LESSONS TO GROW BY

Lessons to Grow By – Plant Needs

In this series of Lessons to Grow By, we are exploring plant needs. For healthy growth and development, plants must obtain just the right amounts of light, water, air, and nutrients and they also need space to grow. These five requirements are the basic needs for all plant life.

Fortunately for our world full of diverse environments, different plants need different amounts of each of these essentials so there are plants well adapted to grow in almost all environmental conditions.

Through these activities, kids will investigate plant needs to better understand how to take care of their green friends while also gaining a deeper appreciation for how the living and nonliving elements in an ecosystem work together.

Week 2: Water

Learning Objectives:
This week focuses on the plant need of water. Kids will:

- Learn about the water cycle and the role plants play in this important natural process.
- Investigate how much water plants need and what happens if they get too little or too much water.
- Compare the benefits and challenges of different kinds of watering methods.

Materials Needed for the Week

Activity 1: Round and Round: The Water Cycle

- Round and Round Reading Page

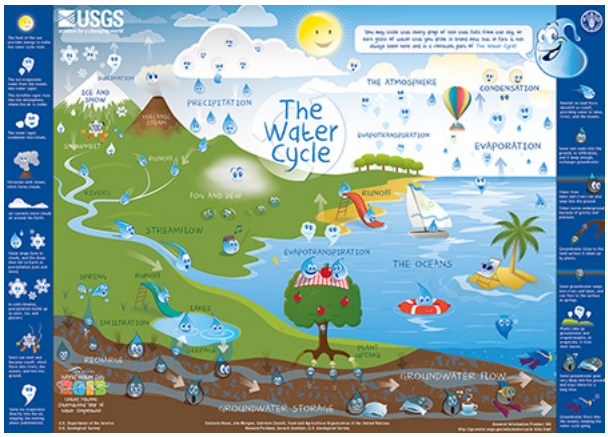
- USGS Water Cycle Diagram, available at: https://www.usgs.gov/special-topic/water-science-school/science/water-cycle
- Indoor or outdoor plant(s)
- Plastic sandwich bag(s)
- Rubber band or twist tie or string(s)
- Terrarium supplies (optional)

Activity 2: Water Experiments

- 4 to 5 potted plants of the same variety and approximately the same size (herbs in 4” pots work well) or
- Seed viewers (bean seeds, paper towels, clear plastic cups)
- Water Experiment Data Collection Worksheet

Activity 3: Fulfilling Plants’ Water Needs

- Irrigation Comparison Worksheet



Water Cycle Diagram

Introduction

Water is a critical component of all living things, including plants, and it plays an important role in basic functions and structure. It is also an element that is continually lost by organisms and therefore must also be constantly replaced.

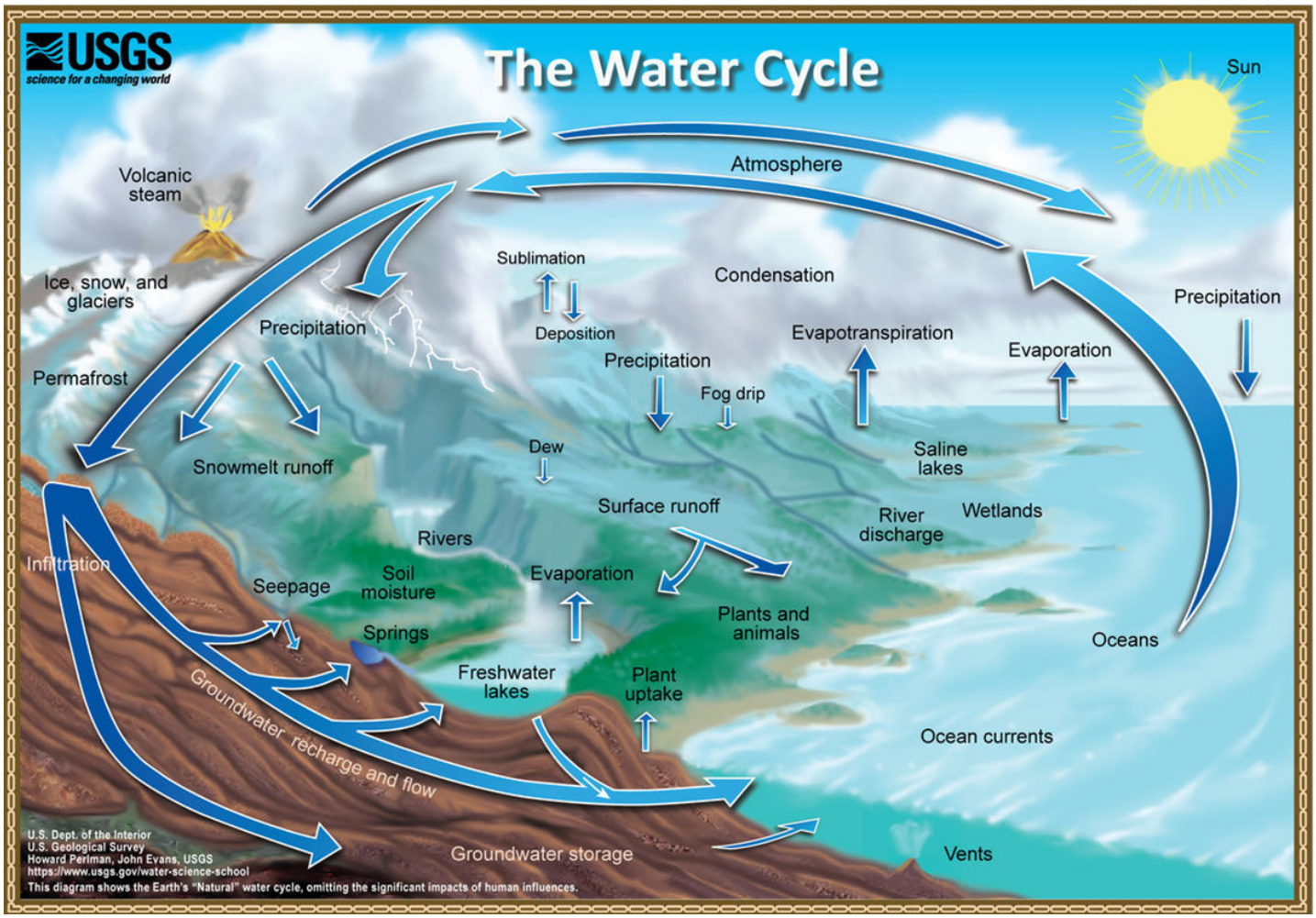
Most of the water used by plants comes from the soil. Water is absorbed by plant roots, moves up the stems and then into leaves. On this journey, it is used in plant cells as needed, and then some of it exits the leaves through small openings called stomata. This process is called transpiration, which is much like sweating in humans. The movement of water provides support for the plant and helps it adapt to varying conditions in its environment. Water is also a key component needed for photosynthesis which is how the plant makes food. There are some plants that are able to take in water through their leaves, but the vast majority of water used by plants enters through roots.

The Water Cycle

The cycling of water through the plant is also part of a bigger phenomenon known as the water cycle. In the water cycle, water vapor condenses in the air and then falls to land in the form of rain. When water hits land’s surface, it follows one of two main pathways — either it infiltrates into the soil or it runs off into local streams, lakes, and rivers.

Infiltration of water into the soil provides many environmental benefits. Healthy soil works like a sponge, soaking up water and allowing it to be processed slowly into the environment while impurities are removed. The presence of plant roots in the soil is very important for creating healthy soil and aiding in this infiltration process.

Plants then take up the water in the soil and use it to sustain their basic functions, including making the food energy for all life through photosynthesis. The plants also release water vapor into the air through transpiration — and then water cycle begins again.



The Water Cycle. Credit: Howard Perlman, USGS. https://usgs.gov/media/images/water-cycle-natural-water-cycle

Water Use and Plant Adaptations

The speed at which a plant takes in and uses water depends on a number of factors, including the size of the plant and the environmental conditions the plant is living in. Smaller plants generally use less water, while larger plants usually need larger quantities. Temperature and sun exposure — which can vary by season and location — are also critically important. Plants in hot, dry climates will lose water more quickly. Plants in cold climates will lose water more slowly. During the winter, many plants drop their leaves and enter a dormant state where they hardly use any water at all.

Because the amount of water available varies greatly in different environments, plants have developed different adaptations to help them survive the conditions they live in. Plants like cacti that live in deserts where water is scarce have modified leaves that decrease the rate of transpiration and stems that have a special ability to store extra water. Tropical plants in a rainforest where water is plentiful have pointy tips (drip tips) and waxy surfaces that help water slide off quickly. These help prevent water buildup that could lead to decay and mold.

Water: A Precious — and Endangered — Resource

Water is one of our most valuable resources. Unfortunately, it's rapidly becoming one of the most endangered. Water shortages loom as growing cities and suburbs bring increased demands in concentrated areas, and droughts threaten various regions every year. Adopting efficient watering practices that provide just the right amount of water plants need should be a priority for all gardeners because it conserves water and boosts plant health.

When we are lucky, Mother Nature provides most of the water our plants need through rain. However, for indoor plants, and for many outdoor plants too, gardeners frequently need to provide supplemental water. Here are some wise watering techniques to teach kids to make sure they know how to efficiently use water in their gardens:

When to water. Irrigate during early morning hours. Much water applied in the heat of the day is lost through evaporation. Evening watering can contribute to disease problems because plant leaves stay wet longer. Avoid watering during windy periods because wind increases water loss.

Where to apply water. Since plants absorb moisture through their roots, it makes most sense to apply water to the soil. Watering leaves is inefficient and can lead to disease problems. Soaker hoses and drip irrigation, which apply water directly to the soil, conserve water compared to overhead sprinklers (More on this below.) If your garden is in a dusty area, however, rinse plants occasionally if dust builds up on leaves.

Watch the weather. As best you can, adapt your watering schedule to weather and changing seasons. Although watering every Monday and Wednesday might be convenient for you, it may not be the right schedule for your plants.

How much to water. It is better to water thoroughly a few times a week rather than a little bit every day. For most plants, you want the soil to absorb water to a depth of 6 to 8 inches to encourage deep, strong root growth. For large plants like trees and shrubs, water until soil is moist to a depth of 8 to 12 inches. For all but new seedlings and fast-growing, shallow-rooted plants, allow soil to dry to a depth of 1 inch before watering again.

Avoid runoff. Avoid letting your irrigation water run off onto paved areas or down storm drains. If you notice runoff, apply water more slowly in cycles, taking small breaks between applications to allow the soil time to soak up moisture.

Know your soil. How fast your soil absorbs water will vary by soil type and amount of organic matter in the soil. Clay soils are slow to absorb water but tend to hold moisture longer, so they need less frequent watering. Sandy soils drain quickly and do not hold water well, so they dry out faster. Adding compost and other organic matter to your soil will improve water penetration in clay soil and water retention in sandy soil.

Keep moisture in the soil. Mulch beds and around the base of trees (but don't pile mulch up against tree trunks) to decrease water loss from evaporation. Mulch also helps regulate soil temperature and decrease weed growth.

What to plant. Choose plants adapted to your weather, climate, and soils. Native plants adapted to the conditions in your garden are often a good choice because their moisture needs have evolved within regional weather patterns. Group plants with similar water needs. It's better for the plants and makes your job easier.

Choosing an Irrigation Method

There are many different ways to deliver water to plants. Below is background information about the most common watering techniques that you can use to help kids complete Activity #3.

Hand Watering

This method is usually the cheapest in terms of equipment costs. By using proper techniques, it can also be an efficient use of water. As you use a hose or watering can to irrigate you can be selective, watering each plant or plot as it needs. You can monitor how far moisture penetrates into the soil and adjust your watering time as necessary. It's important to apply water directly to the soil beneath the plants and to avoid excessive runoff onto sidewalks and other paved surfaces.

If you choose to use watering cans, select models that are the right size for your gardeners to avoid spills and injury. Remember that a gallon of water weighs 8 pounds, so cans get heavy quickly! Fortunately, watering cans are available in many different sizes. Or you can save money by using half-gallon or gallon milk and juice jugs with handles.

If you prefer using hoses, choose adjustable spray nozzles that allow you to stop the flow without having to turn off the spigot, and that offer a range of volume and pressure options. This will ensure that you have the appropriate pressure for various kinds of plantings and reduce water waste.

The downside of hand watering is the time and energy needed. Plants need water when they need water, so you will need to work on their schedule, not yours. This can be challenging, especially during vacation breaks.

Sprinklers

Sprinklers decrease the time and effort needed for watering. You can purchase hose-end sprinklers or install a system of underground pipes with spray heads. Both types can be made even more efficient and flexible by attaching manual or automatic timers.

Hose-end sprinklers are the least expensive option and can be a good choice if you have lots of beds scattered around. Some produce a spray that moves in a circular motion, others cast a fan that can move back and forth, and still others that resemble mini-tractors “drive” through the garden guided by the hose! You can turn them off and on by hand or purchase a timer to do it for you. The first time you operate your sprinkler, observe the spray pattern to make sure it's applying water where you need it and not to paved surfaces.

Built-in sprinklers use underground pipes and spray heads. They tend to be more sophisticated to use and expensive to install, but they can be useful for permanent beds and lawns. There are many different types of spray heads available, including pop-ups, rotors, and bubblers that allow you to choose the direction and pressure of water delivery. Most built-in sprinklers are controlled by automatic timers you can program to water at the most appropriate time of day — even if you're away. A helpful feature available on some automatic timers is a moisture sensor that prevents sprinklers from activating during rain! It is important to check the system regularly to make sure broken sprinkler heads are not wasting water or delivering spray to paved areas, and that spray isn't overlapping and overwatering some plants.

The main benefit of sprinklers on automatic timers is convenience, and this is also what makes them the least efficient irrigation method. Once they're on schedule, we often forget to monitor them and end up with dried up or drowned plants and wasted water. You also have very limited control over the spray, so some plants get water whether they need it or not. Much of water sprayed into the air is lost to evaporation and wind drift, and since you don't have to be present to operate them, it might be weeks before you discover a broken sprinkler head that is wasting water or starving plants of moisture.

Drip Irrigation and Soaker Hoses

Drip irrigation and soaker hoses provide a happy medium between hand watering and sprinklers. They allow for more selective water application and can provide the convenience of automatic watering. The equipment is more costly on the front end than hand watering, but less expensive than installing underground sprinkler systems. Water savings and convenience can give you a rapid return on your initial investment.

Soaker hose

Soaker hoses have small pores throughout their surface that leak water directly to the soil at a slow rate, allowing for increased soil absorption and less water waste. Soaker hose is a good option for rows and beds of vegetables and annual plants.

Drip irrigation features emitter hoses with components that are calibrated to deliver a precise amount of water, such as 1/2 or 1 gallon per hour. There are a variety of types. One kind features pipes with built-in

emitters; others allow you to attach small-diameter flexible tubes capped with emitters to a main feeder hose, allowing you to locate emitters right under individual plants or in pots. Emitter irrigation is a great system for watering landscape beds with permanent plantings.

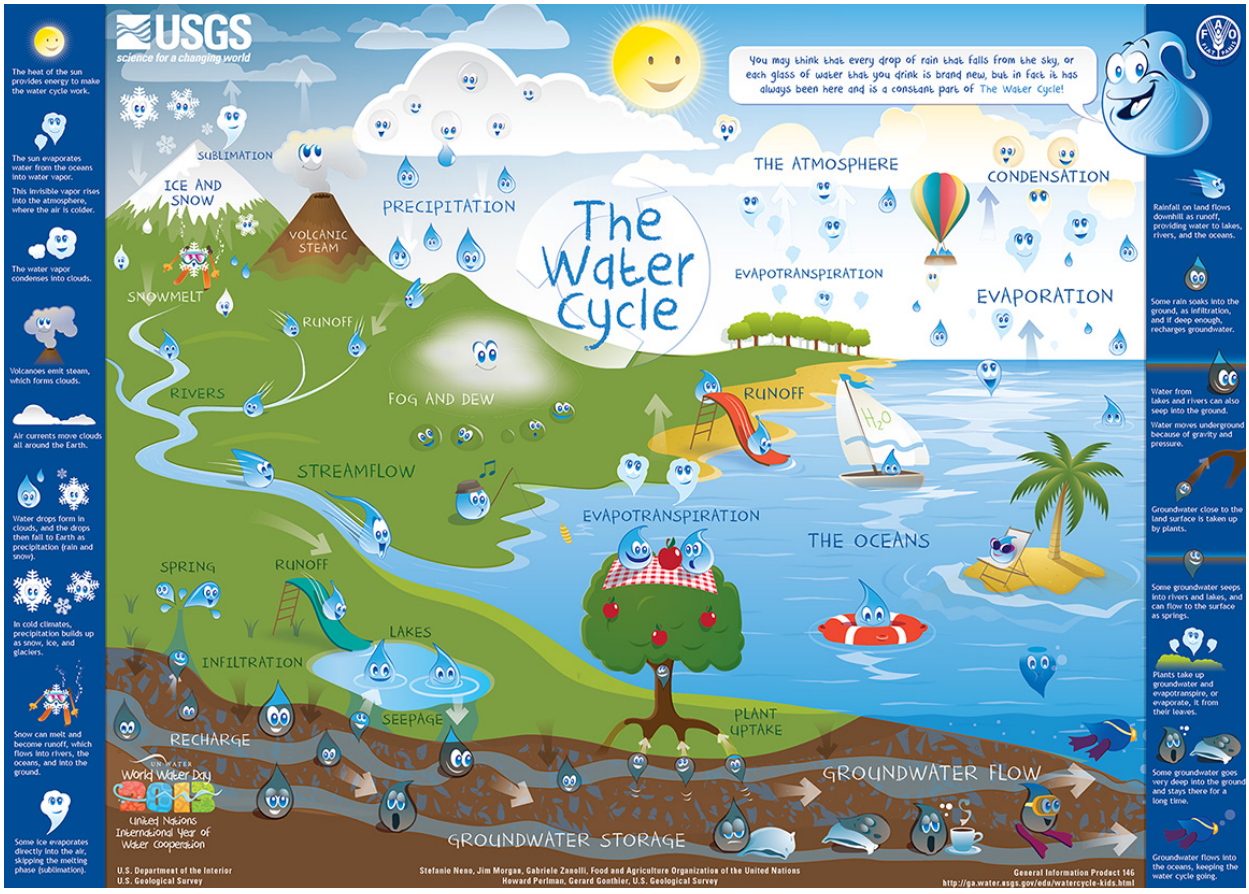
Both options deliver water more efficiently than sprinklers with less chance for water loss due to wind and runoff, and can be attached to timers and moisture monitors to allow for increased flexibility in scheduling. By delivering water directly to the soil, they are more selective than a sprinkler, but not quite as targeted as hand watering.

For optimal operation, you may need to add a pressure regulator to reduce and equalize water flow through the system and a filter to prevent small particles in the water from clogging pores and emitters. In some areas, insects such as ants may enter emitters in search of water and may cause clogs.

Activity 1: Round and Round: The Water Cycle

1. Together or independently, read the **Round and Round Reading Page**. Have your kids complete the reading comprehension questions and then discuss your answers together.

2. Download one of the USGS **Water Cycle** diagrams to share this important process with your kids. There are two versions: one designed for younger students (shown below) and one for older students. Both are available at: https://www.usgs.gov/special-topic/water-science-school/science/water-cycle.) Talk about the role plants play in the water cycle.



USGS Water Cycle diagrams are available at: https://www.usgs.gov/special-topic/water-science-school/science/water-cycle

3. Launch an experiment to see transpiration in action to demonstrate how plants add to the water vapor in the air. Place a plastic bag over the stem of a plant and use a twist tie, rubber band or string to close it snugly around the stem, being careful not to damage the plant. This experiment will work best with outdoor plants located in full sun and in warmer temperatures, but you can try it on any plant and use indoor plants instead during winter months. Make sure to check that the leaf (or leaves) that you place in the bag is/are dry at the start of the experiment.

4. Place the bag on your plant in the morning and return in the afternoon to see what happens. By the end of the day, you should find water vapor accumulating on the insides of the plastic bag. Explain transpiration and talk about why water is important to plants and all living creatures.

Water vapor has condensed into droplets on the inside of this plastic bag.

Extend the Lesson: You can extend this lesson by building your own terrarium. A terrarium is a miniature garden grown inside a covered glass or plastic container. It is a low-maintenance way to incorporate plants into your classroom or home and an excellent tool for teaching children about the water cycle as it demonstrates evaporation, condensation, and precipitation. Detailed instructions are available at: https://kidsgardening.org/garden-activities-building-a-terrarium/.

Activity 2: Water Experiments

1. One of the best ways for kids to understand the impact of water on plant health is to watch the same kind of plants receive different water treatments and watch how they react by observing differences in their physical appearance and growth.

   Challenge your kids to brainstorm ideas for creating a water experiment. Explain to them that since the goal is test the impact of water availability on plants, you need to limit the number of variables that might impact your results and focus on only changing the amount of water you deliver. Here are some tips for their experiment:

   - Use the same size containers
   - Grow the same kind of plants
   - Try to find plants that are approximately the same size and health at the start of your experiment
   - Grow all the plants in the same environmental conditions (same light, temperature, and humidity)

   If you do not have any potted plants readily available, you can also start some seed viewers of bean seeds to experiment with.

To make a seed viewer:

- Cut a piece of construction paper into a rectangular strip to fit inside the plastic cups. This is optional, but it helps with viewing.
- Ball up a few pieces of paper towels and place them inside the construction paper liner until the cup is full.
- Place 3 to 4 beans in the cup between the side of the cup and the paper towels or construction paper liner so the seeds are visible from the outside of the cup.
- Gently water the paper towels in the center until saturated.
- Place the cup (or cups if you would like to try multiples) on a shelf or windowsill and watch them grow. First you will notice the seed coat expanding (wrinkling) as the seed absorbs water. The root will start to grow in 2 to 3 days. Water as necessary to keep the paper towel and seeds continually moist.

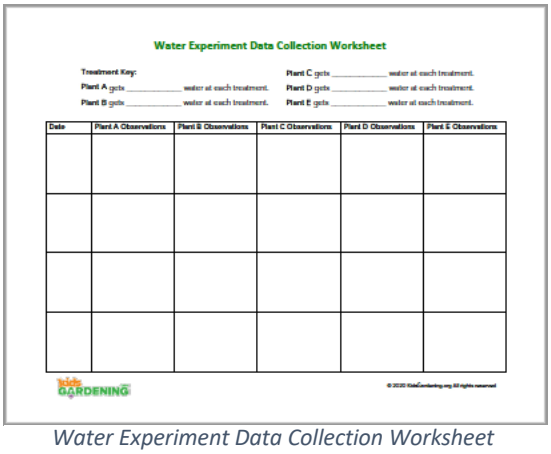
Seed viewer

*Please note: If using seed viewers, you can start testing the effects of varying water availability right from the start and also look at the impact on seed germination, or you can wait to begin your experiment after the first set of true leaves appears. Seeds viewers grown outside will dry out very quickly. This may help speed up your water experiments, but they may need to be watched more closely than indoor seed viewers.

2. Once your location and plants are selected, water all of your plants to the point of saturation. If you are using potted plants, add water until excess water is running out of the drainage holes. If you are using seed viewers, fill your cups with water and let the paper towels become thoroughly soaked and then drain the extra water. This is done to try to make sure all of the containers are all starting at the same point of water availability.

3. Create your water schedule. You want to water all of the plants at the same time, but just give them different amounts of water. Make sure to label each plant so you remember which treatment to give each one. For example, Plant A may get 1 cup of water every other day, Plant B may get half of cup of water every other day, Plant C may get 1 TBSP of water every day and Plant D may get 1 TSP of water every other day, etc.

4. Track your observations using the **Water Experiment Data Collection Worksheet** or your garden journal. If you are not seeing much variation in the appearance and growth of your plants, you may need to adjust your water schedule or the amount of water you are using.


Water Experiment Data Collection Worksheet

Treatment Key:

Plant A gets _____ water at each treatment.

Plant B gets _____ water at each treatment.

Plant C gets _____ water at each treatment.

Plant D gets _____ water at each treatment.

Plant E gets _____ water at each treatment.

Date	Plant A Observations	Plant B Observations	Plant C Observations	Plant D Observations	Plant E Observations

Water Experiment Data Collection Worksheet

5. Discuss your results. Did some of your plants grow better than others? What happened if your plants did not get enough water? What happened if your plants got too much water?

Extend the Activity: Different types of plants are adapted to need different amounts of water. If you want to extend this activity, try it again using a different type of plant for your observations and compare the results.

Activity 3: Fulfilling Plants' Water Needs

1. Water, especially clean water, is a very precious resource in our world. If you have older kids, you may want to research some of the water shortage crises that have occurred around the world in recent years. If you are looking for a historical perspective, check out the Dust Bowl of the 1930s in the United States. In nature, plants mostly rely on rain to fill their water needs. Ask kids, Where do our garden plants get their water from? If there is not enough rain, what do we do?

2. Introduce kids to some of the basic types of watering techniques used by gardeners listed in the Background Information. If possible, find ways to demonstrate these different methods in your schoolyard or look for examples in nearby landscapes. The Digging Deeper below has links to some watering-related video that can supplement if you do not have access to live demonstrations.

3. Use the Irrigation Comparison Worksheet to evaluate the pros and cons of each of the main types of watering techniques. After making your lists ask, Is there one best technique? Or do different techniques work better in some garden situations than others? What would be best for our school or home garden?

   Here are some possible responses for the Irrigation Comparison Worksheet:

Irrigation Method	Benefits	Challenges
Hand watering	• inexpensive • allows targeted water delivery • allows you to monitor soil conditions as you water	• time consuming • labor intensive
Sprinklers	• can be inexpensive • save time	• often waste water • built-in systems can be costly and complex to design/install
Soaker hoses & drip irrigation	• efficient water delivery • saves time	• may not be as targeted as hand watering • more expensive initially than hand watering and many sprinklers

4. Conclude by talking about how important it is for us to conserve water and protect our water resources. You can extend the lesson by having kids create ads to encourage others to use water wisely.

Digging Deeper

You can use the following resources to dig deeper into this week's lessons:

Books and Additional Resources:

Seed School by Joan Holub

Jack's Garden by Henry Cole

Up in the Garden and Down in the Dirt by Kate Messner

Plantzilla by Jerdine Nolen

A Place to Grow by Stephanie Bloom

The United States Geological Survey Water Science School:
https://water.usgs.gov/edu/

Videos:

National Science Foundation: The Water Cycle:
https://www.youtube.com/watch?v=al-do-HGuIk

How to Water Your Plant Right:
https://www.youtube.com/watch?v=7faaR8SoYDs

10 Ways to Water Your Garden Better:
https://www.youtube.com/watch?v=ueQCiSD5AdM

5 Watering Mistakes You're Probably Making:
https://www.youtube.com/watch?v=VaTkzYv8sMo&t=118s

Grow Organic Peaceful Valley Drip Irrigation Series:
https://www.youtube.com/watch?v=SNZ5xOVO_SM

Fine Gardening: Drip Irrigation Basics:
https://www.youtube.com/watch?v=tmEj3MQPITY

HortTube with Jim Putnam: How to Install Drip Irrigation:
https://www.youtube.com/watch?v=PetfxgFeOkM

Additional Related KidsGardening Lessons and Activities to Try:

Building a Terrarium:
https://kidsgardening.org/garden-activities-building-a-terrarium/

Catching Water:
https://kidsgardening.org/garden-activities-catching-water/

Wise Watering:
https://kidsgardening.org/gardening-basics-wise-watering/

Rain Gardens:
https://kidsgardening.org/lesson-plans-rain-gardens/

Weather -Tracking Tools:
https://kidsgardening.org/lesson-plans-weather-tracking-tools/

Digging into Soil:
https://www.diggingintosoil.org/

Photosynthesis Runs the World:
https://kidsgardening.org/lesson-plan-photosynthesis/

Photosynthesis 101:
https://kidsgardening.org/garden-how-to-photosynthesis-101/

Tropical Rainforests:
https://kidsgardening.org/lesson-plan-tropical-rainforests/

Round and Round: The Water Cycle

Plant Needs Week 2 Reading Page

Have you ever heard someone tell you that we are drinking the same water that the dinosaurs drank? They can say that because of the **water cycle**.

What is the water cycle? On our planet, water moves round and round in a constant way. Water from the Earth's surface heats up in the sun and turns from a liquid into a gas. This water vapor then floats into the air. This part of the cycle is called **evaporation**.

When it gets high enough up into the sky, it gets colder and all of the water vapor gathers together to make clouds. This stage is called **condensation**.

When enough water gets together, it gets heavy and comes back down to earth in the form of rain or snow. This final part of the cycle is called **precipitation**.

Once back on land, water then follows one of two main pathways:

- It can go into the soil and get stored in the soil or in special places called aquifers (ACK-wiff-ers) below the soil.
- It can run off into local streams, lakes, and rivers.

It is in these two locations (from in or under the soil, and from bodies of water) that plants and animals can find the water they need to drink to live. Water then evaporates again (from bodies of water and also from liquid released by living creatures who have consumed it) and it all begins again.

The water cycle is a very important process in our world. Water is a basic need for all living creatures — from the little lady bugs eating aphids on your plants to the giant redwoods in California. We all need water to keep our cells alive, to grow, and to keep all of our systems working right.

Through the process of changing from liquid to gas back to liquid again (and sometimes to solid in the case of snow and ice) in the air and also through the process of soaking down into soil, another very important thing happens: Water is cleaned. Contaminants that have become mixed in the water are removed in a few different ways as water travels on this journey. Living things need clean water to be healthy.

Plants get most of the water they use from the soil. Water is absorbed by plant roots, moves up the stems and then into leaves. On this journey, it is used in plant cells as needed. It also exits the leaves through small openings called stomata (stow MAH tah) as a result of a process called **transpiration**, which is much like sweating in humans.

The movement of water through the plant provides support for the plant and helps it adapt to varying conditions in its environment. Water is also a key component needed for photosynthesis, which is how the plant makes food. The movement of water through plants is also an important part of the water cycle as plants move water stored in the soil back into the atmosphere again.

How much water do plants need? This depends on many different things. Some plants need lots of water to grow and others can get by with very little. For instance, cacti (word for more than one cactus) are adapted to desert conditions and need very little water, while water lilies live fully submerged in water. Smaller plants usually do not need as much water as big ones. Young plants with short roots need small amounts of water applied frequently because the soil near the surface dries quickly. Plants in cool, humid, and shady environments will lose water to transpiration more slowly than those exposed to sunny, warm, arid (dry), and windy conditions. Learning how much water to give garden plants is one of the most important skills gardeners need to learn. A well-watered garden — not too much and not too little — is a happy garden!

Reading Comprehension Questions:

1. True or false: All living things need water.

2. Which of the following is not a stage in the water cycle?
   - ☐ Precipitation
   - ☐ Condensation
   - ☐ Pollination
   - ☐ Evaporation

3. What two things can happen to rain when it hits land?

4. What part of the plant takes in the water the plant needs to live?

5. Based on question number 4, if the plants in our garden need water, where should we put it?

Water Experiment Data Collection Worksheet

Treatment Key:

Plant A gets _____ water at each treatment.

Plant B gets _____ water at each treatment.

Plant C gets _____ water at each treatment.

Plant D gets _____ water at each treatment.

Plant E gets _____ water at each treatment.

Date	Plant A Observations	Plant B Observations	Plant C Observations	Plant D Observations	Plant E Observations

Irrigation Comparison Worksheet

Irrigation Method	Description	Potential Cost	Benefits of this Method	Challenges of this Method
Hand Watering				
Sprinklers				
Soaker Hoses & Drip Irrigation				