

DO NOT WRITE ON THIS SHEET

Nitrogen Cycle Activity

Introduction:

Chemical elements on earth exist in a closed system. This means all chemical elements, including nitrogen, are neither created nor destroyed; rather, there is a finite amount of each. Consider the way air is recycled on an airplane. The air is repeatedly taken from the passenger cabin through a filter and passed through a duct back into the passenger cabin. Similarly, chemical elements repeatedly cycle through reservoirs (storage areas) in an ecosystem. They are reorganized and recombined in different molecular forms such that the quantity of each element within the ecosystem remains the same.

Nitrogen is an element that is found in both the living (organic) portion of our planet and the inorganic (non-living) parts of the Earth system. The nitrogen cycle is one of the biogeochemical cycles and is very important for ecosystems. Nitrogen moves slowly through the cycle and is stored in reservoirs such as the atmosphere, living organisms, soils, and oceans along its way.

Most of the nitrogen on Earth is in the atmosphere. Approximately 80% of the molecules in Earth's atmosphere are made of two nitrogen atoms bonded together (N_2). All plants and animals need nitrogen to make amino acids, proteins and DNA, but the nitrogen in the atmosphere is not in a form that they can use. The molecules of nitrogen in the atmosphere can become usable for living things when they are broken apart during lightning strikes or fires, by certain types of bacteria in the soil, or by bacteria associated with legume plants (like soybeans). Other plants get the nitrogen they need from the soils or water in which they live mostly in the form of inorganic nitrate (NO_3^-).

Nitrogen is a limiting factor for plant growth. Animals get the nitrogen they need by consuming plants or other animals that contain organic molecules composed partially of nitrogen. When organisms die, their bodies decompose bringing the nitrogen into soil on land or into the oceans. As dead plants and animals decompose, nitrogen is converted into inorganic forms such as ammonium salts (NH_4^+) by a process called ammonification. The ammonium salts are absorbed onto clay in the soil and then chemically altered by bacteria into nitrite (NO_2^-) and then nitrate (NO_3^-). Nitrate is the form commonly used by plants. It is easily dissolved in water and leached from the soil system. Dissolved nitrate can be returned to the atmosphere by certain bacteria in a process called denitrification.

Certain actions of humans are causing changes to the nitrogen cycle and the amount of nitrogen that is stored in reservoirs. The use of nitrogen-rich fertilizers can cause nutrient enrichment in nearby waterways as nitrates from the fertilizer wash into streams and ponds. The increased nitrate levels cause algae to grow rapidly until they use up the nitrate supply and die. This process is called eutrophication and will lead to lower dissolved oxygen levels in the water. Additionally, humans are altering the nitrogen cycle by burning fossil fuels, which releases various solid forms of nitrogen into the atmosphere. Farming also affects the nitrogen cycle. The waste associated with livestock farming releases a large amount of nitrogen into soil and water. In the same way, sewage waste adds nitrogen to soils and water.

Directions:

1. During this activity you will play a nitrogen atom traveling through different reservoirs.
2. At each station you will roll the dice provided at the station and move based on the directions given. Record the following on your handout:
 - a. How you traveled
 - b. Where you went (Station Name)
 - c. Appropriate Nitrogen Cycle Vocabulary Word
 - d. Description of the process using AP Information (refer to vocabulary list)
3. Travel around the room until your handout is full.
4. Return to your seat. Answer the conclusion questions on the back of the handout.

Nitrogen Cycle Vocabulary:

- **Ammonia:** NH_3 is a product of the decomposition of animal waste.
- **Ammonification:** The process where decomposers (bacteria and fungi) break down organic material (such as animal waste and dead organisms) into ammonium ions (NH_4^+). Ammonium ions (NH_4^+) can be taken up and used by plants.
- **Ammonium Ions:** NH_4^+ is a water-soluble form of nitrogen that can bind to the surface of soil particles. It is formed during ammonification. This form of nitrogen can be absorbed by plant roots.
- **Assimilation (Plant Uptake):** Plant roots absorb ammonium ions (NH_4^+) and nitrate ions (NO_3^-) for use in making molecules such as DNA, amino acids, and proteins.
- **Denitrification:** The process by which denitrifying bacteria (a specialized bacteria) reduce organic, chemically reactive forms of nitrogen, nitrite (NO_2^-) and nitrate (NO_3^-), and release nitrogen gas (N_2) into the atmosphere. Reduction is a chemical process where oxygen atom(s) are detached from the compound, which results in a net gain in positive charge.
- **Eutrophication:** The process of nutrient enrichment. Excess nitrates/phosphates enter an aquatic (water) ecosystem, which cause an over-abundance of phytoplankton (algae) and a subsequent reduction in dissolved oxygen levels when the algae die and decay.
- **Fertilizer:** Used to promote plant growth. Contains nitrates. Inorganic fertilizers are mined or synthetically manufactured mineral supplements. Organic fertilizers consists of the remains or wastes of organisms including animal manure, crop residues, or compost.
- **Food Web Relationships:** Nitrogen moves through the food web when consumers eat producers.

- **Nitrogen Gas (N₂):** Nitrogen makes up 78% of our atmosphere by mass. The nitrogen gas in the atmosphere is not biological available, which means it is not able to be used by plants and animals.
- **Nitrification:** The process in which soil-dwelling bacteria oxidize ammonia (NH₃), into nitrite (NO₂⁻) and nitrate (NO₃⁻). Oxidation occurs when an oxygen atom is attached to a compound. Nitrite and nitrite ions can be taken up and used by plants. Negatively-charged nitrite and nitrates can't bind to clay particles, so they are easily leached (washed) from the soil into the groundwater.
- **Nitrogen Fixation:** Converts N₂ from the atmosphere (inert nitrogen gas (N₂) is "fixed" or changed into a compound form). Biotic processes convert N₂ to ammonia (NH₃). Abiotic processes convert N₂ to nitrate (NO₃⁻).

Nitrogen fixation can occur in several ways:

- 1) **Abiotic (non-living):** By the intense energy of lightning strikes. In this process, nitrogen gas (N₂) combines with oxygen to form nitrogen oxides such as NO and NO₂, which are carried to earth's surface in rainfall as nitric acid (HNO₃).
- 2) **Biotic (living):** When air in the top layer of soil comes into contact with nitrogen-fixing bacteria that typically live on the roots of legumes (plants like soybeans, peas, and clover), N₂ can be converted into NH₃, and then changes to ammonium (NH₄⁺) in the soil.

Water Cycle Vocabulary:

- **Aquifer:** Sponge-like regions of rock and soil that hold groundwater. The upper limit of groundwater held in an aquifer is called the water table.
- **Infiltration:** Water soaks down into the ground.
- **Precipitation:** Water vapor condenses in the atmosphere and falls as rain, snow, sleet, or hail.
- **Watershed:** The area of land where all of the water that is under it or drains off of it goes into the same place. Small creeks will run into streams, which run into larger rivers, which eventually carry water to the ocean.

Other Vocabulary:

- **Decomposition:** The breakdown of dead organic material into simpler constituents that can then be taken up and used by plants.
- **Limiting Nutrient:** Organisms need nitrogen in relatively high amounts. Because so much is required, nitrogen is often a limiting nutrient for producers. In other words, a lack of nitrogen constrains the growth of the organism.