Expedition 14: Demo for Density
(Suitable for grades 6-9)

Density is a measure of the mass per unit volume of a substance (density = mass ÷ volume). As an example, milk is less dense than chocolate syrup: If you measure out a quarter of a cup of each, that amount of syrup will weigh more than the same amount of milk.

When talking about how dense something is, you could use any terms of mass and volume, such as pounds per gallon. Oceanographers usually refer to density in terms of grams per cubic centimeter (grams ÷ cubic centimeters).

The density of seawater depends on many factors such as the concentration of salt dissolved in it and its temperature. Density is an important property in the ocean because water that is more dense sinks and stays below water that is less dense. That can affect how and where currents flow and where nutrients occur in the ocean. (See a demonstration of this in "Deep Ocean Circulation" in the "Deeper Discovery" section of Dive & Discover.)

Deep hypersaline anoxic basins (**DHABs**) in the Eastern Mediterranean are salty brines that accumulate at the bottom of the sea where ancient salt deposits called **evaporites** have dissolved into the seawater. (See the Classroom Activity "Make Your Own Evaporite.") These brines are about 10 times denser than seawater because of all the extra salt that is dissolved in them. Because they are so much denser than seawater, these brines do not mix with the overlying ocean water. Instead, they stay in depressions on the ocean floor. The boundary between the brine and the overlying seawater is called the **halocline**. This transition zone can be as thin as 1-2 meters! Tiny dead organisms and bits of fecal matter constantly sink down toward the ocean floor. Many of these particles stop when they encounter the halocline. They do not sink further into the brine because of its very high density.

Let's see how this can happen by making a model of a density gradient similar to what we find in a DHAB .

It is difficult to make a brine solution that is as salty as a DHAB in our classroom because DHABs are very deep—more than two thousand meters below the surface of the sea—and pressures there are so high they drive much more salt into solution. So instead of using salt, we will use other ordinary household liquids that have different densities to see how density can create layers of liquid and can affect where small particles stay in the liquid. We'll use beads, glitter, and confetti to represent the dead organisms of different sizes that sink down toward the DHABs.

Materials each student will need:

Plastic screwcap test tubes similar to the ones shown below (16 x 125mm plastic tubes with caps or similar)
Test tube rack
Two ~250 ml beakers
Vegetable oil
Light Karo syrup
Tap water
Food coloring (red, yellow)
Assortment of small wooden beads
Glitter
Plastic confetti or sequins
Assortment of small plastic beads
One small metal bead

Instructions

PART A—Making a DHAB density gradient model

1. In one beaker, mix several drops of red food dye with ~100ml of tap water so that it is a strong red.
2. Use a waterproof marker such as a Sharpie to place a mark ¼ of the way up the tube and label this "A". Use the marker to place another mark half way up the tube and label this "B". Place a third mark ¾ of the way up the tube and mark this "C".
3. Add red tap water to your test tube so that it is up to the "A" mark (1/4 full). If you have a way to measure the volume of red water you added, record what this volume is.
4. In another beaker, mix several drops of yellow food dye with 100ml of Karo syrup so that it is a strong yellow.
5. Add yellow Karo syrup to your test tube until the top surface of liquid in the test tube reaches the "B" mark. Do this **gently** so that the two liquids do not mix. You should tip your test tube slightly and pour the yellow Karo syrup in **very slowly** along the side.

6. Add vegetable oil (no color added) to the top of the red water layer using the same gentle method you used for adding the Karo syrup.
7. Set the tube in the rack and note where each liquid is.

Print out Worksheet 1. Color in the 3 layers in your tube and label them next to the tube.

Which liquid was the MOST dense?_____. (hint: this will be at the bottom of the tube)

Which liquid was the LEAST dense? Where is it in the tube? _____.

DISCUSSION
You added equal volumes of 3 different liquids to your tube, and they settled into 3 different layers in the tube instead of mixing together. This is because they all have different densities.

D (density) = mass ÷ volume

You added the same volume for all three, and so if you think about it, the liquid with the highest density has the greatest mass for the same volume. Discuss as a class what this means.

CHALLENGE FOR MORE ADVANCED STUDENTS:
Calculate the density of the 3 liquids by using a pipette to measure a precise volume of each into a pre-weighed container, finding the mass of that liquid by weighing the container with the liquid and subtracting the mass of the container, and then dividing that mass by the volume measured (in milliliters).

PART B—Adding particles to the model

Now you will add particles of different densities to your model DHAB density gradient.

1. With your test tube in the test tube rack, add a pinch of glitter and without disturbing your test tube, see where it ends up.
2. Add several pieces of confetti or sequins.
3. Add a small wooden bead.
4. Add a couple of small plastic beads.
5. Add one metal bead.

6. Now add to your drawing above. Draw where the metal bead, the wooden bead, and the plastic beads ended up. Draw in where the glitter and the confetti/sequins ended up.

After the particles settle, show on your drawing (Worksheet 1) where each kind of particle ended up.

DISCUSSION
Can you tell something about the density of the things you added (confetti, beads, glitter, etc)? Which ones are LESS dense than the oil? Which ones are denser than the oil, but less dense than either the water or the Karo syrup? Which ones are denser than all 3 liquids?

CHALLENGE FOR MORE ADVANCED STUDENTS:
Estimate the density of the various objects you added to your gradient, using the densities of the fluids you calculated in Part A and your observations of where the objects settled in the tube. Explain your reasoning. How could you measure the exact density of the objects? (Hint: look up the ancient Greek mathematician Archimedes.)

PART C—Final challenge!

1. Put the cap on your tube and shake it up.
2. Put the tube in the test tube rack and watch what happens as the fluid in it settles.

Print out Worksheet 2 and fill in the tube to show your new layers. How many are there? What color are they?

DISCUSSION
You might see that instead of 3 layers, you now have 2! This is because the Karo syrup is soluble in the water, so those two layers mixed, forming an orange layer! And this new mixture has a different density than the oil, but is still DENSER than the oil.

Now you have a situation just like that in the DHABs, where the brine is much denser than the overlying seawater, and sits on the bottom of the ocean. The objects you added are just like the dead plants and animals (microscopic and larger) that sink down through the ocean. Some make it all the way to the bottom of the brine because they are denser than the brine, but some get stuck at the transition zone created by the change in density between the two liquids. This transition zone represents the halocline in DHABs where dead organisms get stuck and provide a rich food source for bacteria and protists.