GRADES 3–5

The water cycle is the system by which Earth's water is collected, purified, and distributed from the environment to living things and then returned to the environment. Through modeling and an experiment, students explore the various steps of the water cycle and make connections between the water cycle and all living things.

WATER WONDERS

SUBJECTS
Science, English Language Arts, Social Studies

PLT CONCEPTS
3.1, 3.7, 4.1

STEM SKILLS
Data Analysis, Investigation, Organization

DIFFERENTIATED INSTRUCTION
Hands-on Learning, Higher-order Thinking, Literacy Skills, Personal Connections

MATERIALS
Part A: Seven dice, labels for seven stations, watch or stopwatch.

Part B: Two sloped areas or stream tables (see Getting Ready), watering can or coffee can.

TIME CONSIDERATIONS
Preparation: 30–60 minutes

Activity: Part A: 50 minutes
Part B: 50 minutes

OBJECTIVES

Students will

- Describe the various components of the water cycle and the path that a water molecule might take on its way through this cycle.
- Explain why the water cycle is important to living things.
- Describe how plants affect the movement of water in a watershed.

BACKGROUND

Water covers 71% of Earth's surface. It can exist in liquid, vapor, or solid (ice) forms. It consists of two parts hydrogen to one part oxygen. Its unique physical properties enable life to exist on Earth. Those properties include water's ability to remain liquid in a wide range of normal Earth temperatures and its ability to dissolve and transport other substances. It constitutes 50–70% of the weight of all plants and animals, including humans.

Water is constantly moving. In general, it evaporates from oceans and lakes into the atmosphere (as water vapor), condenses into clouds, falls as rain or snow, and eventually returns to oceans through a drainage system of streams and rivers. This journey is called the **water cycle**. The cycle is powered by energy from the sun, which promotes evaporation, and by gravity.

In the coldest regions of Earth, water is stored for a long time as ice and hard-packed snow. But even ice and snow are in motion. Glaciers are essentially rivers of ice, always changing shape and sometimes melting as they move inch by inch. Icebergs break away from glaciers and float in the ocean, slowly melting as they move into more temperate climates and warmer waters.

The movement of water is greatly influenced by the contours of land and by geographic features such as mountains, valleys, and hills. A watershed is the area of land that collects water and guides it into a particular stream or river system; it may be large, as in the Mississippi River watershed, or small, as in the watershed for a local creek. Water's movement in the watershed, in turn, creates the contours of the land through erosion and sedimentation.

In addition to clouds, oceans, rivers, and land, living organisms are part of the water cycle. All living things need water to live because it is essential to their bodily functions. Plants and animals take in water and return it to the atmosphere as vapor (by breathing or transpiring) or to the soil as liquid (by excreting).

FOREST FACT

did you know

Urban forests and neighborhood trees help to prevent runoff and erosion, thus maintaining water quality. For example, 1 inch of rainfall on a 10,000-square-foot area with no trees will generate 639 cubic feet of runoff, but if 30% of the area is covered by tree canopy, it will generate just 3.9 cubic feet of runoff.

Forests greatly affect watersheds. When rain falls on the forest, it drips down through the forest canopy to the forest floor. Trees, other plants, and layers of plant litter muffle the impact of precipitation and absorb water, reducing erosion and runoff. Tree roots also help to hold soil in place so that it doesn't wash away. But when rain falls on bare ground, the full force of raindrops can wash soil into streams, making them muddy, and reducing the quality of that water for human use and aquatic life.

Forests help improve water quality by helping to regulate flow, and by filtering out impurities that could be potentially harmful in streams or groundwater (water found in the cracks and spaces in soil). Through the process of transpiration, water that is absorbed by tree roots is released as vapor through the leaves, and impurities (many of which are good for a tree) remain in the tree.

Although the gradual wearing down and erosion of soil is a natural process, human activities such as clearing vegetation for development, engaging in unsustainable logging practices, farming, and draining wetlands will increase the rate of erosion in watersheds and reduce water quality. But practices such as reforesting areas, engaging in sustainable forestry, practicing conservation agriculture, and restoring wetlands can limit erosion and help to maintain water quality.

Changes in the Earth's climate due to the increase of greenhouse gases also affect the water cycle. Rising temperatures may cause increases in water evaporation, the rate at which sea ice melts, runoff, distribution and growth rates of forests, and other effects.

ESTIMATE OF GLOBAL WATER DISTRIBUTION

Water source	Water volume (cubic miles)	Water volume (cubic kilometers)	Percent of total water*
Oceans	321,000,000	1,338,000,000	96.54
Icecaps, glaciers	5,844,970	24,364,000	1.762
Groundwater	5,614,000	23,400,000	1.69
Lakes	42,320	176,400	0.013
Soil moisture	3,959	16,500	0.001
Atmosphere	3,095	12,900	0.001
Swamps	2,752	11,470	0.0008
Rivers	509	2,120	0.0002
Biological water (water in living things)	269	1,120	0.0001

*Note: Percents do not add to 100 due to rounding.

Source: U.S. Geological Survey. "Where Is Earth's Water?" https://www.usgs.gov/special-topic/water-science-school/science/where-earths-water

GETTING READY

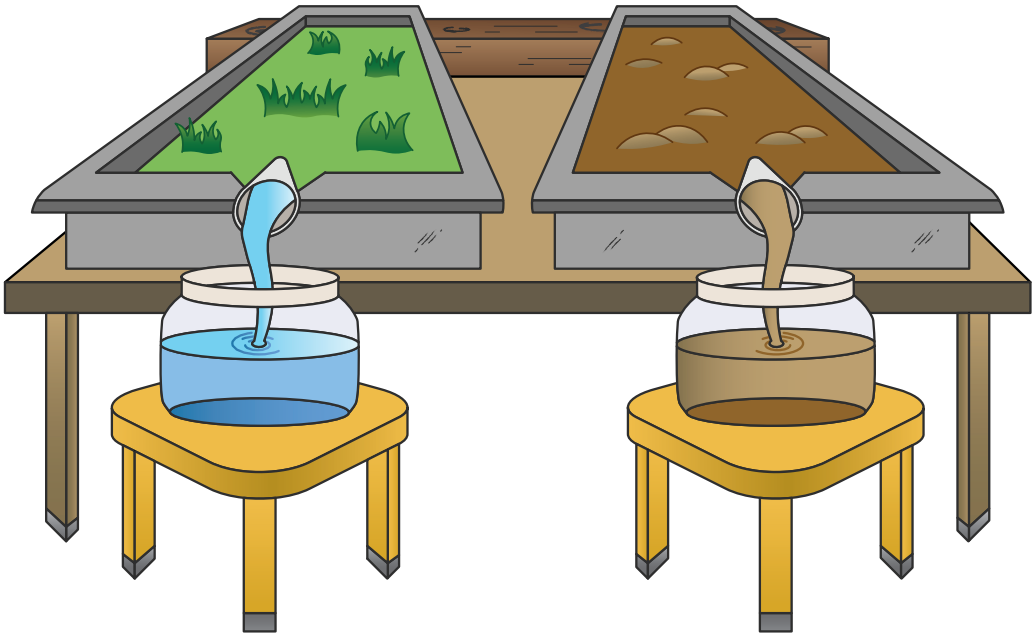
PART A:

- Make copies of the Go to the Head of the Cloud student page and cut the station instructions apart. Also make copies of the Water Cycle Data Sheet student page.
- Using paper and marking pens, make a large label for each of seven stations: Cloud, Glacier, Stream, Groundwater, Ocean, Plant, and Animal. You may want to draw or download pictures that you attach to each label.
- Set up seven stations around the room with the labels. At each station, put a die and the relevant directions from the Go to the Head of the Cloud student page. If you have a large group, use two or more dice at each station.

PART B:

- On or near your site, find two sloped areas with about the same angle of slope. One should have little or no vegetation on the soil (a roadway cut bank or steep bare slope works well), and one should be covered with grass, shrubs, or trees.
- As an alternative to the sloped areas, make two stream table boxes about 16" long x 12" wide x 4" deep (40.6 cm x 30.5 cm x 10.2 cm). You may use planter boxes, cake pans, or aluminum foil roasting pans with the approximate dimensions. Make them water-tight by lining them with plastic material or aluminum foil. At one end of each box, cut a v-shaped notch about 1.5" (3.8 cm) deep and fit it with a spout of stiff paper that it directs water off the table into a container, as in the diagram *Stream Tables* below. Put a piece of sod (cut from a pasture, field, fence row, or lawn) in one box and place an equivalent amount of bare soil (preferably from the same location) in the other. Set both boxes on a table so the spouts extend over the edge; place boards under the opposite ends to give both boxes the same slope. Place jars on stools underneath the spouts to collect the water that runs off.

STREAM TABLES



- Another alternative is to use two five-gallon buckets with a hole cut in the bottom of each. Partially fill each bucket with equal amounts of soil. In one bucket, add a layer of leaf litter from a nearby forest area on top of the soil. Place the buckets in a sink or on the ground outside.

DOING THE ACTIVITY

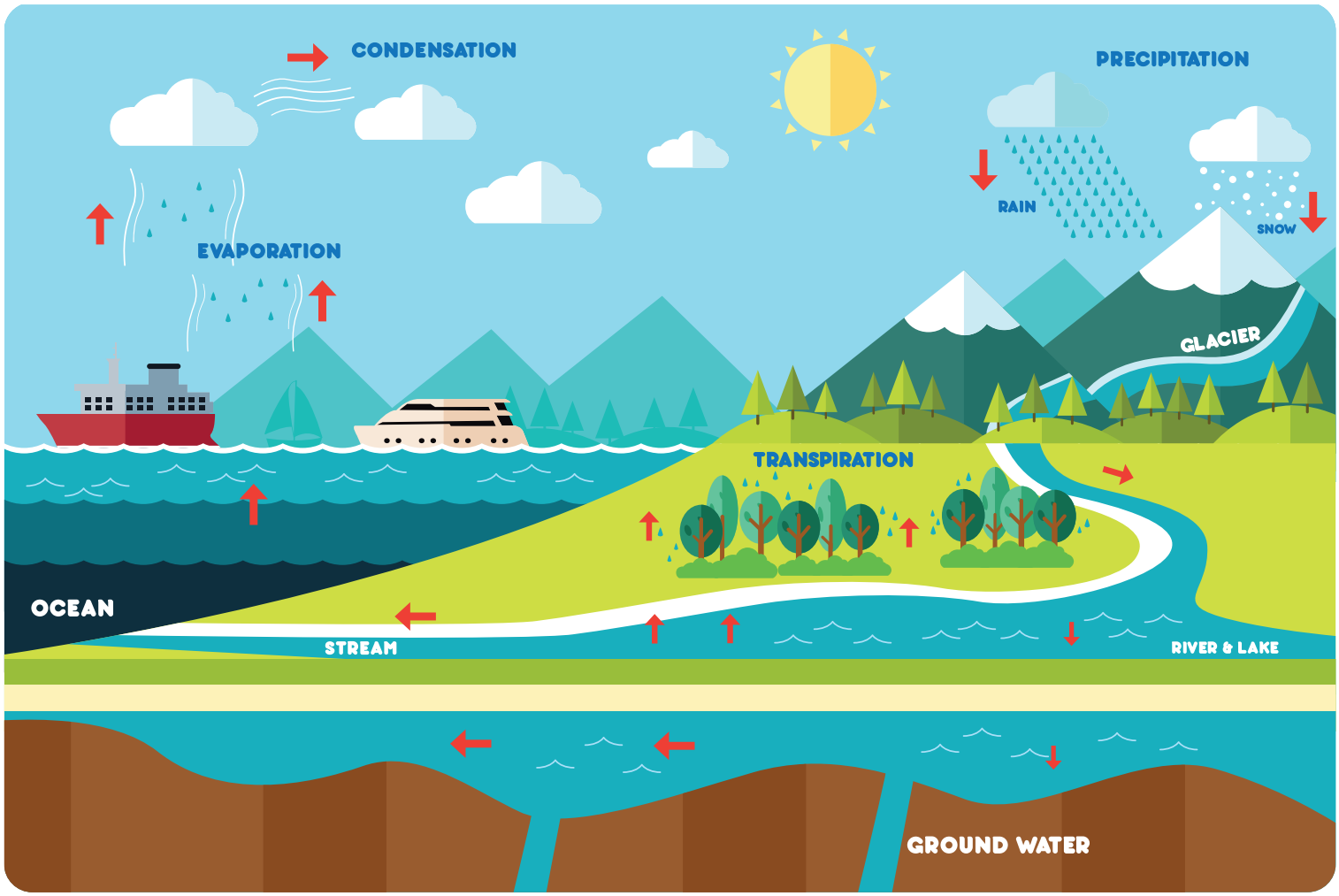
PART A: GO TO THE HEAD OF THE CLOUD

1. Divide the group into pairs and ask the pairs to write down words that describe what they know about the water cycle. Then ask them to write a description or create a drawing of the water cycle. Ask volunteers to share their description or drawing with the whole group.

2. **LITERACY SKILLS** Optional: Share a diagram of the water cycle like the one shown below. As needed, review sequencing words like "next," "after," "before," "while," "during," etc. Help students understand the terms evaporation, groundwater, etc. (see the Glossary at plt.org/glossary).

3. Explain that the water cycle is really a simplified model for looking at the "journey" of a water molecule. Ask students whether they think water always follows the same path in the water cycle. Challenge them to think of times that water may follow a different path.

THE WATER CYCLE



4 Ask students how they might model the water cycle to learn more about it. Suggest that they can follow the different paths a water molecule might take. Explain that you have set up a sample model where they can do just that. Distribute the Water Cycle Data Sheet student page to record the path they follow in the model. Later, they will compare data.

5 Divide students into seven groups and have each group begin at one of the stations. Explain that each student will be a water molecule in the model. Have students roll the die and read the statement for their station corresponding to the number on the die. On their Water Cycle Data Sheet student page, they should write their current station, what happens to them according to the die roll, and their next destination. Call out "cycle," to have students go to the next station as directed by the station statements.

6 Repeat Step 5 about 10 times or until most students have cycled through the Cloud station a couple of times.

7 Ask students to write a brief story from a water molecule's point of view that describes the journey they took through the water cycle in the activity. For example, a student whose journey was Glacier > Stream > Ocean > Cloud > Stream > Animal > Cloud > Glacier > Ocean might start their story like this: "I was a lonely water molecule frozen in a glacier on top of a mountain. When the spring came and the ice thawed, I melted into a stream. The stream roared down the mountain, going over large boulders. After a long journey, I reached the ocean."

8 Write the names of the seven stations where everyone can see them. Beginning with Cloud, ask students to share all the different ways they got to Cloud. Show each response by drawing arrows to the word Cloud. Repeat with the other stations.

9 **HIGHER-ORDER THINKING**

Discuss the following questions:

- Even though individual molecules took different paths, what was similar about the journeys they took?
- Which stations were visited by the most water molecules, regardless of their particular journeys? What can we infer from this?
- Can you think of other parts of the water cycle that were not included in the model? (e.g., lakes, rivers, wells) Where might they be added?
- Do you think simple diagrams of the water cycle are useful, even if they don't include all the paths water might take? Why or why not?
- What would happen if the sun's energy were blocked from reaching Earth?
- What might happen if all of Earth's water stayed in the oceans? In the clouds?
- How is the water cycle important to plants and animals?

TAKE IT OUTSIDE

Take students outdoors to look for evidence of the water cycle. Challenge them to find evidence of:

- **Evaporation (such as a dried-up mud puddle, low water levels in a pond, or a dried leaf)**
- **Condensation (such as clouds, dew on grass, or fog)**
- **Precipitation (such as rain, hail, or snow)**
- **Other elements of the water cycle**

Ask them whether the amount of sunlight affects the water cycle and, if so, how.

PART B: ON A SLOPE

1 **PERSONAL CONNECTIONS** Ask students to name some ways that people try to control the water cycle directly (e.g., building dams, making snow at ski resorts). Ask them how humans' activities affect the water cycle indirectly (e.g., climate change from rising levels of greenhouse gases increases glacier melt and evaporation).

2 Ask students what effect plants might have on the water cycle. Ask how they could find out more about this.

3 Suggest that one way would be to compare how water acts on two sloped surfaces, one with and one without plants. Take them to the two sites or use two stream tables (see Getting Ready). Describe the experiment to students (see Step 4). Then have them predict whether there will be any difference in what occurs on the two slopes.

4 **HANDS-ON LEARNING** Fill the watering can or coffee can with water. Help students hold the can at the same height so they can pour or sprinkle water at the same rate over the same point of each slope. Have students look for the following:

- The plants' effect on the water's speed
- The amount of run-off from each slope
- The appearance of the run-off water
- The water's effect on the contour (shape of the surface) of each slope

5 As you lead a discussion about what students observed, ask questions such as these:

- What happened to the water on the bare slope? What do you think will be the water's next stop in the water cycle? (probably entering a stream)
- What happened to the water on the planted slope? What do you think will be the water's next stop in the water cycle? (absorbed by plants, entering groundwater, or entering a stream)
- In what ways do plants affect the movement of both water and sediment (soil carried in water) through the water cycle? (For example, they slow down the water so that more of it soaks into the ground rather than running off, and they hold soil with their roots so it doesn't wash away.)
- What effect did the two slopes have on the quality of the water? Why?
- How are forests important for maintaining the balance of water in a watershed? How are forests important for maintaining quality of life for people? Aquatic animals?

ACADEMIC STANDARDS

SCIENCE

Practices

- Developing and using models

Concepts

- Earth materials and systems
- Systems and system models
- Cause and effect

ENGLISH LANGUAGE ARTS

Practices

- Speaking and listening: presentation of knowledge and ideas

SOCIAL STUDIES

Practices

- Applying disciplinary concepts

Concepts

- Geography: geographic representations
- Geography: human–environment interactions

ASSESSMENT

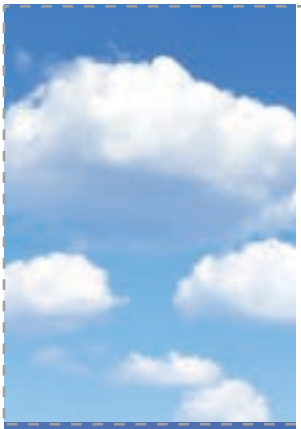
Ask students to

- Write a story describing the journey of a water molecule (as in Part A). The story should:
  - » Include all stops of their water molecule's journey, in chronological order.
  - » Include details about the journey, explaining accurately how and why the water molecule went where it did.
  - » Convey the importance and cyclical nature of the water cycle.
- Create a diagram of the water cycle based on the model they simulated in Part A.
- Write individually or in groups a response to the following prompt: Imagine two pieces of land that are exactly alike, except one is bare and the other is covered by a forest. Now imagine a stream running through each area. What differences might you see between the two streams? Think about how the water might move and how clear the water would be in each.

ENRICHMENT

- Use terrariums to observe the water cycle in action. Build two identical terrariums with a layer of soil, small plants in the soil, and a small cup of water to simulate a pond. Cover one tightly with plastic wrap and the other with aluminum foil. Lightly moisten the soil and plants of each terrarium and place them both in indirect sunlight. Invite students to observe what happens in each terrarium as time passes. What causes the changes? Based on what you see in the two terrariums, what role does the sun's energy have in the water cycle?
- Explore the quantity and distribution of water on Earth. Toss an inflatable globe to a student. When the student catches the globe, ask them if their right thumb is on water or land. Have that student toss the globe to another student and ask the same question. Continue tossing the ball, tallying student responses after each catch. With enough tosses, about three-fourths of the time the students' thumbs should land on water, and one-fourth of the time on land. Ask students what they learned from this exercise.

NAME _____ DATE _____



CLOUD Station

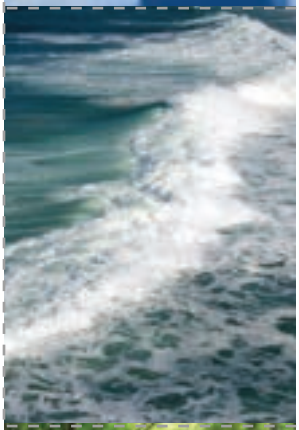
If you roll a . . .

1: You fall as rain onto an ocean. Go to Ocean.
2: You fall as rain onto an ocean. Go to Ocean.
3: You fall as rain onto a stream. Go to Stream.
4: You fall as snow onto a Glacier. Go to Glacier.
5: You fall as snow onto the ground. Go to Groundwater.
6: You fall as rain into a forest. Go to Stream.

GLACIER Station

If you roll a . . .

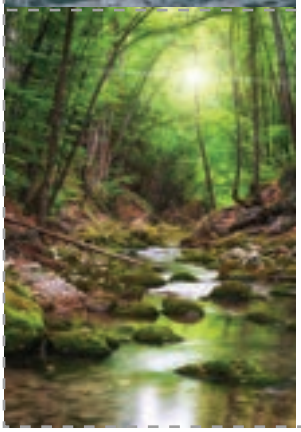
1: You evaporate into the air. Go to Cloud.
2: You stay frozen in ice. Stay at Glacier.
3: You stay frozen in ice. Stay at Glacier.
4: You stay frozen in ice. Stay at Glacier.
5: You melt and become part of a stream. Go to Stream.
6: You break off from the glacier and fall into the ocean. Go to Ocean.



OCEAN Station

If you roll a . . .

1: You are one of countless water molecules in an ocean and you stay there. Stay at Ocean.
2: You are one of countless water molecules in an ocean and you stay there. Stay at Ocean.
3: You are one of countless water molecules in an ocean and you stay there. Stay at Ocean.
4: You are one of countless water molecules in an ocean and you stay there. Stay at Ocean.
5: You evaporate into the air. Go to Cloud.
6: You evaporate into the air. Go to Cloud.



STREAM Station

If you roll a . . .

1: You evaporate into the air. Go to Cloud.
2: You evaporate into the air. Go to Cloud.
3: An animal comes to the stream and drinks you. Go to Animal.
4: You continue rolling downhill and become part of an ocean. Go to Ocean.
5: You continue rolling downhill and become part of an ocean. Go to Ocean.
6: A human purifies water from the stream and then drinks it. Go to Animal.

NAME _____ DATE _____

GROUNDWATER Station

If you roll a . . .

1: You move slowly downward and become part of an aquifer (an underground layer of rock containing water). Stay at Groundwater.

2: You move slowly downward and become part of an aquifer (an underground layer of rock containing water). Stay at Groundwater.

3: You move slowly underground between grains of sediment and eventually flow into a wetland and from there into a stream. Go to Stream.

4: You move slowly underground between grains of sediment and eventually flow into a wetland and from there into a stream. Go to Stream.

5: A plant absorbs you through its roots. Go to Plant.

6: You are pumped out of the ground from a well to irrigate a farm. Go to Plant.

ANIMAL Station

If you roll a . . .

1: After using you to process food, the animal urinates and you end up in the ground. Go to Groundwater.

2: After using you to process food, the animal urinates and you end up in the ground. Go to Groundwater.

3: You are exhaled from the animal's lungs into the air as vapor. Go to Cloud.

4: You are exhaled from the animal's lungs into the air as vapor. Go to Cloud.

5: A human uses you for brushing their teeth and spits you out; you travel from the sink down into the pipes, then through a sewage treatment plant and into a stream. Go to Stream.

6: A human drinks you. When they urinate, you travel from the toilet down into the pipes, then through a sewage treatment plant and into a stream. Go to Stream.

PLANT Station

If you roll a . . .

1: The plant transpires you through its leaves and you evaporate into the air. Go to Cloud.

2: A tree transpires you through its leaves and you evaporate into the air. Go to Cloud.

3: The plant transpires you through its leaves and you evaporate into the air. Go to Cloud.

4: The plant uses you to grow. Stay at Plant.

5: A tree stores you in its edible fruit and you are eaten by an animal. Go to Animal.

6: The plant stores you in its edible leaves and you are eaten by an animal. Go to Animal.

Water Cycle Data Sheet STUDENT PAGE

NAME _____ DATE _____

ROUND	STATION STOP	WHAT HAPPENS TO THE WATER MOLECULE?	NEXT STOP
Example	*Cloud*	*Falls as rain*	*Ocean*
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

CAREER CORNER

HYDROLOGISTS (hye-DRAW-luh-jists) investigate water in forests by studying how it travels through the forest, into the soil, and eventually to a stream. In addition to learning about the water cycle, hydrologists may try to solve questions such as how streamflow affects forests or how climate change impacts watersheds.