Cartesian Diver Activity

This activity serves as an extension of the materials on fossils and Iowa's geology. The trip to Graf, IA investigated a layer of fossils found in a rock outcrop. These unique fossils are known as nautiloid cephalopods and are ancient relatives to modern-day squid and nautiluses.

The nautiloid cephalopods found in Graf were creatures with straight shells.
Image from Wikimedia Commons.

The outcrop in Graf has a layer in the rock that is full of nautiloid cephalopod fossils.

Overview

Students will investigate the internal structure of the nautiloid cephalopod fossils in order to understand how they navigated Iowa's ancient sea. Emphasis should be placed on the internal chambers inside the fossil. After investigating these internal structures, students will build a cartesian diver as a model of how these creatures moved in the water. After careful observation and discussion, students should make connections between the cartesian diver model and internal chambers of the nautiloid cephalopods.

Next Generation Science/Iowa Core Standards

- 4th Grade - ESS1-1 Earth's Place in the Universe: Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.
- 4th Grade - LS1-1 From Molecules to Organisms: Structures and Processes - Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

Teacher Background Knowledge

The ancient nautiloid cephalopods moved horizontally in the water by ejecting water from their bodies. But how did they move up and down in the water? As the image below shows, the shells of these creatures contained many chambers. By changing which chambers were filled with water, the nautiloid cephalopods could adjust their density. A lower density, meaning more chambers were empty, made them float higher in the water. A higher density, meaning more chambers were filled with water, made them float lower. The modern nautilus uses its chambers in the same way.

The terms “density” or “buoyancy” may be inappropriate for fourth-grade students, but they should be able to understand that more water in the shell makes the creature heavier, therefore causing it to sink deeper in the water. Less water in the shell makes the creature lighter, therefore causing it to float higher in the water.

This nautiloid cephalopod fossil shows the chambers in the shell. Each segment is a chamber.
Image from Wikimedia Commons.

This is a modern-day nautilus that students could see in a zoo.
Image from Wikimedia Commons.

The modern nautilus also has chambers in its shell. The white spots between chambers are valves.
Image from Wikimedia Commons.

Students can model how the ancient nautiloid cephalopods moved in the water by creating a cartesian diver.

Introduction

Begin the activity by showing students images of the nautiloid cephalopod fossils found in Graf, IA. Students should observe and list the characteristics of the fossils, including the segmentation. While clear segments or parts along the shell of the fossil can be seen, it is not immediately clear that these were chambers. This may require teacher explanation, and using images of modern nautiluses may help students understand the idea of chambers within the shell.

Here is an image from Graf that shows nautiloid cephalopod fossils with clear segments in the shells.

Questions for Students

- What do these fossils tell us about Iowa's past?
- How did these creatures move up and down in the water without any fins?
- What might the chambers inside the shell have been used for?

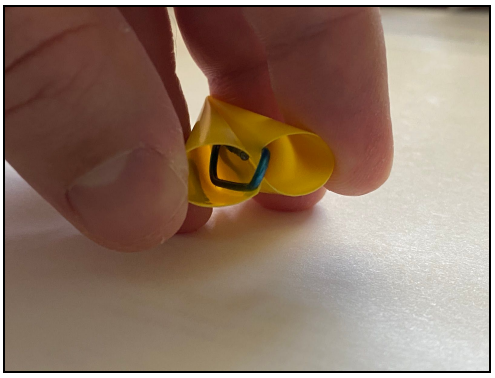
After students have investigated the fossils and learned about their internal chambers, have them build the cartesian divers.

Cartesian Diver Materials

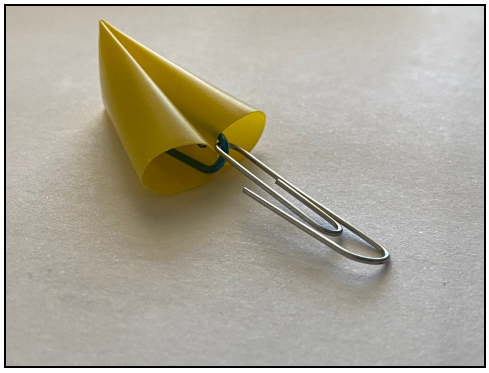
- Empty, clear bottle with cap
- Paper clips
- Scissors
- Plastic straws (any will work, but clear is best to help students see what is going on)
- Water

Cartesian Diver Instructions

1. With the scissors, cut a section of one straw so that it is 2-3 inches long.
2. Fold the cut straw section in half.
3. Insert a paper clip into the open ends of the straw section so that it keeps the straw section folded.
4. Loop another paper clip onto the paper clip that was inserted into the straw section.
5. Fill the empty bottle with water so that it is completely filled.
6. Place the straw section with attached paper clips in the bottle, making sure to place the straw in the water so that the openings are facing down.
7. Secure the cap on the bottle.
8. Squeeze the bottle and observe what happens.



Step 3

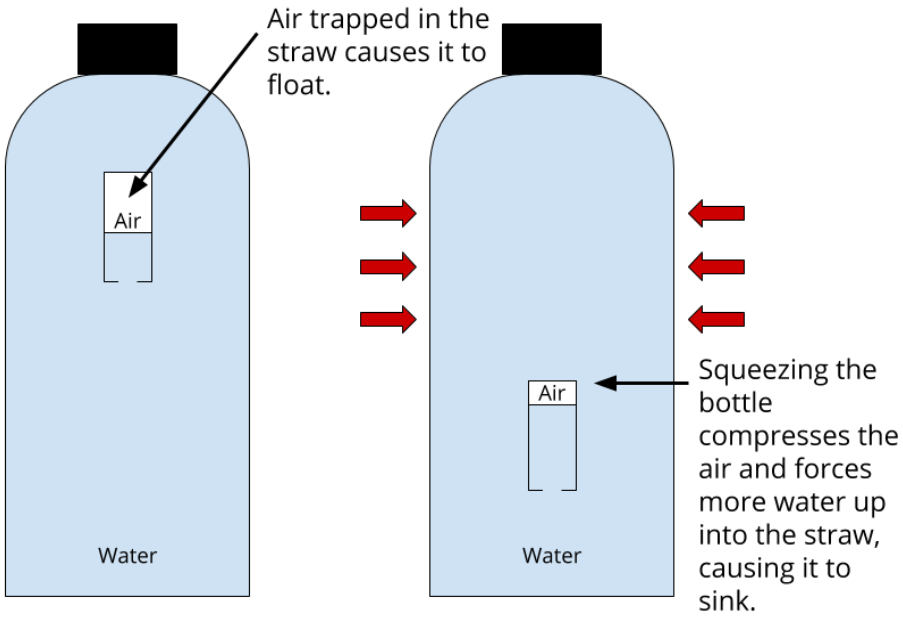


Step 4

Students may need to tip the bottle back and forth initially for it to work.
[Need more help? Watch a video of this being done on YouTube.]

Cartesian Diver Explanation

Folding the straw and placing it in the water with the openings facing down causes some air to be trapped in the straw. The air causes the straw to float in the bottle. Squeezing the bottle reduces the amount of space available for the water, so it has no place to go other than up into the straw. This fills the straw with more water and compresses the air inside the straw. This makes the straw heavier (denser), causing the straw to sink. Releasing the bottle will cause the air to decompress, forcing some water out of the straw, and causing the straw to float higher again.



Discussion/Debrief

- Before providing an explanation, have students make observations and discuss what they believe is happening when they squeeze and release the bottle. Having the students make drawings to explain their thoughts and observations is recommended.
- After students have figured out why the straw sinks when the bottle is squeezed, ask them to imagine that the straw is the nautiloid cephalopod and that this creature went higher and lower in the water in a similar way as the straw.
- Ask students questions to get them to make the connection between the fossils and cartesian diver:
    - How would the nautiloid cephalopod rise and lower on its own in the water?
    - How might their shell have helped them do this?