SCI – NITROGEN CYCLE

The nitrogen cycle has aspects of both the carbon cycle and the phosphorus cycle. Like carbon, nitrogen possesses a gas phase; like phosphorus, it acts as a limiting factor. The nitrogen cycle is otherwise unique, as bacteria in soils, water and sediments perform many of the steps of the cycle.

The main reservoir of nitrogen is the air, which is about 78% nitrogen gas (N_2). This is called nonreactive nitrogen; only a small number of microbes can use it. The remaining forms of nitrogen are called reactive nitrogen, because they readily move between organisms and environmental systems and are responsible for many changes in those systems.

Plants in terrestrial ecosystems take up reactive nitrogen as ammonium ions (NH_4^+) or nitrate ions (NO_3^-). The plants incorporate the nitrogen into essential organic compounds such as proteins and nucleic acids. The nitrogen then follows the classic food web from producers to herbivores to carnivores and finally, to decomposers. At various points, nitrogen wastes are released, primarily as ammonium compounds. A group of soil bacteria, the nitrifying bacteria, oxidizes the ammonium to nitrate in a chemosynthetic process that yields energy for the bacteria. At this point, the nitrate is once again available for uptake by green plants.

Nitrogen Fixation

A number of bacteria and cyanobacteria (chlorophyll-containing bacteria, formerly referred to as blue-green algae) can use nonreactive nitrogen through a process called biological nitrogen fixation. In terrestrial ecosystems, the most important among these nitrogen-fixing organisms are bacteria in the genus *Rhizobium*, which live in nodules on the roots of legumes, the plant family that includes peas and beans. This is another example of mutualistic symbiosis as the legume provides the bacteria with a place to live and with food (sugar) and gains a source of nitrogen in return. From the legumes, nitrogen enters the food web. The legume family includes a huge diversity of plants, ranging from clovers (common in grasslands) to desert shrubs and many trees. Every major terrestrial ecosystem, from tropical rainforest to desert and tundra, has its representative legume species, and legumes are generally the first plants to recolonize a burned-over area. Without them, all production would be sharply impaired due to a lack of available nitrogen. In aquatic ecosystems, cyanobacteria are the most significant nitrogen fixers.

Three other important processes also fix nitrogen. One is the conversion of nitrogen gas to the ammonium form by discharges of lightning in a process known as atmospheric nitrogen fixation; the ammonium then comes down with rainfall. The second is the industrial fixation of nitrogen in the manufacture of fertilizer; the Haber-Bosch process nitrogen gas and hydrogen to ammonia. The third is a consequence of the combustion of fossil fuels, during which nitrogen from coal and oil is oxidized. Both of these process lead to nitrogen oxides (NO_X) in the atmosphere, which are soon converted to nitric acid and brought down to Earth as acid precipitation.

Denitrification

Denitrification is a microbial process that occurs in soils and sediments depleted of oxygen. A number of microbes can take nitrate (which is highly oxidized) and use it as a substitute for oxygen. In so doing, the nitrogen is reduced (loses oxygen) to nitrogen gas and is released back into the air. Large amounts of organic matter are decomposed in this manner. Farmers seek to avoid denitrification because it reduces soil fertility. Accordingly, they plow as early as possible in the spring in order to restore oxygen to the soil. In sewage treatment systems, denitrification is a desirable process and is promoted to remove nitrogen from the wastewater before it is released into the environment.