Energy flow through the Ecosystem

According to Raymond Lindeman (1942) "The basic process in the trophic dynamics is the transfer of energy from one part of the ecosystem to another". All function, and indeed all life, within an ecosystem depends upon the utilization of an external source of energy, solar radiation. Portion of this incident energy is transformed by the process of photosynthesis into the structure of living organisms."

The amount of energy at trophic level is determined by the net primary production (NPP) and the efficiency at which food energy is converted into biomass. The plants use 15 to 70 percent of assimilated energy for the maintenance which is not available to the consumers. The herbivores and carnivores are comparatively more active as compare to plants which uses more assimilated energy for the maintenance. So, the productivity at each trophic level lies between 5 to 20 percent that of the level below it. The percentage of energy which is transferred from one trophic level to the next trophic level is called as ecological efficiency.

In general, secondary producers utilize 55% to 75% of assimilated energy in maintenance. Temperature and moisture are two components of the habitat and the type of species determine the maintenance cost. The dry and hot regions require higher maintenance cost, irrespective of the species.

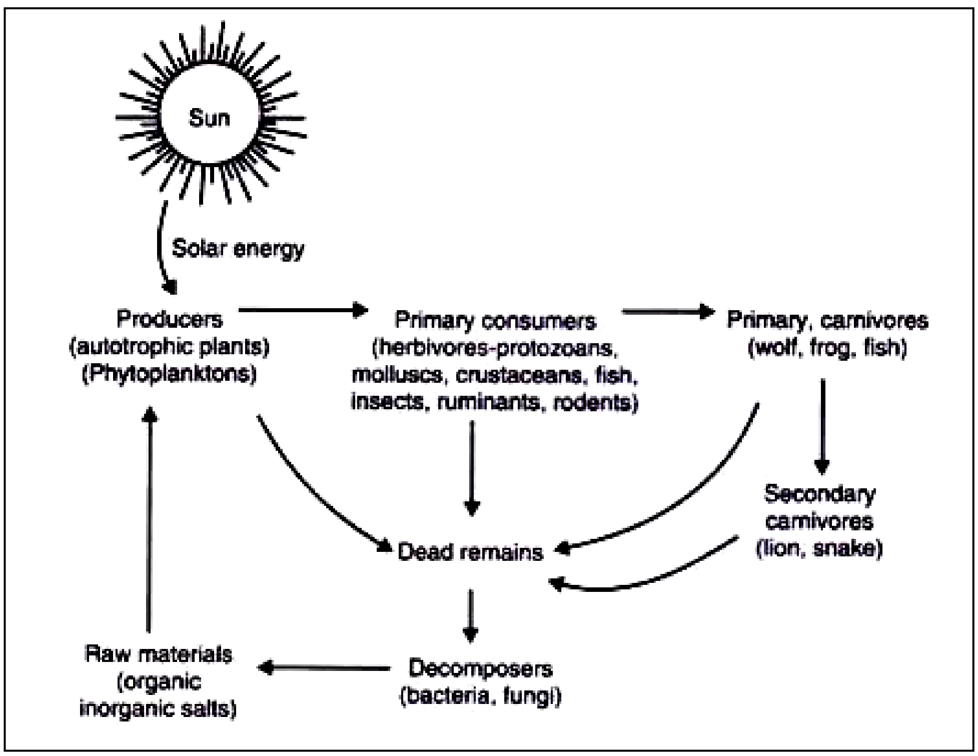
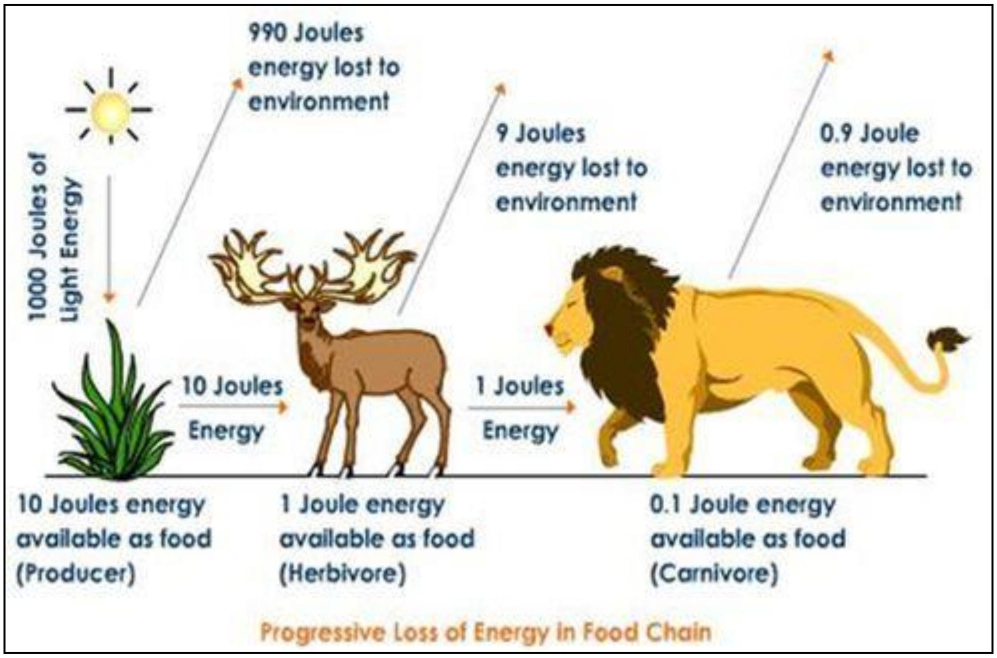


Fig: Flow of energy at different level of ecosystem

[Primary production is the rate of organic biomass growth or accumulation by plants. Primary production is commonly split into two components, gross primary productivity (GPP) and net primary productivity (NPP). Gross primary productivity is the overall rate of biomass production by producers, whereas net primary productivity is the remaining fraction of biomass produced after accounting for energy lost due to cellular respiration and maintenance of plant tissue. Thus, NPP = GPP – respiration.]

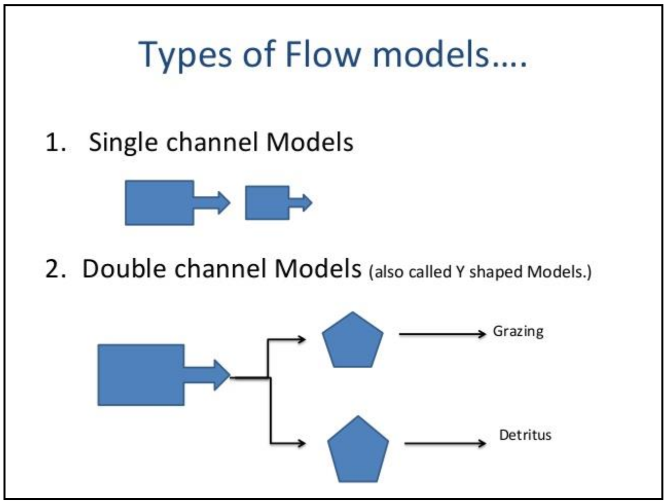
The 10 Percent Energy Law:
The transfer of the energy in the food chain is limited; and hence, the number of trophic levels in the food chain is limited. There is only 10% of the transfer of energy from each lower trophic level to the next/higher trophic level. This law, known as the 10% energy law, was proposed by **Raymond Lindeman**. The primary consumers do not acquire 100% of the energy transfer from the plants/producers; some of the energy of the sun is consumed by the plants during the process of photosynthesis.



Ecological efficiency can be defined as the product of efficiencies in which organisms exploit their food resources and convert them into biomass for next higher trophic level. As biological production is almost consumed, the overall exploitation efficiency remains 100 percent, whereas, ecological efficiency is dependent on two factors: the proportion of assimilated energy incorporated in growth, storage and reproduction. The first proportion is called as assimilation efficiency and second is net production efficiency.

The product of the assimilation efficiency and net production efficiencies is called as gross production efficiency. It is the proportion of food energy that is transformed into consumer biomass energy. Net production efficiency of plants is the ratio of net production to gross production.

Energy flow models:



1.**The single / linear channel model**: The single or linear channel energy flow model is one of the first published models pioneered by H. T. Odum in 1956. This model depicts a community boundary and, in addition to light and heat flows, it also includes import, export and storage of organic matter.

There is loss of energy at every successive trophic level; also a corresponding decline in biomass. However, it does not specify any correlation between the biomass and energy. The connection between biomass and energy content may vary according to different conditions. For example, one gram of algae may be equivalent to several grams of forest leaves, due to the fact that the production rate of algae is higher than the forest leaves. The higher biomass of the organism does not necessary indicate the higher productivity. Energy flow in the system balance the energy out flows as required by the First law of thermodynamics and each energy transfer is accompanied by loss of energy (in the form of unavailable heat energy (respiration) as stated by second law of thermodynamics. The energy flow is significantly reduced at each successive trophic level. Thus, at each transfer of energy from one trophic level to another trophic level, major part of energy (90%) is lost in the form of heat or any other form.

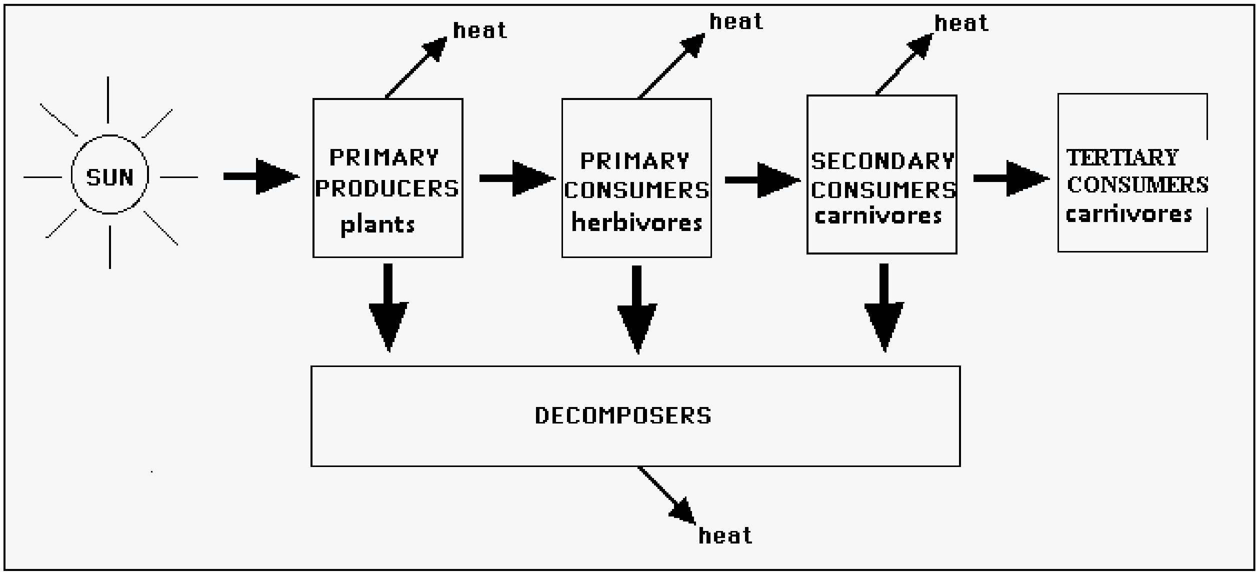


Fig: Single channel Energy Flow

2. **Y- shaped/ Double channel model:** Y- shaped model shows a common boundary, light and heat flow as well as import, export and storage of organic matter. In this model of energy flow, grazing and detritus food chain are sharply separated. It is more practical than simple linear chain energy model as: i) It confirms the basic stratified structure of ecosystem ii) It separates the grazing food chain from detritus food chain (Direct consumption of living plants and utilization of dead organic matter respectively) in both time and space. iii) Macro consumer (animals) and micro consumers (bacteria & fungi) differ greatly in size-metabolism relations.

In Y-Shaped model one arm represents the grazing food chain and the other arm represents detritus food chain. The two arms differ fundamentally in such a way that they can influence primary producers. For Example, in marine bay, the energy flow through grazing food chain is larger than the energy flow via detritus food chain. Whereas reverse is true for forest food chain where 90% or more of net primary production is normally utilized in detritus food chain. Thus, in marine ecosystem the grazing food chain is the major pathway of energy flow whereas in the forest ecosystem, the detritus food chain is more important. In grazing chain, herbivore feed on living plant, therefore they directly affect the plant population. What they not eat is available, after death, to the decomposer. As a result, decomposers are not able to directly influence the rate of supply of their food.

The Y-shaped model further indicates that the two food chains are in fact, under natural conditions, not completely isolated from one another. For example, dead bodies of small animals that were once part of grazing food chain become incorporated in the detritus food chain as do the feces of grazing food animals. The importance of two food chains may differ in different ecosystem, in some cases, grazing is more important and in others, detritus is more important.

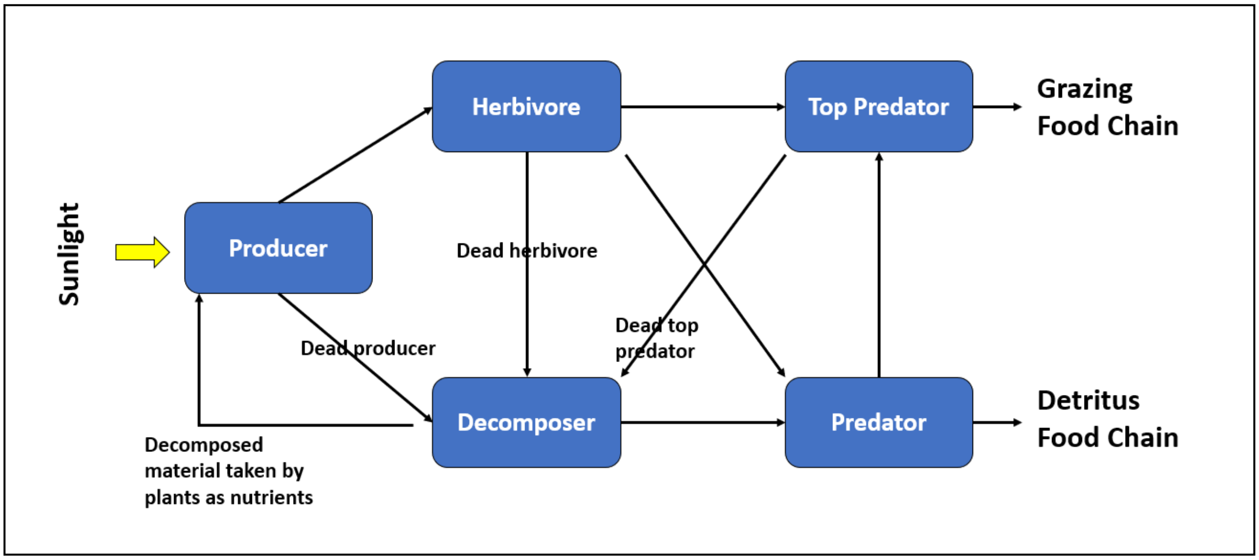


Fig: Y-Shaped/ double Channel Energy Flow Model

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