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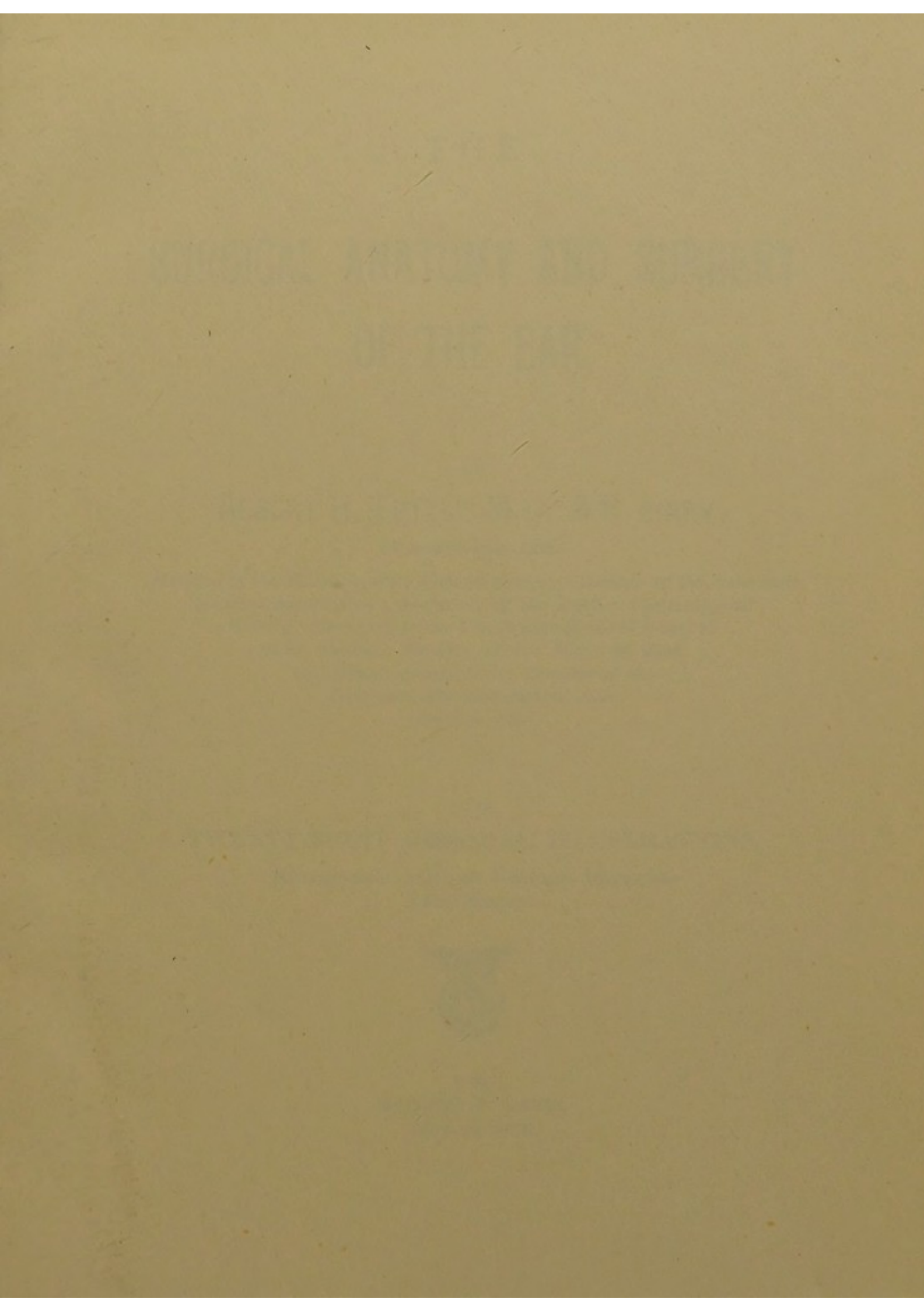
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THE
SURGICAL ANATOMY AND SURGERY
OF THE EAR.

BY

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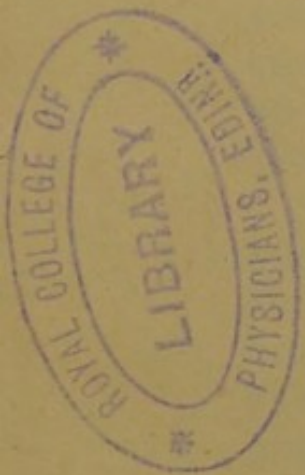
TWENTY-EIGHT ORIGINAL ILLUSTRATIONS,

REPRODUCED FROM THE WRITER'S DRAWINGS
FROM NATURE.



1892.

GEORGE S. DAVIS,
DETROIT, MICH.



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PREFACE.

THE following production is the outcome of special study to determine the topographical anatomy of the ear, with reference to the more modern surgical procedures. Some cases of ear disease having come under my treatment which I thought might be benefited by operative measures, I set to work on the skull, making sections and drawings to obtain, as nearly as possible, an accurate knowledge of the dangers and difficulties of the operations before me. As a result of this study, I soon had a collection of plates which were interesting, at least to me; and thinking they might perhaps be of some help to others, I have gathered them together in the following work, the scope of which I have extended somewhat, so as to make a short treatise on the surgery of the ear.

A work of this magnitude cannot include all the important questions on the subject of aural surgery and anatomy, and, although I have tried to select those which offer the greatest interest from a surgical standpoint, I am fully aware that I have made many omissions, among which are subjects of great practical importance, and on the other hand have treated on cases which are of comparatively rare occurrence. I hope this fact will not be severely criticised, but allowed to pass as a peculiarity of the writer. I am obliged to Doctors H. O. Marcy, A. P. Clarke, and H. L. Morse, for the use of material during these investigations, and wish to express my thanks to the same.

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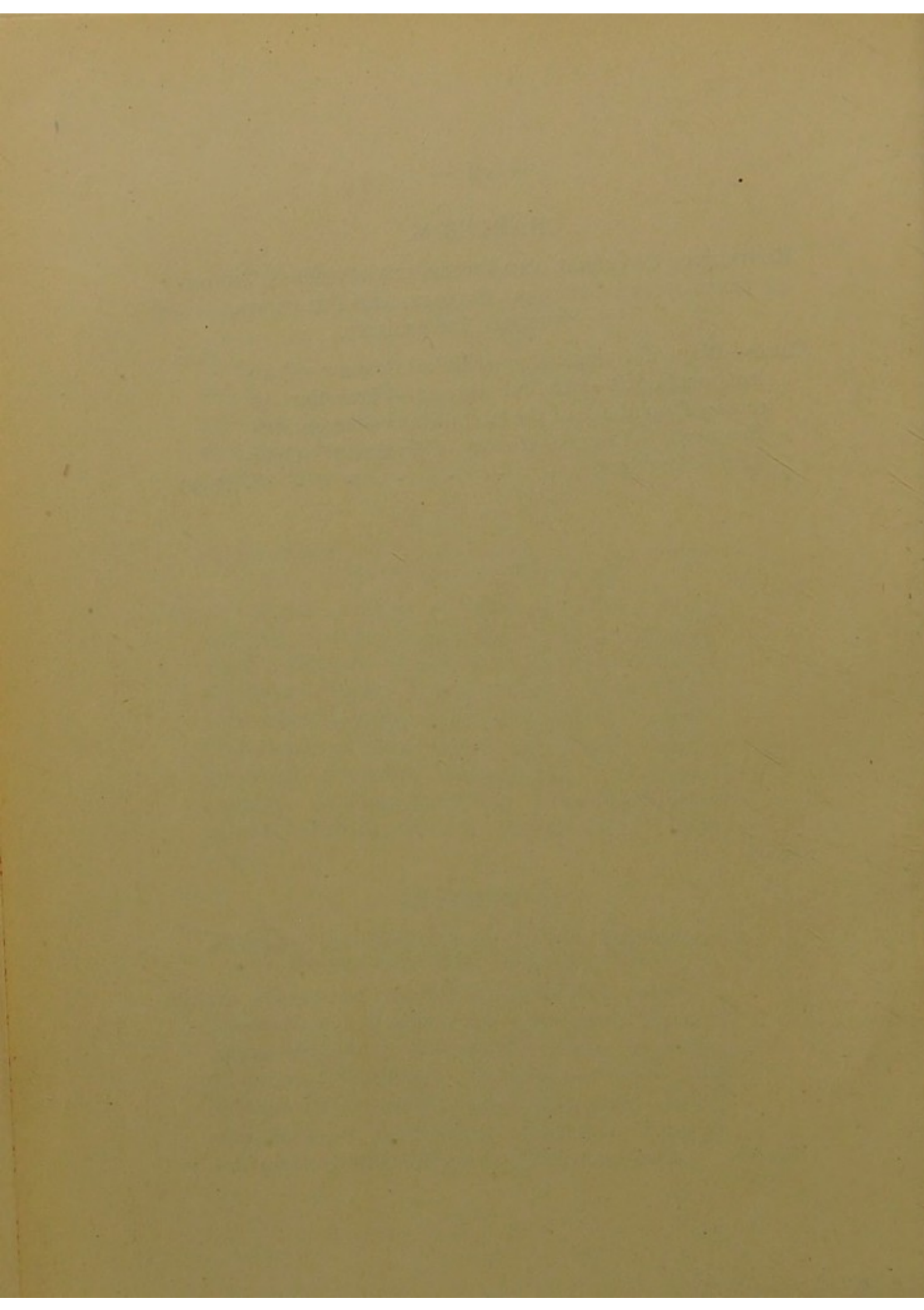
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CHAPTER I.

ANATOMY OF THE EAR.

Although the anatomy of the ear has been understood for many generations, and any further demonstration or discussion is apparently useless, yet the great stride taken in the progress of surgery during the past few years has brought with it certain operations upon the ear which had either become entirely discarded or are quite new, and it is in view of these facts that I have undertaken to more accurately determine the topographical relations as applied to these operations.

There are three principal considerations to be borne in mind while studying the anatomy of the ear from a surgical standpoint, viz.: How shall we attack disease of the tympanum without injuring the many delicate structures connected with that organ? when we open the mastoid cavity, what is the best point of entrance, and what are the dangers we are likely to encounter? if in the course of ear disease we get an extension to the cerebral cavity, is there any chance left the patient by surgical interference, and, if so, in what direction shall we proceed?

The external ear is made up of the auricle and its muscles, and the external auditory meatus. The auricle, or pinna, is formed from several cartilages and covered with thin skin. Owing to its great vas-

cular supply, it may be disarticulated and turned down as a flap, completely separated from its connection with the bony meatus, without loss of its vital integrity.

The temporal artery lies just anterior to the ear, close to the bone, and very near the cartilage that forms a part of the meatus. There is no need of injuring this vessel in any of the incisions or dissections required for the usual operations upon the ear. The temporal artery supplies the ear with a large branch, the anterior auricular, and several smaller branches. To avoid cutting the temporal artery, the incision above the ear should not extend anterior to a perpendicular line drawn through the base of the tragus. The posterior auricular, a branch from the external carotid, passes upwards between the cartilaginous meatus and the mastoid process, until it reaches about the superior margin of the bony auditory canal, where it divides into two branches, the anterior of which anastomoses with the anterior auricular. Both branches of the posterior auricular artery are liable to be injured in the long crescentic incision made in this region.

The external auditory meatus may be divided into two portions—one formed by the cartilage of the pinna, the other by a bony ring. The latter is only wholly developed near puberty. The canal curves forward in the cartilaginous portion, so that in order to inspect the deeper portions it becomes necessary

to draw back on the pinna. When this is done, the tragus is brought so far over the opening of the meatus that a speculum is required to push this forward out of the field of vision.

The cutis lining the meatus is exquisitely thin, and in the inner segment it is closely adherent to the bone, so that its separation is difficult.

The meatus varies very much, both with the age of the individual and in different subjects; it is usually, however, about one and one-quarter inches in length, the cartilaginous portion forming nearly half an inch of this distance. Owing to the inner end terminating obliquely from above downward and inward, the floor of the meatus is of greater length than the roof. (Compare Figs. 6, 10, 27.) The canal is not straight, but directed obliquely forward and inward; it is also slightly curved upon itself, so that the middle portion is higher than either the drum or the external end; when within from one-eighth to three-sixteenths of an inch of the drum, the upper and posterior wall of the canal slopes more or less abruptly downward and forward, a condition not usually mentioned in works of anatomy. (Compare Fig. 3.) A vertical section through the centre of the meatus and in the same direction as the axis of the canal, offers the best means of demonstrating this fact. In such a section, the superior wall of the bony meatus may run straight inward until just in front of the membrane, when it turns sharply downward

after forming an obtuse angle, or perhaps curving more or less abruptly.

A cross section of the canal is oval in shape, the longest diameter of which is in a vertical direction at the orifice and obliquely from above and forward, to downward and backward at the tympanic end, the long transverse diameter of Grey. (Compare Figs. 1, 9, 14, 17, 23, 24.) After removing the soft parts, the bony canal presented is somewhat funnel-shaped, with the narrowest portion just in front of the superior border of the tympanic membrane.

The Glasserian fissure generally is well defined; it leads into the tympanum and forms a small notch in the floor of the attic, which transmits the tympanic branch of the internal maxillary artery and contains the laxator tympani muscle and processus gracilis of the malleus. (*f*, in Figs. 1, 17, 19, 22, 23, 27.) Malignant parotidean growths usually find their way into the tympanum through this fissure.

In front of the Glasserian fissure is the middle root of the zygoma (*m r*), and below the vaginal process (*v p*), on which the parotid gland rests.

The upper posterior wall of the bony meatus is of the greater importance in aural surgery. Its thickness varies greatly; though often only one-sixteenth of an inch thick, it may be one-quarter of an inch, or even formed by a solid mastoid. The thinnest portion * is just exterior to the attachment of the mem-

*Called the pars ossea membrana.

brana tympani, and separates the aditus ad antrum and the antrum from the external meatus. (Figs. 3, 6, 9, 14, 17, 21, 27.) This portion of the wall is most frequently destroyed by cholesteatomatous growths, and in suppurating disease of the mastoid forms a common site for fistulous openings. Wolf selected this site for his operation in mastoid disease. The antrum lies inward and backward from this point, and the highest part of its floor is one-eighth of an inch above the Mt. This region is a common seat for adenomatous growths.

The ring, forming the bony meatus, is separated from the mastoid region by the auricular fissure (*au f*, in Figs. 1, 2, 6, 7, 8, 9, 10, 19, 22, 23). The fissure is sometimes well developed, and may be traced in a section of the bone upward and inward, as far as the mastoid antrum.

Above this fissure, about the level of the highest point of the meatus, is a small bony prominence, the spina supra meatum, which terminates a small ridge that splits off from the linea temporalis, above the external meatus, and stretches off in the rear. It is rarely absent, but varies much in form; sometimes it is a point, again a notch, at other times absent altogether and its position occupied by a little pit, that may yet be sufficient for purposes of orientation, for which it is much used. (*s s*, Figs. 4, 23.)

The mastoid process (m) is a more or less nipple-shaped projection of the temporal bone which ex-

tends downward and somewhat forward just behind the external auditory meatus. It consists of an external shell, the cortex, and an internal trabeculate structure containing spaces which in the normal bone are probably filled with air. The anterior border is perpendicular, whereas the posterior inclines from above downward and forward.

The external surface forming the cortex is more or less rounded or raised up into a low elevation (*s p*), which extends nearly parallel to the posterior border and marks the lower edge of a furrow (*h*). Occasionally the surface appears nearly flat, and so rough that any special prominence cannot be made out; in this case the line of demarcation between the smooth surface of the furrow and the rough part of the mastoid serves to indicate its usual place. The roughened surface behind the elevation receives the attachment of the sterno-mastoid, splenius-capitis, and trachelo-mastoid muscles.

In the mastoid region one finds few prominent features that can be used as landmarks; the temporal ridge, or line (*z r*), which is the posterior zygomatic root and is directly continuous with the zygomatic process backwards and slightly upwards, becomes a portion of the attachment of the temporal muscle; it begins at a point directly above, and forms the superior border of the external auditory meatus, and terminates at the posterior border of the temporal bone, reaching its greatest prominence midway between

these points; it varies in smoothness and size, but can easily be determined in an adult by placing the finger on the mastoid close to the back of the concha and moving it upward; it passes into a groove, and then rides upon the superior wall which is formed by the ridge. On the dry skull it is very exceptional that this ridge is not well developed and readily recognized, especially for a distance of three-quarters of an inch behind the meatus.

Sometimes the ridge is more or less flattened and irregular, and the definition of a ridge does not well apply to it; this seems to be the case more particularly in strong, muscular subjects with thick, heavy bones, and in these cases the lower border is more or less defined and will serve to guide one in the operations in this region. In thin-boned patients the ridge is well developed and quite uniform in shape, the crest corresponding for the first half-inch behind the meatus to the top of the petrous, or that portion of the floor of the middle fossa in juxtaposition to it. This bony development may be made use of in determining the position of the antrum which lies just behind the auricular fissure and immediately below the crest of the ridge. (See Figs. 2, 3, 4, 16, 19.)

The ridge also serves to define a hollow (*h*) between the ridge and the mastoid process. This hollow or furrow is well marked in delicate bones, and is an excellent guide to the meatus during the dissection of the ear in a flap when the meatus cannot be

seen owing to a traction on the pinna forwards; starting nearly an inch behind the posterior wall of the meatus, it slopes forward, inward, and slightly downward to the auricular fissure, gradually deepening and broadening in its course. The bony surface forming the floor of the furrow is smooth, and in this respect differs in all subjects from the remaining portion of the mastoid. The anterior limit of the furrow is sharply defined by the auricular fissure and the auricular process of the bony meatus, which forms a jagged, more or less prominent line. In the operation on the living subject the dissection of the tissues is very easy in the furrow, but exceedingly more difficult when the rough process is reached; as one advances toward the auricular fissure the furrow naturally directs the separation of the parts in the right direction until you suddenly come to a place where you may feel you can proceed no further; this is the auricular fissure, and here begins the bony meatus proper.

On the inner surface of the mastoid there is a deep groove (*d f*) for the digastric muscle; it varies considerably in shape, being sometimes deeply gouged out of the mastoid, again so superficial as to give it little prominence. Behind the fossa, and running in nearly the same direction, is the smaller groove (*o g*) for the occipital artery.

The posterior part of the mastoid usually presents a number of small foramen which transmit veins to

the lateral sinus, and it is through these channels that infective thrombosis of that vessel often occurs; this explains why suppurative inflammation in this region so often proves fatal.

At birth the mastoid process is not developed, but the antrum is represented by a large cavity behind the tympanum.

The mature bone presents a great variety of internal arrangement, from the solid almost ivory-like hardness of some, to the light, hollow, thin-walled structure of others, where nearly the whole process is formed by one large air-cell. (Compare Figs. 6, 7, 8, 9, 10, 12, 16, 19.)

*The membrana tympani** is of an elliptical or irregularly oval shape, with the long diameter nearly vertical. For descriptive purposes it is divided into quadrants; it is inserted at its periphery into a narrow groove which encircles the inner end of the meatus, and is situated in an inclined plane that forms an angle to the axis of the meatus which varies between 20° and 55° . (Bezold gives it at 27° – 30° , Sappey 20° – 25° , Huschke 55° , Tillaux 45° ; 30° may be taken as the average.)

Inspection of the normal Mt. through a mirror shows the long process of the malleus situated in the upper half of the long or vertical diameter, with a high light extending from its tip downward and for-

*Abbreviated Mt.

ward. The short process of this ossicle is seen at the base of the long process, and is usually readily determined by a small circular high light situated at its most prominent point. From the short process, a loose fold of membrane extends backward, across the upper posterior quadrant, to the peripheral attachment of the Mt.; this defines the lower border of the membrana flaccida, or Shrapnell's membrane.

When the membrane is strongly retracted, as a result of pathological changes, the long process of the incus may be seen through the Mt., situated behind the manubrium near the centre of the posterior upper quadrant, and extending downward from one-fourth to one-third of the long diameter of the Mt. The situation of the incudo-stapedial joint at the tip of the process is readily determined under these circumstances.

In the worst form of middle-ear disease, termed attic cases, the perforation of the drum is usually seated in the upper posterior quadrant, in the membrana flaccida.

The middle ear includes the tympanum, Eustachian tube, and mastoid. The tympanic cavity is about half an inch in height and width, and of irregular, shallow depth. Henle compares its shape to a low cylinder bounded by concave terminal surfaces, and Bezold has shown by his corrosive specimens that this description is practically correct.

The roof, or tegmen tympani, is made of very thin

bone, which is often deficient in places, the cavity being then separated from that of the cranium only by its mucous membrane and the dura. The openings are supposed to be congenital fissures which have failed to close. Bezold describes a bony ridge which runs transversely over the centre of the tympanum, forms a part of the roof, and gives attachment to the fold of the mucous membrane that extends from this line downward to the tensor tympani. He has designated it the *crista transversa tympani*. The ridge serves to define the *aditus* which begins immediately behind it. The malleo-incudal articulation, with the head of both ossicles, is situated immediately under the roof (Figs. 18, 21, 24, 25, 27), and cannot be seen *in situ* from the external canal. The *chorda tympani* passes between the long processes of the larger ossicles upward and outward, close to the neck of the malleus.

The floor of the tympanum is formed of a narrow layer of thin bone, and in some cases seems to be entirely wanting, inasmuch as the lower attachment of the drum often extends inward quite to the base of the promontory, and in other cases leaving only a small groove which can be called the floor; this consists of a very thin osseous plate, which extends under the labyrinth and separates the tympanum from the jugular fossa (Figs. 7, 10) and carotid canal.

The front wall of the tympanic cavity is distinguished by the mouth of the Eustachian tube,

which is situated somewhat above the level of the floor (*e*, in Figs. 3, 7, 8, 10, 18, 21). Above the tube is the process cochleariformis, containing in its canal the tensor tympani, and terminating at a small aperture which gives exit to the tendon. (*c*, Figs. 6, 7, 8, 12, 14, 16, 18.) The facial canal, in its arch over the tympanum, passes close to the tensor tympani canal, and forms a portion of the inner tympanic wall. (*a f*, in Figs. 2, 3, 7, 8, 16, 18, 27.—The rounded prominence is not always lettered.)

Immediately below the arch of the facial canal the oval window is situated, in the extreme posterior portion of the inner tympanic wall, above and behind the promontory, and often obscured from inspection through the meatus by a downward development of the lower margin of the *pars ossea membrana*. (*o*, Figs. 3, 6, 7, 8, 18, 19.) The long diameter of the window, which corresponds to the base of the arch of the stapes, is in an antero-posterior direction.

When extracting this ossicle, the point of the hook used in extraction must be directed upward, nearly parallel to the manubrium, and in the same direction as the long process of the incus; the hook should be allowed to touch the inner wall of the tympanum, with its shank close to the annulus, and, while still in contact with the tympanic wall, passed upward under the tip of the long process of the incus, which can be seen. By this manœuvre the hook will pass between the processes of the stapes, unless it has too

large a curve. The arch, or ring of the stapes, is only about one-sixteenth of an inch in diameter, and the foot plate is inserted below the general surface of the tympanic wall, in a sulcus* formed by the promontory below and the facial canal above; in this manner the small ossicle is well protected, and will admit only a very small hook to pass under its arch.

The promontory, a rounded prominence, forms a great part of the inner tympanic wall (*po*, Figs. 3, 6, 7, 8, 12, 13, 14, 18, 19, 27); it is grooved in the form of a Y, for the tympanic plexus of nerves. The round window is situated in its lower back border (*r*). Below the promontory there is an arrangement of small bony buttresses, which extend from its base to the thin layer of bone which separates the tympanic cavity from the jugular fossa and carotid canal. (See Figs. 8, 10, 12, 13, 14, 18, 19.) This structure is occasionally the seat of caries, which destroys the floor of the tympanum and, reaching the jugular, sets up a fatal phlebitis and thrombosis, or destroys life by ulceration of the carotid and subsequent hemorrhage.

The topography of the inner wall of the tympanum includes the great blood-vessels, carotid artery and jugular vein. Below the base of the skull the two vessels lie close together, with the artery in front; when they reach the base of the skull their courses

*Fossula fenestra ovalis. (Rüdinger.)

widely diverge; the artery passes obliquely upward and forward, and then arches inward and forward, to enter the middle cerebral fossa near the tip of the petrous bone, whereas the jugular is first directed upward, backward, and slightly inward, then curves sharply outward and backward, entering the posterior cerebral fossa in a direction diametrically opposite to that of the carotid. Their bony channels are therefore separated by a more or less wedge-shaped osseous partition, the base of which is upward and corresponds approximately in thickness to the width of the tympanum. The carotid is separated from the front portion of the tympanum and Eustachian tube by a thin lamina of bone, which is often absorbed, or wanting, leaving only a membranous separation between the vessel and the middle ear. (Compare Figs. 7, 10, 14, 27.) It is well protected from injury in accidents to the middle ear, owing to its anterior situation. The same is true of the jugular, which has a safe position behind and under the promontory (*j*, Figs. 3, 10.) The bone separating the jugular fossa and tympanum varies very much, in some cases being a delicate, thin lamina, and easily punctured, whereas in other cases it is quite thick and strongly fortified by small bony spiculæ. The differences in these cases depend on the development of the jugular fossa.

The outer wall of the tympanum is formed by the Mt., manubrium, and pars ossea membrana, parts

which may be removed with but little difficulty or inconvenience to the patient.

The posterior wall of the tympanum is formed in greater part of thick cancellous bone, which is often very dense, and is a part of the mastoid. (Figs. 2, 3, 4, 5, 7, 10, 27.) It contains the facial and external semi-circular canals, and the opening of the mastoid passage. (*a a*, Figs. 2, 5, 7, 9, 16, 19.)

The facial canal arises from the mastoid foramen directly internal to the auricular fissure, one-eighth of an inch behind the posterior margin of the Mt., at the same depth as the centre of this structure, at which height it arches forward and inward, reaching the inner tympanic wall immediately above the oval window, over which it passes in a forward direction as far as its bifurcation at the anterior border of this aperture, when the main canal turns abruptly inward, to enter the internal auditory meatus, and the branch continues forward, and slightly inward to enter the middle cerebral fossa, at the hiatus Fallopii. (*a f*, Figs. 2, 3, 4, 5, 6, 7, 8, 13, 15, 16, 18, 27.) The position of the canal on the inner tympanic wall is about the level of the superior border of the Mt., or somewhat above it. The canal is separated from the tympanic cavity by a very thin layer of bone. (Figs. 13, 16, 18.) Facial paralysis usually arises from an injury to the nerve in its course about the tympanum, either from carious ulceration, or trauma during mastoid operations.

The external semi-circular canal lies above the arch of the facial canal, in a somewhat deeper position. Hartmann found in fifty bones that on an average it was situated at a depth of 21.5 mm. internal to a point on the surface of the skull 1 cm. behind the spina supra meatum, whereas the facial canal was only 22 mm. from the same point. Its situation, combined with the solid character of its bony walls, should be sufficient to protect it from injury during operation, if a reasonable amount of care is taken.

The eminentia stapedi is a small conical projection containing a cavity often connected with the facial canal, with a small opening at its tip, situated behind and a little below the oval window, on the rounded eminence of the facial canal, above and external to the round window, and just internal to the posterior margin of the Mt. In its cavity is the stapedius muscle, from which a small tendon arises, passes out through the small opening in the tip of the process, and becomes attached to the edge of the capitus stapedi. (*p* and *op cp*, Figs 6, 7, 8, 13, 18, 27.)

The upper portion of the tympanic cavity, called the attic (Leidy), cupola (Hartmann), or the malleo-incudo-squamous space, is a small but very important region, situated above a line drawn directly inward from the superior margin of the Mt., and bounded exteriorly by the sloping plate of bone, pars ossea membrana, which forms the inner portion of the superior wall of the meatus. Posteriorly is the begin-

ning of the aditus ad antrum, and the rounded prominence of the facial and external semi-circular canals; whereas internally, above, and before, the cavity is limited by a thin plate of bone, which forms the roof of the tympanum, and separates this space from the brain cavity. The space projects over the meatus somewhat, and is separated from the main cavity of the tympanum by a fold of mucous membrane, which arises from the lower border of the pars ossea membrana, attaches itself to the malleus about the short process, passes to the incus long process, then across the tympanic cavity, to the rounded eminence of the facial canal, and finally becomes fixed to a small bony ridge which extends from the opening in the processus cochleariformis upward and forward, to be lost near the upper anterior portion of the annulus tympanicus. (Figs. 24, 25.)

This fold of membrane often prevents suppurative inflammation of the lower portion of the tympanum from extending to the attic and mastoid regions; when, however, such extension occurs, the outlet for inflammatory products is small, usually situated between the long processes of the larger ossicles just below the superior attachment of the drum-head, in Shrapnell's membrane, and quite insufficient for perfect drainage. As a result, the products thicken, are retained, and keep up a constant irritation, often of years' duration.

The space contains the greater portion of the incus

and the head of the malleus, the former being loosely attached to the external wall, whereas the latter is strongly bound by its fixation to the Mt. (Figs. 21, 24, 25, 27.) These ossicles and membrane shut off a comparatively large communication with the mastoid antrum, and their removal must be considered a true scientific surgical procedure; by this means alone, not only bad cases of attic suppuration, but also mastoid disease, may be cured.

The cavity of the tympanum is traversed by a number of membranous folds which serve to carry vessels and nerves, and act as ligaments for the ossicles.*

The mastoid is divided into three types, according to the number, size and development of the pneumatic cells, and the thickness of their walls, termed diploetic, pneumatic, and sclerosed.

The diploetic type, which represents the most common form, is made up of a great number of small cells, the largest about one-quarter of an inch in diameter, with thin osseous walls, and constituting a light, strong bone. (See Figs. 6, 10, 12.)

In the pneumatic form the mastoid contains a few very large, thin-walled cells, which are usually separated from the antrum by a number of smaller ones; the cortex may only be the thickness of paper, and

*These have been carefully studied by Bryant and Blake, whose works should be consulted for further knowledge.

the bone is so extremely delicate that it may easily be crushed, or punctured with a probe. (Figs. 8, 9, 19.)

The third type is characterized by a great development of the osseous material; the pneumatic cells have disappeared entirely in some places, and are greatly reduced in size in others, apparently from an increase in the thickness of their bony walls, which in their growth have encroached upon and finally obliterated the lumen of the cells. (Figs. 7, 16.) In this form the bone may become nearly or quite solid, and cases have been reported where it has been drilled to a depth of over half an inch without showing a trace of pneumatic or diploetic cell.

It is impossible to predict the character of the mastoid before the cortex is removed, but the large, well developed, smooth bones are more often pneumatic. All forms of mastoid structure may exist independent of disease or signs of previous inflammation, although it has been supposed that chronic inflammation has much to do in producing the sclerosed condition; in support of this view, Green stated that in 40 per cent. of his cases of osteosclerosis the mastoid symptoms were chronic. Senile changes have also been considered a causative factor of sclerosis.

A hint at the original structure of the air-cells may be derived from the specimen (Fig. 11), which shows an enormous development of the air-cavities. The

space between the two tables of bone is divided by thin osseous plates, which form a true trabeculate structure for the support of the principal walls. These plates are so arranged that the air-spaces between them are freely communicating with one another. A careful examination shows there is a communication between most of the air-cells with others lying in contiguity, a condition which is very apparent among the larger cells found in the tip of the process. In the smaller cells which form the outer wall of the antrum, the connection between one another cannot always be made out, yet it is found sufficiently often to lead us into the belief that a communication between all the air-cells in the mastoid process, either directly or through the intervention of the antrum, which serves as a vestibule, was the original plan in the development of this organ.

The mastoid antrum, atrium, or, as Lane prefers to call it, simply the antrum (*ma*), is a cavity of variable shape and size, situated in the superior and deeper portion of the mastoid, immediately behind the middle ear, with which it is connected by a narrow passage. (Figs. 4, 7, 8, 9, 14, 16, 19, 21.) The space exists at birth, and its size increases simultaneously and proportionately with that of the middle ear.

Lane considers the only purpose of this cavity is the secretion of a viscid mucus which lubricates the lining membrane and contents of the middle ear.

The cavity of the antrum varies greatly in size, but

in the normal condition is about five-sixteenths of an inch in diameter. It is apparently in communication with the mastoid cells by means of a series of short channels which, in many bones, have a definite scheme of arrangement. A careful study of the part shows a number of small pits, arranged in a more or less stellate form, at the bottom of which are the small mouths of the communicating passages. (Figs. 9, 21, *c m.*) At other portions of the antrum the pneumatic cells open directly into its cavity. (Figs. 7, 8, 16, 19.)

The antrum is separated from the middle and posterior fossæ of the cranial cavities by dangerously thin walls, which are often perforated by caries or absorption resulting from the pressure of cholesteatomatous masses. (Compare Figs. 4, 5, 7, 8, 9, 12, 16, 19, 20.) The roof of the antrum forms a part of the highest posterior portion of the floor of the middle fossa. (Figs. 9, 16, 19.) The bony partition between these cavities is not only very thin, but in its extreme anterior limit near the attic is often perforated by small holes, giving it a worm-eaten appearance. The back inner wall is also thin, and forms the only separation of the cavity from the sigmoid portion of the lateral sinus and posterior cerebral fossa. (Figs. 7, 9, 16, 19.) The superior petrosal sinus extends from behind and outward, to forward and inward, across the upper posterior margin of the petrous bone, and is separated from the antrum by a comparatively thin bony partition (*Spg*).

It is on account of these relations that when middle-ear disease extends to the cranial cavity, meningitis and abscess of the middle cerebral lobes are most frequent; and should the small brain become affected, there will often occur simultaneously a thrombosis of the lateral sinus; moreover, such a thrombosis occasionally occurs independently of any other cerebral disease.

The anterior limit of the antrum is defined by a rounded eminence (Figs. 2, 5, 7, 8, 19), which forms the floor of the aditus, and contains in its upper portion the external semi-circular canal, and deep-seated the aqueductus Fallopii; this is carefully depicted in Figs. 2, 3, 4, 5, 7. The communication with the tympanum lies above, and anterior to, the eminence at the highest portion of the antrum.

The facial canal is in a plane which crosses the plane of the Mt. at an acute angle near the centre of the latter; at this level, which corresponds to the centre of the meatus, the canal is three-sixteenths of an inch behind the posterior margin of the Mt. To avoid injury to the nerve and external semi-circular canal, perforations of the bone should not exceed a depth beyond the centre of the Mt. The external wall of the antrum is always, as far as I can determine, exterior to the plane of the Mt.

A drill placed just anterior to the drum, on the upper posterior wall of the meatus, and directed slightly upward and backward, will enter the antrum through

thin bone. This is the shortest route through the bone to this cavity, and when absorption of the osseous structure from pressure of cholesteatomatous masses occurs, a fistula forming a communication between the antrum and meatus usually occupies this site.

A line drawn directly inward from the spina supra meatum will always enter the antrum, or some of the pneumatic cells that are in direct communication with it, at a depth of half an inch. (Compare Figs. 4, 6, 27.) The surgical space is from one-quarter to three-eighths of an inch wide, limited above by the extreme upper border of the meatus, and by the floor of the bony meatus below. (Compare Figs. 2, 3, 4, 5, 6, 9, 10, 12, 16, 19, 27.)

The topography of the temporal bone yet presents, for study, its relations to the cerebral fossæ and great sinuses.

Körner made a careful study to determine whether the exact position of the floor of the middle cerebral fossa, and the course of the lateral sinus in the temporal bone, in any way depended upon the shape of the skull. He found the floor of the middle fossa situated at a higher point above the porus acusticus and spina supra meatum in skulls which have a much longer occipito-frontal than bi-parietal diameter.*

*A skull of this type is called dolichocephalous, whereas those with nearly equal diameters are termed brachycephalous.

I have found, in a number of skulls, that the position of the floor of the middle cerebral fossa, above the spina, varied between one-eighth and one-quarter of an inch, and it is nearly twice this height half an inch behind the spina. (See Figs. 2, 3, 4, 7, 16, 19.)

The petrous portion of the temporal bone serves to define the limit of the middle fossa in its direction, and its posterior surface is directed more or less forward and inward, according to the type of skull. (Fig. 20.) In the brachycephalous type the bone is directed nearly straight inward. The hind border of the mastoid process represents fairly well the posterior limit of the petrous bone (Fig. 20), and the anterior boundary of the other portion of the posterior fossa.

A knowledge of the exact situation of the lateral sinus is of the utmost importance in operating in this region. Its relative position varies greatly according to the curve of the sigmoid flexure and the corresponding depth of the sulcus sigmoides. Körner has shown that this is greater in brachycephalous skulls, although the depth of the sulcus is not commensurate with the degree of brachycephalicy, and, furthermore, that it is greater on the right side than on the left. Birmingham found that the sinus does not run horizontally forward from the occipital protuberance, as it is usually described, but that it is distinctly arched. It ascends, gradually or rapidly, from the torcular until it reaches a point about one and one-

half inches behind and nearly three-quarters of an inch above the centre of the meatus, when it bends gently or abruptly, passes downward just in front of the posterior margin of the mastoid process, about half an inch behind the meatus, and runs inward and forward, to turn into the jugular foramen just below the level of the tympanic floor. (Compare Figs. 6, 9, 10, 11, 12, 15, 20, 27.)

For surgical purposes, the situation of the anterior wall of the sinus may be considered one-half inch behind the centre of the meatus, and the hind wall three-quarters of an inch farther backwards. Very rarely the sigmoid sulcus is so deep that it reaches within a quarter of an inch of the meatus and the lateral sinus would be injured in the ordinary operations for mastoid disease.*

Ballance determines the seat of trephining from Reid's base line—a line drawn through the centre of the external auditory meatus, and touching the lower margin of the orbit.

To open the antrum, the centre of a quarter-inch trephine is inserted one-quarter inch above the base line and one-half inch behind the centre of the meatus.

To examine the floor of the middle fossa and roof of the tympanum, the centre of a half-inch trephine

*Körner has depicted a case of this kind.

is inserted seven-eighths of an inch above the centre of the meatus.

The lateral sinus is opened with a five-eighth-inch trephine, centering one-fourth of an inch above Reid's line and one inch behind the centre of the meatus.

Temporo-sphenoidal abscess is trephined with a half-inch instrument, centered an inch and a quarter above and behind the centre of the meatus; and cerebellar abscess one-quarter of an inch below Reid's line and one and a half inches behind the centre of the meatus.

CHAPTER II.

THE EXTERNAL EAR—DISEASES AND TREATMENT.

The external ear is subject to the same skin diseases found in other localities, and should be treated by their specifics.

Perichondritis is a rare affection, and often proves obstinate to treatment. The skin is red and swollen, the ear appearing greatly enlarged; an abscess may form and break spontaneously. It soon heals over, but only to break down again; this is often repeated several times, when at last spontaneous cure is effected, often leaving the ear disfigured. Treatment consists in clearing away the diseased tissue with a sharp spoon, and dressing with iodoform or boracic acid.

Morbid growths are not rarely found in the external ear.

Othæmatoma may be idiopathic or traumatic. It is recognized by a tumor of a cystic, fluctuating nature, somewhat hot, which forms rapidly, often reaching the size of an egg in twenty-four hours. It is situated in the pinna behind the auditory canal, and the tragus is probably never involved. The tumor may be of a bluish or a dusky hue, or covered with skin of normal appearance. It was supposed to be caused by injury always, but there have been so

many cases in the insane which could not be accounted for by this means that a number of writers have come to the conclusion that there is an idiopathic form of the disease.

If left alone, a spontaneous cure may be effected, but it will be slow; the tumor tends to increase until it reaches a considerable size, and with the natural recovery often leaves the ear badly deformed.

The treatment should be an early incision, as soon as the diagnosis is made, and before the rapid growth can dissect up the tissues; by this means the blood is let out, the tumor evacuated, and its cavity can then be packed with cotton moistened with a hæmstatic, such as Monsel's solution, or tannin, and the growth of the tumor immediately checked. A great many prominent aurists believe the growth is best treated by cooling applications, and with tincture of iodine, massage, tincture arnica, etc., to promote absorption. A puncture with a trocar and evacuation of blood is usually followed by a re-filling of the tumor, leaving the case as bad as before.

Carcinoma or *Sarcoma* of the ear is not of frequent occurrence; according to Bürkner it occurs in 0.32 out of every 1000 cases of ear disease. It may be primary or secondary. Toynbee believed that in two of his cases the disease originated in the mucous membrane of the tympanum. Bilroth reported a case of primary epithelial disease in a middle ear which was previously normal. Bürkner says carcinoma may

arise from the soft tissues of the external canal; Roudot reported a case that began in the mastoid process, and Politzer also published a case that was of the same origin. The patients in whom the disease occurs are usually over thirty-five years of age.

Epithelial disease may start in the basis crani and grow into the cavities of the ear. Two such cases have been reported, one each by Tüerck and Gerhard.

Sarcomatous growths in various forms are more common. The disease may be primary in the meatus, as in a case of round-cell sarcoma reported by Green and supposed to have been caused by chronic otorrhea, or in the tympanum, as a case of osteo-sarcoma of this origin has been reported by Böke. Wilde also reported a case of osteo-sarcoma of the ear, but the origin of the disease is not mentioned.

Secondary growths are more common. Chondrosarcoma of the ear is primary in the parotid gland, and grows through the Glasserian fissure into the tympanum. Knapp and Schwartze have reported cases of this kind. Myxo-sarcoma may arise in the cerebral cavity and find its way into the tympanum, as in Pomeroy's case. Finally, Sexton has reported a case of cylindrical-cell adenoma which destroyed the whole petrous bone, except the apex, and proved fatal. The sarcomatous growths usually occur in patients under thirty years of age.

A diagnosis of epithelioma is not always possible until examined microscopically. At first a small

module is formed; this is usually picked and irritated by the patient and becomes covered with dry secretions, removal of which reveals a small, irregular-shaped ulcer with thickened, hard edges and a strong tendency to bleed from slight causes. In the early stages the disease is not painful.

When the above condition is presented, the patient should be carefully watched to determine the progress of the disease; if it increases in spite of rational treatment, a small piece of tissue should be excised and microscopically examined; should it show the usual structure of epithelioma (collections of epithelium, surrounded by a stroma of fine connective tissue), the diagnosis is certain.

The prognosis of epithelial disease of the ear is extremely bad unless the case is treated very early. The destruction of tissue is very extensive before death closes the scene, and, owing to the many important nervous structures liable to be encroached upon, the suffering may be terrible. In one of Lucae's cases, before the man died the greater part of the temporal bone was destroyed.

Treatment.—If the diagnosis is made early enough, a complete removal of the growth by excision should be attempted. It will often be found necessary to remove a considerable part of normal tissue in order to be sure of the total extirpation of the disease. In a case reported by Green, the whole pinna was removed. When this is done, the skin covering the

back of the pinna should be carefully dissected back, in the form of a flap, and the deeper tissues somewhat more extensively removed in order to admit closing the wound, as far as possible, by drawing the skin over and sewing it to the lining of the meatus.

Primary union may sometimes be obtained in this manner, and there is less danger of stenosis of the auditory canal. If the disease has reached the tympanum, an attempt may yet be made to remove it by chiseling away the outer and posterior walls of this cavity, and extensively curetting with a sharp spoon.

Lucae has reported a case of primary epithelioma in the external meatus, of polypoid form and of three months' duration, where he effected a permanent cure by injections of aqua chlorinati, followed by inflations of equal parts savin and alum.

Sarcomatous growths are more rapid in their development than epithelial; the patient is younger; it is rarely primarily in the ear (Gruber says never); the tumor is less dense; it may be derived by metamorphosis from a slow-growing benign tumor that later in its course breaks down, ulcerates, and assumes the common features of malignant disease.

It should be treated by total extirpation when possible, in the same manner as cancer.

The prognosis is bad, as the disease usually arises in situations where it cannot be removed.

The non-malignant growths affecting the external ear, are the bony growths of the meatus, and polypi.

The so-called aural polypus is an exuberant growth of granulation tissue which has become more or less pedunculated, according to the seat of its origin and the circumstances which surround it. If it arises from the tympanum and passes into the meatus through a small perforation in the drum—a common occurrence—it will have a distinct pedicle. Chronic inflammation of the lining of the meatus, Mt., or tympanum, carious ulceration of the ossicles, or walls of the meatus and tympanum, or mastoid disease with a fistula opening into the meatus, are the principal causes.

The trouble is recognized as an irregular-shaped mass, blood-red or pink, occupying a position in the meatus near the Mt., and which is often prone to bleed when touched with a probe.

By means of a probe it is found to be more or less movable, and can be partially raised from the wall of the meatus, or Mt., against which it rests. Volto-*lini* claims that if a polypus or polypoid excrescence gives great pain when touched with a probe, the prognosis is bad, as there is sure to be carious bone or some other serious trouble present.

If the growth is of old formation, and has been exposed to the influences of the air, it may become lighter colored and bleed less easily.

Besides the tumors above described, there may be others which are polypoid and belong to the group of papillomata. The growth causes hemicrania, ver-

tigo, retention of pus, and sometimes general debility; a constant or intermitting otorrhea is usually present.

Treatment.—The removal of the growth should be practiced, if it is of any considerable dimensions. This is best effected by means of a snare, such as Wilde's, or Blake's, and Sexton's modification. The canal must be well illuminated by means of a head mirror, and a Gruber's speculum of large calibre inserted; the snare is then introduced and looped over the growth, with the end of the tube as near its pedicle as possible; it is then tightened, and on gentle traction the growth is removed. Free hemorrhage sometimes follows.

As the parts are usually very tender, the operation causes considerable pain. This can be relieved in a measure by the previous use of a strong solution of cocaine, 10-per-cent., but can be avoided in greater part by a careful selection of the material used in making the loop. The ordinary steel wire used for this purpose is too stiff and harsh. A finer wire is made and used especially for E strings of a mandolin; this is better, but still unnecessarily stiff. The finest platinum wire is excellent, but breaks so easily in manipulating that it hardly pays to use it. In the tail of the common barn rat, there are about 100 fine tendons, which are exceedingly strong and delicate, about eight inches long, and just suited for this purpose. In preparing them the tail is macerated in a solution of hydronaphthol for a few days, then sep-

arated and kept in alcohol. Two strands are tied together and used at once. Horse hairs, taken from the tail of a male animal, form an excellent loop; if they are too stiff, dipping in hot water will obviate the difficulty. Silkworm gut has been used, but it is too thick and stiff to handle easily.

Stone has reported a case where a polypus was so firmly adherent to the wall of the meatus that its removal could not be effected with a snare, but it was successfully removed by a hollow gouge under narcosis.

After a polypus has been removed, it will be found necessary, in most cases, to treat the stump the same as a granulating wound in other localities. Wilde recommended the use of nitrate of silver in solid form, but it is difficult to manage and may set up unnecessary trouble. Seeley recommended the use of chromic acid; this is of some value in broad pedicles. A silver probe is heated and touched to the caustic, which melts upon it and hardens; it is only necessary then to touch the parts with the end of the probe. The caustic is deep, and produces some aching for a short time.

Politzer introduced the use of strong alcohol in the treatment of polypi. He found that many polypi completely disappeared after instilling this material into the ear three times a day and allowing it to remain for ten minutes. I have found this is of value in the after-treatment, and causes but little pain.

The effect is increased if a small quantity of salicylic acid is used with it.

℞ Acid salicyl., 02.00
Absolute alcohol, 100.00

This makes an excellent antiseptic, and can be used with good results for this purpose before all sorts of operations in the meatus. Hydrogen peroxide is another substance which is of great value in this and all other suppurating diseases of the ear. It should be used in full strength, unless it causes too much pain, when it can be diluted in any proportion.

This material is of the greatest benefit to cases arising from caries of the bone, where it not only destroys the pus but oxidizes all dead material, leaving a clean granulating surface, free from bacteria, which readily heals.

The galvano-cautery has been used for removing these growths, but it is liable to do harm. The sharp spoon is often of value in removing the granulations which cannot be snared.

Osseous growths in the meatus are not of infrequent occurrence. I believe much credit is due Cassels (1881) for his careful study and classification of these tumors. He divided them into two groups which differ in origin, site, shape, structure, and number, called *Hyperostoses* and *Exostoses*—names which had been previously used, but indiscriminately.

A *hyperostosis* is a hyperplasia, and is never seen until the osseous meatus has been completely ossified;

it is always situated at the inner end of the meatus, is of conical shape, never pedunculated, of ivory-like hardness, immovable on pressure, often found independent of other diseases of the ear, and when such are present they are not a cause of it. It is frequently multiple, and may exist with normal hearing. When deafness is due to the presence of this growth, it is the result of mechanical obstruction, either directly, or from its interfering with the escape of discharges from within, so that complete occlusion of the meatus follows, with danger to the structures behind it. It is only under the latter circumstances that a removal of the growth is justifiable.

Exostosis, on the contrary, appears before the canal is completely ossified, situated near the junction of the bony with the cartilaginous meatus, is of a variety of shapes and always pedunculated. Before it is completely ossified it can be pierced to varying depths, and it is slightly movable on pressure, even after ossification is complete. It is nearly always complicated with other diseases, and attended with difficult hearing. The tumor is single.

The causes of these growths are variable. Hyperostosis is a result of gouty or rheumatic diathesis and perhaps syphilis; whereas exostosis is due to inflammatory changes of long standing. Delstanche described a bony tumor of the meatus which he considered was an inflammatory proliferation of the papillæ and con-

nective tissue, with a deposit of lime within it (osteoid metamorphosis).

Histologically these tumors present a true bony structure.

Treatment.—Exostoses should be removed. Cassels passes a wire loop over the tumor, draws it tight about the pedicle, then with a few blows upon a gouge placed at the base of the tumor it is easily removed. Jacquemart tried to remove the growth with a galvano-cautery snare, with the loop inserted around the pedicle; it failed, but burnt the tissue so much that the growth was easily removed afterward by means of a lever. Knapp chiseled away the bony wall from which the growth originated. Burnett removed a growth by means of bone forceps and a chisel. Ellis found a dentists' curved forceps an excellent and adequate instrument for removal of the growth. Pooley reported two cases where the tumor was removed by the electro-osteotome,* with good results. Finally, Shield has displaced the auricle as a preliminary operation, and then removed the growth with a chisel and mallet. The methods of Ellis and Cassels should be tried first.

Most writers report an improvement in hearing after the tumor is removed.

Hyperostoses should be let alone unless causing trouble, when it may be necessary to remove them.

* An instrument invented by Dr. M. J. Roberts.

Cassels operated with a dental drill, cutting them down from the apex. Field worked in the same manner, and used a spatula to protect the lining of the meatus. Brown first drilled a small hole in the centre with a dentists' drill and engine, and then several smaller ones in the base of the tumor; an attempt was then made to remove the tumor with an instrument screwed into the central hole, but the instrument broke off, leaving a piece in the tumor. The growth was finally removed in two portions by means of a strong pair of forceps, not, however, without rupturing the Mt. Recently a case has been reported where the base of the tumor was perforated by a number of small holes and then left to nature; the whole tumor came away *en masse*, in a few days, by a process of sequestration.

Foreign bodies in the external meatus are often of considerable surgical importance. These substances are usually placed in the ear by children. The larvæ of insects may develop from eggs deposited near the meatus by the female, whither it is attracted by the secretions, and occasionally the perfect insect is found. In Sexton's report of 101 cases of foreign bodies in the outer ear, there were thirteen cockroaches, five bed-bugs, five flies, and five maggots. These pests cause greater suffering than inanimate objects. Seeds of various kinds form common articles for children to stick in their ears.

The results of foreign bodies in the external meatus

are varied. Kollock has reported a case where two apple-seeds were contained in the ear for forty years without causing trouble; deafness, independent of the foreign bodies, finally called attention to their presence. Bezold has collated six cases where death ensued as a result of foreign bodies in the meatus. The nature of the body has much to do with the amount of injury. Molten metal is sometimes spattered into the ear, and may cause considerable disturbance. After a body gets into the ear, kind but injudicious friends often attempt its extraction, push it through the drum, and in this manner cause serious results. Several cases have been reported where a bullet has been shot into the ear and become lodged in the tympanum.

In some cases a foreign body may do no harm, but in spite of this it does not belong there and should be removed; so that the practical question is, how may it be removed? Insects are rendered insensible almost immediately by saturating them, in a tight box, with chloroform or benzine, less so with ether and hydrocyanic acid, and they can be easily killed with kerosene, turpentine, and similar oils. To remove the insect, it is well to prepare a towel in the form of a cone, in the same manner as for etherizing, put in it a spoonful of chloroform, and place it against the ear, at the same time holding the head over to one side. In a minute or two, syringe the ear or attempt extraction of the insect with forceps. If this does not

succeed, instil a few drops of chloroform into the meatus, plug the orifice with the tip of the finger, and after a few seconds wash out the meatus with a syringe-ful of warm water to remove the chloroform. If the insect is not washed out, it can be removed with forceps. The chloroform causes considerable pain if the meatus or drum is diseased. Benzine is less irritating and the result equally as good; it may be syringed into the ear.

Solid Bodies.—Writers are unanimous in their opinion that the syringe is the first instrument that should be used in the attempt to remove a foreign body from the meatus. If the body will not fall out of the meatus by its own weight, after the head has been placed in a favorable position, a stream of water or oil may be directed against the wall of the meatus with considerable force, in such a manner that the ear will be flushed, and thus force out the obstruction. If the body consists of matter that will swell with water, oil should be used; and if it has already swollen and fits tightly in the canal, glycerin and alcohol may be instilled into the meatus with the hope of shriveling it. If the use of the syringe fails to extract the body, other methods should be tried. There are a variety of forceps in the market, specially designed for this purpose. If the patient is young and not easily controlled, an anæsthetic should be administered first. Forceps may be tried if there is space enough between the object and the wall of the meatus to

admit them; if not, a small hook made like a cystotome can be inserted over the body, passing through the skin lining the meatus if necessary, and used to hold it while a thin scoop is inserted underneath. By drawing on both instruments the body can now be extracted. The snare also forms a valuable means, in some instances, for removing foreign bodies.

Voltolini recommended the use of the galvano-cautery for removing organic bodies, like beans, etc. Few would think of practicing this method. Nicolaysen removed a pebble from the middle ear after first resecting a portion of the annulus tympanicus by means of a fine saw and chisel. Israel, Langenbeck, Schwartz, Green, Moldenhauer, Buck, and Berger, have each removed foreign bodies by first disarticulating the auricle.* In Green's and Berger's cases a bullet had been shot into the middle ear, and in the latter case the ball had to be chiseled down before it could be removed from the tympanum. There have been several cases reported where a foreign body has been removed by glueing to it leather or other substance, and then exerting gentle traction.

Otomycosis.—Among the affections of the external ear that should be understood before attempting any form of aural surgery, is that of otomycosis, the name given by Virchow to a chronic inflammatory disease of the meatus, caused by the growth of fungi. Wrenden of St. Petersburg was the first to emphati-

cally call the attention of aurists to this disease, and since then there has been much written upon the subject. There are several forms of fungi which invade the ear; some are easily destroyed, whereas others are very resistant.

The clinical features of the disease consist in a mass in the meatus which presents an appearance somewhat like ear-wax, but it often has a woolly look, with furfuraceous desquamation, in places is yellowish, and is more moist than wax, and less shiny. It is not easily softened by oils or water. If a portion be placed on a microscope-slide, treated with a little caustic potash solution, and examined, it will show the mycelium threads, and perhaps the fruit, of a fungus. Kirchner found the trouble caused violent and persistent itching, tinnitus, impaired hearing, and sometimes considerable pain.

If the fungus is found in the canal, it should be thoroughly removed before operating on the drum or membrane, otherwise it will prevent healing.

Treatment.—Clean out the canal with a warm 1-per-cent. saline solution, then fill the meatus with

R Chinoline salicylatis, 0.50
Pulv. acid boric., 8.00

Or a 2-per-cent. solution of salicylic acid in absolute alcohol, which is to be inserted twice or three times a day for a few days. The small pieces of membrane that form, can be picked out with forceps as soon as they become loosened.

CHAPTER III.

OPERATIONS FOR THE REMOVAL OF THE OSSICLES AND MEMBRANA TYMPANI.

Schwartz, in 1873, removed the Mt. and malleus in a case of sclerosis of the tympanum, and was probably the first to operate in this manner, although, according to the writings of Moure, the subject has attracted the attention of otologists for some time.

To Kessel most of the credit is due for establishing the operation for the removal of the ossicles; he called the attention of otologists to the subject in 1875, after he had removed the Mt. and malleus and incus in a case where he believed fixation of the stapes was the cause of deafness. About this time he removed all the ossicles in dogs and doves, and showed that their hearing remained unchanged by the operation. In April, 1877, he removed the stapes from a human subject, and demonstrated that the operation could be done without danger to the patient, and at the same time proved the fears of Schwartz and others, that there would be an extension of purulent inflammation to the labyrinth and brain, with fatal issue, were groundless; the success of this operation also refuted the statement of Toynbee, that the base of the stapes could not be removed without total loss of hearing. Kessel believed that good results in hearing could only be expected when the

stapes was removed. This he insisted upon in a later writing.

In 1880 he tabulated the conditions requiring the removal of the ossicles as follows:

1. When there is incurable occlusion of the Eustachian tube.

2. In entire calcification of the Mt. combined with difficult hearing and a normal acoustic nerve.

3. In caries of the ossicles of the middle ear or its walls.

4. In ankylosis of the stapes with distressing tinnitus.

5. In cholesteatoma of the tympanum and mastoid cavities which cannot be removed in the usual manner.

He reported a number of cases to show the good results of the operation.

Weber-Liel reported a case of dizziness following a destruction of the stapes with loss of labyrinthine fluid, in 1880; and in his text-book (1883) Politzer advocated a division of the adhesions about the stapes in certain cases of deafness.

Lucae, stimulated by the success of Kessel, performed the operation fifty-three times for the removal of the Mt., malleus, and incus, and then (1885), discouraged by his results, abandoned it until such time as more accurate knowledge of the operation should be formed. Of his fifty-three cases, six received marked improvement in hearing, nineteen slight, and eighteen

none; in seven there was a deterioration of hearing. He observed that the best results were in cases where a permanent opening was established in the Mt.

In 1885, Bishop reported fourteen cases of deafness operated upon by the removal of a piece of the Mt. without injuring the ossicles; although the patients all expressed themselves as hearing better, the writer could detect no difference.

Rossi (1886) disarticulated the stapes from the incus in two cases of ankylosis of the hammer and anvil, of which he reported brilliant results in hearing.

In the same year Sexton performed the operation of removal of the larger ossicles and Mt., for the relief of chronic purulent tympanitis; his idea was to remove all obstruction to the free discharge of pus, and establish a better condition for cleansing and medicating the cavities of the middle ear. Sexton found the operation an especially valuable one for this trouble—which, by the way, practically comes under the third and fifth indications for operating formulated by Kessel; he also made the same observation as Lucae, that a permanent opening is necessary for good hearing, and in his later work maintained this condition by repeated removal of the re-formed membrane with a small knife and the aid of a 10-per-cent. solution of cocaine. The membrane soon ceased to re-form.

McKeown (1886) made some observations which

have a bearing on this point, although he has not connected the two; he found that an opening made in the Mt. by cutting a triangular flap with the base downward, would remain patent for a long time; the apex or free end of the flap falls down, and becomes fixed to the lower portion of the drum membrane by blood and exudates. A similar operation was proposed by Troeltsch.

In 1887, Baracz operated for tinnitus, removing the drum-head and larger ossicles; a permanent opening was maintained at the end of a year, and, although there was no benefit in hearing, the subjective noises were diminished.

Burnett operated on a case in 1888, where there was severe vertigo, tinnitus, and deafness. The malleus was removed with the Mt., and the stapes disarticulated from the incus. The tinnitus and vertigo were relieved, but the deafness was unchanged.

About the same time, an article appeared by Berthold (1888) which revived the earlier observations of Kessel, under the clear title, "What can the Human Ear Hear without the Stapes?" In an attempt to remove a synechia, Berthold accidentally removed the stapes complete; a rent had occurred spontaneously in the posterior segment of the Mt.; this was enlarged by forcible inflation, and a synechotome passed through into the tympanum. A slow turning motion was made with the instrument, when almost immediately the stapes tilted up, and was extracted

by means of a hook. It was found in this patient that hearing was greatly improved, and, farther, that it was best when a piece of egg-membrane was placed over the opening—then there was hearing of whispered words at fifteen feet.

In the same year, Stacke divided the cases which required a removal of the ossicles, into two groups: 1, on surgical grounds for the removal of dead bone, caries, obstruction to discharges, etc.; 2, for the benefit of hearing. At the same time he reported ten cases.

Sexton, shortly after this, reported twenty-nine cases operated upon for the removal of the ossicles in middle-ear disease, and introduced a new electrical head-lamp to be used in operating, modified from the light of Trouvé.

The next year (1889) Clark published the history of a case where there was a loss of the Mt., malleus, incus, and stapes from syphilitic disease, yet there was good hearing. V 29'—watch 1".

Wetzel (1889) reported twenty-eight cases of removal of the Mt. and larger ossicles, for chronic suppuration of the middle ear, with seven complete cures, great improvement in six, and no improvement in thirteen.

Ludwig (1889) gives the history of thirty-two cases in his own practice, with perfect results in twenty; and Colles thirteen cases, with eight cures, and great benefit to the remaining.

Among the reviews of 1890 there is one criticising a French aural surgeon, name not given, who devised an ingenious operation for releasing the stapes from adhesions. "An incision is made in the membrana tympani, a delicate hook is inserted in the opening, and by this means the stapes is moved freely, or removed altogether." This is a good description of the operation proposed by Miot (1888). The hook he employs is an instrument made like a miniature hoe.

At the Tenth International Congress, Stacke reported nine successful cases of removal of the larger ossicles and Mt. by a new method for chronic sup-
puration of the middle ear.

In the early part of 1891, Botey reported the results of his experiments in the avulsion of the stapes in lower animals, and concluded it was a harmless operation and left the animals with good hearing; although, without good reason, he thought it should not be practiced on human subjects.

Grunert in 1892 reported one hundred and fifty-one cases operated on by Schwartze for the removal of the ossicles, from March, 1889, to December, 1891, or during some thirty months. There was fifty-one per cent. of cures, and forty-six per cent. of failures. The mastoid was simultaneously opened in forty-eight cases, nineteen times in the usual way, and twenty-nine times through the canal, after the method of Stacke. In eighteen cases Schwartze was unable to extract the incus; and in three cases neither ossicle

could be removed on account of their obscure position and the natural obstacles to the operation, including the results and products of inflammatory changes. The benefit to hearing was very slight in most cases.

Milligan (1892) in four instances removed the Mt. and malleus for chronic purulent otitis, with perfect results. In the same year, Dench liberated the stapes from adhesions, by cross cuts, and reported four cases of improved hearing thereby.

Jack (1892) reported three cases of removal of the Mt. and larger ossicles for chronic otitis media, and in a later paper reported sixteen cases where the *stapes*, alone or with other ossicles, was removed, with the uniform result of great improvement in hearing. To Jack is due the credit of establishing a distinct operation for the complete removal of the stapes, without injury to the other ossicles or normal arrangement of the Mt., in the treatment of cases of chronic deafness where there is a normal acoustic nerve.

In reviewing the cases which have been operated upon for a removal of the Mt. and ossicles, it is obvious that the division proposed by Stacke must be made, and the operation will be selected accordingly. In the first class, the relief of deafness must be considered secondary to the cure of the inflammatory changes, necrosis, and purulent discharge, which are a constant menace to life; in the second, the operation is done with the sole purpose of improving the hearing.

The first class is characterized by a persistent otorrhœa, which resists all local treatment. There is usually caries in the head of the malleus, and perhaps in the incus and walls of the tympanum; a small perforation exists, and is generally found in Shrapnell's membrane; the attic is filled with granulations or cheesy accumulations of pus, and sometimes cholesteatomatous masses. The whole tympanic cavity may be filled with inflammatory tissue in various stages of metamorphosis. The hearing is greatly impaired, and the history shows the changes are commonly the result of long standing disease, often ten or more years. The pathological changes are not always limited here, but often extend along the aditus to the antrum and mastoid cells, or, after first producing a caries of the roof of the tympanum and antrum, result in purulent meningitis and inflammation of the cerebral sinuses. Sometimes the infection progresses along the course of the vessels and nerves, and in this manner forms the most common cause of abscess of the brain.

The indications for operating are based on purely surgical grounds, which should be the same in this region as in any other, and they demand the removal as far as possible of all the diseased tissues and the establishment of free drainage.

There are two ways of proceeding, either through the long canal formed by the soft tissues, or, after a preliminary disarticulation of the auricle, as recom-

mended by Stacke. The choice of method will depend upon the case; if there is reason to believe extensive caries in the tympanic walls exists, or cholesteatomatous masses are present in the antrum, with simultaneous mastoid disease, Stacke's method is undoubtedly the best, because the operation is done with direct light, without a speculum, in a short wide canal, unhindered by curves, with less interference from hemorrhage, which permits a more complete removal of diseased tissue, and with less risk of injuring other parts. The operation can be performed in the narrowest meatus; and if mastoid disease is determined during the operation by the presence of cholesteatoma along the aditus, a mastoid operation can be performed under the same narcosis.

When a careful examination of the patient fails to reveal any evidence of mastoid disease, the direct method is preferable. In cases where the diagnosis is doubtful, and there is reason to suspect the presence of disease of the mastoid, the advantage of the Stacke method is apparent.

In order to remove the Mt. and ossicles through the external canal, a good illumination is indispensable. Sexton uses an electric head-light of his own invention.

Abroad, many operators prefer the photophore of Trové, while others make use of a head-mirror and a strong light such as that produced by the calcium oxy-hydrogen apparatus. Personally, I have found

sunlight or the light produced by the ordinary gas jet, fitted with an Argand burner and a McKenzie concentrator, sufficient for all purposes.

A Gruber's speculum is inserted into the meatus, using as large a size as possible, and the Mt. detached from its peripheral adhesions with a spear-pointed paracentesis knife, which is passed close to the bone. The tensor tympani muscle is then severed, if possible, with Gruber's knife, or one similar, and the malleus removed by a snare, the loop of which is passed over its neck. A clear view can now be obtained of the tympanic cavity; it should be douched with an antiseptic solution, and cleansed of blood, pus, and any granulations curetted. The incus is usually concealed in the upper posterior portion of the tympanum when it has not previously been swept away with the discharge or destroyed by carious changes; the long process should be brought into sight by passing a hook over the incudo-stapedial joint. A disarticulation can now be made with the hook or a knife, and the loop of the snare passed high up and around the incus, which is easily extracted.

On account of the excellent results following the removal of the stapes for deafness, its extraction in this operation should be practiced. After the malleus and Mt. are removed, and the tympanum cleansed, the stapes can be loosened by passing a spear-pointed knife about the foot plate, the stapedius muscle severed at the same time, and the bone drawn from

its position by passing a hook over the long process of the incus, when both ossicles may be extracted at once with a snare. If these ossicles have been separated by carious ulceration, it is still possible to remove the stapes by cutting around the foot plate and extracting with a hook made like an ophthalmic cystotome.

Before operating, the ear and canal should be made as nearly aseptic as possible by douching with a one-per-cent. solution of common salt, then swabbing the canal with spirits of turpentine, and finally cleansing with ether and a 1:1000 solution of bichloride. To minimize the hemorrhage, a 10-per-cent. solution of cocaine should be placed in the ear a few minutes before operating. At the close of the operation, the middle ear should be cleansed by thoroughly douching with a 1:2000 bichloride solution, or a saturated solution of boracic acid; treated with dry boracic acid or iodoform, either in powder form or ethereal solution; and the canal filled with absorbent cotton. Some aurists seal the canal tight with a collodion dressing, but I am not convinced of the value of this proceeding, since there is always a discharge, either serous or muco-purulent, after the operation.

When Stacke's method is the choice of operation, the ear is prepared antiseptically, and a long crescentic incision made extending from the temporal region just above, and in front of, the attachment of the auricle, over the articulation of the jaw, backward

and downward, close behind the auricular insertion, to the tip of the mastoid; the blood-vessels are tied, and the auricle drawn forward and downward; the periosteum is loosened from its attachment to the bone and pushed forward toward the meatus. By this means the rough bony edge of the meatus is exposed above and behind, and the funnel-shaped lining of the canal defined. This cutaneous funnel is then separated from its attachment to the bone by means of a small bone-scraper.* In this manner, the upper posterior half of the lining of the canal is loosened as far as the Mt., and is cut across, exposing the lumen of the canal. The anterior wall can now be loosened from within, outward, and the cartilaginous external ear drawn away from its attachment sufficiently to expose the whole bony meatus. Whatever is left of the Mt. and malleus is now removed, and the osseous lamella above the membrana flaccida and the bony portion of the external tympanic wall is cut down with a chisel so as to expose the attic, or malleo-incudo-squamous space, as far back as the aditus; this portion of the work can be performed very neatly with a dental engine and a large drill-burr made with a shank two and one-half inches long. The incus is now easily removed, the cavity cleansed, and all hemorrhage stopped by the plentiful use of hot antiseptic solutions; the cavity of the tympanum is then carefully inspected for carious

*I have employed a dental instrument used for working vulcanized rubber.

spots, which when found must be thoroughly removed with a curette; and if there is no mastoid disease, which is easily determined by the absence of cholesteatoma and pus escaping from the antrum and aditus, and the touch of a probe, the auricle is brought back into place, and the incision sutured. The cavity of the tympanum is filled with boracic acid—or a little iodoform, dry or in ethereal solution, may be used,—a drainage tube placed in the meatus as far as the tympanum, and a dry gauze dressing placed over the whole site of operation.

The ear heals by first intention in a few days without causing any deformity, and is not followed by a considerable drooping of the auricle as Burnett has predicted. Syringing of the ear is to be avoided.

After the first incision is made, and before the lining of the meatus is dissected out, it is necessary to place the patient in a sitting position, in order to keep the hemorrhage from obscuring the field of operation.

It will be seen in the history of the operation, that many cases recover with a great improvement in hearing, but this cannot be foretold; a large per cent. of the cases which heal without formation of a new drum-head have good hearing, and this is obviously a desirable condition and should be maintained if possible, whenever the stapes or its foot plate is left *in situ*. It seems to me we must look for the best results in the future, as far as hearing is concerned,

from a complete removal of all the ossicles. Whether it is more wise to perform this removal in two operations—the first for the surgical treatment of the disease, and the second for the relief of deafness—or to make a clean sweep at one sitting, yet remains to be determined.

In the second class of cases the pathological changes have generally ceased activity, and their result, deafness, from a fixation of the stapes, forms the only reason for operating. The hearing ability of the auditory nerve and internal ear is tested by placing a tuning fork in vibration against the mastoid, the teeth, or vertex; bone conduction is usually good, and the sound of the instrument is distinctly heard, which shows the internal ear and nerve is not diseased, and that the trouble lies in the conducting power of the ossicles and Mt.* An inspection of the middle ear usually shows the Mt. strongly retracted, the malleus handle prominent, and the long process of the incus very distinctly visible through the transparent membrane; frequently there are adhesions between the Mt. and inner wall of the tympanum.

To relieve the deafness, it is necessary to mobilize the stapes by freeing it from all adhesions, or to substitute a vibrating membrane which forms after its complete removal. If the stapes is simply mobilized, the best hearing occurs when the Mt. is perforated

*The tuning fork may not be heard at times when the nerve is unaffected.

and the sound-waves fall directly upon it, because it rarely can be freed sufficiently to produce normal vibrations. The failure to get good hearing after the removal of the larger ossicles, when the nerve and inner ear are normal, depends on the rigidity of the stapes and surrounding cicatrix. If there has been no injury to the foot plate of the stapes, a disarticulation of the incudo-stapedial joint, with or without a tenotomy of the stapedius muscle, will result in good hearing. This is demonstrated by the two cases of Rossi, and in a specimen in the possession of Politzer,* where, in the course of chronic otorrhea, a spontaneous disarticulation occurred from a necrosis of the long process, which resulted in good hearing. Politzer was the first to advocate this operation, which he performed by means of a pair of scissors of his own design.

In the majority of cases this will be insufficient for good hearing, and to avoid a second operation the removal of the stapes should be performed at once. After making the ear as aseptic as possible, a triangular flap is cut out of the Mt. over the incudo-stapedial joint, with the base downward, and the flap turned out; the long process of the incus and its articulation is now readily seen, and the stapedius muscle can be severed from the ossicle by passing a slender ear-knife through the aperture in the Mt. be-

* Randall & Morse, Photography of the Ear, fig. 45.

hind the joint. The muscle should be completely divided near the head of the stapes to prevent it from drawing the ossicle out of sight when the foot plate is detached. The incudo-stapedial joint is then cut across by a small knife, with the blade at an angle to the shaft. If now the stapes is not perfectly loose, a spear-pointed myringotome can be placed around the foot plate, and then a hook caught under the head will extract it upon gentle traction. The incus is often loosened in the operation, and under these circumstances it will be better to extract it with a small hook.

The foot plate is sometimes fixed immovably by bony union with the edge of the oval window.* This may exist only in part of its circumference, and under these circumstances I have been able to extract the larger part of the plate, after both crura had broken off and been removed with the head of the ossicle, by inserting a delicate hook into the oval window at the side of the stapes, turning it so as to catch on the inner surface of the foot plate, and exerting gentle traction. The plate is torn from its bed in whole, or part, and removed with forceps.

* This explains in part why former operations gave such a variety of results, since with more or less ankylosis of the foot plate, the stapes could not be mobilized, and deafness would persist after the *membrana tympani* and larger ossicles had been removed.

CHAPTER IV.

DISEASES AND OPERATIONS ON THE MASTOID, AND NECROSIS OF THE TEMPORAL BONE.

Until recently, the operation for acute disease of the mastoid formed the principal surgical operation upon the ear. It was near the close of the fifteenth century that Riolanus proposed opening the mastoid cells; later, about the year 1650, Sir Thomas Brown advised against such a procedure, and it was not until one hundred years later that the operation was first performed by Petit, for the removal of secretions. In 1776 Jasser performed the operation for caries of the bone with great success, but, after his decease, surgeons lost sight of the true indications for operating, and opened the bone for various purposes, until the death of Bergen, a noted Danish surgeon, upon whom the operation was performed for the relief of deafness and ended in fatal meningitis. The operation then fell into disrepute, and nearly a century elapsed before it was re-established by Forget (1849), Follin, and Troeltsch (1859).

When there was swelling and tenderness of the skin over the mastoid, Troeltsch made an incision down to the bone to prevent necrosis; and if the symptoms indicated a deeper seat of the disease, he perforated the bone with a blunt probe. To prevent injury to the brain or lateral sinus, he placed the instrument on a line with the meatus, and worked it forward and inward in a horizontal plane. If the

cortex was thick, he recommended the use of a small trephine. The sinus was kept open by means of a piece of lint.

To Schwartz is due the credit of developing the operation; his communication of fifty cases he had operated upon up to 1879 was by far the largest series on record at that time, and in 1883 he reported his second series of fifty cases. His indications for operating were as follows, viz.:

1. Acute inflammation of the mastoid process, with retention of pus, continuous œdematous swelling, pain, and fever.

2. Repeated swelling of the mastoid region, even without severe symptoms, and when subacute abscesses and fistulæ are present at the mastoid process.

3. When the mastoid process is sound externally, but there is a bulging of the skin in the posterior upper wall of the meatus, and retention of pus in the middle ear. (Pain, fever, and offensive pus.)

Roosa formulated the groups of symptoms which indicated the necessity of Wildes' incision, and the opening of the mastoid, as follows:

1. The integument and periosteum should be incised where there is pain, swelling, and tenderness over the mastoid.

2. The same incision should be made in cases of severe pain referred to the middle ear, that resists the usual treatment of hot applications.

3. In case the presence of retained pus or caries is suspected.

4. After Wildes' incision is made, the mastoid should be perforated if the bone is found diseased or if one has good reason to believe that there is retained pus in the middle ear or mastoid cells.

Green, after an experience with two hundred and fifty operations on the mastoid, and a careful analysis of many of these cases, has determined that the following symptoms and facts bear direct evidence of mastoid disease, and are of value in its diagnosis:

1. The history of an existing or preceding inflammation of the middle ear, with or without an otorrhœa.

2. Pain in the mastoid and over the side of the head. (A subjective symptom, which is quite common.)

3. Sensitiveness of the bone on pressure. (Objectively, the most important single symptom; it must be looked for carefully; is often only developed on deep pressure, and may be very limited in extent and on any part of the mastoid, although most frequently found over the antrum; it is sometimes wholly wanting.)

4. Œdema of the upper posterior wall of the meatus near the Mt. (When present, this is an almost certain sign of existing mastoid disease; it is characteristic of inflammation of the antrum, and therefore

may be absent when the changes are confined to the lower portion of the mastoid.)

5. Œdema of the external tissues. (This is the most common indication that pus is forming beneath the periosteum; it may exist without pus, as the result of the extension of the inflammation to the overlying tissues, or from simple otitis.)

6. Fluctuation. (A very uncertain symptom.)

7. The continuance of a tympanic suppuration in spite of thorough rational treatment, when no other cause, such as caries or granulations, can be found.* (This is a very important symptom.)

8. The pulse and temperature. (Of value in acute cases only.)

Pathology.—Mastoid disease usually begins as a simple suppuration of the mucous membrane lining the antrum and pneumatic cells, which results from the direct extension of disease in the tympanum. As the disease progresses, the diplœ becomes affected, and finally terminates either in caries or necrosis, or osteo-sclerosis. The disease may extend to the

*The value of this symptom was well illustrated in a case where I had removed the drum-head and ossicles for middle-ear disease, and after the tympanum had healed entirely there was a drop of pus formed daily, which was discovered only in the morning. There can be no doubt that the pus came from the mastoid, and showed itself in the meatus only after the patient had assumed the horizontal position long enough to admit of the draining of this cavity.

exterior of the bone, either by direct extension of the inflammation through the vessels, or after first producing a carious perforation, or even necrosis of a large area of bone. If the inflammation extends forward, there is frequently perforation of the posterior wall of the meatus, with caries, necrosis, subperiosteal abscess, and the formation of a fistula. The inflammation may extend downward toward the apex, and break through the outer or inner surface of the bone; on the outer surface it forms an abscess in the neck, somewhat superficially seated, but if it breaks behind (a condition that was first described by Bezold), the abscess will form along the digastric fossa, deeply seated in the neck, beneath the cervical fascia and covered up by a thick layer of muscles which prevent its coming to the surface, and with the force of gravitation directs its course downward, to finally enter the cavity of the chest.

The large cervical abscesses which form under these circumstances, are especially painful; there is a hard, painful swelling in the retro-maxillary fossa, which may be devoid of redness, and which limits the patient in opening the jaws; sometimes there is considerable swelling in the mouth, behind the upper jaw, and along the pillars of the fauces, when the abscess points in this direction. This is one of the worst forms of the disease, and even under active treatment often ends fatally.

If the disease extends backward and inward, but

above the tip of the process, it will enter the posterior cerebral fossa, and may be complicated with subdural and cerebellar abscesses, phlebitis, and sinus thrombosis and meningitis. This is not of common occurrence. It will be considered, with the following complication, in another chapter. When the inflammation extends upward, through the floor of the middle cerebral fossa, there may arise subdural abscess, meningitis, abscess of the temporo-sphenoidal cerebral lobe, and other complications of the brain.

There have been reported from time to time, by men high in authority on aural subjects, cases of mastoid disease such as was first described by Voltolini, characterized by tenderness and swelling over the process; the trouble is considered a primary and simple periostitis, with or without suppuration. The disease is independent of changes within the interior of the bone at the outset, but may progress until a carious ulceration or necrosis of the cortex is set up, unless the pus makes its escape, as it frequently does, by breaking through the thin lining of the meatus near the union of the auricle. The condition may arise *per se*, or by infection from the tympanum, meatus, or skin covering the seat of the disease.

Hessler has described, under the name of empyemic caries of the mastoid cells, an affection of the mastoid which he believes is a distinct disease, and different from the usual form of mastoid inflamma-

tion, inasmuch as it is not due to extension of sup-
puration from the middle ear, through the antrum,
but appears simultaneously with tympanic disease in
remote pneumatic cells which are not directly con-
nected with the antrum.

Prognosis.—There is no doubt that many cases
of chronic inflammation of the mastoid, with caries,
may persist for years without causing greater incon-
venience than the daily discharge of a slight quan-
tity of pus into the meatus, yet as long as this con-
tinues the life of the patient is in imminent danger
from the liability to cerebral and other serious com-
plications. The older the disease, the greater the
tendency to extend into the cranial cavity, and the
acute form is often rapidly destructive from brain
and other complications.

After operative interference, twenty per cent. of
Schwartz's first series died, and with greater exper-
ience the rate of mortality in his second series re-
mained unchanged. In Green's last series of eighty
cases, operated upon, and published at the close of
1890, there was a mortality of eight and six-eighths
per cent.

All of Green's patients died of cerebral complica-
tion, and this is the most common cause for fatal ter-
mination.

In operative cases, the earlier the operation the
better the prognosis, since there have been very few
fatal cases that were directly attributed to the opera-

tion, and a free opening of the bone tends to immediately check the progress of the disease.

The duration required for complete cure after the operation, is very variable. Among Ferrer's cases, some were under treatment over a year, the majority from three to five months, whereas several got well in three to four weeks. Some cases did not entirely heal. Among Green's eighty cases, three were not cured; the time usually required for cure is not mentioned in his paper. The duration of after-treatment depends considerably upon the thoroughness of the operation. Cases of mastoid inflammation, with caries and perforation but without cerebral or cervical complications, usually require from four to eight weeks for cure, when the cortex has been extensively opened and the carious bone and diseased tissue freely and completely removed, a communication established with the tympanum and meatus, and the whole well irrigated with an antiseptic solution.

Treatment.—After the diagnosis of mastoid disease, comes the question whether it is necessary to operate or not, and, if so, in what manner. It is obvious that all acute forms, whether complicated with brain symptoms or not, require opening the process and free draining; also chronic forms when associated with severe symptoms.

The treatment of chronic mastoid inflammations, without severe symptoms and with only slight yet persistent otorrhea, is a subject of dispute. The opin-

ions of prominent aurists have not yet been wholly expressed. Many English operators, such as Lane and Frothingham, believe in early operations. In Ferrer's cases there was nearly, if not always, an extension of the disease to the cortex, or some serious complication indicating the necessity of immediate surgical interference. Lewenburg recommends to promote the flow of pus, and institute antiseptic treatment, and to trephine only as a last resort. Sexton also maintains the same position. Lane operates to obliterate the antrum, which, he claims, is a cul-de-sac that can never be drained.

With this form of mastoid disease, there is usually extensive disease of the tympanum, a large perforation in the upper posterior segment of the drum, and a more or less free communication with the antrum, especially if the incus has been swept away. The remains of the ossicles are buried in inflammatory tissue, and tightly held to the inner wall of the cavity of the middle ear. Under these circumstances, and bearing in mind the long period of after-treatment required in many cases of mastoid trephining, it seems to me that, at least as a preliminary operation, one is justified in clearing out the tympanum, applying antiseptics, and attempting to effect a cure by these measures.

If it is desired to promote the discharge of pus through the tympanum and meatus, the remains of the drum-head, ossicles, and all granulations must be

removed as far as possible. Stacke's operation is just suited for these cases, although much can be done by the ordinary method. After the tympanum has been cleared of diseased tissue, I have made a practice of irrigating it well with bichloride solution, and then curetting out with a small sharp spoon the contents of the fossula fenestræ ovalis. It is impossible to tell whether the foot plate of the stapes is removed or not, but the amount of vertigo afterwards is some indication of it.

I have found the hearing greatly improved by this means.

It is very difficult, at times, to extract the incus, and perhaps the malleus, owing to their adhesions, yet it is very important to do so, since by this means the greater obstacle to the flow of pus from the antrum is eliminated—a fact that is readily seen by viewing the bones *in situ* in the dry skull.

The cavity is filled with iodoform, and a plug of absorbent cotton. A profuse discharge of serum follows for the first twenty-four hours, but does not necessitate removing the cotton. After three or four days, the ear is irrigated with a one-per-cent. solution of common salt; hydrogen peroxide, in full strength, is then instilled, and renewed from time to time, while the patient lies on his side, with the diseased ear uppermost; it is kept in the ear fifteen to twenty minutes; then an oily solution of iodoform is dropped in, and allowed to remain a minute or

two, after which boracic acid is insufflated, and a plug of cotton applied. As a rule, there is a great improvement in hearing, the discharge is diminished, and may entirely cease after a few months' treatment.

In the beginning of acute mastoid disease, counter-irritation, leeches to the process, large doses of stimulants, one-quarter to half a grain of morphine, and ten to twenty grains of quinine, internally, with hot stimulating pediluvia, and water bottles to the feet, with rest in bed, may be sufficient to prevent the progress of the disease; if it should not, then the bone should be opened, to give free vent to pus or to prevent its forming.

There are four principal methods for opening the mastoid and antrum, the oldest of which, as well as the one most frequently employed, is that of Schwartze. This consists in removing the cortex with a gouge and mallet, and then chiseling away the pneumatic structure, layer by layer, until the antrum is reached. The bone is opened close to the meatus, just behind the auricle, and on a level with the meatus. The course of chiseling is directly inward and slightly upward and forward, and in his first writings Schwartze recommended penetrating to a depth of 3 cm., but later concluded the depth should only be 2.5 cm. If a fistula is found, this is enlarged by means of a chisel or gouge, and the softened contents of the bone scraped out with a sharp spoon.

Schwartzze was strongly opposed to the use of drills.

Lane, Jacobson, Ferrer, Frothingham, Ricard, Schmiegelow, and others, prefer the gouge, chisel and mallet for opening the bone and antrum; on the other hand, there are a large number of men who advocate the use of the drill. Buck first opens the cortex with a drill, and then enlarges the opening with a sort of reamer, or counter-sink. Dolly and Snell use a drill with a stop arrangement on it. Green removes the cortex with a gouge, and then clears away the diseased bone with a burr and dental engine.

Wolf devised a method of opening the antrum, which, on account of its difficulty, is not much used. It is sometimes used in removing exostoses and hyperostoses, and for opening the antrum in mastoid disease, where from the shape of the skull there is reason to believe the sigmoid flexure of the lateral sinus penetrates so deep into the bone that it would be injured by operating in the usual manner.

The operation is performed through the meatus; the soft parts, and then the bone at the inner end of the meatus, near the drum, which forms the partition between antrum and meatus, are removed in successive layers, just as though the meatus was to be widened posteriorly. The greatest difficulty arises from the inability to see and guide the instruments, and on this account one is liable to injure the neighboring parts. I would suggest to disarticulate the auricle and oper-

ate through the short bony meatus, if Wolf's operation is to be performed. By this preliminary procedure the operation is made as easy as any other. I believe, however, that one of Wolf's original ideas in instituting this method was to avoid cutting the integuments.

Kuster makes a hole in the posterior wall of the meatus through the cartilaginous canal, as far from the drum as possible, when it is intact. The antrum is reached much in the same manner as in Wolf's operation. If the drum-head is perforated and the tympanum filled with granulations, as much of the posterior wall of the meatus as possible is removed, going into the drum cavity, and all diseased tissue removed with a sharp spoon. By Kuster's method the cavities of the middle ear, aditus, antrum, and meatus are converted into one, in severe cases.

v. Bergmann's method consists, first, in disarticulating the auricle* and removing the soft tissues from the auditory canal; then a chisel is driven into the bone which forms the upper posterior portion of the meatus as far as the insertion of the Mt. and below the temporal line, care being taken not to enter the middle cerebral fossa. From this cut, the bone is removed in a backward and downward direction by means of a chisel, so as to obliterate the partition between the antrum, meatus, and tympanum, and convert these three cavities into one.

* For detail of operation, see page 53.

Stacke practically operates by the same method, but in restoring the cutaneous canal he slits the latter open on the posterior side, and pushes the flaps thus formed into the cavity of the mastoid, through the opening which has been made in the posterior wall of the bony meatus, and in this manner establishes a cavity lined with skin and permanently in free communication with the external meatus, through which it can be medicated.

In many cases, Schwartze considered the removal of the posterior wall of the meatus an excellent practice, as it affords a better chance to treat the usually accompanying disease of the middle ear; and the objection Kuster and v. Bergmann have made to Schwartze's operation is, that it does not freely admit of this treatment.

Bogroff, on theoretical grounds, proposed to open the mastoid by successive cauterizations with the galvano-cautery. The method was not received with favor, and I do not know of anyone who has practiced it. Hessler's disease demands simply to open the pus cavity, clean it out with a sharp spoon, and leave the remaining portion of the bone alone.

Finally, the question may arise, while the case is pending an operation, whether the symptoms are caused by a periostitis or deeper seated disease, and it is important to determine this point before the bone is opened. In either case, there should be made a free incision down to the bone, and if the periosteum

is hyperæmic, swollen, thick and easily detached from the bone, and there is an entire absence of symptoms which would indicate internal disease, the diagnosis of simple periostitis is complete, and the operation should proceed no further. The incision alone is all that is necessary to effect a cure.

Accidents or unlooked-for conditions occasionally occur during the operation. The most frequent is a perforation of the sulcus sigmoïdes and injury to the lateral sinus. When this occurs, a profuse hemorrhage follows, which must be checked by plugging the cavity with antiseptic gauze or a similar substance; the operation will have to be abandoned, for the time at least, or the bone perforated from another direction. This accident is not so serious as was formerly supposed. Sometimes there is an enlarged diploetic vein which is opened and causes profuse hemorrhage. Green and Schwartze have both reported such cases. This complication must be treated by pressure, as in injury of the sinus. If care is not taken, the facial nerve may be injured, and the result is often permanent.

The after-treatment has been considerably modified since Schwartze's earlier communications, as might be supposed.

At first daily irrigations of a two-per-cent. carbolic, or a three-fourths solution of chlorinated soda, were used, and the sinus maintained open by means of a leaden nail. Later, after Bezold introduced boracic

acid into aural therapeutics, irrigations of a saturated solution of this substance were extensively used. To-day some operators use a solution of bichloride, 1:2000 to 1:5000; others, hydrogen peroxide. Finally, Hessler says, in a very recent review of the subject, that irrigations should not be practiced, since they are dangerous, and do not prevent the transmission of disease to the cranial cavity, but often favor such by forcing septic matter through the non-suppurating yet softened bone. I cannot appreciate the force of this argument. Irrigation should not be used with sufficient force to penetrate the tissues, but merely to wash off any loose material, such as blood and pus. It is of value during the operation, and at its close.

Iodoform is of special value in promoting bone granulation, and should be used freely, either as a powder or in ethereal solution. It not infrequently causes skin irritation, and when this happens it may be replaced by finely powdered boracic acid. Green uses a rubber drainage-tube, but drainage is not necessary if the disease has been thoroughly removed. The leaden nail is no longer employed. The wound can be filled with iodoform, or boracic acid, and covered with an aseptic gauze dressing, which need not be changed for several days. If a free discharge comes on at the end of a few days, daily irrigations will be found useful. A one-fourth-per-cent. solution of common salt, injected warm, forms a good cleansing wash; to this may be

added a small quantity of carbonate of soda. Hydrogen peroxide is also of value. Iodoform or boracic acid should be inserted, and a clean plug of cotton. If there is much pain, opium and hot applications are demanded.

Necrosis of the temporal bone is a somewhat rare affection, and usually occurs in children, rarely in adults. The principal cause is acute inflammation of the ear, following exanthemata of a severe type. Certain cases have been reported in older patients where the cause was suppurative disease of the middle ear.

In most cases the cochlea alone forms the sequestrum; but portions of the facial canal, the walls of the tympanum, or even the greater portion of the petrous bone, may be exfoliated, and Gruber has reported a case where both cochleæ were affected.

Deafness is usually complete in the diseased ear; there are, however, a number of cases on record where there was good hearing preserved, the seat of the disease not involving any essential structure of hearing.

The process of exfoliation is generally slow, and causes marked nervous irritability of the patient, and not infrequently there is an extension to the cranial cavity with fatal issue.

Diagnosis is rendered probable by the age of the patient, and the following symptoms: A purulent discharge from the meatus, or frequently from a sinus

behind the ear, extreme sensibility of the parts to touch, often facial paralysis, perhaps corneal irritation, with deafness and sometimes cerebral symptoms. The sequestrum may project from a sinus, or be discovered by means of a probe through the meatus.

Treatment.—This is based on general surgical principles. If not already loosened, a short time should be allowed for the sequestrum to separate; it is then to be removed. A small piece of bone may be removed through the meatus; if, however, the sequestrum is larger, it will be better to extract it from behind the ear. The auricle can be dislocated if necessary, the sinus, if present, enlarged, and the bone drawn out with forceps. In certain cases the whole posterior wall of the meatus, and contiguous parts, will require removal in order to produce an opening of sufficient size to permit the extraction of the sequestra.

The prognosis is good, and recovery is usually rapid after operation.

CHAPTER V.

MENINGITIS, CEREBRAL AND CEREBELLAR ABSCESS, THROMBOSIS OF THE CEREBRAL SINUSES, AND PHLEBITIS, WITH SURGICAL TREATMENT.

In reviewing the literature on suppurating diseases of the brain and its membranes, one cannot help feeling impressed with the fact that in most cases the cause was acute, or more often chronic, suppurating disease in the middle-ear and mastoid cavities. Indeed, if we leave out the cases of tubercular meningitis, and disease directly following and a result of trauma, comparatively few instances of suppurative inflammation of the brain or its meninges will be found unassociated with middle-ear disease. The importance of the study of these diseases as a part of aural surgery must therefore be apparent.

The relation between cause and effect of these two groups of diseases was misunderstood at the time of their early recognition, when it was thought that the inflammation in the ear was the complication by extension of disease in the cerebral cavity downward, in an attempt to evacuate pus through this organ. Morgagni was the first to appreciate the true nature of the disease, and maintained that the brain affection came from an extension of the inflammation in the ear.

The ways in which ear disease may be transmitted to the cranial cavity have been carefully studied. A direct extension through the roof of the tympanum and antrum is the most common path, but there may be ulcerative changes in any wall of the middle ear which will ultimately terminate in brain disease. A path is sometimes found along the blood-vessels, or abscess may result from embolic infarction. Troeltsch and Magnus have reported a case each, where this occurred on the side of the head, remote from the ear disease. Hoffman reported a case with extension along the facial nerve; Kipp also had a fatal case of cerebellar abscess where the infection came from farunculosis of the external meatus, and was transmitted along the aqueduct Fallopii.

Abscess of the cerebrum or cerebellum, as a rule, does not begin in contact with the meninges, but is deeper seated, which seems to indicate that there is a common mode of transmitting the infection along the nerves or vessels.

When the disease extends directly to the cranial cavity by caries of the bone, a subdural abscess usually forms, and there may be no other complication. Phlebitis and thrombosis of the lateral sinus usually occur in the same manner when the seat of caries is in the bone forming the wall of the sulcus sigmoides. When necrosis of a large part of the temporal bone occurs as a result of fever or trauma, there is subsequent suppuration, and the dura may

become involved, as in ordinary caries. There is a greater chance of spontaneous recovery in these cases, owing to the natural formation of an outlet for the pus.

CLINICAL HISTORY.—*In purulent meningitis* there is usually an otorrhea and often a history of long standing disease of the middle ear.

Headache appears as a constant symptom; it becomes severe, somewhat intermittent, and steadily increases, until dulled by stupor.

There is fever, which ranges between 100–103° F. during the early part of the disease, and just before death it rises nearly to 105°. A cessation of fever sometimes occurs in the course of the disease, as though there were two attacks, with an interval of perhaps a week between.

Dizziness is frequently complained of, and lasts for several days, and there may be vomiting at the same time. These symptoms are more common at the onset.

Chills and chilly sensations may occur, although not a constant symptom.

The rate of the pulse is increased to between ninety and one hundred beats, and the respiration often in a greater ratio; the latter becomes stertorous and slow as pressure on the brain ensues, and just before death.

There are no special optic symptoms, yet after a

time optic neuritis may set in, although it is not characteristic of the disease.

The tongue is usually furred and coated.

Paralyses are common; they vary much, and hemiplegia is the usual form, but special paralysis may occur, particularly of the facial nerve.

Generally there is a retraction of the head, or it is fixed in one position, and there may be a rigidity of the spinal column and even opisthotonos.

The so-called *tache cérébrale* is often present and well marked.

The mind is clear at first, and cerebation is perfect for a considerable time; as stupor comes on, it is still good, but sluggish; later, confusion of the mind deepens into stupor, and finally complete coma. Convulsions may be present or absent; muscular twitchings are more common, and a general tremulousness is not an infrequent symptom later in the disease. Toward the close the bowels are confined, and the urine is retained and often contains considerable sugar or albumen, with a low specific gravity.

Cerebral Abscess.—There is commonly a history of otorrhea and disease of the tympanum, with more or less deafness; bone conduction is, however, usually good.

Pain of an intense nature suddenly occurs, referred to the temporal or frontal region, on one side of the head, near the seat of the disease; it persists until consciousness is dulled. There may be pain referred

elsewhere, as in the neck, and there is tenderness on pressure or percussion over the seat of the abscess.

Chills are usually present at the beginning; there are more than one, and yet not many; they are of a distinct type, and may be of very long duration. They may be entirely absent.

The pulse may be quickened in the beginning, but as the disease progresses it nearly always becomes abnormally slow, and perhaps irregular. There may be but ten beats to the minute. Later, just before the fatal termination, the pulse increases.

The temperature varies with the pulse; perhaps slightly increased at first, it soon comes down, and stays near the normal limit, or toward evening is even subnormal. At a later period it rises, and often reaches as high as 107° F. just before death. The low temperature and slow pulse should be considered together.

The respiration becomes slow, labored, stertorous, and irregular.

Paralyses are nearly always present, in the form of hemiplegia, and paralysis of the facial and ocular nerves on the side opposite to the seat of the disease. Tendon reflexes may be lost.

The vision is generally affected, the pupils sluggish, slightly contracted, or dilated, often irregular; and an optic neuritis or choked disc, in both eyes or in the one on the same side as the disease, may be

present. Nystagmus is also common, and the cornea may be insensible to touch.

The abscess forms slowly, and it is not for some time that acute symptoms set in; when they do, cerebation almost immediately is greatly impaired, the patient appears stupid, answers questions incoherently and hesitatingly, or there may be complete aphasia. The patient passes rapidly into a state of stupor, and so continues, as a rule, until complete coma ensues. At first the patient may be irritable, and appear provoked because he is not understood.

Convulsions of a general type, or local muscular spasm, may be present. The limbs are sometimes flexed, or there may be trismus or rigor of the nucha, with other hemispasms.

Vertigo is a frequent symptom.

The bowels are confined, or there is involuntary defecation.

The urine often contains albumen, and there is retention, or incontinence.

Great restlessness, especially at night, and mild or active deliria, may be present during any stage of the disease.

Vomiting is a frequent symptom at the beginning, or any stage of the disease. As a rule it is generally not attended with previous nausea.

There is a general wasting of the tissues, which progresses very rapidly.

Cerebellar Abscess.—The symptoms are the same

as in cerebral abscess, but disease in this locality is more frequently complicated with phlebitis and sinus thrombosis.

The pain is referred to the occiput in most cases, but it may be frontal, and it is frequently intermittent. It is not so severe as in cerebral abscess. The tenderness on deep pressure and percussion is situated over the seat of the disease.

Bone conduction is entirely absent in many cases, owing to involvement of the auditory nerve.

The mastoid process is often simultaneously inflamed and tender along the outer and posterior border.

There is less hemiplegia and hemispasm, and generally the patient is younger.

Cerebration is not so rapidly affected as in cerebral abscess, and may remain good.

Vomiting is more frequent, worse when the pulse is lowest, and there is commonly great vertigo, manifest by sitting up in bed.

Stupor and coma come on late, and in the greater number of cases death rapidly follows.

Thrombosis of the Lateral Sinus.—Pain comes on rapidly, is very severe and persistent, being much worse at night, may be referred to the frontal or occipital regions, and increases with cough or movements of the body.

Chills are frequent and repeated, of a severe type, and generally of short duration.

The temperature runs very high, 104–107° F., and there is the usual evidence of acute inflammation. Profuse perspiration may occur, is often excessive, and may be attended with suppression of urine.

The pulse is increased, and respiration is noisy.

Vomiting may be constant; it is usually present, and more or less severe.

Cerebration may be very perfect, but is somewhat sluggish; pressure symptoms from complications may arise, and the mind become dull and confused. In many cases there is perfect cerebration and clear mind to within a few hours of death.

Paralyses are not very common. The facial nerve may be implicated, and with it the auditory. The tendon reflexes are sometimes greatly exaggerated, and there may be difficulty in swallowing.

Delirium is common, of an active type, with intermissions. Convulsions are common, severe, and frequently of an hysterical type.

Deafness is marked, and bone conduction lost, in most cases. This latter symptom is important, as when present it shows the nerve is complicated.

Pupils may be irregular, and are commonly moderately dilated. An extreme protrusion of one or both eyes is sometimes observed, when the horizontal sinus becomes affected. Divergent strabismus and optic neuritis may be present.

Edema in the mastoid, temporal, and zygomatic regions, of a painless nature, and without redness of

the skin, is a symptom of disease of the lateral sinus; in the temporal region it extends downward, and is lost near the tragus. It is not always present, and depends on a peculiar anatomical condition. Œdema of the lids and eyeballs is characteristic of thrombosis of the longitudinal sinus.

Speech is frequently incoherent.

Pulmonary symptoms, with cough and œdema, are frequent, due to extension of clot to the lungs, or pulmonary embolism.

Abscess and general pyæmia are nearly sure to follow in the course of the disease. Pleuro-pneumonia is a common cause of fatal termination.

Diagnosis.—When, with a history of disease of the middle ear, there appears severe pain, of a constant nature, becoming more intense during febrile exacerbations, often fixed and located over the seat of the disease, which is increased on pressure and percussion, a diagnosis of brain complication is almost certain. If there is imperfect cerebation and stupor, there is no doubt of the diagnosis. Symptoms, which can be divided into three different classes, will appear: there are those due directly to the suppuration; others resulting from an increase of the intercranial pressure and displacements of the brain substance; and the so-called focal symptoms, which correspond to the site of the disease.

The inflammatory symptoms are especially marked in meningitis and thrombosis of the sinuses, and may be quite wanting in abscess of the hemispheres. Pressure symptoms do not occur in disease of the sinuses alone, and are most common with the formation of an abscess. Focal symptoms, unfortunately, are not common, and when present cannot always be depended upon.

Meningitis or subdural abscess is rendered probable when the temperature and pulse are moderately increased, cerebation good [but slow, single chills only occur, and the symptoms common to brain disease are present. A diagnosis separate from abscess cannot be made, but as treatment is the same for both diseases it is of no practical importance.

On the other hand, an indefinite history of previous illness, with severe pain, increased by percussion over the skull, with a low, normal, or subnormal temperature, and slow pulse, imperfect cerebation, and an inclination to sleep, are strong indications of an abscess forming in one of the hemispheres. When there is strabismus, disturbance of speech, and irritation or paralysis of the facial nerve, the abscess has reached to near the posterior division of the frontal convolution, and if hemianopia is present it indicates disease in the occipital lobe. Deafness occurring suddenly in the ear opposite the side affected, in unilateral suppuration, indicates that the

centre of hearing in the temporal lobe has become affected.*

The youthfulness of the patient, a great amount of vertigo, a more or less clear condition of the mind, absolute deafness on the diseased side, the locality of the pain produced by percussion, with or without symptoms of sinus infection, favor the diagnosis of abscess in the cerebellum, when combined with the common symptoms of brain disease.

The most important indications of thrombosis of the lateral sinus are: The occurrence of a succession of short, sharp chills, followed by a rapid rise in temperature, often reaching 105° F., or even 107° F., later dropping; a tenderness over the jugular, or corded sensation to touch, with a stiffness of the back or side of the neck, and tenderness on deep pressure at the posterior border of the mastoid below the occipital protuberance.

History of Treatment.—During the operations for mastoid disease the lateral sinus and brain have been accidentally exposed from time to time, and it was considered a serious affair that would probably terminate fatally. If the sinus was opened, the patient died with pulmonary symptoms—as an illustration of which, I have only to mention a case reported by Zaufal (1884), where the sinus was accidentally

*The centre of hearing, for instance, in the right ear, is situated in the left temporal lobe.

opened, and then syringed with a two-per-cent. carbolic solution; the case terminated fatally at the end of fourteen days from pleuro-pneumonia.

In 1885, Schondorff reported a case of cerebral abscess which was cured at the end of three months. Three days after opening the mastoid, and removing the whole posterior wall of the meatus, a fistula appeared connected with the cranial cavity, and was probed to the depth of 2 cm. in an oblique and backward direction. The opening, which was formed in part spontaneously, proved sufficient for a cure.

In 1886, Truckenbrod reported a case operated on by Schede, with a history similar to the above; the mastoid was opened, and pus escaped on a level with the linea temporalis; a fistula was found in rough bone, and a probe entered the cerebral cavity. The bone was removed with a chisel as far as the dura, which was covered with granulations, and fluctuation discovered. The dura was punctured, and fetid pus and broken-down brain tissue escaped, with foul air. The bone was further removed for free drainage, and the patient completely recovered at the end of five months. Schede afterwards obtained eleven cures out of twenty cases on which he operated.

A third case was operated on by Barker in October, 1886, and was the first case where cerebral abscess due to tympanic disease was *diagnosed, localized, and evacuated* with success.

Greenfield reported a fourth case, operated upon

by Caird in January, 1887, with rapid improvement; and during the same month Macewen performed a similar operation with success.

About this time Von Bergmann, in an essay on surgical treatment of brain affections, did much to develop the operation for this disease.

At the congress of otologists held at Brussels in 1888, Barr reported six cases operated on, with five recoveries.

These operations were for the relief of abscess of the cerebrum, and it was not until the early part of 1889 that the cerebellum was first successfully operated upon for abscess, by Macewen—a feat that was considered especially difficult, owing to the situation of the lateral sinus.

In March of the same year, Orlow reported a case where he supposed he opened into the lateral sinus and removed a dirty, gray, cheesy mass, and foul pus, the case recovering.

In April, 1889, Lane reported a case of thrombosis of the lateral sinus, where he cut down upon and ligatured the internal jugular vein to prevent the extension of infection. The case recovered. This treatment was suggested by Horsley in 1886.

In May, 1890, Ballance reported four cases operated on in a similar manner, with two cures. The vein was tied in two places and cut between the ligatures; the upper end was then sewed into the top of the wound in the neck. The sinus was then laid open

freely from above, through the mastoid, and its contents syringed out.

Operation.—This should be carried out with thorough aseptic precautions.

The patient is prepared by cleansing the head with soap and water, and shaving the field of operation; in fact, many operators, following the rules of Horsley, shave the whole head. This is carried out the day before the operation, and the site of incision is further prepared by keeping it moist with antiseptic solutions until the time of operating. The bowels are completely evacuated the night before the operation by repeated doses of a saline cathartic, a tablespoonful of saturated solution of magnesia sulphate every hour in a tumblerful of water until there have been three stools. An enema is given on the morning of operation, and the patient is requested to take nothing into the stomach except a cup of warm beef-tea, made from the extract of beef.

Before administering the anæsthetic, it is well to give the patient a subcutaneous injection of one-quarter grain of morphine. Chloroform is the best anæsthetic, as it causes a depression of the cerebral centres, whereas ether is an excitant.

The primary incision* is usually made in the form of a cross, and produces four flaps. Horsley makes

*The measurements for determining the site of operation are given on page 25.

a semicircular flap, which is preferable. The incision should be carried through to the bone, and all the tissues above the periosteum raised in the flap. A crucial incision is then made in the periosteum, which is to be deflected so as to expose the bone.

A trephine of the right size is then selected; the best instrument is Robert's antiseptic trephine, which admits of being thoroughly cleansed. The size commonly used for abscess of the brain and subdural space, is one-half an inch in diameter; and five-eighths of an inch for the lateral sinus. If the opening made by the trephine is not large enough, as is often the case in operations on the lateral sinus, a second may be made, and the bone between them removed by means of a Hey's saw, or, what is better still, the small circular saw used by dentists and run by a dental engine (the latter cuts rapidly, true, and is easily directed).

The dura should be incised in the form of a circular flap, cutting one-eighth of an inch from the margin of bone, and for four-fifths of the circumference; this admits of it being sewed back in place at the end of the operation, if necessary. Curved scissors are useful for this purpose.

The brain bulges into the opening in the skull, as a rule, if disease is present. The abscess is usually situated at some depth in the brain tissues, and surrounded by a more or less firm capsule in the majority of cases. In order to reach the abscess cavity and

determine its exact position, a small trocar is inserted into the brain substance, in the direction it is supposed to lie. If pus escapes, the opening is further enlarged with a sharp spoon.

In the case of abscess, the simple evacuation of the pus is all that should be attempted, and all treatment such as syringing, etc., should be carefully avoided. It is not necessary to clean out thoroughly the cavity; but after giving it free vent, and making sure that it is the abscess, which has produced the symptoms indicating the brain complication, leave it alone.

If pus is not found, an attempt may be made to restore the closure of the opening in the skull. The dura is stitched together; the bone, which should have been preserved in a one-quarter-per-cent. solution of common salt, is inserted in the opening, the periosteum replaced and stitched, and the skin wound closed. The wound is dressed with iodoform and an aseptic gauze pad, which is not changed for several days. The finest catgut is the best material for suturing. The skin wound should be healed at the end of a week.

If an abscess is found, it will be useless to treat the wound in this manner, as the bone has little chance of becoming else than a foreign body, which will later have to be removed. The opening in the bone can be left open, a soft-rubber drainage tube being inserted into the abscess cavity by some operators, others using a quill or bone drain, or a piece of aseptic

gauze or wicking. The skin wound can be partly closed, and the whole dusted with iodoform or boracic acid and covered with an aseptic gauze pad.

If the sinus has become thrombosed as a result of infection from the ear, general pyæmia is sure to follow with fatal results, and the bold methods employed by Lane and Ballance should be resorted to as the only chance of saving the life of the patient. An incision should be made in the neck, along the anterior edge of the sterno-cleido muscle, about two or three inches in length, beginning at the angle of the jaw, and cutting downward. The external jugular passes outside of this muscle, and gives off a branch at the angle of the jaw, which ultimately, if not directly, communicates with the facial vein and internal jugular. The internal jugular is seated beneath the muscle, and runs in the same general direction. The vein should be tied just above the entrance of the facial vein and internal to, and above, the communicating branch. During this part of the operation, an able assistant should stand with his fingers pressed against the neck, over the vein, below the site of the operation, ready in case of accident to exert pressure, shut off the vein between the heart and incision, and thus prevent the suction of air into the circulation, which would almost immediately prove fatal. The vessel is tied in two places, and cut between the ligatures, the upper end is brought out, and the wound closed. The great danger of pulmonary com-

plication is now over, and, if the condition of the patient warrants it, trephining can be performed. The sinus is exposed and opened, clots broken up and removed, and the vessel irrigated with a solution of boracic acid or with hydrogen peroxide.

Irrigation plays an important part in cleansing the sinus, which it does not in brain abscess. The danger of secondary hemorrhage is not great, and it can easily be controlled, especially if the opening in the skull is sufficiently large to admit of free manipulation.

The collateral circulation is insufficient to carry further infection into the system.

Lane, in one case, not only ligated the vein in the neck, but also the sinus outside of the torcular, and allowed the case to remain in this condition until a clot formed between the two points. The result was that the clot not only formed, but extended along the petrosal sinuses, and terminated fatally. Lane believes the tying of the sinus is of great advantage, as the sinus can then be opened leisurely, cleansed, and treated, without being obscured by the free flow of blood; but, owing to this accident, he opens the sinus at once, without waiting for a clot to form.

As a matter of fact, the hemorrhage is easily controlled, as shown in three cases where the sinus was accidentally opened by Weir, as well as by the practice of other operators; and as it is only necessary to give vent to the suppuration about to ensue, the oper-

ation should not be complicated by additional measures. There is sufficient evidence to show that the simple opening of the sinus which has become thrombosed may be sufficient for the relief of the disease.

The after-treatment should be the same as for abscess. The wound should be kept clean, dusted with iodoform or boracic acid, and dressed with aseptic gauze. The dressing should not be changed for several days, and then only as often as it is made necessary from the quantity of the discharge.

Prognosis.—This has been greatly changed during the past few years; a large part of what were formerly fatal cases, now being permanently cured by operative measures.

When there is uncomplicated abscess of the cerebrum, which is encapsulated, the prospect of cure is best after operation, and is then very great; certainly over fifty per cent. of cases recover, and there may be over eighty per cent. Ballance cured fifty per cent. of the cases of sinus thrombosis that he operated upon. Cerebellar abscess is not so favorably situated for treatment, but does not occur so often. Of seventy-six cases, Barr found the abscess situated fifty-five times in the temporal lobe, thirteen in the cerebellum, and three elsewhere. Körner, in sixty-seven cases, found the abscess thirty-one times in the cerebrum, nineteen in the cerebellum, four times an abscess in both cerebrum and cerebellum; in eight

cases of abscess of the cerebrum there was thrombosis of the longitudinal sinus, and five cases of the cerebellar abscess were complicated with thrombosis of the lateral sinus. A diffuse abscess is more serious than an encapsulated one, and an abscess complicated with thrombosis of the lateral sinus is still more so. Finally, there is no case reported where thrombosis of the longitudinal sinus, either alone or associated with cerebral abscess, has recovered.

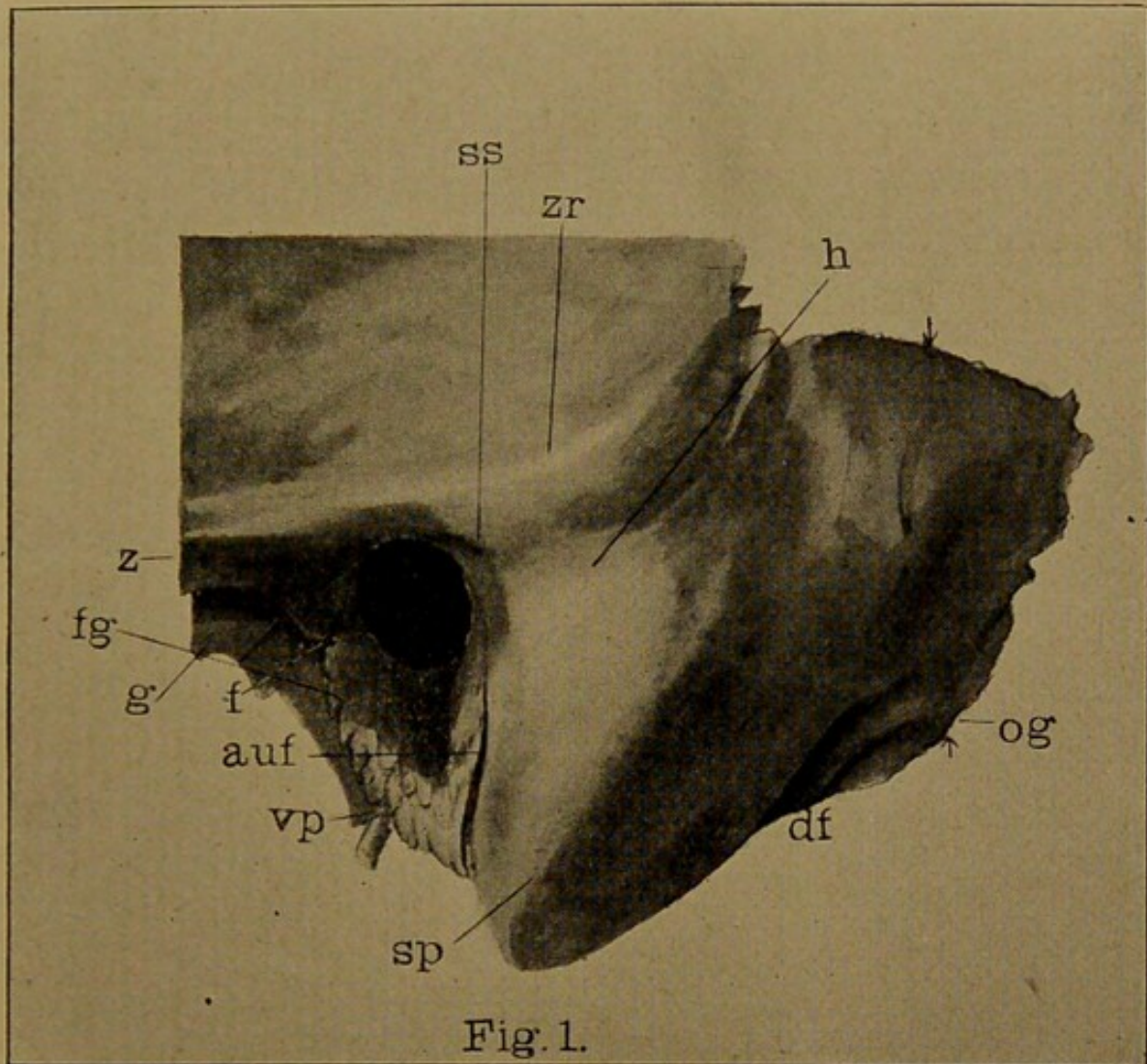
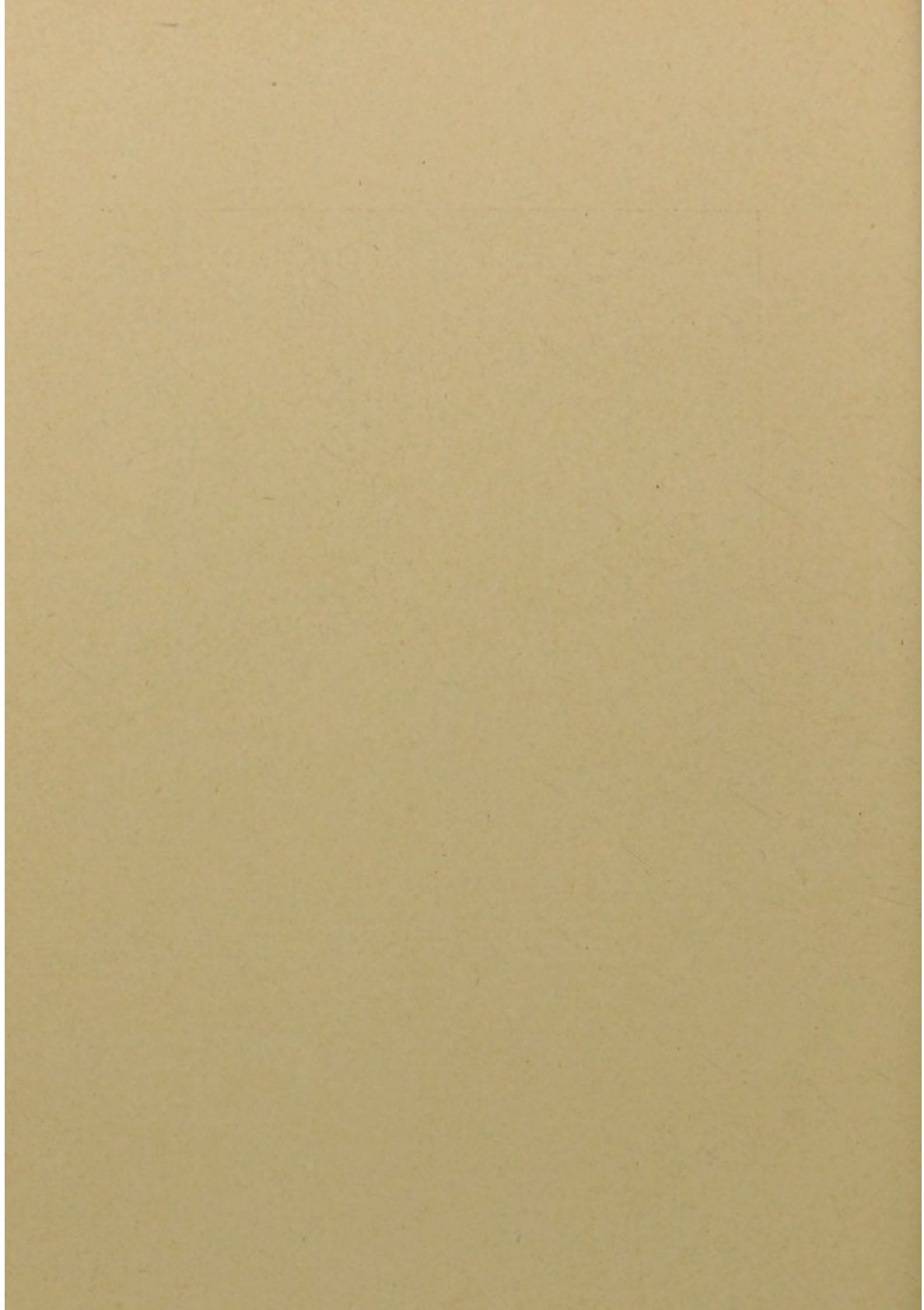


Fig. 1.

FIG. 1. The external bony canal and mastoid region.
 auf—Auricular fissure. df—Digastric fossa. f—Glasserian fissure. fg—Fossa for the parotid gland. g—Glenoid fossa. h—Hollow between the temporal line and elevated or roughened portion of the mastoid. og—Occipital groove. sp—Elevated portion of the mastoid. ss—Spina supra meatum. vp—Vaginal process. z—Zygoma. zr—Zygomatic ridge, or temporal line.



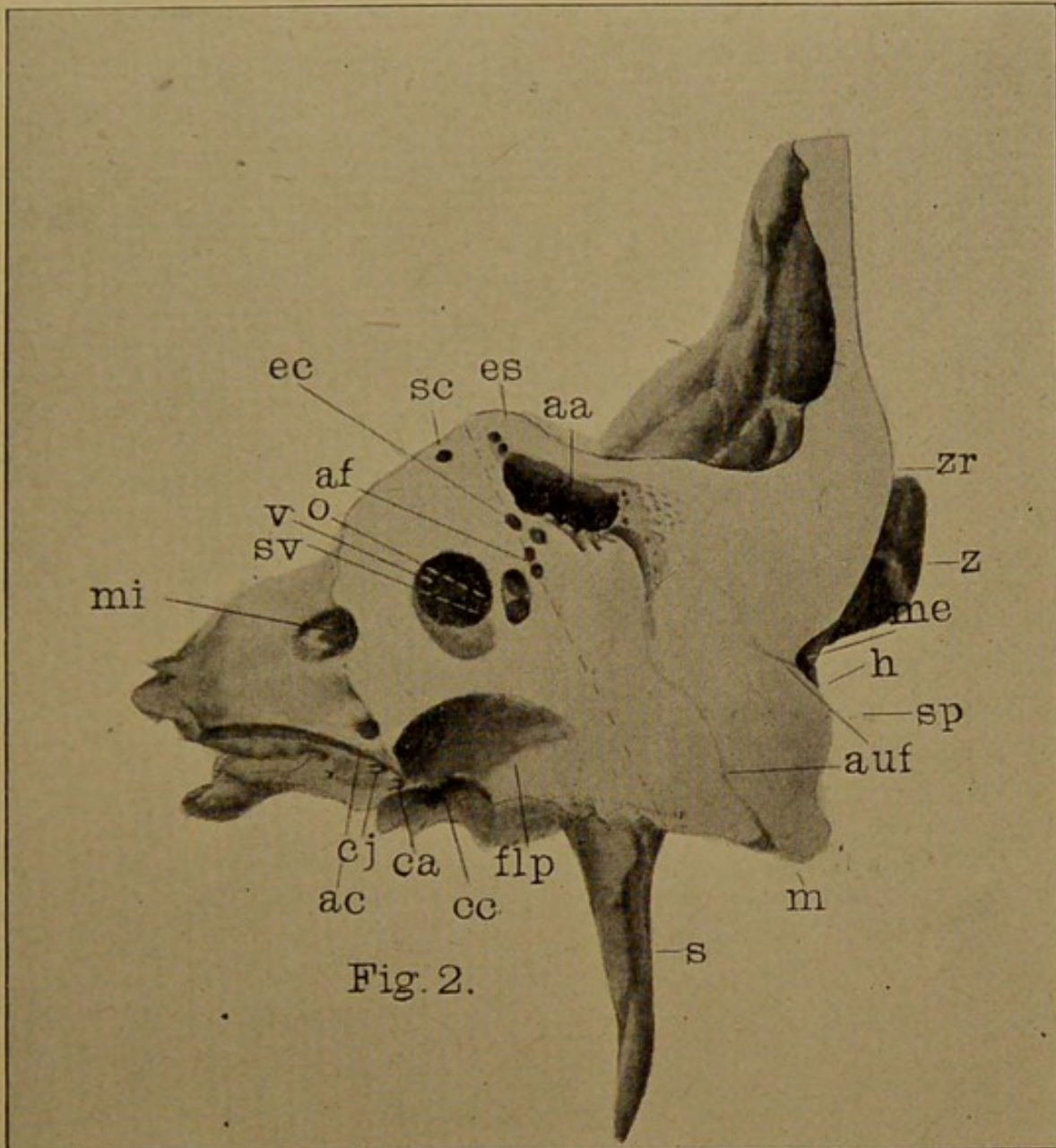


Fig. 2.

FIG. 2. A section of the temporal bone nearly parallel to the external and internal auditory meatus. The section comes within one-sixteenth of an inch of the posterior attachment of the membrana tympani, and shows a section of the aditus ad antrum just where it opens into the antrum. In opening the antrum this surface becomes the anterior wall of the excavation, except in such an operation as suggested by Stacke, where this wall is removed and a communication formed between the attic, antrum, and external meatus. The relation of the facial nerve and the external semi-circular canal to the aditus and the antrum, are particularly shown.

aa—Aditus ad antrum. ac—Aqueductus cochlea. af—Aqueductus Fallopii. auf—Auricular fissure. ca—Opening of the canal for Arnold's nerve. cc—Carotid canal. cj—Opening of the canal for Jacobson's nerve. ec—Section of the external semi-circular canal. es—Eminence of the superior semi-circular canal. flp—Foramen lacerum posterius. h—Hollow between temporal line and elevated portions of mastoid. m—Mastoid process. me—Meatus auditorius externus. mi—Meatus auditorius internus. o—Fenestra ovale. s—Styloid process. sc—Superior semi-circular canal. sp—Elevated or roughened portion of mastoid. sv—Scala vestibuli. v—Vestibule. z—Zygoma. zr—Temporal line.



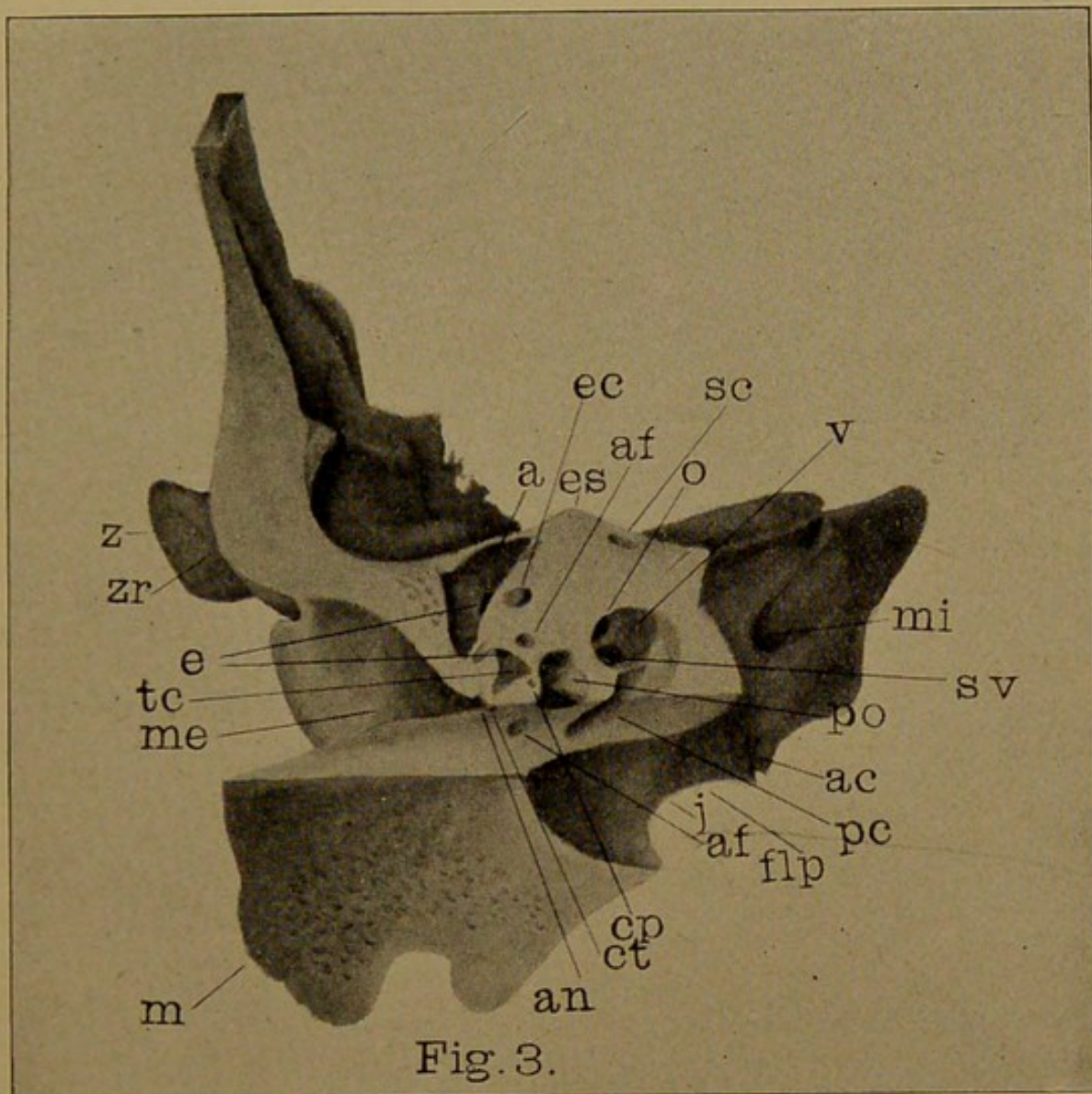


Fig. 3.

FIG. 3. The bone was cut first perpendicularly, 5-16 of an inch behind the posterior margin of the membrana tympani; then a block 5-16 of an inch thick, and in the same plane as the first cut, was removed as far as the centre of the meatus. The tympanic attic is opened, and its relation to the meatus shown, also the position of the tympanic opening and facial nerve.

a—The tympanic attic, or cupola. ac—Aqueduct cochlea. af—Aqueduct Fallopii. an—Annulus tympanicus. cp—Cavity of pyramid for stapedius muscle. ct—Track of chorda tympani: iter chordæ posterius. e—Eustachian tube. ec—Section of external semi-circular canal. es—Eminence of superior semi-circular canal. flp—Foramen lacerum posterius. j—Jugular fossa. m—Mastoid. me—Meatus auditorius externus. mi—Meatus auditorius internus. o—Foramen ovale. pc—Posterior semi-circular canal. po—Promontory. sc—Superior semi-circular canal. sv—Scala vestibuli. tc—Tympanic cavity. v—Vestibule. z—Zygoma. zr—Temporal ridge.



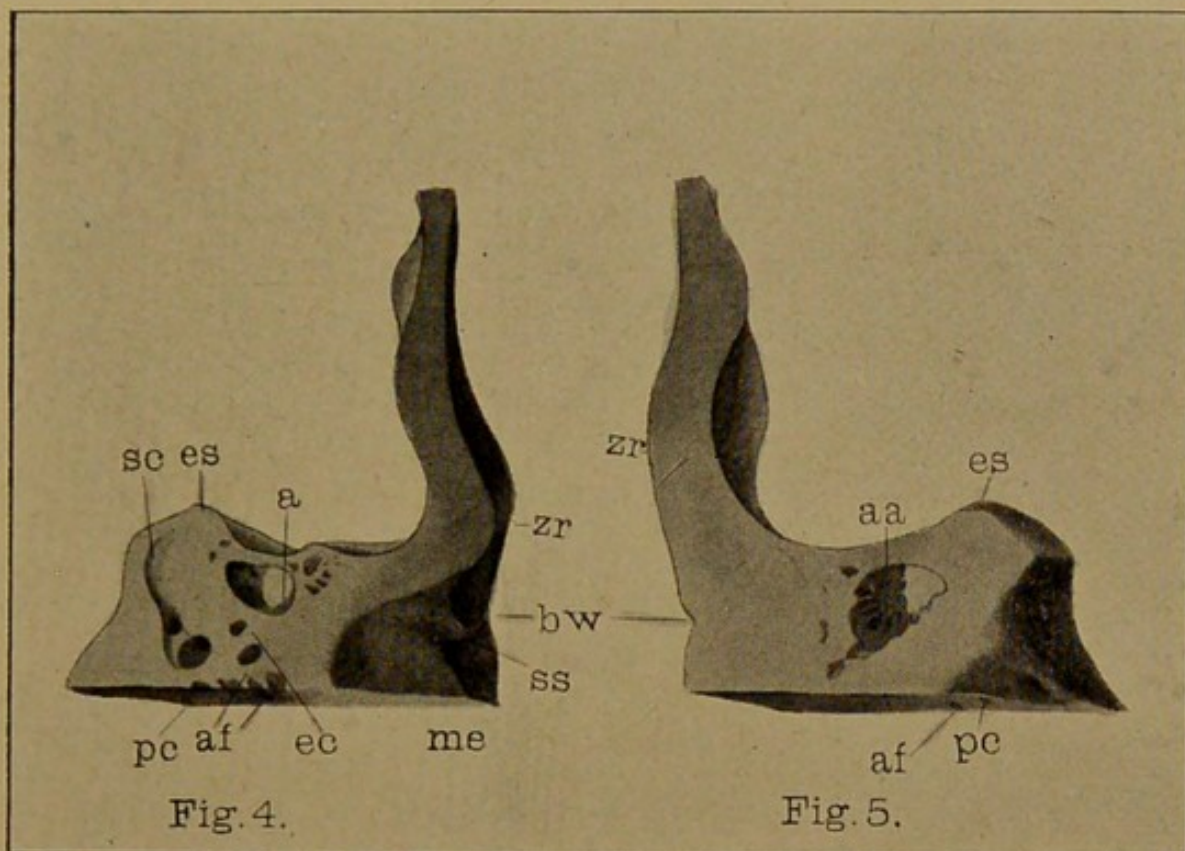


FIG. 4. The block removed from the bone in Fig. 3, showing its anterior face; this section includes all the structures in the anterior plane of the operation for mastoid disease.

FIG. 5. The same block as Fig. 4, showing the posterior face; the aditus is more especially shown in this section, which includes its entire length and a portion of the antrum.

a—Attic. aa—Antrum, and its passage. af—Aqueduct Fallopii. bw—Bone directly exterior to the antrum. ec—Section of external semi-circular canal. es—Eminence of the superior semi-circular canal. me—Meatus auditorius externus. pc—Posterior semi-circular canal. sc—Superior semi-circular canal. ss—Spina supra meatum. zr—Temporal line.



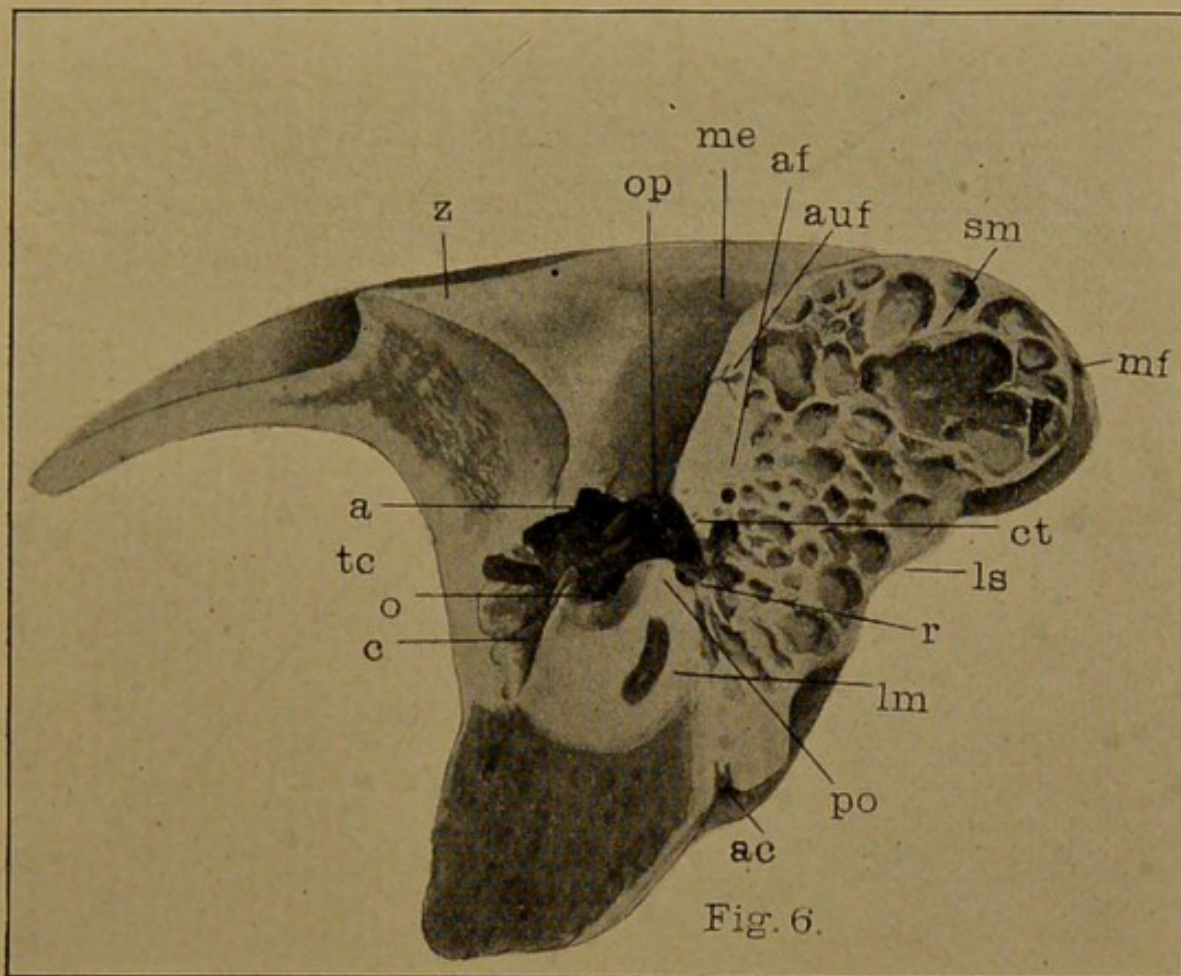


FIG. 6. A view of the upper section of a temporal bone which has been cut in a horizontal plane, on a level with the centre of the meatus. The mastoid is of the common, or diploëtic type. The figure especially shows the situation of the attic, the thinness of the bone forming the pars ossea membrana, and the shape of the transverse section of the tympanum. The relation of the mastoid and lateral sinus to the drum-cavity and meatus is carefully shown.

a—Attic space of tympanum. ac—Aqueduct cochlea. af—Aqueduct Fallopii. auf—Auricular fissure. c—Processus cochleariformis. ct—Track of chorda tympani: iter chordæ posterior. lm—Section of cochlea. ls—Lateral sinus: the sulcus sigmoides. me—Meatus auditorius externus. mf—Mastoid foramen. o—Fenestra ovale. op—Opening in pyramid. po—Promontory. r—Fenestra rotunda. sm—Section of mastoid. tc—Tympanic cavity. z—Zygoma.



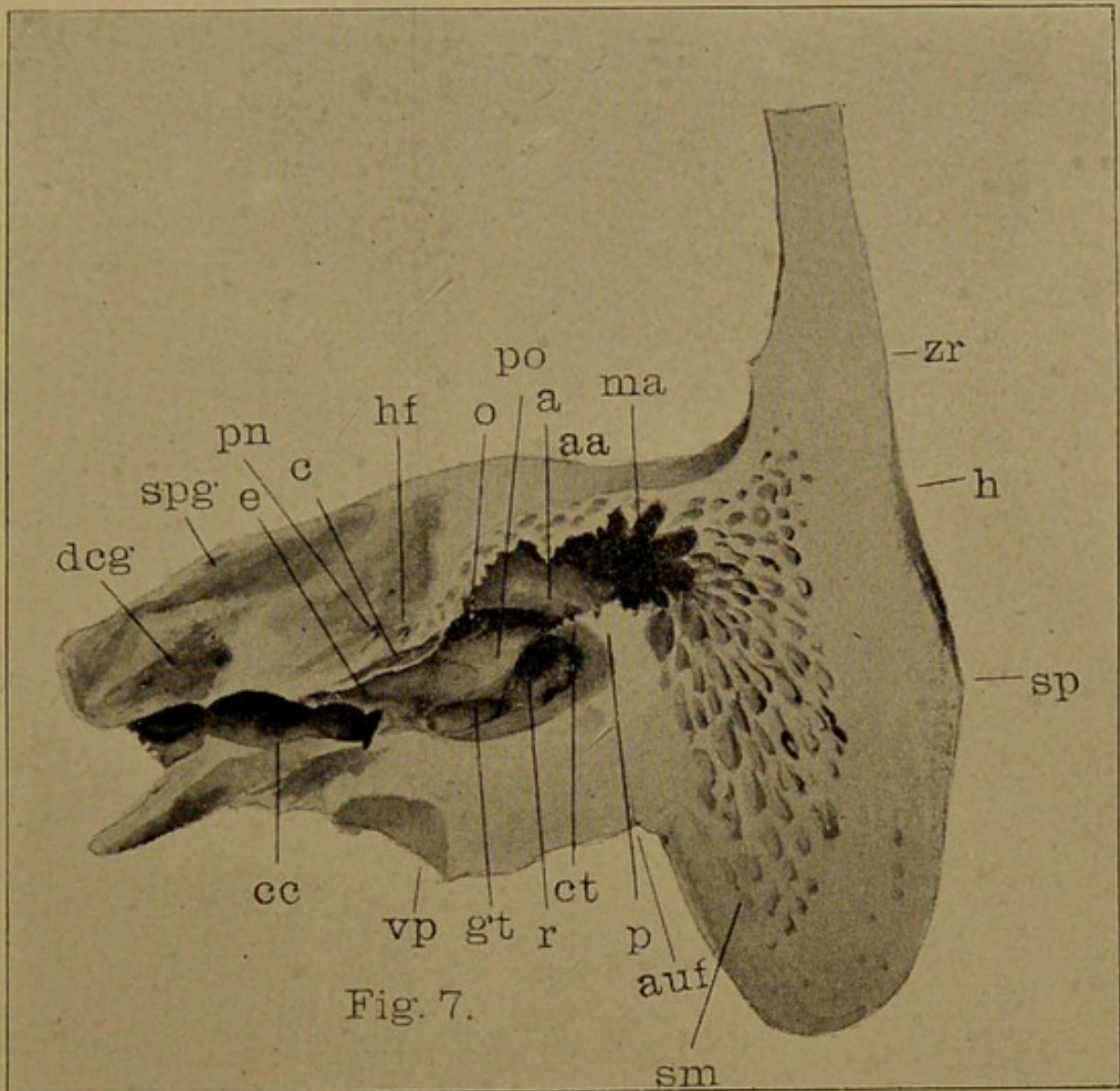
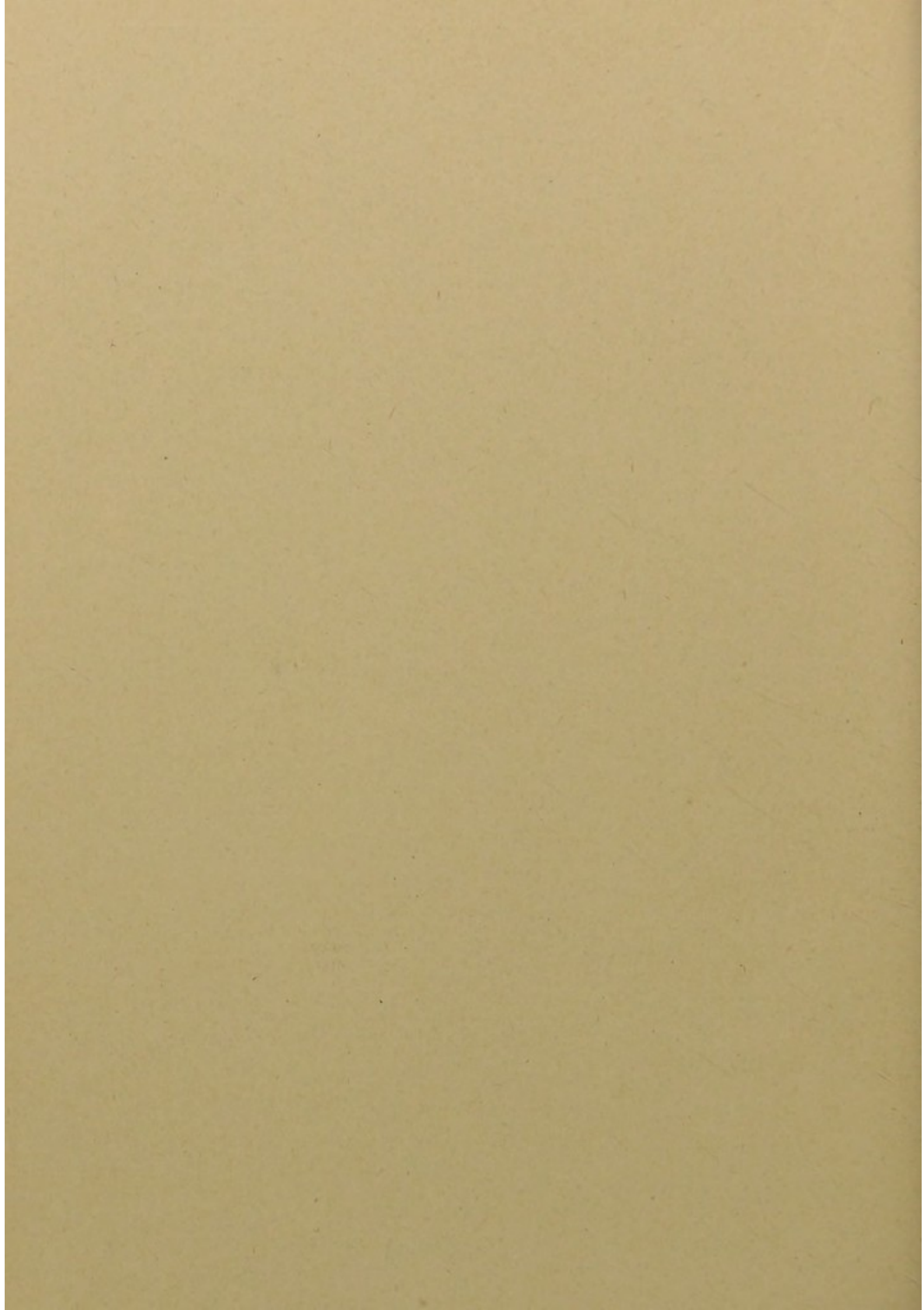


Fig. 7.

FIG. 7 is taken from a temporal bone which has been sawn in a perpendicular plane, and in a direction which corresponds very nearly to the long axis of the petrous. The cut begins $\frac{5}{8}$ of an inch behind the posterior margin of the meatus, crosses the tympanum, and bisects the Eustachian tube. A portion of the thin wall which separates the carotid canal and Eustachian tube has been removed, to better show its dangerous relation to the tube and tympanum. The relative position of the antrum and tympanum is depicted, and also the rounded prominence formed by the walls of the facial and external semi-circular canals. The bone represents a good specimen of the sclerosed type of mastoid.

a—Attic. aa—Aditus ad antrum. auf—Auricular fissure. c—Processus cochleariformis, with cavity for tensor tympani, laid open. cc—Carotid canal. ct—Track of chorda tympani. dcg—Depression for the Casserian ganglion. e—Eustachian tube. gt—Groove for the tympanic plexus. h—Hollow on mastoid below the temporal line. hf—Hiatus Fallopii. ma—Mastoid antrum. o—Fenestra ovale. p—Pyramid. pn—Groove and foramen for petrosal nerve. po—Promontory. r—Round window. sm—Section of mastoid. sp—Roughened, or prominent, portion of mastoid. spg—Superior petrosal groove. vp—Vaginal process. zr—Zygomatic ridge, or temporal line.



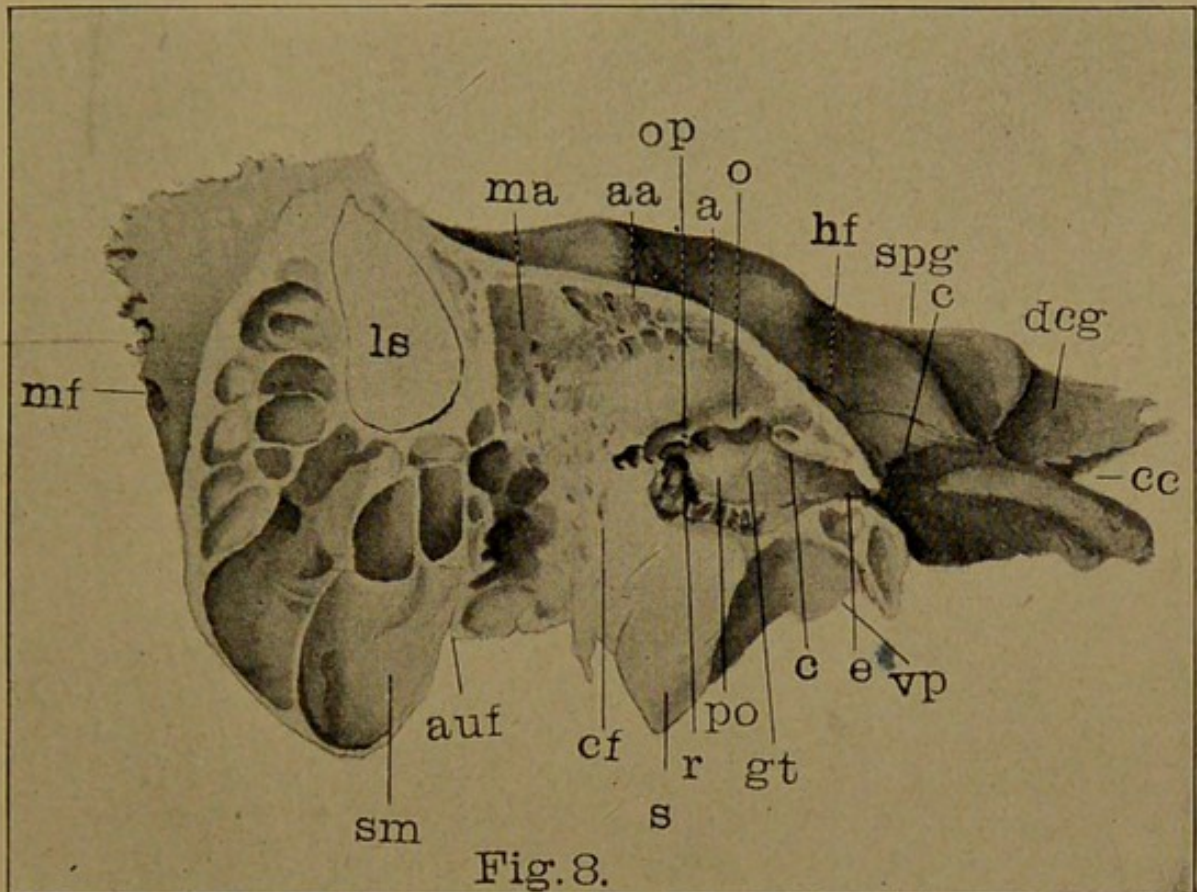


FIG. 8 is taken from a temporal bone with a mastoid of large pneumatic-cell type. The section is cut in a slight inward curve, and perpendicular. Beginning near the posterior margin of the mastoid, the section curves inward and forward, passes through the sulcus sigmoides, close to the inner wall of the tympanum, and divides the Eustachian tube into two nearly equal parts. The section is just external to the facial canal, and the prominence formed by its wall is seen arching over the oval window. The relations of the internal wall of the tympanum and the lateral sinus, in the field of operation, are carefully shown.

a—Attic. aa—Aditus ad antrum. auf—Auricular fissure. c—Processus cochleariformis. cc—Carotid canal. cf—Channel of the chorda tympani. dcg—Depression for Casserian ganglion. e—Eustachian tube. gt—Groove for tympanic plexus. hf—Hiatus Fallopii. ls—Lateral sinus. ma—Mastoid antrum. mf—Mastoid foramen. o—Fenestra ovale. op—Opening in the pyramid. po—Promontory. r—Fenestra rotunda. s—Base of the styloid process. sm—Section of mastoid. spg—Superior petrosal groove. vp—Vaginal process.



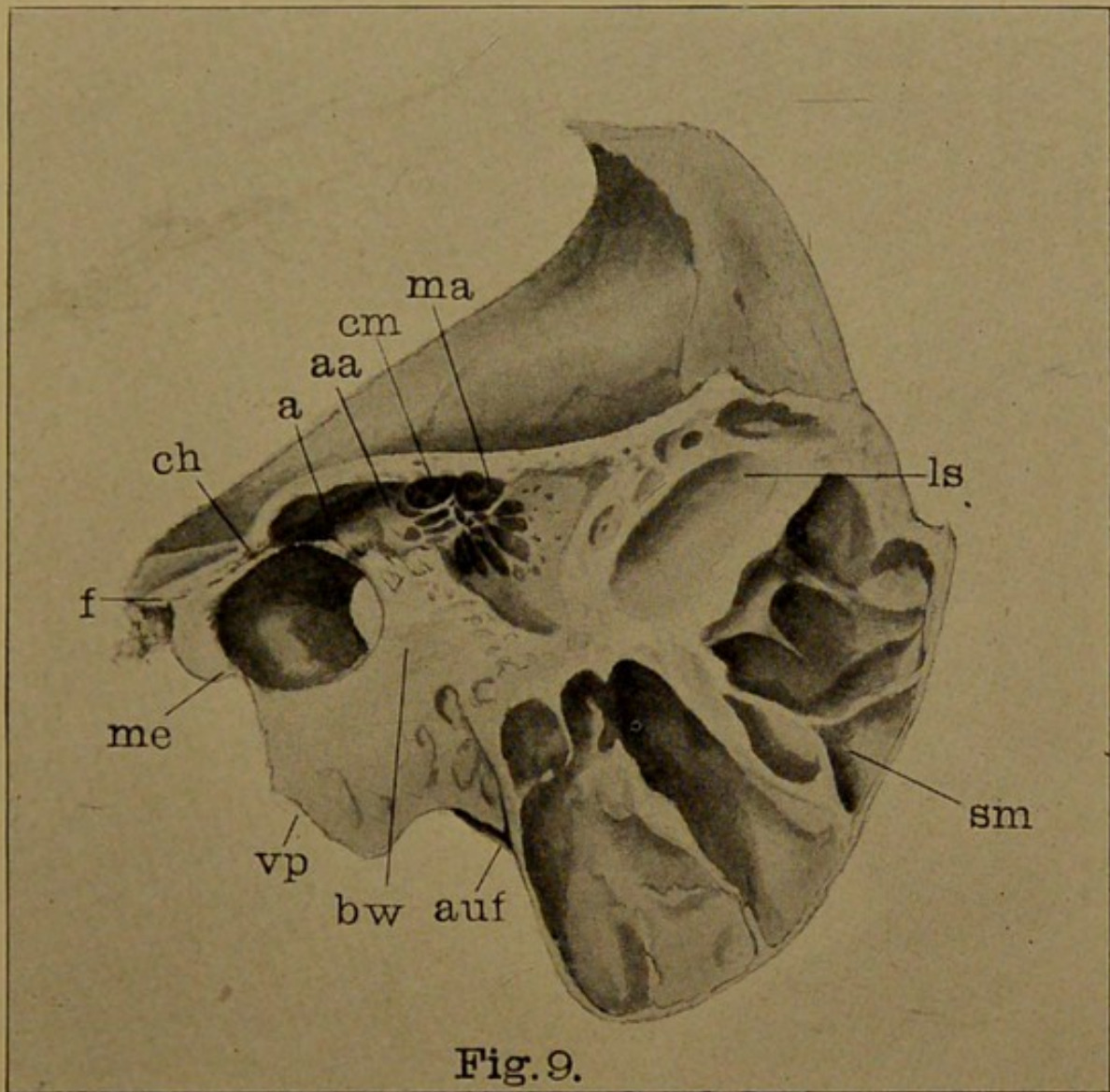


Fig. 9.

FIG. 9 represents the outer portion of the bone depicted in Fig. 8. The relative positions of the attic, antrum, meatus and lateral sinus, middle and posterior cerebral fossæ, are accurately shown.

a—Attic. aa—Aditus ad antrum. auf—Auricular fissure. bw—The bony wall separating the antrum and meatus. ch—Canal of Huguier: iter chordæ anterioris. cm—A collection of mouths of the channels that communicate between the mastoid cells and antrum. f—Glasserian fissure. ls—Lateral sinus: the sulcus sigmoides. ma—Mastoid antrum. me—External meatus. vp—Vaginal process. sm—Section of mastoid.



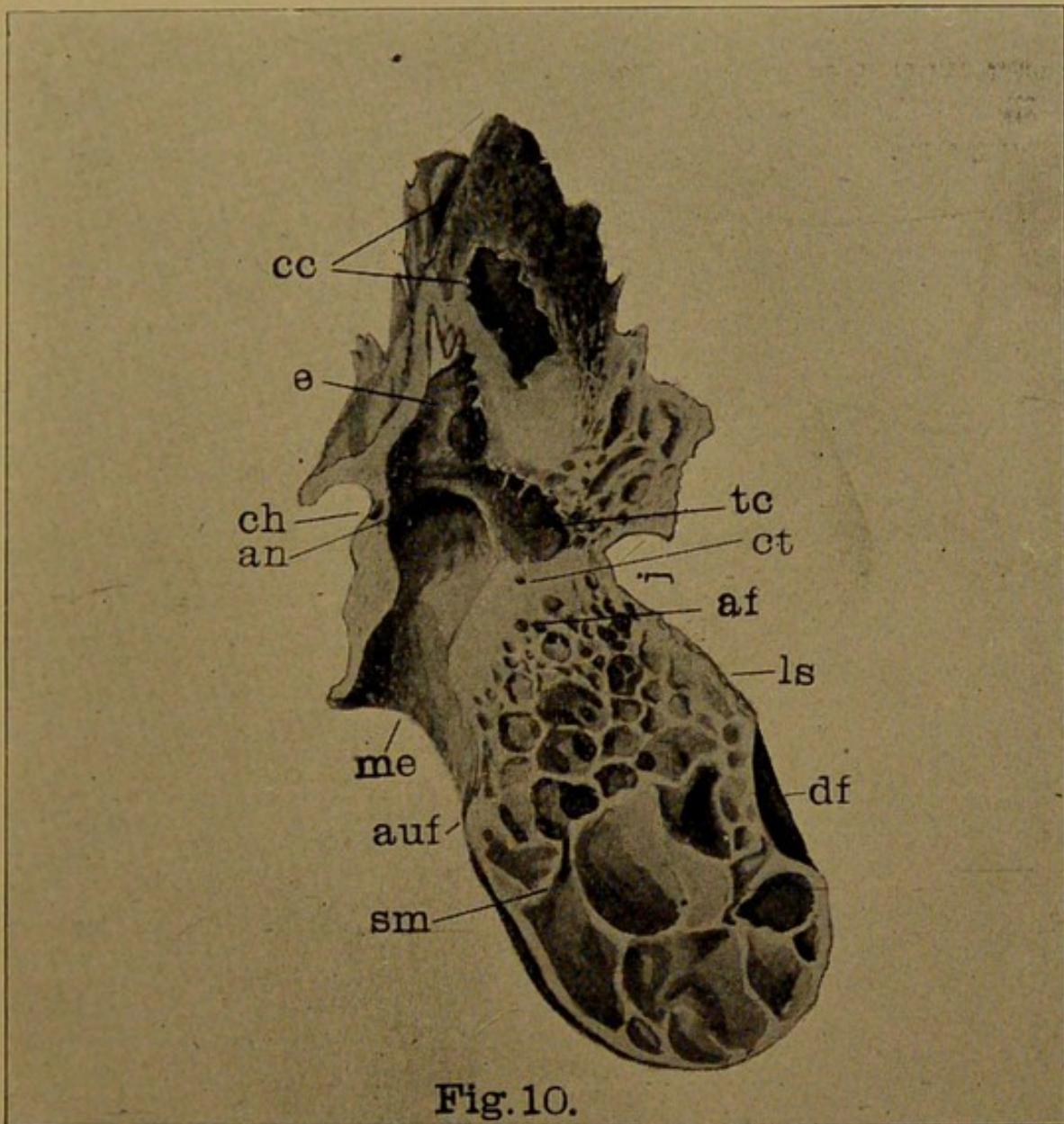


Fig. 10.

FIG. 10. A view of the lower section of the bone shown in No. 6. It shows the form of the lower half of the meatus, the deep position of the lower margin of the Mt., the relation of the carotid canal, jugular fossa, and Eustachian tube to the floor and inner wall of the tympanum, the meatus and mastoid process.

af—Aqueduct Fallopii. an—Annulus tympanicus. auf—Auricular fissure. cc—Carotid canal. ch—Canal of Huguierer: iter chordae anterior. ct—Iter chordæ posterior. df—Digastric fossa. e—Eustachian tube. j—Jugular fossa. ls—Position of the lateral sinus. me—External meatus. sm—Section of the mastoid. tc—Tympanic cavity.



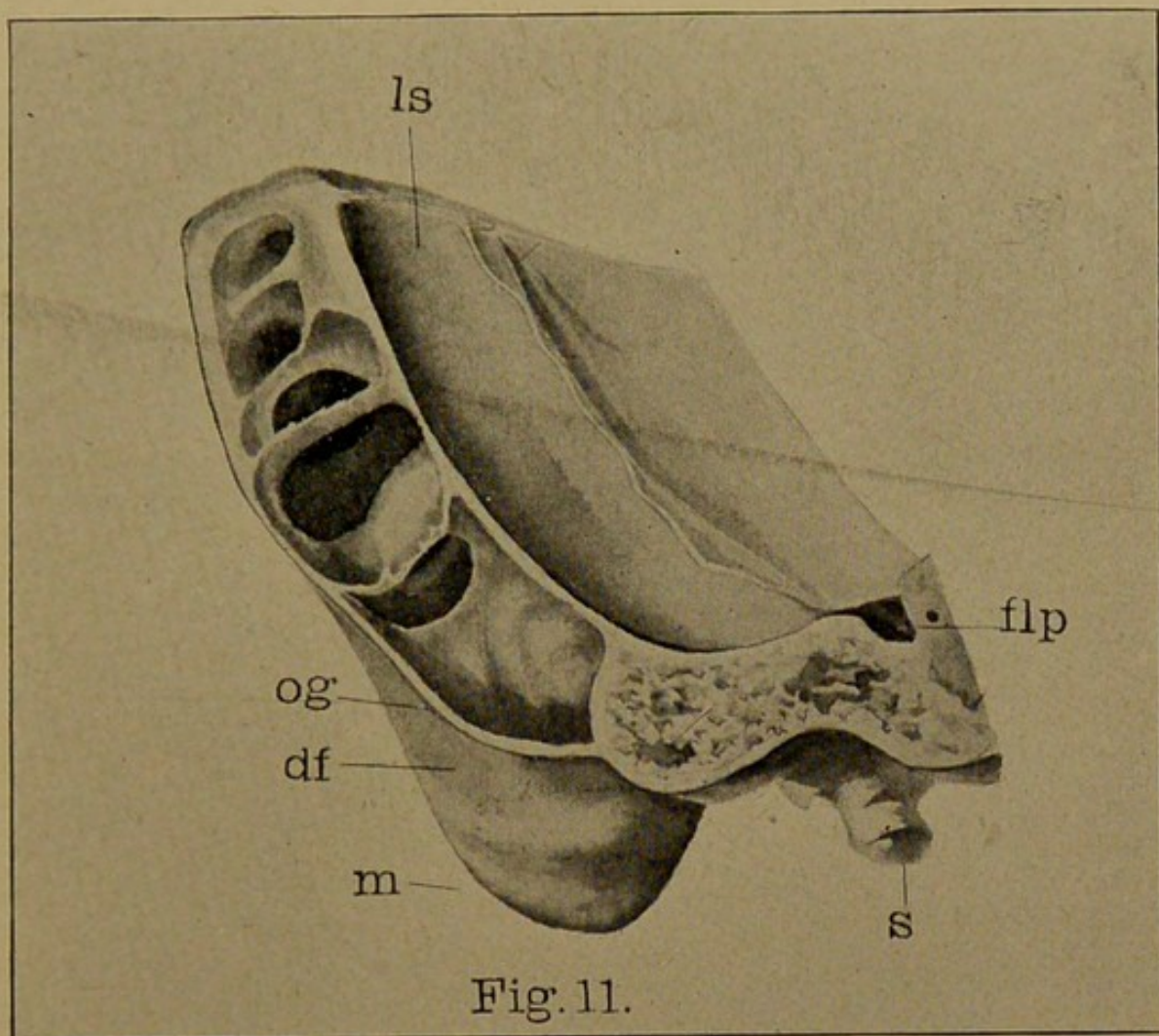


FIG. 11. A section of the temporal bone cut 3-8 of an inch behind the posterior border of the mastoid process, or 1 1-8 inches behind the posterior wall of the meatus—see arrows in Fig. 1. The top of the section is 1 3-8 inches above the tip of the mastoid process, and on a level with the roof of the tympanum. The specimen, which has been preserved in alcohol, shows an enormous development of the pneumatic cells, which extend far beyond the usual situation. The lateral sinus is seen partially removed, extending to the opening of the jugular foramen. There was nothing in the external appearance of this bone that would indicate the great magnitude and situation of these cells, and they were only determined after sectioning the bone. These pneumatic cells extended 1-4 of an inch further backwards than the section, *i. e.*, 5-8 of an inch beyond the posterior border of the mastoid. The thickness of the skull where the cells are shown is 7-16 of an inch. The pneumatic cells have very thin walls, and freely communicate with one another; the bony wall separating them from the lateral sinus is also extremely thin, more so than in any skull I have examined. The styloid is covered with remains of various ligamentous attachments.

df—Digastric fossa. flp—Foramen lacerum posterius. ls—Lateral sinus; sigmoid flexure. m—Mastoid process. og—Occipital groove. s—Styloid process.



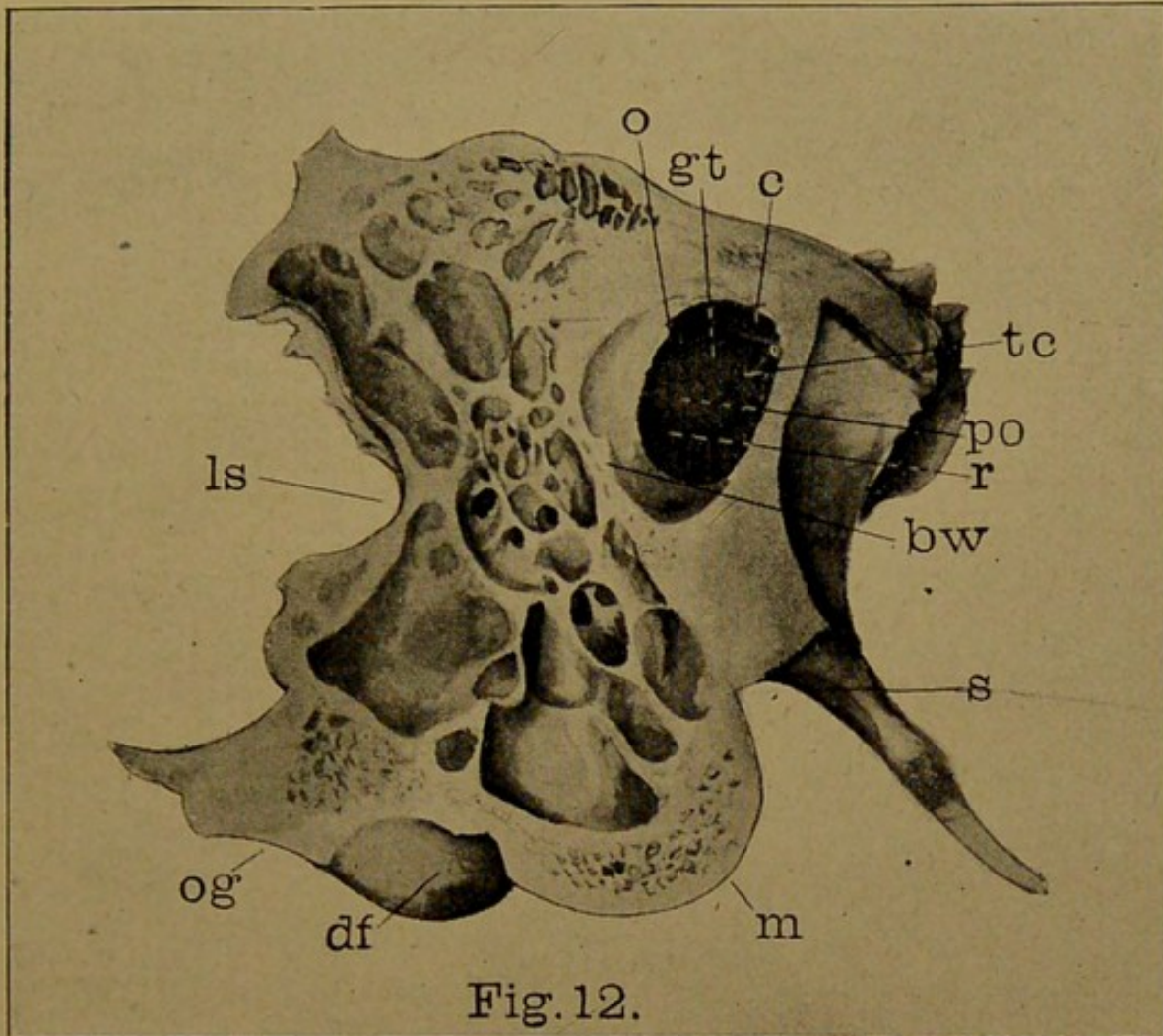


Fig. 12.

FIG. 12. An outwardly curved section of the temporal bone, nearly parallel to and about $\frac{1}{4}$ of an inch from its surface. It is a particularly important section to show the relation between the lateral sinus and the meatus, and the breadth of the field of operation in trephining the antrum. The bone is of the usual type, and the outer cells are separated from the antrum by a number of smaller ones with unbroken walls.

bw—Bony wall between the cavity of the mastoid and meatus. c—Processus cochleariformis. df—Digastric fossa. gt—Groove for tympanic plexus. ls—Lateral sinus: sulcus sigmoides. m—Mastoid. o—Fenestra ovale. og—Occipital groove. po—Promontory. r—Fenestra rotunda. s—Styloid process. tc—Tympanic cavity.



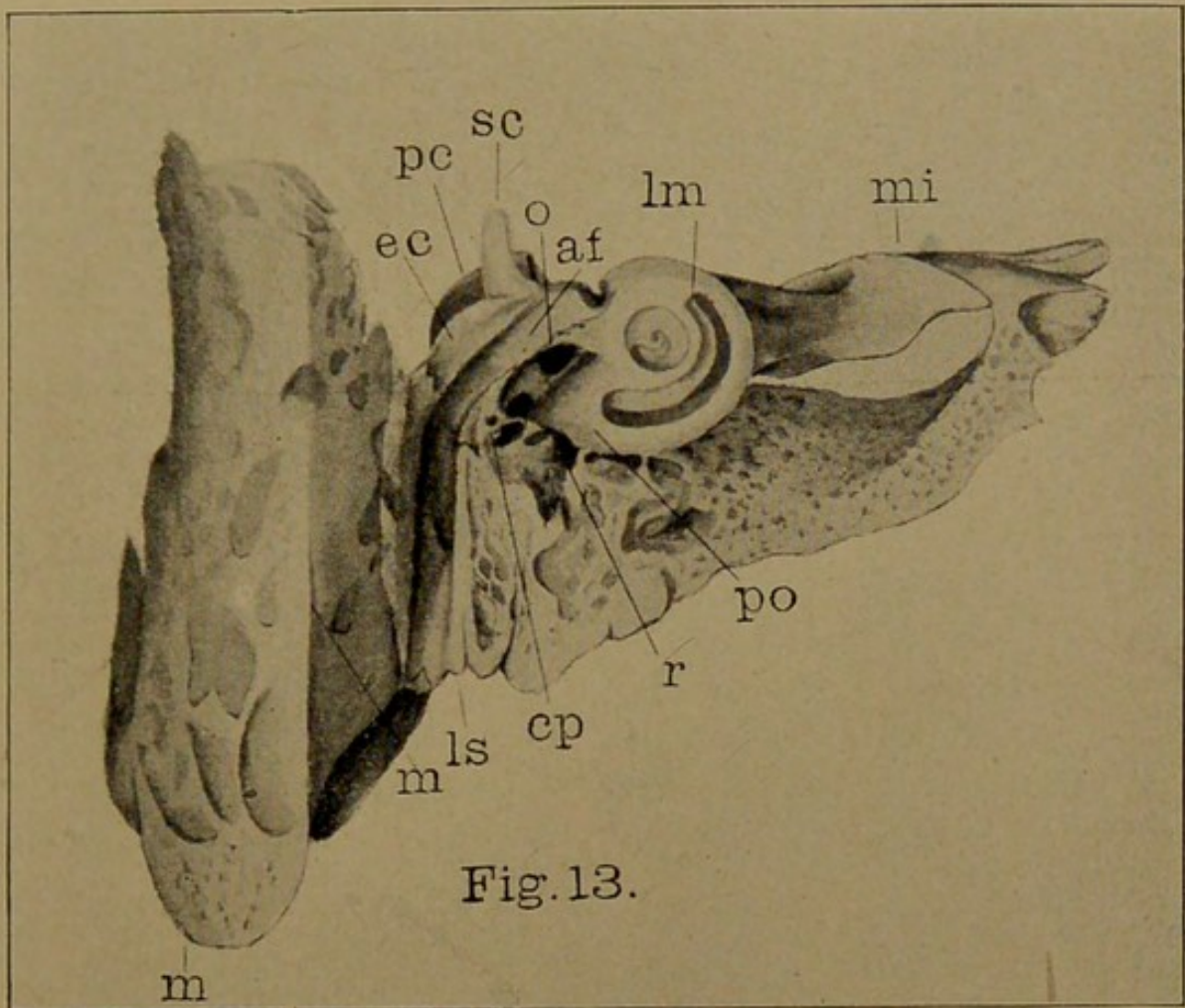


Fig. 13.

FIG. 13. Another view of the same bone depicted in Fig. 12. The cancellous bone and some other parts have been carefully removed, to show the internal auditory apparatus. The bony meatus and anterior wall of the tympanum have also been removed, and a section extends from the cut surface of the mastoid backward, as far as the facial canal, which has been exposed throughout its length. The relation of the external semi-circular and facial canals is well shown. That part of the posterior wall of the tympanum including the round and oval windows and a part of the promontory, has been left intact; the bone is viewed nearly at right-angles to its long axis, and obliquely to the side of the head.

af—Aqueduct Fallopii. cp—Cavity of the pyramid. ec—External semi-circular canal. lm—Section of cochlea showing lamina spiralis. ls—Position of the lateral sinus. m—Mastoid. mi—Meatus internus. o—Fenestra ovale. pc—Posterior semi-circular. po—Promontory. r—Fenestra rotunda. sc—Superior semi-circular.



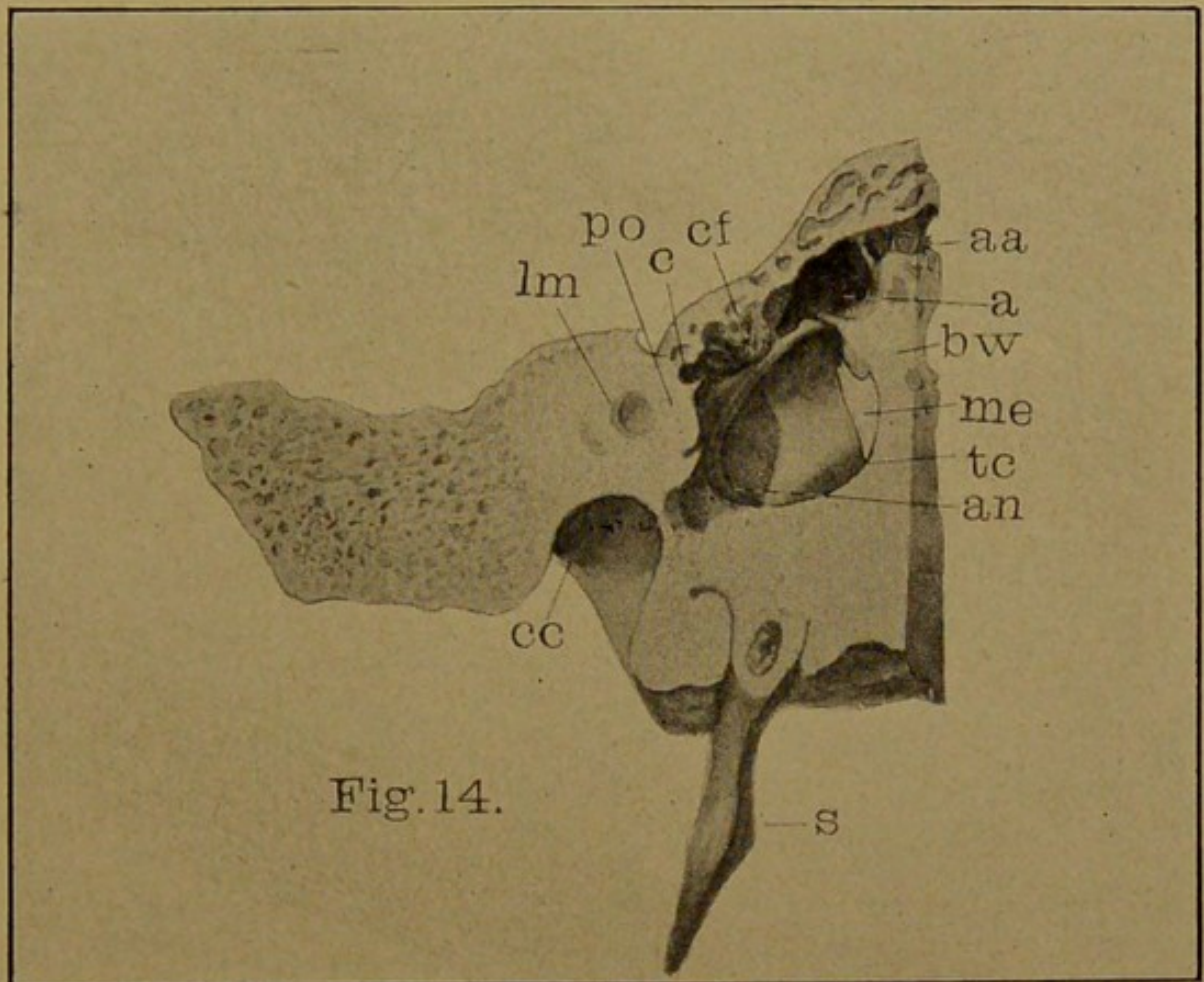


Fig. 14.

FIG. 14. A section removed from the bone depicted in the preceding figure, showing the relation of the attic and aditus to the external meatus, and the carotid canal to the floor and inner wall of the tympanum, promontory, and lower attachment of the Mt.

a—Attic. aa—Passage to antrum. an—Annulus tympanicus. bw—Bone separating meatus and antrum. c—Processus cochleariformi. cc—Carotid canal. cf—Channel for chorda tympani. lm—Section of cochlea. me—External meatus. po—Promontory. tc—Cavity of the tympanum.



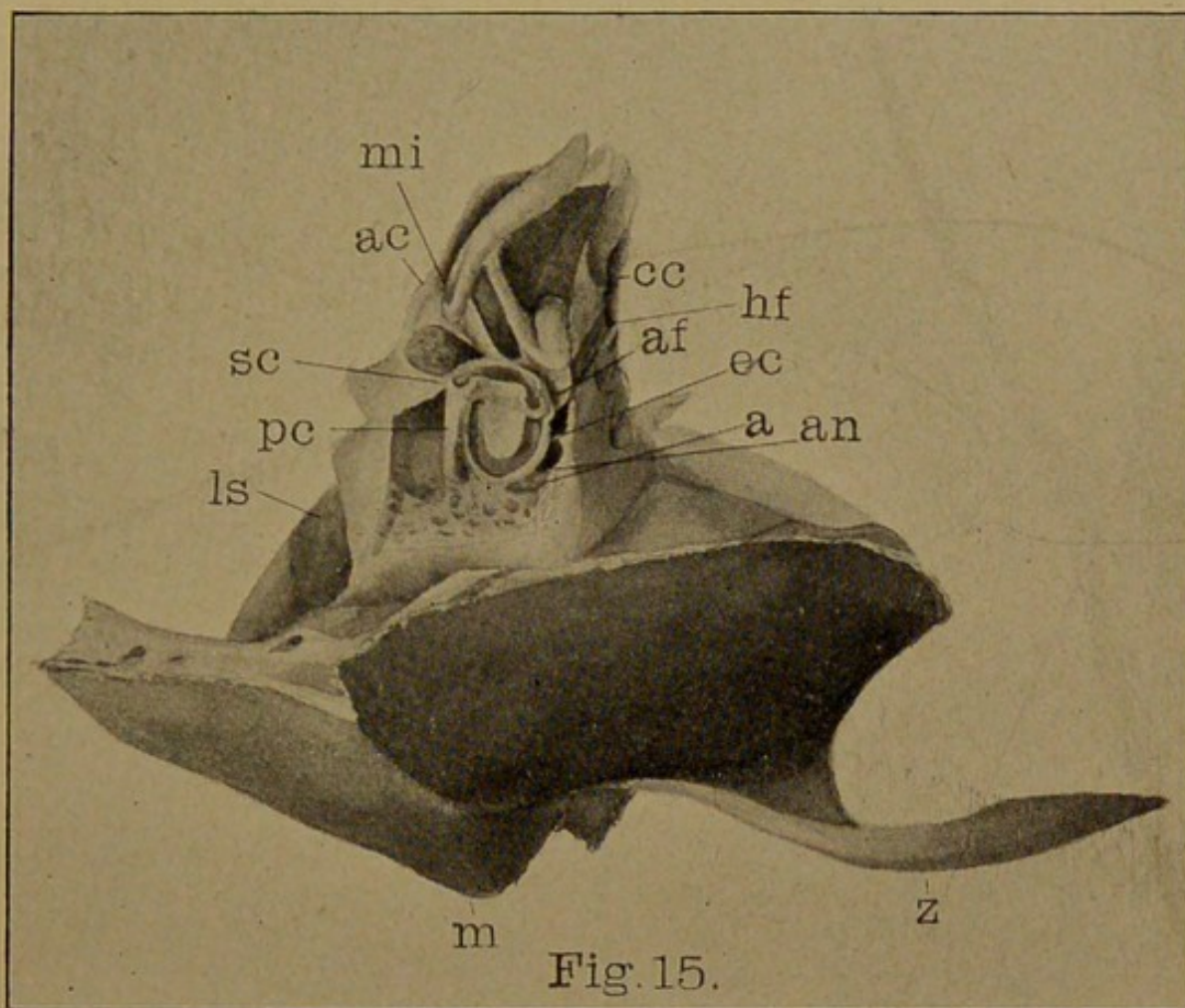


Fig. 15.

FIG. 15. A view of the temporal bone from above; the bone has been partially cut away to show the structure of the internal ear. The position of the lateral sinus is indicated by the groove on the left, or posterior side of the drawing.

a—Attic. ac—Aqueduct cochlea. af—Aqueduct Fallopii. an—Annulus tympanicus. cc—Carotid canal. ec—External semi-circular canal. hf—Hiatus Fallopii. ls—Lateral sinus: sulcus sigmoides. m—Mastoid. mi—Internal meatus. pc—Posterior semi-circular canal. sc—Superior semi-circular canal. z—Zygoma.



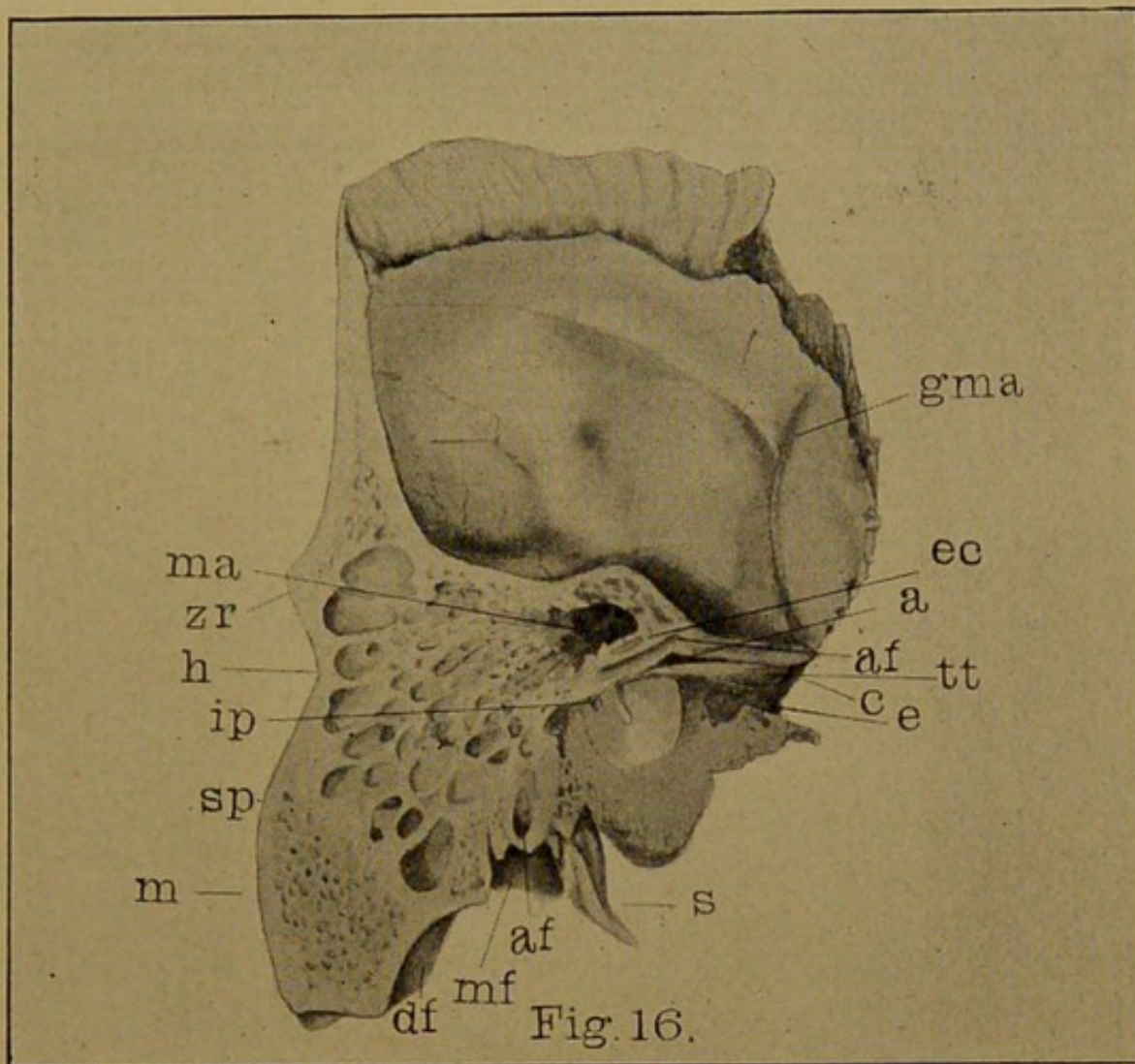


FIG. 16. A section of the temporal bone, beginning perpendicularly, $\frac{3}{8}$ of an inch behind the auditory meatus, and passing inward and forward in an inwardly curved direction to the inner wall of the Eustachian tube. The section has left the attic and antrum in the external half of the bone, and a part of the rounded prominence formed by the facial and external semi-circular canals, the relations of which are carefully depicted. The drawing shows the drumhead, the long processes of the incus and malleus, and a partially sclerosed mastoid.

a—Attic. c—Processus cochleariformis. df—Digastric fossa. e—Eustachian tube. ec—External semi-circular canal. gma—Groove for the posterior branch of the middle meningeal artery. h—Hollow below the zygomatic ridge. ip—Long process of the incus. m—Mastoid. ma—Antrum. mf—Stylo-mastoid foramen. s—Styloid process. sp—Elevated portion of mastoid. tt—Tensor tympani muscle. zr—Zygomatic ridge: temporal line.



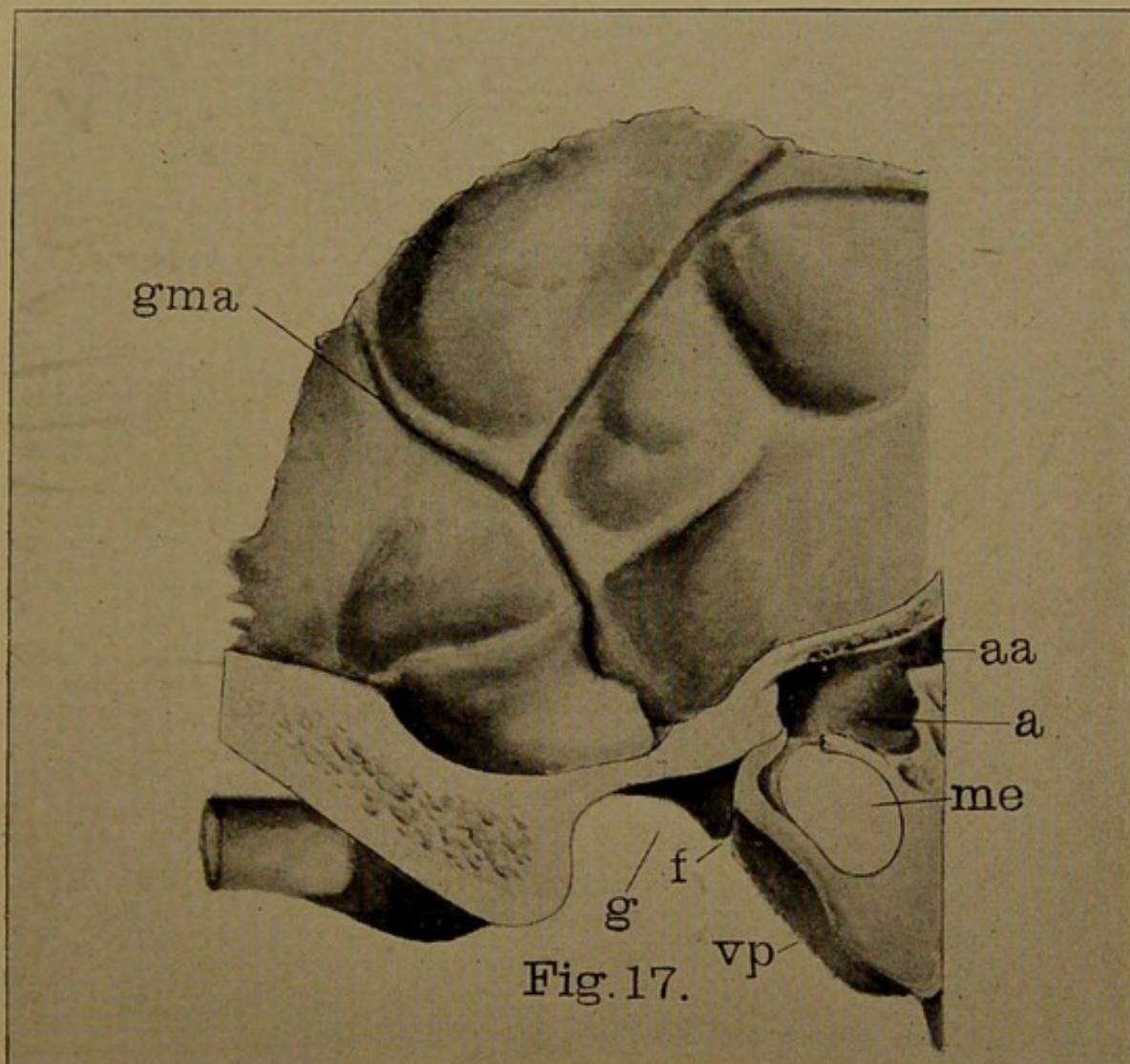


FIG. 17. A view of the squamous portion of the temporal bone, from within. The bone was sawn just internal to the superior attachment of the Mt. The cut shows the pars ossea membrana, the position of the meningeal artery, and the relation of the attic space to the external meatus.

a—Attic. aa—Passage to antrum. f—Glasserian fissure. g—Glenoid fossa. gma—Groove of middle meningeal artery, the posterior branch. me—External meatus. vp—Vaginal process.



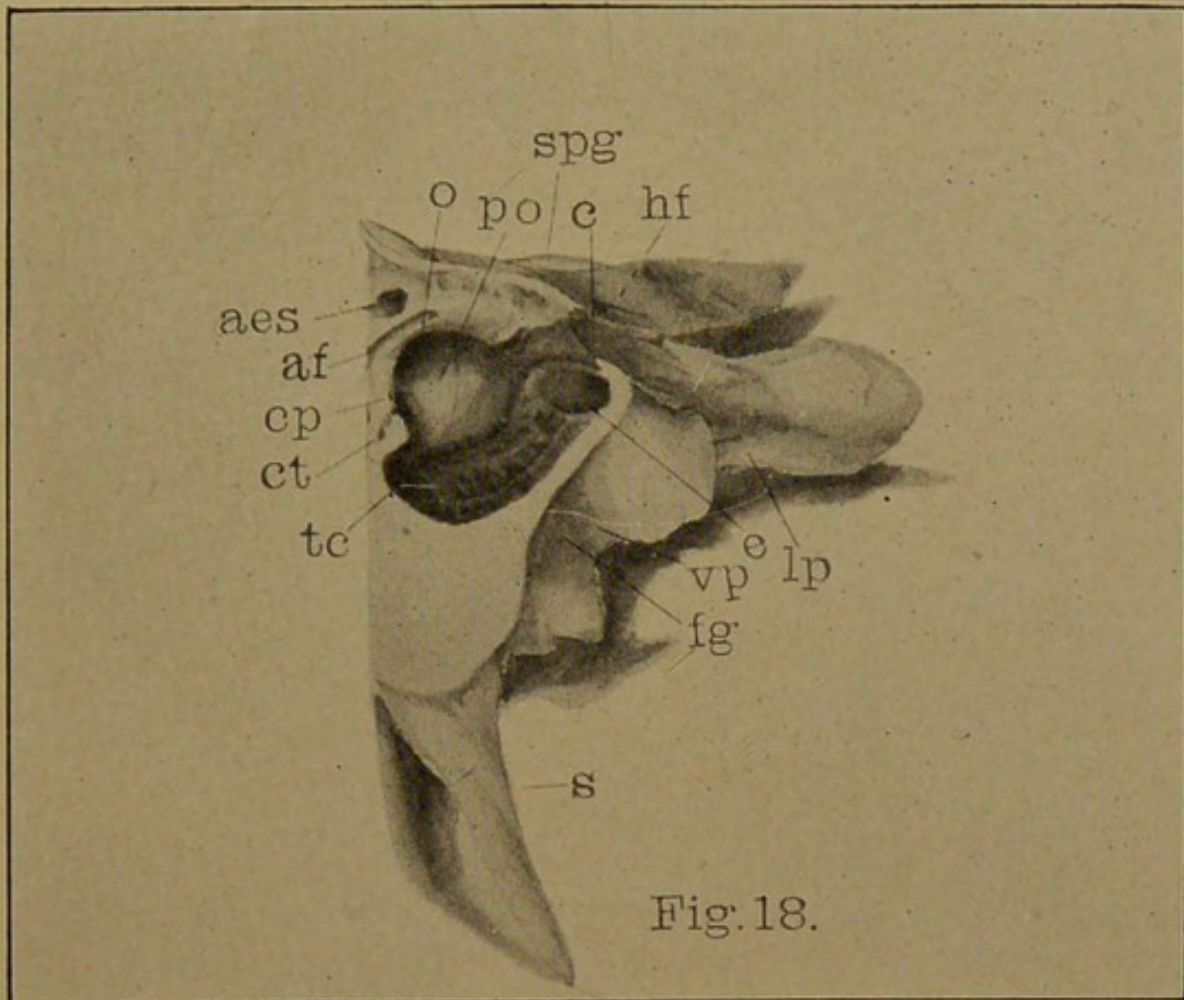


Fig. 18.

FIG. 18. The inner section of the bone represented in Fig. 17. The relation of the tympanum and its special parts to the meatus, which lies just external, is especially shown, the view being such as is seen through the meatus, but more extensive. The fossula fenestra ovalis, between the promontory and arch of the facial canal, with the oval window in its depth, is carefully shown.

aes—Section of ampulla of external semi-circular canal. af—Aqueduct Fallopii. c—Processus cochleariformis. cp—Cavity of pyramid. ct—Opening for chorda tympani. e—Eustachian tube. fg—Fossa for parotid gland. hf—Hiatus Fallopii. lp—Attachment of levator palati. o—Fenestra ovale. po—Promontory. s—Styloid process. spg—Superior petrosal groove for sinus. vp—Vaginal process.



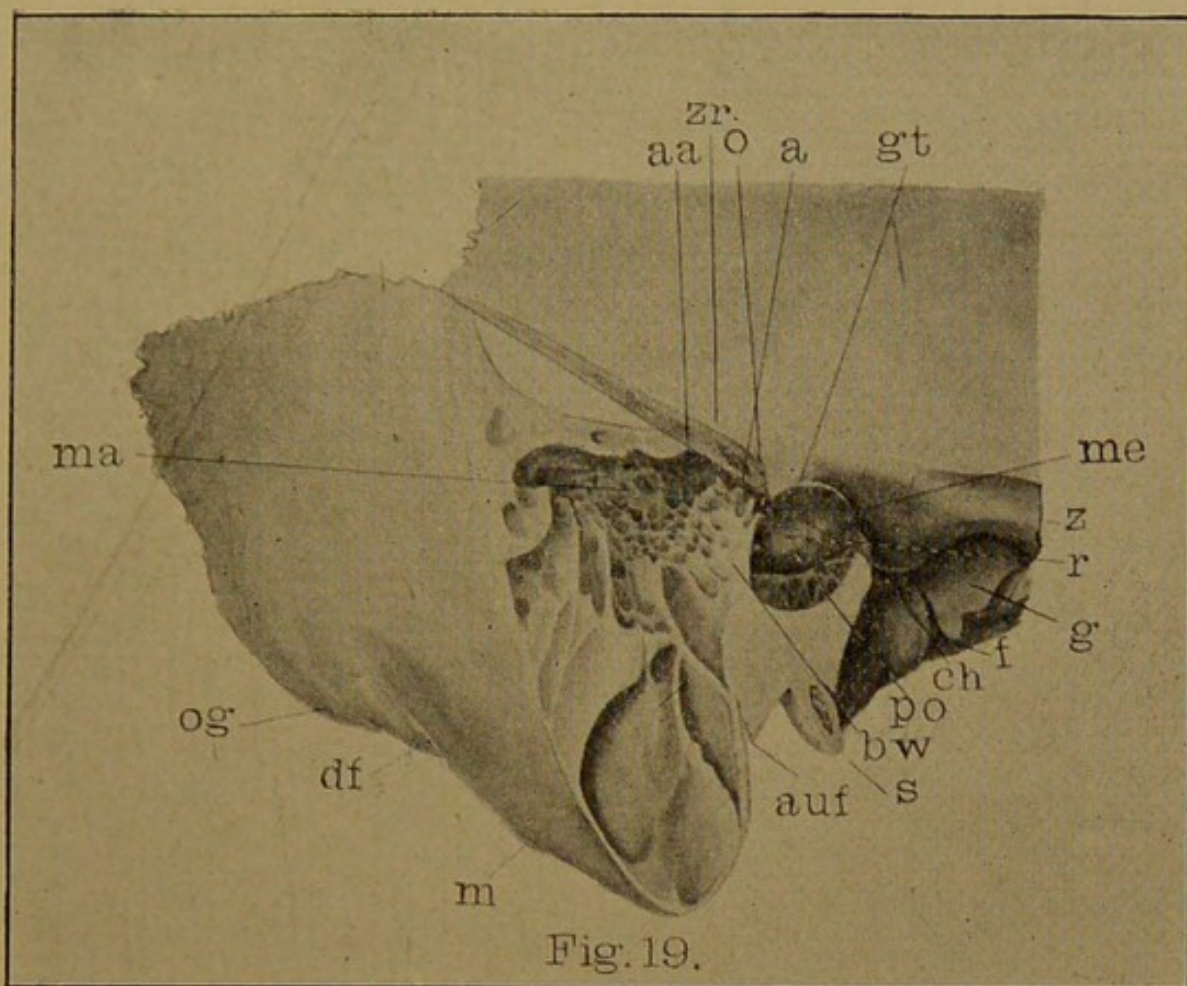


Fig. 19.

FIG. 19. A temporal bone from which a small section has been removed, beginning $\frac{3}{4}$ of an inch behind the centre of the meatus, and just taking in a small portion of the upper posterior quadrant of the annulus tympanicus. The section is external to the facial canal, but sufficiently deep to open the cavities of the mastoid, antrum, aditus, tympanum, and meatus. The mastoid is of a large pneumatic-cell type, and all the cavities in the process are in free communication with each other. The middle cerebral fossa has been opened, and its relation to the antrum and meatus is well shown.

a—Attic. auf—Auricular fissure. bw—Bony partition between the meatus and antrum. ch—Iter chordæ anterioris. df—Digastric fossa. f—Glasserian fissure. g—Glenoid fossa. gt—Groove for tympanic plexus. m—Mastoid. ma—Mastoid antrum. me—External meatus. o—Fenestra ovale. og—Occipital groove. po—Promontory. r—Fenestra rotunda. s—Styloid process. z—Zygoma. zr—Temporal ridge.



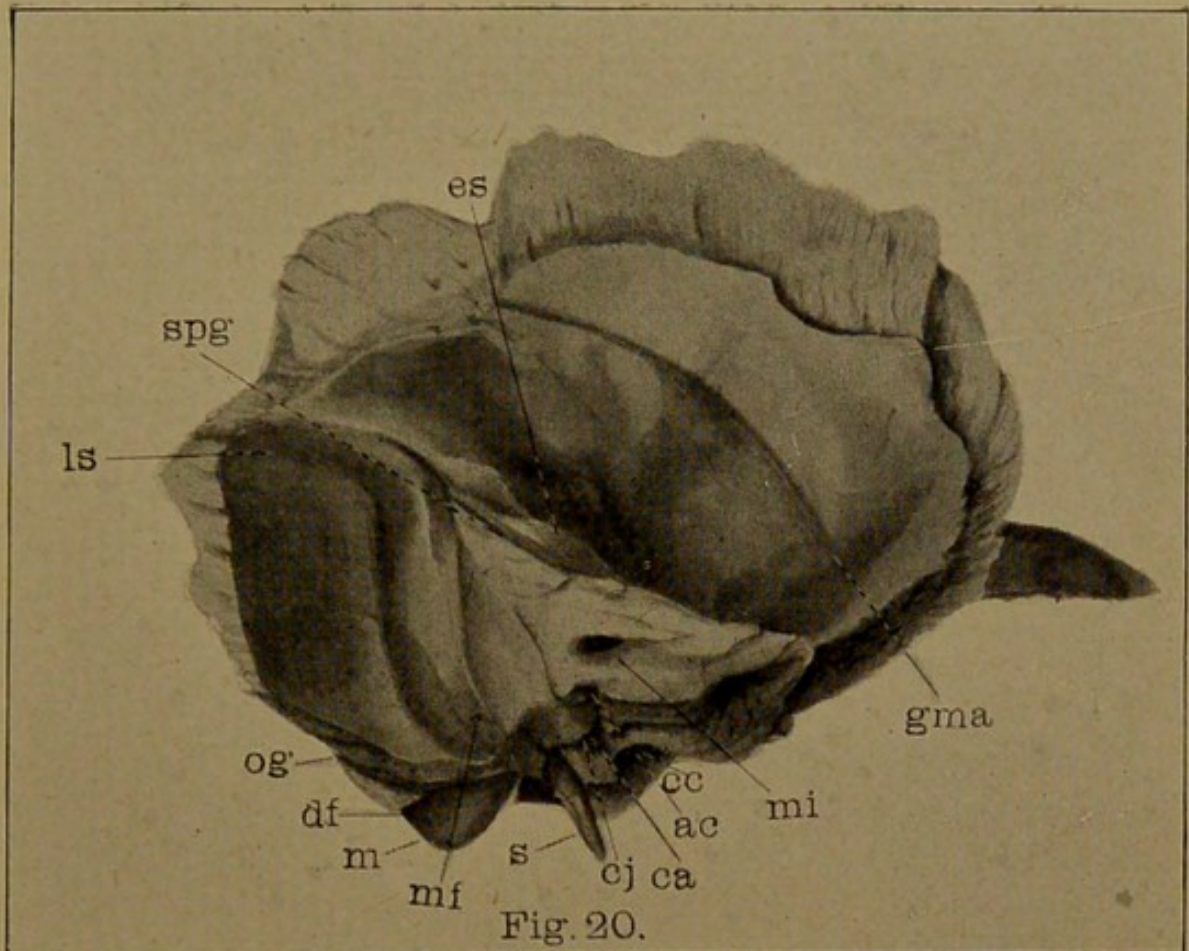
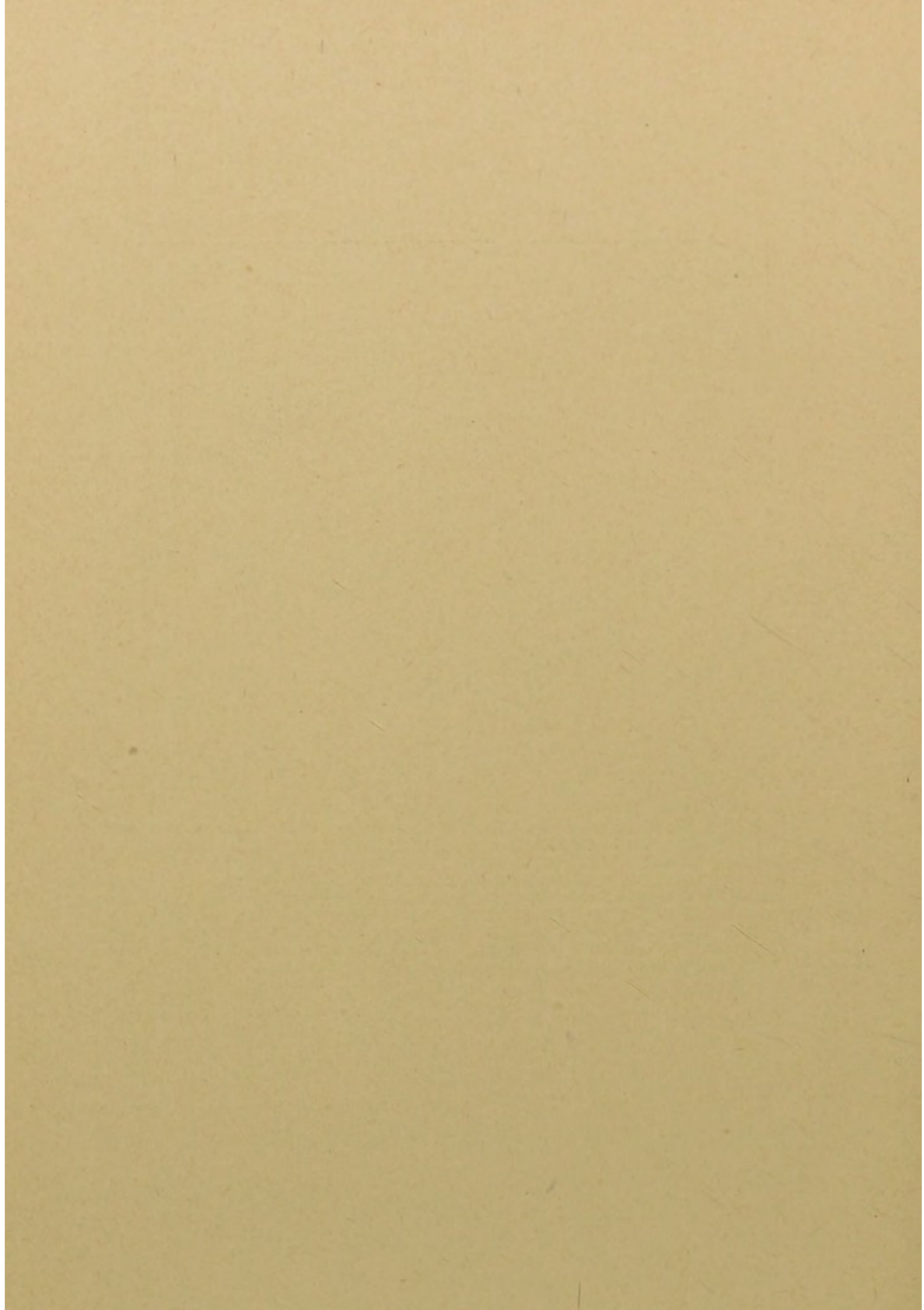
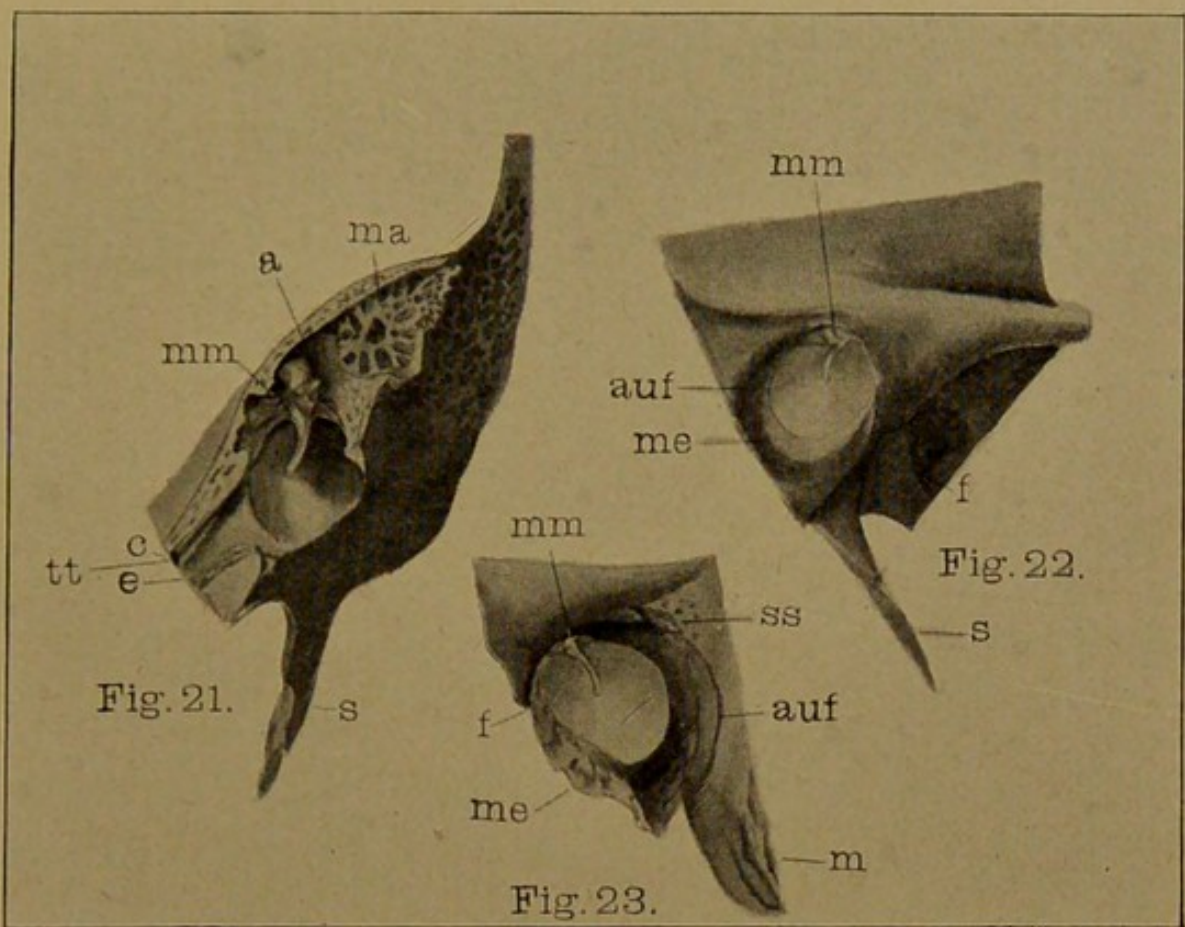


FIG. 20. A view of the temporal bone from within; it especially shows the relations of the petrous to the middle and posterior cerebral fossa, and the sigmoid sulcus, or lateral sinus.

ac—Aqueduct cochlea. ca—Opening for Arnold's nerve. cc—Carotid canal. cj—Opening for Jacobson's nerve. df—Digastric fossa. es—Eminence for superior semi-circular canal. gma—Groove for the posterior branch of the middle meningeal artery. ls—Lateral sinus: sulcus sigmoides. m—Mastoid. mf—Mastoid foramen. mi—Meatus auditorius internus. og—Occipital groove. spg—Superior petrosal groove for sinus.



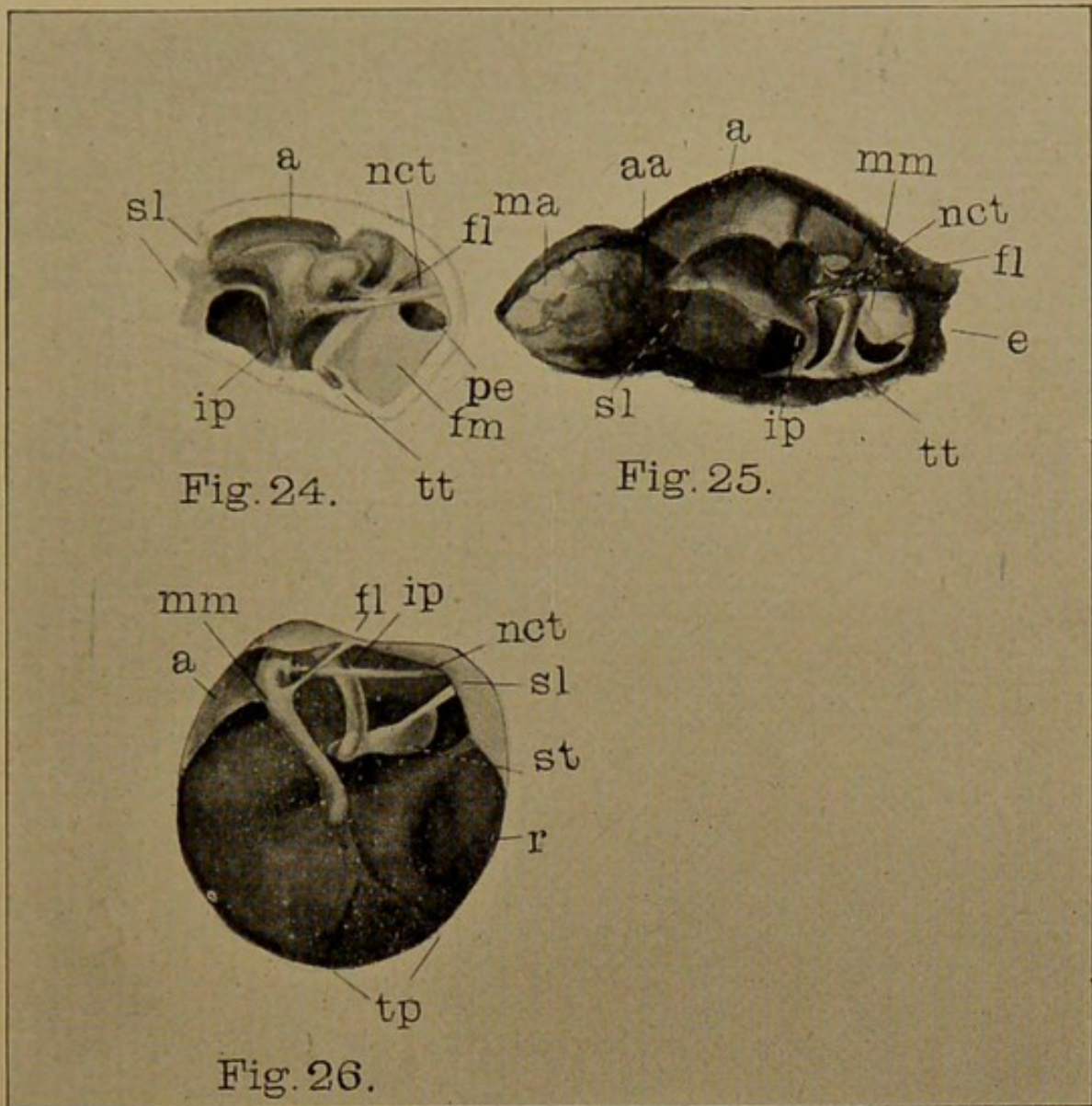


FIGS. 21-22. A view of a small portion of the right temporal bone, including the external meatus, the attic, external half of the Eustachian tube, with the drum and malleus *in situ*. Schrapnell's fold is not clearly defined, owing to changes due to drying. The drawings show how the head of the malleus is situated above the drum, out of view from the meatus, in a position which sometimes makes its removal difficult, especially when the long process is ulcerated away.

FIG. 23 is from the left temporal bone. It shows the position of the manubrium, and a view of the drum from without.

a—Attic. auf—Auricular fissure. c—Processus cochleariformi. e—Eustachian tube. f—Glasserian fissure. m—Mastoid. ma—Antrum. me—External meatus. mm—Manubrium. s—Styloid process. ss—Spina supra meatum.





FIGS. 24-25. A view of the tympanum from above, after removing a portion of the bone forming the roof. The folds of the mucous membrane are kept intact in Figure 24, except a small perforation—pe—which was made for the purpose of more strongly defining it in the drawing, and removed in Fig. 25. The incus and head of the malleus, with the malleo-incudal joint, are shown, also the long process of the incus, and its joint with the stapes, the tensor tympani, and attachments of the incus and malleus. In Fig. 25 there is a view of the manubrium and the retracted membrana tympani, with the light shining through it.

FIG. 26. A view of the left tympanum in a child at birth. The ossicles, muscles, and nerves are represented in place, after the drumhead has been dissected away.

a—Attic. aa—Aditus ad antrum. e—Eustachian tube. fl—Processus gracilis, with fibres forming a ligament. fm—Folds of mucous membrane. ip—Long process of the incus. ma—Antrum. mm—Manubrium: long process of malleus. nct—Nerve chorda tympani. pe—Perforation artificially made in a fold of the mucous membrane. r—Fenestra rotunda. sl—Tendon of the stapedius muscle. st—Stapes. tp—Tympanic plexus of nerves. tt—Tensor tympani muscle.



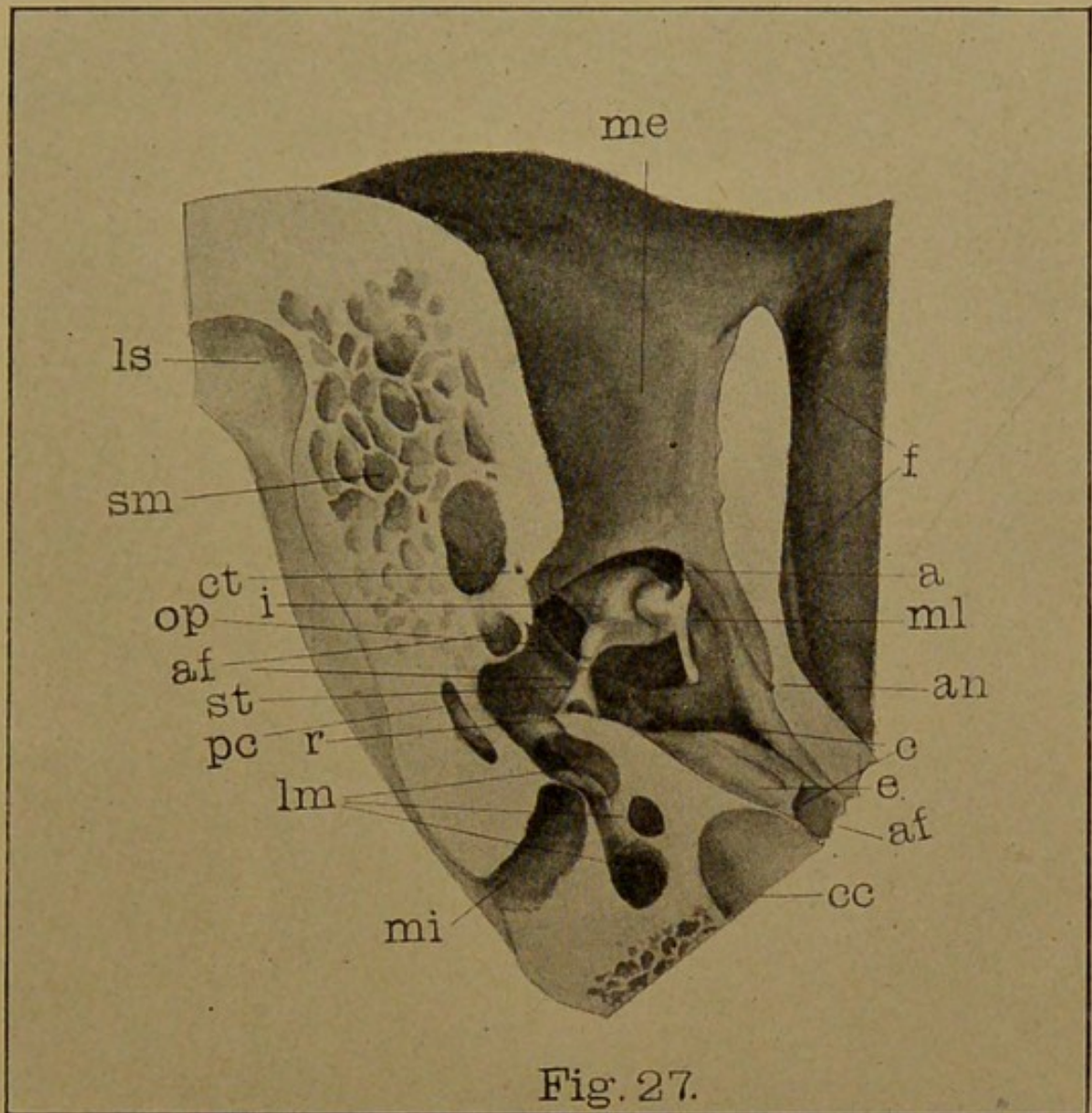
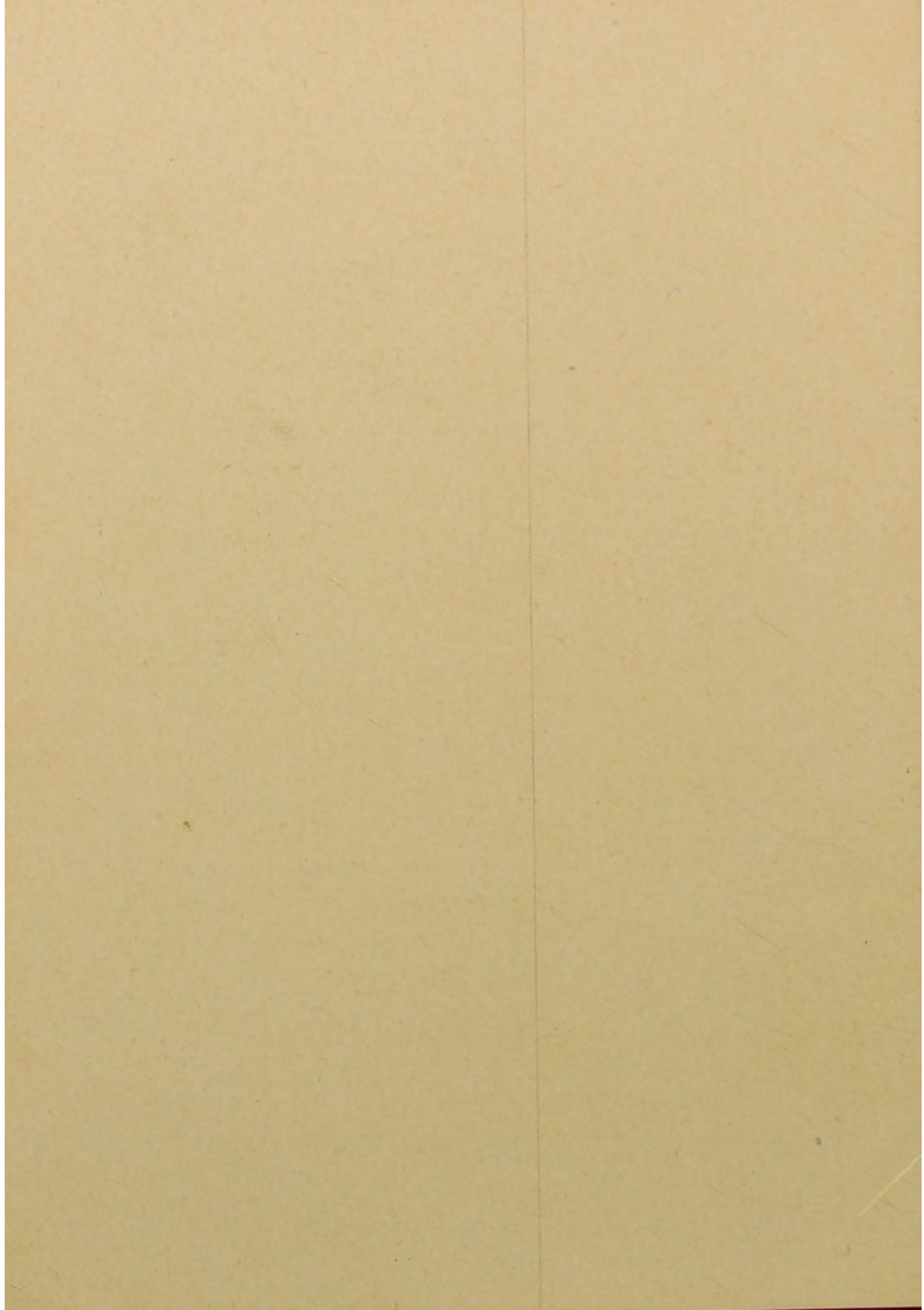


Fig. 27.

FIG. 27. The temporal bone has been sawn in two in a horizontal plane, at a level with the meatus. The ossicles are preserved in their natural position, and show how great an obstruction they offer to the discharges from the antrum through the aditus and attic to the tympanum and meatus. The position of the facial canal at this level is clearly defined, as well as the general topography of the upper portion of the tympanum, the internal meatus, promontory, and round window.

a—Attic. af—Aqueduct Fallopii. an—Annulus tympanicus. c—Processus cochleariformis. cc—Carotid canal. ct—Iter chordæ posterius. e—Eustachian tube. f—Glasserian fissure. i—Incus. lm—Section of the cochlea. ls—Lateral sinus: a part of sulcus sigmoides. me—External meatus. mi—Internal meatus. ml—Malleus. op—Opening in the pyramid. pc—posterior semi-circular canal. r—Fenestra rotunda. sm—Section of mastoid process. st—Stapes.



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