The Truth About Sharks
Investigating the Lateral Line

Grade: 6-8	Implementation Practice: Developing and Using Models
Subject Area: Life Science	Estimated Duration: Two 45 minute periods

Learning Objective - Students will be able to:
- **explain** how the lateral line of sharks responds to stimuli and guides behavior which aids survival
- **develop** a model of the structure and function of the lateral line
- **evaluate** the quality of their model and use their evaluation to **iterate** their design

Standards Supported

NGSS	Performance Expectation **MS-LS1-8.** Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.		
	Disciplinary Core Idea(s)	Science and Engineering Practices	Crosscutting Concept(s)
	• LS1.D: Information Processing	• Developing and Using Models • Engaging in Argument from Evidence	• Systems and System Models • Structure and Function

Activity Summary

Students will investigate the lateral line of sharks and how it responds to stimuli and guides behavior. Then, students develop a model of the structure and function of the lateral line. Lastly, students use the design engineering process to evaluate and iterate their models.

Advance Preparation

- Review the Student Guide
- Review Content Background Information.
- Gather necessary materials (listed below)
- Design and iterate a model of the lateral line (see Elaborate section) in order to familiarize yourself with the student experience. An example of a potential way to model the lateral line is included below:
    - Have the students form a circle. Select a student to act as the predator (PR). The rest of the students will be schooling bait fish/prey (BF).
    - Direct the blindfolded PR to stand in the middle. Distribute one sponge ball to each BF and a few to the PR. As the teacher points to a BF, that BF tosses his or her sponge ball underhand at the PR (shoulders and lower) simulating the movement or vibration in the water.
    - Once the PR feels the “vibration” or “hit” by the BF via their lateral line, he/she/they will turn towards the stimulus and lob a sponge ball, thus attempting to ”predate” the BF. The BF cannot move his or her feet to escape being hit by the sponge ball. A BF must remain in place while ducking, dipping, or bending, etc. Remind students that fish can hear in the water. Play the game for a few minutes; no player is “out” of the game.

Materials Needed

- Student guide: one per student. Consider delivering this resource digitally so that students may modify their work space as necessary.
- Instructor Rubric: one per student
- Digital resources:
    - Schooling snapper video
    - Lateral line video
    - Fish sense blog post
    - Whitetip reef shark video
- Access to everyday materials for modeling the lateral line

Instructor Notes

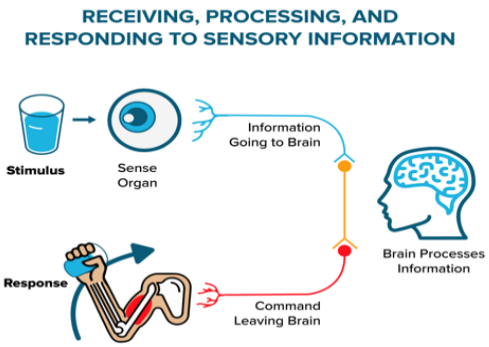
Depending on the level of your students, you may wish to further scaffold the model design.

Content Background Information

Receiving, Processing, and Responding to Sensory Information

All living things respond to their environments. Even single celled organisms like *Amoeba* and *Euglena* can detect stimuli (information) from the environment and respond to it. Plants can respond to their environments by orienting their leaves to capture more direct sunlight or sending roots to grow into places with higher moisture. However, most animals (sponges are the exception) receive, process, and respond to stimuli using a set of structures collectively called the nervous system. Some organism's nervous systems are quite simple while others are more complex. In general, vertebrate organisms (those with a backbone) have more complex nervous systems than invertebrates, arthropods (insects, spiders, crustaceans, centipedes, and millipedes), and cephalopods (octopuses, squids, cuttlefish, and nautiluses) being exceptions. All these types of invertebrates (animals without backbones) have complex nervous systems, including brains. Much of our understanding of the human nervous system comes from studying invertebrate nervous systems.

The sensory division of the vertebrate nervous system consists of specialized neurons (nervous system cells) called sensory receptors that are triggered by specific environmental stimuli. These sensory receptors are grouped together in sense organs, structures evolved to gather information from the environment and relay that information to the brain where the information is processed (meaning is made from it). For example, sensory receptors called photoreceptors are able to sense light coming into the eye from the surrounding environment. These photoreceptors are located in a sense organ called the eye. The eye then sends a message to the brain where the incoming light is processed into an image. The perception of the image prompts some sort of response that will help the organism survive and reproduce. The response could be a learned or instinctual behavior, a reflex, or an automatic involuntary response like "fight-or-flight". In addition, animals often encode sensory information in their brains as memories and use these memories to guide future actions.



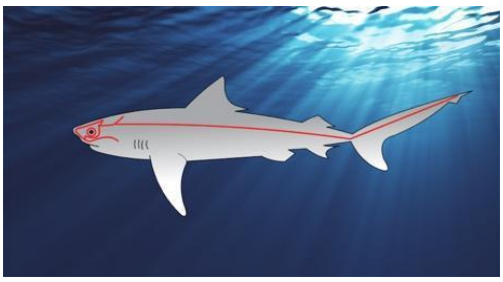
The figure at left illustrates, in simple terms, how the brain receives information from a sense organ, makes meaning from it (perception), and then initiates a response that aids survival. In this case, the response is a learned behavior. The person has learned that water in a glass can be consumed to alleviate thirst.

There are many different types of sensory receptors. The table below lists five basic ones, the stimuli to which they respond, and the sense organ in which they are located. These five basic sensory receptors correspond to a human's five basic specialized senses. Different animals have different sensory abilities because they have different sensory receptors and sense organs. However, all vertebrate animals share these same basic sensory abilities.

Basic Human Specialized Senses			
Sense	Sensory Receptor	Stimulus	Sense Organ
Sight	Photoreceptor	Light	Eye
Hearing	Mechanoreceptor	Sound	Ear
Smell	Chemoreceptor	Substances in air	Nose
Taste	Chemoreceptor	Substances in food	Tongue
Touch	Mechanoreceptor	Pressure	Skin

The Lateral Line of Fish

The lateral line is a sensory system found in aquatic vertebrates that uses mechanoreceptors to sense pressure, vibration, and movement in the surrounding water. It is sometimes commonly referred to as "contactless" touch. This sense organ is used to detect depth and water pressure, the presence of prey and predators, as well as used to sense strength and direction of currents. It helps the fish orient in the water and avoid collisions. As such, the lateral line plays an important role in coordinating schooling behavior. The lateral line is usually visible as a series of small pores running the length of the fish from the gills to the tail.



The lateral line (outlined in red in the image) consists of a series of canals that run along the head and body within the skin. The canals are filled with a fluid called endolymph which is the same fluid that is within the human inner ear. The canals are lined with groups of sensory cells called neuromasts which are sensitive to vibration. Each neuromast consists of a bundle of hair cells These bundles are covered by a flexible cupula that connects the bundles with canal fluid, or in some cases with the water surrounding the fish. The cupula is sensitive to movements of the watery endolymph fluid through the canal. Pressure changes bend the cupula, and in turn bend the hair cells inside. This, in turn, sends a message to the fish's brain.

The Truth About Sharks
Investigating the Lateral Line Rubric

Name:

Glows: Student meets or exceeds performance standard	Performance Standard	Grows: Improvement needed in order to meet performance standard
	Student can explain how the lateral line of sharks responds to stimuli and guides behavior which aids survival.	
	Student can develop a model/simulation of the function of the lateral line.	
	Student use observations to improve the model/simulation.	
	Student can give constructive feedback to other groups about their models/simulations.	
	Student can effectively share model/simulation with classmates.	

Comments:

Name: _____ Date: _____

The Truth About Sharks
Investigating the Lateral Line
Student Guide

Engage

1. Watch the footage of snapper, linked here. Write at least three observations of their behavior as pointed phrases in the space below. Observations do not need to be complete sentences, but should be complete thoughts.

Snapper Observations

Explore

1. Take 60 seconds and explain, to the best of your current ability, the sense(s) fish use to coordinate this behavior. Record your explanation in the space below.

2. Discuss your observations and explanation with a classmate. Revise and/or expand on your explanation. Add your new thoughts in the space above.

Explain

1. Watch the short video on the lateral line linked here.

2. Then, read the blog post from the University of Florida - Institute of Food and Agricultural Sciences about fish senses, linked here.

3. In the space below, explain how the metaphor of a river helps one to understand the structure of the lateral line. A good answer will include the following aspects of the metaphor and how they relate to the lateral line: river, surface water flowing in the river, groundwater, springs, and springheads.

4. In the space below, draw a visual that represents your current understanding of the structure of the lateral line. Include the following parts: **lateral line canal**, **endolymph**, **neuromasts**, **hair cells**, **hair bundle**, **cupula**. Make each part a different color and label it. Then, write a 3-5 sentence caption explaining how the lateral line works to the best of your ability. Use credible online resources to assist you if necessary.

5. Share and discuss your visual with a partner. Prepare at least two clarifying questions to ask your instructor about the structure and/or function of the lateral line. Record your questions in the space below.

Elaborate

1. With a partner, use your knowledge of the function of the lateral line to develop a way to simulate with a model the function of the lateral line as it relates to schooling behavior. Your model should use everyday materials. Determine what you can use to represent the following: the stimulus, the sensory information being received by the neuromast, and the response by the fish.

Model description including all components listed above.

2. Use your model to run your simulation. Then, discuss how you could modify your model and/or simulation to demonstrate the function of the lateral line as it relates to schooling more accurately.

Model revisions explanations.

2. Make the modifications you explained above. Be prepared to present and explain your model and simulation to your classmates.

Evaluate

Demonstrate your knowledge of the lateral line by doing the following:

1. Present and explain your model and simulation to your classmates. Make sure to narrate what you are doing and how your simulation models the lateral line responding to a stimulus and resulting in a specific behavior. Be prepared to give feedback to other groups in terms of what aspects were modeled well and specific ideas about how to improve the accuracy of their model and /or simulation.

2. Fish also use their lateral line system to locate prey. This footage shows whitetip reef sharks hunting for food. Usually, they would be doing this in the dark; the light in this footage is added by the camera. In the space below, use your knowledge of the lateral line to explain with authority how sharks, like these whitetips, use their lateral line to locate prey.

3. Complete the Self Reflection on the next page.

Investigating the Lateral Line
Self-Reflection

Glows: Things I can do well	Standard	Grows: Things that I need to improve
	I can explain how the lateral line of sharks responds to stimuli and guides behavior which aids survival.	
	I can develop a model/simulation of the function of the lateral line.	
	I can use my observations to improve my model/simulation.	
	I can give constructive feedback to other groups about their models/simulations.	
	I can effectively share my model/simulation with my classmates.	

My favorite part of investigating the lateral line was…

The most important thing I learned is…

Something I'd like to know more about is...