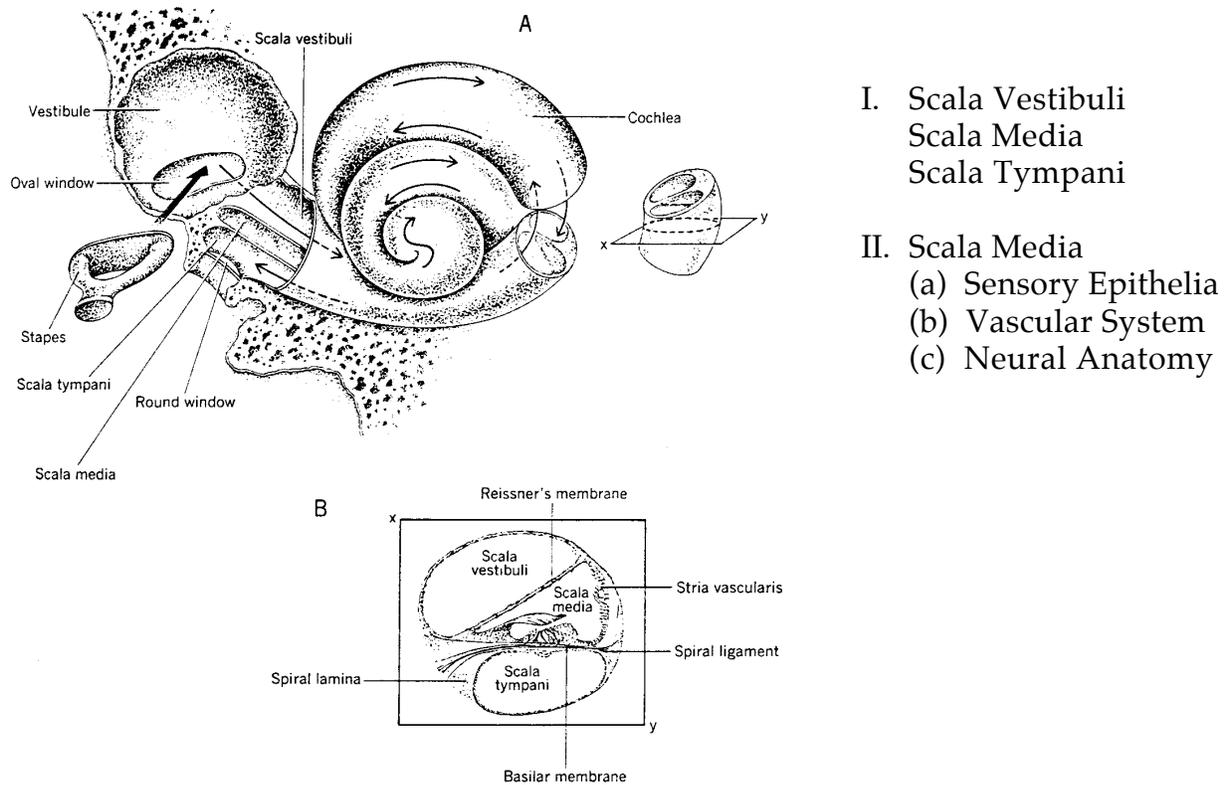


GENERAL COCHLEAR ANATOMY



I. Scala Vestibuli
Scala Media
Scala Tympani

II. Scala Media
(a) Sensory Epithelia
(b) Vascular System
(c) Neural Anatomy

Fig. 12. A. The cochlea of the right ear showing the relative positions of the scala vestibuli, scala media, and scala tympani. Only the scala vestibuli communicates directly with the vestibule. The arrows show possible paths of sound
B. A cross section of the cochlear tube.

III. Sensory Epithelium

Note: Connective tissue faces the perilymph scala. ~ not quite true.
Epithelial tissue faces the endolymph space.

(a) Basement membrane usually separates connective from epithelial tissue except at the stria-spiral ligament interface.

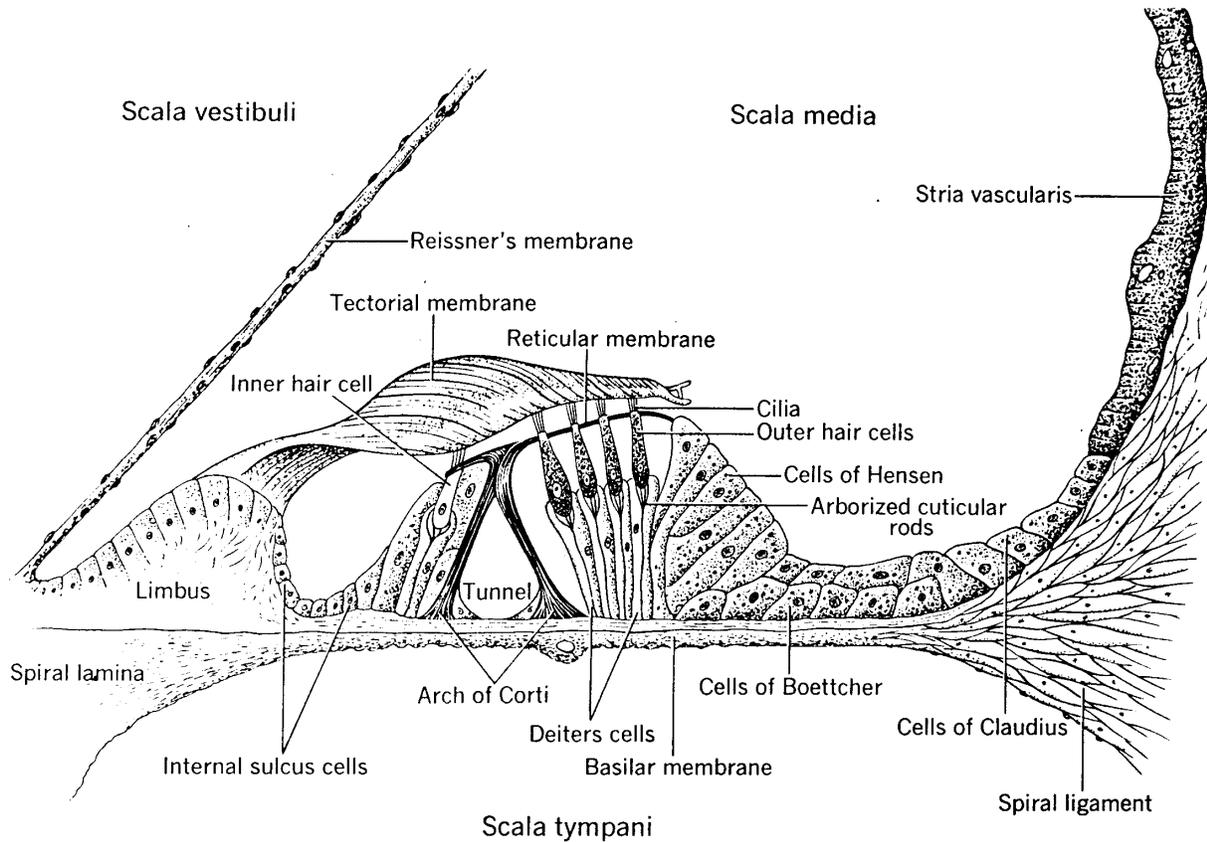


Fig. 13. Cross section of the scala media showing the organ of Corti.

IV. Basilar Membrane

pars tecta	ground substance - fibers
para pectinata	connective tissue cells

consists mostly of radial fiber - Note: However, strong longitudinal connections via "glue-like" ground substance also few longit. fibers - fiber characteristics change from base to apex.

Apex radial fibers "seem" more or less independent. Fibers of the basilar membrane run into the fibers of the spiral ligament laterally and into the fibers of the spiral limbus.

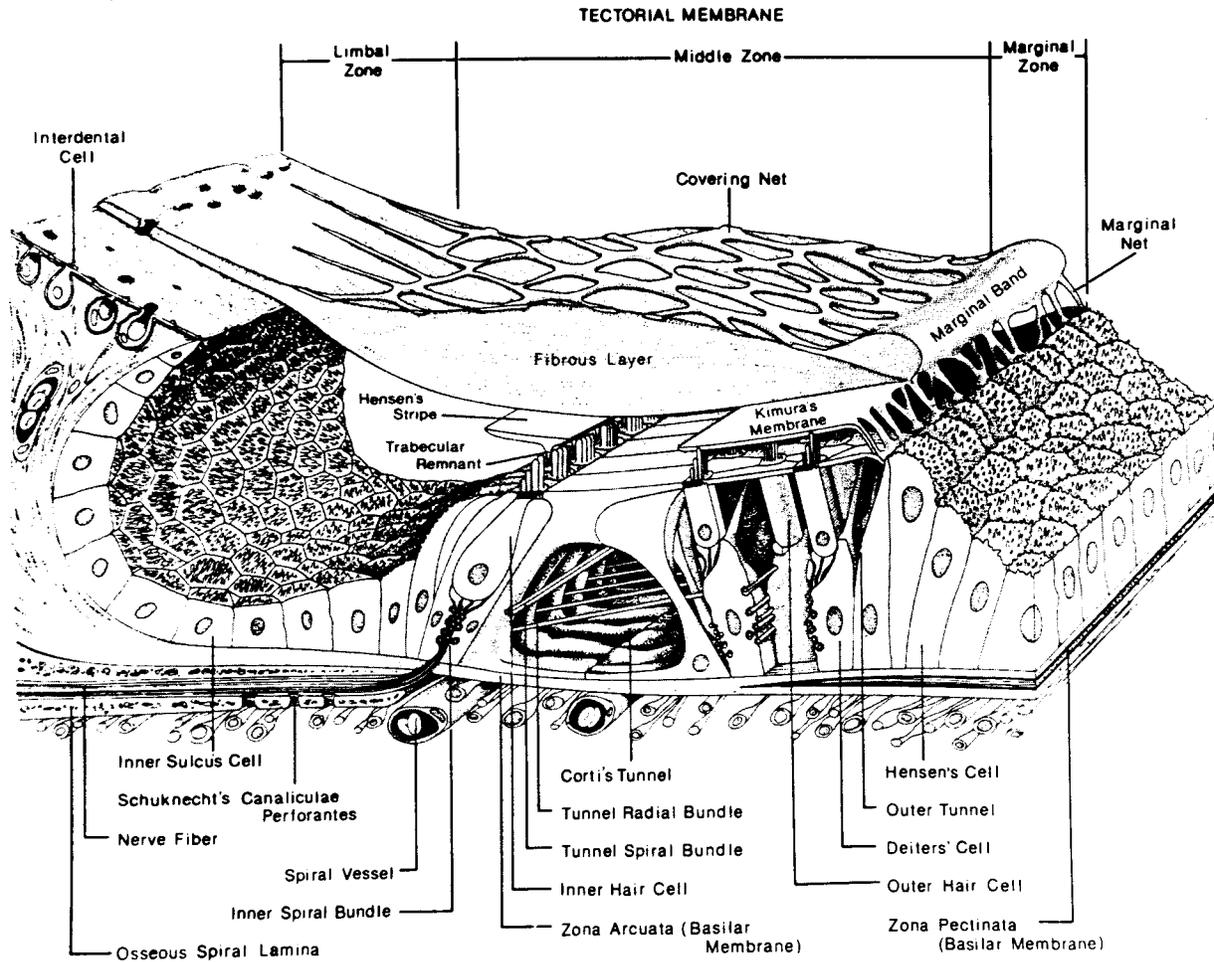


Fig. 14. Detailed Anatomy of the organ of Corti.

- V. Spiral Limbus - Connective tissue cells - much ground substance and fibrous material Huschke teeth - Interdental cells very dynamic in developmental stages - numerous Golgi and endoplasmic rect. may be responsible for secreting tectorial membrane.
- VI. Tectorial Membrane:
 Limbal Zone, Middle Zone, Marginal Zone:
 Note prominent structures and overall complexity of this membrane:
 Covering net, marginal band, marginal net, Hensen's Stripe, Kimura's membrane, fibrous layer: Note how these structures are interrelated - chemical composition? and relation to stereocilia.
- VII. Inner Sulcus - Cubodial epithelium - joins with connective tissue layer of spiral limbus and with interdental cells at the medial aspect. Sulcus cells terminate laterally with the "obscure" border cells. Note interrelationship of border cells, inner hair cell, inner Phalangeal cell, and morphology of inner pillar cell.

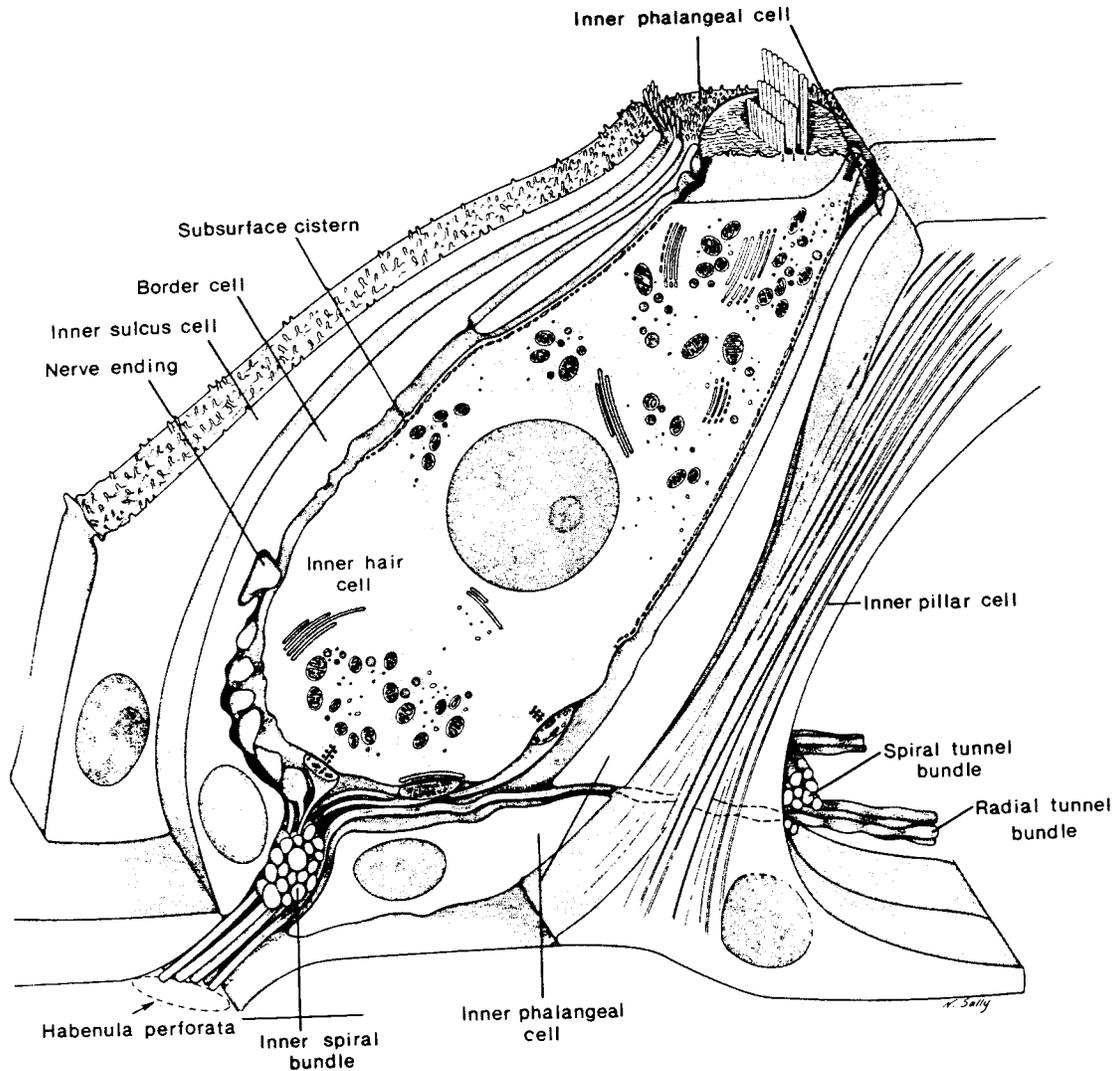


Fig. 15. Detailed Anatomy of the Inner Hair Cell.

VIII. (a) Inner hair cells - Apical Zone - cuticular plate, basal body area ~ hairs/cell, arranged longitudinally. Accumulation of many organelles.

Intermediate Zone -

Perinuclear Zone -

Basal Zone -

IHC - larger than OHC - bottle shaped - nucleus positioned differently and whole morphology in general is different.

VIII. (b) OHC - cylindrical in shape - organelle description about the same as for IHC. Stereocilia W shaped vertex points to lateral wall. Note IHC and OHC cuticular area - reticular lamina junctional complex. no possibility of intermixing endolymph into the organ of Corti fluid spaces.

IX. Supporting Cells:

(a) Cells with fibers, Deiters' cells

Inner, outer pillar

(b) Cells without fibers. Hensen cells

Claudius cells

Boettcher cells

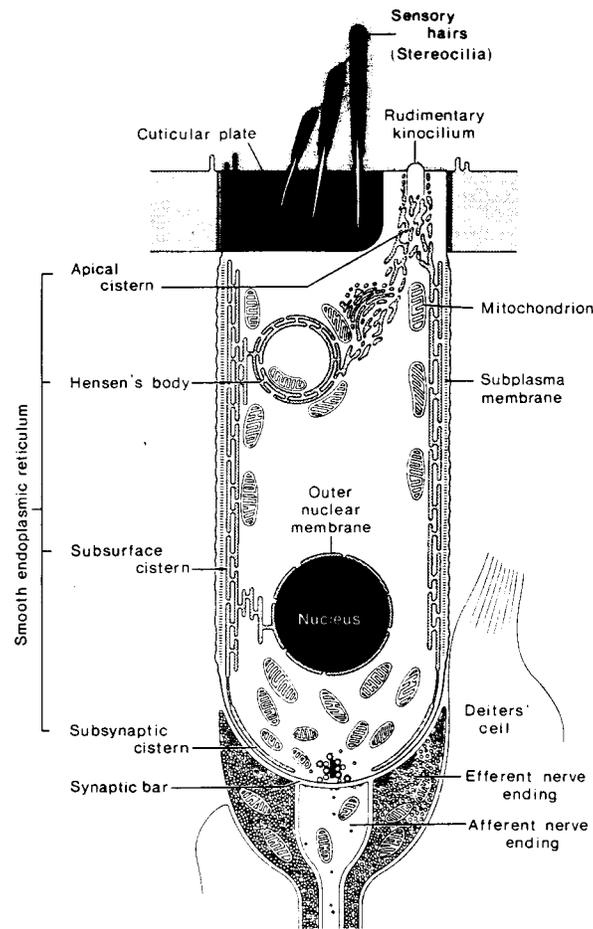


Fig. 16. Detailed Anatomy of the Outer Hair Cell.

SUMMARY OF COCHLEAR INNERVATION

Peripheral Innervation:

All fiber lose myelin sheaths as they enter O of C.

- (1) Radial Fibers (a) to IHC and (b) tunnel crossing radial fibers to OHC.
- (2) Internal Spiral Bundle
- (3) Tunnel Spiral Fibers
- (4) Outer Spiral Fibers

Afferent and Efferent

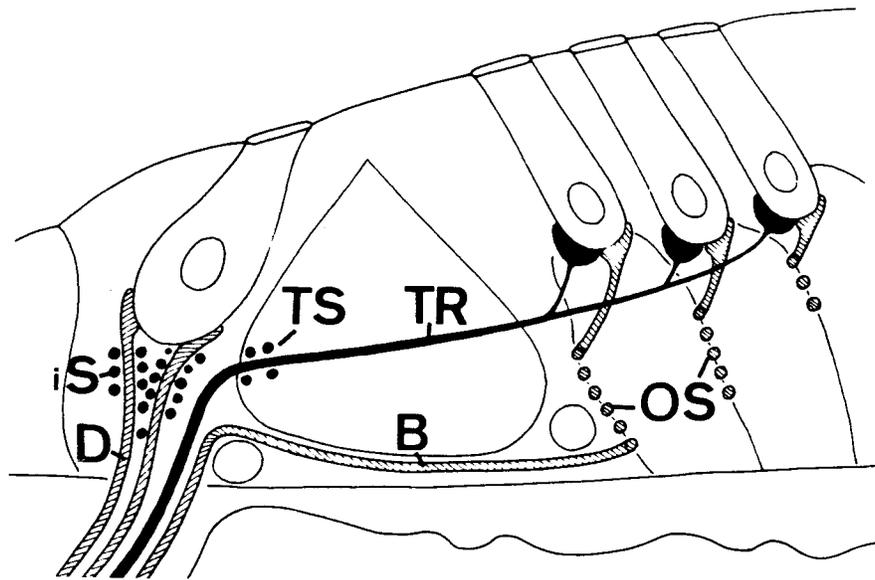


Fig. 17. Schematic representation of different groups of nerve fibers in the organ of Corti. The efferents are drawn in black. D : radial fibers to inner hair cells; iS : internal spiral fibers; TS : tunnel spiral fibers; TR : tunnel radial fibers; B : basilar fibers; OS : outer spiral fibers.

Efferent Innervation:

Rasmussen: Olivocochlear bundle brings an efferent supply to the cochlea from the contra and homolateral superior olives. Reaches the cochlea with the vestibular nerve through the anastomosis of Oort.

- (1) Efferent endings in the Organ of Corti are characterized by:
 - (1) large size;
 - (2) synaptic vesicles;
 - (3) postsynaptic cisterna.
- (2) Efferents generally contact OHC directly but direct contact with IHC is rare.

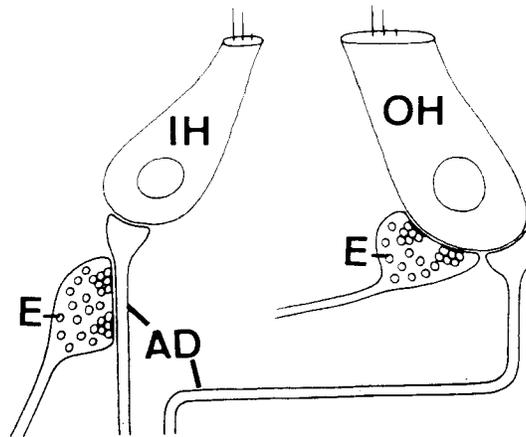


Fig. 18. Schematic representation of efferent synaptic connections in the organ of Corti of the cat. At the outer hair cells (OH) synaptic contacts are almost exclusively with the sensory cell and at the inner hair cells (IH) only with the afferent dendrites (AD). E : efferent ending.

Degeneration Studies

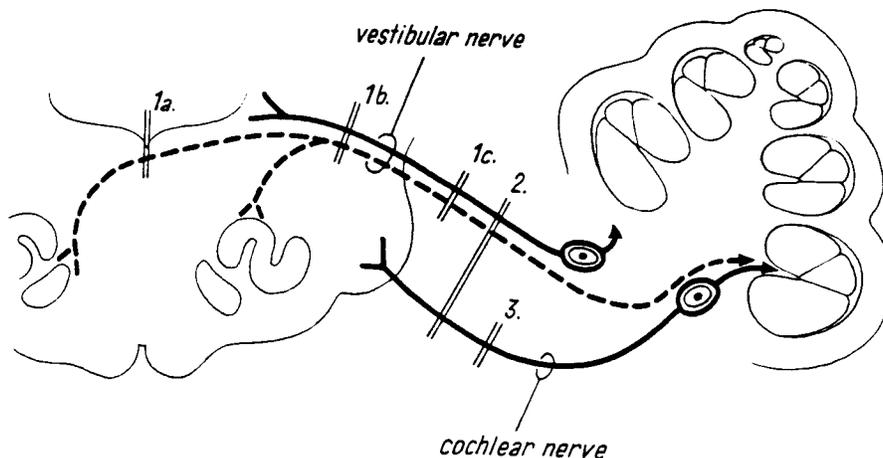


Fig. 19. Outline of experimental lesions, which have been carried out on cats. 1a-1c show the possible sites of interruption of the olivo-cochlear fibers; 2 the total transection of the eighth nerve, and 3 a selective lesion of the cochlear nerve.

By transection of the entire olivocochlear bundle; large nerve endings degenerate, as well as all inner and tunnel spiral fibers.

Observations:

(1) 1st row of OHC - most abundant efferent supply

(2) In the base all three rows have an efferent supply but as apex is approached, 2nd and 3rd rows lose their efferent supply. (6-8 endings/cell in the base).

Estimated 40,000 endings + several hundred inner spiral fibers originate from the olivocochlear bundle consisting of only about 500 neurons.

Only small % age of fibers passing through the habenular opening are efferent. (20-30 fibers pass through each opening).

OHC Innervation:

Fibers getting to the OHC cross the tunnel either at the middle level or at the bottom as basilar fibers.

All upper tunnel fibers are efferent. Since these disappear when olivocochlear bundle is cut. But this does not reduce number of outer spiral fibers.

Efferent innervation to OHC is predominantly radial.

Selective transection of the olivocochlear bundle shows that 75% of the fibers originate from contra lat. and remainder from homo lat. superior olive.

Iurato: shows contra lat. fibers (in rat) go to OHC

homo lat. " " go to inner spiral
fibers and OHC

Spoendlin: shows only ~ 10% efferent in OHC arise from homo lat. bundle.

Contra later. fibers produce most efferent innervation to OHC and about 1/2 to the inner spiral fibers, but homo lat. contribute other 1/2 of inner spiral fiber and only a few to OHC.

Synaptic Connection:

At OHC, efferents make direct synapse with OHC. Synapse is characterized by synaptic vesicles at presynaptic membrane and post synaptic membrane differentiation.

At IHC level efferents make direct contact with the afferent dendrites. The main demonstrated effect of the olivocochlear fibers is inhibition. Anatomy shows: presynaptic inhibition in OHC and post synaptic inhibition at the dendrites to IHC.

After efferent innervation is eliminated; what's left?

- (1) Radial fibers to inner H.C.
- (2) Basilar fibers
- (3) Outer spiral fibers

*Spoendlin estimates 3-4000 efferent axons destined for the OHC, this implies that the majority of cochlear neurons lead to IHC i.e.: about 50,000!

Q: Are upper tunnel radials efferent?
Spoendlin says Yes
Eldridge says Maybe

Afferents enter in bundles of 20 through each habenular opening. Fibers disperse between supporting cells of IHC. Majority continue till reaching an IHC; others spiral a little before becoming basilar. Out of 20 fibers only 1 or 2 become basilar. Majority do not branch and end with a single nerve ending at a single IHC. Synapse characterized by synaptic bar.

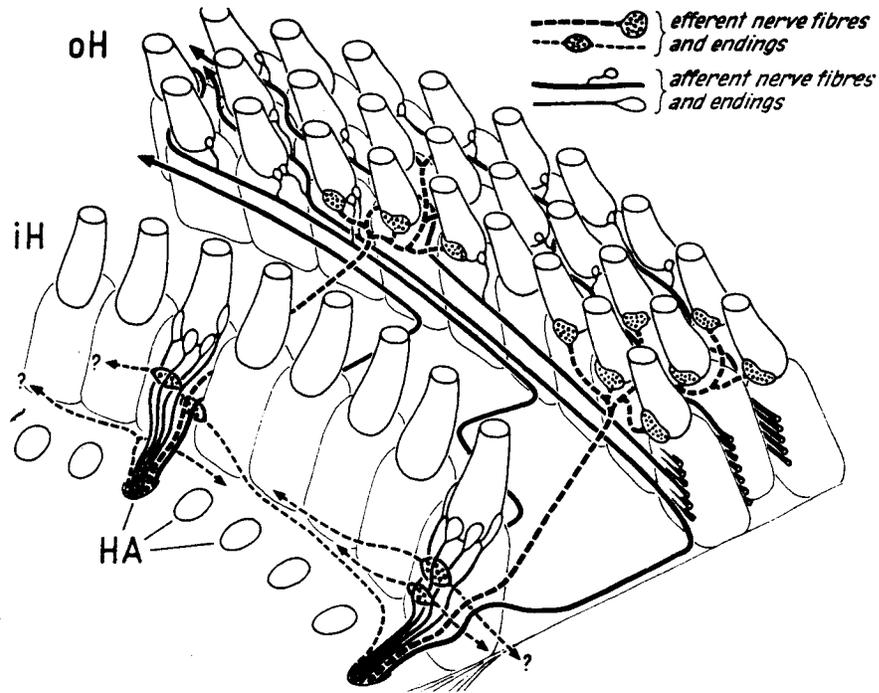


Fig. 20. Schema of the general innervation pattern of the organ of Corti. oH: outer hair cells; iH: inner hair cells; HA: habenular openings.

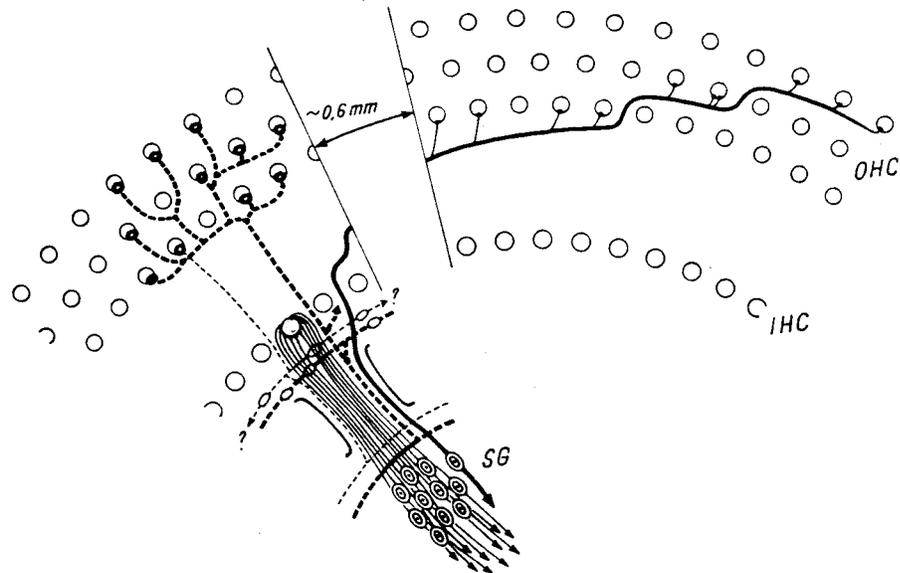


Fig. 21. Schematic outline of the fiber distribution of the organ of Corti. Full thick lines: afferent fibers to the outer hair cells. Full thin lines: afferent fibers to the inner hair cells. Interrupted thick lines: efferent nerve fibers from the contralateral olivocochlear bundle. Thin interrupted lines: efferent nerve fibers from the homolateral olivocochlear bundle.

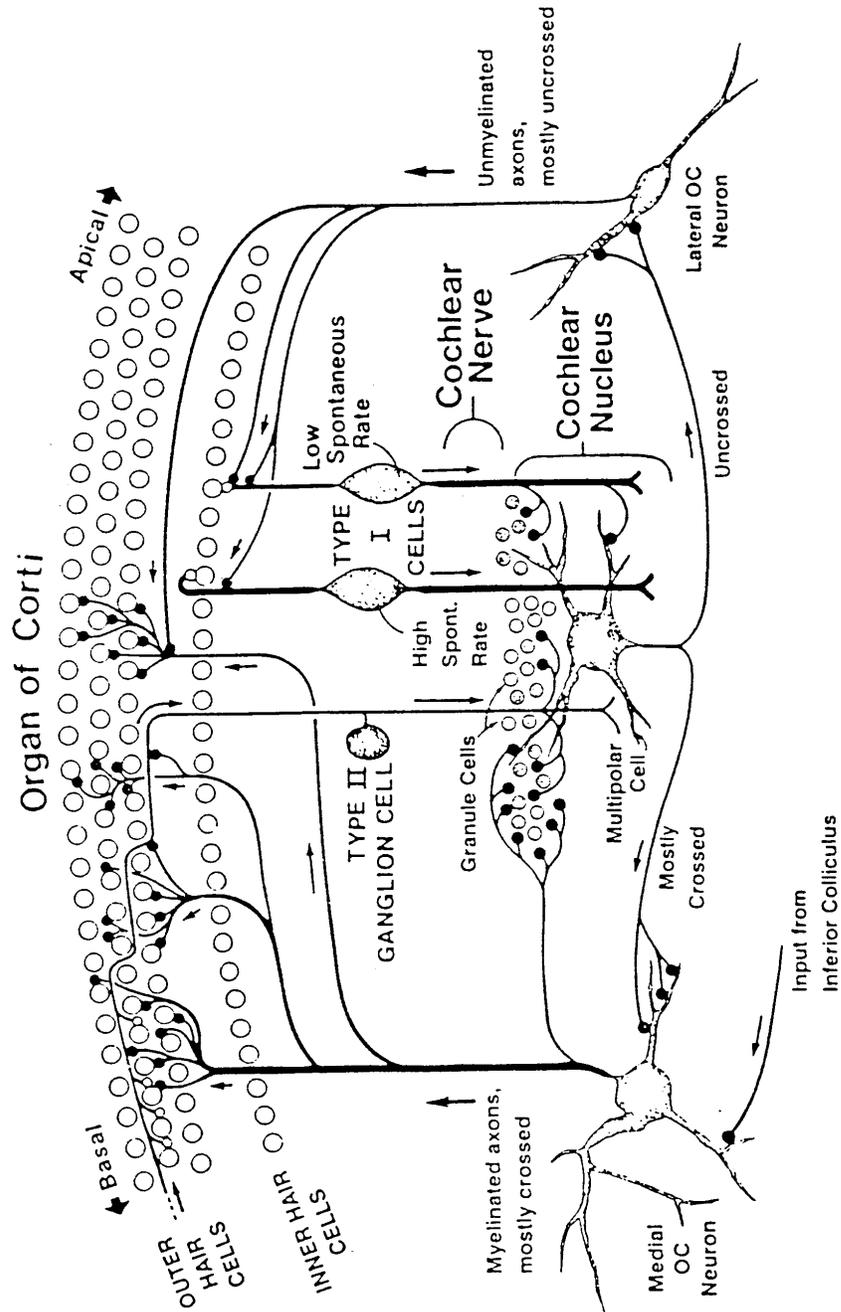


Fig. 22. Schematic diagram summarizing known and hypothesized connections of olivocochlear neurons. Reflex circuits of a representative LOC neuron (right) and representative MOC neuron (left) are depicted. A cochlear nuclear multipolar cell, with dendrites extending into the granule cell region, is shown hypothetically linking the periphery to the two kinds of OC neurons and receiving feedback in the form of a collateral from the MOC neuron. A projection by this multipolar neuron to OC neurons has yet to be demonstrated.

COCHLEAR VASCULATURE

Experiments show that during exposure to noise, many of the peripheral blood vessels in the body contract. Vascular contraction is also apparent in the cochlea after noise exposure. It has been shown that the O₂ content in scala media is reduced and that a cochlea deprived of O₂ is more susceptible to noise induced damage.

The possible reasons for this sensitivity become apparent when one considers the pathways of the cochlea vessels and the function of the various capillary beds.

The spiral modiolar artery supplies the entire cochlea (Fig. over). Branches from this artery course over scala vestibuli to vascularize the lateral wall of the cochlea; another branch runs into the area of the spiral limbus and basilar membrane.

The lateral wall contains an extremely vascularized area known as the stria vascularis. The stria together with the cells of the outer sulcus are believed to be involved in maintaining the chemical composition of the endolymph. Alterations in the chemical composition of the endolymph lead to degeneration of the organ of Corti.

The second group of vessels spiral beneath the basilar membrane, and are believed to supply O₂ to the organ of Corti. Similarly, loss of sensory cells is often seen in areas with severe capillary occlusions.

The Vascular Anatomy of the Cochlear in the Guinea Pig and In Man

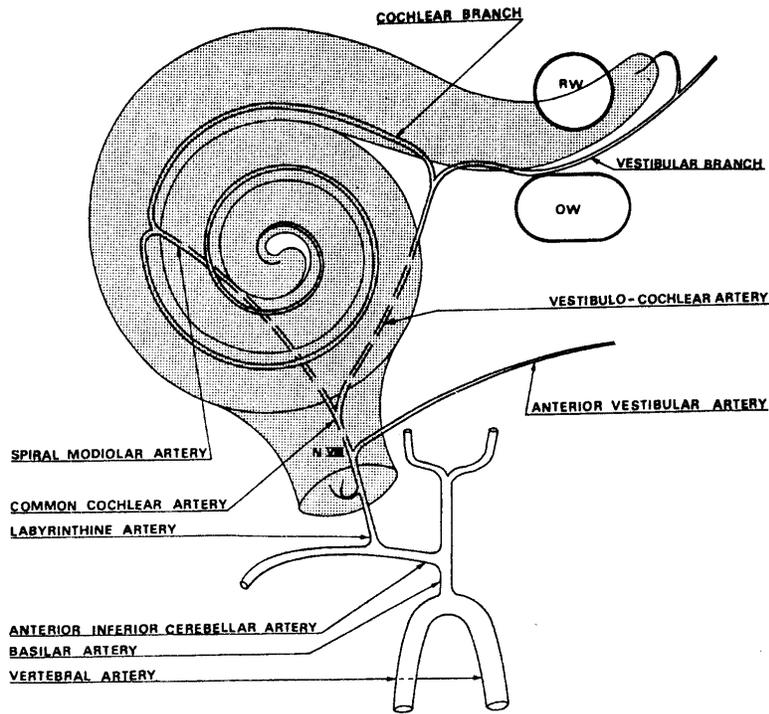
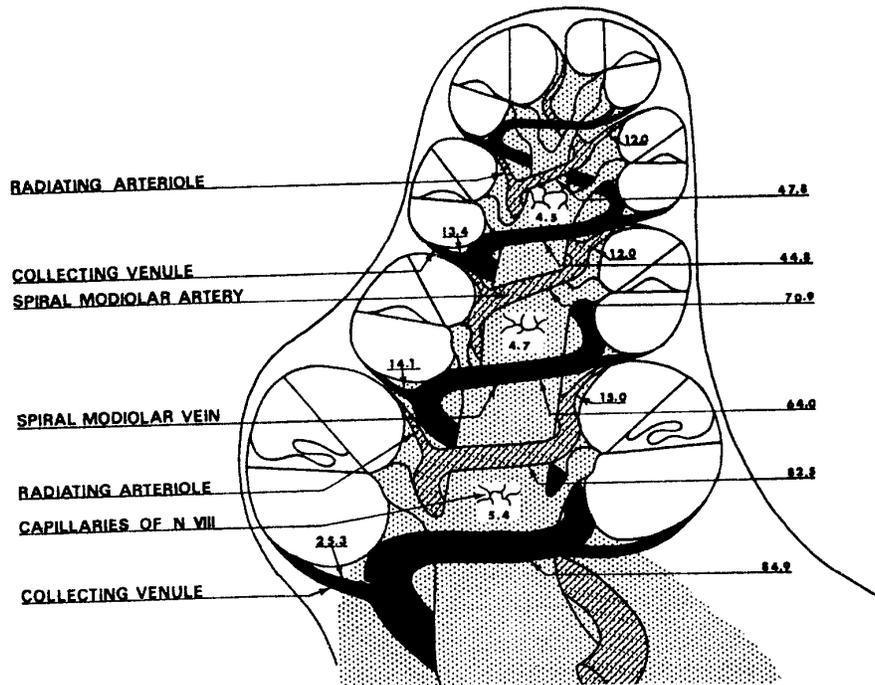


Fig 23. Man, arterial system, schematic. OW = oval window, RW = round window, N VIII = acoustic nerve.



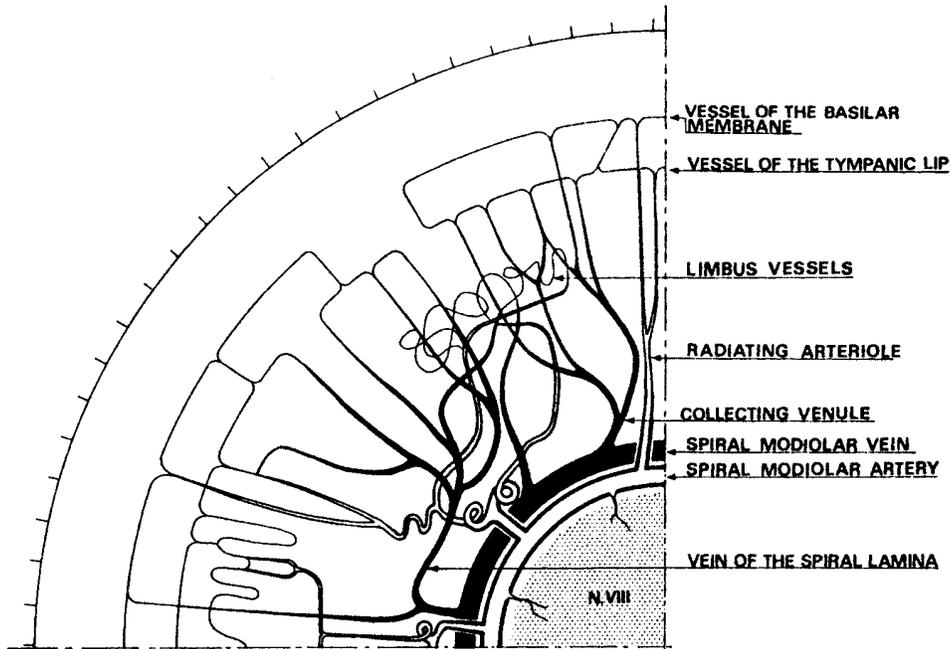


Fig. 25. Guinea pig and man, spiral lamina and limbus, schematic. The vascular system is arcadic with peripherally radiating arterioles, spirally running capillary vessels, and centrally radiating venules. The region peripheral to the vessel of the basilar membrane is principally avascular. The vessel of the basilar membrane is situated under the tunnel of Corti. The vell of the tympanic lip, which is located in the region of the habenula perforata, receives most of the radiating vessels. Capillaries in the spiral limbus form irregular limbus vessels.

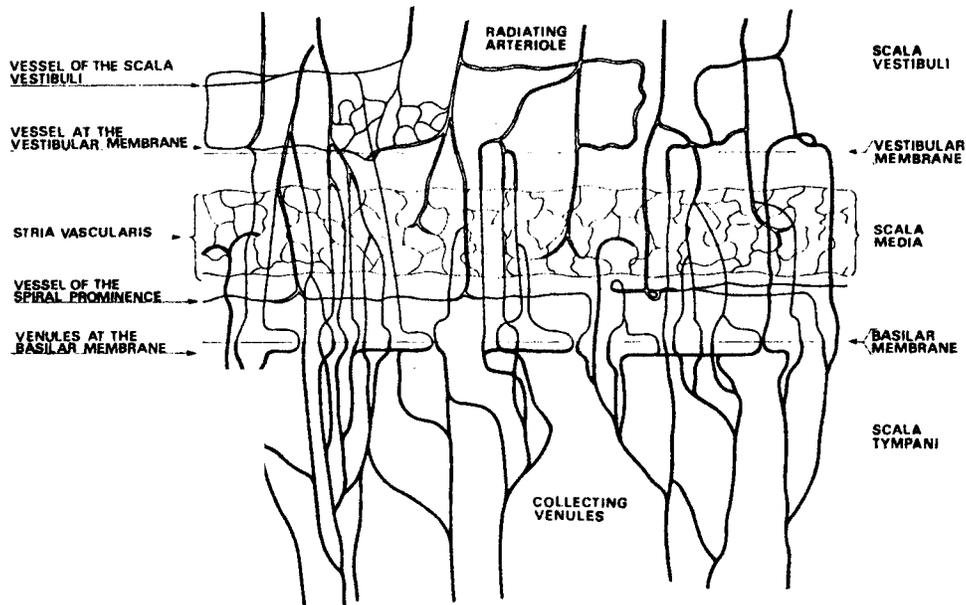


Fig. 26. Guinea pig and man, external wall, radial section, schematic. Radiating arterioles predominate in the scala vestibuli and supply spiral vascular systems; the vessel of the scala vestibuli, the vessel at the vestibular membrane, the stria vascularis, and the vessel of the spiral prominence. Collecting venules predominate in the scala tympani and drain spiral capillary vessels and the capillary net in the scala vestibuli. A spiral vessel is formed basally to the basilar membrane. Radiating arterioles and collecting venules connect with one another by arterio-venous anastomoses lying externally to the stria vascularis.