ACTIVITY 3

Properties of Ocean Water

OBJECTIVES

Students determine the salinity of "ocean water" by measuring the density of the water.

The students

- discover how the presence of salt increases the density of ocean water
- observe that the denser a liquid, the higher things float in that liquid
- make a simple hydrometer and use it to measure the relative density of salt water samples

SCHEDULE

Session I About 20 minutes
Session II About 40 minutes

VOCABULARY

density
hydrometer

MATERIALS

For each student

1	Activity Sheet 3, Parts A and B
1	pencil*

For each team of four

1	pencil, hydrometer, 10-cm
1	sticker, preprinted (for wooden hydrometer)
1	thumbtack
1	tube, plastic, with base

For the class

4	containers, plastic, 1-gal
17	cups, plastic, 10-oz
1	egg, fresh*
1 bag	marbles
1 roll	paper towels*
1	pen or marker*
1 cont	salt, table
1	spoon, plastic
1 roll	tape, masking*
1	tube, plastic, with base
	water, tap*

*provided by the teacher

PREPARATION

Session I

1. Make a copy of Activity Sheet 3, Part A, for each student.
2. You will need a tube filled with marbles and some tap water for a class demonstration on density. (You may choose to use salt instead of tap water for the density demonstration.) You will need a clear plastic cup, table salt, a plastic spoon, some tap water, and an egg for a demonstration on buoyancy in dense (salty) water.

Session II

1. Make a copy of Activity Sheet 3, Part B, for each student.
2. To show students how a hydrometer works, you will need an assembled wooden hydrometer (see step 6), a plastic tube, a plastic cup, some tap water, some table salt, and a spoon.

3. Prepare four water samples ahead of time, as follows (2 qt equals half of the 1-gal container):

   Sample A: 2 qt water + 1 c salt
   Sample B: 2 qt water + ½ c salt
   Sample C: plain tap water (no salt)
   Sample D: 2 qt water + 1½ c salt

   Mix each sample in a 1-gal container and let sit for several hours, so that the water clears up.

4. Set up four distribution stations: A, B, C, and D. At each station place four plastic cups. Label the station and the cups using masking tape and a pen or marker. Then fill the four cups with the corresponding water sample (total: 16 cups). Keep the large containers of each sample handy for refills, as needed. If you have more than four teams of students, the cupfuls will be tested by more than one team.

5. Each team of four will need one 10-cm hydrometer pencil, a preprinted hydrometer sticker, one thumbtack, one plastic tube with base, and access to the water samples at each distribution station. Have paper towels available in case of spills.

BACKGROUND INFORMATION

Ocean water is approximately 3.5 percent dissolved salts—enough to make the water taste salty. This salt content is large enough to change some other properties of ocean water, too. For example, the presence of dissolved salts makes ocean water denser than fresh water.

Density refers to the amount of matter in a given volume of a substance. When salts are dissolved in water, the ions that make up the salt crystals fill in the spaces between the water molecules. The more salt dissolved in the water, the denser the solution.

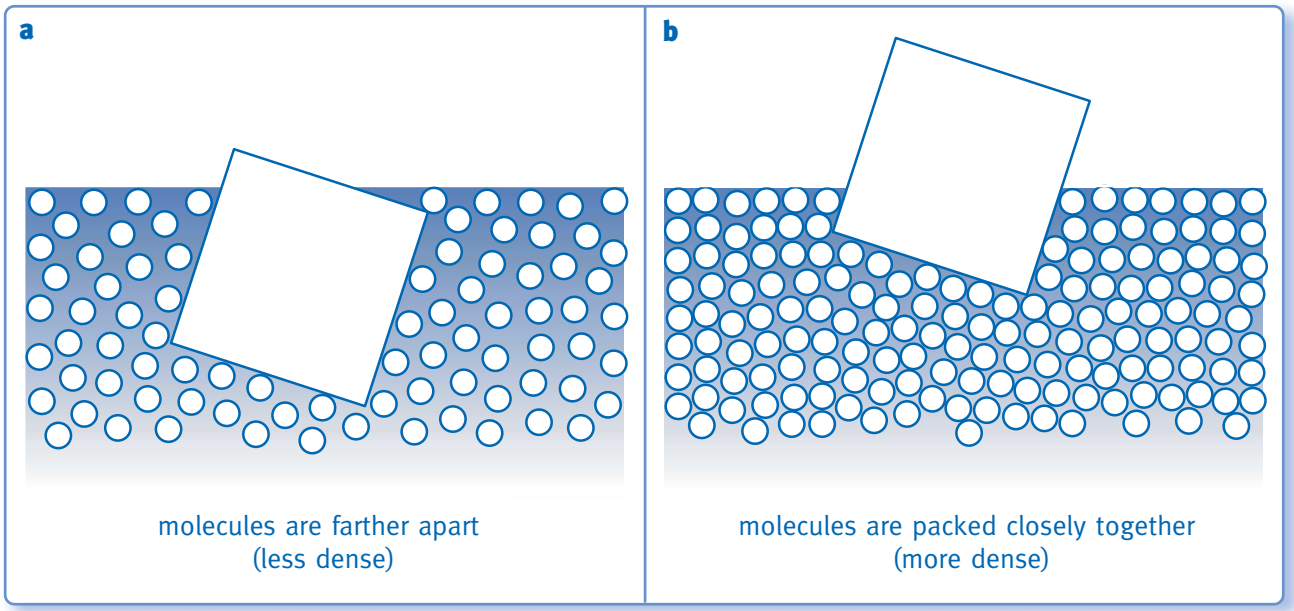
The density of a liquid affects how high an object floats in it. For example, when an object is placed in fresh water, the object will displace, or push out of the way, a volume of water molecules equal to the weight of the object. Naturally, the heavier the object, the more molecules it displaces and the lower it sinks. (See Figure 3-1a.)

When an object is placed in denser salt water, however, fewer molecules get displaced, or pushed aside, by the object. So the object sinks less in the salt water than it does in fresh water. (See Figure 3-1b.)

A ***hydrometer*** is an instrument used to measure the density of a liquid compared to that of water. A hydrometer consists of a weighted glass tube that floats vertically when placed in a liquid. The tube is calibrated and a reading is made at the surface of the liquid. The higher the hydrometer sits in the liquid (the better it floats), the higher the reading and the denser the liquid.

Oceanographers and aquarists (people who establish and maintain aquariums) use hydrometers to measure the density of ocean or aquarium water. By measuring the density of the water, they can determine the salinity—salt content—of the water. Fresh water, for example, has a density of 1.000 g per cubic centimeter (g/cm^3). Ocean water has an average density of about 1.025 g per cubic centimeter.

In this activity, students make their own hydrometers and use them to measure the relative density of some "ocean water" samples. From their readings they can determine the relative salinity of the water samples.

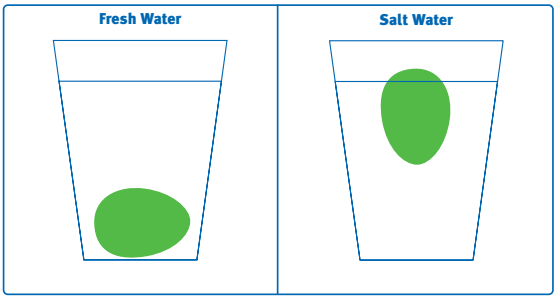


▲ ***Figure 3-1.*** *The denser the liquid, the higher an object floats in it.*

▼ Activity Sheet 3, Part A

Properties of Ocean Water

1. Which contains more matter: a tube full of marbles or a tube full of marbles and water?
   a tube full of marbles and water
2. Which is denser: a tube full of marbles or a tube full of marbles and water?
   a tube full of marbles and water
3. Which contains more matter: a container of fresh water or a container of salt water?
   a container of salt water
4. Which is denser: fresh water or salt water? salt water
5. Draw a picture to show what happened to the egg in each cup of water.



6. What can you conclude about the density of a liquid and how well objects float in it?
   Objects float better or higher in a liquid that is dense such as salt water.

▼ Activity Sheet 3, Part B

Properties of Ocean Water

1. What does a hydrometer measure?
   A hydrometer measures the density of water.
2. How can knowing the density of a water sample help you determine the salinity (salt content) of the sample?
   The denser the water sample, the saltier it is. High density means high salinity.
3. Test each water sample with your wooden hydrometer. Then write your results in the table below.

Water Sample	Hydrometer Reading
A	Readings will vary
B	but order from
C	low to high is
D	C, B, A, D.

4. Which sample has the lowest density? Sample C
   Which sample has the highest density? Sample D
5. Which water sample has the lowest salinity? Sample C
   Which water sample has the highest salinity? Sample D

Guiding the Activity

Session I

1 Review the composition of ocean water: 96.5 percent water, 3.5 percent salts. Tell students, We know that salt changes the flavor of ocean water. Ask, **But what other properties of water are affected by salt?**

Hold up a plastic tube filled with marbles. Ask, **Is this tube full?**

Pour tap water into the tube, and fill it to the top. Hold up the tube again and ask, **Is the tube full now?**

Tell students that this is a model of how salt dissolves in water to form salt water. Explain that the blue marbles in the tube represent water molecules magnified many millions of times. The water between the marbles represents particles of dissolved salt filling in the spaces between the molecules of water. This is what happens whenever dissolved salts are present in water, as they are in ocean water. (See Figure 3-2.)

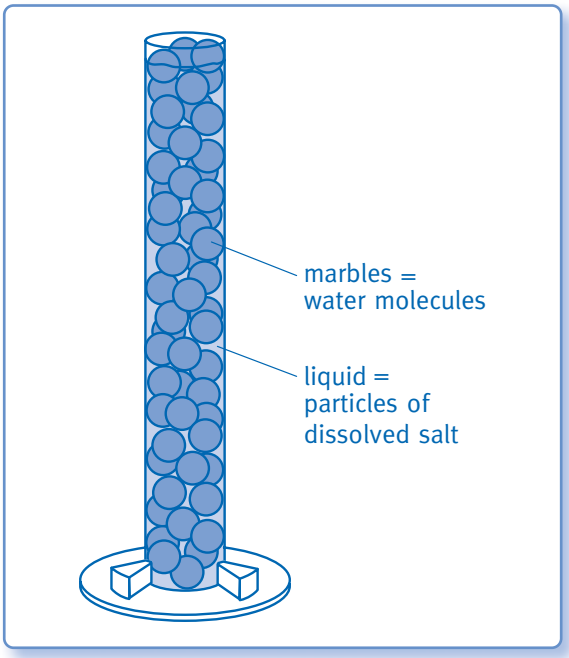
Additional Information

Students who live near the coast may know that salt water takes longer to freeze than fresh water. Students who like to cook may know that adding salt to water makes the water boil faster. (Salt lowers the freezing and boiling points of water). Accept all answers.

The correct answer is that the tube is full of marbles, but it is not "full" at all. There is air in the spaces between the marbles.

Students should see that the spaces between the marbles are now filled in with water. The tube is now full.

If students have trouble equating the water in the tube with particles of dissolved salt, use salt instead of water.



▲ ***Figure 3-2.*** *When salt dissolves in water, the particles of dissolved salt spread out and fill in the spaces between the water molecules, the way water fills in the spaces between marbles in a container.*

Guiding the Activity

Additional Information

2 Distribute a copy of **Activity Sheet 3, Part A,** to each student. Then write the words *dense* and *density* on the board. Ask, **What does the word *dense* mean?**

Students may respond with words such as thick, solid, *or* hard. *Accept all reasonable answers.*

Tell students that **density** refers to the amount of matter in a given volume. Matter is "stuff"—anything that takes up space. The more matter in a given volume of substance, the denser that substance is said to be.

Ask, **Which tube contains more matter: the tube full of marbles or the tube full of marbles and water? Which is denser?** Have students answer question 1 on their activity sheets.

The tube of marbles and water contains more matter and is therefore denser.

Ask, **Which contains more matter: a tube full of fresh water or a tube full of salt water? Which is denser?** Have students write their answers to question 2 on their activity sheets.

Students should infer from the model that a container of salt water contains more matter and is therefore denser than a container of fresh water.

Explain that the presence of dissolved salt changes the density of water. The more salt dissolved in water, the denser the water becomes. Ocean water, therefore, is denser than fresh water.

3 Empty the tube of marbles and water. Fill a clear plastic cup with warm tap water to about 2 cm (¾ in.) from the top. Place the cup of water on a table for students to see. Hold up an egg and ask students, **What do you think will happen if I place this egg in the cup of water?**

Some students may predict that the egg will float, while others may predict it will sink. Accept all answers.

Gently place the egg in the cup of water and ask students to observe what happens. Have students draw what they see on their activity sheets.

A fresh egg should sink in ordinary tap (fresh) water.

Remove the egg from the cup of water. Add four spoonfuls of salt to the water and stir until there are no more crystals on the bottom of the cup. Ask, **What do you think will happen if I put the egg in this cup of salty water?**

Accept all answers.

Guiding the Activity

	Additional Information
Gently place the egg in the water and ask students to observe what happens. Have them draw what they see on their activity sheets.	*The water will be cloudy because of some undissolved salt in the water, but students should be able to see the egg floating near the top of the cup of salt water.*
To review, ask, **Which is denser: salt water or fresh water?**	*Salt water is denser than fresh water.*
Ask, **In which cup of water did the egg float better: in the cup of salt water or in the cup of fresh water?**	*in the cup of salt water*
Ask, **What can you conclude about the density of a liquid and how well things float in it?** Have students answer question 6 on the activity sheet. Then review the answer as a class.	*The denser the liquid, the better, or higher, things float in it.*
Ask, **How could you use what you have just learned to determine the salinity, or salt content, of salt water?**	*Students have just learned that the saltier the water, the more dense it is and therefore the higher things float in it. Conversely, by observing how high something floats in water, they should be able to determine how dense the water is and therefore how much salt the water contains.*
Tell students that in the next session they are going to do just that.	
Save the cup of salt water with the egg in it. Set it aside for several hours, or until the water is no longer cloudy. Then have students look at it again. They should have a clearer picture of the egg floating at the top of the water. If they ask, explain that the white residue at the bottom of the cup is the undissolved salt that was making the water cloudy.	
Return the marbles, container of salt, and plastic spoon to the kit.	

Guiding the Activity

Session II

4 Hold up the pencil hydrometer you have assembled. Ask students if they know what it is.

Write the word *hydrometer* on the board. Tell students that a **hydrometer** is a device that measures the density of a liquid. Explain that a scientific hydrometer consists of a glass tube with a weighted bulb at the bottom. The hydrometer is placed in a liquid, so that it floats upright. The higher it floats in the liquid, the denser the liquid is said to be. Your wooden pencil hydrometer works in the same way.

Distribute a copy of **Activity Sheet 3, Part B,** to each student. Tell students to answer question 1.

5 Demonstrate how a hydrometer works. Fill a plastic tube with tap water and set the tube on its base. Lower the hydrometer into the tube. Ask a student volunteer to note the level at which the hydrometer is floating in the water.

Next, pour the water from the tube into a plastic cup. Add 1 spoonful of salt and stir for one minute. Pour this salt water sample back into the tube and drop in the hydrometer. Ask a student volunteer to read the level at which the hydrometer is floating.

Ask, **What does a higher reading indicate?**

The reading should be higher.

Adding salt to the water increased the density of the water; that is, salt water is denser than fresh water.

Explain that oceanographers and people who maintain salt water aquariums use hydrometers to determine the salinity of water. Hydrometers indicate the salinity of water by measuring the water's density. Have students answer question 2 on the activity sheet.

Tell students they are now going to make their own hydrometers.

Additional Information

Guiding the Activity

6 Divide the class into teams of four. Distribute one 10-cm hydrometer pencil, one hydrometer sticker, one thumbtack, and one plastic tube with its base to each team.

Tell students to peel off the hydrometer sticker from the backing and affix the sticker just above the metal ring on the pencil, with the 20 toward the eraser end.

Once applied, the stickers are difficult to peel off. Tell students to place their pencil flat on their desk, center the sticker numbers over the pencil, and carefully press on the sticker. Pick up the pencil and wrap the remainder of the sticker around it.

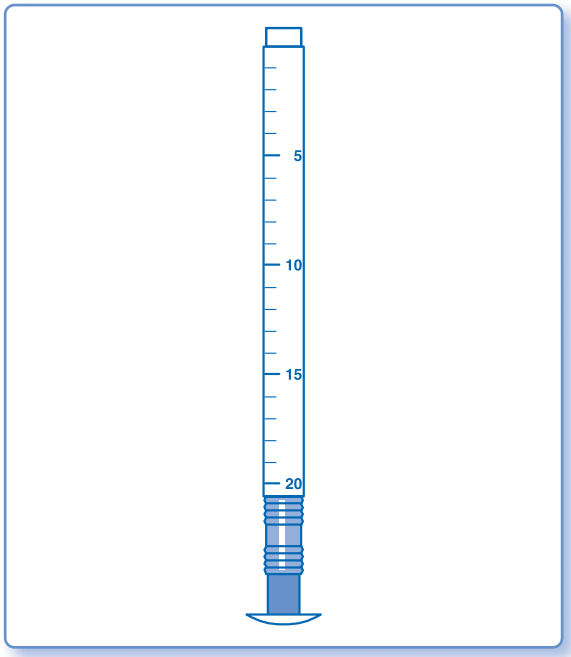
Tell them to carefully push the thumbtack into the eraser. This end will be the bottom of the hydrometer. The top of the hydrometer is the end closest to 1 on the sticker. (See Figure 3-3.)

7 Bring students' attention to the four distribution stations you have set up: A, B, C, and D. Point out that each station has a different water sample for students to test, and each team will have the opportunity to test a sample from all four stations.

Explain the procedure, as follows: A student from each team is to go to a distribution station, get a cupful of the water sample, and bring the sample back to his or her work station. Each team will then test the sample with their wooden hydrometer.

To test the water sample, students will pour the cup of water into the tube. Then they will insert the hydrometer into the tube of water and record the reading in the table on their activity sheets, next to the letter of the sample. (See Figure 3-4.)

Additional Information



▲ ***Figure 3-3.*** *A wooden hydrometer.*

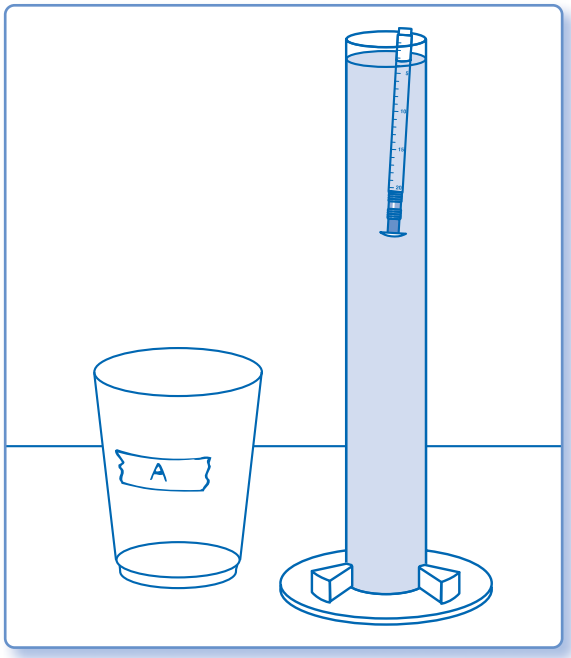
Have extra quantities of each sample on hand in case of spills.

Guiding the Activity

When each team has finished testing the sample, they are to pour it back into the cup and return it to the station where they got it. Then they are to collect a sample at the next station.

Assign each team to a distribution station, and have them begin.

Additional Information



▲ ***Figure 3-4.*** *Testing a water sample with the wooden hydrometer.*

8 When students have finished testing all four samples, review their results as a class. Ask, **Which water sample has the lowest density? Which sample has the highest density?** Have students write their answers to question 4 on their activity sheets.

Sample C is plain tap water and should have the lowest density. Sample D contains more salt than the others. It has the highest density.

Then ask, **Which sample has the lowest salinity? Which sample has the highest salinity?** Have students write their answers to question 5 on their activity sheets.

The sample with the lowest density (C) has the lowest salinity. The sample with the highest density (D) has the highest salinity.

Finally, ask, **Why might sailors be interested in knowing the salinity of the water in which they are traveling?**

The saltier the water, the higher their boats will float. The higher the boats float, the more weight they can carry without sinking. The danger lies in bringing heavily loaded boats from salt water bodies (oceans or seas) into fresh water bodies (rivers or lakes).

Tell students that in the next activity, they are going to switch gears from water to land—that is, the land beneath the oceans.

Reinforcement

Have students make up their own samples of salt water of different densities. They can then use their wooden hydrometers to measure the relative density of the new samples.

Assessment Opportunity

This Reinforcement also may be used as an ongoing assessment of students' understanding of science concepts and skills.

Science Journals

Have students place their completed activity sheets in their science journals.

Cleanup

Discard the water samples. Collect the tubes and cups, rinse and dry them, and return them, along with the container of salt and plastic spoon, to the kit. Collect the wooden hydrometers. You will need six wooden hydrometers for the Assessment Activity. After the Assessment, remove the stickers by soaking the pencils in warm soapy water. Rinse the pencils and allow them to air dry.

Connections

Science Challenge

Do the following activity after students have explored the densities of various liquids in the second Science Extension below. Before class, label four tall, clear plastic cups A, B, C, and D, and fill them with plain water, salt water, rubbing alcohol, and glycerol. Show students the cups and name the liquids, but do *not* tell them which cup contains which liquid. Ask students how they might be able to identify the liquid in each glass without tasting or smelling it, testing it with a hydrometer, or layering the liquids in one container. Students may suggest floating identical objects (such as wooden blocks) in the cups to see which liquid causes the object to float higher (and thus is more dense) and which causes it to float lower (and thus is less dense). Try this test as a demonstration, then let students order the liquids from least to most dense and identify each liquid.

Science Extension

- To clarify the concepts of density and volume, give each student a piece of aluminum foil about 10 cm (4 in.) square. Have students crumple the foil into a loose ball and measure its diameter. Then tell them to compress the ball tightly and remeasure its diameter. Ask: Did the amount of aluminum foil in the ball change? (No.) Did the volume of the ball change? How? (Yes; the volume decreased.) When you decreased the volume of the ball, what happened to the ball's density? (It increased. There was more "stuff" squeezed into a smaller space.)

- Provide a variety of other liquids for students to test with their hydrometers, such as distilled water, milk, vinegar, cooking oil, rubbing alcohol, and glycerol. (Beforehand, tint the clear liquids [except the cooking oil] with different colors of food coloring so students can differentiate between them easily.) Have students set up a table similar to the one on Activity Sheet 3, Part B, for recording their results.

Science and Math

Let students make a bar graph of their results in the second Science Extension. Tell them to label the vertical axis *Hydrometer Reading,* arrange the liquids along the horizontal axis from least dense (alcohol) to most dense (glycerol), and label each bar with the name of the liquid.

Science and Language Arts

Write *hydrometer* on the board, and underline *meter.* Explain that *-meter* at the end of a word means "a device for measuring," and the first part of the word tells what is measured—in this case, *hydro,* meaning "water." Ask students to suggest other words that end with *-meter* and identify what is measured by each device. (Examples: *thermometer,* measures temperature or heat; *altimeter,* measures altitude; *barometer,* measures atmospheric pressure; *odometer,* measures distance traveled.)

Science and Social Studies

Encourage your more advanced students to find out about high-salinity bodies of water such as the Dead Sea, Great Salt Lake, and Mono Lake (in California). Why are these bodies of water so salty? How does their high salinity affect the kinds of organisms that can survive there? Let students report their findings to the class.