Fisiología de la Audición

FACULTAD DE MEDICINA
UNIVERSIDAD DE CHILE

Hayo A. Breinbauer Krebs (Dr.med/PhD).
Universidad de Chile – Departamento Neurociencias
Universidad de Chile – Hospital San Juan de Dios

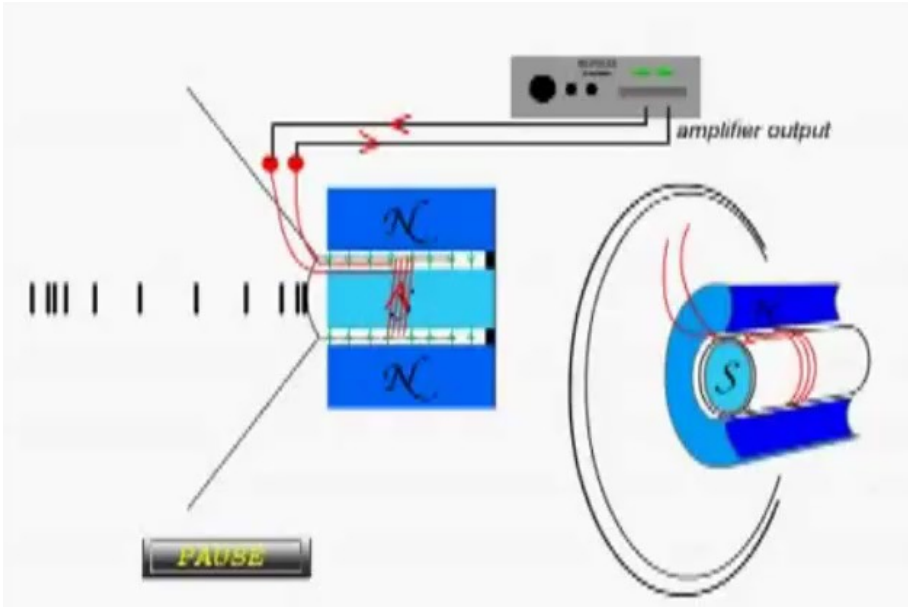
La audición en un minuto

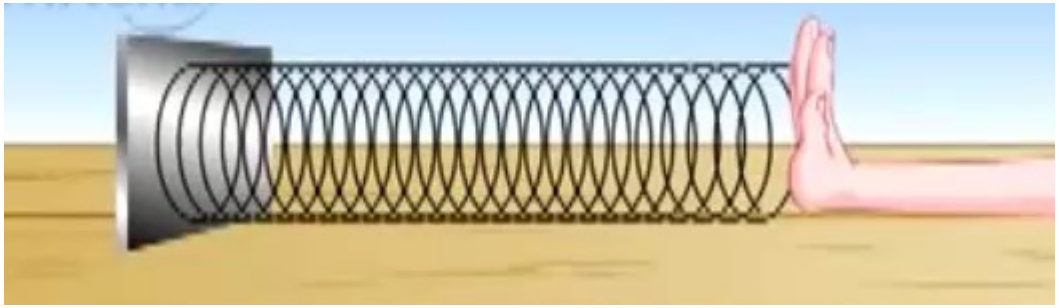
La audición en un minuto

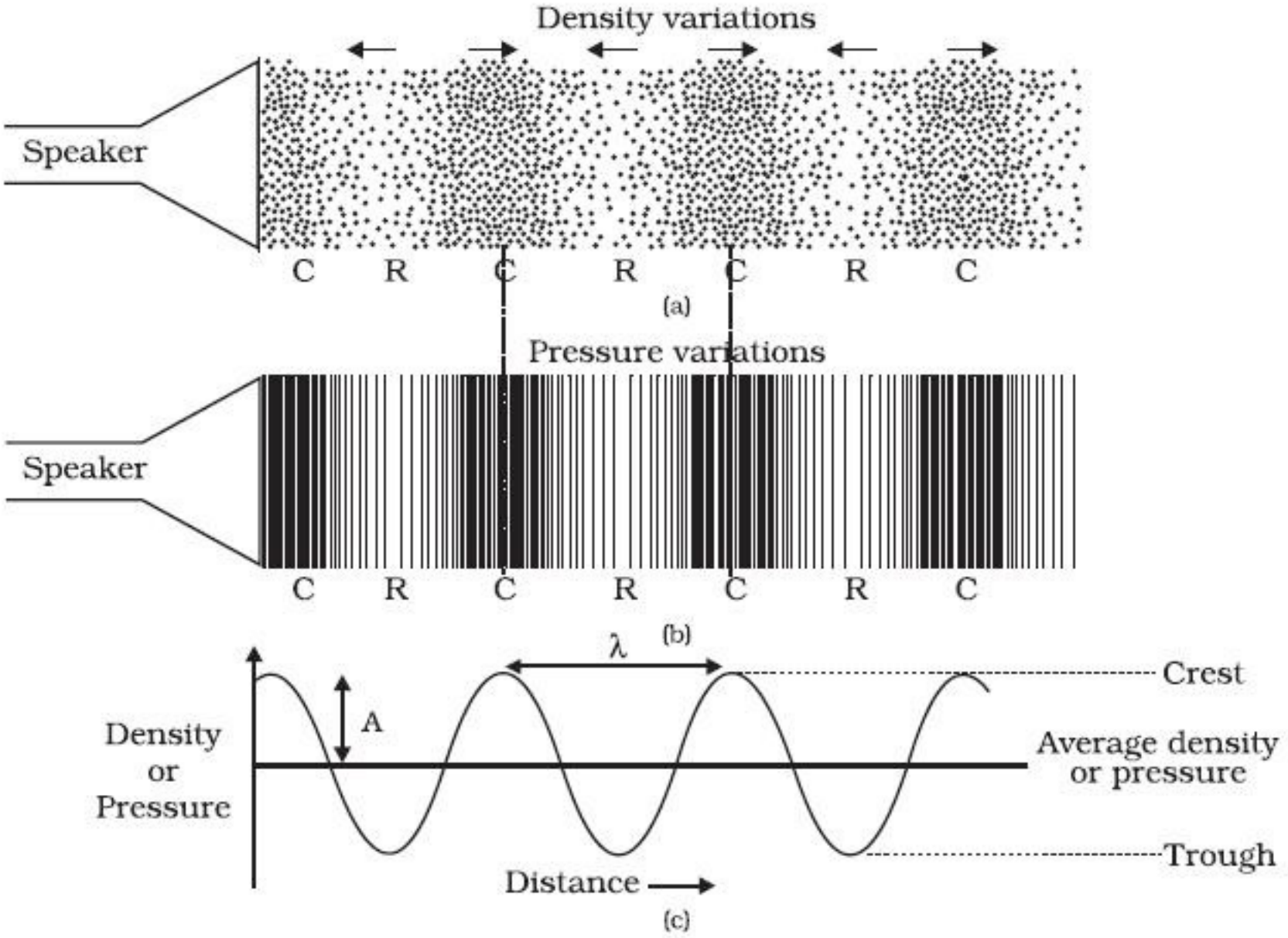
¿Qué es el sonido?

¿QUÉ ES EL SONIDO?

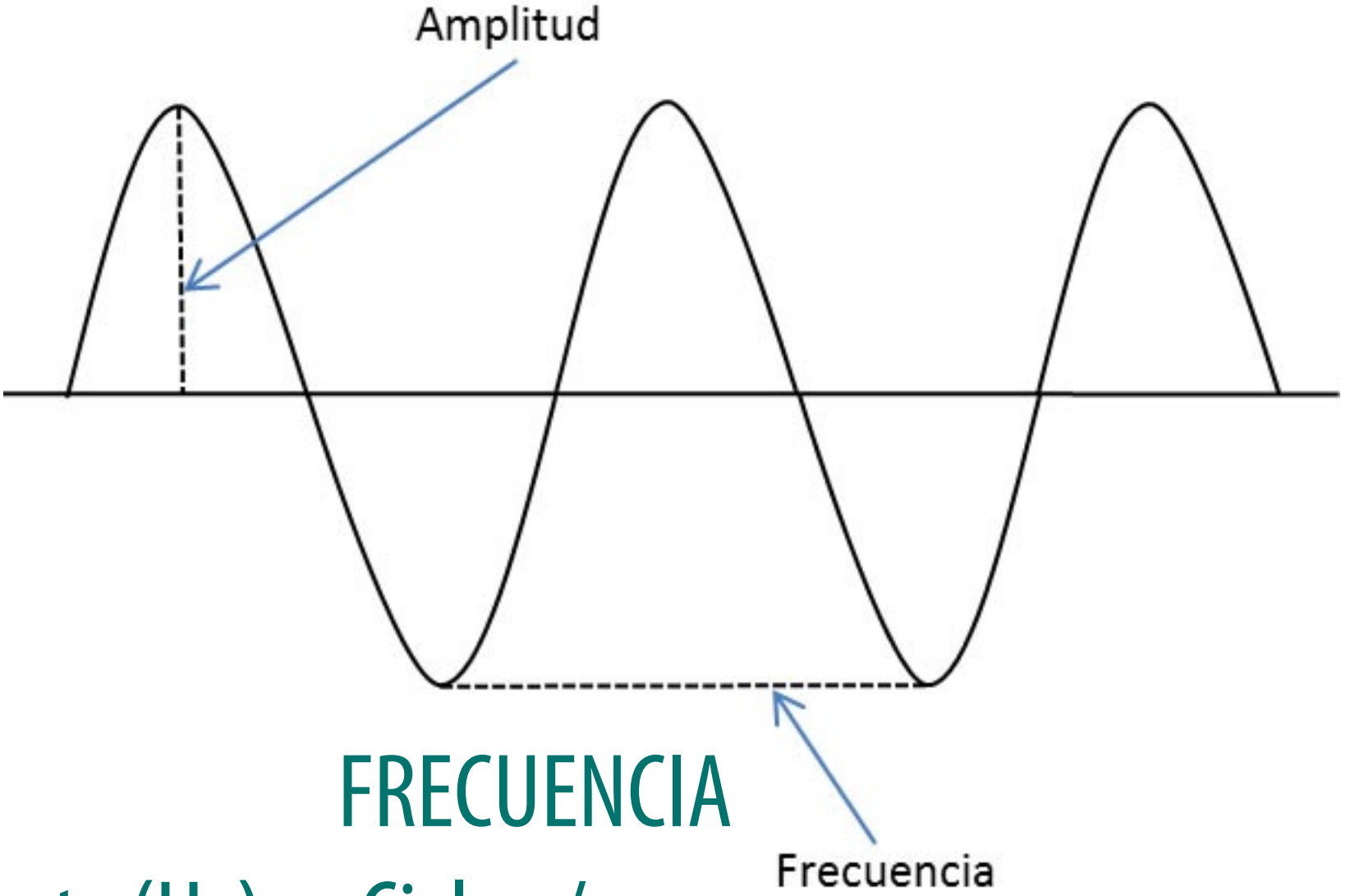
Vibración u **oscilación** de un **medio elástico**, la cual se **propaga** como **onda** a través de dicho medio.






Density variations
Speaker
C R C R C R C
(a)
Pressure variations
Speaker
C R C R C R C
(b)
λ
A
Density or Pressure
Crest
Average density or pressure
Trough
Distance
(c)

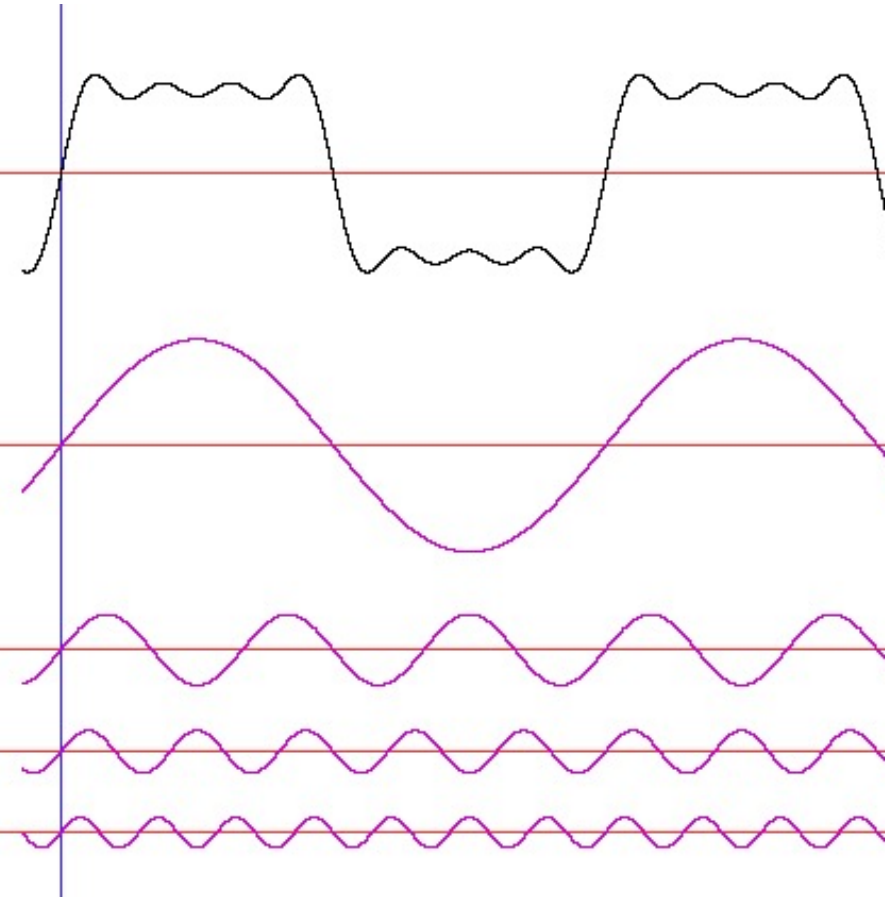
INTENSIDAD = DECIBEL (dB)

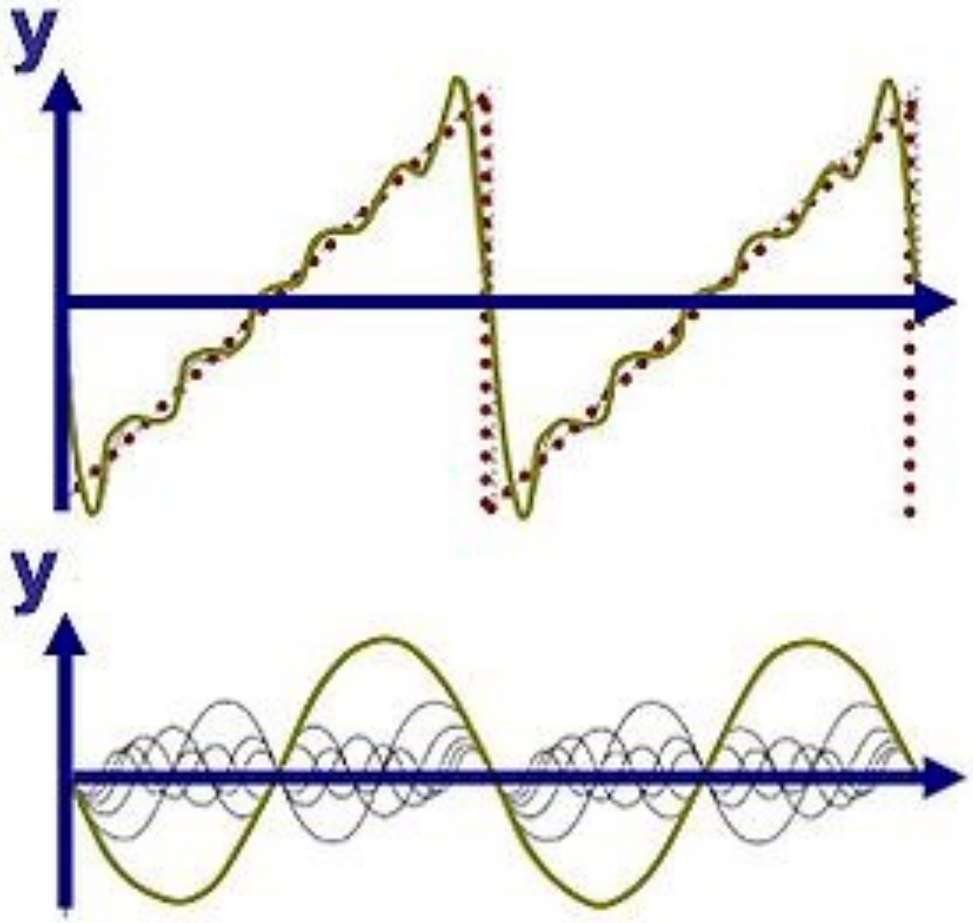


FRECUENCIA

Hertz (Hz) = Ciclos / seg.

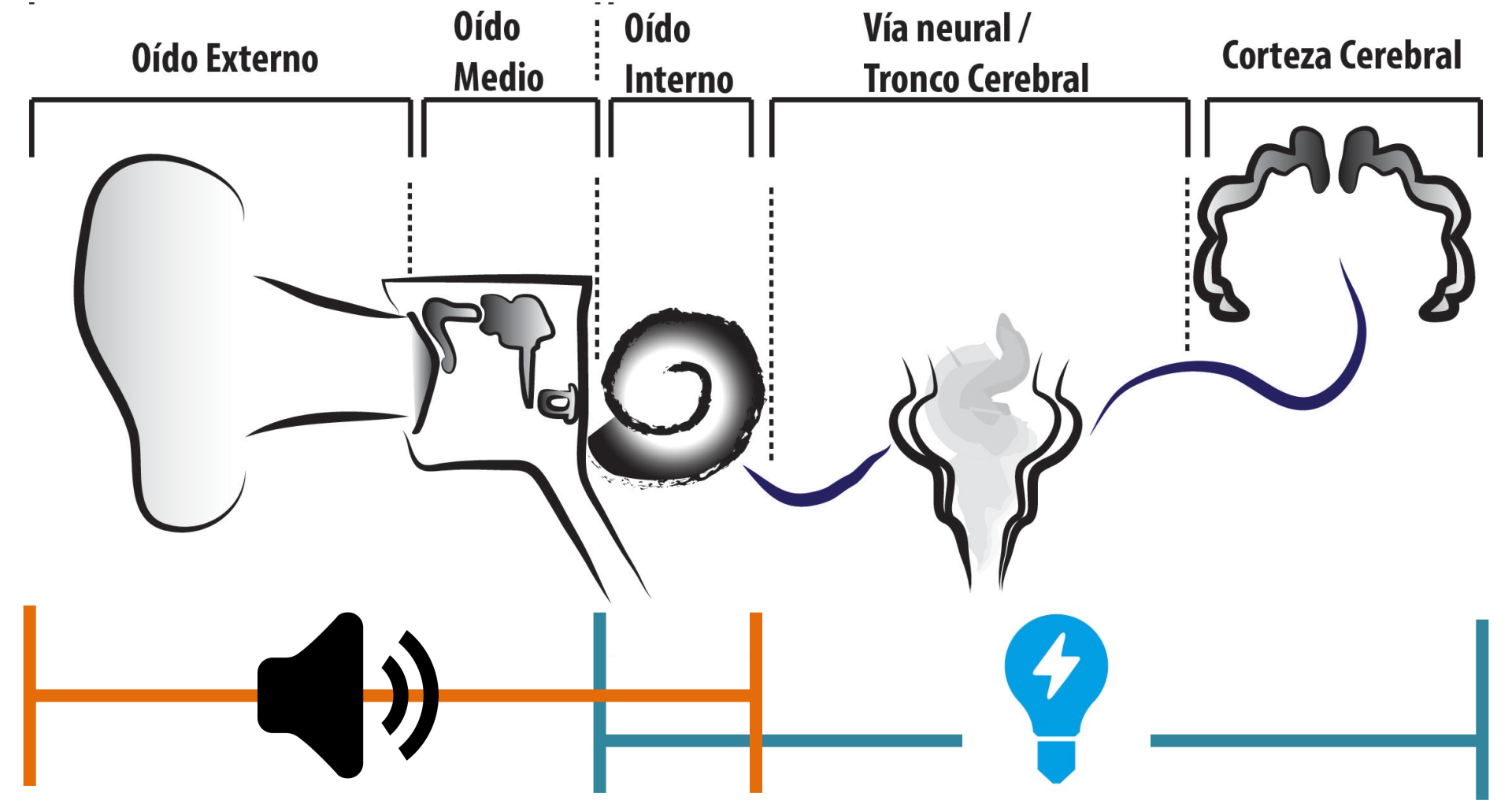

Low
frequency
High
frequency





DESCOMPOSICIÓN FRECUENCIAL FOURIER

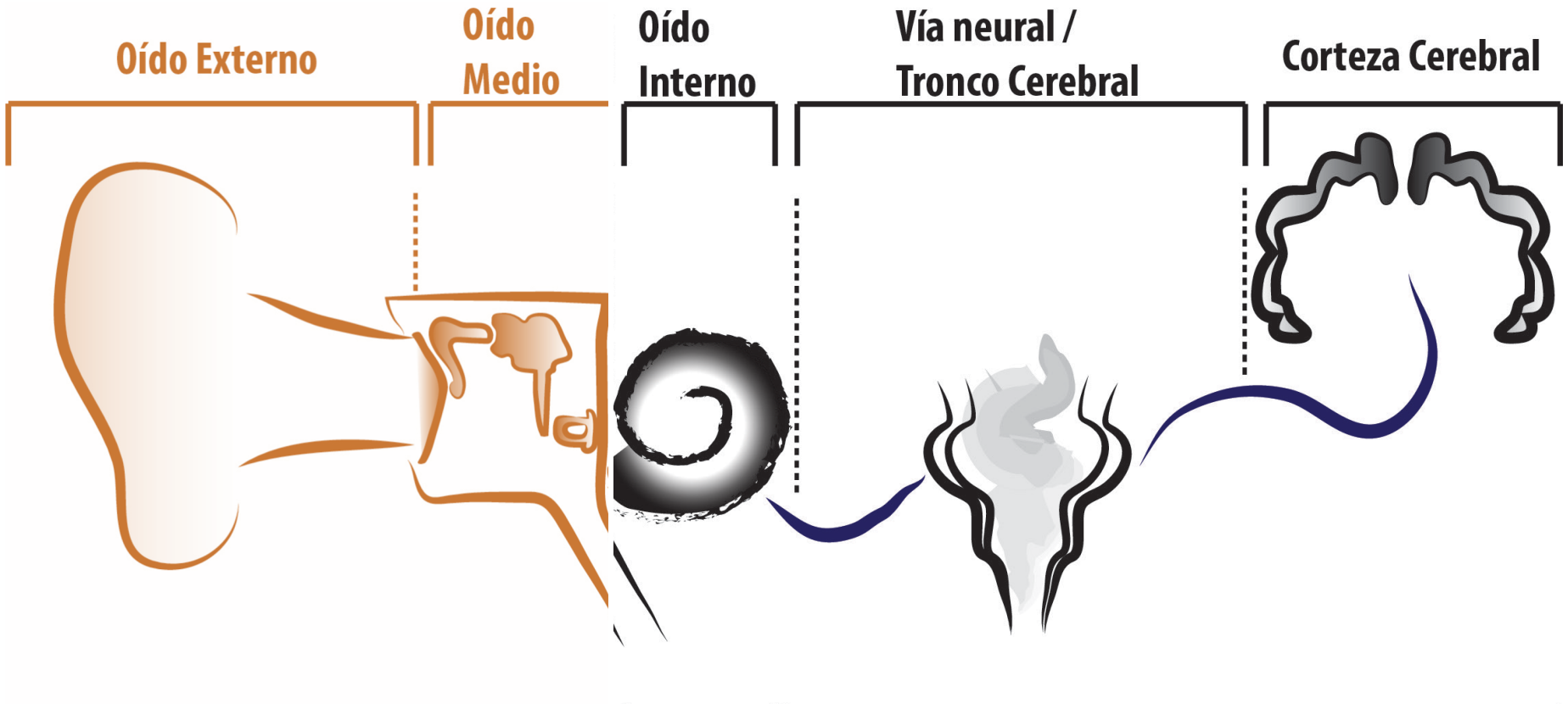
Partes de la vía auditiva

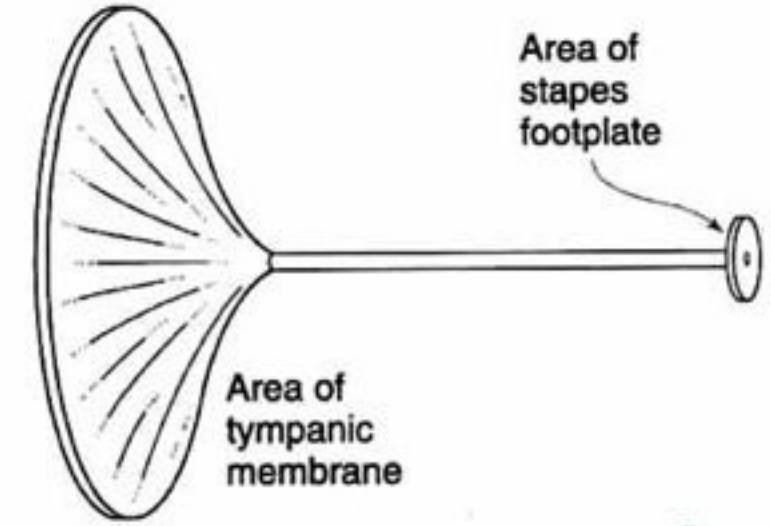


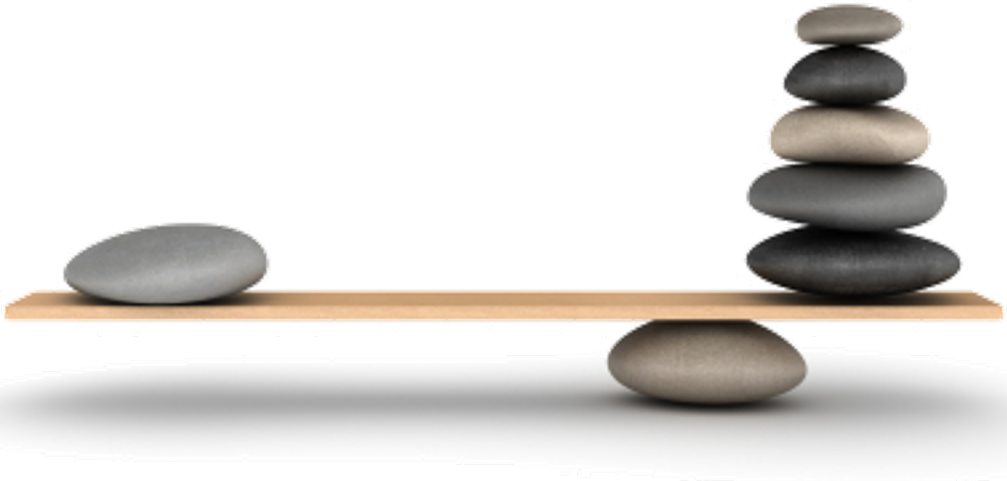
Onda Mecánica

Señal bio-eléctrica

Oído medio y externo

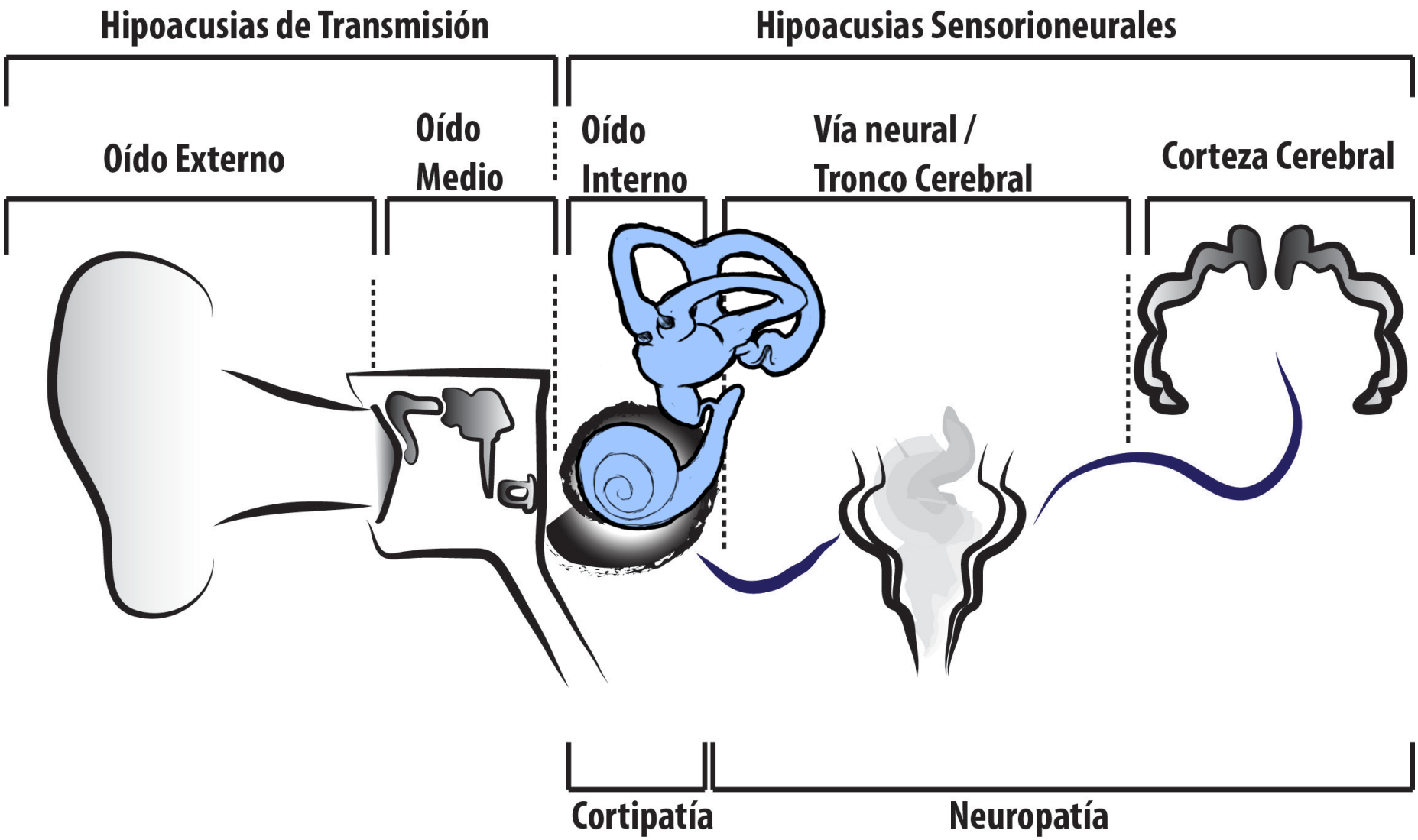

Oído Externo
Oído Medio
Oído Interno
Vía neural / Tronco Cerebral
Corteza Cerebral

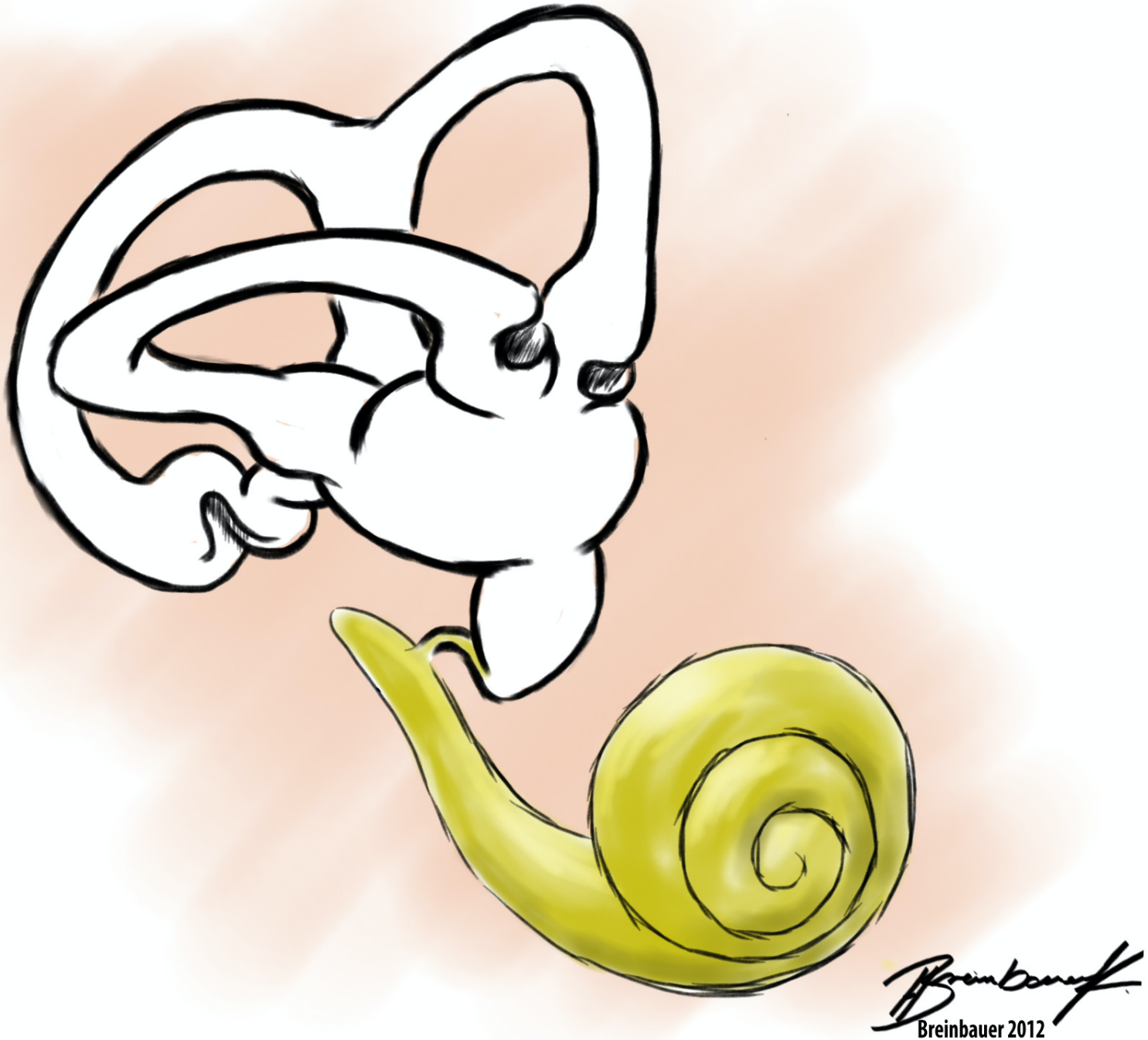

Area of
stapes
footplate
Area of
tympanic
membrane

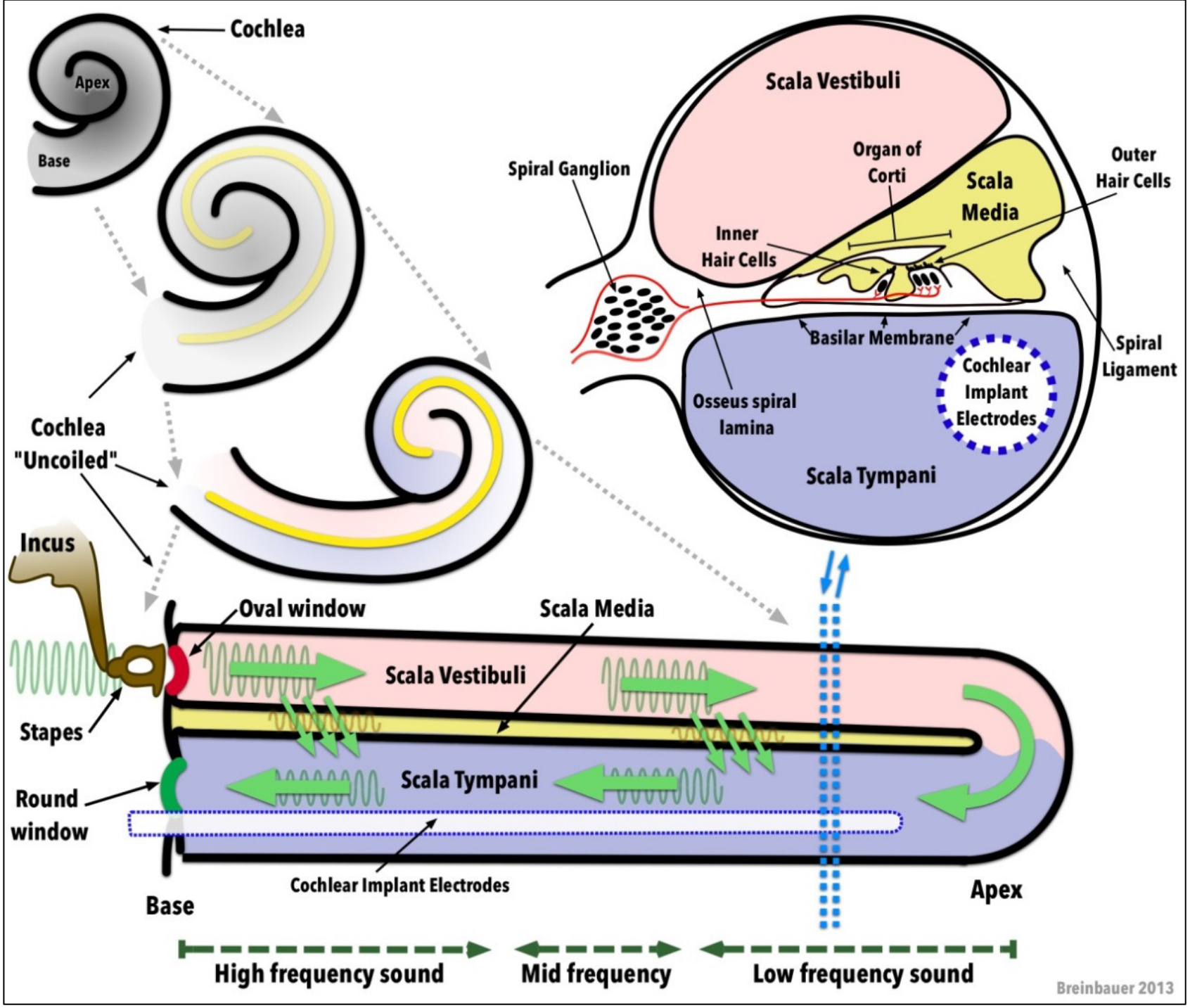


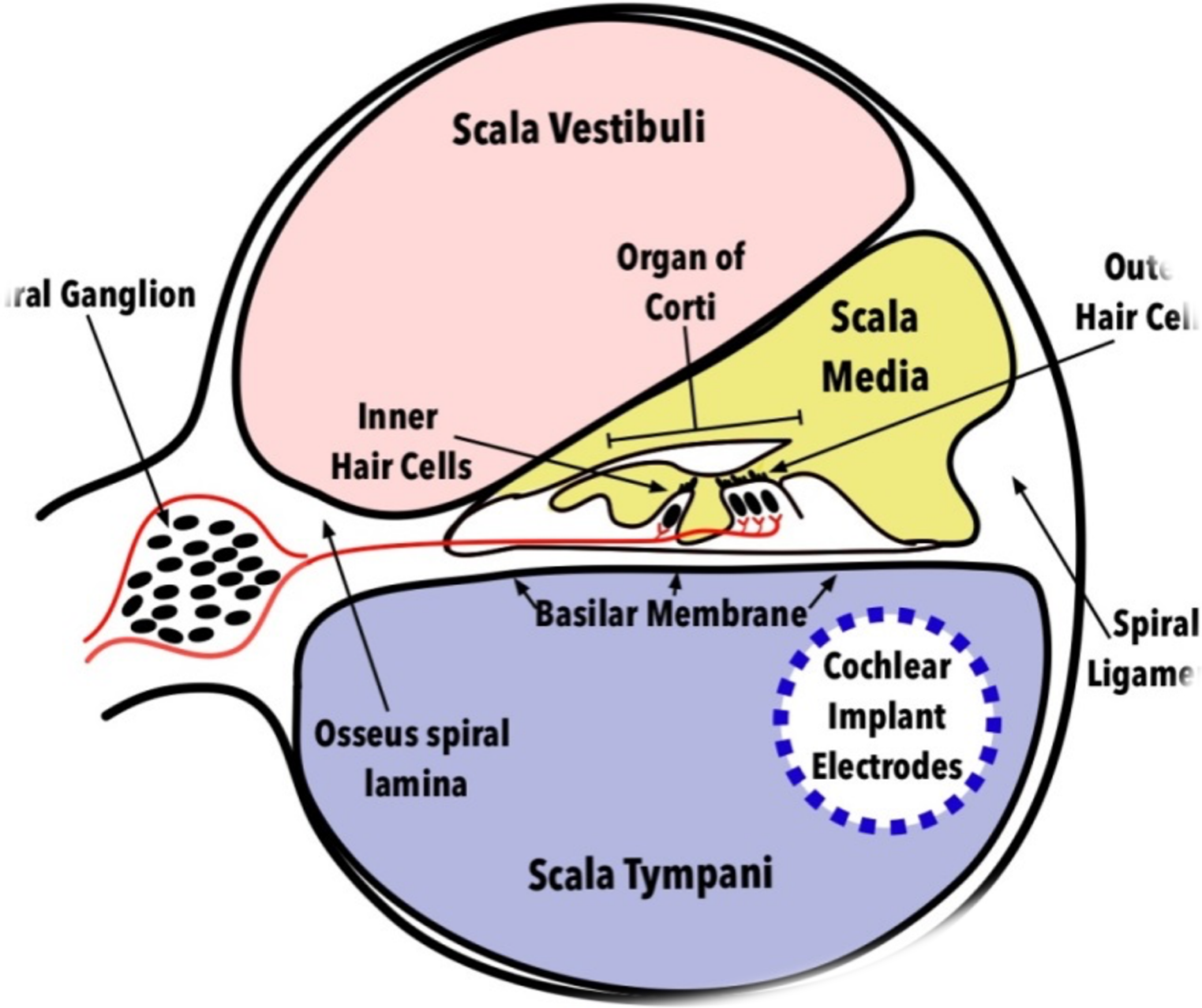
Oído interno

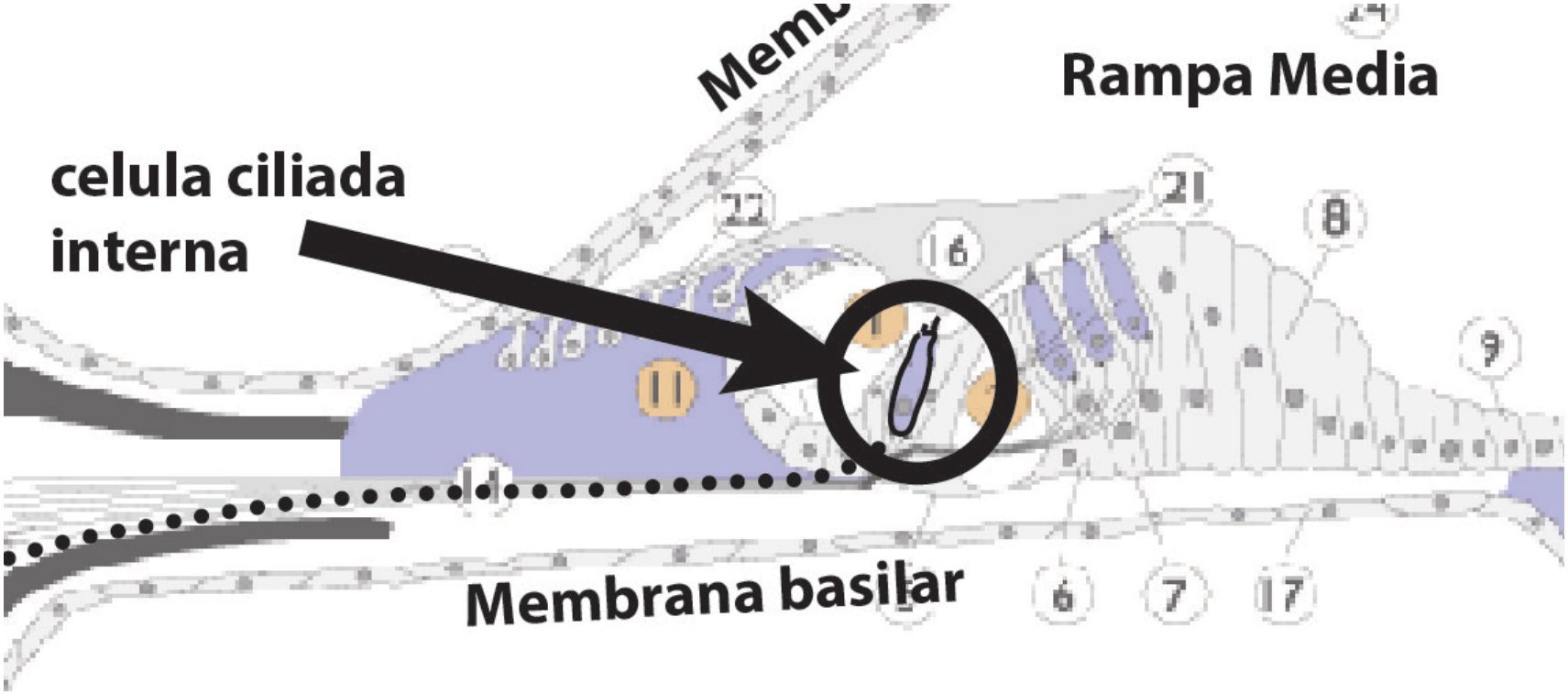
células ciliadas internas

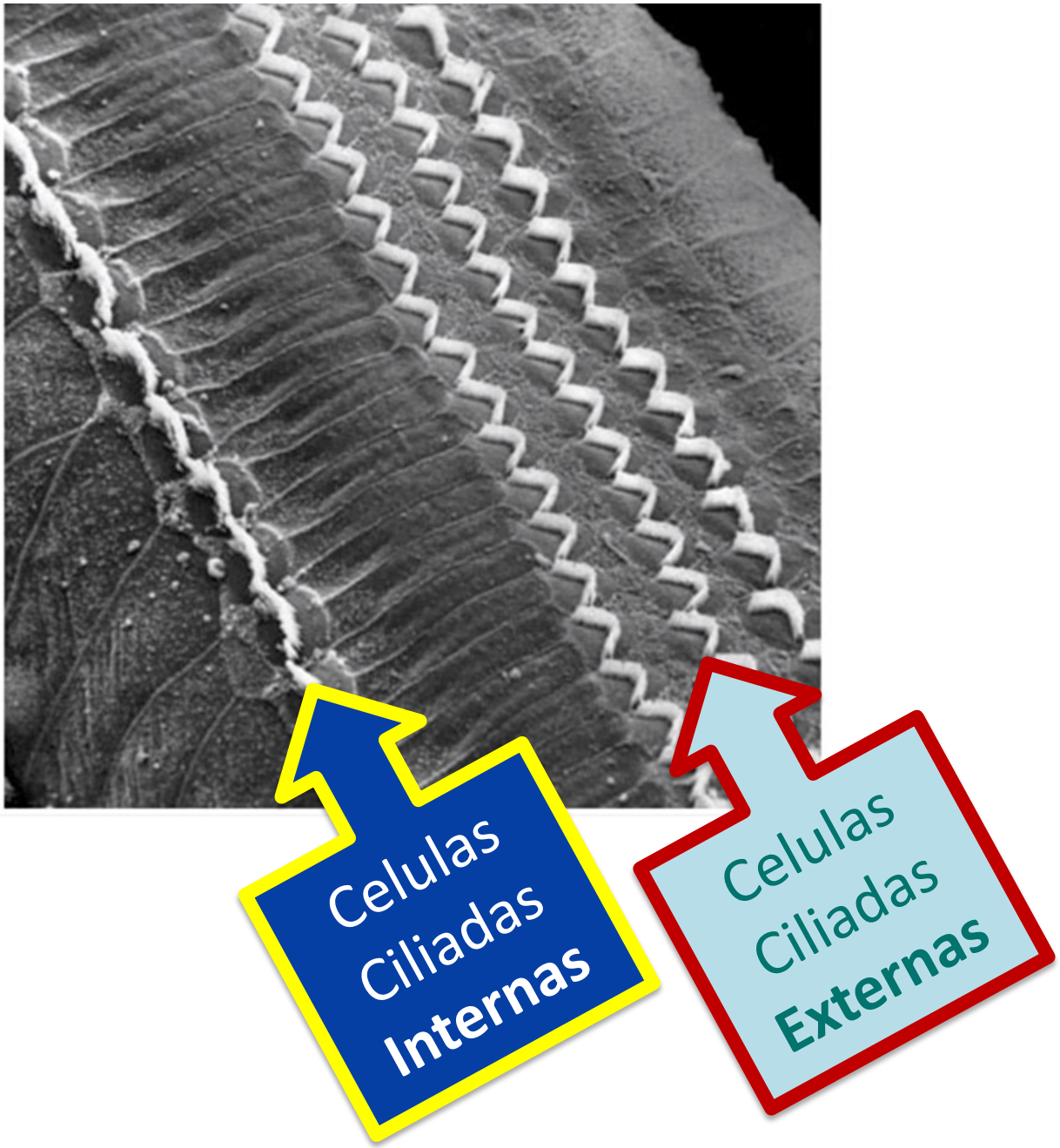

Hipoacusias de Transmisión
Hipoacusias Sensorioneurales
Oído Externo
Oído Medio
Oído Interno
Vía neural / Tronco Cerebral
Corteza Cerebral
Cortipatía
Neuropatía

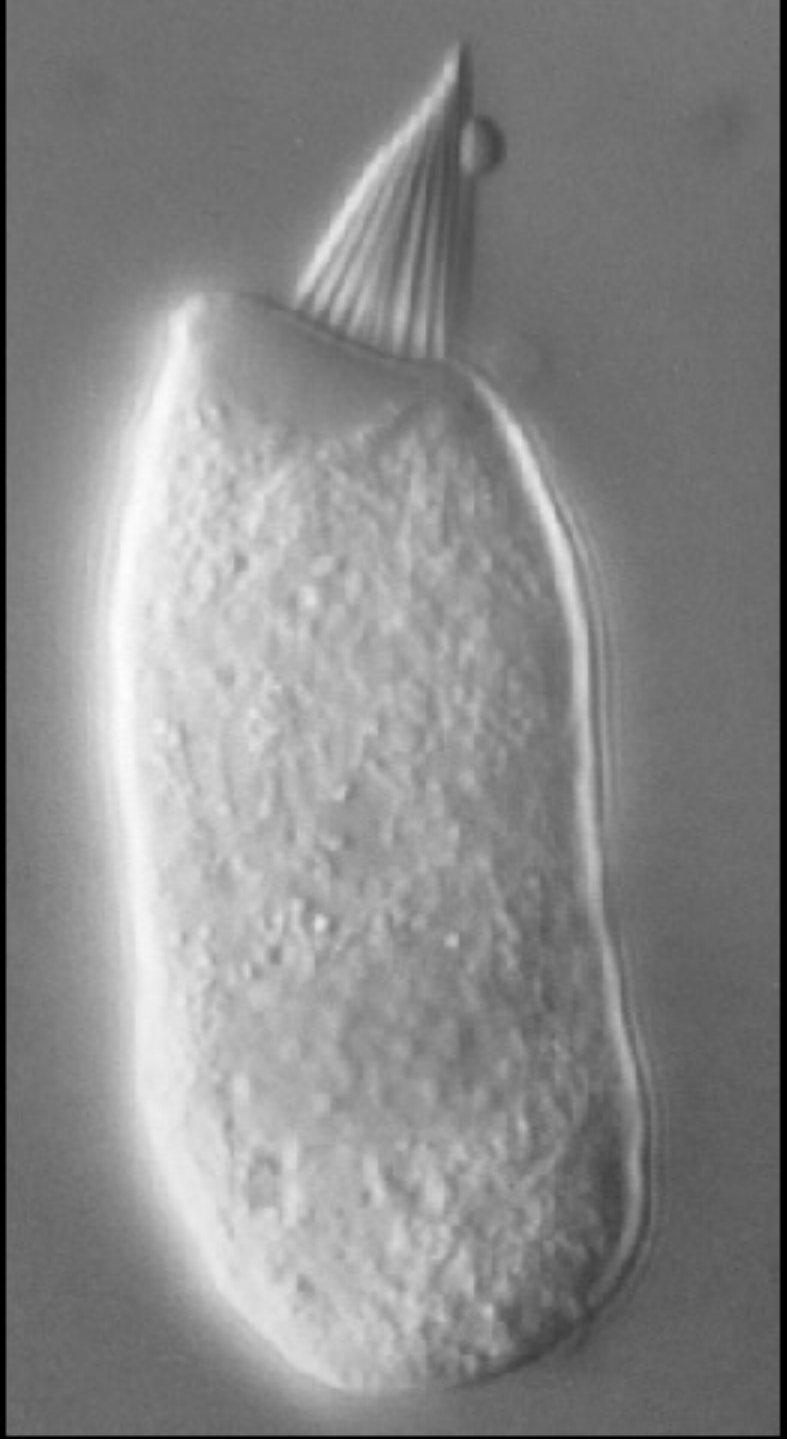

Breinbauer 2012

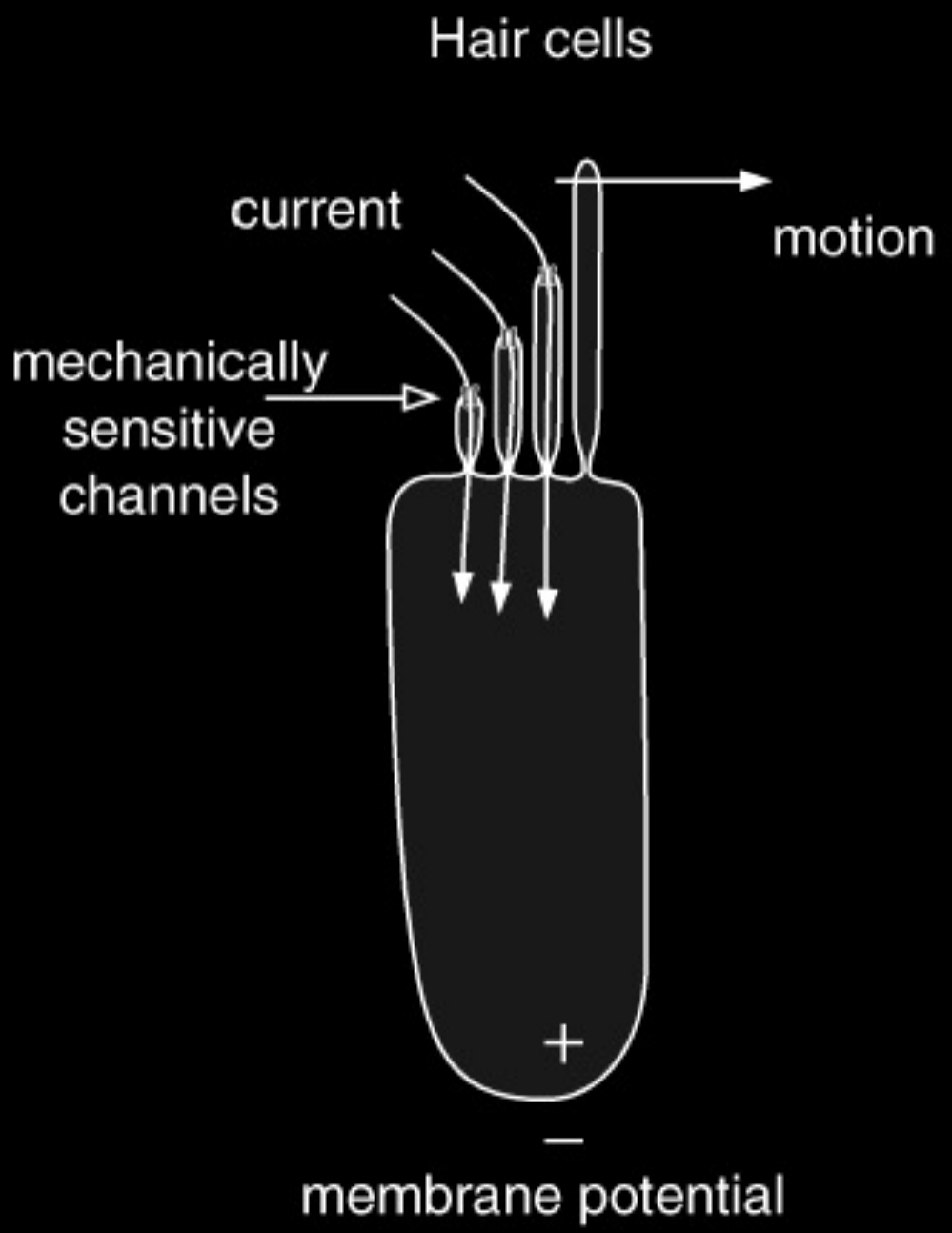

Cochlea
Apex
Base
Cochlea "Uncoiled"
Scala Vestibuli
Organ of Corti
Scala Media
Spiral Ganglion
Outer Hair Cells
Inner Hair Cells
Basilar Membrane
Spiral Ligament
Cochlear Implant Electrodes
Osseus spiral lamina
Scala Tympani
Incus
Oval window
Scala Media
Scala Vestibuli
Stapes
Scala Tympani
Round window
Cochlear Implant Electrodes
Base
Apex
High frequency sound
Mid frequency
Low frequency sound
Breinbauer 2013

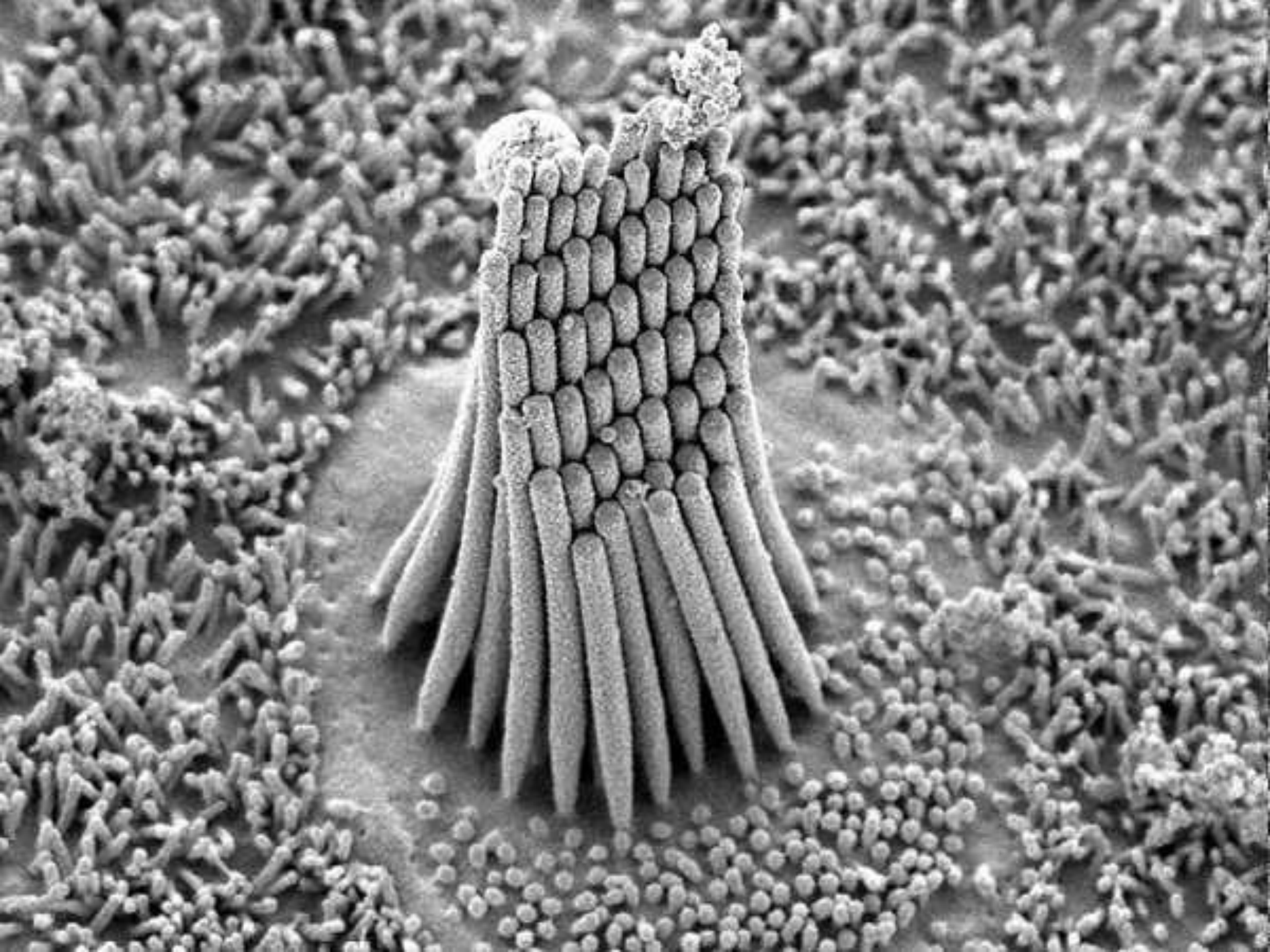

Scala Vestibuli
Organ of Corti
Scala Media
Inner Hair Cells
Basilar Membrane
Osseus spiral lamina
Cochlear Implant Electrodes
Scala Tympani

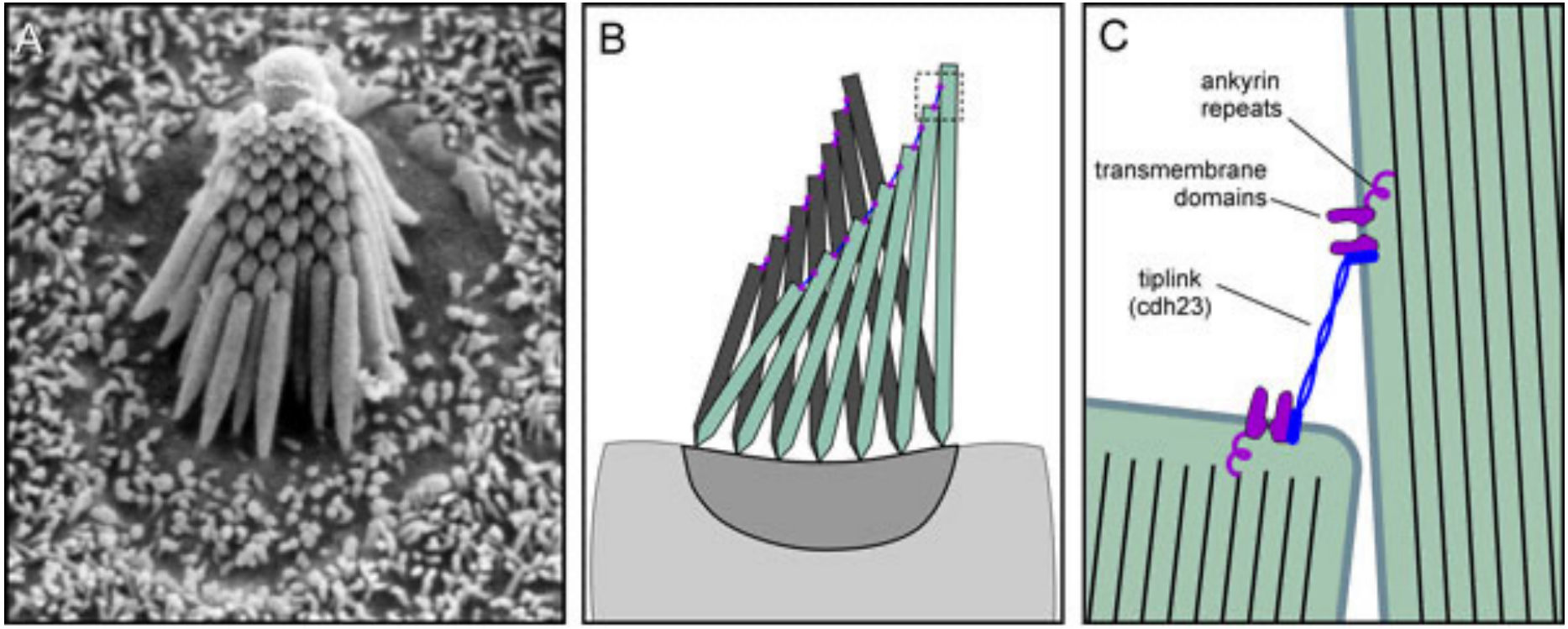

Rampa Media
celula ciliada
interna
Membrana basilar


Celulas
Ciliadas
Internas
Celulas
Ciliadas
Externas



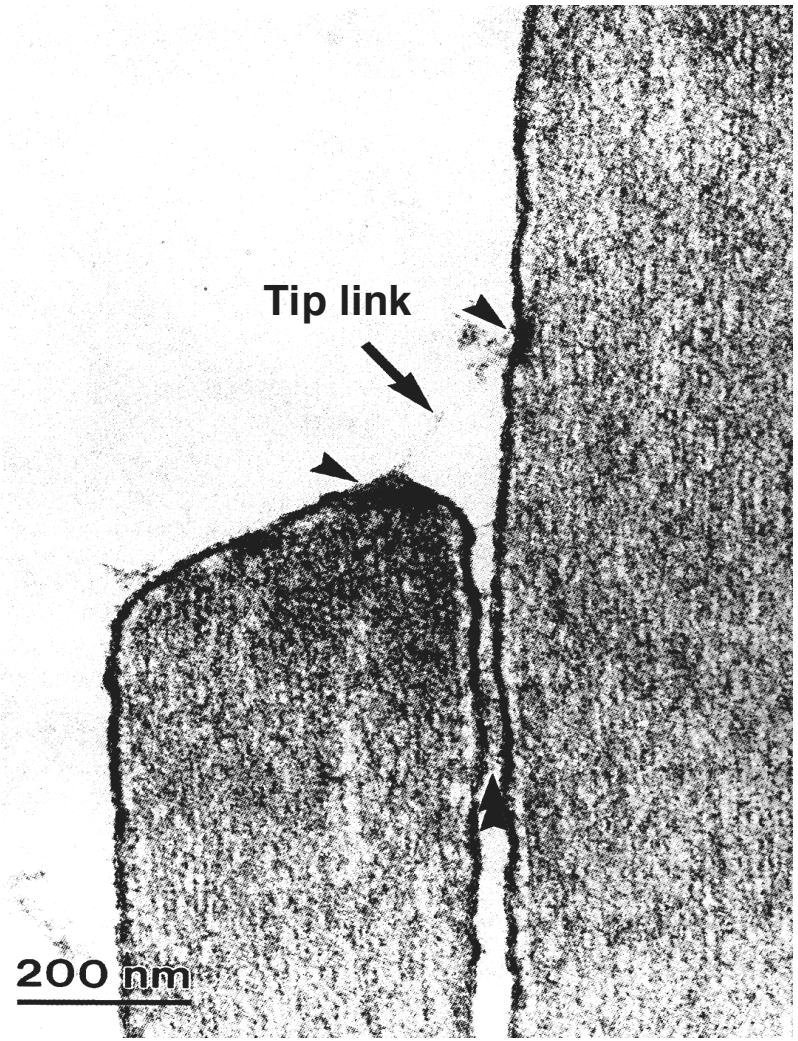

Hair cells
current
motion
mechanically
sensitive
channels
+
–
membrane potential

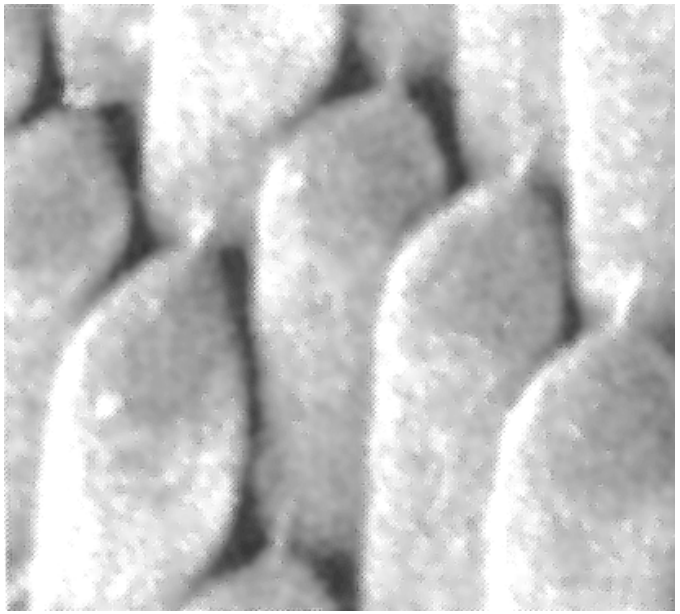


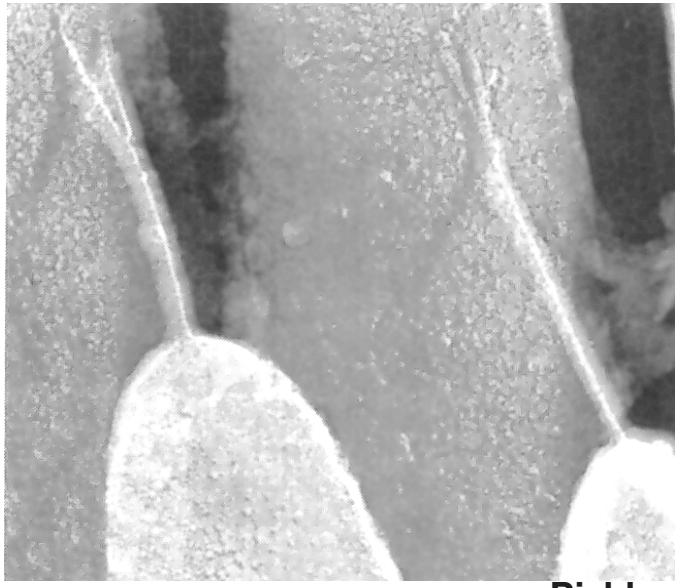


Theoretical and Computational Biophysics Group
Beckman Institute
University of Illinois at Urbana-Champaign

Tip links



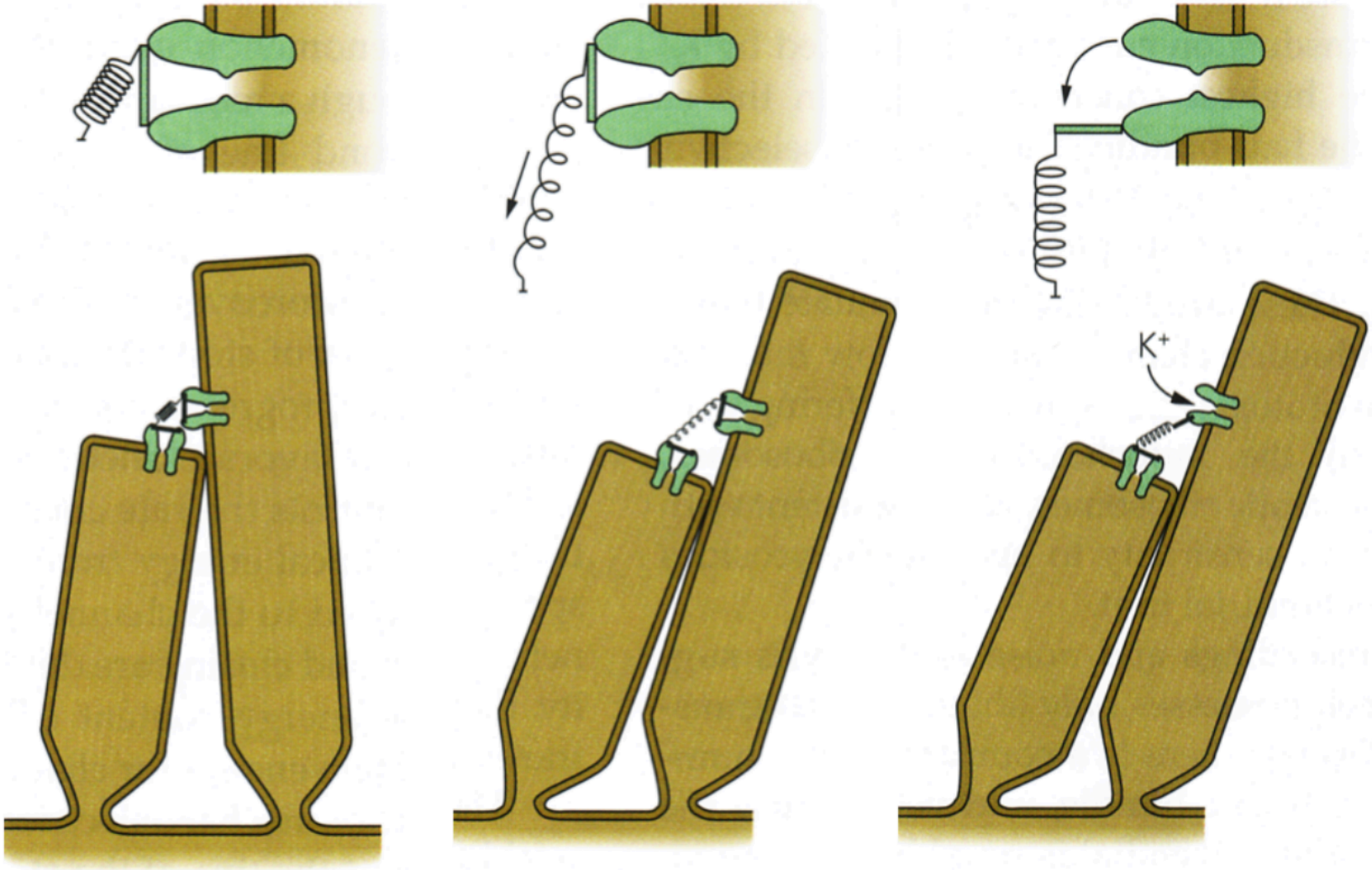




Pickles, 1984

Deflection of stereocilia opens K+ channels

K+ rushes into hair cell, causing depolarization



Deflexión Cilios
Apertura Canales por tensión
Tip-links

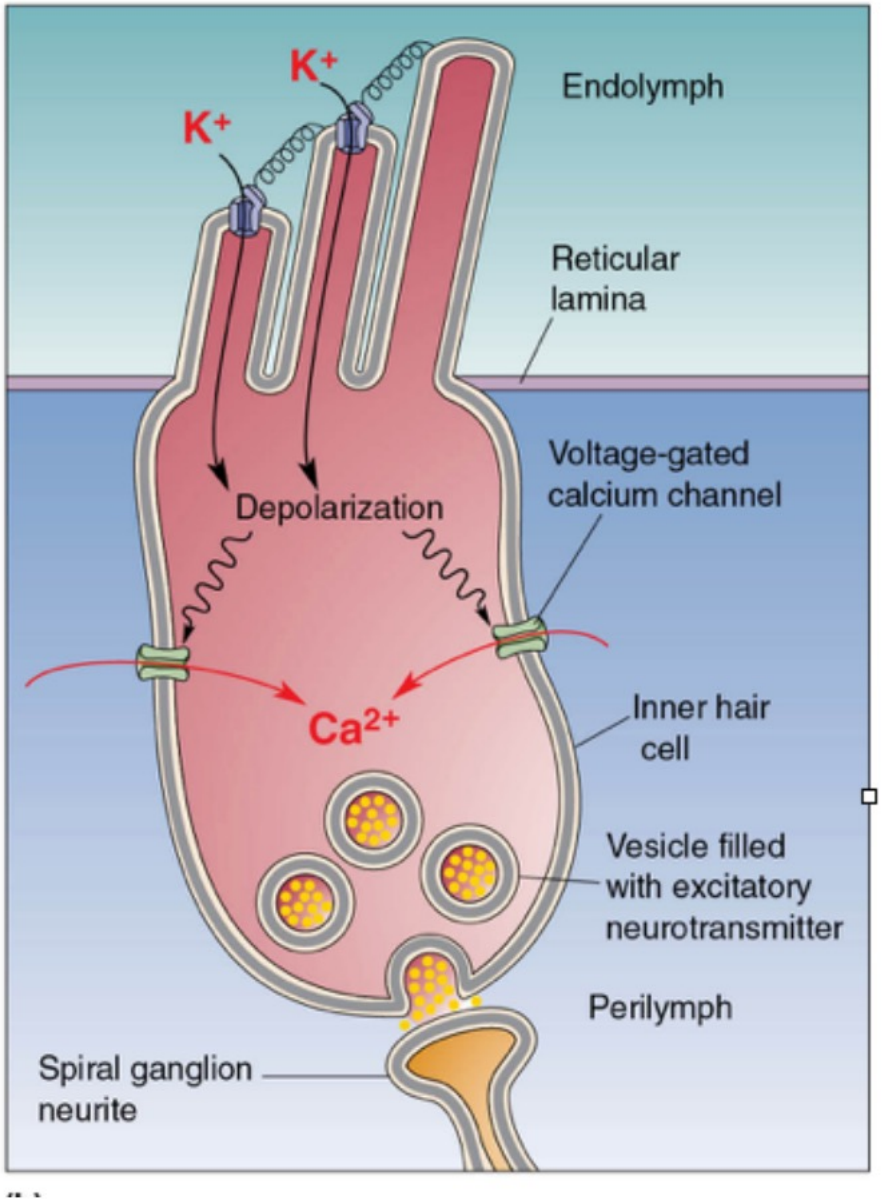
Ingreso K^+

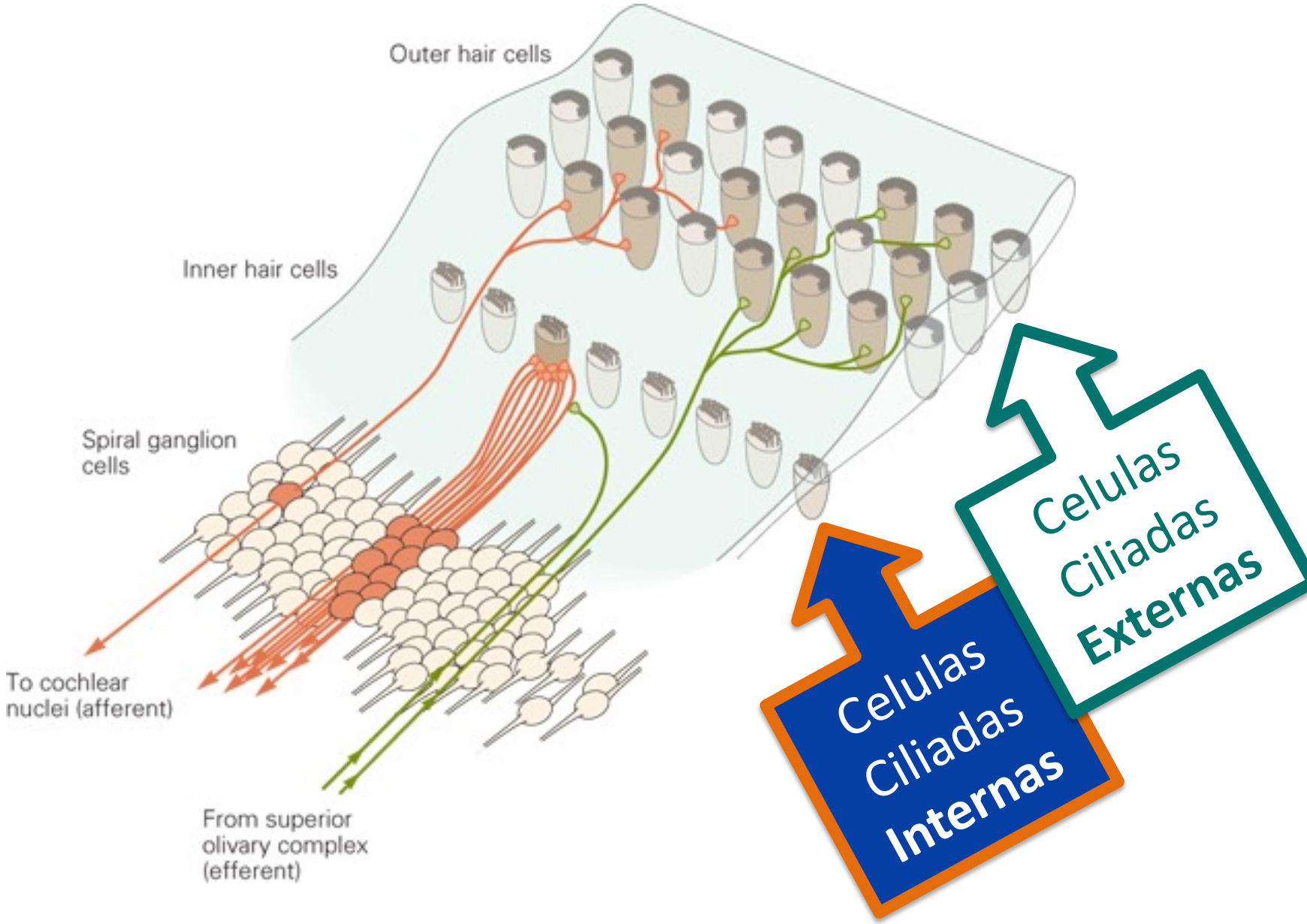
Depolarización

Apertura
Canales de Ca^+

Excositosis Vesiculas con
Neurotransmisores
(Glutamato)

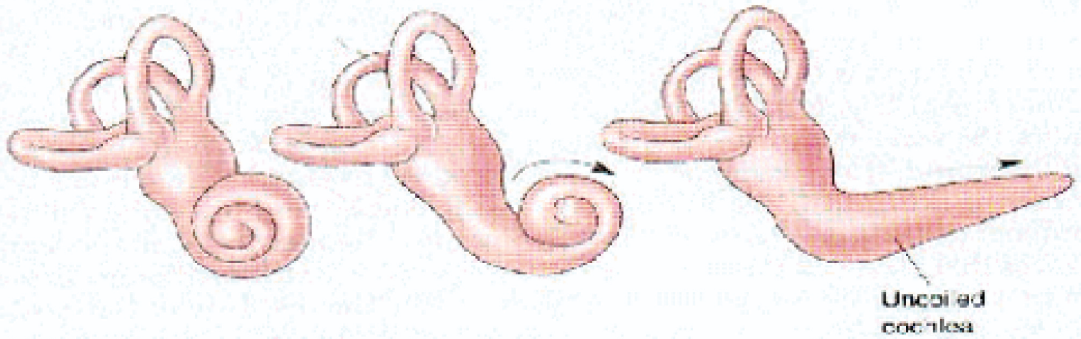
Dentrita Aferente → Potencial de
Acción en Ganglio de Scarpa

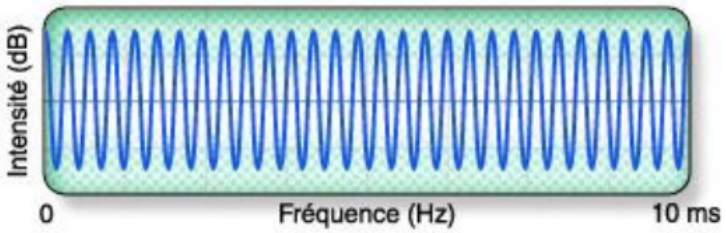



Outer hair cells
Inner hair cells
Spiral ganglion cells
To cochlear nuclei (afferent)
From superior olivary complex (efferent)
Celulas Ciliadas Externas
Celulas Ciliadas Internas

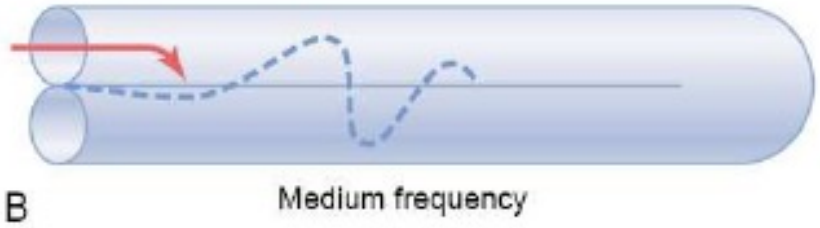
Tonotopía

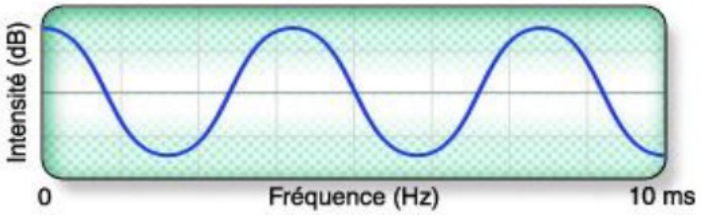
Distribución Tonotópica



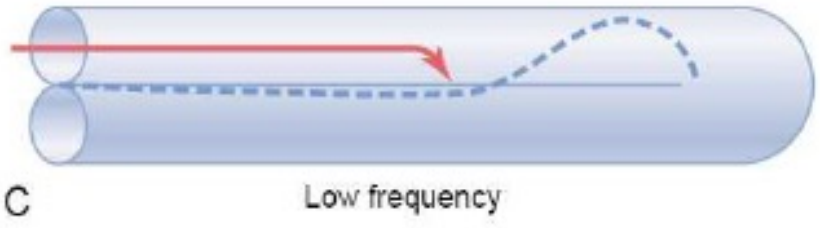


Tono Alta Frecuencia





Tono Baja Frecuencia



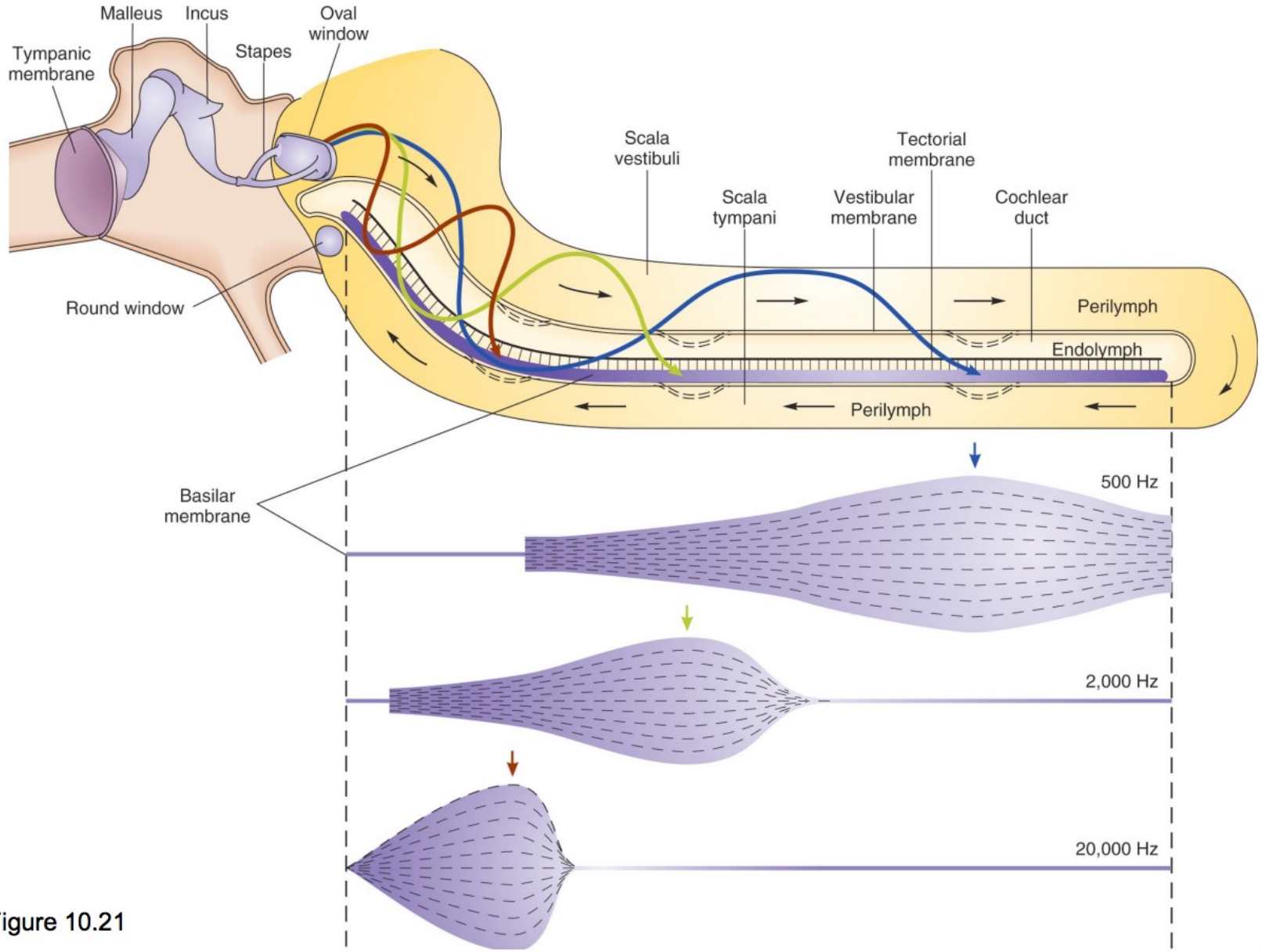
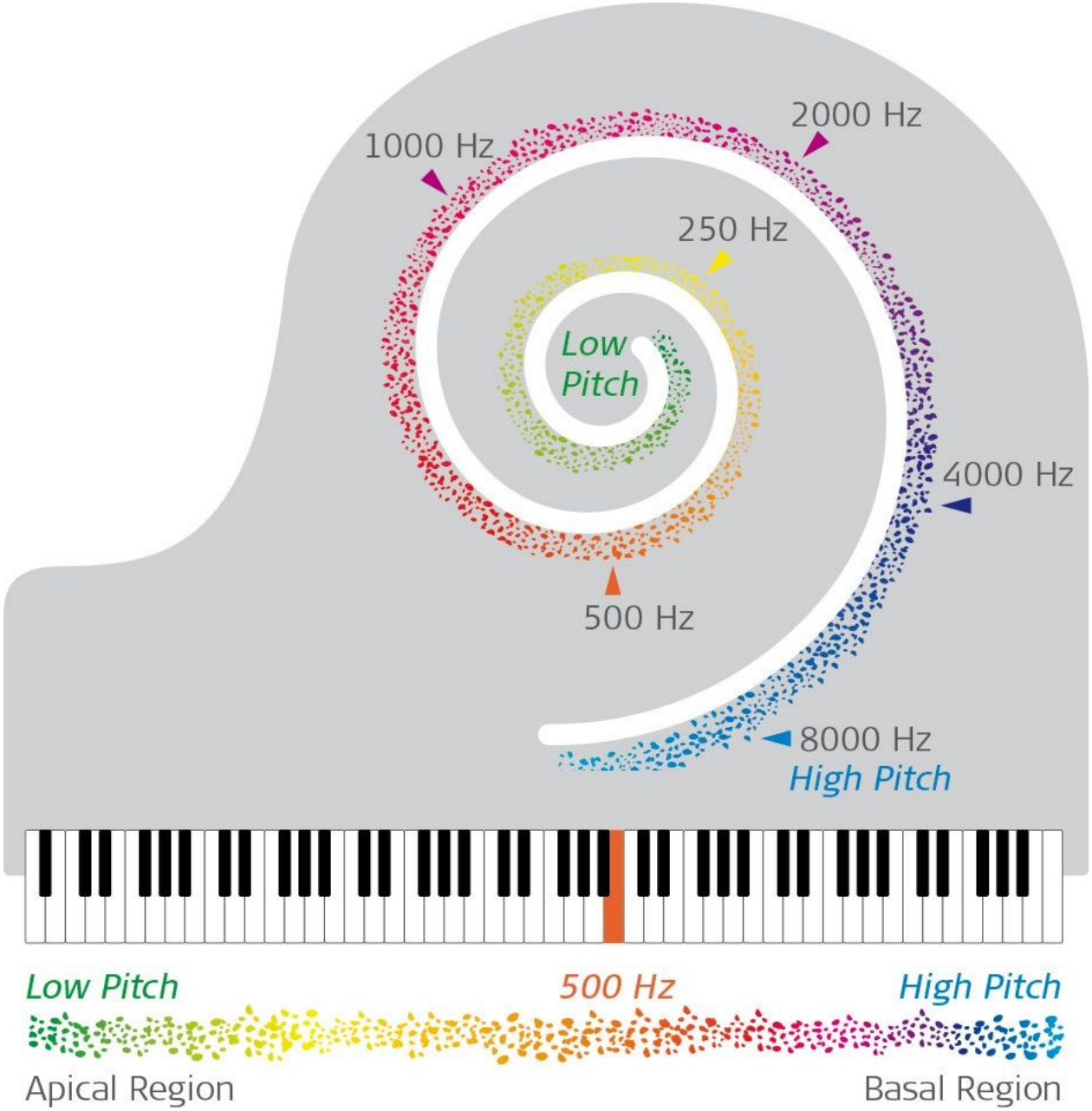
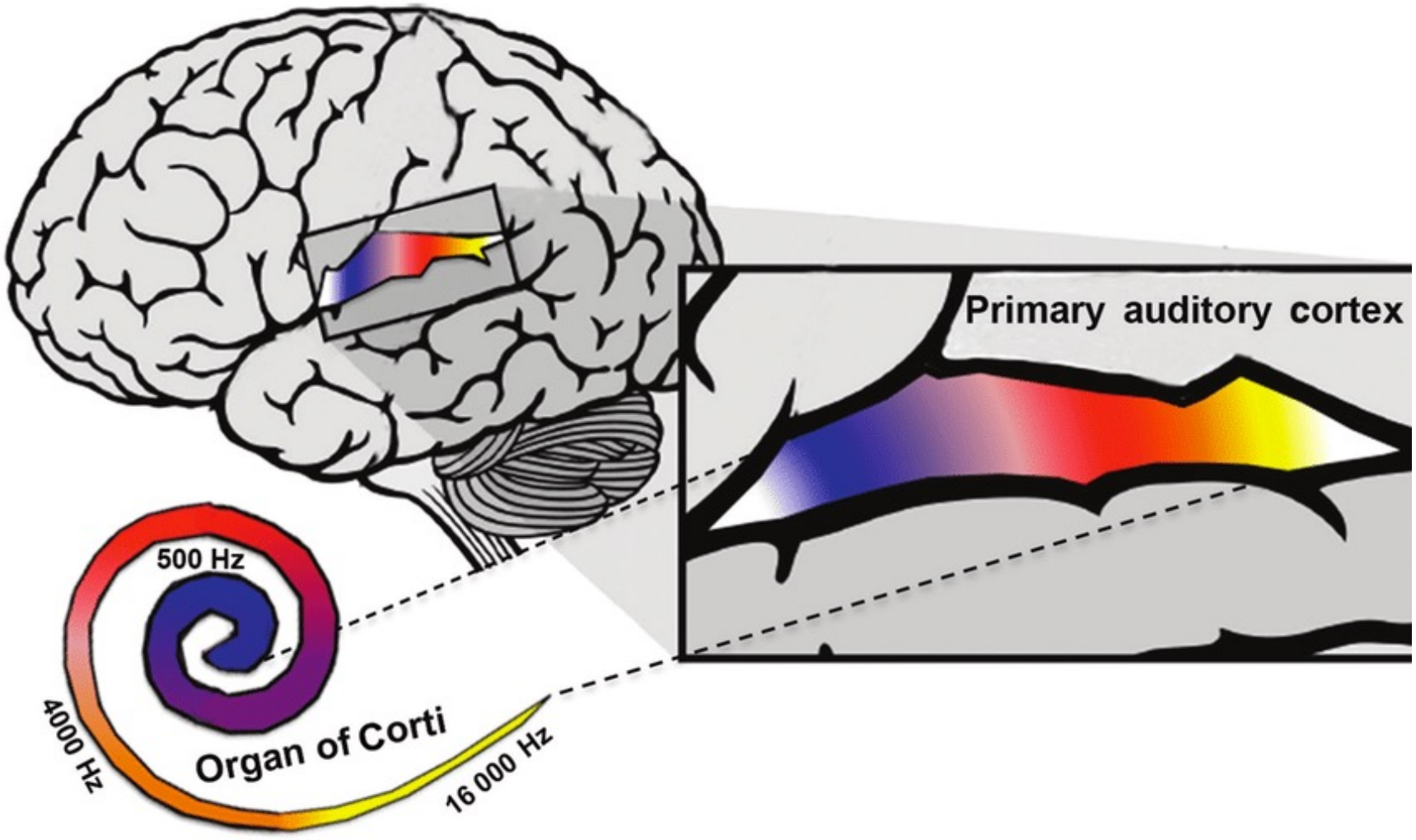
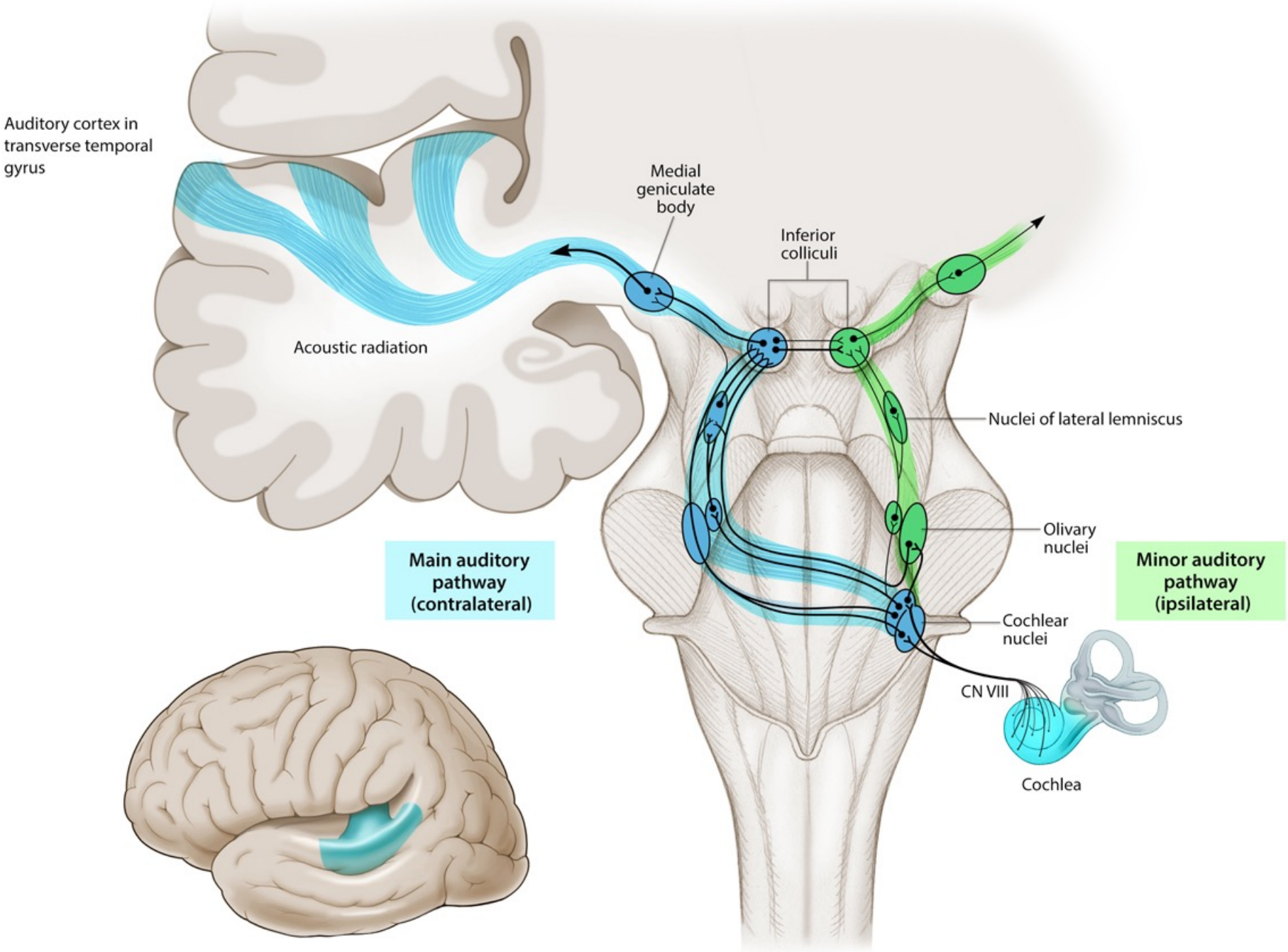

Malleus
Incus
Oval window
Tympanic membrane
Stapes
Scala vestibuli
Tectorial membrane
Scala tympani
Vestibular membrane
Cochlear duct
Round window
Perilymph
Endolymph
Perilymph
Basilar membrane
500 Hz
2,000 Hz
20,000 Hz

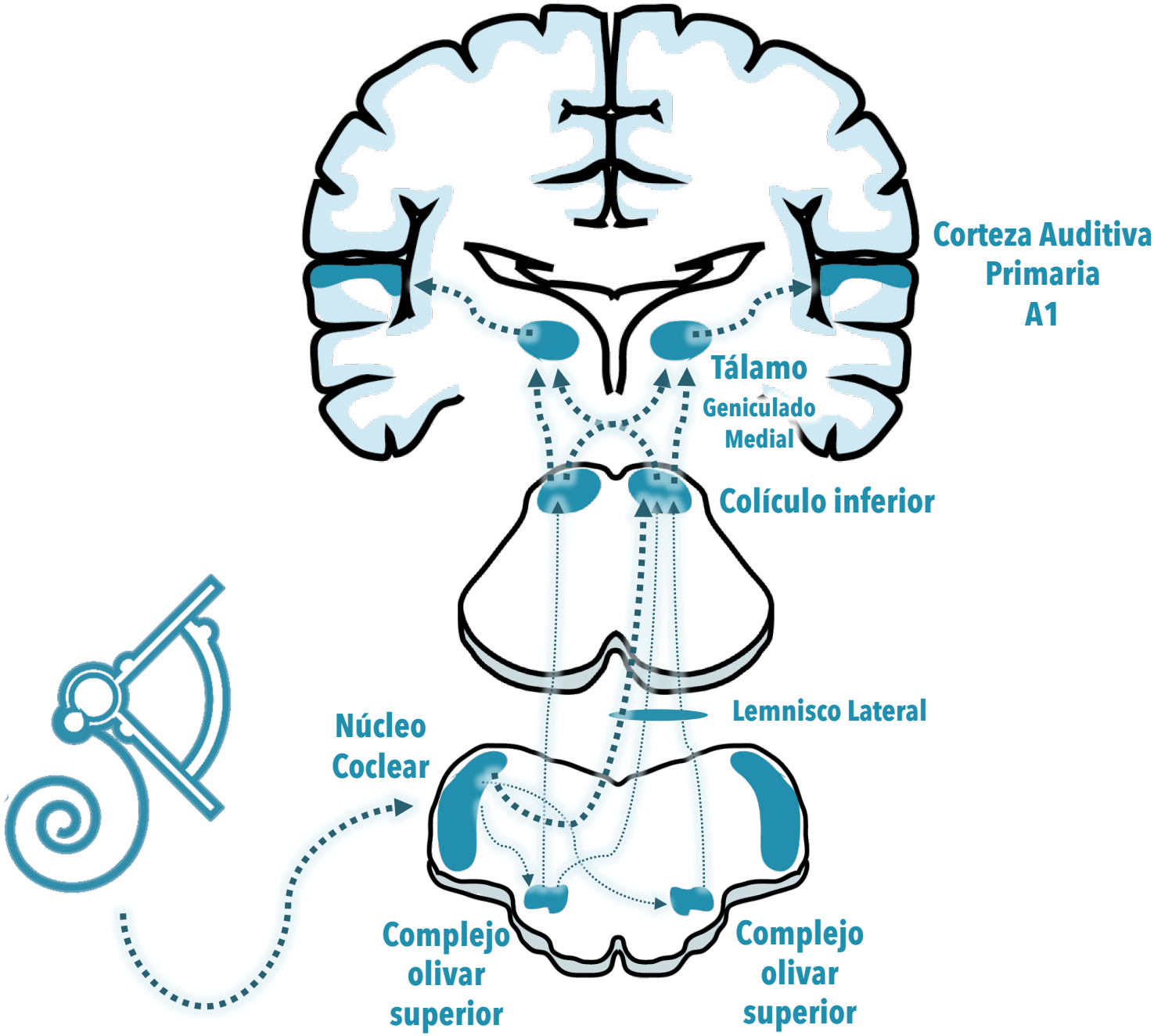
Figure 10.21


1000 Hz
2000 Hz
250 Hz
Low
Pitch
4000 Hz
500 Hz
8000 Hz
High Pitch
Low Pitch
500 Hz
High Pitch
Apical Region
Basal Region

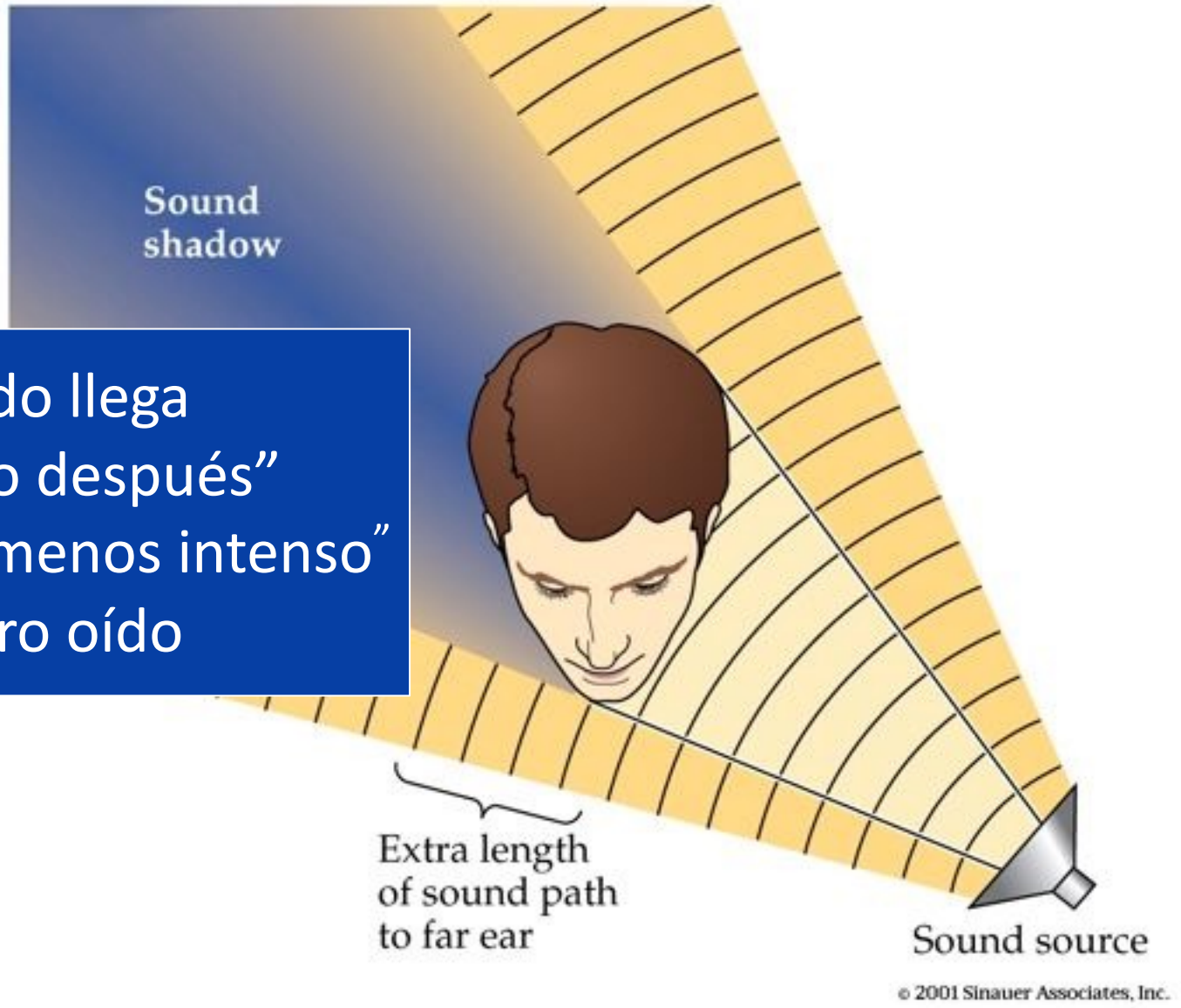

Primary auditory cortex
500 Hz
4000 Hz
Organ of Corti
16 000 Hz

Vía auditiva central


Auditory cortex in transverse temporal gyrus
Medial geniculate body
Inferior colliculi
Acoustic radiation
Nuclei of lateral lemniscus
Olivary nuclei
Main auditory pathway (contralateral)
Minor auditory pathway (ipsilateral)
Cochlear nuclei
CN VIII
Cochlea

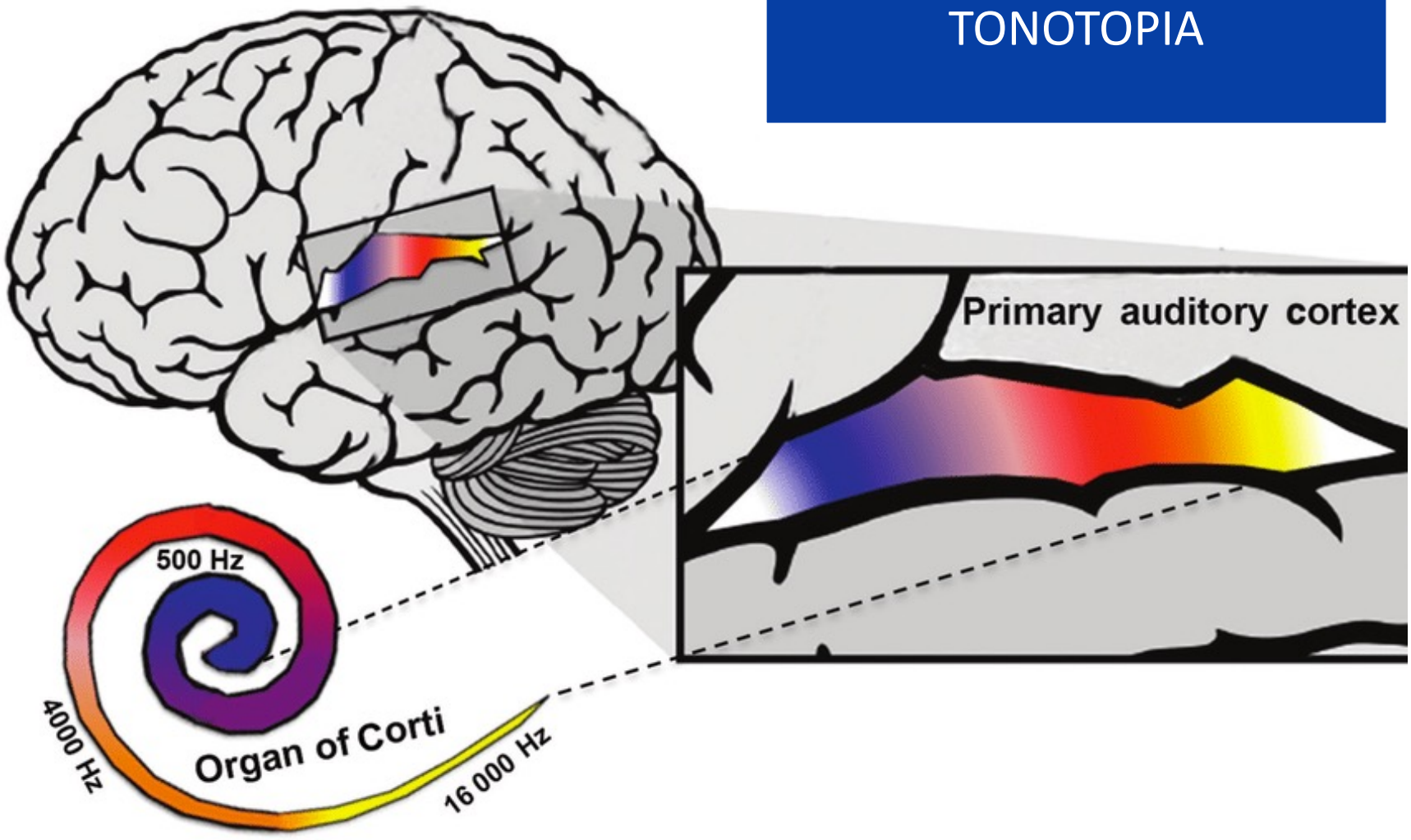

Corteza Auditiva
Primaria
A1
Tálamo
Geniculado
Medial
Colículo inferior
Lemnisco Lateral
Núcleo
Coclear
Complejo
olivar
superior
Complejo
olivar
superior

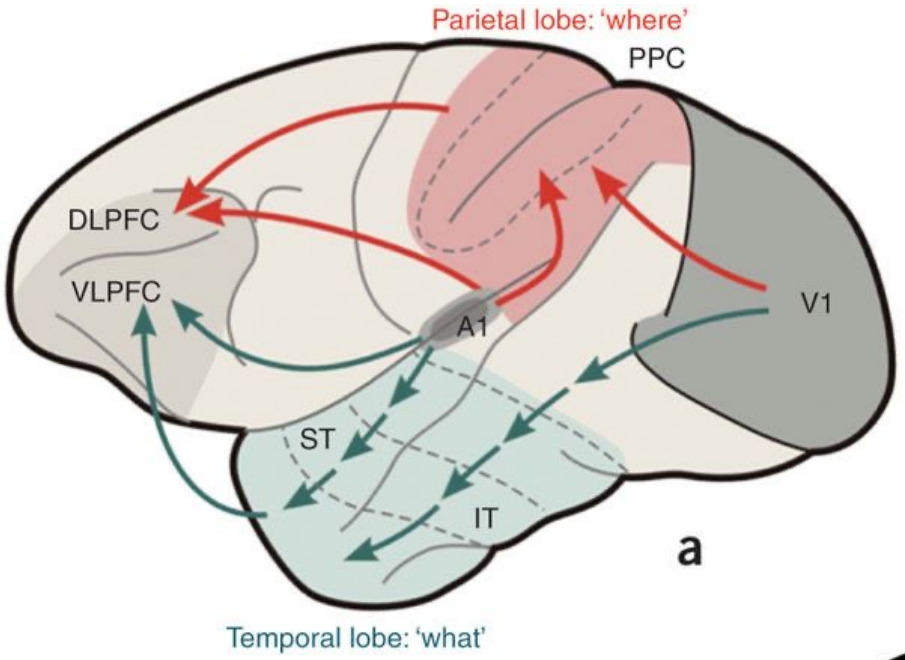
Sound localization



Sonido llega
“un poco después”
y ”un poco menos intenso”
al otro oído

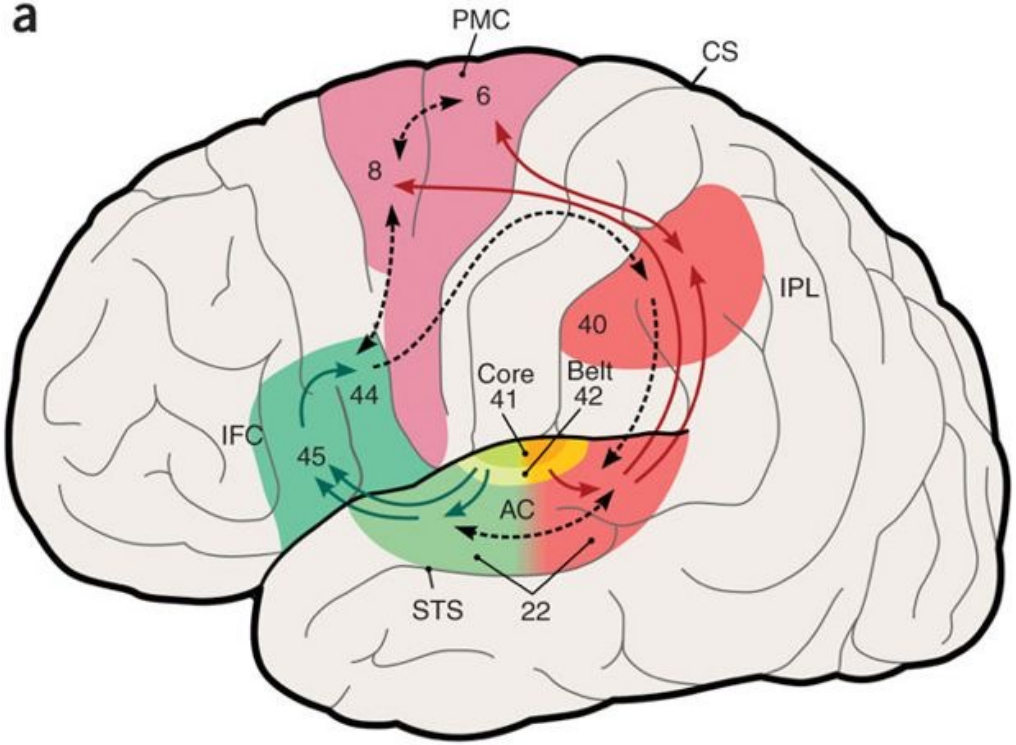
SIEMPRE SE MANTIENE TONOTOPIA



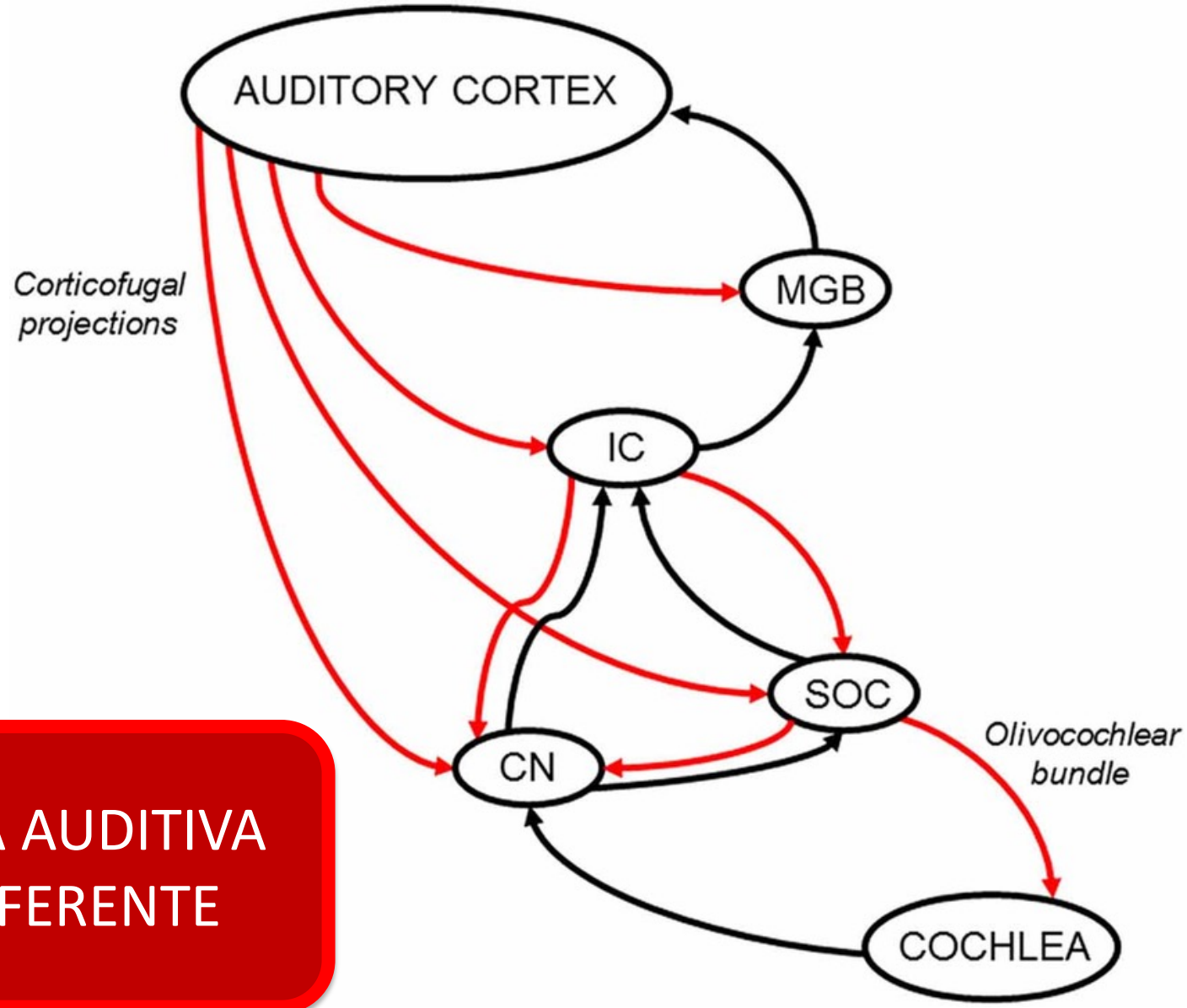


a

RED AUDITIVA CENTRAL

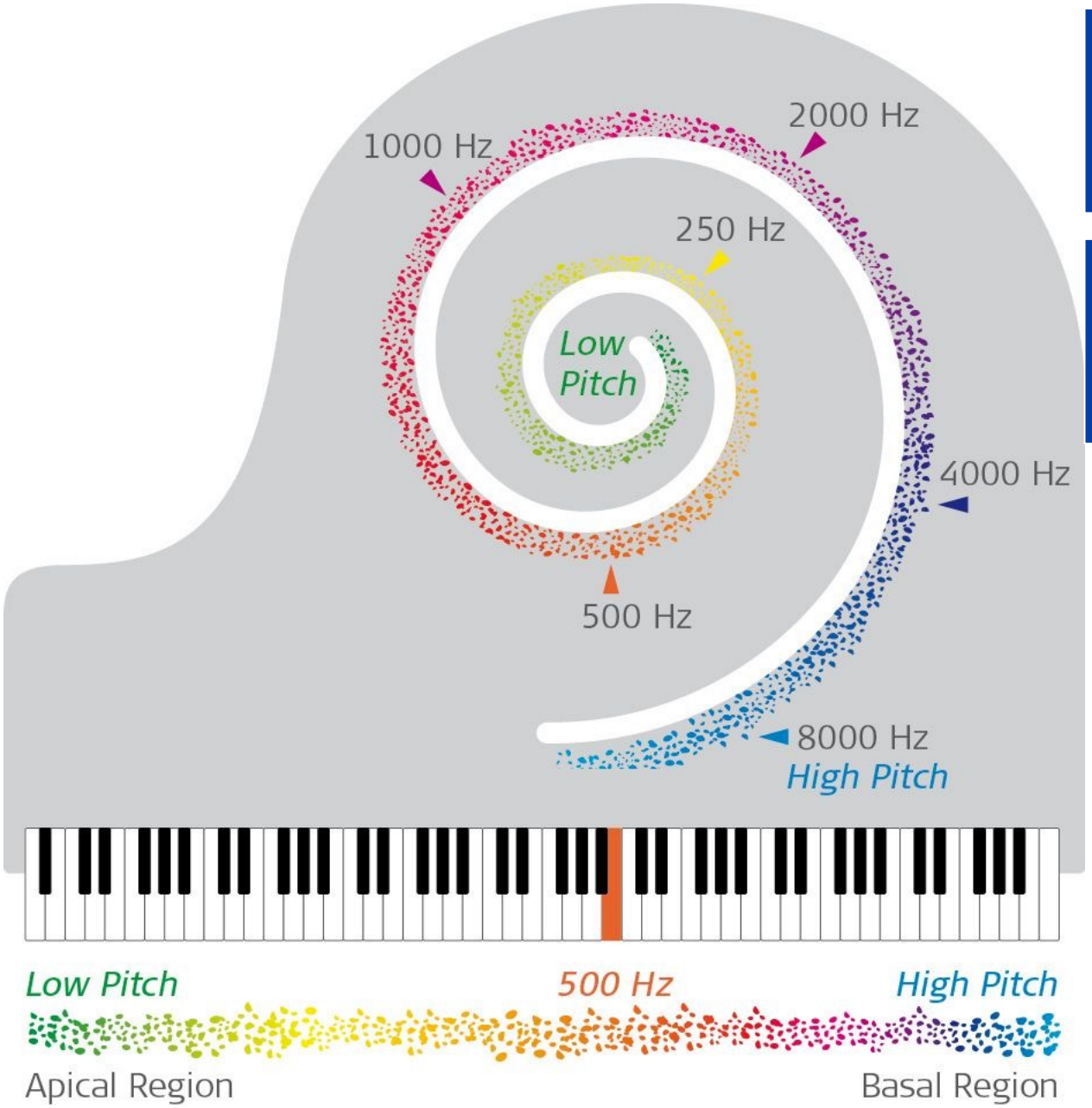


VIA AUDITIVA EFERENTE



El Oído Activo

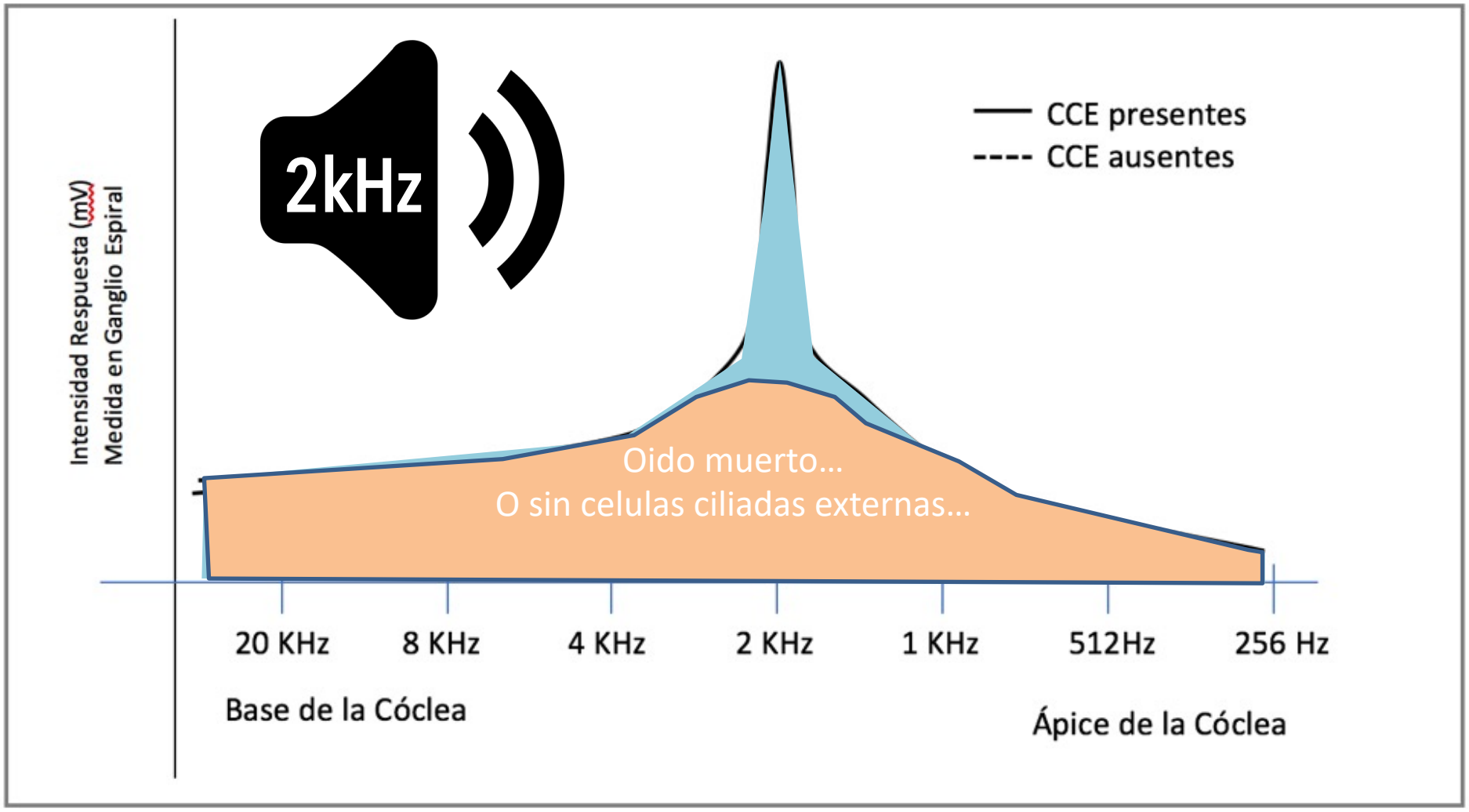
células ciliadas externas

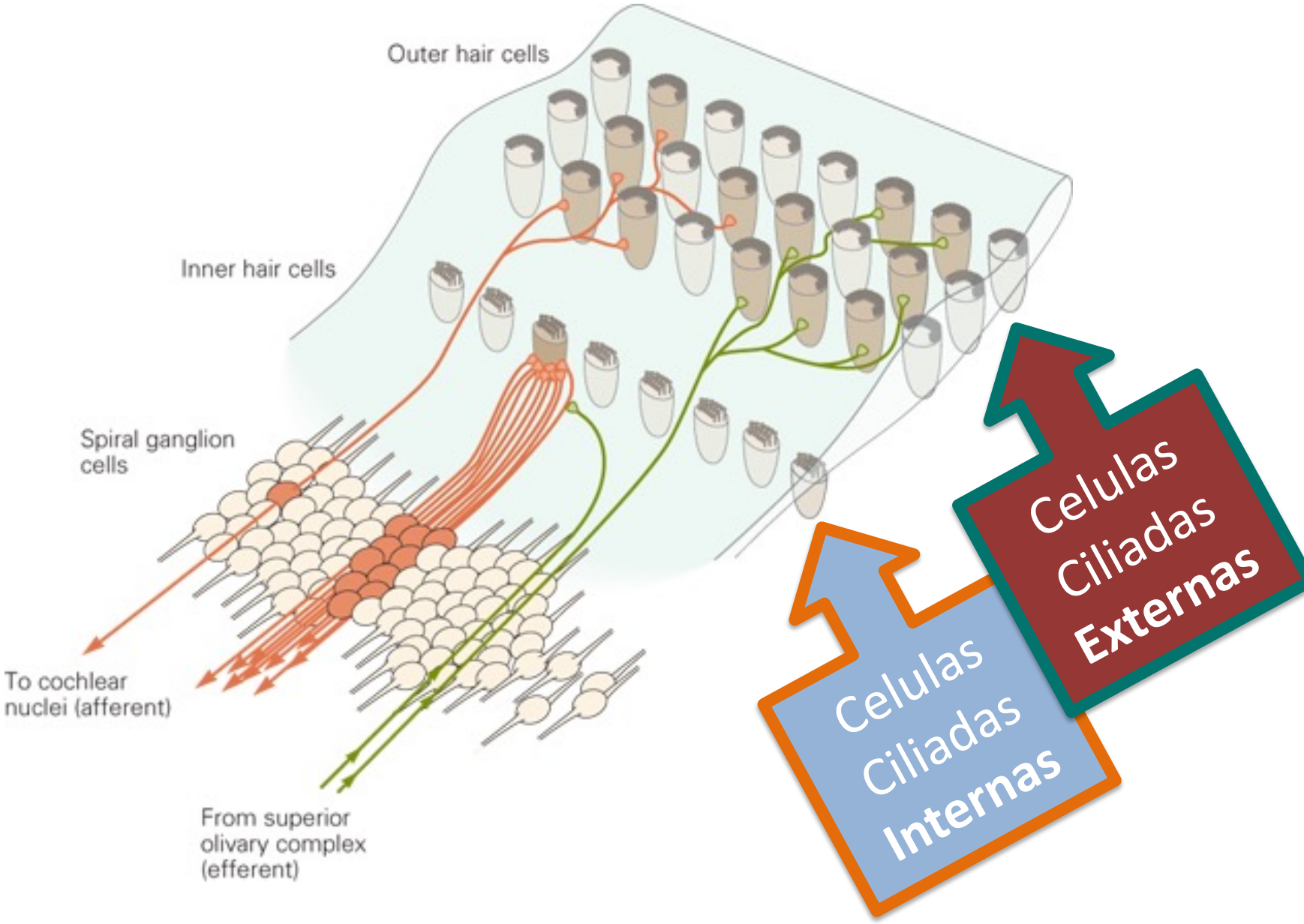


TONOTOPIA funciona en oído vivo

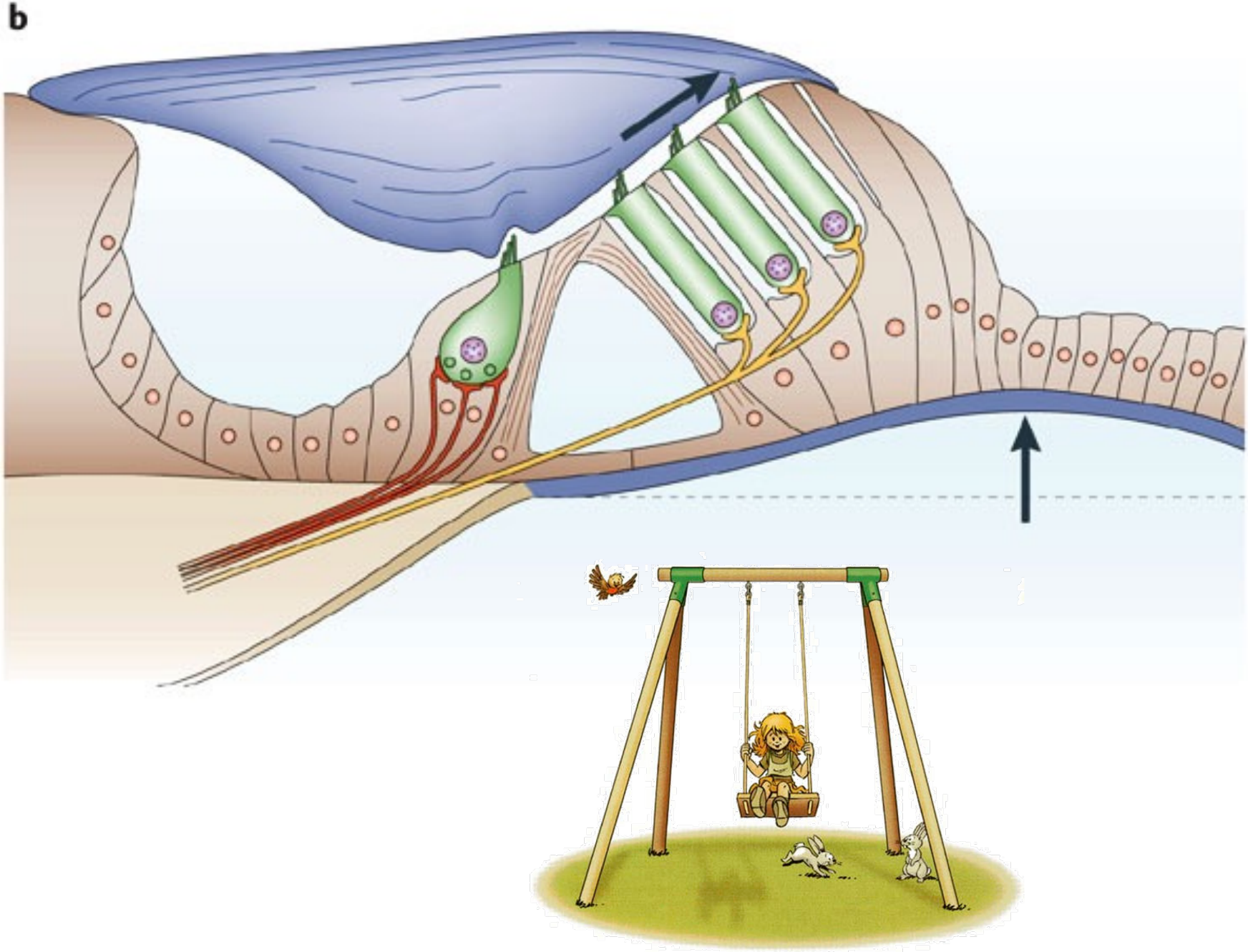
En el muerto…

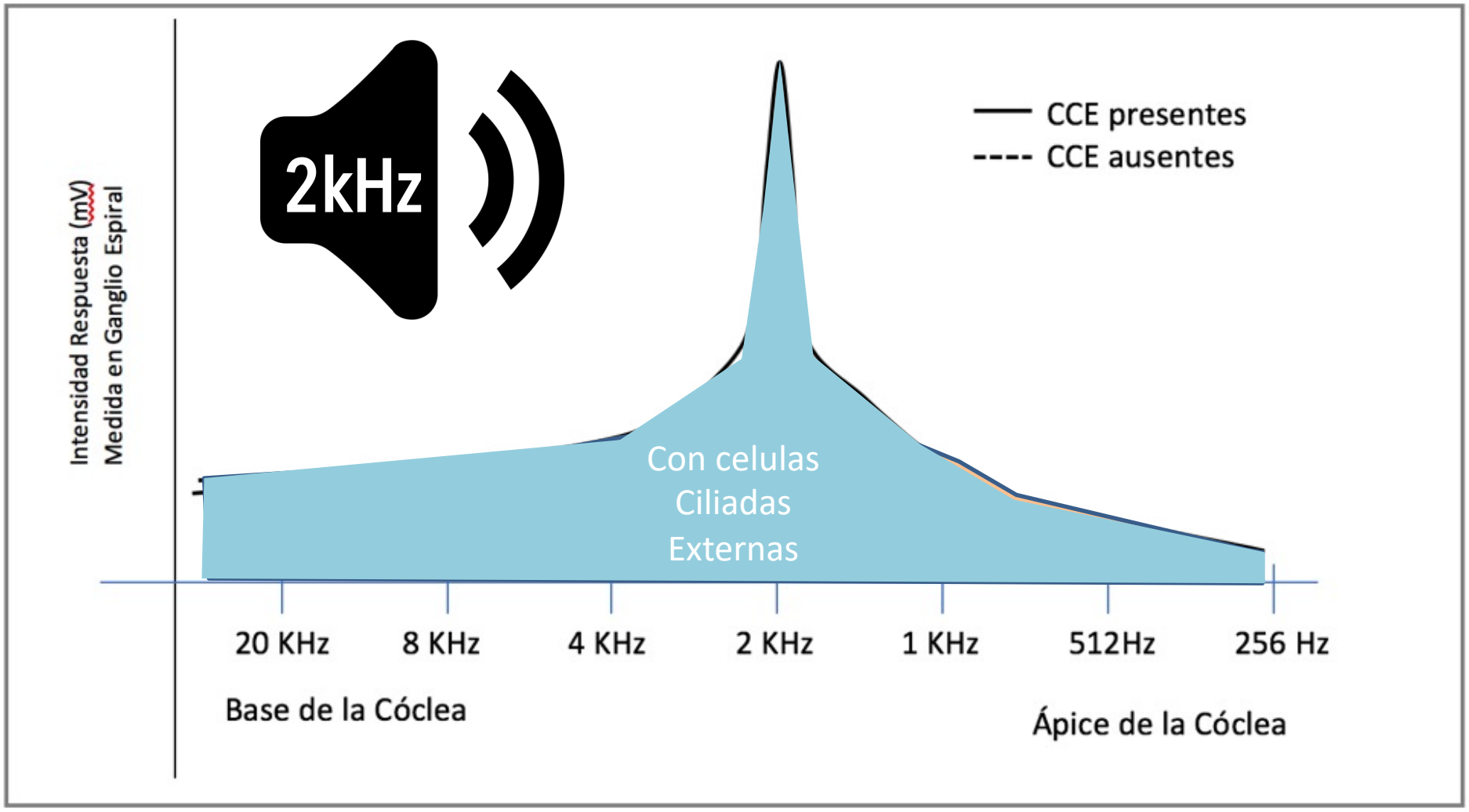
NO


2kHz
CCE presentes
CCE ausentes
Intensidad Respuesta (mV)
Medida en Ganglio Espiral
Oido muerto…
O sin celulas ciliadas externas…
20 KHz
8 KHz
4 KHz
2 KHz
1 KHz
512Hz
256 Hz
Base de la Cóclea
Ápice de la Cóclea


Outer hair cells
Inner hair cells
Spiral ganglion cells
To cochlear nuclei (afferent)
From superior olivary complex (efferent)
Celulas Ciliadas Externas
Celulas Ciliadas Internas

Célula Ciliada Externa


b


2kHz
CCE presentes
CCE ausentes
Intensidad Respuesta (mV)
Medida en Ganglio Espiral
Con celulas
Ciliadas
Externas
20 KHz
8 KHz
4 KHz
2 KHz
1 KHz
512Hz
256 Hz
Base de la Cóclea
Ápice de la Cóclea

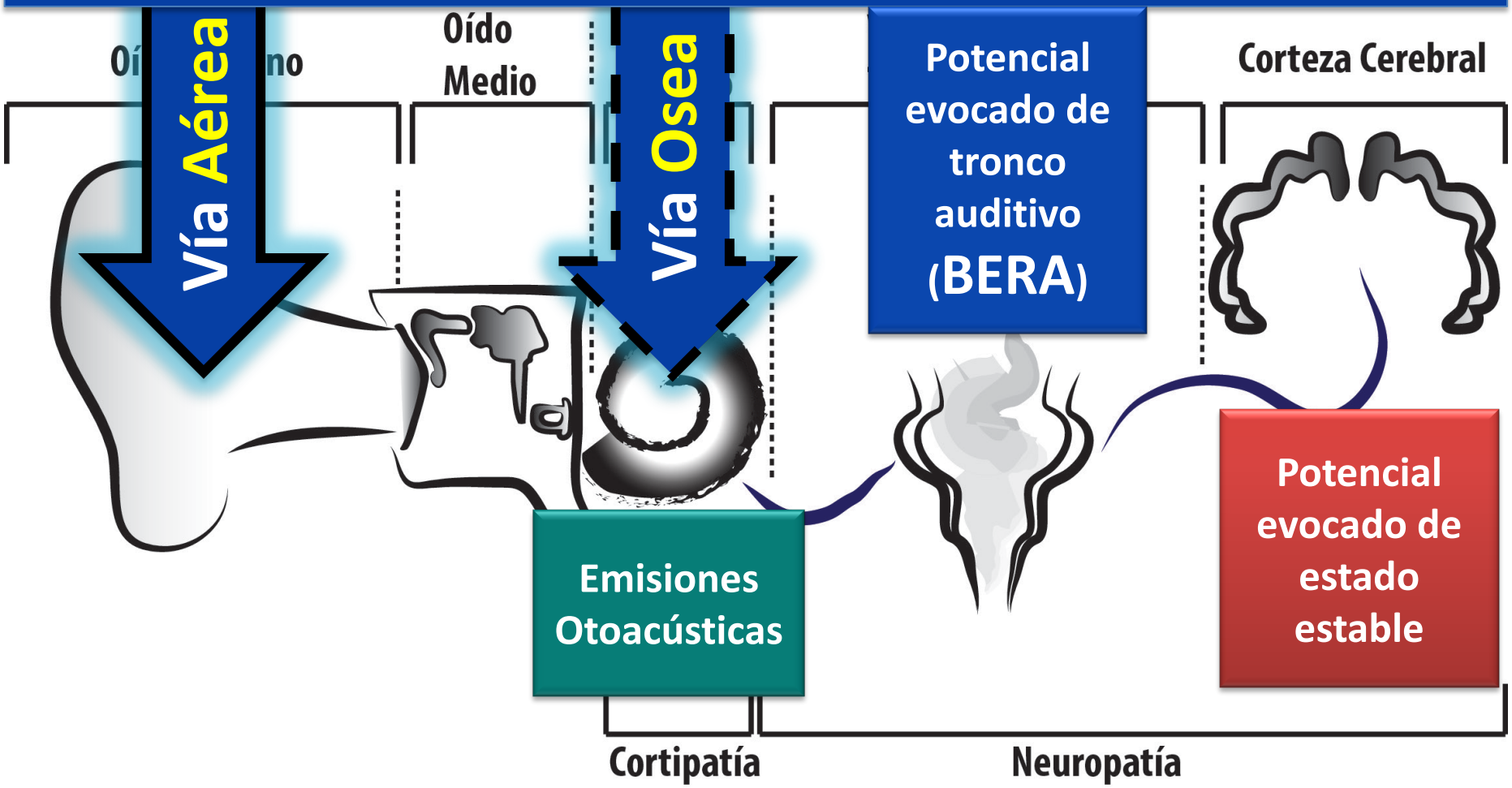
Fisiología de la Audición

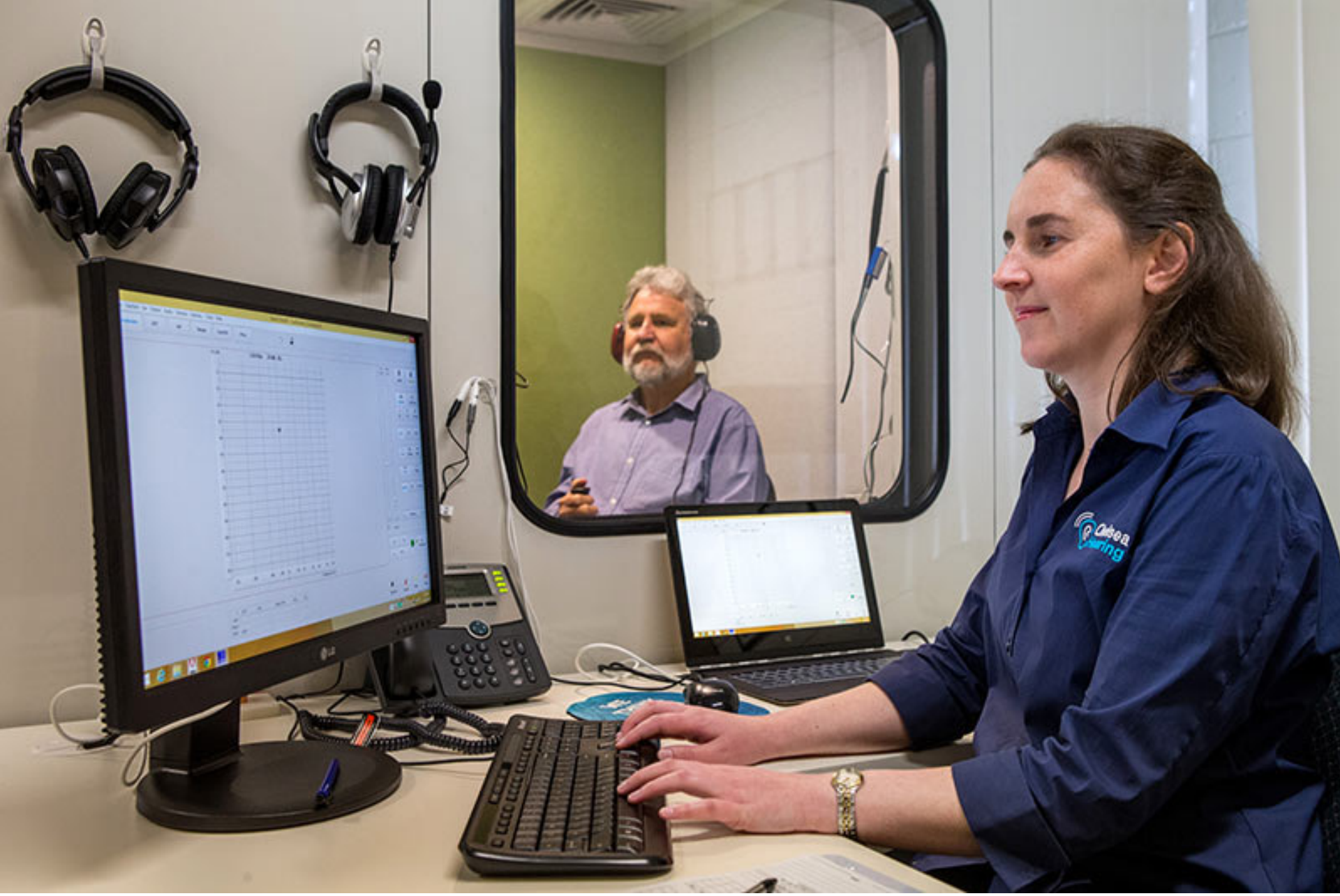
FACULTAD DE MEDICINA
UNIVERSIDAD DE CHILE

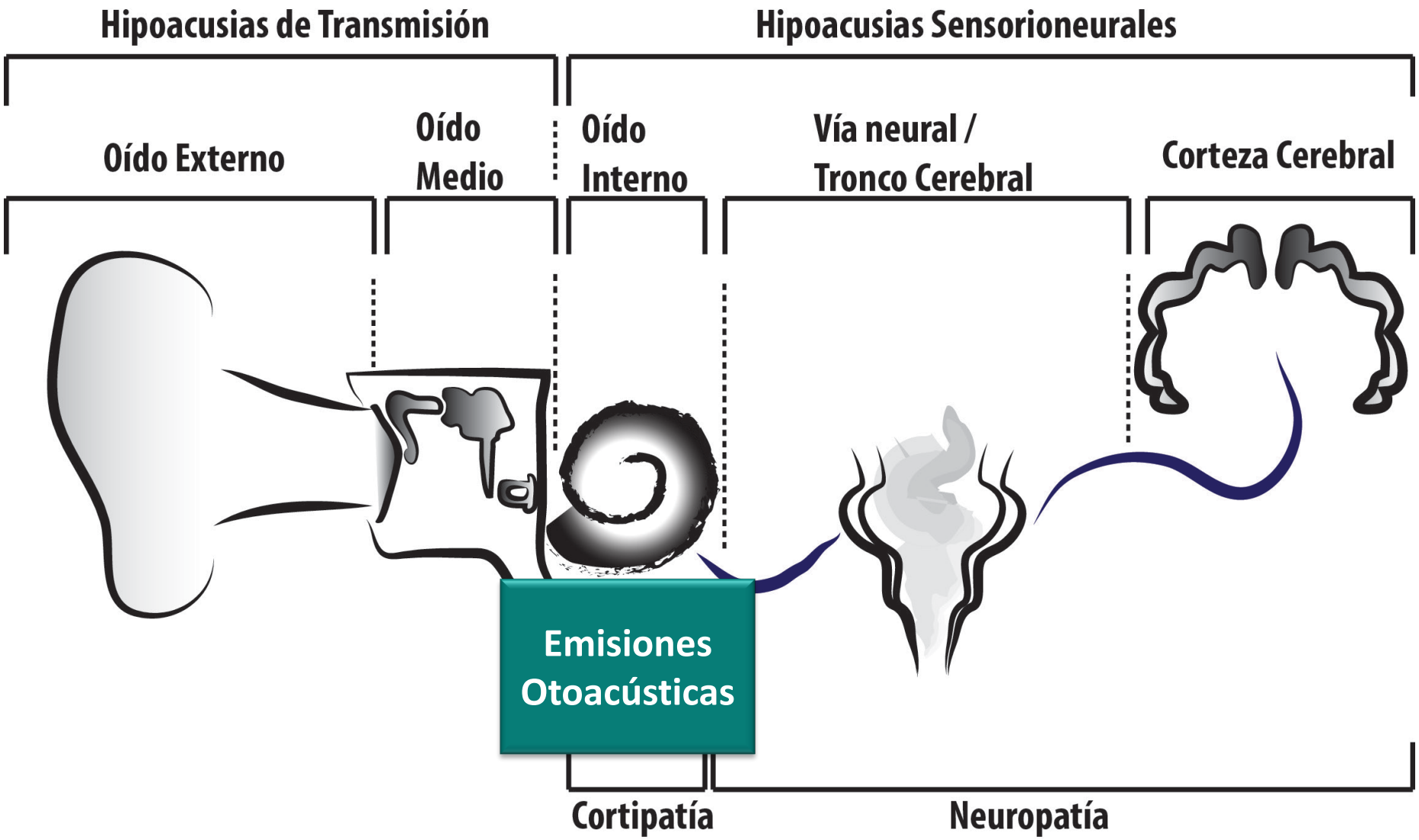
Hayo A. Breinbauer Krebs (Dr.med/PhD).
Universidad de Chile – Departamento Neurociencias
Universidad de Chile – Hospital San Juan de Dios

Mediciones de la Audición

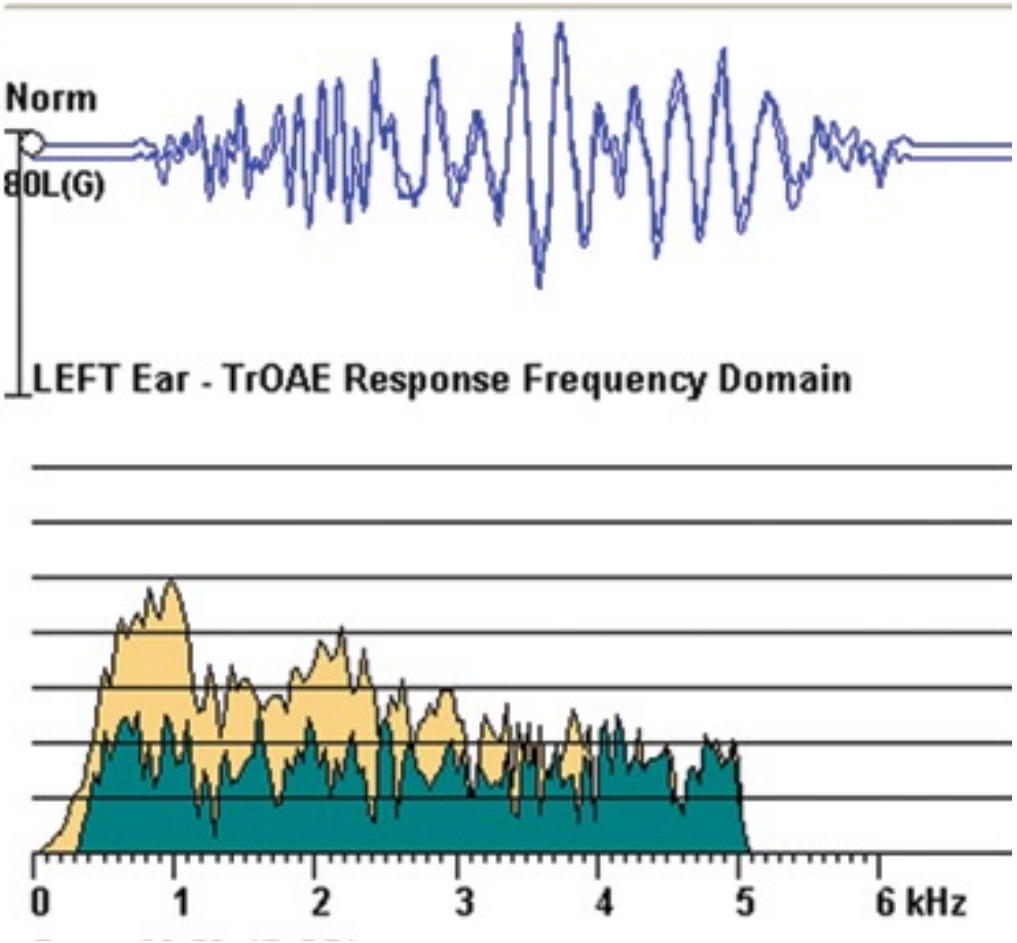
AUDIOMETRIA



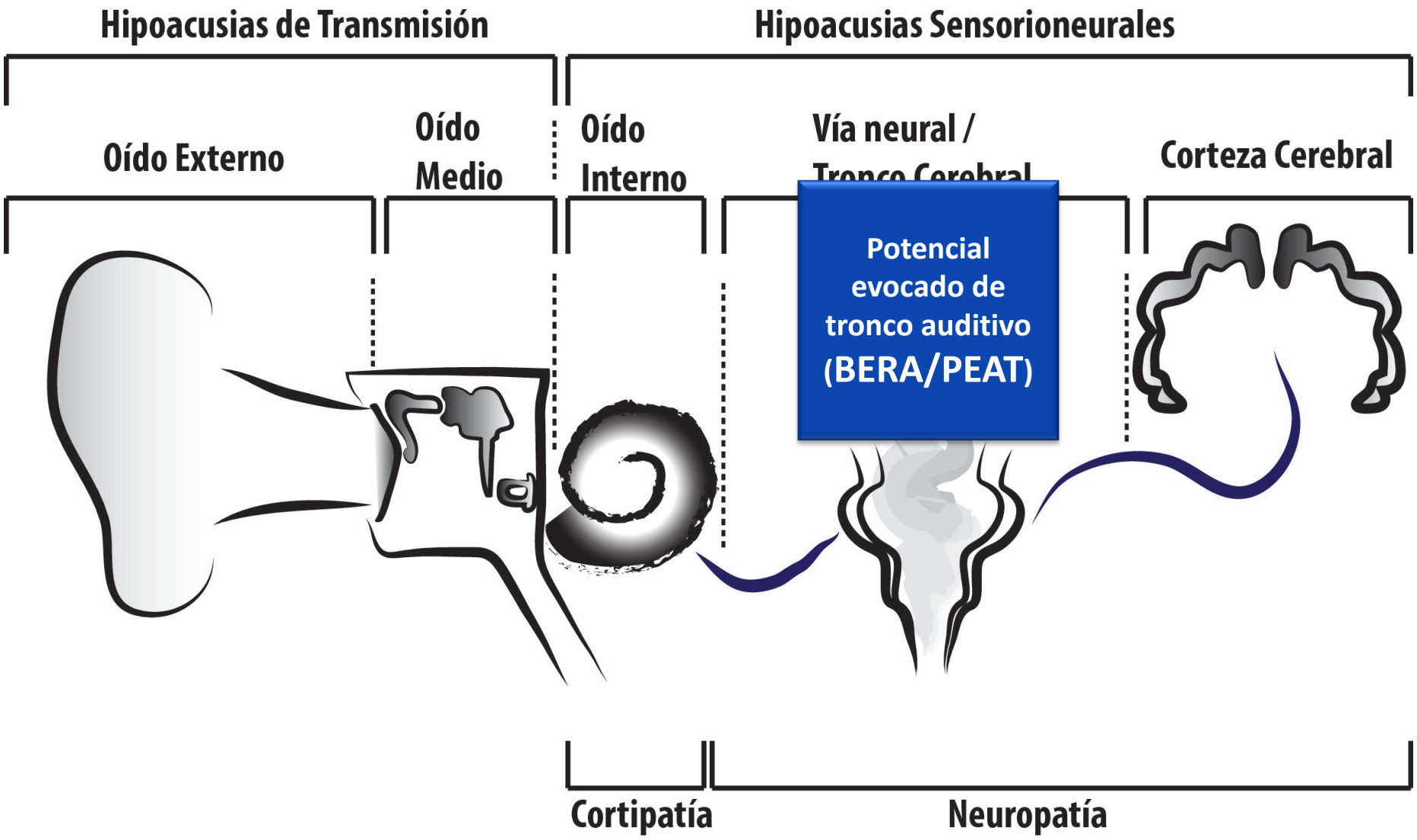



Hipoacusias de Transmisión
Hipoacusias Sensorioneurales
Oído Externo
Oído Medio
Oído Interno
Vía neural / Tronco Cerebral
Corteza Cerebral
Emisiones Otoacústicas
Cortipatía
Neuropatía

Emisiones Otoacústicas

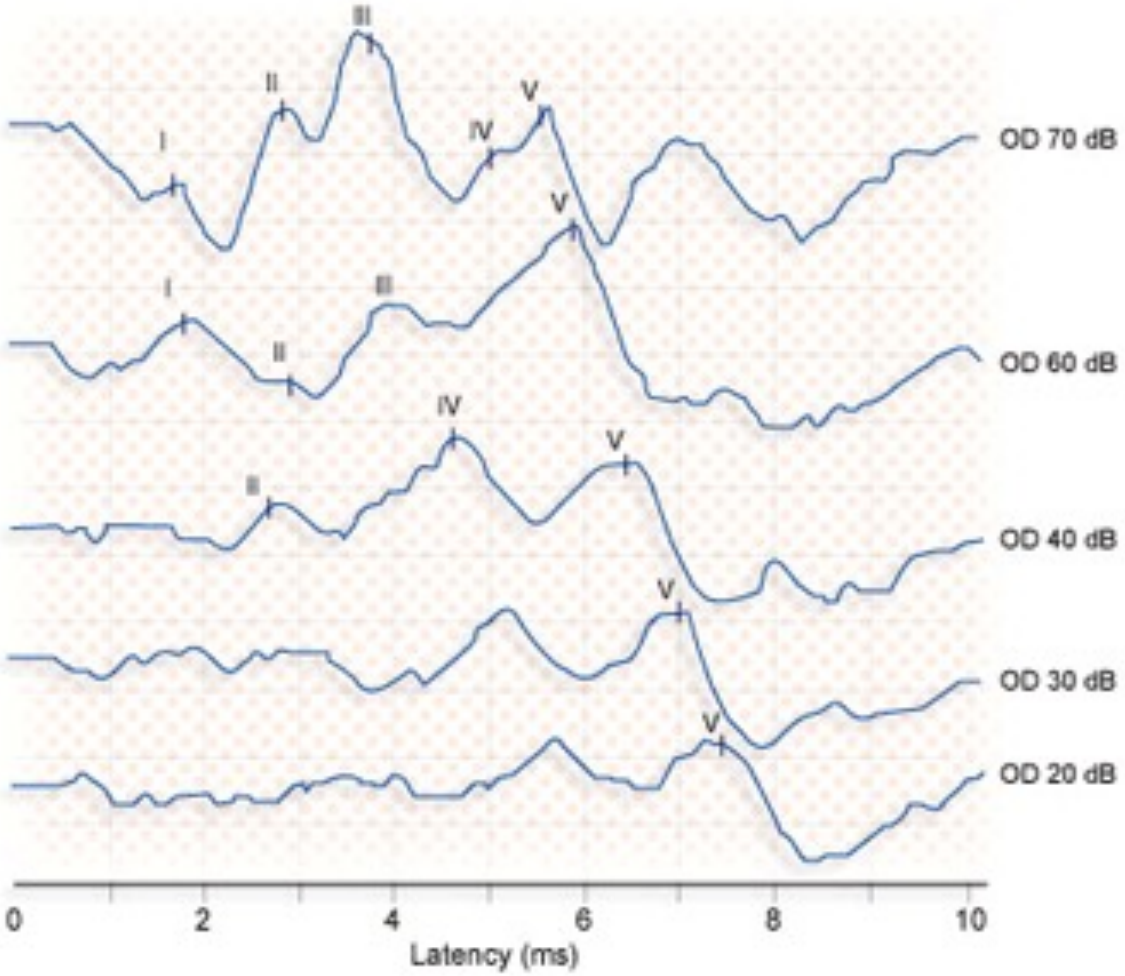


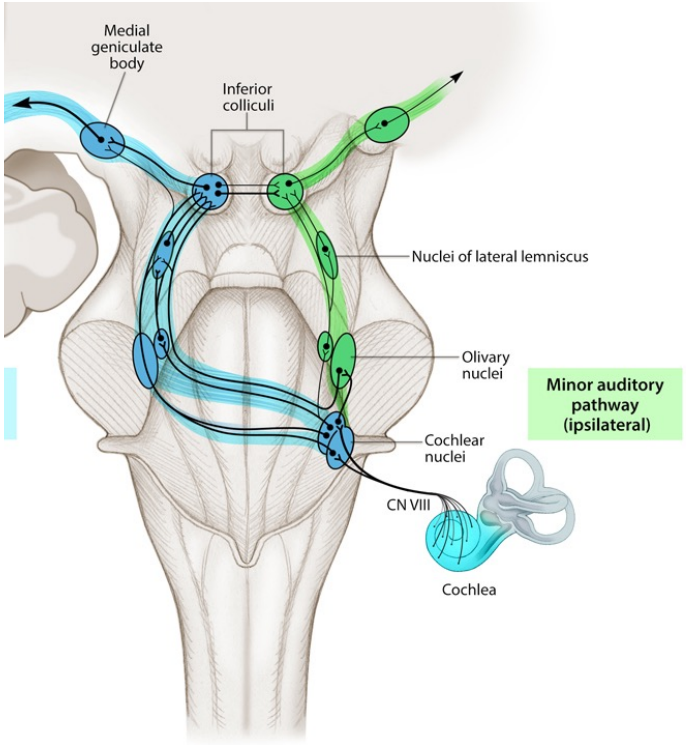
Transientes

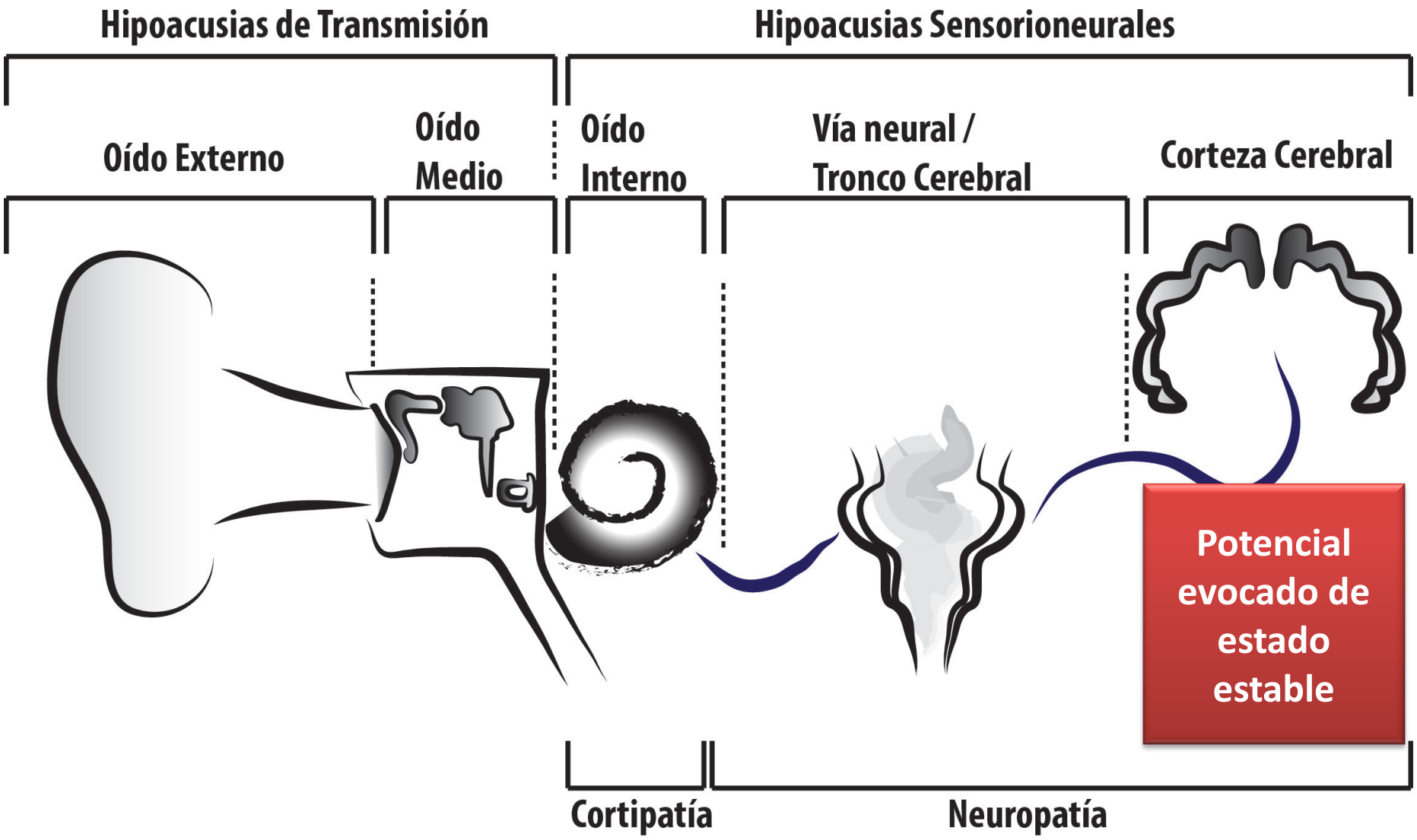

Hipoacusias de Transmisión
Hipoacusias Sensorioneurales
Oído Externo
Oído Medio
Oído Interno
Vía neural / Tronco Cerebral
Corteza Cerebral
Potencial evocado de tronco auditivo (BERA/PEAT)
Cortipatía
Neuropatía

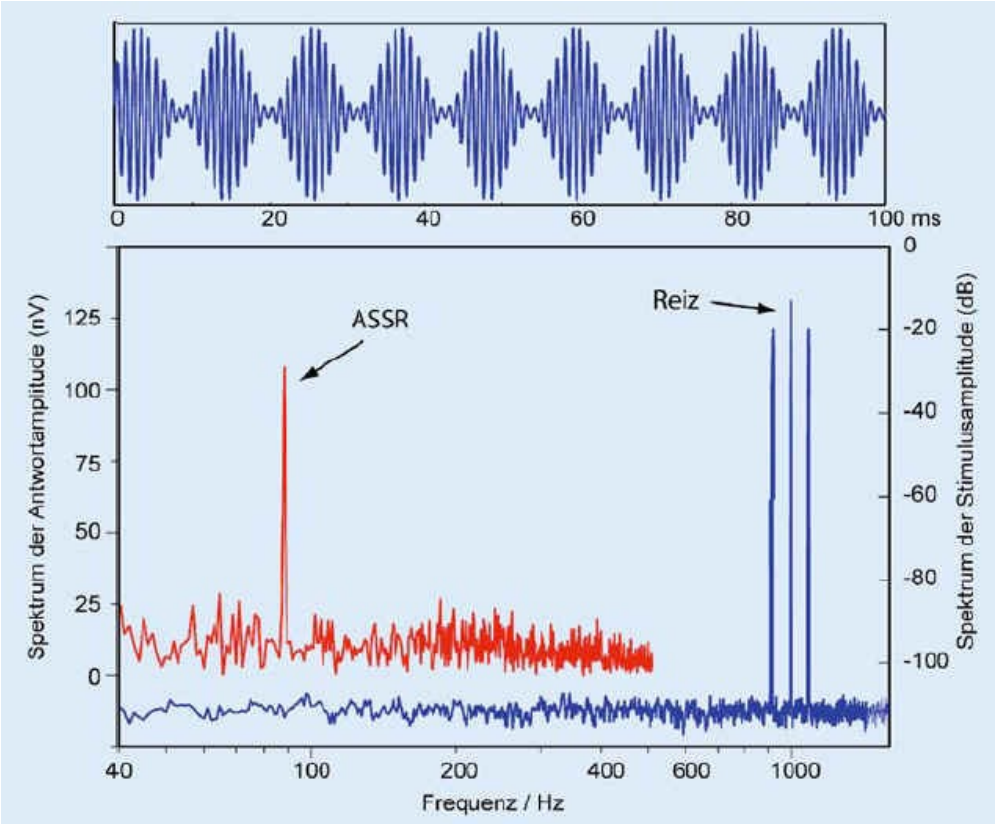

ABR
ABR

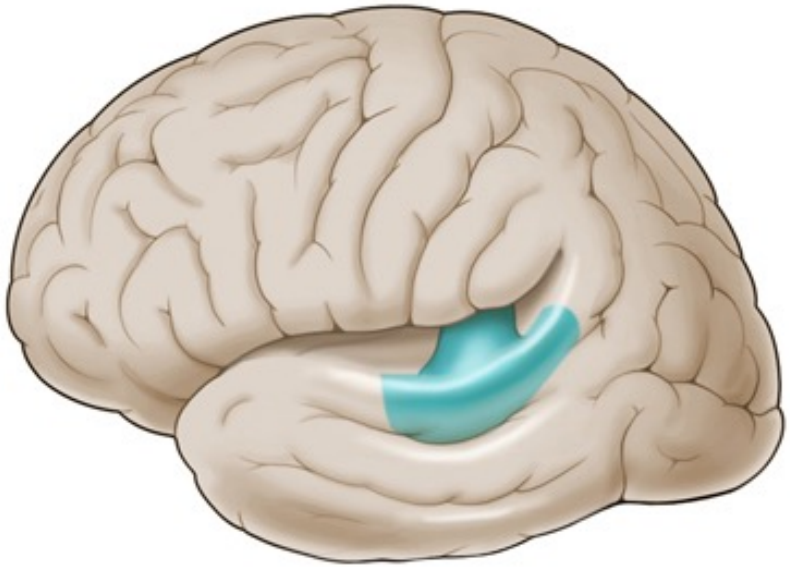
BERA / PEAT
(Potenciales de tronco auditivo)






Hipoacusias de Transmisión
Hipoacusias Sensorioneurales
Oído Externo
Oído Medio
Oído Interno
Vía neural / Tronco Cerebral
Corteza Cerebral
Potencial evocado de estado estable
Cortipatía
Neuropatía


0
20
40
60
80
100 ms
ASSR
Reiz
Spektrum der Antwortamplitude (nV)
125
100
75
50
25
0
0
-20
-40
-60
-80
-100
Spektrum der Stimulusamplitude (dB)
40
100
200
400
600
1000
Frequenz / Hz

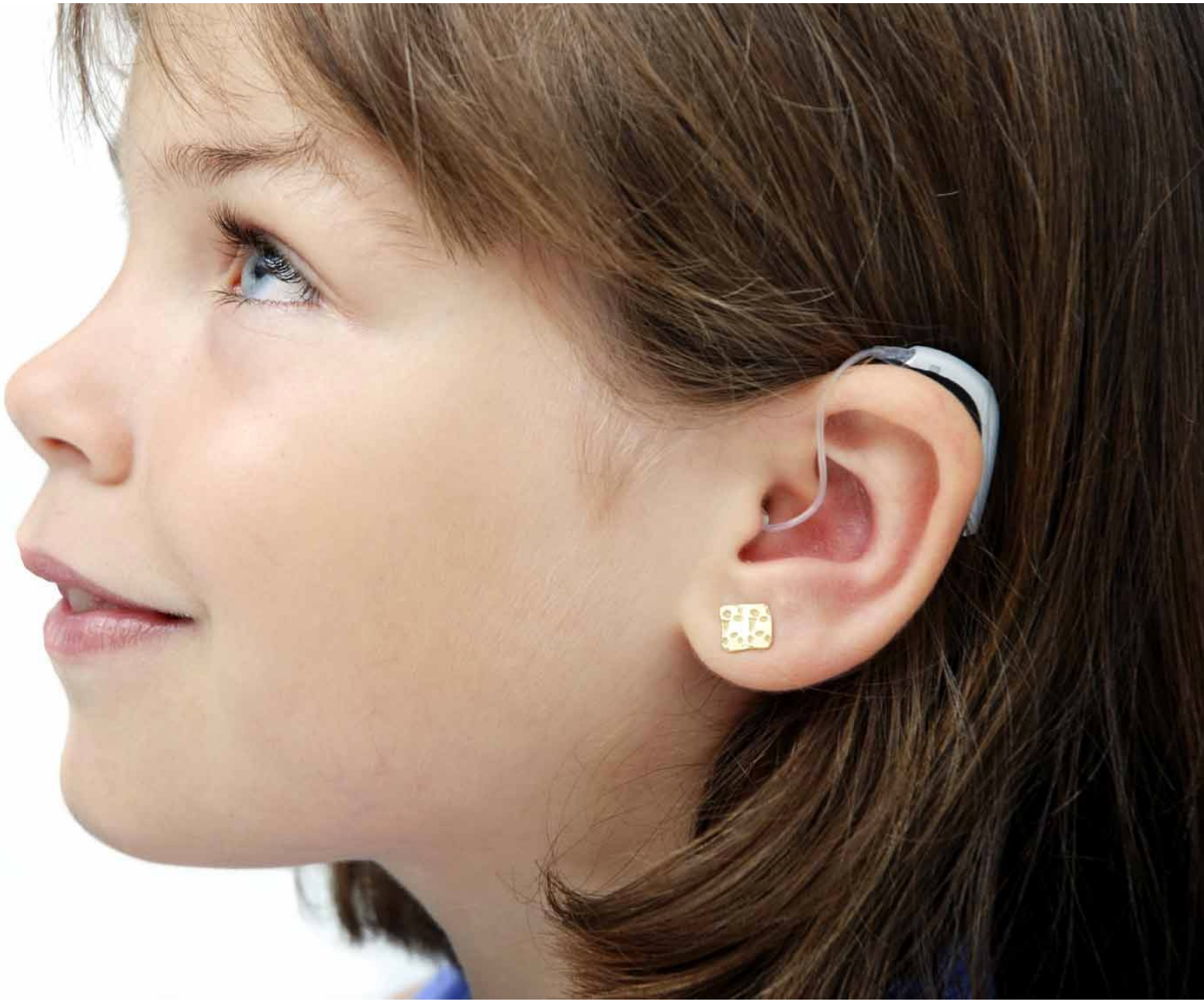


Audifonos, Audioprótesis & Implante Coclear

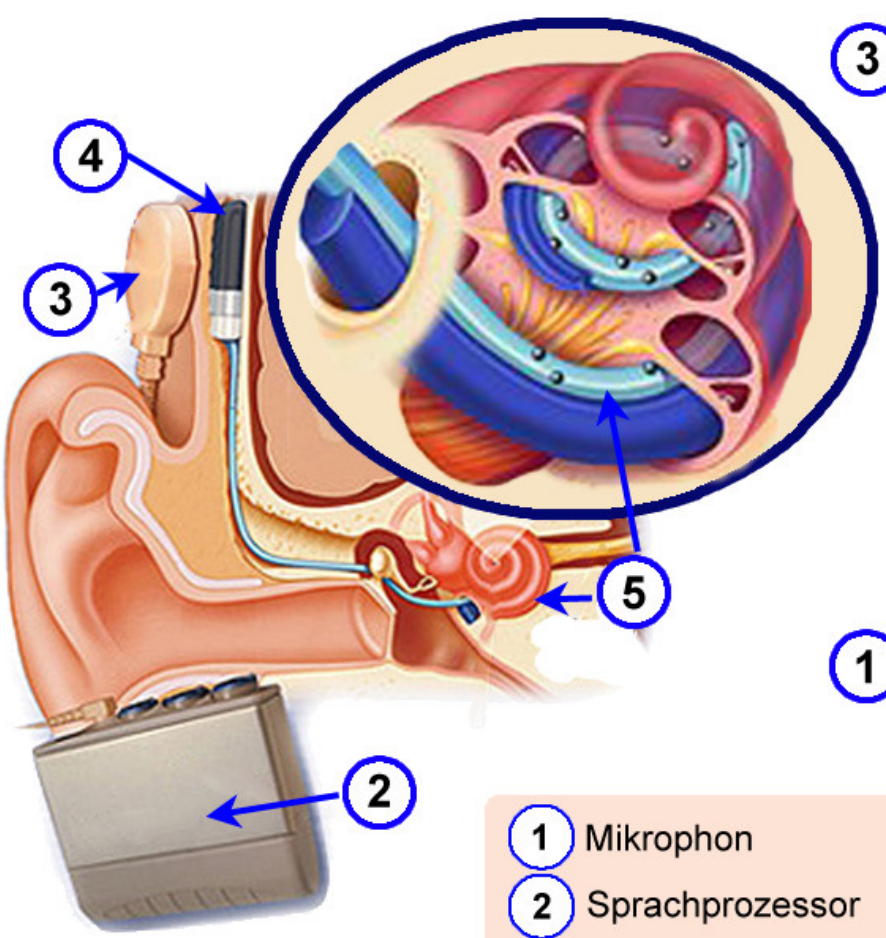
Interfaz humano maquina

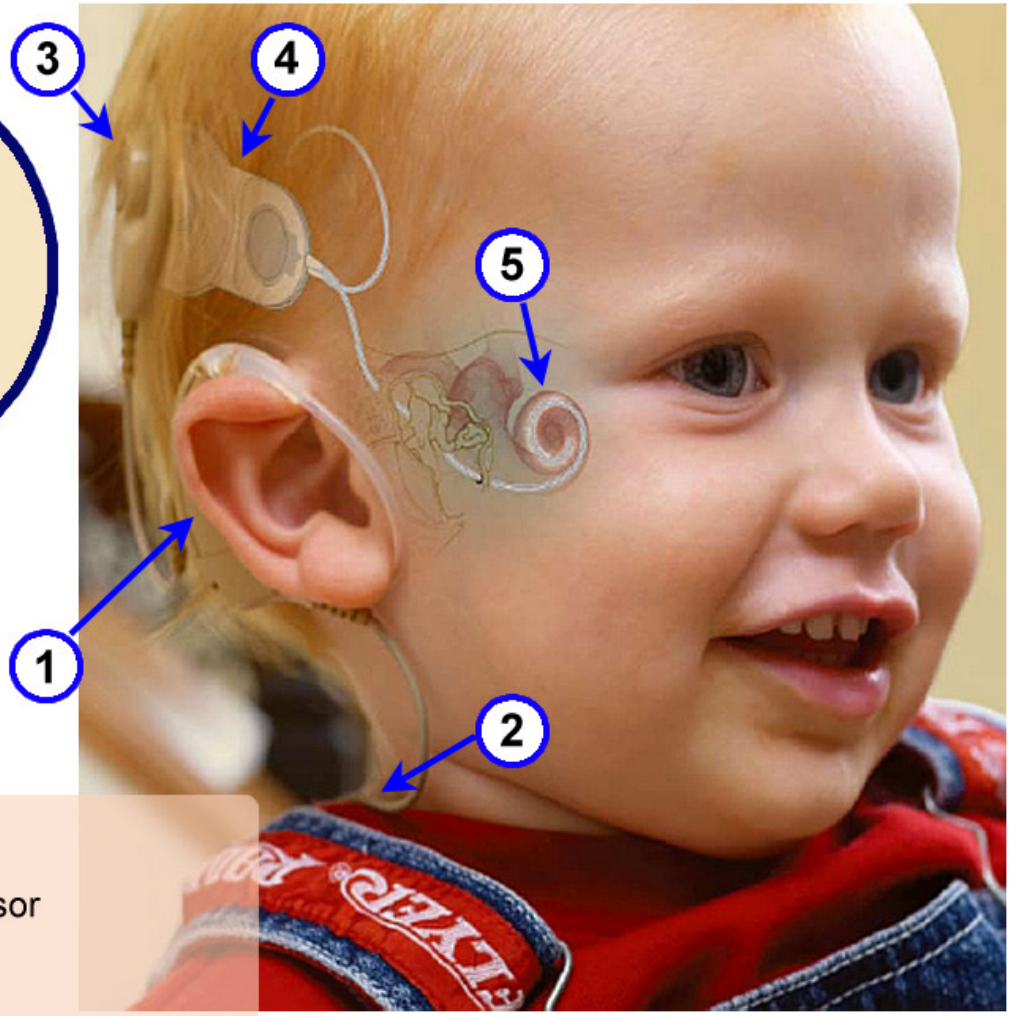
10/10

Audífonos



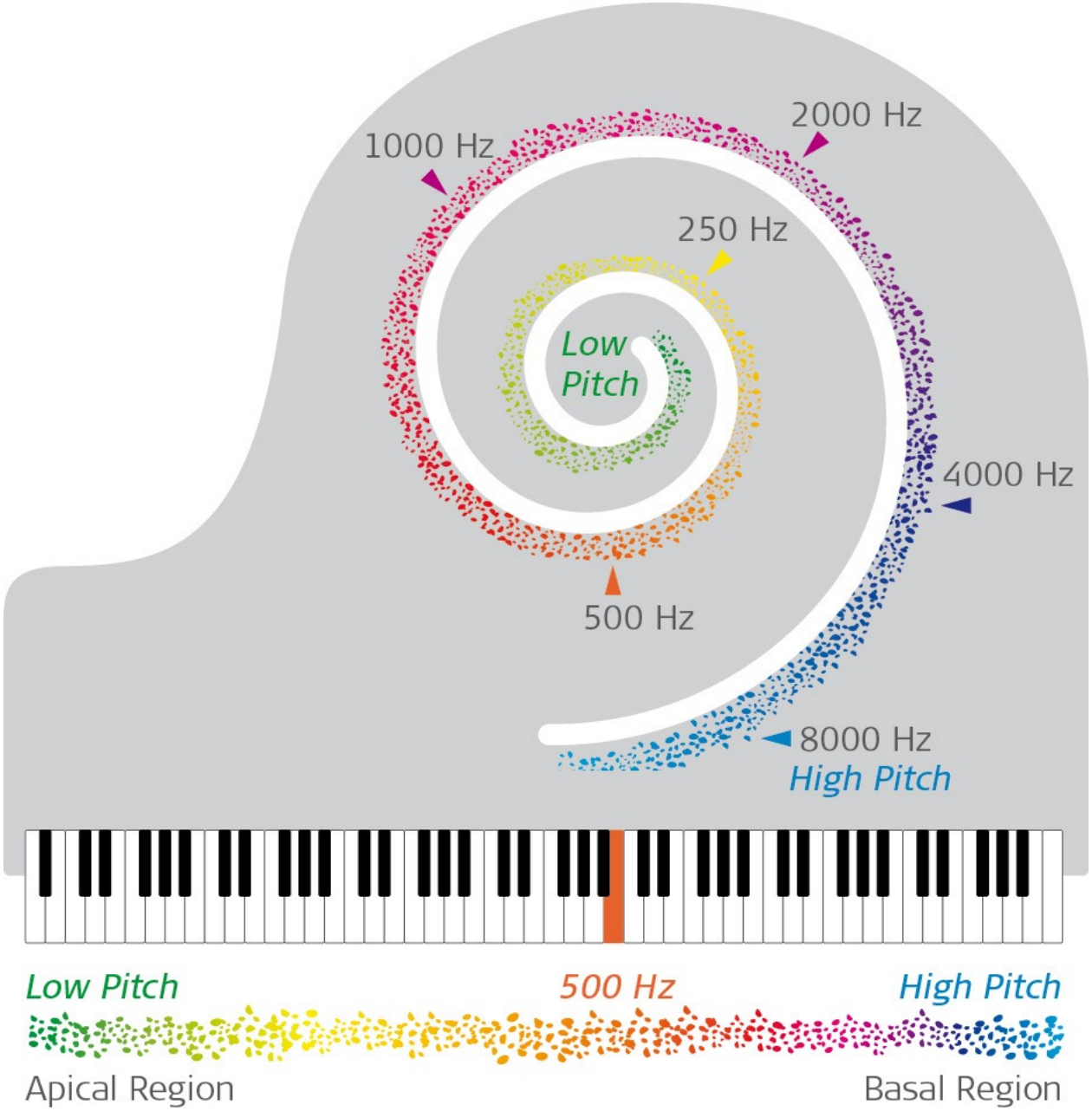
Implante Coclear

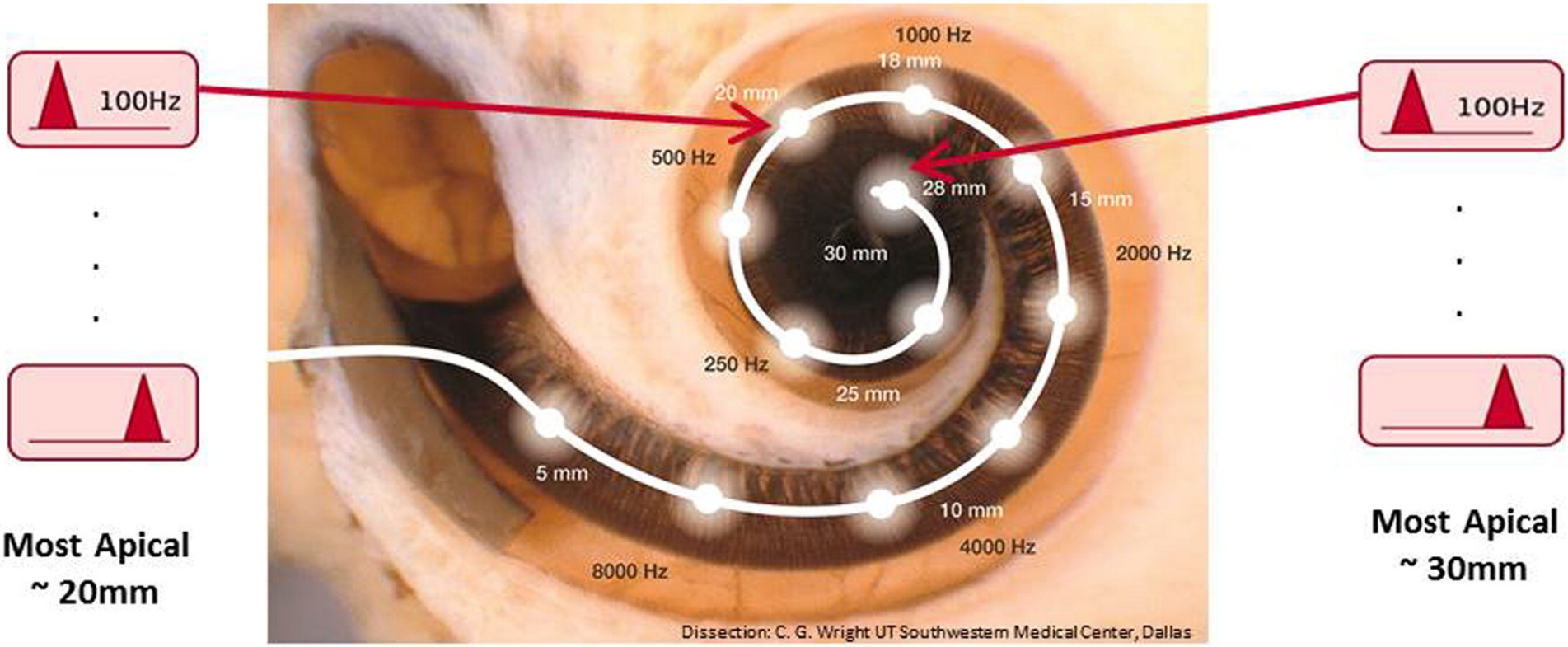




1. Mikrophon
2. Sprachprozessor
3. Sendespule
4. Implantierte Empfänger
5. Intracochleären Elektrode

Cochlear Implants


1000 Hz
2000 Hz
250 Hz
Low
Pitch
4000 Hz
500 Hz
8000 Hz
High Pitch
Low Pitch
500 Hz
High Pitch
Apical Region
Basal Region


100Hz
Most Apical
~ 20mm
1000 Hz
18 mm
20 mm
500 Hz
28 mm
15 mm
30 mm
2000 Hz
250 Hz
25 mm
5 mm
10 mm
4000 Hz
8000 Hz
Dissection: C. G. Wright UT Southwestern Medical Center, Dallas
100Hz
Most Apical
~ 30mm

Fisiología de la Audición

FACULTAD DE MEDICINA
UNIVERSIDAD DE CHILE

Hayo A. Breinbauer Krebs (Dr.med/PhD).
Universidad de Chile – Departamento Neurociencias
Universidad de Chile – Hospital San Juan de Dios