ECOLOGY

The subject of **ecology** will help us explore the 'living world' that exists on the earth. Ecology is the study of 'life at home'. In other words, ecology is the study of the interconnections and interdependences of plants, animals and their environment.

Ecosystems: An ecosystem is a community of organisms involved in a dynamic network of biological, chemical and physical interactions between themselves and with the nonliving components. Such interactions sustain the system and allow it to respond to changing conditions. Thus an ecosystem includes the community, the nonliving components and their interactions.

The sum total of all the ecosystems on planet Earth is called the **biosphere**, which includes all the earth's living organisms interacting with the physical environment as a whole to maintain a steady-state ecosystem.

5. **Ecosystems:**

An ecosystem is the combination of an area's abiotic and biotic factors.

Abiotic Features:

- air
- water
- rainfall
- temperature
- soil
- rocks
- elevation
- humidity

Biotic Features:

ANYTHING LIVING!!!

Now let's think of your house like an ecosystem! What are the abiotic factors of your home and the biotic ones?

Definitions:

Biomass	Refers to the total mass of living plants, animals, fungi, and bacteria in a given area
Energy Flow	Flow of energy from an ecosystem to an organism and from organism to organism
Producers	Produce food in the form of carbs during photosynthesis
Consumers	Eat food produced by consumers. Consumers can become energy for other consumers if they are eaten
Decomposition	Breaking down of organic wastes and dead organisms
Biodegradation	The action of living organisms such as bacteria to break down dead organism.
Decomposers	Changes waste and dead organisms into useable nutrients.
Autotrophs	Use energy from the environment to fuel the assembly of simple inorganic compounds to complex organic compounds.
Herbivores	Eat Plants only
Carnivores	Eat meat only
Omnivores	Eat both
Detrivores	Feed on plant and animal remains and other dead material (Earthworms, snails, crabs)
Decomposers	Break down organic matter (Bacteria or Fungus)

All ecosystems need certain materials.

Living things depend on their environment to meet their needs. You can think of those needs in terms of the material, or matter, required by all living things.

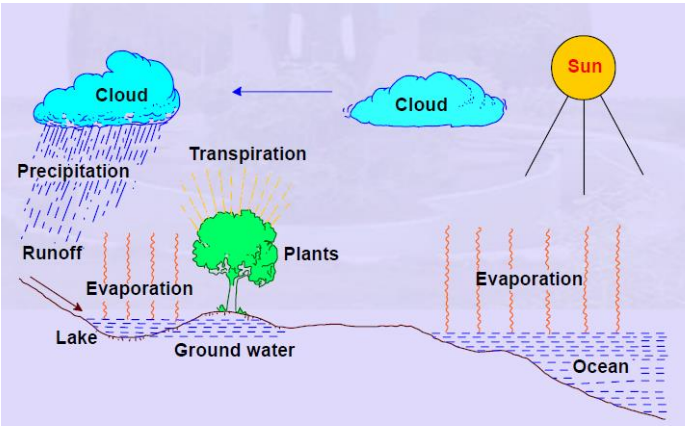
Nutrient cycling : linking the biotic and abiotic

In nature, the nutrient elements and their compounds continuously move from nonliving environment to the living organisms and back to the nonliving environment. The cyclic movement of minerals from their reservoirs (air, water and soil), to the living components, and back to the reservoirs is called nutrient cycling or *biogeochemical cycles*. These complex series of invisible, delicately balanced, and interrelated biochemical reactions fuel life on earth. These nutrient cycles, driven directly or indirectly by incoming solar energy and gravity, include the carbon, oxygen, nitrogen, phosphorous, sulphur and hydrologic cycles. Nutrients are available on the earth in fixed quantities. In nature, the nutrient cycles operate in a balanced manner.

Each nutrient e.g. carbon, oxygen, phosphorous, magnesium and so on, follows a unique cycle. Some elements like oxygen and nitrogen, cycle quickly and so are readily available for use by organisms. Others, such as phosphorous, magnesium, etc., take time for cycling, as they are released slowly. It is usually such slow cycling nutrients that become the limiting factors for plant growth. It is for this reason that such nutrients are supplied to crop species through synthetic fertilizers.

Water Cycle

As water moves through an ecosystem, it changes in physical form, moving back and forth between gas, liquid, and solid. Water in the atmosphere is usually in gaseous form—water vapor. Water that falls to Earth's surface is referred to as precipitation.



Water returns to the atmosphere when heated, changing back into vapor, a process called evaporation. There is more rainfall on lands than evapotranspiration. Living things also release water vapor. Animals release water vapor when they breathe, or respire. Plants release water vapor through a process called transpiration.

Carbon cycles through ecosystems.

Carbon is an element found in all living things. Carbon moves through Earth's ecosystems in a cycle referred to as the carbon cycle. It is through carbon dioxide gas found in Earth's atmosphere that carbon enters the living parts of an ecosystem.

The Carbon Cycle

CO2 is <u>added</u> to the atmosphere by:

1. **<u>Respiration</u>**:
   $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$
2. **<u>Burning fossil fuels</u>**:
   $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$
3. **<u>Roasting limestone</u>**:
   $CaCO_3 \longrightarrow CaO + CO_2$

The Carbon Cycle

CO2 is <u>removed</u> from the atmosphere by:

1. **<u>Photosynthesis</u>**:
   $6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$
2. **<u>Dissolving in water</u>** (oceans, rivers, lakes, rain etc)
   $CO_2 + H_2O \longrightarrow H_2CO_3$

Carbon in Oceans

The oceans are by far the largest carbon sink in the world; Some 93 percent of carbon dioxide is stored in algae, vegetation, and coral under the sea.

- Some sea life use bicarbonate to produce shells and body parts (coral, oysters, clams, some algae)



The oceans also play a major role in regulating the level of carbon-di-oxide in the atmosphere. Earth's oceans contain far more carbon than the air does. In water ecosystems—lakes, rivers, and oceans—carbon dioxide is dissolved in water. Algae and certain types of bacteria are the photosynthetic organisms that produce food in these ecosystems. Marine organisms, too, release carbon dioxide during respiration. Also, in these ecosystems, some organisms use carbon-di-oxide or other forms of carbon to build shells and skeletons. When these organisms die and as their bodies settle down at the bottom of the oceans, the carbon contained in them gets stored in the ocean floor. In fact most of the earth's carbon is stored in the ocean floor sediments and on the continents. This carbon enters the cycle at a very slow pace as the sediments dissolve. This carbon then becomes dissolved in the water and then enters the atmosphere.

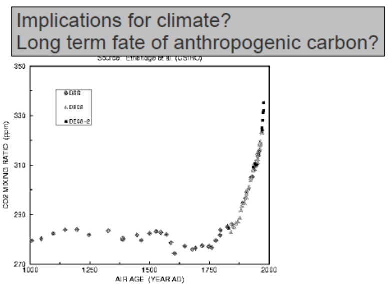
Large amounts of carbon are stored underground. The remains of plants and animals buried for millions of years decay slowly and change into fossil fuels, such as coal and oil. The carbon in fossil fuels returns to ecosystems in a process called combustion. As humans burn fossil fuels to release energy, dust particles and gases containing carbon are also released into the environment. Carbon plays a key role in the temperature regulation mechanism of our earth (GHG)—If too much carbon is removed, the earth will cool; if too much Carbon is generated, the earth will get hotter.

Human alteration of the carbon cycle

Since the [Industrial Revolution](), humans have greatly increased the quantity of carbon dioxide found in the Earth's atmosphere and oceans. Nowadays, of course, enormous quantities of carbon are put into the atmosphere by burning of fossil fuels. Atmospheric levels have increased by over 30%, from about 275 parts per million (ppm) in the early 1700s to just over 365 PPM today.

Atmospheric CO2 in the industrial era

Scientists estimate that future atmospheric levels of carbon dioxide could reach an amount between 450 to 600 PPM by the year 2100. but that increase is in part offset by dissolution into the oceans and in part by increase in total plant biomass.



NITROGEN CYCLES THROUGH ECOSYSTEMS

Nitrogen is another element important to life that cycles through Earth in the nitrogen cycle. Almost four-fifths of the air you breathe is clear, colorless nitrogen gas. Yet, you cannot get the nitrogen you need to live from the air. All animals must get nitrogen from plants. Plants cannot use pure nitrogen gas either. However, plants can absorb certain compounds of nitrogen. Plants take in these nitrogen compounds through their roots, along with water and other nutrients.

So how does the nitrogen from the atmosphere get into the soil?

(i) One source is lightning. Every lightning strike breaks apart, or fixes, pure nitrogen, changing it into a form that plants can use. This form of nitrogen falls to the ground when it rains.

(ii) A far greater source of nitrogen is nitrogen-fixing bacteria. These bacteria live in the oceans as well as the soil. Some even attach themselves to the roots of certain plants, like alfalfa or soybeans.

When organisms die, decomposers in the ocean or soil break them down. Nitrogen in the soil or water is used again by living things. A small amount is returned to the atmosphere by certain bacteria that can break down nitrogen compounds into nitrogen gas.

- **Org N $\rightarrow NH_3 \overset{O2}{\rightarrow} NO_2^- \overset{O2}{\rightarrow} NO_3^-$**

Plants take up NH_3, NOs dissolved in soil-pore water and convert them into proteins, DNA. Animals get their Nitrogen by eating plants or plant eating animals

Nitrogen Cycle

- Nitrogen Fixation
- Nitrification
- Ammonification/mineralization
- Denitrification

Bacteria involved in different steps:

• N2 fixation	• Cyanobacteria and rhizobium
• Nitrification	• Autotrophic bacteria: Nitrosomonas and nitrobacter
• Ammonification	• Ammonifying bacteria
• Denitrification	• Facultative heterotrophic bacteria like: Bacterium denitrificans :Pseudomonas anchromobacter

Nitrogen fixation

Conversion of atmospheric nitrogen to other chemical forms. There are two main ways nitrogen is '*fixed*':

Fixation by Lightning

The energy from lightning causes nitrogen (N_2) and water (H_2O) to combine to form ammonia (NH_3) and nitrates (NO_3). Precipitation carries the ammonia and nitrates to the ground, where they can be assimilated by plants.

Biological Fixation

About 90% of nitrogen fixation is done by bacteria present in water soil and root nodules of legumes alfalfa, beans. $N_2 + 3\,H_2 \rightarrow 2\,NH_3$

Ammonia can be used by plants directly. Ammonia and ammonium ion may be further reacted in the nitrification process (*consider the red portion of the diagram*).

NITRIFICATION

Two step reactions (*consider the red portion only*) that occur together:

- 1rst step catalyzed by *Nitrosomonas*: $2\ NH_4^+ + 3\ O_2 \rightarrow 2\ NO_2^- + 2\ H_2O + 4\ H^+$
- 2nd step catalyzed by *Nitrobacter*: $2\ NO_2^- + O_2 \rightarrow 2\ NO_3^-$

Ammonification or Mineralization

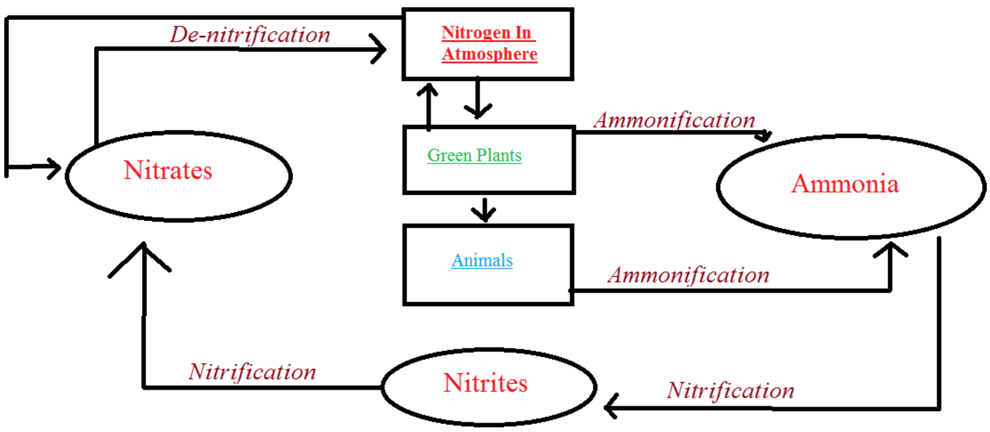
Plants die or bacterial cells lyse → release of organic nitrogen. Organic nitrogen is converted to inorganic nitrogen (NH_3)

Denitrification

- Removes a limiting nutrient from the environment
- $4NO_3^- + C_6H_{12}O_6 \rightarrow 2N_2 + 6\ H_2O$

Through denitrification, oxidized forms of nitrogen such as nitrate and nitrite (NO_2-) are converted to dinitrogen (N_2) and, to a lesser extent, nitrous oxide gas (consider the red portion of the diagram). Noxide (N_2O) is an important greenhouse gas, thereby contributing to global climate change.

Once converted to dinitrogen, nitrogen is unlikely to be reconverted to a biologically available form because it is a gas and is rapidly lost to the atmosphere. Denitrification is the only nitrogen transformation that removes nitrogen from ecosystems (essentially irreversibly), and it roughly balances the amount of nitrogen fixed by the nitrogen fixers described above.



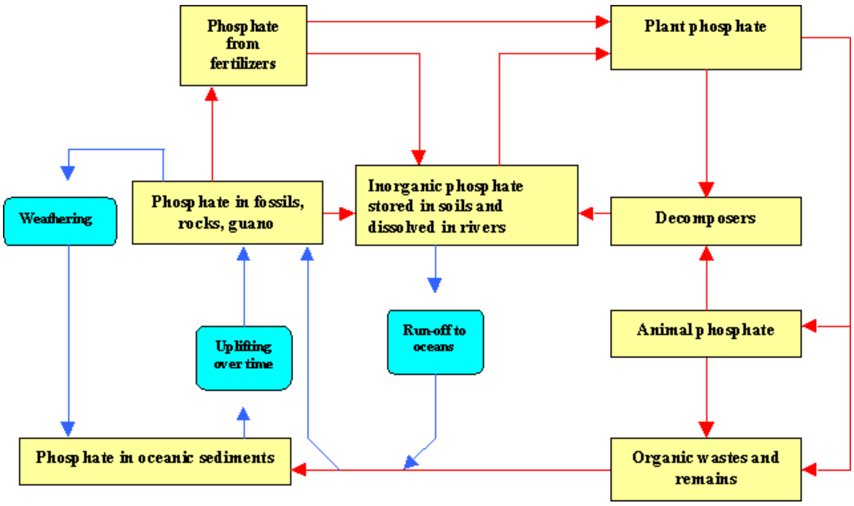
Nitrogen Cycle

PHOSPHORUS CYCLES THROUGH ECOSYSTEMS

Phosphorus is the second most abundant mineral in the human body, surpassed only by calcium. It makes up more than 20 percent of the mineral ash in the body, about one percent of total body weight. Nearly 80 percent of the P in humans is found in bones and teeth. The remainder is widely distributed...in combination with proteins, fats, and salts. Mineral supplements containing P may be prescribed by doctors when a P deficiency is diagnosed. Strong teeth and bones depend on an adequate supply of P.

Phosphorus pool

- The phosphorus cycle is a "sedimentary" cycle in which the earth's crust is the major reservoir. On land, phosphate rock deposits are the primary source of phosphorus. Through natural and human induced erosion processes, phosphates from these rock deposits are washed into rivers, and eventually to the oceans, where they form shallow and deep ocean phosphate rock deposits.
- Plants and animals play a role in the phosphorus cycle. As plant roots absorb phosphates from the soil, phosphorus is carried up through the food chain, eventually returning to the soil via animal waste and decay. However, these returns are small compared to the amount of phosphate which is continually eroding from the land to the oceans each year.



- Phosphorus, more than any other element, can become the limiting factor for agricultural plant growth. Many tonnes of phosphate rock are mined each year in the production of fertilizers to replace some of the phosphates lost from farmland through erosion, crop production exports and lawns, and to make phosphate Phosphorus Cycle

BIOGEOGRAPHIC REGIONS OF INDIA

Because of the influence which abiotic factors exert on organisms, different ecosystems develop differently. The major factors that determine the growth and type of ecosystem include temperature, rainfall, soil type and the location (the latitude and altitude). These factors, their interactions with each other and with the local biotic community have resulted in a variety of ecosystems. India, the seventh largest landmass in the world, possesses a variety of ecosystems. These include mountains, plateaus, rivers, wetlands, lakes, mangroves, forests and coastal ecosystems. This section looks at the ecological profile of India.

1. The Himalayan region
2. The desert
3. The North East
4. The Western Ghats
5. Islands and Wetlands : India also has two major groups of islands—Lakshwadeep islands in the Arabian Sea, and Andaman & Nicobar islands in the Bay of Bengal. These islands receive both the southwest and the northeast monsoons. Being tropical in climate, these islands are home to tropical rainforests.

India, with its varied terrain and climate, supports a rich diversity of in land and coastal wetlands. A total of 21 **wetlands** have been declared as National Wetlands. An important wetland of the country is the Keoladeo National Park in Bharatpur, Rajasthan, which is a human-made wetland. Among the various migratory species of birds that visit this Park almost every winter, is the endangered Siberian Crane (*Grus leucogeranus*).

Another important wetland is Chilika (1,100 sq km), the largest brackish water lake in India, situated in Puri and Ganjam district of Orissa.

WETLANDS AND THEIR SIGNIFICANCE : Wetlands are areas where water is the primary factor controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of the land or where the land is covered by shallow water. Wetlands are areas of great ecological and economic significance. In their natural condition, wetlands supply numerous ecological, economic, and cultural benefits to local communities, including water quality protection, flood control, erosion control, fish and wildlife habitat, aquatic productivity, and unique opportunities for education and recreation.

One of the most important functions of wetlands is the ability to maintain good surface water quality in rivers, streams, and reservoirs and to improve degraded surface waters. Wetlands do this several ways:

a) by removing and retaining nutrients.

b) by processing chemical and organic wastes.

c) by reducing sediment loads.

d) Wetlands are particularly good water filters. Due to their landscape position between uplands and deep water, wetlands intercept surface water runoff before it reaches open water and filter out nutrients, wastes, and sediments from flood waters. This function is particularly important in urban and agricultural areas.

In some places, wetlands contribute to the recharge of groundwater sources of drinking water. During periods of heavy runoff, such as major storms or snowmelt in the spring, wetlands adjacent to streams and in depressions collect excess water. When the water table drops, the water held in the wetlands infiltrates slowly back through the soil into the aquifer to replenish groundwater. Also by temporarily storing and slowly releasing flood waters, wetlands help protect adjacent and downstream property owners from flood damage. Wetlands provide critical habitat for several species— many amphibians, fishes, variety of plants including grasses.