THE SCIENCE OF
Water

How Much Water Is in a Fruit?

from *The Science of Water Teacher's Guide* and for *Mystery of the Muddled Marsh*

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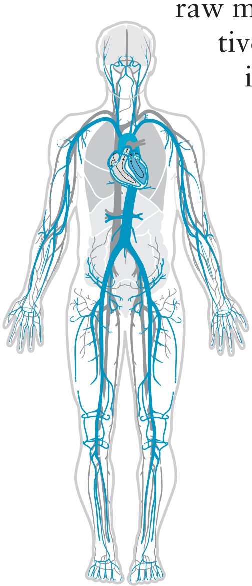
Water in Our Bodies

Life Science Basics

Every living organism, whether it consists of one cell or billions, relies on water for the transport of nutrients and, in most cases, oxygen. Water also is used to carry waste products away from cells. Even the countless reactions that happen inside cells must take place in water. Organisms consisting of one to just a few cells interact directly with their environments. In such organisms, obtaining raw materials and eliminating wastes are relatively simple processes, because each cell is in contact with the outside (usually water-containing) environment. More complex organisms, however, must find ways to maintain a constant internal fluid environment. They also must provide cells with the materials they need and remove waste products.

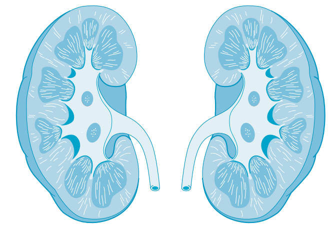


Human circulatory system

In vertebrate animals, nutrients, gases and wastes are carried throughout the body by the circulatory system—which consists of a heart and numerous blood vessels. Water is a significant component of blood and also is the base for the solutions that surround cells throughout the body. In fact, about 50% of the water in the body of a complex animal is found in fluids outside of cells.

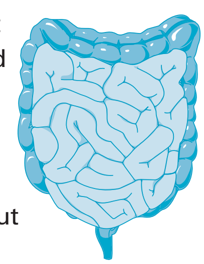
Vertebrates take in water and food through the mouth. Materials reach the stomach, where food is mixed and broken up. Food exits the stomach as a soupy mixture, which passes into the small intestine, where most digestion and absorption of nutrients occurs. Most food molecules must be broken down into smaller components before they can be absorbed into the body. These and other nutrients, like salts and minerals, pass through the cells that form the walls of the small intestine into the bloodstream. Water is essential to transport nutrients released during digestion. Materials that have passed through the small intestine enter the large intestine, where much of the water used during the digestive process is reabsorbed.

The removal of wastes from cells also depends on water. Cells release waste products into the blood, which carries them to the kidneys, organs located near the lower back that remove potentially toxic materials from the blood. The kidneys use very little water in this process. Waste materials are concentrated as urine, which is stored in the bladder until being eliminated. The kidneys also control the relative amounts of water retained within the body and/or released in urine.



The kidneys filter more than 170 liters of liquid each day. Imagine how many glasses of water this represents!

Water loss always is a threat to the survival of living organisms. Water can be lost by evaporation from surfaces involved in breathing (inside the lungs, for example), by evaporation from other surfaces (such as through perspiration), and by elimination (both in urine and in feces). Water that is lost must be replaced. Additional water can come from food, from drinking liquids and as a byproduct of energy-releasing reactions inside cells.



The small intestine of an adult human is about 23 feet long and about an inch in diameter.

The large intestine is about 5 feet long and about 3 inches in diameter.

How Much Water Is in a Fruit?

Life Science

CONCEPTS
- Water is a major component of most foods.

OVERVIEW
Students investigate the amount of water in an orange and an apple.

SCIENCE, HEALTH & MATH SKILLS
- Making and recording observations
- Weighing
- Measuring volume
- Estimating
- Predicting

TIME
Preparation: 10 minutes

Class: Two 30-minute sessions

MATERIALS
- Equal arm balance (1 per group if possible)
- Interlocking 1-cm/1-g cubes (weight for balance)

Each group will need:
- Beaker, 1,000-mL (or clear plastic cup calibrated in milliliters)
- Beaker, 250-mL (or clear cup calibrated in mL)
- Drinking straw (or 2 sheets of paper towel)
- Hand lenses (magnifiers)
- Juicer (see SETUP)
- Plastic serrated knife
- Apple
- Orange
- Water
- Copy of "How Much Juice Is in an Orange" page

The cells and tissues that make up living organisms are mostly water. For example, water comprises about 90% of the weight of a tomato, 80% of the weight of an earthworm, 70% of the weight of a tree, and 70% of the weight of a human body.

In this activity, students will investigate the amounts of water in two different fruits and use measures of weight and volume. The activity also introduces students to the concept of drying (or removing water) as a means of preserving foods. Drying can be traced back to ancient times, and was an important method of food preservation used by American Indians and early settlers in North America. When foods are dried, most of the moisture is removed. Drying makes many grains, meats and vegetables much less suitable environments for the growth and reproduction of molds, bacteria and insects.

Dehydration also makes foods lighter, and easier to store and transport. Other methods for preserving food that involve dehydration include smoking—which is faster and more effective because the absorbed smoke is toxic to many microorganisms—and salting, which draws moisture out of the food items.

Unit Links

Mystery of the Muddled Marsh

Story, pp. 18–22

Explorations

Water in Your Body, p. 8

SETUP
You will need a juicer for each group of students. If commercial juicers are not available, make your own by combining the top and bottom pieces of a 2-liter soft drink bottle (see sidebar, p. 25).

This activity will take at least two periods and may be extended to three. It should be conducted with groups of four students.

PROCEDURE
Session 1: How much liquid does an orange have?

1. While holding a bag of oranges in front of the class, ask, *How much water do you think is in this bag?* Lead a class discussion about the amount of water in an orange. Ask the students to predict the amount of water contained in one orange. Make sure they equate orange juice with water.
2. Show the students how to measure the volume of an orange by observing and measuring "how much space it takes up." Fill a prepared beaker with 800 mL of water. Record the number of mL in the beaker on the board. Then place an orange into the water. Hold it down gently, so that the whole orange

is submerged. Ask, *Did the water level go up or down? How much? Why?* To help students understand the concepts of displacement and volume, talk about what happens to the water when someone gets into a bathtub.

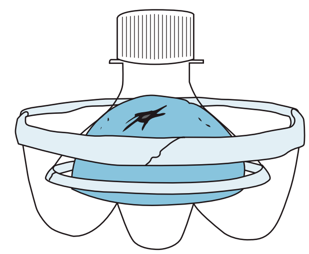
3. On the board, subtract the original volume of water in the container from the volume in the container after the orange was added. Calculate and record the difference. Ask, *What does the difference represent?* (A standard juice orange will displace about 140–150 mL and will yield 40–50 mL of squeezed juice.)
4. Have each group measure the volume of an orange by submergence, as you demonstrated. Ask the students to suggest ways to measure the amount of juice inside their oranges.
5. Show the students how to squeeze the juice out of an orange. Have them cut their oranges in half using serrated plastic knives. Use the top and bottom portions of soft drink bottles as "juicers" (see sidebar, right), use purchased plastic juicers, or let students devise their own ways to squeeze out the juice. Have each group squeeze the juice out of one orange. Make sure the students save the remainders of their oranges.
6. Have each group measure the amount of juice obtained by pouring it into a 250-mL beaker. Ask, *How can the remaining material be measured?* If students suggest weighing, have them consider the conversions necessary to equate the weight information with their earlier measurement in mL. Have students place the remaining orange pieces without juice into the beaker prepared with of 800 mL water and read the new volume. Ask, *Has the amount of water displaced changed? Why? What was the volume of the entire orange? What is the volume of the remaining "stuff"? What fraction of the orange was water?* Have students record the values they obtained on the "How Much Juice Is in an Orange" observations sheet.

Session 2: How much liquid does an apple have?

1. Ask the class, *Do you think other foods contain water? How about an apple?* Encourage the students to predict whether apples and other fruits and vegetables contain water. Ask, *How could we find out? Could we squeeze an apple?*
2. Give each group of students an apple and a plastic serrated knife. Direct the students to weigh their apples, record the values and cut their apples into slices vertically (about 1/2 cm in thickness). Have students place the slices between two sheets of paper towel, or skewer the slices along a straw (see illustration, right). Then let the apples sit in a warm place for 3–5 days. (The amount of time will vary depending on the temperature; see next step.)
3. Have students weigh their sliced apples every day and record the weights (or mass) in grams. When the slices no longer

Continued

The ancient Greek scientist, Archimedes, was the first to note that a submerged object displaces an amount of water equal to its own volume.



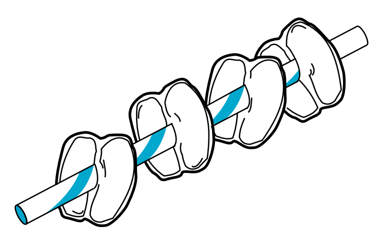
Juicer made from top and bottom parts of a 2-liter plastic soft drink bottle.

Safety note: Cover sharp edges with masking tape.

WHAT IS VOLUME?

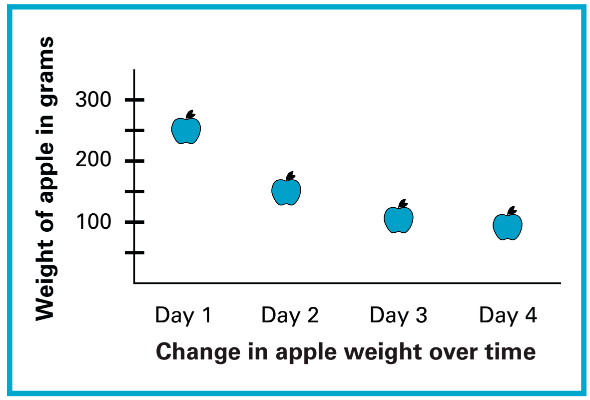
Volume is a measure of three-dimensional space that is occupied by an object or a substance.

The capacity of a container refers to the volume of material that the container can hold.



Students use a plastic straw as a skewer for apple slices.

show an appreciable change in weight from one day to the next, they have dried as much as will be possible. Have older students make a graph of the daily weights of their apple slices. Ask, *What does the graph tell us about the weight of the apple?*



4. Have students in each group subtract the final weight of the slices from the starting weight of the apple. The difference will be the weight of the water lost from the apple during the experiment.

VARIATIONS

- **Students also may want to compare weight (mass) differences between raisins and grapes, dehydrated potatoes slices (packaged potato casserole mixes) and fresh potato slices, banana chips and fresh slices of banana, beef jerky and strips of raw beef, or dried peas and fresh peas.**
- Approximately 70%, or 7/10, of the human body consists of water. Have students use the following formula to calculate approximately how much of their own weight is water.

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1. Your weight × 7 =
2. Value from Step 1 ÷ 10 = approximate amount of water in body.

OR

1. Count out the number of snap-together math cubes equal to your weight (i.e., 45 lb = 45 cubes).
2. Separate the cubes into 10 equal groups.
3. Place 7 groups in one set and 3 in another.
4. The largest set represents the portion of your body that is water.

- Have students estimate the volume of water in their bodies (1 lb of water represents approximately 2 cups).

QUESTIONS FOR STUDENTS TO THINK ABOUT

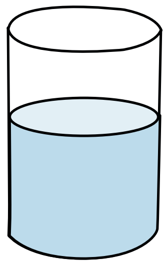
In this activity, water is measured in two ways: by volume and by weight.

- Which of these two measures is used most commonly for liquids? Why do you think so?
- Can you find a way to convert a measure of volume to a measure of weight, or vice versa?

How Much Juice Is in an Orange?

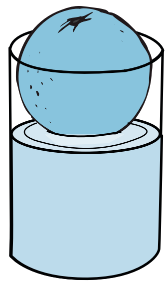
We usually measure liquids in milliliters. We also can use milliliters to measure how much space something takes up (volume).

1



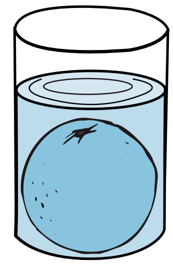
Fill a container with 800 mL of water.

2



Carefully place an orange in the container. Did the water go up or down?

3



Now, push the orange under the water and hold it there. What happened to the water?

How many milliliters are in the container now? ____________ mL

What was the change, in milliliters, from figure 1 to figure 3? ____________ mL

ESTIMATE

How much of the orange is juice? Write your estimate in milliliters. ____________ mL

DO

Squeeze the juice from the orange and measure it. How many milliliters of juice did you get? ____________ mL

COMPARE

Compare your original estimate with the actual amount of juice you measured. Did you estimate more or less juice than the amount you found? ________________ What is the difference? ____________ mL

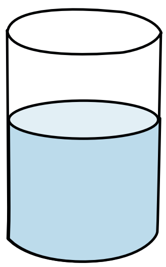
What is left of the orange? ____

Measure the leftover pieces of orange by putting them into the container of water and recording the change in volume. How many milliliters did the water level go up? ____________ mL

¿Cuánto jugo tiene una naranja?

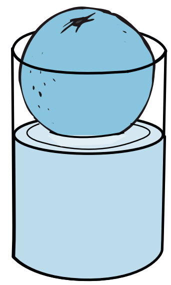
Generalmente medimos los líquidos en mililitros. También podemos usar mililitros para medir el espacio ocupado por un objeto (el volumen).

1



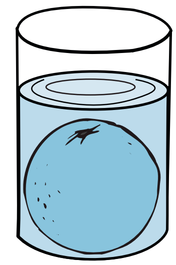
Llena un envase con 800 mL de agua.

2



Con mucho cuidado, mete una naranja en el envase. ¿Subío o bajó el nivel del agua?

3



Ahora, empuja la naranja hacia abajo del agua y detenla allí. ¿Quele pasó al nivel del agua?

¿Cuantos mililitros hay en el envase? ____________ mL

¿Cuantos mililitros cambió el nivel del agua de figura 1 a figura 3? ____________ mL

ESTIMAR

¿Qué tanto de la naranja es jugo? Escribe tu estimación en mililitros. ____________ mL

HACER

Exprime todo el jugo que puedas de la naranja. ¿Cuantos mililitros de jugo obtuviste? ____________ mL

COMPARAR

Compara tu estimación con la cantidad de jugo que obtuviste. ¿Hubo más o menos jugo de lo que estimaste? ______________¿Cuanto es la diferencia? ____________ mL

¿Qué quedó de la naranja? ____

Ahora, puedes medir el volumen de los pedazos restantes de la naranja. Sumérjelos todos en el envase con agua y observa el cambio en el nivel del agua. ¿Cuantos mililitros subió el nivel del agua? ____________ mL