Ecology: The Nitrogen Cycle

*Lesson 12*_06 - 07

Text Reference, Section 2.6 Page 66 - 68

Life depends on the cycling of nitrogen, as it is used for making proteins and DNA.

Plants get their nitrogen from the soil in the form of nitrates, whilst animals get their nitrogen by eating plants or herbivores.

All plants and animals need nitrogen, they use it to make proteins.

79 % of Earth's atmosphere is nitrogen gas, $N_{2\ (g)}$, however, plants can not use the nitrogen in the air, since it is a very stable molecule, $N \equiv N$, and is not useable by most organisms.

How , then, does nitrogen become part of living things?
To be useful to organisms, the nitrogen gas, $N_{2\ (g)}$, in the atmosphere must be converted into nitrates, NO_3^{-1}, since nitrates are water soluble and are taken up by the roots of green plants; and can therefore be absorbed by the plants. The nitrogen is thus fixed in plant tissue.

The process by which nitrogen gas, $N_{2\ (g)}$, is converted into nitrates is called **Nitrogen Fixation**.
This is achieved by two means:

1. lightening and
2. bacteria in the soil

1. Nitrogen Fixation by Lightening:

The energy from lightening causes nitrogen gas, $N \equiv N_{(g)}$, to react with oxygen in the air producing nitrates, NO_3^{-1}.
The nitrates dissolve in rain or surface water, enter the soil and then move into plants through their roots.

2. Nitrogen Fixation by Bacteria:

Nitrifying bacteria capable of fixing nitrogen are found mainly in the soil and in the root swellings called **nodules** on the roots of legumes such as clover peas, and beans.

These nitrifying bacteria (and also blue-green algae) can take in nitrogen from the air and convert it to nitrates that can hence be used by plants, simultaneously the plant supplies sugars from the process of photosynthesis to the bacteria.

Excess nitrates move into the soil, providing nitrogen for other plants.

The traditional agricultural practices of including legumes in rotation helps with bacterial nitrogen fixation by introducing ammonia into nitrogen-poor soil.

Nitrogen and Decomposers

When organisms die, decomposers break down nitrogen containing chemicals in the waste or body into simpler chemicals such as ammonia, NH_3.

Other nitrifying bacteria convert ammonia into nitrites and then to nitrates.

$$\text{ammonia} \longrightarrow \text{nitrites} \longrightarrow \text{nitrates} \longrightarrow \text{protein}$$

The bacteria require oxygen to function.

Denitrification

Bacteria also perform denitrification, to complete the nitrogen cycle.

Some of the nitrates in the soil are used by plants, however, some of the nitrates are converted back into nitrogen gas, $N_{2\ (g)}$, to be released back into the atmosphere.

The process of converting nitrates into nitrogen gas is called **Denitrification**, and the bacteria are called **denitrifying bacteria**.

nitrates ⟶ nitrites ⟶ nitrogen gas

Denitrifying bacteria do not require oxygen.

Gardeners aerate their lawns to prevent denitrifying bacteria from converting the nitrates into $N_{2\ (g)}$.

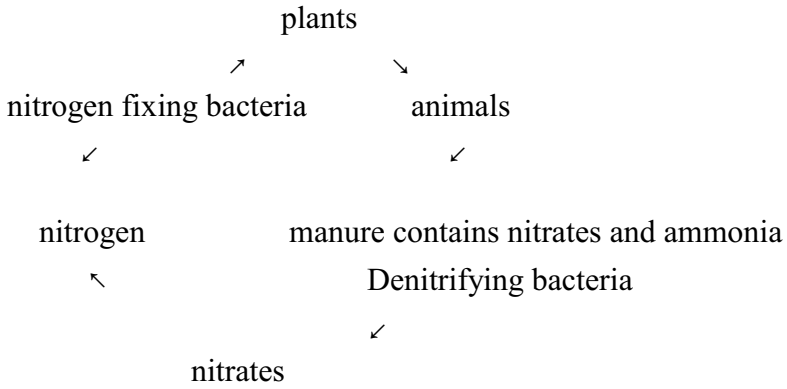
Human Impact

Use of fertilizers:

- ♦ Increases acidity of soil, thus affecting sensitive crops
- ♦ spring runoff increases algae growth, thus reducing available oxygen in water
- ♦ increases level of nitrites which can attach to hemoglobin and decrease the amount of oxygen carried in the blood

Two important abiotic factors that control the rate of decomposition are: (1) temperature, (2) oxygen.

Summary of the Nitrogen Cycle



The nitrogen cycle consists of nitrification and denitrification processes that are interconnected.

Through nitrification, nitrogen gas is converted into nitrates that can be used by plants and, through denitrification nitrogen is removed from decaying material and released as gas to complete the cycle.

Homework

Read pages 66 - 67
Page 69 # 1-4, 6, 8, 9, 10, 11
Worksheet- Nitrogen Cycle
Worksheet- Nutrient Cycle

THE PHOSPHOROUS CYCLE

Text Reference: Section 2.6 page 68

Phosphorus is important in cell membranes, involved in the release of chemical energy from food, making DNA and found in bones as calcium phosphate.

Phosphorus cycles through living organisms and the rocks of the Earth crust in the form of the phosphate ion, PO_4^{-3}.

Phosphates are soluble in water and when dissolved out of rock can be absorbed by photosynthetic organisms and so can be passed into the food chain.

Human Impact:

Use of fertilizers: spring runoff increases algae growth, thus reducing available oxygen in water.

Variations in Nutrient Cycling

Definition: **Nutrients** are chemicals that are essential to living things, such as nitrates and phosphates.

The rate at which nutrients cycle through an ecosystems is linked to the rate of decomposition, which is affected mainly by the temperature and oxygen levels, (cycling is the fastest in the tropical rain forest, and slowest in the desert and Arctic ecosystems).

Homework

1. Read pages 68-71
2. Worksheet- Phosphorus Cycle
3. Worksheet- Carbon, Nitrogen, and Phosphorus Cycles
4. Worksheet- Cycle Review

5. Answer the following questions:

(i) Why do living things need Nitrogen?

(ii) How do plants obtain Nitrogen?

(iii) How do animals obtain Nitrogen?

(iv) Describe three ways in which Nitrogen is changed to nitrates.

(v) How does Carbon from the air get into the bodies of plants and animals?

(vi) What is the equation for photosynthesis?

(vii) What is the equation for cellular respiration?