In this activity, students will construct a model ear to learn how different materials transmit sound.

**Overview**

**Topic:** Modeling Sound Transfer

**Real World Science Topics**
- An exploration of the anatomy of the human ear
- An exploration of how sound is transferred through different materials

**Objective**

Students will explore the various parts of the human ear and how those parts allow for the transfer of sound.

**Materials Needed for Each Team of 2-3 Students**
- Cardboard paper towel tube
- Plastic sandwich bag
- Index card (3 in. x 5 in.)
- Rubber band
- Double-sided tape
- Aluminum foil
- Poster board
- Scissors

**Materials Needed for Demonstration Per Student**
- Rubber band

**Standards Met**

**National Science Standards Addressed**

Content Standard A: Science as Inquiry Students:
- Develop descriptions, explanations, predictions, and models using evidence
- Think critically and logically to make the relationships between evidence and explanations

Content Standard B: Life Science

**National Technology Standards Addressed**

Use models and simulations to explore complex systems and issues.
Contribute to project teams to produce original works or solve problems.

**Sources**

**National Science Teachers Association**
http://books.nap.edu/html/nses/overview.html#content

**National Council of Teachers of Mathematics**

**National Educational Technology Standards**
http://cnets.iste.org/currstands/cstands-netss.html
1. **Warm-up Activity:** Have each student place one or two fingers on his or her throat or Adam’s apple and hum. Ask them what they feel. If they are unfamiliar with the term, tell them that it is called vibration. Ask them whether they think that there is a link between the sound they are making and the **vibration**. If they are not sure, have them talk and hold their fingers on their throats. They should feel the same vibrations.

Now hand out rubber bands. Tell them that they are only to use the rubber bands as instructed. Have each student stretch a rubber band between his or her fingers and pluck it. They should now see, feel, and hear the vibrations.

Explain that a vibration is a rapid back-and-forth motion. When they hum or speak, it makes the vocal cords in their throats vibrate. When they pluck the rubber band, it vibrates. Explain that the vibrations from an object, such as a rubber band or vocal cords eventually reach our ears, and we hear them as **sounds**.

2. Distribute the *Hear Ye! Hear Ye!* handout and materials to each group of 2–3 students. In this activity, you will lead the class in building a model ear to demonstrate how we hear sounds. After each step, you should ask questions to identify what students have learned about the transfer of sound to make sure they are following along. A detailed set of instructions for building the ear is found at the end of this activity.

3. Students have seen in the warm-up activity that vibrating materials, such as rubber bands, can cause sounds. They will do this by stretching a sandwich bag over one end of the cardboard tube. The bag should be stretched as tightly as possible without ripping it. Students should use a rubber band and tape to secure the bag in the tightly stretched position. The rubber band should also be as tight as possible. Having both elements as tight as possible will increase the sensitivity of the bag to sound entering the tube.

4. Have students talk into the open end of the tube and gently place a finger on the bag. Ask students to describe what they feel. Does the bag vibrate like the vocal cords that they felt in the warm-up activity? Have them record their observations on the handout. Ask them to explain how they think that the sound made the plastic wrap move even though they weren’t touching it.

There may be many misconceptions about how sound is transmitted. There are several alternative answers – including that the sound is transmitted through the tube itself and not the air. To have them test this, you can have them hold up a piece of a plastic bag and vocalize towards it. It should vibrate without having to pass through solid material.

You could also remind them of the rubber band. When it was plucked the sound made it to their ears without passing through a solid material. They may also think the bag is vibrating because they are blowing on it as they talk into it. To help them dispel this, have them talk facing across the mouth of the tube instead of into it. They may need to talk louder to get the tube to vibrate, but it
should still work. If they have other possible explanations, ask the students to devise a way to
test that theory. This will be a good way to test their inquiry skills as well as to teach them about
transmission of sound.

5. Have each student hold an index card near his or her mouth with the card facing up. Then
have the student talk or hum toward the cardboard. Ask them if they can feel it vibrate. They will
probably not feel any vibrations in the card. Now have them cut the index card using the template
at the end of this activity.

6. Have students tape the single end of the index card cutout to the plastic bag on the cardboard
tube. The cardboard wishbone should be perpendicular to the bag, with tape on each side
holding it to the bag. Students will have to be careful not to puncture the bag while attaching the
wishbone. Ask them whether they think they will be able to feel vibrations in the index card if they
talk or sing into the open end of the tube. After you have discussed their reasoning, have them test
this out and record their observations in the handout. They should hold the tube in one hand and
the cardboard wishbone in the other and talk into the tube. Explain that some materials transfer
sound better than others.

7. In the next step, the students will cut out a piece of aluminum foil in a 15 cm X 15 cm square.
They should then tape the foil square to the forked end of the index card cutout. The aluminum
should be taped so that it is perpendicular to the plane of the cardboard. This will require the
student to use two pieces of tape for each part of the cardboard wishbone. Ask them to use what
they have observed so far to predict what will happen to the foil when they talk into the open
end of the tube. They should by now recognize that sound can be transferred through a variety
of different materials, and will probably predict that the aluminum foil will vibrate when they talk
into the tube.

Have them once again talk into the open end of the tube. They should observe that when they do
this not only does the aluminum foil vibrate, but it also makes a noise. Ask them why the foil makes
a noise. They should recognize that the vibrations from their voices are transferred through the air,
to the bag, through the index card, and into the foil. The vibrating foil makes the air vibrate in a way
that then produces sound, which is picked up by the students’ ears.

8. To make the final piece of the ear model, students will roll a large piece of paper into a cone
and tape the narrow end to the inside of the cardboard tube. Before they do this they should speak
in the direction of the open end of the tube, but from the side. They should observe whether the
plastic bag moves. Unlike the bag on the other side of the tube, this portion does not need to be
attached very tightly, although the cone should be sturdy enough to retain its shape. After they
have attached the cone they should once again speak from the side. Is there any difference?
The cone acts to funnel sound waves towards the tube.
9. **Wrap-up Activity:** Show the students the picture of the ear below. Ask them if it looks familiar. They might recognize that the model they have built to demonstrate the transfer of sound through different materials is very similar to the ear. Tell the students that during this activity they actually built a simple model of the ear. The picture below corresponds to a similar diagram in the student handout. Ask the students to describe how sound is transferred in each part of the real ear based on their model ear. Discuss how the model and the ear are alike and how they differ. For example, students may notice that the model stops at the oval window (the foil square in the model), but the real ear has more parts such as the cochlea and various nerves. Tell the students that the ear is more complex because it has to convert sounds into signals that your brain can interpret.

http://faculty.washington.edu/chudler/hearing.html

Many of the parts of the human ear are represented in our simple model. The outer ear (or pinna) is represented by the cone. The ear canal (or external auditory meatus) is represented by the cardboard tube. The ear drum (or tympanic membrane) is represented by the bag. Only one of the three ossicles is used in this lab – the stapes. It is represented by the cardboard cutout. The oval window is represented by the foil square.

**Hear Ye! Hear Ye! Extension Activity**

To extend this activity, have the students think about things that could cause the ear model to stop working. For example, have the students stuff the tube full of paper. Have them try to talk into the tube and observe whether sound still makes it through. They should see that it does not. Tell them that this corresponds to many problems such as ear infections, which fill the tubes within the ear with fluid. Tell them that any part of the ear can be damaged. Ask students to describe why damaging any one part can damage the ability to hear.
What is sound?
Sound is caused by vibrations of the particles within materials. Those vibrations must ultimately be transmitted to the ear and then to the brain for a person to hear a sound. When objects collide or move through air they cause the molecules around them to vibrate. In many cases, vibrations are transmitted to air molecules. The air molecules then vibrate, causing a wave of sound to move across an area. Eventually that sound wave may reach an ear, where it causes parts of the ear to vibrate and the person to sense an audible sound.

How does the ear work?
The process involved with hearing sound is a complex series of transfers, like people working on an assembly line. First, sound waves from the air enter the outer ear. These vibrations are funneled into the ear canal by the pinnae, which is the part most people recognize as the ear. At the inside end of the ear canal is the tympanic membrane, which is also called the eardrum. The vibrations in the ear canal cause vibrations in the eardrum. In the middle ear there are three tiny bones called ossicles: the malleus, the incus, and the stapes. The ossicles intensify and transmit the vibrations of the eardrum. The malleus touches the eardrum and vibrates when the eardrum vibrates. The malleus is connected to the incus, which is connected to the stapes. Vibrations in the malleus cause the incus to vibrate, which in turn causes the stapes to vibrate. The stapes is attached to a membrane called the oval window. The oval window is connected to an organ called the cochlea. When the stapes vibrates, the vibrations are transmitted to the oval window and into the cochlea. The cochlea is filled with liquid. Vibrations of the oval window are transmitted into this liquid and cause it to vibrate. The vibrations cause the tiny hairs lining the cochlea to vibrate. The hairs are connected to nerves. When the hairs move, the movement generates nerve impulses that are relayed to the brain and interpreted as sound.

What are some types hearing loss?
There are two general types of hearing loss—those caused by interference in the transmission of sound from the outside to the inner ear, and those caused by problems in the inner ear (the cochlea and auditory nerves). Interference with the transmission of sound, also called conductive hearing loss, is quite common, and frequently reversible. For example, ear infections, excess ear wax, or fluid in the ear can cause some loss of hearing. Other causes, such as a perforated eardrum or damage to the ossicles, can be more serious. Damage to the cochlear hair cells and other portions of the inner ear and nerves are generally permanent. Current scientific research is directed at solving these problems.

Key Vocabulary
Vibrations: oscillations around a point
Sound: vibrations transmitted through gas, liquid, or solid
**STEP 1**
Slide the plastic bag over the tube and secure tightly.

**STEP 2**
Cut out wishbone shape on index card.

**STEP 3**
Cut out 15cm X 15cm aluminum foil square.

**STEP 4**
Attach the index card to the bag and the foil to the index card.

**STEP 5**
Roll large piece of construction paper into a cone and tape to tube.
Cut out
Cut along the dotted line.
What did you observe when you talked into the tube with the bag attached to one end?
[When I talked into the tube, the bag vibrated.]

What did you observe when you talked toward the index card? Did the card vibrate?
[The card did not vibrate.]

What did you observe when you talked into the tube after you attached the index card cutout to the bag?
[The cutout vibrated along with the bag.]

What did you observe when you attached the foil to the cardboard and talked into the tube?
[Talking into the tube caused the foil to vibrate and make its own noise.]

Use the space below to sketch your model. Draw lines connecting parts of the ear to the similar parts of your model.
[Answer should have a line connecting the pinna to the cone, the ear canal to the tube, the ear drum to the bag, the stapes to the cardboard cutout, and the oval window to the foil.]
Name ________________________________ Date __________________

What did you observe when you talked into the tube with the bag attached to one end?

What did you observe when you talked toward the index card? Did the card vibrate?

What did you observe when you talked into the tube after you attached the index card cutout to the bag?

What did you observe when you attached the foil to the cardboard and talked into the tube?

Use the space below to sketch your model. Draw lines connecting parts of the ear to the similar parts of your model.