CHAPTER

25

ECOSYSTEM

Animation 25: Ecosystem
Source and Credit: Microbewiki

INTRODUCTION

The term ecology comes from the Greek words oikos. meaning “the family household”, and logy, meaning “ the study of”. The term originally was coined by the German zoologist Ernst Haeckel in 1866. He called it oecologic and defined it as the study of the relationship of animals (organisms) to their environment.

Environment includes not only the physical but also the biological conditions under which an organism lives. Relationship includes interactions with the physical world and with members of other species and the same species.

ECOSYSTEM

The major unit of ecology is the ecosystem. Organisms interact with their environment within the confines of the ecosystem. The eco part of the word is related to the environment and the system part means a collection of related parts that function as a unit. The ecosystem consists of two basic interacting components, the living or biotic, and the physical or abiotic factors.(Fig.25.1)

Biotic components consist of animals, plants, fungi, micro-organisms etc. and abiotic components are atmosphere, climate, soil, and water.

The various kinds of organisms that inhabit an ecosystem make up populations. **Population** is a group of interbreeding individuals (same species) occurring together in space and time. Populations of plants and animals in the ecosystem do not function independently of each other.

Animation 25: Ecosystem
Source and Credit: Water for Life

Some populations compete with other populations for resources, such as food, water, or space. In some cases, one population is the food resource for another. Two populations may mutually benefit each other. All populations within an ecosystem are known as a **community** and are in one or another manner interconnected to one another.

The ecosystem has many levels. On our level, individual organism, including man, both responds to and influences the physical environment. At the next level, individuals of the same species form population, that can be described in terms of number, growth rate, and age distribution. Further, individuals of these populations interact among themselves and with individuals of other species and form a community.

Major types of ecosystems, those that occupy broad geographical regions are called biomes. Each biome consists of a combination of plants and animals in the fully developed climax community, and is characterized by a uniform life-form of vegetation such as grass or coniferous trees. Some major terrestrial biomes are forest, grass land, and desert. Combined the biomes of earth together form the planetary ecosystem.

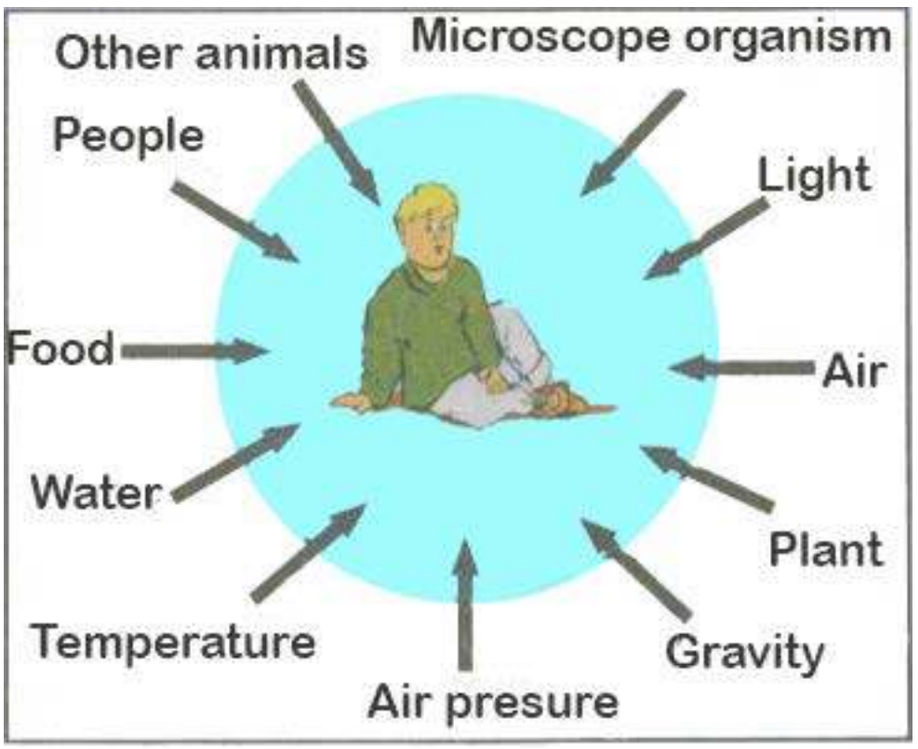


Fig. 25.1 Your environment

Biosphere

Biosphere is a thin layer of earth in which all living organisms exist. Organisms within the biosphere not only adapt themselves to the environment but also interact to modify and control chemical and physical conditions of the biosphere. An organism lives in a habitat.

An organism responds to a variety of environmental factors, and only when all of them are within the range of tolerance, it can inhabit a location. The actual location of place where an organism lives is called its **habitat.**

In 1917, Joseph Grinnell an American ornithologist first proposed the term niche in ecology. The habitat and niche are closely related. Niche is defined as the ultimate distributional unit within which a species is restrained by the limitations of its physical structure and its physiology. Charles Eltan considered the niche, the basic role of an organism in the community-what it does in and for living community, its relationship to its food and enemies. In other words, he defined the niche as the species's occupation.

It refers to a profession or job of an organism. Ecosystems are composed of organisms with different jobs or ways of life, particularly concerned with feeding, the role of a particular species within an ecosystem, including all aspects of its interaction with the living and the non-living environment.

"A niche is defined as the role a species plays in a community including behavior and influence."

Ecological niche with habitat also specifies how the organism gets its supply of energy and materials - for example organism's predators, prey and competitors as well as its behavior and interactions are considered elements of its niche.

In addition, niche includes all the physical factors of the environment necessary for survival, such as range of temperature, amount of humidity, the pH of the water and soil.

Autecology

Ecology is the study of relationship of living organisms to their environment. When you are studying a single population's relationship to its environment it will be called as autecology. For example, you are studying 50 to 100 plants of soybean in order to know the effect of water pollution on their growth and yield, you are studying the single or one population of soybean plant, this study is autecology.

Synecology

Growth responses of individual plants to their environment are a complex factor. One factor can aggaravate the other factor. These factors interact with one another. Complexity of environment depends upon the combination of various factors. The study of the relationship of different communities (grouping of populations) to their environment is called **synecology** or **community ecology.**

When you study only one population, at different places in an environment it will be autecology. But when you see all the populations at the same time it will be synecology. In synecology (the study of a community) you have to see the various aspects of community like the origin, structure and composition of the community. You have to consider the history of community and also its dynamics because community is not a fixed entity but different changes are going to occur at different times. While studying the community we come across three levels of integration : (i) individual (ii) population (iii) community.

Fig. 25.2(a) A population of birds

Fig. 25.2(b) A community

COMPONENTS OF ECOSYSTEM

As discussed earlier the ecosystem can be divided into two main components.

1. Biotic Components

Biotic components include all living organisms including plants and animals supported by biosphere. Biosphere is spread out over the surface of plant earth extending about 8-10 kilometers to the upper reaches of atmosphere and also the same distance into the depths of oceans.

Animation 25.2:Biotic v/s Abiotic Components
Source and Credit: Ameoba Sisters

2. Abiotic Components

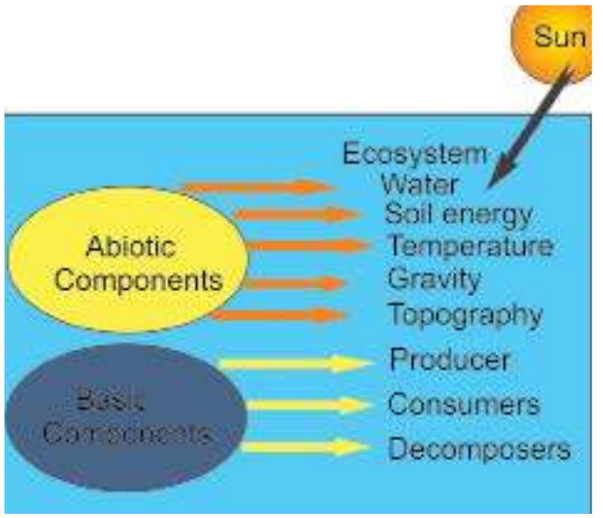
Abiotic components include all non-living components air, water, and soil. In ecological term they are called as : (a) atmosphere — (atmo - air, sphere - place) (b) hydrosphere — (hydro - water, sphere - place) (c) lithosphere — (litho - earth,soil, sphere - place).

Processes in Ecosystem and Interaction between Biotic and Abiotic Components:

The main processes occurring in an ecosystem include feeding and the circulation of chemical elements, together with the energy flowing through the ecosystem.

An ecosystem is made up of three main components, the producers, the consumers and the decomposers. All are concerned with the feeding processes, the circulation of chemical elements and the flow of energy.

Producers are the autotrophs green photosynthetic plants, which capture and bring light energy into the ecosystem. They are able to manufacture organic food from simpler inorganic substances. They are autotrophic organisms.



Consumers are all the organisms, primarily animals, which obtain energy directly or indirectly from the producers as ready-made organic food. They are mainly heterotrophic organisms.

Decomposers are mainly the fungi and bacteria, which obtain their energy from the dead and decaying plants and animals. They release chemical elements as ions. The main chemical ions are nitrates, ammonia, phosphates, potassium and calcium.

Food Chain

Basically, all animals depend on plants for their food. Eagle may eat blue bird, but blue bird eats insects like caterpillar and caterpillar feeds on grass or green leaves. This is an example of a simple food chain.

Food Web

Food web is actually “the combination of many food chains”. Food webs are not really as simple as described in Fig. 25.3, because most animals eat more than one type of food at different times as fox does not feed entirely on rabbit but also takes beetles, rats etc.

All the food chains and food webs begin with a green plant (producer) and may consist of three to five links or trophic levels (Fig. 25.3).

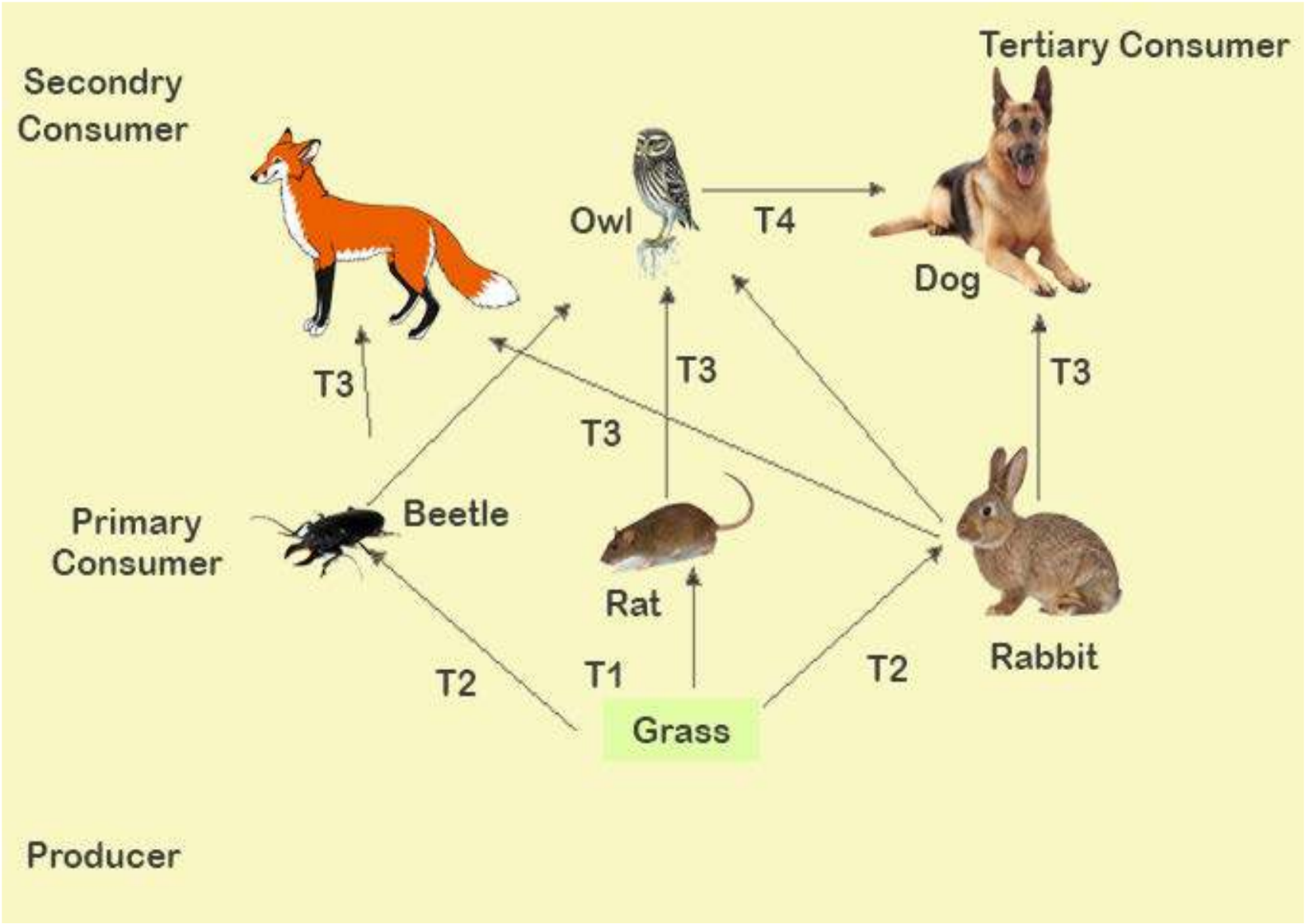


Fig 25.3 Food Web and various trophic level

In a food web you will find more complex trophic levels or food links. In fig (25.3). food chain T_1 is the first trophic producer level, Includes all green plants, grass, and phytoplankton; T_2 , second trophic level - primary consumers; T_3, third trophic level - secondary consumers; T_4 ,fourth trophic level - tertiary consumers.

The variety of pathways in a food web helps to maintain the stability of the ecosystem. For example, owls prey on rabbits and mice. If a disease reduces the rabbit population; fewer plants are consumed. The larger plant population produces more fruits and seeds, which, in turn, support a larger mouse population. The increased number of mice becomes the major food source for the owls. The rabbit population gradually increases, and these primary consumers once again become a food source for the owls. Thus nature maintains a balance.

SUCCESSION

Succession is a squence of changes in the community structure of an ecosystem over a period of time. Community changes alter the ecosystem in ways that favours the competitors and species to replace their predecessors in somewhat predictable manner until a stable, self sustaining climax community is reached. Succession is a kind of “community relay” in which assemblages of plants and animals replace the earlier ones in a sequence that is at least somewhat predictable. The precise changes occurring during succession are as diverse as the environments in which succession occurs, but certain general stages can be recognized.

Animation 25.3: Succession
Source and Credit: Ameoba Sisters

In each case succession is initiated by a few hardy invaders called **pioneers** and it ends with a diverse and relatively stable **climax community.**

Two Major Forms of Succession

Succession on dry land takes two major forms, primary succession and secondary succession. During **primary succession,** an ecosystem is forged from bare rock, sand or clear glacial pool where there was no trace of previous life.

The formation of an ecosystem from scratch is a process often requiring thousands of years. During secondary succession a new ecosystem develops after an existing ecosystem is disturbed as in case of forced fire or an abandoned farm field. Secondary succession happens much more rapidly than primary succession because the previous community has left its mark in the form of improved soil and seeds. Primary succession starting in a pond is called hydrosere and that on a dry soil or habitat is called xerosere. Plants growing in xeric condition are called xerophytes, which are able to withstand prolonged periods of water shortage. Succullent plants such as the cacti have water stored in large parenchyma tissue, others have leaf modification. Xerosere has the following different stages.

Crustose lichen stage : A crust is any external protective surface and crustose means crusts on the substratum. Special types of lichens get impregnated in the form of crust. They can live in extreme conditions. Sometimes, their surface is wet due to rain and dew- drops. They absorb water during dry season. They are quiescent or dormant, normally desiccated during dry season.

Foliage lichen stage: In this stage the lichens are just like crumpled leaves attached at one point. It produces shade to the crustose lichens as a result of which their growth is reduced or decreased. The area becomes rough , as more and more fissures and depressions develop. Common examples are, Dermatocarpon, Parmellia, etc. At this stage other plants invade called moss stage, because now soil is more porous with some litter of lichens.

Moss stage : This is the third stage with mosses like, Polytrichum, Tortula etc. They compete with lichens for water and penetrate much deeper into the soil as compared to the lichens, adding more humus to the soil.

Herbaceous (plant) stage : Small seedling of herbaceous plants now establish due to the more availability of moisture, humus and soil for anchorage.

Shrub stage : Shrubby plants now start growing, dominating and shadowing herbaceous plants which die to add more humus to the soil.

Climax forests: The soil is improved to an extent that it now allows the growth/ establishment of woody plants. The shade of these plants inhibits the growth of most plants other than mosses, lichens, a few ferns etc. Woody plants dominate and this stage in succession remains essentially the same if nothing changes in the environment to upset the balance. Because it is a stable stage in succession, the woody forest is considered to be the climax stage for this region (Fig. 25.4).

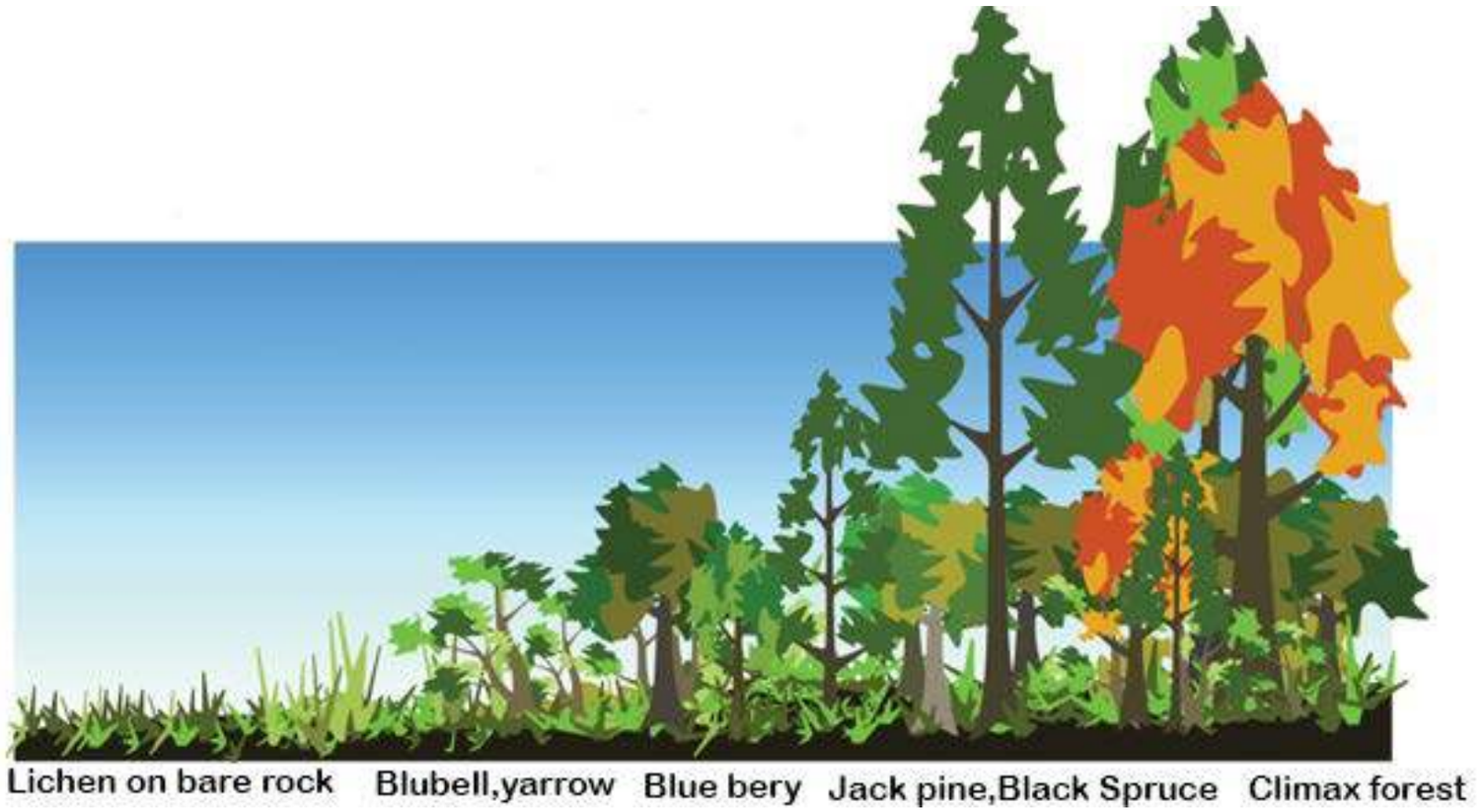


Fig. 25.4 Primary Succession

Seral communities (seral stages)

Bare ground → Lichens+algae → Mosses+ferns → Grasses → Shrubs → Trees

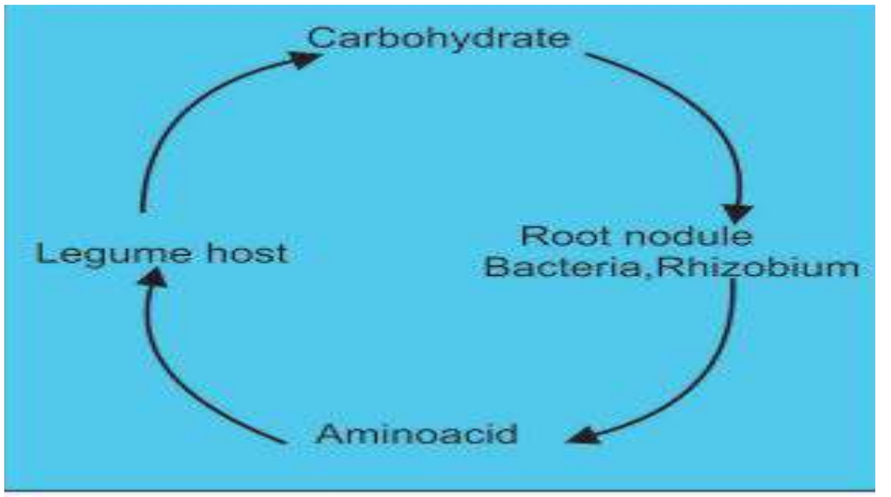
Pioneer community — Climax community

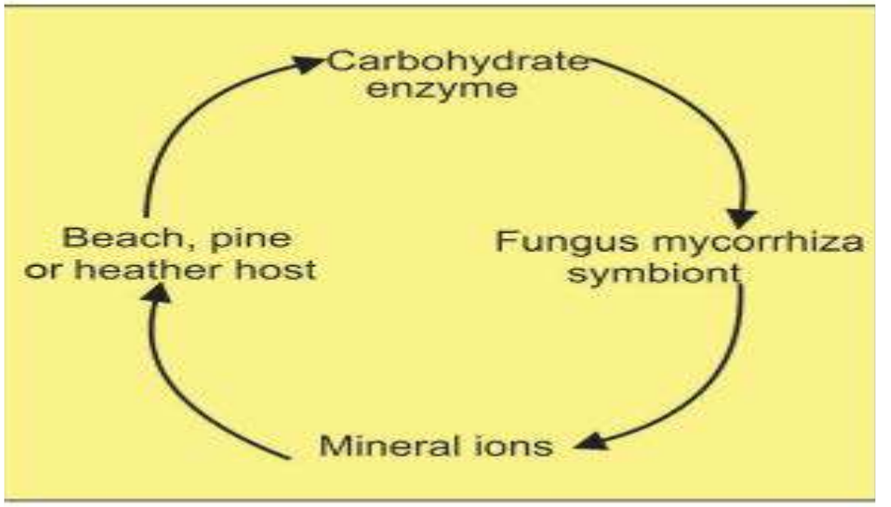
Predation and its Significance

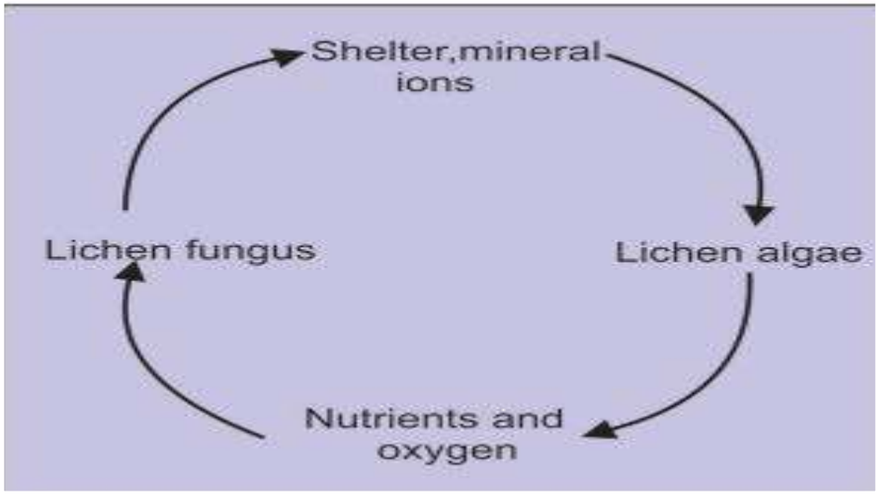
An animal that preys on other animals is a predator. A predator is a consumer. The animal that is caught and eaten is the **prey.** The over all process is called predation.

The sizes of populations of predator and prey are related to each other. The size of each population is determined by the size of the other. If the number of prey is large, this leads to an increase in the number of predators; as predator feeds upon the prey, the number of prey begins to fall. The number of predators also decreases, since they have smaller food supply. As the number of predators decreases, the number of prey begins to increase. This food relationship of predator - prey creates a "cycle".

Examples: cat/mouse, fox/rabbit, seal/fish, frog/mosquito, hawk/small birds etc.







Parasitism and its Significance

This is an association between a host and a parasite, which involves providing the parasite with food, protection and conditions for its survival. The parasite may or may not harm the host. Diseases in living organisms, which are caused by parasites are called **infestations.** Parasites may be **ectoparasites,** living outside the body of the host e.g. fungi causing dandruff in hair and **endoparasites,** living inside the body of the host e.g. tape worm in intestine of man.

Symbiosis

It is an association between two organisms, which brings benefit to both the organisms.

Root Nodules: The legume plant , pea and bean, are the hosts to symbiont bacteria, which inhabit the roots forming root nodules. The bacteria in the root nodules fix nitrogen in soil from air, converting it into amino acid, which the host uses. In return, host provides bacteria with food and protection.

Mycorrhiza : Mycorrhiza is an association between the roots of plants growing in acid soil and certain fungi. The host is pine, beech or heather and it provides the fungus with an enzyme to digest carbohydrates in leaf litter. In return, the fungus symbiont passes mineral ions from the soil to the host.

Mutualism:

It is the relationship between two organisms in which both the organisms benefit from each other. Lichens are an example of mutualism between a fungus and an alga. The relationship between insects and flowering plants is another example. The insect gets nectar from the flower; the flowers are able to reproduce because the insects carry pollen from flower to flower.

Lichens:

Lichen is a dual organism composed of symbiotic association of an alga living within a fungus mycelium. The lichens grow on exposed rock surfaces and are important colonizers of bare ground.

Commensalism

In this type of relationship only one organism benefits from the relationship. The other is not affected at all. For example, sharks may have small fish called remoras attached to them. As the shark feeds, the remoras pick up the scraps. The remoras benefit . from this relationship, the shark is not affected at all.

Grazing

Many animals like rabbits, goats, sheeps, cows, buffaloes and horses feed on grasses. This mode of feeding is called grazing and these animals are called grazers. These animals live in pastureland where they feed on grasses, herbs and shrubs. If too many animals are kept on pasture, they eat the grasses down to the root though grasses are more resistant than herbaceous plants and have ability to regrow very fast, but the hooves of grazing animals trample the soil into hard layer as a result of which rain water will not penetrate this soil. It runs off from the upper surface removing the fertile topsoil with it. The final result of over - grazing is totally barren land. Grazing is very important factor in determining the ecosystem. Moderate grazing is very helpful to maintain grassland ecosystem. It destroys the competitors and helps the grass to grow well. Over grazing may lead to the transformation of a grassland into a desert.

BIOGEOCHEMICAL CYCLES

The chemical elements essential for life in living organisms are called biogenic elements or nutrient elements. Macronutrients are elements required by organisms in large amount like water, carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur and calcium. Micronutrients are elements required by organisms in small quantity or in trace amount like zinc, molybdenum, iron, iodine. The nutrient cycles are also called biogeochemical cycles as the nutrients move from living to nonliving to living portions of ecosystem in a cyclic manner.

The Nitrogen Cycle

The chief reservoir of nitrogen is the atmosphere; in fact nitrogen makes up 78 percent of the gases in atmosphere. Since most living things, however, cannot use elemental atmospheric nitrogen to make amino acids and other nitrogen containing compounds, they are dependent on nitrogen present in soil minerals. So, despite the abundance of nitrogen in the atmosphere, shortage of nitrogen in the soil is often the major limiting factor in plant growth. The process by which this limited amount of nitrogen is circulated and re-circulated throughout the world of living organisms is known as the nitrogen cycle (Fig. 25.5).

Animation 25.4: Nitrogen Cycle
Source and Credit: MicrobeWiki

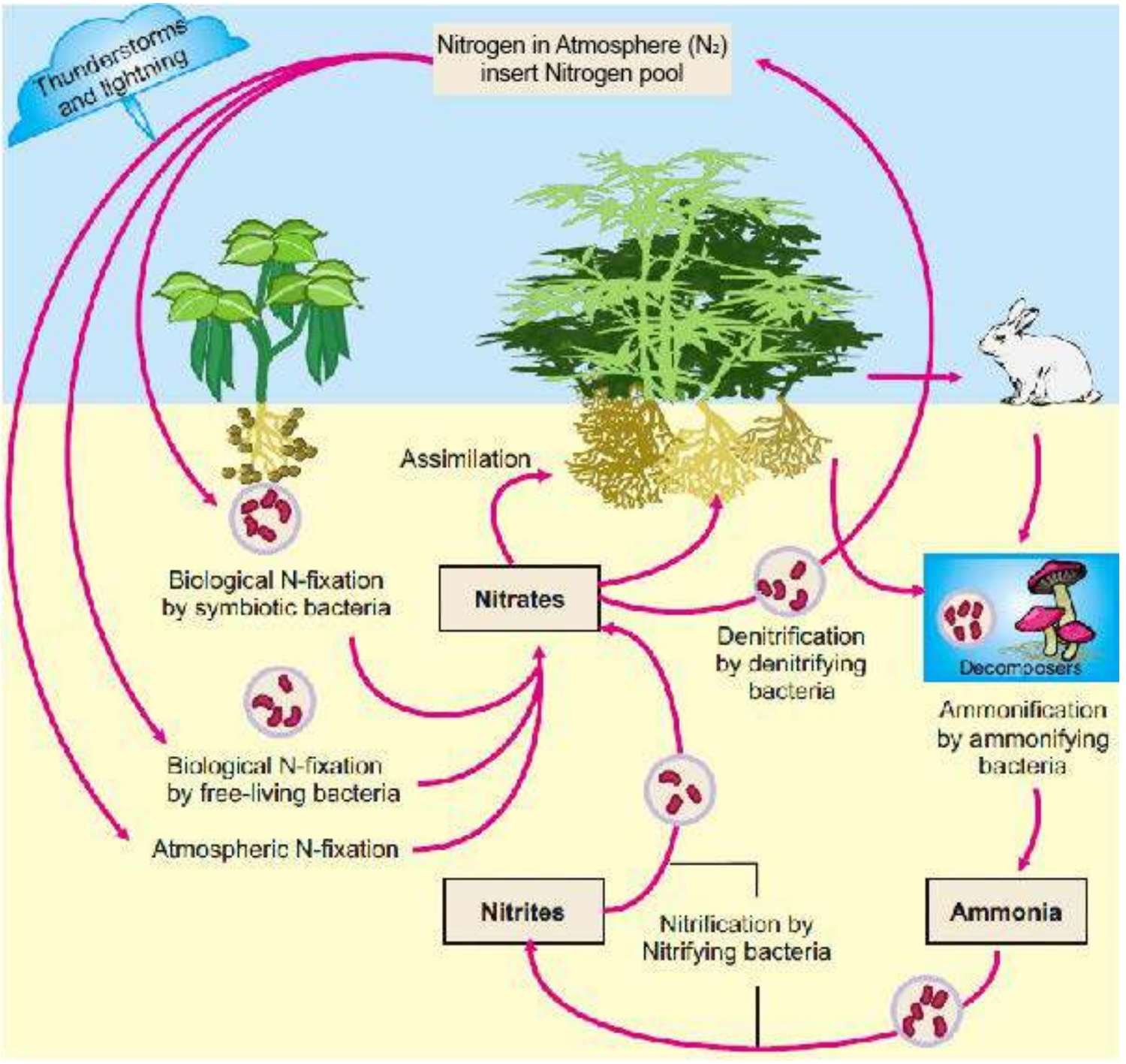


Fig 25.5 The Nitrogen Cycle

Three principal stages of this cycle are, **ammonification, nitrification, and assimilation.**

Much of the nitrogen found in the soil is the result of the decomposition of organic materials and is in the form of complex organic compounds, such as proteins, amino acids, nucleic acids and nucleotides. These nitrogenous compounds are usually rapidly decomposed into simple compounds by soil-dwelling organisms chiefly bacteria and fungi. These microorganisms use the proteins and amino acids and release excess of ammonia (NH_3) or ammonium ions (NH_4^+). This process is known as ammonification.

Several bacteria in soil are able to oxidize ammonia or ammonium ions, this oxidation is known as nitrification.

Although the plants can utilize ammonium directly, nitrate is the form in which most nitrogen moves from the soil into the roots. Once nitrate is within the plant cell, it is reduced back to ammonium. In contrast to the nitrification, this assimilation process requires energy. The ammonium ions thus formed are transferred to carbon - containing compounds to produce amino - acids and other nitrogenous organic compounds needed by the plant.

Animation 25.5: Nitrogen Cycle
Source and Credit: OrganicSoilTechnology

Nitrogen Depletion and its Remedies

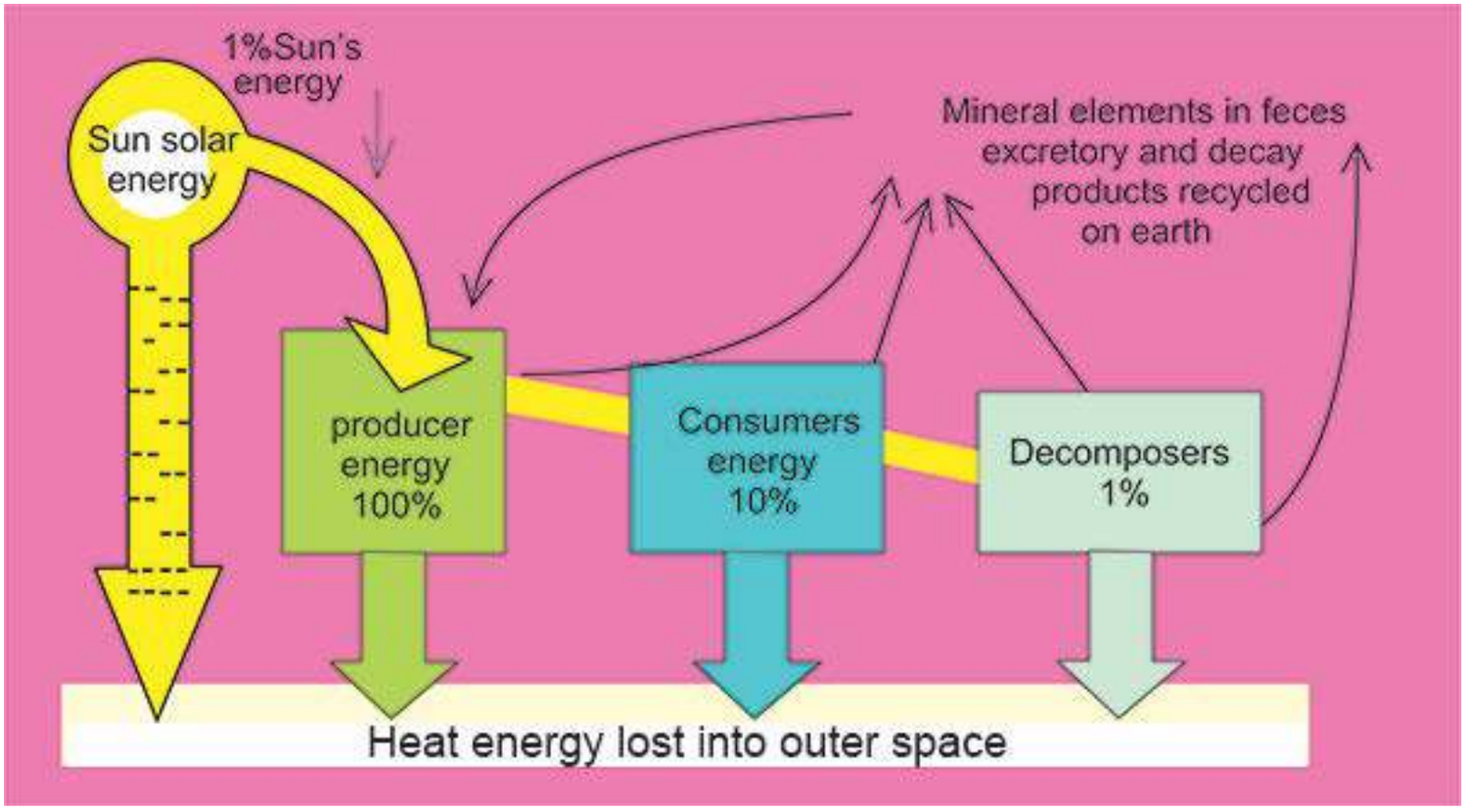
Although the nitrogen cycle appears complete and self - sustaining, nitrates are steadily lost due to the soil erosion, fire and water percolating down through the soil. Nitrates are also lost as a result of the activities of certain soil bacteria; in the absence of oxygen these bacteria break down nitrates releasing nitrogen back into the atmosphere and using the oxygen for their own respiration. This process is known as denitrification, in poorly drained (poorly aerated) soils. The cycle is maintained despite these losses primarily by the activities of the nitrogen - fixing bacteria, which incorporate gaseous nitrogen from air into organic nitrogen containing compounds. Just as all organisms are ultimately dependent on photosynthesis for energy, they all depend on nitrogen fixation for their nitrogen. Soil nitrogen resources are also strengthened by the addition of nitrogen ferlitizers by the man himself.

The flow of Energy in Food Chain of an Ecosystem

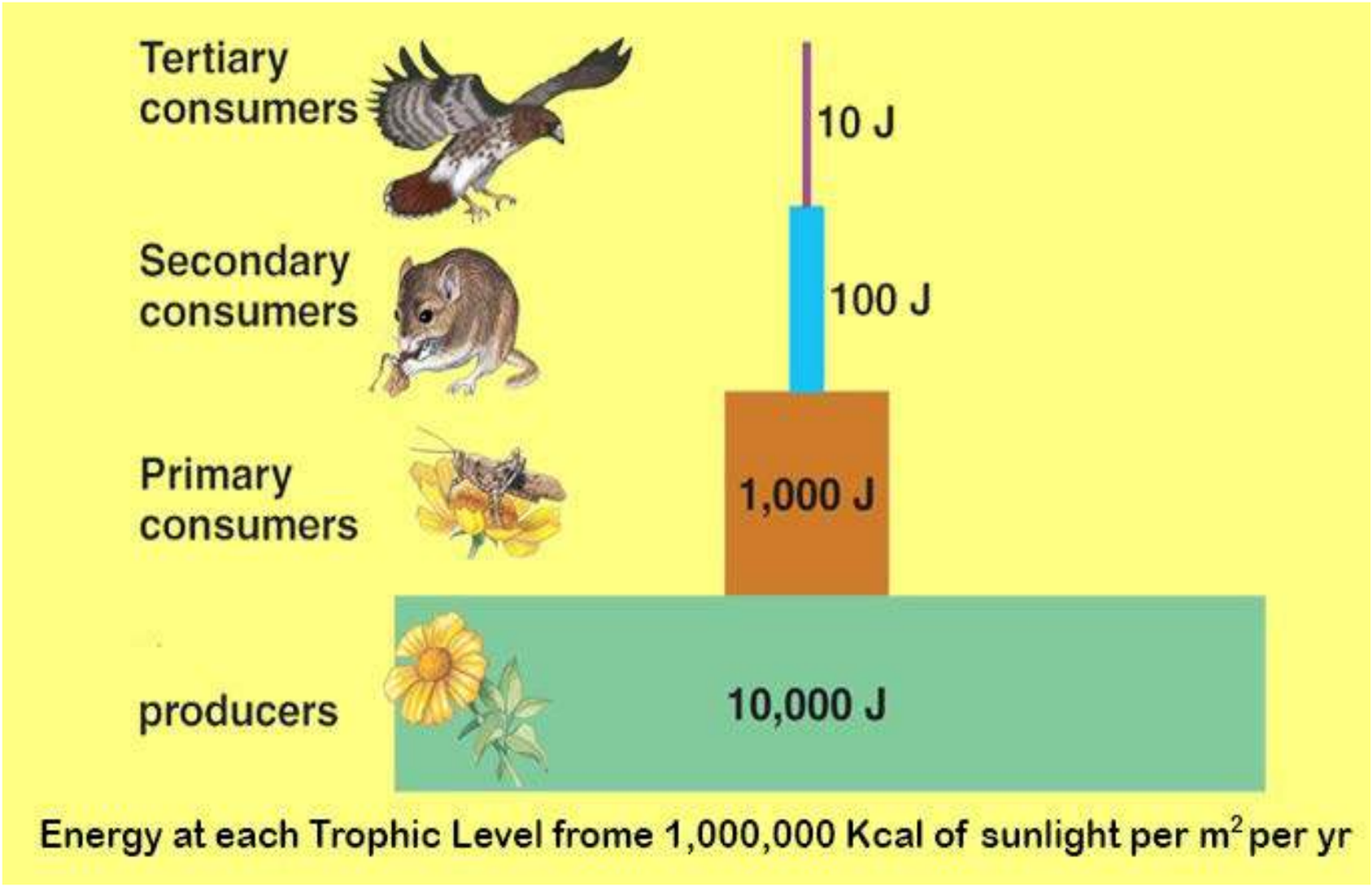
Energy in the form of radiant heat and light from the sun flows through an ecosystem passing through the different trophic levels (links) and radiates again back into outer space. The total amount of energy fixed by plants is gross primary production. The amount of energy left after plants have met their respiratory needs is net primary production, which shows up as plant **biomass.**

Animation 25.6:Flow of Energy
Source and Credit: Steemit

About 1% of the total energy from the sun is trapped by the producers in an ecosystem. The remaining 99% of solar energy is used to evaporate water, heat up soil and is then lost to the outer space. As energy is transferred from one trophic level to the next, from producer to primary consumer, between 80 to 90% of last as the original energy is heat as a by product of respiration. However, a continuous flux of energy from the sun prevents ecosystem from running down. A pyramid of energy can be constructed showing energy transfer in a community of organisms.



A short food chain of two or three links supports a community more efficiently than a long chain of five Links where much of the original energy from the producers would never reach those organisms at higher trophic levels. Decomposers are able to obtain energy by converting plant and animal tissues and waste into inorganic mineral ions.



An Energy Pyramid

EXERCISE

Q1 Fill in the blanks.

1. A group of similar organisms living together in space and time is called_____ .
2. Organisms which can synthesize their own food are called_____ .
3. Animals, non-green plants and microorganisms directly or indirectly depend upon green plants for their food so they so are called_____ .

Q.2 Write whether the statement is true or false and write the correct statement if false.

1. At different places in an environment when you study only one population, it will be synecology.
2. Abiotic components include all living components.
3. Primary succession starting in a pond is called xerosere.
4. The animal that is caught and eaten is the predator.
5. Endoparasites live inside the body of the host.

Q.4 Short questions.

1. What are the biogeochemical cycles?
2. Sketch three mainsteps in nitrogen cycle.
3. Define grazing.
4. What percentage of sun energy reaches to plants?
5. What is autecology?
6. Define synecology.

Q.5 Extensive Questions.

1. Define environment. What must environment supply for insects, green plants, birds, animals and people?
2. What factors in the environment can affect all living things? Are they important to survive in a biome?
3. What can you conclude about all the physical and biological factors in an environment?
4. What is biosphere? What must the biosphere provide for living things? Why is a biosphere absent on moon?
5. Define succession. Discuss succession on land.