SN EDUCATOR GUIDE

November 12, 2016

Spider Hearing and Robot Senses

Cross-Curricular Discussion

After students have had a chance to review the article "Jumping spider hears distant sounds," lead a classroom discussion based on the questions that follow. General questions outlined in Blackline Master 3 can be handed out to students before your discussion to help them prepare. If you don't want to use all the questions, you can circle or state those specific questions you want your students to focus on.

Before starting the discussion, have students watch the video of the jumping spider that is embedded in the online version of the article. The video shows a spider reacting to sound wave stimuli.

BIOLOGICAL SCIENCES

Discussion Questions:

1a. Ask students how many animals they can think of that don't have ears similar to human ears. Students might brainstorm or research a list of animals and then identify whether or not they have these kind of ears. This article sheds light on the concept that one doesn't need ears like human ears to sense sound or interpret sound vibrations. How else do animals sense sound? At the same time, you can ask your students: Do all animals need to sense airborne sound? Why or why not? What other ways do animals take in qualitative information to understand the world around them? Students can use the chart provided in Blackline Master 3 to help them organize their thoughts.

1b. The article mentions that wasps prey on jumping spiders. Ask students why they think these spiders need to be able to perceive very low frequency sounds? Why might this ability have evolved over time? [*Being able to hear the wing sounds of fast-flying predatory wasps could increase a spider's chances of survival.*]

1c. Humans and spiders hear best at different frequency ranges. Ask students to find these ranges as stated in the article [*Spiders: 70–200 hertz. People: 500–1,000 hertz*]. Ask students what they know about how we hear sound. Students may have studied this in elementary or middle school. Can they name the parts of the body involved in sensing and processing sound? [*Sound waves enter the ear canal. When they reach the eardrum, the vibrations move the middle ear bones (ossicles). The movement of the bones moves fluid, which moves the tiny hair cells in the cochlea. The vibrations are changed into electrical signals that are sent to the brain.*]

Extension Prompts:

1d. Ask students to select a specific animal they'd like to learn more about. Ask how this animal sees, tastes, smells and touches (or doesn't)? Have students think about what makes their animal well-suited to survive in its environment.

1e. Ask students what they can hear? Start with a site like Noise Addicts Hearing Test to determine the range of frequencies they can hear. Ask students to do research to determine if their frequency range is considered normal for someone their age. Can the ability to hear a wide range of frequencies decline over time? Why is it important for humans to hear? Do humans need hearing to communicate? This question can lead to a discussion about coping with hearing loss or lack of any hearing ability. Students might want to brainstorm ways they can protect their hearing.

PHYSICAL SCIENCES

Discussion Questions:

2a. Ask students to brainstorm different types of waves [*ocean waves, X-rays, ultraviolet waves, microwaves, sound waves, radio waves, visible light waves, earthquake waves, waves of the hand*]. Have students define the different types of waves. Penn State's site on Longitudinal and Transverse Wave Motion has animations for students to explore. Have students sort their examples of waves into the correct types. How would they characterize a sound wave? Tell students the parts of a wave (as described at this link from www.schoolphysics.org) and have them use this vocabulary to describe waves on the electromagnetic spectrum. [*Sound is a mechanical wave because air particles move as the energy of the sound wave passes through. Sound is a longitudinal wave because the direction that air particles move is parallel to the direction of wave propagation. Sound can also be described as a pressure wave because the pressure of the air increases and decreases as the sound wave moves.*] How are sound waves similar to or different from other kinds of waves?

2b. The "Jumping spider hears distant sounds" article says that scientists have long known that spiders can sense the vibrations of the surfaces on which they are standing. Ask students to describe a time when they felt sound more than heard it. [*Students might refer to a time when they stood close to a speaker at a concert and felt the base, or when they felt the vibration of their own voice by placing a hand on their neck.*]

Extension Prompts:

2c. There are many ways to model longitudinal and transverse waves using a piece of string and a Slinky. If your students haven't studied wave characteristics before, you might want to take some time to demonstrate these wave characteristics. Students can also manipulate waves using animations, like these PhET simulations from the University of Colorado Boulder, to compare and contrast the characteristics of sound and electromagnetic waves, for example.

2d. Ask students what they know about how sound waves are measured. What units of measurement are used? [*Hertz, decibels, meters/second.*] Students can research what each unit of measure is used for and some examples of the unit's use. [*Hertz (Hz) measures the frequency of sound, the number of pressure oscillations that occur per second. Decibels describe the loudness of the sound on a logarithmic scale. The speed of sound (meters/second) describes how fast the sound wave travels, which is dependent upon the medium it travels through.*]

2e. Students can explore sound waves and the relationship between sound and vibration through a number of simple demonstrations, including this one available from the Acoustical Society of America, which helps students explore sound using a tuning fork. Ask students to consider what they think

would happen to a sound wave under different conditions (use prompts given on Black Master 3). Then have them brainstorm how they could revise the demonstrations to test their own ideas.

2f. Based on what students know about the science of sound, ask them why music is sometimes described as something that is felt rather than heard. Discuss the types of music or specific instruments that resonate most with students and what it means when they "feel the music." Have students examine an instrument and explain how its sound is made.

ENGINEERING AND EXPERIMENTAL DESIGN

Extension Prompts:

3a. After students watch the video embedded in the version of the article that appears online, have them explain the experiment that they are seeing. Have them identify the hypothesis tested and the experimental variables. Have them explain experimental modifications that were made. Ask them to design another experiment for testing the jumping spiders' sense of sound.

3b. After discussing types of musical instruments, students can take the idea further by exploring instruments that people including Gunnar Schonbeck and Philip Glass have created on their own. Or, students can design their own musical instruments.

QUALITATIVE OBSERVATION AND ROBOTS

These questions and prompts will explore qualitative observation through the article "Robot awakening."

Discussion Questions:

4a. Ask students what "artificial intelligence" means to them? As robots become better at everyday tasks, are there things that a robot should not be allowed to do? Are there ethical lines that should not be crossed?

4b. According to the article, why is it important for robots to be able to sense their environment? What are some different methods scientists in the article are using to build robots that can make decisions based on the qualitative data they collect (their senses)?

4c. What are some ways that robots are being used in your community? What services do they provide and how are they an asset? Are there downsides to having robots perform these tasks?

4d. Scientists and engineers are looking to nature to find inspiration to solve problems. Explain the concept of biomimicry to your students. What are some examples cited in the article? [*The gecko-inspired "stickybot" that climbs walls, for example.*] Ask students if they can think of other examples.

Extension Prompts:

4e. Ask students to brainstorm some tasks that they wish a robot could do for them, like finishing their homework. Have them sketch their own design for such a robot and encourage them to borrow ideas from nature to help the robot perform a task. Have students share their designs with each other and compare those that would accomplish similar tasks. How might students determine which design is best?

4f. The "Robot awakening" article talks about the challenge of robots needing to prioritize incoming sensory information from their environment. Have students work in pairs or small teams to write a set of directions for the robot to follow so it can prioritize information and know what information requires a response or attention. If your students are experienced with a coding language, have them use it to design directions for a robot. If your students are less experienced with coding, consider having them write out the instructions as a series of logic statements. Have groups share their instructions and look for ways to make them even better. Students who want to learn more about coding can explore Hour of Code, where there are a variety of coding experiences across levels and interest areas.

SN IN HIGH SCHOOLS

November 12, 2016

Spider Hearing and Robot Senses

Cross-Curricular Discussion

Directions: The following list of discussion questions is provided to help you take notes, brainstorm ideas and test your thinking in order to be more actively engaged in class discussions related to the articles.

BIOLOGICAL SCIENCES

1a. List as many animals as you can think of that don't have ears like human ears.
What are some ways that animals without ears like human ears sense sound and other vibrations? Make a chart of the senses and list how different animals accomplish this sensory task. Identify as many ways of sensing as you can.

Sense	Animal	How the animal accomplishes the task
Hearing (perceiving sound)		
Sight		
Touch		
Taste		
Smell		

1b. Why might it be helpful for spiders to perceive low frequency sounds? Why might this ability have been selected for over time?

1c. What frequency ranges can humans hear best and what frequency ranges can spiders hear best, as stated in the article?
How do humans hear sound? What do you know about the biology of the human ear? Research and name the parts of the body involved in human hearing and processing sound?

1d. Select a specific animal you would like to learn more about. Do research to determine how this animal sees, tastes, smells and touches (or doesn't). In what ways is this animal well-suited to its environment?

1e. Explore the site Noise Addicts Hearing Test (www.noiseaddicts.com/2009/03/can-you-hear-this-hearing-test) to determine the range of frequencies you can hear best. Do research to determine if this frequency range is normal for your age.
Why is hearing important for humans?
Can your ability to hear a wide range of frequencies decline? Research and explain. How can you protect your ability to hear the frequencies you can hear today?

PHYSICAL SCIENCES

2a. List as many examples of waves as you can.
How would you describe a sound wave? How is it different from and similar to other waves (ocean waves, light waves, etc.)?
Explore different types of waves and their characteristics by visiting Penn State's site on Longitudinal and Transverse Wave Motion (www.acs.psu.edu/drussell/demos/waves/wavemotion.html).
Which waves that you listed above are longitudinal, transverse and surface waves?
Draw a representation of both a transverse and longitudinal wave and label their parts.

2b. Think of a time when you thought you could feel sound, not just hear it. Describe where you were and what you were doing. What does it mean to say you were "feeling" sound? How did you know you were sensing sound?
What does it mean to "feel the music"? How would you feel the vibrations that your voice makes when you speak or sing?

2c. Using the resources provided by your teacher, explore the similarities and differences of sound waves and electromagnetic radiation waves.

2d. How are sound waves measured? What units of measurement are used? List some examples of when you would use each unit of measure.

2e. What do you think would happen to a sound wave as it travels…

- from air to under water?
- through a solid versus a liquid versus a gas?
- on a hot versus a cold day?

How could you test out your ideas about how a sound wave moves through different media and conditions?

2f. Deconstruct a musical instrument from a scientific perspective. How is sound produced by the instrument? Identify the sound frequency range of the instrument.

ENGINEERING AND EXPERIMENTAL DESIGN

3a. Explain the experiment that the researchers in the article "Jumping spider hears distant sounds" performed. State their hypothesis and experimental variables. What were some of the challenges they faced? Design your own experiment to test spider hearing. What question would you ask? How would you set up the experiment? What would the variables be? How would you minimize experimental error?

3b. Explore instruments that people including Gunnar Schonbeck and Philip Glass have created on their own. Use these instruments as inspiration to design your own musical instrument. Be ready to explain your design to your classmates.

QUALITATIVE OBSERVATION AND ROBOTS

4a. What is "artificial intelligence"? Give one example from the article and one from your experience. Are there certain tasks that should not be performed by robots? Are there ethical lines that need to be considered?

4b. According to the article, why is it important for robots to be able to sense their environments? What are some different methods scientists in the article are using to build robots that can make decisions based on the qualitative data they collect (their senses)?

4c. What are some ways that robots are being used in your community? What services do they provide and how are they an asset? Are there downsides to having robots perform these tasks?

4d. Explain how scientists and engineers are looking to nature to find inspiration to solve problems. Define biomimicry and give examples of biomimicry that were mentioned in the article.

4e. What are some tasks that you'd like a robot to be able to do for you? Pick a task and design an idea for how a robot could be built and programmed to perform the task. Try to incorporate biomimicry into your design. Sketch your design and be prepared to share it with your classmates.

4f. "Robot awakening" discusses the challenge of robots needing to prioritize incoming sensory information from their environment. With a partner, write a set of directions for the robot to follow so it can prioritize information and know what information requires a response or attention.