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Teacher Resource Package

Let us help you piece together the science!

Background Information an overview of the topic and theoretical concepts.

Hands-on Activities
Activity 1 - pen/paper activity
Activity 2 - short, easy-to-do activity (30-60min)
Activity 3 - short, easy-to-do activity (30-60min)
Activity 4 - longer activity (greater than 1 hr)
Activity 5 - complex activity

Teacher Resources
Literary Resources
Website Resources
Interactive White Board Resources
Multi-media

Student Resources
Literary Resources
Interactive Websites

Please help us improve our teacher resource packages!

If you have any feedback about this package or suggestions for new resources to include, please don't hesitate to contact us at: inquiries@scientistsinschool.ca.

Sound is Music to my Ears

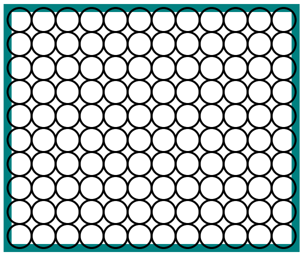
“Give me 5!”….a phrase you have likely used many times to get the students’ attention…but why don’t they hear you?! Perhaps one student is sharpening a pencil, at the same time that another is washing their hands and simultaneously, there are groups of students chatting. All these sounds combine together and this causes the sound level to go up. Your voice is just one of many sounds their ears have to hear. What can you do to help them understand that all the extra noise makes you lose your voice when you strain to be heard? Well, let’s introduce the science behind it!

Background Information

Sound is a form of energy which is created when an object vibrates. When we hear sounds, it is because a vibrating object creates a disturbance in the air around us that cause the surrounding air molecules to vibrate. These air molecules contact and transfer energy to adjacent air molecules. This process creates waves that move in an outward direction. Sound waves are analogous to water waves, where when a rock is dropped into a body of water, the water waves move outwards from the rock.

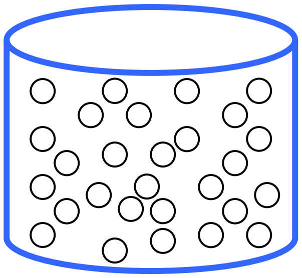
When the sound waves reach our ears, the air molecules in our ears vibrate which causes parts of our ears to vibrate and this allows us to hear the sound. Objects may vibrate in any state of matter: solid, liquid or gas. Although, sound waves we hear travel most commonly through gas (air), sound waves travel better in liquids and solids. Since molecules in a liquid and even more so, molecules in a solid, are in closer proximity to each other, the energy from the vibrations passes through them more efficiently.

Molecules in a solid



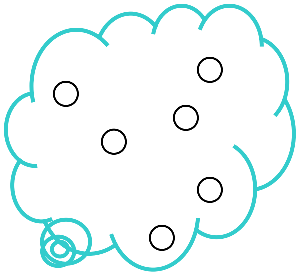
Speed of Sound
= 6000 m/s

Molecules in a liquid



Speed of Sound
= 1500 m/s

Molecules in a gas

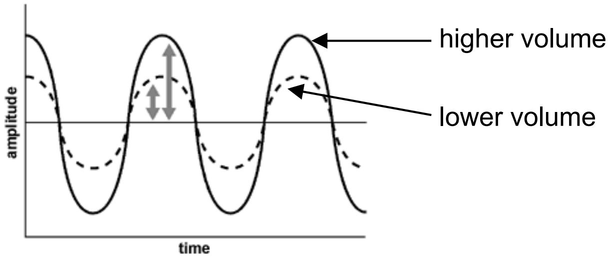


Speed of Sound
= 330-350 m/s

The properties of a sound wave include volume, pitch and sound quality.

Volume or Amplitude

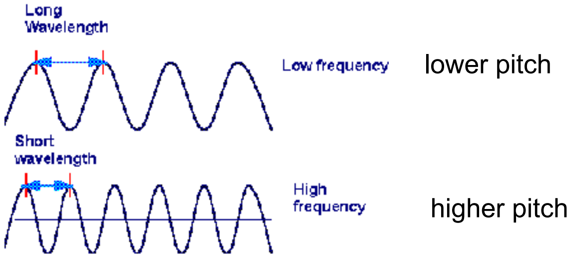
Volume measures the amount of energy that is in a sound wave and is measured in decibels (dB). As sound travels, it causes the surrounding molecules to vibrate. The distance of the molecule’s movement from its original position equates to the amplitude. The amplitude of a wave represents the volume of sound. The higher the amplitude, the more energy the wave has, thus the louder the sound. Students whispering in a library would measure around 30 dB, normal conversation is around 60 dB however headphones playing music at maximum volume measures around 100 dB. Listening to sound measuring 85 dB or higher for an extended period of time is harmful to human ears and can cause hearing loss.



Source: http://science.education.nih.gov/supplements/nih3/hearing/guide/info-hearing.htm

Pitch or Frequency

Pitch measures the number of waves, or vibrations, per second and is measured in Hertz (Hz). Pitch is the frequency of a sound wave. An object that vibrates faster produces a higher frequency and it sounds like a higher pitch. Less waves traveling per second is considered a low frequency or lower pitch.



Source: http://wwwp.cord.edu/faculty/manning/physics215/studentpages/angieevanson.html

The sounds that are audible to humans range from 20 Hz to 20,000 Hz. Animals hear a vast range of audible frequencies. The chart below demonstrates differences between humans and some animals:

	Lower range of audible frequency	Upper range of audible frequency
Humans	20 Hz	25,000 Hz
Dogs	67 Hz	45,000 Hz
Cats	45 Hz	64,000 Hz
Owl	200 Hz	12,000 Hz
Porpoise	75 Hz	150,000 Hz

Musical instruments produce sounds of varying pitch with each musical note having an associated frequency. For example, middle C (C_4) would have a frequency of approximately 262 Hz, whereas the C note that is one octave higher (C_5) is approximately 523 Hz. For other comparisons of notes to frequency, refer to Website Resources under the Teacher Resources section.

Factors that can change the pitch on a musical instrument include:

- **thickness** - when a thicker string is plucked on a guitar, the material vibrates slower in comparison to a thinner string, thus creating a lower pitch;
- **tension** – when the tension on the strings of a violin is adjusted, the pitch will change. When a string is tightened, the speed of vibration increases as the bow is run across the string and this results in a higher pitch;
- **length** – when the wire length changes from shorter (treble) to longer (bass) on a piano, then a different musical note is played. As the piano keys are played from right to left on a keyboard, this is equivalent to notes that range from a treble to bass clef. Thus when a key towards the treble or right side is struck, the note is a higher pitch as compared to a key on the bass or left side.

Many musical instruments, such as the guitar, violin and piano, use a combination of all three factors to affect the pitch (notes) it plays.

Sound Quality or Timbre

Timbre is the uniqueness or quality of a sound. This attribute helps to distinguish between sounds of the same volume and pitch. Timbre is caused by the uniqueness of the sound waves from each musical instrument or vocal performance. If two singers sing the same song, they are singing the same pitch however they likely will each have a unique sound distinguishable from each other. This would be a comparison of the timbre or sound quality differences between them.

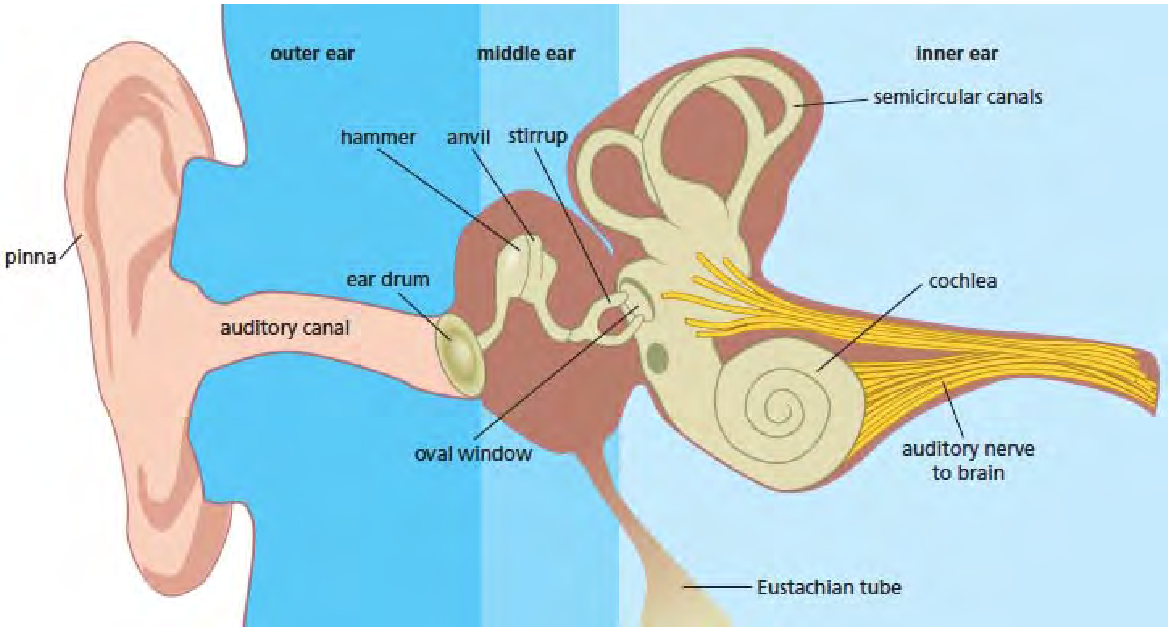
Movement of a Sound Wave

Sound travels in waves and it can either be absorbed or reflected. The amount of absorption depends on the object or medium it is traveling through. When the object is an uneven soft surface, the energy of the sound waves is absorbed. If sound waves hit a smooth, hard surface, the sound waves reflect, losing little energy. This reflected sound is called an echo. Bats have very poor eyesight and rely on their sense of sound for survival. They produce sound waves up to 160,000 Hz (called ultrasound) to reflect off objects and then use the echoes and their highly sensitive hearing to help navigate around obstacles or to find prey. This process is called echolocation. Humans are also capable of teaching themselves to echolocate. By generating a clicking noise, the volume of the returning sound waves helps someone to “see” their surroundings. For example, if one side receives a much louder wave than the other, it indicates that the sound bounced back faster or took a shorter route and therefore there is an obstacle on that side.

Parts of an Ear

The ear is comprised of three main sections:

- Outer ear - the section which collects sound waves from the surroundings and transfers the energy to the middle ear via the ear canal;
- Middle ear – the section which transfers the sound waves into vibrations that are passed on to the inner ear. This area contains the eardrum and three bones: hammer, anvil and stirrup, which are the smallest bones in the human body. The eardrum transfers the vibrations from the ear canal to these small bones, which passes them to the inner ear.
- Inner ear – the section which converts the vibrations into nerve signals that are sent to the brain. Sound enters the cochlea which contains tiny hairs and liquid. Vibrations cause the hairs to move and create signals in the auditory nerves. If the ear is exposed to loud and prolonged sounds, the hairs can be damaged which contributes to hearing loss. Once damaged, these hairs cannot regenerate and this results in permanent hearing impairment. The inner ear also contains semicircular canals that help with directional balance.



Source: http://9-1obrien.wikispaces.com/The+Eye+and+Ear

Activity 1: Do You See What I Hear?

Time: 30-60 minutes

Other Application:
Language

Group Size: Individual

Materials (per student):

☐ “Do You See What I Hear?” worksheet

☐ “Dogs for the Deaf” worksheet

☐ pencil

Learning Goal: Students will learn about different ear shapes and compare the internal ear parts of a human to those of a dog.

The ear has two functions: hearing and balance. When sound waves hit the eardrum, the eardrum begins to vibrate. The vibration moves the three small bones called ossicles. The vibration then travels to the fluid-filled cochlea and causes the cilia or hairs to move. The hair cells send sound information via the auditory nerve to the brain. Ear shape affects how animals hear.

Hearing dogs for the deaf have been trained to assist people with physical impairments of the ear that have caused significant hearing loss.

Procedure:

1. Provide a copy of “Do You See What I Hear?” worksheet to each student.
2. Ask students to identify which ear shape belongs to each animal. Have the students draw a line to match the animal with its ear shape.
3. Have the students read through each of the advantages for particular ear shapes. Have the students draw a line from the ear shape to the best advantage description.
4. Provide a copy of “Dogs for the Deaf” worksheet. Ask students to identify and label the different sections of a human ear and a dog ear: outer ear, middle ear and inner ear.
5. Have the students identify parts of the dog ear as compared to the human ear by drawing arrows to the various parts.
6. Discuss the different parts of an ear and have a class discussion about the differences and similarities between human and dog ears.
   a) Outer Ear:
      - pinna: visible part of ear residing outside of the head;
      - ear canal: tube running from outer ear to eardrum;

   b) Middle Ear:
      - eardrum: transmits sound from air to ossicles; ultimately converts vibration in the air to vibration in the fluid;
      - ossicles: small bones that help to transmit sound from air to fluid-filled cochlea;

   c) Inner Ear:
      - semicircular canals: filled with little hair cells that act as a motion sensors; whenever the head moves, the hair cells move which is communicated to the brain;
      - cochlea: transforms the vibration in the liquid into a neural signal;
      - Eustachian tube: tube that protects, aerates and drains the middle ear; regulates pressure in the ear (e.g. ears popping when descending from high elevation).

Fun Fact:
Ear Growth

The outer ear never stops growing in your lifetime. The middle ear is the size of an M&M and the inner ear is the size of a pencil eraser in circumference!

Discussion:

Review the “Teacher Answer Key for the “Do You See What I Hear” worksheet” for correct matches. Discuss with students why ear shape matters to an animal. The shape of the ear is designed for collecting sounds and funneling the sound waves to the middle ear. An animal’s ear size and shape is often a physical adaptation to help it survive and it reveals a lot about the animal’s environment and how it lives. What other animals have different ear shapes and what are their benefits?

The following table illustrates the different frequencies and ranges that animals can hear to assist with a more detailed class discussion (*Source: http://www.lsu.edu/deafness/HearingRange.html*).

Animal Species	Hearing Range (Hz)
Porpoise	75 – 150,000
Dog	67 – 45,000
Elephant	16 – 12,000
Human	20 – 20,000
Bat	2,000 – 110,000
Tree Frog	50 – 4,000

Review the “Teacher Answer Key for the “Dogs for the Deaf!” worksheet” for correct labelling of the sections of the ear and identification of the ear parts in a dog as compared to the human ear. What are the similarities of the human ear and a dog ear? Both have an outer, middle and inner ear as well as an eardrum and ear canal. What are the differences? The main difference is that the outer ear shape is different. Why do dogs hear better than humans? The shape of the dogs’ outer ear is more efficient than humans. The cup shape allows them to amplify and maximize the sound. The pinna can move independently in a dog whereas in most humans it is fixed. About 10-20% of people are able to wiggle their ears. A dog can hear up to four times further away than a human can. Dogs are able to move their outer ears and point them to the direction of sound. Dogs also hear a higher range of frequencies than humans.

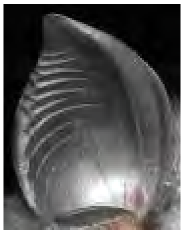
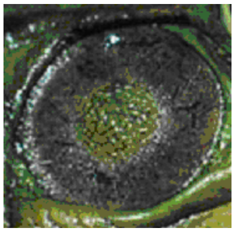
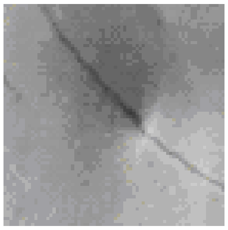
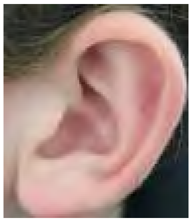
Hearing loss can be due to a physical problem in the ear that prevents sound waves from moving or it could be due to damage of the auditory nerve or the delicate hair cells that sense sound waves. Hearing dogs are specially trained to alert people to household and public sounds that are important for everyday safety and function. The dog will make physical contact with the owner and take them to the source of the sound. For example, a hearing dog will alert their owner to a door knock, phone ringing, smoke detector as well as approaching traffic.

Fun Fact: No ears

Insects feel vibration through specialized body parts similar to our eardrum. Insect “ears” are not on their heads but can be located on many different body parts such as the abdomen of a grasshopper, antennae of a mosquito or the wing of a butterfly. Snakes use their jawbones and fish use pressure changes to hear.

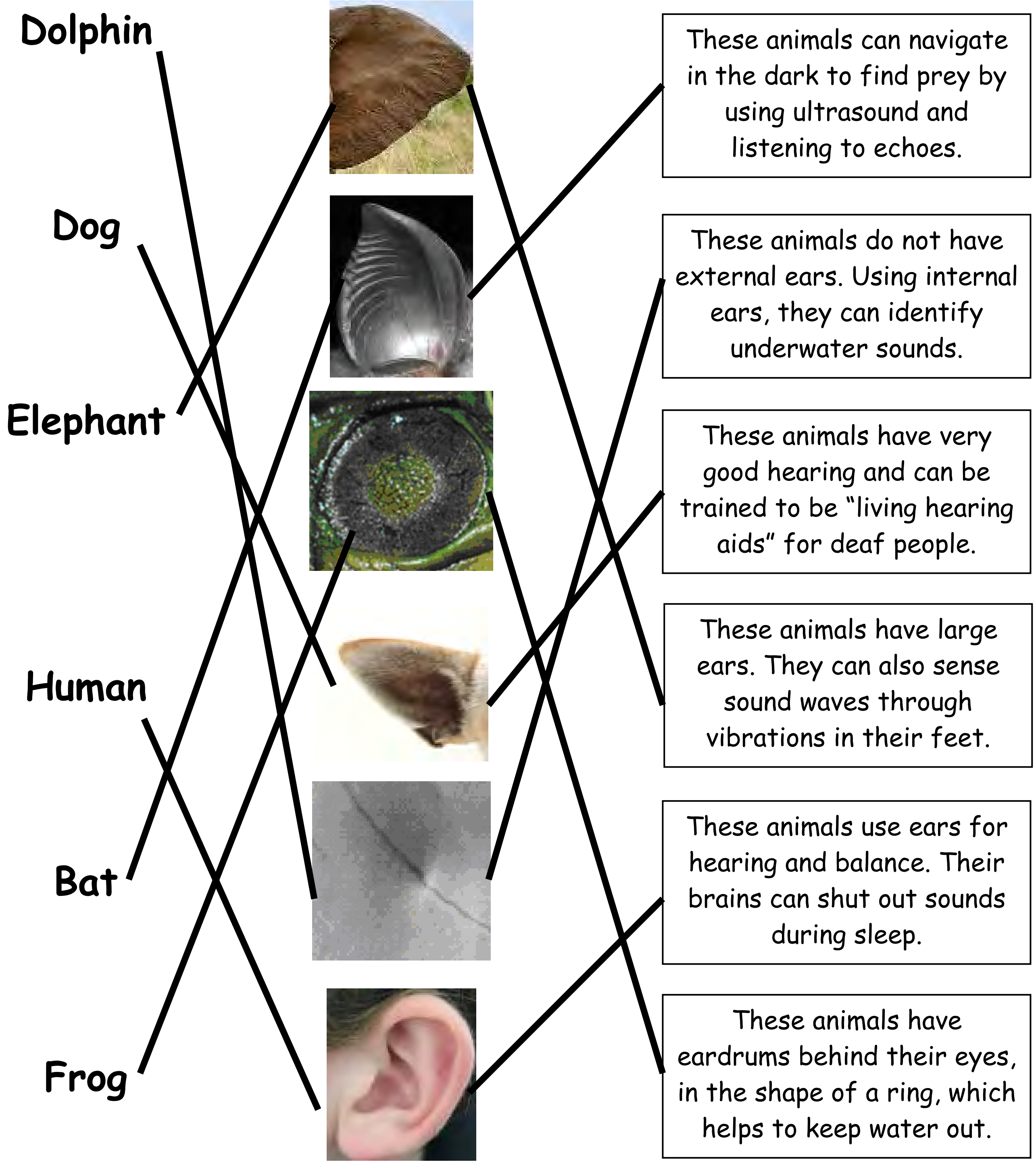
Name: ____________________

Do You See What I Hear?

Animal Name	Ear Shape	Advantage
Dolphin		These animals can navigate in the dark to find prey by using ultrasound and listening to echoes.
Dog		These animals do not have external ears. Using internal ears, they can identify underwater sounds.
Elephant		These animals have very good hearing and can be trained to be "living hearing aids" for deaf people.
Human		These animals have large ears. They can also sense sound waves through vibrations in their feet.
Bat		These animals use ears for hearing and balance. Their brains can shut out sounds during sleep.
Frog		These animals have eardrums behind their eyes, in the shape of a ring, which helps to keep water out.

Teacher Answer Key for “Do You See What I Hear?” worksheet

Animal Name **Ear Shape** **Advantage**



Dolphin

Dog

Elephant

Human

Bat

Frog

These animals can navigate in the dark to find prey by using ultrasound and listening to echoes.

These animals do not have external ears. Using internal ears, they can identify underwater sounds.

These animals have very good hearing and can be trained to be “living hearing aids” for deaf people.

These animals have large ears. They can also sense sound waves through vibrations in their feet.

These animals use ears for hearing and balance. Their brains can shut out sounds during sleep.

These animals have eardrums behind their eyes, in the shape of a ring, which helps to keep water out.

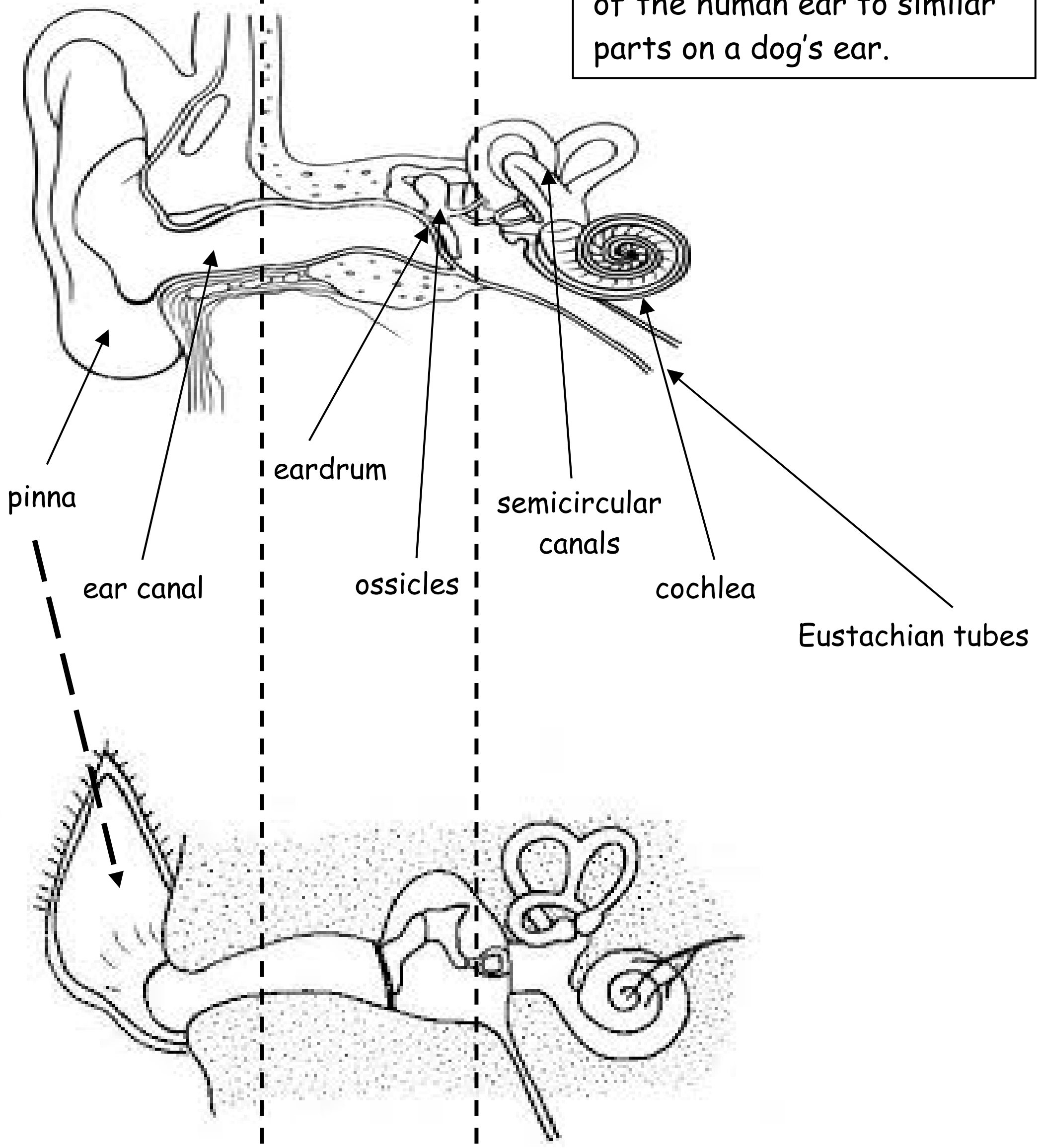
Name: ____________________

Dogs for the Deaf!

Label Sections of the Human Ear:

________ ________ ________

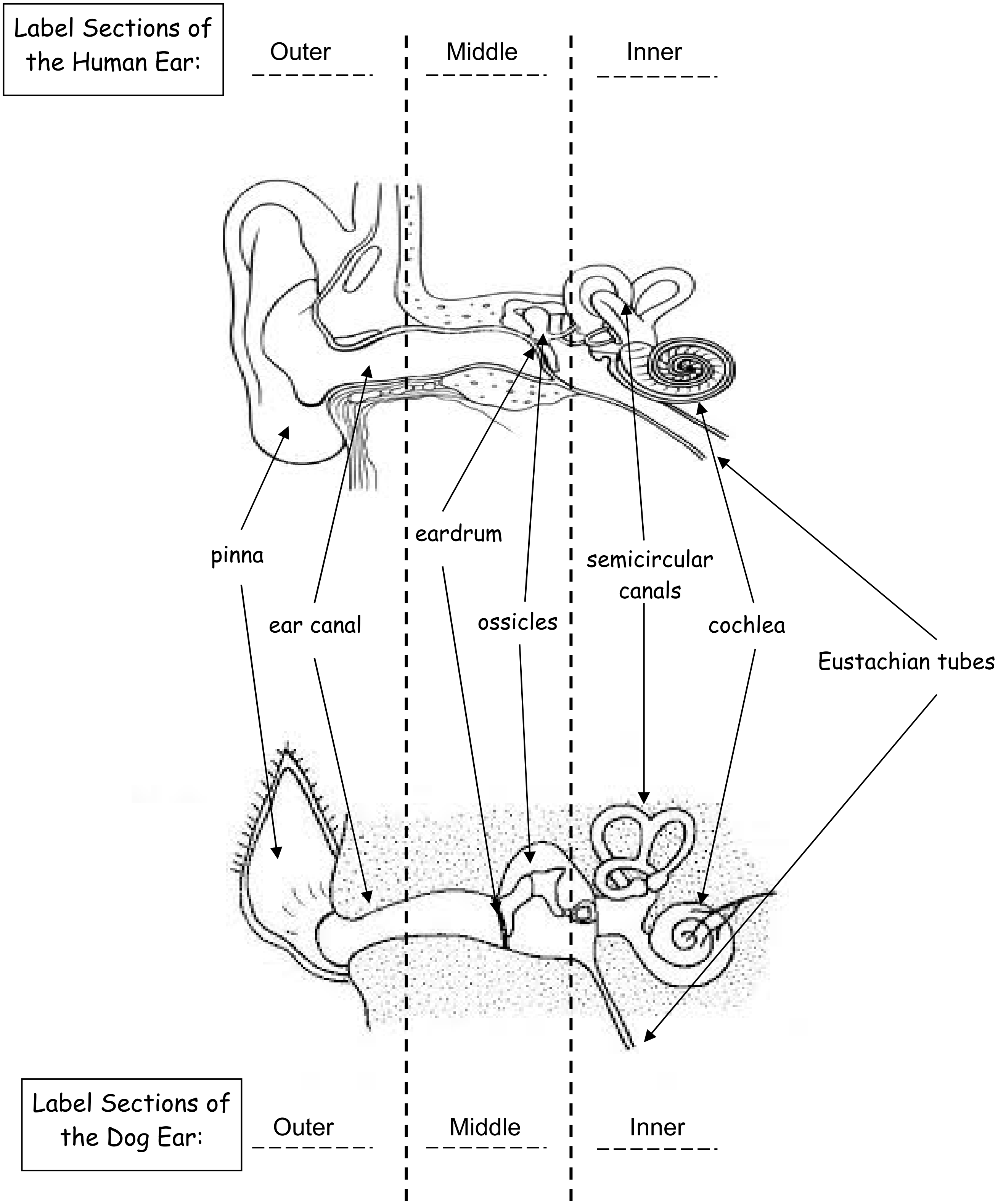
Draw arrows to match parts of the human ear to similar parts on a dog's ear.



Label Sections of the Dog Ear:

________ ________ ________

Teacher Answer Key for “Dogs for the Deaf!” worksheet



Activity 2: Make it louder!

Time: 30-60 minutes

Other Application: Art, Language

Key Terms: amplify, volume

Group Size: Pairs

Materials (per pair):

☐ music player (mp3 player, iPod, etc)

☐ earbuds

☐ 2 balloons

☐ paper cups

☐ sharpened pencil or scissors

☐ recyclable materials such as paper towel rolls, plastic cups, containers, foil pans

☐ utility knife or scissors

☐ masking tape

Examples of homemade amplifiers

Learning Goal: Students will learn about different ways to amplify sound using everyday objects.

Passive speakers are an energy-efficient method to amplify music without using electricity.

Procedure:

1. Make an amplifier with balloons:
    a. Have the students set their music player to play at mid to high volume. Have each student blow up a balloon half way filled with air. Do not tie the end but have the students hold the end with their fingers. Have the students take turns placing the earbud against one side of the balloon and place their ear on the other side. Does it sound quieter or louder against the balloon?
    b. Ask students to blow up their balloon fully with air. Pinch the end to keep air in. Repeat step (a) at the same volume level. Is there any change in the loudness of the music?
2. Make an amplifier with a paper cup:
    a. Place the earbud at the bottom of a paper cup. Point the cup towards the ear. Is there a difference in sound when using only the earbud as compared to using the earbud with the cup?
    b. Using a sharp pencil or scissors, poke a hole at the bottom of the cup, large enough so one of the earbuds can fit through. Place an earbud attached to the music player into the hole at the bottom of the cup so the bud is inside the cup. Point the cup towards the ear. Is there any difference in the sound?
3. Create a homemade holder / amplifier of any design:
    a. Encourage students to collect and bring in from home a variety of recyclable materials such as paper towel rolls, foil pans, plastic tubs, magazines, paper, plastic cups etc.
    b. Encourage the students to use ideas of concentrating or directing the sound waves. Students should find a way to hold the music player (without earbuds) and amplify the sound using the materials collected. Keep in mind that smooth, hard surfaces will reflect sound waves better then soft uneven surfaces.
    c. Test to see if the amplifier works, then decorate and enjoy!

Observations:
The students should observe that the balloon works as an amplifier best when it was fully filled with air. The students will hear about a 5 – 10 dB increase in volume with the full balloon.

The earbud in the hole of the cup will also create about 10 – 15 dB increase in volume compared to the earbud at the bottom of the cup.

From the four comparisons (balloon inflated half-way, fully inflated balloon, earbud against cup and earbud inside the cup), students should discover that the best amplifier was the cup with the earbud in the hole.

Discussion:
Discuss with students which amplifier they thought worked the best and why. The balloon worked well when it was fully filled with air since the air molecules were compressed together. This allowed the sound waves to travel more efficiently from one side to the other.

The paper cup amplifier helped to reflect the sound waves in one direction, concentrating the waves which added to each other for more energy. This allowed the sound to amplify in volume.

With the homemade holder and amplifiers, have students explain their designs and how or why their design worked or didn't work to increase the volume of their music.

Extension:
Students can download the free app for the Ipad/Ipod called Decibel 10th by SkyPaw Co. Ltd *(27/07/15)*. This app is like a professional sound meter that measures the sound pressure level (the force (N) of sound on a surface area (m^2) perpendicular to the direction of the sound). It will show real-time decibel readings and create a visual line graph of the noise volume. Students can repeat the activity using the app and actually measure the volume.

Fun Fact: Duo of Bell and Watson

The telephone was invented in 1876 by Alexander Graham Bell, who was not only a Canadian scientist, but also a teacher for the deaf. His invention came from attempting to improve the telegraph, creating a harmonic telegraph that could transmit multiple notes on the same wire. Once this was proven, Tom Watson and Bell found that they could convert sound energy into electrical energy, and back into sound energy again, thus inventing the telephone! In fact the unit to measure volume "deci**bel**s" is named after him.

Activity 3: Where Did the Waves Go?

Time: 30-60 minutes

Other Application: Math Language

Key Terms: reflect, absorb

Group Size: 6 students

Materials per group:

☐ 3 large cardboard boxes (approximately 35 x 60 cm in size)

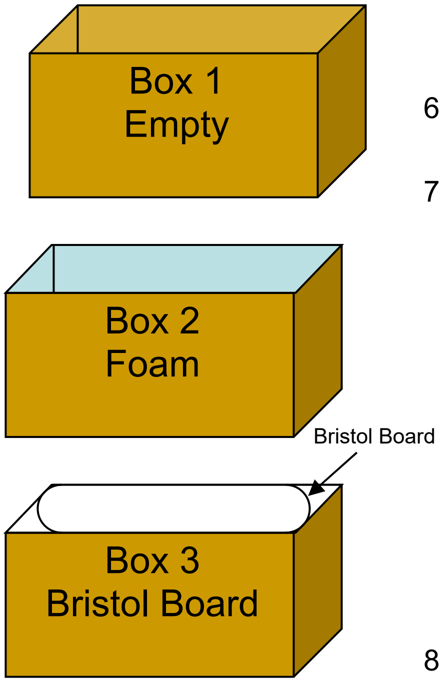
☐ polyurethane foam (such as mattress topper, chair pad foam etc) – enough to line interior of one box

☐ Bristol board

☐ scissors

☐ marker

☐ “Where Did the Wave Go?” datasheet



Learning Goal: Students will learn about how sound waves reflect and absorb using different materials.

A sound wave will behave differently depending on the material it meets. When a sound wave hits an object, part of the energy within the sound wave is transferred to the particles making up the object. This is called absorption. Conversely, reflection occurs when the energy of a sound wave hits an object and it bounces off the surface back to the source.

Procedure:

1. Before class, collect sufficient sets of three large cardboard boxes to accommodate the class (one set per group of six students). A good source of these boxes is grocery or bulk stores. The boxes should be approximately 60 x 35 cm, large enough to comfortably fit two students’ heads.
2. Divide the class into groups and provide them with a set of materials including three boxes, polyurethane foam, Bristol board, scissors and marker.
3. Have the students label one empty box as Box #1.
4. Have the students line the interior of a second box with polyurethane foam. The foam can be contoured such as a mattress topper or flat such as craft foam used in chair padding. Label this box as Box #2.
5. Using Bristol board, have students cut and place the Bristol board in the interior of the third box, so that it creates a smooth curved surface on the interior at the short ends of the box (width). Label this box as Box #3.
6. Hand out “Where Did the Wave Go?” datasheet to each student and have them work in pairs within a group.
7. Have each pair of students cycle through the set of boxes and record their observations on the datasheet.
    a. Have the pair of students stand back-to-back and place one of the boxes over their heads so that their voice will be reflecting off the ends of the box. Start a conversation and listen carefully to how it sounds, for a set amount of time (suggested 2-3 minutes). Have the students record their observations on the datasheet.
    b. Have the pair of students switch to a different box in their groups’ set of three boxes. Repeat Step 7a.
    c. Have the pair of students switch to the last box they have not experimented with yet. Repeat step 7a.
8. Have the students answer questions on the datasheet as to why their conversations sounded different in each box.

Observation:
Box # 1 – The volume of their conversation would generally be in the middle range (volume ranking of level 2) in an empty box.

Box # 2 – The volume in a box lined with foam in the interior would be the lowest (level 1).

Box #3 – The volume in the box with the Bristol board curved at the ends should have the highest volume (level 3).

Discussion:
Discuss with students which box they found to be the quietest and which one was the loudest.

In Box #1, the sound waves generated by their voices would carry through the box interior which is generally smooth but has corners. The sound waves would reflect in the interior however they may reflect unevenly.

In Box #2, when the sound waves hit the foam, the sound waves cause the soft porous fibres of the foam to vibrate. The energy from the vibration converts to small amounts of heat thus absorbing the energy from the sound waves. Using contoured foam helps to reduce sound even more as the uneven surface can direct sound waves back into the foam for more absorption.

In Box #3, since the Bristol board is positioned at the ends, the sounds waves will reflect back into the box when holding a conversation. This will also help reflect sounds waves that are transmitted from the other end. The placement of the Bristol board allows the energy of the sound waves to maintain their amplitude and therefore the volume of the conversation is higher.

Extension:
Students can download the free app for the Ipad / Ipod called Decibel 10th by SkyPaw Co. Ltd *(27/07/15)*. This app is like a professional sound meter that measures the sound pressure level (the force (*N*) of sound on a surface area (m^2) perpendicular to the direction of the sound). It will show real-time decibel readings and create a visual line graph of the noise volume. Students can repeat the activity using the app and actually measure the volume.

Fun Fact: Sonic Boom!
Do you wonder why we hear a large boom when a fast jet flies by? When a jet flies through the air faster than the speed of sound, the sound waves press in front of the jet and break through it, causing a sonic boom, which sounds like an explosion!

Name: ____________________

Where Did the Wave Go?

Box #	**Material used**	**Observation** (ranking scale: 1 – quiet, 3- loud)
1	Empty cardboard box	Volume Ranking (circle one): 1 2 3 Comments:
2	Cardboard box with foam	Volume Ranking (circle one): 1 2 3 Comments:
3	Cardboard box with Bristol board	Volume Ranking (circle one): 1 2 3 Comments:

Which box made the conversation quieter? Why do you think this happened?

____

____

____

Which box made the conversation the loudest? Why do you think this happened?

____

____

____

Activity 4: Stretch your music!

Time: 60-90 minutes

Other Application: Music, Art

Key Terms: pitch, frequency

Group Size: pairs

Materials (per pair):

- ☐ recyclable cardboard container (i.e. shoebox)
- ☐ scissors
- ☐ elastic bands of varying sizes and thickness
- ☐ two pencils
- ☐ cloth or tissue paper

Learning Goal: Students will build a musical instrument and learn about factors that affect the pitch of a sound.

On a string instrument, the pitch, or frequency, can be affected by the tension, length and thickness of the string.

Procedure:

1. Ask each pair of students to bring in a recyclable cardboard container, preferably rectangular in shape such as a shoe box.
2. Have the students create their musical instrument by using scissors to cut a circular shape in the middle of the top of the container.
3. Create a station for students to select varying elastic bands as needed.
4. **Tension:** Ask students to choose four elastic bands of varying lengths but the same thickness. The four elastic bands allow the students to strum them at the same time similar to a guitar. When placed on the box, this will test out bands of differing tension.
    a. Students should place the elastics over the width of the container, positioned over the hole, in order of shortest to longest. Then place a pencil to act as a bridge under all the elastics, on the top of the container but not over the hole, to allow the bands to sit off the box.
    b. Have students test each elastic band and observe which has the highest pitch and lowest pitch.
    c. Students can try to identify the pitch on each elastic to a musical note (C,D,E,F,G,A,B) by using a piano, keyboard or a website to assist with identification of the notes (e.g. http://www.onlinepianist.com/virtual_piano/ *(27/07/15))*.
5. **Length:** Have students perform the test using the same elastics as the Tension test above. Stretch the bands to differing lengths until they all have the same tension.
    a. Using the four elastic bands of the same thickness, place another pencil diagonally on the other side of the box.
    b. Stretch the bands so that the longer band is stretched out the furthest. Check the tension on each elastic band and adjust until all the elastic bands have approximately the same tension.
    c. Allow the elastics to freely vibrate between the pencils (i.e. no obstruction).
    d. Strum the elastics in order of shortest to longest and observe if the pitch changes.

Step 4: Varying Tension

Step 5: Varying Lengths

Step 6: Varying Thickness

6. Choose four elastics with varying thicknesses but with approximately the same length.
   a. Place each elastic band in order of thinnest to thickest on the box, positioned over the hole. Replace the pencil as the bridge.
   b. Test each elastic band by strumming them and observe the varying pitch they make.
   c. Students can try to identify what notes the elastics make.
7. Have the students fill the box with a cloth or tissue paper and then repeat steps 4, 5 and 6. Observe and compare the quality of the sounds the elastics make when the box is filled with a soft, uneven material as compared to an empty box.

Observations:
Students will discover that when they vary the tension of the elastics (step 4), the looser or less tense elastic, will produce a lower pitch.

When the students vary the length of the elastic band (step 5), they will discover that the longer band will produce the lowest pitch.

When the students vary the thickness of the elastic bands (step 6), they will discover that the thickest bands will produce the lowest pitch.

When the cloth or tissue paper is inside the box, the students will discover that the sound did not resonate as well and is not as full or rich.

Discussion:
Discuss with students how string instruments make sounds through the use of vibrating strings. The pitch varies depending on the thickness, tension and length of the strings. A long string will produce a lower tone than a shorter string. A thick string will produce a lower sound than a thinner string. A tight string will produce a higher sound than a looser string. Although on a guitar the strings are the same length, they sound different. The way a string instrument is played also affects the type of sound it makes. String instruments can be plucked, bowed or struck.

Why do acoustic guitars have a hole in them? Similar to the differences observed when a cloth or tissue was added to the box, the hollow body of the guitar amplifies the vibrations of the strings and it will add to the richness of the sound.

Extension:
Students can make their instruments with the elastic bands of their choice (varying thickness, length) and record the notes on the container by comparing the notes played to a known note on a piano or website such as http://www.onlinepianist.com/virtual_piano/.

Another option is to use an application on a tablet with similar capabilities. Challenge the students to create a simple song.

Activity 5: Sound is Beautiful!

Time: 60-90 minutes

Other Application: Art

Key Term: tonoscope

Group Size: 2-4 students

Materials (per group):

☐ 1 recyclable large cylindrical plastic tub (e.g. yoghurt or ice cream tubs)

☐ 1 latex sheet (cut apart a 25 cm giant balloon (e.g. from dollar store))

☐ elastic band

☐ marker

☐ 2 recyclable paper towel rolls

☐ utility knife

☐ duct tape

☐ sheet of newspaper or cardboard

☐ sand or salt

☐ camera or video

Learning Goal: Students will learn about sound waves by using an acoustic tonoscope to visually demonstrate what beautiful patterns can be created from their voices.

The study of vibrations, such as sound, made into a visible form is called cymatics. A good video that shows kids using a tonoscope can be found at http://vimeo.com/33797702 *(*0:13 min, *27/07/15)*.

Procedure:

1. Ask students to collect clean recyclable materials for this project, such as large cylindrical plastic tubs (yoghurt, ice cream, etc) and paper towel rolls.
2. Building a tonoscope:
   a. Stretch a piece of latex over the open top of a recyclable plastic container. Secure it on the sides with an elastic band. Ensure that the latex is taut but not too stretched out.
   b. Trace a circle the same diameter as a paper towel roll on a lower area on the side of the plastic tub. Carefully cut out this circle with a utility knife.
   c. Using duct tape, securely tape a paper towel roll to the hole.
   d. On the second paper towel roll, cut an angle of approximately 45 degrees. Fit this paper towel roll to the open end of the first roll, so that the second one is close to vertical (see diagram). Using duct tape, secure the two paper towel rolls together and ensure there are no gaps between them.
3. Using the tonoscope:
   a. Place the bottom of the tonoscope on a sheet of newspaper or cardboard to help capture loose salt/sand.
   b. Sparingly sprinkle sand or salt on the top of the tonoscope (on the latex).
   c. Make a tone or talk loudly into the paper towel roll. It is important that the tonoscope stays level with the tabletop and that no air is added by lifting the top of the tonoscope. Have the students adjust or change the pitch and loudness and observe the sand/salt.
   d. Take pictures or videos as the pattern varies to capture the voice art! Have the students create a project that they can share with the class.

Observations:
The students will observe that the sand or salt will move as their voices vibrate the latex sheet. They will observe that as they increased the frequency or pitch of their voices, the sand/salt pattern becomes more intricate. As their voices become louder and they increase the amplitude, the students will observe that the motion becomes more turbulent. The sand/salt may vibrate so much that it bounces off the tonoscope.

Discussion:
Discuss with students what they think is happening when the patterns appear and why they change with pitch and loudness. The sound energy can affect physical matter. This can be seen when the vibration from their voices caused a transfer of energy. The sound waves travel along the tube, into the plastic container. The air particles in the tonoscope vibrate which causes the membrane to vibrate and move the salt/sand. When a higher frequency is produced, the pattern becomes more complicated as the waves are more frequent.

Why does it appear that the sand/salt is in waves? The sound waves reflect off the walls of the container. The waves may interfere with each other and cancel each other out or amplify the wave. In the areas that are cancelled out, the sand/salt will gather.

Cymatics is the study of how vibrations can create waves in substances. Many scientists had discovered that vibrations could shift matter into patterns; however three scientists who are most notable for their contributions to the studies include: Robert Hooke (1680's), Ernst Chladni (1780's) and Hans Jenny (1960's-70's). An excellent video resource that includes a brief history and application of cymatics today: http://www.ted.com/talks/evan_grant_cymatics (4:39 min, *27/07/15*).

Fun Fact: Seeing Sound

Oscilloscopes are machines that can be used to visually see the sound waves by converting the sound wave from a microphone, for example, into an electrical signal. One can see how high the pitch is by how frequent the waves are or how loud it is by how big the waves are on the screen of an oscilloscope.

Fun Fact: Not in Space

Ever wonder if you could hold a conversation in space? Well, outer space is considered a vacuum and if there is no medium such as air or water for the sound waves to travel through, then one cannot hear another person talk in space, that is, unless you are inside a space shuttle that is full of air!

Teacher Resources

Literary Resources

Sound from Whisper to Rock Band. Christopher Cooper. 2003. Heinemann library. ISBN 140340956-0. An excellent resource to explain sound in simple concepts.

Sound and Vibration. Gerard Cheshire. 2006. Evans Brothers Ltd. ISBN 978-1-58340-997-8. The impact of sound and vibration on our everyday lives.

Sound: Stop Faking it! Finally understanding science so you can teach it. William C. Robertson, Ph.D. 2004. NSTA Press. ISBN 978-0873552165. A great resource for teachers to help students.

Sound and Light: Science facts and experiments. David Glover. 2002. Kingfisher. ISBN 978-0753455128. Fun and educational ways to learn about properties of sound and light.

Website Resources

www.phy.mtu.edu/~suits/notefreqs.html; http://www.audiology.org/news/hearing-aids-and-music-interview-marshall-chasin-aud (link to PDF conversion chart at bottom of interview) *(27/07/15)*). Online guides to compare music notes to frequencies.

http://www.bsharp.org/physics/guitar *(27/07/15)* An in-depth look at the physics behind the guitar.

http://www.frederickcollection.org/works.html *(27/07/15)* In-depth description on how a piano works.

http://science.wonderhowto.com/how-to/make-paper-plate-speaker-actually-works-for-under-1-0141522/ *(27/07/15).* A neat experiment on how to build a paper plate speaker.

http://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_soundandlight/cub_soundandlight_lesson3_activity1.xml *(27/07/15)*
A website that outlines how to build a variety of musical instruments.

http://www.nidcd.nih.gov/health/education/Pages/default.aspx *(27/07/15)*
National Institute on Deafness and other Communication Disorders site includes activities and videos.

http://science.education.nih.gov/customers/MSHearing.html *(27/07/15)*
Site for teachers and students regarding hearing and the ear.

http://cymascope.com/cyma_research/history.html *(27/07/15)*
An excellent resource that outlines the history of studies in cymatics.

http://www.soundingoutaeolus.com/ *(27/07/15)*
Resource on sound and acoustics including using a tonoscope.

http://pbskids.org/zoom/activities/sci/ *(27/07/15)* Site with science experiments (see section on Sound.

http://www.balloondrums.com/index.html *(27/07/15)* How to build your own balloon drums.

http://schools.smcps.org/gkes/images/The_Amazing_Facts_About_Sound.pdf *(27/07/15)*
Reference on the science of sound.

http://kidshealth.org/kid/htbw/ears.html# *(27/07/15)*

Site in kid-friendly language that explains how the ear works as well as ear health.

http://www.smm.org/sound/nocss/top.html *(27/07/15)*
Museum of Minnesota sound site includes activities and discussions on sound.

http://www.philtulga.com/MSSActivities.html *(27/07/15)*
Informative website including visual examples and charts on sound.

https://faculty.washington.edu/chudler/amaze.html *(27/07/15)* List of range of animal hearing.

Interactive Whiteboard Resources

"Sound"
http://exchange.smarttech.com/details.html?id=dcc6d381-1054-4227-bd91-2571b547da07 *(27/07/15)*
Reviews sound wave concept, pitch and frequency.

"Sound"
http://exchange.smarttech.com/details.html?id=be58c714-45d9-410b-adbe-6ddb495bee70 *(27/07/15)*
Interactive questions on sound, how it travels, etc.

Multimedia

http://www.discovery.com/tv-shows/other-shows/videos/is-it-possible-real-life-bat-man.htm 2:54min *(27/07/15).* A neat video illustrating a deaf person using flash sonar, echolocation.

"**The Tuning Fork**" by TiAu Engineering UG – a free app that turns your device (Ipad/Ipod) into a tuning fork that is able to adjust the frequency to hear different notes.

Student Resources

Literary Resources

Energy in Action – Sound Waves. Ian F. Mahaney. 2007. Rosen Publishing Group Inc. ISBN 1-4042-3480-2. A book that explores sound and ear anatomy.

Science of Sound. Rennay Craats. 2004. Gareth Stevens Publishing. ISBN 0-8368-2682-5. A book reviewing musical instruments, larynx, vocal chords and ear anatomy.

Interactive Resources

http://www.exploratorium.edu/music/ *(27/07/15)* Site with games regarding sound and music.

http://www.wonderville.ca/asset/how-we-hear *(27/07/15)*
Interactive investigation on the ear and what the sound waves look like when testing different objects.

http://www.bbc.co.uk/schools/scienceclips/ages/9_10/changing_sounds_fs.shtml *(27/07/15)*
Testing length and volume on a guitar online.

http://www.nidcd.nih.gov/health/education/decibel/pages/decibel.aspx *(27/07/15)*
Demonstrates decibels on varying sounds using a sound ruler.

References
In addition to resources listed above, the following resources were also used to develop this package:
http://www.physicsclassroom.com/class/sound *(24/07/15;* http://method-behind-the-music.com/mechanics/strings/ *(24/07/15).*
http://www.smithsonianmag.com/science-nature/how-human-echolocation-allows-people-to-see-without-using-their-eyes-1916013/?no-ist *(13/08/15);* http://www.lsu.edu/deafness/HearingRange.html *(13/08/15).*

SCIENTISTS IN SCHOOL
SCIENTIFIQUES À L'ÉCOLE

Get kids excited about science

Science Education Through Partnership

Scientists in School is a leading science education charity that reaches more Kindergarten to Grade 8 youth than any other science non-profit in Canada – more than 700,000 in the 2018-19 school year.

Through our hands-on, inquiry-based science, technology, engineering, math (STEM) and environmental classroom and community workshops, we strive to ignite scientific curiosity in children so that they question intelligently; learn through discovery; connect scientific knowledge to their world; get excited about science, technology, engineering and math; and have their interest in careers in those fields piqued.

By making science a verb - something you do - our workshops allow children's natural curiosity to reign, inspire kids to see themselves as scientists and engineers, and make connections between science and the world around them. This sets the stage for a scientifically-literate future generation who will fuel Canada's economic prosperity and think critically about the scientific challenges facing our society.

Scientists in School relies upon corporate, community, government and individual donors, as well as school board partners for support to develop new programs, continuously improve our existing programs, reach new geographic areas, provide complimentary workshops to less-privileged schools, and subsidize the cost of every one of our 24,872 annual classroom workshops.

Our Partners

Catalyst Level:

Natural Sciences and Engineering Research Council of Canada, TD Friends of the Environment Foundation

Innovation Level:

Amgen Canada, John and Deborah Harris Family Foundation, Nuclear Waste Management Organization, Ontario Power Generation, Toronto Pearson International Airport

Imagination Level:

ArcelorMittal Dofasco, General Motors Canada, McMillan LLP, Superior Glove Works Ltd., TELUS

Discovery Level:

Alectra Utilites, Aviva Community Fund, Cadillac Fairview, CAE, Cameco Corporation, Canadian Nuclear Safety Commission, Carolyn Sifton Foundation, Celestica, Hamilton Community Foundation, MilliporeSigma, Modern Niagara, Niagara Community Foundation, Pendle Fund at the Community Foundation of Mississauga, Purdue Pharma, S.M. Blair Family Foundation, Society of Petroleum Engineers Canadian Educational Foundation, Syngenta Canada Inc., Systematix Inc., The McLean Foundation

Exploration Level:

Ajax Community Fund at Durham Community Foundation, Brant Community Foundation, Cajole Inn Foundation City of Brantford, Community Foundation Grey Bruce, Dwight and Karen Brown Family Fund – Ottawa Community Foundation, Elexicon Energy, LabX Media Group Charity Fund at the Huronia Community Foundation, Siemens Milltronics Process Instruments, The Community Foundation of Orillia and Area, The County of Wellington, The Source, The Township of Tiny, Whitby Mayor's Community Development Fund