PROJECT O*CEANOLOGY*

Nutrient Cycle Activities

Overview:

In this series of activities, students are introduced to nutrient cycles. They begin by learning about the carbon cycle through an interactive game, then move on to build models for other nutrient cycles and even design their own games. Each of the activities below can also be used in isolation.

Activity 1: Carbon Cycle

Have students play Jennifer Ceven's carbon cycle game. See separate PDF for details. Materials needed: dice.

Activity 2: Nitrogen and Phosphorus Cycles

In class, students work in groups with large sheets of paper and markers to make diagrams showing the nutrient cycle for either Nitrogen or Phosphorus, using the information provided below. Groups take turns presenting their cycle diagrams to the class.

Optional: Do not provide the human impacts information at the bottom of each sheet. Instead, have students brainstorm how humans might affect the cycle they have studied, the conduct research to support or reject their predictions.

Activity 3: Extension of Knowledge

Students work in small groups to design a game that could be used to learn about their assigned nutrient cycle.

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Nitrogen

Assignment: Use the information provided below to draw a diagram of the nitrogen cycle. Begin by drawing a diagram or map of the major reservoirs. Then, use arrows to show how nitrogen moves between the reservoirs. Next to each arrow, indicate the process that takes place.

Major reservoirs:

Atmosphere (48%): *Nitrogen in the atmosphere is primarily in the form of N_2, nitrogen gas. The atmosphere is the biggest reservoir of nitrogen on earth.*

Rocks (25%): *Nitrogen is absent from newly formed volcanic (igneous) rock, but it can be found in sedimentary and metamorphic rocks.*

Soil (26%): *Nitrogen in soil is found primarily as ammonium (NH_4^+) and nitrate (NO_3^-). Special nitrogen-fixing bacteria are needed to convert atmospheric nitrogen (N_2) to these other forms.*

Ocean (4%): *Nitrogen is present in the ocean as dissolved nitrogen gas (N_2), as ammonium (NH_4^+), as nitrate (NO_3^-), or several other forms.*

Plants and Animals (<1%): *Plants and animals need nitrogen, but they cannot get it from the atmosphere. Plants can absorb ammonium and nitrate from the soil or the ocean, and animals get nitrogen by eating the plants. Although living organisms contain only a very small percentage of the world's nitrogen, they are responsible for many of the processes of the nitrogen cycle.*

Major processes:

Process	Description
Nitrogen fixation	Nitrogen gas (N_2) is converted to ammonium (NH_4^+) by special bacteria. These bacteria often live in symbiosis with plants.
Nitrogen uptake	Plants absorb ammonium or nitrate into their roots, and the nitrogen is then incorporated into proteins and other molecules that make up the plant.
Nitrogen mineralization	After organisms die, decomposition occurs. Nitrogen contained in various compounds in the body 'decays' back into ammonium (NH_4). The ammonium is then present in the soil or water and available again.
Nitrification	In the presence of oxygen, ammonium can be converted to nitrate (NO_3^-). Like ammonia, nitrate can be taken up by plants. Ammonium tends to be retained in soils because it is positively charged, but nitrate is negatively charged and can be leached away by rainwatrer.
Denitrification	Bacteria can convert nitrate to atmospheric nitrogen gas (N_2). The gas then rejoins the atmosphere. Denitrification and nitrogen fixation roughly balance each other.

How do humans affect the nitrogen cycle?

Humans increase the amount of fixed nitrogen available by using fertilizer and by cultivating legumes, which are typically associated with nitrogen-fixing bacteria. Industrial activity can increase levels of rarer nitrogen gas forms such as nitric oxide (found in smog) and nitrous oxide (a greenhouse gas that also causes acid rain).

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Phosphorus

Assignment: Use the information provided below to draw a diagram of the phosphorus cycle. Begin by drawing a diagram or map of the major reservoirs. Then, use arrows to show how nitrogen moves between the reservoirs. Next to each arrow, indicate the process that takes place.

Major reservoirs:

Rocks: *Phosphorus is found in a wide variety of rock types. Most of the phosphorus on earth is found in rocks and sediments.*

Sediment/soil: *Phosphorus tends to accumulate in sediments because it is not very soluble and gets absorbed onto sediment particles.*

Water: *Water leaches phosphorus from rocks and soils, but phosphorus is not very soluble in water and so eventually settles out into sediments.*

Plants and Animals: *All organisms need phosphorus to live. Phosphorus is found in DNA and in many other important biological molecules. Phosphorus is often a limiting factor in ecosystems, because its availability usually depends on the proximity of phosphate-containing rocks. Plants are able to absorb phosphorus from the environment, but animals must get it by eating plants.*

Major processes:

Process	Description
Weathering	Phosphates are dissolved out of rocks and enter the soil or water.
Phosphorus uptake	Plants absorb phosphate ions from the soil, or from seawater. Animals obtain phosphorus by eating plants.
Decomposition	Fungi and bacteria decompose phosphorus from animals and plants and from their waste, returning it to soil and water.
Sedimentation	Sediments containing phosphorus are converted into sedimentary rock through the process of sedimentation.

How do humans affect the phosphorus cycle?

The phosphorus cycle is one of the slowest cycles, because phosphorus tends to end up in sediments on ocean floors and lake bottoms. It is only replenished through the very slow geological process of sedimentation (when sediments are turned into rock). That sedimentary rock can eventually move back into terrestrial environments through geological uplift.

Humans affect this process primarily through the use of fertilizers. Phosphates enter waterways via runoff from agricultural areas, and also from sewage seepage and other industrial processes. Excess phosphate in the water can cause algal blooms in rivers and oceans, leading to eutrophication (dead zones). Phosphate is harvested from specific types of sedimentary rock with high phosphate content, and these rocks are considered a non-renewable resource because they are harvested at a much faster rate than they are generated by sedimentation and made available by uplift.