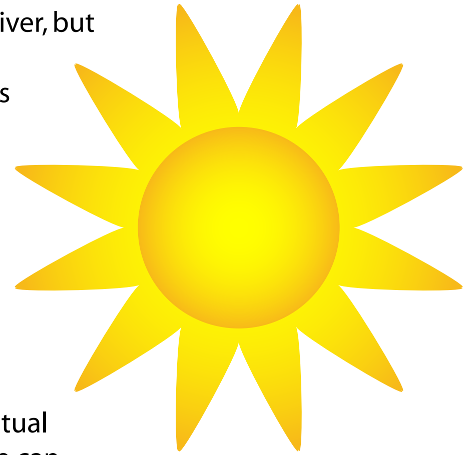
The Water Cycle

Where did the water you drank today come from?

Summary
With a roll of the dice, you can simulate the movement of water within the water cycle.

Objectives
Students will learn the complex movement of water through the water cycle through role playing, and, they will identify the states of water and changes in state as it moves through the water cycle.

http://response.restoration.noaa.gov/watercyclegame



Water is constantly in motion. Sometimes quickly, as in a fast-flowing river, but sometimes it moves quite slowly, like in underground aquifers. Understanding the details of how water moves about, on a watershed scale, is critical to understanding how either dissolved contaminants, or those attached to particles that are carried along in a water stream, are transported around within the watershed.

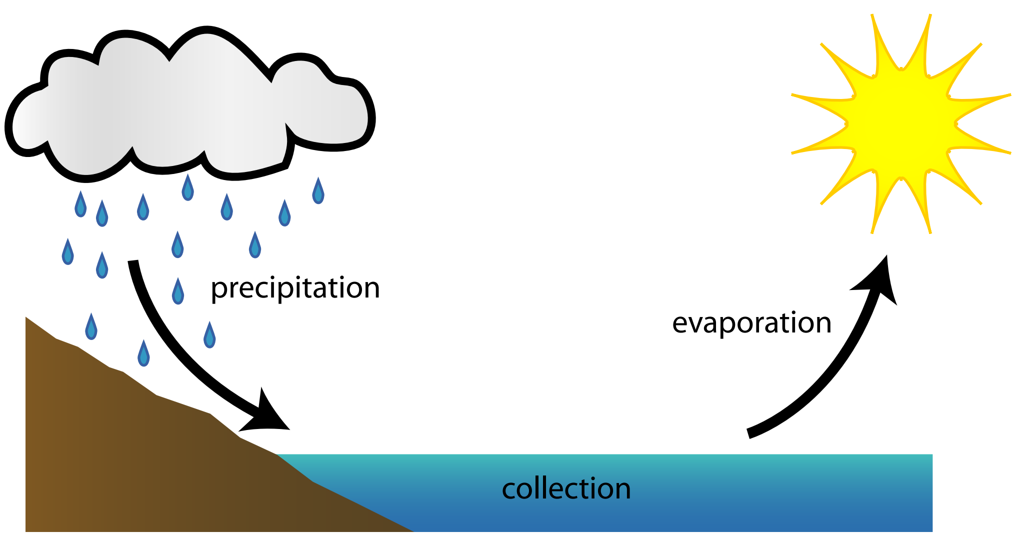
The movement of water, the water cycle, is often shown as a simple circular cycle (as in the diagram below) in which water evaporates from the ocean, is carried over land, falls as rain, and then is transported back to the ocean through rivers. This depiction tends to oversimplify the actual movement of water. There are many places, or compartments, where water may be found during its cycle. And the actual path any given water molecule follows within the complete water cycle can be quite varied and complex. Nor do such simple figures help to convey the period of time that any given water molecule may spend within certain compartments. For instance, the Antarctic Bottom Water, deep ocean water formed in the Antarctic, takes over 250 years to travel along the bottom of the Pacific Ocean before it re-surfaces in the Aleutian Islands.

Water may change state from a liquid to a gas or solid as it travels along its path. Water in its liquid form is the most visible and obvious. Water can be seen flowing in rivers and surging in ocean waves. Water even travels underground, though slowly, where it seeps through the spaces between grains of soil, sometimes coming to the surface as artesian springs. Although gravity works on ground water, geologic formations play a critical role in determining which direction water actually travels while underground.

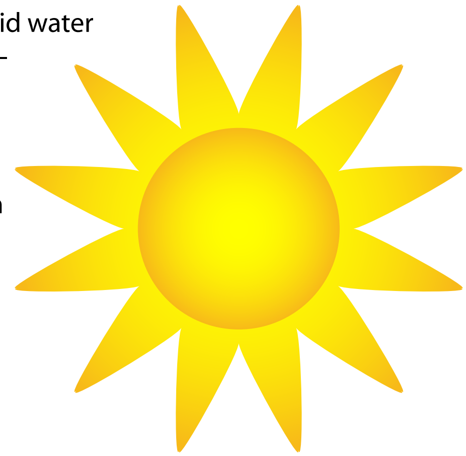
Living organisms also move water about. Water, either directly consumed as liquid or extracted from food, is carried within bodies. It then leaves as a gas during respiration, is excreted, or may evaporate from the skin as perspiration.

Plants are the major biotic movers of water. Their roots collect water for distribution throughout the plant. Some is used in photosynthesis, but most travels to the leaves where it is easily evaporated or transpired. Plants and their roots are also a major determining factor in the ability of a landscape to retain surface runoff or not.

Although most water vapor cannot be seen, fog and clouds do give some indication of water vapor in the atmosphere. Water condensation, seen as early morning dew or even on a cold glass, is one visible example of the water vapor present in our air. In clouds, water molecules condense and collect on microscopic dust particles until they reach such a weight that gravity pulls the water down as precipitation.



The impact of gravity on the water cycle is viewed elsewhere as well. Liquid water certainly conforms to the laws of gravity as it flows. But even ice on mountaintops obeys the laws of gravity as glaciers slowly move downward.



The following role-playing game allows you to better understand the complexity of the actual water cycle. Stations are set-up for each of nine different compartments of the water cycle. A roll of the die at each station tells you where to move next or to stay. This game is meant to be played with a group of people, so that the path each player takes can be compared with everyone else's. (It can be done over and over by one person to achieve the same results though. Adjust the following instructions accordingly.) Trackers – either colored beads or strips of paper are used to track each person's journey through the water cycle.

Materials

- Nine special cubes or die with movement instructions (download and print this file)
- Nine station illustrations or signs (download and print this file)
- A timer
- Any noisemaker, such as a bell or whistle
- Nine different colors of beads or paper strips (other than black)

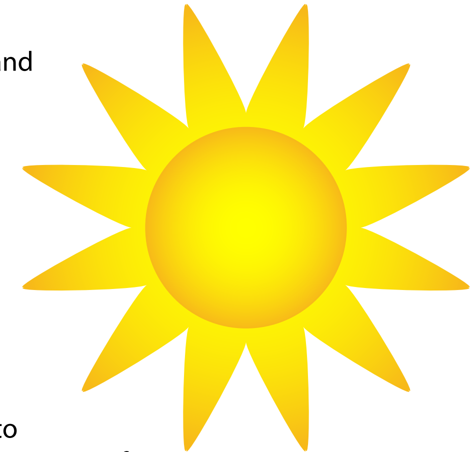
Preassessment

- Explain to the students that they will be tiny bits of water (molecules) in the water cycle. Have them then list all the places where water can be found in the water cycle. Compare their list to the nine compartments.
- Before handing out the instruction die to each station, ask the students at each station to list where they think water might go next from their station. Have them compare their list against the instruction die.
- Introduce the concept that water may not go anywhere from a station for some time. Also, have students list what forms of water (i.e., states)—liquid, solid, or gas—might be involved in possible moves from their stattion.

Instructions

1. Set up stations for the nine die. Place colored beads or paper strips (the trackers) in the die, with only one color in each die.
2. Randomly assign people evenly among the stations. If there is an odd number, assign the odd person to the ocean.
3. To start, each person collects a tracker from their first station, and then rolls the dice. Allow enough time for everyone at a station to roll.
4. At the sound of the signal, each person then follows the movement instructions from their dice roll and moves to that station. At the new station, they collect a tracker there and then roll the dice at that station. If their instructions were to stay, they should collect another tracker and then roll the dice with everyone that just moved to that station during the turn.
5. Sound the signal at even intervals (the amount of time depends on how many people play) to designate each turn of play. At each turn, players move; collect a tracker from their new station; and then roll for new movement instructions for the next turn.
6. After a pre-set number of turns (at least 9), compare the trackers from one player to the next. Observe the differences. Notice how long a player might have stayed in one station

Assessment



- Have students identify the various compartments of the water cycle, and the states in which water may be found.
- Have students describe where in the water cycle changes of state occur.
- Have students write an essay describing the water cycle and how water can take different paths through the cycle or they can use their own trackers to write creative story about the places water might visit in its movements.

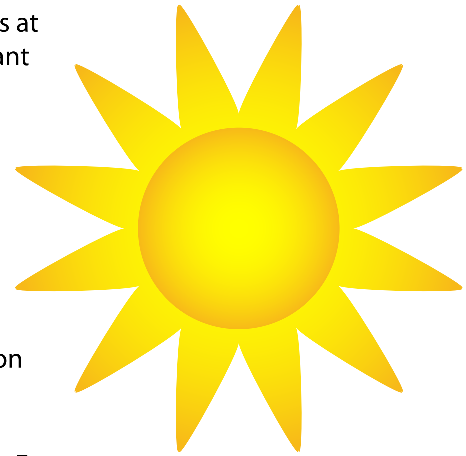
Contamination Connection

Although many contaminants are hydrophobic (i.e., they tend to sorb onto particles), the water cycle plays a very influential role in determining the transport of contaminants. The game can be played with an extension to illustrate how water quality is altered as water moves about. In this version, students collect or remove pollution (black trackers) as they move among compartments according to the chart below:

If a student moves from	***to***	***Action:***
Clouds	All	Collect 1 as airborne contaminants are sorbed
Animal	Soil	Collect 2 for wastes
Animal	Clouds	Remove all as water is purified as it is respired
Soil	Plants	Remove 1 as some plants absorb pollutants
Soil	River	Collect 2 as runoff carries pollutants
Soil	Groundwater	Remove 1 as soil filters some pollutants
Soil	Clouds	Remove all as water is purified as it evaporates
Plants	Animals	Collect 1 as contaminants are ingested
Plants	Clouds	Remove all as water is purified as it transpires
Ocean	Clouds	Remove all as water is purified as it evaporates
Lake	Clouds	Remove all as water is purified as it evaporates
Lake	Groundwater	Remove 1 as soil filters some pollutants
Lake	Animal	Collect 1 as contaminants are ingested
Lake	River	Collect 1 as water moves downstream
Glacier	Groundwater	Remove 1 as soil filters some pollutants
Glacier	River	Collect 1 as runoff carries pollutants
Glacier	Clouds	Remove all as water is purified as it sublimates
Groundwater	Lake or River	Remove 1 as soil filters some pollutants
River	Groundwater	Remove 1 as soil filters some pollutants
River	Lake or Ocean	Collect 1 as water travels downstream
River	Clouds	Remove all as water is purified as it evaporates
River	Animal	Collect 1 as contaminants are ingested

If a student stays in Lake, River, or Ocean, collect one tracker as pollution is discharged into these water bodies. For any other moves, students retain the black pollution trackers they already have. Students collect trackers at the end of a turn of play when they arrive at their new station or have stayed where they are. If they are removing trackers, they leave them at their station before they move.

For this extension, place containers with an equal number of black trackers at all stations except Animals and Plants. Place an empty container at the Plant and Animal stations. At the end of play, compare the number of pollution trackers each student has, plus the number left in containers at each station against the original number.



For assessment, students can compare and contrast the effects that movement among different water compartments has on water quality.

Extensions

- To add an art element to this exercise, students can illustrate the station labels for the nine stations.
- Have students explain how energy from the sun, gravity, geology, and gravity can affect the movement of water from various compartments. For instance, solar energy drives greater evaporation from the Red Sea than from the Bering Sea.
- Have students identify whenever they need to change state to accomplish their instructed moves from one compartment to another. Have them track how many state changes they go through.
- Have students compare the movement of water during different seasons and at different locations around the globe. Have them suggest how the instruction die might be altered to better match conditions for a particular location and season.
- To simulate the influence of heat on the movement of water, introduce the following addition after several turns of play: have students stop where they are and ask them what would happen to water at their station if it were hotter (generally, molecules move faster) or colder (molecules move slower). Have them proceed with the game pretending that the water they represent is now hot (not boiling). Do the same for water that is nearly frozen. You can even make distinctions for warm- and cold-blooded animals.
- To illustrate how events can alter water quality, introduce pollution scenarios partway through the game. For instance, have the students stop where they are and then read them a scenario card you have written. For example, an oil spill occurs. Or, a neighbor changes the oil in his car and dumps the used oil down the drain during a rain storm which then washes into a river. Several extra pollution trackers would be collected in the appropriate stations under these situations.
- For a math extension, explain to students they are assigned equally among stations to keep the exercise flowing and to better illustrate the water cycle. However, if they were assigned to stations according to how much water should be there, the numbers would not be even. Have them calculate how many students should be assigned to each compartment if that figure were proportional to the amount of water actually in that compartment. Use the following figures:

  Oceans – 79%
  Soil and Ground water – 18.8%
  Ice – 1.2%
  Lakes and rivers – 0.002%
  Atmosphere – 0.0006%

Vocabulary and Concepts Used

Evaporation
Sublimation
Percolation
States of matter
Precipitation
Transpiration
Ground water
Effects of heat upon water movement

References and Resources

Some of this material has been adapted from the Project WET Curriculum and Activity Guide, 1995, Bozeman, MT.

Garrels, R.M. et al. 1975. Chemical Cycles in the Global Environment. William Kaufmann, Inc. 206 pp.