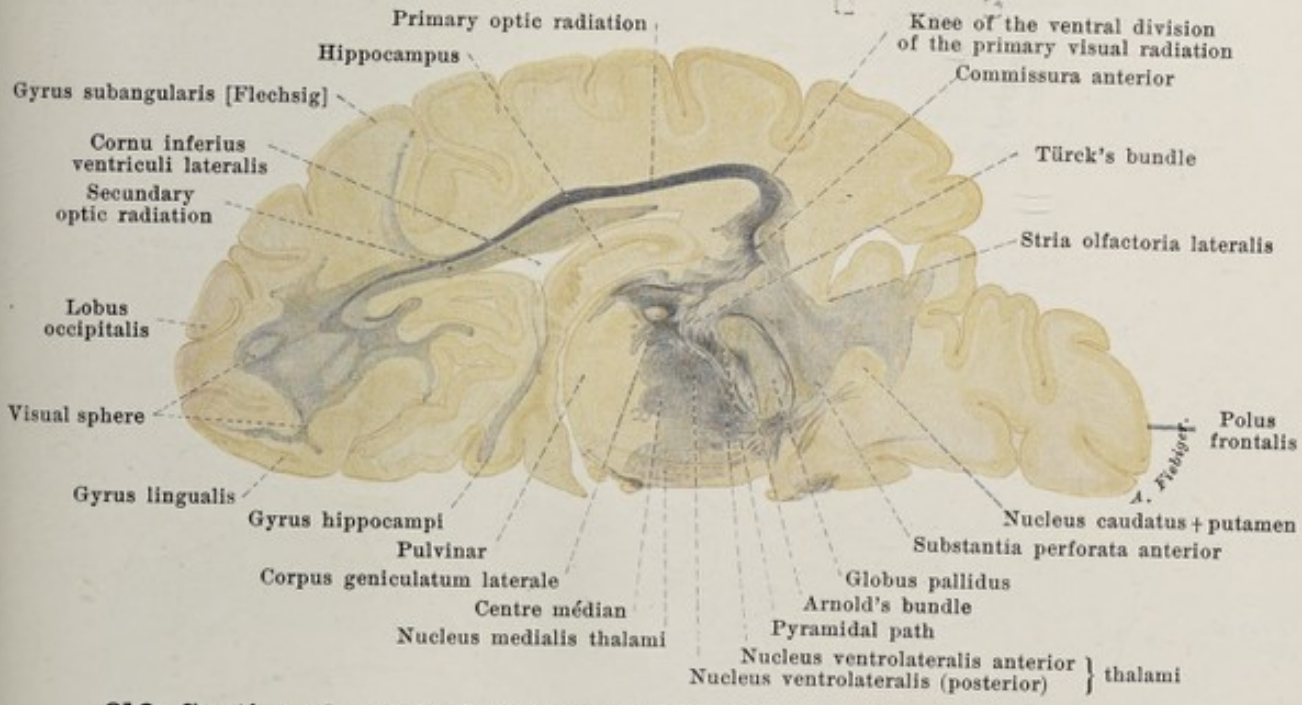
a) *Frontal [cerebro]pontile path (Arnold's bundle).* It arises from the frontal layers of the somaesthetic area and ends in the gray matter of the pons. On its way it lies in the anterior (frontal) areas of the internal capsule, and farther down in the medial part of the base of the cerebral peduncle. Toward the pyramidal tract lie special motor conduction paths for the nuclei of the motor cerebral nerves *(corticobulbar path).*

b) *Temporal [cerebro]pontile path (Türck's bundle).* It unites the temporal lobe with the pons. It lies in the most posterior part of the capsule, which it, together with the auditory conduction path, bounds; farther down, in the base of the cerebral peduncle, it lies lateral from the pyramidal tract.

c) *Pyramidal tract.* It arises in the large pyramidal cells of the anterior central gyrus. Besides the motor fibres for the nuclei of the cerebral nerves, it carries also chiefly fibres for the motor anterior horns of the spinal cord. In the internal capsule the paths for the motor nerves of the upper extremity lie more frontalward and are separate from those for the lower extremity.



809. Sagittal section through the brain of a 7 weeks old infant.

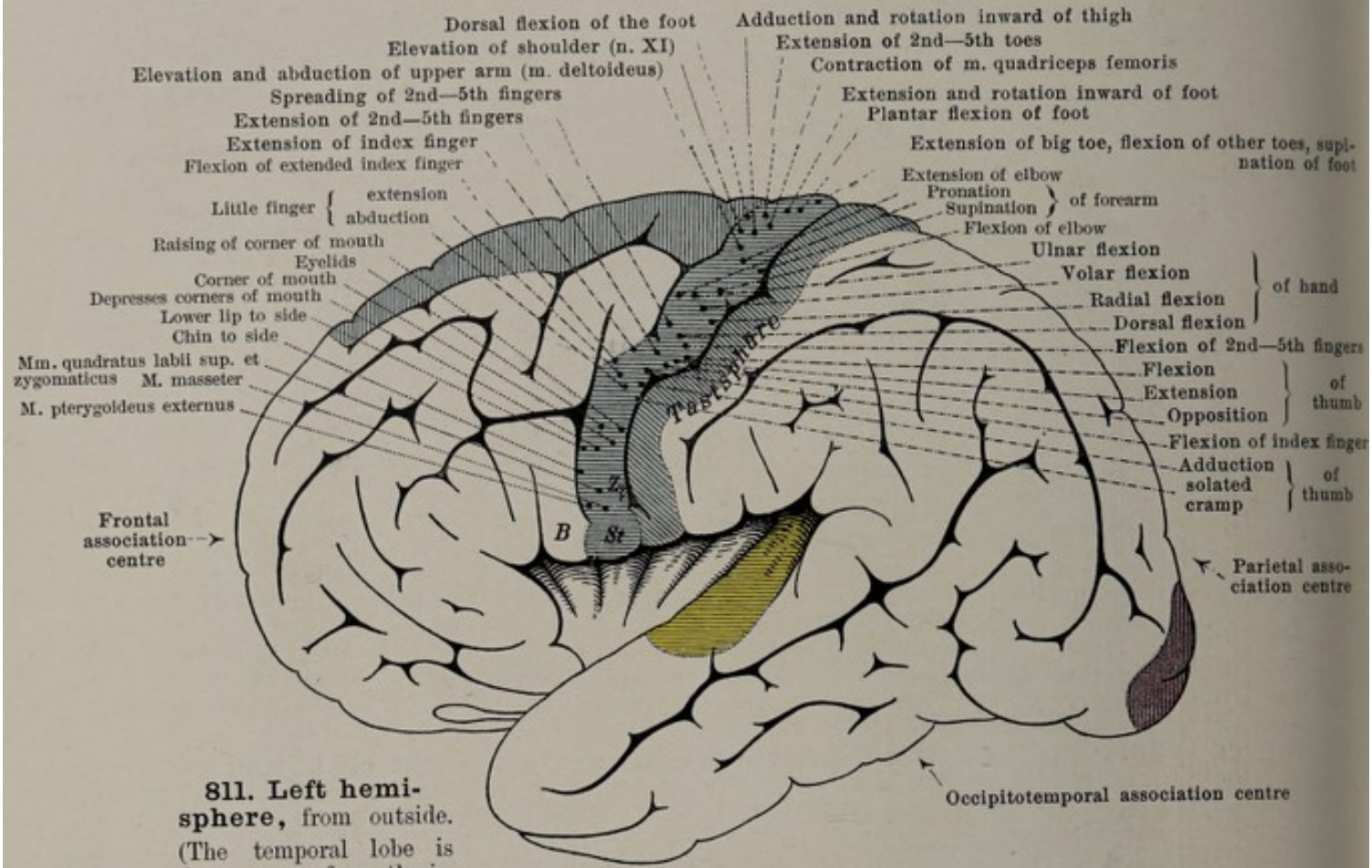


810. Section through the cerebral hemisphere of a 16 days old infant.

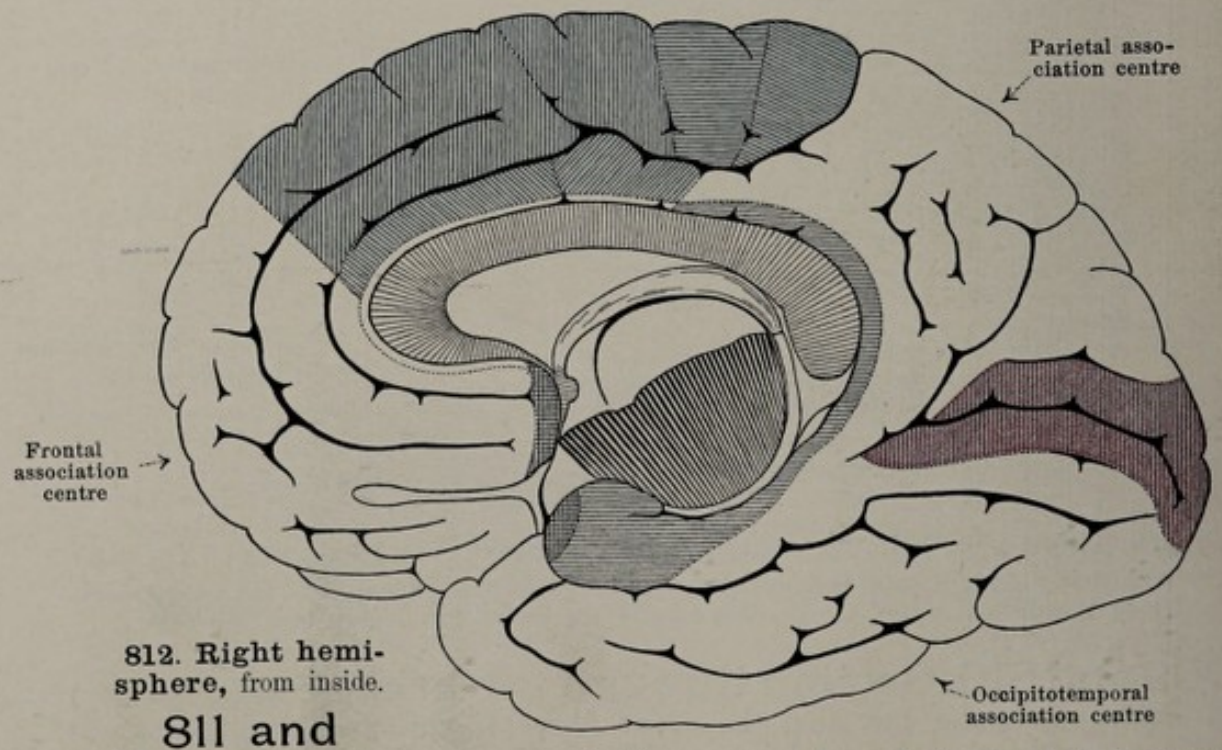
The section is made obliquely and deviates from the horizontal plane so that, the border neighboring the median plane (the lower border of the figure) lies higher than the convex.

809 and 810. Section through the brain (after P. Flechsig) to demonstrate the fact that the nerve fibres of various central paths are ensheathed by medulla at different times. Natural size.

(The medullated nerve fibres are blue.)



811. Left hemisphere, from outside. (The temporal lobe is drawn away from the island to expose the transverse gyri [Flechsig].) The dots indicate the points of electric stimulation after F. Krause. Z(?) = Tongue; St = Vocal cords; B = Broca's convolution.

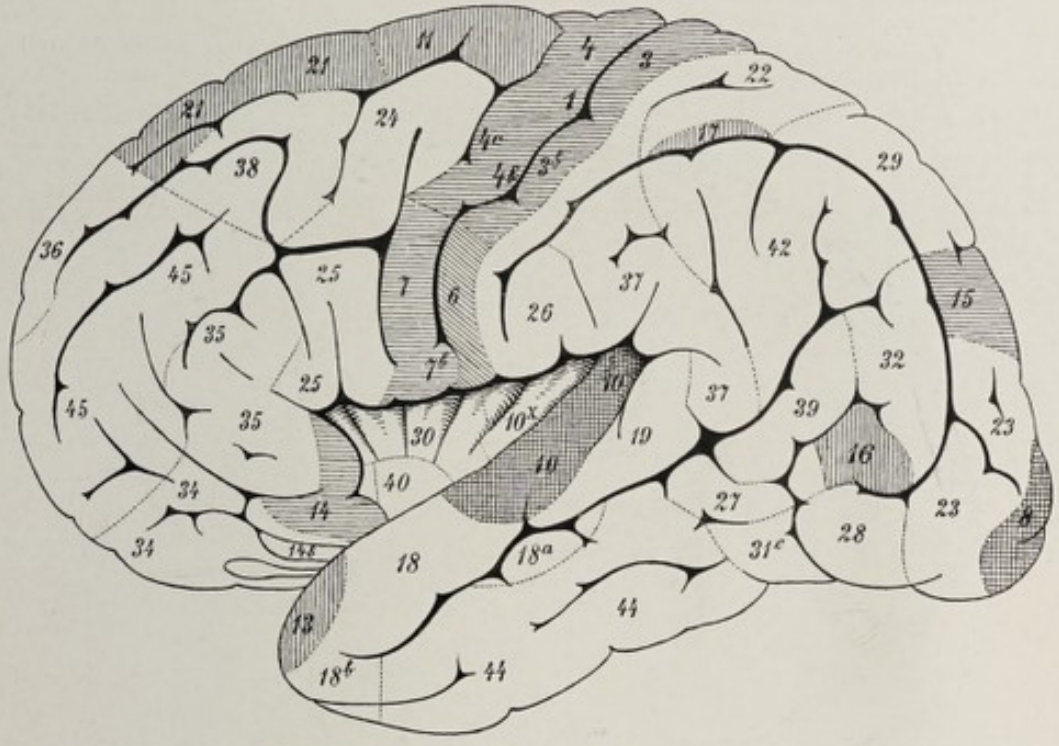


812. Right hemisphere, from inside.

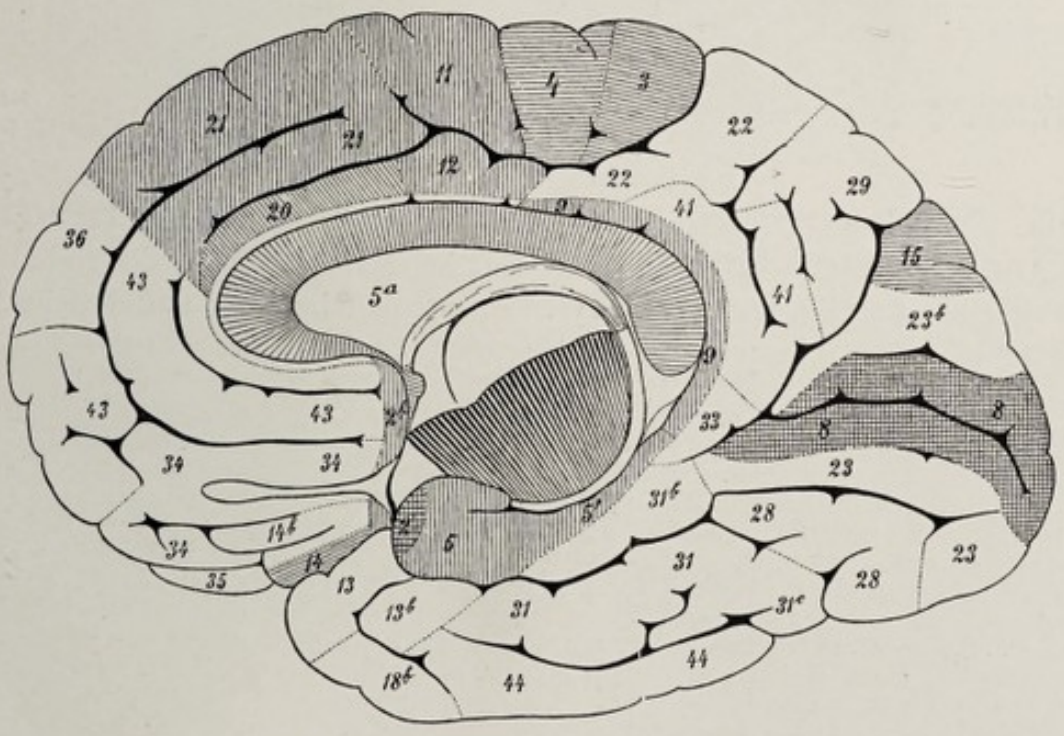
811 and 812. Cortical areas of the cerebral hemispheres

(after P. Flechsig). (For names of gyri, sulci etc. see Figs. 759—762.)

Sphere of general sensibility and mobility blue; olfactory and gustatory (?) spheres dotted blue, visual sphere violet, auditory sphere yellow, association centres white.



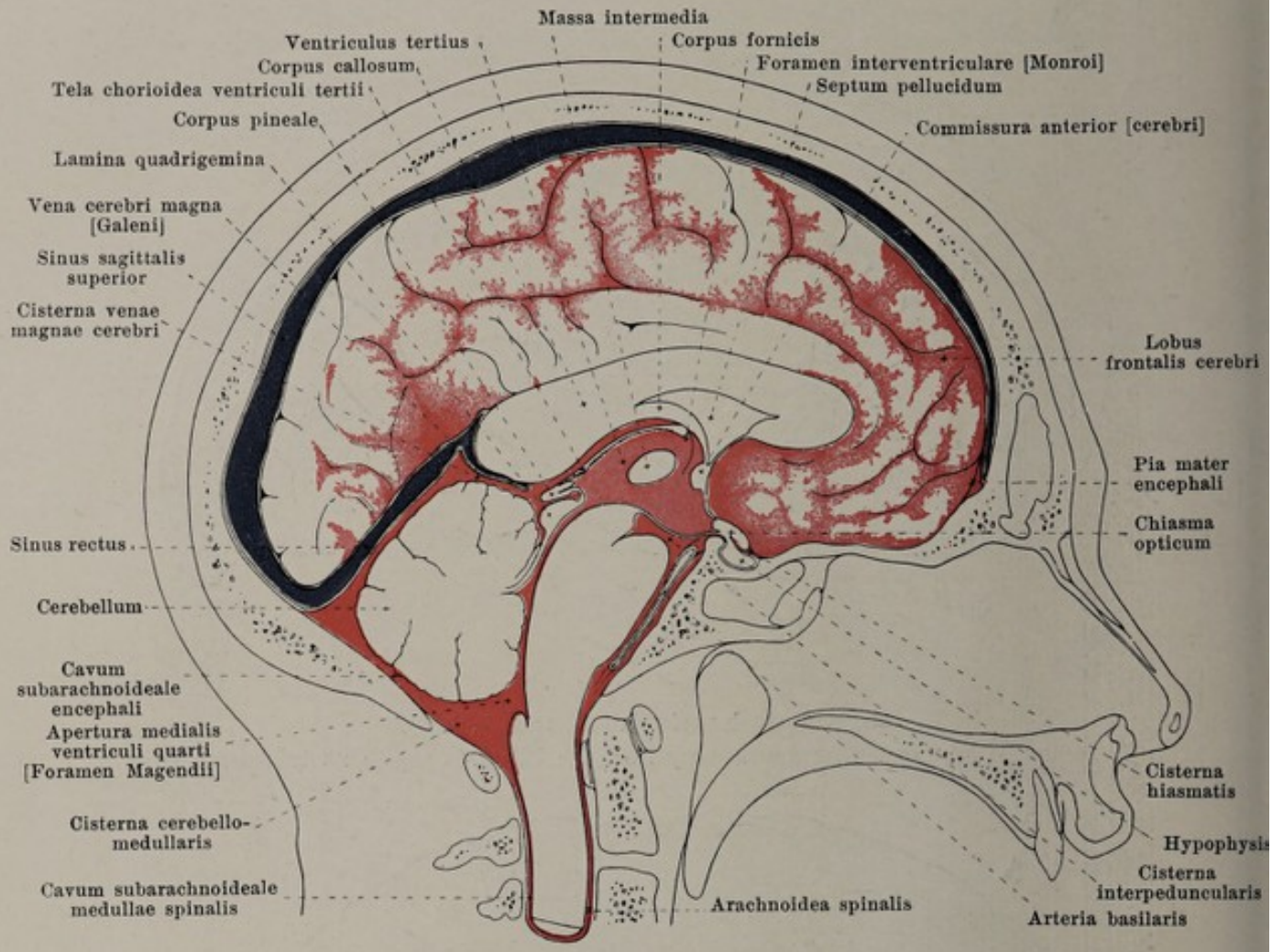
813. Left hemisphere, from without.
(The temporal lobe somewhat drawn away from the island to expose its transverse gyri.)



814. Right hemisphere, from within.

813 and 814. Medullation of the cortical areas of the cerebral hemispheres (after P. Flechsig).

(For names of convolutions, sulci etc. see Figs. 759—762.) The figures indicate the order in which the fibres in the various areas are medullated. The shaded areas are medullated at birth.

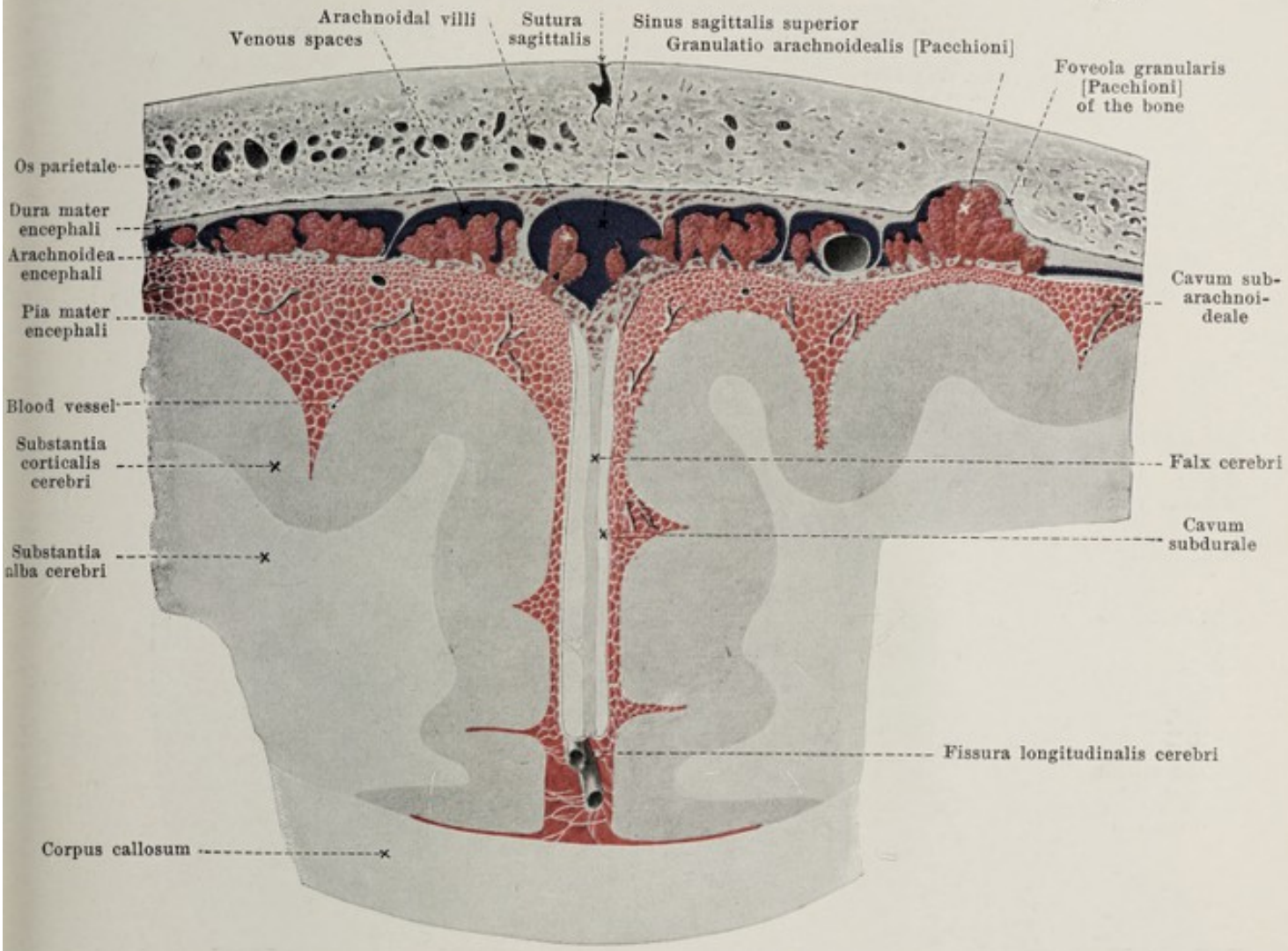


815. The subarachnoideal spaces in a median section of the head, left half, viewed from the right.

(Partly after illustrations by W. Braune, and by Key and Retzius.)

(The subarachnoidal spaces and the ventricles of the brain connected with them have been injected with a red-colored mass. The falx cerebri has been removed.)

The ***arachnoidea encephali*** *(cobweb membrane)* (see also Fig. 816) is a very delicate non-vascular membrane loosely attached to the pia mater encephali (see p. 674) by numerous strands and membranes which transform the *cavum subarachnoideale*, situated between the pia mater and the arachnoidea and filled with serous *liquor cerebrospinalis*, into a system of smaller and larger communicating spaces. On the convex surface of the cerebrum the arachnoidea is attached to the summits of the gyri by shorter strands; it does not penetrate into the sulci with the exception of the fissura longitudinalis cerebri, but is stretched out over these from one gyrus to the next. Hence larger spaces arise over each sulcus. Still larger cavities, *cisternae subarachnoideales*, are to be found, especially at the base of the brain. The largest of these, *cisterna cerebellomedullaris*, arises through the fact that the arachnoidea encephali as a continuation of the arachnoidea spinalis extends from the dorsal surface of the medulla oblongata over the fissura transversa cerebelli (see p. 655) directly to the lower surface of the cerebellum. The arachnoidea does not even penetrate into the fissura transversa cerebri (see p. 657); hence in the neighborhood of the vena cerebri magna [Galeni] arises the *cisterna venae cerebri magnae*, which extends far forward between the layers of the tela chorioidea ventriculi tertii (see p. 674). From the anterior surface of the medulla oblongata the arachnoidea stretches in front of the pons and the brachia pontis lateralward as far as the surface of the cerebellum, then, passing out from the upper margin of the pons bridges over the corpora mamillaria and their neighborhood (see Fig. 758) to reach the temporal lobes lateralward and the frontal lobes forward, in front of the chiasma opticum.

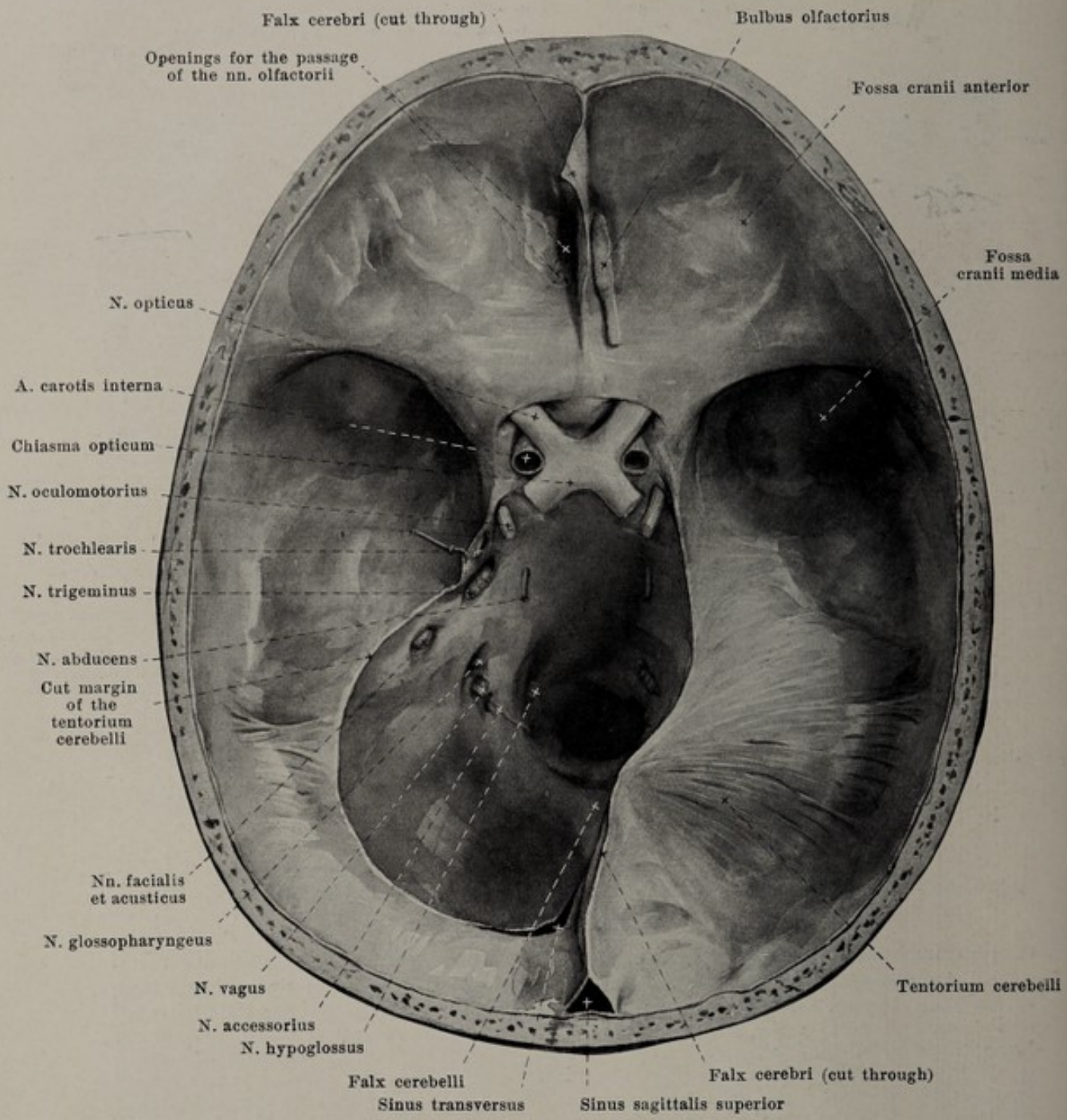


816. Frontal section through the skull, meninges and brain (after Key and Retzius).

(The subarachnoidal spaces have been injected with a red-colored mass.) Magnification: 5:2.

Arachnoidea encephali (continued) (see also Fig. 815). There thus arises a large subarachnoidal space, through which pass the a. basilaris, the tractus optici and the beginnings of the cerebral nerves; the portion situated behind the infundibulum is called the *cisterna interpeduncularis*, that below and in front of the chiasma opticum the *cisterna chiasmatis* (see Fig. 815). Adjacent to these lateralward on each side is the *cisterna fossae cerebri lateralis [Sylvii]* (not illustrated), which owes its origin to the fact that the arachnoidea does not penetrate into the depth of the fissura cerebri lateralis, but stretches out directly from the surface of the temporal lobe to the frontal lobe.

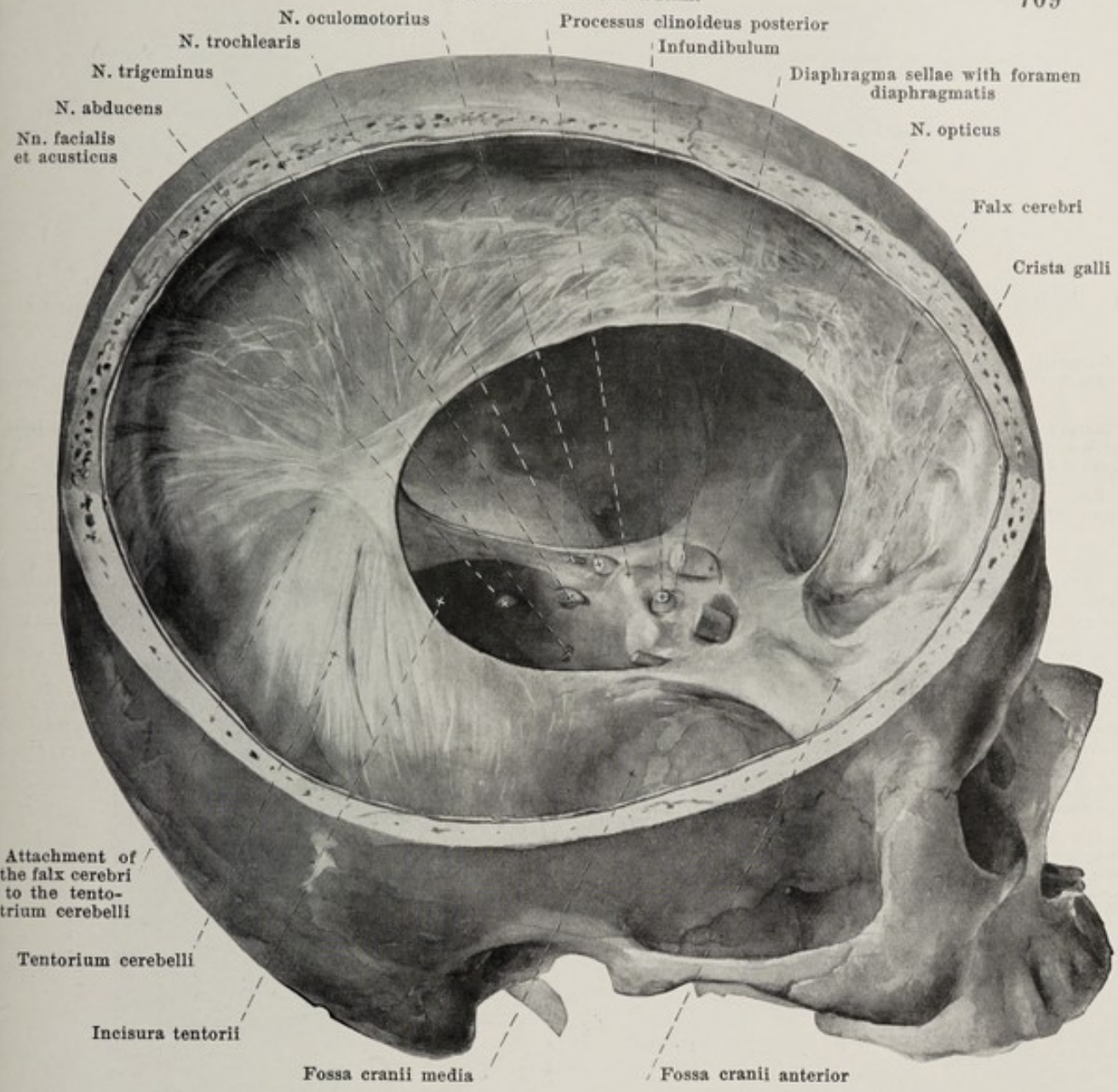
Projecting from the outer surface of the arachnoidea encephali are numerous grayish-red villus-like appendages *(arachnoidal villi)*, varying in size from that of a millet-seed to that of a grain of wheat, which are united as a rule in groups as the *granulationes arachnoideales [Pacchioni]*. They are remarkably variable, are absent in early childhood, usually appear in the tenth year of life, are regularly present in the adult, and especially abundant in old age; they are less developed in woman than in man. They are attached to the arachnoidea by delicate pedicles in the form of flask-like outgrowths, and contain within them a network of connective tissue strands as well as of subarachnoidal spaces. They penetrate the dura mater and project into the sinuses or into venous spaces with which these communicate. They can become so large that the bone opposite them is absorbed and becomes deepened to form a *foveola granularis [Pacchioni]*. They are most numerous and largest in front at the sinus sagittalis superior and in its neighborhood, especially in the middle portion; they are smaller and less numerous at the pole of the temporal lobe, as well as, from the cerebellar surface, at the sinus rectus, sinus transversus and sinus petrosus superior.



817. Dura mater, viewed from above.

(The falx cerebri has been almost completely removed, the tentorium cerebelli on the left side only.)

The ***dura mater encephali*** *(hard membrane of the brain)* (see also Figs. 818 and 819), a white, tough, connective tissue membrane, glistening like tendon, lines the cavity of the skull like a periosteum. In children it is everywhere firmly attached to the bone, but in the adult is intimately attached only in the region of the base of the skull and at the cranial sutures, being elsewhere united with it only loosely by means of numerous connective tissue threads; in the latter places a capillary lymph space, ***cavum epidurale,*** exists between it and the bone. The inner surface of the dura mater is smooth and is separated from the outer, likewise smooth surface of the arachnoidea encephali, by a capillary slit, ***cavum subdurale,*** which is lined on all sides by endothelium and contains only a very small amount of fluid (see Fig. 816).

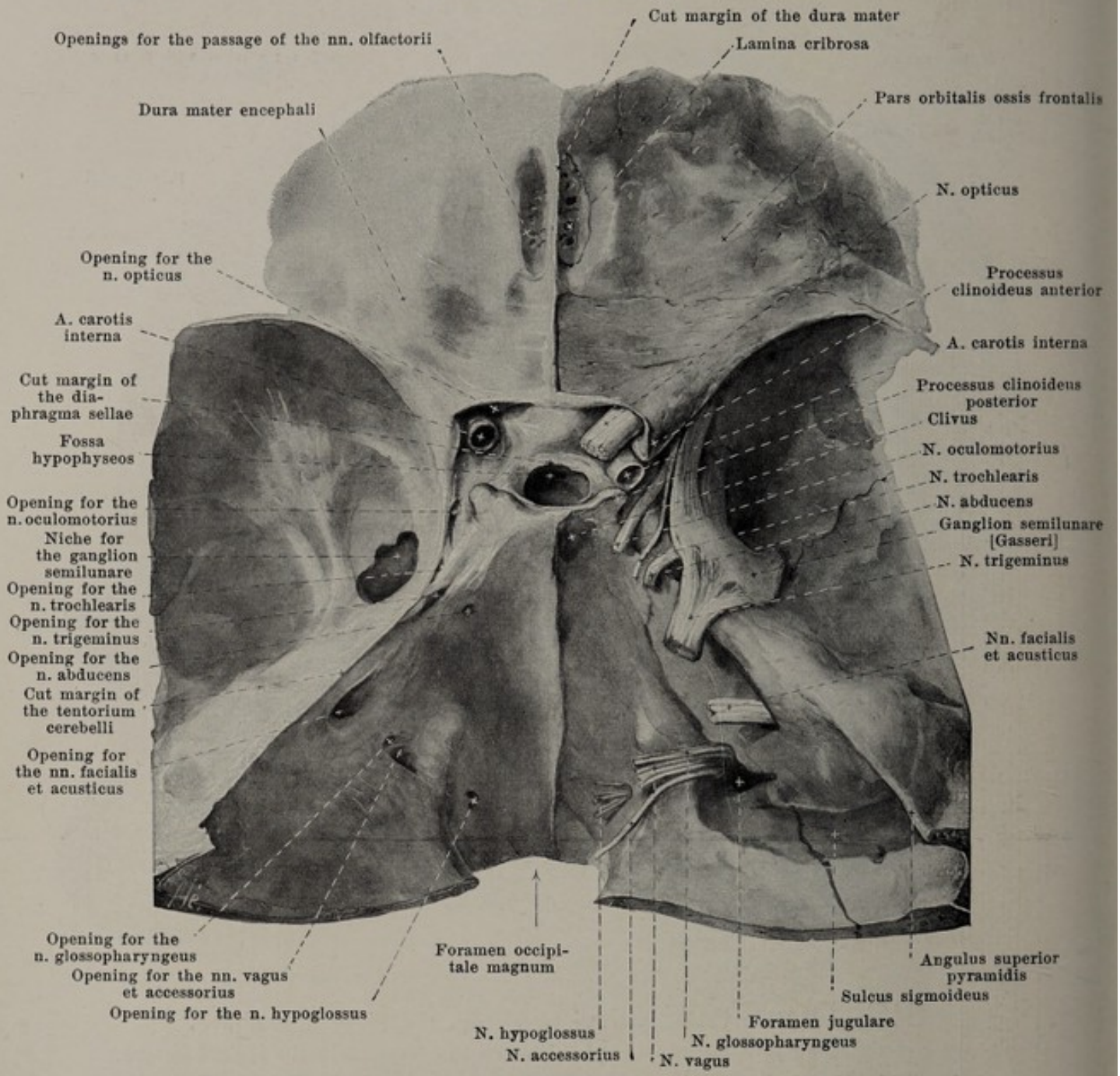


818. Dura mater, viewed from the right and above.

(A sector of the skull has been removed on the right side by a horizontal and a sagittal saw-cut.)

Dura mater encephali (continued) (see also Figs. 817 and 819). The dura mater completely lines the depth of the fossa hypophyseos, spreads out above the same between the tuberculum sellae and the upper margin of the dorsum sellae as *diaphragma sellae,* and there presents only a small opening, *foramen diaphragmatis [sellae],* for the passage of the infundibulum. It then runs lateralward on each side and stretches out from the processus clinoideus anterior and from the upper part of the processus clinoideus posterior to the angulus superior pyramidis (lateral from the impressio trigemini); thence it passes, behind, downward to the clivus and to the facies posterior pyramidis, laterally and in front, however, obliquely downward to the middle cranial fossa (lateral from the foramen rotundum and foramen ovale), and thus helps to enclose a large space (see Figs. 533 and 819), in which are situated the a. carotis interna, the sinus cavernosus, the n. oculomotorius, n. trochlearis, n. trigeminus along with its ganglion semilunare and its branches, as well as the n. abducens. The dura mater possesses three tough processes:

1. The *tentorium cerebelli (cerebellar tent)* (see also Figs. 535 and 817) goes off on each side in transversal direction from the angulus superior pyramidis and from the horizontal portion of the sulcus transversus, is sickle-shaped and in the middle elevated like the ridge of a roof; by its anterior, deeply notched margin it bounds the *incisura tentorii.* The occipital lobes of the cerebrum rest upon its upper surface.



819. Passage of nerves through the dura mater and the skull.

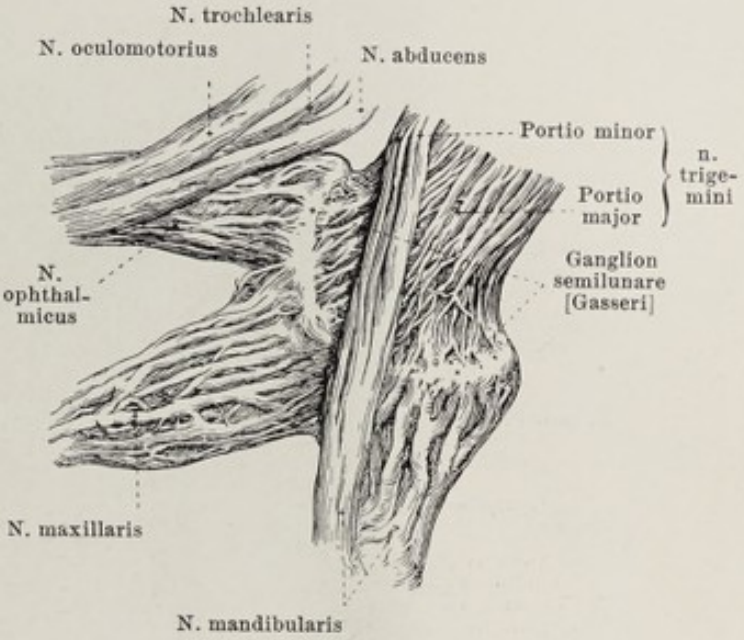
(On the right side the dura mater has been completely removed, on the left the tentorium cerebelli has been cut away at the temporal bone and the niche for the ganglion semilunare opened.)

Dura mater encephali (continued). 2. The *falx cerebri (cerebral sickle)* (see Figs. 535, 817 and 818), a septum increasing in height from before backward, penetrates from above in the median plane between the two cerebral hemispheres. It is attached at the crista galli, at the crista frontalis and at the sulcus sagittalis as far as the protuberantia occipitalis interna to the bone, fuses behind with the ridge-like edge of the tentorium cerebelli, and possesses below a concave margin which does not reach down as far as the corpus callosum of the brain (see Fig. 816). 3. The *falx cerebelli (cerebellar sickle)* (see Fig. 817) arises behind on the bony ridge which passes from the protuberantia occipitalis interna to the foramen occipitale magnum, is shoved in from behind as a low plate into the incisura cerebelli posterior, and ends in front with a concave margin; above it is united with the under surface of the tentorium cerebelli and below it runs out into two diverging low folds, which grasp the foramen occipitale magnum from behind.

820. Right ganglion semilunare [Gasseri],

viewed from the medial side.

Magnification: 2:1.



Twelve pairs of **nervi cerebrales, cerebral nerves,** go off from the brain. Of these, three (nn. olfactorii, optici, acustici) are pure sensory nerves, six (nn. oculomotorii, trochleares, abducentes, faciales, accessorii, hypoglossi) pure motor, three (nn. trigemini, glossopharyngei, vagi) mixed in nature. The nn. intermedii (see p. 724) are also of a mixed nature.

I. **Nervi olfactorii,** *olfactory nerves* (see Figs. 825 and 826), are sensory nerves, of which approximately twenty non-medullated threads of different size on each side leave the inferior surface of the bulbus olfactorius and arrive in the nasal cavity through the openings of the lamina cribrosa of the ethmoid bone. As they go they become ensheathed with processes of the meninges and of the subrarachnoidal spaces, divide into a lateral row which passes to the regio olfactoria of the lateral wall of the nose, and a medial row which goes to that of the nasa septum; they generally do not anastomose with one another. Their domain of distribution extends lateralward over a large part of the upper concha, and medianward it is of similar extent (see Fig. 984).

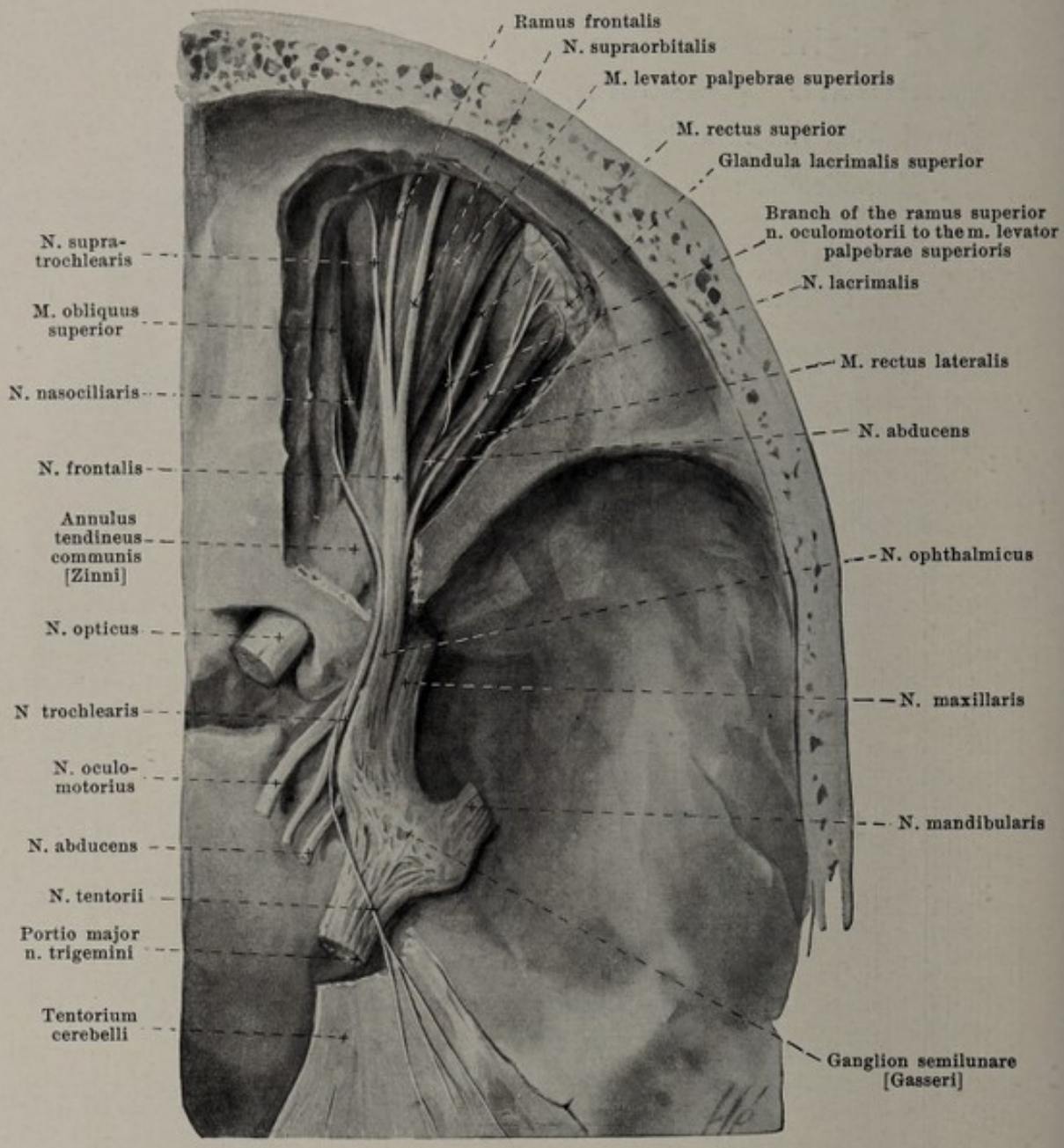
II. **N. opticus,** *visual nerve* (see Figs. 758, 817, 819, 822, 919 and 924), is a sensory nerve, but it is not comparable with the other cerebral nerves, since from its development and architecture it belongs to the brain and must be looked upon as a central intracerebral cord. It proceeds on each side from the anterior angle of the chiasma opticum (see p. 665) and, somewhat flattened, runs obliquely lateralward and forward to the foramen opticum, passes through this as a round cord along with the a. ophthalmica (see p. 415) and then extends obliquely to the posterior surface of the eye-ball (see p. 795). In the horizontal direction it forms a slightly S-shaped curve, so as to be convex behind lateralward and in front medianward; in the vertical direction it presents a slight bayonet-like curve. It is surrounded by sheet-like processes of the meninges, and of the subdural and subarachnoidal spaces.

III. **N. oculomotorius** (see Figs. 748, 749, 758, 765, 817—819, 821—823, 915, 916 and 920—922), motor, emerges by a medial group of (on the average) 8 flat bundles from the sulcus n. oculomotorii (see p. 656) and by a very variable but approximately as large posterior, lateral group from the ventral surface of the cerebral peduncle (see Figs. 748 and 749). The root bundles converge and form a round cord, which passes forward and lateralward between the a. cerebelli superior and a. cerebri posterior (see Fig. 495), and perforates the dura mater lateral from the processus clinoideus posterior (see Figs. 817—819). It then runs forward and a little downward in the lateral wall of the sinus cavernosus (see Fig. 533), lateralward from the a. carotis interna; in this course it lies at first over the n. trochlearis and the n. ophthalmicus and is then crossed on its lateral surface by both of these, so that finally it reaches the fissura orbitalis superior below them, and passes within the annulus tendineus communis [Zinni] (see Figs. 819, 821—823, 915 and 916). There it divides immediately into two branches, a smaller, *ramus superior,* and a larger, *ramus inferior.*

a) *Ramus superior* (see Figs. 821 and 823) passes forward and upward lateral from the a. ophthalmica and from the n. opticus to the mm. rectus superior and levator palpebrae superioris.

b) *Ramus inferior* (see Figs. 822 and 823) divides into a branch which runs under the n. opticus to the m. rectus medialis, a short branch to the m. rectus inferior, and a long branch which passes along the lateral margin of the m. rectus inferior to the m. obliquus inferior. A short, thick thread, *radix brevis ganglii ciliaris,* runs from the latter to the posterior inferior part of the ganglion ciliare (see p. 714).

Anastomoses: In the sinus cavernosus it receives sympathetic fibres from the plexus cavernosus.



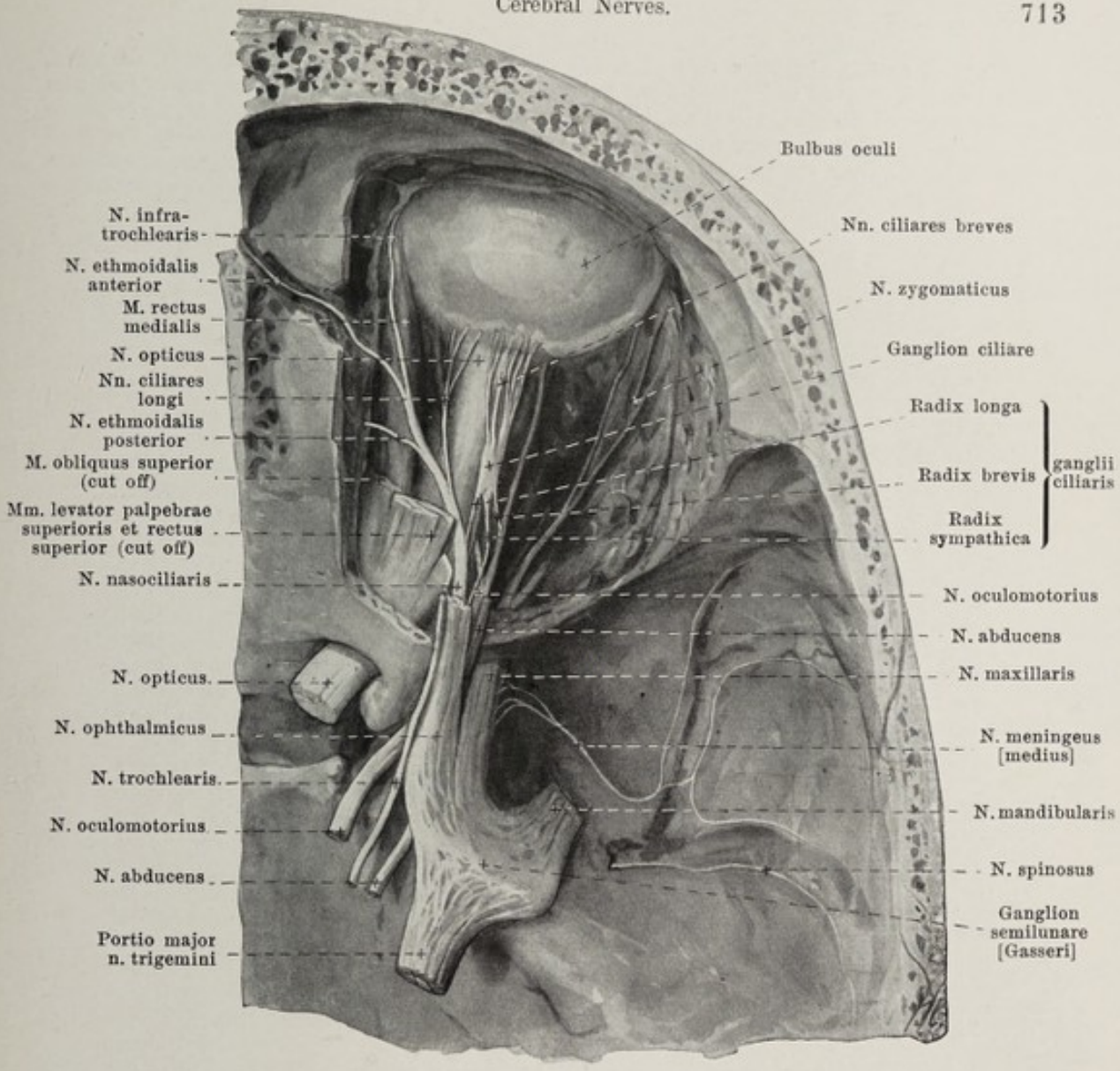
821. Nerves of the right orbital cavity,

viewed from above, 1st layer.

(The roof of the orbit has been removed and the fissura orbitalis superior partly exposed. The dura mater and the upper layer of the tentorium cerebelli have been dissected away.)

IV. **N. trochlearis** (see also Figs. 749, 750, 755, 757, 758, 817—820, 823, 833, 915, 916 and 919—921), motor, leaves the brain (see Fig. 757) on each side near the frenulum veli medullaris anterioris (see p. 655), runs (see Figs. 749, 750, 755, 757 and 758) as a delicate, curved cord along the upper margin of the pons, around the pedunculus cerebri, forward and perforates the dura mater lateral from the n. oculomotorius and below the most anterior jag of origin of the tentorium cerebelli (see Figs. 817—819). It then passes forward in the lateral wall of the sinus cavernosus (see also Fig. 533) under the n. oculomotorius and over the n. ophthalmicus, then crosses the former on its lateral side, goes through the fissura orbitalis superior outside the annulus tendineus communis [Zinni] (see also Figs. 915 and 916) and extends over the origin of the m. levator palpebrae superioris obliquely forward and medianward to the m. obliquus superior.

Anastomoses: In the sinus cavernosus it receives sympathetic fibres from the plexus cavernosus and usually anastomoses with the n. ophthalmicus (V).



822. Nerves of the right orbital cavity,

viewed from above, 2nd layer.

(Same preparation as in Fig. 821. In addition most of the eye muscles and the lateral wall of the orbit have been removed; the foramen ethmoidale anterius has been opened. The nn. meningeus and spinosus have been introduced according to *F. Arnold.)*

V. **N. trigeminus** (see also Figs. 749, 750, 755, 758, 817—821, 823—830 and 833), a mixed nerve, makes its appearance on the anterior surface of the pons (see p. 651) with two roots, the thick, sensory *portio major* and the thin, motor *portio minor*; the site of emergence of the round portio minor is somewhat rostral and dorsal from that of the flattened portio major (see Figs. 749, 750, 755 and 758). The portio minor loops around the medial margin of the portio major to its under surface; both pass forward and upward and perforate the dura mater beneath the line of departure of the tentorium cerebelli (and beneath the sinus petrosus superior) over the impressio trigemini of the pyramid of the temporal bone (see Figs. 817—819). Immediately in front of this spot, in a blind sack-like protrusion of the dura mater (see Fig. 819) the portio major becomes broader and goes over into the flat, sickle-shaped *ganglion semilunare [Gasseri]* (see also Figs. 758, 819—821 and 823); this lies adjacent to the a. carotis interna, lateral from the sinus cavernosus, over the foramen lacerum, or is separated from the artery by a thin layer of bone. On its under surface lie the nn. petrosi superficiales. The ganglion is similar in structure to the spinal ganglions and contains the cells of origin of the sensory fibres (see p. 698). The portio minor runs, on the inferior surface of the ganglion and without forming a nervous connection with it, to the n. mandibularis (see Figs. 758 and 820). The convexity of the ganglion is directed forward and downward, and from it diverge three branches: *n. ophthalmicus, n. maxillaris* and *n. mandibularis.*

a) ***N. ophthalmicus*** (see Figs. 819—823), sensory, the smallest branch, flattened, passes forward, upward and lateralward in the lateral wall of the sinus cavernosus (see also Fig. 533), where it lies beneath the n. trochlearis and lateral from the n. abducens, at first also beneath the n. oculomotorius, which passes forward on its medial side; it receives fine sympathetic threads from the plexus cavernosus and usually anastomoses with the n. trochlearis. In the sinus it gives off the fine *n. tentorii* (see Fig. 821) which passes backward at first close to the n. trochlearis, then runs to the tentorium cerebelli, and in it as far the sinuses. The n. ophthalmicus then enters the fissura orbitalis superior and divides, usually before its entrance, into three branches: *n. lacrimalis*, *n. frontalis* and *n. nasociliaris*.

1. *N. lacrimalis* (see Figs. 821,824,915,916 and 919—921), the finest branch, passes lateral from the n.frontalis (and annulus tendineus communis [Zinni]) into the orbital cavity, and runs close to the periorbita and over the m. rectus superior to the upper lachrymal gland, some threads passing through this to the conjunctiva and skin at the lateral angle of the eye; a fine connecting thread, *ramus anastomoticus cum n. zygomatico* (see Fig. 824), on the lateral wall of the orbit brings to it the secretory fibres for the lachrymal gland, which are believed to arise from the n. intermedius, to extend from the ganglion geniculi through the n. petrosus superficialis major to the ganglion sphenopalatinum and to pass from this into the n. maxillaris and the n. zygomaticus.

2. *N. frontalis* (see Figs. 821, 823, 832, 915, 916 and 919—922), the thickest branch, enters the orbital cavity lateral from the annulus tendineus communis between the n. trochlearis and the n. lacrimalis and runs forward over the m. levator palpebrae superioris. Branches:

α) *N. supraorbitalis*, the largest of them, goes forward in the direction of the main trunk and passes through the incisura supraorbitalis (or through the foramen supraorbitale) to the forehead. It sends numerous large branches to the skin of the forehead as far back as the vertex and some smaller branches to the skin and conjunctiva of the upper eyelid. One branch, running at the upper margin of the orbital cavity, unites with a branch of the n. facialis.

β) *Ramus frontalis*, forward and somewhat medianward to the incisura frontalis; it is distributed medial from the n. supraorbitalis and like it, to the forehead and upper eyelid.

γ) *N. supratrochlearis*, the finest branch, extends forward and medianward on the roof of the orbita and over the trochlea m. obliqui superioris to the upper eyelid, the root of the nose and the forehead. In front of the trochlea it anastomoses with the n. infratrochlearis.

3. *N. nasociliaris* (see Figs. 821—823, 915, 916 and 919—922) enters the orbit within the annulus tendineus communis [Zinni], runs at first between the m. rectus superior and the n. opticus forward and medianward, then forward between the mm. obliquus superior and rectus medialis and divides into the n. ethmoidalis anterior and n. infratrochlearis. Branches:

α) *Radix longa ganglii ciliaris*, slender, arises usually while still outside the orbital cavity and passes on the lateral side of the n. opticus and of the a. ophthalmica to the ganglion ciliare.

β) *Nn. ciliares longi*, usually two, on the medial side of the n. opticus to the eyeball (see p. 802).

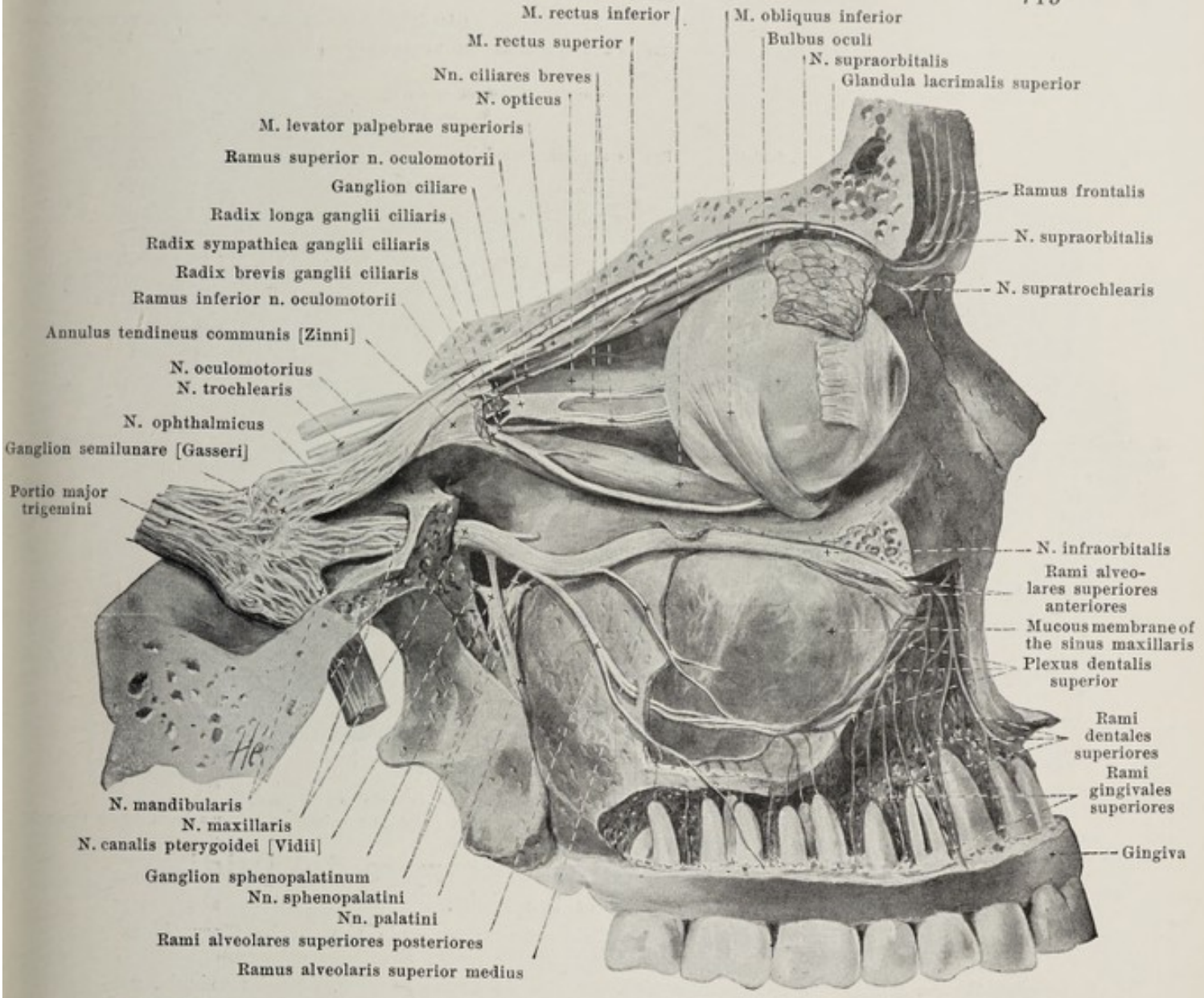
γ) *N. ethmoidalis posterior*, very fine, passes through the foramen ethmoidale posterius to the mucous membrane of the posterior ethmoidal cells and of the sphenoidal sinuses.

δ) *N. ethmoidalis anterior* goes through the foramen ethmoidale anterius upon the upper surface of the lamina cribrosa, gives there a fine branch near the a. meningea anterior to the dura mater and the falx cerebri, then perforates the lamina cribrosa and divides into several *rami nasales anteriores*. Of these, the *rami nasales interni* go to the mucous membrane of the anterior part of the septum (*rami nasales mediales*, see Fig. 826) and to the lateral wall of the nasal cavity (*rami nasales laterales*, see Fig. 825); the *ramus nasalis externus* (see Fig. 825) runs first behind the spina frontalis, then in the sulcus ethmoidalis of the nasal bone, passes outward between the nasal bone and the nasal cartilage, and supplies the skin of the tip of the nose and of the alae nasi (see Fig. 832).

ε) *N. infratrochlearis* passes forward under the m. obliquus superior and divides (see Fig. 832) under its trochlea into a *ramus palpebralis superior*, which helps to supply the eyelids and usually anastomoses with the n. supratrochlearis, and a *ramus palpebralis inferior* to the tear-sack, caruncula lacrimalis, eyelids and nose.

Ganglion ciliare (see Figs. 822 and 823) a sympathetic ganglion, lies as a small, oblong-quadrangular, flattened disk, on the lateral surface of the n. opticus. At its posterior margin it is united: 1. at the inferior angle with the n. oculomotorius by means of the short, thick *radix brevis* (see p. 711), 2. at the upper angle with the n. nasociliaris (vide supra) by the long, delicate *radix longa* and 3. with the plexus cavernosus by the delicate *radices sympathicae*. From its anterior margin 3—6 *nn. ciliares breves* go to the eyeball (see p. 802).

b) ***N. maxillaris*** (O. T. superior maxillary) (see Figs. 822—826), sensory, passes flattened forward in the lateral wall of the sinus cavernosus (see also Fig. 533) to the foramen rotundum, runs through this as a round cord, extends obliquely forward, lateralward and downward through the uppermost part of the fossa pterygopalatina over the end extremity of the a. maxillaris interna to the sulcus and canalis infraorbitalis and from there on is known as the *n. infraorbitalis*.



823. Nerves of the right orbit and the upper jaw, viewed from the right.

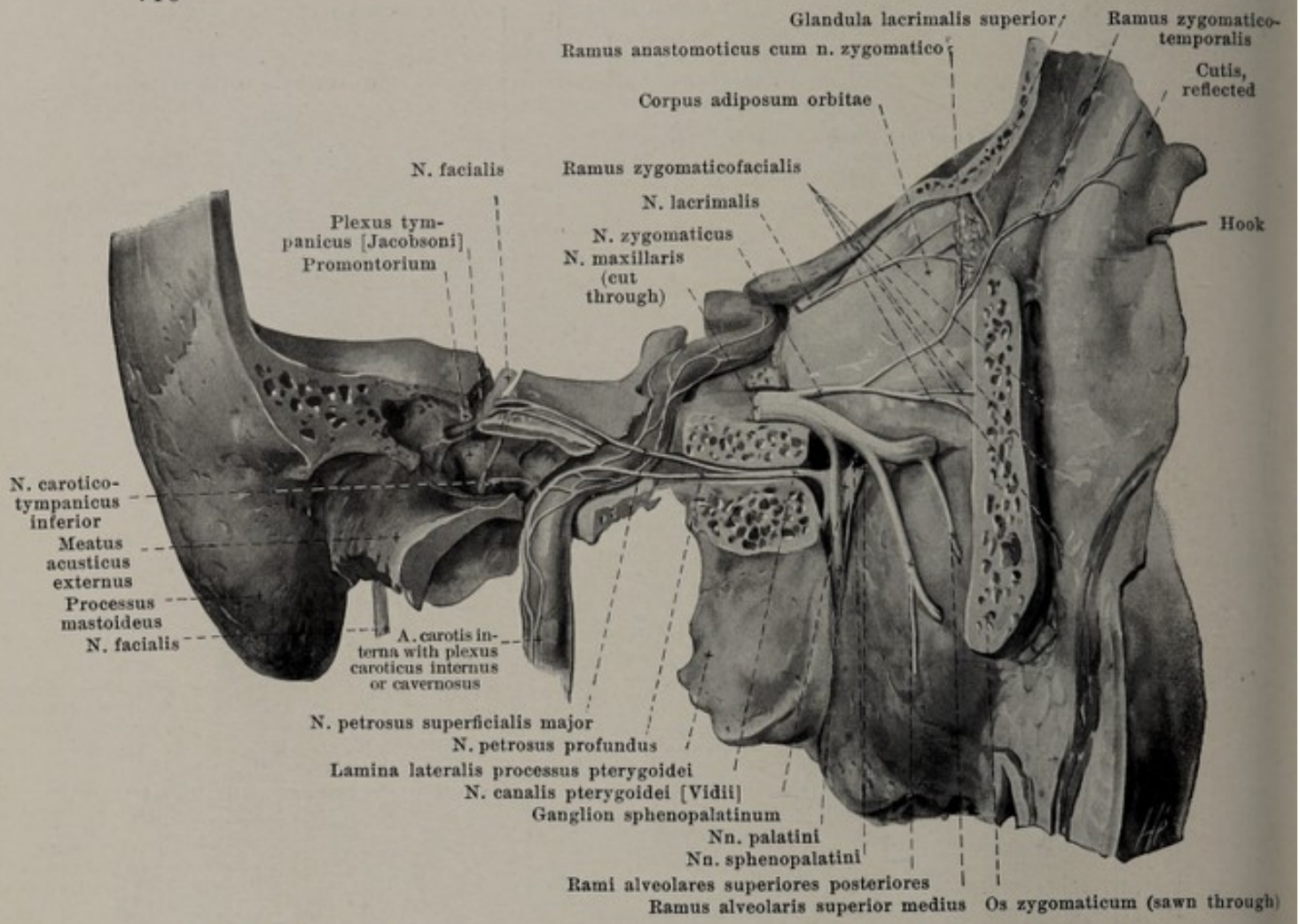
(The lateral wall of the orbit have been completely removed, the upper wall of the orbit as well as the wall of the upper jaw partly; the m. rectus oculi lateralis has also been removed.)

b) ***N. maxillaris*** (see also Figs. 822 and 824—826) (continued). Within the skull cavity it gives of the fine *n. meningeus [medius]* (see Fig. 822), which passes lateralward to the anterior branch of the a. meningea media, breaks up in the dura mater in its neighborhood and anastomoses with the n. spinosus (see p. 719). Outside the skull cavity the following branches are given off:

1. *N. zygomaticus* (see Figs. 822 and 824), a small branch from the upper margin within the fossa pterygopalatina, runs lateralward in the connective tissue closing the fissura orbitalis inferior and then passes forward along the lateral wall of the orbit. Branches:

α) Ramus zygomaticotemporalis, the upper of the two, gives off a fine communicating thread to the n. lacrimalis (see p. 714), passes through a foramen zygomaticoorbitale into the yoke-bone, and leaves this again through the foramen zygomaticotemporale; it thus arrives in the temporal fossa, and thence, usually divided into two branches, extends over the upper margin of the yoke-bone, through the fascia temporalis to the skin of the temporal region (see Figs. 824 and 832). It anastomoses manifoldly with its own twigs or with those of neighboring branches and varies much in its distribution.

β) Ramus zygomaticofacialis, sometimes doubled, runs from a foramen zygomaticoorbitale to the foramen zygomaticofaciale through a canaliculus of the yoke-bone to the facies malaris of the latter and spreads out in the skin in the anterior part of the yoke-bone region and at the lateral angle of the eye (see Figs. 824, 828 and 832).



824. Right nervus canalis pterygoidei [Vidii], viewed from the right.

(The lateral wall of the orbit has been for the most part removed; the canales pterygoideus [Vidii], caroticus et facialis and the tympanic cavity have been exposed.)

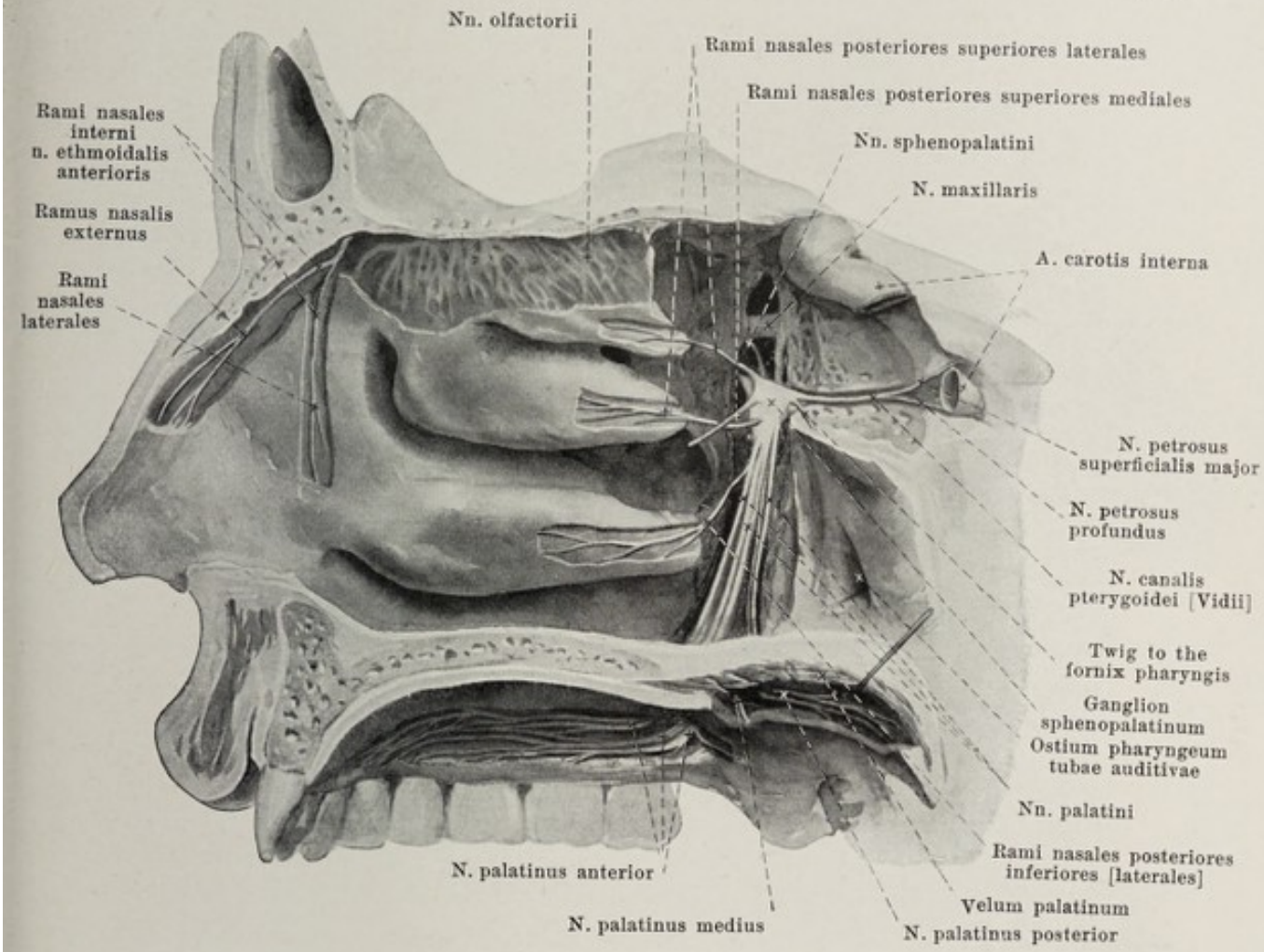
2. *Nn. sphenopalatini* (see also Figs. 823 and 825), two or three, sometimes single, go downward in the fossa pterygopalatina from the lower margin of the n. maxillaris. A very small part of their fibres, sometimes interwoven, enters the ganglion sphenopalatinum; the largest part, however, passes on its lateral surface or in front of it and goes over directly into the rami orbitales, rami nasales posteriores and nn. palatini, which are usually designated as branches of the ganglion (see p. 718).

3. *Nn. alveolares superiores* (see also Fig. 823) arise partly from the n. maxillaris, partly from the n. infraorbitalis (see p. 717).

α) *Rami alveolares superiores posteriores*, usually two, arising a little before the entrance into the orbit, run downward and forward upon the facies infratemporalis maxillae and pass through the foramina alveolaria into the canales alveolares and help to form the plexus dentalis superior (vide infra).

β) *Ramus alveolaris superior medius* is given off from the n. infraorbitalis in the posterior part of the canalis infraorbitalis and passes downward and forward in a special bony canal of the lateral wall of the maxilla to the middle part of the plexus dentalis superior (vide infra).

γ) *Rami alveolares superiores anteriores*, given off from the n. infraorbitalis close behind the foramen infraorbitale, run downward in the canales alveolares of the anterior wall of the maxilla. With the other rami alveolares within the canales alveolares they form a plexus, *plexus dentalis superior*, which is curved so as to be convex downward; this anastomoses with that of the other side. From it arise *rami dentales superiores* to the roots of the individual teeth, *rami gingivales superiores* to the gums, as well as branches to the bone and to the mucous membrane of the sinus maxillaris.



825. Nerves of the right lateral wall of the nose.

(The fossa pterygopalatina and the canales palatini have been exposed from inside.)

4. The *n. infraorbitalis* (see p. 714), usually a flat plexus, perforated at the beginning of the canalis infraorbitalis by the a. infraorbitalis, leaves the canalis infraorbitalis through the foramen infraorbitale and divides there quickly into its terminal branches (see Figs. 828 and 832), which partly unite with branches of the n. facialis. The terminal branches are:

α) *Rami palpebrales inferiores,* several delicate branches, go through the caput infraorbitale of the m. quadratus labii superioris to the skin of the lower eyelid and of the two angles of the eye.

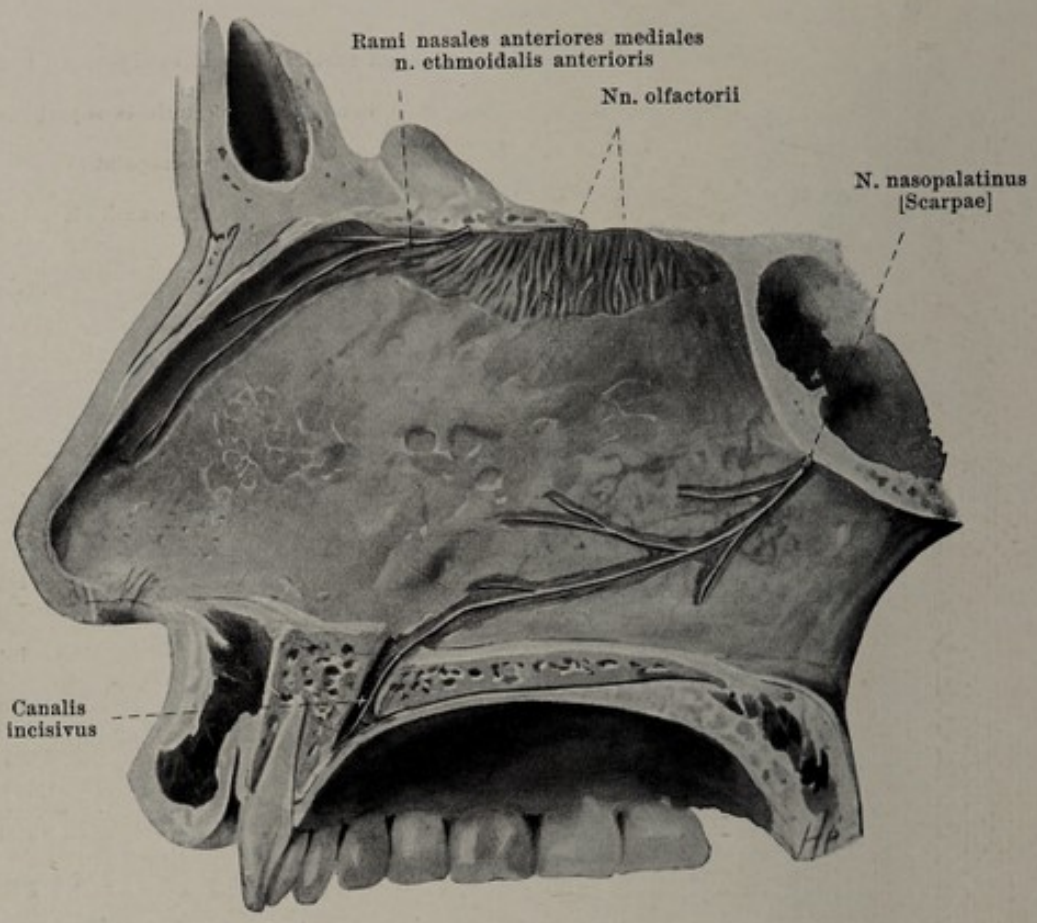
β) *Rami nasales,* 2—3, run upon the m. nasalis to the skin of the ala nasi *(rami nasales externi)* and of the septum mobile nasi *(rami nasales interni).*

γ) *Rami labiales superiores,* 3—4, pass between the m. quadratus labii superioris and the m. caninus downward to the skin and mucous membrane of the upper lip and to the gums.

Ganglion sphenopalatinum (see also Figs. 823 and 824) is a sympathetic ganglion (see p. 788) and lies as a small, flattened wedge, with its apex behind, in the fossa pterygopalatina, just in front of the anterior opening of the canalis pterygoideus [Vidii], a few millimeters below and medianward from the n. maxillaris. The following are usually designated as its *roots:*

1. *N. canalis pterygoidei [Vidii],* enters the posterior apex of the ganglion, runs in the canalis pterygoideus [Vidii], there arising through the union of two threads:

α) *N. petrosus superficialis major* (see also Figs. 824, 829 and 831) comes off from the n. facialis at the ganglion geniculi (see p. 724), anastomoses with the n. petrosus superficialis minor (see Fig. 831) and arrives through the hiatus canalis facialis in the sulcus n. petrosi superficialis majoris of the temporal bone. It then passes lateral from the a. carotis interna through the fibrocartilago basalis, filling up the foramen lacerum, to the canalis pterygoideus. In this branch run certainly the sensory and perhaps also the taste fibres of the anterior two-thirds of the tongue (see p. 723); in addition it carries the secretory fibres for the lachrymal gland (see p. 714).



826. Nerves of the nasal septum, viewed from the left.

Ganglion sphenopalatinum (see Figs. 823—825) (continued):

β) *N. petrosus profundus* (see Fig. 824) arises from the sympathetic plexus caroticus internus, woven around the a. carotis interna, from the horizontal part of the artery, and goes through the fibrocartilago basalis to the posterior opening of the canalis pterygoideus.

2. Fibres of the *nn. sphenopalatini*, which connect the ganglion with the n. maxillaris (see p. 716).

The following nerves are usually mentioned as *branches* of the ganglion, although they are, for the most part, direct branches of the nn. sphenopalatini (see p. 716) and are only strengthened by a variable number of threads from the ganglion.

1. *Rami orbitales* (not illustrated), 2—3 extremely fine threads, which pass through the fissura orbitalis inferior into the orbital cavity and through the foramen ethmoidale posterius or special small openings to the mucous membrane of the ethmoidal cells and sphenoidal sinus.

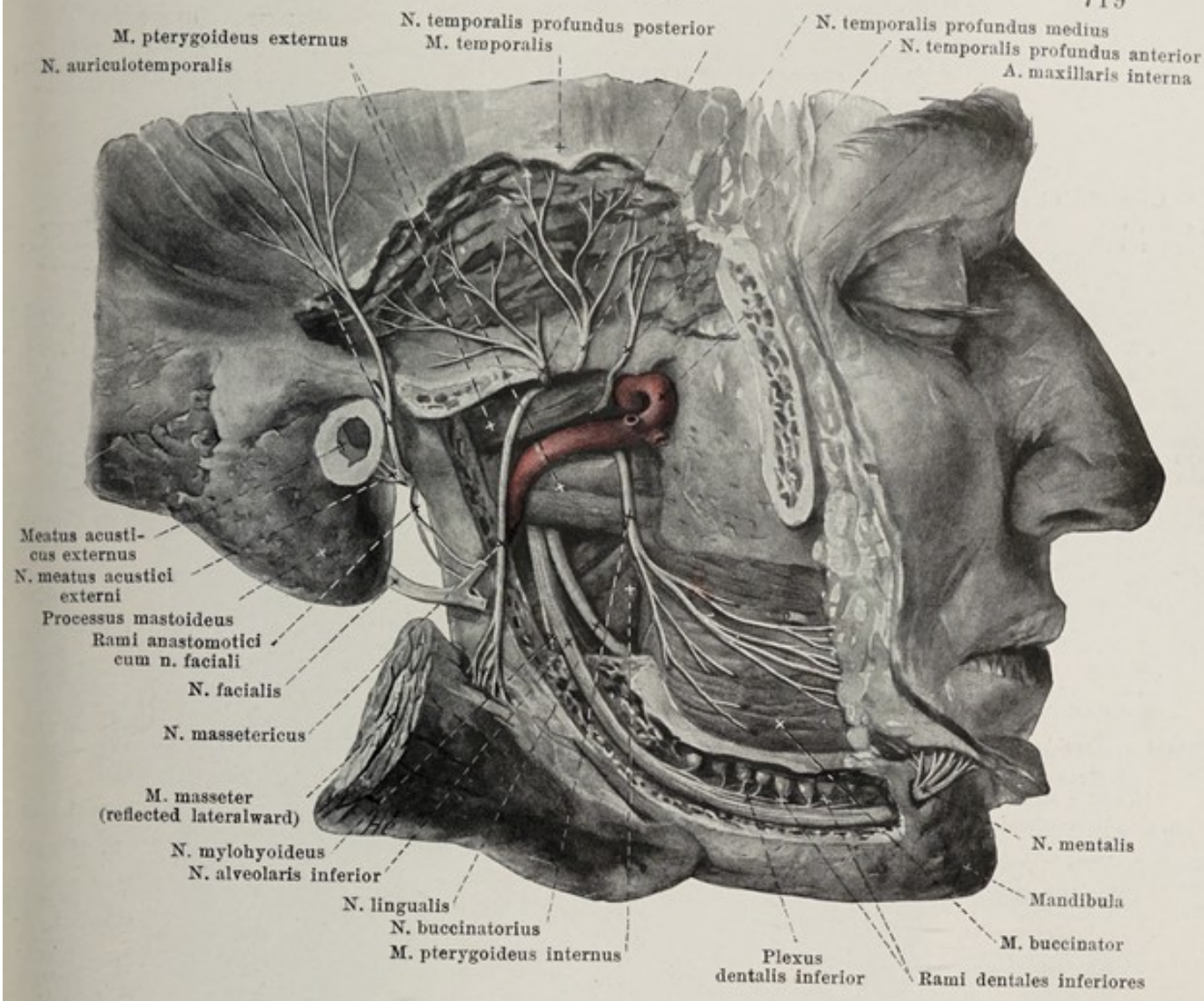
2. *Rami nasales posteriores superiores* (see also Fig. 825), several fine threads, enter the nasal cavity through the foramen sphenopalatinum, and, as *rami laterales*, arrive in the mucous membrane of the upper and middle nasal conchae (some also through the canales pharyngeus and basipharyngeus to the fornix pharyngis and ostium pharyngeum tubae auditivae), as *rami mediales* on the inferior surface of the body of the sphenoid bone to the nasal septum: of the latter the largest, *n. nasopalatinus [Scarpae]*, extends forward and downward on the septum to the canalis incisivus, anastomoses with that of the other side and ends in the mucous membrane of the hard palate.

3. *Rami nasales posteriores inferiores [laterales]* (see Fig. 825), usually branches of the n. palatinus anterior (vide infra), pass through small openings in the pars perpendicularis oss. palatini into the nasal cavity and to the mucous membrane of the inferior concha.

4. *Nn. palatini* (see Figs. 823—825) run downward through the canalis pterygopalatinus and the canales palatini, dividing into three branches:

α) *N. palatinus anterior*, the largest, passes through the foramen palatinum majus on the inferior surface of the hard palate, passes forward on it, divided in several branches, and supplies the mucous membrane of the soft and hard palate and the gums.

β) *N. palatinus medius*, the smallest, goes through a foramen palatinum minus to the mucous membrane of the soft palate and to the region of the tonsil.



827. Branches of the right n. mandibularis (V), more superficial layer, viewed from the right.

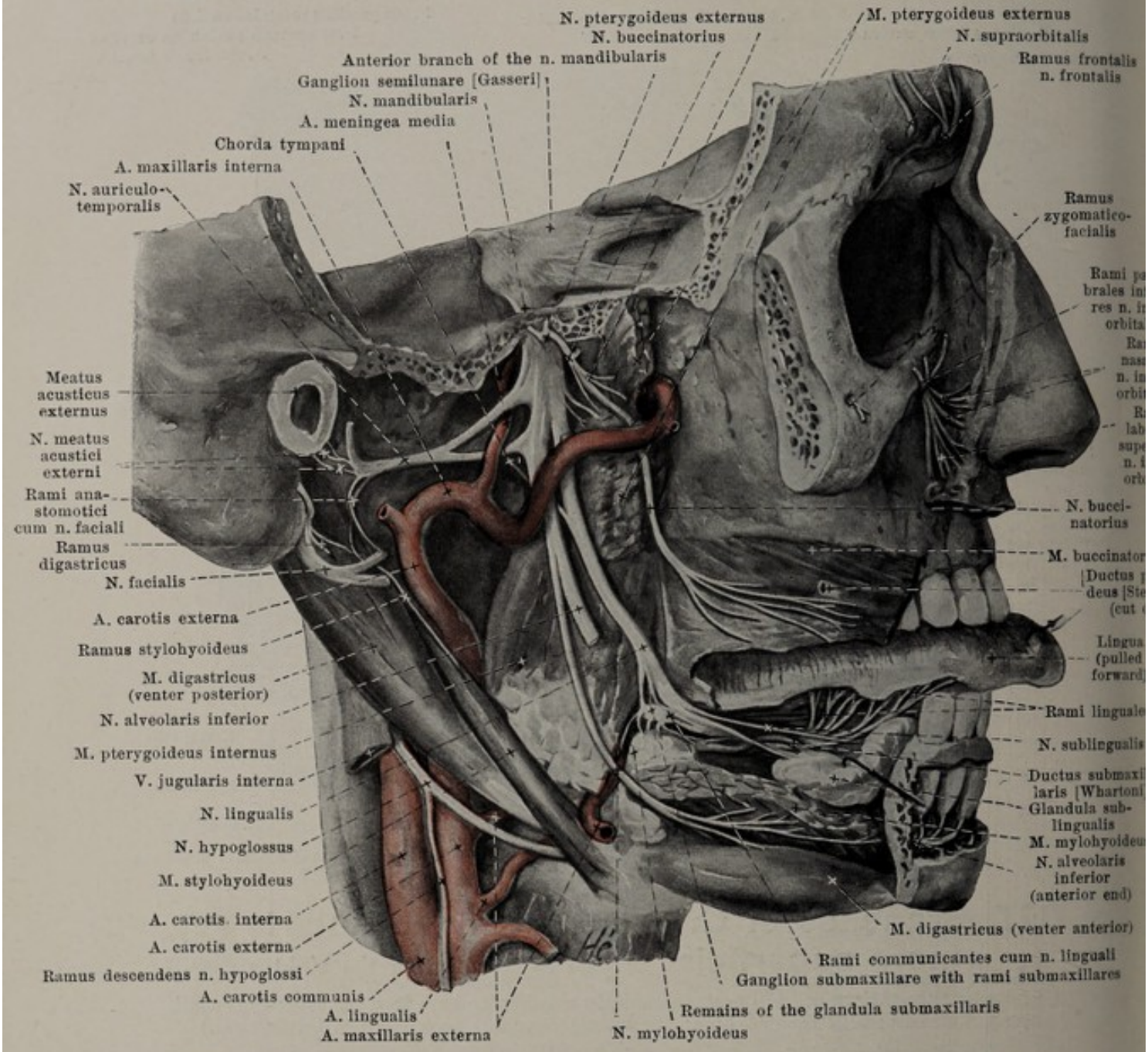
(The arcus zygomaticus and the proc. coronoideus mandibulae have been removed; the canalis mandibulae has been chiseled open; the m. masseter has been reflected lateralward.)

Ganglion sphenopalatinum (see Fig. 825) (continued):

g) *N. palatinus posterior* goes through a foramen palatinum minus and then passes backward to the mucous membrane of the inferior surface of the soft palate.

c) ***N. mandibularis*** (O. T. inferior maxillary) (see also Figs. 820, 822, 823, 828, 829 and 834), a mixed nerve, the largest branch, is formed of the (sensory) inferior division of the ganglion semilunare [Gasseri] and of the smaller (motor) portio minor (see p. 713), which are partly interwoven with one another beneath the ganglion. It runs downward through the foramen ovale (surrounded by the venous rete foraminis ovalis) and immediately beneath the same gives off the delicate *n. spinosus* (see Figs. 822 and 829), which receives a strand from the ganglion oticum (see p. 723), goes backward again into the skull cavity through the foramen spinosum with the a. meningea media and arrives along with the branches of the artery to the dura mater of the great wing of the sphenoidal bone and the mastoid cells.

The n. mandibularis divides into a smaller anterior and a larger posterior branch. The *anterior* branch is chiefly motor; into it almost the whole portio minor goes and is continued into the pure motor *nn. massetericus, temporales profundi, pterygoideus externus* (all these together with the n. pterygoideus internus, being designated as the *n. masticatorius);* it contains only a few fibres which are not motor, viz., the pure sensory *n. buccinatorius.*

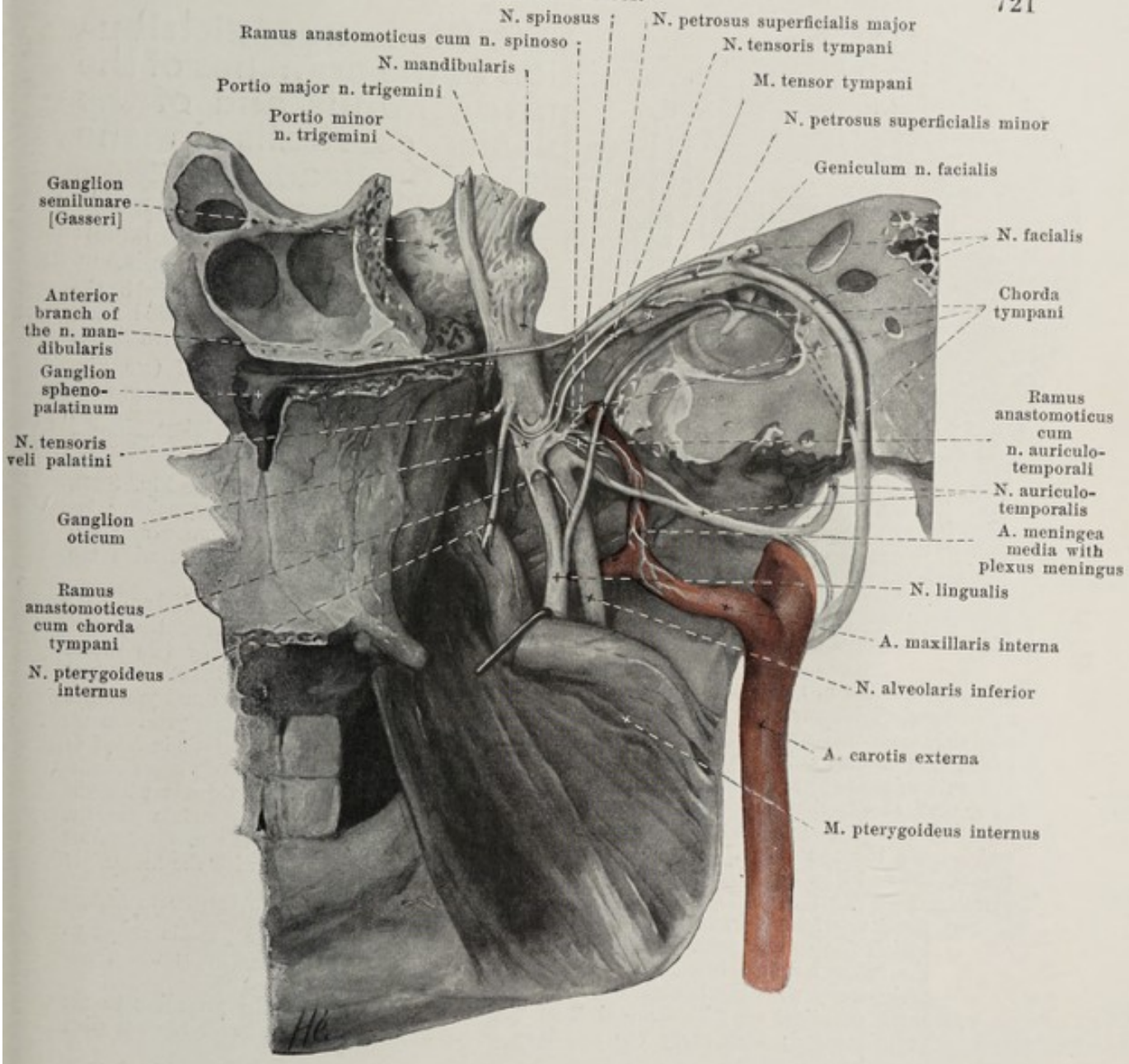


828. Branches of the right n. mandibularis (V), deeper layer, viewed from the right.

(Like Fig. 827, but the lower jaw and masticatory muscles have been almost completely removed; all but a small part of the glandula submaxillaris has been removed.)

c) ***N. mandibularis*** (see also Figs. 827, 829 and 834) (continued): The *posterior* branch is almost exclusively sensory; it carries only a few motor fibres to the pure motor *n. pterygoideus internus*, *n. tensoris veli palatini*, *n. tensoris tympani* and *n. mylohyoideus;* the latter is a branch of the *n. alveolaris*, which otherwise contains only sensory fibres, and together with the pure sensory *nn. auriculotemporalis* and *lingualis* makes up the main mass of sensory fibres of the n. mandibularis. The posterior branch is united by (usually two) short, fine threads with the upper margin of the ganglion oticum (see p. 723).

1. *N. massetericus* (see Fig. 827) arises usually with the n. temporalis profundus posterior, passes horizontally lateralward on the facies infratemporalis of the sphenoid bone, above the m. pterygoideus externus, and then runs lateralward and downward through the incisura mandibulae to the medial surface of the m. masseter; it gives off 1—2 threads for the joint of the jaw.



829. Right ganglion oticum, viewed from within.

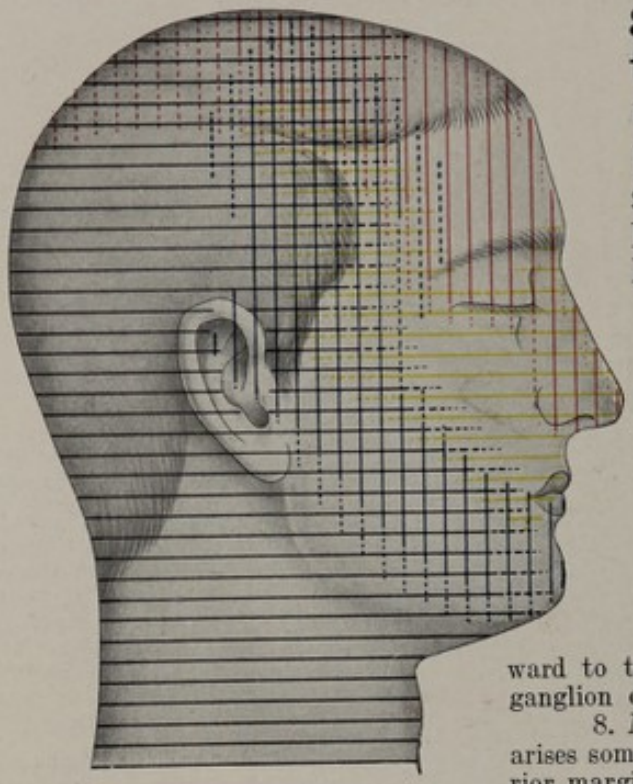
(From one portion of a head cut in half the viscera and spine have been removed; the internal ear and the apex of the pyramid of the temporal bone have been cut away.)

2. *Nn. temporales profundi* (see Fig. 827), usually three, a *posterior, medius* and *anterior*, of which the middle one may be absent; the posterior usually arises in common with the n. masseterius, the anterior with the n. buccinatorius. They run at first horizontally lateralward like the n. masseterius (see p. 720) (the anterior often between the two heads of the m. pterygoideus externus), then bend vertically upward and finally break up, anastomosing with one another in the m. temporalis.

3. *N. buccinatorius* (see Figs. 827, 828 and 832) (see also above) passes downward, forward and lateralward, either between the two heads of the m. pterygoideus externus or between the two mm. pterygoidei, arrives upon the lateral surface of the m. buccinator and there anastomoses with branches of the n. facialis. It sends branches through the m. buccinator to the mucous membrane of the cheek and is distributed also to the skin of the angle of the mouth; there fore it is a pure sensory nerve.

4. *N. pterygoideus externus* (see Figs. 828) arises almost always in common with the n. buccinatorius and runs downward and lateralward to the m. pterygoideus externus.

5. *N. pterygoideus internus* passes near the ganglion oticum or through it, connected with it by fine threads, downward to the medial surface of the m. pterygoideus internus.



830. Domains of distribution of the branches of the n. trigeminus and of the plexus cervicalis in the skin of the head, after R. Zander. Red: n. ophthalmicus; yellow: n. maxillaris; blue: n. mandibularis; black: branches of the plexus cervicalis.

(The regions which are regularly supplied by the nerves concerned are indicated by solid lines, those not regularly supplied by dotted lines.)

6. *N. tensoris veli palatini* (see Fig. 829), usually a branch of the foregoing, runs forward and downward to the m. tensor veli palatini; it is connected with the ganglion oticum by a fine thread.

7. *N. tensoris tympani* (see Fig. 829), usually a branch of the n. pterygoideus internus, very fine, passes backward and upward to the m. tensor tympani; it is connected with the ganglion oticum by a delicate thread.

8. *N. auriculotemporalis* (see Figs. 827—829 and 832) arises somewhat beneath the foramen ovale from the posterior margin of the n. mandibularis, usually by two roots, which include the a. meningea media between them and then unite. It runs at first backward and somewhat downward on the medial surface of the m. pterygoideus externus and processus condyloideus mandibulae above the a. maxillaris interna, bends around the collum proc. condyloidei, first lateralward, then upward through the substance of the glandula parotis in front of the cartilaginous external acoustic meatus, to pass finally, behind the a. temporalis superficialis, in a vertical direction to the skin of the temple. It is united by several threads with the ganglion oticum (see p. 723); these lead to it the secretory fibres of the glandula parotis, which come through the n. petrosus superficialis minor (see p. 723) and the n. tympanicus (see p. 730 and Fig. 831) from the n. glossopharyngeus leaving the brain with the latter. It gives off 1—2 fine threads to the joint of the jaw, and in addition:

α) *Rami anastomotici cum n. faciali* (see Figs. 827, 828 and 833), usually two, go off behind the collum proc. condyloidei and pass forward through the parotid gland to the upper terminal branch of the n. facialis; they contain sensory fibres which run peripherally with the branches of the n. facialis.

β) *Rami parotidei* (not illustrated) from the main stem or from the preceding to the parotid gland; they carry the secretory fibres to it which arise from the ganglion oticum (vide supra).

γ) *Nn. meatus acustici externi* (see Figs. 827 and 828), usually two, run backward, penetrate at the junction between the cartilaginous and bony external acoustic meatus into the latter, supply its skin and send a fine branch, *ramus membranae tympani*, to the ear-drum membrane.

δ) *Nn. auriculares anteriores* (see Fig. 832) to the skin of the anterior part of the auricle.

ε) *Rami temporales superficiales* (see Fig. 832), usually two, to the skin of the temple; they anastomose above with branches of the nn. ophthalmicus (V) and occipitalis major and alternate in their distribution with the n. zygomaticotemporalis.

9. *N. alveolaris inferior* (see Figs. 827—829), the largest branch, passes first on the medial surface of the m. pterygoideus externus and of the a. maxillaris interna, then between the ramus mandibulae and the m. pterygoideus internus, slightly curved, downward to the foramen mandibulare and thence forward in the canalis mandibulae with the a. and v. alveolaris. It gives off the following branches:

α) *N. mylohyoideus* (see Figs. 827 and 828) goes off close above the foramen mandibulare and passes downward and forward in the sulcus mylohyoideus mandibulae, at first lateral from the m. pterygoideus internus, then beneath the m. mylohyoideus; it supplies the latter and the venter anterior m. digastrici.

β) *Rami dentales inferiores* (see Fig. 827) and *rami gingivales inferiores*, fine branches, which go off in the canalis mandibulae; of the former there is one for each root of a tooth; the latter go to the alveoli and to the gum. They form a plexus, *plexus dentalis inferior*, above the n. mandibularis.

γ) *N. mentalis* (see Fig. 827), a large branch, leaves the canalis mandibulae by way of the foramen mentale, covered by the m. triangularis. It divides into *rami mentales*, which, perforating this muscle, go to the skin of the chin, and *rami labiales inferiores*, which pass upward to the skin and mucous membrane of the lower lip.

10. *N. lingualis* (see Figs. 827—829 and 834), almost as large as the n. alveolaris inferior, runs in front of the latter nerve and somewhat medianward from it, on the medial side of the m. pterygoideus externus and of the a. maxillaris interna, then between the m. pterygoideus internus and the ramus of the lower jaw, slightly curved, downward and forward, then passes under the m. mylopharyngeus and in front of the m. styloglossus (see Figs. 606, 628 and 834) on the lateral side of the latter, and, under the mucous membrane of the floor of the mouth, passes forward over the m. mylohyoideus and the glandula submaxillaris, goes around the ductus submaxillaris [Whartoni] lateral and below (see also Fig. 591) and then breaks up.

Upon the m. pterygoideus internus it unites with the chorda tympani (see p. 724), which approaches it at an acute angle from behind and above. This anastomosis with the n. facialis carries certainly: 1. to the n. lingualis the secretory fibres for the glandula submaxillaris und sublingualis, which arise from the n. intermedius, 2. from the n. lingualis the pure sensory fibres and the taste fibres from the anterior two-thirds of the tongue (see Fig. 836) to the n. facialis. From there on the sensory fibres pass through the n. petrosus superficialis major to the ganglion sphenopalatinum, to the n. maxillaris (V) and farther centralward. The farther path of the taste fibres is questionable: either they run from the n. facialis also through the n. petrosus superficialis major to the ganglion sphenopalatinum, thence to the n. maxillaris (V) and farther centralward, or through the ramus anastomoticus cum plexu tympanico to the n. petrosus superficialis minor, to the ganglion oticum, to the n. mandibularis (V) and farther centralward, or they arrive in the brain by way of the n. intermedius.

The n. lingualis is united farther by several threads with the ganglion submaxillare (vide infra) and anastomoses upon the lateral surface of the m. hyoglossus with the n. hypoglossus through one or two *rami anastomotici cum n. hypoglosso* (see Fig. 834), by means of which sensory fibres probably pass over into the peripheral part of the n. hypoglossus. Branches:

α) *Rami isthmi faucium* (see Fig. 834), fine, go between lower jaw and m. pterygoideus internus to the tonsil and to the posterior part of the mucous membrane of the mouth.

β) *N. sublingualis* (see Figs. 591 and 828) runs forward, lateral from the glandula sublingualis, innervates this gland (vide supra) and the neighboring mucous membrane.

γ) *Rami linguales* (see Figs. 828 and 834) pass through the musculature of the tongue to the mucous membrane of the back and of the margins of the anterior two-thirds of the tongue (see also above and Fig. 836). They anastomose manifoldly with the same branches of the other side and with those of the n. glossopharyngeus.

Ganglion oticum (see Fig. 829), is a sympathetic ganglion (see also p. 788), a grayish-red, flatly rounded body, which lies close under the foramen ovale, immediately adjacent to the medial surface of the n. mandibularis; medianward it lies close to the pars cartilaginea tubae auditivae; close behind it runs the a. meningea media. The so-called *roots* of the ganglion are:

α) Communicating threads with the n. mandibularis, usually two, very delicate, from the upper margin.

β) Communicating threads with the sympathetic plexus meningeus (see p. 788).

γ) Communicating threads through a special canal with the n. canalis pterygoidei [Vidii].

δ) *N. petrosus superficialis minor* (see Figs. 829 and 831), is in largest part a continuation of the n. tympanicus (IX) (see p. 730), but it also receives a thread of communication from the n. facialis (see p. 724) and anastomoses with the n. petrosus superficialis major; it runs through the upper part of the canaliculus tympanicus, goes through its apertura superior into the sulcus n. petrosi superficialis minoris and then passes either through the fissura shenopetrosa or through a special canaliculus, medianward, forward and downward to the ganglion. In it run secretory fibres for the glandula parotis (see p. 722: n. auriculotemporalis), as well as taste fibres perhaps (vide supra: n. lingualis).

So-called *branches* of the ganglion (see Fig. 829):

α) Threads to the nn. pterygoideus internus, tensoris tympani and tensoris veli palatini.

β) *Ramus anastomoticus cum n. spinoso*, fine thread to the n. spinosus.

γ) *Ramus anastomoticus cum n. auriculotemporali*, fine threads to the n. auriculotemporalis, in which the secretory fibres for the parotid gland run (see p. 722).

δ) *Ramus anastomoticus cum chorda tympani*, one or two fine threads to the chorda tympani.

Ganglion submaxillare (see Figs. 591 and 828) is a sympathetic ganglion (see also p. 788), a spindle-shaped body lying directly in front of the m. pterygoideus internus, under the n. lingualis and over the glandula submaxillaris. It communicates with the n. lingualis by means of several *rami communicantes cum n. linguali*, some of them pass upward and are attached to the n. lingualis in centripetal direction, others run forward to the peripheral part of the n. lingualis. It farther communicates by means of fine threads with the sympathetic *plexus maxillaris externus* surrounding the a. maxillaris externa. From the lower margin

several threads, *rami submaxillares*, go to the glandula submaxillaris (see p. 723) and to the ductus submaxillaris [Whartoni].

VI. **N. abducens** (see Figs. 749, 750, 758, 817—822, 916, 919—921), motor, leaves the brain, on each side, at the lower, posterior margin of the pons in the groove between this and the pyramid, runs between the pons and the clivus upward, lateralward and forward (see Fig. 758) and perforates the dura mater medialward from and beneath the n. trigeminus, somewhat below the apex of the pyramid; it then passes over this into the sinus cavernosus, goes forward in the middle through it (see also Fig. 533), lateral from and below the a. carotis interna, medial from the n. ophthalmicus (V), enters the annulus tendineus communis [Zinni] under the nn. oculomotorius and nasociliaris (V) through the fissura orbitalis superior, becomes applied to the medial surface of the m. rectus lateralis and ends in it.

Anastomoses: In the sinus cavernosus it receives sympathetic fibres from the plexus cavernosus.

VII. **N. facialis** (see Figs. 749, 750, 758, 817—819, 824, 827—829, 831—833 and 837), motor, appears on each side lateral from the n. abducens, just medial from the nn. intermedius and acusticus, at the inferior, posterior margin of the brachium pontis (see p. 651) above and somewhat lateral from the olive; it passes lateralward along with the nn. intermedius and acusticus at the upper margin of the flocculus in front of the brachium pontis upon the tuberculum jugulare oss. occipitalis and upon the facies posterior pyramidis, and runs upward and forward to the porus acusticus internus (see Figs. 819 and 833) and into the meatus acusticus internus. In this the n. facialis lies over the n. acusticus in a groove of the latter, the n. intermedius between the two; they have a sheath in common formed by continuations of the meninges, and of the cavum subdurale and subarachnoideale, all of which reach as far as the bottom of the meatus. From there on it runs lateralward with the n. intermedius (vide infra) in the canalis facialis (see Figs. 829 and 831) to the geniculum canalis facialis, there bends sharply around, *geniculum n. facialis (facial knee)*, and extends further, first backward and lateralward and then downward. At the foramen stylomastoideum it leaves the canalis facialis, enters the substance of the parotid gland and within it runs in an arch concave upward and medianward (see Figs. 827—829), in front of the posterior belly of the m. digastricus and laterally from the proc. styloideus, a. carotis externa and v. facialis posterior upon the lateral surface of the ramus of the lower jaw, there to break up into its terminal branches (see Fig. 832). It innervates the whole mimic musculature of the face.

N. intermedius (see Figs. 749 and 758), a mixed nerve, leaves the brain just lateral from the n. facialis, between it and the n. acusticus (n. vestibularis), enters the canalis facialis with the n. facialis (vide supra), and is at first loosely and then more intimately united with the n. facialis. Its sensory part forms at the geniculum n. facialis the *ganglion geniculi* (see Fig. 831), a conical aggregation of ganglion cells comparable to those of the spinal ganglia, with its apex directed medianward and intimately united with the n. facialis; the ganglion geniculi anastomoses with the ganglion vestibulare by a delicate nerve-thread. The farther course of the fibres is only partly known; the secretory fibres in it coming from the brain for the glandulae submaxillaris and sublingualis go over into the chorda tympani (vide infra); the latter is often looked upon as the direct continuation of the n. intermedius; the fibres for the lachrymal gland, all of which are carried by it, enter into the n. petrosus superficialis major (see also p. 714).

A. Branches of the n. facialis (and partly of the n. intermedius) within the temporal bone:

1. *N. petrosus superficialis major* from the geniculum n. facialis to the ganglion sphenopalatinum (see p. 717).

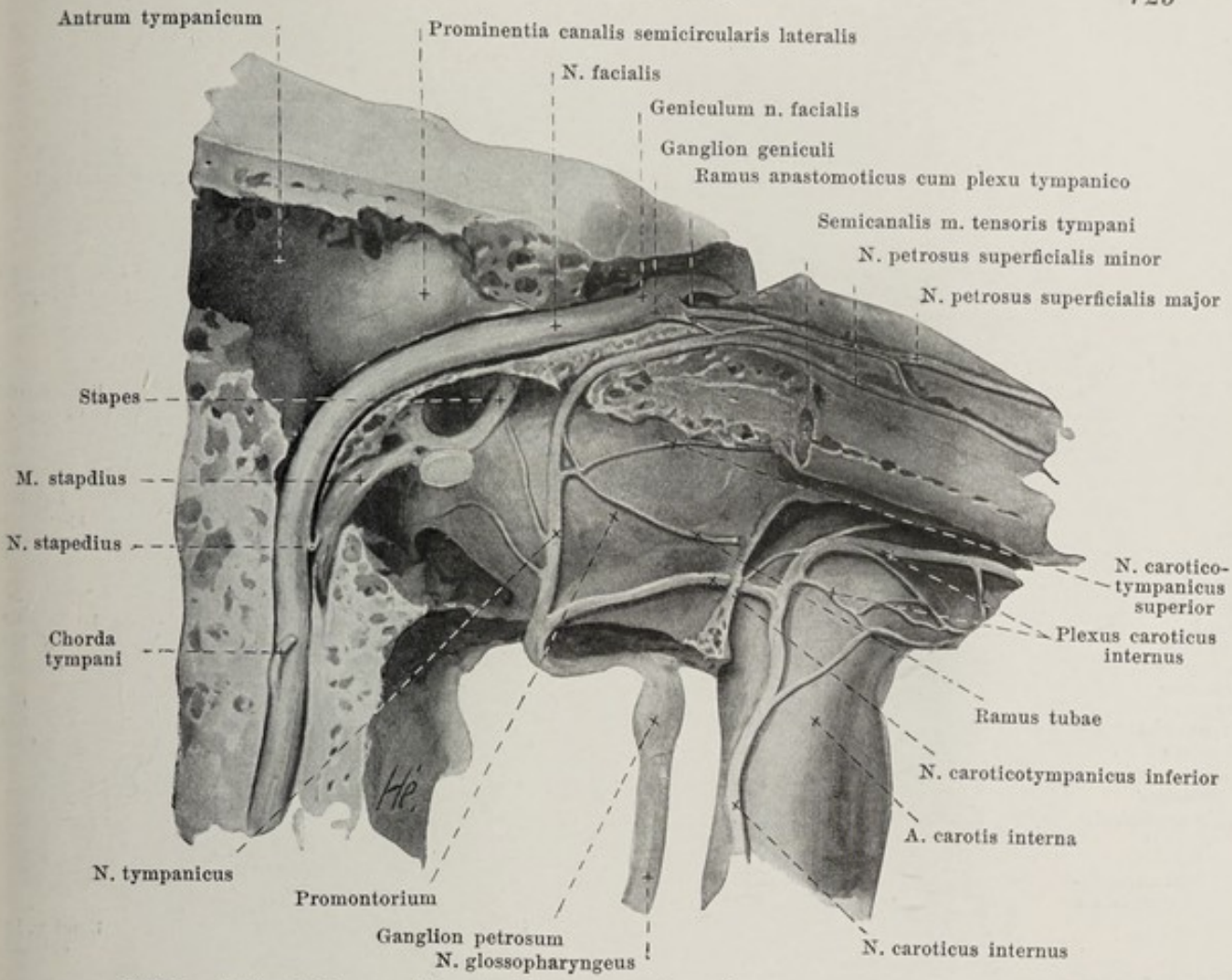
2. *Ramus anastomoticus cum plexu tympanico* (see Fig. 831), a fine thread, from the geniculum n. facialis to the n. petrosus superficialis minor (see p. 723).

3. *N. stapedius* (see Fig. 831) arises in the vertical part of the canalis facialis and passes through a small opening to the m. stapedius, situated within the eminentia pyramidalis.

4. *Chorda tympani* (see Figs. 828, 829, 831, 834, 945, 947 and 948) goes off beneath the preceding, running back in an acute angle open above; it runs at first through the canaliculus chordae tympani to the cavum tympani, then in the plicae malleolares posterior and anterior between the crus longum incudis and manubrium mallei, and finally in the fissura petrotympanica [Glaseri], in order to pass medial from the spina angularis, a. meningea media, and the nn. auriculotemporalis and alveolaris inferior downward to the posterior margin of the n. lingualis (see p. 723). In its course it describes a curve, convex upward and lateralward, and is connected by one or two fine threads with the ganglion oticum (see p. 723). Concerning its fibres see n. lingualis, p. 723.

B. Branches of the n. facialis outside the skull:

1. *N. auricularis posterior* (see Figs. 832, 837 and 845) arises close under the foramen stylomastoideum, runs upward and backward on the anterior surface of the processus mastoideus, between this and the external ear, near the a. auricularis posterior, anastomoses by fine threads with the sensory nn. occipitalis minor (C_2 C_3) and auricularis magnus (C_3), and sends an anterior branch upward to the mm. auriculares posterior and superior, as well as to the mm. transversus auriculae, obliquus auriculae and antitragicus, and a posterior branch horizontally, *ramus occipitalis*, to the m. occipitalis.



831. Right n. facialis and plexus tympanicus,

viewed from in front. Magnification: 4 : 1.

(The canalis facialis, canaliculus tympanicus and canalis caroticus have been opened.)

2. *Ramus digastricus* (see Figs. 828 and 837) arises close under the preceding and passes downward to the anterior surface of the venter posterior m. digastrici, which it innervates. Branches:

α) *Ramus stylohyoideus*, a long thread, downward and forward to the m. stylohyoideus.

β) *Ramus anastomoticus cum n. glossopharyngeo* (see Fig. 837) given off in the m. digastricus or previously, runs medianward in a curve, convex below, to the n. glossopharyngeus, which it reaches below the ganglion petrosum.

C. Terminal branches of the n. facialis (see Figs. 832 and 845), an upper, usually the larger, and a lower; the two usually form an obtuse angle with one another. The upper one passes upward and forward, the lower one to the angulus mandibulae. Their branches form a plexus, *plexus parotideus* (see Fig. 832), often distinct only above. The upper branch communicates by two threads with the n. auriculotemporalis (see p. 722). The terminal branches are subdivisible into:

1. *Rami temporales*, over the zygomatic arch, upward to the mm. helicis major, helicis minor, tragicus, mm. auriculares superior and anterior, as well as upward and forward to the mm. frontalis, orbicularis oculi and corrugator.

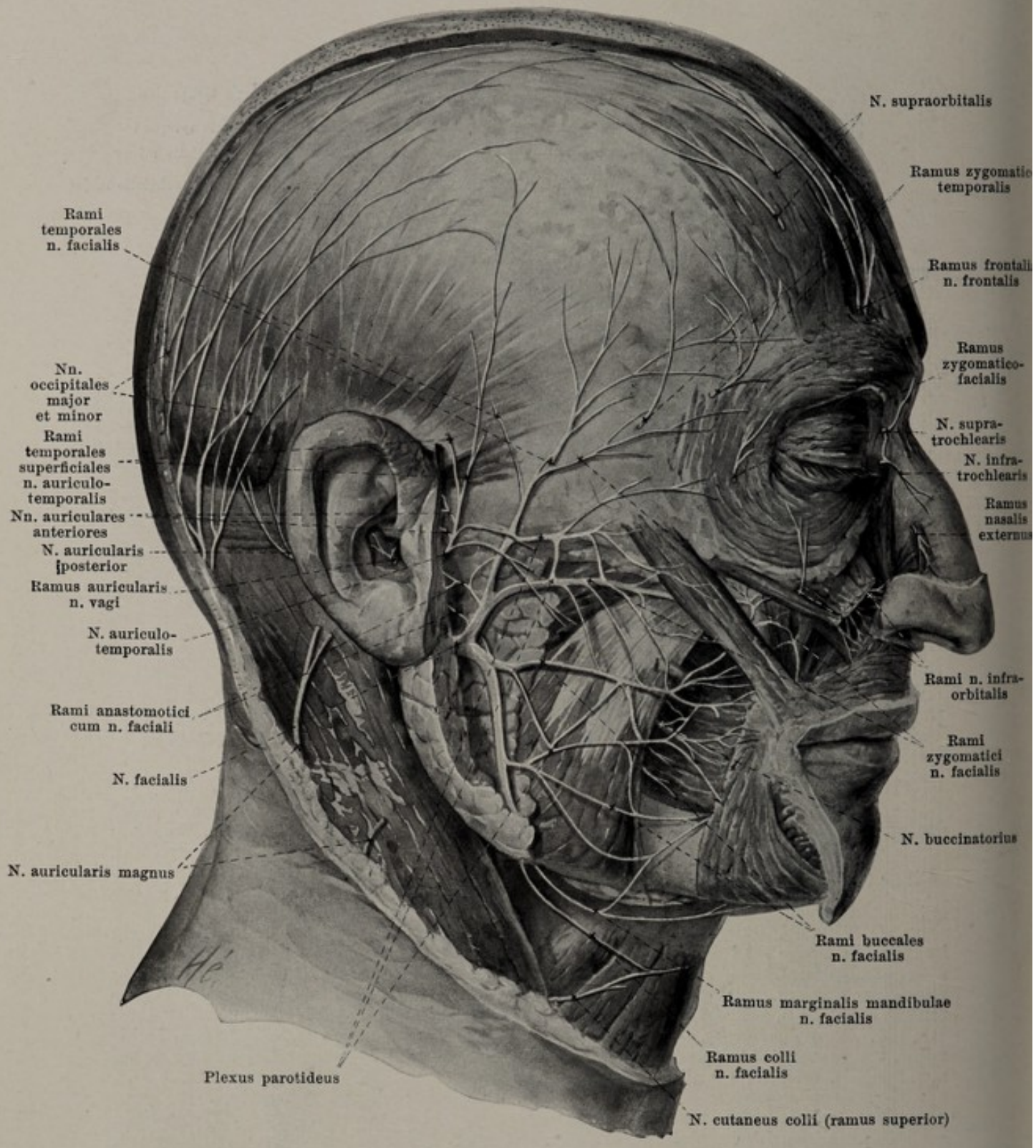
2. *Rami zygomatici* forward to the mm. orbicularis oculi and zygomaticus.

3. *Rami buccales*, upon the m. masseter, forward to the mm. risorius, zygomaticus, quadratus labii superioris, procerus, caninus, buccinator, incisivi, orbicularis oris, triangularis, quadratus labii inferioris and to the muscles of the nose.

4. *Ramus marginalis mandibulae* runs along the base of the lower jaw to the region of the chin and gives branches to the mm. quadratus labii inferioris and mentalis.

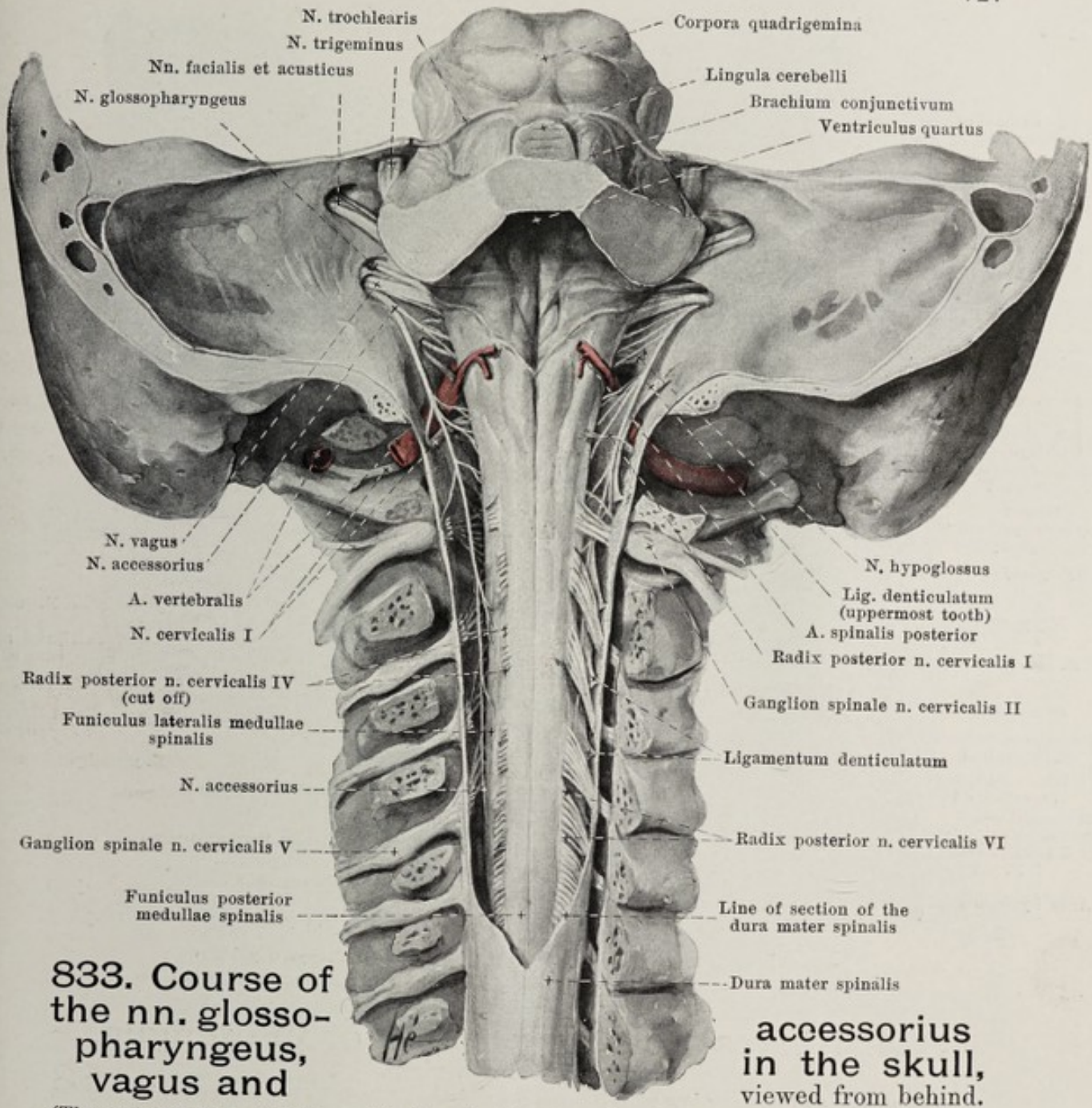
5. *Ramus colli* from the angle of the lower jaw on the neck forward and downward, covered by the platysma, which it alone innervates. It anastomoses with the (sensory) n. cutaneus colli (C_2, C_3).

These branches form numerous anastomoses with branches of the n. trigeminus, especially the rami temporales with the n. supraorbitalis and the rami buccales with the n. buccinatorius.



832. Nerves of the face, viewed from the right.

(The platysma has been removed: a piece has been cut out of the glandula parotis.)



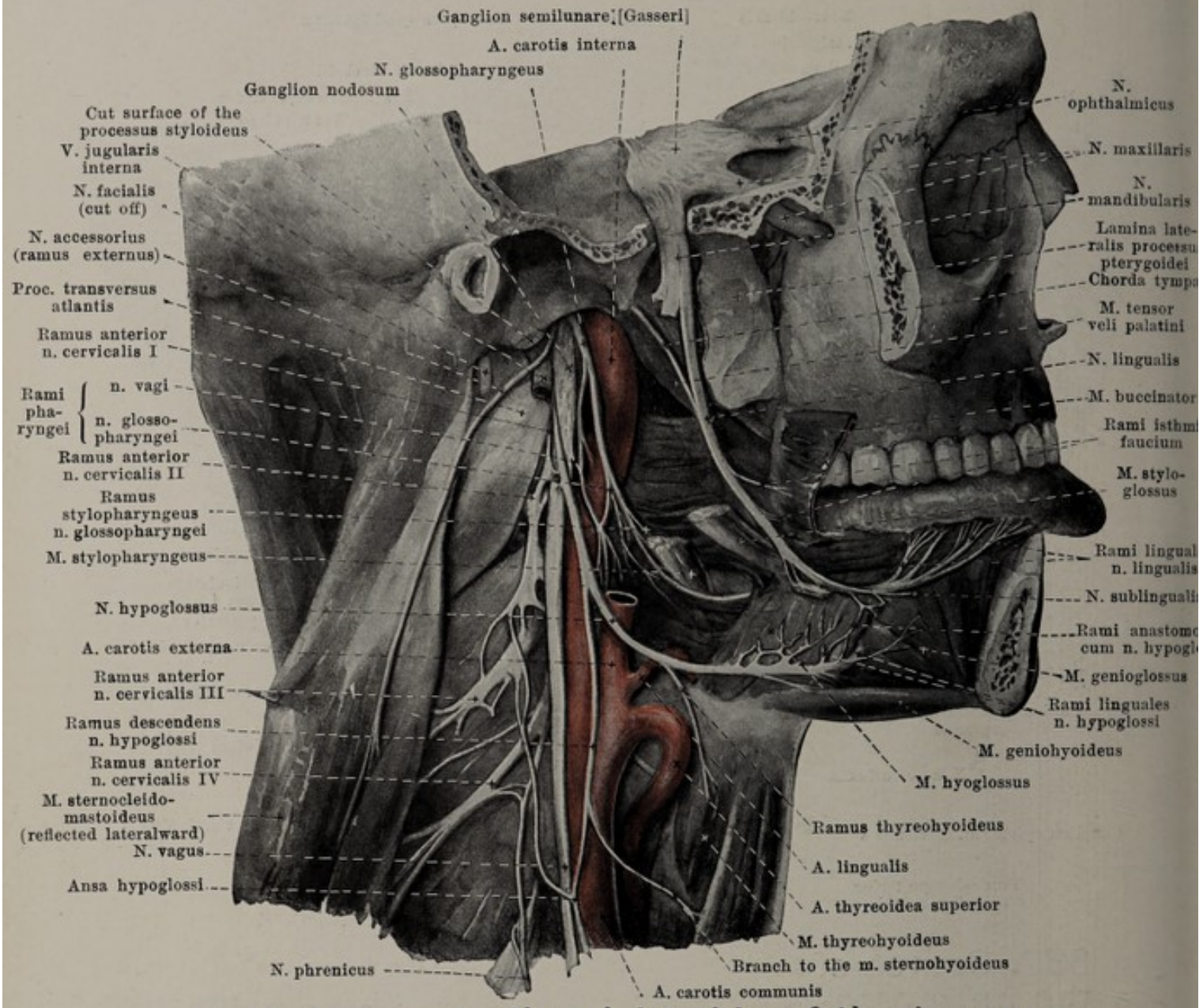
833. Course of the nn. glossopharyngeus, vagus and accessorius in the skull, viewed from behind.

(The occipital bone and the vertebral arches have been largely sawn away, the cerebrum and cerebellum cut away; the sac of the dura mater spinalis has been opened. On the left the posterior roots of the cervical nerves have been partly removed, the lig. denticulatum completely.)

VIII. **N. acusticus,** *acoustic nerve* (see also Figs. 749, 750, 755, 758, 817—819, 972 and 973), is a sensory nerve, which appears on each side with two roots at the lower posterior margin of the brachium pontis above and behind the olive. The medial root *(radix n. vestibularis)* appears just lateral from the n. intermedius in front of the corpus restiforme, the lateral *(radix n. cochlearis)* passes around the latter like an arch from the outside. The n. acusticus passes with the nn. facialis and intermedius into the meatus acusticus internus (see p. 724) and there divides into two branches, the *n. vestibularis* and the *n. cochlearis.*

1. The *n. vestibularis* (s. Figs. 972 and 973) is interrupted at the bottom of the internal acoustic meatus by a ganglion, *ganglion vestibulare* (which anastomoses by a thread with the ganglion geniculi [see p. 724]), and divides into an upper and a lower terminal branch. The former goes from the area vestibularis superior to the macula cribrosa superior vestibuli; its branches run as follows:

α) *N. utricularis* to the macula acustica utriculi,
β) *N. ampullaris superior* to the ampulla membranacea superior and
γ) *N. ampullaris lateralis* to the ampulla membranacea lateralis.



834. Nerves to the right side of the tongue,

viewed from the right.

(The right half to the lower jaw with its muscles and the processus styloideus with its muscles have been removed; the foramen ovale has been exposed from the lateral side.)

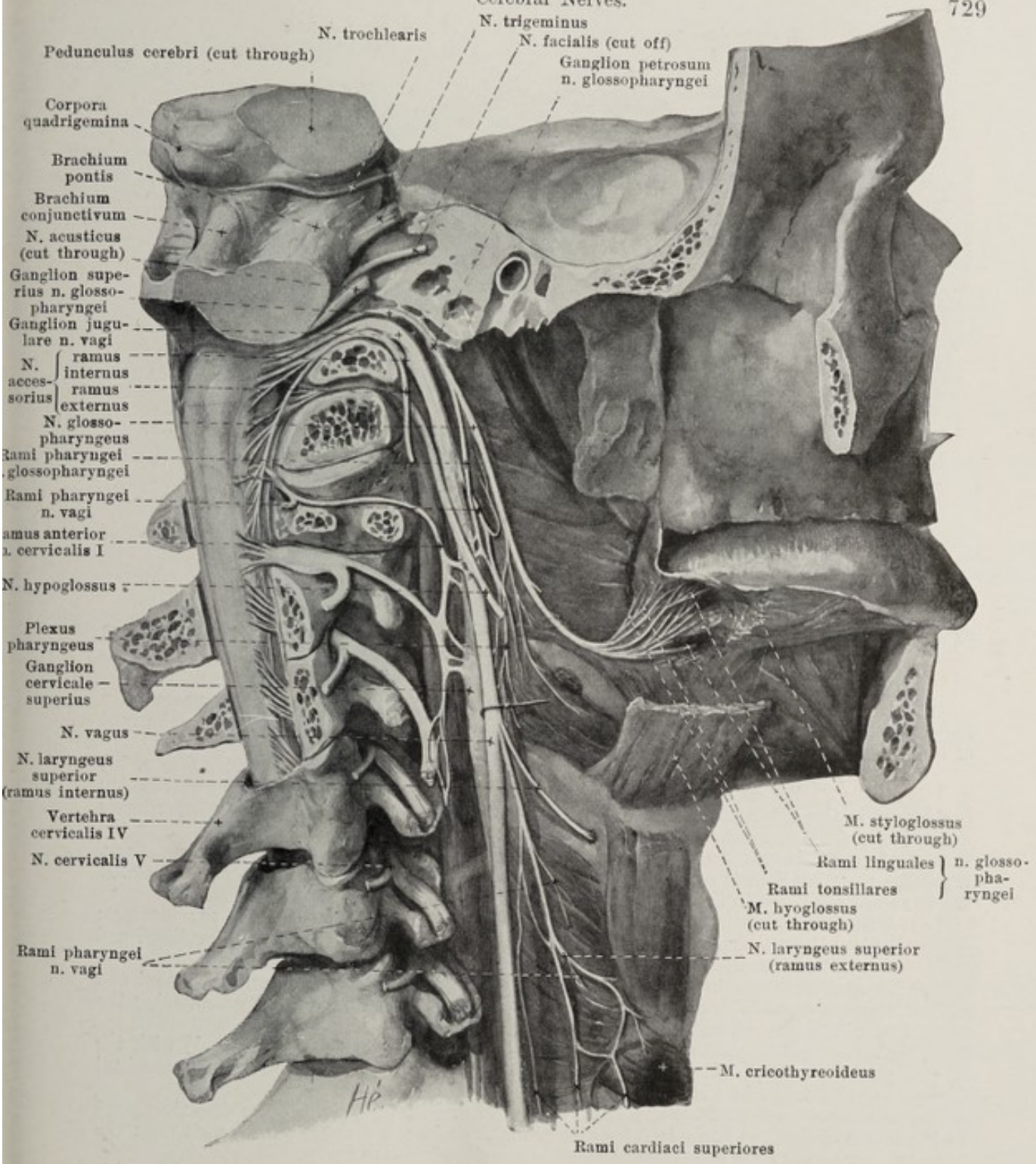
1. *N. vestibularis* (continued) (see Figs. 972 and 973). Its lower terminal branch divides into:

δ) *N. sacccularis*, which passes out from the area vestibularis inferior through the macula cribrosa media vestibuli to the macula acustica sacculi, and

ε) *N. ampullaris posterior*, which passes from the foramen singulare through the macula cribrosa inferior vestibuli to the ampulla membranacea posterior.

2. *N. cochlearis* goes through the tractus spiralis foraminosus into the canales longitudinales modioli and in the canalis spiralis modioli forms the long stretched-out *ganglion spirale*.

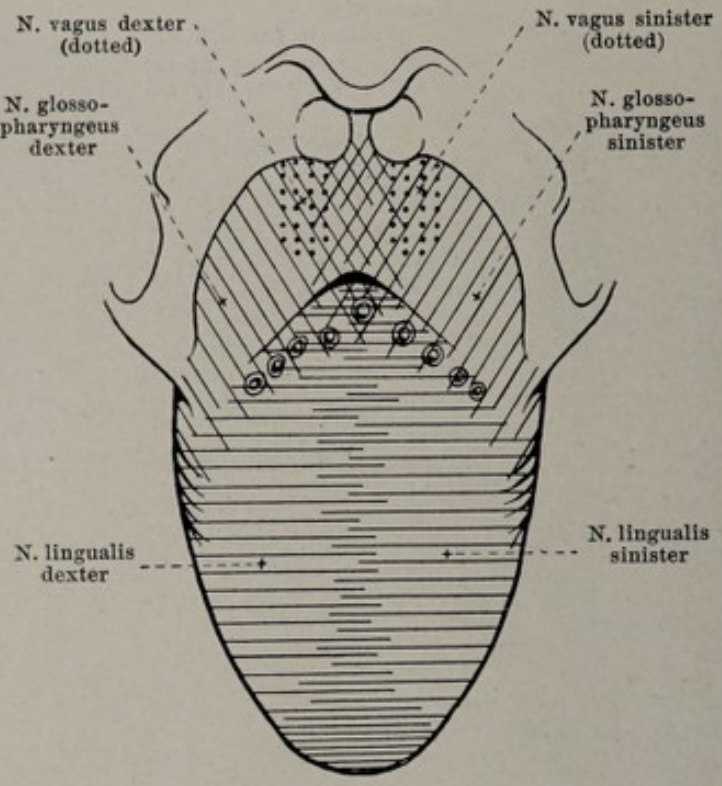
IX. **N. glossopharyngeus** (see also Figs. 749, 750, 755, 758, 817, 819, 831, 833, 835 and 837), a mixed nerve, appears with 5—6 threads below the n. acusticus in the upper part of a groove of the medulla oblongata running behind the olive (see p. 649); upon the tuberculum jugulare under the flocculus it passes almost horizontally lateralward and forward to the foramen jugulare; it runs through the most anterior, medial part of the latter, separated from the n. vagus and n. accessorius by a strip of dura mater (see Figs. 817, 819 and 835), passing in a curve downward and forward. In the foramen jugulare it becomes swollen to form the small *ganglion superius* and beneath this in the fossula petrosa to form the somewhat larger, elongated *ganglion petrosum* (see Figs. 831 and 835).



835. Right nerves of the pharynx, viewed from the right and somewhat from behind. (The preparation is similar to that of Fig. 834; in addition the medulla oblongata and the course of the nerves in the bone have been exposed; the muscles of the spine have been completely removed, those of the tongue partly.)

IV. **N. glossopharyngeus** (continued). The two ganglia may fuse with one another; they are similar in construction to the spinal ganglia and contain the cells of origin of the sensory fibres of the nerve (see p. 700); the motor fibres run past these ganglion cells.

Outside the skull the nerve goes downward, at first behind, then lateral from, the a. carotis interna, between it and the m. stylopharyngeus and then bends around the posterior margin of the latter upon its lateral surface (see also Fig. 834).



836. Distribution of sensory nerves in the mucous membrane of the tongue, schematic (after R. Zander).

IX. **N. glossopharyngeus** (see Figs. 834 and 835) (continued). It then passes in a curve, convex downward and backward, on the medial side of the m. styloglossus to the root of the tongue. Branches: A) From the ganglion petrosum:

1. *N. tympanicus* (see Fig. 831) runs upward in the canaliculus tympanicus (see p. 14) first into the cavity of the tympanum, then in the sulcus promontorii, becomes directly continuous in the upper part of the canaliculus tympanicus with the n. petrosus superficialis minor (see p. 723) and communicates by a fine thread with the n. facialis (see p. 724). In the lowermost part it is surrounded by a swelling of vascular tissue, the *intumescentia tympanica.* Upon the promontorium it forms with its branches the *plexus tympanicus [Jacobsoni].* In it run the secretory fibres to the glandula parotis (see p. 722). Branches:

α) *Ramus tubae*, delicate, runs forward to the mucous membrane of the ear trumpet; besides it sends delicate branches backward to the region of the fenestra vestibuli and fenestra cochleae.

β) *N. caroticotympanicus superior*, delicate, runs medianward in the cavum tympani and through a special canal to the sympathetic plexus caroticus internus surrounding the a. carotis interna, sometimes also to the n. petrosus superficialis major.

γ) *N. caroticotympanicus inferior* connects the plexus tympanicus [Jacobsoni] with the plexus caroticus internus; at the same time it passes through one or two canaliculi caroticotympanici and runs upon or under the promontorium.

2. *Ramus anastomoticus cum ramo auriculari n. vagi* (see Fig. 837), a delicate thread to the ramus auricularis n. vagi; it may be absent. Besides, a delicate thread goes from the ganglion petrosum to the vagus, just below the ganglion jugulare (see p. 733).

3. A communicating thead with the ganglion cervicale superius (branch of the n. jugularis).

4. A branch to the ramus digastricus n. facialis (see p. 725).

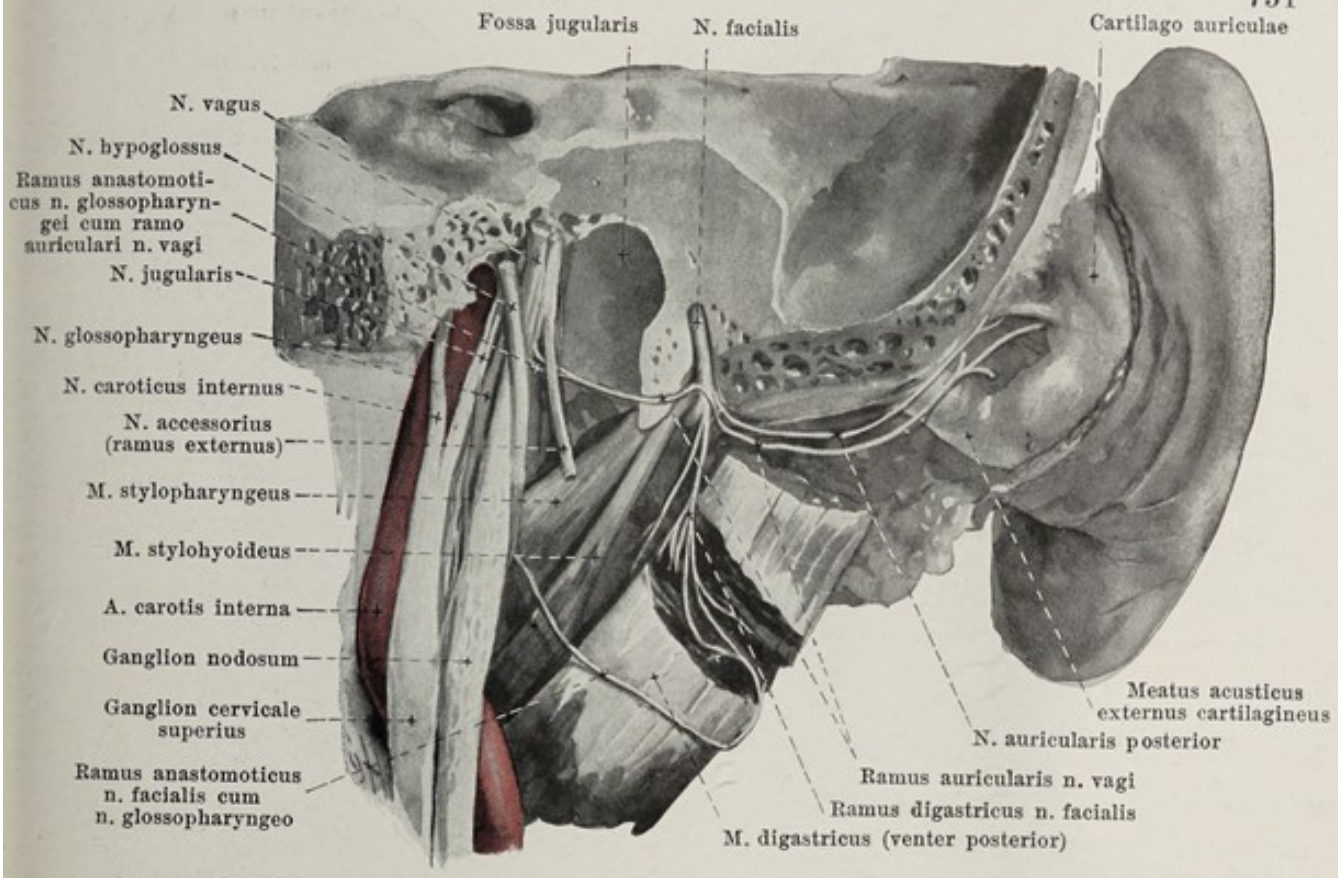
B. Peripheral branches:

5. *Rami pharyngei* (see Figs. 834 and 835), 2 or 3, go off at variable levels on the lateral surface of the a. carotis interna and help to form the plexus pharyngeus (see p. 733).

6. *Ramus stylopharyngeus* (see Fig. 834) goes off behind the m. stylopharyngeus and passes to this muscle (these fibres are said not to be motor, see p. 733: rami pharyngei n. vagi).

7. *Rami tonsillares* (see Fig. 835) arise close behind the root of the tongue and pass to the mucous membrane of the tonsil and of the palatine arch.

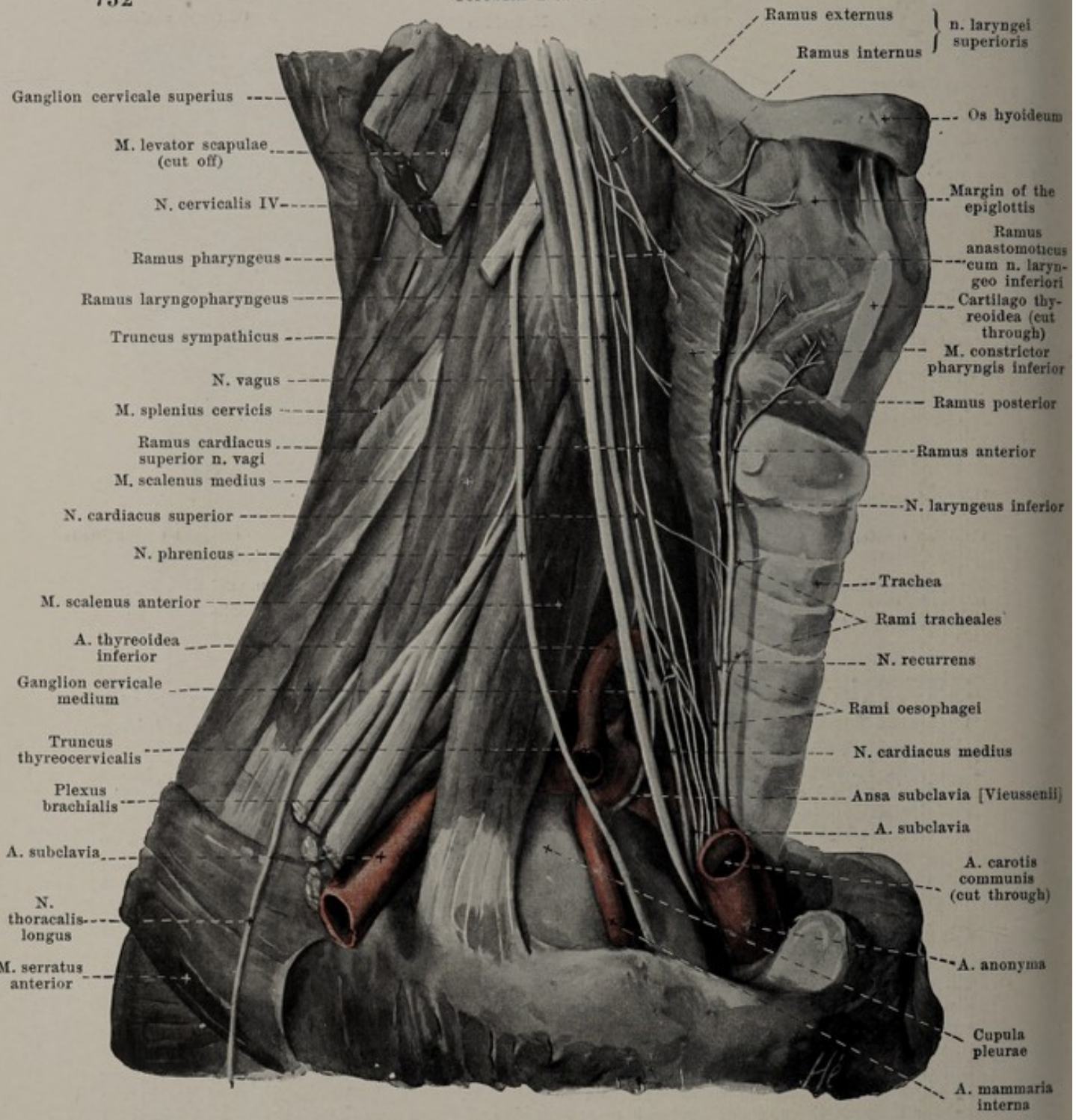
8. *Rami linguales* (see Fig. 835) to the mucous membrane of the posterior third of the tongue (see Fig. 836); they unite manifoldly with one another, and carry chiefly the taste fibres and other sensory fibres for this region. Numerous anastomoses exist between the right and left branches and those of the nn. linguales (V).



837. Right ramus auricularis n. vagi, viewed from behind.

(The head has been removed from the spine by a frontal section; the processus mastoideus with the origin of the m. digastricus has been subsequently removed.)

X. **N. vagus** (see Figs. 749, 750, 755, 758, 817, 819 and 833—839), a mixed nerve, leaves the brain with 10—15 fila radicularia just below the n. glossopharyngeus in a sulcus of the medulla oblongata running behind the olive (see p. 649). The fibres converge to form a round nerve stem which passes lateralward in front of the tonsilla cerebelli on the tuberculum jugulare to the anterior compartment of the foramen jugulare, and downward through this in a curve (see Figs. 817, 819, 833 and 835). It together with the n. accessorius is accompanied there by a process of the dura mater and arachnoidea and is separated by these from the n. glossopharyngeus. In the foramen jugulare it presents a small swelling, *ganglion jugulare* (see Fig. 835); below it receives the ramus internus n. accessorii (see p. 734), and becomes thickened, its bundles loosening up plexus-like, to form the elongated spindle-shaped *ganglion nodosum* (see also Figs. 834 and 835). Both ganglia are in the main similar in structure to the spinal ganglia and contain the cells of origin of the sensory fibres of the nerve (see p. 700); the motor fibres run past the ganglion cells. Just beneath the foramen jugulare (see also Figs. 834 and 835) the n. vagus lies behind the n. glossopharyngeus, in front of the n. accessorius and the v. jugularis interna and lateral from the n. hypoglossus, which then loops around past the posterior surface of the ganglion nodosum to the lateral side of the n. vagus. The n. vagus then lies in the groove between the a. carotis interna or communis and v. jugularis interna (see also Fig. 358) and passes with these vessels down the neck (see Figs. 834, 835 and 838) as far as the upper aperture of the thorax; in its course it lies somewhat lateralward and in front of the ganglion cervicale superius and the truncus sympathicus. From there on downward the right and left nerve behaves somewhat differently. On the r i g h t side (see Figs. 838 and 846) the nerve runs in front of the a. subclavia (medial from the truncus thyreocervicalis) and downward behind the v. subclavia and gives off here the n. recurrens which loops around the inferior surface of the a. subclavia in a curve backward and upward. The nerve then passes downward and backward (see Figs. 680 and 682) on the right side of the trachea to the posterior surface of the bronchus dexter (in front of the v. azygos) and there breaks up into an elongated plexus. From this one or several strands run on the p o s t e r i o r surface of the oesophagus, anastomose with one another there *(plexus oesophageus posterior)* and exchange fibres with the left n. vagus so that after its passage through the diaphragm the right nerve is always a least twice as thick as the left nerve.



838. Right n. vagus in the neck, viewed from the right.

(The scapula and clavicle with their muscles, the hyoid muscles and the thyroid gland have been completely removed; the large vessels have been partially removed.)

X. **N. vagus** (continued): The l e f t n. vagus (see Figs. 681—683, 839 and 846) descends between the aa. carotis communis and subclavia sinistra, directly in contact with the pleura mediastinalis to the anterior, left surface of the arcus aortae and there sends off the n. recurrens, which runs upward and backward in a curve around the inferior surface of the arcus aortae. The further course of the n. vagus differs from that of the right side only through the fact that it lies upon the a n t e r i o r surface of the oesophagus (there forming with branches of the right n. vagus the *plexus oesophageus anterior);* on its farther communication with the right n. vagus see also p. 731.

Branches from A) Cephalic part of the n. vagus (between brain and ganglion nodosum):

1. *Ramus meningeus* (not illustrated), from the ganglion jugulare, upward and recurrent through the foramen jugulare, gives off branches to the dura mater around the latter.

2. Anastomosis with the ganglion cervicale superius (branch of the n. jugularis).

3. *Ramus auricularis* (see Fig. 837) arises close below the ganglion jugulare, but usually receives a thread from the n. glossopharyngeus (see p. 730), passes in front of the n. accessorius and the bulbus v. jugularis superior in the fossa jugularis to the canaliculus mastoideus and through this to the canalis facialis, and lies in contact with the n. facialis as far as the foramen stylomastoideum, it then runs upward in a curve at the anterior margin of the processus mastoideus near the n. auricularis posterior, perforates the membranous part of the auricula and is distributed to the concave surface of the auricula (see Fig. 832) and to the external acoustic meatus.

4. *Ramus anastomoticus cum n. glossopharyngeo* (see Fig. 835, not designated), 1—2 fine threads of communication between the ganglion petrosum n. glossopharyngei and the n. vagus.

5. Communication of the n. vagus with the ramus internus n. accessorii (see p. 731 and 734).

B) Cervical part of the n. vagus (as far as the origin of the n. recurrens):

1. Anastomoses between the ganglion nodosum and α) the ganglion cervicale superius (see Fig. 837) and β) the n. hypoglossus (see Figs. 834 and 835).

2. *Rami pharyngei* (see Figs. 834 and 835), usually two, from the ganglion nodosum, between the a. carotis interna and externa, downward and forward to the pharynx, interweaving upon the m. constrictor pharyngis medius with the rami pharyngei n. glossopharyngei (see p. 730) and the rami laryngopharyngei of the sympathicus to form the *plexus pharyngeus*. From this arise the motor fibres for the mm. constrictores pharyngis, levator veli palatini, uvulae, glossopalatinus, pharyngopalatinus, which leave the brain in the n. vagus, and for the m. stylopharyngeus, which come from the brain in the n. glossopharyngeus and go into the n. vagus (vide supra) in the foramen jugulare, as well as the sensory fibres for the mucous membrane of the pharynx and of a part of the root of the tongue (see Fig. 836.

3. *N. laryngeus superior* (see Figs. 835 and 838), from the inferior extremity of the ganglion nodosum, runs downward and forward upon the m. constrictor pharyngis medius on the medial side of the a. carotis interna and externa; in its course it anastomoses by delicate threads with the plexus pharyngeus and the ganglion cervicale superius and gives off a delicate branch to the a. carotis interna. At the cornu superius oss. hyoidei it divides into two branches:

a) *Ramus externus* (see Figs. 835 and 838), the smaller of the two, descends almost vertically upon the external surface of the m. constrictor pharyngis inferior to the m. cricothyreoideus, supplies this with motor fibres and gives sensory fibres to the mucous membrane of the larynx. It receives a thread from the ganglion cervicale superius, anastomoses with the plexus pharyngeus and gives off *rami pharyngei* to the m. constrictor pharyngis inferior, often also a ramus cardiacus superior (vide infra).

b) *Ramus internus* (see Figs. 835 and 838) runs forward and downward medial from the a. thyreoidea superior and from the m. thyreohyoideus on the membrana hyothyreoidea (see also Fig. 834), perforates the latter along with the a. laryngea superior (see also Fig. 660), extends medianward and downward in the plica nervi laryngei (see Figs. 600 and 602) and divides into several branches (see Fig. 838). Some of these go upward near the epiglottis to its mucous membrane and to that of a small part of the root of the tongue (see also Fig. 836), others supply the mucous membrane of the larynx above the glottis and the pharyngeal mucous membrane behind the cartilagines arytaenoideae and cricoidea; a delicate twig, *ramus anastomoticus cum n. laryngeo inferiori*, passes downward upon the internal muscles of the larynx to the n. laryngeus inferior.

4. *Rami cardiaci superiores* (see Figs. 835, 838, 839 and 846), 1—3, arise at a variable height between the n. laryngeus superior and n. recurrens, the uppermost often wholly or partly from the n. laryngeus superior; they pass along the a. carotis communis (and, on the right side, the a. anonyma) to the aorta and there help to form the plexus cardiacus (see p. 791). They anastomose even in the neck with the nn. cardiaci of the sympathicus.

5. *N. recurrens* (see Figs. 685, 838, 839 and 846) (for origin see pp. 731 and 732) bends medianward and upward on the right around the inferior surface of the a. subclavia, on the left around that of the arcus aortae (lateral from the lig. arteriosum), passes from there, close to the trachea, vertically upward, on the right side on the right margin of the oesophagus, on the left side on its anterior surface, and ends above as the *n. laryngeus inferior*. It anastomoses with the ganglion cervicale inferius and the n. cardiacus superior. Branches:

a) *Rami cardiaci inferiores* (see Figs. 839 and 846), variable in number, arise partly from the thoracic part of the n. vagus and pass on the right side close to the a. anonyma, on the left side on the arcus aortae to the plexus cardiacus (see p. 791), which they help to form.

b) *Rami tracheales* (see Fig. 838) (some also from thoracic part of the n. vagus) to the musculature and mucous membrane of the trachea.

c) *Rami oesophagei* (see Fig. 838) to the wall of the oesophagus and of the pharynx.

d) *N. laryngeus inferior* (see Fig. 838) ascends usually between, more rarely behind or in front of the terminal branches of the a. thyreoidea inferior, on the medial surface of the lateral lobe of the thyroid gland, passes under the m. cricopharyngeus (see also Figs. 606 and 685) on its medial side and divides behind the articulatio cricothyreoidea into two branches.

The *ramus anterior* passes upward and forward upon the mm. cricoarytaenoideus lateralis and thyreoarytaenoideus and supplies these, as well as the mm. vocalis, arytaenoideus obliquus, aryepiglotticus and thyreoepiglotticus; the *ramus posterior* runs upward to the mm. cricoarytaenoideus posterior and arytaenoideus transversus, supplies them and anastomoses with the ramus internus n. laryngei superioris (see p. 733).

C) Thoracic part of the n. vagus (downward as far as the hiatus oesophageus):

1. Numerous anastomoses with the branches of the sympathicus.

2. *Rami bronchiales anteriores* (see Fig. 839) go over and under the bronchus to its anterior wall on it, with branches of the sympathicus, form a plexus, *plexus pulmonalis anterior*, which penetrates with the bronchus into the lung.

3. *Rami bronchiales posteriores* (see Fig. 839), larger and more numerous, form with branches of the sympathicus a narrow-meshed plexus upon the posterior surface of the bronchus, *plexus pulmonalis posterior*, which is manifoldly connected which that of the other side behind the bifurcatio tracheae; it passes forward with the bronchus into the lung.

4. *Rami oesophagei* (see Fig. 839) from the plexus oesophagei to the oesophagus.

5. *Rami pericardiaci* (not illustrated), several delicate branches from the stem of the n. vagus or from the plexus pulmonales and oesophagei to the surfaces of the pericardium.

D) Abdominal part of the n. vagus:

The l e f t n. vagus (see Fig. 839) sends several diverging branches, *rami gastrici*, to the anterior wall of the stomach which anastomose with one another and with sympathetic nerves, and also along the curvatura minor small branches, *rami hepatici*, to the liver.

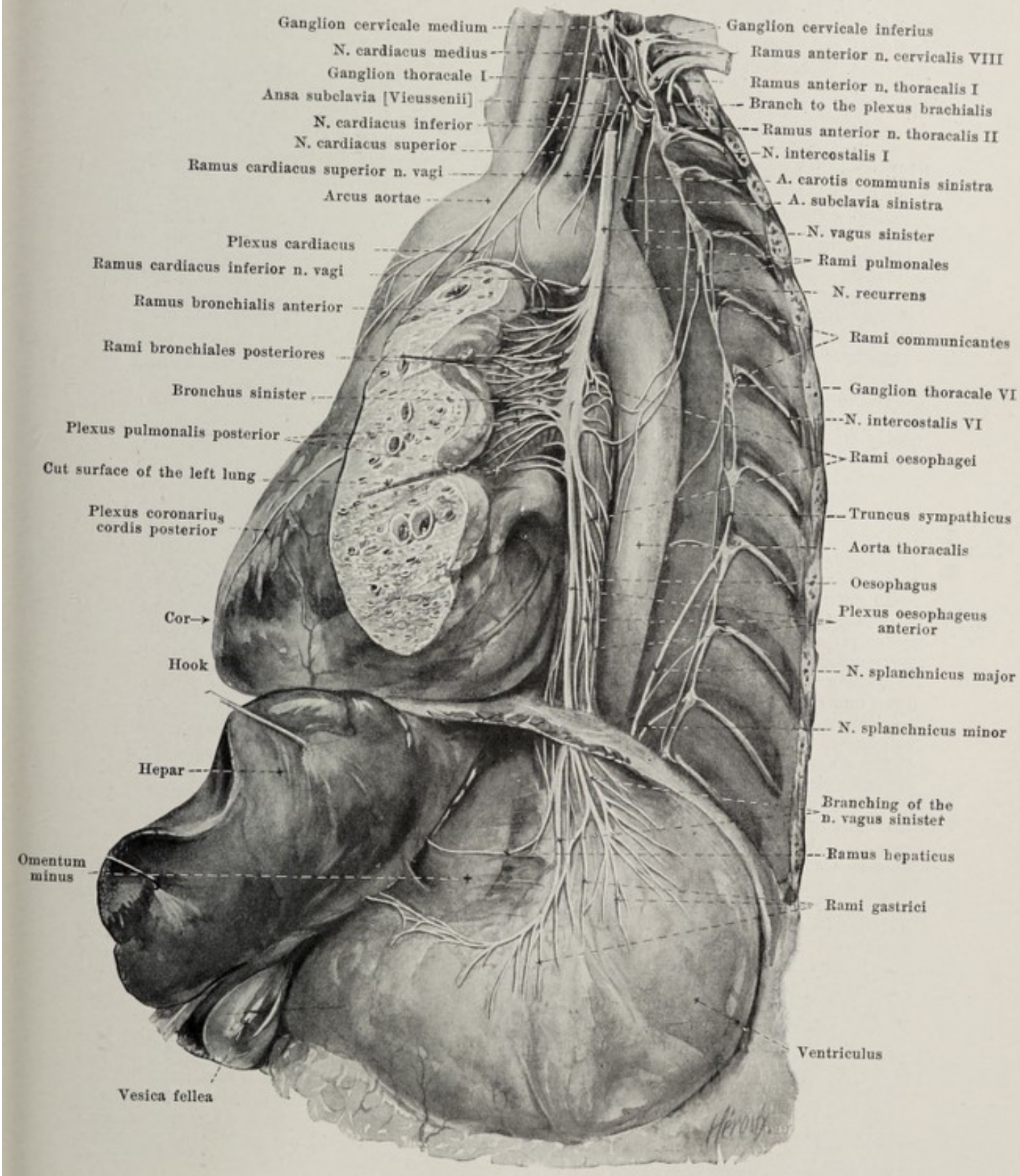
The r i g h t n. vagus (see Fig. 891) gives in a similar way branches, *rami gastrici*, to the posterior wall of the stomach; with the majority of its fibres *(rami coeliaci)* it passes near the a. gastrica sinistra to the ganglia coeliaca, then comes to lie close to the a. mesenterica superior and reaches along with the branches of this artery the entire small intestine (not large intestine). Besides these it sends small branches to the spleen *(rami lienales)*, to the pancreas, to the kidneys *(rami renales)* and suprarenals. The nerve anastomoses everywhere freely with sympathetic plexuses.

XI. **N. accessorius** (see Figs. 749, 750, 755, 758, 817, 819, 833—835, 837 and 845), motor, leaves the central organ by two kinds of root threads, superior and inferior. The 3—6 s u p e r i o r t h r e a d s appear just below the n. vagus in a sulcus of the medulla oblongata running behind the olive (see p. 649), the i n f e r i o r, added thereto, come from the funiculus lateralis of the cervical cord, usually down as far as the exit of the 5th, more rarely of the 7th cervical nerve, so that usually there is a root thread corresponding to each segment (see Figs. 833 and 835). The i n f e r i o r t h r e a d s unite to form a small stem which ascends between the posterior roots of the cervical nerves and the lig. denticulatum; it often forms connections (usually only apparent) with the posterior roots of the first, more rarely of the second cervical nerve; it then passes behind the a. vertebralis through the foramen occipitale magnum into the skull cavity, unites with the superior root fibres and, passing in front of the tonsilla cerebelli below the n. vagus to the foramen jugulare, goes downward through this in a curve (see p. 731). On emergence from the foramen jugulare the n. accessorius divides into two branches (see Fig. 835):

1. *Ramus internus* (see Fig. 835), the smaller of the two, formed chiefly of the superior root fibres, unites with the n. vagus above the ganglion nodosum (see p. 731).

2. *Ramus externus* (see Figs. 834, 835, 837 and 845) runs behind or in front of the v. jugularis interna, behind the processus styloideus and its muscles and behind the venter posterior m. digastrici upon the proc. transversus atlantis downward and lateralward to the medial surface of the m. sternocleidomastoideus, usually to perforate the deep layer of this muscle, sometimes however to run past it on its medial surface. It anastomoses into the muscle with branches of the n. occipitalis minor (from C_2) and supplies the muscle in common with this nerve. At about the middle of the posterior margin of the m. sternocleidomastoideus it enters the regio colli lateralis (see Fig. 845) and goes downward and backward in its fatty layer to the anterior surface of the m. trapezius, in order to supply it in common with branches of the plexus cervicalis (see Figs. 844 and 845) (from the nn. cervicales II and III, or III and IV) with motor fibres.

XII. **N. hypoglossus** (s. Figs. 749, 750, 755, 758, 817, 819, 828, 833—835, 837, 844 and 847), motor, appears with 10—15 threads between the pyramid and the olive from the sulcus lateralis anterior of the medulla oblongata (see p. 649). The threads converge lateralward behind the a. vertebralis (see Fig. 833) to the canalis hypoglossi, enter the canal, usually in two bundles, more rarely as a single stem, through openings in the dura mater and run through it forward and lateralward as a single stem surrounded by the venous rete canalis hypoglossi. On emergence from the canal (see Figs. 835 and 837) the nerve lies medial from and behind the n. vagus, passes in front of the v. jugularis interna, behind the n. vagus, downward upon its lateral side (see Figs. 834, 835 and 837), goes downward and forward on it and on the lateral surface of the a. carotis interna, covered by the m. stylohyoideus and venter posterior m. digastrici, to the lateral side of the a. carotis externa (below the origin of the aa. occipitalis, maxillaris externa and sternocleidomastoidea) (see Figs. 485, 828 and 834) and then runs forward in a curve, convex below and behind, upon the lateral surface of the m. hyoglossus, there to break up into its terminal branches.



839. Left n. vagus in the thoracic and abdominal cavities, viewed from the left.

(The ribs and the left lung have been almost wholly removed, the latter and the liver have been drawn to the right, the stomach to the left and downward; the diaphragm has been partly cut away; the pleura has been dissected off. Of the sympathicus only a few branches are drawn.)

XII. **N. hypoglossus** (continued). In front it crosses the medial surface of the m. stylohyoideus and venter posterior m. digastrici close above the hyoid bone (see Figs. 485, 828 and 834) and is covered externally by the glandula submaxillaris, v. facialis communis and platysma. Branches:

1. Anastomosis by a delicate thread between the upper end of the ganglion cervicale superius and the n. hypoglossus just under the canalis hypoglossi (not illustrated).

2. Anastomosis with the ganglion nodosum n. vagi (see Figs. 834 and 835).

3. Anastomosis with the ramus anterior n. cervicalis I (and II) (see Figs. 834, 835 and 844), by which motor fibres are brought to the n. hypoglossus for the mm. thyreohyoideus, omohyoideus, sternohyoideus, sternothyreoideus and geniohyoideus.

4. Delicate thread in the canalis hypoglossi running back to bone and sinus occipitalis.

5. *Ramus descendens* (see Figs. 828, 834, 844 and 847) usually goes off at the point where the n. hypoglossus crosses the a. carotis interna, passes downward upon it and upon the a. carotis communis (see also Fig. 358), often lying against the n. vagus, and communicates through one or several loops, *ansa hypoglossi* (see Figs. 832, 844 and 847), situated upon the lateral surface of the great vessels (sometimes also between them), with branches of the plexus cervicalis from the nn. cervicales II and III, which bring to it motor fibres for the mm. omohyoideus, sternothyreoideus and sternohyoideus. From this loop arise the branches for the muscles named.

6. *Ramus thyreohyoideus* (see Fig. 834) arises at the cornu majus oss. hyoidei and runs downward and forward to the lateral surface of the m. thyreohyoideus (for origin: vide supra).

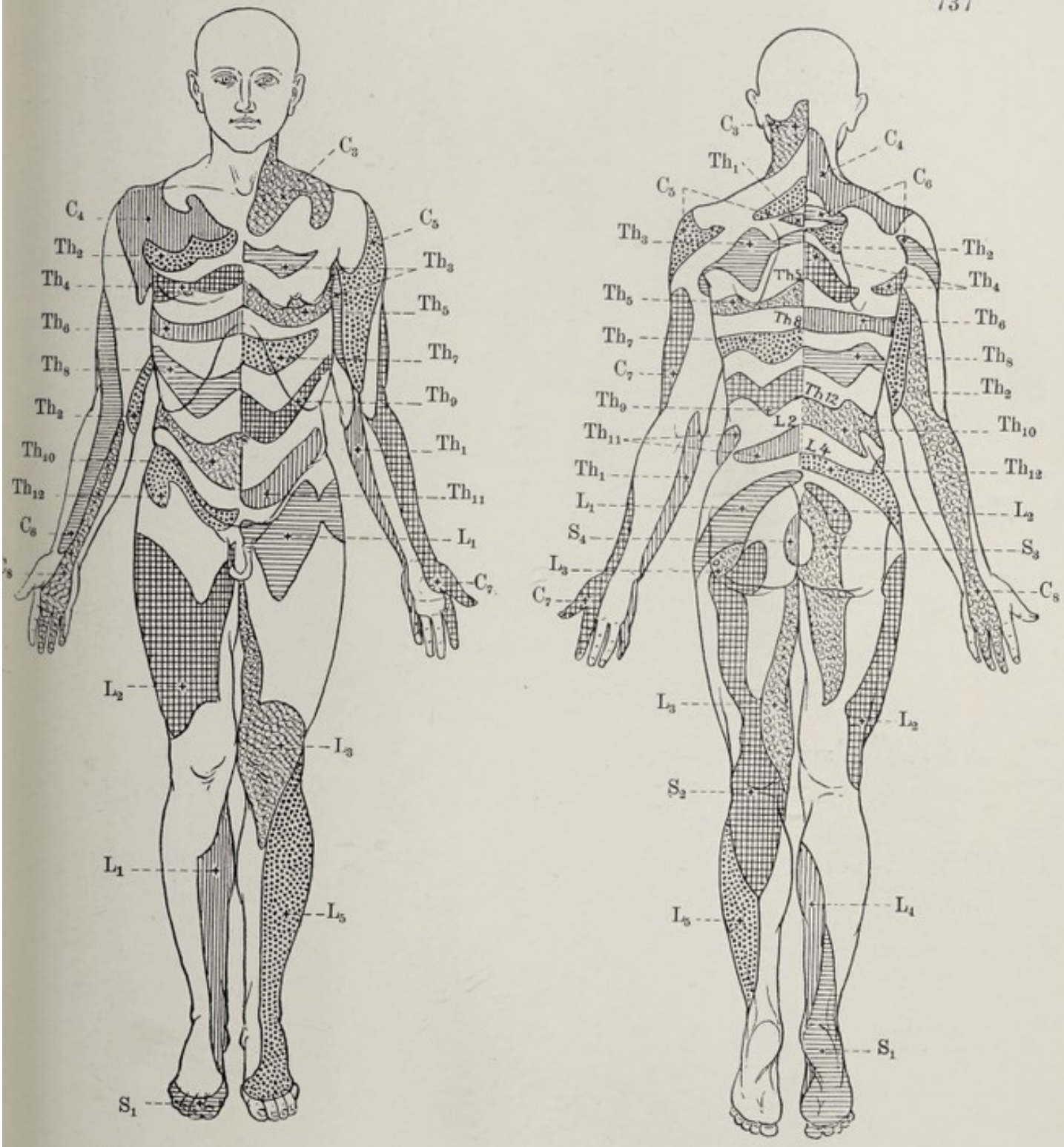
7. *Rami linguales* (see Fig. 834), terminal branches, to the mm. geniohyoideus (fibres partly from C_1 [C_2], see also above), hyoglossus, styloglossus, genioglossus, longitudinales, transversus and verticalis linguae. They anastomose with each other and upon the m. hyoglossus with the branches of the n. lingualis (V) (see p. 723).

Nervi spinales, spinal nerves, go off from the spinal cord. They appear there (see Figs. 734, 740, 803 and 804) with two rows of *root threads, fila radicularia*, an anterior row at the sulcus lateralis anterior, a posterior row at the sulcus lateralis posterior (see p. 638); the former contains the motor, the latter the sensory fibres. The root threads of the anterior row converge in groups lateralward, each group forming a small stem, an *anterior root, radix anterior*, the posterior row situated at the same level, forming a *posterior root, radix posterior* (see Figs. 734, 740, 758 and 833). Each anterior passes with a posterior root toward the corresponding foramen intervertebrale (see below and Fig. 743), and the two there perforate the dura mater spinalis (see p. 643). The direction of the roots (see Figs. 734, 736, 737, 741, 742, 833 and 835), is horizontal for the uppermost cervical nerves, becomes more oblique lower down and caudalward descending more and more. The foramen intervertebrale for the inferior cervical nerves lies approximately one vertebral level lower, for the 1^{st}—10^{th} thoracic nerve two lower, than the level of emergence of the roots concerned from the spinal cord. The roots of the lowermost thoracic, of the lumbar, sacral and coccygeal nerves run downward for a considerable distance within the sack of the dura mater (see p. 642) before they leave it; they form in it a thick bundle of strands running longitudinally, the *cauda equina (horse's tail)* (see Figs. 737 and 742), in the middle of which lies the filum terminale. Each posterior root becomes swollen in the foramen intervertebrale to form the egg-shapped *spinal ganglion, ganglion spinale* (see Figs. 737, 740, 743 and 804), which contains the origin-cells of the sensory fibres, and lateralward from this fuses with the corresponding anterior root to form a (mixed) *n. spinalis, spinal nerve*, which divides after a short course, into a *ramus posterior* and a *ramus anterior* (see Figs. 742 and 743). The number of the spinal ganglia corresponds to that of the spinal nerves. The spinal ganglion of the first cervical nerve is very small, it and the posterior root being often absent; it lies in the sulcus a. vertebralis of the atlas. The ganglia of the lower lumbar nerves lie partly, those of the sacral nerves completely, within the canalis vertebralis or sacralis between the dura mater and the bone (see Fig. 742). The ganglion of the n. coccygeus lies at variable level inside the dura mater.

There are 31 nn. spinales on each side. They are divided (see Figs. 734 and 736) into 8 *nn. cervicales, cervical nerves*, of which the first emerges between the occipital bone and the atlas, the second between the atlas and the epistropheus, the eighth between the 7^{th} cervical and 1^{st} thoracic vertebra, 12 *nn. thoracales, thoracic nerves*, the first between the 1^{st} and 2^{nd} thoracic vertebra, the twelfth between the 12^{th} thoracic and 1^{st} lumbar vertebra, 5 *nn. lumbales, lumbar nerves*, 5 *nn. sacrales, sacral nerves* and 1 (2—3, see p. 642) *n. coccygeus, coccygeal nerve*, which emerge like the thoracic nerves. An increase in the number of vertebrae is accompanied by a corresponding increase in that of the spinal nerves.

In the 1^{st} and 2^{nd} cervical nerve the posterior branches are larger than the anterior, otherwise the reverse is true. Each anterior branch is connected by at least o n e fine thread, *ramus communicans*, with a ganglion of the sympathicus (see Figs. 743, 835, 839, 871, 876, 890 and 892). Besides, it gives off a *ramus meningeus* (not illustrated), which receives sympathetic threads from the ramus communicans, passes back through the foramen intervertebrale of its nerve into the vertebral canal, anastomoses with others and is distributed to the wall of the canal.

Neigboring nerves anastomose manifoldly with one another through *ansae, loops*, which are regular and large, on the anterior branches of the cervical, lumbar and sacral nerves.



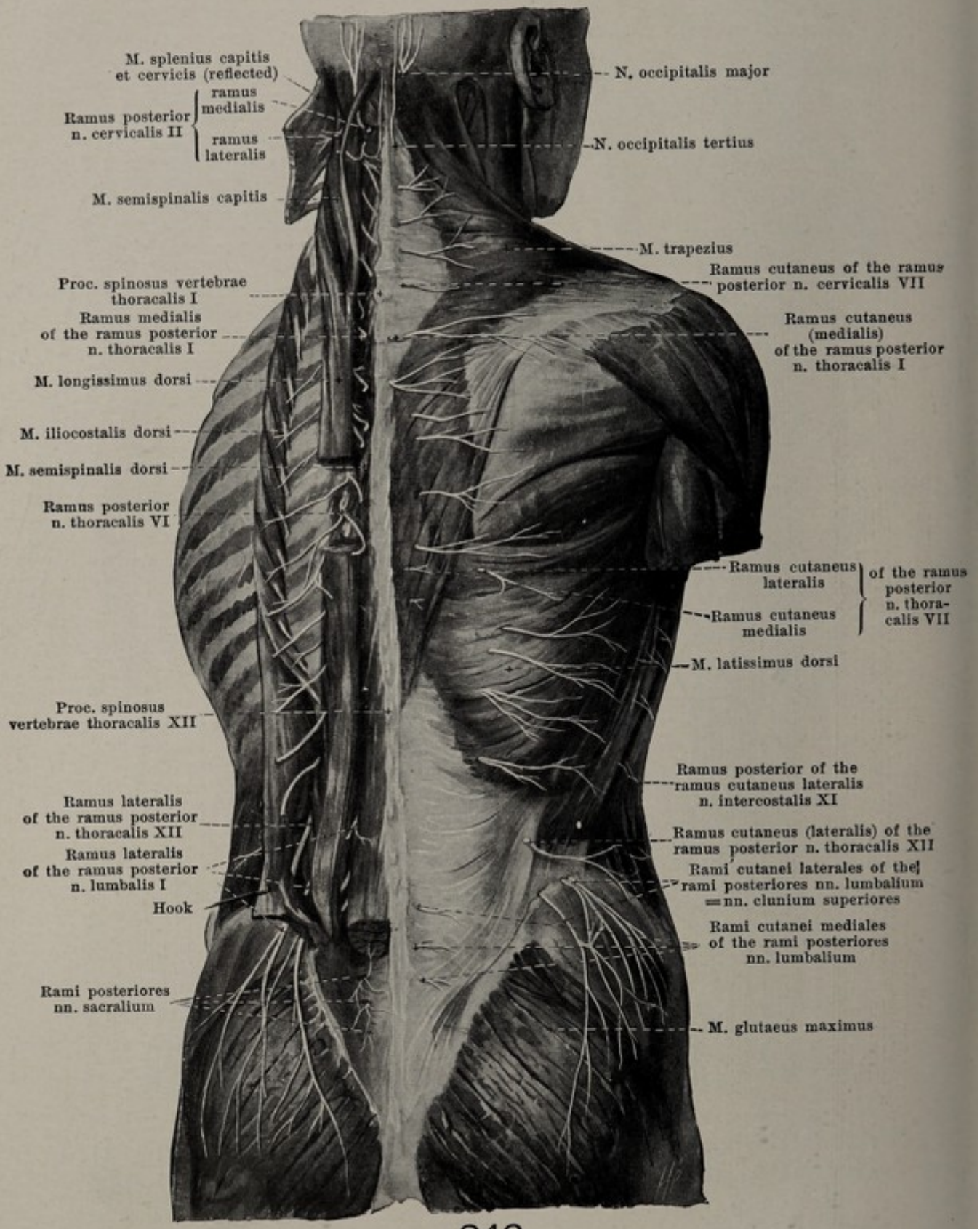
840 and 841. Areas of distribution of the individual spinal nerves in the skin (after H. Head),

viewed from in front. viewed from behind.

In reality the individual areas overlap one another more or less.

(The designation Th5, L2 etc. printed inside the Fig. 841 indicate the position of the proc. spinosus vertebrae thoracalis V, lumbalis II etc.. Concerning the other designations vide infra.)

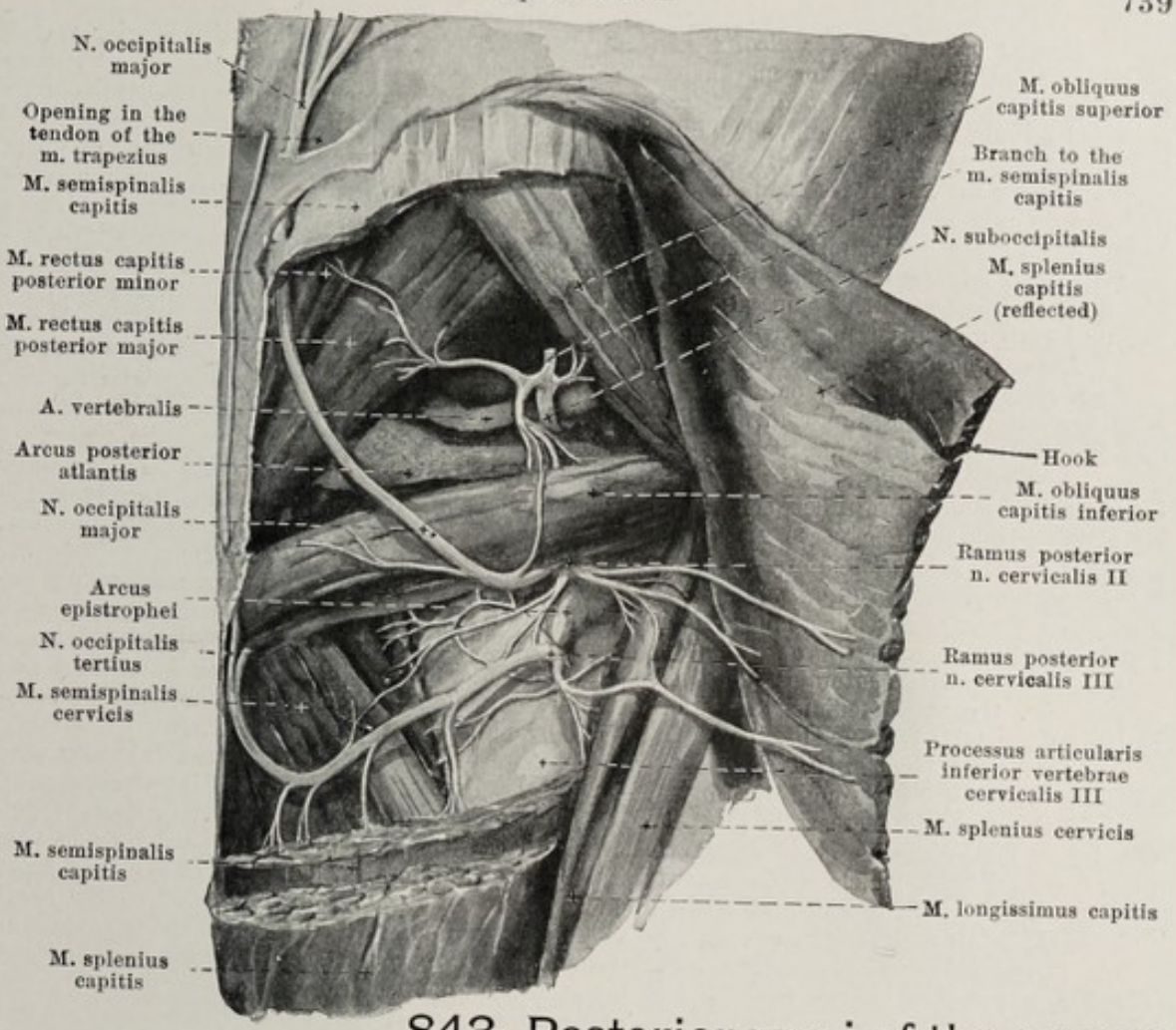
Note: In the figures and descriptions of the spinal nerves means C = n. cervicalis, Th = n. thoracalis, L = n. lumbalis, S = n. sacralis, Co = n. coccygeus; thus C_5 = n. cervicalis V etc.



842.

Posterior rami of the spinal nerves, viewed from behind.

(On the left the shoulder girdle with its muscles, along with the mm. latissimus dorsi, rhomboidei and the fascia lumbodorsalis have been removed. The long muscles of the back have been isolated [see Figs. 387—389], and pieces have been cut out of them; the posterior surface of the sacrum is exposed.)



843. Posterior rami of the upper cervical nerves of the right side, viewed from behind.

(The m. splenius capitis has been reflected lateralward, the m. semispinalis capitis has been for the most part removed, the m. trapezius completely removed.)

The **rami posteriores nn. spinalium** (see also Figs. 743 and 842) with the exception of the three upper cervical nerves are smaller than the anteriores. In a typical nerve (middle thoracic) each ramus posterior passes dorsalward medial from the ligg. costotransversarium anterius and intertransversarium (mm. intertransversarius posterior for the cervical nerves, lateralis for the lumbar nerves), and divides (excepting the first cervical, fourth and fifth sacral and the coccygeal nerves) into a *ramus medialis* and a *ramus lateralis*, which enter the musculature and of which usually only o n e (in the upper half the medial, in the lower half the lateral) goes to the skin. Almost all the rami run also caudalward, especially the lower ones, so that their distribution in muscle and skin lies below their emergence from the foramen intervertebrale (see Figs. 841 and 842). The rami behave differently at different levels.

A. ***Rami posteriores nn. cervicalium*** (see also Figs. 835 and 842). Each *ramus lateralis* passes lateralward around the m. semispinalis capitis and branches on it (C_1—C_4), on the m. intertransversarius posterior (C_2—C_8), the mm. longissimi capitis (C_1—C_3 [C_4]) and cervicis ([C_3] C_4—C_8) and the splenius (C_1—C_4 [C_5]). The *ramus medialis* supplies the mm. semispinalis capitis (C_1—C_4) and cervicis (C_3—C_6 [C_7]), between which it runs, and also the mm. multifidus, rotatores, interspinales and spinalis cervicis (C_3—C_8); near the proc. spinosus it perforates the mm. semispinalis capitis and trapezius (true usually only of the 4^{th}—6^{th} cervical nerve), to bend around lateralward as the *ramus cutaneus* to the skin. The course and distribution of the posterior rami of the first, second and third cervical nerve deviate somewhat.

Ramus posterior n. cervicalis I=N. suboccipitalis, considerably larger than the corresponding anterior ramus, purely motor, passes backward under the a. vertebralis in the triangle between the mm. obliqui capitis and rectus capitis posterior major. It supplies these muscles as well as the mm. rectus capitis posterior minor and semispinalis capitis, longissimus capitis and splenius, gives off branches to the articulatio atlantooccipitalis and anastomoses with the posterior branch of the 2^{nd} cervical nerve.

Ramus posterior n. cervicalis II (see Figs. 842 and 843), the largest posterior ramus of all, divides at the inferior margin of the m. obliquus capitis inferior into a small ***ramus lateralis*** and a large ***ramus medialis.*** The former sends motor branches to the mm. semispinalis capitis, longissimus capitis and splenius; the latter anastomoses with the posterior branches of the first and third cervical nerve, gives motor fibres to the mm. semispinalis capitis and obliquus capitis inferior and, with its main mass as the sensory ***n. occipitalis major,*** passes in a curve medianward and upward between the m. semispinalis capitis on the one side, the mm. obliquus capitis inferior and recti capitis posteriores on the other side, perforates the m. semispinalis capitis near the lig. nuchae and goes through an opening in the tendon of the m. trapezius (see Fig. 347) to run under the skin. Its branches go upward as far as the vertex (see Figs. 830, 832 and 845) and anastomose with one another and with branches of neighboring nerves.

Ramus posterior n. cervicalis III (see Figs. 842 and 843) differs from the inferior cervical nerves in that the end of its ramus medialis, as the sensory ***n. occipitalis tertius,*** after perforation of the mm. semispinalis capitis and trapezius goes either to the adjacent skin (see Fig. 845) or passes upward connected wholly or in part with the n. occipitalis major.

B. ***Rami posteriores nn. thoracalium*** (see Figs. 743 and 842). Each *ramus lateralis* passes lateralward between the mm. longissimus and iliocostalis dorsi and usually on the 7^{th} or 8^{th}—12^{th} thoracic nerve gives off through the m. latissimus dorsi a branch to the skin, ***ramus cutaneus lateralis,*** lateralward and somewhat downward, that for the 12^{th} nerve reaching the crista iliaca. The ***ramus medialis*** goes medianward toward a proc. spinosus between the mm. longissimus and semispinalis dorsi, that for the 1^{st}—7^{th} or 8^{th} nerve usually gives off through the m. trapezius a ***ramus cutaneus medialis*** lateralward. The rami mediales decrease in size downward, the laterales increase. The rami laterales supply the mm. iliocostalis and longissimus, the rami mediales the mm. rotatores, multifidus, interspinales (Th_1—Th_{12}), semispinalis dorsi ([Th_3] Th_4—Th_6, Th_{11}, Th_{12}), and spinalis dorsi (Th_2, Th_6—Th_8).

C. ***Rami posteriores nn. lumbalium*** (see Fig. 842). The *rami laterales* pass obliquely lateralward through the m. sacrospinalis, supply it and the mm. intertransversarii mediales (L_1—L_5) and decrease in size below. The three upper usually send skin branches through the fascia lumbodorsalis close above the crista iliaca, the ***nn. clunium superiores*** (see also Figs. 879 and 886), which go downward to the buttock (lateralward as far as the trochanter major). The small *rami mediales* extend medianward to the m. multifidus and to the short muscles (L_1—L_5); the three lower ones send very delicate branches to the skin of the sacral region.

D. ***Rami posteriores nn. sacralium et n. coccygei*** (see Fig. 842), very delicate. The four upper ones emerge through the foramina sacralia posteriora, those of the 5^{th} sacral and coccygeal nerve through the hiatus sacralis between the ligg. sacrococcygea posteriora (see Fig. 742). They anastomose with one another upon the posterior surface of the sacrum. *Rami laterales* are present only on the three upper sacral nerves; they perforate the origin of the m. glutaeus maximus and there go as *nn. clunium medii* to the skin (see Figs. 879 and 886). The *rami mediales* go to the m. sacrolumbalis and send most delicate branches to the skin (like the preceding).

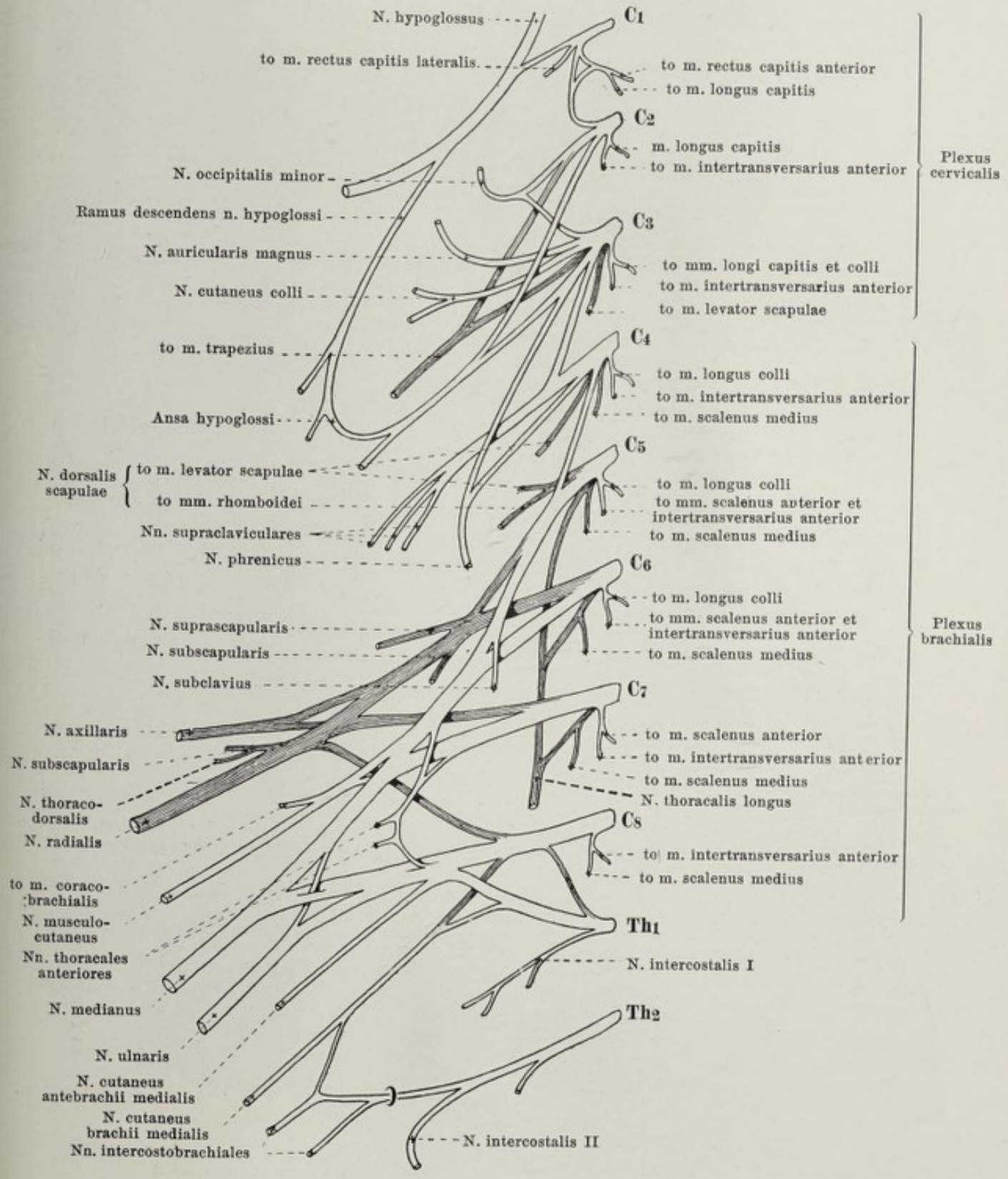
The **rami anteriores nn. spinalium** remain independent in their course only in the region of the thoracic nerves. In the cervical, lumbar and sacral regions they form connections with one another, at the same time dividing, so as to give rise to complicated plexusses, *plexus,* of which there are three on each side, *plexus cervicalis, brachialis* and *lumbosacralis.*

Rami anteriores nn. cervicalium. Those for the 3^{rd}—8^{th} nerve run lateralward behind the a. vertebralis in the sulcus n. spinalis of the corresponding vertebra (see Fig. 835) between the mm. intertransversarii anterior and posterior; they appear lateral from the mm. longi capitis and colli and the origins of the m. scalenus anterior, medial and in front of the origins of the mm. splenius cervicis, levator scapulae and scalenus medius (see Fig. 834). That of the first nerve goes forward under the a. vertebralis (see Figs. 833 and 835) and appears between the mm. recti capitis anterior and lateralis; that of the second (see Fig. 835) grasps the a. vertebralis from behind and without and turns forward, medial from the m. intertransversarius posterior.

The anterior rami of the 1^{st}—4^{th} cervical nerve anastomose with one another and thus form the ***plexus cervicalis,*** *cervical plexus* (see Figs. 834, 835 and 844). This, covered by the m. sternocleidomastoideus, attached to the fascia praevertebralis, lies in front of the origins of the mm. splenius cervicis, levator scapulae and scalenus medius. The plexus communicates with the main trunk and ramus descendens of the n. hypoglossus (see p. 736), as well as with the ganglion cervicale superius and the truncus sympathicus (see Fig. 835) by rami communicantes, at least one for each cervical nerve. The rami of the plexus are divisible into cutaneous and muscular branches.

A. *Cutaneous branches* (see Figs. 830 and 845), appear at the middle of the posterior margin of the m. sternocleidomastoideus:

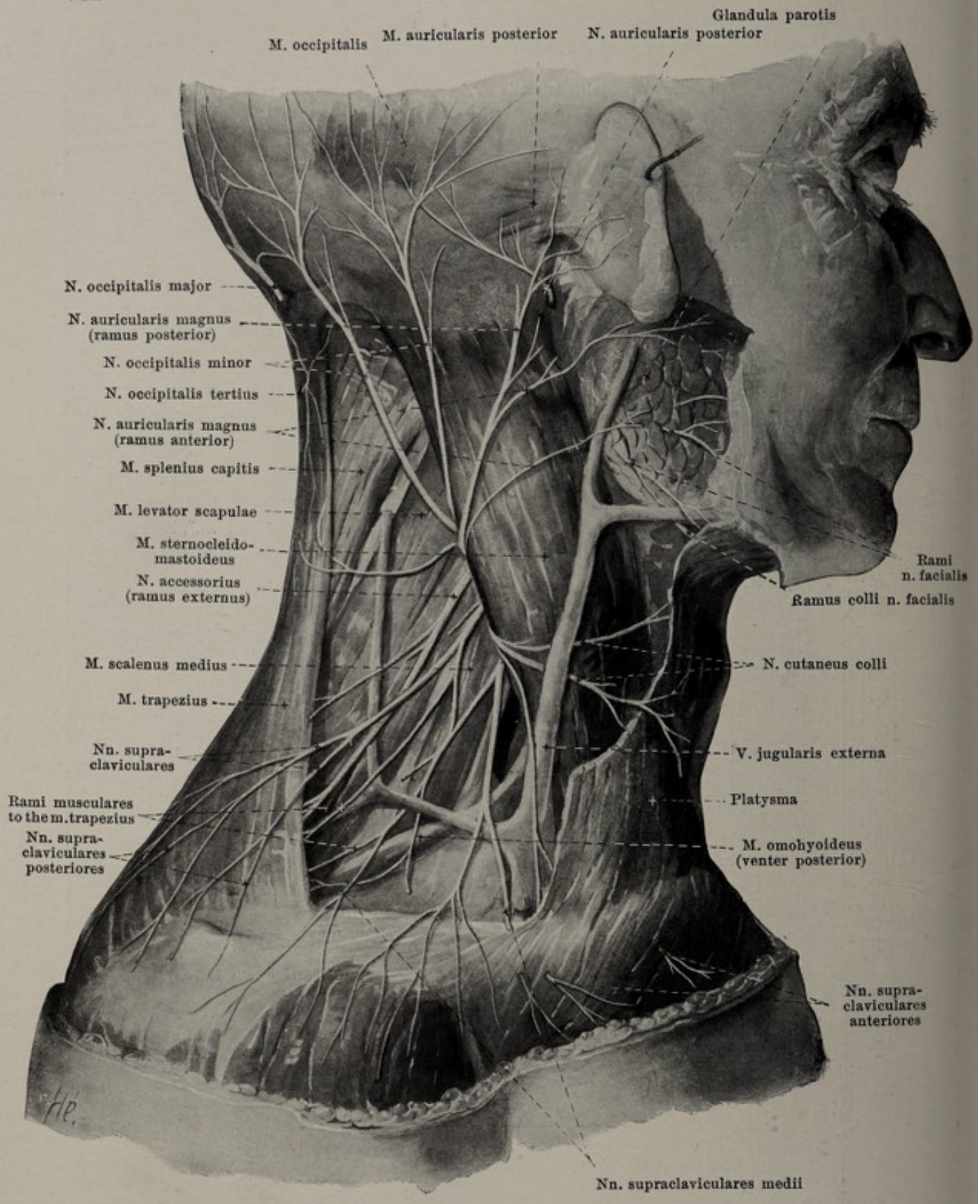
1. *N. occipitalis minor* (see Figs. 832, 844 and 845), from C_2 and C_3, runs upward at the posterior margin of the m. sternocleidomastoideus upon this and the m. splenius, and sends its terminal branches to the skin of the lateral occipital and the temporal region; it anastomoses with branches of the nn. auricularis posterior (VII) occipitalis major and auricularis magnus. A few branches help to supply the m. sternocleidomastoideus and anastomose in it with branches of the n. accessorius.



844. Right plexus cervicalis and brachialis,

schematic (after P. Eisler). (The rami communicantes are not shown.)

(The darkly shaded strands are derivatives of the dorsal half of the plexus.)



845. Cutaneous branches of the right plexus cervicalis, viewed from the right.

(The platysma has been partially removed.)

2. *N. auricularis magnus* (see Figs. 832, 844 and 845), from C_3, usually the largest branch, ascends in front of the preceding upon the lateral surface of the m. sternocleidomastoideus behind the v. jugularis externa, vertically to the ear. At the level of the angulus mandibulae it undergoes division. The smaller *ramus anterior* passes forward and upward under the ear, and passes sometimes partly through the parotid gland, to the skin of the lateral inferior half of the face (see Fig. 830), as well as to that of the lobule of the ear and of the concave surface of the auricula. The *ramus posterior* runs behind the ear to the skin on the convex side of the auricula and forward as far as the skin of the temporal region. It anastomoses with branches of the nn. auricularis posterior (VII) and occipitalis minor.

3. *N. cutaneus colli* (see Figs. 844 and 845), from C_3, or C_2 and C_3, passes forward, under the foregoing, upon the lateral surface of the sternocleidomastoideus, covered by the platysma, medial or lateral from the v. jugularis externa. It divides into *rami superiores* of which one unites with the ramus colli n. facialis (see Fig. 832 and p. 725), and *rami inferiores*. They perforate the platysma, are all sensory and go to the skin of the regio sternocleidomastoidea and of the regio colli anterior upward as far as the margin of the lower jaw.

4. *Nn. supraclaviculares* (see Figs. 844, 845, 850, 852, 864 and 865) from C_3 and C_4, usually from a small trunk, run superficially, covered only by the platysma, through the fossa supraclavicularis major, diverging downward, and divide into three groups:

a) *Nn. supraclaviculares anteriores* pass downward upon the v. jugularis externa and in front of the clavicle and through the platysma to the skin down under the medial part of the clavicle.

b) *Nn. supraclaviculares medii* go downward in front of the clavicle to the skin over the clavicle and over the m. pectoralis major as far as the region of the nipple.

c) *Nn. supraclaviculares posteriores* pass downward and backward upon the m. trapezius to the skin over the m. deltoideus, rarely still farther distalward.

B. *Muscular branches*, partly directly from the cervical nerves (see Fig. 844):

1. For the mm. rectus capitis lateralis from C_1, rectus capitis anterior from C_1 and C_2, longus capitis from C_1—C_3, longus colli from C_2—C_6, scalenus medius from (C_4) C_5—C_8, levator scapulae from (C_2) C_3—C_4 and intertransversarii anteriores from C_2—C_8.

2. Branch to the ramus descendens hypoglossi (see Figs. 834 and 844), from C_2 and C_3; it helps to form the ansa hypoglossi (see p. 736) under the m. sternocleidomastoideus.

3. Branches to the m. sternocleidomastoideus (C_2), from n. occipitalis minor (see p. 740).

4. Branch for the m. trapezius (see Figs. 844 and 845), from C_2 and C_3, or C_3 and C_4, frequently a branch of the nn. supraclaviculares posteriores; anastomosis with the n. accessorius.

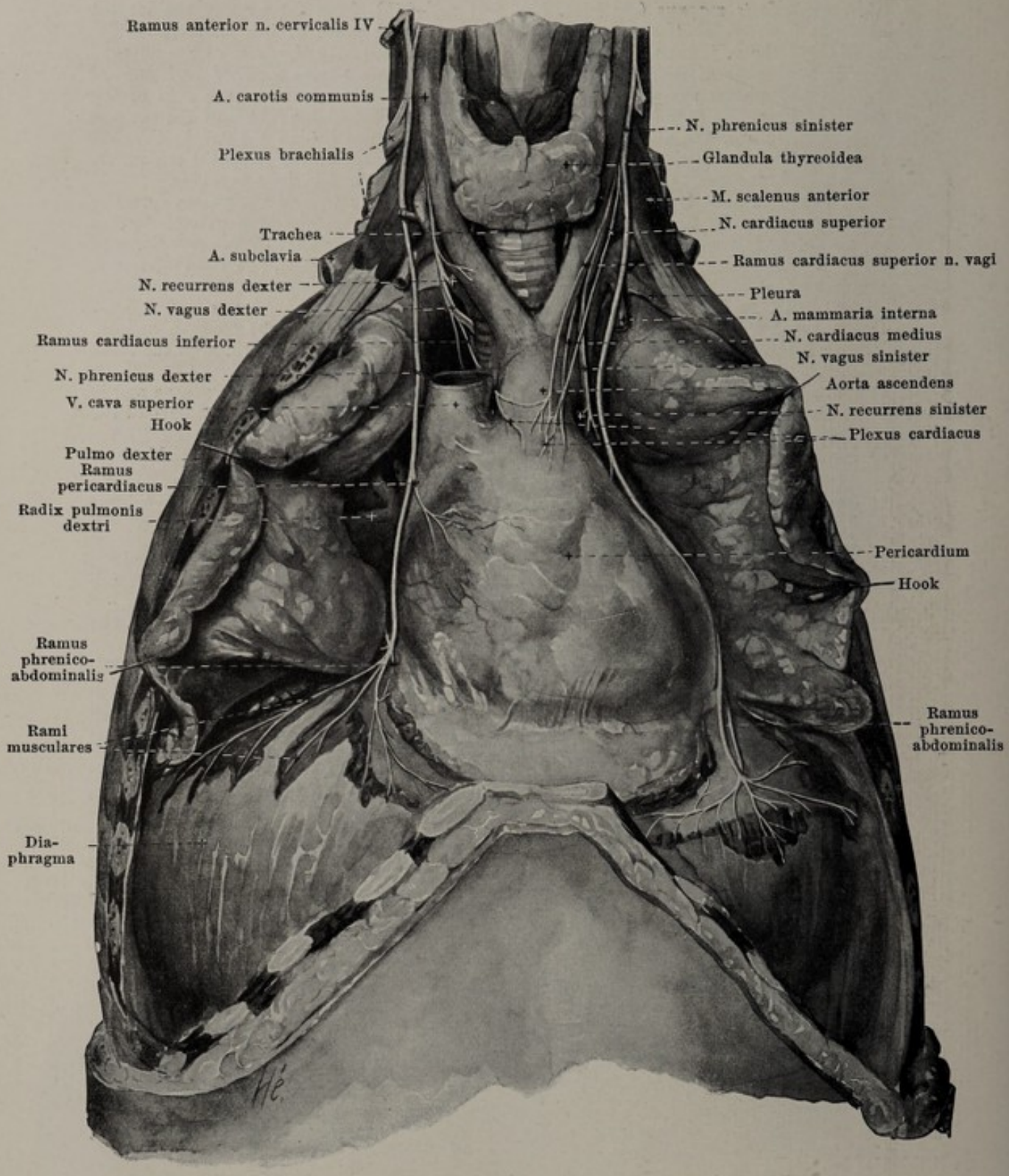
5. *N. phrenicus* (see Figs. 834, 838, 844, 846 and 847), a mixed nerve, from C_3 and C_4 or C_4 and C_5, with the largest root from C_4, passes downward and somewhat medianward upon the anterior surface of the m. scalenus anterior (see Fig. 838), lateral from the a. cervicalis ascendens, runs between the a. and v. subclavia, lateral from the truncus thyreocervicalis and n. vagus, in front of or behind the a. mammaria interna, to the anterior medial declivity of the cupula pleurae, and enters the thoracic cavity behind the articulatio sternoclavicularis. There it passes under the pleura mediastinalis along with the a. pericardiacophrenica in front of the root of the lung to the pericardium and then between this and the pleura pericardiaca to the diaphragm (see also Figs. 680—682). In its course on the r i g h t side it lies on the lateral surface of the v. anonyma dextra and vena cava superior, close in front of the radix pulmonis, and reaches the diaphragm somewhat in front of and lateral from the foramen venae cavae. On the l e f t side it runs lateral from the arcus aortae, lies farther ventral from the root of the lung and reaches the diaphragm farther lateralward and forward than on the right side. It communicates by delicate threads with the ganglion cervicale inferius of the sympathicus and very often receives a branch from the n. subclavius (see Fig. 847). Branches (see Fig. 846):

a) *Ramus pericardiacus*, usually right only, upon the v. cava superior to the pericardium.

b) Very delicate branches to the pleura (not illustrated).

c) Terminal branches, perforate the diaphragm; as *rami musculares* they innervate the musculature from the concave side and give some threads to the serosa of the diaphragm; as *rami phrenicoabdominales* they anastomose with the plexus phrenicus of the sympathicus, and send threads to the tunica serosa of the liver and to the suprarenal glands.

The anterior rami of the 5^{th}—8^{th} cervical nerve together with a small part of the 4^{th} cervical nerve, with the upper, larger part of the 1^{st} thoracic nerve and very often with a delicate branch of the 2^{nd} thoracic nerve form the ***plexus brachialis***, *arm plexus* (see Figs. 838, 839, 844, 847, 849 and 890). Its roots pass lateralward behind the origins of the m. scalenus anterior, in front of those of the m. scalenus medius; the 5^{th}—7^{th} cervical nerve runs at the same time markedly downward, the 8^{th} horizontally, the 1^{st} (and 2^{nd}) thoracic nerve upward in front of the neck of the 1^{st} rib. They unite to form an elongated plexus which lies in the space between the mm. scaleni anterior and medius, with its three upper root portions over, and with the two lower behind, the a. subclavia, thence the plexus, narrowed, passes immediately adjacent to the artery, behind the clavicle and the mm. subclavius and pectorales into the axilla.

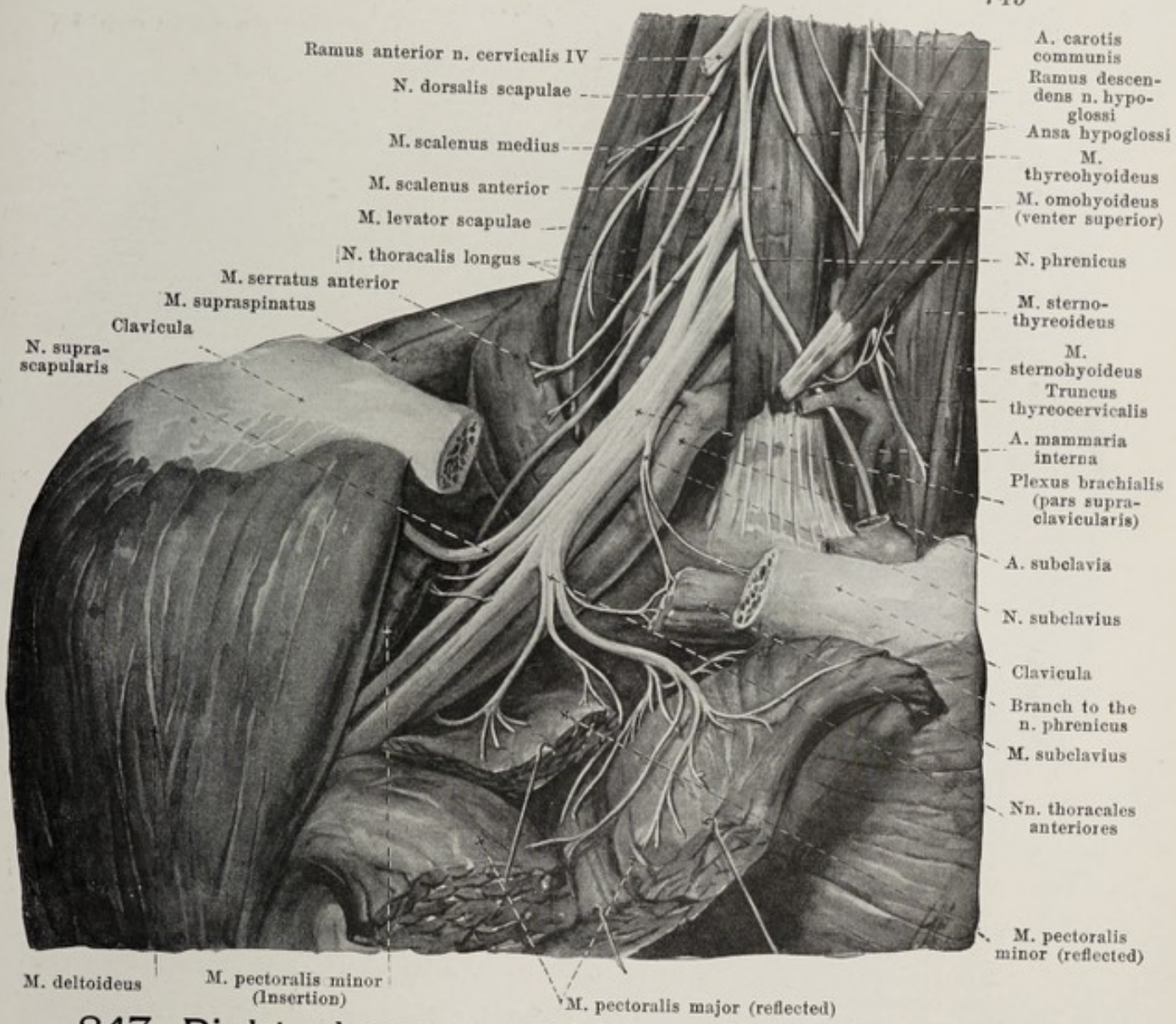


846. Nn. phrenici, viewed from in front.

(The anterior wall of the thorax has been removed; the thymus has been cut away and the pleura dissected off. The lungs have been drawn aside by hooks.)

Plexus brachialis (continued). Each of the nerves composing it sends off a ramus communicans to the ganglion cervicale medium or inferius of the sympathicus, before it enters the plexus (see Figs. 839 and 890).

The plexus is divisible into a *pars supraclavicularis* and a *pars infraclavicularis.*



847. Right plexus brachialis with its short branches, viewed from in front.

(The mm. sternocleidomastoideus and trapezius have been completely, the mm. omohyoideus and subclavius partially removed; a piece has been sawn out of the clavicle; the mm. pectorales have been incised and reflected.)

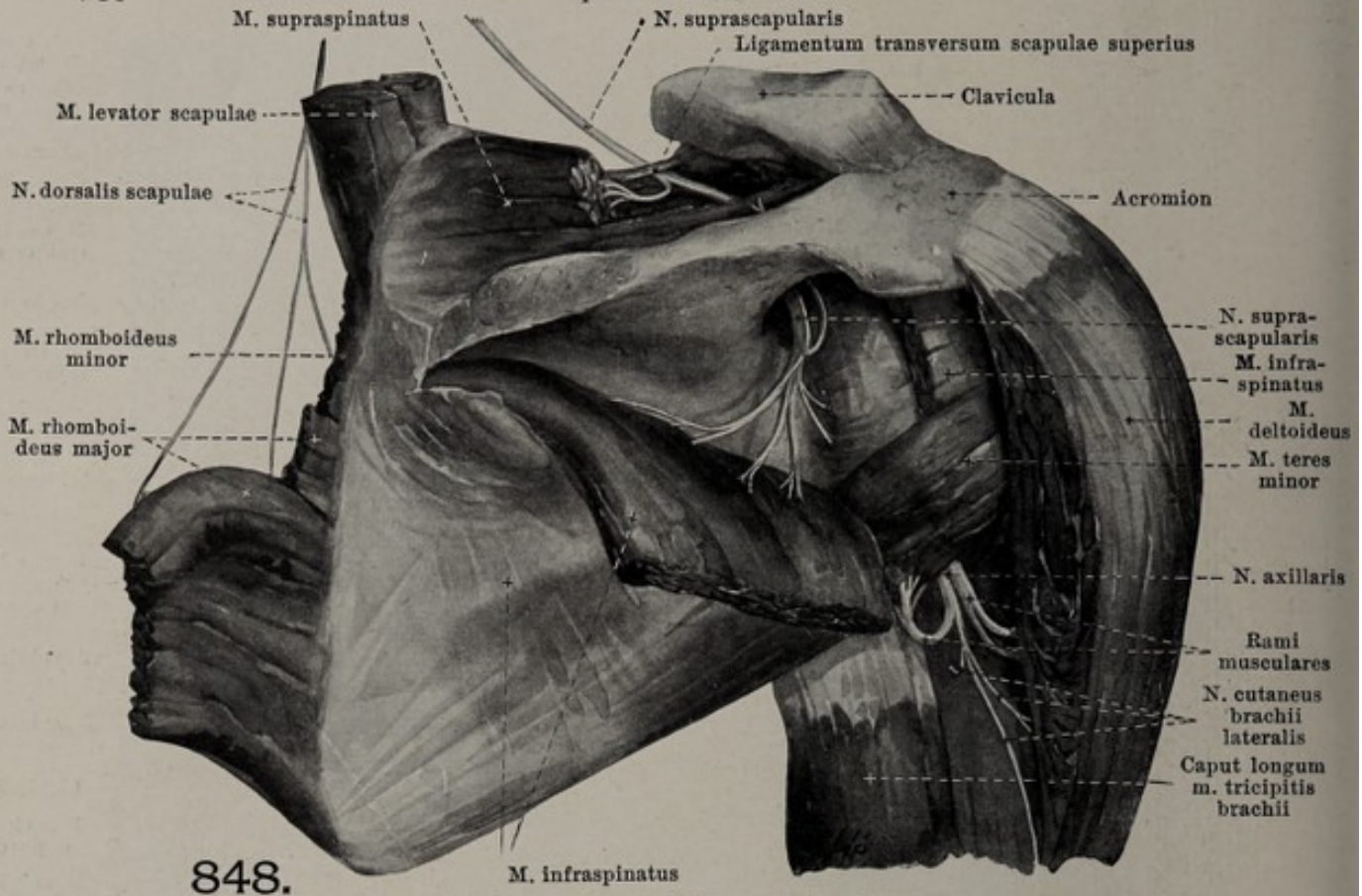
The *pars supraclavicularis* of the *plexus brachialis* reaches distalward as far as the clavicle, adjoins the mm. scalenus medius and serratus anterior dorsalward, is perforated (usually between C_6 and C_7) by the a. transversa colli and is crossed in front by the posterior belly of the m. omohyoideus and by the aa. cervicalis superficialis and transversa scapulae; all the short branches are counted as belonging to it, even if they are not given off until the axillary fossa is reached; these are the branches which run to the deep muscles of the neck and to those of the shoulder girdle.

1. Threads (directly from the trunks of the cervical nerves) for the mm. longus colli, scalenus medius and intertransversarii (see p. 743) and a root of the n. phrenicus (see p. 743).

2. Direct branches (from the trunks of the cervical nerves) to the mm. scalenus anterior from (C_4) C_5—C_7, scalenus posterior from C_7 or C_8 (see Fig. 844), and scalenus minimus from C_8, also to uppermost m. levator costae from C_8, and often to m. serratus posterior superior from C_8.

3. *Nn. thoracales posteriores* (see also Figs. 838, 844 and 848) appear through the m. scalenus medius. To this belong:

a) *N. dorsalis scapulae* (see also Fig. 848), from (C_4) C_5, runs downward on the anterior surface of the m. levator scapulae, the lowermost tooth of which it supplies (see also p. 743), to the ventral surface of the mm. rhomboidei (C_5), in which it ends.



848. Nerves of the right shoulder blade, viewed from behind.

(The mm. supraspinatus and deltoideus have been partially cut away, the infraspinatus reflected.)

b) *N. thoracalis longus* (see Figs. 838, 844, 847, 849 and 869), from C5, **C6**, **C7**, (C8), the roots of which usually unite first in front of the m. scalenus medius, descends behind the plexus brachialis, nearly in the axillary line, upon the lateral surface of the m. serratus anterior giving branches dorsalward to the single digitations of this muscle.

4. *N. subclavius* (see Figs. 844 and 847), from C_5 (C_6), in front of the a. subclavia, in front of or behind the v. subclavia, to the m. subclavius, sends a branch medianward to the n. phrenicus (see p. 743).

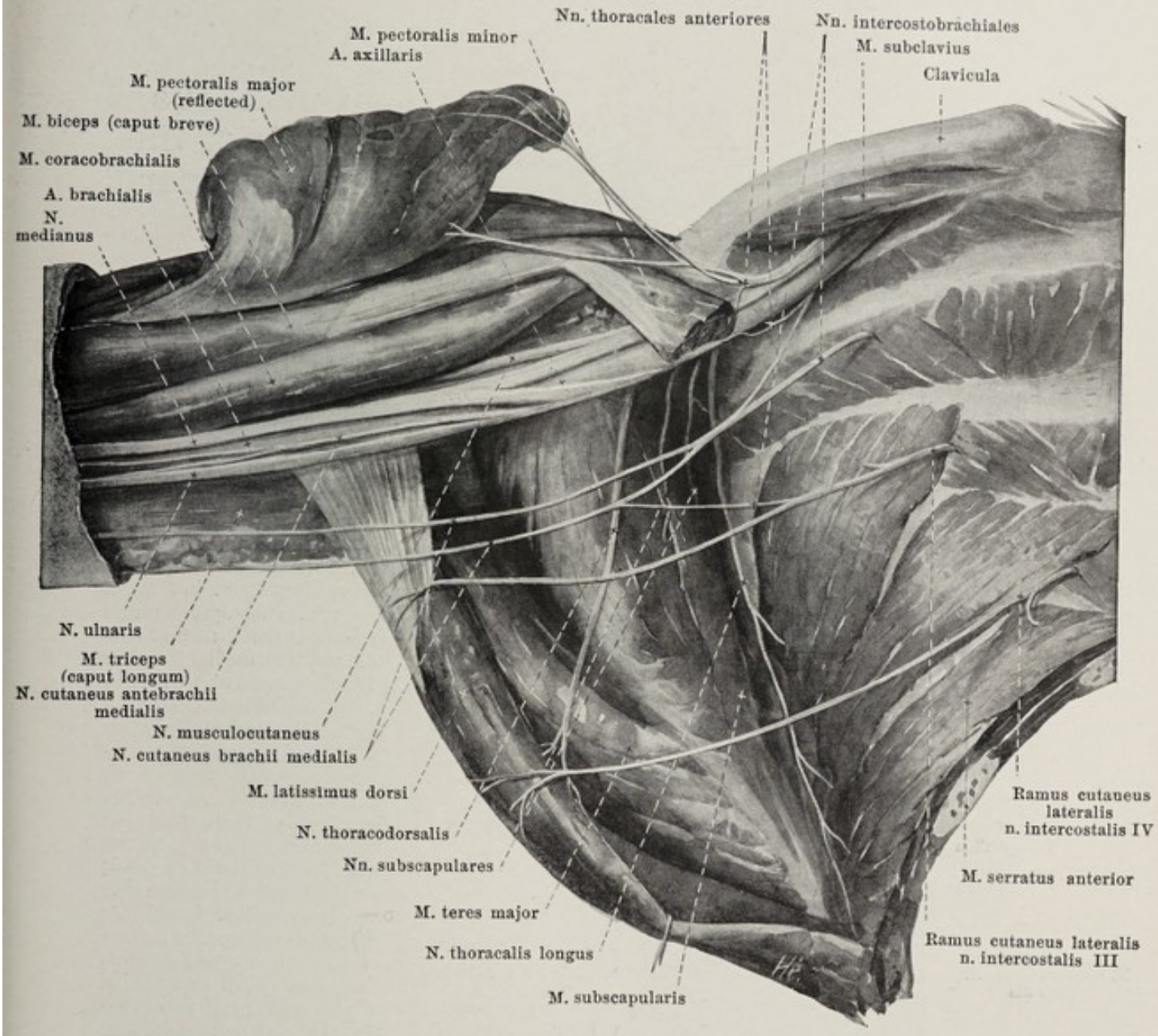
5. *Nn. thoracales anteriores* (see Figs. 844, 847 and 849), from C_5—Th_1, usually two, run forward and downward in front of and behind the artery, then between the a. and v. subclavia, anastomosing, to the mm. pectoralis minor (C_7, C_8) and pectoralis major (C5, **C6**, **C7**, **C8**, Th_1).

6. *N. suprascapularis* (see also Figs. 844 and 847), from (C_4), C_5 and C_6, large, passes lateralward near the lateral part of the a. transversa scapulae under the m. trapezius and venter posterior m. omohyoidei and under the clavicle; it then passes beneath the lig. transversum scapulae superius into the fossa supraspinata, and behind the collum scapulae in front of the lig. transversum scapulae inferius into the fossa infraspinata. It supplies the mm. supraspinatus ([C_4], C_5, [C_6]) and infraspinatus ([C_4], **C5**, **C6**) and gives off branches to the shoulder-joint.

7. *Nn. subscapulares* (see Figs. 844, 849 and 854), from C_5—C_7, usually two, from the dorsal surface of the plexus or from the n. axillaris; they run downward on the ventral surface of the m. subscapularis to this (C_5, C_6, [C_7]) and to the m. teres major (C_6, C_7).

8. *N. thoracodorsalis* (see Figs. 844, 849 and 854), from (**C6**), **C7** and C8, arises like 7), passes along the margo axillaris scapulae to the anterior surface of the m. latissimus dorsi.

9. *N. axillaris* (see also Figs. 844, 852, 854, 862, 864 and 865) (O. T. circumflex nerve), from C_5, C_6 (C_7), large, arises in the axillary fossa from the fasciculus posterior of the pars infraclavicularis (see p. 747), runs behind the a. axillaris with the a. circumflexa humeri posterior, at first backward between the humerus, m. subscapularis, m. teres minor, caput longum m. tricipitis and teres major, then lateralward upon the collum chirurgicum, covered by the m. deltoideus. It sends branches to the shoulder-joint, *rami musculares* to the mm. teres minor (**C5**, **C6**, [C7]) and deltoideus (**C5**, C6) and gives off also the *n. cutaneus brachii lateralis* (C_5, C_6, [C_7]) between the m. deltoideus and the caput longum m. tricipitis to the skin over the posterior and lateral part of the upper arm. Some of the nerves supplying the m. deltoideus give off branches which pass through the muscle to the skin. The lower cutaneous branches anastomose with the nn. cutanei brachii posterior and antebrachii dorsalis.



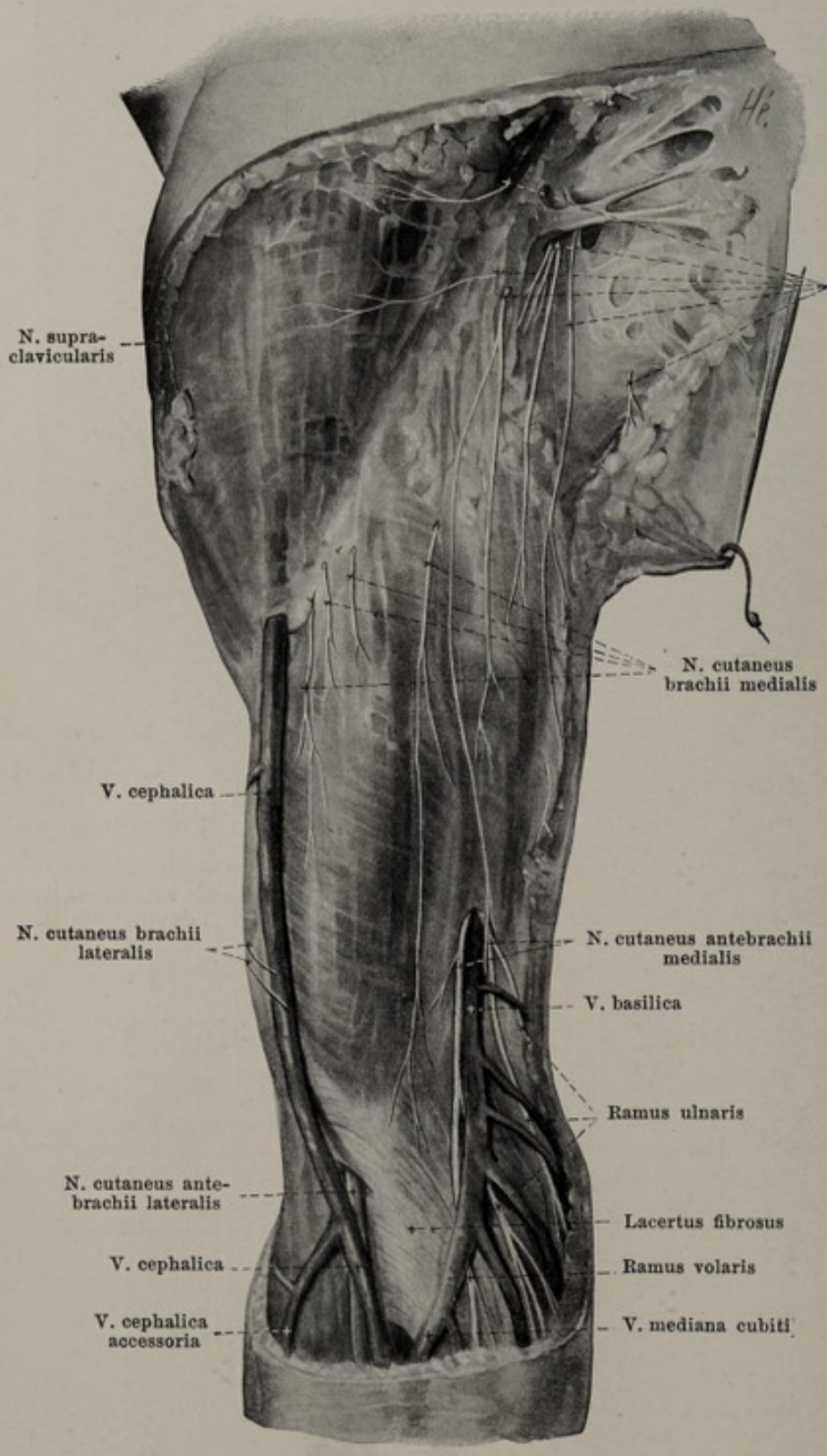
849. Right plexus brachialis (pars infraclavicularis) in the axillary fossa, viewed from below and in front.

(The mm. pectorales major et minor have been in large part removed; the attachment of the former has been reflected.)

The *pars infraclavicularis* of the *plexus brachialis* (see also Figs. 847 and 854) passes distalward from the clavicle through the axillary fossa and breaks up in its lower half into its branches, which may also be designated as the long branches of the plexus; they go exclusively to the arm. It is bounded medianward by the m. serratus anterior, dorsalward by the m. subscapularis, is covered in front by the mm. pectorales and distalward lies, with its branches, in the groove between the mm. subscapularis and latissimus dorsi on the one side and the m. coracobrachialis on the other. The constituents of the plexus are arranged in three cords, which lie in direct contact with the a. axillaris, the *fasciculus posterior* running dorsalward, the *fasciculus lateralis* (when the arm is elevated horizontally) above and lateralward, and the *fasciculus medialis* below and medianward from the artery. The v. subclavia and the v. axillaris lie directly in front of and medianward from this bundle of the nerves and artery. From the fasciculus medialis proceed the *nn. cutaneus brachii medialis, cutaneus antebrachii medialis, ulnaris,* and the inferior root of the *n. medianus,* from the fasciculus lateralis the upper root of the *n. medianus* and the *n. musculocutaneus,* from the fasciculus posterior the *nn. axillaris* (see p. 746) and *radialis.*

850. Cutaneous nerves of the right upper arm,

viewed from in front.



(The arm has been abducted; the fascia has been preserved throughout.)

1. *N. cutaneus brachii medialis* (O. T. lesser internal cutaneous) (see also Figs. 844, 849, 864, 865 and 869), from (C_8) Th_1, runs downward in the axillary fossa, in front of the mm. subscapularis and latissimus dorsi, at first dorsal, and then medial from the v. axillaris, and unites here in a very variable manner with the n. intercostobrachialis (see p. 766) of the second, sometimes also with that of the third intercostal nerve. The branches of these stems or their anastomoses perforate the fascia axillaris or fascia brachii in different places; they supply the skin of the axillary fossa and of the medial surface of the upper arm as far as the elbow joint, in addition a proximal portion of the anterior surface and a distal portion of the posterior surface.

2. *N. cutaneus antebrachii medialis* (O. T. internal cutaneous) (see also Figs. 844, 849, 851—854, 864 and 865), from C_8 and Th_1, lies on the anterior medial side of the v. axillaris and passes distalward near it; it perforates the fascia brachii in the middle of the upper arm or somewhat lower, usually at the point where the v. basilica vanishes under the fascia into the depth, and then (or previously) divides into two branches, which lie upon the fascia antebrachii.

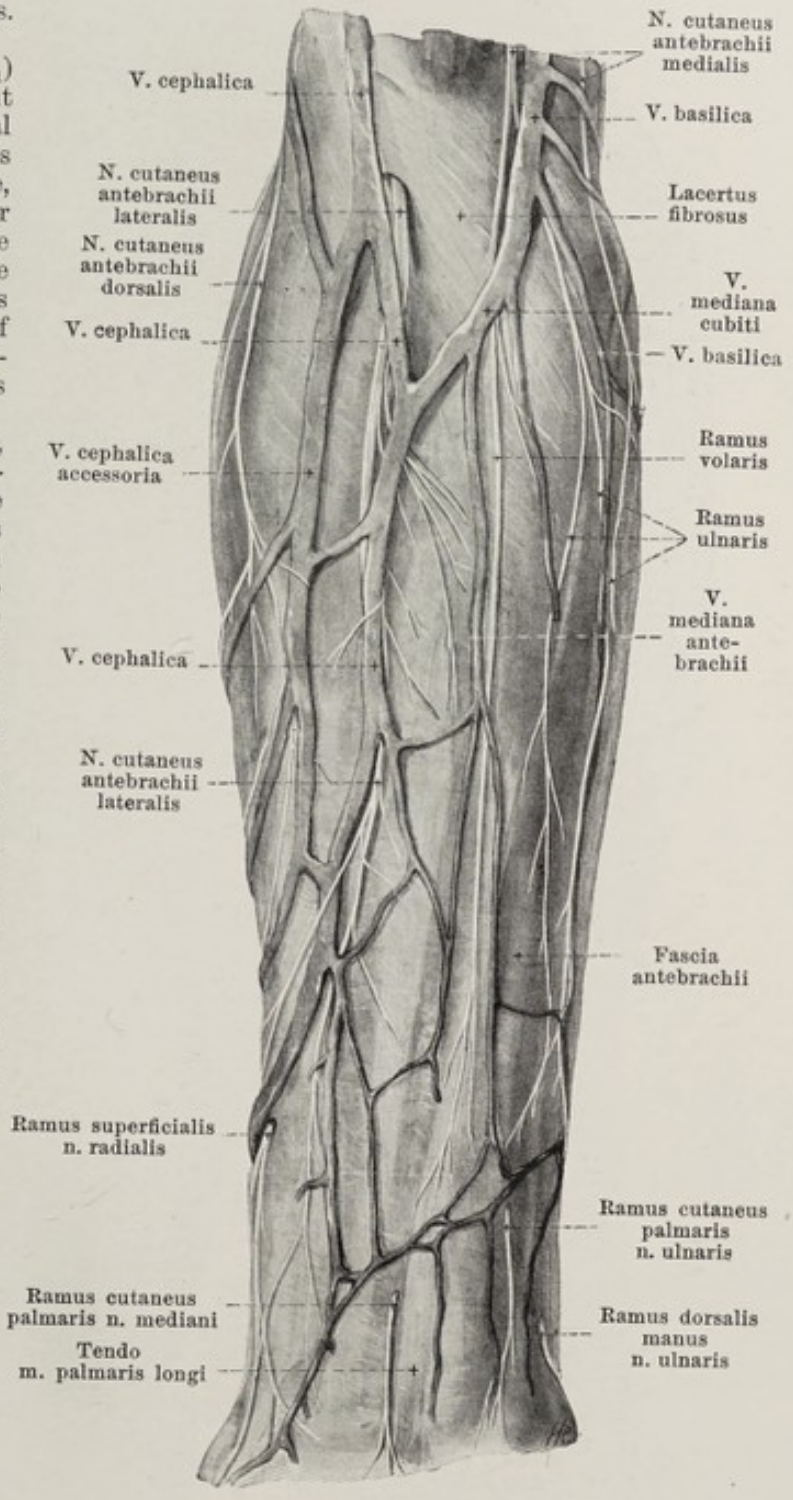
851. Cutaneous nerves of the right forearm, volar surface. (The fasciae brachii and antebrachii have been preserved.)

2. *N. cutaneus antebrachii medialis* (continued) (see also Figs. 850, 852, 853, 864 and 865).

α) *Ramus volaris* (from Th_1) runs downward at first in front of the lacertus fibrosus, lateral from the v. basilica, then crosses it, usually on its posterior surface, and is distributed to the ulnar half of the volar surface of the forearm as far as the eminence of the little finger. It anastomoses in the forearm with branches of the n. cutaneus antebrachii lateralis and of the ramus cutaneus palmaris n. ulnaris.

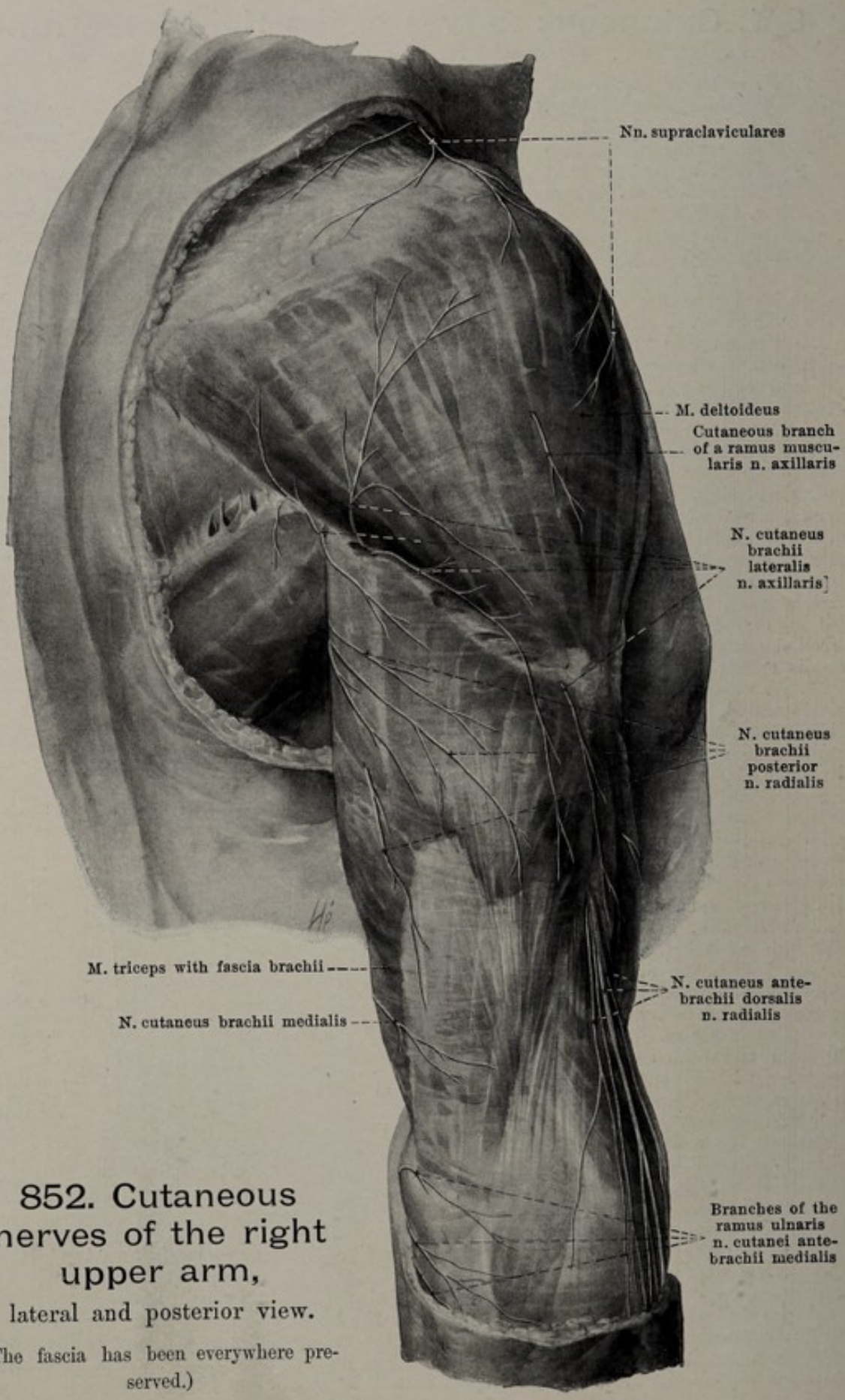
β) *Ramus ulnaris* (from C_8), smaller, passes over the epicondylus to the ulnar margin of the forearm and along this almost as far as the region of the capitulum ulnae. It sends its branches to the skin of the ulnar half of the dorsal surface of the forearm and anastomoses in the forearm with branches of the n. cutaneus antebrachii dorsalis and of the ramus dorsalis manus n. ulnaris.

3. *N. musculocutaneus* (see also Figs. 844, 849, 850, 853 to 855 and 864–866), from C_5, C_6 (C_7), behaves like a branch of the n. medianus. It runs distalward, at first lateral and dorsal from the n. medianus and from the a. axillaris, perforates obliquely the substance of the m. coracobrachialis, passes distalward and lateralward between the m. biceps brachii and m. brachialis, to finally perforate the fascia brachii with its terminal branch, the *n. cutaneus antebrachii lateralis*, close above the elbow lateral from the tendon of insertion of the m. biceps, medial from and behind the v. cephalica. In about one third of the cases it anastomoses in the upper arm (see Fig. 855) with the n. medianus by a branch which is usually directed distalward toward the latter. It gives off:



a) *Rami musculares* (see Fig. 855) to the mm. coracobrachialis (C6, C7) (from the first part of the nerve), biceps (C_5, C_6 [C_7]) and brachialis (C_5, C_6 [C_7]).

b) *N. cutaneus antebrachii lateralis*, (see also Figs. 853, 860 and 864—866) from C_5 and C_6, passes upon the fascia antebrachii near the v. cephalica distalward usually as far as the hand; it supplies the skin upon the radial margin and the radial half of the volar surface of the forearm, upon the ball of the thumb and upon the thumb region of the back of the hand, and anastomoses in the forearm with the n. cutaneus antebrachii medialis, in the hand with the ramus superficialis n. radialis and ramus dorsalis manus n. ulnaris.



852. Cutaneous nerves of the right upper arm,

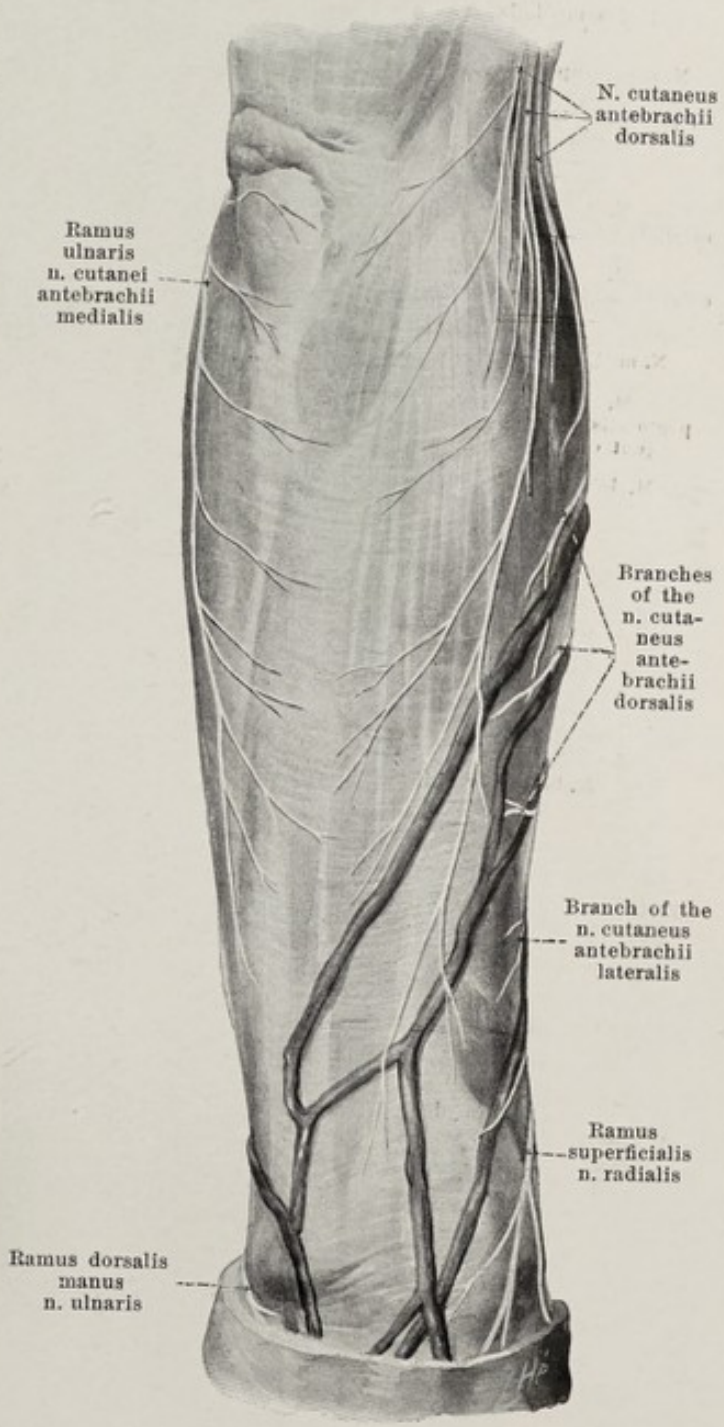
lateral and posterior view.

(The fascia has been everywhere preserved.)

853. Cutaneous nerves of the right forearm, dorsal surface.

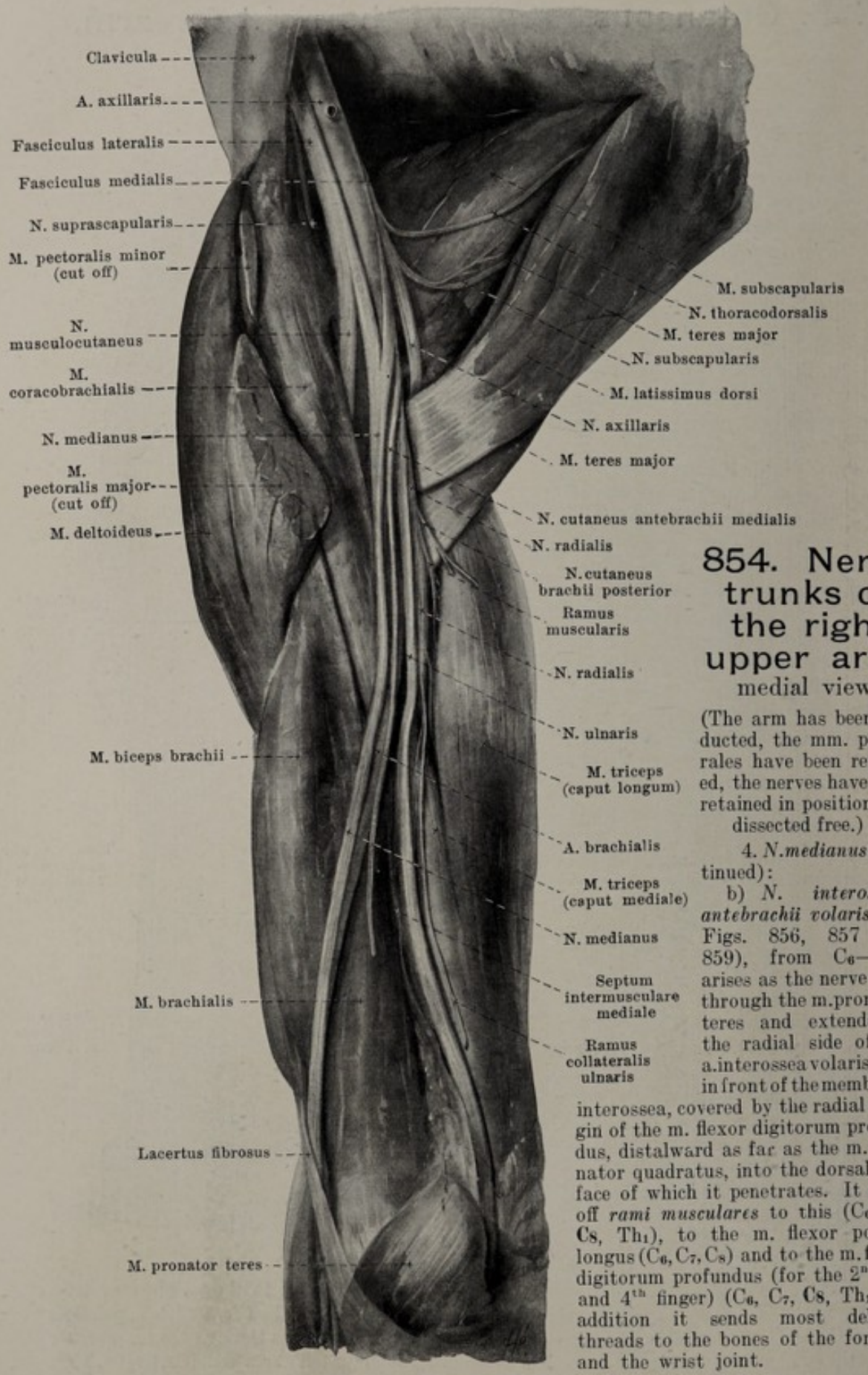
(The fasciae brachii and antebrachii have been preserved.)

4. *N. medianus* (see Figs. 844, 849, 851, 854—859, 861, 864 and 865) arises by two roots from the plexus, an upper (from C_5, C_6 and C_7) from the fasciculus lateralis and a lower (from C_8 and Th_1) from the fasciculus medialis. The two roots converging pass to the anterior lateral surface of the a. axillaris, where they combine. The nerve runs distalward with the a. brachialis, at first on the dorsal surface of the m. coracobrachialis, then in the sulcus bicipitalis medialis, and passes under the lacertus fibrosus upon the m. brachialis in the depth of the elbow; in its course it lies above on the anterior lateral side of the artery and then, above the elbow, gradually passes in front of it (rarely behind it) to its medial surface. In the forearm it passes in front of the a. ulnaris between the two heads of the m. pronator teres and below the tendinous arch of the m. flexor digitorum sublimis on the dorsal surface of the latter and extends to the wrist, approximately in the axis of the forearm, in the groove between the mm. flexor pollicis longus and flexor digitorum profundus along with the a. mediana (see also Fig. 507). Close above the wrist between and under the tendons of the mm. flexor carpi radialis and palmaris longus it approaches (see Fig. 856) again the surface under the fascia antebrachii. It then turns to the volar surface of the tendons of the mm. flexores digitorum and passes with these dorsal from the lig. carpi transversum in the canalis carpi to the hand (see Fig. 857). In the upper arm it receives in about one third of the cases a thick bundle from the n. musculocutaneus (see p. 749 and Fig. 855), and in the forearm it anastomoses by a fine thread with the n. ulnaris between the mm. flexores digitorum. It gives off no branches in the upper arm.



Branches in the forearm:

a) *Rami musculares* (see Figs. 855—857), go off at the level of the epicondylus medialis humeri to the m. pronator teres (usually two) (**C6**, C7) and through this to the mm. flexor carpi radialis (C6, **C7** [C8]), palmaris longus (C_7, C_8, Th_1) and flexor digitorum sublimis; as the trunk passes through the m. pronator teres still other branches arise for the m. flexor digitorum sublimis (all fibres from [C6, C7] **C8**, Th1).



854. Nerve trunks of the right upper arm, medial view.

(The arm has been abducted, the mm. pectorales have been removed, the nerves have been retained in position and dissected free.)

4. *N. medianus* (continued):

b) *N. interosseus antebrachii volaris* (see Figs. 856, 857 and 859), from C_6—Th_1, arises as the nerve goes through the m. pronator teres and extends on the radial side of the a. interossea volaris, just in front of the membrana interossea, covered by the radial margin of the m. flexor digitorum profundus, distalward as far as the m. pronator quadratus, into the dorsal surface of which it penetrates. It gives off *rami musculares* to this (C_6, C_7, C_8, Th_1), to the m. flexor pollicis longus (C_6, C_7, C_8) and to the m. flexor digitorum profundus (for the 2nd, 3rd and 4th finger) (C_6, C_7, C_8, Th_1); in addition it sends most delicate threads to the bones of the forearm and the wrist joint.

855. Muscle nerves of the right upper arm,

viewed from in front.

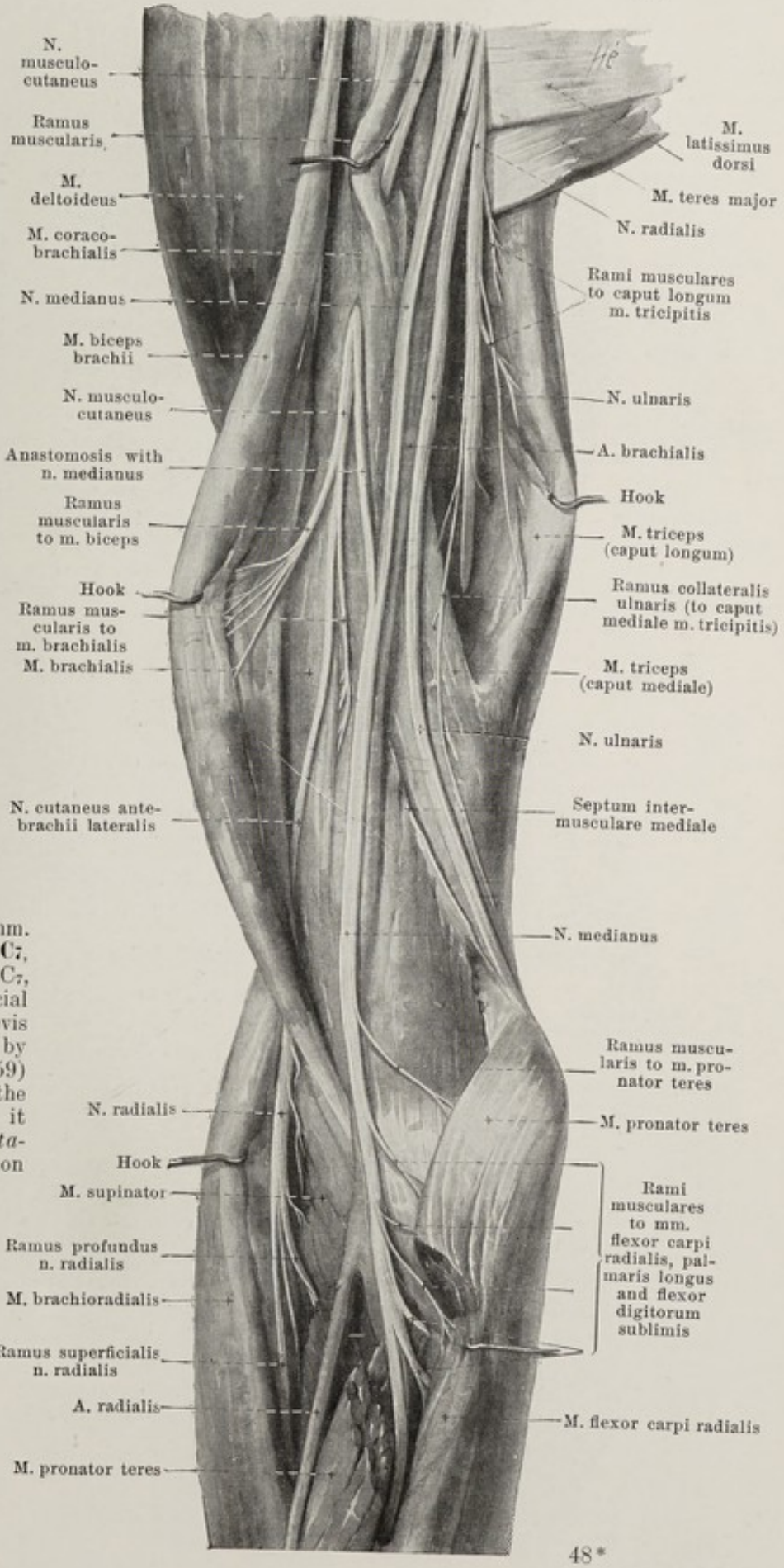
(The arm has been abducted; the mm. biceps, triceps and brachioradialis have been drawn aside; a piece has been cut out of the m. pronator teres.)

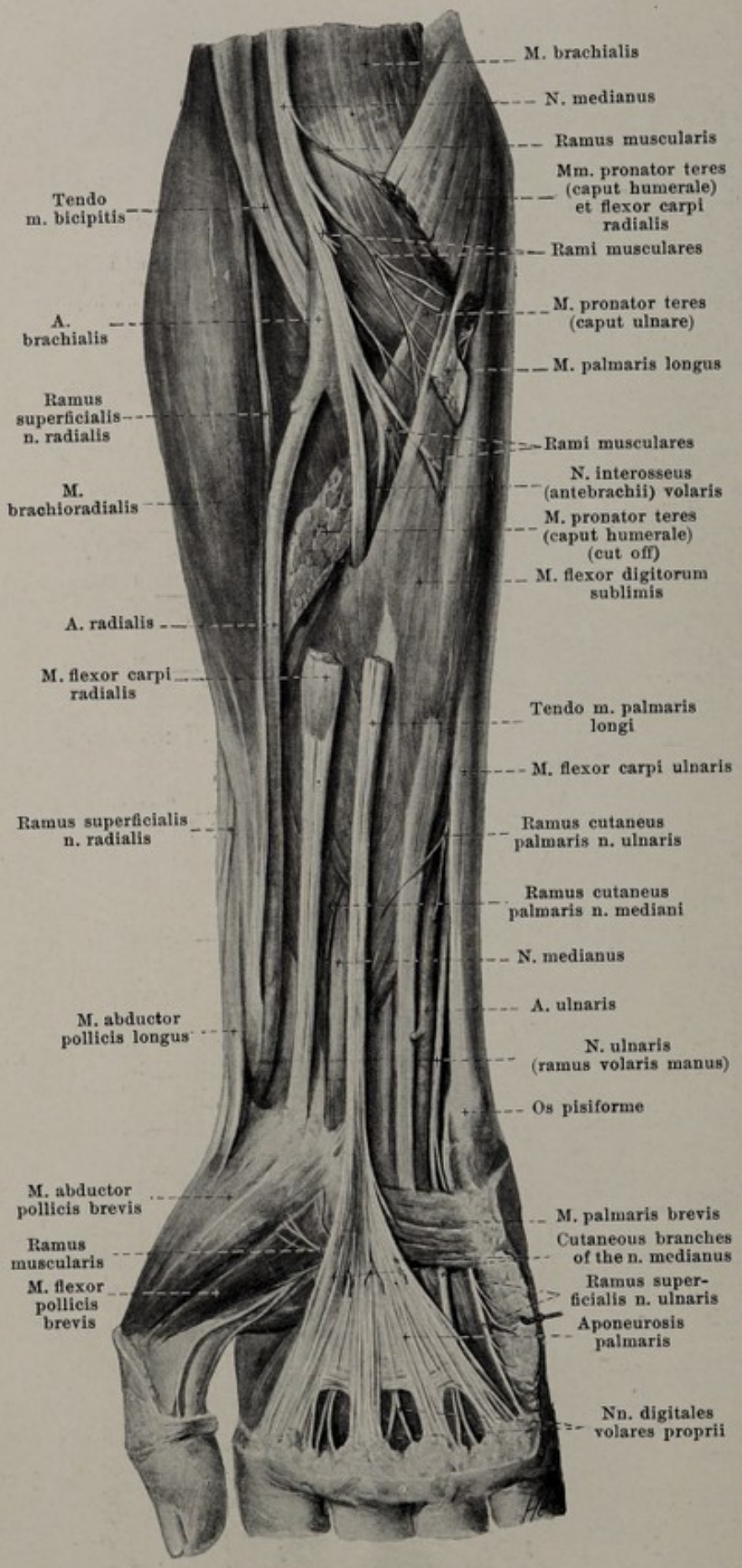
4. *N. medianus* (continued):

c) *Ramus cutaneus palmaris* (see Figs. 851, 856 and 864) arises at a variable level above the wrist, perforates the fascia between the mm. flexor carpi radialis and palmaris longus, and passes upon the fascia to the skin of the ball of the thumb and of the hollow of the hand.

Branches in the hand:

d) *N. digitales volares communes* (see Figs. 856 to 859, 861 and 864—867), three, pass in the 1st to the 3rd spatium interosseum metacarpi under the aponeurosis palmaris and the arcus volaris superficialis, diverging distalward. The first gives off a *ramus muscularis* to the mm. abductor pollicis brevis (C_6, **C_7**, [C_8]), opponens pollicis (C_6, C_7, [C_8, Th_1]) and to the superficial head of the m. flexor pollicis brevis (C_6, **C_7**, C_8) and anastomoses by a delicate branch (see Fig. 859) passing into the depth with the ramus profundus n. ulnaris; it then divides into three *nn. digitales volares proprii*, which run on the radial and ulnar margins of the volar surface of the thumb and on the radial margin of the volar surface of the index finger as far as the tips of the fingers; the first anastomose with the digital branches of the n. radialis, the last usually sends cutaneous branches to the back of the finger (see Figs. 858 and 861) and a muscular branch to the m. lumbricalis I (C_7, C_8, Th_1) (see Fig. 858).





856. Nerves of the right forearm,

viewed from in front, more superficial layer.

(The caput humerale of the m. pronator teres, as well as the muscular bellies of the mm. flexor carpi radialis and palmaris longus have been in large part removed.)

4. *N. medianus* (continued): d) *Nn. digitales volares communes:*

The second and the third n. digitalis volaris communis (see Figs. 857, 858 and 864—867) send a twig to the mm. lumbricales II and (often) III (C_7, C_8, Th_1); each divides into two *nn. digitales volares proprii* for the adjacent margins of the 2nd, 3rd and 4th finger, which usually supply also the dorsal surfaces of their second and third phalanges. The third unites in a variable manner by means of a *ramus anastomoticus cum n. ulnari* with the ramus superficialis n. ulnaris (see Figs. 857 and 858).

The nn. digitales volares communes send delicate branches through the aponeurosis palmaris to the skin of the palm. In the region of the fingers numerous small *corpuscula lamellosa [Vateri, Pacini]* (see Fig. 858) are to be found; they are united with the nerves by small twigs.

5. *N. ulnaris* (see Figs. 844, 849, 851, 854—860 and 864 to 867), from C_7, C_8 and Th_1, passes distalward at first on the posterior medial surface of the aa. axillaris and brachialis in front of the n. radialis, m. latissimus dorsi and caput longum m. tricipitis, and then runs superficially downward, covered only by the fascia brachii, on the anterior medial surface of the caput mediale m. tricipitis behind the septum intermusculare mediale, gradually becoming separated from the a. brachialis, to the sulcus n. ulnaris of the humerus.

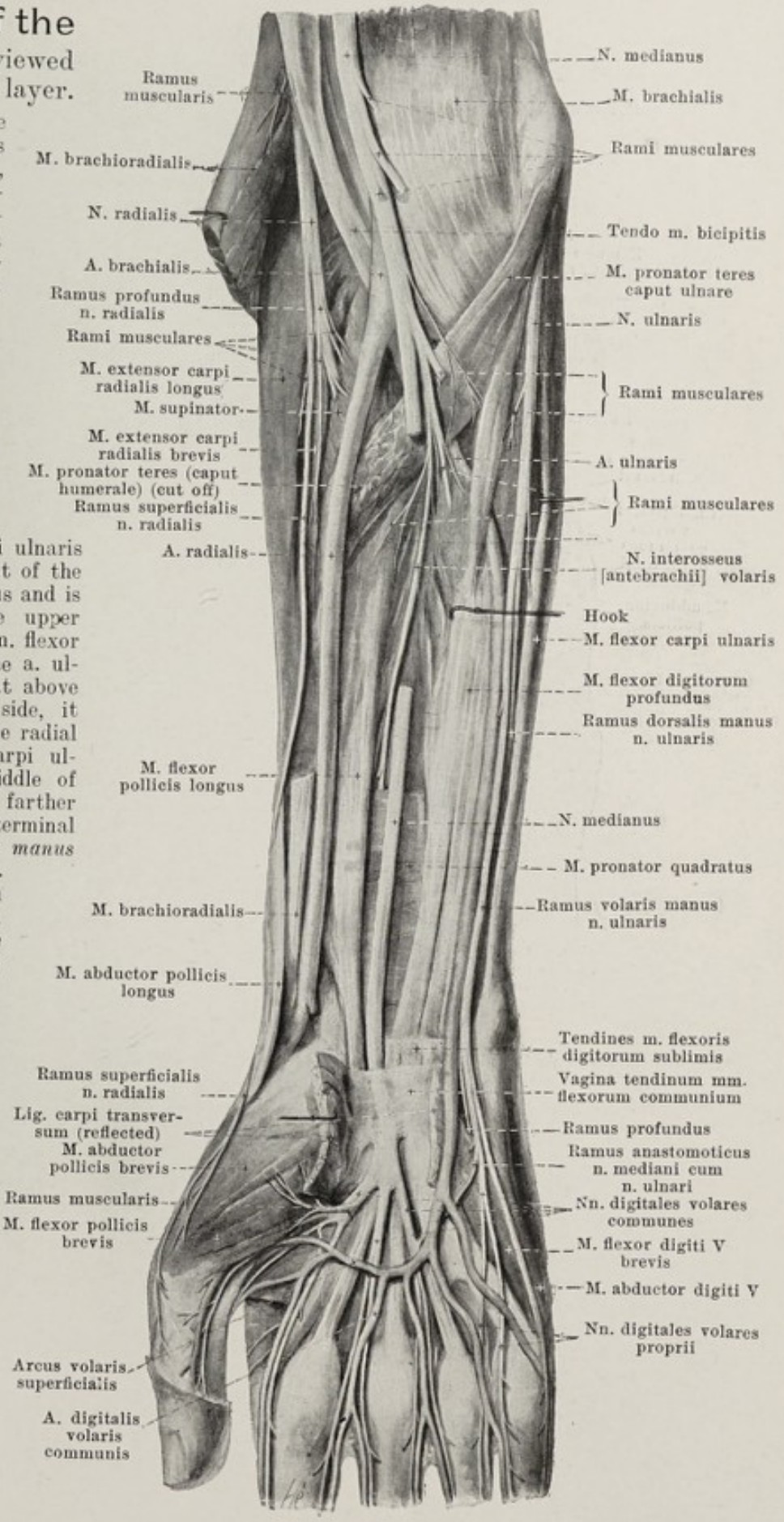
857. Nerves of the right forearm, viewed from in front, deeper layer.

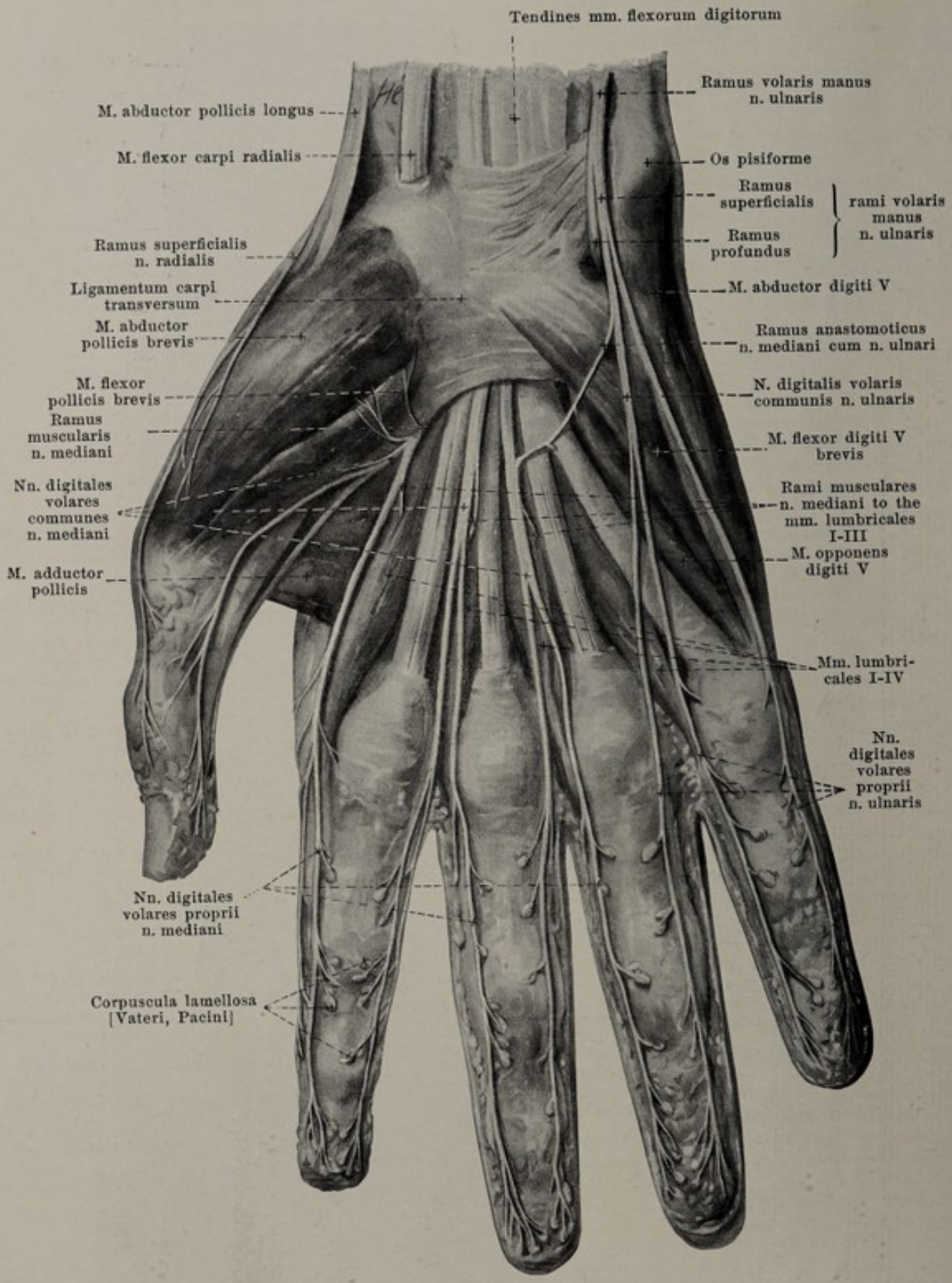
(The caput humerale of the m. pronator teres, as well as the mm. brachioradialis, flexor carpi radialis, palmaris longus and flexor digitorum sublimis have been removed; the lig. carpi transversum has been cut through and reflected.)

5. *N. ulnaris* (see also Figs. 851, 856, 858—860 and 864—867) (continued): In the sulcus n. ulnaris of the humerus it lies between the epicondylus medialis humeri and the olecranon ulnae directly upon the bone. Thence it passes between the two heads of the m. flexor carpi ulnaris on its radial surface in front of the m. flexor digitorum profundus and is accordingly covered in the upper half of the forearm by the m. flexor digitorum sublimis. Near the a. ulnaris, which comes, somewhat above the middle, on its radial side, it passes next distalward on the radial margin of the m. flexor carpi ulnaris and divides in the middle of the foramen or somewhat farther distalward into its two terminal branches, the *ramus dorsalis manus* and the *ramus volaris manus*. It gives off no branches in the upper arm; in the forearm it anastomoses by a delicate branch with the n. medianus (see p. 751) and sends off the following branches:

a) *Rami musculares* to the m. flexor carpi ulnaris (C_8, Th_1) and to the m. flexor digitorum profundus (to the 3rd, 4th and 5th finger) (C_8, Th_1).

b) *Ramus cutaneus palmaris* (see also Figs. 851, 856 and 864), delicate, arises in the middle of the forearm or more proximalward, accompanies the a. ulnaris as far as the hand and in the forearm sends a twig through the fascia distalward to the skin of the volar surface of the wrist and of the ball of the little finger; this twig anastomoses with the n. cutaneus antebrachii medialis.



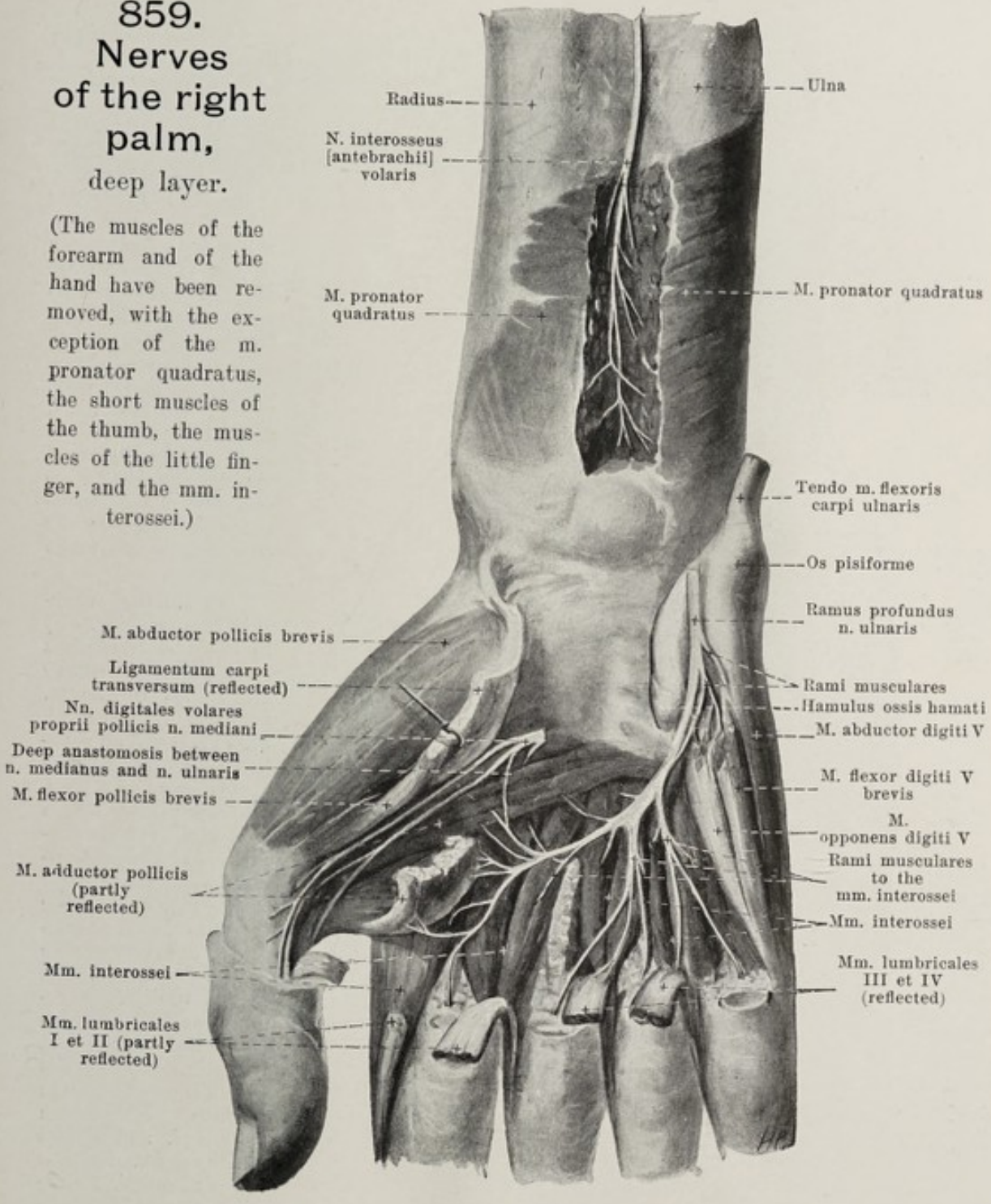


858. Nerves of the right palm, superficial layer.

(The fascia antebrachii and the aponeurosis palmaris have been removed.)

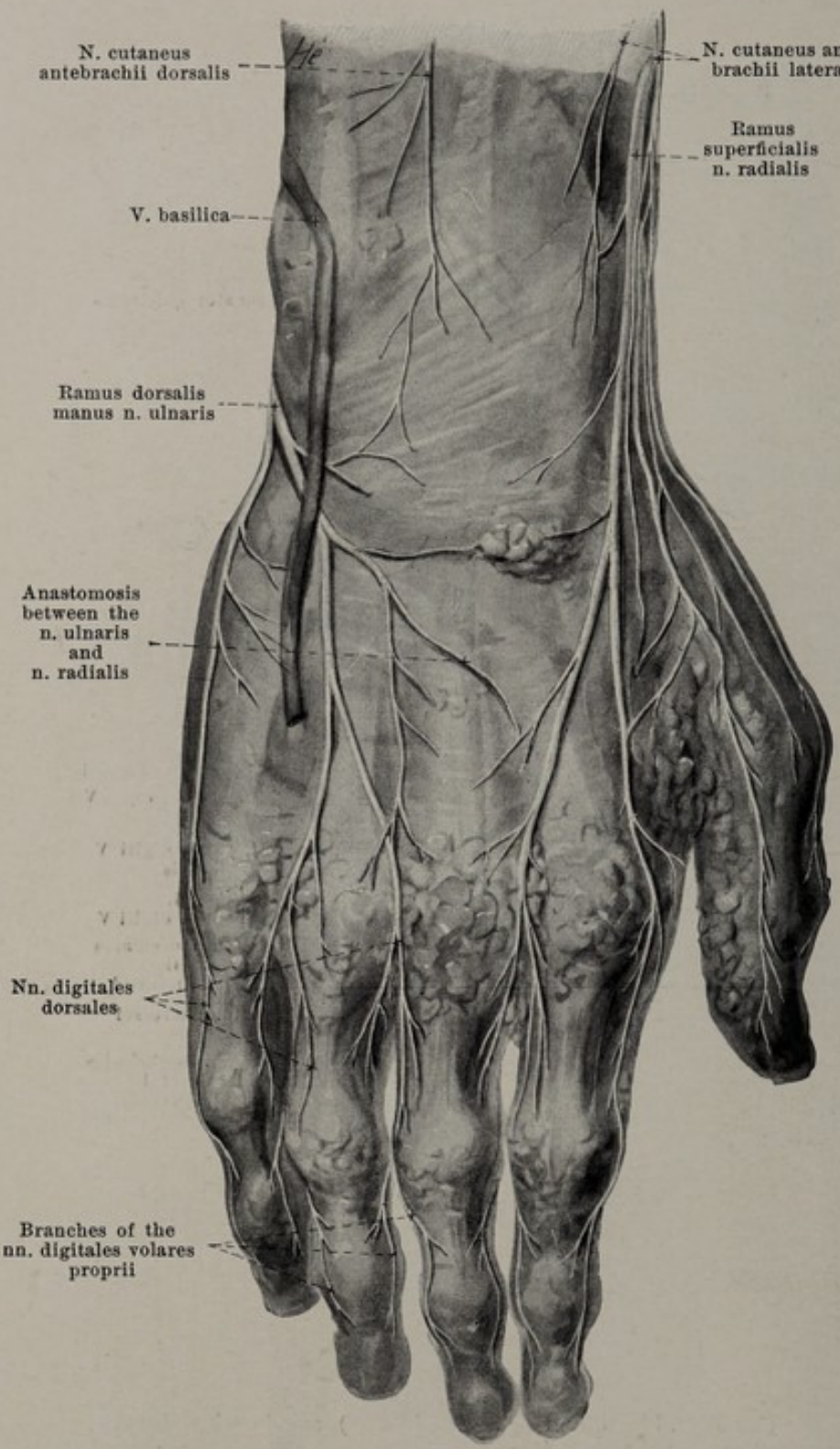
859. Nerves of the right palm, deep layer.

(The muscles of the forearm and of the hand have been removed, with the exception of the m. pronator quadratus, the short muscles of the thumb, the muscles of the little finger, and the mm. interossei.)



5. *N. ulnaris* (continued):

c) *Ramus dorsalis manus* (see Figs. 853, 857, 860 and 864—867), one terminal branch, usually the smaller, passes along the ulna, between it and the tendon of the m. flexor carpi ulnaris, distalward upon the dorsal surface of the capitulum ulnae. There it perforates the fascia antebrachii and divides upon the lig. carpi dorsale. It sends delicate branches radialward, which anastomose with branches of the nn. cutanei antebrachii medialis, dorsalis and lateralis and of the ramus superficialis n. radialis, and 5 *nn. digitales dorsales* distalward, which run along the ulnar margin of the 5th, 4th and 3rd finger, and the radial margin of the 5th and 4th finger, reaching constantly to the base of the nail on the 5th finger, but on the 4th finger usually and on the 3rd finger almost constantly not going beyond the first phalanx.



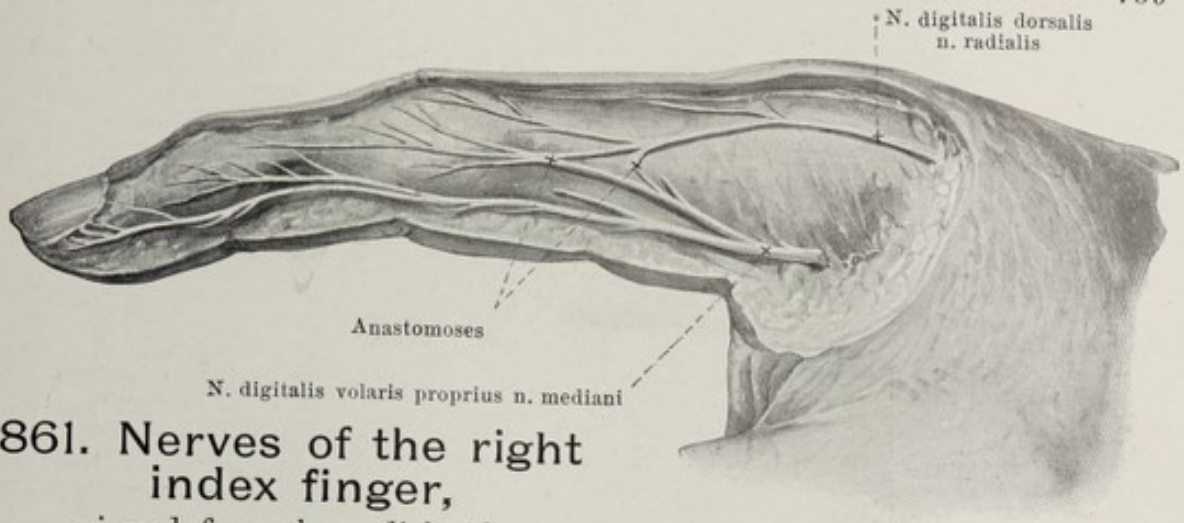
860. Nerves of the dorsum of the right hand.

(The fascia has been everywhere preserved; the veins have been in large part removed.)

5. *N. ulnaris* (continued):

d) *Ramus volaris manus* (see Figs. 856 to 859 and 864), the second terminal branch, runs in the direction of the stem on the ulnar side of the a. ulnaris and at the radial margin of the m. flexor carpi ulnaris, between this and the m. flexor digitorum sublimis, covered only by the fascia antebrachii and the lig. carpi volare, to the hand, and there divides in front of the lig. carpi transversum on the radial side of the os pisiforme into the *ramus superficialis* and *ramus profundus*.

α) *Ramus superficialis* (see Figs. 856 to 858 and 864) gives off at first a fine *ramus muscularis* to the m. palmaris brevis ([C_7], C_8, [Th_1]) and an anastomosing branch to the n. medianus (see p. 754). It then divides into a *n. digitalis volaris proprius*, which runs distalward upon the muscles of the ball of the little finger to the ulnar margin of the volar surface of the 5th finger, and into a *n. digitalis volaris communis*, which runs distalward just beneath the aponeurosis palmaris, upon the fourth spatium interosseum metacarpi, and divides into two *nn. digitales volares proprii*, for the adjacent margins of the volar surfaces of the 4th and 5th finger, that for the 4th finger usually supplying also the dorsal surface of the 2nd and 3rd phalanx. They are connected with small *corpuscula lamellosa [Vateri, Pacini]* (see p. 754).



861. Nerves of the right index finger,

viewed from the radial side.

5. *N. ulnaris* (continued): d) *Ramus volaris manus:*

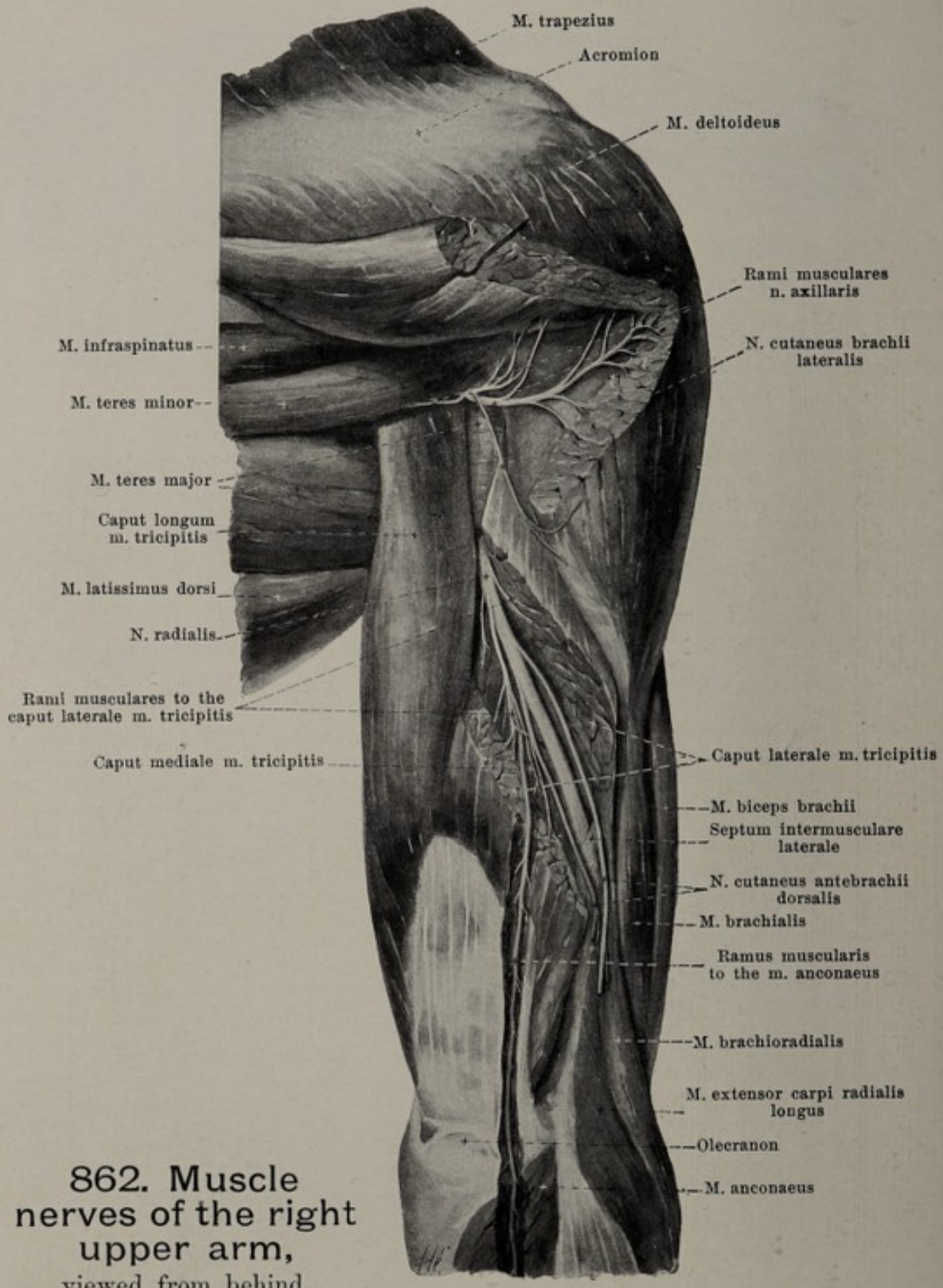
β) Ramus profundus (see Figs. 858 and 859) with the ramus volaris profundus a. ulnaris bends into the depth between the origins of the mm. abducor digiti V and flexor digiti V brevis through the origin of the m. opponens digiti V and at the same time in a curve radialward around the hamulus ossis hamati; it then lies upon the volar surface of the mm. interossei, crosses the arcus volaris profundus and ends in a delicate anastomosis with the n. medianus (see p. 753). It gives off *rami musculares* at its beginning to the short muscles of the little finger ([C_7], C_8 [Th_1]), in the depth to the mm. interossei ([C_7] C_8, Th_1), the mm. lumbricales IV and (often) III (C_7, C_8, Th_1), the m. adductor pollicis (C_7, C_8, Th_1) and the deep head of the m. flexor pollicis brevis (C6, **C7**, C8), in addition branches to the joints and bones of the hand.

6. *N. radiales* (O.T. musculospiral nerve) (see also Figs. 844, 851—858, 860 and 862—867), from C_5, C_6, C_7, C_8 and Th_1, passes distalward behind the n. ulnaris and the a. axillaris in front of the m. subscapularis and the tendons of the mm. latissimus dorsi and teres major (see Figs. 854 and 855), and lateral from the caput longum m. tricipitis bends behind the artery, and then on the dorsal surface of the humerus in its sulcus n. radialis, covered by the caput laterale of the m. triceps, runs distalward and lateralward in a long drawn-out spiral (see Figs. 402 and 862); in its course it lies at first near the a. profunda brachii, then near the a. collateralis radialis (see also Fig. 505). At the junction of the middle and lower thirds of the humerus it perforates the septum intermusculare laterale and the origin of the m. brachioradialis (see Figs. 402, 404 and 862) and on the medial surface of the latter arrives in the groove between the m. brachioradialis and the m. brachialis; in this it lies behind on some bundles of the latter and passes distalward near the a. recurrens radialis, to divide in front of the capitulum radii or somewhat higher up into the *ramus profundus* and *ramus superficialis* (see Figs. 855, 857 and 863). Before dividing it gives off the following branches:

a) *N. cutaneus brachii posterior* (see Figs. 852, 854 and 865) (C_7, C_8) arises, often along with a muscular branch for the caput longum m. tricipitis, at the lower margin of the fossa axillaris in front of the tendon of the m. teres major, then runs in front of the caput longum of the m. triceps and around its medial margin obliquely curved upon its posterior surface, there perforates the fascia brachii and branches in the skin of the back of the upper arm, about over the caput laterale and mediale of the m. triceps. It anastomoses with branches of the n. cutaneus brachii lateralis.

b) *Rami musculares* (see Figs. 854, 855 and 862), to the three heads of the m. triceps (C6, **C7**, **C8** [Th_1]); the branch for the caput mediale, *ramus collateralis ulnaris* (see Figs. 854 and 855), runs for some distance superficially, just behind the n. ulnaris distalward, and a long branch passes first in the caput laterale (see Fig. 862), then in the caput mediale between the olecranon and the epicondylus lateralis humeri downward to the m. anconaeus ([C6], **C7**, C8 [Th_1]).

c) *N. cutaneus antebrachii dorsalis* (see Figs. 851—853, 860, 862 and 864—867) (C_6, C_7, C_8 [Th_1]) arises (see Fig. 862) in the sulcus n. radialis in front of the caput laterale of the m. triceps, passes in front of it lateralward and downward near the n. radialis, and lateral from this muscle perforates the fascia brachii (see Fig. 852), between the insertion of the m. deltoideus and the epicondylus lateralis humeri, behind the septum intermusculare laterale and the v. cephalica. There it divides into several branches and passes distalward to the skin of the radial part of the elbow and to the dorsal surface of the forearm as far as the proximal part of the back of the hand. In its course it anastomoses with the branches of the nn. cutanei brachii lateralis and antebrachii medialis, as well as with the ramus dorsalis manus n. ulnaris and the ramus superficialis n. radialis.



862. Muscle nerves of the right upper arm, viewed from behind.

(Pieces have been cut out of the m. deltoideus, caput laterale m. tricipitis and m. anconaeus.)

6. *N. radialis* (continued):

d) *Rami musculares*, after perforating the septum intermusculare laterale (see Figs. 855, 857 and 863), go to the mm. brachioradialis (C_5, C_6), extensor carpi radialis longus ([C_5] C_6, C_7, C_8); often a delicate thread also to the lateral part of the m. brachialis (C_5, C_6).

863. Muscle nerves of the right forearm,

viewed from behind and lateralward.

(The mm. brachioradialis, extensores carpi radialis and digitorum communis have been cut through and reflected dorsalward and ulnarward. A piece has been cut out of the m. supinator.)

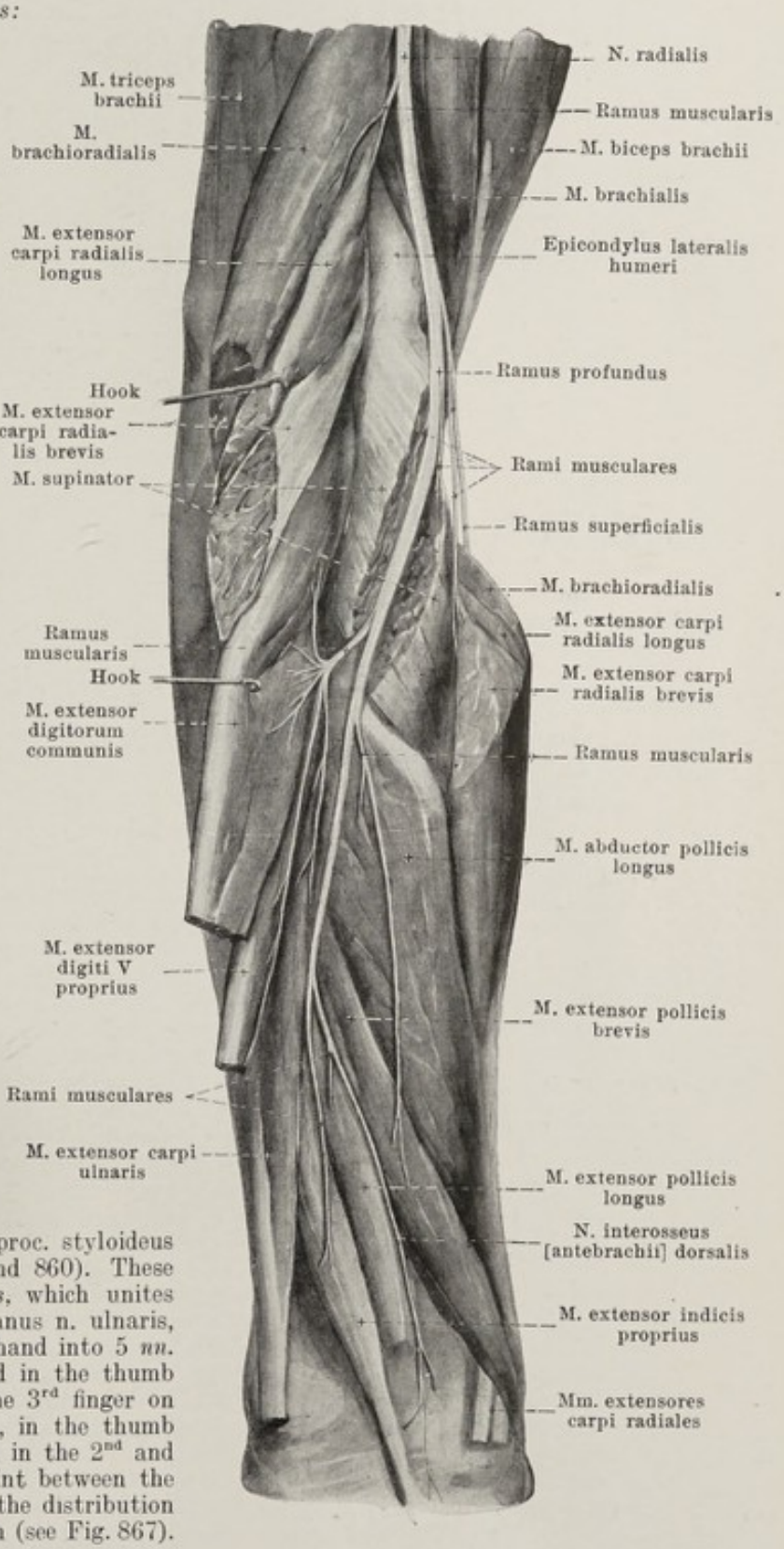
Terminal branches of the n. radialis:

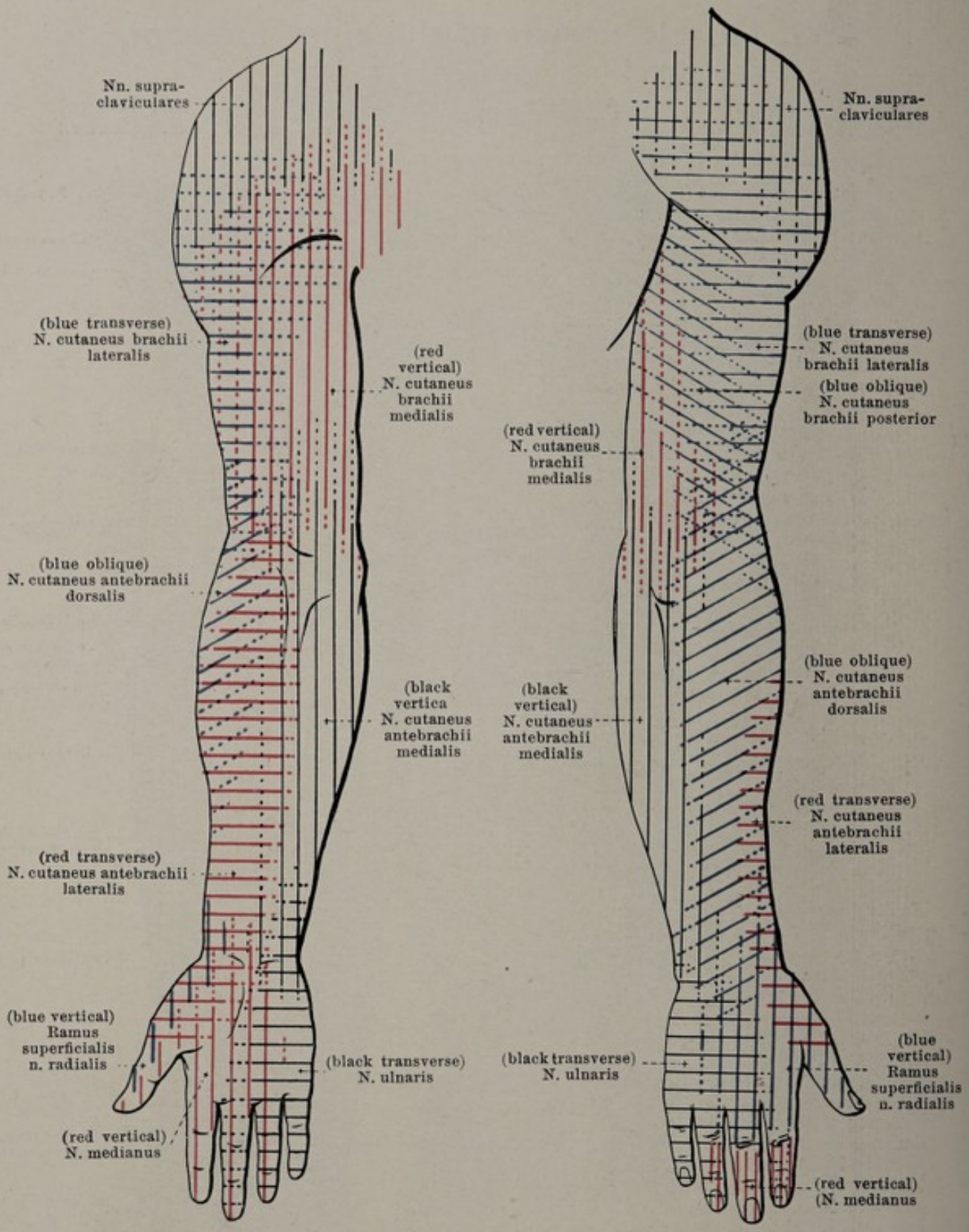
e) *Ramus profundus* (see also Figs. 855 and 857), the larger of the two, penetrates the volar surface of the m. supinator, and passes within this muscle in a long spiral winding around the collum radii to the dorsal surface of the radius, where it runs distalward upon the mm. abductor pollicis longus and extensores pollicis and ends as the *n. interosseus [antebrachii] dorsalis*. It gives off:

α) *Rami musculares*, before entrance into the m. supinator, to the mm. extensor carpi radialis brevis (C_6, C_7 [C_8]) and supinator ([C_5] C_6, C_7, C_8), on the back of the forearm to the mm. extensores digitorum communis ([C_6] C_7, **C8**), digiti V proprius (C_7, C_8) and carpi ulnaris ([C_6] C_7, **C8**), abductor pollicis longus, extensores pollicis and extensor indicis proprius ([C_6] C_7, C_8).

β) *N. interosseus [antebrachii] dorsalis* passes between the mm. extensores pollicis to the membrana interossea and upon it to the bones and ligaments of the forearm and of the hand.

f) *Ramus superficialis* (see also Figs. 855—858, 860, 861 and 864—867) runs (see Figs. 856 and 857) distalward in front of the m. supinator behind the ulnar margin of the m. brachioradialis, at first near the a. recurrens radialis, then radialward from the a. radialis; it passes in a long curve between the m. brachioradialis and m. extensor carpi radialis longus gradually to the radial margin of the forearm, and there perforates the fascia antebrachii in the lower third of the forearm. Here it anastomoses with the n. cutaneus antebrachii lateralis and divides into two branches, which pass upon the lig. carpi dorsale over the lateral surface of the proc. styloideus radii to the hand (see Figs. 857, 858 and 860). These give off a *ramus anastomoticus ulnaris*, which unites with branches of the ramus dorsalis manus n. ulnaris, and then divide upon the fascia of the hand into 5 *nn. digitales dorsales*. These run distalward in the thumb and index finger on both margins, in the 3rd finger on the radial margin of the dorsal surface, in the thumb regularly as far as the base of the nail, in the 2nd and 3rd finger usually only as far as the joint between the 1st and the 2nd phalanx. Variations in the distribution of the n. radialis in the hand are common (see Fig. 867).

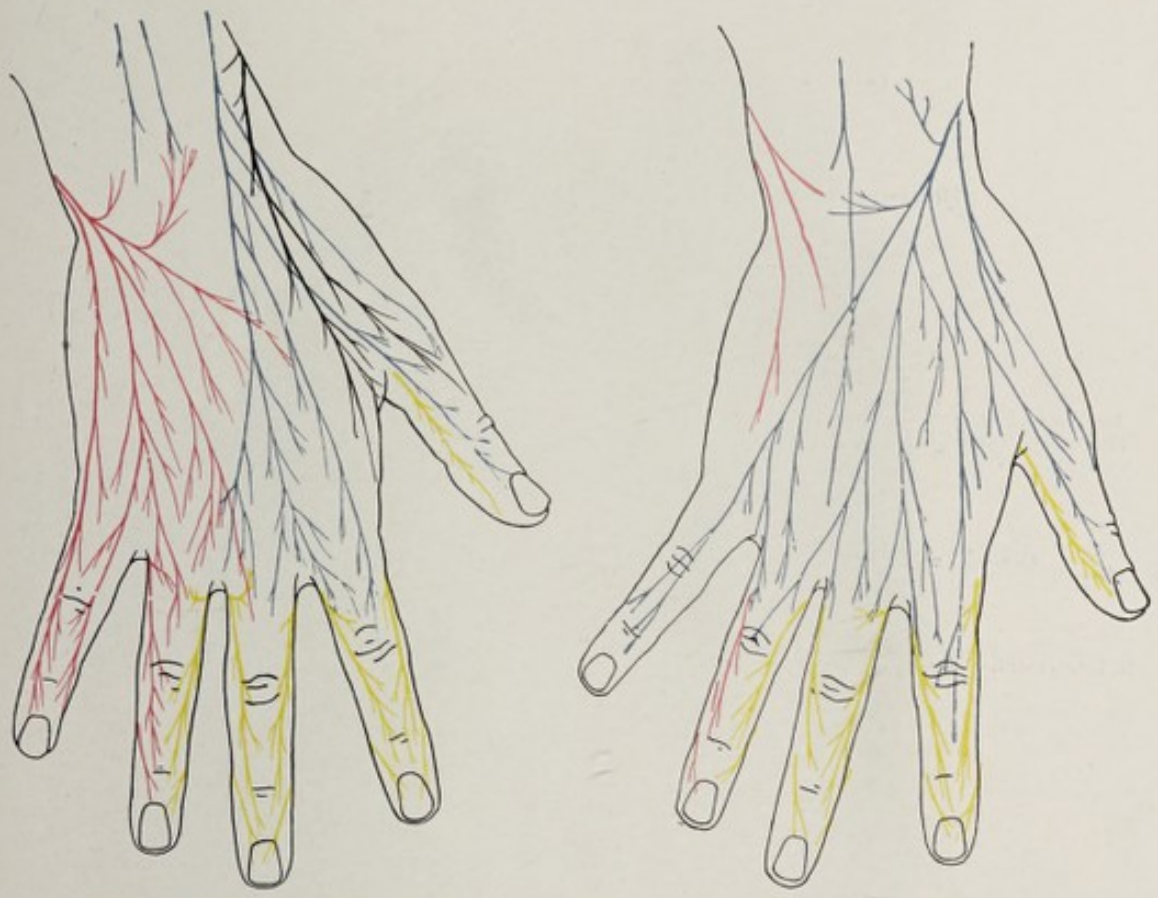




864 and 865. Areas of distribution of the cutaneous nerves of the right arm,

viewed from in front. viewed from behind.

(The areas constantly supplied by the nerves concerned are indicated by solid lines, those inconstantly supplied by dotted lines.)



866 and 867. Branching of the cutaneous nerves on the back of the right hand (after E. Hédon)

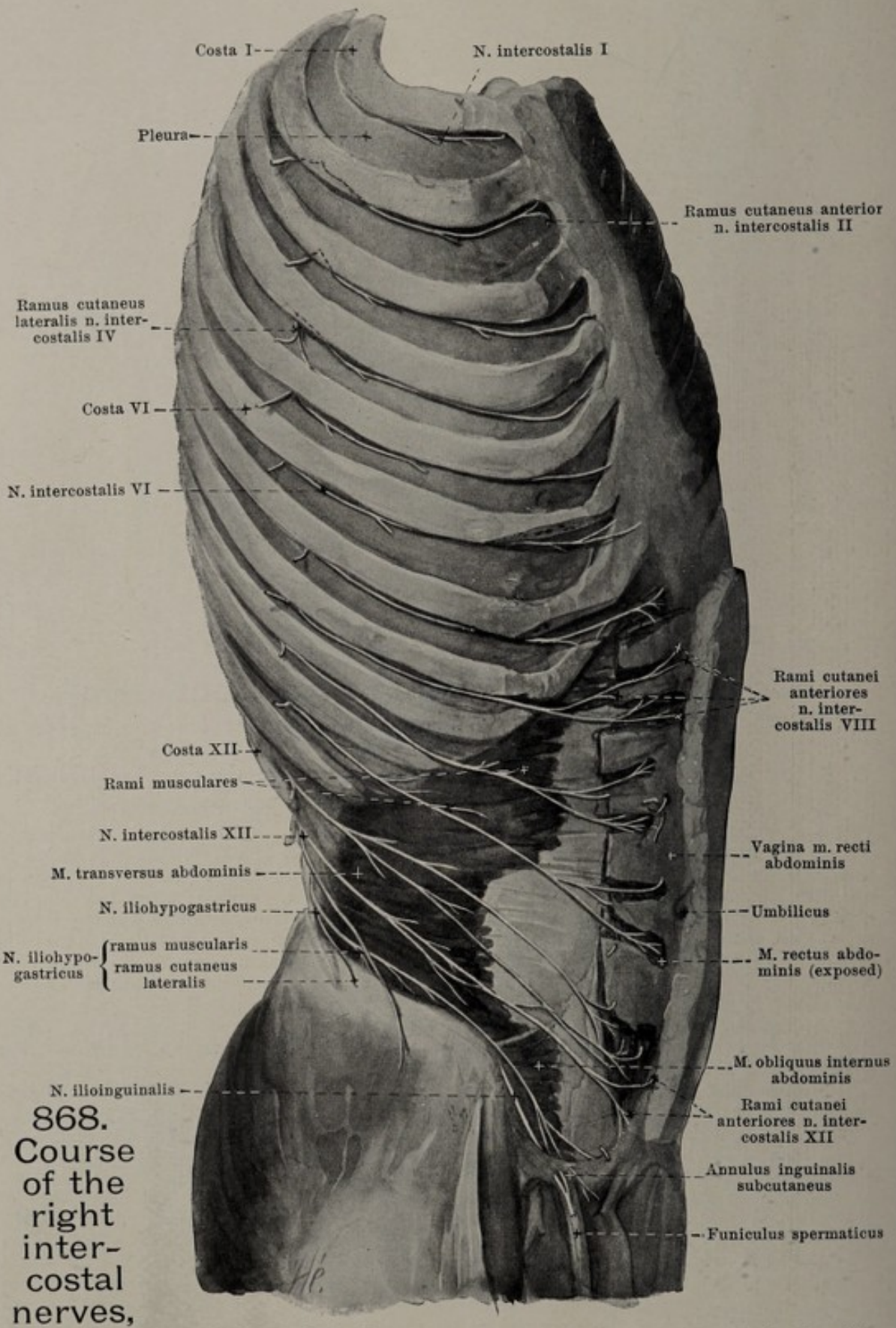
(see also Fig. 860).

Ordinary arrangement. Arrangement when the ramus superficialis n. radialis is markedly developed.

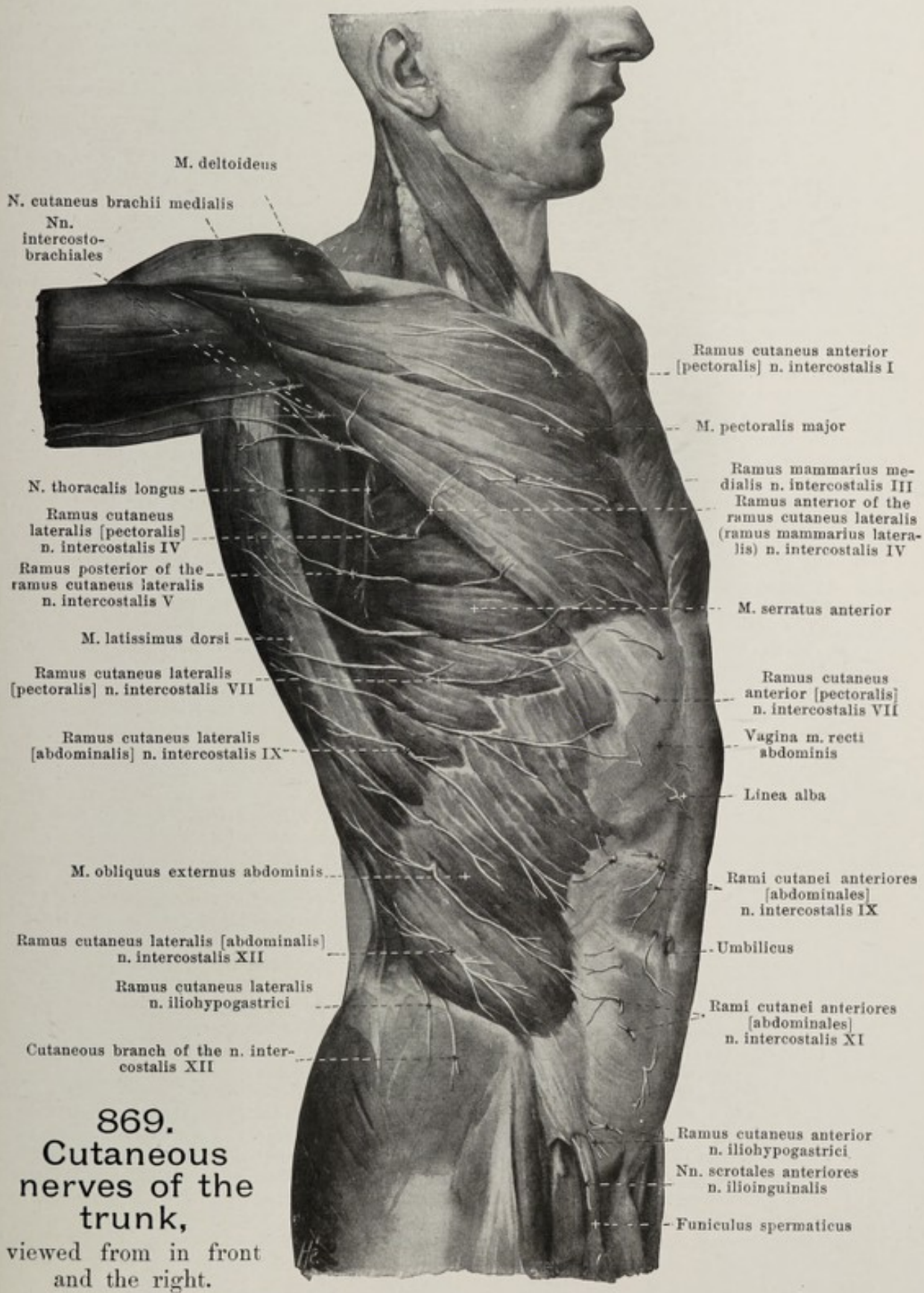
(Black: n. cutaneus antebrachii lateralis; red: n. ulnaris; blue: n. radialis; yellow: n. medianus.)

The ***rami anteriores of the nn. thoracales*** (see Figs. 743, 839, 868, 869, 871 and 890) go forward in a curve in the intercostal spaces (the 12th at the lower margin of the 12th rib), and hence are called the ***nn. intercostales.*** Each of them (see Fig. 743 and 890) is connected at its beginning by one or several *rami communicantes* with the ganglia or truncus of the sympathicus. Most of the intercostal nerves form an anastomosis only exceptionally with adjacent ones where they begin; such connections are constantly present only between the 1st thoracic and the 8th cervical nerve, since the former sends its main mass to the plexus brachialis (see p. 743) and goes on as the n. intercostalis I only by a delicate thread, and between the 12th thoracic and 1st lumbar nerve, whereby a part of the former goes over into the tract of the latter; usually also the 2nd thoracic nerve connects with the first and with the plexus brachialis (see p. 743).

Each runs just beneath the a. intercostalis (see also Figs. 363, 680 and 681) lateralward in front of the lig. costotransversarium anterius and internal from the mm. intercostales externi, covered only by the fascia endothoracica and pleura, in the middle of the intercostal space, then at the angulus costae approaches the upper rib; it passes along it behind between the mm. intercostales externi and interni, in front between the two layers of the latter as far as the anterior extremity of the bones of the ribs and then comes to the inner side of the mm. intercostales interni (see p. 285), there to pass again to the middle of the intercostal space. It ends in the 1st—6th intercostal space near the sternum in a ramus cutaneus anterior pectoralis. The 7th, 8th and 9th pass behind the anterior ends of the costal cartilages, the 10th, 11th and 12th under the anterior end of the corresponding rib, between the mm. obliquus internus abdominis and transversus abdominis and go medianward between these in the direction of the bony ribs as far as the m. rectus abdominis; the 7th assumes between the abdominal muscles a course ascending somewhat cranialward, the 8th an approximately horizontal, the 9th—12th a course descending more and more caudalward.



868. Course of the right intercostal nerves, viewed from the right and in front. (The mm. intercostales and obliqui abdominis have been removed; pieces have been cut out of the m. rectus abdominis.)



869. Cutaneous nerves of the trunk, viewed from in front and the right.

(Figs. 868 and 869 have been drawn from the same cadaver.)

N. intercostales (continued): In the whole length of their course they give off delicate *rami musculares* to the neighboring muscles (see Figs. 868 and 890), including the mm. intercostales externi, interni (and subcostales) and levatores costarum from Th_1—Th_{11}, mm. serratus posterior superior from Th_1—Th_4, serratus posterior inferior from Th_9—Th_{11}, transversus thoracis from (Th_2) Th_3—Th_6, mm. obliquus externus and transversus abdominis from Th_5 to Th_{12}, m. rectus abdominis from Th_6—Th_{12}, m. obliquus internus abdominis (Th_{10}—Th_{12}) and m. pyramidalis from Th_{12}; in addition, sensory fibres go to the peritonaeum of the anterior abdominal wall and to the marginal zone of the diaphragm.

Each n. intercostalis gives off two cutaneous branches, *rami cutanei lateralis et anterior.*

a) *Ramus cutaneus lateralis [pectoralis et abdominalis]* (see Figs. 868 and 869) goes off about midway between the spine and the sternum, is usually larger than the continuation of the trunk, and is absent only on the 1st intercostal nerve. It appears between the digitations of the m. serratus anterior, lower down between those of the mm. latissimus dorsi and obliquus externus abdominis, about midway between the mamillary and axillary lines, and divides into two branches. The *ramus posterior* passes around the lateral margin of the m. latissimus dorsi, approximately horizontal, to the skin, toward the branches of the rami posteriores nn. thoracalium (see also Fig. 842 and p. 740); the branch of the 2nd and sometimes of the 3rd intercostal nerve unites, as the *n. intercostobrachialis* (see also Fig. 849), with the n. cutaneus brachii medialis, and goes wholly or in part to the skin of the medial surface of the upper arm. The *ramus anterior* of the 2nd—6th intercostal nerve bends around the lateral margin of the m. pectoralis major medianward to the skin over this muscle; in the female branches from the 4th—6th nerve, *rami mammarii laterales*, enter the mammary gland; the anterior ramus of the 7th—11th intercostal nerve passes upon the external surface of the m. obliquus externus abdominis obliquely downward and medianward to almost in front of the sheath of the rectus, that of the 12th usually runs with a large branch over the crista iliaca downward to the skin upon the mm. glutaeus medius and tensor fasciae latae and there alternates with the ramus cutaneus lateralis n. iliohypogastrici (see also Figs. 874, 885, 886 and p. 768).

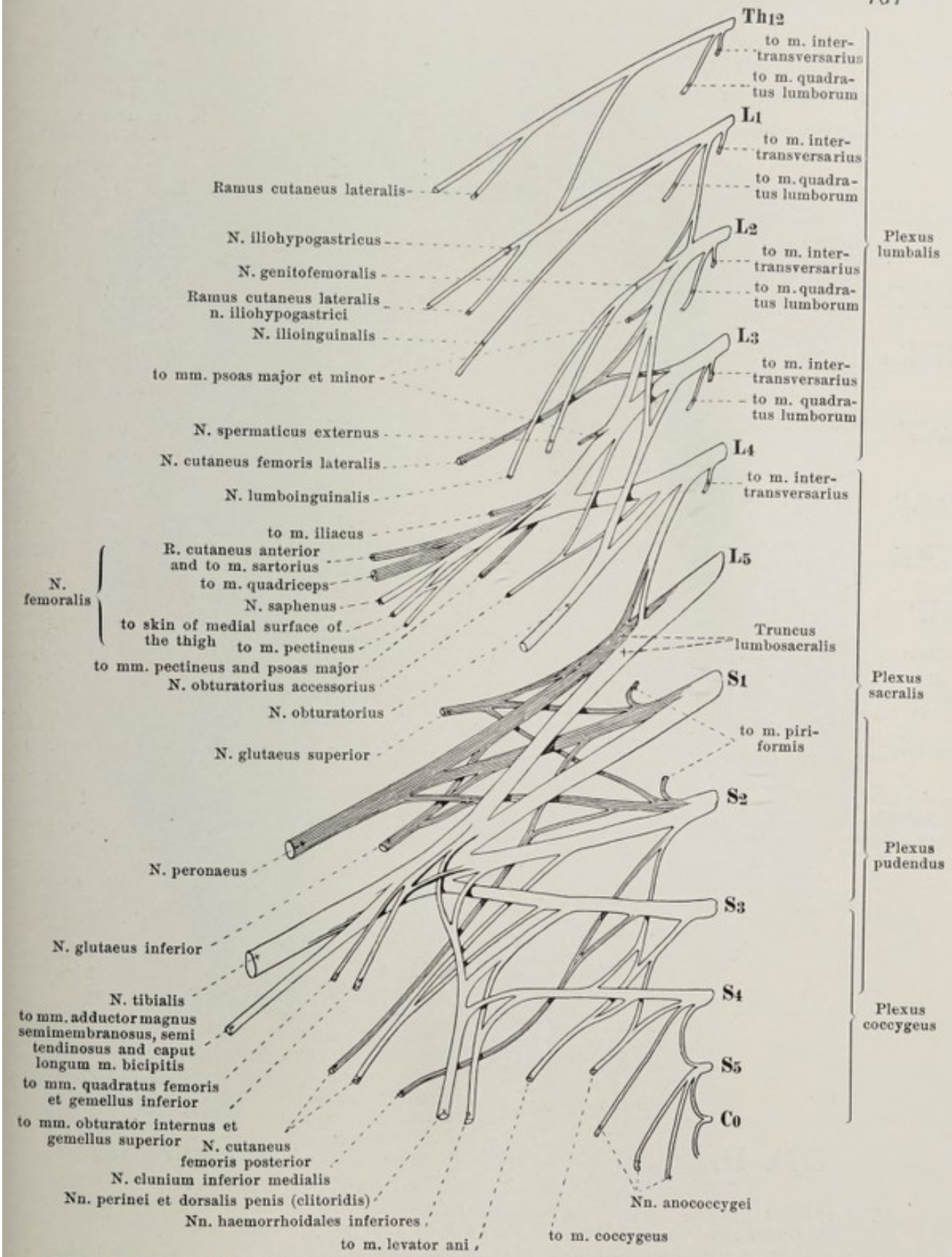
b) *Ramus cutaneus anterior [pectoralis et abdominalis]* (see Figs. 868 and 869) passes from the upper 6 intercostal nerves close to the lateral margin of the sternum through the m. pectoralis major to the skin of the anterior surface of the chest; branches from the 2nd—4th pass as *rami mammarii mediales* to the mammary gland in the female. Those from the lower 6 intercostal nerves perforate the m. rectus abdominis and the anterior layer of the rectal sheath, often subdivided into several twigs, and go to the skin in front of the same, that of the 10th usually at the level of the umbilicus.

The ***rami anteriores of the nn. lumbales*** pass through the foramina intervertebralia, those of the ***nn. sacrales*** through the foramina sacralia anteriora (see Figs. 871 and 876); that of the ***n. coccygeus*** (see Fig. 742) runs through the hiatus sacralis between the ligg. sacrococcygea posteriora, surrounds the root of the cornu coccygeum from below and perforates the lig. sacrospinosum and the m. coccygeus. In general they increase in size from L_1 to S_1, then quickly decrease; they are all connected with the trunk and ganglia of the sympathicus by one or several rami communicantes (see Figs. 871 and 876). They all anastomose with one another and thus form the large *plexus lumbosacralis* (see Figs. 870, 871 and 876), which is subdivisible into the *plexus lumbalis*, *plexus sacralis* (see p. 773), *plexus pudendus* (see p. 786) and *plexus coccygeus* (see p. 787).

The ***plexus lumbalis*** (see Figs. 870 and 871) is formed by the whole of the 1st, 2nd and 3rd and a part of the 4th lumbar nerve and receives also fibres from the n. intercostalis XII through one of its branches. It lies in front of the procc. transversi of the lumbar vertebrae within the m. psoas major, between its origins from the vertebral bodies and from the procc. transversi. It gives off:

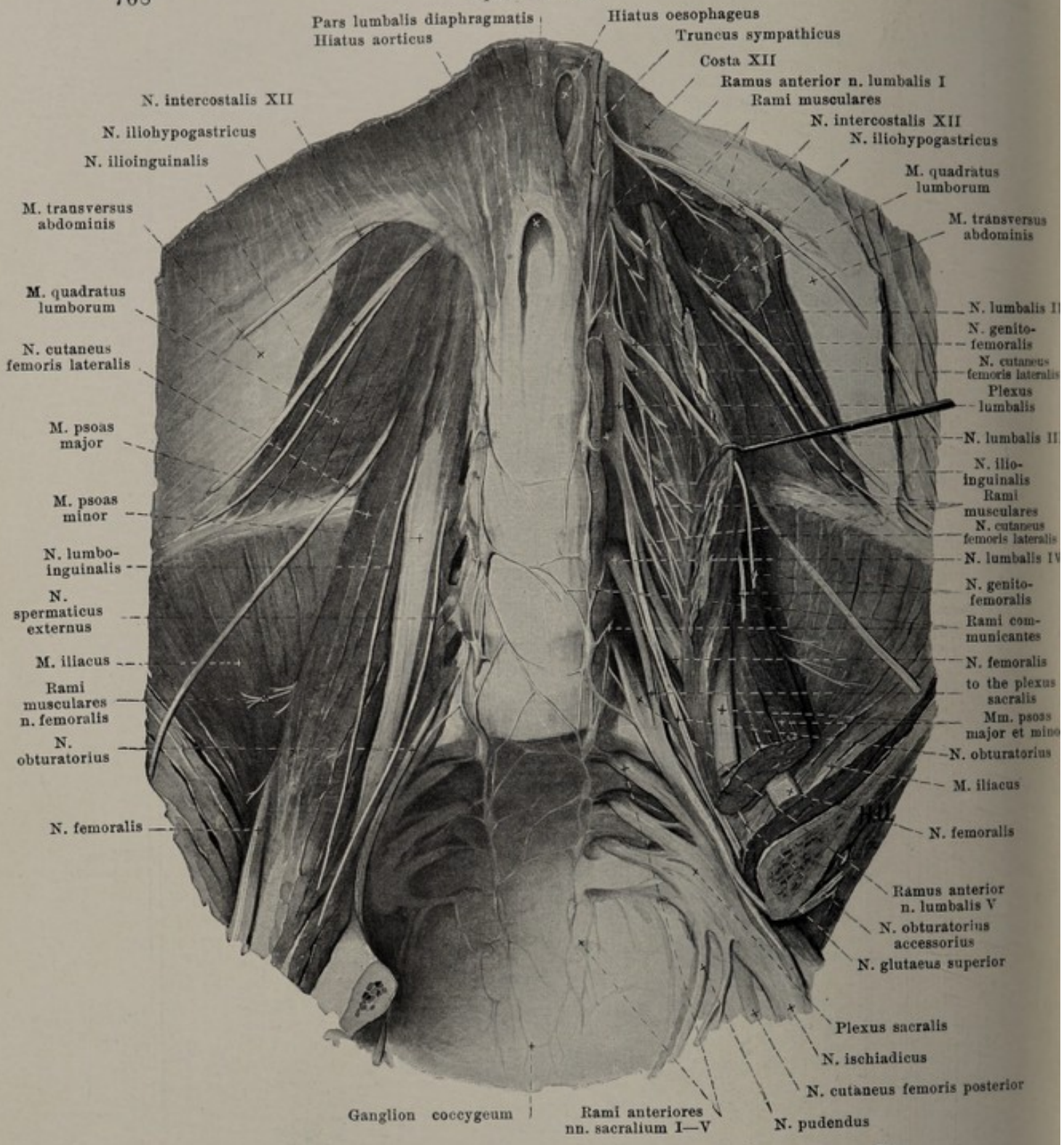
1. *Rami musculares* (see Figs. 870 and 871), short, directly from the roots of the plexus, to the mm. intertransversari laterales from Th_{12}, L_1—L_5, and to the m. quadratus lumborum from (Th_{12}) L_1 (L_2); farther to the m. psoas major from L_2, L_3 and L_4 and to the m. psoas minor from L_1 and L_2 (perforates the m. psoas major).

2. *N. iliohypogastricus* (see Figs. 868—871, 874, 879, 885 and 886), from Th_{12} and L_1, often in a common stem with the n. ilioinguinalis, is larger than the latter and together with it corresponds in its behavior almost exactly to an intercostal nerve. It runs (see Fig. 871), at first parallel to the 12th intercostal nerve, in front of the m. quadratus lumborum and behind the lower part of the kidney lateralward and downward to the tendon of the m. transversus abdominis which it perforates above the crista iliaca. Thence it passes (see Figs. 868 and 874), at first between the mm. transversus and obliquus internus abdominis, close above the crista iliaca, then between the mm. obliqui abdominis, above the ligamentum inguinale as far as into the sheath of the rectus; from this part of its course it gives off an anastomosis to the n. ilioinguinalis. During its entire course between the broad muscles of the abdomen it gives off *rami musculares* to them, as well as sensory branches to the peritonaeum. In addition it gives off:



870. Right plexus lumbosacralis, schematic, viewed from in front (after P. Eisler). (The rami communicantes are not shown.)

(The darkly shaded trunks are derivatives of the dorsal half of the plexus



871. Branches of the plexus lumbosacralis,

viewed from in front.

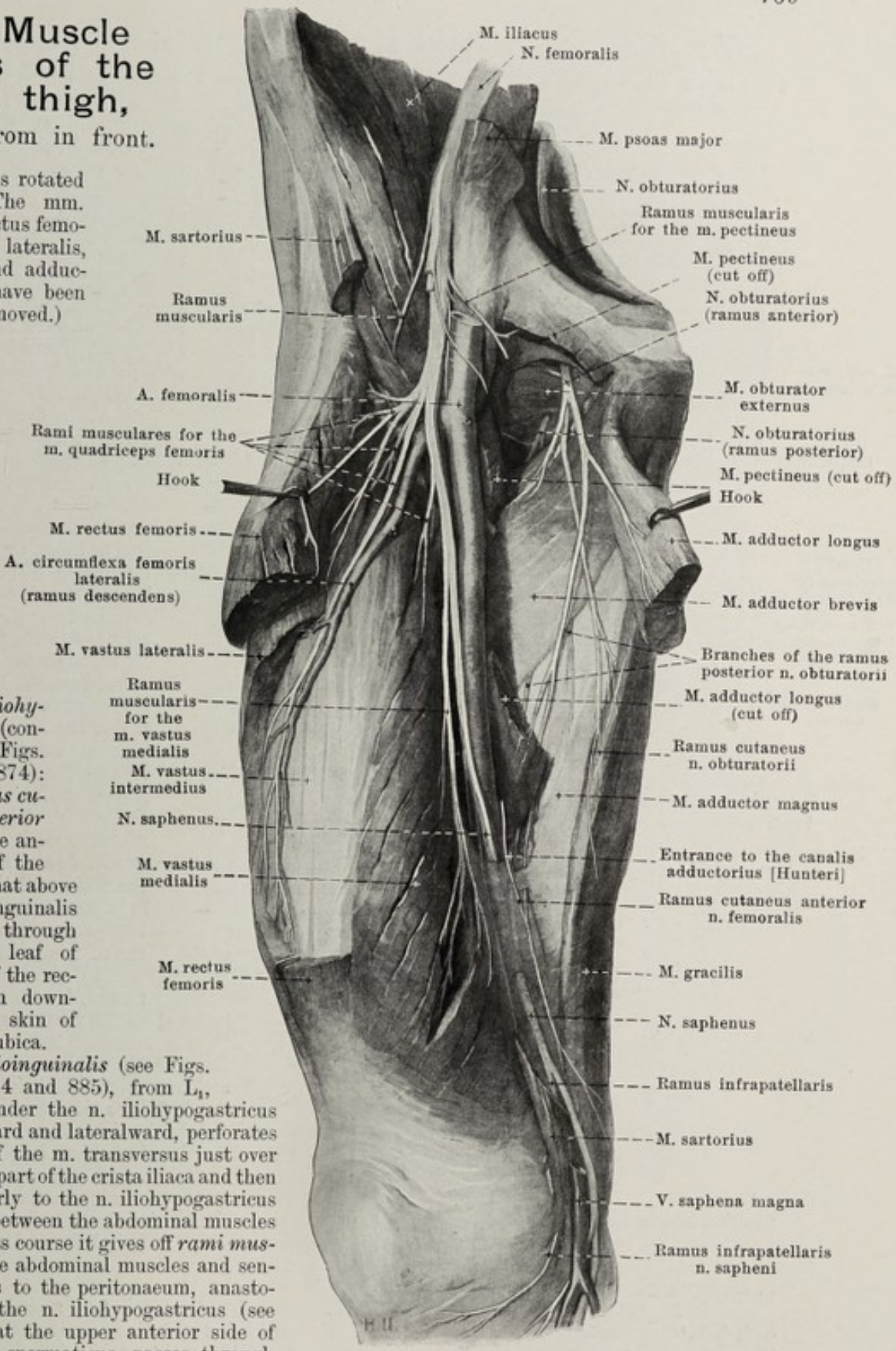
The anterior part of the pelvis and the viscera have been removed; on the left in addition the mm. psoas and quadratus lumborum have been partly loosened and reflected.)

2. *N. iliohypogastricus* (continued) (see also Figs. 868, 869, 879, 885 and 886):

α) *Ramus cutaneus lateralis* goes downward over the middle of the crista iliaca through the mm. obliqui abdominis to the skin over the mm. glutaeus medius and tensor fasciae latae. Its size and area of distribution vary inversely as those of the corresponding branch of the ramus cutaneus lateralis n. intercostalis XII (see p. 766).

872. Muscle nerves of the right thigh, viewed from in front.

(The thigh is rotated outward. The mm. sartorius, rectus femoris, vastus lateralis, pectineus and adductor longus have been partly removed.)



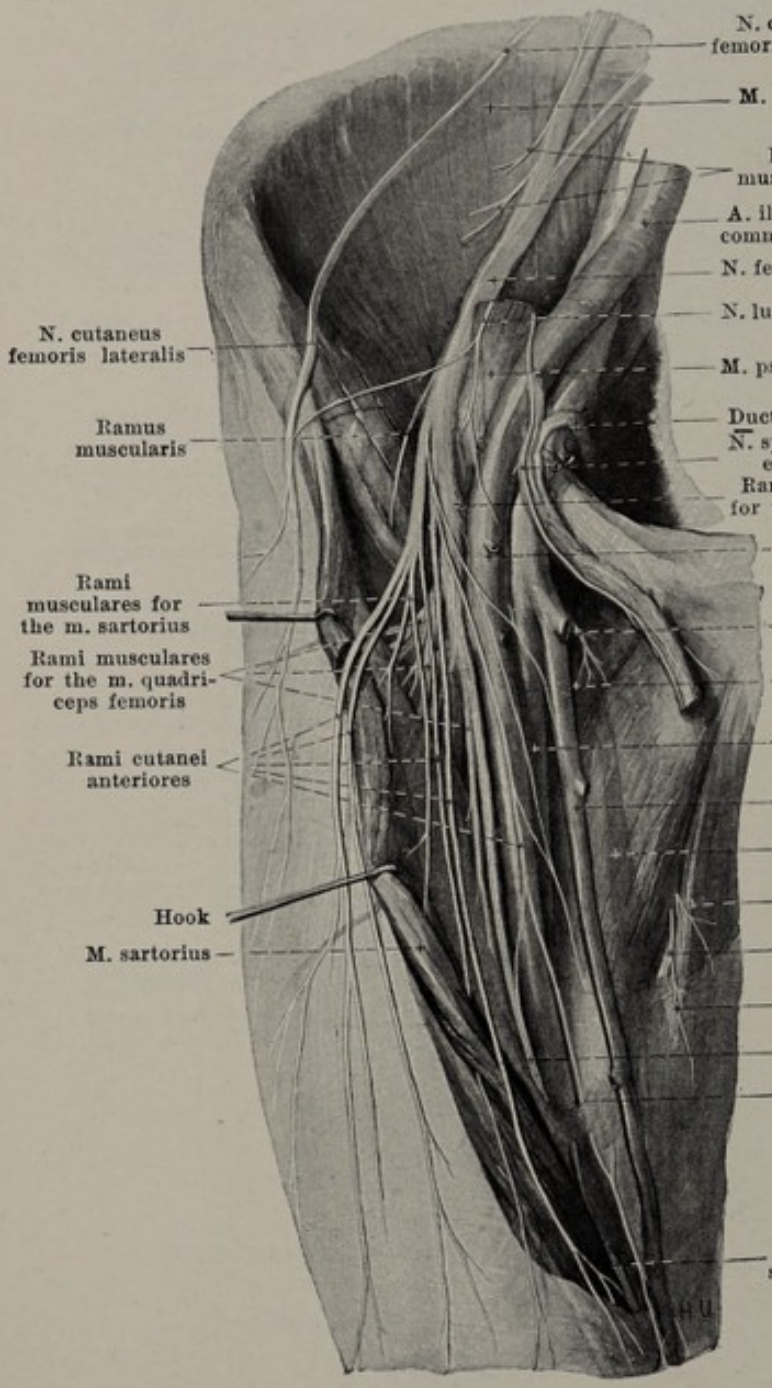
2. *N. iliohypogastricus* (continued) (see Figs. 868, 869 and 874):

b) *Ramus cutaneus anterior* goes from the anterior end of the nerve somewhat above the annulus inguinalis subcutaneus through the anterior leaf of the sheath of the rectus and then downward to the skin of the region pubica.

3. *N. ilioinguinalis* (see Figs. 868—871, 874 and 885), from L_1, runs close under the n. iliohypogastricus (q. v.) downward and lateralward, perforates the tendon of the m. transversus just over the posterior part of the crista iliaca and then passes similarly to the n. iliohypogastricus but below it, between the abdominal muscles forward. In its course it gives off *rami musculares* to the abdominal muscles and sensory branches to the peritonaeum, anastomoses with the n. iliohypogastricus (see p. 766) and at the upper anterior side of the funiculus spermaticus, passes through the annulus inguinalis subcutaneus. There it gives off descending branches to the uppermost, medial part of the thigh, which anastomose with branches of the n. spermaticus and may take the place of these, and *rami scrotales (labiales) anteriores* transversely to the lower part of the mons pubis, as well as to the anterior upper part of the scrotum (labium majus in the female).

873. Nerves of the right thigh, viewed from in front.

(The fascia lata has been partly removed; the m. sartorius has been lifted and drawn aside.)

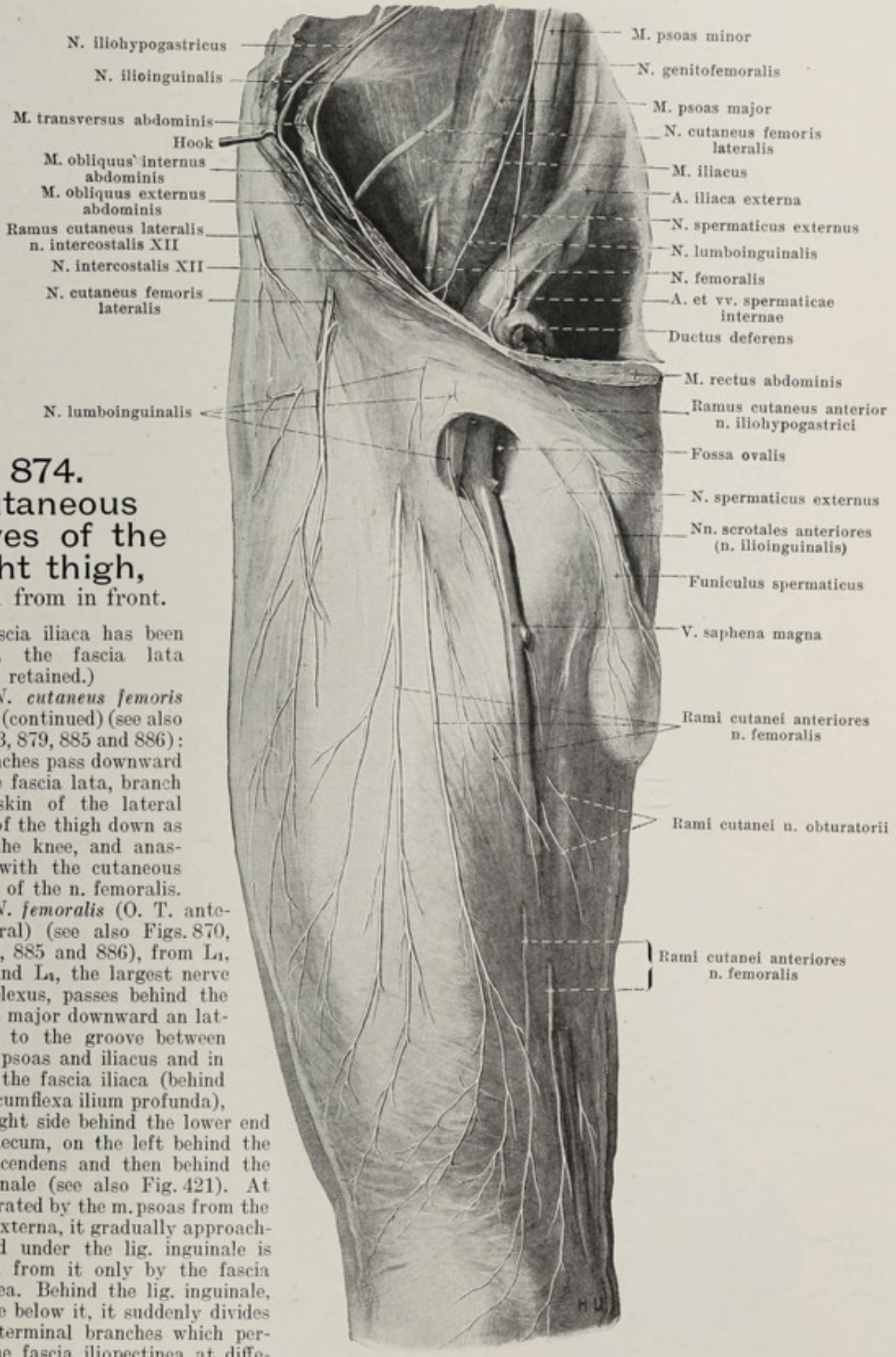


4. *N. genitofemoralis* (see also Figs. 870, 871, 874 and 885), from L_1 and L_2, perforates the m. psoas major obliquely downward and appears on its anterior surface at the level of the third lumbar vertebra, either undivided (see Fig. 874) or subdivided into its two branches (vide infra) (see Fig. 871). It passes downward in front of the m. psoas, behind the peritonaeum, and behind the ureter, and divides into two branches:

a) *N. lumboinguinalis*, from L_2, runs in the direction of the trunk downward, behind the a. and vv. spermaticae internae, first behind, then in front of the fascia iliaca, lateral from the a. iliaca externa, and in its course often gives off a branch to the n. cutaneus femoris lateralis and not rarely one to the n. ilioinguinalis through the m. transversus abdominis. It then passes lateral from, and in front of, the a. femoralis through the lacuna vasorum, and partly in the fossa ovalis, partly lateral from it through the fascia to the skin in the neighborhood of the fossa ovalis, sometimes as far as the middle of the thigh. Its branches often anastomose with cutaneous branches of the n. femoralis.

b) *N. spermaticus externus*, from L_1 and L_2, runs in front of the m. psoas, first behind, then in front of the fascia iliaca, in front of the a. iliaca externa and the a. and vv. spermaticae internae, downward, arrives through the annulus inguinalis abdominalis or through the posterior wall of the inguinal canal into this and goes on the posterior inferior surface of the funiculus spermaticus through the annulus inguinalis subcutaneus to the m. cremaster (L_2 or L_1, L_2) to the tunica dartos, to the skin of the scrotum (labium majus in the female) an to the uppermost medial part of the tigh. It also gives fibres to the mm. obliquus internus and transversus abdominis, anastomoses with branches of the n. ilioinguinalis and may take its place.

5. *N. cutaneus femoris lateralis* (O. T. external cutaneous) (see also Figs. 870, 871, 874, 876, 879, 885 and 886), from L_2 and L_3, passes behind or through the m. psoas major, in front of the m. quadratus lumborum, crista ilica and the m. iliacus, behind the fascia iliaca, downward and lateralward, on the right side behind the caecum, on the left behind the colon descendens, often receiving a branch of the n. lumboinguinalis. It then goes behind the a. circumflexa ilium profunda, medial from the spina iliaca anterior superior, behind the lig. inguinale downward and, in front of the m. sartorius, perforates the fascia lata, usually with two or three separate branches. It may be included in the n. femoralis as far as the lig. inguinale.

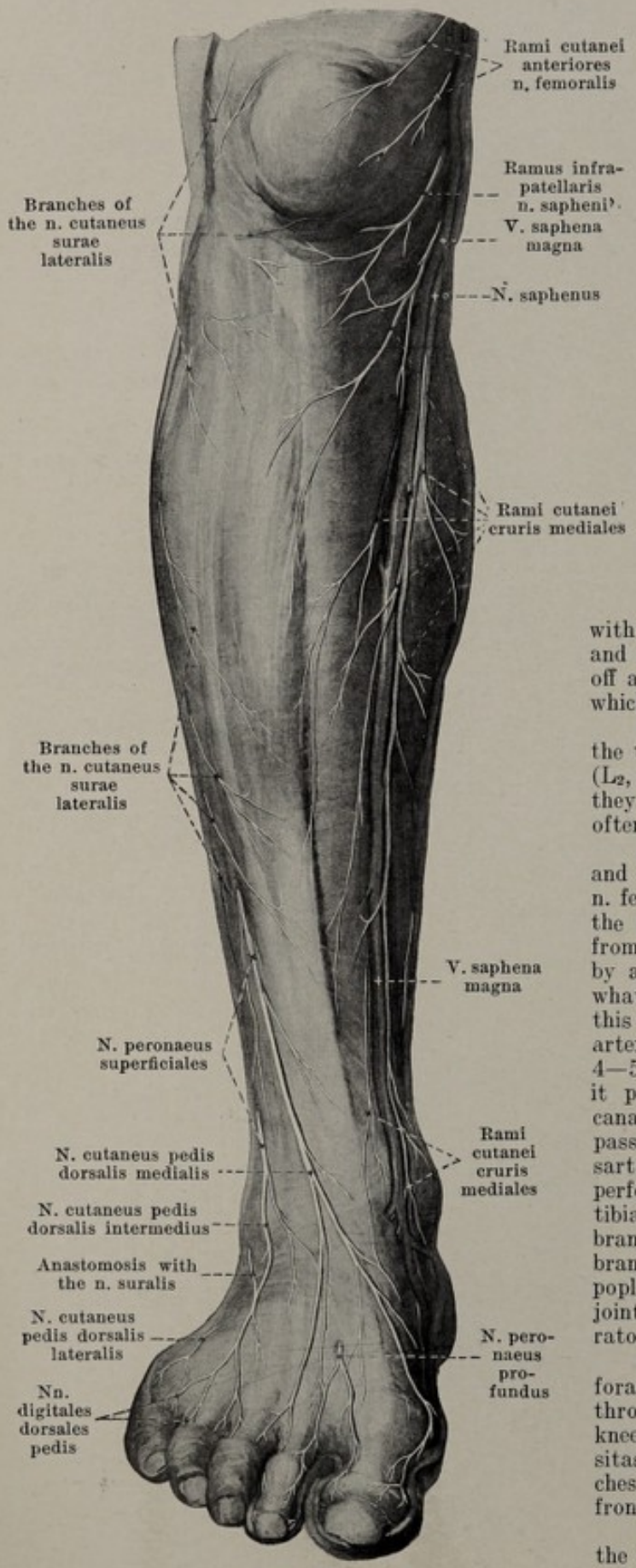


874. Cutaneous nerves of the right thigh, viewed from in front.

(The fascia iliaca has been removed, the fascia lata retained.)

5. *N. cutaneus femoris lateralis* (continued) (see also Figs. 873, 879, 885 and 886): The branches pass downward upon the fascia lata, branch in the skin of the lateral surface of the thigh down as far as the knee, and anastomose with the cutaneous branches of the n. femoralis.

6. *N. femoralis* (O. T. anterior crural) (see also Figs. 870, 873, 875, 885 and 886), from L_1, L_2, L_3 and L_4, the largest nerve of the plexus, passes behind the m. psoas major downward an lateralward to the groove between the mm. psoas and iliacus and in it under the fascia iliaca (behind the a. circumflexa ilium profunda), on the right side behind the lower end of the caecum, on the left behind the colon descendens and then behind the lig. inguinale (see also Fig. 421). At first separated by the m. psoas from the a. iliaca externa, it gradually approaches it and under the lig. inguinale is separated from it only by the fascia iliopectinea. Behind the lig. inguinale, or a little below it, it suddenly divides into its terminal branches which perforate the fascia iliopectinea at different levels.



875. Cutaneous nerves of the right leg, viewed from in front.

(The fascia cruris has been retained.)

6. *N. femoralis* (continued): Branches:

a) *Rami musculares* (see Figs. 870—873), short, in the fossa iliaca to the m. iliacus (L_2, L_3) and to the distal part of the m. iliopsoas (L_2, L_3, L_4).

b) *Rami cutanei anteriores* (see also Figs. 872—874, 885 and 886), in two groups. One group goes partly through the m. sartorius, at the same time innervating it (L_2, L_3), partly over its medial margin through the fascia to the skin on the anterior surface of the thigh almost as far as the knee-cap; they anastomose above with branches of the nn. lumboinguinalis and cutaneus femoris lateralis. The others run along the medial margin of the m. sartorius, perforate the fascia at different levels and run, one close to the v. saphena magna, to the skin of the anterior medial surface of the thigh; they anastomose with branches of the ramus cutaneus n. obturatorii and of the n. saphenus; one of these branches gives off a *ramus muscularis* (L_2, L_3) for the m. pectineus which runs behind the a. and v. femoralis.

c) *Rami musculares* (see Figs. 872 and 873) in the thigh to the heads of the m. quadriceps femoris (L_2, L_3, L_4) and to the m. articularis genus (L_3, L_4); they send fine threads to the hip- and knee-joint, and often also a thread to the m. tensor fasciae latae (L_4).

d) *N. saphenus* (see also Figs. 872—874, 885 and 886) runs in a way as the continuation of the n. femoralis, covered by the m. sartorius, in front of the a. circumflexa femoris lateralis, at first lateral from the a. femoralis downward, separated from it by a continuation of the fascia iliopectinea; somewhat above the middle of the thigh it passes through this fascia, lies on the anterior medial surface of the artery and with it goes into the canalis adductorius. 4—5 cm below the entrance to the canalis adductorius it perforates the lamina vastoadductoria of the canalis, usually along with the a. genus suprema, passes downward on the posterior margin of the m. sartorius, behind the epicondylus medialis femoris, perforates the fascia at the level of the tuberositas tibiae and divides immediately into its two terminal branches. In the thigh it gives off a fine cutaneous branch to the medial surface of the thigh and to the popliteal space and an articular branch to the knee-joint and anastomoses with a branch of the n. obturatorius. Terminal branches:

α) *Ramus infrapatellaris*, goes around or perforates the tendon of the m. sartorius and passes through the fascia in the form of a curve under the knee-cap lateralward as far as in front of the tuberositas tibiae; it anastomoses with the cutaneous branches of the n. femoralis and supplies the skin in front of the knee-cap and beneath it.

β) The continuation of the main nerve runs along the v. saphena magna, usually behind it, distalward

as far as the medial margin of the foot and anastomoses there with branches of the n. peronaeus superficialis. It sends *rami cutanei cruris mediales* to the anterior and posterior surfaces of the leg, which anastomose behind with branches of the n. cutaneus surae medialis.

7. *N. obturatorius* (see Figs. 870—874, 876, 879, 885 and 886), from (L_1), L_2, **L_3** and L_4, goes almost vertically downward at first in the m. psoas major between the n. femoralis and truncus lumbosacralis, then leaves the m. psoas major on its medial surface in front of the articulatio sacroiliaca and then passes forward lateralward and downward somewhat below the linea terminalis and above the a. obturatoria directly upon the fascia pelvis to the canalis obturatorius; in its course it runs at first lateral from the vena, then from the a. hypogastrica, then from the ureter and in the female crosses the lateral surface of the ovarium. In the canalis obturatorius it gives off a branch to the dorsal surface of the m. obturator externus (L_3, L_4). It then divides into the two terminal branches:

a) *Ramus anterior* (see Figs. 872—874, 885 and 886) passes distalward over the upper margin of the m. obturator externus, then behind the mm. pectineus and adductor longus, between the latter and the m. adductor brevis, and gives off motor branches to the mm. adductores longus (L_2, L_3) and brevis (L_2, L_3, L_4), m. graciles (L_2, L_3, L_4) and not rarely to the m. pectineus (L_2, L_3). It ends as the *ramus cutaneus*, which usually passes between the mm. adductor longus and gracilis in the middle of the thigh through the fascia lata to the skin and supplies the lower half of the medial surface of the thigh. It anastomoses with the n. saphenus.

b) *Ramus posterior* (see Fig. 872) not infrequently perforates the m. obturator externus and runs downward between the mm. adductores brevis, minimus and magnus; it sends motor branches to the three mm. adductores mentioned (L_2, L_3, L_4) and branches to the hip-joint.

8. *N. obturatorius accessorius* (see Figs. 870 and 871), often present, from (L_2) L_3 and L_4, passes distalward under the fascia iliaca at the medial margin of the m. psoas major, then over the pecten oss. pubis and between the mm. iliopsoas and pectineus into the depth. It gives off branches to the latter and to the hip-joint and finally enters the n. obturatorius. When markedly developed it may partly substitute for the n. obturatorius.

Plexus sacralis (see Figs. 870, 871 and 876) is formed of the anterior branches of the nn. lumbales IV (partly) and V, as well as of the nn. sacrales I—III, all of which converge downward and lateralward. The n. lumbalis IV sends from half to nine-tenths of its fibres to the plexus sacralis; these are separated from the n. lumbalis V by the ramus iliacus a. iliolumbalis, and with it form a common stem, *truncus lumbosacralis*, which passes obliquely downward over the basal surface of the pars lateralis oss. sacri into the small pelvis and is separated from the n. sacralis I by the a. glutaea superior. The last root of the plexus arises usually from the n. sacralis III, more rarely II or IV. The plexus sacralis yields exclusively nerves for the pelvic girdle and the lower extremity.

The nerves for the pelvic viscera, for the muscles and for the skin of the perineum come from the *plexus pudendus* (see also p. 786), which is in a way a portion introduced into the plexus sacralis (see Fig. 870), and arises from S_1, S_2, S_3 and S_4.

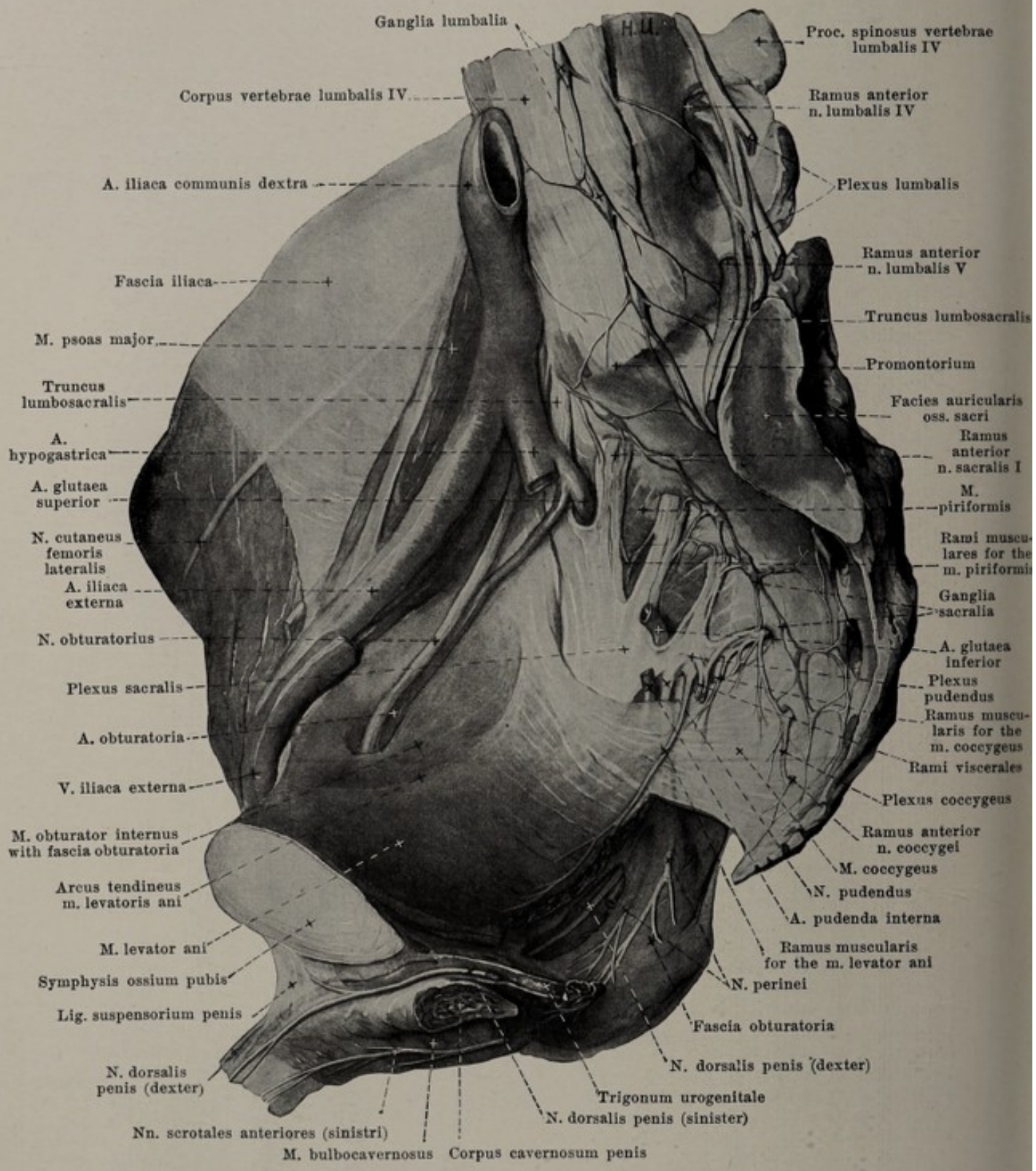
The plexus sacralis lies as a flat, triangular mass on the anterior surface of the m. piriformis as far as the upper margin of the m. coccygeus; its inferior apex is directed toward the lower portion of the foramen ischiadicum majus and goes over into the n. ischiadicus. The plexus is covered in front by the most posterior portion of the fascia pelvis, by the branching of the a. and v. hypogastrica and by peritonaeum and lies near the lateral surface of the rectum. It sends branches A. to the pelvic girdle and B. to the extremity.

A. Branches to the pelvic girdle:

1. *Rami musculares* a) for the m. piriformis (see Figs. 870 and 876) from S_1 and S_2, pass directly into the anterior surface of the muscle; b) for the mm. obturator internus, gemelli and quadratus femoris (see Figs. 870 and 877) from L_4, L_5, S_1, S_2 (S_3); they pass through the foramen ischiadicum majus upon the dorsal surface of the spina ischiadica and there divide into two trunks: the medial gives branches to the m. gemellus superior (L_5, **S_1**, S_2, [S_3]) and passes lateral of the a. pudenda interna through the foramen ischiadicum minus to the medial surface of the m. obturator internus (L_5, **S_1**, S_2, [S_3]), the lateral runs upon the capsule of the hip-joint, to which it gives branches, distalward to the mm. gemellus inferior (L_4, **L_5**, S_1) and quadratus femoris (L_4, **L_5**, S_1).

2. *N. glutaeus superior* (see Figs. 870, 871, 877 and 878), from L_4, **L_5**, S_1 (S_2), runs lateralward above the m. piriformis (not rarely by one bundle through it) lateral from, and below the a. glutaea superior through (the foramen suprapiriforme of) the foramen ischiadicum majus and then between the mm. glutaei medius and minimus; it supplies these and, usually partly perforating the m. glutaeus minimus, sends a twig into the medial surface of the m. tensor fasciae latae.

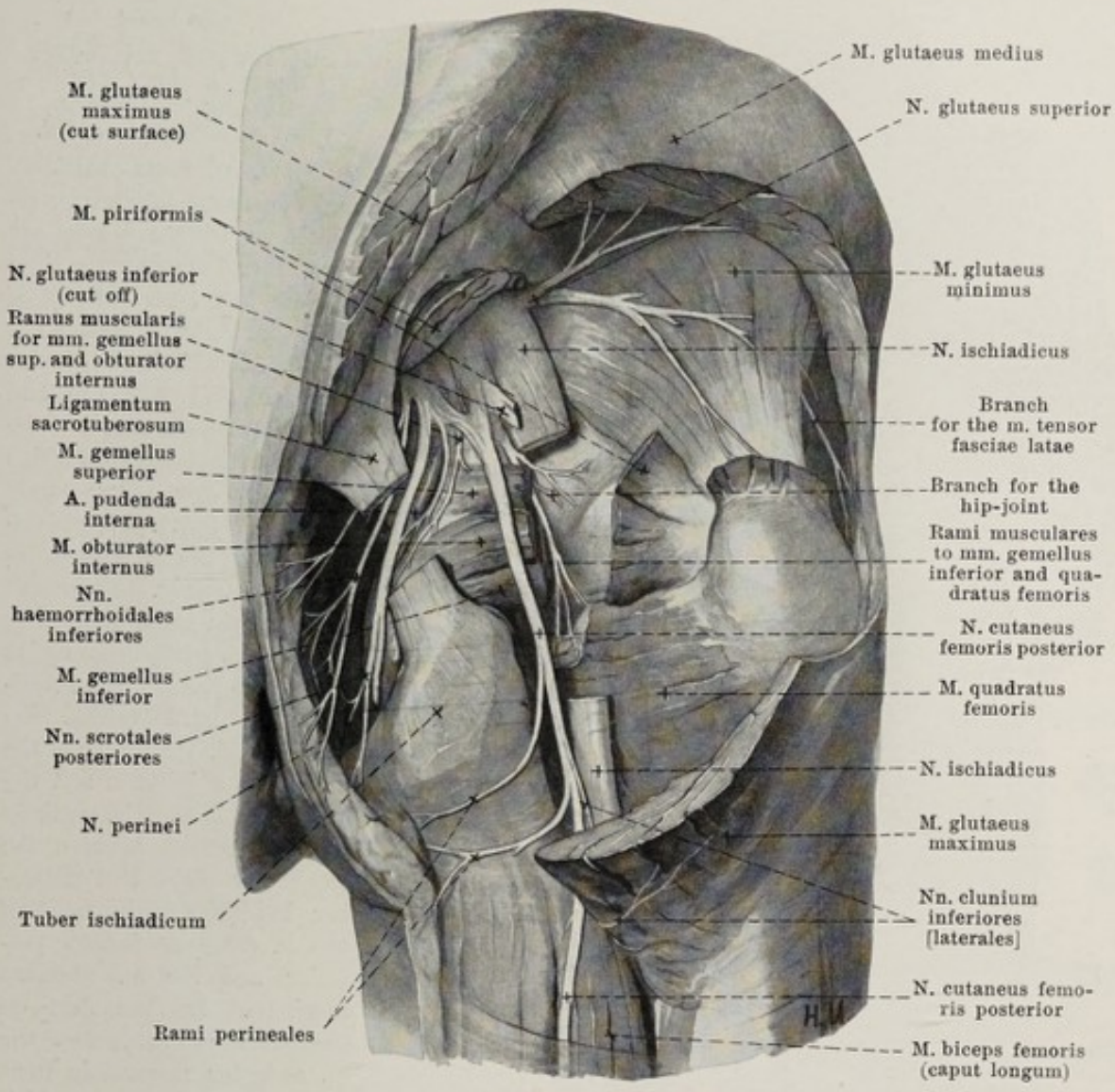
3. *N. glutaeus inferior* (see Figs. 870, 877 and 878), from (L_4), L_5, **S_1** and S_2, passes in front of the distal margin of the m. piriformis between it and the n. ischiadicus, lateral from the a. glutaea inferior through (the foramen infrapiriforme of) the foramen ischiadicum majus and enters the anterior surface of the m. glutaeus maximus.



876. Nerves of the right half of the pelvis,

viewed from the left.

(The viscera have been removed, the fascia pelvis has been completely, the fascia iliaca partly, removed. Of the m. levator ani only the lateral part has been preserved; a piece has been cut out of the fascia obturatoria.)



877. Deep nerves of the right buttock, viewed from behind.

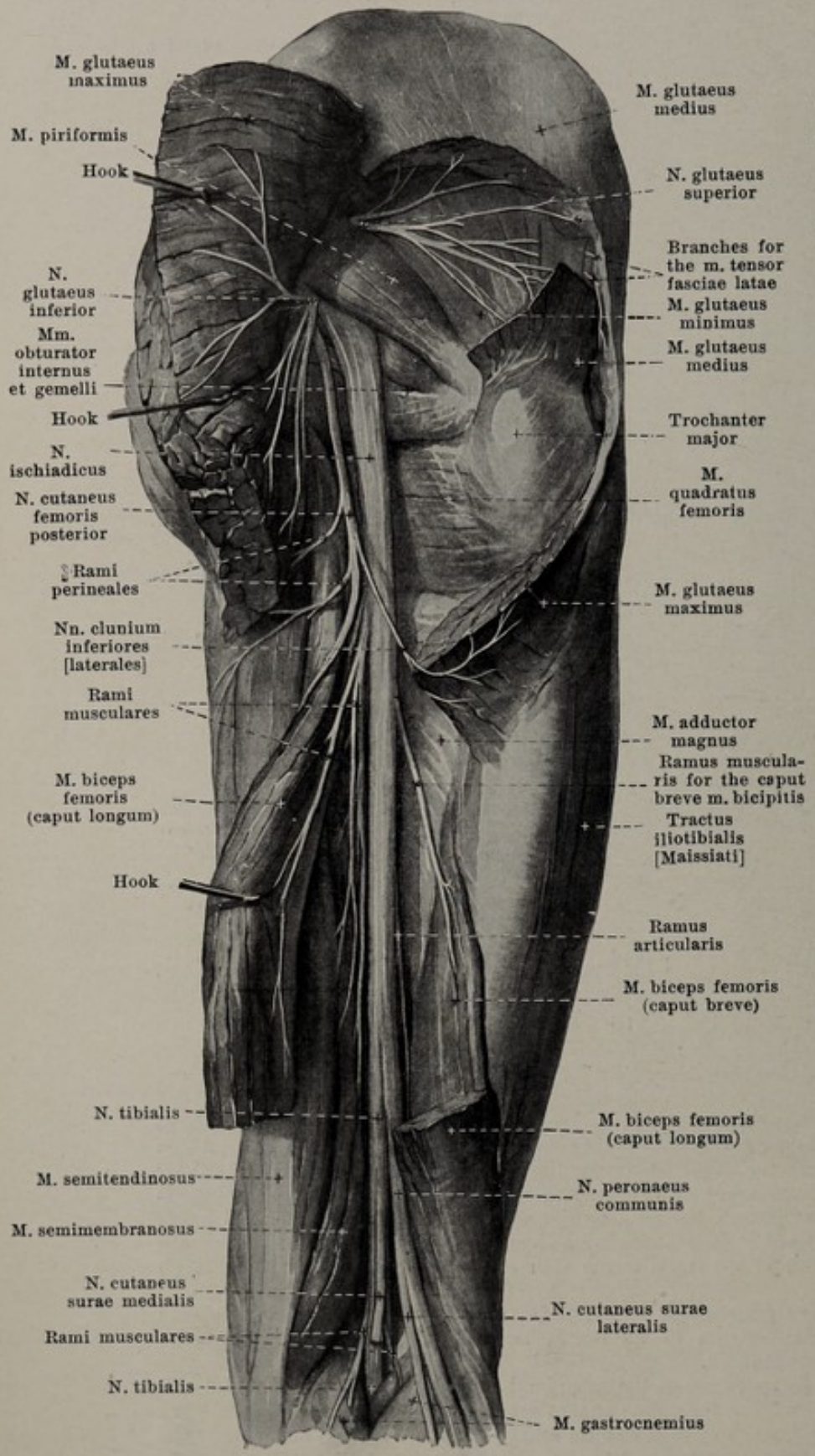
(The mm. glutaei maximus and medius, piriformis, obturatores and gemelli, as well as the lig. sacrotuberosum have been partially removed; a piece has been cut out of the n. ischiadicus.)

B. Branches to the lower extremity:

4. *N. cutaneus femoris posterior* (O. T. small sciatic) (see also Figs. 870, 871, 878—880 and 886—888), from S_1, S_2 and S_3, runs through the foramen ischiadicum majus under the distal margin of the m. piriformis (through the foramen infrapiriforme), behind the n. ischiadicus, lateral from the a. and v. glutaea inferior and goes distalward directly in front of the m. glutaeus maximus somewhat medially from the middle between the tuber ischiadicum and the trochanter major. It then crosses at a sharp angle the dorsal surface of the caput longum m. bicipitis and runs farther in the groove between the mm. semitendinosus and biceps under the fascia lata into the popliteal space. It sends larger, medial and smaller, lateral branches, which are shorter above, longer below, through the fascia to the skin of the posterior surface of the thigh and of the calf; in addition:

a) *Nn. clunium inferiores [laterales],* two or three, arise in front of the m. glutaeus maximus, loop around its distal margin to its dorsal surface and go cranialward to the skin over the lateral part of the buttock.

b) *Rami perineales,* usually two, arise at the same level as the preceding, run at first downward in front of the m. glutaeus maximus, then close under the tuber ischiadicum medianward upon the muscles springing from it, and go through the fascia lata to the skin of the uppermost part of the medial surface of the thigh, of the perineum and to the posterior surface of the scrotum (labium majus in the female); they anastomose there with the nn. scrotales (labiales) posteriores.



878.
Nerves of the right thigh,
viewed from behind.

(The m. glutaeus maximus and the caput longum m. bicipitis femoris have been cut through and drawn to the side; a piece has been cut out of the m. glutaeus medius.)

5. *N. ischiadicus* (see also Figs. 870, 871, 877, 881 and 887), the largest nerve of the body, is a flattened cord which passes under (very rarely through) the m. piriformis lateral from the a. glutaea inferior (see also Fig. 528) through (the foramen infrapiriforme of) the foramen ischiadicum majus and thence passes almost vertically downward behind the mm. gemelli, the tendon of the m. obturator internus and the m. quadratus femoris, medially from the middle between the trochanter major and the tuber ischiadicum, in front of the n. cutaneus femoris posterior and the m. glutaeus maximus. It then runs on the posterior surface of the m. adductor magnus in front of the caput longum m. bicipitis as far as the upper apex of the popliteal space and there divides into the *n. tibialis* and the *n. peronaeus communis*. In about 15% of the cases this division occurs as high up as the plexus itself, in which event the n. peronaeus runs through the m. piriformis, the n. tibialis below it. In the other cases this separation can be easily brought about artificially, and thus it is easy to establish whether the branches which go off to the thigh from the n. ischiadicus belong really to the n. tibialis or to the n. peronaeus communis. Branches:

879. Cutaneous nerves of the right thigh, viewed from behind.

(The fascia lata except for a middle strip has been preserved.)

A. Branches in the thigh:

a) Belonging to the n. tibialis (from its ventral surface):

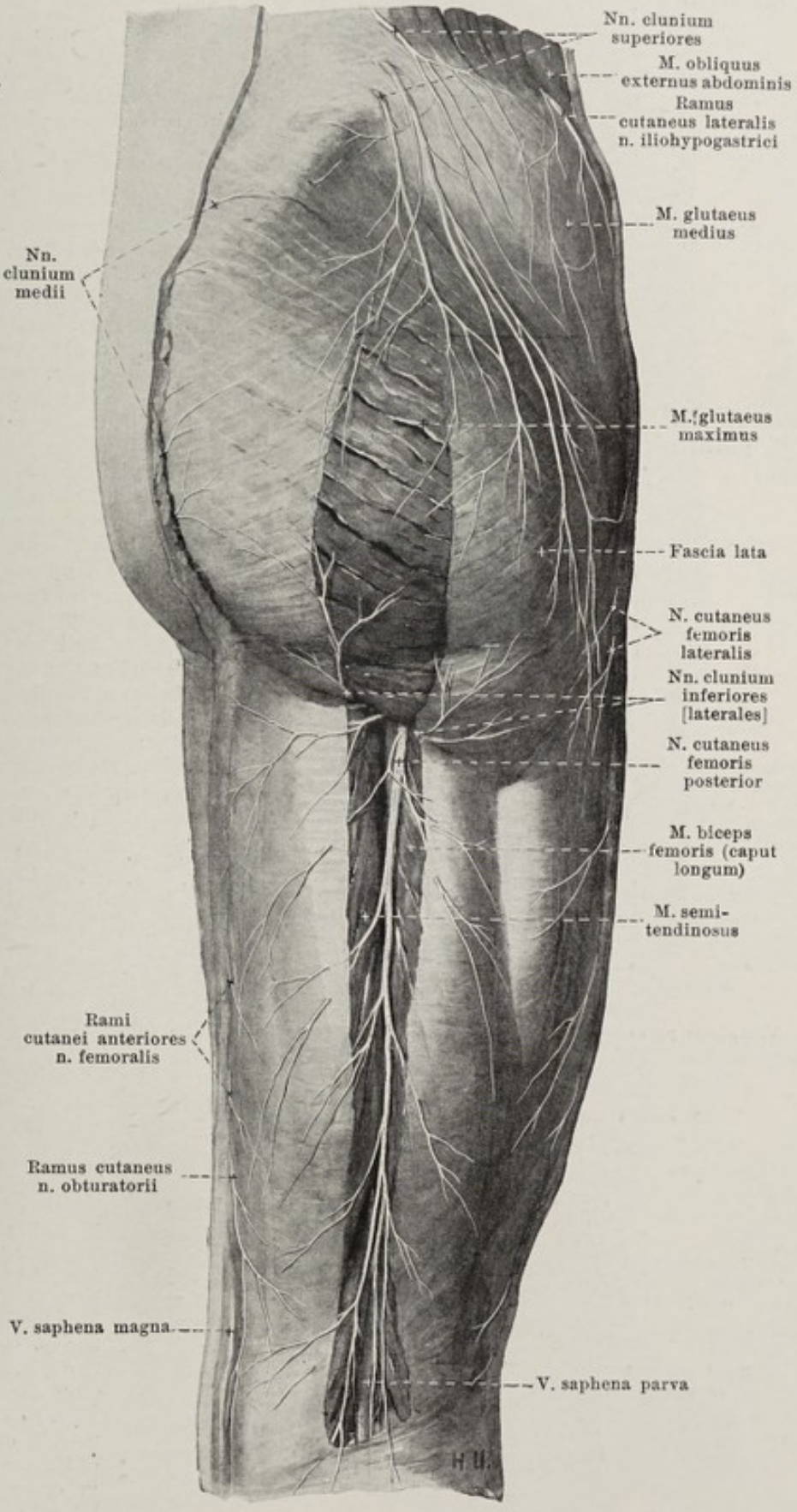
Rami musculares (see Fig. 878), from L_4, L_5, S_1, S_2 and S_3, for the m. semitendinosus (an upper from S_1, S_2 and a lower from L_4, L_5, S_1), for the caput longum m. bicipitis from (L_5), S_1, **S_2**, S_3, the m. semimembranosus from (L_4), L_5, S_1 and for the dorsal part of the m. abductor magnus from L_4, L_5.

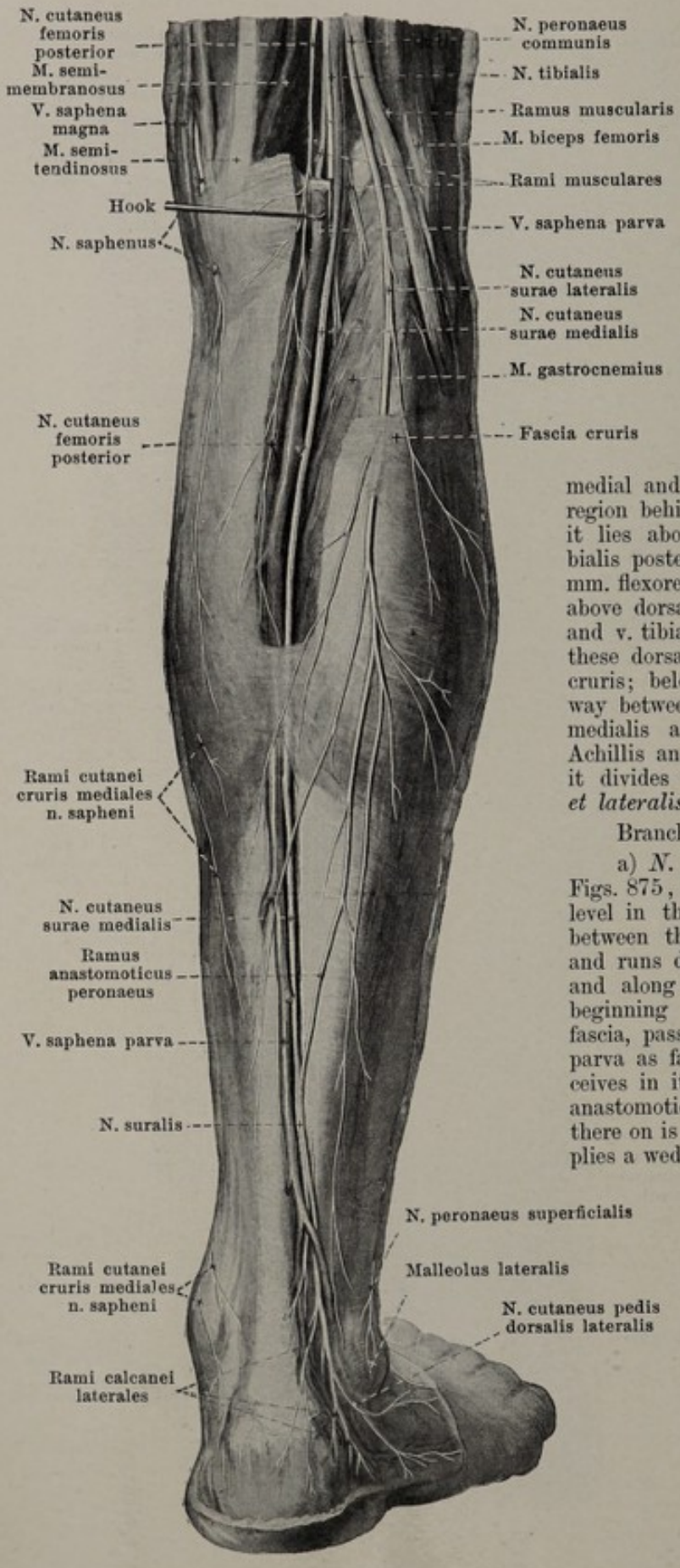
b) Belonging to the n. peronaeus:

Ramus muscularis (see Fig. 878) from L_4, L_5 and S_1, for the caput breve m. bicipitis.

Ramus articularis downward to the capsule of the knee-joint.

B. *N. tibialis* (see Figs. 870, 878, 880—883, 885 and 886), from L_4, L_5, S_1, S_2 and S_3, runs almost perpendicularly from the upper to the lower angle of the popliteal space and passes between the two heads of the m. gastrocnemius into the depth, behind the m. popliteus and in front of the tendinous arch in the origin of the m. soleus.





880.
Cutaneous nerves of the right leg,
viewed from behind.

(The fascia has been preserved, except for its upper part.)

B. *N. tibialis* (continued) (see also Figs. 878, 881—883, 885 and 886): In the popliteal space it lies directly beneath the fascia, dorsal and lateral from the v. poplitea, which itself runs dorsal and lateral from the a. poplitea; below it is separated from the m. popliteus by the vessels. In the leg it descends above in front of the middle of the m. soleus, below medial and in front of the tendo Achillis to the region behind the medial malleolus; in this course it lies above on the dorsal surface of the m. tibialis posterior, below in the groove between the mm. flexores digitorum longus and hallucis longus, above dorsalward elsewhere lateralward from the a. and v. tibialis posterior, being covered along with these dorsalward by the deep layer of the fascia cruris; below the nerve runs approximately midway between the posterior margin of the malleolus medialis and the medial margin of the tendo Achillis and at the same time behind the vessels; it divides there into the *nn. plantares medialis et lateralis.*

Branches in the popliteal space:

a) *N. cutaneus surae medialis* (see also Figs. 875, 881 and 884—886) arises at a variable level in the popliteal space, goes to the groove between the two bellies of the m. gastrocnemius and runs downward in it beneath the fascia cruris and along with the v. saphena parva. At the beginning of the tendo Achillis it perforates the fascia, passes upon it lateral from the v. saphena parva as far as behind the malleolus lateralis, receives in its course at a variable level the ramus anastomoticus peronaeus (see p. 782) and from there on is called the *n. suralis.* In the leg it supplies a wedged-shaped distal portion of the dorsal and lateral surfaces (see Fig. 886) and gives off *rami calcanei laterales* to the dorsal and lateral portions of the skin of the heel. It then runs forward in front of the v. saphena parva, passing in a curve behind and below the lateral malleolus, anastomoses with the n. cutaneus dorsalis intermedius (see Fig. 875) and goes as the *n. cutaneus dorsalis pedis lateralis* (see also Figs. 875 and 884) along the lateral margin of the foot as far as the base of the terminal phalanx of the 5th toe, in order usually to break up on the lateral margin of this toe, more rarely also on the dorsal surfaces of the 4th and half of the 3rd toe.

881. Muscle nerves of the right leg,

viewed from behind.

(The mm. semitendinosus, semimembranosus, biceps, gastrocnemius, plantaris, soleus and flexor hallucis longus have been wholly or partly removed.)

B. *N. tibialis* (continued):

b) *Rami musculares* (see also Figs. 878 and 880) to the two heads of the m. gastrocnemius from S_1, S_2, to the mm. plantaris from L_5, S_1, S_2, soleus from L_5, S_1, S_2 and popliteus from L_4, L_5, S_1.

c) *Rami articulares* to the knee-joint.

d) *N. interosseus cruris* (see also Fig. 884) passes distalward near the a. tibialis anterior inside the membrana interossea cruris and gives branches to the vessels, bones and syndesmosis tibiofibularis.

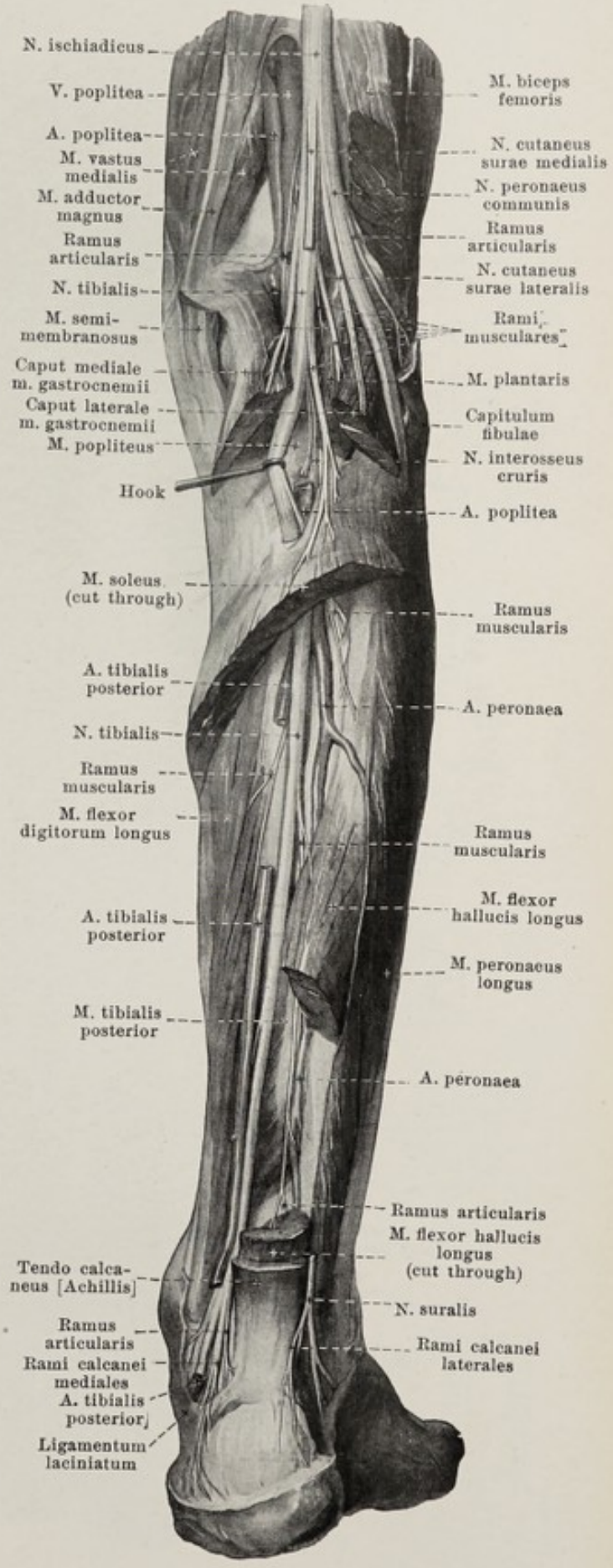
Branches in the leg:

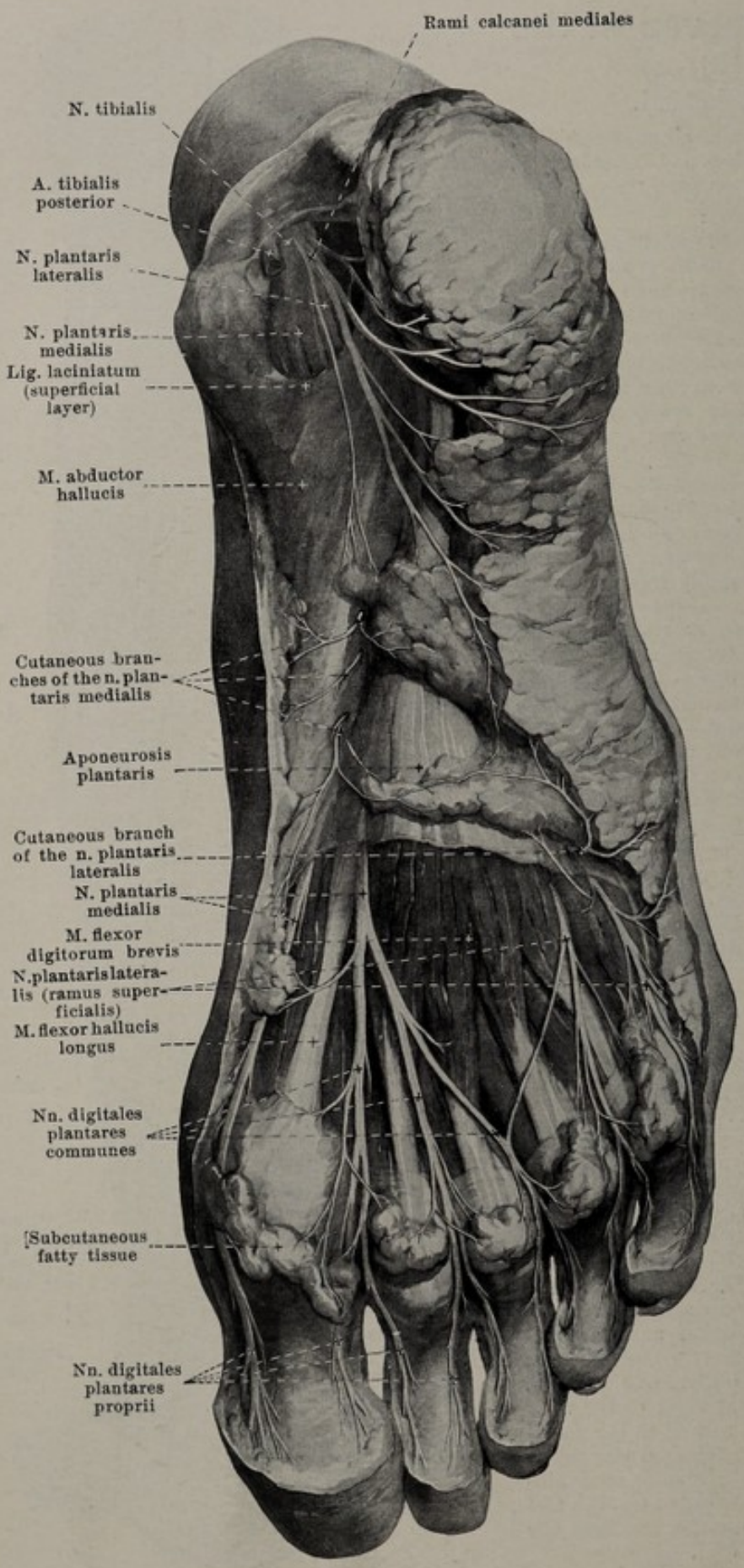
e) *Rami musculares* to the mm. tibialis posterior from L_5, S_1, flexor digitorum longus from L_5, S_1 and flexor hallucis longus from L_5, S_1, S_2.

f) *Rami articulares*, partly from e) to the ankle joint.

g) *Rami calcanei mediales* (see also Figs. 882, 885 and 886), frequently going off from a trunk in the lower third of the leg, extend to the skin on the posterior medial surface of the heel and on the posterior part of the sole of the foot; they anastomose with branches of the nn. suralis and plantares.

h) *N. plantaris medialis* (see Figs. 882 and 883), the larger terminal branch, runs at first between the two layers of the lig. laciniatum (in the upper compartment, see p. 379), then on the lateral surface of the m. abductor hallucis and arrives on the lower surface of the tendon of the m. flexor digitorum longus and finally on the medial surface of the m. flexor digitorum brevis, crossed by the vessels more superficially situated. In its course it gives off small branches (see Fig. 882) to the skin of the medial portion of the hollow of the foot, as well as *rami musculares* (see Fig. 883) to the mm. flexor digitorum brevis (bellies of 2nd to 4th toe) (L_5, S_1), abductor hallucis (L_5, S_1) and flexor hallucis brevis (L_5, S_1). It then sends (see Figs. 882 and 883) a *n. digitalis plantaris proprius* to the medial margin of the plantar surface of the great toe, which also sends a branch to the medial head of the m. flexor hallucis brevis, and divides into three *nn. digitales plantares communes*, which pass distalward between the m. flexor digitorum brevis and the aponeurosis plantaris of the 1st—3rd spatium interosseum and divide at the level of the articulationes metatarsophalangeae, each into two *nn. digitales plantares proprii*. The latter supply the adjacent sides of the volar surfaces of the 1st—4th toe, as well as the dorsal surfaces of the corresponding terminal phalanges. The first n. digitalis plantaris communis sends also a small branch to the m. lumbricalis I (L_5, S_1), and the third often receives an anastomosis from the n. plantaris lateralis (see p. 781).





882. Cutaneous nerves of the sole of the right foot,

viewed from below.

(The aponeurosis plantaris has been removed in front.)

B. *N. tibialis* (continued):

i) *N. plantaris lateralis* (see also Fig. 883) lies at first between the two layers of the lig. laciniatum (in the lower compartment, see p. 379), then runs distalward and lateralward between the mm. flexor digitorum brevis and quadratus plantae, gives off as it goes *rami musculares* to the mm. flexor digitorum brevis (belly of 5th toe) (S_1, S_2), quadratus plantae (S_1, S_2) and abductor digiti V (S_1, S_2) and divides into a *ramus profundus* and a *ramus superficialis.*

α) *Ramus profundus* goes into the depth with the arcus plantaris and runs medianward on the dorsal surface of the m. quadratus plantae and of the caput obliquum m. adductoris hallucis, between it and the mm. interossei. It gives branches to the joints as well as *rami musculares* to the mm. interossei of the 1st—3rd spatium interosseum (S_1, S_2), to the mm. lumbricales II to IV (S_1, S_2), the m. adductor hallucis (S_1, S_2) and rarely to the lateral belly of the m. flexor hallucis brevis (S_1, S_2).

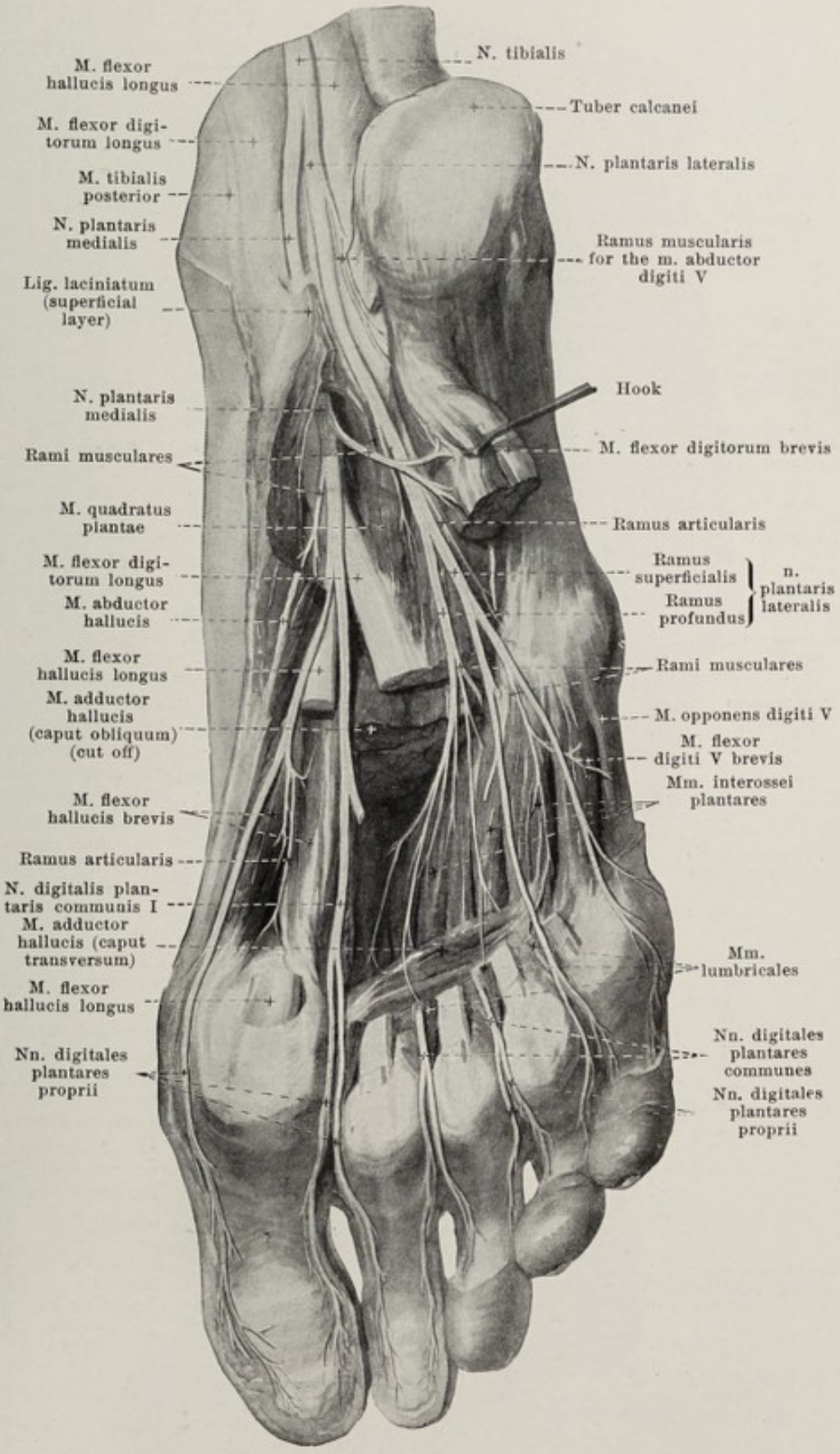
883. Deep nerves of the sole of the right foot,

viewed from below.

(The muscles of the toes have been partially removed.)

i) *N. plantaris lateralis* (continued) (see also Fig. 882):

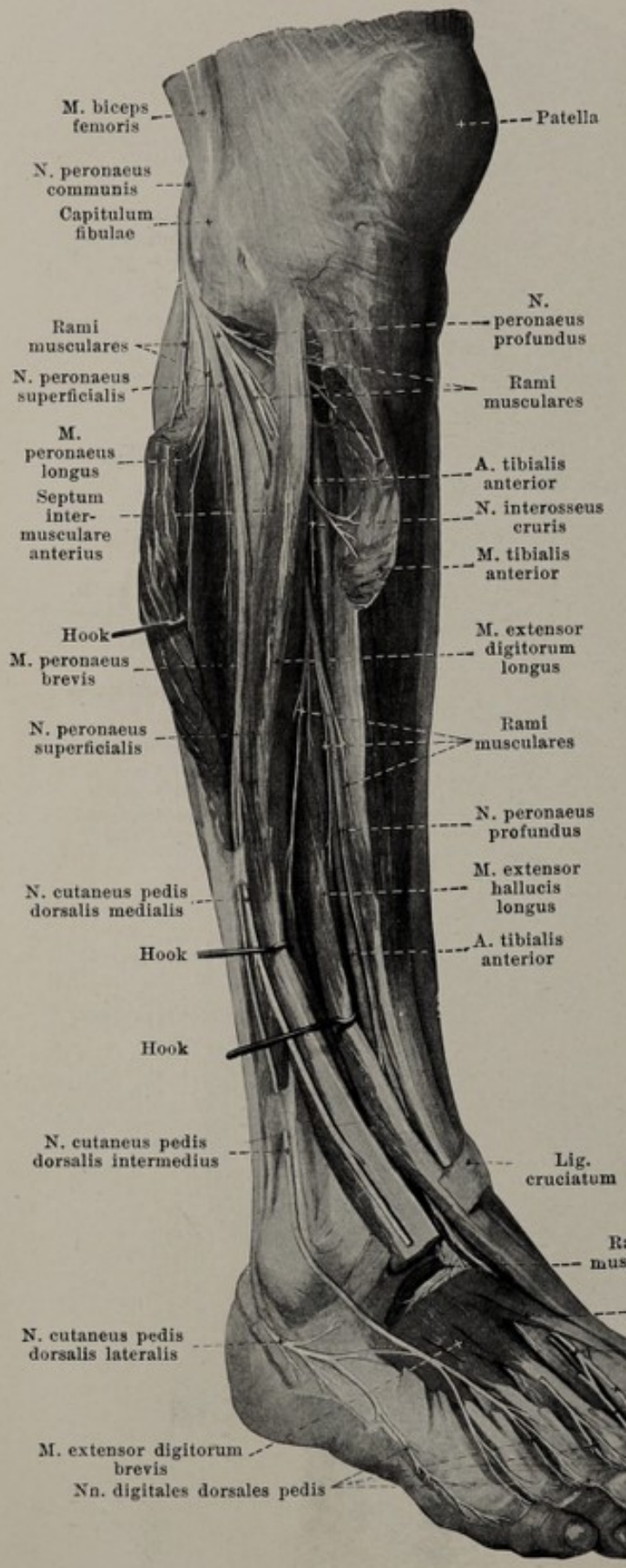
β) Ramus superficialis divides at the lateral margin of the m. flexor digitorum brevis into a medial and a lateral branch. The medial *n. digitalis plantaris communis IV* runs distalward upon the 4th spatium interosseum, sends an anastomosis to the n. plantaris medialis (see p. 779) and divides into two *nn. digitales plantares proprii* for the adjacent sides of the volar surfaces of the 4th and 5th toe and for the dorsal surfaces of the terminal phalanges. The lateral branch runs as a *n. digitalis plantaris proprius* along the surface of the m. flexor digiti V brevis distalward and lateralward to the lateral margin of the 5th toe; in its course it gives off *rami musculares* to the mm. flexor digiti V brevis (S_1, S_2) and opponens digiti V (S_1, S_2) and the mm. interossei of the 4th spatium interosseum (S_1, S_2).



884. Deep nerves of the right leg,

viewed from in front and lateralward.

(The mm. peronaeus longus, extensores digitorum and tibialis anterior have been partly removed and drawn asunder.)



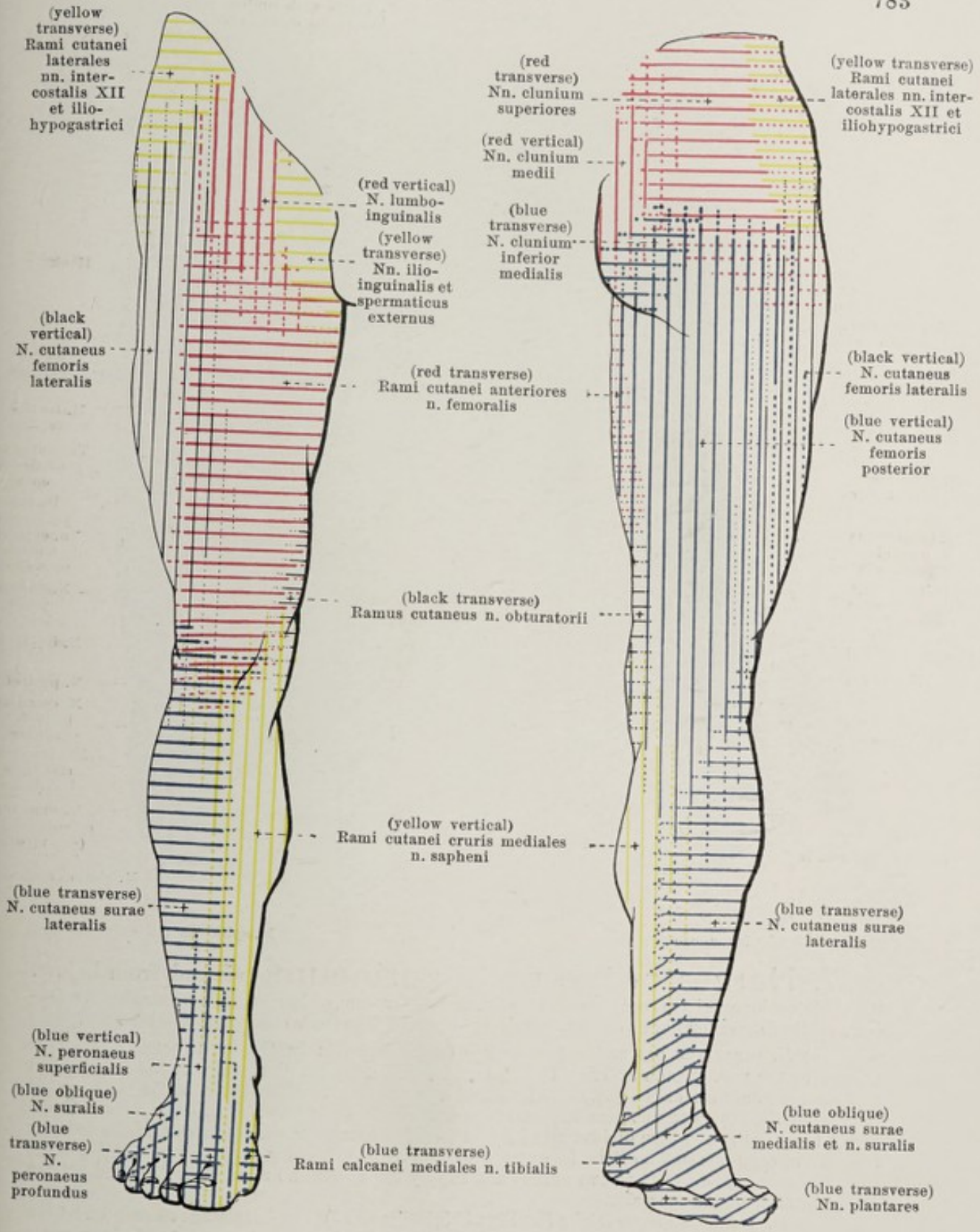
C. *N. peronaeus communis* (see also Figs. 870, 878, 880, 881, 885 and 886), from L_4, L_5, S_1 and S_2, runs along the medial margin of the m. biceps femoris upon the dorsal surface of the caput laterale m. gastrocnemii distalward and lateralward, then behind the capitulum fibulae to the lateral margin of the collum fibulae, where it divides into its two terminal branches, both of which pass through the canal located in the origin of the m. peronaeus longus (see also Fig. 446). It gives off in the popliteal space:

a) *Ramus articularis* (see Fig. 881) to the articulationes genus and tibiofibularis.

b) *N. cutaneus surae lateralis* (see Figs. 878, 880, 881, 885 and 886), very variable, arises in the upper part of the popliteal space, runs downward upon the posterior surface of the caput laterale m. gastrocnemii, under the fascia cruris and gives off at a variable level the *ramus anastomoticus peronaeus* (it sometimes has a separate origin), perforates the fascia at a variable height and unites on the posterior surface of the tendo Achillis with the n. cutaneus surae medialis to form the *n. suralis* (see p. 778). In addition it gives off branches to the skin of the lateral half of the leg as far down as the lateral malleolus.

Terminal branches:

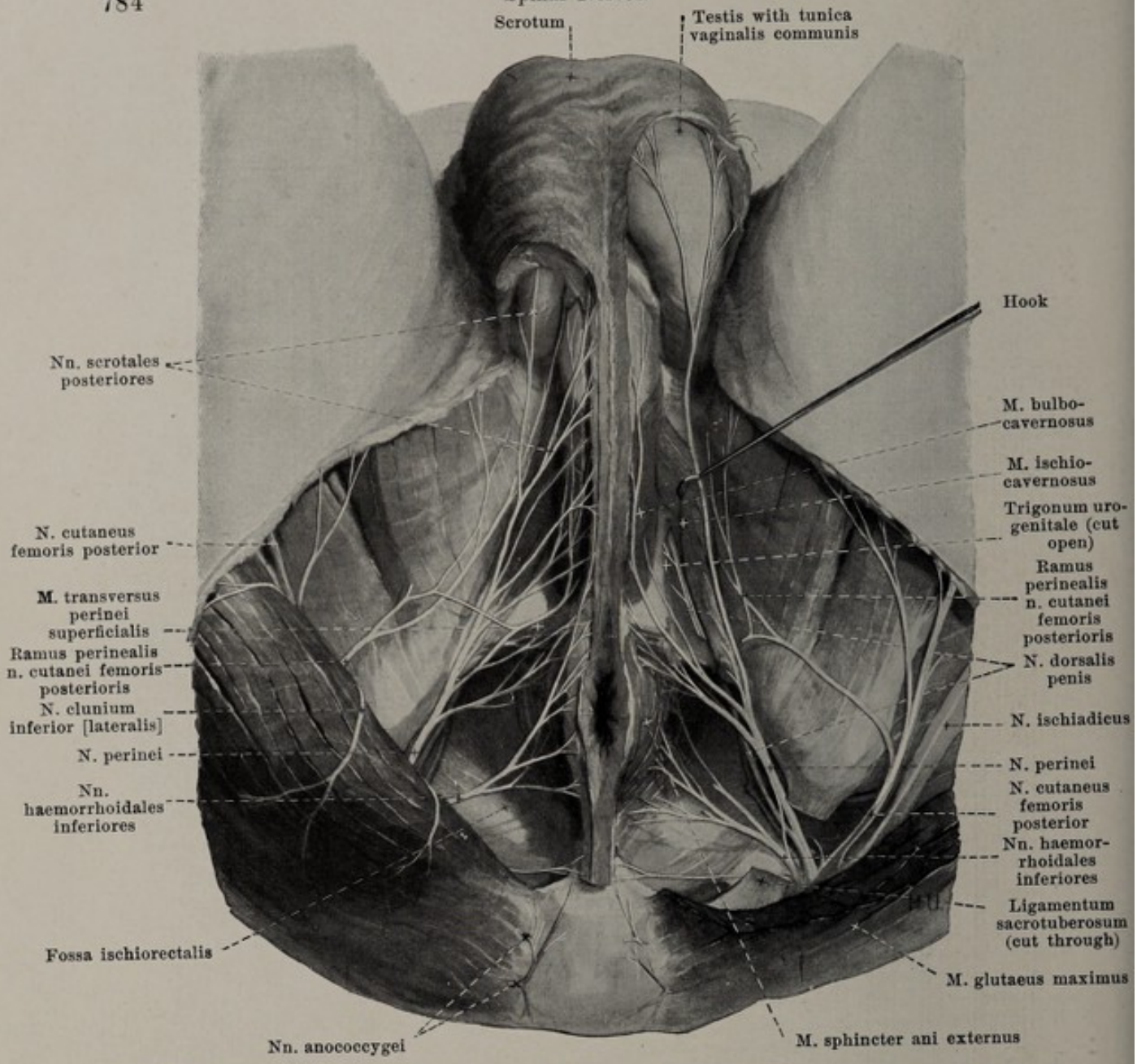
c) *N. peronaeus profundus* passes directly upon the lateral surface of the collum fibulae through an opening of the septum intermusculare anterius (see Fig. 443), covered by the mm. peronaeus longus and extensor digitorum longus, in a curve distalward and medianward and arrives alongside of the a. and vv. tibiales anteriores. Near these, first lateral from them, then in front of, and finally laterally or medially from them, it runs downward between the m. tibialis anterior on the one hand, and the mm. extensores digitorum longus and hallucis longus on the other, passes behind the ligg. transversum and cruciatum cruris (and behind the tendon of the m. extensor hallucis longus) upon the dorsum of the foot and there passes at first between the mm. extensores hallucis longus and brevis, then behind the tendon of the latter to the first spatium interosseum.



885 and 886. Areas of distribution of the cutaneous nerves in the right lower extremity,

viewed from in front. viewed from behind.

(The areas constantly supplied by the nerves concerned are indicated by solid lines, the areas not constantly supplied, by dotted lines.)



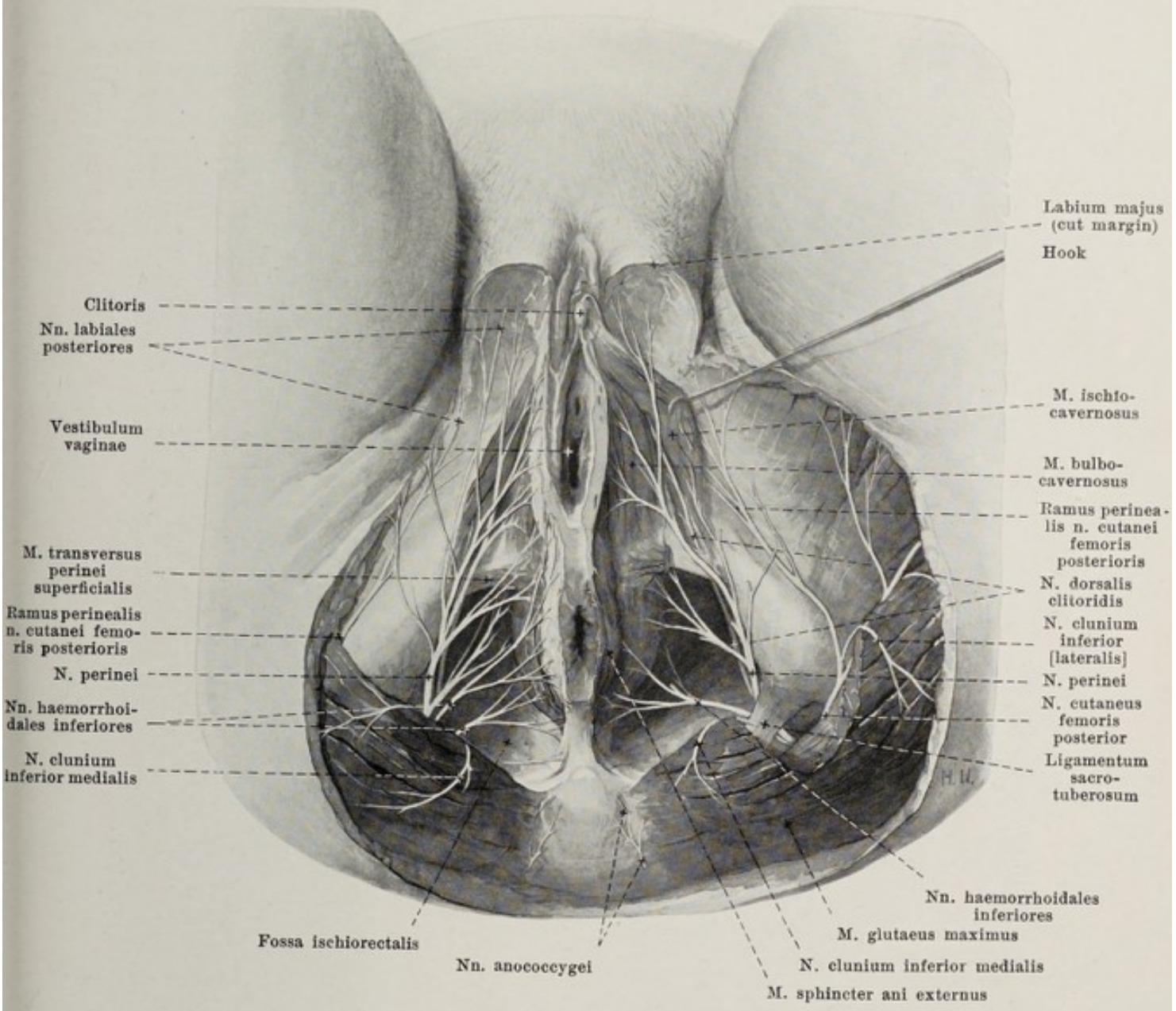
887. Nerves of the male perineum, viewed from below.

(On the left side parts have been cut out of the lig. sacrotuberosum, of the mm. glutaeus maximus, transversus perinei superficialis and of the trigonum urogenitale. The fascia obturatoria has been removed.)

c) *N. peronaeus profundus* (continued) (see Fig. 884): In the leg it sends *rami musculares* to the mm. tibialis anterior (2—3) (L_4, L_5, S_1), extensor digitorum longus (L_4, L_5, S_1) and extensor hallucis longus (L_4, L_5, S_1), as well as a *ramus articularis* to the ankle-joint, on the dorsum of the foot a ramus muscularis lateral behind the vessels to the m. extensor digitorum brevis (L_4, L_5, S_1) and then divides into its two terminal branches: *nn. digitales dorsales hallucis lateralis et digiti secundi medialis* (see also Figs. 875 and 885), which anastomose with branches of the n. cutaneus dorsalis pedis medialis and supply the adjacent halves of the 1st and 2nd toe as far as the terminal phalanx.

d) *N. peronaeus superficialis* (see Figs. 875, 884 and 885) runs distalward — covered by the m. peronaeus longus — at first on the fibula, then on the lateral anterior surface of the m. peronaeus brevis and as it goes gives off *rami musculares* to the mm. peronaei (L_4, L_5, S_1). It then perforates the fascia cruris in the lower half of the leg and divides into two terminal branches:

α) *N. cutaneus dorsalis pedis intermedius*, the smaller, passes upon the fascia in the direction of the base of the 4th toe, sends branches to the skin of the leg and dorsum of the foot, anastomoses with the n. suralis or its n. cutaneus dorsalis pedis lateralis (see p. 778) and finally divides into four *nn. digitales dorsales pedis* for the adjacent halves of the dorsal surfaces of the 3rd—5th toe.



888. Nerves of the female perineum, viewed from below.

(On the left side pieces have been cut out of the mm. glutaeus maximus, transversus perinei superficialis and the trigonum urogenitale. The fascia obturatoria has been removed.)

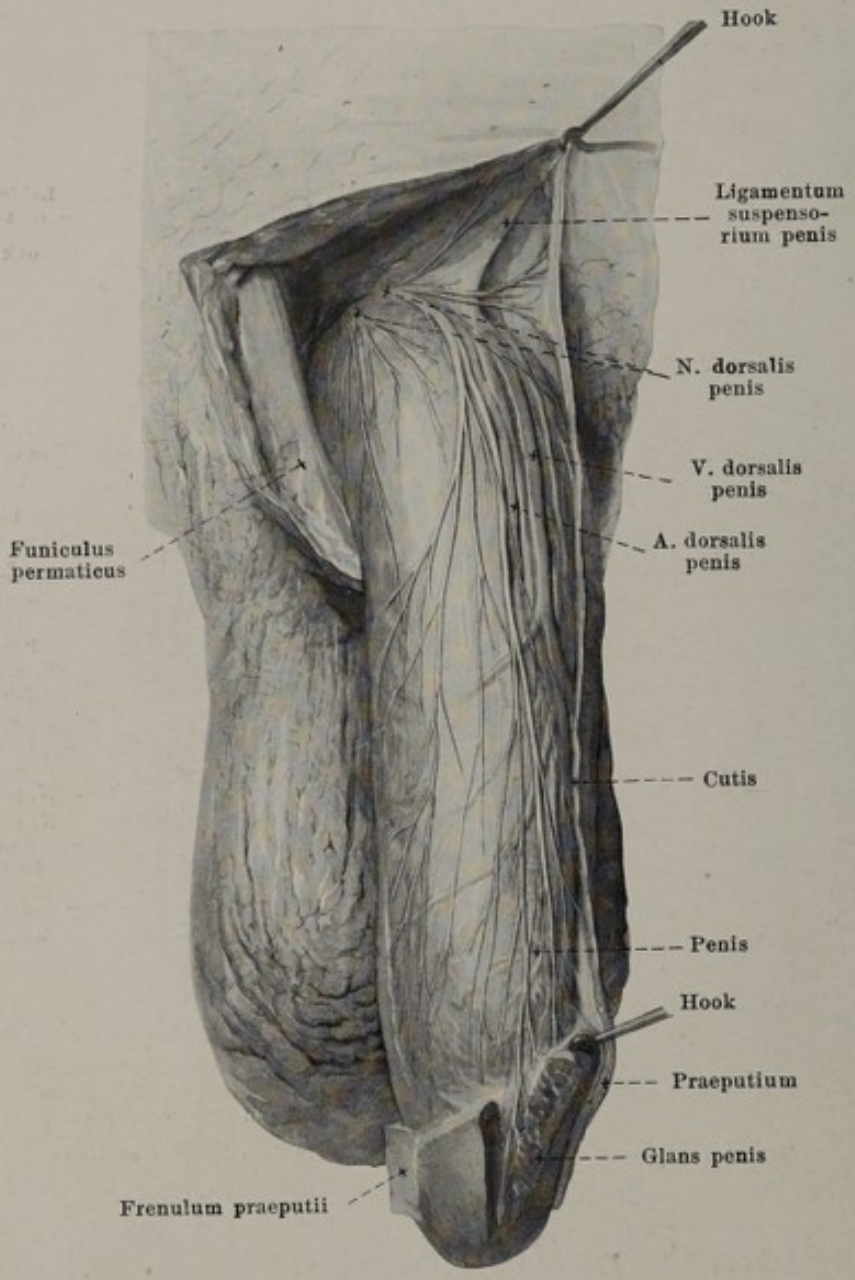
d) *N. peronaeus superficialis* (continued) (see Figs. 875, 884 and 885):

β) *N. cutaneus dorsalis pedis medialis* runs upon the fascia cruris distalward and medianward to the dorsum of the foot, gives off branches to the skin of the leg and to the dorsum of the foot and divides into a medial branch, which passes to the medial margin of the foot and of the great toe as far as its terminal phalanx, anastomosing with the n. saphenus and n. peronaeus profundus, and a lateral branch, which goes to the 2nd interosseous space, often anastomoses with the n. peronaeus profundus and divides into two *nn. digitales dorsales pedis* for the adjacent halves of the dorsal surfaces of the 2nd and 3rd toe.

7. *N. clunium inferior medialis* (see also Figs. 870 and 886), from S_2 and S_3, goes with the n. pudendus through the foramen ischiadicum majus on the back of the spina ischiadica and thence alone in front of or behind the lig. sacrotuberosum, or also through its whole breadth to the inferior margin of the m. glutaeus maximus, passes around the latter and goes upward through the fascia to the skin over the medial part of the buttock.

889. Nerves of the penis, viewed from in front and from the right.

(The skin has been partly removed; the glans has been incised.)



The ***plexus pudendus*** (see Figs. 870 and 876) is formed by the branches of the spinal nerves, which go to the pelvic viscera and to the muscles and skin of the perineum. It is shoved partly in the lower part of the plexus sacralis. Its chief root is S_3; besides it receives contributions from (L_5) S_1, S_2 and S_4. It lies in front of the lowermost parts of the m. piriformis, is crossed in front by the a. and vv. sacrales laterales, and is separated from the ampulla recti by the excavatio rectovesicalis (rectouterina in the female). It gives off the following branches:

1. *Rami musculares* (see Figs. 870, 876 and 892) for the m. levator ani, from (S_2) S_3 and S_4, and the m. coccygeus, from S_3, S_4 (S_5), forward to the inner surface of the same.

2. *Rami viscerales*, 4—6, (see Figs. 876 an 892), from (S_2) S_3 and S_4, run upward on the sides of the pelvic viscera. The go partly directly, partly after union with sympathetic plexuses (see p. 793), to the rectum *(nn. haemorrhoidales medii)*, to the urinary bladder *(nn. vesicales inferiores)* and to the vagina *(nn. vaginales)*.

3. *N. pudendus* (see also Figs. 870, 871, 876, 877, 887, 888 and 892), the largest nerve of the plexus, from (S_1) S_2, S_3 and S_4, runs under the m. piriformis, dorsal- and a little medialward from the a. pudenda interna upon the back of the spina ischiadica, then turns downward, forward and medianward between the fascia obturatoria and the m. obturator internus and divides at the tuber ischiadicum into the *n. perinei* and the *n. dorsalis penis (clitoridis)*. Before division it gives off the *nn. haemorrhoidales inferiores*, from S_3 and S_4, which pass through the fascia obturatoria and medianward and forward through the fossa ischiorectoralis, to supply the m. sphincter ani externus (S_3, S_4) and the skin of the anus and its neighborhood and to anastomose with branches of the n. perinei. Terminal branches:

a) *N. perinei*, from S_2, S_3 and S_4, passes in a curve forward and downward on the medial surface of the tuber ischiadicum, and with its branches perforates the fascia obturatoria behind the trigonum urogenitale; its superficial branches, *nn. scrotales (labiales) posteriores*, go to the skin of the perineum and of the scrotum (labium majus in the female), its deep branches to the mm. transversus perinei superficialis (S_3), bulbocavernosus (S_3) and ischiocavernosus (S_3), as well as into the penis; it anastomoses with the nn. haemorrhoidales inferiores and rami perineales n. cutanei femoris posterioris, as well as with branches of the n. dorsalis penis (see p. 787).

b) *N. dorsalis penis (clitoridis)* (see Figs. 870, 876, 887—889 and 892), from S_2 and S_3, smaller than the n. perinei, passes forward in the trigonum urogenitale (see also Figs. 711 and 726), lateral from the a. penis (clitoridis) between the lig. transversum pelvis and the lig. arcuatum pubis and near the lig. suspensiorum penis, to the back of the penis (clitoris); on its way it sends fine branches to the mm. transversus perinei profundus (S_3) and sphincter urethrae membranaceae (S_3) and anastomoses with the nn. cavernosi penis (see p. 793). Upon the penis its lateral, superficial branches go to the corpus cavernosum penis and to the skin of the lateral and inferior surfaces, anastomosing with terminal branches of the n. perinei; its medial, deep branches run lateral from the a. dorsalis penis as far as the glans. Upon the clitoris the nerve is very delicate; it supplies the skin of the clitoris and gives off twigs to the small and large lips.

Plexus coccygeus (see Figs. 870 and 876) is formed chiefly by the anterior branches of the n. sacralis V and the n. coccygeus (see p. 766), but receives also branches from the nn. sacrales III and IV. It lies in front of the origin of the m. coccygeus from the sacrum and coccyx, unites with the lower end of the truncus sympathicus and sends fibres to the viscera. Besides it gives off branches to the mm. sacrococcygei (S_4, S_5) as well as the *nn. anococcygei* (see also Figs. 887 and 888), three to five, which run near the inferior end of the sacrum and near the coccyx through or below the m. coccygeus, backward to the skin over the coccyx and in its neighborhood.

Systema nervorum sympathicum *(sympathetic nervous system, sympathicus)* is formed 1. by a chain of ganglia *(ganglia trunci sympathici)* lying on each side along the spinal column, the ganglia being united with one another by vertical bundles of nerve fibres to form a longitudinal cord, *truncus sympathicus*, 2. by the rami communicantes of the nn. spinales (see p. 736) and communicating rami of the nn. cerebrales, which bring fibres of the spinal and cerebral nerves to the sympathetic ganglia and its branches and also reversely bring sympathetic fibres to the branches of the former, and 3. through peripheral branches, which carry the fibres arising from the cells of the ganglia of the truncus sympathicus, usually accompanying the arteries, to all the organs of the body and which in so doing are characterized by numerous plexus-like communications of their branches wich one another and with those of the cerebral and spinal nerves. In these plexuses, *plexus sympathici*, smaller and larger groups of ganglion cells, *ganglia plexuum sympathicorum (peripheral sympathetic ganglia)*, are frequently intercalated. The branches supply the smooth musculature, the heart musculature, the gland cells and the pigment cells, probably also the cross-striped musculature (tonus) and perhaps the capillaries; they contain also sensory fibres, which, however, pass by the sympathetic ganglion cells.

The sympathicus is divisible into a *head and neck portion, pars cephalica et cervicalis*, a *thoracic portion, pars thoracalis*, and an *abdominal and pelvic portion, pars abdominalis et pelvina;* these are, however, only indistinctly separable from one another.

The ***truncus sympathicus*** (see Figs. 837—839, 871, 876, 890 and 892) extends from the foramen caroticum externum to the coccyx; it sends a continuation (see Figs. 824 and 831) upward into the canalis caroticus, to unite with the ganglia lying upon the branches of the n. trigeminus, and with these to form the head part of the sympathetic trunk. The ganglia of the sympathetic trunk are in general arranged segmentally in the thoracic, abdominal and pelvic portions, that is to say, there is a ganglion corresponding to each spinal nerve, though neighboring ganglia may be united with one another; in the cervical portion they are fused with one another to form two or three ganglia. They are of oblong, rounded or angular form and according to the region of the body in which they are situated are designated as *ganglia cervicalia, thoracalia, lumbalia, sacralia, coccygeum.*

The *rami communicantes of the nn. spinales* (see Figs. 752, 839, 871, 876, 890 and 892) are single or double, sometimes triple and arise usually from the corresponding n. spinalis, sometimes also by single threads from its anterior and posterior roots. Equivalent to these may be regarded the communicating rami of the cerebral nerves, namely of the V., IX., X. and XII. with the sympathicus.

A. ***Pars cephalica et cervicalis systematis sympathici.*** It begins as the *n. caroticus internus* (see Figs. 831 and 837), which proceeds from the upper end of the ganglion cervicale superius (see p. 788), in a way as a continuation of the truncus sympathicus; it lies upon the posterior surface of the a. carotis interna, and by continued subdivision and anastomoses forms a wide-meshed plexus, *plexus caroticus internus* (see also Fig. 824), which accompanies the artery as far as its division and in the sinus cavernosus becomes most close meshed as the *plexus cavernosus.* Delicate plexuses go off from it upon the branches of the a. carotis interna as the *plexus ophthalmicus* (around the a. ophthalmica), *plexus arteriae cerebri anterioris, arteriae cerebri mediae* and *arteriae chorioideae*, and most delicate threads pass to the lobus anterior of the hypophysis cerebri. By means of the *radices sympathicae ganglii ciliaris* (see p. 714 and Figs. 822 and 823), which go from the plexus cavernosus through the

fissura orbitalis superior to the ganglion ciliare, it is continued as far as this, and through the *n. petrosus profundus major* (see p. 718 and Fig. 824) it is connected with the ganglion sphenopalatinum. These two ganglia, like the ganglion oticum (see p. 723 and below), which in their structure resemble other sympathetic ganglia, are accordingly to be looked upon as the uppermost head ganglia of the sympathicus. In addition the plexus cavernosus or caroticus internus communicates by fine threads with the nn. oculomotorius (see p. 711), trochlearis (see p. 712), ophthalmicus (V) (see p. 714), abducens (see p. 724), as well as by nn. caroticotympanici (see p. 730) with the n. tympanicus (IX).

In the neck the trunk contains only two or three ganglia (see p. 787). The *ganglion cervicale superius* (see Figs. 835, 837 and 838) is a swelling of the trunk, usually spindle-shaped, approximately 2 cm long, and 5—8 mm broad; it lies in front of the transverse processes of the 2^{nd}—4^{th} cervical vertebra on the fascia praevertebralis and the m. longus capitis, and in front and medialward adjoins the a. carotis interna, in front and lateralward the n. vagus. From its lower end the sympathetic trunk (see Fig. 838) passes in front of the fascia praevertebralis and the mm. longi capitis and colli, behind the a. carotis communis, behind and somewhat medial from the n. vagus downward and presents at about the 6^{th} cervical vertebra on the anterior or posterior surface of the a. thyreoidea inferior the very variable (often absent) small *ganglion cervicale medium* (see Figs. 838, 839 and 890). From the lower end of this ganglion go off usually two (or more) fibres, of which one, the shorter and larger descends behind the a. subclavia, while the other passes around the artery from in front and below like a loop *(ansa subclavia [Vieussenii]:* these go down into the *ganglion cervicale inferius* (see Figs. 838, 840 and 890), a flattened irregular mass situated in front of the transverse process of the 7^{th} cervical vertebra and in front of the neck of the first rib behind the a. subclavia and the origin of the a. vertebralis; it is often wholly or partly fused with the uppermost ganlion thoracale. The ganglion submaxillare (see p. 723 and below) also belongs to the cervical part of the sympathetic system.

The ganglion cervicale superius is united by the delicate *n. jugularis* (see Fig. 837), which passes upward from the upper end close by the n. caroticus internus and bifurcates with the ganglion petrosum n. glossopharyngei and ganglion jugulare n. vagi, also by fine threads with the ganglion nodosum n. vagi and with the n. hypoglossus, as well as by rami communicantes with the 1^{st}—4^{th} (or 3^{rd}) cervical nerve (see Fig. 835). The ganglion cervicale medium (or when this is absent, the corresponding part of the trunk) is united by rami communicantes usually with the (4^{th}) 5^{th}, 6^{th} (and 7^{th}) cervical nerve, the ganglion cervicale inferius with the (7^{th}) 8^{th} cervical and 1^{st} thoracic nerve (see Fig. 890).

The following are designated as peripheral branches:

1. From the ganglion cervicale superius:

a) Vascular branches (as a rule, not illustrated): They arise usually as two fine threads, *nn. carotici externi* (not illustrated), which run to the a. carotis externa and downward on it as far as its origin; they form a plexus, *plexus caroticus externus,* around this artery, from which plexus-like twigs are given off to the branches of the artery, namely: *plexus thyreoideus superior, lingualis, maxillaris externus* (from which the *radix sympathica gangli submaxillaris* for the ganglion submaxillare [see p. 723 and above], similar in structure to other sympathetic ganglia is derived), *plexus occipitalis, auricularis posterior, temporalis superficialis, maxillaris internus, meningeus* (on the a. meningea media, from which go off threads to the ganglion oticum [see p. 723 and above], which belongs to the sympathicus, and *plexus pharyngeus ascendens* on arteries of corresponding name; the main plexus is continued as the *plexus caroticus communis* upon the a. carotis communis.

b) Visceral branches: *Rami laryngopharyngei* (see Fig. 838) go off independently or from one of the branches, pass partly to the n. laryngeus superior and with this to the larynx, partly to the lateral wall of the pharynx, there to form the plexus pharyngeus (see p. 733) with the rami pharyngei of the nn. glossopharyngeus and vagus.

c) *N. cardiacus superior* (see Figs. 838, 839 and 846), larger on the left side, arises simply or by several roots from the lower end of the ganglion or from the trunk, passes medial from the latter behind the a. carotis communis, downward directly in front of the fascia praevertebralis, behind or in front of the a. thyreoidea inferior, on the r i g h t side along the a. anonyma, on the l e f t side along the a. carotis communis to reach the arch of the aorta and the plexus cardiacus. In the neck it unites repeatedly with the n. laryngeus superior, the rami cardiaci superiores n. vagi and the n. recurrens (see p. 733) and sends fine threads to the plexus thyreoideus inferior.

2. From the ganglion cervicale medium or from the front of the trunk corresponding to it:

a) Vascular branches, very fine, partly to the *plexus caroticus communis* (vide supra), partly to the a. thyreoidea inferior, around which they form the *plexus thyreoideus inferior* (not illustrated), together with branches of the ganglion cervicale inferius and of the nn. cardiaci superior and medius.

890. Right sympathetic trunk in the thoracic cavity,

viewed from the right and from in front.

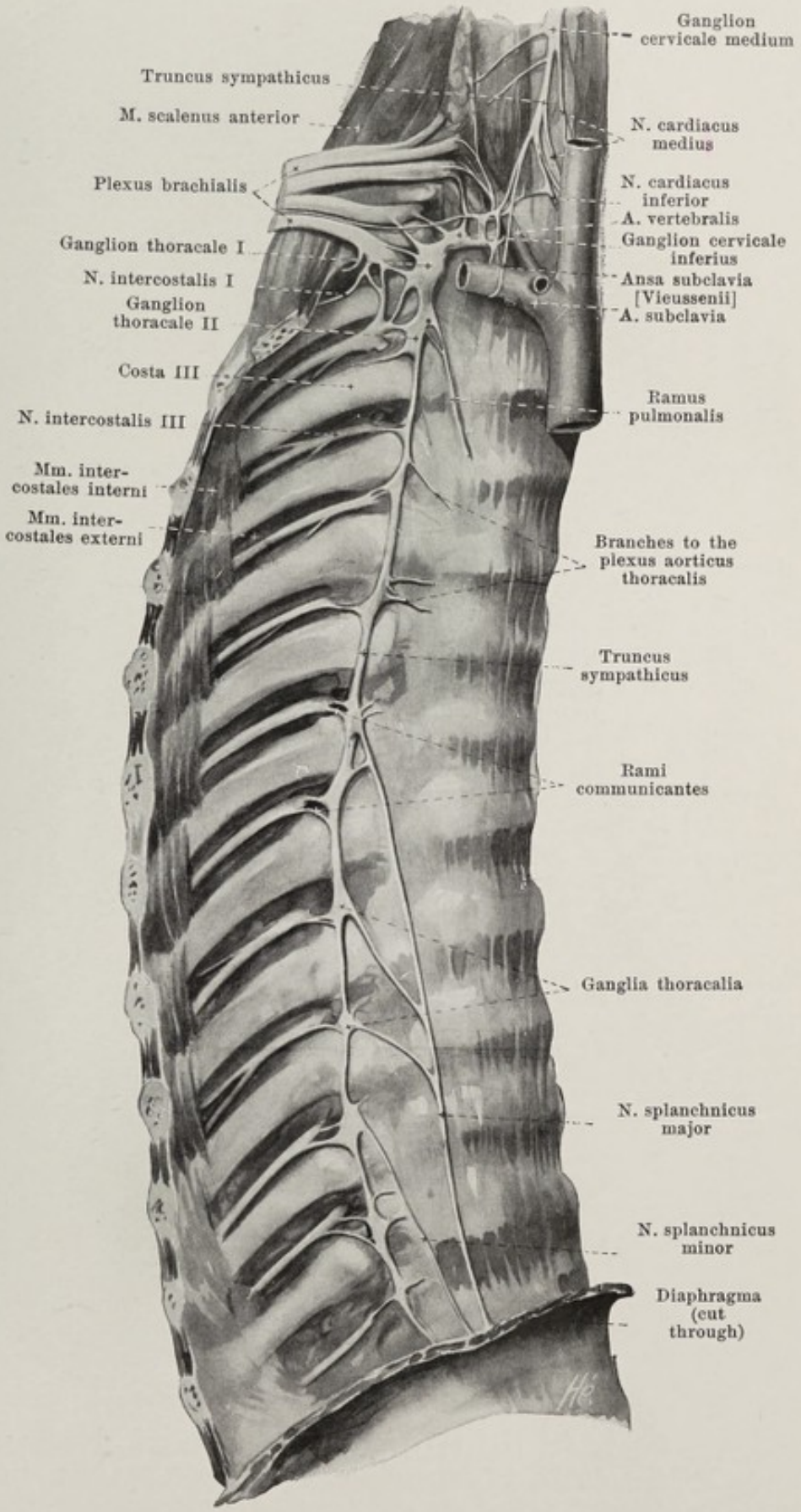
(The pleura and fascia endothoracica have been removed. Of the sympathicus only a few branches are drawn.)

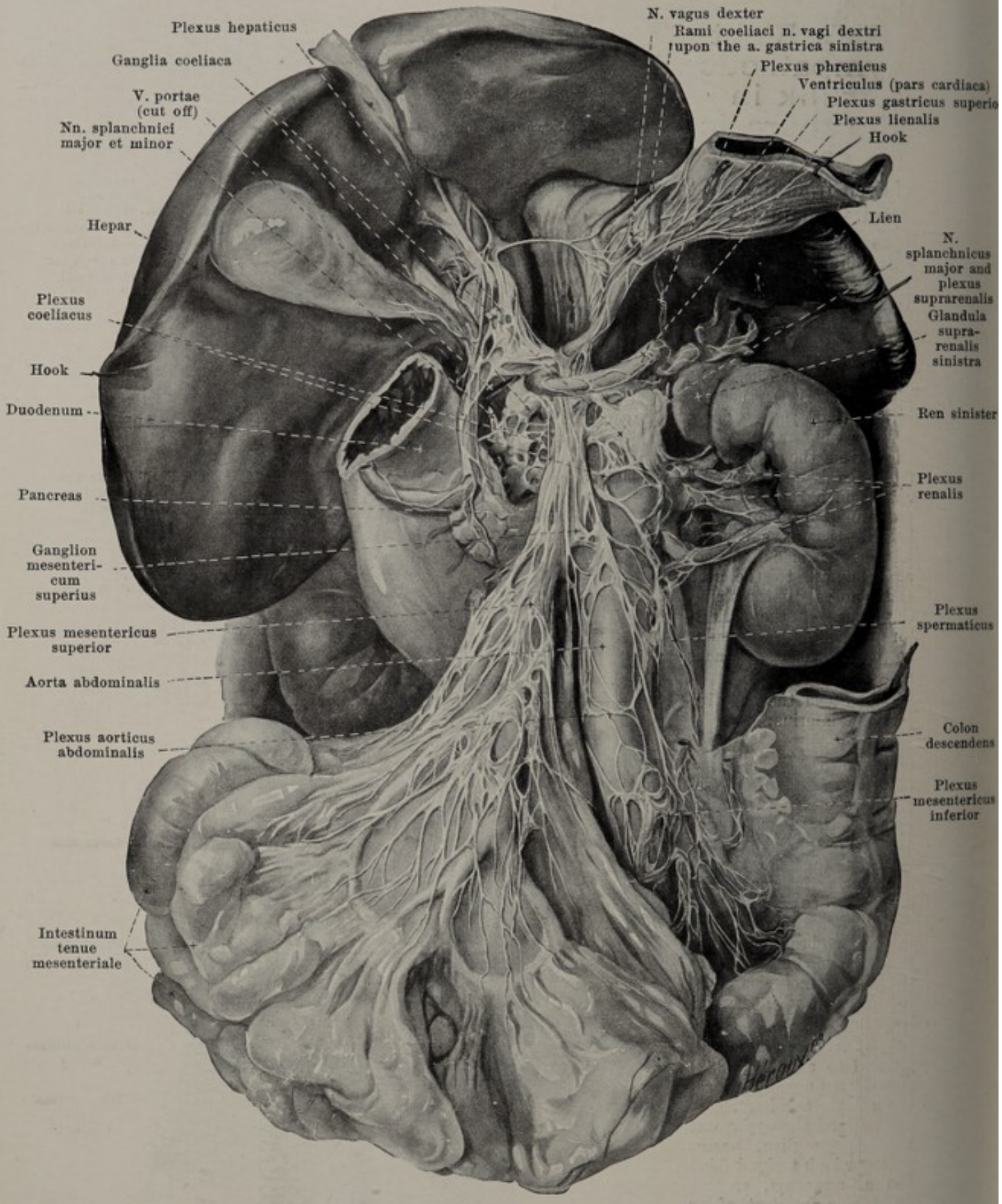
b) *N. cardiacus medius* (see also Figs. 838, 839 and 846), usually larger than the superior, arises simply or by several roots from the ganglion or from the trunk itself and runs behind the a. carotis communis, in front of or behind the a. subclavia, on the right side along the a. anonyma, to the arch of the aorta and the plexus cardiacus. In the neck it forms anastomoses similar to those of the n. cardiacus superior (see p. 788).

3. From the ganglion cervicale inferius:

a) Vascular branches (not shown) to the *plexus thyreoideus inferior* (see p. 788), *plexus subclavius* (around the a. subclavia) and *plexus mammarius internus* (around the a. mammaria interna), but especially to the *plexus vertebralis*, surrounding the a. vertebralis, a plexus which during its course to the brain communicates by fine threads with the cervical nerves.

b) *N. cardiacus inferior* (see also Fig. 839) goes off usually by several roots from the lowermost cervical and the uppermost thoracic ganglion, passes on the r i g h t side behind the a. anonyma, on the l e f t side in front of or behind the a. subclavia to the arcus aortae and plexus cardiacus.





891. Abdominal plexuses of the sympathicus, viewed from in front. (Stomach and large intestine have been for the most part removed; the pars ascendens duodeni has been excised. The liver is displaced upward, the stomach and the spleen to the left, the small intestine downward. The peritonaeum has been partly dissected off.)

Plexus cardiacus, heart plexus (see Figs. 839 and 846), is formed by the plexus-like anastomoses around the arch of the aorta of the rami cardiaci n. vagi and the nn. cardiaci of the sympathicus of both sides as well as by branches of the 1st to the 5th ganglion thoracale. In it there can be distinguished a feebler, superficial portion, spread out on the left, anterior part of the aortic arch, between it and the site of bifurcation of the a. pulmonalis, and formed chiefly by the rami cardiaci of the left n. vagus and by the left n. cardiacus superior, and frequently possessing the *ganglion cardiacum [Wrisbergi]* (not illustrated), as well as a larger, deeper portion; the latter lies on the right, posterior surface of the aortic arch, between it and the bifurcation of the trachea, and is formed by all the other heart-nerves. The heart plexus sends direct branches to the atria, as well as the *plexus coronarius cordis anterior* on the a. coronaria [cordis] dextra and the *plexus coronarius cordis posterior* on the a. coronaria sinistra, besides others to the plexus pulmonales of the nn. vagi (see p. 734).

C. ***Pars thoracalis s. sympathici*** (see Figs. 680—682, 839 and 890). The sympathetic trunk extends caudalward in front of the heads of the ribs and in front of the aa. and vv. intercostales, covered directly by the pleura and contains 10—12 *ganglia thoracalia*, situated in front of the heads of the ribs or in front of the intercostal vessels or nerves; below it turns somewhat ventralward and passes between the crus intermedium and crus laterale of the diaphragm into the abdominal cavity. Each ganglion is united by one or several rami communicantes with the adjacent n. intercostalis. The ganglia give off besides numerous branches to the n. vagus:

a) Vascular branches to the arcus aortae (see above) and to the aorta thoracalis; these together with outrunners from the plexus cardiacus form the *plexus aorticus thoracalis*, which is connected below with the plexus coeliacus.

b) *Rami pulmonales* (from the 1st to the 6th ganglion thoracale) to the plexus pulmonales (see p. 734), as well as branches to the plexus oesophagei (see p. 734).

c) *N. splanchnicus major* arises with several roots from the 5th or 6th to the 9th thoracic ganglion, is of a white color like the spinal nerves; its fibres arise chiefly from the spinal cord and go past the sympathetic ganglion cells. It runs distialward and somewhat medianward upon the bodies of the thoracic vertebrae and possesses in front of the 12th thoracic vertebra, regularly on the right side, and frequently on the left side, a small *ganglion splanchnicum* (not designated); it passes between the crus mediale and the crus intermedium of the diaphragma into the abdominal cavity and enters the corresponding ganglion coeliacum (see Fig. 891).

d) *N. splanchnicus minor*, of the same appearance and structure as the foregoing, arises from the 10th—12th thoracic ganglion, extends close to the foregoing nerve, sometimes united with it, downward through the diaphragm, enters the ganglion coeliacum near the a. renalis and sends a *ramus renalis* (not designated) to the plexus renalis.

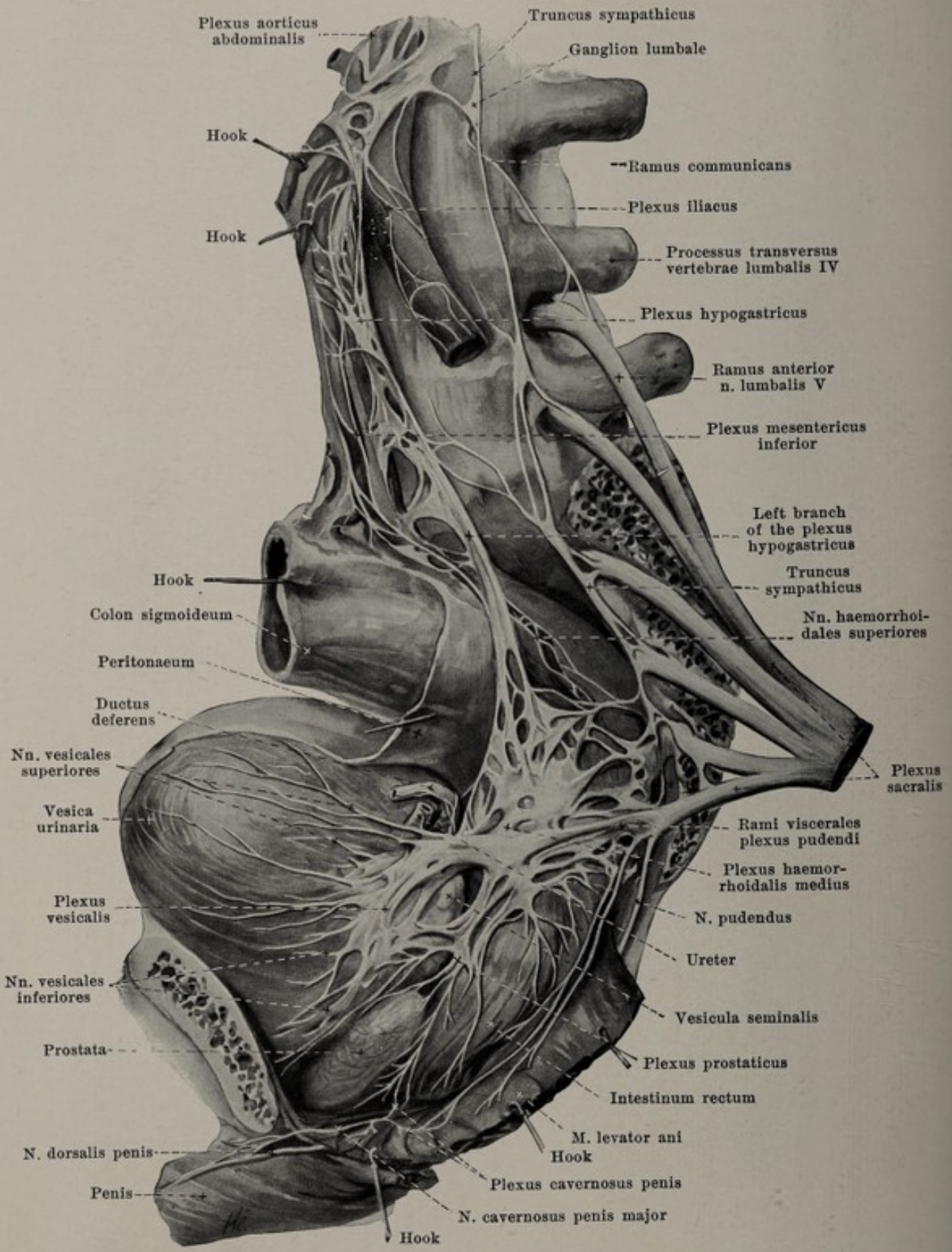
D. ***Pars abdominalis s. sympathici*** (see Figs. 871, 876 and 891). The sympathetic trunk runs directly upon the bodies of the lumbar vertebrae, ventral and medianward from the origins of the m. psoas major, on the right side behind the v. cava inferior, on the left behind the aorta abdominalis downward and near the promontorium curves upon the facies pelvina oss. sacri; it contains 5 (or 4) small *ganglia lumbalia*. Its rami communicantes are usually double and run near the aa. lumbales between the bodies of the vertebrae and the tendon arches of the m. psoas.

Its main plexus is the unpaired *plexus coeliacus*, which lies behind the pancreas and the bursa omentalis directly upon the anterior surface of the aorta abdominalis and the crura diaphragmatis, surrounds the origins of the aa. coeliaca and mesenterica superior, lateralward as far as the suprarenals reaches downward as far as the origin of the aa. renales, and is continuous upward through the hiatus aorticus with the plexus aorticus thoracalis. It is formed by the nn. splanchnici major and minor of both sides, by the rami coeliaci of the right n. vagus, and by threads from the upper lumbar ganglia of the sympathicus. Intercalated in this plexus on each side there is constantly a large, flat, very variable *ganglion coeliacum*, which may be subdivided into several small ones, and often a small *ganglion mesentericum superius* is found beneath the root of the a. mesenterica superior.

The following branch-plexuses go off from the plexus coeliacus chiefly with the arteries:

Paired plexuses:

Plexus phrenicus with the a. phrenica inferior, which unites with the rami phrenicoabdominales n. phrenici (see p. 743) and on the right side possesses a small *ganglion phrenicum* (not illustrated); *plexus suprarenalis*, numerous fine threads to the dorsal surface of the suprarenal; *plexus renalis* with threads from the lumbar ganglia around the a. renalis to the kidney, receiving the ramus renalis of the n. splanchnicus minor; *plexus spermaticus* around the a. spermatica interna in the male to the testicle, in the female *(plexus arteriae ovaricae)* to the ovarium and fundus uteri, where it anastomoses with the plexus uterovaginalis.



892. Pelvic plexuses of the sympathicus,

viewed from the left.

(The left half of the pelvis with its muscles has been in large part removed; the plexus sacralis and the m. levator ani have been drawn somewhat aside.)

Unpaired plexuses (see Fig. 891):

Plexus lienalis with the a. lienalis to the spleen, to the pancreas and fundus ventriculi; *plexus hepaticus* near the a. hepatica and the ductus choledochus to the liver (anastomosing with rami hepatici n. vagi sinistri) and gall bladder, to the pylorus and along with the branches of the a. gastroduodenalis to the pancreas, duodenum and to the curvatura major ventriculi (*plexus gastricus inferior*, not designated); *plexus gastricus superior* along with the a. gastrica sinistra to the curvatura minor ventriculi, where it unites with branches of the nn. vagi; *plexus mesentericus superior*, the largest, accompanies the a. mesenterica superior and its branches to the pancreas, duodenum, small intestines, caecum, colon ascendens and the larger part of the colon transversum and forms within the wall of the small intestine, between the longitudinal and circular walls of muscle, the narrower-meshed *plexus myentericus*, in the tela submucosa the wider-meshed *plexus submucosus* (not illustrated).

Plexus aorticus abdominalis (see Figs. 891 and 892) consists essentially of two lateral cords uniting by transverse threads which are developed from the plexus coeliacus and receive threads from the lumbar ganglia. Around the a. mesenterica inferior it is continued as the *plexus mesentericus inferior* and thus arrives at the colon transversum, descendens and sigmoideum, and as the *mm. haemorrhoidales superiores* to the upper part of the rectum, where it anastomoses with the plexus haemorrhoidalis medius; in the wall of the intestine it behaves like the plexus mesentericus superior.

The plexus aorticus is continuous below with the *plexus hypogastricus* (see Fig. 892), which at first runs as an unpaired, flat, broad plexus, as far as the promontorium, there bifurcates and then extends on each side on the medial side of the a. hypogastrica, dorsal and lateral from the rectum, as far as the large pelvic plexus (vide infra); it receives branches from the lumbar and sacral ganglia.

Another continuation of the plexus aorticus is met with in the feebler *plexus iliacus* upon the a. iliaca communis; it again goes over into the delicate *plexus femoralis* upon the a. femoralis and *plexus popliteus* upon the a. poplitea.

E. ***Pars pelvina s. sympathici*** (see Figs. 871, 876 and 892). The sympathetic trunk lies directly upon the facies pelvina of the sacrum, medial from the foramina sacralia anteriora, dorsal and lateral from the rectum, and usually presents there four *ganglia sacralia;* the right and left trunk converge somewhat caudalward, so that on the anterior surface of the 1st coccygeal vertebra they either unite by a simple loop, or both end there (more rarely) in a small unpaired *ganglion coccygeum*. Each ganglion is united by one or two rami communicantes with the corresponding nerves.

On the lateral surface of the pelvic viscera, between them and the medial upper surface of the diaphragm pelvis is the large pelvic plexus (see Fig. 892), which is only indistinctly separable into the single portions belonging to individual viscera. It is formed by the lower ends of the plexus hypogastrici, by branches of the pelvic ganglia, as well as by the rami viscerales of the plexus pudendus (nn. haemorrhoidales medii, nn. vesicales inferiores and nn. vaginales) (see p. 786). Of the subdivisions of this large plexus the following are common to both sexes:

a) *Plexus haemorrhoidalis medius*, farthest dorsalward, on the lateral surface of the rectum, around the a. haemorrhoidalis media, receives the nn. haemorrhoidales superiores and sends branches to the wall of the rectum.

b) *Plexus vesicalis*, situated farthest ventralward, on the lateral surface of the bladder; it sends *nn. vesicales superiores* to the upper, *nn. vesicales inferiores* to the lower part of the bladder; the former give off branches to the ureter, the latter to the urethra.

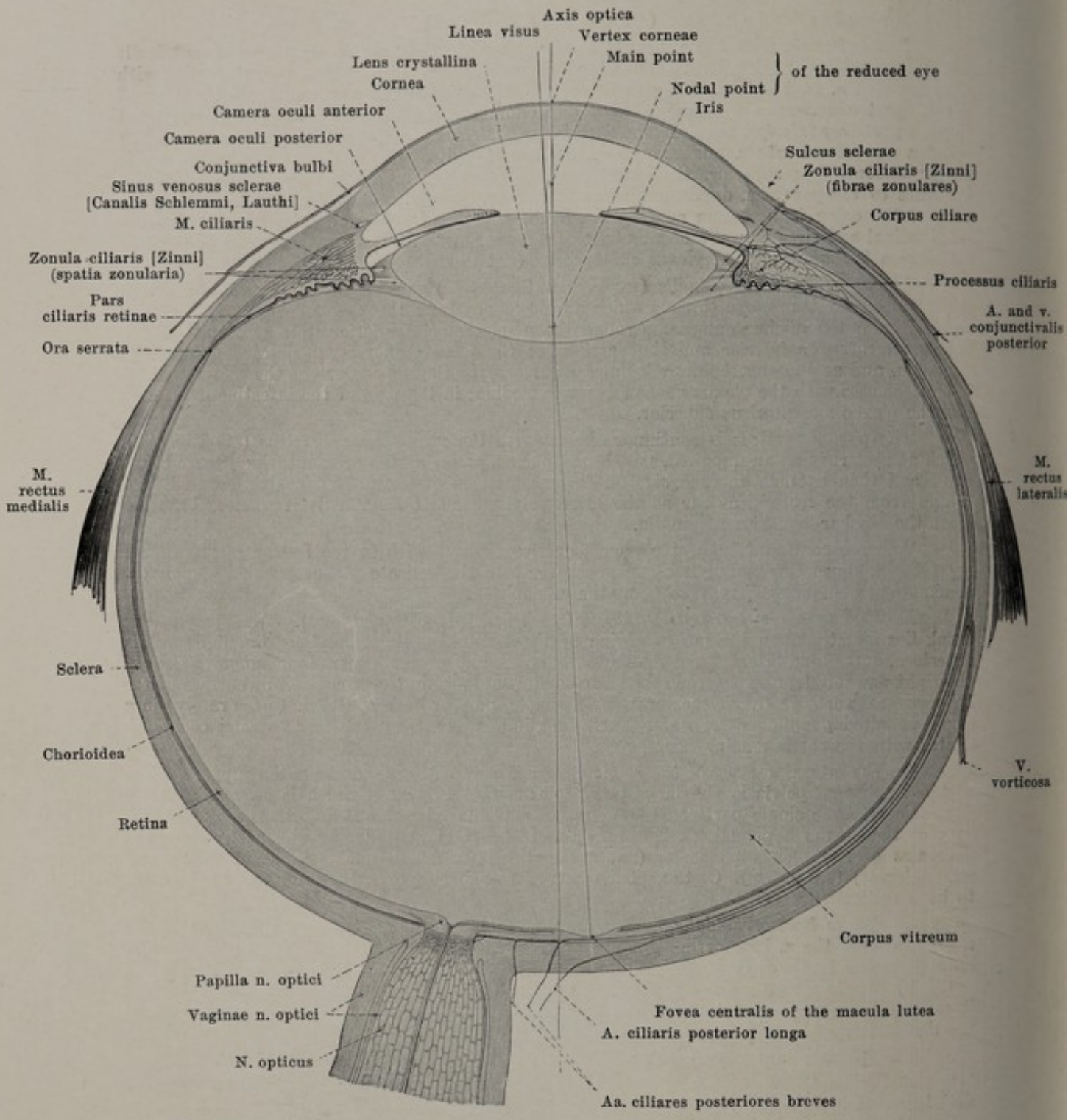
The following are present in the male only:

c) *Plexus deferentialis* (not designated) about the seminal vesicle and ductus deferens, with branches to these.

d) *Plexus prostaticus*, lateral from and behind the prostata, which branches to it.

e) *Plexus cavernosus*, a continuation of the preceding; it passes lateral and dorsal from the prostata to the trigonum urogenitale, and through this upon the back of the penis, where it anastomoses with branches of the n. dorsalis penis. It gives off branches to the pars membranacea of the urethra, and ends in the *nn. cavernosi penis major et minores*, which penetrate the corpora cavernosa penis .

In the female: f) *Plexus uterovaginalis* (not illustrated) in the parametrium on the lateral surface of the cervix uteri and of the upper part of the vagina, sends branches with the a. uterina to the uterus (anastomoses with the plexus arteriae ovaricae), as well as to the vagina. From the anterior surface of the vagina a fine *plexus cavernosus clitoridis* with *nn. cavernosi clitoridis major et minores* goes to the clitoris.



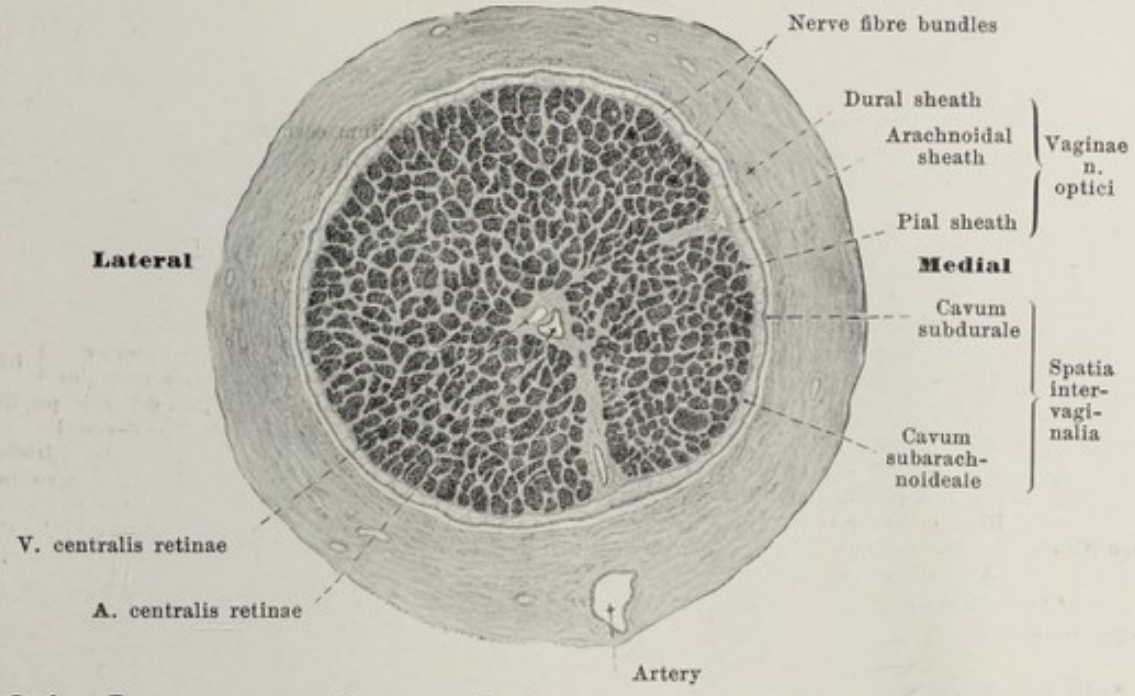
893. Schematic section through the right eye in the horizontal meridian, viewed from above (after H. Sattler).

Magnification: 5:1.

The **organon visus** *(organ of vision)* consists of the *eye (oculus)* and of the *appendages of the eye (organa oculi accessoria).*

The *eye* consists of the *n. opticus (optic nerve)* and the *bulbus oculi (eyeball).*

The *accessory organs of the eye* include the *musculi oculi (eye muscles), fasciae orbitales (fascia of the orbital cavity), palpebrae (eyelids), conjunctiva* and the *apparatus lacrimalis (tear apparatus).*



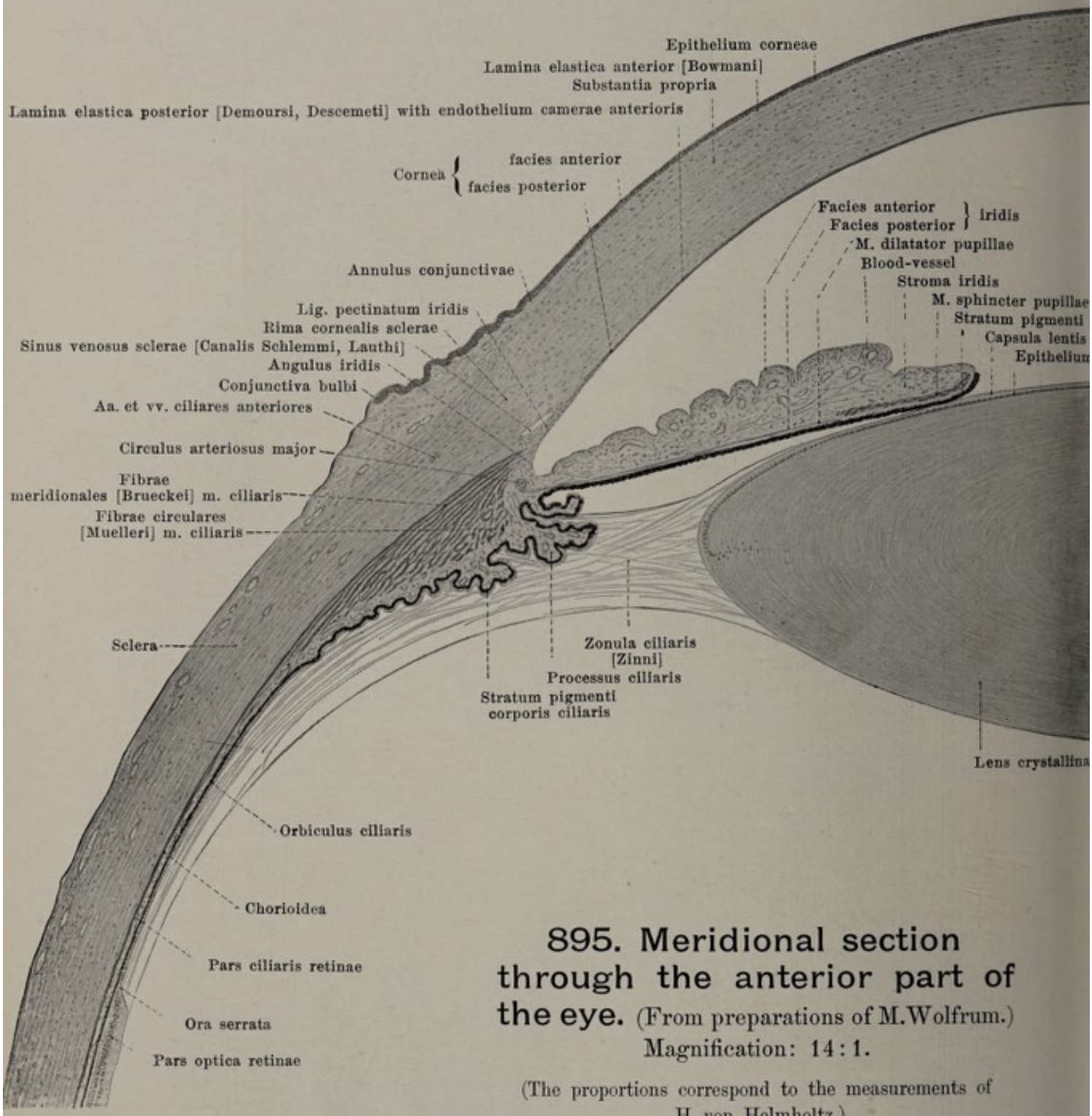
894. Cross-section of the optic nerve a little in front of the entrance of the a. centralis retinae. (After a preparation by H. Sattler.)
Magnification: 15:1.
(The bundles of nerve fibres are dark in the drawing.)

The **n. opticus** *(optic nerve)* (see also p. 711 and Figs. 893, 904, 905 and 919—924) is variably curved in the orbital cavity; in the vertical direction it is curved so as to be slightly bayonet-shaped, in the horizontal direction slightly S-shaped, behind lateralward, in front medianward convex, and enters into the posterior surface of the eyeball about 3 mm medial from, and somewhat below, the posterior end of the optic axis. It is enclosed in its *sheaths, vaginae n. optici* (see also Figs. 893, 904 and 905), which are continuations of the brain-membranes, and at the eyeball go over into the sclera. The outer thickest *dural sheath* consisting of tough connective tissue, is derived from the dura mater and forms the periosteum lining the foramen opticum. Following upon this is the delicate *arachnoidal sheath*, a continuation of the arachnoidea, and upon this a continuation of the pia mater, the *pial sheath*, which is connected by fine strands with the arachnoidal sheath and sends septa in between the bundles of nerve fibres. The sheaths are separated from one another by the *spatia intervaginalia*, and between the dural and arachnoidal sheaths is a continuation of the cavum subdurale, between the arachnoidal and pial sheaths a continuation of the cavum subarachnoideale; both of these extend forward as far as the sclera but do not communicate with one another there.

The a. and v. centralis retinae enter the optic nerve about 1 cm behind the eyeball, constantly entering in the medial part of its inferior circumference; they then run farther forward in the axis of the nerve.

The fibres of the n. opticus are medullated, but lose their myelin-sheaths immediately behind the lamina cribrosa sclerae (see p. 797 and Fig. 904); the nerve accordingly narrows on passage through the coats of the bulbus.

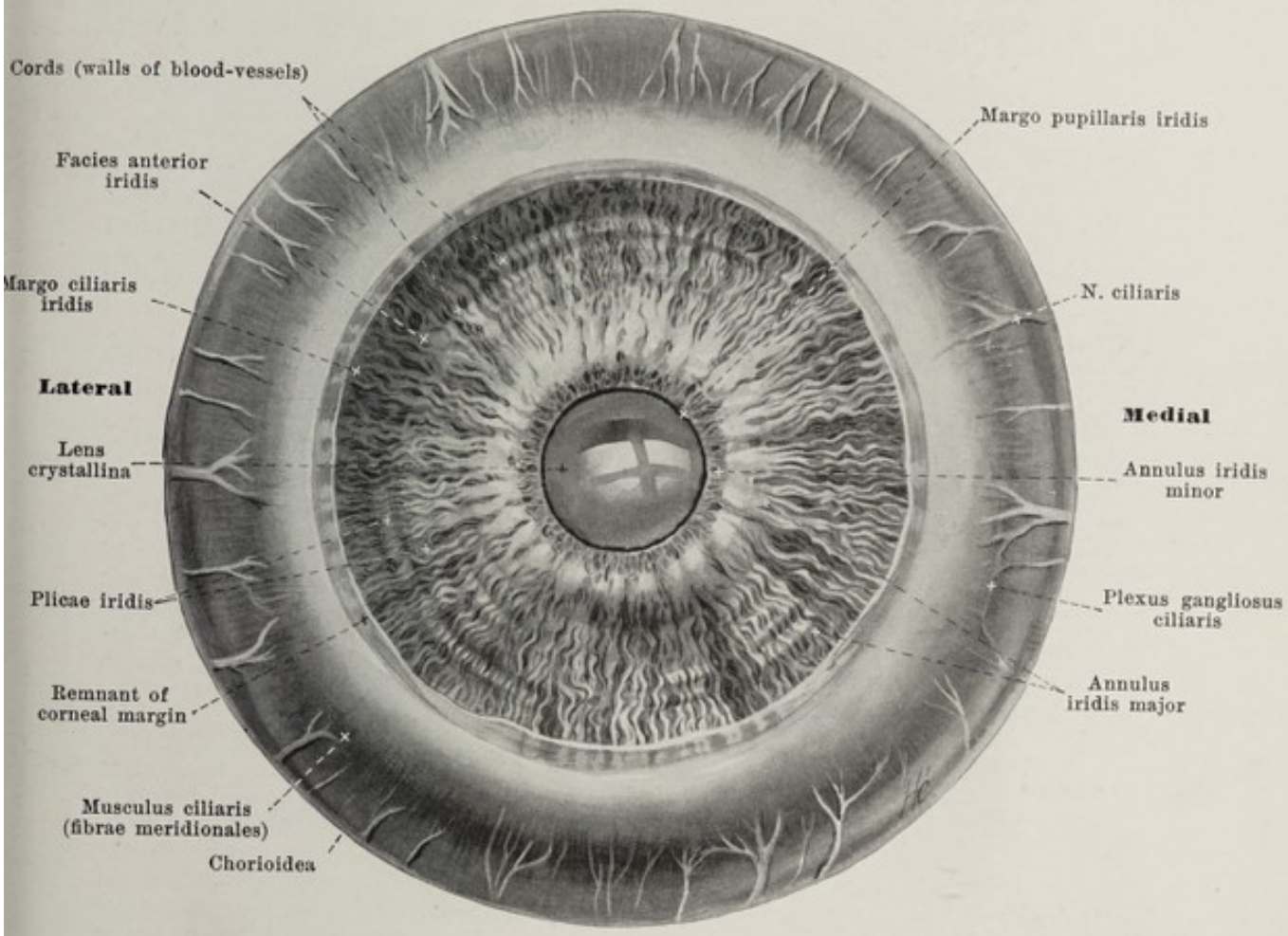
The **bulbus oculi** *(eyeball)* (see Figs. 893 and 900) lies, surrounded by fat, fasciae and muscles, in the orbital cavity and presents, roughly speaking, the form of a sphere. In describing it, therefore, expressions corresponding to those used for the globe are employed, thus an *anterior pole, polus anterior*, in the vertex corneae is spoken of, and a *posterior pole, polus posterior*, in the middle point of the posterior convexity, somewhat medianward and a little above from the spot in the sclera corresponding to the fovea centralis. The line uniting the two poles is called the *axis oculi externa*, the distance measured upon it, between the posterior surface of the cornea, and the anterior surface of the retina, being called the *axis oculi interna;* it coincides with the *optic axis, axis optica*, which contains the centres of the different refracting surfaces of the eye. The largest circle, the plane of which stands perpendicular to the optic axis, is called the *aequator;* circles which go through both poles are called *meridiani;* by the vertical and the horizontal meridian the bulbus is divided into four quadrants. The name *visual line, linea visus*, is given to the line which in the reduced eye is drawn from an external object through the nodal point to the fovea centralis.



895. Meridional section through the anterior part of the eye. (From preparations of M. Wolfrum.) Magnification: 14 : 1.

(The proportions correspond to the measurements of H. von Helmholtz.)

The **bulbus oculi** resembles a section of a sphere fairly complete only in its posterior half. The anterior half possesses a frontal, shallow, circular indentation, *sulcus sclerae* (see Fig. 893), from which the most anterior part projects as a small segment of a sphere (see p. 798) with smaller radius of curvature. This projection belongs to the cornea, the other part of the surface to the sclera, so that the sulcus sclerae indicates at the same time the external junction between the cornea and the sclera.



896. Iris of a grayish-blue right eye, along with corpus ciliare and chorioidea, viewed from in front.

Magnification: 6 : 1. (The cornea and sclera have been removed.)

The **bulbus oculi** (see Fig. 893) is formed of the *contents (nucleus) of the eyeball*, in the interior, and of the *coats of the eye* ensheathing these externally. The former, from before backward, consists of 1. the *humor aqueus*, 2. the *lens crystallina*, *lens*, and 3. the *corpus vitreum*, *glass body*. The coats of the eye are concentrically laminated and consist, from the outside in, of 1. the *tunica fibrosa oculi*, 2. the *tunica vasculosa oculi*, and 3. the *retina*.

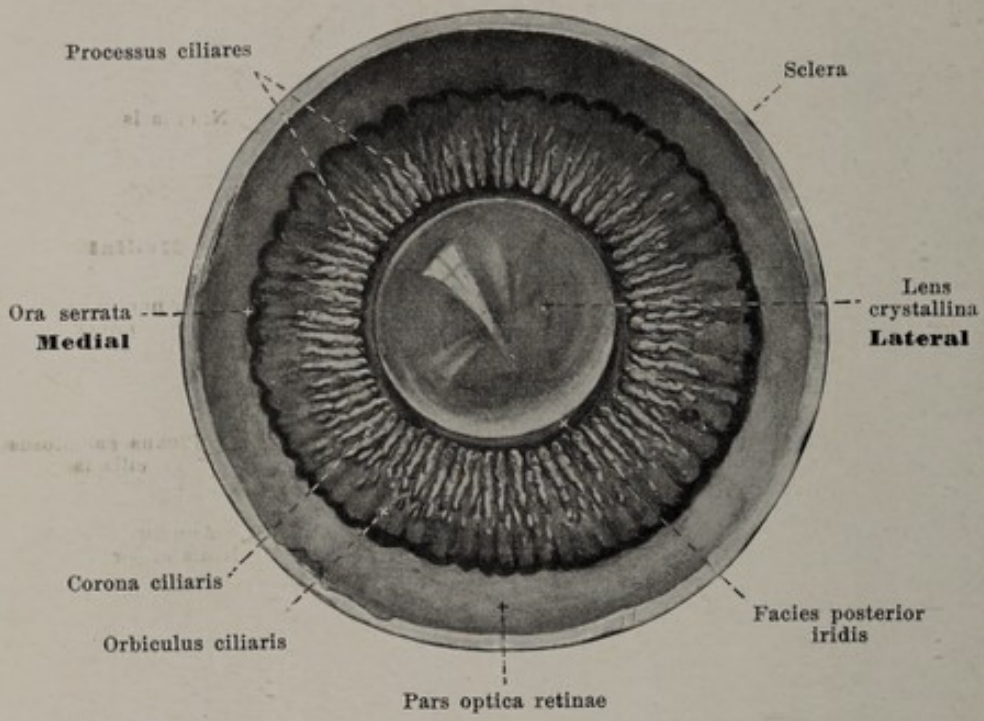
The **tunica fibrosa oculi** (see Figs. 893 and 895) is a tough, thick membrane completely enclosing the eyeball, and conditioning its form. About five-sixths of it consists of the non-transparent *sclera*, one sixth of the transparent *cornea*, which surrounds the anterior pole.

The ***sclera***, *white* or *hard coat of the eye* (see Figs. 893, 895, 900, 904, 905, 923 and 924), is a tough connective tissue membrane, usually of a pure white color. It is thickest at the entrance of the optic nerve, the sheaths of which go over directly into it, and passing forward it becomes gradually thinner as far as the attachments of the straight eye-muscles, the tendon bundles of which interweave with it and strengthen it in its most anterior part. It is loosely covered in its anterior part by the conjunctiva bulbi, and is thus far also visible in the lid-slit as the white of the eye (see Figs. 927 and 928). In front the non-transparent bundles of the sclera go over directly into the transparent ones of the cornea; this transition occurs, so that the sclera in a way forms a groove, *rima cornealis*, for the reception of the margin of the cornea, *limbus corneae*. Just behind this transition in a furrow of the sclera, runs a circular blood-vessel, *sinus venosus sclerae [canalis Schlemmi, Lauthi]* (see p. 802), which is bounded internally by the lig. pectinatum iridis. The sclera is perforated behind by the n. opticus; bundles of connective tissue arranged in the form of a net-work separate the individual bundles of nerve fibres from one another and form a perforated plate, *lamina cribrosa sclerae*, for the passage of the latter. In addition the sclera possesses openings for the passage of the aa., vv. and nn. ciliares.

897. Anterior part of a right eye, viewed from behind.

Magnification: 3:1.

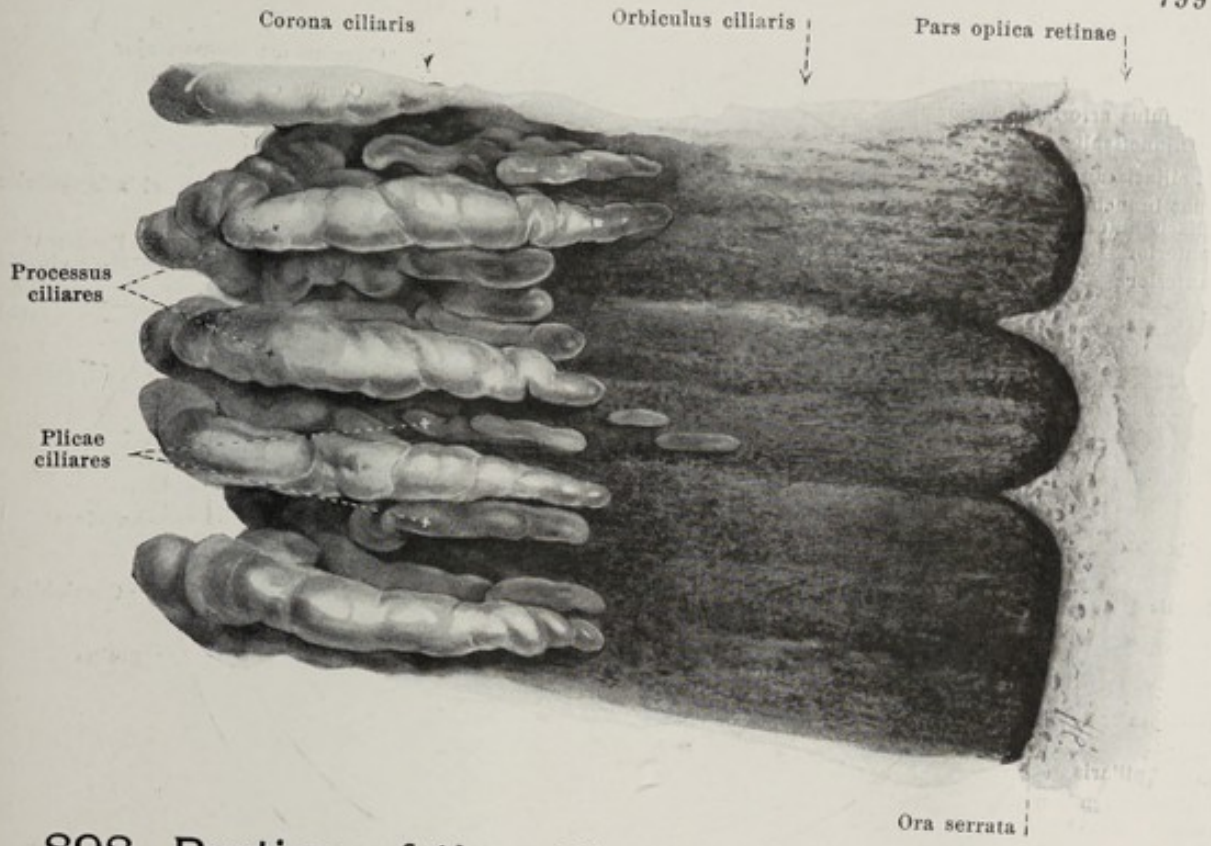
(The zonula ciliaris [Zinni] has not been represented.)



Sclera (continued): On its outer surface it is united by a delicate net-work with the surrounding fascia bulbi [Tenoni] (see p. 816), which, however, does not inhibit the movability of the eyeball. Its innermost layer lies everywhere in direct contact with the tunica vasculosa, is colored brownish by numerous pigment cells, and is accordingly called the *lamina fusca sclerae.*

The ***Cornea*** (see Figs. 893, 895, 924, 927 and 928) is a colorless, transparent and non-vascular connective tissue membrane, and has the shape of a flat, round bowl curved so as to be convex in front, concave behind. At its margin, *limbus corneae* (see p. 797), the sclera above and below reaches somewhat farther forward than medially and laterally; hence the circumference of the cornea viewed from in front looks like an ellipse with its longest diameter placed transversely; viewed from behind it is circular. The anterior surface of the cornea resembles approximately an ellipsoid of rotation only in the zone of the pole; it is thereby a little more markedly curved in the vertical direction than in the transversal. Its thickness is greater than that of the neighboring sclera, but diminishes gradually from the margin on and is least at the point of greatest convexity, the *vertex corneae.* The convex, anterior surface, *facies anterior,* lies free to view in the lid-slit and is covered by the *epithelium corneae,* an indirect continuation of the epithelium of the conjunctiva bulbi, which is attached for the most part loosely on the anterior surface of the sclera and is connected with it firmly only in a narrow, often ridge-like strip, *annulus conjunctivae,* immediately surrounding the cornea, and which then goes over without sharp limit into the anterior layers of the cornea. The epithelium corneae rests upon the narrow, very transparent *lamina elastica anterior [Bowmani],* and this goes over behind into the laminated *substantia propria,* which forms the main mass; then follows the *lamina elastica posterior [Demoursi, Descemeti],* which resembles the anterior but is thinner, and finally the *endothelium camerae anterioris;* this covers the facies posterior of the cornea, forms the anterior boundary of the anterior chamber of the eye filled with aqueous humor, and is continuous lateralward upon the angulus iridis.

The **tunica vasculosa oculi** (see Fig. 893) with its main mass lies directly on the inner surface of the sclera; only its most anterior portion, the *iris,* projects inward free into the bulbus from the region of the rima cornealis, approximately transversely to the optic axis. The part lying against the sclera is divisible into a larger, posterior, smooth portion, the *chorioidea,* and a narrow, anterior, ridged portion, the *corpus ciliare;* it is firmly fused with the sclera behind only at the entrance of the optic nerve and in front at the rima cornealis, but otherwise is separated from it by a slit-like space, *spatium perichorioideale,* transversed by numerous fine, pigmentholding lamellae, which is bounded externally by the lamina fusca sclerae (vide supra) and internally by the most superficial layer of the chorioidea, the *lamina suprachorioidea,* and is perforated by some vessels and nerves. All portions of it are very delicate and contain an extraordinarily large number of blood vessels, numerous nerves and ganglia; the corpus ciliare and the iris contain smooth muscles in addition.

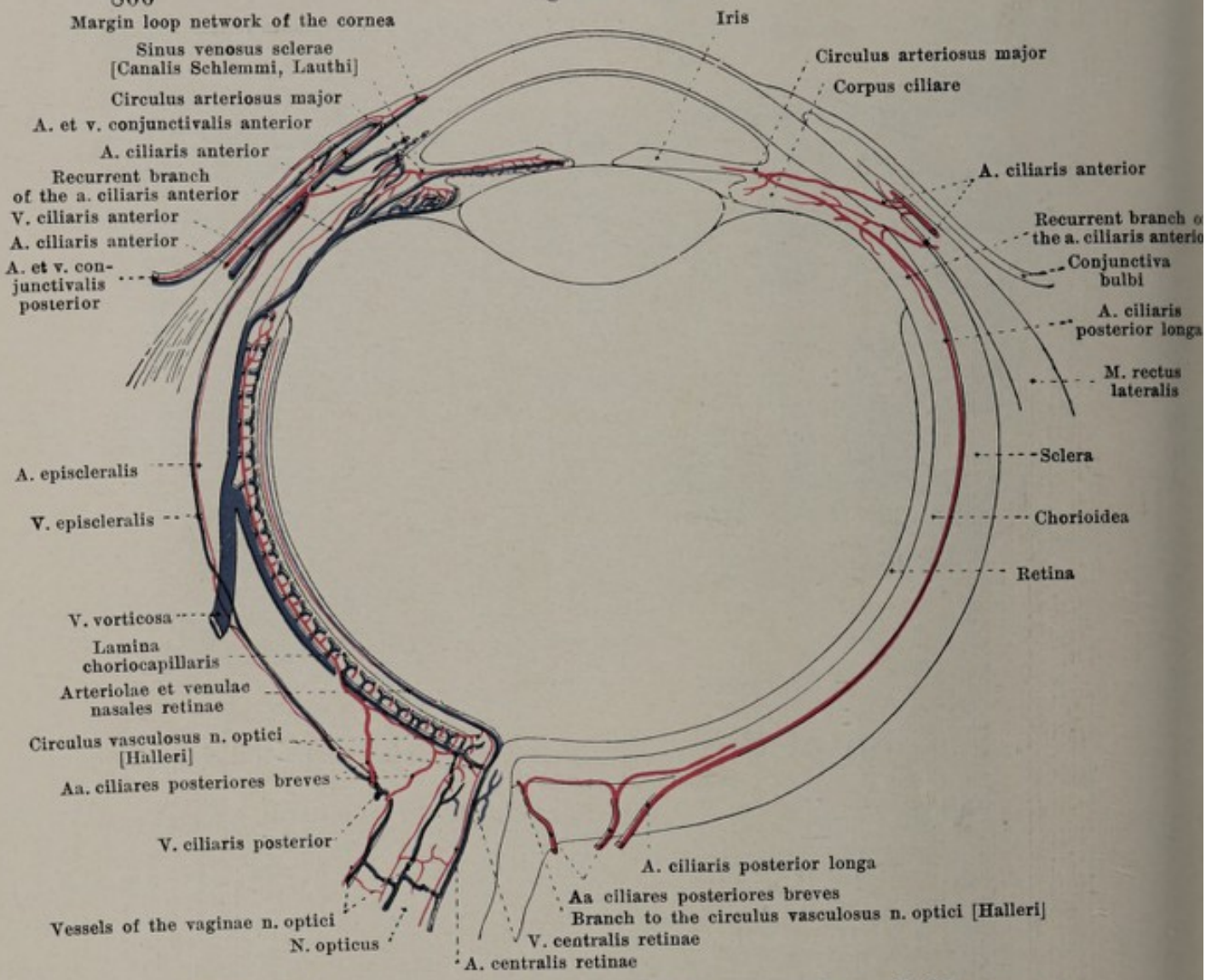


898. Portion of the ciliary body, viewed from behind.

Magnification: 25 : 1.

Chorioidea, *choroid coat of the eye* (see Figs. 893, 895, 896, 904 and 905), is very thin, includes approximately the posterior two-thirds of the eyeball, and is sometimes lighter, sometimes darker, according to the amount of pigment it contains. It possesses behind a round opening for the passage of the optic nerve. In it five layers are distinguishable microscopically. Upon the *lamina suprachorioidea* (see p. 798) follows the pigmented *lamina vasculosa* with the coarser vessels, namely the roots of the vv. vorticosae (see Fig. 900) and nerves; then the *layer of medium-sized vessels,* then the non-pigmented *lamina choriocapillaris* with the blood capillaries and upon this the *lamina basalis;* in contact with the latter is the stratum pigmenti of the retina, which remains attached to it even after separation of the retina (during life and after death).

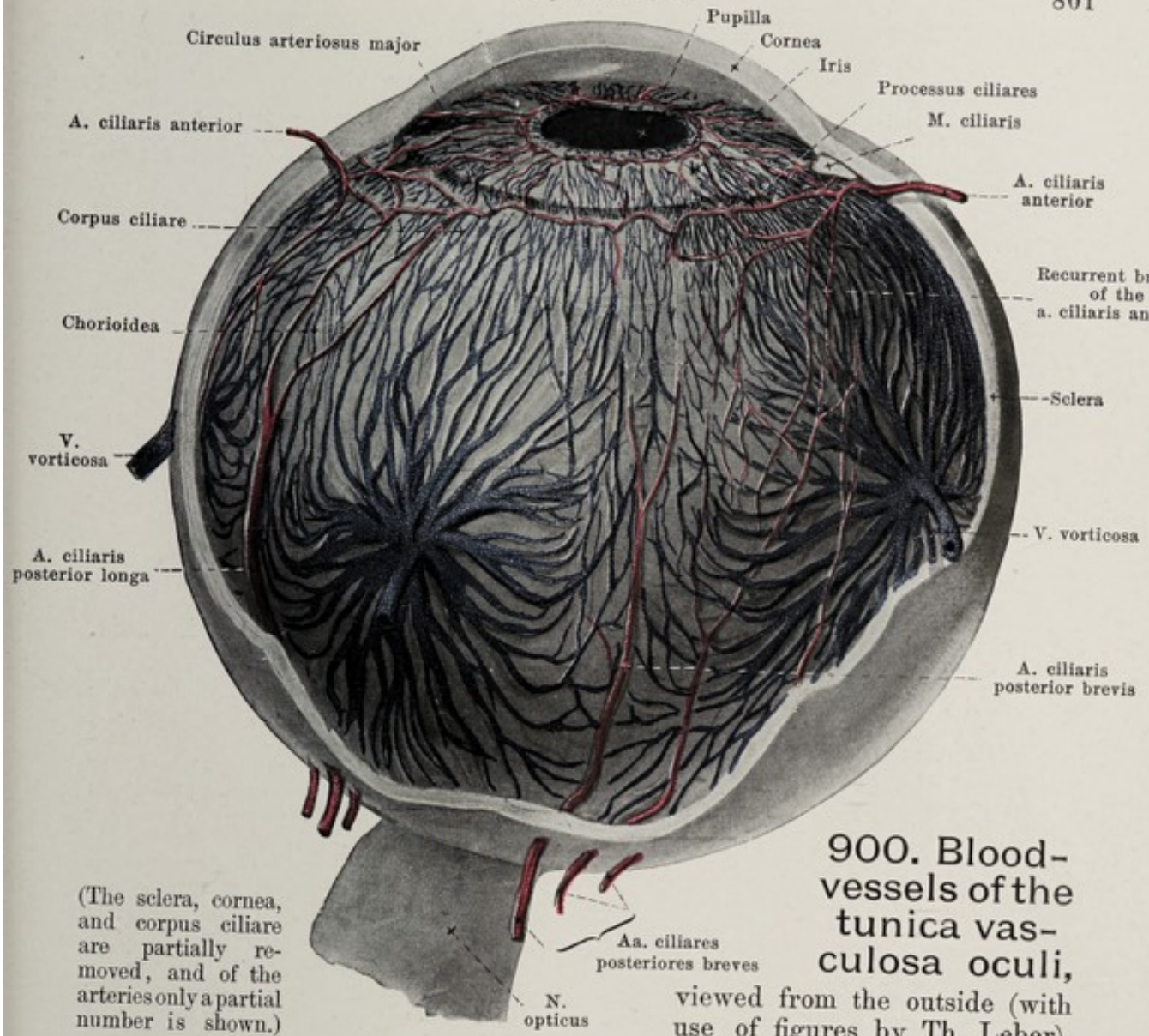
Corpus ciliare, *radiating body, ciliary body* (see also Figs. 893, 895—897, 899 and 900), reaches from the ora serrata retinae (see p. 804) to the margo ciliaris of the iris and is lined inside by the *pars ciliaris retinae,* which is but little pigmented on the combs of the ciliary processes and folds. Its posterior portion, *orbiculus ciliaris,* approximately 4 mm broad, differs from the chorioidea essentially by the absence of the lamina choriocapillaris and by the addition of muscle fibres; the inner surface presents fine, meridionally placed, markedly pigmented grooves which often go out from the tips of the teeth of the ora serrata. The anterior portion of the ciliary body forms a three-sided circular ridge parallel to the equator, and is formed chiefly by the m. ciliaris. Its external anterior surface lies against the sclera: its internal surface is united with the margo ciliaris of the iris and otherwise adjoined to the chambers of the eye; its posterior surface adjoins to the vitreous body. From the posterior and internal surfaces about seventy narrow, meridionally placed, glistening white, markedly ridged, very vascular folds, *processus ciliares, ciliary processes,* arise, which are low where they begin laterally and end with a margin projecting internally over the margo ciliaris of the iris (see Fig. 906); in the upper nasal portion they are longer and higher and more widely separated. Between them lie smaller folds, *plicae ciliares.* The totality of processes and folds is called the *corona ciliaris.* The *m. ciliaris* (see Fig. 895) appears as a trilateral-prismatic, light ring of smooth muscle fibres, which arise largely from the internal wall of the sinus venosus sclerae; it is innervated by fibres which arise from the n. oculomotorius and pass the ciliary ganglion. The fibres adjoining the sclera, *fibrae meridionales [Brueckei]* run in a meridional direction and extend as far as into the chorioidea; connected with them are fibres diverging backward in meridional planes and uniting in the form of net-works with one another and with the others; in addition near the inner posterior angle are fibres which run circularly, *fibrae circulares [Muelleri],* especially developed in hypermetropic eyes. In the m. ciliaris the nn. ciliares form a circular plexus, *plexus gangliosus ciliaris* (see Fig. 896), with numerous ganglion cells.



899. Scheme of the bloodvessels of the eye

(after Th. Leber) (see Fig. 893). Magnification: ca. 4:1.

Iris, *rainbow coat* (see Figs. 893, 895 and 896), is a round disc with a round opening, *pupilla (star of the eye, pupil)*, which usually lies centrally, and not infrequently, deviates from it somewhat downward and nasalward. At its outer, attached margin, *margo ciliaris*, it proceeds from the ciliary body, and by its inner, free margin, *margo pupillaris*, it rests on the anterior surface of the lens. Its medial margin lies in front of the plane of the fixed margin (see Fig. 893), so that the whole disc has the form of a very flat funnel. On widening of the pupil it becomes narrower and thicker. Its greatest thickness lies near the margo pupillaris and corresponds to the junction between the annuli iridis (vide infra); from there on it diminishes slowly toward the thin margo ciliaris, quicker so toward the margo pupillaris. The anterior surface, *facies anterior* (see Figs. 895 and 896), is visible through the cornea as far as the marginal part. It looks blue when pigmentless, gray or gray-green when the stroma contains a little pigment, brown when it contains much pigment; the color is often unsymmetrical, darker near the pupil than in the periphery. Somewhat lateralward from the margo pupillaris runs a jagged line, which separates a narrow, inner zone, *annulus iridis minor*, from a broader, outer, *annulus iridis major*. In the former, small, anastomosing cords run to the margo pupillaris, which itself is formed by a fine, notched, darkbrown edge belonging to the stratum pigmenti iridis (see Figs. 895 and 896). In the outer zone run in addition to radiating cords (walls of blood-vessels) several usually incompletely circular contraction grooves, *plicae iridis*, concentric to the margo pupillaris. Small hollows (crypts) of very varying shape and number are also visible on the anterior surface. The posterior surface of the iris, *facies posterior*, is covered by the *stratum pigmenti iridis*, is uniformly black and is studded with very fine radiating and finest circular folds.



(The sclera, cornea, and corpus ciliare are partially removed, and of the arteries only a partial number is shown.)

900. Blood-vessels of the tunica vasculosa oculi,

viewed from the outside (with use of figures by Th. Leber).

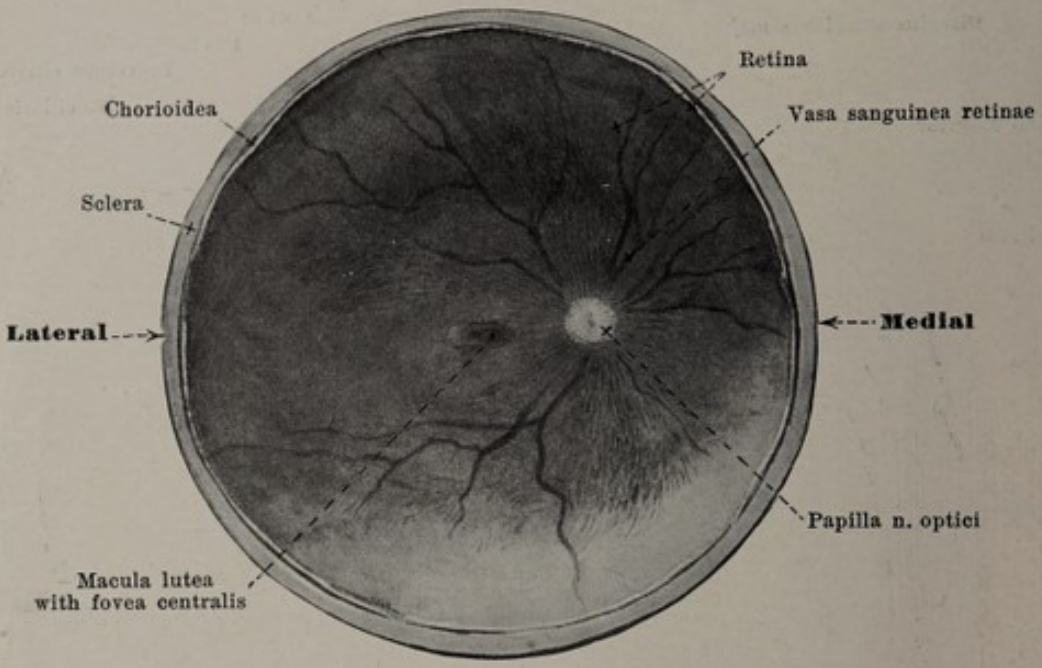
Magnification: ca. 4:1.

Iris (continued) (see Figs. 893 and 895) consists mainly of the soft *stroma iridis* rich in bloodvessels and more or less pigmented; in its posterior part it contains close to the margo pupillaris a circular muscle, *m. sphincter pupillae*, innervated by fibres of the n. oculomotorius which pass the ganglion ciliare, and the fibres of the *m. dilatator pupillae* (innervated by sympathetic fibres of the nn. ciliares longi), diverging from it toward the periphery; the latter are differentiated parts of the cells of the anterior layer of the stratum pigmenti iridis from which develop all the muscle fibres of the iris.

The groove in front of the margo ciliaris iridis is called the *angulus iridis* (see Fig. 895 and p. 807). It is bounded externally by a network of circular strands covered by endothelium, the *lig. pectinatum iridis;* between the strands are oblong spaces, *spatia anguli iridis [Fontanae].* This network of strands forms the inner boundary of the sinus venosus sclerae (see pp. 797 and 802), is connected in front with the deepest layer of the cornea, behind with the margo ciliaris iridis and gives origin to a large part of the m. ciliaris.

Bloodvessels of the tunica vasculosa oculi. A. *Arteries* (see also Fig. 899).

1. *Aa. ciliares posteriores breves* (see also p. 416) give fine branches to the posterior half of the external surface of the sclera and perforate the sclera by about twenty branches in the neighborhood of the n. opticus; they run forward in the lamina vasculosa chorioideae and break up in the close capillary network of the lamina choriocapillaris. In front they unite with fine, recurrent branches of the aa. ciliares posteriores longae and ciliares anteriores. Some branches from these vessels in the sclera close to the exit of the n. opticus form a closed, vascular circle, *circulus vasculosus n. optici [Halleri],* from which branches enter into the n. opticus and anastomose with branches of the a. centralis retinae.



901. Posterior half of a right eye, viewed from in front.
Magnification: 4:1.

2. *Aa. ciliares posteriores longae* (see p. 416 and Figs. 899 and 900), two, perforate the sclera very obliquely in the neighborhood of the n. opticus and in the horizontal meridian, one on the lateral, the other on the medial side of the eyeball, pass forward in the lamina suprachorioidea as far as the corpus ciliare. There each divides into two diverging branches, which near the margo ciliaris iridis along with the branches of the other corresponding artery and with those of the aa. ciliares anteriores form a large, circular anastomosis, *circulus arteriosus major* (see also Fig. 895), and which give branches to the m. ciliaris.

3. *Aa. ciliares anteriores* (see p. 416 and Figs. 899 and 900), usually 5—6, give off on the external surface of the sclera 1. backward fine branches, *aa. episclerales*, to the anterior half of the same and 2. forward branches, *aa. conjunctivales anteriores*, to the conjunctiva bulbi, which anastomose with the aa. conjunctivales posteriores from the aa. palpebrales mediales and laterales (see pp. 416 and 417) and give off fine branches to the extraordinarily delicate marginal *loop network of the cornea*, situated in the annulus conjunctivae. They then perforate the sclera with 8—10 branches in the region of the m. ciliaris, send branches to this and enter the *circulus arteriosus major* (vide supra). From this branches pass to the m. ciliaris, to the processus ciliares, as well as recurrently to the union with the aa. ciliares posteriores breves; besides, numerous branches pass out of it into the iris and run in its anterior layers toward the margo pupillaris, part of them reaching this, part of them branch off shortly before this without anastomosing with one another.

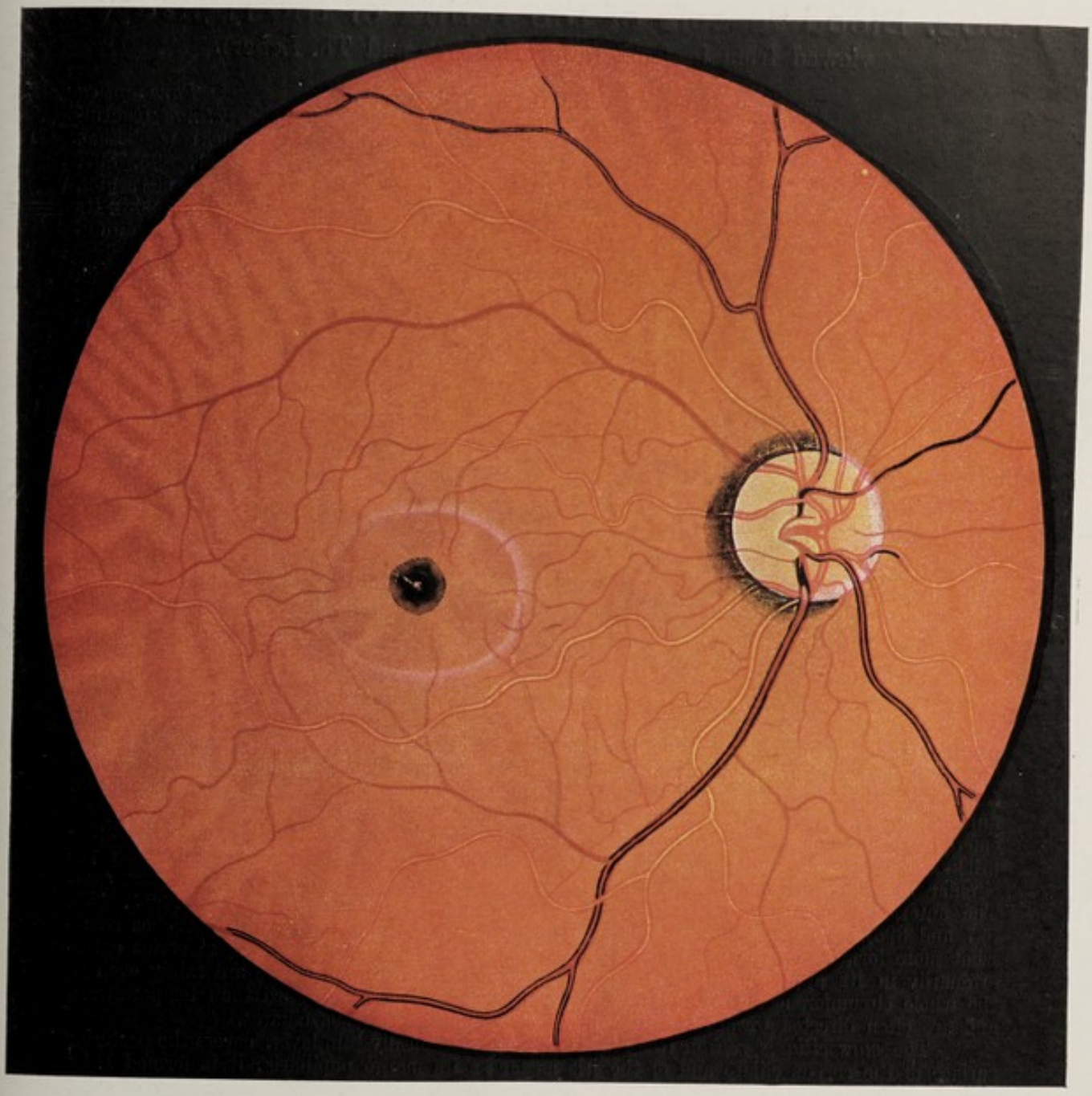
B. *Veins* (see pp. 460 and 461 and Figs. 899 and 900).

1. *Vv. vorticosae*, 4, more rarely 5 or 6, form the chief channels of exit for the blood; they arise by the running together, in groups radially toward 4 (5 or 6) spots on the equator, of the veins proceeding from the capillary network of the lamina choriocapillaris, and of numerous large branches from the corpus ciliare and from the iris in the lamina vasculosa chorioideae; they then perforate the sclera very obliquely and open into a v. ophthalmica.

2. *Vv. ciliares anteriores* perforating the sclera near the aa. ciliares anteriores, are numerous derivatives of the *sinus venosus sclerae [canalis Schlemmi, Lauthi]* (see also p. 797 and Fig. 895), a circular venosus plexus, which receives small branches from the m. ciliaris. Upon the sclera they receive farther the *vv. conjunctivales anteriores* and *vv. episclerales*, corresponding to the arteries of the same name. They open into the veins of the mm. recti of the eye.

3. *Vv. ciliares posteriores* collect the blood near the n. opticus upon the external surface of the sclera from the vessels situated upon the surface of the latter and anastomose in front just as do the vv. episclerales with the vv. vorticosae. They therefore do not correspond to the aa. ciliares posteriores.

Nerves of the eyeball. The *nn. ciliares longi* and *breves* (see p. 714) perforate the sclera with about 20 branches in the neighborhood of the n. opticus, run forward in the lamina suprachorioidea, form the *plexus gangliosus ciliaris* (see p. 799 and Fig. 896) in the m. ciliaris, and send branches to the chorioidea, sclera, cornea, corpus ciliare and iris.



902. Background of a living right eye.

(After J. Oeller.)

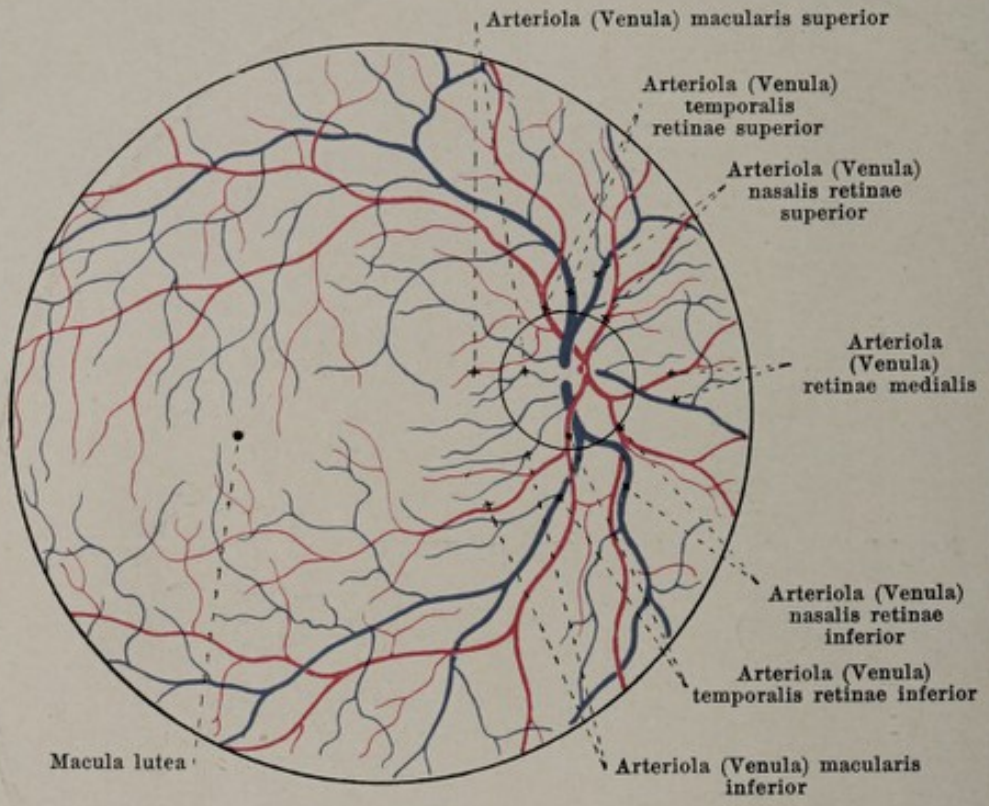
(The vv. vorticosae are partially visible as light stripes; the arteries of the retina look lighter than the veins.)

Retina (see also Figs. 893, 895, 897—899, 901 and 903—905) lies everywhere directly adjacent internally to the tunica vasculosa oculi, and is divisible into a larger posterior portion, *pars optica retinae*, which contains the expansion of the n. opticus, as well as the sensory epithelium, sensitive to light, and a smaller anterior portion, *pars ciliaris retinae*, which belongs to it embryologically, but which possesses neither nerves nor elements sensitive to light. The junction between the two portions is formed by the *ora serrata* (see p. 804).

The *pars optica retinae* is smooth and transparent like glass in the living eye and permits the stratum pigmenti and the chorioidea lying external to it to appear as dark-red surfaces, their distinctly visible details varying according to the pigmentation; the blood-vessels of the retina lie internally upon it.

903. Blood vessels of the retina of the right eye,

viewed from in front (after E. Jäger and Th. Leber).

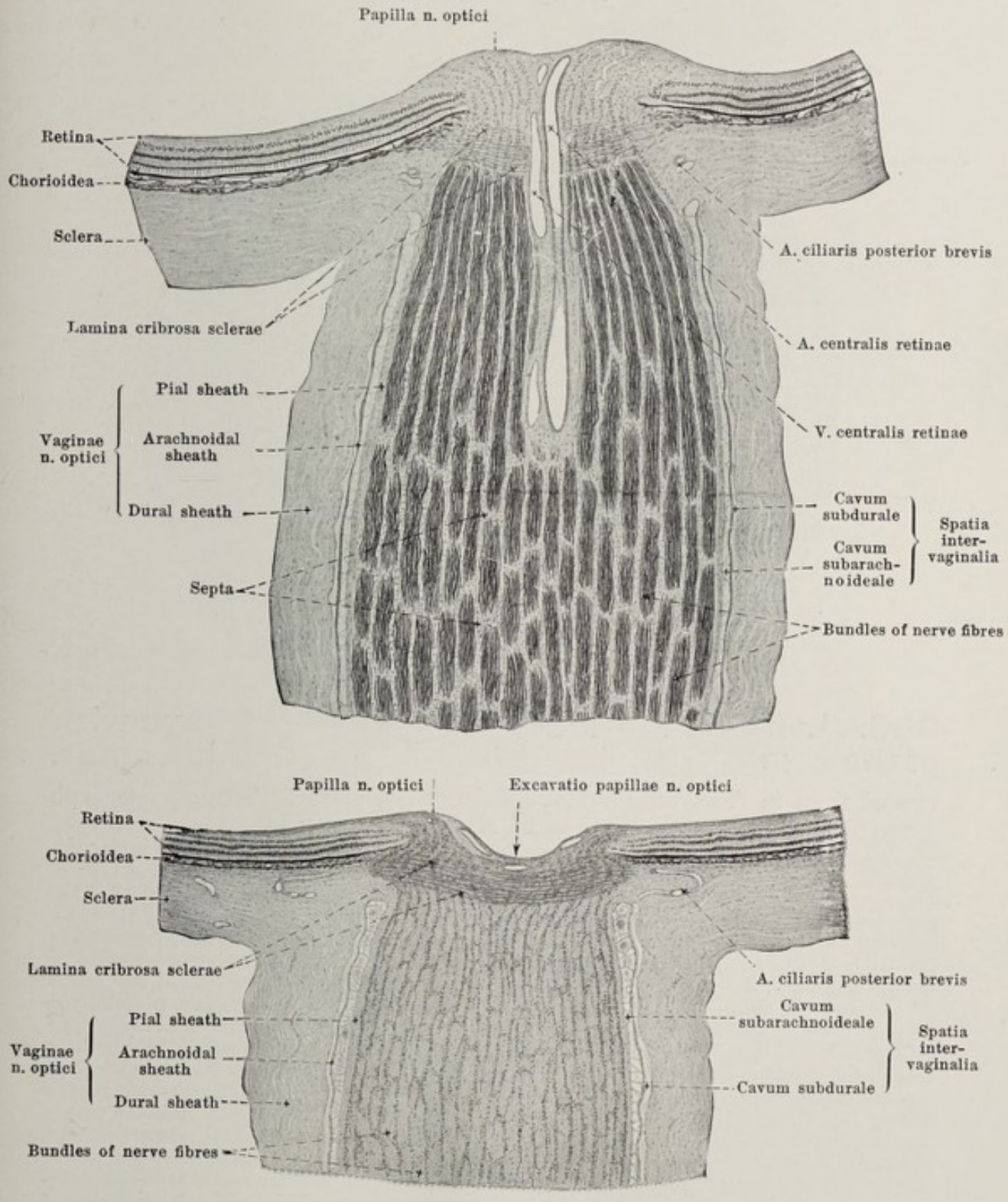


Pars optica retinae (continued) (see Figs. 893, 895, 897, 898, 901, 902, 904 and 905). Its thickness diminishes slowly from the papilla n. optici (vide infra) forward. The n. opticus after perforating the sclera, chorioidea and retina arrives on the inner surface of the retina, whence it spreads out on all sides; the place where it enters, situated medianward from the posterior end of the axis oculi externa and somewhat below it, has the form of a rounded hillock, *papilla n. optici* (see Figs. 893, 901, 902, 904 and 905), which is slightly depressed in the middle, or presents a fossa-like depression, *excavatio papillae n. optici (physiological excavation)*, reaching as far as the level of the chorioidea; the papilla appears during life as a circular, whitish spot from the middle of which the blood-vessels of the retina emerge. About 4 mm lateralward from the centre of the papilla and a little deeper down lies a pin-prick-like depression, the *fovea centralis* (see Figs. 893, 901 and 902), in the middle of the circular or transversely oval, not sharply defined, yellow-colored *macula lutea, yellow spot.* The anterior boundary of the pars optica is formed by the *ora serrata* (see Figs. 893, 895, 897 and 898). This is a line with minute outward curved projections, which reaches somewhat more forward on the nasal side than on the temporal side, but otherwise varies extraordinarily in its appearance. Its teeth directly toward the corpus ciliare are rarely even in the whole circumference; they are more often better developed nasalward than temporalward and are often directed toward the interspaces between the processus ciliares.

The *pars ciliaris retinae* (see Fig. 895), a microscopically thin layer, covers the posterior surface of the corpus ciliare and of the iris as far as its margo pupillaris; it is formed 1. by the stratum pigmenti corporis ciliaris et iridis (vide infra) and 2. by an inner layer of cells, which is also pigmented on the iris, but is colorless on the corpus ciliare.

The outermost layer of the retina, which lies directly in contact with the tunica vasculosa, consists of a simple layer of pigmented cells, *stratum pigmenti*, which is designated on the pars optica retinae as the *stratum pigmenti retinae*, on the pars ciliaris retinae as the *stratum pigmenti corporis ciliaris* (see p. 799) and *stratum pigmenti iridis.*

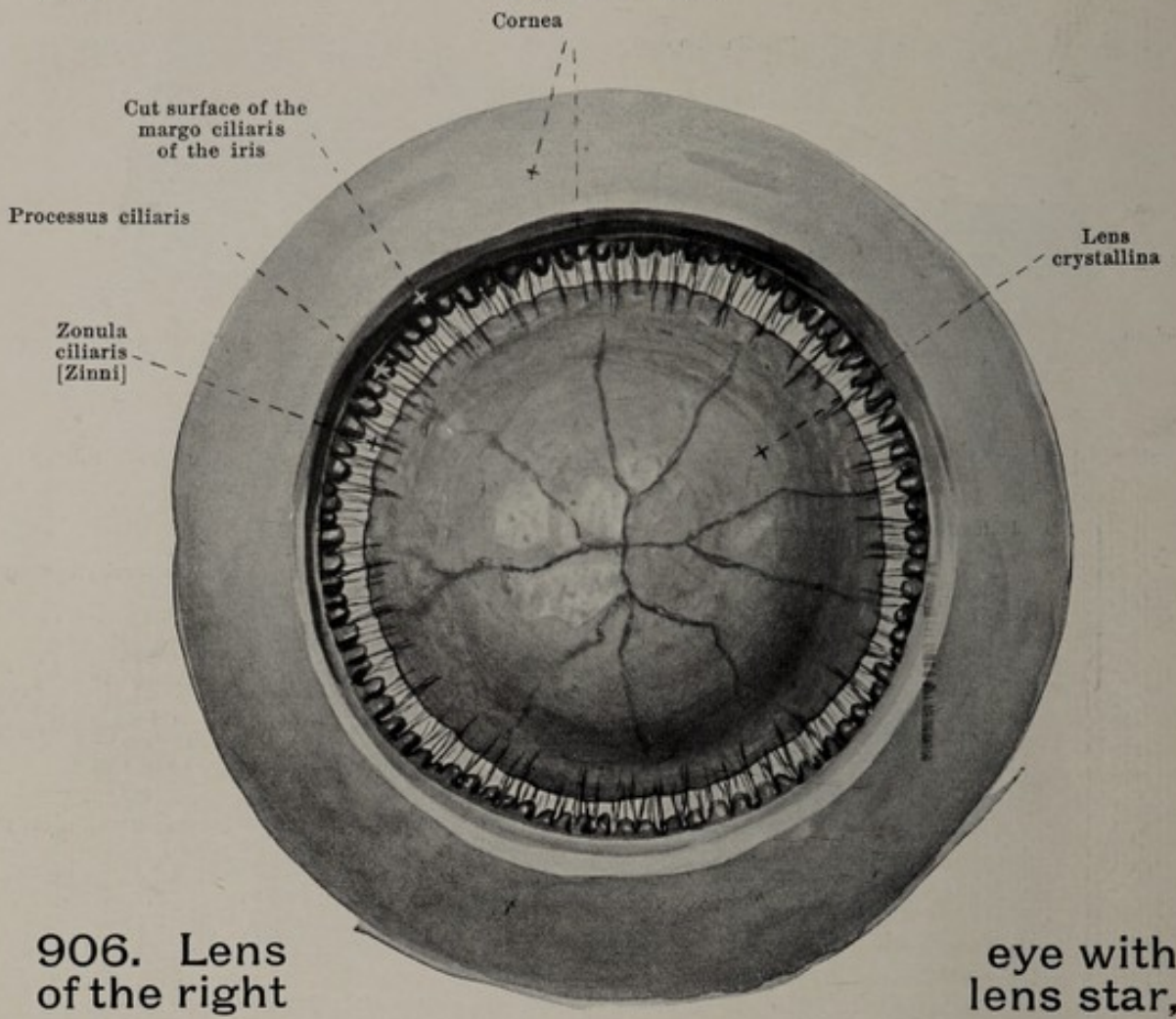
Vasa sanguinea retinae (see also Figs. 899 and 902) are branches of the a. and v. centralis retinae (see pp. 416, 460, 795), the larger branches of which lie in the layer of optic nerve fibres; arteries and veins run almost parallel with one another. The arteries of the retina do not anastomose with one another. Aside from the anastomoses with the aa. ciliares posteriores breves, mentioned on p. 801, they are completely separate from the vessels of the tunica vasculosa. The a. and v. centralis retinae divide on the surface of the papilla, or somewhat deeper, first into an upper and a lower branch, and each of these divides again into a shorter branch running nasalward, *arteriola (venula) nasalis retinae superior, inferior,* and a lateral, longer, *arteriola (venula) temporalis superior, inferior.* In addition two small vessels run from the papilla lateral to the macula lutea, *arteriola (venula) macularis superior, inferior,* and usually one vessel medianward, *arteriola (venula) retinae medialis.*



904 and 905. Longitudinal sections of the n. opticus and of the papilla n. optici,

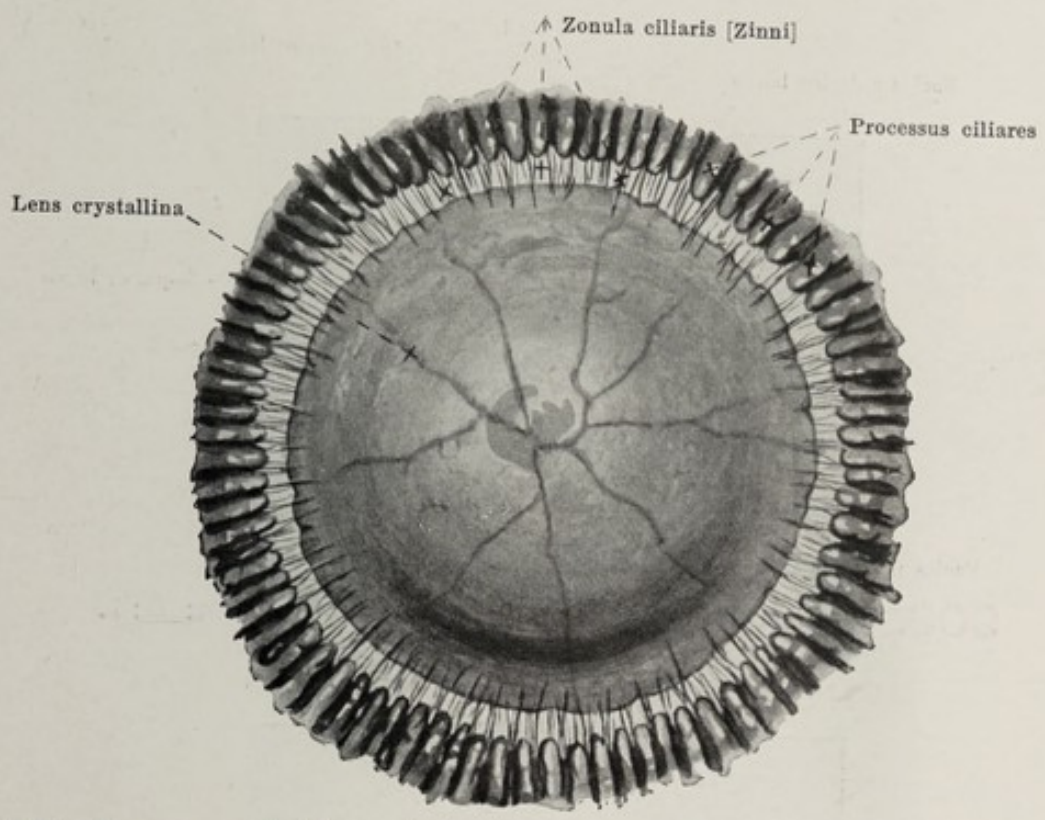
the upper without, the lower with the excavatio papillae n. optici (after preparations by H. Sattler). Magnification: 15:1.

(On the upper figure the medullated portions of the nerve fibres are shown dark; the lower section has not been cut axially.)



906. Lens of the right eye with lens star, viewed from in front, after removal of the cornea and iris (from a photograph by M. Wolfrum). Magnification: 6 : 1.

Lens crystallina, *lens* (see also Figs. 893, 895—897 and 907—910), is a very transparent, colorless, biconvex body, the two surfaces of which meet in a rounded, sometimes jagged margin, *aequator lentis*. The anterior surface, *facies anterior lentis*, is more feebly curved than the posterior surface, *facies posterior lentis*, neither corresponding, however, exactly to a portion of a spherical surface. Besides, the radius of the middle part of the lens surfaces differs according as the eye is fixed for near or distant objects; the radius of the anterior surface on fixation for distant objects, is 8.3 mm, for near 5.2 mm, the radius of the posterior surface on fixation for distance 6.0 mm, for near 5.0 mm. The midpoint of the anterior surface is called the *polus anterior lentis*, that of the posterior surface the *polus posterior lentis*, the straight line uniting the two is called the *axis lentis* and on fixation for distant objects is 3.7 mm, for near 4.4 mm long. The equatorial plane of the lens stands perpendicular to the axis of the eye, in the plane of the corpus ciliare. The lens is there held in position by the *zonula ciliaris [Zinni]* (see p. 807); its anterior surface touches the posterior surface of the margo pupillaris of the iris, and its posterior surface lies in the fossa hyaloidea of the corpus vitreum (see p. 807). The lens substance, *substantia lentis*, is ensheathed by a structureless membrane (thicker in front), *capsula lentis*, and consists of a softer, juicier cortical layer, *substantia corticalis*, and a firmer nucleus, *nucleus lentis*, which gradually go over into one another, their relations varying in different individuals. The lens substance consists of the one-layered cubical *lens epithelium, epithelium lentis*, covering its anterior surface, and the band-like *lens fibres, fibrae lentis*, making up the remaining mass, the two merging at the equator. These fibres run in curves from points in front of the equatorial surface to points behind it, in that way that fibres which originate in front near the pole, end behind far from it and vice versa. They are attached in front and behind to stellate collections of intercellular substance, which on maceration of the lens open up as slits. These *lens stars* have three rays, *radii lentis*, in the fetus and new-born, of which one on the anterior surface is directed upward, the others downward and medianward and downward and lateralward; on the posterior surface they are displaced by 60°.



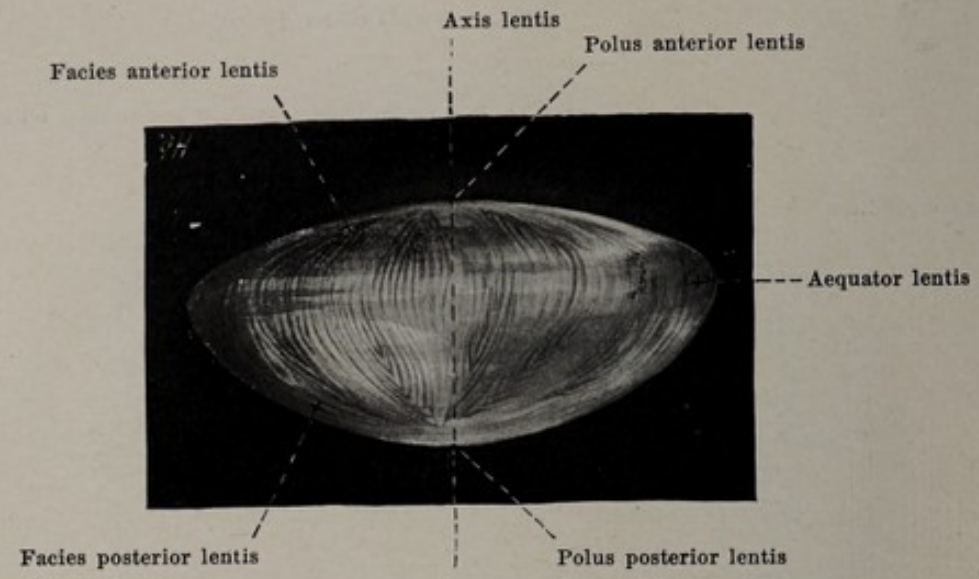
907. Lens of the right eye with lens star, viewed from behind, after removal of the cornea and iris (after C. Rabl). Magnif.: 6 : 1.

Lens crystallina (continued) (see also Fig. 906). The *lens star* of the adult usually presents in the nucleus the triradiate type; in the external layers it is nine- to twelve-rayed, alternating usually on the anterior and posterior surfaces so that one anterior ray lies in the middle between two posterior and vice versa.

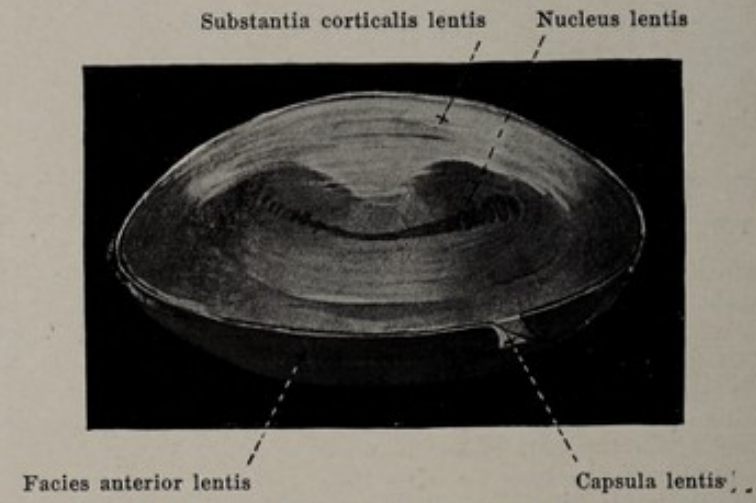
The **zonula ciliaris [Zinni],** *radiate platelet* (see also Figs. 893, 895 and 906), is the suspensory apparatus of the lens and consists of innumerable extremely fine fibrils, *fibrae zonulares,* which originating in the cells of the pars ciliaris retinae in the region of the ora serrata, of the orbiculus ciliaris and the corpus ciliare, stretch radially to the equator of the lens and there enter the capsula lentis. In so doing they run only in the grooves between the processus ciliares. The fibres arising behind are distributed in several bands over the whole equator, those arising in front reach the lens behind it; accordingly the fibres undergo partial decussation. The large spaces between the fibres, *spatia zonularia,* are filled with aqueous humor and communicate freely among one another and with the part of the posterior chamber of the eye lying in front of them; behind they adjoin the anterior surface of the vitreous body.

Humor aqueus, *aqueous humor,* is a fluid, poor in albumen, which fills up the space between the anterior surface of the lens (and of the vitreous) and the posterior surface of the cornea. It is subject to a slow but steady flow, is probably produced mainly by the processus ciliares and is led away by filtration into the sinus venosus sclerae. The space filled with aqueous humor is divided by the iris into two compartments, the *camera oculi posterior* and *camera oculi anterior, posterior* and *anterior chambers of the eye* (see Figs. 893 and 895). The former includes also the spatia zonularia and is bounded behind by the vitreous booy, externally by the inner surface of the corpus ciliare and of the processus ciliares, in front by the iris and internally by the lens. The anterior chamber of the eye is surrounded in front by the cornea, behind by the iris and by that part of the anterior surface of the lens visible in the pupil; its gutter-like lateral margin which in front touches the cornea, behind the iris, and externally the lig. pectinatum iridis, is called the *angulus iridis* (see also p. 801).

Corpus vitreum, *vitreous* or *glassy body* (see Fig. 893), a colorless, transparent, gelatinous body, fills up the space between the retina and the lens, reaches forward as far as the zonula ciliaris and presents a fossa-like depression, *fossa hyaloidea,* for the reception of the posterior surface of the lens. It connects externally with the innermost layer of the retina and consists of a frame-work of very fine fibres, *stroma vitreum,* the meshes of which are filled with fluid, *humor vitreus.*

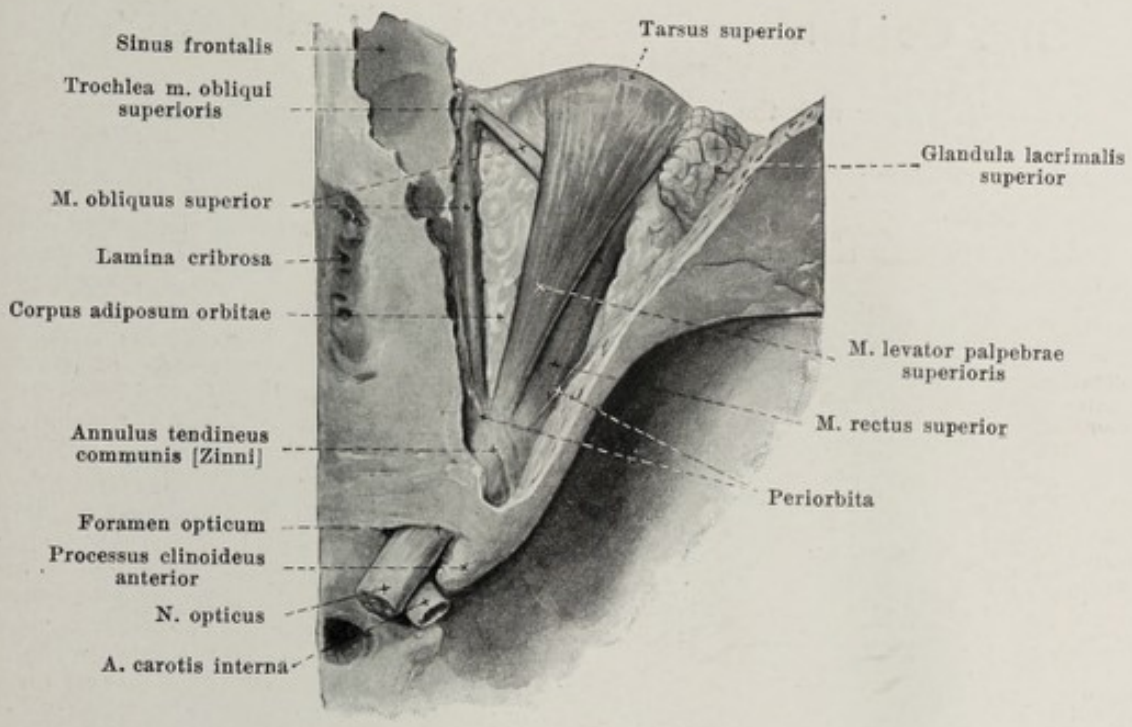


908. Lens, viewed from above. Magnification: 6:1.

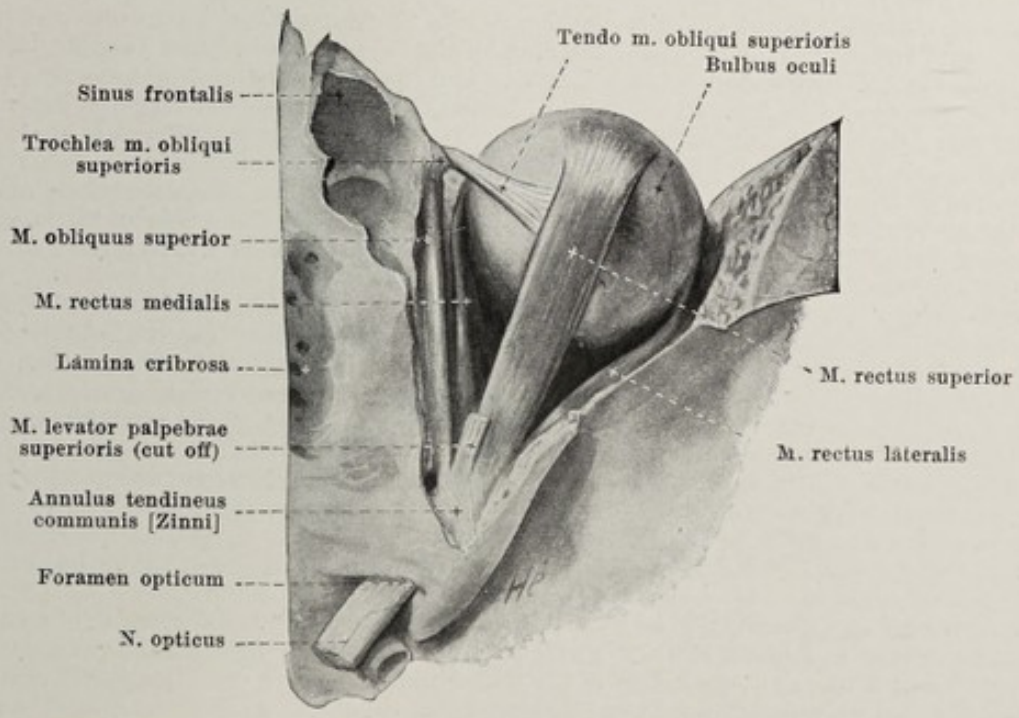


909. Lens, cut through horizontally. Magnification: 6:1.
(The capsule of the lens has been loosened somewhat.)

910. Lens of a seven months' fetus,
viewed from in front. Magnification: 6:1.



911. Contents of the right orbital cavity, viewed from above.

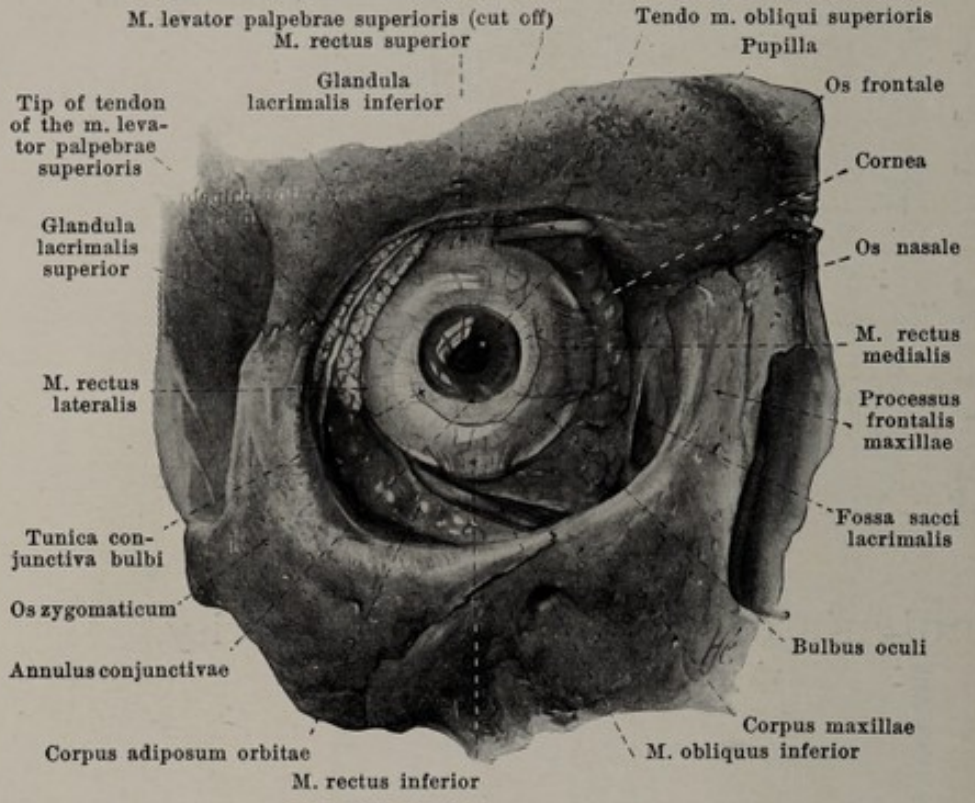


912. Muscles of the right eye, viewed from above.
(The m. levator palpebrae superioris, the corpus adiposum orbitae, the lachrymal gland and the eyelids have been removed.)

913. Contents of the right orbital cavity,

viewed from in front.

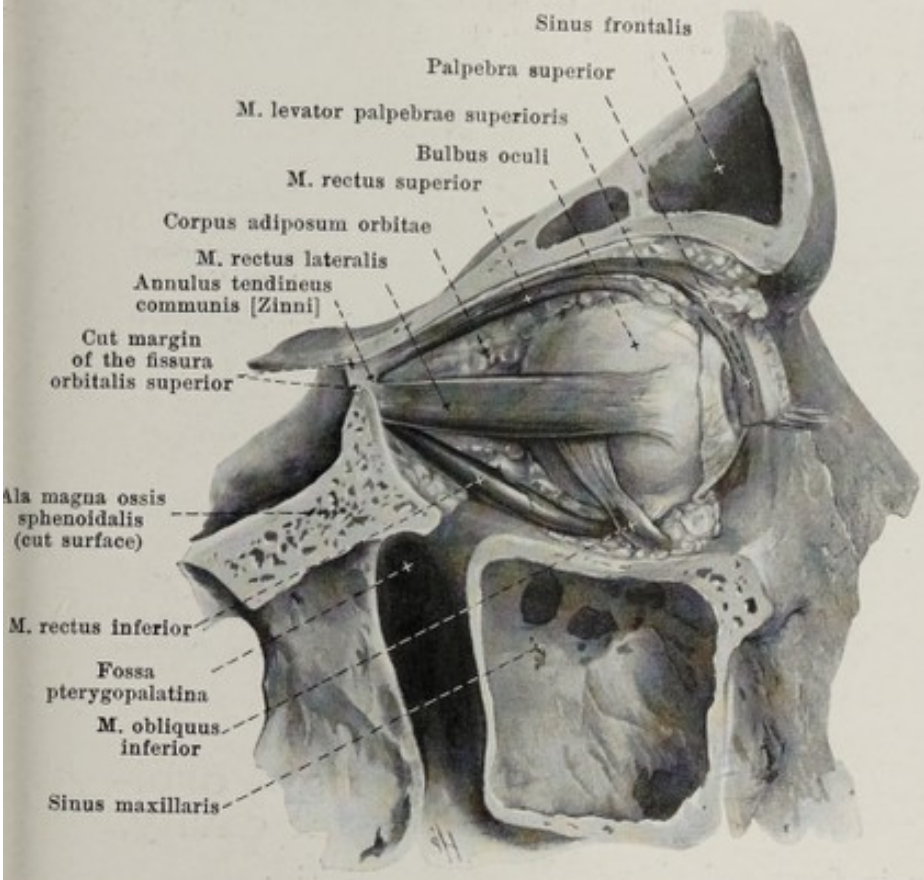
(The eyelids along with the tear sack and lachrymal canal have been removed.)



Musculi oculi, muscles of the eye (see also Figs. 911, 912 and 914—924). The mm. recti arise by a funnelshaped tendinous ring, *annulus tendineus communis [Zinni]* (see Figs. 911, 912 and 916), which passes around the upper medial margin of the foramen opticum and is attached lateralward to a bony process of the facies orbitalis alae magnae ossis sphenoidalis; it is very firmly connected with the dural sheath of the n. opticus, and with the tough membrane formed by the union of the periorbita with the dura mater encephali which closes the fissura orbitalis superior, and its transversely oval lumen surrounds the foramen opticum (with the n. opticus and the a. ophthalmica) and a part of the fissura orbitalis superior (with the nn. oculomotorius, nasociliaris and abducens). Of this tendinous ring (see Fig. 916) the origins of the mm. recti superior, medialis, inferior, lateralis take the superior, medial, inferior, lateral part; the origin of the m. rectus lateralis is strengthened by a second head, which arises through the *lacertus musculi recti lateralis* somewhat lateralward on the facies orbitalis of the ala magna oss. sphenoidalis. The m. levator palpebrae superioris arises immediately above the tendinous ring, and is there fused with it. The origin of the m. obliquus superior lies medial on the body of the sphenoid bone a little in front of the foramen opticum and above joins the origin of the preceding muscle.

1. *M. levator palpebrae superioris* (see also Figs. 911, 912, 914—916 and 920—924). Form: oblong-triangular, flat. Position: chiefly directly beneath the upper wall of the orbit. Origin: annulus tendineus communis [Zinni] (vide supra). Insertion: it passes from the equator of the bulbus in a curve downward and divides into two lamellae. The stronger, posterior, is attached fan-like to the whole upper margin of the tarsus superior and contains smooth muscle fibres, *m. tarsalis superior* (see also p. 820 and Figs. 924 and 930). The anterior lamella passes together with the septum orbitale in front of the tarsus downward and forward, attaches on the lateral wall of the orbit and sends bundles through the septum orbitale and the m. orbicularis oculi to the skin of the lid (to the sulcus orbitopalpebralis superior). Action: lifts the upper eyelid and causes the superior palpebral fold (see p. 821). Innervation: n. oculomotorius.

2. *Mm. recti* (see also Figs. 911—912 and 914—924) are oblong, flat muscles of parallel fibres, narrow behind and broad in front which all arise from the annulus tendineus communis [Zinni] (see above); they run forward close to the orbital wall (the upper one separated from it by the m. levator palpebrae superioris), pass in its anterior half through the fat body toward the eyeball, are situated upon it for some distance from the region of the equator on, and go over by broad, thin tendons in front of the equator into the sclera. The longest of them is the superior, next comes the medial, then the lateral, then the inferior. The mode of action of the mm. recti superior et inferior and of the mm. obliqui depends on the size of the angle between the visual line and the course of the muscle.



914. Contents of the right orbital cavity, viewed from the right.

(The glandulae lacrimales and the lower eyelid have been removed; the muscles are exposed.)

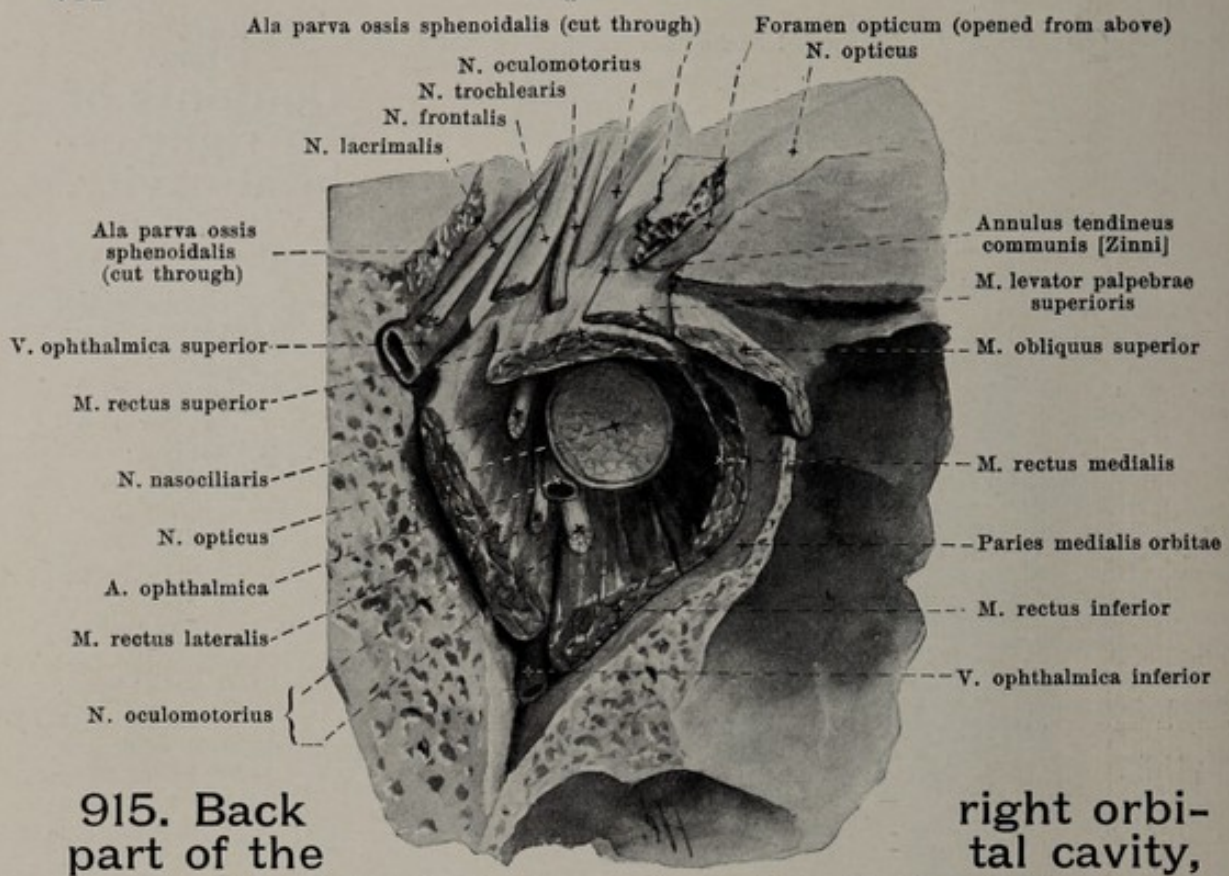
a) *M. rectus superior.* Position: just beneath the m. levator palpebrae superioris, projecting beyond it behind and lateralward; it passes forward and lateralward and forms an angle of about 25° with the visual line directed straight forward. Insertion: on the average 7.75 mm from the margin of the cornea; the line of insertion is 10.8 mm long, curved so as to be slightly convex forward, asymmetrical, oblique. Action: it draws the anterior pole upward and medianward and rolls the upper pole medianward. The influence of the elevating component is greatest on looking lateralward, that of the rotating on looking medianward. Innervation: n. oculomotorius.

b) *M. rectus medialis* (O. T. internal rectus). Position: on the medial wall of the orbital cavity. Insertion: on the average 5.5 mm from the margin of the cornea; the line of insertion is 11 mm long, curved so as to be slightly convex forward, usually symmetrical. Action: turns the anterior pole medianward. Innervation: n. oculomotorius.

c) *M. rectus inferior.* Position: on the inferior wall of the orbital cavity, separated from it in front by the m. obliquus inferior; it runs obliquely forward and lateralward and forms an angle of about 25° with the visual line directed straight forward. Insertion: on the average 6.6 mm from the margin of the cornea; the line of insertion is 10 mm long, usually curved so as to be markedly convex forward and symmetrical, always somewhat oblique. Action: it turns the anterior pole downward and medianward and rolls the upper pole lateralward. The influence of the depressing component is greatest on looking lateralward, that of the rolling on looking medianward. Innervation: n. oculomotorius.

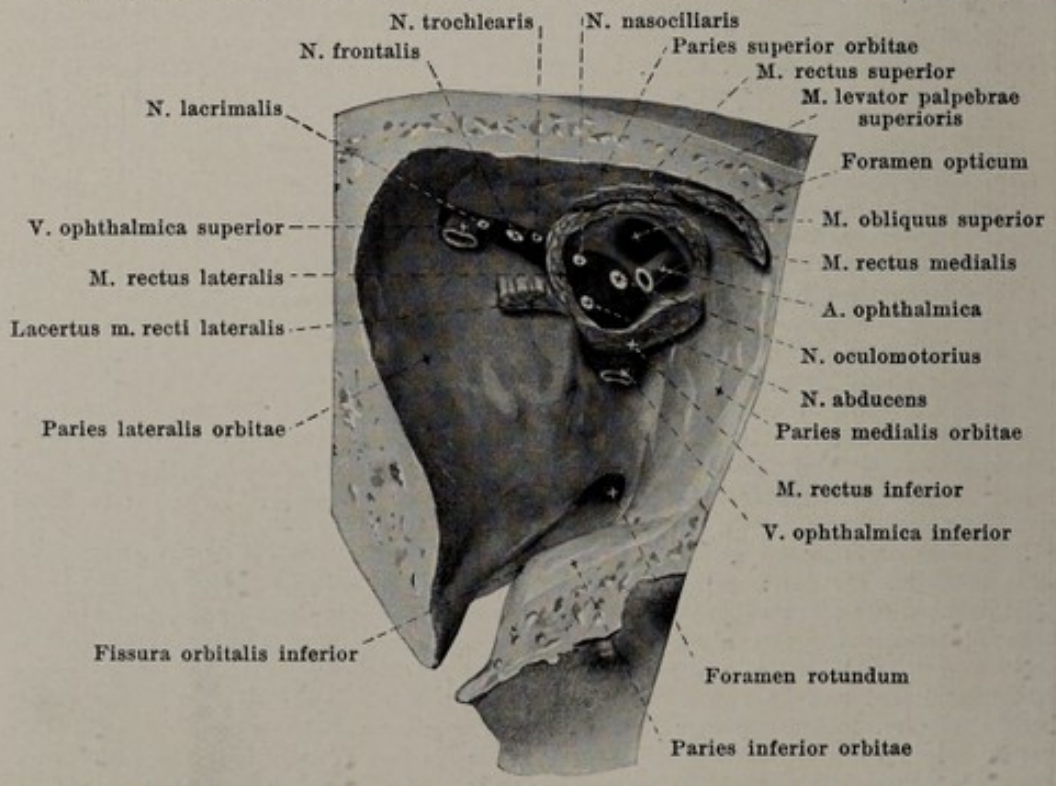
d) *M. rectus lateralis* (O. T. external rectus), with two heads (see p. 810). Position: on the lateral wall of the orbital cavity; it passes obliquely forward and lateralward. Insertion: on the average 7 mm from the margin of the cornea; the line of insertion is 10 mm long, curved so as to be slightly convex forward, usually symmetrical. Action: it turns the anterior pole lateralward. Innervation: n. abducens.

3. *M. obliquus superior* (see also Figs. 911—913, 915, 916, 918—922 and 924), the longest and thinnest eye-muscle. Origin: see p. 810. Insertion: It lies with its oblong rounded belly at the junction between the upper and medial walls of the orbit, directly on the bone, runs forward with its rounded tendon through a short fibrocartilaginous tube, *trochlea*, fastened to the fovea or spina trochlearis (here is a small bursa, *bursa trochlearis)* and bends at an angle of about 50° lateralward and backward through the fat to the bulbus; on this it passes on directly beneath the m. rectus superior and enters in a very variable manner behind the equator into the sclera by a tendon about 10 mm broad; its line of insertion is curved so as to be convex behind and lateralward, lies asymmetrically and obliquely (see Fig. 918) and is distant from the posterior end of the external axis of the eye by about 8 mm. Action: it turns the anterior pole downward and lateralward and rolls the upper pole medianward. The more the eye is directed medianward, the greater is the influence of the depressing component, the less that of the rolling. Innervation: n. trochlearis.



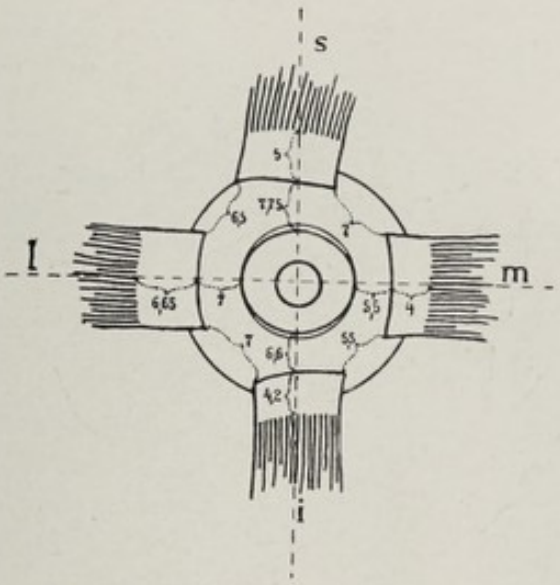
915. Back part of the right orbital cavity, viewed from in front and above. Magnification: 5:2.

(The fissura orbitalis superior and the foramen opticum have been opened from above.)



916. Origins of the muscles of the right orbital cavity, viewed from in front. Magnification: 3:2.

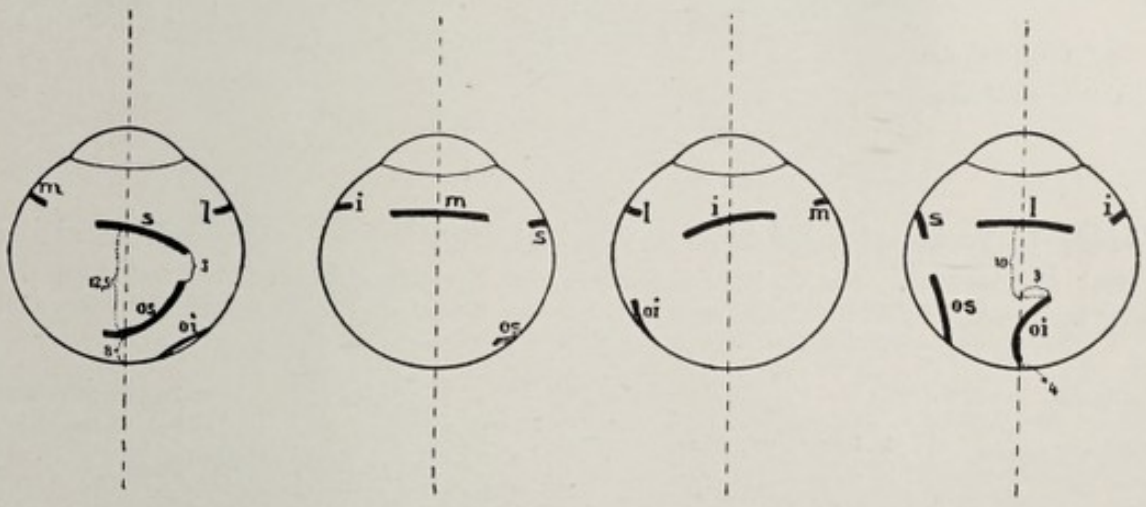
(The muscles, vessels and nerves have been cut off short.)



917. Insertions of the muscles on the right eyeball,

viewed from in front.

(The muscles have been pulled off from the eyeball.)



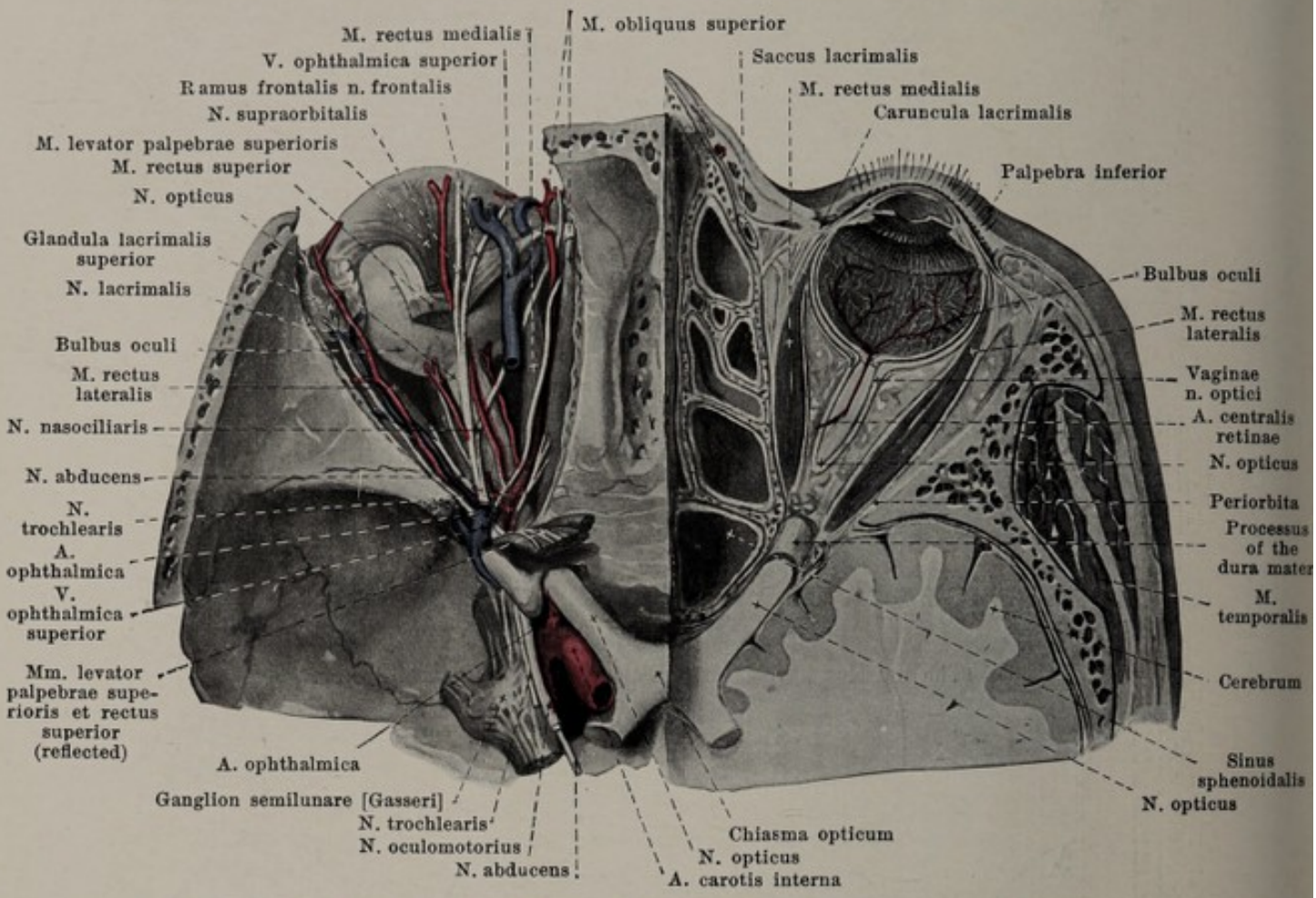
918. Insertions of the muscles on the right eyeball,

viewed from above. viewed from the medial side. viewed from below. viewed from the lateral side.

The Figs. 917 and 918 have been constructed from measurements made by H. Sattler.

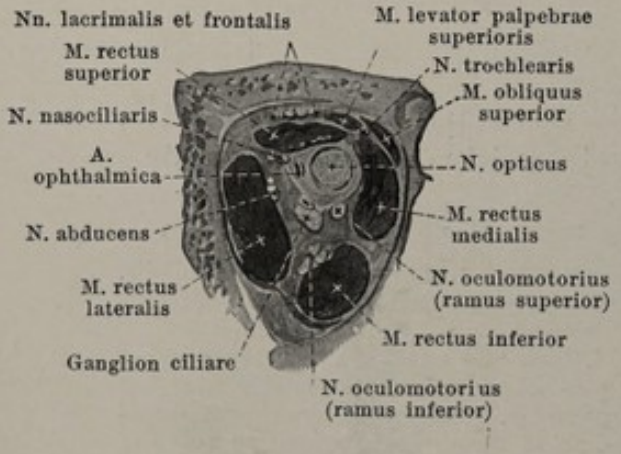
The figures indicate millimeters; s = m. rectus superior, m = m. rectus medialis, i = m. rectus inferior, l = m. rectus lateralis, os = obliquus superior, oi = m. obliquus inferior.

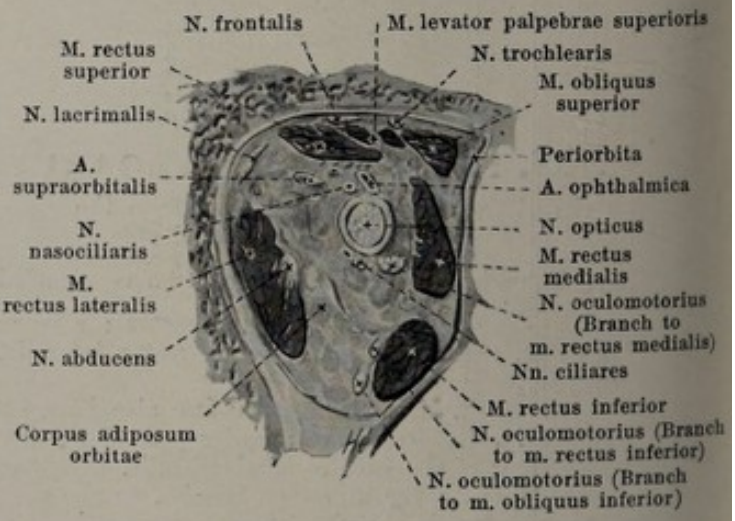
4. *M. obliquus inferior* (see also Figs. 913, 914, 923, 924 and 932), the shortest eye muscle, arises from the anterior part of the inferior wall of the orbit, just lateral from the beginning of the canalis nasolacrimalis, passes through the fat, lateralward, upward and backward, beneath the m. rectus inferior, to the posterior half of the eyeball forming an angle of about 50° with the visual line directed straight forward and enters the sclera in a very variable manner by a tendon about 10 mm broad at the horizontal meridian; the line of insertion is curved so as to be slightly convex upward and is distant at its medial end by about 4 mm from the external axis of the eye. Action: it turns the anterior pole upward and lateralward and rolls the upper pole lateralward. The influence of the elevating component is greatest on looking medianward, that of the rolling on looking lateralward. Innervation: n. oculomotorius.



919. Contents of the orbital cavities, viewed from above (after H. Sattler).

(On the left side the mm. levator palpebrae superioris and rectus superior have been partly removed and the vessels and nerves dissected out; on the right a horizontal section has been made at a somewhat deeper level.)

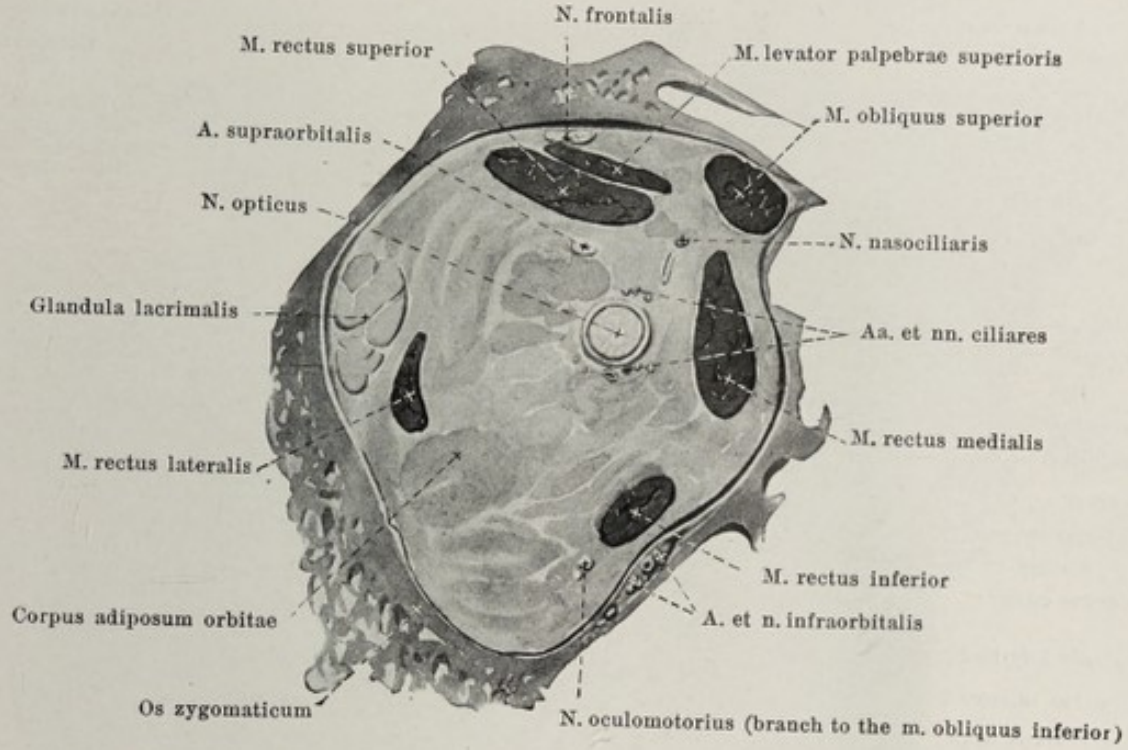




920 and 921. Frontal sections through the right orbital cavity, viewed from in front. Magnification: 3:2.

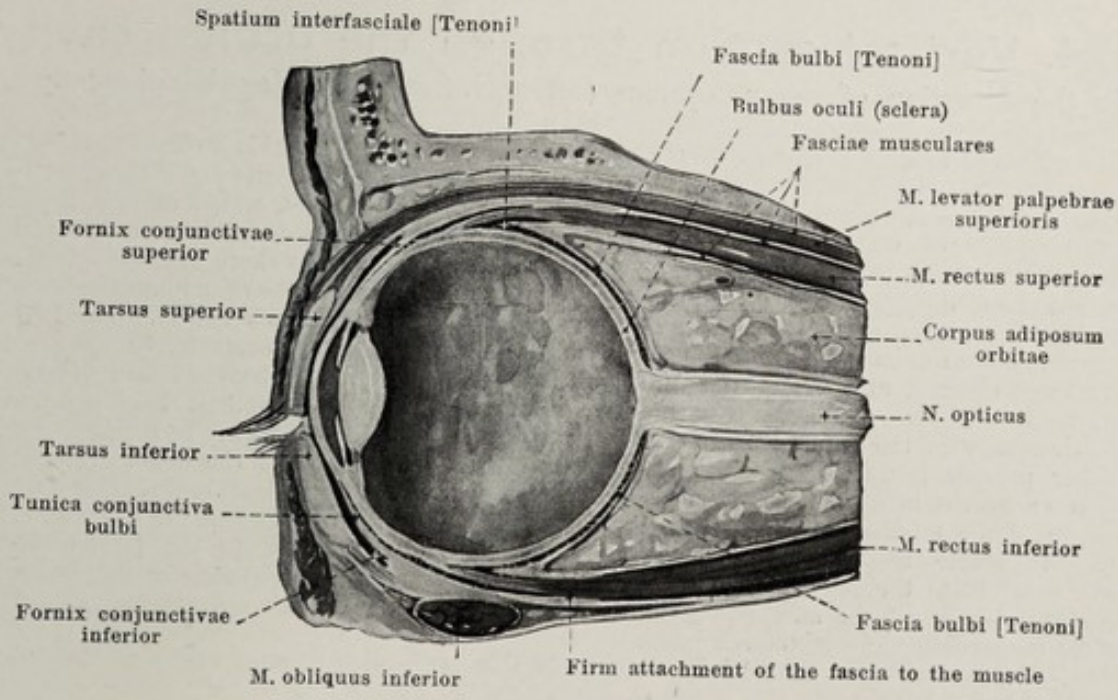
Close in front of the foramen opticum.

Midway between foramen opticum and bulbus.



922. Frontal section through the right orbital cavity, viewed from in front close behind the bulbus.

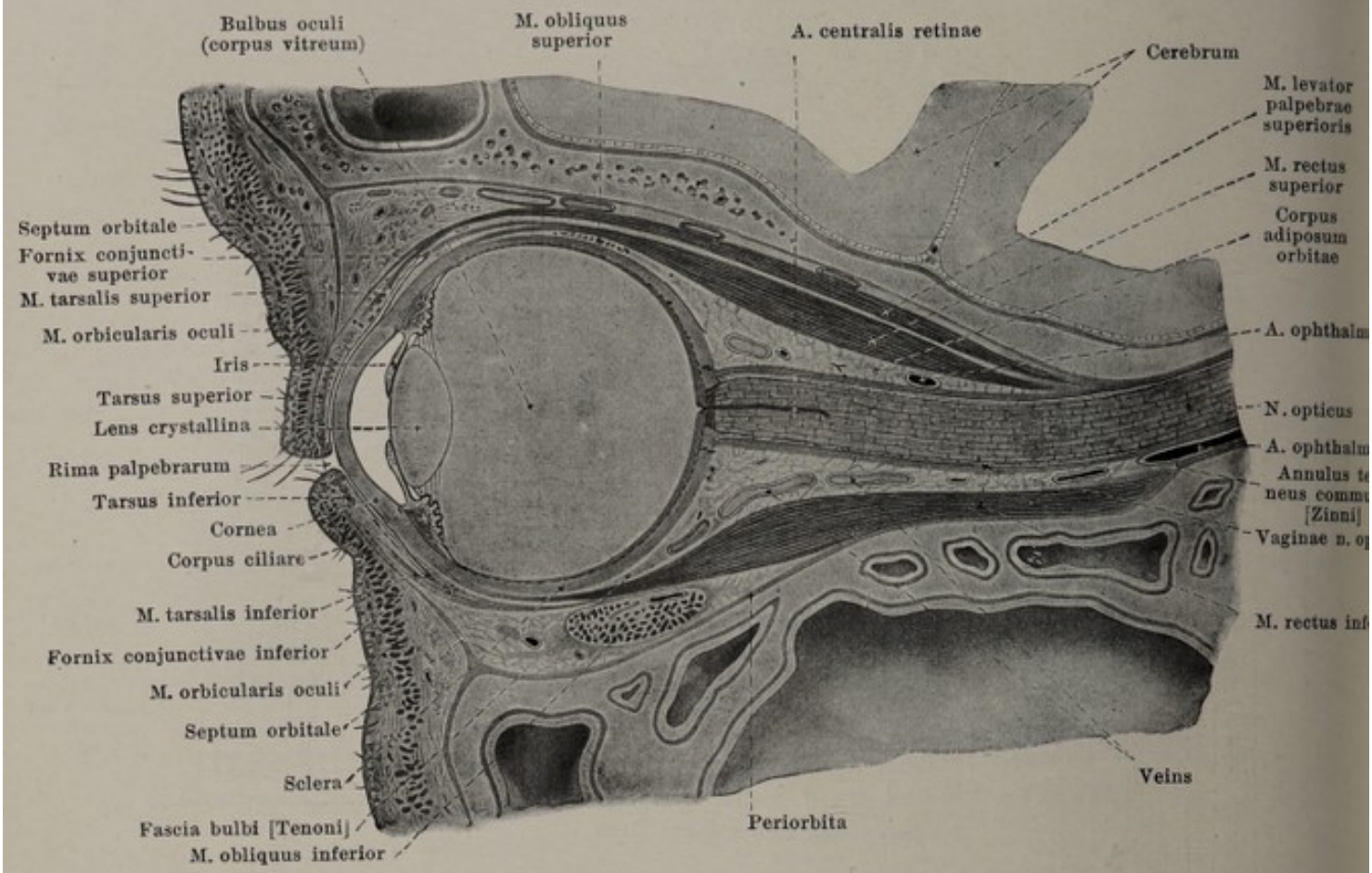
Magnification: 3:2.



923. Vertical section through the eyeball,

somewhat schematic (with use of a figure by H. Virchow).

Magnification: 7:5.

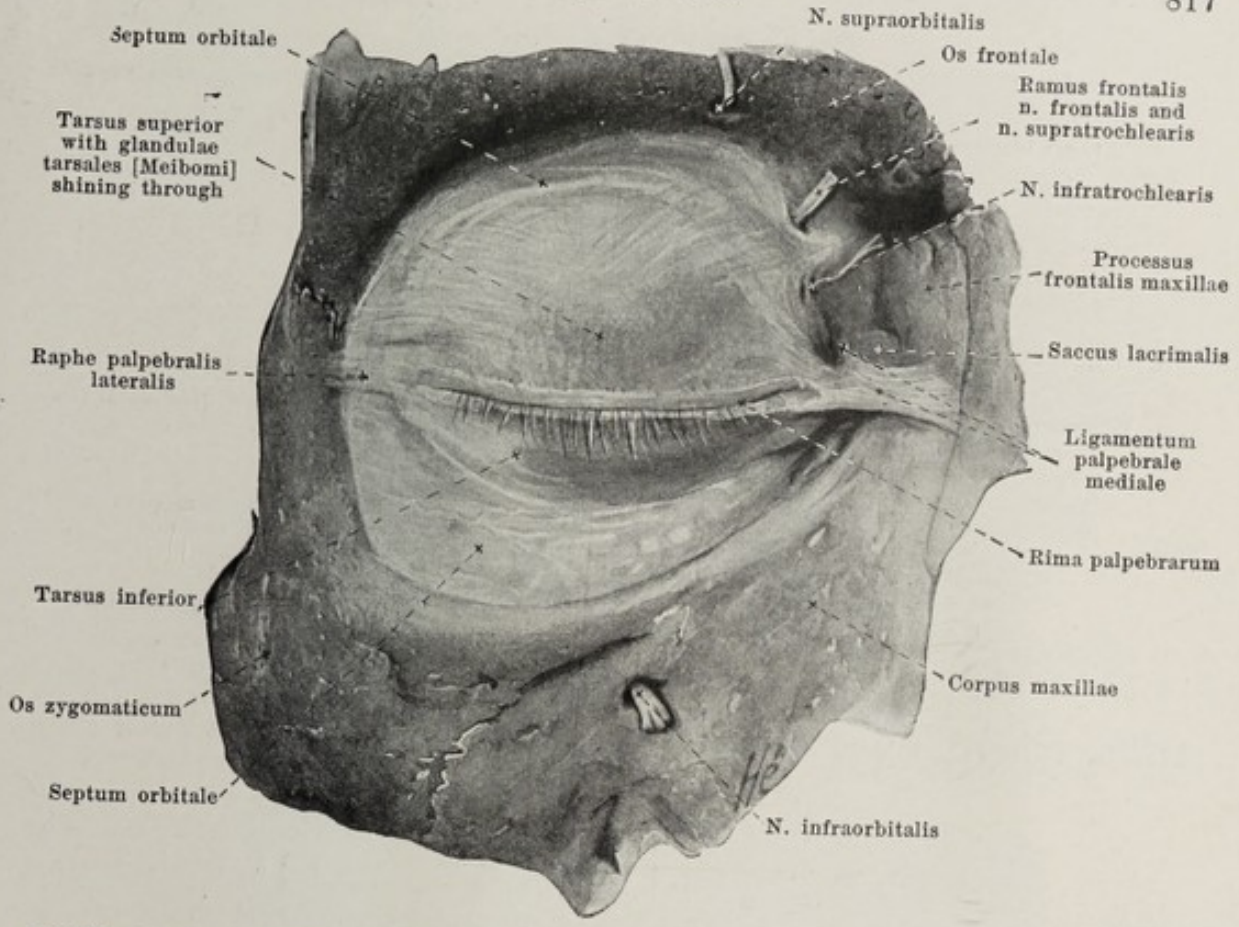


924. Vertical section through the orbital cavity,

in the direction of the n. opticus (after H. Sattler). Magnification: 8:5.

Fasciae orbitales, fascias of the orbital cavity (see also Figs. 911, 913, 914, 919—923 and 925). The eyeball, with the exception of the corneal portion, is directly ensheathed by a connective tissue membrane, *fascia bulbi [Tenoni] (Tenon's capsule),* which in turn is again directly connected with the surrounding fat. This capsule has a lamellar structure and is relatively firm and of somewhat variable thickness. It is united everywhere with the sclera and the tendons of the eye-muscles (vide infra) by delicate reticular tissue, the communicating meshes of which are spoken of as the *spatium interfasciale [Tenoni] (Tenon's space).* The capsule is continuous in front with the conjunctiva bulbi and conjunctiva palpebrarum, behind it ends, very much thinned, at the point of entrance of the optic nerve (a little removed from it laterally). The tendons of the eye-muscles pass through slits in the capsule to the bulbus. Each eye-muscle is surrounded in the anterior half by a fascia, *fascia muscularis,* which becomes gradually thicker passing forward and which appears as a tube-like process of the fascia bulbi; this fascia ensheaths in front a continuation of Tenon's space, and somewhat behind the point of passage of the tendon through the fascia bulbi, is firmly united with the muscle (see Fig. 923). Tenon's capsule is attached in front by expanding bands laterally to the lateral orbital wall, medially to the fascia situated behind the pars lacrimalis m. orbicularis oculi and besides near the tendon of the m. obliquus superior to its trochlea. Tenon's space projects in front as far as beneath the conjunctiva bulbi.

The orbital cavity is lined by a tolerably thin periosteum known as the *periorbita;* this is connected behind with the dural sheath of the n. opticus (see p. 795), partly closes the fissurae orbitales and goes over in front into the periosteum of the bones of the face; in the fissura orbitalis inferior it contains the thin (not illustrated) *m. orbitalis,* innervated by the sympathicus, consisting of smooth muscle fibres and also similar isolated bundles in other places. The space between the eyeball, the optic nerve, the muscles and the lachrymal glands is filled up by fatty connective tissue, *corpus adiposum orbitae, fat body of the orbital cavity,* through which the vessels and nerves run.

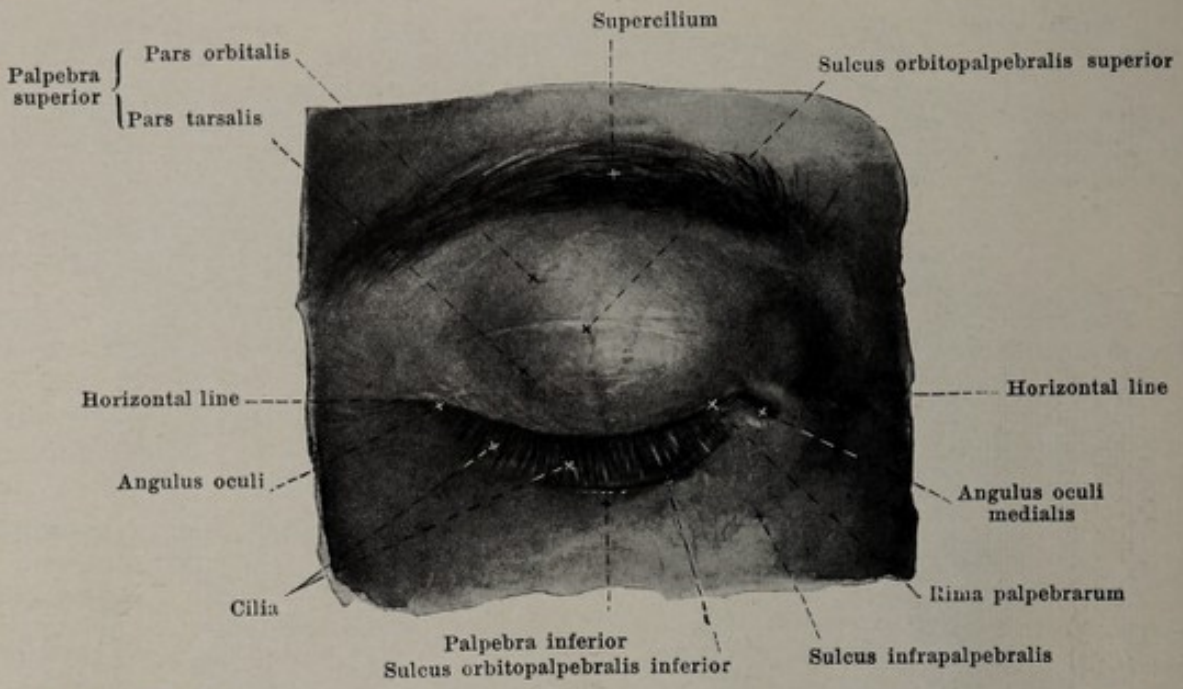


925. Right septum orbitale, viewed from in front. Magn.: 4:3.

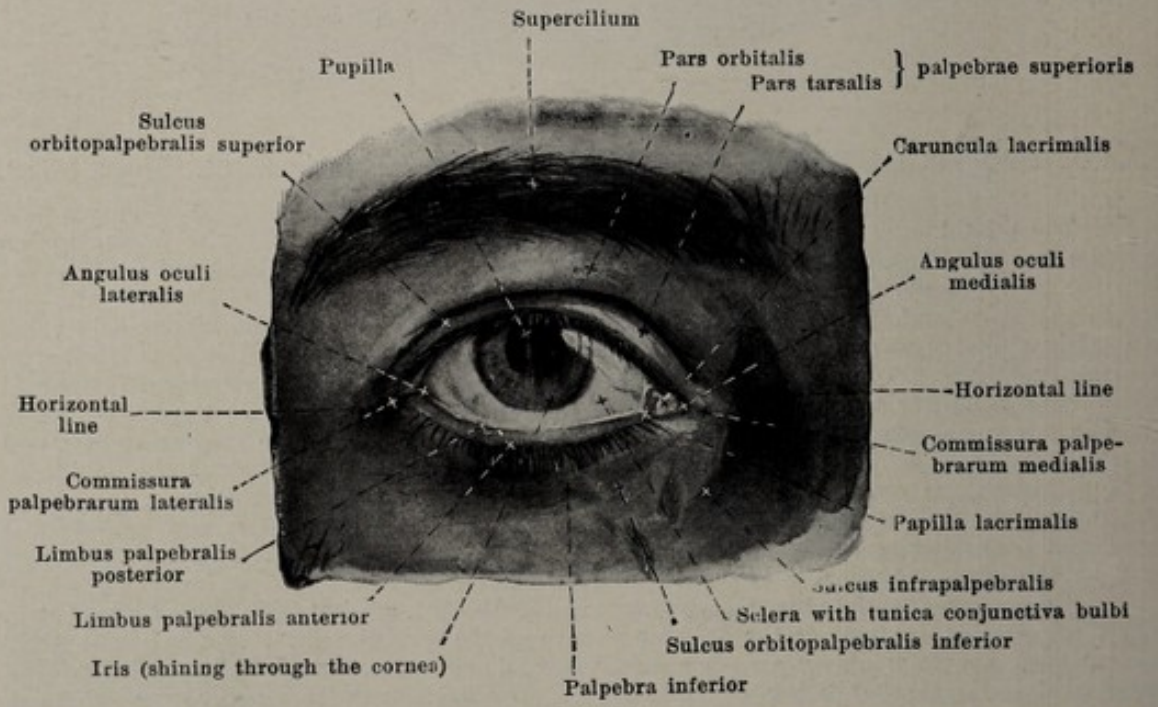
(The m. orbicularis oculi has been dissected off.)

The orbital cavity is bounded in front toward the eyelids by a layer of fascia, *septum orbitale* (see also Figs. 924 and 930), which is fastened to the aditus orbitae and stretches out into the lids. In the upper lid it coincides with the anterior expansion of the m. levator palpebrae superioris and, united with it, passes downward behind the m. orbicularis oculi, being intimately united with the anterior surface of the tarsus; in the lower lid it runs isolated in a corresponding way. The septum therefore lies in front of the conjunctival sack. Above it arises from a narrow tough marginal strip of connective tissue fastened to the margo supraorbitalis which transforms the incisurae supraorbitalis and frontalis into canals; medianward its attachment lies behind the crista lacrimalis posterior (therefore also behind the pars lacrimalis m. orbicularis oculi). The septum is not everywhere of the same thickness, being most powerfully developed at the upper circumference while at the lower it is very delicate and sometimes perforated by fat lobules; it is also very thin upon the tarsi; laterally it is strengthened by the *raphe palpebralis lateralis* (see p. 261).

Palpebrae, *eyelids* (see Figs. 923, 924 and 926—931), are two folds of the external skin, which are shoved in front of the anterior surface of the eyeball until they touch with their free margins, one from above, *palpebra superior,* and one from below, *palpebra inferior.* The upper eyelid is somewhat larger than the lower. The boundary of the upper eyelid above is to be seen in the *eyebrow, supercilium;* this is a ridge, convex upward, running at the level of the margo supraorbitalis; it is thickly studded with stiff hairs directed in general lateralward; the position and size of the eyebrows varies greatly, and so does the color. The lower eyelid is indistinctly bounded below by a gutter-like groove, *sulcus infrapalpebralis,* which begins medial from the inner angle of the eye, passes lateralward and downward and ends somewhat above the level of the margo infraorbitalis; in old age the groove becomes deeper and there are added to it other furrows especially at the lateral angle of the eye. The free margins of the eyelids which bound the *lid-slit, rima palpebrarum,* have each an anterior and a posterior, sharp or (especially in front) slightly blunted edge, *limbus palpebralis anterior* and *posterior;* at the lateral and medial ends of the lid-slit they go over into one another at the *commissura palpebrarum lateralis* and *medialis* and with these bound the lateral and medial *angles of the eye, angulus oculi lateralis* and *medialis.*



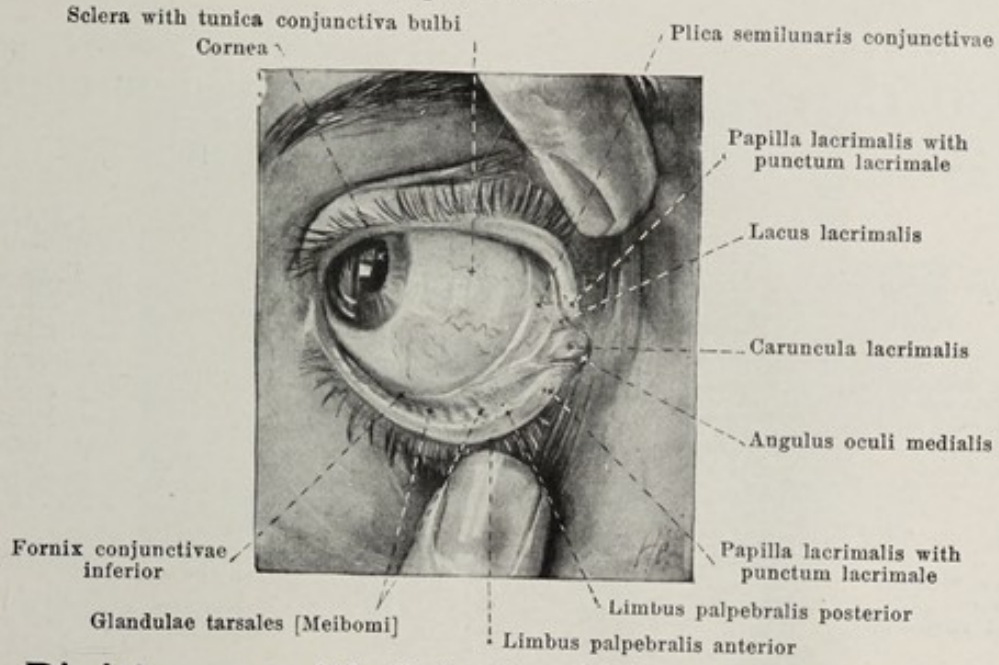
926. Right eye, closed, of a twenty-year old girl, viewed from in front.



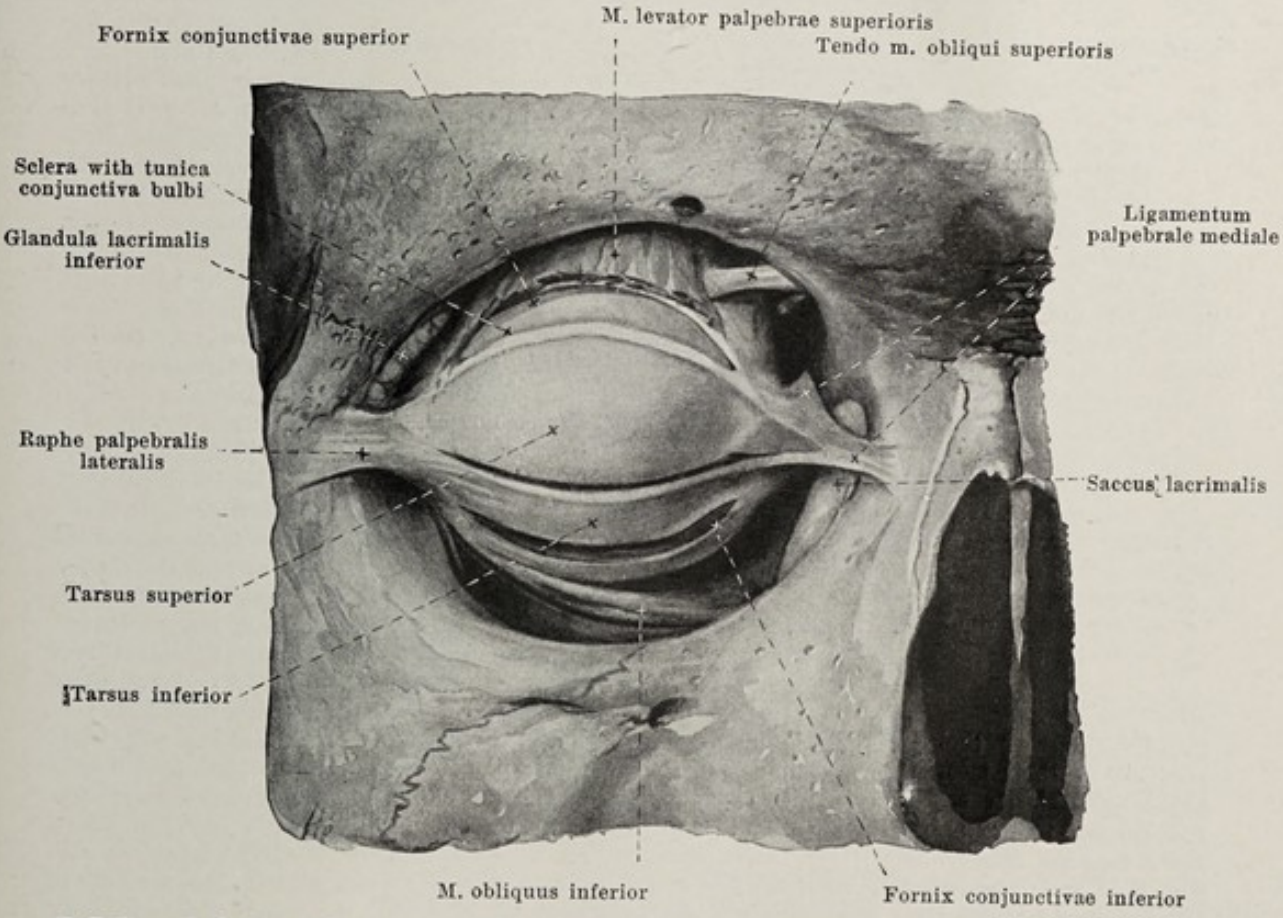
927. Right eye, open, of a twenty-year old girl, viewed from in front.

(The horizontal lines in Figs. 926 and 927 correspond to one another.)

Palpebrae (continued) (see also Figs. 923, 924 and 928—932). The *angulus oculi lateralis* is acute; the *angulus oculi medialis* is situated somewhat deeper, is a rounded evagination of the lid-slit and surrounds the *lachrymal lake, lacus lacrimalis.* When the lids are open, a small club-shaped elevation of the conjunctiva, *caruncula lacrimalis*, is visible and lateral from it a sickle-shaped fold of the mucous membrane, *plica semilunaris conjunctivae*, concave lateralward, passes from the fornix superior to the fornix inferior of the conjunctiva. The lachrymal lake reaches laterally as far as a small cone-shaped elevation of each eyelid, *papilla lacrimalis*, upon the apex of which directed somewhat backward, the lachrymal tubule begins as a punctate opening, the *punctum lacrimale*, somewhat larger in the lower lid than in the upper.



928. Right eye, with lids forcibly pulled apart, of a twenty-year old girl, viewed from in front. (The eyeball has been turned to the right.)

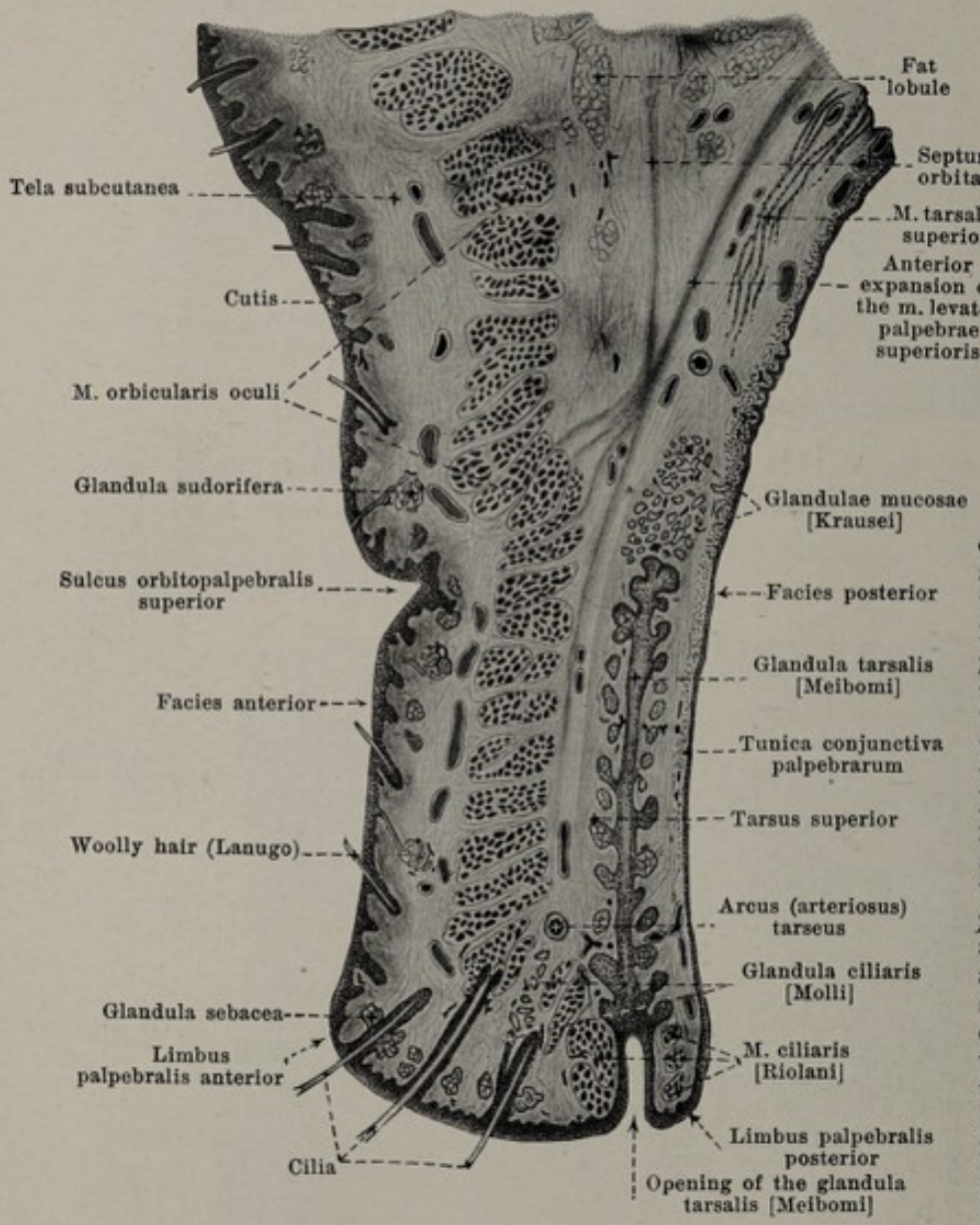


929. Lid-plates of the right eye, dissected out, viewed from in front. Magnification: 4:3.

(The lid-plates and the eye-muscles have been dissected out; the insertion of the m. levator palpebrae superioris has been removed, and the conjunctival sack has been opened from in front above and below the lid-plates.)

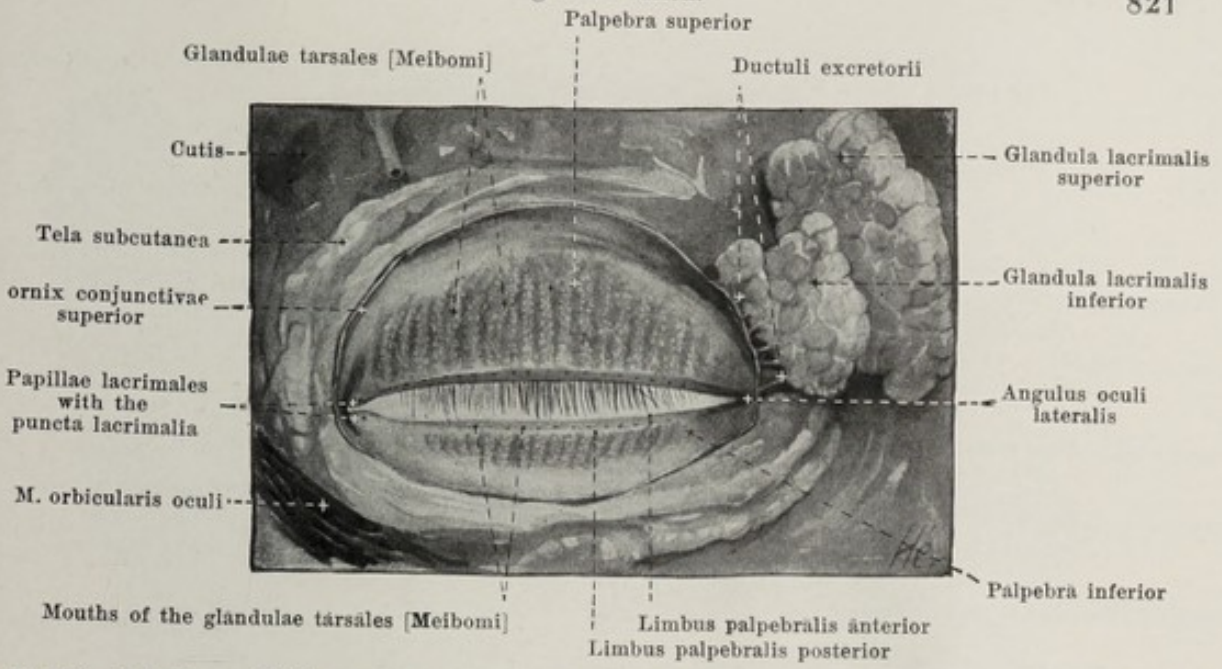
930. Cross-section through the upper eyelid

(after H. Sattler). Magnification: 14:1.



Palpebrae (continued) (see also Figs. 923, 924, 928, 929 and 931): The *rima palpebrarum* when the lids are open is biconvex and presents marked individual variations. When the lids are closed, it is a curved slit, convex below, which passes below a horizontal line drawn through the two angles of the eye.

The eyelid is curved saucer-like so as to be convex forward, and on its posterior surface, *facies posterior palpebrarum*, is separated from the eyeball only by the slit-like space of the conjunctival sack. Its firm foundation is formed by two tough, saucer-like connective tissue discs, the *lid-plates, tarsus superior* and *inferior*, which are united with the surrounding tissue and especially intimately with the conjunctiva; these discs are curved so as to be convex forward and present a convex margin turned toward the insertion of the lid and a straight margin reaching to the lid-slit. At their medial, blunter angles, they are continuous with the lig. palpebrale mediale, at their lateral sharper angles, with the raphe palpebralis lateralis; the upper disc is twice as high as the lower. In the substance of the lid-plates lie the *glandulae tarsales [Meibomi]*, in the upper lid 30—40, in the lower lid 20—30, usually closely crowded into a row, running approximately vertically through the whole height of the lid-plate (see also Fig. 931) and corresponding in their fine structure with the sebaceous glands; on account of their richness in fat they show through yellowish upon the back side of the lid; their excretory ducts end by punctate openings on the free margin near the limbus palpebralis posterior. Their secretion, *sebum palpebrale*, is rich in fat. To the upper margin of the tarsus superior is attached the posterior tendinous expansion of the m. levator palpebrae superioris and the *m. tarsalis superior* (see p. 810). to the lower margin of the tarsus inferior the *m. tarsalis inferior* (see Fig. 924), a bundle of smooth muscle fibres which passes out from the region of the fornix conjunctivae inferior.

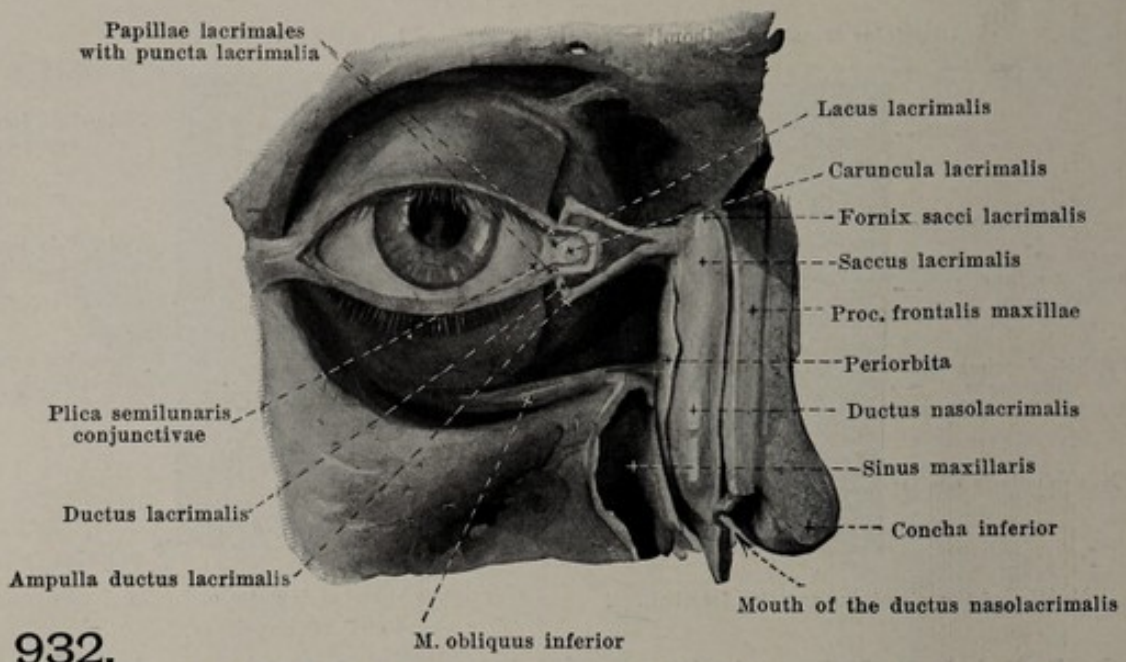


931. Lids of the right eye with the lachrymal glands, viewed from behind.

(The lids have been loosened from the subjacent tissue; the muscle has been for the most part dissected off.)

Palpebrae (continued) (see also Figs. 923, 924 and 928—930). The anterior surface of the eyelids, *facies anterior palpebrarum*, is formed by the external skin which goes over at the free margin of the lid directly into the tunica conjunctiva palpebrarum; it is delicate and devoid of fat, and presents many fine, transverse wrinkles, in middle and advanced age also numerous vertical folds. In the region of the lidplate, *pars tarsalis palpebrae*, it is firmly united with the subjacent tissue, in the other part, *pars orbitalis palpebrae*, more loosely. The junction between these two portions is formed in the upper lid by the *sulcus orbitopalpebralis superior* (see Figs. 926 and 927), a curve which is deep when the lid-slit is open and above which the pars orbitalis projects as *superior palpebral fold*, and to which the tendon fibres of the m. levator palpebrae superioris are attached; in the lower eyelid a feeble corresponding furrow, *sulcus orbitopalpebralis inferior*, is visible in the medial half only (see Figs. 926 and 927), when the m. orbicularis oculi is contracted highly. Beneath the loose subcutaneous connective tissue the m. orbicularis oculi spreads out (see p. 261), bundles of which directly adjacent to the lid-slit *(m. ciliaris [Riolani]*, see Fig. 930) run between the excretory ducts of the glandulae tarsales, the hair follicles of the eyelashes and the glandulae ciliares [Molli]. The *eyelashes, cilia*, appear on the free margin of the lid and behind the limbus palpebralis anterior; they are arranged generally in three rows and stand closely together and are more numerous (100—150) in the upper lid than they are in the lower (50—75); they are stiff, directed obliquely downward in the upper lid, obliquely upward in the lower lid, and so curved that the convexity of the upper is turned toward that of the lower. The eyelashes possess *glandulae sebaceae, sebaceous glands*, like other hairs and usually receive the mouths of the *glandulae ciliares [Molli]*, modified sweat glands (see Fig. 930). The posterior surface of the lid is covered by the *tunica conjunctiva palpebrarum* (vide infra).

Conjunctiva, *connecting membrane* (see also Figs. 893, 895, 913, 923, 924 and 927—930), is a mucous-membrane-like continuation of the external skin which lines the posterior surface of the lids as the *tunica conjunctiva palpebrarum*, then, forming the upper and lower transition folds, *fornix conjunctivae superior* and *inferior*, it passes over upon the anterior surface of the sclera and extends on in front of the latter as the *tunica conjunctiva bulbi* (see pp. 797 and 798) as far as the cornea; thus when the lids are closed it forms a closed sack, the *conjunctival sack*, the anterior wall of which is formed by the lids and the posterior wall by the eyeball (see also p. 818). The tunica conjunctiva palpebrarum upon the tarsus is firmly united with the subjacent tissue and studded with minute depressions; above the tarsus it is more loosely attached and when the lid is open, presents coarse, concentric folds. Small mucous glands, *glandulae mucosae [Krausei]*, which are looked upon as accessory lachrymal glands, occur on the fornix conjunctivae and in the upper margin of the tarsus superior. Some lymph-nodes, *noduli lymphatici conjunctivales*, not always distinctly defined, are also present in the fornix and its neighborhood under normal conditions.

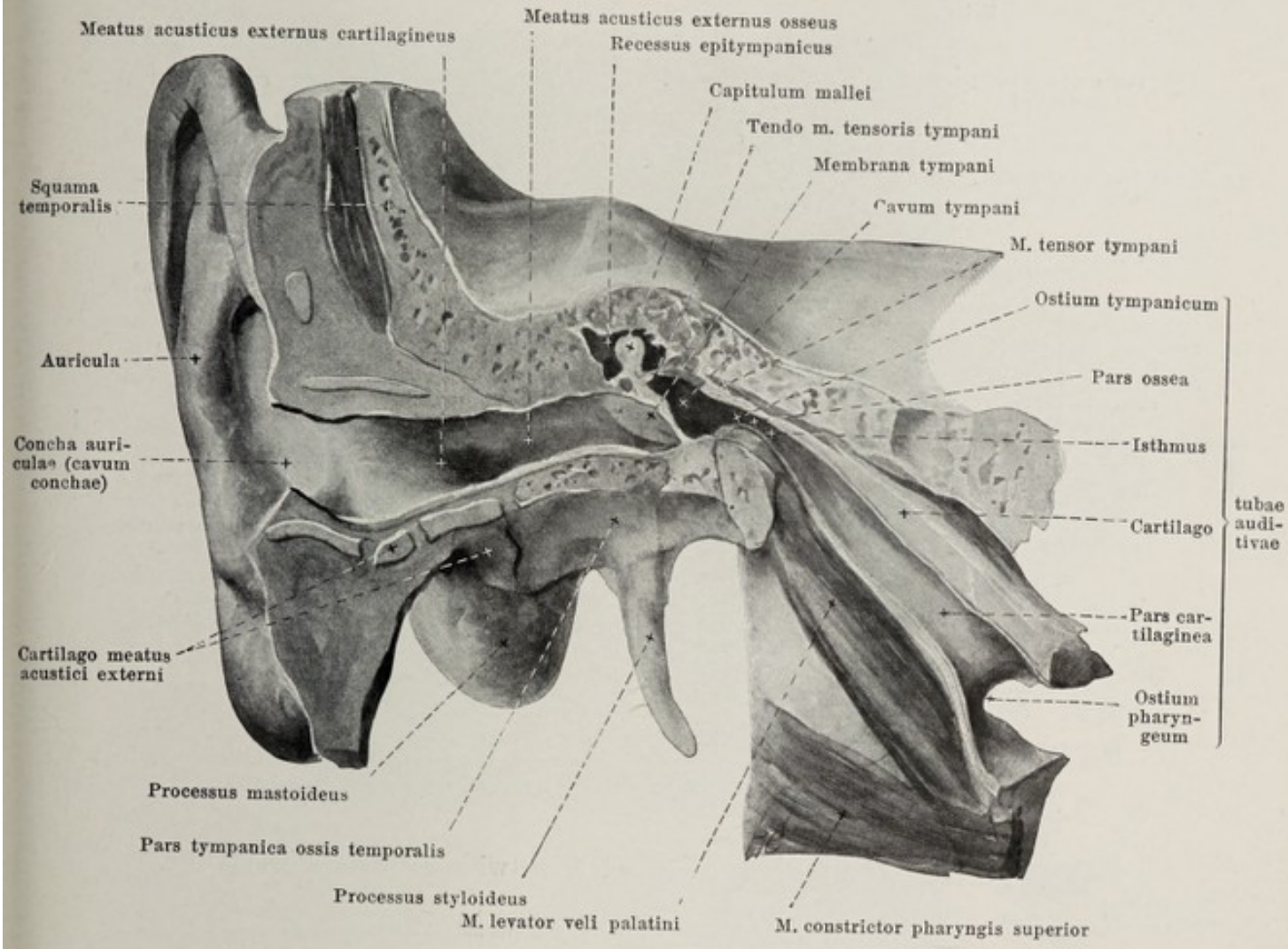


932.
Lachrymal canals of the right eye, viewed from in front.

The medial portion of the lid-plates have been cut off, the lig. palpebrale mediale has been removed, and the canalis nasolacrimalis opened.)

Apparatus lacrimalis, *lachrymal apparatus,* consists of the *lachrymal gland,* and of the lachrymal canals, namely: *ductus lacrimales, saccus lacrimalis* and *ductus nasolacrimalis.* The *lachrymal gland* (see Figs. 911, 913, 919, 922, 929 and 930) is of a reddish gray color and consists of an upper and lower part which are separated from one another by the tendinous expansion of the m. levator palpebrae superioris. The upper part, *glandula lacrimalis superior,* is oval in shape and varies somewhat in size; it lies directly under the periorbita, in the fossa glandulae lacrimalis of the frontal bone, and is attached there by laminae of connective tissue; it reaches lateralward as far as the suture between the frontal and zygomatic bones. The lower, smaller part, *glandula lacrimalis inferior,* is more loosely constructed and reaches downward as far as the fornix conjunctivae superior and the lateral angle of the eye. Its *excretory ducts, ductuli excretorii [glandulae lacrimalis],* consist of approximately twelve delicate tubules which open in the conjunctival sack, just in front of the fornix, the lowermost and largest at the level of the lateral angle of the eye (see Fig. 931); the ducts of the upper gland perforate the lower gland.

The *tears, lacrimae,* moisten the free surface of the eyeball, are dispersed over it by the lid-beating and when the lids are closed, can run medianward in a narrow triangular slit, sometimes present, *rivus lacrimalis,* which remains open between the anterior surface of the bulbus and the free margins of the lids. They pass into the lacus lacrimalis and thence through the puncta lacrimalia (see p. 818) into the *ductus lacrimales, lachrymal tubules.* These are two thin-walled canals, about 10 mm long, which run at first for a short distance vertically (and somewhat medially); they then turn medianward and grasp the lig. palpebrale mediale between them, and open, finally, into the tear sack, usually separately, more rarely by a common terminal portion; at the bend of each duct is a small pear-shaped dilatation, *ampulla ductus lacrimalis.* The *tear sack, saccus lacrimalis,* (see also Figs. 925 and 929), is a canal, closed above like a blind-sack, which goes over below without boundary, into the ductus nasolacrimalis and above receives the lachrymal ducts laterally. It fills up the fossa sacci lacrimalis completely, but projects with its pointed cupola, *fornix sacci lacrimalis,* not at all or only slightly beyond the *lig. palpebrale mediale,* which stretches out as a narrow curved plate from the crista lacrimalis posterior to the proc. frontalis maxillae and is fused with the wall of the tear sack by means of loose tissue. Laterally the tear sack is also covered by the periorbita which is stretched out between the cristae lacrimales. Its lumen is a sagittally placed slit. The *nasolachrymal duct, ductus nasolacrimalis,* a membranous canal filling up the canalis nasolacrimalis, is narrowest at the upper end of the bony canal and possesses a wider lumen than the tear sack. Its mucous membrane often shows small folds and pockets. It opens in the lower nasal meatus by passing obliquely through the mucous membrane, usually by a longitudinally oval slit; the lip of mucous membrane which guards this opening above, is called the *plica lacrimalis [Hasneri]* (see Fig. 983).



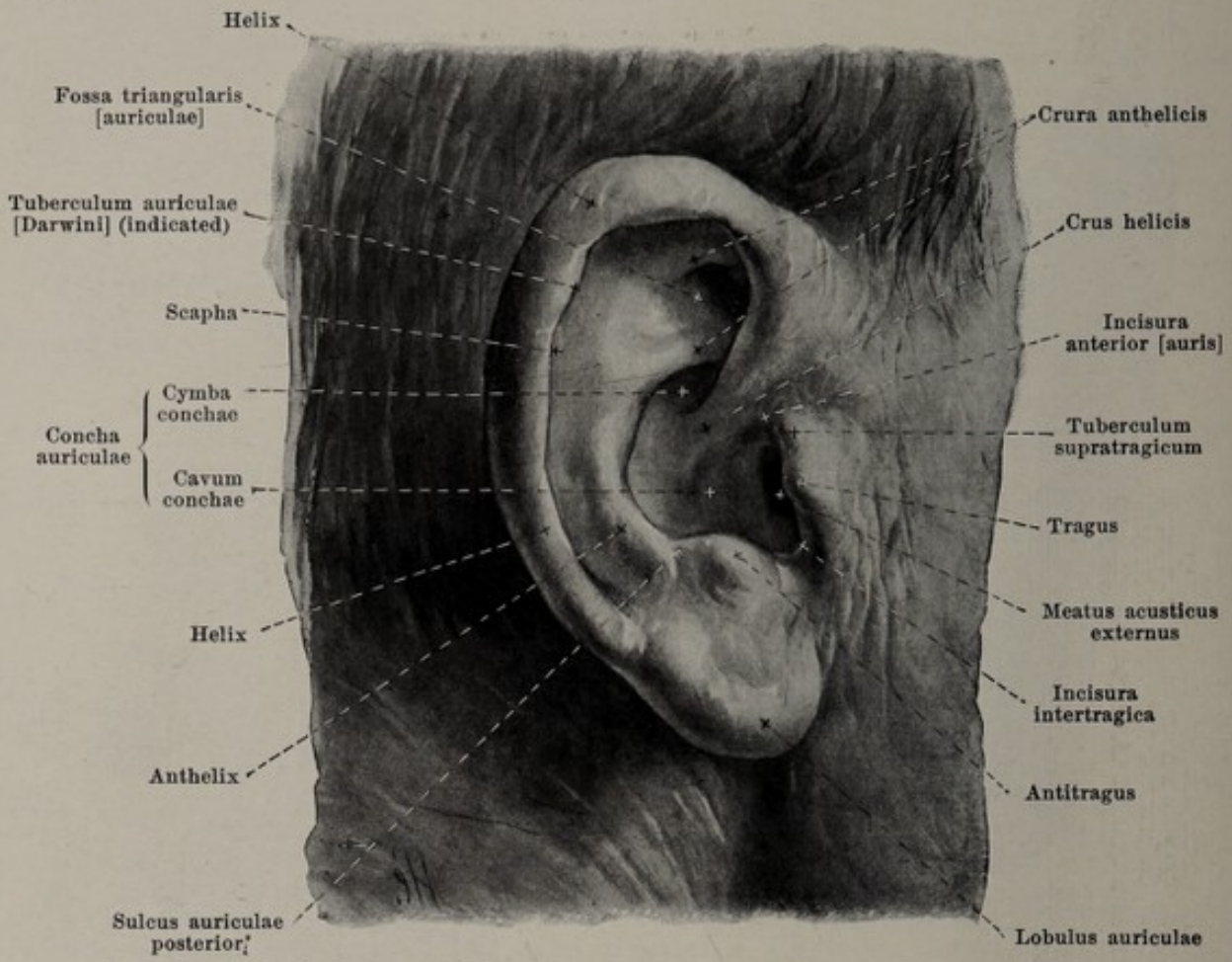
933. General view of the right external ear and middle ear, looked at from in front and externally.

(The external ear has been opened by a frontal section; the tympanic cavity and Eustachian tube have been opened by a vertical section carried obliquely medianward and ventralward.)

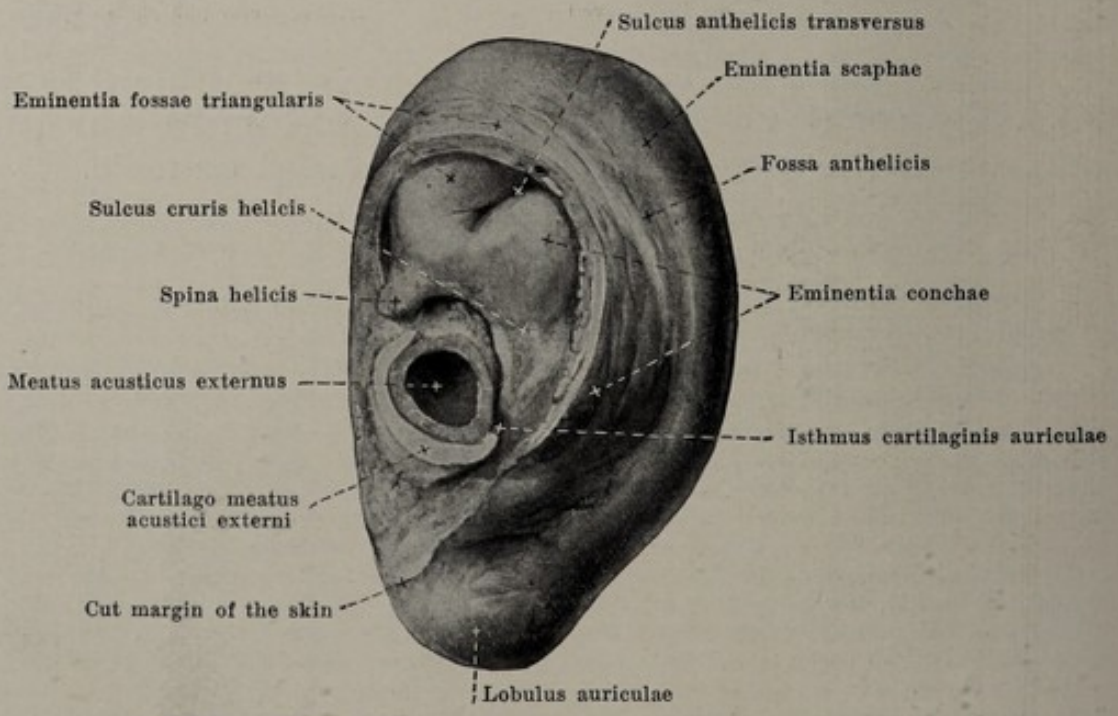
Organon auditus, *organ of hearing,* is divisible into the *external ear, auris externa,* the *middle ear, auris media,* and the *internal ear, auris interna.*

Auris externa, *external ear* (see also Figs. 934—941), is formed of the *outer ear proper, auricula,* and the *external auditory canal, meatus acusticus externus.*

The *auricula,* or *outer ear proper* (see also Figs. 934—941), is an oblong, flat fold of skin, in general irregularly shell-shaped, which surrounds the opening of the external acoustic canal; it is approximately twice as long as broad, and is bent in and out in different directions, but so that its lateral surface is essentially concave while its medial surface, turned toward the skull, is convex. It contains within it the *ear cartilage, cartilago auriculae,* consisting of elastic cartilage, which is chiefly covered only by thin skin and so determines the essential form of the auricle, but below it is somewhat shorter than this. The ear cartilage is continued in front and below directly into the cartilago meatus acustici externi (see Figs. 936 and 937) and together with it forms a half tube, open above; the posterior limb of the tube belonging to the ear cartilage is connected with the anterior limb formed by the cartilage of the acoustic canal and of the lamina tragi by a narrow intermediate piece, *isthmus cartilaginis auriculae,* the lateral margin of which forms the deepest part of the *incisura intertragica* (see p. 825) and the medial margin of which helps to bound the corresponding medial notch between the two limbs, the *incisura terminalis.*

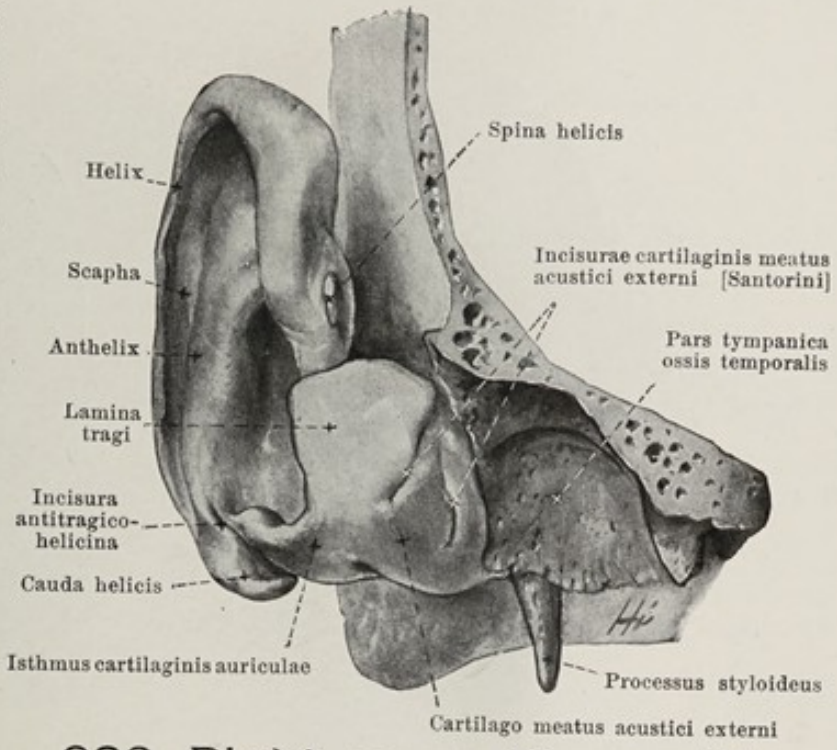


934. Right auricle, viewed from without (drawn from life).

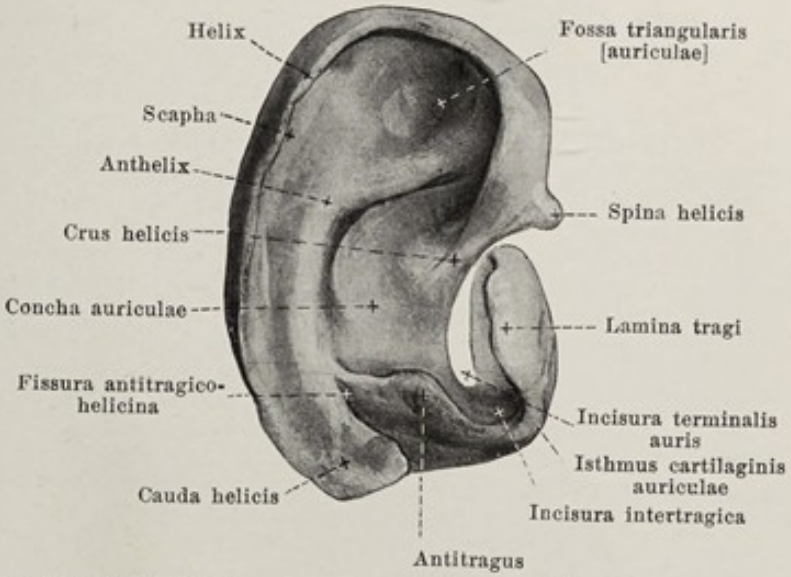


935. Right auricle, viewed from within.
(The auricle has been removed from the head by a clean cut.)

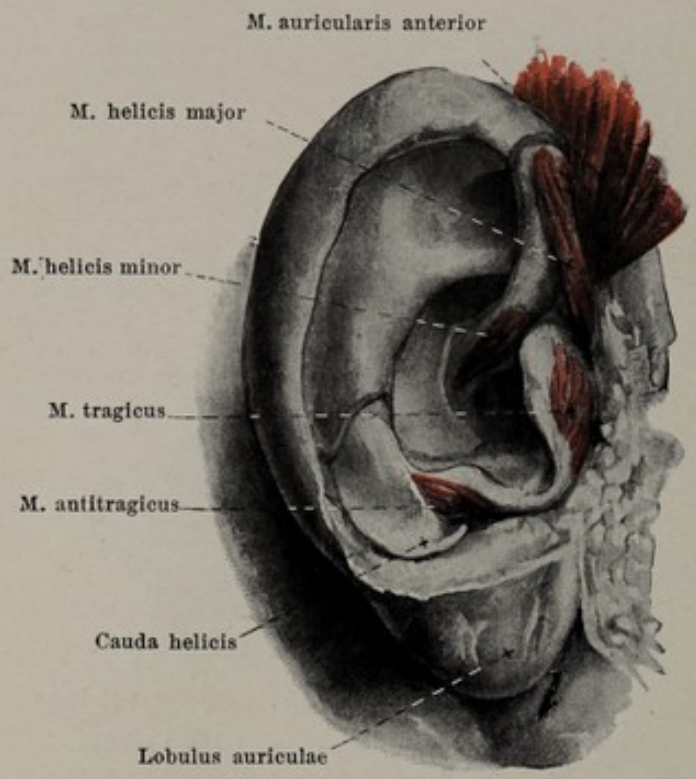
Cartilago auriculae (continued) (see also Figs. 934, 935 and 938—940). Its posterior and superior markedly curved margin, turned up outward, *helix (ear border)*, arises from the cavity of the auricle by means of a slightly curved projection, *crus helicis*, and at its anterior margin sends a small nodule, *spina helicis*, forward and downward; below it ends in a plate, *cauda helicis*, curved around forward, which is separated from the neighboring antitragus by a deep notch, *incisura antitragicohelicina;* its free, tolerably sharp edge often possesses, in the upper part of the posterior portion, a small process, *tuberculum auriculae [Darwini]*. Running approximately parallel to the helix upon the lateral surface is an elongated ridge, *anthelix;* it begins in front and above under the helix by two limbs which converge behind, *crura anthelicis*, which include between them a flat depression, *fossa triangularis [auriculae];* behind, it is separated from the helix by an elongated depression, *scapha*, and below it goes over into the antitragus, often insensibly, sometimes separated from it by a depression, *sulcus auriculae posterior*. The lower part of the ear cartilage turns around near the cauda helicis and forms a small triangular plate, projecting free upward, the *antitragus*, which is separated in front by a shallower or deeper notch, *incisura intertragica*, from the *lamina tragi*. This quadrangular disc of cartilage is the lateral part of the cartilago meatus acustici (see pp. 823 and 829) and forms the basis of the *tragus* of the auricle; it overlies the opening of the external acoustic canal like a valve in front, and not rarely presents on its upper part a small tubercle, *tuberculum supratragicum*. The deep depression between the anthelix, tragus and antitragus, is called the *concha auriculae* and is incompletely divided by the crus helicis into a smaller upper part, *cymba conchae*, and a larger lower part, *cavum conchae*, which leads in its anterior portion directly into the meatus acusticus externus. The projections present on the convex medial surface of the auricle correspond to the fossa-like depressions of the concave lateral surface, and are correspondingly designated: *eminentia fossae triangularis, eminentia scaphae* and *eminentia conchae*.

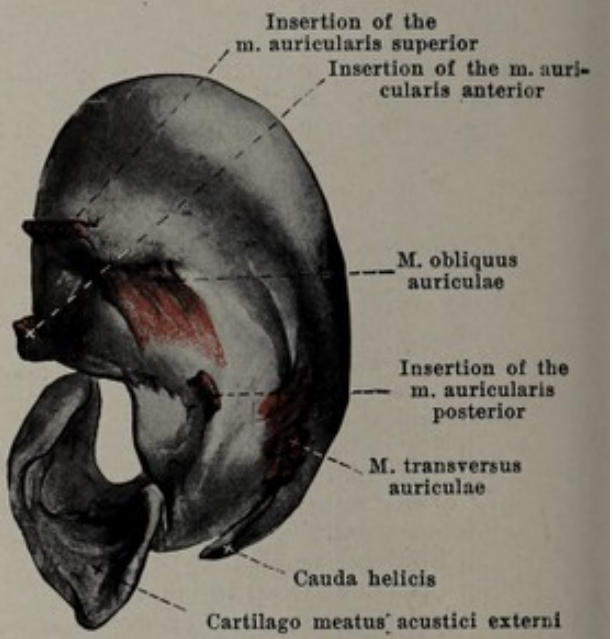


936. Right ear cartilage, with its attachments to the bone, viewed from in front and externally.



937. Right ear cartilage, isolated, viewed from without.





938. Cartilage of right ear with the muscles,

partly dissected out of the auricle, viewed from the outside.

939. Cartilage of right ear, isolated, with the muscles,

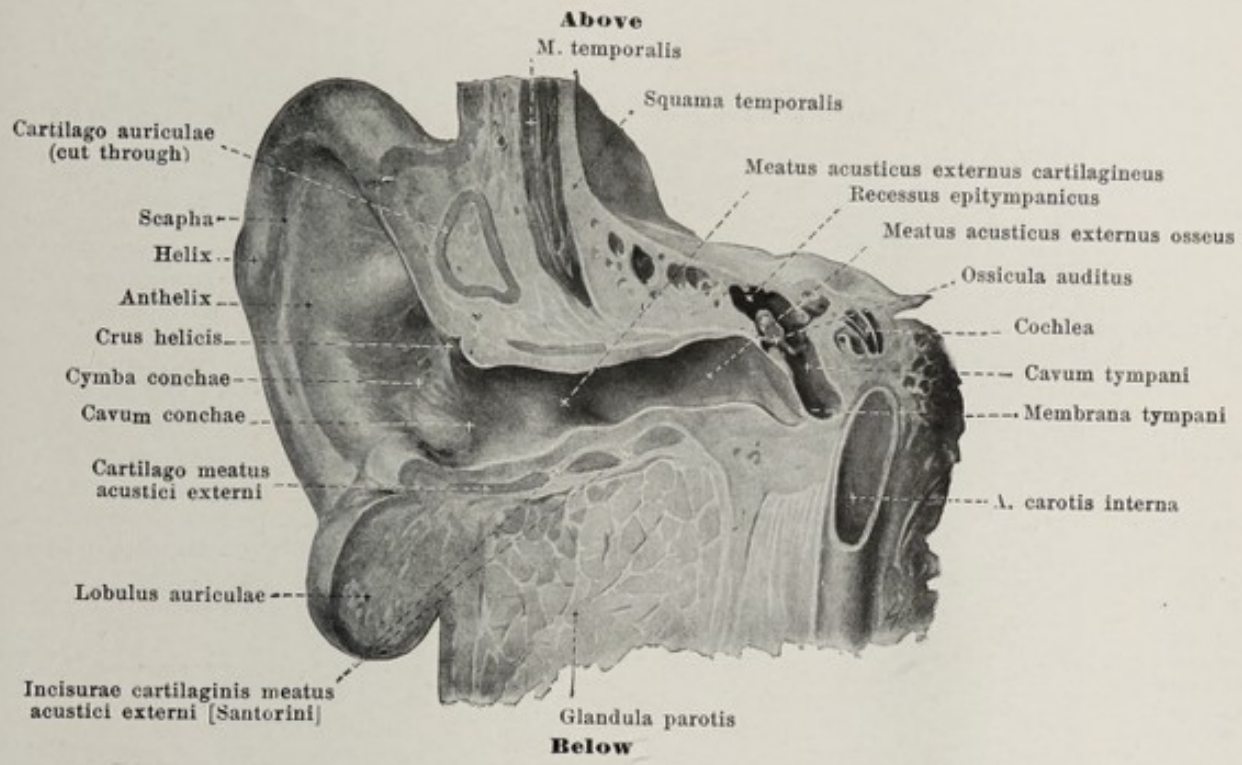
viewed from the inside.

Cartilago auriculae (continued) (see also Figs. 935—937), medial, convex surface. The eminentia fossae triangularis is separated from the eminentia conchae by the *sulcus anthelicis transversus;* it corresponds to the lower crus anthelicis, and goes over arch-like into the long *fossa anthelicis* which is directed downward and which causes the bulging of the anthelix on the lateral surface. Upon the surface of the eminentia conchae running approximately horizontally is the flat *sulcus cruris helicis,* corresponding to the crus helicis.

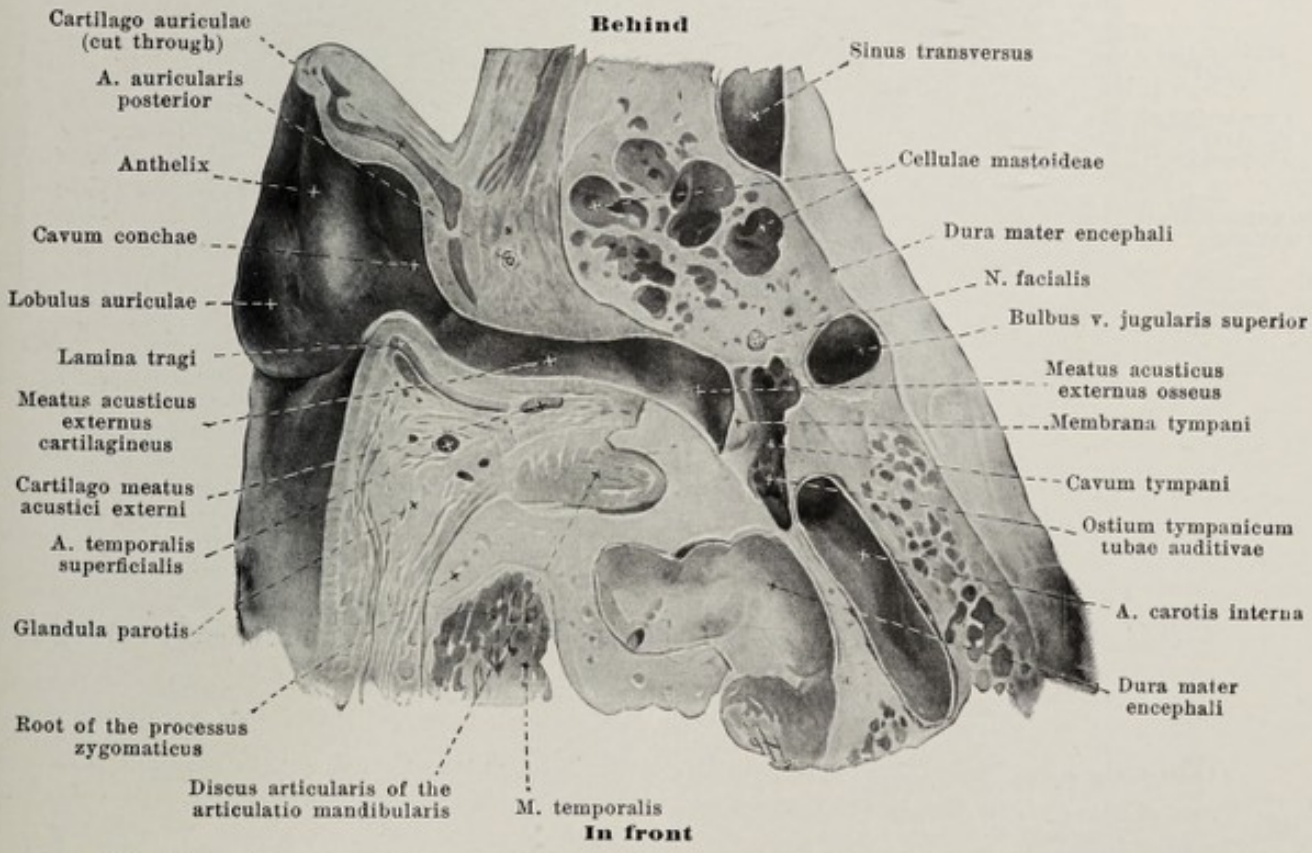
The cartilage of the auricle is fastened to the temporal bone by a more or less connecting fibre-mass in which are distinguishable three bands of fibres, *ligamenta auricularia [Valsalvae]* (not illustrated): the *lig. auriculare anterius* from the root of the zygomatic arch to the helix and lamina tragi, the *lig. auriculare superius* from the upper margin of the porus acusticus externus to the spina helicis and the *lig. auriculare posterius* from the lateral surface of the proc. mastoideus to the eminentia conchae.

The cartilage of the ear possesses small intrinsic muscles composed of striped fibres; they are pale, usually six in number, of very variable development, all innervated by the n. facialis. Upon the lateral surface: *m. helicis major* from the spina helicis upward to the helix; *m. helicis minor* upon the crus helicis; *m. tragicus* upon the lamina tragi; *m. antitragicus* upon the antitragus and partly to the cauda helicis; these two are said to narrow the entrance to the external acoustic meatus. Upon the medial surface: *m. transversus auriculae,* horizontal, from the eminentia scaphae to the eminentia conchae; *m. obliquus auriculae,* nearly vertical, from the eminentia fossae triangularis to the eminentia conchae.

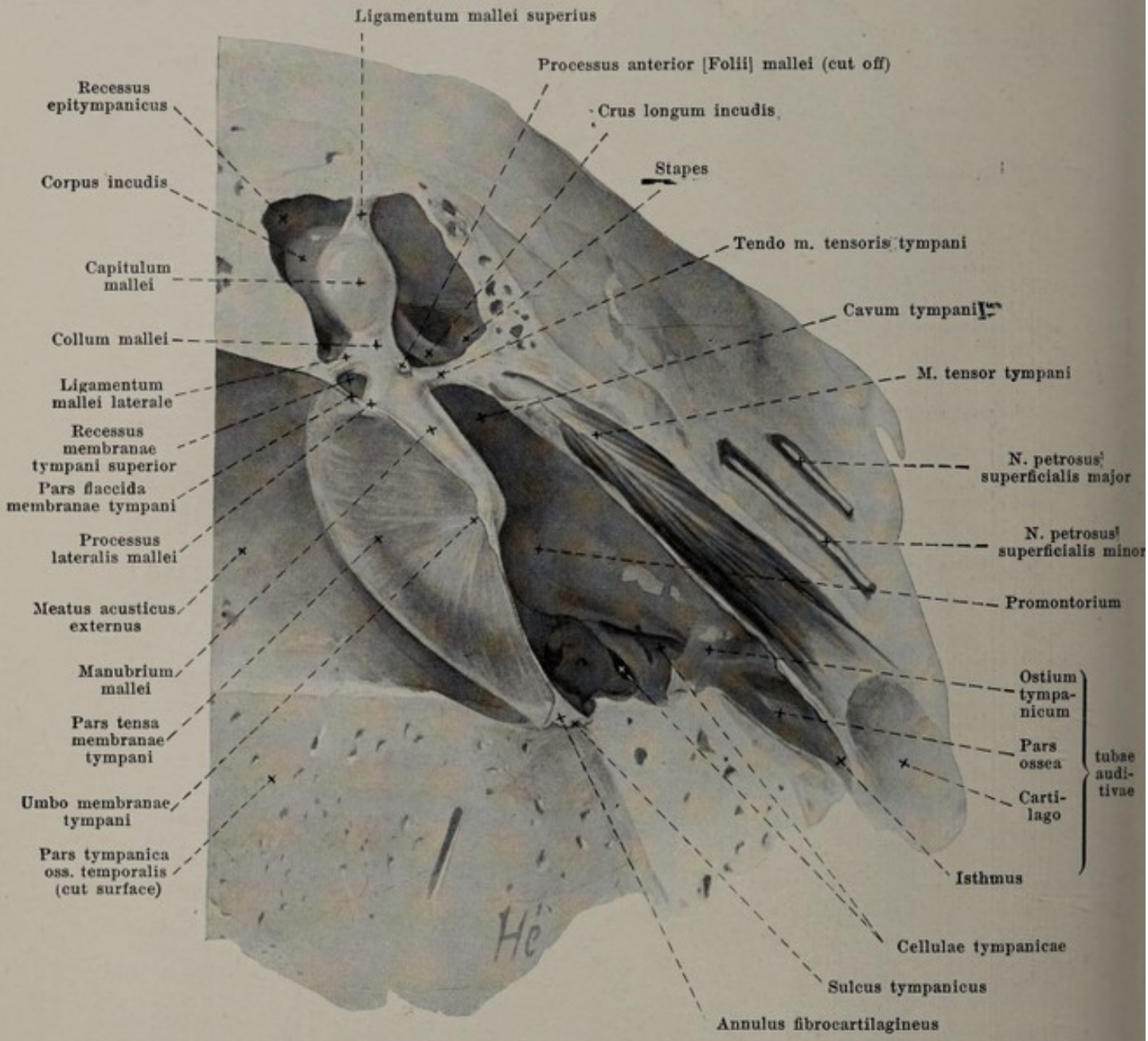
The *auricula, auricle* (see also Figs. 934 and 935) (O. T. pinna), is completely covered by the skin on its lateral surface which bridges over the notch between the crus helicis and lamina tragi and transforms it into a groove, *incisura anterior [auris],* and is then continued into the skin of the cheek. On the medial surface the skin covers only the upper and posterior part of the ear cartilage whence it curves around into the skin of the head. Below, the skin over the cauda helicis and the antitragus forms a flat, rounded, fatty duplicature, *lobulus auriculae, lobule of the ear,* which hangs down and is very variable in different individuals.



940. Vertical section through the right external acoustic canal, viewed from in front.



941. Horizontal section through the right external acoustic canal, viewed from above.



942. Vertical section through the right ear-drum,

viewed from in front. Magnification: 6:1.

(The section has been carried approximately frontally through the external acoustic canal; medial from this it has been carried obliquely forward and medianward.)

Meatus acusticus externus, external acoustic canal (see Figs. 933—937 and 940—942), is divisible into a lateral portion, the *cartilaginous acoustic canal, meatus acusticus externus cartilagineus*, and a medial part, the *bony external acoustic canal, meatus acusticus externus osseus.*

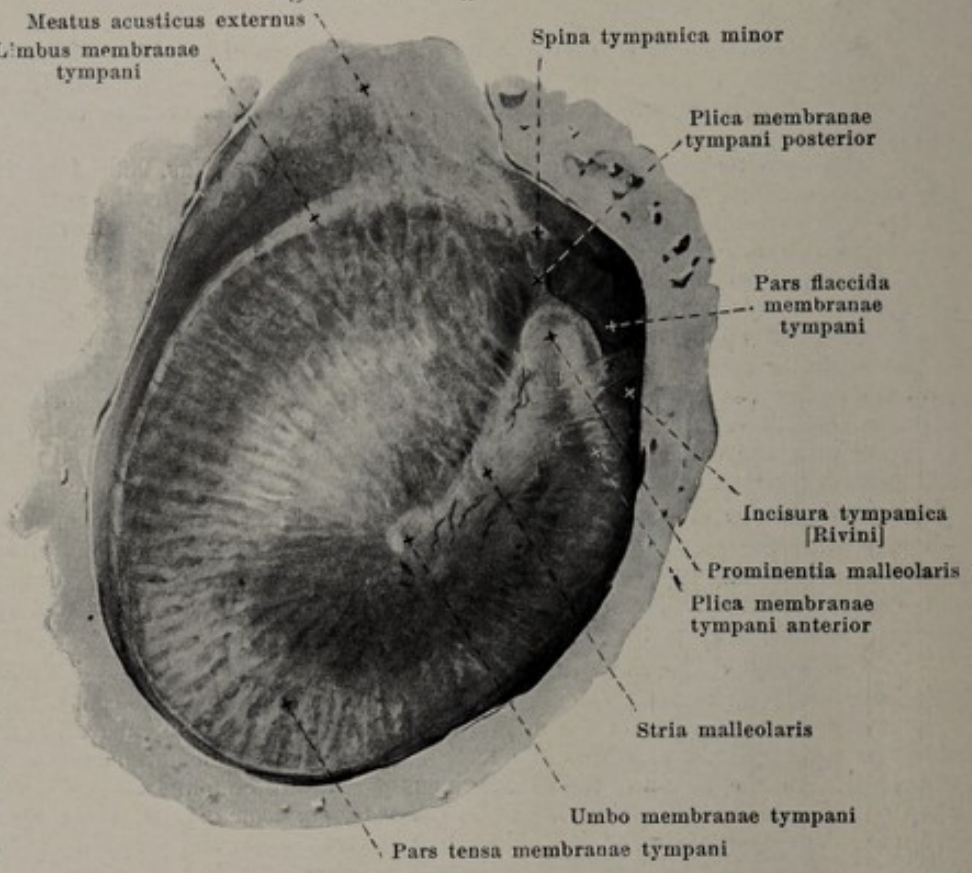
The *meatus acusticus externus cartilagineus* (see Figs. 933—942) begins laterally in the cavum conchae (see p. 825) and reaches medianward as far as the porus acusticus externus. Its anterior and inferior walls are formed by a groove-like cartilage, *cartilago meatus acustici externi*, which is continued laterally into the lamina tragi (see p. 825) and behind is connected with the cartilago auriculae (see p. 823). This cartilage is usually interrupted in two places by approximately vertical slits, *incisurae cartilaginis meatus acustici externi [Santorini]*, which are filled up by connective tissue; it is fastened firmly (see Fig. 936) in front and above to the posterior root of the proc. zygomaticus, in front and below to the lateral margin of the pars tympanica oss. temporalis. The upper and posterior somewhat shorter wall of the cartilaginous acoustic canal is formed by a connective tissue plate which unites the upper margin of the cartilage with the cartilage of the ear and with the bone and is attached medially to the upper and posterior circumference of the porus acusticus externus (and to the spina supra meatum).

The *meatus acusticus externus osseus* belongs to the temporal bone (see p. 9); it begins laterally with the *porus acusticus externus* and possesses smooth walls of which the anterior and inferior are slightly convex toward the lumen and longer, the superior and inferior slightly concave and shorter. Medianward it ends in the *sulcus tympanicus* and the *incisura tympanica [Rivini]* (see p. 15 and Figs. 965 and 966).

The *meatus acusticus externus* (see Figs. 933, 940 and 941) is lined internally by a thin perichondrium and periosteum and clothed by a blind-sack-like continuation of the external skin, which in the region of the pars tympanica is thinner than above and inseparably united with the periosteum, and covers the lateral surface of the membrana tympani as an especially thin layer. In the region of the cartilaginous part are to be found numerous strong hairs, called *tragi (ear-hairs)* and the *glandulae ceruminosae, ear-wax glands*, which secrete the *cerumen, ear-wax.* The acoustic canal is subject to numerous individual variations in length, lumen and course. In general it is directed horizontally and frontally, but slightly curved like the letter S in a horizontal and vertical plane, so that in the horizontal direction it is curved laterally so as to be convex forward, and medially so as to be convex backward; in the vertical direction it is convex below laterally, and convex above medially. The lateral portion of the curvature belongs to the cartilaginous part and is longer than the medial. The cross-section of the lumen is irregularly oblong elliptical; its long axis stands approximately vertically lateralward and medianward approaches the horizontal; the narrowest part is the junction between the cartilaginous and the bony portion. The medial boundary is formed by the membrana tympani. It is due to the oblique position of the latter that the anterior and inferior walls of the acoustic canal are longer than the posterior and superior.

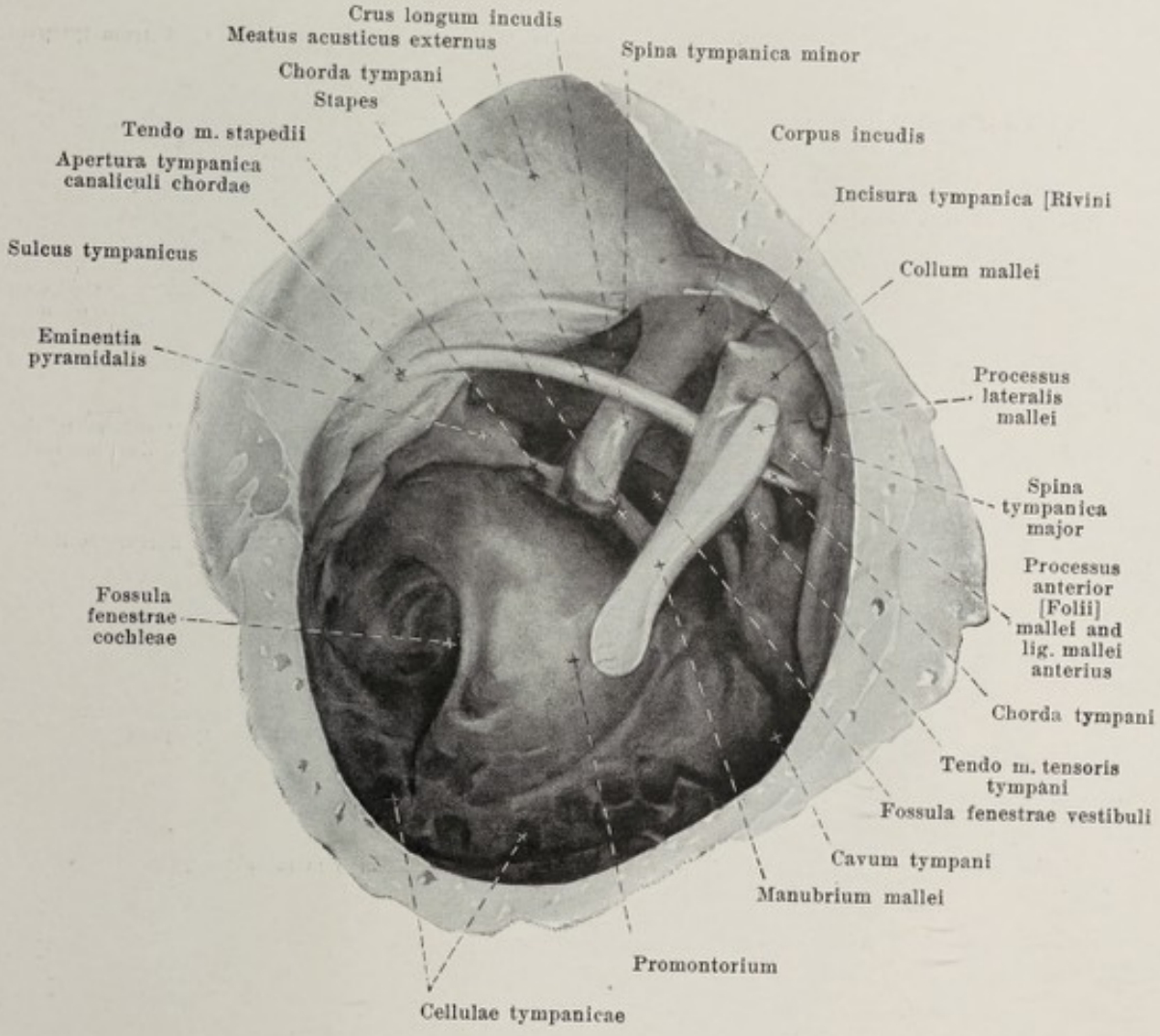
The *ear-drum membrane, membrana tympani* (see Figs. 933, 940—943 and 946—948), is a very thin, smooth membrane (about 0,1 mm thick), stretched out between the external acoustic canal and the cavity of the tympanum, separating these two from one another completely and thus separating also the outer ear from the middle ear. It is subject to marked individual variations in form, size and obliquity.

The membrana tympani is usually elliptical, sometimes quite oval and has a longitudinal diameter (obliquely from above and in front downward and backward) from 9—10 mm and a transverse diameter of 8—9 mm. It is stretched out in the sulcus tympanicus and in the incisura tympanica [Rivini] and is so inclined in the body that a plane passing through the sulcus tympanicus looks medianward, backward and upward; corresponding to this is the variable length of the walls of the external acoustic canal (see above). In the new-born, the incline is such that the membrana tympani stands almost horizontal. The small, anterior upper portion, situated within the incisura tympanica, is loose and is called the *pars flaccida;* it reaches downward as far as the button-like *prominentia malleolaris* pushed forward by the proc. lateralis mallei, and as far as two folds going out from the spinae tympanicae and converging toward this point, namely the shorter, *anterior* and the longer, *posterior ear-drum membrane folds, plica membranae tympani anterior* and *posterior.* The larger inferior portion of the membrana tympani is tightly stretched and is called the *pars tensa;* it is drawn in, so as to be funnel-shaped medianward, by the tip of the handle of the hammer imbedded in its substance, so that upon its lateral surface there occurs a flat depression, *umbo membranae tympani;* the walls of this funnel are curved so as to be convex outward. The umbo does not lie exactly in the middle but is displaced somewhat downward and forward. On the external surface one sees a whitish stripe, *stria malleolaris,* passing from the prominentia malleolaris to the umbo, due to the handle of the hammer situated there showing through; it runs obliquely from in front and above backward and downward.



943. Right ear-drum, viewed from the outside, from in front and below. Magn.: 6 : 1.

944. Right ear-drum as viewed through speculum; from life (after O. Körner). Magn.: ca. 6 : 1.

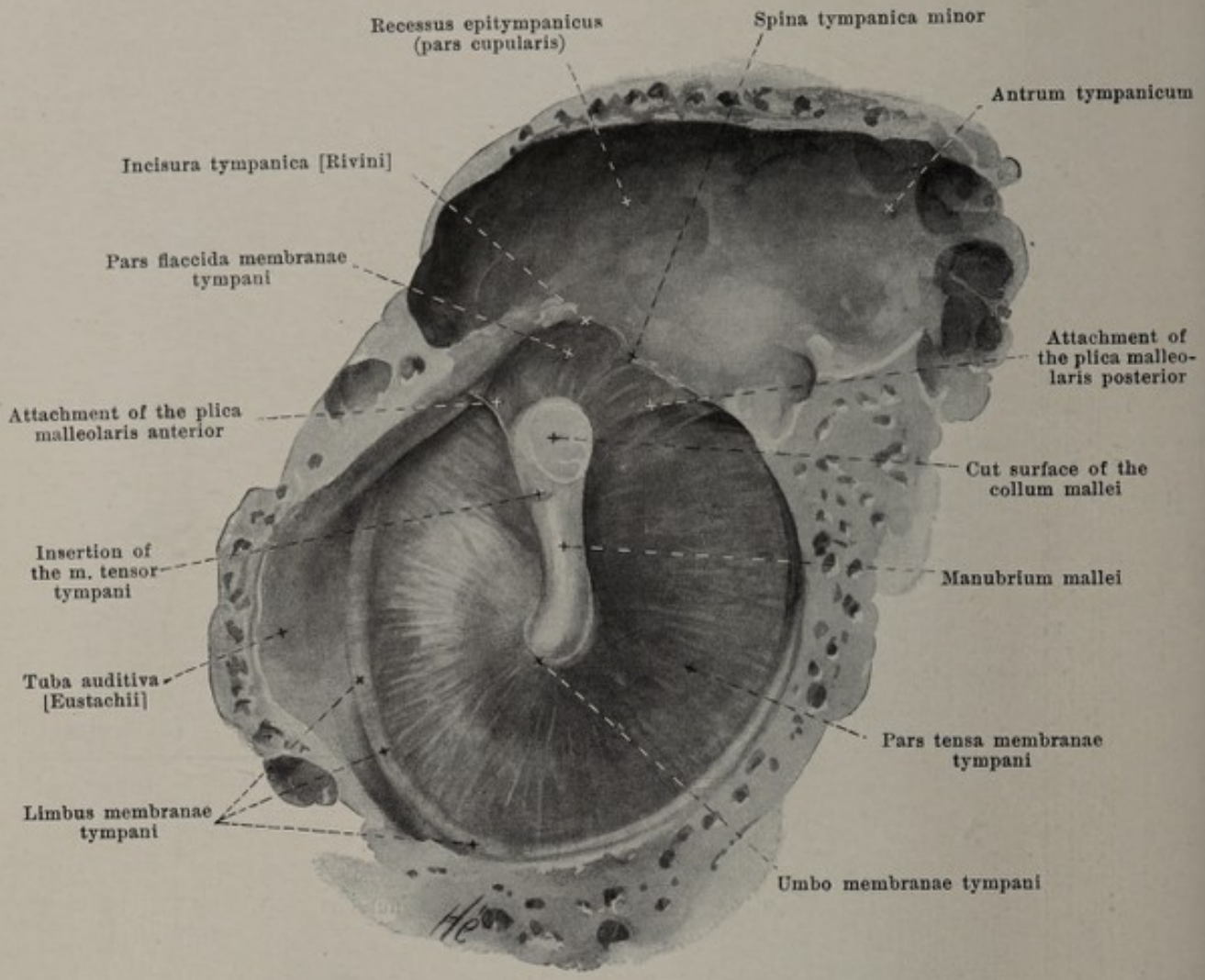


945. Small bones of the right ear,

after removal of the ear-drum, viewed from the outside, in front and below.

Magnification: 6:1.

The *membrana tympani* (continued) (see also Figs. 933, 940—943 and 946—948) is fastened by a somewhat thickened margin, *limbus membranae tympani*, in the sulcus tympanicus by means of the fibrocartilaginous *circular pad, annulus fibrocartilagineus*, and is there sharply marked off from its surroundings; in the incisura tympanica [Rivini] the fibrocartilaginous ring is absent and the skin of the acoustic canal goes over gradually and without sharp limit into the membrane. In the ear-drum we distinguish four sheets. On its lateral surface it is covered by the *stratum cutaneum*, a continuation of the external skin which is somewhat thicker in the region of the stria malleolaris but is elsewhere very thin. Following upon this is a connective tissue membrane, composed of a lateral layer of radial fibres, *stratum radiatum*, in which stiff fibres run approximately radial to the handle of the hammer, and of a medial layer of circular fibres, *stratum circulare*, in which the fibres are arranged in circles closer together at the periphery than near the centre; both layers are connected with the annulus fibrocartilagineus; they are lacking in the pars flaccida. The medial surface is covered by the *stratum mucosum*, a continuation of the mucous membrane of the tympanic cavity.



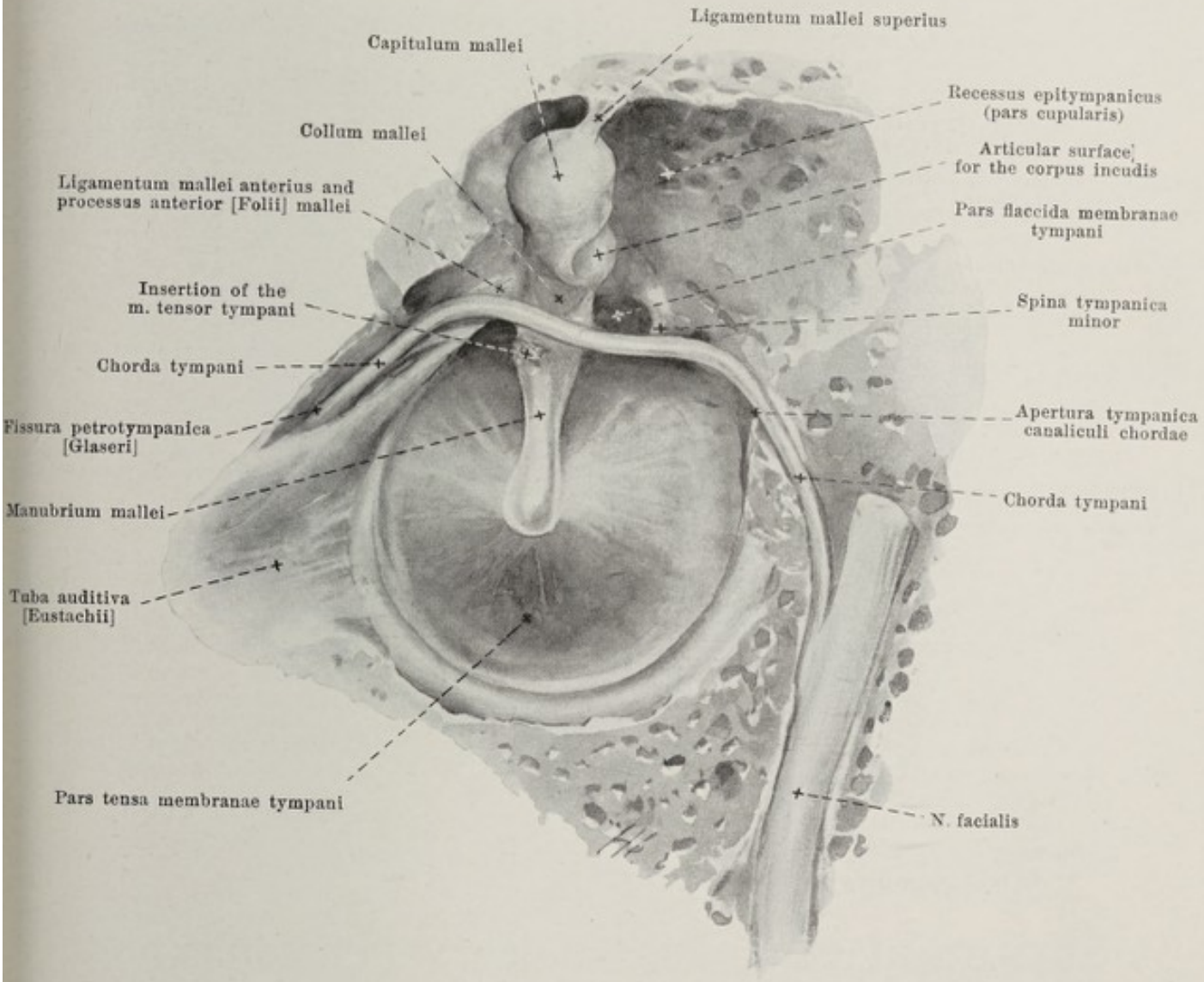
946. Right ear-drum with handle of hammer,

viewed from within, behind and above. Magnification: 6:1.

(The chorda tympani and the head of the hammer, with the folds of mucous membrane have been removed.)

Auris media, *middle ear* (see Figs. 933, 940—942, 945, 947, 948 and 952—957), is formed by the *cavum tympani* with the *ossicula auditus* and by the *tuba auditiva [Eustachii].*

The *cavum tympani, tympanic* or *ear-drum cavity* (see Figs. 933, 940—942), lies within the temporal bone so that it is bounded laterally and in front by the squama and the pars tympanica, medially and behind by the pars petrosa. It is a slit-like air-containing space lined by mucous membrane which is continuous behind and lateralward with the air-containing cellulae mastoideae, while in front and medianward it opens into the pharynx through the tuba auditiva [Eustachii]; laterally it is completely separated by the membrana tympani from the external acoustic meatus and medially by the basis stapedis and the membrana tympani secundaria from the internal ear. Its slit-like space forms with the median plane an angle of about 45°. Its form is comparable with that of a biconcave lens, the broad surfaces of which are placed vertically and correspond to the medial, posterior and lateral, anterior walls and the margin of which forms a narrow anterior, inferior, posterior and superior wall; the distance between the medial and lateral walls varies much in different individuals, but is wider behind and above than in front and below and is least between the umbo and the promontorium.



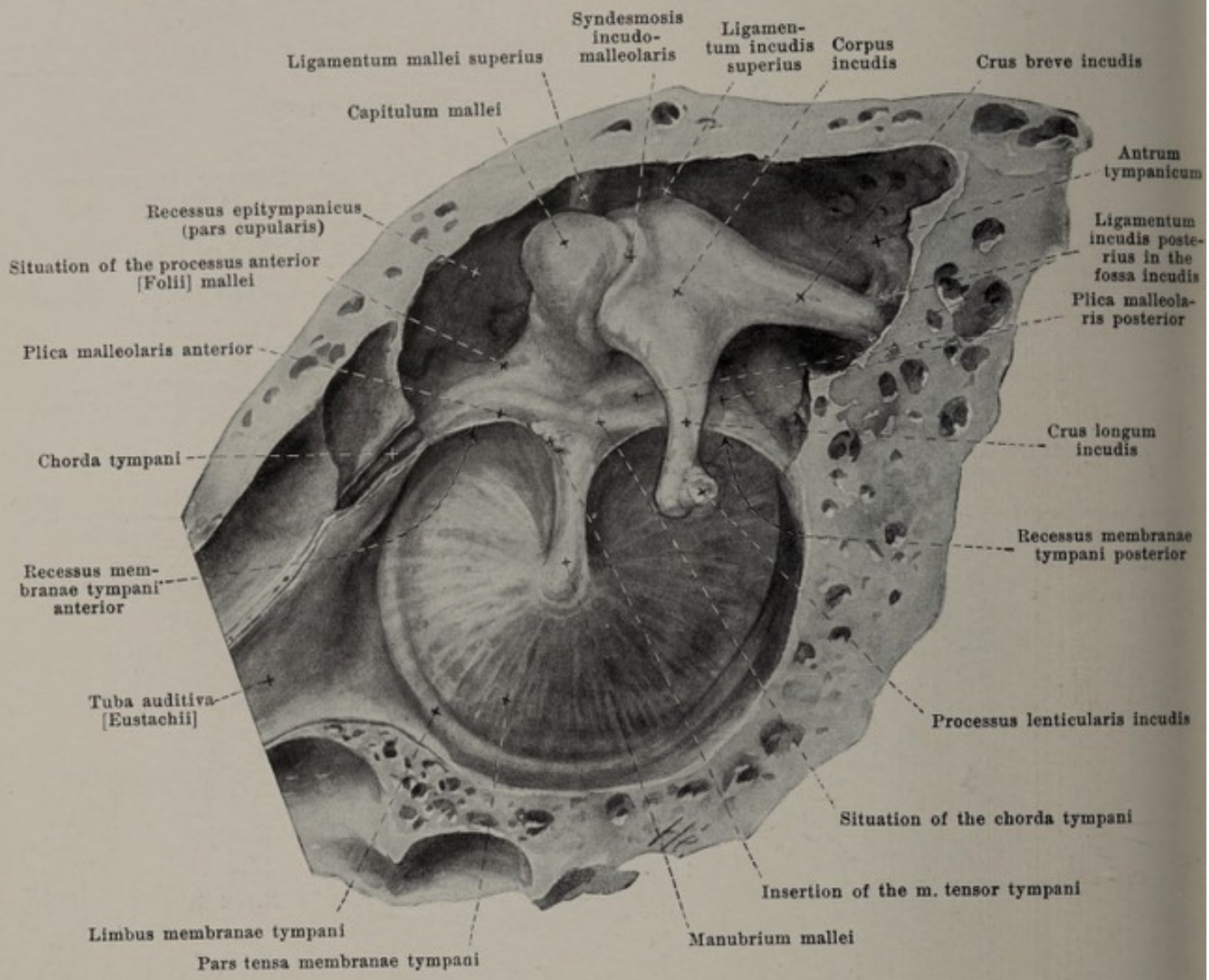
947. Right membrana tympani with the hammer and the chorda tympani, viewed from within, behind and above.

Magnification: 6:1.

(The folds of mucous membrane have been removed; the course of the chorda tympani and of the n. facialis has been exposed.)

Cavum tympani (continued).

The lateral wall (see Figs. 940—942, 946 and 948) is in large part occupied by the membrana tympani, and is therefore designated as *paries membranaceus*. It exceeds the limits of the membrana tympani below a little and in a very variable manner, considerably on the other hand above; in the latter situation it is formed by a bony plate which extends laterally over the end of the external acoustic canal, belongs to the squama temporalis and laterally bounds the *pars cupularis* of the *recessus epitympanicus* (see p. 835). In front the lateral wall goes over into the tuba auditiva, immediately above which the fissura petrotympanica [Glaseri] can be recognized in a macerated preparation.



948. Right membrana tympani with hammer and anvil, viewed from within, behind and above. Magnification: 6:1.

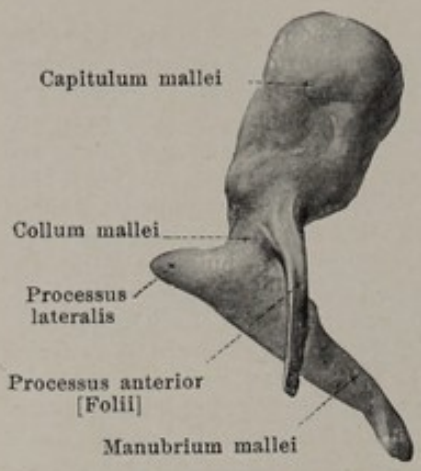
(The fold of mucous membrane, plica incudis, passing from the anvil upward and the fold running forward from the head of the hammer, the two of which bound the pars cupularis of the recessus epitympanicus medianward, are not shown in the drawing.)

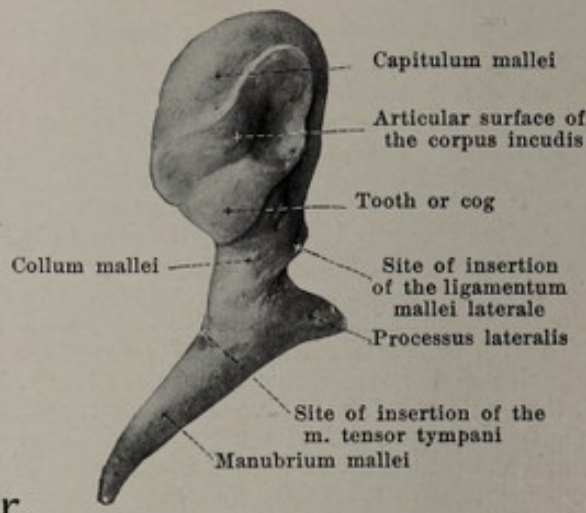
Cavum tympani (see also Figs. 13, 933, 940—942 and 952) (continued): The medial wall adjoins the labyrinth and is therefore called the *paries labyrinthicus.* In the macerated bone, one notices almost in its middle a transversely oval opening, *fenestra vestibuli, vestibular window,* leading into the vestibulum, this opening being situated at the bottom of a fossa, *fossula fenestrae vestibuli* (see also Figs. 945, 952, 965—967). Medial from it and to the front, the canalis musculotubarius passes forward and the posterior end of its septum bends lateralward and forms the *processus cochleariformis.* Beneath this the *promontorium,* a large projection due to the beginning of the basal turn of the cochlea, goes forward medially without sharp limit, over into the wall of the tuba auditiva; on its surface is a groove, *sulcus promontorii,* for the reception of the plexus tympanicus [Jacobsoni]; on the upper end of the main groove at the root of the processus cochleariformis lies an opening of the canaliculus tympanicus (see p. 14). On the inferior, posterior, sharply cut-off declivity of the promontorium a triangular fossa, *fossula fenestrae cochleae,* leads forward, upward and medianward, to the *fenestra cochleae, cochlear window,* which opens into the beginning of the basal turn of the cochlea (in its scala tympani); it is bordered by a narrow bony ridge, *crista fenestrae cochleae,* to which the membrana tympani secundaria is attached.

The fossula fenestrae cochleae is bounded above by a smooth bony projection, *subiculum promontorii*, which passes out dorsalward from the promontorium and forms the inferior boundary of the *sinus tympani*, a deep fossa, going over above into the fossula fenestrae vestibuli and bounded behind by the eminentia pyramidalis and the prominentia canalis facialis. Above and behind the fenestra vestibuli is the canalis facialis, passing in a curve backward and downward to vanish behind the eminentia pyramidalis. It is separated from the cavum tympani by a very thin bony leaflet which bulges the wall lateralward in the form of the *prominentia canalis facialis*. Just above it is the broad bulging of the wall due to the lateral semicircular canal and called the *prominentia canalis semicircularis lateralis*. These two bulgings form the medial boundary of the *recessus epitympanicus* (see below). The inferior wall, *paries jugularis*, goes over gradually into the anterior and posterior walls; it is sometimes smooth, sometimes studded with numerous nitches, *cellulae tympanicae*, separated by bony spicules, and contains one opening of the canaliculus tympanicus (see p. 14). At the boundary toward the posterior wall, there often projects an irregular nodule, *prominentia styloidea* (see Fig. 965), which corresponds to the upper end of the proc. styloideus. The wall abuts below partly on the fossa jugularis and varies extraordinarily in thickness. The posterior wall, *paries mastoideus*, possesses below many *cellulae tympanicae* (see above). Just near the sulcus tympanicus one sees in it a fine opening, the *apertura tympanica canaliculae chordae* (see Figs. 945, 947, 965 and 966), and at the same level, farther medianward, a small wedge-shaped elevation, *eminentia pyramidalis*, which, at its tip, possesses a small opening and in its interior an elongated cavity (see Fig. 961) for the m. stapedius; a bony spar stretched out between these two forms the lower boundary of a depression, *sinus posterior* (see Figs. 952, 962 and 965); following upon this is a step-like place in the upper deepened cartilaginous surface of which, *fossa incudis* (see Figs. 948, 952, 962 and 965), the crus breve incudis is attached by means of the lig. incudis posterius. The portion of the tympanic cavity lying above this receives the head of the hammer and the largest part of the anvil. It is called the *recessus epitympanicus* (see Figs. 933, 940, 942, 946—948 and 952) and reaches forward and downward as far as the prominentia canalis facialis, upward as far as the tegmen tympani; concerning its lateral and median walls see p. 833 and above. Its uppermost portion, which extends downward between the lateral wall on one side, the capitulum mallei, corpus and crus breve incudis and the folds of mucous membrane stretched out from them to the upper and anterior walls on the other side (see also p. 839) ends below in the form of a blind sack, called the *pars cupularis* (see Fig. 948), over the lig. mallei anterius. The recessus epitympanicus is directly continuous behind with the *antrum tympanicum*, a larger cavity roofed in above by the tegmen tympani; it forms the entrance to the very variable *cellulae mastoideae* (see also p. 11). The upper wall of the tympanic cavity, *paries tegmentalis* (see Figs. 952 and 966), is formed by the tegmen tympani (see p. 13) and is slightly rough. The anterior wall, *paries caroticus* (see Fig. 952), is bony only in its lower portion, where it possesses *cellulae tympanicae* and the openings of the canaliculi caroticotympanici (see p. 15). It is formed by a bony leaflet of variable thickness which separate it from the ascending part of the canalis caroticus (see Figs. 831, 940, 941 and 961). Its upper part is occupied by the *ostium tympanicum tubae auditivae*.

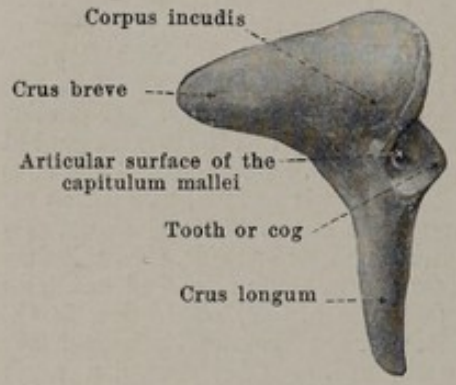
Ossicula auditus, small bones of the ear (see Figs. 933, 940—952), lie in the upper part of the tympanic cavity, are articulated with one another and form a chain which begins in the membrana tympani and ends in the fenestra vestibuli. They show considerable individual variations. (Development see p. 68.)

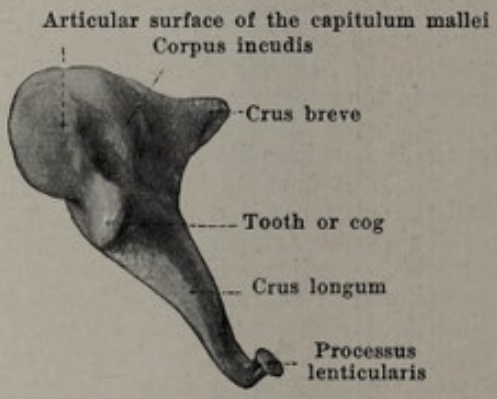
1. *Malleus, hammer* (see Figs. 933, 942—949), the largest of them, lies farthest lateral and forward. Its upper part, *capitulum mallei, head of hammer*, situated in the recessus epitympanicus, is thick and club-shaped and presents on its posterior and medial surfaces an elongated approximately saddle-shaped articular surface for the corpus incudis, which encroaches below upon a toothlike process, *tooth* or *cog of the hammer*. The head is separated by a constriction, *collum mallei, neck of the hammer*, from the *manubrium mallei, handle of the hammer;* the latter is a thin, bony rod, oval in cross-section, which tapers off toward the tip, where it ends like a spatula; its largest cross-section plane is perpendicular to the plane of the membrana tympani with the middle plate of which the handle of the hammer is fixed; on its lateral margin it has a cartilaginous covering; its lateral surface gives rise to the stria malleolaris (see p. 829) and internally it is covered by the mucous membrane of the tympanic cavity. With the head of the hammer, the handle forms an angle varying according to race, age and individual (on the average of about 130°) being always somewhat greater on the right than on the left. Its angle with the horizontal plane varies also, and amounts on the average on the right to about 50°, on the left to 45°. Above and laterally the handle of the hammer is continued into the small, tapered *processus lateralis*, which bulges out the prominentia malleolaris of the tympanic membrane. From the anterior surface of the neck, there passes forward the thin *processus anterior [Folii]* which appears longer in the infant.



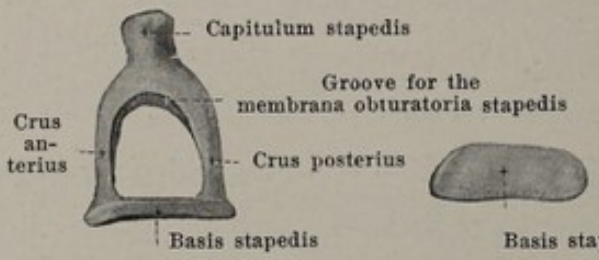


949. Right hammer, viewed from in front. Magn.: 6:1. viewed from behind.





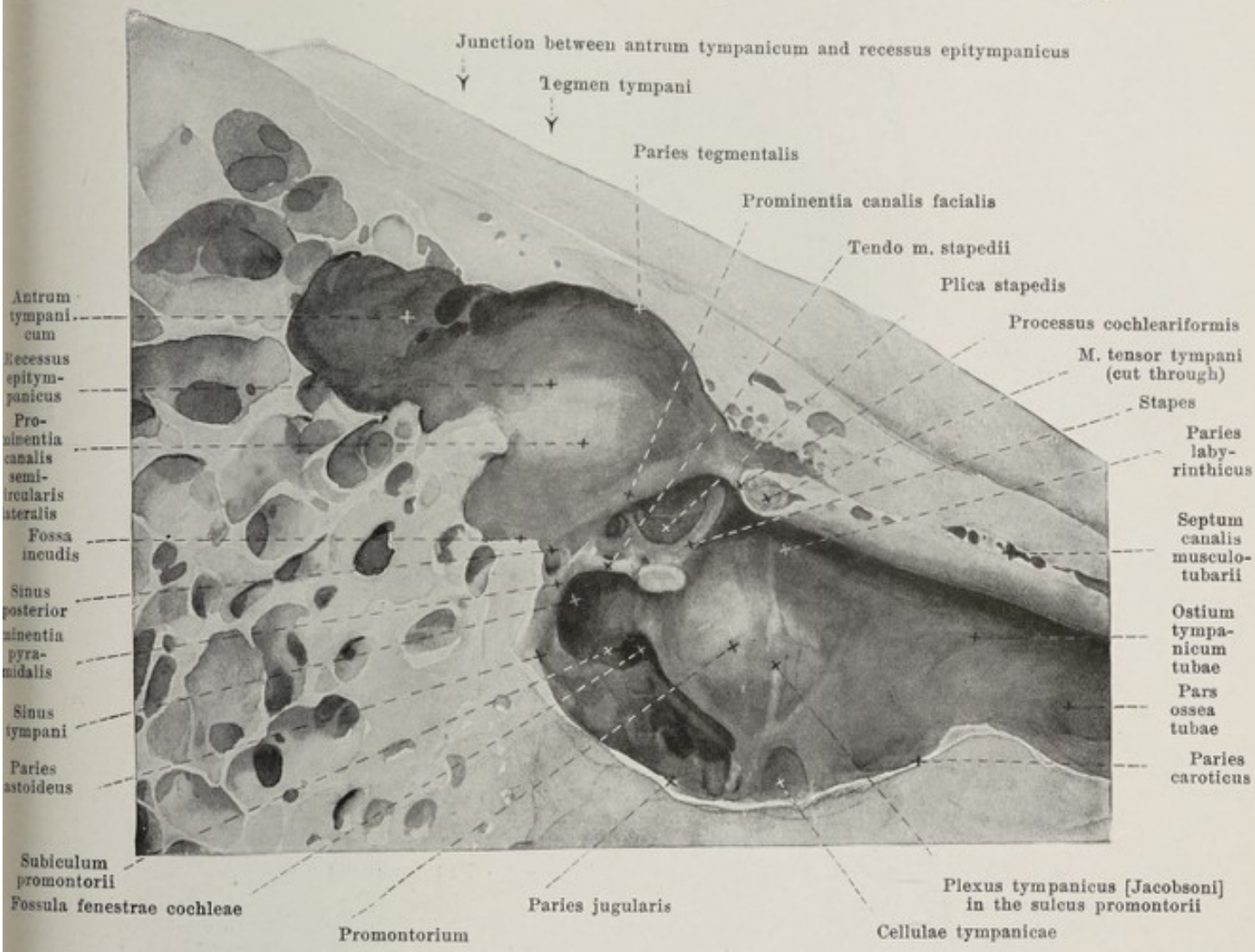
950. Right anvil, lateral view. Magn.: 6:1. medial and front view.



951. Right stirrup, viewed from above. Magn.: 6:1. medial view.

2. *Incus, anvil* (see also Figs. 942, 945 and 948), has approximately the form of a tooth with two roots. To the crown of the tooth corresponds the flattened *body, corpus incudis;* on its free basis it presents a saddle-shaped articular surface which encroaches somewhat upon a ridge on the lateral surface, the *tooth* or *cog of the anvil,* and serves for the reception of the head of the hammer. To the roots of the tooth correspond the *crus breve* and *crus longum, short* and *long leg;* the short leg is thicker and plumper; both taper out toward their tips and diverge from one another forming an angle of about 100°. The short leg is directed horizontally backward; its tip is covered with cartilage and lies in the fossa incudis (see p. 835). The long one runs parallel to the manubrium mallei and lies somewhat medially and dorsally from it. On the mediai side of the tip of the long leg is a small process, *processus lenticularis.*

3. *Stapes, stirrup* (see also Figs. 942, 944 and 952), possesses a *foot-plate, basis stapedis,* two *legs, crus anterius* and *posterius,* and a *small head, capitulum stapedis.* The foot-plate fills up the fenestra vestibuli nearly completely, is flat and possesses an upper, convex and a lower, straight or slightly concave margin. The two legs are hollowed out groove-like on their concave side, and are of approximately equal length; the anterior is finer than the posterior and less markedly curved; the latter possesses near its capitulum a small rough area for the insertion of the m. stapedius. Between the legs and the foot plate is stretched out a thin connective tissue membrane, *membrana obturatoria stapedis* (not illustrated). The capitulum is very variable and presents on its lateral free end a small articular surface covered with cartilage for the processus lenticularis. The plane of the stirrup lies approximately horizontally and is laterally inclined somewhat downward (see Fig. 952).



952. Medial wall of the right tympanic cavity,

lateral view. Magnification: 5 : 1.

The small bones of the ear are united with one another by joints, *articulationes ossiculorum auditus*, namely by the *syndesmosis incudomalleolaris* (see Fig. 948) between the head of the hammer and the body of the anvil, the *articulatio incudostapedia* between the processus lenticularis of the anvil and the capitulum stapedis and the *syndesmosis tympanostapedia* between the cartilage-covered margins of the fenestra vestibuli and the basis stapedis, the interspace of which is filled up by a ligamentous mass, *lig. annulare basis stapedis* (not illustrated).

The small bones of the ear are fastened in the wall of the tympanic cavity so that the manubrium mallei is inserted in the membrana tympani and the basis stapedis is fastened in the fenestra vestibuli; in addition there are interosseous ligaments, *ligamenta ossiculorum auditus:*

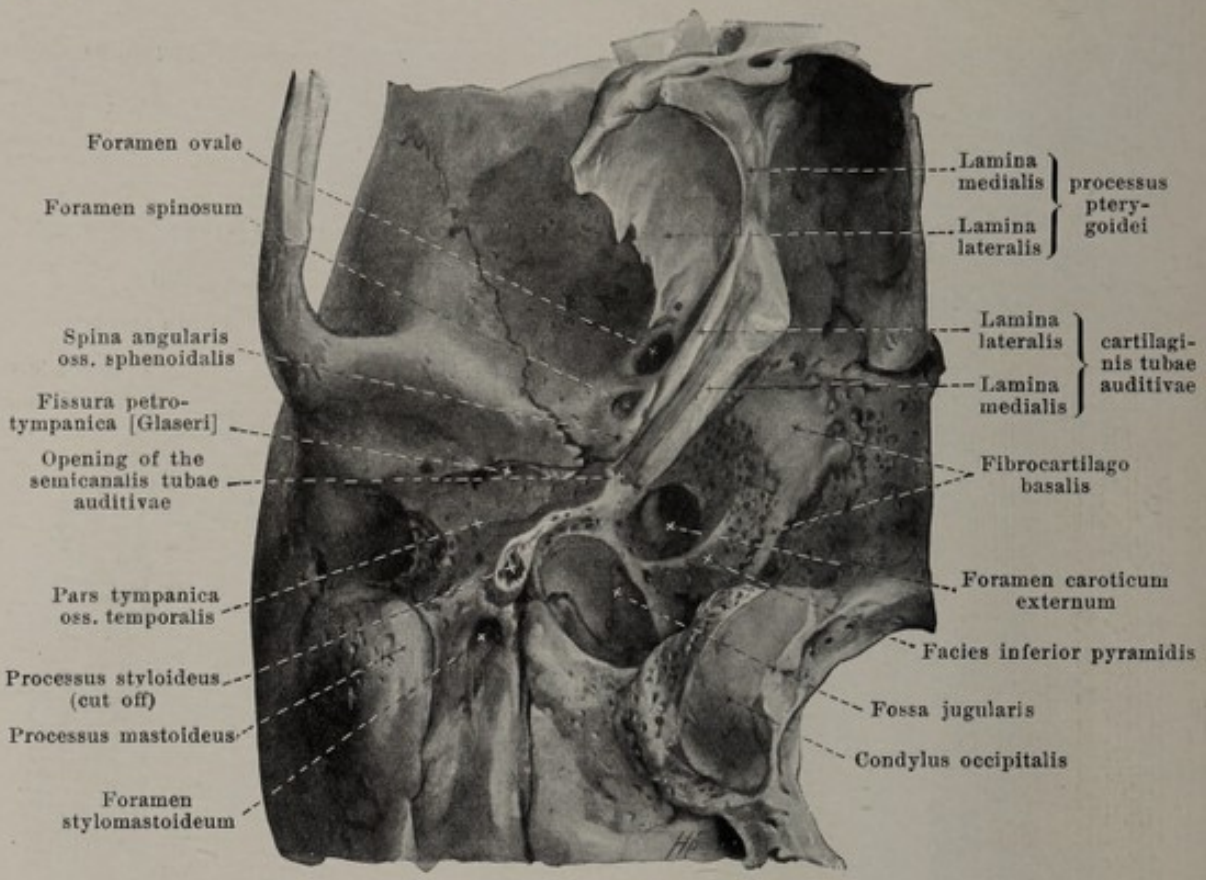
1. *Lig. mallei anterius* (see Figs. 945 and 947), in the plica malleolaris anterior, from the proc. anterior [Folii] mallei, ensheathing it; it passes into the fissura petrotympanica [Glaseri] and goes on as far as the spina angularis of the sphenoid bone.

2. *Lig. mallei laterale* (see Fig. 942), diverging from the neck of the hammer to the spinae tympanicae major and minor and to the margin of the incisura tympanica [Rivini].

3. *Lig. mallei superius* (see Figs. 942, 947 and 948), variable, from the roof of the recessus epitympanicus downward to the upper end of the head of the hammer.

4. *Lig. incudis posterius* (see Fig. 948) passes from the crus breve incudis to the posterior wall of the tympanic cavity and fastens the former in the fossa incudis.

5. *Lig. incudis superius* (see Fig. 948) from the roof of the recessus epitympanicus downward to the corpus incudis; it is only a bridge of mucous membrane and contains no ligamentous fibres.



953. Cartilage of the right Eustachian tube, viewed from below.

(The processus styloideus has been cut off at its root.)

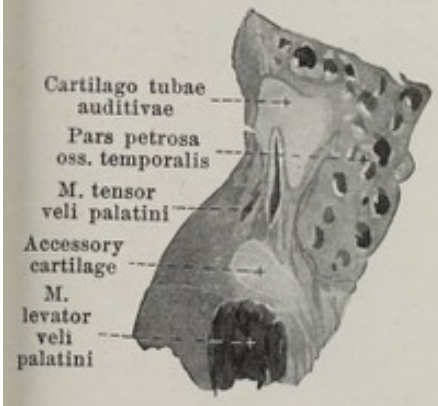
Musculi ossiculorum auditus.

1. *M. tensor tympani* (see Figs. 933, 942, 945—948 and 952), spindle-shaped, bipinnate lies in the semicanalis m. tensoris tympani (see p. 13) the bony wall of which is completed by a tough connective membrane. It arises from the upper surface of the cartilago tubae auditivae and from the walls of the canal (especially the upper). The rounded tendon bends around, almost at a right angle, at the proc. cochleariformis, passes lateralward through the tympanic cavity, covered by mucous membrane, and becomes attached to the handle of the hammer near the neck of the hammer. It draws the manubrium mallei medianward and stretches the membrana tympani. Innervation: n. tensoris tympani (V).

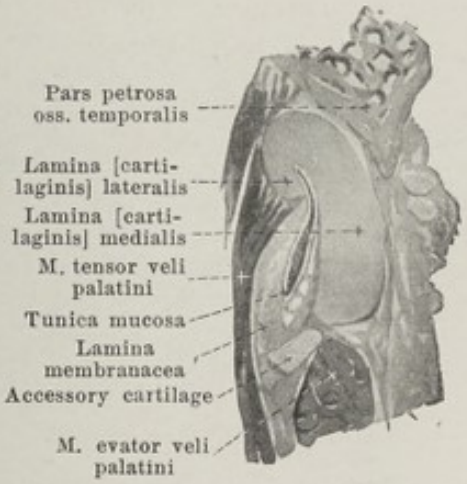
2. *M. stapedius* (see Figs. 831, 945 and 952), pinnate, fills up the cavity situated in the eminentia pyramidalis (see Fig. 961). Its tendon appears at the tip of the eminentia pyramidalis, bends somewhat downward at an obtuse angle and, covered by mucous membrane, passes forward and medianward to the posterior margin of the capitulum stapedis. It moves the posterior end of the basis stapedis somewhat inward, the anterior end more strongly outward. Innervation: *n. stapedius* (VII).

Tunica mucosa tympani, mucous membrane of the tympanic cavity (see Figs. 942, 946, 948 and 952), lines the surface of the whole tympanic cavity, of the cellulae mastoideae, of the small bones of the ear, of the membrana tympani (see p. 831), as well as of the tendons and ligaments, as a thin membrane and is intimately united with the periosteum. In approaching some of these structures, duplicatures or *folds, plicae*, are formed, most of which are very variable.

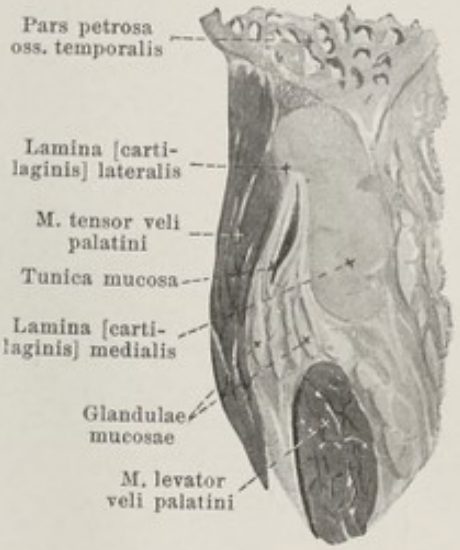
The most constant folds are the following: the *anterior hammer fold, plica malleolaris anterior* (see Figs. 946—948), goes off from the membrana tympani between the spina tympanica major and the manubrium mallei, ensheaths the proc. anterior [Folii] mallei, the lig. mallei anterius, and the anterior part of the chorda tympani, and ends in a free concave margin; the pocket ending blind above, situated between it and the membrana tympani, is called the *anterior pocket of the membrana tympani, recessus membranae tympani anterior.* The larger, *posterior hammer fold, plica malleolaris posterior* (see Fig. 948), goes off from the membrana tympani between the spina tympanica minor and the manubrium mallei, is fastened behind to the uppermost part of the sulcus tympanicus, encloses below the posterior part of the chorda tympani and ends with a free concave margin.



954. Near the lateral end of the cartilaginous part.



955. At the junction between the lateral and middle thirds.

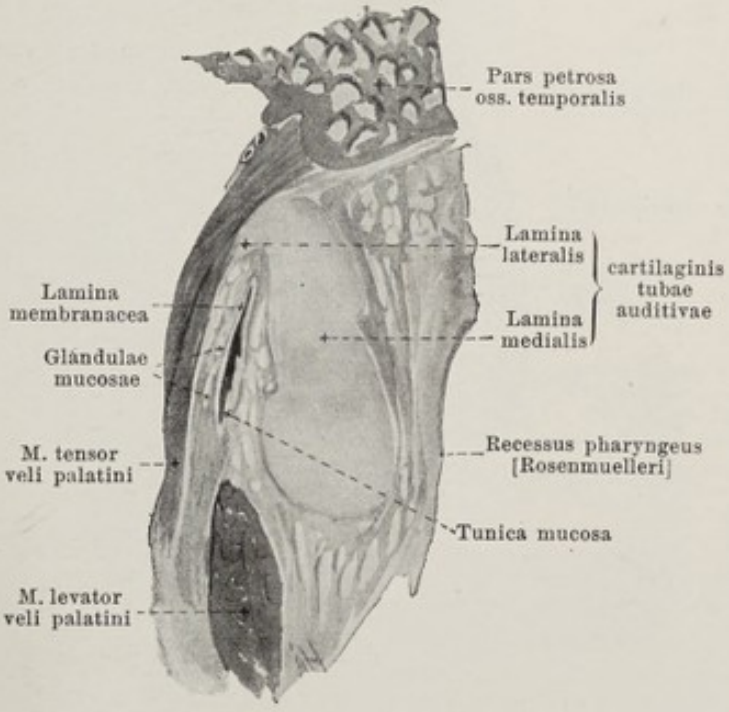


956. At the junction between the middle and medial thirds.

954—957. Cross-sections through the cartilaginous Eustachian tube of the right side,

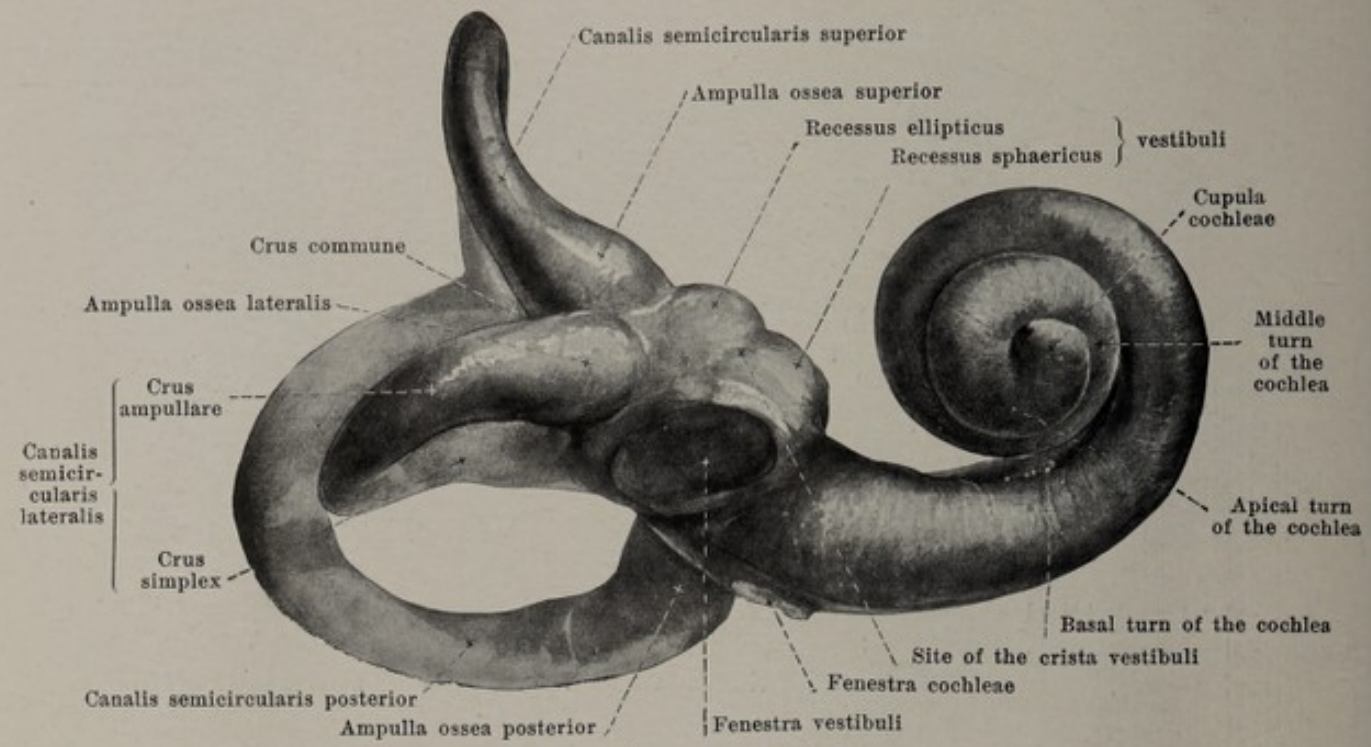
viewed from the medial side.

Magnification: 3 : 1.

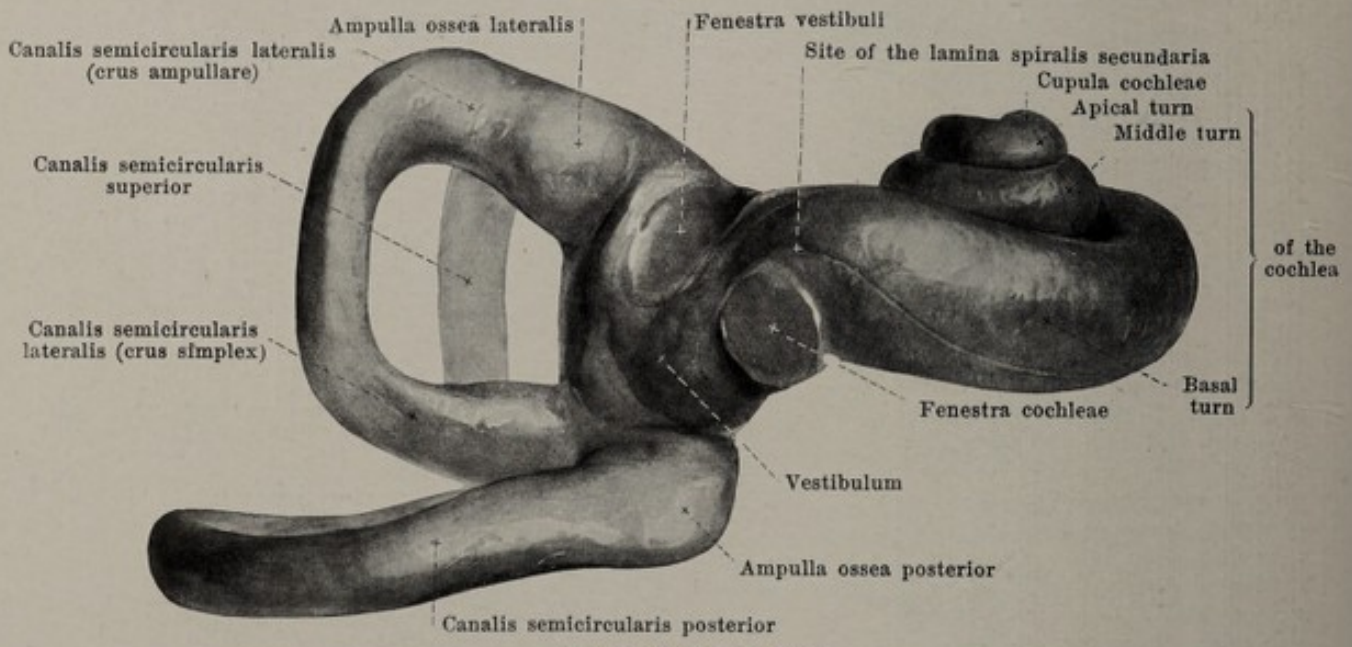


957. Near the ostium pharyngeum tubae auditivae.

Tunica mucosa tympani (continued) (see Figs. 942, 948 and 952). Between the posterior hammer fold and the membrana tympani lies the *posterior pocket of the membrana tympani*, *recessus membranae tympani posterior*. It ends blind above or is continued above directly into the *upper pocket of the membrana tympani*, *recessus membranae tympani superior* (see Fig. 942), enclosed by the pars flaccida of the membrana tympani, the lig. mallei laterale as well as the collum and proc. lateralis mallei; the pocket may also open inward through a special foramen. From the roof of the recessus epitympanicus a vertical fold, *plica incudis* (not illustrated), descends to the corpus and crus breve incudis and a similar fold goes from the head of the hammer to the anterior wall; they help to form the medial wall of the pars cupularis of the recessus epitympanicus (see p. 835). The *plica stapedis* (see Fig. 952) ensheaths the whole stirrup along with the membrana obturatoria stapedis and the tendon of the m. stapedius and often stretches out also to the posterior wall of the tympanic cavity. Over the fenestra cochleae the mucous membrane, as it passes, helps to form the *membrana tympani secundaria* (see p. 854).



Lateral and front view.

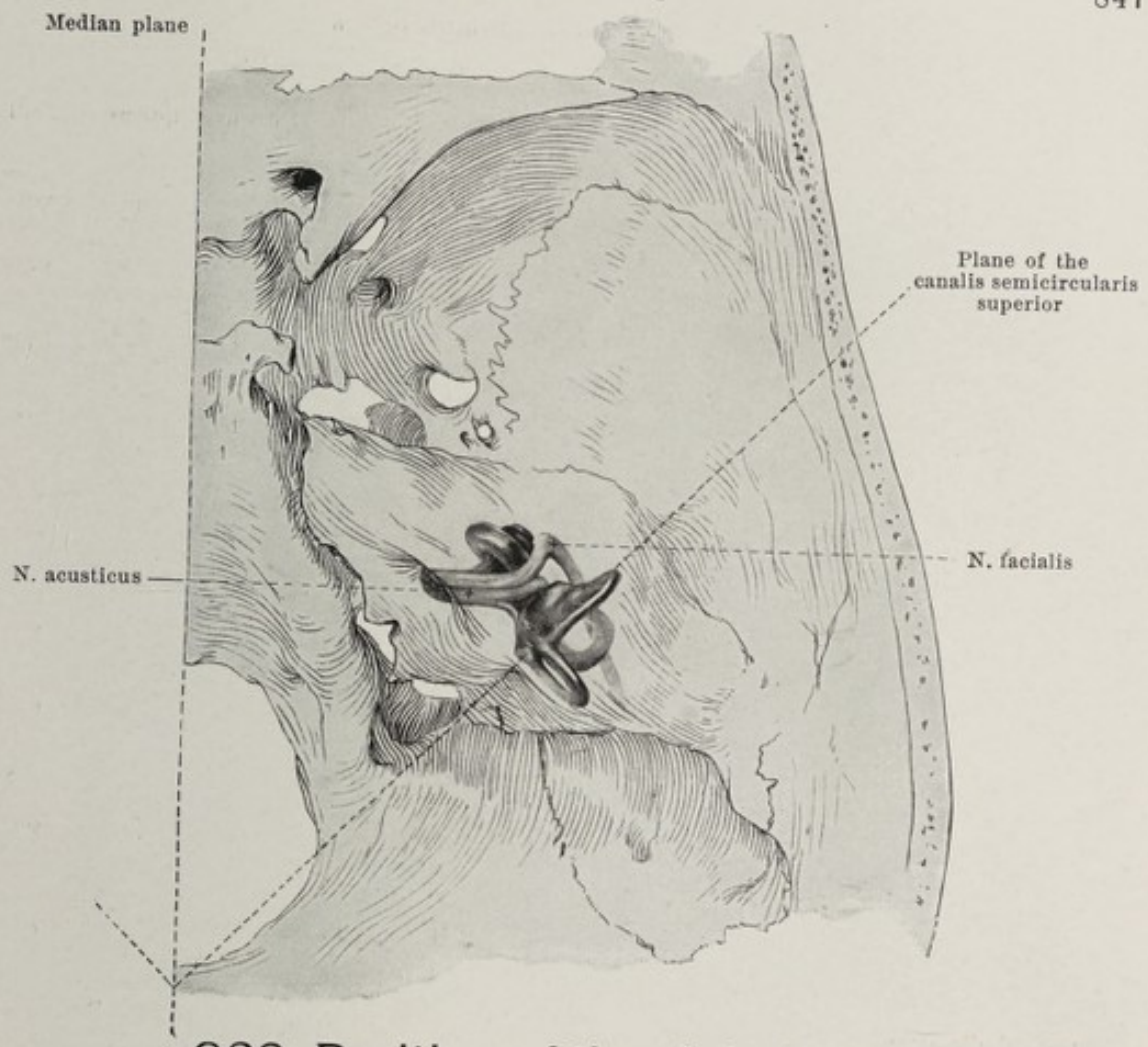


Viewed from below.

958 and 959. Corrosion preparation of the right bony labyrinth of the ear. Magnification: 6 : 1.

Tuba auditiva [Eustachii], ear trumpet, Eustachian tube (see Figs. 596, 600—604 933, 941, 942, 948 and 952—957), unites the tympanic cavity with the pharynx, runs in general obliquely forward medially and downward and divides into a lateral shorter bony part and a medial longer cartilaginous part. These form with one another a large obtuse angle open below, the vertex of which corresponds to the narrowest part of the lumen, the *isthmus tubae auditivae.*

The bony part, *pars ossea tubae auditivae,* begins in the anterior wall of the tympanic cavity (see p. 835) with the oblong-oval *ostium tympanicum tubae auditivae* and includes the semicanalis tubae auditivae (see p. 13). Its lumen narrows medianward and is approximately triangular; the upper wall is formed by the tegmen tympani.

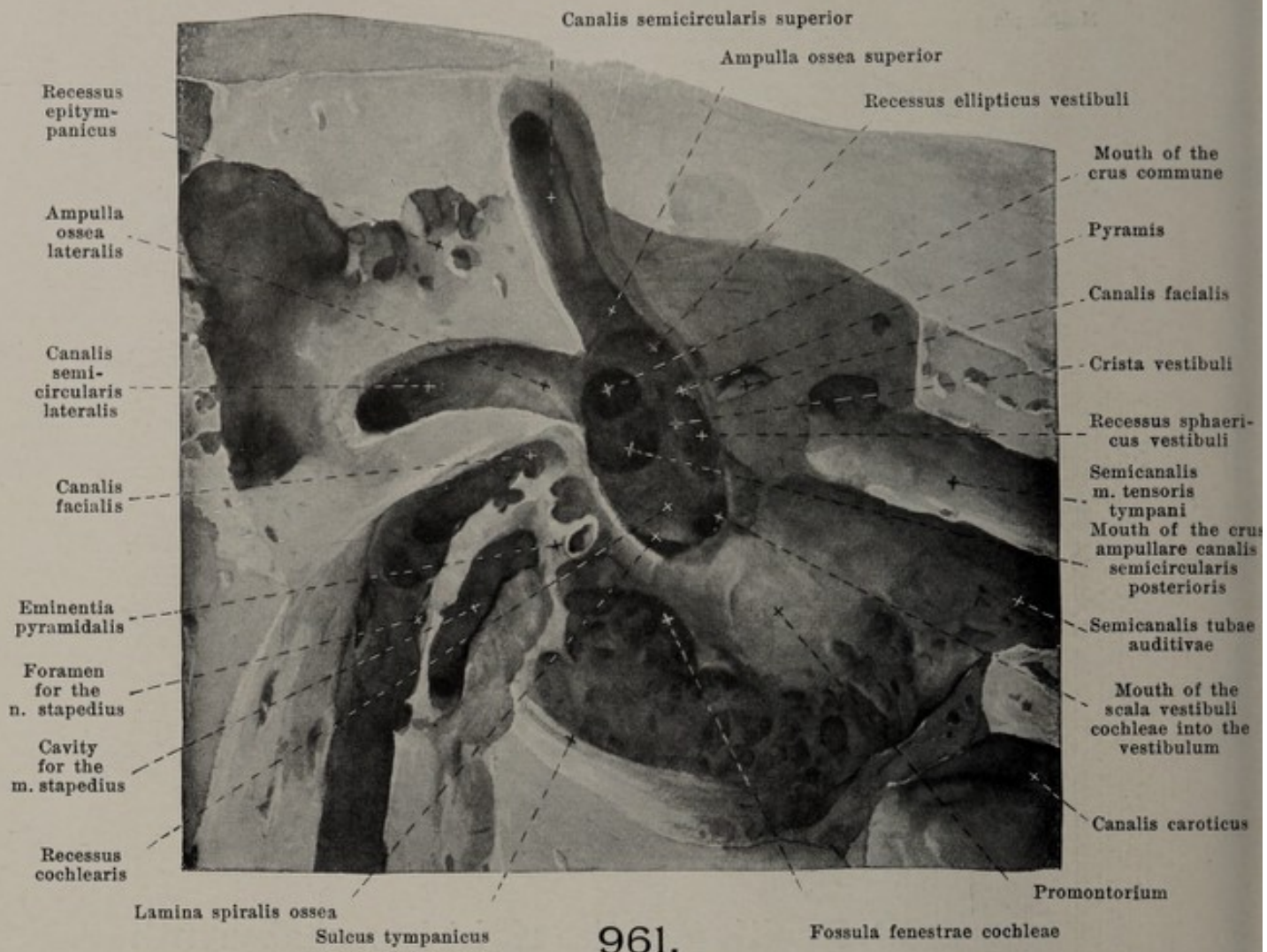


960. Position of the right bony labyrinth of the ear in the skull, viewed from above.

(The temporal bone is considered transparent and the labyrinth drawn in from a corrosion preparation.)

Tuba auditiva (continued) (see Figs. 596, 600—604, 933, 941, 942, 948 and 952—957). The medial wall of the bony part is formed partly by the septum canalis musculotubarii and its connective tissue supplement (see p. 838), partly by the continuation of the medial wall of the tympanic cavity and lies laterally very close to the canalis caroticus (see also Fig. 968). The lateral wall is shorter than the others and consists of the pars tympanica of the temporal bone; the lower boundary is groove-like and near the tympanic cavity presents several variably developed small evaginations, *cellulae pneumaticae tubarii.*

The cartilaginous part, *pars cartilaginea tubae auditivae,* reaches as far as the *ostium pharyngeum tubae auditivae* (see p. 523), its form being essentially determined by the *cartilago tubae auditivae* which consists partly of hyaline, partly of elastic cartilage. This together with the broad plate, *lamina [cartilaginis] medialis,* which is somewhat thickened below, forms the whole posterior, medial wall, and together with the narrow, upper continuation of the former, bent around sharply downward, the *lamina [cartilaginis] lateralis,* forms the upper part of the anterior, lateral wall; the cartilage directly adjoins the bone of the pars ossea and laterally is somewhat longer, since there the bone stops sooner (vide supra). The upper edge of the cartilage is united firmly along and under the fissura sphenopetrosa with the fibrocartilago basalis, the lateral plate adjoins laterally the sulcus tubae auditivae oss. sphenoidalis and medially the posterior margin of the proc. pterygoideus. The lateral wall is formed beneath the lamina lateralis by the fibrous *lamina membranacea.* From it and the lamina lateralis arise fibres of the m. tensor veli palatini (see p. 524). The whole inner surface of the Eustachian tube is lined by mucous membrane, *tunica mucosa.* This is very thin in the bony part; in the cartilaginous part it is thicker and contains numerous mucous glands, *glandulae mucosae,* and various lymph nodules, *noduli lymphatici tubarii.* The lumen of the cartilaginous part is slit-like and in the middle of its length is closed when the velum palatinum is loose.



961.

Right vestibule and semicircular canals in the macerated bone, open from the outside. Magn.: 5 : 1.

(In addition the canales caroticus and facialis, as well as the cavity for the m. stapedius have been opened up.)

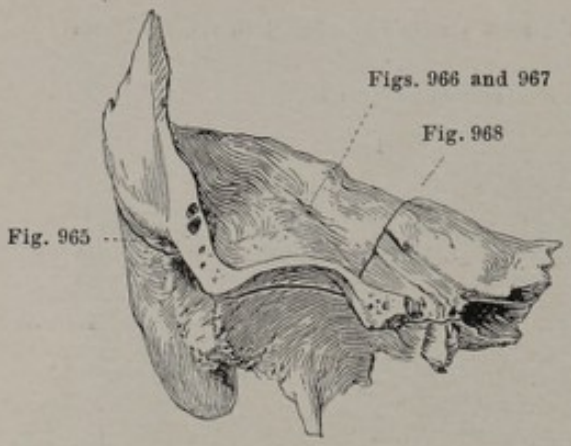
Auris interna, *internal ear*, consists of a hollow space in the bone, the *bony labyrinth*, *labyrinthus osseus*, and the *membranous labyrinth*, *labyrinthus membranaceus*, surrounded by it.

Labyrinthus osseus, bony labyrinth (see also Figs. 958—960 and 962—970), lies within the pars petrosa oss. temporalis, lateralward adjoins the paries labyrinthicus of the tympanic cavity, medianward the floor of the meatus acusticus internus, being connected through the latter with the skull cavity. It is surrounded by a very hard layer of bone, 2—3 mm thick, the *bony labyrinthine capsule* (see Figs. 965 and 968), which in the fetus and new-born in many places reaches the surface of the pars petrosa, in others is separated by spongy bony substance distinctly from the rest of the bony mass of the pyramid of the temporal bone, while in the adult it lies more in the interior and is in large part fused with the compact bony substance of the neighborhood. The bony labyrinth is almost as large in the new-born as in the adult. It surrounds a system of cavities in which three parts may be distinguished: a middle, the *vestibule*, a medial, anterior, the *cochlea*, and a lateral, posterior, the three *semicircular canals*. The *bony labyrinth* has a maximal length of about 20 mm and lies approximately parallel to the posterior surface of the pyramid of the temporal bone; thus situated the cochlea lies in front medially and below, the semicircular canals behind laterally and above. The basis of the cochlea adjoining the meatus acusticus internus is directed parallel to the plane of the posterior semicircular canal; both run approximately vertically and form an angle of 45° with the median plane, as does the plane of the superior semicircular canal which stands perpendicular to both; the meatus acusticus internus is directed nearly horizontally and frontally.

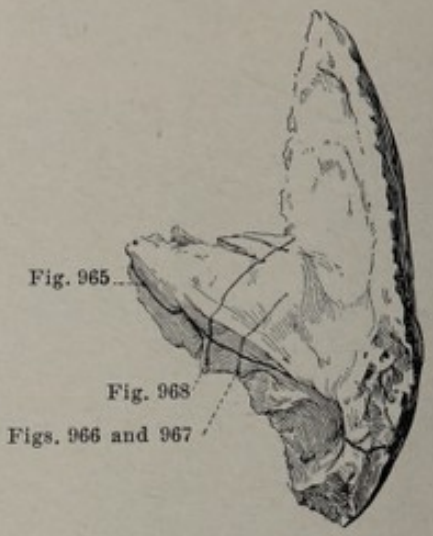
962. Right cochlea in the macerated bone open from the outside. Magnification: 5:1.

(The canalis caroticus has been laid open; a fine probe has been passed through the fenestra cochleae.)

The *vestibule, vestibulum* (see Figs. 958, 959, 961 and 965—967), is a small oval cavity, the wall of which is almost everywhere smooth. Its medial wall (see Figs. 961, 965 and 967) helps in its anterior part at the same time to form the fundus meatus acustici interni, namely the part of the same occupied by the areae vestibulares. On it (see Fig. 967) runs a delicate ridge, *crista vestibuli*, which begins laterally over the fenestra vestibuli, runs at first obliquely backward and downward, but then straight downward and marks off from one another two deepened areas of unequal size. The posterior, superior elongated oval area, *recessus ellipticus*, serves for the reception of the utriculus (see p. 851) and contains in a small depression the *apertura interna aquaeductus vestibuli* (see p. 11). The anterior, inferior rounded area, *recessus sphaericus*, receives the sacculus (see p. 852) and in its middle contains a small, perforated area, *macula cribrosa media*, in which open the fine foramina of the area vestibularis inferior (see p. 850) and the n. saccularis (see p. 728) arrives in the vestibule.



963. Right temporal bone, viewed from in front and above, after removal of the anterior part of the squama temporalis,



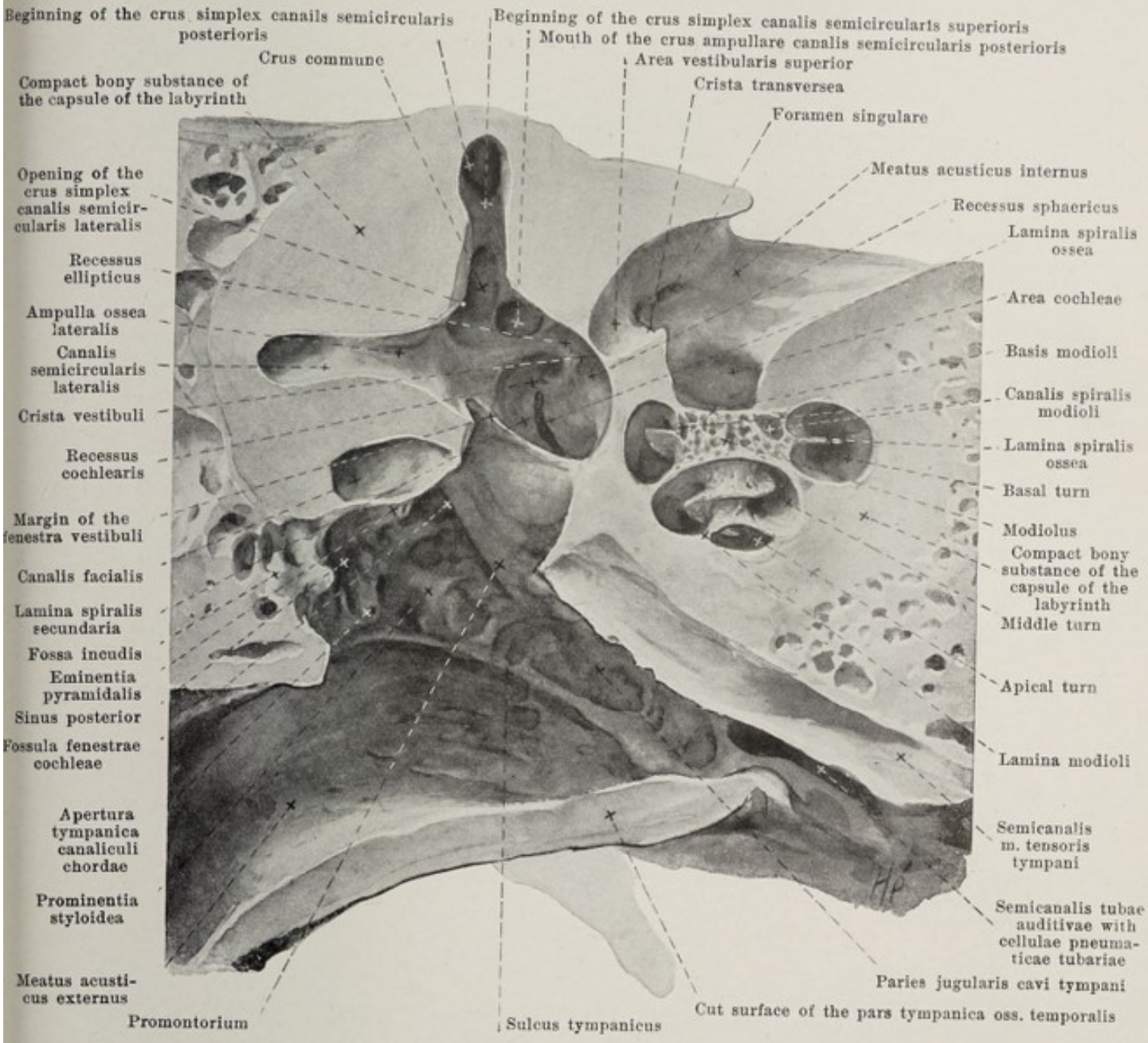
964. Right temporal bone, viewed from above and behind,

giving the direction of the sections pictured in Figs. 965—968.

The *vestibule, vestibulum* (continued) (see Figs. 958, 959, 961, 962 and 965—967). The crista vestibuli close behind and over the fenestra vestibuli presents a variably developed prong, *pyramis vestibuli.* Upon this and in its immediate neighborhood are the minute openings which correspond to the foramina of the area vestibularis superior (see p. 850) and serve for the passage of the upper branch of the n. vestibularis (see p. 727); together they are designated as the *macula cribrosa superior.* Under the forked posterior end of the crista vestibuli lies a small depressed area, *recessus cochlearis* (see Figs. 965—967); it is separated behind by a ridge from the opening of the crus ampullare canalis semicircularis posterioris, goes forward immediately upon the beginning of the lamina spiralis ossea and lamina spiralis secundaria and receives the caecum vestibulare of the ductus cochlearis (see p. 853). Close behind this area, in the anterior wall of the ampulla ossea posterior (see Fig. 967), a small, perforated area, *macula cribrosa inferior,* is visible, which contains the openings of small canals beginning in the foramen singulare (see p. 850) and through which the n. ampullaris posterior (see p. 728) arrives in the vestibulum. The recessus cochlearis leads medianward directly into the vestibular opening of the scala vestibuli cochleae (see p. 849) which occupies the lowermost portion of the medial wall of the vestibule.

The vestibule is connected in the macerated bone in front laterally with the tympanic cavity through the *fenestra vestibuli* (see p. 834), in which the foot-plate of the stirrup is fastened by the lig. annulare basis stapedis. Opening into the vestibule besides are the semicircular canals, the five mouths of which are so distributed over the lateral and inferior walls (see Fig. 966) that the crus ampullare of the lateral canal opens over the fenestra vestibuli and over it the crus ampullare of the superior semicircular canal; behind the former lies the opening of its crus simplex and over this that of the crus commune, and in the posterior part of the floor the opening of the crus ampullare of the posterior semicircular canal is to be found.

Bony semicircular canals, canales semicirculares ossei (see also Figs. 958—961 and 965—967), are three nearly semicircular curved bony tubes, each of which is connected at two places with the wall of the vestibule. They lie in three planes nearly perpendicular to one another and together form a right-angled corner (see Figs. 958—960). In detail, however, these angles as well as the form, length, width and curvature of the semicircular canals are subject to fairly great variations, but are alike on the right and the left side of the same individuals. The shortest of them, *canalis semicircularis lateralis,* is directed lateral and backward, adjoins lateralward and forward the recessus epitympanicus and there causes the prominentia canalis semicircularis lateralis; it does not lie exactly in a („horizontal") plane drawn through the lowest points of both infraorbital margins and the highest points of both ear-openings but forms with it an angle of about 24°, open lateralward, dorsalward and downward.

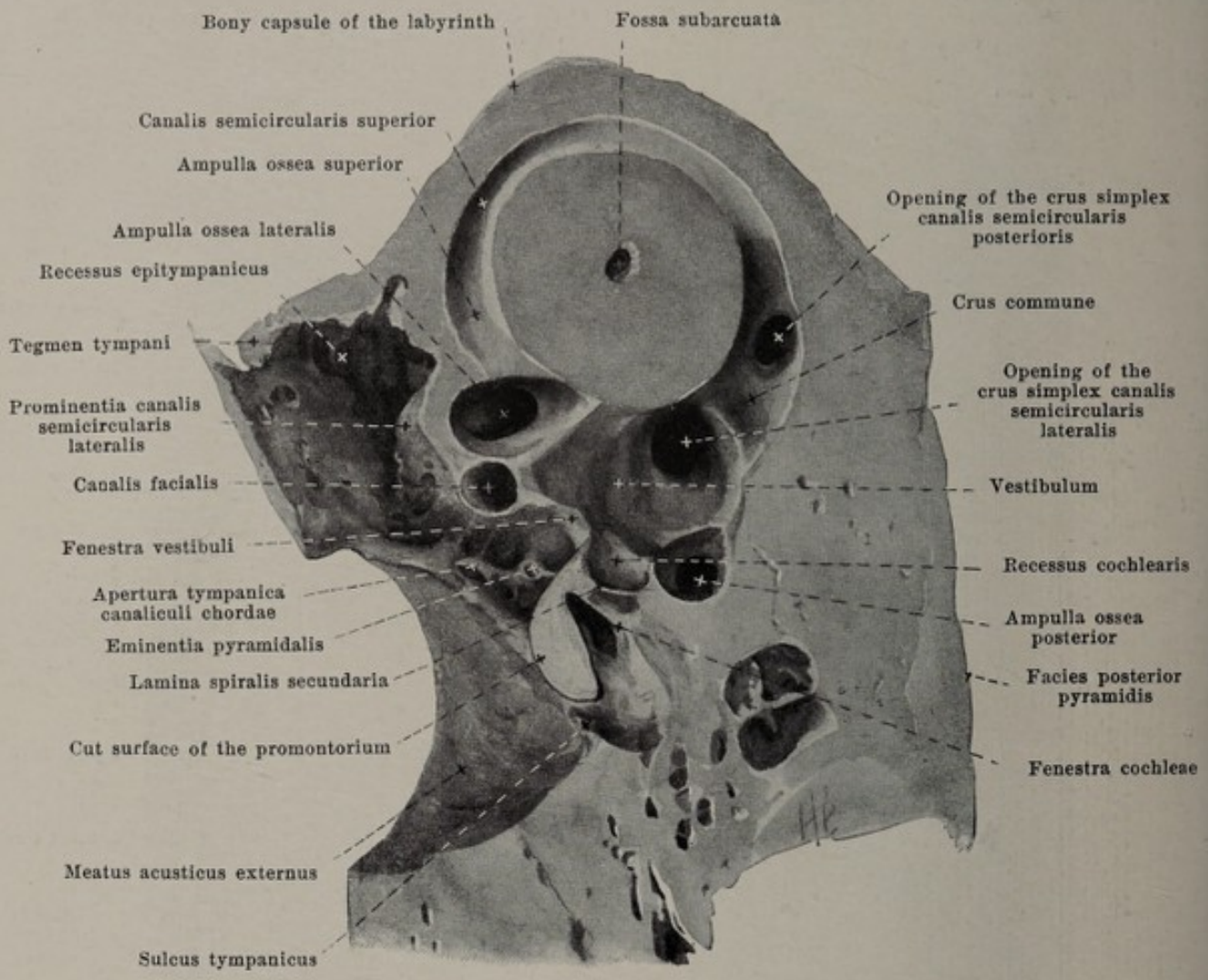


965. Transversal section through the right temporal bone, lower half, viewed from above. Magnification: 5:1.

Concerning the direction of the section see Figs. 963 and 964.

(The crus commune, which was not struck by the section, has been subsequently opened.)

Bony semicircular canals (continued) (see Figs. 958—961, 966 and 967). The two other semicircular canals run in approximately vertical planes (see p. 842); one of them, *canalis semicircularis superior*, stands at right angles to the axis of the pyramid of the temporal bone, and usually gives rise on its facies anterior to the projecting eminentia arcuata, the other, the longest of all, *canalis semicircularis posterior*, lies nearly parallel to the facies posterior pyramidis and goes above and below considerably beyond the plane of the lateral semicircular canal. Each of them deviates in part somewhat from its plane and so presents a slight "surface curvature"; the posterior and superior, viewed from the side, appear slightly S-shaped, the horizontal curved so as to be slightly C-shaped. The lumen of each semicircular canal has the form of an ellipse the largest diameter of which falls in the plane of the canal; it is largest (measured at the vertex of the semicircular canal) in the posterior canal, smallest in the superior.

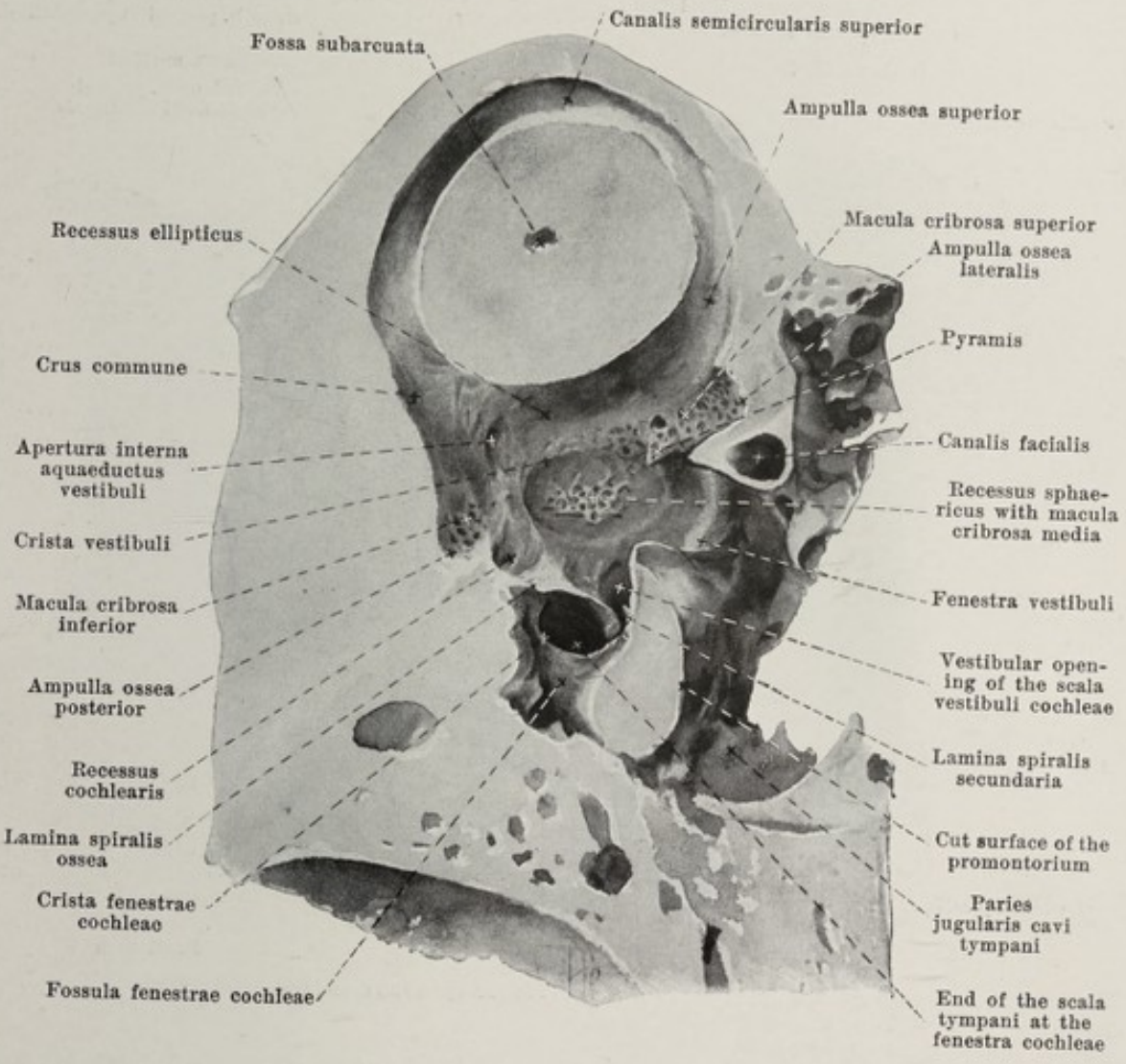


966. Vertical section through the right temporal bone, lateral portion viewed from the medial side.

Magnification: 5:1.

(For the corresponding medial portion see Fig. 967.) Concerning the direction of the section see Figs. 963 and 964.

Bony semicircular canals (continued) (see also Figs. 958—961, 965 and 967). One of the two ends of each semicircular canal presents a flask-like dilatation, *ampulla ossea;* the corresponding limb of the semicircular canal is called the *crus ampullare,* the other non-dilated one, the *crus simplex.* The ampullae osseae vary somewhat in length and width, that of the lateral semicircular canal, *ampulla ossea lateralis,* and that of the superior semicircular canal, *ampulla ossea superior,* lie at their lateral ends, that of the posterior semicircular canal, *ampulla ossea posterior,* at its inferior end. The two ends of the lateral semicircular canal open separately into the vestibule; the same is also true of the crura ampullaria of the posterior and of the superior semicircular canal, the former on the lower wall, the latter close to the upper wall of the vestibulum. The simple limbs of the superior and posterior semicircular canals unite on the contrary to form a common round limb, *crus commune,* $3^1/_2$—4 mm long, which forms an angle of 40—50° with the horizontal plane (see p. 844) and opens directly behind and over the crus simplex of the lateral semicircular canal into the vestibule.

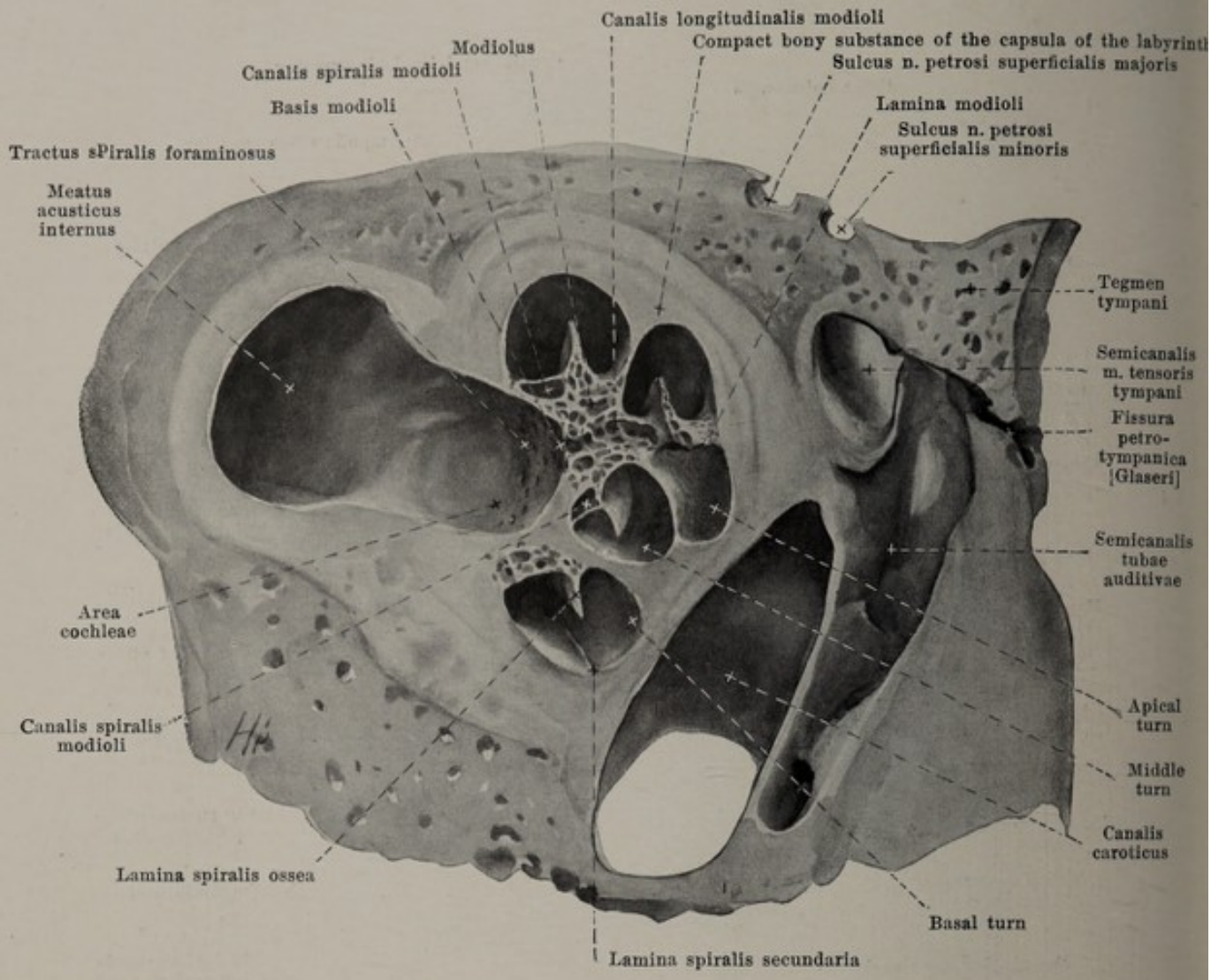


967. Vertical section through the right temporal bone, medial portion, viewed from the lateral side. Magnification: 5:1.

(The corresponding lateral portion is shown in Fig. 966.)

Concerning the direction of the section see Figs. 963 and 964.

The *snail, cochlea* (see also Figs. 958—962, 965, 968 and 969), is a low cone formed of hard bony substance, its axis being placed horizontally; its base, *basis cochleae* (see also p. 842), is directed toward the anterior part of the fundus meatus acustici interni, its blunt *apex, cupula*, toward the semicanalis m. tensoris tympani; its inferior, anterior wall directly adjoins the rectangular curvature of the canalis caroticus in the temporal bone. In its interior it contains a spirally wound canal, *canalis spiralis cochleae*, which begins in the anterior and lowest portion of the vestibule (see p. 844) and at the fenestra cochleae, and ends blind at the apex. The canalis spiralis cochleae is on the average 37.5 mm long, runs from its beginning in the vestibule at first curved somewhat downward, medial from the promontorium, forward and medianward as far as the canalis caroticus (see Fig. 962), there bends around upward and curls up on itself first loosely, then more closely, in the form of a spiral, so that usually 2¾ turns arise, called the *basal turn*, the *middle turn* and the *apical turn;* these turns do not lie in one plane, but each subsequent one becomes elevated laterally over the preceding and is at the same time more markedly curved than it (see Figs. 958 and 962); the *cupula* is formed by the blind end and the last portion of the third turn.

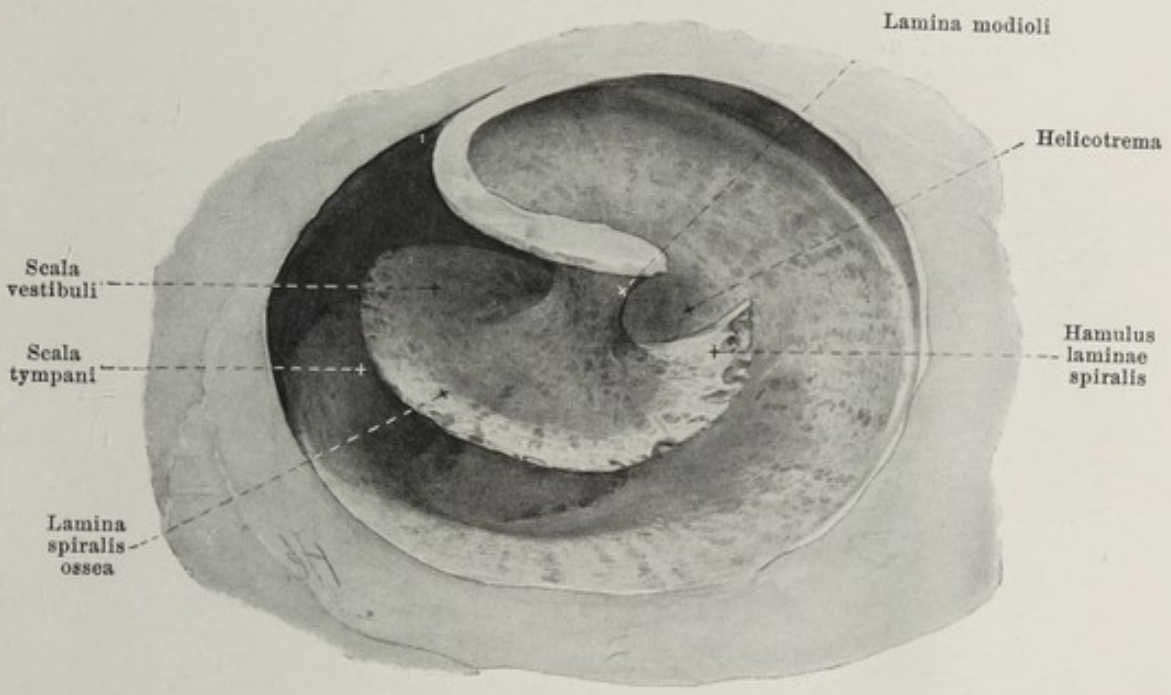


968. Vertical section through the right cochlea,

medial portion viewed from the lateral side. Magnification: 6:1.

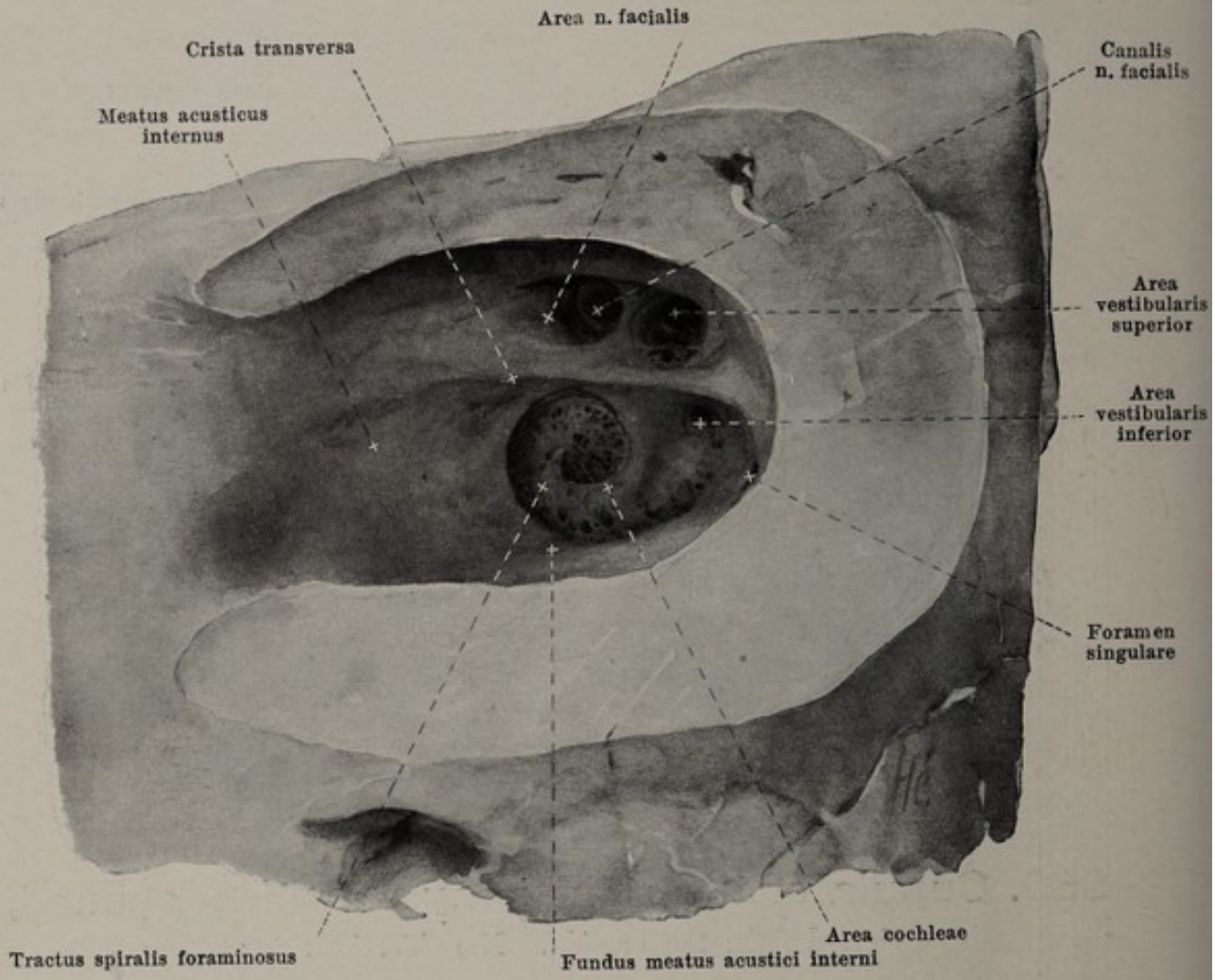
Concerning the direction of the section see Figs. 963 and 964.

Cochlea (continued) (see also Figs. 958—962, 965—967 and 969). The axial space of the cochlea around which the canalis spiralis is coiled consists of spongy bone-substance and is called the *modiolus (spindle)*; this represents at the same time the inner wall of the canal; the outer wall of the canal is formed by the compact bony capsule of the labyrinth (see p. 842) and is connected with the spindle by thin lamellae of bone, which at the same time form the septa between the neighboring turns. The modiolus is hollowed out on that surface which is turned toward the fundus meatus acustici interni, *basis modioli*, almost as far as half the height of the first turn and there forms the floor of the area cochleae (see p. 850). The spindle is perforated by one larger or several smaller canals, *canales longitudinales modioli*, running parallel to the axis. At the apex the spindle goes over into a thin, compact bony layer, *lamina modioli* (see also Figs. 962, 965 and 969), around which the end of the apical turn curves; the lamina modioli ends by a concave margin, is attached to the cupula and goes over directly into the septum between the second and the third turn. The diameters of the lumen of the canalis spiralis cochleae parallel and perpendicular to the axis of the modiolus are almost equal (about 2 mm) in the first half of the basal turn; in the second half of the basal turn and in the middle turn, the height (parallel to the axis) is 2 mm, the breadth (perpendicular to the axis) 1.5 mm; in the third turn the height quickly diminishes and the breadth exceeds it.



969. Cupula of the right bony chochlea, opened, viewed from the outside. Magnification: 15:1.

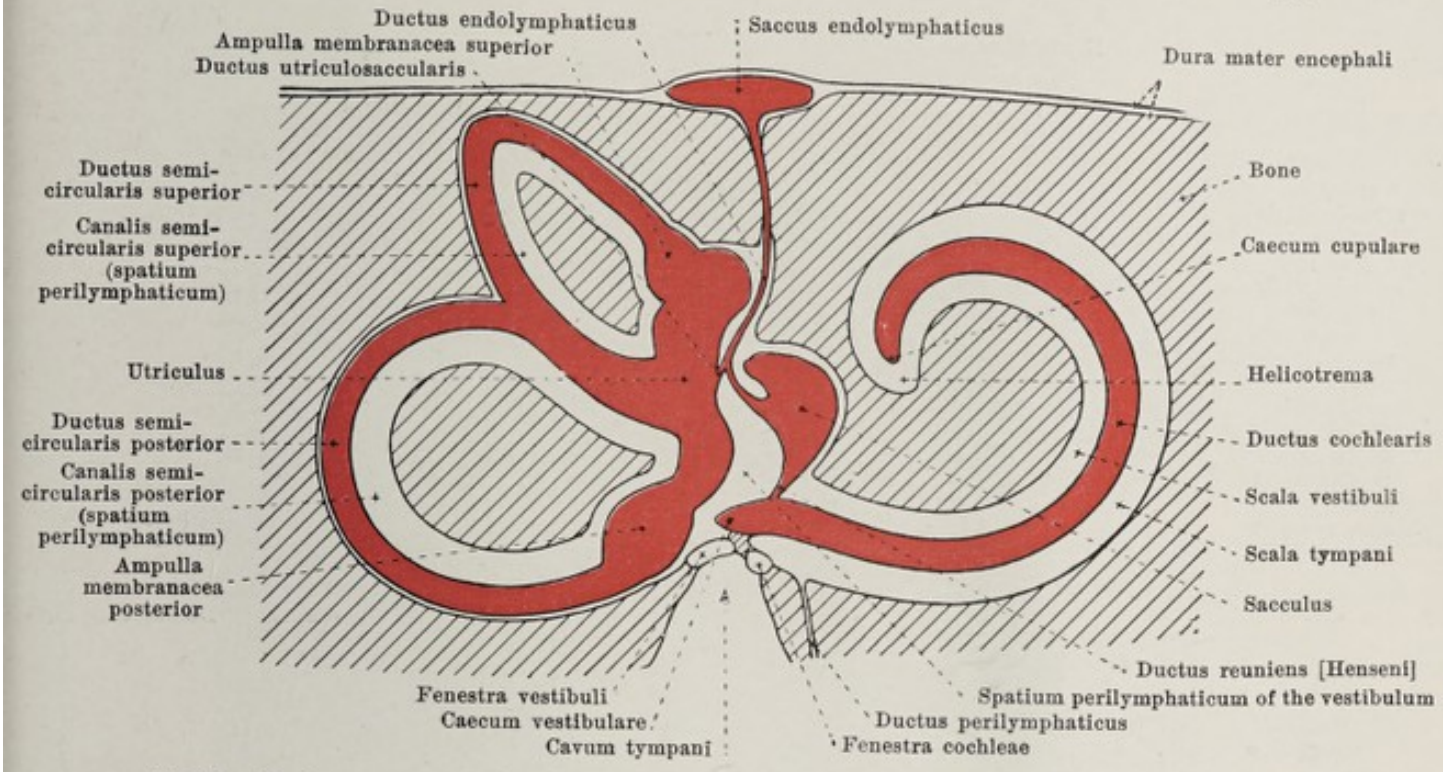
Cochlea (continued) (see also Figs. 958—962 and 965—968). Springing out from the spindle is a delicate bony plate, *lamina spiralis ossea, bony spiral layer,* midway between two septa, for some distance into the lumen of the canalis spiralis; it divides this incompletely into the *scala vestibuli, vestibular staircase,* turned toward the cupula, and the *scala tympani, tympanic staircase,* nearer the base of the cochlea, the two becoming completely separated by the interposition of the membranous cochlear canal. The spiral layer as well as the vestibular and tympanic staircases run along the whole canalis spiralis and are therefore also turned in a spiral. In the region of the basal turn the scala tympani is wider than the scala vestibuli; in the middle and apical turn the reverse is true. The breadth of the spiral layer corresponds approximately to half the breadth of the canalis spiralis cochleae (see p. 848) and accordingly diminishes somewhat from the base toward the apex; at the beginning of the third turn, the spiral layer becomes separated from the modiolus and ends in a free projecting process, *hamulus laminae spiralis,* ending tapered off; between the concave margin of the latter, the lamina modioli and the terminal portion of the ductus cochlearis (see p. 853), a round opening, *helicotrema* (see also Figs. 972 and 974), forms the sole connection between the scala vestibuli and scala tympani which are otherwise separated from one another by the ductus cochlearis. Along the attachment of the lamina spiralis ossea in the modiolus runs a triangular canal, *canalis spiralis modioli,* for the ganglion spirale n. cochlearis. The lamina spiralis ossea begins directly lateral from and in front of the recessus cochlearis of the vestibule (see Figs. 962, 965 and 967) as a broad plate and goes over there behind into a smaller, similarly formed bony platelet, *lamina spiralis secundaria,* which runs at first separated from it by a narrow, then by a broader slit, on the inferior surface of the first half of the basal turn (see also Figs. 959, 962, 965, 967 and 968), becoming gradually lower as it goes and finally vanishing. Only the space situated lateral (toward the apex) from the two laminae spirales, the scala vestibuli, opens at its beginning in the vestibule; the medial (toward the base) of them, the scala tympani, ends there blind and in the macerated bone communicates with the tympanic cavity through the fenestra cochleae (see p. 834), but is otherwise separated from it by the membrana tympani secundaria; in this latter blind-sack-like portion lies the internal opening of the *canaliculus cochleae* (see p. 11).



970. Right internal acoustic canal, viewed from the medial side. Magnification: 6:1.

(The upper, posterior and inferior walls have been in large part removed.)

Meatus acusticus internus, internal acoustic canal (see also p. 11 and Figs. 960, 965 and 968), is a short canal running nearly transversely and frontally, the lumen of which varies individually and which begins medial in a transversely oval opening, *porus acusticus internus*, bounded by a sharp lateral and blunt medial margin; the lateral end, *fundus meatus acustici interni, floor of the internal acoustic canal*, is closed by a bony plate, which is in large part also the medial wall of the vestibule and cochlea. It is divided into an upper and a lower area by a horizontal sharp ridge, *crista transversa*. The upper, smaller area, in an anterior depression, *area n. facialis*, contains the internal opening of the canalis facialis [Falloppii] (see p. 14) and in a posterior funnel-shaped depression, *area vestibularis superior*, contains several delicate openings of small canals which conduct the branches of the upper terminal ramus of the n. vestibularis (see p. 727) to the macula cribrosa superior of the vestibule (see p. 844). The lower, larger area presents in front a rounded depression, *area cochleae*, in which begins a broad, spiral band, curved like the cochlea, of variably-sized openings, *tractus spiralis foraminosus*, which ends in the lateral part; these foramina carry the bundles of the n. cochlearis directly to the basal turn or through the canales longitudinales modioli to the middle and apical turns. In the posterior part of the inferior area, close below the crista transversa, lies an area with small openings, *area vestibularis inferior*, which conducts the bundles of the n. saccularis (see p. 728) through small canaliculi to the macula cribrosa media of the vestibule (see p. 843), and somewhat medianward and behind it is to be found a single, larger opening, *foramen singulare*, whence the n. ampullaris posterior (see p. 728) passes through a longer, delicate canaliculus to the macula cribrosa inferior (see p. 844).



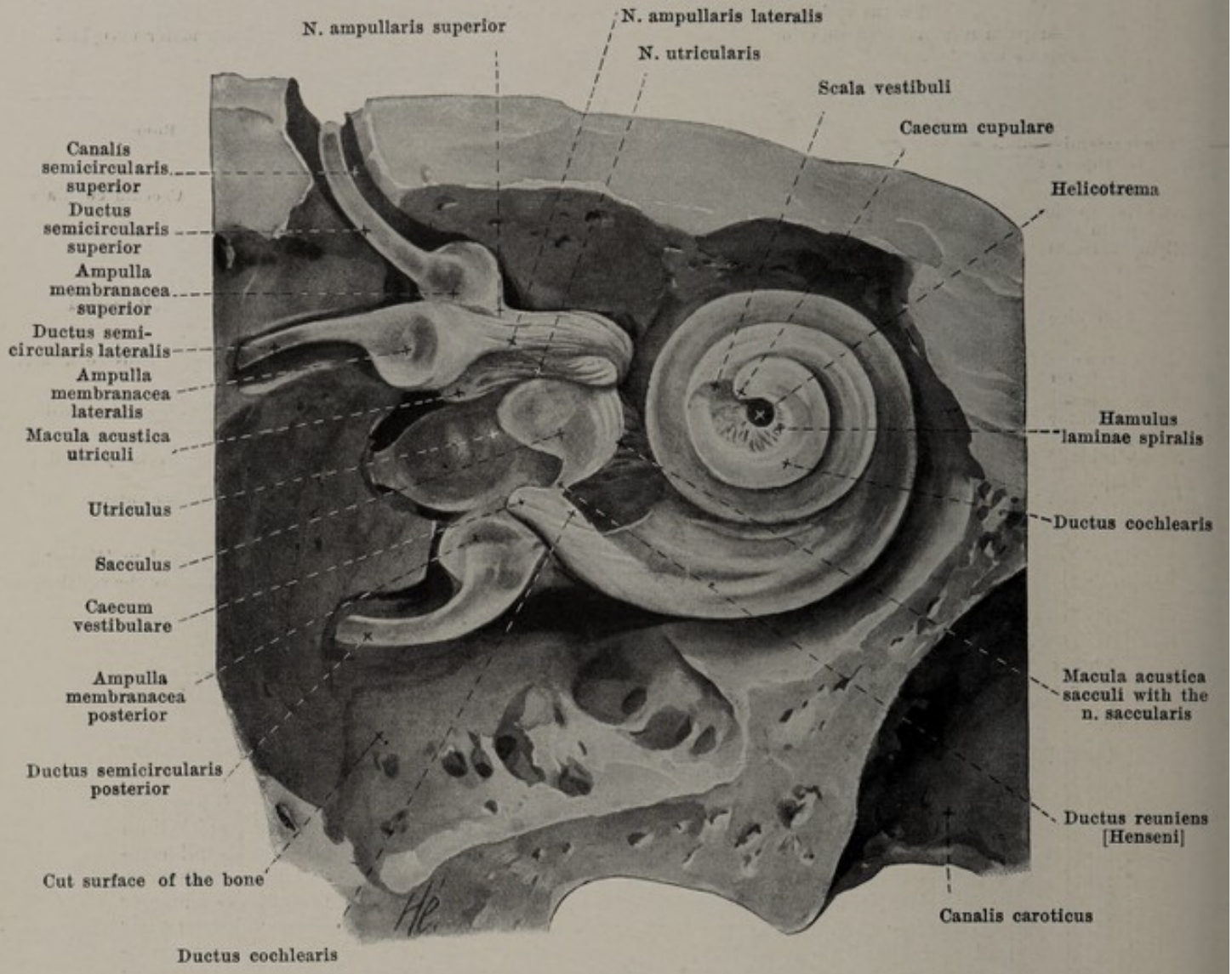
971. Scheme of the right bony and membranous labyrinth. Magnification: 5 : 1.

(The perilymphatic space is shown in white, the endolymphatic in red. The lateral semicircular canal it not shown.)

Labyrinthus membranaceus, membranous labyrinth (see also Figs. 972—977), is a system of connective tissue tubes which contain the terminations of the n. acusticus, lined by epithelium and filled by a clear fluid, *endolympha*, poor in albumen. These tubes or canals all communicate with one another but are completely shut off from the outside and lie in the spaces of the bony labyrinth, the forms of which they approximately repeat. Their transverse diameter is everywhere smaller than that of the bony canals concerned, and there remains between their delicate wall and the bone a system of communicating spaces which are lined with endothelium, containing a clear, somewhat thinner fluid, *perilympha*, poor in albumen, and together are known as the *spatium perilymphaticum*.

In the vestibulum the membranous labyrinth is formed by the two *vestibular saccules*, the *utriculus* and the *sacculus*. The *utriculus* (see also Figs. 972, 973 and 976) is an approximately tube-shaped vesicle directed from above and in front downward and backward; it lies in the recessus ellipticus of the vestibule (see p. 843), is there in large part fairly firmly attached to the bone by connective tissue, and by the bundles of the n. utricularis emerging from the macula cribrosa superior, but otherwise separated by perilymphatic spaces from the wall of the vestibule. The upper slightly constricted part presents on its anterior, lateral surface an oval thickened place of a whitish color, *macula acustica utriculi*, in which the fibres of the n. utricularis (see p. 727) terminate.

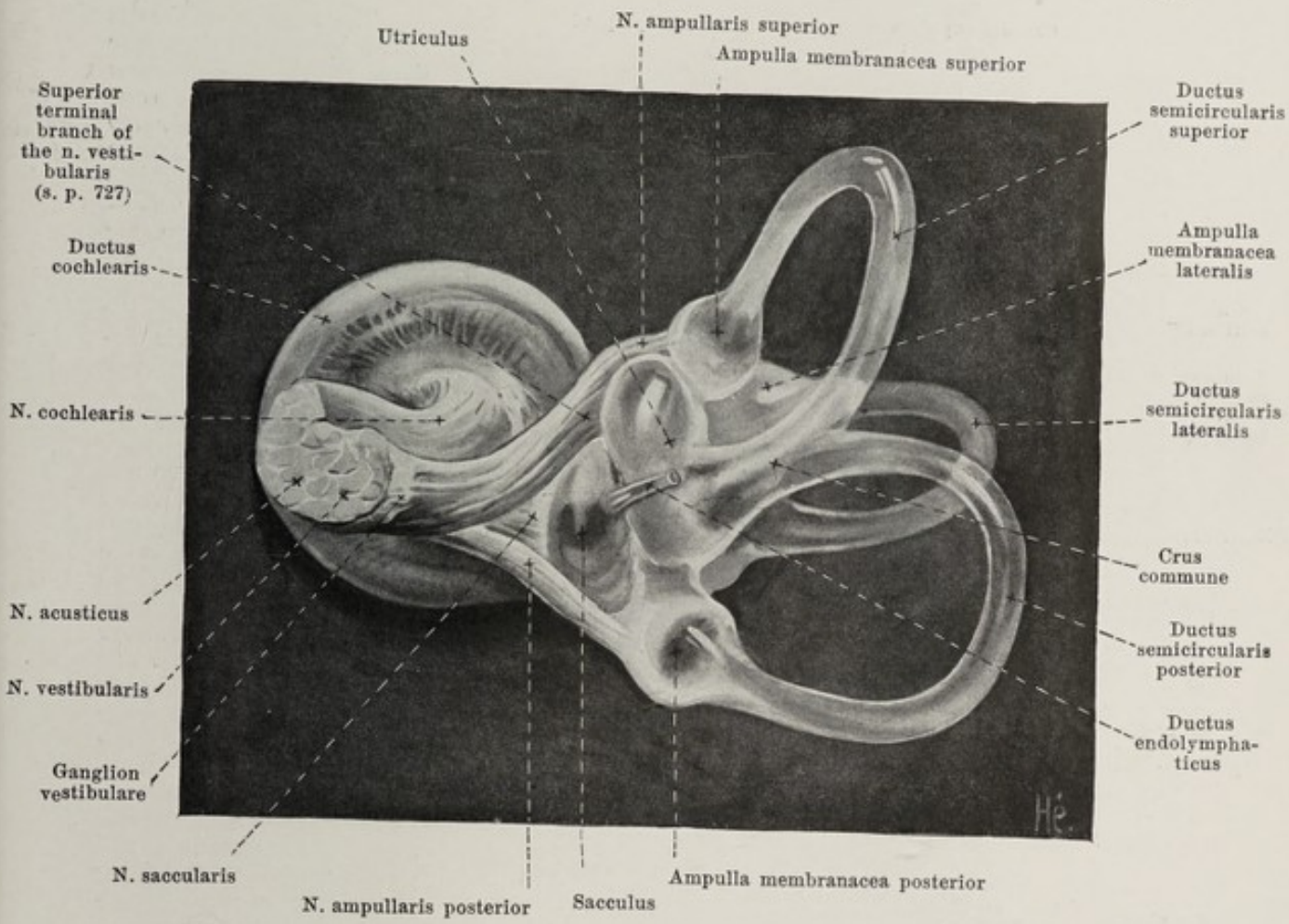
In the utriculus open the three *membranous semicircular canals, ductus semicirculares*, which lie in the three bony semicircular canals, correspond to them exactly in arrangement and course, and are distinguished accordingly as *ductus semicircularis lateralis, superior, posterior;* they empty by five openings into the utriculus. Each membranous semicircular duct lies eccentrically on the convex side of the bony canal, and its diameter is only one-third of that of the bony canal; the perilymphatic space is also very large here and is crossed by single strands of connective tissue. Corresponding to the three ampullae osseae there are also three *ampullae membranaceae* in the membranous ducts, which analogous to the bony ones are designated *ampulla membranacea lateralis, superior, posterior;* they represent very marked dilatations of the membranous ducts, appear sharp and large on the concave side of the ducts and much more completely fill up their bony space; each of them presents on its surface corresponding to the convex side of the semicircular canal a transverse groove, *sulcus ampullaris*, in which the n. ampullaris (see pp. 727 and 728) enters, and a sickle-shaped ridge, *crista ampullaris*, projecting thence into the lumen.



972. Right membranous labyrinth of an adult, partially exposed, lateral and front view. Magnification: 5:1.

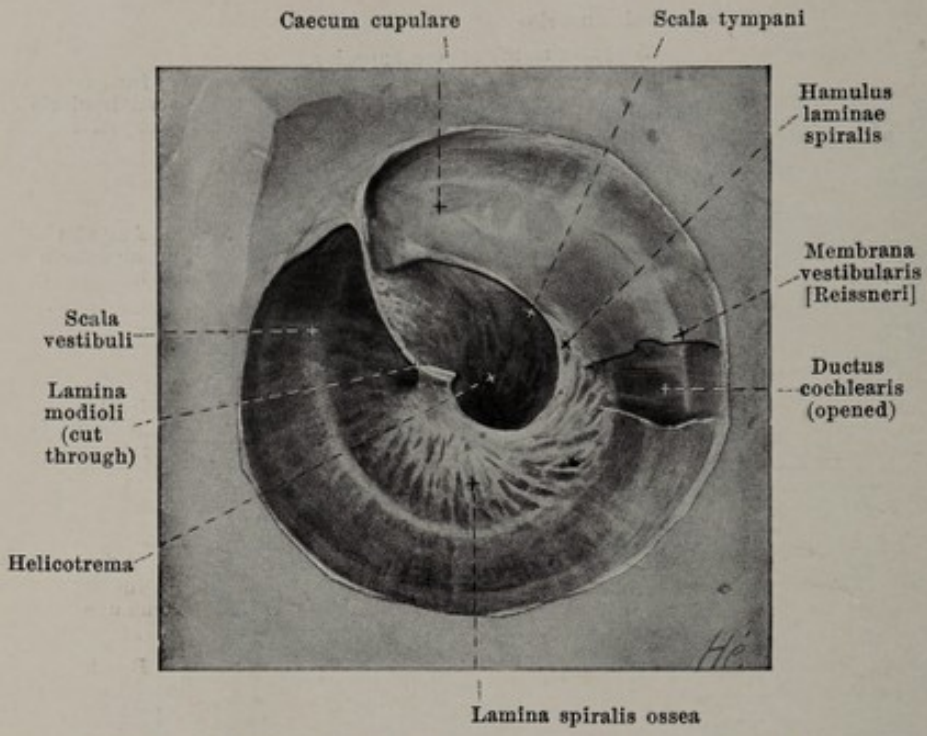
(The lateral and upper portions of the bony capsule of the labyrinth have been removed in a decalcified temporal bone. The scala vestibuli has been opened only at its beginning and at its end.)

Labyrinthus membranaceus (continued) (see also Figs. 971 and 973—977). The *sacculus* is a flattened oval vesicle with its long diameter vertically placed; it lies in the recessus sphaericus of the vestibule (see p. 843), is fairly firmly attached to the bone there by connective tissue and the bundles of the n. saccularis emerging from the macula cribrosa media, but otherwise is separated from the walls of the vestibule by a large, perilymphatic space. Its lower end narrows gradually to become the *ductus reuniens [Henseni]*, a delicate duct, 0.5 mm wide, 1 mm long, connecting the sacculus with the ductus cochlearis (see p. 853). On the medial, anterior surface of the sacculus a thickened area, *macula acustica sacculi*, can be made out in which the fibres of the n. saccularis (see p. 728) terminate. The sacculus is not directly connected with the utriculus, but only indirectly through the *ductus endolymphaticus;* this arises as a very fine canal from the posterior wall of the sacculus, receives the short and very fine *ductus utriculosaccularis* which goes off from the anterior, medial wall of the utriculus, and then passes through the aquaeductus vestibuli to the posterior surface of the pyramid of the temporal bone; it ends there in a flattened caecal dilatation, *saccus endolymphaticus*, which is situated just below the apertura externa aquaeductus vestibuli in a duplicature of the dura mater encephali and is not connected with the surrounding lymph spaces.

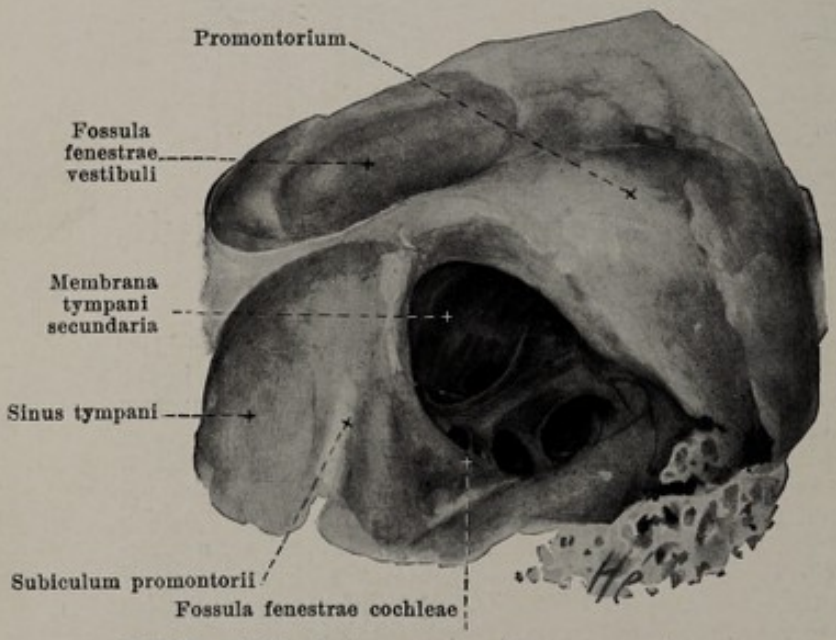


973. Right membranous labyrinth of an adult, isolated, medial and posterior view. Magnification: 5:1.

Labyrinthus membranaceus (continued) (see also Figs. 971, 972 and 974—977). The cochlear part of the membranous labyrinth is formed by the *ductus cochlearis*. This begins in the recessus cochlearis of the vestibule, extends within the canalis spiralis cochleae as a narrow spirally turned duct as far as the end of the apical turn where it ends blind; near its beginning it is united with the sacculus by the ductus reuniens [Henseni]. It is in large part triangular in cross-section (see Fig. 977). Its outer wall unites with the thickened periosteum of the inner surface of the cochlear canal. Its wall parallel to the base of the cochlea runs in the direction of the lamina spiralis ossea from its free margin to the *ligamentum spirale cochleae*, a ridge-like projection of the periosteum of the outer wall; it consists of a fibrous plate of connective tissue, *lamina basilaris*, and supports the *organon spirale [Cortii]*, an epithelial structure which contains the termination of the fibres of the n. cochlearis (see p. 728). The third wall, *membrana vestibularis [Reissneri]*, is remarkably thin, arises from the lamina spiralis ossea near its free margin and passes at an angle of approximately 45° to the outer wall. The ductus cochlearis thus separates two perilymphatic spaces from one another, of which that near the membrana vestibularis is called the *scala vestibuli*, that near the lamina basilaris, the *scala tympani*. In the apical turn (see Fig. 974) the somewhat flattened ductus cochlearis projects beyond the hamulus laminae spiralis, its blind end, *caecum cupulare*, being deposited in the cupular cavity of the apical turn and so helping to form the *helicotrema* (see p. 849). The beginning of the ductus cochlearis is also in the form of a blind-sack, and projects a little beyond the opening of the ductus reuniens [Henseni]; this portion is called the *caecum vestibulare* and rests in the recessus cochlearis of the vestibule (see p. 844). The perilymphatic space communicates with the cavum subarachnoideale by a fine canal, *ductus perilymphaticus*, situated in the canaliculus cochleae, near the v. canaliculi cochleae.



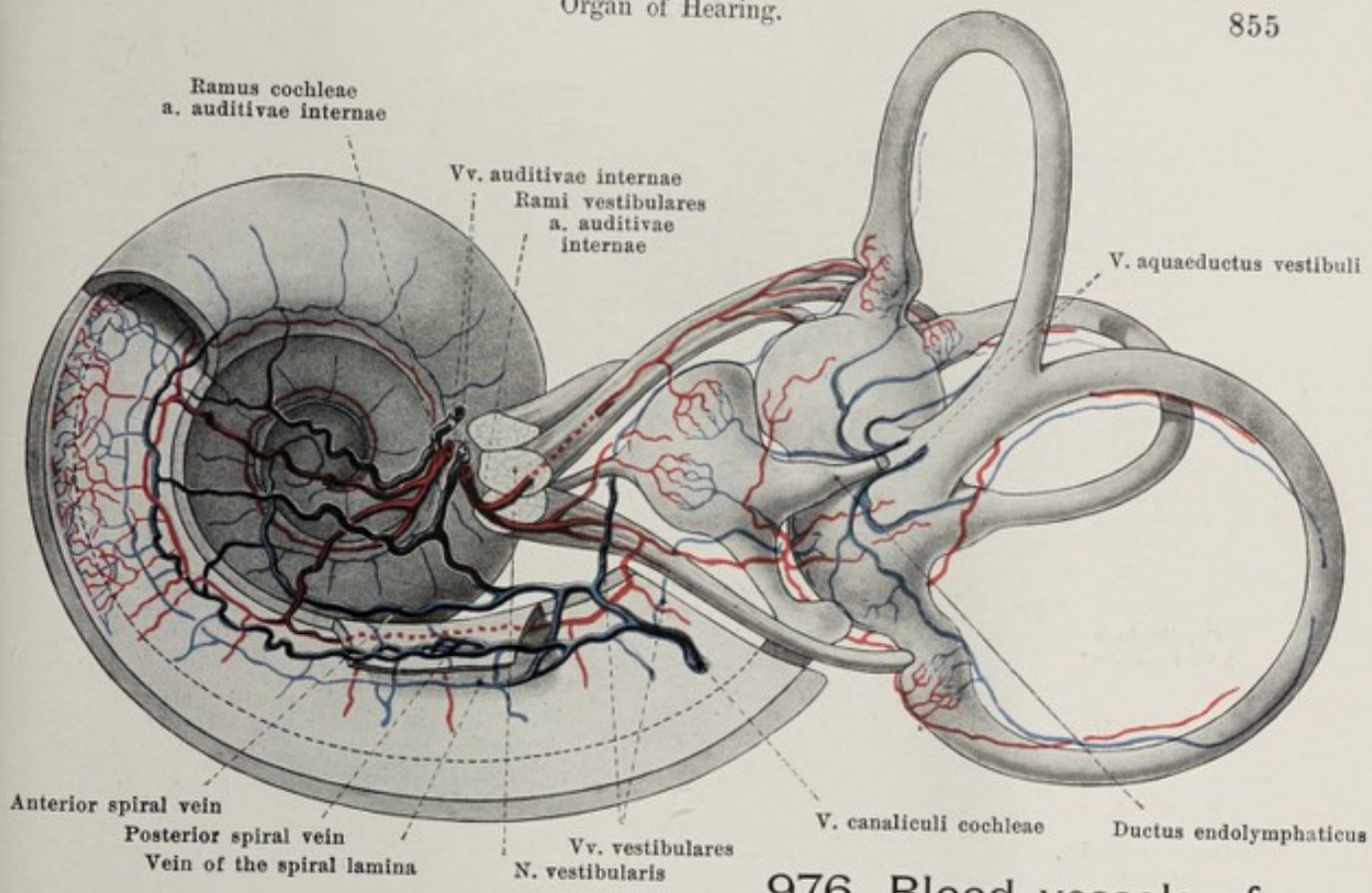
974. Cupula of the right cochlea, opened, viewed from the outside. Magnification: 15:1.



975. Right membrana tympani secundaria, lateral and inferior view. Magnification: 12:1.

The fenestra cochleae is closed by a thin connective tissue membrane, *membrana tympani secundaria (accessory ear-drum membrane)* (see Fig. 975), which arises on the crista fenestrae cochleae (see p. 835) and is usually bulged somewhat into the scala tympani; its lateral surface is covered by the mucous membrane of the tympanic cavity which is continued upon it with one or several folds.

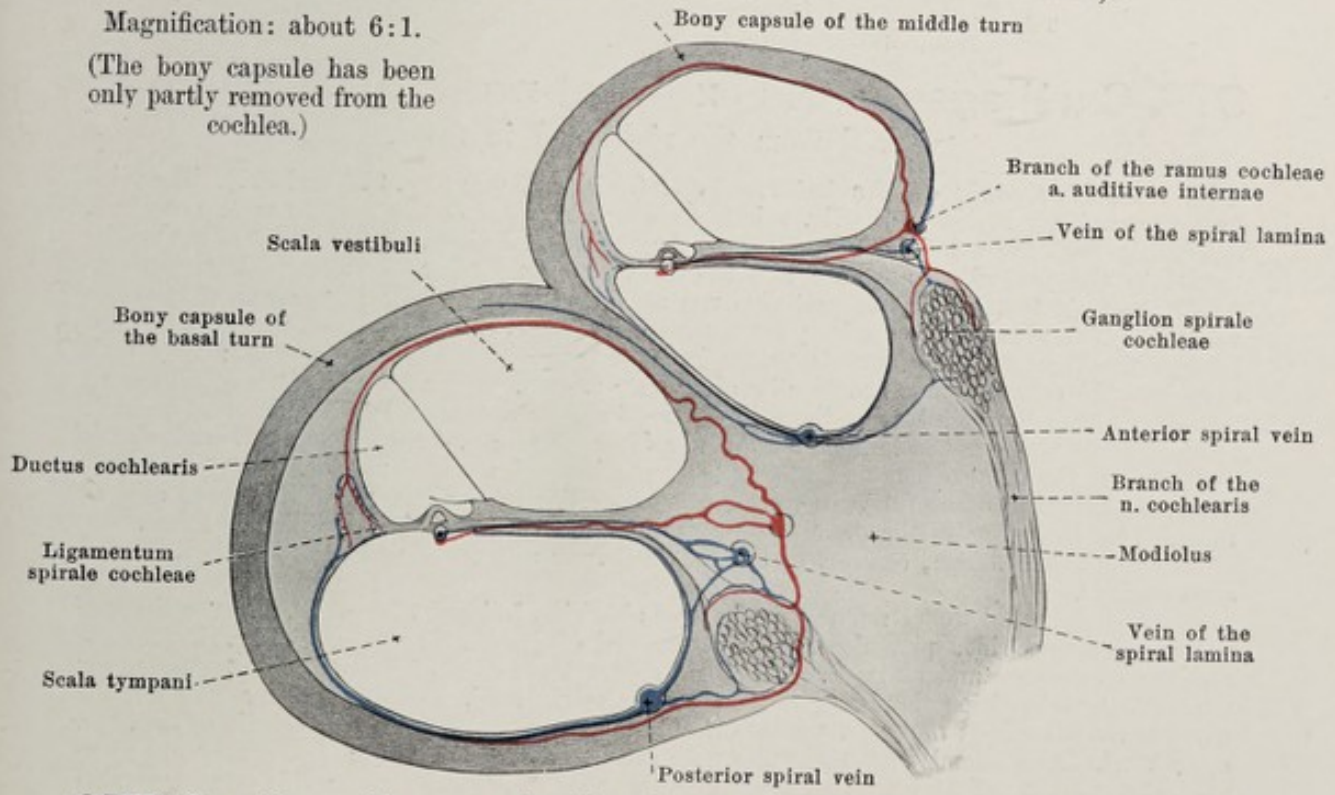
Blood vessels of the internal ear, vasa auris internae (see Figs. 976 and 977). The single afferent vessel is the *a. auditiva interna* (see also p. 422) which enters the internal acoustic meatus along with the n. acusticus; there it divides into *rami vestibulares* and the *ramus cochleae*. The former pass with the single nerve branches to the sacculus, utriculus and the membranous semicircular canals, form a rich vascular net-work on the maculae acusticae and ampullae membranaceae and send branches to the lining of the spatium perilymphaticum; one of these branches goes over to the first third of the basal turn and anastomoses there with a branch of the ramus cochleae. The *ramus cochleae* enters the spindle, usually sends two branches to the rest of the basal turn, and by its terminal branch supplies the whole middle and apical turn; these branches run in the modiolus close to the origin of the lamina spiralis ossea and give off terminal branches continuously: 1. to the ganglion spirale cochleae, 2. into the lamina spiralis ossea as far as the organon spirale [Cortii] and 3. in the wall of the scala vestibuli as far as the lig. spirale cochleae. The *vv. vestibulares* collect the blood from the capillary domains of the semicircular ducts and the vestibular saccules; they form in largest part the delicate *v. aquaeductus vestibuli*, run in separate canals and empty into the sinus petrosus superior; a part of them open also into the v. canaliculi cochleae (see p. 856). The capillary domain of the lamina spiralis empties its blood through radial vessels in the *vein of the spiral lamina* which runs along the origin of the lamina spiralis and empties into the two spiral veins at the beginning of the basal turn.



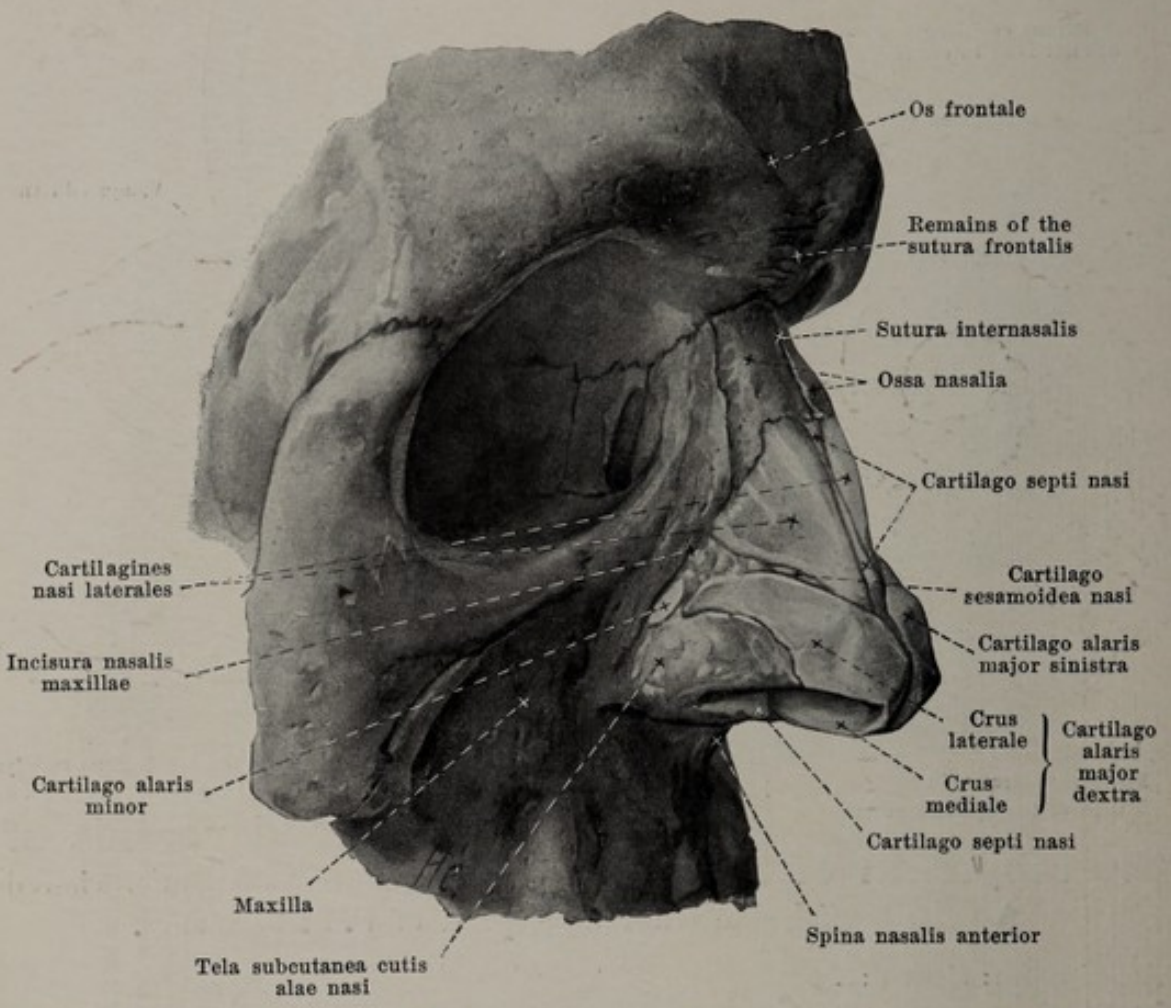
976. Blood vessels of the labyrinth of the right ear, somewhat schematic, viewed from the medial side (after description of F. Siebenmann).

Magnification: about 6:1.

(The bony capsule has been only partly removed from the cochlea.)



977. Section through the basal and middle turns of the cochlea, schematic (after F. Siebenmann). Magnification: about 18:1.



978. Cartilages of the external nose, dissected out,

viewed from the right and in front.

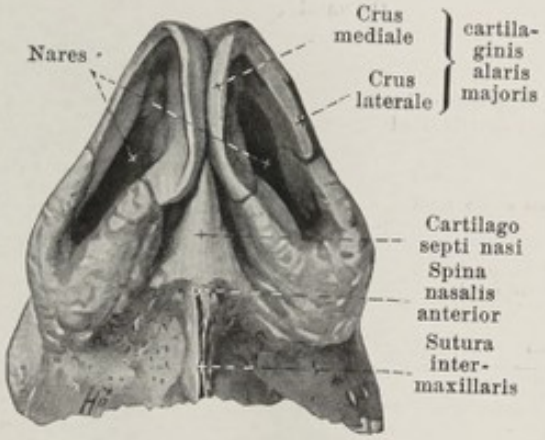
Blood vessels of the internal ear (continued) (see Figs. 976 and 977). The veins from the capillary region of the lig. spirale cochleae, from that of the ganglion spirale cochleae, and partly from the spiral lamina empty in the region of the basal and of a part of the middle turn into the *posterior,* otherwise into the *anterior spiral vein;* the afferent branches surround the scala tympani but in part also run along with the arteries in the wall of the scala vestibuli. The spiral veins together are spoken of as the *v. spiralis modioli,* and each of them lies on the basal wall of the scala tympani of the turn of the cochlea concerned; they both open into the conspicuous *v. canaliculi cochleae* (see p. 464). From the vein of the spiral lamina as well as from the spiral veins there is given off always a branch into the internal acoustic meatus, there to enter the large *vv. auditivae internae* (see p. 462) which receive tributaries mainly from the n. acusticus and the walls of the internal acoustic meatus.

The **Organ of Smell, organon olfactus,** lies in the *nose;* but this must also be regarded as belonging to the organs of respiration, the initial portion of which it forms.

The **nose,** *nasus,* consists of the *external nose* and the *nasal cavity* with its *accessory cavities.*

The **external nose,** *nasus externus* (see also Figs. 564 and 979—983), has the shape of an irregular three-sided pyramid which is connected on its basal surface, *basis nasi,* with the skeleton of the face and at its margin projects from the region of the upper jaw. The upper narrow end which joins the forehead is called the *radix nasi, root of the nose;* from this the *dorsum nasi, back of the nose,* passes obliquely downward and forward to the *tip of the nose, apex nasi.* The lateral surfaces of the nose are fairly straight above; below they are more markedly curved, project more and are limited laterally by a sharp groove; this part is movable and corresponds to the *nasal wings, alae nasi,* the lower free margin of which, *margo nasi,* surrounds the *nasal openings, nares;* the latter are separated from one another by the most anterior, movable part of the nasal septum, *septum mobile nasi.*

979.
Cartilages of the external nose, dissected out,
viewed from below.

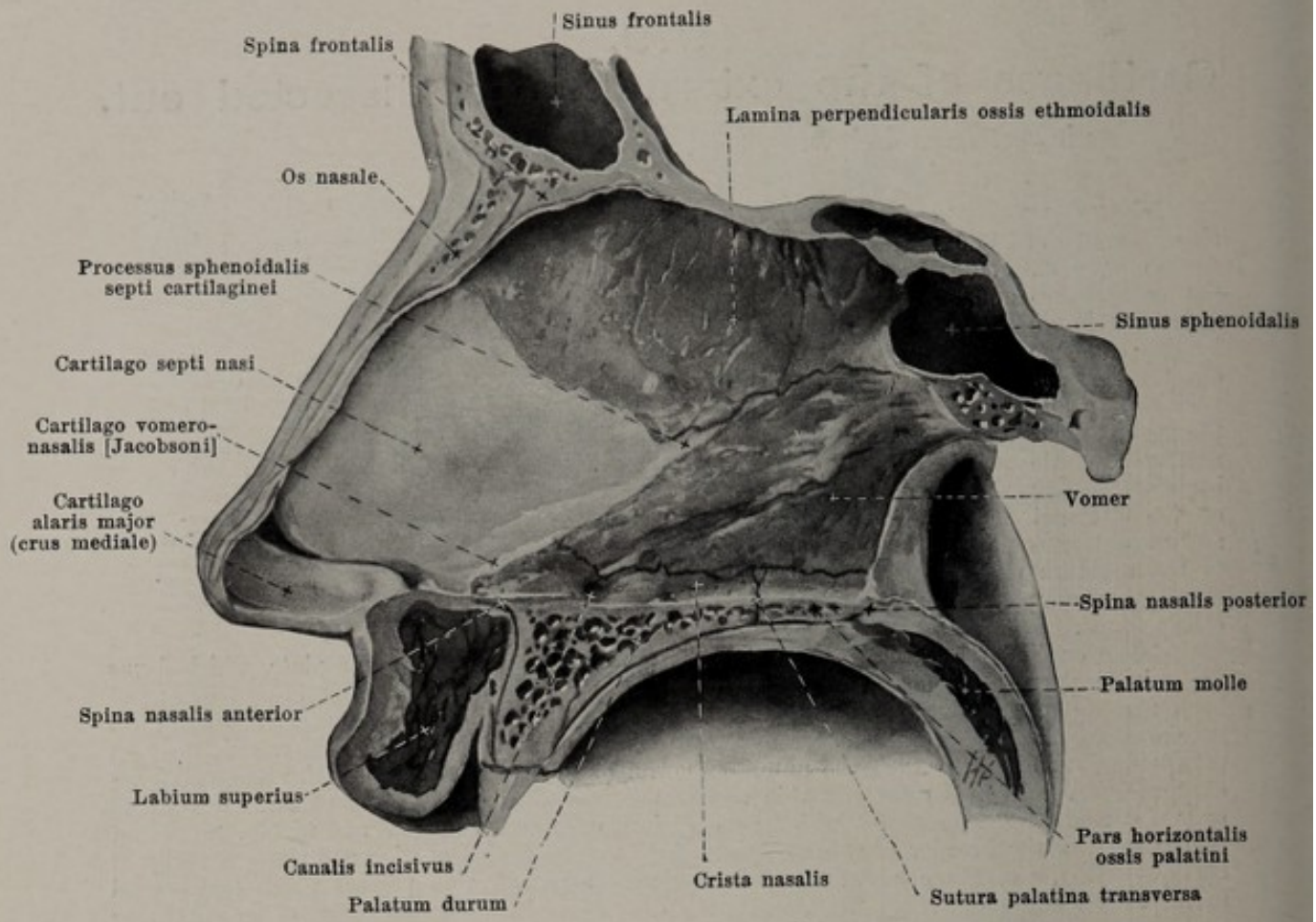


Nasus externus (continued) (see also Figs. 978 and 980—983). The framework of the external nose is formed by the nasal bones and by the *nasal cartilages, cartilagines nasi*, which consist of hyaline cartilage. Both are partly covered on the external surface by the nasal muscles, and by the external skin, while the inner surface is clothed by the mucous membrane of the nasal cavity. The nasal bones form only the upper, smaller part of the external nose; the cartilaginous and membranous part is attached directly to the apertura piriformis (see p. 64) and closes this completely with the exception of the nares.

The *cartilago nasi lateralis*, paired, is a thin, irregular triangular plate, which forms the middle part of the lateral wall. Its upper margin is shoved somewhat behind the nasal bone and the proc. frontalis maxillae and is attached to this by tough connective tissue; its inferior margin reaches partly as far as the cartilago alaris major; its medial margin fuses on the dorsum nasi partly with the anterior margin of the cartilago septi nasi. The *cartilago alaris major*, paired, is especially thin and of uncommonly variable development. It consists of two curved horse-shoe plates which go over into one another in front and which so surround the nares that the broader *crus laterale* may help to form the nasal wing and above is partly in contact with the cartilago lateralis and behind with a narrow thin process which may extend as far back as into the nasal wing, while the *crus mediale*, along with that of the other side passes for some distance backward in the septum mobile nasi and unites with this and with the cartilago septi loosely. The *cartilagines alares minores* are small, irregular pieces of cartilage which are found separated from the preceding in a variable number on each side in the posterior part of the nasal wing. The name *cartilagines sesamoideae nasi* is given to one or two very small pieces of cartilage which are situated on each side between the cartilago lateralis and the cartilago alaris major. In the posterior inferior portion of the nasal wing is a region of variable size which is free from cartilage; it is formed by a duplicature of the skin only.

The *cartilago septi nasi, septal cartilage* (see also Figs. 978 and 980), is an unpaired, median, irregular quadrilateral plate of cartilage which forms the anterior inferior part of the nasal septum and is inserted in the angle between the lamina perpendicularis oss. ethmoidalis and the vomer. The posterior superior margin is united with the lamina perpendicularis; the posterior inferior is laid in the groove of the vomer (see p. 28) and on the anterior part of the crista nasalis of the united maxillae. The anterior superior margin begins above behind the sutura internasalis and extends forward below as far as the dorsum nasi between the two cartilagines laterales, uniting with both above. The anterior inferior margin forms in front the upper boundary of the septum mobile nasi, reaches behind somewhat deeper and is attached there to the spina nasalis anterior. From the posterior angle a process of variable height, *processus sphenoidalis septi cartilaginei*, is inserted backward and upward into the anterior groove of the vomer (see p. 28), between it and the lamina perpendicularis oss. ethmoidalis, sometimes extending close to the sphenoid bone. The cartilage of the septum is, like the bony nasal septum (see p. 64), partly displaced to one side or the other. The *cartilago vomeronasalis [Jacobsoni]* (see Fig. 980) is a small strip of cartilage which lies close over the spina nasalis anterior on each side of the cartilago septi nasi (see also p. 859).

The external skin of the nose is very thin, is fastened above to the subjacent tissue by looser connective tissue free from fat, and to the nasal wings by tough connective tissue. Its hairs, especially toward the tip, are very fine. Its sebaceous glands, especially on the posterior part of the nasal wings are extraordinarily large. The skin is reflected at the nares upon the inner surface of the nose and at the limen nasi gradually goes over into the mucous membrane; it presents for some distance in the nares sebaceous glands and hairs which are here called the *vibrissae* and which may reach a considerable size.

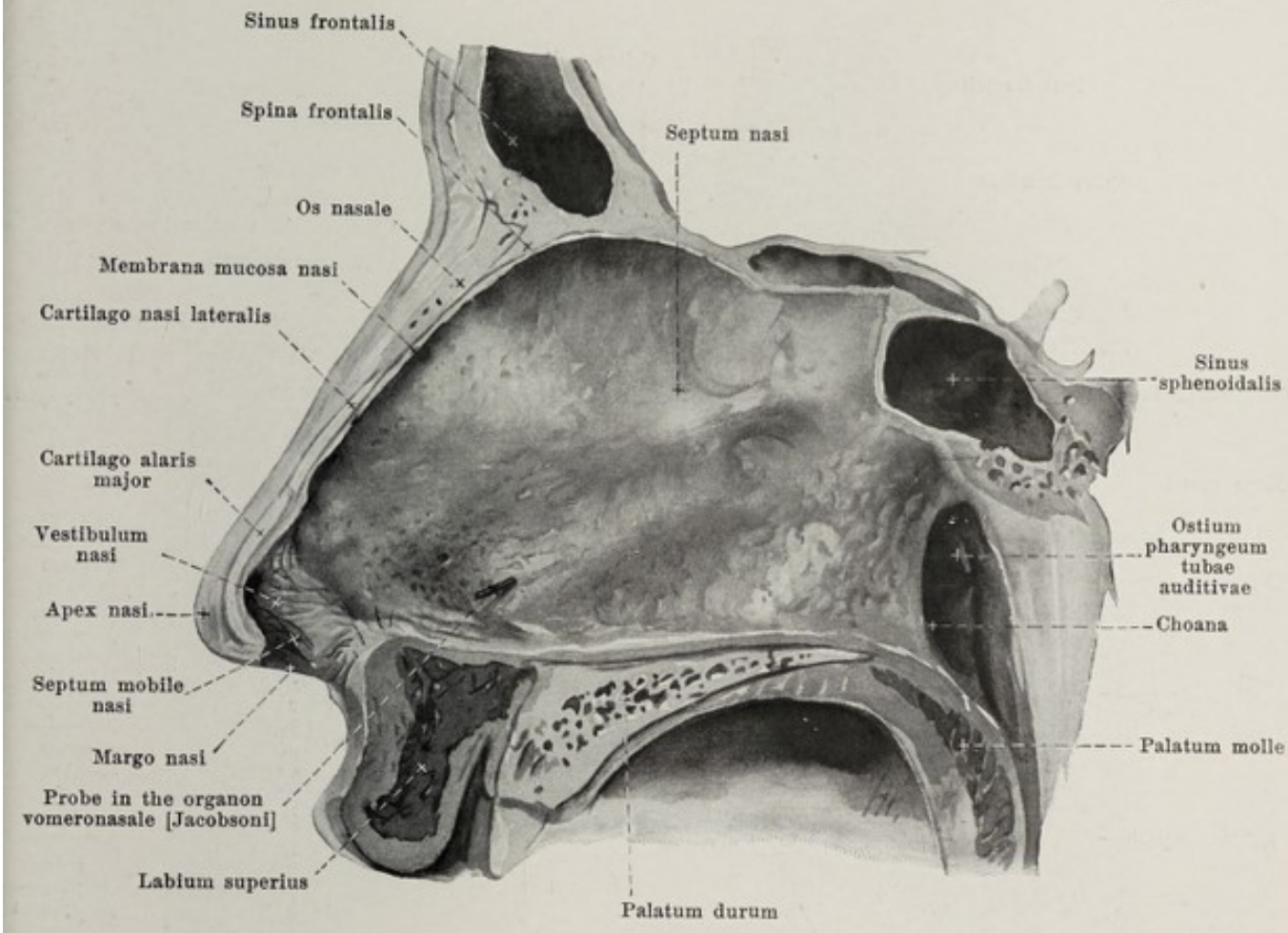


980.
Nasal septum without the mucous membrane,
viewed from the left.

(Figs. 980 and 981 come from the same preparation, but are from a different head than that used in Figs. 982 and 983.)

The ***nasal cavity,*** *cavum nasi* (see also Figs. 76—78, 568, 600, 601 and 981—984), is bounded by the inner surface of the external nose and by bone (see p. 62). It opens in front through the *nares, nasal openings,* bordered only by skin and situated on the inferior surface of the external nose; they are of very variable form and are somewhat obliquely placed. Behind, the nasal cavity communicates with the pharynx through the two adjacent, quadrilateral *choanae* (see p. 62). It is divided into two approximative symmetrical halves by the medianly-placed *nasal septum, septum nasi,* which usually deviates somewhat to one side. The upper and posterior part of the septum is bony and is called the *septum nasi osseum* (see p. 64); the anterior part is formed by the cartilago septi nasi (see p. 857) and is called the *septum cartilagineum;* attached to this in front and below is the *septum membranaceum* which lies between the two nares, contains the crura medialia of the cartilagines alares majores and is also designated the septum mobile nasi (see p. 856).

The walls of the nasal cavity are lined by mucous membrane, *membrana mucosa nasi.* This is of fairly even thickness and is markedly thicker only upon the middle and inferior turbinated bones. It repeats therefore on the whole the form of the nasal cavity and its (cartilaginous and bony) walls, which have already been exactly described on pp. 62—64, the only difference being that the air-containing inner spaces are more or less narrowed.



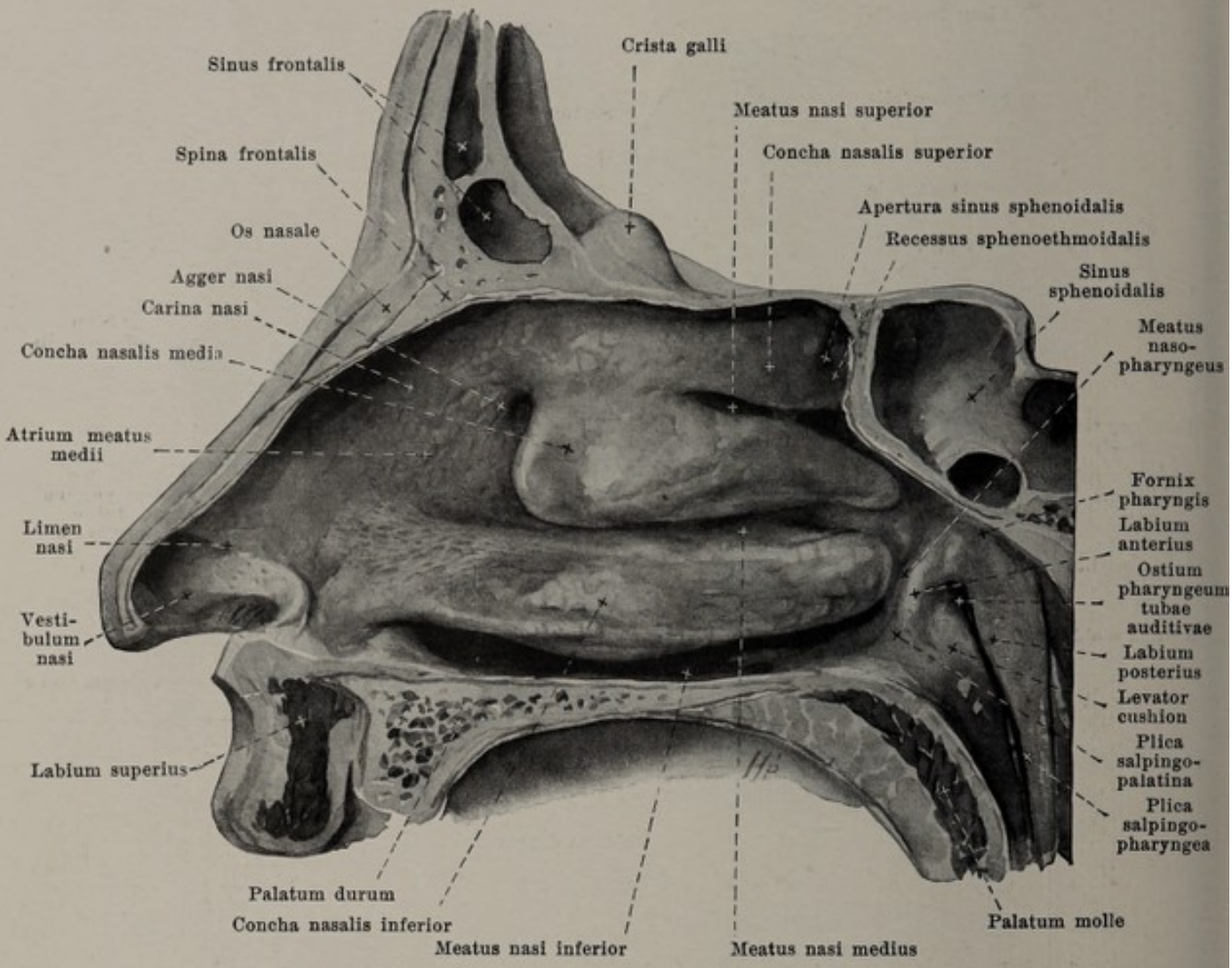
981. Nasal septum with the mucous membrane intact, viewed from the left.

(Figs. 980 and 981 have been taken from the same preparation, though from another head than that used in Figs. 982 and 983.)

Nasal cavity (continued) (see also Figs. 76—78, 568, 600, 601, 980 and 982—984). The space, which is enclosed by the movable nasal wings is called the *vestibule, vestibulum nasi;* it is marked off above from the nasal cavity proper by a distinct ridge on the lateral wall, *limen nasi*, which projects from the upper margin of the cartilago alaris major.

The *septum nasi* is evenly covered by mucous membrane. A little above the spina nasalis anterior it presents very often a fine opening which leads into a short canal ending blind and passing backward directly upon the cartilago septi, the *organon vomeronasale [Jacobsoni];* this with the cartilago vomeronasalis [Jacobsoni] (see p. 857) forms the homologue of a larger structure constant in a large series of animals to which (in these animals) fibres of the nn. olfactorii can be followed. Below and behind this opening in the floor of the nasal cavity there is often a pin-point-like opening which leads into a canaliculus, the *ductus incisivus* (not illustrated); this enters the canalis incisivus and usually ends blind, though it may open by a very fine unpaired opening upon the papilla incisiva of the palate (see p. 517); it is the rudiment of *Stenson's passage*, so well developed in many mammals.

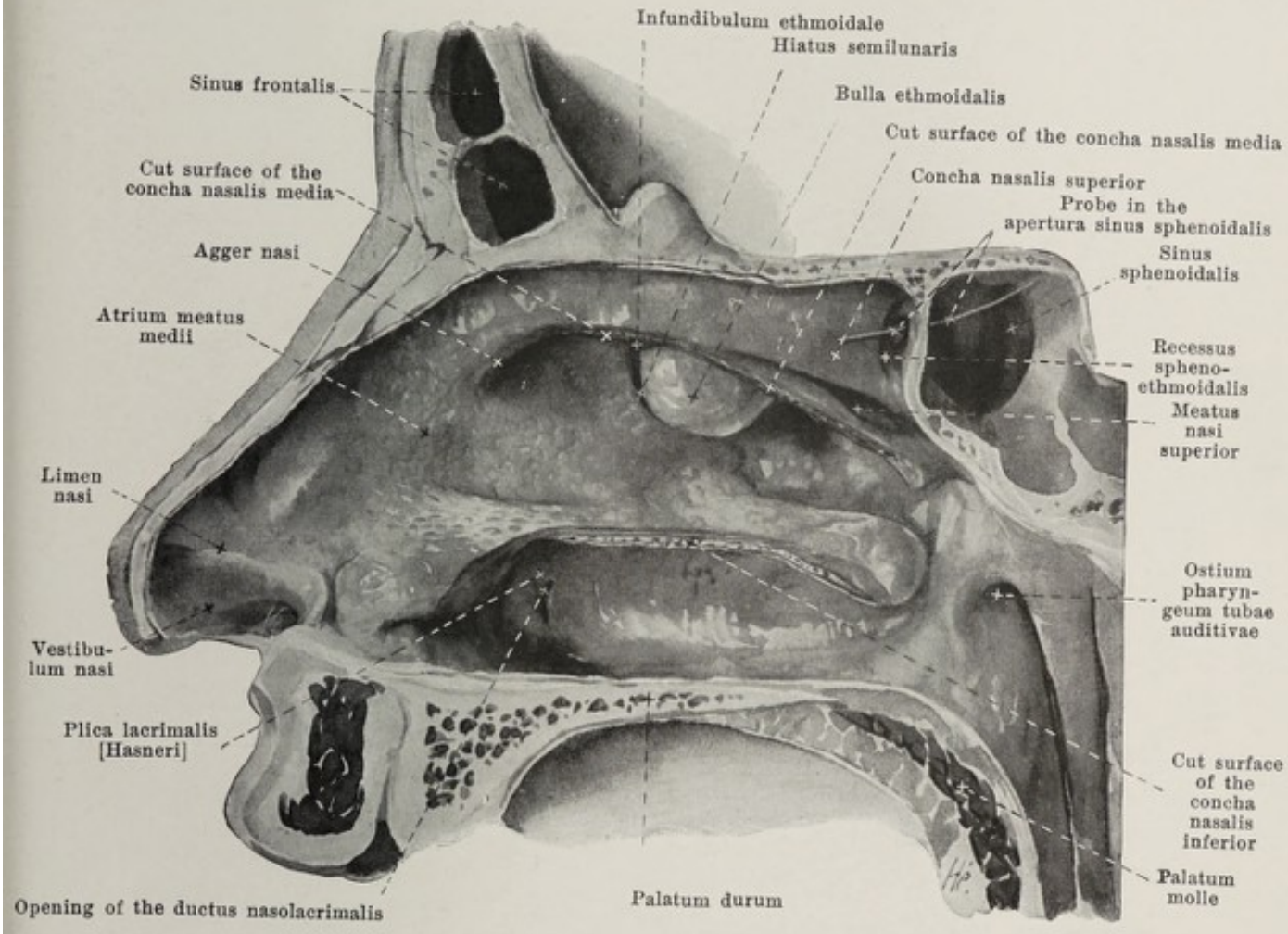
The narrow superior and the broad inferior walls are covered by smooth mucous membrane.



982. Right wall of the nasal cavity with the mucous membrane, viewed from the left.

(Figs. 982 and 983 are from the same preparation though from another head than Figs. 980 and 981.)

Nasal cavity (continued) (see also Figs. 76—78, 568, 600, 601, 980, 981, 983 and 984). The lateral wall presents free turbinated bones, *nasal mussels* (usually four, sometimes three), *concha nasalis inferior, media, superior, suprema,* and also below each and lateral from it (see also Fig. 568) the corresponding *nasal meatus, meatus nasi inferior, medius, superior* and *recessus sphenoethmoidalis* (see pp. 62 and 63). The inferior concha arises in front very gradually from the wall; it and the lower meatus are longest, the upper concha and upper meatus shortest. The middle concha hangs down valve-like from its insertion for quite a distance (especially in front) and ends in front in an approximately vertically-placed free margin from the upper end of which extending downward in a curve is a small ridge, *agger nasi;* this bounds from above a slightly depressed area, *atrium meatus medii,* which reaches below as far as the upper margin of the inferior nasal concha and gradually goes over backward into the middle meatus. The narrow space situated between the agger nasi and the inner dorsum of the nose and which extends obliquely upward and backward as far as the upper wall of the nasal cavity is called the *carina nasi.* Concerning the *recessus sphenoethmoidalis* and *meatus nasi communis* see pp. 62 and 63. The *meatus nasopharyngeus* (see also p. 62) is in the nasal cavity, covered by mucous membrane, bounded lateralward by a narrow groove situated behind the posterior end of the middle and inferior conchae; dorsalward from this is the labium anterius of the ostium pharyngeum tubae auditivae (see p. 523) and an elevation, *plica salpingo-palatina,* which passes to the soft palate.

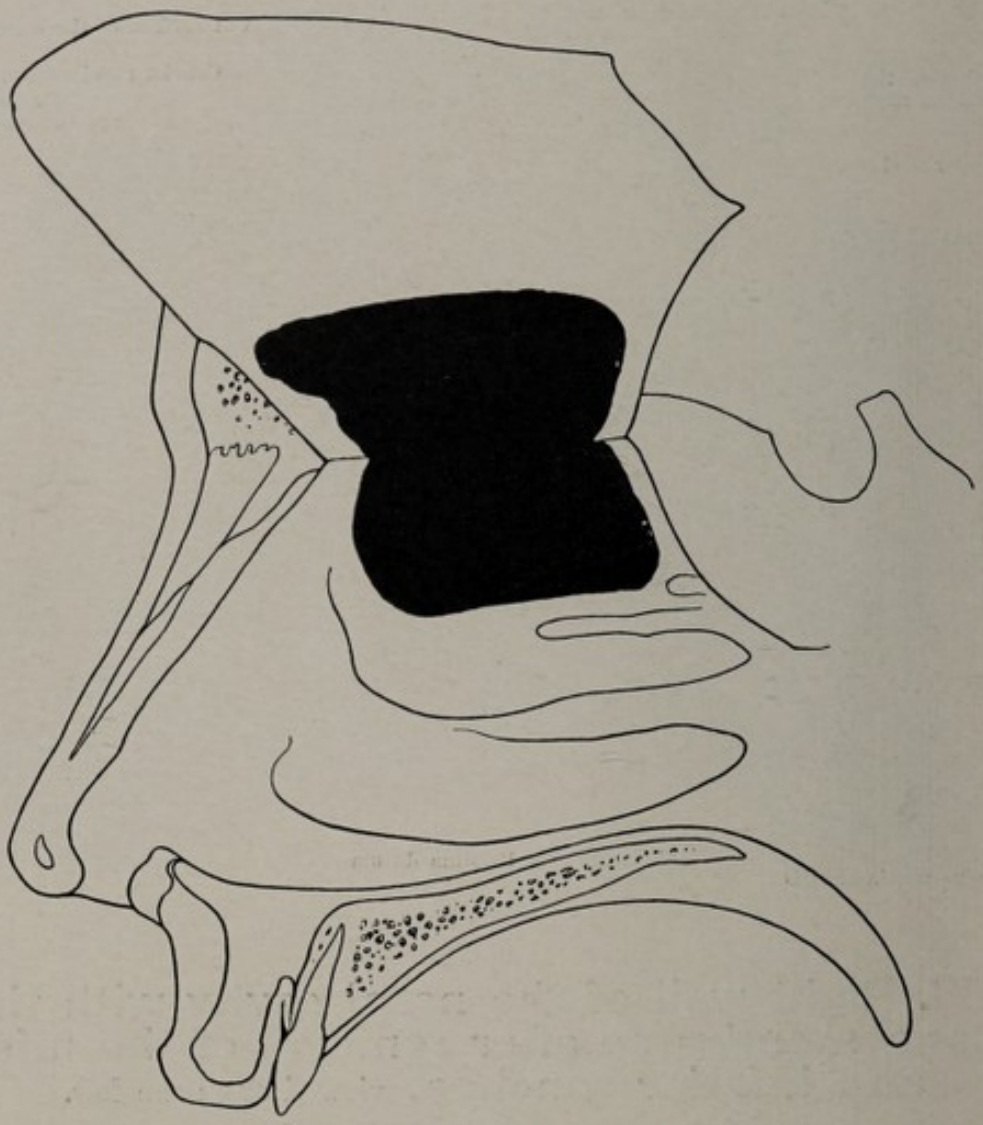


983. Right wall of the nasal cavity with the mucous membrane after removal of the middle and inferior conchae, viewed from the left.

(Figs. 982 and 983 come from the same preparation though from another head than Figs. 980 and 981.)

Nasal cavity (continued) (see also Figs. 76—78, 568, 600, 601, 980—982 and 984). The essentials concerning the *accessory cavities of the nose, sinus paranasales*, and their communications with the nasal cavity have been mentioned on pp. 6, 19, 23, 30 and 62. The opening of the sinus frontalis is found in the upper part of the infundibulum ethmoidale. The sinus maxillaris opens also usually in the infundibulum ethmoidale, and through the hiatus semilunaris (see p. 63) in the middle nasal meatus; sometimes behind and below this main opening an accessory opening exists, also in the middle meatus, which corresponds to the spot free from bone, situated behind the proc. uncinatus (see Fig. 77). The ductus nasolacrimalis opens in the inferior nasal meatus (see p. 822).

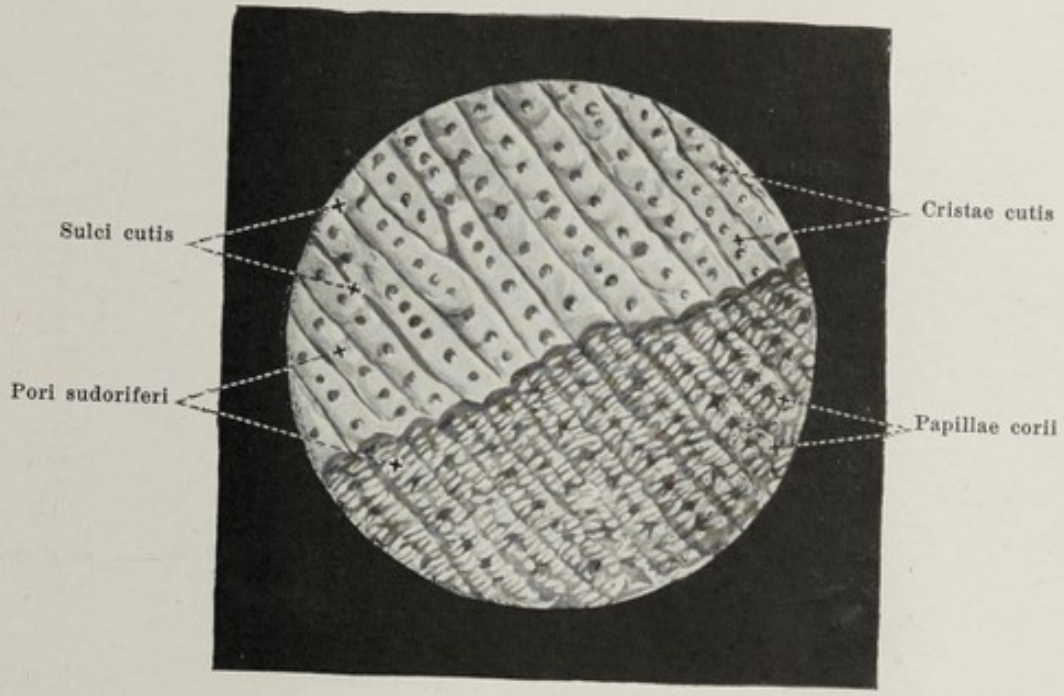
The *nasal mucous membrane, membrana mucosa nasi* (see also p. 858), is continuous in front with the skin of the face (see p. 857), at the choanae with the mucous membrane of the palate and of the pharynx. In the nasal cavity proper, it is firmly attached to the periosteum of the bone and to the perichondrium of the cartilage, and is studded with numerous glands, *glandulae nasales*. It presents in its tela submucosa numerous venous networks, which are developed to form very thick erectile tissue plexuses, *plexus cavernosi concharum*, on the middle and inferior conchae and are the cause of the marked thickness of the mucous membrane in these places. The mucous membrane is continued into all the accessory cavities and lines their walls as a very thin membrane, poor in glands.



984. Extent of the true olfactory mucous membrane (after Effie A. Read).

(The nasal septum has been reflected upward and the regio olfactoria on it and on the lateral wall indicated in black.)

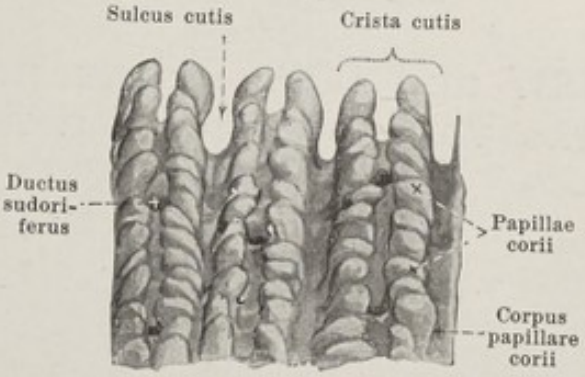
Nasal cavity (continued) (see also Figs. 980—983). The mucous membrane is of a reddish color, of variable shade. A large region of the concha suprema and concha superior and a corresponding portion of the septum is characterized even macroscopically by a brownish color-tone; it is at the same time somewhat thicker, contains the terminations of the nn. olfactorii in an especially constructed epithelium and is called the *regio olfactoria;* it is characterized by long tube-like glands, *glandulae olfactoriae.* This part of the mucous membrane alone can be designated the *olfactory organ, organon olfactus,* in the strict sense. The rest of the mucous membrane is distinguished from it as the *regio respiratoria.*



985. Skin ridges and papillae in the sole of the foot. Magnification: 8:1.

(In the upper part the epidermis has been partly macerated off, in the lower part completely.)

The **external skin,** *integumentum commune,* an external sheath for the body of about 1.6 sq. meters in extent, covers the whole surface and at the opening of the respiratory, digestive, urinary and sexual passages, goes over uninterruptedly into the mucous membranes. It is divisible into the skin in the stricter sense, *cutis,* and its accessory structures, *hairs, pili,* and *nails, ungues,* which are products of the epidermis just as are the *cutaneous glands, glandulae cutis,* which are situated in the cutis.



986. Papillae of the skin of the sole of the foot. Magnification: 21:1.

(The epidermis has been completely removed.)

The *cutis* (see Fig. 993) consists of two parts sharply separable from one another in their development and in their structure, an epithelial part, the *epidermis, scarf-skin,* and a part consisting essentially of connective tissue, which is farther subdivisible into the *corium, leather skin,* and the *tela subcutanea, subcutaneous tissue.*

The *epidermis, scarf-skin* (see also Fig. 993), consists of a lamellated epithelium and forms the external visible surface of the skin; it covers the corium directly and completely and sinks into its depressions. Its thickness varies in different individuals and is also very variable in the same individual; in the sole of the foot it measures about 2 mm in depth, in the palm of the hand about 1 mm and elsewhere varies between 0.07 and 0.17 mm. In white races the epidermis contains a little pigment (except in the non-pigmented albinos); in colored races there is much pigment.

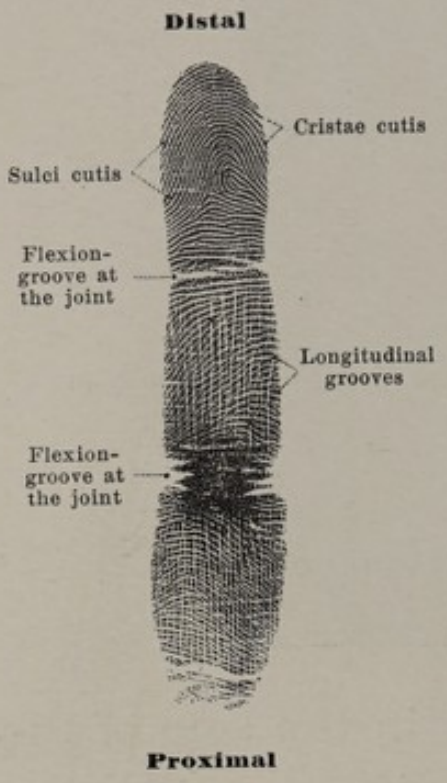


Fig. 987.

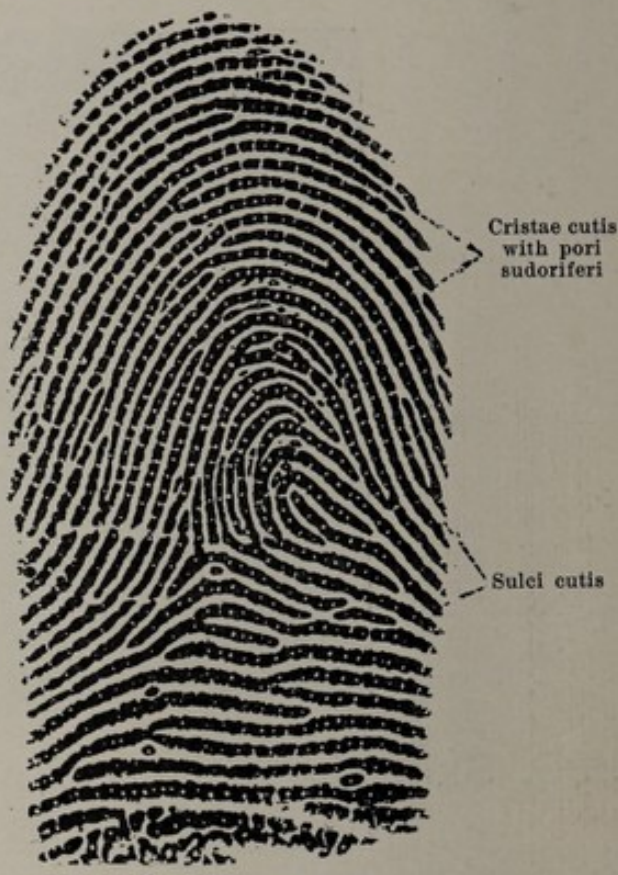


Fig. 988.

987 and 988. Ridges and sulci in the skin of the volar surface of a finger of the right hand, obtained by impression.

Natural size. Distal part of Fig. 987, magnified 4 times.

The *corium, leather skin* (see Figs. 985, 986, 993 and 994), consists of a close plexus of bundles of connective tissue along with elastic fibres and smooth muscle fibres. The connective tissue bundles, especially in the deeper layers, are usually directed only a little obliquely toward the surface, run nearly parallel to it and as they go are interwoven with one another as in straw-matting; corresponding to the permanent or often repeated tension which usually is exerted upon them from their surroundings, certain particular directions are preferably followed by them and the bundles parallel to these directions are more tightly stretched than those perpendicular to them; accordingly wounds which are situated in the direction of the tighter stretching gape less than those directed perpendicular to it. The smooth muscles are found usually in connection with the hair follicles, but may be spread out in a surface as in the tunica dartos; but in the latter case it belongs to the tela subcutanea.

The thickness of the corium varies according to race, sex (somewhat thicker in the male than in the female), age (much thinner in the child than in the adult) and individually; it also varies in the same body in different places: it is thinnest in the eyelids and in the genitalia (0.3—0.6 mm), thickest on the back, buttock, palm and sole (2—3 mm).

The surface of the corium turned toward the epidermis is studded by microscopically small thread-like or cone-like processes, *papillae.* They, together with the more superficial layer of the corium from which they project, are spoken of as the *corpus papillare* and consist of especially closely interwoven fine connective tissue fibres; the other, larger part of the corium which is more loosely woven of coarser bundles is called the *tunica propria.* The papillae in different parts of the body are of different length, form and frequency; they are absent only in a few places (forehead, external ear, perineum, parts of the scrotum and of the axilla); the longest (0.1—0.2 mm) are found in the palm and sole.

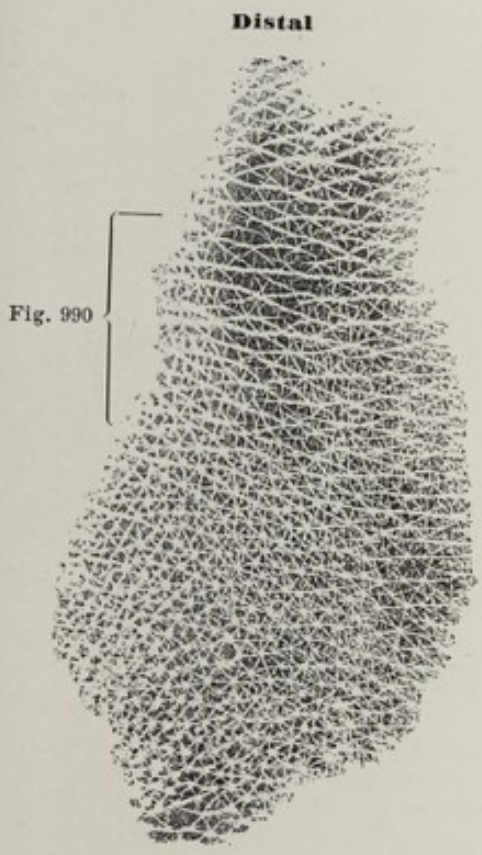


Fig. 989.

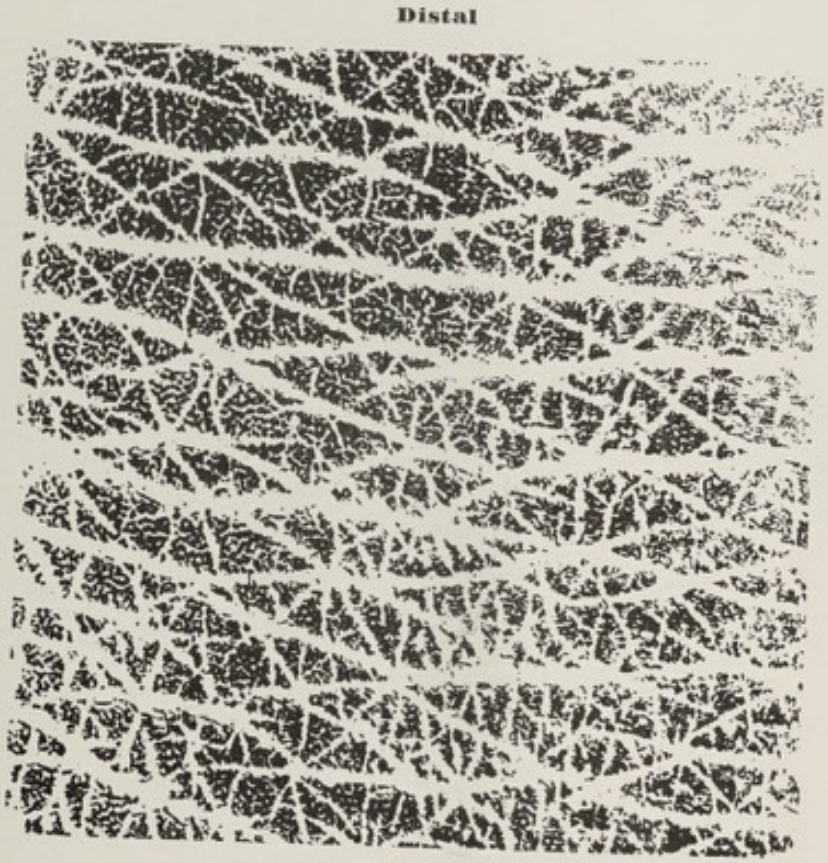


Fig. 990.

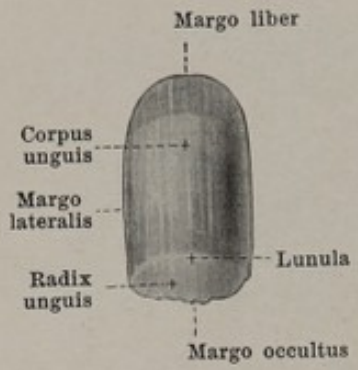
989 and 990. Skin sulci and cutaneous areals on the surface of the back of the left hand (ulnar portion), obtained by impression.

Natural size.

The area in the bracket in Fig. 989 is here shown magnified 4 times.

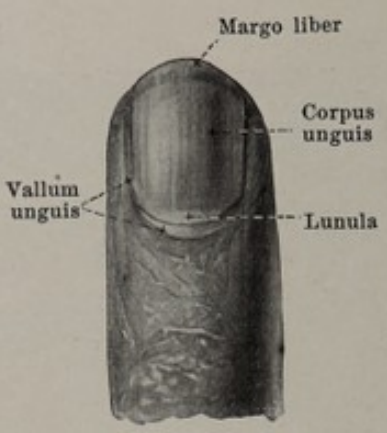
(The hairs were shaved off before the impression was taken; they emerge in the middle of the stellate white figures distinctly visible especially in the proximal part of Fig. 989.)

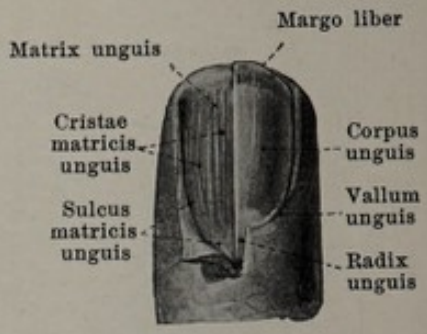
The *papillae* (continued) (see also Figs. 985—988 and 992—994) project into the lower layers of the epidermis and very often cause corresponding smaller hillock-like projections on the surface of the epidermis. When this is not the case, the surface of the epidermis looks smooth and the presence of the papillae appears first on cross-section. In other cases even on the free surface a delicate marking can be seen which depends upon the fine *cutaneous sulci*, *sulci cutis*, and the groups of papillae projecting slightly above the surface situated between them. This marking is very variable in different parts of the body, and in part also shows great individual variation (especially in the fingers). In the palm and the fingers, in the sole of the foot and in the toes the papillae are arranged in rows, but the epidermis does not sink in near each one of them but forms small wall-like *cutaneous ridges*, *cristae cutis*, of which each regularly covers over two rows of papillae and is separated from the next by a groove-like cutaneous sulcus (see above); the sweat glands open at the top of these cutaneous ridges and enter into the corpus papillare in the groove between the two corresponding rows of papillae.



991. Fingernail,

viewed from the dorsal surface, isolated.





992. Fingernail and bed of nail,

viewed from the dorsal surface.

(The left half of the nail has been removed.)

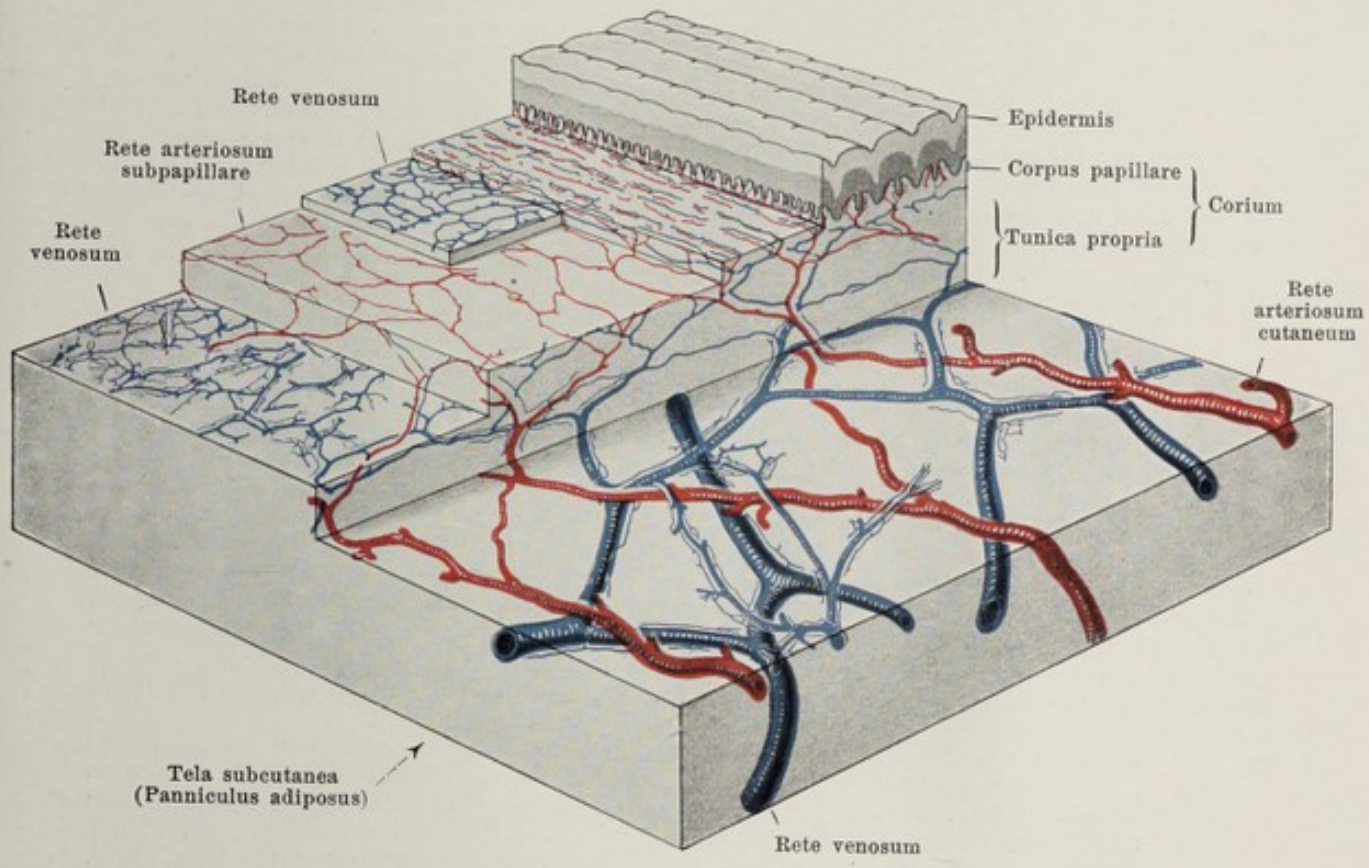
in situ.

The *tela subcutanea, subcutaneous tissue* (see Fig. 930), is not sharply separated from the corium but passes out of it without sharp limit; it is distinguishable from the corium by the greater thickness and looser interweaving of the bundles of connective tissue as well as by the fact that it may contain fatty tissue in a very variable way, arranged in smaller or larger lobules. When the fat is abundant the subcutaneous tissue is called the *panniculus adiposus;* the connective tissue septa between the lobules may then become thickened to form a septal wall, parallel to the surface, which divides the fat into two layers. The subcutaneous tissue everywhere unites the corium with the deeper-lying structures; the more sharply limited tougher connecting bands between these and the corium are called *retinacula cutis* (see also p. 636).

The *hairs, pili,* are found upon the whole surface of the body except the red border of the lips, the palms of the hands, the soles of the feet, the dorsal surfaces of the endphalanges of the fingers and toes, the nipples of the breast, the glans penis and the inner surface of the praeputium, as well as the labia minora pudendi and the vestibulum vaginae; they are epidermoidal structures and project into the corium or into the subcutaneous tissues. They usually stand obliquely to the surface and in definite directions varying according to the region of the body and thus form *hair-streams, flumina pilorum,* and *hair whirlpools, vortices pilorum* (not illustrated), which are more distinct in embryos than in adults. The hairs are of very different length and thickness; they include the *capilli (hairs of the head), supercilia (hairs of the eyebrows), cilia (eyelashes), barba (hairs of the beard), tragi (hairs of the ear), vibrissae (hairs of the nose), hirci (axillary hairs)* and *pubes (pubic hairs);* the very fine hairs found on other parts of the body are together spoken of as *lanugo (woolly hairs).*

The *nails, ungues,* are quadrilateral, curved plates consisting of horny cells of the epidermis which end distalward in the *margo liber.* Their lateral margins, *margines laterales,* and their proximal sharpened margin, *margo occultus,* are enclosed in a groove-like depression of the cutis, the *ungual fold, sulcus matricis unguis,* and are overlaid on the surface by the *ungual wall, vallum unguis.* The main mass of the nail, *corpus unguis,* rests upon the *bed of the nail, matrix unguis,* which is beset with numerous longitudinal ridges, *cristae matricis unguis.* The generation of the nail substance takes place at the proximal part hidden beneath the ungual wall, which accordingly is called the *root of the nail, radix unguis;* this part consists of cells which are not yet hornified and not yet dry, and is recognizable by its whitish color; it often projects beyond the distal end of the ungual wall as a small sickle-shaped area, the *lunula.*

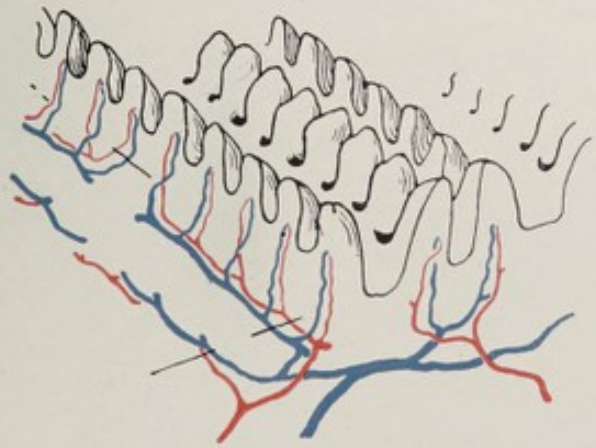
The *glands of the skin, glandulae cutis,* occur in two varieties, *glandulae glomiformes, coil glands,* and *glandulae sebaceae, sebaceous glands.* To the former belong the *glandulae ciliares [Molli]* (see p. 821), the *glandulae ceruminosae* (see p. 832), the *glandulae circumanales* (especially large sweat glands in the immediate neighborhood of the anus) and the *glandulae sudoriferae, sweat glands.* The latter (see Fig. 930) consist of a simple tubule, which by a coil-like rolling up of its blind end forms the spherical gland-body, *corpus glandulae sudoriferae.* This lies in the subcutaneous tissue or in the corium and sends its excretory duct, *ductus sudoriferus,* perpendicular to the surface, where it opens by a small rounded opening, *porus sudoriferus,* at the top of the cristae cutis where these are present (see p. 865).



993. Distribution of the blood vessels in the skin of the sole of the foot, in a staircase-like model.

Magnification: about 12:1.

(The sweat-glands and their vessels have not been illustrated; only the uppermost part of the subcutaneous tissue is shown.)



994. Distribution of the blood vessels in the corpus papillare of the corium. Magnification: about 40:1.

(The epidermis is not shown.)

Glands of the skin (continued). The sweat glands vary greatly in size and number. They are most numerous in the palm of the hand and sole of the foot, where in one square centimeter about 1000 are counted; they are absent only from the red part of the lips, from the glans penis, from the internal surface of the praeputium and from the vestibulum vaginae.

The *sebaceous glands, glandulae sebaceae* (see Figs. 565 and 930), are simple flask-like or manifoldly bulged sacks which lie in the cutis and, as a rule, appear as appendages of the hair follicles; they secrete the *sebum cutaneum*. They, like the hair, are absent from the palm of the hand and the sole of the foot. They are everywhere of about the same size; the largest of them are found in connection with the very fine woolly hairs in the skin of the external nose. They are found entirely independent of any connection with hair follicles on the red part of the lips and on the glans penis.

Blood vessels of the external skin, vasa sanguinea integumenti communis (see Figs. 993 and 994). The arteries which enter the skin are destined to supply this exclusively or they are branches of the arteries to the muscles. Their number and their diameter are different for the surface unit in different places; they are larger in those places which are frequently exposed to external pressure (for instance palm of hand, sole of foot, regio glutaea). These arteries pass through the subcutaneous connective tissue, anastomose with one another in the lowermost layer of the corium and form there a leaf-like cutaneous network, *rete arteriosum cutaneum*, the concentration of which varies in the same way as do the number and diameter of the tributary branches. The vessels supply the superficial fat layer and the sweat glands by means of finer twigs. From this network proceed branches which form in the upper third of the corium a second laminar network, the *subpapillary network, rete arteriosum subpapillare*, and from this arise minute twigs, which do not anastomose with one another (end-arteries); they run in the sole of the foot, usually a short distance in the direction of the rows of the papillae, and finally send off smallest twigs into the papillae; from the subpapillary network go off also the branches to the hair follicles and the sebaceous glands.

The blood arising from the capillaries of the papillae passes through several venous networks, *retia venosa*, of which the uppermost is situated close beneath the rows of papillae, the lowermost, largest, at the junction between the corium and the subcutaneous tissues; between these two, in the sole of the foot, still two other networks are interpolated. These networks receive also the small veins from the hair follicles, the glands and the fatty tissue. The veins run only partly beside the arteries. From the deepest network larger trunks enter the subcutaneous tissue and open usually into the large veins of the skin (venae cutaneae).

A.

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(The numbers always refer to pages; the references to the figures will be found there in the text. Exceptionally a name may not be mentioned in the text, in which event the figure to be found upon the page referred to is meant.)

Latin words with several syllables bear above the vowel of their last syllable but one (if it was considered necessary also of the other syllables) a sign of length to denote their correct accentuation.
Thus the accentuation of words with 3 and more syllables is governed by the following 2 rules:
1. The last syllable but one is to be accented, if the vowel of this syllable is long.
2. The antepenult is to be accented, if the vowel of the last but one syllable is short.
Of dissyllables the last syllable but one is to be accented.

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B.

List of the names

which occur in the Anatomical Nomenclature used

with short Biographical notes.

Achilles — tendo calcaneus

Arantius — ductus venosus
— ligamentum venosum
— nodulus valvulae semilunaris
Giulio Cesare Aranzi (Julius Caesar Arantius) (1530—1589), Professor of Medicine and Anatomy at Bologna.

Arnold — Arnold's bundle (Frontal [cerebro-] pontile path)
— substantia reticularis alba
Friedrich Arnold (1803—1890), Professor of Anatomy at Zürich, of Anatomy and Physiology at Freibourg, Tübingen and Heidelberg.

Bartholinus — glandula vestibularis major
Casparus Bartholinus (1655 till 1738), first Professor of Philosophy, then of Natural Science and Medicine, afterwards „Generalprocureur" and Deputy of Finances in Copenhagen. He was the son of Thomas Bartholinus (1616 till 1680) who was generally considered to be the greatest anatomist of his time.

Bechterew — nucleus nervi vestibularis superior
Wladimir von Bechterew (1857 till 1927), Professor of Psychiatry at Kazan and St. Petersburg.

Bertin — columnae renales
Exupère-Joseph Bertin (1712 till 1781), Anatomist and Physiologist at Paris.

Blandin — glandula lingualis anterior
Philippe-Frédéric Blandin (1798 till 1849), Professor of Surgery at Paris.

Bochdalek — trigonum lumbocostale
Victor Bochdalek junior (1835 till 1868), Prosector of anatomy at Prague.

Botallo — ductus arteriosus
Leonardo Botallo was born in 1530, Anatomist and Surgeon at Pavia and Paris.

Bowman — lamina elastica anterior corneae
Sir William Bowman (1816—1892), Professor of Anatomy and Physiology, also Oculist in London.

Breschet — canales diploici
Gilbert Breschet (1784—1845), Professor of Anatomy at Paris.

Broca — area parolfactoria
Paul Broca (1824—1880), Professor of Surgery at Paris; famous also as Anatomist, Anthropologist and Pathologist.

Bruecke — fibrae meridionales m. ciliaris
Ernst Wilhelm v. Bruecke (1819 till 1892), Professor of Physiology at Königsberg, of Physiology and Microscopic Anatomy at Vienna.

Brunner — glandulae duodenales
Johann Konrad Brunner (1653 till 1727), first Professor of Medicine at Heidelberg, then Physician to the Elector Palatine.

Burdach — funiculus cuneatus
Karl Friedrich Burdach (1776 till 1847), Professor of Anatomy and Physiology at Dorpat and Königsberg.

Chopart — articulatio tarsi transversa
François Chopart (1743—1795), Surgeon at Paris.

Civinini — processus pterygospinosus ossis sphenoidalis
Filippo Civinini died in 1844, Professor of Surgical Pathology and of Anatomy at Pistoia.

Clarke — nucleus dorsalis
Jacob Augustus Lockhart Clarke (1817—1880), Physician at London.

Cloquet — septum femorale
Jules-Germain Cloquet (1790 till 1883), Anatomist and Professor of Surgery at Paris.

Colles — ligamentum inguinale reflexum
Abraham Colles (1773—1843), Professor of Anatomy and Surgery at Dublin.

Cooper — fascia cremasterica
Sir Astley Paston Cooper (1768 till 1841), first Professor of Anatomy, then of Zoophysics, and finally of Surgery. Physician to King George IV. and to King William IV. in London.

Corti — organon spirale
Marchese Alfonso Corti (1822 till 1876), Physician, Hyrtl's Prosector in Vienna (1848), then he devoted mostly at Würzburg under Koelliker his time to research work. Afterwards he took up viticulture at his estate near Casteggio being compelled by ill health to give up his former work.

Cowper — glandula bulbourethralis
William Cowper (1666—1709), Surgeon and Anatomist in London.

Darwin — tuberculum auriculae
Charles Robert Darwin (1809 till 1882), studied medicine, then theology and finally took up natural science. After a 5 years cruise round the world on the „Beagle" he devoted himself entirely to natural science and research at his estate in Kent.

Deiters — nucleus nervi vestibularis lateralis
Otto Friedrich Karl Deiters (1834 till 1863), Physician at Bonn.

Demours — lamina elastica posterior corneae
Pierre Demours (1702—1795), Oculist in Paris.

Descemet — lamina elastica posterior corneae
Jean Descemet (1732—1810), Physician and Botanist in Paris.

Douglas — cavum Douglasi (excavatio rectouterina)
— linea semicircularis
— plica rectouterina
James Douglas (1675—1742), Physician in London.

Eustachius — tuba auditiva
— valvula venae cavae
Bartolomeo Eustachi was born between 1500 and 1510 and died in 1574. Professor of Anatomy at Rome.

Falloppio — canalis facialis
— tuba uterina
Gabriele Falloppio (1523—1562), Professor of Anatomy at Ferrara, Pisa, and of Anatomy and Botany at Padua.

Ferrein — processus Ferreini (pars radiata lobuli corticalis renis)
Antoine Ferrein (1692—1769), Professor of Medicine and Surgery in Paris.

Flechsig — fasciculus anterior proprius
— fasciculus lateralis proprius
— nucleus nervi vestibularis superior
Paul Emil Flechsig was born in 1847, Professor of Psychiatry at Leipzig.

Folius — processus anterior mallei
Cecilio Folli (Folius) was born in 1615 and died about 1650; Professor of Anatomy at Venice.

Fontana — spatia anguli iridis
Felice Fontana (1720—1805), Professor of Philosophy at Pisa and afterwards Director of the Museum of Natural Science in Florence.

Galenus — vena cerebri magna
Galenos was born in 129 A. D. at Pergamon. Resided as Physician and successful writer on medical topics in Rome. Physician to the Emperor Commodus. He died at the beginning of the 3rd century.

Gartner — ductus epoophori longitudinalis
Hermann Treschow Gartner (1785 till 1827), Physician in Copenhagen.

Gasser — ganglion semilunare
Johann Ludwig (or Laurenz) Gasser was Professor of Anatomy in Vienna in the middle of the 18th century.

Gennari — linea Gennari
Francesco Gennari lived in the second half of the 18th century. His book „De peculiari structura cerebri" was published at Parma in 1782.

Gimbernat — ligamentum lacunare
Don Antonio de Gimbernat was professor at Barcelona in the second half of the 18th century; afterwards he was appointed Physician to King Charles III. in Madrid.

Glaser — fissura petrotympanica
Johann Heinrich Glaser (1629 till 1675), was Professor of Anatomy and Botany at Basel.

Goll — funiculus gracilis
Friedrich Goll (1829—1903), Professor of Pharmacology at Zürich.

Gowers — fasciculus anterolateralis superficialis
William Richard Gowers was born in 1845 and was Professor of Clinical Medicine in London.

Graaf — folliculi oophori vesiculosi
Reinier de Graaf (1641—1673), Physician at Delft.

Gratiolet — radiatio occipitothalamica
Louis Pierre Gratiolet (1815 till 1865), first Professor of Anatomy and subsequently Professor of Zoology in Paris.

Haller — arcus lumbocostales
— circulus vasculosus n. optici
— rete testis
Albrecht von Haller (1708—1777), Professor of Anatomy, Surgery and Botany at Göttingen. In later years he resided at Bern, his native town. Haller was not only an eminent scientist, but he was also famous as a poet.

Hasner — plica lacrimalis
Josef Hasner, Ritter von Artha (1819—1892), Professor of Ophthalmology at Prague.

Havers — Haversian canals of bone
Clopton Havers, an English Anatomist, lived in London in the second half of the seventeenth century and at the beginning of the eighteenth century.

Heister — valvula spiralis
Lorenz Heister (1683—1758), Professor of Anatomy and Botany at Altdorf, Professor of Surgery and Botany at Helmstädt.

Helweg — Helweg's bundle
Hans Kristian Saxtorph Helweg (1847—1901), Head Physician of the Oringe Lunatic Asylum near Vordingborg (Sealand, Denmark).

Hensen — ductus reuniens
Victor Hensen (1835—1924), Professor of Physiology at Kiel.

Hesselbach — ligamentum interfoveolare
Franz Kaspar Hesselbach (1759 till 1816), Anatomist and Surgeon at Würzburg.

Highmore — corpus Highmori (mediastinum testis)
Nathanael Highmore (1613—1685), Physician at Sherburn (Dorsetshire).

Horner — pars lacrimalis m. orbicularis oculi
William Edmonds Horner (1793 till 1853), Professor of Anatomy at Philadelphia.

Hunter — canalis adductorius
John Hunter (1728—1793), Surgeon in London.

Jacobson — plexus tympanicus
— cartilago vomeronasalis
— organon vomeronasale
Ludwig Levin Jacobson (1783 till 1843), Physician in Copenhagen, afterwards Army Surgeon with the French armies and after the Battle of Leipzig with the English-Hanoverian Legion.

Kerckring — plicae circulares
Theodorus Kerckring (1640—1693), Physician in Amsterdam and afterwards „Resident to the Duke of Tuscany" at Hamburg.

Krause — glandulae mucosae conjunctivae
Karl Friedrich Theodor Krause (1797—1868), Professor of Anatomy at Hannover.

Lauth — canalis Lauthi (sinus venosus sclerae)
Ernst Alexander Lauth (1803 till 1837), Professor of Physiology and Head of the Anatomical Preparations in the Medical Faculty at Strassburg.

Lieberkühn — glandulae intestinales
Johann Nathanael Lieberkühn (1711—1756), Physician in Berlin.

Lieutaud — trigonum vesicae
Joseph Lieutaud (1703—1780), first Physician at Aix, afterwards appointed Physician to Louis XV. and Louis XVI. at Versailles.

Lisfranc — articulationes tarsometatarseae
— tuberculum scaleni
Jacques Lisfranc (1790—1847), Professor of Surgery in Paris.

Lissauer — Lissauer's marginal zone of the spinal cord
Heinrich Lissauer (1861—1891), Assistant Physician at the Breslau University Hospital for Psychiatry.

Littre — glandulae urethrales
Alexis Littre (1658—1726), Anatomist and Surgeon in Paris.

Lower — tuberculum intervenosum
Richard Lower (1631—1691), Physician in London.

Luys — corpus Luysi (nucleus hypothalamicus)
Jules-Bernard Luys (1828—1897), Physician in Paris.

Magendie — foramen Magendii (apertura medialis ventriculi quarti)
François Magendie (1783—1855), Physician and Professor of Physiology and Pathology in Paris.

Maissiat — tractus iliotibialis
Jacques-Henri Maissiat (1805 till 1878), Physician, Professor in Paris; Conservateur en chef at the Museum of the Ecole de médecine.

Malpighi — pyramides renales
Marcello Malpighi (1628—1694), Professor of Medicine at Bologna, Pisa and Messina, finally Physician to Pope Innocence XII. at Rome. Malpighi is the originator of microscopic anatomy.

Marshall — vena obliqua atrii sinistri
John Marshall (1818—1891), Professor of Surgery and Anatomy in London.

Meckel — Meckel's cartilage
Johann Friedrich Meckel the Younger, (1781—1833), Professor of Anatomy and Surgery at Halle.

Meibom — glandulae tarsales
Heinrich Meibom (1638—1700), Professor of Medicine, History and Poetry at Helmstädt.

Meynert — fasciculus retroflexus
Theodor Meynert (1833—1892), Professor of Neuropathology in Vienna.

Moll — glandulae ciliares
Jacob Anton Moll (1832—1914), Oculist at the Hague (Netherlands).

Monro — foramen interventriculare
— sulcus hypothalamicus
Alexander Monro (Tertius) (1773 till 1859), Professor of Anatomy and Surgery at Edinburgh.

Montgomery — glandulae areolares
William Fetherston Montgomery was born about 1797 and died in 1859, Obstetrician in Dublin.

Morgagni — appendices vesiculosae epoophori
— appendix testis
— columnae rectales
— foramen caecum linguae
— fossa navicularis urethrae
— lacunae urethrales
— ventriculus laryngis
Giovanni Battista Morgagni (1682—1771), Professor of Anatomy at Padua.

Müller — fibrae circulares m. ciliaris
Heinrich Müller (1820—1864), Professor of Anatomy at Würzburg.

Müller — Müller's duct
Johannes Müller (1801—1858), Professor of Anatomy and Physiology in Berlin.

Nuhn — glandula lingualis anterior
Anton Nuhn (1814—1889), Professor of Anatomy at Heidelberg.

Pacchioni — foveolae granulares
— granulationes arachnoideales
Antonio Pacchioni (1665—1726), Anatomist in Rome.

Pacini — corpuscula lamellosa
Filippo Pacini (1812—1883), Professor of Anatomy at Florence.

Petit — trigonum lumbale
Jean-Louis Petit (1674—1760), Surgeon in Paris.

Peyer — noduli lymphatici aggregati
Johann Konrad Peyer (1653—1712), Physician and subsequently Professor of Rhetoric and Natural Science at Schaffhausen.

Poupart — ligamentum inguinale
François Poupart (1616—1708), Surgeon in Paris, Physician to Lady Maintenon in the reign of Louis XIV.

Purkinje — stratum gangliosum cerebelli
Johannes Evangelista Ritter von Purkinje (1787—1869), Professor of Physiology and Pathology at Breslau, of Physiology at Prague.

Rathke — Rathke's pouch
Martin Heinrich Rathke (1793 till 1860), first Professor of Physiology and Pathology at Dorpat, then of Zoology and Anatomy at Königsberg.

Reil — sulcus circularis insulae
Johann Christian Reil (1759 till 1813), Professor of Clinical Medicine at Halle and in Berlin.

Reißner — membrana vestibularis
Ernst Reißner (1824—1878), Professor of Anatomy at Dorpat.

Riolan — musculus ciliaris
Jean Riolan, the son, (1580—1657), Professor of Anatomy, Botany and Pharmacology in Paris, Physician to Henry IV. and to Louis XIII, Head-physician of the Queen-Mother Maria of Medici.

Rivinus — incisura tympanica
August Quirinus Rivinus (1652 till 1723), first Professor of Physiology and Botany, then of Pathology and finally of Therapeutics at Leipzig. Known for his classification of plants.

Rolando — substantia gelatinosa
— sulcus centralis
Luigi Rolando (1773—1831), Physician to King Victor Emanuel of Sardinia, Professor of Medicine at Sassari, of Anatomy at Turin.

Rosenmüller — recessus pharyngeus
Johann Christian Rosenmüller (1771—1820), Professor of Anatomy at Leipzig.

Santorinus — cartilago corniculata
— concha nasalis suprema
— ductus pancreaticus accessorius
— incisurae cartilaginis meatus acustici externi
— papilla duodeni
— tuberculum corniculatum
Giovanni Domenico Santorini (1681—1737), Professor of Anatomy at Venice.

Sappey — venae parumbilicales
Marie-Philibert-Constant Sappey (1810—1896), Professor of Anatomy at Paris.

Scarpa — fossa Scarpae major (trigonum femorale)
— nervus nasopalatinus
Antonio Scarpa (1752—1832), Professor of Anatomy and Surgery first at Modena, then at Pavia, finally Professor of Surgery at Pavia.

Schlemm — canalis Schlemmi (sinus venosus sclerae)
Friedrich Schlemm (1795—1858), Professor of Anatomy in Berlin.

Schwalbe — nucleus nervi vestibularis medialis
Gustav Schwalbe (1844—1916), Professor of Anatomy at Leipzig, Jena, Königsberg and Strassburg.

Spigelius — linea semilunaris
— lobus caudatus
Adrian van den Spieghel (Spigelius), (1578—1625), Professor of Anatomy and Surgery at Padua.

Stenonis — ductus parotideus
— Stensen's passage
Niels Stensen (Nicolaus Stenonis, alias Steno, alias Stenonius), was born in Copenhagen in 1638, wrote (usually in Italy) on anatomical, physiological and geological topics, was appointed Physician to the Grand-Duke Ferdinand II. of Tuscany, turned Roman Catholic in 1667, was Professor of Anatomy in Copenhagen from 1672 till 1674, in 1675 he was ordained a priest at Florence, in 1677 he journeyed as „Bishop of Titiopolis" to Münster, Hanover and Brunswick with the intention of winning back the North for the Church of Rome. He died in 1686 at Schwerin. He was buried in the Medicean Vault at St. Lorenzo in Florence by order of the Grand-Duke Cosimo.

Stilling — nucleus dorsalis medullae spinalis
Benedict Stilling (1810—1879), Surgeon and Anatomist at Cassel.

Sylvius — aquaeductus cerebri
— fissura cerebri lateralis
— fossa cerebri lateralis
Franz de le Boë (Sylvius) (1614 till 1672), first Physician in Amsterdam, then Professor at Leyden.

Tarin — fossa interpeduncularis
Pierre Tarin (was born about 1725, and died in 1761), Anatomist in Paris.

Tawara — Tawara's node
Sunao Tawara was born in 1875. Professor of the Pathological Institute in the Imperial University at Kyushu (Japan).

Tenon — fascia bulbi
— spatium interfasciale
Jacques-René Tenon (1724—1816), Surgeon and Oculist, Professor of Pathology in Paris.

Thebesius — foramina venarum minimarum
— valvula sinus coronarii
Adam Christian Thebesius, lived at the close of the 17th and at the beginning of the 18th century, Physician at Hirschberg (Silesia).

Türck — Türck's bundle (Temporal [cerebro-] pontile path)
Ludwig Türck (1810—1868), Neurologist and Laryngologist in Vienna.

Valsalva — ligamenta auricularia
— sinus aortae
Antonio Maria Valsalva (1666 till 1723), Professor of Anatomy and Surgeon at Bologna.

Varolio — pons
Costanzo Varolio (1543—1575), Professor of Anatomy and Surgery at Bologna, Professor at Rome, Physician to Gregor XIII.

Vater — corpuscula lamellosa
Abraham Vater (1684—1751), Professor of Anatomy, finally of Therapeutics at Wittenberg.

Vicq d'Azyr — fasciculus thalamomamillaris
Felix Vicq-d'Azyr (1748—1794), Physician in Paris, published works especially on Anatomy and Zoophysics.

Vidius — canalis pterygoideus
— arteria, nervus, vena canalis pterygoidei
Guido Guidi (Lat. Vidus Vidius), was born at the beginning of the sixteenth century, was Appointed Physician to Francis I. and Professor of Medicine in Paris, then Professor of Philosophy and Medicine at Pisa where he died in 1569.

Vieussens — ansa subclavia
— limbus fossae ovalis
Raymond de Vieussens (1641 till 1716), Physician at Montpellier, from time to time in Paris.

Wharton — ductus submaxillaris
Thomas Wharton (1610—1673), Physician in London.

Willis — circulus arteriosus
Thomas Willis (1621—1675), first Professor of Natural Science at Oxford, afterwards Physician in London.

Winslow — foramen epiploicum
— pancreas Winslowi (processus uncinatus pancreatis)
Jakob Benignus Winslow (1669 till 1760), Professor of Anatomy in Paris.

Wirsung — ductus pancreaticus
Johann Georg Wirsung was born in 1600 at München; he was assassinated in 1643; 5 years Prosector at Padua.

Wrisberg — cartilago cuneiformis
— ganglion cardiacum
— tuberculum cuneiforme
Heinrich August Wrisberg (1739 till 1808), Professor of Anatomy at Göttingen.

Zinn — annulus tendineus communis
— zonula ciliaris
Johann Gottfried Zinn (1727 till 1759), Professor of Medicine and Director of the Botanical Garden in Göttingen.

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