Fluid Demo #4: Crunch Time

OBJECTIVE	Demonstrate the effect of heat on pressure.
OVERVIEW	A plastic 2-liter bottle will be crushed by the normal atmospheric pressure in the room.
TOTAL TIME	10 minutes
SUPPLIES	Two empty 2-liter bottles, hot tap water.
PRINTED/AV MATERIAL	None
TEACHER PREPARATION	None

Background

Pressure is not only a matter of altitude but also is dependent upon the temperature. As the temperature increases so does the pressure. The molecules and atoms that comprise the air we breath gain energy as they absorb heat. That increase in energy results in faster moving atoms which we observe as an increase in energy. The opposite occurs when the temperature decreases. As the molecules loose energy, their motion is decreased and we observe a decrease in pressure.

Procedure

1. Place two cups of hot tap water into each two 2-liter bottle.
2. Place your thumb over each bottle opening and shake. This ensures the air inside the bottle is warmed.
3. Pour the water out of each bottle and screw a bottle cap on only one of the two bottles.
4. Stand both bottles side-by-side and observe over the next five minutes.

Discussion

The bottle that was capped will eventually begin to collapse. This is a result of the cooling air inside that bottle. The air cools because the molecules and atoms inside the bottle loose energy as they collide with the bottle side that is exposed to the cooler surrounding air. As their energy decrease so does their velocity and therefore the pressure decreases. Since the pressure inside the bottle decreases, the force of the air outside the bottle begins to crush the bottle.

However the uncapped bottle remains unchanged. As the air cools inside, the drier outside air flows in to take up the space thereby keeping the pressure the same both inside and outside of the bottle.

Fast Facts

We can only swim down to a relatively shallow depth, about 250 feet, before the increased pressure from the water crushes our bodies. At a certain point, outward pressure in the lungs exceeds the structural integrity of the rib cage, and the rib cage collapses. Obviously, this would kill a human being.

However, whales can withstand this pressure because their bodies are more flexible. Their ribs are bound by loose, bendable cartilage, which allows the rib cage to collapse at pressures that would easily snap our bones.

A whale's lungs can also collapse safely under pressure, which keeps them from rupturing. This allows sperm whales, which dive to depths of 7,000 feet (2,100 m) or more to hunt for giant squid.

NOAA – National Weather Service