WATERWISE GARDEN EXPLORERS LESSON GUIDE

Water is critical for all life, including plants. In this unit of Waterwise Garden Explorers, students will investigate the role of water in the garden and the importance of using sustainable watering techniques. For optimal health, plants must obtain the right amount of water — too much or too little can impact their growth and development.

This unit includes five modules:

- Plant Needs
- The Water Cycle
- Watering the Garden
- Water Conservation
- Water-Friendly Garden Design

Each module includes background information along with three water-focused activities, so students can engage in hands-on experiences to observe how plants obtain and use water. Young gardeners will also learn about best practices for watering the garden and how to protect and conserve all water resources. The target age for content and activities is kindergarten through fifth grade.

Waterwise Garden Explorers
Module 1: Plant Needs

Learning Objectives

This module focuses on why plants need water and how much they need for healthy growth. Young gardeners will:

- Learn that plants absorb water through their roots.
- Observe that seeds need water to germinate.
- Conduct experiments to see the impact that different quantities of water have on plant growth.

Materials Needed

Activity 1:

- At least two potted plants of the same variety and approximate size (herbs in 4" pots are good choices)
- Plastic wrap
- Tape or rubber bands
- Water spray bottle
- Roots or Leaves Experiment Data Collection Worksheet

Activity 2:

- Materials to make seed viewers: bean seeds, construction paper, paper towels, and clear plastic cups (one for each student or group of students)
- Germination Experiment Data Collection Worksheet

Activity 3:

- Four or five plants of the same variety and approximate size
- Liquid measurement tools (teaspoon, tablespoon, and measuring cup with gradations)
- Water Experiment Data Collection Worksheet

Introduction

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

Most of the water that plants use comes from the soil. It's the job of roots to absorb the water and nutrients a plant needs to grow and thrive. Although some plants are specially adapted to take in water through their

leaves, the vast majority of plants take up water through their roots. Water enters through the roots, then moves up the stems and into the leaves. On this journey, it's used in plant cells as needed. Water is needed for photosynthesis, which is how the plant makes food.

Cacti are adapted to ecosystems where water is scarce.

Some of the water taken in by a plant eventually exits the leaves through small openings called stomata. This process is called transpiration and is a bit like sweating in humans. This movement of water keeps the stems rigid and upright and allows the leaves to spread out so they can efficiently capture sunlight. Transpiration also helps plants adapt to varying environmental conditions.

The rate at which a plant takes in and uses water is not constant. Water movement depends on a number of factors, including the size of the plant and its environmental conditions. Temperature and sun exposure — which can vary by season and location — are also critical factors. Plants in hot, dry conditions will lose water more quickly than plants in cool, humid conditions. During the winter, some plants drop their leaves and enter a dormant state where they hardly use any water at all.

Because water availability varies greatly in different environments, plants have developed a variety of adaptations to help them survive in their particular habitats. On one extreme are cacti that live in deserts where water is scarce. They have modified leaves (spines) that decrease the rate of transpiration, and their stems have a special ability to store extra water. At the other extreme are rainforest plants, many of which have pointy tips (drip tips) and waxy surfaces that help excess water slide off quickly. These help prevent water buildup that could lead to decay and mold.

Plants in the rainforest have adaptations that allow them to thrive in wet conditions.

Activity 1

1. Begin your water explorations by demonstrating that water is absorbed by roots from the soil. Obtain at least two potted plants; these should be the same type of plant and approximately the same size. Houseplants or outdoor bedding/landscape plants are good options.
2. Start by making sure the growing media in the containers is equally moist. Next, cover the top of one of the pots around the stem with a layer of plastic film so that the soil will not get wet. Use tape and/or rubber bands to help hold the film in place.

Water as needed using a watering can to apply water to the soil for one plant and a spray bottle to apply water to the leaves of the other.

3. Over the next couple of weeks, water the soil of the plant without the plastic film as needed to keep the soil moist, using a watering can or water bottle. Water the plant with the plastic film by spraying the leaves with a spray bottle. Have students track their observations using the Roots or Leaves Experiment Worksheet.
4. After a couple of weeks, have students compare the results. The time it will take to see a difference between the two watering techniques will vary depending on the type of plants and how long it takes for the soil in the plastic-covered plant to dry out. (Note: The plastic will keep new water from being added to the soil, but it will also decrease water loss by evaporation, which is why this experiment may take a few weeks.) At the end of your observations, ask students, “Did our experiment prove that plants take in water through their roots? Why or why not? How can we apply this information in our garden?”

Activity 2

1. Use simple bean seed viewers to demonstrate that seeds need water to germinate and grow.
2. Begin by making multiple seed viewers (if possible, allow each student to make one). To make a seed viewer:
    - Cut a piece of construction paper into a rectangular strip to fit inside the plastic cup. 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 three to four 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. Make sure to put the same number of seeds in each cup.
3. Ask students to brainstorm treatments for the seed viewers to test if the bean seeds need water to begin growing. For example, they might divide the viewers into three groups that receive different amounts of water:
    - Select a group of viewers that will receive no water.
    - Select another group of viewers that will receive just enough water so that the paper towels and seeds stay moist.
    - Select a third group of viewers that will be completely filled with water so that the seeds remain fully submerged.

Seed viewer

4. Place the cups on a shelf or windowsill* and have students observe them regularly, using the Germination Experiment Data Collection Sheet to track their observations. Water (or don't water) to keep the moisture level consistent based on their experimental groups.

   Although the seeds that are fully submerged may sprout and begin to grow, the sprouts will eventually begin to rot and die. If possible, allow the experiment to continue to this point to show that too much water can be just as detrimental to plant health as too little.
5. You can repeat the experiment using different quantities of water, or just allow students to make new seed viewers to take home and use their experience to determine how much water to provide.

* Keep the seed viewers out of direct sun to prevent them from drying out too quickly. If placing them outdoors, put them in a shady spot out of the wind and monitor the moisture levels carefully, since they are likely to dry out more quickly than they would indoors.

Activity 3

1. Now that students understand that seeds need water (but not too much water) to germinate, plan new experiments to test the impact of the quantity of water on continued plant growth and health. One of the best ways for students to understand the impact of water on plant health is to watch the same kind of plants receive different water treatments and observe the differences in their physical appearance and growth.
2. Challenge your students to brainstorm ideas for creating a water experiment. Explain to them that since the goal is to test the impact of water availability and quantity 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)
3. Once your location and plants are selected, water all 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. This is done to try to make sure all of the containers are all starting at the same point of water availability.
4. Create your watering 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 a half-cup of water every other day, Plant C may get 1 TBSP of water every other day, and Plant D may get 1 TSP of water every other day.
5. Have students track their observations using the Water Experiment Data Collection Worksheet or their garden journal. If there isn't much variation in the appearance and growth of the plants, adjust your water schedule or the amount of water you are using.
6. Discuss the results. Did some of the plants grow better than others? What happened if the plants did not get enough water? What happened if the 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 (See Module 5, Activity 1). You can also try adding different substances to water (like salt) to change the quality of the water instead of the quantity.

Roots or Leaves Experiment Data Collection Worksheet

	Plant 1: Water Soil	Plant 2: Water Leaves
Date Watered:		
Observations: How well is the plant growing?		
Date Watered:		
Observations: How well is the plant growing?		
Date Watered:		
Observations: How well is the plant growing?		
Date Watered:		
Observations: How well is the plant growing?		

Results: Did one of your plants grow better or look healthier?

Conclusion: What did we learn about how plants meet their water needs from this experiment?

Germination Experiment Data Collection Worksheet

Use the table below to record the number of seeds that have sprouted/germinated in each seed viewer.

Date of Observation:	Seed Viewer 1 Amount of Water Added:	Seed Viewer 2 Amount of Water Added:	Seed Viewer 3 Amount of Water Added:
	Number of seeds growing:		

Which seeds sprouted first?

Did all the seeds that sprouted continue to grow?

Based on this experiment, do seeds need water to grow?

Water Experiment Data Collection Worksheet

Use the chart below to make observations about how well your plants are growing with different amounts of water.

Date of Observation	Plant A gets _____ of water.	Plant B gets _____ of water.	Plant C gets _____ of water.	Plant D gets _____ of water.
	Observations about plant growth:			

Water Experiment Data Collection Worksheet (continued)

Did you observe any differences in how well the plants were growing?

What does this experiment tell you about how much water plants need to grow?

Do you think your findings would be different if you used different plants?

Do you have any ideas for additional water experiments?

Waterwise Garden Explorers

Module 2: The Water Cycle

Learning Objectives

This module explores the water cycle and plants' role in filtering and cleaning water through transpiration. It will also investigate how plant roots are important for preventing soil erosion. Young gardeners will:

- Create a model of the water cycle by planting a terrarium.
- Design an experiment to show how plant roots prevent soil erosion.
- Observe how water moves through a plant by capturing moisture lost through the transpiration process.

Materials Needed

Activity 1:

- An enclosed container
- Pea gravel or small rock
- Seed-starting mix or sterile potting soil
- Small indoor or tropical plants
- Charcoal (optional)
- USGS Water Cycle Diagram: https://www.usgs.gov/media/images/natural-water-cycle-jpg or The Water Cycle Kids: https://www.usgs.gov/media/images/water-cycle-kids-jpg

Activity 2:

- Two or more old 9" x 13" baking pans or disposable aluminum pans
- Potting soil or soil from a garden
- Fast-growing seeds such as grass or beans
- Plastic trays
- Watering can
- Measuring cups
- Soil Erosion Experiment Worksheet

Activity 3:

- Indoor or outdoor plant(s)
- Plastic sandwich bag(s)
- Rubber band, twist tie, or string(s)

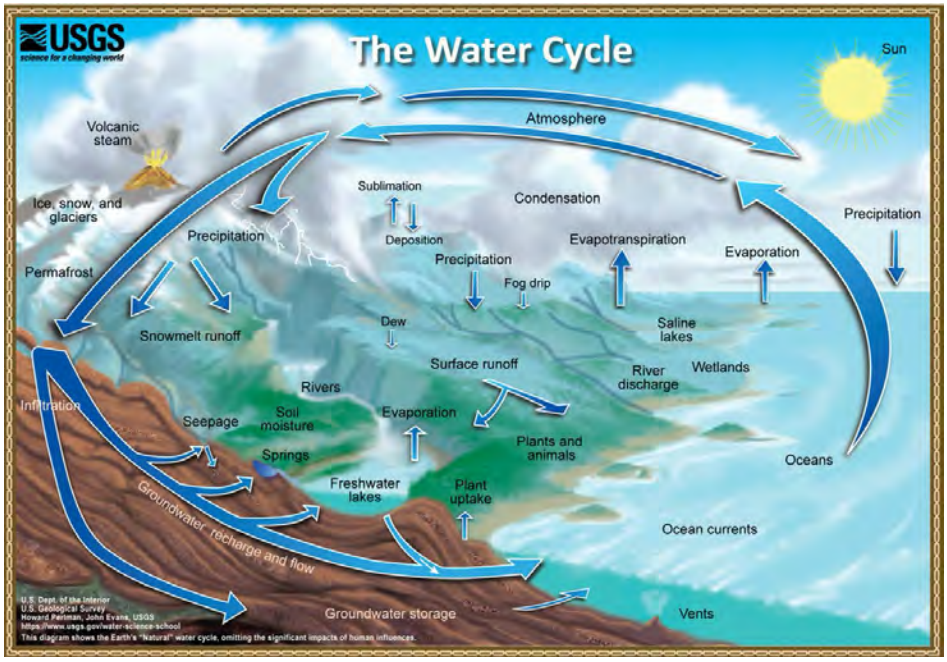
Introduction

The cycling of water through the plant is 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 the land's surface, it follows one of two main pathways — either infiltrating into the soil or running 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.

Share public domain diagrams from USGS:
https://www.usgs.gov/media/images/natural-water-cycle-jpg
https://www.usgs.gov/media/images/water-cycle-kids-jpg



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

Activity 1

1. Share one of the USGS Water Cycle diagrams found above to introduce students to the water cycle. Highlight the role that plants play in the process.

2. Plant class or individual terrariums to model the water cycle. 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 because it demonstrates evaporation, condensation, and precipitation.

   In the presence of light and heat, water evaporates from the plants through transpiration and from the soil. Since a terrarium is an enclosed environment, the water vapor will condense when it hits the side of the container. Once enough water accumulates or the temperature decreases, the condensation will then precipitate down the sides of the container back into the soil. Depending on supplies, you can build one large class terrarium or small terrariums for individual students or in groups. To build the terrariums:

   - Find an appropriate container. Glass jars, fish bowls and tanks, clear plastic bottles, and food containers can all make fine terrariums. Just make sure there's enough room to reach your hand into your container for planting and maintenance.

     Clear, 2-liter plastic soda bottles are commonly used in school settings for individual terrariums because they are readily available and inexpensive. Create 8" high planting containers by cutting off the tops of the bottles. After planting, you can either tape the tops back on or just cover them tightly with plastic wrap. For larger classroom terrariums, plastic containers that were used for bulk food distribution, like pretzels and animal crackers, can work well.

   - Add drainage. Clean the container using soapy water and rinse well. Dry completely. Add a layer of pea stone for drainage. Use ½" stone for small containers and larger stone — up to 1½" — for large containers. This mimics the bedrock found under natural soils and creates a reservoir to hold water that drains through the soil. You can also add a few granules of filtering charcoal (not the type used for barbecuing, but rather the kind used in aquariums) to the top of the gravel to help remove odors. The charcoal is optional and is not needed if your terrarium maintains proper moisture levels.

- **Prepare the planting medium.** To avoid problems with molds and fungi, use a sterile seed-starting mix or sterile potting soil, available at most garden centers. Do not use soil from outdoors.

  Moisten the planting medium by pouring it into a bowl or tub and mixing with water until the soil is just moist enough to keep its shape when pressed into a ball in your hand. If it's too dry to hold together, add a bit more water. If water drips from the soil when pressed into a ball, then it's too wet, and you should add more dry potting soil. Getting this moisture level right is important to the success of your terrarium.

  Many potting mixes contain slow-release fertilizers. If the soil you purchased does not contain any fertilizer, you may want to mix in a small amount of slow-release fertilizer or some worm castings before planting. Don't overdo it — you want your plants to stay small and grow slowly.

- **Add the planting medium to your terrarium.** Carefully add the moist potting mix until the container is one-third to one-half full. Try to avoid getting soil particles stuck on the sides of the container above the soil level. The amount of soil you put in will depend on the size of the container (you need to have enough room for plant roots).

- **Select your plants.** Look for small, slow-growing plants that are adapted to warm, moist climates. Most garden centers have an area reserved for indoor plants, and you can usually find a variety of plants in 2" to 4" pots. Good options include:

  African violet
  Artillery fern
  False aralia
  Jade plant
  Peperomia
  Nerve plant
  Oxalis
  Pink polka dot plant
  Prayer plant
  Small ferns
  Small peace lilies
  Small philodendrons
  Spider plant
  Strawberry begonia
  Swedish ivy

- **Plant your terrarium.** How you arrange the plants will depend on the size and location of the terrarium. If you'll be viewing the terrarium from one side, place the tallest plants in the back and the shortest plants in the front. If your terrarium will be viewed from all sides or you plan to rotate it, plant the tallest plants in the middle and the shorter plants along the outside.

- **Add the final touches.** In addition to plant material, your class can get creative and add other objects to create mini landscape scenes. For instance, you may want to add decorative rocks, small animal figurines, small bridges, or mirrors to look like mini ponds. When you're done, attach the lid or cover with plastic. Place the terrarium in a windowsill with indirect lighting or under grow lights. Do not place it in strong, direct sunlight, or the water will evaporate too quickly, and the plants may burn.

3. Observe your terrarium closely for the first few days to make sure you have the proper moisture level. You'll know that the terrarium contains the right amount of water if the sides and top get misty with water droplets when in bright light. If there’s no moisture along the sides, then you need to add some more water. If the sides are always very wet and it’s hard to see the plants, then there's too much water and you should remove the top for a few hours to allow some of the excess water to evaporate. Once you achieve the perfect balance, it will not need frequent attention.
4. Encourage students to monitor the terrarium periodically. As a class, discuss how your terrarium mimics the water cycle. Prune off excessive growth and try to prevent foliage from touching the sides of the container to prevent rot. You can experiment with plants as needed. If they appear to grow too vigorously or respond poorly to the humidity, remove them and try something new. You can also try growing plants from seeds and cuttings. Check on the moisture levels as some water may be lost over time.

Activity 2

1. One of the important roles plants play in the water cycle is to hold the soil in place when it rains. In this activity, create a simple demonstration to show the role of plants in preventing soil erosion.
2. Fill two or more old 9" x 13" baking pans (or disposable aluminum plans) with potting soil or soil from the garden.
3. In one pan (or more, if you plan to do more than two), plant fast-growing seeds, such as beans or grass, and then let them grow for few weeks until they've become established. If you have supplies to do multiple pans, you can try growing different kinds of plants. Leave at least one pan unplanted. Allow plants to grow until you can give them a gentle tug and feel that they're firmly rooted.
4. Set the pans on a table at a slight angle (10° to 20°) with the bottom end placed in a waterproof tray. Use a watering can to simulate rain on your different "pan landscapes," exposing each pan to the same amount of water at the same rate of delivery. Track and apply the water until it's flowing out of both pans.
5. Compare the quality of water runoff from each landscape. Measure the amount of water collected and record the amount of soil lost by erosion. Which landscape held on to the most soil and water? Which one held on to the least soil and water? Look around your garden and schoolyard to find similar soil conditions in your landscape and decide if you need to make any changes to maximize the water being absorbed by your soil.

The water draining from the "pan landscape" with plants should contain less soil.

Activity 3

1. This activity shows transpiration in action to demonstrate how plants add to the water vapor in the air. In this experiment, you'll place a plastic bag over the stem and leaf/leaves 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. Make sure that the foliage you place in the bag is dry at the start of the experiment. 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.

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

2. 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 condensing on the insides of the plastic bag.
3. Ask students what would have happened to the water if we had not put a bag on the leaf. Introduce students to transpiration and explain its role in the water cycle.

Soil Erosion Experiment Worksheet

Treatment: Record the amount of “rain” water sprinkled on each pan:

Pan #	How much water was collected in the drainage pan?	How much soil did the drainage water contain?	Additional observations:
Pan 1 No plants			
Pan 2 Type of plant growing:			
Pan 3 Type of plant growing:			
Pan 4 Type of plant growing:			

Based on this experiment, how do plants help soil when it rains?

Why are plants important for soil?

How can we use this information when taking care of our garden or schoolyard?

Waterwise Garden Explorers
Module 3: Watering the Garden

Learning Objectives

Although rainwater is an important source of water for plants, gardeners will often need to provide additional water for their gardens. In this module, students will:

- Investigate different ways gardeners provide water to their garden plants.
- Create a root viewer to observe the impact of shallow versus deep watering.
- Explore how drip irrigation works.

Materials Needed

Activity 1:

- Watering can
- Example of a sprinkler irrigation system
- Example of a drip irrigation system
- Irrigation Comparison Worksheet

Activity 2:

- Two or more ½ gallon juice or milk cartons, cleaned and dried
- Transparency film or other sturdy, clear, plastic film
- Packing tape
- Construction paper
- Potting soil
- Grass or bean seeds
- Root Viewer Observation Worksheet

Activity 3:

- Soil sample (about 2 cups of soil)
- Two empty, clear, 2-liter drink bottles
- Two coffee filters
- Measuring cup (able to hold 4 oz or more)
- Plastic pipette or water dropper

Introduction

There are many different ways to deliver supplemental water to plants. The most common methods include hand watering, sprinklers, and drip irrigation.

Hand Watering

Hand watering is usually the cheapest in terms of equipment costs. By using proper techniques, it can 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 needed. You can monitor how far moisture soaks 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.

Choose the watering can size based on the size of the gardener. A gallon of water weighs 8 lb, so cans get heavy quickly! Fortunately, watering cans are available in many different sizes. Or you can save money by making your own, such as by using half-gallon or gallon milk and juice jugs with handles.

Hand watering also includes using hoses. A hose with an adjustable spray nozzle allows you to choose the best spray pattern as well as increase volume and water pressure to best suit your needs.

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

Sprinklers

Compared to hand watering, sprinklers decrease the time and effort needed for watering and help deliver consistent moisture in gardens to promote healthy plant and crop production. Some sprinklers can be attached to the end of a hose; others are more sophisticated systems with underground pipes connected to spray heads. When using sprinklers, it's important to keep a careful watch on where the water is going and when it's applied. Water that's sprayed into the air can be lost to evaporation and wind drift. It can also be difficult to adjust spray patterns to avoid overwatering some plants while underwatering others. In addition, it's crucial to avoid wasteful overspray onto non-garden areas, such as sidewalks. Sprinklers can be an effective option if used with care.

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, while others cast a fan that can

move back and forth. 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 onto paved surfaces.

Built-in sprinklers use underground pipes and spray heads. They tend to be more complex to use and cost more to install, but they are very useful for permanent garden beds. There are many different types of spray heads available, including pop-ups, rotors, and bubblers, that allow you to choose the direction and quantity of water delivery. It's a good idea to consult facilities staff and irrigation professionals when installing a permanent sprinkler system.

Overhead watering can result in wet foliage that can lead to disease problems.

Automatic timers allow you to program the system to water at the most appropriate time of day while delivering the adequate quantity of water — even if you're away. Some timers even feature a rain sensor that prevents sprinklers from activating during rain! Although automatic timers offer convenience, they can also lead to wasted water if not monitored properly. To prevent this, make sure to check automated sprinkler systems regularly for broken sprinklers, overspray onto paved areas, and overlapping spray that may be overwatering some plants.

Drip Irrigation and Soaker Hoses

Drip systems are a happy medium between hand watering and sprinklers. Drip irrigation offers many benefits over sprinklers. It slowly delivers water right to the soil, minimizing water loss due to evaporation, wind, and runoff. It also keeps foliage dry, minimizing disease problems. Like sprinklers, drip systems can be automated with timers and moisture monitors.

Though a drip system is more expensive than a hose and watering can, it can be less expensive than installing an underground sprinkler system. By saving you both time and water, these systems can give you a rapid return on your initial investment.

Soaker hoses and drip tape: Soaker hoses apply water through small pores, allowing it to soak in from the soil surface. They're a sufficient and low-cost option for rows and beds of vegetables and annual plants, but they don't distribute water evenly. Soaker hoses can be installed in various patterns within a garden space, from winding shapes to straight rows.

Similarly, drip tape releases water through slightly larger, manufacturer-cut holes when it expands into a tube under pressure. Spaced at regular intervals, these holes are less likely to clog in regions with mineral-rich water but need to be replaced seasonally. Soaker hoses and drip tape are typically not pressure-compensating, which means more water is applied closer to the water source than toward the end of the hose. This may result in uneven garden bed watering. Irrigation controllers can be used to manage and automate irrigation for both soaker hoses and drip tape systems.

Emitter hoses: These feature components that are calibrated to deliver precise amounts of water. Some have pipes with built-in emitters; others have flexible tubes that allow you to configure the emitters to deliver water right under individual plants or in pots.

Both options deliver water with less chance for water loss due to wind and runoff and can be attached to timers and moisture monitors 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.

Drip irrigation provides water to the plants in this raised bed.

Point-source drip emitter irrigation: Point-source drip emitter irrigation slowly delivers water directly to the soil at the base of plants, minimizing water loss from evaporation and wind drift. Individual drip emitters, connected to distribution tubing, are installed throughout the garden space at the base of plants. This allows for flexibility in both plant type and spacing. These drip emitters can be custom-spaced, ensuring that only areas requiring water are irrigated and that plants with higher water needs can receive additional drip emitters. Drip systems generally reduce water splash on plant leaves, which helps lower the risk of disease. Though a drip system is more expensive than a hose and watering can, it's far less costly than installing an underground sprinkler system. Like sprinklers, irrigation controllers may be added to drip systems to provide automated irrigation to garden beds.

Inline drip tubing: Inline drip tubing combines the technologies of drip emitters and soaker hoses, offering a highly efficient irrigation solution for garden beds. Drip emitters are preinstalled inside a flexible distribution tube at specific intervals to provide even water application throughout the garden bed. This design not only enhances irrigation efficiency but also reduces installation and maintenance requirements as the emitters are safely enclosed and less prone to damage from gardening activities. Inline drip tubing is quite flexible and can be installed in rows, winding shapes, or circular shapes. The addition of irrigation control also adds automated irrigation scheduling to ensure soil moisture levels remain consistent for healthy plant growth.

Olla Pots

For thousands of years, people have buried these porous, clay pots in the soil and filled them with water. This ancient form of drip irrigation allows the water to slowly seep into the soil, where it's available to nearby plants. Although this provides an excellent education opportunity for students, this method of irrigation is impractical for larger garden beds and requires regular attention for hand watering.

Comparing Irrigation Techniques

The most common irrigation techniques associated with school garden programs are hand watering, overhead sprinklers, and drip irrigation.

Hand Watering: Although time-consuming and not always practical, hand watering can be a waterwise and low-cost option, requiring just a hose and/or watering can. It allows you to selectively apply water only to the plants that need it, observe if water is being absorbed by the soil, and alter the flow to prevent runoff.

Benefits and Considerations

- Selective Watering: Hand watering allows you to be precise, ensuring that each plant gets the right amount of water.
- Observation: This method provides a chance to closely observe your plants and the soil, allowing you to make adjustments as needed.
- Fun Activity: Hand watering can be an enjoyable task for students, fostering a sense of responsibility and connection to the garden.

Challenges

- Time-Consuming: Hand watering may not always be practical. It can be a time-consuming activity, especially when ensuring the garden receives adequate water.
- Managing Breaks: Hand watering during school breaks may require significant coordination to prevent the soil from becoming hydrophobic and difficult to rehydrate when school resumes.

Tips for Effective Use

- Appropriate Equipment: Choose equipment that is appropriately sized for your gardeners. Remember, a gallon of water weighs 8 lb, so watering cans can get heavy!
- Adjustable Hose-End Spray Nozzles: If using hoses, select adjustable hose-end spray nozzles that allow you to stop the flow, control the flow rate, and change the spray pattern.
- Soil Absorption: Pay attention to whether the soil is absorbing the water. Adjust your watering technique as needed to ensure the water penetrates the soil rather than running off.
- Schedule: Develop a watering schedule to ensure all plants receive enough water, especially during hot or dry periods.
- Team Effort: Encourage teamwork by assigning different students to watering duties on different days.
- Off-Season Care: Plan for watering during school breaks. You might organize a volunteer schedule or use self-watering systems to keep the garden healthy.

By following these guidelines, hand watering can be an effective and enjoyable way to maintain your school garden, ensuring it remains healthy and vibrant year-round.

Sprinklers: Overhead application sprinklers provide convenience for garden irrigation, although this convenience does come at a cost. Hose-end sprinklers can be an affordable and handy option. Built-in sprinklers, while more costly and requiring additional education for installation, are most commonly used for permanent garden beds. Irrigation controllers may be installed and programmed to provide automated

irrigation, ensuring consistent water application to the garden year-round. Some of these controllers can even adjust irrigation schedules to align with plant needs and suspend irrigation during rain.

Benefits and Considerations

- Convenience: Overhead sprinklers offer the convenience of automated watering, freeing up time for other gardening activities.
- Uniform Water Distribution: These systems are designed to distribute water evenly, making them ideal for large garden areas.

Challenges

- Mixed Water Needs: Gardens with plants that have different water requirements may struggle with overhead sprinklers as water is typically distributed evenly across the area.
- Fungus and Disease: Some plants are susceptible to fungus and disease issues caused by continuous wet leaves. Overhead sprinklers can add to this problem.
- Maintenance: Regular maintenance is necessary to ensure that spray patterns are not blocked by growing plants, sprinklers are clean and operating properly, and water is not being wasted due to wind drift or overspray onto nearby areas.
- Efficiency: Sprinklers are moderately efficient, meaning that water is easily lost through evaporation, wind drift, and inefficient delivery patterns.

Tips for Effective Use

- Assess Plant Needs: Evaluate the water requirements of different plants in your garden to determine if overhead sprinklers are suitable.
- Conduct Regular Inspections: Check sprinklers regularly to ensure they're not blocked or damaged and that they're delivering water efficiently.
- Adjust Settings: Use irrigation controllers to adjust watering schedules according to the specific needs of your garden and weather conditions.
- Monitor for Issues: Keep an eye out for signs of fungus or disease, and adjust your irrigation practices as needed to minimize these risks.

By considering these factors, you can make the most of overhead sprinklers while minimizing potential downsides, ensuring your garden remains healthy and vibrant.

Soaker Hoses and Drip Tape: Soaker hoses apply water through small pores, allowing it to soak in from the soil surface. As a low-cost option for rows and beds of vegetables and annual plants, they can be installed in various patterns within a garden space, from winding shapes to straight rows. Similarly, drip tape releases water through slightly larger, regularly spaced holes that are less likely to clog in regions with mineral-rich water but need to be replaced seasonally.

Benefits and Considerations

- Cost-Effective: Both soaker hoses and drip tape are relatively inexpensive options for garden irrigation.
- Flexible Installation: They can be installed in a variety of patterns, making them a versatile option for different garden layouts.

- Convenient Automation: Irrigation controllers can be used to automate the watering schedule, ensuring consistent and timely irrigation.

Challenges

- Pressure Compensation: Soaker hoses and drip tape are typically not pressure-compensating, meaning that more water is applied closer to the water source than to the end of the hose. This can result in uneven watering of garden beds.
- Maintenance: Regular maintenance is required to prevent clogging and ensure that holes are not punctured through the hose during gardening activities.

Tips for Effective Use

- Even Distribution: Be mindful of the length of the soaker hose or drip tape used. To ensure even watering, avoid using excessively long lengths from a single water source.
- Regular Inspections: Check regularly for clogs or punctures. Clean or replace clogged sections as needed.
- Controller Integration: Use irrigation controllers to automate and improve watering schedules, adjusting based on plant needs and weather conditions.
- Proper Installation: Install soaker hoses and drip tape in patterns that maximize water delivery to plant roots while avoiding excessive overlap that could lead to water waste.

By using soaker hoses or drip tape, you can achieve efficient and effective irrigation for your garden, supporting healthy plant growth and water conservation. Regular maintenance and thoughtful installation will ensure effective, long-term operation.

Emitter Hoses: Emitter hoses are designed to deliver precise amounts of water. As a more efficient alternative to sprinklers, they reduce the chance of water loss from wind and runoff. By delivering water directly to the soil, they are more selective than a sprinkler but not quite as targeted as hand watering.

Point-Source Drip Emitter Irrigation: Point-source drip emitter irrigation slowly delivers water directly to the soil at the base of plants, minimizing water loss from evaporation and wind drift. Offering flexibility in plant type and spacing, this method allows you to customize your irrigation to ensure each plant gets the right amount of water based on its specific needs.

Benefits and Considerations

- Water Efficiency: By delivering water directly to the root zone, drip systems significantly reduce water waste.
- Flexibility: Drip emitters can be spaced according to the specific needs of the plants, allowing for tailored irrigation.
- Disease Reduction: Reducing water splash on leaves helps minimize the risk of fungal diseases.
- Automation: Like sprinklers, irrigation controllers can be added to drip systems to automate watering schedules, ensuring consistent and timely irrigation.

Challenges

- Cost: While a drip system is more expensive than a hose and watering can, it's far less costly than installing an underground sprinkler system.
- Maintenance: Regular maintenance is required to ensure that drip emitters are functioning properly and have not popped off the distribution tubing, which could create wasteful water jets.

Tips for Effective Use

- Regular Checks: Inspect the system regularly to ensure all emitters are working correctly and that there are no leaks.
- System Setup: Customize the spacing of drip emitters based on plant water requirements and available space.
- Controller Use: Use irrigation controllers to automate the watering schedule, adjusting it according to the needs of the plants and weather conditions.
- Emitter Maintenance: Keep emitters clean to prevent clogging and ensure efficient water delivery.

By implementing a drip irrigation system, you can achieve efficient and effective watering of your garden, supporting healthy plant growth while conserving water.

Inline Drip Tubing: Inline drip tubing combines the technologies of drip emitters and soaker hoses, offering a highly efficient irrigation solution for garden beds. Drip emitters are preinstalled inside a flexible distribution tube at specific intervals to provide even water application throughout the garden bed. This not only enhances irrigation efficiency but also reduces installation and maintenance requirements as the emitters are safely enclosed and less prone to damage from gardening activities.

Benefits

- Efficiency: Preinstalled drip emitters deliver water precisely where it's needed, reducing water waste and ensuring that each plant receives adequate moisture.
- Flexibility: Inline drip tubing is highly flexible and can be installed in various patterns, such as rows, winding shapes, or circular layouts, to accommodate different garden bed shapes.
- Easy Installation: With emitters already integrated into the tubing, installation is straightforward, saving time and effort.
- Reduced Maintenance: The enclosed emitters are protected from physical damage, leading to fewer maintenance issues compared to other drip systems.
- Automated Irrigation: When paired with irrigation controllers, inline drip tubing can be part of an automated irrigation schedule, ensuring consistent soil moisture levels for healthy plant growth.

Maintenance Considerations

Although inline drip tubing is less prone to maintenance issues compared to other drip systems, some maintenance is still necessary to ensure optimal performance:

- Regular Inspections: Periodically check the system for clogs or blockages in the emitters. Clear any debris that may have accumulated.
- Water Quality: Use filtered water, if possible, to prevent sediment from clogging the emitters.
- Winter Preparation: In regions with freezing temperatures, ensure that the tubing is properly drained or removed to prevent damage from ice growth during the winter months.

Tips for Effective Use

- Plan the Layout: Design the layout of the inline drip tubing to match the specific needs of your garden bed, ensuring that water reaches all plants evenly.
- Use an Irrigation Controller: Incorporate an irrigation controller to automate the watering schedule, adjusting for plant needs and weather conditions.
- Monitor Soil Moisture: Regularly check soil moisture levels to ensure that plants are receiving the right amount of water.

Using inline drip tubing, you can achieve a high-efficiency irrigation system that supports healthy plant growth while conserving water. Regular monitoring and maintenance will ensure the system remains effective and reliable over time.

Olla pots: Olla pots have been used for thousands of years to provide supplemental irrigation to plants and crops. These porous, clay pots are buried in the soil and filled with water, allowing the water to slowly absorb into the surrounding soil to support nearby plants. This ancient method offers an excellent educational opportunity for students, demonstrating how traditional irrigation techniques can effectively conserve water.

Benefits and Considerations

- Water Efficiency: Olla pots provide a slow and steady release of water directly to the plant roots, reducing water waste from evaporation or runoff.
- Educational Value: Students can learn about early irrigation methods, water conservation, and the importance of efficient watering techniques.
- Low Cost: Olla pots are relatively inexpensive to use, making them perfect for small garden projects.

Challenges

- Impractical for Large Gardens: While effective for small plots, olla pots are not suitable for larger garden beds, as they can't cover large areas efficiently.
- Manual Maintenance: This method requires regular attention to refill the pots, which can be labor-intensive, especially during dry seasons.
- Limited Coverage: Each olla pot can only irrigate a small area around it, so multiple pots are needed for even moderate-sized gardens.

Tips for Effective Use

- Strategic Placement: Place olla pots near plants that benefit most from consistent moisture. This is particularly useful for plants with deep root systems.
- Regular Monitoring: Check the water levels in the pots frequently to ensure they are consistently filled, especially during hot or dry periods.
- Educational Activities: Incorporate the use of olla pots into classroom activities, allowing students to observe and measure the effects of this irrigation method on plant growth and soil moisture.

Olla pots offer a unique and educational approach to garden irrigation, teaching students valuable lessons about water conservation and traditional farming practices. However, due to their limitations in coverage

and need for regular maintenance, they're best suited for small garden plots and educational demonstrations rather than sizable gardening projects. For larger areas, consider using olla pots with other irrigation methods to maximize efficiency and coverage.

In addition to considering how to water, there are a number of additional practices that can ensure more efficient watering. The following activities will also explore these watering tips:

Apply Water to Soil

Since plants absorb moisture through their roots, it makes the most sense to apply water to the soil. Watering the foliage is inefficient and can lead to disease problems.

Water Deeply

It's better to water plants thoroughly a few times a week rather than a little bit every day. Apply enough water so it soaks in to a depth of 6" to 8" to encourage roots to grow deep into the soil. The exceptions to this are seedlings, shallow-rooted plants, and some fast-growing plants growing in hot climates that benefit from consistently moist surface soil.

Water Slowly

Even soils with excellent water-holding capacity can only absorb so much water at a time. Applying water slowly allows it to percolate into the pockets of pore space in the soil.

Water Consistently

Vegetable gardens require consistent moisture to perform and produce. Consider providing adequate water to ensure a healthy garden and learning opportunity.

Activity 1

1. Ask students, “Where do our garden plants get their water from? In nature, plants mostly rely on rain to fill their water needs. If there is not enough rain, what do we do?”

2. Introduce them to the basic types of watering techniques used by gardeners, listed in the Introduction. Find examples of each type of system (hand watering, sprinklers, and drip irrigation) and let them observe a demonstration of each method in your schoolyard.

3. Explain to students that water, especially clean water, is a very precious resource in our world. If you have older students, you may want to share information about some of the water shortage crises that have occurred in the United States and around the world in recent years. Drought conditions have impacted drinking water availability and food production and have also contributed to devastating wildfires. Ask students to consider the irrigation demonstrations they observed. Which one do they think used the most water? Which system seemed to get the most water directly to the plant?

4. As a class, work together to complete the Irrigation Comparison Worksheet to evaluate the pros and cons of each of the main types of watering techniques. After making your lists, ask students again to consider: Is there one best technique? Do different techniques work better in some garden situations than others? What would be best for our school or your home garden?

   Here are some possible responses for the Irrigation Comparison Worksheet:

Irrigation Method	Benefits	Challenges	Example Garden Situation to Use
Hand Watering	• Inexpensive • Allows for targeted water delivery • Allows you to monitor soil conditions as you water	• Time consuming • Labor intensive	• Small container garden • A garden bed where only a few plants need extra water regularly
Sprinklers	• Can be inexpensive • Save time	• Can waste water if not monitored • Built-in systems can be costly and complex to design/install	• Large garden area with lots of plants needing frequent water • Large garden bed where all plants need the same amount of water
Drip Irrigation (soaker hoses, emitter hoses, and olla pots)	• Efficient water delivery • Save time	• May not be as targeted as hand watering • More expensive initially than hand watering and many sprinklers	• Small-to-medium-sized in-ground beds and raised beds • Garden areas where plants may need different amounts of water

5. 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 students create ads to encourage others to use water wisely.

Activity 2

1. In addition to choosing systems that use water efficiently, there are a number of sustainable watering techniques that support plant and soil health. One of these practices is to water deeply. It's better to water plants thoroughly a few times a week rather than a little bit every day. It's also important to apply enough water so it soaks in to a depth of 6" to 8" to encourage roots to grow deep into the soil. You can grow some grass or bean seeds in a homemade root viewer to let students observe the difference between shallow and deep watering.
2. First, make two or more root viewers. Clean and dry two or more half-gallon juice or milk cartons. Open or cut the top off the carton and drill four or five small holes into the bottom (this can be done with a screwdriver). Next, carefully cut a window from one side and cover with a piece of transparency film or other sturdy, clear, plastic film. Secure it with clear packing tape.
3. Fill your viewer with moist soil and then plant a few seeds close to the window. Cut a piece of construction paper to cover the window and tape it at the top so it's easy to lift for observation. Roots tend to grow away from light, so you'll want to minimize the amount of light entering the viewer, except during times of observation.
4. Carefully water each viewer. For one viewer, slowly add water until just the top few inches of the soil are moist. Repeat as needed to keep just that top layer moist. For the second viewer, slowly apply water until it reaches down to the bottom of the carton. Make sure you have plenty of drainage holes at the bottom and use a tray to collect excess water. Empty the tray after watering so the container doesn't sit in water. You want to keep the soil moist but not too wet.
5. Check viewers every few days and add water as needed, as described in Step 4. Have students observe growth for four or more weeks and record their observations on the Root Viewer Observation Worksheet.
6. Discuss findings with students. Ask, "Why is it better for roots to grow deeper? What are the benefits?"

Activity 3

1. In this activity, students will explore how applying water to soil slowly can increase the amount of water that's absorbed by the soil compared to applying water quickly. Begin by creating a soil funnel. Cut two empty, clean, 2-liter bottles in half. Remove the lids and invert the tops of the bottles into the bottoms. Place a coffee filter into the crafted funnel to keep soil from falling through the hole during the experiment.
2. Go out to your garden or schoolyard and dig up a soil sample. About 2 cups of soil should be enough. Try to find an area that is moist but not saturated with water.
3. Divide your soil evenly into the two soil funnels. Try to make sure the consistency of each sample looks the same.

Using a measuring cup, pour a ½ cup (4 oz) of water into one of the soil samples as fast as possible (without causing the water or soil to spill out over the side). Next, fill up the cup again, this time using a plastic pipette or water dropper to slowly apply the same amount of water into the soil.

*Note: You may need to adjust the amount of water used depending on your soil type to be able to observe a difference. Sandy soil will naturally drain faster and hold less water. An alternate option is to begin by applying the water through the pipette and stop when water begins to drain out. Then apply that exact same amount of water quickly to the other funnel to compare.

4. Compare the amount of water that drained out of the soil into the bottle bottom. If no water leaked to the bottom of either, try the experiment again, this time adding more water (adding quickly to one and slowly to the other).
5. Ask students what they learned from this experiment. Based on their results, is drip irrigation an efficient way to water plants? Why or why not?

*At the end of this experiment, empty out and clean your 2-liter bottles and save them for an activity in Module 4.

Irrigation Comparison Worksheet

Irrigation Method	Observations	Benefits	Challenges	Example Garden Situation to Use
Hand Watering				
Sprinklers				
Drip Irrigation: (soaker hoses, emitter hoses, and olla pots)				

Which of these irrigation methods do you think save the most water? Why is it important to save water?

Which of these irrigation methods do you think are least expensive? Most expensive?

Which of these irrigation methods do you think would be best for our garden? Why?

Root Viewer Observation Worksheet

Date	Root Viewer 1: Water only top of soil	Root Viewer 2: Water to the bottom of soil
	Record the length of the roots along with any observations:	

Did you notice any differences between the roots in Root Viewer 1 and Root Viewer 2?

Which watering method do you think is better?

How can we use this information in our garden?

Waterwise Garden Explorers
Module 4: Water-Conserving Gardening Techniques

Learning Objectives

There are many techniques that can help gardeners use water efficiently and effectively in the garden. This module explores some of these sustainable practices. Young gardeners will:

- Track weather to learn the importance of monitoring plant needs.
- Conduct experiments using mulch in the garden.
- Compare the water-holding capacities of different kinds of soil.

Materials Needed

Activity 1:

- Outdoor thermometer
- Rain gauge
- Weather app or website
- Weather Garden Journal Pages

Activity 2:

- Two or more old 9" x 13" baking pans or deep, disposable, aluminum pans
- Potting soil or soil from a garden
- One or more types of mulch (e.g., shredded hardwood, cedar bark chips, pine straw mulch, leaf litter, compost)
- Clear, plastic trays
- Watering can
- Soil Erosion Experiment Worksheet

Activity 3:

- Two or more different soil samples from the garden, schoolyard, or other green space — look for samples representing varying amounts of sand, silt, and clay
- Two or more empty, clear, 2-liter drink bottles
- Measuring cups

- Two or more coffee filters
- Stopwatch or stopwatch app
- Soil Composition Experiment Worksheet

Introduction

In addition to wise watering practices, there are many other techniques that can lower a garden's water needs and usage while still ensuring plants have enough moisture for healthy growth. Through the activities in this module, students will learn about the following sustainable gardening practices through hands-on exploration:

Water only when needed. Track weather and environmental conditions to better monitor when you need to apply supplemental water. Adapting your watering schedule to supplement natural rainfall only when needed promotes efficient use of water. Although watering every Monday and Wednesday might be convenient for you, it may not be the right schedule for your plants. Your garden will need more water during the hot and dry times of summer than it will need in spring, fall, or winter.

Avoid watering with sprinklers on windy days. Watering during windy periods increases water loss due to drift and evaporation.

Know your soil. Clay soils are slow to absorb water, but they tend to hold moisture longer and can become oversaturated. Sandy soils drain quickly, so they dry out faster. Both can be improved by adding compost. Organic matter like compost improves water infiltration in clay soils and boosts water-holding capacity in sandy soils.

Protect your soil. A layer of organic mulch, such as bark chips or pine straw, keeps soil cool, conserves moisture, and helps keep weeds at bay. Plus, as the mulch breaks down, it adds nutrients and organic matter to the soil, supporting the soil ecosystem and improving the soil's ability to absorb water. Mulch also helps prevent erosion during heavy rain.

Activity 1

1. Install a few simple weather tracking tools in your garden. An outdoor thermometer and a rain gauge are a reasonably priced place to start. You can add to your collected weather information by using a weather app or website.
2. Have young gardeners use the Weather Garden Journal Page to track weather for three to four weeks. Record both weather information and observations about their plants so they can later reflect on how the weather impacted plant health and growth. Also make note of any supplemental irrigation that was provided.
3. At the end of their journaling, take time to discuss the findings. Was there enough rain to keep plants happy? How much water did our plants need? Do you think it helped to write down this data? Do you think it helped us be better gardeners? Do you think it helped us save water?

There are many different types of weather stations and weather monitoring tools available to meet a wide variety of budgets.

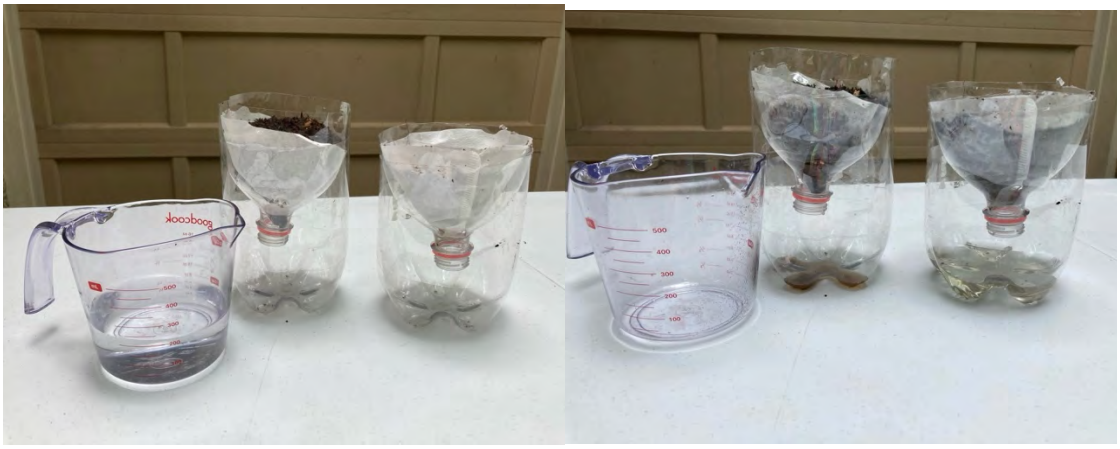
Activity 2

1. Using a similar setup as used in Module 2 to investigate how roots help with water absorption, help students create a model that demonstrates how mulch can help conserve water in the garden.
2. Fill two or more old 9" x 13" baking pans or deep, disposable, aluminum pans with moist potting soil or soil from the garden. Fill one pan to the rim of the pan. In the second pan, leave 1" or 2" open at the top for mulch.
3. In the second pan (or additional pans), place a 1" to 2" layer of moist mulch over the soil.
4. Set the pans on a table at a slight angle (10° to 20°) with the bottom end placed in a plastic tray. Use a watering can to simulate rain on your different “pan landscapes,” exposing each pan to the same amount of water at the same rate of delivery.
5. Compare the water runoff from each landscape. Do they look different or the same? Measure the amount of water collected and record the amount of soil lost by erosion. Which landscape held on to the most water? Which one held on to the least water? What color is the water? How much soil washed away? How does this compare to the plant root experiment from Module 2?
6. Leave the pans of bare soil and mulch-covered soil in the garden and come back a day or two after the experiment. Have students touch the soil to investigate its moisture. Are they both equally wet, or did one soil dry out more than the other? Why or why not? Based on this demonstration, how do you think mulch helps conserve water? Do you think we can use mulch on all garden beds?

Activity 3

1. The amount of sand, silt, clay, and organic matter in soil influences how it absorbs water. Sandy soils drain quickly while clay soils hold water tightly. Most common garden plants do best in a loamy soil, which has a mix of sand, silt, and clay along with a good amount of organic matter. In this activity, students will explore how water moves through and is absorbed by different kinds of soil. Begin by creating soil funnels (similar to the ones used in Activity 3 of Module 3). Cut two or more empty, clean, 2-liter bottles in half. Remove the lids and invert the tops of the bottles into the bottom. Place a coffee filter into the crafted funnel to keep soil from falling through the hole during the experiment.
2. Collect two or more soil samples from your garden, schoolyard, and other locations in the community. Using at least one sample with a lot of sand and one with a lot of clay provides a strong contrast. A soil high in organic matter is also good for comparison and exploration. You can use a quick ribbon test to get a rough estimation of a soil's composition.

   To conduct a ribbon test, take a small clump of the soil and add water until it makes a moist ball. Rub the soil together between your fingers. If the soil makes a nice, long ribbon, then it has a lot of clay in it (thus sticks together well). If it crumbles in your hand, then it has a lot of sand. If it is somewhere in between, then you probably have a good mix (loam).
3. Place an equal amount of each soil sample in a different soil funnel.
4. Using a measuring cup, pour a ½ cup (4 oz) to 1 cup (8 oz) of water at the same speed into each of the soil samples. Use a stopwatch to record how long it takes for water to begin draining out of the bottom. Once the water has stopped draining, measure the amount of water that collected at the bottom of the bottle. Use the Soil Composition Experiment Worksheet to compile your results. Note: If no water leaked to the bottom, try the experiment again, this time adding more water to each sample.
5. Discuss your results. Which soil absorbed the most water? Why would this be beneficial for your plants? In a garden setting, how does this information help us understand how to use water efficiently? Why do we need to be concerned about using water efficiently?
6. Follow up this experiment by engaging students in researching ways gardeners can improve their soil by adding organic matter.



Weather Garden Journal

Date:

Time: Temperature:

Reported High/Low Temperature for the Day:

Rainfall:

Did we water today?

Observations about plant growth and health:

Date:

Time: Temperature:

Reported High/Low Temperature for the Day:

Rainfall:

Did we water today?

Observations about plant growth and health:

Soil Erosion Experiment Worksheet

Treatment: Record the amount of “rain” water sprinkled on each pan:

Pan #	How much water was collected in the drainage pan?	How much soil did the drainage water contain?	Additional Observations:
Pan 1 No mulch			
Pan 2 Type of mulch:			

Based on this experiment, how can mulch help gardens when it rains?

Did the soil in the pans feel equally moist? Describe any differences.

How can we use this information when taking care of our garden or schoolyard?

Soil Composition Experiment Worksheet

Collect 2 or more soil samples and compare how each absorbs and drains water.

Soil Sample	How long did it take for water to drain out of the funnel?	How much water drained out of the soil?	Additional Observations:
Soil Sample 1: Sandy Soil			
Soil Sample 2: Clay Soil			

Which soil sample absorbed the most water?

Which soil sample absorbed the least water?

How can we use this information in our garden?

Waterwise Garden Explorers
Module 5: Waterwise Garden Design

Learning Objectives

In this module, young gardeners will explore ways to design a garden that uses water efficiently. Students will:

- Discover that different plants require different quantities of water.
- Learn how rain gardens and rain barrels help capture rainwater so that it doesn't end up in storm drains.
- Explore hydroponic garden systems designed to grow plants using less water.

Materials Needed

Activity 1:

- Two 4" potted plants: one plant that needs a lot of water and one plant that doesn't need much water. Easy-to-obtain samples include an herb like basil (with higher water needs) and a succulent (with lower water needs).
- Measuring cup or measuring spoons
- Water Experiment Data Collection Worksheet

Activity 2:

- An empty pan or tray with sides
- Cup of water
- Access to a schoolyards or green spaces
- Graph paper
- Clipboard

Activity 3:

- 2-liter bottle
- Aquarium air pump
- Rockwool or a cotton ball
- Lettuce seeds
- Hydroponic nutrient mix

Introduction

Waterwise gardening begins before the first plant ever goes into the ground. Careful planning of your garden's landscape design and plant selection can help your efforts to use water efficiently. Some water-saving planning and design considerations include:

Proper plant selection. Different plants require different amounts of water. Gardeners who want to lower supplemental water needs should consider plants native to or naturalized in their local environment. Native plants are usually well adapted to the natural rainfall in their ecosystem, so once established in the garden, they'll be able to meet most of their water needs from rain during a typical year.

Install a rain barrel. Rain barrels are designed to capture the rain so you can save it for future use. To capture the most rain, rain barrels are often placed at the end of a gutter downspout to take advantage of the surface area of a roof. Note: It's generally not recommended to use rain barrel water on edible plants, as it may hold chemicals or debris from the roof.

Design a rain garden. Rain gardens are planted in sunken or low-lying areas that naturally collect water. This design allows them to trap and store stormwater before it causes erosion or runs off into storm drains or sewer systems. As the water slowly filters into the garden, soil and plants help remove pollutants and prevent them from entering waterways. It's important to select the right plants for rain gardens, as they'll experience excess moisture and increased levels of nutrients often found in stormwater runoff. Tough, native plants that can handle periods of dry and wet soil will do best. Rain gardens are most useful if situated downhill from water-resistant surfaces, such as rooftops and roads, to collect runoff. They can also benefit from a thick layer of mulch to help prevent erosion and keep soil moist during dry periods.

Consider alternative growing techniques. When considering water-efficient gardening techniques, thinking beyond traditional gardens can also provide solutions. For example, hydroponic gardening is a technique in which nutrients are supplied to plants via their water supply rather than through the soil. Hydroponic systems are designed to capture and reuse water, so the only water lost is that which the plants absorb and need for healthy growth. They are water-efficient and typically use less water than tradition growing systems where water is lost to runoff and evaporation. Growing plants hydroponically allows gardeners to grow in smaller areas, such as greenhouses, living rooms, classrooms, and rooftops. There are some challenges when using hydroponic systems. Most require a continuous energy source and specific equipment to support the delivery of water and nutrients. Additionally, only select plants are well-adapted to growing in hydroponic systems.

Activity 1

1. Obtain two or more 4" plants with different water needs. Examples of plants that are usually easily available are herbs like basil (with higher water needs) and succulents like echeverias (with lower water needs).
2. Place the plants in a sunny window. As a class, choose a specific amount of water to give them each week and a day you plan to water them. Use a measuring cup (or measuring spoons if your class wants to keep the amount low) to make sure each gets the same amount.
3. Use the Water Experiment Data Collection Worksheet and make observations about your plants.
4. After a few weeks, discuss your findings. How did your plants do? Were they both happy with the amount of water you gave them? What kind of differences did you notice? Why do you think different plants need different amounts of water? How can we use this information to help plan our garden? How can we learn about plants that grow well in the amount of water available in our garden?
5. Research native plants in your area. You may want to begin your search by locating your local Native Plant Society by using the North American Native Plant Society website or by contacting your local Wild Ones Chapter.

Basil has relatively high water needs.

Succulents have low water needs.

Activity 2

1. Ask students to think about what happens to the water that falls when it rains. Where does the water go? Does it stay in once place? Does it all get absorbed into the soil? If you think it moves, how does it decide where to go?

2. Hold a cup of water over a shallow pan or tray. Ask students, "If I dump this water in the tray/pan, what will happen? Where will the water go? What if I tilt the pan/tray in one direction? Why does the water move?"

3. Explain to students that water will always move to the lowest point, including when rain falls outside. As gardeners, we can use this to our advantage when trying to move more rainwater into our garden. Introduce them to the idea of rain gardens and the benefits they offer.

4. Visit your schoolyard or a local green space. Make a rough sketch of the space on a piece of graph paper. Then walk around and see if you can identify some low points in the space and mark them on your map. Add in some arrows to show how you think water may flow when it rains.

5. There are other ways that gardeners capture rainwater. Look along the sides of the school building to see if there are any gutters. Explain how gutters help move water off the roof. Discuss how some gardeners use special rain barrels under the gutter downspouts to catch water for their garden for later use. Mark the locations of any downspouts near your growing space.

6. Return to the schoolyard or green space after a rainfall and look for evidence of how the rain moved across the land. Did it pool in any locations? Are there any spots in your schoolyard that might be good for a rain garden? Would a rain barrel be a practical addition for your garden?

Activity 3

1. Introduce students to the idea of hydroponic growing systems and how you will be exploring them as ways to conserve water. Set up a do-it-yourself (DIY) hydroponic unit for students to observe how plants' needs are met through these systems. Below are instructions for a simple DIY hydroponic unit that uses a 2-liter bottle for a container, an aquarium pump to provide aeration, and rockwool (or a cotton ball) to start the seeds and support the roots:

Soda Bottle Hydroponic System

- Soak small squares of rockwool or cotton balls in a dilute hydroponic nutrient solution. Plant two or three lettuce seeds in each one, then place them on a waterproof tray or shallow container and keep them moist until the seeds germinate. Once they've started to grow and form roots, they're ready to transplant into your soda bottle system.
- Cut the top off a 2-liter soda bottle, leaving a bit of the sloping neck. For this system, you'll invert the top of the bottle into the bottom. The inverted top will hold your plant while the opening of the bottle will allow access to the nutrient solution you'll place in the bottom. Use a permanent marker to place a mark where the bottom of the inverted bottle opening falls. This mark is the nutrient solution line; you'll be keeping the bottom of the bottle filled with nutrient solution to this point.

- Choose a spot on the side of the bottom half of the bottle above the nutrient solution line and create a small hole so you can insert aquarium pump tubing. Insert the tubing through the hole so it reaches near the bottom of the bottle (without fully touching the bottom). As an optional feature, consider attaching the submerged tubing to an air stone, then connecting the other end of the tubing to your pump. Air stones can be made of different types of materials but are typically porous stones used to diffuse the air being pumped into water into smaller bubbles. The stone will also add weight to your bottle, help your tubing stay in place, and potentially decrease the sound produced by your system.
- Fill the bottom of the bottle with a nutrient solution up to the nutrient solution line. Invert the bottle top and place the rockwool or cotton ball containing your lettuce seedlings so that it securely fits into the hole. Then place the inverted top into the bottom half of the bottle.
- Add nutrient solution as needed to keep the bottom filled to the nutrient solution line. Change out the nutrient solution every two weeks or so.

Water Experiment Data Collection Worksheet

Treatment: Plants received _____ of water.

Date of Observation	Plant 1: _____	Plant 2: _____	Plant 3: _____	Plant 4: _____
	Observations about plant growth:			

Did you observe any differences in how well the plants were growing?

Did some plants grow better than others? Do you think the amount of water made a difference?

How can we use this information in our garden?

Digging Deeper

Additional supporting resources available from KidsGardening:

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

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

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

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

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

Exploring Hydroponics: https://kidsgardening.org/resources/curricula-books-exploring-hydroponics/

Discovering Through Hydroponics: https://kidsgardening.org/resources/curricula-books-discovering-hydroponics/

Digging into Soil: https://kidsgardening.org/digging-into-soil/

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

Photosynthesis 101: https://kidsgardening.org/resources/digging-deeper-photosynthesis-101/

Next Generation Science Standards

The following standards inspired the activities in the Waterwise Garden Explorers Unit:

K-PS3-1. Make observations to determine the effect of sunlight on Earth's surface.

K-LS1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive.

LS1.C: Organization for Matter and Energy Flow in Organisms

- All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow. (K-LS1-1)

K-ESS3-3. Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.*

ESS3.A: Natural Resources

- Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. (K-ESS3-1)

ESS3.C: Human Impacts on Earth Systems

- Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things. (K-ESS3-3)

1-LS1-1. Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.

LS1.A: Structure and Function

- All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. (1-LS1-1)

2-LS2-1. Plan and conduct an investigation to determine if plants need sunlight and water to grow.

LS2.A: Interdependent Relationships in Ecosystems

- Plants depend on water and light to grow. (2-LS2-1)

2-ESS2-1. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.

ESS2.A: Earth Materials and Systems

- Wind and water can change the shape of the land. (2-ESS2-1)

2-ESS2-3. Obtain information to identify where water is found on Earth and that it can be solid or liquid.

3-LS3-2. Use evidence to support the explanation that traits can be influenced by the environment. [Clarification Statement: Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted.]

3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.

4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.]

ESS2.A: Earth Materials and Systems

Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1)

5-LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water.

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