

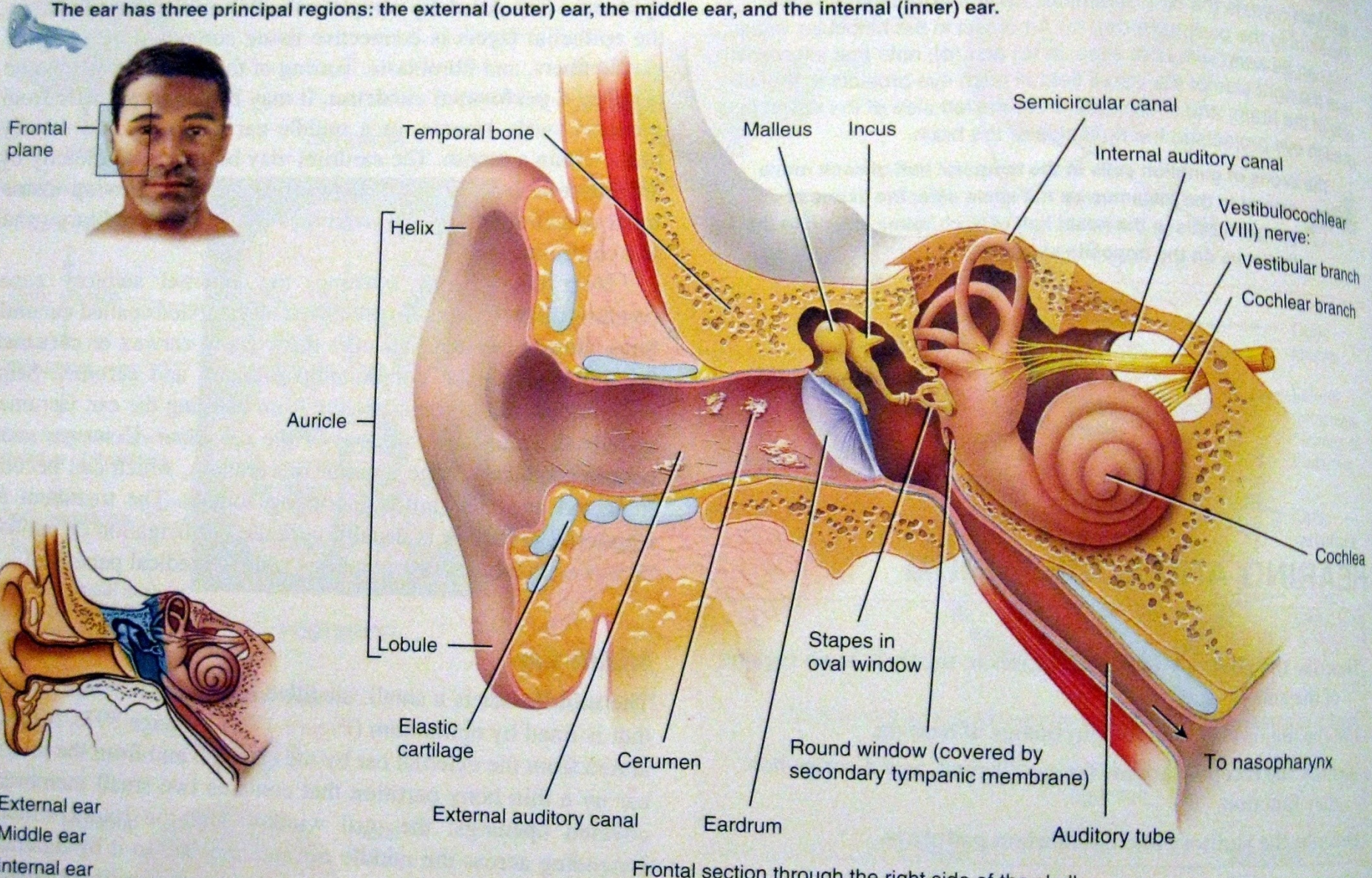
Élettan II.

Látás, hallás

Molnár Péter, Állattani Tanszék

Figure 17.16 Anatomy of the ear. (See Tortora, *A Photographic Atlas of the Human Body, Second Edition*, Figure 9.4a.)

The ear has three principal regions: the external (outer) ear, the middle ear, and the internal (inner) ear.



Frontal section through the right side of the skull showing the three principal regions of the ear

To which structure of the external ear does the malleus of the middle ear attach?

Gyönybagoly (*Tyto alba*) tájékozódása

Hangforrás lokalizációja 1-2 fok pontossággal (teljesen sötétben is képes vadászni)

Mi alapján?

Beérkező jelek összehasonlítása (2 „fül”)

1. Hangerősség
2. Hang beérkezési/végződési latencia
3. Hanghullám fázisdifferenciája

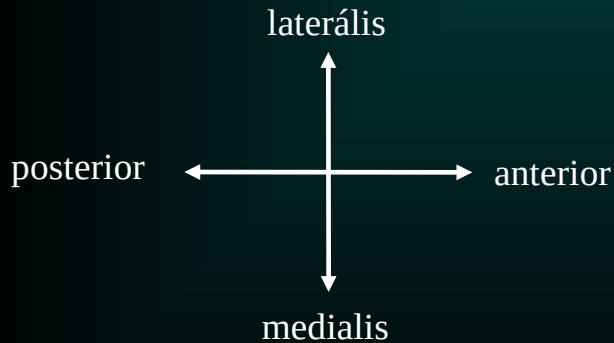


Hallójáratba helyezett hangszóró
10-80 mikrosec fáziskülönbségű hangok
Merre orientál a madár?

Bagoly előtti tér reprezentációja

Hallási topografikus térkép

Specifikusan érzékeny
Neuronok területei
Számok a középagy
Mélységi reprezentációi



Horizontális metszet:

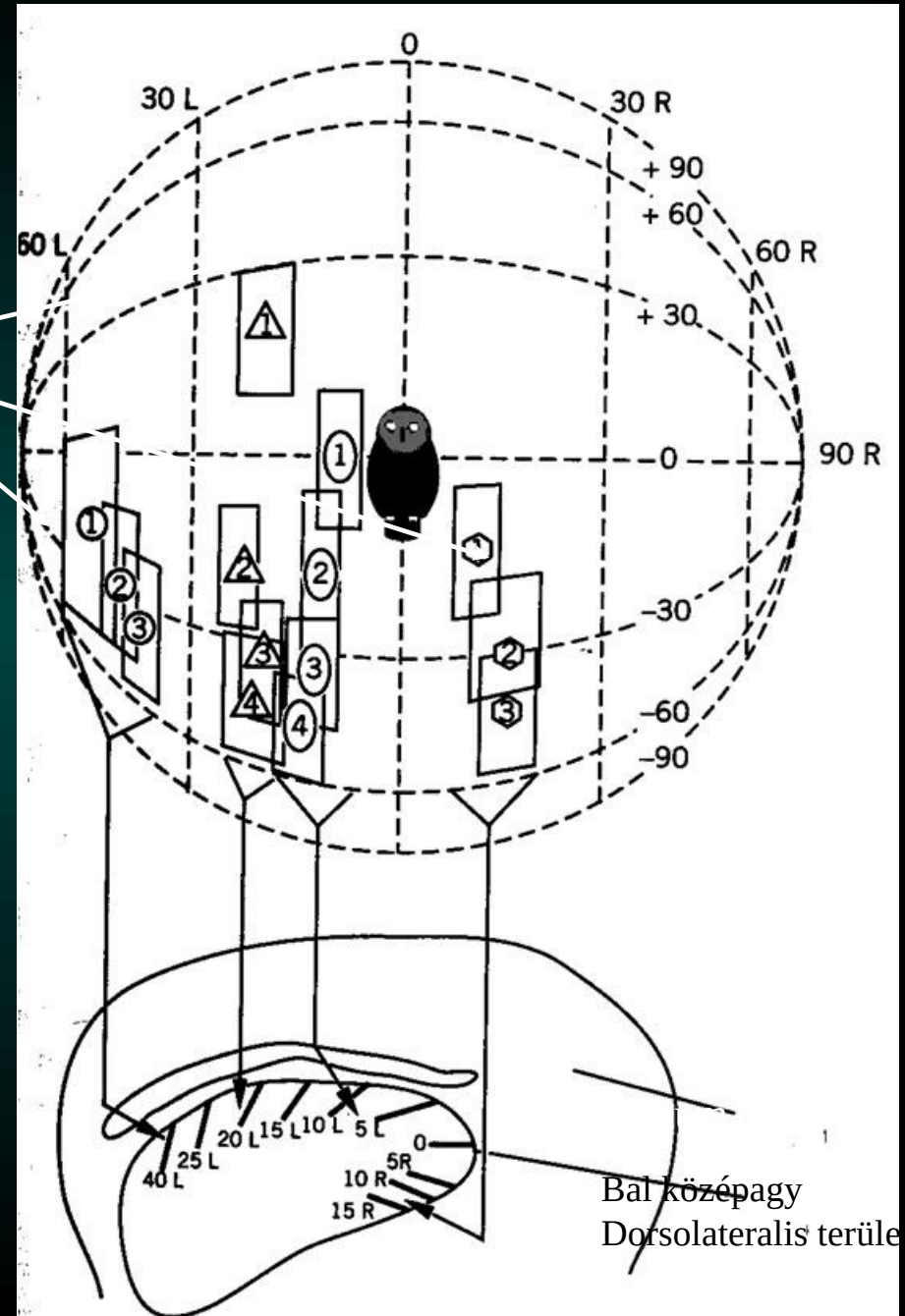
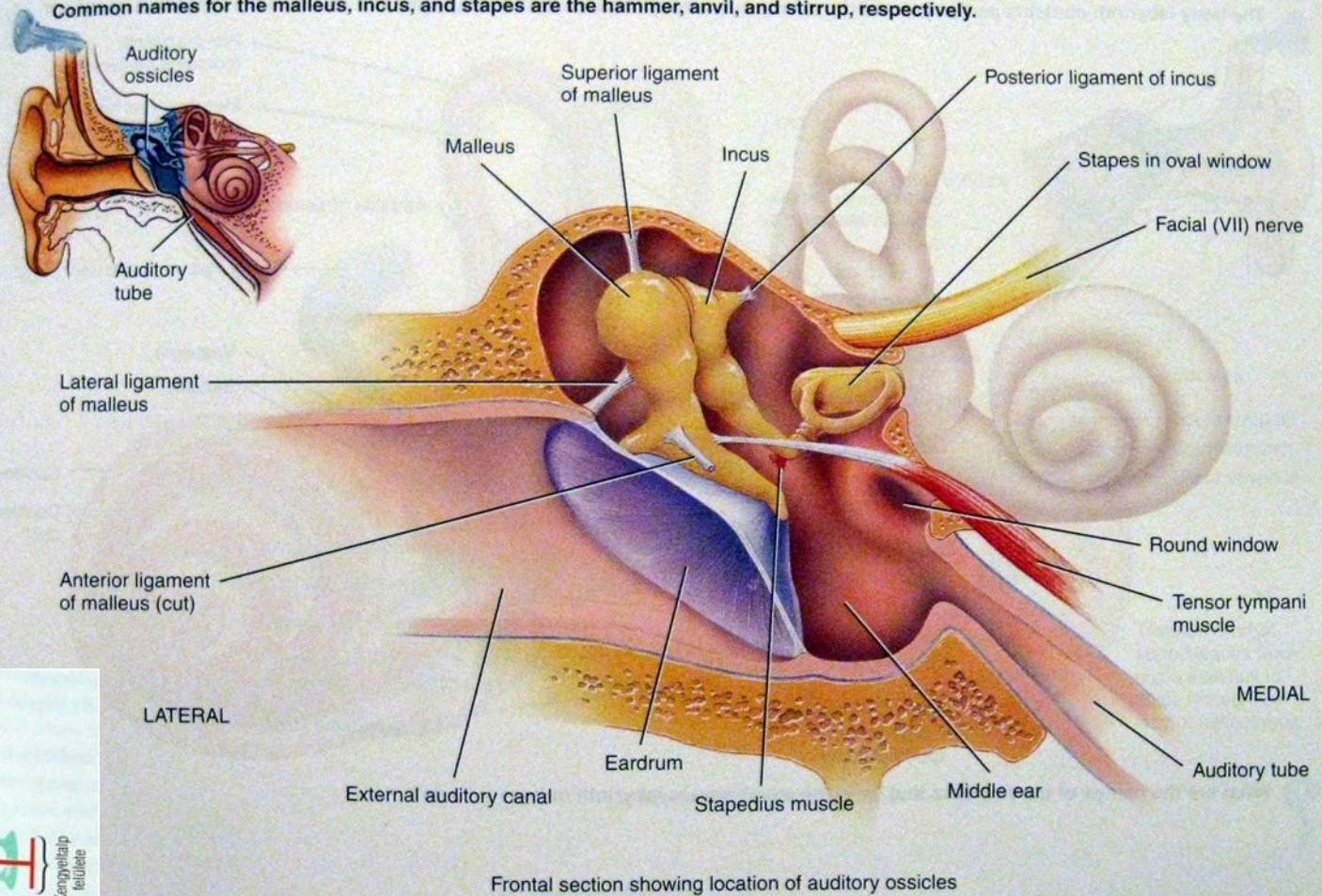
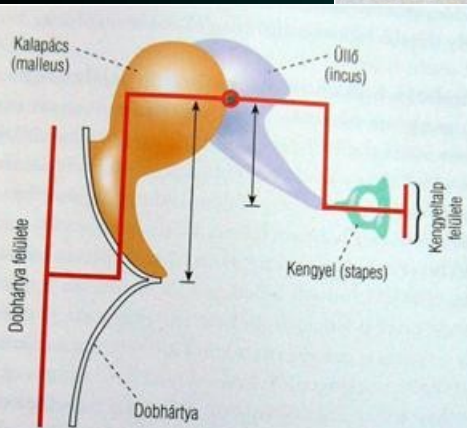


Figure 17.17 The right middle ear containing the auditory ossicles. (See Tortora, *A Photographic Atlas of the Human Body, Second Edition*, Figure 3.14.)

Common names for the malleus, incus, and stapes are the hammer, anvil, and stirrup, respectively.



Frontal section showing location of auditory ossicles
structures separate the middle ear from the internal ear?

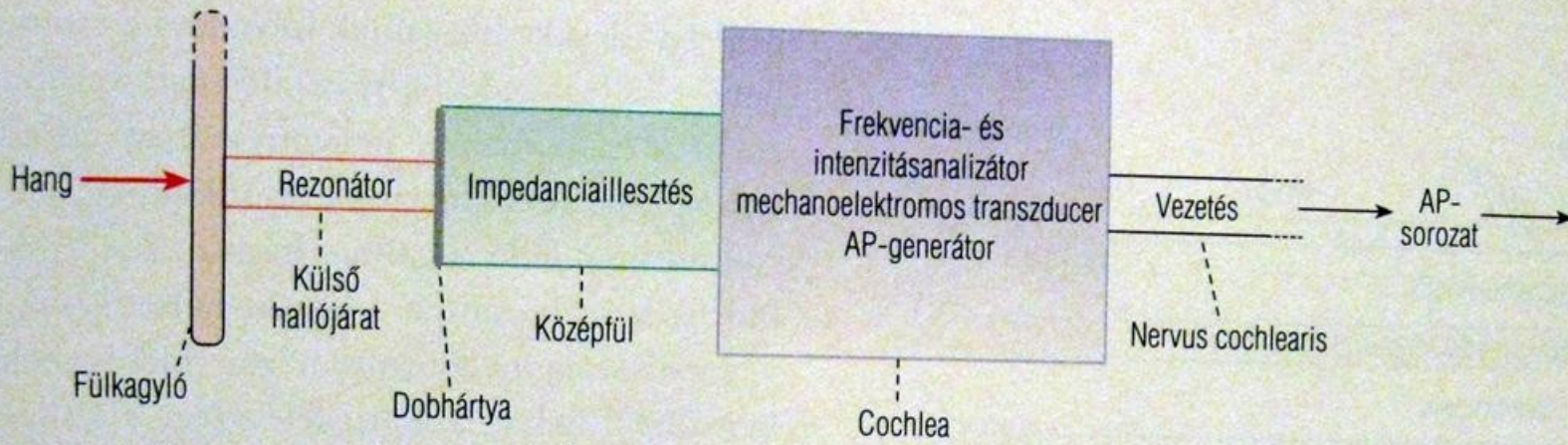


40-4. ábra

A középfül mechanikája: a dobhártya és a hallócsontocskák

Relkin, E. M. (1988): In *Physiology of the Ear*. Szerk. Jahn, A.E., Santos-Sacchi, J. Raven Press, New York alapján]

Az ábrán a mechanikai ekvivalens modellt piros színnel tüntették fel

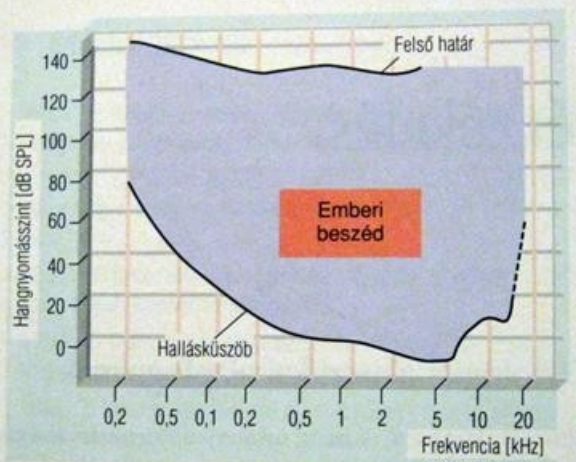


40-3. ábra
Az auditív periféria vázlata

40-1. táblázat

A különböző hangforrásokkal keltett hangok hangnyomásszintje (dB SPL) és ezeknek a 20 µPa referenzszintre vonatkoztatott hangnyomása

Hangforrás	Hangnyomásszint (dB SPL)	20 µPa-ra vonatkoztatott hangnyomás
Referenzszint	0	1
Vidéki csend	20	10
Suttogó beszéd	40	100
Átlagos beszéd	60	1000
Utcai zaj (nagy forgalmú város)	80	10 000
Ipari zaj	100	100 000
Mennydörgés, lövés	120	1 000 000
Repülőgépmotor zaja	140	10 000 000



40-2. ábra
Az emberi hallás frekvencia- és intenzitástartománya

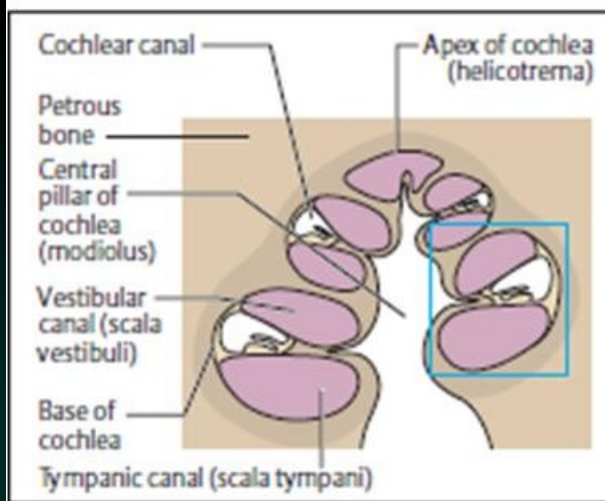


Fig. 15.16 Cross-section through a human cochlea. Apex of the cochlea (helicotrema) with transit from the vestibular canal (scala vestibuli) to the tympanic canal (scala tympani). (Blue box indicates section for Fig. 15.17)

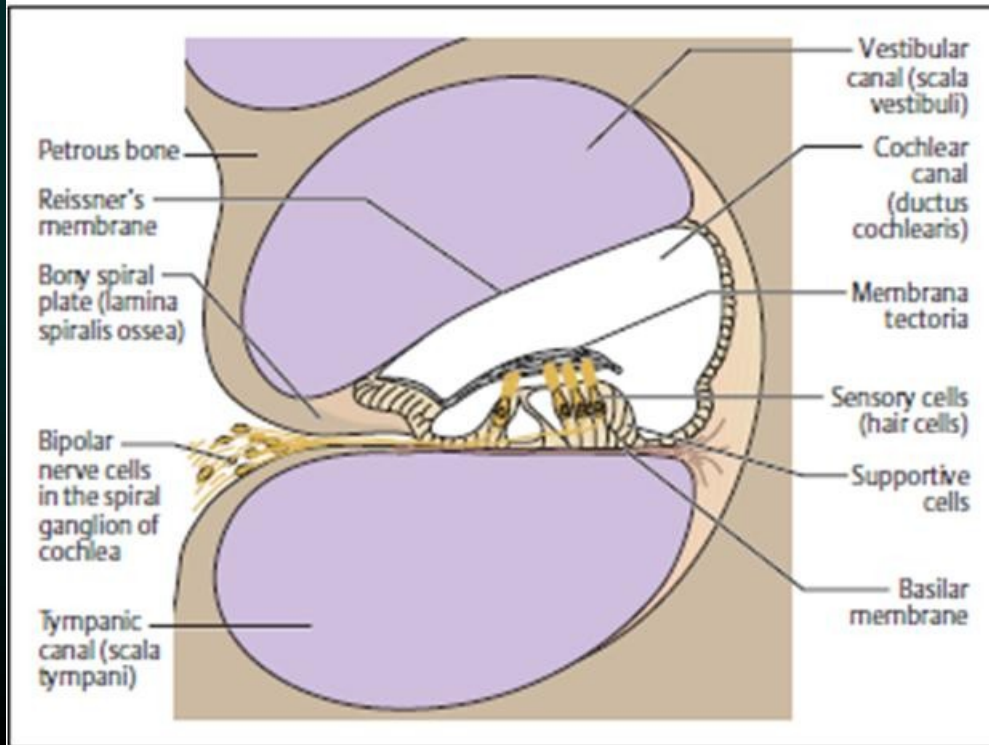
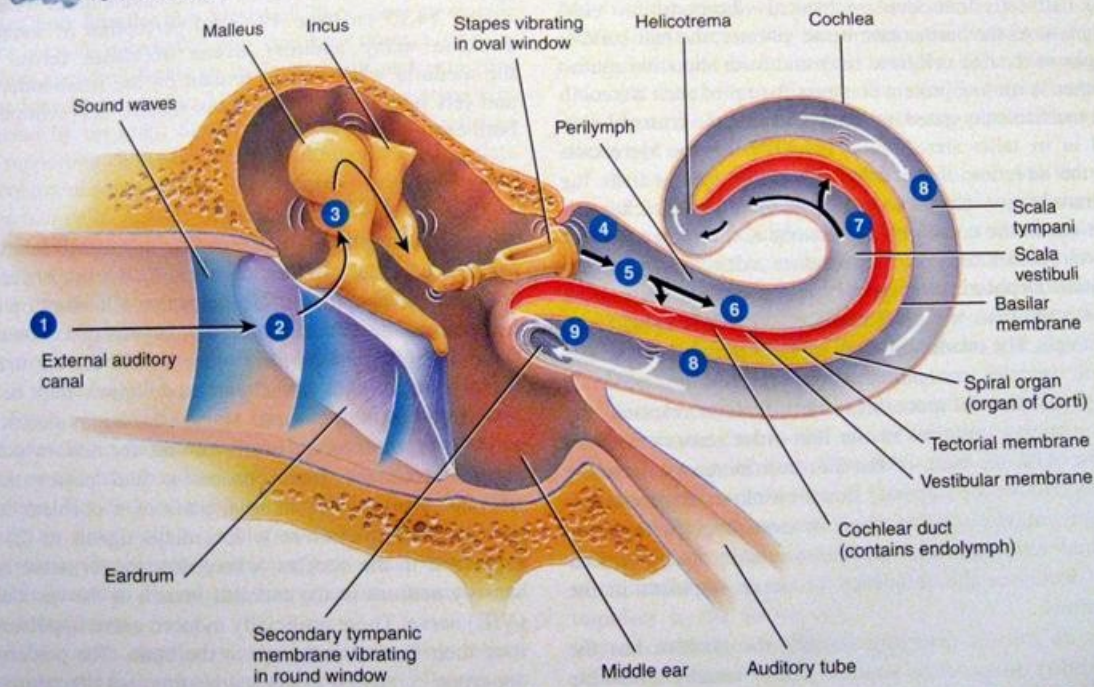


Figure 17.20 Events in the stimulation of auditory receptors in the right ear. The numbers correspond to the events listed in the text. The cochlea has been uncoiled to more easily visualize the transmission of sound waves and their distortion of the vestibular and basilar membranes of the cochlear duct.

Hair cells of the spiral organ (organ of Corti) convert a mechanical vibration (stimulus) into an electrical signal (receptor potential).

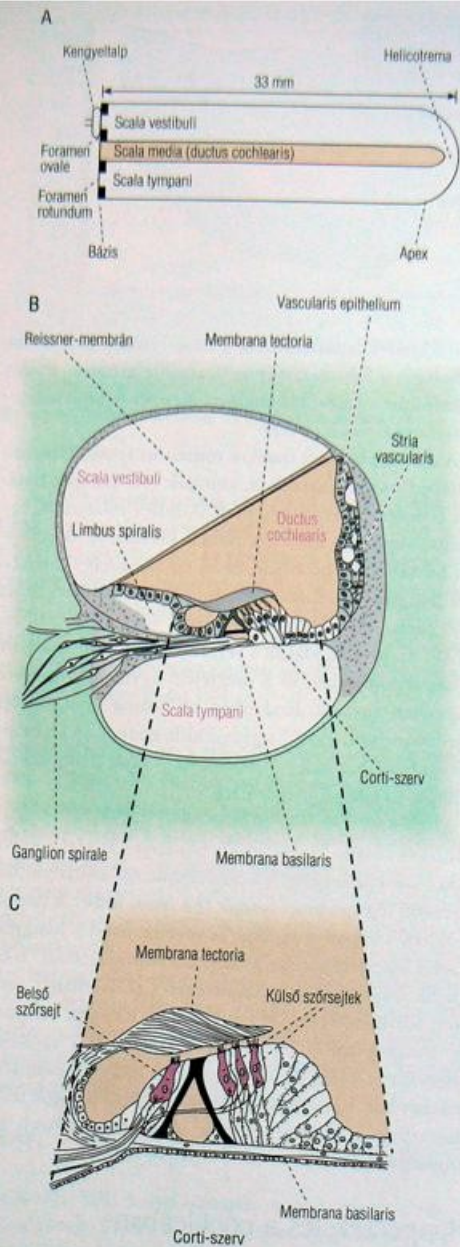


Which part of the basilar membrane vibrates most vigorously in response to high-frequency (high-pitched) sounds?

Physiology of Hearing

The following events are involved in hearing (Figure 17.20):

- 1 The auricle directs sound waves into the external auditory canal.
- 2 When sound waves strike the eardrum, the alternating high- and low-pressure of the air causes the eardrum to vibrate back and forth. The distance it moves, which is very small, depends on the intensity and frequency of the sound waves. The eardrum vibrates slowly in response to low-frequency (low-pitched) sounds and rapidly in response to high-frequency (high-pitched) sounds.
- 3 The central area of the eardrum connects to the malleus, which also starts to vibrate. The vibration is transmitted from the malleus to the incus and then to the stapes.
- 4 As the stapes moves back and forth, it pushes the membrane of the oval window in and out. The oval window vibrates about 20 times more vigorously than the eardrum because the ossicles efficiently transmit small vibrations spread over a large surface area (eardrum) into larger vibrations of a smaller surface (oval window).
- 5 The movement of the oval window sets up fluid pressure waves



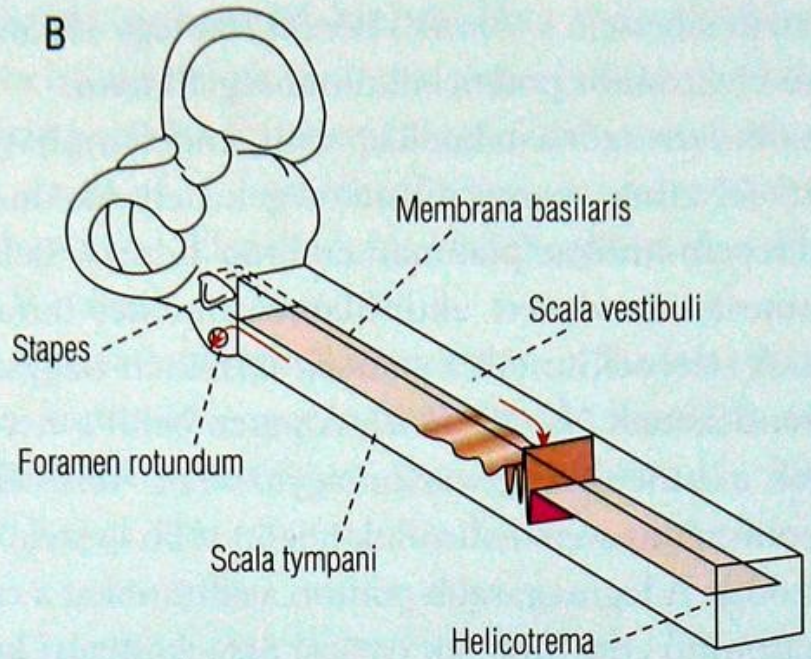
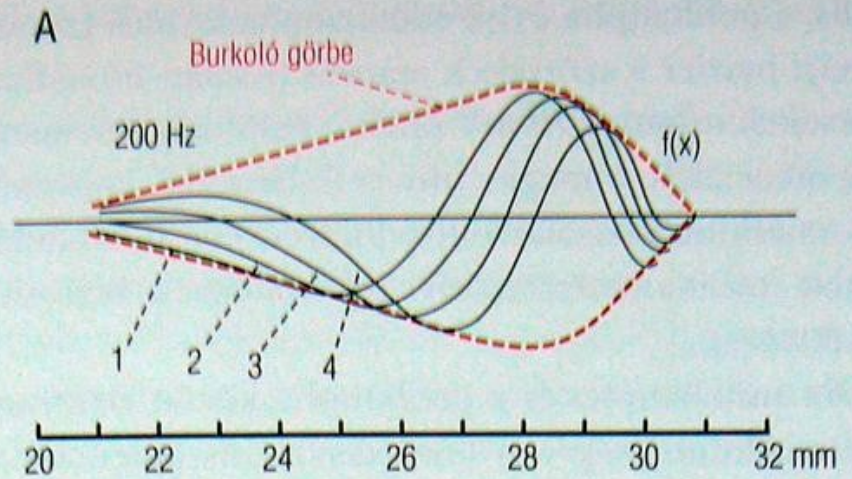
40-5. ábra

A cochlea hosszmetzeti és keresztmetzeti képe

A) A síkban kiterített cochlea hosszmetzeti képe von Békésy, G. (1960): Experiments on Hearing, McGraw-Hill, New York alapján

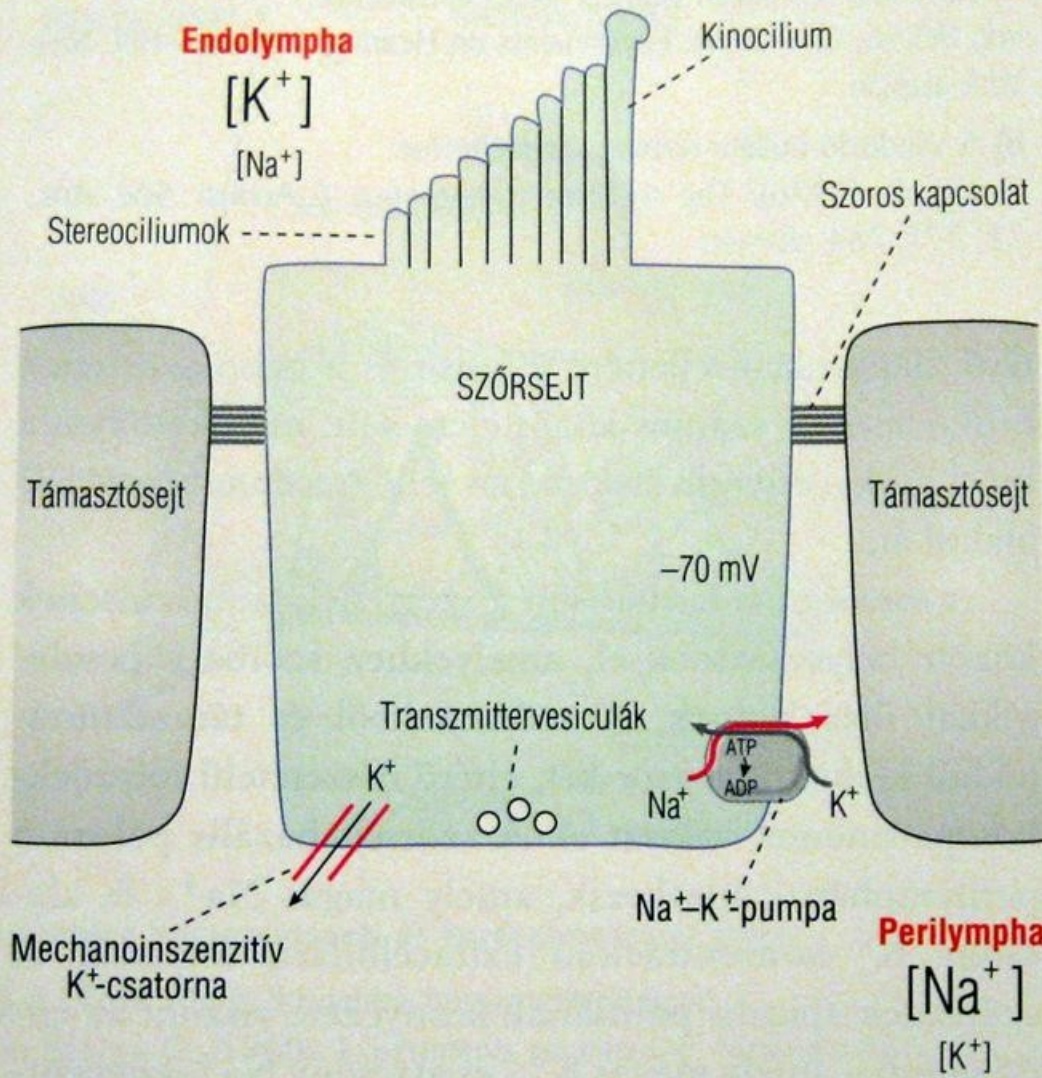
B) A cochlea keresztmetzeti képe

C) A Corti-szerv nagyított ábrázolása



40-7. ábra

A vándorló hullám a cochleában

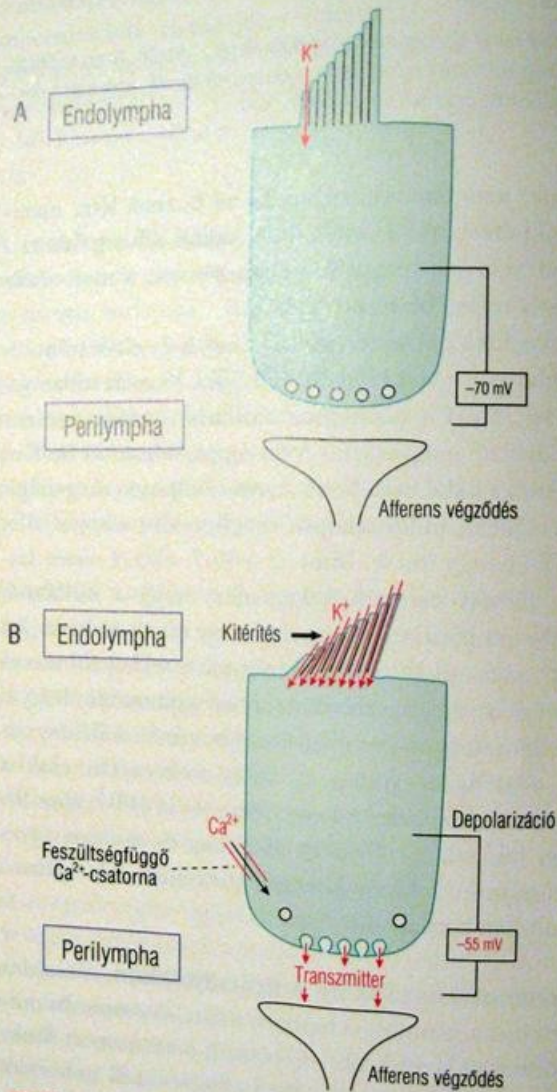


40-8. ábra

A mechanoszenzitív szőrsejt vázlatja

40-9. ábra

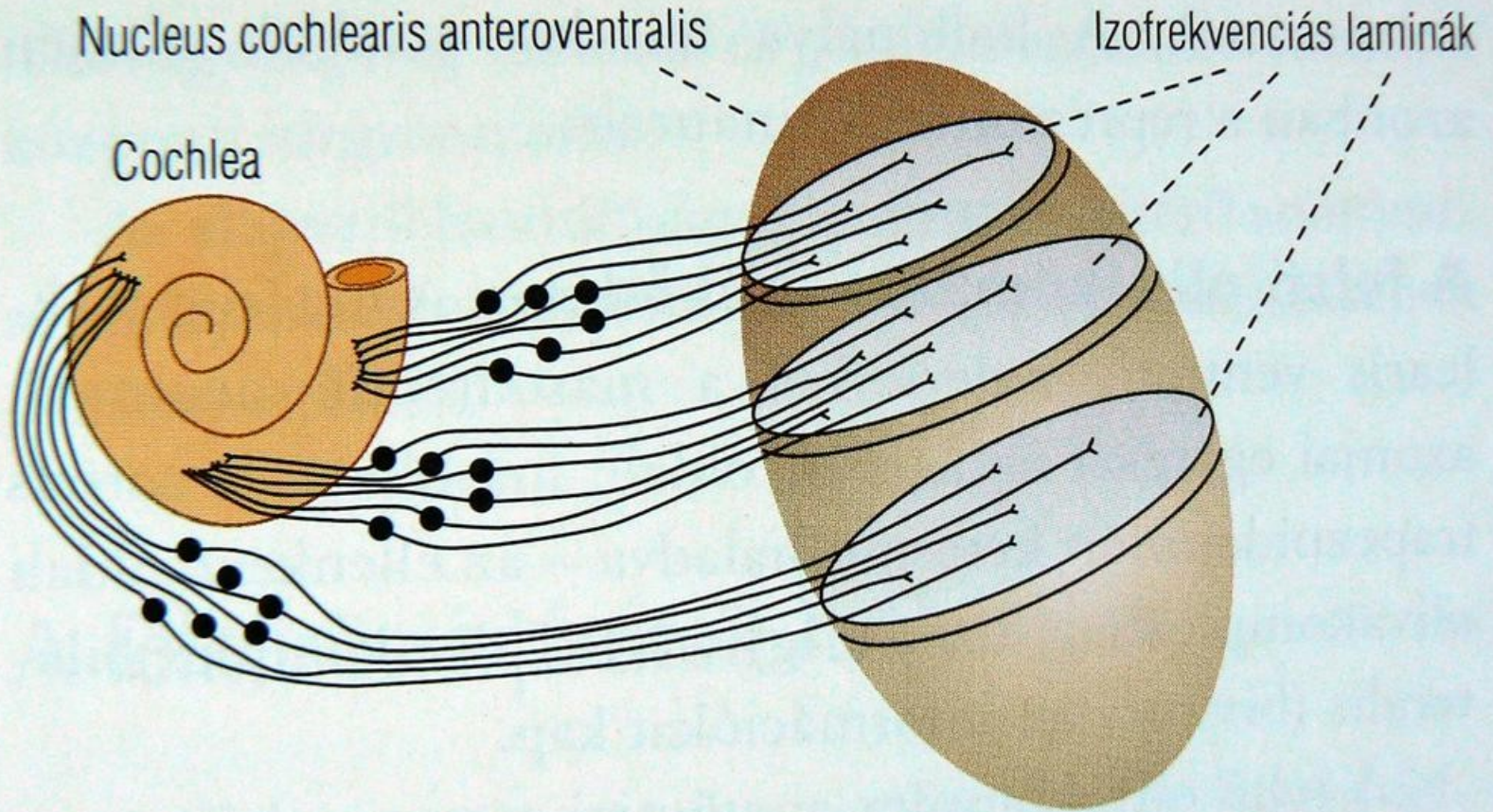
A cochlea folyadékkompartmentjei és az endocochlearis potenciál



40-10. ábra

Mechanoelektromos transzdukción a szőrsejtben

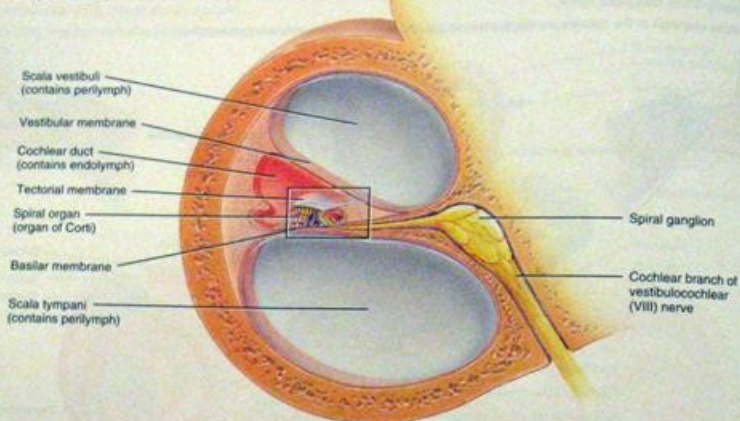
- A) A szőrsejt nyugalmi állapotban
- B) A szőrsejt depolarizációja a stereociliumok kitérésének hatására



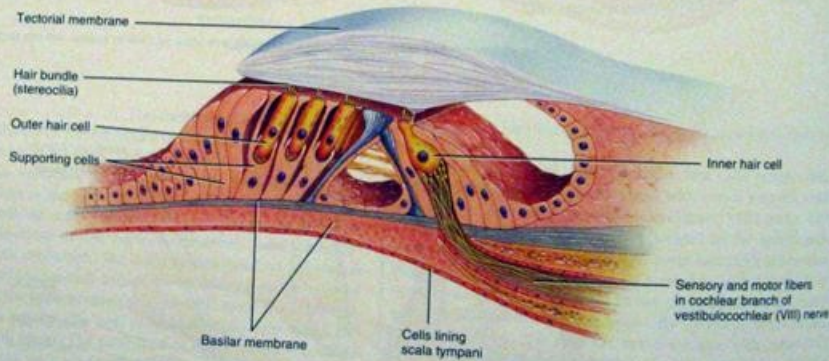
40-13. ábra

Tonotopia az anteroventralis cochlearis magban

Figure 17.19 (continued)

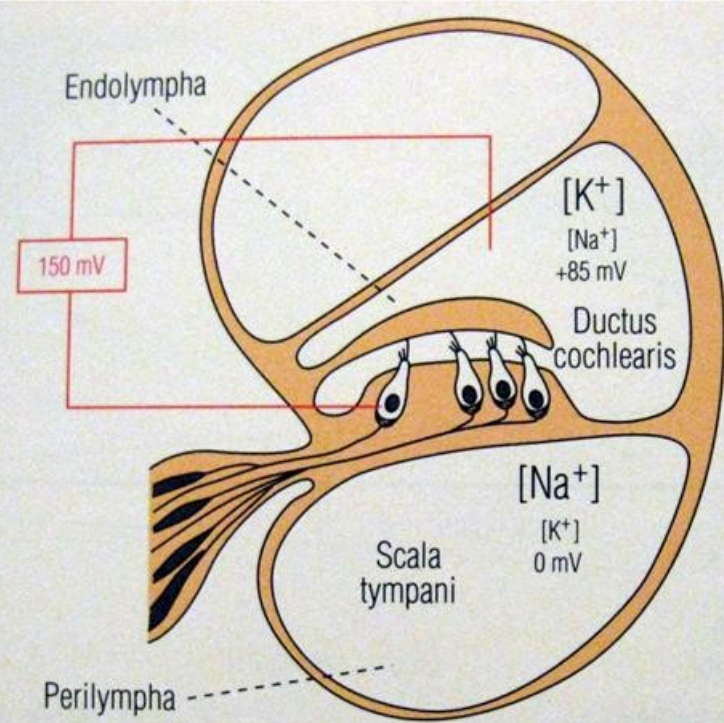


(c) Section through one turn of the cochlea



(d) Enlargement of spiral organ (organ of Corti)

What are the three subdivisions of the bony labyrinth?

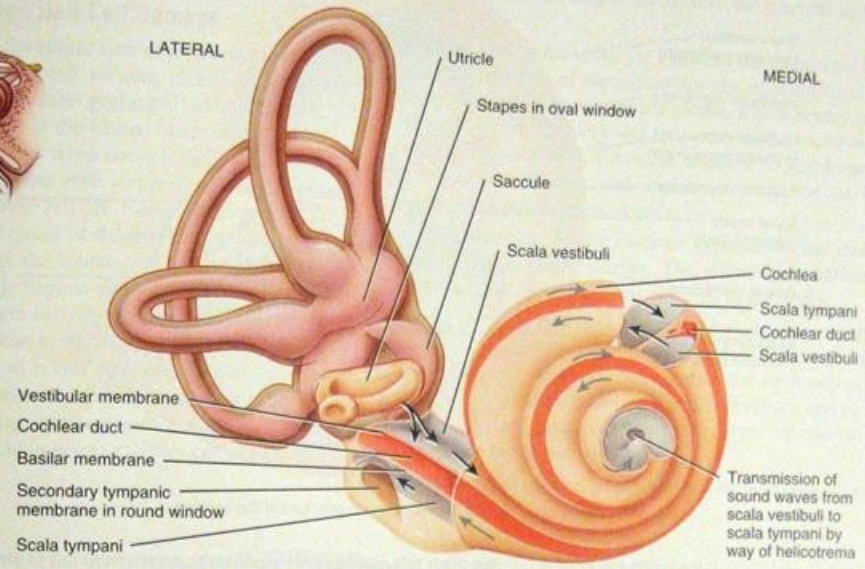
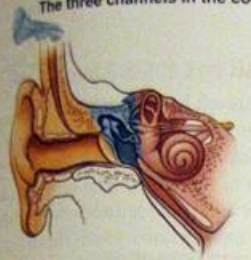


40-9. ábra

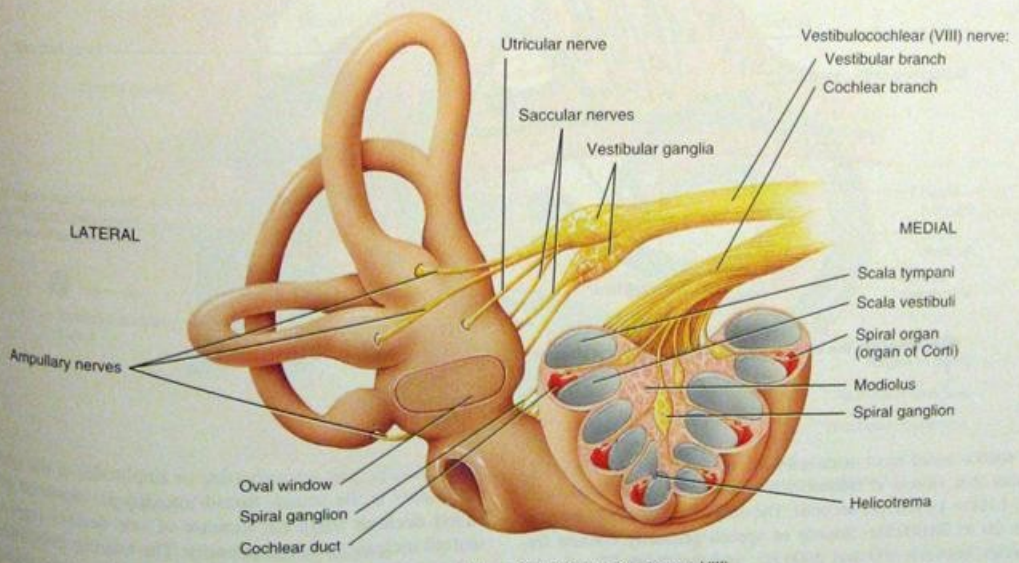
A cochlea folyadékkompartmentjei és az endocochlearis potenciál

Figure 17.19 Semicircular canals, vestibule, and cochlea of the right ear. Note that the cochlea makes nearly three complete turns.

The three channels in the cochlea are the scala vestibuli, the scala tympani, and the cochlear duct.



(a) Sections through the cochlea

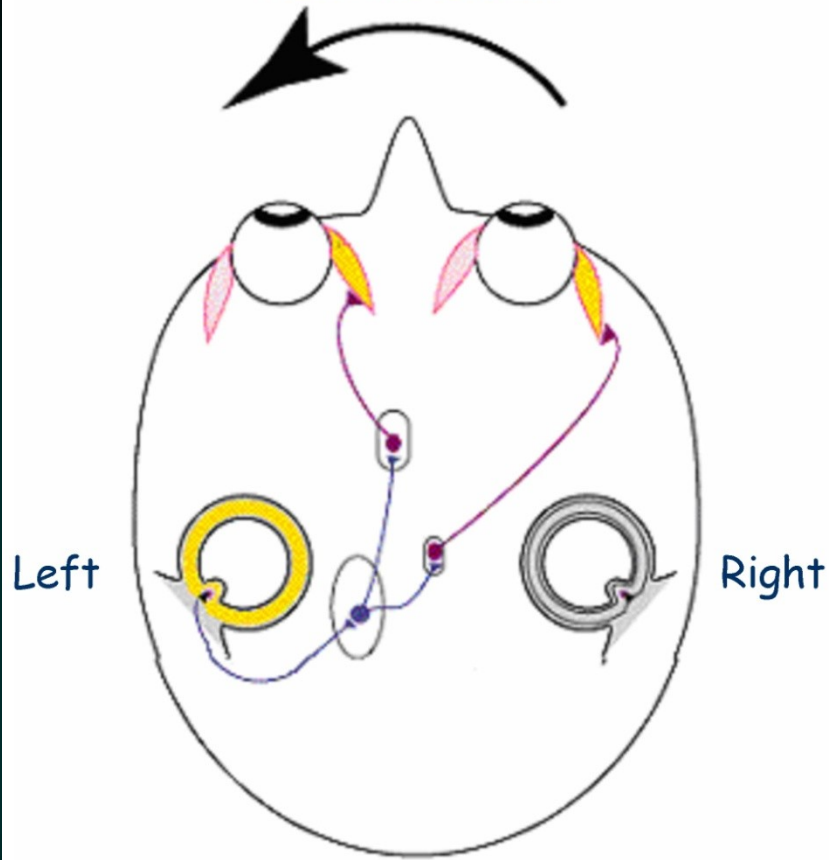


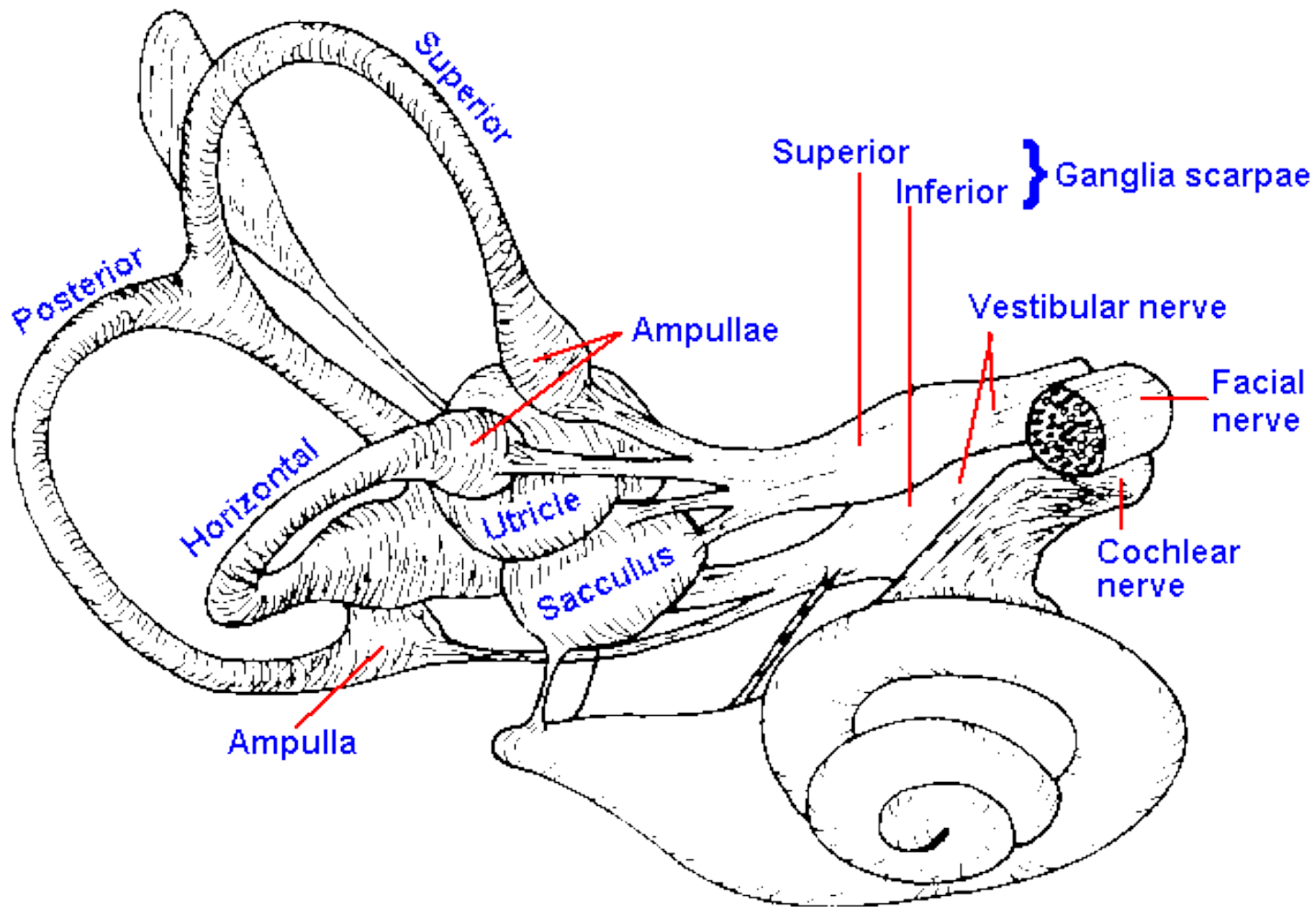
(b) Components of the vestibulocochlear nerve (cranial nerve VIII)

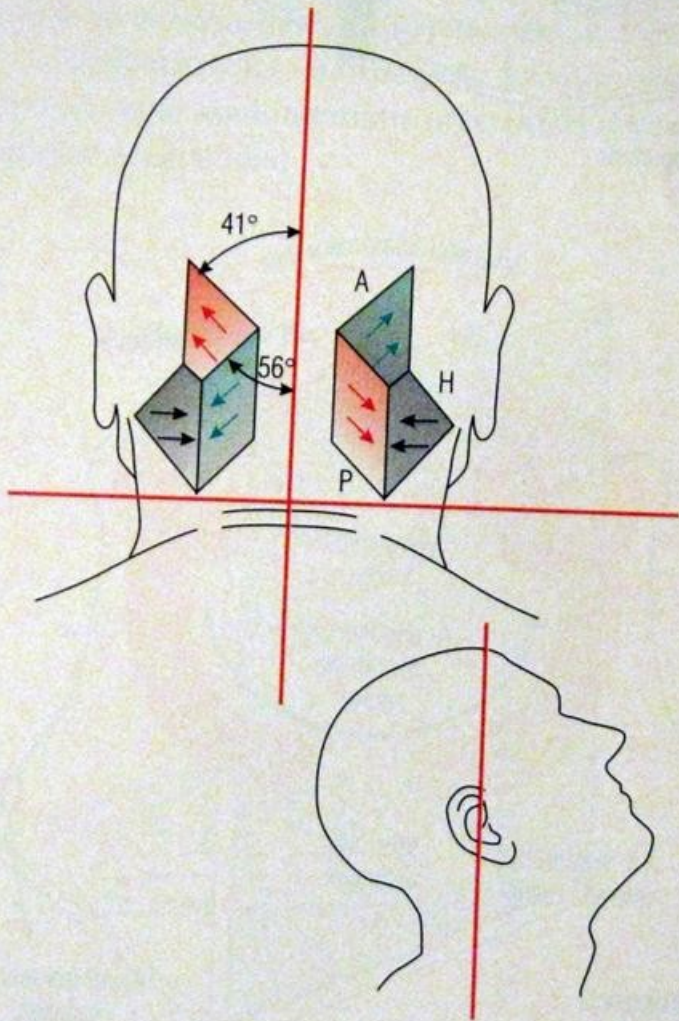
Egyensúly

Vestibuláris szerv

head movement



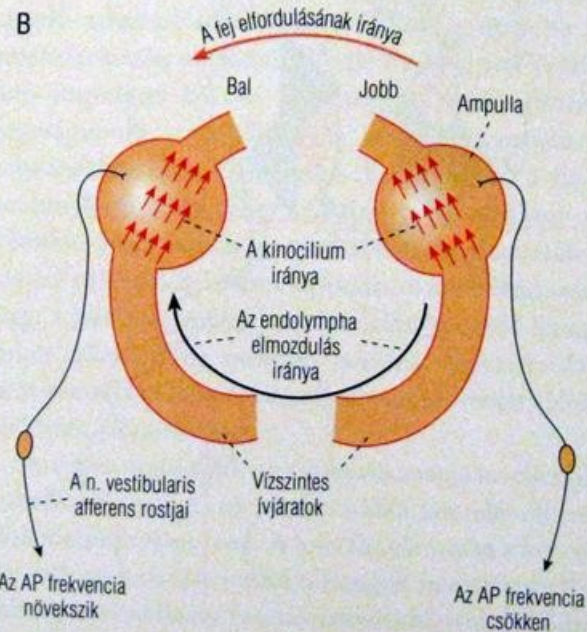
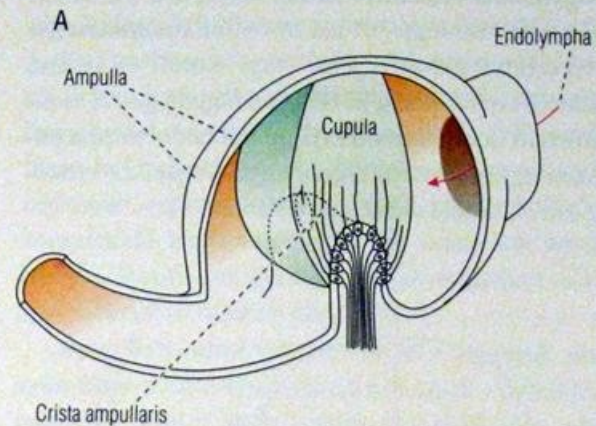




40-14. ábra

A félkörös ívjáratok fejen belüli elhelyezkedésének vázlata

A felső vázlaton a kétoldali ívjáratok síkját ábráztuk. Az egyes ívjáratoknál feltüntetett nyilak a szőrsejteknek az ívjáraton belüli orientációját jelzik, a nyíl hegye a kinociliumok irányába mutat. Az alsó vázlaton a fejen az a helyzet szerepel, amely mellett a két horizontális ívjárat (a felső vázlaton H) valóban vízszintesen, a négy függőleges ívjárat (A és P) valóban függőlegesen fekszik.



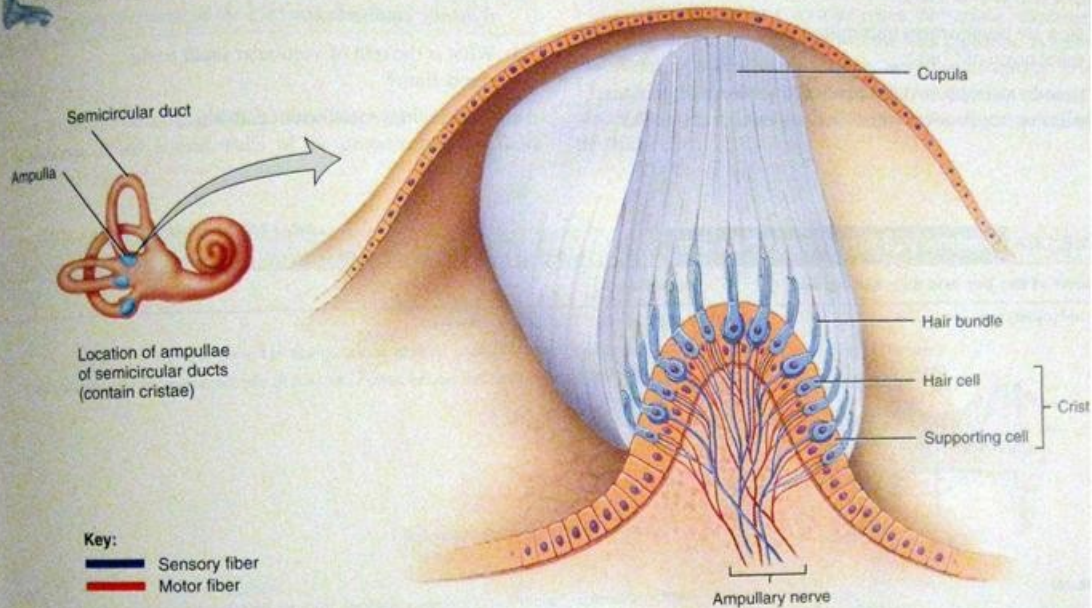
40-15. ábra

Az ampulla szerkezete és a horizontális félkörös ívjárat működése

- A) Az ampulla szerkezete
- B) A horizontális ívjárat receptorainak aktivitásváltozása a fej balra történő forgatásakor

Figure 17.22 Location and structure of the semicircular ducts of the right ear. Both first-order sensory neurons (blue) and motor neurons (red) synapse with the hair cells. The ampullary nerves are branches of the vestibular division of the vestibulocochlear (VIII) nerve.

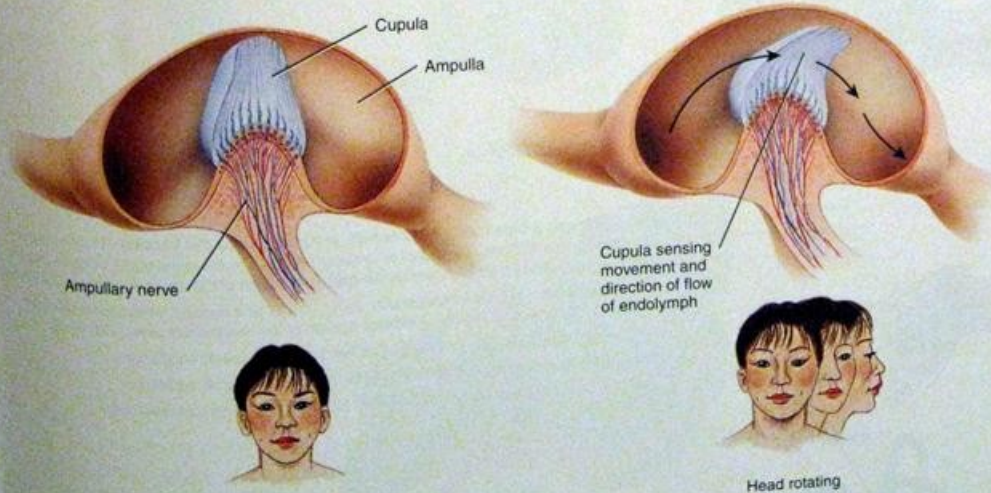
The positions of the semicircular ducts permit detection of rotational movements.



Location of ampullae of semicircular ducts (contain cristae)

Key:
— Sensory fiber
— Motor fiber

(a) Details of a crista



Cupula sensing movement and direction of flow of endolymph

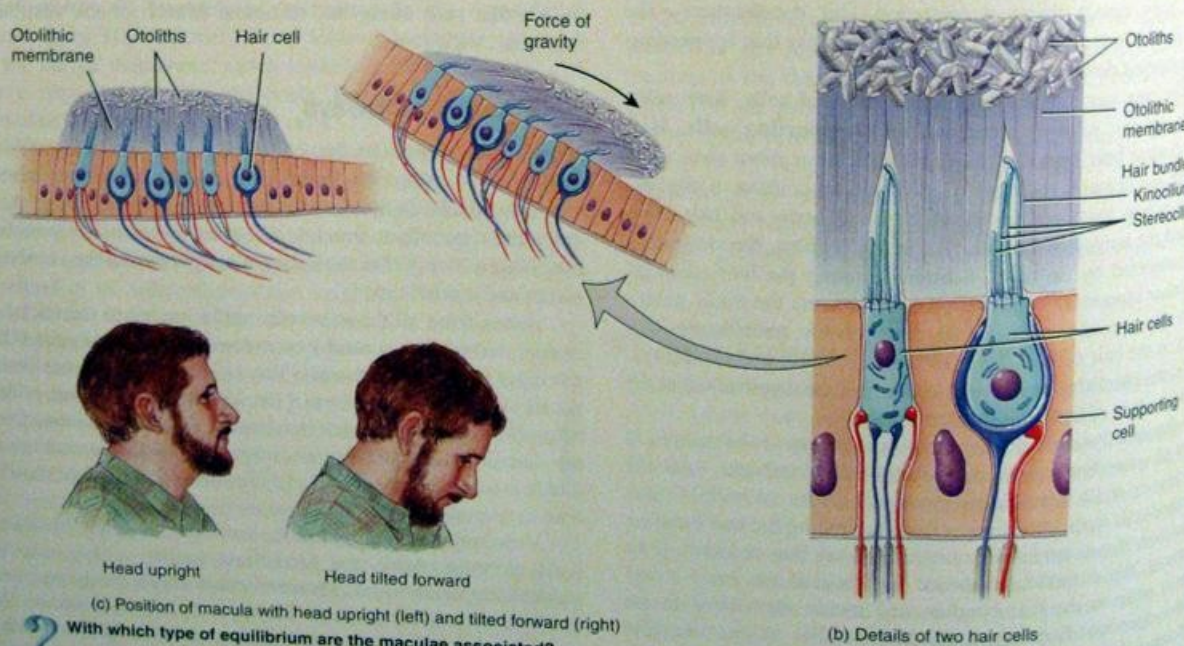
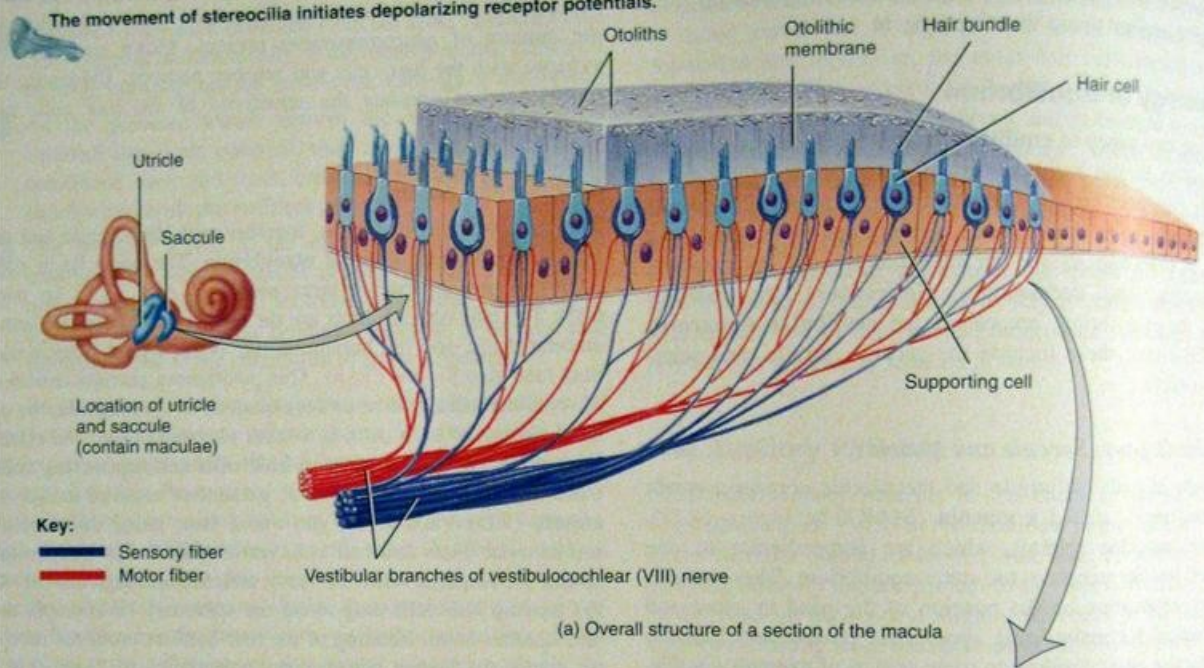
Head in still position

Head rotating

(b) Position of a cupula with the head in the still position (left) and when the head rotates (right)

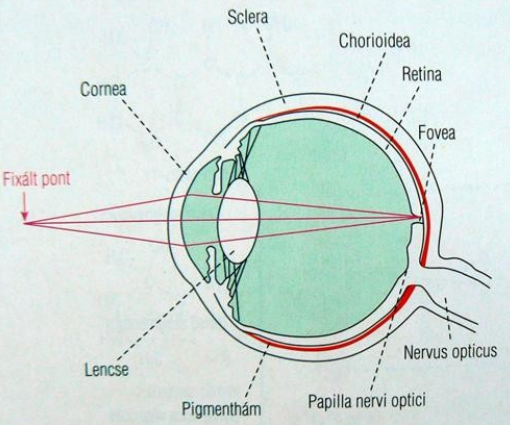
With which type of equilibrium are the semicircular ducts associated?

Figure 17.21 Location and structure of receptors in the maculae of the right ear. Both first-order sensory neurons (blue) and motor neurons (red) synapse with the hair cells.

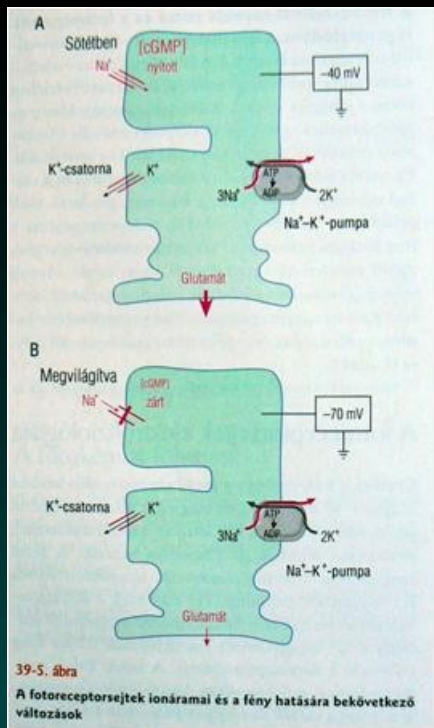


(c) Position of macula with head upright (left) and tilted forward (right)

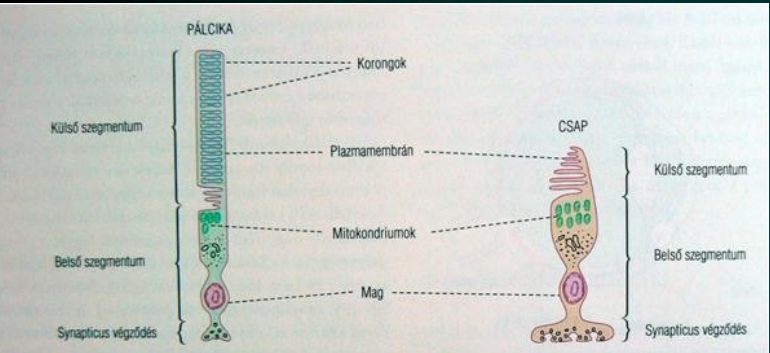
With which type of equilibrium are the maculae associated?



39-1. ábra
A szem vázlata horizontális metszeten

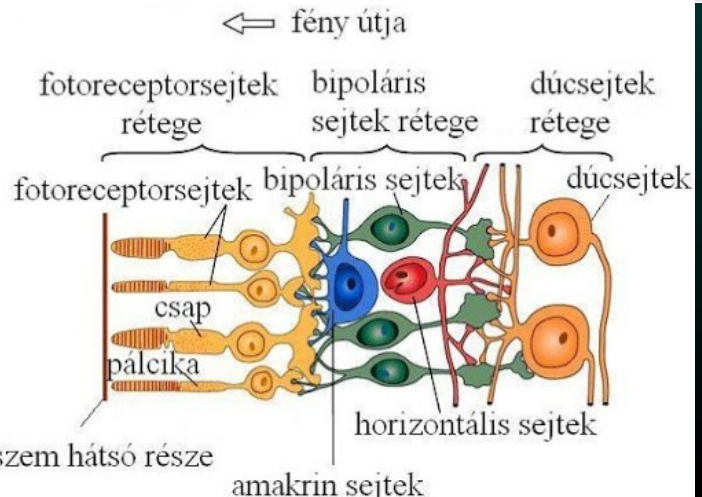
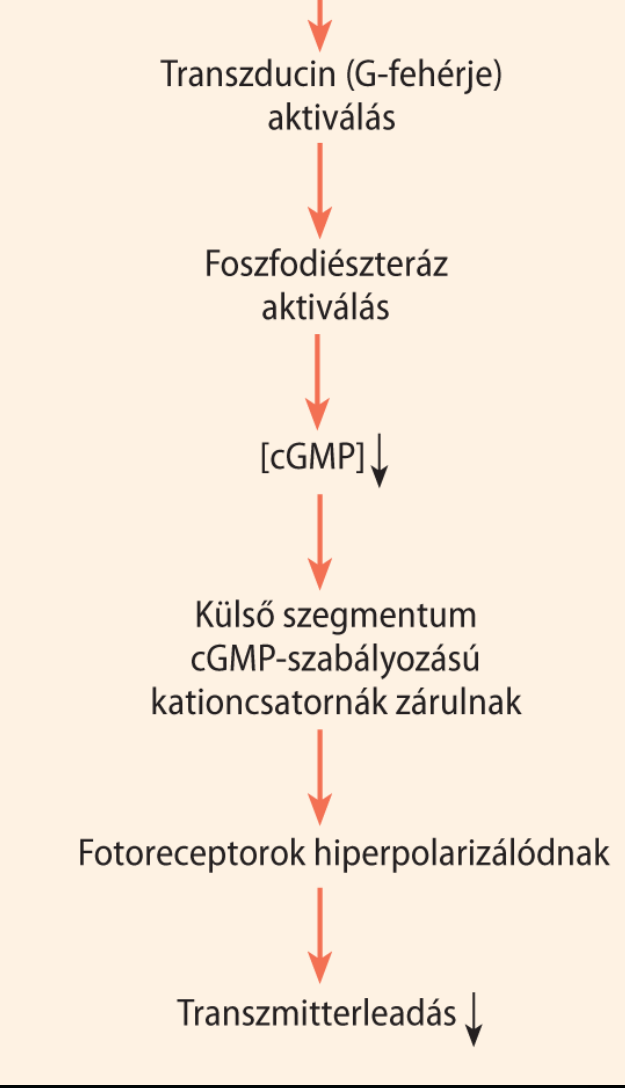


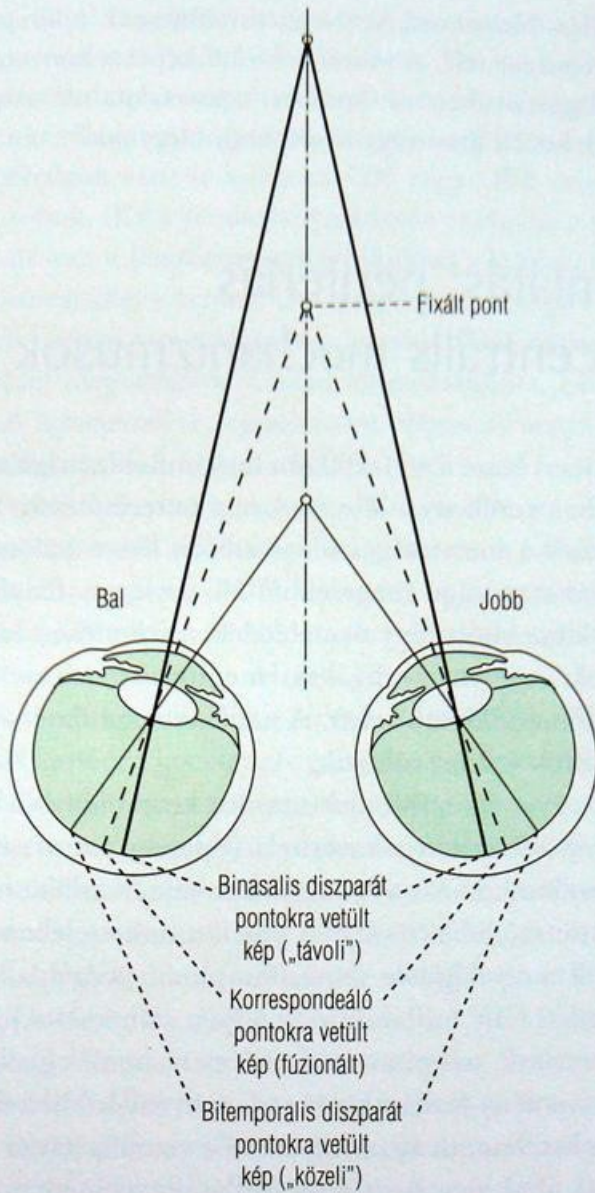
39-5. ábra
A fotoreceptorsejtek ionáramai és a fény hatására bekövetkező változások



39-2. ábra
A két fotoreceptor típus, a pálcikák és a csapok szerkezete

Látás

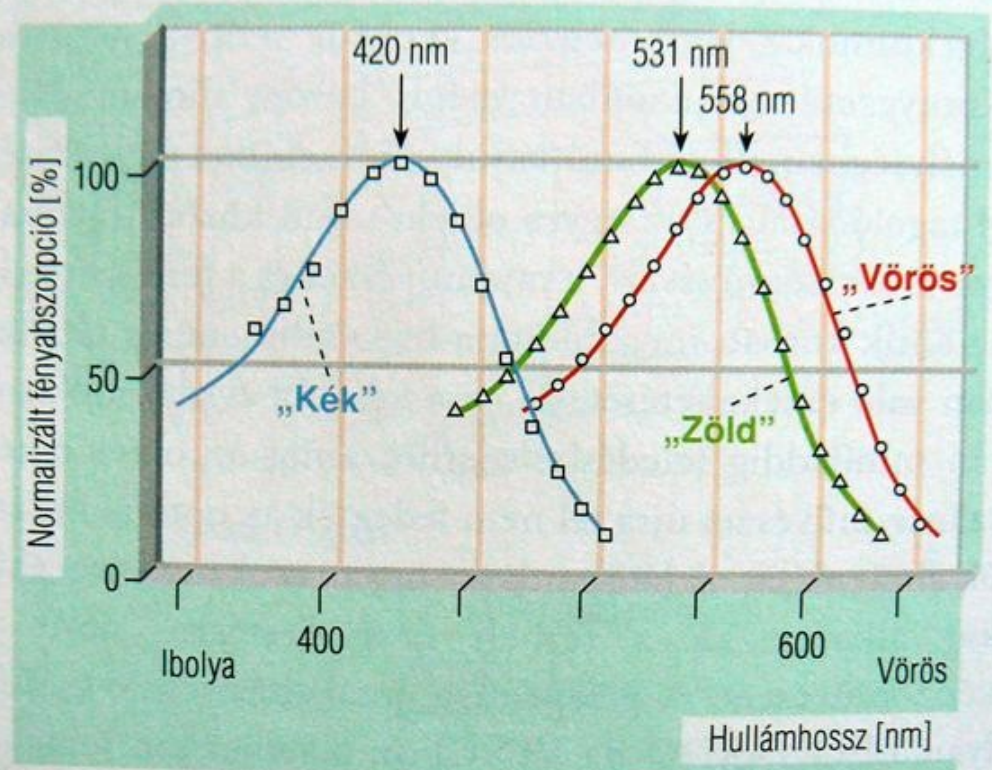




39-11. ábra

Az eltérő távolságban elhelyezkedő pontok leképezése a két retina korrespondeáló és diszparát pontjaiban

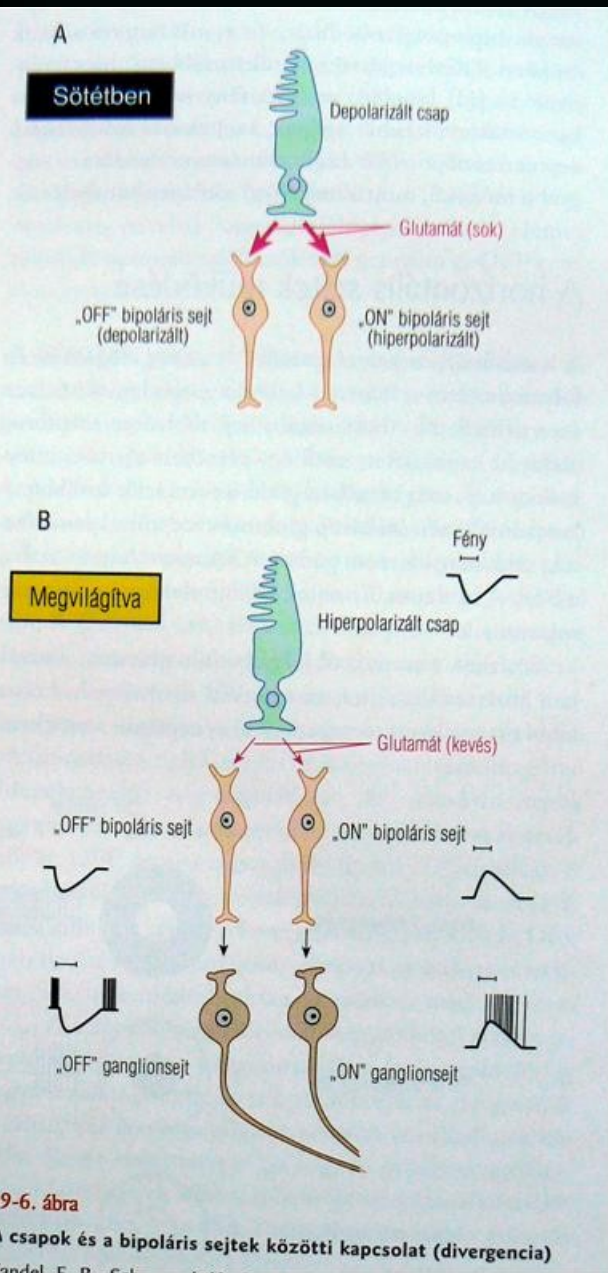
Kandel, E. R., Schwarz, J. H., Jessel, T. M. (1991): Principles of Neural Science. 3. kiadás, Prentice-Hall Inc. Englewood Cliffs, New Jersey.



39-12. ábra

Az emberi csapok abszorpciós spektruma

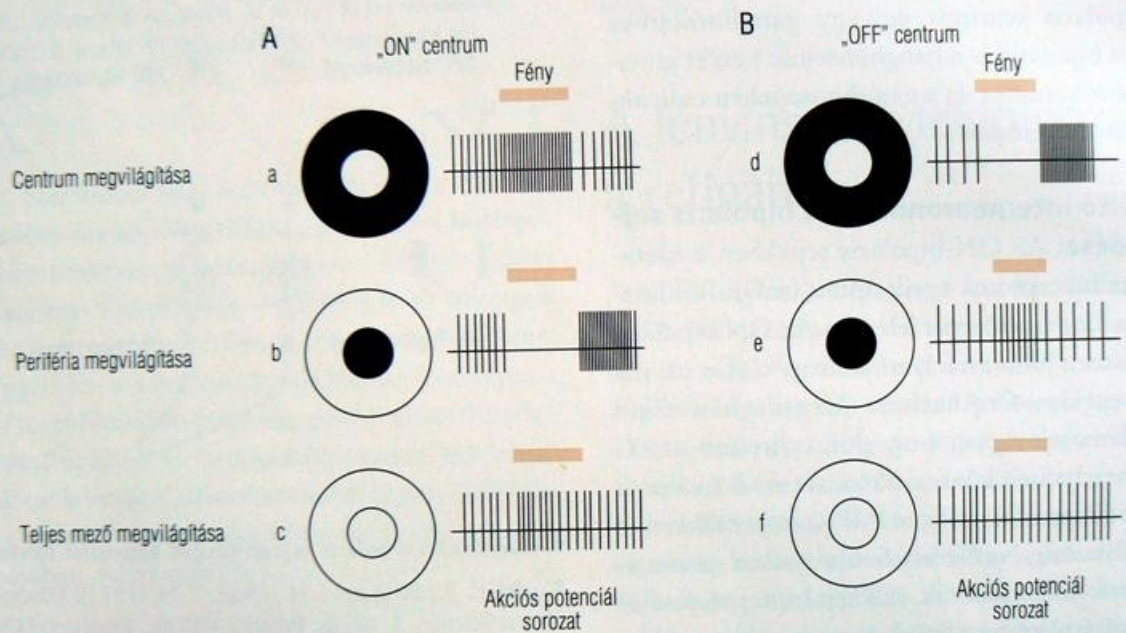
Dartnall, H. J. A., Bowmaker, J. K., Mollon, J. D. (1983): in Color Vision: Physiology and Psychophysics, Mollon, J. D. és Sharpe, L. T. (szerk.), Academic Press, New York alapján



39-6. ábra

A csapok és a bipoláris sejtek közötti kapcsolat (divergencia)

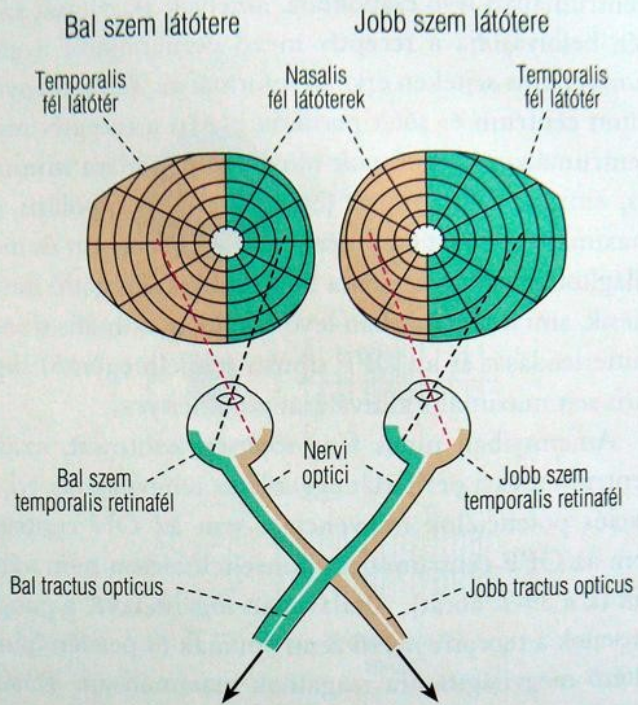
Kandel, E. R., et al.



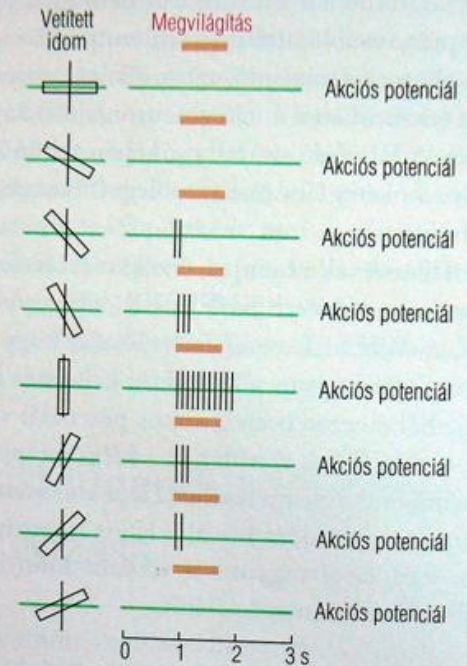
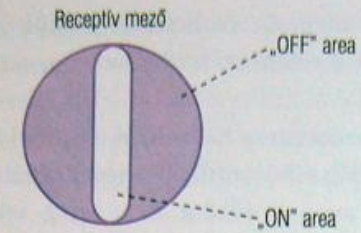
39-7. ábra

ON centrum és OFF centrum típusú ganglionsejtek receptív mezői

Kuffler, S. W. (1953): Discharge pattern and functional organization of mammalian retina. J. Neurophysiol., 16. 37-68. alapján

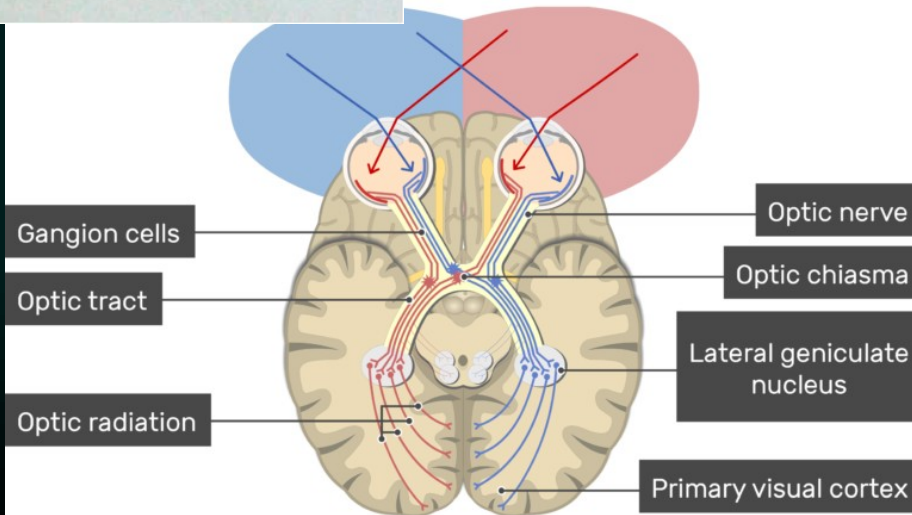


39-8. ábra
A látópálya hemidecussatiója

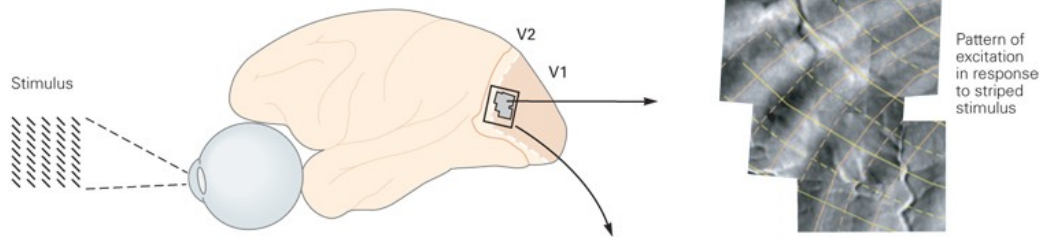


39-9. ábra
Az „egyszerű” kérgi sejt válasza a retinára vetített geometriai alakzatok orientációjának változásra

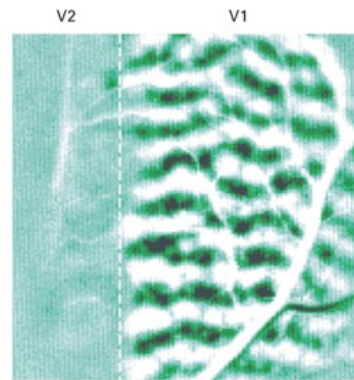
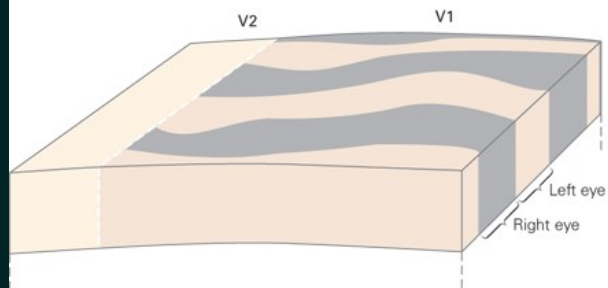
Hubel, D. H., Wiesel, T. N. (1959): Receptive fields of single neurons in the cat striate cortex. J. Physiol. London, 148, 544-591. alapján



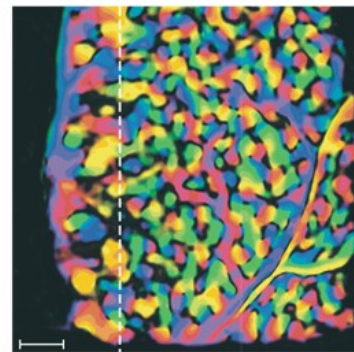
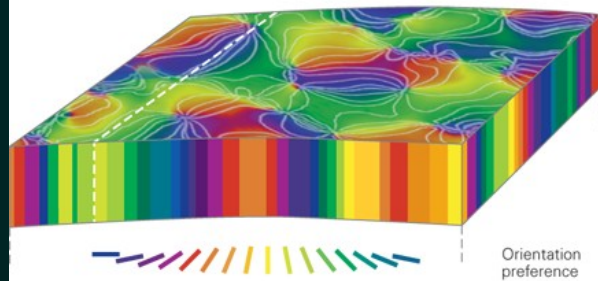
A Visuotopic map



B Ocular dominance columns



C Orientation columns



D Blobs, interblobs (V1), and stripes (V2)

