Properties of Water

The water cycle has always served as nature’s principal water purification process.

When water evaporates, contaminants are left behind.

Pure water should fall as precipitation but contaminants enter the water supply again.

- water is called the UNIVERSAL SOLVENT – it is able to dissolve many different substances
- clear (transparent), colourless, odourless and tasteless
- high heat capacity means that large bodies of water act as heat reservoirs
- density of 1.0 g/mL but solid water is LESS dense than liquid water (thus, ice floats on water acting as an insulator)
- Water is a polar molecule

- Dipoles allow intermolecular force called HYDROGEN BONDING, allowing water molecules to be more tightly held together

- Melting point/ freezing point of 0°C and boiling point of 100°C – water is a liquid at room temperature – water has a high boiling point because lots of energy is required to break H bonds

- Able to dissolve other polar molecules and ionic compounds
  
  http://www.northland.cc.mn.us/biology/biology1111/animations/dissolve.html

Since water is such a good solvent, water can easily become contaminated with a great variety of substances

GROUND WATER → water that seeps underground and collects in aquifers
  
  Impurities in soil and rock add iron, zinc, magnesium and calcium to water

SURFACE WATER → water in lakes, ponds, rivers and streams
  
  Primary source of drinking water
Water Cycle

Vocabulary: aquifer, condensation, evaporation, freezing, glacier, melting, phase change, precipitation, reservoir, runoff, transpiration, water cycle

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

1. When you turn on a water faucet, where does the water come from?
   
   *Most drinking water is piped in from artificial reservoirs.*

2. Animals and plants have been using water for millions of years. Why don’t we run out?

   *Water is continually recycled throughout the planet.*
   *Eg. Plants and animals release water back into the air and soil when they breathe and excrete wastes. Water is also returned to soil when plants and animals die and decompose.*

Gizmo Warm-up

Water on Earth is always in motion. These motions form a repeating circuit called the **water cycle**. The Water Cycle Gizmo™ allows you to explore the different paths water takes as it moves from Earth’s surface to the atmosphere and back.

1. Click **Oceans**. What percentage of Earth’s water is found in the oceans? **97.25%**

2. Click **Atmosphere**. How does water get to the atmosphere? **By evaporation**

3. Click **Clouds**. How do clouds form? **Water vapor in the atmosphere cools and condenses.**

4. Click **Precip (rain)**. (“Precip” is short for **precipitation**, or water falling to Earth’s surface.)

   What causes it to rain? **Rain occurs when water droplets in clouds are large enough to fall.**

5. Click **Oceans** again, and then choose the PATH tab. Because it has the same beginning and end, the path is a complete cycle. How many steps does this cycle have? **5 steps**

<table>
<thead>
<tr>
<th>Activity: The water cycle</th>
<th>Get the Gizmo ready:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Select the SIMULATION tab, and click <strong>Reset</strong>.</td>
</tr>
</tbody>
</table>
Question: What are the parts of the water cycle?

1. **Collect data**: Create two water cycles using the Gizmo. Each cycle should have at least four steps and should begin and end at the same location. Choose any starting point from the list on the right. When the cycle is complete, choose the PATH tab and write the steps below.

   **Cycle 1:**   
   __eg. Ocean, atmosphere, clouds, precipitation, rivers, soil, vegetations, wildlife, atmosphere, clouds, rain, reservoir, person, wastewater, ocean

   **Cycle 2:**   
   ______________________________________________________________________________________
   ______________________________________________________________________________________

2. **Analyze**: Use the information presented in the Gizmo to answer the following questions.

   A. What percentage of Earth’s water can be found in soil? 0.005%
   B. What percentage of Earth’s water is stored in ice and snow? 1.9%
   C. What percentage of Earth’s fresh water is stored in ice and snow? 68.7%
   D. What percentage of Earth’s water is found in lakes? 0.009%
   E. What is **transpiration**? (Hint: Click the Vegetation button.)
      __*Plants releasing water vapor from their leaves.*__
   F. What human activity uses the most water worldwide? *Agriculture (70%)*
   G. What human activity uses the most water in the United States? *Industry (59%)*
   H. What organisms break down chemical wastes in a treatment plant? *Bacteria*
   I. What is an **aquifer**? *An aquifer stores water in the ground.*
   J. What is a **reservoir**? *A body of water (often a lake) that stores water for human use.*
   K. In what ways can **runoff** be a problem?
      __*Runoff causes flooding and erosion and can also wash pollutants into rivers.*__

(Activity continued on next page)
Activity (continued from previous page)

3. **Define**: A phase change is a change from one state to another, such as from a liquid to a gas. Based on what you have read in the Gizmo, fill in the blanks with the words “liquid,” “gas,” or “solid” to define each change.

- **Evaporation**: Change from a *liquid* to a *gas*
- **Condensation**: Change from a *gas* to a *liquid*
- **Melting**: Change from a *solid* to a *liquid*
- **Freezing**: Change from a *liquid* to a *solid*

4. **Practice**: Fill in the process that causes each transition. Your choices are evaporation, condensation, precipitation, melting, and freezing.

   A. Ocean → Atmosphere  
   B. Atmosphere → Clouds  
   C. Cloud → Snow  
   D. **Glacier** (river of ice) → River  
   E. Cloud → Soil

   - Evaporation
   - Condensation
   - Freezing
   - Melting
   - Precipitation

5. **Practice**: Fill in the two processes that cause each of the following transitions.

   A. Ocean → Cloud  
   B. Cloud → Glacier

   - Evaporation, condensation
   - Freezing, precipitation (or precipitation, freezing)

6. **Think and discuss**: Water covers over two-thirds of Earth’s surface. Yet water shortages are a major problem for many people around the world. Why do you think this is the case?

   *Answers will vary. There are many acceptable answers to this question. Sample answer:*

   Over 97% of Earth’s water is salt water, which is not useful for people. Most of the fresh water on Earth is locked up in glaciers and ice caps, so it cannot be used either. Only about 1% of Earth’s water is available for human use. Many parts of Earth are very dry, and there is not enough water for agriculture, industry, and human consumption. Some people use excessive amounts of water, leaving less for others to use.*
Assessment Questions (5):

1. Which of the following contains the largest percentage of the Earth's water?
   - A. Atmosphere
   - B. Oceans
   - C. Ice/Snow
   - D. Vegetation

2. What is the defining characteristic of a water cycle?
   - A. The water passes through at least five different locations.
   - B. It does not include any human water usage.
   - C. It passes through plants, animals and the ocean.
   - D. It has the same starting and ending point.

3. What human activity uses the most water, worldwide?
   - A. Drinking
   - B. Industry
   - C. Agriculture
   - D. Bathing

4. Where is the majority of the Earth's fresh water stored?
   - A. In glaciers and icecaps
   - B. In lakes
   - C. In plants
   - D. In the atmosphere

5. What sequence of processes transports water from the ocean into a cloud?
   - A. Evaporation and condensation.
   - B. Condensation and freezing.
   - C. Precipitation and condensation.
   - D. Evaporation and precipitation.
### GIZMO: Water Pollutants

<table>
<thead>
<tr>
<th>Explanation</th>
<th>Toxic</th>
<th>Sediment</th>
<th>Nutrient</th>
<th>Bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials that cause DEATH, DISEASE and BIRTH DEFECTS in organisms that ingest them</td>
<td>Consists of SOIL, SAND and MINERALS washed from land into water after rain. Sediments pile up in reservoirs, rivers and harbors, destroy fish and wildlife habitat and cloud the water so that sunlight cannot reach aquatic plants.</td>
<td>Contamination of water resources by excessive amounts of nutrients. A nutrient is a substance used by living things to promote growth (eg. Nitrogen and phosphorus) Too many nutrients causes excess algal production, reducing the amount of sunlight entering lakes, rivers.</td>
<td>Microscopic living organisms that can help with pollution control by breaking down organic matter in sewage, oil spills and other pollutants. Some bacterial in soil, water and air can cause human, animal and plant health problems.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Examples</th>
<th>Toxic</th>
<th>Sediment</th>
<th>Nutrient</th>
<th>Bacterial</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint, gas, battery acid, mercury, pesticides</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Careless farming, mining and building activity exposes sediment material</td>
<td></td>
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<tr>
<td>Excess fertilizer, manure and human waste.</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Animal manure, improper food handling and human waste.</td>
<td></td>
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</tbody>
</table>

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<tr>
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<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmer dumps chicken manure into nearby river.</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td>Manure contains bacteria causing illness; nutrients can cause algae overgrowth</td>
</tr>
<tr>
<td>Several trips to the grocery store instead of one.</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td>Car exhaust and fluids are toxic; nitrogen oxide can cause nutrient problems</td>
</tr>
<tr>
<td>Using lots of pesticides and not rotating crops.</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>Pesticides are toxic to many animals.</td>
</tr>
<tr>
<td>Activity</td>
<td>X</td>
<td>X</td>
<td>Impact</td>
<td></td>
<td></td>
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<tr>
<td>-------------------------------------------------------------------------</td>
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<td>------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Chopping down trees to build movie theatre.</td>
<td>x</td>
<td></td>
<td>Wind and rain will erode soil causing sediment to build-up in nearby waterways</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dumping car oil and antifreeze in an alley.</td>
<td></td>
<td></td>
<td>Toxic to land and water animals.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chopping down shrubs and trees.</td>
<td></td>
<td>x</td>
<td>Soil will erode leaving too much sediment in the river.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Putting paint and solvents into a garbage bag.</td>
<td>x</td>
<td></td>
<td>Toxic chemicals can leak during transport or contaminate soil and water at landfill site.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using too much water in showers and in toilets.</td>
<td>x</td>
<td>x</td>
<td>Excess sewage goes into waterways untreated – bacteria can cause illness and excess nitrogen will cause algal growth.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foods individually packaged with paper products.</td>
<td>x</td>
<td></td>
<td>More paper = more trees cut down leading to soil erosion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subdivision with a parking lot/ park beside water.</td>
<td>x</td>
<td>x</td>
<td>Chemicals from cars will leak into water supply; erosion will occur while subdivision is being built.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overfertilizing your lawn.</td>
<td>x</td>
<td></td>
<td>Unused fertilizer washes away with the rain causing extra nutrients in nearby waterways.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaking or overflow in septic tanks.</td>
<td>x</td>
<td>x</td>
<td>Human waste contains bacteria causing sickness and high nitrogen content leading to nutrient pollution.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.2 What’s in Clean Water?

Bottled water comes from:
- Tap water that is reprocessed by DISTILLATION (water is vaporized and then condensed) – this is pure H\textsubscript{2}O
- Underground springs and wells - this is water that seeps through soil and rock and therefore contains many dissolved ions.

Ions can be found in drinking water that are:

i) helpful
- eg. Fe\textsuperscript{+2}, Fe\textsuperscript{+3}, and Mg\textsuperscript{+2} ions
  - low concentrations of these ions give water flavour and benefit human health

ii) harmful
- S\textsuperscript{-2} has a bad odour
- Too many Fe ions gives bad taste
- Heavy metals are dangerous for health $\rightarrow$ cancer, mutations/defects

**Hard water**

Refers to water that contains many dissolved minerals (eg Ca\textsuperscript{+2}, Mg\textsuperscript{+2}, Fe\textsuperscript{+2}, Fe\textsuperscript{+3}, and Mn\textsuperscript{+2})

Hard water causes:
- Bathtub ring
- Scale deposits on heating devices
- Reduces the sudsing ability of soaps

Water can be softened by:
- Adding sodium carbonate or sodium hexametaphosphate
- The soda-lime process is used in some municipalities in Ontario – soda (sodium carbonate) and lime (calcium hydroxide) are added to remove Ca\textsuperscript{+2} and Mg\textsuperscript{+2} ions

**Dissolved oxygen**

The amount of oxygen in water is also monitored as it affects what is able to survive in the water.

Too little oxygen results in the death of many large fish and decreases aquatic diversity.

http://www.youtube.com/watch?v=9z14l51ISwg 3 min video on municipal drinking water treatment
http://www.youtube.com/watch?v=-bjbW1-lXaU&feature=related video on wastewater treatment
### 4.3 What’s in Polluted Water?

In the activity last day, we looked at several types of pollutants. These can be further classified as below.

<table>
<thead>
<tr>
<th>Type of pollutant</th>
<th>Definition</th>
<th>Examples</th>
<th>Method of removing from water</th>
</tr>
</thead>
</table>
| Physical contaminants  | Objects that do not dissolve in water                                                           | • Oil and petroleum products  
• Garbage  
• Tree branches  
• Silt, clay, soil (also called sediment)                                                                 | • Removal by screens  
• Some less dense chemicals can be skimmed off  
• Sand filtration  
• Flocculation                                                                 |
| Biological contaminants| Bacteria and viruses                                                                            | • E. coli bacteria from agricultural (farm) runoff or human waste                                                                       | Adding chlorine kills bacteria                                      |
| Chemical contaminants  | Substances that are soluble in water (dissolve)                                                | • Manufactured chemicals  
• Metal ions and compounds (Pb, Hg, Cd)  
• Pesticides  
• Fertilizers  
• Soluble petroleum products  
• salts                                                                 | • Some chemicals degrade naturally  
• Bacteria are able to break down some chemicals  
• Some may not be removed and remain toxic to plants, animals and humans |

Ways you can help with the water pollution problem

1. **School laboratory**
   Any unsafe chemicals are collected for special hazardous waste disposal.

2. **At home**
   Household hazardous wastes (cleaners, paints, batteries) – anything labeled CORROSIVE, FLAMMABLE, REACTIVE or TOXIC – should be brought to designated hazardous waste facility.
4.6 Case Study: Protecting Canada’s Great Lakes Environment

1. a) What are the three main goals of the Great Lakes Action Plan?
   - To establish a healthy environment
   - To protect the health of citizens
   - To sustain communities

   b) List the seven specific objectives required to meet those goals.
   - To restore areas of concern
   - To conserve ecologically important areas
   - To control the introduction of exotic species
   - To advance sustainable use of the Great Lakes Basin
   - To reduce harmful pollutants
   - To assess and manage ecosystem health

2. a) What is an AOC? Why are they a concern?
   AOC = area of concern
   In these areas, pollutants from industrial sources, sewage treatment plants, landfills, and agricultural runoff have entered the waterways, destroyed the quality of the water, and created unsafe situations for people and wildlife

   b) What is a RAP?
   - RAP = remedial action plan
   - a plan designed to restore the ecological health of an area and to make recreational use possible
   - identifies contaminants & sources, treatment needed to clean the water, preventative measures to relieve future contamination

3. a) Identify and explain one reason for the success of the RAP for Hamilton Harbour.
   - success was achieved because government, environmentalists, business people, people from industries, and concerned individuals worked together to solve the problem

   b) Explain the “Yellow Fish” program
   - to raise awareness about the impact of toxic substances on local waters, participants paint yellow fish symbols beside storm drains to remind people not to pour harmful, hazardous materials (oil, cleaners, paints, pesticides, products with warning labels, soap) down the drains

   c) Describe two examples of evidence of the successful restoration of Hamilton Harbour.
   - people are swimming in the harbour
   - public access to the harbourfront has been improved
   - fish populations are increasing

   d) Give two ways that human health has benefited from the restoration of the harbour?
   - reducing exposure to contaminants
   - health and well-being are increased by habitat restoration, improvement of water quality, rehabilitation of shorelines and creation of shoreline trails
Great Lakes: Troubled Waters

1. List some of the chemicals that are polluting the Great Lakes and their sources.
   Pesticides
   Plastic
   PCB’s
   Dioxins
   Mercury, silver, lead, arsenic
   Sewage
   Industrial waste
   Waste from pulp mills
   cyanide

2. Give three options chemists have regarding chemical pollutants.
   i) stop using chemicals
   ii) invent other chemicals to break down harmful substances
   iii) use different chemicals

3. What is an AOC? Give an example of one.
   AOC = area of concern
   Example: Great Lakes – exposed to hazardous wastes and sewage
   Around the Great Lakes there are 42 AOC’s since more businesses and people are located close to the water.

4. How can the amount of pollution in water be measured?
   Monitoring wildlife – monitor numbers of animals/birds/insects; monitor reproduction rates, monitor eggs
   Monitor tumors and cancer in fish
   Chemical analysis – directly measure chemicals in the water

5. Complete these statements:
   a. “What we do with the environment today, _______ will come back to haunt us tomorrow.
   b. Dilution is not the solution to pollution.