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ATLAS AND EPITOME

OF

OTOLOGY

BY

GUSTAV BRÜHL, M.D.
of Berlin

WITH THE COLLABORATION OF

PROF. DR. A. POLITZER
of Vienna

AUTHORIZED TRANSLATION FROM THE GERMAN

EDITED BY

S. MacCUEN SMITH, M.D.
Clinical Professor of Otology, Jefferson Medical College, Philadelphia;
Otologist and Laryngologist to the Germantown
Hospital, Philadelphia

With 244 Colored Figures on 39 Lithographic Plates and 99
Text Illustrations

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EDITOR'S PREFACE.

THIS excellent little volume represents the work of a well-known and distinguished teacher, being characteristic of the thorough and comprehensive methods of German authors and instructors. The translator aims to give an accurate but liberal expression of the author's ideas, rather than a literal exposition of the German text. Some few additions and omissions were deemed necessary better to elucidate the English text, but are in no sense considered subversive of the author's views.

The book is both didactic and clinical in its teaching, the latter aspect being especially adapted to the wants of the student. The editor wishes to call particular attention to the very complete exposition of the minute anatomy of the ear, a working knowledge of which is so essential to an intelligent conception of the science of otology. The illustrations are beautifully executed in colors, and illuminate the text in a singularly lucid manner, portraying pathologic changes with such striking exactness that the student should receive a deeper and more lasting impression than the most elaborate description could produce.

The association of Professor Politzer in the preparation of the work, and the use of so many valuable specimens from his notably rich collection, should especially enhance the value of this treatise, which seems destined to fill a niche long vacant, an object never before attempted or attained, so far as the editor is aware, in the English language—viz., an illustrated clinical handbook to act as a worthy substitute for personal instruction in a specialized clinic.

It is to be hoped that the English translation will meet with the same cordial support that has been accorded the German edition, and thus prove of value to both the student and the teacher of otology.

1700 WALNUT STREET, PHILADELPHIA.
March 17, 1902.

PREFACE.

In September, 1898, Mr. J. F. Lehmann, of Munich, honored me with a commission to compile an atlas and abstract of otology for his series of Medical Hand-Atlases. The work was to contain "everything of importance in the elementary study of otology." I felt convinced that the success of such an atlas would depend on the plates representing pathologic specimens, which I believed would be rendered more intelligible by adding a number of plates illustrating anatomic specimens. This could be accomplished only by a careful selection from large masses of material; and as my own collection was quite inadequate, I addressed myself to my esteemed former chief, Professor Politzer, in Vienna, with a request to be allowed to select from his very extensive collection the specimens which I still lacked to complete the atlas. Professor Politzer in the kindest way placed his collection at my disposal for this purpose, and, further, gave me his valuable assistance by undertaking the supervision of the original pictures drawn from his preparations. I therefore wish to express my warmest thanks to Professor Politzer for his share in both the planning and the carrying out of the work. Professor Politzer's collection contributed thirty macroscopic and twenty-four microscopic preparations (indicated in the explanations of the plates by "P."); my own collection furnished fifty-four macroscopic and forty microscopic preparations (marked "B."). Besides these, there are twelve plates representing diseases of the auricle (five from Politzer), and forty-eight flash-light pictures of drumheads taken from patients in my polyclinic, and slightly enlarged. In addition to the explanation of the plates, the atlas was to contain an epitome with text figures. This epitome is my own exclusive work, and, as space was limited, had to be exceedingly condensed, especially in the part relating to special pathology and treatment. The anatomy of the ear is discussed somewhat at length, as I considered a thorough explanation absolutely necessary to enable the student to understand the plates.

The plates were prepared under my constant supervision by Mr. Hammerschmidt. The microscopic pictures drawn with Seibert's ocular are given in circular form, to save space. The dies for the figures of the instruments were made from models in the possession of the Medizinischer Warenhaus, who very kindly allowed me the use of them. Mr. Hammerschmidt deserves great credit for his faithful reproduction of the preparations and for the great care with which he prepared the figures in the text, and I wish to express to him my thanks for his unflagging industry. I also wish to express my thanks to the publisher, Mr. J. F. Lehmann, who spared no pains to make the atlas a success.

DR. GUSTAV BRÜHL.

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EXAMINATION.

PATHOLOGY AND TREATMENT.

LIST OF COLORED PLATES.

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Tab. 1.

Fig. 1.

a

Fig. 3.

Fig. 2.

b

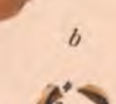

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PLATE 1.

Fig. 1. Left Temporal Bone of an Adult (B.).

1. Parietal border.
2. Squamous portion.
3. Groove for middle temporal artery.
4. Supramastoid crest (linea temporalis).
5. Zygomatic process.
6. Zygomatic tubercle.
7. Glenoid fossa.
8. Inferior process of tegmen tympani, or post-glenoid tubercle.
9. Petrosquamous suture.
10. Petrotympanic suture.
11. External auditory meatus.
12. Tympanic groove.
13. Suprameatal spine.
14. Mastoid fossa.
15. Squamomastoid suture.
16. Tympanomastoid fissure.
17. Styloid process.
18. Tympanic portion.
19. Mastoid portion.
20. Parietal notch.
21. Petrosal portion.
22. Mastoid foramen.
23. Mastoid (digastric) groove.

Fig. 2. Left Temporal Bone of New-born Infant (B.).

1. Tympanic ring or annulus.
2. Roof of external auditory meatus.
3. Inferior process of tegmen tympani, or post-glenoid tubercle.
4. Squamomastoid suture.

Fig. 3. Left Temporal Bone of New-born Infant, Disarticulated (B.).

(*a*) *Squamous Portion.*

1. Posterior border (squamomastoid suture).
2. Insertion of anterior limb of tympanic ring.
3. Upper border; notch of Rivinus.
4. Insertion of posterior limb of tympanic ring.
5. Glenoid fossa.

(*b*) *Tympanic Ring.*

1. Anterior tympanic tubercle.
2. Posterior tympanic tubercle.
3. Posterior (greater) tympanic spine.
4. Notch of Rivinus.

(*c*) *Petrous Portion.*

1. Mastoid process.
2. Mastoid antrum.
3. Tegmen tympani.
4. Fenestra vestibuli.
5. Fenestra cochleæ.
6. Sinus tympani.
7. Pyramidal eminence.
8. Prominence formed by facial canal.
9. Prominence formed by the lateral semicircular canal (tuberculum ampullare).
10. Cochleariform process.
11. Canal for carotid artery.
12. Groove in promontory for (Jacobson's) nerve.
13. Stylomastoid foramen.

PLATE 2.

Fig. 1. Left Temporal Bone of New-born Infant. Front View of Tympanic Membrane and Ossicles (B.).

1. Tympanic ring.
2. Notch of Rivinus.
3. Tympanic membrane.
4. Prominence formed by short process of malleus.
5. Streak formed by manubrium.
6. Umbo.

Fig. 2. Specimen No. 1. Seen from Within (B.).

1. Horizontal layer of squamous portion.
2. Roof of mastoid antrum.
3. Attic (epitympanic recess).
4. Malleus.
5. Slender or Folian process in Glaserian fissure.
6. Incus.
7. Stapes.
8. Chorda tympani.
9. Anterior malleolar fold.
10. Posterior malleolar fold.

Fig. 3. Left Temporal Bone of New-born Infant. Seen from Within (B.).

1. Petrosquamous suture.
2. Sigmoid groove.
3. External opening of the aquæductus vestibuli.
4. Eminentia arcuata.
5. Fossa subarcuata.
6. Prominence due to posterior semicircular canal.
7. Internal auditory meatus.
8. Foramen nervi facialis (area vestibularis).
9. Superior cribriform area.
10. Middle cribriform area.
11. Foramen singulare.
12. Foramen centrale cochleare and spiral cribriform tract.
13. Falciform crest.
14. External orifice aquæductus cochleæ.

Fig. 4. Chain of Ossicles. Lateral View. Right Side (× 3) (B.).

1. Malleus.
2. Tooth-process.
3. Incus.
4. Stapes.
5. Posterior limb of stapes.

Fig. 5. The Same. Median View (B.).

1. Tooth-process of incus.
2. Lenticular process.
3. Base of stapes.
4. Anterior limb.
5. Posterior limb.

Fig. 6. Left Chain of Ossicles. Lateral View (B.).

Fig. 7. Left Chain of Ossicles. Median View (B.).

Fig. 8. Left Chain of Ossicles. Isolated View (B.).

(*a*) *Malleus.*

1. Head of malleus.
2. Articular surface.
3. Neck of malleus.
4. Slender or Folian process.
5. Tooth-process.
6. Crest of malleus.
7. Short process.
8. Manubrium.
9. Umbilical surface.

(*b*) *Incus.*

1. Body of incus.
2. Short process.
3. Tooth-process.
4. Inferior articular surface.
5. Long process.
6. Lenticular process.

(*c*) *Stapes.*

1. Head of incus.
2. Anterior crus.
3. Posterior crus.
4. Base.
5. Sulcus stapedis.

Fig. 9. Malleus (1) **with Tensor Tympani Muscle** (2). **Life Size. Posterior View** (B.).

Fig. 10. Stapes (1) **with Stapedius Muscle** (2). **Life Size** (B.).

Tab. 2.

Fig. 2.

Fig. 1.

Fig. 4.

Fig. 5.

Fig. 3.

Fig. 6.

Fig. 8.

Fig. 7.

Fig. 9.

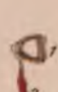

Fig. 10.

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Fig. 1.

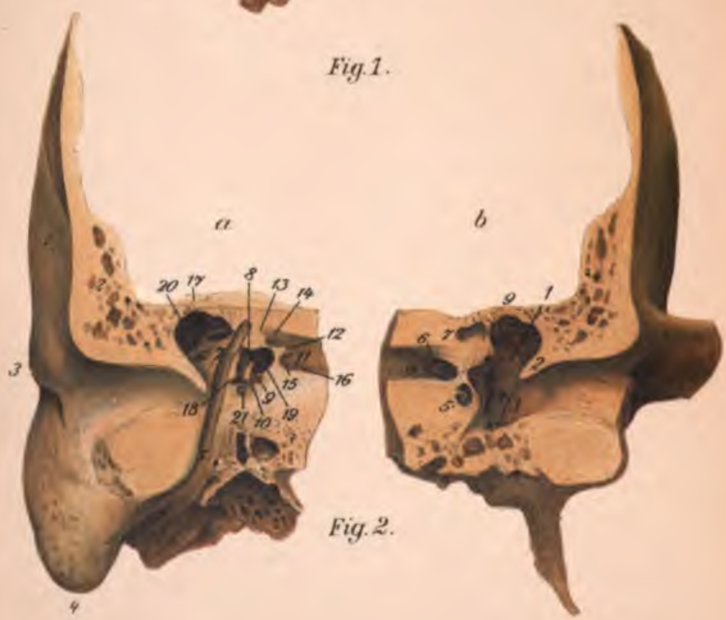

Fig. 2.

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PLATE 3.

Fig. 1. Sagittal Section through the Right Organ of Hearing of an Adult (B.).

1. Pinna.
2. Squamous portion of temporal bone.
3. Temporal muscle.
4. Skin.
5. Cartilaginous portion of external auditory meatus.
6. Tragi and ceruminous glands.
7. Parotid gland.
8. Mastoid process.
9. Cartilage of auditory meatus (floor).
10. Fissura Santorini major in cartilaginous portion of external auditory meatus.
11. Fissura Santorini minor in cartilaginous portion of external auditory meatus.
12. Triangular process.
13. Connective tissue.
14. Roof of auditory meatus.
15. Floor of auditory meatus.
16. Osseous portion of auditory meatus.
17. Styloid process.
18. Tympanic portion.
19. Recess of external auditory meatus.
20. Tympanic membrane.
21. Tympanic cavity.
22. Promontory.
23. Malleus.
24. Tegmen tympani and superior ligament of malleus.
25. Osseous portion of attic.
26. Prussak's space (superior recess of tympanic membrane), bounded above by the lateral ligament of the malleus, in front by Shrapnell's membrane, and below by the short process of the malleus.
27. Incus.
28. Stapes.
29. Facial nerve.
30. Vestibule.
31. Cochlea.
32. Internal auditory meatus.
33. Carotid canal.

Fig. 2. Sagittal Section through Right Temporal Bone.

(*a*) *Posterior Half.*

1. Squamous portion.
2. Cells in squamous portion.
3. Suprameatal spine.
4. Mastoid process.
5. Stylomastoid foramen communicating with facial canal.
6. Entrance to mastoid antrum.
7. Tuberculum ampullare.
8. Fenestra vestibuli.
9. Osseous portion of lamina spiralis.
10. Secondary portion of lamina spiralis.
11. Internal auditory meatus.
12. Falciform crest.
13. Foramen for seventh nerve.
14. Superior cribriform area.
15. Middle cribriform area.
16. Foramen singulare.
17. Roof of antrum.
18. Pyramidal eminence.
19. Vestibule, with opening of semicircular canals.
20. Mastoid antrum.
21. Tympanic sinus beneath the ponticulus.

(*b*) *Anterior Half.*

1. Attic.
2. Osseous portion.
3. Tympanic groove.
4. Tympanic opening of Eustachian tube.
5. Cochlea.
6. Facial nerve.
7. Spurious opening of facial canal.
8. Spiral cribriform tract.
9. Tegmen tympani.
10. Floor of tympanic cavity.

PLATE 4.

Fig. 1. Coronal Section through the Organ of Hearing of an Adult (B.).

1. Pinna.
2. External opening of auditory meatus.
3. Tragus.
4. Fissura Santorini major.
5. Anterior cartilaginous wall of auditory meatus.
6. Cartilage of pinna.
7. Fibrous portion.
8. Tympanic portion.
9. Floor of mastoid antrum.
10. Mastoid cells.
11. Transverse sinus.
12. Internal carotid.
13. Tympanic membrane.
14. Head of malleus.
15. Incus.
16. Stapes.
17. Tensor tympani muscle with tendon.
18. Geniculate ganglion of seventh nerve.
19. Lesser superficial petrosal nerve.
20. Great superficial petrosal nerve.
21. Auditory nerve.
22. Cochlear portion.
23. Vestibular portion.
24. Internal auditory meatus.
25. Dura mater.
26. Anterior ligament of malleus.
27. Ligament of incus.
28. Posterior ligament of auricle.

Fig. 2. Coronal Section through the External Ear of an Infant about Two Months Old (B.).

1. Eustachian tube.
2. Tympanic membrane, with cross-section of malleus.
3. Anterior wall of auditory meatus (lamina tympanica fibrosa).
4. Cartilaginous portion of auditory meatus, with fissure of Santorini.
5. Posterior portion of auditory meatus.
6. Pinna.

Fig. 3. Coronal Section through the Temporal Bone of an Adult. The Facial Canal Laid Open (B.).

1. External auditory meatus.
2. Sigmoid sulcus.
3. Mastoid antrum (floor).
4. Tympanic cavity.
5. Facial canal.
6. External semicircular canal.
7. Ampulla of superior semicircular canal.
8. Crus commune.
9. Posterior semicircular canal.
10. Superior opening of tympanic canaliculus.
11. Spurious opening of facial canal.

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Fig. 3.

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Tab.5.

Fig.1.

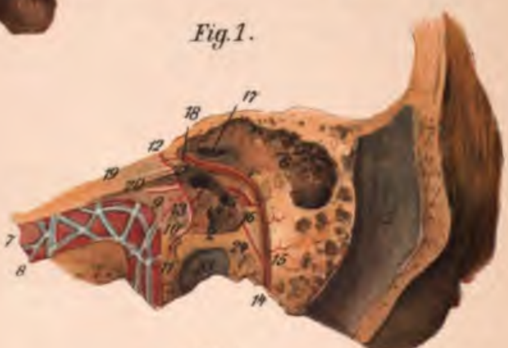

Fig.2.

Fig.3.

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PLATE 5.

Fig. 1. Petrous Portion of Left Temporal Bone of an Adult, with Eustachian Tube (B.).

1. Internal carotid.
2. Pharyngeal opening of Eustachian tube.
3. Isthmus.
4. Tympanic opening of tube.
5. Tensor tympani muscle as far as cochleariform process.
6. Air-cell in the floor of the Eustachian tube (cellula pneumatica tubaria).
7. Prominence formed by facial canal.
8. Prominence formed by external semicircular canal.
9. Mastoid cells.
10. Pyramidal eminence of stapes, from which the tendon of the stapedius muscle passes to the stapes.
11. Sulcus promontorii (groove for Jacobson's nerve).
12. Stapes in fenestra vestibuli.
13. Fenestra cochleæ.

Fig. 2. Petrous Portion of Temporal Bone, with Vessels and Nerves (In Part Diagrammatic) (B.).

1. Fenestra vestibuli within the fossula fenestræ vestibuli.
2. Fenestra cochleæ.
3. Ponticulus promontorii.
4. Subiculum promontorii.
5. Sinus tympani.
6. Mastoid antrum.
7. Internal carotid.
8. Plexus of veins around internal carotid.
9. Caroticotympanic nerve (lesser deep petrosal nerve, from the plexus about the internal carotid).
10. Inferior tympanic artery.
11. Glossopharyngeal nerve, with petrosal ganglion.
12. Superior tympanic artery.
13. Anastomosis of superior and inferior tympanic arteries.
14. Stylomastoid artery, lying on facial nerve.
15. Mastoid branches.
16. Nerve to stapedius muscle.
17. Horizontal semicircular canal (laid open).
18. Geniculate ganglion of seventh nerve.
19. Great superficial petrosal nerve.
20. Lesser superficial petrosal nerve.
21. Anastomosis of lesser superficial petrosal nerve with geniculate ganglion of seventh nerve.
22. Transverse sinus.
23. Superior bulb of jugular vein.
24. Chorda tympani and posterior tympanic artery (pass through apertura tympanica canaliculi chordæ).

Fig. 3. Posterior Surface of Petrous Portion of Temporal Bone, showing the Sinuses in Dura Mater and the Endolymphatic Sac (B.).

1. Trifacial nerve.
2. Superior petrosal sinus.
3. Inferior petrosal sinus.
4. Transverse sinus.
5. Bulb of jugular vein.
6. Tenth nerve (vagus).
7. Eleventh nerve (recurrens).
8. Ninth nerve (glossopharyngeal).
9. Occiput.
10. Saccus endolymphaticus.
11. Internal auditory meatus with seventh (facial) and eighth (auditory) nerves.
12. Mastoid process.

PLATE 6.

Coronal Sections Through Six Temporal Bones.—That portion of the mastoid process that projects over the osseous portion of the auditory meatus has been removed. The triangle *a b c*, in which *a* represents the suprameatal spine, *b* the outermost portion of the mastoid antrum, and *c* the outermost portion of the sigmoid sulcus, indicates the distances between these three points.

Fig. 1. Temporal Bone of an Infant Several Weeks Old (B.).

1, Tympanic ring; 2, mastoid process; 3, mastoid antrum; 4, sigmoid sulcus. *a b* = 2 mm.; *b c* = 10 mm.; *a c* = 12 mm.

Figs. 2–6. Adult Temporal Bones (B.). The figures being the same in all, as follows:

1. External auditory meatus.
2. Mastoid process.
3. Suprameatal spine.
4. Mastoid antrum.
5. Sigmoid sulcus.

Fig. 2. Diploëtic Mastoid Process. Section through Diploë. *a b* = 11 mm.; *b c* = 15 mm.; *a c* = 12 mm.

Fig. 3. Diploë-pneumatic Mastoid Process. *a b* = 7 mm.; *b c* = 10 mm.; *a c* = 11 mm.

Fig. 4. Pneumatic Mastoid Process (From Child). *a b* = 6 mm.; *b c* = 12 mm.; *a c* = 6 mm.

Fig. 5. Pneumatic Mastoid Process. *a b* = 9 mm.; *b c* = 11 mm.; *a c* = 16 mm.

Fig. 6. Sclerotic (Eburnated) Mastoid Process. *a b* = 11 mm.; *b c* = 12 mm.; *a c* = 7 mm.

Tab. 6.

Fig. 1.

Fig. 2.

Fig. 3.

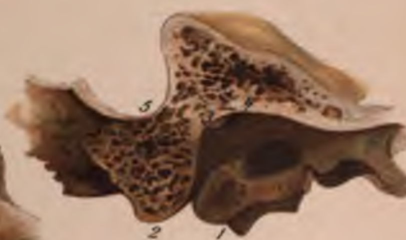

Fig. 4.

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Tab. 7.

Fig. 1.

Fig. 3.

Fig. 2.

Fig. 4.

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PLATE 7.

Fig. 1. Right Temporal Bone. The Semicircular Canals, the Canal of the Facial Nerve, and the Sigmoid Sulcus Exposed Through the Mastoid Process (B.).

1. Sigmoid sulcus.
2. Superior semicircular canal.
3. External semicircular canal.
4. Posterior semicircular canal.
5. Canal for facial nerve.
6. Posterior wall of auditory meatus.
7. Suprameatal spine.
8. Mastoid cells.

Fig. 2. Petrous Portion of Right Temporal Bone of a Child. Cochlea Exposed (B.).

1. Cochlea.
2. Fenestra vestibuli.
3. Fenestra cochleæ.
4. Eminentia arcuata.

Fig. 3. Preparation of a Right Labyrinth by Corrosion with Wood's Metal (B.).

1. Cochlea.
2. Superior semicircular canal.
3. External semicircular canal.
4. Posterior semicircular canal.
5. Superior ampulla.
6. Crus commune.
7. External ampulla.
8. Posterior ampulla.
9. Fenestra vestibuli.
10. Fenestra cochleæ.

Fig. 4. Left Temporal Bone, Showing Semicircular Canals and Aqueducts from Behind (B.).

1. Superior semicircular canal.
2. External semicircular canal.
3. Posterior semicircular canal.
4. Aquæductus vestibuli.
5. Internal auditory meatus.
6. Aquæductus cochleæ.
7. Cochlea.
8. Juga cerebralia.
9. Groove for middle meningeal artery.
10. Sigmoid sulcus.

PLATE 8.

Fig. 1. Right Temporal Bone from Child. Transparent. Labyrinth Injected with Mercury. Front View (B.).

1. Superior semicircular canal.
2. External semicircular canal.
3. Posterior semicircular canal.
4. Mastoid antrum.
5. Tympanic cavity.
6. Tympanic ring.
7. Cochlea.
8. Aquæductus cochleæ.
9. Canal of carotid artery.
10. Squamous portion.
11. Mastoid process.

Fig. 2. Same Specimen Seen from Behind (B.).

1. Superior semicircular canal.
2. External semicircular canal.
3. Posterior semicircular canal.
4. Vestibule.
5. Ampulla superior.
6. Ampulla posterior.
7. Cochlea.
8. Aquæductus cochleæ.
9. Aquæductus vestibuli.
10. Petrosquamous suture.
11. Jugular fossa.
12. Eminentia arcuata.

Fig. 3. Left Temporal Bone from Child. Transparent. Labyrinth Injected with Mercury. Front View. Numbers as in Fig. 1.

13. External ampulla.
14. Jugular fossa.

Fig. 4. The Same Specimen Seen from Behind (B.). **Numbers as in Fig. 2.**

15. Sigmoid sulcus.

Tab. 8.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

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Tab. 9.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

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PLATE 9.

Fig. 1. Right Labyrinth Isolated and Laid Open with a File (× 4) (**Half Diagrammatic**) (B.).

1. Fenestra cochleæ.
2. Osseous portion of superior ampulla.
3. Crista anterior.
4. Superior semicircular canal.
5. Crus commune.
6. Posterior semicircular canal.
7. Posterior ampulla.
8. Crista posterior.
9. Macula cribrosa inferior.
10. Pyramid of vestibule and macula cribrosa superior.
11. Crista vestibuli.
12. Recessus sphæricus (fovea hemisphærica).
13. Macula cribrosa media.
14. Recessus ellipticus (fovea hemielliptica).
15. Internal opening of aqueduct of vestibule.
16. Fossula sulciformis.
17. Recessus cochlearis.
18. Osseous portion of primary spiral lamina.
19. Osseous portion of secondary spiral lamina.
20. Scala tympani and internal opening of aqueduct of cochlea.
21. Scala vestibuli.
22. Cochlea.
23. First turn of cochlea.
24. Septum (spiral lamina).
25. Second turn: (*a*) of scala tympani; (*b*) of scala vestibuli.
26. Modiolus.
27. Cupula.
28. Lamina modioli (scyphus Vieussenii).
29. Hamulus laminæ spiralis.
30. Foramina for the passage of filaments of cochlear nerve.
31. External semicircular canal.
32. External ampulla.
33. Crus simplex.

Fig. 2. The Same as Fig. 1, with the Membranous Labyrinth Preserved (**Half Diagrammatic**) (P. and B.).

1. Recessus utriculi.
2. Utriculus proprius.
3. Posterior sinus.
4. Superior sinus.
5. Crus simplex.
6. Membranous ampulla with crista ampullaris and superior ampullary nerve.
7. Lateral ampulla with crista ampullaris and lateral ampullary nerve.
8. Crus commune.
9. Posterior ampulla with crista ampullaris.
10. Macula acustica utriculi, with utricular nerve.
11. Sacculus with sinus utricularis sacculi.
12. Macula acustica sacculi, with saccular nerve.
13. Ductus utriculosaccularis (endolymphaticus).
14. Ductus reuniens (Hensenii).
15. Superior semicircular canal.
16. External semicircular canal.
17. Posterior semicircular canal.
18. Cæcum vestibulare.
19. Osseous portion of secondary spiral lamina.
20. Cochlear duct.
21. Lamina basilaris (spiralis membranacea).
22. Membrana vestibularis (Reissner's membrane).
23. Ligamentum spirale cochleæ.
24. Scala tympani.
25. Scala vestibuli.
26. Cæcum cupulare.
27. Helicotrema.
28. Coarse bundles of cochlear division of eighth nerve.
29. Fine bundles of cochlear division of eighth nerve.

PLATE 9 (*Continued*).

Fig 3. Section (with a Saw) through Right Cochlea of Child (× 4) (B.).

1. Internal auditory meatus.
2. Spiral cribriform tract.
3. Modiolus.
4. Longitudinal canals of modiolus.
5. Spiral canal of modiolus.
6. First turn: (*a*) of scala tympani; (*b*) of scala vestibuli.
7. Septum (lamina spiralis).

Fig. 4. The Same as Fig. 3, with Cochlear Nerve and Cochlear Duct.

1. Cochlear division of eighth nerve.
2. Spiral ganglion.
3. Osseous portion of lamina spiralis (primary).
4. Lamina basilaris (spiralis membranacea).
5. Membrana vestibularis (Reissner's membrane).
6. Cochlear duct.
7. Cæcum cupulare.
8. Helicotrema (Breschetii).

PLATE 10.

Fig. 1. Left Temporal Bone Showing Dura Mater of Cerebrum and Cerebellum, the Transverse Sinus, the Tympanic Membrane, and the Interior of the Mastoid Antrum (B.).

(The anterior wall of the auditory meatus has been removed.)

1. Dura mater.
2. Middle meningeal artery.
3. Transverse sinus.
4. Mastoid emissary.

Fig. 2 Left Temporal Bone Showing the Brain and Interior of Mastoid Antrum. The Dura Mater and the Tympanic Membrane Have Been Removed (B.).

1. Squamous portion.
2. Dura mater.
3. Second temporal fissure.
4. Third temporal convolution.
5. First temporal fissure.
6. Second temporal convolution.
7. First temporal convolution.
8. Fossa of Sylvius.
9. Third temporal fissure.
10. Fusiform gyrus.
11. Mastoid antrum.
12. Mastoid process and cells.
13. Cells in squamous portion.
14. Malleus.
15. Incus.
16. Chorda tympani.
17. Transverse sinus.
18. Cerebellum, with great horizontal fissure.
19. Emissarium Santorini.

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Tab. II.

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PLATE 11.

Base of the Skull: Left Labyrinth Exposed on the Right Side; the Grooves in the Base of the Skull are Shown; the Sinuses of the Dura Mater are Marked in Blue. Two-thirds Life-size (B.).

1. Crista frontalis (on the left, beginning of the superior longitudinal sinus).
2. Foramen cæcum (emissarium Santorini).
3. Crista galli.
4. Lamina cribrosa (olfactory nerve).
5. Lesser wing of sphenoid.
6. Optic foramen (optic nerve, ophthalmic artery).
7. Anterior clinoid process.
8. Sella turcica, flanked by the median clinoid process.
9. Dorsum ephippii, with posterior clinoid process.
10. Foramen rotundum (second division of fifth nerve).
11. Foramen ovale (third division of fifth nerve).
12. Foramen spinosum (middle meningeal artery and recurrent branch of fifth nerve).
13. Carotid canal and foramen lacerum anterius (great and lesser superficial petrosal nerves, Eustachian tube, and tensor tympani muscles).
14. Anterosuperior surface of pyramid.
15. Cochlea.
16. Semicircular canals.
17. Tegmen tympani and roof of antrum laid open.
18. Anterior condyloid foramen (twelfth nerve).
19. Posterior condyloid foramen (emissarium Santorini).
20. Foramen magnum.
21. Superior petrosal sinus.
22. Transverse sinus (descending portion).
23. Transverse sinus (horizontal portion).
24. Superior longitudinal sinus and torcular Herophili (confluence of the sinuses).
25. Occipital sinus.
26. Occipital sinus.
27. Vein of aquæductus vestibuli (emerging at the external aperture of aquæductus vestibuli).
28. Internal auditory vein (emerging in the internal auditory meatus).
29. Vein of aquæductus cochleæ (emerging at the external aperture of aquæductus cochleæ).
30. Inferior petrosal sinus emptying into the cavernous sinus.
31. Circular sinus (Ridley).
32. Groove traversing anterior fossa of skull.
33. Sinus of lesser wing of sphenoid.
34. Groove for meningeal artery.
35. Transverse groove through middle fossa of the skull.
36. Longitudinal groove through petrous portion of temporal bone (tegmen tympani).
37. Groove through apex of pyramid.
38. Transverse fissure (between posterior condyloid foramen and foramen magnum).
39. Longitudinal groove through posterior fossa of skull.
40. Impressio carotica (corresponding to the bend in the internal carotid artery).
41. Juga cerebralia and impressiones digitatæ.

PLATE 12.

The Anterior Portion of the Right Side of the Skull has been Rendered Transparent. The Accessory Cavities of the Nose Filled with Wood's Metal. A Catheter is Passed into the Eustachian Tube (B.).

1. Catheter.
2. Rosenmüller's fossa (recessus pharyngeus).
3. Tubal fold (torus tubarius) and plica salpingopharyngea.
4. Pharyngeal opening of Eustachian tube.
5. Plica salpingopalatina.
6. Levator palati muscle.
7. Hard palate.
8. Soft palate and uvula.
9. External nose and naris.
10. Inferior turbinate.
11. Middle turbinate.
12. Superior turbinate.
13. Frontal sinus.
14. Ethmoid cells in middle nasal meatus: two ethmoid cells appear, one above the other, extending to the middle turbinate.
15. Ethmoid cells in superior nasal meatus.
16. Sphenoidal sinus.
17. Antrum of Highmore, seen through the interior of the nose in the middle meatus—
18. Same in the inferior meatus.
19. Mouth and lacrimonasal duct.
20. Superior meatus.
21. Alveolar process with three teeth: the roots are faintly seen within the alveolar process.
22. Roof of orbit seen in anterior fossa of skull.
23. Juga cerebralia and impressiones digitatæ.
24. Lesser wings of the sphenoid with anterior clinoid processes and optic foramen.
25. Sella turcica.
26. Middle fossa of skull.
27. Lamina cribrosa.
28. Crista galli.
29. Frontal bone.

Tab. 12.

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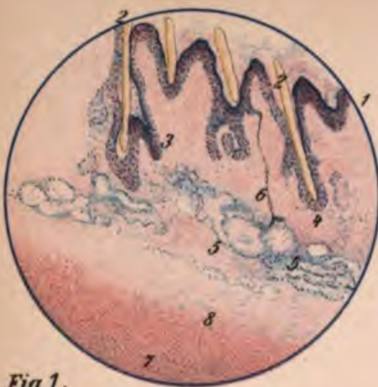
Tab. 13.



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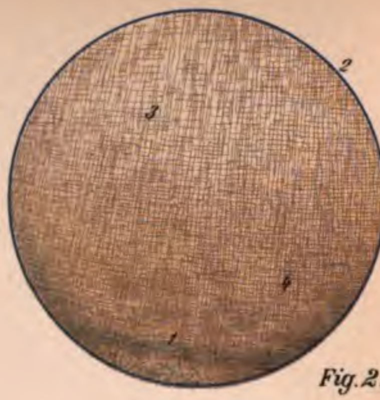

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PLATE 13.

Fig. 1. Cartilaginous Portion of Auditory Meatus (× 18) (Hematoxylin-Eosin) (B.).

1. Epiderm.
2. Hair.
3. Sebaceous gland.
4. Hair-follicle.
5. Ceruminous glands.
6. Duct of a ceruminous gland.
7. Elastic cartilage.
8. Perichondrium.

Fig. 2. Surface Preparation of Tympanic Membrane Taken from Lower Half of Ear Drum (× 54) (B.).

1. Peripheral zone.
2. Intermediary zone.
3. Stratum radiatum.
4. Stratum circulare.

Fig. 3. Mucous Membrane of Promontory from a Five Months' Embryo (Hematoxylin-Eosin) (B.).

1. Cuboid epithelium with granular deposit.
2. Embryonal mucous tissue.

Fig. 4. Mucous Membrane of Promontory from Adult (Hematoxylin) (× 60) (B.).

1. Cuboid epithelium.
2. Capillary.
3. Tympanic nerve.
4. Connective-tissue layer of mucous membrane with lymphocytes.
5. Periosteal layer.
6. Tympanic artery and vein.

Fig. 5. Mastoid Cell with Mucous Membrane (Hematoxylin-Eosin) (× 100) (B.).

1. Squamous epithelium.
2. Connective tissue.
3. Periosteal layer.
4. Bone.

Fig. 6. Tympanic Groove, Fibrocartilaginous Ring, and Tympanic Membrane (Radial Section) (Hematoxylin) (× 60) (B.).

1. Tympanic sulcus.
2. Radiating fibers of fibrocartilaginous ring with a few circular fibers in transverse section.
3. Periosteum of auditory meatus.
4. Epiderm of auditory meatus.
5. Cuticle of auditory meatus with vessels.
6. Mucous membrane lining tympanic cavity (cylindric epithelium), with papilla.
7. Blood-vessels.
8. Mucous layer of tympanic membrane (cuboidal epithelium).
9. Layer of circular fibers (stratum circulare), tunica propria.
10. Layer of radial fibers (stratum radiatum), tunica propria.
11. Epiderm (stratum cutaneum).

PLATE 14.

Fig. 1. Eustachian Tube (Cartilaginous Portion) (Hematoxylin-Eosin) (× 16) (B.).

1. Ciliated epithelium with basal cells.
2. Lumen.
3. Adenoid tissue of mucous membrane.
4. Mucous glands.
5. Median plate of cartilage (elastic cartilage).
6. Hook-like bend.
7. Lateral plate of cartilage.
8. Fibers of tensor tympani muscle.
9. Submucous fatty tissue.
10. Lateral wall of the tube (membranous).

Fig. 2. Incudomalleolar Articulation from Right Ear (× 12) (P.).

1. Incus with medullary spaces.
2. Malleus with medullary spaces.
3. Median capsular ligament.
4. Lateral capsular ligament.
5. Fibrocartilaginous band.

Fig. 3. Base of Stapes in Fenestra Vestibuli (Syndesmosis Tympanostapedia) from Left Ear (Hematoxylin) (× 14) (B.).

1. Base of stapes.
2. Layer of hyaline cartilage covering base of stapes.
3. Anterior limb, with cartilaginous investment.
4. Posterior limb, with cartilaginous investment.
5. Mucous membrane of tympanic cavity.
6. Osseous portion of fenestra vestibuli, with covering of hyaline cartilage.
7. Annular ligament of base of stapes.
8. Periosteum of vestibule.

Fig. 4. Section through the Middle and Internal Ear of a New-born Infant (× 14) (P.).

1. Tympanic membrane with cross-section of malleus.
2. Tympanic ring.
3. Posterior limb and head of stapes (crus posterius, capitulum stapedis).
4. Fenestra vestibuli.
5. Promontory.
6. Fossula fenestræ cochleæ.
7. Facial nerve.
8. Perilymphatic cistern (contains perilymph).
9. Utriculus (contains endolymph).
10. Macula acustica utriculi.
11. Ampulla posterior.
12. Crista ampullaris posterior.
13. Connective tissue.
14. External auditory meatus.
15. Pad of mucous membrane in fossula fenestræ vestibuli.

PLATE 14 (*Continued*).

Fig. 5. Section through One of the Turns of the Cochlea in Man (× 12).

1. Scala vestibuli.
2. Scala tympani (containing perilymph).
3. Cochlear duct (containing endolymph).
4. Reissner's membrane (membrana vestibularis).
5. Crista spiralis: (*a*) labium vestibulare; (*b*) labium tympanicum.
6. Canal of Rosenthal with ganglion cells (ganglion spirale).
7. Nerve bundle from the cochlear nerve.
8. Osseous spiral lamina.
9. Lamina basilaris (spiralis membranacea).
10. Crista basilaris.
11. Spiral ligament of cochlea.
12. Organon spirale (Corti's organ).
13. Corti's membrane.
14. Nerve-fibers of cochlear portion of auditory nerve in modiolus.
15. Outer wall of the cochlea.

Fig. 6. Cochlear Duct from Guinea Pig (× 66) (B.).

1. Spiral ligament with blood-vessels.
2. Crista basilaris.
3. Prominentia spiralis.
4. Sulcus spiralis internus with epithelium.
5. Stria vascularis.
6. Cells of Claudius.
7. Tympanic covering of lamina basilaris.
8. Hensen's sustentacular cells.
9. Deiter's cells.
10. Three external hair-cells (roots).
11. Corti's tunnel with external and internal supporting cell and two basal cells.
12. Inner hair-cells and inner sustentacular cells.
13. Internal spiral sulcus with epithelium.
14. Membrane of Corti.
15. Labium vestibulare.
16. Crista spiralis.
17. Reissner's membrane (membrana vestibularis).
18. Upper } lamella of osseous spi-
19. Lower } ral lamina.
20. Spiral ganglia.
21. Medullated nerve-fibers.
22. Labium tympanicum.
23. Scala vestibuli.
24. Cochlear duct.
25. Scala tympani.

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Tab.14.

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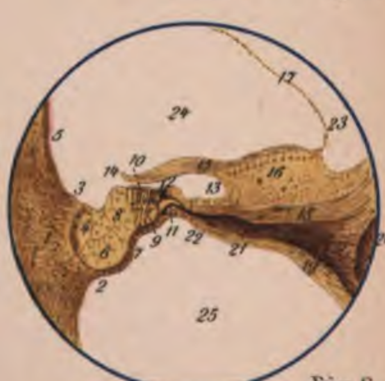

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Tab. 15.

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PLATE 15.

Fig. 1. Sarcoma of Auricle (P.).

Fig. 2. Lupus Vulgaris of Auricle (P.).

Fig. 3. Carcinoma of Auricle and Temporal Bone (P.).—Left ear of a man forty-six years of age who had suffered from aural discharge. The carcinoma extended into the body of the temporal bone.

Fig. 4. Acquired Stricture of External Auditory Meatus (B.).—Left ear of a man who had been run over by a wagon in early childhood. Immediately behind the opening of the auditory meatus there is a connective-tissue septum stretched across the canal like a diaphragm, with a round opening that admits a sound the size of a pin-head. He can hear whispered conversation at a distance of three meters.

Fig. 5. Othematoma of Auricle (B.).—The tumor developed without any ascertainable cause in the fossa triangularis of a man twenty-three years of age.

Fig. 6. Spontaneous Cure of an Othematoma (B.).—Ear of a man thirty-six years of age afflicted with paralytic dementia, who had had an othematoma several years before. The triangular fossa and the anti-helix are disfigured by atrophy of the cartilage and cicatricial contraction.

PLATE 16.

Fig. 1. Fibrous Tumor (Keloid) of Right Auricle (P.).

Fig. 2. Cyst of Left Auricle, Growing from Posterior Surface (P.).

Fig. 3. The So-called Darwinian (Darwin-Woolner) Ear; Acquired Coloboma of the Lobe of the Ear (B.).—Right ear of a woman sixty years of age suffering from paralytic dementia. 1, Darwinian point (true point of the ear); 2, laceration of the lobe by wearing ear-rings.

Fig. 4. Wildermuth's Ear; Adherent Lobe; Auricular Appendages (B.).—Right ear of an alcoholic subject forty years of age: 1, Antihelix projecting well beyond the helix; 2, the lobe is adherent and extends to the cheek; 3, auricular appendages (added from the ear of another subject).

Fig. 5. Cercopithecus Ear: Combination of Satyr and Darwinian Point; Congenital Fistula Auris (B.).—Right ear of a man fifty years of age suffering from paralytic dementia: 1, Satyr point; 2, Darwinian point; 3, congenital fistula auris (added from the ear of the other side).

Fig. 6. Microtia, with Congenital Atresia Auris (B.).—Male, thirty-seven years of age. The right ear is deformed; the left, a cat ear. Arrested development of the right side of the skull. Impaired mobility of the right half of the palate. Deviation of the nasal septum to the right. When the left ear is held shut, the patient can hear low-pitched, but not high-pitched, whispered words at a distance of five centimeters. Tuning-forks C, c, c^1, c^2, when placed on vertex, heard in the right ear. Air-conduction absent; bone-conduction good. The Galton whistle is heard at the mark 4 (normal 2). Instead of an auricle, the subject possessed a long fold of skin containing a plate of cartilage extending to the lower portion (lobe) (1). Above, the cartilage contains a short, blind canal—adhesion of descending and ascending helix (2); below the middle the cartilage contains a tubercle (3) (union of middle portion of helix with tragus); behind the latter there is a blind depression (rudimentary auditory meatus).

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Tab. 17.

Fig. 1.

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Fig. 4.

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PLATE 17.

Fig. 1. Exostosis on the Squamous Portion of the Temporal Bone and Hyperostosis of the External Auditory Meatus (B.).—Right temporal bone seen from in front: 1, Exostosis on the squamous portion (added from another temporal bone); 2, leaf-shaped suprameatal spine; 3, constricted heart-shaped auditory meatus.

Fig. 2. Gaping Posterior Half of Median Wall of Tympanic Cavity and Bulla Jugularis (B.).—Left tympanic cavity seen from in front, after removing the anterior bony wall of the auditory meatus. The bulb of the jugular vein was closely applied to the tympanic membrane and covered by the mucous membrane of the tympanic cavity: 1, Promontory with fenestra vestibuli and cochleæ; 2, gap.

Fig. 3. Anterior Displacement of Genu Caroticum (B.).—The right tympanic cavity after removal of the anterior bony wall of the auditory meatus seen from in front. The carotid canal (1) reaches almost to the promontory (2) in the tympanic cavity.

Fig. 4. Downward Displacement of the Middle Fossa of the Skull and Forward Displacement of the Transverse Sinus (B.).—Right temporal bone; the osseous portion of the attic (1) removed after Stacke; the mastoid antrum opened through the auditory meatus; the lateral portion of the posterior bony wall of the auditory meatus has been left (2) in place. By opening the mastoid process ($\frac{1}{2}$ cm. behind the suprameatal spine (3)), the dura mater of the cerebrum (4) at a point $\frac{1}{2}$ cm. below the supramastoid crest (5) and the transverse sinus (6) were exposed; the lower extremity of the latter approaches within 4 mm. of the posterior bony wall of the auditory meatus; 7, promontory.

PLATE 18.

Fig. 1. Normal Syndesmology (P.).—Wall of left promontory from an individual with normal power of hearing. The crura of the stapes are connected to the margin of the fenestra vestibuli by strands of mucous membrane (1); similar strands are seen at the margin of the fenestra cochleæ (2). Prominence of facial canal (3).

Fig. 2. Membranous Ankylosis of Stapes (Chronic Catarrh) (P.).—Wall of left promontory from a deaf woman seventy-four years of age. The stapes is fixed in the fenestra vestibuli (1) by means of dense bundles of connective tissue; from the floor of the tympanic cavity a robust mass of connective tissue passes over the margin to the fenestra cochleæ (2) and on to the head of the stapes (3).

Fig. 3. Chronic Catarrh (P.).—Wall of left promontory from a woman seventy-three years of age very hard of hearing. The mucous membrane of the tympanic cavity contains tendinous bands. The margins of the fenestra vestibuli (1) and fenestra cochleæ (2) are obliterated by masses of connective tissue; the head of the stapes (3) alone projects above the thickened mucous membrane.

Fig. 4. Membranous Ankylosis of Stapes; Osseous Atresia of Fenestra Cochlea (P.).—Wall of left promontory from a deaf-mute forty years of age. The fenestra cochleæ is replaced by a solid mass of bone (1); the stapes is firmly attached to the contracted margin of the fenestra vestibuli by means of connective-tissue bands (2); the promontory is flattened (3). Facial nerve (4).

Fig. 5. Normal Network of Threads in the Mastoid Antrum with Pedunculated Corpuscles (P.).—The tympanic cavity and mastoid antrum of the right temporal bone from a man sixty-one years of age with normal power of hearing; seen from above after removal of tegmen tympani and roof of antrum (1). The tendon of the tensor tympani in its passage across the tympanic cavity is accompanied by a fold of mucous membrane; the mastoid antrum contains a branching network of threads with a few pedunculated corpuscles (2). Head of malleus (3). Incus (4).

Fig. 6. Normal Fold of Mucous Membrane Running from the Body of the Incus to the Mastoid Antrum (B.).—Right tympanic cavity and mastoid antrum seen from above after removal of tegmen tympani. Taken from an individual with normal power of hearing. Body of incus (1); fold of mucous membrane (2); mastoid antrum (3); head of malleus (4); anterior ligament of malleus (5); lateral incudomalleolar fold (6); tendon of tensor tympani muscle (7); Eustachian tube opened from above (8).

Tab. 18.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

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Tab. 19.

Fig. 1.

Fig. 2.

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PLATE 19.

Fig. 1. Membranous Ankylosis of Incus and Stapes; Malformation of Incus (P.).—Petrous portion of right temporal bone from a deaf-mute girl, after removal of tympanic membrane and malleus. Front view. The body of the incus is wrapped in dense connective tissue (1); the long process of the incus is elongated and bent over backward (2); its union with the stapes (3) is fixed to the upper wall of the margin (4); the tendon of the stapedius muscle (5) passes obliquely upward; the mucous membrane lining the tympanic cavity is thickened and tendinous; the margin of the fenestra cochleæ is obliterated by connective tissue. Carotid canal (7).

Fig. 2. Ankylosis of Long Process of Incus (P.).—Right tympanic cavity and labyrinth from a deaf-mute, opened from the front. The malleus is freely movable. The long process of the incus is firmly fixed to the posterior wall of the tympanic cavity below the prominence formed by the facial canal (2). At (3) the movable base of the stapes is seen in the fenestra vestibuli. Malleus (4). Tympanic membrane (5).

Fig. 3. Remains of a Chronic Suppurative Otitis Media. Membranous Adhesions Between the Drumhead and the Stapes (P.).—Left temporal bone from a woman eighty-one years of age after removal of the anterior bony wall of the auditory meatus. In the superoposterior portion of the tympanic membrane there is a round scar, the center of which is fixed to the head of the stapes (1); the long process of the incus has been destroyed by caries.

Fig. 4. Fig. 3 Seen from Above after Removal of Tegmen Tympani (P.).—The scar (1) passes from the body of the incus (2) to the head of the stapes. Head of malleus (3). Tendon of tensor tympani muscle (4). Tympanic membrane (5).

Fig. 5. Remains of a Chronic Suppurative Otitis Media (Dry Preparation) (P.).—Left temporal bone after removal of the anterior bony wall of the auditory meatus. The entire tympanic membrane except a narrow border near the periphery (1) is destroyed; the end of the manubrium is fixed to the promontory by connective tissue (2). Owing to carious destruction of the long process of the incus the stapes (3) is free below and in front; the last remnant of the tympanic membrane passes to the promontory.

Fig. 6. Specimen of Fig. 5 Seen from Above after Removal of Tegmen Tympani.—The malleus (1) passes backward to the promontory, where it is fixed; the tendon of the tensor tympani (2) passes transversely across the tympanic cavity; nothing remains of the incus but the body and the short process (3), so that the stapes is free (4).

PLATE 20.

Fig. 1. Sagittal Section through the Attic and Malleus in an Adult (Carmin) (× 3) (P.).

1. Extremity of the bony roof of the auditory meatus.
2. Extremity of the bony floor of the auditory meatus.
3. Head of malleus.
4. Manubrium.
5. Tympanic membrane.
6. Attic—external portion.
7. Prussak's space (recessus membranæ superior).
8. Lateral ligament of malleus.
9. Shrapnell's membrane.
10. Short lateral process of malleus.
11. Pedunculated corpuscle from lower wall of Prussak's space.
12. Neck of malleus.

Fig. 2. Sagittal Section through the Attic and Malleus in a New-born Infant (× 26) (P.).—1, Prussak's space filled with embryonal connective tissue; 2, a space lined with epithelium, beginning development of Prussak's space; 3, lateral (short) process of the malleus.

Fig. 3. Sagittal Section through the Attic and Malleus in Chronic Suppurative Otitis Media (× 18) (P.).—1, Destroyed ligament of malleus; 2, outer portion of attic, and 3, inner portion of attic, filled with rapidly proliferating mucous membrane; 4, mucous membrane denuded of epithelium; 5, free exudate; 6, tegmen tympani; 7, diverticula in the bone.

Fig. 4. Sagittal Section through the Attic and Malleus in Chronic Middle-ear Catarrh (× 26) (P.).—1, Prussak's space filled with connective tissue; 2, cysts.

Fig. 5. Sagittal Section through the Attic and Malleus in Chronic Middle-ear Catarrh (× 26) (P.).—1, Shrapnell's membrane partially attached to the neck of the malleus by connective tissue; 2, connective tissue; 3, remains of Prussak's space.

Fig. 6. Adhesions Between Drumhead and Promontory after Chronic Suppurative Otitis Media (Hematoxylin) (× 18) (P.).

1. Drumhead.
2. Promontory.
3. Investment of mucous membrane.
4. Reticulated and perforated connective tissue.
5. Cochlea.
6. Medullary spaces.

Tab.20.

Fig.1.

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Tab. 21.

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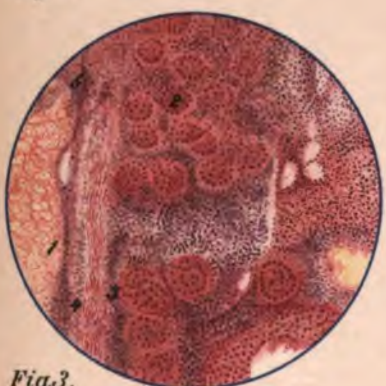

Fig. 3.

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PLATE 21.

Fig. 1. Calcareous Deposits in the Drumhead (× 4) (P.).

1. Head of malleus
2. Attic.
3. Drumhead.
4. Calcareous deposits.

Fig. 2. Union of the Incus with the Wall of the Tympanic Cavity. Chronic Suppurative Otitis Media (× 9) (P.).—1, Incus; 2, granulation tissue; 3, median wall of the tympanum.

Fig. 3. Medullary Carcinoma of the Auricle (Hematoxylin-Eosin) (× 66) (B.).

1. Cartilage.
2. Cancer-nests.
3. Round-cell infiltration.
4. Infiltrated perichondrium.
5. Infiltration penetrating into the cartilage.

Fig. 4. Lupus Vulgaris of the Auricle (Polychrome Methylene-blue) (× 54) (B.).

1. Epiderm.
2. Proliferations of the epiderm dipping down into the subdermal region.
3. Central necrobiotic nodules with giant-cells.
4. Plasma cells.

Fig. 5. Hyperplasia of the Pharyngeal Tonsil as seen in the Mirror (B.).

1. Hyperplastic pharyngeal tonsil.
2. Vomer.
3. Soft palate.
4. Uvula.
5. Middle turbinate (above superior turbinate).
6. Inferior concha.
7. Rosenmüller's fossa.
8. Tubal fold.
9. Pharyngeal opening of tube.

Fig. 6. Hyperplasia of the Pharyngeal Tonsil (Hematoxylin-Eosin) (26 ×) (B.).—1, Squamous epithelium; 2, longitudinal furrow; 3, follicles; 4, diffuse adenoid tissue.

PLATE 22.

Fig. 1. The Deposition of Fatty Tissue in the Fossula of the Fenestra Cochleæ after Chronic Suppurative Otitis Media (× 18) (P.).—1, Promontory; 2, secondary tympanic membrane; 3, fatty tissue in the fenestra of the cochlea.

Fig. 2. Obliteration of the Fossula Fenestræ Cochleæ by Fatty and Connective Tissue in a Deaf-mute (× 15) (P.).—1, Promontory; 2, fatty and connective tissue in the fossula fenestræ cochleæ; 3, secondary tympanic membrane; 4, ligamentum spirale; 5, scala tympani.

Fig. 3. Connective Tissue Occurring in the Fossula Fenestræ Cochleæ after Chronic Suppurative Otitis Media (× 26) (P.).—1, Connective tissue with cyst-like spaces.

Fig. 4. Osseous Ankylosis of the Stapes (× 14) (P.).—1, Base of the stapes; 2, anterior, 3, posterior, crura; 4, bony new formation at the posterior margin of the fenestra vestibuli, and union with the border of the base of the stapes; 5, mucous membrane.

Fig. 5. Osseous Ankylosis of the Stapes, From a Man Seventy-four Years of Age and Very Hard of Hearing (× 14) (P.).—1, Base of the stapes; 2, anterior, 3, posterior, crura; 4, osseous new formations on both borders of the margin; union with the borders of the base of the stapes (4) and with 5, the posterior limb.

Fig. 6. Osseous Ankylosis of the Stapes, From a Woman Fifty Years of Age and Very Hard of Hearing (× 14) (P.).—1, Osseous new formation near the margin and involving the base of the stapes; 2, old bone; 3, mucous membrane.

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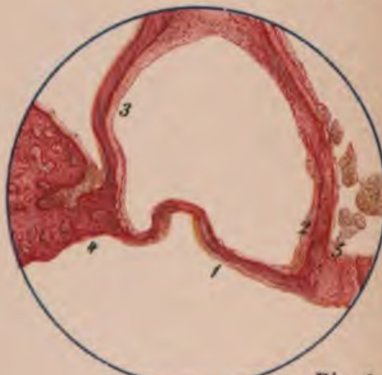

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PLATE 24.

Fig. 1. Chronic Suppurative Otitis Media; Caries of the Tegmen Tympani (P.).—Left temporal bone from a man sixty-five years of age, seen from in front, after removal of the anterior bony wall of the auditory meatus. Total destruction of the tympanic membrane, malleus, and incus. Through the defect in the tegmen tympani (1) light enters from above into the tympanic cavity (2); stapes (3).

Fig. 2. Specimen of Fig. 1 Seen from Above.—The tegmen tympani is riddled like a sieve (1). Tip of the petrous portion of the temporal bone (2).

Fig. 3. Chronic Suppurative Otitis Media; Caries of the Auditory Meatus, the Auditory Ossicles, the Tegmen Tympani, and the Antrum; Pachymeningitis; Perforation of the Dura Mater; Leptomeningitis (P.).—Left temporal bone from a girl eighteen years of age, seen from above, after removal of the anterior bony wall of the auditory meatus. The lower half of the tympanic membrane is still preserved and thickened (1); the head of the malleus has been destroyed by caries; the manubrium remains (2); the incus is destroyed; the head of the stapes is rough (3); the tympanic mucous membrane is greatly thickened, the inner upper extremity of the bony auditory meatus (pars ossea) is destroyed (4); there is also a linear defect in the posterior upper portion of the wall (5); in its immediate vicinity are several vesicular openings enlarged by the carious process.

Fig. 4. Specimen of Fig. 3 Seen from Above after Reflection of the Dura Mater (P.).—The tegmen tympani (1) is discolored and shows one large defect and two smaller gaps with ragged edges (2). The large opening behind is filled with granulation tissue (3) that is connected by means of strands of connective tissue with the thickened mucous membrane of the mastoid process (4); the portion of the dura mater in contact with the defect is thickened, covered with mucus, and perforated by fistulous tracts in three places (5).

Fig. 5. Chronic Suppurative Otitis Media; Caries of the Mastoid Process of the External Auditory Meatus, of the Tegmen Tympani, and of the Antrum; Central Necrosis of the Mastoid Process; External Pachymeningitis (P.).—Left temporal bone seen from in front. The cortex of the mastoid process in the mastoid fossa has been partially destroyed by the carious process (1); the tympanic cavity contains a sequestrum (2), which made its way from the mastoid process through a carious defect in the posterior wall of the auditory meatus. Zygomatic process (3); mastoid process (4).

Fig. 6. Specimen of Fig. 5 Seen from Above after Reflection of the Dura Mater (P.).—The tegmen tympani and roof of the antrum have been completely destroyed and replaced by a thickened mass of mucous membrane (1) perforated in various places. The contiguous dura mater is thickened and covered with exudate (2), while the cerebral aspect of the membrane is normal. Tip of the petrous portion (3).

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PLATE 25.

Fig. 1. Chronic Suppurative Otitis Media; Necrosis of the Mastoid Process; Caries of the Roof of the Antrum; Pachymeningitis; Perforation of the Dura Mater; Abscess of the Temporal Lobe (P.).—Left temporal bone from a woman fifty-nine years of age after removal of the anterior bony wall of the auditory meatus and of the uninjured cortical portion of the mastoid process. Front view.

The tympanic membrane is thickened and perforated in its lower portion (1). The cells of the pneumatic mastoid process form a movable sequestrum (2) imbedded in a cloaca lined with granulation tissue (3). The mastoid fossa gapes in two places where the thickened mucous membrane is exposed (4). Zygomatic process (5).

Fig. 2. Specimen of Fig. 1 Seen from Above after Removal of the Tegmen Tympani and Reflection of the Dura Mater (P.).—Roof of the antrum destroyed by caries (1); the sequestrum (2) is closely applied to the dura mater (3), the latter is thickened and presents a fistula (3) surrounded by a rampart of purulent granulation tissue, communicating directly with the abscess in the temporal lobe to which the dura mater is adherent. The tympanic cavity, malleus (4), and incus (5), the mastoid antrum (6), and the Eustachian tube (7) are filled with dense masses of proliferating connective tissue.

Fig. 3. Chronic Suppurative Otitis Media; Polypi in the Tympanic Cavity; Gaping of the Tegmen Tympani; Pachymeningitis; Perforation in the Dura Mater; Abscess of the Temporal Lobe (P.).—Left temporal bone from a girl twenty-one years of age, after removal of the anterior bony wall of the auditory meatus. Complete destruction of the tympanic membrane and auditory ossicles. A polypus with five processes projects from the tympanic cavity (1). Mastoid process (2).

Fig. 4. Preparation of Fig. 3 Seen from Above after Reflection of the Dura Mater (P.).—The tegmen tympani presents a crevice with smooth edges (1). The dura mater is thickened, covered with granulations (adherent to the brain), and traversed by a fistulous tract (2) that communicated directly with the abscess in the temporal lobe. Eminentia arcuata (3); tip of pyramid removed (4).

Fig. 5. Chronic Suppurative Otitis Media; Caries of the External Auditory Meatus, of the Tegmen Tympani, and of the Petrous Portion (Neuritis of the Seventh Nerve). Necrosis of the Osseous Labyrinth; Thrombosis of the Superior Petrosal Sinus; External Pachymeningitis; Cerebellar Abscess (P.).—Left temporal bone from a scrofulous woman thirty-six years of age. Front view, after removal of the anterior bony wall of the auditory meatus. The tympanic membrane (1) is thickened, and Shrapnell's membrane (2) is perforated. The head of the malleus, the incus, and the osseous portion of the attic are destroyed (3). Polypoid granulations project from the defect in the bone and the perforation in the membrane. Mastoid process (4).

Fig. 6. Specimen of Fig. 5 Seen from Above and Behind (P.).—Carious destruction of the tegmen tympani. The gap is filled by thickened mucous membrane that is perforated at one place (1). The contiguous dura mater was thickened and covered with granulations, the superior petrosal sinus was thrombosed, and the groove was perforated (2). On the posterior surface of the pyramid is a defect with eroded edges through which the roughened and necrotic capsule of the labyrinth can be seen (3). In the adjacent portion of the cerebellum were two abscesses that communicated directly with the defect. The carious destruction begins within the tympanic cavity, in the spongy bone surrounding the compact capsule of the labyrinth, and extends to the posterior surface of the pyramid. (See Plate 26, 2.) Internal auditory meatus (4); sigmoid groove (5).

PLATE 26.

Fig. 1. Chronic Suppurative Otitis Media; Caries of the Tympanic Cavity and Labyrinth; Meningitis (P.).—Right temporal bone from a girl after removal of the anterior bony wall of the auditory meatus and tip of the pyramid. Total destruction of the tympanic membrane and auditory ossicles. The walls of the tympanic cavity are carious, the promontory and its fenestræ have been destroyed, so that the tympanic cavity (1) communicates freely with the labyrinth (2). Below and in front, over the first turn of the cochlea, a small remnant of the edge of the promontory (3) is preserved. On either side of this remnant the osseous lamina spiralis of the carious cochlea comes into view (4). On the floor of the internal auditory meatus (5) there is a carious opening (6), through which the labyrinth communicates with the internal auditory meatus. The pus from the tympanic cavity had penetrated through the labyrinth and the internal auditory meatus into the cranial cavity. Antrum (7); cells on the floor of the tympanic cavity (8).

Fig. 2. Caries of the Labyrinth; Neuritis of the Facial Nerve (P.).—Specimen of Fig. 6, Plate 25, seen from above and in front, after removal of the anterior bony wall of the auditory meatus. A large portion of the tegmen tympani is carious (1). The tympanic cavity (2) and the antrum (3) are filled with dense granulation tissue. The capsule of the labyrinth is separated by a mass of granulations from the spongy bone, so that the roughened cochlea (4) and the superior semicircular canal, which contains a carious opening (5), are freely exposed. The facial nerve (6) is swollen and infiltrated with pus. The suppurative process began in the spongy bone, and, passing around the capsule of the labyrinth, invaded the posterior surface of the pyramid. Tip of the petrous portion of the temporal bone (7); mastoid process (8).

Fig. 3. Chronic Suppurative Otitis Media; Caries of the Tympanic Cavity and Labyrinth; Destruction of the Seventh Nerve; Meningitis (P.).—Petrous portion of the right temporal bone from a phthisical subject, fifty-nine years of age. The wall of the promontory contains two fistulæ (1) that established a communication between the tympanic cavity and the interior of the cochlea. The lower portion of the Fallopian canal and of the seventh nerve is destroyed (2). The horizontal semicircular canal (3) has been perforated by the carious process, and the median wall of the mastoid antrum (4) is roughened. The pus entered the labyrinth through the openings in the promontory, and made its way through the internal auditory meatus to the cranial cavity.

Fig. 4. Chronic Suppurative Otitis Media; Caries of the Petrous Portion (Carotid Canal); Fatal Hemorrhage.—The carotid has been drawn out of its canal. Petrous portion of the right temporal bone from a phthisical patient thirty-two years of age. The promontory (1) is completely undermined by granulation tissue; the vestibule and the superior and external ampullæ (2) are perforated. The carotid canal (3) immediately above its lower extremity contains an opening (4) 3 mm. in length and 1.5 mm. in height; the corresponding spot on the carotid artery presents a similar defect that is surrounded by a wall of granulation tissue (5).

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PLATE 27.

Fig. 1. Fistulæ of the Mastoid Process After Chronic Suppurative Otitis Media (P.).—Left temporal bone from a man. Front view. On the mastoid process, immediately behind the auricle, we see a large fistula (1) covered with skin and communicating with a cavity in the mastoid process. The latter is also covered with skin, and communicates with the auditory meatus (3) through a large defect in the posterior wall of that canal (2). The tympanic membrane (4) is thickened, in places atrophic, and adherent to the wall of the promontory. Tip of petrous portion (5).

Fig. 2. Cholesteatoma of the External Auditory Meatus; Chronic Suppurative Otitis; Gap in the External Auditory Meatus (P.).—Right temporal bone from a woman thirty years of age. Front view. Cholesteatoma has been removed. The anterior bony wall of the auditory meatus presents a kidney-shaped defect (1). The posterior wall of the auditory meatus is roughened, and contains diverticula (2). The superior anterior quadrant of the tympanic membrane (3) has been destroyed (it is hidden in the picture by the osseous portion of the auditory meatus). Mastoid process (4); tip of petrous portion (5).

Fig. 3. Chronic Suppurative Otitis Media; Fistula of the Mastoid Process; Perforation in the Tegmen Tympani; External Pachymeningitis; Cerebral Abscess; Thrombosis of the Transverse Sinus (P.).—The left temporal bone after removal of the anterior bony wall of the auditory meatus. The fistula is situated behind the ear (1). The tympanic membrane is destroyed, except a narrow peripheral border that is adherent in places to the wall of the tympanic cavity (2). Mastoid process (3).

Fig. 4. Specimen of Fig. 3 Showing the Flap of Skin Perforated by Fistulous Tracts (1) (P.).—The cortical portion of the mastoid process is perforated by fistulæ; whitish-brown masses of cholesteatoma (2) appear through the opening.

Fig. 5. Specimen of Fig. 3 Seen From Above.—The posterior half of the petrous portion is laid open by a coronal section after reflection of the dura mater. The upper portion of the tympanic cavity (1) and the mastoid antrum are filled with successive layers of cholesteatomata. The roof of the mastoid antrum is perforated (2). The contiguous portion of the dura mater is discolored and thickened (3). The left temporal lobe contains a large abscess. Eighth nerve (4); cochlea (5); vestibule (6).

Fig. 6. Specimen of Fig. 3 Seen from Behind; the Transverse Sinus Laid Open.—The lower portion of the transverse sinus contains a parietal thrombus (1). Mastoid process (2); dura mater (3).

PLATE 28.

Fig. 1. Chronic Suppurative Otitis Media; Cholesteatoma of the Tympanic Cavity (P.).—Right temporal bone seen from in front after removal of the anterior bony wall of the auditory meatus. Destruction of all but a small remnant of the tympanic membrane (1), which contains the remains of the manubrium. The incus and the crura of the stapes are wanting; the tympanic membrane is replaced by a whitish layer of epiderm (2) directly continuous with the remnant of tympanic membrane (proliferation of epidermic cells from the auditory meatus).

Fig. 2. Specimen of Fig. 1 Seen from Above; Coronal Section through the Upper Half of the Petrous Portion (P.).—The cholesteatoma, made up of successive layers, fills the entire cavity of the middle ear like a sac, from the Eustachian tube (1) to the enlarged mastoid antrum (2). Internal auditory meatus (3); vestibule (4); cochlea (5).

Fig. 3. Cholesteatoma of the Tympanic Cavity and Mastoid Process; Destruction of the External Auditory Meatus and Tympanic Cavity (P.).—Right temporal bone from a woman eighty years of age, after removal of the anterior bony wall of the auditory meatus. The cholesteatoma (1) completely fills the tympanic cavity, the auditory meatus, and one of the cavities in the mastoid process. Mastoid process (2).

Fig. 4. Specimen of Fig. 3 after Removal of the Cholesteatoma (P.).—By the complete destruction of the bony wall of the auditory meatus and the disappearance of the bone, the tympanic cavity (1), the auditory meatus (2), and the mastoid antrum (3) have been converted into a single large cavity whose upper wall (4), which comes in relation with the middle fossa of the skull, is as thin as paper. The wall of the promontory contains two deep diverticula (5). These diverticula, as well as the windows of the labyrinth and the entire artificial cavity, are invested by a shining membrane covered with epidermis. At the posterior boundary of the tympanic cavity the seventh nerve (6) appears in this membrane as a yellow band without any bony investment.

Fig. 5. Chronic Suppurative Otitis Media; Cholesteatoma of the Tympanic Cavity and Mastoid Process; Destruction of the External Auditory Meatus (P.).—Left temporal bone from a man forty-two years of age after removal of the anterior bony wall of the auditory meatus.

The lower half of the tympanic membrane presents a round perforation (1). The floor of the auditory meatus is rough and uneven (2); the upper and posterior wall is absent, except for a small portion near the center (3). The cholesteatomatous masses have been removed from the auditory meatus. The auditory meatus, like the cavity, is lined by membrane covered with epidermis; masses of cholesteatoma tissue project from the mastoid process into the auditory meatus (4). Proliferation of the epiderm from the auditory meatus after carious destruction of the posterior bony wall.

Fig. 6. Specimen of Fig. 5 Seen from Above after Removal of the Tegmen Tympani and Roof of the Antrum (P.).—The cavities of the middle ear, from the Eustachian tube (1) as far as the enlarged antrum (2), are filled with a cholesteatoma in the form of a sac; the sac contains concentric layers, the central ones of which are softened (3).

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PLATE 29.

Fig. 1. Method of Detaching the Auricle for the Purpose of Removing a Foreign Body (B.).—The incision is made behind the insertion of the auricle. After the cartilaginous portion of the auditory meatus has been pushed forward it is divided at the point where it begins to become osseous (1). A strip of gauze passed around the auricle (2) serves as a retractor. The foreign body (3) is seen in the osseous portion of the auditory meatus. Supramastoid crest (4); mastoid fossa (5); tendon of sternocleidomastoid (6).

Fig. 2. Perforation of the Cortical Portion of the Mastoid Process in Acute Otitis Media and Mastoiditis (B.).—The incision was made through the highest point of the swelling behind the ear; half an ounce of pus was liberated. The soft parts and the periosteum are held aside with retractors; the mastoid fossa shows a defect filled with granulations: 1, Tendon of sternocleidomastoid; 2, suprameatal spine; 3, supramastoid crest; 4, squamomastoid suture; 5, fistula in mastoid fossa; 6, posterior membranous portion of auditory meatus.

Fig. 3. Method of Opening the Mastoid Antrum with a Chisel (after Schwartze) (B.).—1, Auditory meatus displaced forward; 2, suprameatal spine; 3, supramastoid crest; 4, infundibuliform opening in the bone made with a chisel, ending in the antrum; 5, traces of squamomastoid suture; 6, sternocleidomastoid muscle.

Fig. 4. Free Opening of the Mastoid Process with a Chisel, and Ablation of the Posterior Bony Wall of the Auditory Meatus (B.).—7, Pinna and auditory meatus held forward by means of a strip of gauze passed through the auditory meatus; 8, tympanic membrane with manubrium; 9, osseous portion of attic; 10, remaining lower portion of the posterior bony wall of the auditory meatus (suture); 11, threshold of antrum.

Fig. 5. Same Specimen as Fig. 4 After Removal of Tympanic Membrane, Malleus, Incus, and Osseous Portion of Tympanic Recess. Completed Radical Operation. Plastic Operation on the Auditory Meatus (after Körner) (B.).—12, Prominence of facial canal; 13, tympanic cavity with stapes in the fenestra vestibuli, stapedius muscle, fenestra cochleæ; 14, prominence formed by external semicircular canal; 15, flap taken from the posterior membranous wall of the auditory meatus (after Körner): (*a*) upper incision; (*b*) lower incision.

Fig. 6. Exposing the Dura Mater Covering the Temporal Lobe and Transverse Sinus, after Performing a Radical Operation; Plastic Operation on the Auditory Meatus after Panse, and Plastic Operation for a Retro-auricular Opening after Schwartze (B.).—16, Dura mater of cerebrum; 17, transverse sinus; 18 (*a*) upper quadrilateral flap, (*b*) lower quadrilateral flap from auditory meatus, after Panse; 19 (*a*) upper flap, (*b*) lower flap for the retro-auricular plastic operation, after Schwartze; 20, anterior portion of supramastoid crest, which has remained intact; 21, flattened spur.

PLATE 30.

Fig. 1. Circumscribed Otitis Externa. Pus Obtained by Incision. Dry Cover-slip Preparation (Methylene-blue) (× 1090) (B.).—1, Polynuclear leukocytes; 2, squamous epithelium from auditory meatus; 3, staphylococci.

Fig. 2. Acute Catarrh of the Middle Ear. Exudate Obtained by Paracentesis (Methylene-blue) (× 1090) (B.).—1, Cylindric epithelial cells; 2, staphylococci; 3, polynuclear leukocytes.

Fig. 3. Acute Perforating Otitis Media. Pus Obtained by Paracentesis (Methylene-blue) (× 1090) (B.).—1, Polynuclear leukocytes; 2, diplococci.

Fig. 4. Acute Periostitis and Mastoiditis. Pus Obtained by Incising an Abscess in the Mastoid Process (Methylene-blue) (× 1090) (B.).—1, Red blood-cells; 2, mononuclear leukocytes; 3, polynuclear leukocytes; 4, streptococci.

Fig. 5. Purulent Thrombosis of the Transverse Sinus; Pyemia; Blood Obtained from the Sinus by Aspiration with a Pravaz Syringe (Carbolfuchsin) (× 1090) (B.).—1, Streptococci.

Fig. 6. Otomycosis (**Aspergillus Niger**). **Section of Hardened Fungous Membrane** (Hematoxylin-Eosin) (× 200) (B.).

1. Mycelium.
2. Free conidia (spores).
3. Hyphen.
4. Receptaculum.
5. Sterigmata.
6. Spores.
7. Squamous epithelium from auditory meatus.

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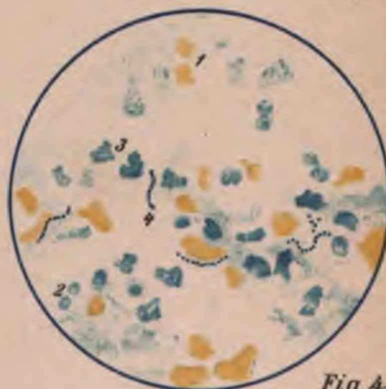

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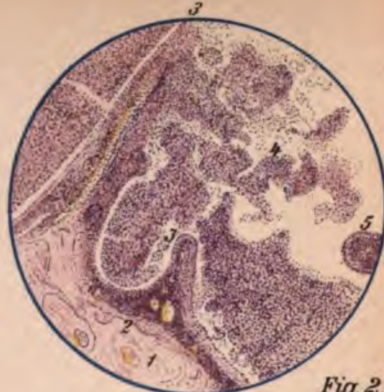

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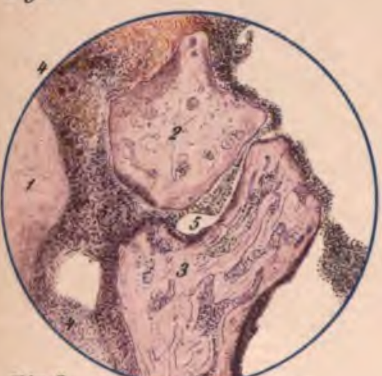

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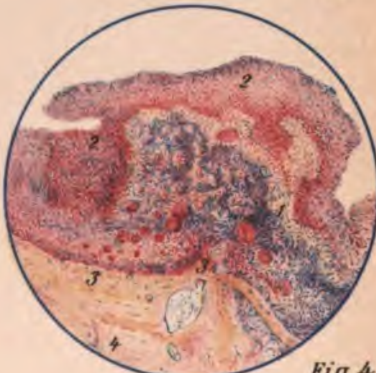

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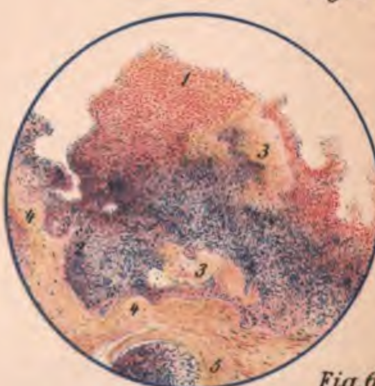

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PLATE 31.

Fig. 1. Transverse Section of Tympanic Membrane in Acute Otitis Media from a Child Two Months Old (Hematoxylin) (× 13) (B.).

1. Manubrium.
2. Tunica propria (radial fibers, stratum radiatum).
3. Macerated epidermis, epithelial cells coming away.
4. Round-cell infiltration and dilated vessels of cutis.
5. Stratum mucosum, showing round-cell infiltration; in places the epithelium is preserved.
6. Papillary elevations on the tympanic membrane and manubrium.
7. Hyaline cartilage covering the manubrium.

Fig. 2. Acute Otitis Media from a Child; Wall of Promontory (Hematoxylin) (× 13) (B.).

1. Bone.
2. Mucosa with round-cell infiltration and dilated vessels.
3. Marked papillary elevations, in part covered with epithelium.
4. Exudate.
5. Transverse section of a papilla with cylindric epithelium.

Fig. 3. Caries of the Incudomalleolar Articulation in Chronic Suppurative Otitis Media (Cupula) (Hematoxylin) (× 13) (B.).

1. Osseous portion of attic.
2. Malleus.
3. Incus, with dilated medullary spaces and eroded surface; periosteum is covered with granulations.
4. Mucous membrane undergoing marked proliferation and infiltrated with pus.
5. Incudomalleolar articulation: the ligaments have been destroyed, and the granulation tissue has penetrated into the articular cleft and into the bone.

Fig. 4. Promontory in Chronic Suppurative Otitis Media; Peripheral Caries (Hematoxylin-Eosin) (× 13) (B.).

1. Mucous membrane undergoing marked proliferation and infiltrated with pus; the blood-vessels dilated.
2. Exudate and deposits of fibrin.
3. Carious margin of bone.
4. Bone.

Fig. 5. Wall of Promontory in Chronic Suppurative Otitis Media in Tuberculosis (Male, Forty Years of Age) (Hematoxylin) (× 13) (P.).

1. Mucous membrane undergoing marked proliferation and showing round-cell infiltration.
2. Necrotic areas on the surface.
3. Carious bone.
4. Medullary space in relation with mucous membrane.
5. Necrotic nodule.

Fig. 6. Wall of Promontory in Chronic Suppurative Otitis Media; Necrotic Caries (Hematoxylin-Eosin) (× 13) (B.).

1. Granular deposit.
2. Mucous membrane undergoing marked proliferation and showing round-cell infiltration.
3. Piece of carious bone in process of sequestration.
4. Carious margin of bone.
5. Bone.

PLATE 32.

Fig. 1. Fissure in Temporal Bone (Developmental Anomaly) (P.).—Left temporal bone seen from in front. The squamous portion contains one large cleft (1) with lateral branches, and two smaller clefts (2); the upper (3) and anterior (4) bony wall of the auditory meatus presents a cleft with smooth walls. That part of the petrous portion that enters into the formation of the base of the skull presents nothing unusual; symmetric clefts are seen in the right temporal bone.

Fig. 2. Neurofibroma of the Auditory and Facial Nerves (P.).—Left temporal bone of a deaf woman who became blind and demented three months before her death. There was facial paralysis on the left side. Death was preceded by convulsions and coma. The tympanic cavity and external auditory meatus were opened by means of a horizontal section with a saw.

The tympanic membrane (1), malleus (2), incus (3), vestibule (4), and cochlea (5) present nothing unusual. The auditory and facial nerves are converted into a massive cone that completely fills the enlarged internal auditory meatus without being adherent to the walls (6). That portion of the neoplasm that lies within the internal auditory meatus appears to be the stalk of a tumor the size of a walnut, firm in consistence and smooth on the surface (7), which is closely applied to the posterior surface of the pyramid. The nerves are lost in the tissues of the tumor, and their connection with the brain is interrupted. Nerve-fibers cannot with certainty be demonstrated in the microscopic preparation that is shown on Plate 36, Fig. 2. Transverse sinus (8); carotid artery (9); trifacial nerve (10); glossopharyngeal, vagus, and recurrent nerves (11).

Tab.32.

Fig.1.

Fig.2.

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Tab. 33.

Fig. 1.

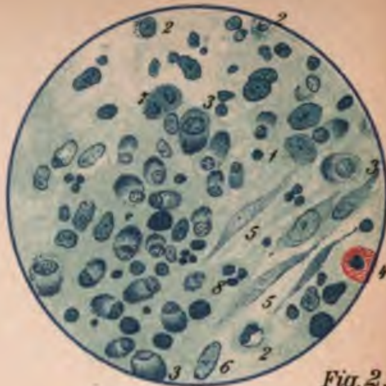

Fig. 2.

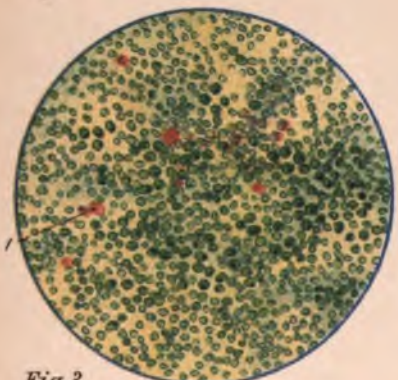

Fig. 3.

Fig. 4.

Fig. 5.

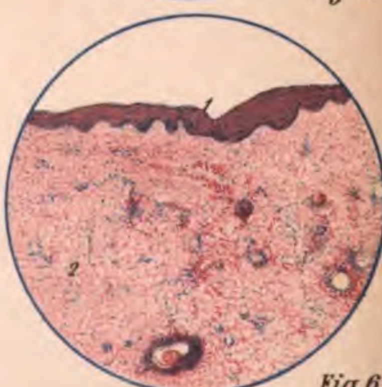

Fig. 6.

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PLATE 33.

Fig. 1. Polypoid Granulations in Chronic Suppurative Otitis Media in a Tubercular Subject (Hematoxylin-Eosin) (× 50) (B.).—1, Necrotic portion; 2, granulation tissue.

Fig. 2. Polypoid Granulation (Polychrome Methylene-blue, after Unna) (Seibert immersion lens, $\frac{1}{12}$ eye-piece O) (B.).

1. Lymphocytes.
2. Large mononuclear lymphocytes.
3. Plasma cells.
4. Mast-cells.
5. Fibroblasts with faintly stained protoplasmic corpuscles.
6. Nucleus with unstained protoplasm.
7. Leukocyte with double nucleus.
8. Polynuclear leukocytes.

Fig. 3. Polypoid Granulation with Hyaline Bodies (Russel's corpuscles) (Hematoxylin saffranin picric acid, after Unna) (× 200) (B.).—1. Russel's corpuscles (red).

Fig. 4. Polypoid Granulations Springing from the Wall of the Promontory (Hematoxylin-Eosin) (× 66) (B.).

1. Ciliated epithelium.
2. Tubular depressions.
3. Granulation tissue.
4. Epithelium covered over by wandering leukocytes.

Fig. 5. Polypoid Fibroma Springing from a Pneumatic Cell in the Posterior Bony Wall of the Auditory Meatus (Hematoxylin-Eosin) (× 18) (B.).—1. Squamous epithelium; 2, epithelial process dipping down into the tissue; 3, fibrous tissue with here and there accumulations of lymphocytes.

Fig. 6. Polypoid Myxofibroma Springing from the Wall of the Promontory (Hematoxylin-Eosin) (× 18) (B.).—1, Squamous epithelium with small papillæ; 2, myxofibrous tissue with vessels in transverse section.

PLATE 34.

Fig. 1. Acute Mastoiditis and Periostitis Following Scarlet Fever, From a Child Five Years of Age (Hematoxylin-Eosin) (× 20) (B.).—1. Periosteum showing purulent infiltration; 2, cortical portion of mastoid process; 3, Haversian canal filled with purulent granulation tissue; 4, mastoid cells: the lining mucous membrane shows marked proliferation and purulent infiltration; at (5) it encroaches on the bone.

Fig. 2. Chronic Suppurative Otitis; Connective-tissue Growth in the Mastoid Cells (× 13) (P.).—1, Bone; 2, pneumatic cells filled with connective tissue; 3, exudate.

Fig. 3. Suppurative Leptomeningitis after an Acute Otitis in a Child (Hematoxylin-Eosin) (× 26) (B.).—1, Brain; 2, pia and arachnoid, showing purulent infiltration.

Fig. 4. External Pachymeningitis Accompanying Chronic Suppurative Otitis and Caries of the Tegmen Tympani: Granulations from the Dura Mater Project into the Tympanic Cavity through an Opening in the Tegmen Tympani (Hematoxylin-Eosin) (× 66) (B.).—1, Dura mater showing round-cell infiltration; 2, fibrous tissue of the dura mater.

Fig. 5. Purulent Phlebothrombosis of the Transverse Sinus (Pyemia). Caries of the Mastoid Process Accompanying Acute Otitis Media after Diphtheria, in a Child Three Years of Age (Hematoxylin-Eosin) (× 14) (B.).

1. Bone with enlarged Haversian canals filled with granulating mucous membrane.
2. Extrusion of the granulations into the wall of the sinus.
3. Wall of the sinus showing round-cell infiltration, and—
4. Minute abscesses.
5. Parietal thrombus in process of purulent disintegration.

Fig. 6. Purulent Phlebitis of the Transverse Sinus Accompanying Chronic Otitis Media (Pyemia) (Hematoxylin-Eosin) (× 26) (B.).

1. Purulent thrombus.
2. Fibrinous deposits.
3. Normal sinus wall.
4. Portion of sinus wall contiguous to the thrombus showing purulent infiltration.

Tab. 34.

Fig. 1

Fig. 2.

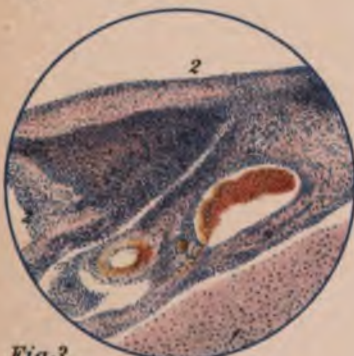

Fig. 3.

Fig. 4.

Fig. 5.

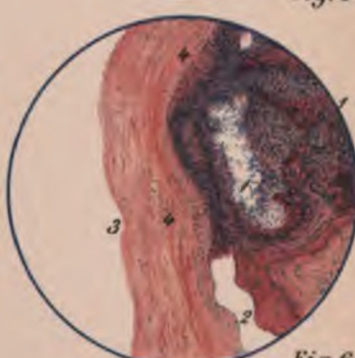

Fig. 6.

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Tab.35.

Fig.1.

Fig.2.

Fig.3.

Fig.4.

Fig.5.

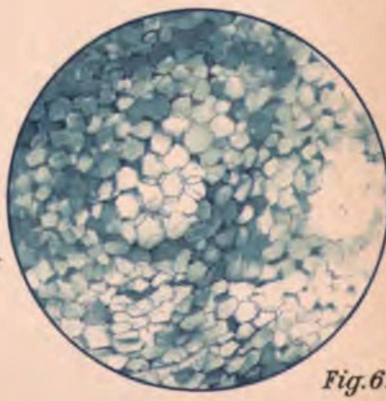

Fig.6.

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PLATE 35.

Fig. 1. Keratosis (Horny Change) of the Membranous Auditory Meatus after Removal of a Plug of Epiderm (Hematoxylin-Eosin) (× 66) (B.).

1. Atrophic epiderm.
2. Cutis.
3. Sections of hair-follicles.
4. Horny layer.
5. Enlarged hair-follicle filled with layers of horny tissue (cholesteatoma).

Fig. 2. Elephantiasis and Hyperkeratosis (Pachydermatocele) from the Leg (× 18) (B.).

1. Hypertrophic papilla.
2. Layers of horny tissue (cholesteatoma) arranged in layers between two papillæ.
3. Epiderm.
4. Pearls of horny tissue.
5. Hypertrophic cutis with inflammatory foci.

Fig. 3. Hyperkeratosis Accompanying Elephantiasis (× 200) (B.).

1. Cutis.
2. Hypertrophic rete Malpighii.
3. Transitional layer.
4. Horny layer (plates without nuclei).
5. Horny layer (lamella).

Fig. 4. Proliferation of Epiderm from Auditory Meatus into the Tympanic Cavity in Chronic Suppurative Otitis Media (× 54) (P.).

1. Epiderm from auditory meatus.
2. Remains of tympanic membrane.
3. Proliferating point at the upper border of the perforation.
4. Mucous membrane of drumhead covered with epiderm.
5. Mucous membrane of the tympanic cavity covered with epiderm.

Fig. 5. Mucous Membrane of the Tympanic Cavity Covered with Epiderm; Hyperkeratosis Accompanying Cholesteatoma (Hematoxylin-Eosin) (× 300) (B.).

1. Cutis.
2. Rete Malpighii; layer of cylindrical cells.
3. Layer of prickle cells.
4. Layer of granular cells.
5. Horny layer (hypertrophic) (cholesteatoma lamellæ).

Fig. 6. Cholesteatoma of the Mastoid Process. Section Taken from the Body of the Tumor (Hematoxylin) (× 200) (B.).—Compare Figs. 3 and 6, Figs. 1, 2, and 5.

PLATE 36.

Fig. 1. Carcinoma of the Cochlea ($\times$ 8) (see Plate 23, Fig. 1) (P.).

1. Apex of the cochlea laid open.
2. Lamina spiralis with artificial perforation.
3. Cancer cells in the scala tympani.
4. Cancer cells in the scala vestibuli.
5. Cancer cells in the scala tympani (lower turn).
6. Cancer cells on the lamina basilaris (spiralis membranacea).

Fig. 2. Neurofibroma of the Auditory Nerve (Hematoxylin-Eosin) ($\times$ 100) (P. B.).—See Plate 32, Fig. 2. Fibrous tissue with numerous spindle-cells (nerve nuclei (?)), in places sarcomatous.

Fig. 3. Connective-tissue Growth in the Attic Following Chronic Suppurative Otitis Media ($\times$ 9) (P.).

1. Osseous portion of attic.
2. Median bony wall.
3. Fibrous tissue.
4. Cystic space.

Fig. 4. Exudate and Connective-tissue Growth in the Superior Semicircular Canal after Fracture of the Base of the Skull ($\times$ 18) (P.).

1. Membranous semicircular canal with papillæ on the inner surface; exudate within the lumen.
2. Exudate in the perilymphatic space.
3. Connective tissue.
4. Thickened portions of periosteum.
5. Bony semicircular canal.

Fig. 5. Proliferation of Connective Tissue in the Cochlea after Fracture of the Base of the Skull ($\times$ 18) (P.).

1. Connective tissue in the scala tympani.
2. Exudate in the scala vestibuli.
3. Lamina spiralis with proliferation of the epithelium of Corti's organ; the nerve-bundles are replaced by granular masses.
4. Rosenthal's canal filled with granular masses.
5. Nerve-fibers.

Fig. 6. Exudate in the Cochlea after Fracture of the Base of the Skull ($\times$ 7) (P.).

1. Exudate in the scala tympani.
2. Exudate in the scala vestibuli.
3. Thickening of the inner periosteum.
4. Modiolus.

Tab.36.

Fig.1.

Fig.2.

Fig.3.

Fig.4.

Fig.5.

Fig.6.

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Tab.37.

Fig.1.

Fig.2.

Fig.3.

Fig.4.

Fig.5.

Fig.6.

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PLATE 37.

(Compare Plate 14, Figs. 5, 6; Plate 9, Fig. 4.)

Fig. 1. Hemorrhage into the Superior Semicircular Canal in Otitic Meningitis (× 26) (P.).—1, Bony semicircular canal; 2, membranous semicircular canal filled with blood; 3, hemorrhage in the perilymphatic space.

Fig. 2. Otitis Interna Accompanying Chronic Suppurative Otitis Media. Perforation through the Fenestra into the Labyrinth. Meningitis (Hematoxylin-Eosin) (× 16) (B.).—1, Hemorrhage in scala tympani; 2, seropurulent exudate in scala tympani; 3, round-cell infiltration of Rosenthal's ganglion, and 4, of the nerve-fibers of the cochlear portion in the lamina spiralis membranacea and the contiguous part of the (5) ligamentum spirale.

Fig. 3. Connective-tissue Growth in the Superior Semicircular Canal in Leukemia (× 18) (P.).—1, Bony semicircular canal; 2, membranous semicircular canal filled with lymphocytes; 3, connective tissue containing blood-vessels in the perilymphatic space.

Fig. 4. New Formation of Bone in the Cochlea in Leukemia (× 8) (P.).—1, Atrophic auditory nerve; 2, atrophic ganglion cells in Rosenthal's canal; 3, new bone formation in the scala tympani of the lower turn of the cochlea; 4, new bone formation in both scalæ.

Fig. 5. Destruction of the Ganglion Spirale in Syphilis (× 20) (P.).—1, Rosenthal's canal filled with granular masses; 2, lamina spiralis ossea without nerve-fibers.

Fig. 6. Atrophy of the Ganglion Spirale in a Deaf-mute (× 20) (P.).—1, Rosenthal's canal in part defective; isolated cells; 2, remains of nerve-fibers.

PLATE 38.

1. Normal Drumhead (Right) from an Individual with Normal Power of Hearing (B.).

2. Normal Drumhead (Left) Showing the Articulation Between the Incus and Stapes, the Promontory, and the Fenestra Rotunda.—From a boilermaker forty years of age, who was hard of hearing. Whispered conversation not heard on the right side; on the left, heard close to the ear. Rinne positive. Schwabach shortened. Upper tone limit diminished.

3. Normal Drumhead (Right) with the Bulb of the Jugular Vein Shining Through.

4. Two Spheric Exostoses on the Posterior, and One on the Anterior, Bony Wall of the Auditory Meatus.—The right drumhead was normal. From an individual with normal power of hearing.

5. Chronic Serous Catarrh of the Middle Ear.—Retraction of the drumhead with accumulation of serous exudate in the tympanic cavity. The level of the exudate lies in front of the umbo. From a fifteen-year-old boy the subject of recurrent attacks of catarrh. Whispered conversation heard at ½ m. Rinne partially negative up to *c*. Schwabach prolonged.

6. Acute (Serous) Catarrh of the Middle Ear.—Accumulation of serous exudate in the tympanic cavity. Level of exudate below the manubrium. From a man thirty-two years of age the subject of coryza. Whispered conversation heard at 3 m. Rinne partially negative up to *c*. Weber in the diseased ear. Schwabach prolonged. Upper tone limit normal.

7. Chronic Catarrh of the Middle Ear (Catarrhal Adhesions).—Retraction of the drumhead with prominence of short process of the malleus, and foreshortening of manubrium. Marked posterior fold in the drumhead; punctate reflex in the antero-inferior quadrant and in Shrapnell's membrane. From a man twenty-seven years of age the subject of hypertrophic rhinitis. Whispered conversation heard at ½ m. Rinne partially negative up to c^1. Schwabach prolonged. Upper tone limit normal. Gellé positive.

8. Chronic Catarrh of the Middle Ear: Adhesion of Shrapnell's Membrane.—Marked retraction of the drumhead. The manubrium appears so greatly foreshortened that its extremity lies on a level with the short process of the malleus, which is very prominent. Marked posterior fold in the tympanic membrane. Light reflex distorted. Shrapnell's membrane adherent to the neck of the malleus. From a man thirty-five years of age who had been hard of hearing for four years, and a sufferer from chronic rhinitis. Whispered conversation heard at 20 cm. Weber in left ear. Rinne partially negative up to c^2. Schwabach prolonged. Upper tone limit normal. Gellé positive.

9. Chronic Catarrh of the Middle Ear (Catarrhal Adhesions).—The drumhead is opaque and milky, with a more intense, semilunar intermediate opacity in the posterior half. From a woman fifty-two years of age who had been hard of hearing for eight years. Whispered conversation heard at 30 cm. Weber in right ear. Rinne partially negative up to c^1. Schwabach prolonged. Upper tone limit normal. Gellé positive.

10. Chronic Catarrh of the Middle Ear: Calcareous Deposits.—Drumhead opaque; calcareous deposit in front of manubrium and in posterosuperior quadrant. From a man thirty-two years of age who had been hard of hearing for eight years. Whispered conversation at 1 m.

PLATE 38 (*Continued*).

11. Chronic Catarrh of the Middle Ear: Calcareous Deposits (Nervous Deafness).—Drumhead opaque; horseshoe-shaped calcareous deposit. From a woman fifty years of age who had been hard of hearing for ten years. Rinne partially negative up to *c*. Whispered conversation heard at ½ m. Weber in head. Duration of sound perception from vertex shortened. Upper tone limit reduced. Gellé positive.

12. Ankylosis of the Stapes (With Partial Nervous Deafness).—Normal right drumhead. Behind the manubrium the hyperemic promontory shines through. From a woman thirty years of age who had been hard of hearing for ten years. Whispered conversation heard close to the ear. Rinne absolutely and totally negative up to c^2 inclusive; *C* heard only through the bone. Weber in the right ear. Duration of sound perception from vertex shortened. Upper tone limit reduced. Gellé positive.

13. Acute Myringitis.—Vesicle on the posterior half of the drumhead, which is reddened and presents small hemorrhages in the antero-inferior quadrant. From a man thirty years of age. The affection developed after the entrance of water into the ear. Whispered conversation heard at 6 m.

14. Chronic Granular Myringitis.—Small granules on the upper half of the drumhead. The membrane is opaque. From a man twenty-three years of age. Whispered conversation heard at 6 m.

15. Traumatic Rupture.—The anterosuperior quadrant of the drumhead presents a perforation with hemorrhagic edges; punctate hemorrhages in the immediate vicinity. The tympanic mucous membrane is of a pale-yellow color. The patient, a man twenty-eight years of age, had his ears boxed from behind three days ago. Whispered conversation heard at 1.5 m. for high-pitched, and ¾ m. for low-pitched, words. Rinne partially negative to c^1. Weber in the right ear. Schwabach prolonged. Upper tone limit normal.

16. Traumatic Rupture with Labyrinth Disease.—Perforation with hemorrhagic edges in the lower half of the drumhead. After a plug of cerumen had been removed the membrane was found to be hyperemic. The patient, a man thirty years of age, had his ears boxed three days before. Whispered conversation heard up to ½ m. The ticking of a watch is heard close to the ear, but not when applied to the mastoid process. Rinne partially negative up to *C*. Weber in the sound right ear. Schwabach shortened. Upper tone limit diminished. Gaps in the scale.

17. Simple Acute Otitis Media.—Injection of the radial vessels and of the vessels of the manubrium in an otitis media developing after acute middle-ear catarrh. The patient was a man forty years of age; the attack was brought on by a Russian bath.

18. Simple Acute Otitis Media.—The manubrium is indistinct; the epidermis is macerated; the drumhead is injected and the surface irregular. From a man thirty years of age. The condition, which followed an attack of angina, had lasted three days.

19. Simple Acute Otitis Media.—Ecchymosis on the reddened drumhead; in the anterosuperior quadrant the short process projects as a yellow spot. From a man thirty years of age. The trouble followed a severe attack of sternutation.

PLATE 38 (*Continued*).

20. Acute Suppurative Otitis Media (With Hyperemia of the Labyrinth).—Vesicular bulging of the posterosuperior quadrant of the drumhead. The manubrium is not visible. Ecchymoses are seen on the reddened membrane. From a girl eighteen years of age. The condition developed on the second day of an attack of influenza. Whispered conversation heard at 1½ m. Rinne partially negative up to *C*. Weber in the diseased ear. Schwabach somewhat prolonged. Upper tone limit reduced.

21. Acute Suppurative Otitis Media.—Dusky red bulging of the posterior half of the drumhead. The manubrium is obscured. The condition developed in a boy twelve years of age after an attack of sore throat.

22. Acute Suppurative Otitis Media.—Villous bulging of the posterosuperior quadrant of the drumhead. A droplet of pus exudes at the apex. Manubrium not visible. Developed in a child five years of age after an acute attack of coryza. Intense suppuration with great sensitiveness to pressure in the mastoid process. Recovery in eight weeks.

23. Acute Suppurative Otitis Media.—Diffuse reddening of the drumhead. The manubrium is not visible; the antero-inferior quadrant contains an abscess. Developed in a boy eleven years of age after coryza, three days before the appearance of measles.

24. Acute Suppurative Otitis Media.—Drumhead reddened; the only parts of the malleus that are visible are the short process and the upper portion of the manubrium. The antero-inferior lower quadrant contains a perforation the size of a hemp-seed, and shows pulsating pus. The condition developed in a man thirty-two years of age on the twelfth day after influenza.

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Tab. 39.

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PLATE 39 (B.).

1. Chronic Suppurative Otitis Media.—Drumhead opaque and retracted; round perforation behind the umbo. Mucous membrane of tympanic cavity reddened. Male, forty years of age; suppuration has existed four years. Whispered conversation heard at a distance of 1½ m. Rinne absolute and partially negative up to c'. Weber in the right ear. Schwabach prolonged. Upper tone limit normal.

2. Chronic Suppurative Otitis Media.—Small reniform perforation below the handle of the malleus. Umbo projects into the perforation. In the posterosuperior quadrant the articulation between the incus and stapes is visible. Boy, twelve years of age. Suppuration has existed ten years.

3. Chronic Suppurative Otitis Media (Exacerbation).—Reniform perforation with granulating edges below the handle of the malleus. Mucous membrane of tympanic cavity reddened. Female, thirty-five years of age. Suppuration existed during childhood, but ceased years ago. Six weeks ago, after a bath, the suppuration reappeared.

4. Chronic Suppurative Otitis Media.—Large reniform perforation below the handle of the malleus. Girl, twelve years of age. Suppuration after measles in the second year.

5. Chronic Suppurative Otitis Media.—Destruction of all but a narrow peripheral strip of the tympanic membrane; the handle of the malleus projects into the perforation. In the posterosuperior quadrant one sees the articulation between the incus and the stapes; in the postero-inferior quadrant the margin of the fenestra cochleæ. Male, eighteen years of age. Suppuration began three years ago after scarlet fever.

6. Chronic Suppurative Otitis Media (Caries of the Incus and Floor of the Tympanic Cavity).—Destruction of all but a narrow peripheral strip of the tympanic membrane; extremity of the malleus is adherent to the promontory; in the posterosuperior quadrant the head of the stapes is seen; the long process of the incus is wanting. Small granulations are seen on the floor of the tympanic cavity. Female, twenty-four years of age. Aural discharge since childhood.

7. Chronic Suppurative Otitis Media (Handle of Malleus; Caries of Incus).—Nothing remains of the tympanic membrane but Shrapnell's membrane and a short stump of the malleus. The handle of the malleus and the long process of the incus have been destroyed. In the postero-inferior quadrant the margin of the fenestra rotunda, and in the posterosuperior quadrant the head of the stapes, are seen. The long process of the incus is wanting. A blood-vessel is seen to pass over the promontory from below upward. Postscarlatinal suppuration of twenty years' standing.

8. Chronic Suppurative Otitis Media (Caries of the Tympanic Cavity).—Total absence of the tympanic membrane, the malleus, and the incus. Granulations on the floor of the cavity. In the posterosuperior quadrant the head of the stapes, and in the postero-inferior the margin of the fenestra rotunda, are seen. Postscarlatinal suppuration of fifteen years' standing.

9. Chronic Suppurative Otitis Media. Polypoid Granulations (Caries of the Malleus and Incus).—Of the tympanic membrane nothing remains but Shrapnell's membrane and a small remnant of the malleus; the handle of the malleus is completely destroyed. On the posterior half of the wall of the tympanic cavity there is a spheric polyp with broad base. Male, thirty years of age. Running from the ear since childhood.

PLATE 39 (*Continued*).

10. Chronic Suppurative Otitis Media. Polypoid Granulations (Caries of the Malleus and Incus).—Nothing remains of the tympanic membrane but Shrapnell's membrane and a remnant of the malleus. The handle of the malleus is completely destroyed. In the postero-superior quadrant the long process of the incus, which is necrotic and drawn out into a point, projects into the cavity. The mucous membrane lining the tympanic cavity is covered with numerous granulations. Girl, eighteen years of age. The aural discharge came on after diphtheria and has existed one year.

11. Chronic Suppurative Otitis Media; Cholesteatoma (and Nervous Deafness).—The drumhead is destroyed except for a narrow peripheral strip above and in front; the stump of the malleus is adherent to the promontory. The mucous membrane of the tympanic cavity is covered with epiderm, and in its postero-inferior portion with granulations. Above and behind cholesteatomatous masses arranged in layers project from the passage into the antrum. Female, thirty years of age. Has had running of the ear since childhood. Whispered conversation inaudible. Ordinary conversation heard at a distance of ½ m. Rinne absolute and partially negative up to c^1. Weber in the head. Schwabach prolonged. Upper tone limit greatly lowered.

12. Chronic Suppurative Otitis Media.—Entire absence of the drumhead, malleus, and incus. The mucous membrane of the tympanic cavity is covered with epiderm except for a few granulating areas. Woman, sixty years of age. Has had aural discharge since childhood. Whispered conversation inaudible; ordinary conversation heard at ¾ m. Rinne absolute and partially negative to c^2.

13. Chronic Suppurative Otitis Media. Double Perforation.—Perforation in front of and behind the handle of the malleus. Patient was a girl sixteen years old, of tubercular diathesis. Suppuration had existed three months.

14. Chronic Suppurative Otitis Media. Perforation in Shrapnell's Membrane (Caries of the Incus).—Small perforation behind and above the small process of the malleus. Male, twenty years of age. Aural discharge since childhood.

15. Chronic Suppurative Otitis Media. Perforation in Shrapnell's Membrane. Polypoid Granulations (Caries of the Attic).—Perforation above the short process of the malleus. Defect in the osseous portion of the attic. A spheric polyp projects downward from the defect in the bone into the perforation. Male, forty years of age. Aural discharge since childhood. Whispered conversation heard on the right side at 1½ m. Rinne partially negative to c^1. Weber in the diseased ear. Schwabach prolonged. Upper tone limit normal.

16. Chronic Suppurative Otitis Media. Cholesteatoma.—Destruction of Shrapnell's membrane and the osseous portion of the attic. The cholesteatomatous masses project from the perforation into the auditory meatus. The drumhead is opaque, and granulations are seen at the handle of the malleus. Woman, thirty-eight years of age. Aural discharge since childhood.

17. Remains of a Chronic Suppurative Otitis Media. Dry Perforation.—Reniform dry perforation. Behind and below in the opening of the perforation the margin of the fenestra rotunda is visible. A blood-vessel passes over the promontory. Female, twenty-three years of age. Had aural discharge in her nineteenth year. The discharge ceased two years ago.

PLATE 39 (*Continued*).

18. Remains of a Chronic Suppurative Otitis Media. Dry Perforation. Calcareous Deposits.—In the posterosuperior quadrant a perforation in which the margin of the fenestra rotunda and the articulation between the incus and stapes are visible. In front and above a remnant of drumhead containing calcareous deposits. Male, twenty-four years of age Had aural discharge fifteen years ago.

19. Remains of a Chronic Suppurative Otitis Media. Adherent Cicatrix.—Drumhead retracted. In the antero-inferior quadrant a scar adherent to the wall of the promontory. Female, twenty years of age; aural discharge during childhood. Whispered conversation heard at 1 m. Rinne partially negative up to c'. Weber in the right ear. Schwabach prolonged. Upper tone limit normal.

20. Remains of a Chronic Suppurative Otitis Media. Adherent Cicatrix.—Of the handle of the malleus only the short process is visible. The anterior half of the drumhead contains a depressed scar adherent to the opposite wall of the tympanic cavity. Female, twenty-five years of age. Aural discharge in childhood.

21. Remains of a Chronic Suppurative Otitis Media. Calcareous Deposits. Cicatrix.—The anterosuperior and posterosuperior quadrants contain calcareous deposits. Below the handle of the malleus there is a reniform, slightly movable scar. Male, fifty years of age. Aural discharge in childhood. Whispered conversation heard at 2 m. Rinne partially negative up to c. Weber in the head.

22. Remains of a Chronic Suppurative Otitis Media. Adherent Cicatrices.—The drumhead distorted by cicatrix. The handle of malleus immovably adherent to promontory. Female, thirty years of age. Aural discharge in childhood. Whispered conversation inaudible on the right side. Ordinary conversation heard at ½ m. Rinne absolute and totally negative. Weber in the right ear. Schwabach prolonged.

23. Remains of a Chronic Suppurative Otitis Media. Cicatrix and Calcareous Deposit.—A crescent-shaped calcareous deposit surrounds the handle of the malleus. Above and behind is a cicatrix loosely adherent to the bone, so that the margin of the fenestra rotunda and the articulation between the incus and stapes are distinctly seen. Female, twenty-four years of age. Aural discharge in childhood. Whispered conversation heard at 1½ m.

24. Scar from Fig. 15 after Politzer's Procedure.—Vesicular bulging of the scar. The characteristic points on the inner wall of the tympanic cavity have disappeared. Whispered conversation heard at 6 m.

[redacted]

ANATOMY AND PHYSIOLOGY OF THE ORGAN OF HEARING.

I. ANATOMY.

A. INTRODUCTION.

THE organ of hearing consists of two main portions, lodged mostly within the temporal bone:

(*a*) The sound-conduction apparatus; (*b*) the sound-perception apparatus.

The conduction apparatus is composed of the external ear—the pinna and the external auditory meatus—and of the middle ear—the drumhead, the tympanic cavity, the ear ossicles, the Eustachian tube, and the mastoid process.

The perception apparatus is composed of the internal ear—the labyrinth, the auditory nerve, and the central nervous organs.

B. MACROSCOPIC, MICROSCOPIC, AND TOPOGRAPHIC ANATOMY.

(A) THE SOUND-CONDUCTION APPARATUS.

1. The **auricle,** or **pinna** (see Fig. 16, Plate 16), is a reflection of skin over a framework of yellow elastic cartilage. On the posterior aspect the finger sinks into the interval between the auricle and the skull to a depth equal to half the width of the ear. The pinna forms an angle of 45 degrees with the head, the upper extremity presenting a slightly backward inclination. Its level is indicated by horizontal lines extending backward from the eyebrow above and the tip of the nose below; its posterior insertion corresponds to the squamomastoid suture, being situated 15 mm. behind the suprameatal spine. The auricle consists of two cartilaginous rings covered with skin—the helix and the antihelix. The helix begins in the concha auriculæ; the first portion is known as the crus helicis, and divides the concha into two portions: the scaphoid

FIG. 1.—Cartilage of left ear, with muscles. Front view (muscles after Schwalbe): 1, Superior auricular; 2, anterior auricular; 3, musculus helicis major; 4, musculus helicis minor; 5, musculus tragicus on the cartilage of the tragus; 6, musculus antitragicus; 7, spina helicis; 8, cauda helicis; 9, fissura antitragohelicina.

fossa above and the cavum below. At the beginning of the helix there is a subcutaneous nodule, the spina helicis (Fig. 1); below, it terminates in a process, the cauda helicis, which is separated from the antitragus by a cleft closed with connective tissue, the fissura antitragohelicina. The antihelix is formed by the junction of the two crura of the antihelix, which are separated by the triangular fossa. It begins in the upper anterior portion of the auricle and occupies a deeper level than the helix. The hollow between the helix and the antihelix is known as the scaphoid fossa (scapha). Behind and below, the antihelix forms a prominence known as the antitragus. Opposite this, and separated from it by the incisura intertragica, is the tragus, which overlaps the mouth of the ex-

Fig. 2.—Cartilage of the left ear with muscles. Rear view (muscles after Schwalbe): 1, Superior auricular; 2, musculus obliquus auricular; 3, anterior auricular; 4, posterior auricular; 5, transversus auriculæ; 6, spina helicis; 7, cauda helicis; 8, cartilaginous portion of auditory meatus with the two fissures of Santorini; 9, triangular process; 10, eminentia conchæ; 11, ponticulus; 12, eminentia fossæ auricularis; 13, incisura terminalis; 14, fissura antitragohelicina.

ternal auditory meatus. The lowest portion of the auricle is formed by the lobe, which contains no cartilage. The eminences and depressions on the external or lateral concave surface of the auricle correspond to depressions and elevations on the inner or median convex surface, which bear the same names (Fig. 2). Thus we have, corresponding to the outer concha auriculæ, the eminentia conchæ on the inner surface, which presents a ridge known as the ponticulus. The cartilage is attached to the skull by means of ligaments that are continuous with the perichondrium of the auricle and of the auditory meatus, and with the periosteum of the temporal bone; above, to the squamous portion (superior auricular ligament); in front, to the zygomatic process (anterior auricular ligament); and behind, to the mastoid process (posterior auricular ligament) (Plate 4). The muscles are derivatives of the platysma myoides, and, like the latter, innervated by the facial nerve. On the outer surface are attached the helicis major and minor and the tragicus and antitragicus; on the inner surface the transverse auricular and oblique auricular. Elevation of the auricle is effected by contraction of the superior auricular (attolens), which is, as a rule, very imperfectly developed (origin, aponeurosis of occipitofrontalis; insertion, upper portion of auricular cartilage). Attraction is performed by the anterior auricular muscle (attrahens) (origin, aponeurosis of occipitofrontalis; insertion, helix), retraction by the posterior auricular muscle (retrahens) (origin, mastoid process; insertion, ponticulus).

Histology.—The auricle is composed of a plate of elastic cartilage rich in cells and covered with perichondrium and an investment of skin. On the outer or lateral surface the skin is immovably attached to the perichondrium by elastic fibers; at this point the epiderm (stratum corneum, mucosum) is thin, the corium contains small papillæ, and the subcutaneous layer is sparingly supplied with fat. In the neighborhood of the incisura intertragica there are a number of long hairs and some sebaceous glands. On the inner or median surface of the auricle the skin is movable, the epidermic layer is somewhat thicker, and the subcutaneous layer is rich in fat; it is covered with fine soft hairs and contains sebaceous and small sudoriferous glands.

2. The **external auditory meatus** (Plates 3 and 4) is composed of a fibrocartilaginous and a bony portion.

The cartilaginous portion is the continuation of the auricular cartilage (see Figs. 1 and 2), the boundary being marked posteriorly by a cleft known as the incisura terminalis. In front and below, at the tragus, the auricular cartilage gradually develops into the cartilaginous portion of the auditory meatus, which is open behind and above, the canal being completed by fibrous tissue connected with the posterior auricular ligament. The cartilaginous and cutaneous lining of the auditory meatus is loosely attached to the smooth upper border of the bony portion of the canal, but the union with the lower roughened border is more firm. The extremity of the cartilaginous portion of the auditory meatus is drawn out to a point known as the triangular process. In front and below, the cartilage of the auditory meatus contains two clefts covered in by fibrous tissue: a longer lateral and a shorter median cleft, known as the incisuræ Santorini (pus-channel to articulation of lower jaw and to parotid gland). The cartilaginocutaneous portion of the meatus joins the bony portion, which merges into the temporal bone (Plate 1). (For further description of the auditory meatus see under 3.)

3. The **temporal bone,** which lodges the organ of hearing, is composed of three portions (Plate 1), readily separated in the new-born: (α) The *squamous* portion or squama; (β) the *tympanic* portion (annulus tympanicus); and (γ) the *petrous* portion, or pyramid. The temporal bone articulates in front with the greater wing of the sphenoid; above, by means of the temporofrontal suture, with the frontal; and behind with the occipital bone. The petrous portion articulates with the sphenoid and with the occipital bone.

(α) The **squamous portion** of the temporal bone, or squama temporalis, consists of a plate of bone thinner at the center than at the periphery, and protects the temporal lobe. In front the zygomatic process, formed by two roots separated by the mandibular fossa, takes its origin. The anterior of these two roots, known as the auricular tubercle, is thicker than the posterior and receives the auricular process of the inferior maxilla when the mouth is opened. Since the auricular process of the inferior maxilla comes in relation by means of its inner half with the bony, and by means of its outer half with the cartilaginous, portion of the auditory meatus, the anterior cartilaginous wall of the meatus is drawn forward when the mouth is opened, and the cartilaginous portion is accordingly enlarged; hence we open the mouth when listening intently. The upper border of the zygomatic process gradually fades away into a ridge known as the supramastoid crest (linea temporalis), which passes upward and backward and usually lies somewhat deeper than the floor of the middle fossa of the skull, though in brachycephalic individuals it often lies on a higher plane (Körner) (Plates 10, 17). The supramastoid crest forms the upper boundary in the operation for opening the mastoid process. The squama is traversed by a groove that lodges the middle temporal artery. The inner surface presents depressions known as the juga cerebralia and impressiones digitatæ, which correspond to convolutions and fissures of the brain. In the adult the inner surface of the temporal portion is joined to the pyramid by the remains of the petrosquamous suture. In the new-born the junction is effected by a distinct cleft containing vascular connective tissue, through which pus may pass from the middle ear to the middle fossa of the skull (Plate 2). This cleft is formed by a horizontal plate from the temporal portion being pushed under a corresponding horizontal plate from the pyramid; the latter is known as the tegmen tympani et antri.

That part of the squamous portion lying below the supramastoid crest in the adult forms almost a right angle with the bony roof of the auditory meatus; in the new-born it forms an obtuse angle with the plate of bone from which the bony roof of the auditory meatus develops (superficies meatus, Plates 2, 3). The posterior inferior process of the squamous portion in the new-born forms the outer covering of the mastoid antrum. The squamo-mastoid suture marks its union with the posterior extremity of the petrous portion (pars mastoidea), and traces of it are sometimes seen in the adult (pus-channel) (Plate 1). The inner surface of the squamous portion in the new-born contains pneumatic cells, and with the growth of the latter the antrum, which in the new-born lies superficially, gradually takes up a deeper position. The inner surface of the superficies meatus is smooth and becomes the outer surface or osseous portion of the attic, a space designed for the reception of the head of the malleus and body of the incus (Plate 2).

(β) The **tympanic portion** in the new-born forms a ring open above and anteriorly (annulus tympanicus and incisura Rivini), which becomes closed by apposition to the superficies meatus. This ring of bone contains a furrow, the tympanic sulcus, for the attachment of the drumhead (Plate 2). The anterior and posterior limbs of the tympanic ring are occupied by prominences known as the anterior and posterior tympanic tubercles. The inner surface of the anterior limb in addition presents two spines (separated by an oblique ridge), the anterior and posterior (major) tympanic spines. Below these spines, through a furrow known as the sulcus malleolaris, the chorda tympani, the anterior ligament of the malleus, and the anterior tympanic artery and vein pass out from the tympanic cavity (Plate 4). The bony portion of the meatus is formed in part by the tympanic ring, which contributes the roof, the anterior and a part of the posterior wall, and in part by the superficies meatus (of the squama), which contributes the roof and part of the posterior bony wall of the meatus. The growth being more active about the tympanic tubercles than in other portions of the tympanic ring, two bony ridges are formed, beginning at each of the tympanic tubercles and growing in opposite directions to unite in the second year. Between these two ridges there is usually a gap that does not close before the fifth year. Occasionally it persists in the adult, in the anterior lower wall, and offers a passage for pus from the auditory meatus to the articulation of the jaw (Plate 27). The roof and part of the posterior bony wall of the meatus are formed by an almost right-angled reflection of the superficies meatus, which in the new-born joins the squama at an obtuse angle. The *external auditory meatus* in the *new-born* consists of skin and cartilage only; it is attached to the superficies meatus and tympanic ring. The roof of the meatus is formed by the superficies meatus, in the continuation of which the almost horizontal drumhead is found. The outer portion of the floor is cartilaginous, and the inner fibrous. The latter is continuous with the tympanic ring (Plate 4). The lumen of the auditory meatus in the new-born is extremely small and occluded by vernix caseosa. The floor is closely applied to the drumhead, hence to obtain a good view it must be drawn away from the membrane by drawing the auricle backward and downward (Plate 4). The bony portion of the meatus is usually completed by the third year. With the completion of the bony meatus the drumhead descends, its upper pole becomes elevated, and the membrane is separated from the floor of the meatus, so that the lumen becomes enlarged.

In the *adult* the *bony auditory meatus* forms a tube with an oval external opening—the porus acusticus externus (Plate 1). The posterior extremity of the anterior bony wall of the meatus, which is in relation with the articular surface of the inferior maxilla (crushing of the anterior wall of the meatus by a fall on the inferior maxilla), presents a fissure which is divided by a bony plate projecting from the pyramid (processus inferior tegminis tympani) into the petrosquamous fissure above and the petrotympanic or Glaserian below. The latter is constant and lodges the chorda tympani, the tympanic artery and vein, and the anterior ligament of the malleus.

The parotid gland comes in relation with the anterior wall and floor of the auditory meatus (Plate 3). (Contraction of the cartilaginous portion of the meatus by tumors of the parotid gland.) The posterior bony wall of the meatus is divided from the mastoid process by the tympanomastoid fissure, through which the auricular nerve, a branch of the vagus, passes to the posterior wall of the meatus. The posterior bony wall of the meatus is divided from the mastoid cells by a plate of bone 1 or 2 mm. in thickness, from the sigmoid groove by about 12 mm. of bony substance, and its deeper portion from the antrum by 5 mm. of bone. The roof of the auditory canal consists of two compact plates of bone that often contain pneumatic cells. The floor of the third temporal convolution (gyrus temporalis III, Plate 10), which is about $\frac{3}{4}$ cm. in thickness, is formed by these plates. The inferior lamella of the roof is continuous with the outer wall of the osseous portion of the attic (Plate 3). At the junction between the roof and posterior wall of the auditory canal, close to the drumhead, the bone presents a number of canaliculi containing blood-vessels and connective tissue, through which pus may burrow from the antrum under the periosteum of the auditory canal. On the outer surface and behind and above the bony portion of the auditory canal is an eminence,—the suprameatal spine,—and immediately above, in a depression known as the mastoid fossa, are a number of canaliculi for the transmission of blood-vessels. Through these canaliculi pus may make its way from the antrum to the surface of the mastoid process (Plates 1, 6).

The general direction of the external auditory meatus is from without inward and slightly forward, so that the two axes of the auditory canal form an angle of 80 degrees with the median plane (see Fig. 5). The auricle and the cartilaginous portion of the meatus are, so to speak, suspended from the bony portion of the canal, so that the cartilaginous and bony portions form an angle with the vertex pointing upward. The vertical plane between the free border of the tragus and the projecting border of the cavum conchæ (Schwalbe) is regarded as the external opening of the auditory meatus (Plate 4). The first portion (cartilaginous), from this point to the incisura Santorini major (Fig. 3, *a*), runs slightly forward; the second portion (cartilaginous), from the incisura Santorini to the porus acusticus externus (*b*), is deflected backward, while the third portion of the canal (osseous) (*c*) again takes a somewhat forward direction. To straighten out the cartilaginous portion in the adult, for the purpose of examining the drumhead, the pinna must be drawn backward and upward (Plate 4, Fig. 3).

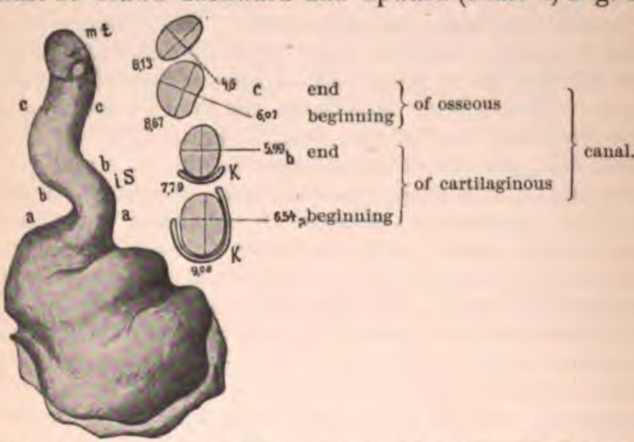


Fig. 3.—*K*, cartilage; *i S*, fissure of Santorini; *m t*, drumhead; $a + b =$ cartilaginous; $c =$ osseous portion of auditory canal. Metal cast of the external ear (right) from above, and transverse sections of the external auditory meatus with the largest and smallest diameters (after Bezold). The cast is shown in the position it would assume after being drawn out of the right ear.

The roof of the auditory canal runs almost horizontally as far as the drumhead. The floor in the bony portion is convex above, sometimes to such an extent that the lumen is contracted and the anterior half of the tympanic membrane obscured. The posterior bony wall of the canal runs vertically or somewhat obliquely backward, making a right or obtuse angle with the outer surface of the mastoid process. In the latter case the sigmoid groove often approaches close to the posterior bony wall (Plate 6, Trautmann). Immediately in front of the drumhead the bony floor of the auditory canal is convex above and forms an acute angle (27 degrees) with the membrane. This space, known as the recessus meatus acusticus externus (Plate 3), often becomes a lodging-place for small foreign bodies. The floor of the canal is longer than the roof, and accordingly extends further into the interior. The anterior wall is longer than the posterior, and, like the floor, extends farther in than the posterior wall.

The lumen is greater at the two extremities than at the middle of the canal; in the cartilaginous portion it contracts uniformly from without inward. In the bony portion the contraction is greatest at the inner third (isthmus), where foreign bodies are apt to be found (see Fig. 3). The length of the auditory meatus is about 14 mm.; that of the cartilaginous portion, measured from the tragus, 21 mm., the entire length being, therefore, about 35 mm. (Bezold) (Plate 4).

Histology (Plate 13).—The skin covering the cartilaginocutaneous portion of the canal presents small papillæ below the epidermis, and a number of hairs with tubular sebaceous glands and about 1500 large ceruminous glands, the latter consisting of cuboid epithelial cells containing a brownish granular pigment imbedded in the subcutaneous stratum. The narrow ducts of these glands, after making a sharp bend, terminate in a common depression with hair-follicles and sebaceous glands. The pigmented secretion from these glands, mingling with the fat from the sebaceous glands and desquamated epithelium, forms cerumen which often contains pathogenic micro-organisms (Rohrer) and the demodex folliculorum. The skin covering the bony meatus is thin except in that portion (the posterior portion of the roof) which is derived from the superficies meatus, where it is thicker and also contains hairs and glands; this wedge-shaped strip of skin extends down as far as the drumhead (Plate 31).

(γ) **Petrous Portion** (Plates 1, 2, 5).—The petrous portion of the pyramid in the new-born is distinguished from that of the adult by its size and the greater distinctness of the bony ridges. The petrous portion presents a quadrilateral pyramid. The anterior border, assisted by the sphenoid bone, forms the foramen lacerum anterius (Plate 11), which transmits the carotid artery, Eustachian tube, and the great and lesser superficial petrosal nerves. The upper border presents a groove that lodges the superficial petrosal sinus; the posterior border lodges the inferior petrosal sinus, and forms, with the occipital bone, the foramen lacerum posterius, or jugular foramen. The latter is divided by a bony spine into a smaller anterior compartment for the transmission of the glosso-pharyngeal, vagus, and spinal accessory nerves, and a larger posterior compartment for the transmission of the internal jugular vein (Plate 5). The lower border forms a sharp ridge on the continuation of the mass of bone that surrounds the styloid process. The anterior upper surface of the pyramid presents at its apex a depression that lodges the semilunar ganglion of the fifth nerve, and on the outer side of the depression two parallel grooves with separate openings: a median opening that transmits the great superficial petrosal nerve to the spurious opening in the Fallopian canal (a bristle introduced into the stylomastoid foramen emerges at this opening), and a lateral opening that transmits the small superficial petrosal nerve to the apertura superior canaliculi tympanici (Plate 5). About the middle of the pyramid, near its upper border, there is a bony ridge (eminentia arcuata) that overlies the superior semicircular canal (Plates 2, 7, 8). When, as occasionally happens, there is a defect in this ridge, pus may pass through the labyrinth to the brain. To the outer side of this ridge is a smooth plate of bone about the thickness of paper, and occasionally, especially in brachycephalic subjects, divided by a fissure that contains pneumatic cells. It is the tegmen tympani et antri (roof of the tympanum and antrum), and permits the passage of pus from the middle ear to the middle fossa of the skull. It is joined to the squamous portion of the tegmen by the petrosquamous suture.

The roof of the tympanum and antrum supports the third temporal convolution, to the inner side of which is found the fusiform gyrus of the occipital lobe, while still farther inward, on the apex of the pyramid, is found the hippocampal gyrus, a continuation of the lingual convolution of the occipital lobe (Plate 10). About the middle of the posterior superior surface of the pyramid there is an oval opening, the porus acusticus internus, which transmits the auditory and facial nerves, and the internal auditory artery and vein (Plates 2, 13, 4, 5). The floor of the internal auditory meatus is divided by a transverse ridge, the falciform crest, into an upper and a lower fossa (see Fig. 14). The upper fossa presents, in front, near the apex of the pyramid, an opening for the seventh nerve, and behind this several canaliculi forming the superior cribriform area (area cribrosa superior sive vestibularis), which transmits the utricular and the superior and lateral ampullary nerves. The lower fossa in front presents a number of spiral openings (tractus spiralis foraminosus) with a large central foramen (foramen centrale) for the passage of the cochlear portion of the auditory nerve, and behind this another foramen (the foramen singulare) for the transmission of the inferior ampullary nerve. Between and above these two foramina are several smaller openings constituting the middle cribriform area (area cribrosa media sive vestibularis inferior) for the saccular nerve. These foramina may become channels for the passage of pus from the labyrinth to the posterior fossa of the skull. On the posterior surface of the pyramid, especially in the new-born, the superior and posterior horizontal canals appear very distinctly (Plate 2). Underneath there is a cleft in the bone that communicates with the external opening of the aquæductus vestibuli. This also affords passage for pus from the labyrinth to the posterior fossa of the skull (Plates 2, 7). The superior semicircular canal is undermined by a fossa that contains vascular connective tissue (fossa subarcuata), and allows pus to pass from the interior of the petrous portion to the posterior fossa of the skull.

Behind the porus acusticus internus the great horizontal fissure of the cerebellum comes in relation with the petrous portion; while in front of the porus acusticus internus, between the petrous portion and the middle peduncle of the cerebellum, there is a lateral diverticulum of the subarachnoid space (Zuckerkandl) (Plate 10). On the posterior inferior surface of the pyramid, between the mastoid process and the styloid process, the stylomastoid foramen transmits the seventh nerve and the stylomastoid artery and vein. In front lies the jugular fossa, which is usually deeper on the right than on the left side, and lodges the bulb of the jugular vein (Plate 5); this is sometimes defective and permits pus to pass from the tympanic cavity to the bulb (Plate 17). A small foramen within the fossa transmits the auricular nerve (a branch of the vagus) to the tympanomastoid fissure.

Behind the anterior portion of the postero-inferior surface of the pyramid, which unites with the occiput by means of the petrobasilar suture (Plate 11), is the external opening of the carotid canal, which transmits the internal carotid artery, with its accompanying plexus of veins and the sympathetic nerve plexuses. The walls of the canal are pierced by small foramina (canaliculi caroticotympanici) through which small blood-vessels enter the tympanic cavity. These may form pus-channels from the tympanic cavity to the carotid (Plate 5). Between the jugular fossa and the external opening of the carotid canal is a small depression, the fossula petrosa, for the reception of the petrosal ganglion of the ninth nerve. Through a foramen in this fossa (apertura externa canaliculi tympanici) the tympanic nerve passes into the tympanic cavity (Plate 5). Behind and to the median side of the latter is an infundibuliform depression (Plates 7, 8) leading into the aqueduct of the cochlea (apertura externa aquæductus cochleæ). Through this channel pus may pass from the labyrinth into the subarachnoid space of the posterior fossa of the skull. On the antero-inferior surface of the pyramid the internal carotid emerges from the bone through the apertura interna canaliculi carotici. To its outer side and sometimes separated by a thin plate of bone (pus-channel from the Eustachian tube to the carotid artery) lies the canalis musculotubarius (Plates 1, 5). The latter is divided by a thin plate of bone into an upper compartment for the tensor tympani and a lower compartment for the Eustachian tube.

In the adult the posterior segment of the antero-inferior surface of the pyramid, which enters into the formation of the tympanic cavity, is covered by the anterior bony wall of the auditory meatus and by the drumhead; in the new-born it is freely exposed by removing the membrane (Plate 1). The median wall of the tympanic cavity and outer covering of the beginning of the cochlea is formed by the wall of the promontory. The latter consists of a plate of bone, convex externally, with two openings lodged in depressions or foveæ,—the fenestra vestibuli (ovalis) and the fenestra cochleæ (rotunda),—the corresponding foveæ bearing the same appellations (pus-channels from the tympanic cavity into the labyrinth—Plates 1, 5). The promontory is traversed by a groove running from below upward, which lodges the tympanic nerve and artery.

Above and in front of the fenestra vestibuli is an excavated plate of bone, the processus cochleariformis, for the attachment of the tendon of the tensor tympani muscle. It forms the posterior extremity of the upper segment of the canalis musculotubarius. The lower segment, corresponding to the bony portion of the Eustachian tube, begins at the tympanic opening of the tube in the anterosuperior portion of the tympanic cavity. The floor of the tube contains pneumatic cells (cellulæ tubariæ) that often extend to the carotid and allow the passage of pus (Plate 5). The floor of the tympanic cavity is excavated (cellar) and contains pneumatic cells (cellulæ tympanicæ) that often communicate in the substance of the petrous portion with the carotid and the inferior petrosal sinuses (pus-channels). The posterior portion of the floor of the tympanic cavity is smooth and forms the roof of the jugular fossa. When this portion is abnormally developed, it sometimes bulges, and may be defective (bulla jugularis).

Behind and below the fenestra vestibuli (Plate 5) is a hollow eminence, the eminentia pyramidalis, through which the tendon of the stapedius muscle passes to be attached to the head of the stapes (pus-channel to the seventh nerve). By the side of the eminentia pyramidalis and hard by the tympanic sulcus there is a small opening for the transmission of the chorda tympani (pus-channel to the seventh nerve). Below the eminentia pyramidalis the cellulæ tympanicæ empty into a small depression, the sinus tympani, which is bounded above by a trabecula of bone, the ponticulus, and below by a somewhat heavier ridge, the subiculum (Plates 1, 5). The wall of the promontory above and behind fades away into the median wall of the attic and of the mastoid antrum. As these portions are covered by the superficies meatus and, in the adult, by the bony tissue developed therefrom, they cannot be exposed without removing the squamous portion (Plates 1 and 5). The posterior border of the attic is formed by a compact, convex ridge of bone (prominentia canalis facialis), above and behind the fenestra vestibuli, which overlies the seventh nerve. This ridge is occasionally defective, and may then transmit pus from the tympanic cavity to the seventh nerve.

The facial nerve, after giving off the deep auricular nerve, enters the stylomastoid foramen. Here it is invested with a compact envelope of bone (Plates 3, 4, 5).

At the anterior border of the mastoid process, opposite the center of the bony auditory canal, where it gives off the chorda tympani and nerve supplying the stapedius muscle, the seventh nerve passes upward, and, at the level of the lower half of the posterior bony wall, bends inward, running close to the fenestra vestibuli as far as the spurious opening in the facial canal. At this point it forms the geniculate ganglion and gives off the great superficial petrosal nerve and the anastomosis with the lesser superficial petrosal nerve, after which it bends at a right angle inward and, accompanied by the eighth nerve and the pars intermedia, traverses the internal auditory meatus, and enters the brain between the pons and the crus (see Plate 14).

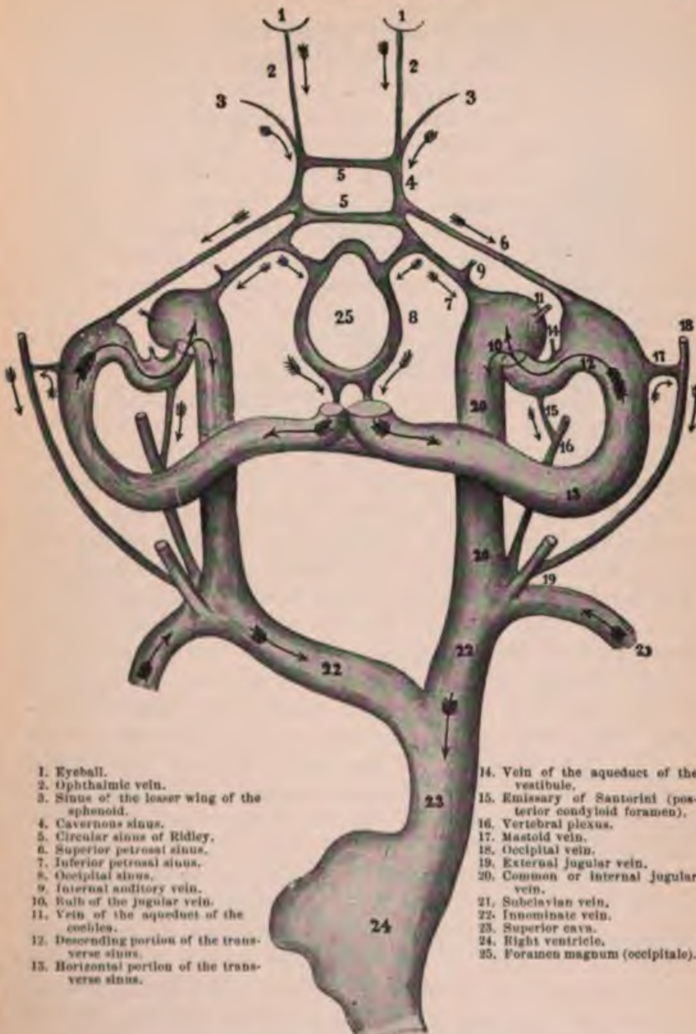
Above the prominentia canalis facialis is a compact horizontal ledge of bone, convex externally, which overlies the ampullæ of the superior and external semicircular canals (prominentia canalis semicircularis lateralis); when this is defective, pus may pass from the attic to the labyrinth (Plates 3, 5). In the adult the distance between this point—the threshold of the antrum (limes antri), so called because it lies in front of the antrum—and the extremity of the posterior bony wall of the auditory meatus (pars ossea) is about 6 mm. (Plate 3). At the point where the posterior wall of the tympanic cavity is bent backward and downward to the floor of the antrum (about 5 mm. below the tegmen tympani) the short process of the incus is attached in a small depression (the fossa incudis) (Plate 4). If the osseous portion of the canal is broken through in opening the mastoid process, there is danger of the chisel injuring the semicircular canal or the facial nerve or both these structures (Plates 3, 29).

The posterior extremity of the petrous portion of the temporal bone is formed by the mastoid process (Plates 1, 5, 6). In the new-born it represents a small prominence that contains no air-spaces except the bean-shaped antrum. The latter lies posteriorly to the attic, in a line passing through the Eustachian tube, the tympanic cavity, and the threshold of the antrum. The axis of the auditory canal (see Fig. 5) meets this line at an angle of 30 degrees. The line connecting the Eustachian tube with the antrum intersects the median plane at an angle of 45 degrees, and forms an angle of 30 degrees with the horizontal. The tympanic opening of the tube is, therefore, more deeply situated than the threshold of the antrum. The antrum in the new-born resembles in shape and size that of the adult; it is about 12 mm. long, 8 mm. high, and 6 mm. broad. At birth it lies immediately beneath the cortical portion of the squama, but as the superficies meatus becomes bent on itself and the mastoid cells develop, it assumes a deeper position (Plate 6). The mastoid cells reach their full development in the third year. From the true mastoid portion the mastoid cells develop backward toward the sigmoid groove and tip of the mastoid process; the cellulæ squamosæ develop from the cortical portion of the squama downward as far as the squamomastoid fissure, upward and forward into the zygomatic process, and backward into the occiput. The largest cells are usually found on the posterior and internal surfaces of the tip of the mastoid process (Plate 6). Occasionally the inner table covering them is deficient and allows pus to pass from the mastoid cells to the surface (Plate 25). The pneumatic mastoid cells converge toward the antrum; the large end-cells empty into transitional cells, and these into the antrum. Occasionally the entire mastoid process is pneumatic (37 per cent.); more frequently (43 per cent.) the structure is diploetic at the tip and pneumatic above. In a small proportion of cases it is eburnated (sclerotic) and contains no cells; this is probably always a pathologic condition. In 20 per cent. of the subjects it is diploetic (Zuckerkandl). The antrum is always present, though sometimes it is very small. Its distance from the surface of the mastoid process varies according to the size of the cavity. The floor of the antrum is about 10 to 12 mm. below the suprameatal spine. As the osseous portion is only 6 mm. distant from the tuberculum ampullare and the prominence of the canal of the seventh nerve, it follows that the external semicircular canal and the seventh nerve are from 16 to 18 mm. below the suprameatal spine (Plates 3, 6). The floor of the antrum corresponds to a point half way up the posterior bony wall of the auditory canal, at a distance of about 5 mm. from its inner portion.

The external contour of the mastoid process is subject to wide variations; its surface frequently presents the squamomastoid suture (a pus-channel, Plate 1). The tip of the mastoid gives origin to the sternocleidomastoid muscle; more posteriorly are the origins of the splenius and trachelomastoid muscles. Its inner side is marked by the digastric fossa (incisura mastoidea), which gives attachment to the digastric muscle. To the median side of the latter is a groove for the occipital artery, and still further inward are found the jugular process of the occipital bone, the styloid process, the jugular fossa, and the deep muscles of the neck. The periosteum is intimately adherent to the bone, especially at the squamomastoid suture. Defects in the cells at the tip of the mastoid may afford passage for pus along the sheath of the sternocleidomastoid muscle; more rarely along the large blood-vessels, as far as the axilla, or along the muscles attached to the styloid process to the retropharyngeal space and the thoracic cavity. The osseous wall between the antrum and the posterior fossa of the skull is thin and spongy; hence if it is defective, passage is afforded for pus from the antrum to the posterior fossa of the skull.

The posterior surface of the mastoid process is marked by the sigmoid groove (Plates 5, 7, 11) for the reception of the descending portion of the transverse sinus. It is usually found 10 mm. behind the suprameatal spine. About 30 mm. behind the spine, and the same distance above the tip of the process, is the mastoid foramen, which transmits one of the emissary veins of Santorini (communication between the transverse sinus and the occipital vein). The sigmoid groove, like the jugular fossa, lies deeper on the right than on the left side, especially in brachycephalic subjects (Körner), because the right transverse sinus and the right jugular vein are thicker. Occasionally the sinus is displaced forward so that it lies immediately underneath the surface of the mastoid process and behind the bony wall of the auditory meatus (Plate 17). In such cases the posterior bony wall of the auditory meatus follows an oblique course.

The greater part of the venous blood from the brain empties into the longitudinal and right transverse sinuses, the remaining portion being carried off by the straight sinus and the left transverse sinus (Fig. 4). As the jugular vein and the right innominate vein form a more direct passage for the venous blood of the brain to the heart on the right side than on the left, the transverse sinus and jugular vein on the right side are thicker than on the left. The venous blood from the eye is collected by the ophthalmic vein, and with the contents of the sinus of the lesser wing of the sphenoid is emptied into the cavernous sinus. The latter communicates with the cavernous sinus of the opposite side by means of the circular sinus of Ridley. The wall of the cavernous sinus accommodates the carotid artery and the trigeminus, abducens, oculomotor, and trochlear nerves. The cavernous sinus and the internal auditory vein empty into the inferior petrosal sinus, which enters the bulb of the jugular vein. The vein of the aqueduct of the cochlea empties directly into the bulb, whereas the vein of the aqueduct of the vestibule empties directly into the transverse sinus. Owing to its position below the deepest point in the descending portion of the transverse sinus, the bulb of the jugular vein serves to retard the flow of blood from the sinus (MacEwen). The superior petrosal sinus receives small veins from the tympanic cavity and connects the cavernous and transverse sinuses.



1. Eyeball.
2. Ophthalmic vein.
3. Sinus of the lesser wing of the sphenoid.
4. Cavernous sinus.
5. Circular sinus of Ridley.
6. Superior petrosal sinus.
7. Inferior petrosal sinus.
8. Occipital sinus.
9. Internal auditory vein.
10. Bulb of the jugular vein.
11. Vein of the aqueduct of the cochlea.
12. Descending portion of the transverse sinus.
13. Horizontal portion of the transverse sinus.
14. Vein of the aqueduct of the vestibule.
15. Emissary of Santorini (posterior condyloid foramen).
16. Vertebral plexus.
17. Mastoid vein.
18. Occipital vein.
19. External jugular vein.
20. Common or internal jugular vein.
21. Subclavian vein.
22. Innominate vein.
23. Superior cava.
24. Right ventricle.
25. Foramen magnum (occipitale).

FIG. 4.—Diagram of the venous system that carries off the blood from the interior of the cranium. Base of the skull viewed from above and behind.

The inferior petrosal sinus communicates through the basilar plexus with the anterior spinal plexus, whereas the occipital sinus establishes a communication between the transverse sinus and the posterior spinal plexus. The mastoid process sends a number of small veins to the transverse sinus, most of which enter its anterior convex surface. The mastoid vein passes through the mastoid foramen and joins the occipital and external jugular veins. The emissary vein of Santorini, which passes through the posterior condyloid foramen, connects the transverse sinus with the vertebral plexus. The veins from the temporal bone and labyrinth, which enter the sinuses, may convey pus from the sinuses to the nuchal region (occipital vein) or to the upper cervical region (emissary vein of Santorini and vertebral plexuses).

The transverse sinus (Plate 10) is in relation with the lateral surface of the cerebellum. The sinuses represent tubes formed by two layers of dura; they are so arranged as to maintain a uniform flow of blood within the brain, which prevents the inspiratory collapse seen in the jugular vein. When the sinus becomes occluded by a clot, as in ligation of the jugular vein, the blood is either carried off by the emissaries or returns and is carried off by the sinuses of the other side, depending on the seat of the thrombus. A common sheath surrounds the jugular vein, the carotid artery, and the pneumogastric nerve. The vein lies to the outer side of the carotid artery, underneath the sternocleidomastoid, and at a point opposite to the bifurcation of the carotid receives the common facial vein (see Fig. 98).

4. **The Drumhead.**—Corresponding to the obliquity of the inner extremity of the bony auditory canal, determined by the difference in the lengths of its walls, the plane of insertion of the drumhead is also oblique both in the lateral and vertical direction. The anterior wall of the canal is longer, and accordingly extends further inward, than the posterior wall; hence the anterior pole of the drumhead lies nearer the median line than the

posterior pole, so that the plane of the membrane, if prolonged anteriorly, would intersect the median plane at an

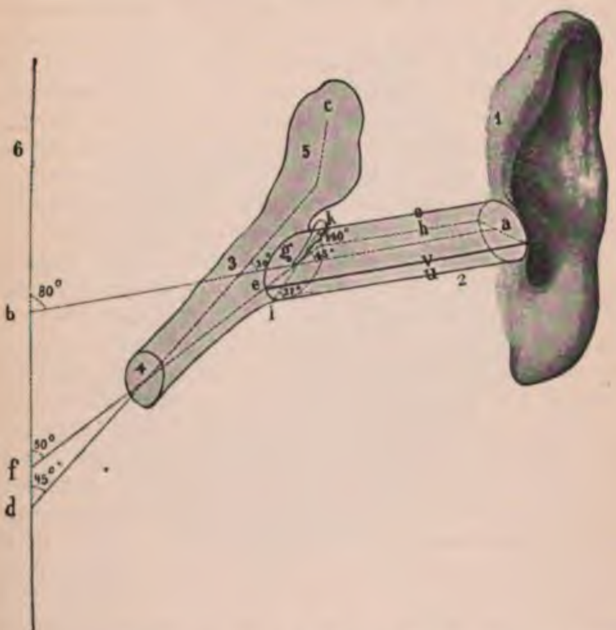


FIG. 5.—Diagrammatic view of the position of the organ of hearing within the skull. Left organ of hearing (front view): 1, Auricle; 2, auditory canal; 3, tympanic cavity; 4, Eustachian tube; 5, antrum; 6, median plane of the skull; *o*, roof of the meatus; *u*, floor of the meatus; *v*, anterior wall of the meatus; *h*, posterior wall of the meatus; *ab*, axis of auditory meatus; *cd*, line passing through antrum, tympanic cavity, and opening of Eustachian tube; *ef*, diameter of the plane of the drumhead prolonged forward; *g*, intersection of the axis of the auditory meatus with the plane of the drumhead; *ki*, vertical axis of the drumhead; ∢ *gefb*, declination of the drumhead 50 degrees; ∢ *agk*, inclination of the drumhead 45 degrees.

angle of 50 degrees, with its vertex pointing forward. This is known as its declination. The floor of the auditory meatus is longer than the roof and, therefore, extends further inward; accordingly, the inferior pole of the drumhead lies nearer the median line than the superior pole, and the axis of the meatus intersects the drumhead at an angle of 45 degrees, with its vertex pointing downward. (This is known as the inclination of the drumhead.) The roof of the auditory meatus meets the plane of the drumhead at an obtuse angle of 140 degrees, whereas the floor forms with it an acute angle of 27 degrees. The drumhead corresponds in size and shape to the border of the tympanic ring to which it is attached (Plates 2, 10, 38). It represents a membrane 10 mm. in height, 9 mm. in breadth, 0.1 mm. in thickness, and separates the auditory meatus from the tympanic cavity. Its oval outline is interrupted in front and above by the incisura Rivini; behind and above, by a sinuosity. In the cadaver it is opaque and of a pearly gray color. It is attached in the tympanic groove by means of the fibrocartilaginous ring. Its surface is traversed by the handle of the malleus. In the anterior upper portion the short process of the malleus appears as a yellow nodule and forms an important landmark. From that point the handle of the malleus passes backward and downward, so that the short process in the right ear is seen above and to the right; in the left ear, above and to the left. The expanded extremity of the handle of the malleus extends into the lower half of the membrane and lies nearer the wall of the promontory than the short process. Accordingly the membrane, which is firmly attached to the handle of the malleus (Plate 3), is drawn inward in the shape of a funnel, the highest portion corresponding to the extremity of the handle of the malleus (umbo). In the anterior half, owing to the diminished width of the membrane, the walls of the funnel are more abrupt than in the posterior half. The umbo lies nearest to the promontory (2 mm.), the posterior inferior portion of the membrane being farthest removed from that point (point of election for paracentesis). That portion of the ear-drum lying above the short process of the malleus is more yielding than the portion below that structure, and is traversed

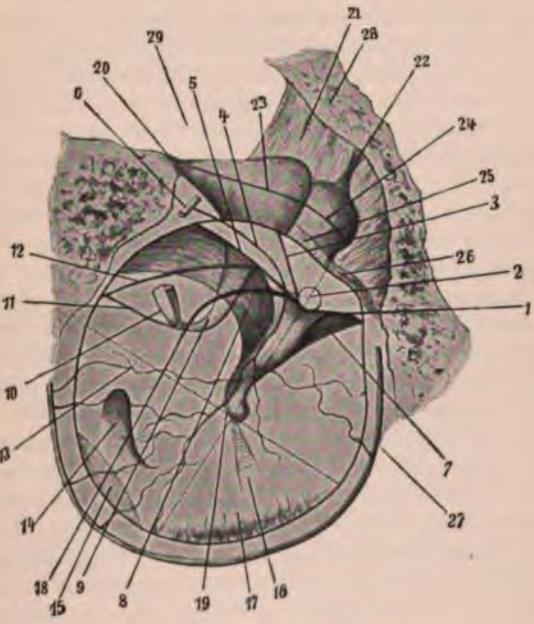


FIG. 6.—The drumhead and tympanic ossicles (schematic): 1, Anterior boundary fold; 2, short process of malleus; 3, superior fold; 4, arteria manubrium mallei; 5, posterior boundary fold; 6, branch of deep auricular artery; 7, anterior pouch of tympanic membrane; 8, posterior pouch of tympanic membrane; 9, long process of incus; 10, stapes; 11, tendon of stapedius muscle; 12, chorda tympani; 13, anastomosis of arteria manubrii mallei with peripheral system of blood-vessels; 14, fenestra cochleæ; 15, bulb of jugular vein; 16, cone of light; 17, tympanic cells; 18, posterior fold; 19, umbo; 20, posterior ligament of incus; 21, superior ligament of incus; 22, superior ligament of malleus; 23, lateral fold of incus; 24, lateral fold of malleus; 25, external ligament of malleus; 26, anterior ligament of malleus; 27, peripheral system of blood-vessels; 28, tegmen tympani; 29, threshold of antrum.

by two folds running from the short process to the extremities of the incisura Rivini; these are known as the boundary folds. The portion situated above the short process and bounded by the incisura Rivini and the anterior and posterior boundary folds is known as the flaccid portion, membrana flaccida, or Shrapnell's membrane. This portion is frequently traversed by a fold, higher than the other two, which runs obliquely backward and upward from the short process. Retraction of the drumhead produces a pathologic posterior fold, which passes from the short process downward into the tympanic membrane (Plate 38, Fig. 8). The greater portion of the drumhead lies below the short process and is known as the pars tensa. An imaginary line drawn from the extremity of the handle of the malleus to the lower border of the drumhead, and a horizontal line making a right angle with the axis of the handle of the malleus drawn through the drumhead at the level of the umbo (Fig. 6), divide the membrane into a lesser anterior and greater posterior, or into a greater upper and lesser lower, portion. The anterior half is divided into anterosuperior and antero-inferior quadrants; the posterior into posterosuperior and postero-inferior quadrants; the anterosuperior quadrant is the smallest, the posterosuperior the largest. This division of the drumhead is of great practical usefulness, because the pathologic appearances occurring in various portions of the membrane differ greatly in importance. Thus, the anterosuperior quadrant (Plates 10, 38, 39) corresponds to the region of the tympanic opening of the tube, the canal for the tensor tympani muscles, and the anterior pouch of the drumhead. The antero-inferior quadrant corresponds to the carotid canal. The posterosuperior quadrant contains the long process of the incus, the stapes, and the articulations of these bones, the fenestra cochleæ, the eminentia pyramidalis, and stapedius muscle, the posterior pouch of the drumhead, the chorda tympani, and the posterior fold (pathologic). The postero-inferior quadrant contains the fenestra cochleæ, the tympanic cells in the floor of the tympanic cavity, and the bulb of the jugular vein (Plate 38, Fig. 3). The flaccid portion, or Shrapnell's membrane, corresponds to the neck of the malleus and Prussak's space (Plates 3, 20).

Histology.—The tympanic membrane consists of three layers: (*a*) The stratum cutaneum, derived from the integument of the auditory meatus; (*b*) the stratum fibrosum, derived from the tendinous ring (annulus tendinosus); (*c*) the stratum mucosum, derived from the mucous membrane lining the tympanic cavity. In the pars flaccida only (*a*) and (*c*) are represented (Plates 13, 31).

(*a*) The *stratum cutaneum* is thin, except in the prolongation of the strip of skin covering the superficies meatus, which passes behind the handle of the malleus (Plate 31). This portion is somewhat thicker and contains within its loose-meshed cuticular layer the malleolar vein, artery, and nerve. It consists of layers of squamous epithelium, with cylindric cells in the deepest, and horny cells in the most superficial, layer. Owing to the eccentric growth of the horny layer, hemorrhages within the epiderm are sometimes displaced laterally as far as, and even beyond, the tympanic ring. The cutis is thin, devoid of glands or hairs, and contains a few poorly developed papillæ and blood-vessels, which become somewhat more conspicuous in the above-mentioned thickened strip.

(*b*) The *stratum fibrosum* is composed of an outer layer of radial and an inner layer of circular connective-tissue fibers, crossing one another at acute angles (stratum radiatum and stratum circulare). It contains but few elastic fibers, and the drumhead is accordingly very inelastic. It often bursts with a loud report and wrinkles easily. The fibers of the tendinous ring are continuous with the periosteum and bone of the auditory meatus and of the tympanic cavity. The stratum radiatum is attached to the tendinous ring and to the lower and middle third of the handle of the malleus (Plate 13); it serves to attach this structure to the drumhead by passing around it and becoming adherent with its periosteum. Wherever the anterior surface of the handle of the malleus (Plate 31) comes in contact with the drumhead it is covered with hyaline cartilage. The radial fibers of the drumhead are separated by narrow spaces containing connective-tissue cells (corpuscles of the tympanic membrane). The intersection of the circular with the radial fibers begins at the tendinous ring. The circular fibers decrease in number from the periphery to the handle of the malleus, to the upper two-thirds of which they become attached. At the umbo the radial fibers are so closely packed that an opacity is produced whenever cartilage cells are deposited in this region (yellow spot: Trautmann). The thinnest portion of the drumhead is the point where the intermediate zone fades away into the center. The posterior half of the drumhead is occupied by a branching network of connective tissue that bulges the mucous membrane forward (Gruber's dendritic structure).

(c) The *stratum mucosum* consists of a layer of connective tissue containing numerous lymphocytes covered by a single layer of cuboidal cells (Plate 13). At the junction of the drumhead with the mucous membrane of the tympanic cavity the epithelial cells increase in height and become ciliated (on the floor of the tympanic cavity). The connective tissue forms papillary elevations, the depressions between the papillæ resembling tubular glands. In the new-born the layers (*a*) and (*c*) are more strongly developed than in the adult; hence the drumhead is thicker and more opaque and offers greater resistance to perforation in otitis media.

5. The drumhead forms the outer wall of the **tympanum**; its bony walls have been described under 3, γ. Its name is derived from its shape, which corresponds to a short cylinder and serves for the reception of the tympanic ossicles and their muscles. The inner wall of the promontory (Plates 1, 5) contains the fenestra vestibuli, looking directly forward and parallel to the plane of the drumhead; it is closed by the base of the stapes. The

head of the stapes lies at a somewhat deeper level than the base; to it is attached the tendon of the stapedius muscle, which passes across the posterior portion of the cavity. The fenestra cochleæ lies on the floor of a depression looking toward the posterior wall of the tympanic cavity, and accordingly forms a right angle with the fenestra vestibuli. The fenestra cochleæ is closed by a layer of connective tissue known as the secondary membrane of Scarpa (membrana tympanica secundaria), the outer surface of which is concave and covered with mucous membrane, its inner surface being covered with endothelium; it may be exposed to view by removing the anterior border of the bone (Plate 14). The floor of the tympanic cavity extends below the lower border of the drumhead, forming the "cellar," or hypotympanic recess (Kretschmann); hence secretions on the floor of the tympanic cavity are not necessarily seen through the membrane. When the bulb of the jugular vein is larger than normal, it encroaches on the posterior half of the drumhead; in such cases the bone is often deficient in places as far as the edge of the fenestra cochleæ, and the wall of the vein is directly covered by mucous membrane. This affords passage for pus, and the vein is in danger of injury in paracentesis. When the condition is present, a bluish, crescentic sheen is seen in the posterior lower portion of the drumhead (Plate 17; Plate 38, Fig. 3). At the level of the tympanic opening of the Eustachian tube the knee of the internal carotid, which lies near the median line, approaches the anterior wall, and is therefore beyond the region of the drumhead (Plate 5). Occasionally the carotid canal is displaced into the tympanic cavity as far as the promontory; hence if there is any defect in the bone, there is danger of injuring the carotid artery in paracentesis (Gruber) (Plate 17).

Corresponding to the "cellar," or hypotympanic recess, which extends below the tympanic cavity, is the attic (Hartmann) above, which receives the head of the malleus and the body of the incus, and is bounded, above, by the tegmen tympani; externally, by the osseous portion of the roof and the posterior wall of the auditory meatus. Hence the drumhead does not correspond exactly to the boundaries of the tympanic cavity either above or below. This has an important bearing on the question of determining the origin of pus in the middle ear. The ossicles establish a communication (Plate 2, Fig. 7) between the drumhead and the fenestra vestibuli; the malleus is on the drumhead, the stapes is in the fenestra vestibuli, and between the two lies the incus (Plate 3). The malleus presents a head that occupies the attic, a neck behind Shrapnell's membrane, and a handle in the pars tensa. The posterior and lateral aspects of the head present an articular surface in the form of an 8. Its inferolateral face presents a prominence, the tooth process; its posterior face an oblique ridge, the crista mallei.

Underneath are openings for the passage of blood-vessels. The head is joined to the handle by means of the neck, which presents, in front, a small eminence, the long process, the remains of Meckel's cartilage (processus anterior Folii); the handle begins at the short process (processus lateralis), which is seen distinctly in the drumhead, and presents, in front and behind, a roughened area for the insertion of the tensor tympani muscle. The extremity of the handle is expanded (superficies umbilicalis). The incus presents a body occupying the attic, with a lateral articular surface, in the form of an 8, by which it articulates with the malleus, and a more medianly situated eminence, the tooth process; behind and projecting horizontally is the short process (crus breve), which is firmly attached to the floor of the tympanic recess by the posterior ligament of the incus (Plate 4). The long process arches backward and downward through the tympanic cavity, behind and almost parallel with the handle of the malleus. Its extremity articulates by means of a convex tubercle, the processus lenticularis, with the head of the stapes. The stapes lies within the tympanic cavity, its base closing the fenestra vestibuli. It possesses a thin straight anterior and a thicker curved posterior limb; the inner surface of the two limbs is marked by a groove (Plate 2).

Histology.—The ear ossicles consist of compact bone, and contain numerous Haversian canals that expand into large medullary spaces in the head and body. The articular surfaces and the entire lateral border of the malleus, which is in contact with the drumhead, are covered by hyaline cartilage. The articulations between the malleus and incus (Plate 4) and the incus and stapes are of the symphyseal varieties. The articulations are connected by means of fibrocartilaginous discs containing lymph-spaces (Siebenmann), which are reinforced by periosteal bands and, on the inner side, by more robust capsular ligaments. The fossa incudis and the extremity of the short process of the incus are also covered with cartilage. The base of the stapes is attached to the fenestra vestibuli by means of the annular ligament (Plate 14); both the base of the stapes and the border of the fenestra are covered with cartilage. In front the annular ligament is $6\frac{1}{2}$ times as wide as behind (100μ by 15μ); it is formed by radial fibers of connective and elastic tissue running from the perichondrium of the margin of the fenestra to the base of the stapes. At the center the fibers are less compact than at the periphery. The minute distance between the base and limbs of the stapes and the margin of the fenestra (0.25 mm.) explains why motor disturbances of the stapes are so common in pathologic conditions.

Muscles of the Tympanic Ossicles (Plates 2, 4, 5).—The stapedius muscle has a length of 5 cm. and lies within the eminentia pyramidalis; it is innervated by the seventh nerve (Politzer). Its tendon is attached to the articulation of the incus and stapes. Its action is to lift the anterior pole of the base of the stapes above the fenestra vestibuli, the annular ligament being broader in front than behind. It is antagonized by the tensor tympani muscle, which is 20 mm. in length, and is innervated by the fifth nerve (Politzer); this muscle has its origin in the canalis musculotubarius, on the roof of the Eustachian tube and greater wing of the sphenoid bone, and sends its tendon, which measures 2.5 cm., along the processus cochleariformis vertically forward to the handle of the malleus. The tensor tympani muscle is connected to the tensor veli palatini and rotates the malleus inward and forward, at the same time pressing the stapes deeper into the fenestra vestibuli.

Mechanism.—The movements of the ossicles are controlled by ligamentous bands. The anterior ligament of

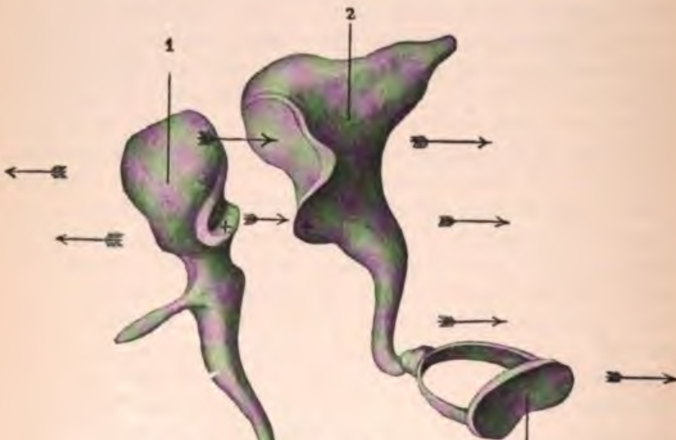


FIG. 7.—The tympanic ossicles (posterior view; schematic; right ear): 1, Malleus; 2, incus; 3, stapes; +, tooth process.

the malleus connects the long process (Plate 4) with the spina tympani posterior, which passes through the Glaserian fissure to the sphenoid bone. The superior ligament of the malleus connects the head of the malleus with the tegmen tympani. The lateral ligament of the malleus

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connects the neck of the malleus behind and externally with the upper border of the notch of Rivinus (Helmholtz) (Fig. 6). The superior ligament of the incus passes from the body of the incus to the tegmen tympani. The limbs of the stapes are connected by the membrana obturatoria. The posterior portion of the lateral ligament forms, with the anterior ligament of the malleus, the rotary axis of the malleus. When the handle moves inward, the head moves outward, and vice versâ. When the handle moves inward, its tooth process presses on the corresponding tooth process of the incus, which lies opposite and somewhat more to the median side; accordingly, the body of the incus moves outward with the head of the malleus, and the long process, inward with the handle of the malleus. The short process of the incus being fixed, is the pivot of the ossicle. As the long process of the incus is shorter than the handle of the malleus, the effect of leverage is to force the load (the stapes) inward a shorter distance, but with greater force (Helmholtz). The maximum excursion of the stapes is from $\frac{1}{14}$ to $\frac{1}{18}$ mm., that of the end of the handle of the malleus, 0.7 mm. (Bezold). If, on the contrary, the handle of the malleus is forced outward,—as, for instance, when the air pressure within the tympanic cavity is increased,—the tooth process of the malleus moves away from that of the incus; the joint opens, and the incus and stapes remain immovable; in this way traction on the stapes and injury of the labyrinth are prevented (Fig. 7).

Histology of the Tympanic Mucous Membrane.—The tympanic cavity and its structures (Plate 13) are covered, in the adult, by a thin layer of mucous membrane. In the embryo the investment is, on the contrary, so thick that the lumen of the tympanic cavity is very narrow and appears to be filled by a reddish plug of tissue (Wendt). The swelling is particularly marked at the promontory, and is due to the presence of mucous tissue beneath the epithelium similar to that found in the umbilical cord, being a wide-meshed tissue containing stellate cells with many branches. At the end of the eighth month, or sometimes after birth, owing to compression by the air that enters the tube during respiration, the intercellular substance is absorbed and the subepithelial tissue disappears. After the regenerative process in the tympanic cavity is completed, the attic still contains a pad of mucous membrane (Plate 20). (Schmaltz's method

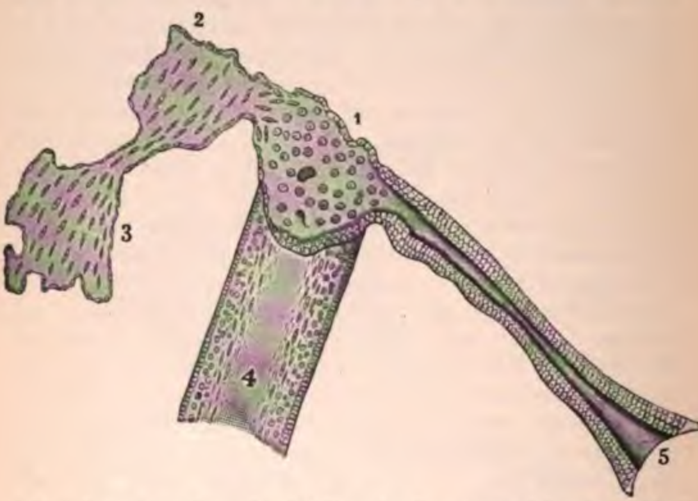


FIG. 8.—Destruction of epithelium in the organ of hearing (schematic): 1, Tympanic cavity; 2, mastoid antrum; 3, mastoid cells; 4, external auditory meatus; 5, Eustachian tube.

of determining whether a child has breathed—by the presence of swelling of mucous membrane in the tympanic cavity—is not reliable.) But even in the new-born loose-meshed vesicular mucous membrane may be found, as in the adult (disposition to inflammation in the new-born). In the embryo the mucous membrane on the promontory consists of cuboidal cells; elsewhere the cells are flat. In the adult the type varies from a single layer of cuboidal epithelium on the promontory to ciliated cylindric cells in one or two layers on the floor of the cavity and in the vicinity of the tympanic extremity of the tube, and entirely flat epithelium resembling a string of beads on the roof of the tympanum, in the aditus, antrum, and mastoid cells (Plate 13). The subepithelial tissue close to the bone consists of periosteal connective-tissue fibers, arranged in parallel rows containing few cells, and, at the surface, of loosely arranged bundles of connective tissue, in places containing numerous lymphocytes. The vessels form an irregular network in the periosteal layer, and occasionally are surrounded by adipose tissue. Glands are rare or altogether absent. Gland-like depressions are often formed by the papillary elevations of the mucous membrane near the drumhead, found especially in children.

Folds and Pouches.—As the lumen of the tympanic cavity becomes enlarged by the disappearance of the embryonal pad of mucous membrane, the mucous membrane passes over and between the ear ossicles, their muscles, and the chorda tympani, forming regular and irregular folds, pouches, and thread-like bands. In the anterosuperior and in the posterosuperior quadrant a fold of mucous membrane passes along the posterior surface of the drumhead from the tympanic ring to the handle of the malleus, constituting the anterior (Plate 2) and posterior tympanic folds, which lodge the chorda tympani. Above, between the tympanic folds and the drumhead, are the two pouches of the drumhead, the anterior of which ends in a cul-de-sac, whereas the posterior communicates with Prussak's space. Owing to the transparency of the membrane the pouches can be seen from in front.

On the anterior surface of the drumhead (see Fig. 6), lying within the notch of Rivinus, is Prussak's space (Plates 3, 20) (recessus membranus tympanicus superior). It is bounded in front by the flaccid portion, or Shrapnell's membrane; behind, by the neck of the malleus and the upper extremities of the pouches of the drumhead;

below, by the short process of the malleus; and above, by the lateral ligament of the malleus. Through openings in the lateral ligament of the malleus Prussak's space communicates with the attic, and through its communication with the posterior pouch of the drumhead it reaches the tympanic cavity.

The attic is divided by the head of the malleus and body of the incus into an outer and an inner segment (see Plate 3, Fig. 76). These segments are sometimes divided by a fold of mucous membrane running from the head of the malleus and body of the incus upward to the tegmen tympani (upper incudomalleolar fold, Fig. 6). This fold is usually interrupted by a number of openings, and passes from the anterior ligament of the malleus as far as the inner surface of the entrance to the antrum. It includes within itself the superior ligament of the malleus and incus. If these openings are absent, the antrum communicates only with the outer segment of the attic, the inner portion of the attic opening downward into the tympanic cavity. The outer segment of the attic is bounded externally by the osseous portion of the posterior wall of the auditory meatus; internally, by the outer surface of the head of the malleus and body of the incus; below, by the lateral ligament of the malleus. The outer segment of the attic is divided into the upper and lower incudomalleolar space by a fold of mucous membrane running horizontally from the anterior ligament of the malleus to the posterior ligament of the incus, and attached to the head of the malleus and body of the incus on one side, and the pars ossea on the other (lateral incudomalleolar fold, Plate 4). The lower incudomalleolar space lies above the lateral ligament of the malleus (Prussak's space); the upper incudomalleolar space leads into the antrum along the short process of the incus. As a rule, all the various folds of mucous membrane are perforated so that there is free communication between the various spaces. If these folds are not destroyed in otitis media, circumscribed areas of inflammation may occur. Thus suppuration in the outer segment of the attic may exist without involvement of the tympanic cavity. Pus from the upper incudomalleolar space is likely to find its way backward into the antrum, or downward into the lower incudomalleolar space, and thence into Prussak's space, where it leads to perforation of Shrapnell's membrane (Plate 39, 14). Suppuration within Prussak's space may extend to the tympanic cavity by way of the posterior fold.

The tendon of the tensor tympani is accompanied by a fold of mucous membrane (Plate 4). The long process of the incus is connected by a fold of mucous membrane to the wall of the promontory. The margin of the round window and the antrum are traversed by bands of mucous membrane. The limbs of the stapes are connected with the margin of the fenestra; the drumhead with the incus and wall of the promontory. The threads of mucous membrane often contain oval thickenings consisting of nodules of lamellar connective tissue, the so-called pedunculated corpuscles (Politzer).

6. The Eustachian tube (tuba auditiva Eustachii) is about 36 mm. in length, and establishes communication between the tympanum (Plate 5) and the nasopharynx. The tympanic opening is about 4 mm. in height and situated in the anterosuperior portion of the tympanum; hence the canal is not well adapted for drainage. It ends at the pharyngeal opening in the pharynx, which is about 5 mm. in height. The roof of the tympanum gradually merges into the upper wall of the tube; the lower wall of the tube is bent at an angle, the cartilaginomembranous tube hanging down from the bony margin of the canalis musculotubarius. Accordingly the pharyngeal opening is 25 mm. lower than the tympanic opening. The canalis musculotubarius contains the bony portion of the tube; one-third (12 mm.) of the tube is bony, the remaining two-thirds (24 mm.) being made up of the cartilaginous and membranous portions, at the junction of which is the isthmus, the narrowest portion of the tube (2 mm.). The cartilagino-membranous portion consists principally of a median groove of cartilage, closed on its outer side by connective tissue. The plate of cartilage lies parallel with the middle line of the body and gradually increases in height from the isthmus to the pharyngeal opening, so that at

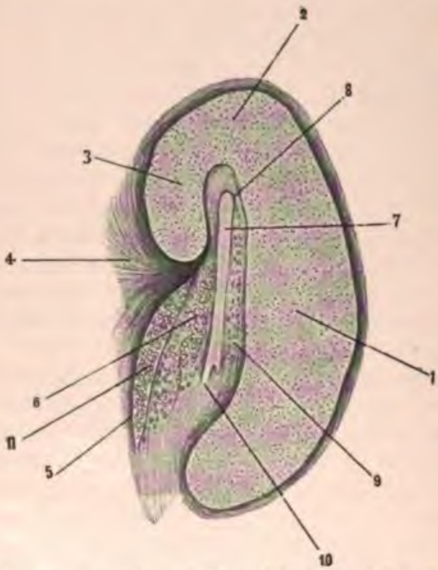


Fig. 9.—Transverse section of Eustachian tube (after Schwalbe): **1**, Median plate of cartilage; 2, hook; 3, lateral cartilage of tube; 4, tendon of musculus sphenosalpingostaphylinus; 5, salpingopharyngeal fascia; 6, pad of fat; 7, lumen of tube; 8, mucous membrane; 9, mucous glands; 10, fold of mucous membrane; 11, adipose tissue.

the latter point cartilage is found not only in the median, but also in the upper and outer, portion of the tube. The cartilage at this point is bent like a hook from within outward (*hamulus*) (Fig. 9). The upper wall of the tube is attached to the base of the skull by means of fibrous cartilage. The course of the tube is from the pterygoid process of the sphenoid bone inward to the lateral wall of the nasopharynx. In an anteroposterior section of the skull, after removal of the septum narium (Plate 12), the lateral wall of the nose is traversed by the inferior, middle, and superior turbinate bones, between which lie the inferior, middle, and superior meati. Below the anterior extremity of the inferior turbinate is the mouth of the lacrimonasal duct; below the anterior extremity of the middle turbinate, at the anterior extremity of a cleft known as the hiatus semilunaris, is the opening of the frontal sinus, at the posterior extremity of which is the opening of the antrum of Highmore, whereas in the middle, above the two, is the opening of the anterior ethmoidal labyrinth. The posterior ethmoidal labyrinth terminates in the upper meatus, and immediately beneath the roof of the nose is the orifice of the sphenoidal sinus. The posterior nares (choanæ) lead into the highest portion of the pharynx,—the nasopharynx,—bounded below by the velum palati. Its roof is formed by the basilar portion of the sphenoid and occipital bones; the posterior wall, by the atlas and axis. On the roof of the nasopharynx is found the pharyngeal tonsil, which in the new-born is indicated by several sagittal folds, continues to grow until the third year, and undergoes atrophy during puberty (Trautmann). It may become hypertrophied either as a whole or in lobules (adenoid vegetations) (Plate 21). The pharyngeal opening of the Eustachian tube is situated in the lateral wall of the nasopharynx, 15 mm. beneath the base of the skull, 10 mm. above and behind the hard palate, 15 mm. from the posterior wall of the pharynx, and 80 mm. from the choanæ, at the level of the posterior extremity of the superior turbinate bone.

The inner margin of the pharyngeal opening (tubal fold) is pushed forward by the end of the cartilaginous portion of the tube; a fold of mucous membrane (musculus salpingopharyngeus, Plate 12) passes from its lower extremity to the posterior arch of the fauces, forming the plica salpingopharyngea. Behind the tubal fold is a depression known as Rosenmüller's fossa (recessus phar-

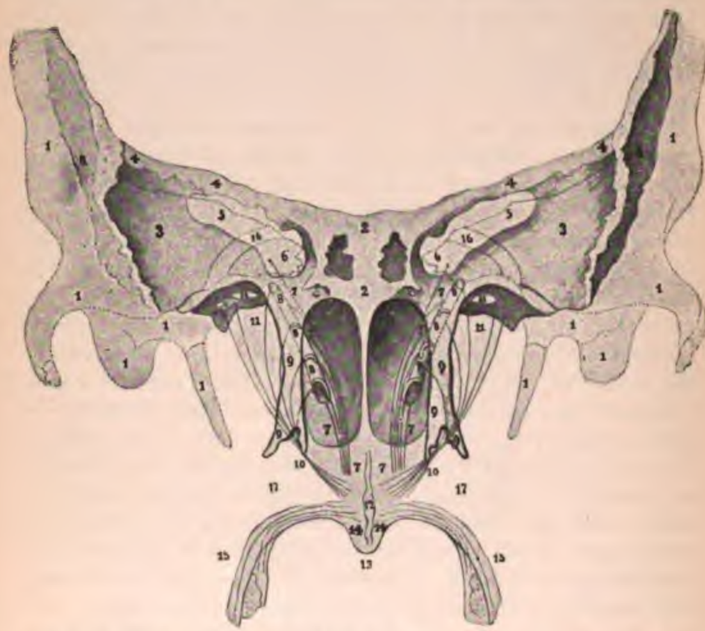


FIG. 10.—Sphenoid bone and both temporal bones. Front view, showing the Eustachian tube and its muscles (schematic). The temporal bones are indicated by dotted lines: 1, Temporal bone; 2, body of sphenoid; 3, superficies orbitalis; 4, ala minor and (*a*) ala major; 5, superior orbital fissure; 6, tip of the petrous portion of the temporal bone, seen through the superior orbital fissure, with part of the levator veli palatini; 7, musculus levator palatini; 8, Eustachian tube (cartilaginous portion); 9, pterygoid process; 10, musculus tensor veli palatini surrounding the hamulus; 11, origin of musculus tensor veli palatini on the tube, the spina angularis, and the margins of the foramen ovale and foramen spinosum; 12, musculus azygos uvulæ; 13, uvula; 14, palatopharyngeal muscles; 15, glossopalatine muscles; 16, carotid canal; 17, velum palati.

yngeus Rosenmülleri), which is often filled with adenoid tissue. The outer margin of the opening of the tube is less prominent than the inner, and fades away into the plica salpingopalatina and mucous membrane of the choanæ. The triangular lumen of the orifice of the Eustachian tube is marked below by a prominent fold (the fold of the levator) that becomes intensified during phonation (contraction of the musculus levator veli palatini) (see Figs. 39, 40). In the child the tube is shorter and more patulous than in the adult, owing to incomplete development of the cartilage. The pharyngeal opening is deeper, being underneath the hard palate in the embryo. The nasopharynx in the new-born is about 10 mm. in width, depth, and height. In the adult it is 20 mm. in width and height, and 25 mm. in depth (Trautmann). The muscles of the Eustachian tube are each surrounded by fascia and serve to dilate the tube, which is usually closed (see Fig. 10).

1. The musculus petrosalpingostaphylinus or levator veli palati derives its nerve supply from the seventh nerve through the great superficial petrosal nerve. It has its origin in the tip of the pyramid and floor of the Eustachian tube. Its course is from the floor of the tube to the median side of the inner lamella of the pterygoid process. Its insertion is in the soft palate, and its action consists of dilating the mouth of the tube and elevating the velum palati.

2. The musculus sphenosalpingostaphylinus or tensor veli palati derives its innervation from the otic ganglion of the third division of the trigeminal nerve. It has its origin in the foramen ovale, the foramen spinosum in the sphenoidal bone, and the hamulus of the tube. In its course it is separated from the levator veli palati by the salpingopharyngeal fascia, and lies to the outer side of the inner lamella of the pterygoid process. The tendon passes around the hamulus of the pterygoid process. Its insertion is in the soft palate, and its action is to draw down the hamulus of the tube, dilate its lumen, and elevate the palate.

3. The musculus retrahens tubæ forms part of the

palatopharyngeal muscle and is supplied by the pharyngeal plexus of the pneumogastric. Its origin is in the tubal fold, and its course within the plica salpingopharyngea. Its insertion is in the posterior pharyngeal wall, and its action is to draw the tubal fold backward and dilate the tube.

Histology.—The tube is covered by mucous membrane (Plate 14) presenting numerous folds in the lateral walls and on the floor and becoming very thin in the bony por-

FIG. 11.—Skiagraph of the organ of hearing, after injection of mercury through the Eustachian tube into the cavities of the middle ear: 1, Eustachian tube; the cartilaginous portion is dilated by the mercury; 2, cavum tympani; 3, mastoid antrum; 4, mastoid cells; 5, transverse sinus.

tion. The epithelium consists of two layers of cylindric cells that become ciliated as they approach the pharynx. The cartilaginous portion and, more rarely, the recesses of the bony portion contain racemose mucous glands with tall epithelial cells. These glands are especially abundant beneath the median plate of cartilage.

On the sides and along the floor of the cartilaginous portion the submucous tissue is richly supplied with fat;

the lower segment of the tube contains numerous lymphocytes, both single and arranged in follicles (tubal tonsil).

A general view of the entire middle ear is readily obtained by means of the Röntgen rays (Fig. 11).

(B) THE SOUND-PERCEPTION APPARATUS.

(Plates 7, 8, 9, 14.)

1. The bony labyrinth is a capsule of compact bone, 20 mm. in length, containing within its substance the internal ear or membranous labyrinth. The bony labyrinth (Plate 11) is imbedded in the spongy tissue of the petrous portion of the temporal bone, its direction corresponding with the long axis of the pyramid. The only openings are the orifices of the aqueducts, the internal auditory meatus, and the windows (possible pus-channels from the labyrinth to the cranial cavity). In the new-born there is little spongy substance in immediate contact with the bony labyrinth, so that the latter often touches the outer surface of the petrous portion of the bone (Plates 1 and 2). In the adult the capsule of the labyrinth is 3 mm. in thickness, and separated from the compact bone of the surface of the pyramid by an abundance of spongy tissue, and comes in contact with the surface only at one or two places (eminentia arcuata, posterior semicircular canal at the posterior surface of the pyramid, prominence of the lateral semicircular canal, promontory) (pus-channels from the labyrinth into the cranial and tympanic cavities). To study the shape of the bony labyrinth it must be removed from the spongy tissue of the pyramid. (The spongy tissue forms a pus-channel that may completely surround the labyrinth and isolate it from the bone.) In the new-born the internal ear may be isolated by dissection (Plate 7). It is easier, however, especially in the adult, to dissolve the bony tissue with some corrosive substance, such as caustic potash, after filling the labyrinth with Wood's metal. It can readily be studied by means of the Röntgen rays (Plate 12), or by transillumination after filling the labyrinth with mercury (Plate 8).

The bony labyrinth is divided into a vestibule that communicates with the semicircular canal behind and the cochlea in front. The outer wall of the vestibule forms the wall of the promontory, and is perforated by the two windows. Three semicircular canals begin and end in the vestibule; each canal is provided with an ampulla. The superior semicircular canal, with its ampulla, is placed above the horizontal or external semicircular canal, and behind the two is the common shaft of union of the superior and posterior canals. Beneath the latter lies the external canal, which overlies the ampulla of the posterior semicircular canal (Plates 7, 8). Beneath the ampullæ of the superior and external semicircular canals and above the oval window is a groove for the seventh nerve. The external semicircular canal is the shortest, the posterior the longest.

Immediately in front of the round window in the vestibule is the beginning of the cochlea, which makes two and a half turns. It is wound about a central column—the modiolus—which is 5 mm. in height and inclines forward and downward, the apex being expanded into the funnel-shaped lamina modioli. The tip of the cochlea is known as the cupola; it lies to the outer side and behind the knee of the carotid (median wall of canalis musculo-tubarius, Plate 8), with its base directed toward the internal auditory meatus (Plate 11). The first portion of the cochlea is covered by part of the promontory and runs at first horizontally. After the first turn the successive turns are superposed vertically one above the other. When the specimen is laid open (Plate 9), the openings of the semicircular canals are seen one above the other in the posterior portion of the vestibule, the superior and posterior ampullæ being separated from the remaining portion of the vestibule by the crista ampullaris.

The vestibule is divided by a ridge of bone, the crista vestibuli, which begins above the oval window, into two circular depressions: in front, the smaller recessus sphæricus (fovea hemisphærica); behind, the larger recessus ellipticus (fovea hemielliptica). The postero-inferior boundary of the recessus ellipticus is formed by a groove—the fossula sulciformis—that runs to the common opening of the superior and posterior semicircular canals, where it ends in the apertura interna aquæductus vestibuli. The aqueduct of the vestibule, which measures 6 mm. in length (Plates 7, 8), begins at this point and

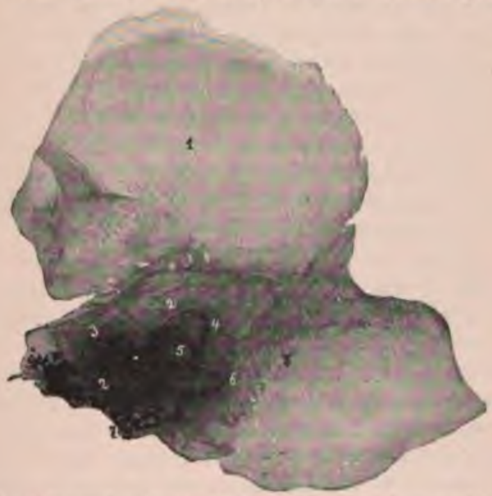


FIG. 12.—Skiagraph of macerated temporal bone from an infant. The labyrinth has been filled with mercury: 1, Squamous portion of temporal bone; 2, capsule of labyrinth (compact bone); 3, cochlea; 4, superior semicircular canal; 5, external semicircular canal; 6, posterior semicircular canal; 7, aquæductus cochleæ; 8, squamomastoid suture.

passes in a convex curve to the posterior surface of the pyramid. In the inferior ampulla, corresponding to the end of the foramen singulare, is the macula cribrosa inferior, for the passage of the inferior ampullary nerve. At the beginning of the crista vestibuli (pyramid), corresponding to the superior cribriform area, is found the macula cribrosa superior, which transmits the utricular and the superior and lateral ampullary nerves. In the fovea hemisphærica, corresponding to the middle cribriform, is the macula cribrosa media, for the nerve to the saccule.

The cavity of the cochlea begins in the vestibule, at the round window, in a small depression known as the recessus cochlearis. Situated in front of the crista ampullæ inferior is the beginning of a minute plate of bone, the lamina spiralis ossea. This, at first 1 mm. broad, gradually decreases in width as it winds around the modiolus like a spiral staircase, and ends at the apex of the cochlea in the hamulus, which projects into the cavity of the cochlea. The base of the modiolus is directed toward the internal auditory meatus (tractus spiralis), and, like the lamina spiralis ossea (especially the inferior lamella), is perforated by minute canaliculi for the transmission of the cochlear nerves. In the central portion of the modiolus, corresponding to the attachment of the lamina spiralis ossea, is the canalis spiralis, which sends out branches through the lamina spiralis ossea (Plate 9).

Opposite the lamina spiralis ossea, at the end of the first turn of the staircase, is another minute plate of bone, ½ mm. wide, the lamina spiralis secundaria, separated from the former by a narrow cleft that lodges the membranous cochlea. In the macerated specimen a sound passed through this cleft emerges below at the round window (Plate 9). Above the end of the first turn the lamina secundaria disappears, and the cleft gradually becomes enlarged to form the space between the lamina primaria and the outer wall of the cochlea. If we imagine this cleft to be filled with bone, as in snails, each turn of the cochlea would be divided into an upper and a lower staircase or scala. The upper staircase (Plate 9) would begin in the recessus cochlearis vestibuli, and therefore form the scala vestibuli; the lower, at the fenestra cochleæ, and would therefore form the scala tympani, leading to the tympanic cavity. At the foot of the scala tympani lies the apertura interna aquæductus cochleæ. This canal, which is 10 mm. in length, runs from this point horizontally and somewhat downward, and terminates by a funnel-shaped opening at the postero-inferior surface of the pyramid (Plate 8).

2. The membranous labyrinth, which more or less resembles a small bladder, is suspended within the bony labyrinth by means of fibrous bands at the points where the nerve-fibers enter the labyrinth. It consists of the sacculus on the median wall of the vestibule, the semicircular canals on the external convex wall, the membranous cochlea between the lamina spiralis ossea, primaria and secundaria, or between the lamina primaria and the outer wall of the cochlea (Plate 9). The interval between the bony and the membranous labyrinth is occupied by perilymph, a clear fluid containing mucin and albumin—a product of the capillaries situated in the walls of the staircase outside of the membranous cochlea. The cavity of the membranous labyrinth contains the endolymph, a tenacious mucoid fluid not containing albumin, and a product of the stria vascularis. The endolymph has no outlet, as the aqueduct of the cochlea that contains it terminates in the saccus endolymphaticus, a cul-de-sac 1 cm. in length formed by the two layers of the dura on the posterior surface of the pyramid (pus-channel from the labyrinth to the dura mater) (Plate 5). The perilymph, on the contrary, flows through the aqueduct of the cochlea into the subarachnoid space and also communicates with the subdural space by means of the sheath of the auditory nerve (pus-channel from the labyrinth to the subarachnoid and subdural spaces).

The brain is covered by three membranes, the innermost of which is the pia mater, the outermost the dura mater, while between them lies the arachnoid (Plate 10, Fig. 13). Between the brain and the pia mater is the epicerebral space; between the pia mater and the arachnoid lies the subarachnoid space, filled with loose connective tissue; between the arachnoid and dura, the subdural, and between the dura and the bone, the epidural, space.

The epidural and subdural spaces communicate by means of lymph-spaces and processes of the arachnoid with the subarachnoid space. The processes of the arachnoid often lead directly into the sinuses of the dura mater. The subarachnoid space communicates with the ventricles of the brain and the lymph-channels of the nerves (pus-channels).

The central portion of the membranous labyrinth occu-

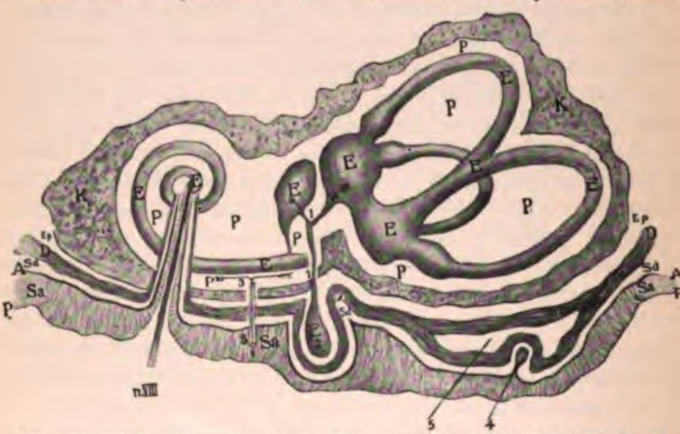


FIG. 13.—Diagrammatic view of the membranous labyrinth in its relation to the meninges. Right ear, seen from behind. *E. p*, Epidural space; *K*, bone; *P*, perilymph; *E*, endolymph; *D*, dura mater; *A*, arachnoid; *S. d*, subdural space; *S. a*, subarachnoid space; *P*, pia mater; 1, ductus endolymphaticus; 2, saccus endolymphaticus; 3, aquæductus cochleæ; 4, tag of arachnoid tissue; 5, transverse sinus.

pies the vestibule (Plate 9) and consists of two portions, the sacculus, lying in the fovea hemisphærica, and the utriculus, in the fovea hemielliptica. The posterior walls of the saccule and utricle are closely applied to the bone; between their anterior walls and the bone (promontory) is a cleft 2 mm. in width which contains perilymph (cisterna perilymphatica) (Plate 14). The utricle measures 6 mm. in height and communicates by means of its upper, drawn-out portion (recessus), its central portion (utriculus proprius), and its posterior portion (sinus posterior), with the three ampullæ and the two limbs of the membranous semicircular canals (ductus semicircularis). On its upper surface is a whitish, oval spot, the macula acustica utriculi, which corresponds with the nerve-ending of the utricular nerve. The membranous semicircular canals fill one-third of the bony lumen, and present, on their ampullæ, three crescentic ridges, the cristæ acusticæ ampullares, corresponding to the endings of the superior, lateral, and inferior ampullary nerves.

The communication between the utricle and saccule is not a direct one, but is effected by means of a canaliculus, the ductus utriculosaccularis, which begins behind in the recessus utriculi and ends in the ductus endolymphaticus coming from the saccule. The saccule is 3 mm. in height; its upper portion lies directly in front of the recessus utriculi, and is marked on its upper surface by a whitish spot, the macula acustica sacculi, corresponding to the ending of the saccular nerve. The ductus endolymphaticus begins in the posterior wall of the saccule, and, after receiving the canalis utriculosaccularis, terminates in the bony aquæductus vestibuli. The lower extremity of the saccule is drawn out into a canaliculus 1 mm. in length, which terminates in the upper portion of the membranous ductus cochleæ. This canaliculus is known as the ductus reuniens Hensenii. It transmits the endolymph from the saccule into the membranous ductus cochlearis, which lies between the lamina spiralis ossea and the outer wall of the cochlea, and divides the cochlea into the upper scala vestibuli and lower scala tympani. The scalæ contain perilymph. The membranous cochlea therefore differs somewhat from the osseous; it represents a hollow ribbon rolled up in a spiral and fills only a small portion of the bony cochlea. The ductus cochlearis ends blindly in the recessus cochlearis (cæcum vestibulare) below, and in the same way above in the tip of the cochlea at the hamulus (cæcum capillare), so that the endolymph that it contains is completely shut in. The cæcum capillare does not completely fill the space between the hamulus and the top of the modiolus; it ends at the tip of the hamulus, leaving an opening to the inner side of the hamulus between it and the top of the modiolus, the helicotrema (Plate 9). Through this opening the perilymph flows from the scala vestibuli down into the scala tympani, at the foot of which it strikes against the membrane of the round window.

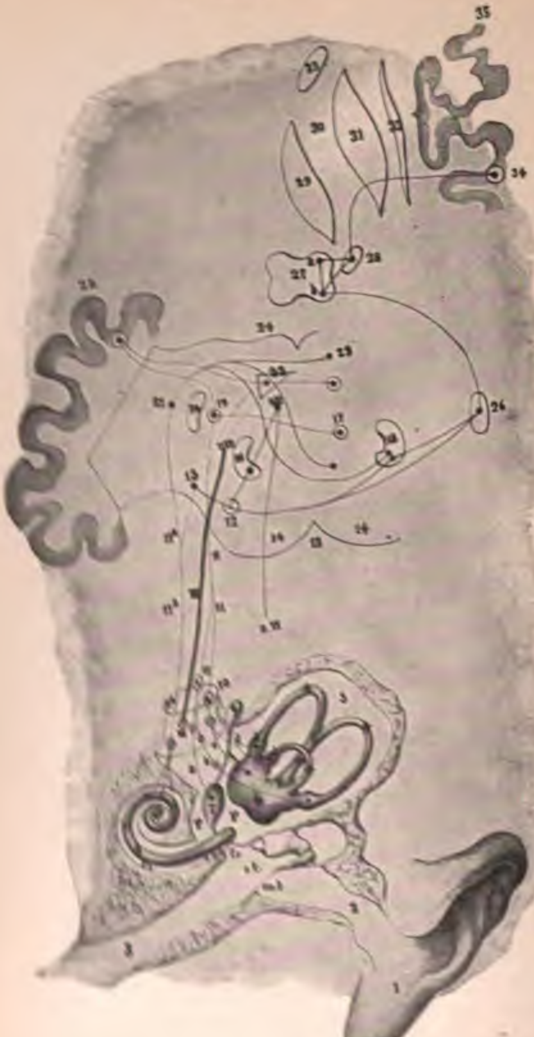
In transverse section the ductus cochlearis appears triangular (Plates 9, 14). Its lower wall forms the membranous continuation of the lamina spiralis ossea, and consists of radial fibers (lamina basilaris) stretched between the lamina spiralis ossea and the outer wall of the cochlea or lamina spiralis secundaria below. The fibers of the basilar membrane increase in width about twelvefold from the base to the tip. The upper wall is formed by a membrane (membrana vestibularis Reissneri) of uniform length, which passes from the end of the lamina spiralis ossea at an angle of 45 degrees obliquely upward to the outer wall of the cochlea. The outer wall forms the periosteum of the outer wall of the cochlea, which increases in height toward the top. The basilar membrane supports the nerve-endings of the auditory nerve, known as Corti's organ; the cæcum vestibulare and cæcum capillare have no nerve-endings.

3. **The auditory nerve** has six endings in the membranous labyrinth: Corti's organ, the macula acustica sacculi, macula acustica utriculi, and the crista ampullaris superior, lateral, and inferior. Accompanied by the facial nerve and intermediate portion, which lie above, and the internal auditory artery and vein, the auditory nerve, covered by a sheath of dural and arachnoidal tissue, enters the porus and meatus acusticus internus, where it divides into two portions, each provided with ganglia:

(*a*) The **vestibular portion**, consisting of bundles of nerve-fibers that enter through the openings in the macula cribrosa, and through the foramen singulare, with a superior branch (nervi utricularis, ampullaris superior et lateralis), and a middle branch (nervus saccularis and nervus ampullaris inferior), each supplied with a ganglionic swelling (intumescentia ganglioformis Scarpi).

(*b*) The lower flattened **cochlear portion**, which enters the central and spiral canal of the modiolus through the foramen centrale and the tractus spiralis foraminosus. Within the spiral canal the cochlear nerve forms a spiral ribbon of ganglion cells (ganglion spirale cochleæ Rosenthali) containing oval and round bipolar ganglionic elements. These ganglia are connected by medullated nerve-fibers, derived from the cochlear nerve within the central canal of the modiolus, which pass out between the lamellæ of the lamina spiralis ossea. Here they form at first a loose-meshed and then a more compact network of nerve-fibers that finally emerge as non-medullated fibers through the openings in the periosteal thickening at the margin of the lamina spiralis ossea (habenula), and terminate in the basal membrane (Plates 9 and 14).

The auditory nerve enters the cerebrum to the outer side of the facial, between the latter and the glossopharyngeal, and between the medulla oblongata and the pons. The central portions of the cochlear and vestibular nerves, like the peripheral, follow a separate course. The cochlear nerve runs to the outer side of the restiform body and enters the accessory auditory nucleus, which lies in close contact with the trunk of the nerve and contains the tuberculum acusticum, lying on the corpus restiforme. Here the fibers divide into two tracts, the one running downward and inward, toward the ventral and median surfaces of the brain, the other upward, in a dorsal direction, around the restiform body (Fig. 14). Part of the ventral tract passes through the trapezoid body to the superior olive of the same side, the greater portion crossing over and entering the superior olive of the opposite side. From the olive the fibers go to the lateral fillet, and from there to the posterior, a few to the anterior, corpus quadrigeminum, which also contains the origin of



the oculomotor fibers. From the corpora quadrigemina they pass through the median geniculate body to the posterior part of the inner capsule, and from there to the cortical cells of the superior and middle convolutions of the temporal lobe (Obersteiner). The dorsal tract, embracing the fibers that surround the corpus restiforme (striæ acusticæ), is non-medullated and passes under the floor of the fourth ventricle toward the raphe, the greater portion undergoing decussation and going to the tegmentum, after which they possibly proceed to the optic thalamus, and finally to the superior olive, which also contains reflex nerve tracts for the ocular muscles. The superior olive communicates with the nucleus of the abducens nerve, which supplies the external rectus, and with the nucleus fastigii of the cerebellum.

The median vestibular portion runs to the outer side of the restiform body. A few filaments enter the triangular (dorsal) nucleus, from which fibers go directly to the cerebellum and to the tegmentum. The greater portion of the fibers enter the large-celled nucleus on the outer

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FIG. 14.—Diagrammatic view of the entire organ of hearing. (The central organ is based on a diagram by Obersteiner.) Left ear: *m. t*, Drumhead; *c. t*, tympanic cavity with ossicles, and stapes within the round window; *f. c*, fenestra cochleæ; *s. t*, scala tympani; *a. c*, aquæductus cochleæ; *E*, endolymph; *P*, perilymph; (*c*) utricular branch; (*d*) anterior and external ampullary twigs; 1, auricle; 2, external auditory canal; 3, Eustachian tube; 4, semicircular canals; 5, perilymph; 6, utricle; 7, saccule; 8, ductus cochlearis; 9, saccus endolymphaticus; 10, internal auditory meatus; 11, median, deep portion of auditory nerve = vestibular nerve; I, intumescentia ganglioformis Scarpæ of the median branch (nervus sacculo-ampullaris); (*a*) saccular branch, transmitted by macula cribrosa media; (*b*) posterior ampullary branch, transmitted by foramen singulare and macula cribrosa inferior; II, intumescentia ganglioformis of the superior branch (nervus utriculo-ampullaris), transmitted by macula cribrosa superior; 11 (*a*) lateral superficial portion of auditory nerve, cochlear nerve (ramus inferior acusticus, transmitted by tractus foraminosus); 12, trapezoid body; 13, raphe; 14, pyramid; 15, accessory nucleus; 16, olive; 17, tegmentum; 18, olive; 19, Deiters' nucleus; 20, corpus restiforme; 21, tuberculum acusticum; 22, triangular nucleus; 23, sound-rod; 24, medulla oblongata; 25, cerebellar cortex; 26, lemniscus lateralis; 27, corpus quadrigeminum (*a*) anterius, (*b*) posterius; 28, median geniculate ganglion; 29, optic thalamus; 30, internal capsule; 31, lentiform nucleus; 32, claustrum; 33, caudate nucleus; 34, temporal lobe; 35, cerebral cortex.

side of the restiform body. The latter is divided into Deiters' nucleus on the floor of the fourth ventricle, and Bechterew's nucleus, situated dorsally in the lateral wall of the ventricle. From the large-celled nucleus the fibers pass to the crus cerebelli and vermiform process of the cerebellum, a small portion going to the tegmentum and trapezoid body. Deiters' nucleus is connected with the nucleus of the abducens nerve.

Histology.—The endosteum of the inner wall of the bony labyrinth is covered by endothelium (Plate 14). The walls of the membranous labyrinth consist of fibrillary connective tissue, in places containing numerous cells and a structureless basal membrane that in the semicircular canal forms papillæ (Plate 36) and is covered by a thin squamous epithelium. The saccule, the utricle, and the semicircular canal are attached to the bone by bridges of vascular connective tissue. The maculæ acusticæ are richly supplied with blood-vessels. In the vicinity of the nerve-endings the squamous epithelium becomes cuboidal, and at the nerve-endings themselves assumes the high cylindric type of special sense epithelium. Near the maculæ and cristæ acusticæ are the bottle-shaped auditory cells supplied with delicate cilia, and cylindric sustentacular cells with their nuclei lying near the base. The base of the auditory cells is surrounded by the network of non-medullated nerve-fibers of the vestibular nerve.

At the cristæ acusticæ the auditory cilia are extremely long and often glued together with mucus (cupola); at the maculæ acusticæ the auditory cilia are covered by a dense mass (otoconia) composed of white hexagonal crystals of calcium—the otoliths. The cavity of the bony cochlea is lined by a layer of periosteum covered with endothelium that becomes thicker near the end of the lamina spiralis ossea and corresponding portion of the wall of the cochlea. At the end of the lamina ossea the periosteum forms the limbus spiralis, with an upper (labium vestibulare) and a lower (labium tympanicum) lip. Between the two lies the sulcus spiralis internus. On the outer wall of the cochlea the thickening forms the ligamentum spirale cochleæ. The ligamentum spirale consists of loose connective tissue covered with cuboidal epithelium ; underneath and within the epithelial layer is a network of blood-vessels, the stria vascularis, from which the endolymph is derived. At one point it protrudes and forms the prominentia spiralis, which overlies

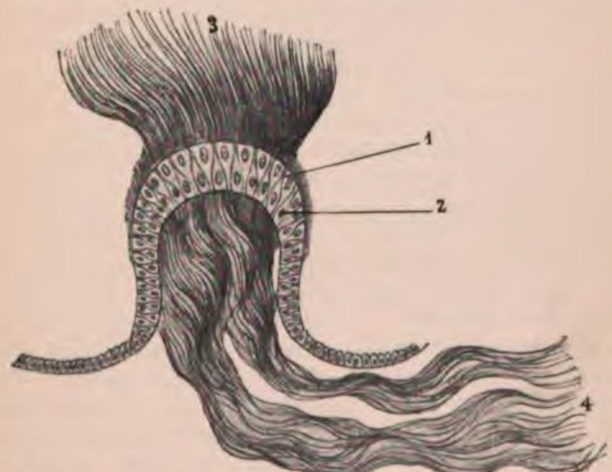


FIG. 15.—Crista acustica from guinea-pig (partly diagrammatic): 1, Hair-cells; 2, sustentacular cells; 3, cupola; 4, nervus ampullaris.

the sulcus spiralis externus (Plate 14). The membrana vestibularis Reissneri consists of connective tissue, covered above by endothelium and below by squamous epithelium. The basilar membrane is stretched between the limbus spiralis and the ligamentum spirale. The limbus spiralis consists of tough periosteal connective tissue forming hemispheric papillæ (Huschke's auditory teeth) at the labium vestibulare, and covered with cylindric epithelium. The labium vestibulare is connected

with the labium tympani by means of the sulcus spiralis internus, which is covered with squamous epithelium. The labium tympani presents from 3000 to 4000 openings, the foramina nervina, in the habenula perforata (Waldeyer), which transmit the fibers of the cochlear nerve to the basilar membrane; the latter consists of radially striated fibers (the auditory fibers) that increase in width twelve-fold from the base to the top. The lamina basilaris, or zona tecta, near the limbus spiralis, supports Corti's organ (organum spirale). To the outer side of the organ the striped basilar membrane is denuded (zona pectinata). The under surface of the basilar membrane is covered by a loose layer of connective tissue (tympanic covering) containing veins (vas spirale). This layer of connective tissue is covered with endothelium, but the basilar membrane within the ductus cochlearis supports the highly specialized epithelium known as Corti's organ. Where it joins the sulcus spiralis internus, this is composed first of cylindric sustentacular cells, then of the inner ciliated hair-cell and Corti's arch (arcus spiralis). The latter is formed by the internal pillar of Corti, the concave head of which rests against the convex head of the external pillar. The corners of the tunnel are rounded out with sustentacular cells. To the outer side of Corti's arch are four (in the guinea-pig three) cylindric ciliated hair-cells, separated and supported by four club-shaped Deiters' cells; the spaces between the latter and the hair-cells form Nuël's space. The outer hair-cells and Deiters' cells are covered by a strip of cuticle, the membrana reticularis, through which the auditory hairs project. On the outer side Deiters' cells are joined by high cylindric transitional epithelium (external sustentacular cells of Hensen), and these by a lower variety (Claudius' cells), which finally merge into the epithelium of the zona pectinata and sulcus spiralis internus. A delicate membrane, the membrana tectoria, extends from the labium vestibulare and limbus spiralis as far as the outer hair-cells, covering over Corti's

organ. The medullated nerve-fibers of the cochlear nerve, covered with the sheath of Schwann, pass through the ganglion spirale, which consists of bipolar ganglion cells and an endothelial envelope containing many nuclei, and enter the lamina spiralis ossea and the limbus spiralis. In the latter structure they pass through the labium tegmentum as naked axis-cylinders, and join the inner hair-cells, some passing through Corti's tunnel to the outer hair-cells, around the base of which they form a basket-work.

VASCULAR AND NERVOUS SUPPLY OF THE ORGAN OF HEARING.

Part Supplied.		Vessel.	Course.
Auricle.	Helix, tragus, lobe.	Anterior auricular artery (superficial temporal).	In front of the ear.
	Greater part of the auricle.	Posterior auricular artery (external carotid), perforating branches. Veins empty into the superficial temporal and external jugular veins.	Posterior auricular fossa and through the cartilage.
External auditory canal.	Cartilaginous: Anterior wall.	Anterior auricular artery.	Entrance through junction of the cartilaginous and bony auditory canal.
	Cartilaginous: Posterior wall.	Posterior auricular artery.	
	Bony.	Deep auricular artery (internal maxillary).	
Drumhead.	Stratum cutaneum.	Arteria manubrii mallei (deep auricular).	Annulus tendineus and stratum cutaneum behind manubrium mallei. Radial anastomoses.
	Stratum mucosum.	Anterior tympanic artery (internal maxillary), perforating branches (anastomoses between stratum cutaneum and stratum mucosum).	Through Glaserian fissure and stratum cutaneum behind manubrium mallei. Radial anastomoses.
Eustachian tube.	Roof.	Branches of the middle meningeal artery (internal maxillary).	Petrosquamous fissure.
	Floor.	Basilar branch of ascending pharyngeal artery (external carotid) and Vidian artery (superior palatine).	
Mastoid process.	Mastoid cells.	Mastoid branches (stylomastoid artery).	From the Fallopian canal.
	Attic and antrum.	Branches of the middle meningeal artery. Veins empty into the posterior auricular vein and transverse sinus.	Petrosquamous fissure.
Tympanic cavity.	Anterior portion.	Caroticotympanic branch of external carotid artery.	Caroticotympanic canaliculi.

Part Supplied.		Vessel.	Course.
Tympanic cavity.	Anterior ligament of malleus.	Anterior tympanic artery (internal maxillary artery).	Glaserian fissure.
Tympanic cavity.	Posterior portion.	Posterior tympanic artery (stylomastoid).	Canal for chorda tympani.
	Stapedius muscle.	Stapedic (stylomastoid artery).	Pyramidal eminence.
	Stapes.	Branch to the stapes (stylomastoid artery). Anastomosis of stylomastoid artery with superficial petrosal branch.	From the Fallopian canal.
	Tensor tympani muscle.	Branch to tensor tympani (middle meningeal artery).	Spurious hiatus.
	Upper portion.	Superior tympanic artery (middle meningeal). Superficial petrosal branch (middle meningeal).	Roof of tubes.
	Lower portion.	Inferior tympanic artery (ascending pharyngeal).	Apertura superior canaliculi tympanici.
	Wall of promontory and endosteum of labyrinth.	Branches that communicate with branches of the internal auditory artery.	Vascular perforations in promontorial wall (Politzer).
		Veins empty into middle meningeal and deep auricular veins.	
Labyrinth.	Osseous semicircular canals.	Arteria subarcuata.	Fossa subarcuata.
	Capsule.	Internal auditory artery (basilar).	Porus acusticus internus.
	Membranous semicircular canals, utricle, and saccule, especially the cristæ and maculæ acusticæ.	Vestibular artery (internal auditory).	With vestibular nerve.
	Cochlear nerve, spiral ganglia, osseous spinal lamina, scala vestibuli, periosteum of walls of scalæ, spiral ligament.	Cochlear artery (internal auditory).	With cochlear nerve. Venous blood flows off in scala tympani (vas spirale).
	Utricle and saccule, cochlea.	Internal auditory vein.	Into inferior petrosal sinus
	Semicircular canals, utricle.	Vena aquæductus vestibuli.	Into transverse sinus.
	Cochlea.	Vena aquæductus cochleæ.	Into bulbar jugular vein.

cæcum capillare does not completely fill the space between the hamulus and the top of the modiolus; it ends at the tip of the hamulus, leaving an opening to the inner side of the hamulus between it and the top of the modiolus, the helicotrema (Plate 9). Through this opening the perilymph flows from the scala vestibuli down into the scala tympani, at the foot of which it strikes against the membrane of the round window.

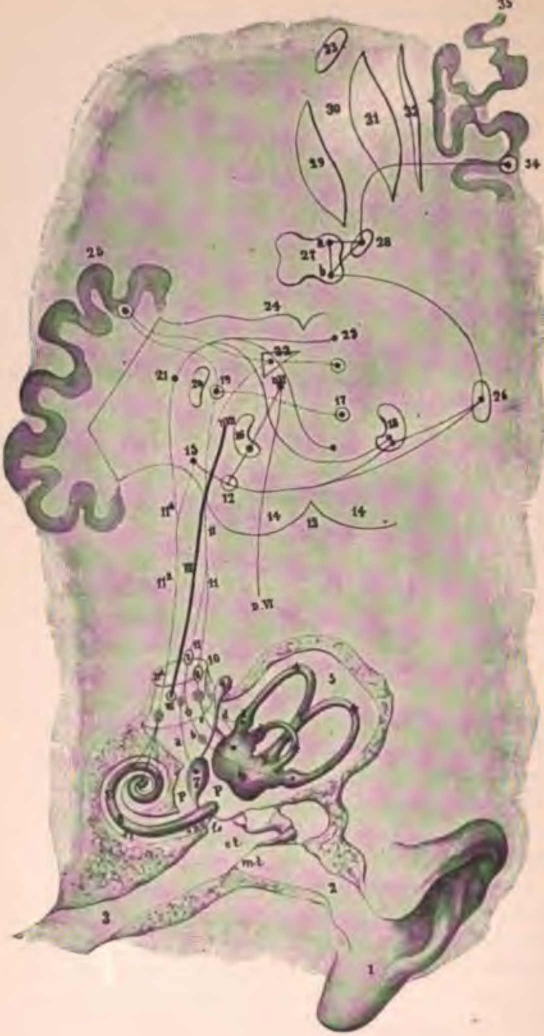
In transverse section the ductus cochlearis appears triangular (Plates 9, 14). Its lower wall forms the membranous continuation of the lamina spiralis ossea, and consists of radial fibers (lamina basilaris) stretched between the lamina spiralis ossea and the outer wall of the cochlea or lamina spiralis secundaria below. The fibers of the basilar membrane increase in width about twelvefold from the base to the tip. The upper wall is formed by a membrane (membrana vestibularis Reissneri) of uniform length, which passes from the end of the lamina spiralis ossea at an angle of 45 degrees obliquely upward to the outer wall of the cochlea. The outer wall forms the periosteum of the outer wall of the cochlea, which increases in height toward the top. The basilar membrane supports the nerve-endings of the auditory nerve, known as Corti's organ; the cæcum vestibulare and cæcum capillare have no nerve-endings.

3. **The auditory nerve** has six endings in the membranous labyrinth: Corti's organ, the macula acustica sacculi, macula acustica utriculi, and the crista ampullaris superior, lateral, and inferior. Accompanied by the facial nerve and intermediate portion, which lie above, and the internal auditory artery and vein, the auditory nerve, covered by a sheath of dural and arachnoidal tissue, enters the porus and meatus acusticus internus, where it divides into two portions, each provided with ganglia:

(*a*) The **vestibular portion**, consisting of bundles of nerve-fibers that enter through the openings in the macula cribrosa, and through the foramen singulare, with a superior branch (nervi utricularis, ampullaris superior et lateralis), and a middle branch (nervus saccularis and nervus ampullaris inferior), each supplied with a ganglionic swelling (intumescentia ganglioformis Scarpi).

(*b*) The lower flattened **cochlear portion**, which enters the central and spiral canal of the modiolus through the foramen centrale and the tractus spiralis foraminosus. Within the spiral canal the cochlear nerve forms a spiral ribbon of ganglion cells (ganglion spirale cochleæ Rosenthali) containing oval and round bipolar ganglionic elements. These ganglia are connected by medullated nerve-fibers, derived from the cochlear nerve within the central canal of the modiolus, which pass out between the lamellæ of the lamina spiralis ossea. Here they form at first a loose-meshed and then a more compact network of nerve-fibers that finally emerge as non-medullated fibers through the openings in the periosteal thickening at the margin of the lamina spiralis ossea (habenula), and terminate in the basal membrane (Plates 9 and 14).

The auditory nerve enters the cerebrum to the outer side of the facial, between the latter and the glossopharyngeal, and between the medulla oblongata and the pons. The central portions of the cochlear and vestibular nerves, like the peripheral, follow a separate course. The cochlear nerve runs to the outer side of the restiform body and enters the accessory auditory nucleus, which lies in close contact with the trunk of the nerve and contains the tuberculum acusticum, lying on the corpus restiforme. Here the fibers divide into two tracts, the one running downward and inward, toward the ventral and median surfaces of the brain, the other upward, in a dorsal direction, around the restiform body (Fig. 14). Part of the ventral tract passes through the trapezoid body to the superior olive of the same side, the greater portion crossing over and entering the superior olive of the opposite side. From the olive the fibers go to the lateral fillet, and from there to the posterior, a few to the anterior, corpus quadrigeminum, which also contains the origin of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The median vestibular portion runs to the outer side of the restiform body. A few filaments enter the triangular (dorsal) nucleus, from which fibers go directly to the cerebellum and to the tegmentum. The greater portion of the fibers enter the large-celled nucleus on the outer

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FIG. 14.—Diagrammatic view of the entire organ of hearing. (The central organ is based on a diagram by Obersteiner.) Left ear: *m. t*, Drumhead; *c. t*, tympanic cavity with ossicles, and stapes within the round window; *f. c*, fenestra cochleæ; *s. t*, scala tympani; *a. c*, aquæductus cochleæ; *E*, endolymph; *P*, perilymph; (*c*) utricular branch; (*d*) anterior and external ampullary twigs; 1, auricle; 2, external auditory canal; 3, Eustachian tube; 4, semicircular canals; 5, perilymph; 6, utricle; 7, saccule; 8, ductus cochlearis; 9, saccus endolymphaticus; 10, internal auditory meatus; 11, median, deep portion of auditory nerve = vestibular nerve; I, intumescentia ganglioformis Scarpæ of the median branch (nervus sacculo-ampullaris); (*a*) saccular branch, transmitted by macula cribrosa media; (*b*) posterior ampullary branch, transmitted by foramen singulare and macula cribrosa inferior; II, intumescentia ganglioformis of the superior branch (nervus utriculo-ampullaris), transmitted by macula cribrosa superior; 11 (*a*) lateral superficial portion of auditory nerve, cochlear nerve (ramus inferior acusticus, transmitted by tractus foraminosus); 12, trapezoid body; 13, raphe; 14, pyramid; 15, accessory nucleus; 16, olive; 17, tegmentum; 18, olive; 19, Deiters' nucleus; 20, corpus restiforme; 21, tuberculum acusticum; 22, triangular nucleus; 23, sound-rod; 24, medulla oblongata; 25, cerebellar cortex; 26, lemniscus lateralis; 27, corpus quadrigeminum (*a*) anterius, (*b*) posterius; 28, median geniculate ganglion; 29, optic thalamus; 30, internal capsule; 31, lentiform nucleus; 32, claustrum; 33, caudate nucleus; 34, temporal lobe; 35, cerebral cortex.

side of the restiform body. The latter is divided into Deiters' nucleus on the floor of the fourth ventricle, and Bechterew's nucleus, situated dorsally in the lateral wall of the ventricle. From the large-celled nucleus the fibers pass to the crus cerebelli and vermiform process of the cerebellum, a small portion going to the tegmentum and trapezoid body. Deiters' nucleus is connected with the nucleus of the abducens nerve.

Histology.—The endosteum of the inner wall of the bony labyrinth is covered by endothelium (Plate 14). The walls of the membranous labyrinth consist of fibrillary connective tissue, in places containing numerous cells and a structureless basal membrane that in the semicircular canal forms papillæ (Plate 36) and is covered by a thin squamous epithelium. The saccule, the utricle, and the semicircular canal are attached to the bone by bridges of vascular connective tissue. The maculæ acusticæ are richly supplied with blood-vessels. In the vicinity of the nerve-endings the squamous epithelium becomes cuboidal, and at the nerve-endings themselves assumes the high cylindric type of special sense epithelium. Near the maculæ and cristæ acusticæ are the bottle-shaped auditory cells supplied with delicate cilia, and cylindric sustentacular cells with their nuclei lying near the base. The base of the auditory cells is surrounded by the network of non-medullated nerve-fibers of the vestibular nerve.

At the cristæ acusticæ the auditory cilia are extremely long and often glued together with mucus (cupola); at the maculæ acusticæ the auditory cilia are covered by a dense mass (otoconia) composed of white hexagonal crystals of calcium—the otoliths. The cavity of the bony cochlea is lined by a layer of periosteum covered with endothelium that becomes thicker near the end of the lamina spiralis ossea and corresponding portion of the wall of the cochlea. At the end of the lamina ossea the periosteum forms the limbus spiralis, with an upper (labium vestibulare) and a lower (labium tympanicum) lip. Between the two lies the sulcus spiralis internus. On the outer wall of the cochlea the thickening forms the ligamentum spirale cochleæ. The ligamentum spirale consists of loose connective tissue covered with cuboidal epithelium; underneath and within the epithelial layer is a network of blood-vessels, the stria vascularis, from which the endolymph is derived. At one point it protrudes and forms the prominentia spiralis, which overlies

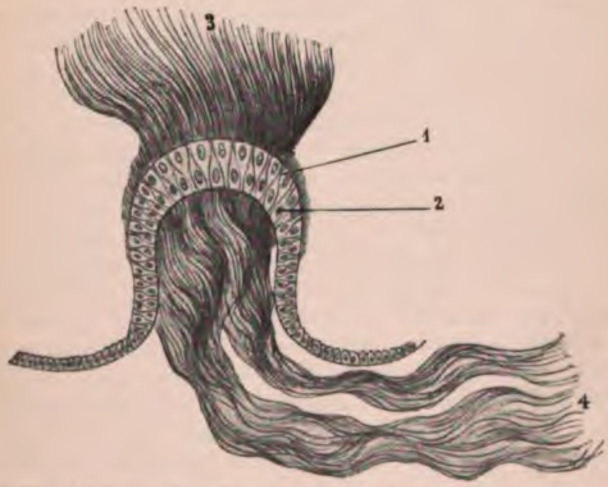

FIG. 15.—Crista acustica from guinea-pig (partly diagrammatic): 1, Hair-cells; 2, sustentacular cells; 3, cupola; 4, nervus ampullaris.

the sulcus spiralis externus (Plate 14). The membrana vestibularis Reissneri consists of connective tissue, covered above by endothelium and below by squamous epithelium. The basilar membrane is stretched between the limbus spiralis and the ligamentum spirale. The limbus spiralis consists of tough periosteal connective tissue forming hemispheric papillæ (Huschke's auditory teeth) at the labium vestibulare, and covered with cylindric epithelium. The labium vestibulare is connected

with the labium tympani by means of the sulcus spiralis internus, which is covered with squamous epithelium. The labium tympani presents from 3000 to 4000 openings, the foramina nervina, in the habenula perforata (Waldeyer), which transmit the fibers of the cochlear nerve to the basilar membrane; the latter consists of radially striated fibers (the auditory fibers) that increase in width twelve-fold from the base to the top. The lamina basilaris, or zona tecta, near the limbus spiralis, supports Corti's organ (organum spirale). To the outer side of the organ the striped basilar membrane is denuded (zona pectinata). The under surface of the basilar membrane is covered by a loose layer of connective tissue (tympanic covering) containing veins (vas spirale). This layer of connective tissue is covered with endothelium, but the basilar membrane within the ductus cochlearis supports the highly specialized epithelium known as Corti's organ. Where it joins the sulcus spiralis internus, this is composed first of cylindric sustentacular cells, then of the inner ciliated hair-cell and Corti's arch (arcus spiralis). The latter is formed by the internal pillar of Corti, the concave head of which rests against the convex head of the external pillar. The corners of the tunnel are rounded out with sustentacular cells. To the outer side of Corti's arch are four (in the guinea-pig three) cylindric ciliated hair-cells, separated and supported by four club-shaped Deiters' cells; the spaces between the latter and the hair-cells form Nuël's space. The outer hair-cells and Deiters' cells are covered by a strip of cuticle, the membrana reticularis, through which the auditory hairs project. On the outer side Deiters' cells are joined by high cylindric transitional epithelium (external sustentacular cells of Hensen), and these by a lower variety (Claudius' cells), which finally merge into the epithelium of the zona pectinata and sulcus spiralis internus. A delicate membrane, the membrana tectoria, extends from the labium vestibulare and limbus spiralis as far as the outer hair-cells, covering over Corti's

organ. The medullated nerve-fibers of the cochlear nerve, covered with the sheath of Schwann, pass through the ganglion spirale, which consists of bipolar ganglion cells and an endothelial envelope containing many nuclei, and enter the lamina spiralis ossea and the limbus spiralis. In the latter structure they pass through the labium tegmentum as naked axis-cylinders, and join the inner hair-cells, some passing through Corti's tunnel to the outer hair-cells, around the base of which they form a basket-work.

VASCULAR AND NERVOUS SUPPLY OF THE ORGAN OF HEARING.

Part Supplied.		Vessel.	Course.
Auricle.	Helix, tragus, lobe.	Anterior auricular artery (superficial temporal).	In front of the ear.
	Greater part of the auricle.	Posterior auricular artery (external carotid), perforating branches. Veins empty into the superficial temporal and external jugular veins.	Posterior auricular fossa and through the cartilage.
External auditory canal.	Cartilaginous: Anterior wall.	Anterior auricular artery.	Entrance through junction of the cartilaginous and bony auditory canal.
	Cartilaginous: Posterior wall.	Posterior auricular artery.	
	Bony.	Deep auricular artery (internal maxillary).	
Drumhead.	Stratum cutaneum.	Arteria manubrii mallei (deep auricular).	Annulus tendineus and stratum cutaneum behind manubrium mallei. Radial anastomoses.
	Stratum mucosum.	Anterior tympanic artery (internal maxillary), perforating branches (anastomoses between stratum cutaneum and stratum mucosum).	Through Glaserian fissure and stratum cutaneum behind manubrium mallei. Radial anastomoses.
Eustachian tube.	Roof.	Branches of the middle meningeal artery (internal maxillary).	Petrosquamous fissure.
	Floor.	Basilar branch of ascending pharyngeal artery (external carotid) and Vidian artery (superior palatine).	
Mastoid process.	Mastoid cells.	Mastoid branches (stylomastoid artery).	From the Fallopian canal.
	Attic and antrum.	Branches of the middle meningeal artery. Veins empty into the posterior auricular vein and transverse sinus.	Petrosquamous fissure.
Tympanic cavity.	Anterior portion.	Caroticotympanic branch of external carotid artery.	Caroticotympanic canaliculi.

Part Supplied.		Vessel.	Course.
Tympanic cavity.	Anterior ligament of malleus.	Anterior tympanic artery (internal maxillary artery).	Glaserian fissure.
Tympanic cavity.	Posterior portion.	Posterior tympanic artery (stylomastoid).	Canal for chorda tympani.
	Stapedius muscle.	Stapedic (stylomastoid artery).	Pyramidal eminence.
	Stapes.	Branch to the stapes (stylomastoid artery). Anastomosis of stylomastoid artery with superficial petrosal branch.	From the Fallopian canal.
	Tensor tympani muscle.	Branch to tensor tympani (middle meningeal artery).	Spurious hiatus.
	Upper portion.	Superior tympanic artery (middle meningeal). Superficial petrosal branch (middle meningeal).	Roof of tubes.
	Lower portion.	Inferior tympanic artery (ascending pharyngeal).	Apertura superior canaliculi tympanici.
	Wall of promontory and endosteum of labyrinth.	Branches that communicate with branches of the internal auditory artery.	Vascular perforations in promontorial wall (Politzer).
		Veins empty into middle meningeal and deep auricular veins.	
Labyrinth.	Osseous semicircular canals.	Arteria subarcuata.	Fossa subarcuata.
	Capsule.	Internal auditory artery (basilar).	Porus acusticus internus.
	Membranous semicircular canals, utricle, and saccule, especially the cristæ and maculæ acusticæ.	Vestibular artery (internal auditory).	With vestibular nerve.
	Cochlear nerve, spiral ganglia, osseous spinal lamina, scala vestibuli, periosteum of walls of scalæ, spiral ligament.	Cochlear artery (internal auditory).	With cochlear nerve. Venous blood flows off in scala tympani (vas spirale).
	Utricle and saccule, cochlea.	Internal auditory vein.	Into inferior petrosal sinus
	Semicircular canals, utricle.	Vena aquæductus vestibuli.	Into transverse sinus.
	Cochlea.	Vena aquæductus cochleæ.	Into bulbar jugular vein.

Part Drained.		Lymph-Gland.	Lymph-Vessel.
Lymph-channels.	Cavum conchæ, external auditory canal.	Lymph-gland in front of tragus.	Lower anterior lymphatic vessel.
	Triangular fossa, anterior surface of helix.	Highest mastoid gland.	Upper anterior lymphatic vessel.
	Helix, antihelix, posterior surface.	Mastoid and cervical glands.	Posterior lymphatic vessel.
	Lobe, auditory canal.	Parotid glands.	Posterior lymphatic vessel.
	Drumhead, tympanic cavity.	Mastoid glands on sternocleidomastoid.	
	Labyrinth.		Aquæductus cochleæ in subarachnoid.

Nerve Supply.	Motor.	Sensory.	
Extrinsic muscles of the ear.	Posterior auricular nerve (facial nerve).	Muscle of the ear.	Auricularis magnus nerve (third cervical nerve).
	Anterior auricular nerve (right temporal nerve—seventh).	Auditory canal.	Auriculotemporal nerve (fifth nerve).
Stapedius muscle.	Stapedius nerve (seventh nerve).	Cartilaginous—	Nerve of the external auditory meatus (auriculotemporal nerve).
Tensor tympani muscle.	Tensor tympani nerve (otic ganglion and fifth nerve, 3).	Bony posterior wall.	Auricular nerve, vagus nerve (tympanomastoid fissure).
	Seventh nerve through great superficial petrosal nerve (from geniculate ganglion through spurious hiatus, anterior lacerated foramen, Vidian canal to the nasal ganglion, pterygopalatine nerves).	Drumhead.	Nervi membranæ tympani (nerve of the external auditory meatus).
		Tympanic cavity.	Plexus tympanicus.
Tensor veli muscle.	Otic ganglion, fifth nerve, 3.	Eustachian tube.	(a) Caroticotympanic branch (lesser deep petrosal nerve) (internal carotid plexus of sympathetic).
Retrahens tubæ.	Pharyngeal plexus, vagus nerve.		(b) Tympanic (Jacobson's) nerve from petrous ganglion. Ninth nerve through inferior aperture and superior tympanic canal to small superficial petrosal nerve. Anastomosis with eighth nerve through the anterior lacerated foramen to the otic ganglion of the fifth nerve and parotid.
Vasoconstrictors of the entire ear.	Sympathetic nerve.		
Secretory.			
Taste of anterior half of tongue; salivary secretion of submaxillary and sublingual glands.	Chorda tympani (seventh nerve); fibers of the chorda tympani are joined to the seventh nerve by the intermediate portion of the ninth, and extend through the apertura canaliculi chordæ between hammer and incus to folds of drumhead; through the Glaserian fissure to the lingual nerve (fifth nerve).		

C. EMBRYOLOGY AND COMPARATIVE ANATOMY.

The auricle is formed (at the end of the first month) from six auricular protuberances (three glenoid, three hyoid), which are formed in the neighborhood of the first pharyngeal cleft in the upper lower jaw and lower hyoid arch, and from a fold appearing behind it (free ear fold); the embryonic auricle shows the satyr point at the top, the Darwinian tip above and behind, the angular curve of the helix below and behind. The external auditory canal arises at the interior partition of the auricular pro-

FIG. 16.—Schematic development of the ear: 1, 2, 3, Glenoid auricular protuberance; 4, 5, 6, hyoid auricular protuberance; 7, *a*, *b*, *c*, free fold of the ear; 1, tragus; 2, crus helicis; 3, helix ascendens; 4, crus anthelicis inferiosus; 5, cymba conchæ; 6, antitragus; 7*a*, crus superiosus anthelicis and antihelix; 7*b*, helix; 7*c*, lobe; 8, Darwinian protuberance; 9, incisura intertragica; 10, triangular fossa; 11, scapha; 12, cavum conchæ.

tuberance, and from the gelatinous closing lamina of the pharyngeal cleft, the drumhead, which becomes attenuated later on. The labyrinth is formed (at the end of the first month) above the first pharyngeal cleft, beside the metencephalon, by segmentation of a hollow vesicle

with the labium tympani by means of the sulcus spiralis internus, which is covered with squamous epithelium. The labium tympani presents from 3000 to 4000 openings, the foramina nervina, in the habenula perforata (Waldeyer), which transmit the fibers of the cochlear nerve to the basilar membrane; the latter consists of radially striated fibers (the auditory fibers) that increase in width twelve-fold from the base to the top. The lamina basilaris, or zona tecta, near the limbus spiralis, supports Corti's organ (organum spirale). To the outer side of the organ the striped basilar membrane is denuded (zona pectinata). The under surface of the basilar membrane is covered by a loose layer of connective tissue (tympanic covering) containing veins (vas spirale). This layer of connective tissue is covered with endothelium, but the basilar membrane within the ductus cochlearis supports the highly specialized epithelium known as Corti's organ. Where it joins the sulcus spiralis internus, this is composed first of cylindric sustentacular cells, then of the inner ciliated hair-cell and Corti's arch (arcus spiralis). The latter is formed by the internal pillar of Corti, the concave head of which rests against the convex head of the external pillar. The corners of the tunnel are rounded out with sustentacular cells. To the outer side of Corti's arch are four (in the guinea-pig three) cylindric ciliated hair-cells, separated and supported by four club-shaped Deiters' cells; the spaces between the latter and the hair-cells form Nuël's space. The outer hair-cells and Deiters' cells are covered by a strip of cuticle, the membrana reticularis, through which the auditory hairs project. On the outer side Deiters' cells are joined by high cylindric transitional epithelium (external sustentacular cells of Hensen), and these by a lower variety (Claudius' cells), which finally merge into the epithelium of the zona pectinata and sulcus spiralis internus. A delicate membrane, the membrana tectoria, extends from the labium vestibulare and limbus spiralis as far as the outer hair-cells, covering over Corti's

organ. The medullated nerve-fibers of the cochlear nerve, covered with the sheath of Schwann, pass through the ganglion spirale, which consists of bipolar ganglion cells and an endothelial envelope containing many nuclei, and enter the lamina spiralis ossea and the limbus spiralis. In the latter structure they pass through the labium tegmentum as naked axis-cylinders, and join the inner hair-cells, some passing through Corti's tunnel to the outer hair-cells, around the base of which they form a basket-work.

VASCULAR AND NERVOUS SUPPLY OF THE ORGAN OF HEARING.

Part Supplied.		Vessel.	Course.
Auricle.	Helix, tragus, lobe.	Anterior auricular artery (superficial temporal).	In front of the ear.
	Greater part of the auricle.	Posterior auricular artery (external carotid), perforating branches. Veins empty into the superficial temporal and external jugular veins.	Posterior auricular fossa and through the cartilage.
External auditory canal.	Cartilaginous: Anterior wall.	Anterior auricular artery.	Entrance through junction of the cartilaginous and bony auditory canal.
	Cartilaginous: Posterior wall.	Posterior auricular artery.	
	Bony.	Deep auricular artery (internal maxillary).	
Drumhead.	Stratum cutaneum.	Arteria manubrii mallei (deep auricular).	Annulus tendineus and stratum cutaneum behind manubrium mallei. Radial anastomoses.
	Stratum mucosum.	Anterior tympanic artery (internal maxillary), perforating branches (anastomoses between stratum cutaneum and stratum mucosum).	Through Glaserian fissure and stratum cutaneum behind manubrium mallei. Radial anastomoses.
Eustachian tube.	Roof.	Branches of the middle meningeal artery (internal maxillary).	Petrosquamous fissure.
	Floor.	Basilar branch of ascending pharyngeal artery (external carotid) and Vidian artery (superior palatine).	
Mastoid process.	Mastoid cells.	Mastoid branches (stylomastoid artery).	From the Fallopian canal.
	Attic and antrum.	Branches of the middle meningeal artery. Veins empty into the posterior auricular vein and transverse sinus.	Petrosquamous fissure.
Tympanic cavity.	Anterior portion.	Caroticotympanic branch of external carotid artery.	Caroticotympanic canaliculi.

Part Supplied.		Vessel.	Course.
Tympanic cavity.	Anterior ligament of malleus.	Anterior tympanic artery (internal maxillary artery).	Glaserian fissure.
Tympanic cavity.	Posterior portion.	Posterior tympanic artery (stylomastoid).	Canal for chorda tympani.
	Stapedius muscle.	Stapedic (stylomastoid artery).	Pyramidal eminence.
	Stapes.	Branch to the stapes (stylomastoid artery). Anastomosis of stylomastoid artery with superficial petrosal branch.	From the Fallopian canal.
	Tensor tympani muscle.	Branch to tensor tympani (middle meningeal artery).	Spurious hiatus.
	Upper portion.	Superior tympanic artery (middle meningeal). Superficial petrosal branch (middle meningeal).	Roof of tubes.
	Lower portion.	Inferior tympanic artery (ascending pharyngeal).	Apertura superior canaliculi tympanici.
	Wall of promontory and endosteum of labyrinth.	Branches that communicate with branches of the internal auditory artery.	Vascular perforations in promontorial wall (Politzer).
		Veins empty into middle meningeal and deep auricular veins.	
Labyrinth.	Osseous semicircular canals.	Arteria subarcuata.	Fossa subarcuata.
	Capsule.	Internal auditory artery (basilar).	Porus acusticus internus.
	Membranous semicircular canals, utricle, and saccule, especially the cristæ and maculæ acusticæ.	Vestibular artery (internal auditory).	With vestibular nerve.
	Cochlear nerve, spiral ganglia, osseous spinal lamina, scala vestibuli, periosteum of walls of scalæ, spiral ligament.	Cochlear artery (internal auditory).	With cochlear nerve. Venous blood flows off in scala tympani (vas spirale).
	Utricle and saccule, cochlea.	Internal auditory vein.	Into inferior petrosal sinus
	Semicircular canals, utricle.	Vena aquæductus vestibuli.	Into transverse sinus.
	Cochlea.	Vena aquæductus cochleæ.	Into bulbar jugular vein.

pressure is diminished by swallowing with the mouth and nose held shut (Toynbee's experiment).

The rhythmic movements transmitted to the foot-plate of the stapes by the chain of ossicles are continued onward to the membranous labyrinth. The stapes (see Fig. 14, Plate 9) as it is forced inward displaces the incompressible perilymph and sets up a current that passes from the vestibule up the scala vestibuli and down over the apex of the cochlea, through the helicotrema, flowing down the scala tympani and causing the membrane over the fenestra cochleæ to bulge in the same degree as the stapes is forced inward. At the same time that the current flows through the scala vestibuli the yielding basilar membrane and cochlear duct that it supports are forced out against the scala tympani and rub against the auditory hairs of the hair-cells in Corti's membrane. The stimulus thus conveyed to the fibers of the auditory nerve is conducted for the most part to the temporal lobe of the opposite side, with the coöperation of association tracts in other portions of the cortex, as, for example, the visual sphere in the occipital lobe, when the stimulus is interpreted as a sound perception (Gad).

The fibers of the basilar membrane, according to Helmholtz, represent a series of strings of different pitch, and every nerve-fiber that terminates on the basilar membrane produces a special note. Thus when the note C is produced, only that portion of the basilar membrane intended for the production of the tone C bulges and is thrown into vibration. Corresponding to the varying lengths of the basilar fibers the highest tones are produced by vibrations in the first turn; the deepest, in the apex of the cochlea. When a complex tone is produced, as many different portions of the basilar membrane as there are components in the sound are thrown into vibration; hence a practised ear is able to analyze a sound. If, for instance, the vowel *e* is sounded, the fibers b^3, f^1 (b), which are tuned to produce its component parts, are chiefly thrown into vibration. Sounds of from 16,000 to 50,000 vibrations fall within the limit of hearing (C_{II} to e^8). From D_I to h^4 constitute the musical range. Human speech lies between C_{II} (sound of R) and c^5 (sound of S). The ability to hear a tone depends on two factors: vibration of the corresponding fiber of the basilar membrane and irritability of the corresponding nerve-fiber. If, for instance, the fibers b^3, f^1, b, have been destroyed by some morbid process, the vowel sound

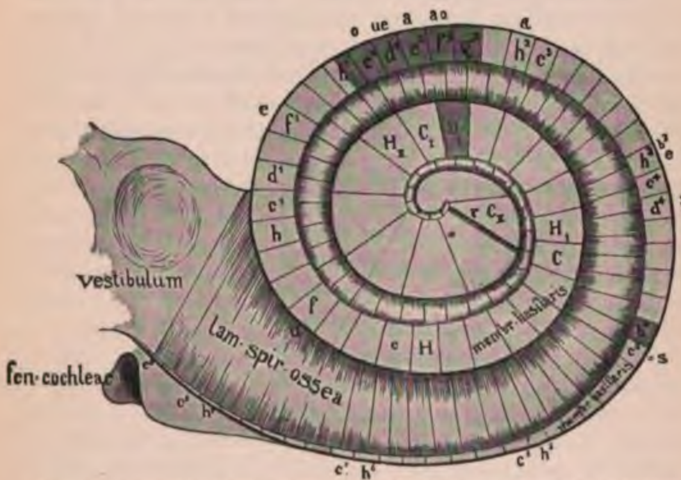

FIG. 18.—Normal auditory image in the basilar membrane (Helmholtz's hypothesis): Scale of musical tones from D^I to h^4. Scale necessary for speech perception, b^1 to g^2.*

e cannot be heard. Speech perception is possible even after extensive destruction of the basilar membrane, providing the range from b^1 to g^2 is capable of function (Bezold).

The irritability of the auditory nerve is subject to periodic variations, and when listening intently we note

* h in the German scale is equivalent to b English; b in the German scale is equivalent to b-flat English.

an alternate increase and decrease in the sounds. Once the auditory nerve has been excited, perception is at first intensified, but soon becomes fatigued if the irritation is continued for any length of time. Visual impressions (seeing colors), twitching of the ears, vertigo, and starting of the whole body may be produced reflexly through the auditory nerve. The subjective auditory sphere in binaural hearing lies in the head (Urbantschitsch). Irritation of one ear increases the perceptive power of the other. The maculæ and cristæ acusticæ are not affected by sound, but are by movements of the body, especially of the head, the movements being transmitted to the endolymph, which displaces either the otolith membrane on the hair-cells of the maculæ acusticæ, or the cupola of the cristæ acusticæ. The stimulus is then conducted through the vestibular nerve to the cerebellum, where, with the coöperation of the visual and tactile senses, the equilibrium is regulated by reflex alternations in the innervation of the muscles, and the position of the head is ascertained. Rectilinear movements are regulated by the maculæ acusticæ; rotary movements, by the cristæ acusticæ (Mach, Breuer).

Ordinarily the maintenance of equilibrium is an unconscious act and we become aware of it only when, owing to some disturbance, the cristæ and maculæ acusticæ are irritated. Thus, lesion of the external semicircular canal is followed by pendulum movements of the head from side to side; in lesion of the superior canal the head moves backward and forward and tends to fall forward. In lesion of the posterior canal there are nodding movements and the head tends to fall backward (Flourens). If a stimulus ordinarily produced only by movement of the head excites the apparatus of equilibration without the head having moved, the false interpretation of the position of the head leads to vertigo and staggering gait. When a stimulus continues to act for a long time, as in protracted rotary movements, vertigo likewise results.

The vestibular apparatus is also connected by reflex paths with the visual centers, so that irritation of the apparatus—as, for instance, in long-continued rotary movements—is followed by movements of the eyes. Irritation of the external semicircular canal is followed by horizontal nystagmus; of the posterior canal, by vertigo; of the superior canal, by diverging nystagmus (Cyon). If the vestibular apparatus is completely destroyed, the possibility of such stimulation is lost. In deaf-mutes, in whom the semicircular canals are often absent, rotary movements about the axis of the body not infrequently produce neither vertigo nor nystagmus. The vestibular apparatus of the two ears are entirely equivalent, so that one can replace the other. If both are completely destroyed, the equilibrium is regulated by means of the visual and tactile senses (Gad).

III. EXAMINATION.

THE object of the aural surgeon is the prevention, cure, or amelioration of diseases of the organ of hearing. Hence proper treatment can be instituted only after making the diagnosis. The diagnosis is based on the patient's statement (anamnesis) and the data obtained by examination.

Ordinary data, such as name, age, and social condition, may be obtained during the examination. Childhood and work in the open-air predispose to inflammatory disease of the internal ear; old age and occupation amid noisy surroundings (boiler-makers) predispose to diseases of the auditory nerve.

The **duration and course** of the aural trouble are next inquired into. The prognosis is more favorable if the aural disease is recent and the deafness sudden than when the onset has been insidious. In chronic conditions incorrect statements are often obtained, because the disease began during childhood, or because it did not at first give rise to any subjective disturbances. Much may be learned by inquiring what the patient's power of hearing was at school, or when he was in the army, etc.

The **causes** of the disease are next inquired into. The prognosis is more favorable in simple otitis media—such as follows a cold, for instance—than after general diseases, such as scarlet fever or tuberculosis; it is better in deafness following the use of drugs, such as salicylic acid and quinin, and intoxications, as by phosphorus, than in deafness due to injury or exposure to an intense sound impression, such as an explosion. Again, the prognosis is better in deafness due to nasal obstruction (mouth-breathing, dryness of the mouth on awakening, snoring, inattention at school) than in deafness following general diseases, such as tabes and lues, or in hereditary deafness either directly inherited from the parent or occurring in the third generation (atavism). Often the patient has himself brought on the disease by the use of a syringe, by scratching or inserting foreign bodies into the ear, or by too frequent recourse to Valsalva's experiment. Not infrequently, especially in cases of progressive deafness, no cause at all or a very inadequate cause is elicited.

The **subjective symptoms,** as related by the patient, are of some significance. Deafness is complained of in most diseases of the middle and internal ear. In chronic catarrh the patient says he hears better in a noise (paracusis Willisii); many patients complain of continuous or intermittent noises, either high-pitched or low-pitched, and buzzing in the ear or head. In cardiac disease pulsating sensations are complained of. Constant tinnitus affects the prognosis unfavorably. Pain occurs in acute inflammations (excepting tuberculosis); in caries with intense subjective noises; neuralgic pains in caries of the teeth; ulcers of the throat and larynx; and in diseases of the fifth nerve. Pain and tinnitus may be so severe as to produce insomnia. A sense of fulness and pressure in the ears, tightness of the head, vibration of the voice in the ear, vertigo, nausea, and vomiting are frequent symptoms. Aural discharge often occurs in patients who complain only of deafness; occasionally the ear emits a foul odor, and there is a bad taste in the mouth accompanying the fetid discharge from the ear. Information that may assist the surgeon to interpret what he finds in the ear may be obtained by inquiring when and for how long a time the patient has been treated, what has been the nature of the treatment, and what success has attended it.

Present Condition.—An idea of the general condition is obtained from the history. If there is any question of operation, the strength of the patient is observed. If the patient is in bed, the attitude, color of the skin (jaundice and pyemia), appearance of the face (peculiar vacant expression in deaf persons), hippocratic facies (tumor of the brain), facial palsy (caries), the fact that he keeps his mouth open (nasal obstruction), are all points to be carefully considered. Special signs are scars at the angle of the lower jaw in scrofulous children, slowing of the pulse, aphasia (brain abscess), ocular palsies, delirium, vomiting (meningitis), collapse, sweating, vertigo, staggering gait (inflammation of the labyrinth and cerebellar abscess), chills (pyemia). Even before making a general examination of the body the aural surgeon determines the condition of the organ of hearing.

1. Inspection.—By inspection we recognize disease of the pinna and adjacent portions, variations in form and color, such as malformations, inflammations, and tumors. In suppurative otitis media, pus and polypi may be seen in the auditory meatus. In disease of the bone, fistulæ will appear in the vicinity of the ear. Scars and remains of fistulæ on the mastoid process point to spontaneous rupture or a former operation. Anomalies in the position of the pinnæ are recognized by examining the head from the side, from in front, and from behind, and especially by comparing the two ears. Subperiosteal abscess of the mastoid process forces the upper portion of the pinnæ outward and displaces the entire organ downward, obliterating the postauricular groove. This is not to be confounded with edema from external otitis, nor with prominent ears—so-called "cat-ears." In Bezold's variety of mastoiditis the lower portion of the pinna is forced outward and there is simultaneous swelling of the neck.

2. Palpation.—The data obtained by inspection are confirmed by palpation. By carefully palpating a tumor we distinguish between a neoplasm and fluctuation, between edema (otitis externa) and infiltration (mastoiditis). The false fluctuation of the soft parts and the emphysematous crackling in pneumatocele of the mastoid process can be determined. The presence of glandular swelling in front of the tragus (otitis externa), on the mastoid process, and in the parotid gland (otitis media) is detected. The sensitiveness of the parts is ascertained by pressure on the tragus, tip of the mastoid, mastoid fossa (otitis media), and by pulling the ear (otitis externa).

3. Otoscopy.—Since the light that directly enters the auditory meatus does not suffice to illuminate the canal and the drumhead, we use a stronger source of light, such as a small electric lamp, which may either be attached to the forehead (Fig. 19) or held in the hand (Fig. 20). To examine the deeper portions of the ear, however, it is better to use reflected light (von Troltsch).

Fig. 19.—Electroscope (after Kuttner).

Fig. 20.—Lamp used in trans-illumination (after Heryng).

This is accomplished by means of a concave mirror, about 15 cm. in diameter, with a focal distance of 15 cm. (Fig. 21), and provided with a central opening. The reflector is held in the hand or between the teeth, or attached to the forehead by means of an elastic band and a ball-and-socket joint so as to permit free motion in any direction. The light may be bright sunlight, when a plane mirror should be used (Lucæ), or artificial light, such as a candle, an oil lamp, an electric light, or a Welsbach gaslight. An earthenware or asbestos-lined chimney, provided with an opening, may be placed over the glass chimney to protect both patient and surgeon from the heat, and to reinforce the light. Both patient and surgeon should be seated. The ear under examination is turned away from the source of light and faces toward the surgeon. The light should be placed at the level of the ear, to the right and somewhat behind the patient's head. The patient turns his head sideways toward the light, so that the rays of light impinge on the mirror at an angle of 45 degrees. With the right hand the mirror is held close to the examining eye, in contact with forehead and nose. The surgeon looks through the opening in the center. After throwing the light on the pinna and external auditory

FIG. 21.—Head mirror (after Hartmann).

FIG. 22.—Reflector with mouth-plate (after Lucæ).

meatus, the canal is first examined without a speculum by seizing the pinna between the index- and middle fingers of the left hand, and drawing it upward and backward; in children, up to the second year, downward and backward. We note the color and condition of the skin, the width and contents of the auditory meatus, furuncles, polypi, and, in recent inflammations, the presence or absence of pulsating pus. If the canal is wide and poorly supplied with hair, it is often possible to obtain a view of the drumhead without a speculum, especially if the patient is told to open the mouth and the tragus is bent over forward. The normal color of the pinna and auditory meatus is a pale pink. The integument of the auditory canal is shiny, and often covered with brownish masses and shreds of epidermis. In the bony portion of the meatus the skin is smooth and somewhat yellowish. As a rule, however, the presence of hairs at the meatus, epithelial scales, and cerumen in the canal, and the close apposition of the cartilaginous walls make it impossible to obtain a view of the deeper portions. We, therefore, use the aural speculum to overcome these obstacles and dilate the cartilaginous portion of the canal.

The speculum consists of a cylindric (Fig. 23) or conic (Fig. 24) tube, made either of hard rubber, which is

FIG. 23.—Aural speculum (after Politzer).

FIG. 24.—Aural speculum (after Lucæ).

appropriate for the introduction of medicaments, or of metal, which has the advantage of being easily sterilized by boiling. Four sizes are generally used. Before introducing the speculum the external meatus must be carefully illuminated and examined without a speculum, after which the pinna must be seized between the index- and middle fingers of the left hand and drawn upward and backward, while the speculum, held between the thumb and index-finger of the right hand, is carefully introduced by a rotary motion into the cartilaginous portion of the meatus. If the speculum is introduced without first illuminating the canal, unnecessary pain is often inflicted, and morbid conditions, such as furuncles, for instance, may be overlooked. The introduction of the speculum is painless, although it occasionally excites cough, rarely vomiting and syncope, by irritating the auricular branch of the pneumogastric. Bringing the speculum forcibly against the bony margin of the auditory canal gives rise to pain and produces excoriations. The largest speculum that can be introduced is selected; a fresh one should always be used for each patient, otherwise an opportunity may be afforded for observing an epidemic of otitis externa. The speculum is held in place with the thumb and index-finger of the left hand, the pinna being at the same time steadied with the middle and the index-finger of the same hand, leaving the right one free to handle the instruments. The examiner should bring his eye as closely as possible to the patient's ear. If he is myopic or hyperopic, he uses his ordinary glasses or a correcting lens attached behind the central opening of the mirror. The light reflected into the auditory meatus through the speculum produces a bright illumination of the deeper portions of the meatus and drumhead. The extent of the illuminated and visible portion depends on the width of the canal and the degree of convexity of the inferior and anterior walls. If the floor of the canal, for instance, has a strong convexity, it will be impossible to see the antero-inferior half of the drumhead, as it is impossible to dilate the bony portion of the meatus with the speculum. The deepest portion of the meatus cannot always be seen, and foreign bodies contained in it may, therefore, escape the surgeon's eye.

As it is possible to see only as much of the drumhead as corresponds to the lumen of the speculum, the different portions of the meatus and drumhead must be brought into view by successively lifting, depressing, and moving the speculum from side to side. The posterosuperior wall of the meatus, which is often the seat of fistulæ, has a uniform pale white color; it is often the first thing seen on introducing the speculum, and must never be mistaken for the drumhead. The drumhead occupies the antero-inferior portion of the canal, and under normal conditions presents a peculiar color and certain characteristic details. If the introduction of the speculum does not suffice to displace the scales of epidermis or cerumen contained in the meatus, but, as occasionally happens, merely scrapes them away from the walls, so that they

FIG. 25.—Aural forceps (after Politzer).

FIG. 26.—Foreign body forceps (after Hartmann).

obstruct the lumen and thus prevent a good view of the drumhead, then the surgeon must first proceed to cleanse the canal. This is done by syringing, or, if the operator possesses the necessary skill, by scraping with an ear curet, with a pair of forceps bent at an obtuse angle (Fig. 25), or with the ear forceps (Fig. 26), always under illumination. These instruments must be so constructed that they can be opened within the smallest speculum. Syringing is the safest plan. It is done with a large aseptic piston syringe (Trautmann) or an india-rubber aural syringe with a glass tube that can be removed and sterilized by boiling (Fig. 27). A specially devised glass vessel (Fig. 28) or a kidney basin is held under the ear to catch the water. The ear is drawn backward and upward, and the point of the syringe applied—not too deeply—to the posterosuperior wall of the meatus, whereupon the stream of water will flow horizontally along the roof of the canal to the ear-drum, thence downward into the deepest portion of the meatus, so that the return current will wash out the obstacle. Very little pressure

Fig. 27.—Aural syringe.

Fig. 28.—Hartmann's ear-glass.

Fig. 29.—Cotton applicator (Hartmann).

should be used at first. Water at 28° C. (95° F.), sterilized by boiling, is used. If the pressure is too great or cold water is used, vertigo, tinnitus, or syncope may result. If the drumhead is perforated, the water may run into the throat. Instrumental removal of obstacles in the external auditory canal should be attempted by experts only, as much damage may result from unskilful manipulation. Sterile water should always be used, since, if a perforation is present,—as, for instance, after an explosion,—it may be covered up with cerumen, and irrigation with non-sterilized water might infect the tympanum. Before introducing the syringe it should be held with the bulb up so as to remove any air-bubbles contained in the water. After the irrigation is completed the pinna should be dried with cotton. The auditory meatus is wiped out with a cotton-wound applicator (Fig. 29) by moving it up and down and from right to left. Rotary movements within the auditory canal are unpleasant to the patient. After the passage has been cleared in this way, the funnel-shaped, retracted drumhead is seen in the antero-inferior portion of the meatus. It presents the following landmarks (Plate 38):

(1) Above and in front (in the right ear to the right, in the left ear to the left) is a yellowish prominence, the short process of the malleus; (2) from this point the handle of the malleus extends backward and downward as a yellowish-white streak; (3) the handle ends a little below the middle of the drumhead, at a point where the membrane is retracted—the umbo; (4) in front of and below the umbo is a triangular cone of light, the apex corresponding with the umbo. This cone of light extends nearly to the periphery of the drumhead, and is sometimes divided longitudinally or interrupted at the center. In front of and above the short process of the malleus lies the somewhat depressed Shrapnell's membrane, bounded below by the anterior and inferior folds; it contains the superior fold (Fig. 6). By the help of these landmarks the drumhead is readily divided into anterosuperior, posterosuperior, antero-inferior, and postero-inferior quadrants. The drumhead presents for observation the following characteristics:

(*a*) **Color and Transparency.**—The color is complex, being a mixture of the grayish color of the membrane itself, and, owing to its transparency, of the color of the tympanic structures or wall of the promontory. The normal color of the drumhead is grayish, a little darker in the anterior than in the posterior half. In children and aged individuals the color is a yellowish white.

The annulus tendineus forms a whitish streak most conspicuous in the posterosuperior quadrant. Changes in the color of the drumhead may be produced by changes in the membrane itself, as in inflammation, or by changes in the color of the contents of the cavity, which becomes yellowish in the presence of a yellow exudate or of the color of the wall of the promontory (reddening). The introduction of the ear speculum often produces congestion of the handle of the malleus, owing to irritation of the artery of the external auditory meatus.

The normal contents of the tympanic cavity may sometimes be seen through the transparent membrane. Thus the long process of the incus, the stapes, the pouches of Trölt, the chorda tympani, and the margin of the fenestra rotunda may be visible (Fig. 6). When, owing to a scar in the posterosuperior quadrant, for instance, the ear-drum is thinner than normal, the incudostapedial articulation is sometimes so plainly seen that it appears to be uncovered (Plate 39, 23). When the membrane is perforated, the various structures of the tympanic cavity complicate the image. In total absence of the drumhead the wall of the promontory appears (Plate 39, 7) and, when the bone in the osseous portion is defective, the attic may be seen (Plate 39, 15). The normal transparency of the drumhead may be impaired by thickening of the membrane, calcareous deposits, maceration of the epidermis, or infiltration (Plate 38, 9). An opacity around the umbo is normal.

(*b*) **Luster, Inclination, and Convexity.**—The covering of fat that the drumhead receives from the ceruminous glands gives its surfaces a glistening appearance. In the living subject the membrane presents a light reflex which, owing to the funnel shape of the ear-drum and the convexity of the antero-inferior quadrant, appears triangular (Trautmann, Politzer); in addition there is often a reflex in front and below, in the tympanic sulcus (Bezold) and in Shrapnell's membrane (Plate 39). The triangular reflex depends on the inclination of the antero-inferior quadrant of the ear-drum. In retraction or in bulging of the membrane the reflex becomes divided, punctiform, and recedes from the umbo (Plate 38, 8). The concavity of the ear-drum may be altered by the presence of scars that cause retraction, or by exudates in the tympanic cavity that cause the membrane to bulge. Retraction of the drumhead causes a marked prominence of the process of the malleus in the posterosuperior quadrant (sometimes also in the anterosuperior quadrant), producing a fold known as the posterior fold (Plate 38, 8). The extremity of the handle of the malleus, which is directed inward, often comes in contact with the promontory; the handle is then fore-

FIG. 30.—Pneumatic ear-funnel.

shortened so that the umbo appears to lie immediately below the short process. Accordingly the lower half of the drumhead appears larger than the upper, the posterior half smaller than the anterior.

The mobility of the ear-drum is tested by means of Siegle's pneumatic funnel, which consists of an aural speculum occluded by an obliquely placed glass disc (Fig. 30). The space below the glass disc (*a*) communicates with a rubber ball, by means of which the pressure may be altered at will. Since the ear-drum is movable, alternate compression and relaxation of the rubber ball, providing the funnel fits tightly into the external meatus, will cause the membrane to move to and fro. The largest excursion normally occurs in the posterior half of the drumhead, at the extremity of the manubrium, and is accompanied by shortening of the light reflex and injection of the manubrial vessels. The mobility is impaired when the membrane is thickened, and entirely lost whenever there are adhesions. In places where the membrane is thin (scars), the mobility is increased; in large perforations movement is absent. If there is pus, it may be aspirated when the air is exhausted, when it is important to observe from what part of the tympanic cavity the pus is obtained. Owing to the pallor of the tympanic mucous membrane aspiration will bring into view hyperemic blood-vessels. If it is desired to magnify the image of the drumhead, a biconvex lens is inserted into the Siegle speculum instead of the glass disc.

In extensive defects of the drumhead a simple metal mirror attached to a handle can be introduced into the tympanic cavity and thus a view of the roof, the region of the antrum, and any adhesions that may be present can be obtained (intratympanal otoscopy) (von Tröltsch, Botey, Bing).

4. **Probing.**—The results of inspection need to be confirmed and supplemented by means of the probe. In probing, either a straight instrument (Fig. 31) or one bent in two places, as shown in Fig. 32, is used. The patient's head should be carefully steadied, and the operator should always use a head mirror. Unskilful tympanic probing may lead to irreparable injury and should be manipulated by well-trained hands only. By means of the probe we distinguish between the soft tympanic membrane and the hard wall of the promontory; between a furuncle, an exostosis, and a polyp; between a perforation and an exudate. By its aid we determine the hardness of the mass of cerumen, the nature of a foreign body, find the base of a polyp, test the sensitiveness of the auditory meatus and drumhead, or discover the painful points in neuralgia.

5. Percussion.—In disease of the mastoid process deep percussion of that structure with the finger may reveal a change in the note on the two sides, besides showing increased sensitiveness, provided there is no change in the soft parts. Normally, the sound is tympanitic; a flat note indicates necrosis of the bone (Körner).

6. Transillumination by means of Röntgen rays reveals ossified areas in the pinnæ, fractures in the squamous portion of the bone, the presence of bullets, knife-points, or other foreign bodies in the mastoid process or

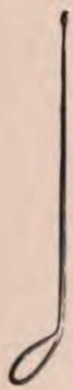

FIG. 31.—Silver probe (after Stacke).

FIG. 32.—Copper probe (after Hartmann).

in the pyramid. Transillumination of the mastoid process is unsafe. An electric lamp, as shown in Fig. 20, is applied to the mastoid process while an aural speculum is introduced into the ear. In a dark chamber a reddish reflex is seen in the speculum when the mastoid is normal; it is absent in necrosis (Urbantschitsch) (of no significance unless careful comparison is made with the other ear and it occurs in the course of treatment).

7. Functional Tests.—In any form of deafness the patient must be subjected to a functional examination.

This, in the absence of otoscopic findings, assists in determining the degree of deafness and its seat. Most patients complain of inability to understand spoken words. Quite often the deafness is at once shown, by an otoscopic examination, to be due to a plug of cerumen. But even after this is removed and when the drumhead is quite normal, the deafness may persist—if, for instance, the auditory nerve is diseased. It is therefore necessary in every case to test the power of hearing for whispered speech before proceeding with treatment, so as to have some means of determining whether the patient is improving or losing ground after treatment has been begun.

(*a*) The hearing should always be tested for *whispered conversation*, such as is produced by the residual air after a deep expiration (Hartmann), since loud speaking can be heard even when the ears are closed. As words are composed of sonorous vowels and practically silent consonants,—that is to say, of high and deep tones,—the distance at which they can be heard varies even in a normal ear. The average distance at which whispered words can be heard by a normal ear is about 6 m. The patient is told to stand as far away as possible and turn the ear to be examined toward the operator, holding the other ear closed with the finger. The patient should not see the movements of the mouth. Each ear is tested separately. If the patient hears everything that is said in a whisper at a distance of 6 m., we may exclude marked disturbance of the hearing. The words must be carefully chosen, since many patients—such, for instance, as those suffering with nervous deafness—cannot understand high-pitched tones nor words composed of high-pitched tones as readily as low-pitched tones; whereas other patients—such, for instance, as those suffering from disease of the conduction apparatus—have greater difficulty in understanding low-pitched tones or words formed from them, than high-pitched tones. For high tones, such words as twenty, thirty, six, sixty, seven, sister, Swiss, ice, fleece, sense, hissing, etc., may be used; for low-pitched tones, such words as five, one hundred, Robert, brother, organ, to-morrow, pump, doctor, wound, hound, etc., are appropriate (Bloch). The patient should repeat every word that he understands. If he does not understand the word, it should be repeated at a shorter distance until all the words belonging to one category are understood. When a word has been heard once, it may later be understood at a greater distance as the patient learns to combine the vowels he has heard. Hence repeated tests should be made, changing the words and the order in which they are given so as to obtain trustworthy results. If whispered speech cannot be heard at all, the hearing for ordinary conversational tones is tested. If this also fails, the power of hearing single sounds pronounced in a loud voice is tested. If the deafness is confined to one ear and the diseased ear is tested by speaking in a loud voice, the patient may repeat the words, although he has really heard nothing with the diseased ear, since loud tones may be heard by a normal ear even when it is tightly covered. To determine, therefore, whether the patient hears with the diseased ear he must be asked to close the latter also, whereupon he should no longer be able to repeat the words correctly (Dennert). The results of the functional test with whispered conversation will suggest the diagnosis. Inability to hear high-pitched words indicates nervous deafness, whereas inability to hear low-pitched words points to disease of the conduction apparatus. If the patient is unable to hear whispered speech at 6 m., the power of hearing—

(β) The *ticking of a watch* is tested. The watch is first held at a considerable distance and gradually brought nearer the patient's ear until he hears it. After air-conduction has been tested, the bone-conduction is determined by placing the watch against the mastoid process or on top of the head and observing the result. After the sixtieth year and in nervous deafness bone-conduction is usually absent; in disease of the conduction apparatus it is usually present in the diseased ear.

(γ) The *acoumeter*. As the vocal organs, as well as the watches of different examiners, vary in strength and pitch, and the results obtained differ accordingly, Politzer has constructed an instrument (Fig. 33) consisting of a small steel hammer that falls on a wooden block from a constant height and with constant force. The noise that it produces has a pitch of c^2, and can be heard by air-conduction at a distance of 15 m. Bone-conduction may be tested by means of a small steel rod held against the mastoid process. As, however, the human auditory apparatus is accommodated to a great number of tones, it is impossible to construct an absolutely uniform acoumeter (see Fig. 18).

FIG. 33.—Politzer's acoumeter.

(δ) *Tuning fork.* "The ability to hear a simple tone of a certain pitch appears to represent the sensory unit of the sense of hearing" (Gad). A tone of this kind is produced by the tuning-fork. The overtones are subdued by means of clamps (Fig. 34, Politzer). To obtain an accurate knowledge of the power of hearing it must be tested for all the notes for which it is accommodated. Bezold's series contains all simple tones from C_{II} to e^8 (?). These tones are produced by tuning-forks without overtones and by whistles. In very accurate work, as in deaf-mutism and aphasia, the entire series of notes must be tested. In ordinary cases of deafness it suffices to test for notes an octave apart, as, for instance, C_{II}, C, c^1, c^2, c^3, c^4, or for the series b^1 to g^2, which, according to Bezold, is most important for understanding ordinary speech. In testing with the tuning-fork

FIG. 34.—Tuning-fork C.

the same force should be used in striking the instrument against the table, and the fork should be held at the same distance from the ear, the two limbs in the direction of the axis of the meatus. The examiner determines whether the note is heard; if so, for how many seconds; the shortening of the time of perception; gaps in the scale; mistaking one note for another in disease of the nervous apparatus. Tuning-forks up to the twice accented octave may be used both for air- and for bone-conduction; above that octave the notes are too loud to be of any use for testing bone-conduction alone. The upper tone limit (notes from a^2 to e^8 (?) and over) is determined by the Galton-Edelmann whistle (Fig. 35). In performing the test the whistle is held in front of the ear with the mouth-piece directed outward so that the patient does not feel the current of air. In very deaf persons the sensation of feeling the vibration of low-pitched tuning-forks may deceive the patient into believing that he hears the note. The upper tone limit is lowered in nervous deafness.

By means of the tuning-fork bone-conduction is also tested and compared with air-conduction.

(ε) *Rinne's Experiment.*—If, after the sound of a tuning-fork held against the mastoid process with uniform force and on the same spot (mastoid fossa) has ceased to be heard, the vibrating ends of the fork are held in front of the ear or introduced into a rubber tube inserted into the ear, the sound will again be heard if the ear is normal; that is to say, owing to our habit of hearing by air-conduction, bone-conduction is normally less than air-conduction (positive result of Rinne's experiment, or positive Rinne). For air-conduction to be greater than bone-conduction, especially for low-pitched notes, the tension of the sound-conducting apparatus must be normal. The greater the tension, the less will be the air-conduction and the better the bone-conduction. Hence, in diseases of the sound-conduction apparatus,—as, for instance, in retraction of the drumhead,—in perforation, in ankylosis of the stapes, the tuning-fork is heard longer than normally on the mastoid process, usually even longer than through the air (negative Rinne). In some cases the tuning-fork may be heard exclusively by bone-conduction (absolutely negative Rinne). Rinne's experiment also indicates the degree of disturbance in the sound-conduction apparatus, since a negative Rinne high up in the scale (c^2) indicates grave obstruction to the sound-conduction apparatus ; in minor disease of the sound-conduction apparatus it will be negative only for low-pitched notes, or even remain positive, though the time of perception by bone-conduction is longer than normal. Thus Rinne must be negative for C_I and C, and positive for c (Rinne partially negative to c exclusive, for instance, in acute catarrh) ; on the other hand, in grave obstruction of the sound-conduction apparatus, as in ankylosis of the stapes, Rinne is usually absolutely negative—that is to say, negative for C_{II}, C, and negative for c, c^1, c^2.

FIG. 35.—Galton-Edelmann's whistle.

That the fibers of the basilar membrane are capable of vibrating for C_I and C when Rinne is absolutely negative for C_I and C, although these notes are not heard through the air, is proved by the fact that the C_I and C fibers can be stimulated through the bone. When a positive Rinne has been obtained, it is not necessary to continue the test for higher notes ; in such cases Rinne is never negative for a higher note, though for deeper notes the test may show a negative Rinne. In some deaf persons

Rinne is positive for the lowest tuning-fork, as in normal individuals; in this case the seat of the disease is to be sought not in the sound-conduction, but in the nervous apparatus.

(ζ) *Weber's Experiment.*— After the Rinne test the tuning-fork should be placed on the vertex. In normal individuals the sound vibrations are transmitted from that point evenly through both ears (see Fig. 17), as may be demonstrated by auscultation of the ear under examination by means of an otoscope. If, owing to disease of the auditory nerve, perception is absent on one side, the sound is not heard in both ears or in the head as under normal conditions, but solely in the sound ear (Weber in the sound ear). If, on the other hand, owing to obstruction in the sound-conducting apparatus,—as, for instance, in obstruction of the ear by the tip of the finger or by a plug of wax, or in middle-ear suppuration, —the flow is interrupted on one side, the sound-waves are reflected on that side back to the interior of the head and reinforced so that the sound is heard better in the affected ear (Weber in the affected ear).

(η) *Schwabach's Experiment.*— A normal individual continues to hear the sound of a tuning-fork for a certain length of time when it is placed on the vertex,—C, for instance,—for twenty-six seconds. If there is any obstruction to the sound-conduction apparatus, causing a delay in the flow of the sound-waves, the tuning-fork is heard longer than under normal conditions (forty seconds, for instance, Schwabach prolonged). In affections of the labyrinth, on the other hand, the fork is not heard so long as under normal conditions, owing to impairment of the auditory nerve. It may be heard for only ten seconds (Schwabach shortened).

(δ) *Gellé's Experiment.*—The mobility of the foot-plate of the stapes is tested by means of Gellé's experiment (Bloch). If a rubber tube 5 cm. in length is attached to a Politzer bag and introduced into the auditory meatus with air-tight precautions, the conducting power of the ear-drum and chain of ossicles can be diminished by compressing the bag and thus raising the pressure within the auditory meatus, providing the chain of ossicles, particularly the foot-plate of the stapes, is movable. The momentary increase in intra-labyrinthine pressure thus produced at once becomes neutralized and is not responsible for the weakening of the sound; but when the vestibular apparatus is irritable, vertigo and tinnitus may be produced. If a tuning-fork, c^1, for instance, is placed on the side of the head to be examined, the sound heard in the corresponding ear, providing the mobility of the base of the stapes is normal, is at once diminished when the bag is compressed (Gellé positive). If, on the other hand, the base of the stapes is immovable, as in ankylosis, the intensity of the sound is not affected by compressing the bag (Gellé negative). It follows that when Rinne is positive for C, Gellé is also positive—under normal conditions and in nervous deafness. If Rinne is partially negative up to c, we determine by means of Gellé's experiment whether the deafness is due to immobility of the stapes or to some other cause.

To obtain a general idea of the degree of deafness and its seat without too much loss of time it is enough to test the hearing for whispered conversation and to determine Rinne, Weber, and Schwabach for C and c^1. To obtain trustworthy results the hearing test must frequently be repeated and all the results obtained carefully compared. Sources of error, such as self-deception on the part of the patient, errors in striking the tuning-fork, etc., must be eliminated. Deafness is often due not to an isolated disease of the middle ear or of the labyrinth, but to a combination of diseases that modify the results obtained with the tuning-fork according as the disease is more pronounced in one region than in another, without, however, destroying their value altogether. If the tests have been carried out accurately and the results are carefully compared, the latter, even though they may at first appear to be contradictory, can always be brought into harmony and will eventually lead to a diagnosis.

(ι) The *irritability of the auditory nerve* may be tested with a fair degree of accuracy by the galvanic current. The anode (positive pole) is placed in front of the tragus, and the cathode (negative pole) in the nape of the neck (external method, Erb). With a current of 6 milliampères and over (Pollak) an intense auditory sensation, consisting of ringing and whistling sounds, is produced by cathodal closure, and a weaker one by anodal opening. In cathodal opening, while the current is passing, and during anodal closure nothing is heard (Brenner). In inflammatory conditions of the auditory nerve irritability is increased so that auditory sensations are produced by currents from 1 to 3 milliampères in strength (Gradenigo). In paralysis of the auditory nerve irritability is lost entirely. If the vestibular apparatus is irritated during the examination, electric vertigo may occur.

(κ) *Testing the Equilibrium* (von Stein).—When vertigo is complained of, the power of maintaining the equilibrium is tested by asking the patient to perform certain movements. The eyes are closed, if necessary by means of a bandage, and the patient is asked to bend over and suddenly resume the erect position (Romberg), or to stand first on one leg and then on the other, to jump, or to move backward and forward in a straight line and suddenly turn around, the examiner observing any deviations from the normal, such as swaying, dizziness, tendency to vomit, falling toward the diseased side, or nystagmus. The latter symptom may be absent after rotary movements, especially in deaf-mutes.

(λ) *Anterior and Posterior Rhinoscopy; Digital Examination.*—Before Politzer's experiment is performed the nose must be examined carefully to determine whether there is any obstruction that might interfere with the test for the permeability of the Eustachian tube. The nose, like the ear, may be illuminated by means of a concave mirror perforated at the center, or directly by means of an electric lamp attached to the forehead. To increase the field of vision we use a dilatable nasal speculum (Figs. 36, 37), which is carefully introduced into the vestibule of the nose and pressed against the ala. Care must be exercised not to impinge on the septum or on a possible deviation. The septum appears in the median line, laterally from this the inferior, and unless it is very much congested, the middle turbinate, with the nasal passages between the two. In widely open noses the glistening posterior wall of the pharynx, which moves

FIG. 36.—Nasal speculum (after Fränkel).

FIG. 37.—Nasal speculum (after Hartmann).

during phonation, may be seen at the posterior extremity of the inferior nasal meatus. Occasionally a cleft—the pharyngeal opening of the tube—may be discerned immediately above the floor of the nose, at the level of the posterior extremity of the inferior turbinate. It is bounded by the posterior Eustachian fold and a lesser inferior fold corresponding to the levator palati muscle. During deglutition and phonation the Eustachian fold moves backward and toward the median line with lightning-like rapidity (see Figs. 39, 40), exposing the descending salpingopharyngeal fold. The levator palati becomes thicker and forces the lips of the tube apart. Within the nose the examiner notes the presence of deviations, spines, and ridges on the septum, atrophy and hypertrophy of the turbinates, polypi, pus in the nasal passages, and its exact location (ozena, atrophy, fetid odor, crust formation), conditions that are all fruitful causes of aural affections. The posterior portions of the nose are examined through the mouth with as large a laryngeal mirror as practicable (Fig. 38). If the structures are very irritable, they should first be anesthetized with a 10 per cent. cocain solution. Within the mouth we observe the teeth (caries, abnormalities of growth), the gums (lead line), the tongue, the hard palate (ulcers, the width of the arch), the soft palate (adhesions, oblique position), the tonsils (hypertrophy), and the posterior wall of the pharynx (adenoid vegetations, scars). The tongue is held out of the way with a spatula, exerting uniform but moderate force, and the mirror, after being warmed, is introduced between the uvula and the palatal arches, taking care to avoid contact. By depressing the handle and turning it from side to side an image of the choanæ and of the septum is obtained (Plate 21). The following points should be noted: In the roof of the pharynx the pharyngeal tonsil and the presence of pus pockets; the choanæ (hypertrophy of the posterior extremities of the turbinates); the opening of the Eustachian tube; the normal color of the mucous membrane is yellow: in otitis media the membrane is reddened and the lumen is occluded by mucus and pus; behind the opening of the tube is Rosenmüller's fossa. This may contain adenoid growths obstructing the pharyngeal opening, or syphilitic scars distorting the Eustachian tube. As it is often impossible

FIG. 38.—Postnasal speculum.

to examine children with a mirror, we substitute digital examination. After disinfecting the hands and trimming the nails closely, the forefinger of the right hand, protected with a metal cap against biting, is introduced into the postnasal space. The posterior extremity of the turbinates and the Eustachian fold must not be mis-

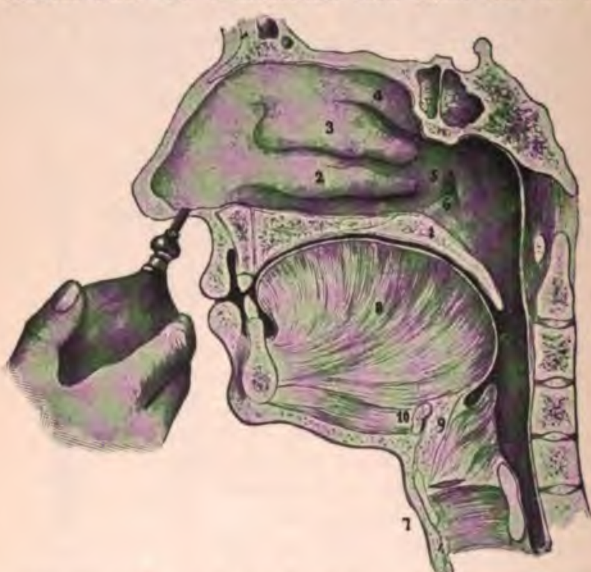

FIG. 39.—Sagittal section of the head during quiet respiration. Politzer's experiment (first step): 1, Velum palati during quiet breathing; 2, inferior turbinate; 3, middle turbinate; 4, superior turbinate; 5, pharyngeal opening of the Eustachian tube; 6, fold of levator palati muscle (small); 7, larynx; 8, tongue; 9, epiglottis; 10, hyoid bone.

taken for adenoid vegetations. The child's head is fixed with the left hand during the operation.

8. Examination of the Eustachian Tube. Middle-ear Inflation; Bougies; Dilatation with General Treatment through the Eustachian Tube. —By the term air-douche or inflation is meant the forcible introduction of air into the middle ear through the Eustachian tube. It is used for the purpose of diagnosis and prognosis, and has also some therapeutic value (Deleau); hence it is necessary, before employing inflation, to test the hearing for whispered conversation.

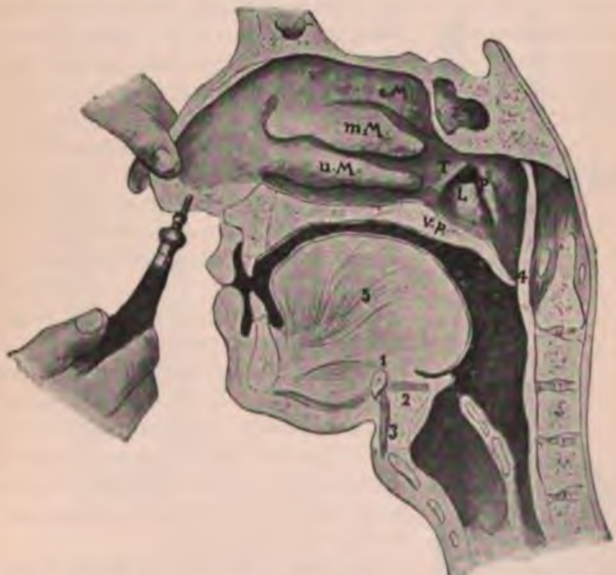

FIG. 40.—Sagittal section of the head during deglutition. Politzer's experiment (second step): *u. M,* Inferior turbinate; *m. M,* middle turbinate; *o. M,* superior turbinate; *v. p,* velum palati; *T,* Eustachian tube; *P,* salpingopharyngeal fold; *L,* fold of levator palati (thickened); 1, hyoid bone; 2, hyo-epiglottic ligament; 3, thyrohyoid ligament; 4, Passavant's fold; 5, tongue.

(*a*) *Valsalva's Experiment.*—The patient is told to expire forcibly, at the same time holding mouth and nose closed, so that the pressure in the postnasal space is increased and the air is driven into the middle ear through the tube. The drumhead bulges outward, and the cone of light appears shortened. The noise produced by the forcible introduction of air resembles crackling, and can be heard with a rubber tube connecting the patient's ear with the examiner's (otoscope) (Fig. 42). If the drumhead is perforated, a shrill whistling sound is produced that can be heard at some distance. If the middle ear contains any secretion, it is forced out into the auditory meatus. In order to render Valsalva's experiment successful, expiratory pressure must be great enough to open the tube; this is the case under normal conditions. If there is any obstruction, such as swelling of the tubal mucous membrane, as in otitis media, the experiment will not succeed. If the experiment is successful, the prognosis is favorable. It is not advisable as a therapeutic measure, however, as its repeated performance produces hyperemia of the vessels of the head and tends to increase inflammatory symptoms in the ear.

FIG. 41.—Politzer bag with glass bulb (*a*). Politzer bag with catheter (*b*).

(β) In *Politzer's procedure* air is forced through the nose into the postnasal space at the moment when the tubes are opened, and the postnasal space is closed below by the ascent of the velum palati. This occurs during the act of swallowing (Figs. 39, 40). The air is compressed by means of a large rubber bag with a small aperture burned into the side (Fig. 41). The bag is connected with a rubber tube, 3 cm. in length (Löwenberg), or by means of a piece of rubber tubing with a glass bulb that can be boiled (Jacobson) (Fig. 41, *a*). The ear to be examined is connected, by means of the otoscope, with the corresponding ear of the examiner (Fig. 42), or, if two wish to auscult, by means of a double otoscope (Fig. 43)—that is, an otoscope provided with a T-piece. The bag is held firmly in the right hand, the thumb above, the forefinger below, so that the opening is closed by the palm. The glass bulb is introduced carefully into the naris corresponding to the diseased side ; the other naris is closed firmly by pressing the ala against the bulb with the thumb of the left hand from below,

FIG. 42.—Otoscope.

FIG. 43.—Double otoscope.

and the left middle and index-fingers from above. The patient is asked to take a mouthful of water and to swallow at the word "now" (first step). The moment the patient swallows and the larynx is seen to rise, the bag is forcibly compressed (second step). The force to be used in compressing the bag depends on the resistance encountered in the tube. If the experiment is successful, a gurgling sound will be heard at some distance, due to the forcible thrusting aside of the velum palati. Instead of asking the patient to swallow, he may be told to make certain sounds, as to say "huck" (Lucæ). The bag should be pressed at the instant the sound of "k" is made.

In children, Politzer's procedure may often be performed without any difficulty (Schwartze); it is facilitated by crying. To assist in forcing the air into the diseased ear and prevent its entering the sound ear, the resistance in the latter is increased by holding it shut. By means of the opening in Politzer's bag the latter may be filled with air without removing the glass bulb from the nose.

FIG. 44.—Coronal section through the tympanum (schematic, after Politzer): *a*, Extremity of the upper, *b*, extremity of the lower, bony wall of the meatus; *c*, auditory meatus; *d*, tegmen tympani; e_1, attic, external portion; e_2, internal portion; *f*, malleus and superior ligamentum mallei; *g*, incus; *h*, stapes within the fenestra vestibuli; *i*, promontory; *k*, Prussak's space; *l*, tendon of tensor tympani muscle; *m*, hypotympanic recess (cellar); 1, scar in the lower half of the drumhead in apposition with the promontory; 2, remains of drumhead.

Otherwise the bulb would have to be removed from the nose as often as the experiment is repeated, so as to prevent the aspiration of mucus from the nose. The auscultatory phenomena will be discussed later. If the drumhead is inspected during Politzerization, it is seen to bulge wherever there is a weak spot (recent scars, Figs. 44, 45). A retracted drumhead resumes its normal position and color; the manubrium becomes injected; secretion is forced into the auditory meatus from the tympanum; structures, such as the incudostapedial articulation, that may be visible on account of the presence of scars, disappear when the scar is pushed outward (Plates 39, 24). Exudates are enabled to escape, and a distinct improvement in the hearing follows. Politzer's experiment is also of use in removing secretions from the postnasal space (Lucæ) and accessory cavities of the nose, the openings of which are incidentally ventilated (Hartmann).

FIG. 45.—See Fig. 44. 1, Scar driven outward during Politzer's procedure.

Occasionally Politzerization is accompanied by the entrance of air into the esophagus and stomach, producing pain, nausea, and occasionally syncope. The air that has been swallowed is expelled by belching. Rarely a scar or atrophic area gives way during the experiment. Instead of air, medicated vapors, such as menthol chloroform, turpentine, iodethyl, or ether, can be introduced with Politzer's bag for therapeutic purposes. Fluid medicaments are better injected by means of the catheter. To give the ear a thorough cleansing, Politzerization may be performed after filling the diseased ear with a substance such as peroxid of hydrogen, the patient holding his head on one side. As the air passes through the fluid it brings the latter in contact with every part of the middle ear.

(γ) *Catheterization.*—If Politzerization cannot be carried out, even with the employment of great force, air must be introduced directly into the tube by means of the catheter. Catheterization should be employed only in cases in which it is impossible to perform Politzer's experiment, when it is desired to introduce medicinal substances into the tubes, or an accurate auscultation of the middle ear is indicated. It cannot be performed in children under six years of age. The procedure is more unpleasant to the patient, and often not so effective as Politzerization. The catheters are made of metal or hard rubber, about 14 cm. in length, and provided with a downward bend at a point 2 cm. from the extremity. They are made in four different sizes, from 1.5 to 3 mm. (see Fig. 41, *b*). To determine the position of the point of the catheter in the postnasal space the extremity is provided with a ring that has also a downward inclination. The catheter is introduced through the inferior auditory meatus, or, if the nose is impassable on both sides, through the mouth, and made to enter the pharyngeal opening of the tube (Plate 12). The patient is first requested to blow his nose. If the structures are sensitive or the nasal passages unusually narrow, the inferior meatus should be anesthetized with a 10 per cent. solution of cocain, and if there are choking and retching, the pharynx as well. The ear to be catheterized is connected by means of an otoscope with the corresponding ear of the surgeon, who sits in front of, and on the same level as, his patient. A small catheter is used at the first trial, after which as large a one as possible should be introduced.

First step—introduction of the catheter into the postnasal space: The tip of the nose being raised with the thumb of the left hand, the surgeon seizes the catheter near its extremity like a pen with his right hand, and places the tip on the floor of the nose from below; the end of the catheter is then raised so that it lies at the same level as the tip, and the catheter is gently introduced through the inferior nasal meatus between the floor of the nose and the septum. By using a head mirror any obstructions that may be present can be avoided by simply turning the tip of the catheter outward and away from the septum. If the surgeon possesses a light hand, he may allow the catheter to make its own way past any obstruction in the nose; the instrument during its progress sometimes makes a complete revolution. Care must be taken to avoid entering the middle meatus. As the catheter enters the postnasal space the velum palati frequently contracts and arrests its further advance. If this happens, the surgeon should wait a moment or ask the patient to inspire deeply through the nose. As soon as the tip of the catheter leaves the floor of the nose it falls into the postnasal space. If it can be done without using force, the catheter is pushed back until it comes in contact with the posterior wall of the pharynx.

Second step—introducing the catheter into the pharyngeal opening of the tube: At this stage of the proceeding the catheter is held firmly with the left hand, the thumb below, the index-finger above, in front of the naris, the remaining fingers being applied to the dorsum of the nose. The catheter is then held by its extremity and can be introduced into the tube in one of the following ways: (1) By gently turning the tip outward and withdrawing the catheter for a distance of about 1 cm. A slight elastic resistance is then felt at the tubal fold. If the instrument is now carefully withdrawn a little farther, the tip will glide over the fold and slip into the opening, at the same time performing a slight outward and upward rotation. The ring of the catheter is then directed toward the external canthus of the same side (Bonnafont). (2) The catheter may be withdrawn until it catches on the velum palati, when it is rotated upward and outward until it enters the tubal opening (Kramer). (3) The catheter may be withdrawn, and the tip at the same time be turned toward the opposite side from the one to be catheterized, so that the beak of the instrument catches on the edge of the vomer. It is then turned upward through 180 degrees, and thus enters the tubal opening (Frank, Löwenberg). If the first method fails, the second and third methods should be tried.

The other ear can also be catheterized by rotating the tip of the catheter to the other side in a horizontal plane, at the same time pressing the end of the catheter against the ala of the side opposite the one to be catheterized. By this procedure the beak of the catheter enters Rosenmüller's fossa of the opposite side, and enters the tubal opening by gliding down over the tubal fold from in front (Deleau).

If the tip of the catheter enters the middle meatus or catches in folds of mucous membrane in Rosenmüller's fossa, and when one side of the nose is absolutely impassable, catheterization is impossible; in that case an attempt may be made to catheterize through the other side of the nose. If the catheter is introduced properly, the beak cannot be moved backward, forward, or upward. After the catheter is in the right position it should be fixed in front of the naris.

Third step—introduction of air through the catheter: The air is forced in by means of a Politzer bag, which is provided with a rubber tube about 80 cm. in length, instead of the glass bulb (Fig. 41, *b*), and a coupling that fits into the catheter. After being fitted into the catheter the coupling is held fast in front of the naris. The bag lies in the surgeon's lap and is held in the right hand, as in Politzerization, so that the opening in the bag is occluded with the ball of the thumb. It is then pressed for from six to eight times, the ball of the thumb being removed from the opening each time. When there is much swelling of the tubal mucous membrane, moderately firm pressure may be employed. The entrance of air will be facilitated by the act of swallowing. If it is desired to use a continuous current of air, a Lucæ bellows is used. The inflation should be almost painless; occasionally it is followed by slight nausea or retching. If the mucous membrane has been injured by the tip of the catheter, air may be forced under the mucous membrane and cutaneous emphysema result, with the production of whitish blebs in the mucous membrane and side of the neck, which crepitate during palpation. If asphyxia develops from emphysema of the epiglottis, incisions are indicated. The emphysema disappears rapidly under application of cold compresses.

Fourth step—withdrawal of the catheter: After disconnecting the rubber tube and bag, the catheter is withdrawn slowly through the inferior nasal meatus with the right hand, the tip of the nose being elevated. If the catheter is stained with blood from laceration of the mucous membrane, the patient must be forbidden to blow his nose for two or three hours on account of the danger of cutaneous emphysema.

Auscultation during the introduction of air through the catheter is of the greatest importance. Normally a coarse, dry, blowing sound, gradually increasing in intensity, is heard, due to the bulging of the drumhead and blowing of the in-rushing air. In stenosis of the tube the sound is short and diminished in intensity. If the tube is filled with secretion, fine or coarse crepitant rales are heard close to the ear. They should not be confounded with coarser, more distant crepitant rales produced outside the tube in the postnasal space. If there are scars, or if the drumhead is atrophied, a high-pitched vibrating murmur is produced. In perforation of the drumhead the air strikes our own ear with an unpleasant sensation, and we hear a loud whistling sound if the perforation is small. If secretions are present, the sound is accompanied by crepitation. During inflation the mastoid process may be auscultated with a stethoscope (Lænnec). Normally the entrance of air into the cells produces a characteristic crepitant sound that is absent in occlusion of the tubes, in perforation of the drumhead, and in mastoid disease. There is little danger of introducing infectious material from the nose and postnasal space into the tubes and middle ear during inflation. In catheterization this may be avoided by blowing air through the catheter while introducing it (Lucæ). The danger of infecting the opening of the tube with the tip of the catheter during catheterization—as with lues, for instance—is avoided by aseptic precautions. When the lips of the tube are swollen, Politzerization cannot be performed, whereas catheterization, on the other hand, is quite easy. After the inflation the hearing is again tested with the same whispered words that the patient was unable to hear before.

The mechanical effect of a current of air entering the tubes is as follows: (1) The lumen is dilated, any secretion that may be present is blown out, and secretion contained in the tympanic cavity is enabled to escape. The escape of secretion is facilitated by asking the patient to drop his head forward and toward the sound side. (2) The lateral pressure produced within the tube forces the blood out of the hyperemic vessels and thus diminishes inflammation and regulates the circulation in conditions of stasis. (3) The ear-drum, or, when there are perforations, the remains of the ear-drum, is forced outward; the chain of ossicles also moves outward, and abnormal tension is removed. Anomalies in the inclination of the membrane are neutralized. (4) Inflammatory adhesions in the tympanum and around the margins of the fenestræ are subjected to tension and break down. The blood- and lymph-vessels of the tympanic mucous membrane regain their normal pressure, and the absorption of exudate is facilitated; the intralabyrinthine pressure is regulated. (5) Secretion contained in the tympanum is thrown out into the auditory meatus through a perforation. If, as frequently happens, marked improvement in the hearing follows the employment of the air douche, the prognosis is favorable, especially if the improvement is permanent. If, in spite of successful air douche and the absence of secretion in the tympanic cavity, there is no change in the power of hearing, the prospect of restoring it is unfavorable. Changes occurring in the drumhead after catheterization are ascertained by means of the otoscope, just as after the performance of Politzerization.

By means of the air douche medicated vapors and other remedial agents can be introduced into the middle ear for therapeutic purposes. The catheter is best adapted for this purpose. Thus, aqueous vapor can be introduced into the tubes by means of a bottle containing boiling water or the vapor of ammonium chlorid in a nascent state. By means of a rubber bulb (Fig. 46) the vapor of hydrochloric acid is forced into a vial containing ammonia; the vapor of ammonium chlorid thus produced is purified by passing it through water, and after traversing

FIG. 46.—Ammonium chlorid steam apparatus.

a glass sphere enters the rubber tube connected with the catheter. A ball of cotton saturated with menthol chloroform, ether, or turpentine may be introduced into the glass sphere so that the vapors from these substances, even without ammonium chlorid, can be introduced into the tubes. Before attempting any therapeutic measures through the tube the operator must satisfy himself by auscultation that the catheter has been properly introduced. Medicinal substances are injected into the Eustachian tube for the purposes of diminishing secretion, loosening the mucous membrane or ossicles, or dissolving inspissated secretions. After the catheter has been introduced a few drops of the drug are injected by means of a Pravaz syringe, and propelled into the middle ear by forcing air through the apparatus. With the otoscope the drug is heard to enter the middle ear with a bubbling sound. Quite often it can be seen behind the drumhead; in such cases the manubrium is usually congested and may present ecchymoses. If the tube is permeable and there is a perforation in the drumhead, the tympanic cavity can sometimes be very satisfactorily flushed out with the catheter. For this purpose sterile water at a temperature of 28° C. (95° F.) is gently injected into the cavity with a large piston syringe or through a small elastic tube (Weber-Liel) introduced directly into the cavity through the catheter. The water returns through the affected ear.

(δ) *The Use of Bougies in the Eustachian Tube.*—If stenosis persists in spite of inflation, an attempt may be made to remove it by introducing a celluloid bougie through the catheter, the thickness varying from $\frac{2}{3}$ to $1\frac{1}{2}$ mm. (Urbantschitsch). The bougie incidentally furnishes a means of recognizing a stenosis and its situation. In a normal tube a bougie of $1\frac{1}{2}$ mm. will easily pass the narrowest portion—the isthmus of the tube. Before introducing the bougie, the length of the catheter is indicated by a mark; $2\frac{3}{4}$ cm. further back another mark is made. After the bougie has been introduced as far as the first mark it has passed the length of the catheter, after which it should gradually be pushed forward an additional distance of $2\frac{3}{4}$ cm., as far as the second mark, when the narrowest portion of the isthmus will have been passed. If the bougie has been pushed in too far,—over 3 cm.,—it will enter the tympanic cavity and endanger the integrity of the ossicles. After the bougie has been in place ten minutes it is removed and air is forced in through the catheter. If the catheter was improperly introduced, the bougie, instead of entering the opening of the tube, is forced into the mucous membrane of the nasopharynx and may produce lacerations. If, on removing the bougie, the end is found to be bloody, inflation must not be practised and the patient must be warned against blowing his nose on account of the danger of subcutaneous emphysema. The passing of the bougie is often followed by distinct improvement in the hearing, and may act reflexly by stimulating the auditory centers (Urbantschitsch). In the treatment of stenosis bougies of gradually increasing calibers must be used. By rapidly moving the bougie to and fro and setting up a slight vibration, massage of the tube can be practised. The mucous membrane can be cauterized by means of medicaments painted on the bougies, or a metal bougie to which a caustic, such as silver nitrate, has been welded may be employed. [The bougie should be employed only in the hands of experts.]

10. General Examination.—If the examination of the ear leads the surgeon to suspect that the aural affection depends on some general disease, such as tuberculosis, diabetes, anemia, leukemia, syphilis, etc., a general examination of the entire body and its secretions—urine, sputum, and blood—is indicated. An aural affection caused by some general disease cannot be cured by local measures without the co-operation of constitutional treatment. If there is any suspicion of intracranial disease, the eye-ground must be examined (choked disc, optic neuritis—rare in uncomplicated cases of otitis media, most frequent in perisinuous abscess with sinus thrombosis: choked disc is more common in tumors; optic neuritis, in brain abscess). Lumbar puncture may also afford valuable information in intracranial complications. Before administering an anesthetic the general condition must always be subjected to a rigorous examination.

11. Malingering.—Wide experience, an extensive knowledge of human nature, and a thorough examination and functional test of the ear are requisite to the detection and conviction of a malingerer. Malingerers feign unilateral or bilateral, partial or complete, deafness. When a malingerer is to be examined, his eyes should be tightly bandaged. If he pretends bilateral deafness, which he rarely does, the fraud being, as a rule, easily exposed by witnesses, he can be convicted only by a trick, such as by suddenly saying to him, "You may go," or by rousing him from normal sleep or that induced by anesthetics by calling to him, or by watching him while he is in a state of intoxication. When bilateral deafness is alleged, each ear is tested separately, the other being carefully closed. In performing the test certain definite words, as well as the acumeter, are used. The distance at which the individual hears is carefully noted, and his statements are subjected to a rigorous control test by repeated examinations. The control test may be made even more rigorous by closing both ears with aural specula, one of which is open while the other is sealed with wax (Tschudi). By means of the tuning-fork the time of perception for individual notes, both for air- and bone-conduction, is tested, and the tests repeated several times. In this test also there is room for cunning on the part of the examiner. If, for example, the individual says that he hears the tuning-fork when it is placed on the vertex, the examiner proceeds to stop up both ears. If the subject is malingering, he will frequently say that he can no longer hear the tuning-fork, whereas as a matter of fact he should be able to hear it better than before. When unilateral deafness is alleged, the truth or falsity of the statement will again be decided by performing repeated tests, both with the voice and with tuning-forks, and carefully comparing the patient's statements at each examination. If the malingerer is suffering from middle-ear disease and the tuning-fork is placed on the vertex, he will rarely say that he hears it in the affected ear. Usually he says that he hears the note in the sound ear, and, if the sound ear is stopped up, he will say that he does not hear anything, which at once convicts him of malingering (Moos). As a further test the power of hearing whispered conversation may be determined first for the sound ear, and then for the pretended deaf ear, without stopping up the sound ear. If the individual examined says he hears nothing, he is a malingerer, since he must be able to hear with the sound ear (Hartmann). Another plan is to pretend to stop up the sound ear, using a perforated cork (Voltolini). If one shouts into the pretended deaf ear while the sound ear is closed tightly, the malingerer must hear with the sound ear in spite of its being closed. If the bulb of a double otoscope is inserted into each ear of a malingerer, and a tuning-fork is placed on the T-piece of the otoscope behind the patient, the note—if the right ear, for example, is alleged to be deaf—should be heard only by the left ear of the examiner. If the rubber tube going to the right (deaf) ear is compressed, the sound should be louder in the left (sound) ear. If, on the other hand, the right ear is really deaf, the sound should disappear completely if the tube leading to the healthy ear is compressed (Bloch).

As a further test an ear-trumpet may be inserted into each ear, and two examiners, standing behind the subject, at the same time whisper certain words in rapid succession, the suspected malingerer being asked to repeat immediately what he has heard. If he is really deaf on one side, the words whispered into the healthy ear are at once repeated without hesitation; but if he is malingering, some of the words whispered into the pretended deaf ear are also repeated or else he becomes confused (Lucæ, Hummel).

The artificial production of objective symptoms, such as aural discharge (Chimani), and attempts to deceive by alleging subjective symptoms, such as tinnitus, vertigo, and pain, may be detected by examination or by careful observation in a hospital.

12. Bacteriologic and Histologic Examination.—Pus, cerebrospinal fluid, etc., are to be examined microscopically and by making cultures. If streptococci are found in active suppurative processes, the prognosis is more unfavorable than when the secretion contains only diplococci. The course of a streptococcus otitis is likely to be more severe than that of a pneumococcus otitis; in the latter variety mastoid disease and epidural abscesses are more likely to remain after the otitis media has subsided. Pyemia is most common in streptococcus otitis. In chronic suppurative processes staphylococci are usually found (Zaufal, Leutert). The finding of diphtheria bacilli, tubercle bacilli, actinomyces, aspergillus, and cholesterin crystals in aural pus is of great diagnostic significance. In certain cases the diagnosis may eventually be determined by excising small portions of tumors in the pinnæ, auditory meatus, or tympanic cavity (carcinoma, sarcoma, polypoid granulations, fibroma, etc.).

IV. PATHOLOGY AND TREATMENT.

A. GENERAL PATHOLOGY AND TREATMENT.

(a) **Frequency of Aural Disease.**—"During the first decennium of adult life (from twenty to thirty) one man out of every three men is sure to be suffering from some degree of impaired hearing in at least one ear" (von Tröltsch). Among school-children, 22 per cent. have defective hearing (Reichard, Bezold). Men suffer more from aural disease than women, especially amid unfavorable social conditions. Aural disease is most frequent during the first three decades of life; in the fourth decade a considerable decrease is noted. Of the various portions of the ear, the tympanic cavity is the one most frequently affected, especially in children; next, the external auditory canal, and, last, the internal ear. Cases of bilateral aural disease are almost as common as unilateral cases (Bürkner). Acute inflammatory aural affections increase in frequency during April, May, February, and March, in the order named, and are least frequent during October (Bezold).

(b) **General Etiology.**—Diseases of the organ of hearing are produced by general and specific injuries (infections). Congenital anatomic abnormalities, such as contraction of the fenestra vestibuli or of the tympanic cavity, may become the cause of impaired hearing. Predisposition to disease of the organ of hearing, especially progressive deafness, is hereditary. A mountainous climate favors the production of chronic middle-ear catarrh, whereas a coast climate predisposes to hypertrophy of the pharyngeal tonsil (Gellé) and tubal catarrh, especially in children. Nasal obstruction interferes with the ventilation of the tube and is a frequent cause of aural disease. In 40 per cent. of the patients up to the fifteenth year adenoid vegetations are present (Killian). Injury of the ear, as in head injuries or explosions; intoxication, as by lead, mercury, nicotin, or quinin; work in the midst of excessive noise or marked variations in air pressure (caisson); diseases of the nervous system, such as tabes, hysteria, or brain tumors, leukemia, anemia, or Bright's disease, may all lead to disease of the auditory nerve. Circulatory disturbances in emphysema and cardiac disease may lead to hyperemia of the labyrinth or embolism of the internal auditory artery. Diseases of the digestive organs produce vertigo and tinnitus. In gout, uric acid salts may be deposited in the pinnæ. Diabetes predisposes to external otitis and grave middle-ear inflammation. A reflex otalgia from irritation of the fifth nerve or of the sympathetic nerve also occurs. Vicarious menstruation from the ear occurs in hysteria, and deafness is occasionally observed during pregnancy and in the puerperium.

Disease of the organ of hearing is more frequently due to specific injuries. Many of the causes assigned by the patient to aural disease can be explained only by assuming an infection. Among these are "catching cold," scraping the ear, the use of tampons, cauterizing the nose, coryza, forcible blowing of the nose, spraying of ear and nose, fomentations, and instillations. In the external ear the presence of mold fungi may lead to inflammation; so long, however, as the epidermis remains intact, the cutis will be protected from infection. If the epidermis is injured, the skin of the auditory meatus is in danger of becoming infected. The activity of pathogenic germs appears to be necessary for the production of inflammatory processes in the middle ear. There are three paths by which infection may reach the middle ear: the auditory meatus, the Eustachian tube, and the blood and lymph channels. Pathogenic germs are constantly present in the auditory meatus (Rohrer), but so long as the drumhead is intact they are unable to invade the middle ear. The Eustachian tube connects the middle ear with the postnasal space. Pathogenic germs are always found in the nose and mouth, but the danger of infection through the tube is counteracted by bactericidal activity and by the presence of cilia in the epithelium of the mucous membrane that lines the tubes and tympanic cavity. Just as pathogenic micro-organisms lose their infectiousness in their progress through the nose (the extremities of the turbinates are almost free from germs), so the micro-organisms that invade the tube have their virulence impaired by the bactericidal activity of the mucous membrane, and are thus prevented from entering or infecting the tympanic cavity. Normally, therefore, the tympanic cavity is free from germs (Preysing). So long as its protecting outworks—the drumhead and mucous membrane of the nose and Eustachian tube—remain intact, infection can take place only by way of the vascular and lymphatic channels. If the drumhead is injured or the bactericidal power of the nasal and tubal mucous membrane—as, for instance, the ciliary movement of the epithelium—becomes impaired by "catching cold" (Lipari), the tympanic cavity readily becomes infected either through the auditory meatus or through the tube. As in many infectious diseases the upper air-passages become involved and the general power of resistance of the organism suffers, it follows as a matter of course that any general infection, such as scarlet fever, measles, diphtheria, typhoid fever, or influenza, may be accompanied by a local, specific, or non-specific infection of the tympanic cavity. Infection of the tympanic cavity by way of the blood channels is rare, occurring chiefly in syphilis. In inflammatory diseases of the throat, such as diphtheria (Moos) and thrush (Haug), affections of the mucous membrane may spread directly to the middle ear. General diseases that tend to diminish the resistance of the entire body (scrofula, rachitis) also favor infection of the tympanic cavity. The following are the most important micro-organisms in the etiology of aural diseases: streptococcus pyogenes, staphylococcus pyogenes albus and aureus, diplococcus, gonococcus, aspergillus, bacterium pneumoniæ, and the bacillus of typhoid, influenza, and tuberculosis (Plate 30).

The middle ear and the labyrinth may become infected from a purulent focus in the interior of the cranial cavity along the sheath of the eighth nerve by way of the vessels in the bones or aqueducts.

(c) **General Symptomatology.**—1. **Anomalies of the Sense of Hearing.**—Diminution in the power of hearing, ranging from slight impairment to complete deafness (anæsthesia acustica), is a common occurrence in aural diseases. Occasionally the hearing for isolated tones in the middle of the scale is lost (gaps in the scale). Thus, at the upper limit of the scale deafness for high-pitched notes, such as the sound of "*s*" or the chirping of crickets, is met with in nervous deafness, especially in old persons and in boiler-makers, owing to atrophy of the auditory fibers in the base of the cochlea (Habermann); at the lower limit of the scale deafness for low-pitched notes is found, owing to destruction of the tip of the cochlea (Baginsky) (Fig. 18). Inability to understand conversation does not necessarily exclude some power of hearing musical tones. Many patients can hear spoken words, but are unable to understand them (ankylosis of the stapes). The deafness is often variable (acute catarrh), being greater in the morning and when the weather is cloudy, than in the evening and when the weather is clear. In hysteric patients the deafness may change from one ear to the other (*transfert:* Gellé). Many individuals who are deaf on one side are unable to determine the direction from which the sound proceeds (paracusis loci). Patients suffering from middle-ear disease hear better in a noise and commotion—as, for instance, on the railroad—than amid quiet surroundings (paracusis Willisii), because the shaking-up loosens the rigid chain of ossicles and puts them in better condition to propagate sound (Politzer), or because the auditory nerve, owing to the greater irritation, becomes more sensitive (Urbantschitsch). Hyperesthesia of the auditory nerve manifests itself in increased sensitiveness to any auditory impression, and may be so intense as to become painful. There is frequently increased galvanic irritability. It occurs in cerebral affections as the precursor of paralysis, in hysteria, insomnia, disease of the middle ear, in ankylosis of the stapes, and also in total deafness. Abnormally acute hearing (oxyakoia) sometimes occurs in paralysis of the seventh nerve. Transient acuteness of hearing is occasionally observed after great mental excitement and after narcosis (Urbantschitsch). Sometimes a note is heard incorrectly by one ear—that is, it appears lower or higher in pitch than in the other ear (paracusis); in such a case the production of one tone gives rise to the simultaneous perception of two different tones: double hearing (diplacusis dysharmonica). This may arise in affections of the labyrinth from alterations in tension of that portion of the basilar membrane that is attuned to the corresponding tone (Knapp). Double hearing may also manifest itself in a single tone, being heard twice in quick succession. This is due to aftersensation in hyperesthesia of the eighth nerve, or to an obstruction in the sound-conduction apparatus, the delayed conduction in the diseased ear being slower to produce a central irritation and an auditory impression than is the case in the healthy ear (diplacusis echotica Kayser).

2. **Tinnitus Aurium.**—A noise is termed *subjective* when it is not produced by a specific stimulus of the auditory nerve—namely, a sound. Tinnitus aurium is present in two-thirds of all patients suffering from aural disturbances (Politzer). The noises are produced through irritation of the nervous hearing apparatus by intoxications, excessive mental exertion, or circulatory disturbances; by diseases of the labyrinth, auditory nerve, and auditory centers; by impaction of the stapes, and by reflex action in a healthy organ of hearing, as in trifacial neuralgia, spasm of the facial muscles, or when the ear is syringed. In spasm of the

tensor tympani muscle tinnitus may be produced by the vibration of the column of air in the external meatus (Lucæ). In irritation of the nervous hearing apparatus the subjective noises take the form of high-pitched tones, chirping, singing, the sound of boiling water, or the ringing of bells. When there is central irritation, melodies, the singing of birds, and voices may be heard. These, however, are transitional forms closely related to hallucinations. The latter may be produced in mentally unsound patients by peripheral disease of the organ of hearing, as in such patients tinnitus aurium suffices to give rise to hallucinations.

Entotic murmurs are objective noises derived from some source within the ear or the body, which the individual perceives either because the noise is more intense than under normal conditions, or on account of hyperesthesia of the eighth nerve, or increased resonance within the ear due to some obstruction of the sound-conduction apparatus blocking the passage of the sound-waves. The noises heard when there is obstruction to the sound-conduction apparatus are usually low in pitch (between C and c^1, Panse). Entotic murmurs may proceed from various sources, such as normally or abnormally developed blood-vessels, especially the jugular vein—the venous hum of anemia; bulb of the jugular; a misplaced transverse sinus; abnormal position of the carotid within the tympanic cavity; dilatation of the tympanic vessels. In the last case the noises are pulsating. Finally, the murmurs may be produced by the muscles; thus, contraction of the tensor veli palati muscle produces a cracking sound in the ear by forcibly separating the walls of the tube. The noises can sometimes be produced at will and can be heard by means of an otoscope. The drumhead can be seen to move in contraction of the tensor tympani muscle, and the cone of light is foreshortened. When the Eustachian tube is open, the air entering during respiration gives rise to a buzzing noise. Exudate in the tympanic cavity produces a crepitant sound when the head is moved about, and sometimes after Politzerization or after the patient has blown his nose, a rustling sound or noise suggesting minute detonations is heard.

Tinnitus aurium varies greatly in intensity: it may be almost imperceptible or so oppressive that the victim actually meditates suicide. The character and intensity of the noises undergo frequent variations. As a rule, the noises seem to the patient to be produced in the head or in the ears, at first even outside of the body. If the tinnitus aurium is constant, the prognosis is grave; the noise will probably persist until deafness becomes absolute. Intermittent noises occurring at irregular intervals, especially if they are influenced by inflation and massage, offer a better prognosis. Slight noises during the day are drowned by the noise of the streets. Tinnitus aurium is often a precursor of deafness (lues).

3. Disturbances of the Equilibrium (Vertigo ab aure læsa).—In patients suffering from aural disease, vertigo, due either to direct irritation of the semicircular canals or to reflex causes, occurs, and may or may not be accompanied by nausea, vomiting, syncope, tinnitus aurium, or nystagmus. Vertigo may be brought on reflexly through the sensory nerves of the external and middle ear by syringing the ear, especially with cold water, by the presence of foreign bodies in the auditory meatus, by touching the tympanic mucous membrane, by catheterization, and, finally, by intense auditory impressions, such as detonations or high-pitched tones. The vestibular apparatus may be irritated directly by increase of intralabyrinthine pressure in conditions that tend to raise intracranial pressure (brain tumor), by fluid coming in contact with the fenestra when the ears are syringed, by pressure being exerted on the foot-plate of the stapes during inflation, or when the force of the air is increased as in a disease. It may also be irritated by a galvanic current applied to the head, by an inflammatory process within the labyrinth, by caries of the pyramid and the semicircular canals, by injuries, and by unaccustomed movements of the head, as when riding on a carousal or on ship-board. The disturbance of equilibrium produces a subjective sensation of dizziness, and manifests itself objectively by slight swaying, especially when the eyes are closed, unsteady and staggering gait, or by the patient suddenly falling, usually toward the affected side. The attack may last a few seconds or several hours, and may occur but once or repeatedly. When vertigo is accompanied by deafness, tinnitus aurium, nausea, and vomiting, the condition is called Ménière's symptom-complex.

4. Autophony.—By the term autophony is meant an intensifying of the patient's own voice so that it sounds like a trumpet. It occurs when the tubes are wide open and there is no obstruction to the entrance of the voice into the ear—as, for example, in inflammation of the tube with imperfect closure.

5. Reflex Phenomena.—Urbantschitsch states that disease of the ears exerts a reflex influence on the power of vision; vision is reduced in otitis media. Irritation of the auditory sense may be transmitted to the other special senses. Thus, certain subjective visual impressions, such as the seeing of colors, sometimes attend the hearing of certain notes; foreign bodies, accumulations of cerumen in the auditory meatus, and diseases of the middle ear may give rise to psychic disturbances (reflex psychoses) chiefly through the agency of the fifth nerve. The psychoses may take the form of drowsiness, partial loss of memory, mania, or melancholia (Köppe).

There is a sympathetic communication between the two organs of hearing, so that in disease of one ear, as chronic middle-ear catarrh, the other ear is influenced by any change in the disease, be it for better or for worse. Such sensory reflex phenomena emanating from the organ of hearing are observed chiefly in the distribution of the trifacial, giving rise to toothache, pain in the head, larynx, and in the domain of the vagus, where it produces respiratory distress (Steinbrügge). Foreign bodies and suppuration within the ear give rise to reflex motor phenomena, such as convulsions and epileptiform attacks. Labyrinthine disease may give rise to nystagmus. An intense auditory impression is often followed by convulsive movements of the entire body, sudden elevation of the pinnæ, or movements of the head. Spasm of the tensor tympani muscle occurs when the hearing has been overtaxed. Rarely reflex paralysis of the diseased side of the head has been observed (Schwartze).

6. Diseases of the Facial Nerve and its Branches.—Since the seventh nerve traverses the tympanic cavity (Plates 3, 5), disease in that region not infrequently communicates itself to the nerve and is often the prodromal symptom of a fatal cerebral affection (Politzer). The morbid process reaches the seventh nerve in the temporal bone: (1) Through branches of the stylomastoid artery (paresis due to the pressure on hyperemic vessels); (2) through a deficiency in the bony canal above the fenestra vestibuli (paresis or paralysis due to pressure on the nerve or swollen mucous membrane, or an exudate in the tympanic cavity, sometimes in so-called rheumatic facial palsy); (3) the purulent process may extend through the defect in the bone to the perineurium (perineuritis) and to the nerve itself (neuritis); (4) in carious destruction of the facial canal, and in purulent inflammation or destruction of the seventh nerve, especially in cholesteatoma and necrosis of the labyrinth (Plates 26, 28); (5) by extension of a purulent inflammation from the meninges to the seventh nerve within the internal auditory meatus (Fig. 13); (6) by the pressure of brain tumors, especially cerebellar tumors or abscesses on the seventh nerve within the internal auditory meatus (pressure atrophy); (7) in fracture of the base of the skull infection may extend through a fissure in the internal auditory meatus and injure the seventh and eighth nerves, or hemorrhage into the facial canal may take place.

The seventh nerve offers considerable resistance to suppuration and destruction in its immediate neighborhood. The objective symptoms vary according to the seat of the injury in the nerve (Fig. 47). According to Erb, the symptoms are as follows: (1) Paralysis of the facial muscles on the affected side (injury to the seventh nerve outside of the facial canal, between 1 and 2); (2) paralysis of the facial muscles, disturbance of taste, some-

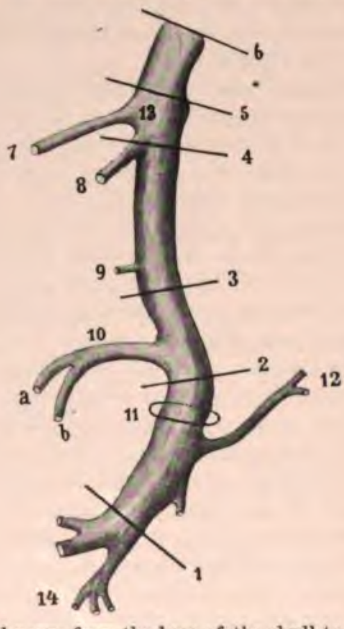

FIG. 47.—Facial nerve from the base of the skull to the pes anserinus (after Strümpell): 1, 2, 3, 4, 5, 6, are explained in the text; 7, great superficial nerve; 8, anastomosis with the small superficial petrosal nerve: 9, nerve to the stapedius; 10, chorda tympani—(*a*) taste-fibers; (*b*) fibers concerned in the secretion of saliva; 11, stylomastoid foramen; 12, posterior auricular nerve; 13, geniculate ganglion; 14, pes anserinus.

times diminished secretion of saliva and dryness of the mouth (injury of the facial nerve in the facial canal, between 2 and 3); (3) paralysis of the facial muscles, disturbance of taste, diminished secretion of saliva, tinnitus aurium and deafness or abnormally acute hearing (injury of the seventh nerve, between 3 and 4); (4) paralysis of the facial muscles, disturbance of taste, diminished secretion of saliva, excessively acute hearing, tinnitus aurium, paralysis of velum palati—the velum is higher on the diseased side and moves toward the sound side during phonation (injury of the geniculate ganglion, between 4 and 5); (5) paralysis of the facial muscles, diminished secretion of saliva, excessively acute hearing, partial palsy of the palate, absence of disturbance of taste, as the fibers of the chorda tympani leave the seventh nerve in the great superficial petrosal to join the fifth nerve (injury above the geniculate ganglion in the internal auditory meatus, between 5 and 6).

Deafness caused by paralysis of the stapedius muscle is accompanied by tinnitus aurium and is due to the fact that the tensor tympani muscle forces the foot-plate of the stapes farther into the fenestra vestibuli than is the case when the function of the stapedius muscle is intact. Abnormal acuteness of hearing, especially for low-pitched notes, is due to an increased activity of those branches to the stapedius muscle that are not paralyzed (Urbantschitsch). In middle-ear disease the sense of taste may be disturbed in the anterior two-thirds of the tongue, on account of direct injury to the chorda tympani; anomalies of the tactile sense also occur. In addition, mechanical irritation of the promontory may, by stimulating the tympanic plexus of the glossopharyngeal nerve, give rise to disturbances of taste in the posterior third of the tongue, and to an increased flow of saliva by irritating the small superficial petrosal nerve, which goes to the parotid gland. The power of tasting bitter substances is tested with quinin, sweet substances with a sugar solution, sour with vinegar, and salty with salt. If the electric irritability is normal, the seventh nerve palsy is slight and recovery may be expected in from two to three weeks. If there are partial reactions of degeneration, diminished faradic and galvanic irritability of the nerve, with increase of the galvanic irritability after from two to three weeks, the palsy is more severe and recovery cannot be expected to take place in less than from four to six weeks. If the reactions of degeneration are well developed,—that is, if both galvanic and faradic irritability of the nerve and faradic irritability of the muscles are lost and galvanic irritability of the muscles is altered,—the injury is grave. Recovery, if it occurs at all, takes place in from three to six months, muscular convulsions and tic convulsif often remaining on the affected side. The prognosis in facial palsy is better in children than in adults. It is good if the electric irritability of the nerve is normal after two weeks. In cerebral palsies the electric irritability remains intact (Strümpell). Pressure palsies develop gradually, and diminish or increase with the changes in the amount of the exudate. Paralysis due to destruction comes on suddenly and shows no variation in degree.

(d) **General Prognosis.**—The position of the organ of hearing in the immediate neighborhood of the largest blood-vessels and of the brain, and its great functional importance in the acquisition of speech, intelligence, and general human intercourse, place diseases of the organ of hearing in the category of vital diseases. The prognosis improves in proportion to the physician's skill, the correctness of his diagnosis, based on accurate examination of the ear, and especially on the timely and judicious use of remedial measures. Of all persons suffering from aural disease, about 60 per cent. are cured, 29 per cent. are improved, 11.5 per cent. are not cured, and about 0.4 per cent. die (Bürkner). One in every 158 individuals (0.46 per cent.) dies from the results of suppurative disease of the ear (Pitt). The mortality in suppurative otitis media is 2.5 per cent., most deaths being caused by sinus disease and brain tumor (Barker), and a small number by meningitis. About one-third of all brain abscesses, two-thirds of all cases of pyemia, and about one-twelfth of all cases of meningitis are caused by otitis media. The fatal cases are most common in the second and the third decade of life (Körner). Among the incurable diseases of the ear we must count progressive deafness, in which the treatment can only be symptomatic. Many patients suffering from deafness can, however, be cured. As a rule, the prognosis can be determined by a single careful examination. Timely and appropriate treatment of acute suppurative processes affords the best prophylaxis against chronic suppuration, deafness, deaf-mutism, and intracranial disease. Even chronic suppurations that have existed for years and that have completely destroyed the power of hearing and threatened the integrity of the brain and blood-vessels by encroaching on the bone can be cured by operation.

(e) **General Treatment.**—1. **Disinfection.**—In any local treatment, especially in the treatment of suppurative

FIG. 48.—Sterilizer.

conditions, in operative interference and during the after-treatment, and in the treatment of injuries general surgical principles must be observed—disinfection and asepsis or antisepsis of the hands, the instruments, the dressing material, and the field of operation. Before any operation in the auditory meatus or middle ear is performed the pinnæ must be cleansed with soap, a 1 per cent.

solution of lysol, ether, and alcohol, and the meatus syringed with a 1 per cent. solution of lysol and dried with sterile gauze, after which it should be wiped with absolute alcohol or an alcoholic solution of bichlorid. The hair must be cut short, and, if the mastoid process is to be opened, the head shaved behind the ear for a distance of three inches. The instruments are sterilized by boiling them in a sterilizer for ten minutes in a 1 per cent. solution of sodium bicarbonate, after which they are

FIG. 49.—Sterilizer for gauze and cotton.

FIG. 50.—Jar for the reception of catheters, etc.

placed in a 3 per cent. solution of carbolic acid (Schwartze), No instrument, not even a speculum or a probe, should be used for two different patients without first being boiled. Cotton and strips of gauze are sterilized in a closed metal box (Fig. 49) in which they are kept ready for use. Catheters and small rubber tubes for the tympanic cavity are kept in special glass jars (Fig. 50). If the patient is allowed to carry out the treatment himself, he must be instructed carefully in regard to cleanliness of the hands, dressing material, syringes, and spoons for instilling drops into the ear. If there is pus, the pinnæ and auditory meatus must be cleansed with a 1 per cent. solution of lysol, ether, and absolute alcohol before any medicament is introduced into the ear.

2. Method of Cleansing the Ear.—Cleansing of the ear is effected by wiping it with cotton—dry method—or by means of a syringe or an ear-bath (moist method). An erroneous impression is prevalent that syringing the ear is a panacea for all kinds of aural affections; this is based on the fact that the symptoms due to the presence of plugs of cerumen are relieved immediately by removing the obstruction. It must be remembered, however, that such plugs of cerumen are present in but very few diseases of the ear. When the meatus is not obstructed and the drumhead is normal, syringing has absolutely no value. The instruments the surgeon should first employ in every case are the ear-speculum and the head-mirror. The ear should be syringed only when there is some substance to be removed from the meatus or middle ear, such, for example, as pus, cerumen, scales of epidermis, or a foreign body. The technique has been discussed on page 78. Pus may be removed from the auditory meatus and tympanic cavity by means of a cotton-wound applicator (Fig. 29). The head mirror should be used, and the cotton should be changed repeatedly until all the pus is wiped away and a good view of the drumhead is obtained. In most acute recent suppurations the cotton applicator is to be preferred to the syringe. If desired, the cotton may be saturated first with a 1 per cent. solution of lysol or hydrogen peroxid. In chronic suppurations, if the secretion is scanty and not fetid, the applicator should be used. If, however, there is profuse and fetid discharge, the syringe should be resorted to. The materials recommended are a 1 per cent. saline solution, 1 per cent. solution of lysol, 1 per cent. solution of lysoform, 1 per cent. solution of resorcin, 0.1 per cent. solution of formalin, or iodin trichlorid at 28° C. (95° F.). Unless absolutely necessary, the patient should not be intrusted with an aural syringe. If this cannot be avoided, either a simple soft-rubber syringe (Fig. 51) that is easily cleansed and has no hard-rubber attachments, or a Jacobson's aseptic aural syringe may be given. The syringing should be continued until the water returns clear, after which a piece of cotton is placed in the auditory meatus, and the tragus is shaken thoroughly with the ear turned downward. The auditory meatus is then wiped dry with a cotton-wound applicator. After the ear has been syringed, it should be kept plugged with cotton until the evening of the same day. If there is purulent discharge, the cotton must be renewed frequently. Sometimes syringing is impossible on account of vertigo, which may occur in suppurative ears even when the water is warm and injected with very little force. If vertigo does occur, air should be aspirated several times from the auditory meatus and Politzerization resorted to.

FIG. 51.—Lucæ's rubber syringe.

To flush the tympanic cavity, the ear may be filled with water or with a medicated solution, and Politzerization performed with the head turned to one side. If the tube is patulous, air-bubbles will appear in the fluid. Another method of flushing the tympanic cavity is by catheterization (see page 105), or by means of a small rubber tube introduced into the tympanic cavity through the catheter; or the rubber tube may be introduced through the auditory meatus (Hartmann), especially when the upper portion of the drumhead is per-

FIG. 52.—Tympanum tube and bulb.

forated and there is stricture of the meatus. The instrument consists of a bent tube of hard rubber or German silver (Fig. 52). The head mirror should be used, and while the patient's head is held securely the instrument is introduced through the perforation with the right hand, which at the same time holds the rubber bag connected to the tube and filled with any fluid desired. After the tube has been introduced the bulb is compressed slowly. By directing the end of the tube toward any suitable point, such as the attic or antrum, every part of the cavity can be cleansed thoroughly. The tube can also be introduced into fistulous openings, such as occur in the posterior wall of the meatus. The returning water should be examined carefully for any admixture of pus, blood, or cholesteatoma. The syringing should be followed immediately by a second syringing with absolute alcohol (Körner), which materially assists in drying the cavity. In withdrawing the tube, great care must be exercised to avoid catching it on the margin of a perforation or of the bone. The syringing is followed by Politzerization, so as to facilitate drying of the cavity and guard against a subsequent swelling of any masses of epidermis that may remain. The tube may also be used for the purpose of injecting drugs, such as hydrogen peroxid. After all the visible secretion has been removed from the canal and from the tympanic cavity, insufflation should be practised so as to force any remaining secretion into the canal, from which it can be removed with a cotton-wound applicator. By means of Siegle's pneumatic speculum pus hidden away in the recesses of the tympanic cavity, in the attic, or in the antrum can be removed by aspiration.

3. Local Application of Drugs.—Aural baths may be given if a protracted action of the drug is desired, or for the purpose of substituting the syringe. Hydrogen peroxid is generally used. The patient inclines the head toward the sound side, so that the diseased ear points upward. The pinna is drawn backward and upward, and, after warming the bottle, the drug is poured directly into the ear until it appears at the mouth of the canal. Under normal conditions skin and mucous membrane react very feebly to hydrogen peroxid, but if the drug comes in contact with pus, oxygen is rapidly developed and the pus-corpuscles are dissolved, with the production of an opaque fluid containing minute whitish flocculi. Ozone is formed, and the middle ear becomes thoroughly disinfected, the inspissated pus being driven out of its hiding-places and liquefied so that it is more readily absorbed (Keller). The efficacy of aural baths may be enhanced by the simultaneous use of Valsalva's experiment or Politzerization. The fluid is allowed to remain in the ear for from five to ten minutes. If there is much suppuration, the aural bath should be repeated frequently—twice a day, or every two hours. After the bath the ear should be dried and filled with cotton. Ear-drops (from five to ten drops) may be instilled directly into the ear with a dropper or with a spoon. The head is held in the same position as for the ear-bath, and the drug is warmed before instillation; after from five to ten minutes it is removed by turning the head to the other side. An alcoholic solution should not be heated before being instilled into the ear. To apply an ointment to the external ear, spread on a strip of gauze and leave in place over night or for twenty-four hours. Ointments are applied within the canal by means of cotton tampons or strips of gauze. If a drug is to be applied externally, as by painting the surface or by rubbing it into the skin, an area around the ear the width of the thumb is so treated. The best way to apply salves is with Unna's gutta-percha plasters. The application of cantharides is not to be recommended, as it is often followed by eczema. Hypodermic injections, as of pilocarpin, are given below the mastoid process. The pharyngeal orifice of the Eustachian tube can be reached by instillation through the nose, or directly with an applicator introduced through the inferior nasal meatus (menthol oil, cocain). For the introduction of drugs into the tube, see pages 99 and 105. If it is desired to apply the remedy to a circumscribed spot on the canal or in the tympanic cavity, a very fine cotton applicator is used, taking care to squeeze the cotton so that it does not drip (trichloracetic acid, chromic acid). Caustics may be fused on a metal probe (silver nitrate, chromic acid). The excess is removed by syringing with a 1 per cent. salt solution. Powdered remedies, such as boric acid, are best applied with insufflators. The kind provided with a changeable glass tip is best, as a fresh tip can be used for each patient. The openings in the glass tip should be fine enough to prevent the escape of any large lumps that would not be dissolved by the secretion. Cauterization as well as insufflation requires the use of the head mirror, and a thorough preliminary cleansing and drying of the meatus. They should never be resorted to unless the otoscopic findings are unmistakable. Before cauterizing or performing any operation on the drumhead or in the tympanic cavity, ten drops of a 20 per cent. solution of cocain may be instilled and allowed to remain in the ear for from five to ten minutes, or a cotton pledget saturated with menthol-carbol-cocain may be left in place for five minutes.

FIG. 53.—Insufflator with glass tip.

4. **Dressings.**—An ear that is suppurating, as well as one with a perforated drumhead, must always be kept closed with cotton. The cotton must be changed whenever it becomes soiled with pus. After all the secretion has been removed from the ear, a strip of aseptic gauze 2 cm. in width, with a hemmed edge to prevent unraveling, may be introduced with forceps as far as the drumhead. This may be allowed to remain for from one to two days, according to the quantity of the secretion. A compress of aseptic gauze is then applied to the pinna; over this a layer of cotton and an ear bandage are secured

to the head by means of tapes (Fig. 54, small ear-dressing). If desired, the strip of gauze may be saturated with a medicament, such as aluminum acetate. In the case of restless children and after any major operation, a head bandage must be applied (large ear dressing). Gauze bandages 5 m. in length and from 5 to 6 cm. in width are used. The bandage is applied around the forehead, ear, and occiput, leaving the lower jaw as free as possible (Körner). If the bandage is applied too tightly, edema of the eyelids may ensue, which may be mistaken for a symptom of thrombosis of the cavernous sinus.

FIG. 54.—Ear bandage (after Hartmann).

5. Blood-letting.—In any acute disease, especially in beginning otitis media and mastoid periostitis, blood-letting is very effective. In diseases of the external or middle ear the blood is abstracted from a point in front of the tragus. In inflammations of the mastoid and internal ear, the site of election is on or beneath the mastoid process. Leeches—four for an adult, two for a child—should be applied, preferably toward evening; or from 30 to 100 gm. of blood may be removed by means of the artificial leech. Before applying the leeches the skin should be disinfected carefully and the auditory canal closed with cotton; after the leeches have been removed the wound should be closed with a dressing of zinc ointment or adhesive plaster.

6. Compresses.—If a hot application is desired, moist hydropathic compresses are to be preferred to dry heat. The compresses, which should be made of linen, about the size of the palm of the hand, are saturated with lukewarm water or a 3 per cent. solution of acetate of aluminum or absolute alcohol, wrung out and placed upon the ear, after which they are covered with waxed paper and cotton and secured with a bandage. The compresses should be changed every three hours. Cataplasms, hot compresses, poultices, and fomentations with chamomile tea are harmful because they tend to hasten perforation of the drumhead, which might otherwise be avoided. They tend likewise to diffuse a suppuration—a result that may be desirable in some portions of the body, but is downright dangerous in the ear (von Tröltsch). Rupture of a middle-ear abscess must always be prevented by a *timely incision* of the membrana tympani. Cold compresses are to be preferred as an antiphlogistic remedy in the region of the ear. When, for example, the canal is obstructed, cold compresses changed every quarter of an hour, ice-bags with a dry cloth interposed between them and the skin, or "regulators" (Leiter coils) made of aluminium tubes applied around the ear, through which a constant stream of water at any desired temperature can be passed (Fig. 55), are employed. Cold compresses applied to the side of the neck diminish hyperemia of the auditory meatus by contracting the carotid artery (Winternitz). Cold is very effective in beginning mastoid periostitis; at first its effect is likely to be unpleasant, and in some cases it cannot be borne.

FIG. 55.—Aluminium "regulator."

7. **Inflation and Aspiration.**—Changing the air pressure. (For the effect of the air-douche see p. 104.) If the drumhead is perforated and the air in the auditory canal is condensed by fitting the glass tip of a Politzer bag into the external meatus and compressing the bulb, the air contained in the canal and in the middle ear is forced through the Eustachian tube into the nasopharynx (inflation), through the auditory canal (after Lucæ), and can be auscultated through the nose (Politzer). Inflation through the auditory meatus is employed for the removal

of secretion from the tympanic cavity when it is not desirable to enter through the nose. If the ear is filled first with water or a medicated fluid, the tympanic cavity will at the same time be flushed out (Politzer). The procedure must be resorted to only when the tube is patulous, as it might otherwise raise the intralabyrinthine pressure.

The pressure in the external auditory canal may be diminished (Cleland) by compressing Politzer's bag before introducing the glass tip into the meatus and gradually allowing it to expand. By this means a retracted drumhead is drawn outward, adhesions in the tympanic cavity are stretched or break down, exudate is aspirated through a perforation or paracentesis opening, excessive intralabyrinthine pressure (such as occurs after syringing the middle ear, for example) is neutralized, and subjective noises and vertigo are diminished. If the negative pressure becomes too great, hemorrhage and laceration of the drumhead may be induced. If the ear is sealed hermetically with cotton, the air in the auditory meatus is gradually rarefied and pressure removed from the drumhead, as, for instance, in chronic catarrh (Politzer). The pressure within the auditory canal may also be altered conveniently by means of Siegle's speculum or with Delstanche's masseur (Fig. 56) and rarefactor. If massage is employed, daily sittings or two sittings a week will suffice, the instrument being used about ten times at each sitting. The tip of the tube is fitted tightly into the meatus, and, by moving the metal cap (*a*) backward and forward, the pressure within the meatus can be increased or diminished.

FIG. 56.—Delstanche's masseur.

8. Massage.—Massage of the external ear is useful in hematoma. The skin should first be anointed with vaselin. Massage of the facial muscles in facial palsy, and of the neck in acute and chronic catarrh, is very useful. Its effect is partly to assist absorption and partly reflex. In massaging the neck the hand is carried from the mastoid process and parotid gland behind the ramus of the lower jaw, along the line of the sternocleidomastoid muscle downward as far as the clavicle; or a special apparatus consisting of a concussor attached to an eccentric handle and driven by a motor (Fig. 57, *a*) may be employed. Two

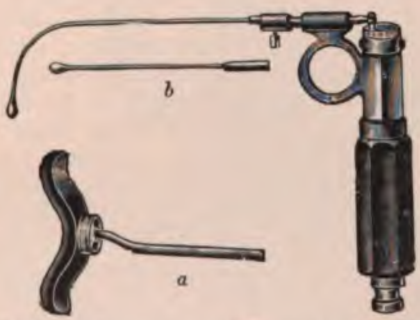

Fig. 57.—(*a*) Concussor for massage of the neck. (*b*) Eccentric handle with straight and curved nasal and post-nasal probe.

sittings a day, each of five minutes, are generally given. In chronic catarrh of the nose and Eustachian tube the mucous membrane may be massaged with a straight cotton-wound probe, the inferior turbinate having first been cocainized. For the orifice of the Eustachian tube a curved probe, introduced through the mouth, is used. Massage should be given daily, about 300 strokes to the minute (Laker, Urbantschitsch) (Fig. 57, *b*). Massage of the middle ear is followed by temporary improvement in adhesive processes within the ear—in chronic catarrh, after otitis media, in immobility of the stapes. It is occasionally useful in nervous deafness accompanied by rigidity of the sound-conduction apparatus. The simplest way of performing massage is by Hommel's method of pressing on the tragus. The tragus is pressed against the opening of the meatus and suddenly released in rapid succession. This is done four times a day, 120 times a minute. Better results are obtained with Delstanche's masseur, with which the air-pressure can be regulated; this should be used every day, about 30 times a minute. The movability of the chain of ossicles can be directly influenced by means of Lucæ's pressure probe (Fig. 58), the pressure of which can be regulated from 100 to 300 grams. A small pledget is held against the short process of the malleus and moved to and fro, at first from 2 to 10 times a day, later 100 times a day. The instrument can be driven by electricity. The head-mirror should be used. Rapid change in the air-pressure may be brought about by means of Breitung's air-pump, which is driven by a motor or driving-wheel (Figs. 59, 60). During the process the movement of the drumhead can be observed by means of a pneumatic ear-speculum (Siegle's speculum). If hyperemia appears in the middle ear, massage must be discontinued. The instrument may be driven at the rate of about 400 blows a minute, the length of the stroke not exceeding 2 mm. As a safety-valve to avoid any injurious effects, Lucæ recommends a small opening in the tube leading to the pneumatic speculum. Daily sittings of from five to ten minutes may be employed. The procedure is contraindicated by vertigo and severe

FIG. 58.—Lucæ's regulating pressure-probe.

tinnitus aurium, especially in persons suffering from nervous deafness, acute inflammation, or atrophy of the drumhead.

9. Electricity.—The constant or galvanic current is more frequently used in the treatment of aural diseases than is the faradic or induced current. In otalgia, espe-

FIG. 59.—Electric motor with Breitung's air-pump.

cially after acute inflammations, a strong faradic current lasting about three minutes is useful (Urbantschitsch). The galvanic current is used for the purpose of testing the irritability of the seventh nerve. In paralysis of the seventh nerve it should be used four times a week, two minutes at each seance. First the anode, then the cathode, is applied in front of the mastoid process, and later the muscles are stroked with the cathode (Strümpell). In the treatment of tinnitus, especially in nervous diseases, different electrodes are used; the positive electrode (anode) is usually applied to the tragus, and the negative electrode (cathode) to the back of the neck (rarely the electric probe is introduced into the Eustachian tube through the catheter). Erb's advice is to apply the current vigorously and persistently, while the irritation is such as is found by experiment to diminish the subjective noises or cause them to disappear altogether, usually during anodal closure and while the

FIG. 60.—Hand air-pump for massage of the drumhead.

anode remains closed, and to pass over as rapidly and lightly as possible the stages when the tinnitus is increased, which usually is during cathodal closure and while the cathode remains closed. Sometimes the reaction is reversed, the subjective noises being diminished by cathodal closure and during continuance of cathodal closure. If, therefore, anodal closure is found to diminish the tinnitus, the anode should be closed and the current allowed to flow from five to twenty minutes, after which the force of the current is diminished by means of a rheostat, taking care that no opening reaction takes place. If the tinnitus disappears during anodal closure, it is a favorable prognostic sign. The improvement in the hearing is, as a rule, less marked than that of the tinnitus and head symptoms. In rare cases the hearing becomes worse.

In using the galvanocautery (Schwartze) for the removal of granulations or the remains of polypi, and for making an artificial opening in the drumhead, platinum wires (Fig. 61), either pointed or with protected points, mounted on Schech's handle, are the best. After instilling a solution of cocain the point is applied to the desired spot and brought to a red-heat. Care must be used to avoid coming in contact with the walls of the meatus or labyrinth. Electrolysis through a catheter may be tried in atresia of the Eustachian tube and strictures of the auditory canal (Ostmann).

10. Ear-trumpets and Hearing Exercises.—Ear-trumpets are used for the purpose of assisting deaf persons to understand conversation. They collect the sound in the conic, funnel-shaped, or trumpet-shaped mouth, reinforce it, and conduct it into the ear. If the deafness is due to a labyrinthine affection and ankylosis of the stapes, flexible trumpets are to be preferred. In deafness due to suppuration metal trumpets are the best. When speaking into an ear-trumpet the speaker should moderate his voice and cease talking from time to time, otherwise the patient will experience tinnitus

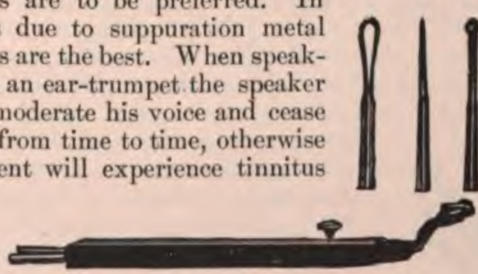

FIG. 61.—Schech's handle—platinum points.

and pain in the ear. The patient should pick out the ear-trumpet that suits him best; the most expensive instruments are not always the most serviceable ones. The simplest and best to recommend is Dunker's ear-trumpet

(Fig. 62). It is a soft tube 1 m. in length, with a conical mouth-piece and a pointed ear-piece. Shorter ear-trumpets are made of tin, leather, or hard rubber; the last are collapsible. An otophone is an instrument that is fastened to the side of the head and is supposed to turn the pinna forward so as to enlarge it and make it better adapted for catching the sound. It does about as much

FIG. 62.—Dunker's ear-trumpet.

good as placing the hand behind the ear. Ear-trumpets are often of distinct use to a deaf person in enabling him to understand conversation, but their effect, as a rule, is not lasting, and the artificial reinforcement of the sound, even in atrophy of the eighth nerve, is usually too unpleasant to be borne. A smaller instrument that can be worn in the ear has been devised by Politzer (Fig. 63). It holds the walls of the meatus apart and catches and reinforces the sound. Audiphones and dentaphones consist of discs of hard rubber or pasteboard that are to be held between the teeth. They are intended to be used in disease of the sound-conduction apparatus to make the fullest possible use of bone-conduction in place of air-

FIG. 63.—Politzer's ear-tube.

conduction. Their usefulness is usually indirectly proportional to the claims put forth by the manufacturers ("electric hearing spectacles!").

The hearing exercises recommended by Urbantschitsch for the purpose of shaking the eighth nerve out of its torpor may be of some use in functional disturbances, such as hysteria, but in organic disease they have no more value than seeing exercises in atrophy of the optic nerve. On the other hand, it is a very good plan to encourage persons who are hard of hearing to utilize what hearing remains to them as much as possible by attending the theater, going to concerts, and into society. After all power of hearing conversation is lost, an intelligent patient may be instructed to read the lips by a competent teacher of deaf-mutes. Great proficiency may be acquired in this art if the learner possesses the necessary patience.

11. **Treatment of the Nasopharynx.**—The nasopharynx plays an important part in the etiology of many aural diseases, and, therefore, frequently requires treatment as well as the ear. Many aural affections, especially acute catarrh, heal of their own accord after the nasal obstruction, which is the original cause, has been removed. The injurious effect of nasal disease on the organ of hearing is due to the habit of breathing through the mouth, which always accompanies nasal obstruction, to the direct compression of the pharyngeal orifice of the Eustachian tube, to insufficient ventilation of the tube, and to the danger of infection that exists in all inflammatory diseases of the nose and throat. Hence any suppurative condition in the nose and pharynx must be vigorously combated by treating the mucous membrane and the accessory cavities. The treatment includes the introduction of bougies, Politzerization, irrigation, the removal of obstructions by operative means, curetting, painting the interior of the nose with substances such as Lugol's solution, and insufflation of sodium sozoiodol, etc. Sprays are useful only when the nose or nasopharynx contains mucus, pus, or crusts that cannot readily be removed by blowing the nose. The patient

should blow each nostril separately. Irrigation is best performed with a small rubber bulb-syringe (Lucæ) or with an English klyso-pump. For instillations into the nose a teaspoon or Fränkel's nasal douche may be used.

The nasopharynx is best cleansed by gargling. The patient takes a mouthful of water, throws his head back, and takes deep breaths through the nose (Mosler). The nasopharynx can be cleansed directly by means of a spray with a bent nozzle, which can be introduced behind the uvula (Schwartze). The fluids to be used in spraying the nose and nasopharynx are a 1 per cent. solution of boric acid, 1 per cent. salt solution, borococain solutions, etc., at a temperature of 28° C. (82° F.). In spraying the nose the patient should drop the head forward; the nozzle of the spray is introduced in the more contracted naris and directed backward, taking care that the nozzle does not fit tightly into the naris. During the operation respiration is carried on through the mouth. If the spraying is done properly, the water will return through the other naris. The procedure is facilitated by making the sound *e* or *a*. The patient should not blow his nose for half an hour after spraying it. If some of the water gets into the ear, there is some danger of infection, and the patient should be told to swallow several times, so as to drain the tympanum through the Eustachian tube.

Acute inflammatory infections of the pharynx are treated by gargles and hydrotherapeutic compresses, chronic conditions by local application of silver nitrate, Lugol's solution, etc. Hypertrophied pharyngeal tonsils are troublesome in much the same way as are adenoid vegetations; they may exert direct pressure on the opening of the tube, or interfere with the action of the uvula and thus prevent proper ventilation of the tube. Hypertrophied tonsils are best removed with Mathieu's tonsillotome. An assistant takes the child on his lap, holding the child's head with the right hand, the hands with the left, and the legs between his knees. If the hypertrophy is slight, simple *incision* of the crypts with a guarded blade is sufficient.

Any pathologic condition in the nose or pharynx that interferes with nasal respiration, such as hypertrophic rhinitis, deviations, and outgrowths of the septum, polypi, polypoid hypertrophies of the ends of the turbinates, polypi in the nasopharynx, and adenoid vegetations must be removed by cauterization with trichloracetic acid, silver nitrate, chromic acid, the galvanocautery, or some other operative means. Temporary improvement may be achieved by massage of the mucous membrane, the instillation of menthol oil, spraying with cocain, inhalations of menthol-chloroform, and coryza powder.

In the treatment of hemorrhage from the nose packing with Bellocq's cannula is to be avoided as much as possible because tamponade of the nasopharynx is one of the most fruitful causes of purulent decomposition and infection of the ear by way of the Eustachian tube. The hemorrhage should be arrested at the bleeding point by cauterizing with chromic acid.

One of the most frequent diseases of the nasopharynx, and one that exerts a marked influence on the organ of hearing, is hyperplasia of the pharyngeal tonsils, diffuse and obstructive—so-called adenoid vegetations—Meyer (Pl. 21). Histologically, adenoid vegetations consist of reticular connective tissue the meshes of which are filled with lymphocytes and contain numerous germ-laden follicles. The surface is covered with ciliated cylindric or squamous epithelium. Adenoid vegetations are caused by chronic inflammation of the pharyngeal tonsil or by developmental anomalies, and appear to be more or less hereditary (Bloch); their development is favored by measles, scarlet fever, and tuberculosis (Trautmann). The hypertrophy frequently extends to the palatal tonsils; in such cases these should be removed first. Adenoid vegetations usually begin to evince symptoms in the second or third year; they interfere with the ventilation of the tubes, exert pressure on the vessels, and thus lead to congestion in the tubes and in the middle ear, and produce middle-ear catarrh, suppuration, partial deafness, and deaf-mutism. Failure to breathe through the nose is followed by a train of symptoms: the patient keeps his mouth constantly open, snores, complains of headache, is restless, does not sleep soundly, loses his appetite, and is unable to blow his nose. Infants are unable to nurse with comfort or to drink more than a mouthful at a time. Later on the speech becomes flat, the development of the bones is interfered with, and a high, narrow palate and anomalies

FIG. 64.—Gottstein's curet.

FIG. 65.—Beckmann's curet.

FIG. 66.—Trautmann's curet.

in the position of the teeth result. The term aprosexia is applied to a symptom-complex consisting of inattention, loss of memory, enuresis, and stammering. The lymphatic glands in the inferior triangle of the neck are often swollen (Thost). The diagnosis is made by the expression of the face, which, however, is common to any form of nasal obstruction, and by examining the nose. If the inferior nasal meatus is open, numerous nodules are seen in the posterior pharyngeal wall (Zarniko) that reflect the light and move upward during phonation. Probing with a sound is painless, and instead of the sensitive, resistant pharyngeal wall, a soft, movable tissue is encountered. The condition is usually accompanied by hypertrophic rhinitis. In older children postrhinoscopic examination reveals in the roof of the pharynx a diffuse swelling or the presence of fingerlike projections that obstruct the choanæ from behind and compress the pharyngeal openings of the tube. Sometimes adenoid vegetations can be seen hanging down behind the uvula by a mere inspection of the mouth. Mucus is often seen trickling down from the nasopharynx along the posterior pharyngeal wall, and even adenoid granulations are sometimes seen. Digital examination confirms, or in small children takes the place of, examination with the mirror.

Numerous instruments have been used for the removal of adenoids. In imitation of Meyer's curet Gottstein constructed a very serviceable three-cornered instrument, which is introduced directly into the postnasal space (Fig. 64). Beckmann's curet is quadrilateral in shape (Fig. 65). Trautmann has contributed a sharp curet (Fig. 66). Jurasz and others use a postnasal forceps bent at an obtuse angle (Fig. 67); Hartmann, a snare, and Schötz, an adenotome that works in a groove (Fig. 68). The swelling may be temporarily reduced by caustics, the insufflation of sodium sozoiodol, or the instillation into the nose of a 5 per cent. solution of menthol in oil, but, as a rule, operative removal is necessary. Children may be held on the lap, or, if they are very unruly, slightly chloroformed in a half-sitting posture or with the head falling forward. In adults the uvula and posterior pharyngeal wall, with the exception of the pharyngeal tonsil itself, is anesthetized with a 20 per cent. solution of cocain. Under strong illumination with the head-mirror the tongue is depressed with the left hand, the curet introduced with the right behind the soft palate, between the uvula and the tonsil, and the handle depressed so that the curet touches the vomer in front. The instrument is then forced against the roof of the nasopharynx and carried downward, first in the median line, with moderate force, so as to cut away the central portion of the adenoid. Two more strokes are then made to the right and left, in Rosenmüller's fossa, taking care not to go out too far so as to avoid the tubal fold.

After removing the curet, which must be done with care so as to avoid its catching on the soft palate, the

FIG. 67.—Jurasz's postnasal forceps.

patient should lean forward and blow each naris separately. Usually there is a severe hemorrhage lasting several minutes, and the tonsil is often swallowed along with blood and mucus. The postnasal forceps is introduced into the postnasal space with the blades closed, and after it is in place the blades are separated so as to seize the tonsil and draw it downward. If the tissue does not

FIG. 68.—Schötz's adenotome.

give way at once, the blades should be opened again so as not to injure any other tissues (vomer, soft palate). This operation should always be followed by a thorough curetting. In the case of infants, a small postnasal forceps is the most useful instrument. After the operation the nose and ears are tamponed and the child is ordered to bed for twenty-four hours. It should remain in the house for three days. For the first two days it should take only lukewarm liquid nourishment, such as milk, eggs, and soup, and gargle with a solution of potassium permanganate—one crystal to ¼ liter of lukewarm water. If there is pain, cracked ice may be given. In rare cases the operation is followed by severe hemorrhage, which may require packing of the postnasal space. Occasionally the operation is followed by acute otitis media. Adenoid vegetations should not be removed during the painful stage of an acute otitis media; otherwise, suppuration from the middle ear is no contraindication. During the after-treatment oil of menthol is instilled into the nose, and, if there is much swelling, the turbinates may be touched with caustic. The results of the operation begin to show themselves in from three to four weeks, and can be determined by inspection with a mirror and by digital examination. Recurrences are not uncommon. It takes some time for the children to accustom themselves to keeping the mouth closed; if necessary, they should wear a respirator or a Schmidt's nose dilator.

12. **Constitutional Treatment.**—If the aural affection is due to a general disease, the local measures must be supported by treatment of the entire organism. Lues, scrofula, tuberculosis, anemia, chlorosis, digestive disturbances, etc., call for the appropriate dietetic and medicinal treatment. Climate frequently exerts a marked influence on aural diseases. Middle-ear catarrh with aural discharge may improve where there is plenty of forest. A high climate, such as that of the Alps, exerts a favorable influence on nervous deafness and stapes ankylosis, and the patient's hearing undergoes a temporary improvement. The seashore is beneficial for scrofulous and tuberculous forms of aural disease, but unsuitable for ankylosis of the stapes and any disease accompanied by marked subjective noises. In addition to climatic treatment a bath or mineral-water cure is of advantage. A four to six weeks' course of sool-baths at a temperature of from 25° to 30° C. (77° to 86° F.), each bath lasting from ten to twenty minutes, one every second or third day, diminishes the

tendency to relapsing middle-ear catarrh and inflammation, especially in scrofula and anemia. (Strong saline waters, Berlin, Harzburg, Ischl; saline waters containing iodids and bromids, Kreuznach, Hall, Krankenheil-Tölz; carbonated ferruginous waters, Schwalbach, Pyrmont, Elster. For aural affections the result of respiratory diseases, alkaline mineral waters, such as those of Ems, Bilin, Vichy; for affections the result of digestive disturbances, Epsom and bitter waters, Karlsbad, Marienbad, Franzensbad. For nervous deafness with marked subjective noises, simple saline springs, Baden-Baden, Homburg, Kissingen; or, simple hot springs, Warmbrunn, Teplitz, Gastein.)

Patients suffering from aural disease should always stop up their ears before taking a bath. Diving, jumping into the water, cold douching, or any vigorous hydropathic measures must not be indulged in. Cold sea-baths are often followed by ill results, especially in ankylosis of the stapes. Warm sea-baths have a curative effect in chronic middle-ear catarrh and in ankylosis due to scrofula and rachitis. Lukewarm baths at 26° C. (79° F.) twice a week have a sedative effect on subjective noises. Russian baths are often very harmful, especially in ankylosis of the stapes. Persons troubled with subjective noises should eschew hot beverages, the use of alcohol, tobacco, coffee, and tea, and avoid overexertion and the wearing of tight clothing.

(f) **General Hygiene of the Ear.**—The body should be hardened by sponging (all but the head) with water at from 7° to 8° C. (45° to 47° F.), by taking regular exercise, and by sleeping with open windows.

Healthy ears should never be closed with cotton; it is indicated only when there is a perforation of the drumhead. During washing or bathing, water should never be allowed to enter the ear, whether it be sound or diseased. The ears should be dried carefully after washing to avoid the development of eczema and frost-bites, to which children are especially subject. Scratching the meatus with a pencil, hair-pin, ear-spoon, etc., the instillation of chloroform, ether, or oil, the introduction of foreign bodies, such as onions or garlic as counterirritants in toothache, are harmful and often lead to painful inflammations. Unsuccessful attempts at removing a foreign body from the ear usually end in thrusting it in further. Boxing the ears is apt to produce lacerations of the drumhead or concussion of the labyrinth. The practice of perforating the lobe of the ear for the purpose of wearing ear-rings is a fruitful cause of inflammation. The best way to remove ear-wax is with the end of a towel or with an ear-spoon, which, however, must never be introduced deeply into the ear. Cataplasms and fomentations for the relief of otalgia are harmful. Over-indulgence in alcohol and tobacco injures the auditory nerve. If the individual is exposed to intense auditory impressions, he should close the ear tightly with cotton. This applies to boiler-makers and gunners. Nervous persons may protect themselves against the noise of the streets by wearing an antiphone (Fig. 69), consisting of a sphere that occludes the auditory meatus. Syringing the ear or nose with piston syringes of doubtful cleanliness is harmful. The nose should be cleansed by blowing each naris separately, the other being firmly closed. Otherwise the air is forced into the ears and the mucus remains in the nose. The teeth should be cleansed after each meal and especially before going to bed, the mouth being thoroughly rinsed, and the throat gargled with a 2 per cent. alcoholic solution of salol. Carious teeth should be extracted; and false teeth should be removed during the night. The nasal passages must be kept open. Nervous patients should not choose an occupation that overtaxes the hearing, such as telephone operating, especially if they are already suffering from aural disease, as overexertion of the hearing is apt to bring on grave nervous troubles, or even a psychosis.

FIG. 69.—Antiphone.

B. SPECIAL PATHOLOGY AND TREATMENT.

(The diagnostic and therapeutic measures mentioned in this section are described on pages 70 to 147; formulas will be found in the Appendix.)

I. Pathology and Treatment of the Sound-conduction Apparatus.

A. Diseases of the External Ear.—(**a**) **Diseases of the Pinnæ.**—The diseases of the pinnæ, if we disregard malformations, neoplasms, and injuries, affect the cutaneous covering more than the cartilage. They do not interfere with the power of hearing unless the swelling is such as to occlude the opening of the meatus. They may, however, extend to the adjoining tissues, and thus threaten both the hearing and the patient's life.

1. **Hyperemia.**—*Etiology.*—Cold, heat, diseases of the skin, venous congestion, as in cardiac disease, angioneurosis of the sympathetic nerve, and disease of the middle ear attended with the production of adhesions.

Symptoms.—Redness and heat of the pinnæ. In angioneurosis the symptoms are generally unilateral, come on in paroxysms, and are accompanied by tinnitus and vertigo.

Treatment.—Cold compresses, dusting-powders, Unna's ointment. In angioneurosis galvanization of the cervical sympathetic.

2. **Traumatic Dermatitis.**—*Etiology.*—Infection after injuries (piercing the ear, laceration by ear-rings), insect bites.

Symptoms.—Redness, swelling of the skin in the neighborhood of the injured point, with pain and a feeling of tension; rarely, circumscribed cutaneous gangrene, manifesting itself by black color and loss of sensation in the skin.

Treatment.—Disinfection of the injured spot, ice compresses, compresses saturated with aluminium acetate, and, if borne, absolute alcohol.

3. Dermatitis Erysipelatosa.—*Etiology.*—Invasion of the skin by the streptococcus erysipelatos (Fehleisen), favored by abrasion of the cutis, due to eczema, particularly in a perforated lobe, or an acne pustule that has been opened. It is frequently secondary to facial erysipelas.

Course and Symptoms.—*General Symptoms.*—Fever up to 40° C. (104° F.), headache, involvement of the sensorium. *Local Symptoms.*—Marked redness, swelling and pain in the pinna and immediate surroundings; the skin is shiny, tense, and sometimes covered with vesicles containing a serous fluid; glandular enlargement is present. Recovery occurs in about eight days; rarely, suppuration or gangrene.

Treatment.—Cooling ointments, dusting-powders, compresses of absolute alcohol.

4. Dermatitis Phlegmonosa et Gangrænosa.—*Etiology.*—Infection of the skin, usually after infectious diseases (typhoid), particularly in reduced patients.

Course and Symptoms.—Fever, intense pain, knocking sounds in the ear, circumscribed or diffuse redness, and swelling of the entire pinna. At the end of three or four days fluctuation develops. Purulent perichondritis may ensue and destroy the cartilage, fistulæ may form, or gangrene may set in. Primary gangrene of the pinna rarely occurs as the result of vascular degeneration in the course of some grave disease, usually shortly before death.

Treatment.—At first ice compresses; when fluctuation develops, deep incision and drainage with strips of iodoform gauze. The dressings should be changed every day. In gangrene the system must be supported by tonics, and necrotic areas removed and aseptic bandages applied. For the pain, morphin sulphate 0.01 gm. (gr. $\frac{1}{6}$) hypodermically.

5. Dermatitis Congelationis et Combustionis (Frost-bite and Burns).—*Etiology.*—Abnormally thin skin, impaired circulation, particularly in chlorosis or in the cardiac deficiency of old age. The pinna may freeze even in moderately cold weather. Scalding of the ear is usually due to hot water or to hot vapors.

Course and Symptoms.—In burns there are pain, heat, redness, and swelling, with an intense itching sensation. Vesiculation and even gangrene may result. In frost-bite circumscribed chilblains, excoriated nodules, especially at the margin of the helix, and sometimes large blebs with hemorrhagic contents and scattered areas of gangrene are produced. Mild cases recover, but if the injury is severe, great deformity and extensive cicatricial contractions result.

Treatment.—For superficial burns dusting-powders and an aseptic bandage or compresses of equal parts of lime-water and linseed oil (carron oil). For severe burns dressing with a 3 per cent. aqueous solution of boric acid or a 2 per cent. solution of acetate of aluminium. Granulations near the mouth of the canal or on the ear itself should be touched with argentic nitrate to prevent adhesions. Sometimes skin-grafting after Thiersch is required. To hasten epithelialization the wound may be dressed with boric acid or silver nitrate ointment. Mild frost-bite may be treated by cold compresses, or compresses wrung out in hot water slightly acidulated with vinegar. The injured areas may be painted with tincture of iodin or traumaticin if the epiderm is intact. The itching is relieved by camphor ointment. If the skin is excoriated, zinc oxid plaster mulls should be applied. In severe frost-bite the necrotic portions must be cut away and the wound dressed antiseptically. Circumscribed ulcers are first cauterized with silver nitrate and then dressed with silver nitrate ointment.

6. **Eczema.**—*Etiology.*—Eczema is produced by any external irritant acting on the skin, such as otorrhea, instillations into the ear, cantharides applied behind the ear, irritating dust, as among metal-workers, iodoform dressings, and the wearing of ear-rings. It occurs secondarily to eczema of the face, pediculosis capitis, and when-

ever the resisting power of the skin has been impaired, as in diabetes, dyspepsia, or dysmenorrhea.

Course and Symptoms.—The eczema begins with itching and a feeling of heat. In children the onset is often attended with fever. The lesions at first appear as small, reddish elevations (papules), most numerous on the posterior surface of the pinnæ. The papules become converted into vesicles and pustules. The latter burst, and the weeping form of eczema is produced (rhagades). As the secretion dries, crusts are formed. If the inflammation subsides after the erosions have been covered with skin, desquamation ensues. The acute form lasts from four to six weeks, and usually ends in recovery. If the original cause persists, eczema of the moist variety ensues. The lymphatic channels may become obstructed and lead to elephantiasis of the pinna, especially of the lobe. Stricture at the mouth of the meatus may be produced by adhesions of excoriated areas lying opposite one another. Chronic eczema is more refractory to treatment than is the acute form, and is very likely to recur.

Treatment.—Removal of the cause, such as pediculosis, by washing the head with a 5 per cent. solution of corrosive sublimate in dilute acetic acid. The patient should not be allowed to irritate the skin by scratching or washing. Acute eczema yields to a simple dusting-powder. The moist variety requires an ointment, such as diachylon, zinc oxid, 1 per cent. ichthyol, or salicylic acid; or a zinc oxid plaster mull may be applied. In chronic moist eczema the part should be bandaged with some ointment, such as diachylon or Wilson's ointment. Crusts may be softened by applying compresses of a 2 per cent. solution of boric acid or acetate of aluminium, or with fresh olive oil. The ointment remaining from the dressing should be removed with cotton dipped in olive oil, not with water. If this fails to cure the condition, the ear must he washed thoroughly with Hebra's tincture of soap before the bandage is applied. A chronic, dry scaly eczema should be treated with one or two daily applications of tar, either in the form of a tincture (liquor carbonis detergens) or as a plaster. Obstinate cases may be cured by the use of chrysarobin ointment or by cauterization with a 1 to 10 per cent. solution of silver nitrate, followed by the application of white precipitate ointment. The general treatment embraces iron, cod-liver oil, etc., and a strict regulation of the diet.

7. **Herpes.**—*Etiology.*—It rests on a nervous basis. Simple herpes follows a cold or an ordinary dermatitis. Herpes zoster, when on the anterior surface of the pinnæ, is due to neuralgia of the auriculotemporal nerve; when on the posterior surface, to neuralgia of the auricularis magnus.

Course and Symptoms.—Groups of vesicles appear, attended with heat, itching, and fever, particularly around the lobe and helix, where the skin is reddened, swollen, and painful. The glands in front and behind the ear are enlarged. Recovery occurs in about two weeks, the vesicles drying up; rarely, they undergo ulceration. Herpes zoster is usually unilateral and does not recur. In rare cases it is accompanied by paralysis of the seventh nerve.

Treatment.—Dusting-powders, diachylon or morphin ointment, boric acid ointment. For pain, hypodermic injections of morphin.

8. **Lupus Vulgaris.**—*Etiology and Pathology.*—Local tuberculosis of the skin of the ear, either primary or, more frequently, secondary to lupus of the face. Microscopically, diffuse infiltration and nodules consisting of plasma-cells, leukocytes, and giant-cells, and containing the tubercle bacillus, are found. The nodules undergo central caseation and ulceration, or resolution and cicatrization result.

Course and Symptoms.—It usually begins in youth. Reddish-brown, desquamating nodules, somewhat depressed below the level of the skin, are first noticed. These disappear and leave atrophic scars, or else they develop into flat ulcers the floor of which consists of a spongy, granulating, bleeding mass. The margins are clear cut; the ulcers are usually covered with crusts.

The infiltration may extend more deeply and invade the cartilage. The skin becomes undermined so that the pinna is converted into an ulcer only partially covered by skin and adherent to the side of the head (Plate 15). Even if recovery ensues, the pinna remains greatly disfigured.

Treatment.—The granulations should be destroyed with the galvanocautery, by the solid stick, by exposure to the Röntgen rays, by the injection of tuberculin, or by excision, including some healthy tissue; the latter procedure to be followed by skin-grafting.

9. Syphilis.—*Etiology.*—Primary infection of the pinna itself, by kissing, scratching, or biting, is rare. The surgeon is more likely to meet with secondary or tertiary phenomena in connection with general symptoms.

Course and Symptoms.—The primary lesion is an ulcer with indurated base and abrupt, indurated edges, with a somewhat depressed center. The lymph-glands are greatly enlarged. In secondary syphilis papular eruptions appear on the pinna in connection with a general cutaneous eruption; or ulceration, particularly at the helix, the entrance of the meatus, and around the perforation in the lobe, may be present. Gumma of the ear manifests itself in thickening and ulceration of the auricle, which at first may be confounded with perichondritis.

Treatment.—Inunctions of mercurial ointment; potassium iodid (5 to 10 : 200) internally; ulcers to be dusted with calomel powder and touched with silver nitrate or dressed with silver nitrate ointment. Carbolic acid and mercurial ointment plaster-mulls may be applied.

10. Othematoma.—*Etiology and Pathology.*—Spontaneous or traumatic laceration of the blood-vessels of the perichondrium with the formation of a fluid effusion between the cartilage and the perichondrium, and in the body of the cartilage. It is favored by softening, vacuolization, and brittleness of the cartilage, such as occurs in old age and in insane individuals.

Course and Symptoms.—On the anterior surface of the pinna, usually in the triangular fossa, a rapidly growing, fluctuating swelling suddenly makes its appearance and may occasionally involve the entire anterior surface of the pinna, leaving only the helix and lobule free. The skin is bluish-red. On transillumination the swelling is found to be opaque. Swellings of spontaneous origin are usually smaller than those due to traumatism. The condition is generally painless. Resorption of the blood is followed by recovery, or, if there is much shrinking of the cartilage, cicatricial contractions and distortions of the pinna (Plate 15). In rare cases, when the integrity of the skin is destroyed, the hematoma suppurates.

Treatment.—Cold compresses, multiple punctures with a small bistoury, under aseptic precautions. Pressure bandage with a pad behind the pinna. If suppuration occurs, incise and remove any necrotic pieces of cartilage. After the third week, massage fifteen minutes a day.

11. **Cysts.**—*Etiology and Pathology.*—When the cartilage undergoes softening, collections of a serous or slightly yellowish exudate are found in the spaces of the cartilage and underneath the perichondrium (Hartmann).

Course and Symptoms.—Without pain or inflammation a swelling gradually develops on the anterior surface of the pinna. It occurs most commonly in males during the prime of life. Recovery in two weeks, without deformity.

Treatment.—Exploratory puncture followed by evacuation of the fluid ; drain with sterile gauze ; apply bandage.

12. **Perichondritis.**—*Etiology.*—Infection following a traumatism, burns, after plastic operations on the auditory meatus, and after otitis externa and media ; rarely in tuberculosis.

Course and Symptoms.—As in othematoma, but more slowly, a dark red, at first doughy, and later fluctuating, swelling develops on the outer surface of the pinna and is attended by intense pain. The skin is hot. As a rule, the entire pinna is involved and the swelling ceases abruptly at the lobe. Depending on the intensity of the process and the extent of cartilage involved the perichondritis ends either in recovery or in necrosis of the cartilage and disfigurement of the pinna. The exudate at first resembles synovial fluid; later it becomes purulent. In tuberculosis we find much granulation tissue that may contain tubercle bacilli.

Treatment.—At first ice compresses or cold wet dressing. If there is fluctuation, incise and remove necrotic cartilage. Drain and apply dressing. In tuberculosis, injections of glycerol of iodoform.

(b) **Diseases of the External Auditory Meatus.**—Diseases of the auditory meatus frequently follow diseases of the external or middle ear. If the lumen of the canal becomes completely occluded, the power of hearing is seriously impaired. In that case the functional test yields the signs of slight impediment to the sound-conduction apparatus: Rinne partially negative; Weber in the diseased ear; Schwabach moderately prolonged. Diseases of the auditory meatus may extend to adjoining regions (the parotid gland, the articulation of the jaw, the middle fossa of the skull, the mastoid process), or the converse may take place. It is important, in all inflammations of the auditory meatus, to exclude participation of the middle ear. This is done: (1) By means of the otoscopic findings (movement of the drumhead by Siegle's pneumatic speculum); (2) by the nature of the pus removed by irrigation (mucopurulent discharge always comes from the tympanum); (3) by the degree of auditory disturbance, which is less in diseases of the auditory canal than when the disease is more deeply situated.

1. **Hyperemia** affects only the bony portion, and follows inflammatory processes in the meatus and middle ear. If it persists for some time, it favors the accumulation of cerumen.

2. **Eczema.**—Usually accompanies eczema of the pinna. *Treatment* is the same as that given for that condition,

page 151. The medicinal substance is introduced on a cotton tampon or strip of gauze, so as to prevent adhesion between excoriated areas on opposite walls. Dusting-powders are introduced with the insufflator. In scaly eczema the parts should be painted with a 10 per cent. solution of silver nitrate. Itching is relieved by white precipitate ointment. If the canal is occluded by the adhesion of crusts, or if there is fetid discharge, it must be syringed with a 3 per cent. solution of boric acid, and the crusts softened with olive oil or menthol vasogen before any local application is made.

3. **Herpes.**—Accompanies herpes of the pinna. To be treated with boric acid ointment on strips of gauze.

4. **Syphilis.**— Usually secondary, rarely tertiary or primary; often accompanies syphilis of the pinna. By the breaking-down of broad condylomata, usually found on the anterior cartilaginous walls of the canal, crater-shaped ulcers with soft floors and granulating edges are produced. The lumen is obstructed, and there is a fetid, serous secretion. With the onset of ulceration violent pain develops, and there is marked glandular enlargement. Recovery occurs with or without stricture of the canal. Diagnosis is based on general examination.

Treatment.—Constitutional. Syringing with a 5 per cent. solution of formalin, packing with iodoform gauze. The granulations are touched with the solid stick. Insufflation of boric acid and application of the small ear-dressing (see p. 130).

5. **Otitis Externa Circumscripta** (**Furuncle**).—*Etiology.*— Infection of the hair-follicles by the staphylococcus pyogenes (Plate 30) through excoriations of the skin, as in eczema, scratching the ear, instillations, the use of ear-spoons, and contaminated ear specula. It also follows otitis media, particularly when the resisting powers of the body are at low ebb, as in diabetes. Relapses frequently occur by auto-infection of contiguous portions of the skin, and the infection may be carried from one ear to the other.

Course and Symptoms.—The patient suffers violent pain in the ear, head, throat, and teeth; he complains of insomnia. The pain usually subsides toward morning. Soon a reddish, painful prominence appears in the cartilaginous, or more rarely in the bony, portion of the meatus. The pain is increased by traction on the ear, by opening the mouth during eating, and by yawning. Unless resolution takes place within two days, the hair-follicle breaks down, and on the fourth or the fifth day the swelling points and a plug of necrotic tissue is extruded. Recovery occurs in about eight days. The surrounding skin is reddened; sometimes a furuncle is found on the opposite wall. Rarely the destructive process extends to the periosteum, and a circumscribed periostitis with superficial necrosis of the bone or granulating fistula results. In rare cases the furuncle bursts through the posterior wall of the canal into the mastoid process (periostitis mastoidea) or through the floor into the retromaxillary fossa, or through the roof into the middle fossa of the skull. Sometimes there is high fever and the mastoid process is edematous. (In mastoiditis we have infiltration without marked rise of temperature.) The lymphatic glands in front of the tragus are enlarged—no enlargement occurs in mastoiditis. Deafness is greater in otitis media than in otitis externa. Pressure on the mastoid process is usually painless in otitis externa, but distinctly painful in mastoiditis. In children otitis media is more frequent than otitis externa.

We distinguish a furuncle on the posterior bony wall of the meatus from the rather shallow bulging of the roof and posterior wall that occurs in mastoiditis by the course of the disease and by palpation with a probe. From deep granulating fistulæ furuncles are distinguished by the comparative absence of elevation, and from exostoses by their softness. The differential diagnosis between a furuncle on the anterior wall and an abscess of the parotid gland rupturing into the auditory meatus is based on the clinical course and possible causal connection between the disease of the auditory meatus and the swelling in front of the ear (pus is forced out by pressure on the parotid). It is important to examine without the speculum in otitis externa in order to avoid pain.

Treatment.—Rest. The diet should be bland; all alcoholic beverages must be interdicted. Internally, 0.5 gm. (8 grains) of phenacetin; morphin, 0.01 gm. ($\frac{1}{6}$ grain) hypodermically; leeches in front of the tragus; sedative inunctions around the ear with such substances as chloroform oil. In the beginning of the otitis externa cold compresses of 3 per cent. solution of acetate of aluminium or ice compresses are serviceable. Cataplasms are contraindicated. The ear may be painted with iodin, and an alcoholic solution of corrosive sublimate instilled into the ear. If pus is discovered, the furuncle should be incised. The necrotic plug is delivered by pressing on the base of the swelling with the probe. A strip of gauze saturated with aluminium acetate is then introduced into the incision, and the treatment with cold compresses continued. The next day instillations of an alcoholic solution of boric acid three times a day are begun, to prevent recurrence. This should be continued two or three times each week until recovery is complete. Granulations at the margin of the furuncle should be touched with the solid stick or removed with a snare or a sharp spoon. To allay the itching, white precipitate ointment is introduced on a tampon. If the furuncles continue to recur, ear baths with a 1 per cent. solution of potassium sulphate for four weeks (Schwartze) should be given.

FIG. 70.—Politzer lancet for furuncles.

6. **Otitis Externa Diffusa.**—*Etiology.*—The same as for the circumscribed form, which it occasionally follows. It

often occurs after the extraction of foreign bodies, burns, and the removal of epithelial plugs, etc.

Course and Symptoms.—The symptoms are more marked than in the circumscribed form, as the greater portion of the skin, especially in the bony portion of the meatus, and sometimes the periosteum also, is involved. The lymphatic enlargement is greater. There is edema of the mastoid process. The canal is reddened, and the lumen is obstructed by maceration and swelling of the epidermis. Sometimes the epidermis separates in layers or as an entire cast of the canal. Granulations frequently occur here and there on the corium. There is a seropurulent and often a fetid discharge. The inflammation may extend to the drumhead and the epidermis of that structure become opaque and fissured. In some cases the subjective symptoms and the swelling of the walls of the meatus subside, whereas the secretion continues and becomes chronic. In rare cases the drumhead softens, a perforation is formed, and the tympanum becomes infected. Extension to the cranial cavity is rare. Stricture of the meatus may result from hypertrophy of the corium and ossifying periostitis, or atresia may develop by adhesions forming between excoriated surfaces on opposite sides of the canal.

Treatment.—The same as for the circumscribed form. The cause of the trouble should be removed, if possible (incision of the walls of the canal to relieve tension is of no avail). Strips of gauze saturated with an alcoholic solution of boric acid or aluminium acetate may be introduced into the canal, or ear-baths in absolute alcohol or an alcoholic solution of sublimate may be ordered. Granulations should be cauterized. If there is a fetid discharge, the canal is syringed with a 3 per cent. solution of boric acid and carefully wiped, after which boric acid powder should be insufflated. A small dressing should be applied over the ear.

7. **Otitis Externa Hæmorrhagica.**—*Etiology.*—Otitis externa or media, especially in influenza; traumatism due

to sudden diminution in the air pressure of the auditory meatus.

Course and Symptoms.—The patient complains of pain and tinnitus aurium. On the bony floor of the meatus linear dark-blue vesicles develop, which quickly collapse when touched with a probe. Rupture of the vesicles is followed by the discharge of a hemorrhagic exudate. Recovery occurs in about two weeks.

Treatment.—Incision of the vesicles, insufflation of boric acid, and small ear-dressing.

8. Otitis Externa Cruposa.—*Etiology.*—Usually follows otitis media and externa in otherwise healthy individuals.

Symptoms and Course.—There is violent pain, and the bony portion of the canal becomes covered with a yellowish membrane consisting of fibrin and recurring after removal. Prognosis is good; recovery occurs in two weeks.

Treatment.—The membrane should be removed with a syringe or with a forceps. This is very easily done. Insufflation of boric acid and small ear-dressing are useful.

9. Otitis Externa Diphtheritica.—*Etiology.*—Infection with the diphtheria bacillus usually by way of the middle ear, in scarlatinal diphtheria, pharyngeal diphtheria, or by way of the external meatus in epidemics of diphtheria.

Course and Symptoms.—The walls of the canal are covered by a dirty gray membrane containing the diphtheria bacillus. In primary diphtheria the membrane is painful. It is removed with difficulty and leaves a bleeding, lacerated surface. There is a thin, purulent secretion. The pinna is reddened and occasionally the seat of ulcers. Lymphatic enlargement in front of the ear and in the neck. Fever, if it is complicated with diphtheria of the middle ear. There is no pain, but the prognosis is less favorable than in primary diphtheria. Separation of the membranes is followed by recovery with or without stricture of the canal. The non-diphtheric epithelial membranes that sometimes occur in otitis media are easily removed and do not leave a bleeding surface.

Treatment.—Constitutional—injection of serum and local treatment of the throat. Locally, ear-bath of lime-water, lasting one-half hour, one every hour, followed by irrigation with a 3 per cent. solution of boric acid and the insufflation of equal quantities of boric and salicylic acid. When the symptoms begin to subside, instillation of alcoholic solution of salicylic acid.

10. Otitis Externa Desquamativa (Epithelial Plugs; Cholesteatoma of the External Auditory Meatus).—*Etiology and Pathology.*—Desquamative inflammation of the skin of the auditory meatus, either idiopathic or after chronic hyperemia. Microscopically, the epidermal layer is found to be atrophic, and the stratum corneum thickened; the latter is covered by successive wavy layers consisting of large polygonal horny cells of squamous epithelium without nuclei. In places the cuticle shows round-cell infiltration. The hair-follicles are dilated and filled with layers of horny cells (Plate 35).

Course and Symptoms.—Tinnitus aurium and impaired hearing when the meatus is occluded. Sometimes pain and fever suddenly come on from maceration of the contents, as after a bath. The auditory canal contains whitish masses, arranged in layers like an onion, firmly adherent to the walls of the canal. If the accumulated material is very great, the pressure on the adjoining bone may lead to atrophy, so that the canal becomes considerably dilated, especially behind and above (Plate 27). Sometimes there is a dilatation of the floor and anterior wall, if there happens to be a spot where ossification has become arrested. Rarely there is an accompanying otitis media. The cholesteatomatous masses can sometimes be drawn out of the ear like a ribbon, but as they easily tear, their removal is often difficult.

Treatment.—The epithelial masses should be softened with glycerin and alcohol, and the canal syringed with a 1 per cent. solution of sodium bicarbonate. Sometimes it may be advisable to soften the plug and separate it from the wall of the canal with a probe. It is not always possible to remove the entire mass at one sitting. Sometimes it may be necessary to use a foreign-body forceps, or to anesthetize the patient and curet the canal with a sharp spoon. After the plug has been removed, instillations of alcoholic solution of boric acid should be kept up for six weeks.

11. **Otitis Externa Parasitica; Otomycosis.**— *Etiology and Pathology.*—Fungous growths, usually from the aspergillus niger, in the auditory canal. They are, as a rule, due to excoriation of the epithelium and serous exudation after inflammatory conditions. They are also favored by instillations of oil, etc. The mycelium (Plate 30) penetrates as far as the rete Malpighii, and in rare cases leads to otitis media. The mycelium consists of desquamated pavement epithelium, tubules with double contours (hyphen), and spheric, blackish spores (conidia). Here and there a hyphen projects from the mycelium with a knob-like extremity (receptaculum). The latter is surmounted by cylindric cells (sterigmata), arranged in a radiating group. The prolongations of the cells contain spores that have separated from the sterigmata. The entire knob-like structure is known as the sporangium.

Course and Symptoms.—The condition is most common in the poorer classes. It begins without any subjective symptoms or with the symptoms of an otitis externa. Invasion of the rete Malpighii by the fungus occasions itching, tinnitus, and pain. If the auditory meatus becomes occluded, the hearing is impaired. Pieces of skin of a dirty-white color may be removed from the ear with the ear-spoon. Within the meatus whitish masses of epithelium that look as if they were sprinkled with soot or epithelial shreds are found. After the material has been removed, the canal appears reddened and in places excoriated. Recovery may occur in a week or be delayed for months. The diagnosis is confirmed by microscopic examination. Relapses are common.

Treatment.—Scratching, washing, or any other procedure that would injure the ear is to be forbidden. The shreds of tissue must be removed with a probe, forceps, or syringe. Alcoholic solutions of corrosive sublimate or salicylic acid should be injected every day for four weeks, and continued twice a week for six weeks following recovery.

Among the rarer conditions in the external ear are mold-fungi (*eurotium repens*), pityriasis versicolor, psoriasis, pemphigus, actinomycosis, and pseudoactinomycosis.

12. Anomalies of Secretion.—*Etiology.*—Rapid secretion and accumulation of cerumen when the ceruminal glands are abnormally active as a result of hyperemia and overnutrition. This occurs after eczema, in otitis media, and when the ear is cleansed too frequently. Diminution of the secretion in atrophy of the glands and in trophic disturbances (ankylosis of the stapes).

Course and Symptoms.—When the secretion is diminished, the soft, brownish cerumen is replaced by whitish granular material. In entire absence of secretion the skin of the canal is dry and scaly and itches. Occasionally in children the cerumen is fluid, like pus, and emits a fetid odor ; in such cases there is some danger of mistaking the condition for an otitis media. The commonest condition is occlusion of the auditory meatus by a brown plug of cerumen, which may be soft or as hard as a stone, and contains a matted mass of epithelium and hair. The plugs may attain to considerable size and contain cholesterin crystals, pathogenic micro-organisms, and, occasionally, small foreign bodies and chalk (otoliths). They may give rise to constitutional manifestations, nervousness, vertigo, neuralgia, or epilepsy. The principal local symptom is a sudden onset of deafness following complete occlusion of the canal by maceration of the plug after bathing or profuse perspiration. The pressure on the drumhead produces tinnitus aurium. If a suppurative otitis media exists, the plugs may lead to retention of the pus and sometimes to meningeal irritation.

The prognosis should be guarded before removal of the plug; after it is removed, the wall of the canal appears scaly, sometimes excoriated in spots, and covered with granulations and secretion. The plugs are occasionally covered with epithelium. Their removal is often followed by temporary tinnitus, vertigo, and hyperesthesia. The hearing should not be tested finally until two days have elapsed.

Treatment.—If the plug is soft, it may be removed with a syringe, if necessary, after loosening it with a probe or prying it off with an ear-spoon. If the plug is hard, it must first be softened by injecting a glycerinated solution of sodium bicarbonate for three days. After the canal has been syringed, a piece of cotton should be worn until evening. Granulations are to be touched with chromic acid. Insufflation of boric acid; small ear-dressing. To guard against recurrence, boroglycerin should be instilled for four weeks after recovery.

FIG. 71.—Schmidt ear-spoon.

13. **Foreign Bodies.**—*Etiology.*—Foreign bodies may get into the canal accidentally while the patient is asleep,—as, for instance, the forficula auricularis,—or they may be put in purposely for the relief of toothache (garlic). Children often put things into their ears in a spirit of mischief or to relieve itching.

Course and Symptoms.—The foreign body may be soft and swell up,—as a pea, for instance,—or it may be hard, as a pearl or a stone, or it may be a living organism, such as cockchaffers, the eggs of flies, and larvæ. A foreign body may remain in the ear for years without giving rise to any symptoms, or it may occasion general manifestations, such as cough, vomiting, epilepsy, and paralysis. A soft body becomes macerated and occasions tinnitus, vertigo, and deafness. If the skin becomes abraded, infection may follow. Living insects may give rise to intolerable pain—in badly neglected cases of suppuration, grubs may be present without producing symptoms. A foreign body in the ear may become a source of danger when an attempt is made to extract it, or if there is otitis media and it leads to pus-retention. The first step, if a foreign body is suspected, is to make sure of its presence by an otoscopic examination, and, if necessary, by carefully sounding with the probe to test its consistency and mobility. If the surgeon neglects to examine with the mirror and at once proceeds to introduce an instrument into the ear, he may get into the wrong ear, or he may not find the foreign body because it has already fallen out. If the foreign body has a smooth surface, such as a pearl or a bean, it may be impossible to seize it with the forceps although it lies near the entrance, in the cartilaginous portion of the canal. The foreign body slips away from the jaws of the forceps and is thrust deeper into the canal, sometimes as far as the isthmus (Plate 3). Then, if the surgeon attempts to remove it forcibly, he may thrust it through the isthmus into the bony portion, where there is danger of its injuring the membranous and bony walls of the canal; or it may perforate the drumhead and enter the tympanum, with the danger of injuring the tympanic ossicles, blood-vessels, the seventh nerve, or the labyrinth. If the foreign body is foul, it may produce an infective otitis media or externa, and the infection may spread to the cranial cavity and terminate fatally. Sometimes a small foreign body escapes detection with the mirror because it is lodged in the recessus meatus acustici externi (Plates 3, 4).

Treatment.—First the presence of a foreign body must be determined beyond a doubt by a careful examination. In most cases it is best removed with a syringe. The stream should be directed wherever an interval is seen between the foreign body and the wall of the canal. Sometimes it may be necessary for the patient to lie down. If the presence of a small body is suspected, an attempt may be made to remove it by syringing even if it cannot be seen. A living insect should first be killed by injecting a drop of oil of turpentine or absolute alcohol. If the foreign body is macerated, an attempt should be made to cause it to shrink by injecting absolute alcohol.

If the canal is inflamed, no attempt at syringing should be made until the swelling has subsided. Instead, compresses are applied or the ear is bathed with an alcoholic solution of boric acid. If the foreign body completely blocks the canal, it should be gently pried loose from the wall with a probe. The syringing must be patiently persisted in for some time. Unless some special danger threatens, there is no hurry about removing the foreign body; but if, on the other hand, there are violent pain, fever, vomiting, and choked disc, and syringing fails to remove the foreign body, it must be removed with an instrument by an experienced hand, if necessary under anesthesia. For this purpose a probe or a blunt hook is used. The instrument is inserted between the foreign body and the wall of the canal, so as to drag it forward from behind. A soft object or a hard one with a rough surface can sometimes be seized with the forceps (Plates 26, 79). If a soft body completely occludes the canal, it may be extracted with an instrument like a corkscrew. If the foreign body is lodged in the tympanum, an attempt to remove or dislodge it may be made by Politzerization or irrigation through the catheter. If the foreign body is wedged fast in the depths of the canal, a waiting policy may be pursued if there are no urgent indications; but if the foreign body is wedged fast in the tympanum and otitis media has developed, it must at once be removed by operative means, even in the absence of alarming symptoms. If the foreign body cannot be extracted through the auditory canal, the patient is anesthetized and the pinna loosened from the skull.

Immediately behind, and parallel with the line of insertion (Plate 29), an incision 5 cm. in length is made down to the periosteum. The pinna and posterior membranous portion of the wall of the canal are then dissected off and thrust forward; at the junction between the posterior membranous portion and the bony portion of the canal the membranous portion is divided transversely as far as the anterior wall. After the hemorrhage has been controlled the pinna is turned over forward so that the bony canal is freely exposed. The foreign body can then be readily removed by syringing it, prying it loose with a probe, or by seizing it with a pair of forceps (Schwartze). If the foreign body is wedged fast in the tympanum, it may become necessary to chisel away the osseous portion of the bone or the posterior bony wall of the canal, as in the radical operation, taking care to do as little damage as possible within the tympanic cavity. The operation is completed by packing the auditory meatus and suturing the wound behind the ear. A large ear-dressing is applied. During the after-treatment scrupulous asepsis must be observed. The granulations at the point where the wall of the meatus has been divided must be touched with silver nitrate and the canal carefully packed with strips of gauze to prevent perichondritis and the formation of adhesions. Otitis media due to the presence of a foreign body usually runs a favorable course. If intracranial complications arise, operative treatment becomes necessary.

14. **Stenosis**—(*a*) **Stricture.**—*Etiology and Pathology.*—Disregarding acute conditions with swelling of the canal, stenosis may be due to chronic thickening of the walls of the meatus, cicatricial adhesions of excoriated surfaces on opposite sides of the canal, careless after-treatment of radical operations, proliferation of the bone from the periosteum after caries, and in old persons to collapse of the walls from atrophy of the cartilage.

Course and Symptoms.—The lumen of the canal is narrowed; in some cases, when the stenosis is due to collapse of the cartilaginous walls, it can be dilated with a probe. The stricture is often circumscribed, and the lumen of the canal is normal in front and behind, so that the obstruction resembles a diaphragm with a circular or cleft-like opening. The condition must not be confounded with perforation (Plate 15). In linear strictures the lumen of the canal is often spiral. When the roof and posterior bony wall are thickened, the lumen of the canal may appear flattened above. The probe enables us to distinguish between a membranous and a bony, or between a short and a long, stricture. Marked impairment of the hearing is observed only in very extensive strictures. In purulent otitis media the stricture is apt to favor retention of pus.

Treatment.—Membranous strictures are dilated by the introduction of tents. Sometimes it is necessary to make longitudinal incisions in the canal or employ electrolysis. In otitis media the tympanum must be flushed out with the tympanum tube. If alarming symptoms develop, the pinna must be separated and the stricture excised. Bony strictures require removal of the hyperostosis with a chisel and Körner's plastic operation on the canal (see below). The wound behind the ear is closed with sutures, and during the after-treatment the meatus is carefully packed with gauze and adhesions prevented by means of the cautery. In collapse of the walls a small hearing tube must be worn in the ear.

(β) **Atresia.**—*Etiology.*—The acquired form is due to adhesions between excoriations on opposite sides of the canal after injury, suppuration, or caries (for the congenital form see below).

Course and Symptoms.—In atresia the canal is occluded by a disc of connective tissue like a septum, or by longitudinal strands of connective tissue, or even by bony tissue, especially in the inner segment of the bony portion of the canal. The nature of the condition is determined by means of the probe or by examination with a Siegle speculum. The walls of the meatus gradually merge into the atresia, which looks like a grayish-white surface without any characteristic points, and usually appears to be nearer than the drumhead. Bony atresia, or atresia due to the presence of longitudinal strands of connective tissue, produces tinnitus and deafness or marked impairment of the hearing. If the atresia is in the form of a septum, there may be but little impairment of the hearing, and even whispered conversation may be heard through an ear-trumpet.

Treatment.—If the atresia is in the form of a septum, an attempt to relieve the condition may be made by dividing the membrane and keeping the orifice open by inserting little tubes of lead until the edges have become covered with skin. In severe cases the pinna is separated and the site of the atresia excised down to the bone.

(γ) **Exostoses and Hyperostoses.**—*Etiology.*—They are due usually to developmental anomalies of the tympanic portion of the temporal bone. More rarely they follow periostitis; they may be hereditary or they may occur in the course of syphilis and gout.

Course and Symptoms.—Exostoses due to developmental anomalies are usually circumscribed and composed of compact bone. They appear in the form of slowly growing yellowish-white tumors (Plate 38) with a broad base or pedunculated, and are attached usually to the roof and posterior bony wall of the canal. They may be single or multiple, and sometimes occur symmetrically in both ears. Occasionally they are found on the squamous portion of the temporal bone (Plate 17). The exostosis produces narrowing of the canal, and if there are two, one on the posterior and one on the anterior wall of the canal, the lumen is reduced to a narrow cleft. The drumhead is partially or completely obscured. If an exostosis is small, there are no symptoms; larger ones interfere with the hearing and occasion tinnitus, and sometimes neuralgia. If an otitis media exists, there is danger of retention. Sudden deafness frequently develops from maceration of cerumen plugs lying in the lumen. Exostoses are hard to the touch. A uniform stricture of the canal may be produced by the concentric proliferations of the tympanic portion of the bone (hyperostoses, Plate 17). An anomalous condition that is often observed consists in exaggerated convexity of the floor of the canal, obscuring the anterior half of the drumhead.

Treatment.—Subjective symptoms occur when the lumen becomes obstructed with secretion and cerumen; these may be relieved by flushing out the canal through a tympanum tube. If there is much interference with the hearing, particularly if the deafness extends to the other ear, and if alarming symptoms develop from retention of pus, the exostosis must be removed by operation under anesthesia. If the canal is open, pedunculated exostoses may be chiseled away with gouges from 2 to 4 mm. in width. Pack with strips of iodoform gauze and apply large ear-dressing. If the exostosis is deeply situated, the pinna is separated, and the growth removed by chiseling under the periosteum. The wound behind the ear is then closed with sutures, and during the after-treatment the granulations are cauterized to prevent adhesions. Drain with strips of gauze. In constitutional diseases, such as syphilis, internal administration of potassium iodid.

B. Diseases of the Middle Ear.—(**a**) **Diseases of the Drumhead.**—Owing to its position at the entrance of the tympanum the drumhead becomes involved in every disease of the middle, and in many diseases of the external, ear. The condition of the membrane therefore affords us a clue as to what is going on in the tympanum; any deviation from the normal appearance in the drumhead is in most cases merely a symptom of disease of the middle ear. The few isolated affections of the drumhead differ from disease of the middle ear in that they give rise to very little auditory disturbance.

1. **Acute Myringitis.**—*Etiology and Pathology.*—Infection of the drumhead by way of the auditory canal, especially after exposure to cold, cold baths, in otitis externa, and as the result of instillations, etc.

Histology.—Maceration of the epithelium, round-cell infiltration, thickening and exudation in the corium; the substantia propria and stratum mucosum are usually not affected. If the inflammation is severe, there may be round-cell infiltration. The inflammation usually subsides by absorption; sometimes opacity or calcification of the membrane remains.

Course and Symptoms.—Sudden onset with pain, a feeling of fulness, pulsation, tinnitus aurium (in children, sometimes fever), reddening of the manubrium, and injection of the radial vessels, or with intense bluish-red discoloration of the entire membrane or only of the postero-inferior quadrant. The manubrium and the cone of light are obliterated; sometimes dark-brown hemorrhagic points are seen in the membrane (Plate 38, 13). The exudation may be serous, or, as in influenza, hemorrhagic, and lead to the formation of bullæ beneath the epidermis, usually in the posterosuperior quadrant (myringitis bullosa). The bullæ rupture, and a small quantity of fluid is discharged into the auditory canal, leaving a grayish-white fissure in the membrane from maceration of the epithelium. In very severe inflammations with suppuration, yellowish-green bullæ may appear on the drumhead. If the blebs are very large, they overlap the manubrium and hide all but the short process. In rare cases an abscess of the drumhead may rupture into the tympanum and result in an acute otitis media. After the inflammation subsides, the drumhead gradually regains its transparency in about eight days, or remains permanently opaque. The epithelium desquamates, and the membrane atrophies or becomes calcified. Ecchymoses frequently wander from the center toward the periphery and into the auditory canal; rarely an acute myringitis may end in chronic inflammation of the membrane.

Treatment.—Rest in bed; instillation of a hot 10 per cent. solution of carbolic acid in glycerin; incision of blebs with a paracentesis needle; removal of the secretion with a cotton-wound applicator, and insufflation of boric acid. If the pain is violent, blood-letting in front of the tragus is indicated, and phenacetin 0.5 gm. (8 gr.) internally.

2. **Chronic Myringitis.**—*Etiology.*—Secondary to acute myringitis when there is persistent irritation, as by cerumen or a foreign body; secondary to otitis externa when the general condition is reduced. Histologically we find thickening of the membrane, fatty degeneration, and desquamation of the epidermis and polypoid proliferations in the corium.

Course and Symptoms.—In most cases the entire drumhead, more rarely only the posterosuperior quadrant or Shrapnell's membrane, is involved in the inflammation. Either there are no symptoms or there may be itching and a fetid discharge. The color of the drumhead is a dirty gray, and the manubrium is reddened; sometimes the drumhead is covered with small nodular granulations resembling raspberries (Plate 38, 14). The secretion may become inspissated and form crusts imbedded in the fetid discharge. The differential diagnosis from chronic suppurative otitis media is made by noting the absence of perforation as determined by the probe, by Siegle's speculum, by inspection and auscultation during Politzerization, and by the absence of any marked interference with the hearing. The condition ends in recovery, or the drumhead becomes permanently thickened and desquamates (myringitis desquamativa).

Treatment.—Removal of the secretion with cotton; insufflation of boric acid and small ear-dressing; granulations to be cauterized with chromic acid or the galvanocautery; instillation of an alcoholic solution of sublimate. If there is desquamation or thickening of the drumhead, oil of sozoiodol is used instead of the sublimate.

In miliary tuberculosis yellowish-red tubercle nodules may appear on the drumhead (Schwartze). Condylomata and gummata are occasionally seen on the drumhead in lues; a rare condition that sometimes follows circumscribed hyperkeratosis consists in the formation of white, pearl-like bodies (cholesteatoma).

(**b**) **Diseases of the Tympanum.**—In any disease of the tympanic cavity the Eustachian tube and mastoid process, as a rule, share in the morbid process. Deafness, deaf-mutism, disturbances of equilibrium, and brain abscess often take their origin in some disease of the tympanic cavity. As the anatomic changes in the mucous membrane of the middle ear do not present any appreciable variations in conditions clinically different, the diseases of the middle ear are classified by their clinical phenomena. We distinguish acute and chronic middle-ear catarrh from acute and chronic middle-ear inflammation. Catarrh of the middle ear runs its course without giving rise to grave constitutional symptoms or producing any marked alterations in the drumhead, being characterized chiefly by a seropurulent exudate. While the cases which threaten the patient's life are exceptional, the hearing very often suffers permanent injury from the adhesions and other sequelæ which are apt to remain. Inflammation of the middle ear, on the other hand, gives rise to violent constitutional symptoms and severe inflammation of the drumhead, with the secretion of a purulent exudate. Both the hearing and the life of the patient may be placed in jeopardy.

1. **Catarrh of the Tympanic Cavity**—(*a*) **Catarrhus Auris Mediæ Acutus (Acute Exudative Middle-ear Catarrh).**—*Pathology and Etiology.*—The mucous membrane of the middle ear is swollen, hyperemic, and covered with a serous exudate and round-cell infiltration (Plate 23); the epithelium is macerated; the spaces of the cavity contain a serous, stringy exudate, showing numbers of desquamated epithelial cells, blood-corpuscles, and pathogenic micro-orgânisms (Plate 30). In the drumhead the stratum mucosum is principally affected by the inflammation. Recovery takes place by absorption and regeneration, or with the development of connective-tissue adhesions. The causes are infection by pathogenic micro-organisms of diminished virulence, nasal diseases, infectious diseases, insufficient ventilation of the Eustachian tube—as, for

instance, in paralysis of the seventh nerve. If the Eustachian tube is obstructed or occluded by neoplasms, by swelling, or by the presence of scars, the air in the middle ear becomes rarefied and leads to passive hyperemia of the mucous membrane with the production of a serous transudation. In some cases, however, the exudate is inflammatory. Very rarely intracranial complications may develop.

Course and Symptoms.—Feeling of fulness, occasionally tinnitus, crumbling, and crackling in the ear; at times impairment of the hearing depending on the weather and on the patient's position. When the patient moves his head, he feels as if there were a rolling body in his ear. The pain is slight. Frequently there are autophonia and nasal aprosexia; rarely, paralysis of the seventh nerve. The drumhead is more glistening than usual (Plate 38, 6), and yellowish red in color. If the tympanum is partly filled with exudate, the upper limit may be seen through the membrane as a clear-cut, slender black line. Air-bubbles within the exudate after insufflation or blowing the nose present the appearance of round pearls. The level of the exudate is seen to change its position as the patient moves his head during Politzerization, or during movements with a Siegle speculum. The color of the drumhead is yellow below the level of the exudate, and gray above. If, at the same time, the ventilation of the tube is disturbed,—as, for instance, by adenoid vegetations,—the drumhead becomes a brownish yellow and retracted. The short process is more prominent than usual, the manubrium foreshortened, and the cone of light shortened, cleft in twain, or punctate (interrupted). The posterior fold is unduly prominent. If only the more yielding (central) portion of the drumhead is retracted, it appears to be divided by a ridge from the more resistant peripheral zone. The impairment of hearing varies with the amount of the exudate. Rinne partially negative; Schwabach prolonged. During inflation of the middle ear crepitant rales may be heard.

After inflation the drumhead regains its normal position and color, the exudate disappears, and sometimes its level is then distinctly seen for the first time. If the hearing is markedly improved by inflation, the prognosis is favorable; but if it is not improved, and there is shortening in the time of bone-conduction, with obstinate occlusion of the tube, the prognosis is unfavorable. Recovery occurs in a few days, or after months. Children are prone to relapses. Rarely the micro-organisms become more virulent—as, for instance, after the application of cataplasms, if otitis media develops, with pain and hyperemia of the drumhead.

Treatment.—Removal of the cause, such as adenoid vegetations, will often suffice to bring about a cure. *General Treatment.*—Regulation of the diet, and removal to a high altitude. *Local Treatment.*—Removal of the exudate through the auditory canal by Politzerization, the patient inclining his head to the sound side. If the mouth of the tube is greatly swollen, catheterization. Inflation to be practised daily until the secretion ceases and no more improvement is noted in the hearing, after which inflation is to be continued every third day for

FIG. 72.—Drumhead of the right ear, showing paracentesis opening and section of the posterior fold (manubrium is shown in its normal position).

four weeks, and every sixth day for an additional four weeks. In marked retraction of the drumhead the air-pressure in the auditory canal must be diminished. To reduce marked swelling of the tube, external massage of the neck and the tubal orifice by introducing a bougie every third day is useful. When the exudate is tenacious, vapor of sal ammoniac must be introduced through the catheter or the tube injected with zinc sulphate. If, after eight days, the exudate is still present, the membrana tympani must be opened. The patient's head is held firmly, and the membrane freely incised in the postero-inferior quadrant (Fig. 73). All the layers of the drumhead are to be divided by as long an incision as possible, parallel with the tendinous ring (Fig. 73). Local anesthesia may be required. The incision is followed by inflation, during which a frothy exudate is thrown into the auditory canal with the production of a perforation murmur. The cavity is then dried with cotton, and aspiration performed with Siegle's apparatus until all the exudate has been removed. The after-treatment consists in inflation. To prevent too rapid obliteration of the opening, sterilized liquid vaselin may be injected into the tympanum daily through a catheter. The operation frequently has to be repeated.

FIG. 73.—Paracentesis needle.

(β) **Catarrhus Auris Mediæ Chronicus (Catarrhal Adhesions).**—*Pathology and Etiology.*—A very common sequel of acute catarrh that often persists after all other symptoms have disappeared. If an acute catarrh persists for some time and the exudate thrown out during the acute stage undergoes absorption and is not discharged regularly, the condition develops into a dry catarrh, which is followed by fibrous changes (sclerosis, Plate 18), shrinking, atrophy, calcification, and ossification of the membrane. Adhesions may form between neighboring portions of the membrane that have been denuded of epithelium (Plate 20). The round cells and plasma cells in the mucous membrane lead to the formation of fibroblasts in great numbers, which become converted into spindle cells and fibrillary tissue. Until this stage is reached there is still a discharge of serous exudate. After the conversion into fibrous tissue, exudation ceases and regeneration becomes impossible. The mucous membrane itself, along with the ligamentous bands formed from it and the slender embryonal threads of mucous membrane that traverse the tympanum, become pale and rigid. The margins of the fenestræ become obliterated and filled with cystic and fatty connective tissue. The drumhead becomes adherent to the walls of the tympanum and abnormally tense. The ossicle-joints are stiffened and sometimes completely ankylosed by the formation of hyperostoses. Thus the articulation between the malleus and incus may become ankylosed, the long process of the incus may adhere to the wall of the tympanum (Plate 19), or the stapes may become fixed by adhesions to the posterior, and particularly to the anterior, wall of the margin of the fenestra ovalis (connective-tissue ankylosis of the stapes). The stapes may become absolutely immovable by calcareous deposition in the annular ligament. The drumhead is opaque, thickened, calcified (Plate 21), or atrophic. The diverticula of the tampon, such as Prussak's space and the attic, are obliterated by connective tissue (Plate 20). Stenosis of the Eustachian tube results from swelling of the mucous membrane, the cartilaginous portion atrophies, and the muscles undergo fatty degeneration. Catarrhal adhesions follow neglected cases of acute catarrh ; they may be caused by chronic disease of the nose and throat, constitutional diseases, such as lues and rheumatism, hereditary disposition, myxedema, the abuse of cold-water cures, or of alcohol and tobacco.

Course and Symptoms.—Catarrhal processes usually occur in both ears in middle-aged persons. The hearing becomes steadily worse; usually the patient complains of continuous and often intolerable, loud-pitched subjective noises, which are worse during bad weather, and often make their appearance before any impairment of the hearing is noted. In rare cases there are neuralgia, auditory hyperesthesia, a feeling of tightness in the head, and vertigo. Sometimes there are sudden attacks of deafness with nausea, vomiting, staggering gait, and tinnitus aurium—in short, Ménière's symptom-complex from congestive hyperemia of the labyrinth. Disease of one organ predisposes to disease of the other ear. The drumhead is opaque and resembles ground glass, either in its entire extent or in certain areas—a crescentic area, for example, in the posterior half of the membrane (Plate 38, 9); the portions that are not opaque appear darker than normal. Sometimes the membrane presents sharply circumscribed areas of calcification of a chalk-white color (Plate 38, 10). There is often great retraction, and, while the exudate persists, the color of the drumhead is a grayish yellow (Plate 38, 5). In total atrophy the drumhead presents radiating wrinkles and numerous light reflexes; in partial atrophy the portions below the atrophic area, such as the incudostapedial articulation, for instance, and the fenestra rotunda, are distinctly seen through the membrane. After Politzerization the attenuated portions of the membrane resemble blebs, and with Siegle's speculum increased mobility is noted. Adhesions of the drumhead appear immovable through Siegle's speculum, and during Politzerization Prussak's space becomes obliterated and replaced by a pit-like depression above the short process (Plate 38, 8). The mobility of the drumhead is impaired in ankylosis of the ossicles. The impairment of hearing varies with the degree of anatomic change and the seat of the adhesions. Paracusis Willisii is often observed. The hearing is affected by mental emotions and is often worse toward evening.

The deafness is greatest when there is ankylosis of the ossicles, especially of the stapes, with rigidity of the fenestra cochleæ. Often there is inability to hear whispered conversation. Rinne is partial, and in fixation of the stapes absolute and totally negative. Weber in the diseased ear, or, if both are affected, in the worse of the two. Schwabach prolonged; Gellé positive, if the stapes is movable. The labyrinth is often involved: in that case Schwabach is shortened, the upper tone limit lowered, and, as a rule, the patient complains of high-pitched subjective noises. If inflation is followed by improvement, it is a sign that the labyrinth is intact, and if there are no continuous subjective noises, the prognosis is more favorable. The prognosis should, however, always be guarded, as complete cure is out of the question, and there is always danger of the hearing becoming progressively worse, either by slow or by sudden gradations.

Treatment.—Symptomatic and constitutional. Locally, attempts should be made to arrest the increasing deafness by stretching or dividing adhesions. Inflation by means of Politzerization and the catheter may be practised every second or third day for a period of six weeks, two or three times a year, if it is followed by improvement. After inflation the pressure in the auditory canal must be reduced. If the hearing becomes worse, inflation must be given up. Massage of the middle ear with Lucæ's pressure probe or by electric pneumomassage frequently has a very favorable influence on the subjective symptoms and occasionally on the hearing. If the treatment is continued too long, the condition often becomes worse. If, after six weeks, no improvement in the subjective or objective symptoms takes place, treatment should be abandoned. The Eustachian tube may be treated with vapor of ether, chloroform, water, sal ammoniac, iodoethyl, or turpentine; solutions of sodium bicarbonate, a 1 per cent. solution of chloral hydrate, pilocarpin, and fluid vaselin may be injected through the catheter. In syphilis, a 2 per cent. solution of potassium iodid may be similarly employed.

Anything that tends to irritate the ear must be avoided. In marked atrophy of the drumhead the resistance of the attenuated areas may be increased by painting them with flexible collodion after making the membrane bulge by inflation. If a sudden change for the worse sets in, put the patient to bed and administer purgatives and potassium iodid, 8 : 200, internally. If the local treatment fails to remove the subjective noises, one may try galvanic treatment, tub-baths at 28°C. (82° F.), change to a forest climate, or medicinal baths. Internally effervescent bromid, potassium bromid, 1 gm. (15 grains) three times a day, sodium bromid, preparations of iron, atropin, 2 mg. ($\frac{1}{60}$ grain) a day. In disease of the thyroid give thyroidin, during the first week 1, during the second week 2, from the third to the sixth week 3 tablets of 0.3 gm. (5 grains) every day, the patient's condition being carefully watched. In tinnitus aurium with attacks of vertigo, quinin 0.5 gm. (8 grains) a day. When all other means fail, operative interference may be attempted, depending on the kind of pathologic changes present.

If the drumhead is greatly thickened and calcified, and there is a stricture of the tube, an artificial perforation may be made with the galvanocautery, so as to bring about direct sound-conduction to the articulation of the stapes and thus improve the hearing. In atrophy of the drumhead multiple incisions, which, by their contraction, increase the tenseness of the tissue, are indicated. If the posterior fold is unduly prominent, it may be divided (Fig. 72) with a probe-pointed knife (Fig. 78, *e*); or an attempt may be made to divide the anterior ligament of the malleus. In marked retraction of the drumhead with secondary shortening of the tendon of the tensor, tenotomy of the tensor tympani muscle may be practised, providing the stapes is movable and the labyrinth intact. An incision is made in the posterosuperior quadrant of the drumhead, 1 mm. behind the manubrium, with a small tenotome (Fig. 78, 2) introduced beneath the tendon of the muscle, which is then divided from below upward by depressing the handle of the tenotome. If the crura of the stapes are adherent to the margin of the fenestra vestibuli, a perforation may be made under anesthesia in the posterosuperior quadrant, and the adhesions divided with a small bistoury (Fig. 75). If the chain of ossicles is absolutely immovable and the distress

FIG. 74.—Method of extracting the ear ossicles (ossiculectomy—schematic) (sagittal section; view of the left tympanum from above and in front): *a*, Auditory meatus; *b*, attic; *c*, hypotympanic recess (cellar); *d*, promontory; *e*, stapes within the fenestra vestibuli; *f*, tensor tympani muscle (tendon); *g*, malleus; *h*, incus; 1, section through the tendon of the tensor tympani muscle with Delstanche's circular knife; 2, division of the incudostapedial articulation.

is intolerable, the ossicles may be removed under anesthesia, providing the labyrinth is intact. The operation is performed as follows: The drumhead is divided from its attachment by a peripheral incision and dissected away from the manubrium; or two incisions may be made, one in front and the other behind the manubrium, and parallel with it from the upper border of the notch of Rivinus to the umbo. The incudostapedial articulation is then divided, the handle of the malleus seized with Delstanche's circular knife, and the tendon of the tensor tympani muscle divided by elevating the blade and depressing the handle (Fig. 74). The malleus is then grasped by its short process with Sexton's forceps and removed by drawing it downward. Next, Ludewig's hook is introduced over the body of the incus, the ossicle loosened by a downward rocking movement and removed with the forceps (Plate 75). In ankylosis of the stapes

FIG. 75.—3. The malleus is drawn downward and out through the auditory canal with Sexton's forceps. 4. The incus is loosened by a downward rocking movement with Ludewig's incus hook. 5. Separation of the crus of the stapes from the lower wall of the fovea hemielliptica with Politzer's synechotome.

an attempt may be made to remove the ossicle after the tendon of the stapedius muscle has been divided. The attempt can be successful only when the labyrinth is intact. During traction on the stapes the crura are easily broken. Operative intervention in conditions attended with catarrhal adhesions are justifiable only when the labyrinth is intact, the suffering unbearable, and experimental paracentesis has been followed by improvement.

2. Ankylosis of the Stapes (Otosclerosis; Formation of

Spongy Bone in the Capsule of the Labyrinth).—*Pathology and Etiology.*—Complete osseous ankylosis of the stapes may result from the formation of spongy bone in the capsule of the labyrinth. The fenestra vestibuli is surrounded by a wall of growing bone (Plate 22) which may extend to the side of the labyrinth. One or both margins of the foot-plate and one or both crura may be involved in the osseous growth. Sometimes there is a sharp line of demarcation between the new and the old bone. Foci of spongy bone may also be found traversing the compact bone in the other portions of the capsule of the labyrinth, around the semicircular canals and the cochlea, and at the promontory (Siebenmann). The newly formed bone contains numerous misshapen bone-corpuscles without any regular arrangement. The bones and the periosteal vessels are hyperemic. The labyrinth is often destroyed, and the nerve-trunks are surrounded by a dense growth of perineural connective tissue. The mucous membrane of the tympanum is intact. The cause of the spongy change is perhaps to be sought in a peculiar anatomic disposition, such as the presence of abundant remains of cartilage in the capsule of the labyrinth; hereditary predisposition has been observed and the condition sometimes follows pregnancy.

Course and Symptoms.—The condition often develops imperceptibly between the twentieth and the thirtieth year; it is somewhat more frequent in women. Sometimes it begins with tinnitus aurium, which gradually becomes worse until, after from ten to twelve years (or earlier), deafness develops. At this time a feeling of tension in the head, vertigo, and auditory hyperesthesia are often complained of. The impairment of hearing usually goes on to deafness. It often begins in one ear after the other has already become deaf. Rinne usually absolute and totally negative; Weber in the worst ear; Schwabach prolonged; Gellé negative. But, as the nervous hearing apparatus usually becomes diseased at the same time, or even before, Schwabach is often shortened and the upper tone limit lowered. When Rinne is partially negative, the primary seat of the disease must be determined by means of Gellé's experiment. The drumhead itself is normal; sometimes the red wall of the promontory is seen through the membrane (Plate 38, 12). Inflation is accompanied by a coarse, sibilant rale. The diagnosis may be confirmed by making a perforation in the postero-superior quadrant and directly probing the stapes. The prognosis is very unfavorable. Sometimes deafness develops very rapidly after the disease has existed for a short time, especially if bone-conduction is much diminished.

Treatment.—All treatment is useless; inflation must be avoided. Sometimes the subjective symptoms may be improved by the careful use of the pressure probe and pneumo-massage. Operative removal of the stapes with the chisel is usually of no avail, owing to the great extent of the spongy change. If an artificial opening is made in the wall of the promontory with a gimlet to replace the occluded fenestra vestibuli (Passow), the opening soon becomes obliterated by the formation of new bone. Constitutional treatment includes 0.01 per cent. solution of phosphorized cod-liver oil (Siebenmann), sodium iodid 1 gm. (15 grains) a day (Politzer), and, as symptoms arise, potassium bromid, galvanization, rubbing with alcohol, purgatives, and hot foot-baths. The patient should wear hearing-tubes, and, if he is quite deaf, he should be taught to read the lips.

3. **Inflammation of the Middle Ear (Otitis Media).**—Inflammation of the middle ear may end in recovery without perforation of the drumhead, or, after perforation has occurred, by cicatrization of the orifice. If chronic aural discharge develops, the condition may remain incurable, or a dry perforation may persist after the flow has ceased, or the perforation may become closed by cicatrization.

(*a*) **Simple Acute Otitis Media.**—*Pathology and Etiology.*—Swelling of the entire mucous membrane lining the middle ear and drumhead, particularly of the stratum mucosum, from hyperemia, round-cell infiltration, and overgrowth of the papillæ (Fig. 23). In places the epithelium is destroyed so that the pus lying on the mucous membrane appears to be directly continuous with the infiltrated mucous membrane (Plate 31). The layers of the drumhead are infiltrated, but not perforated. The bone of the auditory canal and wall of the labyrinth is hyperemic. The exudate is mucopurulent or hemorrhagic, and occupies all the diverticula of the drumhead; it contains blood-corpuscles, pus, epithelial cells, detritus, and pathogenic micro-organisms (Plate 30). Recovery takes place by absorption, or with the formation of adhesions and opacity and calcification of the drumhead. Sometimes acute perforative otitis media results. The cause is infection of the tympanum with specific micro-organisms, favored by exposure to cold (bathing), inflammations of the nose and throat, and infectious diseases, such as measles, scarlet fever, diphtheria, whooping cough, typhoid, pneumonia, and *influenza*.

Symptoms and Course.—Paroxysmal, pulsating pains in the ear, head, and teeth, increased by motion of the head or by pressure on the tragus and angle of the jaw, and becoming worse toward evening. In children there is often high fever, with convulsions and delirium. The drumhead is red, injected either in radial lines or in its entire extent, and the posterosuperior quadrant bulges either as a whole or more rarely as a cluster of pouches. All the landmarks are obliterated, except the short process, which appears as a yellow point (Plate 38, 17–19). The bony portion of the canal is reddened; the boundaries between the drumhead and auditory canal may be recognized during motion through Siegle's speculum. There is rapid impairment of the hearing; Rinne partially negative; Weber in the diseased ear; Schwabach often shortened (hyperemia of the labyrinth). After two or three days, although the hearing grows worse, the pain subsides, the injection of the drumhead diminishes, and in about two weeks the membrane regains its normal appearance.

Distinguished from acute myringitis by greater impairment of hearing and the presence of crepitant rales during auscultation. The disease is apt to recur in the spring and fall.

Treatment.—Rest in bed, liquid diet, avoidance of alcohol, tobacco, and hot beverages. The patient should be enjoined to blow his nose gently and gargle the throat. Locally, instillations of 10 per cent. solution of carbolic acid in glycerin every three hours; ice-bag, or, if the pain is very great, hot compresses may give relief. If pain is elicited by pressure on the mastoid process, leeches, or sedative inunctions with chloroform, or oil of hyoscyamus. If the condition does not improve after three days and the pain and fever continue, a *free incision* must be made at the most dependent point of the bulging membrane, usually the postero-inferior quadrant. The exudate that is evacuated either spontaneously or with Siegle's instrument is carefully wiped away, and a small ear-dressing is applied; in children, a large ear-dressing. Frequently there is no otorrhea. If otorrhea develops, it should be treated the same as acute perforative otitis media (p. 191). When the pain has subsided, usually after a week, daily Politzerization continued for a week, then every other day for another week, and after that every fourth day until the procedure ceases to be followed by improvement in the hearing. External massage of the neck must be given at the same time. Treat the nose and throat.

(β) **Acute Otitis Media of Infants.**—*Pathology and Etiology.*—In infants infection is favored by the hyperemia of the embryonal and often papillary mucous membrane (Plate 13), and by the increased width of the tube, which facilitates the entrance of amniotic fluid, nasopharyngeal secretions, and vomited material into the middle ear, by the greater susceptibility incident to age, by bathing, squeezing out a sponge on the head, hypertrophy of the pharyngeal tonsils, and by digestive disturbances. During labor the tympanum may become infected by gonorrheal discharges from the mother.

Course and Symptoms.—The condition usually begins as a simple acute otitis media (suppuration from a foreign body, after Aschoff), restlessness during sleep, crying, loss of weight, and diarrhea. Pain is elicited by pressure on the tragus; the head is inclined to the diseased side. The infant carries the hand to the ear. Sometimes atrophic conditions are present. After cleaning the auditory canal and drawing the pinna backward and downward, the drumhead is seen to be whitish, with a radial injection (Plate 23). After the exudate has been evacuated, digestion becomes normal, and the body weight increases (Hartmann). If the treatment is successful, the probability of deaf-mutism will be avoided.

Treatment.—*Free* and *early* incision of the distended membrane is of the first importance, followed by instillation of a 5 per cent. solution of carbolic acid in glycerin and Politzerization. Protect the infant against external injuries, especially during the bath. If the nasal passages are obstructed, instillations of 5 per cent. solution of menthol into the nose are indicated.

(γ) **Acute Perforative Otitis Media.**—*Pathology and Etiology.*—The perforative changes are the same as in simple acute otitis media, but more intense. The lumen of the tympanic cavity is encroached upon by the swelling and by the purulent infiltration of the mucous membrane (Plate 23), the ossicles appear to be imbedded in granulations, the epithelium in places is destroyed (Plate 31), so that adhesions may form by the contact of surfaces denuded of epithelium. The purulent exudate contains pus-corpuscles, detritus, a few epithelial cells, and pathogenic micro-organisms (Plate 30). The auditory canal is hyperemic and sometimes covered with vesicles. All the layers of the drumhead are infiltrated with pus, the fibers are forced apart, and at one point there is a perforation. Sometimes there is a circumscribed inflammation in the recesses of the tympanic cavity (Prussak's space). If the inflammation is very violent and embolism develops, the mucous membrane may become necrotic and the underlying bone carious. The labyrinth is frequently hyperemic, rarely inflamed. Recovery by absorption, followed by rapid regeneration, sometimes with thickening, opacity, calcification, and cicatrization of the drumhead and the formation of adhesions, takes place. An acute suppuration may become chronic. The causes of infection of the tympanic cavity are the same as those mentioned under (*a*) (p. 184). In addition, infection may take place through the auditory canal, through a dry or a traumatic perforation, during bathing or syringing of the ear, after the extraction of foreign bodies, and in infectious diseases, especially during the height of the eruption. In rare cases otitis media follows an attack of acute catarrh.

Course and Symptoms.—The disease is usually confined to one side, except after diseases of the nasopharynx, the exanthemata, and typhoid fever. There is very violent, continuous pain in the ear and mastoid process, with vertigo, tinnitus due to pressure of the exudate on the windows of the labyrinth, and sometimes pulsating noises in the ear. Autophonia, elevation of temperature up to 40° C. (104° F.), in children often drowsiness, delirium, irregular pulse, contracted pupils, convulsions, vomiting (to be distinguished from meningitis and teething convulsions), glandular enlargement, disturbance of the sense of taste, and occasionally facial palsy. Pressure on the tragus and tip of the mastoid process increases the pain. There is marked interference with the hearing, and even deafness may occur. Rinne partially negative; Weber in the diseased ear; Schwabach often shortened as the result of hyperemia of the labyrinth. The drumhead is intensely red, and the landmarks are obliterated; the short process occasionally projects as a yellowish point (Plate 38, 20, 21). The posterosuperior quadrant of the drumhead bulges, and the membrane may be covered with ecchymoses and macerated epithelium, or with blebs containing serous and purulent exudate (Plate 38, 23). The auditory canal is injected, and sometimes also contains hemorrhages and purulent blebs. Perforation of the drumhead occurs on the third or fourth day, usually in the antero-inferior quadrant. This region sometimes pulsates before perforation takes place, from hyperemia of the vessels of the drumhead. After perforation, which is rarely delayed until the fourteenth day, has taken place, pulsating pus is observed in the auditory canal, the pulsation being transmitted by the dilated vessels of the drumhead and the tympanic mucous membrane. On inspection with the head-mirror a pulsating reflex is seen. Sometimes the pus is frothy—as, for instance, after the patient has blown his nose; at first it may be sanguineous.

After the pus has been removed, the drumhead appears intensely red, fissured, and covered in its antero-inferior portion with macerated epidermis and exudate. The perforation itself cannot be seen, but may be recognized by the presence of a pulsating droplet of pus or by the constant escape of pus at one spot (Plate 38, 24). Perforation is followed by a cessation of the symptoms of meningeal irritation, pain, fever, etc. If the perforation is large, it appears as a dark orifice that often contains a pulsating drop of pus. If there is a circumscribed bulging of the drumhead, the perforation is found at the apex of a conic prominence (Plate 38, 22). In suppuration and inflammation of the attic, Shrapnell's membrane projects like a sac and overlaps the manubrium like a polyp.

Diagnosis of perforation is based on the following points: (1) Inspection; (2) pulsating reflex; (3) bubbles in the pus; (4) perforation murmur during inflation; (5) aspiration of the exudate with Siegle's instrument (the exudate is deposited on the glass); (6) if there is a large defect, immobility of the membrane in the Siegle speculum; (7) by the following experiment: the otoscope is connected with the diseased ear and submerged in a glass of water; during inflation air-bubbles rise to the surface of the water; (8) mucus threads in the irrigating fluid; (9) during inflation of the auditory canal a perforation murmur can be auscultated through the nose; (10) the knowledge obtained by probing—with the probe we distinguish between a perforation and a deposition of exudate, and between the reddened surface of the drumhead and an exposed promontory. In addition, the drumhead is nearer the eye than the wall of the promontory. During examination with Siegle's speculum the wall of the promontory becomes hyperemic, and some of the discharge is aspirated. What remains of the drumhead is immovable, while, on the other hand, an inflamed drumhead moves to and fro. Even after most of the drumhead has been destroyed, a narrow peripheral strip usually remains, so that when the patient inclines his head to one side a shadow and a cleft appear between the strip of drumhead and the wall of the promontory. In acute suppurations the secretion begins to diminish in the second week and ceases entirely during the third week, when the hearing distance increases. The short process of the malleus again comes into view, and the handle itself may be indistinctly seen on the drumhead. Blood-vessels are seen coursing toward the perforation or its scar. After about six weeks the drumhead may regain its normal condition and no scar be seen, or scars of variable extent may remain, with opacity and calcification of the membrane. If treatment is instituted early, the prognosis is good. If, however, there is extensive degeneration of the drumhead, the prognosis is unfavorable, even if appropriate treatment is employed. The prognosis is unfavorably affected by the following factors: The presence of granulations; paralysis of the seventh nerve; marked glandular enlargement; persistent, copious, and fetid secretion; conic, circumscribed prominence of the drumhead; infectious diseases, such as diphtheria, scarlet fever, influenza, and tuberculosis. Sometimes recovery is delayed for as long as from six to eight weeks, or the suppurative process becomes chronic and involves the bone.

Treatment.—Perforation should always be anticipated by a free incision. If there is a temperature of 38° C. (100° F.) or over, with violent pain and insomnia even during a single night; if there are swelling and pain on pressure on the mastoid process, with marked bulging of the drumhead; if there are any symptoms of meningeal irritation, and, generally, in the course of acute exanthemata, even without alarming symptoms, as large an opening as possible should be made at once. The incision hastens recovery and removes all danger; it may be necessary to repeat it. In spontaneous rupture more of the drumhead is sacrificed and there is greater liability to infection of the cranial cavity. An intracranial complication may begin even before spontaneous rupture of the drumhead has taken place. It does no harm to incise the membrane early, and may prevent serious complications. If the pain continues after incision, in spite of ice compresses, there is danger of retention—that is to say, insufficient drainage. An acute otitis media *must not be allowed to become chronic;* hence it must never be left to itself, but should be watched constantly by examining the ear every day with a mirror until complete recovery ensues. Scrupulous asepsis must be observed during the treatment, to prevent secondary infection by staphylococci, which greatly increases the danger of chronicity. *Constitutional Treatment.*—Put the patient to bed and have him lie on the side of the diseased ear. Practise blood-letting in front of tragus, and give purgatives (calomel, 0.01 to 0.2 gm.—$\frac{1}{6}$ grain to 3 grains) several times a day, also gargles. The insomnia may be combated with sulfonal, 1 gm. (15 grains), the pain with phenacetin, 0.5 gm. (8 grains), or antifebrin, 0.25 gm. (4 grains). Locally the suppurating ear must be cleansed of pus with cotton or by aspiration with Siegle's speculum, after which iodoform gauze strips are introduced and a small ear-dressing is applied, which should be changed every day. If the discharge is very profuse, the patient is instructed to cleanse the ear every day with sterile cotton tampons, keeping the ear stoppered with a piece of cotton. If the suppuration is very profuse, ear baths of a watery solution of hydrogen peroxid are given every three hours, and if the pain is very severe, this is followed by the instillation of a 5 to 10 per cent. solution of carbolic acid in glycerin. If, in spite of the ear baths, the secretion continues profuse and fetid, syringing may become necessary, and both physician and patient must observe the most scrupulous asepsis. If the patient is to treat himself, he should use Lucæ's soft-rubber syringe with a 0.5 per cent. solution of formalin, from one to three times a day. If the discharge from the beginning is slight, or if it diminishes in the course of the disease, boric acid should be insufflated and a small ear-dressing applied, to be changed daily. After the pain has disappeared, Politzerization and external massage of the neck, as stated under (*a*) (p. 173), are indicated. For six weeks after the discharge has ceased the ear must be kept closed with cotton so as to guard against catching cold. If retention of pus sets in, manifesting itself by renewal of fever, symptoms of meningeal irritation, and by the copious flow of pus after the ear has been wiped out with cotton, or by the appearance of pain and sensitiveness on pressure on the mastoid process following a cessation of the discharge, any existing small perforations must be enlarged and a counteropening effected—as, for instance, in perforation of Shrapnell's membrane by incision of the lower half of the drumhead. Granulations and circumscribed conic bulgings of the drumhead are removed with a cutting forceps. Retention of pus is often followed by mastoiditis, caries, and necrosis. In very obstinate cases irrigation through the catheter, Politzerization during the ear bath, and the instillation of liquor plumbi subacetatis into the ear, or hypodermic injections of pilocarpin may be tried. General treatment and local treatment of the nasopharynx are of great importance to bring about recovery.

(δ) **Chronic Suppurative Otitis Media.**—*Pathology and Etiology.*—Chronic suppuration of the middle ear frequently follows (from neglect) an attack of acute suppurative otitis media and endangers the hearing, the general health, and, by extending to the cranial cavity, the life, of the patient. The entire mucous membrane is gradually thickened by infiltration, dilatation of the vessels, and newly formed tissue (Plate 31, 20). After the epithelium has been destroyed, the mucous membrane is replaced by an actively proliferating papillary granulation tissue containing cysts, which covers the walls of the entire middle ear and the tympanic ossicles. Sometimes, after the subsidence of the general inflammation of the tympanic cavity, the various spaces of the tympanum still continue to show inflammation. The bone is not markedly involved in uncomplicated cases of chronic suppuration. Erosions and granulation tissue are sometimes found in the auditory meatus. The remains of the drumhead are thickened; the stratum mucosum and corium sometimes show papillary proliferation. The exudate that has been poured out into the substantia propria and stratum mucosum becomes either absorbed or inspissated. After the inflammation has run its course, what is left of the drumhead remains opaque (Plate 39, 1), owing to fatty degeneration, the deposition of pigment and amorphous calcareous material; rarely, from the formation of new bone (Plate 39, 1). The perforation may be closed by scars in which the substantia propria is not represented. When the stratum mucosum of the drumhead fuses with the mucous membrane of the tympanic cavity, adhesions are formed (Plates 19, 20). Should the epithelium of the drumhead invest the margins of the perforation, a prominent fistulous perforation covered with skin results (Plate 35).

The epithelium of the auditory meatus is particularly prone to invade the tympanic mucous membrane when the perforation is situated near the margin, and may convert the membrane into epidermis and thus bring about recovery or lead to the formation of cholesteatomata. The lumen of the tube suffers a constriction from swelling of the mucous membrane and sometimes becomes entirely occluded. The proliferation in the mucous membrane may disappear, and the normal conditions be approximately reestablished, or dense adhesions may be formed obliterating the attic (Plate 36), the margins of the fenestræ (Plate 22), and destroying the mobility of the tympanic ossicles (Plate 21). Polypi may also be formed. Chronic suppuration is often followed by mastoid disease, osteosclerosis, caries, necrosis, and cholesteatomata. The secretion is mucopurulent in character, at times scanty and inspissated, forming crusts, at other times very copious. It may be blue from the presence of bacillus pyocyaneus; in caries it is thin and contains necrotic bone (bone-sand); in degenerative processes it is fetid; in retention it is inspissated, looks as if it were filtered, and resembles bread-crumbs. The causes of chronic suppurations are found in neglect of an acute otitis media, in the virulence of the infection, in general diseases, such as scarlet fever and diphtheria, or in reduced conditions of the general organism, such as scrofula and anemia, and, finally, in nasal diseases (ozena).

Course and Symptoms.—The beginning of a chronic otitis media is marked, as a rule, by the absence of symptoms. After the pain of an acute otitis has subsided, the patient usually pays no more attention to the ear, and slight interference with the hearing or aural discharge is usually neglected. The physician is not consulted until pain and a renewal of the purulent discharge make their appearance, or alarming general symptoms develop as the result of retention or disease of the bone. Headache is sometimes complained of, but generally after the cessation of the otorrhea. Subjective noises are not marked, and appear only at intervals. Perversions of taste and disordered taste in the mouth are frequently observed. Paralysis of the seventh nerve is rare unless there is caries. The interference with the hearing varies with the amount of the secretion, the degree of obstruction, and the number of adhesions between the drumhead, ossicles, and margins of the fenestræ. Rinne is often absolute and totally or partially negative; Weber usually in the diseased ear, or in the worst one of the two, if both are affected; Schwabach prolonged, unless there is some disease of the labyrinth, when it is shortened and the upper tone limit lowered. The irritation of the discharges often leads to otitis externa and eczema, with glandular enlargements in the neck and throat.

The appearance of the drumhead varies greatly (Plate 39): every grade of perforation is encountered, from a minute opening to total defect of the membrane. In suppurations unattended by marked disease of the bone the perforation is usually situated in the lower half of the drumhead, particularly in the antero-inferior quadrant. In caries of the incus, perforation is often found in the posterosuperior quadrant; in caries of the malleus, in Shrapnell's membrane (see p. 231). Hence the seat of the perforation is of some prognostic importance. The contour of the opening may be smooth or broken; sometimes, especially in tuberculosis, multiple perforations are present (Plate 39, 13). The large perforation is often slightly reddened and covered with granulations. The remains of the drumhead is of a grayish color. The margin of the perforation may clear the promontory and throw a shadow on it, or it is closely applied to the bone, or may even be adherent. The perforation may extend as far as the bony rim (annulus tympanicus), and is then spoken of as peripheral (Plate 39, 9), or it is separated from the tympanic ring by a peripheral zone of tympanic membrane (Plate 39, 6). Owing to the opacity of the drumhead the manubrium is obscured; if the perforation is very large, the manubrium may project into it (reniform perforation, Plate 39, 9). If the tension of the drumhead is relaxed, the manubrium retracts so that its extremity touches the promontory and may even become adherent to it (shortening of the manubrium in caries of the malleus, Plate 19; 39, 6, 7).

The color of the membrane over the promontory varies from yellow to scarlet. The surface may be uniform or covered with granulations (Plate 39, 5 to 10); sometimes it is a dirty, whitish gray when the epidermis of the canal has invaded the cavity (Plate 39, 11, 12). In rare cases yellowish nodular exostoses are observed on the promontory. After the suppuration has ceased a dry perforation often persists. What remains of the ear-drum is opaque, thickened, and often contains sharply circumscribed calcareous spots of a chalky whiteness, or it may be completely calcified. In such cases the tympanic mucous membrane appears pink or pale yellow, has a moist and glistening appearance, or, rarely, may be white from calcification. Sometimes it is hard and dry and covered with epidermis. On the promontory the tympanic artery may often be seen (Plate 39, 17, 18).

According to the seat of the perforation the various structures of the tympanic cavity come into view; thus, in a posterosuperior perforation the incudostapedial articulation. Circumscribed chronic suppuration—as, for instance, in Prussak's space or in the superior or inferior diverticulum of the incus—may be revealed by a perforation in Shrapnell's membrane, also by isolated caries of the malleus and incus and cholesteatoma of the middle ear.

Occasionally another perforation is present in the pars tensa. The drumhead is opaque, and above the short process of the malleus there may be a minute crust or a fetid drop of pus or even granulation tissue (Plates 35, 39, 15, 14). If the inflammation is confined to the attic, the suppurating portions are often shut off from the Eustachian tube, and no secretion is obtained on Politzerization. After suppuration in Prussak's space has ceased, cicatricial adhesions often remain about the neck of the malleus (Plate 20). The hearing is not impaired in perforation of Shrapnell's membrane. Even a large perforation may scar over; the scar appears as a dark, depressed, circular, or reniform area with a strong light-reflex.

The remains of the tympanic membrane at the same time are often calcified. The scar is said to be free when it does not touch the wall of the promontory; in such a case the scar bulges during Politzerization and presents a slight wavy movement in Siegle's speculum. The edges of the scar are not separated from the wall of the prom-

FIG. 76.—Sagittal section through the tympanic cavity (schematic): 1, Scar adherent to 2, stapes; 3, adhesion between the lower portion of the scar and the inner wall of the tympanum.

FIG. 77.—Sagittal section through the tympanic cavity (schematic); the scar bulges like a bleb after Politzerization, showing a constriction at the point where it is adherent (compare Fig. 76).

ontory (Plate 39, 21). If the scars are adherent to the underlying structures, the latter are seen quite plainly but disappear during Politzerization, owing to bulging of the scar (Plate 39, 23, 24). Sometimes a scar may be torn by violent blowing of the nose or by Politzerization. If the scar becomes united with the wall of the tympanic cavity or with the ossicles, it is said to be adherent. Small adherent scars appear dark and glistening; they are immovable in Siegle's speculum during inflation and unyielding when touched with the probe (Plate 39, 19, 20). An adhesion between the scar and the stapes in caries of the long limb of the incus may be recognized as a small nodule (Plate 19). Sometimes the scar becomes partially or totally adherent to the promontory, forming a kind of cul-de-sac; the adherent scar is immovable in Siegle's speculum, and is not affected by Politzerization, while free scars are slightly movable and bulge after Politzerization; the tympanic cavity then appears tendinous, as if traversed by strands of cicatricial tissue. The malleus, as a rule, is immovably fixed to the promontory and can be seen only with difficulty (Plate 39, 22). Bands of cicatricial tissue may shut the tympanic cavity off from the Eustachian tube or from the antrum, and thus make possible circumscribed suppurations in the pouches of the drumhead. Grave disturbances of the hearing may result from scars if they are adherent to important structures or from the presence of calcareous or connective-tissue new growths obliterating the attic, the fenestræ, or the Eustachian tube (Plates 20, 22, 36), or interfering with the mobility of the tympanic ossicles. Permanent perforation or even total absence of the drumhead with loss of malleus and incus may not interfere with the power of hearing if the mobility of the foot-plate of the stapes and the round window is preserved. On the other hand, even a small perforation or scar seriously interferes with the power of hearing if the chain of ossicles is fixed by adhesions (Figs. 81, 84), or if the margins of the fenestræ are obstructed. *Every* chronic otitis media must be regarded as a *grave* disease, the ultimate outcome of which, both as regards the hearing and the life of the patient, cannot be foretold with certainty. In general, a vigorous constitution affects the prognosis favorably. Old persons in whom the suppuration has existed for years, with perforation of the lower half of the drumhead, are in less danger than young individuals. An improvement in the general condition may bring about the spontaneous cure of an uncomplicated suppuration.

Treatment.—Uncomplicated chronic suppurations *can* and *must* be cured so as to avoid intracranial complications and general diseases, such as rheumatism and pyemia. General treatment directed toward the relief of nasal diseases, scrofula, etc., is of the utmost importance. The local measures must be directed toward the removal of pus and the regeneration of the mucous membrane. If the secretion is moderately copious and free from fetor, it must be wiped away with cotton or removed by Politzerization, catheterization, or aspiration with Siegle's speculum. If the discharge is copious or fetid, syringing becomes necessary. The tympanum is either syringed through the auditory meatus with an aural syringe, or if there is a large accumulation of tenacious material and the perforation is small,—as, for instance, when it is situated in Shrapnell's membrane,—the cavity must be flushed out through a small tympanum tube. If the Eustachian tube is patulous, the catheter may be used. Vertigo following the operation is combated by reducing the pressure in the auditory meatus and resorting to inflation. Either a 1 per cent. lysol solution or a 0.5 per cent. solution of formalin may be used (see pp. 124 to 128).

To loosen up masses of epithelium hydrogen peroxid, liquid paraffin, or menthol-vasogen must be injected into the cavity through a tympanum tube. Every syringing must be followed by inflation and careful drying of the ear. If the suppuration is profuse, the patient is ordered to syringe the ear and then bathe it with an alcoholic solution of hydrogen peroxid until the suppuration subsides. The ear must be examined on alternate days by the surgeon. If the suppuration does not subside in about four weeks, silver nitrate should be instilled, the ear being syringed before and after the instillation of silver nitrate, and if the scab comes away, the drug must be reapplied. In obstinate cases various remedies must be tried in succession, such as zinc sulphate, copper sulphate, alcoholic solution of boric acid, tannin-glycerin, 4 per cent. solution of resorcin, and, in tuberculosis, a glycerinated solution of iodoform. Granulations on the mucous membrane and drumhead should be removed by cauterizing with silver nitrate, chromic acid, or with the galvanocautery, or they may be scraped away with the

FIG. 78.—Politzer combination handle with paracentesis needle and, 1, foreign-body hook; 2, tenotome; 3, probe-pointed knife; 4, curet; 5, sharp spoon; 6, circular knife.

FIG. 79.—Foreign body and polyp forceps (after Hartmann).

small sharp spoon, the circular knife (Fig. 78, 5, 6), or Hartmann's cutting forceps (Fig. 79), taking care not to wound the wall of the labyrinth.

When the secretion begins to diminish, or if it is scanty from the beginning, insufflations of boric acid (Bezold), boric acid and alum, or boric acid with turpentine may be practised after syringing the ear, and a small ear-dressing constantly applied (see p. 129). For boric acid and its combinations, either aristol, glutol, or zinc sozoiodol may be substituted. If the perforation is small, it should be enlarged to guard against the danger of retention. If there are any pockets of pus in portions of the mucous membrane other than the site of the perforation, they must be drained by making a second perforation. After the discharge has ceased, the auditory disturbance may be treated by inflation or electric massage. After an otitis media an artificial drumhead may be tried and will sometimes be found to exert a very favorable influence on the hearing. It improves the position of the ossicles by pressing on the remains of the drumhead, or, according to Lucæ, acts favorably by altering the labyrinthine pressure, and, in addition, it increases the amplitude of the vibrations. The artificial drumhead is composed of a thin rubber disc attached to a wire (Fig. 80, Toynbee) or a little ball of cotton moistened in glycerin (Yearsley); it should be placed over the perforation or in the region of the fenestra vestibuli. The best place for conducting sound must be found by experiment, as the effect on the hearing varies greatly with the position of the artificial drumhead. The patient gradually becomes used to the contrivance and is able to wear it all day. Great cleanliness is necessary to prevent recurrence of the suppuration. An artificial drumhead may also be tried for the hearing when there are scars in the postero-superior quadrant. A large scar that bulges during Politzerization may be rendered more resistant by painting it with collodion. Just as in adhesive processes due to catarrh, an attempt may be made to remove the adhesions that remain after a chronic suppuration between malleus and incus, between the drumhead, the ossicles, and the promontory, and between the malleus and the promontory, in the hope of restoring some degree of mobility to the stapes (Figs. 81, 82, 83). Such attempts are often fol-

FIG. 80.—Artificial drumhead (after Toynbee).

lowed by very good results. In ankylosis of the malleus and incus the stapes may be rendered more movable by dividing the long process of the incus. Scars in the neighborhood of the stapes (Fig. 84) may be divided by synechotomy (Fig. 75), by incisions in the scar tissue (Fig. 84), or even by extraction of the stapes if the

FIG. 81.—Sagittal section through the tympanic cavity (schematic) (various changes are shown in the same section): 1, Obliteration of Prussak's space; 2, connective-tissue ankylosis of the stapes; 3, adhesion between manubrium and long process of incus; 4, adhesion between manubrium and promontory; 5, scar adherent to the promontory; 6, remains of drumhead. Incisions to relieve tension are made at 3, 4, 5.

FIG. 82.—Sagittal section through the tympanic cavity (schematic) (various changes are shown in the same section—compare Fig. 83): 1, Obliteration of the attic; 2, Prussak's space; 3, caries of long process of incus; 4, scar adherent to the capitulum of the stapes in the posterosuperior quadrant; 5, umbo adherent to the promontory; 6, remains of the drumhead passing to the umbo.

labyrinth is intact, thus bringing about marked improvement in the hearing. If the closure of a perforation with an artificial drumhead is not followed by tinnitus aurium and diminution in the power of hearing, as is the case when there is limitation of the movements of the malleus and incus, an attempt may be made to get the perforation to heal over. This is done by skin-grafting (Berthold) or by freshening up the edges of the perforation with trichlor-acetic acid. The caustic is applied once a week every week; often a crust is formed and the perforation only appears to be closed. Closing the perforation has the advantage of avoiding any danger of infection through the auditory canal. If spontaneous healing of a perforation is fol-

FIG. 83.—Sagittal section through the tympanic cavity (schematic); incisions for the purpose of relieving tension at 4, 5, and 6 (compare Fig. 82).

FIG. 84.—Sagittal section through the tympanic cavity (schematic); scar (3) adherent to the walls of the tympanic cavity (1), the stapes (2), and the tegmen tympani (4). Two incisions are made in the cicatricial tissue to relieve the tension of the stapes (synechotomy after Politzer).

lowed by a diminution in the hearing or tinnitus aurium, a fresh perforation must be made with a galvanocautery. The sound-waves may then be transmitted directly to the stapes, as in the case of a scar—for instance, in caries of the long process of the incus.

(ε) **Course of an Otitis Media in General Diseases.**—When an aural discharge develops in the course of an acute infectious disease, it is very frequently neglected or its significance is underestimated both by the physician and by the patient; but years later, after the infectious disease has long been forgotten, the gravest complications may develop, which might have been avoided if the proper treatment had been instituted promptly. Thus, 12 per cent. of all cases of chronic middle-ear suppuration and many cases of deaf-mutism are directly due to scarlet fever (Bürkner).

Scarlet fever, diphtheria, and influenza are the diseases that are most dangerous to the ear. In the third or fourth week of scarlet fever—that is, at the end of the period of desquamation—a simple acute otitis media develops, with pain in the ear but without fever, or a perforative otitis media may develop with elevation of temperature. If the proper treatment is applied, these conditions may be cured. On the other hand, an otitis media occurring before and during the period of eruption is usually attended with rapid breaking-down of the drumhead, which may become completely destroyed within four days. The tympanic ossicles fall a victim to caries and necrosis and are exfoliated; the discharge is fetid from the beginning, rupture of the pus through the windows of the labyrinth is followed by destruction of the labyrinth, deafness (panotitis), deaf-mutism, or meningitis. The temperature may rise to 40° C. (104° F.); the seventh nerve is often paralyzed. If there is a complicating diphtheria, the inflammation is apt to spread to the middle ear, and necrotic grayish-white shreds of membrane that are difficult to remove are found in the auditory canal. Mastoid complications are common. Even before the occurrence of perforation death may result from intracranial complications.

Treatment.—Must be instituted early. Spontaneous rupture must be anticipated by an early and free incision; otherwise the gravest consequences may ensue to the general health and throw discredit on the physician. Prophylactic gargles; if symptoms of labyrinthine disease make their appearance, hypodermic injections of pilocarpin.

Diphtheria.—Frequently complicating the middle ear in pharyngeal diphtheria by extension through the tube; usually attended with violent symptoms and great destruction; perforations are usually large. Postdiphtheritic paralysis of the palate may lead to exudative middle-ear catarrh and degeneration of the tubal muscles.

Measles.—The middle ear is always implicated in measles. In mild epidemics a simple acute otitis media is the rule, but usually, during the period of desquamation or in the second week of the eruption, the temperature rises and a perforative otitis ensues. If treatment is applied in time, the prognosis is good; but mastoid complications, caries, and necrosis frequently develop quite early; rarely gangrene of the pinnæ. In 8 per cent. of the cases measles is followed by chronic suppuration of the ear (Bürkner) (Plate 39, 4).

Influenza.—While simple otitis media occurs in catarrhal influenza, the perforative variety, which is common, is attended with intense pain in the mastoid process and in the extremities, high fever, hyperæsthesia acustica, deafness, and often trifacial neuralgia is more common. The drumhead is of a dark, bluish-red color and bulges (Plate 38, 20); bluish-black blebs are seen in the auditory canal (otitis media hæmorrhagica). Sometimes there are nipple-like projections on the drumhead. Perforation occurs early and is soon followed by extensive disease of the bone. Death from intracranial complications is not uncommon. Sometimes a *primary* ostitis mastoidea develops. After the subsidence of the otitis, sometimes even when there has been no otitis, otalgia often develops (Kaufmann).

Typhoid Fever.—Furuncles and gangrene of the pinnæ are rarely observed as a result of trophoneurosis. In from the third to the sixth week of the disease exudative catarrh may develop as a result of cerebral hyperemia. During the fourth or fifth week a specific perforative otitis media makes its appearance, with rise of temperature and usually a small perforation, often with early involvement of the mastoid process. If the membrana tympani is promptly incised, recovery ensues; otherwise the condition is apt to go on to a chronic otitis. During the first days of typhoid fever, owing to disease of the eighth nerve and the central organs of hearing, there may be impaired hearing and tinnitus, though the drumhead is normal. The condition lasts a long time, but ends in recovery or very rarely in deafness.

Pneumonia.—Perforative otitis media with rise of temperature may come on in the second or third week, the infectious material being propelled through the Eustachian tube during the paroxysms of cough (cerebral pneumonia).

Tuberculosis.—Tubercular infection of the middle ear is rarely primary or derived from the blood, the infection being most frequently carried by the sputum by way of the Eustachian tube, which is often dilated as a result of fatty atrophy. On the drumhead grayish-yellow nodules appear and rapidly break down (Schwartze), leaving multiple perforations (Plate 39, 13). A large defect in the membrane may be produced by the confluence of several perforations. The drumhead and mucous membrane are frequently covered with tenacious, whitish layers of fibrin (Scheibe). As a rule, there is no pain, but the hearing is markedly affected and grows rapidly worse. The aural discharge is fetid, thin, and caseous, and contains necrotic bone and tubercle bacilli. The tympanic mucous membrane is greatly swollen and contains caseous areas with and without giant-cells (Plate 31). The epithelium is destroyed, the bone often laid bare and eroded in places. Small sequestræ are seen lying in the granulating mucous membrane. Large portions of the temporal bone are often destroyed by caries (Plate 26). Palsy of the seventh nerve is common. The wall of the promontory feels rough to the probe, the tympanic ossicles are often carious, and the roof of the tympanum is perforated like a sieve (Plate 24); there is often no tendency to external rupture. Death is usually due to the pulmonary disease, more rarely to intracranial complications or erosion of the carotid artery (Plate 26). The prognosis is bad, but a non-tubercular otitis may occur and be recovered from in tuberculosis (Schwabach). In rare cases tubercular bony tumors are formed in the temporal bone (Körner).

Treatment.—Constitutional. Locally, insufflation of iodoethyl, and instillation of glycerinated iodoform. Radical operative intervention is justifiable if the indications are urgent and the general condition is favorable.

Syphilis.—Ulcerations in the nasopharynx in syphilis extend to the Eustachian tube and lead to middle-ear catarrh or inflammation. The interference with the hearing is usually great, particularly if disease of the labyrinth is also present. The functional test is important in establishing the prognosis. If there are symptoms of labyrinthine disease, such as positive Rinne, Weber in the healthy ear, shortening of Schwabach, and lowering of the upper tone limit, the prognosis is unfavorable. A purulent otitis media ends either in recovery or in chronic suppuration.

Treatment.—Constitutional, inunctions, potassium iodid. Local, the same as in non-specific diseases.

Diabetes.—Fulminating perforative otitis media with extensive destruction of the bone, but usually without involvement of the soft parts. Rapidly progressing destruction of bone is also occasionally observed in Bright's disease.

Actinomycosis.—Rarely primary in the middle ear; usually secondary to actinomycosis of the lower jaw. It leads to grave disease of the middle ear and mastoid process. The diagnosis is confirmed by microscopic examination.

(c) **Diseases of the Eustachian Tube.**—Since the Eustachian tube is of the greatest importance to the middle ear as an organ of protection and ventilation, disease of the tube is very frequently followed by disease of other portions of the middle ear, and it is rare that a morbid process is strictly confined to the tube alone.

1. **Foreign bodies** may enter the tube from the mouth during vomiting; a bougie, after being introduced, may break off; gunshot wounds have occasionally been reported. The foreign body is usually forced out of the tube during hawking and swallowing; if it is visible by postrhinoscopic examination, it may be removed with an instrument through the nasopharynx.

2. **Salpingitis.**—(α) **Acute.**—*Etiology and Pathology.*—Infection, especially of the cartilaginous portion, in catarrh of nasopharynx. The tube becomes occluded by swelling and increased secretion of mucus (Plate 23, 3 a).

Course and Symptoms.—In the postrhinoscopic image the pharyngeal orifice of the tube appears reddened and often contains a plug of pus or a crust. During Politzerization air enters the tube with difficulty or not at all. The drumhead is retracted, and its luster normal. At first and so long as the disease is confined to the tube there is no exudate, but the patient complains of fulness in the ears and deafness (closing of a valve in the ear), pain on yawning and swallowing, and itching in the throat when the patient takes snuff. Sometimes the condition changes to chronic catarrh.

Treatment.—Treat the disease of the nasopharynx; inflation, if necessary, with the catheter.

(β) **Chronic Salpingitis.**—*Etiology and Pathology.*—An acute salpingitis may become chronic if the nasal obstruction persists. Stricture of the tube may result from hyperemia of the mucous membrane and the formation of connective tissue, or the lumen may become enlarged through atrophy.

Course and Symptoms.—Great auditory disturbance, with symptoms of catarrhal adhesions in the tympanic cavity. There is no pain. Auscultation reveals a murmur during inflation. If the tube is dilated, there is autophonia.

Treatment.—Inflation alternating with injections of zinc sulphate, ammonium muriate, and a glycerinated solution of iodin through the catheter. Introduction of bougies which may be tipped with a 10 per cent. solution of silver nitrate. Medicated vapors (turpentine, sal ammoniac, menthol). External massage of the neck and massage of the tube. Treat the nose.

3. Ulceration at the Pharyngeal Orifice of the Tube.—Adenoid vegetations are sometimes accompanied by follicular abscesses that may invade the orifice of the tube (Trautmann). Ulceration occurs in diphtheria, tuberculosis, lupus, syphilis, scrofula, variola, and malignant tumors (carcinoma). They result in adhesions and scars at the tubal orifice or between the pharynx and the velum palati, thus occluding the tube.

Treatment.—Constitutional. Treat the disease of the nasopharynx. The ulcers at the tubal orifice may have to be cauterized with chromic acid. Irrigate the nasopharynx.

4. Alterations in the Lumen.—Stricture of the tube, especially in the neighborhood of the isthmus, occurs as a sequel of chronic middle-ear catarrh. Stricture at the pharyngeal opening may be caused by the pressure of a tumor in the nasopharynx, such as adenoid vegetations, hypertrophied tonsils, or polypi; by paralysis of the seventh nerve; and by congenital cleft palate, owing to collapse of the walls of the tube. Atresia results when denuded portions of the walls lying opposite one another become adherent, especially in the cartilaginous portion, and from hyperostosis in the bony portion (Plate 23). Stricture and atresia are recognized by the absence of an auscultation murmur during inflation. Sometimes catheterization meets with great resistance, and high-pitched whistling murmurs are heard, which become lower in pitch after the passage of a bougie. Politzerization and Valsalva's experiment cannot be carried out.

Treatment.—Strictures are dilated by passing bougies of gradually increasing caliber, two or three times a week for fifteen months. Massage of the tube may be useful. If the stricture consists of connective tissue, recovery is rare. In atresia an attempt may be made to divide the obstruction with a probe-pointed knife, introduced through a catheter or by means of electrolysis. If the atresia is incurable, some improvement is obtained by making a perforation in the drumhead with the galvano-cautery, or, if the distress is great, by extirpating the malleus so as to allow air to be forced into the tympanum through the auditory canal. Insufficiency of the tubal muscles should be treated by galvanization.

C. Sequelæ of Suppurative Otitis Media.—(**a**) **Diseases of the Mastoid Process** (after Körner).—Disease of the mastoid process is usually secondary. Primary infection of the mastoid process may occur by way of the blood, as in tuberculosis and osteomyelitis. The diseases of the mastoid process manifest themselves as periostitis and ostitis mastoidea. Mastoid disease may appear to be primary when it occurs after an otitis media has subsided ; this is particularly common in pneumococcus and influenza infection. Periostitis must be distinguished from edema, broken-down lymph-glands, and soft tumors of the mastoid process. The symptomatology and treatment of primary mastoid disease, which is very rare, are the same as in the secondary form. Periostitis of the mastoid is usually secondary to ostitis. Primary periostitis practically occurs only after injuries in connection with abscess of the parotid gland and after otitis externa. It may in that case lead to secondary superficial caries of the cortical portion of the bone, which, however, usually runs a favorable course.

1. **Acute Mastoiditis (Acute Necrosis of the Bone).**—*Etiology and Pathology.*—Infection of the mastoid process occurs after an acute otitis media, particularly in patients suffering from syphilis, tuberculosis, diabetes, or weakened by influenza, scarlet fever, or diphtheria. One of the commonest causes is retention of pus owing to *insufficient drainage*, in *spontaneous rupture* of the drumhead,

when the perforation is too small or is situated too high up, or the outflow is obstructed by polypi or stricture of the auditory meatus. The infection is usually due to streptococci, and is attended with necrosis of the bone (Plate 30). It is probable that the mastoid process contains pus in every case of acute suppuration; in other words, there is an empyema of the mastoid process (Plate 23), but the bone is not necessarily diseased, and if adequate drainage is secured, the suppurative process in the mucous membrane may heal spontaneously. The mucous membrane lining the mastoid process becomes greatly swollen, and the seat of serous and round-cell infiltration (Plate 34), the lumen of the mastoid cells becoming greatly constricted.

When the opening of the mastoid cells or the communication between the threshold of the antrum and the antrum itself become obstructed by excessive swelling of the mucous membrane, pus is not properly absorbed, especially in the pneumatic type of mastoid process, with large apical cells, drainage is insufficient, and retention takes place. These circumscribed purulent foci may remain within the mastoid process after the suppurative process in the tympanum has ceased. The denuded mucous membrane under the pressure of newly formed granulation tissue proliferates into the bony septa which separate the cellular spaces, the septa break down and disappear (Plate 34), so that the entire structure is often converted into a large cavity filled with granulation tissue, pus, and carious bone (see p. 231). The cortical portion of the bone and periosteum are not necessarily involved. The purulent granulations are particularly apt to burrow through the spongy bone until they reach the cranial cavity, breaking through the lamina vitrea and laying bare the sinus and dura mater. Sometimes the granulations follow the Haversian canals and vascular channels, and appear on the outer surface of the bone in the mastoid fossa (Plate 29), or force their way toward the roof and posterior bony wall of the auditory meatus

(Plate 24). More rarely they invade the cellulæ squamosæ and attack the squama or the inner surface of the tip of the mastoid process.

When a plug of granulation tissue gets under the periosteum, the latter is loosened from the bone by the accompanying purulent exudation. The periosteum and the skin become infiltrated, and a subperiosteal abscess is formed, which later, after the periosteum breaks down, becomes converted into a subcutaneous abscess. The skin behind the ear or in the posterior wall of the auditory canal may be perforated by fistulæ, or deep abscesses may develop on the sides or back of the neck. Occasionally the periosteum escapes, even after rupture through the cortical portion of the bone has taken place. In small children, before the squamomastoid suture is closed, an empyema of the mastoid process may lead to a periosteal abscess, without destroying the bone. In such a case, and in fact whenever there has been no caries of the bone, recovery by absorption is possible.

Symptoms and Course.—In acute otitis media, before paracentesis, the mastoid process, especially the tip, is always sensitive to pressure. If, after an incision has been made and sufficient drainage has been obtained, the sensitiveness of the mastoid process increases and the patient complains of continuous pain, or if, after a week's application of ice compresses, the swelling of the periosteum does not subside, the bone is in all probability diseased. In caries of the bone the general condition is greatly affected: in adults there is a subfebrile temperature; in children, high remitting fever and frequently cerebral symptoms, such as vomiting, convulsions, and stupor. The discharge is very profuse, creamy, hemorrhagic, and contains carious bone. If, four weeks after the beginning of an otitis media, the discharge continues profuse, caries of the bone should be suspected. In periostitis and when the pus has burrowed under the skin of the auditory meatus the lumen becomes constricted to a narrow cleft, owing to the depression of the roof and posterior wall of the canal, then there is no doubt that the bone is carious. The same is true if the pus has burrowed under the skin of the mastoid process.

The pinna is pushed downward and away from the skull; the fold of the ear becomes obliterated; if the abscess is superficial, fluctuation is felt; the skin is red and hot; sometimes pus can be squeezed out of the ear by pressing on the swelling. The lymph-glands on the mastoid process and in the neck are swollen. If the soft parts are not involved, the percussion note is absolutely flat, and on transillumination the parts appear dark. The skin behind the ear may be perforated by one or more fistulæ. If the pus burrows into the digastric groove, which does not usually occur in children under six years of age, the insertion of the muscle at the mastoid process is forced outward. The pus then burrows along the sheaths of the muscles as far as the clavicle, or posteriorly into the nuchal region. The head is inclined toward the diseased side, and a swelling is noted along the sternocleidomastoid muscle. Owing to the deep situation of the abscess no fluctuation can be felt (Bezold). Spontaneous recovery is possible after the formation of fistulæ, but leaves large defects in the mastoid process or in the posterior wall of the meatus, which become covered with scar tissue (Plate 27).

Treatment.—In the early stages of ostitis and periostitis of the mastoid process paracentesis openings should be enlarged; if there are polypi, they should be removed and the ear irrigated. Leeches or ice-bag should be applied. If caries of the bone is established beyond a doubt by the presence of fistulæ or depression of the roof and posterior bony wall of the auditory meatus, or if it appears very probable, from the continuance of severe pain, fever, and infiltration on the mastoid process, in spite of a week's application of ice compresses, or if symptoms of intracranial complications develop, the mastoid process must be opened (Plate 29). Incision of the soft parts down to the bone—the so-called Wilde incision

—is insufficient except in the empyema of infants and before the squamomastoid suture has become closed. Since there is caries of the bone the diseased bone must be removed, and if the suppurative process is still active in the tympanum, the source of suppuration—the antrum—must be exposed by a formal opening of the mastoid process after Schwartze.

Before proceeding to operate the contour of the skull should be studied carefully, as the course of the posterior

FIG. 85.—Stacke gouge.

bony wall of the auditory canal varies somewhat in dolichocephalic or brachycephalic skulls (see p. 19). If the tissues behind the ear are swollen and pierced by fistulæ, a curved incision should be made through the swelling; if not, the incision should be made parallel with and $\frac{1}{2}$ cm. behind the insertion of the ear, and carried down to the bone. After the hemorrhage has been controlled, the periosteum is pushed back in both directions and the pinna, with the cartilaginous portion of the meatus,

FIG. 86.—Flat chisel (after Lucæ).

drawn forward until the posterior margin of the bony portion of the canal, the mastoid fossa, the supramastoid crest, and the tip of the mastoid are exposed. If there is a fistula through the bone, the probe should be introduced to determine whether the dura or the sinus is exposed. The granulations are then removed with a curet, the fistula is enlarged with a chisel, and the antrum is laid bare (see below). In small children curetting suffices, as the antrum is very superficial (Plate 6, 1). If the outer surface of the bone is intact, an opening about 1 cm. in diameter is made with the chisel, $\frac{1}{2}$ cm. behind the suprameatal spine and below the supramastoid crest (Plate 29).

The instruments used are gouges (Fig. 85), straight chisels (Fig. 86) with rounded corners, and a steel hammer (Fig. 87). The edge of the chisel must always be directed away from the supramastoid crest, to avoid the middle fossa of the skull, and away from the posterior surface of the wound to avoid the sinus; for safety, therefore, the opening is made parallel to the auditory canal. If the operator is careless, he may wound the dura mater (Plate 10), the sinus, the seventh nerve, or the labyrinth (Plate 7). If the bone underneath the cortex is broken down, pulsating pus and granulations are soon exposed. These should be curetted away. The probe is then introduced, to search for a fistula leading into the antrum; if no fistula is present, the antrum is reached by going in along the posterior wall of the meatus from without, the instrument being directed from behind and above forward, downward, and inward not more than 18 mm., on account of the danger of injuring the seventh nerve and the labyrinth (Plate 7, 29). The posterior bony wall of the auditory canal should not be touched. If the sinus is in an abnormal position and comes into view as soon as the bone is opened (Fig. 17), or if there is a fistula in the auditory canal, the posterior bony wall of the canal must be removed as far as the diseased area in one direction, and as far as necessary to expose the antrum in the other. Overhanging edges of bone are clipped away with a rongeur forceps. If the tip of the process is diseased, it must be cut away with the bone-cutters (Fig. 88), taking care not to wound the occipital artery. If the pus has already dipped into the tissues,

FIG. 87.—Cholewa's hammer.

the incision may have to be enlarged downward or backward. If the incision has been large, the upper angle of the wound should be closed with a suture. The wound behind the ear is then packed with iodoform gauze and strips of sterile gauze introduced into the ear; a pad is placed behind the pinna, and a large ear-dressing is applied. If no fever develops, the dressing need not be changed for four or five days. Either sterile or silver gauze may be used in the dressing. Fever occurring on the day of the operation in patients who were free from fever before is aseptic wound-fever (postoperative fever). If it occurs on the second or third day and there are no other complications—such as angioma, for instance—that have anything to do with the ear, we must suspect infection of the wound, retention of pus, or an intracranial complication, and the dressing should at once be changed. If the discharge is fetid, aluminium acetate should be used. In healthy subjects the cavity in the bone and the incision in the skin heal by granulation. Exuberant granulations may be touched with silver nitrate.

FIG. 88.—Rongeur forceps (after Luer).

The ear itself must be treated at the same time. The aural discharge often subsides before the wound behind the ear has ceased to suppurate; the latter heals in about two weeks and leaves a contracted scar. If the general condition is much reduced, healing may be delayed, and if the carious process in the bone continues, as in tuberculosis, lues, and scarlet fever, the wound does not heal at all. In that case the sequestra must be removed from the mastoid process, the auditory ossicles be extracted, and the radical operation may become necessary. The measures employed to improve the hearing are the same after mastoiditis as after acute perforative otitis media (see p. 186).

2. Chronic Mastoiditis and Osteosclerosis.—*Pathology and Etiology.*—Chronic suppuration of the middle ear almost always involves the mucous membrane of the mastoid process, which appears pale red, swollen or thickened, and tendinous. The granulation tissues with which the mastoid cells are filled may become fibrous (Plate 34) or even undergo ossification. The cellular spaces then become filled by brittle, eburnated bone, and the cavity of the antrum becomes contracted (Plate 6). (Osteosclerosis is an almost constant accompaniment of chronic suppuration.) Even in uncomplicated chronic suppurations, where the perforation in the drumhead is usually found at or near the center, pus is almost always found in the antrum, although the bony walls of the cavity are normal.

Carious processes in the mastoid process are usually due to insufficient drainage and periodic retention. The walls of the antrum crumble and become infiltrated by granulating mucous membrane (see p. 231); the cavity contains granulations and semifluid, caseous, fetid pus. The drumhead is usually entirely destroyed, or peripheral perforations are present in the upper half of the membrane. In osteosclerosis the carious process begins in the antrum, which becomes enlarged from the breaking-down of its walls. From the antrum the pus may be carried to the cranial cavity by the normal channels in the bone, but more frequently the carious process in the antrum reaches the cranial cavity by direct extension (Plates 24–27). The soft parts on the surface of the mastoid process are not so apt to be diseased as in acute ostitis, because rupture toward the surface meets with greater resistance. Disease of the antrum is usually a concomitant of disease of the tympanic cavity and ossicles (pp. 230–235). The danger of a fatal termination is enhanced by retention of pus (exostosis of the auditory canal).

Course and Symptoms.—Chronic disease in the bone of the mastoid process in individuals who have suffered from suppuration in the ear for many years may run its course without giving rise to symptoms. Sometimes the aural discharge is very profuse; frequently the pus may be seen behind and above, trickling down from the region of the antrum, and retains its fetid and caseous character in spite of antiseptic irrigations. It may be scanty and dry up to form crusts; polypi are frequently found in the auditory meatus. There is great destruction of the drumhead (Plate 39, 7, 8); the malleus is wanting, or projects into the tympanic cavity; the incus is destroyed, or very often carious, and a peripheral perforation is frequently found above and behind, in Shrapnell's membrane; sometimes with a carious defect in the bony portion of the meatus. During aspiration with Siegle's speculum pus trickles down out of the antrum, and occasionally the probe comes against rough bone. As a rule, there is no pain unless pus-retention occurs, which manifests itself in tenderness of the mastoid process, periosteal swelling, fever, and sudden cessation of a profuse discharge. Sometimes, if the cortical portion of the bone is diseased, subperiosteal abscesses and fistulæ appear on the outer surface of the mastoid process or on the roof and posterior wall of the auditory canal. Suppuration of the mucous membrane alone may get well spontaneously or under local treatment. While the process of osteosclerosis is going on the patients sometimes complain of neuralgia.

Treatment.—The same as for chronic otitis media, with removal of the granulation and extraction of diseased ossicles, followed by irrigation (see p. 230). If the bone is diseased, the radical operation is indicated (Plate 29). In osteosclerosis with neuralgia a wedge-shaped opening in the mastoid process will suffice (Schwartze). The radical operation is indicated in chronic mastoiditis when the presence of abscesses and fistulæ and repeated swelling of the periosteum make it certain that there is caries of the bone; when caries of the bone is probable from the fact that the retention cannot at once be relieved, particularly in stenosis of the auditory canal; when there are fever, pain on pressure, and periosteal swelling; when the general condition of the patient is impaired and otorrhea ceases. The last condition must not be confounded with otitis externa and constitutional diseases. Further indications are the appearance of the first symptoms of intracranial complications, such as headache, vertigo, vomiting, hyperemia of the optic nerve, and optic neuritis; the extension of the suppuration to the labyrinth, indicated by sudden deafness, nausea, tinnitus aurium, and staggering gait, and, finally, a suddenly developing paralysis of the seventh nerve. The diagnosis of caries not attended by violent symptoms from the otoscopic findings alone often requires a protracted period of observation (see p. 217). In such cases the radical operation is also indicated if local interference has proved unavailing. The object of the radical operation is to expose the antrum and tympanum, to connect the two by removing the posterior bony wall of the auditory meatus, and convert them into one large cavity, thorough inspection of which is secured by the implantation of epidermis (Küster, Zaufal, von Bergmann, Stacke). Before operating, the shape of the skull must be studied carefully; the electric head-lamp should be used during the operation. The steps of the operation are as follows:

1. Separation of the Pinna and Auditory Canal (Plate 29).—A curved incision, ½ cm. behind the ear, from the tip of the mastoid to the supramastoid crest, carried down to the bone, is made. Strip the periosteum and control the hemorrhage. The pinna and posterior membranous wall of the canal are drawn forward and dissected away from the bone as far as the drumhead, close to which they are divided by a transverse incision, taking care not to wound the anterior wall of the canal. A strip of gauze is passed through the auditory canal to act as a retractor. The pinna is then drawn forward until a view of the tympanic cavity is obtained. On the mastoid process the following landmarks must be exposed: The supramastoid crest, suprameatal fossa, mastoid fossa, the tendon of the sternocleidomastoid muscle, the anterior half of the process, and the squamomastoid suture.

2. Opening the Antrum.—When the cortical layers of the bone are healthy, the antrum is opened from the outer surface of the mastoid process after Schwartze, just as in acute mastoiditis. If the cortical layers are traversed by fistulæ, the latter may be utilized (p. 221, Fig. 89).

3. Removing the Posterior Bony Wall of the Auditory Canal.—The bone is chiseled away in layers below the supramastoid crest, taking in the entire width of the posterior wall. If the middle fossa of the skull is displaced downward, there is danger of wounding the dura, but if the asepsis is perfect, this does no harm. As the deeper portions of the canal are reached the floor of the meatus must be avoided more and more because it lodges the seventh nerve (Plate 3). If the sinus is displaced forward, there is danger of opening it, but if the asepsis is perfect, this is of no importance. In anemic individuals there is some danger of air embolism during deep inspiration after the sinus has been opened. Hemorrhage may be controlled by packing with iodoform gauze; if it is very severe, the operation may have to be discontinued. Before the last bridge between the antrum and the auditory canal is broken through with the chisel or rongeur forceps, a probe should be introduced into the entrance to the antrum as a precautionary measure (Fig. 90). If the chisel goes too deep, it will injure the seventh nerve and possibly the external semicircular canal and vestibule.

4. Opening the Attic.—A bent probe is introduced into the attic, and the osseous portion removed until the attic is level with the roof of the tympanum. The antrum, mastoid process, auditory canal, and tympanum have now been converted into a common cavity divided into two parts by the lower portion of the posterior bony wall of the meatus and by a low ridge of bone (spur).

The latter is to be leveled as much as possible, the operator being on the lookout for twitching of the facial muscles, indicating injury to the seventh nerve. By removing the floor of the auditory canal the "cellar" of the tympanum is made more accessible from without (Jansen).

FIG. 89.—Right temporal bone, showing: 1, Opening the antrum after Schwartze; 2, point where the chisel is first inserted in removing the posterior wall of the meatus after Wolf; 3, the same after Stacke; 4, portion of mastoid process removed in same operation, exposing the sinus and cerebellum; 6, exposing the cerebrum (temporal lobe); 7, spur; 8, middle meningeal artery; 9, second temporal fissure; 10, first temporal fissure; 11, fissure of Sylvius; 12, mastoid foramen.

5. *Curetting of the entire cavity* without using force, but thoroughly, especially near the pharyngeal orifice of the Eustachian tube. Overhanging edges of bone are smoothed away until the probe can be passed in every direction without catching.

6. *Plastic Operations on the Auditory Canal.*—(*a*) Two

parallel incisions are made through the upper and lower margins of the posterior membranous wall of the canal, from its free extremity to the cavum conchæ; by this means a flap is obtained with the free posterior edge, which must be made thinner by removing the cartilage (Körner) (Fig. 91). In making the flap the membranous wall of the canal may be held with a Hartmann forceps (Fig. 92).

FIG. 90.—Rongeur forceps (after Jansen).

(*b*) An incision is made in the upper wall of the posterior membranous wall of the auditory meatus, and carried as far as the concha; then a second vertical incision is carried downward so as to form a quadrangular flap free at the lower margin (Stacke).

(*c*) An incision is made about the middle of the posterior membranous wall of the auditory meatus, and carried as far as the cavum conchæ, and two vertical incisions are made, ½ cm. in length, one upward and the other downward, so as to form an upper and a lower flap (Panse).

7. *Arrest the hemorrhage.*

8. *Introduction of from three to five sutures* in the wound behind the ear down to the lower angle.

9. *Packing of the Auditory Meatus.*—Strips of aseptic gauze are loosely packed into the canal to complete the plastic operation. Körner's flap is pushed backward, Stacke's downward, and Panse's flaps upward and downward against the bony wall, to which they become adherent. A gauze drain is introduced into the lower angle of the wound behind the ear.

10. *Application of a Large Ear Dressing.*—If primary suture of the wound is impossible on account of great infiltration of the skin or extensive caries of the mastoid

process, the wound is left open and the plastic operation put off to another time. This course is also pursued if a diseased dura or diseased sinus has been exposed. If, in Schwartze's operation, the antrum is not found at a depth of 1 cm., or if the sinus is displaced forward, Stacke's method, in which the antrum is opened from the auditory canal, should be employed. The drumhead is excised, and the malleus and the incus are extracted. The

FIG. 91.—Schematic view of the plastic operations, showing the flaps obtained from the posterior membranous wall of the meatus: 1, After Körner (solid lines); 2, after Panse (dotted lines).

osseous portion of the attic is then chipped away with a bone chisel (Fig. 93) until the roof of the tympanum is level with the upper wall of the auditory canal (Plate 17). A probe (Stacke's protector) is introduced into the entrance of the antrum, so that it lies between the semicircular canal and the seventh nerve below, and the extremity of the roof and posterior bony wall of the auditory canal above. The bone is then chiseled away in layers over the protecting probe until the antrum is opened. The outer shell is then removed as in 3 (p. 220).

Another method of performing the radical operation consists in at once chiseling away the roof and posterior wall of the auditory canal as if to enlarge the canal backward. In this way the antrum is reached at about the middle of the bony wall of the canal (Wolf). If a fistula

FIG. 92.—Hartmann forceps for seizing the membranous auditory canal.

FIG. 93.—Stacke bent chisel.

is found in the wound, it must, if necessary, be followed as far as the cranial cavity.

After the operation the patient should be kept in bed for a week; if no fever develops, the dressing need not be changed for five days. Aseptic fever as high as 39° C. (102.2° F.) may occur on the day of the operation; if it occurs later, it is a sign of infection, pus-retention, or intracranial complications. If the patient has been free from fever for a week, no intracranial complication need be feared. The wound behind the ear heals by primary intention if asepsis has been perfect. The sutures may be removed after a week if there are no stitch abscesses. During the process of healing in the bone cavity the walls first become covered by granulation tissue; this is converted into fibrous connective tissue and later covered by the flaps of skin derived from the auditory canal, which have been forced into the cavity by the tamponade during the after-treatment. Excessive growth of the granulations and adhesions must be prevented by cauterization with silver nitrate or the galvanocautery. The new growth of epithelium will be materially assisted by avoiding any kind of irritation, by taking care to pack the cavity loosely, by observing strict asepsis, and by the insufflation of boric acid or itrol. If there is persistent suppuration from diverticula in the Eustachian tube or in the floor of the tympanum, the introduction of a crystal of methylene-blue may prove useful. If infection occurs during the after-treatment, perichondritis of the pinna is apt to result. The process of epithelialization may also be assisted by transplanting minute pieces of skin after Thiersch's method. The auditory canal and the cavity in the bone must remain as completely exposed during the after-treatment as they were during the operation. If any pockets are formed, the pus will be retained and lead to fresh disease of the bone. A thorough insight into the cavity is also of importance in preserving the hearing; hence it must not be allowed to become obliterated by granulations.

Sometimes the hearing is improved by the operation if the patient uses an artificial ear-drum. If any diseased bone remains behind, the operation will not be successful. Recovery is also interfered with by impairment of the general health and by any local suppuration—as, for instance, in the cells of the Eustachian tube, or by cyst formation underneath the epidermis (Zeroni). Under favorable conditions recovery results in from one to three months; recurrence is rare. Sometimes the cavity heals, but the plastic operation is unsuccessful. In that case the tympanum is in danger of infection through the auditory canal, just as when there is a dry perforation. During the postoperative period attention must be given to the general condition and the treatment of the nose (Mosler's pharyngeal douche). Recovery is sometimes followed by dermatitis, with the formation of crusts and scales in the epidermal covering of the cavity. This readily yields to treatment. If the subepithelial tissue becomes fibrous, the walls of the cavity present a bright, reflecting surface.

Pneumatocele is the entrance of air under the skin of the mastoid process in defects of the cortical layer of the bone; it may follow inflation.

(b) **Cholesteatoma.**—It occurs rarely as a new formation in the temporal bone (Virchow's margaritoma; dislocation of embryonal epithelial tissue), with secondary suppuration of the ear. Much more commonly it is a product of the epidermis that has wandered into the tympanic cavity and mastoid process from the auditory canal and drumhead in chronic suppurations of the middle ear (otitis media desquamativa) (Habermann, Bezold). Whenever the subcutaneous tissue in the cavity is inflamed, the overlying epidermis is apt to form cholesteatomatous masses which glisten like mother-of-pearl and are arranged in successive layers like the skins of an onion. Thus, in elephantiasis of the leg the intervals between the papillary elevations in the skin are filled with layers of horny tissue consisting of flat polygonal cells devoid of nuclei, which, when examined under the microscope, do not differ from cholesteatomatous masses found in the ear (Plate 35); in aural polypi also the squamous epithelium is prone to form a cholesteatoma. It follows, therefore, that the only conditions necessary for the formation of a cholesteatoma in the middle ear are the presence of epidermis and a moderately inflamed soil. In chronic suppurations, if the epithelium of the tympanic cavity is destroyed and the mucous membrane is not too greatly inflamed, the epidermis from the auditory canal wanders into the tympanum, the attic, and the antrum (Plate 35, 4), and there proceeds to form cholesteatomatous masses which cannot escape from the narrow cavity and its outlet. Immigration of the epidermis is favored by the presence of peripheral perforations, particularly in the posterosuperior quadrant and in Shrapnell's membrane, where a thickened tongue of epidermis extends on to the drumhead. Other favoring factors are fistulæ in the posterior wall of the meatus (Plate 28), adhesion of the edge of the perforation, and adhesion between the end of the malleus and the wall of the promontory. The membrane that lines the cholesteatomatous cavity is composed of inflamed corium (Plate 35), a layer of epidermis including the rete Malpighii, a layer of eleidin cells, and an overlying layer of nucleated squamous cells. The latter is covered by horny tissue arranged in layers, which, seen from above, appear to be composed of flat polygonal cells devoid of nuclei. Between the layers of the horny tissue numerous cholesterin crystals are found. Cholesterin ($C_{26}H_{44}O$) crystallizes in transparent rhomboid plates, greasy to the touch, with a mother-of-pearl luster and frequently with one corner punched out in the form of a step, or it may crystallize in the form of delicate needles. They can be seen in the microscope only under very weak illumination. If a few drops of a solution consisting of one part water and five parts concentrated sulphuric acid are added to the crystals under the microscope, a carmin color appears at the periphery of the crystals and slowly changes to violet. If a small portion of cholesterin is put into a test-tube and dissolved in chloroform, and an equal quantity of concentrated sulphuric acid is added and the mixture shaken for a few minutes, the chloroform in the presence of cholesterin becomes first lemon-yellow and then purplish-red, and if the fluid is poured into a dish, the colors change to blue, then to green, then to yellow (Salkowski).

The epidermis lining the middle ear sends processes into the Haversian canals. The cholesteatomatous masses, containing as they do enormous numbers of pathogenic micro-organisms, act as an irritant on the surrounding tissue and set up an inflammation in the adjoining bony walls of the cavity, which are usually sclerotic. The antrum becomes enlarged by eccentric atrophy and atrophy due to pressure; large portions of the bone, embracing, for instance, the posterior bony wall of the canal, the tegmen tympani and antri, the cortical portion of the mastoid process, and the labyrinth (fistulæ in the semicircular canals), may break down (Plates 27, 28). When there is carious disease of the bone, especially in the tympanic ossicles, abundant polypoid granulations are found. The interior of the cranium may be exposed to infection, and death result from meningitis, sinus thrombosis, or brain abscess. The skin, as it grows into the spaces of the middle ear, forms pockets which may be empty, or filled with layers of epithelium and detritus. The cholesteatoma varies from the size of a hemp-seed to that of a walnut. The central nucleus usually breaks down, turns brown, and emits a fetid odor. The new growth may be confined to the attic and cause the osseous portion to break down. If the inflammation is so violent as to destroy the skin as soon as it enters the middle ear, or if the invasion occurs after the inflammation of the mucous membrane, no cholesteatomata are formed; on the contrary, the morbid process is arrested, and recovery occurs with epithelialization of the tympanic cavity.

Course and Symptoms.—Epithelial masses lying within the middle ear do not give rise to symptoms until they begin to swell; but if the attic is filled, headache, vertigo, and aprosexia often develop. But as soon as the cholesteatomatous masses swell, after syringing, for instance, or as the result of sweating, pressure symptoms, such as headache, vertigo, vomiting, and fever develop. The canal appears filled with whitish, iridescent masses and numerous polypoid granulations; the tympanic mucous membrane is grayish white and covered with epithelium (Plate 39, 12); there is usually a perforation in the posterosuperior quadrant or in Shrapnell's membrane and a defect in the adjoining bone (Plate 39, 11, 16), from which masses of epidermis or polypoid granulations (Plate 39, 15) project. The manubrium and the edge of the perforation are often adherent to the promontory. The purulent discharge is usually scanty and forms crusts. If the tympanic cavity is flushed out for diagnostic purposes, small fragments or shreds of cholesteatomatous material with a few cholesterin crystals that glitter like gold are returned in the water. If the cholesteatoma cavities are accessible, the condition may be cured by syringing; sometimes the material comes away of its own accord. In that case the cavity becomes invested with a cicatricial membrane that presents a reflecting surface. But if the inflammation of the corium progresses, fresh masses of cholesteatoma are formed which may again be expelled or remain within the cavity and produce fresh cerebral symptoms.

If the posterior bony wall of the canal becomes destroyed, the resulting cavity closely resembles the wound cavity after the radical operation (Plates 28, 29). If the cholesteatoma-cavity is large and communicates with the outer air by a narrow passage, retention is very apt to occur, with cerebral symptoms, such as fever, pain, choked disc, and mastoiditis and periostitis, with the formation of fistulæ (Plate 27); or the suppurating cholesteatoma may infect the interior of the skull, either through some preformed channel or after the bony tissue that protects the interior of the skull has broken down.

Treatment.—The invasion of skin must be guarded against by extracting the malleus if it is adherent, and freeing the edges of the perforation. Absolute alcohol is instilled, the tympanic cavity flushed out with a tympanum tube, and polypi removed. If Shrapnell's membrane is perforated, whether or not there is a defect in the osseous portion of the attic, the middle ear is flushed out with a tympanum tube, the osseous portion of the attic scraped with a small sharp curet, and insufflation of air and boric acid employed. If there is an opening in the posterior wall of the canal, the cholesteatoma may be removed through the canal with syringe and forceps, and a cure effected by the insufflation of warmed air and boric acid.

If the suppuration does not cease within three months, the malleus and incus may be removed for the purpose of obtaining better access to the cholesteatoma cavity, and this followed by irrigations with 0.5 per cent. formalin and insufflations of boric acid. If these measures fail to arrest the suppuration and the cholesteatoma resists attempts at removal with the syringe, the radical operation must be resorted to (see p. 219). The latter must be performed at once, and without first resorting to other measures, if signs of intracranial complications develop or if retention of pus occurs and cannot at once be obviated. If a fistula is found, it should be followed into the cranial cavity. The diseased membrane of epidermis is thoroughly curetted away. Primary suture of the wound and plastic operation after Körner; by the latter means even very large cavities can be inspected through the canal (Plate 29). The period of convalescence varies from four weeks to several months. If the opening is so large that a retro-auricular opening becomes necessary, a procedure adopted in every case by some authors, including Trautmann, the attempt to treat the wound cavity through the ear must be abandoned, and a permanent fistula made behind the ear. This is done by transplanting small particles of skin into the wound cavity after Thiersch, or by making a second incision parallel to and a little behind the first incision through the skin, and uniting the two in the center by a transverse incision. The flaps thus formed are then introduced into the wound cavity from above and from below after the posterior membranous wall of the meatus has been extirpated or divided longitudinally (Schwartze). Passow's method may also be employed if a small retro-auricular opening is desired. After a few years the retro-auricular opening may be closed by a secondary plastic operation. Relapses are not uncommon after operations for the relief of cholesteatoma. If crusts form, they must be removed at once, and if the bone becomes diseased, it must be curetted or removed with a chisel.

(c) **Caries and Necrosis.**—*Etiology and Pathology.*—Disease of the mucous membrane following acute and chronic otitis media, especially in the course of tuberculosis, scarlet fever, measles, diabetes, and syphilis, is very apt to extend to the bone, from the fact that the mucous membrane represents the periosteum of the middle ear, and nutritive disturbances in the mucous membrane therefore produce similar nutritive disturbances in the bone. Another factor in the production of caries is pus retention. In caries the bone becomes infiltrated by proliferating granulation tissue containing giant cells (osteoclasts) (Plates 31, 34); a few fragments of bone may remain in the form of sequestra. The favorite sites for caries are the pneumatic and diploetic areas of the temporal bone, the mastoid process (see pp. 210–225), the posterior wall of the auditory canal, the tegmen tympani (Plate 29), and the spongy bone surrounding the capsule of the labyrinth. The layer of periosteal mucous membrane in the tympanic cavity presents round-cell infiltration, and the bone is perforated and eroded by lacunæ (peripheral caries).

The granulation tissue with which the attic is filled frequently invades the spongy bone in the roof of the tympanic cavity (Plate 20), and may slowly advance in the diploetic layer of the mastoid process or in the tissues surrounding the capsule of the labyrinth. The center of the mastoid process and the capsule of the labyrinth are surrounded by a wall of newly formed tissue and thus robbed of their nutrition, while the caries is complicated

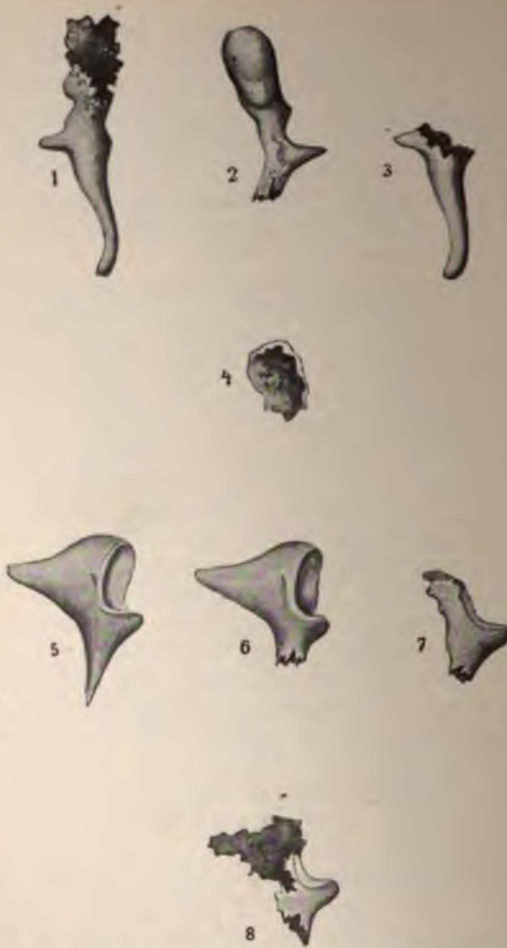

FIG. 94.—Caries of the tympanic ossicles: 1, Malleus: caries of the head; 2, malleus: destruction of manubrium; 3, malleus: destruction of head and neck; 4, remains of head of malleus; 5, incus: the long process drawn out to a point by caries; 6, incus: destruction of long process; 7, incus: destruction of long and short processes; 8, remains of body of incus.

by a central necrosis of the mastoid cells or of the capsule of the labyrinth (Plates 25, 26). The latter may remain as sequestra or make their way to the auditory canal (Plate 24) and undergo exfoliation. In suppuration within the labyrinth the semicircular canals on the outer surface of the pyramid may become carious and (Plates 25, 26) defective; rarely necrosis of the labyrinth occurs after embolism of the internal auditory artery. Sometimes the proliferating mucous membrane invades the vestibule through the windows of the labyrinth or through soft cartilaginous areas in the perforated promontory (Plate 26). The wall of the promontory or the cochlea alone falls a prey to the necrotic process.

The tympanic ossicles may become carious independently or along with the attic and antrum (Fig. 94). The investing mucous membrane becomes thickened, the ossicles themselves infiltrated with granulation tissue which destroys the articular capsule (Plate 31) and produces luxation of the ossicles, as they are held together only by brittle shreds of granulation tissue. The ossicles may be expelled by themselves like sequestra. Local caries of the ossicles sometimes regenerates. The handle of the malleus may become shortened and pointed, the head and neck may be destroyed by suppurative processes within the attic, usually along with the osseous portion (Plate 24). Owing to its isolated position and scant supply of nutrient vessels, the incus is often destroyed by caries without involvement of the other ossicles, thus severing the connection between the malleus and the stapes (Plate 19).

The stapes is less liable to be attacked by caries; the foot-plate, which receives part of its blood supply from the labyrinthine side, nearly always escapes. Caries is the most frequent cause of intracranial complications: meningitis (Plate 24), sinus thrombosis (Plate 26), brain abscess (Plate 25), erosion of the carotid artery (Plate 26). The meninges, nerves, and blood-vessels in the neighborhood of the carious bone become infiltrated with masses of granulation tissue. Recovery may or may not be accompanied by extensive destruction of bone through granulation, sometimes with the formation of hyperostoses. In acute suppurative processes, as after scarlet fever, the mucous membrane is often destroyed, and necrosis of the mastoid process develops. The necrosis generally attacks the wedge-shaped portion of the bone belonging to the squama, the tympanic ring, and the facial canal. The sequestrum thus formed, which is grayish-white in color and of normal shape and consistency, on its outer surface (Plate 25) becomes separated from the hyperostotic and from the healthy bone by granulations.

Course and Symptoms.—Mastoiditis (see pp. 210–225). —Caries is often attended by pain, especially during the night. The aural discharge is profuse, usually fetid, often reddish and sanguinolent, and may contain bone-sand. Fever is present. The roof and posterior wall of the canal frequently collapse, and fistulæ are formed. The probe comes against rough bone or irremovable sequestrum. Great care is necessary in probing the promontorial wall, as the dura mater may be exposed. The mucous membrane is discolored. In necrosis the soft parts early become involved; there is mastoid periostitis. Rarely the pus reappears through the fissure of Santorini and reaches the anterior surface of the ear, the entire pharynx, the parotid gland, or the articulation of the jaw. In such cases a fistula appears in front of the ear, or more rarely in the back of the neck. Necrosis of the labyrinth is often accompanied by paralysis of the seventh nerve (Plate 26); at the same time there are deafness, Weber in the sound ear, vomiting, nausea, and tinnitus. In caries of the manubrium the latter appears pointed (Plate 39, 7, 9, 10); when the drumhead is completely destroyed, a granulating stump of the manubrium is not infrequently found above and in front.

Isolated caries of the head of the malleus produces a perforation in Shrapnell's membrane directly over the short process; granulations are seen constantly growing out of the perforation (Plate 39, 15). In suppuration within the attic and caries of the malleus and incus the perforation is often above and somewhat in front of the short process; in caries of the body of the incus above and behind the short process (Schwartze) (Plate 39, 14). In caries of the long process of the incus a perforation is usually found in the posterosuperior quadrant, but not at the periphery; if the defect is large, the pointed extremity of the long process sometimes appears under the osseous portion (Plate 39, 10), or a small granulation may be seen in the posterosuperior portion. In caries of the attic fistulæ and granulations are found in the osseous portion (Plate 25, 39, 15); the hearing varies according to the seat of the carious process. The prognosis is always grave, on account of the danger of intracranial complications or of marasmus and amyloid degeneration of internal organs.

Treatment.—Irrigation with 0.5 per cent. solution of trichlorid of iodin (Trautmann), irrigation of the tympanic cavity, irrigation of the Eustachian tube with boric acid solution, removal of polypoid granulations; the treatment is the same as in chronic otitis media. Carious areas near the surface should be scraped away with the sharp spoon (Fig. 78, 5), and the excoriated surface covered with gauze saturated in iodol solution (Kretschmann). Sequestra must be extracted after they have become completely loosened. Sometimes it may be necessary to crush them before extraction is possible. In extensive caries of the temporal bone that cannot be arrested by treatment through the auditory canal, or if signs of intracranial complications make their appearance, the radical operation must be performed. In isolated caries of the malleus and incus, irrigations with the tympanum tube, removal of polypoid granulations, curettment of the attic with small sharp spoons, and the instillation of an alcoholic solution of corrosive sublimate may be tried. If these do not bring about a cure within three months, the malleus and incus must be extracted. As the hearing is usually greatly reduced by extraction of these ossicles, it should be resorted to only when there is imminent danger, especially if the other ear is deaf and the ear to be operated on possesses fairly good power of hearing. If the process is not arrested by extraction of the tympanic ossicles, there is caries of the attic and usually also of the antrum; in that case the attic must be exposed by separating the auricle (see p. 223), or the radical operation becomes necessary. In performing the latter the operator may try leaving the tympanic ossicles so as to obtain a better auditory result, providing the articular connections have not been loosened. The local treatment must be supplemented by general treatment, good nutrition, preparations of iron, cod-liver oil, potassium iodid, or a course of medicinal bathing.

(**d**) **Diseases of the Brain and of the Blood-vessels** (**after Körner**).—The most important sequelæ of acute and chronic suppurations of the middle ear—rarely of middle-ear catarrh—are the intracranial complications. Infection most frequently takes place by direct continuity after the destruction of the cranial bones. Sometimes the pus follows preformed channels, such as nerves, blood-vessels, the fenestræ of the labyrinth, defects in the bone and in the processes of the dura mater. The intracranial disease begins at the point where the diseased bone reaches the interior of the skull—that is to say, in the middle fossa of the skull after diseases of the roof of the tympanum, in the posterior fossa of the skull after diseases of the labyrinth or of the posterior portion of the mastoid process. Infection of the interior of the skull is facilitated by pus retention, osteosclerosis, and by traumatism. To guard against mistaking an intercurrent disease of the brain also attended with cerebral symptoms, such as brain tumor, typhoid fever, hysteria, arteriosclerosis, etc., for a complication of aural disease, the patient must be watched with great care and the temperature taken at frequent intervals.

1. Hyperemia, Edema, Meningitis Serosa.—*Etiology and Pathology.*—Hyperemia of the middle ear is very apt to extend to the interior of the cranium by way of the vascular connections between the tympanum and the cranial cavity, especially in children. In chronic suppurations of the ear, in labyrinthine suppurations, edema of the brain and increased secretion of the cerebrospinal fluid in the ventricles and in the cerebral cortex occur. The brain is anemic and swollen, and the transverse sinuses are empty.

Symptoms.—Headache, vertigo, vomiting, loss of consciousness, rigidity of the neck, convulsions, and rapid

FIG. 95.—Lumbar puncture (schematic): 1, Paracentesis needle; 2, second lumbar vertebra; 3, third lumbar vertebra; 4, fourth lumbar vertebra; 5, fifth lumbar vertebra.

development of choked disc. The symptoms often vary in intensity; there is no marked elevation of temperature. Lumbar puncture is followed by the discharge of a large quantity of clear cerebrospinal fluid—as much as 100 c.c. The liquid runs out in a stream under high pressure (above 150 mm.). The diagnosis is confirmed by recovery.

Treatment.—Lumbar puncture, which may have to be repeated several times. Radical operation with exposure and incision of the dura, and, if necessary, draining of the ventricle. Lumbar puncture after Quincke is performed between the third and fourth lumbar vertebræ, the patient occupying the lateral position (Fig. 95). The needle is inserted an inch outside the median line, for a distance of from 2 to 6 cm., so that the point enters the dural sac in the median line (Fig. 96). Anesthesia is usually not necessary.

2. **External and Internal Pachymeningitis.**—*Etiology and Pathology.*—If, as frequently happens in acute and chronic suppuration when there are cholesteatomata, disease of the bone reaches the inner surface of the skull, the dura mater begins to proliferate (Plates 24, 25, 27), forming grayish-green suppurating granulations (Plate 34). The pus collects between the tegmen tympani and the dura, forming an extradural and epitympanic abscess, or between the bone and the transverse sinus, forming a perisinuous abscess. Deep extradural abscesses on the posterior surface of the petrous portion of the temporal bone are produced by fistulæ in the posterior wall of the antrum or by caries of the posterior semicircular canal and mucous membrane of the endolymphatic sac. Rarely the pus may empty itself into the ear through defects in the bone or appear on the squama. More commonly a fistula is formed in the dura, and after the latter has become adherent to the pia and arachnoid, the pus is conducted into the brain, where it produces a brain abscess. The sinus

FIG. 96.—Needle for performing lumbar puncture (after Krönig).

very frequently becomes involved. In most cases the inner surface of the dura also becomes thickened and discolored (internal pachymeningitis). If the pus gets through the dura mater and an adhesion is formed around the site of rupture, a circumscribed, or if no adhesion has taken place a diffuse, leptomeningitis results.

Symptoms.—Either there are no symptoms at all or there are pressure symptoms, such as headache, particularly at night, vomiting and stupor, with fever, retardation of the pulse-rate down to 50 or 60, optic neuritis, and nystagmus. An extradural abscess in the fossa of the cerebellum manifests itself by rigidity of the neck; extradural abscess in the middle fossa of the skull produces crossed paresis and disturbances of sensation. As a rule, a copious otorrhea persists in spite of free opening of the bone. With Siegle's speculum pus can sometimes be aspirated from the interior of the skull. Swelling behind and above the mastoid process is sometimes noted. Caput obstipum (wry-neck) is present. If, after a radical operation has been performed, meningeal symptoms persist, pachymeningitis may be suspected.

Treatment.—After performance of the radical operation, exposure of the tegmen tympani with the rongeur forceps or the chisel (Plate 29) and exposure of the dura mater of the posterior and middle fossa of the skull may be necessary. In deep extradural abscesses the postero-superior edge of the pyramid must be removed; in suppuration of the labyrinth the vestibule must be opened (Jansen).

3. Purulent Leptomeningitis.—External rupture of a brain abscess, internal rupture of an extradural abscess, or sinus thrombosis is often followed by infection of the pia and arachnoid (Plate 24); more rarely it occurs independently in chronic suppurations (cholesteatoma) if the dura has been exposed by the disease in the bone (Plate 26). The pia-arachnoid becomes infiltrated with pus, and the subarachnoidal space filled with closely packed pus-corpuscles (Plate 34); rarely adhesions form, and the meningitis remains localized; more frequently it spreads along the blood-vessels to the base and convex surface of the brain. The cerebral cortex becomes discolored. Infection is rarely conveyed to the cranial cavity by preformed channels, such as the labyrinth, the aqueducts, the internal auditory meatus, and defects in the tegmen tympani. The infection of the meninges is facilitated by pus retention.

Course and Symptoms.—The onset may be insidious or sudden, with violent headache, chills, and fever; sometimes the temperature is variable and may be subnormal. The pain is increased by pressing on the head and on the vertebral column. At first there are irritative symptoms, such as vertigo, vomiting, stupor, delirium, convulsions, constipation, insomnia, rigidity of the muscles of the neck, cutaneous and muscular hyperesthesia (increased reflexes), contraction of the pupils, sluggish or absent reaction of the pupils, and retraction of the abdomen. Later the paralytic symptoms develop: choked disc, unequal and dilated pupils, ptosis, conjugate deviation, trismus, nystagmus, retardation of the pulse-rate with elevation of temperature, hemiplegia, facial paralysis, unilateral paralysis, paralysis of the bladder and rectum, and Kernig's symptom, consisting in inability to extend the knees in the sitting posture. In infants the fontanel is distended. Death comes on suddenly with coma and Cheyne-Stokes respiration, or the disease runs a tedious course with remissions. The disease is distinguished from epidemic meningitis by the existence of an epidemic, rigidity of the muscles of the neck, and opisthotonos. Lumbar puncture usually yields an opalescent or opaque albuminous fluid containing many cells, and sometimes streptococci and floccular coagula. In extensive meningitis without adhesions a purulent fluid with or without bacteria is obtained.

Treatment.—Radical operation as soon as the first meningitic symptoms due to the retention of pus make their appearance. In circumscribed meningitis the dura is exposed and incised; in extensive meningitis the treatment is symptomatic. Ice-bag, warm baths, inunctions with Credé's ointment (silver)—2 grams (30 grains) twice a day.

4. Tubercular Meningitis and Cerebral Tuberculosis.—In tubercular caries of the temporal bone the process spreads directly to the meninges, or the brain becomes infected by way of the blood-vessels (cerebral tuberculosis). Hematogenous infection of the brain and its meninges may occur without preexisting tuberculosis of the ear. The cerebrospinal fluid obtained by lumbar puncture is clear and contains many leukocytes and the tubercle bacilli. Kernig's symptom is absent (Netter).

5. Brain Abscess.—*Etiology and Pathology.*—Usually follows chronic suppuration or cholesteatoma; rarely occurs in acute otitis media. In rare instances the brain becomes infected before perforation of the drumhead occurs. As a rule, the bone is diseased as far as the dura (Plates 25, 27). After the dura has become adherent to the pia-arachnoid and to the brain, a fistula is formed communicating directly with the abscess, or the abscess may be separated from the brain by normal brain substance, but it is never far removed from the diseased bone. If there is healthy brain tissue intervening between the abscess and the bone, the infection has taken place through the pial and lymphatic vessels or through small veins in the temporal bone (venæ aquæductus cochleæ, vena vestibuli, vena auditorii interna) (Plate 11). In rare instances the pus enters through deficiencies in the bone (Plate 25) or along a dural process.

The most frequent seat of brain abscess is in the temporal lobe, next to that in the cerebellum. As a rule, but one abscess is present; it is surrounded by a capsule and varies in size from that of a walnut to that of an egg. It is oftener found on the right than on the left side. The pus is usually putrid, the surrounding brain tissue is softened, and the convolutions are obliterated by the dropsy of the ventricles. Occasionally the abscess ruptures externally and discharges through the ear. Death is usually due to meningitis, rupture into the ventricle, or cerebral pressure.

Symptoms.—The abscess is often latent; sometimes it reveals itself at first by headache, vomiting, fever, and again becomes latent, the headache diminishes, there is some psychic depression, and the temperature becomes subfebrile or even subnormal. The latent period may last two years. Suddenly, sometimes after traumatism (trephining), the active stage sets in with general and local symptoms (von Bergmann).

1. Symptoms of Suppuration.—Low fever, chills, lassitude, loss of appetite, fetid odor from the ear, and tenderness at the postero-inferior angle of the parietal bone on percussion.

2. General Pressure Symptoms.—Headache, nausea, vomiting, vertigo toward the diseased side, depression, delirium, lethargy, general or crossed convulsions, usually attended with loss of consciousness; rarely gradually developing choked disc, more frequently bilateral optic neuritis, retardation of the pulse-rate down to 40, exaggerated patellar reflexes, and conjugate deviation.

3. Focal symptoms vary with the seat of the lesion or of that part of the brain which is affected (Plate 97). In lesion of the third frontal convolution on the left side motor aphasia; of the second frontal convolution on the left side, agraphia and alexia; in lesions of the first temporal convolution on the left side word-deafness, crossed deafness, and anosmia; of the occipital lobe, optic aphasia and hemiopia. When the lesion is situated around the fissure of Rolando, epileptiform convulsions and crossed paralysis of the extremities and facial paralysis; in lesions of the internal capsule, hemianesthesia, crossed hemiplegia, crossed facial paralysis, convulsions, and hemiopia; in lesions of the crus, hemiplegia and crossed oculomotor paralysis. In lesion of the pons, crossed hemiplegia, crossed or bilateral facial palsy; in lesions of the peduncles of the cerebellum, forced movements and forced position; in lesions of the cerebellum, ataxia, vertigo, staggering gait, nystagmus, emaciation, rigidity

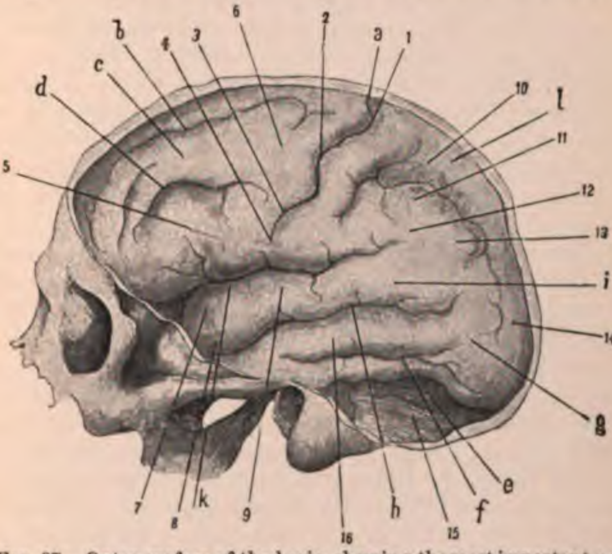

FIG. 97.—Outer surface of the brain, showing the most important areas that give rise to focal symptoms (after Ziehen, Strümpell): The sign + indicates *crossed*; *a*, central fissure; *b*, superior frontal fissure; *c*, frontal lobe; *d*, inferior frontal fissure; *e*, cerebellum; *f*, second temporal fissure; *g*, occipital lobe; *h*, first temporal fissure; *i*, temporal lobe; *k*, fissure of Sylvius; *l*, parietal lobe; 1, + monoplegia (leg); 2, + monoplegia (arm); 3, + monoplegia (mouth); 4, + monoplegia (tongue, twelfth nerve); 5, motor aphasia; 6, + agraphia; 7, + ageusia; 8, + anosmia; 9, sensory aphasia (word-deafness); 10, + hemianesthesia (muscle sense); 11, conjugate deviation; 12, + ptosis; 13, alexia; 14, hemianopsia (bilateral); 15, staggering gait, vertigo, forced movements; 16, + deafness.

of the muscles of the neck. Direct pressure on the base of the brain and internal auditory meatus may produce paralysis of the seventh, sixth, and third nerves and trifacial neuralgia. Death results after coma and Cheyne-Stokes respiration. Rupture into a ventricle manifests itself by chills, rapid pulse, loss of reaction in the pupils, and coma, and terminates fatally within a few hours. The presence of an abscess in the cerebrum is suggested by disease of the tegmen tympani (Plate 25), focal symptoms, paralysis of the third nerve on the same side, and hemicrania at the vertex. Cerebellar disease is indicated by suppuration in the sigmoid fossa, on the posterior surface of the petrous portion of the temporal bone, by rigidity of the neck, vertigo, suppuration in the labyrinth (Weber in the healthy ear), general convulsions, and occipital headache. Brain tumor usually gives rise to choked disc; brain abscess, to optic neuritis. In meningitis more of the cranial nerves are involved, and the onset is sudden, with high fever. In brain abscess that has not ruptured into a ventricle, as in brain tumors, the lumbar fluid is usually clear, contains few leukocytes, little albumin, and no micro-organisms.

Treatment.—The diagnosis, unfortunately, cannot always be made, but once it is settled, the only hope lies in operation. After performing the radical operation any fistulæ that are found are laid open, and the roof of the auditory canal, the lower portion of the squama, and the tegmen tympani (Plates 10, 29) are removed. The dura mater is freely exposed. It may appear normal or perforated by fistulæ. In abscess, pulsation is usually absent. The dura is divided, and if no pus is seen, incisions about 3 cm. in depth are made in the lower surface of the temporal lobe, carrying the knife outward and upward. If this fails to liberate pus, puncture may be tried in various places. The temporal lobe may also be reached through the squama, after von Bergmann, and by this means infection of the healthy brain by way of the middle ear avoided. To open the cerebellar abscess the cavity formed in the bone in doing the radical operation is enlarged posteriorly, the sinus exposed (Plates 10, 29), and the knife introduced into the cerebellum in the angle between the descending and horizontal portions of the sinus. Another method consists in trephining the occipital bone 5 cm. (2 in.) behind the fold of the ear, disregarding the opening made by the radical operation. If pus is liberated, the wound in the brain is enlarged with forceps, drained with iodoform gauze, and a large dressing applied. If the operation is successful, it is often followed by recovery.

6. Sinus Thrombosis and Pyemia.—*Etiology and Pathology.*—Infection of the sinus is often due to breaking down of the bone in chronic suppuration, or to a cholesteatoma in immediate contact with the wall of the sinus (Plates 26, 27). The granulation tissue after breaking through the bone continues to grow into the thickened wall of the sinus (Plate 34), the latter becomes the seat of round-cell infiltration, breaks down in places, and the endothelium is destroyed. An extradural abscess frequently exists at the same time. The diseased portion of the wall becomes the seat of a parietal, and later of an obstructing, thrombus; in rare cases recovery may take place by absorption and obliteration of the thrombus with connective tissue. In the majority of cases the thrombus becomes infected with streptococci from the bone decay (Plate 30), and the pus-producing organisms are carried by metastasis to other portions of the body, with a resulting pyemia.

In rare cases infection follows deficiencies of the bone over the bulb of the jugular vein, or is carried to the sinus by the continuations of small blood-vessels in the bone that have become thrombosed. Usually the upper knee of the transverse sinus, more rarely the petrosal sinuses and the cavernous sinus, become occluded by thrombi. The diseased wall of the sinus granulates and appears thickened and discolored (Plate 26). The neighboring pia and cerebral cortex are also discolored: rupture of the wall of the sinus is followed by meningitis, brain abscess, and rarely by hemorrhage. The thrombus may be continued from the transverse sinus to the transverse sinus of the other side (Plate 11, Fig. 4), or upward into the longitudinal sinus; or forward into the superior and inferior petrosal sinus, into the cavernous sinus, the ophthalmic vein, and through the circular sinus to the other side, usually downward into the bulb and jugular vein, the facial vein, or the vena cava; sometimes backward, through the mastoid vein, into the occipital vein. The lymph-glands surrounding the vena cava sometimes break down and form abscesses. The infected thrombus is usually joined both above and below by a non-infected obstructing thrombus. The pyemia may last from one to several weeks. Death results from metastasis or from meningitis, brain abscess, and paralysis of the pneumogastric.

Symptoms.—Either an absence of symptoms or headache, vomiting, dysphagia, optic neuritis, choked disc, and nystagmus, one or all, may be present. The consciousness is usually clear; there may be high remittent fever, with chills; the temperature rises to 41° C. (105.8° F.) during the chill and falls to or below normal with the sweat. There are jaundice, diarrhea, vomiting, and splenic enlargement; the vertebral column is not sensitive to pressure, but pressure alongside the column is painful, and rotary movements of the head are impossible. Between the attacks there is euphoria. Metastases in the lung are frequent, and produce symptoms of bronchial catarrh; rarely abscess occurs in the joints, muscles, spleen, kidney, and liver.

Symptoms of passive congestion depend on the seat and extent of the thrombus. Edema, pain, and swelling along the posterior border of the mastoid process occur in thrombosis of the mastoid vein (Griesinger). Sometimes the external jugular vein on the diseased side is smaller than on the sound side, because the resistance in the collapsed internal jugular vein is diminished. On the other hand, the external jugular vein is larger on the diseased than on the sound side, when its opening into the internal jugular vein is occluded by a thrombus (Gerhardt). The thrombosed jugular vein is distinctly palpable along the neck as a painful cord. The head is inclined toward the diseased side. In thrombosis of the facial vein there is edema of the face; in thrombosis of the cavernous sinus, edema of the lids, exophthalmos, trifacial neuralgia in the brow and eye, and paralysis of the oculomotor, cochlear, and abducens nerves. Thrombosis of the bulb of the jugular vein (Plate 5) manifests itself by paralysis of the pneumogastric (hoarseness, dyspnea, retardation of the pulse-rate), of the spinal accessory nerve (spasm of the trapezius and sternocleidomastoid muscles), and the glosso-pharyngeal nerve (paralysis of the pharynx). The differential diagnosis from meningitis is based on obtaining a clear fluid, free from micro-organisms, by lumbar puncture (Leutert). If the mouth of the stethoscope is pressed against the normal jugular vein to the inner side of the sternocleidomastoid muscle, a continuous murmur is heard, which is absent in thrombosis (Voss). If fever above 39° C. (102.2° F.) persists for several days, with free discharge of pus, and meningitis can be excluded, disease of the sinus should be suspected (Leutert). The differential diagnosis from malaria and typhoid fever rests on examination of the blood (Brieger).

Treatment.—Operative intervention as early as possible. In acute suppurations, where sinus thrombosis is suspected, expose the sinus and await results. If the fever continues for three days or a chill again develops, the sinus must be laid open. After the radical operation the sinus is exposed by enlarging the wound cavity posteriorly. Normally the sinus is bluish-red in color; in thrombosis it is of a greenish color and unyielding on palpation. Pulsation (transmitted brain pulsation) and the presence or absence of respiratory changes in volume cannot be utilized in diagnosing thrombosis. In exploratory puncture with Pravaz's syringe no blood is obtained if the site of the puncture is thrombosed, pus if the thrombus is broken down, and normal blood when there is a peripheral thrombosis or no thrombosis at all at the site of puncture. If a thrombosis is found, the wall of the sinus above and below the obstruction is laid open until the solid, brownish-red thrombus comes into view or until a slight hemorrhage occurs. The infected thrombus is scraped away, and the diseased wall of the sinus excised. If there is no solid thrombus between the wound and the jugular vein, the latter must be ligated in two places (above and below the mouth of the common facial vein, which is also ligated) (Fig. 98). If necessary, the diseased portions of the vein must be excised. In phlebitis of the jugular vein, thrombosis of the bulb, and when marked respiratory collapse

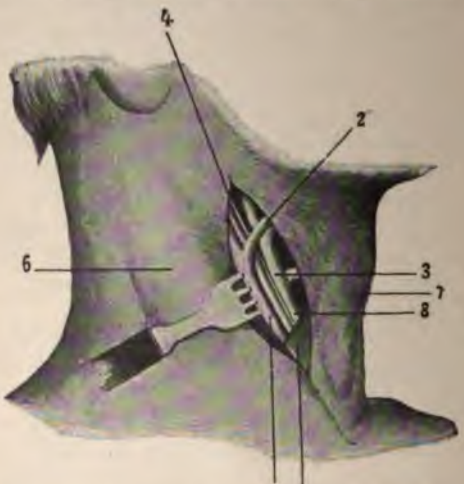

FIG. 98.—Exposing the common or internal jugular vein (partly after Bardeleben): 1, Internal jugular vein; 2, common facial vein; 3, external carotid artery and beginning of superior thyroid artery; 4, descending branch of the hypoglossus nerve; 5, omohyoid muscle; 6, sternocleidomastoid; 7, cricoid cartilage; 8, common carotid artery.

is observed in the sinus, the vein must be ligated before the sinus is opened. Hemorrhage from the sinus is controlled by packing with iodoform gauze. After the sinus has been opened it is dusted with iodoform powder and packed with iodoform gauze, and a dressing applied. Recovery is probable. If fever returns after the operation, the sinus must be again exposed after ligating the jugular vein, and an injection of streptococcus serum

(Marmorek) may be tried; quinin 0.5 gm. (8 grains) four times a day, and inunctions with Credé's ointment.

7. **Osteophlebitis Pyemia (Körner).**—*Etiology and Pathology.*—Rarely pyemia develops without thrombosis from infection of the sinus by the small bone—veins which empty into it; more frequently in acute suppurative conditions. The occurrence of pyemia without thrombosis is denied by some authors.

Course and Symptoms.—Fever, chills, metastatic abscesses, usually in the joints, muscles, and liver, because the micro-organisms are not imbedded in thrombi and are not arrested in the pulmonary circulation. Often terminates favorably.

Treatment.—Radical operation, and, if necessary, exposure of the sinus.

8. **Septic Diseases.**—*Etiology and Pathology.*—Rapidly fatal sepsis in acute and chronic suppurations of the middle ear, with or without suppuration of the sinus.

Symptoms.—High continuous fever without chills or metastasis, somnolence, delirium, cutaneous eruptions, hemorrhages in the muscles and in the retina, endocarditis, and marked glandular enlargement. Sometimes the muscles become greatly swollen and the seat of hemorrhages (dermatomyositis).

9. **Hemorrhage and Thrombosis of the Carotid Artery.**—*Etiology and Pathology.*—Extensive caries of the temporal bone, occurring usually in the course of tuberculosis, may extend to the carotid canal, particularly to the vertical portion (Plate 26). The adjacent wall of the carotid artery becomes infiltrated with granulations, suppurates, and a fistula is formed which leads to fatal hemorrhage. In rare cases the artery becomes thrombosed before rupture occurs.

Symptoms.—Profuse, bright red, often pulsating hemorrhage from the ear and through the Eustachian tube into the mouth. The anemia is rapidly followed by collapse and death. Sometimes there are several attacks, which may have been preceded by venous hemorrhage from the carotid veins (Plate 5) (Bloch). Thrombosis of the carotid artery is followed by embolism of the brain, especially in the region of the fossa of Sylvius.

Treatment.—In arterial hemorrhage compression of the common carotid artery; ligation of the common carotid and tamponage are often futile on account of the rapid development of collateral circulation.

The carotid artery and bulb of the jugular vein sometimes become displaced forward into the tympanic cavity (Plate 17; 38, 3), and there is then danger of wounding them in performing paracentesis. Hemorrhage from the bulb may be controlled by packing with iodoform gauze. To prevent infection, a head-bandage should be applied.

II. Pathology and Treatment of the Sound-Perception Apparatus.

Disease of the sound-perception apparatus is more often secondary than primary. The nervous apparatus of hearing is exposed to injury by the formation of catarrhal adhesions, ankylosis of the stapes, suppurative otitis media, through its nerves and vessels or through the formation of fistulæ. The seventh nerve and its centers frequently become involved in traumatism, in diseases of the central nervous system, in intoxications, and in constitutional and infectious diseases. Whether the peripheral or the central portion of the nervous apparatus is injured can usually not be decided unless other cerebral symptoms are present. As a rule, the most exact diagnosis that can be made is nervous deafness. In such a case, if the drumhead is normal, there will be, in addition to the impairment of hearing, positive Rinne, Weber in the healthy ear or in the better ear of the two, Schwabach shortened, Gellé positive, and reduction of the upper tone limit. Sometimes there will be gaps in the scale, or paracusis. As nervous deafness is very often associated with disease of the middle ear, the result of the functional examination varies, depending on which portion of the ear is most profoundly involved.

(a) Disturbances of Circulation.—1. **Hyperemia.**—Hyperemia of the labyrinth occurs in cerebral congestion, in acute and chronic otitis media, especially in the course of the infectious disease, after the ingestion of quinin and the salicylates and in hysteric neurosis of the sympathetic nerve. The auditory centers become irritated by the cerebral hyperemia, and there may be flashes before the eyes. Anatomically, extravasation of blood is sometimes found in the labyrinth, and in cases of long duration, small concealed infiltration, thickening, and deposition of pigment.

Symptoms.—Vertigo, transient deafness, nausea, vomiting, redness of the face, ears, auditory meatus, and handle of the malleus, and tinnitus aurium.

Treatment.—Blood-letting, cold sponging, hot foot-baths, cold compresses, mustard poultices to the nape of the neck. Alcohol, tobacco, and hot beverages must be interdicted. Potassium bromid should be given internally.

2. **Anemia of the labyrinth** occurs after rapid hemorrhage, narrowing of the lumen, or embolism of the internal auditory meatus, tumors at the base of the skull, or emboli in caisson workers.

Symptoms.—The same as in hyperemia of the labyrinth; the face is often pale.

Treatment.—General treatment. Alcohol, nitroglycerin (1 to 5 drops of a 1 per cent. oily solution) internally, inhalations of amyl nitrite, horizontal position, counterirritation behind the ears by rubbing with alcohol.

3. **Hemorrhage.**—Slight extravasations of blood into the labyrinth occur in rapidly developing hyperemia, in acute otitis media, whooping-cough, anemia, nephritis, and diabetes. More considerable hemorrhages in traumatism, explosions, meningitis, caries, and in caisson workers (Plate 37). The hemorrhages are found in Rosenthal's canal, between the layers of the osseous spiral lamina in the semicircular canals, the maculæ acusticæ, and in the cochlea, especially in the scala tym-

pani and in the trunk of the auditory nerve. In a recent case recovery by absorption of the blood is possible. In many cases the hemorrhage is followed by inflammatory reaction, with atrophy of the auditory epithelium, new formation of connective tissue, and the deposition of pigment.

Symptoms.—Suddenly developing partial or total deafness, with tinnitus, vertigo, nausea, and vomiting.

Treatment.—General treatment, rest in bed, ice compresses, blood-letting; internally, potassium iodid; hypodermically, pilocarpin.

4. Ménière's Disease. Morbus Apoplectiformis Méniere (Lucæ).—*Etiology and Pathology.*—Acute exudation and hemorrhage at the nerve-endings of the auditory nerves, occurring usually without demonstrable cause in previously healthy individuals. Sometimes caused by over-exertion in the heat of summer, in caissons, and when there is insufficient ventilation of the Eustachian tube.

Symptoms and Course.—Without any prodromal symptoms the patient suddenly collapses, the face becomes pallid and covered with a copious perspiration, and he remains unconscious for a short time. Usually there is bilateral deafness, with vertigo, vomiting, and loss of equilibrium, the patient falling toward the diseased side. Sometimes the onset is not attended by disturbances of consciousness. The attack may last a few minutes or for a day; it may occur only once, or recur after days or months. The appearances in the ear are usually normal; sometimes there is a small extravasation of blood in the auditory meatus and retinal hemorrhage. Rinne is positive if the tuning-fork can be heard at all; bone-conduction is absent. None of the other cranial or dorsal nerves are paralyzed. The nausea disappears before the vertigo, but the latter also disappears entirely if there is no new attack, while the deafness usually remains.

Treatment.—Rest in bed in the dorsal position, with the head slightly raised. For the first week quinin, 0.1

to 0.3 gm. three times a day, then potassium iodid, 0.5 to 1 gm. a day, beginning with the third week, hypodermic injections of pilocarpin (0.01 gm.) every day or every other day, to be repeated at least twelve times, and given on an empty stomach while the patient is in bed. Pilocarpin is contraindicated in cardiac and pulmonary disease. The sweating and salivation appear within from five to forty-five minutes, and last about two hours, during which time the patient should remain in bed. If pilocarpin is contraindicated, the patient should be sweated with hot baths and hot packs, and be given hot camomile tea to drink. Pilocarpin may also be injected into the tube every other day for four weeks. Inunctions of iodin ointment should be made to the mastoid process. Cold compresses and cold sponging, laxatives (calomel), and potassium iodid internally are indicated. Ménière's symptom-complex also occurs in disease of the middle ear, but in such cases there is always a history of deafness, and some alterations are found in the drumhead. Finally, it may occur in disease of the brain, meningitis (Plate 37), and cerebellar tumors, usually associated with other nervous phenomena.

(**b**) **Otitis Interna.**—**1. Acute Otitis Interna (Voltolini).**—In rare cases acute purulent ostitis and endostitis, with formation of connective and bony tissue in the cochlea, and degeneration of Corti's organ and the cochlear nerve, without meningitis, occurs. The symptom-complex resembles that observed in an abortive case of meningitis. The purulent discharge from the labyrinth may make its way into the tympanum through the membranes of the fenestra, and set up a secondary otitis media (Politzer, Baginsky). In children bilateral deafness, loss of equilibrium, and vertigo usually develop, with headache, rigidity of the neck, vomiting, convulsions, and fever. The deafness usually remains after the meningitic phenomena and vertigo have subsided.

2. Leukemic Otitis Interna.—The hearing is affected in about 10 per cent. of all cases of leukemia. The middle ear is practically always attacked primarily. Leukemic exudation and lymphatic infiltration, with hemorrhages into the walls and cavities of the membranous labyrinth, develop, followed by inflammatory reaction, ending in the formation of new connective and bony tissue (Plate 37). The symptoms consist in sudden deafness, vertigo, nausea, tinnitus aurium, associated sometimes with paralysis of the seventh nerve and Ménière's symptom-complex.

3. **Otitis Interna Parotitica.**—In mumps the infection may be carried by metastasis to the labyrinth and to the central organs, which ultimately destroy their function. (Infection of the middle ear through the Glaserian fissure has also been observed in mumps.) The symptoms are sudden deafness on one or both sides, without marked vertigo and without fever. The deafness is confined to one ear. Improvement sometimes follows the use of potassium iodid internally.

4. **Syphilitic Otitis Interna.**—*Pathology and Treatment.*—In the hereditary form syphilis of the labyrinth, with or without disease of the middle ear, occurs toward the end of the second or beginning of the third stage, sometimes after many years, and as the sole symptom of luetic infection. Exudation into the labyrinth takes place, followed by the formation of new connective and bony tissue. In addition, the blood-vessels become diseased, the periosteum of the internal meatus and around the fenestra vestibuli undergoes thickening and leads to ankylosis of the stapes, the ganglion cells in Rosenthal's canal undergo granular degeneration, and the fibers of the auditory nerve between the layers of the osseous spiral lamina atrophy (Plate 37). In hereditary syphilis hemorrhage and suppuration in the labyrinth, often associated with otitis media and adhesions, the remains of catarrhal conditions, are observed in about one-third of all cases.

Symptoms.—Almost total deafness develops, usually in both ears, accompanied by marked tinnitus and often vertigo. The drumhead and Eustachian tube are normal.

The deafness usually develops very abruptly; it is unfavorably affected by concussion. Rinne positive, Weber in the better ear, Schwabach shortened, and reduction of the upper tone limit. Deafness occurring in youth without disease of the middle ear should always arouse a suspicion of syphilis. In hereditary syphilis the diagnosis is supported by the presence of corneal opacities and notched incisors (Hutchinson's teeth). Hereditary deafness is usually incurable; acquired deafness of short duration in the absence of adhesions may often be cured.

Treatment.—Constitutional treatment by inunctions and the administration of potassium iodid. The ear should be protected against noises with the antiphone. Hypodermic injections of pilocarpin. If there is catarrh of the middle ear, it should receive local treatment.

5. **Secondary inflammations of the labyrinth** are caused by the disease of the middle ear or of the brain and its membranes. Disease of the labyrinth is rarely caused by acute catarrh, more frequently by adhesions or ankylosis of the stapes, and most frequently of all by suppurative otitis media, especially in the course of an infectious disease (Plate 37). Intracranial pressure may cause auditory disturbances by raising the pressure within the labyrinth. In simple inflammations without suppuration, with symptoms of nervous deafness, the ganglion cells in Rosenthal's canal and the nerve-fibers which they emit, particularly in the first turn of the cochlea, are to be found shrunken and atrophied (Plate 37), while a purulent inflammation of the labyrinth usually produces an active growth of connective tissue and obliteration of the membranous labyrinth. The nerve-endings, the organs of Corti, the membranes of Reissner and Corti, and Rosenthal's ganglion become infiltrated with pus and partly destroyed; ultimately the nerve-endings and nerve-fibers degenerate, the epithelium proliferates, pigment is deposited, and the hemorrhages undergo organization, with the production of connective and bony tissue. If the alterations have not been formed, regeneration is possible.

From the labyrinth the pus may find its way into the internal meatus (Plate 26) and the aquæductus cochleæ, and, after breaking through the endolymphatic sac, to the brain itself.

From the middle ear pus reaches the labyrinth through vascular and nervous channels through the windows of the vestibule, or through fistulæ in the wall of the promontory and of the semicircular canals (Plate 26). The channels by which pus may be conveyed from the brain to the labyrinth, as in meningitis, for instance, are the aquæductus cochleæ, the sheath of the seventh and eighth nerves, and the blood-vessels and connective-tissue processes of the dura mater. Thus in epidemic meningitis a suppurative otitis media may be secondary to suppuration in the labyrinth. If, as happens in scarlet fever and diphtheria, the middle ear and the labyrinth are both involved at once, we speak of panotitis (Politzer). In children it manifests itself by fever, vertigo, loss of consciousness, and convulsions. After the return of consciousness the child is completely deaf. Later, otorrhea develops. The deafness is usually permanent. The treatment of panotitis consists of potassium iodid internally, pilocarpin hypodermically, and a course of medicinal baths. Extension of otitis media to the labyrinth is characterized by the appearance of marked subjective noises and sudden impairment of the hearing, with vertigo, staggering gait, nausea, and occipital headache. Weber in the healthy ear, Schwabach shortened. The prognosis is bad.

Treatment consists of blood-letting, ice compresses, laxatives, potassium iodid and mercury internally, inunctions of iodin ointment behind the ear, galvanization, and local treatment of the middle-ear affection. If there is caries, the radical operation, including opening of the labyrinth, becomes necessary. In rare cases a genuine meningitis may be the cause of inflammation within the labyrinth (in from the third to the eighth week or during the stage of convalescence deafness and disturbance of the equilibrium suddenly develop). Epidemic meningitis is a more frequent cause; in the first or second week deafness and marked disturbance of equilibrium (waddling gait) make their appearance, associated often with loss of function in other portions of the cerebrum, such as optic disturbances and aphasia. The deafness may improve temporarily, but rarely disappears permanently. In little children meningitis is a fruitful cause of deaf-mutism.

Treatment.—Ice-bag, potassium iodid internally, laxatives, hypodermic injections of pilocarpin, and galvanization. If deafness is of long standing, treatment is of no avail. The child should, however, be induced to talk as much as possible, so that it may not lose the power of speech. When speaking to a deaf child, one should always articulate as distinctly as possible. To preserve what remains of the power of hearing, constant exercise is necessary.

(c) **Diseases of the Auditory Nerve and Auditory Centers.**—Hyperemia of the auditory nerve occurs in active or passive hyperemia of the dura. Ecchymoses are found in the auditory nerve chiefly in fractures of the base of the skull and leukemia. Descending neuritis of the auditory nerve has been described in meningitis; ascending neuritis in otitis interna, with redness, purulent infiltration, degeneration and atrophy of the nerve-fibers, amyloid degeneration, the deposition of hyaline bodies, which may be normal, and lime salts in the neurilemma. Atrophy of the eighth nerve from obliteration of the basilar artery and internal auditory artery is a rare condition. In tabes the hearing is often impaired, owing to atrophy of the seventh nerve. Pressure palsies and lacerations of the nerve occur in otitis at the base of the skull (Plate 32) and when there are hyperostoses in the internal auditory meatus (syphilis). Secondary atrophy (atrophy from disuse) and fatty degeneration of the auditory nerve rarely follow catarrhal adhesive processes and ankylosis of the stapes, even when there is total deafness.

The symptoms in disease of the nerve-trunk are the same as in affections of the labyrinth: Partial or total deafness, tinnitus, vertigo, and headache. The drumhead is usually negative (Plate 38, 2) (for the functional tests see p. 87). Treatment is symptomatic. In central disease functional disturbances in other regions of the nervous system sometimes indicate the seat of the lesion. In central disease, such as brain tumor, there is usually choked disc. Bone-conduction is intact even for the watch, while in otitis interna it is shortened or absent. The upper tone limit is normal in central disease, and reduced in otitis interna. Gaps in the scale and paracusis point to peripheral disease. In diseases of the auditory nerve the power of hearing notes in the middle register is particularly affected (Gradenigo). In central disease, such as brain tumor, the electric irritability of the auditory nerve is heightened when the organ of hearing is intact. A central disturbance of the power of hearing is usually unilateral. There is often early involvement of the seventh nerve. Purulent inflammation and softening of the floor of the fourth ventricle in meningitis produce paralysis of the eighth nerve, and usually of other nerves as well. The nuclei of the auditory nerve may be destroyed in apoplexy and encephalitis.

The effect on the hearing in cerebral affections depends on the seat and extent of the disease: Lesion of the internal capsule produces crossed deafness (Fig. 97); acute and chronic hydrocephalus may produce deafness by destroying the nuclei of the auditory nerve. Apparent deafness is observed in pathologic processes in the first temporal convolution, especially on the left side; it is known as sensory aphasia (word- or psychic deafness)—that is, the power of interpreting is lost, although the sounds are heard. A true central word-deafness is distinguished from peripheral deafness by testing with an uninterrupted series of notes. If there are gaps in the scale or the duration of perception is prolonged and ineffective, particularly between b^1 and g^2, it may be assumed that the word-deafness is caused by peripheral changes in the cochlea (Liepman). When the third frontal convolution on the left side has been destroyed, the patient can hear what is said to him, but is unable to repeat the words because the movements of the mouth necessary for articulation are lost (motor aphasia). In psychic deafness, although the patient's power of hearing and understanding is preserved, he is unable to speak, because the entire mechanism of speech is insufficiently developed. The condition may be cured by exercises directed toward the improvement of hearing and articulation. Deaf-mutism is the inability to speak due to deafness. Idiotic deafness with intact hearing depends on general idiocy.

III. Injuries of the Organ of Hearing.

Stab-wounds and incised wounds of the pinna heal without deformity if kept aseptic; contused wounds, especially if they involve the cartilage, are usually followed by deformity of the pinna. The skin covering the auditory meatus may be injured by the instrument of the surgeon during attempts to extract a foreign body, by scratching, by burns, or by cauterization. The anterior bony wall of the meatus is usually included in any injury of the skin; rarely is it involved in injury to the base of the skull—as, for instance, after a fall on the lower jaw. Stricture of the auditory meatus (Plate 15) can be avoided by asepsis during treatment, the introduction of gauze drains, the extraction of splinters of bone, and by cauterizing exuberant granulations. Hemorrhage is controlled by packing.

The auditory canal is frequently involved along with the tympanic cavity and labyrinth in fractures of the base of the skull from a fall or blow. External violence applied to the forehead or occiput results in a longitudinal fracture at the base (Plate 11). The petrous portion of the temporal bone usually fractures at its weakest spot (from the jugular foramen to the tegmen tympani et antri), corresponding to the roof of the auditory meatus, while the capsule of the labyrinth usually escapes. The line of fracture rarely passes through the internal auditory meatus, vestibule, and cochlea, to the inner wall of the tympanum. External violence applied to the side of the head results in a transverse fracture, corresponding in direction to the petrosquamous suture or through the tegmen tympani, roof, posterior wall, and anterior wall of the auditory canal; the tip of the pyramid is often broken off at the same time, the bone at this point being less resistant than the dura mater. The drumhead may or may not be lacerated. Fracture of the temporal bone is followed by hemorrhages into the tympanic cavity, mastoid cells, trunk of the seventh and eighth nerves (rarely laceration), mucous membrane of the tympanic cavity, particularly in the neighborhood of the windows of the labyrinth, canal of Rosenthal, maculæ acusticæ, cochlea (scala tympani), semicircular canals, and utricle and saccule. The hemorrhage is especially marked in the perilymphatic spaces. A small hemorrhage may be absorbed, but in most cases of fracture inflammatory reaction in the labyrinth takes place (Plate 36). If the fracture passes through the tegmen tympani and the dura is lacerated, meningitis may develop from infection through the middle ear; fracture of the posterior wall of the meatus may lead to mastoiditis.

Course and Symptoms.—Fracture of the temporal bone is characterized by profuse hemorrhage; in rare cases hemorrhage occurs from the membranous portion of the auditory canal, the jugular vein and its bulb, or the carotid artery without any bony lesion. Sometimes extravasations of blood and sequestræ may be visible in the auditory canal. The drumhead may be lacerated, and disturbances of taste are observed. If the labyrinth or the cranial cavity has been opened, cerebrospinal fluid is discharged. The injury is usually followed by loss of consciousness, later by headache, vertigo, suddenly developing partial or total deafness, tinnitus aurium, and rarely facial palsy. Other cranial nerves may be paralyzed. Ecchymoses occur in the scalp. Death results usually from meningitis. If the patient recovers, he is usually deaf for life.

Treatment.—Guard against infection. Avoid syringing. Large ear-dressing and rest in bed are indicated. After the general symptoms have subsided, and if the patient is deaf, hypodermic injections of pilocarpin and strychnin and potassium iodid internally are to be employed. If there is hemorrhage into the tympanic cavity, inflation may be employed guardedly.

The **Eustachian tube** may be injured by the passing of a bougie, and rarely by stab- or shot-wounds. The wound may heal with a resulting stricture or atresia.

Penetrating stab-wounds in the region of the ear may injure the interior of the cranium or the lateral sinus, if the mastoid process has been pierced (von Bergmann).

Injuries of the **drumhead** are caused by: (1) Direct injury—burns, ear-spoon, syringe; perforation is in the posterior half of the drumhead, and as infection is the rule, an acute suppuration results. (2) Continuation of a fracture of the auditory canal, perforation in Shrapnell's membrane, followed by suppuration and meningitis; if the patient recovers, adhesions remain. (3) Sudden increase of the pressure in the auditory canal by a blow on the ear, explosions and insufflation, or diminution of the pressure, as in a caisson. A thin tympanic membrane and constricted Eustachian tube predispose to traumatic rupture because the air cannot escape readily into the nasopharynx. The accident is accompanied by a report in the ear, pain, vertigo, tinnitus, and slight hemorrhage. The perforation is oval, more rarely circular, and situated in the posterior half of the drumhead, more frequently in the left than in the right ear. The edges of the perforation are irregular, injected with blood, and sometimes overlap. In rare cases the laceration is linear and may involve only the epidermis and cutis. In the neighborhood of the perforation small hemorrhages are seen on the drumhead. There are no inflammatory symptoms. Sometimes the drumhead is gray, the mucous membrane of the tympanum yellow in color (Plate 38, 15, 16); Valsalva's experiment is successful and attended with a coarse perforation murmur. The hearing is but little affected, Rinne partially negative, Weber in diseased ear, Schwabach normal or prolonged. But if the labyrinth is injured, as in hemorrhage into the auditory nerve, into the scala tympani or maculæ acusticæ, the hearing is greatly affected and there may even be total deafness with intense subjective noises. Rinne positive, Schwabach shortened, Weber in healthy ear, upper tone limit reduced. Uncomplicated rupture of the drumhead heals in from four to six weeks by cicatrization, and the hearing remains normal. If there is labyrinthine involvement, there may be permanent deafness or tinnitus. Concussion of the labyrinth more frequently occurs without injury of the drumhead, the full effect of the sudden rise of pressure in the auditory meatus being felt by the labyrinth wall (Politzer). The tympanic cavity and its contents may be injured in laceration of the drumhead; the handle of the malleus may be fractured; the resulting hemorrhage into the tympanic cavity, known as hematotympanum, may undergo spontaneous absorption or the hematoma may break down, especially in direct violence. The labyrinth may be directly injured by careless extraction of a foreign body or by stab or gunshot wounds. It is more frequently injured indirectly in fractures of the base of the skull. Concussion of the labyrinth is caused by sudden changes in the air pressure, explosions, exposure to detonations (the shriek of a locomotive whistle), or a blow on the ear.

A grave injury of the hearing may result from concussion of the labyrinth, even without any fracture in the bone; it may be attended with hemorrhages into the membranous labyrinth, causing inflammatory reaction and atrophy of the auditory nerve (Plate 36). Concussion of the labyrinth sometimes occurs on the side opposite to that which received the blow; the symptoms then are moderate stupor, vertigo, vomiting, staggering gait, and not infrequently hyperæsthesia acustica. If the concussion has not been very severe, the auditory disturbance and vertigo disappear entirely within a few days. If there has been extensive hemorrhage, however, the auditory disturbance usually increases, while the vertigo remains as it was (Schwartze). Deafness occurring some time after the accident may be due to inflammatory reaction secondary to hemorrhage into the labyrinth. Ears already weakened by previous disease are greatly subject to injury in concussion of the labyrinth; the already existing impairment of hearing may suffer a sudden augmentation.

Treatment.—If the drumhead has been injured, syringing and instillation are contraindicated, so as to avoid any irritation or chance of infection. The treatment consists solely in sealing the ear aseptically and applying a small ear-dressing. The perforation heals without pus unless the wound becomes infected, when a severe purulent otitis media develops. In concussion of the labyrinth with or without injury of the drumhead rest in bed and ice compresses, laxatives, blood-letting, galvanization; internally potassium iodid, hypodermically pilocarpin (gr. $\frac{1}{10}$ to $\frac{1}{6}$) and strychnin (gr. $\frac{1}{80}$ to $\frac{1}{40}$). A constant exposure to sounds may have the same effect as a sudden intense noise. Thus atrophy of the auditory nerve and deafness are observed in certain occupations, such as in locksmiths, blacksmiths, weavers, telephone girls. Such individuals should wear an antiphone as a prophylactic measure.

IV. Neoplasms of the Auditory Meatus.

Among **connective-tissue growths occurring in the pinnæ** may be mentioned fibroma (Plate 16) and keloid, which may appear in the lobe of the ear from the irritation of ear-rings. The fibroma consists of a spheric lobulated tumor frequently containing myxomatous areas (myxofibroma). Tubercular nodules on the lobule of the ear occur rarely, and are distinguished from fibroma by histologic examination. An angioma is a bluish-red pulsating tumor found particularly at the entrance to the ear; it may be telangiectatic, or due to frost or varicose conditions during pregnancy. In rare instances the upper half of the pinna becomes ossified. Large cysts are not infrequently found on the posterior half of the pinna (Plate 16); dermoid cysts occur both behind and in front of the pinna; enchondroma has also been occasionally observed. Sarcoma may begin as an ulcer either in the lobe of the ear or at the tragus. The tumor extends through the soft parts into the bone, and threatens life by intracranial complications. A sarcoma usually originates in the mucous membrane of the tympanic cavity, the mastoid cells, the periosteum of the mastoid process (pseudo-fluctuation), or the dura of the petrous portion of the temporal bone. Destruction of the drumhead ensues, followed by suppuration, polypoid growths in the auditory canal, and later ulceration of the external ear (Plate 15). Sarcoma is distinguished from polypoid granulations by the ulcerating surface, the severity of the pain, the occurrence of hemorrhages, the rapid growth, and the histologic characters. Osteoma and gummatous tumors rarely develop in the periosteum of the mastoid process. Chloroma of the temporal bone has been described by Körner. Within the auditory meatus small white nodules (milium), produced by occlusion of sudoriferous glands, and comedones due to obstruction of sebaceous glands, must be mentioned.

Neoplasms of the middle ear and auditory meatus usually take the form of aural polypi (Plates 25; 33; 39, 9, 10, 15). Polypi are most frequent in chronic otitis media. They are attached to the inner wall or floor of the tympanic cavity, the tympanic ossicles, the drumhead, the margins of fistulæ, pneumatic cells of the roof, and posterior bony wall of the auditory meatus, where they simulate polypi of the auditory canal. Sometimes they are found in Shrapnell's membrane and in the Eustachian tube. They may be bright red, smooth, and shaped like a raspberry, or pale and spheric.

The majority of aural polypi consist of inflammatory tissue (Plate 33), so-called polypoid granulations, being a mixture of polynuclear and mononuclear leukocytes, plasma cells, mast-cells, giant-cells, and fibroblasts imbedded in a partly granular, partly fibrillar, and very vascular ground substance. Sometimes, when they contain a preponderance of fibroblasts and rapidly growing blood-vessels, they evince a tendency to contract (polypoid fibromatous granulations). They do not contain elastic fibers, but may be rich in hyalin corpuscles. The surface may be ulcerated, denuded of epithelium, and covered with squamous or cylindric epithelium. Sometimes both conditions are found at the same time. The cylindric epithelium contains gland-like depressions; true glands, however, are rare. Some aural polypi represent true tumors, being hard, vascular fibromata, covered with squamous or cylindric epithelium, or, when the fibers are separated by an infiltration of fluid, myxofibromata. Polypoid granulations very often depend on disease of the bone, and their presence, like that of fibromata and myxofibromata, is, therefore, a favorable prognostic sign.

Course and Symptoms.—Aural polypi usually coexist with chronic otitis media or caries; they are a fruitful cause of pus retention and persistent otorrhea. Sometimes their reflex irritation is the cause of epilepsy. Spontaneous suppuration and contraction by degenerative processes rarely take place. A polypus may reveal its presence by the occurrence of slight hemorrhage from the ear after sudden movements of the head. The origin of the growth is found by carefully feeling with a probe round its entire periphery (Politzer); polypoid granulations may grow into the auditory canal from the dura mater (external pachymeningitis) through carious defects in the roof of the tympanum (Plates 25, 34).

Treatment.—Tumors of the pinna should be excised, if they are malignant, as early as possible, and, if necessary, the entire pinna should be removed. An angioma may be destroyed with the galvanocautery. Aural polypi should be removed with the snare, unless they show a tendency to bleed, when the galvanocautery may be substituted. After instilling a 20 per cent. solution of cocain into the auditory canal, the snare is adjusted around the polypus, as near its base as possible, under thorough illumination with the head mirror. It is safer always to use a cutting snare—that is, one in which the loop can be drawn back into the hollow carrier (Fig. 99, *a*). If the surgeon uses a tearing snare, or one in which the wire is arrested at the extremity of the tube by a cross-piece (Fig. 99, *b*), he is in danger of lacerating the dura if the tegmen tympani is carious. Small polypi or the remains of polypi may be removed with the cutting forceps (Fig. 79), the circular knife (Fig. 78), the galvanocautery, or destroyed with chromic acid. After the operation a small ear-dressing should be applied. During the after-treatment absolute alcohol should be instilled into the ear at regular intervals, and the associated chronic otitis should also receive treatment. If the patient objects to the knife or the operation is attended with unusual difficulties, as in stricture of the canal, a cure may sometimes be effected by the instillation of alcohol alone (Politzer). Occasionally the removal of polypoid granulations is followed by a suppuration which may necessitate more radical surgical intervention.

FIG. 99.—Hartmann's snare.

Primary connective-tissue tumors of the auditory nerve are rare; they include neuroma, glioma, and fibrosarcoma. The tumors are attached to the nerve like a pear to its branch (Plate 32); the heavy stalk projects into the internal meatus, and interrupts the connection between the nerve and the brain; the seventh nerve is frequently involved. In addition to the deafness there are cerebral symptoms. It happens more frequently that tumors of the brain and dura mater, usually sarcoma, involve the auditory nerve secondarily.

Carcinoma is not uncommon in the ear (Plate 15); it begins in the pinna, at the upper portion of the helix, as a small nodule, and forms a soft, nodulated, ulcerating tumor which later extends to the cartilage, the pinna and its vicinity, and to the temporal bone. Within the auditory meatus it begins as an eczema or as an ulcer, with spongy, rapidly growing, cauliflower-like granulations, that bleed at the slightest touch. Even the middle ear and the mastoid process may become the starting-point of a carcinoma, especially after a long period of suppuration, and when the mucous membrane of the tympanic cavity has become converted into epidermis.

The destruction of the temporal bone may be as great as in extensive caries (Plate 23); even the capsule of the labyrinth and the cochlea may be invaded by the carcinomatous tissue and destruction of the auditory nerve result (Plate 36).

Symptoms of aural carcinoma are: Severe pain, discharge of pus, free bleeding, lymphatic enlargement, early paralysis of the seventh nerve, and the presence of rapidly growing granulations with broad bases within the auditory meatus.

The *diagnosis* is formed by microscopic examination; although a typically growing squamous epithelium is also found in aural polypi covered with squamous epithelium, it is always possible to demonstrate a direct connection with the epithelium of the surface; in transverse sections of the epithelium plugs the cells present a uniform arrangement like a palisade, just as in the rete Malpighii. Death results from meningitis or brain abscess within eighteen months at the latest. Carcinoma of the organ of hearing may be secondary to carcinoma of the parotid gland, the tongue, and the upper jaw.

Treatment.—Whenever possible, an early extirpation of the growth must be done.

V. Malformations of the Organ of Hearing.

Malformations are often the cause of congenital deafness and deaf-mutism. They affect either the entire organ of hearing or only the sound-conduction or sound-perception apparatus. Heredity is an occasional factor. The malformations are explained by the development of the organ of hearing (see p. 61).

In most cases of developmental anomalies of the external ear the middle and internal ear are normal. Thickening of the border of the helix behind and above is known as Darwin's point (Darwin-Woolner's ear) (Plate 16). Instead of the normal infolding of the helix, the upper posterior portion is often drawn out to a point (Macacus ear); when the fetal satyr point persists, the so-called satyr ear results, and when, at the same time, Darwin's point is strongly developed, the condition is described as a cercopithecus ear. The so-called Wildermuth ear is characterized by abnormal bulging of the antihelix. The lobe may be adherent, or may extend down on the cheek or may be cleft (coloboma). Degenerated or so-called Morel's ears are quite as frequent in normal individuals as in the insane. An excessive development manifests itself in macrotia, or unusual size of the ear, polyotia, or the presence of several deformed pinnæ in addition to a normal one, and in auricular appendages in front of the tragus (Plate 16). Not infrequently a small depression or blind fistula (fistula auris congenita) is found in front of the helix. Malformations of the pinna are usually associated with malformations of the auditory canal, the tympanic cavity, and the Eustachian tube, while the labyrinth may be well developed. Entire absence of the pinna is rare; sometimes the organ is replaced by a linear fold of cartilage or skin (macrotia) (Plate 16). The auditory meatus may be occluded by a membrane (atresia), or the opening is merely indicated by a slight depression, especially when macrotia exists. In this condition the bony meatus and drumhead may be normal or entirely wanting. In the latter case there is malformation of the tympanic cavity, the windows of the labyrinth are smaller, and the tympanic ossicles and Eustachian tube underdeveloped or wanting altogether.

Malformation of the ear often coexists with malformations in other portions of the head, asymmetry of the face, harelip, and cleft palate. In macrotia and in atresia the labyrinth is usually intact. It may, however, be defective, or the external ear and auditory meatus may be normal and the labyrinth alone defective, owing to incomplete development of the auditory nerve, the cochlea, and the semicircular canals. Abnormal fissures are sometimes observed in the temporal bone (Plate 32). Defects of the labyrinth produce total deafness, defects in the middle and external ear, only partial deafness. If there are unilateral macrotia and atresia, the condition of the labyrinth may be determined by the functional test; if it is intact, Weber is transposed to the diseased ear. In unilateral atresia, if the corresponding half of the palate is imperfect in development and mobility, it may be inferred that the middle ear also is imperfectly developed (Politzer). If the auditory canal is occluded by a septum, or its bony portion is excessively developed, conversation will be better understood with the use of an ear trumpet. If the middle ear is properly developed, a murmur is heard in the Eustachian tube during catheterization.

Treatment.—Inflammatory fistulæ of the auditory canal should be laid open and excised. Macrotia and prominence of the ears (cat-ears) may be remedied by excising a V-shaped piece from the posterior wall of the pinna.

In macrotia and atresia of the auditory canal an artificial meatus may be made if the bony portion is patent. It is hopeless to attempt to create an artificial canal with a chisel. If the pinna is absent or has been lost by an injury, an artificial ear made of papier-maché may be worn.

VI. Neuroses of the Organ of Hearing.

Nervous otalgia, sometimes intermittent and very violent, with subjective noises and hyperæsthesiæ acustica, may form part of a general trifacial neuralgia; the pinnæ and mastoid process are often red and swollen. Neuralgia of the tympanic plexus may make itself felt in the auditory meatus and in the tympanic cavity. Common causes of neuralgia are carious teeth, inflammation of the Gasserian ganglion, ulcerations of the tongue, larynx, pharynx, and influenza. The diagnosis of otalgia should never be made until every possible source of irritation, either in the ear or in other regions, has been excluded. The treatment is symptomatic. Quinin and potassium iodid may be given alternately. Galvanization, massage, and Lucæ's pressure probe may also be tried; hyperesthesia from exposure to cold must be treated with cold compresses; if due to pruritus, by a soothing ointment. In hysteria and in adhesive processes secondary to catarrh, anesthesia of the pinna and of the auditory meatus is occasionally met with. Spastic contractures of the tensor tympani and stapedius muscles in tic convulsif, blepharospasm, and spasm of the soft palate produce a ticking sound in the ear. Treatment is directed to the general condition, and may include galvanization and massage.

Neuroses of the eighth nerve manifest themselves in hyperesthesia, paracusis, tinnitus aurium (nervous tinnitus aurium without aural disease), oxyecoia, or exaggerated power of hearing, and in functional paresis or paralysis, such as: (1) Angioneurotic paralysis of the auditory nerve: the symptoms are pallor, nausea, vertigo, and momentary deafness lasting several minutes. It occurs in migraine (irritation of the auditory centers). (2) Rheumatic paralysis of the auditory nerve. Symptom: temporary deafness, usually following a cold or an attack of rheumatism. (3) Hysteric deafness. Rare—often associated with auditory hyperesthesia. The characteristic symptoms are sudden changes in the power of hearing, hyperesthesia, and anesthesia and paralysis in the distribution of other nerves, abnormal sensations in the auditory meatus, and vicarious hemorrhage from the nose. (4) Sympathetic paralysis of the auditory nerve: if there is great diminution of the power of hearing on one side, hearing on the opposite side also becomes involved without any objective changes.

Treatment.—Constitutional; in hysteria electricity and metallotherapy. Local treatment is, as a rule, unnecessary (see p. 179). Internally, bromids, potassium iodid; pilocarpin hypodermically; galvanization.

VII. Deaf-mutism.

A person is said to be a deaf-mute when he is unable to speak although the function of the speech mechanism is preserved. Every child is born dumb. It learns to speak by means of its sense of hearing, and thus becomes a speaking animal. If the child is born deaf, it will remain dumb. Children who are born with the power of hearing, but lose their hearing by disease before they have learned to speak, are in the same position as deaf-mutes—they remain dumb. Children who had already learned to speak (up to the seventh year), and then lose their hearing, almost invariably forget what they have learned and again become dumb. The majority of deaf-mutes are not born deaf but have lost their hearing as the result of some aural affection.

Congenital deafness is due to malformation of the organ of hearing (Plates 19, 22, 37), such as absence of the labyrinth, occlusion of the windows of the labyrinth,

labyrinth, malformation of the tympanic ossicles, or imperfect development of the temporal lobe; heredity or consanguinity of the parents may have a like influence. In Switzerland deaf-mutism from central disease occurs endemically and has the same topographic distribution as goiter (Bircher). Acquired deafness is generally due to aural disease occurring during meningitis, scarlet fever, measles, and other infectious diseases. In rare instances temporary and curable deaf-mutism has been observed in hysteric individuals. Educated deaf-mutes do not differ in their mode of thinking from normal individuals. The deafness is not always total. The majority of deaf-mutes, especially those who were born deaf, still possess some remains of the power of hearing, depending on the amount of function retained by the basilar membrane. They may be able to hear sounds, such as the tolling of bells or the musical notes of the scale—either the entire scale or with the exception of some notes (Bezold); or, finally, they may be able to hear vowels or even entire words. The most important range for understanding conversation is from b^1 to g^2. Deaf-mutes in whom this range is lost are unable to hear conversation (Bezold, Fig. 18). The diagnosis of deafness and deaf-mutism during the first years of life is difficult. The appearance of the drumhead gives no information. In acquired deafness, suppuration and the remains of catarrh are frequently found. The parents notice that the child does not hear, and after the second year that it fails to learn to speak. The deafness is finally confirmed when the child fails to respond to clapping of hands, the ringing of a bell, the sound of a whistle, etc. Any palpable concussion, such as the slamming of a door, must be avoided in making the test. The power of hearing the notes of the scale may be tested in deaf-mutes after the first school year by bandaging the eyes and holding the tuning-fork in front of the ear, at the same time carefully avoiding the slightest contact. The examiner then determines whether the child can hear each individual note, and if so, for how long. Repeated control experiments are necessary to guard against errors, which are very apt to creep in. Instead of the musical scale, Urbantschitsch's harmonica must be used for the test. In deaf-mutes the vertigo and ocular movements which follow rotary movements of the body in normal individuals are not infrequently absent.

Prophylactic measures for the purpose of avoiding deaf-mutism are of the greatest importance. In Prussia alone there are 28,000 deaf-mutes (Mygind). Before a child is able to speak it is not able to tell us that it cannot hear. It follows, therefore, that every child suffering from an aural disease is in danger of becoming a deaf-mute unless the loss of its hearing is avoided by timely local treatment, such as paracentesis, the removal of suppuration and of adenoid vegetations, the air douche, etc. Once the hearing has been lost, suppuration may, it is true, be removed, and what little remains of the power of hearing may be preserved, or even possibly augmented, and yet the child will remain a deaf-mute in spite of all our efforts; older children, particularly those who have become deaf, must be constantly made to speak, as this will enable them both to retain their power of speaking and to understand the speech of others. The only place for a deaf-mute to learn to speak is in a special school for the instruction of deaf-mutes, and thither the child should be sent as soon as possible. Deaf-mutes can make themselves understood to one another by means of signs, but this does not enable them to converse with other normal individuals. This is the method employed in France—the so-called gesture speech after Abbé de l'Epée in Paris. The German method by which the deaf-mute learns to speak (Pedro de Ponce, Heinicke) is a much better one. The deaf-mute is taught to speak by imitating the movements of the mouth and muscles of the face and neck through the sense of sight and touch, and he learns to understand the conversation of others by reading the lips. If the child retains any power of hearing, particularly between the range of b^1 and g^2, it must be utilized in teaching him.

It is not possible to bring about an improvement in the hearing by exercises (Urbantschitsch). On the other hand, the instructor may with advantage utilize the power of hearing to supplement his instruction by the eye. An intelligent deaf-mute with some power of hearing will learn to speak quite intelligibly. The voice, as a rule, is more monotonous than in ordinary individuals, and sometimes it may be absolutely unintelligible. About one-third of all deaf-mutes learn to speak well enough to be understood by anybody (Hartmann). The great majority learn enough to follow some suitable calling, such as farming or industrial labor.

VIII. Significance of Aural Diseases in Civil and Military Life.

(a) **Military Service.**—During a period of about thirty years, 15,958 soldiers were discharged from the German army as unfit for service on account of aural troubles. Of these, 86.8 per cent. were already suffering from aural disease when they entered the army (Ostmann). It follows, therefore, that to guard these patients against becoming incapacitated for service by aural disease, every physician should have some knowledge of otology.

In Prussia a man's fitness for service is determined by the following regulations: A man is considered fit to serve among the reserves (1) if he is deaf only in one ear and the deafness is due to some antecedent disease; or (2) if the hearing is only moderately impaired in both ears, so that he hears whispered conversation at a distance of about 4 m. down to 1 m. A man is considered permanently incapacitated when (3) he has lost one auricle; (4) if he is incurably deaf, or hard of hearing in both ears, and the distance at which he can hear whispered conversation is less than 1 m.; (5) if he is suffering from any grave disease of the auditory apparatus that is difficult to cure; and, finally, (6) if he is a mute or a deaf-mute. In the case of fully trained soldiers the conditions mentioned under (1) and (2) constitute an absolute bar to active service in the field. A man is rendered unfit for both field and garrison duty by the conditions mentioned under (3), (4), and (5).

(b) **Insurance.**—Life insurance should be refused in the following conditions: Malignant tumors, chronic otitis media with caries, cholesteatomata, polypi, paralysis of the facial nerve, and vertigo. In perforations of the lower half of the drumhead with moderate suppuration, in dry perforation, and two years after a radical operation, the applicant may be admitted with an increase in the premium. If the applicant is suffering from an acute inflammatory process, admission should be delayed until he is well of his trouble. Impaired hearing due to catarrhal adhesive processes, ankylosis of the stapes, and nervous deafness without lues or leukemia do not disqualify a man for life insurance.

(c) **Accidents and Expert Testimony.**—Expert testimony in regard to aural diseases should not be attempted by any one who is not a specialist; otherwise the patient may suffer from incorrect testimony in regard to his condition, and the physician runs the risk of giving false evidence. Hence a physician who has not made a specialty of aural diseases should refuse to give expert testimony. After any injury to the head an examination of the ears should be made as soon as possible, including at least examination with the speculum and testing the hearing for whispered conversation. If examination is delayed too long after the injury, it may be difficult or impossible to decide whether the aural condition was produced by the accident or not. The only trustworthy signs are recent injuries, such as traumatic rupture and injury to the auditory canal. Recent traumatic rupture is distinguished from a dry perforation of some standing by hemorrhage (Plate 38, 15, 16). The edges of a dry perforation are white, and calcareous deposits are often found in the drumhead. The finding of old alterations in the ears immediately after the accident, or information in regard to impaired hearing before the accident obtained from the patient's friends, is of the greatest importance in the final decision. In some cases the condition of the uninjured ear will assist the examiner in forming an opinion in regard to the injured ear; if, for example, the patient should say that the uninjured ear is perfectly sound, and we find on examination signs of former disease and impaired hearing, it may be inferred that the injured ear was also affected by some disease that escaped the patient's notice.

It often happens that a disease of long standing is attributed to an accident, and, as a matter of fact, it is quite possible that an already existing trouble may have been made worse by the accident. If the drumhead is normal, and malingering is excluded, one will have to depend on the statement of witnesses; if there is recent suppuration, it is usually impossible to decide whether it is traumatic or not. It goes without saying that cholesteatoma, fetid suppuration, and extensive defects of the drumhead cannot be of recent origin. A careful functional test with due regard to the patient's occupation and general condition will not infrequently enable one to arrive at a decision.

If the injury is such as to incapacitate the patient for his work, he is entitled to damages, the amount of which depends on the degree of deafness or subjective symptoms, such as disturbance of the equilibrium, which can be determined only by clinical observation.

Total deafness in both ears incapacitates a man to the extent of from 30 per cent. to 50 or 100 per cent. If his hearing is impaired in both ears, so that he can hear only loud conversation with the better ear at a distance of 10 to 20 m., the injury is considered to be 5 per cent.; if at a distance of 5 to 10 m., 11 per cent.; and from 1 to 2 m., 22 per cent. (Schwarz). Subjective symptoms and unilateral deafness may injure a man to the extent of from

10 per cent. to 100 per cent., depending on his occupation. Incapacity from deafness is usually of long duration and may be permanent. Recovery is possible in subjective noises and in suppurations. It sometimes requires several months to arrive at an opinion in regard to an injury. A traumatic rupture may heal. Concussion of the labyrinth sometimes subsides or may not injure the hearing until some future time. Traumatic ruptures without concussion of the labyrinth and wounds of the external ear are classed as minor injuries. Loss or mutilation of an auricle, bilateral deafness, and injuries which produce chronic suppuration are classed as severe bodily injuries. Secondary infection in traumatic cases may end the patient's life by setting up meningitis, pyemia, or brain abscess—as, for example, after attempts to remove a foreign body.

APPENDIX.

MEDICAL FORMULARY.[1]

EAR DROPS, DOUCHES, AND INJECTIONS THROUGH CATHETER.

℞. Aluminis, 1 gr. xv
Plumbi acetat., 5 ʒj
Aq. destill., q. s. ad 100 f℥iij.
M. Sig.—Instil in ear 3 times a day; let remain ten minutes.

℞. Sol. argenti nit., 3 per cent.
Sig.—Instil 10 drops in ear 3 times a day. Let remain one-half minute.

℞. Sol. ammon. mur., 10 per cent.
Sig.—Inject 5 drops through catheter.

℞. Acid. boric., 1.5 gr. xxv
Aq. destillat.,
Glycerini, āā 20 fʒv.
M. Sig.—Instil 10 drops in ear 3 times a day.

℞. Acid. boric., 4 ʒj
Alcohol. absol., q. s. ad 20 fʒv.
M. Sig.—Instil 10 drops in ear 3 times a day.

℞. Liq. ac. carbol., 0.5–1 ♏viij–xv
Glycerini, q. s. ad 10 fʒiiss.
M. Sig.—Instil 5 drops in ear 3 times a day.

℞. Sol. cupri sulph.,
0.02–20 gr. ss–f℥j.
Sig.—Instil 5 drops in ear 3 times a day.

℞. Glycerini,
Alcohol. absolut., āā 10 fʒiiss.
M. Sig.—Instil 5 drops in ear 3 times a day.

℞. Hydrogen. peroxid., 60 f℥iij
Aq. destill., q. s. ad 100 f℥v.
M. Sig.—Inject into ear 3 times a day.

℞. Hydrogen. peroxid., 60 f℥iij
Alcohol. absolut.,
q. s. ad 100 f℥v.
M. Sig.—Inject into ear 3 times a day.

℞. Iodin. (pur.), 0.3 gr. v
Potass. iodid., 3 gr. l
Glycerini, q. s. ad 30 f℥j.
M. Sig.—Inject 5 drops through catheter.

℞. Iodoformi, 0.2 gr. iij
Glycerini, 1 ♏xv
Aq. destill., q. s. ad 20 fʒv.
M. Sig.—Instil 5 drops in ear 3 times a day.

℞. Iodol, 1 gr. xv.
Alcohol. absolut., 8 fʒij
Glycerini, 20 fʒv.
M. Sig.—Apply with brush to necrotic areas.

℞. Sol. potass. sulph.,
0.2–50 gr. ij–f℥j.
Sig.—Instil 10 drops in ear 3 times a day.

[1] The equivalents in Apothecaries' Weights are only approximate; but the proportions are relatively the same as in Metric System.

℞. Sol. plumbi subacetat., 1-25 gr. xx-f℥j.
Sig.—Instil 5 drops in ear 3 times a day.

℞. Menthol, 2 gr. xxx
Vasogen, q. s. ad 100 f℥iij.
M. Sig.—Instil 10 drops in ear 3 times a day.

℞. Sodii carbonat., 0.5 gr. viij
Aq. destillat.,
Glycerini, āā 10 fʒiiss.
M. Sig.—Instil 10 drops in ear 3 times a day.

℞. Sodii bicarb., 1 gr. xv
Aq. destillat., 20 fʒv
Glycerini, q. s. ad 25 fʒvj.
M. Sig.—Inject 5 drops through catheter.

℞. Sodii carbonat., 0.1 gr. iss
Aq. destillat.,
Glycerini, āā 10 fʒiiss.
M. Sig.—Inject 5 drops through catheter.

℞. Pilocarpin. mur., 0.2 gr. iij
Aq. destill., 10 fʒiiss
Liq. acid. carbol., 0.07 ♏j.
M. Sig.—Inject ½ to 1 Pravaz syringeful hypodermically, or 6 to 8 drops through the catheter.

℞. Acid. salicylic., 0.5 gr. viij
Alcohol. absolut., 20 fʒv.
M. Sig.—Instil 10 drops in ear 3 times a day.

℞. Acid. sozoiodilic., 0.2 gr. iij
Alcohol. absolut., 2 fʒss
Ol. ricini, q. s. ad 10 fʒiiss.
M. Sig.—Instil 10 drops in ear 3 times a day.

℞. Hydrarg. bichlor., 0.02 gr. ⅓
Alcohol. absolut., 20 fʒv.
M. Sig.—Instil 10 drops in ear 3 times a day.

℞. Acid. tannic., 0.5 gr. viij
Glycerini, 20 fʒv.
M. Sig.—Instil 5 drops in ear 3 times a day.

℞. Sol. zinci sulphat., 0.1-20 gr. iss-fʒv.
Sig.—Inject 5 drops in ear (or through catheter) 3 times a day.

VARIA.

℞. Amyl nitrit., 2 ♏xxx
Chloroformi, q. s. ad 10 fʒiiss.
M. Sig.—Place 5 drops on cotton and inhale.

℞. Liq. aluminis acetat., 200 f℥vj.
Sig.—Add 2 tablespoonfuls to a half-pint of water, for compresses.

℞. Acid. boric., 2 gr. xxx
Cocain. mur., 0.2 gr. iij
Aq. destillat., 200 f℥vj.
M. Sig.—Borococain spray.

℞. Chloroformi,
Ol. olivæ, āā 10 fʒiiss.
M. Sig.—For inunction (counter-irritant).

℞. Ol. hyoscyam., 20 fʒv
Chloroformi, 10 fʒiiss.
M. Sig.—For inunction (counter-irritant).

℞. Menthol, 1 gr. xv
Chloroformi, 15 fʒiv.
M. Sig.—Place 5 drops on cotton and inhale.

℞. Menthol, 0.5-1 gr. viij-xv
Ol. olivæ, 10 fʒiiss.
M. Sig.—Instil 3 drops into nose.

℞. Menthol,
Cocain. mur., āā 0.1 gr. iss
Acid. boric., q. s. ad 10 ʒiiss.
M. Sig.—Use as snuff.

℞. Menthol, 1 gr. xv
Cocain. mur.,
Acid. carbol. (crystal), āā 1 gr. xv.
M. Sig.—Moisten a cotton pledget and place on drumhead (or other tissue) three minutes before operating.

℞. Sodii sozoiodol, 1 gr. xv
Acid. boric., q. s. ad 20 ʒv.
M. Sig.—Use as snuff.

℞. Ol. rusci (birch tar),
Alcoholis, āā 15 f℥iv.
M. Sig.—Tincture of tar.

℞. Sapon. vir., 30 f℥j
Alcoholis,
Tr. lavendulæ, āā 30 f℥j.
M. Sig.—Hebra's tincture of soap.

℞. Spts. aromat., 30 f℥j
Spts. formicarum,
Spts. sinapis, āā 30 f℥j.
M. Sig.—For inunction (counter-irritant).

DUSTING-POWDERS.

℞. Aluminis exsiccat., 1.5 gr. xx
Acid. boric. pulv.,
q. s. ad 10 ʒij.
M. Sig.—Ear powder.

℞. Acid. boric. pulv. subt.,
10 ʒij.
Sig.—Ear powder.

℞. Acid. boric. pulv., 5 ʒj
Ol. terebinth., 0.3 ♏v.
M. Sig.—Ear powder.

℞. Iodol, 10 ʒij.
Sig.—Ear powder.

℞. Acid. salicylic.,
Acid. boric., āā 10 fʒij.
M. Sig.—Ear powder.

℞. Zinci sozoiodol. pulv.,
2 gr. xxx
Talc. venet.,
q. s. ad 20 ʒv.
M. Sig.—Ear powder.

℞. Zinci oxid. alb., 10 ʒiiss
Amyli pulv., 20 ʒv.
M. Sig.—Dusting-powder.

OINTMENTS.

℞. Argent. nitrat., 0.3 gr. v
Balsam. peruvian., 3 gr. xlv
Ung. petrolei, 30 ℥j.
M. Sig.—Caustic ointment.

℞. Acid. boric., 1 gr. xv
Lanolin, q. s. ad 30 ℥j.
M. Sig.—Borated ointment.

℞. Camphoræ pulv., 3 gr. xlv
Ung. petrolei,
q. s. ad 30 ℥j.
M. Sig.—Camphor ointment.

℞. Chrysarobin., 5 ʒj
Lanolin, q. s. ad 20 ℥j.
M. Sig.—Chrysarobin ointment.

℞. Emplast. litharg. simpl.,
Ol. olivæ, āā 30 ℥j.
M. Sig.—Diachylon ointment of Hebra.

℞. Hydrarg. præcip. alb., 1 gr. xv
Ung. petrolei,
q. s. ad 10 ʒiiss.
M. Sig.—Precipitate ointment.

℞. Ichthyol, 1 gr. xv
Lanolin, q. s. ad 10 ʒiiss.
M. Sig.—Ichthyol ointment.

℞. Potass. iodid., 2 gr. xxx
Iodin. (pur.), 0.1 gr. iss
Ung. emoll., 20 ʒv.
M. Sig.—Iodin ointment.

℞. Morphin. hydrochlor.,
0.5 gr. viij
Lanolin, q. s. ad 10 ʒiiss.
M. Sig.—Morphin ointment.

℞. Ol. amygdalæ,
Aq. rosæ, āā 10 fʒiiss
Ceræ,
Resinæ alb., āā 1 gr. xv.
M. Sig.—Hebra's cooling salve.

℞. Zinci oxid. alb.,
Amyli pulv., āā 5 ʒj
Lanolin, 10 ʒij.
M. Sig.—Zinc paste.

℞. Zinci oxid. alb., 3 gr. xlv
Adipis benzoinat.,
q. s. ad 30 ℥j.
M. Sig.—Wilson's ointment.

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