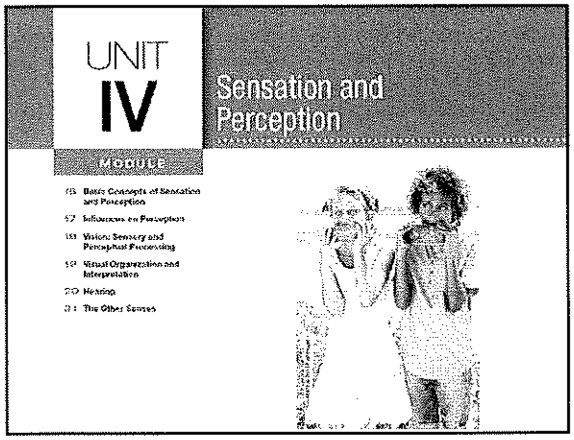
Module 20 HEARING EAR

2/19/2019



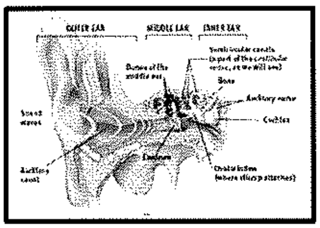
Learning Targets

Module 20

Hearing

- **20-1** Describe the characteristics of air pressure waves that we hear as sound.
- **20-2** Explain how the ear transforms sound energy into neural messages.
- **20-3** Discuss how we detect loudness, discriminate pitch, and locate sounds.

What is *audition*?



the sense or act of hearing

How do air pressure waves become sound?

Draw a bow across a violin, and you will unleash the energy of sound waves.

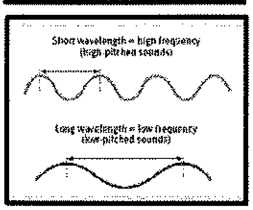
Air molecules, each bumping into the next, create waves of compressed and expanded air, like the ripples on a pond circling out from a tossed stone.

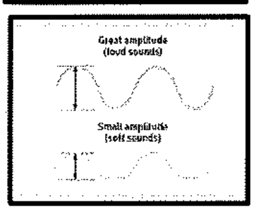
As we swim in our ocean of moving air molecules, our ears detect these brief air pressure changes.

What are characteristics of sound waves?

frequency (wavelength)

amplitude (height)

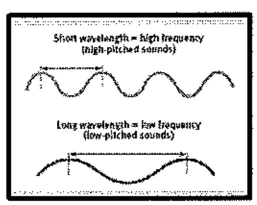


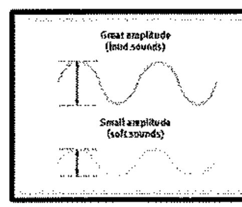


What information do sound waves give us?

What pitch am I hearing?

How loud is the sound I am hearing?





TRY IT

Would you expect long or short wavelengths…

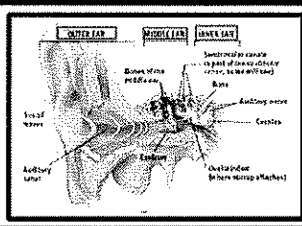
1	…when a soprano sings an aria?
2	…when a baritone sings along?

AP® Exam Tip 1

Note that both light and sound travel in waves.

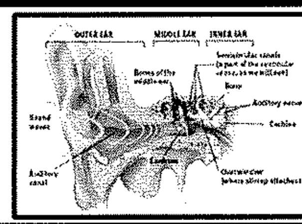
In each case, the amplitude and length of the waves are important to learn for the AP® exam.

What are the three divisions of the ear?



The ear is divided into outer, middle and inner sections.

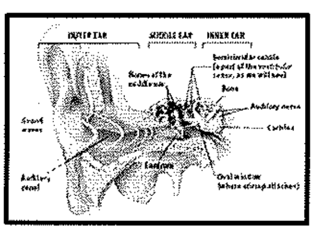
How does the ear transform sound into neural messages?



Passing through accessory structures to sense receptors, vibrating air triggers nerve impulses that the brain decodes as sounds.

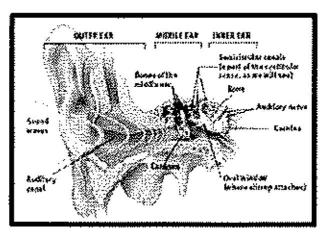
What is the auditory canal?

the channel located in the outer ear that funnels sound waves from the pinna to the tympanic membrane (ear drum)



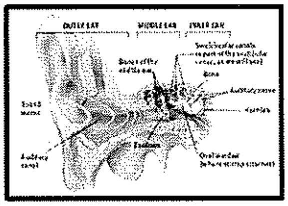
What is the ear drum (tympanic membrane)?

The ear drum, or the tympanic membrane, is a thin layer of tissue that vibrates in response to sound waves.



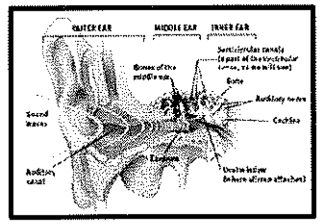
What are the ossicles?

The ossicles, made up of the three smallest bones in the human body, the incus, the malleus and the stapes, transfer the sound wave vibrations from the tympanic membrane to the oval window of the cochlea.



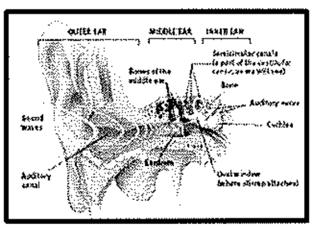
What is the oval window?

The oval window is the membrane-covered opening of the cochlea. It vibrates when it receives the sound waves and causes the fluid inside the cochlea to move.



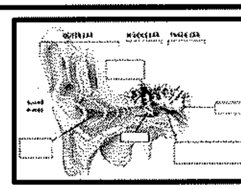
What is the cochlea?

The cochlea is a coiled, bony, fluid-filled tube in the inner ear. Sound waves traveling through the cochlear fluid trigger nerve impulses.



TRY IT

Can you trace the path of sound through the ear so far?



Use the terms you just learned to label each structure.

1. What Would You Answer?

When you listen to music, the sound waves cause your ____ to vibrate first.

A. cochlea
B. hammer, anvil, and stirrup (malleus, incus and stapes)
C. eardrum (tympanic membrane)
D. oval window
E. auditory nerve

AP® Exam Tip 2

You may notice that some sensory structures are referred to in more than one way. The Latin designation is important to know:

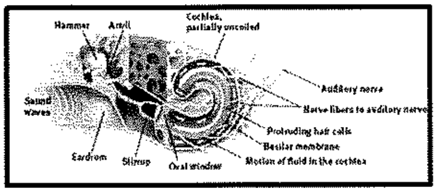
tympanic membrane

Your textbook author has simplified the terms and uses the popular name for the structure:

eardrum

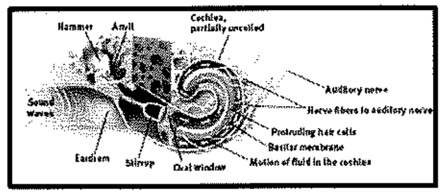
Learn both names and understand they refer to the same structure(s) so you won't be confused on the AP® exam.

How does the sound wave move through the inner ear?



Accessory structures move the sound wave to the sense receptors(stereocilia) in the inner ear where the wave energy undergoes transduction to neural energy that the brain can interpret.

How does transduction occur in the inner ear?



The motion of the sound vibration against the oval window of the cochlea causes ripples in the *basilar membrane,* bending the *hair cells* lining its surface.

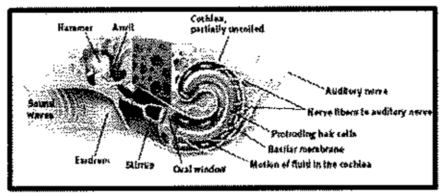
AP® Exam Tip 3

Although the basilar membrane is not considered a key term in your text, it is considered a key term on the AP® exam.

Free-Response Questions (FRQs) and multiple choice questions frequently ask about the basilar membrane.

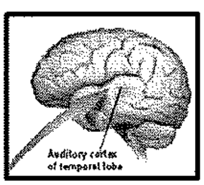
Make sure to learn about the way sound waves are transduced into neural impulses via the cilia on the basilar membrane.

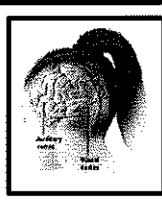
How does the nerve impulse move out of the ear?



The hair cell (cilia) movements in turn trigger impulses in adjacent nerve cells, whose axons converge to form the *auditory nerve.*

How does the message carry to the brain?

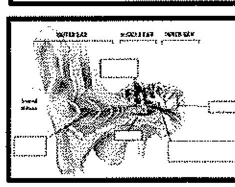


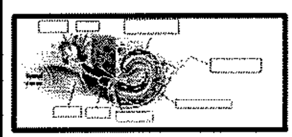


The auditory nerve carries the neural messages to your thalamus and then on to the *auditory cortex* in your brain's temporal lobes.

TRY IT

Trace the path of sound through the ear.





Put it all together and label the process.

AP® Exam Tip 4

Pay attention to how many pages are devoted to each of the senses.

Not only does this represent the complexity of the sensory system, it also represents how likely you are to find questions about that system on the AP® exam.

Given that more pages are devoted to vision than hearing, there are likely to be more exam questions on vision.

What are two types of hearing loss?

sensorineural

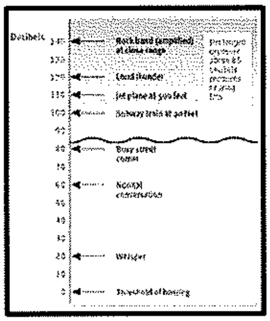
Damage to the cochlea's hair cell receptors or the auditory nerve can cause ***sensorineural hearing loss.*** With auditory nerve damage, people may hear sound but have trouble discerning what someone is saying.

conduction

Damage to the mechanical system—the eardrum and middle ear bones—that conducts sound waves to the cochlea can cause ***conduction hearing loss.*** It is less common than sensorineural hearing loss.

How much sound is too much sound?

As a general rule, any noise we cannot talk over (loud machinery, fans screaming at a sports event, music blasting at maximum volume) may be harmful, especially if prolonged and repeated.
(Roesser, 1998)



What is the problem with headphones?

Headphones direct all of the sound waves into the auditory canal and bombard the basilar membrane. In the open air, sound waves disperse and are not all directed to one location.

How can headphones help?

When Super Bowl-winning quarterback Drew Brees celebrated New Orleans' 2010 victory amid pandemonium, he used ear muffs to protect the vulnerable hair cells of his son, Baylen.

What is the research on hearing loss?

Since the early 1990s, teen hearing loss has risen by a third and now affects 1 in 5 teens.
(Shargorodsky et al., 2010)

After three hours of a rock concert averaging 99 decibels, 54 percent of teens reported not hearing as well, and 1 in 4 had ringing in their ears.

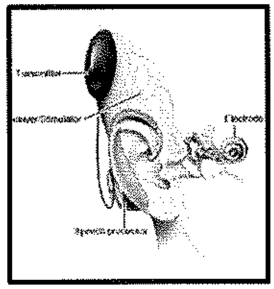
Teen boys more than teen girls or adults blast themselves with loud volumes for long periods.
(Zogby, 2006)

What is a cochlear implant?

a device for converting sounds into electrical signals and stimulating the auditory nerve through electrodes threaded into the cochlea

How does a cochlear implant work?

Cochlear implants work by translating sounds into electrical signals that are transmitted to the cochlea and, via the auditory nerve, relayed to the brain.



2. What Would You Answer?

Because of the repeated exposure to loud noise they experience during their daily jobs, airport ground workers are most susceptible to damage which of the following?

A. olfactory nerve
B. cochlea
C. ganglion cells
D. bipolar cells
E. incus, malleus and stapes

How does the brain detect loudness?

A soft, tone activates only the few hair cells attuned to its frequency.

Given louder sounds, neighboring hair cells also respond.

Thus, the brain interprets loudness from the *number* of activated hair cells.

What is one theory of how the brain detects pitch?

Place theory presumes that we hear different pitches because different sound waves trigger activity at different spots along the cochlea's basilar membrane.

Thus, the brain determines a sound's pitch by recognizing the specific area (on the membrane) that is generating the neural signal.

What is the frequency theory?

Frequency theory (also called *temporal theory*) suggests an alternative: the brain reads pitch by monitoring the frequency of neural impulses traveling up the auditory nerve. The whole basilar membrane vibrates with the incoming sound wave, triggering neural impulses to the brain at the same rate as the sound wave. If the sound wave has a frequency of 100 waves per second, then 100 pulses per second travel up the auditory nerve.

How does the volley principle explain hearing higher frequency sounds?

By firing in rapid succession, neurons can achieve a *combined frequency* above 1000 waves per second

Like soldiers who alternate firing so that some can shoot while others reload, achieving greater combined fire power, neural cells can alternate firing.

How do the two theories work together to explain how we hear pitch?

Place theory best explains how we sense *high pitches.*

Frequency theory, extended by the volley principle, also explains how we sense *low pitches.*

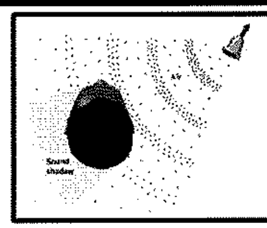
Finally, some combination of place and frequency theories likely explains how we sense *pitches in the intermediate range.*

3. What Would You Answer?

Which of the following reflects the notion that pitch is related to the stimulation of different areas of the cochlea's basilar membrane?

A. place theory
B. frequency theory
C. volley principle
D. sound localization
E. Stereophonic hearing

How do we locate sounds?



Sound waves strike one ear sooner and more intensely than the other. From this information, our nimble brain can compute the sound's location.

Learning Target 20-1 Review

Describe the characteristics of air pressure waves that we hear as sound.

- Sound waves are bands of compressed and expanded air.
- Our ears detect these changes in air pressure and transform them into neural impulses, which the brain decodes as sound. This is ***audition***… or hearing.
- Sound waves vary in amplitude, which we perceive as differing loudness (measured in decibels), and in ***frequency***, which we experience as differing ***pitch***.

Learning Target 20-2 Review

Explain how the ear transforms sound energy into neural messages.

- The outer ear funnels sound to the ***middle ear***
- The ***inner ear*** consists of the ***cochlea***, semicircular canals, and vestibular sacs.
- Sound waves traveling through the auditory canal cause tiny vibrations in the eardrum. The ossicles amplify the vibrations and relay them to the fluid-filled cochlea. Rippling of the basilar membrane, causes movement of the tiny hair cells, triggering neural messages to be sent to the auditory cortex in the brain.

Learning Target 20-2 Review cont.

Explain how the ear transforms sound energy into neural messages.

- ***Sensorineural hearing loss*** (or nerve deafness) results from damage to the cochlea's hair cells or their associated nerves.
- ***Conduction hearing loss*** results from damage to the mechanical system that transmits sound waves to the cochlea.
- ***Cochlear implants*** can restore hearing for some people.

Learning Target 20-3 Review

Discuss how we detect loudness, discriminate pitch, and locate sounds.

- Our brain interprets loudness from the number of activated hair cells.
- ***Place theory*** explains how we hear high-pitched sounds, and ***frequency theory*** explains how we hear low-pitched sounds. A combination of the two theories explains how we hear pitches in the middle range.
- ***Place theory*** proposes that our brain interprets a particular pitch by decoding the place where a sound wave stimulates the cochlea's basilar membrane.

Learning Target 20-3 Review cont.

Discuss how we detect loudness, discriminate pitch, and locate sounds.

- ***Frequency theory*** proposes that the brain deciphers the frequency of the neural impulses traveling up the auditory nerve to the brain.
- By alternating their firing (the volley principle), neural cells enable us to sense sounds with high frequencies.
- Sound waves strike one ear sooner and more intensely than the other. The brain analyzes the minute differences in the sounds received by the two ears and computes the sound's source.