FOR THE TEACHER

ACTIVITY ONE

Observing Mystery Bottles

▼ ***Students closely observe the action of liquids in specially prepared mystery bottles.***

Rationale

Motivate students by appealing to their curiosity. There are a number of ways that students could be introduced to the concepts of the **density** and **viscosity of liquids** and to the ways **of scientifically solving problems**. The particular approach taken here attempts to motivate them by first introducing a very appealing "toy" to stir their curiosity. By not telling them what is in the bottles, even though they are household liquids, the situation becomes a game. After observing the bottles, they are challenged to identify the liquids. In later activities, students mix the different liquids, making comparisons and performing simple tests. Students can deduce what the liquids are in each of the mystery bottles.

The mystery bottles have been found to have a very broad appeal. In trial classes all students have been fascinated with the movement of the liquids. In fact, there are a number of adult toys that tap into the same kind of fascination. Some students have been so intrigued that they have attempted to make similar kinds of bottle arrangements at home. Therefore, it will not take much coaxing to get the students to observe what is occurring in each set of bottles.

Allow students to observe the liquids and to speculate why the liquids behave as they do. The action of the liquids may at first glance appear to be simple. Closer observation will reveal that there are variations in the movement of the liquids. Sometimes the same set of liquids will not behave in the same way each time the bottles are turned upside down.

Help students become more confident about their own ability to make sense of the world of science and to help them develop the skills to do so. They have developed their own personal intuitive theories about many kinds of phenomena, which they apply to their investigations in school. Their thinking may be scientifically wrong when they attempt explanations. At this point, their comments should be accepted because it is more important for them to become involved in attempting explanations than in giving the right answer. As they go through the activities of this unit, they can refine both their observations and their thinking so that it will become more in line with formal science. The activities are designed to help students become more confident about their own abilities to make sense of the world and to help them develop the skills to do so.

You will need to prepare a set of mystery bottles before class.

Materials

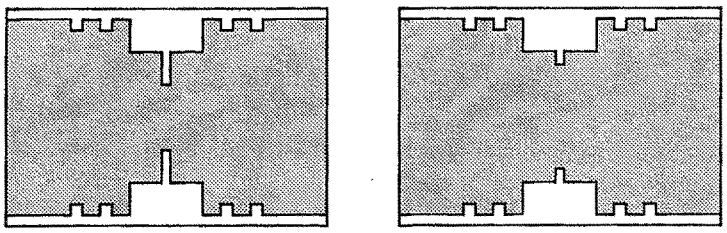
- 12 clean, 16-ounce bottles or 1/2-liter bottles (Ask students to bring these from home.)
- 6 tornado tube connectors
- Round file
- Pipe thread tape
- Set of liquids
  - Cooking oil
  - Baby oil
  - Clear Karo® syrup
  - Alcohol – 70 percent (**Note:** there are two types of alcohol: normal rubbing alcohol is 70 percent; the other kind is 91 percent. Most drug stores carry 70 percent.)
  - Water
  - Salt water (Kosher salt is preferable; see following text for preparation.)
- 1 bottle containing red food coloring
- 1 bottle containing blue food coloring
- 1 bottle containing yellow food coloring

Preparation

You will have to prepare six different mystery bottles, filling each with two different liquids.

Make sure the insides of the bottles are thoroughly cleaned, rinsed, and dried.

Enlarge the hole inside the tornado tube connector. Using the round file, scrape this hole until it is as large as the one shown in the drawing.



Wrap pipe thread tape (about six inches) around the tops of the 16-ounce bottles. This is very important because it will prevent leakage after the bottles are connected.

For each mystery bottle, screw the connector onto one of the 16-ounce bottles. Pour liquid into this bottle up to the top of the connector. Pour another liquid to the top of a second bottle. For each mystery bottle, there are two different liquids.

Here are the combinations contained in each mystery bottle. You will need to color some of the liquids by adding several drops of food coloring to them. Mix these in the liquids before joining the two bottles. It takes a while for the food coloring to mix with the syrup. Try mixing the food coloring with only half of the Karo syrup first and then add syrup to the top.

Pair A: Fill one bottle with **baby oil**. Fill the second bottle with **water** and one drop of **blue** food coloring.

Pair B: Fill one bottle with **cooking oil**. Fill the second bottle with **salt water*** and add one drop of **blue** food coloring and two drops **yellow** food coloring.

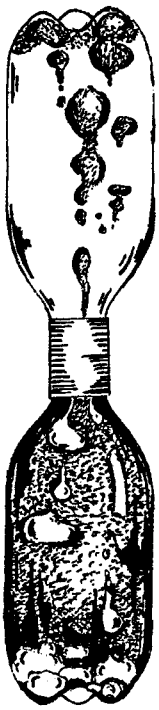
(*Prepare the salt-water solution by placing **10 tablespoons** of **kosher [additive-free] salt** in a two-liter bottle filled with tap water. Shake well and let sit for a few minutes. **Note:** You can use regular table salt. There are additives in regular salt that result in a slightly cloudy solution.)

Pair C: Fill one bottle with **baby oil**. Fill the second bottle with **alcohol** and one drop each of **blue** food coloring and **red** food coloring.

Pair D: Fill one bottle with **cooking oil**. Fill the second bottle halfway with **Karo syrup** and add six drops of **red** food coloring. Turn the bottle over several times to mix the syrup and food coloring before completely filling the bottle with syrup. Continue flipping the bottle over until the syrup is all one color. Then join this bottle to the one with cooking oil.

Pair E: Fill one bottle with **cooking oil**. Fill the second bottle with **water** and one drop of **blue** food coloring.

Pair F: Fill one bottle with **cooking oil**. Fill the second bottle with **alcohol** and one drop each of **red** and **blue** food coloring.



Hold one bottle in each hand. Quickly turn over the bottle without the connector and screw the connector on this bottle. This is an unavoidably messy operation. Try not to allow too many air bubbles into the bottle.

Label each mystery bottle with its letter, A through F.

Leading the Activity

Introducing the Activity The mystery bottles are the **focal point of the next six activities**. Students will attempt to identify which liquids are in each of the bottles. Before they actually mix liquids and attempt to make comparisons with the unknown liquids, they should spend some time closely observing these bottles. These observations will then be the reference point for later activities. Initially, students may make superficial observations and miss some of the subtle action of the liquids. Tell them **the challenge is to see how closely they can observe what is occurring in the bottles when they are turned over**. Some teachers in field tests spent two sessions just having students observe these bottles.

Give each group of students one of the mystery bottles. Whatever way you choose to present them, have students spend some time looking at each bottle in the pair. They can discuss with each other what they see happening.

After a certain amount of observation and note taking, the bottles can be rotated among groups. This allows each group the opportunity to observe each of the liquid containers.

Assisting Students During the Activity Move around the classroom from group to group, observing the students' investigations and listening to what they are discussing. Take notes of what they are saying. These can be used in the follow-up discussion to help determine the questions to ask.

Here are some questions to focus on during your observations:

- What specific features of the liquids are students giving the most attention?
- Are they making comments that refer to liquids they already know?
- Are they comparing the behavior of the liquids in the different bottles?
- Do they make analogies to other kinds of phenomenon?

These questions can also be the basis for an on-going assessment of student behavior and learning.

Leading the Discussion

Reporting the Results First, have students share their observations.

Record their observations on the board or on newsprint sheets. These observations will be used as main reference points and can be referred to later.

Students can compare what they know at that time to what they observe in these initial observations. You can also use them as reference points for embedded assessment.

Discuss the questions on the *For the Student* page. Here are some responses to these questions:

- The liquids always separate from each other. After mixing, some combinations take longer than others for a complete separation to occur.
- If the bottles are vigorously shaken, it may take a much longer time for the two liquids to completely separate.
- The shape of the drops coming from the hole in the connector is not totally predictable.
- The drops of the sinking liquid in each pair of bottles can vary a great deal in shape.
- Some liquids will just form a stream, but others will break into spherical drops.
- The size and shape of the hole in the connector can affect the flow of liquid as they move past each other.
- When the bottles are turned over, air bubbles rise quickly through most of the liquids.

The container having the Karo syrup is particularly interesting to watch. The bubbles may move in erratic ways. It should be apparent that the colored liquid in Bottle D is thick. Ask students what observations they used to determine the thickness in Bottle D. Some students may have noticed that air bubbles rise slowly in this liquid when the bottle is turned over. Also, the tip of the sinking column of liquid curls up on the liquid that is already there instead of immediately mixing.

Each of these observations is an opportunity to probe students' thinking about what is causing these different behaviors to occur. Ask them to give explanations.

Here are some examples to get them started:

- The sinking, colored liquid in Bottle A forms a bubble-like structure for a few seconds before breaking and mixing with the rest of itself. Ask students to speculate why this happens.
- Some of the liquids are the same color. Do the same color liquids behave the same way in each of the bottles? For instance, the purple liquid is always at the top in Bottle F, but it always sinks to the bottom in Bottle C. If the purple liquid is the same in each mystery bottle, what do these observations tell students about the heaviness of the purple liquid relative to the two other liquids? Bottles B, D, E, and F have a yellow-colored liquid. Is it possible that this is the same liquid in each bottle?

At this point tell students that the liquids in the bottles are ones they have around their house, and some are definitely used in cooking. Ask them now to guess what the liquids are.

Assessment

In this session, keep a record of all the comments students make about the liquids. Especially note the explanations given for the behaviors of the liquids. These comments reveal the prior knowledge students are bringing to the investigation and can be used as a reference point. Refer to these comments at the end of the first part of this investigation and check to see how the students' knowledge has changed.

Homework

Ask students to examine and observe liquids in their kitchen at home and to take notes to share in the next class. Tell them that they should **stay away from liquids that are poisonous or flammable.**