MODULE 2
Chapter-1

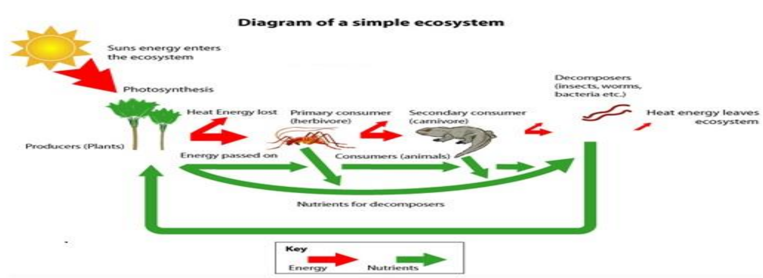
ECOSYSTEMS-CONCEPT, STRUCTURE, FUNCTIONS AND TYPES

An **ecosystem** includes all the living organisms that interact with one another and also with the physical and non-physical factors present.

It is a community of living organisms (plants, animals and microbes) in conjunction with the non-living components of their environment (things like air, water and mineral soil), interacting as a system. These biotic and abiotic components are regarded as linked together through nutrient cycles and energy flows. As ecosystems are defined by the network of interactions among organisms, and between organisms and their environment, they can be of any size but usually encompass specific, limited spaces(although some scientists say that the entire planet is an ecosystem).

All living organisms in an area live in communities of plants and animals. They interact with their non-living environment and with each other at different points in time for a large number of reasons. Life can exist only in small proportion earth's land, water and its atmosphere. At global level the think skin of earth on the land, the sea and the air forms the biosphere.

Ecosystem has been formed on land and in the sea by evolution that has created species to live together in a specific region. Thus ecosystems have both non-living and living components that are typical to an area giving it its own special characteristics that are easily observed



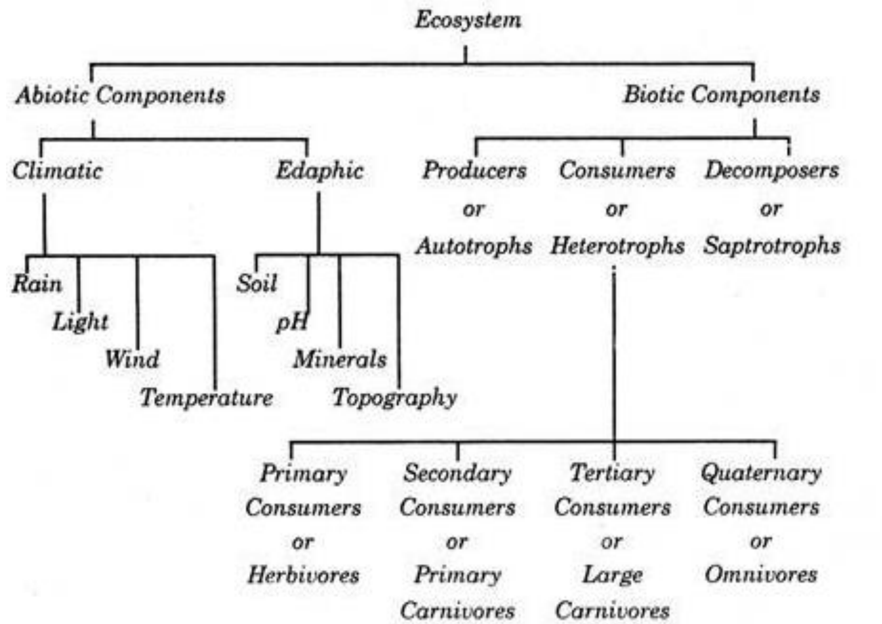
STRUCURE AND FUNCTIONS OF AN ECOSYSTEM

STRUCTURAL ASPECTS

Each ecosystem has two components:
1)Abiotic component
2)Biotic component

Abiotic component-This is the physical or the non-living components of an ecosystem. This includes the climatic factors such as rain, temperature, light ,wind etc. And edaphic factors such as soil, minerals, pH, topography etc.

Biotic component-The living organisms such as plants, animals and micro organisms present in an ecosystem form the biotic component of it. These include,
Producers-Plants
Consumers-Primary, Secondary, Tertiary and Quaternary consumers(Rabbit, Fox, Wolf,Lion)
Decomposers or Reducers-Bacterial and Fungi.



Schematic Representation of the Structure of an Ecosystem.

Edaphic means influenced by the soil.

FUNCTIONAL ASPECTS

The functional aspects includes,
1)The nutrient cycles-Biogeochemical cycles
2)Food chains
3)Energy cycles
4)Inter linkages between organisms
5)Evolution

A detailed study of these aspects are discussed at later stage of this chapter

TYPES OF ECOSYSTEMS

An ecosystem is a collection of communities of both living and non-living things that are interrelated. While many ecosystems exist on land and in the waters of the world; **t**errestrial ecosystems are those that are found only on land and aquatic ecosystems are those found in water. The biotic, or living things found in an ecosystem, include various life forms, such as plants and animals. The **abiotic,** or non-living things found in an ecosystem include the various land-forms and the climate.

Types and Examples of Terrestrial Ecosystems

The ecosystem is classified mainly three types. They are terrestrial, aquatic and manmade. The terrestrial further divided into three divisions according to climatic conditions and flora and fauna. They are forest, grass land, desert and biomes. The forests are four types such as ever green, coniferous, deciduous and tropical rain forests.

While there have been many classification schemes developed over time it is now generally accepted that there are six types of terrestrial ecosystems. These include **taiga**, **tundra**, **deciduous forest**, **grasslands**, **tropical rain forests**, and **deserts**.

Taigas are cold-climate forests found in the northern latitudes. Taigas are the world's largest terrestrial ecosystem and account for about 29% of the earth's forests. The temperature range, as you can see, is -65° F to 70°F (-54 to 21° C). For half of the year, the average temperature is below freezing. In the winter the average air temperature is warmer than it is for tundra, which lies north of the taiga. The taiga climate has an average annual rainfall of 12 - 33 inches (30 - 84 cm). Most of it falls in the summer as rain.

The largest taiga ecosystems are found in Canada and Russia. Taigas are known for their sub-arctic climate with extremely cold winters and mild summers. They primarily consist of coniferous trees, such as pines, although there are some other deciduous trees, such as spruce and elm, that have adapted to live in these areas that receive little direct sunlight for much of the year. Taigas are home to large herbivores such as moose, elk, and bison as well as omnivores such as bears. This image shows the dense forests that make up the taigas. This ecosystem can see in Alaska, to Canada, Scandinavia, Russia and China.

The **tundra** ecosystems of the world are primarily found north of the Arctic Circle. They consist of short vegetation and essentially no trees. The soil is frozen and covered with permafrost for a large portion of the year. Caribou, polar bears, and musk ox are some of the notable species who call the tundra home. This picture below depicts the cold arctic tundra. The tundra is a bleak and treeless place. It is cold through all months of the year summer is a brief period of milder climates when the sun shines almost 24 hours a day. It has been called "the land of the midnight sun". But even the sun can't warm the tundra much. The short summer lasts only 6 to 10 weeks. It never gets any warmer than 45 or 50° F. The warmer weather causes a layer of permafrost, ice that never goes away in the ground, to melt, creating bogs and shallow lakes that don't drain. During the long winter months the sun barely rises and it is dark for most of the day. Bitter cold winds scud across the barren snowscape, exposing high plateaus to barren ground. Winter temperatures don't reach above 20° F and average -20° to -30°F. Endless hour's darkness settles in and the winds blow even harder. The tundra climate spans from most of Greenland to parts of Alaska, northern Canada, and northern Russia. The latitudinal range is 75° N to 60° N. Tundra climates can be found on the coastal areas of the arctic.

Deciduous forest ecosystems make up the eastern half of North America and a large portion of Europe. They typically have an average yearly temperature of fifty degrees Fahrenheit, and they average about 30-60 inches of rain per year. These forests are inhabited by a variety of wildlife including deer, bear, foxes, as well as numerous species of trees, shrubs, and flowers. If you live in or have ever travelled to the eastern United States you have been to a deciduous forest. The forests of North Carolina are classic examples of deciduous forests.

Grasslands: There are many types of grasslands around the world. Some of the grasslands are tropical and some are dry grasslands. Grasslands in North America are known as Prairies, and in South America they are known as the Pampas. Eurasia has the Steppes, and in South Africa they are called Savana and Veldt. If you imagine the Wild West with tumbleweeds is blowing across the plains and large herds of deer and buffalo re-imagining the grasslands. These ecosystems are characterized by 20-35 inches of rain per year and a predominant covering of various species of grasses. They are also known for their very rich soil. The prairies of Nebraska are examples of grassland ecosystems. The prairies of the Midwestern United States are both tall-grass and short-grass. West of the Mississippi River the temperature is moist and humid. This allows for some very tall grasses of up to 10 feet. Summers are warm and humid. Winters are cold but not to the extreme. The farther west and in the interior of the country, the temperatures becomes drier. Moisture from the Pacific Ocean is blocked by the mountains. This is where the short-grass prairies are found. Summers are hot and winters very cold. There are no natural barriers, like trees, so there is a constant wind. Grasses with deep root systems keep the soil from blowing away. Most animals have adapted to the open, treeless prairie by digging burrows. Even owls, like the Burrowing Owl, use the holes dug by prairie dogs as nesting sites. The mean temperature for the prairie in January is 20° F, and 70° F in July. Annual precipitation is 10-30 inches.

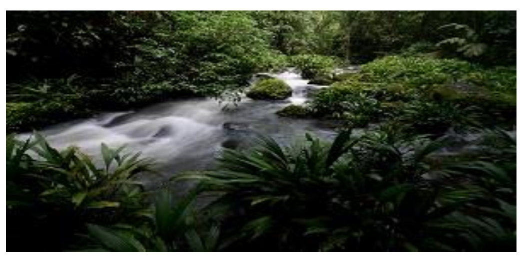
The Savanna is a tropical grassland in Africa. This grassland has a very hot, wet season when warm, moist air from the equator moves in. This is followed by a cooler dry season that can last for 8 months or more. Hot, dry air moves in from the Sahara. It is cooler by a few degrees Celsius because there is no moisture to trap the sun's radiant energy, and most of the heat escapes into space again. The Veldt is in South Africa and is pretty much like a savanna, except in the southern hemisphere.

Southern hemisphere grassland is the Pampas of Argentina. Moist, tropical air dominates this area and there is a lot of rain. Here tall-grass varieties of grasses grow very well.

The Steppes have a cold, dry climate. Here you find short-grass type of plants. The Himalayas block warm, moist air from the Indian Ocean, so there is very little precipitation. Nothing blocks arctic winds though, so winters are very cold and windy.

The grassland biome climate is in a mid-latitude zone. It is classified as a type "B" category, with a "Bs" subtype climate under the Köppen classification system. The grasslands have a very large latitude range, spanning from 55° N to 30° S. This is because of the many different types of grasslands throughout the world. The grasslands are on every continent, except for Antarctica. **About 500 to 900 mm of rain per year.** The prairies of the Great Plains of North America, the pampas of South America, the veldt of South Africa, the steppes of Central Eurasia, and surrounding the deserts in Australia

Tropical rain forest ecosystems have the greatest diversity of plants and animals of all of the ecosystems. They exist 28 degrees north or south of the equator and are known for their high average temperatures as well as a significant amount of rainfall. The lush forests of the Amazon in South America are classic examples of tropical rain forest. Lush tropical rain forests are home to the greatest numbers of plants and wildlife. In an average year in a tropical rain forest, the climate is very humid because of all the rainfall, which amounts to about 250 cm per year. The rain forest has lots of rain because it is very hot and wet. This climate is found near the equator. That means that there is more direct sunlight hitting the land and sea there than anywhere else. The tropical rain forest is a forest of tall trees in a region of year-round warmth. An average of 50 to 260 inches (125 to 660 cm.) of rain falls yearly. Rain forests belong to the tropical wet climate group. The temperature in a rain forest rarely gets higher than 93 °F (34 °C) or drops below 68 °F (20 °C); average humidity is between 77 and 88%; rainfall is often more than 100 inches a year. There is usually a brief season of less rain. In monsoonal areas, there is a real dry season. Almost all rain forests lie near the equator. Rainforests now cover less than 6% of Earth's land surface. Scientists estimate that more than half of all the world's plant and animal species live in tropical rain forests. Tropical rainforests produce 40% of Earth's oxygen. A tropical rain forest has more kinds of trees than any other area in the world. Scientists have counted about 100 to 300 species in one 2 1/2-acre (1-hectare) area in South America. Seventy percent of the plants in the rainforest are trees.



Imagine walking through mountainous dunes of sand as the blistering sun parches your mouth as you search for water. This scene gives you a look at the final terrestrial ecosystem which is the desert. These ecosystems are hot and dry with very little vegetation and very few species of animals that call them home other than reptiles, arachnids, and birds.

Desert Ecosystem: The large Saharan desert takes up much of the northern part of the African continent. Desert ecosystems are the driest places on earth. Deserts cover about one fifth of the Earth's land surface. Most Hot and Dry Deserts are near the Tropic of Cancer or the Tropic of Capricorn. Cold Deserts are near the Arctic part of the world. Hot and Dry Deserts temperature ranges from 20 to 25° C. The extreme maximum temperature for Hot Desert ranges from 43.5 to 49° C. Cold Deserts temperature in winter ranges from -2 to 4° C and in the summer 21 to 26° C a year. Desert areas receive an average of less than 25 cm of rainfall each year. The average temperature varies by desert, but is mainly 20-25 degrees Celsius.

All ecosystems that exist entirely on land are terrestrial ecosystems. They range from the coldest places on earth at the extreme northern latitudes to the hottest deserts found around the equator. Each ecosystem is inhabited by species of plants and animals that have evolved to thrive in them.

Aquatic Ecosystems

Aquatic ecosystems refer to entities with plants and animals relying on a watery environment. An aquatic ecosystem is broadly classified into marine and freshwater ecosystem aquatic ecosystems are systems composed of living organisms and non-living elements interacting in a watery environment. In simple terms, an aquatic ecosystem is a community of plants and animals that primarily depend on water. There are two major types of aquatic ecosystems:

- Marine Ecosystems
- Freshwater Ecosystems

<u>Marine Ecosystems</u>

While terrestrial ecosystems cover only about 28 percent, marine ecosystems cover approximately 71 percent of the earth's surface. Different habitats ranging from coral reefs to estuaries make up this largest aquatic ecosystem in the planet. Prime examples of marine ecosystems include:

1. **Ocean:** Main body of salty water that is further divided into important oceans and smaller seas. Major oceans include the Pacific Ocean, Indian Ocean, Arctic Ocean, Atlantic Ocean and Southern Ocean.
2. **Intertidal zone:** Area which remains underwater at high tide and remains terrestrial at low tide. Different types of habitats including wetlands, rocky cliffs and sandy beaches fall under intertidal zones.
3. **Estuaries:** Areas between river and ocean environments that is prone to tides and inflow of both freshwater and saline water. Due to this inflow, estuaries have high levels of nutrients. There are different names of estuaries such as inlets, lagoons, harbours etc.
4. **Coral Reefs** : Often referred as the "rainforests of the sea", coral reefs are mounds found

in marine waters as a result of accumulation of calcium carbonate deposited by marine organisms like corals and shellfish. Coral reefs form the most varied marine ecosystems in the planet, but cover less then one percent of the world's ocean. Nevertheless, around 25 percent of marine animals including different types of fishes, sponges and molluscs are found in coral reefs.

Common species found in marine ecosystems include:

- Marine mammals such as seals, whales and manatees
- Different species of fish including mackerel, flounder, dogfish, sea bass, etc.
- Organisms such as the tiny planktonic, brown algae corals, echinoderms, etc.

Marine ecosystems are important for the well-being of both terrestrial and aquatic environments. However, they are vulnerable to environmental problems such as climate change, pollution and overfishing, which can be a serious harm to marine biodiversity.

Freshwater Ecosystems

Although freshwater ecosystems are one of the main types of aquatic ecosystems, only 0.8 percent of the earth's surface is covered by them. The water in freshwater ecosystems is non-saline (which means water has no salt content). Approximately 41 percent of the earth's fishes are found in freshwater ecosystems.

Examples of freshwater ecosystems are:

- **(Lotic): Streams and rivers** Lotic ecosystems refer to systems with rapid flowing waters that move in a unidirectional way. Best examples are rivers and streams, which harbour several species of insects and fishes. Crustaceans like crayfish and crabs; and mollusks such as clams and limpets are commonly found in streams and rivers. Various mammals such as beavers, otters and river dolphins also inhabit lotic ecosystems.
- **(Lentic): Lakes, ponds and pools** Lentic ecosystems are still waters such as lakes and ponds that have a community of biotic (living organisms) and abiotic (physical objects) interactions. Ponds and lakes have a diverse variety of organisms including algae, rooted and floating-leaved plants, invertebrates such as crabs, shrimps, crayfish, clams etc, amphibians such as frogs and salamanders; and reptiles like alligators and water snakes.
- **Wetlands:** The best examples of wetlands include swamps and marshes, where the water is completely or partially shallow. Biologically, wetlands are known to be too diverse as it harbors numerous animals and plant species. Plants such as black spruce, water lilies, mangrove, tamarack and sedges are commonly found in wetlands. Various species of reptiles and amphibians are also found in wetlands.

Freshwater ecosystems, which are one of the major types of aquatic ecosystems, are in danger because of the rapid extinction rates of several invertebrates and vertebrates, mainly because of overfishing and other activities that harm the ecosystem.

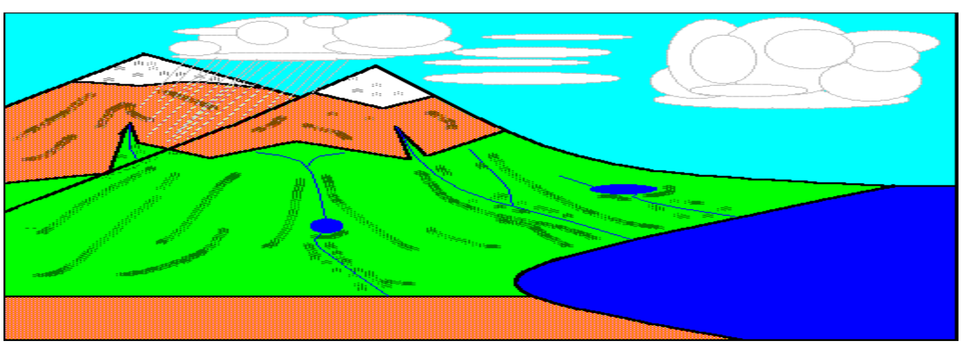
CHAPTER 3 ENERGY FLOW IN ECOSYSTEMS AND ECOLOGICAL SUCCESSION

The study of ecosystems mainly consists of the study of certain processes that link the living, or biotic, components to the non-living, or abiotic, components. Energy transformations and biogeochemical cycling are the main processes that comprise the field of ecosystem ecology. Every ecosystem has several interrelated mechanisms that affect human life. These are the water cycle, the carbon cycle, oxygen cycle, the nitrogen cycle and the energy cycle. While every ecosystem is controlled by these cycles , in each ecosystem its abiotic and biotic features are distinct from each other. The discussion on each cycle is given in detail below.

The Water Cycle:

The water cycle has no starting point, but let's begin with the oceans, since that is where most of Earth's water exists. The sun, which drives the water cycle, heats water in the oceans. Some of it evaporates as vapour into the air; a relatively smaller amount of moisture is added as ice and snow sublimate directly from the solid state into vapour. Rising air currents take the vapour up into the atmosphere, along with water from evapotranspiration, which is water transpired from plants and evaporated from the soil. The vapour rises into the air where cooler temperatures cause it to ccondense into clouds.

Air currents move clouds around the globe, and cloud particles collide, grow, and fall out of the sky as precipitation. Some precipitation falls as snow and can accumulate as ice caps and glaciers which can store frozen water for thousands of years. Snowpack in warmer climates often thaw and melt when spring arrives, and the melted water flows overland as snowmelt. Most precipitation falls back into the oceans or onto land, where, due to gravity, the precipitation flows over the ground as surface runoff. A portion of runoff enters rivers in valleys in the landscape, with stream flow moving water towards the oceans. Runoff, and groundwater seepage, accumulate and are stored as freshwater in lakes.



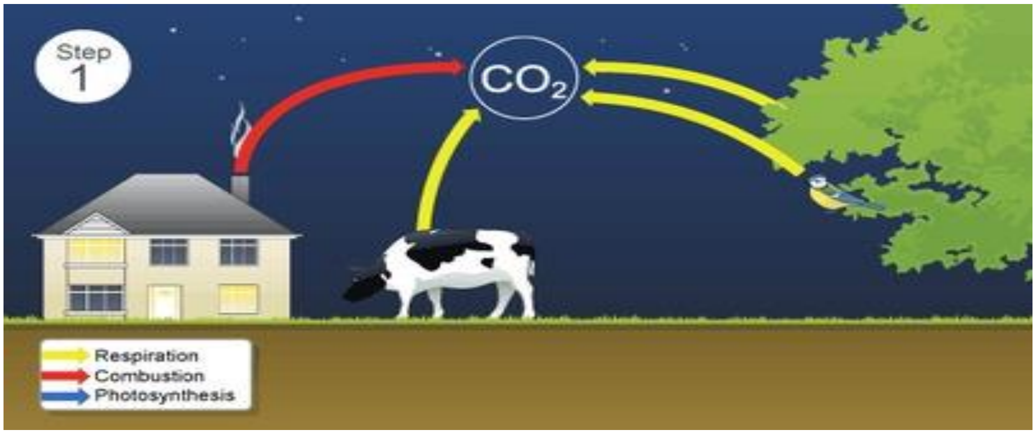
Not all runoff flows into rivers, though. Much of it soaks into the ground as infiltration Some of the water infiltrates into the ground and replenishes aquifers (saturated subsurface rock), which store huge amounts of freshwater for long periods of time. Some infiltration stays close to the land surface and can seep back into surface-water bodies (and the ocean) as groundwater discharge and some groundwater finds openings in the land surface and emerges as freshwater springs. Yet more groundwater is absorbed by plant roots to end up as evapotranspiration from the leaves. Over time, though, all of this water keeps moving, some to renter the ocean, where the water cycle "ends" .that is, where it "begins.

<u>The Carbon Cycle:</u>

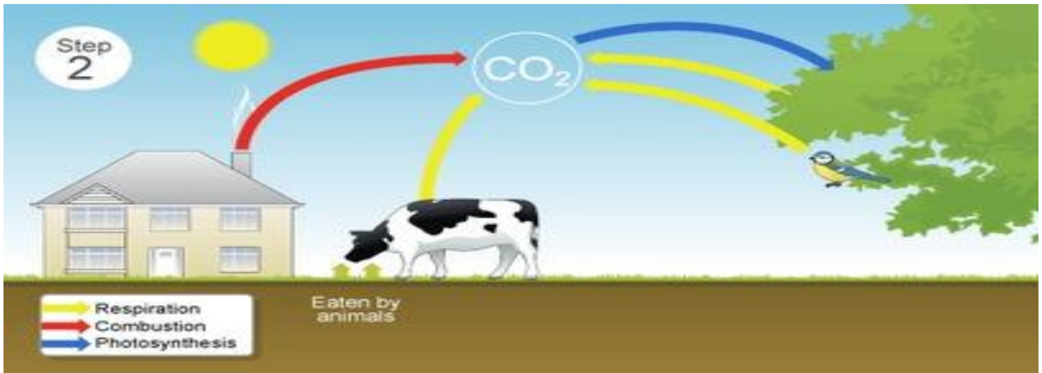
The movement of carbon, in its many forms, between the biosphere, atmosphere, oceans, and geosphere is described by the carbon cycle, illustrated in the adjacent diagram. The carbon cycle is one of the biogeochemical cycles. In the cycle there are various sinks, or stores, of carbon and processes by which the various sinks exchange carbon.

Two other important processes are fossil fuel burning and changing land use. In fossil fuel burning, coal, oil, natural gas, and gasoline are consumed by industry, power plants, and automobiles. Notice that the arrow goes only one way: from industry to the atmosphere. Changing land use is a broad term which encompasses a host of essentially human activities. They include agriculture, deforestation, and reforestation. The steps of carbon cycle are as follows:

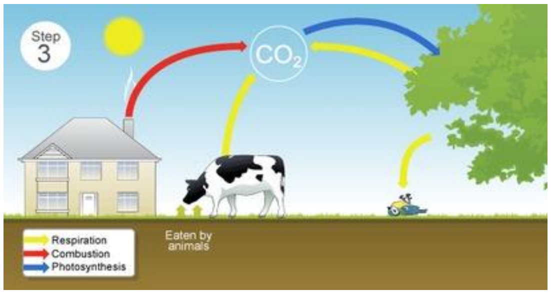
Step 1:
Carbon enters the atmosphere as carbon-dioxide from respiration (breathing) and combustion (burning).



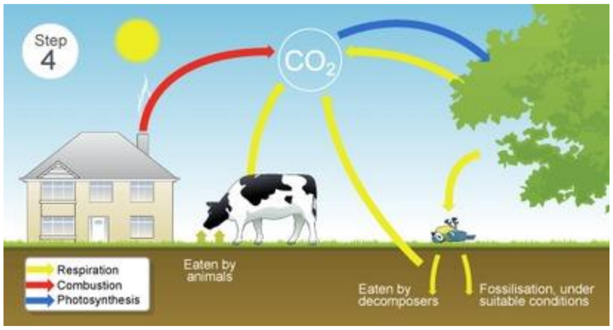
Step 2:
Carbon dioxide is absorbed by producers (life forms that make their own food e.g. plants) to make carbohydrates in photosynthesis . These producers then put off oxygen.



Step 3:
Animals feed on the plants. Thus passing the carbon compounds along the food chain. Most of the carbon these animals consume however is exhaled as carbon dioxide**.** This is through the process of respiration. The animals and plants then eventually die.



Step 4:
The dead organisms (dead animals and plants) are eaten by decomposers in the ground. The carbon that was in their bodies is then returned to the atmosphere as carbon dioxide. In some circumstances the process of decomposition is prevented. The decomposed plants and animals may then be available as fossil fuel in the future for combustion.



<u>The Oxygen cycle</u>

Almost all living things need oxygen. They use this oxygen during the process of creating energy in living cells. Just as water moves from the sky to the earth and back in the hydrologic cycle, oxygen is also cycled through the environment. Plants mark the beginning of the oxygen cycle. Plants are able to use the energy of sunlight to convert carbon dioxide and water into carbohydrates and oxygen in a process called photosynthesis.

$$O_2 \ + \ \text{carbohydrates} \rightarrow CO_2 \ + \ H_2O \ + \text{energy}$$

This means that plants "breathe" in carbon dioxide and "breathe" out oxygen

Animals form the other half of the oxygen cycle. We breathe in oxygen which we use to break carbohydrates down into energy in a process called respiration.

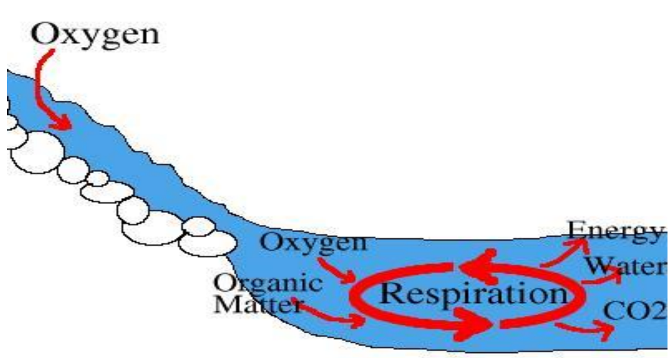
$$O_2 \ + \ \text{carbohydrates} \rightarrow CO_2 \ + \ H_2O \ + \text{energy}$$

Carbon dioxide produced during respiration is breathed out by animals into the air.

So oxygen is created in plants and used up by animals, as is shown in the picture above. But the oxygen cycle is not actually quite that simple. Plants must break carbohydrates down into energy just as animals do. During the day, plants hold onto a bit of the oxygen which they produced in photosynthesis and use that oxygen to break down carbohydrates. But in order to maintain their metabolism and continue respiration at night, the plants must absorb oxygen from the air and give off carbon dioxide just as animals do. Even though plants produce approximately ten times as much oxygen during the day as they consume at night, the night-time consumption of oxygen by plants can create low oxygen conditions in some water habitats.

Oxygen in Water

Oxygen in water is known as dissolved oxygen or DO. In nature, oxygen enters water when water runs over rocks and creates tremendous amounts of surface area. The high surface area allows oxygen to transfer from the air into the water very quickly.



The water in a stream enters a pond, microorganisms in the pond begin to metabolize (break down) organic matter, consuming oxygen in the process. This is another form of oxygen cycle - oxygen enters water in rapids and leaves water in pools.

Oxygen uptake rate (O.U.R.) is the rate at which oxygen is consumed by living organisms in the water. Since organisms are constantly using up oxygen in the water and oxygen is constantly re-entering the water from the air, the amount of oxygen in water remains relatively constant. In a healthy ecosystem, the rates of oxygen transfer (being used up) and oxygen uptake are balanced in the water.

The nitrogen cycle

All life requires nitrogen-compounds, e.g., proteins and nucleic acids. Air, which is 79% nitrogen gas (N_2), is the major reservoir of nitrogen. But most organisms cannot use nitrogen in this form. Plants must secure their nitrogen in "fixed" form, i.e., incorporated in compounds such as: nitrate ions (NO_3^-) , ammonium ions (NH_4^+) , urea $(NH_2)_2CO$. Animals secure their nitrogen (and all other) compounds from plants (or animals that have fed on plants).

Four processes participate in the cycling of nitrogen through the biosphere:

- nitrogen fixation
- decay
- nitrification
- denitrification

Microorganisms play major roles in all four of these.

Nitrogen Fixation

The nitrogen molecule (N_2) is quite inert. To break it apart so that its atoms can combine with other atoms requires the input of substantial amounts of energy.

Three processes are responsible for most of the nitrogen fixation in the biosphere:

- atmospheric fixation by lightning
- biological fixation by certain microbes — alone or in a symbiotic relationship with some plants and animals
- industrial fixation

Atmospheric Fixation

The enormous energy of lightning breaks nitrogen molecules and enables their atoms to combine with oxygen in the air forming nitrogen oxides. These dissolve in rain, forming nitrates, that are carried to the earth.

Atmospheric nitrogen fixation probably contributes some 5– 8% of the total nitrogen fixed.

Industrial Fixation

Under great pressure, at a temperature of 600°C, and with the use of a catalyst, atmospheric nitrogen and hydrogen (usually derived from natural gas or petroleum) can be combined to form ammonia (NH_3). Ammonia can be used directly as fertilizer, but most of it is further processed to urea and ammonium nitrate (NH_4NO_3).

Biological Fixation

The ability to fix nitrogen is found only in certain bacteria and archaea

- Some live in a symbiotic relationship with plants of the legume family (e.g., soybeans, alfalfa).

- Some establish symbiotic relationships with plants other than legumes (e.g., alders).
- Some establish symbiotic relationships with animals, e.g., termites and "shipworms" (wood-eating bivalves).
- Some nitrogen-fixing bacteria live free in the soil.
- Nitrogen-fixing cyanobacteria are essential to maintaining the fertility of semi-aquatic environments like rice paddies.

Biological nitrogen fixation requires a complex set of enzymes and a huge expenditure of ATP.

Although the first stable product of the process is ammonia, this is quickly incorporated into protein and other organic nitrogen compounds.

Decay

The proteins made by plants enter and pass through food webs just as carbohydrates do. At each trophic level, their metabolism produces organic nitrogen compounds that return to the environment, chiefly in excretions. The final beneficiaries of these materials are microorganisms of decay. They break down the molecules in excretions and dead organisms into ammonia.

Nitrification

Ammonia can be taken up directly by plants — usually through their roots. However, most of the ammonia produced by decay is converted into nitrates. This is accomplished in two steps:

-
- Bacteria of the genus **Nitrosomonas** oxidize NH_3 to **nitrites** (NO_2^-).
- Bacteria of the genus **Nitrobacter** oxidize the nitrites to **nitrates** (NO_3^-).

These two groups of autotrophic bacteria are called nitrifying bacteria. Through their activities (which supply them with all their energy needs), nitrogen is made available to the roots of plants.

Both soil and the ocean contain archaeal microbes, assigned to the Crenaracheota, that convert ammonia to nitrites. They are more abundant than the nitrifying bacteria and may turn out to play an important role in the nitrogen cycle.

Many legumes, in addition to fixing atmospheric nitrogen, also perform nitrification — converting some of their organic nitrogen to nitrites and nitrates. These reach the soil when they shed their leaves.

Denitrification

The three processes above remove nitrogen from the atmosphere and pass it through ecosystems.

Denitrification reduces nitrates and nitrites to nitrogen gas, thus replenishing the atmosphere. In the process several intermediates are formed:

- nitric oxide (NO)
- nitrous oxide (N_2O)(a green house gas, 300 times as potent as CO_2)
- nitrous acid (HONO)

Once again, bacteria are the agents. They live deep in soil and in aquatic sediments where conditions are anaerobic. They use nitrates as an alternative to oxygen for the final electron acceptor in their respiration.

Anammox (<u>an</u>aerobic <u>amm</u>onia <u>ox</u>idation)

Under anaerobic conditions in marine and freshwater sediments, other species of bacteria are able to oxidize ammonia (with NO_2^-) forming nitrogen gas.

$NH_4^+ + NO_2^- \rightarrow N_2 + 2H_2O$

The anammox reaction may account for as much as 50% of the denitrification occurring in the oceans.

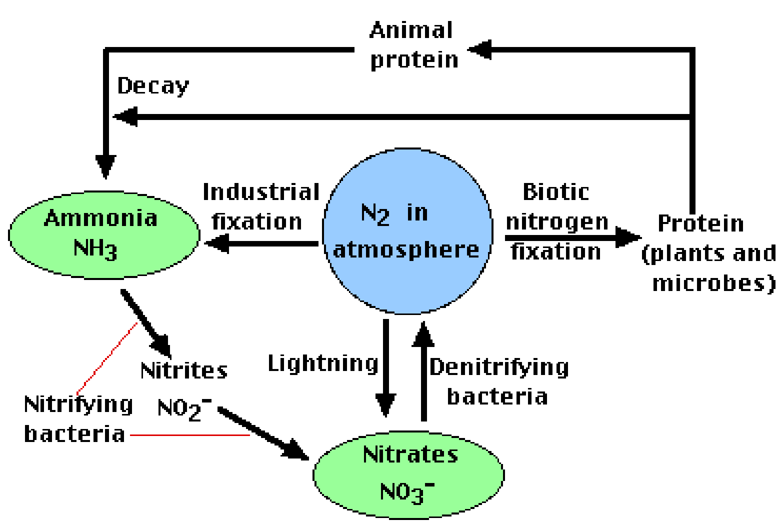
All of these processes participate in closing the nitrogen cycle. re the denitrifiers keeping up?

Agriculture may now be responsible for one-half of the nitrogen fixation on earth through

- the use of fertilizers produced by industrial fixation
- the growing of legumes like soybeans and alfalfa.

This is a remarkable influence on a natural cycle.

Are the denitrifiers keeping up the nitrogen cycle in balance? Probably not. Certainly, there are examples of nitrogen enrichment in ecosystems. One troubling example: the "blooms" of algae in lakes and rivers as nitrogen fertilizers leach from the soil of adjacent farms (and lawns). The accumulation of dissolved nutrients in a body of water is called eutrophication.



ECOLOGICAL SUCCESSION

“Ecological succession" is the observed process of change in the species structure of an ecological community over time. Within any community some species may become less abundant over some time interval, or they may even vanish from the ecosystem altogether. Similarly, over some time interval, other species within the community may become more abundant, or new species may even invade into the community from adjacent ecosystems. This observed change over time in what is living in a particular ecosystem is "ecological succession".

Why does "ecological succession" occur?

Every species has a set of environmental conditions under which it will grow and reproduce most optimally. In a given ecosystem, and under that ecosystem's set of environmental conditions, those species that can grow the most efficiently and produce the most viable offspring will become the most abundant organisms. As long as the ecosystem's set of environmental conditions remains constant, those species optimally adapted to those conditions will flourish. The "engine" of succession, the cause of ecosystem change, is the impacts of established species have upon their own environments. A consequence of living is the sometimes subtle and sometimes overt alteration of one's own environment. The original environment may have been optimal for the first species of plant or animal, but the newly altered environment is often optimal for some other species of plant or animal. Under the changed conditions of the environment, the previously dominant species may fail and another species may become ascendant.

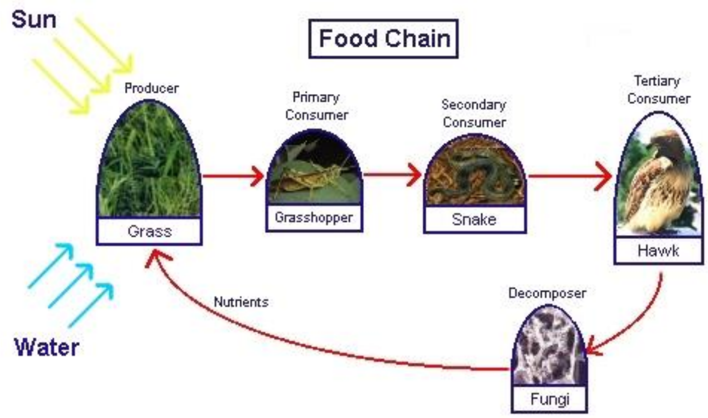
Ecological succession may also occur when the conditions of an environment suddenly and drastically change. A forest fires, wind storms, and human activities like agriculture all greatly alter the conditions of an environment. These massive forces may also destroy species and thus alter the dynamics of the ecological community triggering a scramble for dominance among the species still present.

CHAPTER 3

FOOD CHAINS,FOOD WEBS AND ECOLOGICAL PYRAMIDS

In an ecosystem, plants capture the sun's energy and use it to convert inorganic compounds into energy-rich organic compounds. This process of using the sun's energy to convert minerals (such as magnesium or nitrogen) in the soil into green leaves, or carrots, or strawberries, is called ***photosynthesis***.

Photosynthesis is only the beginning of a chain of energy conversions. There are many types of animals that will eat the products of the photosynthesis process. Examples are deer eating shrub leaves, rabbits eating carrots, or worms eating grass. When these animals eat these plant products, food energy and organic compounds are transferred from the plants to the animals. These animals are in turn eaten by other animals, again transferring energy and organic compounds from one animal to another. Examples would be lions eating zebras, foxes eating rabbits, or birds eating worms.



This chain of energy transferring from one species to another can continue several more times, but it eventually ends. It ends with the dead animals that are broken down and used as food or nutrition by bacteria and fungi. As these organisms, referred to as decomposers, feed from the dead animals, they break down the complex organic compounds into simple nutrients. Decomposers play a very important role in this world because they take care of breaking down (cleaning) many dead material. There are more than 100,000 different types of decomposer organisms! These simpler nutrients are returned to the soil and can be used again by plants. The energy transformation chain starts all over again.

Producers: Organisms, such as plants, that produce their own food are called autotrophs. The autotrophs, as mentioned before, convert inorganic compounds into organic compounds. They are called producers because all of the species of the ecosystem depend on them.

Consumers: All the organisms that can not make their own food (and need producers) are called heterotrophs. In an ecosystem heterotrophs are called consumers because they depend on others. They obtain food by eating other *organisms*. There are different levels of consumers. Those that feed directly from producers, i.e. organisms that eat plant or plant products are called primary consumers. In the figure above the grasshopper is a primary consumer.

FOOD WEBS

A **food web** is a graphical description of feeding relationships among species in an ecological community, that is, of who eats whom. It is also a means of showing how energy and materials (e.g., carbon) flow through a community of species as a result of these feeding relationships. Typically, species are connected by lines or arrows called "links", and the species are sometimes referred to as "nodes" in food web diagrams.

The pioneering animal ecologist Charles Elton (1927) introduced the concept of the food web (which he called food cycle) to general ecological science. As he described it: "The herbivores are usually preyed upon by carnivores, which get the energy of the sunlight at third-hand, and these again may be preyed upon by other carnivores, and so on, until we reach an animal which has no enemies, and which forms, as it were, a terminus on this food cycle. There are, in fact, chains of animals linked together by food, and all dependent in the long run upon plants. We refer to these as 'food-chains', and to all the food chains in a community as the 'food-cycle.

A food web consists of all the food chains in a single ecosystem. Each living thing in an ecosystem is part of multiple food chains. Each food chain is one possible path that energy and nutrients may take as they move through the ecosystem. All of the interconnected and overlapping food chains in an ecosystem make up a food web.

Trophic Levels

Organisms in food webs are grouped into categories called trophic levels. Roughly speaking, these levels are divided into producers (first trophic level), consumers, and decomposers (last trophic level).

Producers

Producers make up the first trophic level. Producers, also known as autotrophs, make their own food and do not depend on any other organism for nutrition. Most autotrophs use a process called photosynthesis to create food (a nutrient called glucose) from sunlight, carbon dioxide, and water.

Plants are the most familiar type of autotroph, but there are many other kinds. Algae, whose larger forms are known as seaweed, are autotrophic. Phytoplankton, tiny organisms that live in the ocean, are also autotrophs. Some types of bacteria are autotrophs. For example, bacteria living in active volcanoes use sulfur, not carbon dioxide, to produce their own food. This process is called chemosynthesis.

Consumers

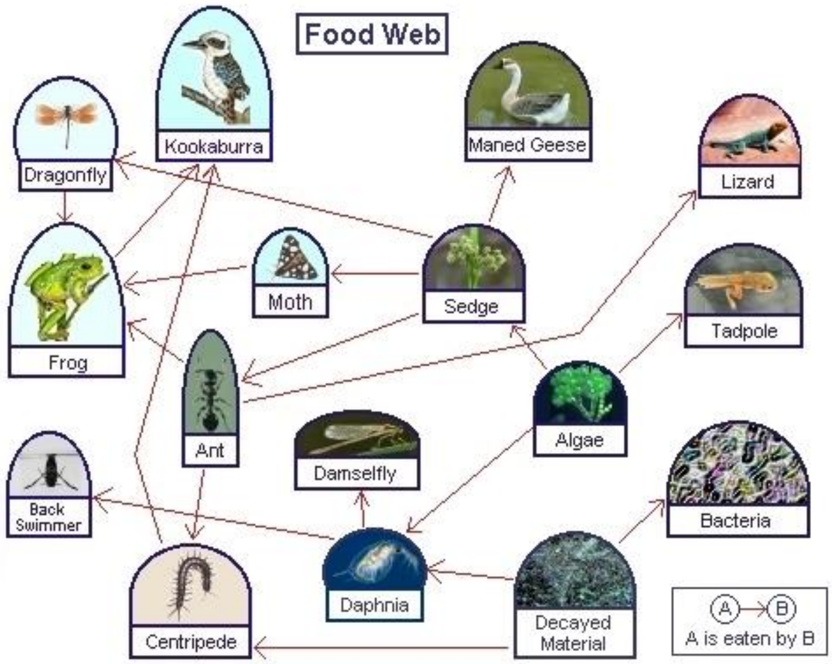
The next trophic levels are made up of animals that eat producers. These organisms are called consumers.

Primary consumers are herbivores. Herbivores eat plants, algae, and other producers. They are at the second trophic level. In a grassland ecosystem, deer, mice, and even elephants are herbivores. They eat grasses, shrubs, and trees. In a desert ecosystem, a mouse that eats seeds and fruits is a primary consumer.
In an ocean ecosystem, many types of fish and turtles are herbivores that eat algae and seagrass. In kelp forests, seaweeds known as giant kelp provide shelter and food for an entire ecosystem. Sea urchins are powerful primary consumers in kelp forests. These small herbivores eat dozens of kilograms (pounds) of giant kelp every day.

Secondary consumers eat herbivores. They are at the third trophic level. In a desert ecosystem, a secondary consumer may be a snake that eats a mouse. In the kelp forest, sea otters are secondary consumers that hunt sea urchins as prey.

Tertiary consumers eat the secondary consumers. They are at the fourth trophic level. In the desert ecosystem, an owl or eagle may prey on the snake.

There may be more levels of consumers before a chain finally reaches its top predator. Top predators, also called apex predators, eat other consumers. They may be at the fourth or fifth trophic level. They have no natural enemies except people. Lions are apex predators in the grassland ecosystem. In the ocean, fish such as the great white shark are apex predators. In the desert, bobcats and mountain lions are top predators.

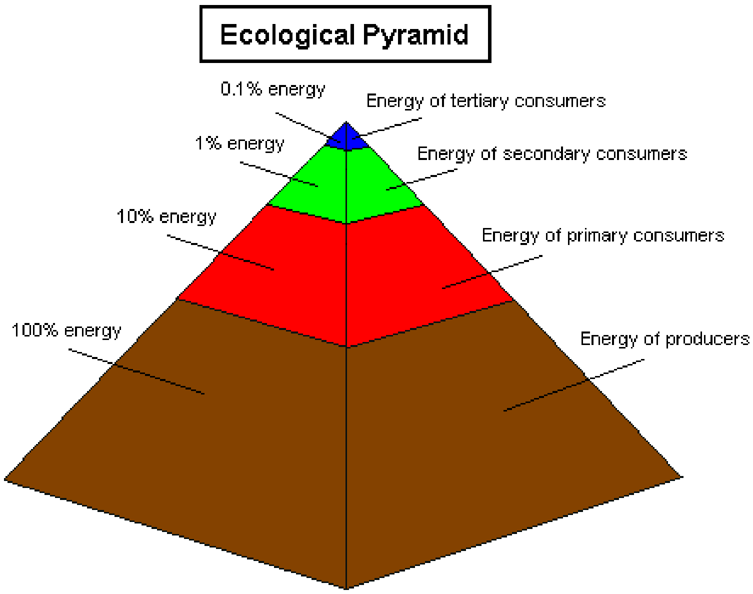


Energy Pyramids

An energy pyramid is a graphical model of energy flow in a community. The different levels represent different groups of organisms that might compose a food chain. In a highly efficient transfer almost all of the energy would be transferred -- 80% or more. In a low efficiency transfer very little energy would be transferred -- less than 20%. In a typical food chain, not all animals or plants are eaten by the next trophic level. In addition, there are portions or materials (such as beaks, shells, bones, etc.) that are also not eaten. That is why the transfer of matter and energy from one trophic level to the next is not an efficient one.

One way to calculate the energy transfer is by measuring or sizing the energy at one trophic level and then at the next. Calorie is a unit of measure used for energy. The energy transfer from one trophic level to the next is about 10%. For example, if there are 10,000 calories at one level, only 1,000 are transferred to the next. This 10% energy and material transfer rule can be depicted with an ecological pyramid that looks like the one below.

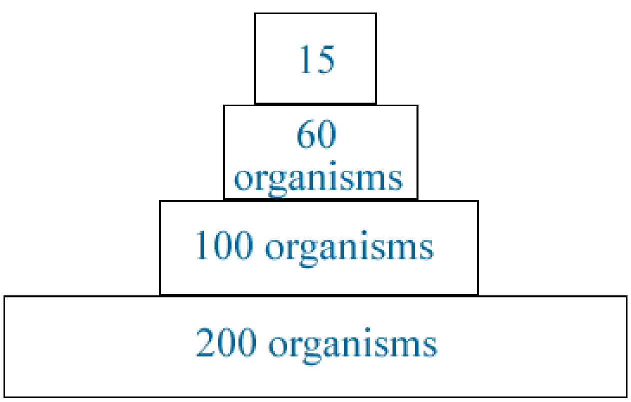
This pyramid helps one visualize the fact that in an ecological system there need to be many producing organisms at the bottom of the pyramid to be able to sustain just a couple of organisms at the top. In looking at the pyramid, can you guess how much larger the volume of each layer is as compared to the one just above it? Take a guess. It might not look like it but they are close to 10 times larger.



A basic pyramid shape often represents a typical food chain or food web. The pyramid represents the decrease in the amount of energy, the number of organisms and the biomass from the producer to the high - order consumer levels. The decrease in the numbers and in the biomass represent the fact that, due to energy loss, fewer organisms can be supported at each successive trophic level.

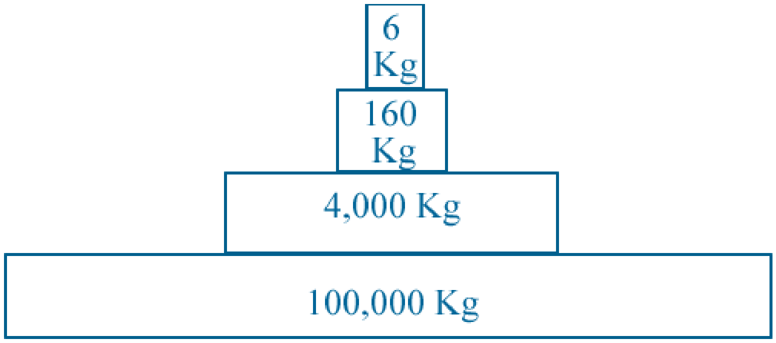
Pyramid of Energy

Energy is lost between each link in a food chain. Much of the potential energy at each level never reaches the next level. Where does the energy go as it moves through a food chain? Some of the energy that enters a food chain is used as each organism carries out its life functions (i.e. foraging, metabolic processes, reproduction, predator/prey behavior, etc.). Producers manufacture their own food source directly from sunlight by the process of photosynthesis. In order to carry out life functions, consumers acquire energy through the 'burning' or breaking down of food molecules they consume (eat). Thermal energy (heat) is produced as a result of the burning of these food molecules. More than half of the energy from each food molecule is lost as heat. Only about 10% - 20% of energy at each trophic level is available to pass on to the next level. In other words, at each level there is only about 10% available energy to put on new biomass (growth).



Pyramid of Numbers

The loss of energy at each trophic level also explains why there are usually fewer organisms in each higher trophic level. The total number of plants in a particular area would generally be higher than the number of herbivores that the plants support and the number of herbivores would be higher than the number of higher order carnivores.



Pyramid of Biomass

Biomass is the total mass of dry organic matter per unit of area. Each higher trophic level contains less biomass than the previous trophic level. Therefore a drawing or graph that represents the amount of biomass at each trophic level would also produce the basic pyramid shape. Biomass is related to the abundance of organisms at each trophic level.

Human Impact on Food Chains and Webs

Humans have the ability to have a great impact on ecosystems. Living organisms are a significant portion of any ecosystem; therefore any activity that affects an ecosystem is also likely to affect the organisms within that ecosystem. If organisms are affected the food chains webs that the organisms are a part of will also feel the effects.

CHAPTER 4

CASE STUDY-THREATS TO WETLANDS IN ASSAM

Wetlands are vital parts of the hydrological cycle and support exceptionally large biological diversity which make them the most productive ecosystems on the earth. Wetlands provided a wide range of ecosystem services and thereby facilitate livelihoods of many marginalised communities living near wetlands.

In India about 5 percent of the country's geographical area is under wetlands supporting about one
fifth of its known biodiversity. At present Assam has an estimated area of 7, 64,372 ha under wetlands which is about 9.74 percent of the state's geographical area. The majority (about 84%) of these wetlands are formed by rivers and streams and riverine wetlands.

Similar to many parts in India, the wetlands of Assam are facing widespread degradation due to encroachment, land filling and conversion to other land uses, pollution, hydrological alterations, over exploitation of aquatic resources and siltation. Many ecologically, socio-economically and culturally important wetlands have disappeared of late succumbing to pressures of growth in settlement, agriculture and other development activities.

The Deepar beel a Ramsar Site (a wetland of international importance), an Important Bird Area (IBA) as well as a Wildlife Sanctuary (at the core), located near Guwahati has shrunk in its area by about 4 square km in last twenty years. This wetland, a repository of rich biological diversity especially of resident and migratory birds us under tremendous pressure from all sides due to development activities and unsustainable land use practices. Discharge of pollutants and effluents, illegal encroachment, impact of brick kilns are major factors responsible for the degradation of the wetland's ecosystem. Siltation caused by accelerated soil erosion from the excessively denuded and quarried adjacent hills as well as sediment and solid waste materials carried by the inlet channels have reduced its capacity significantly leading to rapid depletion of its fish productivity.

As a result many fishermen families have suffered from losing income and livelihoods. Fragmentation of the beel into distinct water pools with overgrowth of water hyacinth is a signal of its ecological degradation.

The connecting channels help wetlands to perform their normal ecological functions efficiently by maintaining natural standards of water quality and quantity. The feeder channels facilitate exchange of water (flow) and sediment fluxes, seasonal replenishment of fish stock, and flushing out pollutants by flood pulses ridding the wetland of high turbidity, nutrient load and eutrophication. They act as conduits for the incoming and outgoing of flood waters thus helping in flood moderation for adjoining areas as well as sediment distribution. Healthy feeder channels are essential for ensuring normal productivity and ecological services of wetlands on which local people depend to get various livelihoods. Many economically important and common edible fish varieties migrate to freshwater wetlands for spawning through the feeder channels from the rivers. If inlet channels are congested or polluted replenishment of fish stock suffers and livelihood of fisher folks is jeopardised. Therefore status of hydrological connectivity of a wetland is a crucial determinant of livelihood benefits to local communities. Maintenance and management of connectivity is vital for ecological health of wetland.

On one hand there is an abysmal lack of enforcement of existing laws and polices related to protection and management of wetlands, on the other hand effective policies and institutions are also not available for wetland conservation at state level. In Assam there is almost no implementation of the provisions of the Wetland (Conservation & Management)Rules, 2010 framed by Government of India under the Environment Protection Act, 1986. Even in the existing policy instruments that relate to preservation and management of wetlands, the importance of hydrological connectivity has been largely ignored.

Conservation of Wetlands

Some conservation measures are-

1. State government must formulate and adopt a wetland policy and ensure its proper implementation. Such a move would have a great effort on future environment security, as well act as a lifeline to numerous people whose lives depend on wetlands.

2. Protection of boundary of wetland, demarcation of boundary by fixing pillars and preventing encroachment.

3. Realizing the gravity of the encroachment problem in the beel areas and stricter legislation to ensure prevention of the fast growing human encroachment and pollution should be enacted. All types of illegal encroachment should be vacated from the beel areas.
4. Control of commercial fishing.

5. Control of exploitation of aquatic products.
6. Extensive survey and quantification of flora and identification of threatened species.
7. All neighbouring residents of the area should make aware of the fact that like open spaces, wetlands also play a vital role in maintaining a healthy environment.