2 ECOLOGY AND ECOSYSTEM

ECOLOGY

Ecology is the science which studies the inter-relationships between biotic and abiotic components of a natural ecosystem on one hand and among biotic components on the other. Thus ecology is the study of interrelationships and various processes between all organisms and their environment as well as among the organisms themselves.

Ernst Haeckel coined the term 'Oekology' (Greek: oikos - house or dwelling as habitat, logos - study of). The concept of ecology evolved from Darwin's concept of evolution of species through natural selection involving interaction between biological species and habitat.

Ecology is studied into two branches. First, autecology is the study of ecological relationship of single species in a given ecosystem. Second, synecology is the study of group of species living together as communities in relation to their habitats of a given ecosystem. It can be mentioned here that a group of individual organisms of the same species in a given area is called a population. While a group of population of different species in a given area is called a community. Based on this we have population ecology and community ecology.

The basic concepts and the focus areas of ecology are as follows:

(1) Ecosystem as the fundamental unit of ecological study.

(2) All living organisms and physical environment are mutually reactive i.e. they act and react on each other and among themselves.

(3) There is unidirectional circulation of energy, while the matter is circulated cyclically, through biogeochemical cycle in such a way that the total mass remains constant.

(4) The homeostatic mechanisms or self-regulatory mechanisms play an important role in keeping natural ecosystem stable.

(5) If the changes brought about by the external factors exceed the resilience of ecosystem then the

INDIVIDUAL (ORGANISM)

It is a distinct living entity or distinct package which carries out all life processes in its body, separate from those in other individuals. An individual organism is the basic unit of **ecological hierarchy** as it continuously exchanges materials and information with its environment. New individuals develop from pre-existing ones. Hereditary characters are transferred during this process. The **constituents of an individual cannot survive independently.**

ecosystem becomes unstable creating environmental problems.

(6) Ecology studies the evolution of species through natural selection and adaptation as well as mutation and reproductive isolation.

(7) There is successional development of ecosystems in a given habitat.

(8) The distribution of biodiversity plays an important role in stability and evolution of species.

Ecology has two main branches:

(i) Autecology/Species Ecology: The study of reciprocal relationships between every stage of development of a population/species and its environment is called autoecology.

(ii) Synecology: It is the study of reciprocal relationships between composition, organisation and development of communities and their environment.

ECOLOGICAL PRINCIPLES

1. **The first and second law of thermodynamics:** 1st law; energy can neither be created nor destroved,: it can only be changed from one form into another.
2. **Limiting Factor Principle :** Too much or too little of any aboiotic factor can limit or prevent growth of a population, even if all other factors are at or near the optimum range of tolerance.
3. **Homeostatic principle:** It is the maintenance of constant interrnal conditions in the face of a varying external environment. The thickening of fur in winter, the darkening of skin in sunlight, the seeking of shade in heat and the production of more red blood cell at high altitude are all examples of adaptations animals make in order to maintain homoestasis.

POPULATION

It is a grouping of similar individuals in a particular geographical, area or space. The different populations **of** the same organism present in particular geographical areas are called **local populations/demes.** A local population adapted genetically to its particular environment is called **ecotype.** There may be several ecotypes of the same organism which show variations amongst them.

ECOSYSTEM

An ecosystem is a community of living organisms (plants, animals and microbes) in conjunction with the nonliving 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

KINDS OF ECOSYSTEM

Ecosystems may be categorized as follows:

1. Natural Ecosystems: These operate by theselves under national conditions without any major interference by main. Based upon the particular kind of habit these are further divided as:
   - Terrestrial as forest, grassland, desert, etc.
   - Aquatic which ay be further distinguished as:

   i. Freshwater which may be lotic (running water as spring, stream or rivers) or lentic (standing water as lake, pond, pools, swamp etc.)

   ii. Marine, such deep bodies as an ocean or shallow ones as a sea or estuary', etc.
2. **Artificial (man-engineered) ecosystems:** these are maintained artificially by man where, by addition of energy and planned manipulations, natural balance is disturbed regularly. For example croplands like maize, wheat, rice-fields. etc. where man tries to control the biotic community as well as the phvsio-chemical environment, are artificial ecosvstems.

Table 1

Descriptions of the Eight Ecological Principles and Associated Concepts

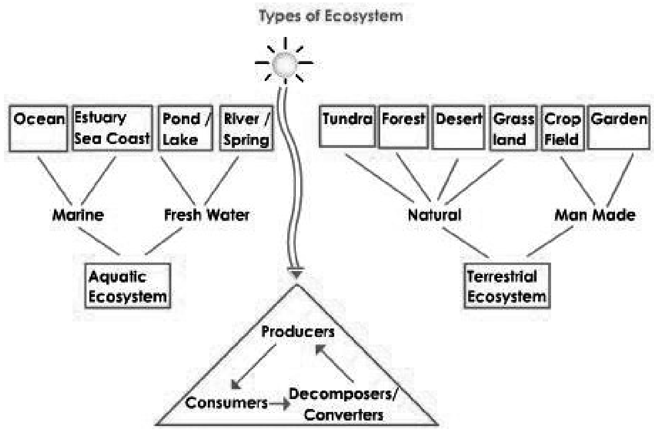
Principle	Description	Associated Concepts
Adaptation	The way a life system looks or behaves is not random or accidental; rather it is the result of changing to survive in a dynamic environment.	Evolution, Life History Patterns, Natural Selection, Survival, Predator-Prey Interactions
Behavior	Living systems evolve behavioral responses to stress and disturbances to enhance survival.	Reproduction, Predator-Prey interactions, Dispersal, Survival (humans and other animal species), Pest Control (exotics, nuisance animals) Harvesting
Diversity	Changes in environmental conditions over time have led to variety within each level of organization.	Competition, Land-Use Practices, Genetics, Survival, Fragmentation
Emergent Properties	When different levels of organization are functioning together, new properties are created that were not operational at lower levels	Complexity, Synthesis, Teamwork, Government
Energy Flow	Energy cannot be created nor destroyed but it can change form. Energy quality is always degraded through transformation.	Thermodynamics, Food Chains, Tropic Levels, Heat Exchange.
Growth and Development	As organisms and systems increase in size, changes occur that allow survival. Growth rate slows as maximum capacity is met.	Succession, Reproduction, Population Dynamics, Competition
Limits	There are limits to how much stress can be tolerated by living systems.	Sustainability, Conservation, Disease, Natural Disaster, Agriculture, Pollution
Regulation	Energy is spent if a signal is sent to increase or decrease some function to maintain balance.	Feedback Loops, Organismal Systems, Cybernetics

BIOLOGICAL OR BIOTIC COMMUNITY

It is an assemblage of populations of different species of plants, animals, bacteria and fungi which live in a particular area and interact with one another through competition, predation, mutualism, etc.

GENECOLOGY

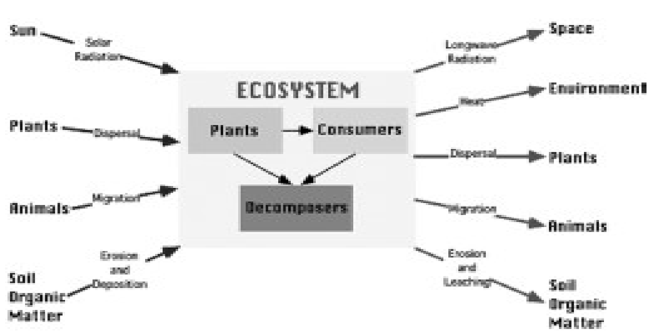
Study of genetic composition and changes in relation to the origin of ecads, ecotypes, new species, etc.



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).

Energy, water, nitrogen and soil minerals are other essential abiotic components of an ecosystem. The energy that flows through ecosystems is obtained primarily from the sun. It generally enters the system through photosynthesis, a process that also captures carbon from the atmosphere. By feeding on plants and on one another, animals play an important role in the movement of matter and energy through the system. They also influence the quantity of plant and microbial biomass present. By breaking down dead organic matter, decomposers release carbon back to the atmosphere and facilitate nutrient cycling by converting nutrients stored in dead biomass back to a form that can be readily used by plants and other microbes.

Ecosystems are controlled both by external and internal factors. External factors such as climate, the parent material which forms the soil and topography, control the overall structure of an ecosystem and the way things work within it, but are not themselves influenced by the ecosystem.[8] Other external factors include time and potential biota. Ecosystems are dynamic entities—invariably, they are subject to periodic disturbances and are in the process of recovering from some past disturbance. Ecosystems in similar environments that are located in different parts of the world can have very different characteristics simply because they contain different species. The introduction of non-native species can cause substantial shifts in ecosystem function. Internal factors not only control ecosystem processes but are also controlled by them and are often subject to feedback loops. While the resource inputs are generally controlled by external processes like climate and parent material, the availability of these resources within the ecosystem is controlled by internal factors like decomposition, root competition or shading.[8] Other internal factors include disturbance, succession and the types of species present. Although humans exist and operate within ecosystems, their cumulative effects are large enough to influence external factors like climate.



Biodiversity affects ecosystem function, as do the processes of disturbance and succession. Ecosystems provide a variety of goods and services upon which people depend; the principles of ecosystem management suggest that rather than managing individual species, natural resources should be managed at the level of the ecosystem itself. Classifying ecosystems into ecologically homogeneous units is an important step towards effective ecosystem management, but there is no single, agreed-upon way to do this.

COMPONENTS OF AN ECOSYSTEM

Organisation or Structural aspect of an ecosystem. An ecosystem comprises of two basic components:

(i) Abiotic components and

(ii) Biotic components

The relationship between the biotic components and abiotic components of an ecosystem is called 'holocoenosis'.

TYPES OF ABIOTIC ENVIRONMENTAL FACTORS

The distribution, abundance, growth and reproduction of the organisms comprising the inc members of populations are controlled by certain environmental or ecological factor environmental factor is any external force, substance or condition which surrounds and affects of an organism in any way. Abiotic environmental factors are customarily classified as follow:

1. Climatic factors
   - (i) Light;
   - (ii) Temperature ;
   - (iii) Water (including atmospheric water, rainfall or precipitation, soil moisture, etc
   - (iv) Atmosphere (gases and wind);
   - (v) Fire.
2. Topographic or physiographic factors
   - (i) Altitude;
   - (ii) Direction of mountain chains and valleys;
   - (iii) Steepness and exposure of slopes.
3. Edaphic factors (soil formation, physical and chemical properties of soil, nutrient'.

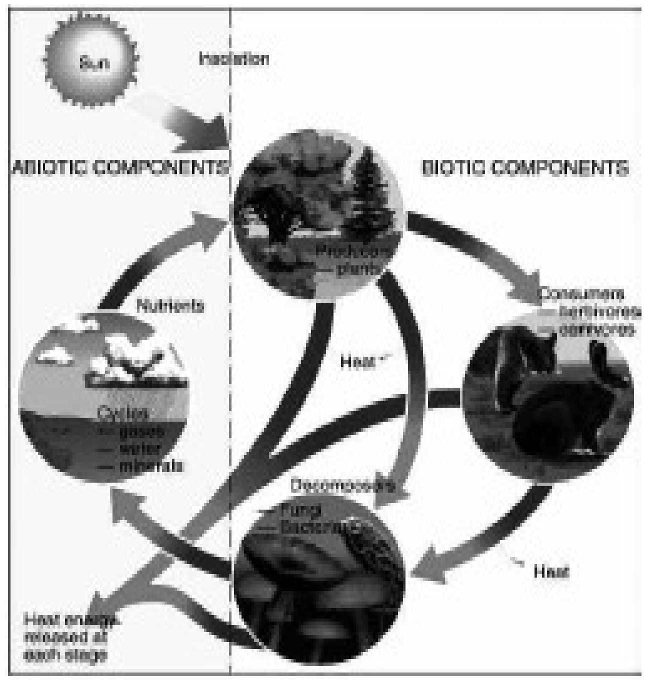
Abiotic Components

These include the non-living, physico - chemical factors such as air, water, soil and the basic elements and compounds of the environment.

Abiotic factors are broadly classified under three categories. Climatic factors which include the climatic regime and physical factors of the environment like light, humidity, atmospheric temperature, wind, etc.

Edaphic factors which are related to the structure and composition of soil including its physical and chemical properties, like soil and its types, soil profile, minerals, organic matter, soil water, soil organisms.

Inorganic substances like water, carbon, sulphur, nitrogen, phosphorus and so on.



Organic substances like proteins, lipids, carbohydrates, humic substances etc.

BIOTIC OR LIVING COMPONENTS

In the trophic structure of any ecosystem, living organisms are distinguished on the basis of their nutritional relationships, which are discussed as follows :

1. Autotrophic component. Autotrophic (*auto* = self; *trough* = nourishing) component of ecosystem includes the producers or energy transducers which convert solar energy into chemical energy (that becomes locked in complex organic substances such as carbohydrate, lipid, protein, etc.) with the help of simple inorganic substances such as water and carbon dioxide and organic substances such as enzymes. Autotrophs fall into following two groups: (i) photoautotrophs which contain green photosynthetic pigment chlorophyll to transduct the solar or light energy of sun, *e.g.,* trees, grasses, algae, other tiny phytoplanktons and photosynthetic bacteria and cyanobacteria (=blue green algae). (ii) Chemoautotrophs which use energy generated in oxidation - reduction

process, but their significance in the ecosystem as producers is minimal, *e.g.,* microorganisms such as *Beggiatoa,* sulphur bacteria, etc.

2. Heterotrophic component. In the heterotrophic *(hetero* = other; *trophic* = nourishing) organisms predominate the activities of utilization, rearrangement and decomposition of complex organic materials. Heterotrophic organisms are also called consumers, as they consume the matter built up by the producers (autotrophs). The consumers are of following two main types:

(a) *Macroconsumers:* These are also called phagotrophs (phago = to eat) and include mainly animals which ingest other organisms or chunks of organic matter. Depending on their food habits, consumers may either be herbivores (plant eaters) or carnivores (flesh eaters). Herbivores live on living plants and are also known as primary consumers , *e.g.,* insects, zooplanktons and animals such as deer, cattle, elephant, etc. Secondary and tertiary consumers, if present in the food chain of the ecosystem, are carnivores or omnivores, *e.g.,* insects such as preying mantis, dragon flies; spiders and large animals such as tiger, lion, leopard, wolf, etc. Secondary consumers are the carnivores which feed on primary consumers or herbivores. Carnivores are, often, recognized as carnivore order - 1 (C,), jamivore order - 2 (C_2) and so on, depending on their food habits.

Ticks and mites, leeches and blood-sucking insects (mosquito, bed-bug) are dependent on herbivores, carnivores and omnivores.

(b) *Microconsumers:* These are also called decomposers, reducers, saprotrophs *(sapro* = decompose), osmotrophs (osmo = to pass through a membrane) and scavengers. Wiegert and Owen (1971) have coined the term, biophages for heterotrophic decomposers which feed on the dead organic matter. Micro-consumers include microorganisms such as bacteria, actinomycetes and fungi. Microconsumers breakdown complex organic compounds of dead or living protoplasm, absorb some of the decomposition or breakdownproducts and release inorganic nutrients in the environment, making them available again to autotrophs or producers. Some invertebrate animals such as protozoa, oligochaeta such as earthworms, etc.,

SHELFORD'S LAW OF TOLERANCE

Organisms may be limited in their growth and their occurrence not only by too little of an element or too low an intensity of a factor but also by too much of the element or too high intensity of the factor For example, carbon dioxide is necessary for the growth of all green plants, small increase in concentration of carbon dioxide in the atmosphere will, under certain circumstances, increase the rate of plant growth, but very considerable increases become toxic. Likewise, small additions of arsenic to *the* human diet actually have a tonic effect, further increase in the dosage, however, soon proves fatal.

The idea that factors could be limiting at their maximum as well as minimum quantities was incorporated in law of tolerance formulated by V.E. Shelford in 1913. This law postulates that each ecological factor to which an organism responds has maximum and minimum limiting effect between which lies a range or gradient that is now known as the limits of tolerance.

Between the lower and upper limits of tolerance lies a broad middle sector of a gradient which is called the zone of compatibility, the zone of tolerance, the biokinetic zone or the zone of capacity Adaptation. The region at either end of the zone of compatibility is called the lethal zone or the zone resistance or zone of intolerance. The zone of compatibility too includes a broad range of optimum and narrow zones of physiological stresses in between the range of optimum and lethal zones.

use the dead organic matter for their food, as they have the essential enzymes and, hence, can be classified as decomposer organisms. Some ecologists believe that micro-organisms are primary decomposers, while invertebrates are secondary decomposers.

The disintegrating dead organic matter is also known as organic detritus (Latin word *deterere* means to wear away). By the action of detritivores (=decomposers), the disintegrating detriuts result into particulate organic matter (POM) and dissolved organic matter (DOM) which play impor in the maintenance of the edaphic environment.

FUNCTIONING OF AN ECOSYSTEM

An ecosystem is driven by the flow of energy and circulation of matter by biogeochemical cycle between the biosphere, lithosphere, hydrosphere and atmosphere. The solar radiation is the basic input of energy entering the ecosystem. In the living organisms or biosphere, the energy (chemical energy) and matter (food), collectively called as food energy, are transferred via food chain and food web through various trophic levels. Thus all the elements of an ecosystem are interdependent and integrated. An ecosystem itself is integrated with other ecosystems and thus they all become interdependent. In fact every ecosystem is part of the larger ecosystem, until the larger ecosystem of the earth – the biosphere – is formed. That is why we see climatic changes happening in one ecosystem affecting the otherecosystems.

PRODUCTIVITY OF ECOSYSTEM

The productivity of an ecosystem refers to the rate of production i.e. the amount of organic matter accumulated in any unit time. Productivity is of the following types:

Primary productivity: It is associated with the producers which are autotrophic, most of which are photosynthetic, and to a much lesser extent the chemosynthetic microorganisms. These are the green plants, higher macrophytes as well as lower forms, the phytoplanktons and some photosynthetic bacteria. Primary productivity is defined as "the rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producers." Primary productivity is further distinguished as follows:

Gross primary productivity: It is the total rate of photosynthesis including the organic matter used up in respiration during the measurement period. This is also sometimes referred to as **total (gross) photosynthesis** or **total assimilation.** It depends on the chlorophyll content. The rate of primary productivity are estimated in terms of either chlorophyll content as, Chl/g dry weight/unit area, or photosynthetic number i.e. amount of CO_2 fixed/g Chi/hour.

Net primary productivity: It is the rate of storage of organic matter in plant tissues in excess of the respiratory utilisation by plants during the measurement period. This is thus the rate of increase of biomass and is also known as **apparent photosynthesis** or **net assimilation.** Thus, net primary productivity refers to balance between gross photosynthesis and respiration and other plant losses as death etc.

Secondary productivity: It referes to the consumers or heterotrophs. These are the rates of energy storage at consumers level. Since consumers only utilise food materials (already produced) in their respiration, simply converting the food matter to different tissues by an overall process, secondary productivity is not divided into 'gross' and 'net' amounts. Thus, some ecologists as Odum (1971), prefer to use the term assimilation rather than 'production' at this level-the consumers level Secondary productivity actually remains mobile (i.e. keeps on moving from one organism to an and does not live in situ like the primary productivity.

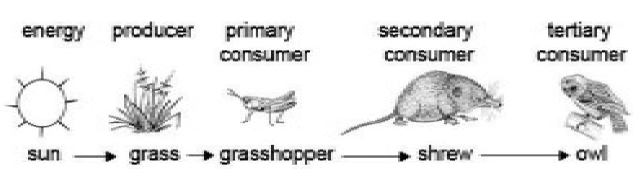
Net productivity: It refers to the rate of storage of organic matter used by the heterotrophs (consumers) i.e. equiv to net primary production minus consumption the heterotrophs during the unit period, as a season or year etc. It is thus the rate of increase of bio of the primary producers which has been left by the consumers. Net productivity is gen expressed as production of C g/m^2 /day, which then be consolidated on month, season or year basis.

FOOD CHAINS IN ECOSYSTEMS

The transfer of food energy from the prod through a series of organisms (herbivores

Type of Ecosystem	Producers	Herbivores	Primary Carnivores	Secondary Carnivores	Tertiary Carnivores
A. Grassland Ecosystem	1. Grasses	Insects	Frogs	Snakes	Predatory Birds
	2. Grasses	Rats and Mice	Snakes	Predatory Birds	
	3. Grasses	Rabbit	Fox	Wolf	Lion
B. Pond Ecosystem	Phytoplank-ton	Zooplanktons	Small Fishes	Large Fishes	Predatory Birds
C. Forest Ecosystem	Trees	Phytophagous Insects, Herbivore Mammals	Lizards Birds Foxes	Lions Tigers Etc.	

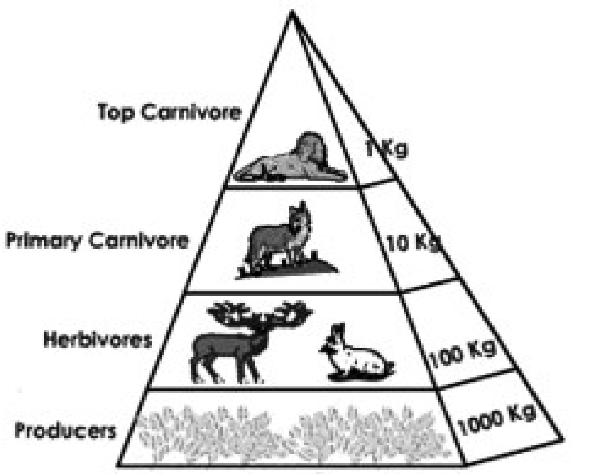
carnivores to decomposers) with repeated eating being eaten, is known as a food chain. Prod utilise the radiant energy of sun which is transf to chemical form, ATP during photosynthesis, green plants occupy, in any food chain, the trophic (nutritional) level-the producers level, are called the primary producers. The energ) stored in food matter manufactured by green plants is then utilised by the plant eaters-the herbivores, which constitute the second trophic level-the secondary consumers level, and are called the secondary consumers (herbivores). Herbivores in turn are by the carnivores, which constitute the third consumer level-the secondary consumers level, and are the secondary consumers (carnivores). These in may be eaten still by other carnivores at tertiary consumers level i.e. by the tertiary cons (carnivores). Some organisms are omnivores the producers as well as the carnivores at their level in the food chain. Such organisms thus occupy



more than one trophic levels in the chain. This classification of all the living org of any ecosystem is one of their functions and of species. Species that are taxonomically w different from each other may occupy the trophic level as they all have the similar functicc the food chain. Typha, Nymphaea, Chara. Vor Nostoc, photosynthetic bacteria, altbc-Konomically much different but all belong to the Nime trophic level — the producers level, as all rave a common function i.e. the fixation of radiant energy into chemical form. In any food chain, energy flows from primary producers to primary consumers herbivores), from primary consumers to secondary consumers (carnivores), and from secondary ronsumers to tertiary consumers (carnivores/rcnnivores) and so on. This simple chain of eating ind being eaten away is known as food chain. A food chain in grassland ecosystem starts with grasses and forbs and goes through grasshoppers, the frogs, the snake, the hawk in an orderly sequential irrangement based on the food habits, whereas in a pond the order would start with phytoplanktons, going through water fleas, smaller fish, bigger fish, birds, larger animal and so on.

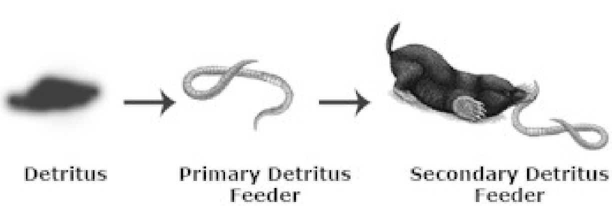
In nature, we generally distinguish the following two general types of food chains:

Grazing food chain: This type of food chain starts from the living green-plants, goes to grazing herbivores (that feed on living riant materials with their predators), and on to carnivores (animal eaters). Ecosystems with such type it food chain are directly dependent on an influx of solar radiation. This type of chain thus depends sr. autotrophic energy capture and the movement of ifeis captured energy to herbivores. Most of the scosystems in nature follow this type of food chain. From energy standpoint, these chains are very important. The phytoplanktons - zooplanktons - fish uence or the grasses-rabbit - fox sequence are examples of grazing food chain.

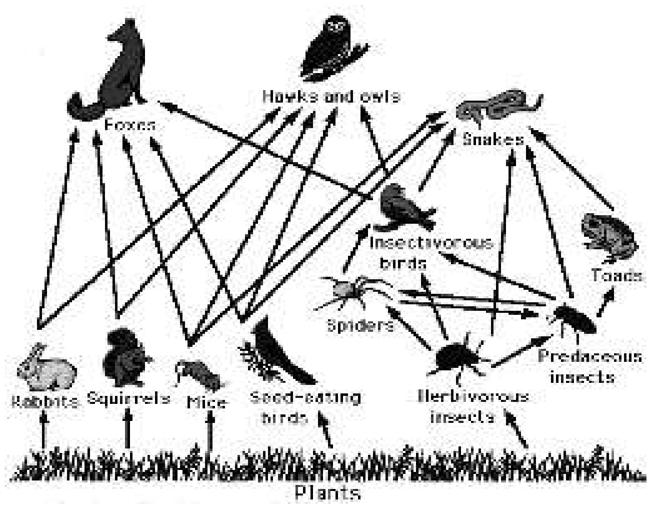


Upright Pyramid of biomass in a Terrestrial Ecosystem

Detritus food chain: This type of food chain goes from dead organic narter into micro-organisms and then to organisms feeding on detritus (dctriti-vores) and their predators. Such ecosystems are thus less dependent on direct energy. These depend chiefy on the influx of organic matter produced in another system. For stimple, such type of food chain operates in the decomposing accumulated litter in a temperate forest. A good example of a detritus food chain is based ob mangrove leaves described by Heald (1969) and W.E. Odum (1970). In the brackish zone of Southern da, leaves of the red mangrove – *Rhizophore mangle* fall into the warm, shallow waters. Only 5 per cent of the leaf material was removed by grazing insects before leaf fall. The fallen leaf fragments (acted on by such saprotrophs as fungi, bacteria, protozoa etc. and colonized mainly by phytoplanktonic and benthic algae) are eaten and re-eaten (coprophagy) by a key group of small animals. These animals include crabs, copepods, insect larvae, grass shrimps, mysids, nematodes, amphipods, bivalve molluscs etc. All these animals are detritus consumers. These detritivores are the key group of small animals, comprising only a few species but very large number of individuals. They ingest large amounts of the vascular plant detritus. These animals are in turn eaten by some minnows and small game fish etc. i.e. the small carnivores, which in turn serve as the main food for larger game fish and fish eating birds which are the large (top) cornivores. The mangroves considered generally as of less economic value make a substantial contribution to the food chain that supports the fisheries, an important economy in that region. Similarly, detritus from seagrasses, saltmarsh grasses and seaweeds support fisheries in many estuarine areas.



***Food webs*:** However, food chains in natural conditions never operate as isolated sequences, but are interconnected with each other forming some sort of interlocking pattern, which is



referred to as a food web. Under natural conditions, the linear arrangement of food diains, hardly occurs and these remain indeed interconnected with each other through different types of organisms at different trophic levels. For example, in grazing food chain of a grassland, in the absence of rabbit, grass may also be eaten by souse. The mouse in turn may be eaten directly by niwk or by snake first which is then eaten by hawk. Thus, in nature there are found alternatives which ill together constitute some sort of interlocking pattern - the food web.

ECOLOGICAL ENERGETICS

The energy used for all plant life processes is derived from solar radiations. A fraction i.e. about 1/50 millionth of the total solar radiation reaches the earth's atmosphere. Solar radiation travels through the space in the form of waves, wavelength ranging from 0.03Å to several km. While most radiations are lost in space, those ranging from 300mμ to 10μ and above 1 cm (radiowaves) enter the earth's outer atmosphere (which is about 18 miles or 28 km altitude). The energy reaching the earth's surface consists largely of visible light (390-760 mμ) and infra-red components. On a clear day radiant energy reaching the earth's surface is about 10 per cent UV, 45 per cent visible and 45 per cent infrared. Plants absorb strongly the blue and red ligir (400-50mμ and 600-700 mμ respectively).

In ecological energetics, we study (i) quantity of solar energy reaching an ecosystem, (ii) quantity of energy used by green plants for photosynthesis and (iii) the quantity and path of energy flow from producers to consumers.

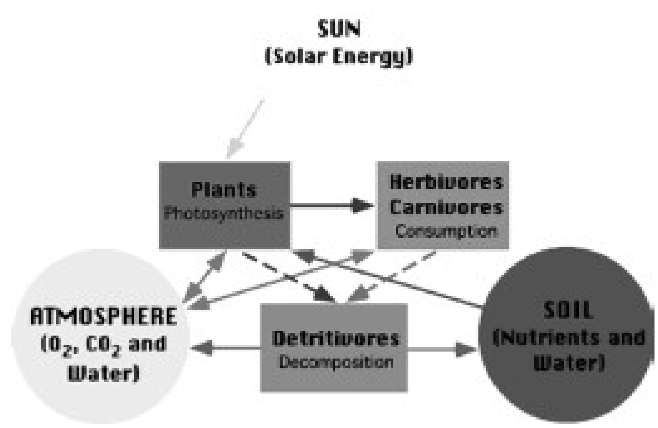
About 34 per cent of the sunlight reaching the earth's atmosphere is reflected back into its atmosphere, 10 per cent is held by ozone layec. water vapour and other atmospheric gases. The resc 56 per cent reaches the earth's surface.

Only a fraction of this energy reaching the earth's surface (1 to 5 per cent) is used by green plants for photosynthesis and the rest is absorbed as heat by ground vegetation or water. In fact, only about 0.02 per cent of the sunlight reaching the atmosphere is used in photosynthesis. Nevertheless it is this small fraction on which all the organisms of the ecosystem depend.

ENERGY FLOW IN ECOSYSTEMS

A general energy flow scenario follows:

- Solar energy is fixed by the photoautotrophs, called primary producers, like green plants. Primary consumers absorb most of the stored energy in the plant through digestion, and transform it into the form of energy they need, such as adenosine triphosphate (ATP), through respiration. A part of the energy received by primary consumers, herbivores, is converted to body heat (an effect of respiration), which is radiated away and lost from the system. The loss of energy through body heat is far greater in warm-blooded animals, which must eat much more frequently than those that are cold-blooded. Energy loss also occurs in the expulsion of undigested food (egesta) by excretion or regurgitation.
- Secondary consumers, carnivores, then consume the primary consumers, although omnivores also consume primary producers. Energy that had been used by the primary consumers for growth and storage is thus absorbed into the secondary consumers through the process of digestion. As with primary consumers, secondary consumers convert this energy into a more suitable form (ATP) during respiration. Again, some energy is lost from the system, since energy which the primary consumers had used for respiration and regulation of body temperature cannot be utilised by the secondary consumers.
- Tertiary consumers, which may or may not be apex predators, then consume the



secondary consumers, with some energy passed on and some lost, as with the lower levels of the food chain.

- A final link in the food chain are decomposers which break down the organic matter of the tertiary consumers (or whichever consumer is at the top of the chain) and release nutrients into the soil. They also break down plants, herbivores and carnivores that were not eaten by organisms higher on the food chain, as well as the undigested food that is excreted by herbivores and carnivores. Saprotrophic bacteria and fungi are decomposers, and play a pivotal role in the nitrogen and carbon cycles.
- The energy is passed on from trophic level to trophic level and each time about 90% of the energy is lost, with some being lost as heat into the environment (an effect of respiration) and some being lost as incompletely digested food (egesta). Therefore, primary consumers get about 10% of the energy produced by autotrophs, while secondary consumers get 1% and tertiary consumers get 0.1%. This means the top consumer of a food chain receives the least energy, as a lot of the food chain's energy has been lost between trophic levels. This loss of energy at each level limits typical food chains to only four to six links.

ECOLOGICAL PYRAMIDS

Charles Elton developed the concept of ecological pyramid. After his name these pyramids are also called as Eltonian pyramids. It is a graphical representation or pyramid shaped diagram which depicts the number of organisms, biomass and productivity at each trophic level. Ecological pyramids begin with the producers at the bottom and proceed through the different trophic level.

An ecological pyramid is an illustration of the reduction in energy as you move through each feeding (trophic) level in an ecosystem. The base of the pyramid is large since the ecosystem's energy factories (the producers) are converting solar energy into chemical energy via photosynthesis. A food chain can also depict a reduction in energy at each feeding level if the arrows, drawn between the different levels, continue to be reduced in size.

The ecological pyramids are of three types:

(i) Pyramid of energy

(ii) Pyramid of Biomass

(iii) Pyramid of numbers

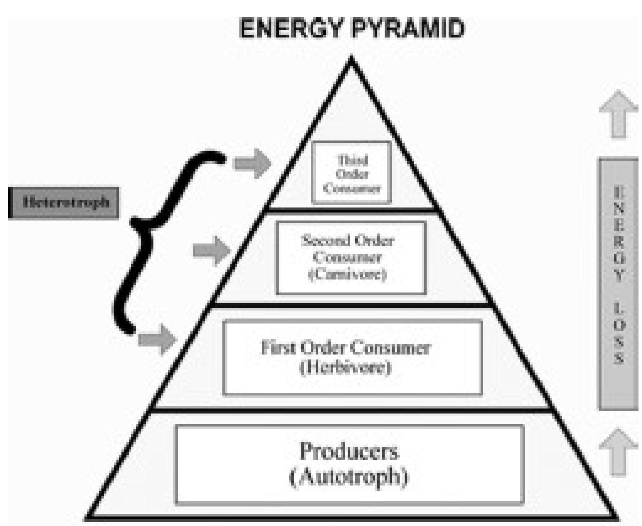
The Pyramid of Energy

The energy pyramids give the best picture of the overall nature of the ecosystem.

Here there will be gradual decrease in the availability of energy from the autotrophs higher trophic levels. In other words, there is decrease in energy flow from autotrophs on\ at successive trophic levels.

In the course of energy flow from one organism to the other, is considerable loss of energy in the form of heat. More energy is available in the autotrophs t in the primary consumers. The least amount of available energy will be in the tertiary consumer. Therefore, shorter the food chain, greater is the amount of energy available at the top.

1. The energy pyramid always upright and errect.
2. It shows the rate of energy flows at different trophic levels.
3. It shows that energy is maximum at producer level and minimum at the carnivores' level.



4. At every successive trophic level there is a loss of energy in the form of heat, respiration etc.

The Pyramid of Biomass

They are comparatively more fundamental, as they, instead of the geometric factor, show j the quantitative relationships of the standing crops. Here there will be gradual decrease in the biomass from the autotrophs to the higher trophic levels. This may be illustrated by studying the trophic levels in a pond.

The biomass in autotrophs like algae, green flagellates, green plants etc. is the maximum. The biomass is considerably less in the next trophic level occupied by secondary consumers like small fishes. The least amount of biomass is present in the last trophic level.

- This pyramid shows the total biomass at each trophic level in a food chain.
- Pyramid in erect.
- It indicates a decrease in the biomass at each trophic level from the base to apex of pyramid.

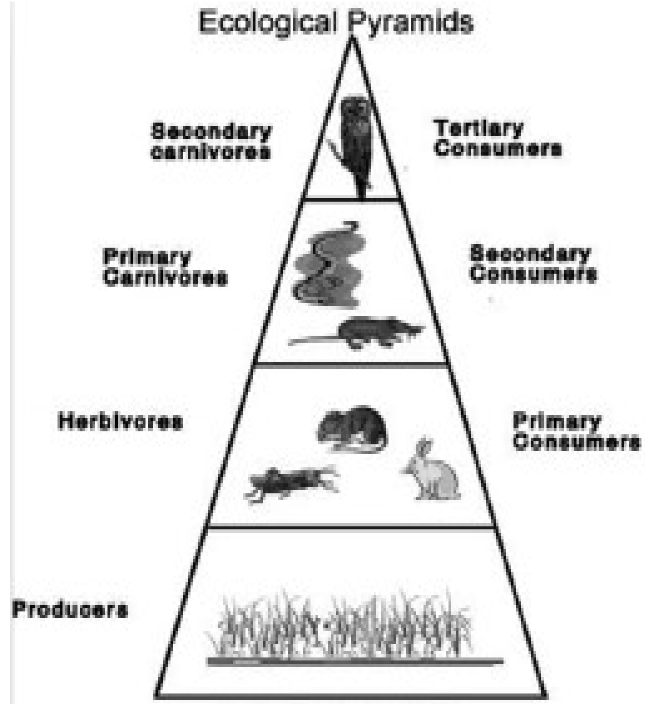
The Pyramid of Numbers

They show the relationship between producers, herbivores and carnivores at successive trophic levels in terms of their number. Here there will be a gradual decrease in the number of individuals from the lower to the higher trophic levels. This may be studied by taking the example of trophic levels in grassland.

The grasses occupy the lowest trophic level and they are abundantly present in the grassland ecosystem. The deers occupy the second level; their number is less than compared to the grasses.

The wolves, which feed upon the deers, are far less in number when compared to the number of deers. The lions, which occupy the next trophic level, feed upon wolves, and the number of individuals in the last trophic level is greatly reduced.

In the parasitic food chain, the pyramid of numbers is founds to be inverted. Here, a single plant or tree might support varieties of herbivore.



These herbivores like birds in turn, support varieties of parasites like lice, bugs that outnumber the herbivores.

Subsequently each parasite might support a number of hyperparasites like bacteria and fungi, which will outnumber the parasites. Thus from the producer level onwards, towards the consumers, in the parasitic food chain there is a gradual increase in the number of organisms, instead of the usual decrease.

As a result of this, the pyramid becomes inverted in the parasitic food chain. There is a gradual increase in the numbers of individuals from autotrophs to the higher trophic levels.

- It shows the number of organism at different levels.
- The pyramid is errect.
- The smaller animals are preyed upon larger animals and smaller animals increase faster in number of organism at each stage of food chain, makes a triangular figure that is known as pyramid of number.

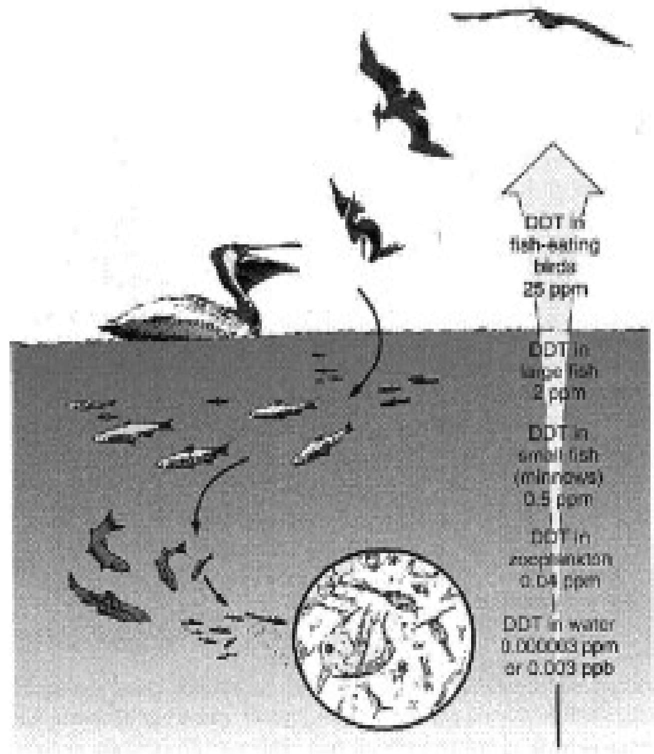
BIOLOGICAL MAGNIFICATION

Biological magnification is the tendency of pollutants to become concentrated in successive trophic levels. Often, this is to the detriment of the organisms in which these materials concentrate, since the pollutants are often toxic.

Biomagnification occurs when organisms at the bottom of the food chain concentrate the material above its concentration in the surrounding soil or water. Producers, as we saw earlier, take in inorganic nutrients from their surroundings. Since a lack of these nutrients can limit the growth of the producer, producers will go to great lengths to obtain the nutrients. They will spend considerable energy to pump them into their bodies. They will even take up more than they need immediately and store it, since they can't be "sure" of when the nutrient will be available again (of course, plants don't think about such things, but, as it turns out, those plants, which, for whatever reason, tended to concentrate inorganic nutrients have done better over the years). The problem comes up when a pollutant, such as DDT or mercury, is present in the environment. Chemically, these pollutants resemble essential inorganic nutrients and are brought into the producer's body and stored "by mistake". This is the first step in biomagnification; the pollutant is at a higher concentration inside the producer than it is in the environment.

CURRENT STATUS OF BIOMAGNIFICATION

In a review of a large number of studies, Suedel *et al.* concluded that although biomagnification is probably more limited in occurrence than previously thought, there is good evidence that DDT, DDE, PCBs, toxaphene, and the organic forms of mercury and arsenic do biomagnify in nature. For other contaminants, bioconcentration and bioaccumulation account for their high concentrations in organism tissues. More recently, Gray reached a similar substances remaining in the organisms and not being diluted to non-threatening concentrations. The success of top predatory-bird recovery (bald eagles, peregrine falcons) in North America following the ban on DDT use in agriculture is testament to the importance of biomagnification.



The second stage of biomagnification occurs when the producer is eaten. Remember from our discussion of a pyramid of biomass that relatively little energy is available from one trophic level to the next. This means that a consumer (of any level) has to consume a lot of biomass from the lower trophic level. If that biomass contains the pollutant, the pollutant will be taken up in large quantities by the consumer. Pollutants that biomagnify have another characteristic. Not only are they taken up by the producers, but they are absorbed and stored in the bodies of the consumers. This often occurs with pollutants soluble in fat such as DDT or PCB's. These materials are digested from the producer and move into the fat of the consumer. If the consumer is caught and eaten, its fat is digested and the pollutant moves to the fat of the new consumer. In this way, the pollutant builds up in the fatty tissues of the consumers. Water-soluble pollutants usually cannot biomagnify in this way because they would dissolve in the bodily fluids of the consumer. Since every organism loses water to the environment, as the water is lost the pollutant would leave as well. Alas, fat simply does not leave the body.

The "best" example of biomagnification comes from DDT. This long-lived pesticide (insecticide) has improved human health in many countries by killing insects such as mosquitoes that spread disease. On the other hand, DDT is effective in part because it does not break down in the environment. It is picked up by organisms in the environment and incorporated into fat. Even here, it does no real damage in many organisms (including humans). In others, however, DDT is deadly or may have more insidious, long-term effects. In birds, for instance, DDT interferes with the deposition of calcium in the shells of the bird's eggs. The eggs laid are very soft and easily broken; birds so afflicted are rarely able to raise young and this causes a decline in their numbers. This was so apparent in the early 1960's that it led the scientist Rachel Carson to postulate a "silent spring" without the sound of bird calls. Her book "Silent Spring" led to the banning of DDT, the search for pesticides that would not biomagnify, and the birth of the “modern” environmental movement in the 1960's. Birds such as the bald eagle have made comebacks in response to the banning of DDT in the US. Ironically, many of the pesticides which replaced DDT are more dangerous to humans, and, without DDT, disease (primarily in the tropics) claims more human lives.

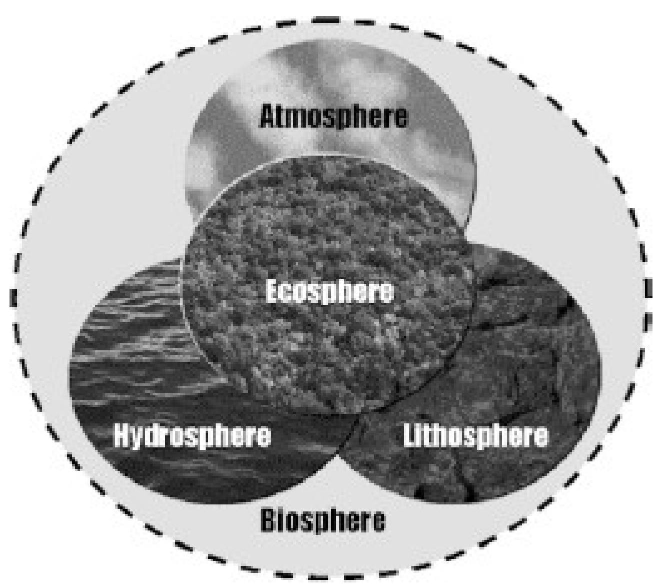
BIOSPHERE

The biosphere is the biological component of earth systems, which also include the lithosphere, hydrosphere, atmosphere and other "spheres" (e.g. cryosphere, anthrosphere, etc.). The biosphere includes all living organisms on earth, together with the dead organic matter produced by them.

The biosphere concept is common to many scientific disciplines including astronomy, geophysics, geology, hydrology, biogeography and evolution, and is a core concept in ecology, earth science and physical geography. A key component of earth systems, the biosphere interacts with and exchanges matter and energy with the other spheres, helping to drive the global biogeochemical cycling of carbon, nitrogen, phosphorus, sulfur and other elements. From an ecological point of view, the biosphere is the "global ecosystem", comprising the totality of biodiversity on earth and performing all manner of biological functions, including photosynthesis, respiration, decomposition, nitrogen fixation and denitrification.

The biosphere is dynamic, undergoing strong seasonal cycles in primary productivity and the many biological processes driven by the energy captured by photosynthesis. Seasonal cycles in solar irradiation of the hemispheres is the main driver of this dynamic, especially by its strong effect on terrestrial primary productivity in the temperate and boreal biomes, which essentially cease productivity in the winter time. The biosphere has evolved since the first single-celled organisms originated 3.5 billion years ago under atmospheric conditions resembling those of our neighboring planets Mars and Venus, which have atmospheres composed primarily of carbon dioxide. Billions of years of primary production by plants released oxygen from this carbon dioxide and deposited the carbon in sediments, eventually producing the oxygen-rich atmosphere we know today. Free oxygen, both for breathing (O_2, respiration) and in the stratospheric ozone (O_3) that protects us from harmful UV radiation, has made possible life as we know it while transforming the chemistry of earth systems forever.

As a result of long-term interactions between the biosphere and the other earth systems, there is almost no part of the earth's surface that has not been profoundly altered by



living organisms. The earth is a living planet, even in terms of its physics and chemistry. A concept related to, but different from, that of the biosphere, is the Gaia hypotheses, which posits that living organisms have and continue to transform earth systems for their own benefit.

The term "biosphere" originated with the geologist Eduard Suess in 1875, who defined it as "the place on earth's surface where life dwells". Vladimir I. Vernadsky first defined the biosphere in a form resembling its current ecological usage in his long-overlooked book of the same title, originally published in 1926. It is Vernadsky's work that redefined ecology as the science of the biosphere and placed the biosphere concept in its current central position in earth systems science.

The biosphere is a core concept within Biology and Ecology, where it serves as the highest level of biological organization, which begins with parts of cells and proceed to populations, species, ecoregions, biomes and finally, the biosphere. Global patterns of biodiversity within the biosphere are described using biomes.

In earth science, the biosphere represents the role of living organisms and their remains in controlling and interacting with the other spheres in the global biogeochemical cycles and energy budgets. The biosphere plays a central role in the biogeochemical processing of carbon, nitrogen, phosphorus, sulfur and other elements. As a result, biogeochemical processes such as photosynthesis and nitrogen fixation are critical to understanding the chemistry and physics of earth systems as a whole. The physical properties of the biosphere in terms of its surface reflectance (albedo) and exchange of heat and moisture with the atmosphere are also critical for understanding global circulation of heat and moisture and therefore climate. Alterations in both the physics (albedo, heat exchange) and chemistry (carbon dioxide, methane, etc.) of earth systems by the biosphere are fundamental in understanding anthropogenic global warming.