ECOSYSTEM

The term ‘ecosystem’ was coined by A.G. Tansley, an English botanist, in 1935.

‘An ecosystem is the structural and functional unit of ecology (nature) encompassing complex interaction between its biotic (living) and abiotic (non-living) components.’

Structure and Function of an Ecosystem:

Each ecosystem has two main components:

(1) Abiotic component

(2) Biotic component

(1) Abiotic components (Nonliving): The abiotic component can be grouped into following categories:-

(a) Climatic Factors: Which include rain, temperature, light, wind, humidity etc.

(b) Edaphic Factors: Which include soil, pH, topography, minerals etc.

(2) Biotic components: The living organisms including plants, animals and micro-organisms (Bacteria and Fungi) that are present in an ecosystem form the biotic components. They are further divided into two types-

(A) Producers: The green plants have chlorophyll with the help of which they trap solar energy and change it into chemical energy of carbohydrates using simple inorganic compounds namely water and carbon dioxide.

This process is known as photo-synthesis. As the green plants manufacture their own food they are known as Autotrophs (i.e. auto = self, trophos = feeder).

The chemical energy stored by the producers is utilised partly by the producers for their own growth and survival and the remaining is stored in the plant parts for their future use.

(B) Consumers: The animals lack chlorophyll and are unable to synthesise their own food. There-fore, they depend on the producers for their food. They are known as heterotrophs (i.e. heteros = other, trophos = feeder).

The consumers are of three types, namely:

(a) Primary Consumers or First Order Consumers or Herbivores: These are the animals which feed on plants or the producers.
They are called her-bivores. Examples are rabbit, deer, goat, cattle etc.

(b) Secondary Consumers or Second Order Consumers or Primary Carnivores: The animals which feed on the herbivores are called the pri-mary carnivores. Examples are cats, foxes, snakes etc.

(c) Tertiary Consumers or Third Order Consumers: These are the large carnivores which feed on the secondary consumers. Example are Wolves.

(C) Decomposers or Reducers: Bacteria and fungi belong to this category.

They breakdown the dead organic materials of producers (plants) and consumers (animals) for their food and re-lease to the environment the simple inorganic and organic substances produced as by-products of their metabolisms.

These simple substances are reused by the producers resulting in a cyclic ex-change of materials between the biotic community and the abiotic environment of the ecosystem.

The decomposers are known as Saprotrophs (i.e., sapros = rotten, trophos = feeder).

Functions of ecosystem

The main functional attributes of eco-system are:

I. Food Chain & Food Web.

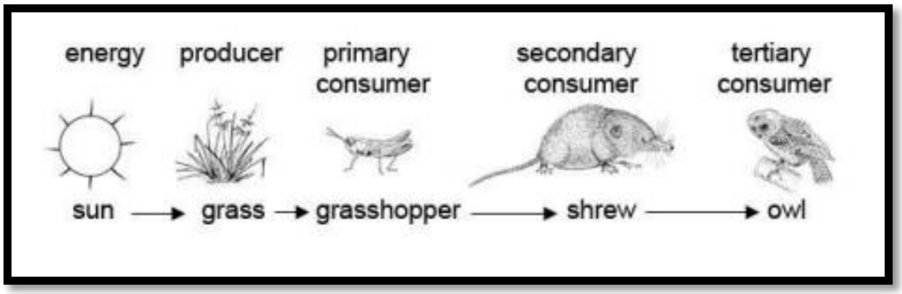
II. Energy flow

III. Ecological pyramids

IV. Ecological regulation

V. Ecological succession

I. Food chain: The transfer of food, energy from producers through a series of organisms with repeated eating and being eaten is known as a food chain.

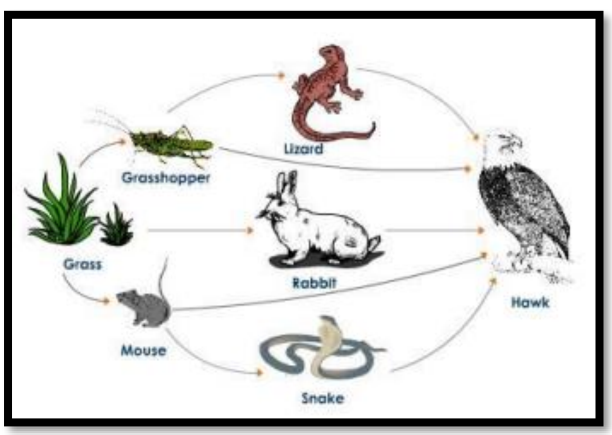


Types of food chains: There are 2 types of food chains:

a. Grazing food chain: This type of food chain starts from the living green plants goes to grazing herbivores and onto carnivores, eco-systems with such type of food chains are directly depend upon the influx of the solar radiation. Most of the eco-systems in nature follow this type of food chain.

b. Detroiter's food chain: This type of food chain goes from dead organic matter into micro organisms and then to organisms which feed on detritivors (decomposers) and predators. Such eco-systems are not dependent on direct solar energy and chiefly depend upon the influx of dead organic matter produced in other eco-systems. Ex: bacteria and fungi feeding on dead organic matter and are eaten by small fish which act as prey to large fish or birds.

Food webs: A complex network of interconnected food chains of different tropic levels in a Biotic community is termed as a food web. The complexity of any food web depends upon the diversity of organisms in that ecosystem. Thus, each species of any eco-system is indeed kept under some sort of a natural check so that the eco-system may remain balanced and this is the significance of a food web. Example-



Significance of food chain & food web

a. They maintain the ecological balance by regulating the nutrient cycles.

b. Biological magnification- It is a process in which the concentration of the non-biodegradable material or any fertilizer accumulates in the food chain. As human beings occupy the highest position in the tropic level, they get highly bio-magnified which is harmful.

Ex:- DDT (dichloro diphenyl trichloro ethane) is an insecticide used for killing insects. Excess usage of this non-biodegradable chemical makes the soil over nourished and its concentration increases as it passes along the food chain.

Energy flow-

All eco-systems are energy driven complexes. The energy concerned to eco-system is light energy, chemical energy, heat energy and the source of all these energies is "solar energy".

This energy gradually transfers to light, chemical and heat energy. 1% of total energy falling on plants used for photosynthesis and this is only source of energy for proper functioning of the eco-system.

The fixation of solar energy by the plants and its utilization in the form of food by living organisms obey the 2 laws of thermodynamics.

1st law: Energy can neither be created nor destroyed; it can only transfer from one form to another.

2nd law: It states that every transformation of energy is accompanied by a simultaneous degradation of energy from concentrated form to disperse. Flow of energy is always unidirectional.

Energy Flow Models: Energy flow in various trophic levels of an ecosystem can be explained with the help of various energy flow models. They are-

A. Universal Energy Flow Model B. Double channel or Y-shaped flow model and C. Single Channel Energy Flow Model

A. Universal energy flow model: This model tells, as the energy flow takes place, there is a gradual loss of energy at every level as indicated in the picture. This occurs mainly due to respiration, locomotion and other metabolic activities.

The shaded box (Fig. 4.6) represents the living, standing crop biomass (generally measured as some kind of weight, such as dry weight, wet weight etc.) of the component which should be expressed in calories, so that its relation with rates of energy flow can be established. The total energy input or intake or ingestion varies. For strict autotrophs, it is light, while, for strict hetero-trophs, it is organic food.

A key feature of the model is the separation of assimilated energy (A) into the production (P) and respiration (R) components. R is the energy that is lost as heat (maintenance energy) and P is the portion transformed to new or different organic matter and is the part that is available to the next trophic level.

At the same time, the non- assimilated component (NU – not utilised), such as feces, enters the detritus food chain. It is important to note that P component is energy that is available to the next trophic level while NU component is energy that is still available at the same trophic level.

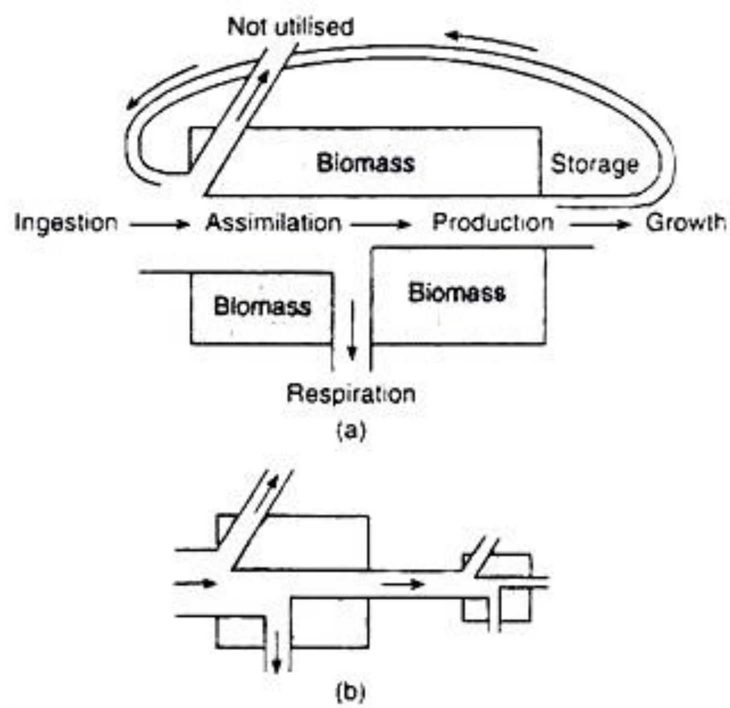


Fig. 4.6 : Universal model of energy flow : (a) Energy flow in one trophic level. (b) A link between trophic levels in a food web

The universal energy flow can be used in two ways:

(1) The model can represent a species population with appropriate energy inputs and its link with other species.

(2) The model can represent a discrete energy level, where the biomass and energy channels represent all or part of many populations supported by the same energy source. For example, foxes obtain their food partly by eating plants (fruits) and partly by eating herbivore animals (rabbit, mice etc.).

B. Y-Shaped/double Channel Energy Flow Model:

In this type of model, the grazing and detritus food chains are shown as separate flows (Fig. 4.5).

This is a more practical working model than the single channel model mainly because:

(1) It relates to the basic stratified structure of ecosystem;

(2) The direct consumption of living plants and dead organic matter are usually separated in both time and space; and

3) The macro consumers and micro consumers differ greatly in size-metabolism relations and in the techniques required for studying them.

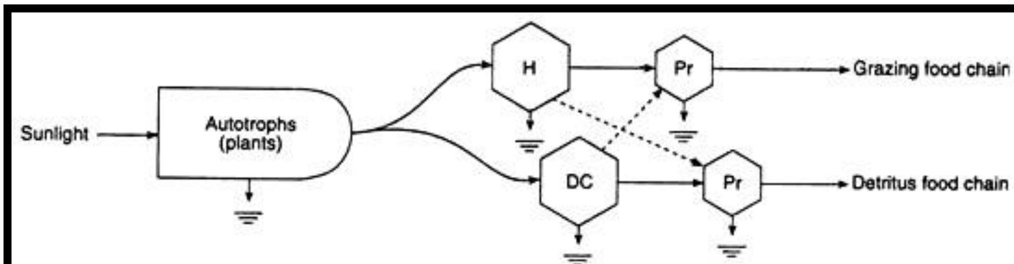


Fig. 4.5 : Y-shaped energy flow model. It shows linkage between grazing and detritus food chain (H = herbivores; DC = detritus consumers; Pr = predators)

The grazing and detritus food chains are inter-connected. Moreover, not all food eaten by grazers is actually assimilated, as some (feces containing undigested material) is diverted to the detritus pathway.

Also, the amount of net production energy that flows down the two pathways varies in different kinds of ecosystems and, often in the same ecosystem; it may vary seasonally or annually.

The energy flow in case of shallow waters and heavily grazed pastures or grassland shows larger energy flow via the grazing food chain than in the detritus pathway.

The reverse is true in case of the forest, marshes and oceans.

C. Single Channel Energy Flow Model:

The single or linear channel energy flow model is one of the first published models pioneered by H. T. Odum in 1956. As can be seen in Fig. 4.4, this model depicts a community boundary and, in addition to light and heat flows, it also includes import, export and storage of organic matter.

Decomposer organisms are placed in a separate box as a means of partially separating the grazing and detritus food chains.

Decomposers are actually a mixed group in terms of energy levels and their importance in this energy flow model is overlooked.

This model will suffice as long as only the imports and exports are considered.

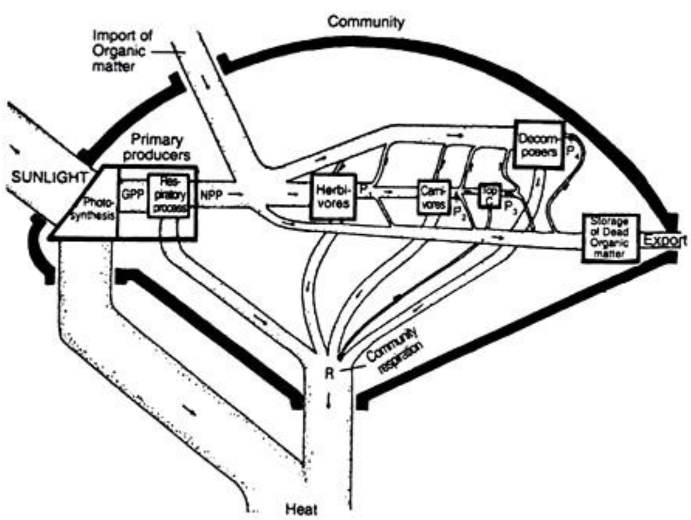


Fig. 4.4 : Single or linear channel energy-flow diagram (P_1, P_2, P_3 and P_4 – secondary production of the indicated level (H. T. Odum, 1956)

III. Ecological pyramids:

The graphical representation of structure and function of tropic levels of an ecosystem, starting with producers at the top and each successive tropic level forming the apex is known as an ecological pyramid. In a food chain starting from the producers to the consumers, there is a regular decrease in the properties (i.e., energy, biomass and the number of organisms) Since some energy is lost in each tropic level, it becomes progressively smaller at the top.

Ecological pyramids are of three types:

1. Pyramid of Numbers

2. Pyramids of Energy and

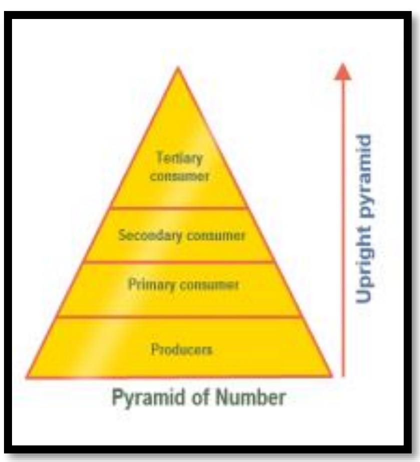
3. Pyramid of Biomass

Pyramid of Numbers- It represents the number of individual organisms present in each tropic level. Ex: A grassland Ecosystem

Producers are grass (small in size and large in number. Hence they occupy the first tropic level. The primary consumers are rats occupying the second tropic level.

It is worthwhile to note that rats are less in number than grass. Secondary consumers are snakes which occupy the third tropic level and they are lesser in number than rats.

Tertiary consumers are Eagles that occupy the next tropic level. This is the last tropic level where the number and size of the tropic level is the least as shown in the diagram.

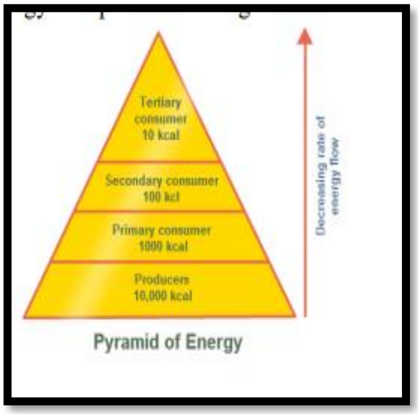


Pyramid of Energy

It represents the amount of energy present in each tropic level.

The rate of energy flow and the productivity at each successive tropic level is shown in the figure below.

At every successive tropic level, there is a heavy loss of energy (almost 90%) in the form of heat. Thus, at each tropic level only 10% is transferred. Hence there is a sharp decrease in energy at each and every successive tropic level as we move from producers to top consumers (carnivores). Pyramid of energy is depicted in the figure below.

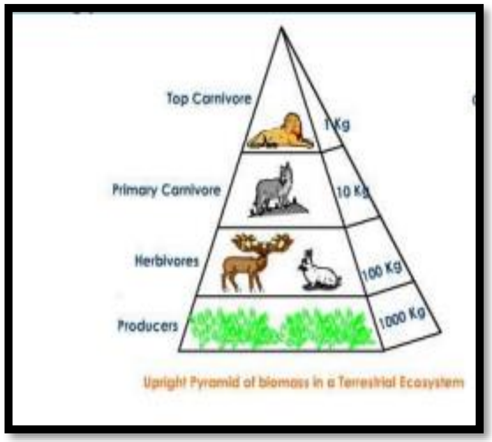


Pyramid of Biomass: It represents the total amount of biomass (mass or weight of biological material) present in each tropic level.

Considering the example of a forest ecosystem, there is a steady decrease in the biomass from the lower tropic level to the higher tropic level.

The producers (trees) contribute a major amount of the biomass.

The next tropic levels are the herbivores (insects and birds) and carnivores (snakes, foxes, etc). The top of the tropic level consists of very few tertiary consumers (Ex: Lions and Tigers) whose biomass is very low. The pyramid of biomass is shown below



Ecological production: The rate of production of organic matter or biomass is called productivity

This is of 2 types:

Primary productivity: it is defined as the rate at which the radiant energy is converted into organic substances by photosynthesis or chemo-synthesis by the primary producers. It is of two types:

GPP (Gross Primary Productivity): The rate at which the producers are able to utilise the radiant energy in photo or chemo synthesis to produce their food is called GPP.

NPP (Net Primary Productivity): The rate at which the energy or organic matter is stored in a producer after respiration is called NPP. Thus, NPP = GPP-R (R= Respiratory loss)

ii) Secondary productivity: The energy stored at consumer level for use by the next trophic level is known secondary production.