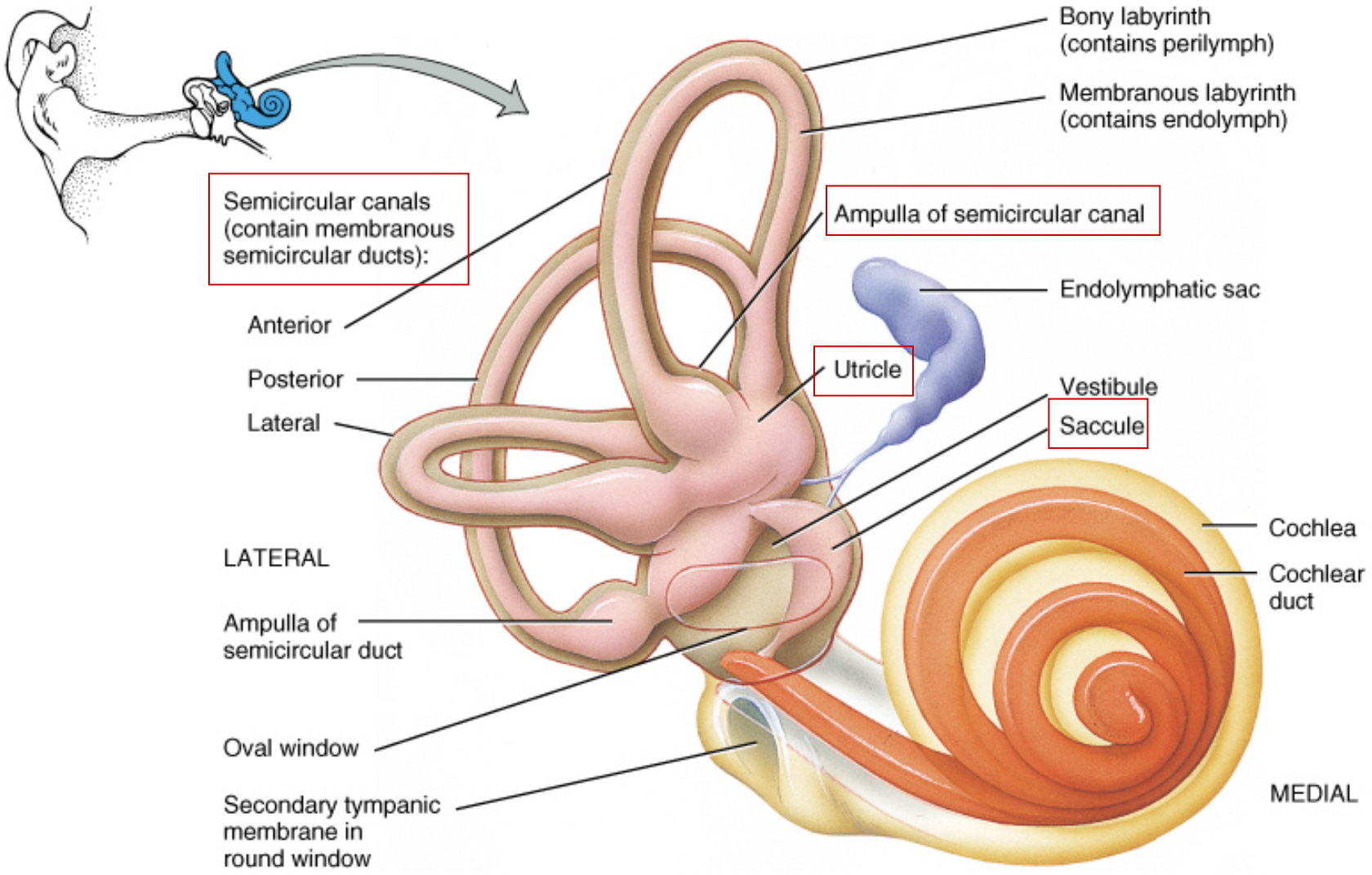
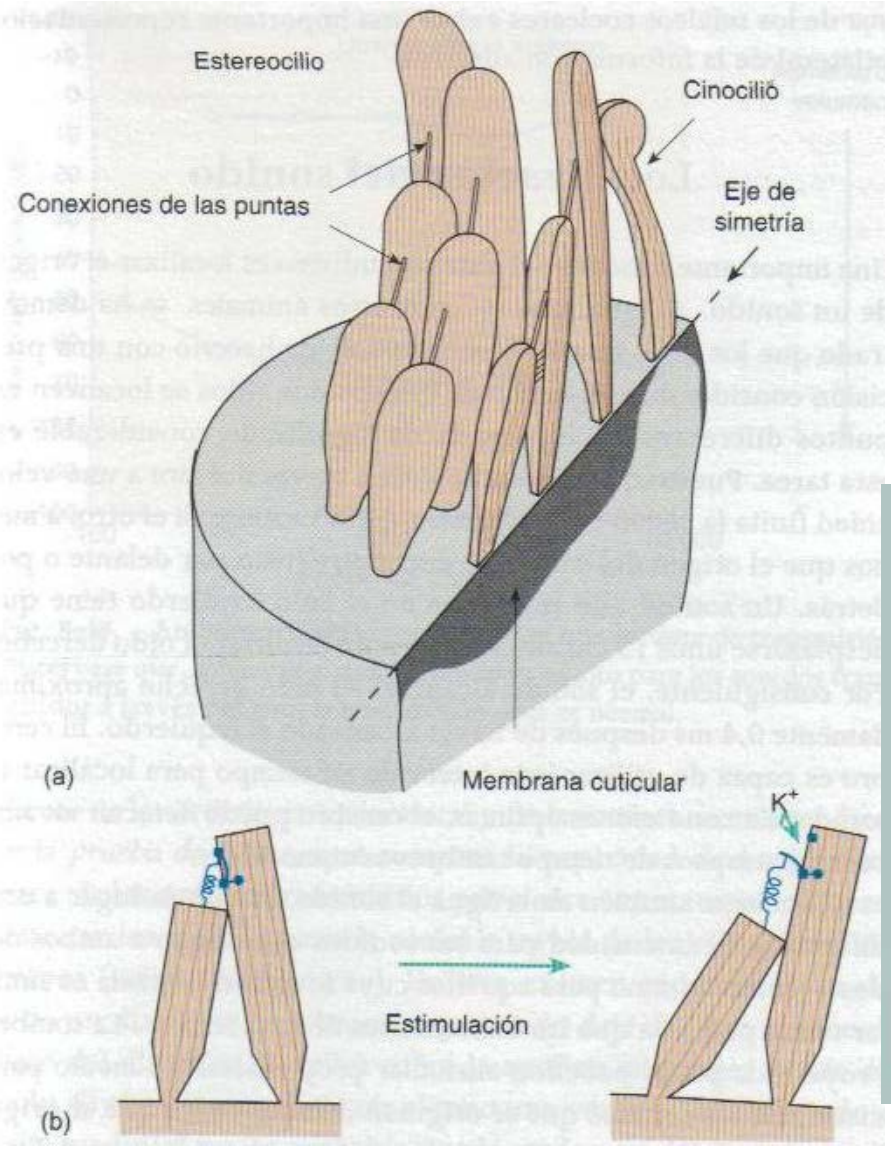
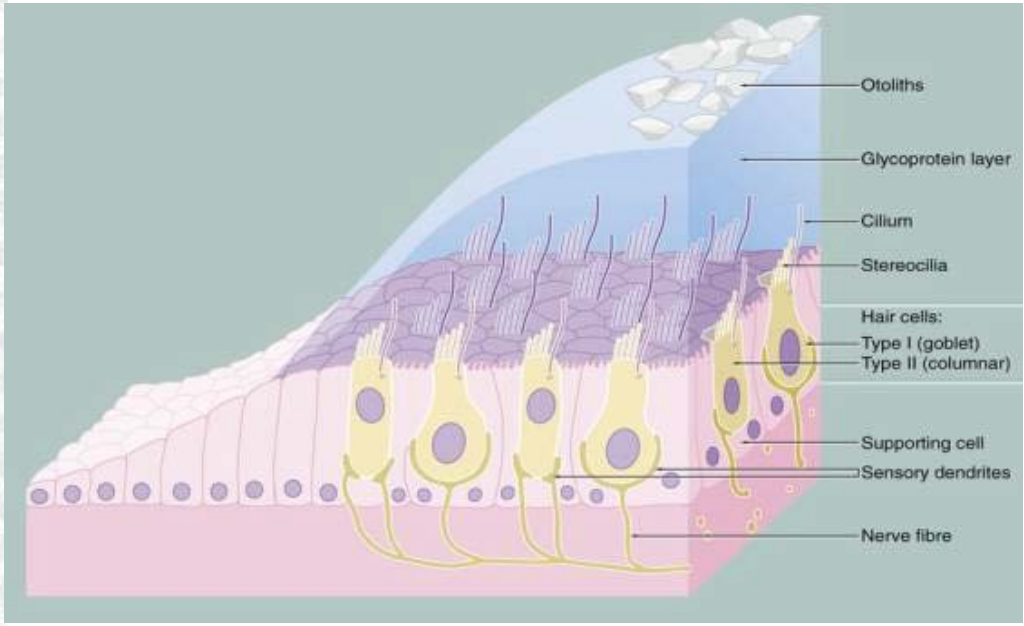
Tema 20

FISIOLOGÍA DEL SENTIDO DEL EQUILIBRIO Y DE LA AUDICIÓN.

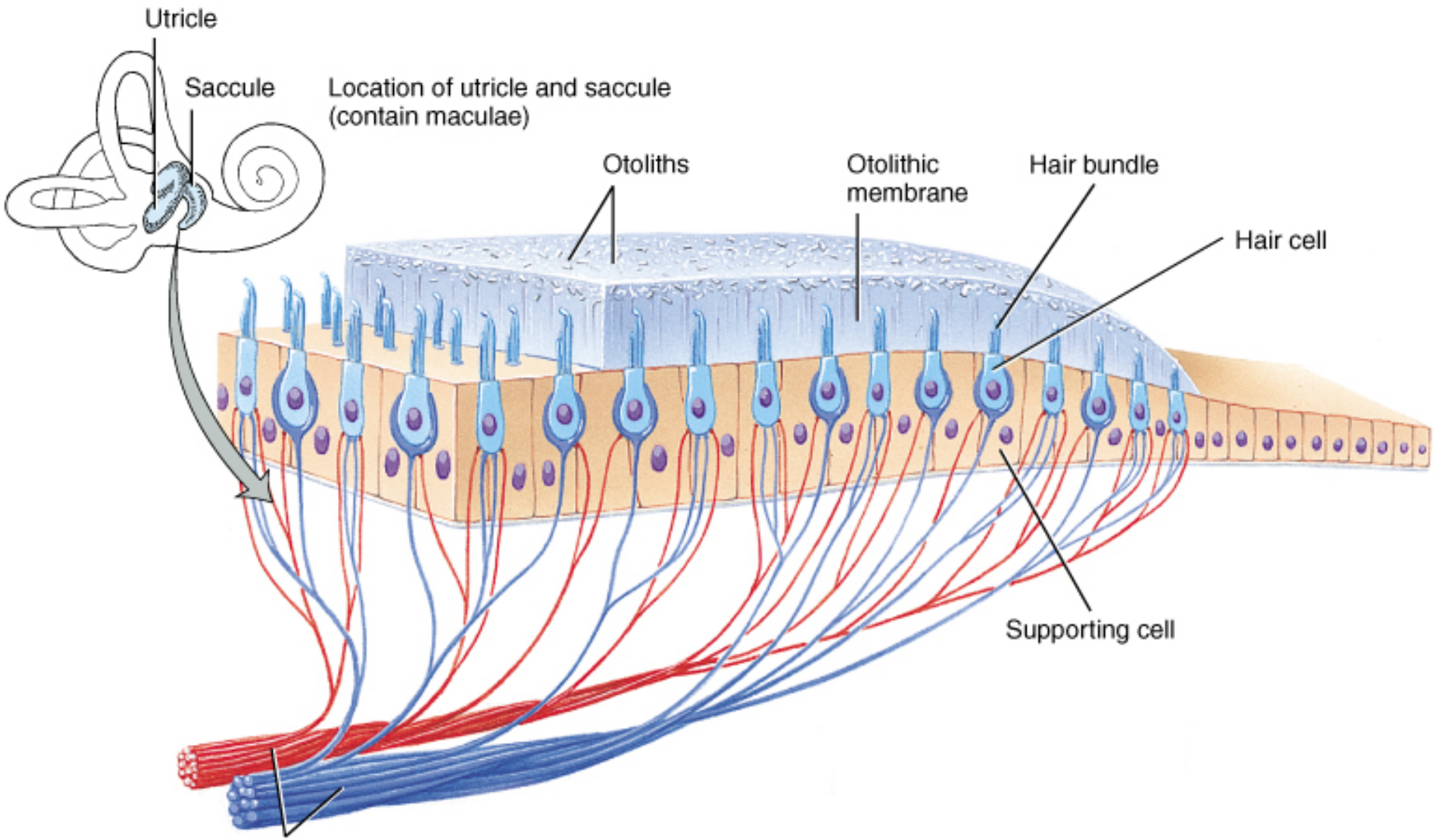
APARATO VESTIBULAR



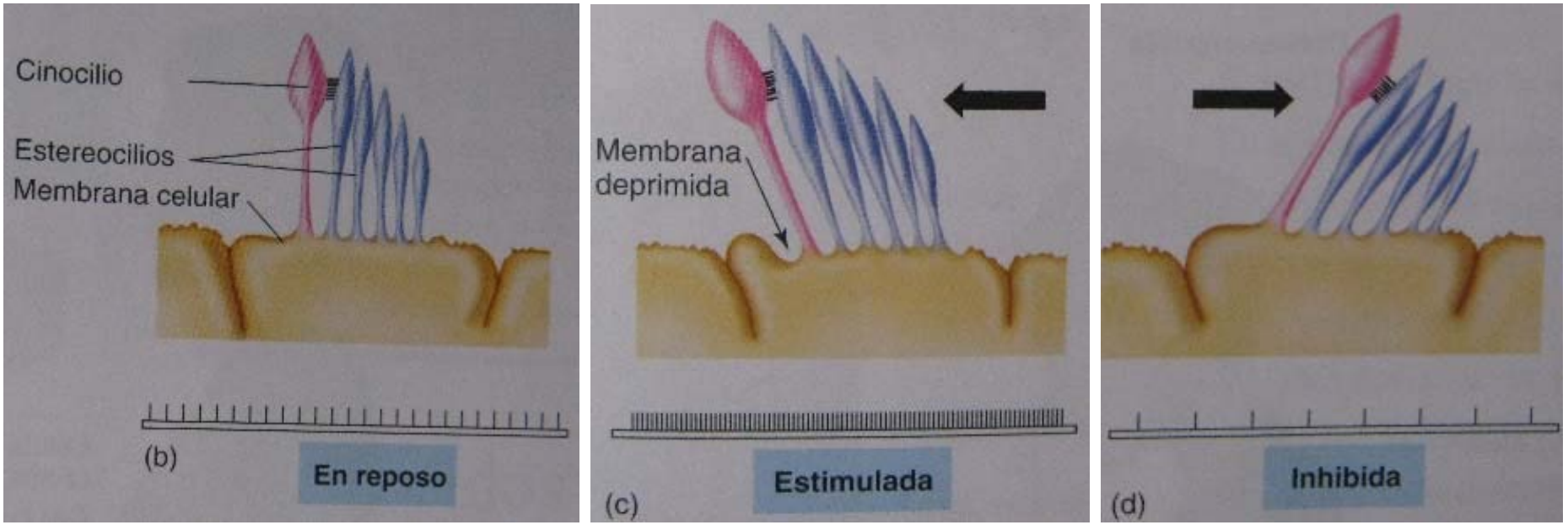

Estereocilio
Cinocilio
Conexiones de las puntas
Eje de simetría
(a)
Membrana cuticular
K^+
Estimulación
(b)


Otoliths
Glycoprotein layer
Cilium
Stereocilia
Hair cells:
Type I (goblet)
Type II (columnar)
Supporting cell
Sensory dendrites
Nerve fibre

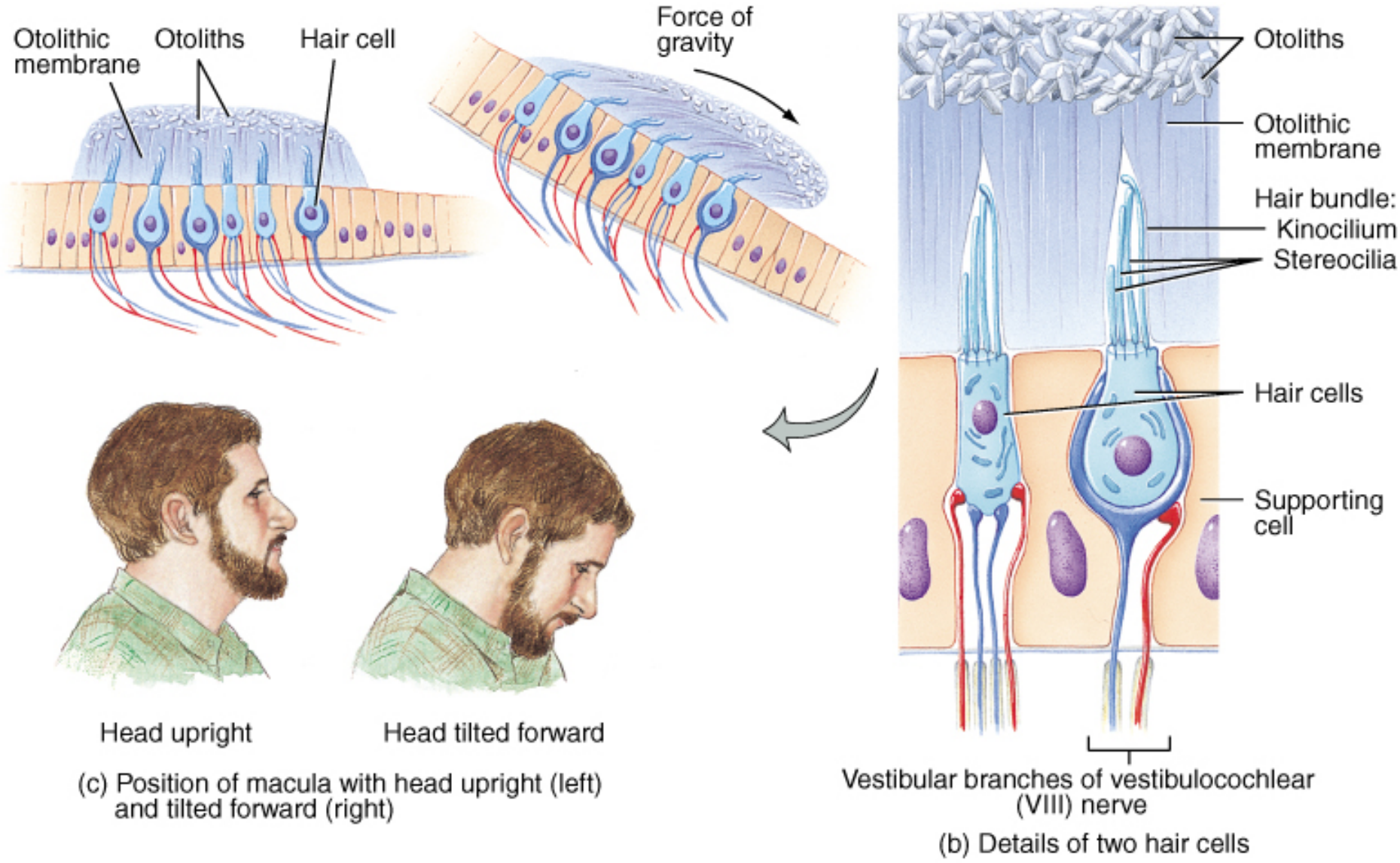
SENTIDO DEL EQUILIBRIO ESTÁTICO



(a) Overall structure of a section of the macula


Cinocilio
Estereocilios
Membrana celular
(b)
En reposo
Membrana deprimida
(c)
Estimulada
(d)
Inhibida

SENTIDO DEL EQUILIBRIO ESTÁTICO



ACELERACIÓN LINEAL

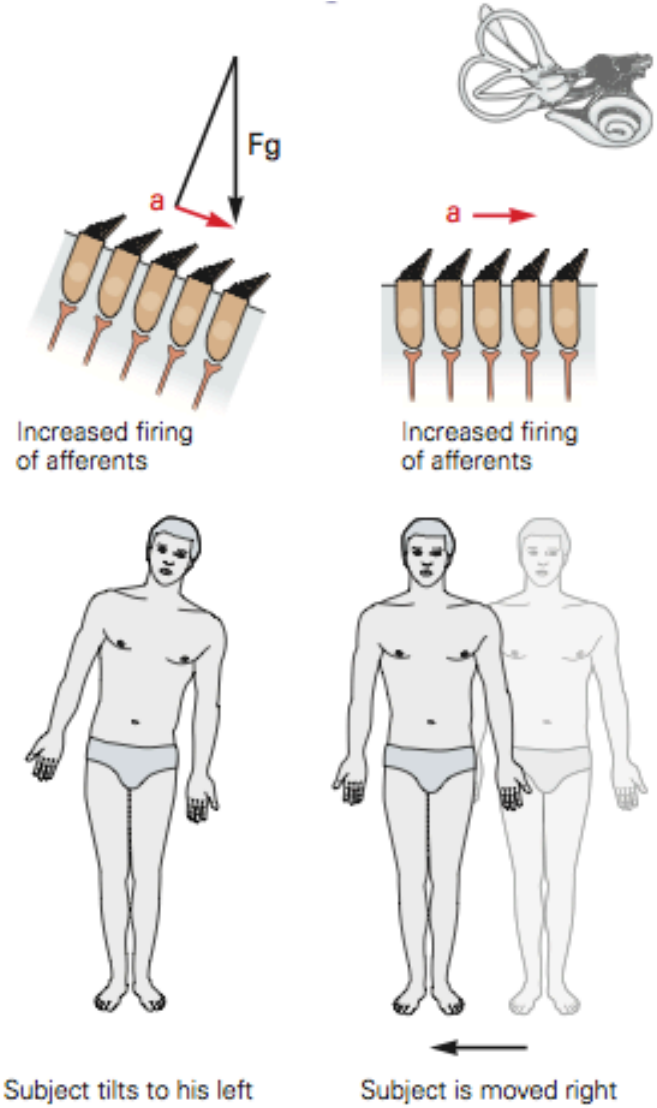
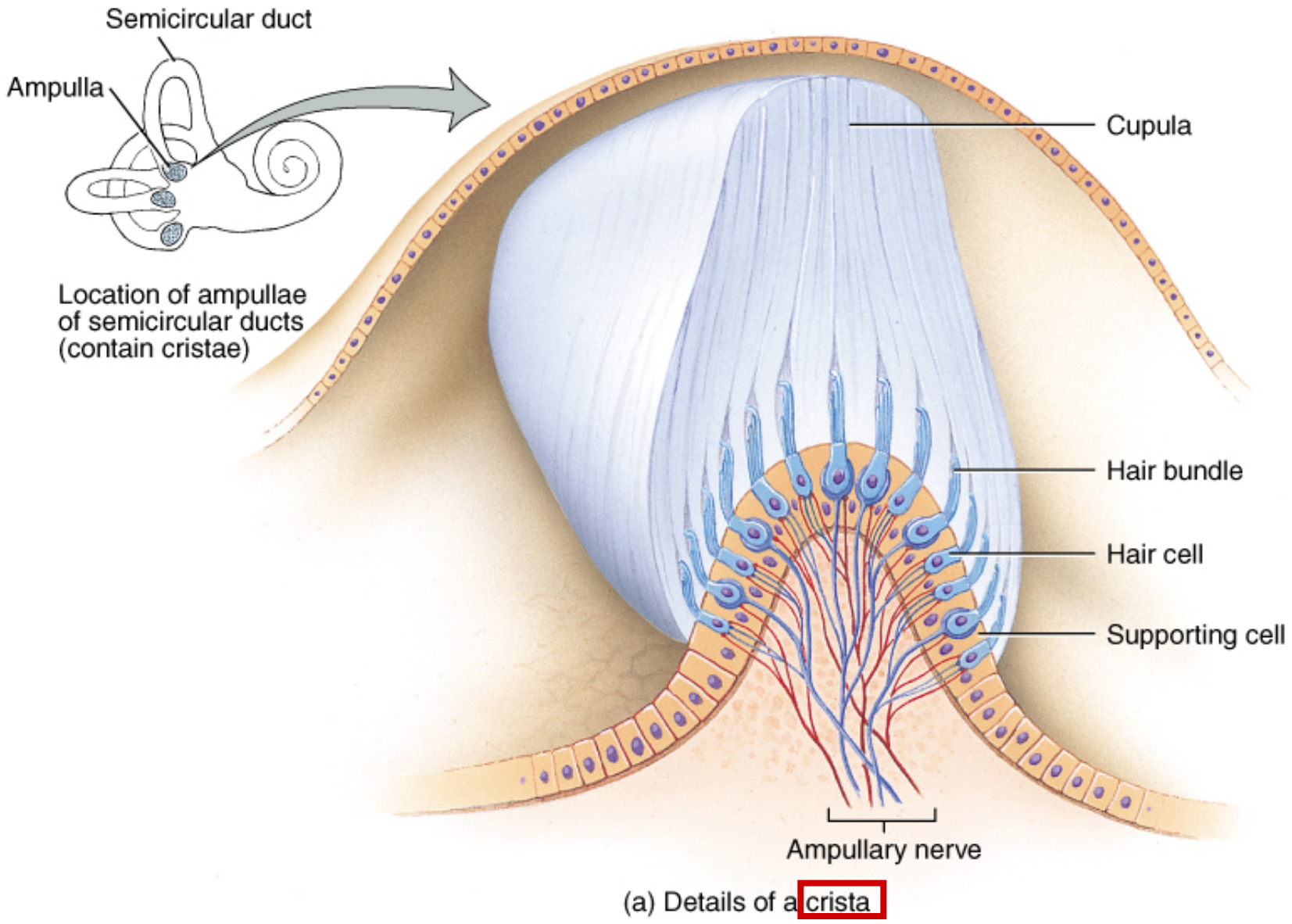
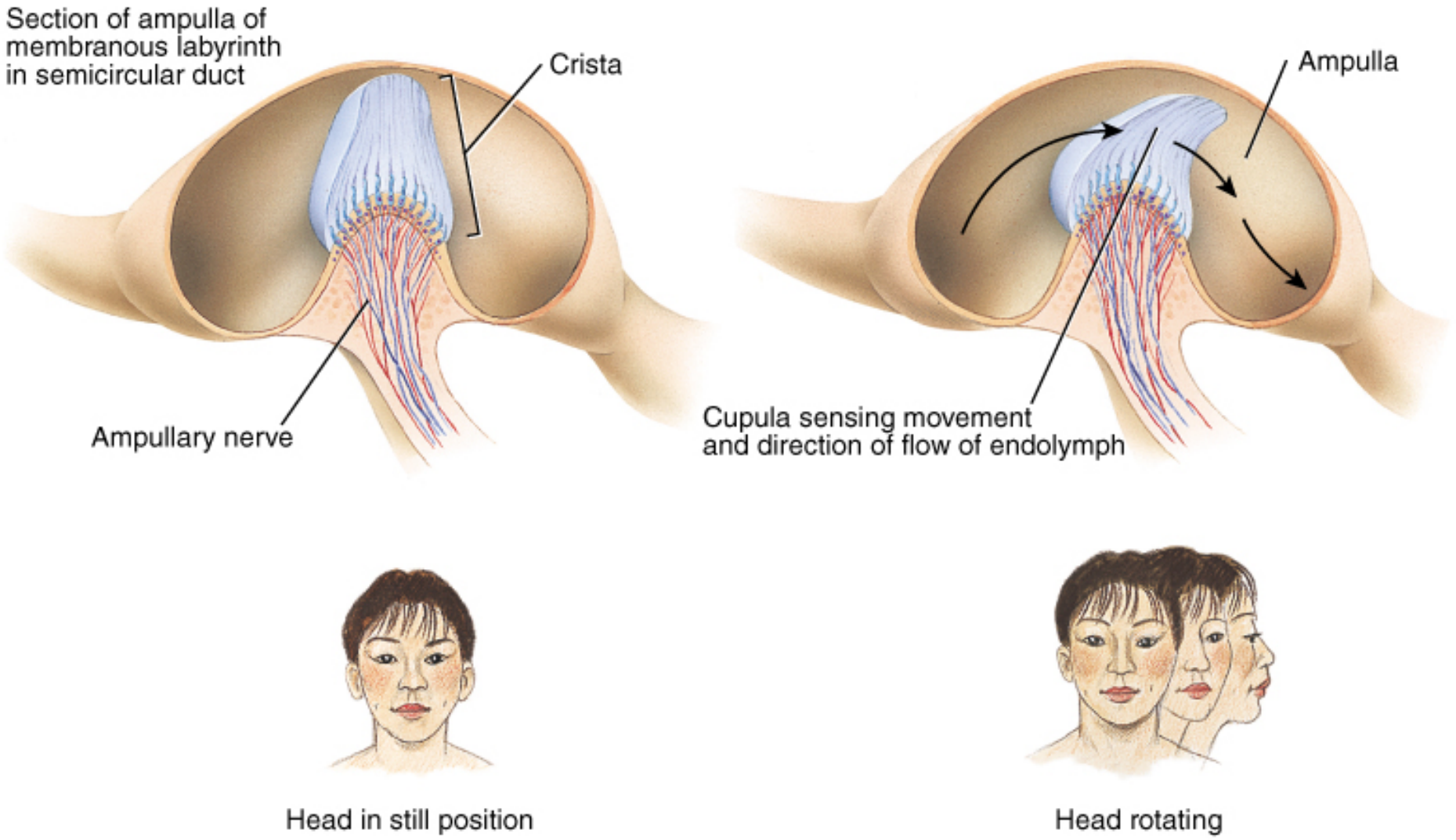


Figure 40–7 Vestibular inputs signalling body posture and motion can be ambiguous. The postural system cannot distinguish between tilt and linear acceleration of the body based on otolithic inputs alone. The same shearing force acting on vestibular hair cells can result from tilting of the head (**left**), which exposes the hair cells to a portion of the acceleration (**a**) owing to gravity (**Fg**), or from horizontal linear acceleration of the body (**right**).

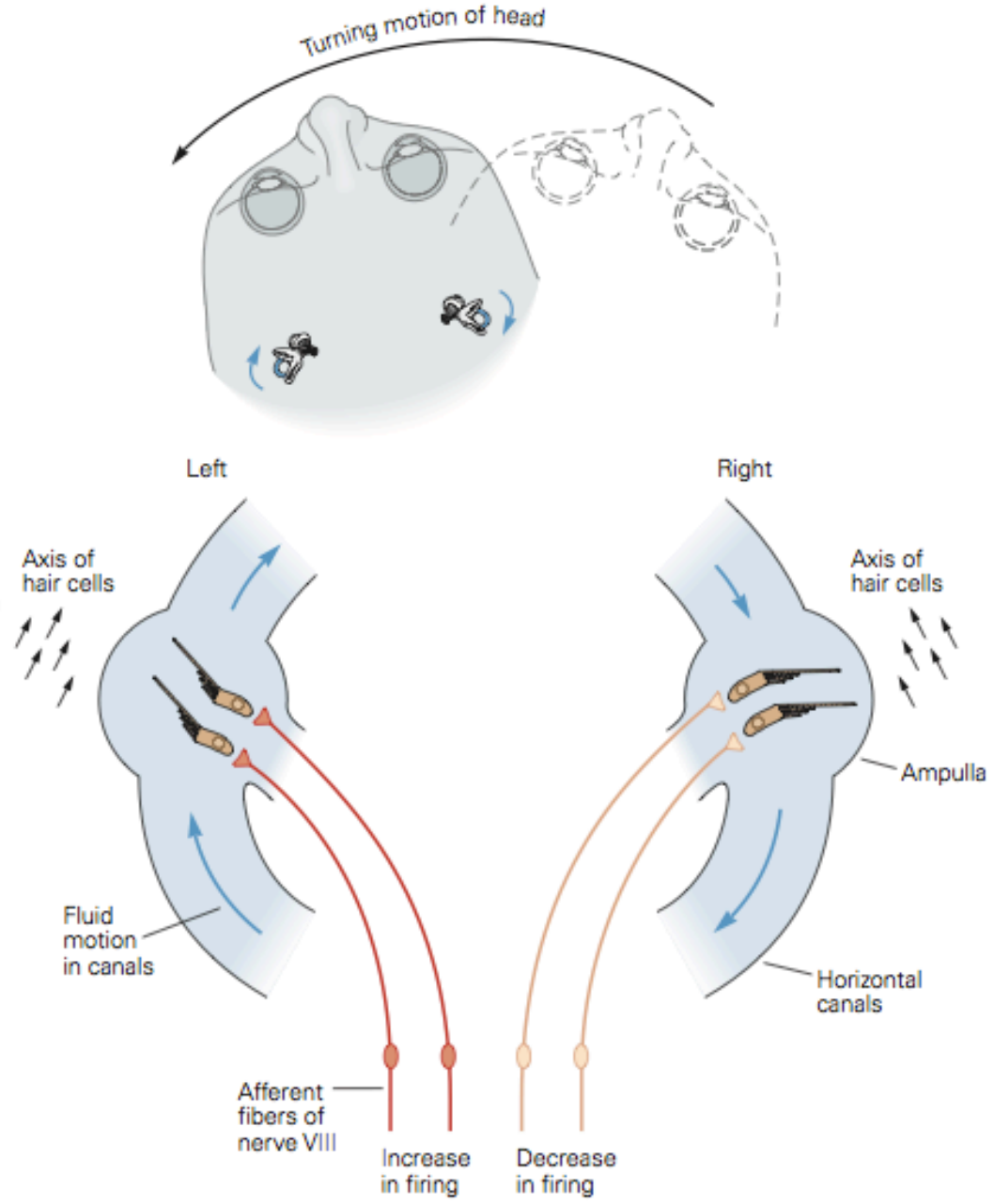
SENTIDO DEL EQUILIBRIO DINÁMICO



SENTIDO DEL EQUILIBRIO DINÁMICO

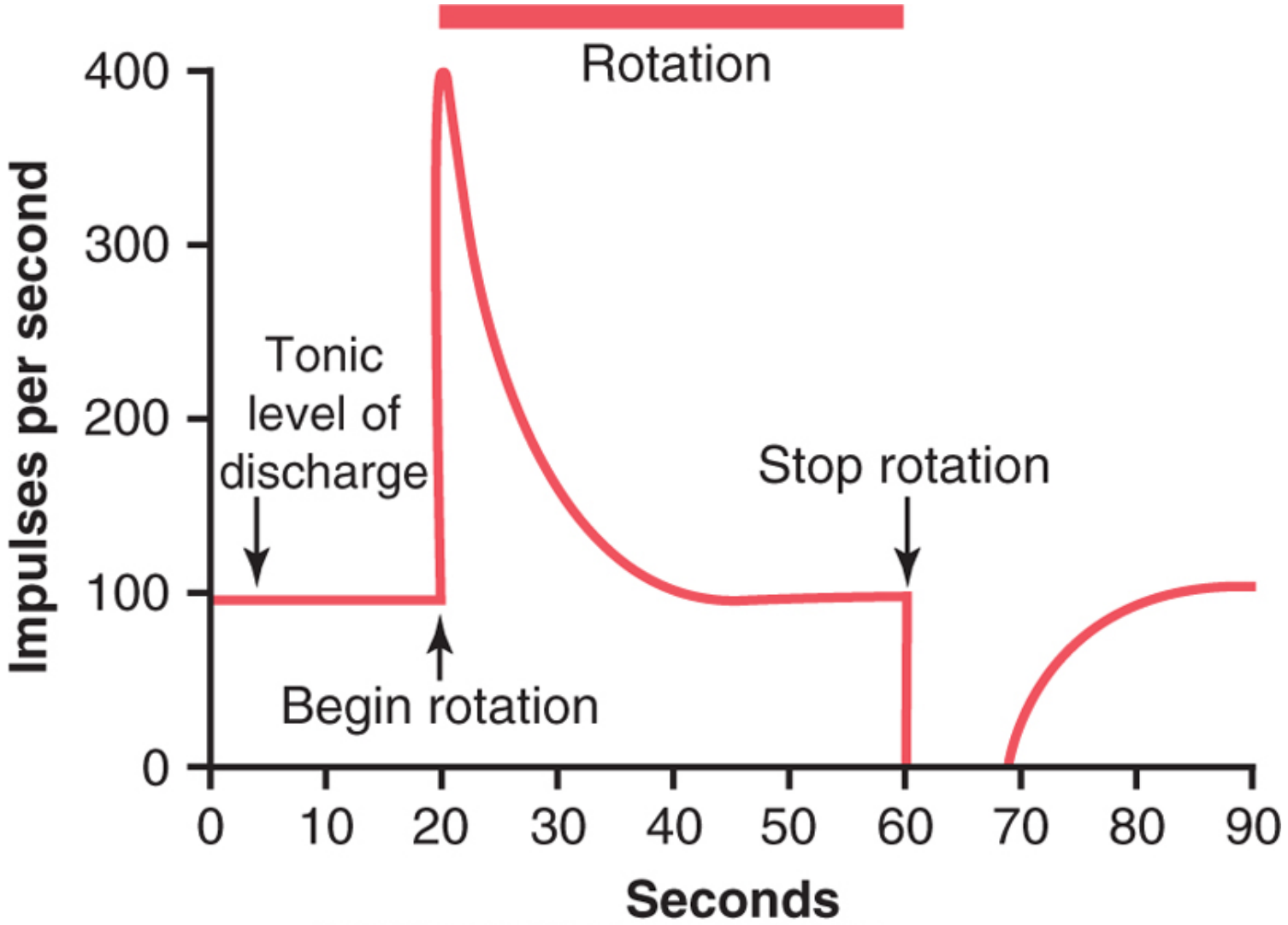


(b) Position of a crista with the head in the still position (left) and when the head rotates (right)


Turning motion of head
Left
Right
Axis of hair cells
Axis of hair cells
Ampulla
Fluid motion in canals
Horizontal canals
Afferent fibers of nerve VIII
Increase in firing
Decrease in firing

SENTIDO DEL EQUILIBRIO

El conducto semicircular informa cuando la cabeza empieza a rotar y cuando acaba (aceleración angular).



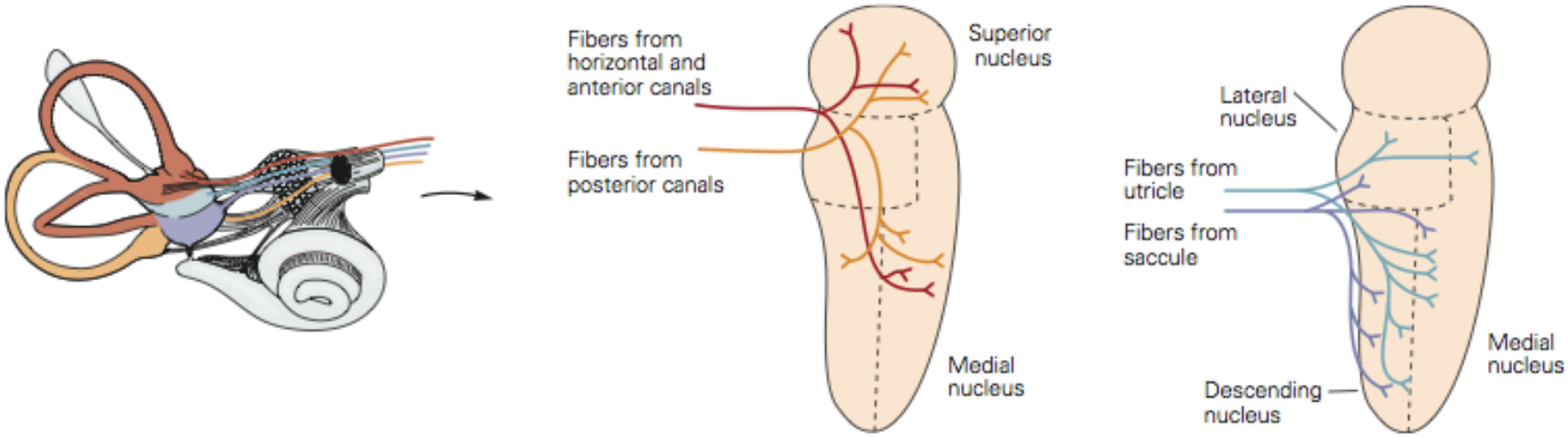


Figure 40–10 Sensory inputs to the vestibular nuclei. Neurons in the superior and medial vestibular nuclei receive input predominantly from the semicircular canals but also from the otolith organs. Neurons in the lateral vestibular nucleus (Deiters' nucleus) receive input from the semicircular canals and otolith organs. This nucleus is concerned predominantly with postural reflexes. The descending vestibular nucleus receives input predominantly from the otolith organs. (Adapted, with permission, from Gacek and Lyon 1974.)

VÍA NERVIOSA

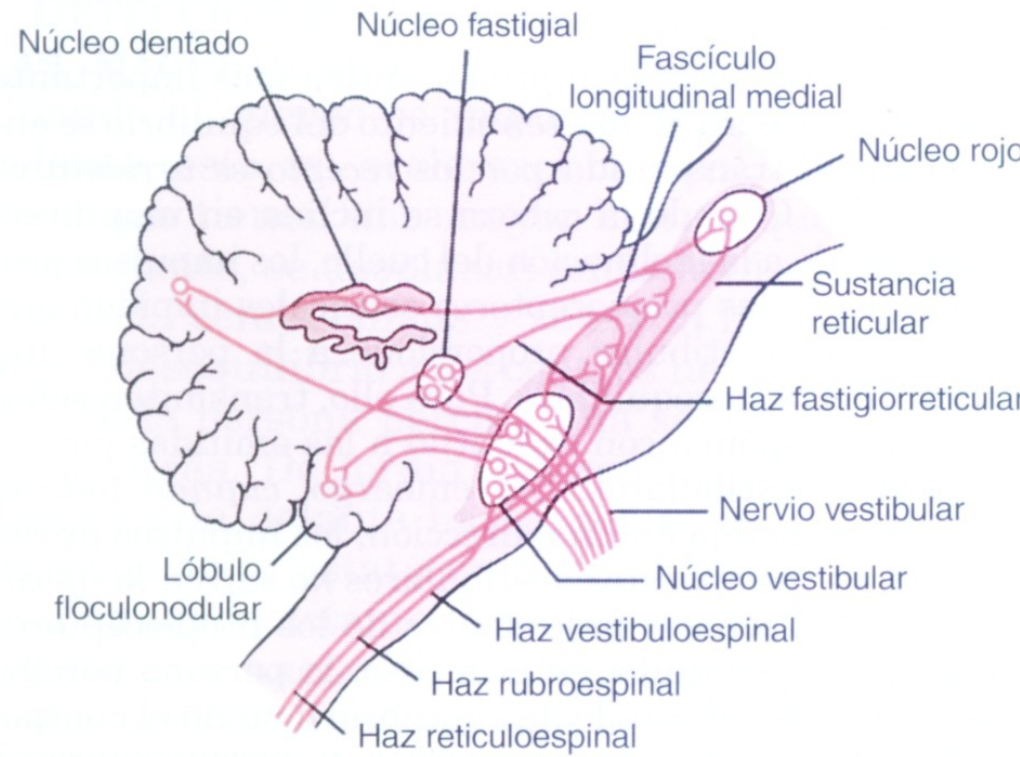
La visión y los propioceptores cervicales ayudan al aparato vestibular en el sentido del equilibrio.

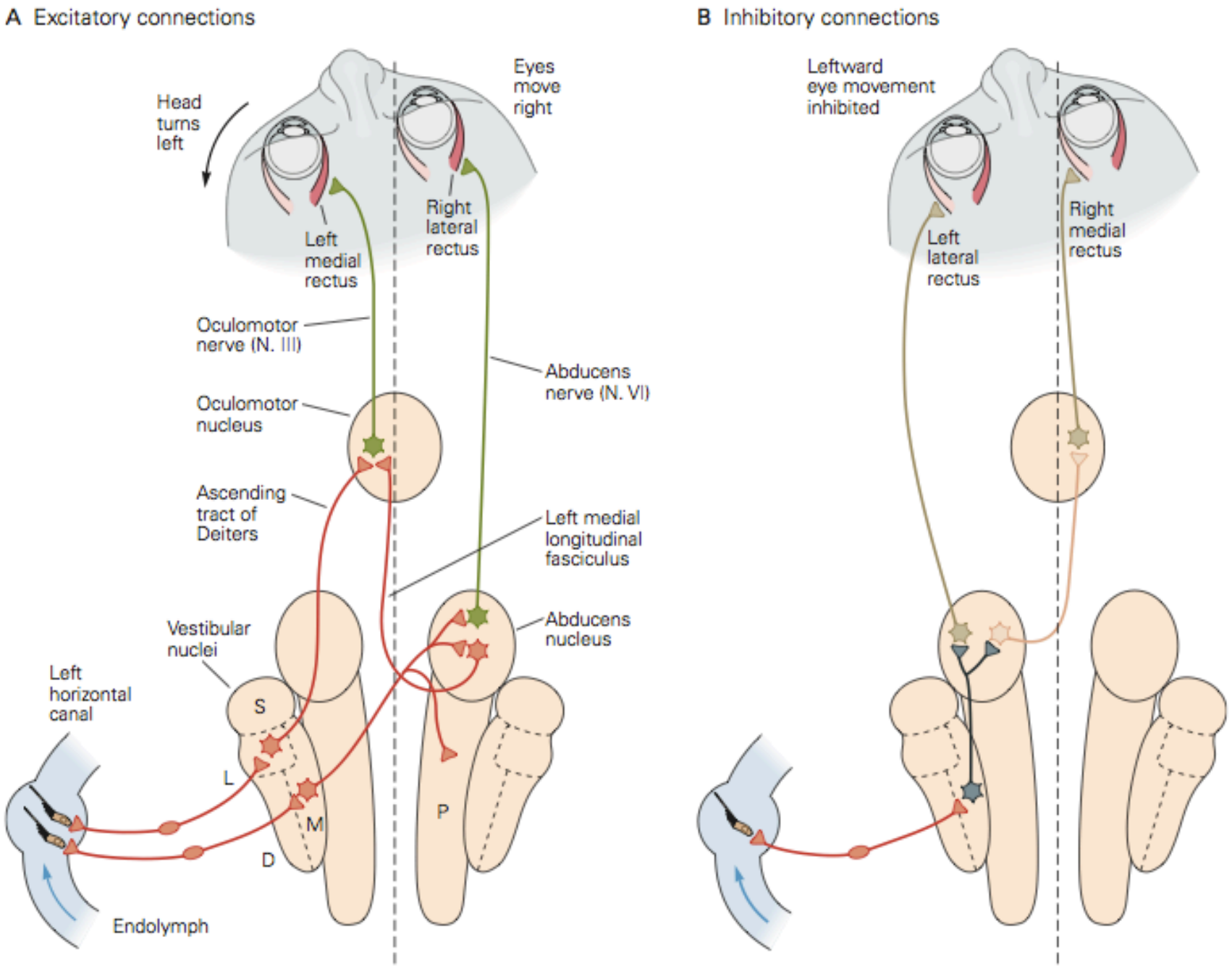
El ap. Vestibular manda sus PA a través del nervio vestibular (VIII par craneal) hacia:

1.- Núcleos vestibulares (Tronco)

2.- Cerebelo

3.- Médula: hacia los Músculos oculares, el IX par Craneal (mov. cabeza y cuello); y hacia los músculos antigravitatorios



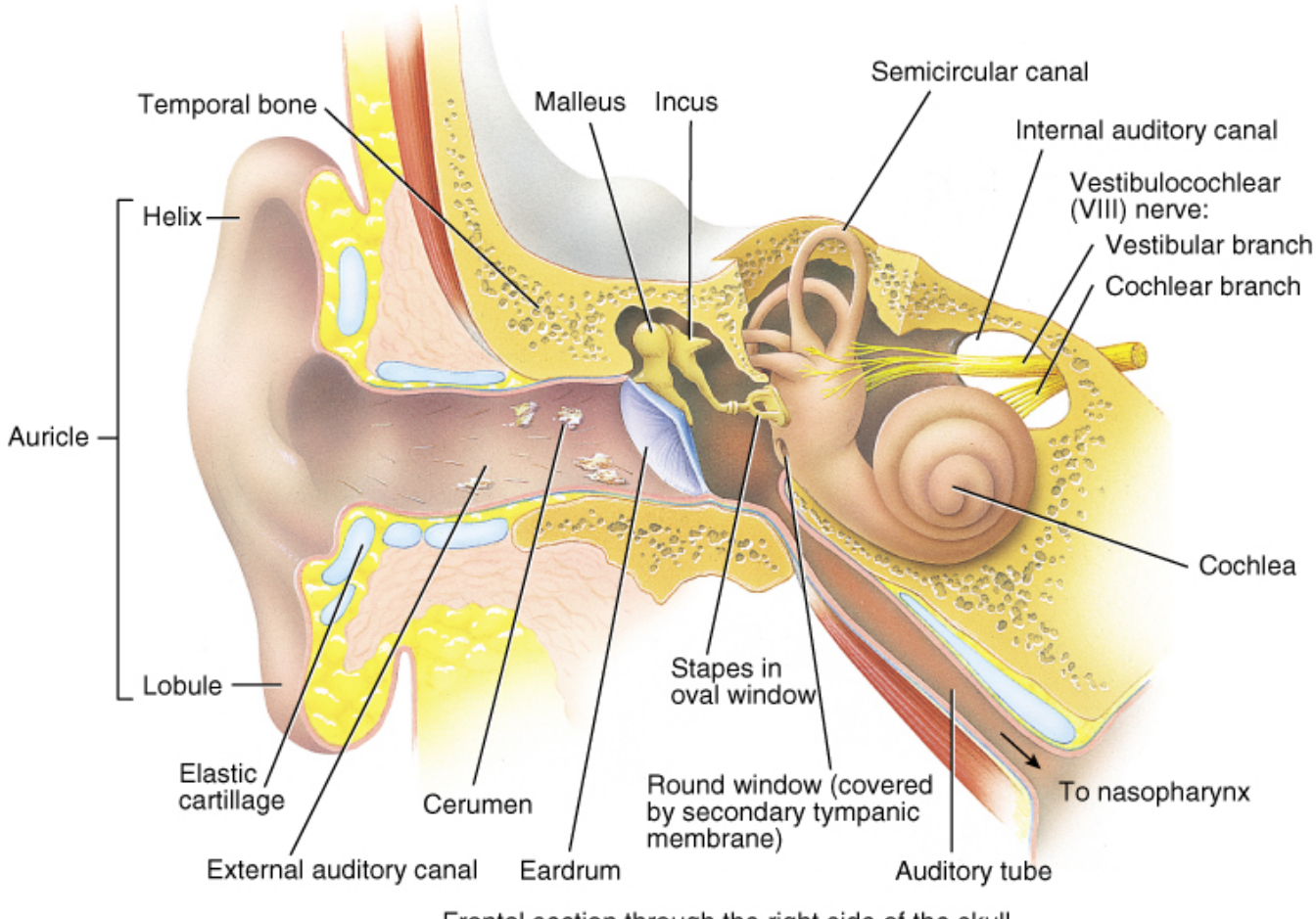


REFLEJO VESTIBULO-OCULAR HORIZONTAL

OIDO

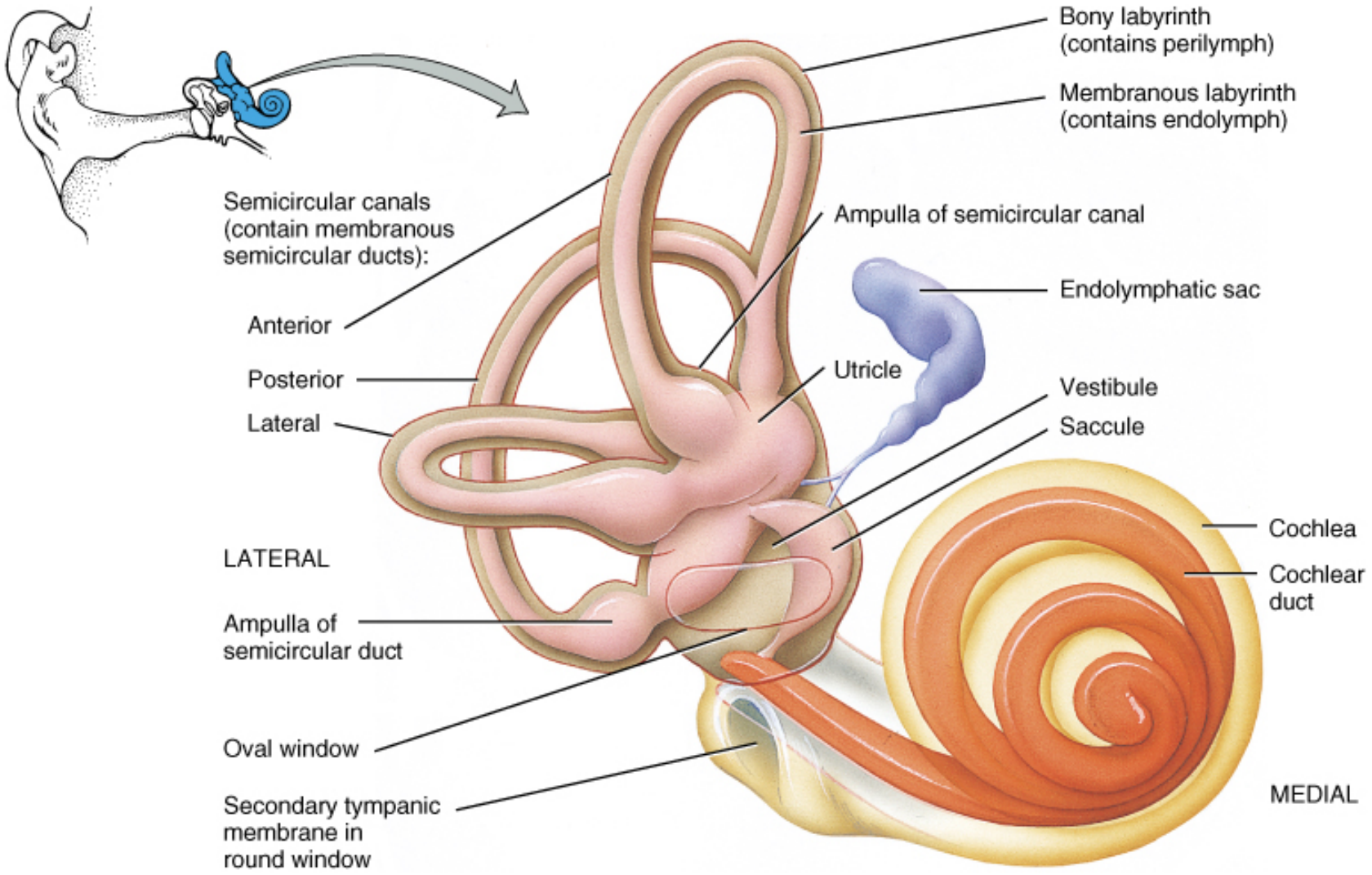
OÍDO EXTERNO:
Pabellón auditivo+conducto+tímpano
Recoge las ondas sonoras y las conduce hacia el interior.

OÍDO MEDIO:
Trompa de eustaquio+huesecillos (martillo, yunque y estribo)
Iguala presiones a ambos lados del tímpano y transmite las vibraciones a la ventana oval.

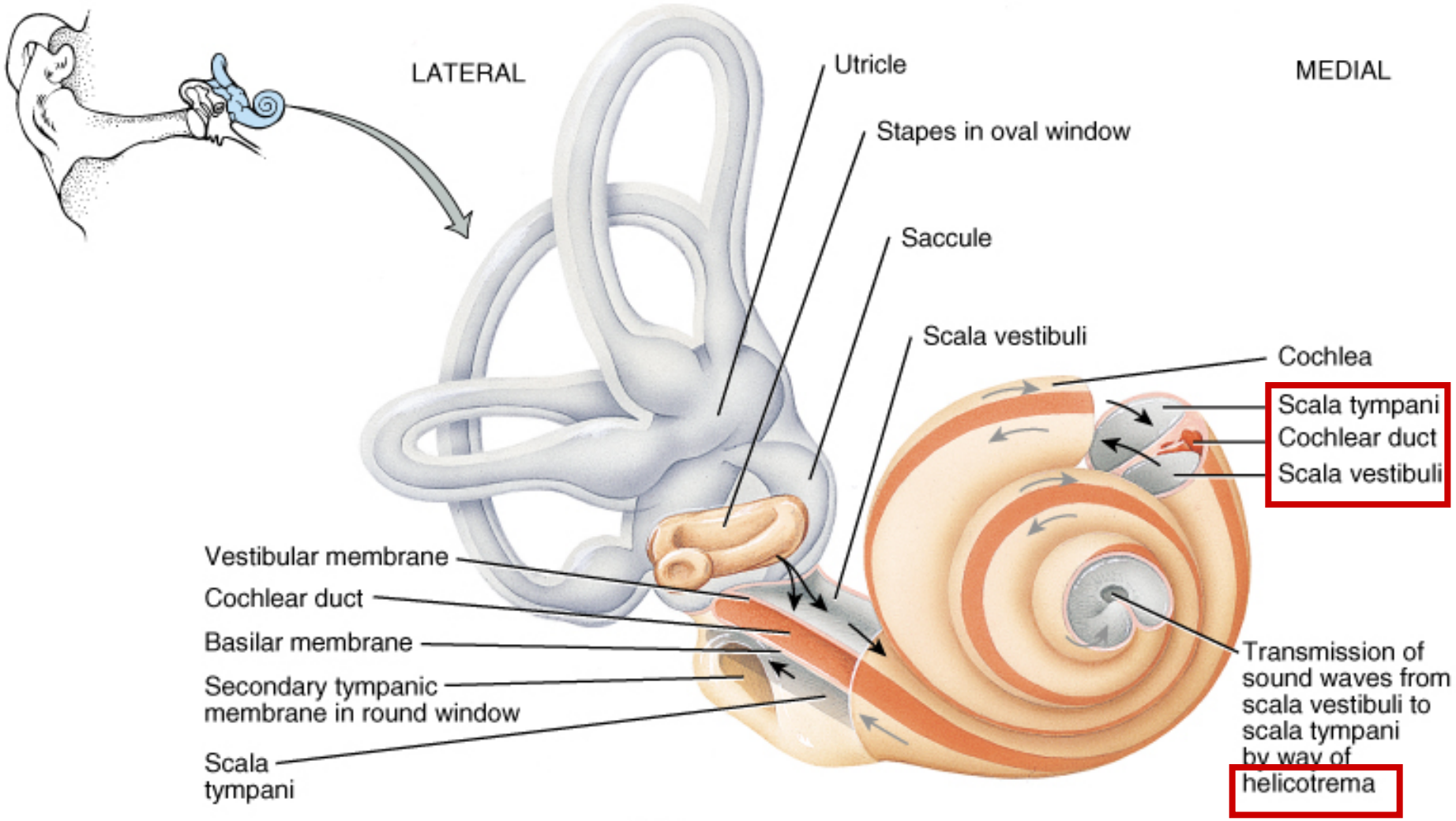


OIDO INTERNO

Utrículo, sáculo y conductos semicirculares: Sentido del equilibrio.
Cóclea: audición.

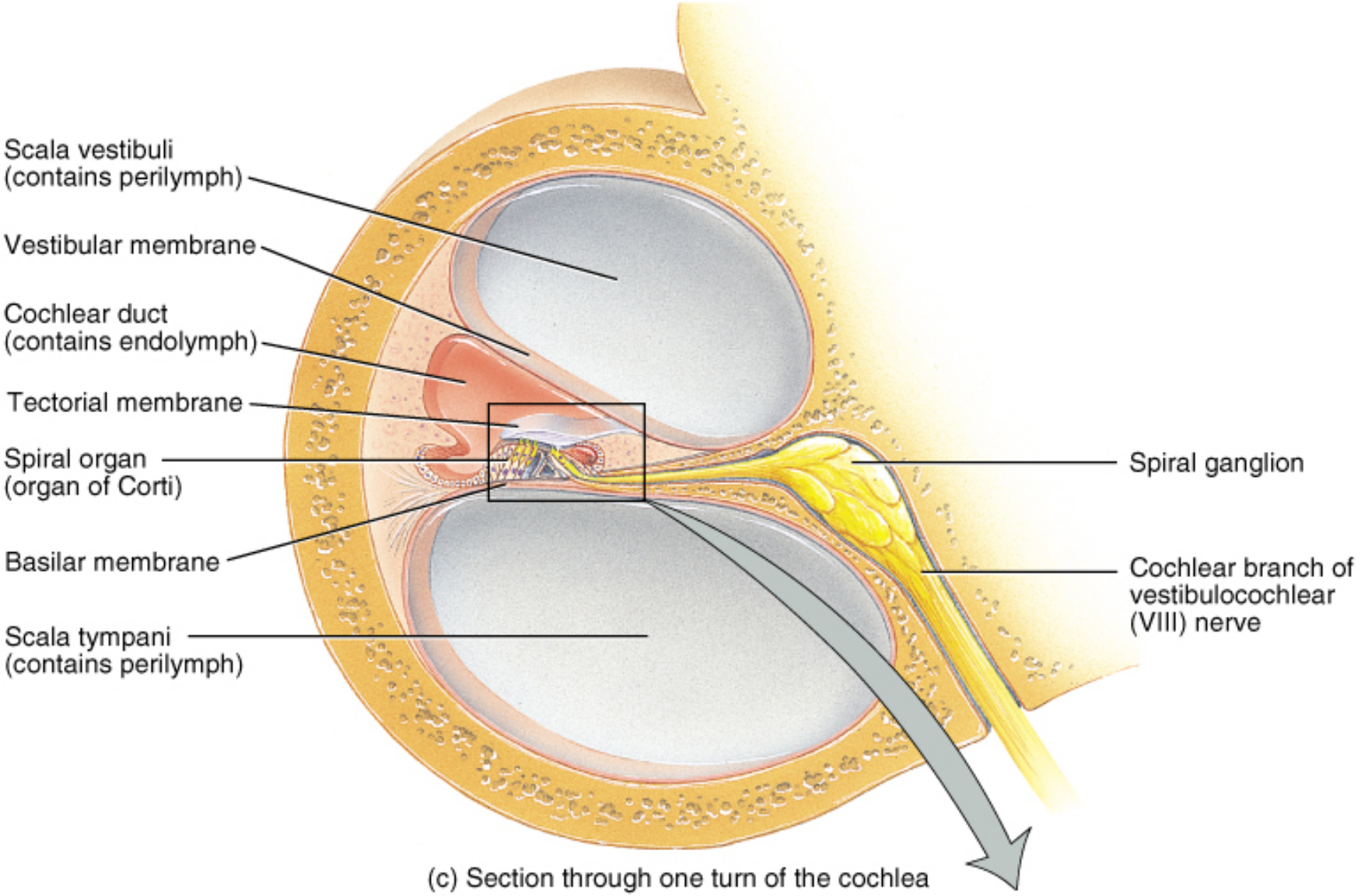


COCLEA (AUDICIÓN)



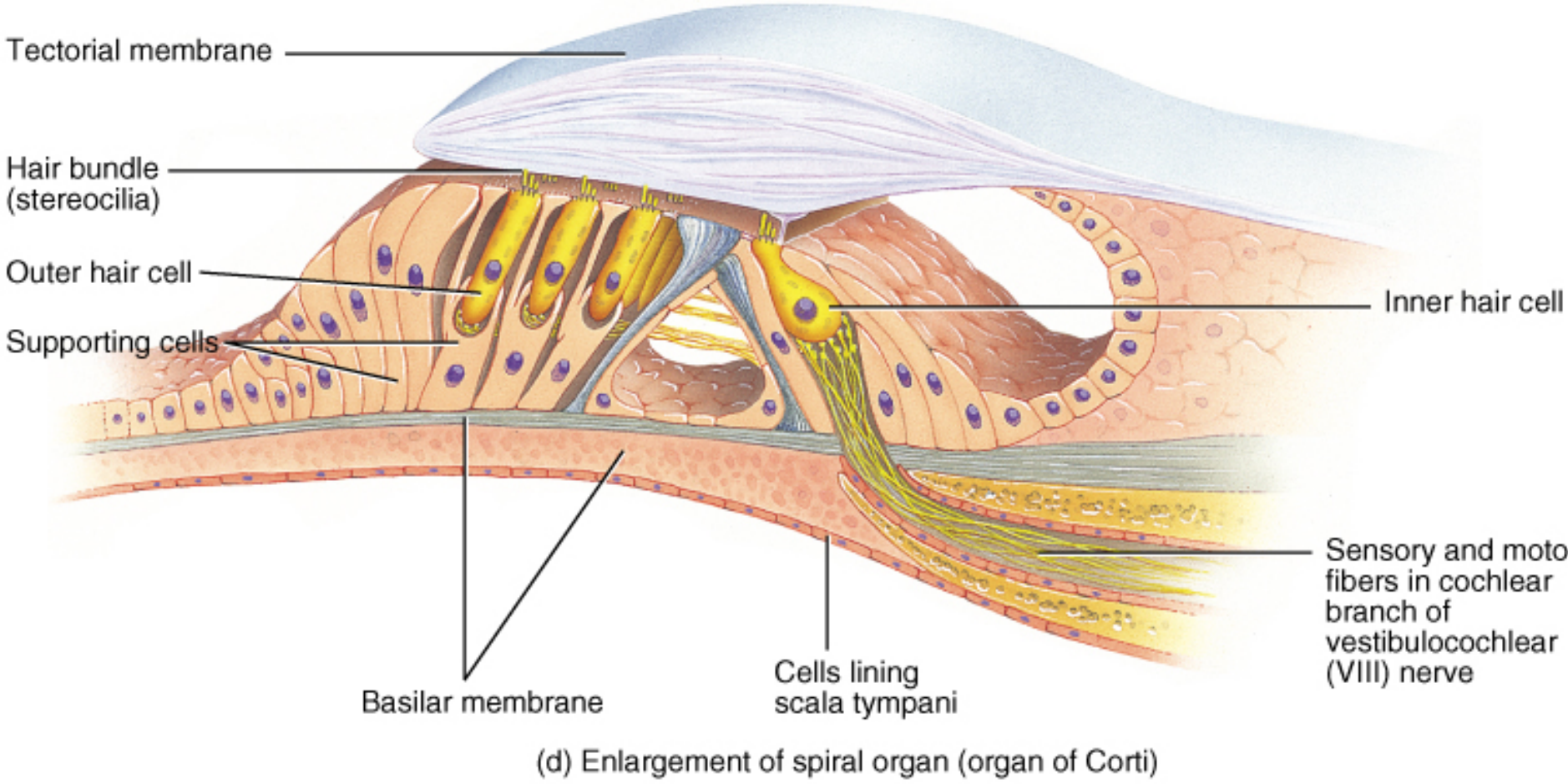
(a) Sections through the cochlea

COCLEA (AUDICIÓN)

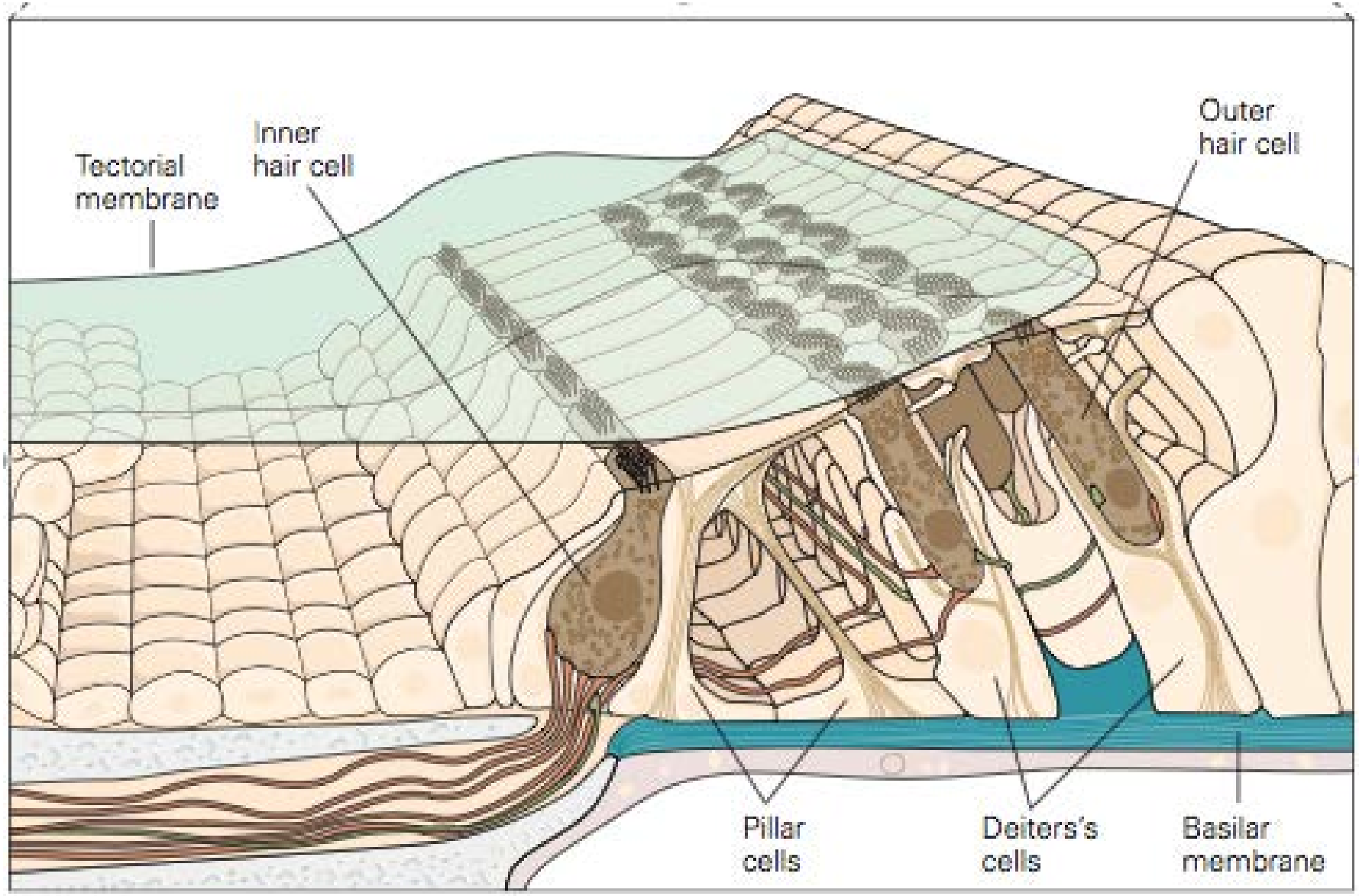


(c) Section through one turn of the cochlea

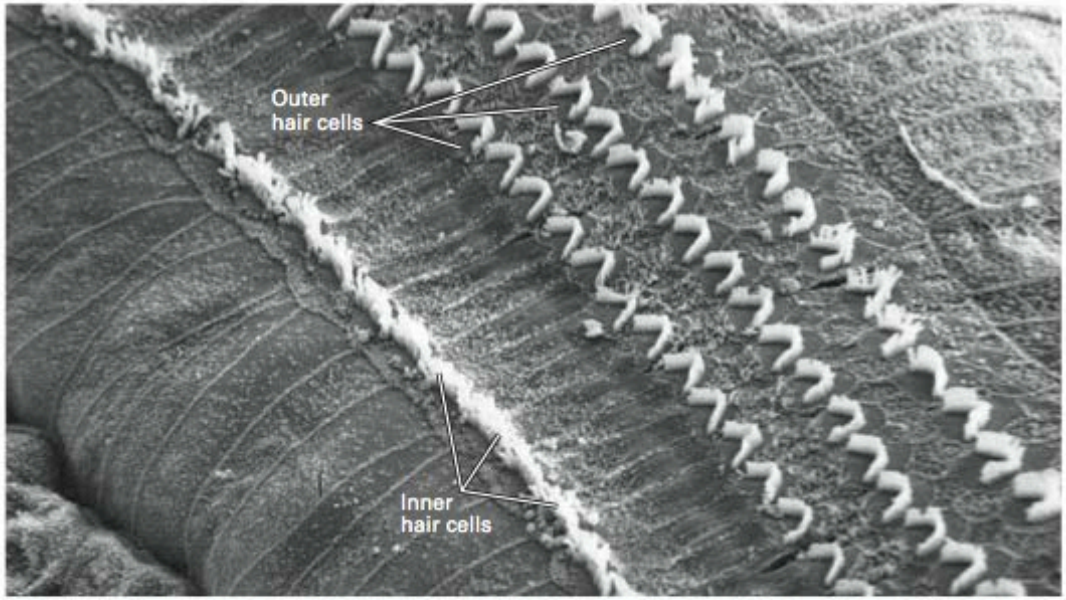
ORG. DE CORTI (AUDICIÓN)



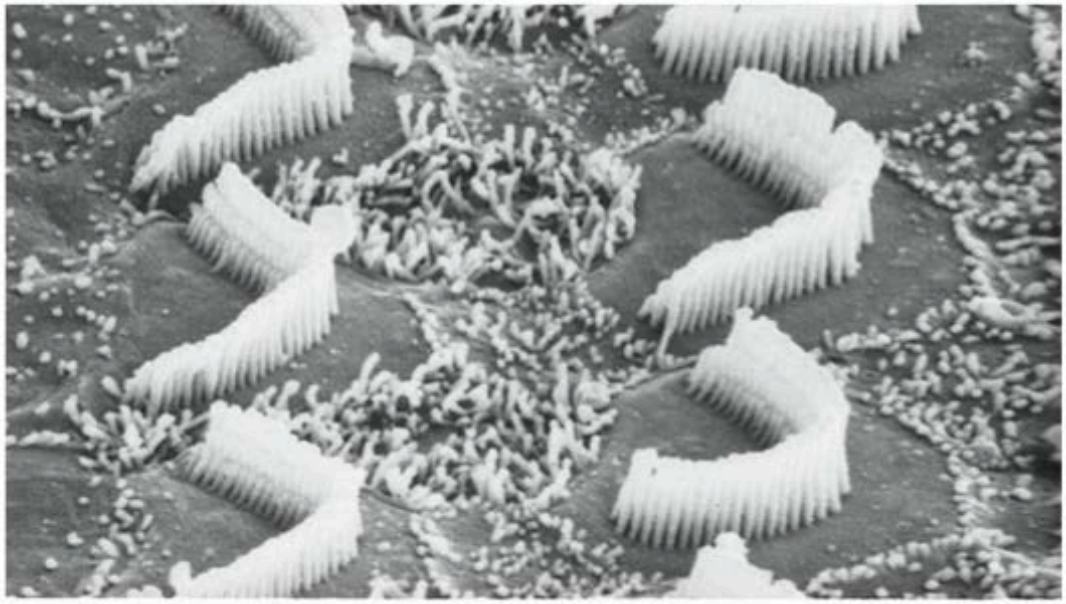
(d) Enlargement of spiral organ (organ of Corti)


Tectorial membrane
Inner hair cell
Outer hair cell
Pillar cells
Deiters's cells
Basilar membrane

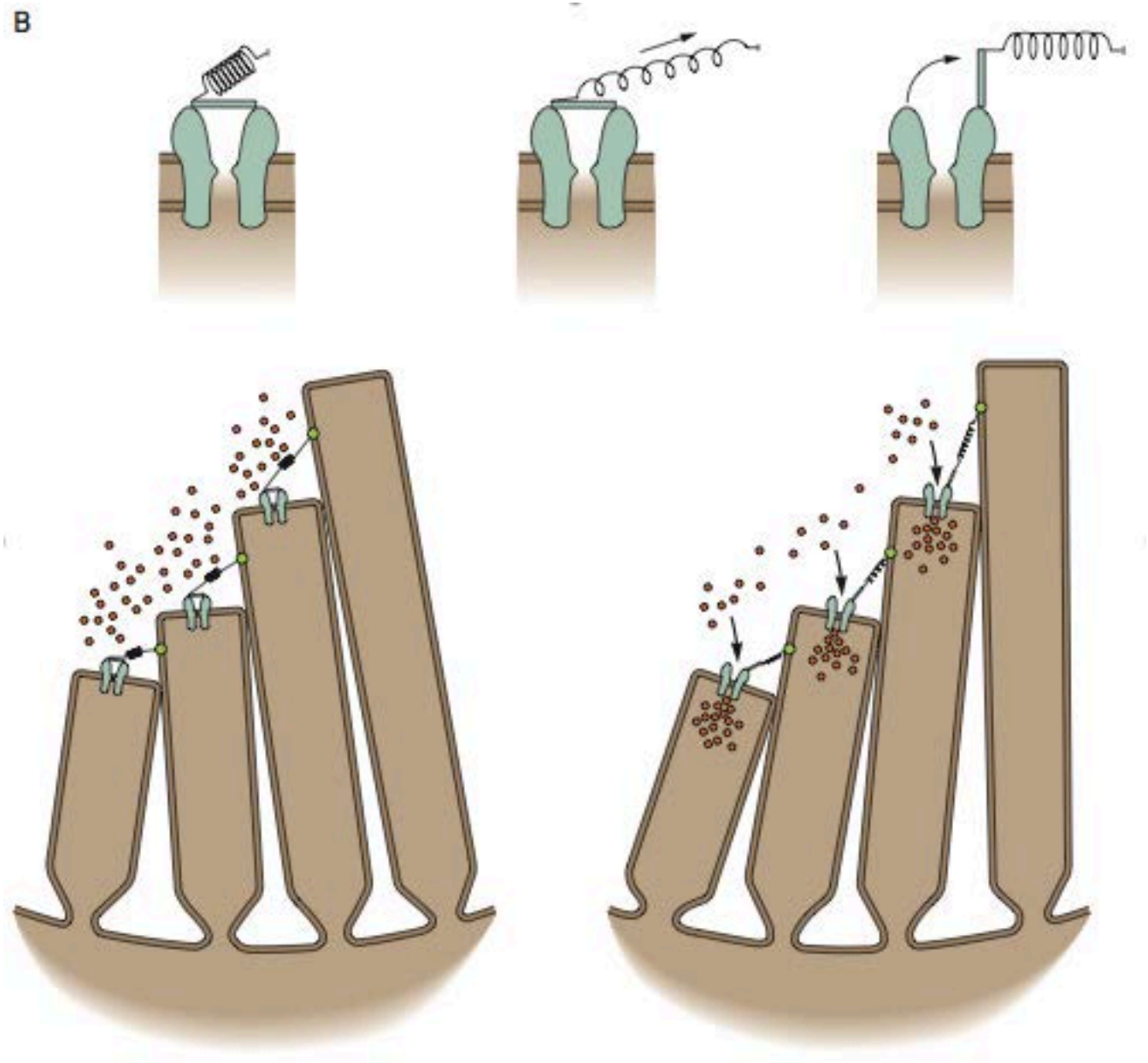
A

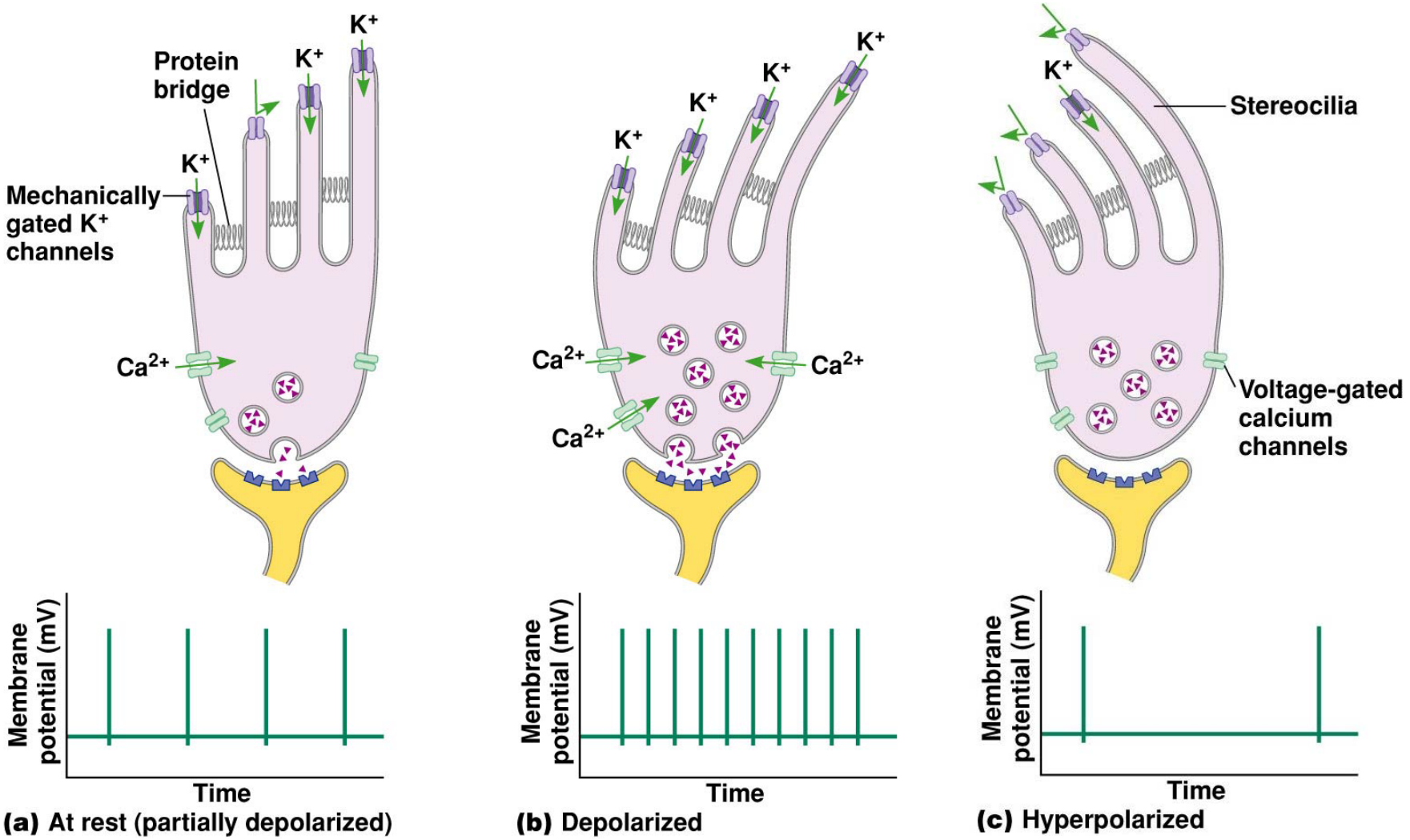


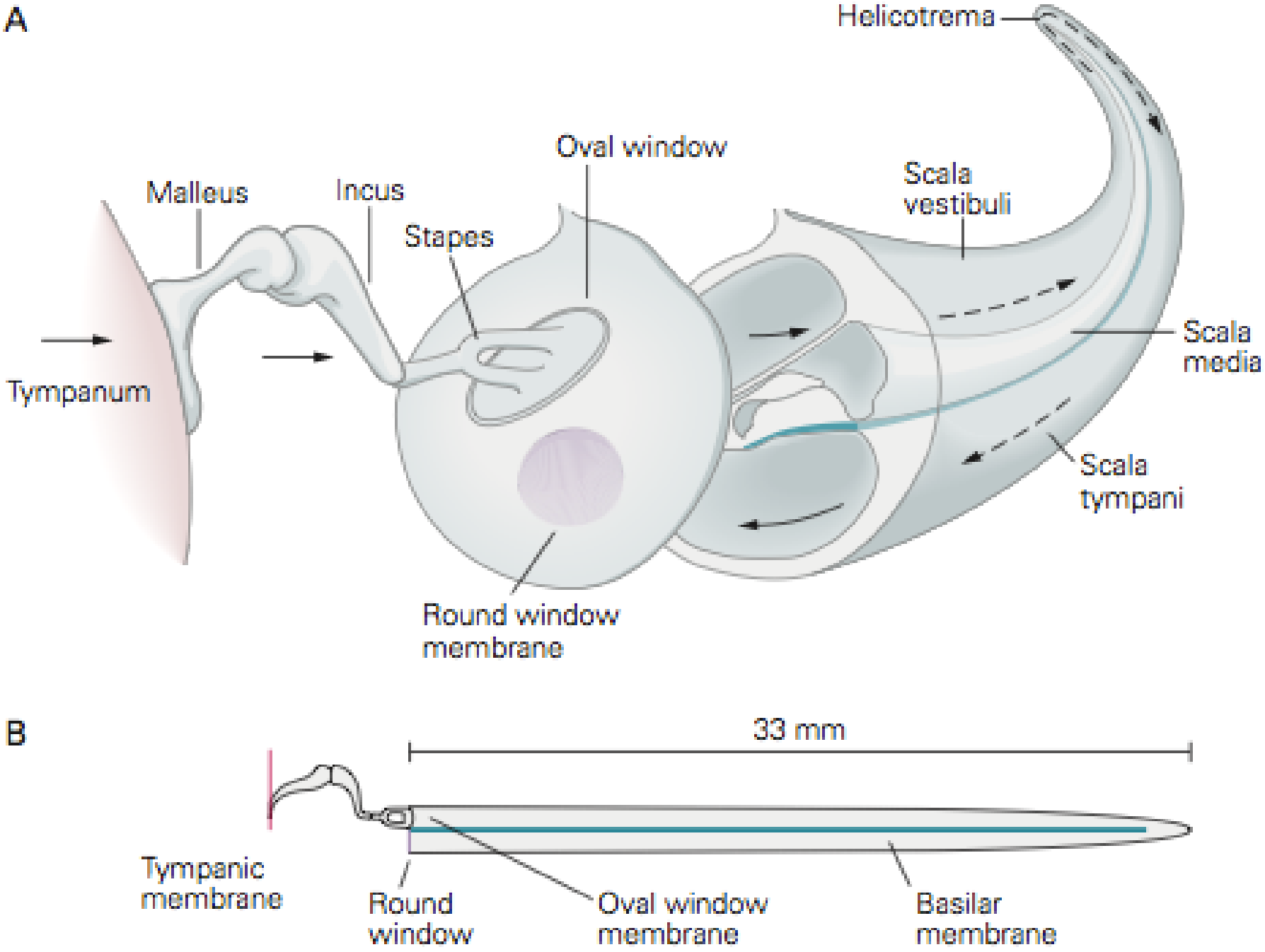
B

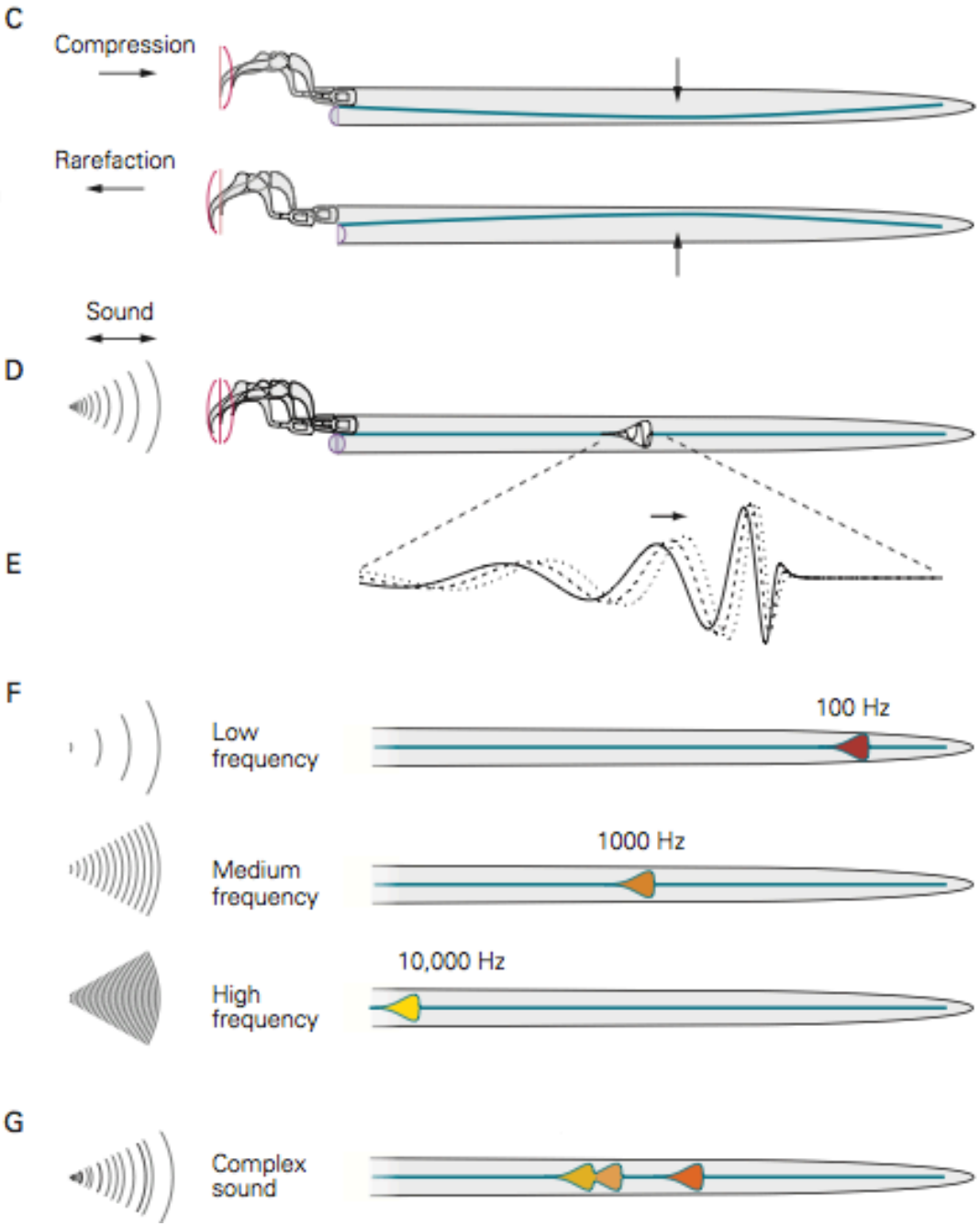


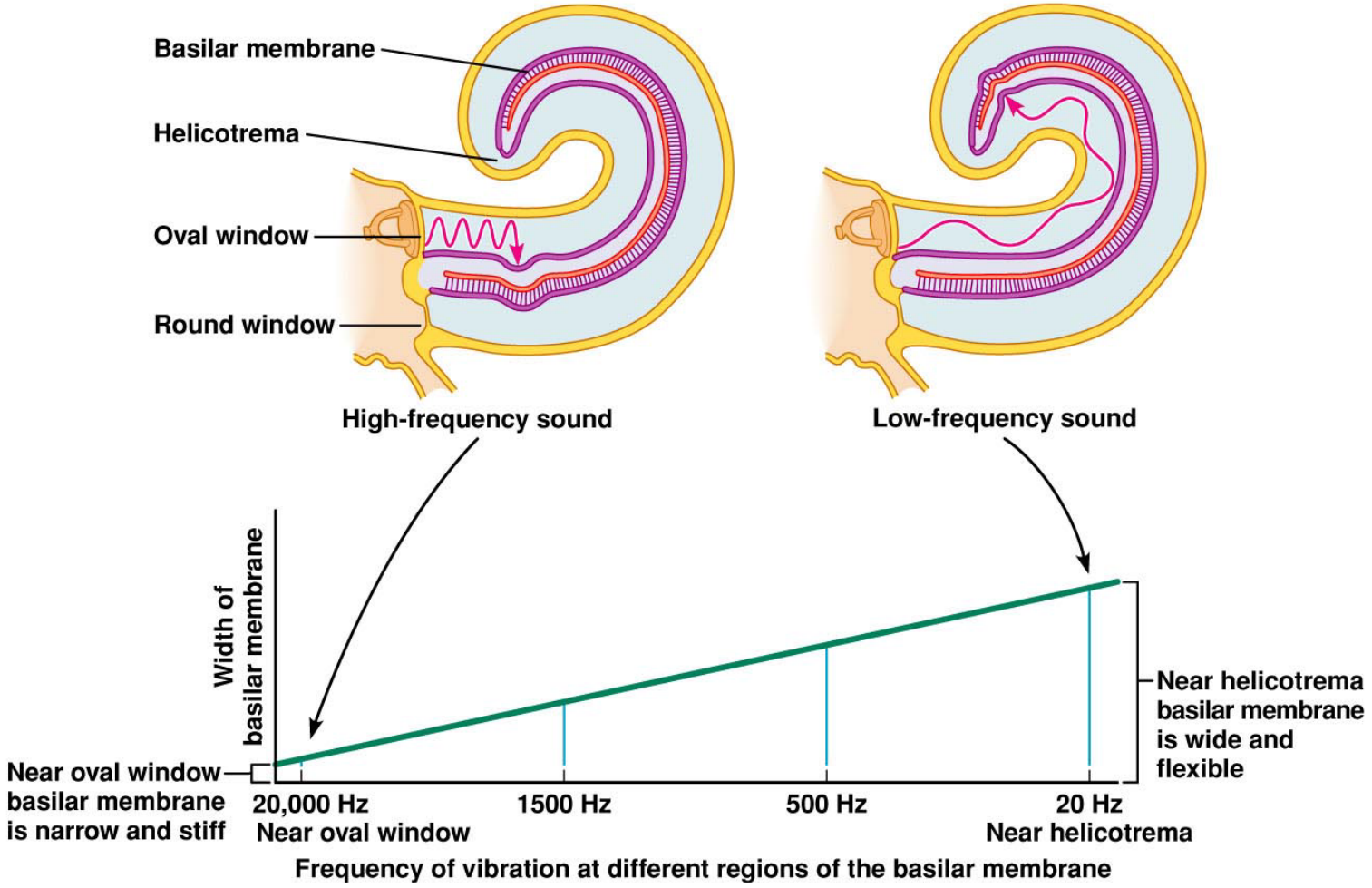
TRANSDUCCIÓN MECANOELECTRICA: NO SEGUNDOS MENSAJEROS. RAPIDEZ

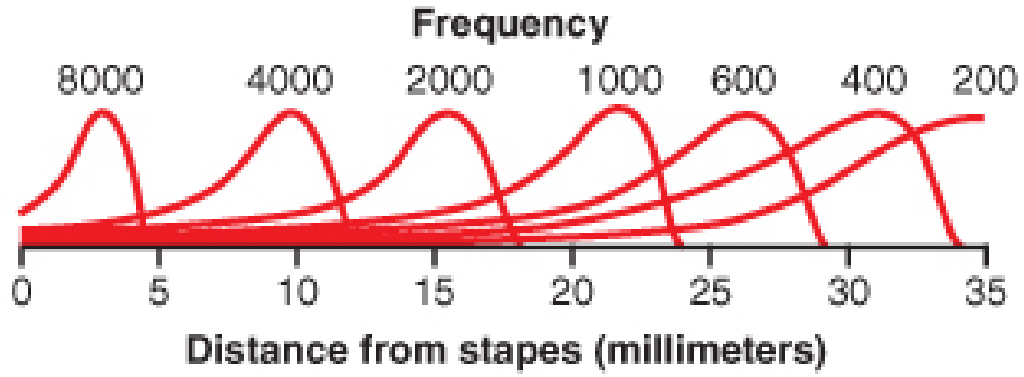


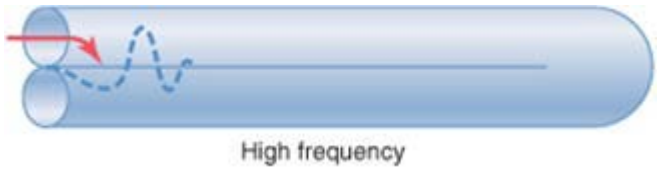

K+
Protein bridge
K+
K+
Mechanically gated K+ channels
Ca2+
Membrane potential (mV)
Time
(a) At rest (partially depolarized)
K+
K+
K+
K+
Ca2+
Ca2+
Ca2+
Membrane potential (mV)
Time
(b) Depolarized
K+
Stereocilia
Voltage-gated calcium channels
Membrane potential (mV)
Time
(c) Hyperpolarized

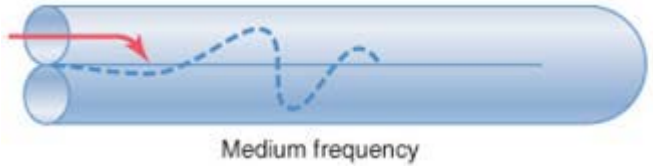

A
Helicotrema
Oval window
Malleus
Incus
Stapes
Scala vestibuli
Scala media
Tympanum
Scala tympani
Round window membrane
B
33 mm
Tympanic membrane
Round window
Oval window membrane
Basilar membrane

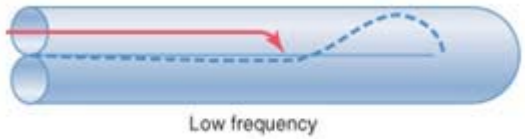

C
Compression
Rarefaction
Sound
D
E
F
Low frequency
100 Hz
Medium frequency
1000 Hz
High frequency
10,000 Hz
G
Complex sound


Basilar membrane
Helicotrema
Oval window
Round window
High-frequency sound
Low-frequency sound
Width of basilar membrane
Near helicotrema basilar membrane is wide and flexible
Near oval window basilar membrane is narrow and stiff
20,000 Hz
Near oval window
1500 Hz
500 Hz
20 Hz
Near helicotrema
Frequency of vibration at different regions of the basilar membrane


Frequency
8000
4000
2000
1000
600
400
200
0
5
10
15
20
25
30
35
Distance from stapes (millimeters)


High frequency

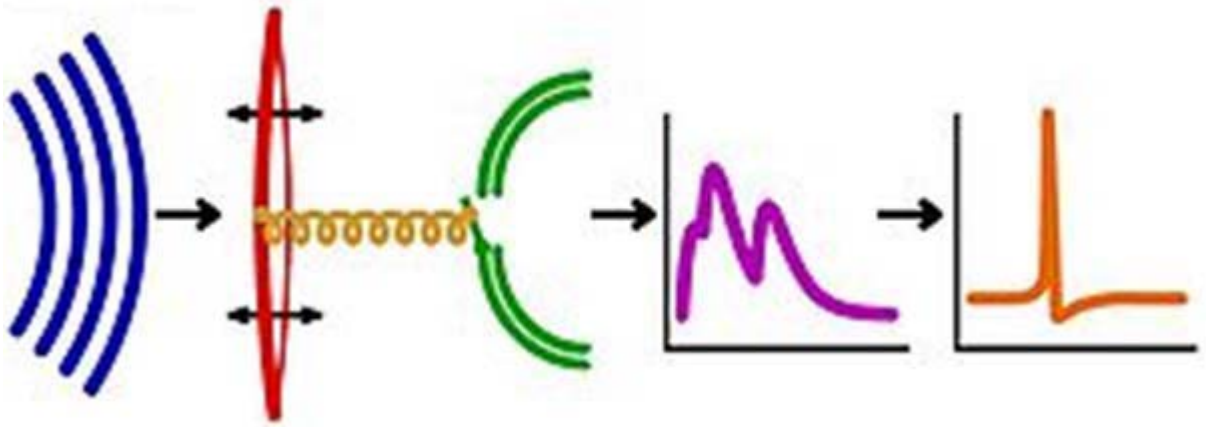

Medium frequency


Low frequency

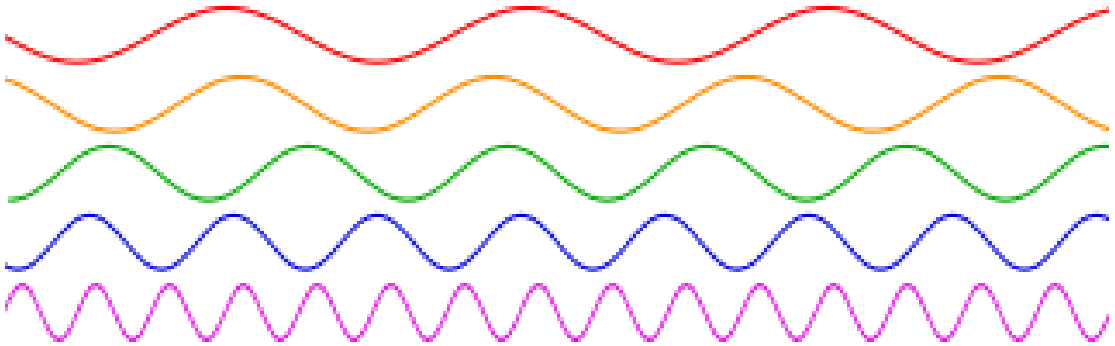
Transducción receptor auditivo

Estímulo

Respuesta

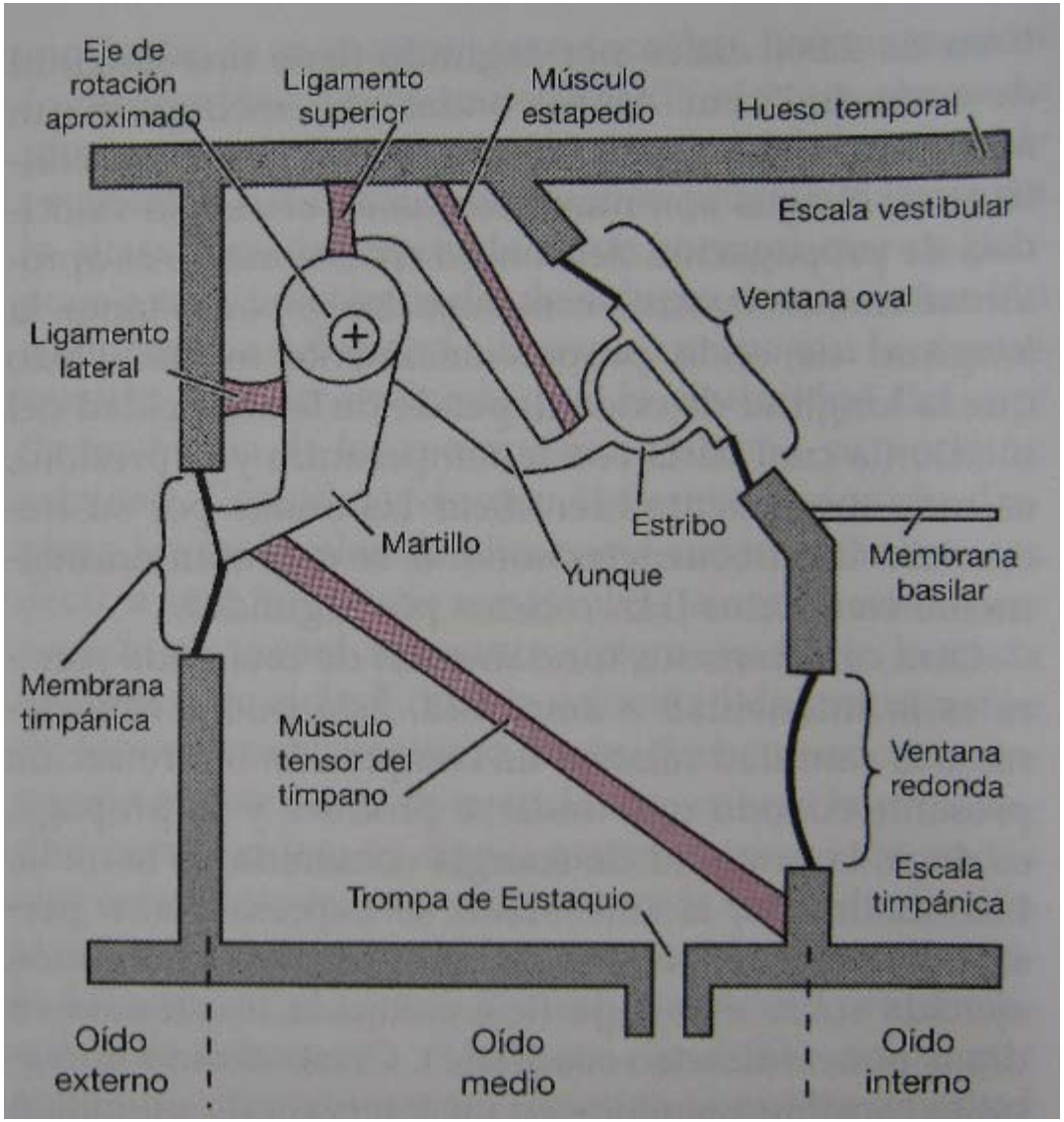


Las ondas sonoras son vibraciones mecánicas que viajan a través de un medio elástico (normalmente aire o agua), con una velocidad de propagación que es constante para cada medio (Aire= 340 m/s. Agua= 1.493 m/s. Hormigón= 4.000 m/s.)

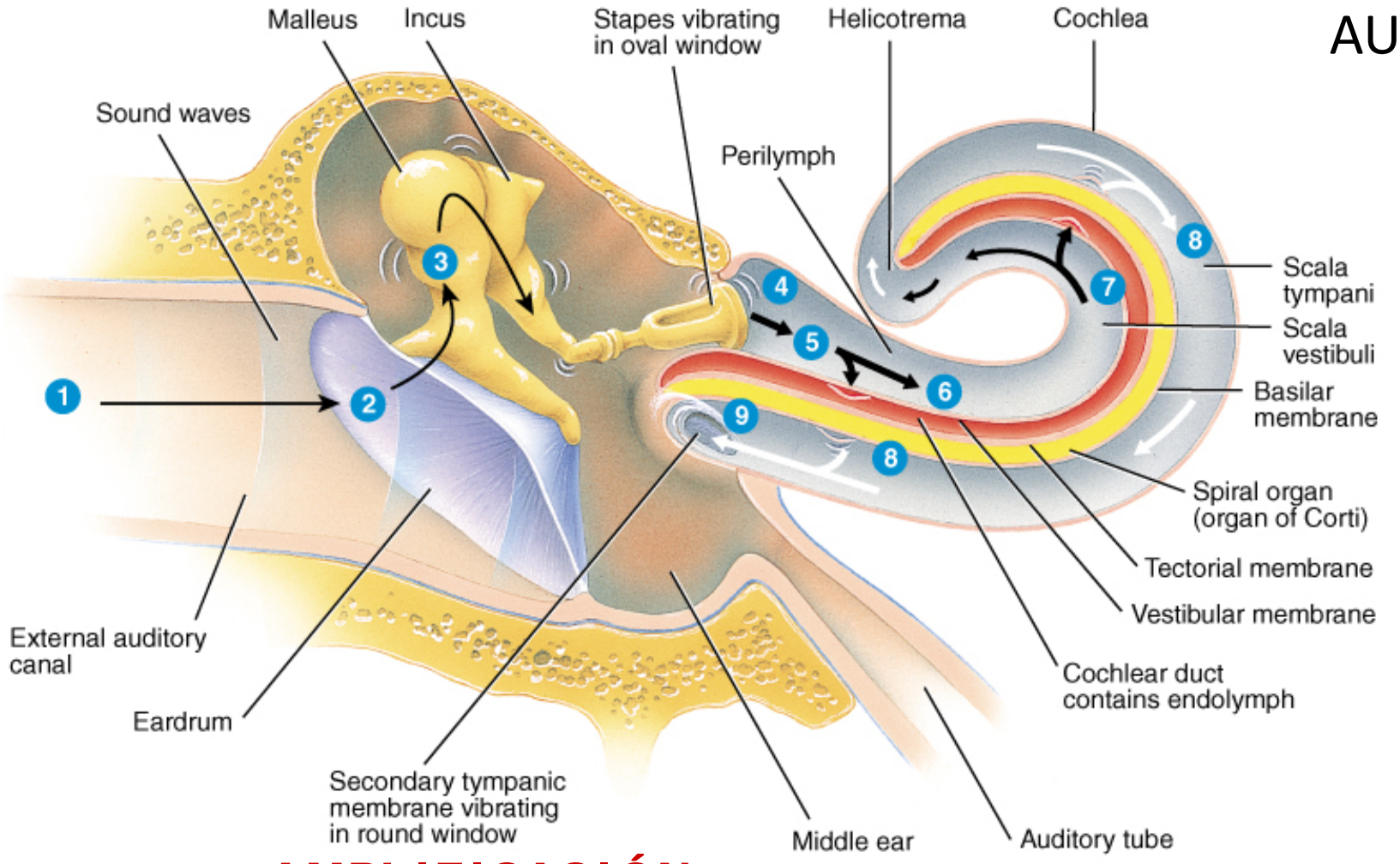


Presión (dyn/cm^2)	NPS (dB)	Fuente del sonido	Presión relativa
0,0002	0	Umbral absoluto	1
0,002	+ 20	Susurro	10
0,02	+ 40	Oficina en silencio	100
0,2	+ 60	Conversación	1.000
2,0	+ 80	Autobús	10.000
20,0	+ 100	Tren del metro	100.000
200,0	+ 120	Trueno	1.000.000
2.000,0	+ 140	Dolor y daño	10.000.000

Modificado de Gulick WA, Gescheider GA, Frisna RD: *Hearing Physiological Acoustics, Neural Coding, and Psychoacoustics*. Nueva York: Oxford University Press, 1989, tabla 2.2, pág. 51.

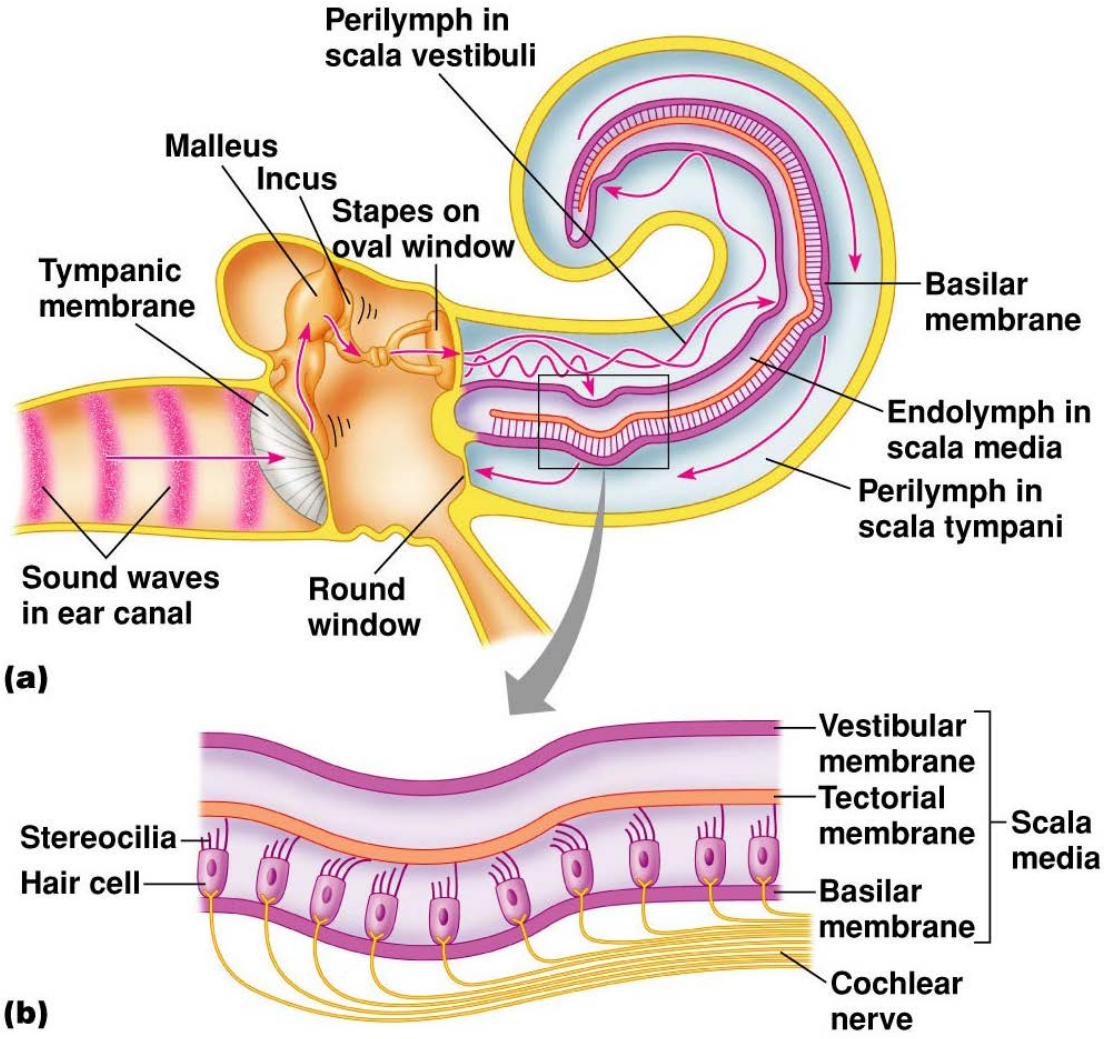

Eje de rotación aproximado
Ligamento superior
Músculo estapedio
Hueso temporal
Escala vestibular
Ventana oval
Ligamento lateral
Estribo
Martillo
Yunque
Membrana basilar
Membrana timpánica
Músculo tensor del tímpano
Ventana redonda
Escala timpánica
Trompa de Eustaquio
Oído externo
Oído medio
Oído interno

AUDICIÓN

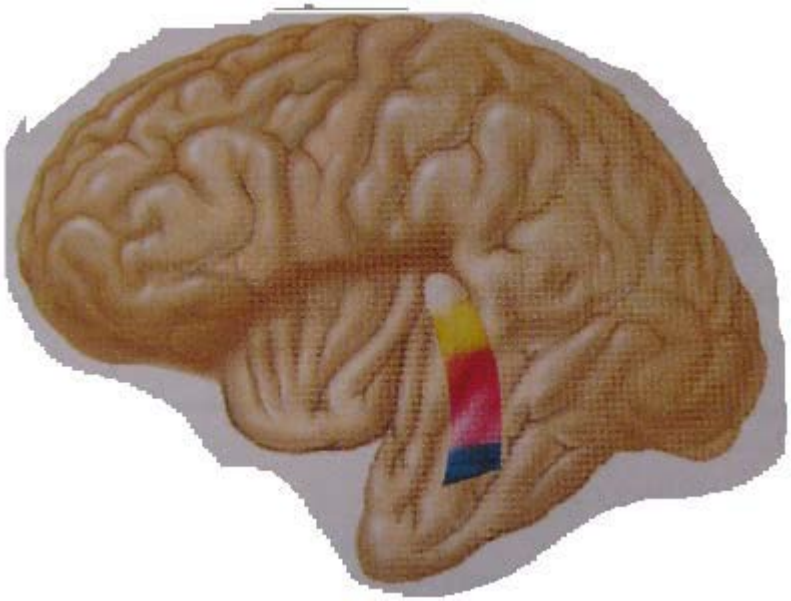


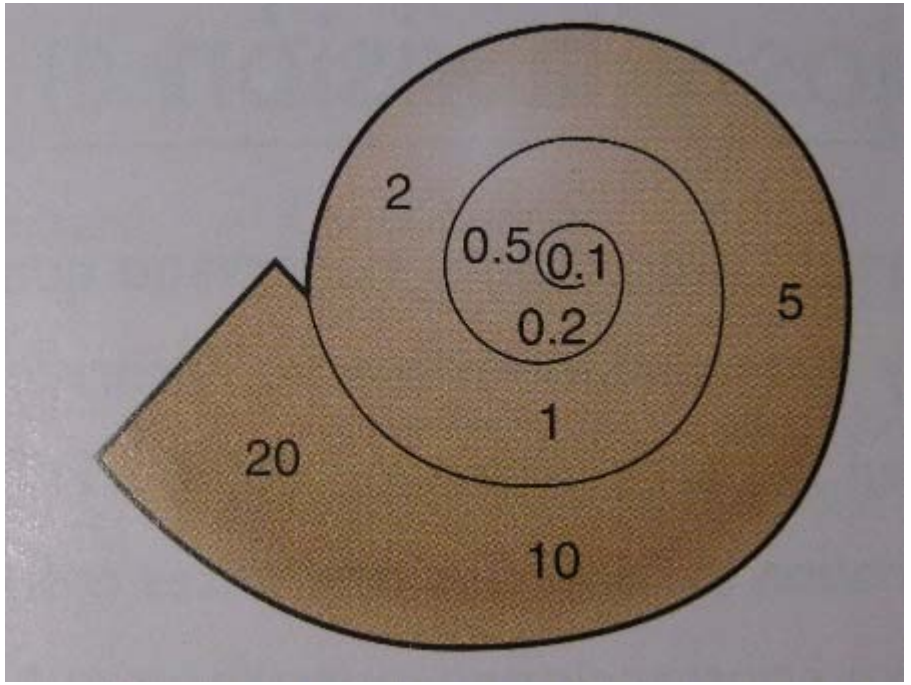
AMPLIFICACIÓN

Los sonidos de alta frecuencia vibran en la base de la cóclea, los más graves en el vértice de la cóclea.
Los sonidos de más intensidad hacen vibrar más la membrana basilar lo que provoca una alta frecuencia de disparo de PA.


Perilymph in scala vestibuli
Malleus
Incus
Stapes on oval window
Tympanic membrane
Basilar membrane
Endolymph in scala media
Perilymph in scala tympani
Sound waves in ear canal
Round window
(a)
Vestibular membrane
Tectorial membrane
Basilar membrane
Scala media
Stereocilia
Hair cell
Cochlear nerve
(b)

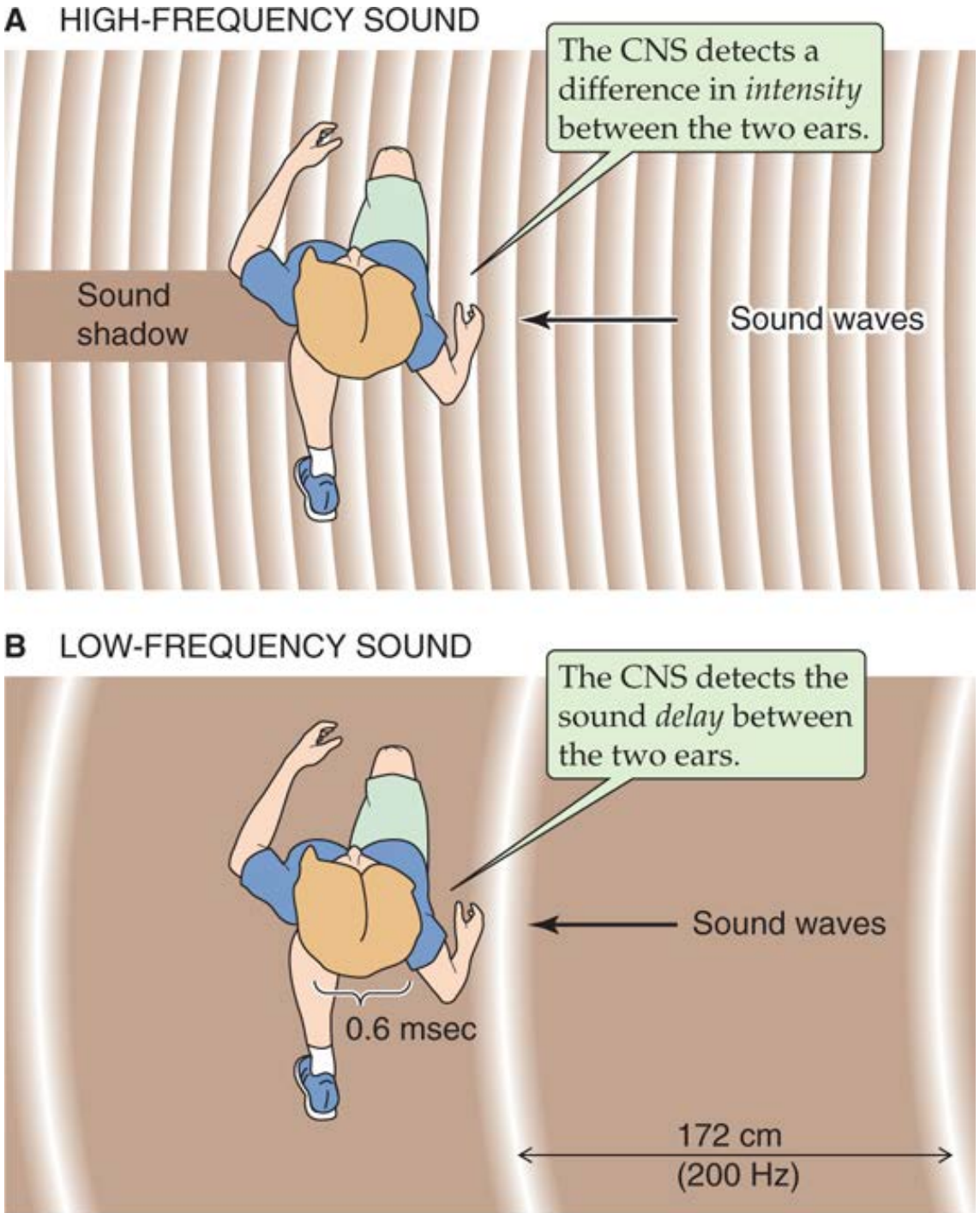
Tonotopía

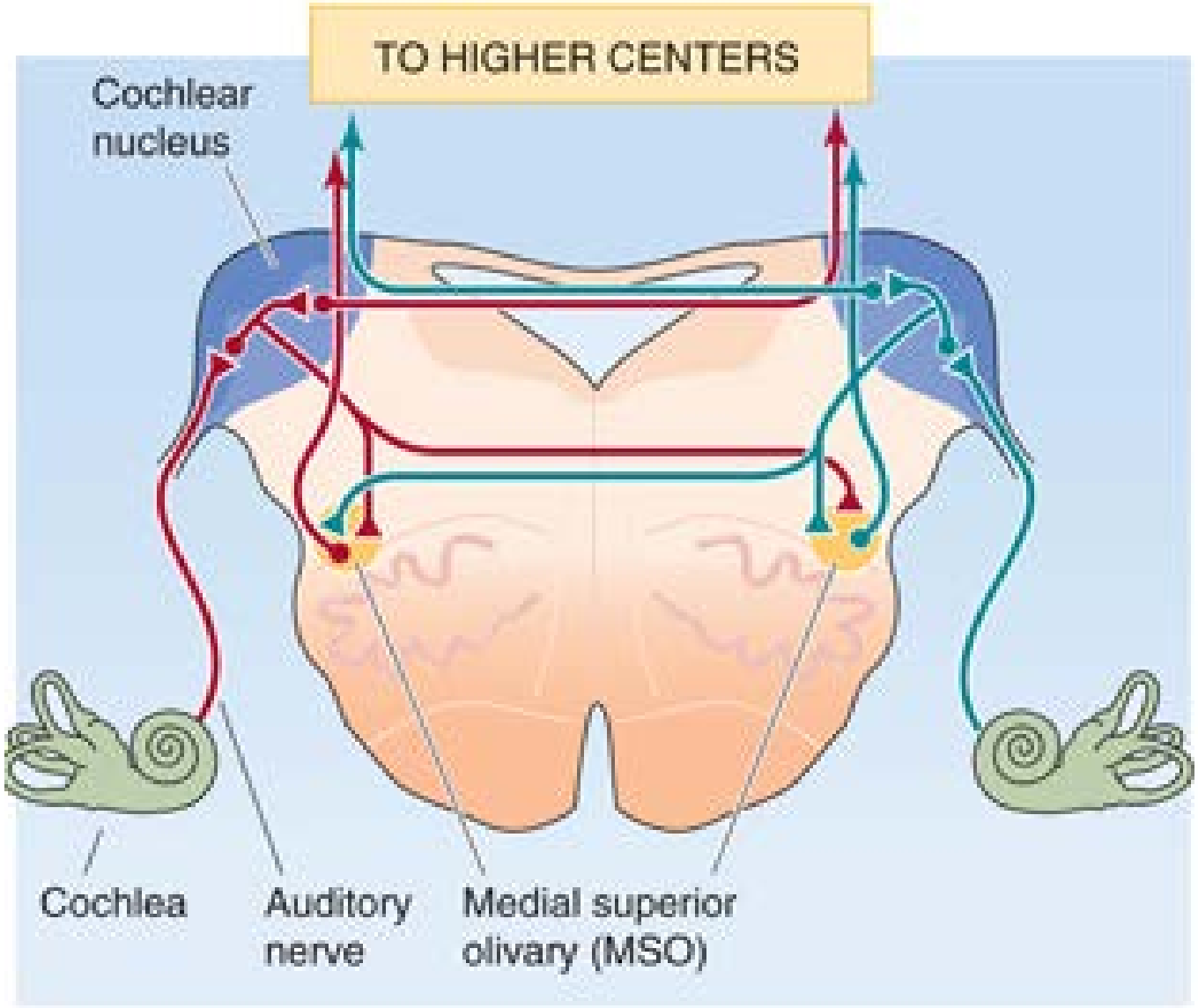


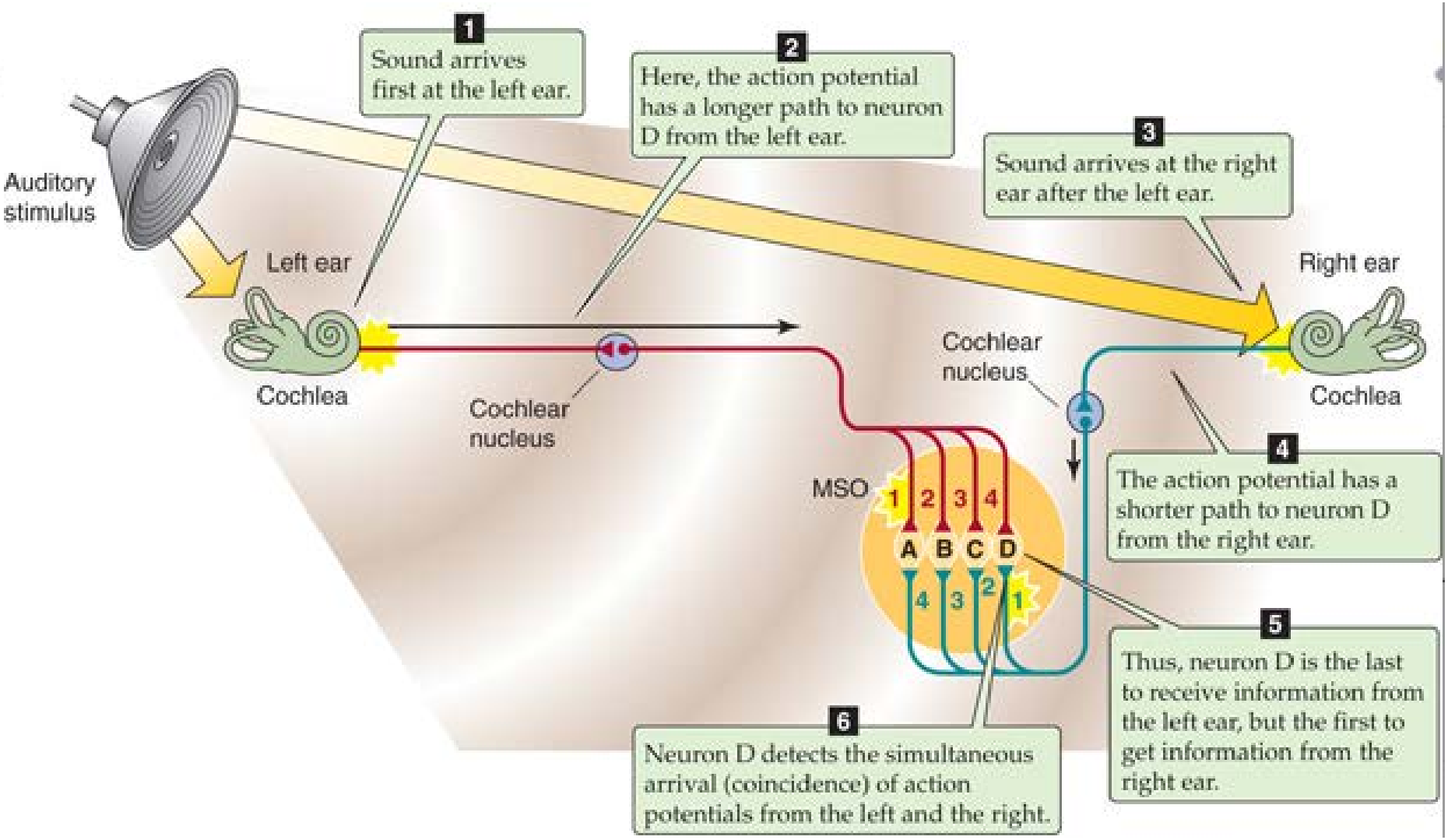


AUDICIÓN

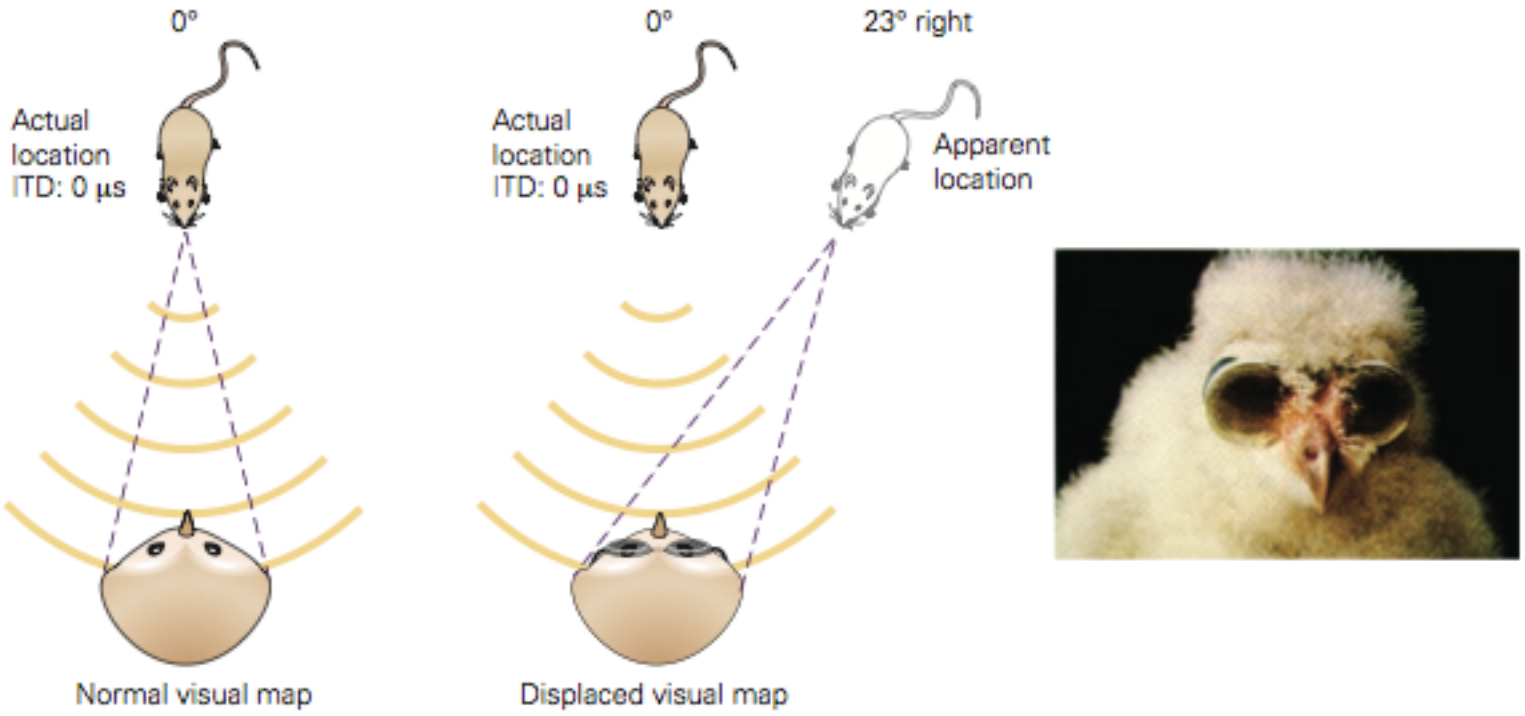
¿CÓMO PUEDO LOCALIZAR APROXIMADAMENTE EL LUGAR DE PROCEDENCIA DEL SONIDO?


A HIGH-FREQUENCY SOUND
The CNS detects a difference in *intensity* between the two ears.
Sound shadow
Sound waves
B LOW-FREQUENCY SOUND
The CNS detects the sound *delay* between the two ears.
Sound waves
0.6 msec
172 cm
(200 Hz)

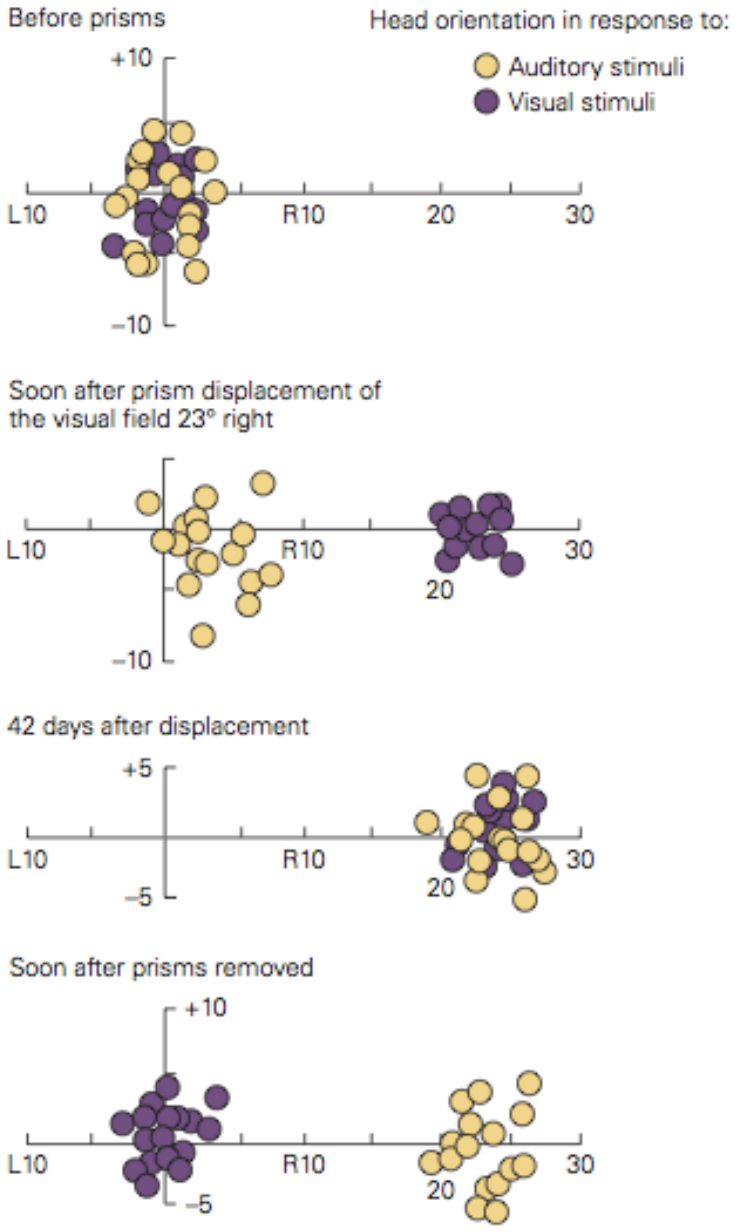

TO HIGHER CENTERS
Cochlear nucleus
Cochlea
Auditory nerve
Medial superior olivary (MSO)

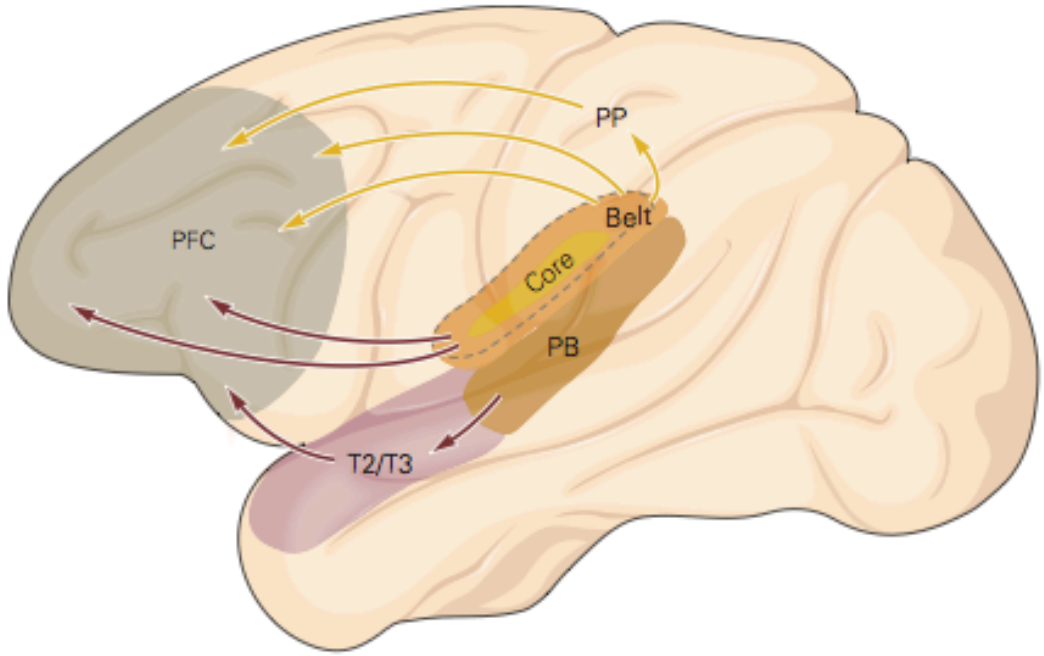

1
Sound arrives first at the left ear.
2
Here, the action potential has a longer path to neuron D from the left ear.
3
Sound arrives at the right ear after the left ear.
Auditory stimulus
Left ear
Right ear
Cochlea
Cochlear nucleus
Cochlear nucleus
Cochlea
MSO
1 2 3 4
A B C D
4 3 2 1
4
The action potential has a shorter path to neuron D from the right ear.
5
Thus, neuron D is the last to receive information from the left ear, but the first to get information from the right ear.
6
Neuron D detects the simultaneous arrival (coincidence) of action potentials from the left and the right.

A Prisms displace visual space



B Prisms alter auditory orienting behavior





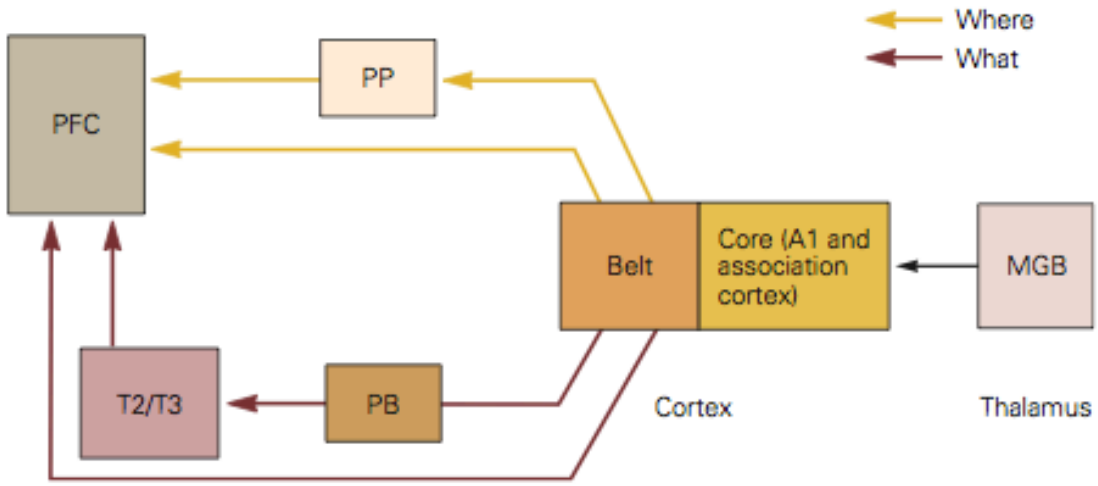


Figure 31–13 The "what" and "where" streams in the auditory cortical system of primates. The ventral "what" stream and dorsal "where" stream originate in different parts of primary and belt cortex and ultimately project to distinct regions of prefrontal cortex through independent paths. (**MGB**, medial geniculate body of the thalamus; **PB**, parabelt cortex; **PFC**, prefrontal cortex; **PP**, posterior parietal cortex; **T2/T3**, areas of temporal cortex.) (Modified, with permission, from Rauschecker 2000 and from Romanski and Averbeck 2009.)