LISTENING DEVICES

Description:
Students design a listening device that will allow them to listen to the sound generated by a specific object inside of a box.

Grade Levels: 3-8

Educational Outcomes:
1. Students will explore the movement and properties of sound waves as they design a listening device.
2. Students will explore ways to trap and reflect sound waves so that they can be heard clearly from a distance.
3. Students will gain a first-hand experience of the design process that scientists and engineers undergo.

Estimated Time: 10 – 30 minutes

California Science Standards Connections:
Grade 3 - Physical Science
1 d. Students know energy can be carried from one place to another by waves, such as water waves and sound waves, by electric current, and by moving objects.
Grade 7 - Life Science: *Structure and Function in Living Systems*
5 g. Students know how to relate the structures of the eye and ear to their functions.
All Grades: Investigation and Experimentation: Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations.

The Tech Museum Connections:
Life Tech Gallery: www.thetech.org/exhibits/gallery.cfm?id=4
- MedTech: Replaceable You
- The Transparent Body: Sensing with Sound

IMAX: Human Body

Materials And Set-Up
Materials:
- Plastic soda bottles
- Paper towel rolls
- Stiff paper
- Straws
- Plastic tubing (varying sizes)
- Masking tape
- Aluminum foil
- Plastic wrap
- Rubber bands
- Rubber balloons
- Clay
- Children's scissors
- Plastic or paper drinking cups
- String

Setup materials:
If using soda bottles, you may want to precut the top parts so kids can use them as funnels.

Testing:
Metronome
Shoebox (or other box that will house metronome effectively)
Padding for box (e.g. bubble wrap, foam, Styrofoam peanuts)

Please note: This activity was initially developed to be a floor activity for guests of The Tech Museum. It can be modified for classroom use and is a good example of an introductory level design challenge.

Teacher Notes:

Early doctors were not able to hear a patient's heartbeat or lungs very clearly. They simply put their ears to a person's chest and listened. This was not always possible, so one doctor, when presented with a female patient, tried something new. He remembered that sound travels in all directions but can become trapped and reflected in a tube. What was his idea?

Rene Laennec created the first stethoscope by rolling up a pile of paper, which made him think of the idea of a wooden tube with a funnel-shaped opening at one end to place against the body. The stethoscope went through many different modifications to what you see in your doctor's office today. One reason is because people found that different types (styles) of instruments allowed them to hear different organs/functions.

Stethoscope derived from the Greek for "I see" and "the chest".

How does sound travel?
Sound travels as waves in all directions from its source in concentric spheres, with the intensity dropping off as the area of the sphere it covers grows. If the waves are confined to an area such as a pipe or tube, though, they are trapped and reflected back and forth within the pipe until reaching the other side. Since they do not spread out, but stay in the same area, the intensity does not drop off as it does when waves are not confined. Prisoners on Alcatraz used to communicate with each other through the water pipes, an idea that works using the same concept.

DESIGN CHALLENGE

Scenario:
You have been given the task of designing a listening device that will be used to hear a patient's heart while exercising. Since the physicians who will use your design will not want to get hit by a stray leg or arm, you will need to make sure that your design can be held at least a foot away from the patient while listening to his heart.

Challenge:
Design and build a device to listen to an object inside of a box.

Constraints:
- Your listening device needs to be held at least a foot away from the testing box.
- You may only use the materials provided.
- You will need to accurately repeat/represent the sound or beat that is heard within the box to indicate the effectiveness of your design.

Testing:
Turn the object (e.g. metronome) on and insert into box, surrounded by padding. If the area is very quiet, then turn a fan or radio on until the object can't be heard unaided. Students should use their device to hear the object inside the box by keeping their ear at least one foot from the box.

Teaching Points to guide Reflection Questions:
- ❑ Sound is created when an object vibrates matter.
- ❑ Sound travels from one place to another in waves.
- ❑ When sound waves are confined to a tube, they are trapped and reflected back and forth until they reach the other side.

Reflection Questions:
- What is the best shape and size for the part against the chest (box)?
- Is it better to cover the object against the chest (box) with a membrane?
- How would your design work if you held it farther away from the box*? (You wouldn't hear the sound as well) Why? (Some of the sound waves would escape and move away from the device)*
- How would different types of materials work as the membrane and why?
- What type of tube is best for connecting to your ear (big/small? Thick/thin?)?

Discussion:
If you were to do this again, how many of you think you could design an even better pump? Discuss how scientists & engineers go through this Design Challenge process daily….learning from their mistakes, reflecting and improving upon what they have already designed.

RESOURCES

Books:

How the Body Works. Steve Parker. The Reader's Digest Association, Inc., Pleasantville, NY. 1994.
The Anatomy Coloring Book. Wynn Kapit & Lawrence M. Elson. Harper Collins College Publishers, New York. 1993.

Websites:

http://people.howstuffworks.com/emergency-room5.htm
http://www.antiquemed.com/monaural_stethoscope.htm
http://www.asahi-net.or.jp/~ig2s-kzm/allabout.html

What is sound?
Sound is created when an object vibrates matter. Consider plucking a guitar string. When the string is plucked, it moves back and forth. When the string is vibrating towards you, it is pushing the air molecules around it, and they in turn are pushing the ones in front of them, and so on, so that they are squished together approaching your ear. This leads to an increase in pressure, called compression. When the string is vibrating away from you, though, it is pulling some of the air molecules with it. This results in a decrease in pressure, called rarefaction. The fluctuations between compression and rarefaction are perceived as sound. The rate at which the fluctuations occur (or frequency) affects the pitch that we hear (how high or low a sound is), while how strong the wave is (or amplitude) affects how loud the sound is we hear.

Two cups and a string:
Sound waves can actually travel along a string that is attached to a cup on each end, when the string is held taut and straight enough. The vibrations created by speaking into one of the cups travel along the string to the other cup. Hence, the bottom of the second cup begins to vibrate back and forth just like the bottom of the first cup, producing sound waves.

Another thing to think about: Sound waves need some sort of medium or matter to travel through, like air or water. Sound can also travel through the earth. During some earthquakes, the waves from the quake will travel through the earth, hit the surface and then cause the air to move as well. You would hear this as a low rumble or boom. In space or some other vacuum, there is nothing for the waves to travel through, so there would be no sound. So, be skeptical of loud explosions from combat in space during science fiction films!