

NOTES ON THE EAR

BY

HORACE J. WHITACRE, M. D.

NEW YORK

1894

THE EAR.

THE ear, the organ of hearing, is subject to three general divisions: the external ear, the middle ear or tympanum, and the labyrinth or internal ear.

The **external ear** includes the pinna, that portion which projects from the head, and the external auditory canal which leads from this to the membrana tympani at the bottom. The general form of the **pinna** is concave, with a surface thrown into various hollows and elevations calculated to collect the sound-waves for transmission to the membrana tympani. The detail of the irregularities of its form is familiar and the designation of the various elevations and depressions can be sufficiently given in diagram. The structure is of a yellow fibro-cartilaginous plate covered by a thin skin, and certain ligaments intrinsic and extrinsic. In addition there are a number of small muscles of little significance.

The **meatus auditorius externus** is the canal, about one inch in length, extending from the concha to the membrana tympani. Its course is forward, slightly upward, and inward, then forward, inward, and downward. It has a cartilaginous and osseous portion. The former occupies less than one half the entire length of the canal, and is formed by an inflection of the cartilage of the pinna. The latter or osseous portion is narrower in calibre, and presents at its inner end a narrow groove, the **sulcus tympanicus**, which extends around the sides and floor of the meatus, but is deficient above. The membrana tympani is inserted into this sulcus. The **skin** of the canal is continuous with that of the pinna and is continued over the outer surface of

the *membrana tympani* as its outer layer. The osseous portion is free from hairs and glands, but the portion exterior to this is supplied by fine hairs and glands (*glandulæ ceruminosæ*) which secrete the ear-wax.

The Middle Ear or Tympanum.

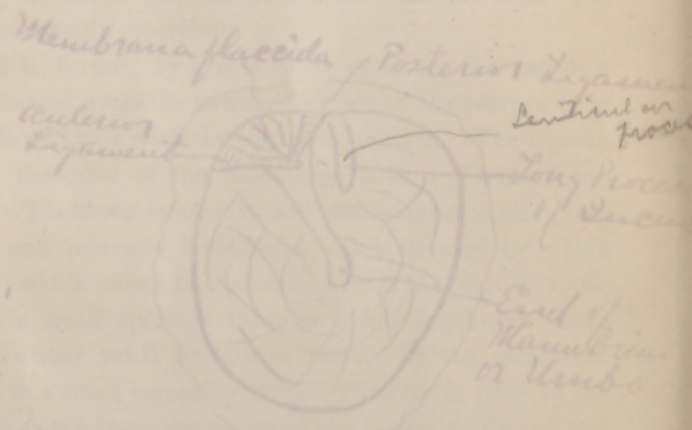
The **middle ear** is an irregular chamber, situated in the petrous portion of the temporal bone, at the bottom of the external auditory meatus. It is empty except for a chain of minute bones across the cavity. The cavity is made quite irregular by various prolongations or depressions (**tympanic recesses**), which are formed when a ligament or nerve stretching across the cavity is covered by a fold of mucous membrane from the wall. Six boundaries are usually described :

The **roof** is formed by a thin plate of bone, the **tegmen tympani**, situated upon the anterior surface of the petrous bone near the angle of union with the squamous portion. The tegmen also roofs in the canal of the Eustachian tube and tensor tympani muscle. The **floor** is narrow, and passes imperceptibly into the anterior and posterior boundaries. It is formed by a thin plate of bone which separates the cavity from the jugular fossa, and presents a small aperture through which Jacobson's nerve passes. The **outer wall** is formed mainly by the *membrana tympani*, but to a small extent by bone. Directly in front of the tympanic ring is the inner extremity of the Glaserian fissure, and very near to this is found the **iter chordæ anterioris**, a small opening for the **exit** of the chorda tympani nerve. The margin of the tympanic ring is incomplete above where the prominent anterior and posterior **tympanic spines** mark off the *incisura Rivini*, a notch at this point.

The **membrana tympani** is an elliptical membranous disk, about nine by ten millimetres, inserted into the *suleus tympanicus*



Outer Wall of Tympanum



Membrana Tympani as seen with Otoscope

at the inner end of the external auditory canal. Its long axis is directed downward and forward, and its plane, a very oblique one, inclined downward, forward, and toward the median line. This oblique placing makes the anterior wall and floor of the auditory canal much the longer. The handle of the malleus descends in contact with the membrane, between its middle and outer layers, and owing to its firm connection at the center and the inward direction of the bone the membrane is given a conical shape, depressed on the outer side. The membrane is about 0.1 millimetres thick, but becomes much thicker, as the **annulus fibrosus**, at its insertion into the sulcus tympanicus. From the anterior and posterior tympanic spines this thickened portion is prolonged as two ligamentous bands to the short process of the malleus, as the anterior and posterior **tympano-malleolar** ligaments, and form the lower boundary of the **membrana flaccida**. The membrane is made up of three elements: the middle fibrous layer or **tunica propria**; the outer covering, a prolongation from the skin of the external auditory meatus; and an inner covering, a portion of the lining membrane of the tympanum. The fibres of the tunica propria are in the main radial with a few circular. The integumental layer is thickened at the **umbo**, the most depressed part, and to some extent along the malleolar line. At the upper and anterior part of the membrane the stronger fibres stretch across the notch of Rivinus, which is occupied by the **membrana flaccida**, of much the same structure as the main membrane.

The **inner wall** of the tympanum is very uneven, and presents many important points. It separates the middle from the internal ear, and through it the communication is established between the two. Near the upper part is an oval opening into the vestibule, the **fenestra ovalis**, which in the recent state is closed in by the base of the stapes and **membrana obturatoria**, an annular ligamentous membrane. Its long axis is antero-

posterior, and about three mm. in length. Above this opening, and separating it from the roof is a tubular ridge indicating the course of the **Fallopian aqueduct**; while below is a more decided rounded prominence, the **promontory**, which represents the first turn of the cochlea, and is marked by numerous grooves for the tympanic plexus. Below and behind the promontory, situated at the bottom of a funnel-shaped depression, is another opening, the **fenestra rotunda**, which in the recent state is closed in by the **secondary membrane of the tympanum**. This membrane separates the tympanum from the **scala tympani**, and, like the membrana tympani, is made up of three elements—a tunica propria, and the lining membranes of the two cavities. A third fossa, the **sinus tympani**, is seen posterior to the promontory and between the two fenestræ.

The **posterior boundary** of the tympanum is mainly formed by the opening into the **antrum mastoideum**, a space of variable dimensions above and behind the tympanum proper. From this the mastoid cells branch off to form the mastoid portion of the temporal bone. The antrum and cells are lined by a mucous membrane directly continuous with that of the tympanum. Just below this orifice into the antrum is a depression for the attachment of the lower ligament of the incus. There is also a conical prominence, the **pyramid**, at this point, just below the antrum and behind the fenestra ovalis and sinus tympani. The apex of the pyramid gives exit to the stapedius muscle, which has its origin on the internal surface and its insertion into the neck of the stapes. In the angle of junction of the outer and posterior walls, on a level with the middle of the membrana tympani, is the **iter chordæ posterius**, the point of entrance of the chorda tympani nerve.

The tympanum gradually narrows **anteriorly** into two orifices, the Eustachian tube, and that for the tensor tympani muscle. The canal which lodges the **tensor tympani** is about

one half inch long, is placed above the Eustachian tube, and separated from it by a thin lamina of bone, the **processus cochleariformis**. The inner orifice of the canal is located just anterior to the fenestra ovalis, and is surrounded by an expansion of the bony lamina. The **Eustachian tube** is a bony and cartilaginous canal about one and a half inches long, extending from the tympanum to a point on the lateral pharyngeal wall just posterior to the inferior turbinated bone and above the hard palate. Its direction from the ostium tympanicum is downward, forward, and inward at a decided angle (about 45°). The **osseous portion** is one half an inch in length, has a funnel shape, with its expanded portion at the tympanic end, and is placed along the line of junction of the squamous and petrous portions of the temporal bone. The **cartilaginous** portion, one inch long, is funnel-shaped in the opposite direction, and is formed by an incomplete fibro-cartilaginous plate. The ostium pharyngeum is rather expanded, and is surrounded by the projection of the cartilaginous plate. The ridge posterior separates it from the **fossa** of **Rosenmüller**, a blind pouch. Through the Eustachian tube the mucosa of the pharynx becomes continuous with that of the tympanum.

The **lining membrane** of the tympanum forms folds over the various structures in such a way that small pouches are partially or wholly shut off. These are known as the pouches of the tympanum, and have received special names.

The **Small Bones** of the ear, the malleus, incus, and stapes, form an angular-jointed rod, extending from the membrana tympani to the fenestra ovalis, which transmits sound vibrations as received by the membrana to the internal ear.

The **malleus** (hammer) is placed in contact with the membrana tympani, and consists of a head, neck, handle, and two processes. The **head** is the rounded upper extremity, presenting on its posterior surface an elliptical articular facet with prominent margins for articulation with the incus. The lower edge

of the facet is prominent as the **spur** of the malleus. The **manubrium**, or handle, separated from the head by the constricted **neck**, is the tapering, slightly twisted point of the malleus which runs downward and inward along the inner surface of the membrana tympani. Its attachment to this membrane is periosteal and cartilaginous throughout its whole length. A small tubercle on its inner side marks the point of attachment of the tensor tympani muscle. The **processus gracilis** is a very slender process of bone extending at right angles from the neck of the malleus downward and forward to the Glaserian fissure, where it is connected by bony and ligamentous fibres. The **processus brevis** is a short, conical projection from the neck, which lies in contact with and is attached to the membrana tympani. *also 2 notes*

The **incus** (anvil) is shaped much like a tooth with two roots differing in size and widely separated. The body presents a saddle-shaped articular area on its anterior surface for articulation with the malleus. The **shorter process**, conical in shape, projects horizontally backward, and is movably articulated by ligaments with the posterior and outer walls of the tympanum near the entrance to the mastoid cells. The **longer process** tapers more gradually, and passes downward and inward parallel to the handle of the malleus, mesial to and behind it. At the extremity it is sharply turned inward, and presents a tubercle, the **lenticular process**, marked off by a narrow neck. The lenticular process articulates with the head of the stapes.

The innermost bone of the chain, the **stapes**, is horizontally placed, and bears a close resemblance to a stirrup. The **head** articulates with the long process of the incus. The **base** is an oval plate of bone which fills the fenestra ovalis, together with the annular ring of elastic fibrous tissue which allows of motion of the base. The **crura** diverge from the neck in a curved course to the ends of the base. The anterior crus is the shorter and straighter of the two.

The articulations of the small bones together are by regular joints with annular ligaments. Their connection with the tympanic wall is by several distinct ligaments. The **anterior ligament of the malleus**, formerly believed to be muscular, is a strong, broad band of fibres connecting the base of the processus gracilis and the part of the malleus just above this to the anterior wall of the tympanum, just external to the fissure of Glaser. Many of its fibres form the thickened anterior margin of the membrana flaccida. The **external ligament** of the malleus is fan-shaped, has its origin from the margin of the notch of Rivinus, and converges to the short process of the malleus. The **superior ligament** is a delicate, round bundle, passing downward and outward from the roof of the tympanum to the head of the malleus. It serves to check outward movement of the malleus and membrana tympani. The **ligament of the incus** is a short, stout band connecting the short process of the incus with the posterior wall of the tympanum, just below the orifice of the antrum mastoideum.

The **muscles** connected with these bones are the tensor tympani and the stapedius. The **tensor** tympani takes origin from the cartilaginous end of the Eustachian tube, the under surface of the petrous bone, and from the canal in which it is contained. Its tendon bends outward at nearly a right angle over the processus cochleariformis, and is inserted into the handle of the malleus near its base. Its **action** is to draw the whole malleus and membrana tympani inward, tightening the latter. It exerts very little rotating action on the malleus. The **stapedius** muscle is a distinct small muscle lodged in the interior of the pyramid. Its tendon emerges from the apex, passes forward in a fibrous sheath, and is inserted into the back part of the neck of the stapes. The muscle draws the head of the stapes backward, and in so doing presses the posterior part of the base inward, while the anterior part is drawn outward.

The Internal Ear or Labyrinth.

The **osseous labyrinth** is another cavity in the petrous portion of the temporal bone, for the reception of the most important organs of hearing. It does not consist of a single chamber, but of a series of regular spaces and passages which communicate with each other, and is constructed in conformity with the membranous labyrinth which is contained within it. The true osseous cavity consists of the vestibule, the cochlea, and the semicircular canals.

The **vestibule** forms a central chamber of the labyrinth, to some extent the place of reunion of the other parts, with the cochlea in front, semicircular canals posterior, and tympanum externally. It is an elliptical shell of bone with six walls. In the **outer** wall is seen the fenestra ovalis opening into the tympanum. Its **inner** wall is in contact with the outer end of the internal auditory meatus, and exhibits, running from above downward, a ridge of bone—the **crista vestibuli**. This is prominent above as the **pyramid of the vestibule**, while inferiorly it bifurcates to inclose the **recessus cochlearis**. The crest separates two fossæ, the anterior (**fovea hemispherica**) and the posterior (**fovea hemielliptica**). Behind the lower part of the crest is a small canal, the **aqueduct of the vestibule**. On the **anterior** wall is seen a large opening, communicating with the **scala vestibuli**, while on the **posterior** wall are the five openings into the semicircular canals.

The **semicircular canals** are three tubes, each forming about two thirds of an ellipse, placed in planes perpendicular to each other, behind and above the vestibule; one extremity of each is dilated (the ampulla) at its point of origin from the vestibule. The contiguous ends of two of the canals are joined, and enter by a common orifice. The **superior** canal is nearly vertical, lies

transversely to the axis of the petrous bone, and forms a bulging (the *jugum pyramidale*) on its upper surface. The **posterior** canal, the largest, is also nearly vertical. Its ampulla is at the lower and back part of the vestibule, and its opposite end terminates in common with the superior. The **external** canal arches horizontally outward and backward, and opens by two distinct orifices into the vestibule.

The **cochlea** is a tapering osseous tube spirally wound about a central bony axis (the *modiolus*), to form a low cone, the base at the bottom of the internal auditory meatus, and its apex pointing downward, forward, and outward. The tube makes two and a half turns about the *modiolus*, and ends by a closed extremity, the **cupola**. This tube is partly divided along its whole extent by a thin osseous plate, the **spiral lamina**, which projects horizontally from the *modiolus*. The division is made complete in the recent state by membranous structures, into the **scala tympani** below and **scala vestibuli** above, which communicate only by a small opening at the apex of the cochlea known as the **helicotrema**. The upper end of the lamina, the **hamulus**, is hooklike, and bounds the *helicotrema*. The **scala tympani** begins at the *fenestra rotunda*, where it is separated from the tympanum by the secondary membrane of the tympanum. The **scala vestibuli** begins in the vestibule. The **modiolus**, a central bony axis for the cochlea, is traversed by many small canals for vessels and nerves and a larger **central canal** of the *modiolus*. Its base at the bottom of the internal auditory meatus presents the **foramen centrale**, which transmits nerves to pass through the central canal for the last turn of the cochlea, and the *tractus foraminulentus*, which transmits many small nerves for the remaining coil and a half.

The Membranous Labyrinth.

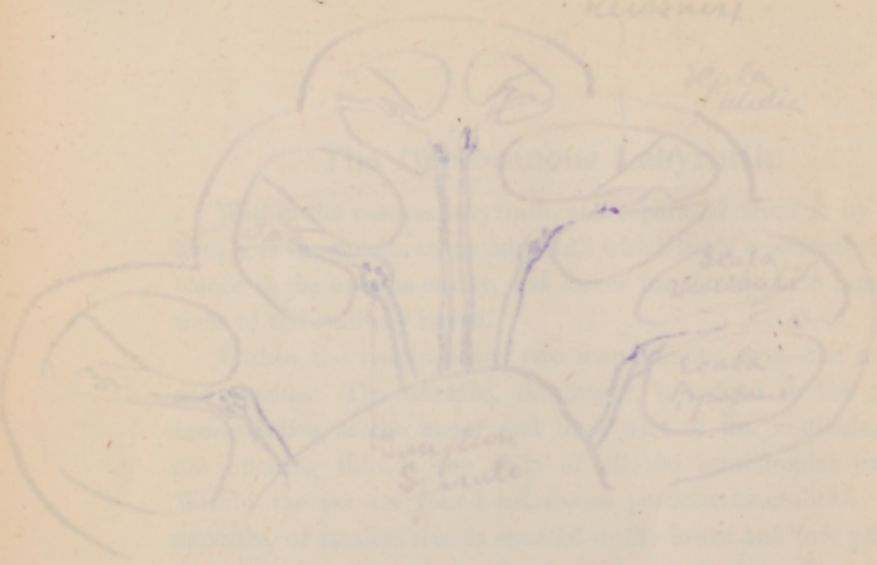
Within the osseous labyrinth, and separated from it by perilymph, is the membranous labyrinth which bears a general resemblance to the osseous cavity, and serves for the ultimate ramifications of the auditory nerve.

Within the vestibule are two membranous sacs—the utricle and saccule. The **utricle**, the larger, is lodged in the fovea hemielliptica, at the upper and back part of the vestibule, and has opening into it the ends of all the semicircular canals. Within the sac are found calcareous particles or otoliths. The **saccule**, of smaller size, is situated in the lower and fore part of the vestibule, and occupies the fovea hemispherica. It narrows below into a funnel-shaped duct, the **canalis reuniens**, which opens directly into the **canal of the cochlea** (scala media).

The **semicircular** canals are but one third to one fifth the diameter of the osseous tubes, and are made up of three layers—a fibrous outer layer, a tunica propria, and a flattened lining epithelium. The ampullæ more nearly fit their osseous cavities, and each presents on its inner surface a transverse projection, the **septum transversum**, which partly divides the cavity. The most prominent part of this septum is covered by columnar auditory epithelium surmounted by long conical filaments (auditory hairs), and is termed the **crista acoustica**.

The **membranous cochlea** is separated into three distinct parts, throughout its whole length, by two membranes. First, the **lamina spiralis** is directly prolonged by the strong **basilar membrane**, which stretches straight across to the outer wall of the cochlea and meets an inward prolongation of the periosteum known as the **spiral ligament**. In this way an upper boundary for the scala tympani is formed, but not a lower boundary for the scala vestibuli, because from the upper surface of the lamina

Membrana
Reissneri



Section Through Cochlea

Membrana
Reissneri

Cochlear Cells



Organ
of
Corti

Basilar
Membrane

Cochlear Duct
Cochlear Cells
Basilar Membrane

Section Through the Organ of
Corti.

spiralis, near its edge, a second delicate membrane, known as **Reissner's membrane**, stretches obliquely upward and outward to the outer wall of the cochlea. In this way a third triangular canal is formed throughout the entire length of the cochlea, known as the canal of the cochlea, or ductus cochlearis, or **scala media**. This canal is lined by variously modified epithelium, and claims greatest attention as the part of the cochlea most concerned in the function of hearing. It terminates in blind extremities at the apex (lagena) and base, but near the latter the small canalis reuniens establishes a communication between the saccule and this canal. The structures on the floor of this canal are of especial importance as making up the highly specialized **organ** of Corti. A detailed description of this region would be almost wholly one of the relations of the various parts of the organ to each other ; and the histological detail being unnecessary in an elementary treatise, it seems that accurate diagrams will serve to give a sufficient idea of the structure of the part.