This is a messy activity! Do your best to limit the mess and help clean at the end.

9. Density Layers

Prove that liquids can float on other liquids. Demonstrate that solids may sink in some liquids but float in others.

Life Skills: keeping records
Science Process Skills: observing, comparing, relating

Time Frame

- Helper Preparation: 25 min. plus time to gather materials and review the *Background Information* and *Youth Activity*.
- Youth Activity: 45 min.

Stuff You Need

Grabber (for the leader/helper only)

- ❑ can of regular soda
- ❑ can of diet version of the same soda
- ☑ bucket, pan, or bowl, 1/2 gallon or larger
- ❑ water

To Prepare for The Challenge

- ☑ measuring cup
- ☑ permanent marker

The Challenge (per youth pair)

- ☑ clean, clear, wide-mouthed jar with tight-fitting lid, pint size (example: mayonnaise jar) — larger cups

- ❑ 1/2 cup light corn syrup
- ❑ 1/2 cup white vinegar or water
- ❑ food coloring
- ❑ 1/2 cup vegetable oil
- ❑ 3 clear plastic cups, 4-oz. size or larger
- ❑ masking tape
- ❑ pencil or marker
- ❑ 3 pennies
- ❑ paper towels for cleanup
- ❑ access to a sink for cleanup
- ❑ 6 small solid objects to test in the liquids, such as:

marble	toothpick	wooden match
button	fastener or brad	pebble or small stone
paper clip	penny	sponge piece
small rubber ball	crayons	eraser
Styrofoam piece	small bolt	nail
screw	bottle cap, metal or plastic	washers or nuts
plastic building block		
pieces of solid food: grape, olive, raisin, cherry, small apple, apricot, pasta elbows or shells, carrot, nuts, dry beans or seeds		

Expanded Activity (per individual)

- ❑ 8-oz. clear plastic cup
- ❑ 1/4 cup light corn syrup
- ❑ 1/2 cup seltzer or carbonated water or lemon-lime soda
- ❑ 2 tablespoons whipped cream
- ❑ food coloring
- ❑ small drinking straw or coffee stir stick

More Challenges (per youth or pair)

- ❑ 15 pennies
- ❑ metric ruler
- ❑ kitchen scale

Safety Considerations

- Youth should not drink the test liquids.
- Wipe up any spills immediately to avoid slipping.
- Be careful of any sharp edges or pointed ends on the test objects.
- Food coloring can stain. Youth should handle it with care and immediately wipe up any spills.

Getting Started

Helpful Hints

1. If you use a variety of jars, you may want to label each jar and its lid so that they can be matched easily.
2. Use plastic cups for the vinegar and oil. These liquids may seep through a paper cup. Paper cups may be used to hold the water or corn syrup.

Before the Activity

1. Gather pint-size jars and lids. Test that the lids fit the jars tightly.
2. Mark the 1/2 cup level on each of the cups that will be used by the youth in the activity: measure 1/2 cup of water into each cup and draw a line at the 1/2 cup level on the outside of the cups using a permanent marker. Dispose of the water.
3. Practice the activity to see for yourself what will happen.

Grabber

1. Fill the container three-quarters full with water.
2. Show the youth the cans of soda and ask them what the difference is between them. They should notice that one can is regular and the other is diet. Explore with them what that means in terms of ingredients in the sodas—the regular soda contains more sugar. Ask them to comment on the relative sizes and shapes of the cans—they are the same.
3. Ask the youth to predict what will happen when you place the cans into the container of water: (a) Will both cans sink? (b) both float? or (c) one sink and the other float? If they predict that one will float and the other sink, ask them which will float and why.
4. Tell the youth to observe what happens when one of the youth places a soda can into the water.
5. Remove the first can, and have another youth put the second can in the water. What happens this time?
6. Discuss with the youth the results of this test: the diet soda floats, whereas the regular soda sinks. Have the youth examine the two cans of soda for any differences between them that might explain the results. Point out that each can contains the same volume and the cans are the same size. The regular soda contains more sugar than the diet version. The volumes of the regular and the diet sodas are the same, but the sugar in the regular version results in the mass of the can of regular soda to be greater than the mass of that same volume of diet soda. The regular soda has a greater density than the diet soda.

Doing the Challenge

1. Have each youth pair get a jar and lid.
2. Have the youth use pieces of masking tape and a pencil or marker to label one cup for each of the three liquids: oil, syrup, water or vinegar.
3. Direct the youth to measure out about 1/2 cup of the liquid into its labeled cup. Point out to them that the line on each cup is the 1/2-cup level.
4. Instruct them to tilt the jar slightly and *slowly* pour each liquid along the side of the jar, being careful not to shake the jar or mix the liquids in it.
5. Tell the youth to observe what happens to the liquids in the jar as they add each one, and then use the diagram of the jar on p. 40 of their activity books to draw what they observed. Remind them to label anything in their illustration that they think might be important. For example, they may want to label which layer is which liquid.

   Why is it important to record observations? + Predict

6. Have the youth add a drop or two of food coloring to the liquids in their jar, without shaking the jar or stirring the liquids. Avoid yellow—it is difficult to distinguish from the color of the oil. Tell the youth to observe what happens to the food coloring.

   The food coloring will diffuse through the liquid layers until it reaches a liquid that is denser than the food coloring. When the food coloring reaches the denser liquid, it will no longer be able to diffuse downward. This is likely to occur at the syrup layer.

Help them make a chart to record their observations in

7. Have the youth record their observations ~~in their activity books~~.
8. Have each youth pair get six objects to test. Have them write down the name of each object ~~on the chart on p. 40 of their activity books~~.
9. For each object, have the youth predict in which liquid layer the object will come to rest. Tell them to write their prediction in the chart next to the object.
10. Direct the youth to drop the objects into the liquid, one object at a time. When the object stops moving through the liquids, they should record on their chart which layer the object settled in. Remind them not to shake or disturb the jar. They can leave the objects in the jar.
11. Instruct them to screw the lid on the jar *tightly*. Have them *gently* turn the jar upside-down and wait a few minutes. Then observe what happens to the liquids and the objects in the jar. Have them write down their observations on p. 41 of their activity books.

    The liquids will separate into three layers, with the layers in the same arrangement as before the jar was inverted. Similarly, the objects will also come to rest in the same liquid layer as before.

12. Ask them what they think will happen if they shake the jar. Challenge them to try it. (to "shake," you can pour contents from one cup to another)

13. Before they shake the jar, have them check that the lid is on tightly. After they shake the jar, have them set it down and wait a few minutes.
14. After the jar's contents have stopped moving, have them observe how many layers are in the jar and where the objects are resting now compared to before they shook the jar. Tell them to draw a new diagram on p. 41, showing the liquid layers and the positions of the objects.
15. To further demonstrate the density and viscosity differences among the three liquids, have the youth fill their labeled cups 3/4 full with the liquid shown on the label. The volume of liquid in each cup needs to be *equal* . To make sure that the volume in each cup is the same, direct the youth to line the cups up on the table and to view the liquid levels through the side of the cups, not from above. If the levels are not the same, tell them to slowly add more or pour off a little liquid until all three cups contain equal volumes of liquid.

Do this as a demonstration or in 2-3 bigger groups

16. Working in teams, have them drop a penny into each of the three cups, releasing the pennies at *exactly* the same moment. Tell them to note which one takes the longest to reach the bottom.

    The penny will take the longest to reach the bottom of the cup of corn syrup. Corn syrup has the greatest viscosity of the three liquids.

Why It Happens

If the liquids do not mix as they are added to the jar, they will form layers. Because the corn syrup has more mass in its 1/2 cup volume than do the other liquids, the syrup will form the bottom layer—the syrup is the densest of the liquids tested. The same volume of oil is lighter than the other liquids, so the oil will float on the other two liquids, forming the top layer. The density of vinegar or water is intermediate to those of syrup and oil and will form the middle layer in the jar. These layers occur because of the differences in density among these liquids.

Similarly, the density of each solid object will determine in which liquid layer the object will come to rest. Each of the solid objects will sink until it reaches a liquid layer that is denser than the object. The object will be suspended at that point in the liquids. Some of the objects are denser than all three liquids and will sink to the bottom of the jar. Some are less dense than the oil; these will float on top of the oil. Where an object comes to rest depends on both the density of the object and the density of the liquid.

When the jar is shaken, the vinegar or water and the corn syrup will mix, producing a new mixture. The result is two liquid layers, instead of the original three layers. The vinegar-or-water/corn syrup mixture is less dense than corn syrup alone and more dense than vinegar or water alone. Because the oil does not mix with the other two liquids and is less dense than the vinegar-or-water/syrup mixture, the oil will gradually separate out and form the top layer in the jar. Sometimes the vinegar or water and corn syrup will not mix evenly. If that happens, the mixture layer will have a gradient of increasing density, with the greatest density at the bottom of the mixture layer. The positions of some of the objects in the jar will change in accordance with their densities relative to the densities of the two liquid layers now contained in the jar.

Density is a measure of the substance's mass relative to its volume. Viscosity describes the resistance to flow of a substance. The more a substance resists flowing or pouring, the more viscous is that substance. Liquids with a high viscosity pour slowly and are usually thick, whereas liquids with a low viscosity pour quickly and are usually fairly thin. For example, molasses is a viscous liquid. Have you ever heard or used the expression, "slow as molasses?" Molasses resists flowing—molasses pours very slowly. In the activity, the speed with which the penny sank is related to the liquid's viscosity: the greater the liquid's viscosity, the slower the penny sinks. The penny moved slowest through the corn syrup because the syrup is the most viscous of the three liquids tested. Viscosity is caused by the internal friction of a liquid's molecules moving against each other. Viscosity affects the rate at which the objects move through the liquid, whereas the density of the object and the liquid determine where the object or liquid settles.

Talking It Over

Sharing

Q: Remember what you observed. Look at your drawings. Can a liquid float on another liquid? Why?

A: Yes, liquids can float on other liquids. This happens because the liquids have different densities. The most dense liquid will sink to the bottom and the least dense liquid will float on top. The liquid having a density intermediate of the other two liquids will stay between them.

Q: Compare your predictions to what happened. How did you do in predicting the results?

A: Some youth may be better at predicting than others, but it is likely that everyone will have had at least one result that differed from their prediction. Unexpected results often happen in science. When unexpected results occur, scientists will usually repeat the experiment to be sure that the result wasn't just a fluke and then do further experiments to figure out why it happened. Similar to other problem-solving processes, the scientific method involves making predictions based on what is known, doing experiments to test the prediction (or hypothesis), and then revising the hypothesis if the result differs from the prediction.

Q: If you shared your data chart with someone else, would they get a good picture of what happened during your experiment? How can you improve your data collection and reporting skills?

A: If you are observant and carefully record what you observe, with words or in pictures, then others should be able to understand what happened from your description. Be sure to include enough detail, such as exactly which layer or layers the object stopped in, so that others will get a good idea of what you saw.

Q: Can a solid object float in one liquid, but sink in another liquid? Give an example.

A: Yes. Several objects may behave this way.

Processing

Q: Does the size of the object affect where it rests in the liquids?

A: Density determines where the object comes to rest. Recall that density is the mass of the object relative to its volume. For example, a large, light object may not settle as far down in the liquids as a smaller, heavier object.

Generalizing

Q: Explain what makes an object sink or float. Consider both the properties of the object and the properties of the liquid.

A: Whether an object floats or sinks in a liquid depends on the object's density relative to the density of the liquid. If the object's density is greater than the liquid's density, the object will sink in that liquid. If the object's density is less than that of the liquid, the object will float on that liquid.

Applying

Q: Pretend that you work for the Coast Guard. You are notified that an oil tanker has hit some rocks just off shore and is leaking oil. Using what you know about density layers, where would you expect to find that oil relative to the water near the tanker? Suggest some ways you might be able to contain and clean up the oil spill.

A: Oil is less dense than water, so the oil will float on top of the water. To clean up the oil, one could skim the oil off of the top of the water.

Frequently Asked Questions

Q: Why does warm air rise and cool air sink?

A: Temperature affects density. When air, water, or other fluids are warmed, their molecules spread out more, so that there are fewer molecules in a given volume of warmer fluid than when the fluid was cooler. Thus, the fluid is less dense when it is warm than when it is cool. This enables such things as hot air balloons to rise—when the air in the balloon becomes warmer than the surrounding air, the balloon rises because the warm air in the balloon is less dense than the surrounding, cooler air.

Expanded Activity

Each youth will make their own special density layer drink.

1. Have each youth put about 1/4 cup of corn syrup in a clear plastic cup.
2. Let each youth add a few drops of food coloring to the corn syrup and stir the coloring into the syrup with the straw or stir stick.

3. Instruct the youth to slowly pour about 1/2 cup of seltzer or carbonated water, or lemon-lime soda into the cup.
4. If desired, they may tint the water or soda with food coloring. Suggest that they use a different color than the one they used to tint the syrup.
5. Direct the youth to top their drinks with a couple of tablespoons of whipped cream.
6. Tell them to observe the three layers in their drinks. They may use their straws or stir sticks to sip and mix the layers. Enjoy!

More Challenges

More Challenges

1. Calculate the volume of a penny using the equation:

   $\text{radius}^2 \times \text{pi} \times \text{height} = \text{volume of a cylinder}$

   The radius of a penny is 9.5 mm (19 mm diameter divided by 2 = radius). The penny's height or thickness is 1/16 in. or 1.59 mm. So, the volume of a penny is: $9.5^2 \times 3.14 \times 1.59 = 450.6\ mm^3$. Convert millimeters to centimeters: $450\ mm^3 \times 0.001 = 0.45\ cm^3$. (The conversion factor is derived from the fact that there are 1000 cubic millimeters in each cubic centimeter: $1\ cm^3/1000\ mm^3 = 0.001$.)
2. Estimate the mass of the penny by weighing ten pennies on a kitchen scale. Divide the total weight by ten to determine the weight of a single penny. A penny weighs about 0.13 oz. or 3.6 g (1 oz. has 28 g).
3. Calculate the density of a penny by dividing its weight by its volume:

   $$\frac{3.6\ g}{0.45\ cm^3} = 8\ g/cm^3$$
4. Refer to the density table on p. 43 of the youth book to determine the likely metals contained in a penny. The density of a penny ($8\ g/cm^3$) is greater than zinc and less than brass. From this information, we can surmise that the penny contains zinc and some denser metal. To figure out which of the denser metals is in the penny, consider other properties of the penny, such as its color. A penny is made of copper-coated zinc.

Adaptations for People with Disabilities

- Youth with visual impairments can work with a partner. Have the visually impaired youth hold identical containers of each liquid to compare their weights. They can select objects to sink to different layers based on their assessment of the weights of the objects.
- Youth with hearing impairments should be able to do this activity without any modifications other than those necessary for communicating the instructions.
- Youth with mobility impairments should work with a partner.