New England Aquarium

Protecting the blue planet

Nautilus Buoyancy

Background

The chambered nautilus lurks in deeper waters during the day, migrating 2,000 feet down to avoid predators like sharks, turtles, and octopuses. At night, the nautilus ascends to search for food around shallow areas and reefs. The ability to control buoyancy as it ascends and descends lies within its elegant chambered shells.

Unlike a snail shell, the nautilus shell is divided into chambers with the animal only occupying the largest, outermost chamber. When it is newly hatched, a nautilus has about four chambers in its shell. As the nautilus progresses to adulthood, the shell grows in a spiral pattern and contains an average of 30 chambers. When the animal is ready to move into a larger chamber, it secretes a wall called a *septum* to seal off the old chamber. Their shells are thick to withstand the extreme pressure of deeper waters.

Nautiluses suspend themselves in the water by maintaining ***neutral buoyancy***, which means their body density needs to be almost the same density as the surrounding water. As it develops, each new chamber is filled with a saline liquid called ***cameral fluid***, which is lower in salinity than the blood. The chambers are connected by the ***siphuncle***, a thin coiled tube that uses osmosis (the movement of liquids of differing salinity separated by a semi-permeable membrane) to empty the cameral fluid into the bloodstream, leaving almost a vacuum. Gases from the blood will eventually diffuse into this space. The nautilus always has cameral fluid in a few of its chambers, and it maintains neutral buoyancy by modifying the ratio of liquid to gas in each chamber. This process is very similar to submarines using ballast tanks or scuba divers using a buoyancy compensator to add or subtract air from their vest.

Recommended Video: **shapeoflife.org/video/molluscs-nautilus-regulates-its-buoyancy**

Buoyancy Activity

Explore how water pressure and gases affect buoyancy by building a Cartesian diver. This is a similar process to how a nautilus manages its buoyancy at different depths.

This activity was adapted from Steve Spangler Science, Inc:
stevespanglerscience.com/sick-science/112wsks99tzofz7z2/

Another version of the same activity is available at:
buggyandbuddy.com/cool-science-kids-make-cartesian-diver/

Materials

- Plastic pipette
- Hex nut
- 1-liter plastic soda bottle with cap
- Pitcher or deep container for water
- Water

What to do

1. Slide the hex nut up toward the base of the pipette bulb until it stops, and then turn a few times to screw it into place. Leave a ¼-inch gap between the hex nut and bottom of the bulb. Use scissors to cut off the stem of the pipette about ¼ inch below the hex nut.
2. Fill the plastic soda bottle almost to the very top rim with water.
3. Fill the glass eyedropper with just enough water so it barely floats in a pitcher (or other deep container). Adjust the amount of water in the eyedropper needed to make it float—if it sinks, just squeeze out a few drops at a time.
4. Place the eyedropper into the soda bottle so it barely floats and water is overflowing from the bottle. Add more water to the bottle if needed and seal tightly with the cap.
5. Squeeze the sides of the bottle and watch the eyedropper "diver" sink. By releasing your grip, the "diver" will float back up.
6. **What is happening?** When you squeeze the bottle, more water forces its way inside the "diver"—this compresses the air inside it. The added water increases the mass (density) of the diver, causing it to sink. Releasing the pressure allows the air in the "diver" to expand, pushing back out as the "diver" floats back up.