mind trekkers

**cartesian diver lesson plan**

amount of time demo takes: ~1 minute

materials:
- eye droppers or similar objects
- modeling clay
- 2 l bottles (recommended), regular soda bottles (not recommended)

set up instructions:
- fill the bottle with water
- take about ⅓ oz of clay and fix it to the open end of the dropper, sealing it.
- place dropper, clay end down, in the bottle.

safety!
- safe demo.

lesson’s big idea
- compressibility of liquids versus gasses
- gas molecules are much further apart than liquid molecules, therefore when pressure is applied, the gas is much easier to squeeze into a smaller volume.
- when the gas molecules are forced into a small enough volume, the density of the gas coupled with the weight of the clay on the tip of the dropper, the dropper will sink.

background information
1. mass density - the amount of mass (or “stuff”) in a given volume. the higher the density, the heavier a substance will be compared to the same volume of a less dense object.
2. compressing air is easy - the molecules are far apart naturally, so bringing them closer together is possible with minimal effort. liquid, on the other hand, has molecules that are close enough to slide past each other naturally, making it markedly more difficult to compress.
3. the “cartesian” diver demonstration is named after rené descartes (1596-1650) and is meant to demonstrate pieces of the ideal gas law and buoyancy.

instructional procedure
1. create a few of the divers following the setup procedure above.
2. ask students to squeeze the bottles as hard as they can, making the diver sink.
3. make sure they notice the end of the eyedropper compress when they’re able to make it sink - this will help convince them that the volume is changing while the absence of bubbles means that the amount of air hasn’t changed.

assessment, sample questions you can ask:
1. what makes an object sink or float in a fluid? (object more dense than the fluid -> sinks.)
2. if gas molecules are really far apart and liquid molecules are close enough to slide past each other, how do you think the molecules of a solid are arranged? (rigid; they don’t slide past each other, but they still vibrate a little due to thermal energy.)
3. why does the gas compress inside the dropper instead of the water in the bottle?
Clean Up
1. If it is a multi-day event, leave the setup in tact for the next day. In the morning, check all the
divers to make sure they still work.
2. If it’s the end of an event, dump out the water and place the clay back in the container.
(Preserving individual colors not necessary, but perhaps preferred.)

References
● For more on buoyancy: http://en.wikipedia.org/wiki/Buoyancy
● For more on density: http://en.wikipedia.org/wiki/Density
● For history about the demo: http://en.wikipedia.org/wiki/Cartesian_diver

National K-12 Science Standards
● List by K-4, 5-8, 9-12 for each standard covered