How heat affects the density of water

BY TODD HOOVER

Many students understand that most materials expand when heated and contract when cooled. This month's discrepant event illustrates that concept by showing students what happens when a container filled with warmer, less dense water is placed on top of a container filled with denser, cooler water.

How it works

Each liquid has its own density, meaning one liquid is either denser or less dense than another liquid. For example, warmer water is less dense than water at room temperature, whereas colder water is denser than water at room temperature.

Density means how much stuff is in a given space, or volume. If 200 mL (the volume) of cold water weighs more (has more mass) than an equal volume of hot water, the heavier water would be denser, because more stuff is packed into the same amount of space. A slight difference in density keeps the water separated—the less dense water will float on top of the denser water. For more information regarding the densities of liquids, read last month's Disequilibrium column "Layered liquids" (Hoover 2017).

Engage

Without giving away the science behind the activity, lead students, working in groups of three, through the first seven steps of the discrepant event. Have a class discussion about why the hot water stays on top. Students should record their observations in their science journals.

Explore

Have students carry out the activity again, but with the hot water in the bottom container and the cold water in the top container. Students should record observations in their science journals.

Explain

Lead the class in a think-pair-share, during which students spend a few minutes thinking about density and how it is affected by temperature and discussing these concepts with the other two members of their group. Subsequently, each group should join with another group in the class to compare ideas, then share their ideas in a whole-class science talk. Have students record in their science journals the class consensus, which is that density keeps the water separated.

Elaborate

Ask students to consider if there are other ways to test the concept that heat affects density. Could you use water that is at room temperature if one container has salt water and the other container has

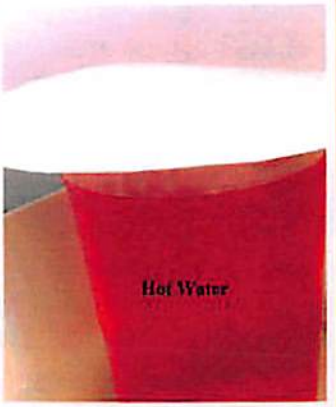
Safety notes

Participants should wear indirectly vented chemical splash goggles, gloves, and aprons during all phases of the activity. Immediately wipe up any spilled liquids. Wash hands with soap and water upon completing this lab activity.

Materials

- two identical clear or translucent containers, such as baby food jars or drinking cups. Containers with rigid mouths that do not bend work best.
- a wax-coated card, the center piece of a wax-coated paper plate, a playing card, an index card, or similar cardstock
- hot and cold water (enough to fill each container)
- two different food coloring colors
- a large pan to catch spills
- indirectly vented chemical splash goggles
- nonlatex apron
- nonlatex gloves
- insulated gloves for handling hot water

FIGURE 1: A wax-coated paper plate sits on top of the container



Teacher instructions

1. Place a container into a spill pan, add three drops of green food coloring into the container, and then fill the container to the top with cold water.
2. Add a few drops of red food coloring and then fill the other container as much as possible with hot water.
3. Place and press a wax-coated card or paper plate on top of the container with hot water (Figure 1). The card must completely cover the mouth of the container.
4. While holding the card in place, flip the container over and ask students what they think will happen when you let go of the card. They may be surprised to learn that the card stays in place. Don't spend too much time on this demonstration, though, or the card may begin to leak water.
5. Carefully place the container with the hot water and the card on top of the container with the cold water, making sure the mouths of each container are directly aligned (Figure 2). Some water is likely to spill out, but most of it will stay in the container.
6. Holding the containers in place, remove the card by sliding it out from between the two containers while keeping the containers aligned.
7. The hot, less dense water will remain floating above the denser cold water.
8. Repeat the discrepant event, but with the hot water in the bottom container and the cold water in the top container. This time, the cold water will sink through the less dense, hot water, causing the water and food coloring to mix. In this case, red and green turned orange (Figure 3).

FIGURE 2: Aligned containers

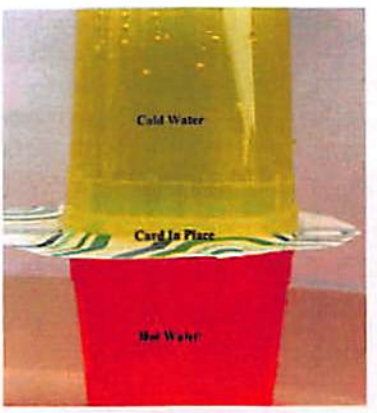


FIGURE 3: The red and green food coloring mix to create an orange color

fresh water? Give students the opportunity to test this or other questions they develop related to the concepts.

Evaluate

Split the class into half (about 15 students) and ask them to use a smartphone to take a picture of their group demonstrating the spread of molecules in the hot versus cold water. For example, to represent cold water, most of the students in the group could stand in a predetermined area while another group member takes a picture or video of them.

To represent the hot water, students (the molecules) will spread out, so that fewer of them will fill the same given area. Try to find a location where students can take the picture or video from above (perhaps from a set of gym bleachers), so that it is easier to see the entire area and students. It may also be helpful to have students create a visual perimeter of the area, perhaps with string, so the images are of good quality. ●

REFERENCE

Hoover, T. 2017. Disequilibrium: Layered liquids. *Science Scope* 40 (8): 16–19.

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