Nutrient Cycles

Living things need more than energy to function. If an organism is to live, grow, and reproduce, it must take in variable amounts of different nutrients (Figure 1.5.6). Nine **macronutrients**—carbon, oxygen, hydrogen, nitrogen, phosphorus, potassium, calcium, magnesium, and sulphur—are the major building blocks of the complex organic compounds found in all living organisms. Macronutrients are required in large amounts by most forms of life to make proteins, fats, and carbohydrates. Many organisms also require trace amounts of **micronutrients** such as boron, copper, iron, zinc, chlorine, manganese, and molybdenum.

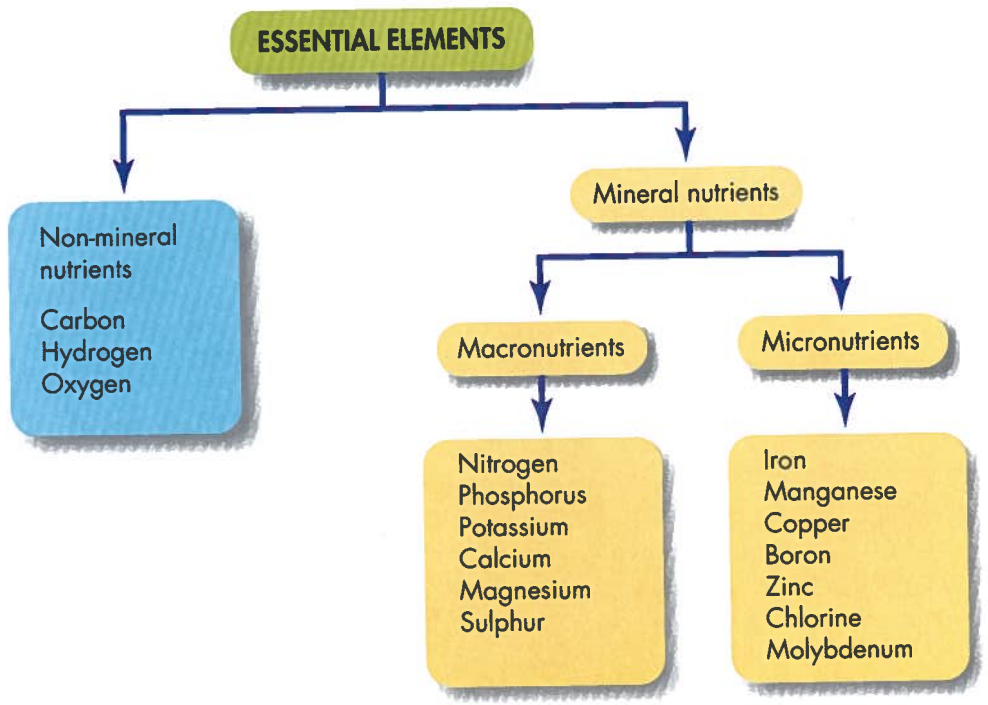

Figure 1.5.6 Classification of plant nutrients. Given that these nutrients are part of a closed system, how do you think plants return these nutrients to the biosphere?

These nutrients are essentially contained within a closed system on Earth, meaning that no nutrients enter or leave the biosphere in large quantities. For this reason, only limited amounts of the essential nutrients are available to living organisms, so the available nutrients, such as carbon, nitrogen, and phosphorus, must be constantly recycled and reused by organisms. The recycling of these nutrients involves interactions between the living organisms and the physical environment, so they are sometimes referred to as **biogeochemical cycles**. In this way, nutrients are continually circulating through Earth's atmosphere, hydrosphere, geosphere, and biosphere, connecting past, present, and future life. The five main cycles, driven directly or indirectly by incoming solar radiation and gravity, are the hydrologic (water), carbon, oxygen, nitrogen, and phosphorus cycles. Each is examined in the pages that follow.

The Hydrologic (Water) Cycle

Water occurs in three forms: liquid, solid (ice), and gas (water vapour). Ninety-seven percent of the water in the hydrosphere is found in the world's oceans. Of the remaining 3 percent, approximately 70 percent is temporarily stored as ice in the polar and mountainous areas, 30 percent is found under the surface as groundwater, and less than 1 percent is found in rivers and lakes. The **water cycle** is the continuous circulation of water through the hydrosphere.

Most of Earth's water is found in its oceans in liquid form. When the Sun shines on any body of water, it causes some of the water to evaporate, becoming water vapour. As water vapour rises up into the atmosphere, it cools; and when water vapour cools, it condenses to form clouds. As clouds cool further, precipitation begins to fall. The form it takes—as rain, snow, hail, or fog, for example—depends upon the temperature.

GEO-FACT
More than half the world's animal and plant species live in water.

The water falls to Earth. If rain flows over the ground and into a body of water, it is called run-off. Run-off flows into streams and rivers and eventually back into the sea. Water can also soak into the ground, where it might be stored as groundwater in the small spaces between particles of soil, sand, and rock. It moves slowly, but eventually flows back into the ocean. Some water evaporates quickly again, or is released as water vapour by the leaves of plants in a process known as transpiration. The cycling of water vapour into the atmosphere by evaporation and transpiration is called evapotranspiration.

It is estimated that each day a total volume of 1170 cubic kilometres of water is involved in the never-ending water cycle. Nine hundred sixty cubic kilometres of water evaporates from the oceans and another 210 cubic kilometres from land surfaces. The same quantity is returned to the surface from the atmosphere by precipitation: 875 cubic kilometres falls over the oceans and 295 cubic kilometres over land surfaces. Therefore, land surfaces gain a surplus of approximately 85 cubic kilometres of water per day. This surplus water makes it back to the sea

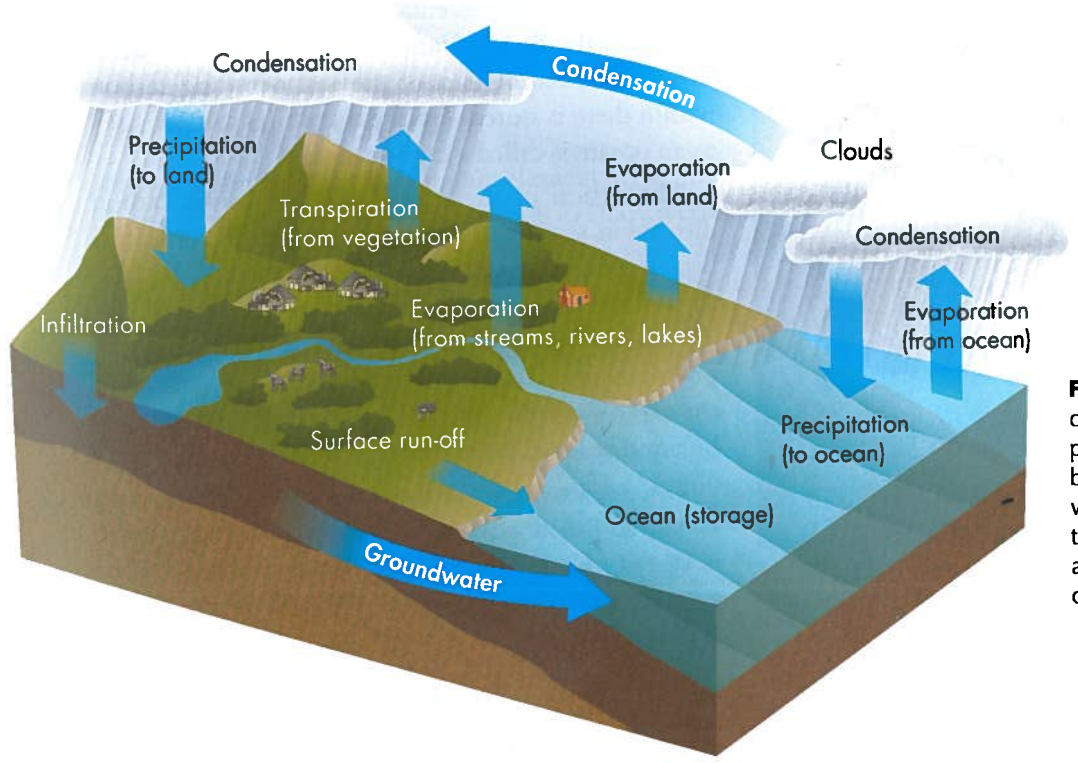

Figure 1.5.7 The water cycle. Explain how it is possible that you may be drinking the same water that flowed through a Roman aqueduct thousands of years ago.