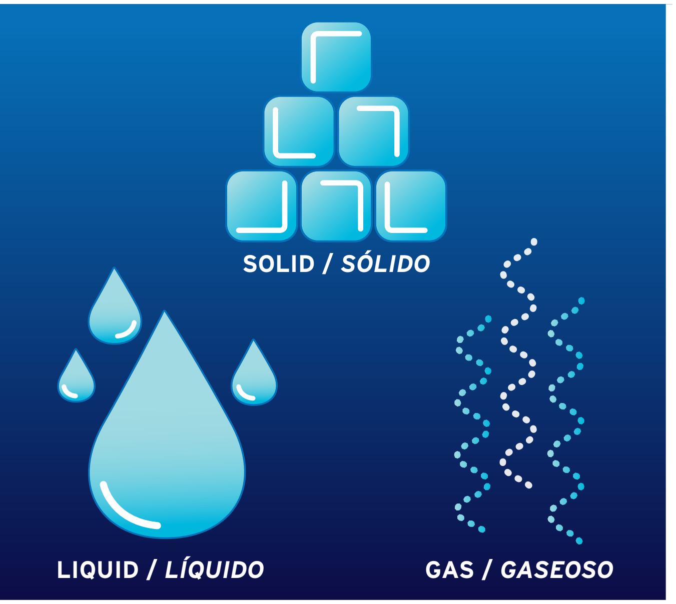
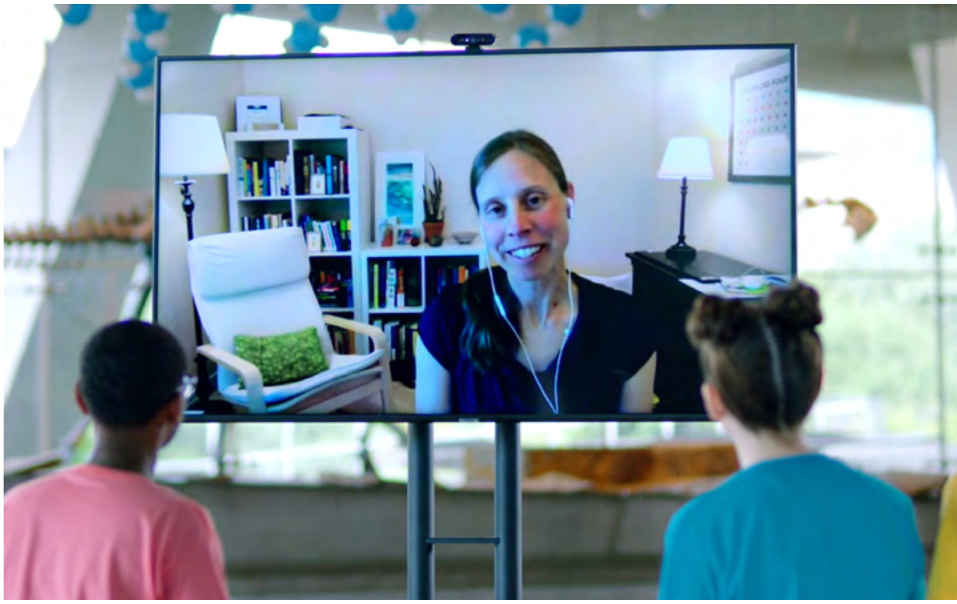
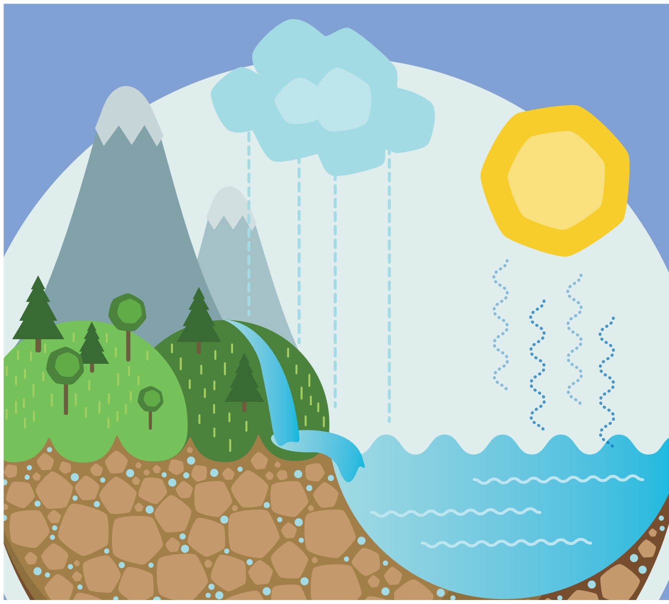
THE WHYNAUTS:

Episode 9: The Water Cycle

EDUCATOR GUIDE SUGGESTED GRADE LEVELS 3-5







The Whynauts

Perot Museum of Nature and Science

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INTRODUCTION

HOW TO USE THIS GUIDE

The Whynauts **"The Water Cycle"** Video explores the continuous movement of water around the Earth through the various processes of the water cycle. This guide is designed to help you incorporate the video into a complete learning experience for your students. It is composed of three main sections:

The **Viewing Strategies and Tools** section includes suggested discussion questions, a student viewing journal, and a pre- and post-assessment to track student learning.

The **Supplemental Activities** section includes four activities that can be used in any order or combination.

The **Additional Resources** section includes a glossary, reading list, and links to continue learning.

LEARNING OBJECTIVES

Students will be able to:

- Describe how water moves through Earth's water cycle, including the processes of evaporation, condensation, and precipitation.
- Explain how energy from the Sun drives the water cycle.
- Recognize the importance of clean water for life on Earth.

TEKS ALIGNMENT

3.6C. Predict, observe, and record changes in the state of matter caused by heating or cooling in a variety of substances such as ice becoming liquid water, condensation forming on the outside of a glass, or liquid water being heated to the point of becoming water vapor (gas).

3.11B. Explain why the conservation of natural resources is important.

3.11C. Identify ways to conserve natural resources through reducing, reusing, or recycling.

4.10A. Describe and illustrate the continuous movement of water above and on the surface of Earth through the water cycle and explain the role of the Sun as a major source of energy in this process.

5.10A. Explain how the Sun and the ocean interact in the water cycle and affect weather.

NGSS ALIGNMENT

5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

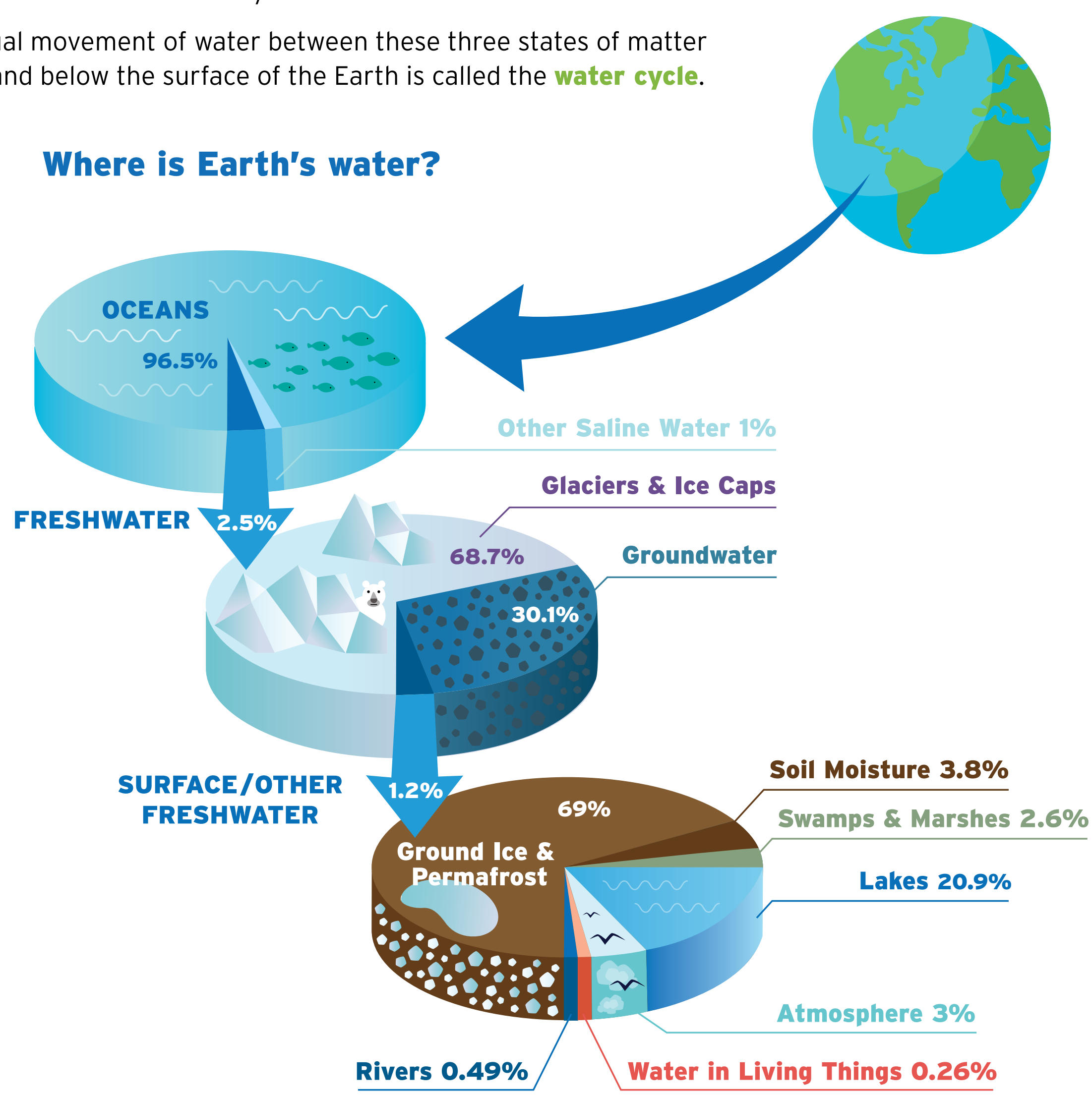
BACKGROUND INFORMATION

"Water, water, every where, Nor any drop to drink."[1]

You may have heard this famous line from the poem, "The Rime of the Ancient Mariner." "Water, water every where" refers to our oceans: about 70% of the Earth's surface is covered in water. "Nor any drop to drink" refers to the fact that the vast majority of it is salt water. Only about 2.5% of all the water on Earth is **fresh water**; and most of that fresh water is locked up in glaciers or underground. That leaves less than 1% in surface water that is readily accessible to us.

Water (H_2O) is unique in that it naturally exists in all three states of **matter** – as a solid, liquid, and gas – within the relatively narrow range of temperatures and pressures found on Earth. **Density** is a measurement of how much matter an object has compared to how much space it takes up (mass divided by volume). Generally, solids tend to be more dense than liquids, and liquids more dense than gasses. But water in its solid form, ice, is actually less dense than liquid water. Thus, ice floats. This is important because if rivers and lakes froze from the bottom up instead of the top down, it would likely kill the organisms living at or near the bottom and have severe repercussions for the entire ecosystem.

The continual movement of water between these three states of matter on, above, and below the surface of the Earth is called the **water cycle**.



[1] "The Rime of the Ancient Mariner," by Samuel Taylor Coleridge (1834).

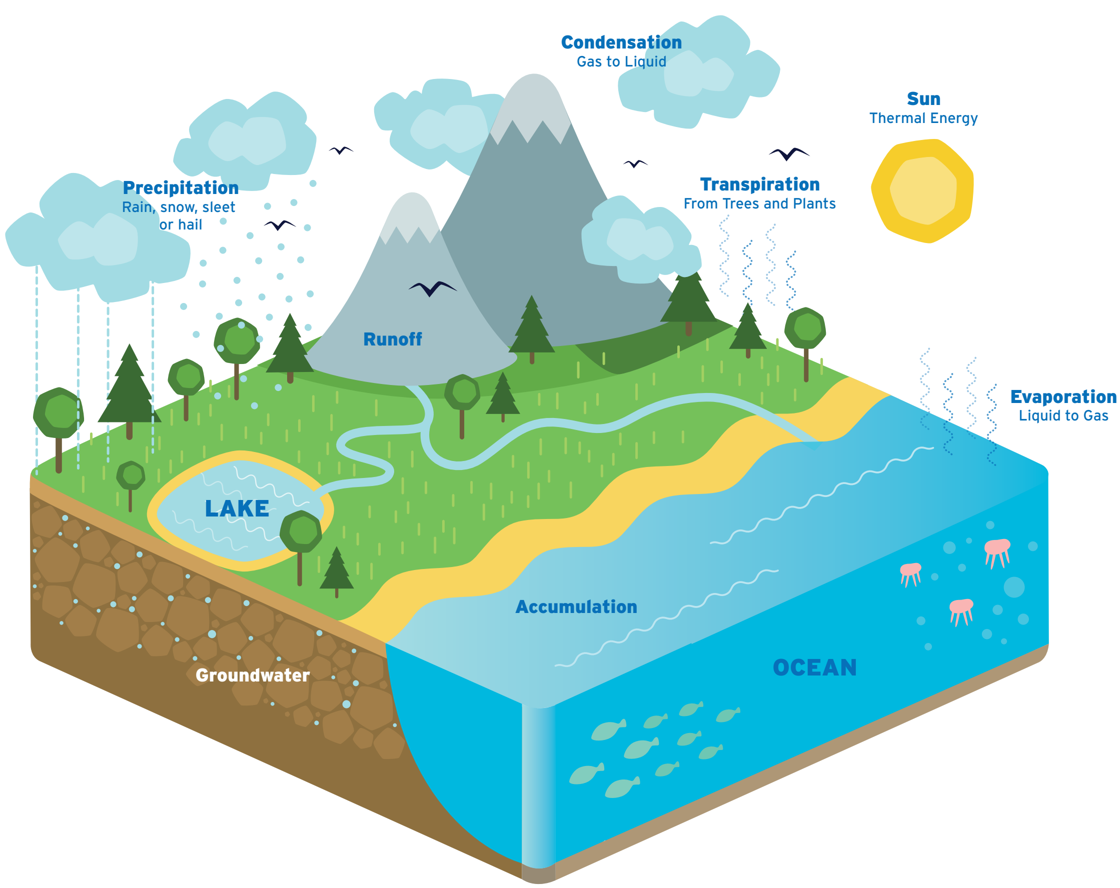
The Water Cycle

The water cycle is happening everywhere all the time! There is no single starting point – that is what a cycle means. But as most water on Earth is found in our ocean basins, that is where many choose to start. Almost all of the water vapor in the **atmosphere** comes from the ocean. **Thermal energy** from the Sun warms the water at the surface, causing it to evaporate. **Evaporation** is the process of water changing from a liquid to a gas, called **water vapor**. We cannot see water in its gaseous state, but we can feel it as humidity, which is the amount of water vapor in the air.

Water vapor rises from the surface of liquid water into the atmosphere. As it travels higher, the temperature drops, air pressure lowers, and the water vapor condenses around tiny particles, such as dust, to form clouds. **Condensation** is the process of water changing from a gas to a liquid. This process occurs once the air becomes completely saturated with water vapor, or 100% relative humidity. Fog and dew are examples of condensation closer to the ground.

When enough water droplets gather and become "heavy," they fall back down to Earth as precipitation. **Precipitation** is water falling from clouds in the form of rain, snow, sleet, or hail. Once water falls back to Earth, it can go many places. It could permeate the soil and be stored as **groundwater** or be soaked up by plants. Or gravity could pull it downhill as **runoff**, where it could flow into a river, lake, or another body where water **accumulates**. Rivers and lakes are great sources of fresh **surface water** for animals. The water could flow downriver all the way to the ocean, where eventually it evaporates back into the atmosphere, and the cycle begins again.

A basic water cycle model may focus on just one or a few possible pathways for simplicity, but it is important to note that the processes of the water cycle can happen anywhere there is water: from the soil, surface water sources such as lakes or puddles, plants **transpiring**, or even when we exhale!

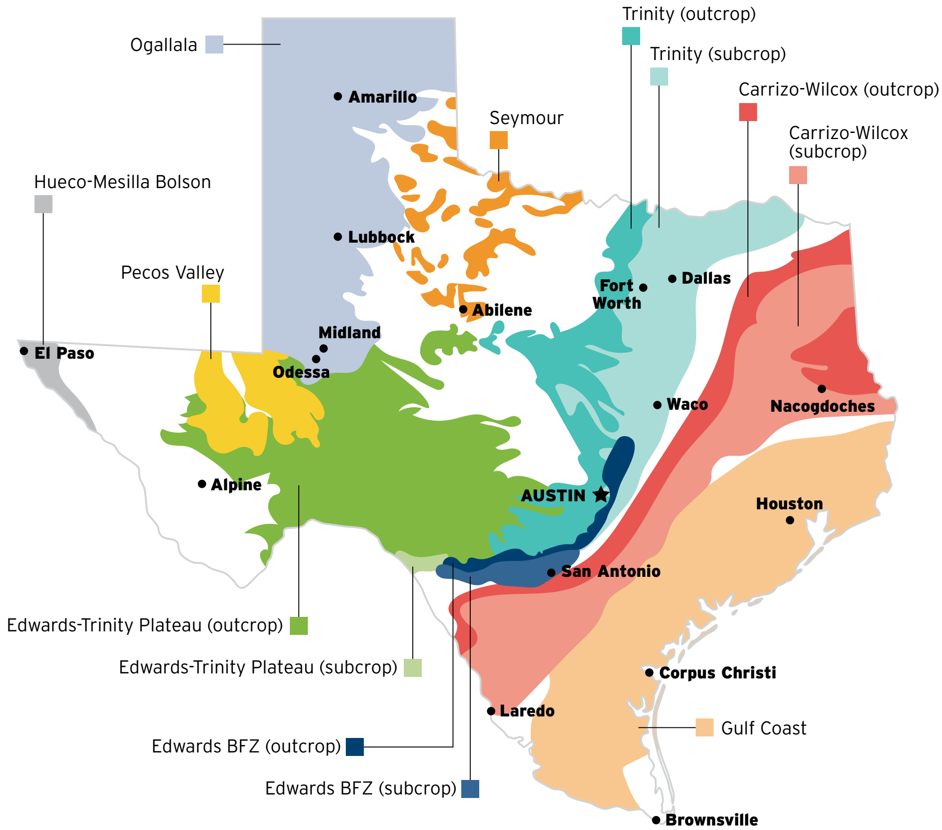


Urban Water Cycle

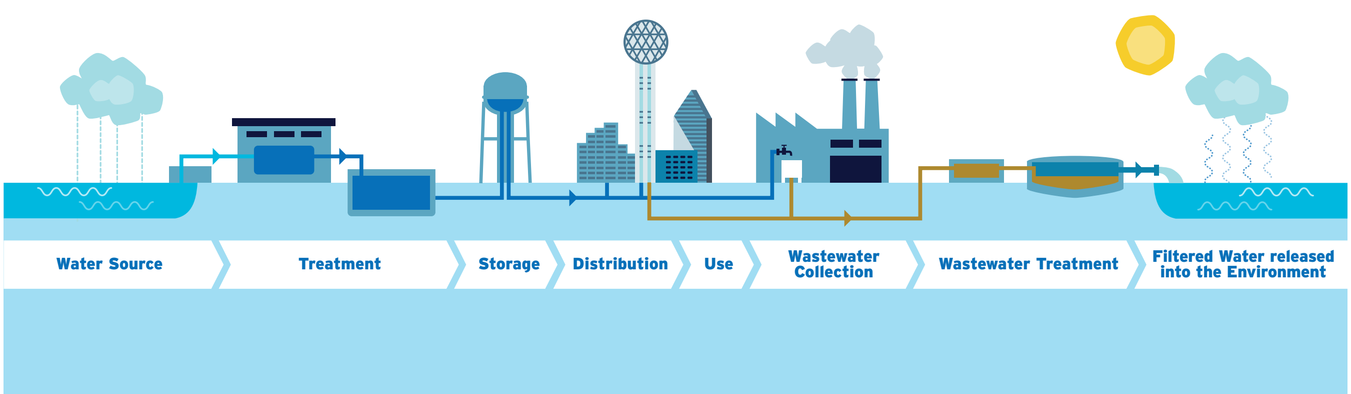
The urban water cycle is a small part of the larger, global water cycle. It describes how the water we use flows through our cities and towns. The water is pumped in from surrounding surface water sources, such as lakes, rivers, or reservoirs, or from **groundwater** sources like **aquifers**.

In Texas, the majority of our water supply (about 60%) comes from groundwater.

Aquifers of Texas



The water then goes through treatment to remove any harmful contaminants or microorganisms. From the treatment plant, it is then distributed to our homes, where we use it to bathe, drink, cook, clean, and water plants. Once used, the wastewater goes down the drain and is transported to treatment plants again, where it is filtered and then reintroduced back into the environment.



Manmade **wetlands**, like the John Bunker Sands Wetland Center in the episode, are a natural part of the water treatment process. Any solid matter settles out in the sedimentation basins. The wetland plants and soils filter out impurities, such as phosphate, nitrate, and ammonia, improving water quality. Wetlands also provide a home for many different kinds of plants and animals, and help reduce flooding and erosion.

Water is Essential

Water plays a major role in all four of Earth's spheres. Liquid water from the wetlands or another body of water (the **hydrosphere**) evaporates and rises into the **atmosphere**.

Water cycling in and out of the atmosphere plays an important part in **weather**, which is the current state of the atmosphere in regard to wind, temperature, cloudiness, moisture, or pressure at a specific time and place. Over time, this also contributes towards a region's long-term weather patterns, or **climate**.

Water in the atmosphere falls and accumulates on land (the **geosphere**), where animals drink it, and plants absorb it (the **biosphere**). Water is essential for life on Earth. That is why it is so important to conserve the little fresh water we do have and prevent the pollution of our water sources.

VIEWING STRATEGIES AND TOOLS

DISCUSSION QUESTIONS

■ SECTION 1: PROPERTIES OF WATER [BEGINNING – 3:22]

1. What are some examples of water as a solid, liquid, and gas?

Solid: snow, hail, glaciers
Liquid: oceans, rivers, lakes, ponds, puddles
Gas: humidity, when humans exhale (respiration), or plants release water (transpiration)

2. Imagine if ice was MORE dense than liquid water. What effects would this have on the environment and our daily life?

Answers will vary but may include:
- We would not be able to ice skate on natural ponds.
- It would kill the organisms living at the bottom of lakes and rivers.
- Ice cubes would sink to the bottom of a glass of water.

■ SECTION 2: WATER CYCLE AND GUEST ATMOSPHERIC SCIENTIST [3:22- 9:01]

1. If you were a raindrop, where would you want to travel? Why?

Answers will vary.

2. How does the water cycle affect climate?

The water cycle plays a key part in weather patterns. When scientists talk about climate, they are looking at averages of precipitation, temperature, humidity, sunshine, or wind speed. Dr. Bailey also gives the example of how the water cycle can affect how quickly the planet warms in response to greenhouse gas pollution because water vapor itself is a greenhouse gas.

■ SECTION 3: WETLANDS CENTER AND THE URBAN WATER CYCLE [9:11 – END]

1. Why are wetlands important?

Wetlands improve water quality, provide a habitat for many different plants and animals (especially migratory birds), and help reduce flooding and erosion.

2. How does the water cycle affect all the living things on Earth (the biosphere)?

Answers will vary but may include:
- All life relies on water. The amount of rainfall in a region affects the type and abundance of vegetation, which in turn acts as the primary food source for animals. Water accumulation in ocean basins forms the habitat for all marine life.
- The water cycle affects weather patterns, which could lead to the formation of storms, flooding, or drought.

3. What are some ways you can help conserve water every day?

Answers will vary but may include taking shorter showers, not letting sink water run when washing the dishes or brushing one's teeth, or avoiding watering outside plants during the middle of the day.

Student Viewing Journal

BEFORE YOU WATCH THE VIDEO:

Use the Know Wonder Learn (KWL) chart to record what you **know** and what you **wonder** about the water cycle.

KWL Chart

WHAT I KNOW	WHAT I WONDER	WHAT I LEARNED

AFTER YOU WATCH THE VIDEO:

Record what you **learned** in the KWL chart and complete these sentences:

This reminds me of

I was surprised by

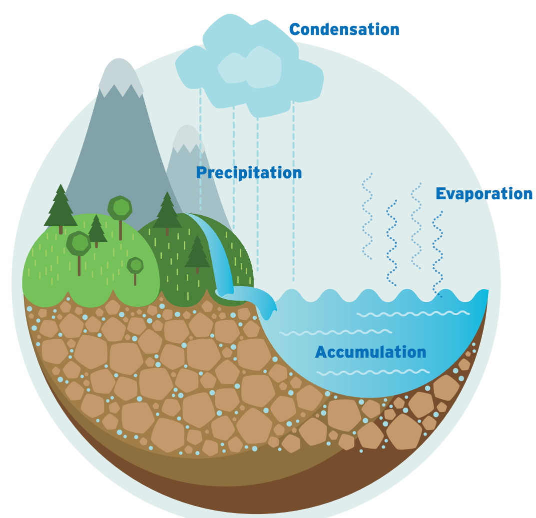
The most interesting thing I learned was

Pre- and Post-Video Assessment

1. Match each process with its definition:

Evaporation	Water released from the clouds as rain, sleet, snow or hail
Condensation	Water vapor changes to liquid water
Precipitation	Water collects in rivers, lakes, streams, and oceans
Accumulation	Liquid water changes to water vapor

2. Which component is missing from this diagram of the water cycle? What role does it play?



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3. Why is clean water essential for life on Earth?

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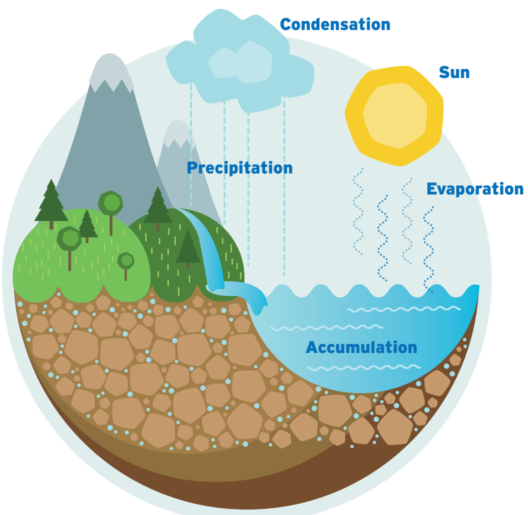


The Sun. The Sun provides thermal energy to fuel the process of evaporation.

3. Why is clean water essential for life on Earth?

Water is essential for all life as we know it. Water is home to millions of species, and polluted water can destroy many habitats and disrupt food chains. Clean drinking water is necessary for our health too, because dirty or contaminated water can make us very ill. Humans also use clean fresh water for cooking, cleaning, growing crops, and leisure.

SUPPLEMENTAL ACTIVITIES

The Traveling Raindrop

Water Cycle in a Bag

Keeping the Water Cycle in Motion

DIY Water Filter

The Traveling Raindrop

HOW DOES WATER CHANGE AS IT MOVES THROUGH THE WATER CYCLE?

Objective

- Students will follow the path of a droplet of water and discover what happens during each stage of the water cycle.

Materials

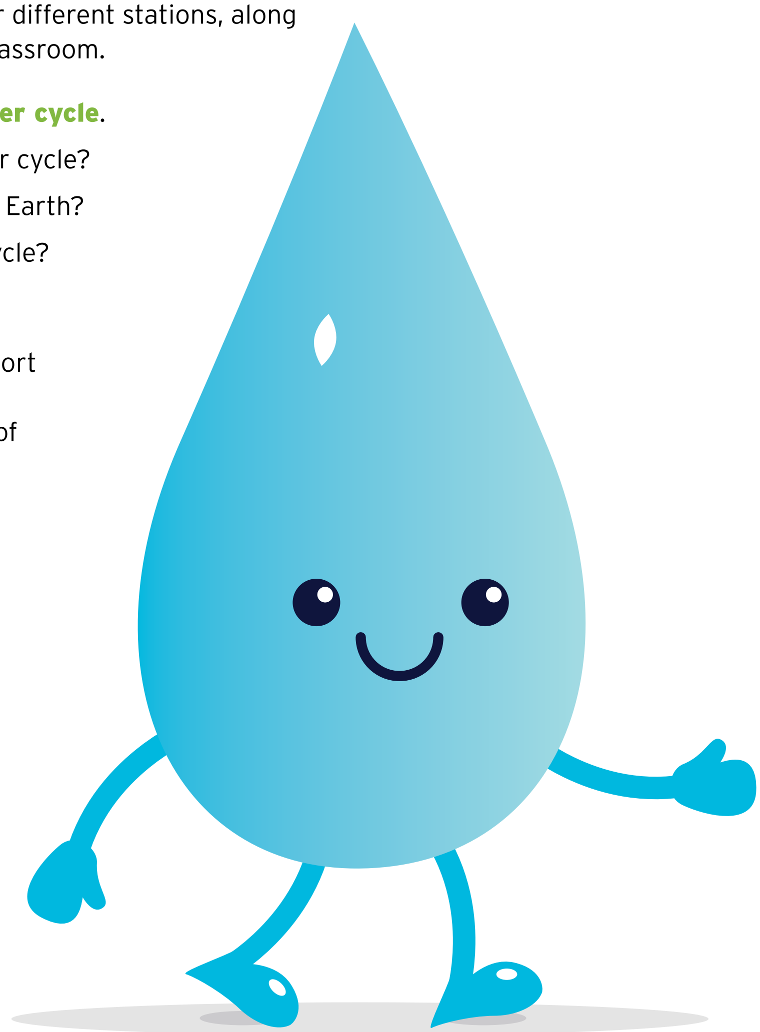
- Activity passport
- Station cards
- Station signs
- Stapler
- Coloring tools (crayons, markers, colored pencils)

Lesson Outline:

1. Prior to this activity, print and cut out the provided station cards, signs, and passports. Place the cards in four different stations, along with the corresponding signs, around the classroom.

2. Begin with a class discussion about the **water cycle**.
   - What do you already know about the water cycle?
   - Why is the water cycle essential for life on Earth?
   - What is the role of the **Sun** in the water cycle?

3. Pass out one blank passport per student.
   - Instruct students on how to fold the passport into a booklet. Then ask them to fill in the information section and sketch a portrait of themselves as a raindrop.
   - Tell students that they will be taking a trip as a raindrop and traveling through some of the major steps of the water cycle. Students will need their passport to document where they traveled and determine where they need to go next.
   - Make sure to note that while their journey today is one possible path, there are many other paths that they could take. Water does not always follow the same path.



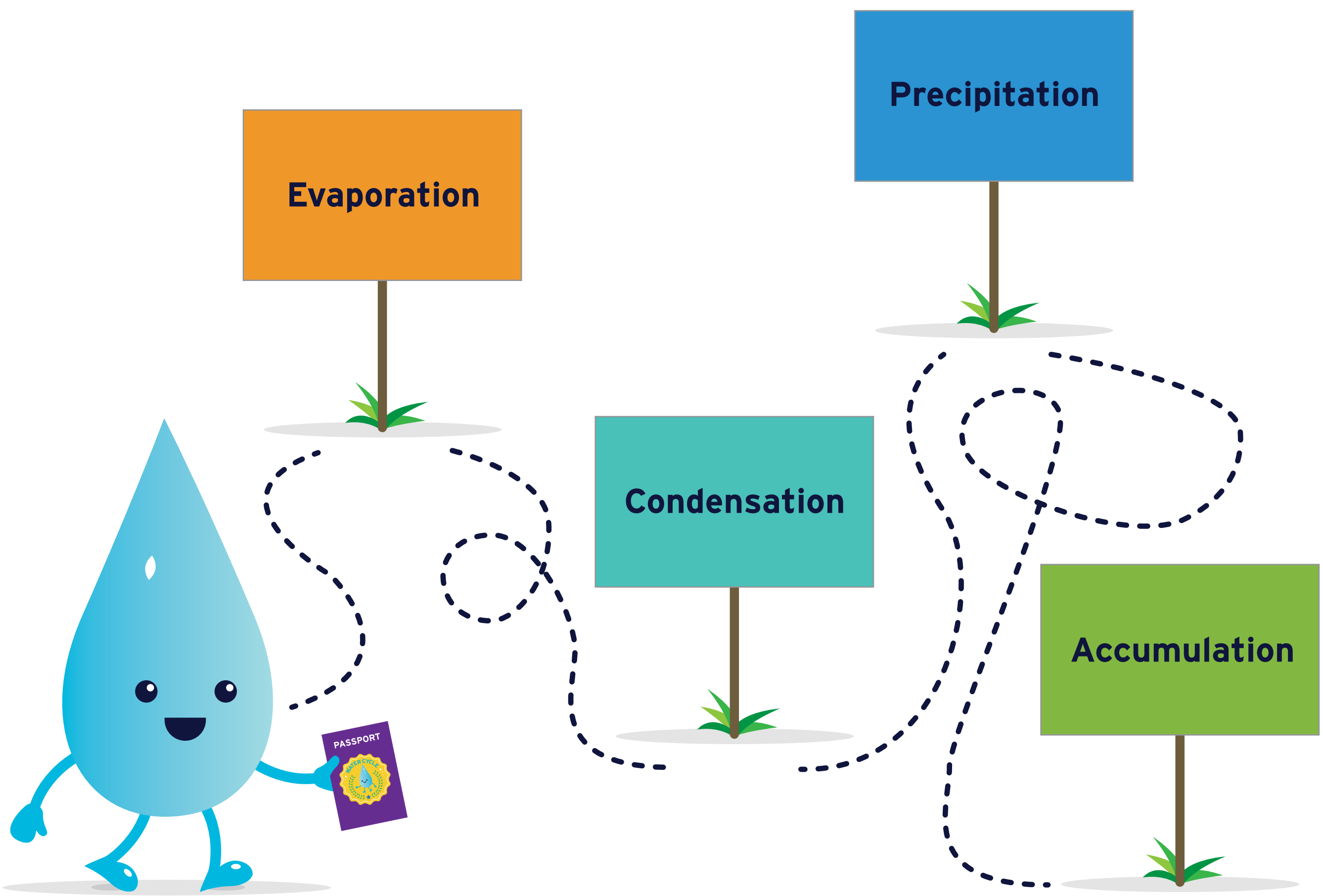
4. Once students are ready for travel, split them up into four different groups. Each group of students will remain with the same group as they move through each station.

- When students arrive at their station, they should open up their passport to that station.
- Next, they must read the card. The card will have information about what is happening to them, the raindrops, at that station. Have students draw a sketch to describe their current location within the water cycle in their passport.
- Students can refer back to the card to help them determine where to go next. Have students write down the next stage in their passport and list clues from the card that helped them to determine what stage of the water cycle they would be going to next.
- When each group of students has visited all of the stations once, they are done.
- Have students go back to their seats and work together to add color and any final details to their passport.

5. The water cycle is happening anywhere there is water. Ask students to share some of their drawings, and discuss as a class different places where each of these processes can occur. *For example, evaporation can happen anywhere thermal energy is added to liquid water, such as the Sun's rays warming a puddle or when we exhale.*

Extensions:

- Play I HAVE, WHO HAS matching game with water cycle vocabulary.
- ELAR – Have each student read a book about the water cycle. Several examples are listed in the resources section of this guide. Then have them write their own short story about their journey as a raindrop. What other paths might they take?



Evaporation

The Sun continues to warm you up, and you start to feel like you are floating and spreading out. Slowly you start to change states of matter! You change from a liquid to a gas and rise higher and higher into the sky.

What happens next?

Condensation

It starts to feel cooler the higher you rise. Suddenly, you start to gather with others and change from a gas back into liquid water. You look around and see where you are. You are part of a cloud high in the sky! More and more raindrops get added to the cloud. Whoa! It's starting to get pretty crowded. As the density of the clouds increases, it gets darker and darker.

What happens next?

Precipitation

The cloud becomes too dense, and the water starts to fall from the clouds. Faster and faster, the raindrops fall.

What happens next?

Accumulation

Splash! Some of us land in lakes and rivers, while others land in puddles on the ground. As you swim around with the other raindrops, it starts to feel pretty hot.

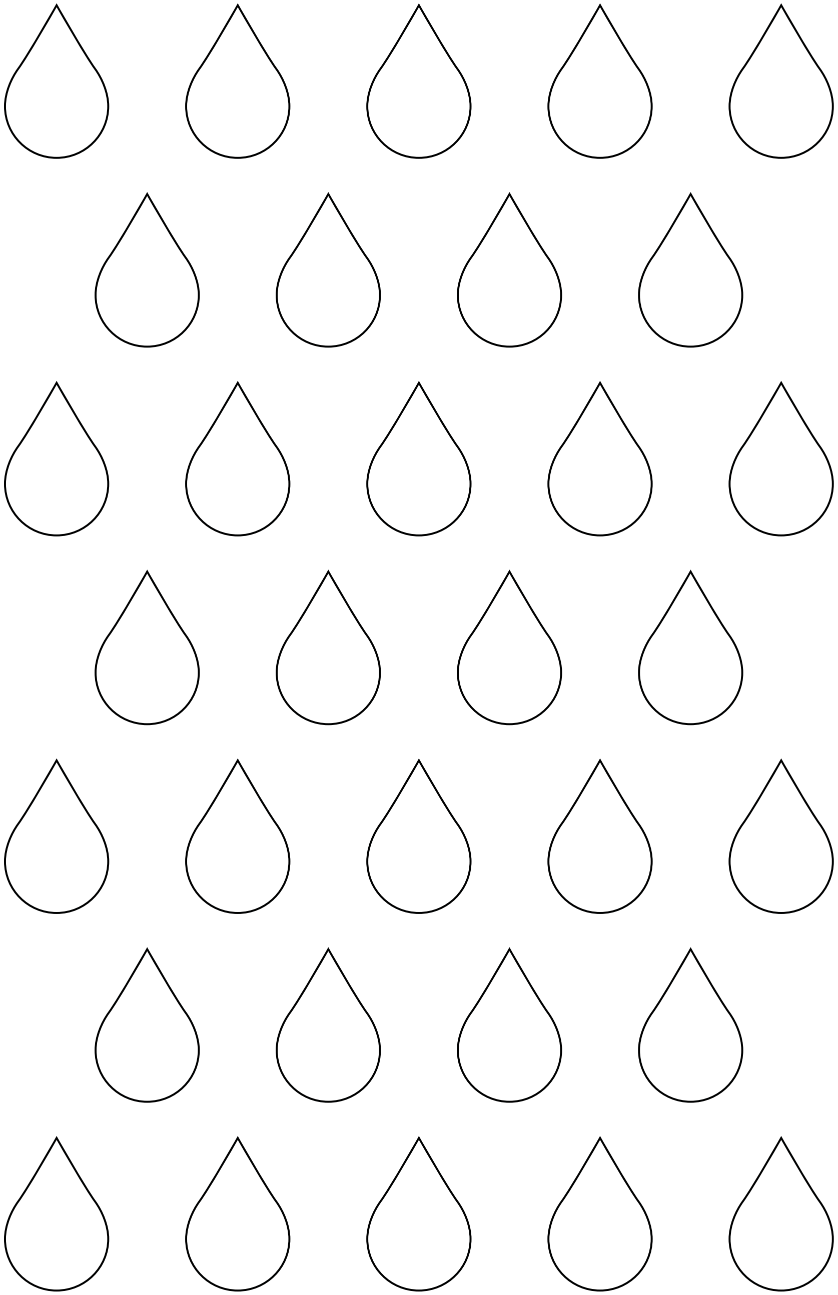
What happens next?

Evaporation

Condensation

Precipitation

Accumulation



PASSPORT

Accumulation Station

Sketch:

Where can water accumulate?

What stage in the water cycle comes next?

What clues helped you to know what stage comes next in the water cycle?

Precipitation Station

Sketch:

What are the different types of precipitation?

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What stage in the water cycle comes next?

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What clues helped you to know what stage comes next in the water cycle?

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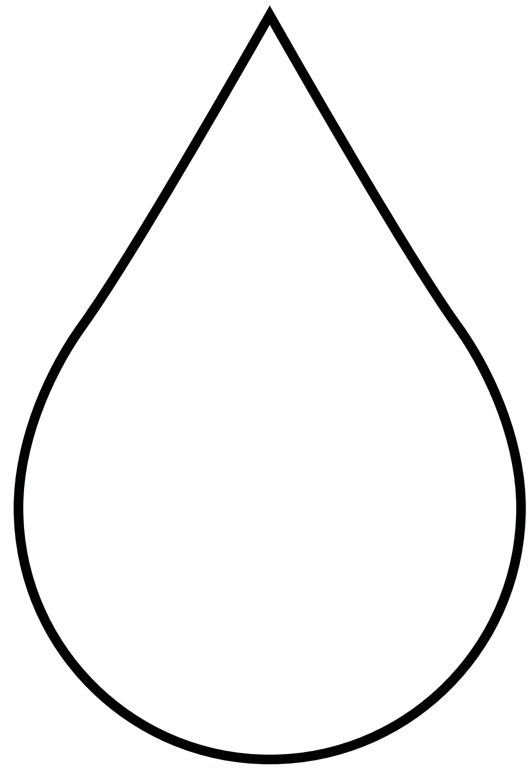
Information



Name: ______________________________________

Date: ______________________________________

Signature: __________________________________

Evaporation Station

Sketch:

What source of energy drives the evaporation of water?

What stage in the water cycle comes next?

What clues helped you to know what stage comes next in the water cycle?

Condensation Station

Sketch:

What is formed during the condensation stage?

What stage in the water cycle comes next?

What clues helped you to know what stage comes next in the water cycle?

The Traveling Raindrop

HOW DOES WATER CHANGE AS IT MOVES THROUGH THE WATER CYCLE?

Materials

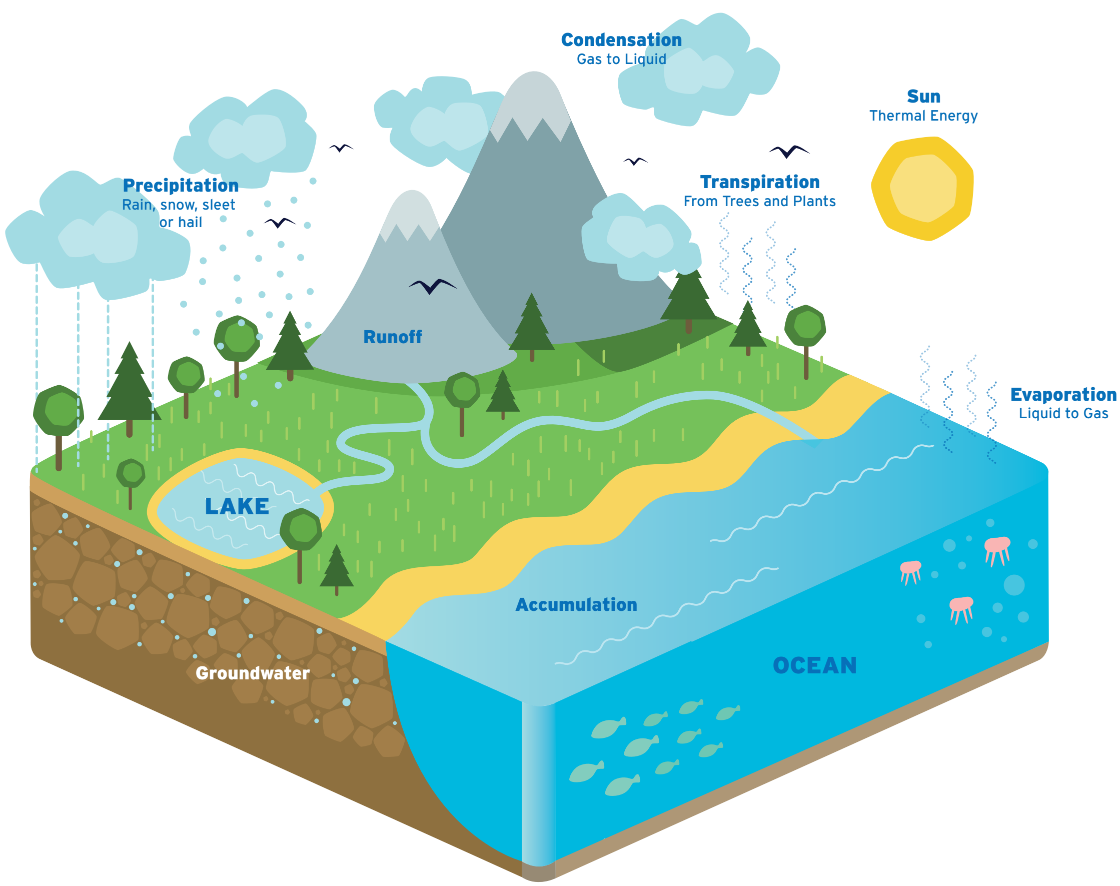
- Activity passport
- Station cards
- Station signs
- Stapler
- Coloring tools (crayons, markers, colored pencils)

INTRODUCTION:

The water cycle is happening everywhere all the time! There is no single starting point – that is what a cycle means. Energy from the Sun drives the water cycle. When liquid water on the surface of the Earth absorbs **thermal energy** from the Sun, it heats up, causing the water to **evaporate**, which means it changes from a liquid to a gas called **water vapor**.

As water vapor rises in the atmosphere, it loses energy (or cools) and condenses to form clouds. **Condensation** is the process of water changing from a gas to a liquid. Fog and dew are examples of condensation closer to the ground.

When enough water droplets gather and become "heavy," they fall back down to Earth as precipitation. **Precipitation** is water falling from clouds in the form of rain, snow, sleet, or hail.



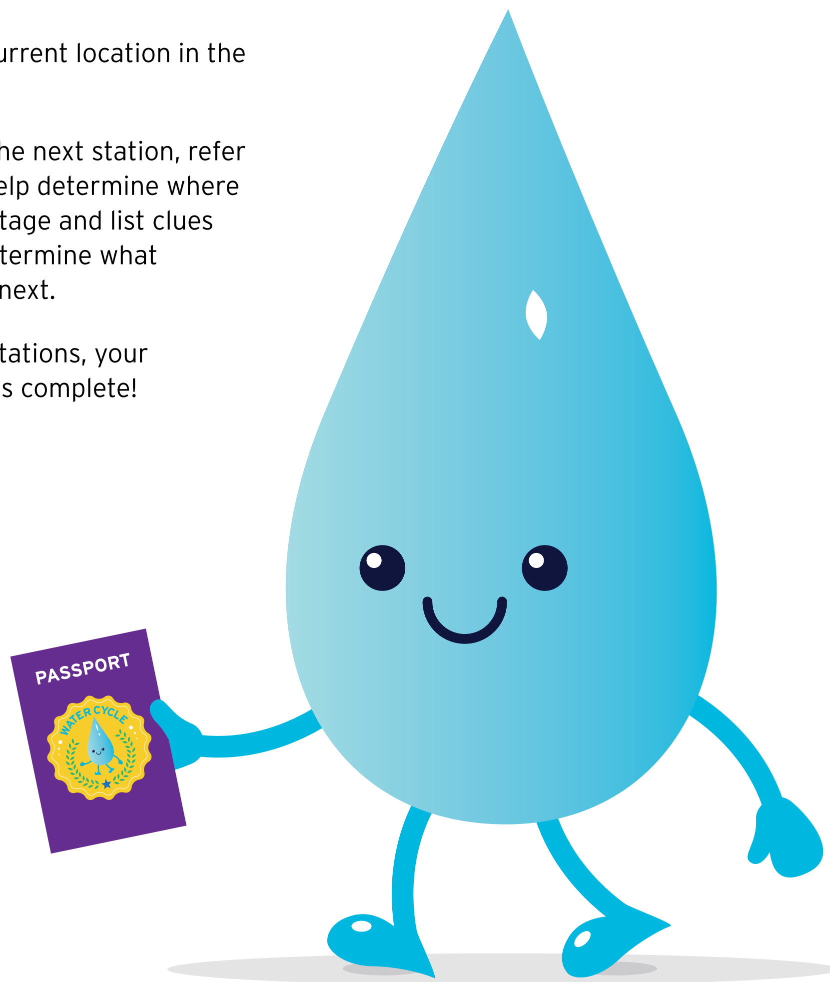
Once water falls back to Earth, it can go a lot of places. It could permeate the soil and be stored as **groundwater** or be soaked up by plants. Or gravity could pull it downhill, as **runoff**, where it could flow into a river, lake, or other body where water **accumulates**. Rivers and lakes are great sources of fresh **surface water** for animals. The water could flow downriver all the way to the ocean, where eventually it evaporates back into the atmosphere and the cycle repeats.

Water cycling in and out of the atmosphere plays an important part in **weather**, which is the current state of the atmosphere in regard to wind, temperature, cloudiness, moisture, or pressure at a specific time and place. Over time, this also contributes towards a region's long-term weather patterns, or **climate**.

Now it is your turn! Follow the path of a raindrop to discover how water changes as it moves through the different processes of the water cycle.

PROCEDURE:

1. Fold your passport pages into a booklet and staple them together.
2. Fill in the information section and sketch a portrait of yourself as a raindrop.
3. Pick a station to begin your journey. When you arrive at your first stop, open up your passport to the corresponding page. Read the card. The card will give information about what is happening to you, the raindrop, at that station.
4. Draw a sketch to describe your current location in the water cycle in your passport.
5. When you are ready to move to the next station, refer back to the water cycle card to help determine where to go next. Write down the next stage and list clues from the card that helped you determine what stage of the water cycle to go to next.
6. Once you have visited all of the stations, your journey through the water cycle is complete!



QUESTIONS:

1. If water does not accumulate in a river, lake, or ocean, where else might it go?

2. How is weather related to the water cycle?

3. How do you participate in the water cycle?

QUESTIONS:

1. If water does not accumulate in a river, lake, or ocean, where else might it go?

It could permeate the soil and be stored as groundwater, be soaked up by plants, consumed by an animal, or if the atmospheric temperature is very cold, it could freeze before it falls and accumulate as ice or snow on a mountaintop.

2. How is weather related to the water cycle?

The water cycle influences the cloudiness, moisture in the air, temperature, and precipitation of a specific time and place.

3. How do you participate in the water cycle?

Answers will vary but may include drinking water, exhaling water vapor, creating ice cubes, helping to conserve water in the urban water cycle, watering plants, or heating water in a pot or kettle to create steam.

Water Cycle in a Bag

WHAT ROLE DOES THE SUN PLAY IN THE WATER CYCLE?

Objective

- Students will investigate the role of the Sun as the major source of energy driving the processes of the water cycle.

Materials

- Plastic zip lock-style bags
- Blue food coloring
- Markers
- Observation booklets
- Tape
- Cups
- Pitcher
- Water

Lesson Outline:

1. Prior to this activity:

- Fill a pitcher up with water and add blue food coloring. Mix and pour into cups for students to use during the activity.
- Determine two locations either in the classroom or throughout the building: one that has windows and one that is in total darkness. The windows should receive at least a few hours of direct sunlight a day. Try to choose a week when the weather predictions call for lots of sun and few clouds.

2. As a class, review the processes of the **water cycle**: **evaporation**, **condensation**, and **precipitation**.

3. Guide students on how to set up the investigation.

- Pass out two plastic bags and at least one marker to each student. Have students write their name on the zipper part of both bags, and label them bag #1 and #2.
- Start with bag #1. Instruct the students to draw the **Sun** and **clouds** at the top of the bag. Imagine the **ocean** at the bottom of the bag (where it will be filled with water).
- Then set up bag #2. This time, do not include the Sun.
- Next, pass out the cups that contain the water with blue food coloring. You can have one cup per student or use one larger cup for each group of students.
- Students can work together for the next step. Have students pour about half a cup of water into each bag and zip up the bag. Have students use a marker to draw a line to mark the present water level.
- For bag #1, place at least two pieces of tape on the top of their bag and attach it to a window in the classroom or somewhere around the building that gets full sun for at least half the day.
- Have the students place bag #2 in a dark place that receives no sunlight, such as a cabinet.

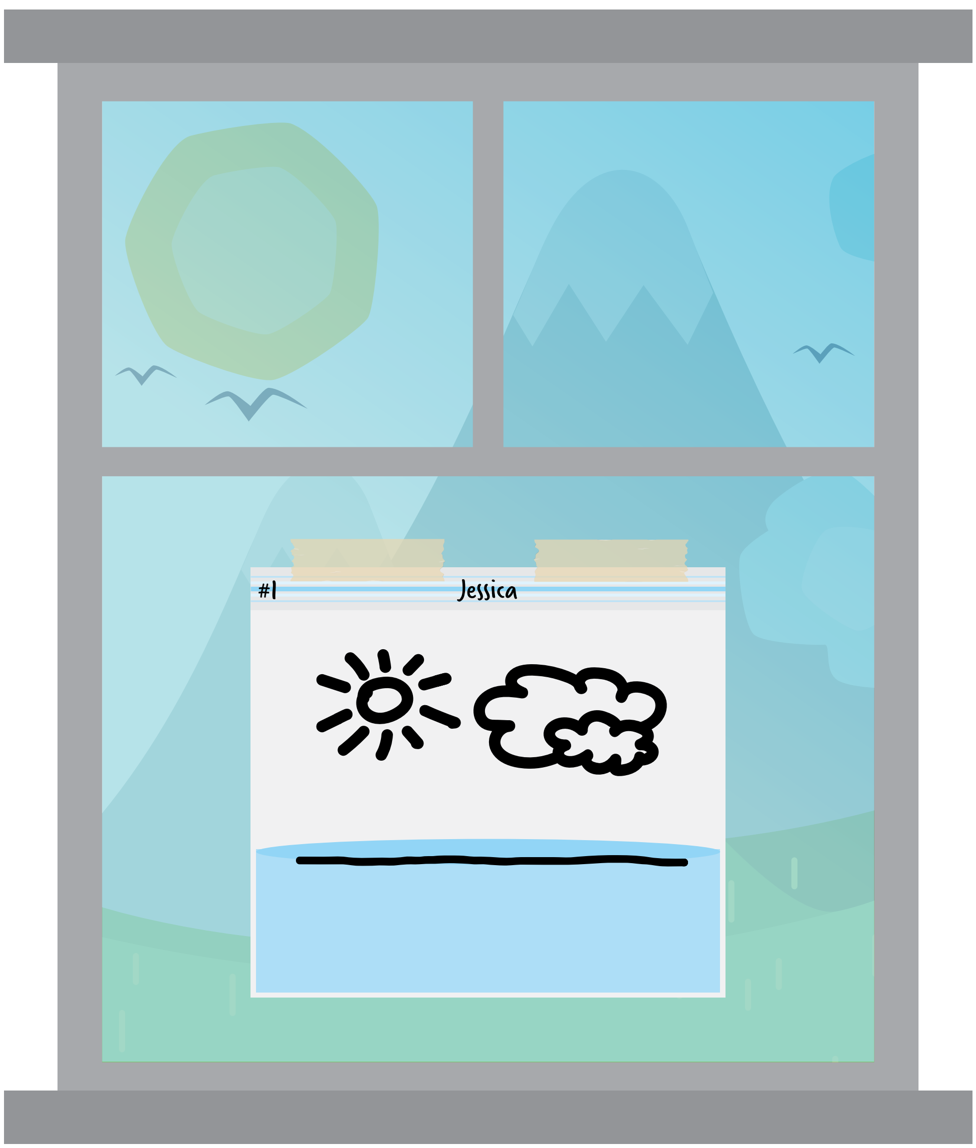
4. Next, have students come back to their seats and, with their group, fill out their predictions in the Water Investigation Journal. As they fill out the journal, help students identify the independent variable (the variable they are changing) and the dependent variable (the variable they are observing or measuring). *The independent variable is the presence of sunlight, and the dependent variable is the amount of liquid water.* What do they think will happen on day 2?

5. The following day, ask the students for their observations of the two bags. Measure the amount of liquid water at the bottom of both bags (without opening the bags, so it remains a closed system). Did the liquid water level in the bag change? Have students complete day two in their journal.

6. Discuss the results of both days together as a class. Were their predictions correct? Why or why not?

Extensions:

- In addition to water, add soil and a seed to explore how the geosphere and biosphere are involved in the water cycle.
- Have students pick a book about the Sun or explore NASA's Solar System Exploration: Our Sun page to learn more about the Sun.



Water Cycle in a Bag

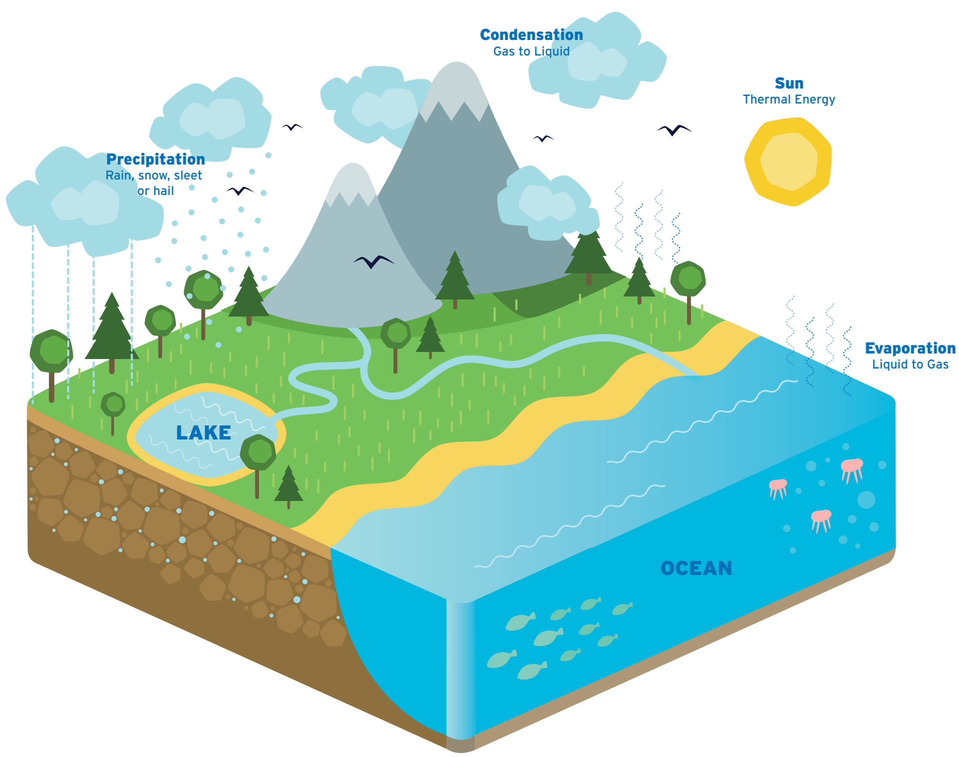
WHAT ROLE DOES THE SUN PLAY IN THE WATER CYCLE?

Materials

- Plastic zip lock-style bags
- Blue food coloring
- Markers
- Observation booklets
- Tape
- Cups
- Pitcher
- Water

INTRODUCTION:

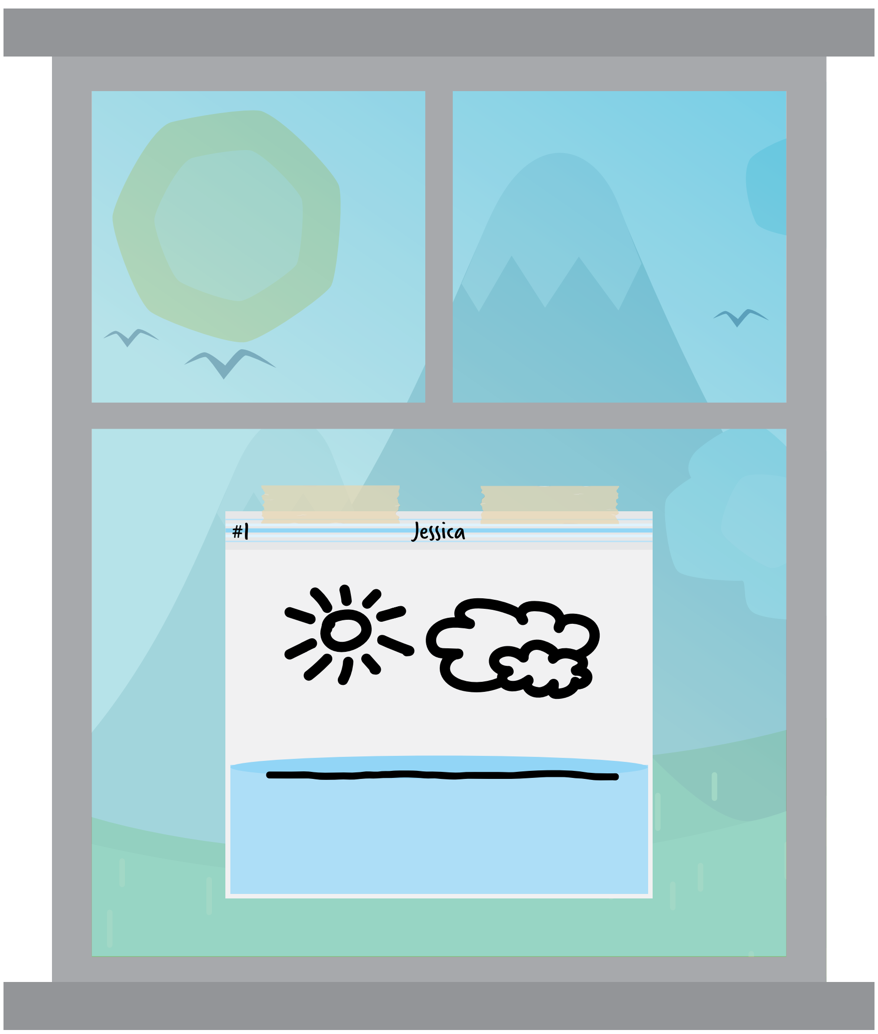
Water plays a role in all four of Earth's spheres. The **water cycle** describes the continuous movement of water between the three states of matter on, above, and below the surface of the Earth. Liquid water from the ocean or another body of water (the **hydrosphere**) evaporates and rises into the **atmosphere**. Water in the atmosphere falls and accumulates on land (the **geosphere**), where animals drink it, and plants absorb it (the **biosphere**).



In this activity, you will be creating a mini-water cycle model inside of a bag. Then you will conduct an investigation to test how changing the amount of sunlight affects the processes of the water cycle. What can this tell us about the role the **Sun** plays in the water cycle?

PROCEDURE:

1. Gather two plastic bags and one marker. Put your name on each bag and label one bag #1 and the other #2.
2. For bag #1, draw clouds and the Sun at the top of the plastic bag. Imagine the ocean at the bottom of the bag (where it will be filled with water).
3. Then set up bag #2. This time, do not include the Sun.
4. Next, fill a cup with approximately 2 cups of water. Add 1-2 drops of blue food coloring to the water, and then pour half the water into bag #1 and half the water into bag #2. Each bag should have about 1-2 inches of water in the bottom of it.
5. Seal the bags completely to ensure no water can escape. For each plastic bag, use a marker to draw a line to mark the present water level.
6. Place at least two pieces of tape on the top of bag #1 and attach it to a window that gets full sun for at least half the day.
7. Place bag #2 in a dark place that receives no sunlight.
8. Record your observations of each bag over the next two days in your Water Cycle Investigation Journal.



Water Cycle Investigation

Name(s): ______________________________

QUESTION

How does ______________________________ affect ______________________________ ?

PREDICTION

What do you think will happen for bag #1? What do you think will happen for bag #2? Why?

EXPERIMENT

What variable did you change?

What variables did you keep the same?

What will you measure?

RESULTS

What happened? Draw a sketch of your bag each day in the space below. Be sure to label all of the parts of the water cycle that are occurring in your sketch.

	BAG #1	BAG #2
DAY 1		
DAY 2		

CONCLUSION

Use your results to answer the question you investigated:

How does ______________________________ affect ______________________________ ?

Was your prediction correct? Why or why not?

What does your investigation tell you about the role of the Sun in the water cycle?

Keeping the Water Cycle in Motion

HOW DOES GRAVITY AFFECT THE MOTION OF THE WATER CYCLE?

Objective

- Students will create a density column to explore how materials with different densities move.

Materials

Each group will need:

- 1 clear beaker, cup, or glass
- 1 liquid dropper
- 1 dry erase marker

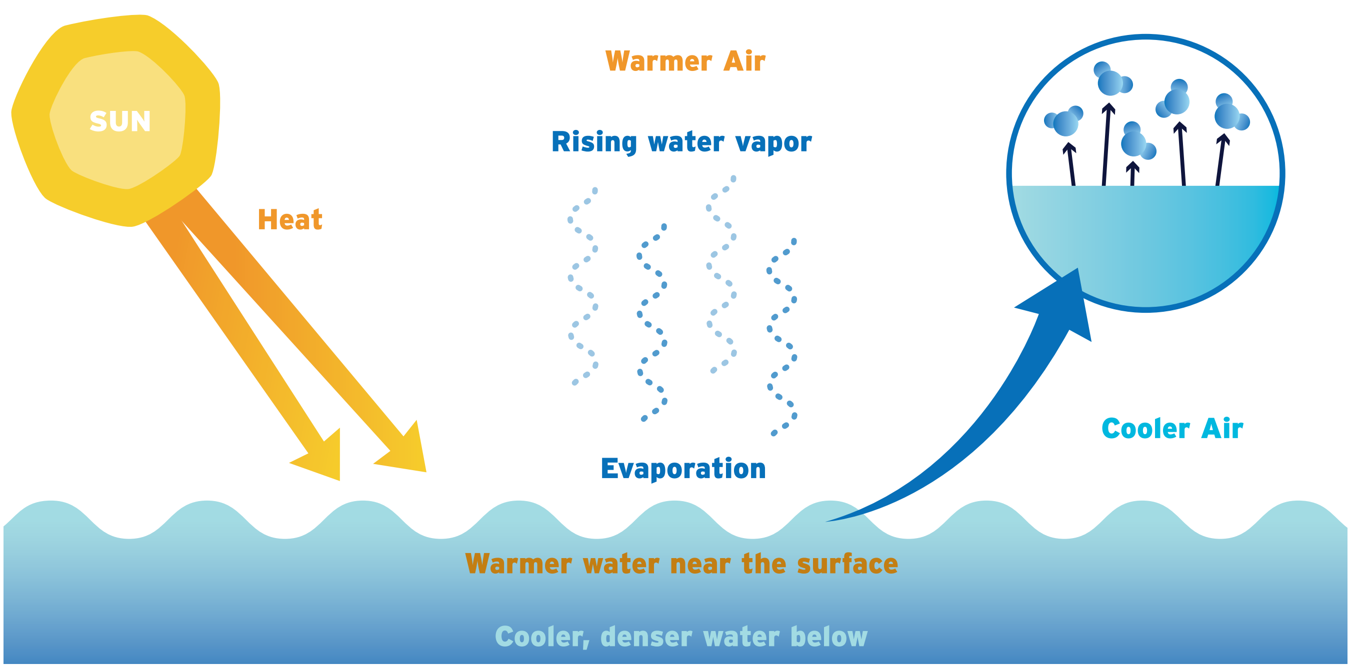
1 cup each of:

- Water
- Baby oil
- Corn syrup

Background Information:
Everything around us is made of **matter**. Water (H_2O) is unique in that it naturally exists on Earth in all three states of matter – as a solid (ice), a liquid, and a gas (water vapor).

Density is a measure of how tightly matter is packed into a given space. Density causes things to sink and float. If an object is less dense than water, like a rubber duck, it will float in water. If an object is denser than water, like a chunk of granite, it will sink in water. Solids aren't the only things that can sink and float – liquids and gases can too.

Cool air is denser than warm air. **Gravity** (a force of attraction that pulls matter together) pulls cooler, denser air downward. This forces warmer, less dense air upward into the **atmosphere**, where water vapor cools down and **condenses** (changes from a gas to a liquid) to form clouds. When enough water droplets inside a cloud gather together, gravity pulls them down towards Earth as **precipitation** in the form of rain, snow, sleet, or hail.



Lesson Outline:

1. Prior to this activity, prep the cups of water, baby oil, and corn syrup for each group.

2. Begin class with a review of matter, density, and gravity. Ask students how they think these terms are related to the **water cycle**?

3. Then have students break into small groups.
   - Instruct students on the order of liquids going into the beaker.
   - Have students record their observations.

4. Once students have completed their observations, explain how they will use the dropper to explore density further.
   - Model for the students how to use the dropper.
   - Have students record their observations.
   - Once all groups have completed the activity, discuss together as a class their answers to the reflection questions. If students had different answers, ask them to explain their reasoning.

Extensions:

- Take it a step further - find a few small items around the room and carefully drop them one at a time in the center of the beaker. Do they all sink?
- Have students create their own comic to teach other students about the roles gravity and the Sun play in driving the movement of the water cycle. Read Raindrop Tales: GPM Meets Mizu-chan, an educational comic about NASA's Global Precipitation Measurement mission, for inspiration!

Keeping the Water Cycle in Motion

HOW DOES GRAVITY AFFECT THE MOTION OF THE WATER CYCLE?

Materials

- 1 clear beaker, cup, or glass
- 1 liquid dropper
- 1 dry erase marker
- Water
- Baby oil
- Corn syrup

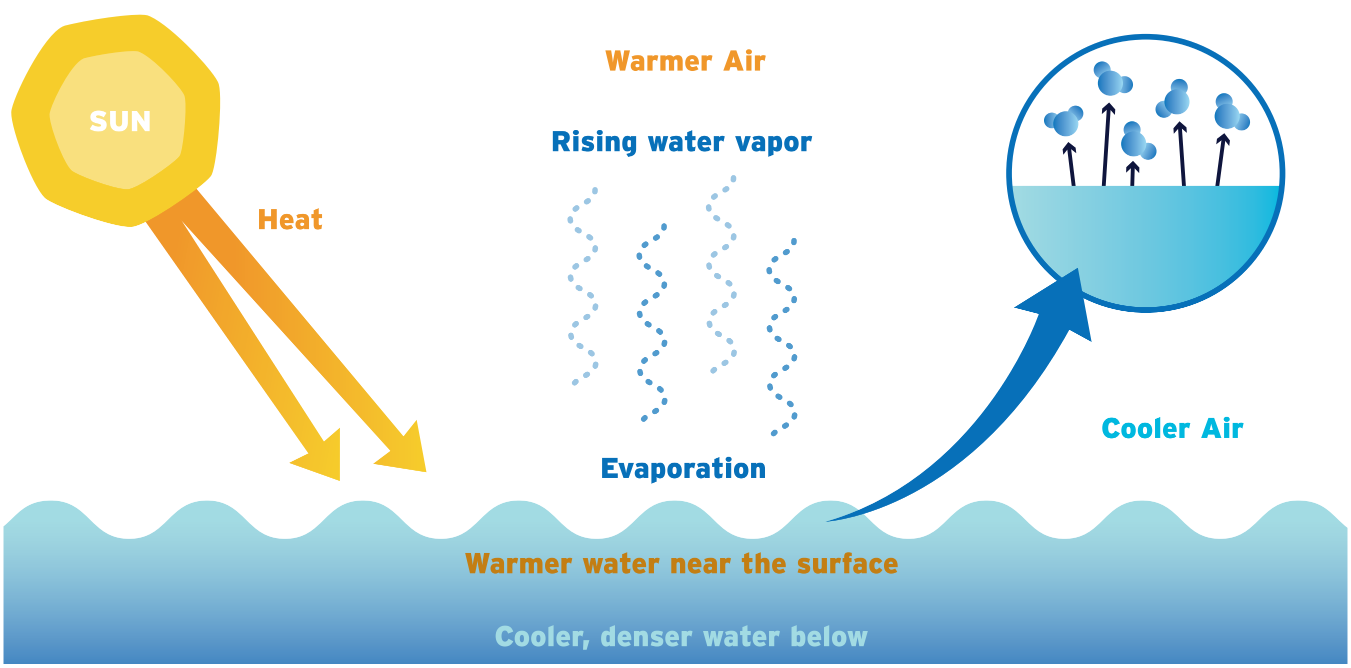
INTRODUCTION:

Everything around you is made of **matter**. Water (H_2O) is unique in that it naturally exists on Earth in all three states of matter – as a solid (ice), a liquid, and a gas (water vapor).

Density is a measure of how tightly matter is packed into a given space. Density causes things to sink and float. You may know that if an object is less dense than water, like a rubber duck, it will float in water. If an object is denser than water, like a rock, it will sink in water. Solids aren't the only things that can sink and float – liquids and gases can too!

Cool air is denser than warm air. **Gravity** (a force of attraction that pulls matter together) pulls cooler, denser air downward. This forces warmer, less dense air upward into the **atmosphere**, where water vapor cools down and **condenses** (changes from a gas to a liquid) to form clouds. When enough water droplets inside a cloud gather together, gravity pulls them down towards Earth as **precipitation** in the form of rain, snow, sleet, or hail.

In this activity, you will explore how materials with different densities move!



PROCEDURE:

1. Slowly pour equal amounts of each liquid into the beaker in the following order. Let each liquid settle before adding the next.
   - First, add corn syrup.
   - Next, add water.
   - Finally, add baby oil.

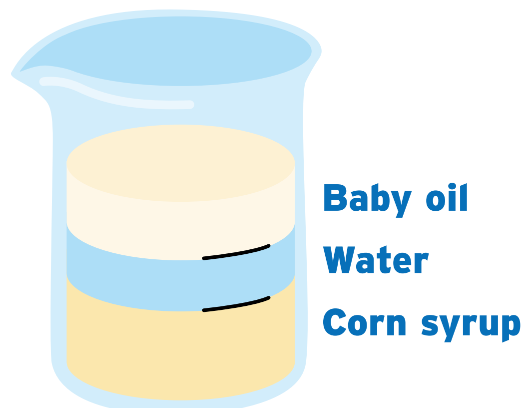
What do you observe?

____

____

____

2. Using a dry erase marker, draw a line each place where the fluids meet, as shown in the example image.



3. Pour a little more corn syrup into the beaker. What happened? Record your observations.

____

____

____

4. Use the dropper to inject some baby oil deep into the bottom layer of the cylinder. What happened? Record your observations.

____

____

____

QUESTIONS:

1. Which of the three liquids is the densest?

Which of the three liquids is the least dense?

2. Think about how the three layers could represent the movement of cooler and warmer air over the ocean.

- Draw waves in the bottom layer to represent the ocean.
- Which layer could represent cooler air? Label this layer with the letter C.
- Which layer could represent warmer air? Label this layer with the letter W.
- Explain your reasoning:

3. Draw a cloud where you think it might form. Why do you think it would form in this layer?

4. What role does gravity play in this process? How else does gravity affect the water cycle?

QUESTIONS:

1. Which of the three liquids is the densest?

Corn syrup

Which of the three liquids is the least dense?

Baby oil

2. Think about how the three layers could represent the movement of cooler and warmer air over the ocean.

- Draw waves in the bottom layer to represent the ocean.
- Which layer could represent cooler air? Label this layer with the letter C. MiddleLayer
- Which layer could represent warmer air? Label this layer with the letter W. Top Layer
- Explain your reasoning:

If students come up with different answers, make sure they can explain their reasoning.

3. Draw a cloud where you think it might form. Why do you think it would form in this layer?

Answers may vary. One example could be that they think a cloud might form in the top layer. Cool, dry air is denser than warm air, and gravity pulls it downward. This forces warmer, less dense air upward into the atmosphere, where water vapor cools down and condenses (changes from a gas to a liquid) to form clouds.

4. What role does gravity play in this process? How else does gravity affect the water cycle?

Gravity (a force of attraction that pulls matter together) pulls cooler, denser air downward. This forces warmer, less dense air upward into the atmosphere.

When enough water droplets inside a cloud gather together, gravity pulls them down towards Earth as precipitation in the form of rain, snow, sleet, or hail. Earth's gravity also pulls runoff downhill and keeps water in the atmosphere from leaving the planet.

DIY Water Filter

Adapted from NASA/JPL Water Filtration Challenge

CAN YOU DESIGN A DEVICE TO FILTER IMPURITIES FROM SIMULATED WASTEWATER?

Objective

- Students will work through the Engineering Design Process to develop a solution that best filters impurities from simulated wastewater.

Materials

- A large pitcher of simulated wastewater (can use a combination of dust, soil, sand, and/or a few drops of yellow food coloring)
- Paper towels (for spills)
- Cups (to scoop out filter media)

Each group will need:

- 1 scale (for measuring amounts of filter media)
- 2 empty plastic .5 L bottles
- Scissors
- Coffee filters
- Rubber bands
- Filter media:
  - Activated carbon
  - Aquarium gravel (clean)
  - Crushed or rocky Zeolite
  - Cheesecloth
  - Cotton balls
  - Potting soil (fresh from a bag to minimize bugs)
  - Sand (clean)

SAFETY NOTE: The filtered water at the end of this challenge SHOULD NOT be consumed.

Lesson Outline:

1. Advance preparation:

- Weeks ahead of time: begin collecting empty and cleaned 0.5 L bottles (to encourage recycling). Remove any labels.
- Day of: prepare a large pitcher of simulated wastewater. Thoroughly rinse the activated carbon and let dry before using (otherwise, it will turn the water black.)

2. Hold a class discussion about clean water.

- What do we mean when we say **fresh water** is clean? *We mean it is safe to drink and use.* Why is clean water important? *Contaminated or polluted water would make us and other animals sick.*
- In *The Water Cycle* episode, the Whynauts visit manmade **wetlands** just outside of Dallas, which help to filter water naturally as part of the **urban water cycle**. How do you think we could recreate this filtration process?

- Review the materials available to them (constraints) and describe any filter media they may not be familiar with (possibly activated carbon and zeolite).
    - What materials do you think would make the best water filter? Why?
- Show students the simulated wastewater. Clearly communicate that the water filtration devices they are about to make will remove some impurities, but they will **NOT** make the water safe to drink. Even if their filtered water looks clean, that does not mean all harmful contaminants have been removed.

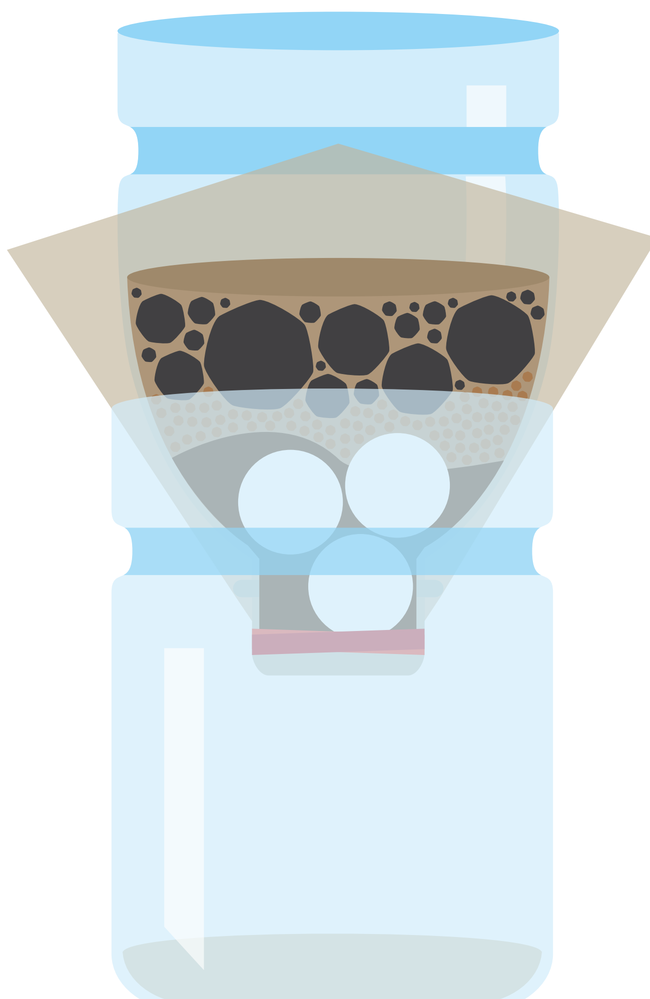
3. Divide the class up into small groups. Remind them that engineers collaborate on projects and that shared ideas can lead to better solutions.

4. Have each group create the nested water bottles. You may need to assist the students with cutting the water bottles.

5. Instruct groups to use the Engineering Design Process Workbook to complete the first three steps: **Ask**, **Imagine**, and **Plan**. They will need to have their plan approved before they begin building a prototype. Once their plan is approved, they can move on to the next step: **Create**.

- Encourage students to take notes on the amounts and sequence of their chosen filter media in their workbooks to help assess which filters are most effective.

6. When everyone is ready or time is up, have each group **Test** their prototype. Pour some dirty water from a pitcher into their filter and qualitatively assess the filtered water. (Hold a piece of white paper behind the filtered water and examine for amount of particulate matter and color.)



7. Remind students that failure is an important part of the Engineering Design Process and that they should not be discouraged if their first design doesn't filter the water well. Have a class discussion about their observations. Ask students:
   - What did you notice about the designs that filtered the water well?
     - Why do you think these designs were successful?
   - What did you notice about the designs that did not filter the water?
     - Why do you think these designs were not successful?

7. Instruct groups to return to their workbooks to record their observations and move on to the next step: **Improve**. Allow them to improve and test as many times as they need to design a successful solution or until they run out of time.

8. Ask groups to complete the last section of the workbook: **Share**. Have each group share out their solution with the class.

9. End the lesson with a class discussion. Ask students:
   - What did you find challenging?
   - How did you and your group members communicate and collaborate?
   - What other problems related to water - such as water scarcity or hydropower- could engineers try to solve?

Extensions:

- Delve further into other problems related to water – such as water scarcity or hydropower – that engineers could try to solve. Complete the Perot Museum's *Amaze Your Brain at Home* Hydropower Challenge, play the Smithsonian's Aquation: The Freshwater Access Game, or challenge your students to design a solution to their own water-related problem using the Engineering Design Process.
- **STEM Career Connections** - connect your students with an environmental engineer, wetland ecologist, or aquatic technician. You can reach out to professionals in your community or use one of the resources listed at the end of this guide.

DIY Water Filter

Adapted from NASA/JPL Water Filtration Challenge

CAN YOU DESIGN A DEVICE TO FILTER IMPURITIES FROM SIMULATED WASTEWATER?

Materials

- Simulated wastewater
- Paper towels (for spills)
- Cups (to scoop up filter media)
- 1 scale (for measuring amounts of filter media)
- 2 empty plastic .5 L bottles
- Scissors
- Coffee filters
- Rubber bands
- At least 3-4 of the following filter media of your choosing:
  - Activated carbon
  - Aquarium gravel
  - Crushed or rocky zeolite
  - Cheesecloth
  - Cotton balls
  - Potting soil
  - Sand

INTRODUCTION:

Water is essential for life on Earth. As humans, our bodies need clean, **fresh water** to function. However, various substances such as microorganisms, soluble chemicals, and other natural waste can easily make water unsafe to drink or use. Filtering out harmful contaminants and making water safe to consume is part of the **urban water cycle**.

Manmade **wetlands** like the John Bunker Sands Wetland Center featured in the episode are a natural part of this water treatment process. After recycled wastewater is treated, it is pumped into the wetlands. Over several days, any solid matter settles out in the sedimentation basins, and the wetland plants and soils filter out impurities, such as phosphate, nitrate, and ammonia, further improving water quality. The water is then pumped back to a reservoir to be used again.

Now it's your turn! In this activity, you will use the Engineering Design Process to develop a solution to filter impurities from simulated wastewater.

PROCEDURE:

1. Discard the screw caps of both water bottles. Use scissors to cut the bottom off the first bottle and the top off the second bottle.

2. Secure a coffee filter tightly over the neck of the bottle (that had the bottom cut off) with rubber bands.

3. Place the bottomless bottle upside-down into the topless bottle, as shown in the diagram.

4. Once you have built the basic structure of your filtration device, follow the steps of the Engineering Design Process Workbook to plan and test out a solution.

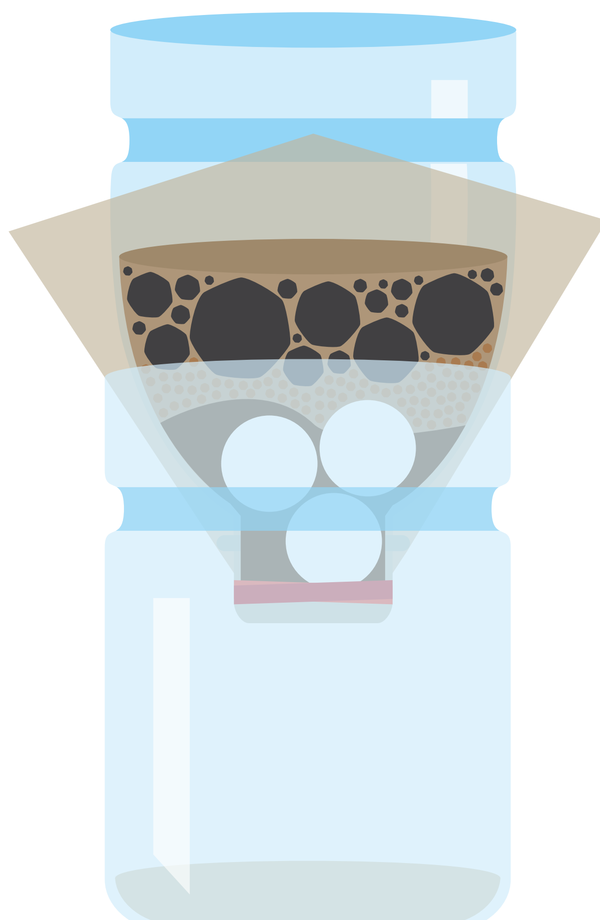
5. Fill the bottle up to 1 inch from the top with different layers of filter media. Record the amounts and order of filter media used in your workbook.

6. When you are ready to test your prototype, slowly pour simulated wastewater into your water filtration device. It may take the water some time to filter through the media.

7. Observe and record how well your design worked.

8. If you feel that your design needs improvement, create a new design, going through the steps of the design process again. Try to get the cleanest filtered water!

SAFETY NOTE: The filtered water at the end of this challenge SHOULD NOT be consumed.



Engineering Design Process Workbook

Name(s): ______________________________

ASK	
	What is the problem you are trying to solve?
	What are the criteria (requirements for success)?
	What are the constraints (limitations like time or materials)?

IMAGINE	
	Brainstorm possible solutions. Consider the ways you could filter out varying sizes and types of contaminants.

PLAN

Choose a solution that you think will work best to solve the problem. Don't forget the criteria and constraints!

Draw a diagram and label the different parts:

What filter media, and how much of each, will you use?

CREATE

Follow your plan to build a prototype.

TEST

Try it out! Test and evaluate your prototype.

Record your observations:

Was your design successful? What worked? What didn't?

IMPROVE

Redesign and retest your prototype as needed.

What changes did you make to your design? What effect did they have?

SHARE

Communicate your solution.

What combination and sequence of filter media was most effective at filtering the water?

What did you learn?

How did you communicate with others throughout the design process?

ADDITIONAL RESOURCES

GLOSSARY

Accumulation – the process by which water collects in rivers, lakes, streams, oceans and other bodies of water

Aquifer – an underground layer of porous rock or sediment that is saturated with groundwater

Atmosphere – collection of gases that surrounds Earth; it contains the air we breathe, weather we experience, and helps protect us from harmful solar radiation

Biosphere – contains all of a planet's living things, including all microorganisms, plants, and animals

Climate – describes the weather patterns over a long period of time (30 years) in a specific place. When scientists talk about climate, they look at averages of precipitation, temperature, humidity, sunshine, or wind speed.

Clouds – a large accumulation of water droplets or ice crystals suspended in the atmosphere

Condensation – process by which water vapor (gas) changes to liquid water. This process forms clouds.

Density – a measure of the amount of matter in an object compared to how much space it takes up

Ecosystem – includes all of the living organisms (plants, animals, fungi, and single-celled microorganisms) in a given area, interacting with each other and with their non-living components (weather, rocks, soil, climate, atmosphere)

Evaporation – process by which liquid water changes to a gas (water vapor)

Fresh water – water containing less than 1,000 milligrams per liter of dissolved solids, most often salt

Groundwater – water that is stored below the Earth's surface

Hail – type of precipitation that falls from the clouds as balls of ice

Hydrosphere – all the water on Earth

Geosphere – all the rocks, sediments, and inorganic parts of soils on Earth

Gravity – a force of attraction that pulls matter together

Matter – anything that has mass and takes up space

Ocean – large body of salt water that covers about 70% of the surface of Earth

Precipitation – solid or liquid water that falls from clouds towards the ground. Can occur as rain, sleet, snow or hail.

Rain – type of precipitation that falls to the ground as drops of liquid water

Reservoir – a manmade lake built by placing a dam across a stream or river. Used to store water and help with flood control.

Runoff – water that flows downhill over land to reach rivers, lakes, streams, or oceans. Some runoff soaks into the ground, some plants absorb it, and some fills underground aquifers.

Sleet – type of precipitation that freezes as it falls towards the ground

Snow – type of precipitation that falls towards the ground as solid ice crystals

Sun – the star (hot ball of glowing gases) at the center of our solar system. It gives us light so we can see and heat so the planet is warm enough for life. Energy from the Sun drives the water cycle.

Surface water – precipitation that is collected in open bodies of water above ground, such as ponds, lakes, streams, rivers, and wetlands

Thermal (heat) energy – a form of energy that we can feel that makes things warmer

Transpiration – the release of water from plant leaves

Urban Water Cycle – a small part of the larger, global water cycle. It describes how the water we use flows through our cities and towns, cycling from source to treatment, distribution, use, collection, and retreatment before being reintroduced into the environment.

Water Cycle – the continuous movement of water on, above, and below the surface of the Earth, as well as the many processes involved

Water vapor – gaseous phase of water. Formed by evaporation, transpiration, or sublimation, water vapor rises into the atmosphere.

Weather – the current state of the atmosphere in regards to wind, temperature, cloudiness, moisture, or pressure at a specific time and place. Weather can change from minute-to-minute, hour-to-hour, day-to-day or even season-to-season.

Wetlands – ecosystems where the soil is saturated with water at least seasonally or year-round

READING LIST

- Barnham, Kay. *The Great Big Water Cycle Adventure*. B.E.S., 2018.
- Boulos, Rana. *Pearl the Raindrop: The Great Water Cycle Journey*. Independent Publishing Network, 2021.
- Kerley, Barbara. *A Cool Drink of Water*. National Geographic Kids, 2006.
- Lichtenheld, Tom. *Cloudette*. Henry Holt and Co., 2011.
- Lord, Michelle. *The Mess That We Made*. Flashlight Press, 2020.
- Moon, Emily Kate. *Drop: An Adventure through the Water Cycle*. Dial Books, 2021.
- Paul, Miranda. *Water Is Water: A Book About the Water Cycle*. Roaring Brook Press, 2015.
- Pêgo, Ana and Isabel Minhós Martins. *Plasticus Maritimus: An Invasive Species*. Greystone Kids; Illustrated edition, 2021.
- Rice, William B. *Inside the Water Cycle: Earth and Space Science*. Teacher Created Materials, 2007.
- Seluk, Nick. *The Sun is Kind of a Big Deal*. Orchard Books, 2018.
- Strauss, Rochelle. *One Well: The Story of Water on Earth*. Kids Can Press, 2007.
- Verde, Susan and Georgie Badiel. *The Water Princess*. G.P. Putnam's Sons Books for Young Readers, 2016.

Online Articles

- Frontiers for Young Minds – an open-access scientific journal written by scientists and reviewed by a board of kids and teens
  - "Computing the Climate: Building a Model World" by Johnny Williams (2020)
  - "The Bark Side of the Water Cycle" Collection (2021)
  - "When Nature Gets Thirsty" by Rebecca H. Weissinger, David Thoma, and Alice W. Biel (2021)
  - "When Water Swims in Water, Will it Float, or Will it Sink? Or: What Drives Currents in the Ocean?" by Mirjam S. Glessmer (2019)
- Science Journal for Kids and Teens – peer-reviewed science research adapted for students and their teachers
  - How Can Your Smartphone Make Water Safe to Drink? (2021)
  - How Can Poop Be Cleaned and Reused? (2020)
- Science News for Students – connects the latest in scientific research to learning in and out of the classroom
  - "Dew Collector Brings Water to Thirsty Plants" by Melissa L. Weber (2021)
  - "Explainer: Earth's Water is All Connected in One Vast Cycle" by Beth Geiger (2018)
  - "Groundwater Pumping is Draining Rivers and Streams Worldwide" by Jonathan Lambert (2019)
  - "Here's One Way to Harvest Water Right Out of the Air" by Sid Perkins (2020)
  - "Warming Cities May See More Rain – and Frequent Flooding" by Bethany Brookshire (2021)

ADRIANA BAILEY

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PERSONAL STATEMENT

When I left college, I thought I'd closed the door on being a scientist for good. I'd done terribly in freshman chemistry and math. And, I was too embarrassed to ask my teachers for help, to admit that I didn't understand. I told myself I simply didn't have what it takes.

I figured the next best thing to being a scientist was to help scientists tell their stories and share their discoveries. Working as a science writer, I transformed complex research (like how secondary organic aerosols form) into easy to understand news stories (you know those fumes from paints and dry cleaning? They can form new particle pollution in the air).

As a kind of translator between scientists and the public, I had to learn how to ask questions effortlessly. And that's when I realized I did have what it takes to be a scientist: the confidence to say, "I don't know; I don't understand," but to keep asking questions until I figure it out.

Five years after thinking I'd left school permanently, I returned for a master's in geography and then a PhD in atmospheric science. Today, I'm a scientist at the National Center for Atmospheric Research asking my own questions and sharing my own discoveries about the water cycle. By studying how moisture moves through the atmosphere, forms clouds, and precipitates back to the ocean and land, I'm helping us understand the important role water plays in shaping how we experience changes in climate.

BIOGRAPHY

Adriana Bailey is an atmospheric scientist who studies the processes that control humidity, cloudiness, and precipitation. Her research probes questions on scales from as small as clouds to as big as the globe and asks how variations in climate affect water availability and hydrological connections between places.

As a scientist at the National Center for Atmospheric Research's aviation facility, Adriana often uses an airplane for her laboratory. She uses laser-based measurements of water's isotopic composition to track how moisture moves through the atmosphere and exchanges with the ocean and land.

Prior to becoming an atmospheric scientist, Adriana worked as a science news writer for the University of Colorado's Cooperative Institute for Research in Environmental Sciences (https://cires.colorado.edu/). She credits writing about science, which requires asking lots (and lots) of questions, for stoking her interest in scientific inquiry and for giving her the confidence to embrace what she doesn't understand.

SEGMENT PITCHES

Unclouding Climate Forecasts

[Setting: Barbados, Jan/Feb 2020, where scientists from around the world will gather to deploy instruments on towers, airplanes, and ships to study the processes that control low-level cloudiness.]

When it comes to predicting future climate, clouds often cloud our forecasts. That's because climate simulations—which are designed to give us a global view of what weather will look like, on average, in a warmer world—have "pixels" about the size of the state of Colorado. Clouds, in contrast, are mere specks, and the processes that control how big they grow or fast they shrink can be even tinier. Our big-picture climate simulations struggle to represent these small-scale processes.

We know clouds matter a lot for climate. Just think about the temperature difference you'd feel if skies were bright blue or overcast on any given day. Temperatures are much warmer during the daytime when there are no clouds in sight. This is why, if low-level clouds vanish in a warmer world, temperatures, overall, will be much higher than if those same low-level clouds persist into the future.

During January and February of 2020, scientists from around the world will launch a major international field campaign to get at the heart of what controls low-level cloudiness. Ships, airplanes, and drones will carry state-of-the-art instrumentation around and through the shallow cumulus cloud fields that pepper the Atlantic ocean around the island of Barbados. Observations collected during the experiment are expected to reduce one of the largest uncertainties in current climate forecasts.

ADDITIONAL LINKS

NCAR Staff Bio

ONLINE RESOURCES

Perot Museum

- Sami Saves Seashells by the Seashore
- Hydropower Challenge

John Bunker Sands Wetland Center

NASA

- Aqua | Earth-observing Satellite Mission
- Climate Kids | What Is the Water Cycle?
- Earth Observatory | The Water Cycle
- Precipitation Education: The Water Cycle
- Raindrop Tales: GPM Meets Mizu-chan - an educational comic about NASA's Global Precipitation Measurement mission
- Solar System Exploration: Our Sun

NOAA | The Water Cycle

Smithsonian | Science Education Center

- Make it Rain! - explores student misconceptions about the water cycle and reveals some of the pitfalls of common representations.
- Aquation: The Freshwater Access Game - use each region's wealth to build pipes, desalinate water, and conduct research to bring water where it is needed most.

TEDEd

- 5 TED-Ed Lessons About Water
- Water: The Source of Life

Texas Parks & Wildlife | Water Education

- Texas Treasures: Wetlands (PDF)
- Texas Waters: Exploring Water and Watersheds (PDF)

USGS

- National Water Dashboard
- The Water Cycle for Schools and Students
- Water Science School | Water Basics

Water Data for Texas

STEM Careers

- IF/THEN Collection
  - Adriana Bailey, Atmospheric Scientist
  - Mission Unstoppable | Aquatic Technicians
- Skype a Scientist
- USGS Careers | I Am A... series – a collection of short animations that show "what society thinks I do" compared to a more accurate representation highlighting tools of the trade.
  - I Am A...Climate Modeler
  - I Am A...Wetland Ecologist
- NASA ClimateKids | A Conversation with Sarah Sherman, Systems Engineer for Environmental Satellite

KEY STAKEHOLDERS

SERIES SPONSORS

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ADDITIONAL SERIES SUPPORT

LYDA HILL PHILANTHROPIES

IF/THEN

City of Dallas | Office of Arts & Culture

For additional information, please email
schoolengagement@perotmuseum.org