S. S. College, Jehanabad

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Topic: Energy Flow in Ecosystem - Food Web

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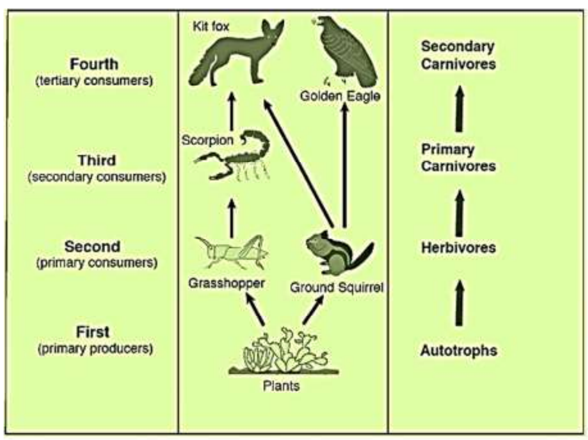
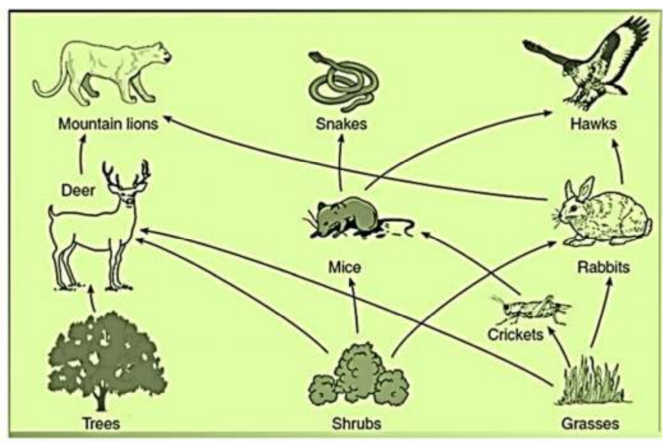
ENERGY FLOW IN ECOSYSTEM - FOOD WEB

Food web is a connection of multiple food chains. Food chains follow a single path, while a food web follows multiple paths. Many animals are part of more than one food chain in an ecosystem because they eat or are eaten by several organisms. Therefore, a food web is a model of interconnected food chains.

It demonstrates how matter and energy are transferred between producers, consumers, and decomposers as the three groups interact within the connected food chains in an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Eventually, decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The molecules that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. As for example, in a food chain grass → mouse → snakes → owls, sometimes mice are not eaten by snakes but directly by owls. This type of interrelationship interlinks the individuals of the whole community. In this way, food chains become interlinked. Similarly in a dessert grassland ecosystem (as shown in figure below), grasshoppers feed on plants; scorpions prey on grasshoppers; kit foxes prey on scorpions. Therefore, this complex of interrelated food chains makes up a food web. Food web maintains the stability of the ecosystem. The greater the number of alternative pathways the more stable is the community of living things.



Food web in a desert grassland ecosystem

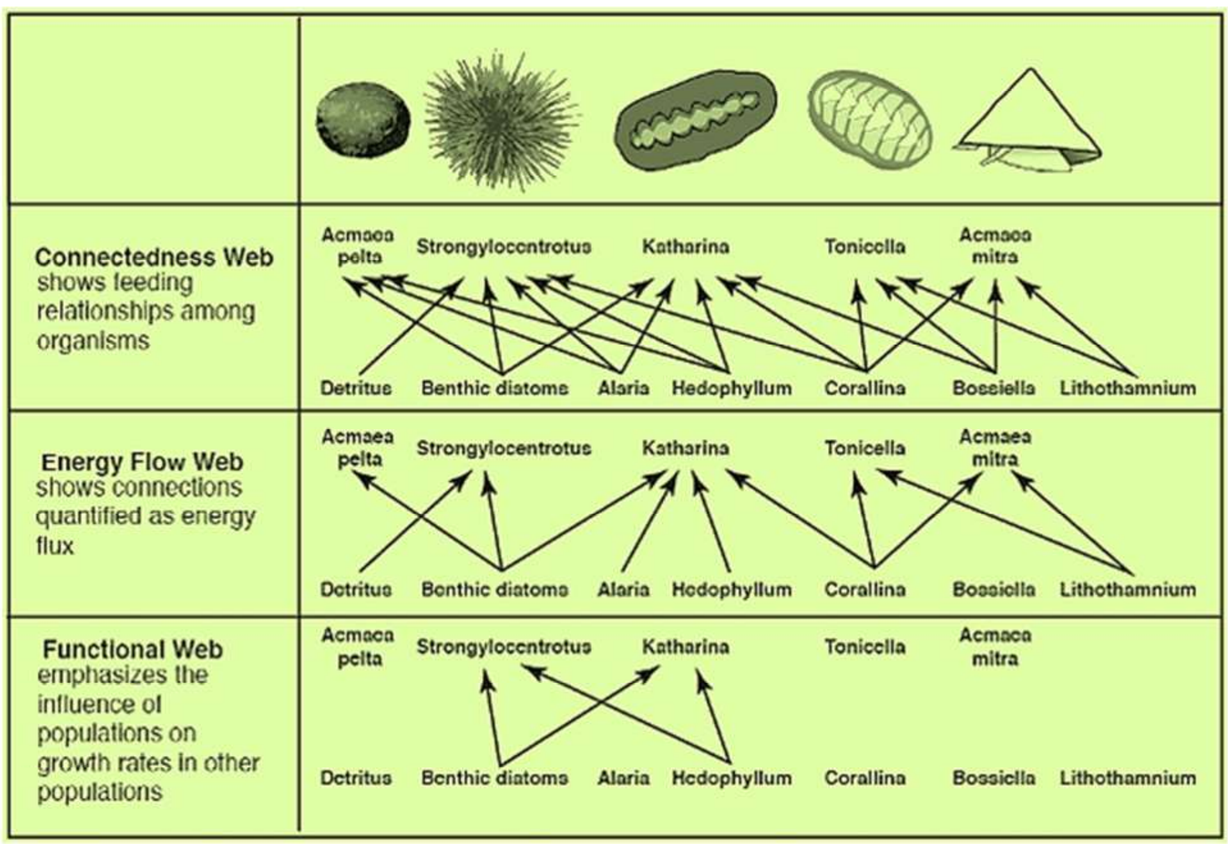


Food web in a common forest ecosystem

It was Charles Elton who first proposed the idea of food chains in the study of ecology and ecological relationship with its organic components. *In 1927, he recognized that the length of these food chains was mostly limited to 4 or 5 links and the food chains were not isolated, but hooked together into food webs (which he called "food cycles").* The feeding interactions represented by the food web may have profound effects on species richness of community, and ecosystem productivity and stability.

Types of food web

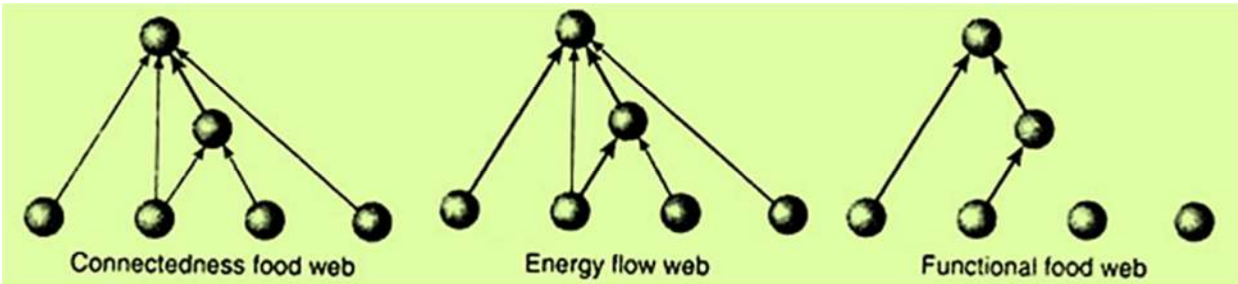
Food webs describe the relationships (links or connections) among species in an ecosystem, but the relationships vary in their importance to energy flow and dynamics of species populations. Some trophic relationships are more important than others in dictating how energy flows through ecosystems. Some connections are more influential on species population change. Based on different ways in which species influence one another, Robert Paine proposed three types of food webs based on the species of a rocky intertidal zone on the coast of Washington (as shown in figure below). These food webs emphasize feeding relationships among species, portrayed as links in a food web. Energy flow webs quantify energy flow from one species to another. Thickness of an arrow reflects the strength of the relationship. Functional webs (or interaction food webs) represent the importance of each species in maintaining the integrity of a community and reflect influence on the growth rate of other species' populations. In figure below, limpets *Acmaea pelta* and *A. mitra* in the community consume considerable food energy (energy flow web), but removal of these consumers has no detectable influence on the abundance of their resources (functional web). The most effective control was exerted by sea urchin *Stronglocentrotus* and the chiton *Katharina*.



Three types of food web as proposed by Robert Paine based on species of a rocky intertidal zone on the coast of Washington.

Connectedness food web: They are also known as topological food web. Such food web emphasizes feeding relationships among organisms, portrayed as links in the web. It depicts only the presence or absence of a trophic interaction i.e. one uses arrow to show one species being consumed by another species. All of the arrows are equally weighted. They, however, do not show the strength of the interaction, nor any change in trophic relationships. For the above reasons, topological food webs are sometimes referred to as static food web.

Energy flow food web: It is sometimes referred to as flow web or as bio-energetic web. It represents an ecosystem viewpoint. Here connections between populations are quantified by the flux of energy between a resource and its consumer.



Types of food web (Heavier the arrow the greater the energy flow

Functional food web: It is sometimes overlapping with interaction food web that identifies the feeding relationships within the topological food web that are most important to community structure. It depicts how different populations influence the growth rate of other populations within the environment.

These three food webs depict the importance of each population in maintaining the integrity of a community. Such interactions are the focus of dynamic food web studies. However, after Paine, some more categories of food web have been put forwarded and described, which are as follows:

Interaction food web: Similar to connected food webs, scientists also use arrows in interaction food webs to show one species being consumed by another species. However, the arrows used are weighted to show the degree or strength of consumption of one species by another. The arrows depicted in such arrangements can be wider, bolder, or darker to denote the strength of consumption if one species typically consumes another. If the interaction between species is very weak, the arrow can be very narrow or not present.

Fossil food web: Food webs can be dynamic and the food relationships within an ecosystem change over time. In a fossil food web, scientists attempt to reconstruct the relationships between species based on available evidence from the fossil record.

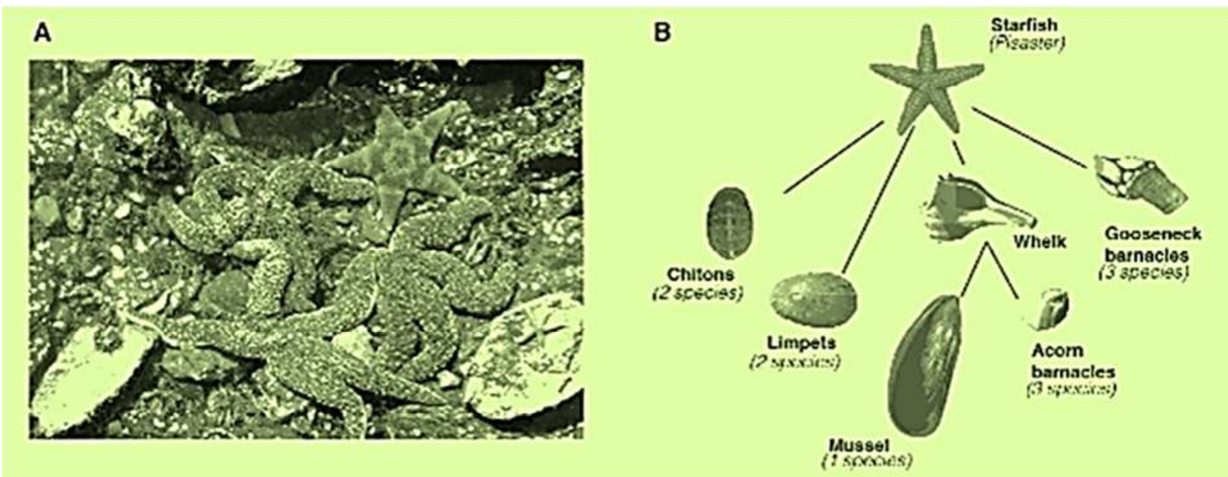
Food webs based on types of ecosystems: Some workers in the field of ecology subdivide the above types of food webs also based on the type of ecosystem. For example, an energy flow aquatic food web depicts the energy flux relationships in an aquatic environment, while an energy flow terrestrial food web shows such relationships on land.

Application of food webs

Study of food web is intended to show how energy moves through an ecosystem from the sun to producers to consumers. This interconnectedness of how organisms are involved in this energy transfer within an ecosystem is a vital element to understanding food webs. Thus, studying food web has various applications, which are as follows;

It can be constructed to describe species interactions (direct relationship): The fundamental purpose of food webs is to describe feeding relationship among species or different feeding groups in a community as described above i.e. producers to primary consumers to secondary consumers or primary carnivores to tertiary consumers or secondary carnivores and so on. Grouping all species into different functional groups or tropic levels helps us simplify and understand the relationships among these species.

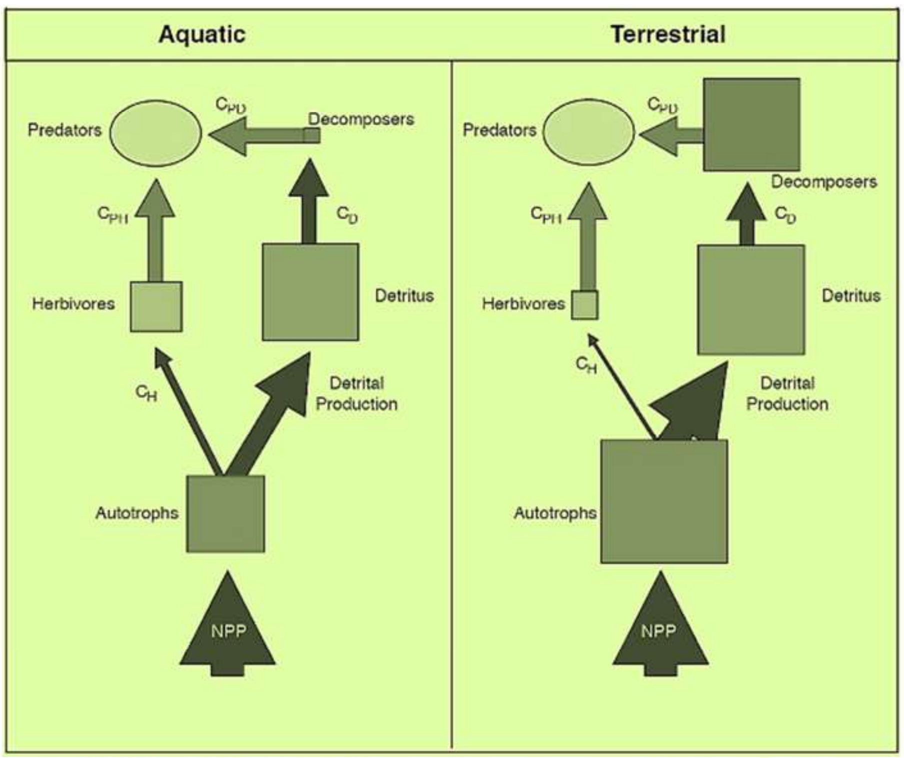
It can be used to illustrate interactions among species: This type of interaction takes place when the organisms do not interact with each other directly, but species can influence one another in many different ways. Robert Paine in an experiment showed that predation can influence the competition among species in a food web. He found that in intertidal zone, which is home to a variety of mussels, barnacles, limpets, and chitons, upon removal of predator i.e. star fish population, a drop in the population of prey from 15 species to 8 species over the time of 2 years. This indicates that predation reduces the abundance of prey species and opens up space for other species to colonize and persist. This type of indirect interaction is called keystone predation.



(a) The rocky intertidal zone of the Pacific Northwest coast is inhabited by a variety of species including starfish, barnacles, limpets, chitons, and mussels. (b) A food web of this community shows that the starfish preys on a variety of invertebrate species. Removal of starfish from this community reduced the diversity of prey species due to increased competition.

It can be used to study bottom-up or top-down control of community structure: Food webs illustrate energy flow from primary producers to primary consumers (herbivores), and from primary consumers to secondary consumers (carnivores). The structure of food webs suggests that productivity and abundance of populations at any given trophic level are controlled by the productivity and abundance of populations in the trophic level below them. This phenomenon is call **bottom-up control**. Correlations in abundance or productivity between consumers and their resources are considered as evidence for bottom-up control. For example, plant population densities control the abundance of herbivore populations which in turn control the densities of the carnivore populations. Thus, the biomass of herbivores usually increases with primary productivity in terrestrial ecosystems. On the other hand, **top-down control** occurs when the population density of a consumer can control that of its resource, for example, predator populations can control the abundance of prey species. Under top-down control, the abundance or biomass of lower trophic levels depends on effects from consumers at higher trophic levels. A trophic cascade is a type of top-down interaction that describes the indirect effects of predators.

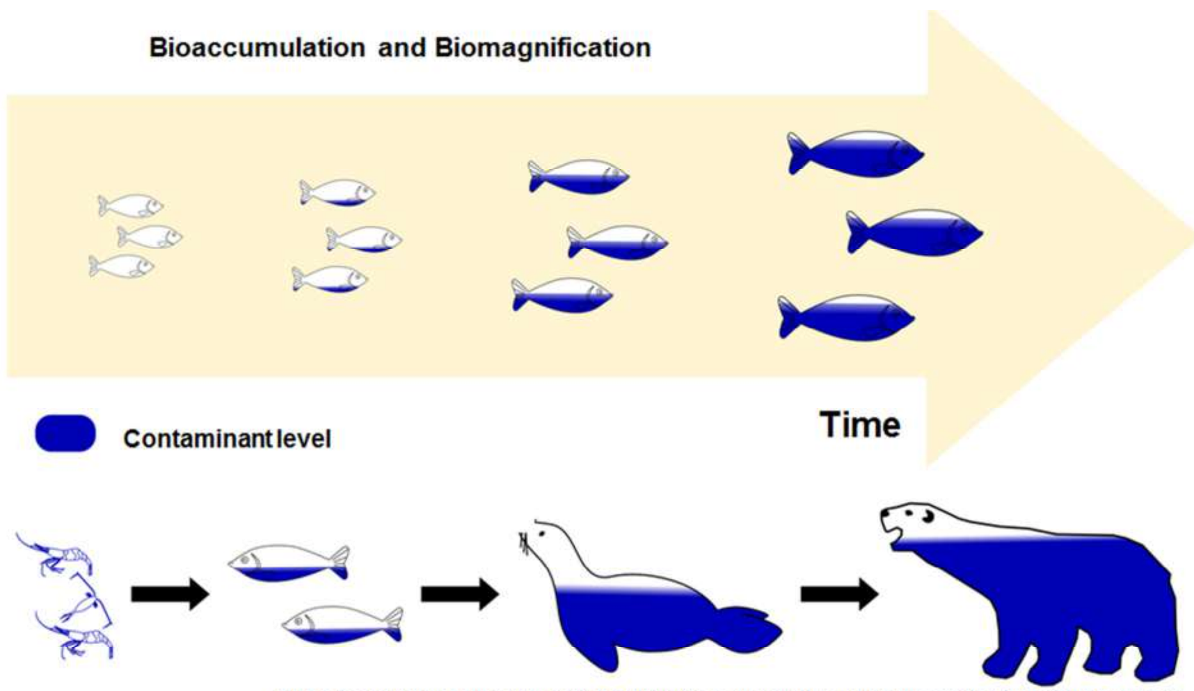
It can be used to reveal different patterns of energy transfer in terrestrial and aquatic ecosystem: Patterns of energy flow differ markedly in terrestrial and aquatic ecosystems in different ecozone or biogeographical realm. Food webs (i.e., energy flow webs) can be used to reveal these differences in energy flow. Through a number of studies, it has been found that on average, the turnover rate of phytoplankton is 10 to 1000 times faster than that of grasslands and forests, thus, less carbon is stored in the living autotroph biomass pool, and producer biomass is consumed by aquatic herbivores at 4 times the terrestrial rate (as shown in figure belwo). Herbivores in terrestrial ecosystems are less abundant but decomposers are much more abundant than in phytoplankton dominated aquatic ecosystems. In most terrestrial ecosystems with high standing biomass and relatively low harvest of primary production by herbivores, the detrital food chain is dominant. In deep-water aquatic ecosystems, with their low standing biomass, rapid turnover of organisms, and high rate of harvest, the grazing food chain may be dominant.



Differences in pathways of carbon flow and pools between aquatic and terrestrial ecosystems.
The thickness of the arrows (flows) and the area of the boxes (pools) correspond to the magnitude. The size of the pools are scaled as log units since the differences cover four orders of magnitude. The C's indicate consumption terms (i.e. CH is consumption by herbivores). Ovals and arrows in grey indicate unknown quantities.

It can be used to analyze the amplification of certain harmful chemical: Since energy can move through an ecosystem, other substances can move through as well. When toxic substances or poisons are introduced into an ecosystem, there can be devastating effects. Upon going up to a trophic level in an ecosystem, on contrary to the flow of energy, it gets accumulated and increases its concentration in each higher trophic level. This phenomenon is called as **bioaccumulation** and **biomagnification**.

Bioaccumulation is the accumulation of a substance, like a poison or contaminant, in an animal. This accumulation in toxic substances can have a profound impact on species within an ecosystem. It occurs when the rate of loss of the substance from the body of the organism through catabolism (breakdown of complex molecules in living organisms), or excretion is lower than the rate of accumulation of the substances, such as persistent organic pollutants like DDT are long-lasting, the risk of bioaccumulation is high even if the environmental levels of the pollutants are not high.



https://www.toppr.com/ask/question/explain-bioaccumulation-and-biomagnification-with-examples/

On the other hand, **biomagnification** refers to the buildup and increase in concentration of said substance as it is passed from one trophic level to another trophic level in a food web. It is a progressive bioaccumulation i.e. increases in concentration at each trophic level with the passage of time. In order for biomagnification to occur, the pollutant must have a long biological half-life i.e. long lived and must not be soluble in water but must be soluble in fats, for example DDT. If the pollutants are soluble in water, then it will be excreted and they are insoluble in water and soluble in fats, they are retained for a long time in the fatty tissue. Marine environments are common examples of how these toxic substances can move from phytoplankton to zooplankton then to fish that eat the zooplankton, then to other fish (like salmon) who eat those fish and all the way up to orca who eat salmon. These levels can cause a number of issues like reproductive problems, developmental issues with their young as well as immune system issues. Therefore, by analyzing and understanding food webs, it is possible to predict how substances may move through the ecosystem.

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