All the Water in the World

Adapted from: Identifying Landforms, A Drop in the Bucket, Water Distribution Lab
https://pmm.nasa.gov/education/lesson-plans/exploring-water-cycle, https://extension.usu.edu, www.troup.org, https://pmm.nasa.gov/education/lesson-plans/earths-water

Lesson Concepts: Water covers nearly 75% of the Earth, and roughly 97% is found in our oceans. Students will learn the about the different sources of fresh water along with relative percentages of these sources. Students will discover with this activity that our water supply is finite, and that the accessible fresh water available for living organisms is less than 1% of the total water on our planet.

New York State Science Learning Standards

5-ESS2-2: Earth's Systems
Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.
MS-ESS3-1 Earth's Systems
Construct a scientific explanation based on evidence for how the uneven distribution of Earth's mineral, energy, and groundwater resources are the result of past and current geological processes.

Science and Engineering Concepts	Disciplinary Core Ideas	Cross Cutting Concepts
Describe and graph quantities such as area and volume to address scientific questions.	Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. Natural Resources Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.	Scale, proportion, and quantity standard units are used to measure and describe physical quantities such as weight and volume.

ELA Connections: RI.5.9 W.5.9	Integrate information from several texts on the same topic in order to write or speak about the subject knowingly. Draw evidence from literary or information texts to support analysis, reflection and research.
Math Connections: MP.2 MP.4	Reason abstractly and quantitatively. Model with mathematics.

Materials: Inflatable Globe, 5 gallon bucket or aquarium, 1 gallon clear container, 2 clear cups, 1 set measuring spoons, eye dropper, food coloring, colored pencils, calculators, compasses, rulers, world maps

Prerequisite: Students should have some prior knowledge and experience with using metric measurements and calculating percentages. Also, students should be familiar with pie graphs and how to use a compass.

Teacher Background: Sources of water are oceans, groundwater, surface water, atmosphere, fresh water lakes, streams, and rivers, and salt water lakes. Most people overestimate the actual amount of fresh water available on Earth for human consumption. Not all of the fresh water sources can be accessed; i.e., frozen water found in the icecaps, water in the atmosphere, and most groundwater. In fact, less than 1% of all the water on Earth can be used for living organisms. Additionally, the water that is available may be compromised due to pollution and other contaminates.

Engage:
Ask students to brainstorm as many water sources as possible and categorize each according to properties of fresh, frozen, and salt.
Have students predict the percentage of water that can be found in each and record into data table on student activity sheet.
Collect probability data related to the amount of Earth's water by gently tossing inflatable globe from student to student, recording each time the right thumb lands on water. (Tally in space provided.)
Toss ball to student and ask student to call out where thumb landed, instruct all students to record type of water into data table…continue until all students have had at least one chance to catch globe.

Discuss results of game and determine in percentage how much of the Earth is covered by water.
Compare student prediction with data collected.

Explain:
Distribute world maps to students (or globes).
Link to PowerPoint with Map for activity: https://pmm.nasa.gov/education/lesson-plans/earths-water
Instruct students to work with partner pairs to locate sources of water.
Instruct students to shade water sources onto map found in Student Activity Page with the following color: oceans red, frozen fresh water grey, wetlands green, rivers and lakes blue

Ask: Can you identify how much of the Earth's water is salt? Fresh?
Can you identify the sources of each?

Call on volunteers to share ideas. Write responses onto board.
Ask: What have you learned about water distribution on Earth?
What does this knowledge cause you to wonder about?

Explore:
Show 5 gallons of water to students and explain this is all the water in the world (can use empty aquarium tank or bucket).

Review water sources listed on board.
Ask: What percentage of this bucket do you think is available to living things? (Less than 1 drop)
What percentage of this bucket do you think is salt water?
Explain that 97.2% of Earth's water is located in the oceans. We will leave salt water in bucket.
Ask what percentage of this bucket do you think is fresh water?
Remove 2.8% of the water from the bucket. (1 and 1/3 Cup plus ¼ teaspoon) and place in clear container.

One at a time, remove from the clear container each amount as called by students:

Source	Remove from 2.8% fresh water container
2.00% is found in icecaps/glaciers	1 Cup
0.62% is found in ground water	1/3 Cup
0.009 is found in Freshwater Lakes	1/8 teaspoon
0.008 is found in Inland seas/salt lakes	1/8 teaspoon
0.001 is found in the Atmosphere	1 drop
0.0001 is found in rivers	1 flick

Ask: What have you learned about water distribution on Earth?

What does this knowledge cause you to wonder about?

Evaluate:

Explain to students that different types of graphs are used to visually display information. Water distribution can be displayed using a pie graph, a circle divided into sections to represent 100% of data. Instruct to students to use the data found on their student activity page to construct a pie graph showing how salt and fresh water sources are distributed around the Earth.

Model process of constructing a circle graph

1. Make a dot in center of space provided.
2. Using the compass, create a circle that stays within borders of space.
3. Use the formula for each water source to complete the data table.
4. Degrees in circle = Percent of Total Water/100% x 360 degrees
   Example: Ocean 97.20% divided by 100 x 360 = 349/.92 degrees = 350 degrees (round)
5. Continue with each water source until all students have data table completed.

Water Source	Percent of Total Water	Degrees in Pie Graph
Oceans	97.2%	350 degrees
Glaciers	2.15%	
Groundwater	0.63%	
Rivers, Lakes, Ponds	0.02%	

www.troup.org

Instruct students to color and label pie graph.

Ask: How much water is available to humans as drinking water compared to rest of the water on Earth?

Elaborate

Ask students to think about how living things use water.

Pair students and distribute large poster paper showing a water drop.

Instruct students to use both illustrations and words/phrases to fill as much of the water drop as possible with their ideas on how fresh water is used by living organisms.

Share water drop models. Post water drop models onto classroom walls and conduct a Museum Walk.

Ask: Why do we need to respect water?

What types of human activities add pollution to our fresh water drinking sources?

The Earth is often called the water planet. Do you agree with this statement? Why or why not?

Instruct students to answer this question on Student Activity Page.

Extensions:

Replace modeling of water on earth using the lesson plan in folder.

Water Distribution Lab or All the Water in the World

Name

All the Water in the World Student Activity

Activity 1: Globe Toss

Data Collecting and Probability Globe Toss

Predict frequency (how many times) for each area right thumb lands on globe.

Indicate actual area by right thumb lands by placing "X" in data table.

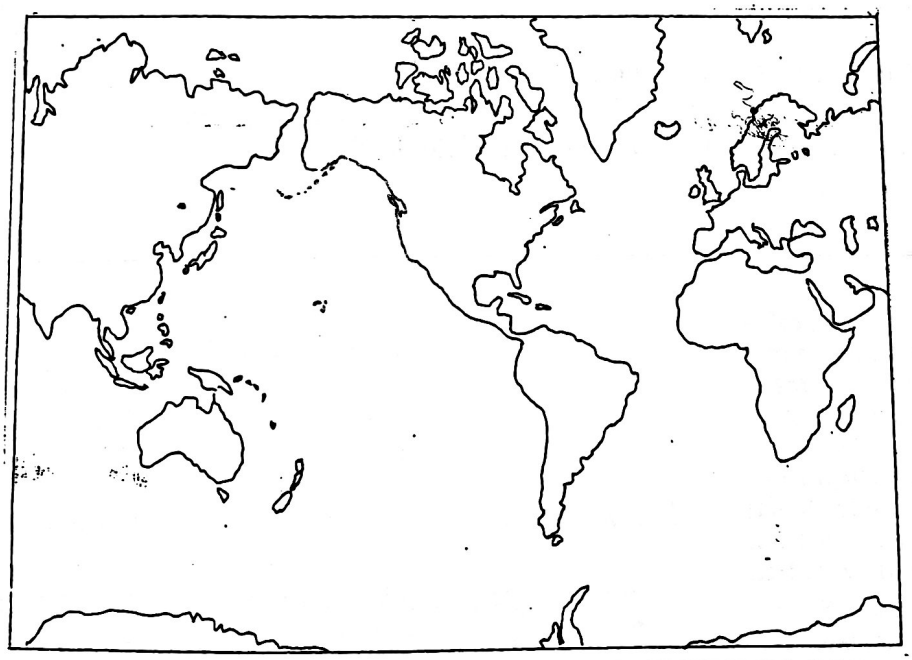
Predict	Land	Salt Water	Fresh Water	Frozen Water
Actual	Land	Salt Water	Fresh Water	Frozen Water

Activity 2: Mapping Water Sources

Work with partner pairs to locate sources of water.

Shade water sources with the following color:

oceans red, frozen fresh water grey, wetlands green, rivers and lakes blue



What are the sources of salt water?

What are the sources of fresh water?

Where do you think our drinking water comes from? Illustrate the source below:

Activity 3: Modeling Water Distribution

Predict: What percentage of the bucket do you think represents fresh water? _____%

What percentage of the bucket do you think represents sat water? _____%

Actual: What percentage represented fresh water available for living organisms? _____%

What have you learned about water distribution on Earth?

What does this knowledge cause you to wonder about?

Activity 4: Calculating Water Percentages

Use the following formula to calculate to be used in Water distribution Pie Graph

Degrees in circle = Percent of Total Water/100% x 360 degrees

Example: Ocean 97.20% divided by 100 x 360 = 349/.92 degrees = 350 degrees (round)

Water Source	Percent of Total Water	Degrees in Pie Graph
Oceans	97.2%	350 degrees
Glaciers	2.15%	
Groundwater	0.63%	
Rivers, Lakes, Ponds	0.02%	

Construct Pie Graph as follows:

1. Make a dot in center of space provided.
2. Using the compass, create a circle that stays within borders of space.
3. Use the formula for each water source to complete the data table.

Activity 5: A Drop of Water

Why do we need to respect our water sources?

The Earth is often called the water planet. Do you agree with this statement? Explain your response.

ACTIVITY 17 WORKSHEET

All the Water in the World

◆Background

This activity asks, "How much water is there on Earth, and where is it located?" You will use 100 L of water to represent "all the water in the world." You will work with a group to guess how to divide this water among different containers that represent the categories of water listed below. Do not worry or be embarrassed if your guesses are inaccurate.

◆Objective

To describe the relative proportions of Earth's water existing as groundwater, ice, lakes and streams, ocean water, and water in the atmosphere

Water is found in the following different forms and locations:

- **Groundwater** is contained in soil and rocks. Some of this ground water is salty.
- Oceans, rivers, lakes, and salt lakes are **surface water.**
- The atmosphere contains **water vapor** (water in the form of a gas).
- The rest of Earth's water is in the form of ice, such as glaciers and **sea ice** (ice formed by freezing of ocean water).

◆Procedure

1. The note cards should be labeled as follows:

- all the water in the world
- oceans
- freshwater lakes
- saltwater lakes
- rivers
- groundwater
- sea ice and glaciers
- water vapor

2. There are 100 L, or 100,000 ml of water in the "all the water in the world" container. Since each milk jug used to fill this container holds 3.8 L, it took a little more than 26 jugs to get 100 L (3.8 L/jug x 26.3 jugs = 100 L).

3. If 100 L is "all the water in the world," how many liters of water would be in the oceans?

Discuss this with other members of the group and decide together on your best guess as to how much water this would be. Record your best guess below:

_____ L of water (out of 100 L total) are in the oceans.

4. Using your estimate for the amount of water in the oceans, calculate how much water would not be in the oceans as follows:

100 L (total) - _____ L (in the oceans) = _____ L of water not in the oceans.

Materials

Each group will need

- several empty 3.8 L (1 gallon) plastic milk jugs
- one or more of each of the following sizes of graduated cylinders: 1000 ml, 100 ml, and 10 ml
- other containers for dividing up "all the water in the world" (2 or 3 buckets or aquaria; 6 or 8 beakers or cups [several each of a range of sizes—1000, 500, 250, and 100 ml beakers]; 6 or 8 test tubes and test tube holders)
- 10 note cards to serve as labels for the containers
- masking tape
- a mop and sponges or rags to clean up spills

Vocabulary

- **Groundwater:** Water below the water table in the zone of saturation. Groundwater fills the spaces between soil and sediments or lies in the cracks and crevices in rocks.
- **Sea ice:** Solid water that forms by the freezing of ocean or sea water. Sea water has an average freezing point of -1.9° C (28.6° F). However, the freezing point varies with the salinity of the water. Sea ice is much of the area around the Earth's North Pole.
- **Surface water:** All water, fresh and salty, on the Earth's surface. Oceans, lakes, streams, snow, and glaciers are all surface water.
- **Water vapor:** The gaseous state of water.

ne of water

water lakes: _____

water lakes: _____

rivers: _____

roundwater: _____

glaciers and other ice: _____

water vapor: _____

Express these nes in terms of iters if that makes the easier. Remember, 1000 ml

5. When your class agrees on how much water is not in the oceans, remove that amount of water from the original 100 L of water.

Save this water that you remove from the "all the water in the world" container. Your next task is to decide how to divide this "not in the oceans" water among the other categories of water.

In the spaces at left, write the group estimates of the volume of water that should be placed in each category.

6. Label an appropriate-sized container for each of the remaining categories of water. From the bucket containing the "not in the oceans" water, measure out the amount of water that you assigned to each of these categories. Pour the water that you measure out into its labeled container.

The water remaining in the "all the water in the world" container should be what you have estimated as the amount of water in the oceans. At this time you should change the label from "all the water in the world" to "oceans."

7. You should now have finished the process of dividing 100 L of water representing "all the water in the world" into 7 major categories on the basis of your previous knowledge.

Your teacher will now demonstrate the correct relative amounts of water in each category.

Were your estimates for each category close to the actual amount of water in the category? Were there any major surprises? Describe your findings below:

_____

_____

_____

_____

_____

_____

_____

_____

_____

GUIDE TO ACTIVITY 17

All the Water in the World

◆What is happening?

When asked to estimate the water supply on Earth, most people overestimate the fresh water available in streams, rivers, and lakes, and greatly underestimate the amount of water in underground deposits and in glaciers.

Very few people will guess that the total amount of fresh water that is reasonably accessible for human use (the water in streams, freshwater lakes, the atmosphere, or less than 1000 m underground) is less than 0.33% of the total amount of water on Earth. Assuming that 100 L constitutes "all the water in the world," Earth's reasonably accessible fresh water would have a maximum volume of about 325 ml—less than the amount required to fill a soft drink can.

In practical terms, the actual amount of accessible fresh water is much smaller, because much of this reasonably accessible water is poor-quality groundwater. Even where groundwater is plentiful and of excellent quality, it is not possible to extract more than a small fraction of the water in an aquifer.

Reducing all the water in the world to 100 L placed in a trash can makes the problem of dividing up the different types of water resources more concrete, and also demonstrates graphically the weight and volume of 100 L of water.

Even when you know the relative amounts of water in different locations, it is very difficult to visualize. Reference materials often describe the Earth's water supply in terms of cubic miles of seawater, or acre feet used for irrigation, or percent of the total water available. The numbers used in these types of descriptions are large and abstract.

◆Time management

Because of the necessary student/teacher interaction, this activity should take about two class periods.

Allow the students to work in small groups to decide how to divide up "all the water in the world." After all the groups have decided upon the relative proportions of the various water resources, write the answers of all the groups on the blackboard or overhead projector. Allow the class to discuss their differences and if possible reach a class consensus on the division of the water resources.

Since they both require the use of 100 L of water, you may wish to perform both this activity and Activity 18 outside on the same day—this way you can use the same 100 L of water for both activities.

A water source such as a garden hose is very handy when setting up these activities.

◆Preparation

Any type of container can be used to hold the different categories of water. If you do not have enough beakers, you can use bottles or cups (plastic, if possible). If you lack graduated cylinders, you can use measuring cups to measure the large volumes of water and medicine dispensers to measure the smaller volumes.

Before beginning this activity with your class, measure out 100 L of water to represent all the water in the world. This is equivalent to 26.3 gallon milk jugs full of water. The water may be placed in a 122 L (32

gallon) trash can, or three 38 L (10 gallon) aquaria. You may wish to add some food coloring to the water to make the water easier to see. You can use the same 100 L of water for each class performing this activity. Be sure to have a mop and plenty of rags or sponges for cleaning up.

You may want to have just one group of students measure and pour the water for the demonstration rather than having each group measure and pour.

After the discussion, have students actually transfer the water from the "all the water" container into the other labeled containers before showing them the correct answers (given below).

You may wish to have a separate set of containers for the "class answer" and the "correct answer," so that students can compare the differences in the volumes.

◆Suggestions for further study

Have students contact the local water-utility to find out about how water is used in their community. Also, where does this water come from—wells, streams, collectors? Is the supply ample? How much treatment is necessary to make the water safe for use?

◆Answers

The relative amounts and location of fresh, salty, and frozen water on the planet Earth are shown in the table that follows.

The final column of the table gives the volume (in ml) for each of these categories of water, assuming that 100 L of water is "all the water in the world."

Category	% of the total water in world	Equivalent in ml (out of 100 L "all the water in the world" container)
freshwater lakes	0.009	9.0 ml
saltwater lakes	0.008	8.0 ml
rivers	0.0001	0.1 ml
groundwater water	0.625	625.0 ml
sea ice and glaciers	2.15	2,150.0 ml
atmospheric water vapor	0.001	1.0 ml
all oceans	97.2	97,206.9 ml

These figures are adapted from information contained in the U.S. Government Pamphlet 1977-0-240-966/44 "Water of the World," by Raymond Nace.