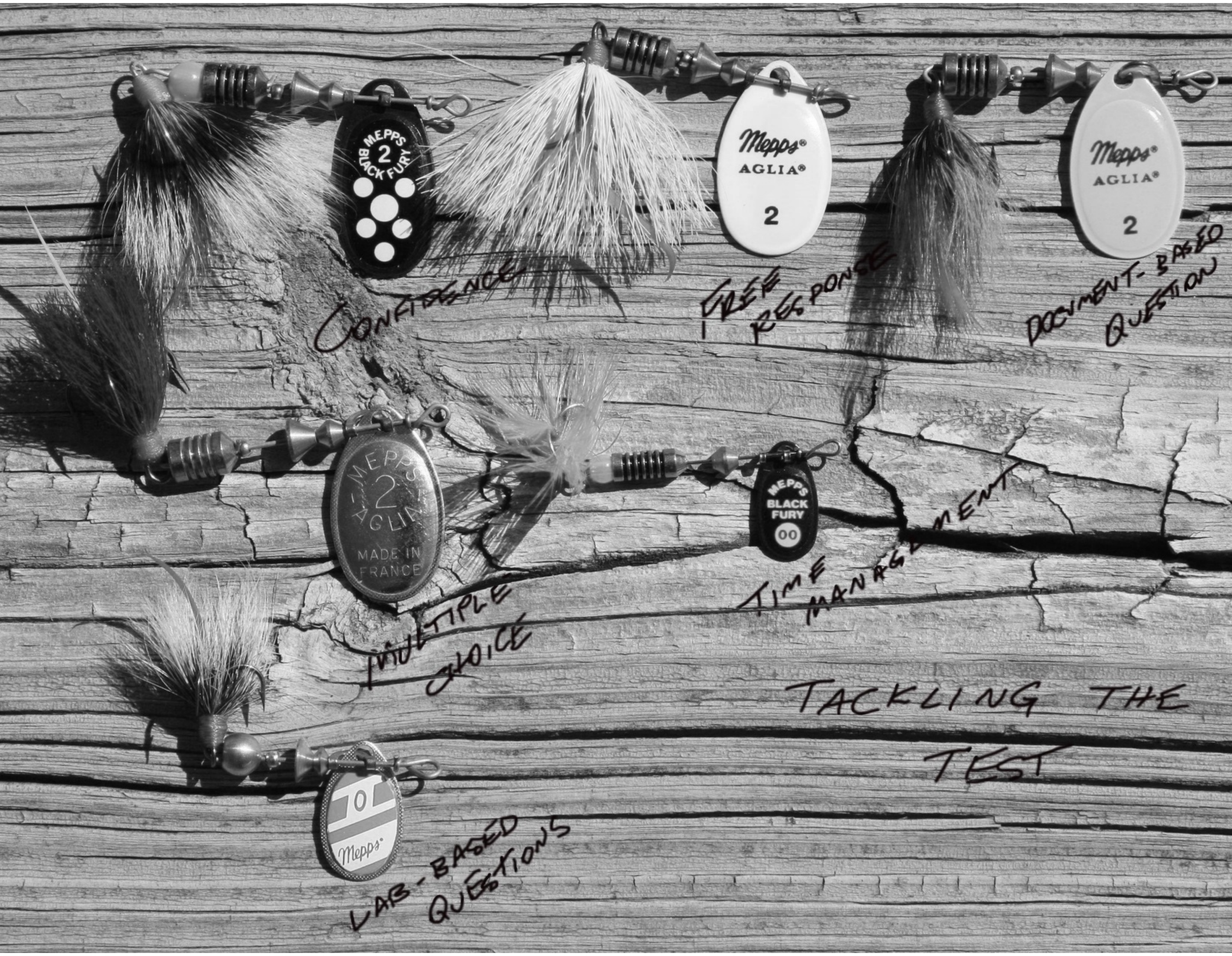
Advanced Placement

ENVIRONMENTAL SCIENCE

Ecology + Biogeochemical Cycles



NATIONAL MATH + SCIENCE INITIATIVE

Student

2014

Ecology

Ecology is the study of the connection between an organism and its environment. The levels studied here will include populations, communities, the ecosystem, and the Biosphere.

- **population** – a group of one species in a given area that interact and breed producing viable offspring
- **community** – all of the biotic (living organisms) factors in a given area
- **ecosystem** – the interaction of a community and its abiotic (non-living) surroundings
- **biosphere** – life-containing parts of lithosphere (land), hydrosphere (water), and atmosphere

How organisms fit into their environment and the resources they exploit is referred to as their **ecological niche.** The ecological niche can be further divided into:

- **fundamental niche** – the total niche an organism can live in
- **realized niche** – the actual part of the niche an organism occupies due to competition

Generalist species are those organisms that have a very broad niche. They can easily move from location to location. A raccoon is a good example. **Specialists** have a very narrow niche and are more susceptible to extinction.

Organisms interact with one another in a variety of ways. **Intra-specific competition** is competition between members of the same species for resources. Example: white-tailed deer competing over the same forage. **Inter-specific competition** is when two different species compete for the same resources. Example: white-tailed deer and mule deer competing for resources. The **competitive exclusion principle** states that the niches of organisms can only overlap for a very brief time. **Resource partitioning** allows for more niches. This occurs when species use resources in different ways and at different times. An example of this is North American woodpeckers partitioning nesting habitats based on size and age of tree with one species preferring older, larger trees and another species choosing the smaller younger trees. Any abiotic factor that limits the growth of a species or population is known as a **limiting factor.**

In addition to competition, **predator-prey relationships** also form in communities. Symbiotic relationships also form between species in a community. These close, intertwined relationships can be defined in three ways.

- **mutualism** – members of both species benefit, example: flower and bee
- **commensalism** – one species benefits while the other is neither helped nor harmed. example: cattle egret and cow
- **parasitism** – one species benefits while the other (host) is harmed.
  example: tick and jackrabbit

Although all the members of the community have a part in the health of an ecosystem, a few species' roles are critical to the well-being of that ecosystem. These species, called **keystone** species, have a greater effect on the ecosystem than their biomass would dictate. Since bees have the ability to pollinate many plants, they are considered keystone species. **Indicator** species are organisms whose presence helps define an ecosystem. Their health also serves as an early warning system for the overall health of the ecosystem.

Ecosystems are maintained by the one-way flow of energy from the sun to producers (**autotrophs**) and then to the consumers (**heterotrophs**). This transfer of energy is illustrated in a variety of ways. Food webs illustrate the flow of energy through the feeding relationships found in an ecosystem (Fig. 1).

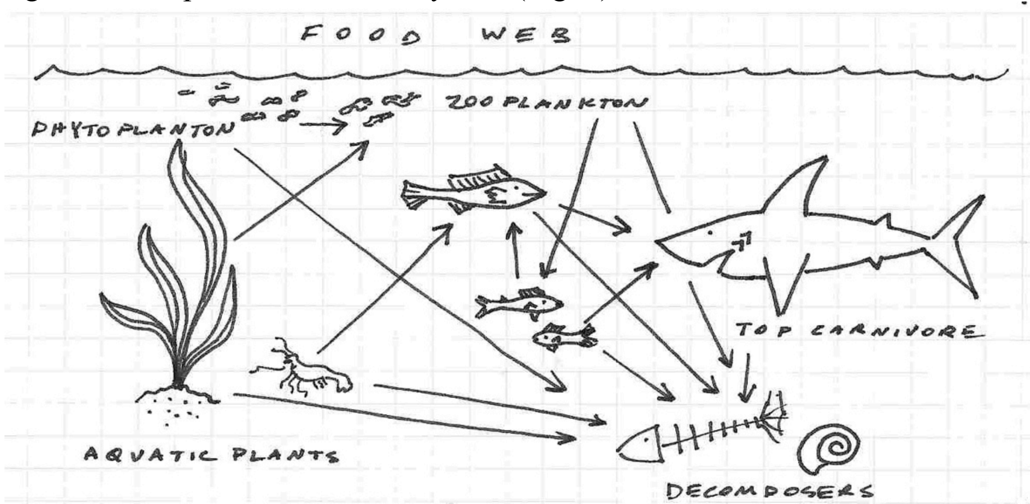


Fig. 1

Ecological pyramids are also used to illustrate the transfer of energy through feeding levels or **trophic levels** (Fig. 2). Energy pyramids represent the efficiency of ecosystems. Ten percent of the energy is usually all that is transferred between the levels. Ecological pyramids are also used to illustrate numbers of species and amount of biomass (Fig. 2).

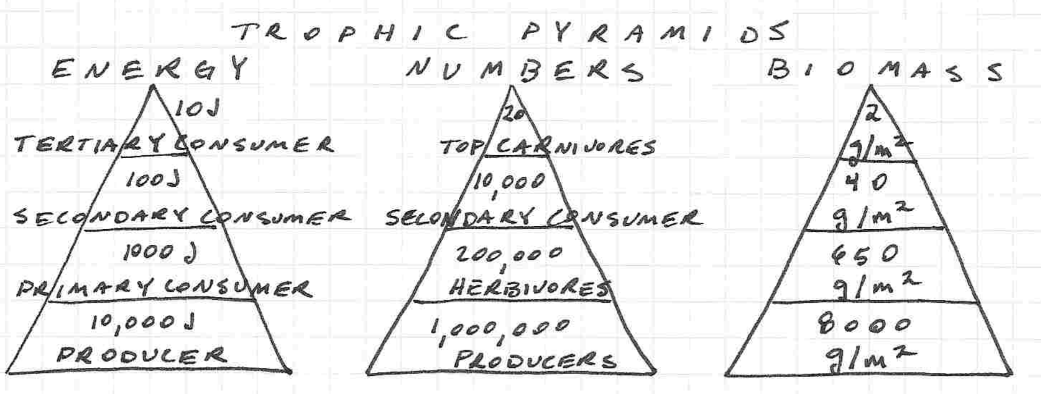


Fig. 2

Although all ecosystems change and remain dynamic, they do reach maturity in a fairly predictable manner. This process is called **ecological succession**. During succession organisms modify their surrounding creating suitable conditions for succeeding organisms. **Primary succession** is the establishment of a community where one has not existed before (lava flow). This is described as a “soil-less” environment. **Pioneer**

species (lichens and mosses) are the first inhabitants. Their effects on rock and the decomposition of their biomass help to create soil. Grasses and herbs move in next, further increasing the richness and depth of the soil. And, if precipitation allows, woody plants and trees follow. Secondary succession occurs in areas that have soil. They are generally areas that have been disturbed by natural disasters (forest fire) or habitat destruction by man (abandoned farm land).

Groups of similar ecosystems that occur throughout the planet are classified as **biomes**. These biomes are generally defined by precipitation, temperature, and the communities they support. Transitions between ecosystems are called **ecotones**. These ecotones create an **edge effect** that are generally very biodiverse.

Ecosystems are also maintained by the recycling of matter or nutrients. While energy flows through an ecosystem matter is conserved. **Biogeochemical cycles** describe the transfer of these nutrients through the living and non-living world. The biogeochemical cycles include:

- **Hydrologic Cycle (water cycle)**
- **Nitrogen Cycle**
- **Carbon Cycle**
- **Phosphorus Cycle**

Hydrologic Cycle

The hydrologic cycle is the movement of water through the biosphere. Many terms such as **condensation, evaporation** and **precipitation** are familiar. However, it also includes **transpiration** (the evaporation of water from the surface of leaves) and **infiltration** (percolation of water through the soil) (Fig. 3).

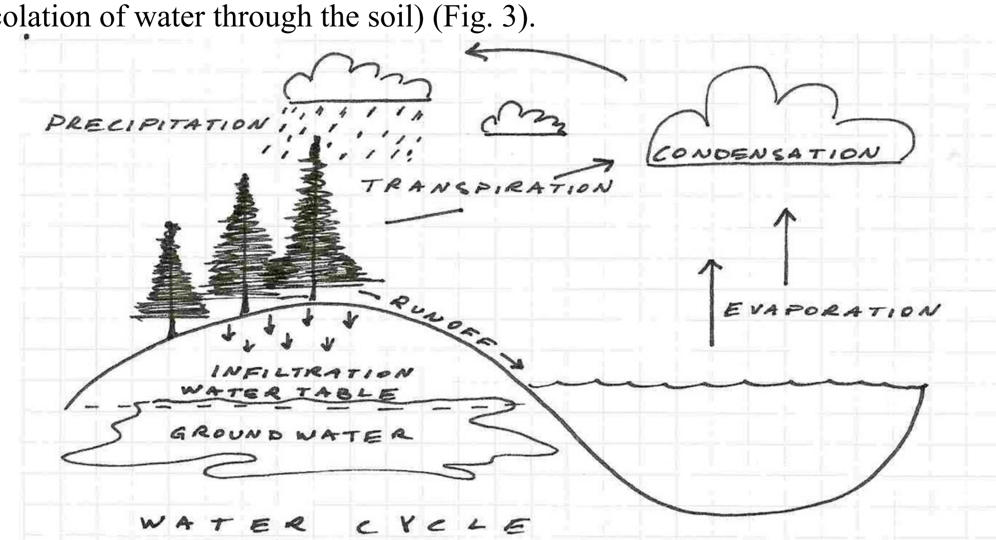


Fig. 3

NATIONAL MATH + SCIENCE INITIATIVE

Ecology

Nitrogen Cycle

Even though nitrogen makes up seventy-eight percent of the atmosphere, it still needs to be converted for organisms to use it. Bacteria are critical in the cycling of nitrogen. Inorganic fertilizers and agricultural runoff are two of the ways man interferes with the nitrogen cycle. Both of these problems can lead to cultural eutrophication of water sources. The steps of the nitrogen cycle follow (Fig. 4):

1. **nitrogen fixation –** the conversion of atmospheric nitrogen (N_2) into ammonia (NH_3) or into nitrate (NO_3). This is most often done by bacteria found in the soil. ***Rhizobium*** bacteria found in the nodules of legumes are important nitrogen-fixing bacteria.
2. **nitrification –** the conversion of ammonium (NH_4) into usable nitrates
3. **assimilation –** plants incorporating the usable forms of nitrogen into biomass
4. **ammonification –** decomposition of biomass that produces ammonia or ammonium
5. **denitrification –** denitrifying bacteria converts nitrates into atmospheric nitrogen

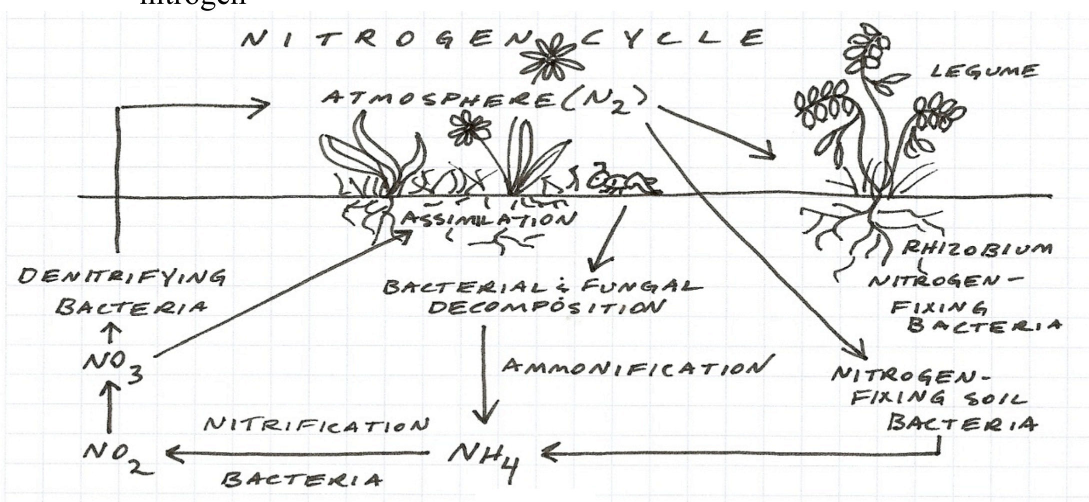


Fig. 4

Carbon Cycle

Carbon is recycled through the biosphere during **photosynthesis** and **cellular respiration**. Plants assimilate carbon dioxide into high energy sugars. When these sugars are consumed by heterotrophs, CO_2 is released back into the atmosphere. When both plants and animals die, carbon is trapped until decomposition releases it. Some of these organisms were buried and subjected to heat and pressure before they decomposed and were converted into coal, oil, and natural gas. By burning these fossil fuels, humans are adding CO_2 back at a rate that may drastically change our climate. The ocean and many types of rocks also serve as reservoirs for carbon.

NATIONAL MATH + SCIENCE INITIATIVE

Ecology

Phosphorus Cycle

The phosphorus cycle is unique in the fact that is does not have an atmospheric component. This makes it a **sedimentary cycle**. This also makes it the slowest of the biogeochemical cycles. Phosphorus is an important component in many biological compounds, such as nucleic acids. Phosphorus is found in rocks and soils and is released through **weathering**. When phosphorus is made available for plants to absorb it is called mineralization. While, the immobilization of phosphorus occurs when inorganic phosphorus is converted into organic phosphorus. Much like the nitrogen cycle, microbial activity is involved.