Water Primer

Key Concept

Water connects all earth systems through the water cycle.

The water cycle, influenced by solar energy, gravity, and the movement of the earth, circulates water from oceans, lakes, streams, icecaps, the land and organisms to the atmosphere and back. The water cycle influences climate, landforms, and the distribution of life on Earth. Events that alter the water cycle, for example, spring flooding and intense storms such as hurricanes, can result in significant and dramatic negative impacts on landscapes and their inhabitants.

Evaporation occurs when the sun's rays heat water enough so that the water molecules lose their hold on one another and liquid turns into a gas: water vapour. Surfaces such as water bodies, glaciers and soils lose water through evaporation. Plants lose water through evapo-transpiration, a combination of water loss from the plant's surfaces and tissues. We lose water through our skin as perspiration. The "steam" you see when you breathe out on a cold winter day represents condensation of the water vapour that you exhale.

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As part of a dynamic atmosphere, water vapour influences climate all over the world. Water vapour condenses back into a liquid when air cools, forming clouds. As the condensed water droplets merge, they fall back to the earth. Most of this precipitation falls into the oceans; the rest falls on land. It can vary from a light spring shower to a heavy winter blizzard. Precipitation on land can return to the ocean quickly from surface run-off that flows into streams and rivers, or remain frozen in glaciers and ice caps for a long time. Between these extremes, standing bodies of water (lakes, ponds) and living organisms hold water temporarily.

Water that falls onto land can also seep below the surface to become soil moisture, which plants can readily access. If it penetrates deeper it becomes stored as groundwater. The upper surface of this saturated ground is called the water table. Soil moisture and groundwater may flow downhill, draining into rivers or lakes, or collect deep underground in aquifers. Aquifers hold signifi cant quantities of water over large areas for extended periods. A variety of wetlands form when water saturates the soil and collects on the surface.

Watersheds connect us to the immediacy of the water cycle because they provide our water and often carry away our wastes. Watersheds, also known as catchment or drainage basins, are defi ned as all the land in an area that drains water into one outlet. They vary in size and often support a variety of ecosystems and human developments. Activities such as dam building and deforestation can severely alter the water cycle in a watershed.

Systems thinking seeks to identify and understand the components of complex systems in the context of their connections to other components and systems. By considering connections and interrelationships, we appreciate and clarify both the complexity and the integrity of the system(s). A few examples of connections between water and other Earth systems, each a major ecosystem concept, follow.

1. **Erosion.** Water has literally shaped the land. As it fl ows over land, water wears away rock and moves large amounts of sediment. Ice can break rocks apart. Glaciers grind away mountains and move enormous boulders. In this way, water and rock create and recreate places for life.

2. **Chemical cycling**. Water dissolves elements and nutrients and transports them. Areas with abundant nutrients can support large assemblages of life.)
3. **Life processes.** Water is a vital component for the biological processes that support life, within organisms, around them, and in the interactions between them.
4. **Weather patterns.** Interactions between topography, air current movement, vegetation cover and the water cycle create local weather patterns.
5. **Global climate systems.** The water cycle, infl uenced by solar energy, the earth's spin, latitude, ocean and air currents and land formations, results in a variety of climates around the world.
6. **Ecosystem biodiversity.** The complex interplay between water, sunlight, atmosphere, nutrient availability, soil composition and life itself has resulted in a vast array of ecosystems.

Key Concept

All living things depend upon water.

Life processes rely upon water.

Water constitutes more than 70% of the human body; indeed all organisms are at least half water, some as much as 90%. Without liquid water, the biochemical reactions fundamental to life would cease. Life simply could not exist. Water is essential to photosynthesis, the process by which green organisms, such as plants and algae, transform energy from the sun into energy rich carbohydrates. It's quite simple: no water, no photosynthesis, no food.

Water provides habitat.

Life originated in water and aquatic habitats continue to support a tremendous array of life. The most productive marine ecosystems are concentrated near shorelines, where the sea is enriched as streams and rivers deliver nutrients from the land, or near the ocean surface, where upwelling circulation brings nutrients from the bottom. Nearshore examples include kelp forests and eel grass meadows, mudflats and estuaries. Productive upper layers of open ocean bloom with algae called phytoplankton that feed billions of krill that nourish food chains that include whales. Life thrives even under polar ice and in the sunless ocean depths. Freshwater habitats include lakes, ponds, rivers, streams and ground water that flows beneath the surface. A ready supply of nutrients from inflow or decomposition often supports wetland habitats that are critical for wildlife, including migratory birds and fishes. Wetlands serve to filter and clean water as it slowly moves through, depositing sediments and contaminants.

Being near water is critical for many terrestrial organisms. Humans have often settled beside large, dependable sources of water such as estuaries, rivers and lakes.

Humans need water.

Our bodies need water for ingesting food, eliminating wastes, maintaining constant body temperature, digesting, reproducing, and enabling all the biochemical pathways in our cells. Without water intake, these systems stop functioning in a matter of days. We notice effects even after one day without water. Humans need clean water; many of the worst human illnesses and diseases are caused by water borne pathogens (harmful microorganisms). Bacteria, viruses and other microorganisms require water to survive and reproduce. When abundant, pathogens contaminate water and threaten our health.

Water is part of all facets of our daily lives. Here are some examples:

- cleaning: ourselves, clothes, dishes, pets, houses, goods
- transportation: people, resources, materials and goods
- agriculture: food for humans and food animals
- cooling / heating homes and industry
- waste removal: municipal sewage systems, factory dumping
- recreation: boating, swimming, gardening
- energy: hydroelectric dams, water wheels
- industrial use: everything from aluminum smelting to car manufacturing

Key Concept

Water is finite.

Earth's oceans formed between 4.0 and 3.8 billion years ago as the cooling atmosphere's water vapour condensed, yielding the rain that solidified molten rock and filled depressions. Water covers over seventy percent of our planet.

The water we use today is this same original, fi nite supply. Resource is a term based in economics referring to a useful or valuable possession; water is a natural resource of Canada, and its seemingly inexhaustible abundance is actually limited. Our society uses water extensively, yet we have only recently become aware of the extent that our actions imperil this invaluable, finite resource.

Potable water refers to water that is directly drinkable or can be used for food preparation. The amount of potable freshwater, including groundwater, is less than one percent of the total on earth. We can potentially make potable water by taking the salt out of seawater or melting glaciers and icebergs, but the huge fi nancial and environmental cost of requisite limited, non-renewable energy sources, such as fossil fuels, is prohibitive.

British Columbia is considered rich in water, yet climate change, increased demand for water throughout North America, and pollution have raised many debates about the future.

Pollution degrades water quality We often do not consider what happens to water before and after we use it. Water quality is determined by measuring the water's composition and comparing to a set of established standards, usually set at the provincial and/or federal level. Water pollution has led to a growing concern over the decreasing amount of water suitable for human consumption and domestic and recreational use. The quality of water can be aff ected by a number of pollutants. Types of pollution can be grouped as chemical, physical, thermal and organic.

Many chemical compounds dissolve in water and if present in high enough concentrations, can kill organisms or detrimentally aff ect health, growth and/or reproduction. Chemical pollution includes pesticides, herbicides, polychlorinated byphenyls (PCBs), solvents, heavy metals, salts and acids. Acidifi cation of water often occurs when sulfur dioxide released from industrial activity and the burning of fossil fuels reacts with water in the atmosphere. The resulting acid rain can damage aquatic and soil ecosystems.

Physical pollutants, sometimes referred to as contaminants, don't dissolve in water but nevertheless reduce water quality. Erosion is an example, where sediment can muddy waters and settle on the bottom, clogging gills and covering organisms. Oil pollution is another example. Thermal pollution changes water temperature, for example streams heated by industrial plant turbines. Many aquatic organisms have a limited tolerance to temperatures outside of their comfort zones. Organic pollution refers to nutrient rich sewage, agriculture manure and pulp mill effl uent, as well as chemical compounds such as fertilizers, which stimulate excess growth to the detriment of the whole ecosystem. Nitrogen and phosphates in fertilizers and sewage can promote algal blooms in streams, lakes and oceans. As the algae grow, nutrients are removed from the ecosystem and light penetration becomes limited, negatively aff ecting the growth of other plant and algal species. As the algae die, they become food for decomposers such as bacteria, who fl ourish and use up oxygen. The drop in dissolved oxygen can kill fi sh and other animals. With further death come more bacteria and less oxygen, and the cycle of eutrophication spirals downward to the death of an ecosystem.

Pollution sources are identified as either point or non-point. Sewers or factory outfalls are examples of point source pollution, which can be relatively easily identified and thus remedied. Non-point source pollution enters a drainage system over a wide area and is therefore much more difficult to identify and rectify. Common sources are agricultural and municipal areas. Non-point pollution increases along with human population. Education campaigns such as storm drain marking are underway worldwide to encourage citizens to become aware of their impact on the water cycle and take action.

Humans not only affect water quality; we also impact water quantity. Damming for reservoirs or hydropower, clearing of vegetation, irrigation, over-exploitation of groundwater, and development all influence where and how much water moves across and through the land. Lowered water tables and depleting aquifers are seen worldwide. Desertification is an extreme example.

British Columbia is considered rich in water, yet climate change, increased demand for water throughout North America, and pollution have raised many debates about the future. Many challenges face water managers, especially when multiple users want the same water for different purposes. Acknowledging a limited water supply and degraded quality, sustainability has become a key focus for scientists, resource managers, politicians, and the public.

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