# Water Cycle Rain Garden

2 weeks

## Authors.

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## SUBJECT/GRADE LEVEL.

**Subject Area:** Science

**Grade Level:** Middle School

## Materials:

### Engage

- Paper or student document - 1 per student
- Writing utensils - 1 per student
- Water cycle diagram

### Explain

- Dice (one per group/one per student)
- Game sheets for students (Different versions are in the Explanation section of this lesson plan.)
- Station Signs (pages 3-10)

### Explore

- Experiment 1
  - 1 short wide-rimmed clear plastic cup
  - 1 tall smaller-rimmed clear plastic cup
  - Hot water (about 50℃)
  - Magnifier
  - Labsheet
- Experiment 2
  Each group needs:
  - 2 quart- size zip-closing plastic storage bags
  - Hot water (about 50℃)
  - Room-temperature water
  - 2 squares of brown paper towel
  - 2 droppers
  - Computers
  - Ruler
  - Labsheet
- Experiment 3
  Each group needs:

- 2 plants of different native plant species, in 4-inch or 1-gallon containers; usually ~$2.50 for a plant in a 4-inch pot and ~$7 for a plant in a 1-gallon pot
- (2) 2-liter or 20-ounce plastic bottles, for 1-gallon and 4-inch plants respectively, or (4) produce baggies
- 4 twist ties - If using produce baggies
- Black permanent marker, such as a Sharpie®
- Scale, accurate to 0.1 gram, such as a triple beam balance or laboratory scale
- 2 stopwatches or timers
- Gallon jug half filled with water
- Calculators
- Pencils, colored pencils or markers, ruler (for graphing)
- Just Breathe Green worksheet or form - one per student

For the entire class to share:

- Scissors, for teacher to cut plastic bottles
- Liquid food coloring, for teacher to prepare colored water, 10 drops per group

- Experiment 4
  - Pan of water
  - Burner
  - Large cookie sheet
  - Ice cubes
  - 2 trash cans
  - Labsheet
- Experiment 5

  Each group needs:
  - Graduated cylinder
  - 4 see-through plastic cups
  - Gravel (enough to fill one cup 3/4 of the way up)
  - Sand (enough to fill one cup 3/4 of the way up)
  - Soil (enough to fill one cup 3/4 of the way up)
  - Marbles (enough to fill one cup 3/4 of the way up)
  - Medium size mixing bowl or small bucket to catch water

- Labsheet

To share with the entire class:

- water and sink/drain

- **Elaborate**
  - Empty water bottles - 1 per group
  - Clay/Play-doh - ¼ of a container per group
  - Aquarium Rocks/Pebbles - approximately 3 oz per group
  - Sand - approximately 3 oz per group
  - Soil- approximately 3 oz per group
  - Water - 100 mL per group
  - Food Coloring - a couple of drops
  - Grass/Leaves - a handful per group
- **Evaluate**
  - Paper or materials for drawing a diagram

## STANDARDS

### Next Generation Science Standards

- MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
- MS-LS2-3 Ecosystems: Interactions, Energy, and Dynamics: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

- MS-ESS2-4 Earth's Systems: Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
- MS-ESS2-6 Earth's Systems : Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
- MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.
- MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

- MS-PS1-4 Develop a model that predicts and describes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

- MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

- MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

## LESSON OBJECTIVE(S)

Students will be able to

- Identify different forms of water on earth in the form of liquid, solid, and gas
- Explain how water moves through the water cycle with an emphasis on the roles of the sun and
- gravity
- Describe the benefits of rain gardens
- Create and optimize a prototype of a rain garden
- Evaluate the relative timing of movement through various locations in the water cycle

## CAREER CONNECTION(S)

**Mentor Background:** Mark D. Ginsberg is a principal investigator in the Materials and Structures Branch, Facilities Division, United States Army Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory (CERL) at Champaign, Illinois. He is an electrical engineer with a B.S. in Engineering Physics, M.S. in Applied Mathematics, and a PH.D. in Electrical and Computer Engineering. His work on enhanced biological contaminant protection for critical infrastructure inspired this lesson plan.

**STEM Careers:** Atmospheric Scientist, Geospatial Information Scientists and Technologists, Mechanical Engineer, Data Scientist, Environmental Engineering, and Water Quality Specialist

## ENGAGEMENT

**Brief Description:** Students will share their prior experiences with the locations of water and its uses to build collective knowledge and brainstorm ways that water may move through a system. Students will then compare their ideas to a water cycle diagram. This section will take approximately 30 minutes.

**Procedures:**

The teacher will begin the lesson by asking students to write or draw about a memorable experience they had with water. The teacher can give examples to get the students started, though this might narrow students' overall responses. Possible example responses might be things like swimming,

sledding on snow/ice, drinking water, taking care of a fish in a tank, watering plants, etc. When students have finished writing/drawing, the teacher can ask for volunteers to share their ideas with the class.

The teacher will then ask the students to think about their story and the other stories that were shared to write or draw all of the locations where water can be found. The teacher can set a three minute timer or allow the activity to run until student written responses begin to slow down. When the students have finished their individual lists, the teacher will ask the students to share their lists with a small group. After allowing about five minutes for small group sharing, the teacher will bring the class together as a whole group and make a list on the board. While making the class list, the teacher may decide to group ideas together. For instance, if students say bathroom and kitchen, the teacher may place those in a "house" or "indoors" activity. The teacher should continue building the list until it includes examples of water in solid, liquid, and gas forms on different parts of the planet. Examples that students may come up with include - glacier, ice, river, pond, stream, puddle, living things (people, plants, animals), clouds, atmosphere, ocean, ground, pool, faucet, and ice cubes. For the purpose of the rest of the lesson, it will be important for the teacher to make sure the list includes living things/plants and groundwater.

The teacher will then ask the groups of students to pick a category (or the teacher could assign each group a category, such as cloud, river, ocean, rain, etc.) and brainstorm ways for how the water got there. This could include writing an explanation or drawing a model. For instance, students might be asked to explain how water got into an ocean/pond/river or how water vapor becomes a cloud. The students will share some of their ideas about how water moves.
To conclude this portion of the lesson, the teacher will display a copy of a water cycle diagram (Interactive Water Cycle USGS Diagram). The teacher could also print out copies that students could annotate. The class will closely examine the water cycle diagram to look for items they included on their brainstormed lists and items they may have not thought about.

This document or this Google form can be used to facilitate students' writing for this portion of the lesson.

Extension Idea: The teacher can revisit the water cycle diagram at the end of each of the following lessons and ask students to explain which part of the water cycle was emphasized during the lesson.

## EXPLORATION

**Brief Description:** Students will explore the various steps in the water cycle. Observing how water moves, allowing them to make the connections needed between each phase. These experiments are hands-on explorations.

**Procedures:**
Experiment 1: What Happens When Water Vapor Condenses?

- In this lab activity students will explore water vapor and the process of condensation. The lab is expected to take around 30 minutes.
- If time is limited and you would like to just watch or assign a video discussing condensation there is one here. Here is a video of a similar experiment.

Experiment 2: Does Adding Energy Increase the Rate of Evaporation?

- In this lab activity students will explore the evaporation of water and how heat increases the rate of evaporation by increasing the movement of the water molecules. This lab is expected to take around 30 minutes.
- If time is limited and you would like to just watch or assign a video discussing evaporation and transpiration there is one here. Here is a video of a similar experiment.

Experiment 3: Measuring Transpiration

- In this lab activity students will explore how water vapor transpires from plant leaves. This lab is expected to take 90 minutes.
- If time is limited and you would like to just watch or assign a video discussing transpiration there is one here. Here is a video of a similar experiment. Here is a video showing the lab procedures.

Experiment 4: The Rainmaker

- In this lab activity students will explore how water vapor condenses into rain. This lab is expected to take 45 minutes.
- If time is limited and you would like to just watch or assign a video discussing precipitation there is one here. Here is a video of a similar experiment.

Experiment 5: Exploring Water Movement

- In this lab activity students will explore how water moves through various materials to model absorption and runoff. This lab is expected to take 40 minutes.
- If time is limited, the teacher could do a brief demo of pouring water on the sidewalk versus into the dirt/grass to demonstrate how runoff works.
- Here are also three videos, two similar to the lab (lab 2) and the other discussing runoff and collection.
- Here is a virtual simulation about runoff. Also included is a worksheet for the students to complete as they explore this virtual environment.

## EXPLANATION

**Brief Description:** Students will learn about the water cycle and explore how water moves through it. This activity was adapted from Goulburn Valley Water. Students will simulate a water droplet going through the water cycle by traveling to various stations that correspond to locations where water can exist in the water cycle. This activity should take about 40-60 minutes.

**Procedures:**

1. **Study Jams: Water Cycle:** Watch the video as a whole class. The teacher can ask students to look for concepts they do not already know to help keep them engaged during the video. After the video, have a brief discussion regarding the concepts students were unfamiliar with.

2. **Water Cycle Journey Game:**

A. Print the station posters from pages 3-10 in the Goulburn Valley Water Activity. These should be distributed around the room as stations. Each station should also have 3-5 dice for students to use when they are at that station.
B. Print and distribute Game Sheets for each student.
    i. For classes with limited time, Game Sheet 1 has only 10 stops and fewer analysis questions.
    ii. For a full game, Game Sheet 2 has 20 stops and reviews vocabulary.
    iii. Game Sheet 3 has 20 stops and also asks students to write about the impact humans have on the water cycle.

3. **Lesson Recap Discussion:** The teacher should discuss the following vocabulary with students in order to check for understanding.
    A. Evaporation: When liquid water turns into gas and goes into the air
    B. Transpiration: When plants release water vapor into the air
    C. Cycle: A series of events that repeat over and over
    D. Water Cycle: The path water takes as it moves from Earth to the air and back again
    E. Condensation: When water vapor in the air turns back into liquid water, forming clouds or dew
    F. Precipitation: Water falling from clouds to Earth as rain, snow, sleet, or hail
    G. Infiltration: When water soaks into the ground
    H. Vaporization: When a liquid turns into a gas
    I. Absorption: When something soaks up a liquid
    J. Runoff: Water that flows over the land, often into rivers or lakes
    K. Simulation: A way to act out or model how something works in real life
    L. Porosity: How many tiny holes or spaces are in a material
    M. Permeability: How easily water can flow through a material
    N. Sediment: Bits of rock, soil, or sand carried by water or wind
    O. Evapotranspiration: Water released into the air from both evaporation and transpiration
    P. Clouds: Tiny water droplets or ice crystals floating in the sky

**4. Discussion Questions:** Next, ask students to talk to a partner about the following questions.

A. Does the hydrological (water) cycle have a starting point and end point? Why or why not?
B. While traveling as a water droplet (during the lab) how did your path compare to your partner's? Discuss similarities and differences.
C. What impacts can pollution in one area have on the entire cycle?
D. Do you have any ideas on how to prevent droughts or flooding in different areas?

Set a timer for 5-8 minutes or let students discuss until conversation quiets. Then, ask those partners to then get into a group of 4 and share their answers. Students will then choose one person in the group to share out with the whole class. This will give the teacher some feedback for the next lesson.

**5. Alternate Activity:** If the teacher prefers, students could perform the Water Cycle Adventure Readers' Theatre.

## ELABORATE

**Brief Description:** Students will use what they have learned about the water cycle and rain gardens to design and test their own prototype of a rain garden. This section is expected to take two 40 minute class periods.

**Procedures:**

The teacher should begin the lesson by asking students to recall what they remember about the water cycle and call on volunteers to share their ideas.
The teacher will explain that the class will use what they have learned about the water cycle to make rain gardens. The teacher will show the students a picture of a rain garden and ask them to think about how rain gardens impact or are impacted by the water cycle.
The teacher can then explain that rain gardens can help prevent runoff, improve water quality, help with groundwater recharge, and increase biodiversity and wildlife habitats.

Rain Garden Activity Instructions

Student Lab Sheet

- In this activity, students will explore how water vapor condenses into rain. This activity is expected to take two 40-minute class periods.
- Here is a video of a similar experiment.
- If a rain garden activity is not an option or you would prefer this link will take you to a great idea for a rooftop garden activity.

## EVALUATION

**Brief Description:** Students will demonstrate their understanding of the water cycle on the local level. This section is expected to take 30 minutes.

**Procedures:**

The teacher will ask students to think about or list some of the key vocabulary terms and concepts they learned about while participating in the lessons. After providing some thinking/writing time, the teacher will ask the students to share their thinking with the class. The students should be able to explain the ideas of precipitation, evaporation, condensation, transpiration, runoff, rain gardens, and groundwater. The students should also be able to explain that while the water cycle is depicted as a complete cycle, a drop of water may not move through the cycle as is depicted in a water cycle diagram. After the class discussion, the teacher will have students work individually or in small groups to create a diagram that represents what the water cycle looks like in their community. The students should also include a rain garden in their diagram.

Instructions and a rubric for the diagram are located here.

The teacher may also have the students complete a quiz Water Cycle Quiz

## REFERENCES


- NorthWest Weather Watch Lab Module: Precipitation
- American Chemical Society: Middle School Chemistry Condensation
- American Chemical Society: Middle School Chemistry Evaporation
- NCWit.org Teach Engineering: Permeability Materials Experiment
- Soak up the Rain: Green Roofs
- Using Green Roofs to Reduce Heat Islands | US EPA
- Roof gardens » Urban Ecology
- An Essential Guide to Rooftop Gardens: Everything You Need to Know - Borst Landscape & Design
- Growing Rooftop Gardens - KidsGardening
- Green Roof or Rooftop Garden Requirements and Plant List
- Do you think rooftop gardens will be effective against certain natural disasters such as floods?
- How Can Green Roofs Reduce Runoff?
- Measuring Transpiration
- LaFountaine of Knowledge YouTube Channel
- RORG Interactive Map
- Soak In/RunOff Models
- Model My Watershed
- Interactive Water Cycle Diagram for Kids (Advanced)
- All About Rain Gardens – What They Are & How to Build One
- Soak Up the Rain: Rain Gardens | US EPA
- Building a rain garden | UMN Extension
- RoofTop Garden
- Rain Garden Modified and used with permission from ScienceBuddies. https://www.sciencebuddies.org/teacher-resources/lesson-plans/rain-garden
- Interactive Water Cycle USGS Diagram
- Activity Water Cycle
- Exploring the Water Cycle Pre/Post Assessment from NASA Global Precipitation Measurement Mission
- Goulburn Valley Water Activity
- Water Cycle Adventure Readers' Theatre