1.3.3 Models and the Scientific Process

Overview

Scientists use models in a variety of ways to help them understand processes on Earth. They use objects that they can manipulate to represent objects in the real world that are difficult to study directly. Simple models are just physical copies of the real thing, like a globe is a model of the Earth. More complex models might rely on computers or mathematical formulas to represent their real-life counterparts. Every model has limitations, but can represent specific features for study in investigations and is modified when necessary. When they use models, scientists can also test theories and make predictions about things that might happen in the future.

Learning Objectives

- Fish have air bladders that can be deflated and inflated, as necessary, to assist them in maintaining buoyancy.
- Other organisms without air bladders constantly swim to maintain their buoyancy.
- Models can be helpful tools for scientists; they help scientists test theories, predict future events, and communicate ideas.

Student Activity: Models and the Scientific Process

Materials

Access to the Internet for initial brainstorming of models
Additional materials to be determined by each team depending on the model

Advance Preparation

Read Section 1.3: Life in the Ocean: Vertebrates
Divide into groups of 3-4 students

Process and Procedures

Model A

1. Brainstorm ways that you could make a model of a fish with a swim bladder. What materials could you use? How will you change the air in the bladder? (*Hint: Search the Internet or other reliable resources for the classic science toy called a Cartesian diver. What ideas can you get from this toy?*)

2. Determine what materials you will need to make your model. What will you use to hold water? How will you make the model move up and down like a real fish? Ask your teacher about materials that might be available in the classroom and then decide how

to obtain any other materials that you need. Have all materials ready by the date set by your teacher.

3. Once you have gathered your materials, assemble your model. Allow time for adjustments and troubleshooting.

4. Test the performance of your model by controlling the vertical movement of your "fish" up and down in a column of water. What makes your model go up? Go down? How much? How far? Use a ruler to measure the vertical movement. Organize and record your observations.

5. Discuss the following questions with your team:
   - How does the volume of air in the swim bladder of your "fish" affect its position in the water?
   - What force pulls down on the "fish"? What force pushes it up?
   - Find out how SCUBA divers adjust their buoyancy. How does their method compare to that of fish with their swim bladders?

Model B

1. With your team, find out the answer to the following challenge:
   - Sharks, dolphins, and whales do not have swim bladders. They are able to stay buoyant only by constantly swimming. Some move their tails up and down and others side to side. Use the Internet to find out which way the tail moves for each of the three.

2. The need to constantly swim uses up the organism's energy. Which type of movement (up-and- down or side-to-side) is the most efficient? How can you find out? Brainstorm some ideas about how to test the efficiency of each movement. Can you make a model? Can you BE the model?

3. Devise an investigation to measure which form is more efficient. Carry out your investigation, make observations, and record your data. How did you measure "efficiency"? Were your data qualitative (descriptive observations) or quantitative (measured in numbers)?

4. Report back to the class the results of your investigation. Discuss the following as a class:
   - How do your results compare to those of other teams? If the results are different, why do you think they differ? What can you do to reach a conclusion?

- What do your results tell you about a day in the life of each organism?

Assessment

Both bony fish and dolphins live successfully in the ocean but stay buoyant in different ways. While both buoyancy systems have their advantages and disadvantages, neither is "better" than the other. Which system would you prefer for a life in the sea and why? What are the perceived drawbacks of the other system that lead you to prefer the one you did? How did your observations of models for both systems?

Students should each produce a written summary of their experience. Student work should reflect an understanding that the two models were meant to demonstrate the differences between how marine animals with and without fish bladders stay buoyant.

A thorough student response should also include an explanation of how using models and collecting data helped them to draw conclusions.

Expected Outcomes

What's the take-away? Marine organisms have unique systems that have adapted and evolved over time to allow them to be successful in a marine environment. However, not all organisms have adapted or evolved in the same manner. A buoyancy system is one such example. While some marine organisms developed a swim bladder, others have alternative methods for staying buoyant. Using models in science allows us to test theories and make predictions about how systems work. Models can also allow us to compare and contrast different systems to see how they work under similar conditions.

What does the student work product look like?

Work product #1: Model A (Swim Bladder)

Students will work in groups to design and construct a model of a fish bladder that can be tested for buoyancy. Each team will create a table to organize their qualitative observations as well as quantitative data collected during testing.

Look for conversations between students to discuss the factors that cause the vertical movement of their model. Students should discuss the forces at work that create the movement and ways that they can control or change the movement.

Work product #2: Model B (No Swim Bladder)

Students will work in groups to design and construct three models: a shark tail, a dolphin tail, and a whale tail. Student groups will devise a manner in which they can test the efficiency of each movement for propelling the animals through the water. Each team will create a table to organize their qualitative observations as well as any quantitative data collected during testing.

Look for conversations between students to include an analysis of the data they collected. Students should make evidence-based assertions as to which tail model is most efficient. Students should identify the forces at work and discuss potential reasons why one tail might be more efficient than another.