

The moment one gives close attention to anything, even a blade of grass, it becomes a mysterious, awesome, indescribably magnificent world in itself.” – Henry Miller

Lola and the Musical Instruments

1 Welcoming Melody of Spring

I was lying on the grass in Lola’s yard as she sat nearby on a blanket. The joy of a cloudless blue sky filled our heart. An ocean above us was reflected in the green waves beneath our feet. Cool, clean smells of lush, newly cut grass filled our souls. We rested on our blankets, sipping juice and enjoying the moment. Our quietness was broken by the melody of a red-winged black bird. Its song rich, varied and oboe-like, finished with a squeaky turn of note. One of the first birds to return from his migration, its bright song is the music of Spring.



Song of the Red-Winged Black Bird

https://www.allaboutbirds.org/guide/Red-winged_Blackbird/sounds



We were picking at the slightly coarse blades of grass. Lola said, “Let’s see if we can sing like the red-wing black bird.” I held my blades of grass between my thumbs, pressing them together at the knuckles with my fingernails facing me. I pulled the grass taut – no kinks – to see the blade’s edge centered in the gap between the base of thumb and knuckle. Pursing my lips, I put my mouth close to my thumbs and blew. After many attempts, I began to mimic the sounds of red-wing black birds.

(How to Whistle with a Blade of Grass:

<https://www.youtube.com/watch?v=qc9Zc2g9D94>)

“We have heard the black bird. Let’s close our eyes. There is more – let’s listen to the wind, and to noise of the life surrounding us, under us”, Lola suggested. Rasping sounds - made by some insect we had yet to see.

Lola gave me a plastic drinking straw and told me to bite the straw, flattening the end. With scissors, she helped me to cut two angles – making two triangular reeds. Holding the straw between my lips so that the reeds were in my mouth, I blew into the instrument. It made a warm, buzzing, humming tone. Soon the air was filled with the sound of an oboe – which copied the sound of the insects under our blankets.

“Do you feel the vibration on your lips?” she inquired.

“Yes, and it is making my lips numb!” I replied.

“This is a fascinating observation – you are feeling the reeds as they are pushing together and springing open again. The air leaves the straw in a series of puffs because of this opening and closing of the reeds – vibrating the air around the straw – which we hear as a hum”, she explained. “ In fact, sound is a type of energy made by vibrations. The vibration is started by some mechanical movement, such as someone plucking a guitar string or knocking on a door. This causes a vibration on the molecules next to the mechanical event (i.e. where your hand hit the door when knocking). When these molecules vibrate, they in turn cause the molecules around them to vibrate. The vibration will spread from molecule to molecule causing the sound to travel.”

Lola went on to explain that many systems have a natural tendency to vibrate. This phenomena is called resonance.

“Resonance occurs in vibrating systems. Take a playground swing, for example. If you push a swing once, it starts to swing, right?” asked Lola.

“Yes, it does,” I replied.

“A swing is a type of pendulum (a long stick or string that has a weight attached to the bottom and is held fixed at one end so it can swing back and forth). We use two terms to describe how quickly a pendulum swings back and forth. The ‘period’ of a pendulum is the amount of time it takes the pendulum to make one full swing back to the same spot. The ‘frequency’ is how many swings the pendulum makes per unit time. The two terms can apply to any motion that repeats over and over again. So we can talk about the frequency of a sound wave, the period of the earth going around the sun (365 days), or the frequency of a Ferris wheel making one rotation.”

Lola continued, “A very important scientist named Galileo described how pendulums worked over 400 years ago. He wondered about the motion of a chandelier he saw hanging from a ceiling. He had observed that the chandelier moved back and forth so regularly it could be used as a clock! In fact, Galileo made a small pendulum to time his pulse rate.”

“Wow,” I exclaimed.

“The fun part of swings is getting it to go higher and higher. What you are trying to do is to increase the amplitude (the maximum distance away from hanging straight down) of the swing. What do you do?” asked Lola.

“I keep pushing it,” I eagerly replied.

“Correct, but how?” she asked.

I tried imagining myself on a swing. Lola was having me do a thought experiment. Thought experiments are performed in the imagination. We set up a situation, we think about what happens, then we try to draw appropriate conclusions. In this way, thought experiments resemble real experiments, except that they are experiments in the mind.

“I have to push at exactly the right moment. If I push at the wrong moment, I actually slow it down.” I observed.

“Exactly! That’s resonance. If you give the swing a short push it will swing at a certain frequency – that is the natural frequency. The frequency you push at is called the driving frequency. In order for your pushing energy to go into the swing, you have to push the swing at its natural frequency or resonance frequency,” Lola explained.

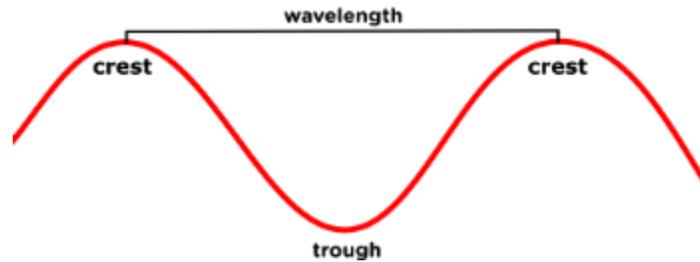
“I see. The swing will swing a little bit higher each vibration if I push at the natural frequency. So it gets a little more energy?” I asked.

“Right! We call this in-sync motion ‘Resonance.’ But, if the push given is irregular (at the wrong part of the swinging motion), the swing will not increase its amplitude and may even decrease. This out-of-sync motion will never lead to resonance and the swing will not go higher.

Resonance occurs everywhere in nature. Resonance frequencies determine the sound you will hear from a musical instruments.” She replied. “And resonance can destroy bridges and buildings.”

There is one more term we need to think about, and that is the word wavelength. You see, waves are all around us. Sound moves in waves. You’ve probably seen waves in the ocean or even in your bathtub. You have probably noticed as you splash in the water that the waves move in a pretty regular pattern. What makes this happen? Energy in the water causes waves to look and act differently due to the amount of energy in them. So, when you measure waves you are really measuring their energy. One way to measure energy is the wavelength or how far apart each wave is,” she continued. “Now let’s do another thought experiment. Imagine you are in the ocean. Think about the distance between each wave crest or the highest point of the wave. As you float on the crest of the wave you can see the crest of the next wave near you. What you are seeing is the wavelength of that wave. So, in order to measure the wavelength, you would

need to measure the distance between two back-to-back crests or you could measure the distance between two troughs.”



One more discovery remained. With scissors in hand, Lola encouraged me to cut the straw oboe shorter, changing the sound from a low pitch to high. As I cut more pieces away....the pitch went higher and higher!

I asked Lola: “Why does cutting the straw shorter change the sound?”

Lola explained, “Wow! What a great question! We can think about this question by using our swing thought experiment. I could change the frequency (and period or wavelength) of the swing by either shortening or lengthening the chain. Longer chains on adult swings will have a lower frequency and longer period (larger wavelength) than children’s swings which have shorter chains. The same situation applies with our straw instrument. In a longer straw, the standing wave will be longer, and the note you hear will be lower. In a shorter straw, the standing wave inside the straw will then be shorter, causing the pitch to be higher.”

Lola now made the connection to bird song. She explained that longer and wider beaks produce songs lower in pitch than birds with smaller and narrow beaks.

“Did you know that the sounds of birds have inspired composers and singers? The famous musician, Vivaldi was moved to compose a flute concerto after listening to the song of the goldfinch. And the three-note call of the European quail was imitated by the oboe in the second movement of Beethoven’s Symphony no. 6 in F major,” Lola informed me.

“And the way in which mockingbirds mimic other song birds, reminds me how Jazz singers, like Ella Fitzgerald, change their voices to imitate instrumental sounds,” she continued.

As the sweeping choruses of frogs and crickets, mixed with refrain of the red-winged black birds, grew around me that warm spring day, Lola opened my mind and heart to the music in the garden through the blending of observation and appreciation that characterizes the best of science. These approaches resonate with my growing love for nature that is forever continuing and deepening.

Activity 1: It Rules – or Long Is Low and Short Is High

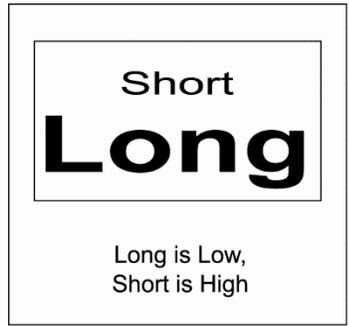
Materials:

- Rulers, flexible plastic, 1y

Procedures:

- 1. Management NOTE: Be sure to tell your child to not press or bend so hard so as to break the ruler!**

2. Encourage your child to position a ruler so that half of it extends beyond the table's edge. They should use one hand to press down on the ruler, keeping it firmly against the desktop.
3. They should use their other hand to bend up the free end of the ruler.
4. They will then release the bent end and listen to the sound.
5. Now ask them to slide the ruler back so that less of it extends beyond the desktop.
6. Repeat the bend and release. Ask: What happened to the sound of the twang? (The pitch is higher). Does the ruler go up and down more quickly or more slowly?
7. Tell them to now retract the ruler farther. What happens to the sound as less of the ruler is extended beyond the desk? (The pitch gets higher and higher). What happens to the speed of the vibration?
8. Slide the ruler in the opposite direction and listen to the sound when the ruler extends over the desk edge.
9. **Explain:** As you guessed, the vibrating ruler produces the twang sound. It's the portion of the ruler that extends beyond the desk that makes the sound. The part that is pressed down cannot vibrate. As less of the ruler was extended beyond the edge, a higher-pitched sound was created. The more it extended, the lower the pitch. What changes do you notice if you increase or decrease the frequency of the wave? (The ruler gets shorter or longer, respectively).
10. **Reinforce:** Long is Low, short is high! Ask them to repeat it back to you.



Activity 2: Tongue Depressor Harmonica

Materials:

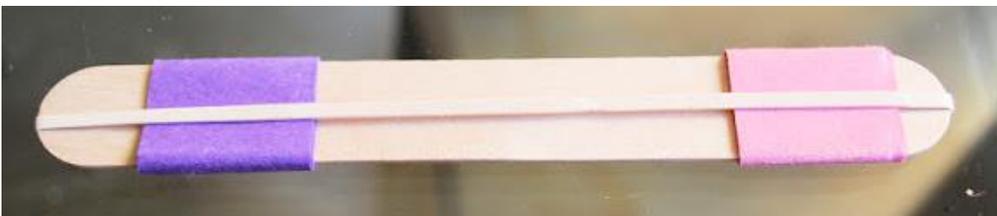
- Craft sticks or Tongue depressors, 2
- Rubber band, thick, med length, 3
- Index card strips or construction paper, 1/2 wide by about 5 long, 2
- Tape, masking, 1 roll (each student will receive four 3-in pieces)

Procedures:

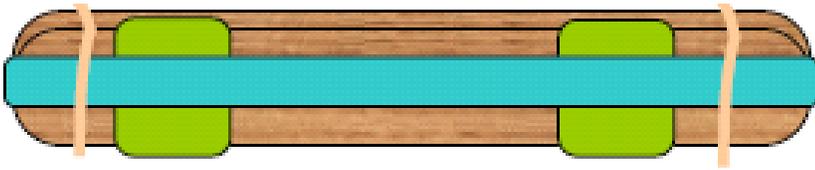
1. Stack both craft sticks or tongue depressors together.
2. Create 2 sliders by wrapping an index strip around the stick stack and secure the strip into shape with tape. Remove 1 craft stick and set it aside.



3. Stretch the wide rubber band lengthwise around the remaining craft stick and its index card sliders.



4. Add the second craft stick back to the stack (place on top of the rubber band and both sliders).



5. Use the masking tape (wrapped in the same manner as the sliders) or rubber bands at each end to secure the craft stick assembly together and form the harmonica.
6. Blow on the long side of the harmonica between the two sliders.
7. Try moving the sliders closer together and farther apart. Try blowing harder. How does the sound change?
8. **Explain:** Sound is caused by vibrations that travel in compression waves through the air (the medium) and into the ear. For the Tongue Depressor Harmonica, the pitch, or frequency, produced is equal to the number of times per second (hertz) that the rubber band vibrates. Higher pitched sounds are higher frequency waves. Tongue Depressor Harmonica players can change the pitch 2 ways: moving the sliders and blowing with varying speeds. In general, a shorter length of material (string, rubber, metal) will vibrate more quickly (higher pitch). So, when the sliders are closer together, the pitch will be higher. Rate of airflow, however, also affects the sound. Flowing air above and below causes the rubber band to vibrate due to turbulence, eddy currents, and vortex shearing. The frequency depends on the air speed; an increase in speed causes an increase in frequency. The same phenomenon actually caused the famous Tacoma Narrows Bridge in Washington to collapse in 1940!
<https://www.youtube.com/watch?v=j-zczJXSxw>

Activity 3: Straw Oboe

Materials:

- Plastic straw
- Scissors
- Tape, optional
- Paper, optional

Procedures:

1. Flatten one end of your soda straw by sticking the end in your mouth, biting down with your teeth, and pulling it out. Do this several times to make a flexible, flat-ended straw.
2. Make two cuts in the now flattened end of the straw in a gently diagonal direction.



3. Insert the triangular tip of the straw into your mouth and blow hard. You should hear a buzzing sound.

It can take some practice to get the sound right. If it doesn't work right away, ask your child to slowly move the straw in and out of their mouth while still blowing until they hear the sound.

4. Explain: When you blow a pulse of compressed air flows down the straw. The pulse travels at a speed of 750 mph, the speed of sound, and bounces off the open end. When the sound bounces off the open end, the compressed air changes into a low-pressure expansion and reverses direction. When a musician forces air through the double reed, the airflow excites the reed and causes vibrations that send pressure waves down the bore. The long, narrow channel of the reed introduces high flow resistance and Bernoulli forces that cause the two blades to beat against each other. When the expanded air reaches the snipped end (reed) of the straw, the reed is forced closed – then bounces open to admit more air. The sound bounces back and forth inside the straw and the reeds open and close to create a sound.
- 5.
6. While your child is blowing on the straw oboe, cut the straw shorter, about 2 inches at a time.
7. **Ask:** What do you notice happening to the sound as the straw gets shorter? (The pitch of the oboe sound goes higher.)
8. **Explain:** The flattened triangular tip acts like the reed found in most wind instruments. The reed vibrates as you blow across it. As you shorten the straw, you decrease the wavelength of the standing wave pattern. This increases the pitch of the note.

Open Investigations

- Make a trombone by sliding a slightly larger straw onto the end.
- Using scissors, cut finger holes into the straw and play it like a recorder. Notes are made in woodwinds by covering holes on the long tubes. This changes the length that the air must travel when vibrating, also causing the note that is played to change. The holes in a recorder are covered with your fingers. By changing which holes are covered and which are open, the notes change. Other more advanced woodwinds, like the saxophone and oboe, have metal keys that are pressed. When a key is pressed by the musician, a soft pad is raised from a hole allowing air to flow through. The keys make it easier to play a long instrument with a lot of holes. The longer the tube or column of air the lower pitch the note will be. This means that to get the lowest note out of a woodwind you should cover all the holes. For the highest pitch, just leave the closest hole to the mouthpiece open.
- Make a bell for your oboe. You can either make a cone from paper or you can use a conical ice cream holder.



Resources

- **Sound Physics:** <http://hyperphysics.phy-astr.gsu.edu/hbase/sound/soucon.html#soucon>
- **Harmonica:** http://www.musicfolk.com/docs/Features/Feature_Harmonica.htm
- **Turbulence:** <http://hyperphysics.phy-astr.gsu.edu/hbase/pturb.html#turb>
- **Tacoma Narrows Bridge:** <http://www.wsdot.wa.gov/TNBhistory/Machine/machine2.htm>
- **Inside Einstein's Love Affair with "Lina" – His Cherished Violin:**
<https://news.nationalgeographic.com/2017/02/einstein-genius-violin-music-physics-science/>

Vocabulary

- **Amplitude:** The height of a wave. Measured from rest to crest
- **Crest:** Highest point in a wave
- **Echo:** Bouncing back of a wave, i.e. echo or reflection
- **Frequency:** The number of crests
- **Interference:** Two types: 1) Constructive: two waves come in contact; the result is a wave with a larger amplitude 2) Destructive: two waves come in contact; the result is a wave with a smaller amplitude
- **Medium:** The matter that waves travel through
- **Node:** Point along the medium that appear to be standing still
- **Reflection:** Bouncing back of a wave
- **Sound:** A kind of energy that you hear
- **Pitch:** how high or how low a sound is
- **Trough:** Lowest point of the wave.
- **Vibrate:** Moves back and forth
- **Wave:** A wave is a transfer of energy without a transfer of matter
- **Wavelength:** Distance from one identical point on a wave to another, i.e. Crest to crest or trough to trough