Vibration and Hearing

Activity Description & Estimated Class Time

In this 50-minute activity, students begin by discussing sound and problems with hearing. Pairs of students then assemble a model of the ear from components, using only prior knowledge. Afterward, the teacher leads the class through the functions of each component of the ear, and students reassemble their model of the ear. The teacher then introduces a diagram of the ear and series of hearing maladies. The class uses these to discuss the path of sound from the ear to the brain.

Correlations to NC Science Standards

PS.6.3.1 Use models of a simple wave to explain wave properties in seismic, light, and sound waves that include: waves having a repeating pattern with a specific amplitude, frequency, and wavelength, and the amplitude of a wave is related to the energy of the wave.

PS.6.3.3 Carry out investigations to conclude the relationship between sound waves (including rate of vibration, the medium through which vibrations travel) and hearing.

Learning Target

Students will develop an understanding of:

- the relationship between the rate of vibration and hearing.
- the relationship between the variations in medium and hearing.
- the correlation between longitudinal waves and hearing.

Brief Science Background

Physical vibrations in materials can produce sounds, and sounds can produce physical vibrations in materials. Plucking a guitar causes the string to vibrate, producing sound. Likewise, sound striking a guitar can cause its strings to vibrate. Vibrations travel from place to place through solids, liquids, and gases. A person with an ear pressed to a solid door can hear sounds on the other side. Whales hear each other under water. Vibrations from a thunder-clap move through miles of air to rattle windows. No matter what material sound moves through, it causes tiny movements (vibration) all along its path. The ear uses these vibrating movements that sound produces. The ear funnels the vibrations to a small drum attached to tiny bones. The drum moves in response, and moves the bones. The bones transmit the movement to a tube filled with liquid, causing the liquid to move. Sensitive hairs in the liquid respond to movement by sending a signal to the brain. To become the nerve impulses that we hear as sound, vibrations travel through air, solid bone, and a liquid.

Vibration and Hearing

Materials

Materials for the Whole Class

- Ear Component Puzzles
- Ear Component Functions (SD 1)
- Ear Puzzle Base (SD 2)
- Ear Diagram (SD 3)
- Ear Problems (SD 4)
- Vibration and Hearing Student Activity Sheet (SD 5), 1 per student

Materials for Pairs of Students

- one set of ear component cards
- one ear puzzle base

Preparation

Punch out the ear component puzzle piece sheets and place one complete set of randomly-numbered (unlabeled) ear component puzzle pieces in an envelope. Be ready to give these out, one per pair of students, but withhold them until step 4 of the procedure.

Procedure

1. Ask for a show of hands responding to the following questions:
   - Who had or knows someone who has had “tubes” in their ears when they were younger?
   - Who had or knows someone who has had “swimmer’s ear?”
   - Who has had people tell them not to turn up their earbuds too loud?
2. Explain that we will explore the ear to make sense of some of the things that happen to the ear. Point out that sound comes in the ear and then somehow gets to the brain. If that pathway is clear, there is no problem. However, lots of things can go wrong with that pathway.
3. Have students reflect back on their knowledge of longitudinal waves and say "Think back to the station with the balloons on the cups. How did you make the sand move? What medium did the waves travel through?"
4. Give each pair of students the puzzle pieces, an Ear Puzzle Base (SD 2) and two Vibration and Hearing Student Activity Sheets (SD 5). Ask each team to spread out the puzzle pieces so that they can see them all and say that these are components of the ear. Say that all of these are necessary for people to hear sounds. Ask teams to place the pieces on SD 2 the way they think they are arranged inside the ear. They will have to explain how they think sound gets into the ear, through each component, and to the brain. Allow 5 minutes.
5. As teams finish, ask them to meet with another team and compare models. Ask them to justify to each other why they have put the pieces where they have them. Make sure they include what they know about how sound travels. If class discussion seems reasonable at this time, it could be useful to get a lot of ideas out.
6. After teams finish comparing models, say that you have information that explains what each part of the ear does, and names of each part. Tell the class that they have exactly 10 minutes to get as much of this information from you as they can. Tell them that when you finish giving this information, each team will use what they learned in this 10 minutes to reassemble the ear model.
7. Ask: “Which number part do you want to know about?” When someone gives you a part number, read the description of the function and the name of the part. Repeat this until you have gone through all of the parts of the ear.
8. Give students another 5 minutes to reassemble their ear models based on what they have learned. As teams finish, again ask them to meet with another team to compare models.

   The path of sound from the air to the brain is k, t, x, d, r, b, m, i.

Procedure cont.

9. Project SD 3, Ear Diagram. Give the class a minute or so to reassemble their models according to the diagram. Together with the class, trace the path of sound through the ear. Try to get students to do as much explaining as possible. Point out where **sound travels as a vibration in air, in a solid bone and in a liquid fluid in the cochlea**. Point out the outer, middle, and inner ear.

Content Connection

Project SD 4, Ear Problems. Discuss with the class how each problem interferes with the path of sound from the ear to the brain. As you go through ear problems, give the following symptoms and ask students to "diagnose" the problems and relate them to the models of the ear.

- Ringing in the ear
- Muffled hearing

Guided Practice/ Formative Assessment

Guided Practices are similar to typical tests, but require students to reveal their thinking about content. They serve as a practice before a test and should not be graded. They are intended to expose misconceptions before an assessment and to provide opportunities for discussion, re-teaching, and for students to justify answers. They are best given as individual assignments without the manipulatives used in the activity. In that context, pose the following "test items" to the class. Ask them to write responses in notebooks.

1. Complete the following sentence with the correct response: To be heard, sound travels…
    a. …as a ray that passes through the eardrum and excites nerves in bones of the skull.
    b. ...as movements in air that vibrate the outer ear, which is connected to the eardrum, causing it to emit nerve impulses.
    c. ...as vibrations in air that are channeled down the ear canal and strike the eardrum, which transfers vibration to a set of tiny bones that move fluid in a canal that triggers nerve impulses to the brain.
    d. …as a ray that travels into the ear canal through the cochlea, then through bones connected to nerves that send impulses to the brain.

2. Complete the following sentence with the correct response: Sound travels…
    a. …as a vibration through many different kinds of materials, including solids, liquids, gases.
    b. …through a vacuum or through air, but it cannot travel through solids or liquids.
    c. …as very fast vibrations through solids, slower vibrations through liquids, and the slowest vibrations through gases such as air.
    d. …through air, and because of this, the ear must transmit the signal to the brain through air.

    Ask students to explain why the wrong answers are wrong.

Answer Key

#1 b. is correct. Sound travels as a vibration in air that is channeled down the ear canal and strikes the eardrum, which transfers the vibration to tiny bones that move fluid in a canal, triggering nerve impulses to the brain.

#2 a. is correct. Sound travels as a vibration through many different kinds of materials, including, solids, liquids, gases. Sound cannot travel in a vacuum, but it can travel through solids, liquids, and gases. The ear transmits the signal to the brain through solids and liquids. Explanations of wrong answers should touch upon the chain of events as sound travels through the ear.

SD 1

Ear Component Functions

b. This fluid-filled snail-shaped sack in the inner ear contains hair cells attached to nerves, which transmit sound information to the brain. Attached to it are three fluid-filled tubes containing hairs that sense movement to provide the sense of balance: **Cochlea**

d. One of three tiny bones in the middle part of the ear between two other tiny bones, receiving vibration from one and transmitting it to the other: **Anvil Bone**

i. This part receives nerve signals and makes sense of them as sound: **The Brain**

k. This part gathers sound from the air and channels vibrations through a canal to the eardrum: **Outer Ear and Ear Canal**

l. This tube connects the middle ear and the back of the nose. It allows fluids to drain from the middle ear and lets air pass to equalize pressure between the middle ear and the atmosphere: **Eustachian Tube**

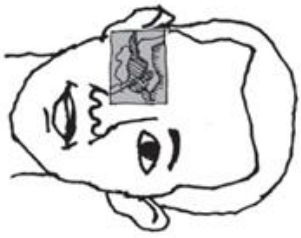
m. This nerve sends all of the information from the nerves in the cochlea to the brain: **Auditory Nerve**

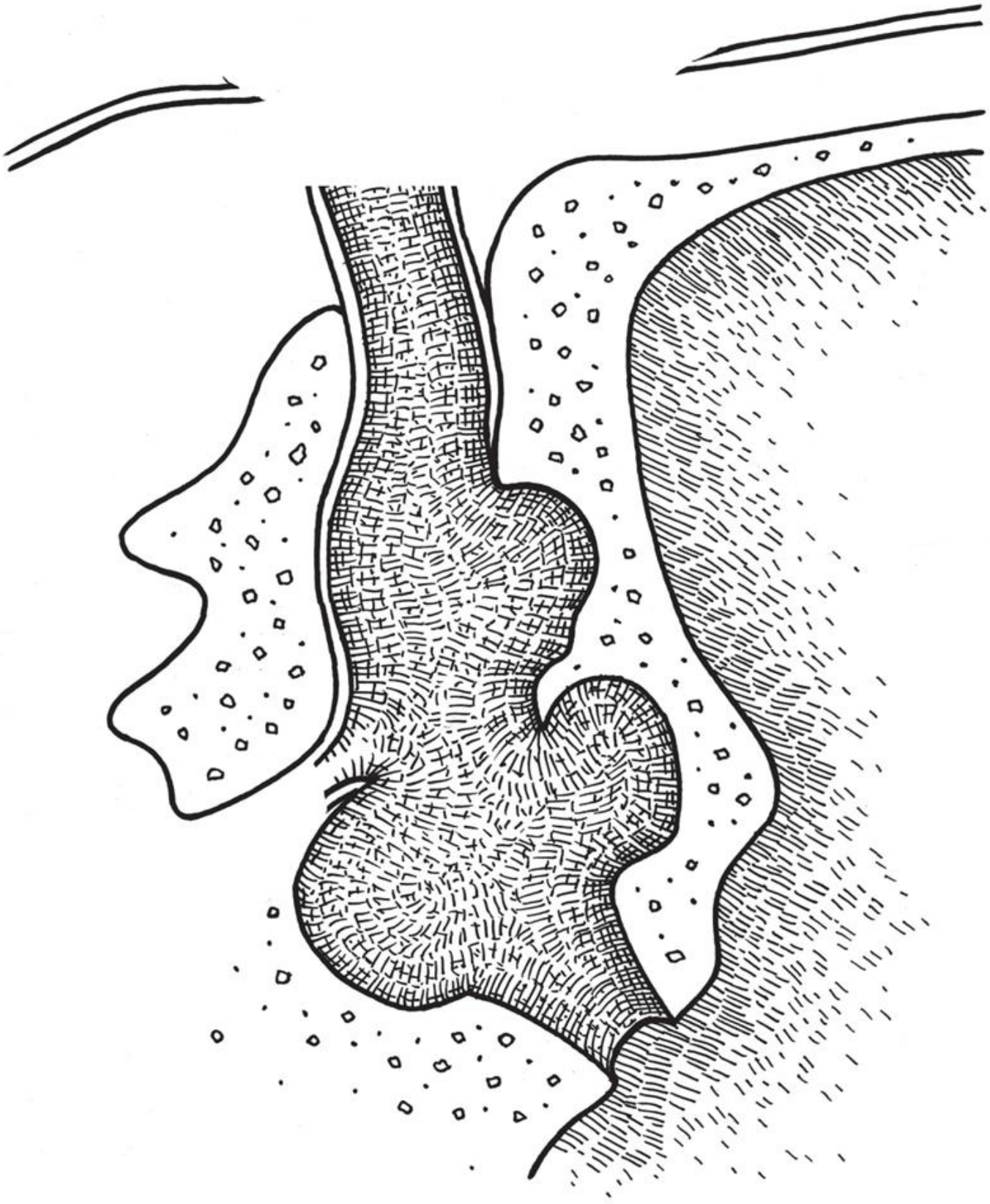
r. One of three tiny bones in the middle ear, the smallest bone in the body, this bone receives vibrations from the other small bones and transmits them to the inner ear: **Stirrup Bone**

t. This thin, sensitive membrane stretched over the entrance to the middle ear vibrates when sound strikes it. It passes vibrations on to the tiny bones in the middle ear : **Ear Drum**

x. One of three tiny bones in the middle ear, attached to the eardrum and to another bone. When the eardrum vibrates, it passes vibration to the other bone, which passes it to another bone attached to the inner ear: **Hammer Bone**

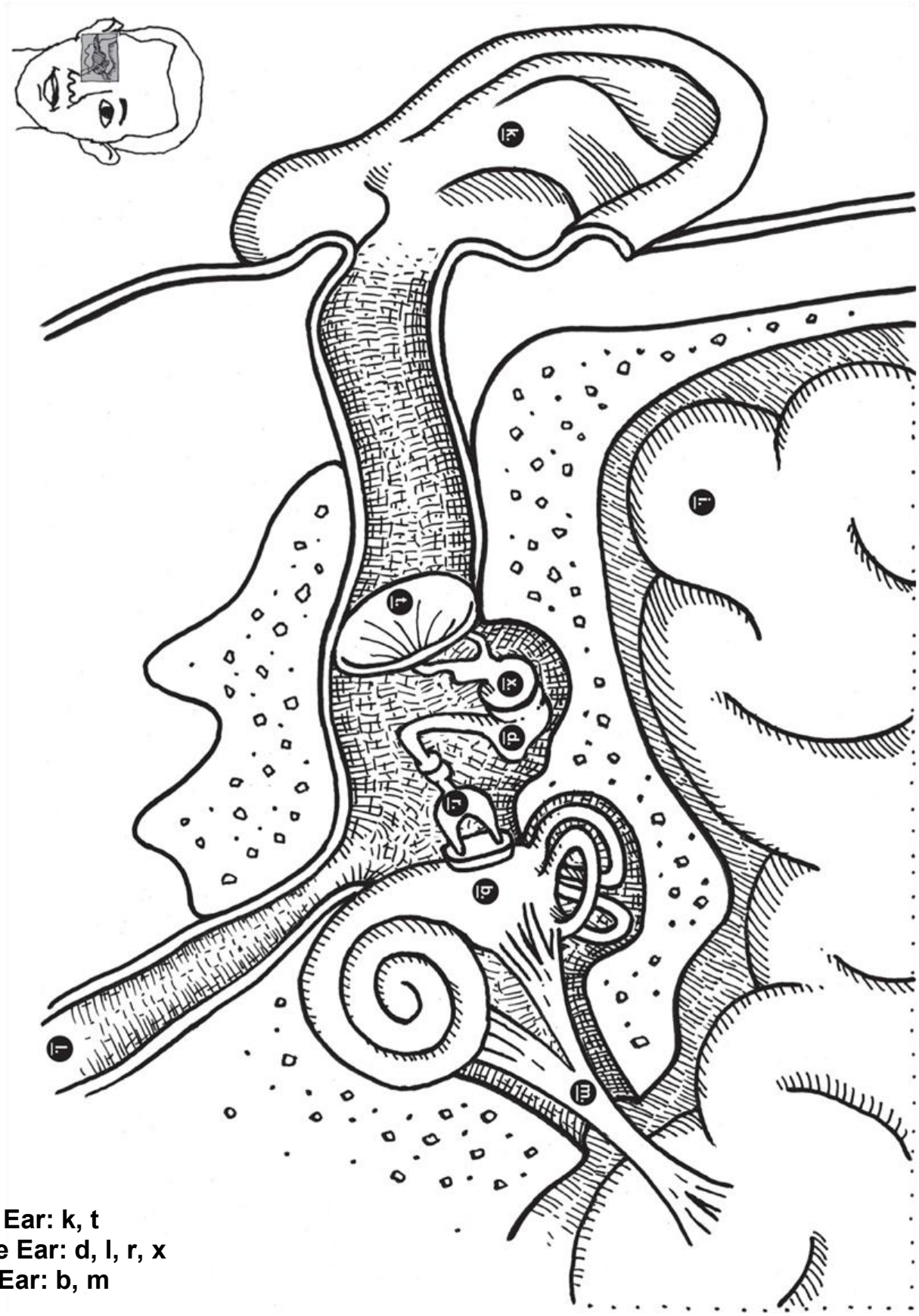
SD 2 Ear Puzzle Base





SD 3

Ear Diagram



Outer Ear: k, t
Middle Ear: d, l, r, x
Inner Ear: b, m

SD 4

Ear Problems

Tubes in Ears

Young children who have colds, allergies, or small ear canals can have a middle ear blocked with mucus, leading to infections and muffled hearing. Normally, a passage between the middle ear and back of the nose, called the eustachian tube, equalizes air pressure with the outside world, but the tube can be closed for many reasons, and pressure builds up. To relieve all of these problems, doctors can insert spool-shaped plastic tubes through the ear drum to equalize air pressure in the middle ear, reduce pressure, and allow fluid to flow out. The tubes generally reduce pain in the ear.

Swimmer's Ear

Sometimes, the outer part of the ear and ear canal can become infected because the ear canal has been compromised. Normally, the ear canal is lined with antibacterial ear wax and fine hairs to trap debris, but extra moisture from showering or swimming can alter the antibacterial qualities of ear wax, allowing bacteria and fungi to invade. Ear plugs, ear buds, hair dyes, bleaches, and shampoos in the ear canal can also disrupt the protective lining. The result is a red ear (usually just one), painful when touched. In severe cases, the ear canal may swell shut and drain clear, white, or yellow fluid that can crust over the ear. Severe cases can result in some temporary hearing loss, ringing in the ear, and dizziness.

The Problem With Ear Buds

Damage to the cochlea can reduce hearing impulses to the brain. When tiny hair cells in the cochlea are damaged or degenerate as we grow older, people notice a loss of high-pitched sounds, then difficulty understanding speech in noisy surroundings. About half of people over 70 have impaired hearing for this reason. Young people get it when loud noises damage hair cells in the cochlea. Playing music through ear buds at high volume can damage these cells. As of now, damaged hair cells cannot be replaced. Sometimes, hearing loss is accompanied by a ringing sound with no external cause, called tinnitus. About 1 in 5 people between 55 and 65 report tinnitus.

Conductive Hearing Impairments

Sometimes malformation or malfunction of bones in the middle ear can reduce the vibrations that are conducted to the cochlea. Injuries such as a severe blow or infection to the ear can damage the hammer, anvil, and stirrup bones so that they transmit less vibration. Sometimes, the hammer and anvil are separated, or the anvil bone is broken or eroded from recurrent ear infections. Some injuries or infections can also separate the anvil from the stirrup or erode the stirrup so that it no longer connects with the inner ear. Any of these conditions greatly reduce hearing.

Ruptured Eardrum

The eardrum is a thin membrane separating the outer and middle ear. A blow to the ear, foreign objects in the ear (often a cotton swab used to clean the ear), or pressure from infection inside the ear can break the eardrum or put a hole in it. When the eardrum is damaged, hearing decreases because the middle and inner ears receive less vibration coming from the outer ear.

SD 5 Vibration and Hearing Student Activity Sheet

Follow your teacher's directions for assembling the puzzle pieces. Once you have your answer, write down how the sound gets in the ear, through each component, and to the brain.

Are there any components that you are unsure of? If so, which ones? Why?

After looking at other models, are there any pieces you would move? Why or why not?

If you could know more about any part of the ear, which one(s) would you ask about?

How did your final model change from your original?

In your own words, explain how sound moves as a wave through the parts of the ear. Remember to include the terms vibration and medium in your explanation.