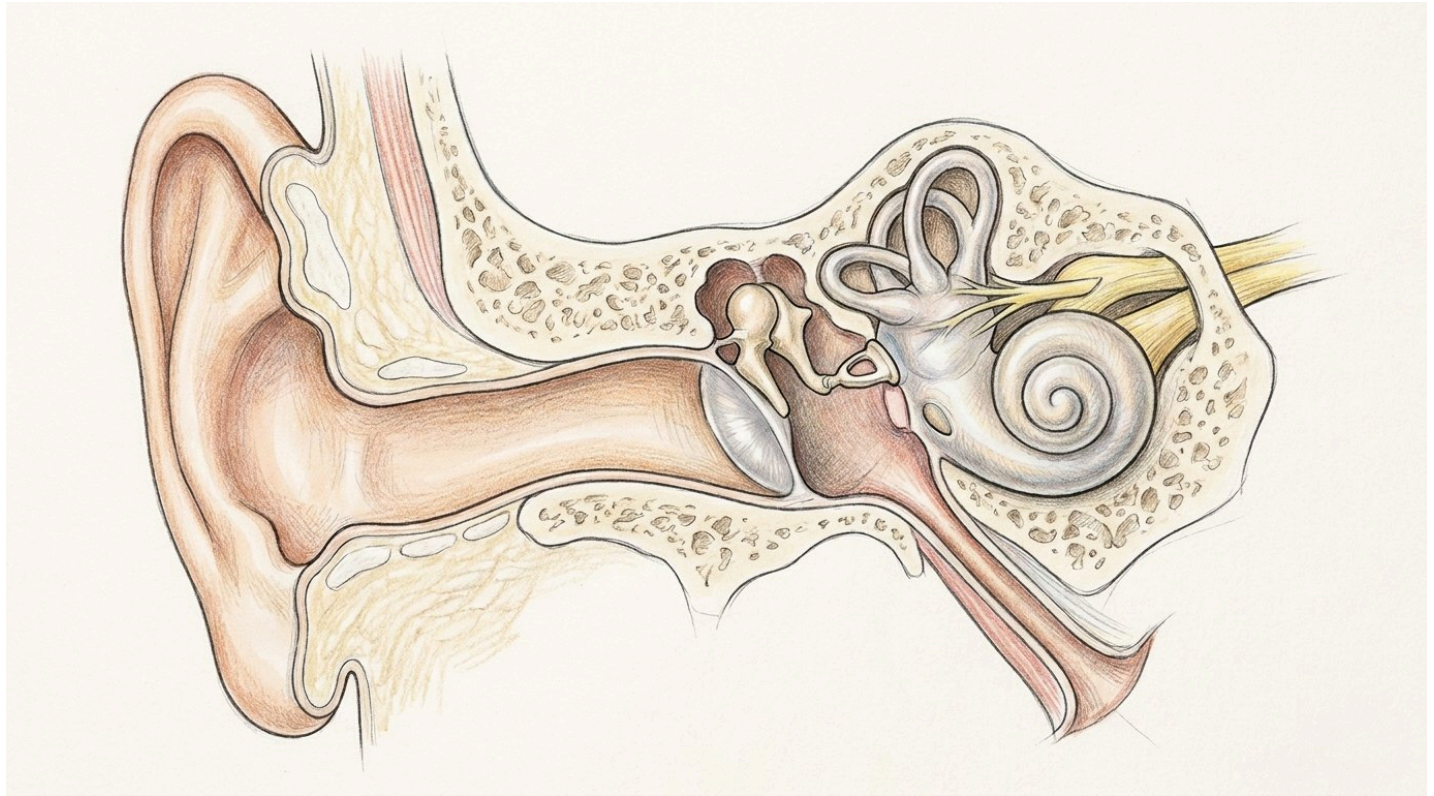


How Sound Becomes a Signal

The ear, the tuning fork, and the audiogram: a labeled guide plus the lab you will run



Inside this guide

1. The ear, labeled and color coded by function
2. The middle ear: why air needs an amplifier
3. The cochlea and its hair cells
4. The vestibular system: balance
5. Two roads to the cochlea: air and bone
6. The tuning fork, the Rinne test, the Weber test
7. Lab design: simulate a conductive hearing loss
8. Reading an audiogram
9. Conductive loss versus the other types; speech in noise and interventions
10. Check yourself, answers, and sources

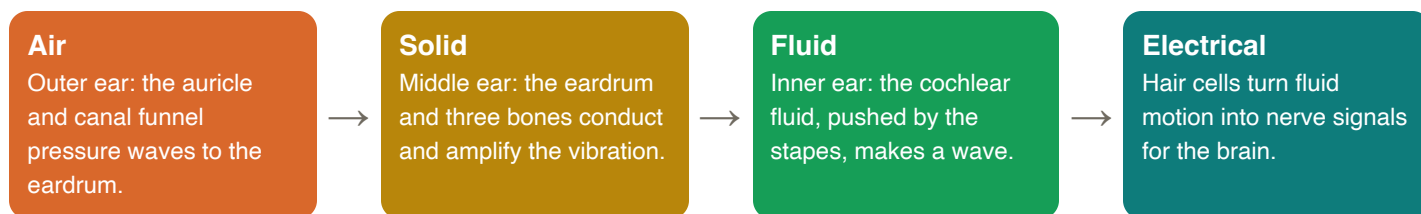
How to use it

Keep this next to your Activity 1.3.2 notebook. The plates answer "what is it and what does it do." The lab pages tell you how to run the Rinne test and record it in PLTW's Data Table 1 format, and how to add one blocked-ear trial that shows conductive hearing loss in action.

Use the 6 Rs as you go: **Record** the labels, **Reduce** each structure to its job, **Review** the color code, **Reflect** on your own data, **Recite** the sound pathway out loud, **Revise** your notes after the check-yourself page.

One sound, four stages

A sound is a vibration. On its way to your brain it passes through four stages (air, solid, fluid, then an electrical signal), and each part of the ear exists to hand the vibration to the next stage without losing it.



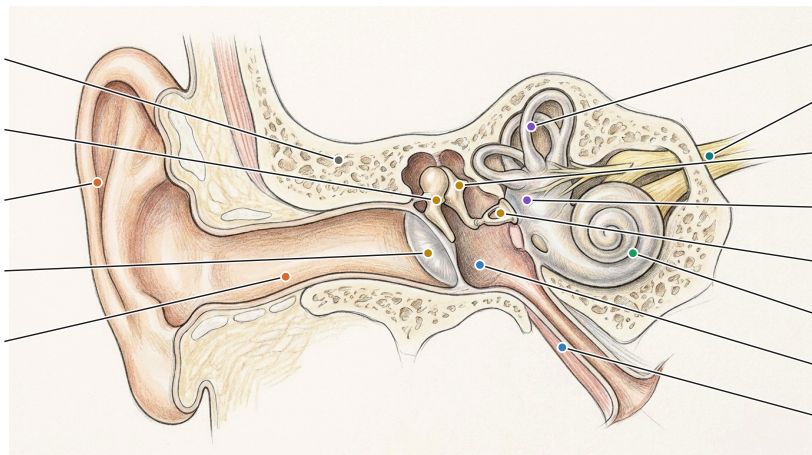
■ Temporal bone

■ **Malleus**
(hammer)

■ **Auricle (pinna)**

■ **Tympanic membrane**
(eardrum)

■ **Ear canal**
(external auditory canal)



Semicircular canals ■

■ **Vestibulocochlear**
nerve (cranial nerve VIII)

■ **Incus**
(anvil)

■ **Vestibule**

■ **Stapes**
(stirrup)

■ **Cochlea**

■ **Middle ear cavity**
(air-filled)

■ **Eustachian tube**
(to the throat)

Plate 1. A coronal cut through a right ear, seen from the front (AI-generated, colored-pencil style). Label squares show each structure's job using the color code below. The cochlea is about the size of a pea.

- Collect and funnel sound ■ Amplify vibration (solid conduction) ■ Equalize air pressure
- Hearing: fluid wave to nerve signal ■ Balance: head motion and tilt ■ Carry the signal to the brain
- Support and protection

Three regions. The **outer ear** (auricle and canal) ends at the eardrum. The **middle ear** is a small air-filled room behind the eardrum that holds the three ossicles and opens to the throat through the Eustachian tube. The **inner ear** is a fluid-filled maze of tunnels in the temporal bone: the cochlea for hearing, and the vestibule and semicircular canals for balance.

Careful with "conductive." Conductive hearing loss means anything that blocks delivery from the ear canal to the stapes footplate: earwax, the eardrum, the ossicles, or fluid trapped in the middle ear. Fluid in the *inner* ear is supposed to be there; fluid in the *middle* ear is not.

Words to know

Hertz (Hz): vibrations per second; how high or low a pitch is.

Air conduction: sound reaching the cochlea through the ear canal, eardrum and ossicles.

Conductive hearing loss: sound is blocked on the way in (outer or middle ear).

Air-bone gap: how much worse air conduction is than bone conduction; a sign of conductive loss.

Decibel (dB HL): how loud a sound must be for a person to just hear it; bigger numbers mean worse hearing.

Bone conduction: vibration of the skull reaching the cochlea directly.

Sensorineural hearing loss: the cochlea's hair cells or the nerve are damaged.

Mixed hearing loss: both types at once.

Every structure has a job

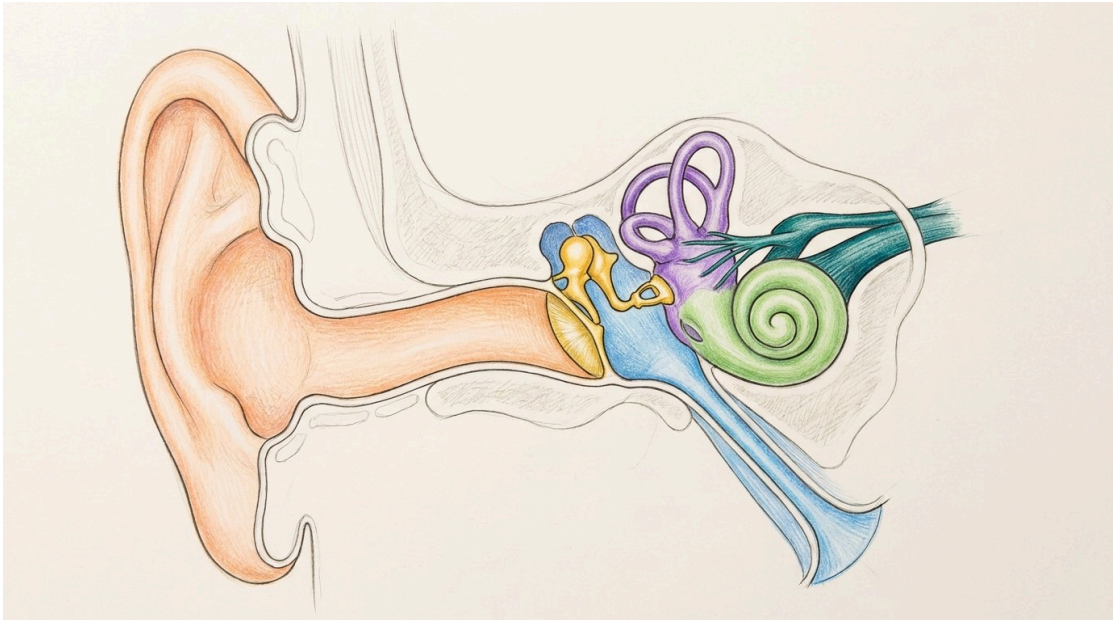


Plate 2. The same cut, colored by job: orange collects, gold amplifies, blue equalizes pressure, green hears, violet balances, teal carries the signal.

- Collect and funnel sound
- Amplify vibration (solid conduction)
- Equalize air pressure
- Hearing: fluid wave to nerve signal
- Balance: head motion and tilt
- Carry the signal to the brain

Structure	What it is	What it does	When it fails
Auricle (pinna)	Skin-covered cartilage flap.	Gathers sound and funnels it inward; its folds help you judge whether a sound is above, below, in front or behind.	Missing or malformed at birth: less sound collected.
External auditory canal	Tube about 2.5 cm long; glands make earwax.	Carries sound to the eardrum; wax and hairs trap dust.	Packed earwax or swelling blocks sound: conductive loss.
Tympanic membrane (eardrum)	Thin, cone-shaped membrane.	Vibrates with every pressure change in the canal and passes it to the malleus.	A hole (perforation) from infection or injury: conductive loss.
Malleus, incus, stapes (ossicles)	Three smallest bones in the body; the stapes is the smallest.	A lever chain that conducts the vibration and increases its pressure about 20 times before the stapes pushes on the oval window.	Otosclerosis glues the stapes in place; long infections can erode the chain: conductive loss.
Stapedius and tensor tympani	Two tiny muscles attached to the ossicles.	Mainly the stapedius tightens the chain during very loud sound (the acoustic reflex), giving partial protection.	Weak reflex: loud sounds feel harsher.
Middle ear cavity and Eustachian tube	Air space linked to the throat (nasopharynx).	The tube opens when you swallow or yawn so air pressure matches on both sides of the eardrum, and it drains fluid.	A blocked tube traps fluid (otitis media): conductive loss, ear pain.

Oval window and round window	Two membrane-covered openings into the cochlea.	The stapes pushes the oval window in; the round window bulges out so the fluid has room to move.	Bone growth that stiffens the windows reduces fluid motion.
Cochlea	Snail-shaped, fluid-filled tube of about 2.5 turns.	Its organ of Corti turns fluid waves into nerve signals and sorts sound by pitch along its length.	Hair cell damage from noise, aging, drugs, infection or genes: sensorineural loss.
Vestibule (utricle and saccule)	Two sacs in the middle of the inner ear.	Sense head tilt and straight-line acceleration (gravity, elevators, cars).	Dizziness and poor balance.
Semicircular canals	Three fluid-filled loops at right angles.	Sense head rotation in any direction.	Vertigo, the feeling that the room is spinning.
Vestibulocochlear nerve (VIII)	Cranial nerve with a cochlear branch and a vestibular branch.	Carries hearing and balance signals to the brainstem; hearing signals continue to the auditory cortex in the temporal lobe.	A tumor on the nerve (vestibular schwannoma): one-sided hearing loss and ringing.

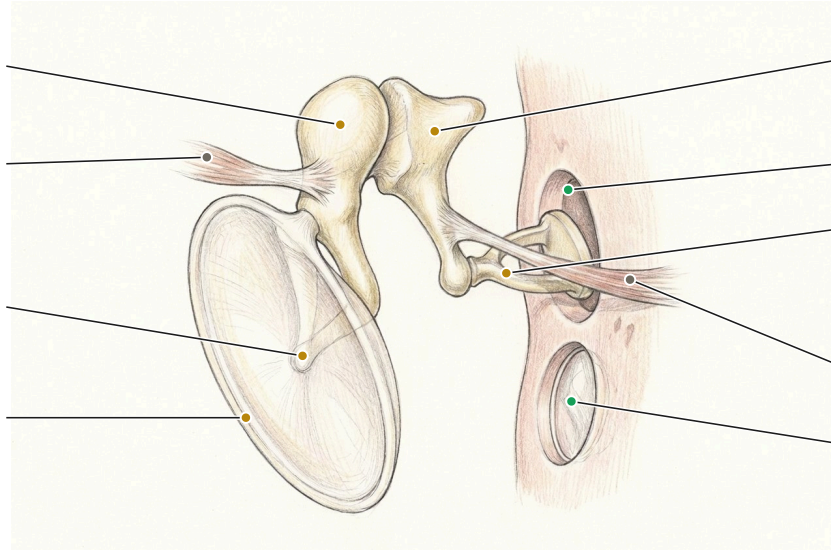
Why air needs an amplifier

■ **Malleus**

■ **Tensor tympani**
(muscle tendon)

■ **Handle of malleus**
(fixed to eardrum)

■ **Tympanic membrane**
(eardrum)



■ **Incus**

■ **Oval window**
(stapes footplate here)

■ **Stapes**

■ **Stapedius**
(muscle tendon)

■ **Round window**

Plate 3. The ossicle chain from the eardrum (left) to the oval window of the inner ear (right). AI-generated, colored-pencil style, enlarged many times; the stapedius tendon is drawn simplified.

The problem: air is thin, fluid is heavy

The cochlea is full of fluid. Air molecules are far easier to push than fluid, so when a sound wave in air hits a fluid surface head-on, more than 99.9 percent of its energy bounces off. Without help, you would lose most of the sound right at the inner ear's front door.

The fix: area plus leverage

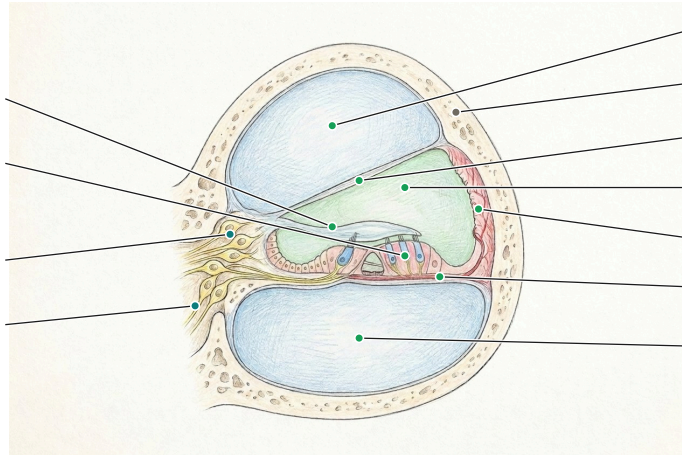
Area. The eardrum (about 55 mm²) collects force and delivers it to the stapes footplate (about 3.2 mm²), roughly 17 times smaller. Same force on a smaller area means more pressure, the way a thumbtack turns a gentle push into a sharp point.

Lever. The malleus and incus act as a lever that adds about 1.3 times more. Together: about 20 times the pressure, roughly a 25 to 30 decibel boost.

Connect it. Anything that stops the eardrum or the ossicles from moving (fluid behind the eardrum, a hole in it, a stapes fixed by otosclerosis) reduces or removes this boost. That is a **conductive** hearing loss: the cochlea is healthy, but less vibration reaches it.

Three fluid tunnels and a living keyboard

- Tectorial membrane
- Organ of Corti
(hair cells)
- Spiral ganglion
(nerve cell bodies)
- Cochlear nerve



- Scala vestibuli
(perilymph)
- Bony wall
- Reissner's membrane
(vestibular membrane)
- Scala media
(cochlear duct, endolymph)
- Stria vascularis
- Basilar membrane
- Scala tympani
(perilymph)

Plate 4. A cut through one turn of the cochlea (simplified; see Plate 5 for hair cell detail). Blue tunnels hold perilymph; the green middle tunnel holds endolymph.

Two fluids

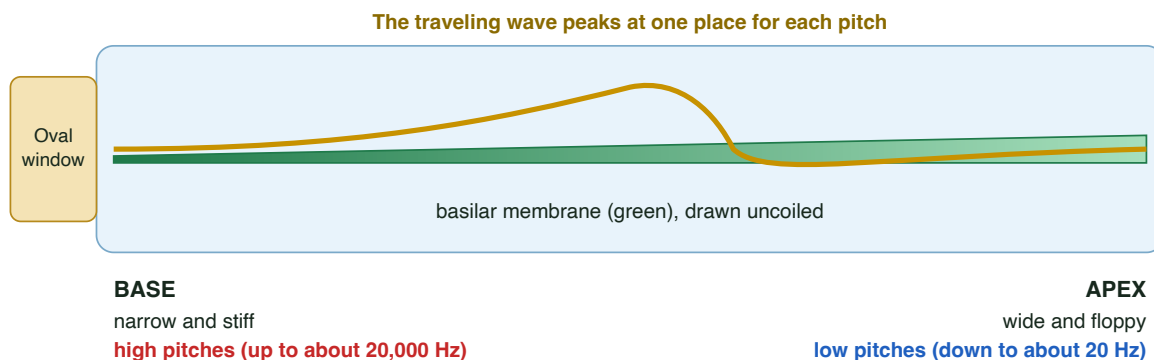
Perilymph fills the scala vestibuli and scala tympani.
Endolymph fills the scala media; it is rich in potassium (K^+), and the stria vascularis keeps it charged at about +80 millivolts. That charge is the "battery" that powers the hair cells.

Sorting by pitch (tonotopy)

Each pitch makes the basilar membrane bulge most at one spot. High pitches peak near the stiff base by the oval window; low pitches travel to the floppy apex. Humans hear roughly 20 to 20,000 Hz. Noise and aging usually damage the base first, so high pitches go first.

The fluid wave

The stapes pushes the oval window, sending a pressure wave through the perilymph. The wave flexes the basilar membrane, and the round window bulges outward because fluid cannot be squeezed smaller.



Where motion becomes a nerve signal

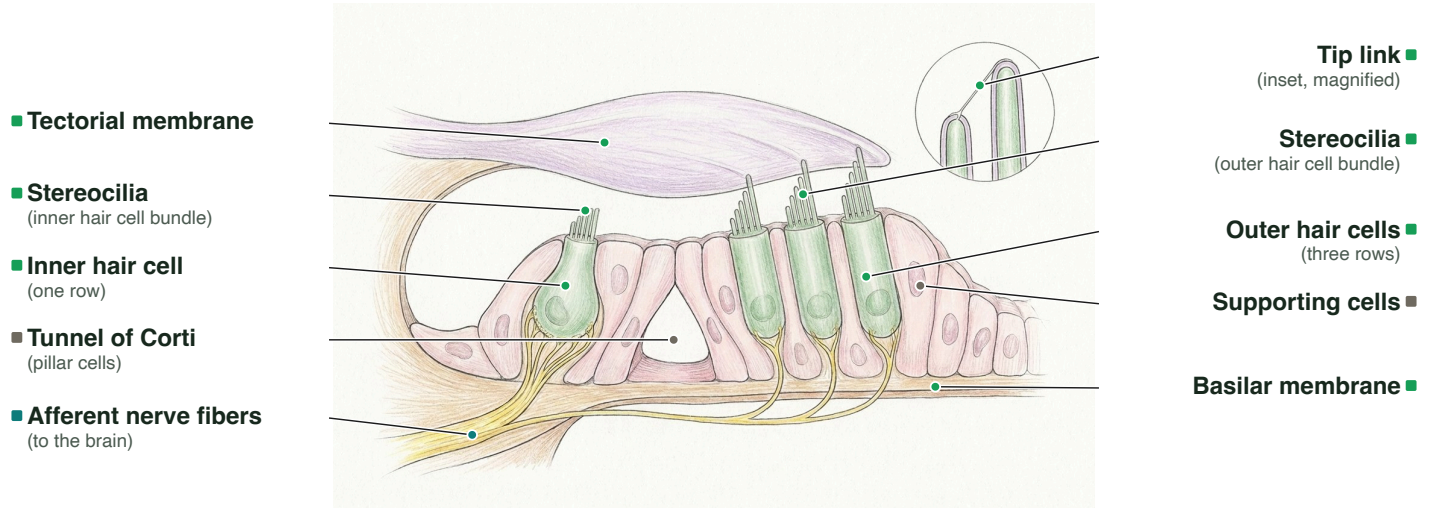


Plate 5. The organ of Corti, side view. Green hair cells sit on the basilar membrane under the tectorial membrane; only the outer hair cells touch it. AI-generated, colored-pencil style. Inset: a tip link joining a short stereocilium to its taller neighbor.

Six steps of transduction

1. The fluid wave moves the basilar membrane up and down.
2. Outer hair cell stereocilia are embedded in the tectorial membrane; inner hair cell stereocilia are bent by fluid sliding between the membranes. Either way, the up-and-down motion becomes a sideways bend.
3. Bending toward the tallest stereocilium stretches the tip links, which pull ion channels open.
4. Potassium (K^+) flows in from the endolymph and the cell depolarizes.
5. The inner hair cell releases neurotransmitter onto the nerve fibers, which fire action potentials.
6. Bending the other way closes the channels. The signal rises and falls with every cycle of the sound.

Inner versus outer hair cells

Inner hair cells (about 3,500, one row) are the true sensors: about 90 to 95 percent of the hearing nerve fibers connect to them.

Outer hair cells (about 12,000, three rows) are amplifiers. A motor protein called prestin makes them stretch and shrink with the sound, pumping extra energy into the basilar membrane so you can hear soft sounds and tell close pitches apart.

Why it matters. Human hair cells do not grow back. Loud noise and aging destroy them, which is why most sensorineural hearing loss is permanent.

On to the brain

Cochlear nerve → cochlear nuclei (brainstem) → superior olivary complex (compares the two ears to locate sound) → inferior colliculus (midbrain) → medial geniculate nucleus (thalamus) → primary auditory cortex (temporal lobe).

Same fluid, same hair cells, different job: balance

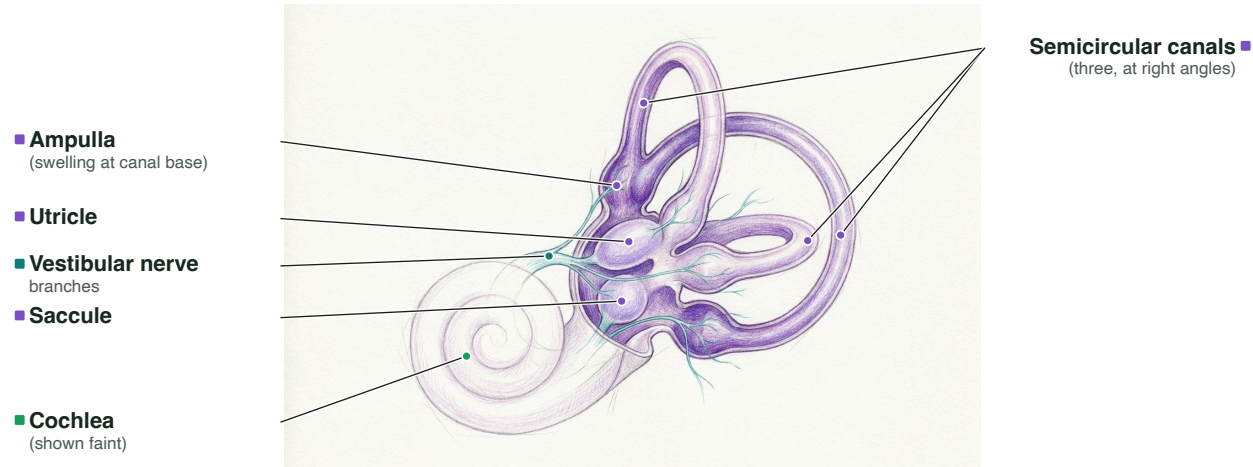


Plate 6. The vestibular labyrinth. One label, three leaders: one for each semicircular canal.

The vestibular system shares the inner ear's fluid, its hair cells and nerve VIII with the cochlea. That is why one inner-ear disease can bring both hearing loss and dizziness (Meniere's disease and labyrinthitis are two examples in your 1.3.1 case studies).

Organ	Senses	Example
Semicircular canals	Rotation of the head	Shaking "no," nodding "yes," tilting toward a shoulder
Utricle	Tilt and mostly horizontal straight-line acceleration	A car speeding up
Saccule	Mostly vertical straight-line acceleration	An elevator starting to rise

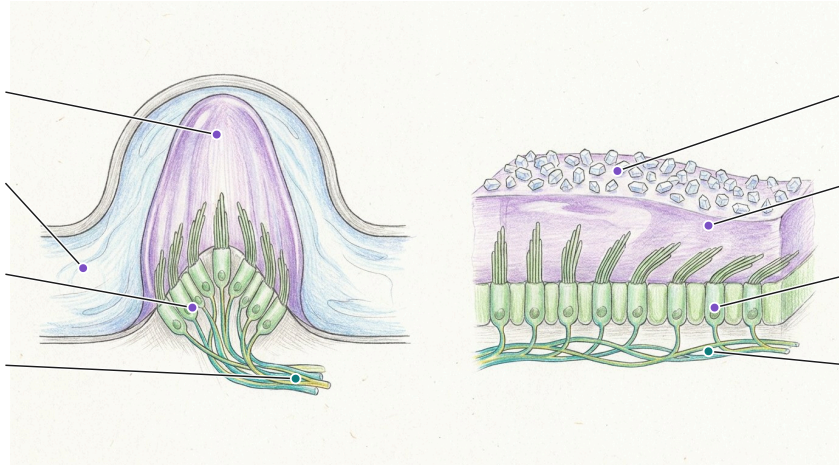
Fluid that lags and crystals that slide

■ **Cupula**
(gel flap)

■ **Endolymph**

■ **Hair cells**
(crista)

■ **Nerve fibers**



■ **Otoconia**
(calcium carbonate)

■ **Otolithic membrane**
(gel)

■ **Hair cells**
(macula)

■ **Nerve fibers**

Plate 7. Left: the crista inside an ampulla. Right: a macula of the utricle, with crystals sitting on the gel.

Rotation: the cupula

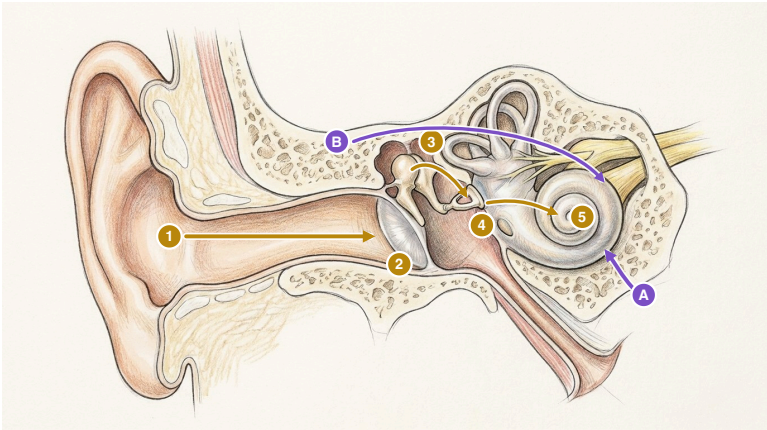
When your head turns, the canal turns with it but the endolymph lags behind, like coffee staying still while you spin the cup. The lagging fluid pushes the cupula, which bends the hair cells' stereocilia and changes their signal.

Tilt and acceleration: the crystals

Otoconia are heavier than the gel they sit on. Tilt your head or speed up, and gravity or inertia slides the crystal-topped gel, bending the hair bundles underneath.

Two roads to the same fluid

Every sound you hear ends as a wave in the cochlear fluid. What differs is how the vibration gets there. The **air road** conducts it through the outer ear and the solid chain of the middle ear. The **bone road** shakes the skull so the fluid moves directly.



Gold numbers 1 to 5: the air road. Violet arrows A and B: vibration traveling through the skull bone itself to the bony shell of the cochlea. (In the Rinne test the fork sits on the mastoid bone behind the ear, outside this cut; in the Weber test it sits on the forehead.)

Air conduction (the everyday road)

1. Pressure waves in air enter the ear canal.
2. The eardrum vibrates.
3. Malleus → incus → stapes conduct the vibration as a solid and raise its pressure about 20 times.
4. The stapes footplate pushes the oval window.
5. A pressure wave runs through the cochlear fluid, the basilar membrane bulges at the spot for that pitch, hair cells bend, and the nerve fires.

Bone conduction (the skull road)

1. A vibrating object touches the skull: a tuning fork stem, a bone-anchored hearing aid, or your own voice.
2. The skull, including the bony shell of the cochlea, vibrates and moves the cochlear fluid directly. This largely skips the canal, eardrum and ossicles.
3. From here it is the same as air step 5: fluid wave, hair cells, nerve.

This is why your recorded voice sounds strange: you normally hear yourself partly through bone.

How to tell the difference: compare the two roads

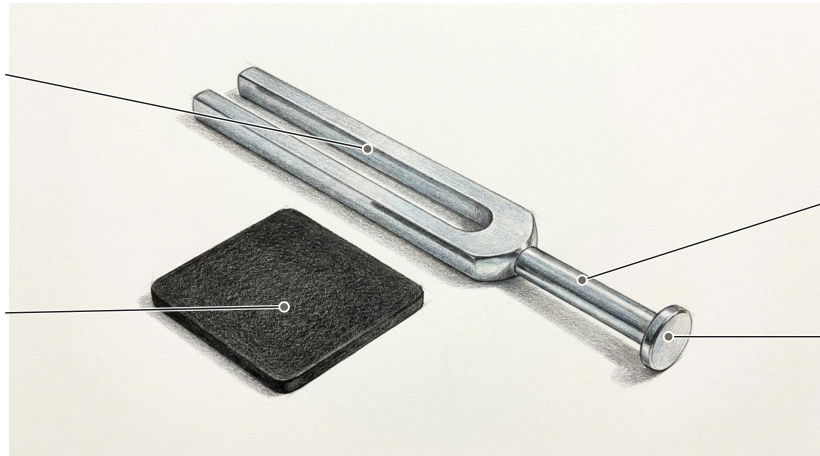
What you find	Where the problem is	Type of loss
Air road worse, bone road normal (a gap between them)	Outer or middle ear: the vibration is blocked before it reaches the fluid	Conductive
Air and bone roads worse by the same amount (no gap)	Cochlea (hair cells) or the nerve: the fluid moves but the signal is not made or sent	Sensorineural
Both worse, and air even worse than bone	Both places at once	Mixed

The tuning fork tests and the audiogram are two ways of measuring exactly this comparison.

A pure tone you can time

■ **Prongs (tines)**
vibrate; never touch them

■ **Rubber striking pad**



■ **Stem**
hold the fork here

■ **Base (foot)**
touches the skull

Plate 8. A steel tuning fork and its striking pad.

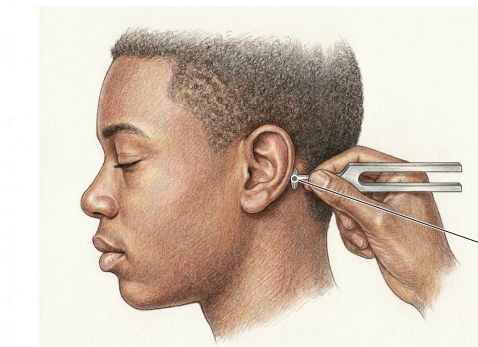
Why a tuning fork works

Struck once, the prongs vibrate at one fixed frequency (stamped on the fork) and slowly fade. Because the sound fades at a steady rate, **how many seconds a person can hear it** becomes a measurement. We use a **512 Hz** fork: it rings long enough to time, and it is high enough that people mostly hear it rather than feel it buzz, a problem mostly with 128 Hz forks (256 Hz forks are also used).

Handle it right

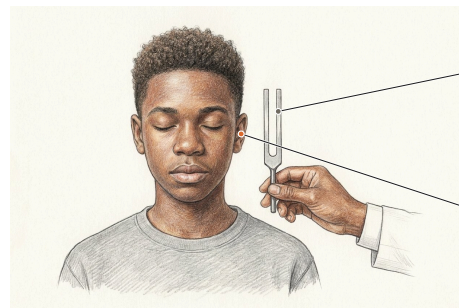
- Hold it by the stem only. Touching the prongs stops the vibration.
- Strike a prong on the rubber pad or your knee. Never a table, metal, or a person.
- Strike with the same gentle force every time; force is a variable.
- Strike the fork away from anyone's head, then bring it in. Only the base touches the head, on the mastoid or the forehead. Keep the prongs away from eyes, and never put the fork in or against the ear.
- Wipe the base with an alcohol wipe before each new partner.

The Rinne test: air versus bone in one ear (PLTW Activity 1.3.2)



■ **Mastoid bone**
stem base here

Step A, bone conduction: the stem base presses on the mastoid bone.



■ **Prongs**
1 to 2 cm out, not touching

■ **Ear opening**
(ear canal)

Step B, air conduction: the prongs stand beside the ear opening with a gap of air (front view).

Two tests, one logic

Rinne: how to run it

- 1. Partner sits, eyes closed, and raises a hand the moment the sound disappears.
- 2. Strike the fork. Press the stem base firmly on the mastoid bone behind the test ear. Start the timer. Stop when the hand goes up: **bone conduction time**.
- 3. Strike again with the same force. Hold the prongs 1 to 2 cm outside the ear opening. Time until the hand goes up: **air conduction time**.
- 4. Repeat for three trials and average. Test the other ear.

Clinic shortcut: when the bone sound stops, move the prongs straight to the ear. If the person still hears it, air is beating bone.

Rinne: what it means

Air heard longer than bone (classically about twice as long) is called a **positive** Rinne. It is normal, and it is also what you find with sensorineural loss, where both times are shorter but air still wins.

Bone heard as long as or longer than air is a **negative** Rinne: the conductive pattern. It usually takes an air-bone gap of about 20 to 30 dB to flip it.

Watch out: with severe loss in one ear only, the Rinne in that ear can look negative because the *other* cochlea hears the bone vibration through the skull. That is why the Weber is run alongside it.



Plate 9. The Weber test: the fork base on the midline of the forehead.

Weber: how to run it and read it

Strike the fork, set the base on the center of the forehead (or top of the head), and ask: "Is it louder in the middle, the left ear, or the right ear?"

- **Middle:** normal, or equal loss in both ears.
- **Louder in the bad ear:** conductive loss in that ear.
- **Louder in the good ear:** sensorineural loss in the other ear.

Why the bad ear wins in conductive loss: the blocked ear hears less room noise, and the blockage traps bone-conducted sound inside the canal (the occlusion effect). Try it: hum, then plug one ear with a finger. The hum moves to the plugged side.

Patient	Weber	Rinne, right ear	Rinne, left ear
Normal hearing	Middle	Positive (air > bone)	Positive
Conductive loss, right ear	Louder on the right	Negative (bone ≥ air)	Positive
Sensorineural loss, right ear	Louder on the left	Positive, both times shortened	Positive

Can a blocked ear canal change how you hear?

You will run the Rinne test in PLTW's Data Table 1 format, then add one controlled change: a foam earplug that models a conductive hearing loss. Your data should show the air road and the bone road splitting apart.

Question

How does blocking the ear canal change air-conduction time, bone-conduction time, and the Weber result?

Hypothesis frame

If the right ear canal is blocked, then its air-conduction time will _____ and its bone-conduction time will _____, because _____.

Variables

- **Independent:** ear canal condition (open versus blocked with a foam earplug).
- **Dependent:** seconds heard by bone conduction; seconds heard by air conduction; side the Weber is heard on.
- **Controlled:** same 512 Hz fork, same pad, same strike force, same tester, same placement (mastoid; 1 to 2 cm from the opening), same timer, same quiet spot, three trials averaged.
- **Control condition:** the open-ear baseline from Part 1.

Materials

- 512 Hz tuning fork
- Rubber striking pad
- Stopwatch or phone timer
- Single-use foam earplugs
- Alcohol wipes
- Lab notebook and Data Tables 1 to 3

What PLTW asks, what we add

PLTW 1.3.2: run the Rinne test on both ears and record bone and air conduction times in Data Table 1.

We add: a blocked-ear trial and the Weber test, so you can see a conductive pattern appear in your own data and explain it.

Safety and respect

- Strike only on the pad or your knee, away from anyone's head. Only the fork's base touches the head; keep the prongs away from eyes; never put the fork in or against the ear.
- Earplugs are single use and you insert your own. Use clean, dry hands, never push past comfort, and twist gently to remove. Skip the plug if you have ear pain, an ear infection, a hole in your eardrum, ear tubes, or recent ear surgery; be the tester instead.
- This is a classroom model, not a hearing test. If you notice a real difference between your ears, tell Mr. Mendoza or the school nurse privately.
- Each student records their OWN ears in their own packet; the tester calls out the times. Use "Subject A" or "Subject B," never a name.

Run it in this order

1

Set up and practice
Quiet corner, partner seated, eyes closed. Practice striking the pad with the same gentle force three times.

↓

2

Part 1, baseline Rinne, both ears open
Three bone-conduction trials and three air-conduction trials per ear. Subject records in Data Table 1.

↓

3

Part 2, baseline Weber
Fork base on the forehead midline. Record middle, left or right in Data Table 3, row 1.

↓

4

Part 3, model a conductive loss
Subject rolls a foam plug thin, pulls the right ear up and back, inserts it, and holds it 30 seconds while it expands.

↓

5

Part 4, repeat with the plug in
Rinne, right ear, in Data Table 2: during air trials the subject presses the LEFT tragus closed. Weber in Table 3, row 2.

↓

6

Part 5, remove, wipe, switch roles
Partner removes and discards the plug. Wipe the fork base. The tester becomes the subject.

Timing for a 40-minute class
Subject A finishes Parts 1 to 4 by minute 17. Switch roles; Subject B finishes by minute 34. Use the last minutes to average your trials. The speech-in-noise test and the audiogram matching are Day 2.

Data Table 1. Rinne test, both ears open (PLTW format, seconds)

	Left ear: bone conduction	Left ear: air conduction	Right ear: bone conduction	Right ear: air conduction
Trial 1				
Trial 2				
Trial 3				
Average				
Air ÷ bone	Left ear ratio =		Right ear ratio =	

Record it, average it, explain it

Data Table 2. Right ear blocked with a foam earplug (seconds)

Right ear: bone conduction		Right ear: air conduction	
Trial 1			
Trial 2			
Trial 3			
Average			
Air ÷ bone	Right ear ratio, blocked =		

Data Table 3. Weber test

Condition	Heard in the middle, left, or right?
Both ears open	
Right ear blocked	

Analysis

Answer in your lab notebook, numbered 1 to 4, then C, E and R.

1. Calculate air ÷ bone for each condition. Above 1 means air won; 1 or below means bone won.
2. Which condition gave a negative Rinne? Which way did the Weber move?
3. Did bone-conduction time drop, stay about the same, or rise with the plug? Use the two-roads page to explain why.
4. List two sources of error (strike force, reaction time, room noise, guessing) and how you controlled each.

Claim, evidence, reasoning

Claim: Blocking the ear canal produced a (conductive / sensorineural) pattern.

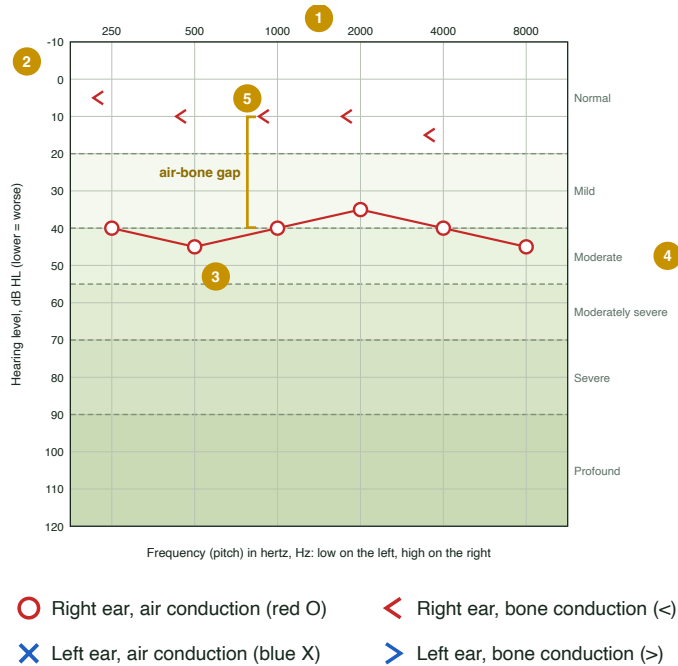
Evidence: Cite your averages from Tables 1 and 2 and your Weber result.

Reasoning: Explain which road the plug blocked, which road it left open, and why that matches a patient with fluid behind the eardrum or otosclerosis.

PLTW also has you run a speech-in-noise test in 1.3.2. That one targets sensorineural loss, which the Rinne test cannot separate from normal hearing on its own.

A map of the softest sounds you can hear

An audiologist plays pure tones through headphones (air conduction) and through a small vibrator on the mastoid bone (bone conduction), and lowers each tone until it can barely be heard. That softest level is the **threshold**, plotted at each pitch.



Degree of loss (dB HL)

Degree	PLTW 1.3.2 resource sheet	ASHA (Clark 1981)
Normal	0 to 20	-10 to 15
Slight	no separate band	16 to 25
Mild	21 to 40	26 to 40
Moderate	41 to 55	41 to 55
Moderately severe	56 to 70	56 to 70
Severe	71 to 90	71 to 90
Profound	more than 90	91 and up

Your Activity 1.3.2 work is graded on the PLTW scale. Clinics differ on where "normal" ends (15, 20 or 25 dB HL), so always say which scale you used.

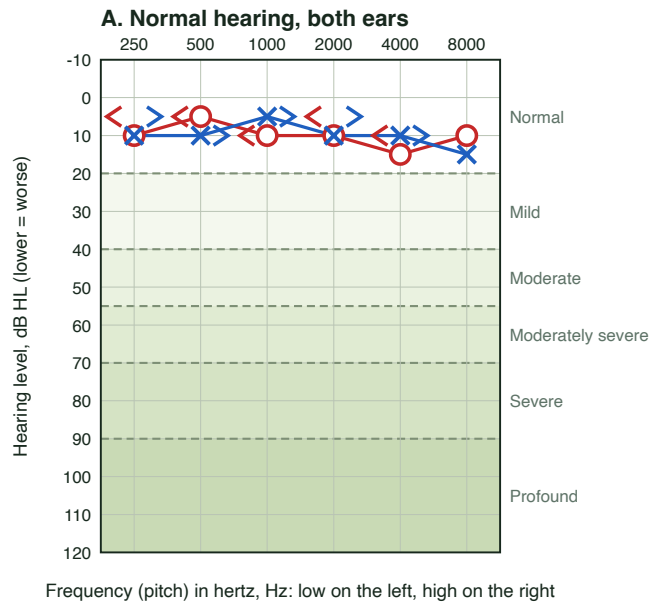
The five parts

- Frequency (x-axis):** pitch in hertz, low on the left, high on the right. Speech lives mostly between 500 and 4,000 Hz.
- Hearing level (y-axis):** decibels hearing level (dB HL). 0 dB HL is the average softest sound young healthy ears hear. Numbers grow *downward*: lower on the chart means a louder sound was needed, so worse hearing.
- Symbols:** O for right ear by air, X for left by air, < and > for bone. Right is usually red and left blue.
- Degree bands:** the shaded zones name how much hearing is lost.
- Air-bone gap:** the distance between a bone symbol and the air symbol at the same pitch. A gap bigger than about 10 dB, with bone in the normal range, means conductive loss.

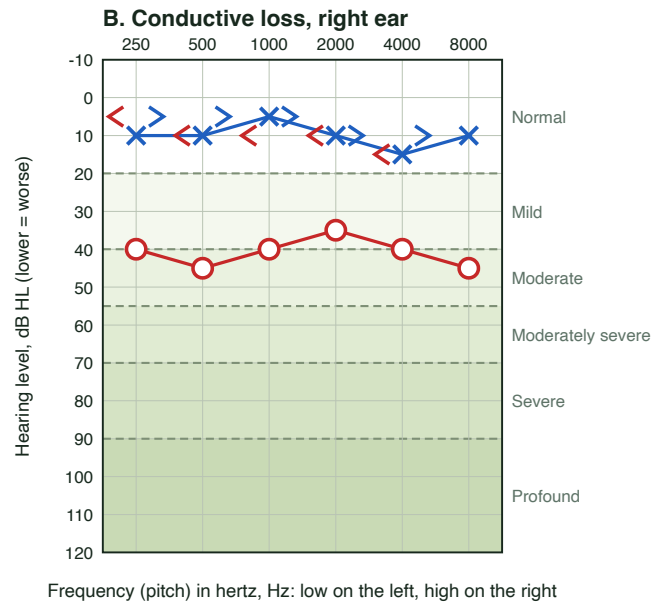
Read any audiogram in five moves

- Find each ear's air line (O and X).
- Name the degree from where most speech-range points sit.
- Compare bone to air at each pitch: gap or no gap?
- Name the shape: flat, sloping down in the highs, a notch near 4,000 Hz (noise), or rising (low pitches worse).
- Say it in one sentence: type, degree, shape, ear.
 Example (the chart at left): "Mild to moderate conductive hearing loss, flat, right ear."

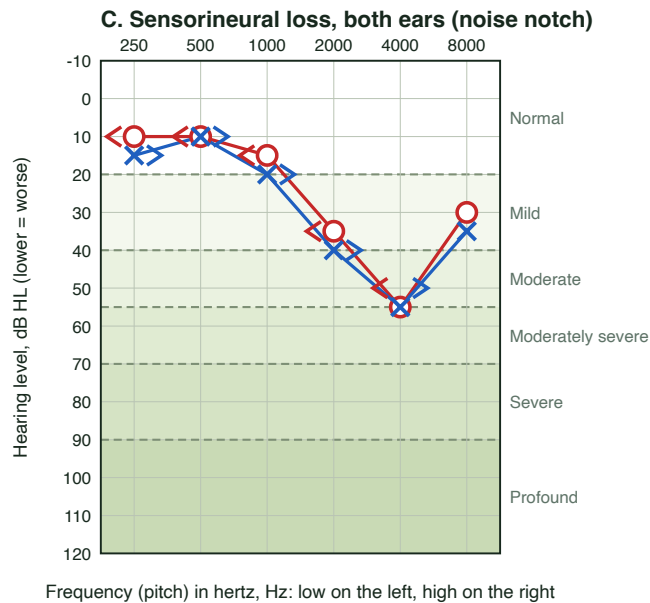
Same chart, four diagnoses



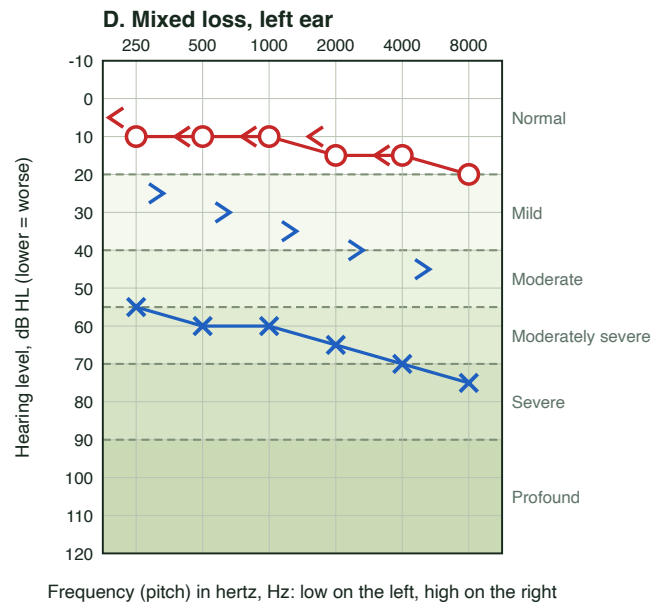
A. Normal. All air and bone points sit at 20 dB HL or better in both ears. No gap.



B. Conductive, right ear (mild to moderate). Right air (O) is down near 40 dB HL, but right bone (<) is normal: a gap of about 25 to 35 dB. The cochlea works; vibration is blocked on the way in, as with fluid behind the eardrum. Weber would go right; right Rinne negative.



C. Sensorineural, both ears. Air and bone drop together (no gap) with a notch at 4,000 Hz that recovers at 8,000 Hz: the classic noise-induced pattern.



D. Mixed, left ear. Left bone (<) is itself below normal (sensorineural part), and left air (X) is about 25 to 30 dB worse still (conductive part). Right ear normal.

These four charts are teaching examples built for this guide, not real patients. Bone conduction is usually tested only from 250 to 4,000 Hz. **Masking:** bone vibration crosses the skull to the other ear almost undiminished, so when the two ears differ (charts B and D), a real audiologist plays noise into the better ear and draws the masked bone results as [(right) and] (left). These charts use < and > to keep it simple.

How conductive loss differs from the others

	Conductive	Sensorineural	Mixed	Neural (retrocochlear)
Where	Outer or middle ear, from the canal to the stapes footplate	Cochlea (hair cells) or the nerve	Both at once	The nerve or brainstem pathway; a subset of sensorineural
What goes wrong	Vibration is blocked or weakened before it reaches the fluid	The fluid moves, but hair cells cannot make the signal, or it is not sent	Both	The cochlea works, but the signal is not carried well
Common causes	Earwax, fluid or infection (otitis media), eardrum hole, otosclerosis, cholesteatoma, a closed canal at birth	Aging (presbycusis), loud noise, genes (such as GJB2), certain drugs, meningitis, Meniere's disease	Chronic ear disease plus aging or noise	Vestibular schwannoma (acoustic neuroma)
Audiogram	Air down, bone normal: gap	Air and bone down together: no gap	Bone down, air further down: gap	Like sensorineural, often one-sided; speech understanding worse than the tones suggest
Rinne (affected ear)	Negative (bone $\geq$ air)	Positive, both shortened	Often negative	Positive
Weber	Toward the affected ear	Toward the better ear	Varies	Toward the better ear
Sounds like	Turning the volume down: sounds are soft but clear once loud enough	Volume down <i>and</i> blurred: hard to separate speech from noise, especially high consonants like s and f	Both	Often ringing on one side and trouble understanding speech
Can it be fixed?	Often: remove wax, treat infection, ear tubes, repair the eardrum, replace the stapes, bone-conduction hearing aid	Usually permanent: hearing aids, cochlear implant for severe to profound loss, protection from further noise	Treat the conductive part; aid the rest	Medical evaluation; treat the cause

The one-sentence difference

Conductive loss is a delivery problem, so bone stays normal and the fork favors bone. Sensorineural and neural loss are receiver or wiring problems, so air and bone fall together and air still beats bone. Mixed loss is both: bone is down, and air is down even more.

Matching your 1.3.1 patients: use the five moves on the audiogram page to decide the type, degree, shape and ear for each case, then check your choice against the case description.

From a diagnosis to a decision

The speech-in-noise test (PLTW 1.3.2)

Follow the PLTW 1.3.2 directions and audio. You repeat words or sentences while a steady whooshing noise plays, and count how many you get right.

Condition	Number correct	Out of
Quiet		
With noise		

What it targets. Vowels are low pitched; consonants like s, f and th are high pitched and soft. Sensorineural loss usually hits high pitches first, so the consonants that tell words apart disappear, and background noise covers what is left. A person can "hear" you but not understand you. The Rinne test cannot catch this; a speech-in-noise test and an audiogram can.

Matching the fix to the problem

Intervention	What it does	Fits best when
Medical or surgical care	Removes wax, treats infection, places ear tubes, repairs the eardrum (tympanoplasty) or replaces the stapes	Conductive loss with a fixable cause
Hearing aid	Makes sound louder in the ear canal; still uses the eardrum, ossicles and hair cells	Mild to severe loss when enough hair cells still work
Bone-conduction (bone-anchored) device	Vibrates the skull, skipping the outer and middle ear	Conductive or mixed loss that cannot be fixed, or deafness in one ear
Cochlear implant	Electrodes in the cochlea stimulate the nerve directly, skipping lost hair cells	Severe to profound sensorineural loss when a hearing aid no longer helps and the nerve works
Prevention	Hearing protection above 85 dBA; limits on loud listening	Everyone, and anyone with noise damage, to stop it getting worse

Decide for your patient

- Where is the problem: outer or middle ear, cochlea, or nerve? (Use the tuning fork logic and the audiogram.)
- How much hearing is lost, and in which ear or ears?
- Can the cause be treated? If yes, start there. If no, which device skips the broken part?
- Write your choice and two pieces of evidence from the case and the audiogram.

Six questions before the checkpoint

1. Subject A hears the fork for 14 seconds on the mastoid and 30 seconds beside the ear. Positive or negative Rinne? Which hearing patterns fit?
2. With the right ear plugged, the Weber is louder on the right. Explain why in two sentences.
3. An audiogram shows right air conduction at 45 dB HL and right bone conduction at 10 dB HL at every pitch. Name the type and the degree (PLTW scale).
4. Which cells turn fluid motion into an electrical signal, and what opens their ion channels?
5. Why does the middle ear need to boost pressure at all?
6. You spin in a chair, stop, and the room keeps spinning. Which structure is responsible, and why?

Your answers

Write your answers in your notebook before you turn the page.

Check your work

Answers

1. Positive (air beat bone, about twice as long). It fits normal hearing or a sensorineural loss; the Rinne alone cannot tell those apart.
2. The plug blocks room noise from masking the right ear, and it traps bone-conducted sound in the canal (the occlusion effect). So the right ear, the one with the conductive problem, hears the fork louder.
3. Conductive (a 35 dB air-bone gap with normal bone). Moderate on the PLTW scale (41 to 55 dB HL).
4. Hair cells in the organ of Corti. Bending their stereocilia stretches tip links, which pull ion channels open so potassium flows in.
5. Sound in air hitting fluid head-on loses more than 99.9 percent of its energy to reflection. The eardrum-to-stapes area difference and the ossicle lever raise the pressure about 20 times.
6. The semicircular canals. The endolymph keeps moving after your head stops, so it keeps pushing the cupula, and the brain reads that as spinning, often in the opposite direction.

Sources (vetted October 16, 2026)

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How this guide was checked: every factual claim was matched to the sources above, and six were reworded to match them exactly (for example, "about 20 times," not a single exact figure). The plates were drawn with an AI image model from anatomical specifications, inspected structure by structure, and redrawn when wrong (two tuning-fork scenes were redrawn four times to get the fork placement right). Three independent reviewers (science, student walkthrough, label placement) red-teamed the guide; every blocking finding was fixed and re-checked before posting.