



# **GRIFFITH OBSERVATORY ONLINE SCHOOL PROGRAM**

## **MODULE 3: THE SEARCH FOR WATER**

**STUDENT GUIDE**



## Preparing for Your Virtual Visit

We are excited that your class will be participating in Module 3: The Search for Water of Griffith Observatory's Online School Program. Together we shall join the tradition of observing. Here are some things you'll need to know before your virtual visit.

- You and your class will experience the entire live program in Zoom. Your teacher will send you the steps to follow to join the Zoom webinar session.
- Before joining the webinar, please set your Zoom name to contain your real first and last name.
- When you are admitted into the Zoom webinar, you will enter muted with your video off.
- You and your class will meet a Museum Guide from Griffith Observatory. The Guide will lead you through the live experience.
- During the program, you will be asked to participate in polls. After a question is asked, a poll will pop up on your screen. Select an answer, and remember to click "Submit!"
- You may use Zoom's chat function to communicate with Griffith Observatory staff if you are experiencing technical difficulties.
- You may submit to the Q&A box any questions about science you might have for Griffith Observatory staff. We shall hold a question-and-answer session at the end of the program and shall try to answer as many of your questions as we can.
- Remember to stay on your best behavior. We encourage you to answer the polls and ask any space or science-related questions you might have, especially those relevant to our discussion. Be polite. Any spamming behavior or inappropriate, rude, or harassing language sent to staff in the chat or Q&A is not tolerated and may result in being dropped from the Zoom session.
- We hope you have a wonderful time!



## Pre-program Materials

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To get the most out of Module 3: The Search for Water, explore the following materials before your visit.

### **Module 3 Glossary**

The glossary lists and defines important words used in Module 3: The Search for Water and the following materials.

#### [Listen to the Module 3 Glossary](#)

If listening helps you remember, this audio file will help you remember the words and definitions in the Module 3 Glossary.

### **NASA: “The Water Cycle” Worksheet**

This worksheet asks you to label the different parts of the water cycle. The diagram has some hints that may help you along the way.

### **Fluid Transport Experiment**

In this at-home or classroom activity, you will learn how the water in a plant’s roots get up to the upper parts of a plant by performing an experiment.

### **Fluid Transport Maze**

Can you help a tree’s roots transport water from the soil up to the rest of the tree in this maze?

### **Properties of Water Experiments**

Learn about water’s many unusual and unique properties by doing seven experiments and activities. Just how special is water?



# Glossary

## MODULE 3: THE SEARCH FOR WATER

**atmospheric pressure** – the weight of air above a given area on Earth’s surface.

**catalyst** – a substance that speeds up a chemical reaction without being affected itself.

**compound** – a substance formed from atoms of different elements.

**condensation** – In the water cycle, condensation is the process by which water vapor in the air is changed into liquid water. Warm water vapor rises up through Earth’s atmosphere and cools, which causes it to turn back into liquid water and form clouds.

**crater** – a bowl-shaped pit or depression on a planetary surface.

**element** – In chemistry, an element is a pure substance containing only one type of atom.

**evaporation** – In the water cycle, evaporation occurs when liquid water on Earth’s surface turns into water vapor in our atmosphere. Heat from the Sun causes water to evaporate from the ocean, lakes, and streams.



Barringer Meteor Crater, Arizona

**extremophile** – an organism that can survive environmental extremes and that has evolved to grow under one or more of these extreme conditions.

**fluid transport** – the transfer of materials both within an organism and between an organism and its environment.

**fresh water** – water with a low amount of dissolved salts.

**gravity** – a fundamental force of nature in which all things with mass or energy – including planets, stars, galaxies, and even light – are brought toward one another.

**groundwater** – water held underground in the soil or sand, or in pores and crevices in rock.

**molecule** – a group of atoms bonded together. The atoms may be the same element or different elements.

**polar molecule** – a neutral molecule that has an uneven distribution of charge that creates partially positive and partially negative regions.

**precipitation** – In the water cycle, precipitation occurs when a cloud becomes full of liquid water and that water falls from the sky, mainly as rain or snow.

**reservoir** – a large natural or artificial lake used as a water supply.

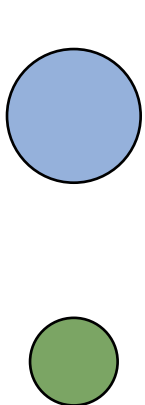
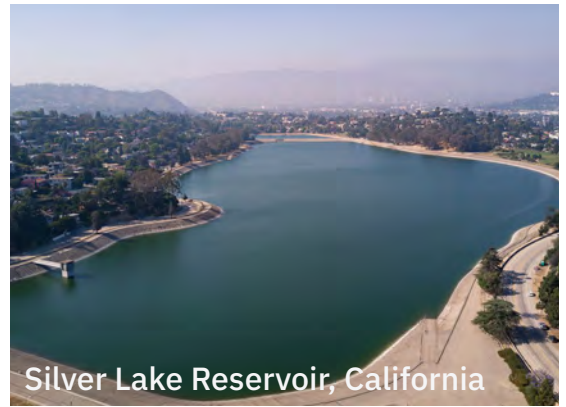
**solvent** – a substance that breaks down or dissolves another substance.

**stable environment** – an environment with little unexpected or sudden change. This applies to most of Earth's environments.

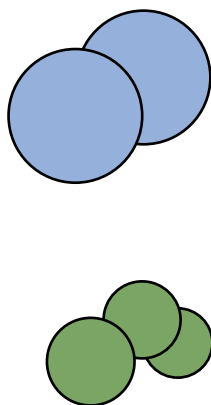
**surface runoff** – water “running off” the land’s surface. Gravity makes rain run downhill off land surfaces.

**transpiration** – In the water cycle, transpiration occurs when the water evaporated from plants and trees enters the atmosphere.

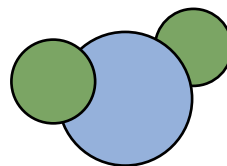
**water cycle** – the path that all water follows as it moves around Earth in different states of matter.



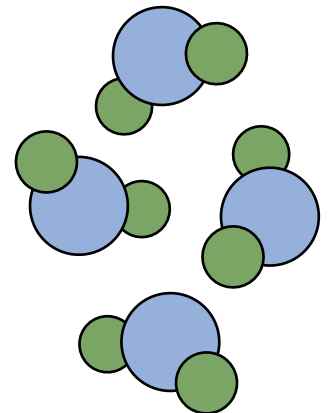
ATOMS



MOLECULES



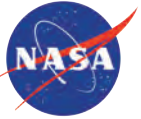
MOLECULE  
& COMPOUND



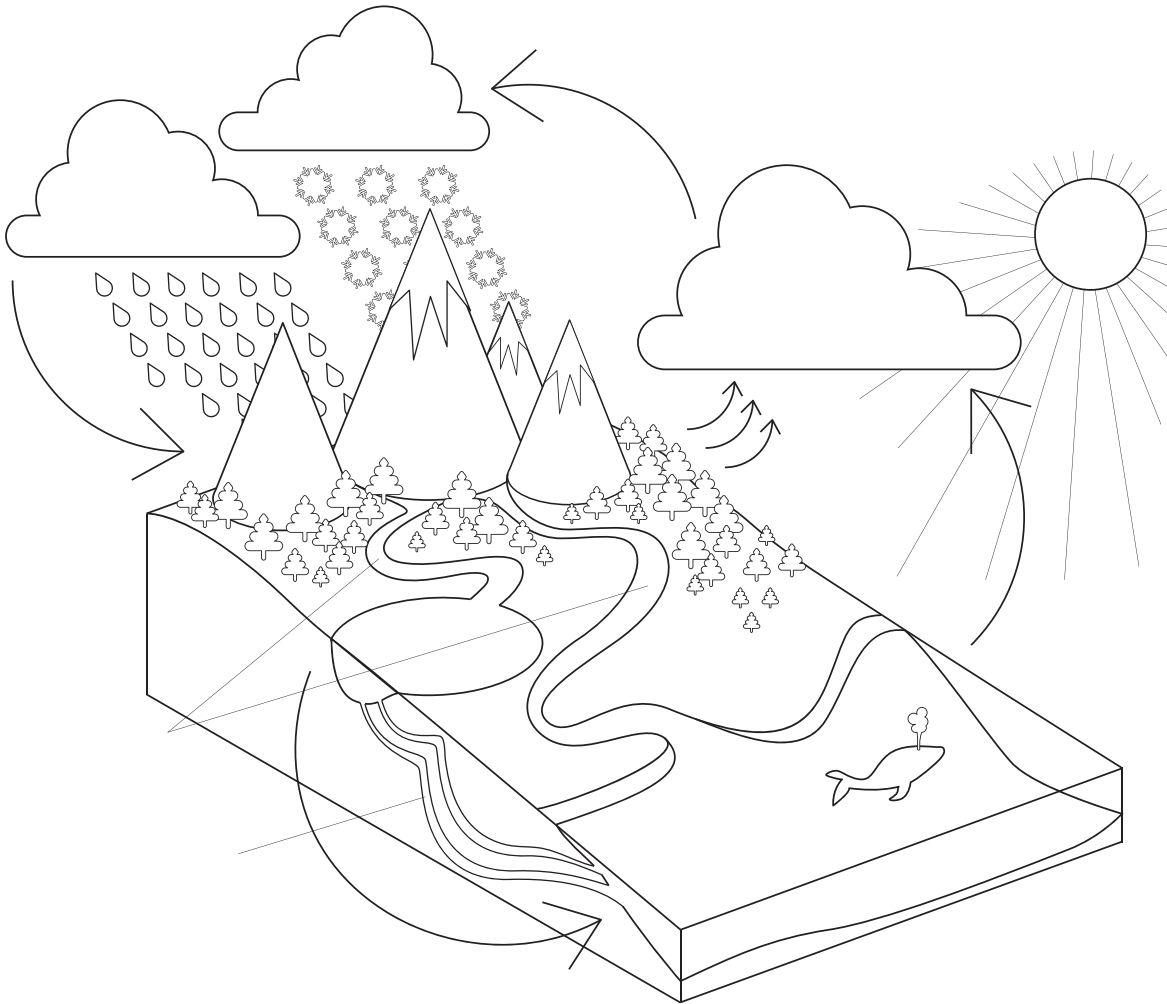
COMPOUND

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# THE WATER CYCLE



A never-ending global process of water circulation from clouds to the land, to the ocean, and back to the clouds.



- 1 EVAPORATION**  
Heat from the Sun causes water to evaporate from the ocean, lakes and streams. Evaporation occurs when liquid water on Earth's surface turns into water vapor in our atmosphere.
- 2 TRANSPIRATION**  
Water from plants and trees also enters the atmosphere. This is called transpiration.
- 3 CONDENSATION**  
Warm water vapor rises up through Earth's atmosphere. As the water vapor rises, the cool air of the atmosphere causes it to turn back into liquid water, creating clouds.
- 4 PRECIPITATION**  
When a cloud becomes full of liquid water, it falls from the sky mainly as rain or snow—also known as precipitation. Rain and snow then fill lakes and streams, and the process starts all over again.
- 5 SURFACE RUNOFF**  
Surface runoff is nothing more than water "running off" the land surface. Rain runs off land surfaces downhill due to gravity.
- 6 GROUND WATER**  
Some water seeps into the ground as soil moisture or groundwater.

# Fluid Transport Experiment

## HOW IS WATER TRANSPORTED IN PLANTS?

Water is essential for all living things, including plants. Plants rely on water in the ground that surrounds their roots, but how does the water in the roots get up to the upper parts of a plant?

Water movement in plants doesn't rely on electric power, biological pumps, or magic. It relies on some basic physical principles operating within plants, and anyone can understand them. We'll see how it works in this home experiment.

## MATERIALS NEEDED

- two glasses or plastic cups
- water
- food coloring
- two stalks of celery, leaves attached
- two small squares of plastic wrap
- a sharp knife
- a cutting board
- an electric fan
- a medium-to-large, clear, sealable plastic box (tall enough to fit inside an upright stalk of celery)
- a marker

## PROCEDURE

- Pick two celery stalks that have similar amounts of leaves. Have an adult help you cut the base off of each stalk so they are roughly the same height.
- Fill each cup with half a cup of water, and stir in five drops of food coloring.
- Place one celery stalk in each cup, leaf-end at the top.
- Mark the level of the water on each cup.
- Wrap one square of plastic wrap over the top of each cup and around the celery stalk. This prevents any colored water from evaporating into the air directly from the cup.
- Fill the bottom of the plastic box with roughly one inch of water. Place one of the cups with the celery stalk inside the box and seal the lid to create a humid, closed environment.
- Place both the boxed celery and the exposed celery in front of a fan, and turn it on the lowest setting. **Record the time:** \_\_\_\_\_ : \_\_\_\_\_ **a.m. / p.m.** (Circle one)
- Wait 24 hours.



**PROCEDURE CONTINUED ON THE NEXT PAGE...**

## PROCEDURE CONTINUED...

- How do the leaves of the two celery stalks look? Record your observations below.

**Boxed celery:** \_\_\_\_\_

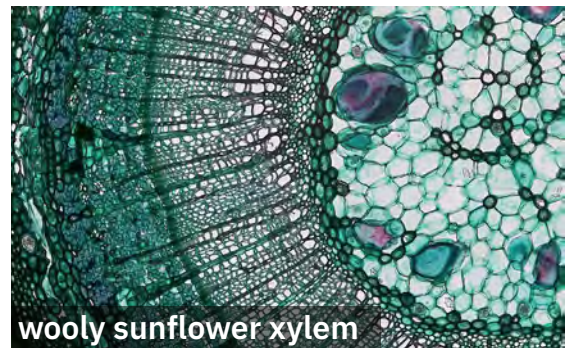
**Exposed celery:** \_\_\_\_\_

- Mark the level of the water on each cup.
  - Take one of the stalks of celery, and slice it in half. What do you notice about the inside of the celery stalk? Record your observations below.
- 

## HOW DOES WATER MOVE UP THE STALK?

Plants have a network of small tubes called **xylem**. The xylem is similar to your blood vessels. In both, water and some nutrients are transported around the organism's body. Plants don't have a heart to pump liquids around their bodies, and so they rely on physical forces to move liquid up to the highest leaf.

Plants contain many xylem vessels that stretch from the roots to the tips of the leaves, just like a series of drinking straws. When you sliced the celery in half and saw colored dots in the stalk, you were looking at the xylem vessels!



Xylem brings water from the ground up into the rest of the plant. The whole process starts out in the leaves. When the plant is photosynthesizing, it opens tiny holes called **stomata**, on the underside of the leaf. The plant does this so that carbon dioxide can enter. There is a downside to this, however: Water escapes out of the stomata at the same time and dries out the inside of the leaf slightly.

As the plant dries out from the leaves, it brings in more water from the xylem vessels. Water is a polar molecule. That means it's slightly "sticky." It forms temporary bonds with itself. This creates **cohesion**, which is the attraction of one molecule to another of the same kind. Water also sticks to the inside of small tubes due to **adhesion** – the attractive force between different molecules. Within the xylem vessels, the forces of cohesion and adhesion are stronger than gravity, and so water travels from the roots to the top of a plant or a tall tree in a process called **capillary action**.

**DISCUSSION CONTINUED ON THE NEXT PAGE...**

## DISCUSSION CONTINUED...

### WHAT FACTORS AFFECT HOW WATER MOVES THROUGH THE PLANT?

Water moves through plants thanks to a few basic physical and chemical principles, but none of these can work without water loss from the leaves. This process, called **transpiration**, happens faster when humidity is low, such as on a hot, windy day. This causes water to evaporate quickly, and so the plant must suck up more water from the ground (or from the cup) to stay hydrated!



When you put the celery stalk inside the plastic box with water, the humid environment kept the celery from losing much water from the leaves. When you placed the exposed celery stalk in front of the fan, on the other hand, it lost a lot of water! In order to catch up, it sucked up more water and the food coloring with it.

When you measured the water levels in the cups at the end of the experiment, you found that the exposed celery actually did suck up more water. You may have observed that the exposed celery had a lot more food coloring within its leaves.

People can't normally see transpiration and water transport happening within plants, but as long as the temperature is above freezing, this process happens on a massive scale all over the world!

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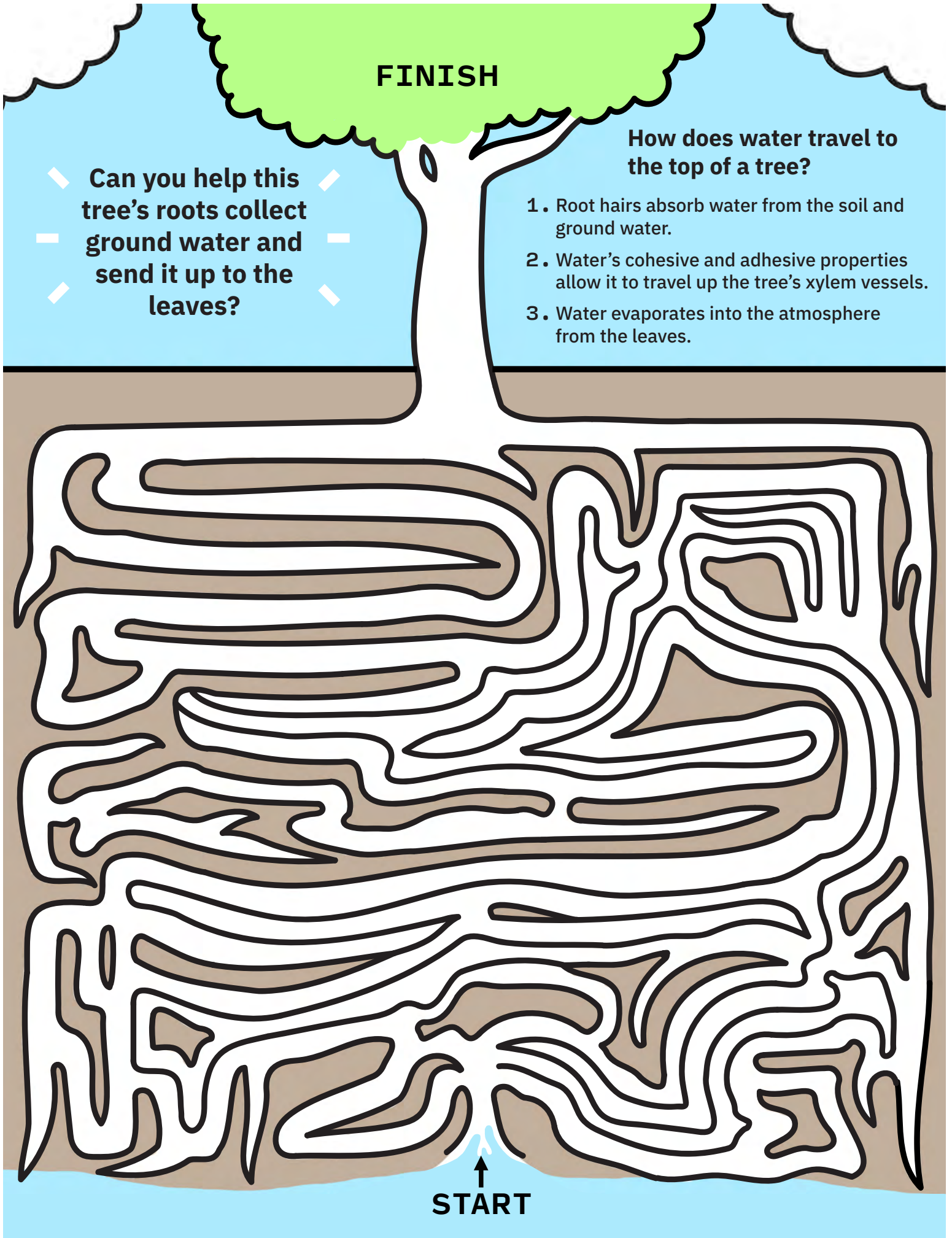
**FINISH**

Can you help this  
tree's roots collect  
ground water and  
send it up to the  
leaves?

**How does water travel to  
the top of a tree?**

1. Root hairs absorb water from the soil and ground water.
2. Water's cohesive and adhesive properties allow it to travel up the tree's xylem vessels.
3. Water evaporates into the atmosphere from the leaves.

**START**



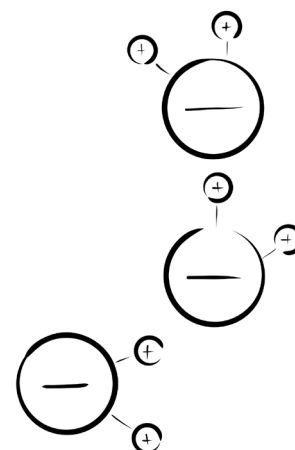
# The Properties of Water

## ACTIVITIES AND EXPERIMENTS

Seventy percent of Earth is covered with ocean water, and 65 percent of our bodies is water. Water is essential for life. This is why we are searching for water on other planets. The presence of water could mean that life exists there. There are three different forms of water, or  $H_2O$ : Solid (ice), liquid (water), and gas (water vapor). Because water may be found everywhere on Earth, many people are unaware of water's unusual and unique properties.

### POLARITY

A water molecule, or  $H_2O$ , has two hydrogen atoms and one oxygen atom. The oxygen end has a negative electrical charge, and the hydrogen end has a positive electrical charge. That makes the molecule polar, kind of like a magnet. Just as magnets attract opposite poles, the positive end of one water molecule will attract the negative end of another molecule. This is called a **hydrogen bond**.

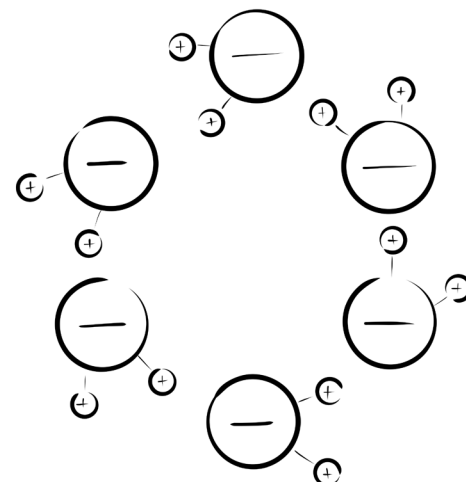


**Activity:** Find a plastic comb or ruler. Run it through your hair several times or rub it in a dry towel for 30 seconds. Adjust a faucet to produce a small stream of water. Slowly bring the comb near the stream of water. Make a drawing of what happens.



### SOLID STATE (ICE)

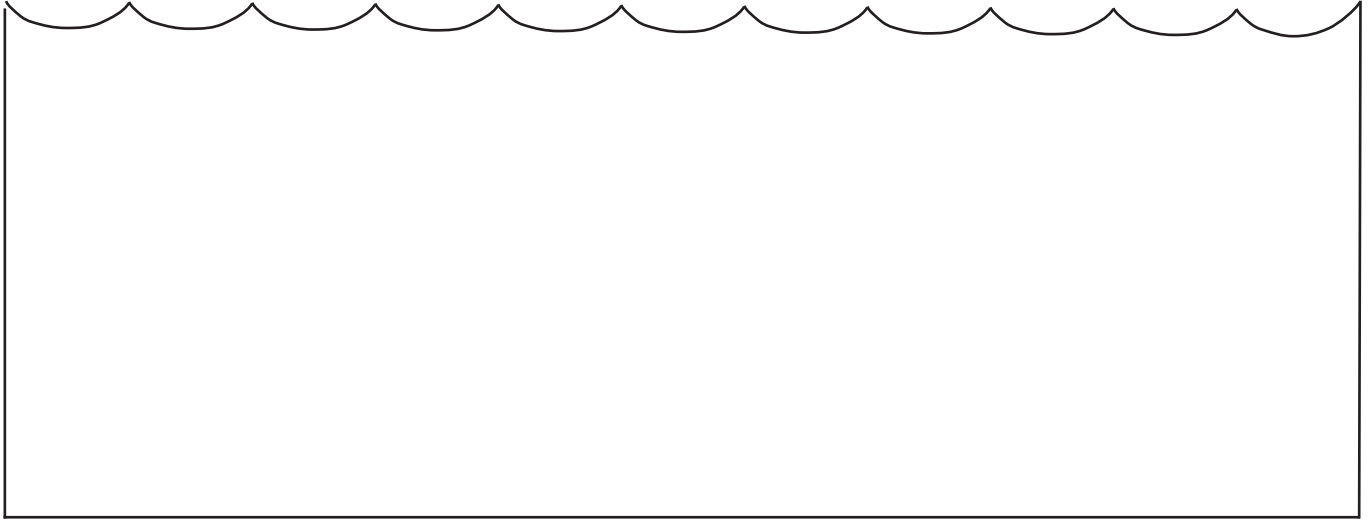
Solid water, or ice, is less dense than liquid water. As water freezes, the molecules begin to move around more slowly. This makes it easier for the water molecules to form hydrogen bonds and arrange themselves into a structure in which they are farther apart from each other than in liquid water. This is why ice is less dense than liquid water and is why ice floats. This property is important, as it keeps ponds, lakes, and oceans from freezing solid and allows life to continue to thrive under the icy surface!



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## SOLID STATE (ICE) CONTINUED...

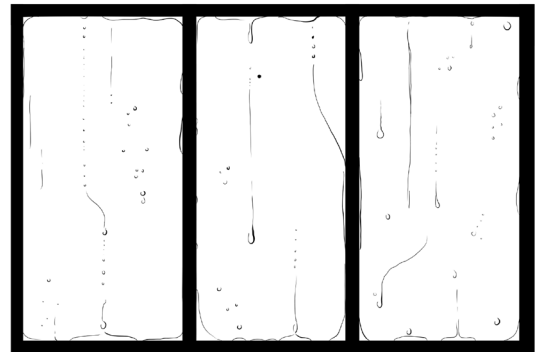
**Activity:** Put ice in a glass of water. What did the ice do? Water floats when it freezes. You already knew that, but why is it important? Draw some creatures in the ocean below. What would happen if the entire ocean froze?



## COHESION AND ADHESION

The polarity of a water molecule gives them strong **cohesive** properties that allow them to stick to molecules of the same kind. Water also has **adhesive** properties that allow it to stick to substances other than itself.

These cohesive and adhesive properties are essential for **fluid transport** in many life forms. For example, they allow nutrients to be transported to the top of a tree against the force of gravity, in a process called **capillary action**.



**Activity:** See “Fluid Transport Experiment,” which is also included in your guide.

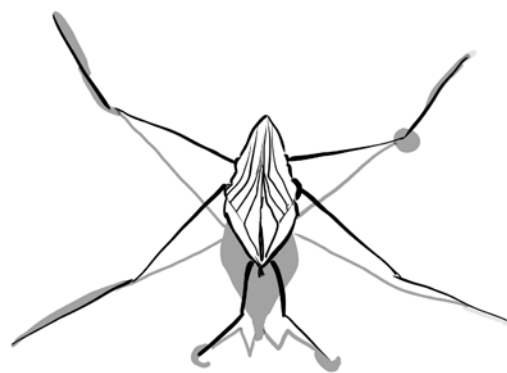
## SURFACE TENSION

**Surface tension** is an effect that may be seen when the surface of a liquid is strong. Water has strong cohesive properties. That means that water molecules stick to other the water molecules beside them. Molecules on the surface have no neighboring molecules above them, and therefore they have a stronger pull to their neighbors on and below the surface. This creates surface tension.

CONTINUED ON THE NEXT PAGE...

## SURFACE TENSION CONTINUED...

Other liquids have surface tension as well, but the hydrogen bonds make the surface tension of water quite strong. Whether you know it or not, you have already seen surface tension at work. Whenever you fill a glass of water too far, you may notice that the level of the water in the glass is actually *higher* than the height of the glass. You may have also noticed that the water that you spilled formed into pools that rose up off the counter. Both of these phenomena are due to surface tension.

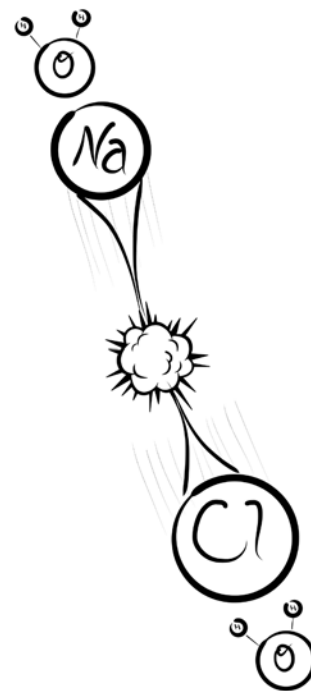


**Activity:** Fill a bowl with tap water. Bend a small metal paper clip into an “L” shape as a holder. Place a second metal paper clip on the holder and dip it slowly in the water. Are you able to make the paper clip float? \_\_\_\_\_  
What happens if you just drop the paper clip in the water? \_\_\_\_\_

## SUPER SOLVENT

Water has the unique ability to dissolve many substances. The polarity of water molecules is responsible. One side of a water molecule carries a slight positive charge, and the other side carries a slight negative charge. These charged sides are attracted to the charged ends of other compounds, such as salt. This attraction then disrupts the attractive forces holding the other molecule together and dissolves it.

This is important to all living things. As water travels through the water cycle, it takes many valuable nutrients along with it. Water doesn't dissolve everything, however. Non-polar molecules, including many organic compounds such as fats and waxes, don't dissolve very well in water.



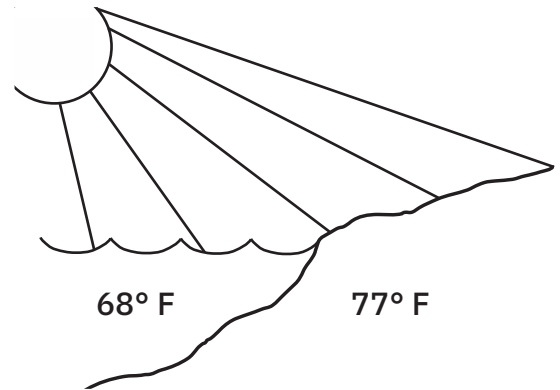
**Activity:** Fill a glass or bowl with water. Add a couple of tablespoons of table salt. Add a couple of tablespoons of cooking oil. Stir for 30 seconds. What happens to the salt and oil? \_\_\_\_\_

CONTINUED ON THE NEXT PAGE...

## THE PROPERTIES OF WATER CONTINUED...

### HIGH SPECIFIC HEAT

**Specific heat capacity** is the heat required to raise the temperature of a specific amount of a substance by one degree. Water has high specific heat capacity. It takes a lot of energy to raise the temperature of a certain amount of water by one degree. Therefore, water helps regulate temperature on Earth's surface.



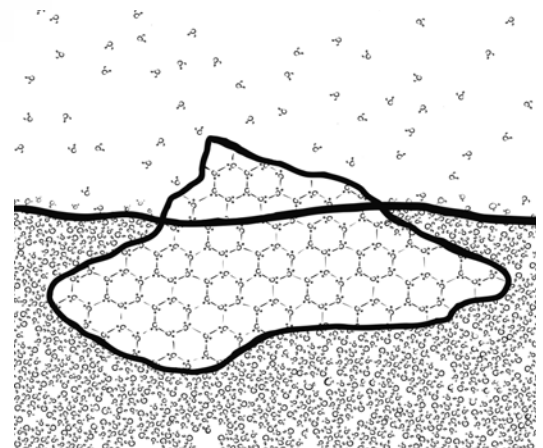
For example, the temperature of water in a pond stays relatively similar from day to night. Water's high specific heat capacity also helps balance Earth's temperatures because water traps heat during the day and releases it slowly at night.

**Activity:** Get two cups. Fill one cup with sand or dirt. Fill the other cup with the same amount of water. Set them on a table overnight so that they both reach room temperature. During the day, set both cups in a sunny spot. Measure the temperature of each cup with a thermometer or your hand and again after 5, 10, 15, and 20 minutes. Which one gets hotter faster? \_\_\_\_\_

### BOILING AND FREEZING POINTS

The ability of water molecules to form hydrogen bonds is responsible for many of water's unique characteristics. Water requires more energy to break its hydrogen bonds before it can boil. This also applies to water's freezing point.

The **boiling** and **freezing points** of water allow the molecules to be very slow to boil or freeze, and this is important to water ecosystems. If water were too easy to freeze or boil, drastic changes to Earth's oceans and lakes would cause all the organisms living in water to die. This is also why perspiration is able to cool our bodies.



**Activity:** At normal atmospheric pressure, water has a boiling point (B.P.) of 212 °F. and a melting point (M.P.) of 32 °F. On the next page, write and color in the parts of the thermometer where water is a solid, liquid, or gas. Do the same for ethanol (B.P. = 173 °F., M.P. = -173 °F.), carbon dioxide (-109 °F. **sublimation** point, where it skips the liquid state and turns straight from solid to gas), and ammonia (B.P. = -28 °F., M.P. = -108 °F.). Is there any difference between them?

# Boiling, Melting, and Freezing Points Worksheet

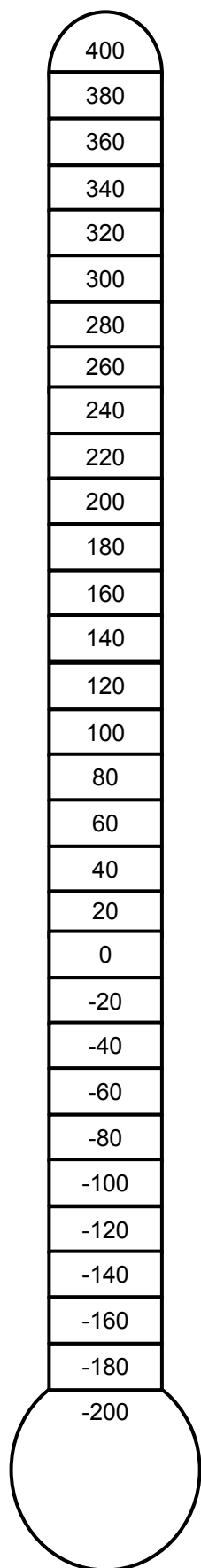
degrees Fahrenheit

water

ethanol

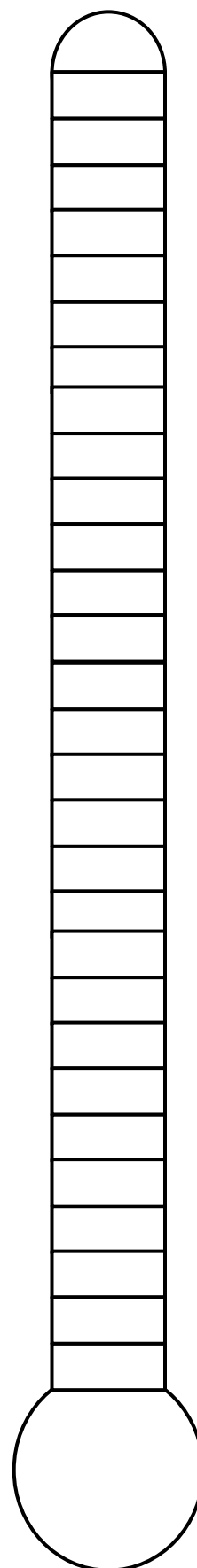
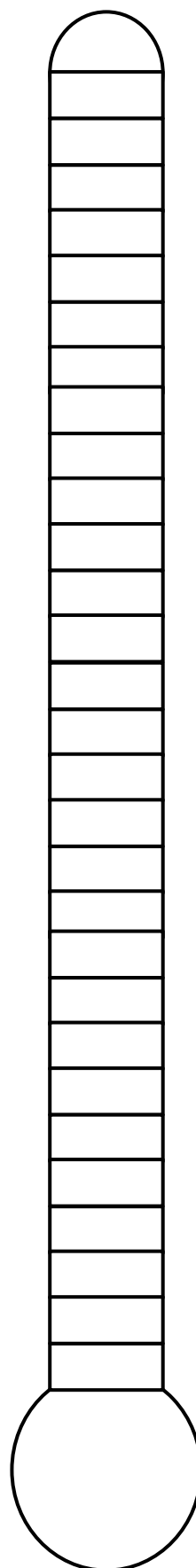
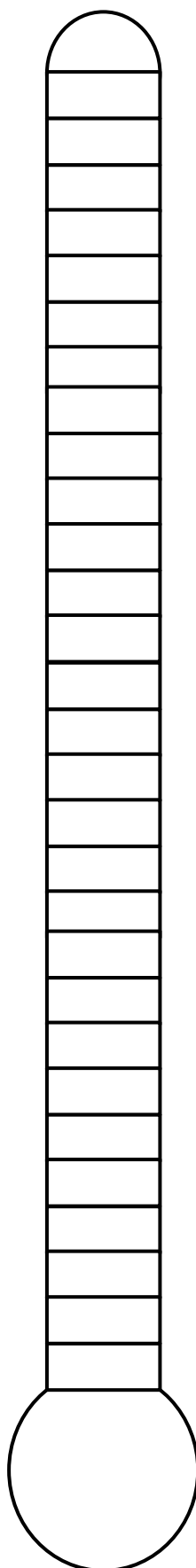
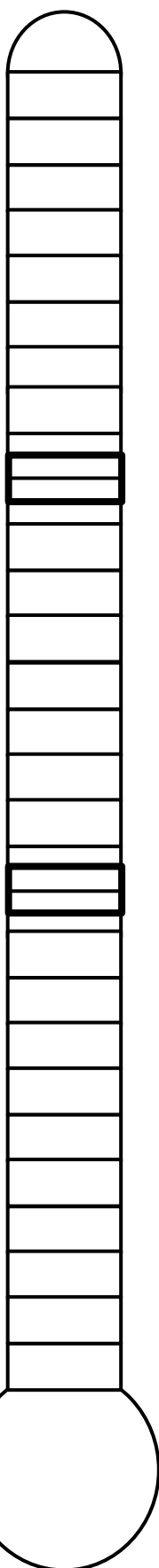
carbon dioxide

ammonia



**B.P.**  
212 °F.

**M.P.**  
32 °F.





## Post-program Materials

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We hope you enjoyed Module 3: The Search for Water of Griffith Observatory's Online School Program. To continue your lifelong journey as observers, here are some activities and resources.

### Module 3 Crossword

This worksheet reinforces the new words you learned in Module 3: The Search for Water and in the program materials. Refer to the Module 3 glossary if you get stuck!

### Coloring the Cosmos

We have included three coloring book activities for a quiet moment.

### [NASA ClimateKids Water Portal](#)

Visit this website, linked above, to learn about NASA's many satellites that observe Earth's water. Where is Earth's water found? How is that changing over time?

### Water Conservation Plan

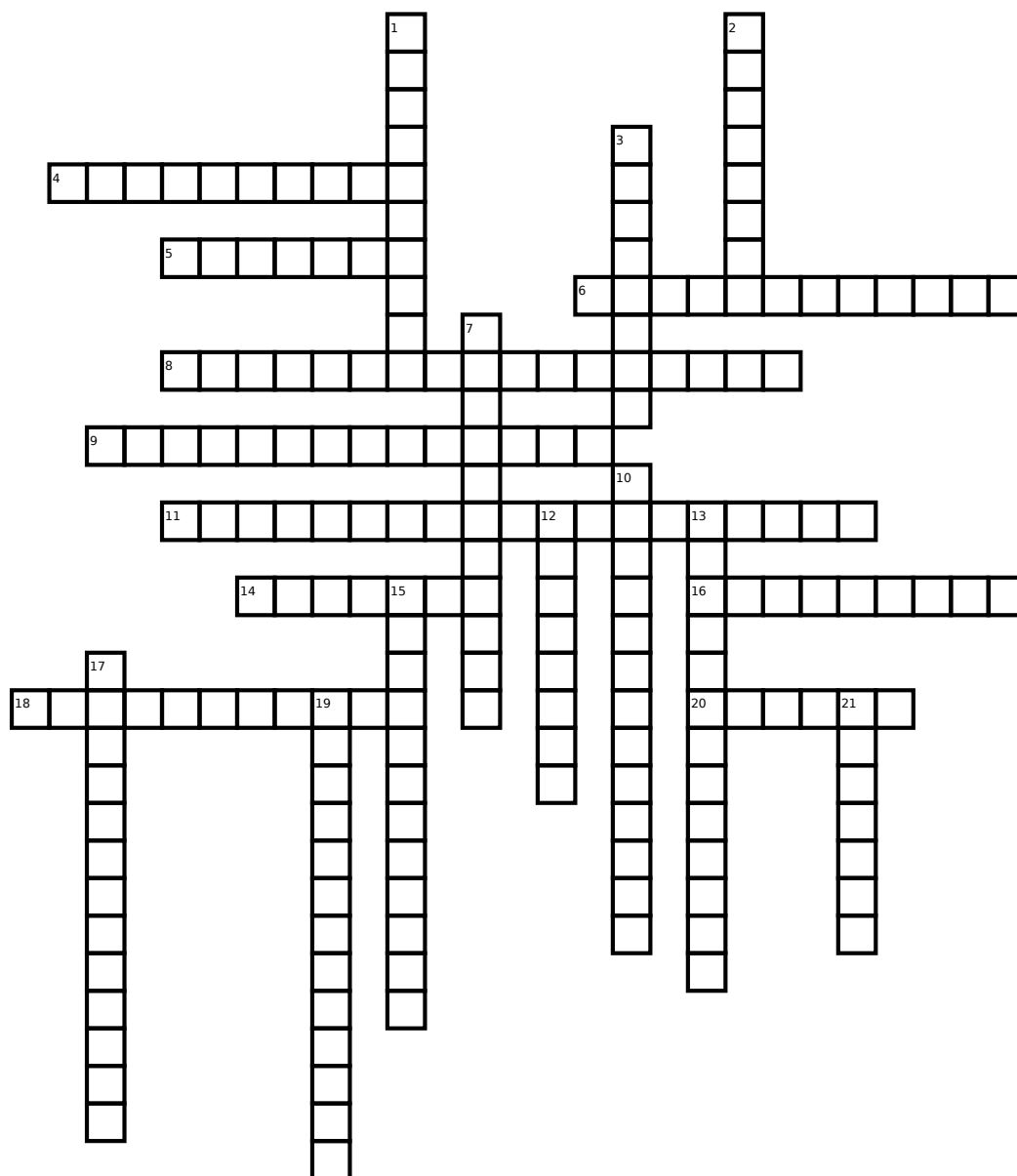
How often do you use water in your daily life? Your observations may surprise you. This plan will help you set goals for conserving water, one of Earth's most precious resources.

### Internet Resources

The internet may be helpful. This resource lists a variety of websites that will help you expand your astronomical knowledge and have fun doing it.

# Module 3 Crossword

Use the hints at the bottom to fill the crossword with Module 3 glossary terms.

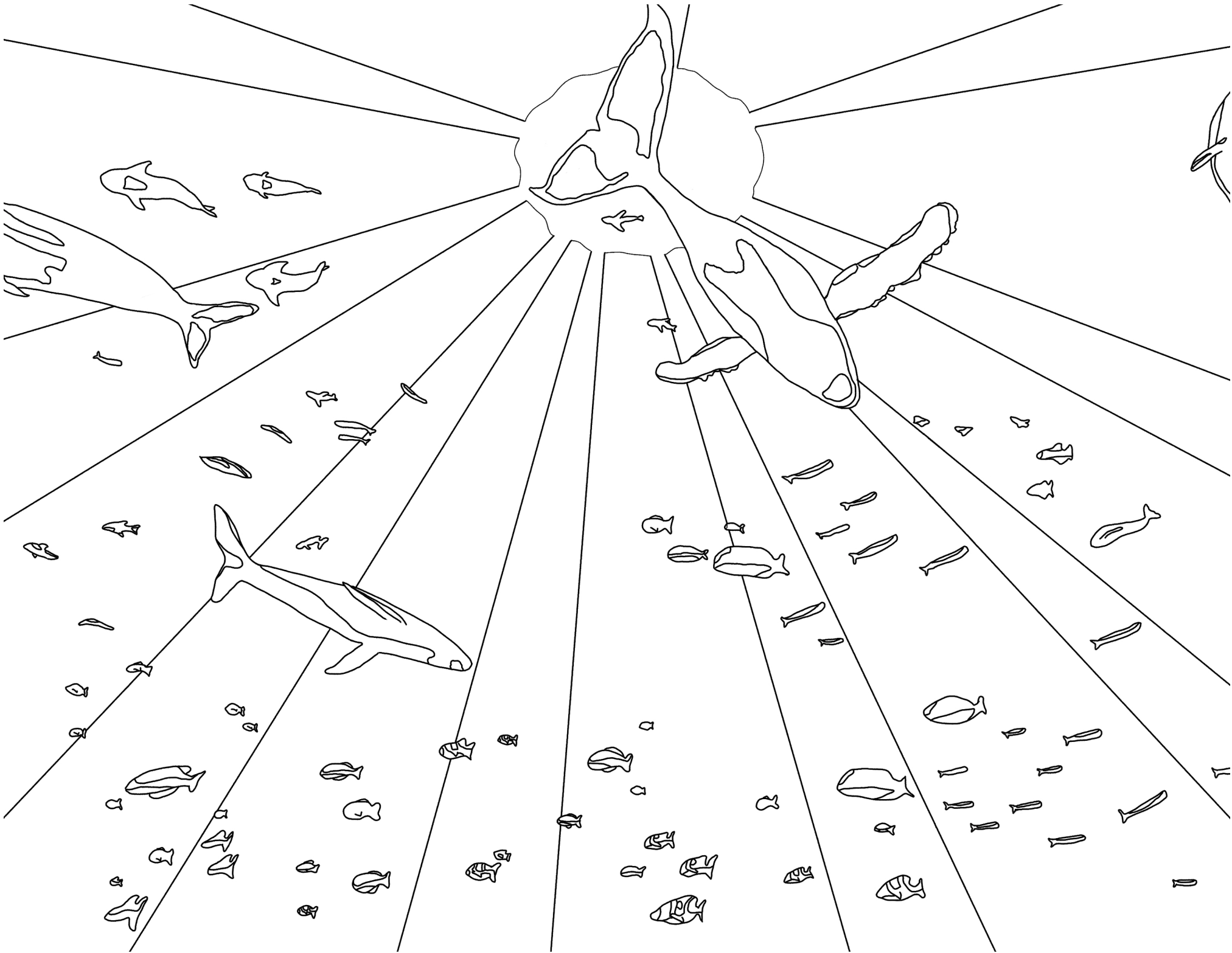


## DOWN

1. water moving around Earth and the atmosphere
2.  $H_2O$  is one of these
3.  $O_3$ , or ozone, is a molecule, but it isn't a...
7. liquid to vapor
10. bring an umbrella
12. speeds up reactions
13. water flowing down, down, down...
15. a creature thriving in an "impossible" place
17. molecules that act like tiny magnets
19. plants exhaling water
21. a pure substance of one type of atom

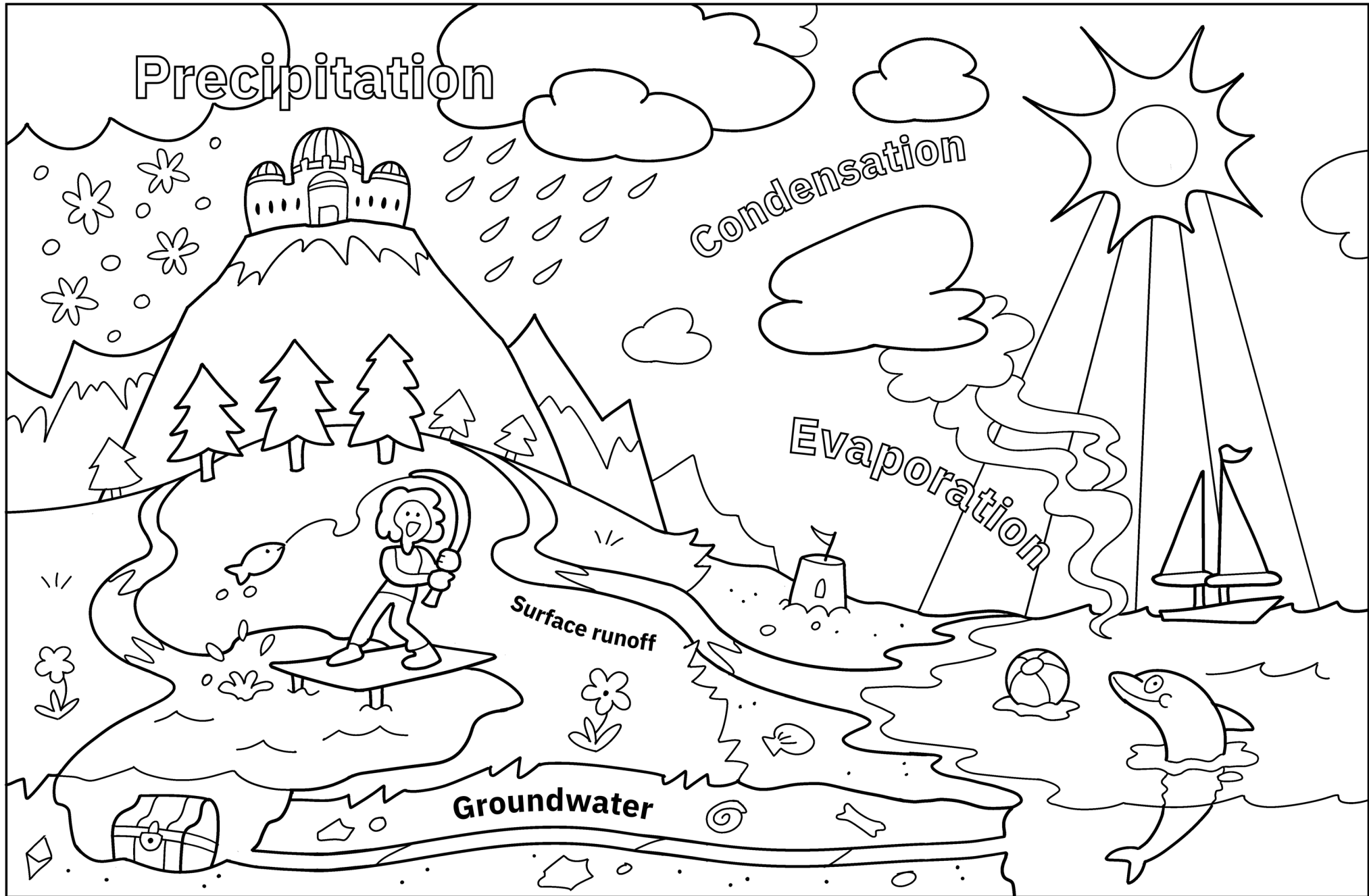
## ACROSS

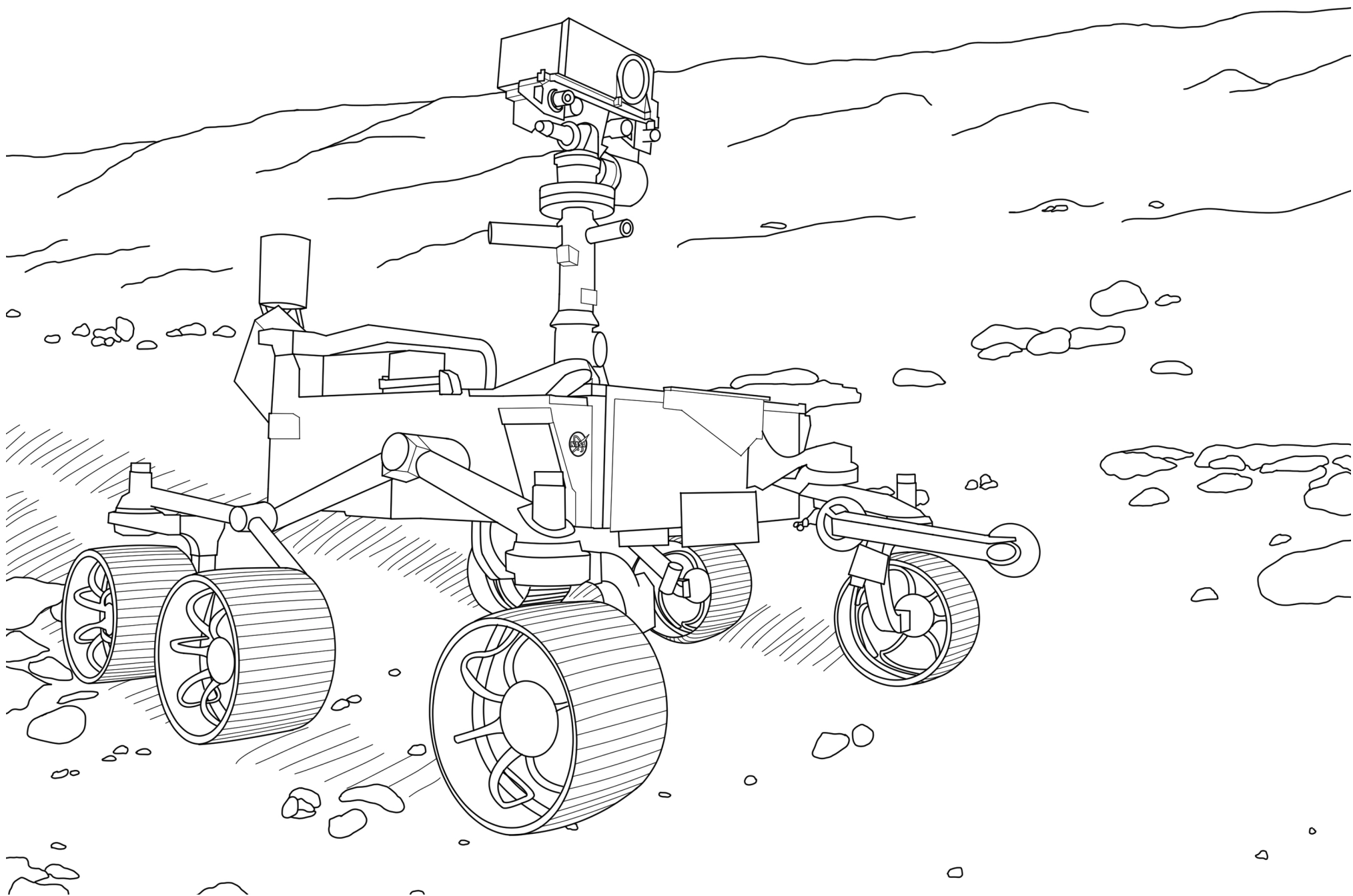
4. drinkable, no salt allowed
5. why your feet stay on the ground
6. forms clouds
8. desert, city, forest, grassland...
9. your bloodstream carrying nutrients
11. air is heavy
14. breaks down substances
16. a common water supply for a city
18. tree roots soak this up
20. a meteor crashed and made a huge...



# The Water Cycle

Name: \_\_\_\_\_







# Water Conservation Plan

**Explore:** Think of all the times that you use water at home each day. Start with when you wake up in the morning, and go through your normal routine. Every time you think of an activity that uses water, write it below.

Morning

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Afternoon

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Evening

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**Directions:** Check all the ways you can and will conserve water and take care of Earth, and add your own ideas on the next page.

- ☐ Turn off the water while you brush your teeth.
- ☐ Take a shower instead of a bath. Use a timer to keep your shower short.
- ☐ Turn off the faucet completely so it doesn't drip.
- ☐ Wash dishes in a bowl or bucket of soapy water instead of running the water in the sink.
- ☐ Choose fewer games and art activities that use a lot of water.
- ☐ Put a bucket outside to catch rainwater. Use this to water plants later.

**Continued on the next page...**

## Water Conservation Plan continued...

- ☐ Only run your dishwasher or laundry machine when you have a full load.
- ☐ Don't use the toilet as a trash can. Every time you flush you use a lot of water!
- ☐ Have special glasses or water bottles for each family member to use all day long instead of getting new cups for every drink of water.

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## Did you know?

In the U.S., thermoelectric power production accounted for 34 percent of freshwater use in 2015.

**Record:** Set a goal to remember to do these things as often as you can.  
Write a reflection in one week to see how you did!

This past week I conserved by...

Date \_\_\_\_\_

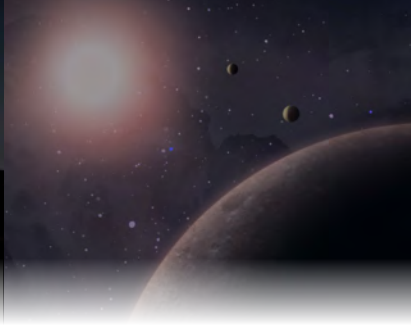
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# Internet Resources

## ASTRONOMY CLUBS

Astronomy clubs are wonderful resources. Amateur (and some professional) astronomers are happy to share their telescopes, their enthusiasm, and their knowledge. Find an astronomy club near you! A list of local clubs and more information may also be found on our website:

<https://griffithobservatory.org/explore/observing-the-sky/astronomy-resources/>

## CITIZEN SCIENCE PROJECTS

You may make a real contribution to astronomy by participating in these scientific projects.

Help scientists with their research into stars, Mars, Earth, galaxies, astronautics, the Sun, and black holes! Multiple projects are listed at this website:

<https://spacehack.org/>

Another useful site that lists multiple Citizen Science projects:

<https://www.zooniverse.org/>

## GREAT WEBSITES FOR SPACE FANS

Check out games and projects for budding space scientists:

<https://spaceplace.nasa.gov/menu/play/>

Explore space with NASA's remarkable app, "NASA's Eyes:"

<https://eyes.nasa.gov/>

Watch NASA on television (or on another device with an internet connection):

<https://www.nasa.gov/multimedia/nasatv/#public>

## GREAT WEBSITES FOR SPACE FANS CONTINUED...

Visit websites dedicated to learning for grades 5 through 8:

<https://www.nasa.gov/stem-at-home-for-students-5-8.html>

Meet the astronauts on the International Space Station (ISS). Make your own rocket out of a straw, or test your driving skills – on Mars:

<https://www.nasa.gov/kidsclub/index.html>

## RESOURCES ON THE GRIFFITH OBSERVATORY WEBSITE

Sky Report:

<https://griffithobservatory.org/explore/observing-the-sky/sky-report/>

Give yourself a tour of the Observatory, and check out the exhibits:

<https://griffithobservatory.org/explore/exhibits/>

Watch the *All Space Considered* space news update:

<https://griffithobservatory.org/visit/calendar/all-space-considered/>

