TwoOldGuys™ Study Guides
BI114 Biological Concepts for Teachers
Chapter 5. Ecology, Basics
5.5. EcoSystem, Nutrient Cycles

Based on Indiana's Academic Standards, Science, as adopted by the Indiana State Board of Education, Nov 2000.
Numbers refer to the age-appropriate grade-level for the content.

Ecosystem, nutrient cycles

Energy flows through the ecosystem. There is a nearly endless supply of energy coming from the Sun to the Earth. As this energy flows through each trophic level, it provides enough energy to keep the organisms of the trophic level alive. However, the flow of energy is similar to a stream flowing out of the mountains to a desert and on to a *playa*, or dry lake. The further across the desert the stream flows, the less water there is due to evaporation. As organisms use energy, there is less available 'down stream' for other organisms.

Nutrients, other than energy, are available only in fixed amounts. If a plant were to remove all of the phosphorus from the soil, there would be no more for other plants. To replenish the nutrients in the soil, the detritus must return these nutrients to the soil.

grades 1: to 3:

Animals eat plants or other animals as food

Food provides not only the energy needed to do the things that living creatures have to do to stay alive, but also provides the nutrients to grow strong bodies. This is why humans have to eat a balanced diet (bread

and cereal, vegetables, fruit, meat, and dairy products) – so they get everything they need to grow healthy, strong bodies. The same applies to other animals, although what is a balanced diet for one animal may not be for another. A balanced diet for cats is mostly meat. In the wild, house cats [called feral cats] eat mostly birds and mice. However, a rabbit would not stay healthy eating birds and mice. They require a diet high in leafy vegetables.

grades 4: to 6:

Animals eat to get materials for growth

All living things require energy to maintain life, plus other nutrients, such as minerals. For example, all red-blooded animals need Iron to form red blood cells. Without the correct amount of each mineral nutrient, animals cannot grow nor repair damage resulting from injuries. Some minerals may also protect from certain infections, assist in digesting food, or help with other processes involved in staying alive.

Plants get material for growth from the soil & air

Since plants do not eat [except perhaps for plants such as Venus Flytrap, which may eat flies], they must get all of their mineral nutrients either the soil, water, or air. Carbon and some Oxygen come from the air; Hydrogen and some Oxygen come from water. Nitrogen, Phosphorus, and Sulfur come from soil (or may be dissolved in water). The other soil minerals required (in smaller amounts) are: Iron, Sodium, Magnesium, Aluminum, Silicon, Chlorine, Potassium, and Calcium. Other minerals may be needed in very small amounts.

grades 7: to 8:

Chemicals cycle through ecosystems

- producer-based ecosystem
- detritus-based ecosystem

Chemicals [minerals] enter the ecosystem as plants pick them up from soil, water, and air. A portion of the mineral content of the producer trophic level is passed to the detritus-based system by the death of plants and the loss of parts (such as leaves), while the majority of the minerals are consumed by the primary consumers. Again a portion of the mineral content of the consumer trophic levels is passed to the detritus-based system by death or loss of parts, while the majority is consumed by members of the next higher trophic level (if there is one).

Most of the nutrients in the detritus are returned to the soil or air by bacteria, fungi, and chemical decomposition, with a portion being eaten by the scavengers. Eventually the scavengers die (or shed hair) returning the nutrients back to the detritus. The return of mineral nutrients from the detritus to the soil [or air] replenishes the nutrient content of the physical environment. This step completes the cycle of mineral movement through the ecosystem.

grades secondary: to college:

Biogeochemical cycles

- carbon cycle
- nitrogen cycle

Carbon:

In the physical environment part of the ecosystem, Carbon is found mostly as atmospheric Carbon dioxide and as Calcium carbonate in rocks. Most texts mention coal, peat and muck as additional reservoirs of Carbon, but for the purposes of this textbook, these reservoirs are considered to be part of the detritus rather than part of the physical environment. If you are uncomfortable with listing coal as rotting vegetation rather than as rocks, then you are free to redefine it as you wish [remember Humpty Dumpty, in Lewis Carroll's version]. For most, if not all, plants, the Carbon source which is "bioavailable," or "able to be absorbed into living organisms' bodies," is atmospheric Carbon dioxide.

In the living part of the producer-based ecosystem, Carbon is released as Carbon dioxide into the atmosphere by exhaling both by plants and by animals. The carbon dioxide is the result of burning sugars, carbohydrates, and fats to release the energy in them. In the living part of the detritus-based ecosystem, the Carbon trapped in detritus is converted to Carbon dioxide by bacteria and fungi. This process is not necessarily fast. Carbon can become trapped in tree trunks for about 250 years for most temperate zone tree species. The oldest known living creature is a small tree (slightly over 1 meter [3 feet] tall) which lives in southwestern North America and which resembles *bonsai*. This tree is around 5,750 years old, and contains carbon trapped there as long ago as 5,750 years.

Some of the Carbon from each trophic level is eventually deposited into the detritus. Some compounds are burned for energy releasing Carbon dioxide to the air. However, some Carbon is returned to the air as Methane (CH_4), which cannot be picked up directly by plants. The Methane must be burned to Carbon dioxide, either by lightning or wildfires before it can return to plants. A portion of the cycling Carbon is withdrawn from the cycle, and stored in geologic form. Carbon in

cellulose and fats and oils may remain in the soil, slowly converting to the fossil fuels, coal and oil. Carbon in some shelled animals [snails, clams, oysters, etc.] is combined with Calcium and Oxygen to produce Calcium carbonate, which is slowly converted to limestone. These geologically stored Carbon reservoirs [including limestone and fossil fuels such as coal and oil] may remain out of the cycling Carbon pool for millions of years. There is some evidence that there is a very long term cycle of Carbon moving into or out of the geological reservoir. Since Carbon dioxide and Methane are "greenhouse gases" which, like water, allow incoming sunlight to add heat to the Earth, but limit the re-radiation of heat energy to deep space, this suggests an equally long cycle of greenhouse warming to virtually worldwide tropical conditions and global cooling to wide-spread glacial conditions. Tropical conditions result when geological Carbon is released, and glacial conditions result when Carbon is being trapped [called "sequestering"] in long term storage.

Nitrogen:

In the physical environment part of the ecosystem, most Nitrogen is in the atmosphere as Nitrogen gas (or molecular Nitrogen, N_2). Nitrogen gas (N_2) is not bioavailable, so cannot be absorbed by plants. In air downwind of some industries [particularly fossil fuel-fired power plants} there is additional Nitrogen in the form of oxides of Nitrogen, NO_x = NO_2 and NO_3.

There are nitrogen-fixing bacteria which live in nodules on the roots of peas, beans and other legumes. Although these are bacteria, they are not technically considered part of the detritus-based system, but do not fit in the producer-based trophic level either. These bacteria convert molecular Nitrogen to Ammonia (NH_4^+) which is bioavailable at least for legumes and a few other plants. Another group of bacteria, the nitrifying bacteria, use the Ammonia to Nitrite (NO_2^-) reaction as an energy source

[chemosynthetic bacteria]. The Nitrite is a substrate used by nitrate-producing chemosynthetic bacteria which produces the byproduct nitrate (NO_3^-). The nitrate is bioavailable for most plants.

In the living part of the producer-based ecosystem, most Nitrogen is trapped in proteins. It is in this form that Nitrogen moves through the trophic levels. Relatively small amounts of the Nitrogen in proteins of plants and animals are converted to various compounds such as ammonia and urea, and returned as waste products to the detritus-based system.

In the living part of the detritus-based ecosystem, the Nitrogen-containing protein is decomposed releasing Ammonia as a waste product. To become available for most plants, the nitrifying and nitrate-producing bacteria must convert the Ammonia to nitrate. Ammonia that escapes conversion is released to the atmosphere where some is converted to nitrite or nitrate by lightning, meteors, and extreme ultra-violet light (cosmic rays).

Other nutrients:

All of the other mineral nutrients go through equally complex cycles between the 'normal' environmental reservoirs, living organisms, detritus-based systems, and geologic storage. For all transition elements [those in the periodic table of the elements between column 2 and column 3; see Appendix D. Chemistry of Life; D.1. Molecules, basic chemistry], these cycles include bio-available forms and forms which are not bio-available.

Detritus-based ecosystems

The detritus based ecosystems serve the dual function of returning nutrients to the soil and of sequestering some materials into geologic deposits.