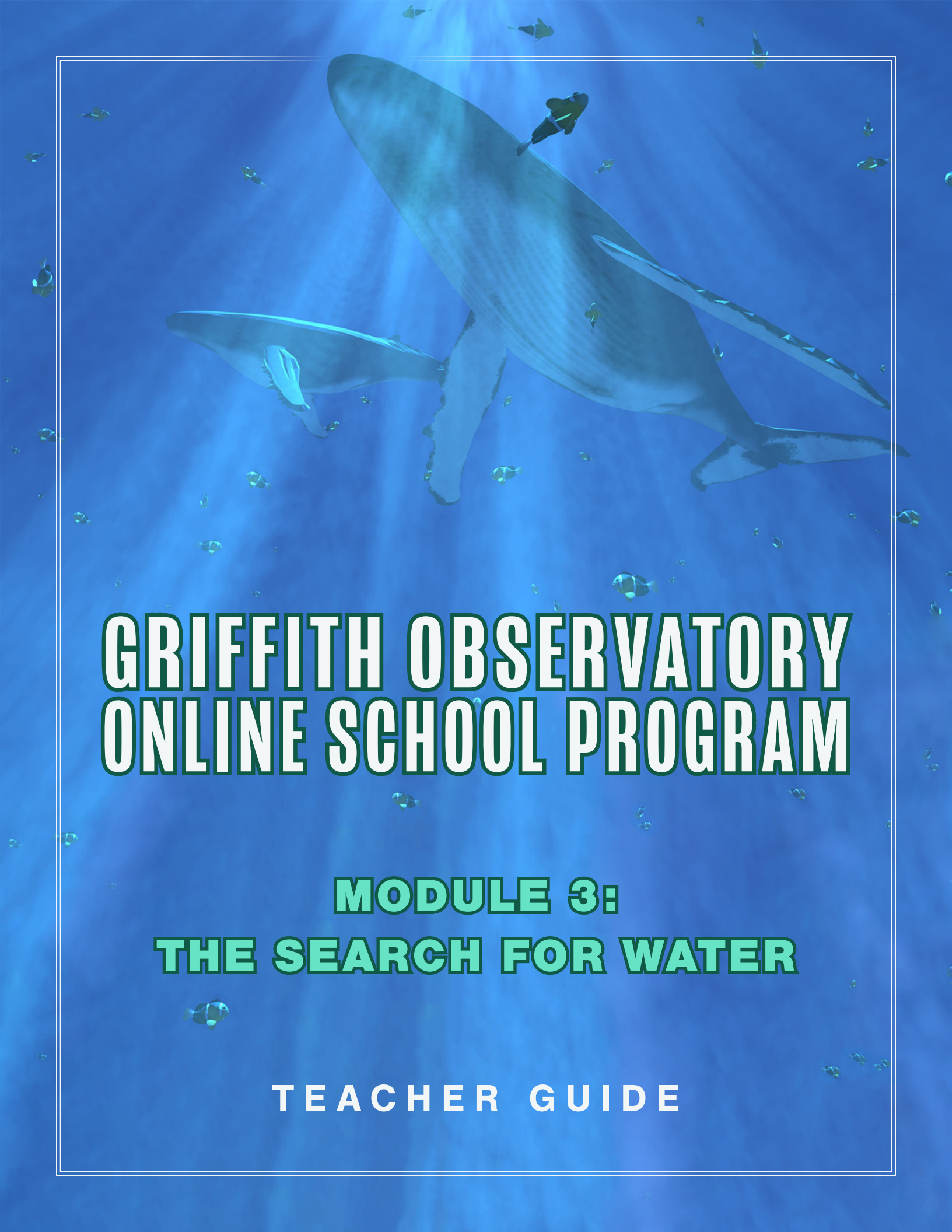


GRIFFITH OBSERVATORY ONLINE SCHOOL PROGRAM

MODULE 3:
THE SEARCH FOR WATER

TEACHER GUIDE

Dear Teacher,

Welcome to Griffith Observatory's Online School Program teacher resources!

It is our mission to inspire everyone to observe, ponder, and understand the sky. With this program, we intend to be your partner in education, providing you access to experts and unique activities that bring science to life in your classroom.

Our Fifth-grade Online School Program modules are

- Entirely free to participate
- Aligned with current fifth-grade education Next Generation Science Standards (NGSS)
- Interactive and presented live by Griffith Observatory's knowledgeable staff
- Intended to inspire students' curiosity for space exploration and S.T.E.M. (Science, Technology, Engineering, and Mathematics) subjects and to expose them to the latest astronomical science and technology

If we learn how to observe and do so carefully, we are rewarded with profound discoveries about the universe and ourselves. This is the unifying theme of our Online School Program modules and what we hope your students will take away from the program.

Thank you for teaching the next generation of critical thinkers and observers!

GRIFFITH OBSERVATORY

REC & PARKS

CITY OF LOS ANGELES FOUNDED 1781

GRIFFITH OBSERVATORY FOUNDATION

Griffith Observatory Online School Program

Overview

Griffith Observatory's online school program is a live, interactive, virtual school program for fifth-grade students. The program offers live and prepared elements that feature Griffith Observatory's knowledgeable Museum Guides and Telescope Demonstrators. Like the in-person school program, this online program is offered to interested schools on a first-come, first-served basis, and we encourage participation by schools in communities that have limited access to special science-outreach initiatives. The online program enables students to have a meaningful, virtual Observatory experience without transportation and geographic barriers to participation. The operation of both programs is funded by Griffith Observatory and Griffith Observatory Foundation.

Griffith Observatory's online school program is hosted entirely through Zoom, is delivered live from Griffith Observatory, and meets current fifth-grade standards (NGSS 2015).

Structure

The program is a series of modules that each address a different aspect of observation. Each module contains live, recorded, and animated elements, lasts about 30 minutes, and is followed immediately with a question-and-answer session. The modules are intended to be experienced in order, though not necessarily within a particular time-frame.

Goals

The modules are designed to accomplish three goals:

- inspire students to be observers
- encourage students to appreciate their place in and relationship to the universe
- expose students to the latest astronomical science and technology

The Modules

MODULE 1: EVERYONE IS AN OBSERVER

"Everyone Is an Observer" examines the observational skills everyone uses to navigate life. Through virtual daytime and night observation with Griffith Observatory's historic coelostat and Zeiss telescope, participants learn how astronomers observe, use scientific instruments, and record data to expand their knowledge of the universe. How has systematic observation changed our understanding of objects in space, and how have our findings helped us understand Earth's relationship to them?

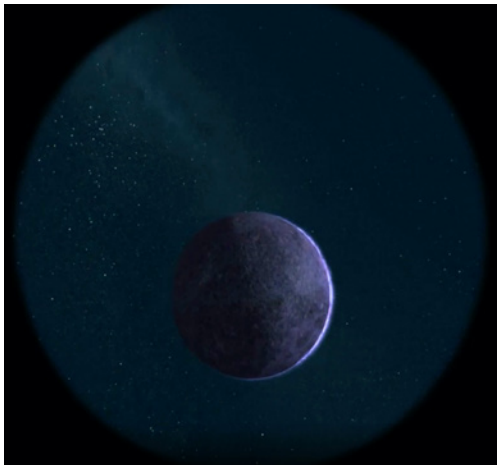
MODULE 2: CLUES FROM COMETS

"Clues from Comets" investigates the process of using observations to understand cause-and-effect relationships between events, exemplified by our understanding of comets over time. Presented live from Griffith Observatory's Leonard Nimoy Event Horizon theater, the program guides students through centuries of records kept on the appearances of comets as people gradually learned about their nature. Midway into the presentation, participants witness the manufacture of a life-ingredient-bearing comet from household supplies. Finally, participants embark on a journey to a real comet in space fashioned from actual photographs from the *Rosetta* mission. What can comets tell us about the solar system and about ourselves?

MODULE 3: THE SEARCH FOR WATER

"The Search for Water" emphasizes that liquid water is essential for life, looks inward at our own planet with thriving life forms, and then outward for other water-lush worlds. Griffith Observatory's *Our Earth*, *Our Moon*, *Elements*, and *Solar System Worlds* exhibits are explored to identify conditions and materials present on our world versus others. The unique properties of water are examined with a variety of demonstrations, and the resilience of life is explored with footage from Earth's extreme places. Students are then guided through the solar system in search of environments that sustain liquid water. The program includes animated elements from Griffith Observatory's planetarium show *Water Is Life* that have been converted to 2-D and enhanced for on-line learning.

Modules continued



MODULE 4: EXOPLANETS ARE EVERYWHERE

"Exoplanets Are Everywhere" outlines the structure of our solar system and shows how a planet's distance from its star, among other circumstances, is essential for making it a habitat for life. Students encounter exoplanet discoveries and what they mean. In this exhibit-based experience with interactive components, participants visit simulated alien worlds and solar systems in search of habitable planets. Students will visit The Gunther Depths of Space, experience the solar system models, see the current exoplanet count, take a tour of The Big Picture, see *Our Sun Is a Star*, and get acquainted with modern exoplanet-hunting technology.

MODULE 5: EARTH IS OUR HOME

"Earth Is Our Home" guides participants on an immersive, 13.8 billion-year journey through Griffith Observatory's *Cosmic Connection* timeline. Environmental change can be caused by cosmic events or by living things. When ecosystems change, life also changes. Real-life stories demonstrate that studying Earth from an astronomical perspective sheds light on how people are changing Earth's ecosystems. Two core messages are emphasized: The evolution of Earth and life are intertwined, and observation and scientific thinking are key for protecting Earth's resources and environment.

Program Rundown

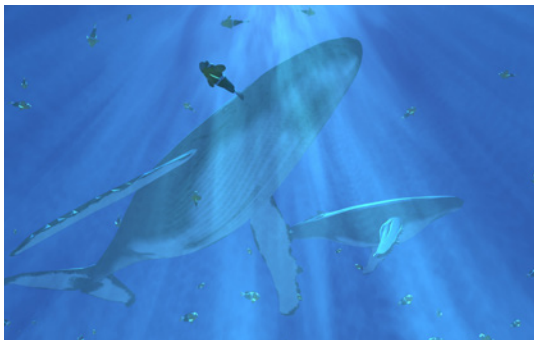
Module 3 Strategies

- Emphasize the importance and pervasiveness of water on individual, global, and cosmic scales.
- Explore the bizarre properties of water with various experiments, polls, and demonstrations.
- Learn the origins of life, what conditions and materials life needs, and how resilient life is.
- Investigate whether other worlds in our solar system are hosts for liquid water.
- Supplement live and recorded content with documents and materials for the classroom and at home, to be used before and after participating in the module.

Module 3 Breakdown

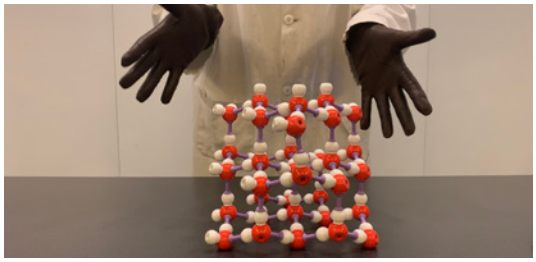
PRE-PROGRAM WAITING ROOM
When logged on early, you encounter a waiting room animation indicating that the program has not yet begun.

ARRIVAL TO GRIFFITH OBSERVATORY ANIMATION
An animation designed and produced by Griffith Observatory's Satellite Studio brings you from the far reaches of the universe to Griffith Observatory.



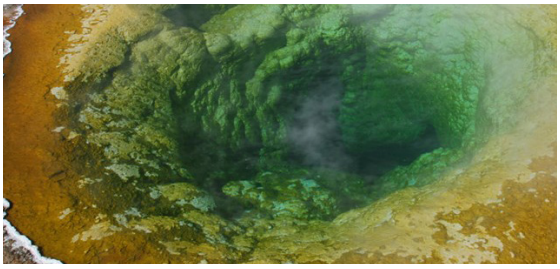
LIVE INTRODUCTION TO YOUR MUSEUM GUIDE
A Museum Guide joins you live from Griffith Observatory's Gunther Depths of Space. The Guide tours students around the world through a combination of real footage and animations from Griffith Observatory's planetarium show *Water Is Life* to find water in its three states: Solid, liquid, and gas. We learn that water is everywhere on Earth and that it is both essential for life and made it possible for life to originate.

EARTH VS. THE MOON
The Museum Guide stops at Griffith Observatory's *Our Moon* exhibit to compare the Moon to our planet, Earth. We see pictures taken from the Moon and rock samples that reveal some of the Moon's characteristics but nothing that indicates the presence of liquid water or any life forms.



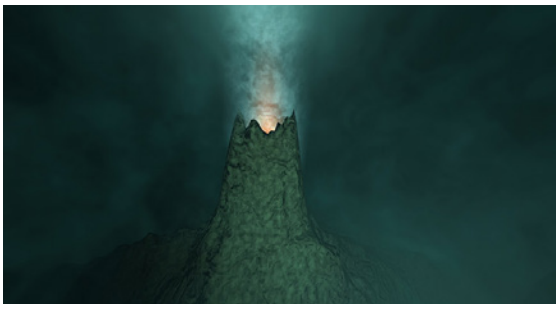
PROPERTIES OF WATER
A series of short video-demonstrations illustrate the unique and unusual properties of water. Griffith Observatory's *Elements* exhibit is explored. An interactive poll and some do-it-yourself experiments are featured. Students learn why the many properties of water molecules make water an essential resource for all life.

Program Rundown continued



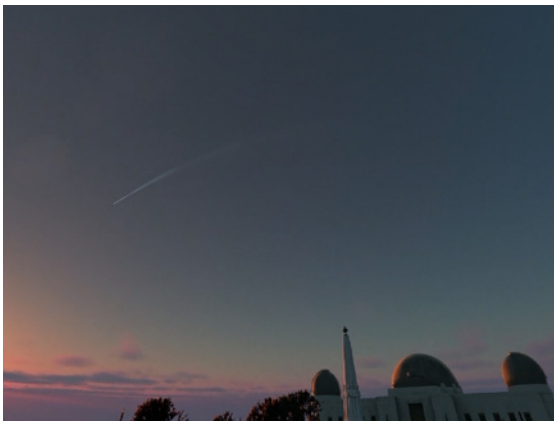
OTHER WORLDS AND OTHERWORLDLY PLACES

The live Museum Guide leads an investigation of Mercury and Venus to find liquid water with the help of Griffith Observatory's *Solar System Worlds* exhibit. We pause on Earth to explore its most extreme environments where extraordinary life forms still thrive, all because liquid water is present.



SEARCHING THE SOLAR SYSTEM FOR WATER

A lengthy animated segment from Griffith Observatory's planetarium show *Water Is Life* plays. We blast off from Griffith Observatory to explore Mars and the rest of the solar system in search of water. We dive into the sub-surface ocean of Europa, one of Jupiter's moons. We continue through the outer solar system and then follow a comet back toward Earth.



CONCLUSION

The live Museum Guide returns with some closing remarks as an animation plays. The Guide uses water to explain our connection to the cosmos. To continue our search for life, the Guide concludes, we must follow the water and look for conditions like those on Earth.

QUESTION-AND-ANSWER SESSION

We transition to a question-and-answer session with the live Museum Guide. The Guide answers questions about science from students.

2015 Next Generation Science Standards Reflected in the Program

Module 3: The Search for Water

GRADE	STANDARD	NGSS DESCRIPTION	HOW THE STANDARD IS ADDRESSED
3	3-LS4-3 LS4.C	For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.	Extremophiles are discussed in the program to affirm that life can survive in extreme environments, just as long as liquid water exists there. Other worlds in our solar system are explored, and we infer whether they may host environments that are hospitable for life.
3	3-ESS2-2	Obtain and combine information to describe climates in different regions of the world.	We visit different climates to witness how the water behaves in each. Later on, we visit extreme micro-climates to learn about extremophiles.
5	5-PS1-2	Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.	A demonstration is conducted to compare how water molecules are arranged in a liquid state versus a solid state. Water is revealed to expand when it freezes. This occurs only because the molecules form a more open structure and not because the amount of water increases.
5	5-ESS2-1 ESS2.A	Earth's major systems are the geosphere, the hydrosphere, the atmosphere, and the biosphere. These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.	Throughout the program we delve into the way water travels through Earth's major systems and may change states in the process. We dive into the ocean to experience an underwater ecosystem. Materials involving the water cycle also demonstrate how Earth's major systems interact.
3-5	Principle III (CA)	Natural systems proceed through cycles that humans depend upon, benefit from and can alter.	After explaining how water travels through Earth's major systems and how it is distributed, we remark that the water from our vast oceans is too salty for us to drink. Rather, we rely on that water evaporating and then falling back to Earth as rain that is safe for us to drink.

Standards continued

GRADE	STANDARD	NGSS DESCRIPTION	HOW THE STANDARD IS ADDRESSED
5	5-ESS2-2	Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.	The program explores the ubiquity of water on Earth, in what states it exists, where it is, how it travels, and how life forms use it. Materials in this guide detail Earth's water distribution.
5	5-PS2-1	Support an argument that the gravitational force exerted by Earth on objects is directed down. [Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.]	Throughout the program we reference gravity as an important physical force that affects both small bodies (like us) and large bodies (like planets). We show how the Moon's low gravity affects objects near its surface and how Jupiter's massive gravity pulls and stretches its moons.
5	5-ESS3-1	Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.	One overarching message conveyed by the program identifies Earth as the only place we know with liquid water on the surface, and so we must protect the conditions on our planet that sustain our liquid water. Materials in this guide show how to conserve water.

Connecting to the Program

Overview

This section contains all of the information you and your students will need in order to join your online school program webinar session and ensure a successful virtual visit to Griffith Observatory. It is essential that you read and follow these instructions carefully.

Within 24 hours of completing the registration process for our program, you should have received a confirmation email from online.sp@griffithmedia.org. The message includes a **Zoom webinar link**, the **date and time** of your session, and other important information and links. You are responsible for forwarding the necessary information, according to the instructions in the message, to your students and all included teachers. Shortly before your scheduled Griffith Observatory Online School Program webinar session, you will receive a reminder message.

What You Need to Know

- Please be as punctual as possible. Your session includes a window for arrivals before the actual program begins, but the program will begin regardless of whether every registered classroom shows up or not.
- A Griffith Observatory staff member will be in the Zoom room to assist you if needed, relay some reminders, and will then act as your main point of contact for any questions you may have during the program. Use the chat feature to message the "Host and Panelists."
- The school program now uses Zoom's "webinar" model. Teachers and students are encouraged enter the webinar all at once. Although you will be muted with your video turned off, you may still use the chat function to message Griffith Observatory staff.
- Students that join the webinar from their individual devices are also not able to unmute themselves or share their video streams. They may not chat with each other. They may, however, use the chat feature to ask for help and use the Q&A feature to submit astronomical questions to staff. Questions submitted in the Q&A feature are not visible to everyone unless a staff member chooses to answer it live.
- You may also choose to project the program to your class. Note: This means you will need to answer the interactive polls and ask questions for the Q&A on behalf of your class.
- In the unlikely event that the Griffith Observatory video stream drops out of the webinar, please instruct your students to wait patiently and remain in the call.

Essential Information for Students

It is your responsibility to make sure your students receive and understand the following information. You may easily copy it and paste it into a message to your students. Make sure you insert your class's registered session **time**, **date**, and unique **Zoom webinar link** into the **orange** areas below. This information may be found in your confirmation email.

Dear Students,

Your class's Griffith Observatory Online School Program webinar time:
[**INSERT YOUR REGISTERED WEBINAR TIME AND DATE**]

Please log on at the time of your scheduled session. Make sure you set your "Zoom name" to contain your first and last name.

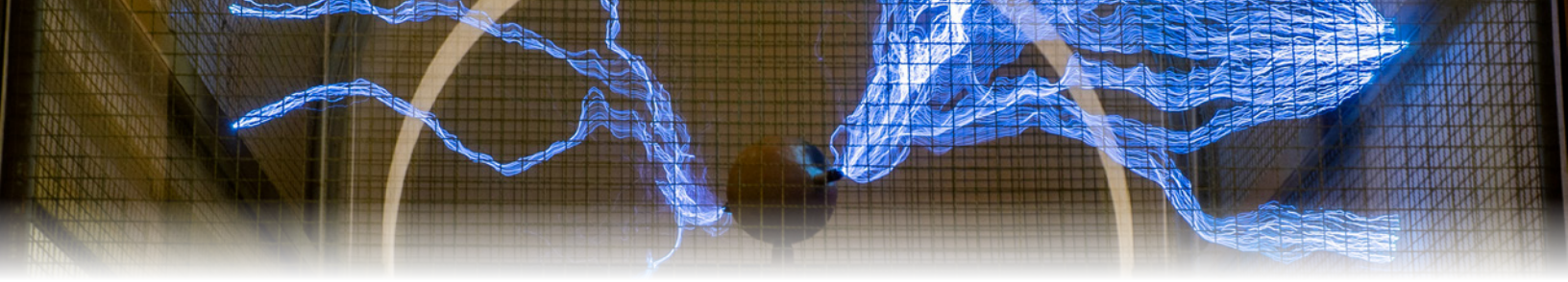
Once you enter the webinar, you will be muted with your video off. You will see a video of Griffith Observatory against a sky that cycles between day and night, and you will hear music. If you do not see the video or hear the music, use this time to work with a grown-up to check your internet connection and sound. You may also use Zoom's chat feature to ask one of the Griffith Observatory hosts for help. Once everything is working perfectly, pay attention to the instructions, and have a great online visit to Griffith Observatory!

Click the link below or copy and paste it into an Internet browser to join the meeting.

YOUR CLASS'S ZOOM WEBINAR LINK:
[**INSERT YOUR GRIFFITH OBSERVATORY ZOOM WEBINAR LINK**]

THIS WEBINAR LINK IS YOURS AND YOURS ONLY. DO NOT SHARE IT WITH ANYONE NOT PART OF YOUR CLASS.

Before the program, please make sure you have reviewed your **Student Guide**.



Frequently Asked Questions

How safe are the online school program's meeting rooms?
Your meeting room has a unique **Zoom webinar link** that will only be issued to the teacher/adult contact(s) you indicated during the registration process and to other teachers and students that have registered for that particular session. The email message with the Zoom webinar link also contains necessary information to relay to your students. This information includes a prohibition on sharing the Zoom webinar link, as keeping the webinar session link private guarantees security. At the beginning of the program, staff will state that any inappropriate, rude, or harassing language or spam sent to staff in the chat or Q&A is not tolerated and may result in being dropped from the Zoom session.

Do my students and I need to download the Zoom app to view the program?
No. You may click the Zoom webinar link or copy and paste it into an internet browser. If you do not have the Zoom app, your browser will present you with an option to "join from your browser." If you do have the Zoom app, you will be redirected to the webinar in your Zoom app after searching the link in your internet browser.

Can I access my registration form to make changes?
There is a link in your confirmation email to make any registration corrections or to reschedule.

What happens if a participant has poor connection, loses connection, or needs help?
Students will be told early in the Zoom webinar what they should do if they need help or if a connection issue occurs. They may use Zoom's chat feature to talk to Griffith Observatory staff members to report or receive help with technical issues. If a participant's call fails, the participant will be able to use the same Zoom webinar link to rejoin the session.

May I or my students record the program?
No. Like the Observatory's in-person school program, the live webinar is designed and intended to be experienced in the moment. We also need to safeguard the program content, quality, and integrity. In the future, we may consider producing recorded versions of the program, but they would be optimized for that format (vs. a live program.)

Contact

For any concerns or questions, contact online.sp@griffithmedia.org.

Pre-program Materials

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

Module 3 Glossary

The glossary identifies and defines important words that are useful for students before they attend "The Search for Water" and explore the following materials.

Listen to the Module 3 Glossary

This helps students become familiar with the terms we shall use in the program. This is recommended as an accessibility resource for students with physical and/or language-related challenges. The audio file includes pronunciations and definitions of important terms used in our program (same as in the Glossary above).

NASA: "The Water Cycle" Annotated Diagram and Worksheet

This annotated diagram from NASA illustrates and explains the journey of water through the water cycle. A worksheet invites students to label the parts of the water cycle on the diagram. See also NASA ClimateKids' Water Cycle page.

Fluid Transport Experiment

In this at-home or classroom activity, students 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

Students help a tree's roots transport water from the soil up to the rest of the tree in this classic maze activity.

Properties of Water Experiments

Students learn about water's many unusual and unique properties by doing seven simple experiments and activities.

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.


BARRINGER METEOR CRATER, ARIZONA

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.

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.


SILVER LAKE RESERVOIR, CALIFORNIA

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

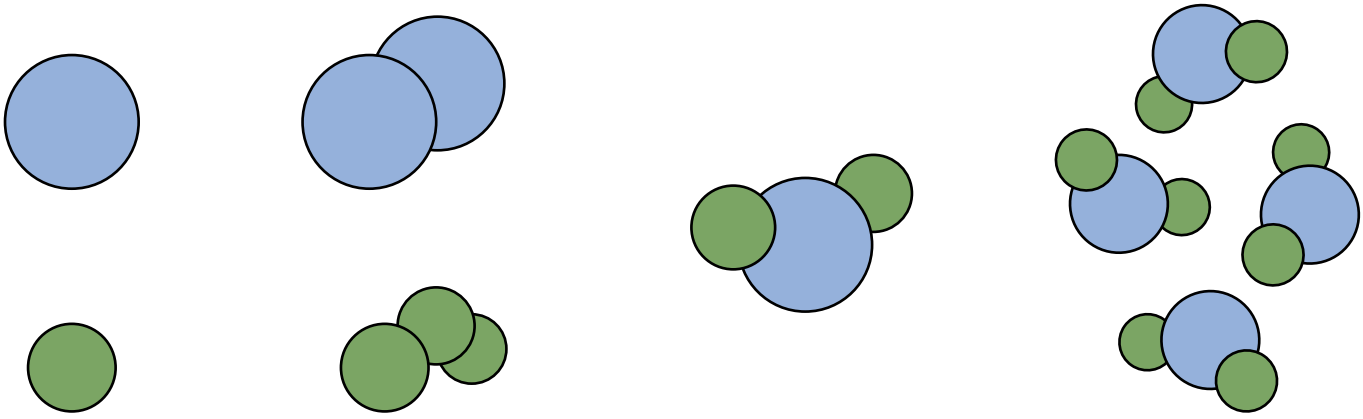
solvent – a substance that breaks down or dissolves another substance.

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

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

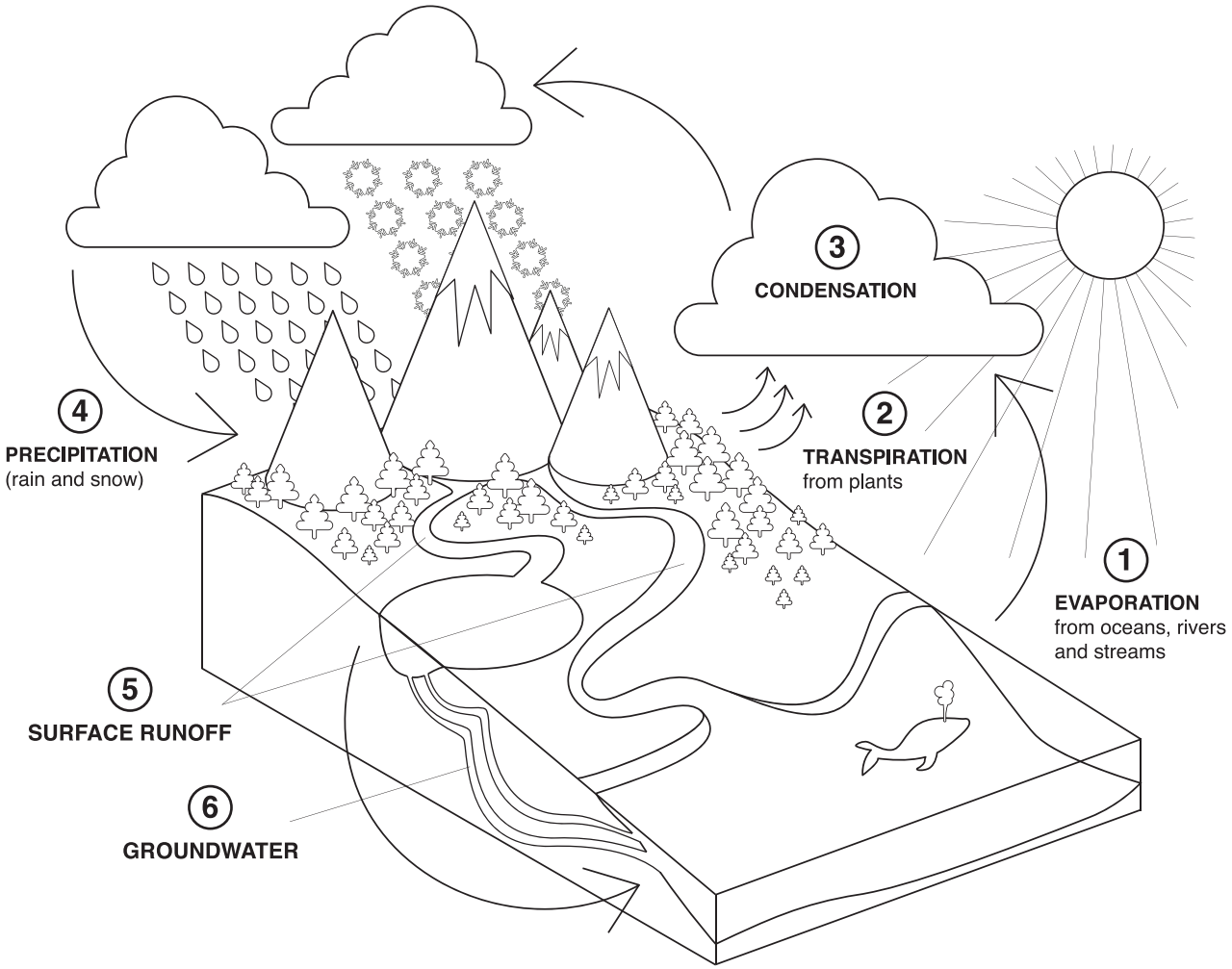
MOLECULE & COMPOUND

COMPOUND

National Aeronautics and Space Administration

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.

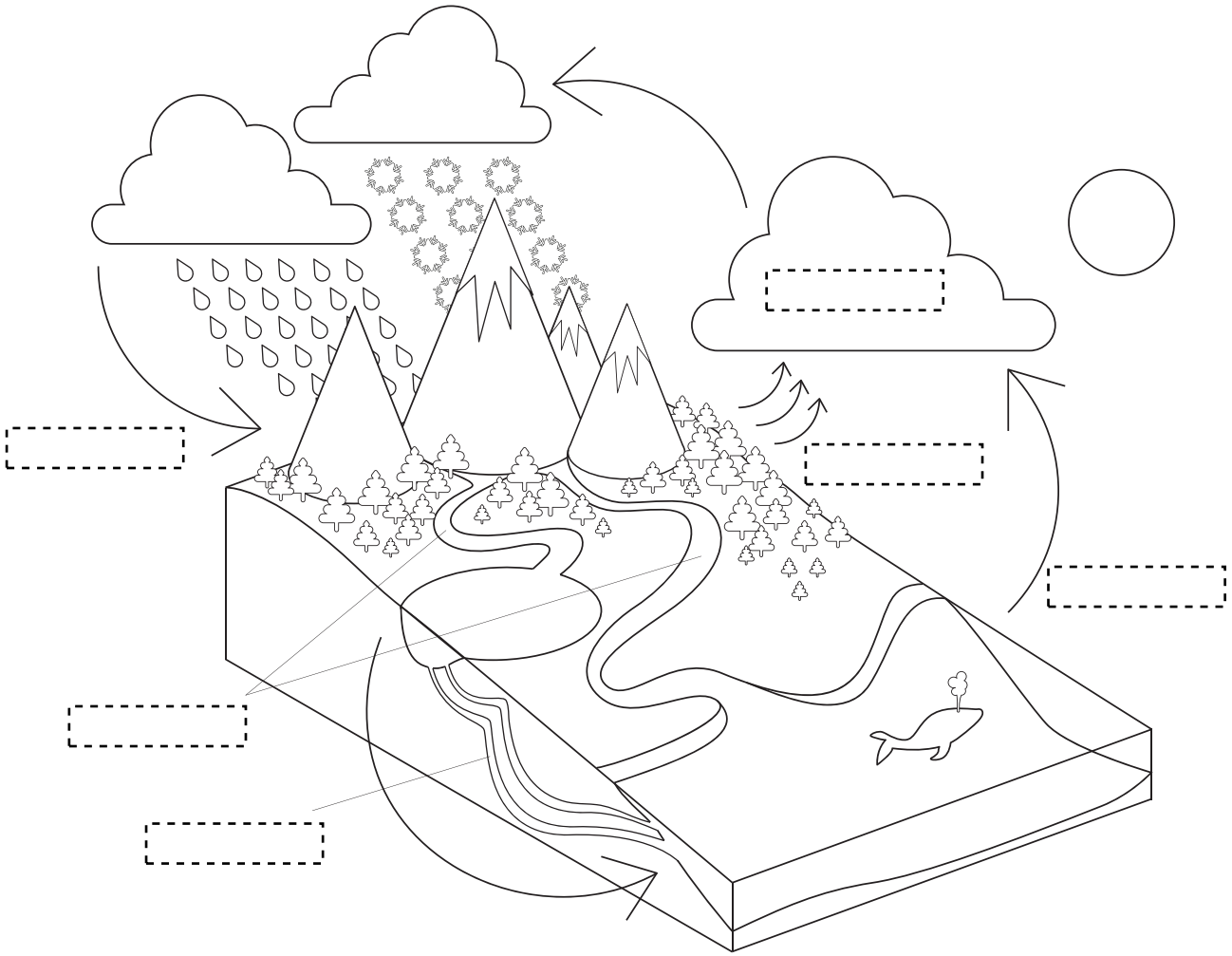
6 GROUND WATER

Some water seeps into the ground as soil moisture or groundwater.

National Aeronautics and Space Administration

THE WATER CYCLE

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



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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.


WOOLY SUNFLOWER XYLEM

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...

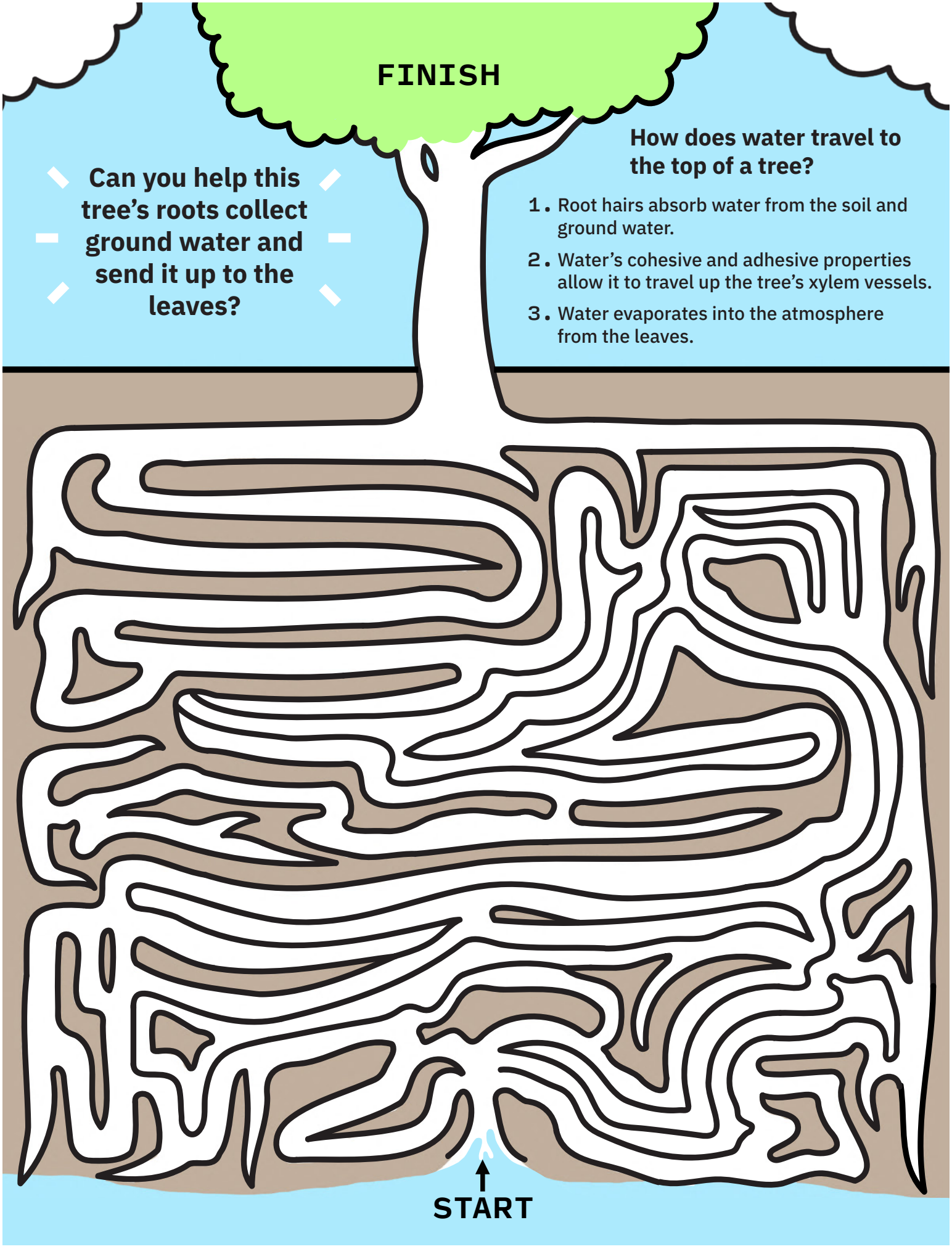
WHAT FACTORS AFFECT HOW WATER MOVES THROUGH THE PLANT?

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!


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

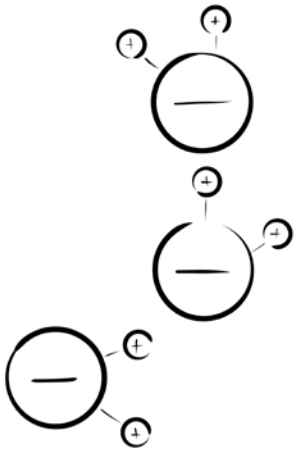
The Properties of Water

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

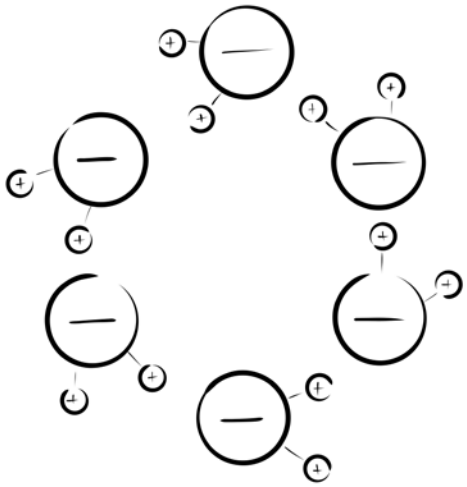
A water molecule, or H_2O, has two hydrogen atoms and one oxygen atom. The oxygen end has a negative electrical charge, and the hydrogen end has a positive electrical charge. That makes the molecule polar, kind of like a magnet. Just as magnets attract opposite poles, the positive end of one water molecule 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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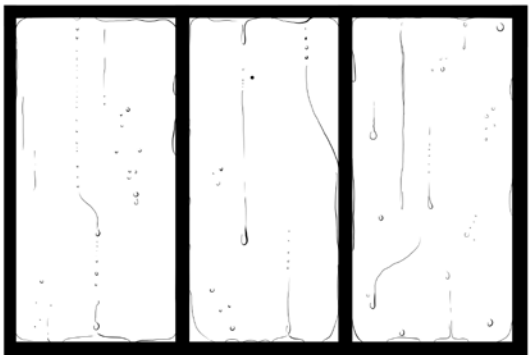
Illustrations by Sarah Vincent

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.

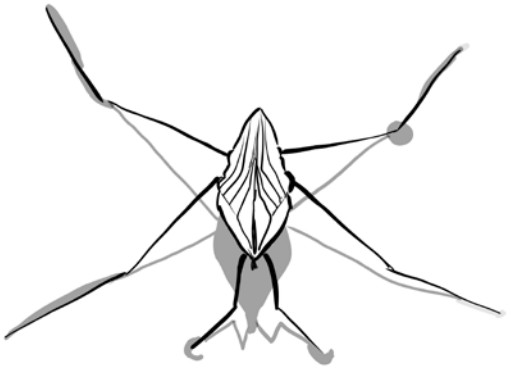
SURFACE TENSION

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...

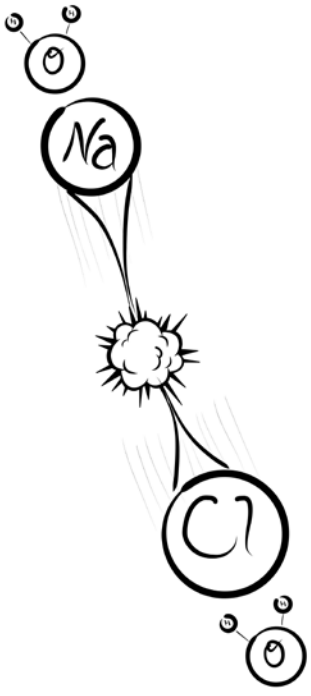
Other liquids have surface tension as well, but the hydrogen bonds make the surface tension of water quite strong. Whether you know it or not, you have already seen surface tension at work. Whenever you fill a glass of water too far, you may notice that the level of the water in the glass is actually *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.



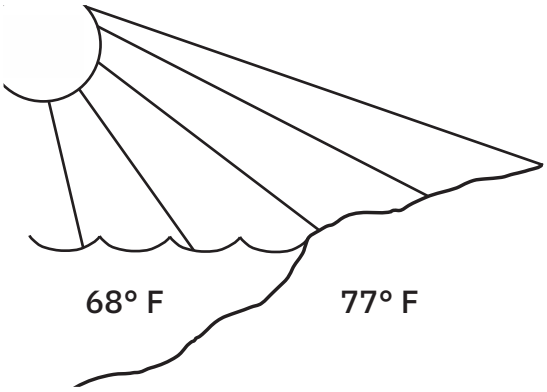
This is important to all living things. As water travels through the water cycle, it takes many valuable nutrients along with it. Water doesn't dissolve everything, however. Non-polar molecules, including many organic compounds such as fats and waxes, don't dissolve very well in water.

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

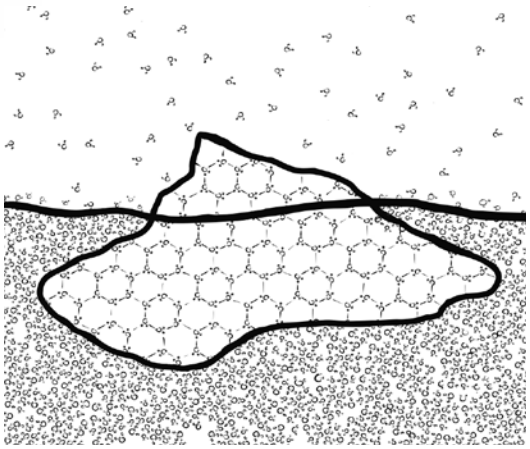


Specific heat capacity is the heat required to raise the temperature of a specific amount of a substance by one degree. Water has high specific heat capacity. It takes a lot of energy to raise the temperature of a certain amount of water by one degree. Therefore, water helps regulate temperature on Earth's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

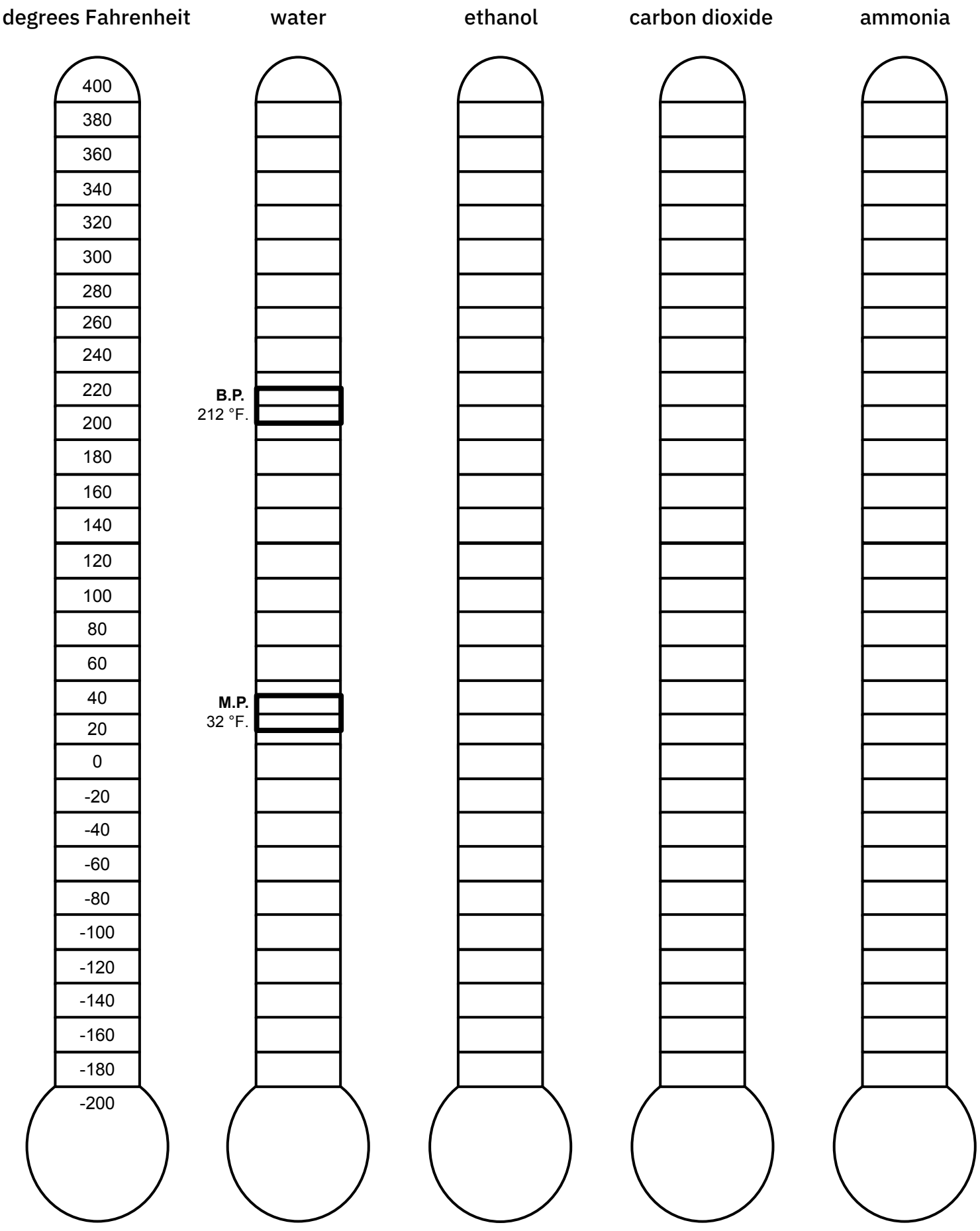


The ability of water molecules to form hydrogen bonds is responsible for many of water's unique characteristics. Water requires more energy to break its hydrogen bonds before it can boil. This also applies to water's freezing point.

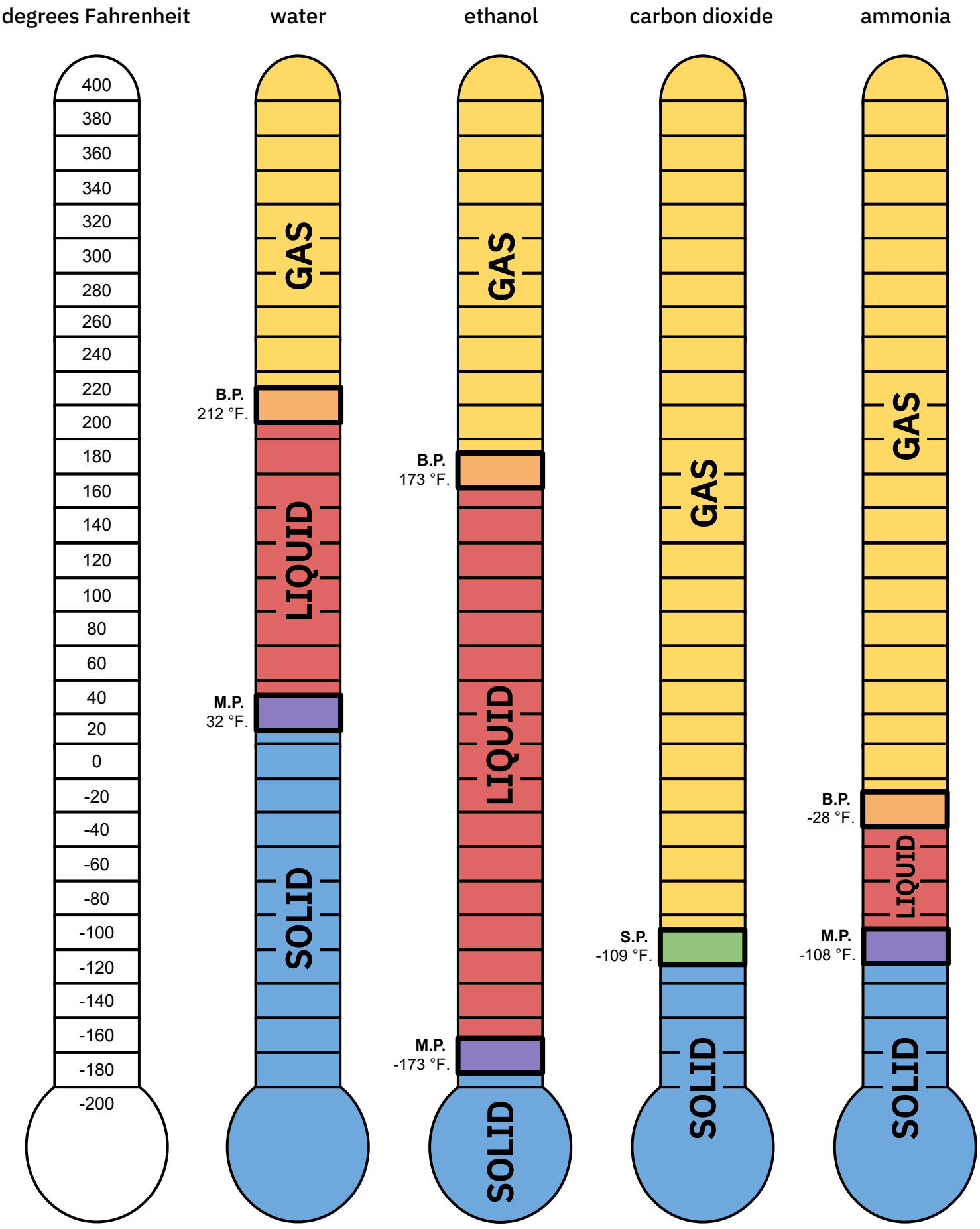
The **boiling** and **freezing points** of water allow the molecules to be very slow to boil or freeze, and this is important to water ecosystems. If water were too easy to freeze or boil, drastic changes to Earth's oceans and lakes would cause all the organisms living in water to die. This is also why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



Boiling, Melting, and Freezing Points Solution



Post-program Materials

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

Module 3 Crossword and Grading Version

This worksheet reinforces the new terms students learn in "The Search for Water" and in the attached materials.

PBS: Earth's Water Distribution (Adapted Lesson)

This fifth-grade lesson plan and demonstration is adapted from a more advanced PBS SoCal lesson plan. In this abridged lesson, students learn how water is distributed on our planet and how much water is available for human consumption.

🔗 NASA: How Can We Tell If Other Planets Have Water? (Lesson)

In this lesson from NASA (linked above), students learn that the presence of craters is an indication of a dry planet. It demonstrates how craters are concealed or obliterated in wet climates. Students also use satellite images to assess the presence of water on two other planets.

🔗 NASA: Rain Gauge Activity (Lesson)

This lesson plan from NASA is an inquiry-based hands-on activity that has been created to engage students in designing and testing out a rain gauge. Click the link above to access the webpage, and then scroll down to download the lesson plan (pdf) and class presentation (ppt).

Coloring the Cosmos

We have provided three coloring-book-style activities for students.

Water Conservation Plan

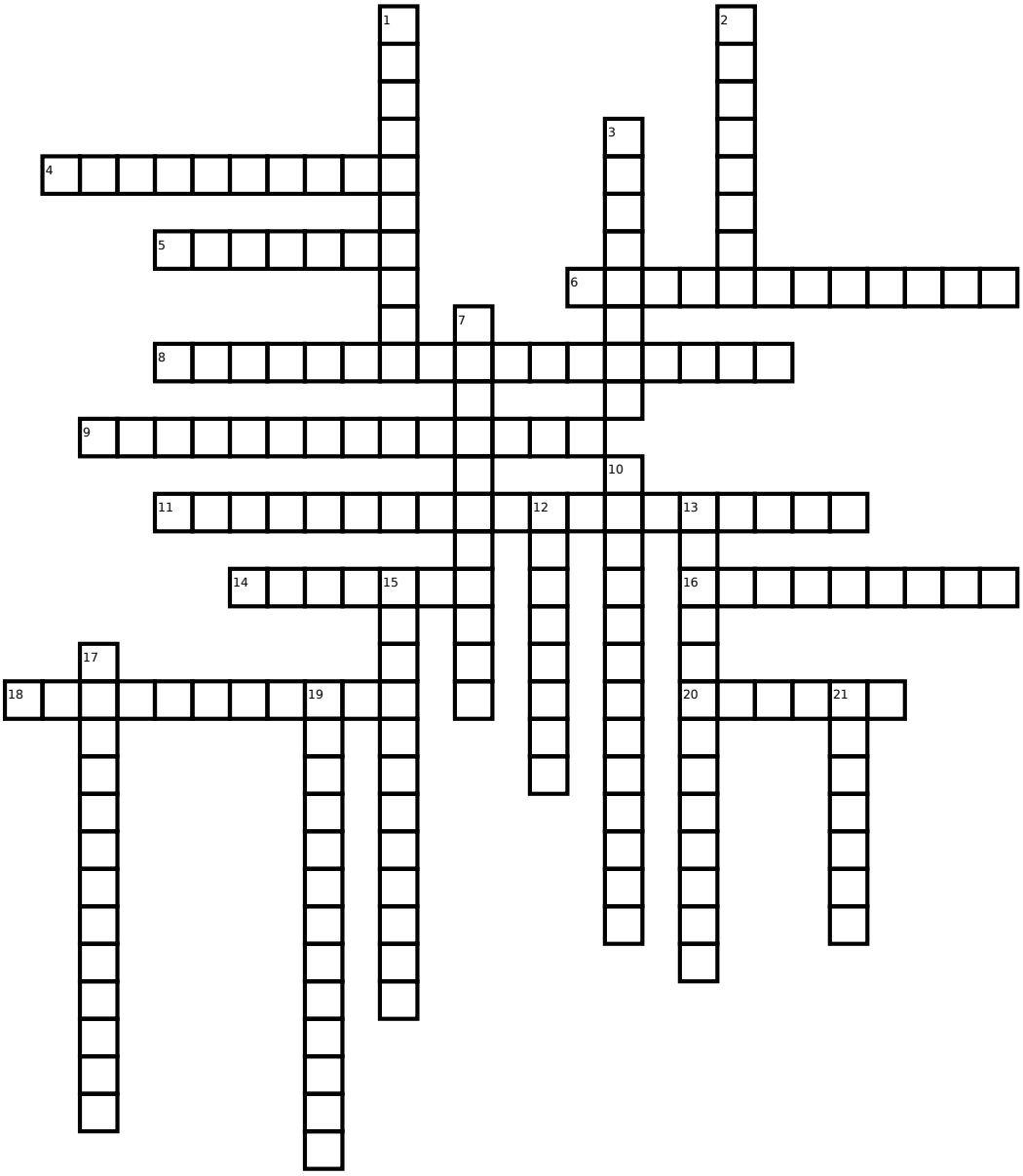
This worksheet invites students to think about the important role that water plays in their daily lives. Ways for conserving water are discussed, and then students set goals for doing so.

Internet Resources

The Internet may be helpful. This variety of websites will help students expand their 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

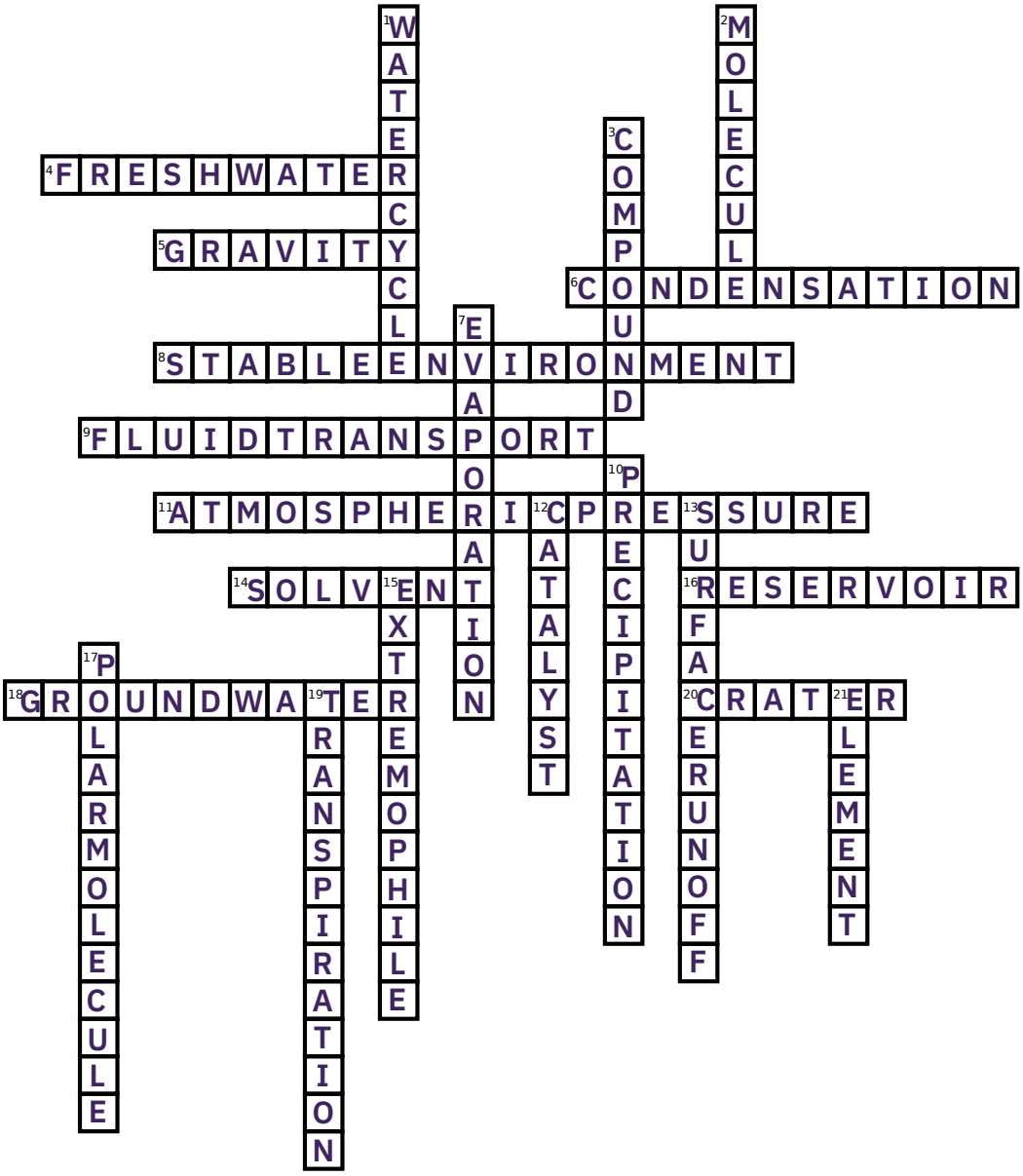
ACROSS

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...

Module 3 Crossword

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

GRADING VERSION



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Earth's Water Distribution

AN ADAPTED PBS SOCAL LESSON AND DEMONSTRATION

MATERIALS NEEDED

- two 2-liter bottles full of water
- food coloring (dark color preferable)
- measuring cups (for measuring amounts ranging from 14.5 ml to 50 ml)
- five clear containers (to hold water ranging in volume from 0.5 ml to 1,950 ml)
- markers and tape for making labels
- notebooks for student work

BEFORE THE LESSON

- Fill two 2-liter bottles with water. Add enough food coloring so that the water is visible from all seats in the classroom.

THE LESSON: HOW MUCH WATER DO WE REALLY HAVE?

- Tell students that you would like them to think about the answer to this question: "What percentage of Earth's water is available for human consumption?" Ask students to write down their answers. You may want to remind students to consider what they know about oceans and about the type of water that is considered usable by people.
- Ask a volunteer to demonstrate his or her answer to the question. Give the student a 2-liter bottle filled with colored water and a clear, empty container. Tell the class that the bottle represents all of the water on Earth. Ask the volunteer to pour into the empty container the amount of water that he or she thinks represents the percentage of Earth's water available for human use. (Provide the student with a measuring cup if needed.)
- Then ask the class to make suggestions about whether more or less water needs to be in the container. Have the volunteer adjust the amount until there is a general consensus among the students. Put the class estimate (the clear container with water) aside.
- Tell students that you will now demonstrate the amount of water on Earth that is available for human consumption.

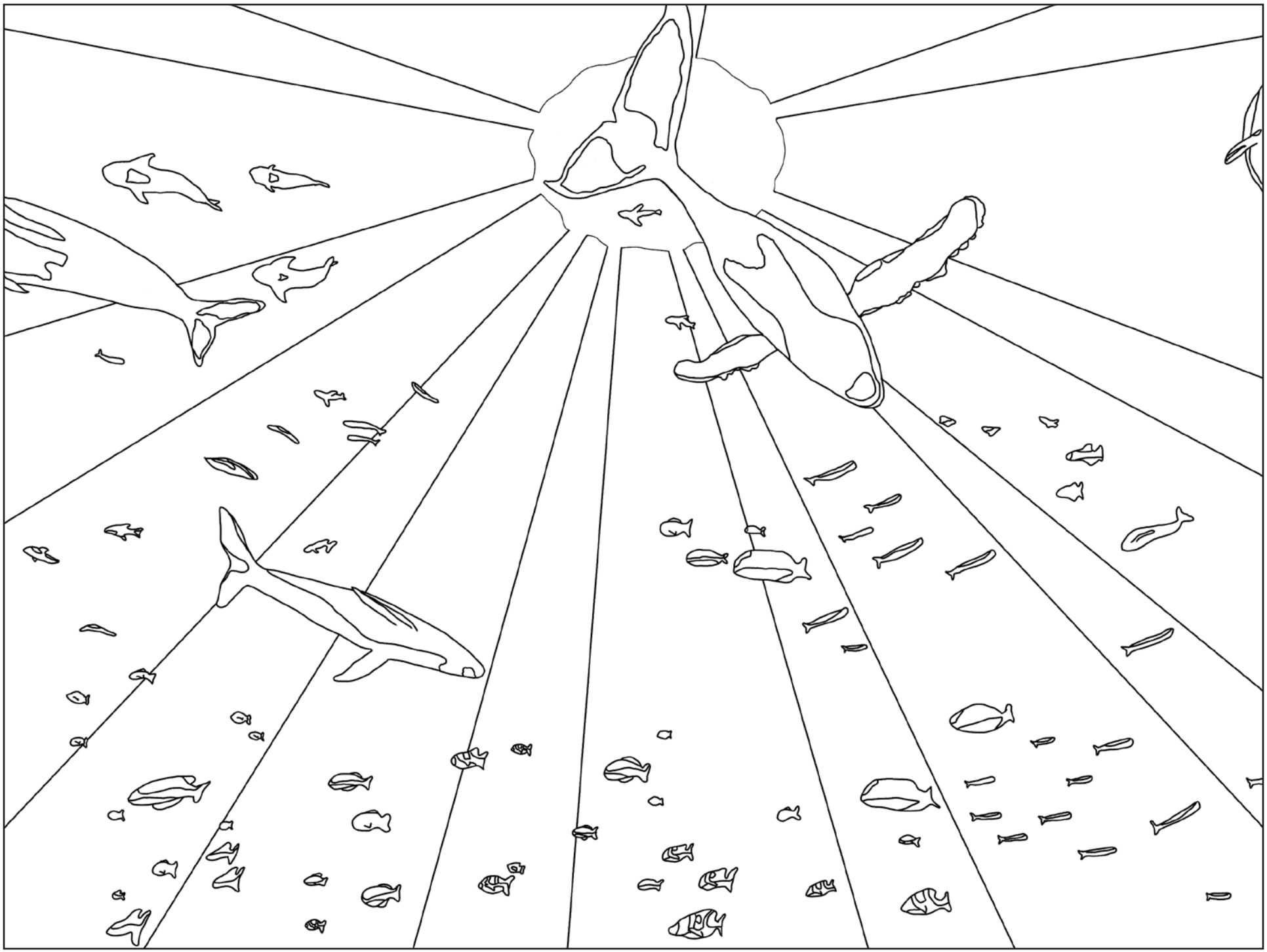
LESSON CONTINUED...

- Show students the second 2-liter bottle filled with colored water. Tell them again that this bottle represents all of the water on Earth. Measure out 1,950 ml of the water and pour it into a clear, empty container. Label the container **SALT WATER**. Tell students that this represents how much of our planet's water is found in oceans — 97 percent.
- Pour the remaining 50 ml from the bottle into another container, and tell students that this represents the amount of fresh water on Earth — 3 percent. Label this container **FRESH WATER**. Ask students to guess what percentage of fresh water is available for human use.
- *Note:* You may also want to place a fresh water sign on the table at this time. As you pour off additional amounts of water in the next two steps, you can place the new containers near the fresh water sign to remind students that each one is part of the "fresh water" category.
- Measure 35 ml of the fresh water into another container. Label the container **ICE CAPS**. Tell students that this water is frozen in ice caps and is not available for us.
- Now measure 14.5 ml of the fresh water into another container. Label the container **AIR, SOIL, AND UNDERGROUND**. Tell them, "Sorry, but this water is found in the air, in the soil, and deep underground, and so it's also not available for human use!"
- There should be about 0.5 ml of water left in the fresh water container (just under two drops.) Hold this up and explain that this represents all of the fresh water available for people. Less than 1 percent of all water on Earth is available for us!
- Show students NASA's "**Show Me the Water**" video to reinforce the data behind the demonstration.

DISCUSSION

- Divide the class into small groups and ask them to discuss what they just witnessed in your demonstration and in the video. (You may want to review the terms "renewable resource" and "nonrenewable resource" as a class before placing students into their groups.) Have students answer the following questions during their small-group discussions.
  - *Where is usable water located?*
  - *Is this water a renewable resource?*
- Bring the class back together and ask student groups to share some of their ideas. Conclude by reminding students that water is necessary for life and thus important to conserve and maintain so that it stays available for human consumption, as well as for consumption by plants and animals.

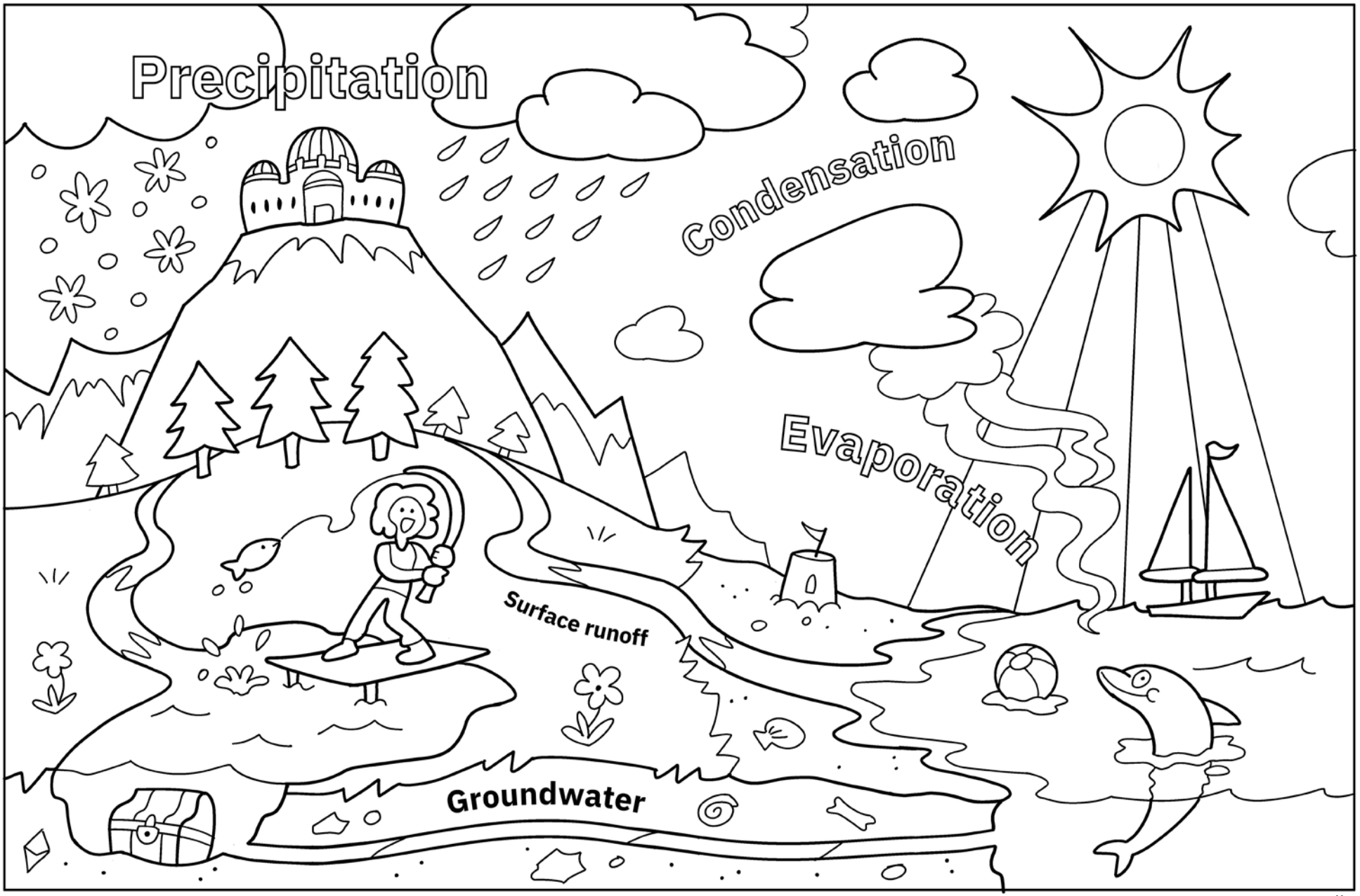
Source: ***https://bit.ly/3r9J3Wg*** **|** *More Information:* ***https://go.nasa.gov/3AZypWs***



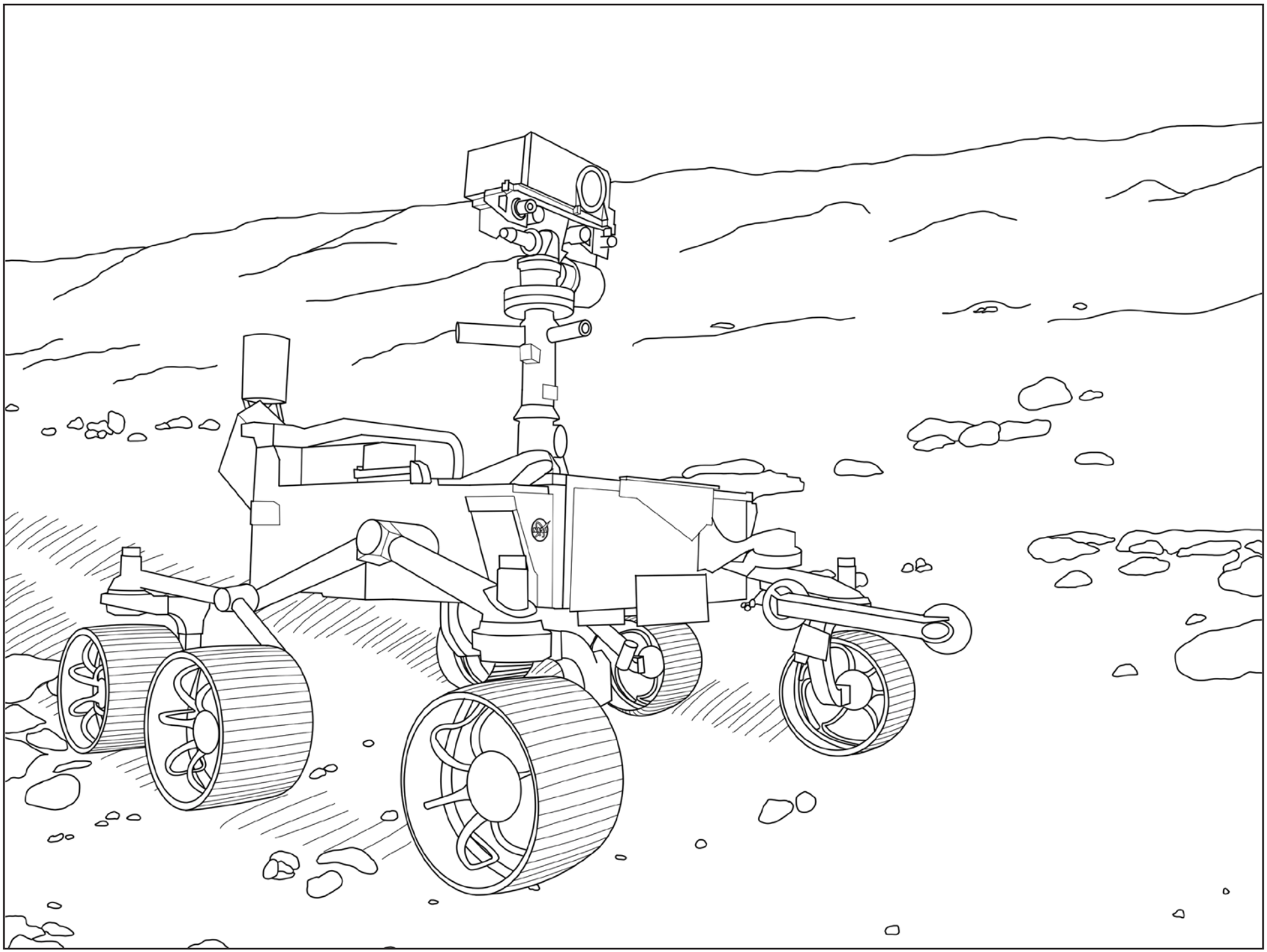
By Molly Ruhl

The Water Cycle

Name: _____



By Ian Crovella



By Molly Ruhl

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

_____

_____

Afternoon

_____

_____

Evening

_____

_____

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.
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____

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 _____

_____

_____

_____

_____

_____

Internet Resources

Not all websites are equally accurate. The world wide web, while convenient, can frequently provide incorrect and incomplete information. Below is a list of some of the best space science websites recommended by Griffith Observatory educators.

GRIFFITH OBSERVATORY

The most-visited public observatory in the world.

https://griffithobservatory.org

ASTRONOMY CLUBS

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

https://obs.la/astronomyresources

CITIZEN SCIENCE PROJECTS

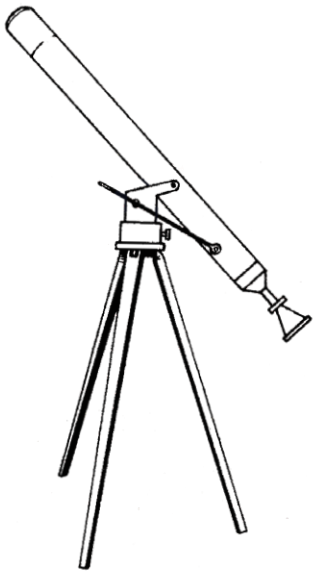
You may make a real contribution to astronomy by participating in these scientific projects.

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

https://science.nasa.gov/citizen-science

Another useful site that lists multiple Citizen Science projects:

https://zooniverse.org



NASA 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://science.nasa.gov/eyes

Visit websites dedicated to learning for grades 5 through 8:

https://nasa.gov/learning-resources/for-students-grades-5-8

Watch NASA's live and original programming for free:

https://plus.nasa.gov

GRIFFITH OBSERVATORY

INTERNET RESOURCES CONTINUED...

RESOURCES FOR TEACHERS

Free lesson plans and activities for K-12 from Jet Propulsion Laboratory:
https://jpl.nasa.gov/edu/

Find Next Gen STEM learning opportunities for students in multiple settings:
https://nasa.gov/learning-resources/for-educators

Search NASA's educational activities and resources by subject, type, and grade level:
https://science.nasa.gov/learn/catalog

YOUTUBE CHANNELS

Griffith Observatory

European Space Agency

PBS Space Time

MORE WEB LINKS

California Science Center: Astronomy education programs, workshops, lesson plans, and resources. https://californiasciencecenter.org

The Lunar and Planetary Institute: Astronomy education programs, workshops, and resources. https://lpi.usra.edu/education

StarDate: The public education and outreach arm of the McDonald Observatory, Texas.
https://stardate.org

WorldWide Telescope: This website turns your computer into a telescope and brings together data and imagery from telescopes around the world.
https://worldwidetelescope.org

Astronomical Society of the Pacific: Organization of professional and amateur astronomers with astronomy education conferences, education programs, and resources, including professional development opportunities for teachers. https://astrosociety.org

Planetary Society: Open membership organization that sponsors planetary events and programs. Its "Space for Kids" page lists many at-home activities.
https://planetary.org/kids

Exploratorium: A resource for at-home experimentation and projects.
https://exploratorium.edu/explore

GRIFFITH OBSERVATORY

Acknowledgments

Griffith Observatory is owned and operated as a public service by the City of Los Angeles, Department of Recreation and Parks. The work of the Department is overseen by the Board of Recreation and Park Commissioners, appointed by the Mayor of Los Angeles with confirmation by the Los Angeles City Council.

The Griffith Observatory Online School Program is made possible by Griffith Observatory Foundation. The primary role of the Foundation is supporting and promoting Griffith Observatory in its mission to inspire everyone to observe, ponder, and understand the sky.

Foundation donors, members, and supporters are a network of passionate people who believe in the value of free public astronomy. You can support Griffith Observatory's programs by donating to Griffith Observatory Foundation by visiting www.GriffithObservatoryFoundation.org

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Kaitlynn McGuire
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Additional Media Credits

We thank the following individuals and organizations for the use of their imagery, footage, and animation to supplement our educational program.

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Charles Fisher

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Jim Peaco

U.S. COAST GUARD
Cynthia Oldham

NATIONAL GEOGRAPHIC SOCIETY
Sam Abell

EYE OF SCIENCE – SCIENCE PHOTO LIBRARY

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KENNETH INGHAM

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