THE UNIVERSITY OF CHICAGO
CENTER FOR INTERNATIONAL STUDIES

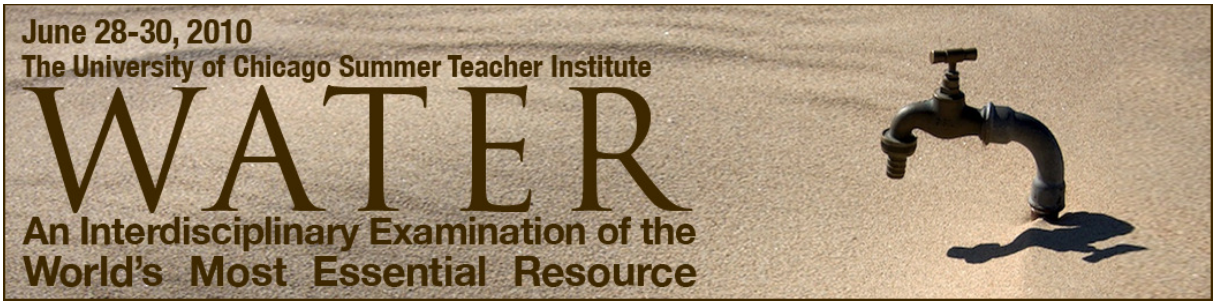
Global Lessons

The University of Chicago Center for International Studies presents *Global Lessons* as part of its commitment to providing educational resources for K-12 educators. These materials offer thematic international & area studies content on topics including culture, economics, politics, history, and environmental issues. With *Global Lessons*, CIS aims to provide classroom materials that will not only help to expose students to global issues, but also to empower them to think critically about their role as global citizens.

Water: An Interdisciplinary Examination of the World's Most Essential Resource

How Human Activities Impact the Water Cycle

The University of Chicago
Center for International Studies



The Center for International Studies' Summer Teacher Institute, "Water: An Interdisciplinary Examination of the World's Most Essential Resource," was held on the University of Chicago campus from June 28-30, 2010. In addition, a curriculum development workshop was hosted on July1st and an optional field trip to the Stickney Water Reclamation Plant and the Chicago Center for Green Technology took place on July 2nd.

The Institute provided an in-depth and multifaceted review of global water issues, as well as those that specifically affect the Great Lakes region. Daily topics addressed included: water issues in politics, effective water management, impacts of dams, water scarcity, sanitation, agriculture, and economics.

Thirteen professors, researchers, environmental engineers, and civic leaders from the University of Chicago and other educational institutions from around the world, spoke each day. Sixty elementary, high school, and college teachers from thirty-eight Illinois schools, as well as 20 other education-stakeholders attended the Institute.

The Institute was cosponsored by the University of Chicago Center for International Studies, the Center for East Asian Studies, the Center for Middle Eastern Studies, the Center for East European and Russian Eurasian Studies, the South Asia Language and Area Resource Center, and the Center for Latin American Studies.

The following lesson was created by Jill Krysinski, Honors Biology and Environmental Science Teacher at Bloom High School, and edited by Jamie Bender, Outreach Coordinator for the Center for International Studies at the University of Chicago. The lesson is based on speakers' presentations at the Institute.

For more information on the Center for International Studies, additional resources and classroom lessons developed based on this Institute, and to download resources from other events, please visit the Center's website: http://cis.uchicago.edu/

THE UNIVERSITY OF CHICAGO
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How Human Activities Impact the Water Cycle

Lesson Overview: In this lesson, students will learn about the movement and storage of water throughout the water cycle. Students will then examine human activities and determine which processes in the water cycle we are impacting. Finally, students will create a water ad campaign to present issues and promote solutions. This lesson is based on information presented at the 2010 University of Chicago Teacher Institute, "Water: An Interdisciplinary Examination of the World's Most Essential Resource."

Written By: Jill Krysinski, Honors Biology and Environmental Science Teacher, Bloom High School

Subject(s): Biology, Environmental Science, Social Studies, Geography

Suggested Grade Level(s): Middle School and High School

Time Duration: 3-4 Class Periods

IL Learning Standards Addressed:

<u>Science</u>
12.B.4a Compare physical, ecological and behavioral factors that influence interactions and interdependence of organisms.
12.E.3a Analyze and explain large-scale dynamic forces, events and processes that affect the Earth's land, water and atmospheric systems
12.E.3b Describe interactions between solid earth, oceans, atmosphere and organisms that have resulted in ongoing changes of Earth.

<u>Geography</u>
17.B.3a Explain how physical processes including climate, plate tectonics, erosion, soil formation, water cycle, and circulation patterns in the ocean shape patterns in the environment and influence availability and quality of natural resources.
17.B.3b Explain how changes in components of an ecosystem affect the system overall.
17.C.2c Explain how human activity affects the environment.

<u>Economics</u>
15.E.4b Describe social and environmental benefits and consequences of production and consumption.

Objectives:

- Explain the 6 processes of the water cycle: condensation, precipitation, evaporation, transpiration, runoff, and infiltration
- Describe how water moves within the water cycle
- Research a process in the water cycle and teach that process to classmates
- Diagram the water cycle
- Evaluate various ways human activities impact the water cycle
- Propose solutions to various water problems
- Research and identify issues that require social action and take part in the actions
- Create a water ad campaign presenting issues and promoting solutions
- Present the water ad campaign

Materials:

- Teacher Background Information Sheet
- Expert group – student research pages
- Water Cycle Expert Group Worksheet
- Water Cycle Diagram Worksheet
- Human Impacts on the Water Cycle Processes Worksheet

Precipitation	Evaporation	Transpiration
• A heat source to boil water • A pot in which to boil water • A Pyrex or other container with a handle • Ice cubes • A pie pan or other container • Oven mitts	• 2 small dishes or jar lids • 1 tablespoons • Water • Light source (sun or lamp/light) • Plastic wrap and or lids to cover dishes	• Two, clear plastic cups • 1 Square piece of cardboard for between the cups • 2 Tree leaves with stem (same size) • Petroleum jelly • Light source • Water • Wax pencil
Infiltration	**Runoff**	**Condensation**
• 4 funnels • 4 ring stands with rings • 4 beakers (25 ml) • 1 graduated cylinder (10ml) • Timer • Sand • Gravel • Soil • Clay	• Plastic box or pan at least one foot by two feet • Sandbox sand, enough to fill half the box • Two cups • One 20 cm by 20 cm square of sod or several smaller grass plugs • Water • Bucket or pot	• A clear plastic bottle with cap (A plastic two-liter pop bottle works best.) • A temperature strip - available from pet stores) • Tape • Matches

Part 1- Activities and Procedures for the Water Cycle Jigsaw Activity:

1. Ask students to imagine a day without water. What would that day look like? How would it be different from a normal day? Ask students to work with a partner to describe what their lives would be like without water. Invite groups to share their answers.

2. Water Notes: Use the Teacher Background Information Sheet to introduce students to water facts and terms. Emphasize the importance of water to all life forms.

3. Jigsaw Activity:

DAY 1

- Prepare demo material boxes for each expert group ahead of time.
- Divide the class into water cycle groups. There must be at least 6 students in each water cycle group.
- Explain to the students that they are going to each research a process in the water cycle for their group. Each student is responsible for teaching their group the process they learn about.
- Assign each student a number 1- 6. Each number represents an expert group.
  - 1 – Precipitation
  - 2 – Infiltration
  - 3 – Runoff
  - 4 – Evaporation
  - 5 – Transpiration
  - 6 – Condensation
- Regroup the students into their expert groups. All the 1's sit together….and so on.
- Give each expert group their Water Cycle Expert Group Worksheet and Information Worksheet with Demo Lab Activity. Pass out demo lab materials.
- Expert groups must take notes on their process and complete the demo activity.
- Explain to expert groups that they must create a short lesson on their process to teach to their water cycle groups.
- Lessons must include a 5-7 minute presentation, an illustration with labels, and handwritten notes to turn into the teacher.
- Give students one class period to work with their expert group.

DAY 2

- Regroup students back into their water cycle expert groups.
- Pass out the Water Cycle Diagram Worksheets.
- In their water cycle groups, have students present their process to the group, one at a time.
- While one student presents, the other students must complete the Water Cycle Diagram Worksheet.

Part 2- Activities and Procedures for How Human Activities Impact the Water Cycle:

1. Pass out the Human Impacts on the Water Cycle Processes Worksheet.
2. Have students read each of the 10 human activities and answer the questions that follow.
3. It might be beneficial to have students work in groups of 2-3 to discuss each activity.
4. As a class, go over the answer key and discuss each activity.

Assessments:

- Water Cycle Expert Group Worksheet
- Water Cycle Diagram Worksheet
- How Human Activities Impact the Water Cycle Worksheet

Adaptations:

- Allow students to use the Internet to do research for the jigsaw activity
- Have students make a PowerPoint presentation.

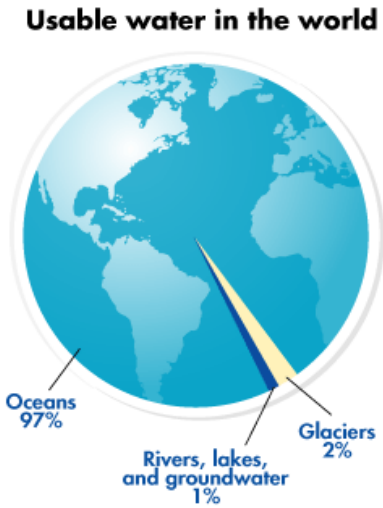
Extra Credit/Additional Resources:

- The Water Cycle - NASA
  http://earthobservatory.nasa.gov/Features/Water/
- Summary of the Water Cycle - USGS
  http://ga.water.usgs.gov/edu/watercyclesummary.html
- How Urbanization Affects the Hydrologic System - USGS
  http://ga.water.usgs.gov/edu/urbaneffects.html
- Ground Water and Surface Water: A Single Resource
  http://pubs.usgs.gov/circ/circ1139/
- How Big is Your Water Footprint?
  http://discovermagazine.com/2010/mar/29-how-big-is-your-water-footprint
- Online water footprint calculator
  http://watercalculator.fieldmuseum.org/
- Water Cycle Videos
  http://www.neok12.com/Water-Cycle.htm

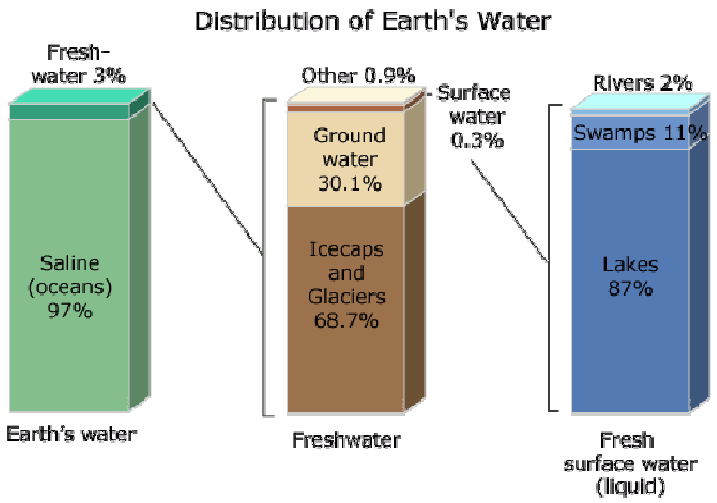
Teacher Background Information – Water and the Water Cycle

Water is essential for life. No living being on planet Earth can survive without it. It is a prerequisite for human health and well-being as well as for the preservation of the environment.

Scientists estimate that less than 1% of water is available for human use. Of the 1% available for human use, half lies a half-mile below the surface of the earth, out of the reach of man. The remaining water supply is in rivers, lakes and groundwater. The other 2% are locked up in glaciers. The remaining 97% of water is in the oceans, however, this water contains salt. We cannot drink salt water or use it for crops because it causes dehydration (loss of body fluids). We can remove salt from ocean water, but the process is very expensive.



Earth's water can exist as a gas stored in the atmosphere, a liquid stored in surface/ground water, or ice stored in ice caps or glaciers. Water that is not moving is stored in areas called **reservoirs.**



FRESH WATER RESERVOIRS
Atmosphere 0.9%
Surface water 0.3% • Lakes, rivers, swamps
Ground water 30.1%
Icecaps and glaciers 68.7%

Scientists also know that the water on our planet is constantly moving and changing forms. This movement of water is called the **water cycle or hydrologic cycle.**

There are **six** important processes that make up the water cycle.

1. **Precipitation** - When the temperature and atmospheric pressure are right, the small droplets of water in clouds form larger droplets and precipitation occurs. The raindrops fall to Earth.
2. **Infiltration** - Infiltration is an important process where rain water soaks into the ground, through the soil and underlying rock layers.
3. **Runoff** - Much of the water that returns to Earth as precipitation runs off the surface of the land, and flows down hill into streams, rivers, ponds and lakes.
4. **Evaporation** - The process where a liquid, in this case water, changes from its liquid state to a gaseous state.
5. **Transpiration** - As plants absorb water from the soil, the water moves from the roots through the stems to the leaves. Once the water reaches the leaves, some of it evaporates from the leaves, adding to the amount of water vapor in the air. This process of evaporation through plant leaves is called transpiration.
6. **Condensation** - The opposite of evaporation. Condensation occurs when a gas is changed into a liquid.

Other important terms:

- **Dew point-** The Dew Point is the temperature at which, if you cool the air, it will get to 100% relative humidity. If a the temperature drops to it's dew point, water will condense out of the air, and outside at night "dew" will form. The air holds less moisture as it gets colder. Basically, dew points tell you the amount of moisture in the air.
- **Frost point –**. When the dew point falls below freezing it is called the frost point.
- **Humidity -** The amount of water vapor in the air; the more water, the more humid it is.
- **Impermeable -** a layer of solid material, such as rock or clay, which does not allow water to pass through.
- **Permeable** - the ability of a material to allow the passage of water through it. Permeable materials are gravel and sand. They allow water to move quickly through them.
- **Saturated –** When all open spaces in the area below the water table are filled with water. Saturation can lead to flooding.
- **Unsaturated -** When the soil pores in the area above the water table are not full with water. In this situation, groundwater can be recharged.
- **Water Table –** most simply defined as the upper-level of groundwater.

* Teacher Background Information adapted from - Water for Life
http://www.un.org/waterforlifedecade/background.html

Name_____Date_____ Period_____

Water Cycle Expert Group Worksheet

1. Assigned process in the water cycle: _____
2. Take notes on your topic here:

3. Summarize what you observed and learned in your demo activity:

_____

_____

_____

_____

_____

4. Your group must develop a mini lesson, or report, to teach to your water cycle group. Your task is to explain the role of your process in the water cycle. You will have between 5-7 minutes to present your information. As a group, develop a mini lesson and write your report below:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

5. Illustration- Draw and label your process using n entire blank piece of paper. Be sure to write a title and label important structures. You can use this illustration when you teach your mini lesson.

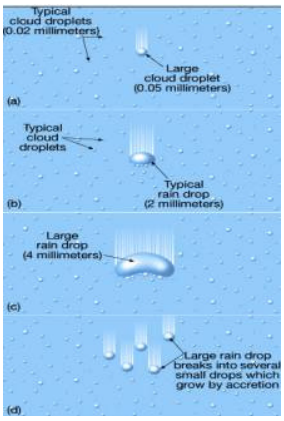
Expert Group 1: Precipitation

Adapted from http://www.kidsgeo.com/

Precipitation

Precipitation takes place when water condensation reaches a high enough level that water droplets are heavy enough to fall back to the surface of the Earth. Precipitation is a very common phenomena in the atmosphere of our Earth. This precipitation always comes from clouds. Yet most clouds do not form precipitation.

This is because the water droplets and ice crystals found in most clouds are too small, and thus not heavy enough to fall to the surface of the Earth. A raindrop large enough to have the weight needed to fall to Earth is millions of times larger than the individual water droplets found inside of most clouds. Two processes that allow raindrop formation have been identified: the Collision-Coalescence Process in "warm" clouds, and the Bergeron Process in "cold" clouds.



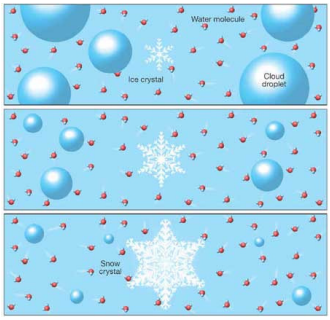
The Collision-Coalescence Process

This process occurs in “warm” clouds that have large water droplets present.

- As a large droplet falls through a cloud, it collides and coalesces (combines) with smaller water droplets in its path.
- Collision and coalescence are repeated over and over again until the droplet is so large that it is heavy enough to fall out of the cloud as a raindrop.

The Bergeron Process

The process occurs in “cold” clouds that contain water vapor, ice crystals and very cold liquid water droplets.



- Water vapor settles on the ice crystals.
- The ice crystals grow larger while the water droplets get smaller.
- As the ice crystals grow larger and heavier, they start to collide and coalesce with water droplets and ice crystals in their path, thereby growing still larger.
- Eventually, the ice crystals become so heavy that they fall out of the cloud.
- If the air below the cloud is above freezing, snowflakes melt and fall as raindrops.

Once a raindrop or a snowflake leaves a cloud, it enters unsaturated air where either evaporation or sublimation can take place. In general, the longer the journey to the ground and the lower the relative humidity of the air beneath the clouds, the greater the quantity of rain or snow that returns to the atmosphere as vapor through evaporation or sublimation.

Eventually an ice crystal or water droplet becomes big enough (heavy enough) to start to fall. Often the particles will catch updrafts as they fall and circulate in the cloud a few times to pick up more water or ice. Many particles that start out as ice crystals never reach the ground. For instance, if the air is very dry, they simply evaporate, while relatively warm air will change ice into rain, and strong winds can break ice crystals into smaller fragments.

How is precipitation measured?

Precipitation is collected and measured using a precipitation gauge (often referred to as a rain gauge) and is usually reported in millimeters or inches.

Types of Precipitation

After water vapor condenses forming ice crystals, and water droplets, it can take on a variety of forms as it falls to the Earth as precipitation. Each of these forms of precipitation is unique with its own important characteristics. *The main types of precipitation are rain, snow, sleet, freezing rain, and hail.*

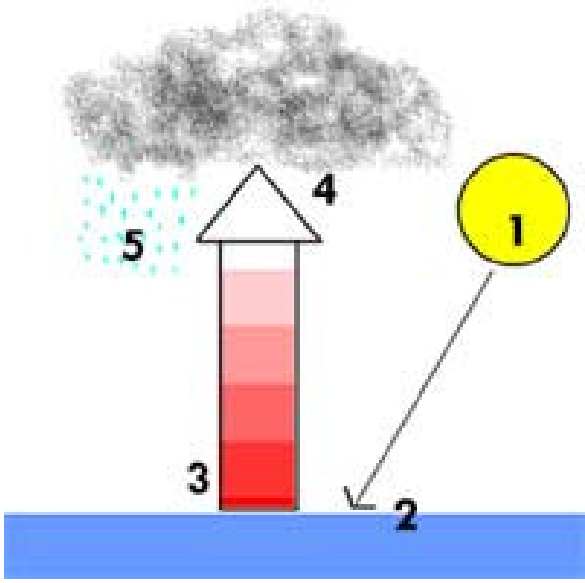
Rain

Rain is by far the most common type of precipitation in our atmosphere.

- Rain takes place when drops of liquid water fall all the way to the surface of the Earth.
- Rain often takes one of two main forms: showers and drizzles.
- A shower lasts just a brief period of time, and usually is made up of large heavy drops.
- Drizzles generally last much longer, and are made up of smaller finer droplets of water.
- Rain can either form as ice crystals melt, or as a collection of many smaller water droplets.

The creation of rain is a simple process to understand.

1. The sun is the driving force behind the process of convection which is the main process behind the creation of rain.
2. The sun heats up the sea and this in turn heats up the air. (The sun cannot directly heat the air.) When the water is heated, it turns to water vapor.
3. As the air is warmed, it rises up into the atmosphere, taking the water vapor with it. As it does so, it cools due to expansion.
4. Eventually, the air and vapor cool to the point where the vapor condenses, making it visible as clouds.
5. Water droplets within the clouds collide and join together to form rain drops, which fall back down to the sea / ground.



Snow

Snow forms when water vapor turns directly into ice without ever passing through a liquid state.

- This happens as water condenses around an ice crystal.
- Snow can take the form of ice pellets, or snowflakes.
- As snow falls to the ground, it often melts on the warm surface of the Earth.
- If the surface of the Earth is chilled sufficiently it begins to pile up creating snow drifts.
- In some locations, such as mountains, these snow drifts can reach several feet in depth.

Sleet

Sleet refers to a mixture of snow and rain, as well as raindrops that freeze on their way down. Unlike snow, the raindrops pass through a liquid form before freezing. The result is that they are not light and fluffy.

Freezing Rain / Glaze

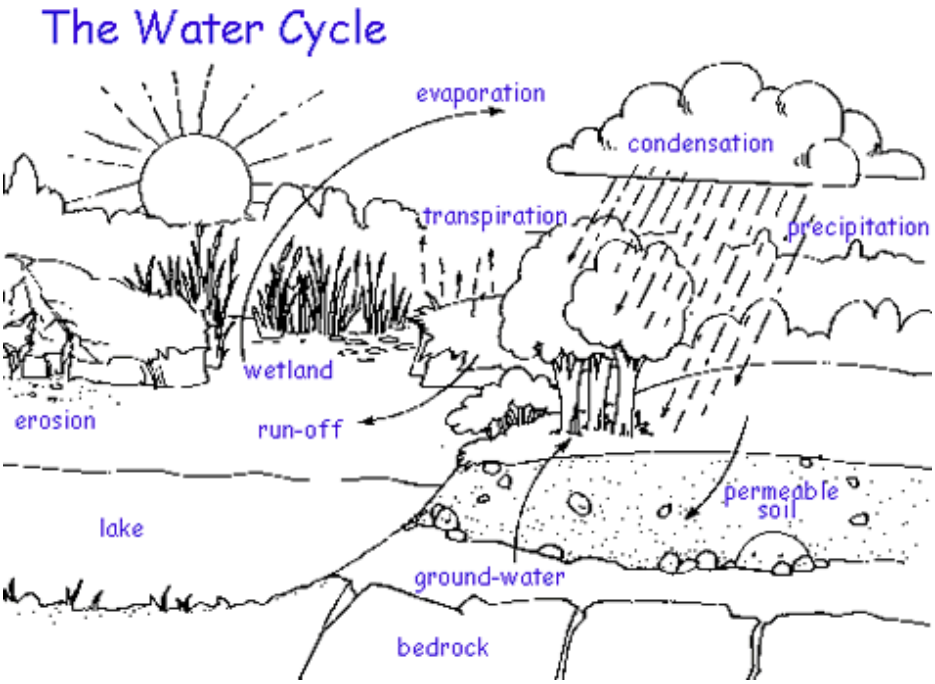
Freezing rain which is sometimes referred to as glaze, takes place when water droplets become super-chilled. They do not freeze in air, but rather freeze the instant they strike an object such as a road, or car. The result can make roads very slippery, and can cause car doors to become frozen shut.

Hail

Hail forms when moisture mixes with wind. Deep within clouds ice crystals form, and begin to fall towards the Earth's surface. As this happens, wind gusts pick up the ice crystals pushing them back up high into the clouds. As they begin to again fall down, they continue growing in size. Again, a wind gust might catch the growing hail stone pushing it back up high into the cloud. This process may be repeated several more times, until the hail stone becomes so large that it is too heavy for the wind to carry, causing it to fall towards the Earth.

The Water Cycle

- Precipitation is the process that occurs when any and all forms of water particles fall from the atmosphere and reach the ground.
- The two processes that cause clouds to release precipitation are the collision-coalescence process and the Bergeron process.
- As water drops reach a critical size, the drop is exposed to gravity and frictional drag.
- Precipitated water may fall into a body of water or it may fall onto land.
- It is then dispersed several ways.
- The water can adhere to objects on or near the planet surface or it can be carried over and through the land into stream channels, or it may penetrate into the soil, or it may be intercepted by plants.
- When rainfall is small and infrequent, a high percentage of precipitation is returned to the atmosphere by evaporation.
- The portion of precipitation that appears in surface streams is called runoff.



Source: http://www.on.ec.gc.ca/community/classroom/c5-water-cycle-ans-e.html

Demo for Precipitation

Materials

- A heat source to boil water
- A pot in which to boil water
- A Pyrex or other container with a handle
- Ice cubes
- A pie tin or other flat container
- Oven mitts

Safety

- Use oven mitts while handling heat source and hot water

Discussion Questions for Expert Group

Answer the following questions, as a group, before the activity:

1. What is rain? How does rain happen?
2. What is snow? How does snow happen?
3. What is hail?
4. What do you think will happen to the bowl of ice, to the steam, to the bottom of the bowl?

Focus on these questions during the next activity.

Procedures

1. Place a pot of water on the heat source until it comes to a boil.
2. Fill the Pyrex pot with ice.
3. Once the water is boiling, hold the bowl of ice over the steam.
4. Place the pie tin so that the water which drips from the bottom of the bowl will collect in the tin.
5. Continue to hold the pot of ice over the boiling water until you have had a clear view of what is happening on the surface of the pot with the ice.

Explanation

The small misty drops which have condensed onto the side of the bowl of ice represent a cloud.

- The winds in a cloud blow the small drops around so that they collide with one another.
- During these collisions, some drops will combine with others making bigger and bigger drops.
- When the drops become so large that the upward motion of the air cannot keep them in the sky, the drops fall as precipitation.
- If the temperature is cold enough the drops will freeze as crystals, making snow. If the drops come together first and then freeze, the precipitation will be hail.

Answer the following questions with your expert group:

- What do you see happening on the bottom of the bowl?
- What do you see happening in the pie tin?
- How does the water get on the bowl?
- Are the water drops on the side of the bowl the same size? Why?
- Which drops are falling from the bowl? Why?
- Which drops look like rain?
- Which drops look like a cloud?
- How are the big drops formed?

Expert Group 2: Condensation

Adapted from http://www.kidsgeo.com/

Water in the atmosphere is a gas called water vapor. To condense means to make the volume smaller or more compact.

Condensation takes place when water vapor in the air condenses from a gas, back into a liquid form, and leaves the atmosphere, returning to the surface of the Earth. Condensation is the opposite of evaporation. Condensation occurs when warm air cools.

Usually in order for condensation to take place, the atmosphere must be fully saturated with water vapor. In other words, the maximum vapor pressure must have been reached.
In addition to being saturated, the nature of water requires that there be a surface upon which water can condense. This surface might be blades of grass, or windows. In the atmosphere condensation often takes place around dust particles, or other particulates such as smoke, and even microscopic bacteria.

Examples of Condensation:

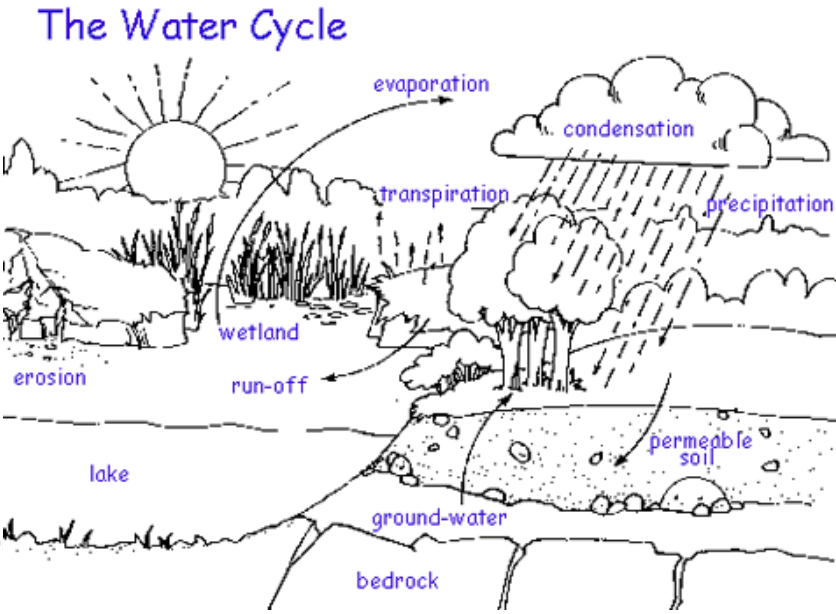
- **Dew:** Water droplets formed by condensation of water vapor on a relatively cold surface of an object. It forms when the temperature of an object drops below the dew point temperature.

- **Fog:** Suspended tiny water droplets or ice crystals in an air layer next to the Earth's surface that reduces the visibility to 1000 m (3250 ft.) or lower.

- **Cloud:** Visible collection of tiny water droplets suspended in the air. It forms when water vapor in the air cools and condenses into a liquid drop.
- Water drops forming on a glass holding a cold drink on a hot summer day.

The Water Cycle

- Condensation is the process by which water vapor changes its physical state from a vapor to a liquid.
- Water vapor in the atmosphere condenses onto small airborne particles to form dew, fog, or clouds.
- Condensation is brought about by the cooling of the air .



Source: http://www.on.ec.gc.ca/community/classroom/c5-water-cycle-ans-e.html

Demo for Condensation

Cloud in a bottle -- *You will need to follow these directions exactly*

Materials

- A clear plastic bottle with cap (A plastic two-liter pop bottle works best)
- A temperature strip - available from pet stores)
- Tape
- Matches

Safety

- Do not overdo the squeezing or it will pop.
- Sometimes it doesn't work, just keep trying.
- Use matches with caution.
- Be careful not to burn yourself while squeezing the bottle, the hot water might condense to go outside the bottle.

Procedures

1. Tape the temperature strip inside the bottle so that you can read it. Screw the bottle cap on tightly.
2. Lay the bottle on its side so that you can easily read the temperature strip.
3. Read and record the temperature of the air inside the bottle.
   _____degrees
4. Now use both hands to squeeze the bottle as hard as you can. After about 1 minute, stop squeezing and read and record the temperature strip. _____ degrees
5. Answer the questions below:
   - What happened to the temperature when you squeezed the bottle?
   - What happened to the temperature after you stopped squeezing the bottle?
6. Open the bottle and drop in 10 droplets of water. Screw the bottle cap on tightly.
7. Swirl the water around the inside of the bottle so that most of the inside of the bottle is wet.
6. Read and record the temperature of the air inside the bottle.
   _____degrees
7. Now use both hands to squeeze the bottle as hard as you can. After about 1 minute, stop squeezing and read and record the temperature strip. _____ degrees
8. Answer the questions below:
   - What happened?
9. Lay the bottle on its side, while pushing push down to flatten the bottle to about 1/2 of its normal size, unscrew the cap and open the bottle.

10. Have someone light a match, blow it out, and put the match into the bottle while it is still smoldering. Quickly release the sides of the bottle and put the cap on tightly.
11. Squeeze the bottle as before, very tightly, for about 1 minute. Quickly let the bottle pop back to its original shape.

    - What happened? (*You should be able to see a cloud.*)

Explanation

Squeezing the sides of the bottle forces the particles to squeeze together or compress. Letting the pressure go lets the air expand, and by doing that, the temperature of the air becomes colder. This cooling procedure lets the particles stick together more easily making tiny droplets around the smoke molecules. Most water droplets are created when water vapor condenses around a condensation nucleus, a tiny particle of smoke, dust, ash, or salt. Clouds in the sky come together while the unseen water vapor in the air condenses into visible water droplets or ice crystals.

Answer the following questions with your expert group:

- Liquid water evaporates and becomes water vapor (note how the terms are similar). Water vapor cannot be seen. When water vapor rises into the atmosphere it becomes clouds and you can see clouds. What are clouds made from?

- In your own words, describe the relationship between changes in air pressure and temperature. What does this relationship have to do with clouds?

Expert Group 3: Evaporation

Adapted from http://www.kidsgeo.com/

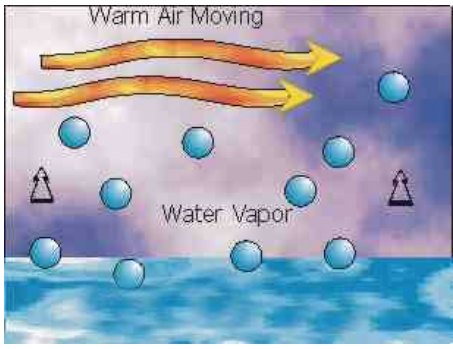
The process of water molecules escaping the surface of the Earth and entering the atmosphere is known as evaporation. Evaporation takes place, as molecules of water escape from a collective body of water. This can be a puddle, a lake, a stream, or just a droplet of water.

As water molecules evaporate, they take with them some of the heat from the object from which they evaporated. This heat is stored in the water molecule, and is referred to as latent heat. The result is that the object's temperature is lowered slightly. Consider what happens to your body on a hot day. As the temperature rises, your body begins to produce sweat. As the sweat evaporates it carries with it some of the heat from your body, causing your body to cool down.

The process of cooling an object via evaporation is known as evaporative cooling. Many air conditioners are actually evaporative coolers, and work by taking advantage of this process.

Some important factors affecting the speed of evaporation are temperature, the amount of water vapor already in the air, and the local wind speed.

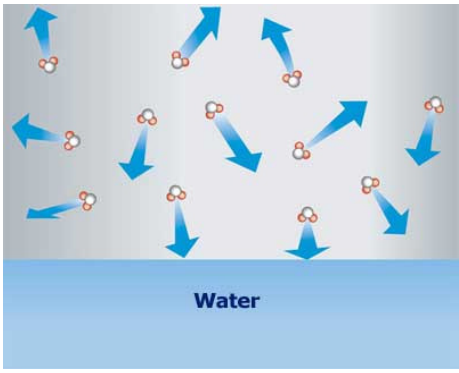
Evaporation and Temperature



Evaporation can take place at any *temperature*. However, increasing the temperature of a body of water also often increases evaporation. This is because as the temperature rises, the water molecules begin moving about more rapidly. This increases the odds that molecules will escape.

Warmer air also affects the *speed* of evaporation. Even if a body of water is cool, warm air above the water can transport some of its energy to the water molecules, allowing them to escape more rapidly.

Amount of Water Vapor in The Air



There is a limit to how much water vapor can enter the atmosphere. As more water vapor enters the atmosphere, the amount of pressure exerted by that water vapor increases. We call this pressure the *vapor pressure*. The higher the temperature of the atmosphere, the more vapor pressure it can withstand. When the vapor pressure maximum is reached, no more water can enter the atmosphere. At this point, we say that the atmosphere is completely **saturated**.

Because the maximum vapor pressure increases with temperature, warmer air can hold more water vapor before becoming saturated.

Evaporation and Local Wind Speed

Wind changes the maximum vapor pressure for the air in the atmosphere. As wind moves the air about rapidly, it causes the air to expand. This creates more room for additional water vapor. Thus, even if the maximum vapor pressure has already been reached, evaporation can continue if the wind begins to blow.

Humidity

The amount of water vapor in the air is referred to as **humidity**. The more water that is in the air, the higher we say that the humidity has risen.

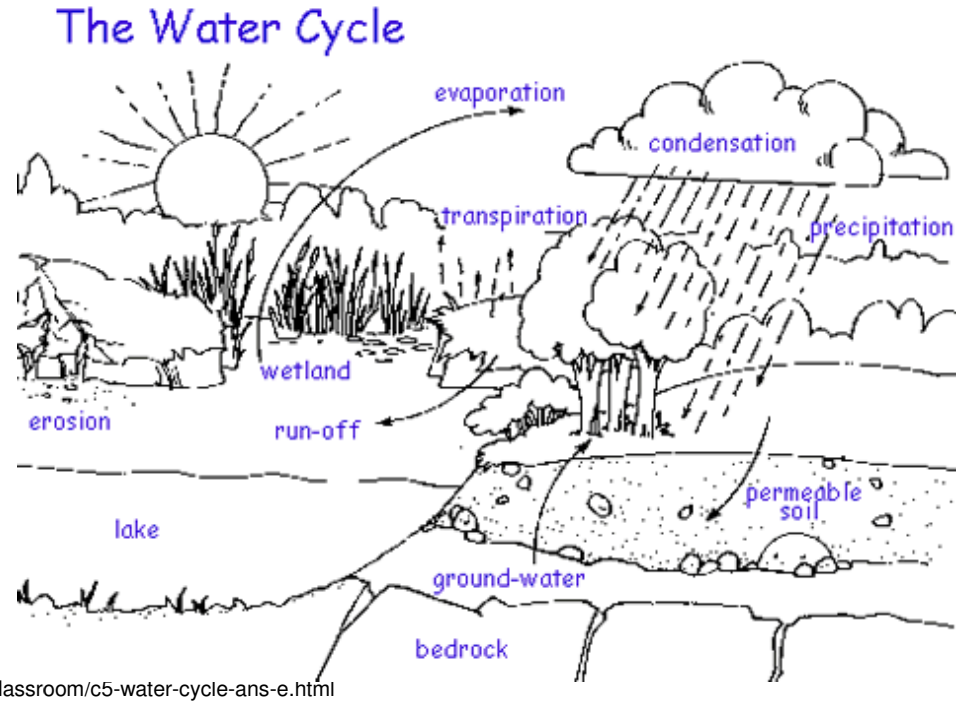
Humidity can be measured in a number of ways. These include absolute humidity, specific humidity, and relative humidity.

- Absolute, and specific humidity measure the exact physical amount of water in the air.
- Relative humidity compares how much water is in the air, with how much could be in the air, or in other words, with the maximum vapor pressure.
- Suppose that given the local temperature and wind, the maximum vapor pressure allows a certain volume of air to hold 100 pounds of water.
- Now suppose that this same volume of air is only holding 30 pounds of air.
- *The relative humidity would be 30%, because only 30% of the maximum vapor pressure has been reached.*
- Thus relative humidity does not tell us how much water vapor is in the air, but rather, what percentage of the maximum vapor pressure has been reached.
- Relative humidity is the most common way that we measure humidity.

The Water Cycle

Evaporation occurs when water is changed from a liquid to a gas. A considerable amount of heat is exchanged during the change of state.

- Solar radiation, air temperature, vapor pressure, wind, and atmospheric pressure affect the amount of natural evaporation that takes place in any geographic area.
- Evaporation can occur on raindrops, and on free water surfaces such as seas and lakes.
- It can even occur from water settled on vegetation, soil, rocks and snow.
- There is also evaporation caused by human activities.
- Heated buildings experience evaporation of water settled on its surfaces.
- Evaporated moisture is lifted into the atmosphere from the ocean, land surfaces, and water bodies as water vapor.
- Some vapor always exists in the atmosphere.



Source: http://www.on.ec.gc.ca/community/classroom/c5-water-cycle-ans-e.html

Demo for Evaporation

Materials

- 2 small dishes or jar lids
- 1 tablespoon
- Water
- Light source (sun or lamp/light)
- Plastic wrap and or lids to cover dishes

Expert Group Discussion Questions:
Answer the following questions, as a group, before the activity:

1. Where does the water go after it forms puddles on the pavement?
2. Where does the water go from the clothes you put in the dryer?
3. Predict what will happen to the water if it is left out overnight in an uncovered dish.
4. Predict what will happen to the water if a dish is covered.

Procedures

1. Put 1 tablespoon of water in two separate dishes.
2. Place one dish in the light source, uncovered.
3. Place one dish is a shaded area, uncovered.
4. Wait 10 minutes. Record observations.
5. Repeat steps 1-4, except cover the dishes. Record observations.

Explanation

The disappearing water did not actually disappear, it went into the air. The process of water "going" into the air is called evaporation. The water vapor molecules are too small to see, so it appears they vanished.

Answer the following questions with your expert group:

1. Which dish evaporated faster?

2. Where did the water go?

3. How did the water evaporate?

Expert Group 4: Transpiration

*Adapted from Georgian Court University, Louise Wootton - http://gcuonline.georgian.edu/wootton_l/transpiration.htm

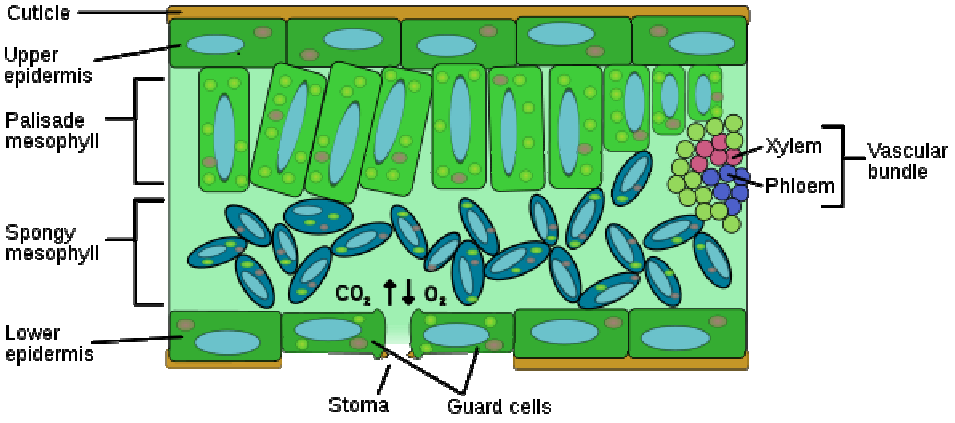
Transpiration is when plants release oxygen gas and water vapors into the atmosphere through their pores. The atmosphere, releases the carbon dioxide that the plant needs to complete the process of photosynthesis.

Transpiration in plants is similar to perspiration in humans. Just like humans sweat and lose water, plants do the same. Sweating provides cooling relief to the plant's foliage as a response to high temperatures and sunlight. Too much heat causes the rapid evaporation of moisture.

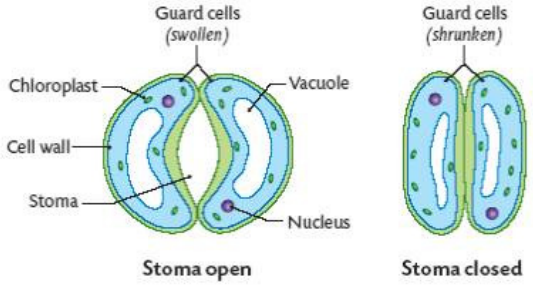
It is essential to understand some basic structures in a leaf, in order to better understand transpiration.

- The epidermis of a leaf is like the skin. There is a top layer, upper epidermis, and a bottom layer, lower epidermis.
- The cuticle is a waxy layer on the top of the leaf that provides protection.
- Xlyem and phloem specialized cells transport food, water, and minerals.
- The mesophyll is the 'meat' of the plant (the inside area).
- The stoma or stomata is an opening, or pore, where gases can move in and out.
- The guard cells surround the stoma; they regulate when the stoma are open or closed

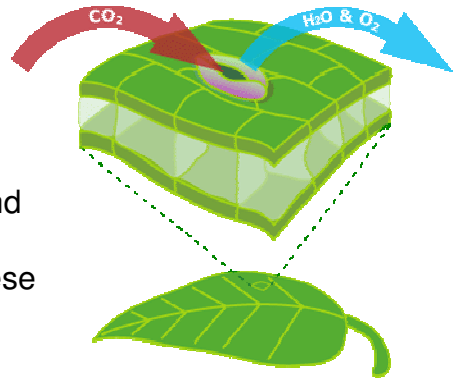
Leaf Cross Section



There are hundreds of stoma in the epidermis of a leaf. Most are located in the lower epidermis. This reduces water loss because the lower surface receives less sunlight than the upper surface. Each stoma allows the carbon dioxide necessary for photosynthesis to enter, while water evaporates through each one during transpiration.



How Plants Breathe



- Air containing carbon dioxide enters the plant through stoma when they are open.
- The carbon dioxide is required for the processes of photosynthesis and respiration.
- Oxygen and water vapor produced by photosynthesis exit through these same stoma.

Transpiration is an important and essential process. It helps keep the plant healthy and therefore contributes to our survival, since photosynthesis must take place in order to supply our oxygen.

Transpiration is also considered detrimental to plant life, since it can result in the loss of water which cannot be replenished. If a plant loses too much water, it can wilt or die. Farmers must closely monitor their crops' transpiration activities.

Factors Affecting Transpiration

The amount of water that plants transpire varies greatly both geographically and over time. There are a number of factors that determine transpiration rates:

- **Temperature**: Transpiration rates go up as the temperature goes up, especially during the growing season, when the air is warmer due to stronger sunlight and warmer air masses. Higher temperatures cause the plant's guard cells which control the openings (stoma), where water is released to the atmosphere, to open, whereas colder temperatures cause the openings to close.

- **Relative humidity**: As the relative humidity of the air surrounding the plant rises, the transpiration rate falls. It is easier for water to evaporate into dryer air than into more saturated air.

- **Wind and air movement**: Increased movement of the air around a plant will result in a higher transpiration rate. This is somewhat related to the relative humidity of the air, in that as water transpires from a leaf, the water saturates the air surrounding the leaf. If there is no wind, the air around the leaf may not move very much, raising the humidity of the air around the leaf. Wind will move the air around, resulting in the more saturated air close to the leaf being replaced by drier air.

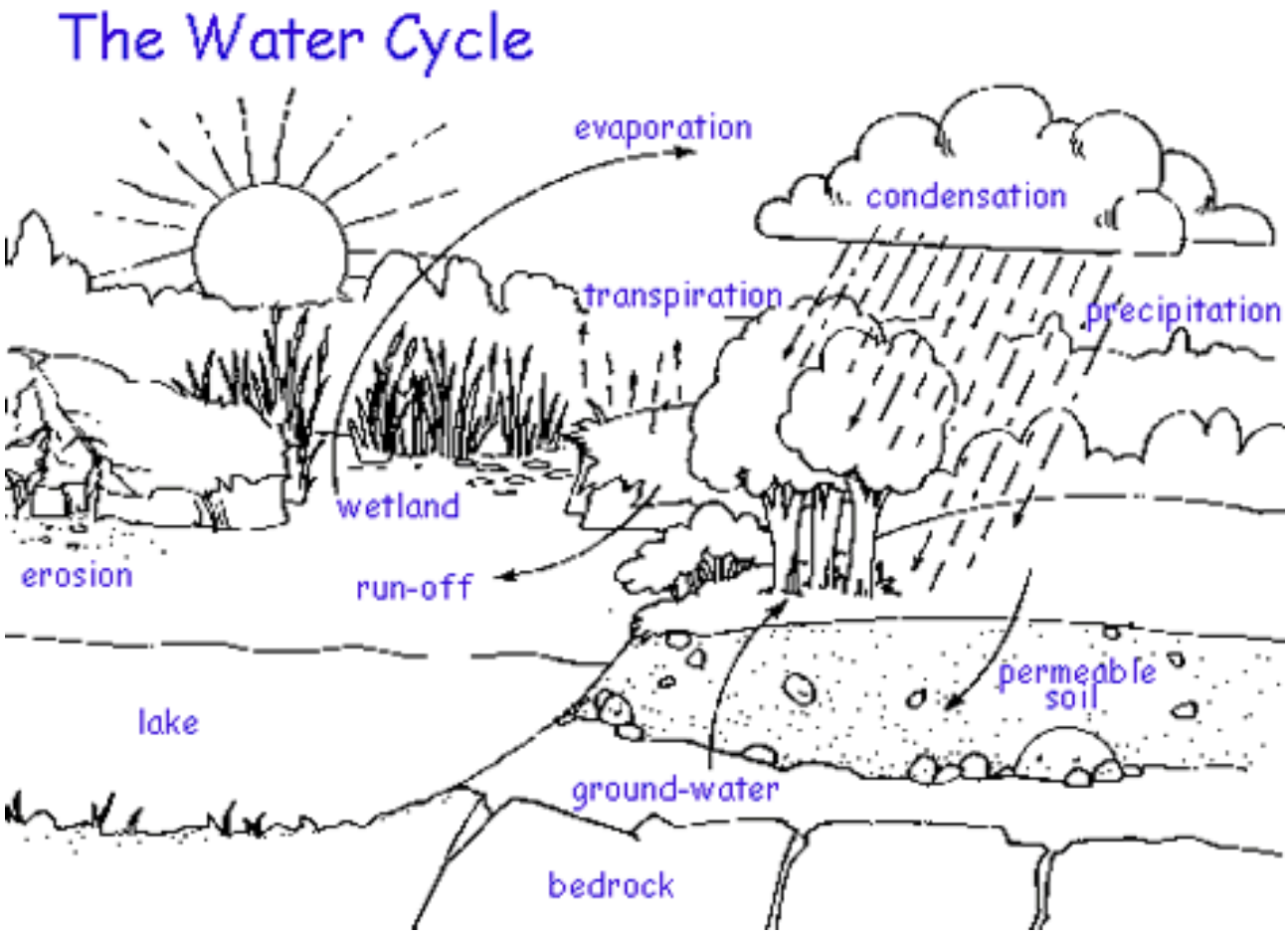
- **Soil-moisture availability**: When soil moisture is lacking, plants can begin to senesce (premature ageing, which can result in leaf loss) and transpire less water.

- **Type of plant**: Plants transpire water at different rates. Some plants which grow in arid regions—for example, cacti and succulents—conserve precious water by transpiring less water than other plants.

The Water Cycle

Transpiration is the biological process that occurs mostly in the day. Water inside of plants is transferred from the plant to the atmosphere, as water vapor exits through numerous individual openings (stoma) on the leaves. As plants transpire, they move nutrients to their upper portions and cool their leaves that are exposed to the sun. Leaves undergoing rapid transpiration can be significantly cooler than the surrounding air.

Transpiration vapors collect as precipitation in the atmosphere.



Source: http://www.on.ec.gc.ca/community/classroom/c5-water-cycle-ans-e.html

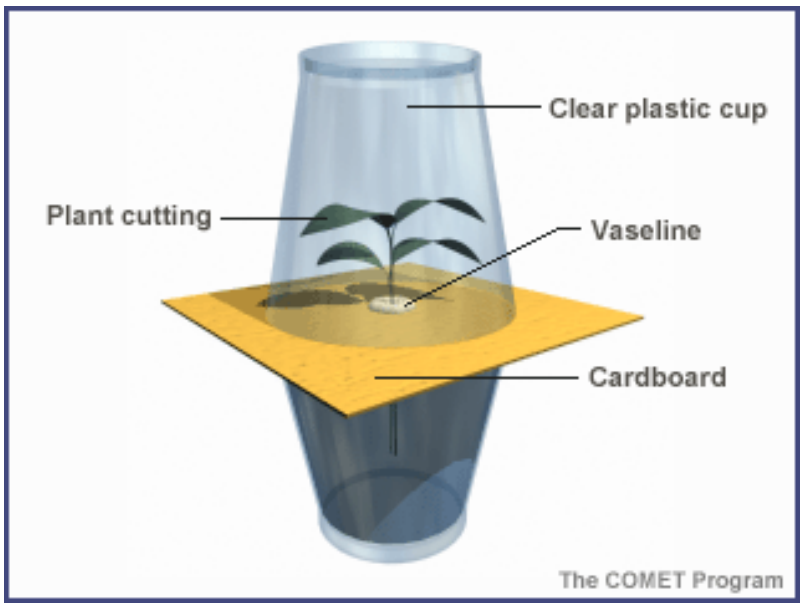
Demo for Transpiration

Materials and Resources

- Two, clear plastic cups
- 1 Square piece of cardboard for between the cups
- 2 Tree leaves with stem (same size)
- Petroleum jelly
- Light source
- Water
- Wax pencil
- Scissors (Use carefully, especially if cutting woody stems!)

Procedures

1. Using the scissors CAREFULLY, make a small hole (just big enough for the plant stem) in the center of the piece of cardboard.
2. Cut the stem on an angle immediately before use, since an angle cut exposes a larger area of the stem for water intake.
3. Pull the plant stem through the hole and seal around the hole with petroleum jelly.
4. Fill the bottom cup with 25 ml of water and mark the level on the plastic cup with a wax pencil.
5. Place the stem with the cardboard collar into the cup.
6. Cover with the clear plastic cup as shown.
7. Put the small terrarium under a lamp for 15 minutes.
8. After 15 minutes, observe both sides of the leaves. Record your observations.



Explanation

The air surrounding the plant is getting heated by the lamp. The hot air is causing the plant to sweat. Water inside the plant cells is being released, to cool the leaves. Water from the bottom of the cup is moving up the stem to replace water lost from transpiration.

Answer the following questions with your expert group:

1. What did you notice about the upper layer of the leaves? What did you notice about the bottom layer?

2. What happened to the volume of water in the bottom of the cup?

3. Predict what would happen if the plant was placed in a windy spot.

Expert Group 5: Infiltration

Adapted from http://www.kidsgeo.com/

Infiltration happens when water, from rain, snow, or other forms of precipitation, soaks into the soil at the ground level. It moves underground and moves between the soil and rocks.

Some of the water will be soaked up by roots to help plants grow. The plant leaves eventually release the water into the air through transpiration.

The rest of the water continues to move below the soil. The water beneath the Earth's surface is called **ground water**.

Groundwater is found underground in the cracks and spaces in soil, sand and rock. Groundwater is stored in--and moves slowly through--layers of soil, sand and rocks called **aquifers**. Aquifers are an important water source for many communities throughout the world. Wells can be drilled to pump water out for domestic use, industry, and agriculture.

Aquifers typically consist of gravel, sand, sandstone, or fractured rock, like limestone. These materials are permeable because they have large connected spaces that allow water to flow through.

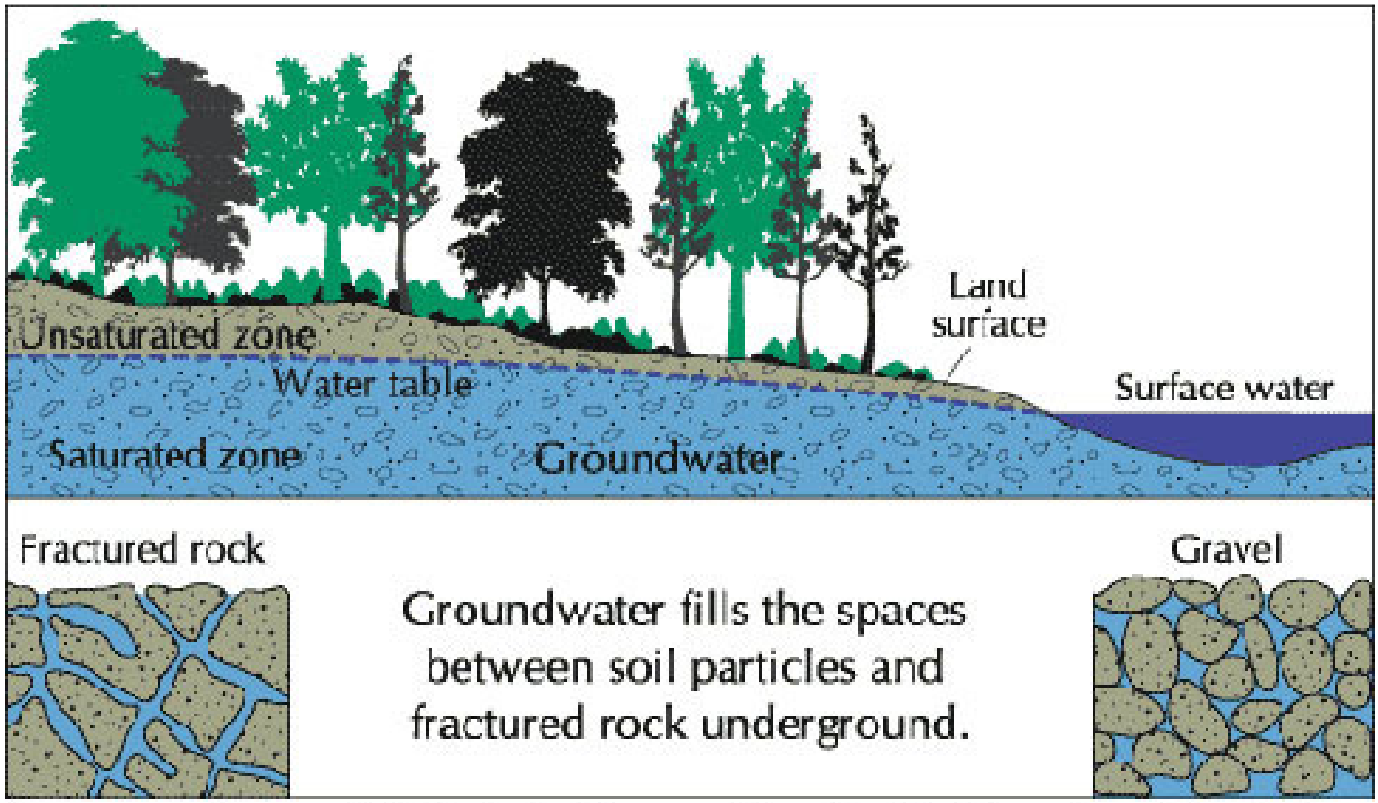
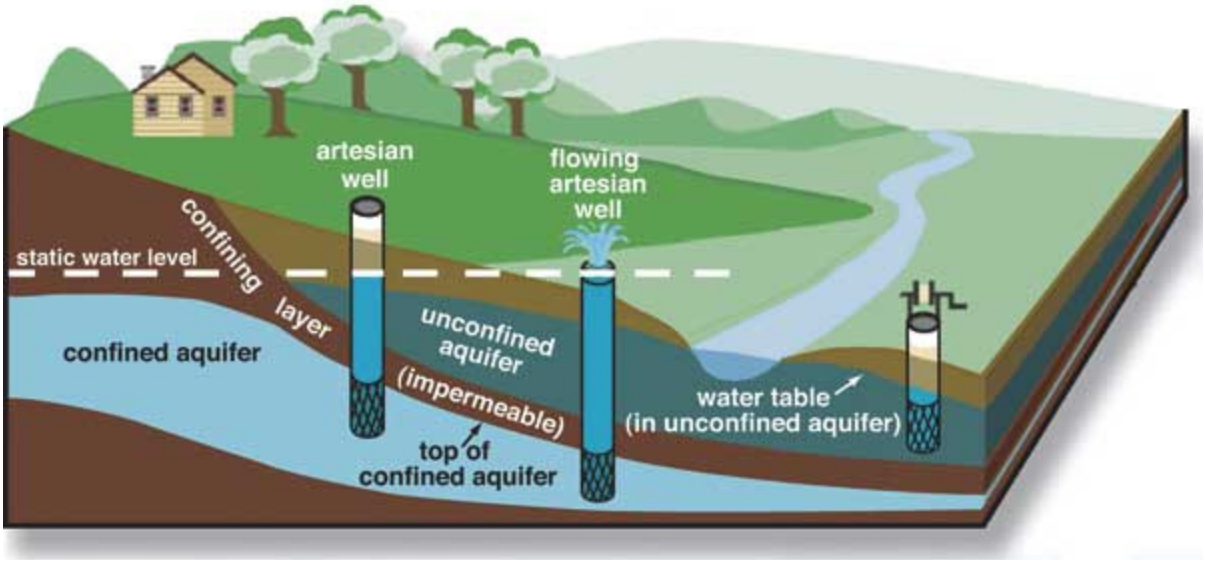


Image compliments of US Geological Survey, adapted by The Groundwater Foundation.

The area where water fills the aquifer is called the **saturated zone**. The top of this zone is called the **water table**. The water table may be located only a foot below the ground's surface or it can sit hundreds of feet down.

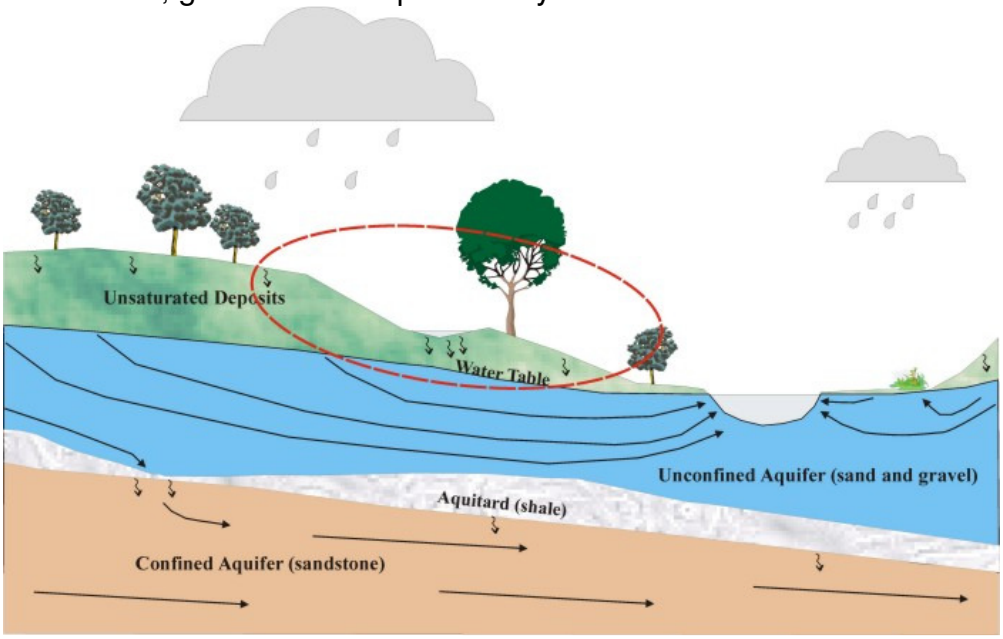
Groundwater can be found almost everywhere. The water table may be deep or shallow; and may rise or fall depending on many factors. Heavy rains or melting snow may cause the water table to rise, or heavy pumping of groundwater supplies may cause the water table to fall.

Water in aquifers is brought to the surface naturally through a spring or can be discharged into lakes and streams. Groundwater can also be extracted through a well drilled into the aquifer. A well is a pipe in the ground that fills with groundwater. This water can be brought to the surface by a pump. **Shallow wells** may go dry if the water table falls below the bottom of the well. Some wells, called **artesian wells**, do not need a pump because of natural pressures that force the water up and out of the well.



Source: http://www.on.ec.gc.ca

Groundwater supplies are replenished, or **recharged**, by rain and snow melt. In some areas of the world, people face serious water shortages because groundwater is used faster than it is naturally replenished. In other areas, groundwater is polluted by human activities.



Source: http://www.on.ec.gc.ca

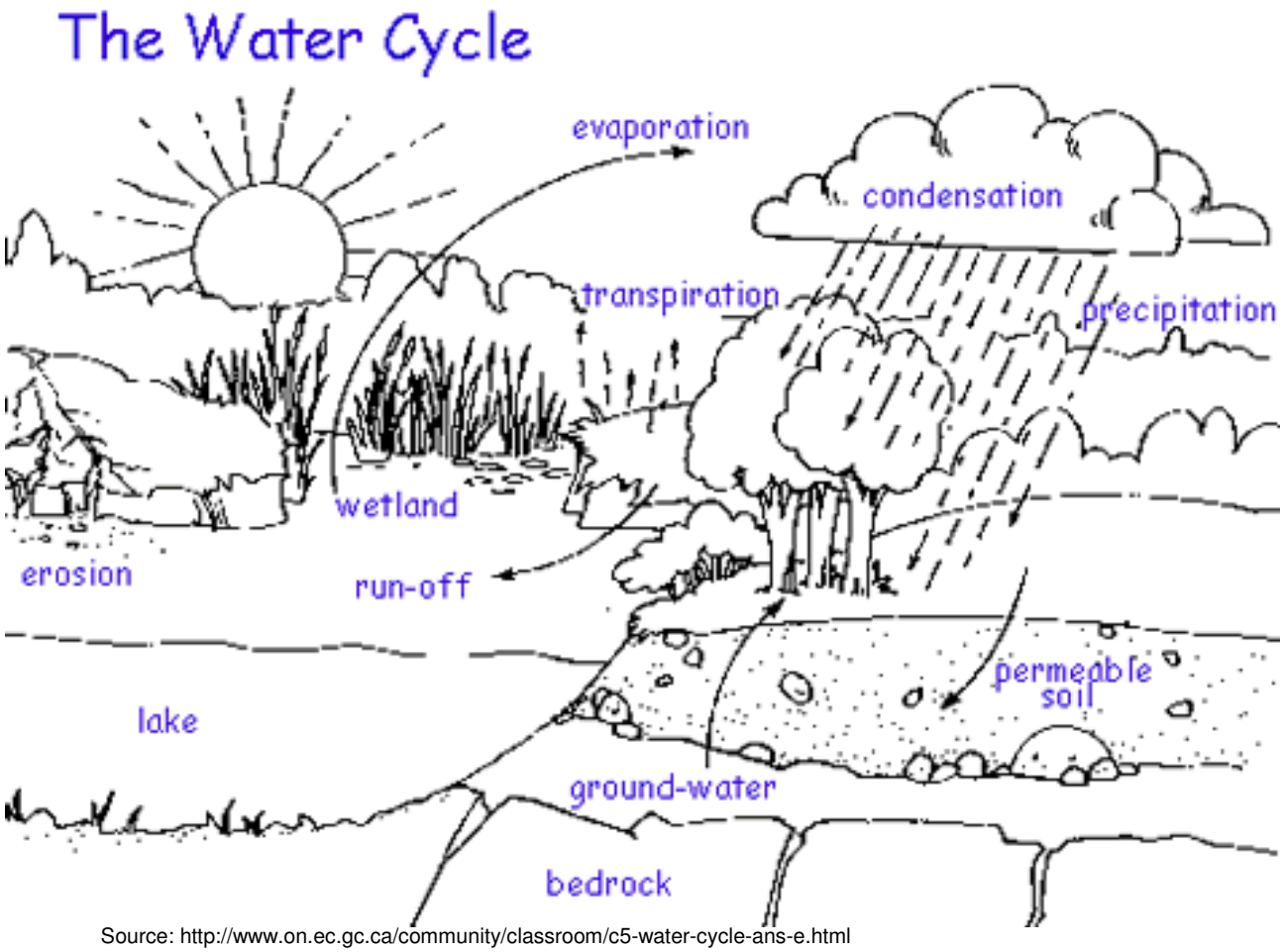
In areas where material above the aquifer is permeable, pollutants can readily sink into groundwater supplies. Groundwater can be polluted by landfills, septic tanks, leaky underground gas tanks, and from overuse of fertilizers and pesticides. If groundwater becomes polluted, it will no longer be safe to drink.

Groundwater is used for drinking water by more than 50 percent of the people in the United States, including almost everyone who lives in rural areas. The largest use for groundwater is for irrigating crops.

The Water Cycle

Infiltration can be great or small, depending on the permeability of the ground. The soil of a rainforest, for instance, has so much organic matter that it is likely to be highly permeable. On the other hand, cities have large amounts of what land developers call impervious surfaces: roads, buildings, and other areas in which concrete and other materials prevent water from infiltrating the ground.

Assuming that water is unable to infiltrate, it becomes **runoff**. Runoff is simply surface water, which may take the form of streams, rivers, lakes, and oceans. If runoff occurs in an area that is not already a body of water, flood conditions may ensue. Thus, water may either infiltrate or become runoff, but as long as it remains close to the surface, it will experience evaporation.



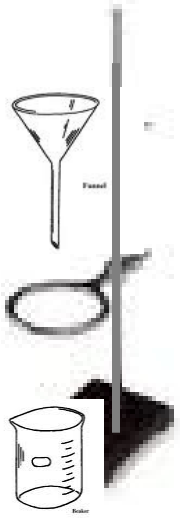
Source: http://www.on.ec.gc.ca/community/classroom/c5-water-cycle-ans-e.html

Demo for Infiltration: Permeable vs. Nonpermeable

Materials

- 4 funnels
- 4 ring stands with rings
- 4 beakers (25 ml)
- 1 graduated cylinder (10ml)
- Timer
- Sand
- Gravel
- Soil
- Clay
- Wax Pencil

Procedures



1. Place a funnel in each ring, and a beaker below the funnel on the ring stand.
2. Number each funnel, 1, 2, 3, and 4 with a wax pencil.
3. Fill the funnels with: #1-sand, #2-gravel, #3-soil, and #4-clay.
4. Pour 10 ml of water into funnel #1, start the timer and record how long it takes for the water to travel to the beaker. Stop the timer after 3 minutes.
5. Record the level of water in the beaker.
6. Repeat steps 4 & 5 for each funnel.

Funnel	Time (sec)	Amount of water in beaker (ml)
1.		
2.		
3.		
4.		

Answer the following questions with your expert group:

1. Which material was the most permeable? Why?

2. Which material was impermeable? Why?

3. What is a problem cities have when they build streets, parking lots, sidewalks, and buildings?

Explanation

Permeable surfaces allow water to percolate into the soil to filter out pollutants and **recharge** the water table. Impermeable surfaces are solid surfaces that don't allow water to penetrate, forcing it to run off.

Impermeable Surfaces: clay, asphalt, concrete, brick, pavers
Permeable Surfaces: soil, mulch, gravel, sand

Impermeable surfaces can negatively impact the environment. Urban and suburban sites typically contain large areas of impermeable surfaces, causing a host of problems:

1. **Pollution of surface water.** When storm water runs off impermeable surfaces, it picks up pollutants as it flows into storm drains. The contaminated water then flows directly into rivers, lakes, wetlands and oceans, generating problems for biodiversity as well as public health.

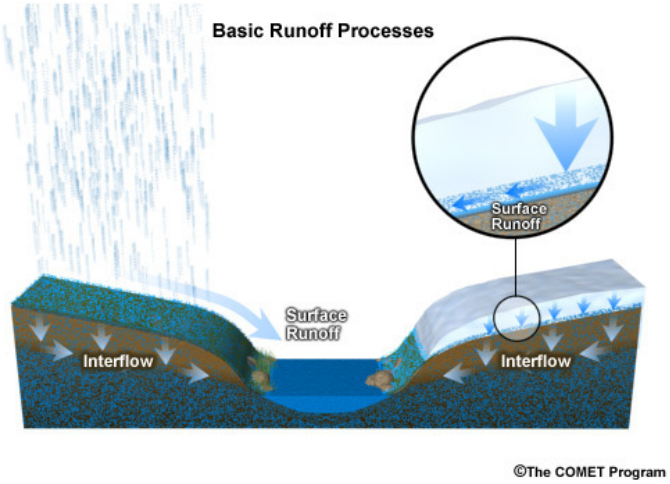
2. **Flooding of surface water and erosion of stream banks.** During periods of heavy rainfall, large amounts of impermeable surfaces generate large amounts of runoff. This sudden influx of runoff into rivers can cause flash flooding and erosion of stream banks.

3. **Water table is not adequately recharged.** Because impermeable surfaces send rainwater into storm drains rather than allow it to percolate down to our aquifers, groundwater may be used faster than it is recharged.

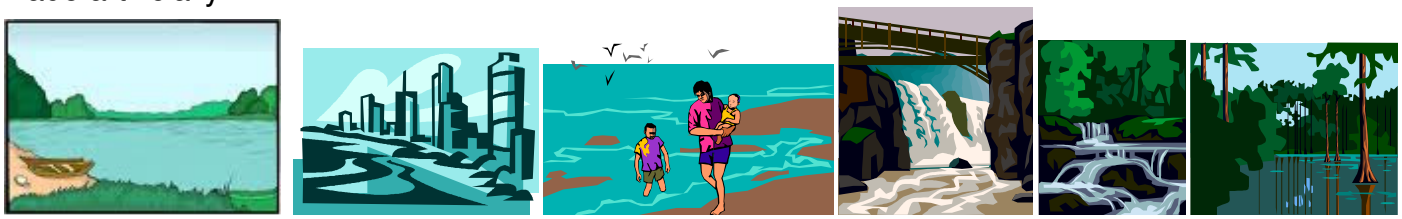
Expert Group 6: Runoff

Adapted from http://www.kidsgeo.com/

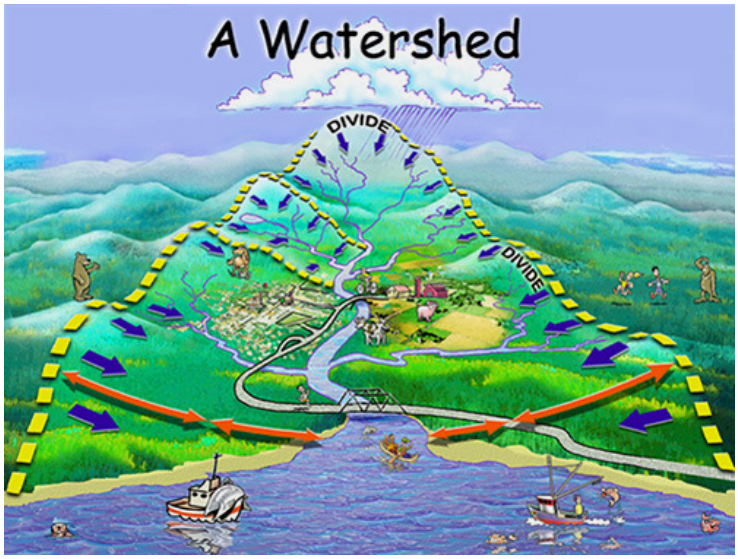
Runoff, or surface runoff, is water from rain, snowmelt, or other sources that flow over the land surface.



Water found above the ground is called surface water. That is because it is located or seen on the Earth's surface. Oceans, lakes, rivers, streams, and wetlands are examples of natural surface water. Most surface water bodies are natural; however, there are many bodies of surface water that are made artificially.



The area where water drains off the land into a river or lake is called a **drainage basin or watershed**. Water that drains off the land into the basin is called **runoff**. Many things determine the runoff in a drainage basin. Water moves slowly along flat land or a gently sloping hill. When the water moves more slowly, it can evaporate or soak into the ground. A steep slope will cause water to flow more quickly into a surface water body. That is why drainage basins with steep slopes often flood.



Vegetation such as plants, trees, and grass help slow the water flowing through a basin. Trees and other plants also help to hold water on or above the ground. By doing so, they allow the water time to soak into the ground or to evaporate.

Different kinds of soil have differing abilities to hold water. Water moves more quickly and easily through layers of sand and gravel than through clay. This is because clay is not as permeable as sand or gravel.

Permeability is how fast water can flow through an object. Because clay particles fit tightly together, water does not flow through clay very easily. Clay is said to be impermeable. The next time it rains, watch what happens to the water running off the sidewalk or street near your home, and then watch the water that falls on ground covered with trees, grass, or other plants. Notice off of which type of surface there is water flowing faster. Rainwater that runs off a paved surface and does not soak into the ground is called storm water runoff. This water usually flows into the nearest body of water.

Runoff that occurs on surfaces before reaching a channel is also called **overland flow**.

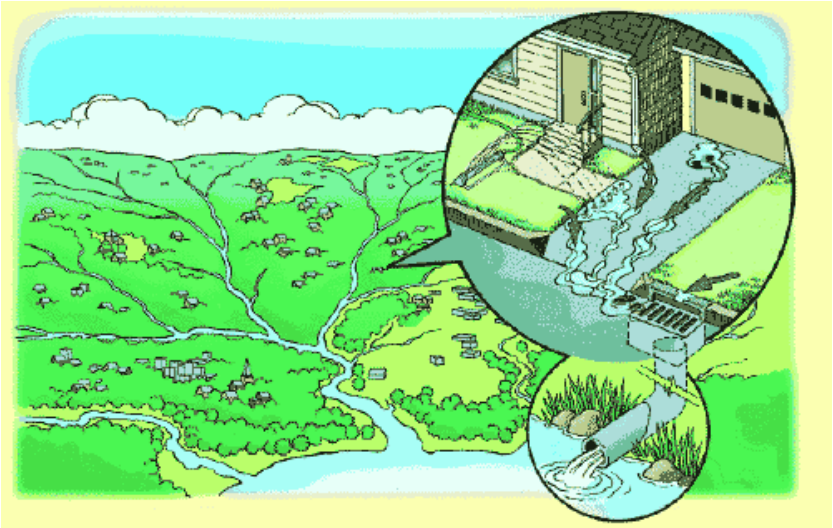
A land area which produces runoff draining to a common point is called a **watershed**.

When runoff flows along the ground, it can pick up soil contaminants such as petroleum, pesticides, or fertilizers that become discharge or overland flow.

Urbanization increases surface runoff, by creating more impervious surfaces. Pavement and buildings do not allow percolation of the water down through the soil to the aquifer.

Water is instead forced directly into streams, where **erosion** and siltation can be major problems, even when flooding is not.

Increased runoff reduces groundwater recharge, thus lowering the water table and making **droughts**.

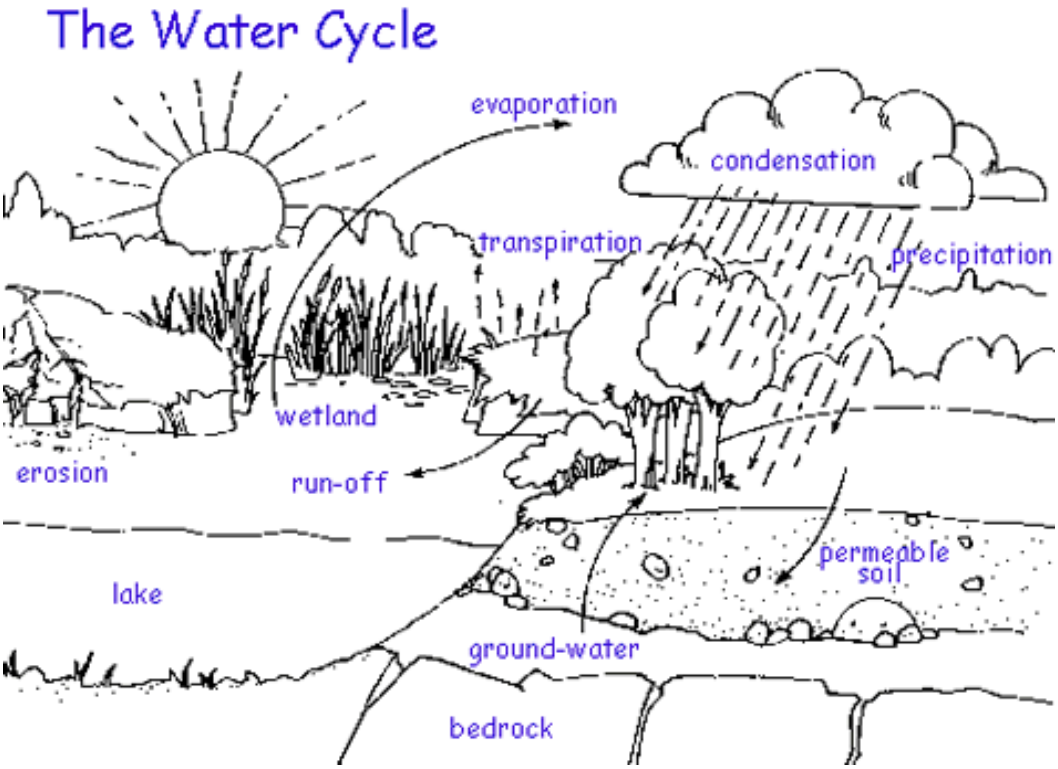


The Water Cycle

Surface water runoff is part of the water cycle on Earth. When precipitation occurs, water only has a few locations where it can go. Water can infiltrate into the ground, evaporate, or become runoff.

Water that does not get absorbed into the soil or rise back into the atmosphere as water vapor will run off surfaces and collect in varied locations. The environment where water lands, will determine if it becomes runoff. For instance, paved areas prevent water from infiltrating into the ground. The water will *run off* the surface if evaporation does not take place.

Flooding can occur if the amount of precipitation in an area exceeds the evaporation rate and infiltration capacity of the soil. Significant floods can also occur as water hits paved areas and has not had a chance to infiltrate into the ground. Hard ground surfaces and impermeable clay surfaces will also prevent water from infiltrating and can cause flash floods.



Source: http://www.on.ec.gc.ca/community/classroom/c5-water-cycle-ans-e.html

Demo for Runoff

Materials

- Plastic box or pan at least one foot by two feet
- Sandbox sand, enough to fill half the box
- Two cups
- One 20 cm by 20 cm square of sod or several smaller grass plugs
- Water
- Bucket or pot

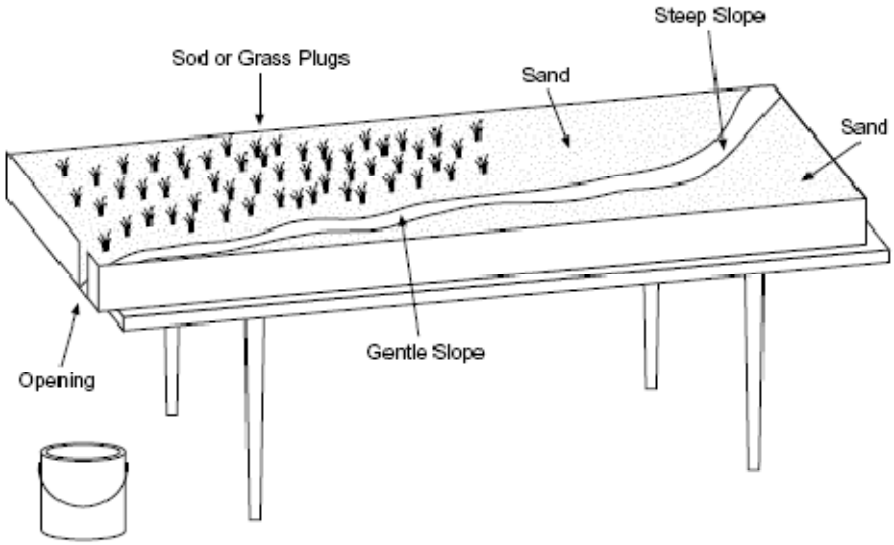
Discuss the following questions with your expert group:

- What is water above the ground called?
- What makes water drain from one area to another?
- What does permeable mean?
- Through what soils does water move quickly?
- Why does water move slowly through clay?
- What does storm water runoff mean?
- Name some examples of things storm water can pick up as it travels over land.
- Where might storm water runoff go in rural areas?

Procedures

1. Fill the box or pan half full of sand. Diagonally, from the top corner of the box to the bottom corner, make a surface water (river) channel.
2. Scoop sand from the middle of the box up onto the sides to form riverbanks. Make a steep slope on one side of the river and a gentle slope on the other side.
3. Place the sod square or several grass plugs on the side with a gentle slope. This represents wetlands vegetation.
4. Place a bucket or pot under opening.
5. Two people must stand at each side of the “river” holding the 8-ounce cups of water.
6. Make it “rain” on the river, very slowly, and at the same time (one student pour water on the sandy side, while the other pours water on the grassy area).

7. Observe which runoff flows faster and drains into the “river” first.



Answer the following questions with your expert group:

1. Which side of the river had the fastest runoff?

2. What effect did the grass or sod have on storm water runoff?

3. Did you see anything in this experiment that would help you decide whether the sand is permeable or impermeable? If so, what?

4. List several things that determine the speed of runoff in a drainage basis.

Explanation

Vegetation and a gentle slope contributed to slowing the water flowing through a basin. As a result, water was able to soak into the ground and/or evaporate. Water can move quickly through the sand, because sand is permeable. The steep slope helps to increase the flow rate as well.

Name_____ Date_____ Period _____

Water Cycle Diagram Worksheet

	Points possible	Points Earned
• Illustrate and label each of the 6 processes - Precipitation, infiltration, runoff, transpiration, evaporation, and condensation		
• Briefly describe each of the 6 processes		
• Provide arrows to indicate where the water is moving		

Name _____ **Date** _____ **Period** _____

Human Impacts on the Water Cycle Processes

Read about each human activity and answer the questions below about each.

Human Activity #1

Humans have been burning fossil fuels for hundreds of years to get energy. They drive cars that burn petroleum, they burn coal for electricity, and they burn natural gas to heat their homes and cook their food. Burning fossil fuels release "greenhouse gases" such as carbon dioxide, water vapor, methane, and nitrous oxide. These greenhouse gases trap heat and light from the sun in the Earth's atmosphere, which is increasing the Earth's average temperature. This is called **global warming.** The average global temperature has already increased by 1°! In the United States, the Midwest has experienced a noticeable increase in average temperatures. Higher temperatures will mean more evaporation and more rain. Southern Illinois has received 49% more rain than they did 50 years ago! In a 2010 news release, the State Director of Environment Illinois, Rebecca Stanfield, said "More frequent downpours, fueled by global warming, will leave the Midwest even more vulnerable to dangerous flooding in years to come".

1. Describe the problem:

_____

_____

_____

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3. What can humans do to solve this problem?

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Human Activity #2

Humans are over-pumping the world's ground water supplies. Ground water is contained in specific rock units called **aquifers**. Water from rain and snow **recharge** (refill) aquifers. Humans drill wells to pump out groundwater for domestic uses, like drinking, cooking, bathing, or for industry and agriculture. The water level in a natural aquifer is called the **water table**. It may rise and fall from season to season and year to year, but usually maintains an average depth.

Humans continue to pump water from aquifers faster than nature can recharged them. This causes an imbalance of net water. When too much water is pumped out and not enough water is able to recharge the aquifer, the aquifer is said to be in **overdraft**. Humans all over the world are over-pumping aquifers. Neighboring communities are intersecting each other's wells and degrading their neighbor's water supply in quantity, quality, and increased cost. Future water supplies are being diminished. All life forms need water to survive. When aquifers are depleted natural lakes, ponds, and streams tend to dry up, and life cannot exist.

In the United States, the Ogallala Aquifer runs underground, from southern South Dakota through parts of Nebraska, Wyoming, Colorado, Kansas, Oklahoma, New Mexico, and northern Texas. These states have all drilled water wells to pump water for agriculture, municipalities, and industries since the 1930's. Currently, the Ogallala Aquifer is being over-pumped and depleted. This depletion of aquifers is happening all over the world. We are consuming water that belongs to future generations. The drilling of millions of wells has pushed water withdrawals beyond the recharge of many aquifers. The failure of governments to limit pumping to the sustainable yield of aquifers means that water tables are now falling throughout the world.

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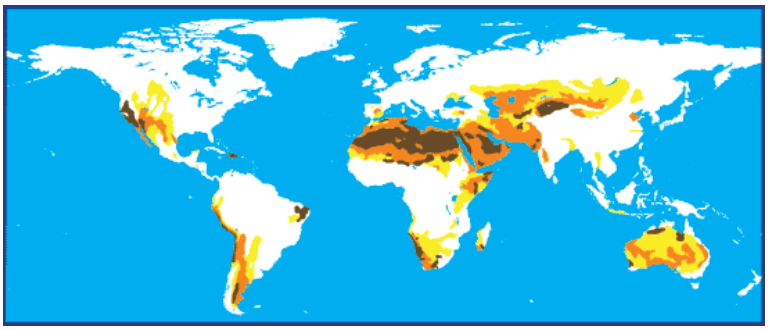
Human Activity #3

Humans are destroying fertile lands throughout the world. Nutrient-rich lands are now dry and arid deserts. This event is called **desertification.** Desertification happens when ranchers overgraze cattle or farmers over-plow the soil. This, along with little rainfall, causes an imbalance in an ecosystem. Since rainfall is infrequent in semiarid regions, the land is not built to support huge fields of crops or supply grazing land for hundreds of thousands of cattle.

New deserts are growing at a rate of 20,000 square miles a year. Nearly half of the world's total land mass is composed of dryland ecosystems, areas defined by low annual rainfall and high temperatures. It's estimated that 10 to 20 percent of these regions are already degraded -- unsuitable for human, animal or plant life.

Less vegetation means less water. Less water means less food production and higher prices for staple crops like rice, wheat and corn. In March 2008, the price of wheat was up 130 percent from a year before and the price of soy was up 87 percent. As a result, countries that are not able to produce their own food, can no longer afford to import.



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Human Activity #4

As more and more people inhabit the Earth, more development and **urbanization** occurs. Urbanization results in natural landscapes being destroyed. In urban areas, most of the permeable surfaces are covered by impervious surfaces, such as roads, houses, parking lots, and buildings. Water runs off of these surfaces, not through them. When it rains, water runs off concrete very quickly. It then flows into the streets towards storm water drains, or into creeks, or into parking lots. This often results in overflows, causing urban flooding when it rains heavily.

And with that runoff comes many problems. The impervious surfaces collect pollutants: pollutants from the atmosphere, nitrogen oxides from car exhaust, rubber particles from tires, debris from brake systems, and phosphates from residential and agricultural fertilizers. The runoff water picks up all the pollutants. This dirty water ends up in our streams, rivers, lakes, and oceans. Rainwater, does not get naturally filtered by soil because it is not absorbed underground. It moves too quickly. In the United States, 65% of our landscape is imperious cover that was designed to accommodate cars!

Momcilo Markus, a researcher at the Illinois State Water Survey, said "Between 1954 and 1999, urbanization, on average, increased from about 11 percent to 62 percent." The result of urbanization is that heavy rains cause flash flooding and high standing water. As urbanization increases, so will the flooding, economic costs, property damage, and insurance rates.

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Human Activity #5

Humans do not realize that most crops require huge volumes of water to grow. That means each of our meals require a substantial about of freshwater.

Examples of Water Requirements (Lenntech Water treatment and Air purification)

Product	Unit	Water Used Liters/ unit		Product	Quantity	Water Used Liters/ unit
Cattle	head	4000		glass of beer	250 ml	75
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Citrus fruits	kg	1		glass of milk	200 ml	200
Palm oil	kg	2		glass of apple juice	200 ml	190
Fresh poultry	kg	6		cup of coffee	125 ml	140

A **water footprint** is a way of measuring the total volume of fresh water used by a nation, to produce the goods and services consumed by that nation. The water footprint includes the water content of goods imported into the country minus goods exported. Once, countries largely grew their own food, but an increasing number no longer do because they are running out of freshwater.

Humans that live in countries where water is scarce can now import virtual water. Virtual water is the amount of water used to grow food crops, raise livestock, or make other products that are exported out of that country. In other words, water scarce countries can now import high water consuming products, like rice and cotton, while exporting low water consuming products, like citrus fruits. Major water exporters include The United States, Canada, Austria, Argentina, and Thailand. Major importers of virtual water include Japan, Sri Lanka, Italy, South Korea, and the Netherlands.

There are serious environmental consequences to exporting this much water. The virtual water trade is emptying the Colorado River and the Rio Grande, which both now fail to reach the ocean for much of the year. Exporting water is sucking dry what was once the country's largest underground water reserve, the Ogallala aquifer beneath the high plains of the Midwest. The Ogallala is being depleted faster than it can be replenished by rain. The water is being shipped away. This water is being exported in the form of crops or livestock. It will enter a water cycle in another part of the world, never to replenish the Ogallala again!

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3. What can humans do to solve this problem?

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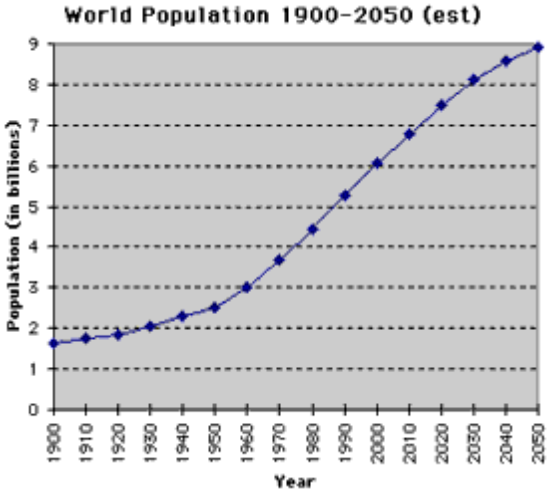
Human Activity #6

Overpopulation is when the number of people living in an area is greater than the resources available to support the population. Many countries that are overpopulated are also suffering from water scarcity issues.



As the growing human population reaches further and further into remote areas in search of room to build cities, housing developments, golf courses, and new farms, it is squeezing wildlife into ever smaller habitat refuges. In many places, population growth is outstripping water availability, destabilizing water-delivery systems and causing crises. The United States is not immune to such crises, just look at the Southwest and South. The Lake Lanier reservoir has shrunk and residents of Atlanta have suffered from water shortages. Between 1990 and 2007, Georgia's population exploded from 6.5 million to 9.5 million, a leap of nearly 50 percent in just 17 years.

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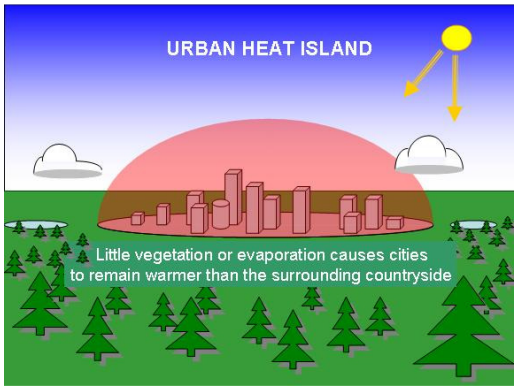
Human Activity #7*

An **urban heat island** is an urban area which is consistently hotter than its surroundings, particularly in Summer. Humans are clearing more rural land to build bigger and bigger cities. Humans cleared away the natural landscape, like trees, shrubs, and grass, to build complex structures such as factories, sky scrapers, businesses, parking lots, streets, sidewalks, homes, and driveways. Scientists believe this effect is caused mostly by the dark surfaces of a city – dark buildings, roofs, and streets. These dark surfaces absorb sunlight, heat up, and retain more heat than the suburban areas. A contributing factor is also the lack of transpiration from vegetation. Transpiration helps to cool the natural environment and create shade. In cities, surfaces are made of materials like brick, asphalt, and concrete which are impervious to water, which makes evaporation or transpiration impossible. Higher temperatures also cause larger volumes of water to evaporate from swimming pools, urban ponds and wetlands and surface-irrigated areas. More water is also consumed to generate power needed to run more air conditioners so humans can endure the heat. This can and will lead to water shortages.



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*Adapted from Urban Heat Island Effect - WeatherQuestions.com http://www.weatherquestions.com/What_is_the_urban_heat_island.htm

Human Activity #8

Humans are cutting down countless forest trees. People cut down trees to collect firewood, to clear land for growing crops, to get lumber to build homes/ furniture, to make paper and other products, and to provide land for animals. The permanent loss of forest land is called **deforestation.** Under normal circumstances trees and bushes act as a 'sponge' for rainfall, holding it and releasing it slowly through transpiration. Without this effect, rain hits the soil directly and runs off, often causing flooding and increases in soil erosion (removal of soil). Nutrients in the soil tend to be leached off, and microorganisms which replenish these nutrients are disturbed.

In China, illegal logging and slash and burn agricultures consume up to 5,000 square kilometers of virgin forest every year. Clear cutting and overgrazing have turned large areas of Qinghai province into a desert. In Yunnan, 50% of the local forest has been cut down. This deforestation has dramatically affected the amount of precipitation in this area. It is estimated there is 15% less rainfall.

1. Describe the problem:

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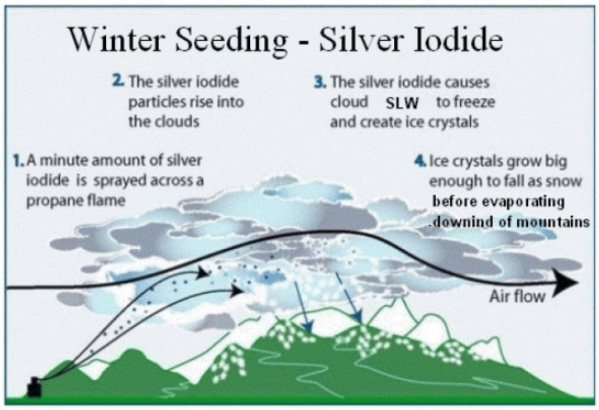
Human Activity #9

Humans are trying to modify and control weather. One way humans do this is by **cloud seeding.**
Scientists will "seed" clouds with chemicals to make rain. Many times, liquid droplets in water evaporate, so scientists "seed" clouds with silver iodide to form ice crystals. This type of cloud seeding is referred to as ***static mode***. Clouds can be seeded with airplanes or from the ground using guns or rockets. Beijing, China is suffering from a severe drought. Its rainfall levels are 35 percent below the world average, and some of its water supplies are significantly polluted. The area relies heavily on cloud seeding. Zhiang Qiang, who runs the Beijing Weather Modification Office, told the Asia Times that water levels in Beijing's water basins have increased up to 13 percent due to cloud seeding. Cloud seeding also has been used to cool Beijing on hot days. Some nations have accused each other of "stealing rain" with cloud seeding techniques, while others question the validity of cloud seeding, arguing that it cannot be tested in controlled conditions, so its results are hard to view objectively. Also, there are still many questions about the safety of silver iodide, how safe it is for long term exposure, and just how safe consumption of this chemical really is for plants, animals, and humans.



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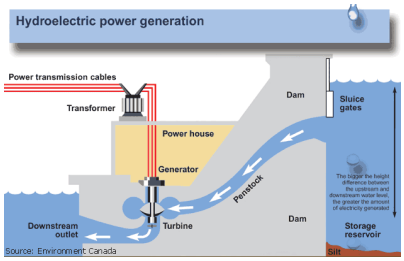
Human Activity #10

Humans use energy for everything, and lots of it! In an effort to get electricity from a clean source, humans developed **hydroelectric dams**. Hydroelectric energy is produced by the force of falling water. To function effectively, these dams require lot of water and a lot of land to build a dam and reservoir. Water builds up behind a high dam, and it accumulates potential energy. This is transformed into mechanical energy when the water strikes the rotary blades of a turbine. The turbine's rotation spins electromagnets which generate current in stationary coils of wire. The dams are great at producing clean energy, but dams contribute to water evaporation by increasing the surface area over which water can evaporate. The Akosombo dam, constructed in 1965, has helped in the economic development of Ghana. It has provided adequate supply of electricity to local industries, urban centers, villages, and to other neighboring countries during the past 41 years. However, the dam has suffered severe drought due to water evaporating from the reservoirs. This has caused power outages for years, resulting in blackouts and interruptions in power to businesses and homes.

In the United States, Nevada's Lake Mead is the largest reservoir in the United States. Lake Mead stores water from the Colorado River. When full, it holds 9.3 trillion gallons, an amount equal to the water that flows through the Colorado River in two years. The water from Lake Mead is used for many things. It irrigates a million acres of crops in the United States and Mexico, and supplies water to tens of millions of people. Its mighty Hoover Dam generates enough electricity to power a half-million homes. Lake Mead's water level dropped 14 feet last year and the Bureau of Reclamation predicts it will drop another 14 feet this year. That's a drop of a whopping 28 feet in just 2 short years (and over 100 since 2000) – leaving the "folks in the know" to put 50:50 odds on Lake Mead being **bone dry** come 2021. Only 12 more years! That's a very scary fact for people living in the Southwest who depend on that water.



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Human Impacts on the Water Cycle Processes -- Answer Key

Name _____ **Date** _____ **Period** _____

Read about each human activity and answer the questions below about each.

Human Activity #1

Humans have been burning fossil fuels for hundreds of years to get energy. They drive cars that burn petroleum, they burn coal for electricity, and they burn natural gas to heat their homes and cook their food. Burning fossil fuels release "greenhouse gases" such as carbon dioxide, water vapor, methane, and nitrous oxide. These greenhouse gases trap heat and light from the sun in the Earth's atmosphere, which is increasing the Earth's average temperature. This is called **global warming.** The average global temperature has already increased by 1°! In the United States, the Midwest has experienced a noticeable increase in average temperatures. Higher temperatures will mean more evaporation and more rain. Southern Illinois has received 49% more rain than they did 50 years ago! In a 2010 news release, the State Director of Environment Illinois, Rebecca Stanfield, said "More frequent downpours, fueled by global warming, will leave the Midwest even more vulnerable to dangerous flooding in years to come".

1. Describe the problem:

The problem is that human pollution is causing the planet to heat up. This is affecting climates all over the globe. The increased heat causes changes in average precipitation patterns. Tropical locations have stronger, more intense storms like hurricanes, typhoons, and tsunamis. Some locations will experience heavy rain storms and flooding. Other locations will get very little rainfall and experience droughts.

2. Which process in the water cycle (condensation, precipitation, infiltration, runoff, evaporation, or transpiration) is being impacted? Explain how it is being impacted.

Global warming impacts PRECIPITATION.
Precipitation increases in some places, causing floods, while decreasing in other places causing droughts.

3. What can humans do to solve this problem?

Human can stop burning fossil fuels for energy. People should use renewable forms of energy. Governments, universities, and independent researchers should invest in the development of new energy technology to implement across the globe.

Humans can change their diets, by eating less meat and more vegetables. Raising cattle is water-intensive and releases a lot of methane, a greenhouse gas, into the environment.

Human Activity #2

Humans are over-pumping the world's ground water supplies. Ground water is contained in specific rock units called **aquifers**. Water from rain and snow **recharge** (refill) aquifers. Humans drill wells to pump out groundwater for domestic uses, like drinking, cooking, bathing, or for industry and agriculture. The water level in a natural aquifer is called the **water table**. It may rise and fall from season to season and year to year, but usually maintains an average depth.

Humans continue to pump water from aquifers faster than nature can recharged them. This causes an imbalance of net water. When too much water is pumped out and not enough water is able to recharge the aquifer, the aquifer is said to be in **overdraft**. Humans all over the world are over-pumping aquifers. Neighboring communities are intersecting each other's wells and degrading their neighbor's water supply in quantity, quality, and increased cost. Future water supplies are being diminished. All life forms need water to survive. When aquifers are depleted natural lakes, ponds, and streams tend to dry up, and life cannot exist.

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1. Describe the problem:

Humans' thirst for water is depleting our ground water sources, without any consequences. People take what they need without considering future generations.

2. Which process in the water cycle (condensation, precipitation, infiltration, runoff, evaporation, or transpiration) is being impacted? Explain how it is being impacted.

Over-drafting aquifers impacts INFILTRATION.
If the water pumped out is not returned to the source in a responsible manner, the aquifers will be pumped dry and forever changed.

3. What can humans do to solve this problem?

Humans can start being responsible when they use water. People should only buy and sell local food. They should use only the water they need, and work consciously to conserve this precious resource.

Governments can make water use policies to end wasteful water use in agriculture, manufacturing, and individual consumption.

New technologies can be developed to conserve water.

Human Activity #3

Humans are destroying fertile lands throughout the world. Once nutrient-rich lands are now dry and arid deserts. This event is called **desertification.** Desertification happens when ranchers overgraze cattle or farmers overplow the soil. This, along with little rainfall, causes an imbalance in an ecosystem. Since rainfall is infrequent in semiarid regions, the land is not built to support huge fields of crops or supply grazing land for hundreds of thousands of cattle.

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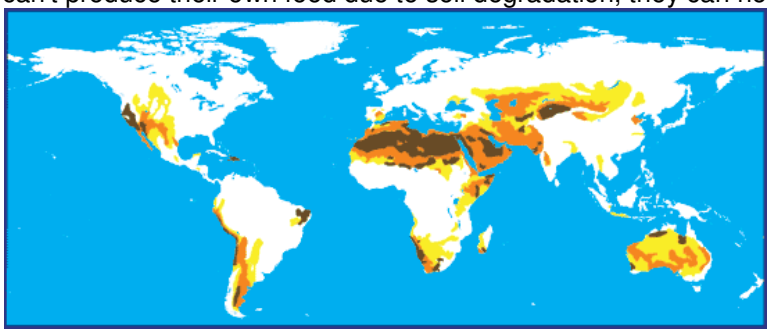
Less vegetation means less water. Less water means less food production and higher prices for staple crops like rice, wheat and corn. In March 2008, the price of wheat was up 130 percent from a year before and the price of soy was up 87 percent. For those countries that can't produce their own food due to soil degradation, they can no longer afford to import.



1. Describe the problem:

Humans over-using land are causing desertification around the globe. Basic needs, such as fresh water and food supplies, are threatened, as is fertile topsoil, vegetation cover, healthy crops and biodiversity levels. Other problems, including poverty, food insecurity, and migration, usually follow.

2. Which process in the water cycle (condensation, precipitation, infiltration, runoff, evaporation, or transpiration) is being impacted? Explain how it is being impacted.

Desertification affects EVAPORATION.
Evaporation happens rapidly, removing surface water.

3. What can humans do to solve this problem?

- Sustainable and equitable land use
- Promotion of policies for sustainable development
- Community-based management of drylands
- Reforestation, soil conservation, land and water management
- Capacity-building in affected communities
- Use of alternative/appropriate technology
- Promotion of sustainable energy sources and food security
- Establishment of a global financial mechanism and other financial resources to assist affected populations

Human Activity #4

As more and more people inhabit the Earth, more development and **urbanization** occur. Rural areas replace the natural landscape as they become urban. Most of the permeable surfaces are covered by impervious surfaces, such as roads, houses, parking lots, and buildings. Water runs off of them, not through them. When it rains, water runs off concrete very quickly. It then flows into the streets towards storm water drains, or into creeks, or into parking lots. Eventually, they all overflows causing urban flooding each time it rains.

And with that runoff comes many problems. The impervious surfaces collect pollutants: pollutants from the atmosphere, nitrogen oxides from car exhaust, rubber particles from tires, debris from brake systems, and phosphates from residential and agricultural fertilizers. The runoff water picks up all the pollutants. This dirty water ends up in our streams, rivers, lakes, and oceans. Rainwater, does not get naturally filtered by soil because it is not absorbed underground. It moves too quickly. In the United States, 65% of our landscape is imperious cover that was designed to accommodate cars!

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1. Describe the problem:

Urbanization is covering our lands with impermeable surfaces. This causes runoff, water pollution, and flooding.

2. Which process in the water cycle (condensation, precipitation, infiltration, runoff, evaporation, or transpiration) is being impacted? Explain how it is being impacted.

Urbanization affects INFILTRATION and RUNOFF.
Urbanization prevents storm water from recharging the ground water. Stormwater becomes runoff, as it flows over surfaces. It picks up pollutants and brings them to the closest surface water. If the storms are heavy, urban areas will flood because there is not enough natural landscape to infiltrate the water.

3. What can humans do to solve this problem?

- Plant more trees and native vegetation; Plants absorb much of this through their roots, and some water makes its way down to the water table, being purified as it gradually percolates through the soil.
- Replace concrete or asphalt slabs with permeable pavers. Water can seep down into the spaces between the individual pavers, thus reducing the amount of runoff.
- Use rain barrels to collect storm water.
- Build a water garden.
- Construct a rooftop garden.

Human Activity #5

Humans do not realize that most crops require huge volumes of water to grow. That means each of our meals require a substantial about of freshwater.

Examples of Water Requirements (Lenntech Water treatment and Air purification)

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There are serious environmental consequences to exporting this much water. The virtual water trade is emptying the Colorado River and the Rio Grande, which both now fail to reach the ocean for much of the year. Exporting water is sucking dry what was once the country's largest underground water reserve, the Ogallala aquifer beneath the high plains of the Midwest. The Ogallala is being depleted faster than it can be replenished by rain. The water is being shipped away. The water will leave the current geographic location and energy a new water cycle.

1. Describe the problem:

Countries that have ample water supplies are shipping their water out to countries that do not have clean water. Water stored in plants or meat, moves from one geographic location to another. That water is now gone from the original geographic location.

2. Which process in the water cycle (condensation, precipitation, infiltration, runoff, evaporation, or transpiration) is being impacted? Explain how it is being impacted.

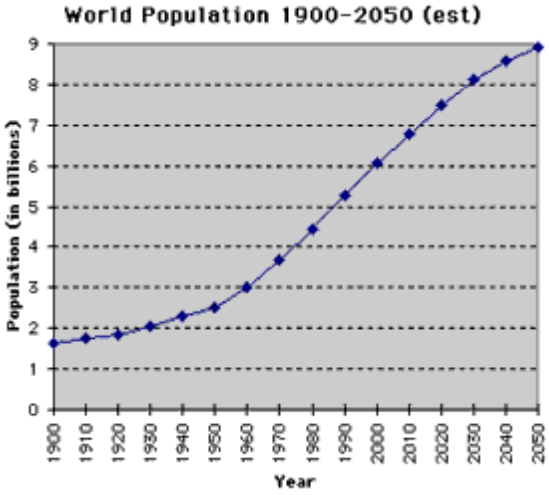
Virtual water affects TRANSPIRATION, EVAPORATION, and PRECIPITATION.
Without the plant to transpire water locally, there will be less local precipitation and less water in the original area. This will lead to more water shortages.

3. What can humans do to solve this problem?

- Stop shipping water to other countries.
- Buy and sell local crops and livestock products.
- Practice sustainable water management.
- Grow crops that require less water and stop growing crops like rice and corn.

Human Activity #6

Overpopulation is when the number of people living in an area is greater than the resources available to support the population. Many countries that are overpopulated are also suffering from water scarcity issues.



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1. Describe the problem:

The Earth's human population continues to grow with each year. There will not be enough water to support all humans' food and drinking needs. Water shortages will cause conflicts and potential water wars.

2. Which process in the water cycle (condensation, precipitation, infiltration, runoff, evaporation, or transpiration) is being impacted? Explain how it is being impacted.

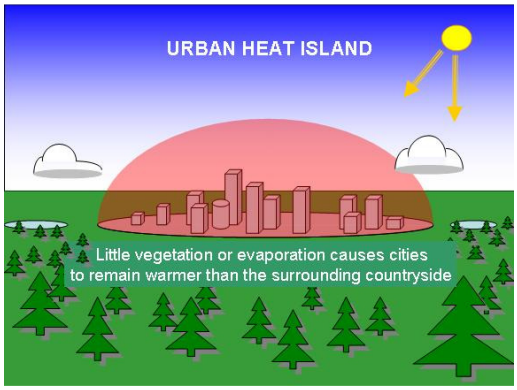
Overpopulation affects INFILTRATION.
More water is demanded. More wells are drilled which may lead to depletion of underground aquifers. A heavier burden may be placed on rivers and streams that provide existing fresh water supplies.

3. What can humans do to solve this problem?

- Educate people about issues.
- Encourage people to reduce their number of offspring.
- Offer incentives to families that have 2 or less children.

Human Activity #7

An **urban heat island** is an urban area which is consistently hotter than its surroundings, particularly in Summer. Humans are clearing more rural land to build bigger and bigger cities. Humans cleared away the natural landscape, like trees, shrubs, and grass, to build complex structures such as factories, sky scrapers, businesses, parking lots, streets, sidewalks, homes, and driveways. Scientists believe this effect is caused mostly by the dark surfaces of a city – dark buildings, roofs, and streets. These dark surfaces absorb sunlight, heat up, and retain more of this heat than the suburban areas. A contributing factor is also the lack of transpiration from vegetation. Transpiration helps to cool the natural environment and create shade. In cities, the built surfaces are made of materials like brick, asphalt, and concrete which are impervious to water, which makes evaporation or transpiration impossible. Higher temperatures also cause larger volumes of water to evaporate from swimming pools, urban ponds and wetlands and surface-irrigated areas. More water is also consumed to generate power needed to run more air conditioners so humans can endure the heat. This can and will lead to water shortages.



1. Describe the problem:

Cities with their large, dark structures are trapping too much heat. The urban areas are very hot. As a result, humans use more energy to run air conditioners to stay cool.

2. Which process in the water cycle (condensation, precipitation, infiltration, runoff, evaporation, or transpiration) is being impacted? Explain how it is being impacted.

Urban heat islands affect TRANSPIRATION and EVAPORATION.
Since there is less vegetation, there is less transpiration. When plants transpire, they release water vapors into the atmosphere, which has a cooling effect. Higher temperatures also rapidly evaporate the surface water.

3. What can humans do to solve this problem?

- Plant trees around individual buildings to shade urban surfaces to reduce their temperature, especially roofs and south-, east-, and west-facing walls. The reduction in surface temperature also leads to substantial reductions in energy use for air conditioning.
- Plant trees to shade roads and parking lots, which would otherwise become very hot during the day and which store heat for later release at night.
- "Green roofs" use living vegetation on roofs in order to help reduce heat accumulation of buildings. For example, the city of Chicago has more than 80 municipal and private green roofs as of June 2004, including the first municipal green roof in the country, the City Hall rooftop garden. A green roof is much cooler than a traditional roof because a significant fraction of the absorbed energy is used to evaporate water rather than to heat the roof and the overlying air.
- Creation of greenspace such as parks can be used to assist in cooling of neighborhoods, and an overall greening of the city can lead to a cooler urban atmosphere.

Human Activity #8

Humans are cutting down countless forest trees. People cut down trees to collect firewood, clear land for growing crops, to get lumber to build homes/ furniture, to make paper and other products, and to provide land for animals. The permanent loss of forest land is called **deforestation.** Under normal circumstances trees and bushes act as a 'sponge' for rainfall, holding it and releasing it slowly through transpiration. Without this effect, rain hits the soil directly and runs off, often causing flooding and increases soil erosion (removal of soil). Nutrients in the soil tend to be leached off, and microorganisms which replenish these nutrients are disturbed.

In China, illegal logging and slash and burn agricultures consume up to 5,000 square kilometers of virgin forest every year. Clear cutting and overgrazing have turned large areas of Qinghai province into a desert. Deforestation is blamed for the 4 percent decline in rainfall, 15 percent in the dry season, in the Xishuangbanna area of Yunnan, where 50 percent of local forest has been deforested

1. Describe the problem:

Deforestation may lead to complete destruction of rainforests and other forests. We rely on forests for oxygen, wood, medicines, and many other products.

2. Which process in the water cycle (condensation, precipitation, infiltration, runoff, evaporation, or transpiration) is being impacted? Explain how it is being impacted.

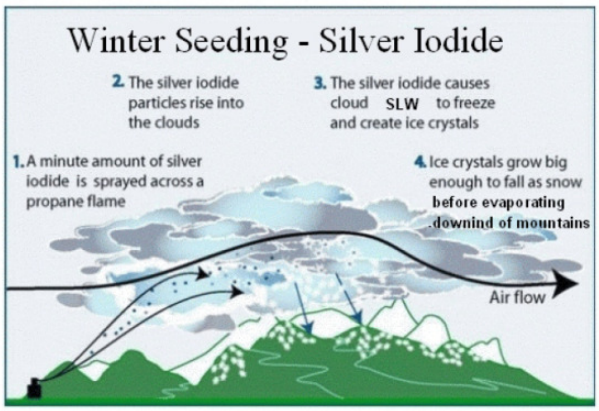
Deforestation affects TRANSPIRATION.
If plants are removed (especially at a high rate such as deforestation) there will be less water returning in the atmosphere. This will eventually cause a reduction in the amount of water returning to the earth's surface such as the seas, lakes, rivers etc.

3. What can humans do to solve this problem?

- Educate local farmers and ranchers about deforestation and impacts.
- Recycle paper products.
- Practice sustainable logging in the rainforest.
- Create deforestation laws.
- Plant replacement trees.
- Reforestation

Human Activity #9

Humans are trying to modify and control weather. One way humans do this is by **cloud seeding.**
Scientists will "seed" clouds with chemicals to make rain. Many times, liquid droplets in water evaporate, so scientists "seed" clouds with silver iodide to form ice crystals. This type of cloud seeding is referred to as ***static mode***. Clouds can be seeded with airplanes or from the ground using guns or rockets. Beijing, China is suffering from a severe drought, its rainfall levels are 35 percent below the world average, and some of its water supplies are significantly polluted. The area relies heavily on cloud seeding. Zhiang Qiang, who runs the Beijing Weather Modification Office, told the Asia Times that water levels in Beijing's water basins have increased up to 13 percent due to cloud seeding. Cloud seeding also has been used to cool Beijing on hot days. Some nations have accused each other of "stealing rain" with cloud seeding techniques, while others question the validity of cloud seeding, arguing that it cannot be tested in controlled conditions, so its results are hard to view objectively. Also, there are still many questions about the safety of silver iodide and how safe it is for long term exposure or how safe consumption of this chemical is for plants, animals, and humans.



1. Describe the problem:

Humans are cloud seeding without considering the long term effects of pollution and rain displacement. When you make it rain in one area that means another area will not get the rain.

2. Which process in the water cycle (condensation, precipitation, infiltration, runoff, evaporation, or transpiration) is being impacted? Explain how it is being impacted.

Cloud seeding affects PRECIPITATION.
Cloud seeding forces precipitation to occur in areas where there is no rain. Also, see the Olympics in China as an example of how they prevented rain.

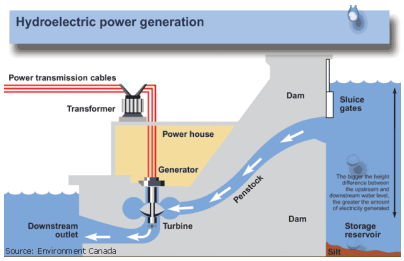
3. What can humans do to solve this problem?

- Stop cloud seeding .
- Make laws about fair cloud seeding and rain rights.

Human Activity #10

Humans use energy for everything, and lots of it! In an effort to get electricity from a clean source, humans developed **hydroelectric dams**. Hydroelectric energy is produced by the force of falling water. To function effectively, these dams require lot of water and a lot of land to build a dam and reservoir. Water builds up behind a high dam, and it accumulates potential energy. This is transformed into mechanical energy when the water strikes the rotary blades of turbine. The turbine's rotation spins electromagnets which generate current in stationary coils of wire. The dams are great at producing clean energy, but dams contribute to water evaporation by increasing the surface area over which water can evaporate. The Akosombo dam, constructed in 1965, has helped in the economic development of Ghana. It has provided adequate supply of electricity to local industries, urban centers, villages, and to other neighboring countries during the past 41 years. However, the dam has suffered severe drought due to water evaporating from the reservoirs. This has caused power outages for years, resulting in blackouts and interruptions in power to businesses and homes.

In the United States, Nevada's Lake Mead is the largest reservoir in the United States. Lake Mead stores water from the Colorado River. When full, it holds 9.3 trillion gallons, an amount equal to the water that flows through the Colorado River in two years. The water from Lake Mead is used for many things. It irrigates a million acres of crops in the United States and Mexico, and supplies water to tens of millions of people. Its mighty Hoover Dam generates enough electricity to power a half-million homes. Lake Mead's water level dropped 14 feet last year and the Bureau of Reclamation predicts it will drop another 14 feet this year. That's a drop of a whopping 28 feet in just 2 short years (and over 100 since 2000) – leaving the "folks in the know" to put 50-50 odds on Lake Mead being **bone dry** come 2021. Only 12 more years! That's a very scary fact for people living in the Southwest who depend on that water.



1. Describe the problem:

Hydroelectric dams cause a rapid increase in reservoir water evaporation, thus causing water loss in major bodies of water throughout the world. Note: It is important to explain to your students that many people find a value in hydroelectric dams. They need to understand that there are both costs and benefits to building these dams. Many areas would not have energy without dams. However, in some areas they are causing problems, as detailed in the information above.

2. Which process in the water cycle (condensation, precipitation, infiltration, runoff, evaporation, or transpiration) is being impacted? Explain how it is being impacted.

Hydroelectric dams affect EVAPORATION.
They speed up surface water evaporation, causing water levels to drop / dry out. They contribute to water scarcity.
They force people to migrate from their homes and move to a place far from the water.

3. What can humans do to solve this problem?

- Stop building hydroelectric dams.
- Invest in other renewable energy sources that do not need water.
- Build fish ladders.
- Consider the environment before construction.

Expert Group Rubric

Each expert must return to their water cycle group and report on their assigned water process.

Report Criteria	Points Possible	Points Earned
Water Cycle Expert Group Worksheet • Completed • Elaborate notes		
Verbal Report to Water Cycle Group • Contains details and accurate information • Minimum of 5 minutes, no more than 7 minutes		
Poster • Illustrate your process • Title • Label		

Name_____Date_____ Period _____

Water Cycle Diagram Rubric

	Points possible	Points Earned
• **Illustrate and label each of the 6 processes - Precipitation, Infiltration, Runoff, Transpiration, Evaporation, and Condensation**		
• **Briefly describe each of the 6 processes**		
• **Arrows to indicate where the water is moving**		