Vnitřní ucho

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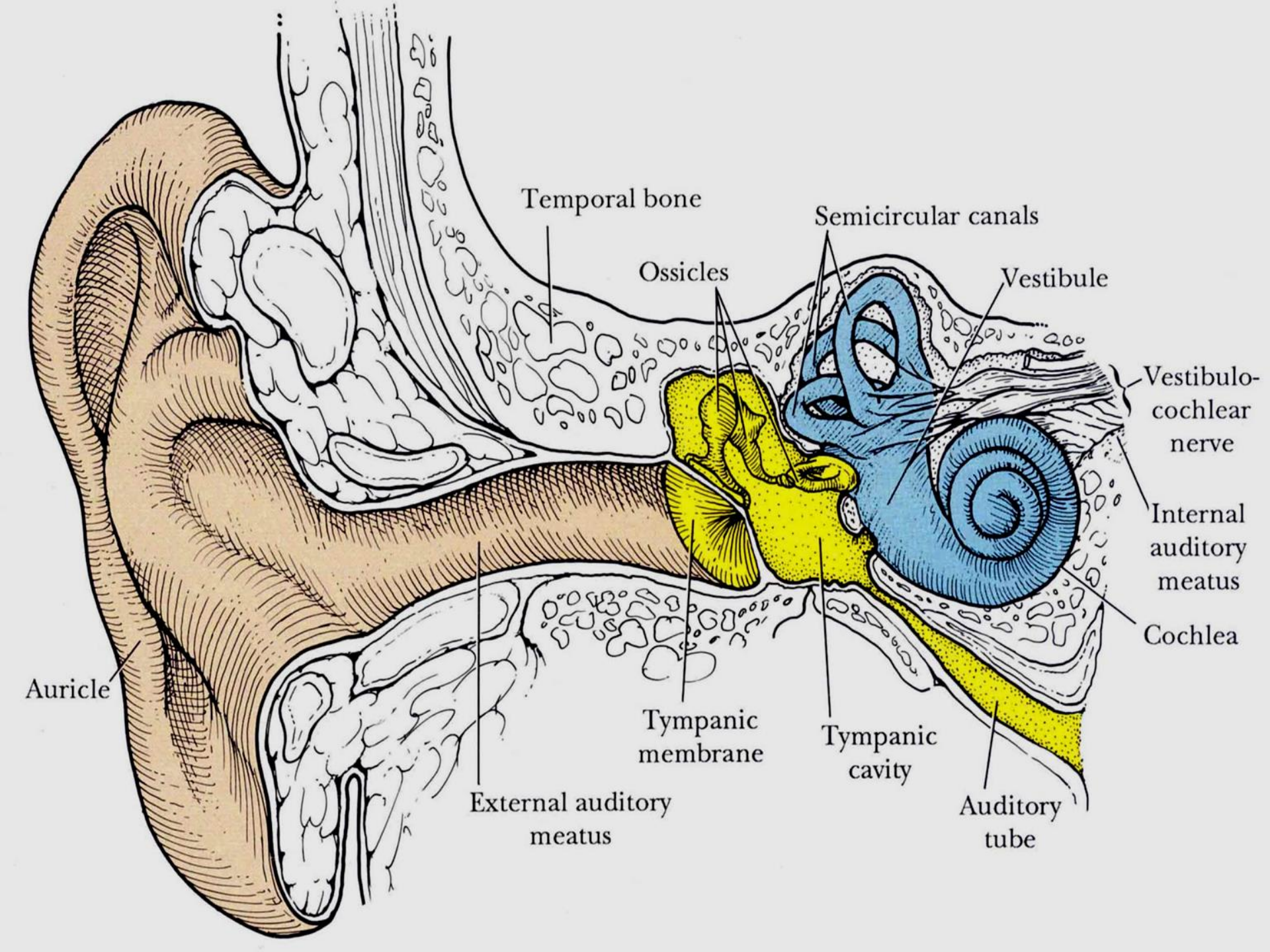
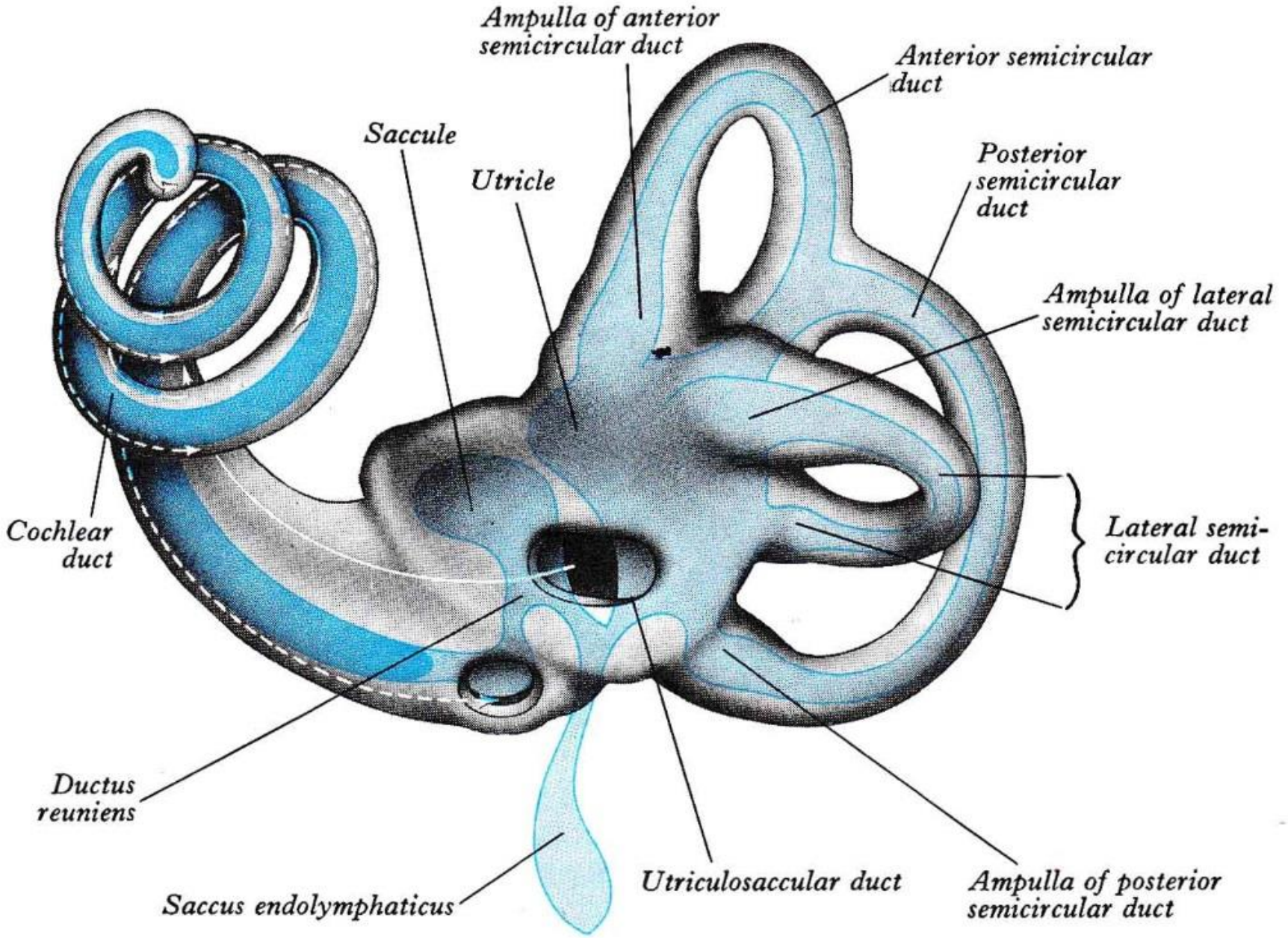
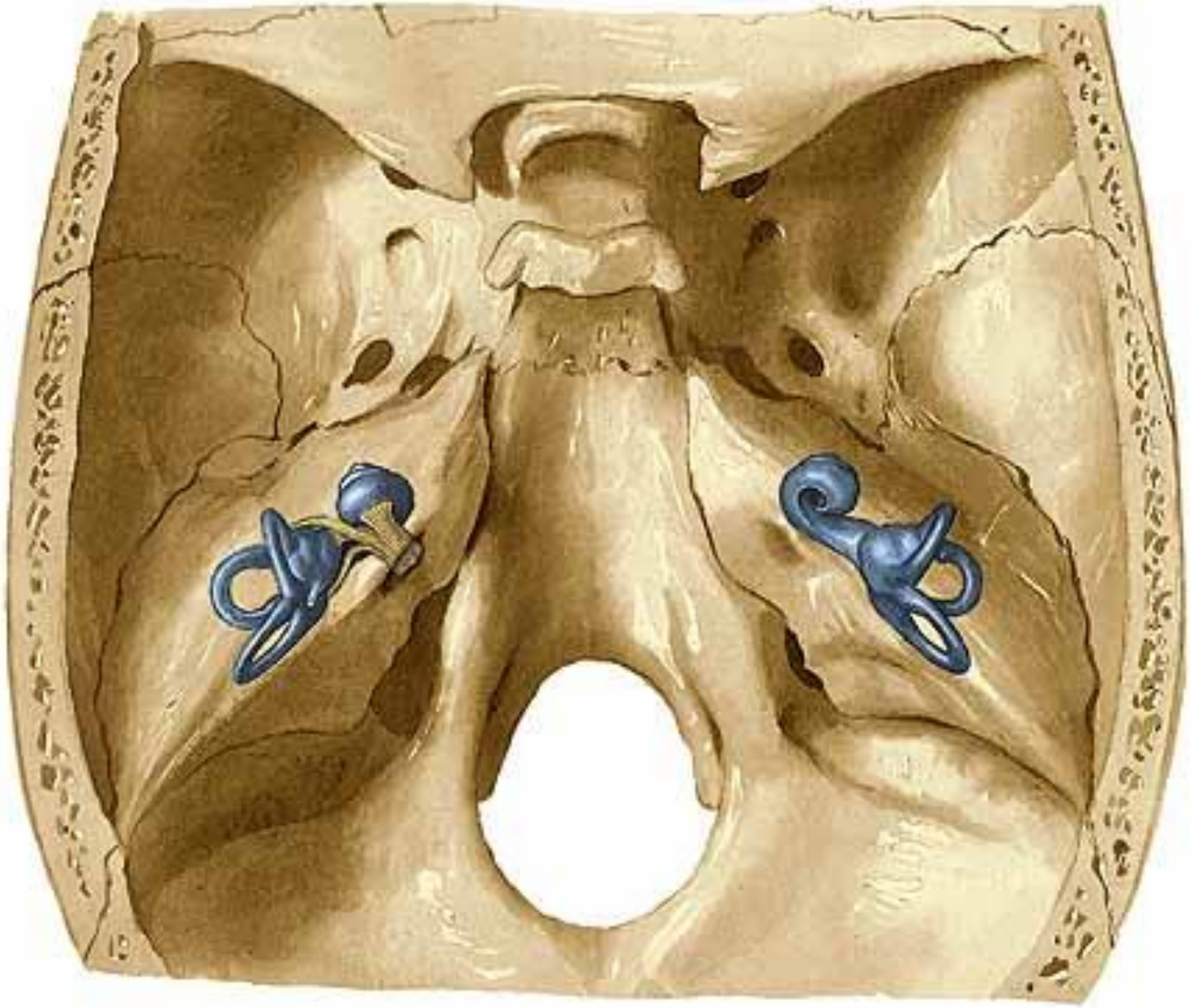
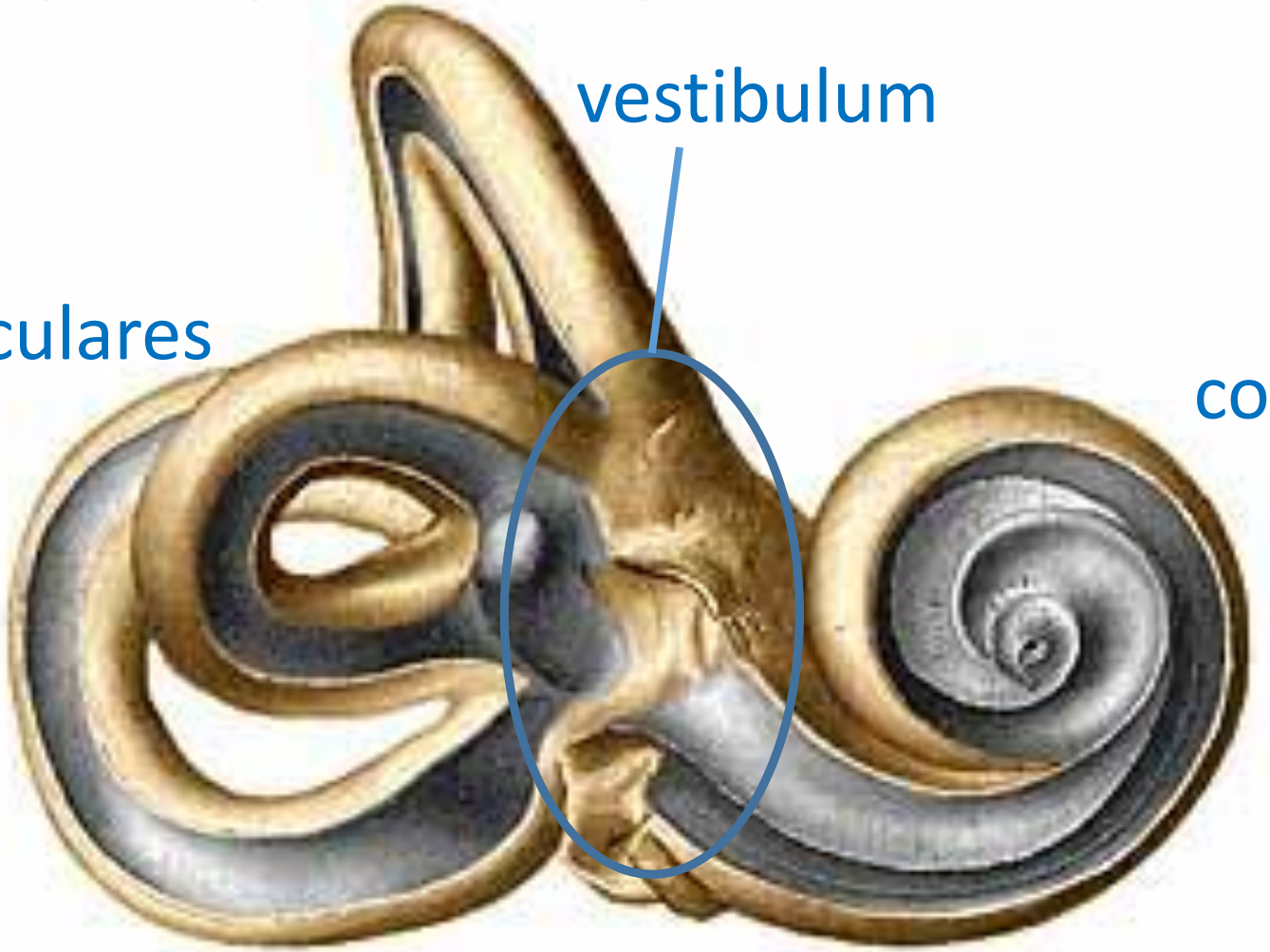

Temporal bone
Semicircular canals
Ossicles
Vestibule
Vestibulo-
cochlear
nerve
Internal
auditory
meatus
Cochlea
Auricle
Tympanic
membrane
Tympanic
cavity
External auditory
meatus
Auditory
tube

Kostěný a blanitý labyrint





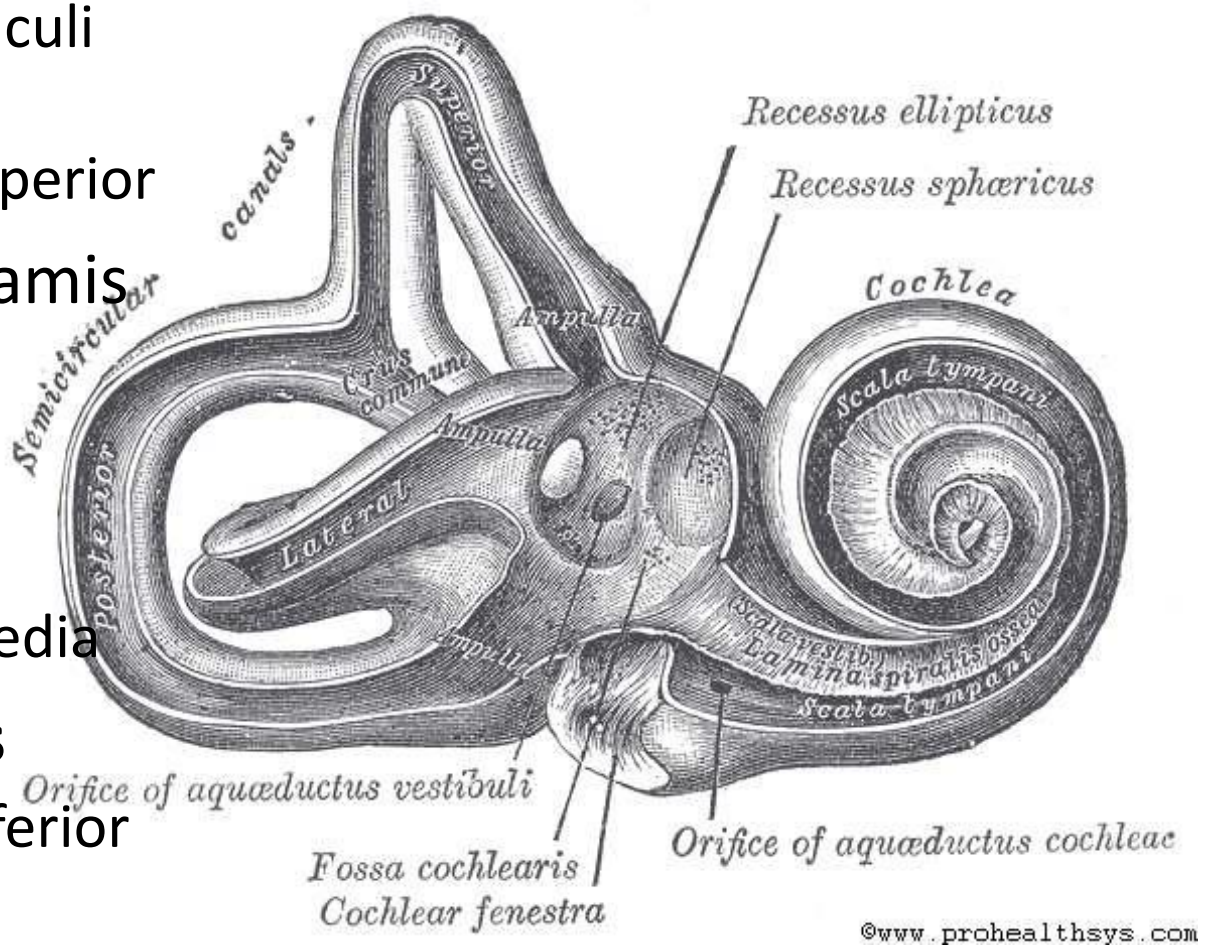
Kostěný labyrint (*labyrinthus osseus*)



Předsíň (*vestibulum*)

cca 5 x 3 mm

- **recessus ellipticus** (utricularis)
  - apertura int. canaliculi vestibuli
  - macula cribrosa superior
- crista vestibuli (pyramis vestibuli)
- **recessus sphericus** (saccularis)
  - macula cribrosa media
- **recessus cochlearis**
  - macula cribrosa inferior



Polokruhové kanálky (*Canales semicirculares*)

- canalis semicircularis anterior (superior) (kolmý na dlouhou osu pyramidy) – eminentia arcuata
- canalis semicircularis posterior (souběžný)
- canalis semicircularis lateralis (vodorovný) – prominentia c.s.l.

ampulla ossea (3)

crus commune – c.s. ant. + post.

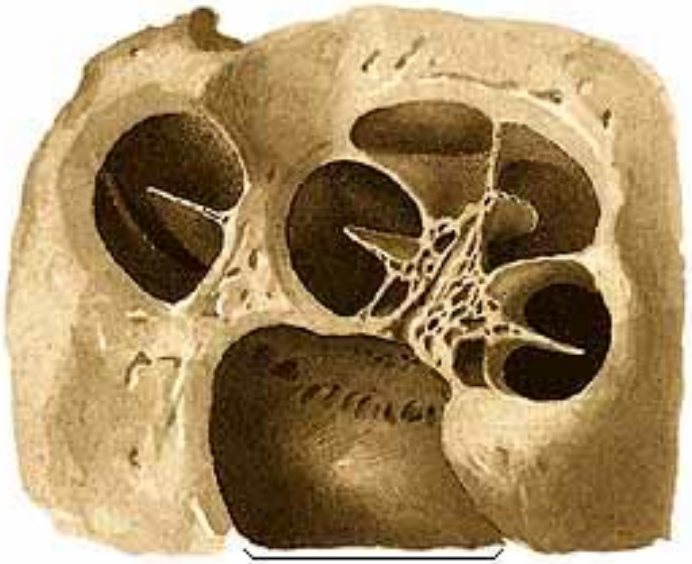
crus simplex – c.s. lat.

a

b

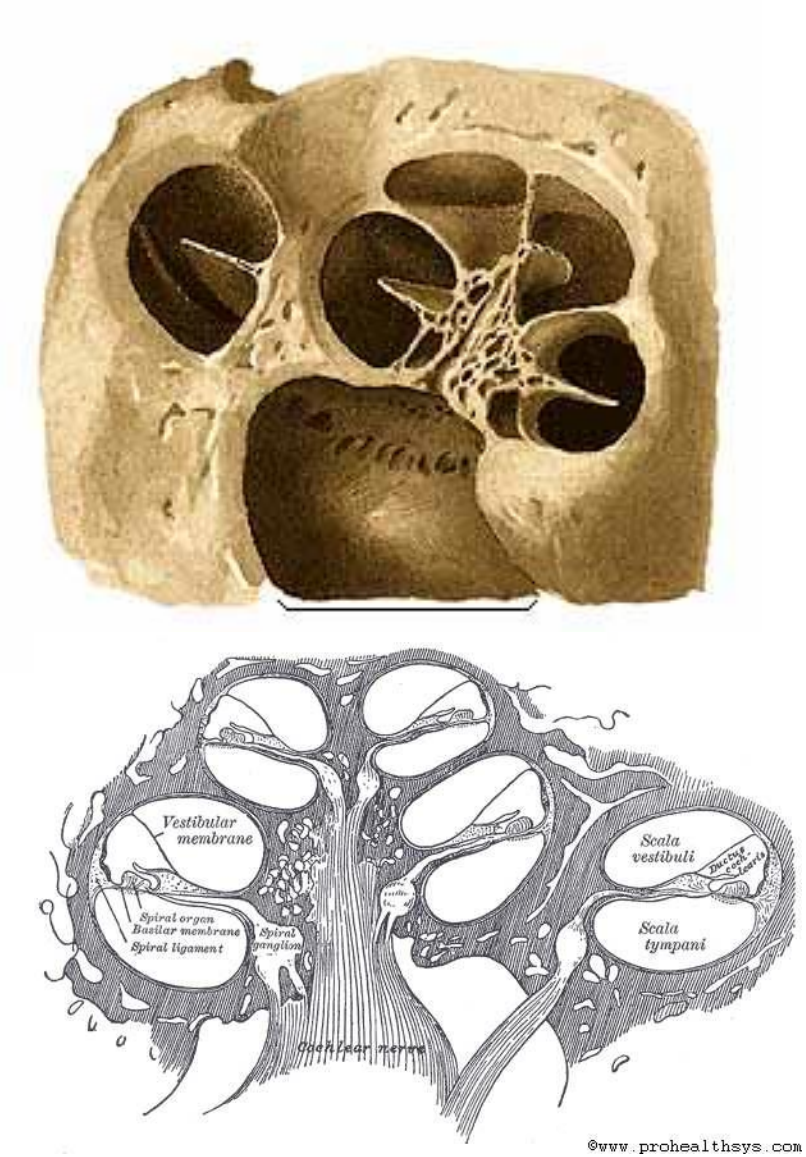
Hlemýžď (*Cochlea*)

- cupula, basis (2 a ½ až ¾ závitu, délka 34 mm)
- scala vestibuli → helicotrema → scala tympani
- canalis spiralis cochleae
- lamina spiralis ossea
  - lamella vestibularis + spiralis
  - hamulus l.s. (konec v helicotrematu)
- lamina spiralis secundaria (jen v prvním závitu)
- apertura interna canaliculi cochleae



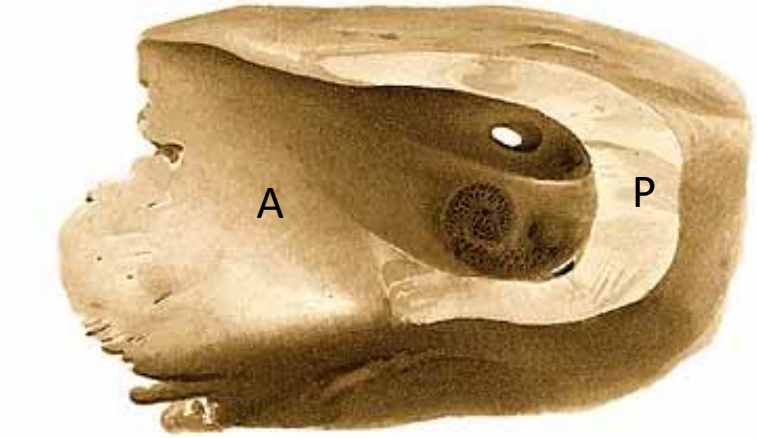
Vřeténko (*Modiolus*)

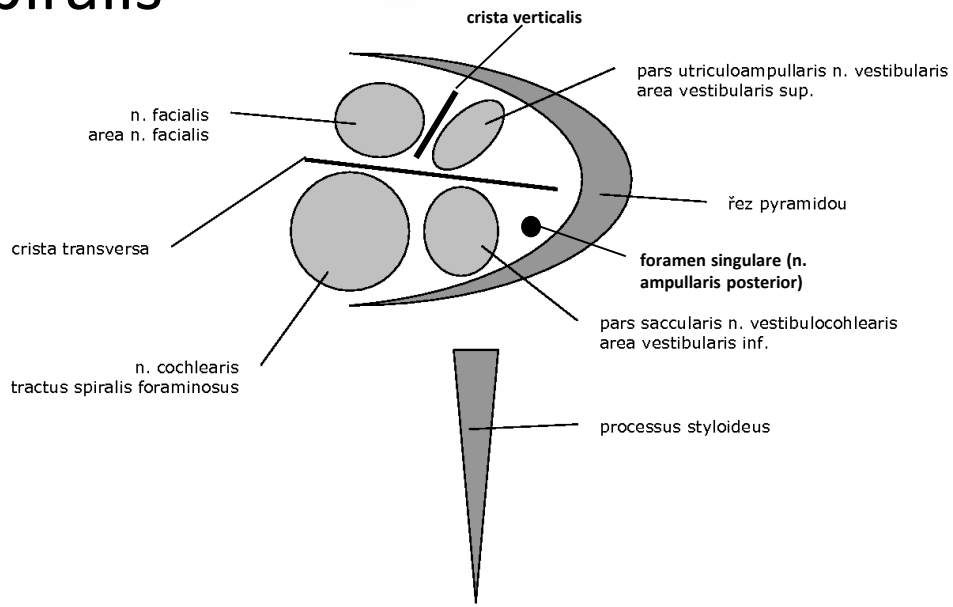
- basis
- lamina
- canalis spiralis – *ganglion cochleare*
- canales longitudinales – *n. cochlearis*



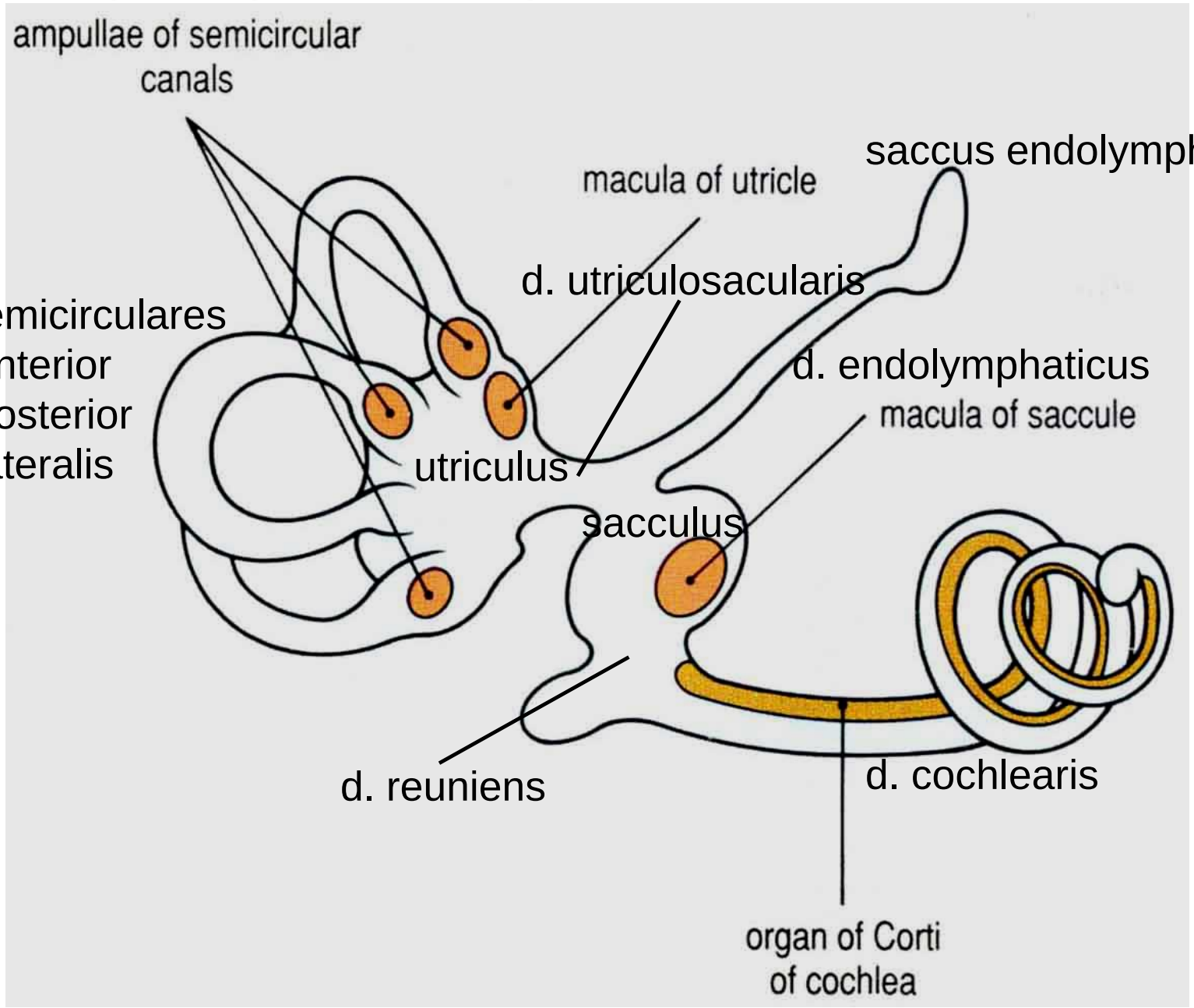
Vnitřní zvukovod (*Meatus acusticus internus*)

- porus acusticus internus
- fundus m.a.i.
- crista transversa + verticalis
- area n. VII.
- area cochlearis – tractus spiralis
- area vestibularis sup. + inf.
- foramen singulare



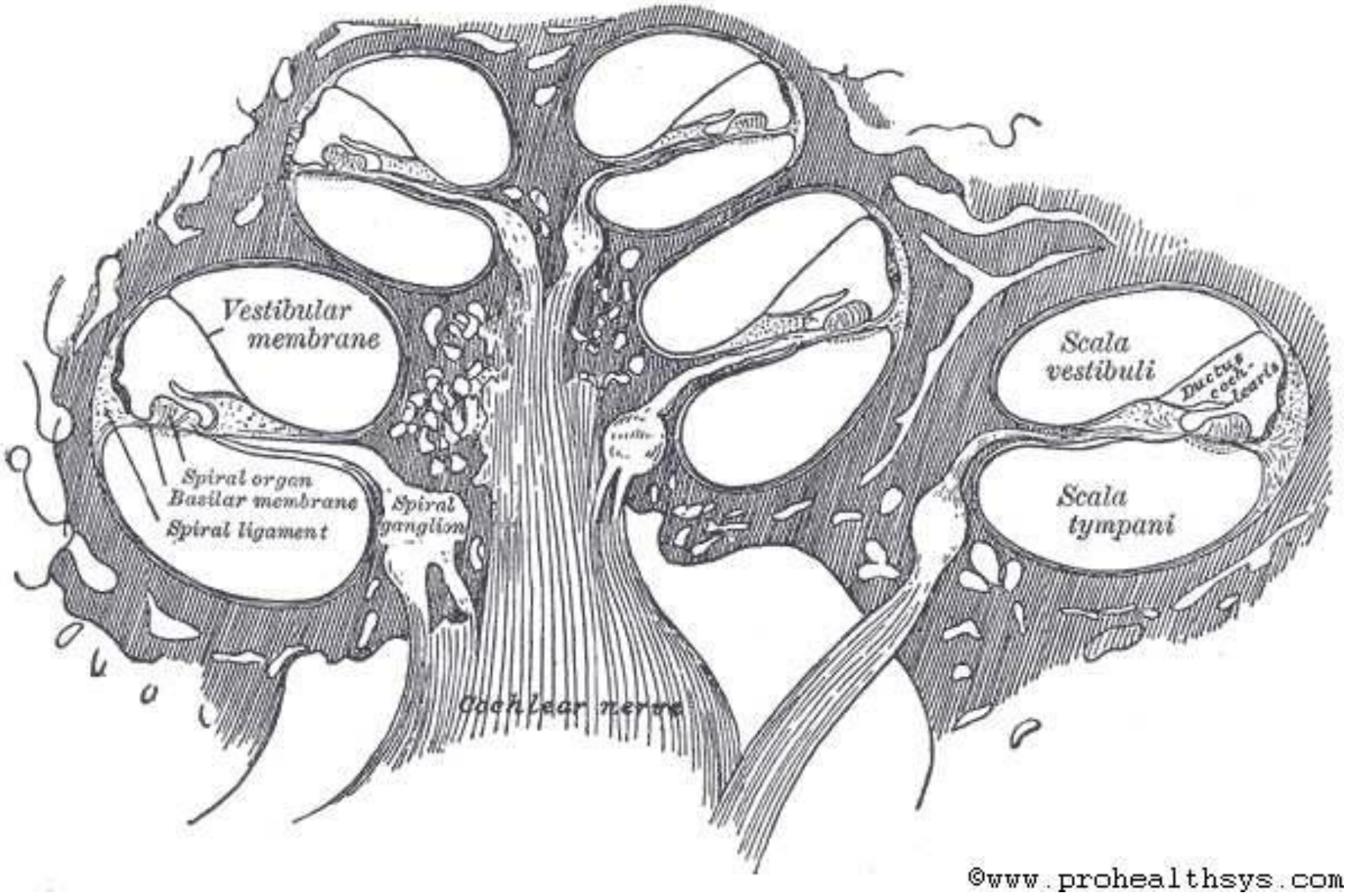


Blanitý labyrint *(Labyrinthus membranaceus)*

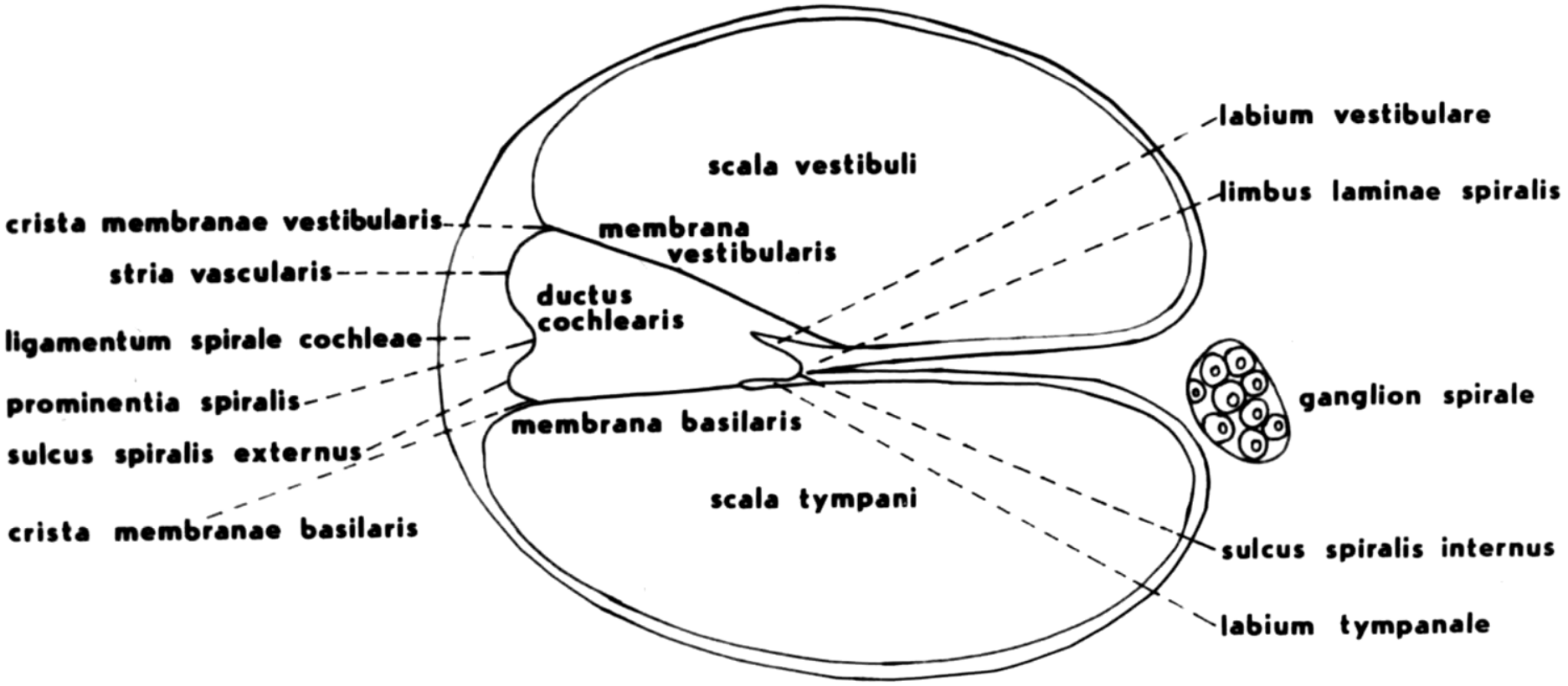


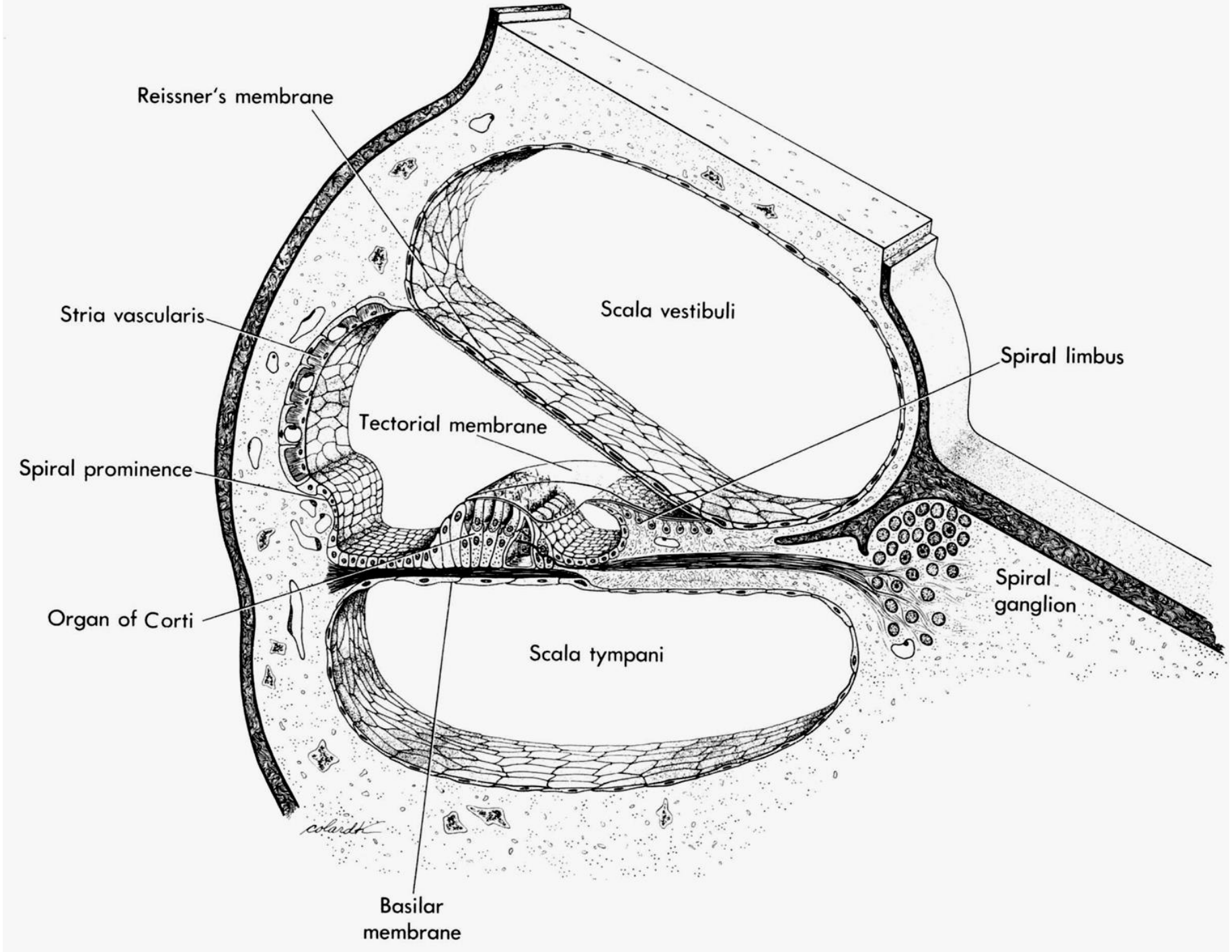
d. semicirculares
- anterior
- posterior
- lateralis

Blanitý hlemýžď *(ductus cochlearis, scala media)*



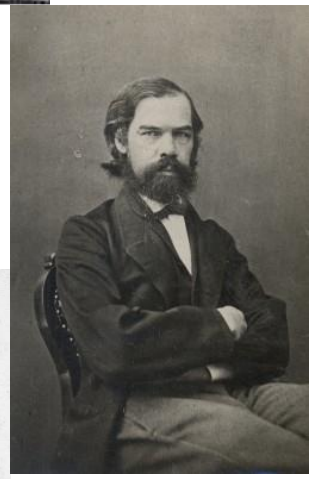
PRŮŘEZ COCHLEOU




Reissner's membrane
Stria vascularis
Scala vestibuli
Spiral limbus
Tectorial membrane
Spiral prominence
Organ of Corti
Spiral ganglion
Scala tympani
Basilar membrane

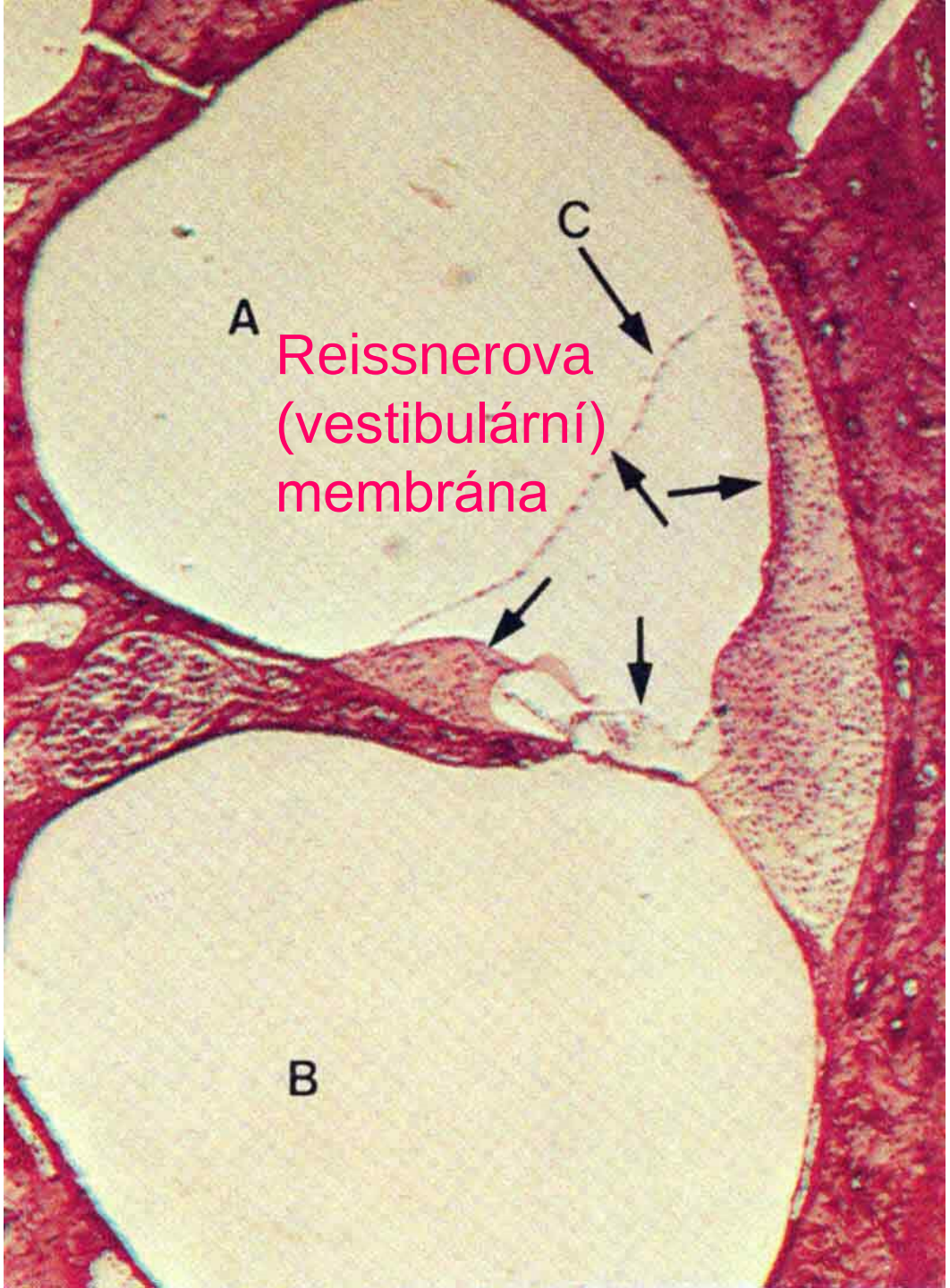
- Alfonso Giacomo Gaspare Corti
  - 1822 – 1876
  - Markýz (Marchese de San Stefano Belbo)
  - organum spirale
  - ganglion cochleare

- Ernst Reissner
  - 1824 – 1878
  - membrana vestibularis

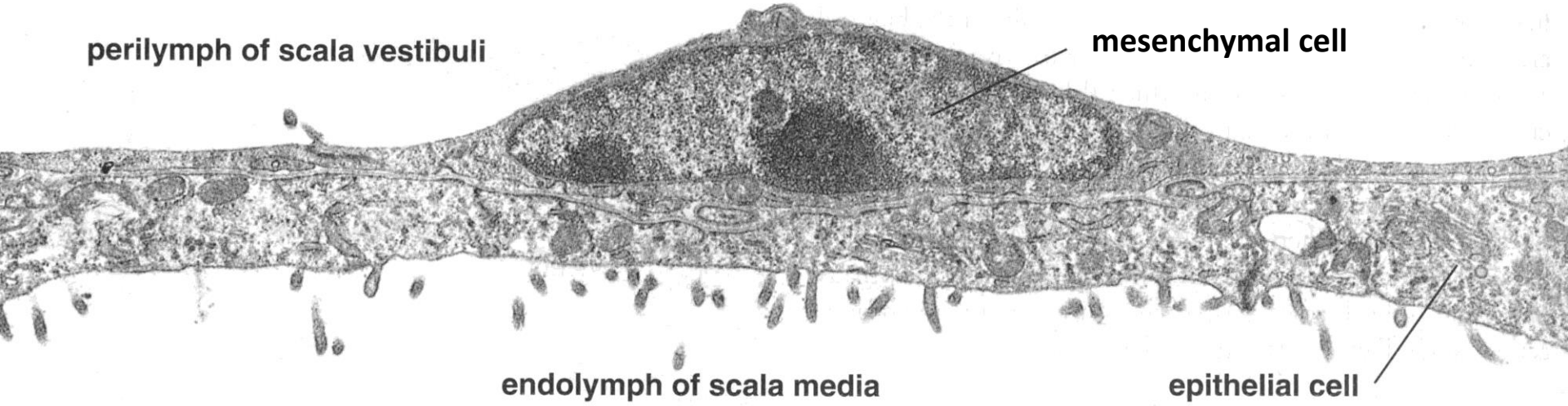


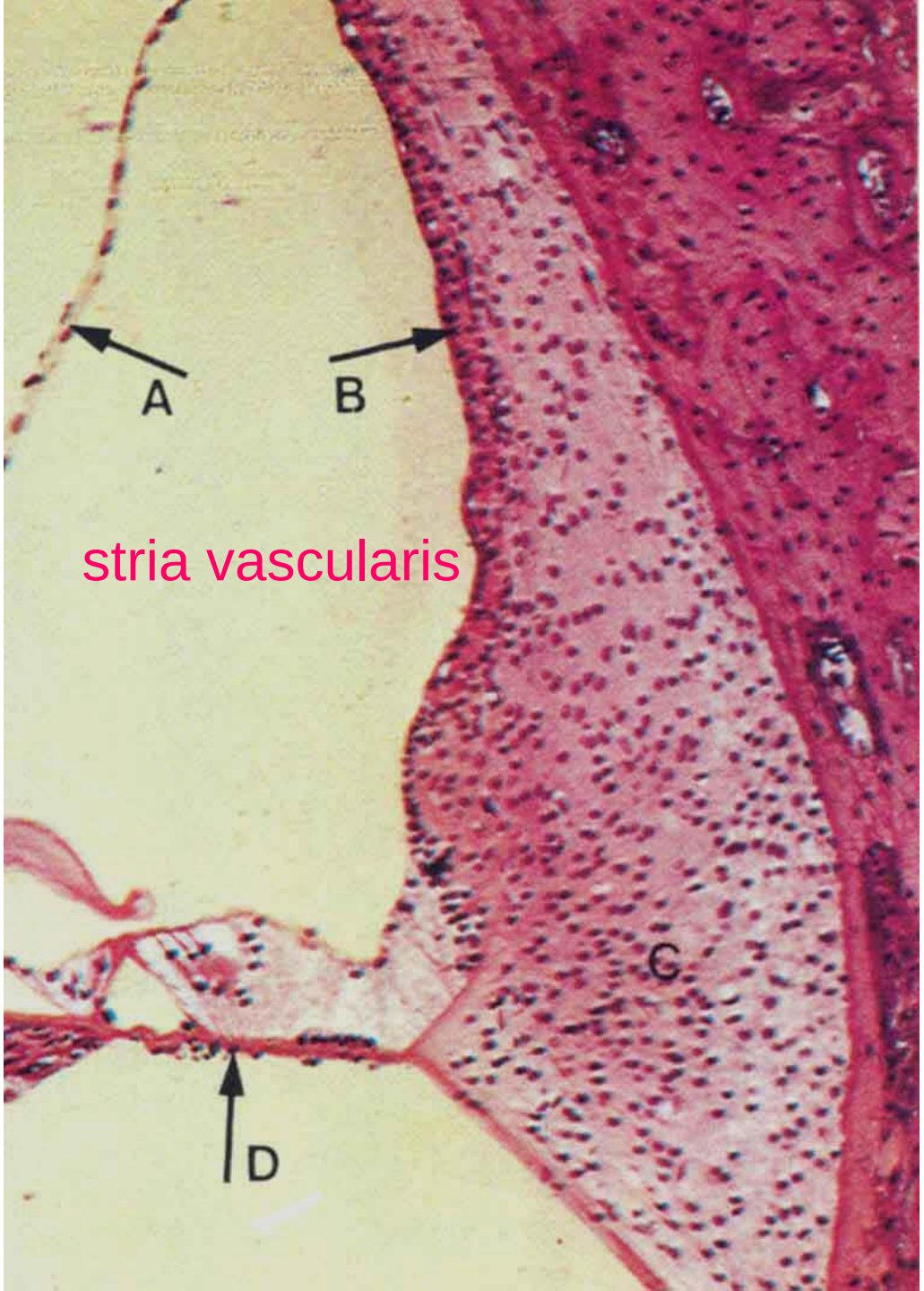
- Antonio Scarpa
  - 1752 – 1832
  - ganglion vestibulare
  - jeho hlava je vystavena v historickém muzeu univerzity v Pavii

- Otto Friedrich Karl Deiters
  - 1834 – 1863
  - zevní falangové buňky, nucl. vestibularis lat.


C
A
Reissnerova
(vestibulární)
membrána
B

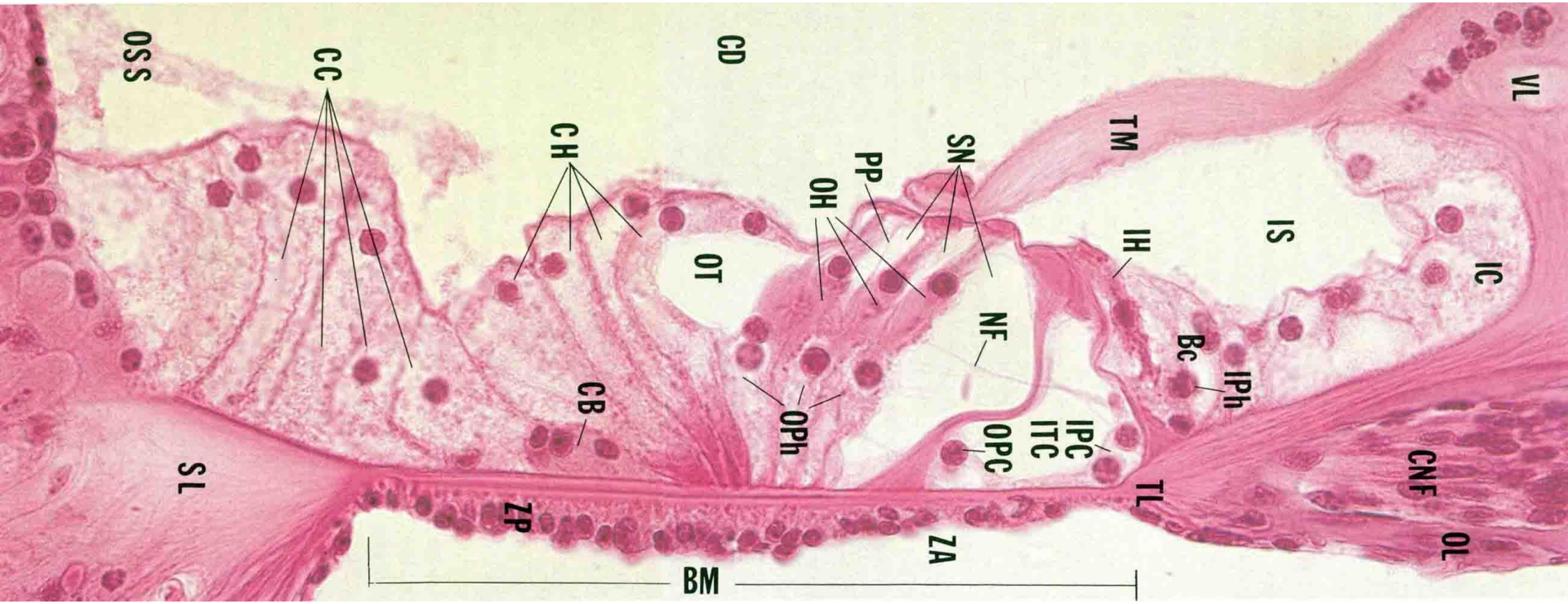
Reissnerova (vestibulární) membrána




A
B
stria vascularis
C
D

stria vascularis

buňky
-marginální
-basální
-intermediální



bazilární membrána (lamina basilaris)

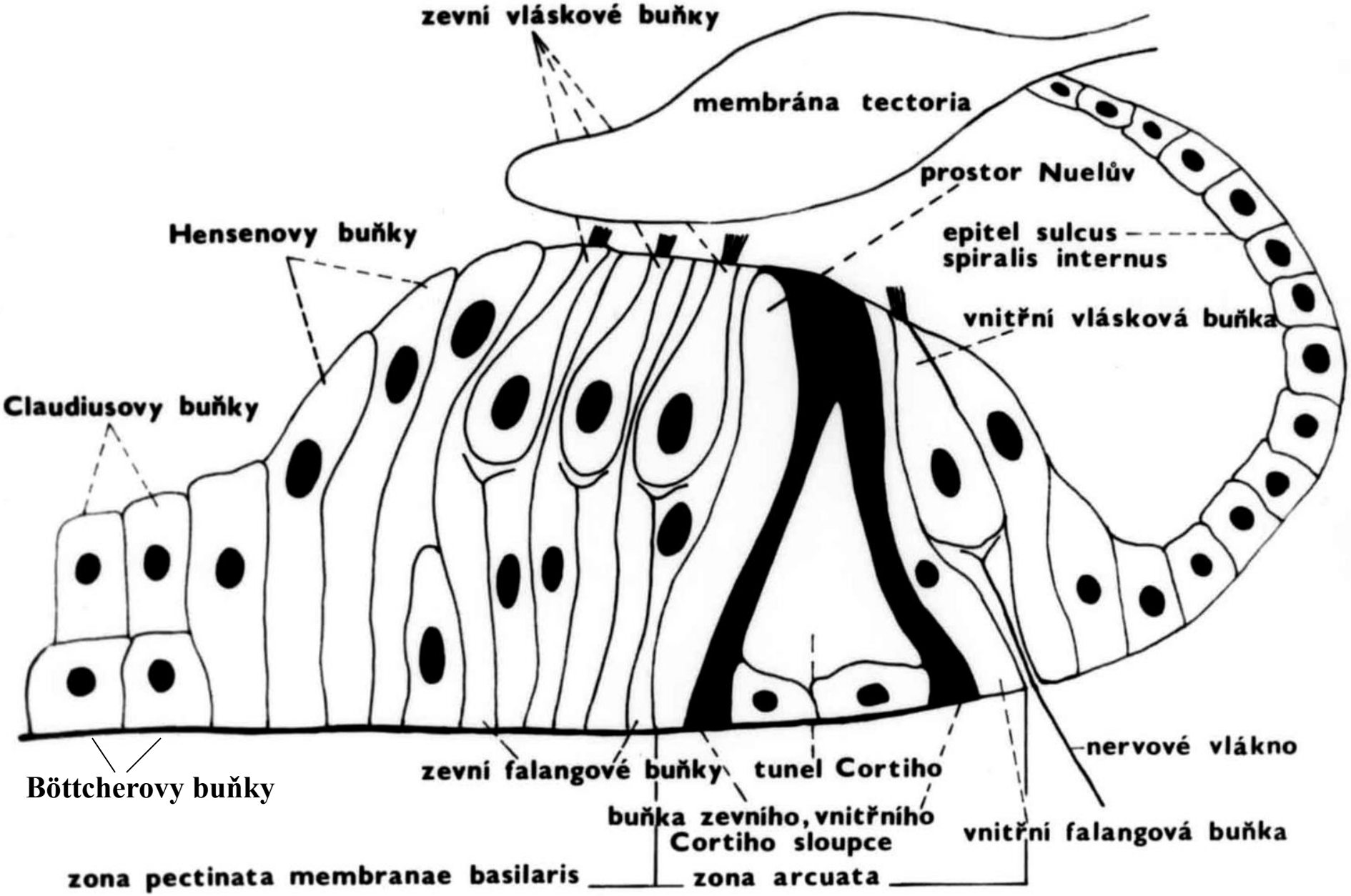
zona pectinata zona arcuata (cévy)

0,42–0,65 mm v apexu kochley, méně napnutá, nízké frekvence

0,08–0,16 mm v bazálním závitu, pevná, vysoké frekvence

kolagen II, proteiny podobné keratinu

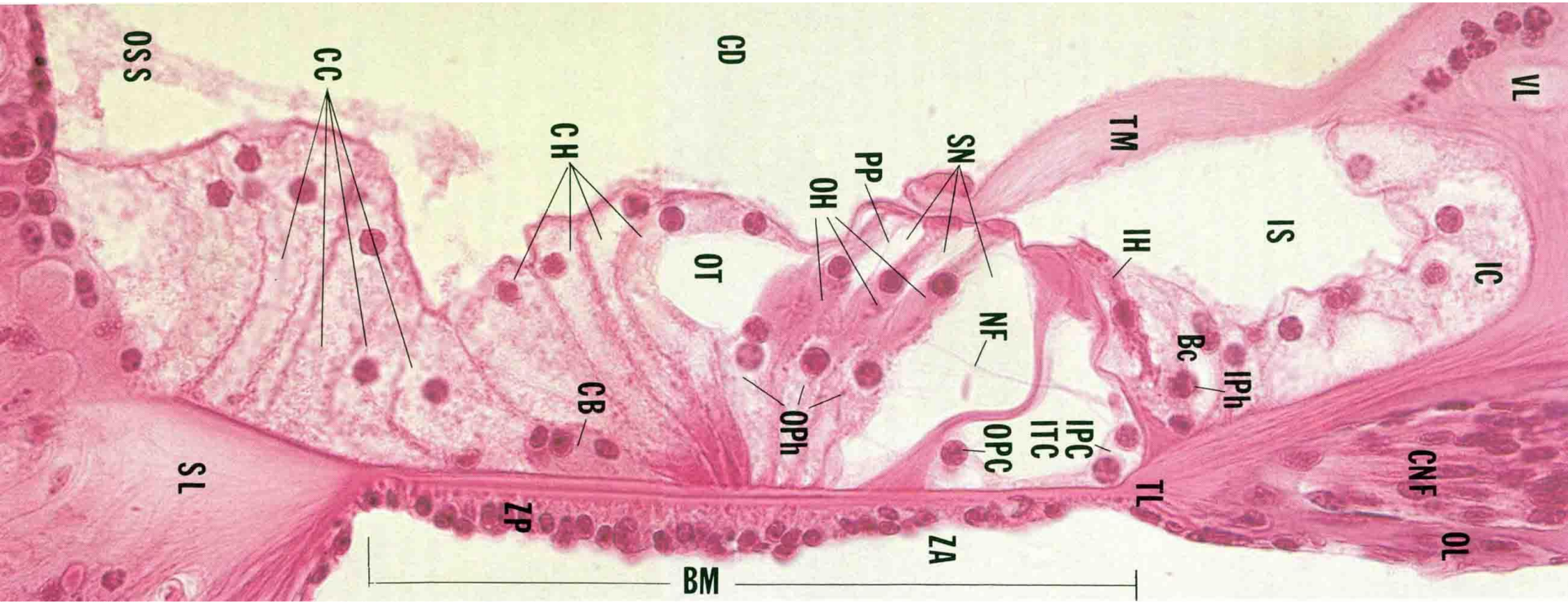
Cortiho orgán



OSS = sulcus spiralis externus
CC = Claudiusovy buňky
CH = Hensenovy buňky
CB = Böttcherovy buňky
CD = lumen ductus cochlearis

OT = zevní tunel
OPh = zevní falangové b. (Deiters)
OH = zevní vláskové buňky
PP = výběžek Deitersovy buňky
SN = Nuelovy prostory

TM = membrana tectoria
IH = vnitřní vlásková buňka
IS = sulcus spiralis internus
Bc = hraniční buňky
IPh = vnitřní falangová b.

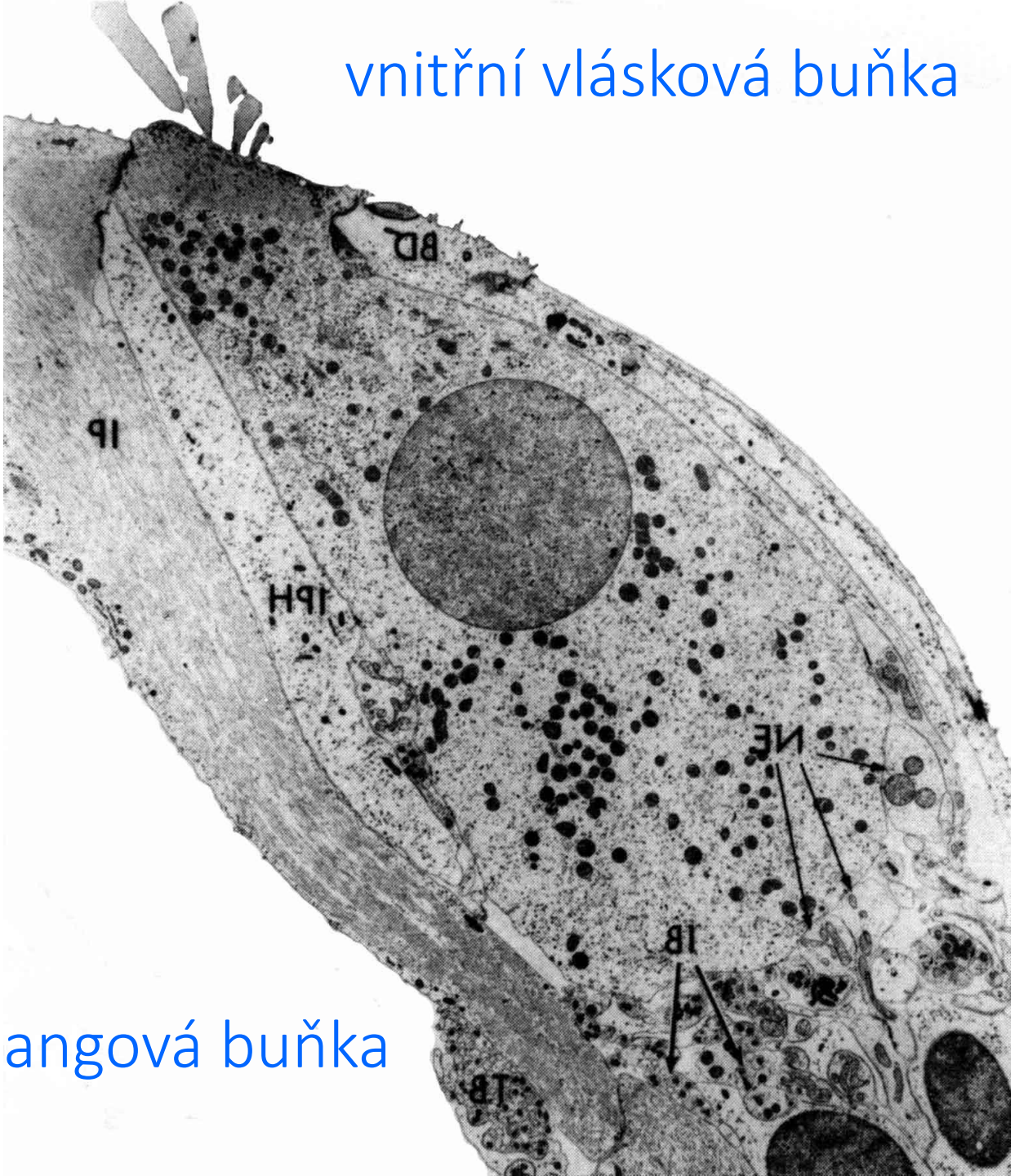


SL = ligamentum spirale
BM = membrana basilaris
ZP = zona pectinata
ZA = zona arcuata
NF = nervové vlákno

OPC = zevní Cortiho sloupec
ITC = Cortiho tunel
IPC = vnitřní Cortiho sloupec
TL = labium typanale
OL = lamina spiralis ossea

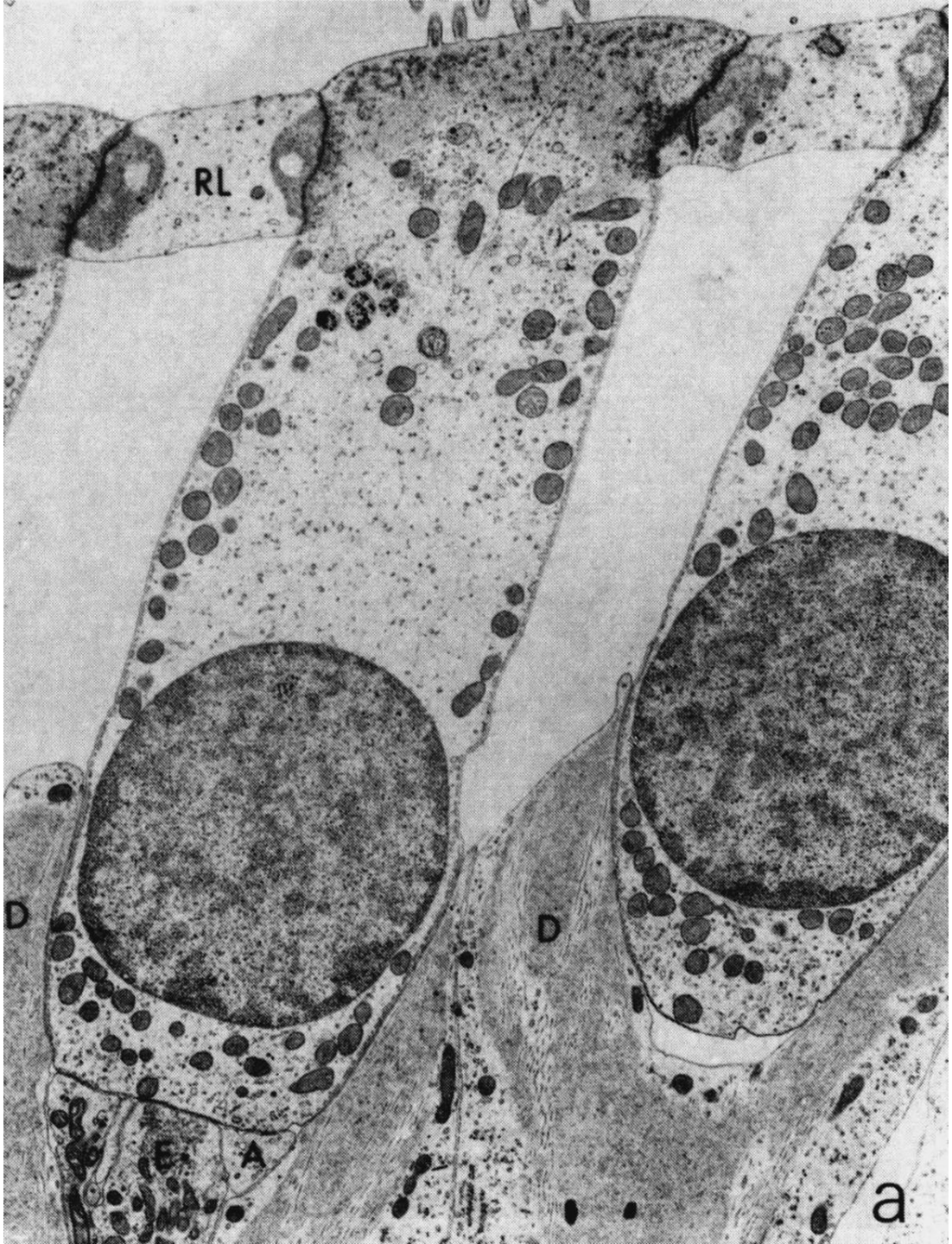
CNF = dendrity neuronů z g. spirale
IC = epitel sulcus spiralis internus
VL = labium vestibulare

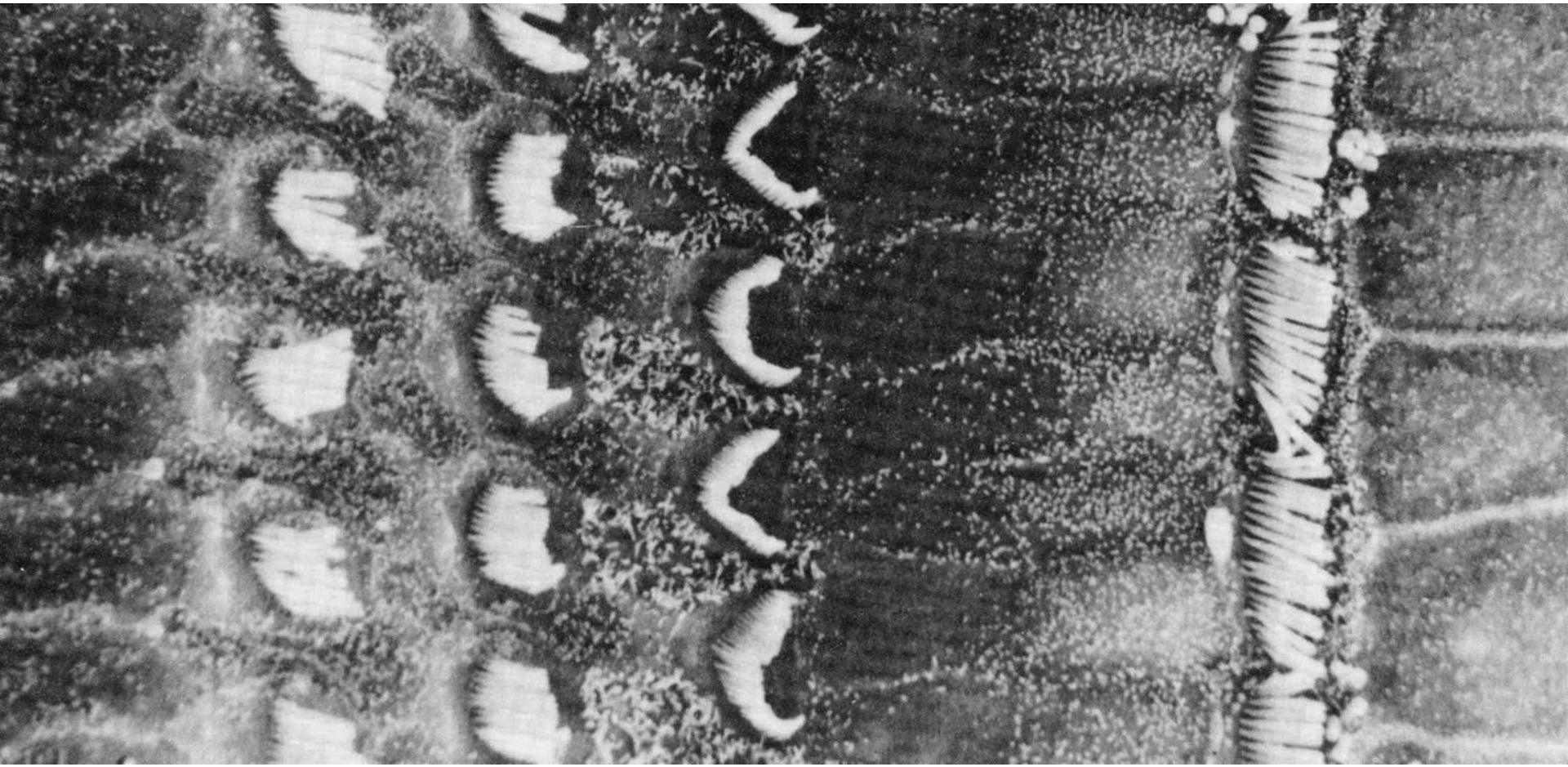
vnitřní vlásková buňka



vnitřní falangová buňka

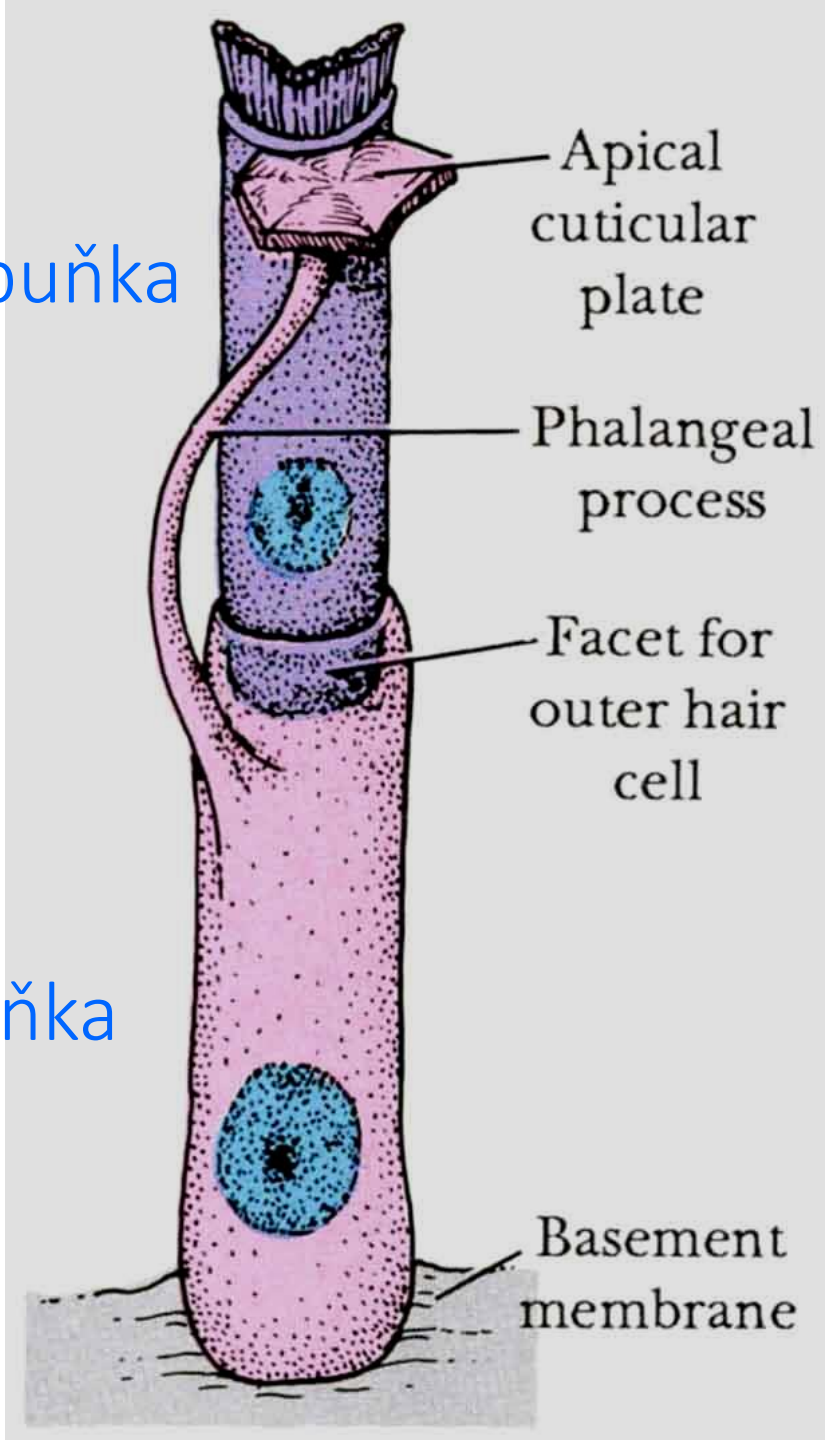
zevní vláskové buňky

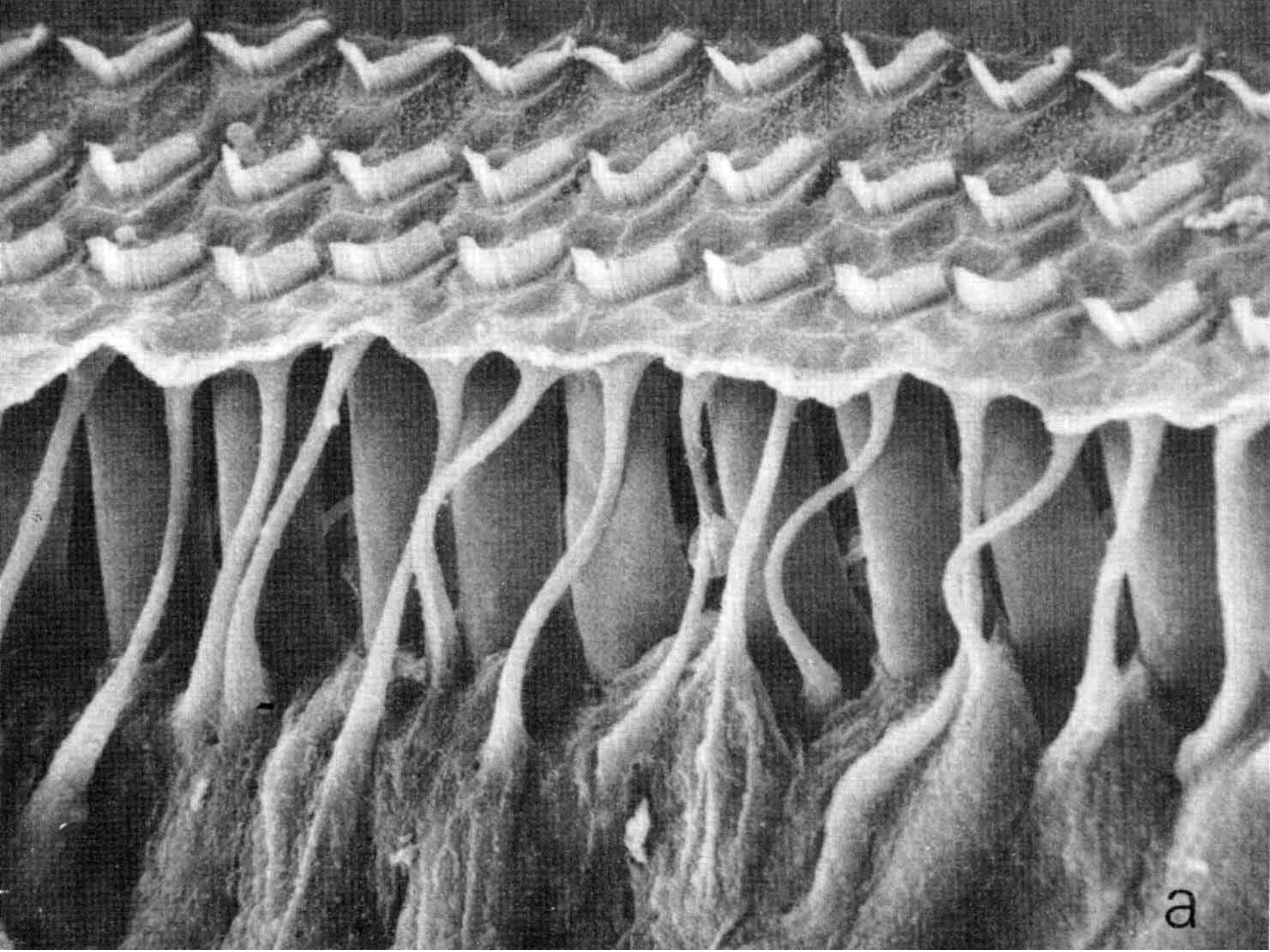


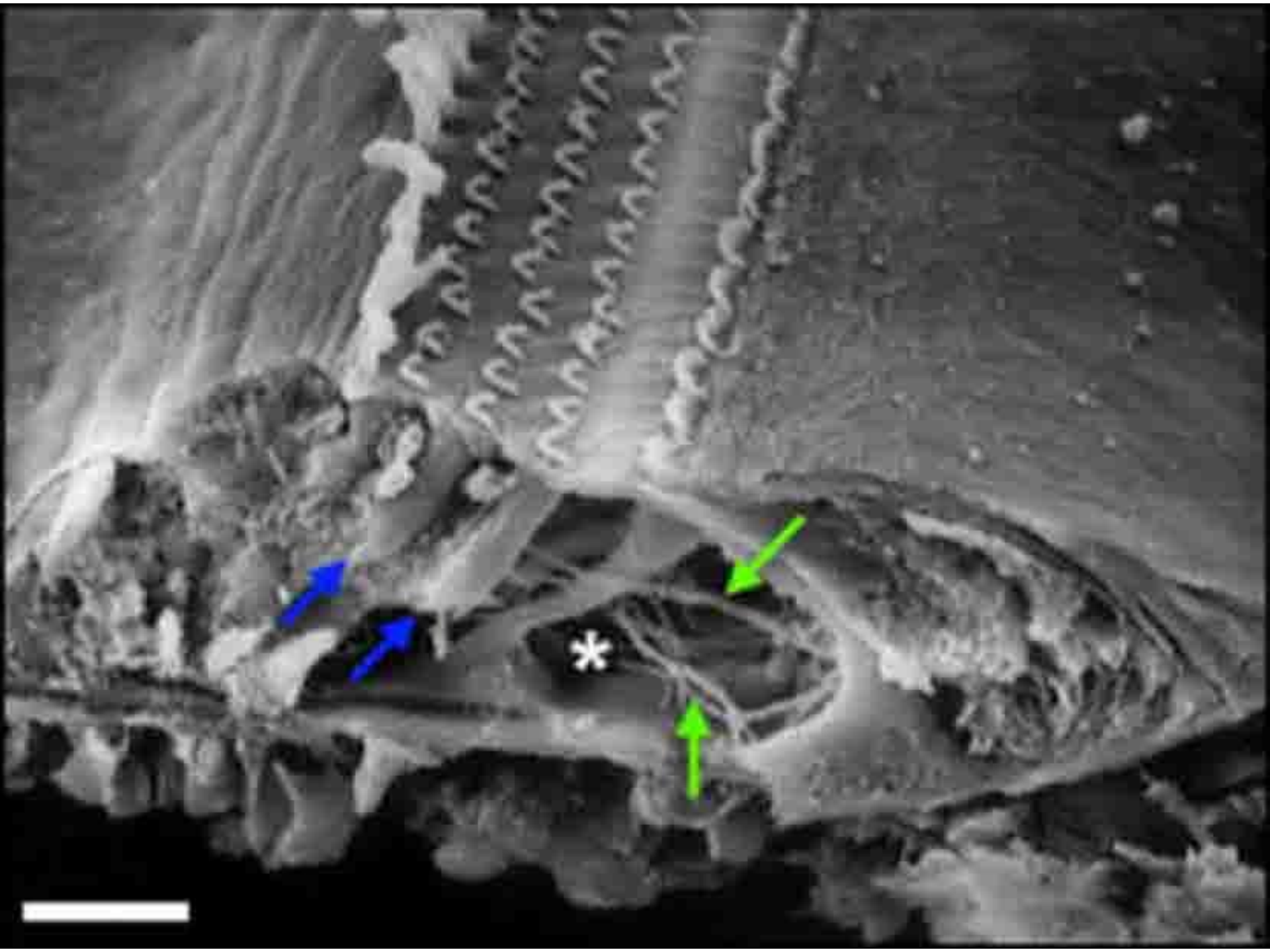


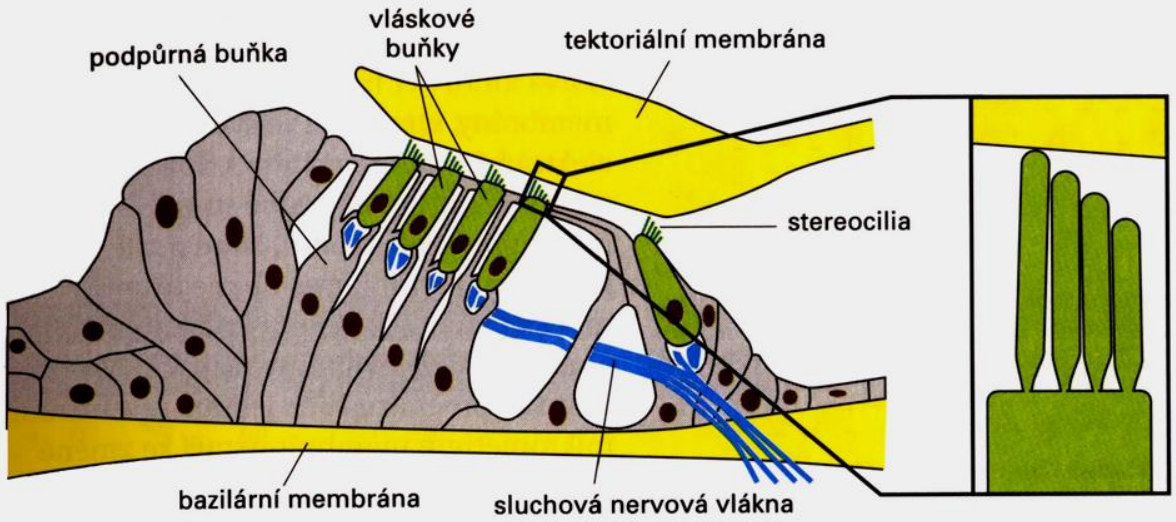
zevní vlásková buňka

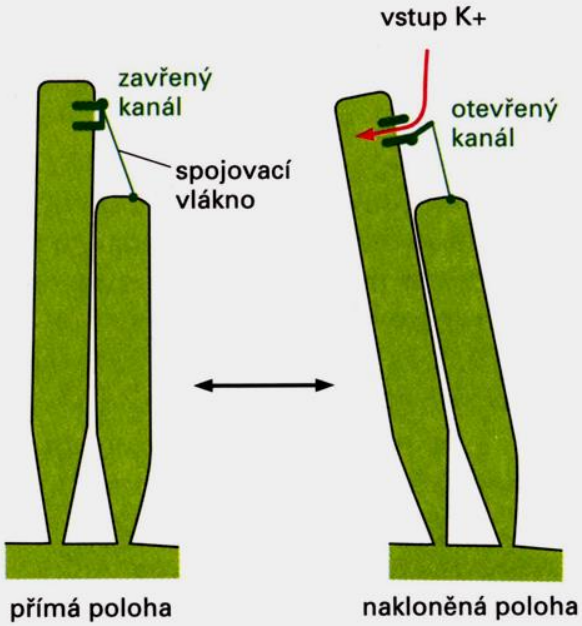
zevní falangová (Deitersova) buňka

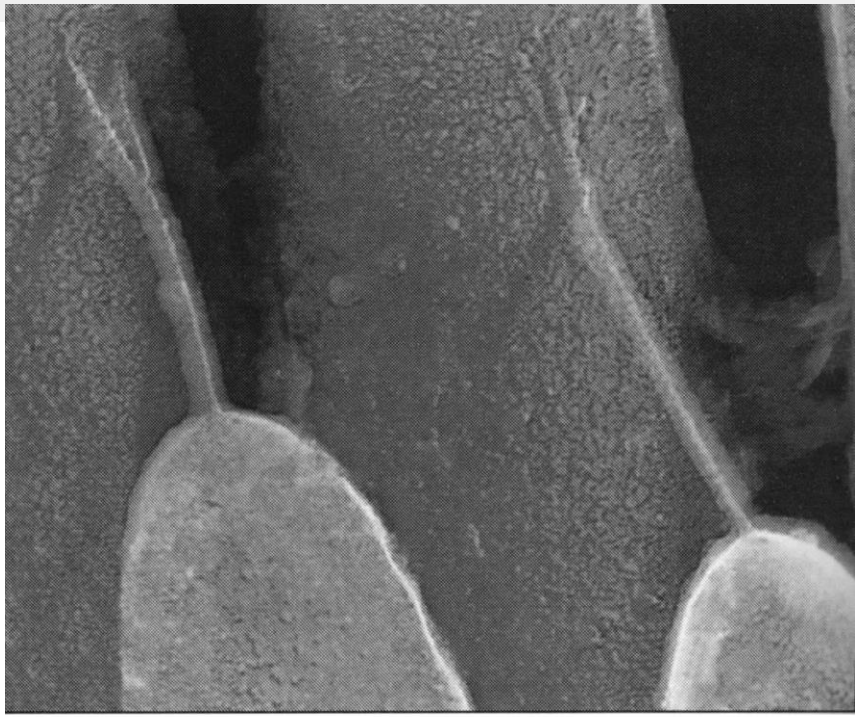



a

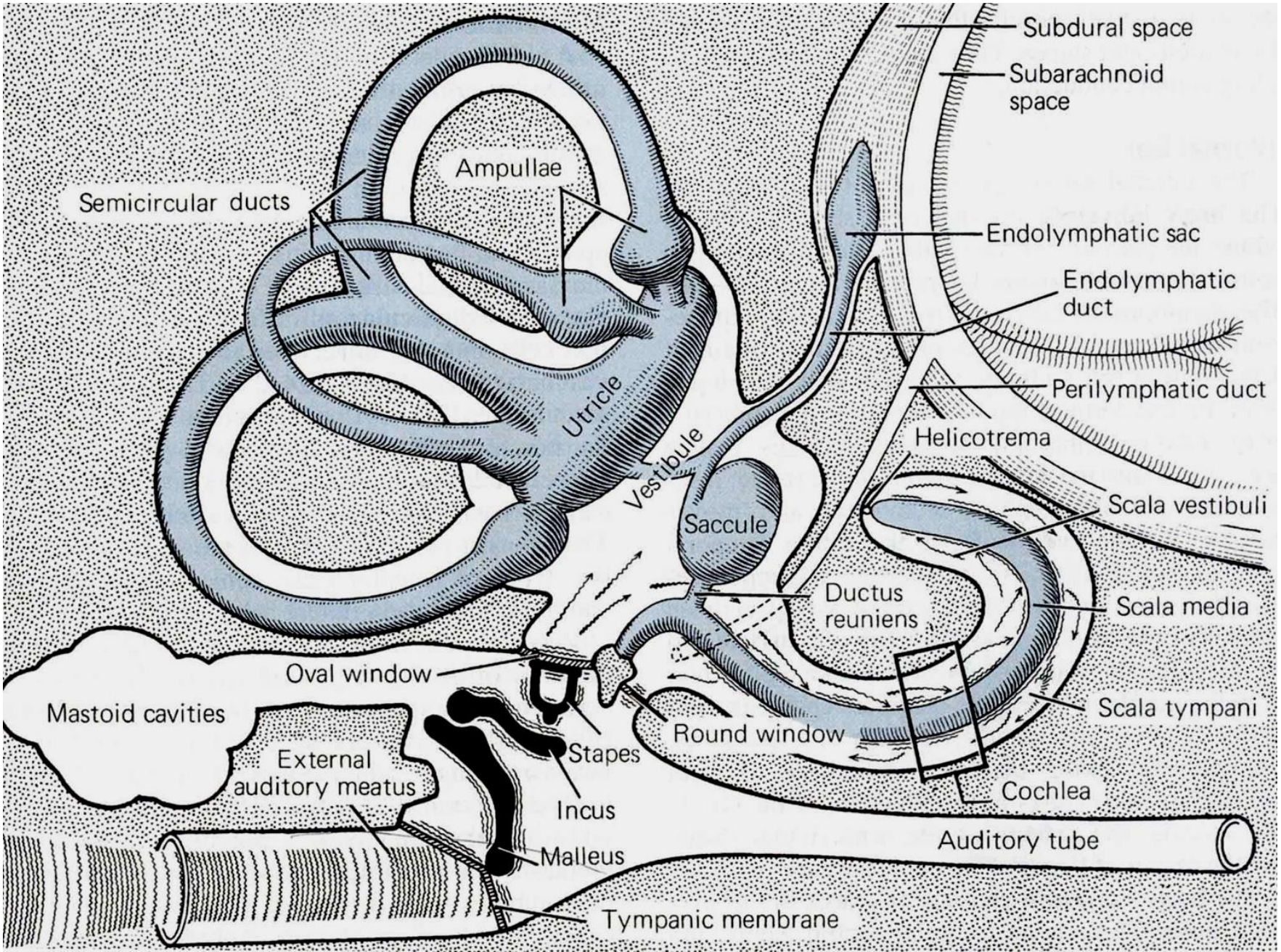



podpůrná buňka
vláskové buňky
tektoriální membrána
stereocilia
bazilární membrána
sluchová nervová vlákna


vstup K+
zavřený kanál
spojovací vlákno
otevřený kanál
přímá poloha
nakloněná poloha


100 nm

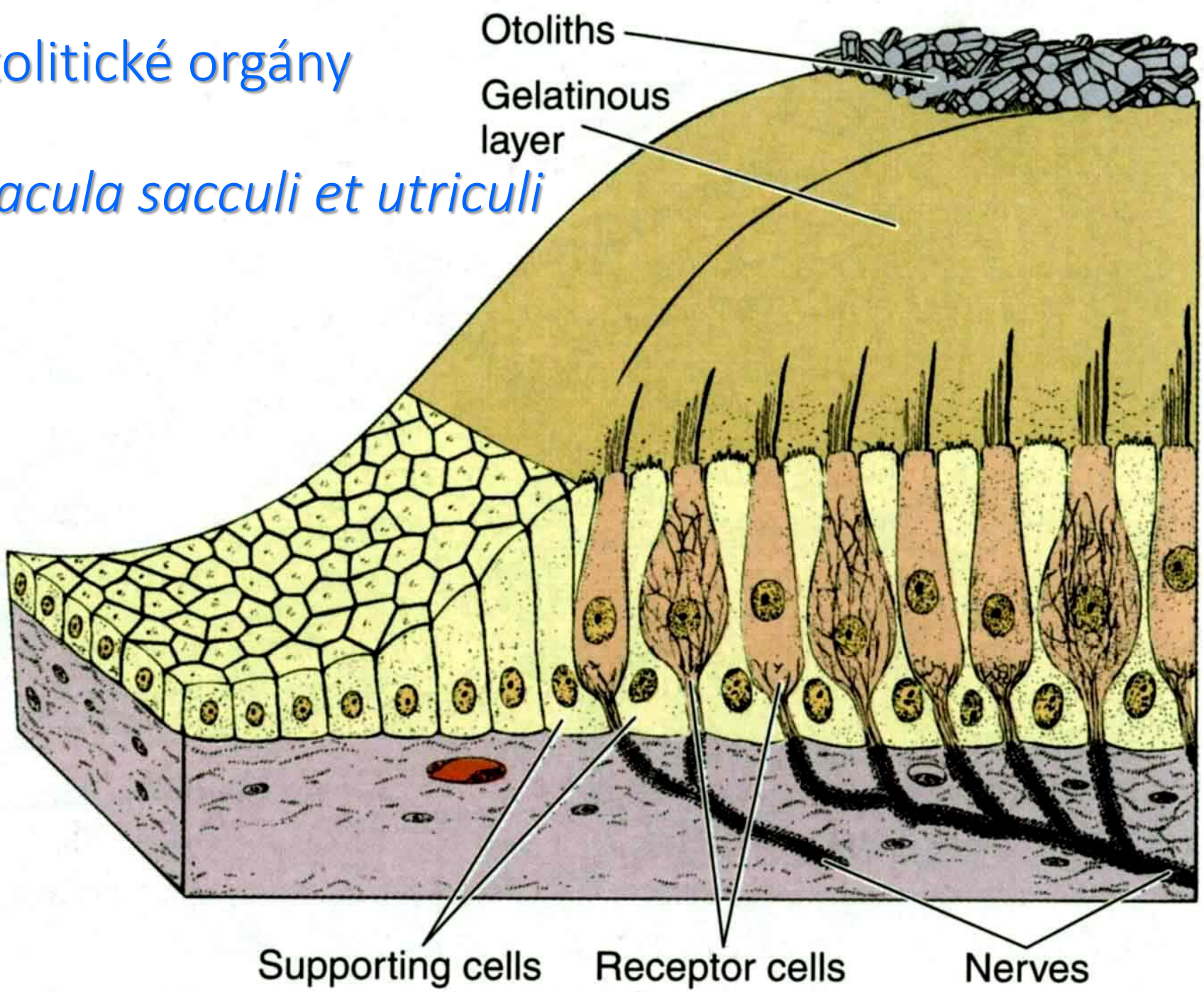
Rovnovážné bludiště (*Labyrinhtus vestibularis)*

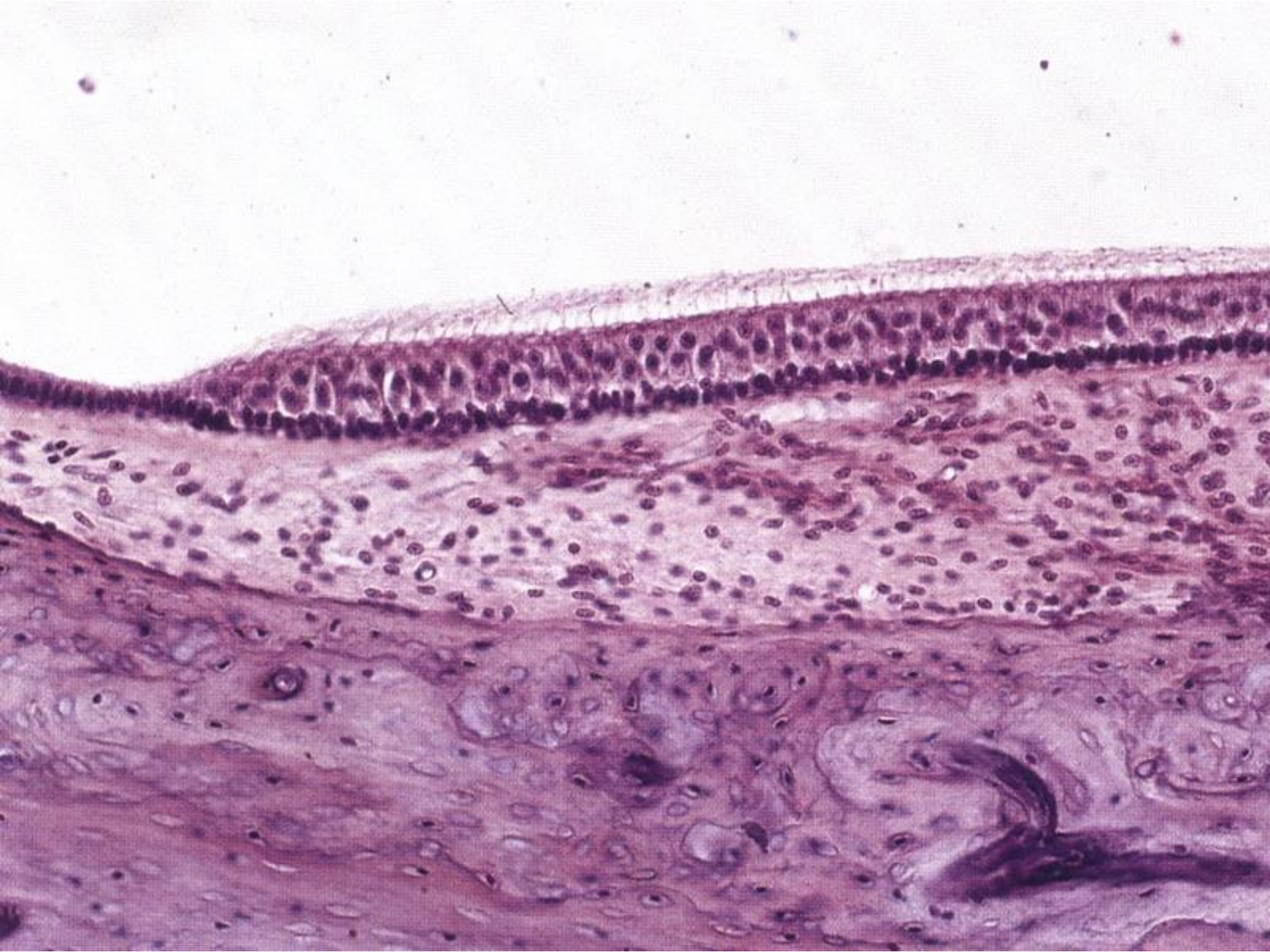


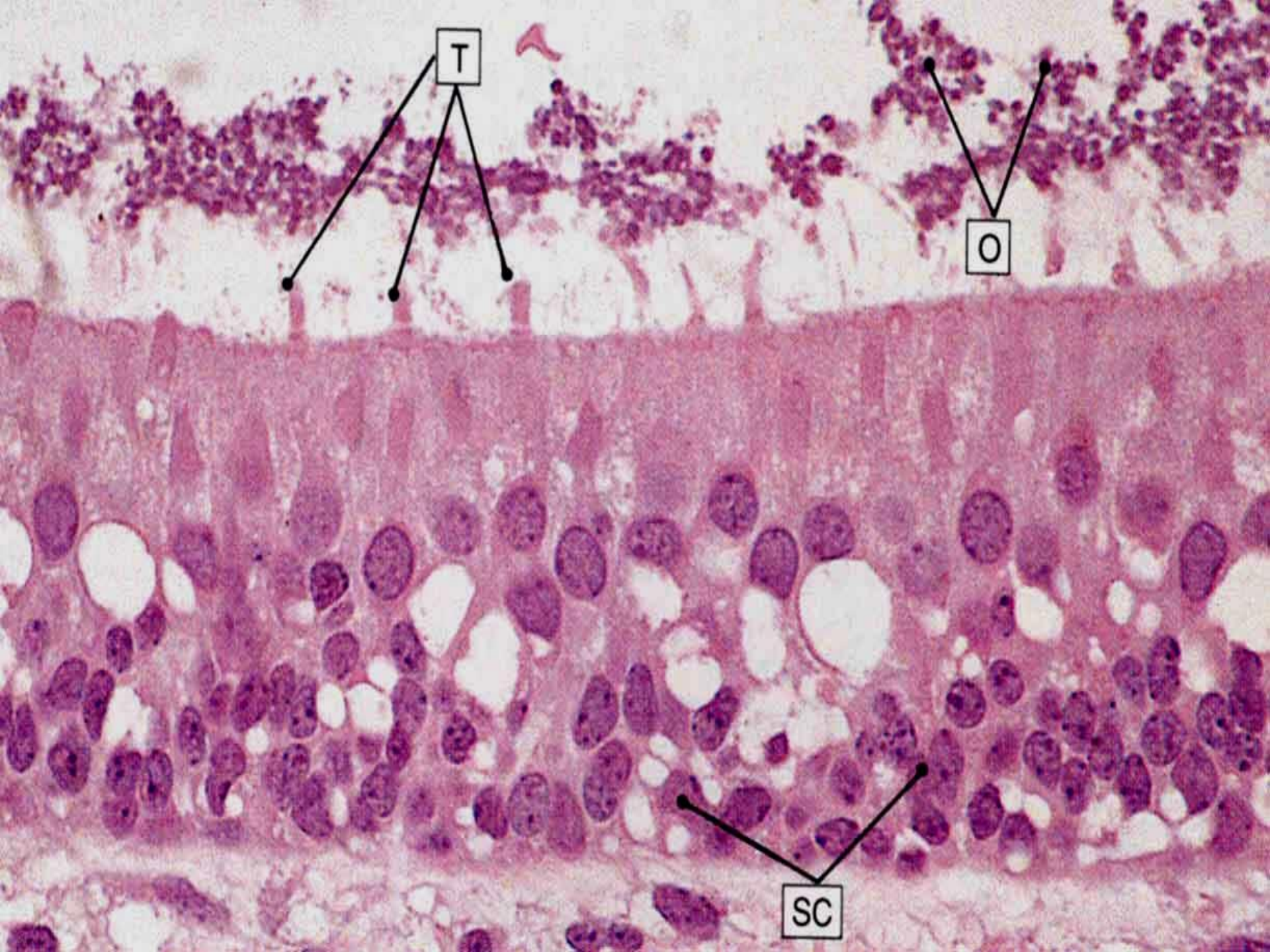

EAR-2_HISTO_40X.svs
macula of saccule
saccule
macula of utricle
utricle
crista ampullaris of
anterior semicircular canal

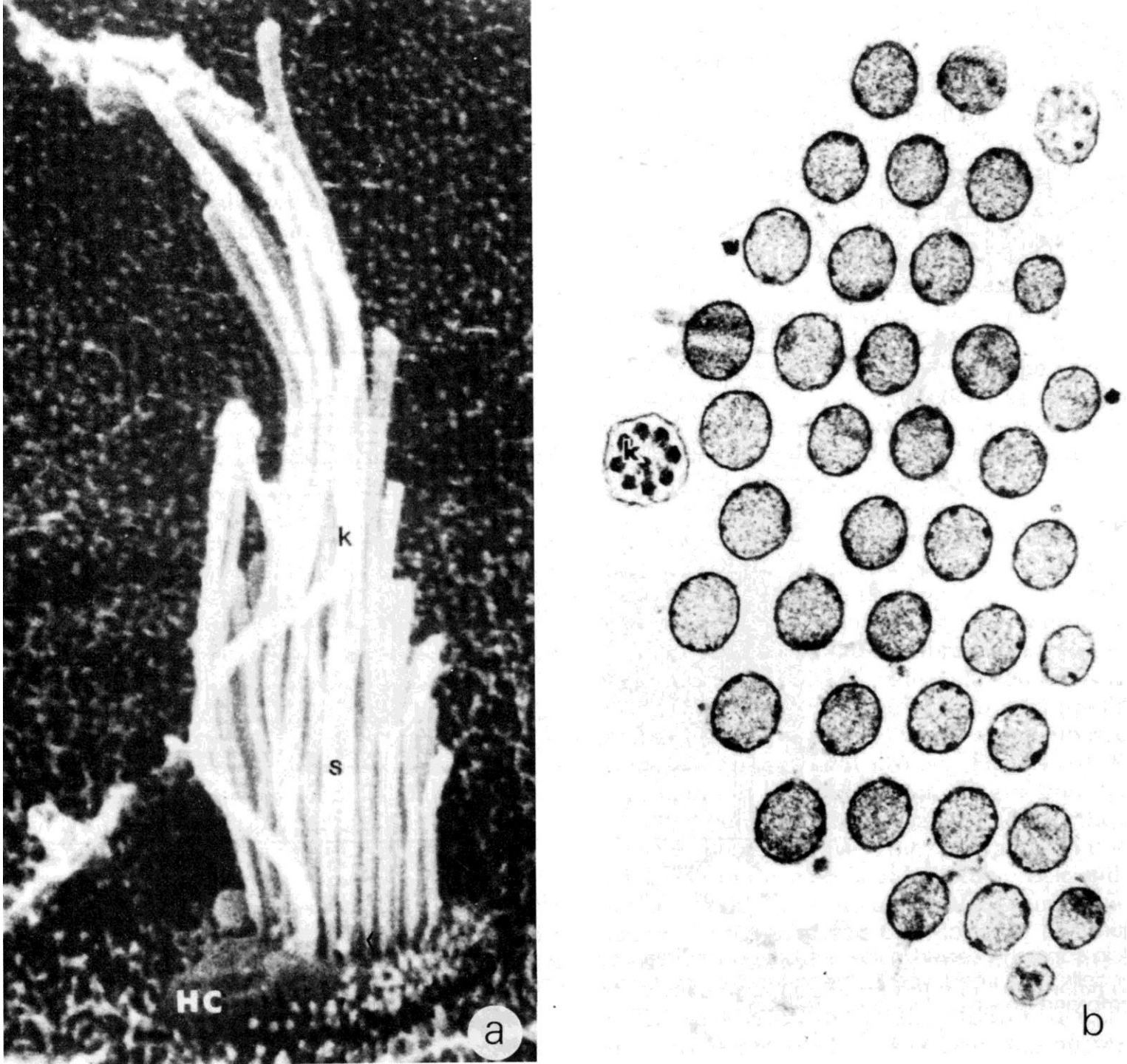
Otolitické orgány

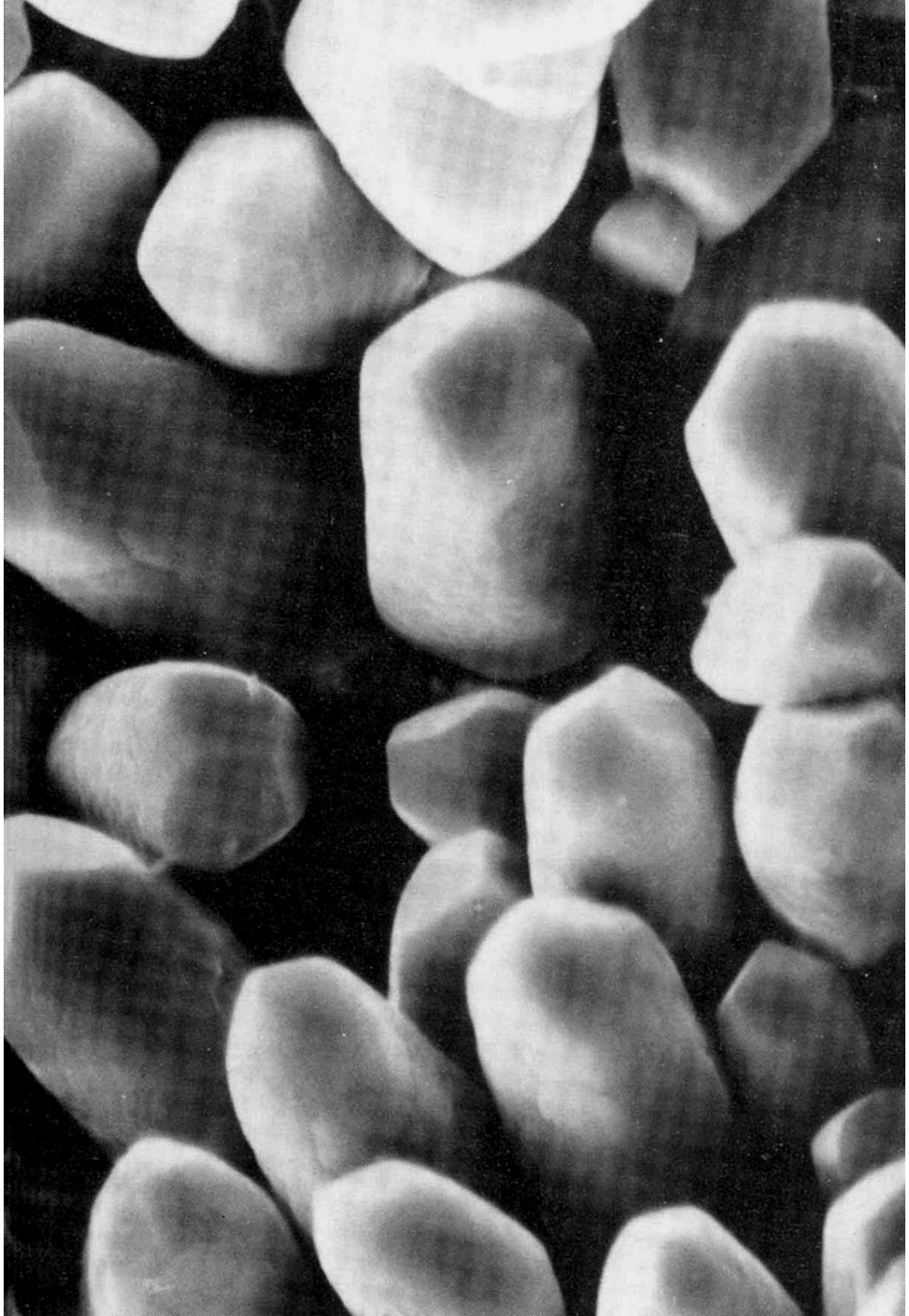
Macula sacculi et utriculi



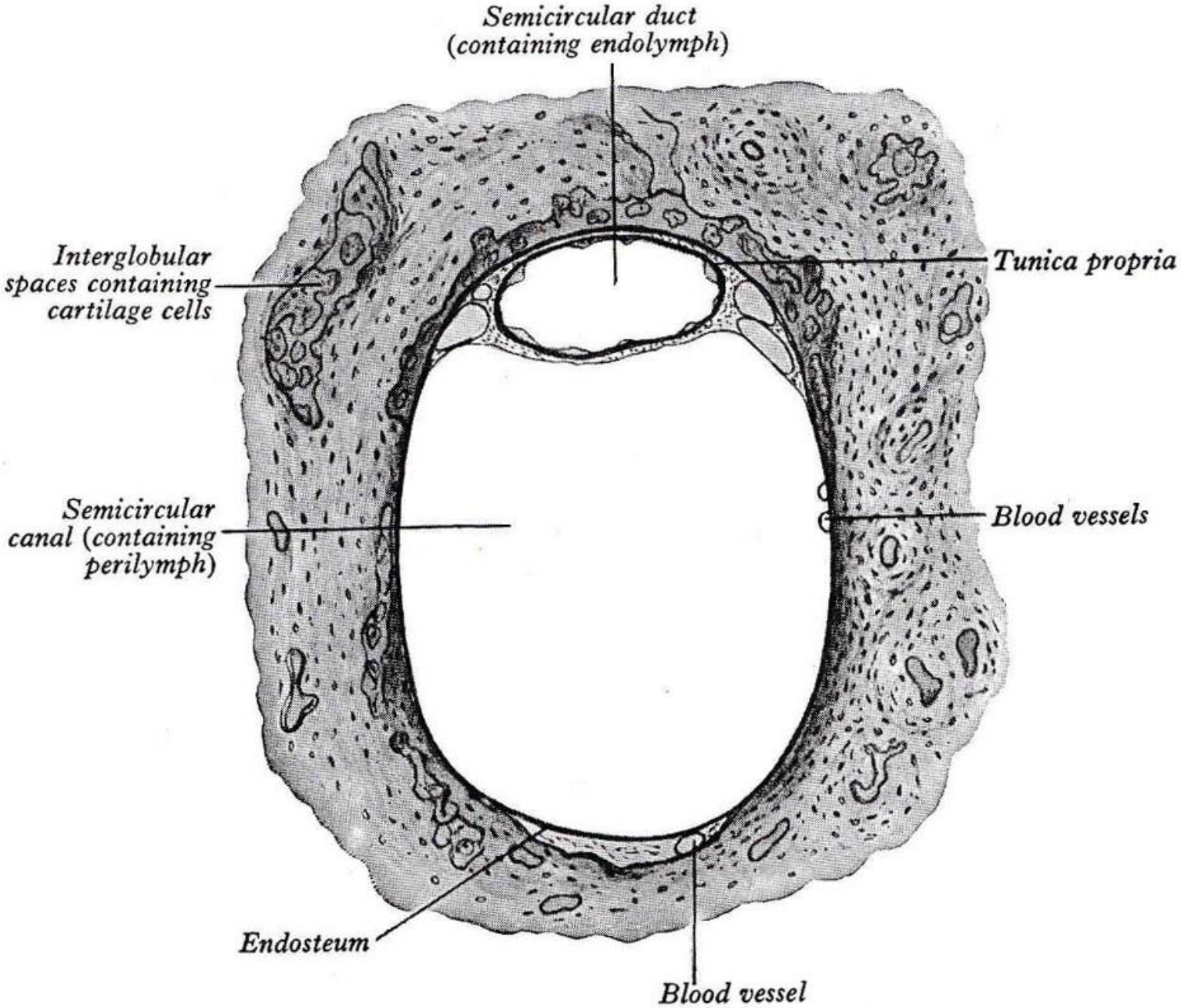



T
O
SC

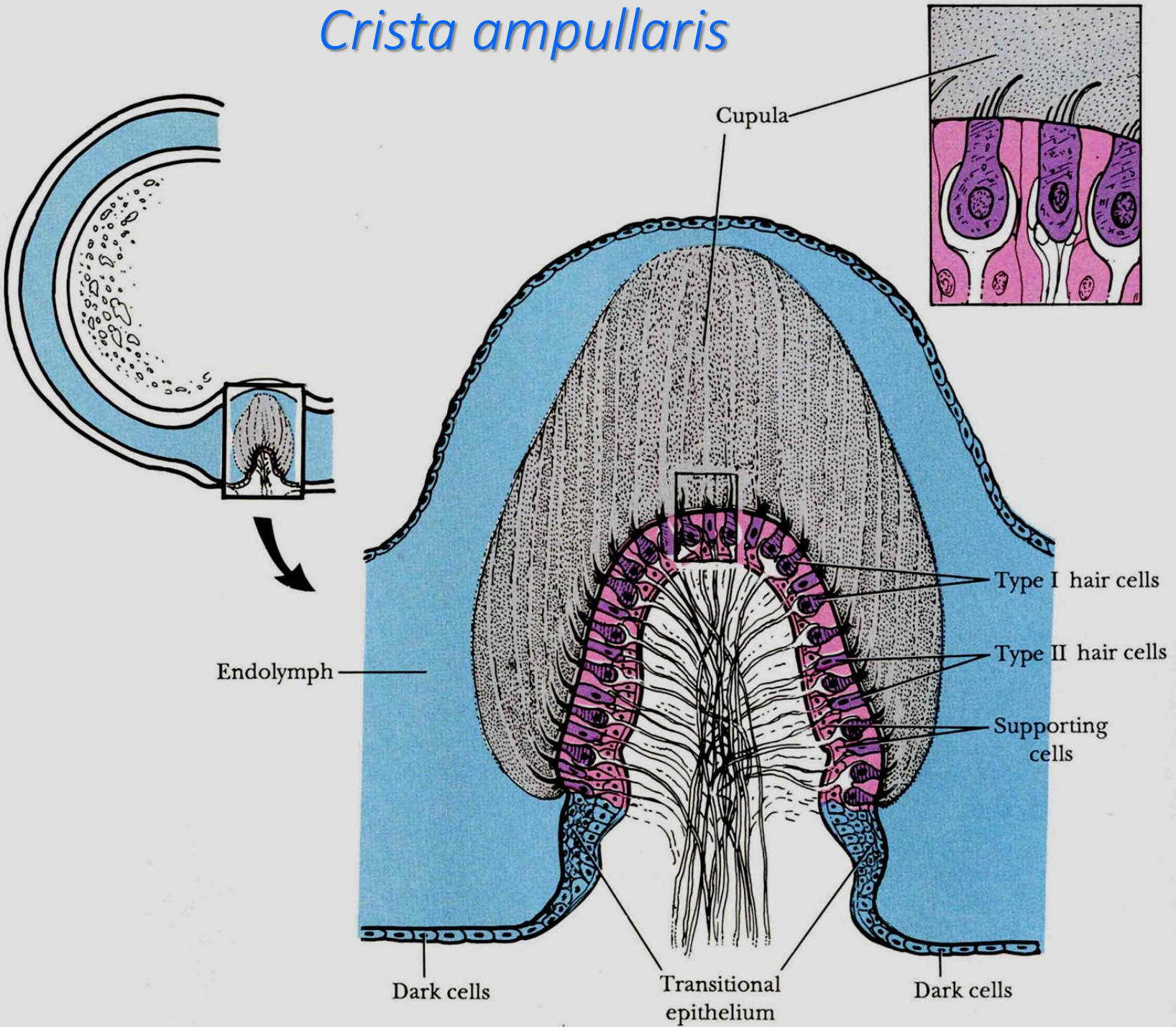

k
s
HC
a
k
b

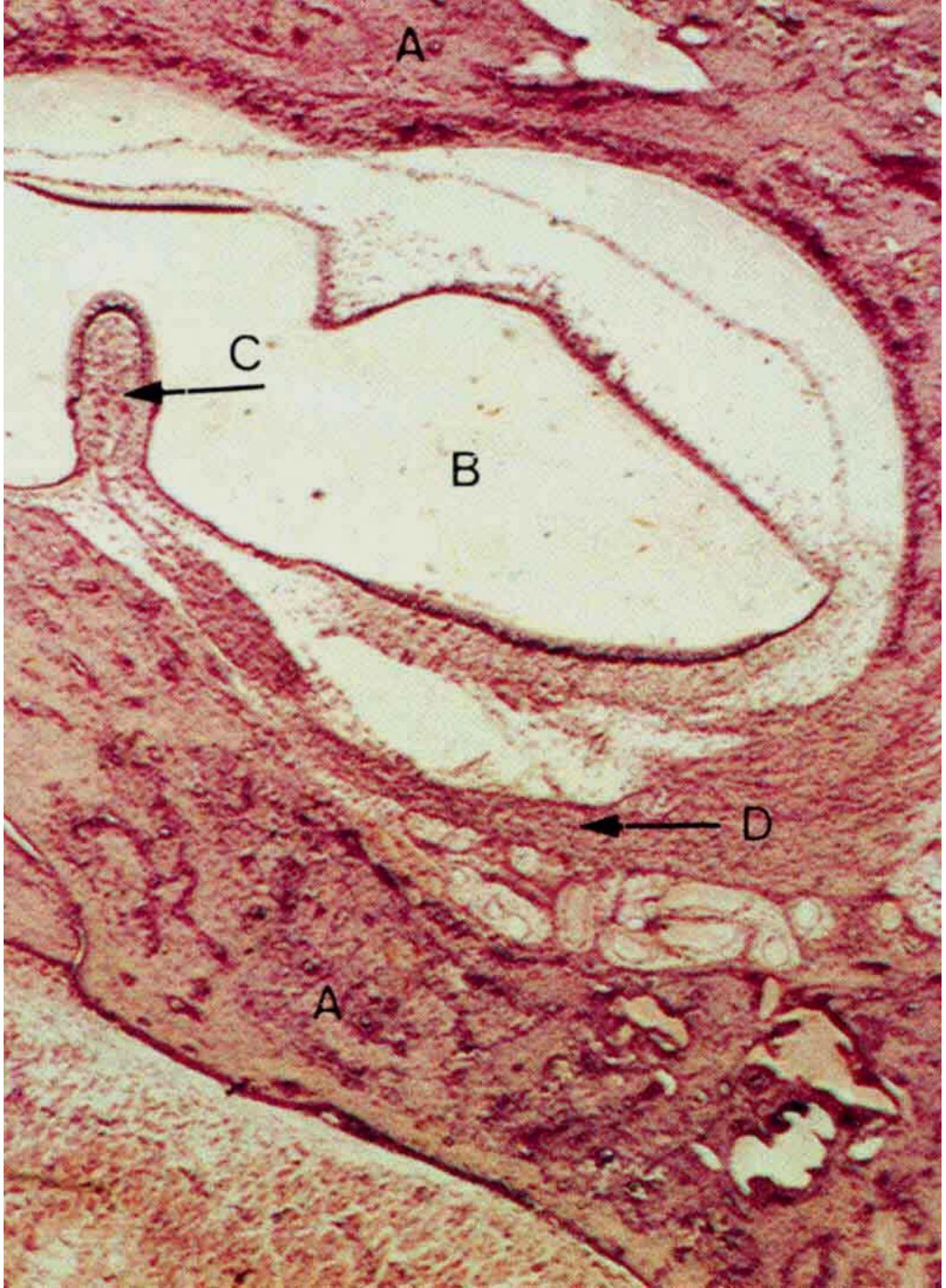


Polokruhové chodbičky *(ductus simicirculares)*

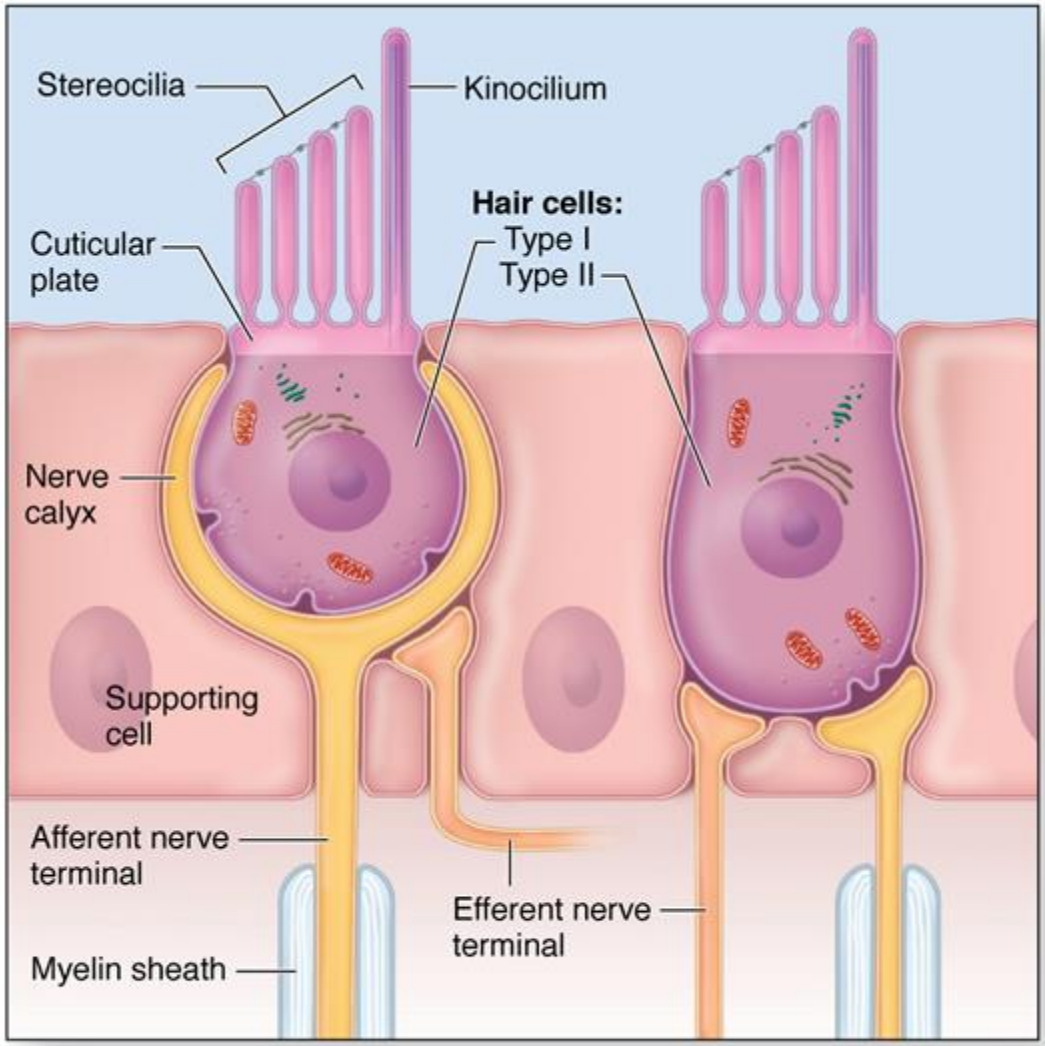


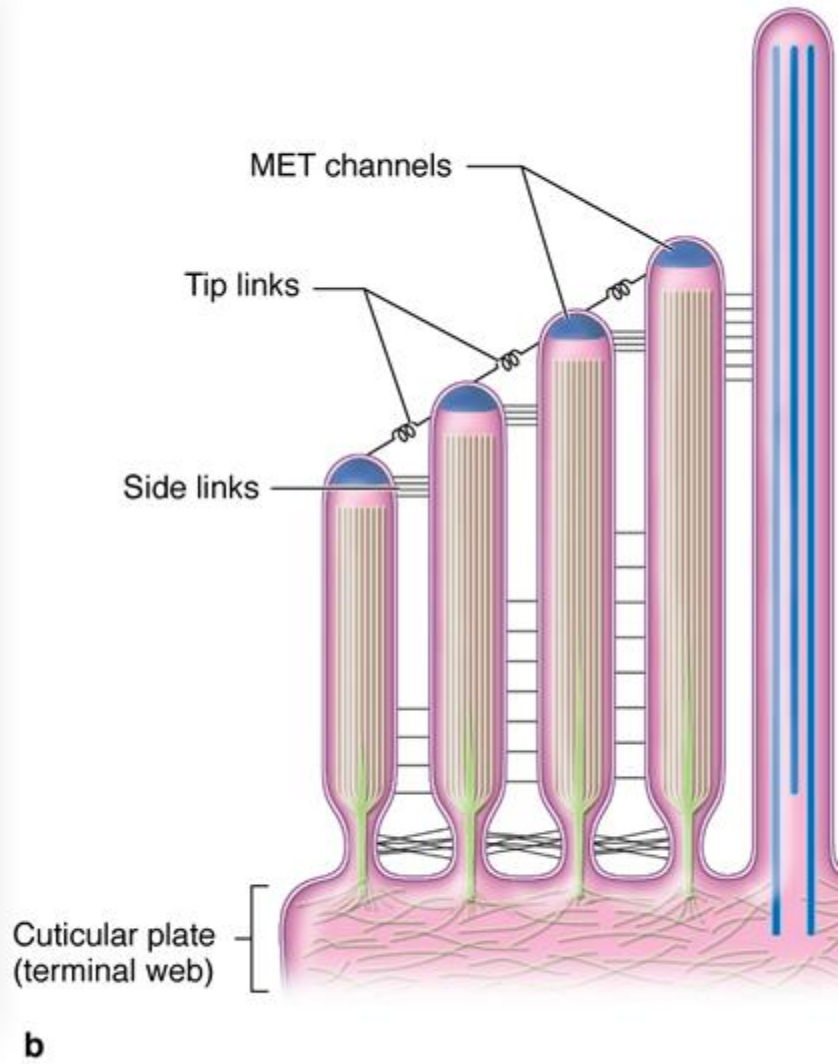
Crista ampullaris

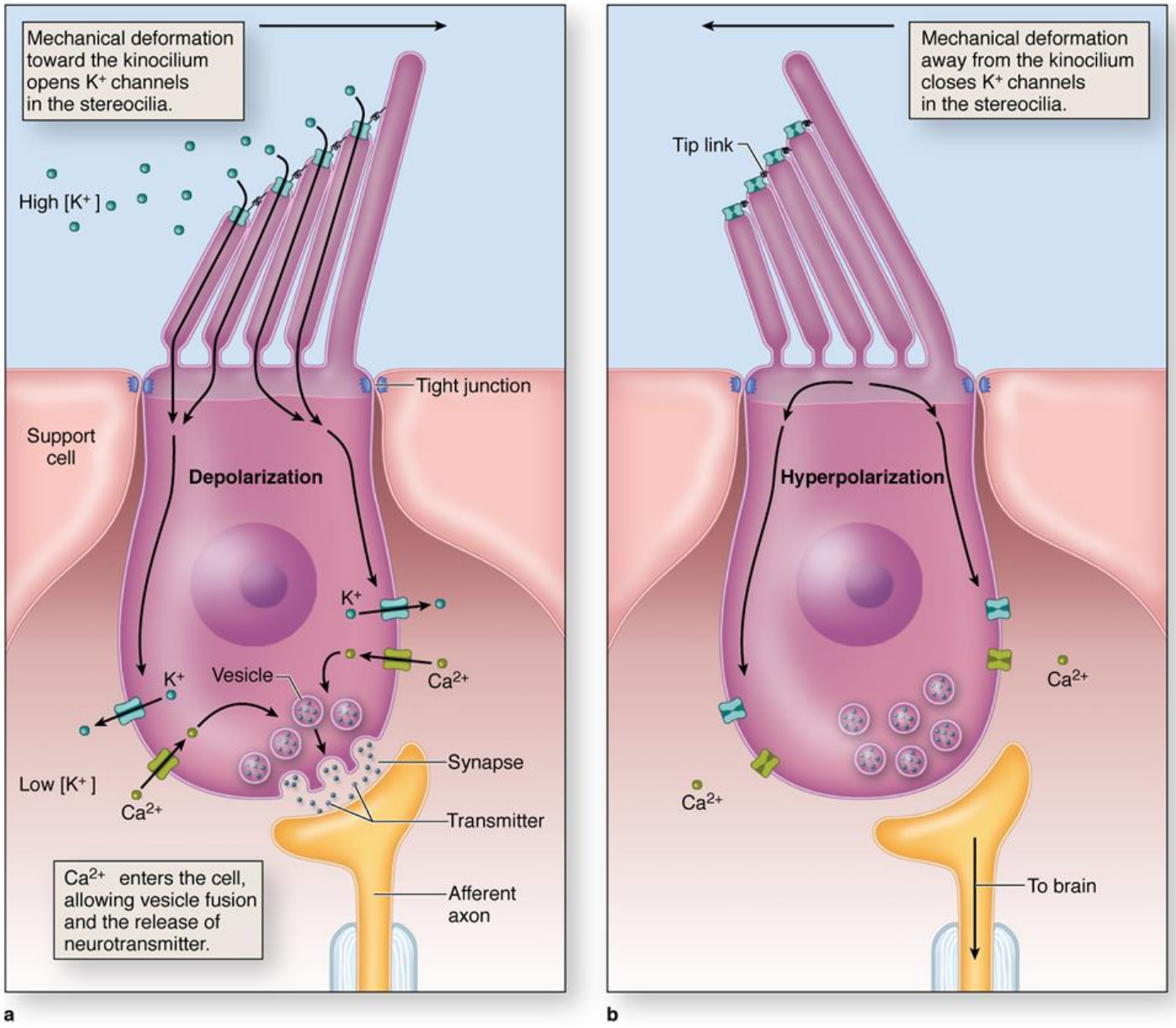



A
C
B
D
A

Vláskové buňky






Mechanical deformation toward the kinocilium opens K+ channels in the stereocilia.
High [K+]
Tight junction
Support cell
Depolarization
K+
Vesicle
Ca2+
K+
Low [K+]
Ca2+
Synapse
Transmitter
Afferent axon
Ca2+ enters the cell, allowing vesicle fusion and the release of neurotransmitter.
a
Mechanical deformation away from the kinocilium closes K+ channels in the stereocilia.
Tip link
Hyperpolarization
Ca2+
Ca2+
To brain
b

Endolymfa a perilymfa

- Endolymfa: podobná nitrobuněčné tekutině

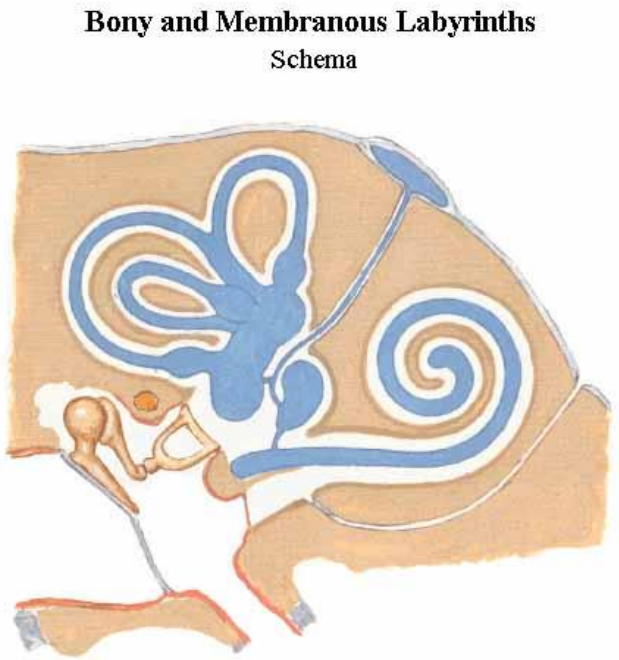
stria vascularis → scala media → ductus endolymphaticus (aqueductus vestibuli) → saccus endolymphaticus (slepý) → žíly

Saccus endolymphaticus – cylindrické buňky, mikroklky, pinocytární vesikuly, fagosomy

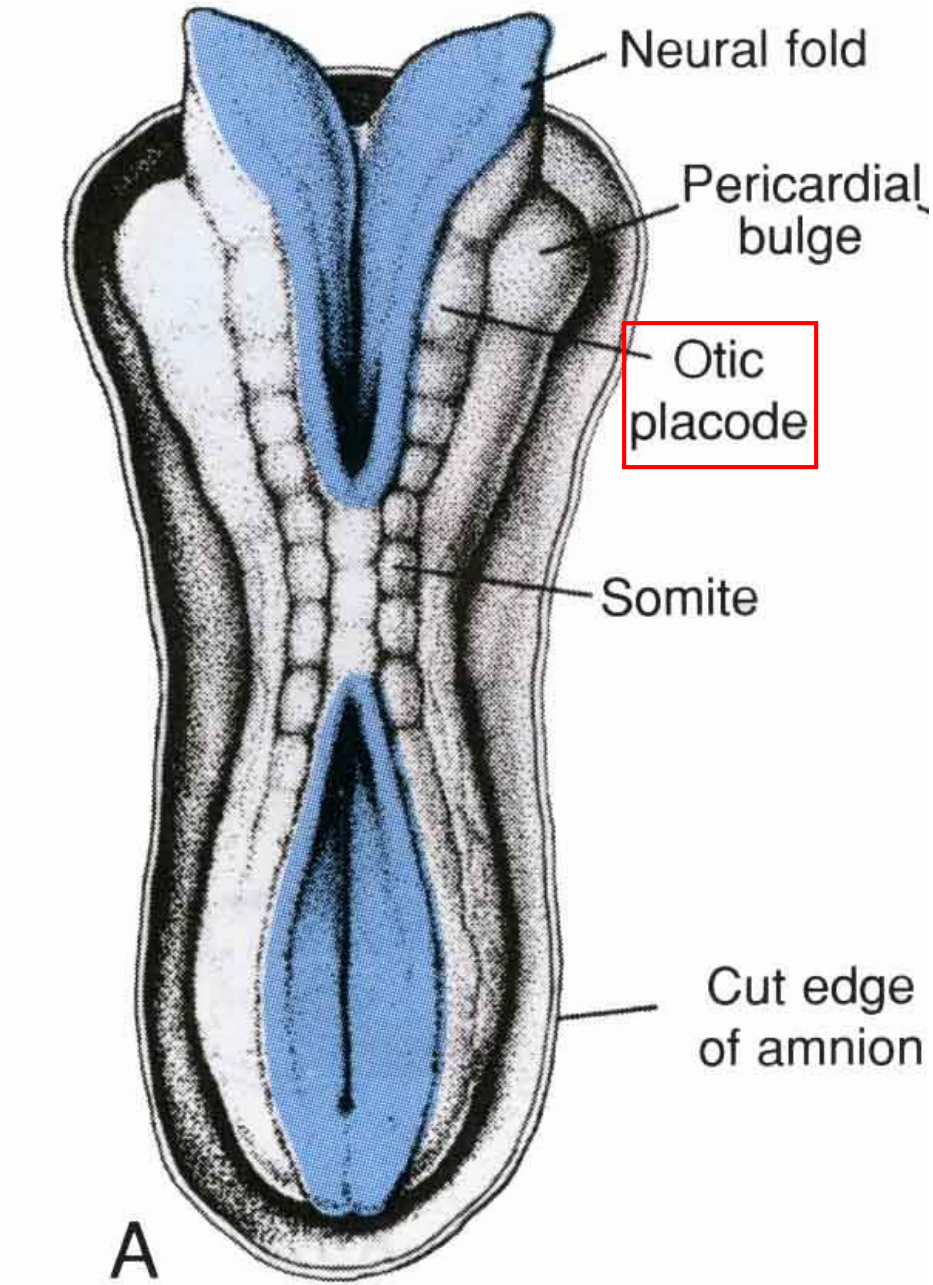
- Perilymfa: podobná MMM

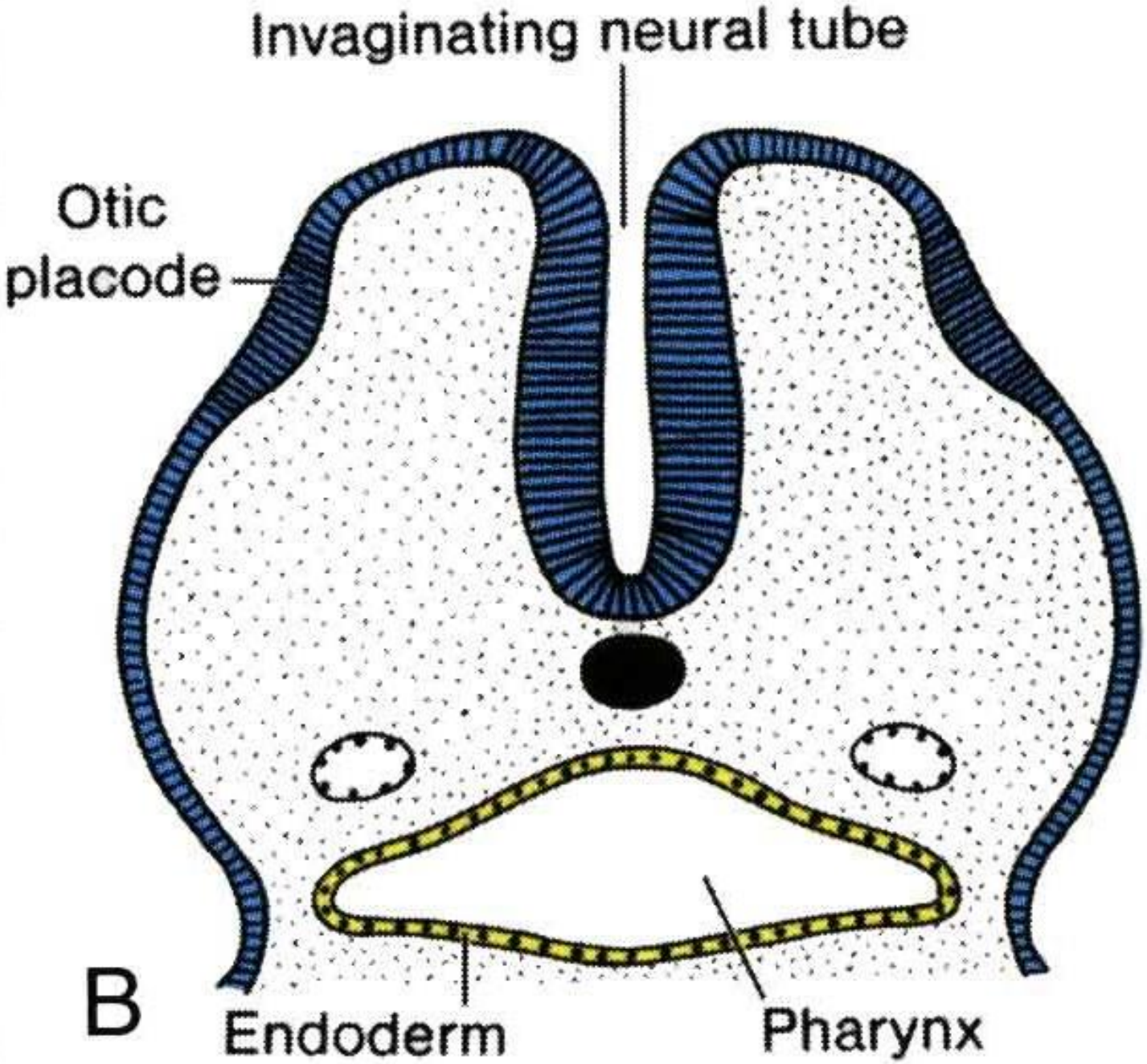
canalicus (aqueductus) cochleae propojen se subarachnoidálním prostorem

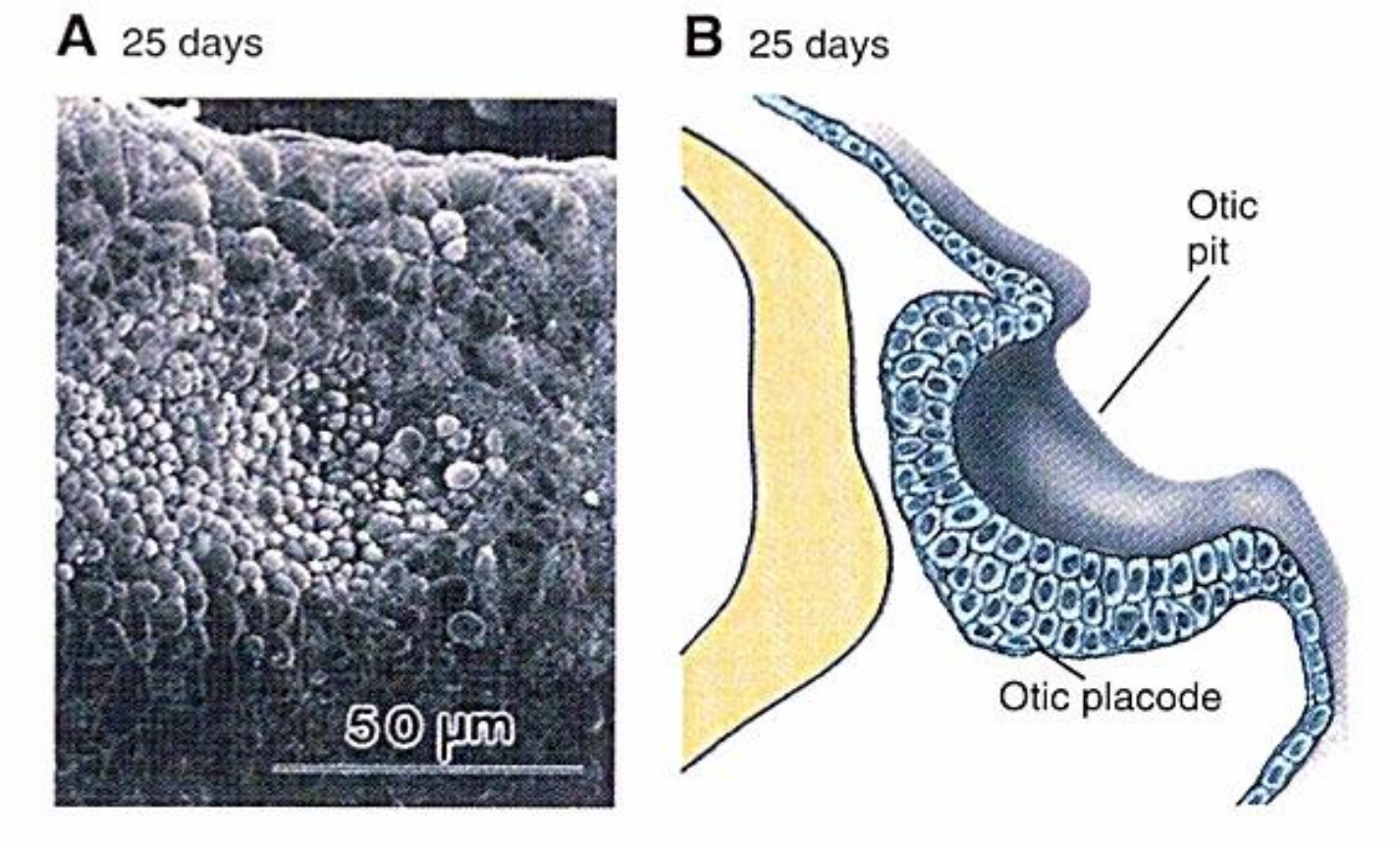
ductus perilymphaticus ?



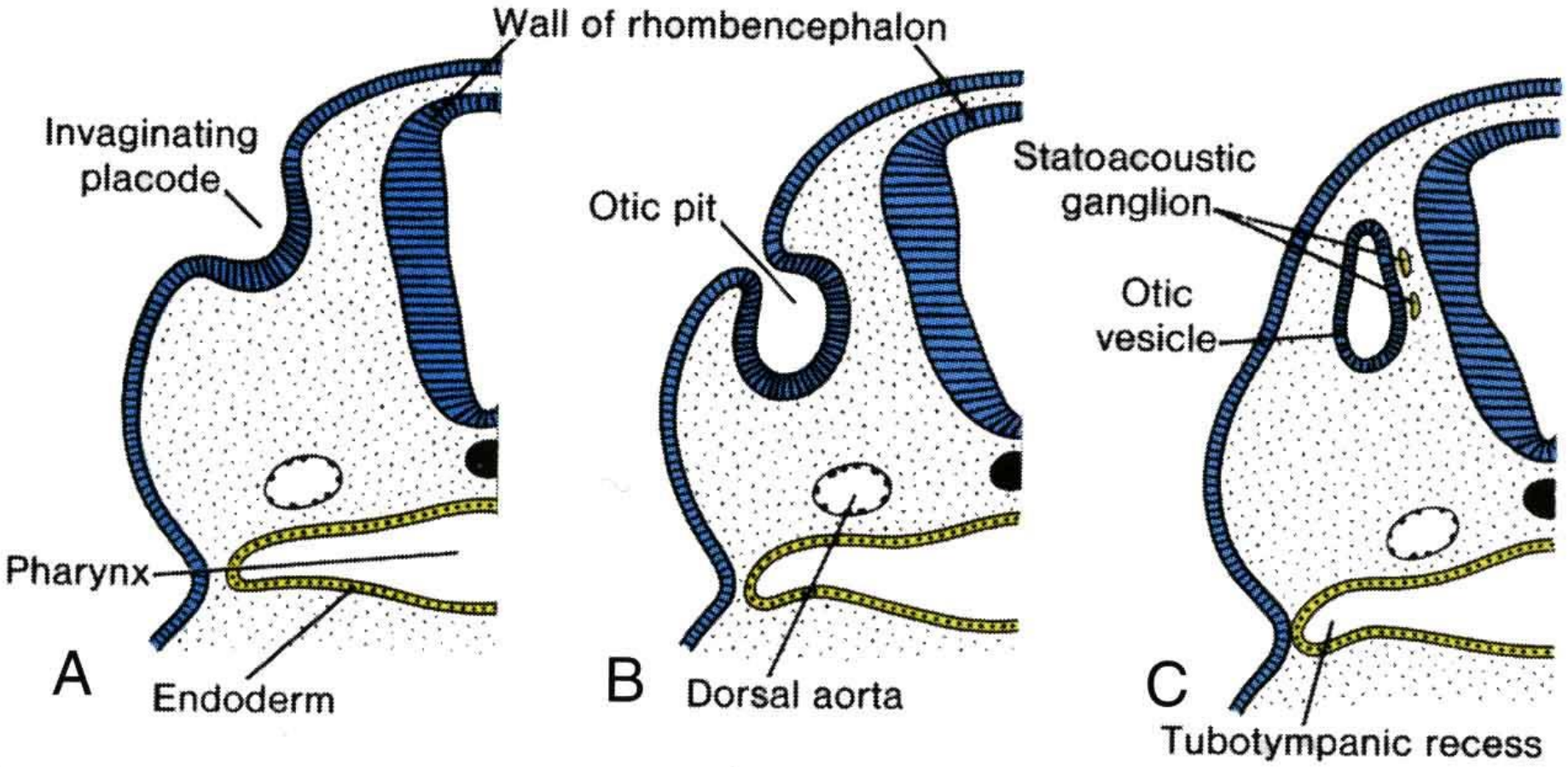
Vývoj vnitřního ucha

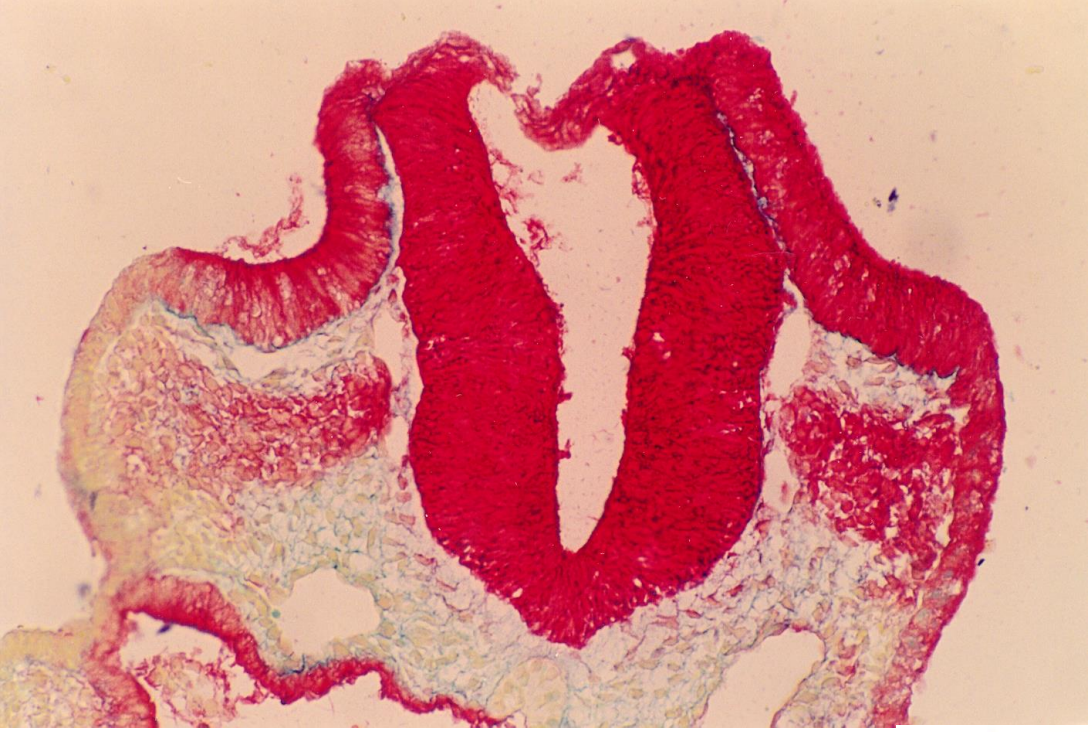


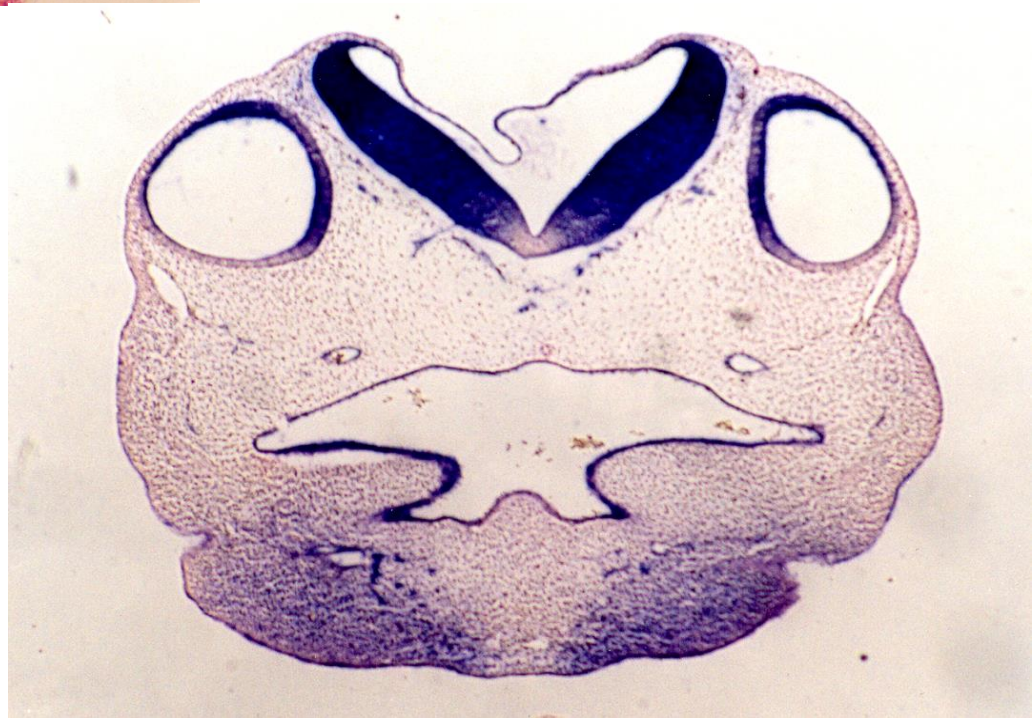

Invaginating neural tube
Otic placode
B
Endoderm
Pharynx

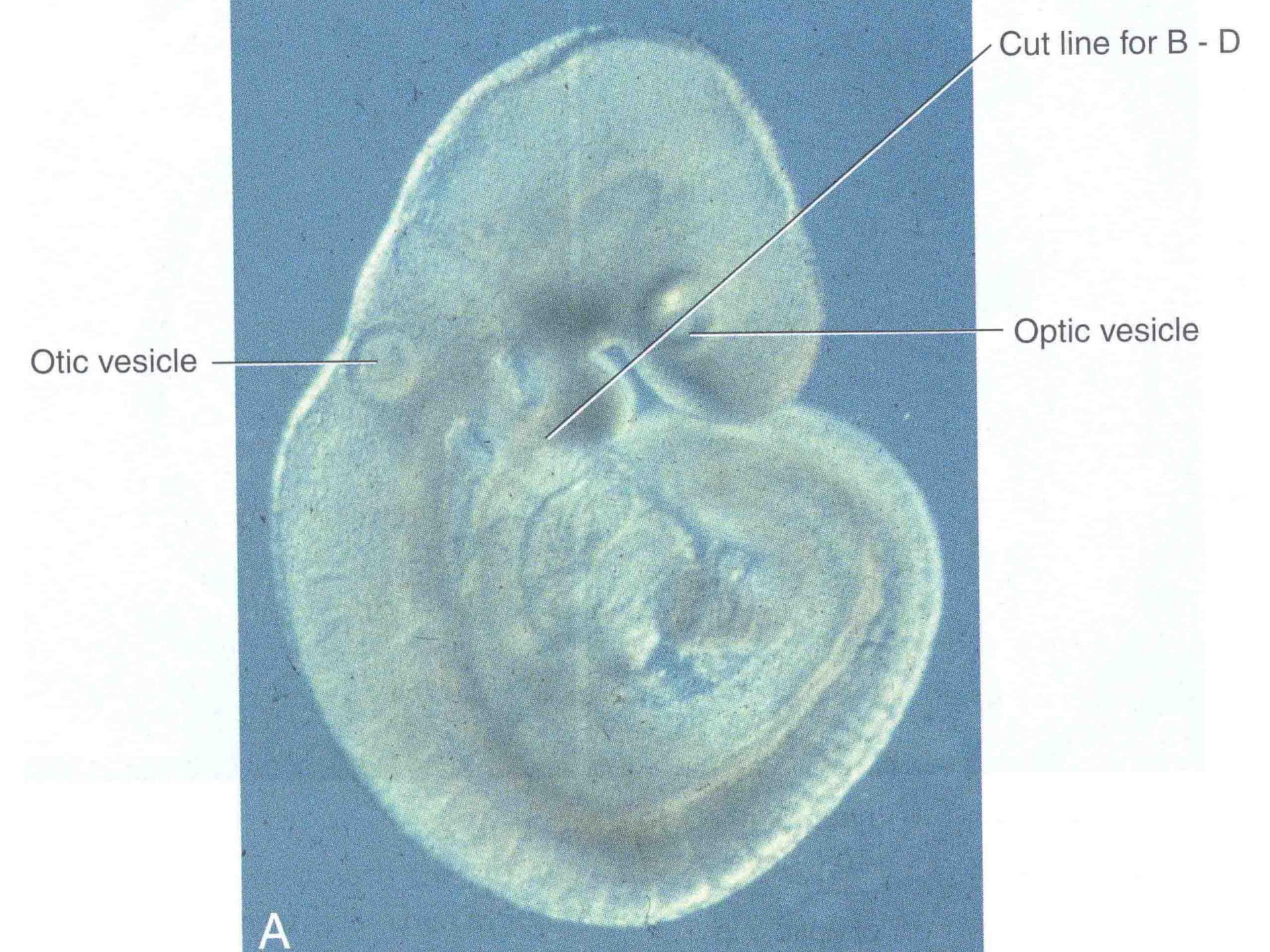


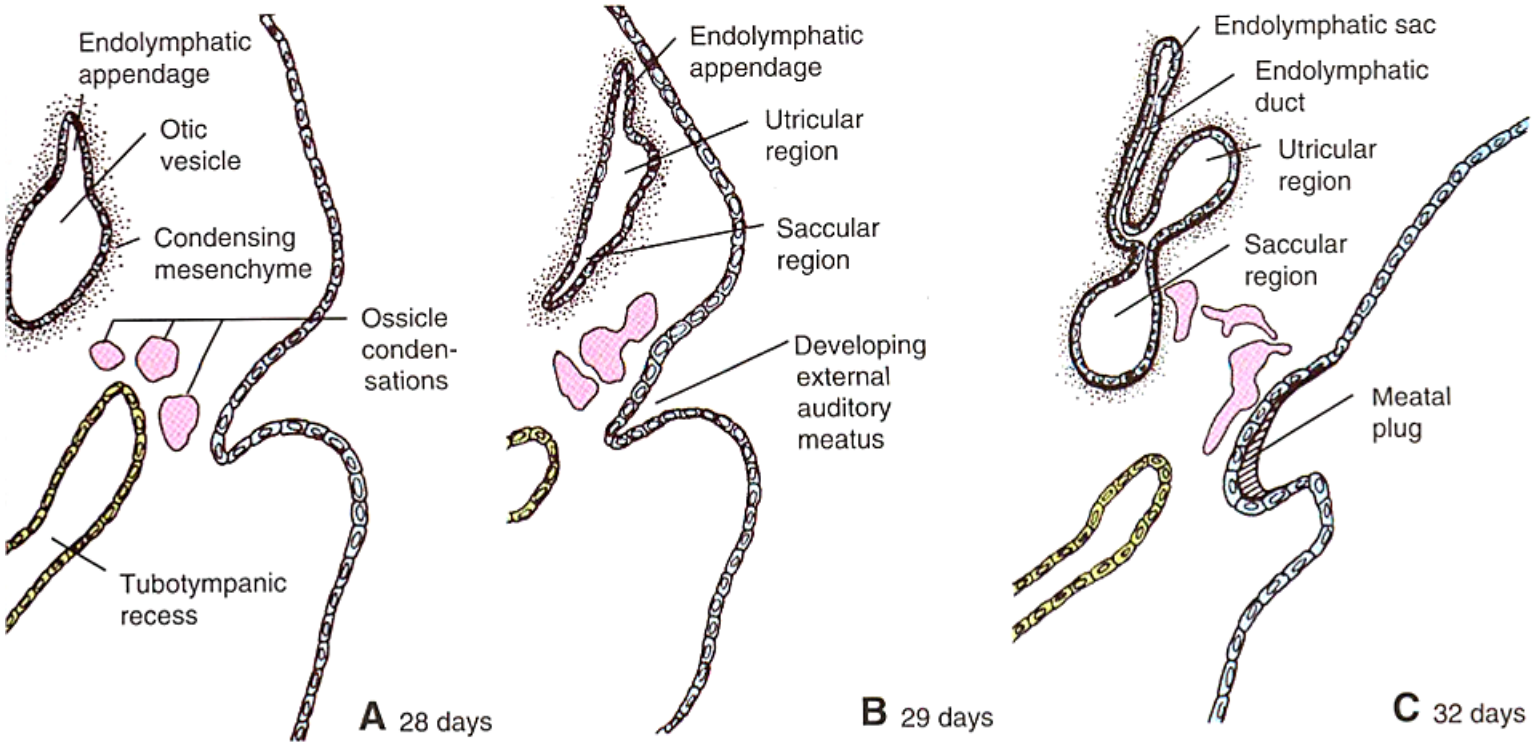
vytvoření otické plakody v ektodermu indukuje FGF signalizace v přilehlém mesodermu a rhombencefalu
SHH indukuje diferenciaci akustické složky blanitého labyrintu, Wnt signalizace indukuje vestibulární složku

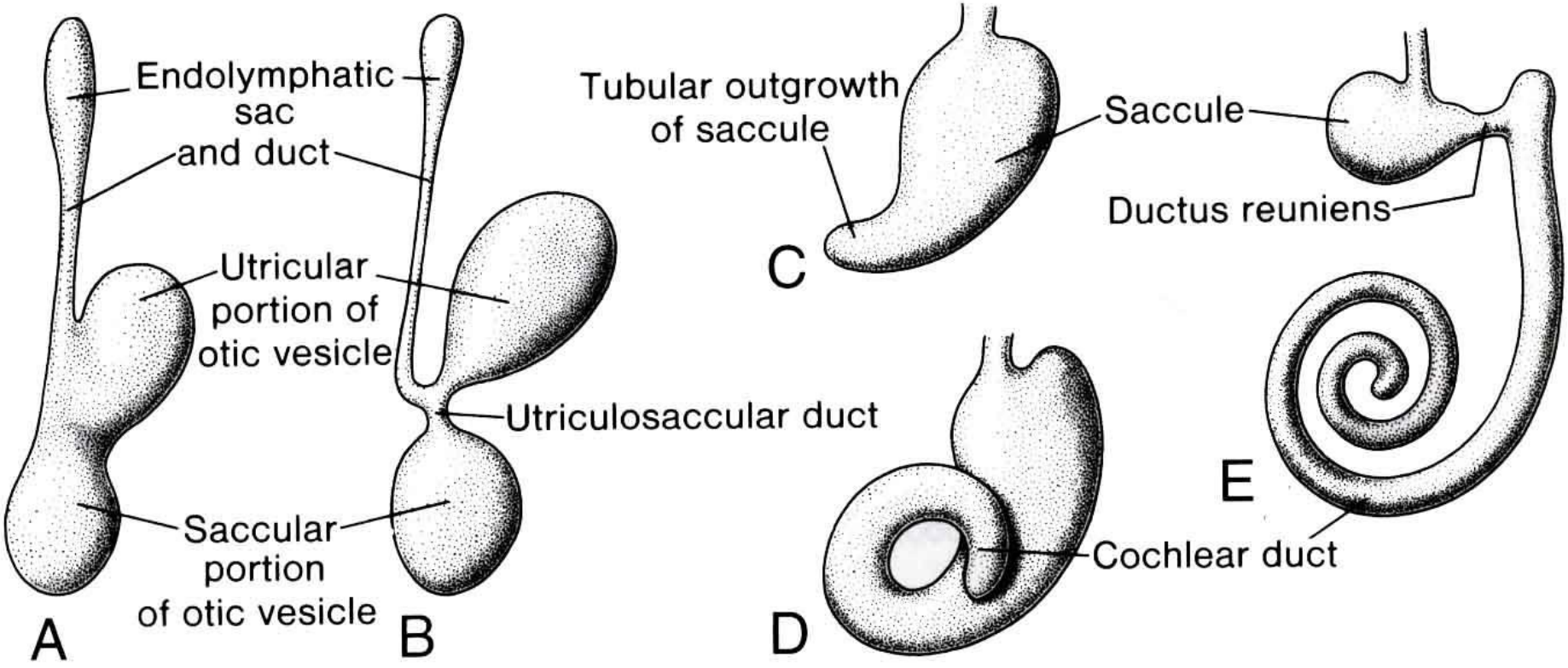

Wall of rhombencephalon
Invaginating placode
Pharynx
A
Endoderm
Otic pit
B
Dorsal aorta
Statoacoustic ganglion
Otic vesicle
C
Tubotympanic recess

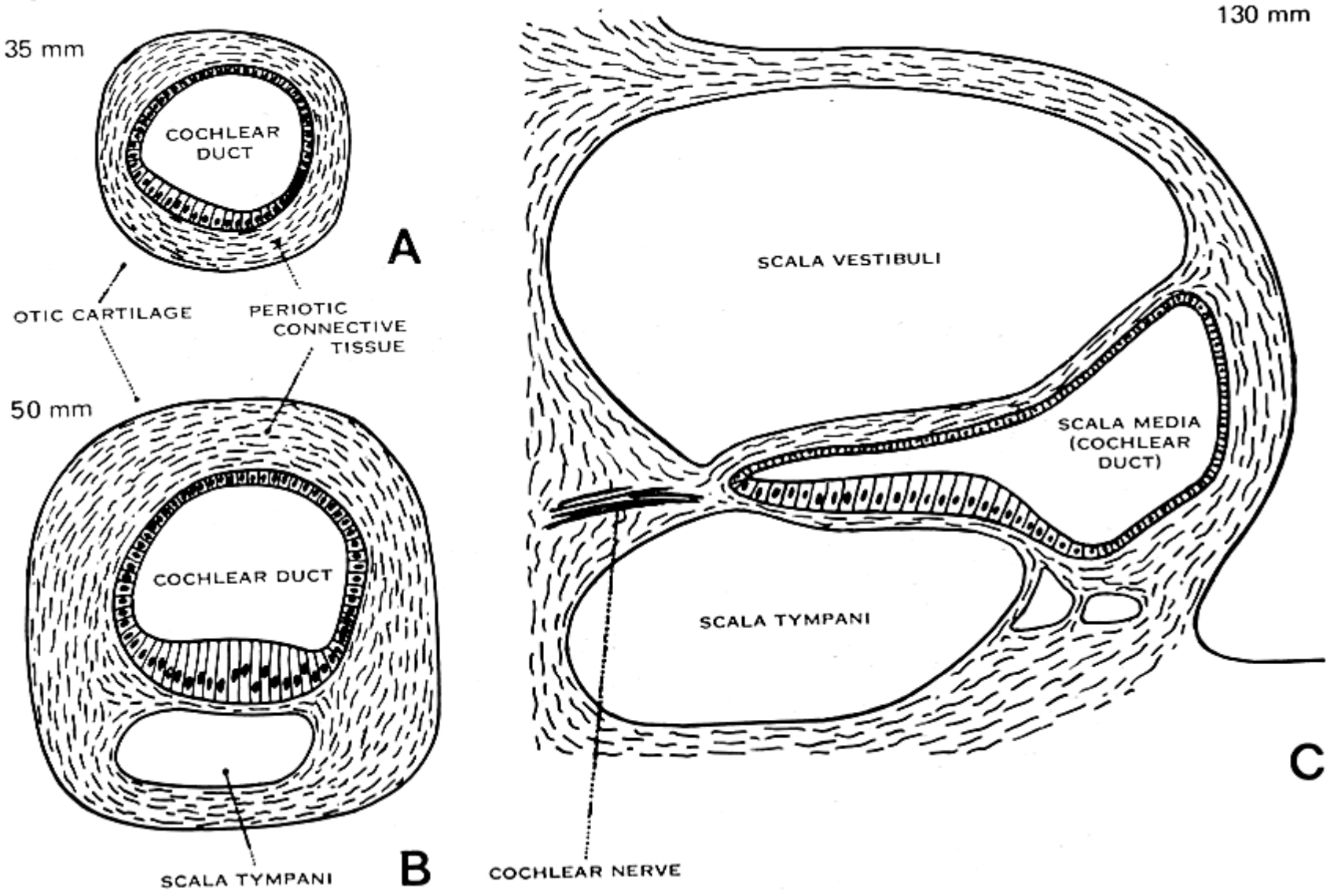


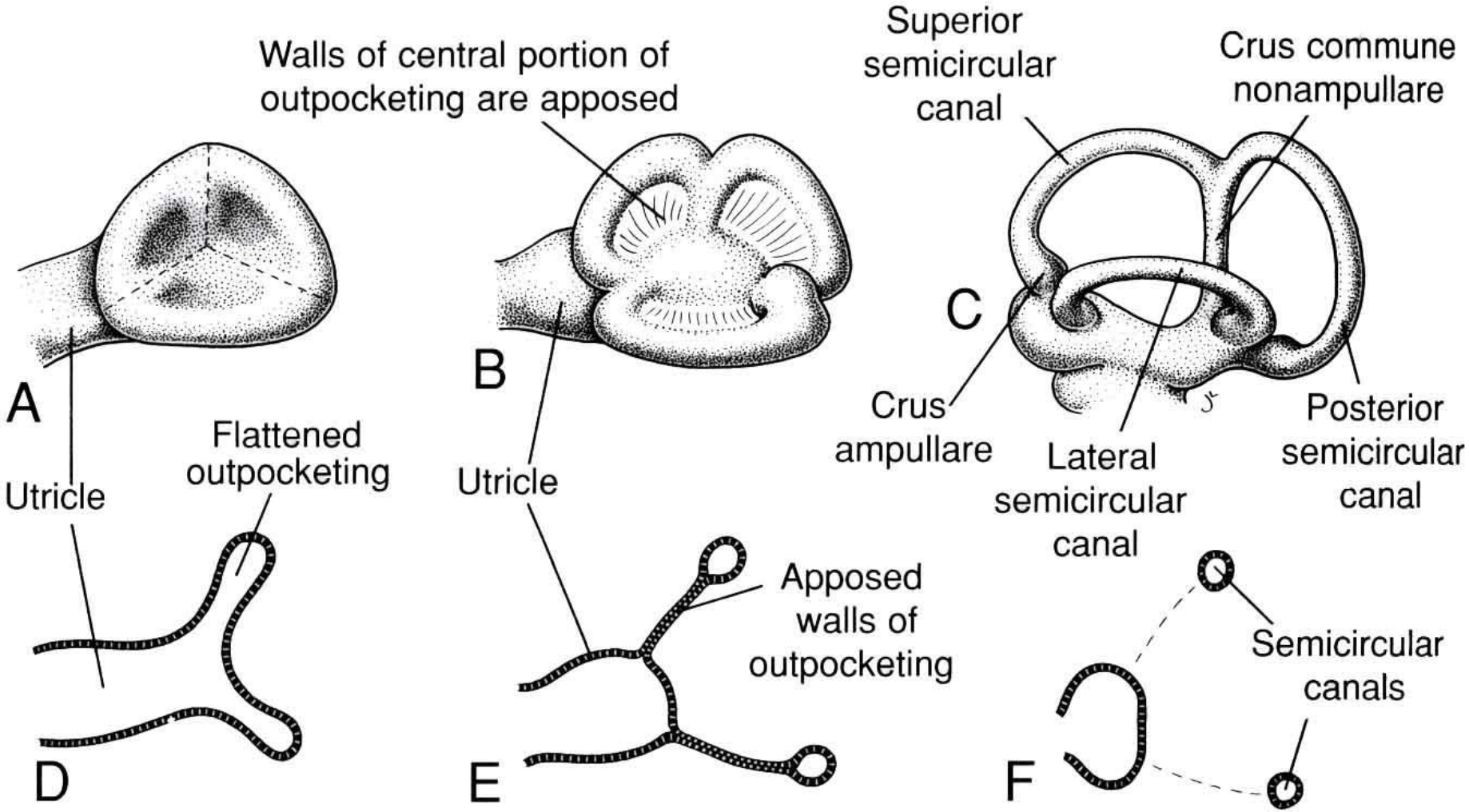


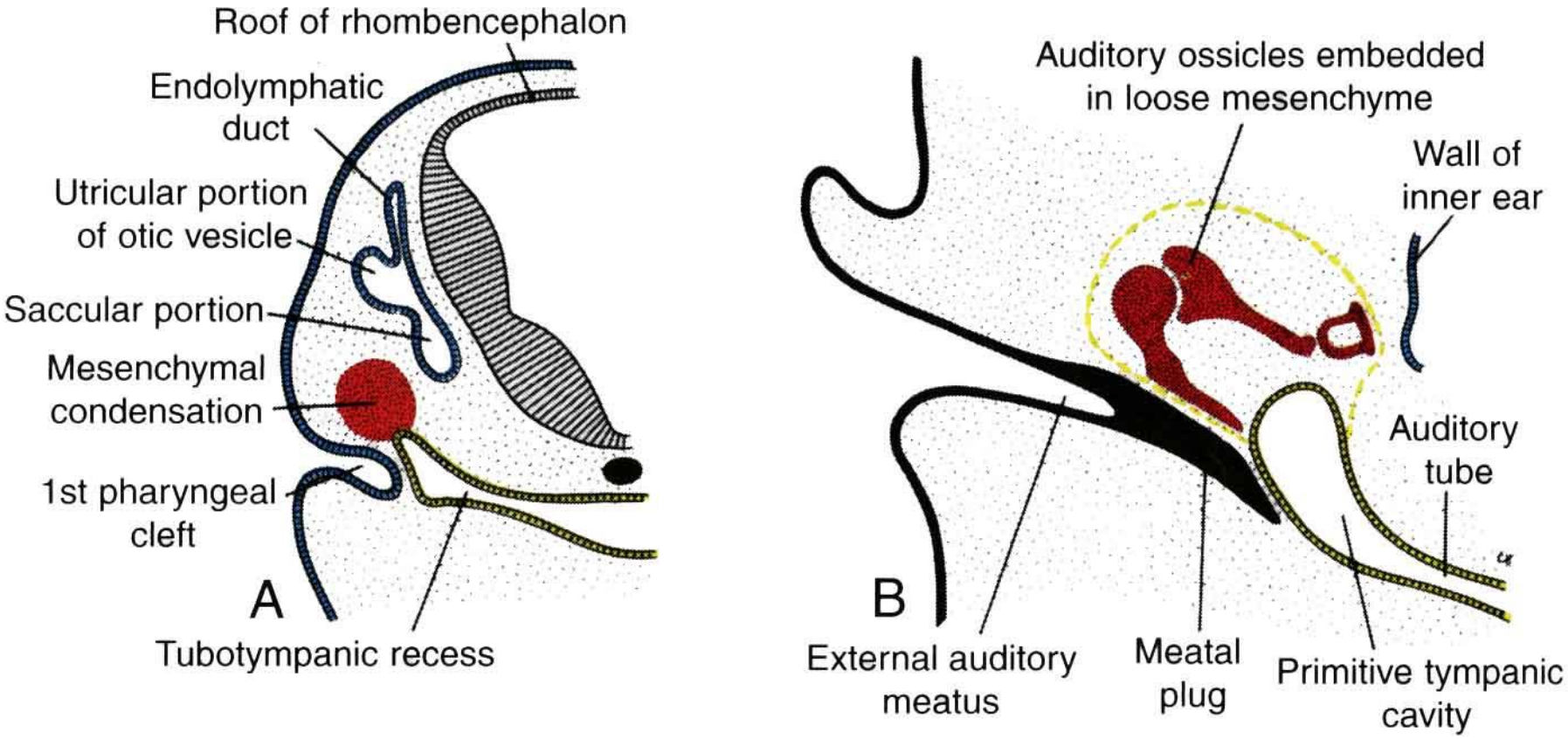

Cut line for B - D
Optic vesicle
Otic vesicle
A

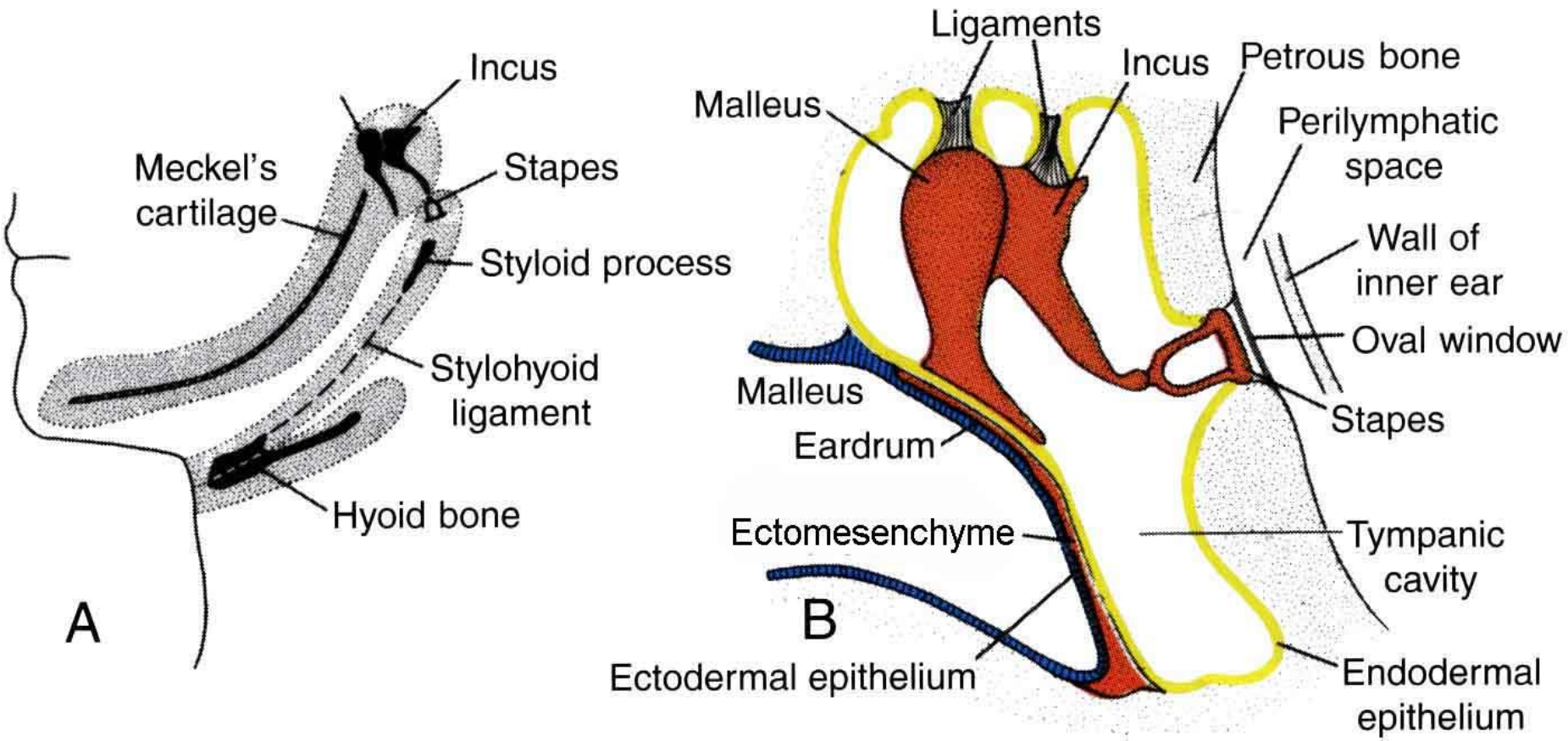

Endolymphatic appendage
Otic vesicle
Condensing mesenchyme
Ossicle condensations
Tubotympanic recess
A 28 days
Endolymphatic appendage
Utricular region
Saccular region
Developing external auditory meatus
B 29 days
Endolymphatic sac
Endolymphatic duct
Utricular region
Saccular region
Meatal plug
C 32 days

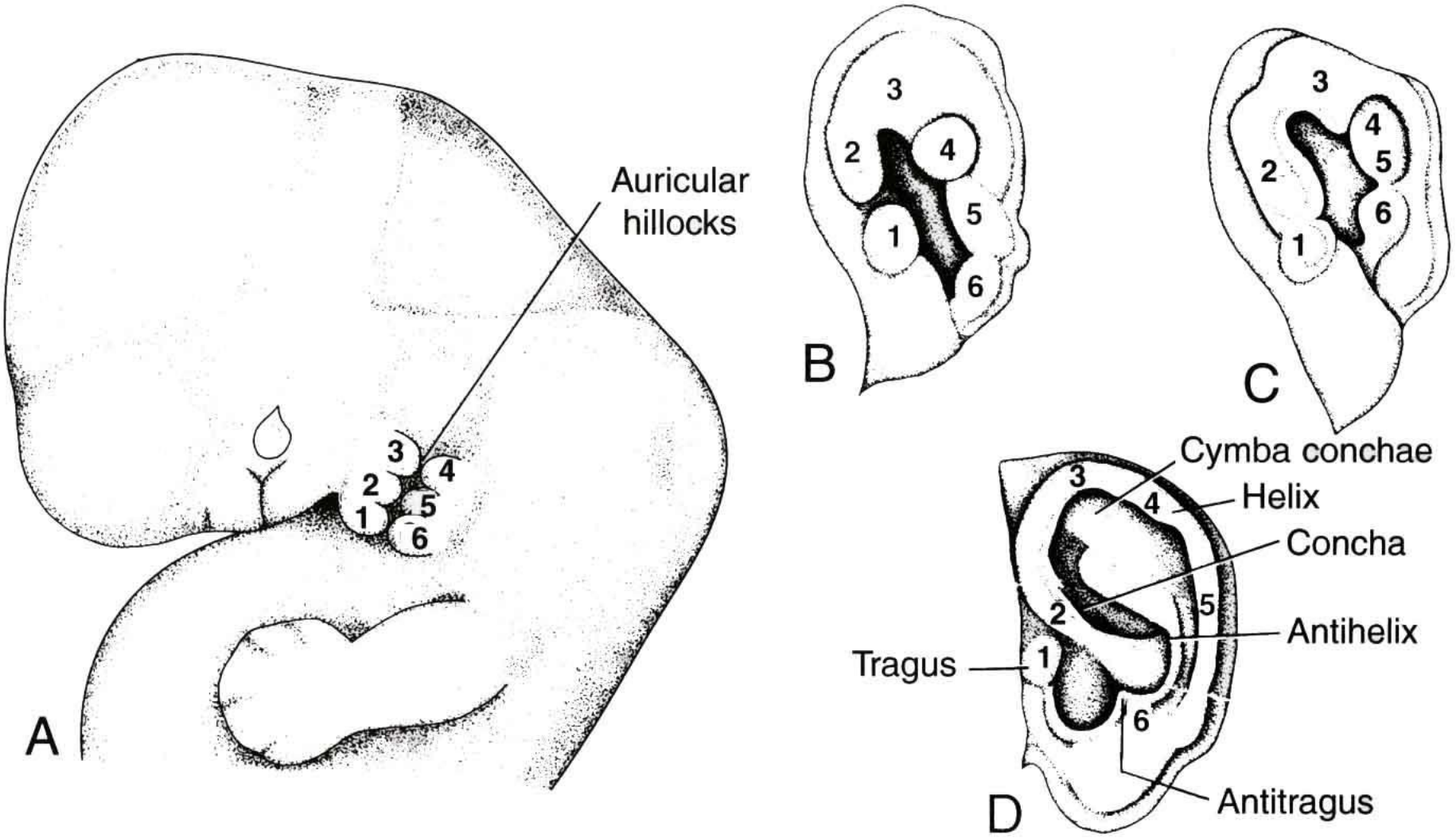

Endolymphatic sac and duct
Utricular portion of otic vesicle
Saccular portion of otic vesicle
A
B
Utriculosaccular duct
Tubular outgrowth of saccule
C
Saccule
Ductus reuniens
D
E
Cochlear duct


35 mm
COCHLEAR DUCT
A
OTIC CARTILAGE
PERIOTIC CONNECTIVE TISSUE
50 mm
COCHLEAR DUCT
SCALA TYMPANI
B
130 mm
SCALA VESTIBULI
SCALA MEDIA (COCHLEAR DUCT)
SCALA TYMPANI
C
COCHLEAR NERVE


Walls of central portion of outpocketing are apposed
Superior semicircular canal
Crus commune nonampullare
A
B
C
Utricle
Flattened outpocketing
Utricle
Crus ampullare
Lateral semicircular canal
Posterior semicircular canal
Apposed walls of outpocketing
Semicircular canals
D
E
F


Roof of rhombencephalon
Endolymphatic duct
Utricular portion of otic vesicle
Saccular portion
Mesenchymal condensation
1st pharyngeal cleft
A
Tubotympanic recess
Auditory ossicles embedded in loose mesenchyme
Wall of inner ear
Auditory tube
B
External auditory meatus
Meatal plug
Primitive tympanic cavity


Incus
Meckel's cartilage
Stapes
Styloid process
Stylohyoid ligament
Hyoid bone
A
Ligaments
Incus
Petrous bone
Malleus
Perilymphatic space
Wall of inner ear
Oval window
Malleus
Stapes
Eardrum
Ectomesenchyme
Tympanic cavity
B
Ectodermal epithelium
Endodermal epithelium


Auricular hillocks
A
B
C
D
Cymba conchae
Helix
Concha
Antihelix
Tragus
Antitragus
1
2
3
4
5
6

Vnitřní ucho – *cévní zásobení*

Tepny: **a. basilaris** → a. cerebelli inf. ant. → **a. labyrinthi**

Žíly:

- vv. labyrinthi → sinus petrosus inf.
- v. aqueductus vestibuli, v. aqueductus cochleae → v. jugularis int.

Míza: mízu nahrazuje endolymfa a perilymfa

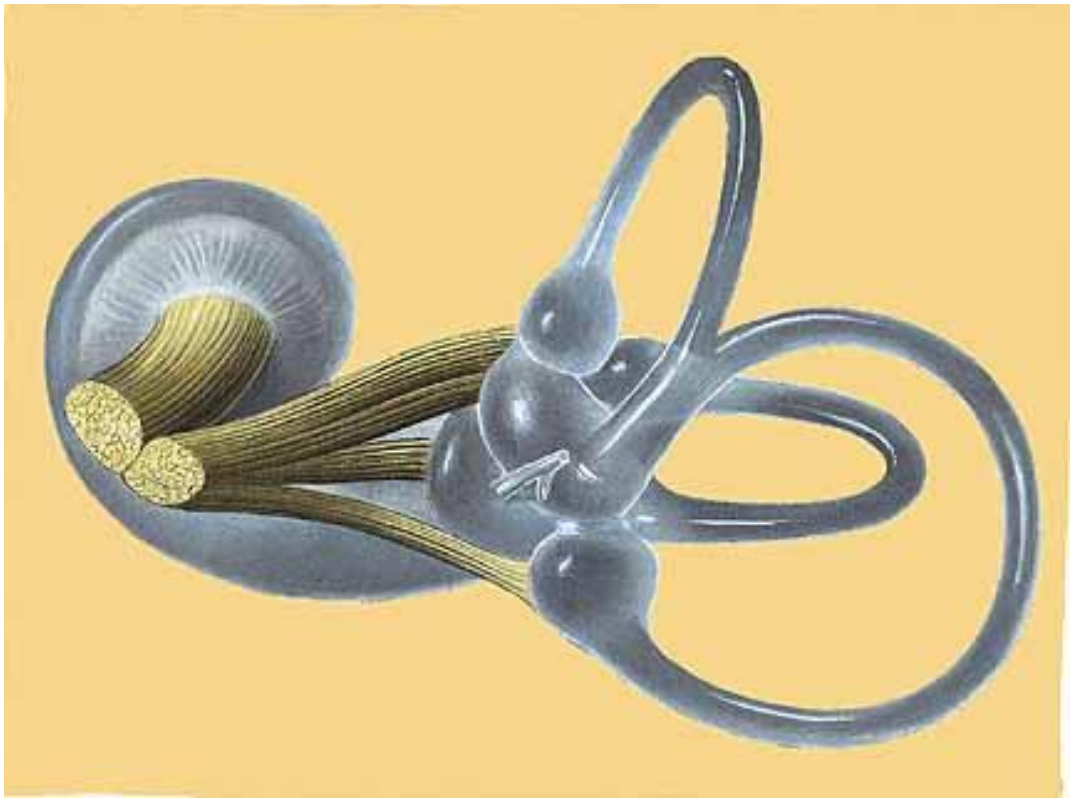
Vnitřní ucho – *nervy*

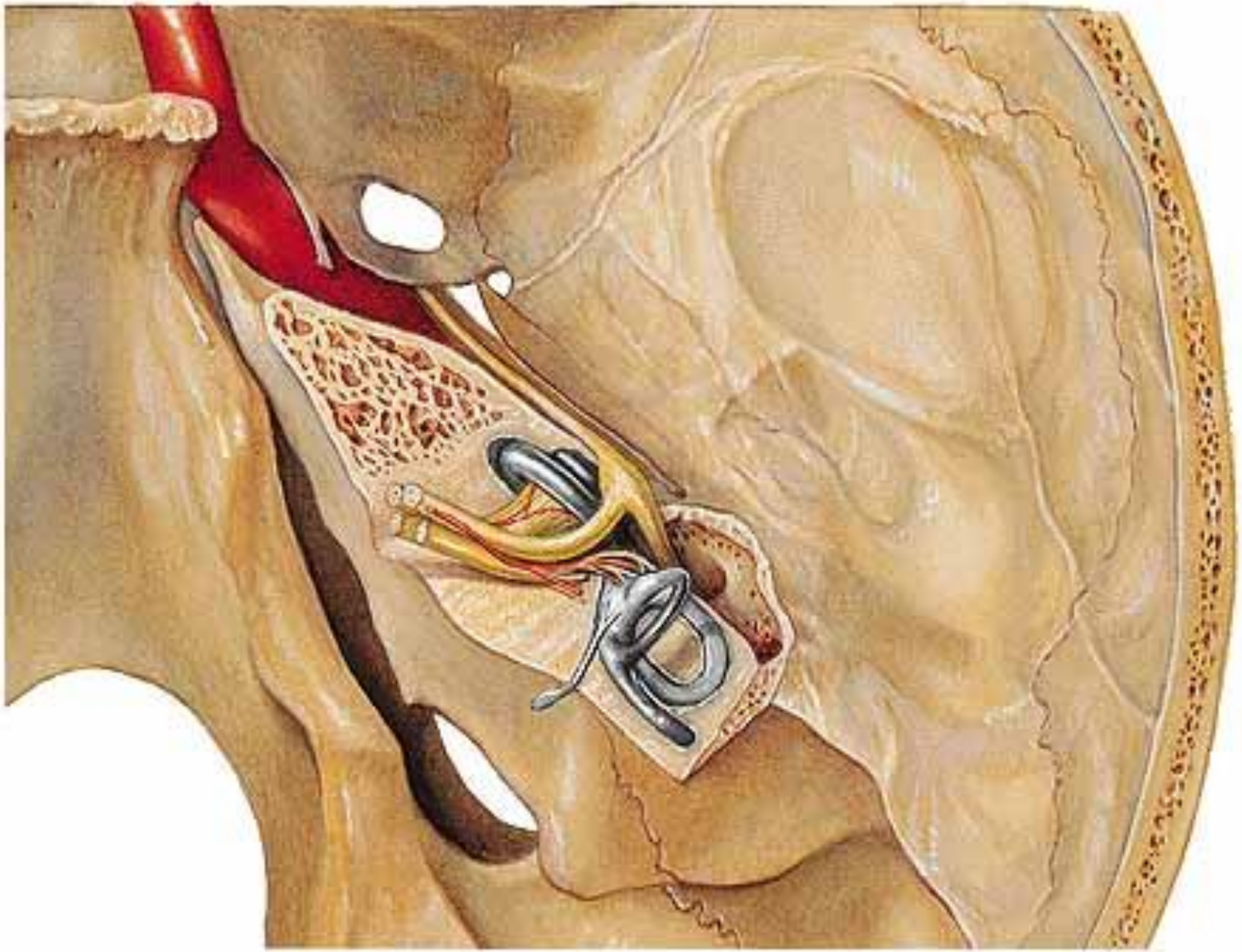
Nervus vestibularis – ggl. vestibulare *Scarpae*

- pars superior
  - n. utriculoampullaris
- pars inferior
  - n. saccularis
  - n. ampullaris posterior

Nervus cochlearis – ggl. cochleare *Corti*

bipolární neurony



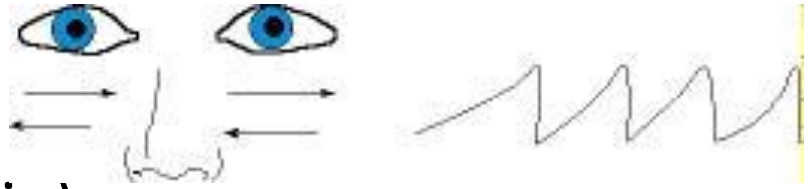


VIII. - Nervus vestibulocochlearis

dráždění / obrna

- porucha slyšení (= hypacusis → anacusis)
  - hluchota (= surditas)

- ušní šelesty (= tinnitus) – hučení, pískání, zvonění…
- závratě (= vertigo)
- vůlí neovlivnitelné pohyby očí (= nystagmus)
  - pomalá složka – silnější strana přetlačuje slabší
  - rychlá složka – kompenzační pohyb zpět – podle ní se popisuje směr nystagmu



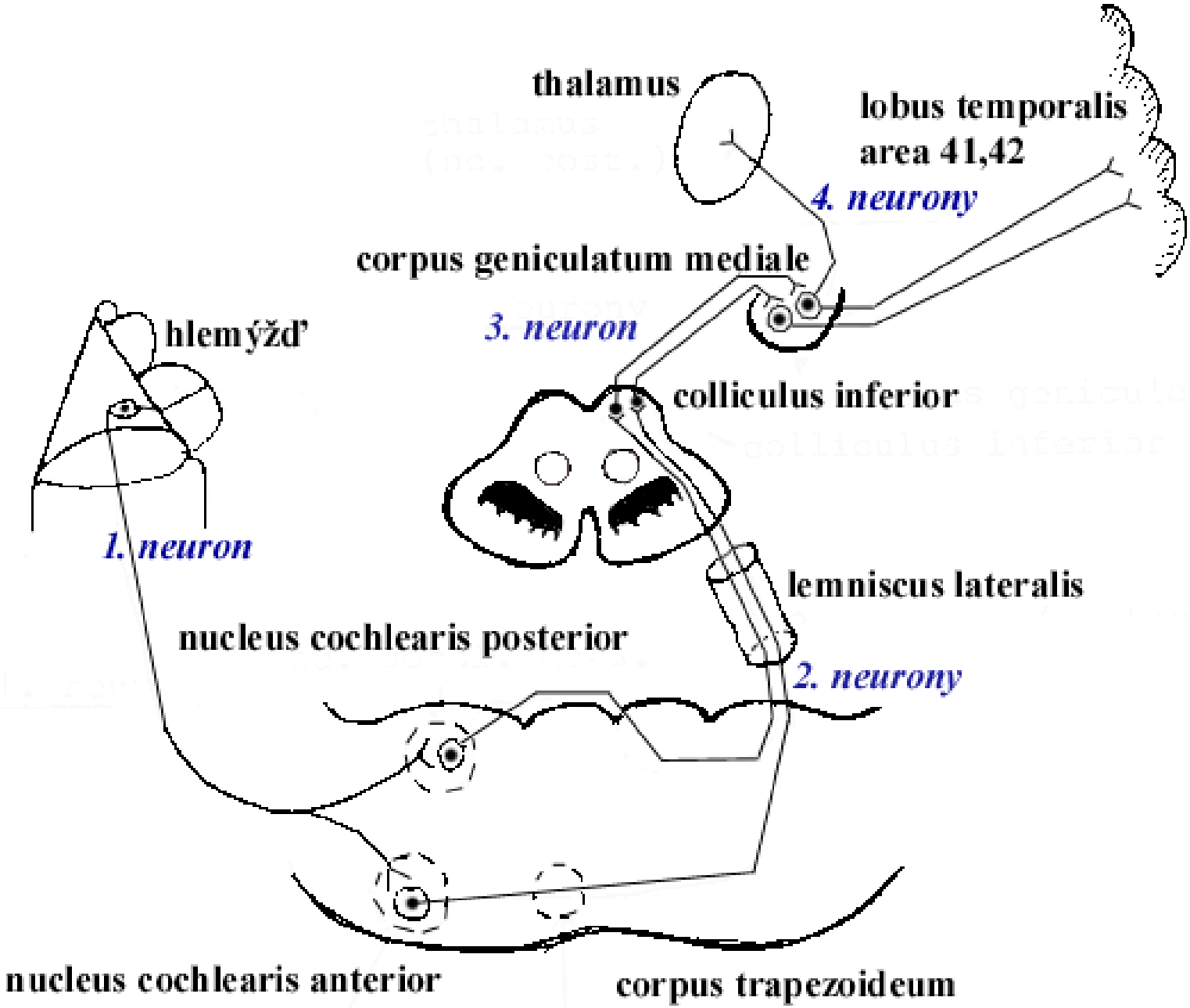
- poruchy stoje a chůze (= ataxie)

Sluchová dráha I.

- Projekční → Vzestupná → Senzorická
- 4 – neuronová
- zkřížená i nezkřížená dráha

1. neuron:

bipolární buňka v ganglion cochleare *Corti* ve tvaru spirály ➔ n. cochlearis ➔ n. VIII ➔ dráha se dělí na 2 části do nuclei cochleares ant. + post.


thalamus
lobus temporalis
area 41,42
4. neurony
corpus geniculatum mediale
3. neuron
hlemýžď
colliculus inferior
1. neuron
lemniscus lateralis
nucleus cochlearis posterior
2. neurony
nucleus cochlearis anterior
corpus trapezoideum

Sluchová dráha II.

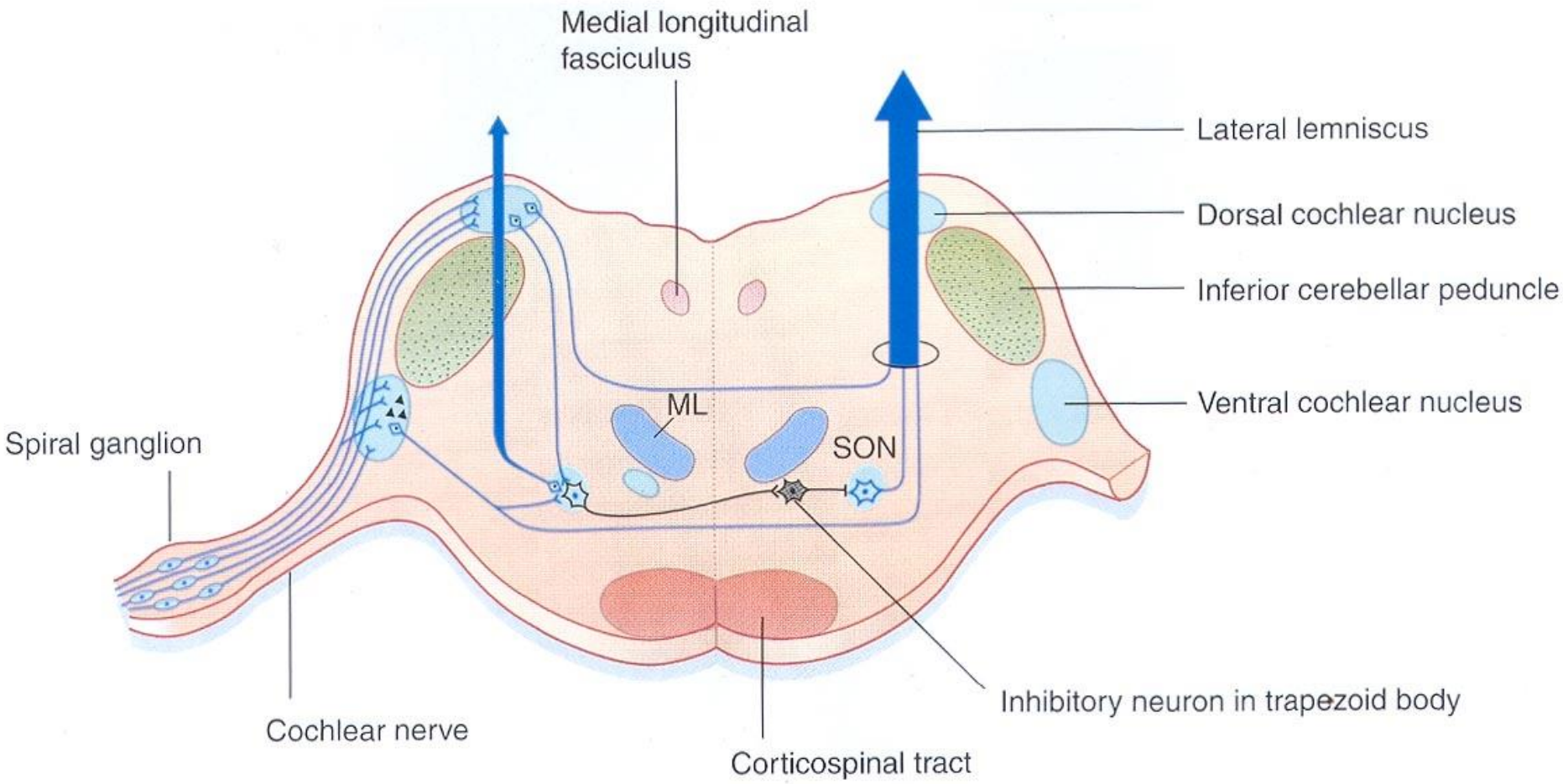
2. neuron: *pons*

buňky v nucleus cochlearis posterior (výška tónů) et anterior (intenzita tónů) – odděleny pedunculus cerebellaris inferior ➔ křížení ➔ lemniscus lateralis ➔ colliculus inferior

odbočka:

nucleus olivaris superior (← kontralaterální je inhibováno z ncl. v corpus trapezoideum) ➔ určení prostorové orientace sluchu

Sluchová dráha



Sluchová dráha III.

3. neuron: *mesencephalon*

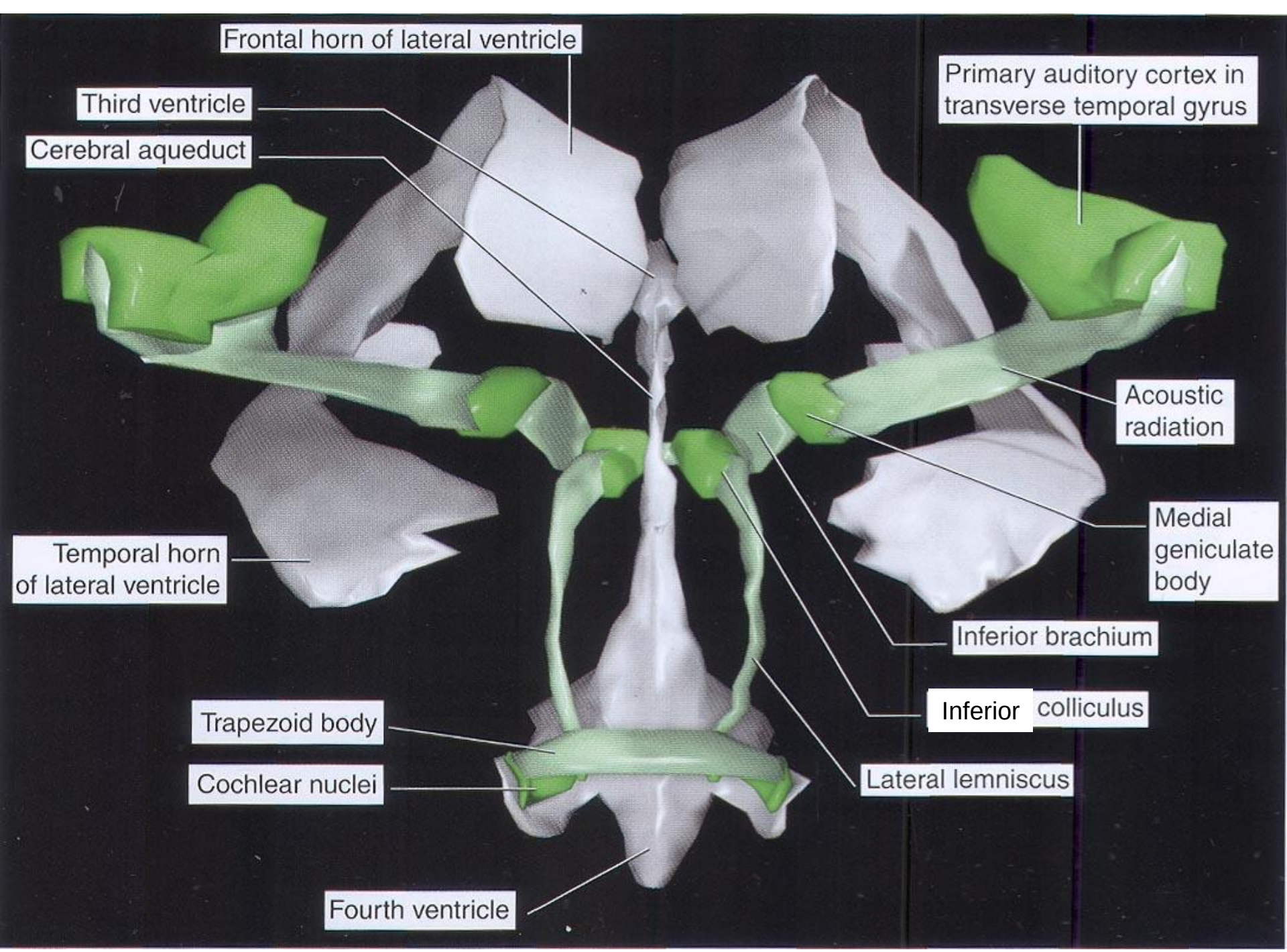
buňky v colliculus inferior ➔ brachium coll.inf.

tonotopické uspořádání

commissura colliculi inferioris

4. neuron: *diencephalon - metathalamus*

buňky v corpus geniculatum mediale ➔ lobus temporalis - gyrus temporalis transversus Heschli, area 41, 42


Frontal horn of lateral ventricle
Third ventricle
Cerebral aqueduct
Primary auditory cortex in transverse temporal gyrus
Acoustic radiation
Medial geniculate body
Temporal horn of lateral ventricle
Inferior brachium
Inferior colliculus
Trapezoid body
Cochlear nuclei
Lateral lemniscus
Fourth ventricle

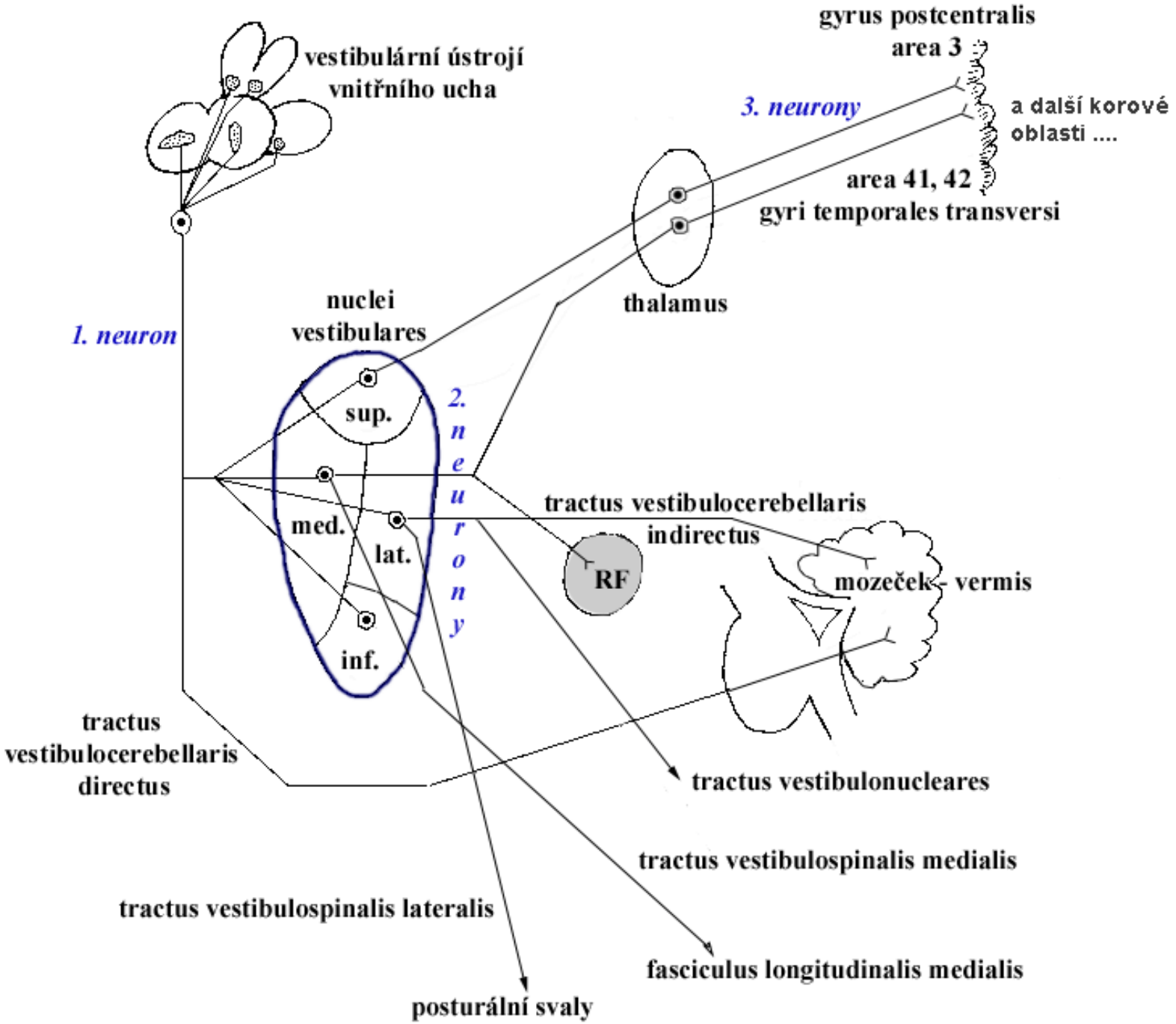
Rovnovážná dráha I.

- Projekční → Vzestupné → Senzorické
- 3-neuronová, zkřížená dráha

1. neuron: bipolární buňka ganglion vestibulare *Scarpae* ➔ n. vestibularis ➔ n. VIII

- část vláken jde jako tractus vestibulocerebellaris directus bez přepojení do mozečku

2. neuron: buňky nuclei vestibulares pontis ➔ axony do různých struktur


gyrus postcentralis
area 3
vestibulární ústrojí
vnitřního ucha
3. neurony
a další korové
oblasti ....
area 41, 42
gyri temporales transversi
thalamus
nuclei
vestibulares
1. neuron
sup.
2. neurony
med.
lat.
inf.
tractus vestibulocerebellaris
indirectus
RF
mozeček - vermis
tractus
vestibulocerebellaris
directus
tractus vestibulonucleares
tractus vestibulospinalis medialis
tractus vestibulospinalis lateralis
fasciculus longitudinalis medialis
posturální svaly

Rovnovážná dráha II. – *kam?*

- mozková kůra
- mozeček
- RF → facilitační descendentní systém
- mícha
- jádra okohybných svalů
  - přes paramediánní pontinní RF
  - *reflex hlava-oko a další vestibulární reflexy*

Rovnovážná dráha III. – *do kůry*

3. neuron: buňky nuclei ventrales thalami ➔ mozková kůra

- lobus parietalis - gyrus postcentralis (area 2) – *primární kůra*
- parieto-inzulární kůra (gyrus insularis longus) + lobus temporalis - gyrus temporalis transversus *Heschli* (area 41,42)
- …a další korové oblasti

Rovnovážná dráha III. – *do mozečku*

- Tractus vestibulocerebellaris directus

vestibulum ➔ corpus juxtarestiforme (v pedunculus cerebel. inf.) ➔ nodulus + uvula *(ipsilat.)*

- Tractus vestibulocerebellaris indirectus

vestibulum ➔ ncl. vestibulares ➔ corpus juxtarestiforme (v pedunculus cerebel. inf.) ➔ lobulus flocculonodularis + vermis *(bilat.)*

Rovnovážná dráha III. – *do míchy*

- Tractus vestibulospinalis lateralis
- Ncl. vestibularis lat. *Deitersi* (*bilat.*) ➔ tr. vestibulospinalis lateralis ➔ alfa + gama-motoneurony extenzorů (posturální svaly)

- Tractus vestibulospinalis medialis
- Ncl. vestibularis medialis + inferior ➔ fasciculus longitudinalis medialis ➔ interneurony (+ a -) v krční míše

reflex hlava-oči