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المرحلة الثالثة - الدراستين الصباحية والمسائية
الفصل الدراسي الاول

تدريسي المادة:

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Lecture 1:

1. Introduction to Ecology and Ecosystem

1.1 Meaning of Ecology

With the growing environmental movement of the late 1960s and early 1970s, Ecology was not known only to a relatively small number of academic and applied biologists. Even now, people confuse it with terms such as *environment* and *environmentalism.* Environmentalism is activism with a stated aim of protecting the natural environment. While environment represents everything that makes up our surroundings and affects our ability to live on the earth—the air we breathe, the water that covers most of the earth's surface, the plants and animals around us, and much more.

So what is ecology? Ecology is a science. According to one accepted definition, **ecology** *is the scientific study of the relationships between organisms and their environment.* Environment includes the physical and chemical conditions.

The term *ecology* comes from the Greek words *oikos,* meaning home or place to live or habitation and *logy,* meaning "the study of". The German zoologist Ernst Haeckel, who originally coined the term *ecology* in 1866 to refer the intr-relationships of living organisms and their environment.

1.2:Ecology has complex roots

The genealogy of most sciences is direct. Tracing the roots of chemistry and physics is relatively easy. The science of ecology is different: its roots are complex. You can argue that ecology goes back to the ancient Greek scholar **Theophrastus**, a friend of Aristotle, who wrote about the relations between organisms and the environment. On the other hand, ecology as we know it today has vital roots in natural history (Natural history provides a descriptive account of organisms and their environment). Early plant ecologists were concerned mostly with terrestrial vegetation. They advanced the ideas of organic nutrient cycling and feeding levels, using the terms producers and consumers marked the beginning of **ecosystem ecology,** the study of whole living systems. Mendel's work on inheritance and Darwin's work on natural selection provided the foundation for the study of evolution and adaptation, the field of **population genetics.** Interest in Malthusian theory stimulated the study of **population ecology,** is concerned with population growth (including birthrates and death rates), and intraspecific and interspecific competition, mutualism, and predation.

Focusing on adaptations, **physiological ecology** is concerned with the responses of individual organisms to temperature, moisture, light, and other environmental conditions. Closely associated with **physiological ecology** is **community ecology,** which deals with the physical and biological structure of communities and community development. Associated with community ecology is **landscape ecology,** the study of causes behind landscape patterns and the ecological consequences of spatial patterns on the landscape. Natural history observations led to studies of animal reactions to their living and nonliving environment. It began with 19th-century behavioral studies including insect, birds and fish, gave rise to **ethology.** Other observations led to investigations of chemical substances in the natural world. Scientists began to explore the use and nature of chemicals in plant and animal defense. Such studies make up the specialized field of **chemical ecology**. Recent years have seen the development of the use of mathematical models to relate interaction of parameters and predict effects **(ecological modeling).** With the development of our understanding of radiation gave rise to **the radiation ecology** which is deals with the study of effect of radiation over the environment and living organisms. And finally**, applied ecology** is a subfield within ecology, which deals with the application of the science of ecology to human needs. Ecology has so many roots that it probably will always remain many-faceted—as the ecological historian Robert McIntosh calls it, "a polymorphic science." Insights from these many specialized areas of ecology will continue to enrich the science as it moves forward into the 21st century.

1.3:Ecology has strong ties to other sciences

The complex interactions taking place within ecological systems involve all kinds of physical, chemical, and biological processes. To study these interactions, ecologists must draw on other sciences. The study of how plants take up carbon dioxide and lose water for example, belongs to plant physiology. Ecology looks at how these processes respond to variations in rainfall and temperature. This information is vital to understanding the distribution and abundance of plant populations and the structure and function of ecosystems on land. Likewise, we must draw upon many of the physical sciences, such as geology, hydrology, and meteorology. They will help us chart other ways organisms and environments interact. For instance, as plants take up water, they influence soil moisture and the patterns of surface water flow. As they lose water to the atmosphere, they increase atmospheric water content and influence regional patterns of precipitation. The geology of an area influences the availability of nutrients and water for plant growth.

In the 21st century, ecology is entering a new frontier, one that requires expanding our view of ecology to include the dominant role of humans in nature. Among the many environmental problems facing humanity, three broad and interrelated areas are crucial: human population growth, biological diversity, and global climate change. As the human population increased from approximately 500 million to more than 7 billion in the past two centuries, dramatic changes in land use have altered Earth's surface. The removal of forests for agriculture has destroyed many natural habitats, resulting in a rate of species extinction that is unique in Earth's history. Due to growing demand for energy from fossil fuels that is needed to maintain economic growth, the chemistry of the atmosphere is changing in ways that are altering Earth's climate. These environmental problems are ecological in nature, and the science of ecology is essential to understanding their causes and identifying ways to mitigate their impacts. In general, there are many branches of sciences with highly relation with ecology as explain in following diagram:

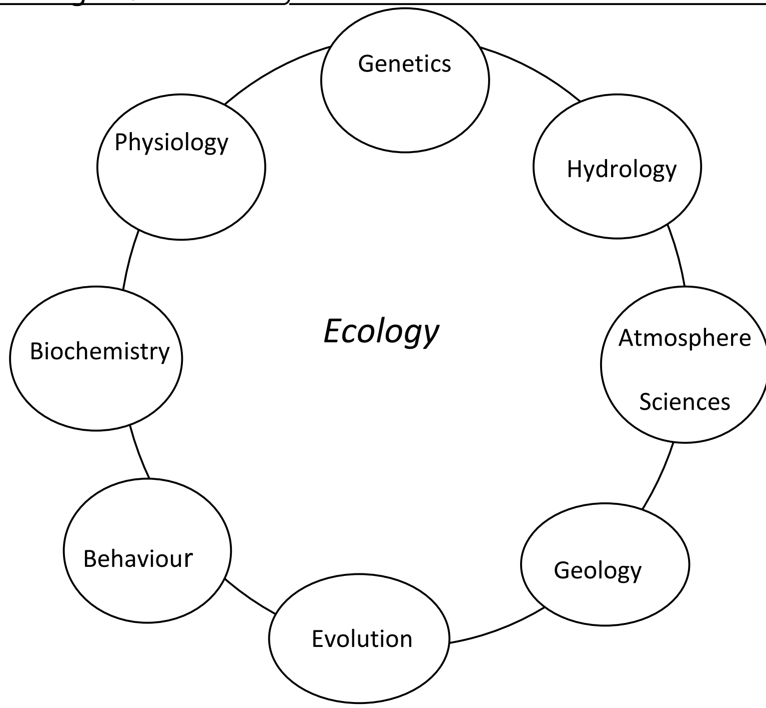


Figure 1: The relationship between ecology and other sciences

1.4: Ecosystems

You know that earth is perhaps the only planet in the solar system that supports life. The portion of the earth which sustains life is called biosphere. Biosphere is very huge and can not be studied as a single entity. It is divided into many distinct functional units called **ecosystem**. All the living and nonliving things that interact in a particular area make up an **ecosystem.** The term 'ecosystem' was coined by Sir Arthur George Tansley in 1935. An ecosystem is a functional unit of nature encompassing complex interaction between its biotic (living) and a biotic (non-living) components.

1.4.1: Components of an ecosystem: They are broadly grouped into:-

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

(1) Physical factors: Such as sun light, temperature, rainfall, humidity and pressure. They sustain and limit the growth of organisms in an ecosystem.

(2) Inorganic substances: Carbon dioxide, nitrogen, oxygen, phosphorus, sulphur, water, rock, soil and other minerals.

(3) Organic compounds: such as carbohydrates, proteins and lipids. They are the building blocks of living systems and therefore, make a link between the biotic and a biotic components.

(B) Biotic components (Living)

(1) Producers (**autotrophs**, i.e. self feeders): The green plants manufacture food for the entire ecosystem through the process of photosynthesis. Green plants are called autotrophs, as they absorb water and nutrients from the soil, carbon dioxide from the air, and capture solar energy for this process.

(2) Consumers (heterotrophs, i.e. other feeders) **:** They are called heterotrophs and they consume food synthesized by the autotrophs. Consumers, depending on their food habits, can be further classified into three types

- **Herbivores** (**Primary consumers)**,e.g. deer, rabbits, cattle, etc., are plant eaters and they feed directly on producers. In a food chain, they are referred to as the primary consumers.
- **Carnivores (Secondary consumers)** are meat eaters and they feed on herbivores (primary consumers). They are thus known as secondary consumers. They are animal eaters, e.g. lions, tigers.
- **Omnivores (Third-** and **higher-level consumers)** eat both plants and animals, e.g. pigs, rats and humans.

(3) Decomposers: Also called **saprotrophs.** These are mostly bacteria and fungi that feed on dead decomposed and the dead organic matter of plants and animals by secreting enzymes outside their body on the decaying matter. They play a very important role in recycling of nutrients. They are also called **detrivores or detritus feeders**. Below, a diagram explains the components of an ecosystem:

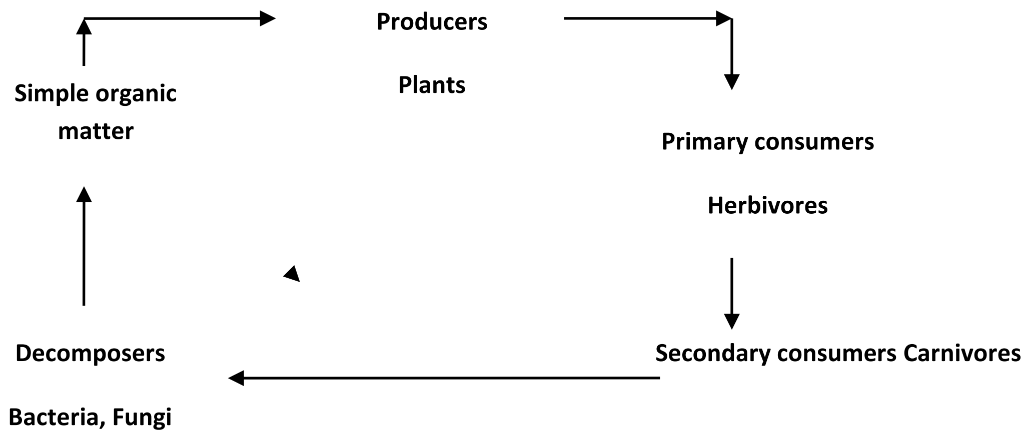


Figure 2: The main components of an ecosystem

1.4.2: Functions of ecosystem

Ecosystems are complex dynamic system. They perform certain functions. These are:-

(1) Energy flow through food chain

(2) Nutrient cycling (biogeochemical cycles)

(3) Homeostasis **(**tendency of ecosystem to resistance the changes**)**

1.4.3: Types of ecosystems

Ellenberg, (1973) has classified the world into a hierarchy of ecosystems. Biosphere is the largest. Next lower level is mega-ecosystems such as marine ecosystems, limnic ecosystems (ecosystems of fresh water) and terrestrial ecosystems. The lower level is macro-ecosystem (forsts, etc.) within each mega – ecosystm. Macro-ecosystems which divided into microecosystems (such as mountain and valleys). We can also divided ecosystems according to diversity of these systems , such as freshwater systems, estuaries ecosystems, marine ecosystems and terrestrial ecosystems. While , it can be divided the ecosystems depending on the presence of the major components (a biotic substances ,producers, consumers and decomposers) to a complete ecosystems and incomplete ecosystems. The ecosystems which do not contain all the four basic components of ecosystem and they may lack one or more are called incomplete ecosystems. For example, depths of the sea and caves lack producers but contain only consumers and decomposers.

Lecture 2:

2. Ecosystem structure: A biotic environmental factors

2.1: Introduction

It is well known that ecology includes a broad area of investigation — from the individual organism to the biosphere. We begin with the individual organism, examining the processes it uses and constraints it faces in maintaining life under varying environmental conditions. The individual organism forms the basic unit in ecology. The individual senses and responds to the physical environment. But before embarking on our study of other aspects of ecological systems, we examine characteristics of the a biotic (physical and chemical) environment that function to sustain and constrain the patterns of life on our planet. Temperature, light, oxygen concentration, carbon dioxide, wind, speed of water flow etc. exert profound effect on organism living or trying to live in the ecosystem. However, because not all factors are equally important for any living organism we used the term limiting factors which we will discuss below:

2.2: Principles of Limiting factors

Ecologists used the term "Limiting Factors" to refer to the all environmental factors that affect an organism's ability to survive in its environment, such as food, light, water, temperature etc. In other words Limiting factors: anything that tends to make it more difficult for a species to live and grow, or reproduce in its environment.

2.2.1: Liebig's Law of the minimum

Liebig's law of the minimum, often simply called Liebig's law or the law of the minimum, is a principle developed by Justus von Liebig. It states that **"Growth of a plant is dependent on the amount of foodstuff which is present in minimum quantity".**

Justus Liebig "father of the fertilizer industry" in 1840 was a pioneer in the study of the effect of various factors on the growth of plant. He found that the yield of crops was often limited not by nutrients needed in large quantities , such as carbon dioxide and water, since these were often abundant in the environment, but by some raw material, as boron for example, needed in minute quantities but very scarce in the soil.

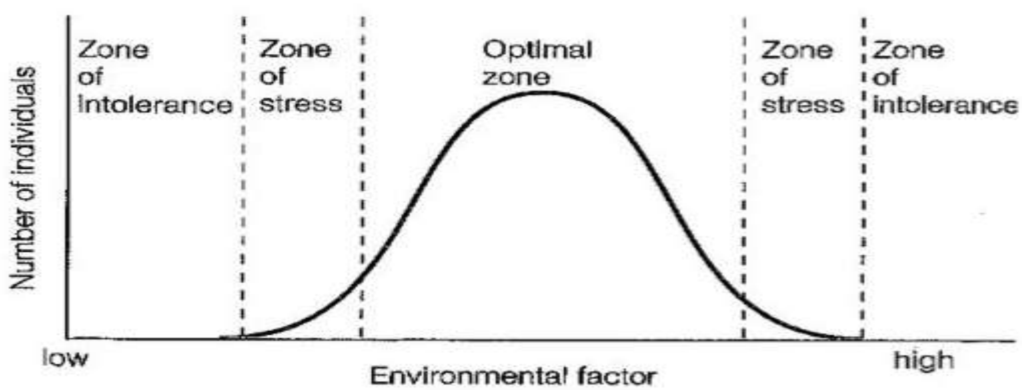
Extensive work since the time of Liebig has shown that two principles must be added to the concept if it is to be useful in practice.

- ❖ The first: Liebig’s law is strictly applicable only under steady state conditions .
- ❖ The second: important consideration is factors interaction.

For explanation, Sometimes organisms are able to substitute, in part at least , a chemically closely related substance fore one that is deficient in the environment. Thus where strontium is abundant, mollusks are able to substitute strontium for calcium to a partial extent in there shells. Other example for factors interaction some plants have been shown to require less zinc when growing in the shade than when growing in full sunlight, therefore, a given amount of zinc in the soil would be less limiting to plants in the shade than under the same conditions in sunlight.

2.2.2. Shelford's law of tolerance

Shelford's law of tolerance is a principle developed by American zoologist Victor Ernest Shelford in 1911. It states **that an organism's have an ecological maximum and minimum, with a range in between which represents the “limits of tolerance”.**



Shelford’s law of tolerance. A plot of the number of individuals of a species as a function of some environmental factor (such as temperature) produces a bell-shaped curve that can be divided into various tolerance zones.

In this law not only may too little of something be a limiting factor , as proposed by Liebig, but also too much , as in the case of such factors as heat, light, and water , thus organisms are constrained by both the maximum and minimum extremes of an environmental condition; these extremes represent the limits of tolerance. The concept of the limiting effect of maximum as well as minimum was incorporated in to the law of tolerance by Shelford in 1913.

Some subsidiary principles to the law of tolerance may be stated as follows:

1.Organisms may have a wide range of tolerance for one factor and a narrow range for another.

2.Organisms with wide ranges of tolerance for all factors are likely to be most widely distributed.

3.When conditions are not optimum for a species with respect to one ecological factor, the limits of tolerance may be reduced with respect to other ecological factors. For example when soil nitrogen is limiting, the resistance of grass to drought is reduced . In other words, that more water was required to prevent wilting at low nitrogen levels than at high levels.

4.Very frequently it is discovered that organisms in nature are not actually living at the optimum range with regard to a particular physical factor. In such cases some other factor or factors are found to have greater importance. Certain tropical orchids, for example actually grow better in full sunlight than in shade, provided they are kept cool, in nature they grow only in the shade because they cannot tolerate the heating effect of direct sunlight. In many cases population interactions such as competition, predators, parasites, and so on prevent organisms from taking advantage of optimum physical conditions.

5. The period of reproduction is usually a critical period when environmental factors are most likely to be limiting. The limits of tolerance for reproductive individuals, seeds, eggs, embryos, and larvae are usually narrower than for non reproducing adult plant or animals . For example, adult blue crab and many other marine animals can tolerate brackish water(fresh water that has a high chloride continent) ,thus individuals are often found for some distance up rivers. The larvae, however cannot live in such waters, there for the species can not reproduce in the river environment.

To express the relative degree of tolerance ,a series of terms have come in to general use in ecology that utilize the prefixes steno meaning narrow and eury meaning wide . Thus

- Stenothermal – eurythermal --- refer to temperature range
- Stenohaline – euryhaline --refer to salinity range
- Stenohydric –euryhydric ----- refer to water range
- Stenophagic – euryphagic ----- refer to food range

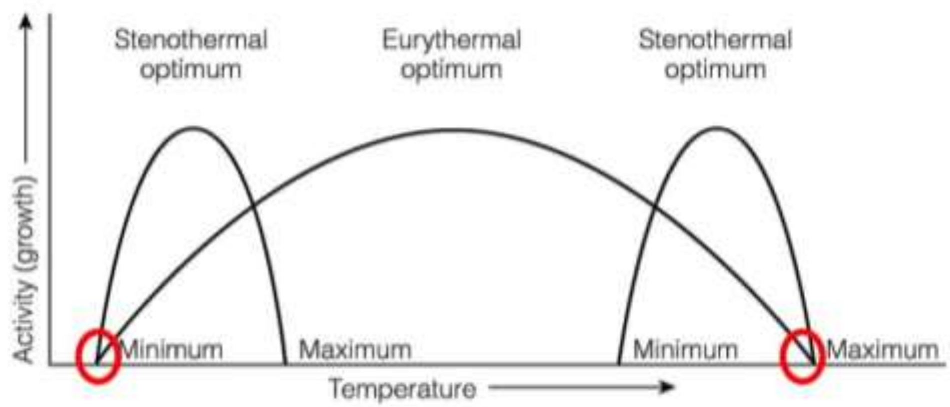


Figure 4: Degree of tolerance

Lecture 3:

3.1 The physical factors as limiting factors

The broad concept of limiting factors is not restricted to physical factors, because of biological interrelations are also important in controlling the actual distribution and abundance of organisms in nature .

3.1.2 Temperature

Temperature is one of the essential environmental factors. Compared with the range of the thousands of degrees known to occur in our universe ,life , as we known it, can exist only within a tiny range of about 300 degrees centigrade-from about – 200 to 100^{o}C . Actually, most species and most activity are restricted to an even narrower band of temperature. Some organisms, especially in resting stage, can exist at a very low temperatures at least for brief periods, whereas a few microorganisms, chiefly bacteria and algae are able to live and reproduce in hot springs where the temperature is close to the boiling point.

In general the upper limits are more quickly critical than the lower limits and the range of temperature variation tends to be less in water than on land, and aquatic organisms generally have narrower limit of tolerance to temperature than equivalent land animals.

Temperature, therefore is universal important and is very often a limiting factor. Temperature , light and water are largely on control the seasonal and daily activates of plants and animals . Temperature is often responsible for the zonation and stratification which occur in both land and water environments.

3.1.3: Animal thermal regulation

Animals fall into three groups relative to temperature regulation

To regulate temperature, some groups of animals generate heat metabolically. This internal heat production is **endothermy,** meaning “heat from within.” The result is **homeothermy** (from the Greek *homeo,* “the same”), or maintenance of a fairly constant temperature independent of external temperatures. Another group of animals acquires heat primarily from the external environment. Gaining heat from the environment is **ectothermy,** meaning "heat from without." Unlike endothermy, ectothermy results in a variable body temperature. This means of maintaining body temperature is **poikilothermy** (from the Greek *poikilos*).

Birds and mammals are notable **hoameotherms,** usually called warm blooded. Fish, amphibians, reptiles, insects, and other invertebrates are **poikilotherms,** often called cold blooded because they can be cool to the touch. A third group regulates body temperature by endothermy at some times and ectothermy at other times. These animals are **heterotherms** (from *hetero,* "different"). Heterotherms employ aboth endothermy and ectothermy, depending on environmental situations and metabolic needs. Bats, bees, and humming birds belong to this group.

Ectotherm and *endotherm* emphasize the mechanisms that determine body temperature. The other two terms, *homeotherm* and *poikilotherm,* represent the nature of body temperature (either constant or variable). Poikilotherms, such as amphibians, reptiles, and insects, gain heat easily from the environment and lose it just as fast.

Environmental sources of heat control the rates of metabolism and activity among most poikilotherms. Rising temperatures increase the rate of enzymatic activity, which controls metabolism and respiration . For every 10°C rise in temperature, the rate of metabolism in poikilotherms approximately doubles. They become active only when the temperature is sufficiently warm. Conversely, when ambient temperatures fall, metabolic activity declines and poikilotherms become sluggish. Poikilotherms have an upper and lower thermal limit that they can tolerate. Most terrestrial poikilotherms can maintain a relatively constant daytime body temperature by behavioral means, such as seeking sunlight or shade. Lizards and snakes, for example, may vary their body temperature by no more than 4°C to 5°C , body temperature of amphibians may vary by 10°C when active. The range of body temperatures at which poikilotherms carry out their daily activities is the **operative temperature range.**

Homeothermic birds and mammals meet the thermal constraints of the environment by being endothermic. They maintain body temperature by oxidizing glucose and other energy-rich molecules in the process of respiration. The process of oxidation is not 100 percent efficient, and in addition to the production of chemical energy in the form of ATP, some energy is converted to heat energy. Therefore, the rate of respiration for homeothermic animals is proportional to their body mass. Homeotherms use some form of insulation— a covering of fur, feathers, or body fat . For mammals, fur is a major barrier to heat flow; but its insulation value varies with thickness, which is greater on large mammals than on small ones. Small mammals are limited in the amount of fur they can carry, because a thick coat could reduce their ability to move. Mammals change the thickness of their fur with the season, a form of acclimation.

Aquatic mammals—especially of Arctic regions—and Arctic and Antarctic birds such as penguins have a heavy layer of fat beneath the skin. Birds reduce heat loss by fluffing the feathers, making the feathered ball. Although the major function of insulation is to keep body heat in, it also keeps heat out. In a hot environment, an animal has to either rid itself of excess body heat or prevent heat from being absorbed in the first place. One way is to reflect solar radiation from light-colored fur or feathers. Another way is to grow a heavy coat of fur that heat does not penetrate. The outer layers of hair absorb heat and return it to the environment. However, some animals use unique physiological means for thermal balance. Due to an animal's limited tolerance for heat, storing body heat does not seem like a sound option to maintain thermal balance in the body. But certain mammals, especially the camel and some gazelles, do just that. The camel, for example, stores body heat by day and dissipates it by night, especially when water is limited. Its temperature can fluctuate from 34°C in the morning to 41°C by late afternoon. By storing body heat, these animals of dry habitats reduce the need for evaporative cooling and thus reduce water loss and food requirements.

Many ectothermic animals of temperate and Arctic regions withstand long periods of below-freezing temperatures in winter through supercooling and developing a resistance to freezing. **Supercooling** of body fluids takes place when the body temperature falls below the freezing point without actually freezing. The presence of certain solutes in the body that function to lower the freezing point of water influences the amount of supercooling that can take place. Some Arctic marine fish, certain insects of temperate and cold climates, and reptiles exposed to occasional cold nights employ supercooling by increasing solutes, notably glycerol, in body fluids. Glycerol protects against freezing damage, increasing the degree of supercooling. Some intertidal invertebrates and certain aquatic insects survive the cold by freezing and then thawing out when the temperature moderates. In some species, more than 90 percent of the body fluids may freeze, and the remaining fluids contain highly concentrated solutes, muscles and organs are distorted. After thawing, they quickly regain normal shape.

3.3.1.2:The ecological rules

There is some rules that correlates organism especially (endothermic animals) with latitudes such as:

- **Bergmann's rule:** It is a biological rule formulated by Christian Bergmann. This rule that correlates temperature with body mass in animals. Generally, animals living in cold areas are larger than their counterparts in warmer areas The rule is often applied only to mammals and birds (endothermic).

- **Allen's rule:** it is an ecological rule posited by Joel Allen. It states that animals from colder climates usually have shorter appendages (such as tail, ear, nose, leg etc) than the equivalent animals from warmer climates. In cold climates, the increase of exposed surface area lead to increasing loss of heat. Animals in cold climates need to conserve as much energy as possible. A low surface area to volume ratio helps to conserve heat. In warm climates, the opposite is true. Therefore, animals in warm climates will have high surface area to volume ratios so as to help them lose heat.

Lecture 4: The physical factors as limiting factors

4.1: Light

Light is the ultimate source of energy ,without which life could not exist. Light energy varies with different media, the transparency of air and water is an important in regulating the amount and quality of light that may be available in particular habitat . Light therefore , is not only a vital factor but also a limiting , both at the maximum and minimum levels. Therefore is not other factor of greater interest to ecologist!.

Radiation consists of electromagnetic waves of a wide range in length. The solar radiation reach the earth surface consist of electromagnetic waves ranging in length from about 0.3 to 10 microns. To the human eye , visible light lies in the range of 390 to 760 nm.

Ecologically , the quality of light (wave length), the intensity , and the duration (length of day) are known to be important. Both animals and plants are known to respond to different wave lengths of light. The growth ,migration, reproduction and diapause are affected by light in different insects , fish, birds , and mammals.

The relationship of intensity to photosynthesis in both land and aquatic plants follows the same general pattern of linear increase up to an optimum or light saturation level, followed in many instances by a decrease at very high intensities.

4.2: Light and animal navigation

Animal navigation is the ability of many animals to find their way accurately without maps or instruments. Birds such as the Arctic tern, insects such as the monarch butterfly and fish such as the salmon regularly migrate thousands of miles to and from their breeding grounds, and many other species navigate effectively over shorter distances.

In the 20th century, Karl von Frisch showed that honey bees can navigate by the sun, by the polarization pattern of the blue sky, and by the earth's magnetic field; of these, they rely on the sun when possible. William Tinsley Keeton showed that homing pigeons could similarly make use of a range of navigational cues, including the sun, earth's magnetic field, olfaction and vision. Several species of animal can integrate cues of different types to orient themselves and navigate effectively. Insects and birds are able to combine learned landmarks with sensed direction (from the earth's magnetic field or from the sky) to identify where they are and so to navigate. Internal 'maps' are often formed using vision, but other senses including olfaction and echolocation may also be used.

The ability of wild animals to navigate may be adversely affected by products of human activity. For example, there is evidence that pesticides may interfere with bee navigation, and that lights may harm some species navigation.

4.3: Biological clocks

The major influence of light on animals is its role in timing daily and seasonal activities including feeding, food storage, reproduction, and migratory movements. The internal mechanisms in organisms used to control the periodicity of various functions or activities are **biological clocks.** An internal biological clock is fundamental to all living organisms, influencing hormones that play a role in the sleep cycle, metabolic rate, and body temperature.

Biological processes fluctuate in cycles, or rhythms, that range from minutes or even to months. Biological processes that cycle in 24-hour intervals are called **daily rhythms**.

When a daily rhythm results from a physiological response to the diurnal environmental cycle, it is called a **circadian rhythm** (Latin *circa*, “about,” and *dia*, “day”). Many autonomic processes of individual organisms exhibit a circadian rhythm, including the control of body temperature, cardiovascular function, melatonin (hormone related to the sleep–wake cycle) secretion, cortisol (primary stress hormone) secretion, and metabolism.

The circadian rhythm, with its sensitivity to light and dark, is the major mechanism for the biological clock—that timekeeper of physical and physiological activity in living things. Circadian rhythms are believed to include at least three elements: (1) *input pathway* that transmits environmental signals (light) to the clock, (2) *pacemaker* (clock), and (3) *output pathway* through which the pacemaker regulates the rhythms.

The input pathway to the pacemaker in mammals begins with photoreceptors in the eye. The retina of the eyes contains "classical" photoreceptors called photo-responsive cells. These cells, which contain a photosensitive pigment, follow a pathway leading to the pineal gland, a small organ shaped like a pine cone (hence its name) and located in the epithalamus region of the brain. The pineal gland provides the output pathway through the secretion of melatonin. Melatonin is a structurally simple hormone that communicates information about the light environment to various parts of the body. Secretion of melatonin peaks at night and declines during the day. Ultimately, melatonin has the ability to entrain biological rhythms. The eye is the only photosensitive organ in mammals. In other vertebrates, such as birds and some lizards, the pineal gland is on the surface of the brain, directly under the skull.

4.4: Bioluminescence

Bioluminescence is the production and emission of light by a living organism . Bioluminescence occurs widely in marine vertebrates and invertebrates, as well as in some fungi, microorganisms including some bioluminescent bacteria and terrestrial invertebrates such as fireflies. In some animals, the light is produced by symbiotic organisms such as *Vibrio* bacteria. Bioluminescence is a form of chem-iluminescence where light energy is released by a chemical reaction. The light-emitting pigment luciferin and the enzyme luciferase. Luciferin reacts with oxygen to create light. Biofluorescence, on the other hand, is not a chemical reaction and biofluorescent organisms do not give off light from their own power source. Instead, biofluorescent organisms absorb light, transform it, and eject – or "re-emit" – it as a different color. When specialized fluorescent molecules are "excited" by high-energy light (like blue light), they lose a fragment of the light energy and release the rest at a lower-energy wavelength (like green). Most marine light-emission is in the blue and green light spectrum.

The most frequently encountered Bioluminescence organisms may be the dinoflagellates present in the surface layers of the sea, which are responsible for the sparkling phosphorescence sometimes seen at night in disturbed water. A different effect is the thousands of square miles of the ocean which shine with the light produced by Bio-fluorescence bacteria, known as mareel or the milky seas effect. Non-marine bioluminescence is less widely distributed, the two best-known cases being in fireflies and glow worms. Other invertebrates including insect larvae and annelids possess Bio-fluorescence abilities. Some forms of Bio-fluorescence are brighter (or exist only) at night, following a circadian rhythm. Bioluminescence used for defense against predators such as Dinoflagellates. They shine when they detect a predator. Also, Bioluminescence is used by a variety of animals to mimic other species. Many species of deep sea fish such as the anglerfish and dragon fish make use of mimicry to attract prey.

Lecture 5 : The physical factors as limiting factors

5.1: Water

A physiological necessity for all protoplasm, water, from the ecological viewpoint, is chiefly a limiting factor in land environments or in water environments in which the amount is subject to great fluctuation. Rainfall, humidity, the evaporating power of the air ,and available surface water supply are the principle factors measured. Rainfall is largely determined geography and pattern of the large air movements or weather system. In temperate climates , rainfall tend to be more evenly distributed throughout the year , with many exceptions. The following tabulation gives a rough approximation of the climax biotic communities that may be expected with different of rainfall distributed in temperate latitudes:

0----- 10 inches per year → desert

10 ------ 30 inches per year → grassland or savanna

30 ------ 50 inches per year → dry forest

Over 50 inches per year → wet forest

In generally, rainfall tends to be unevenly distributed over the seasons in the tropic and sub tropics. In the tropics, this seasonal rhythm in moisture regulates the seasonal activities (especially reproduction) of organisms in much the same manner as the seasonal rhythm of temperature and light regulates temperate zone organisms.

5.2: Maintenance of water balance for terrestrial animals

Living cells, both plant and animal, contain about 75 to 95 percent water. Water is essential for virtually all biochemical reactions within the body, and it functions as a medium for excreting metabolic wastes and for dissipating excess heat through evaporative cooling.

Maintaining this balance between the uptake and loss of water with the surrounding environment is referred to as an organism's **water balance** . Terrestrial animals have three major ways of gaining water and solutes: by 1.drinking, 2.eating and 3.by producing metabolic water in the process of respiration. They lose water and solutes through urine, feces, evaporation from the skin, and from the moist air they exhale.

Some birds and reptiles have a salt gland, and all birds and reptiles have a cloaca—a common receptacle for the digestive, urinary, and reproductive tracts. They reabsorb water from the cloaca back into the body.

Mammals have kidneys capable of producing urine with high ion concentrations. In arid environments, animals, like plants, face a severe problem of water balance. They can solve the problem in either of two ways: by evading the drought or by avoiding its effects. Animals of semiarid and desert regions may evade drought by leaving the area during the dry season and moving to areas where permanent water is available. Many birds use this strategy.

During hot, dry periods the frog (*Scaphiopus couchi*) of the southern deserts of the United States remains belowground in a state of dormancy and emerges when the rains return. Some invertebrates inhabiting ponds that dry up in summer, such as the flatworm develop hardened casings and remain in them for the dry period. Other aquatic or semiaquatic animals retreat deep into the soil until they reach the level of groundwater. Many insects undergo diapause, a stage of stopped development in their life cycle from which they emerge when conditions improve. Other animals remain active during the dry season but reduce respiratory water loss.

Some small desert mammals reduce water loss by remaining in burrows by day and emerging by night. Many desert mammals, from kangaroos rat to camels, extract water from the food they eat—either directly from the moisture content of the plants or from metabolic water produced during respiration—and produce highly concentrated urine and dry feces. Some desert mammals can tolerate a certain degree of dehydration. Desert rabbits may withstand water losses of up to 50 percent and camels of up to 27 percent of their body weight.

5.3: Atmospheric gases

Except for the large variations in water vapor ,the atmosphere of the major part of the biosphere is remarkably homeostatic. The situation in aquatic environments is different from that in the atmospheric environment because amounts of oxygen ,carbon dioxide ,and other atmospheric gases dissolved in water and thus available to organisms are quite variable from time to time and place to place .Oxygen is an a limiting factor ,especially in lakes and waters with a heavy load of organic material. Temperature and dissolved salts greatly effect the ability of water to hold oxygen, the solubility of oxygen being increased by low temperatures and decreased by high salinities.

The oxygen supply in water comes chiefly from two sources ,by diffusion from the air and from photosynthesis by aquatic plants.Carbon dioxide ,like oxygen may be present in water in highly variable amounts ,but its behavior in water is rather different and its ecology is not as well known.

Furthermore, unlike oxygen, carbon dioxide enters into chemical combination with water to form H_2CO_3 which in turn reacts with available limestone’s to form carbonates CO_3 and bicarbonate HCO_3.These compounds not only provide a source of nutrients but also act as buffers ,helping to keep the hydrogen ion concentration of aquatic environments near the neutral point.

5.4: Biogenic salts

Dissolved salts are necessary to life may be termed biogenic salts. Phosphorus and nitrogen are the most important ecologically , although, potassium ,calcium sulfur ,and magnesium merit high consideration , Calcium is needed in especially large quantities by the mollusks and the vertebrates, and magnesium is a necessary constituent of chlorophyll. Elements and their compounds needed in relatively large amounts are often known as macronutrients .In recent years great interest has developed in the study of elements and there compounds which are necessary for the operation of living system ,but which are required only in extremely minute quantities. These elements are generally called trace elements or micronutrients. Eyster (1964) lists ten micronutrients that are definitely known to be essential to plants. These are Iron, manganese, copper, zinc, boron, silicon ,molybdenum, chlorine, vanadium and cobalt. These elements can be arranged in three groups as follows :

Those required for photosynthesis :Mn, Fe, Cl, Zn and V.

Those required for nitrogen metabolism Mo, B, Co and Fe .

Those required for other metabolic functions: Mn, B,Co,Cu and Si.

5.6: Currents and pressure

The atmospheric and hydrospheric media in which organisms live are not often completely still for any period of time .Currents in water not only greatly influence the concentration of gases and nutrients ,but act directly as a limiting factor.Thus ,the difference between a stream and small pond community may be due to the big difference in the current factor. On land ,wind exerts a limiting effect on the activities and distribution of organisms in the same manner .Hurricanes transport animals and plants for great distances and the wind may be change the composition of the forest communities. In dry regions, wind is an especially important limiting factor for plant , since it increases the rate of water loss by transpiration. Barometric pressure has not been shown to be an important direct limiting factor for organisms, although some animals appear able to detect differences .In water the pressure increases one atmospheric pressure for every 10 meters. In the deepest part of ocean the pressure reaches 1000 atmospheric pressure. Many animals can tolerate wide changes in pressure , especially if the body does not contain free air or gas.

5.7: Ecological indicators

We have seen , specific factors often determine rather precisely what kinds of organisms will be present ,we can turn the situation and determine the kind of physical environment from the organisms present. It is found that certain species of micro-organisms , plant and animals have one or more specific requirements and they become very much limited in there distribution . Thus, the occurrence of such species in a particular area indicates special habitat conditions, and such species are called bio indicators or ecological indicators.

Some of the important considerations which should be taken when dealing with ecological indicators follow:

1.In general, steno species make much better indicators than eury species.

2.Large species usually make better indicators than small species

3.The species were selected should be abundant in field.

4.Numerical relationships between species, populations, and whole communities often provide more reliable indicators than single species.

Lecture 6:

6. Ecosystem structure: Biotic components of ecosystems

Biotic, or living, components of ecosystems include all the plants, animals, fungi and microorganisms that make up populations and communities. This lecture will focus on all aspects of the population while leaving the community for the next lecture.

6.1: Population

Although the term *population* has many different meanings and uses, for biologists and ecologists it has a very specific definition. A population is **a group of individuals of the same species occupying a particular space at the same time** .

6.1.1: Organisms may be Unitary or Modular

A population is considered to be a group of individuals, but what constitutes an individual? For most of us, defining an individual would seem to be no problem. We are individuals, and so are dogs, cats, spiders, insects, fish, and so on throughout much of the animal kingdom. What defines us as individuals is our unitary nature. Form, development, growth, and long life of unitary organisms are predictable. The zygote, formed through sexual reproduction, grows into a genetically unique organism. There is no question about recognizing an individual. This simplistic view of an individual breaks down, however, when the organism is modular rather than unitary.

In modular organisms, the zygote develops into a unit of construction (a module) that then produces further, similar modules. Most plants are modular. A tree, shrub, or herbaceous plant grown from a seed is an individual with its own genetic characteristics. Once established, some species of trees, shrubs, and many perennial herbaceous plants grow root extensions to send up new shoots or suckers that may remain attached to root extensions or break off to live independently . These new modules (or clones) may cover a considerable area and appear to be individuals. Plants are the most obvious group of modular organisms. Many other modular animals, such as corals, sponges, and bryozoans, also grow by repeated production of modules.

6.1.2: Properties of population

Populations have unique properties because they are an aggregate of individuals. Populations have structure, which relates to characteristics such as density (the number of individuals per unit area), proportion of individuals in various age classes, and spacing of individuals relative to each other. Populations also display a pattern of continuous change through time that results from the birth, death, and movement of individuals

6.1.2.1: Population density

The density of a population refers to its size in relation to some unit of space. It is generally expressed as the number of individuals , or the population biomass per unit area or volume – for example, 200 trees per acre, 5 million diatoms per cubic meter of water .

- ✓ ***Density and Allee's principle***

The Allee Principle presents the idea that for every population of organisms within the ecosystem there is some intermediate optimal density within its optimal density range at which the population will best flourish. At the higher end of the density range, intraspecific competition (competition within a population/species) becomes heightened and resources become scarce, where as at the lower end of the optimal range we near the critical minimum density for the population at which genetic drift becomes probably due to population loss, thus some middling population density will be the most desirable for the population. The degree of aggregation and the overall density, which lead to optimum population growth, varies with species and conditions, there fore, under population (or lack of aggregation), as well as overcrowding , may be limiting for optimal density this is Allee's principle.

6.1.2. 2: Natality

Population increase because of natality. Natality is the inherent ability of a population to increase. Natality rate is equivalent to the birth rate in the terminology of human population study (demography). However there are two kinds of natality:

1. **Maximum (some times called absolute or physiological) natality-** it’s the theoretical maximum production of new individuals under ideal conditions (in other

word no ecological limiting factors, reproduction being limited only by physiological factors), it is constant for given population.

2.**Ecological or realized natality-** refer to population increase under an actual or specific environmental condition. It is not a constant for a population but may vary with the size and composition of the population and the physical environmental conditions.

✓ ***Biotic potential and environmental resistance***

The term biotic potential or reproductive potential refer to inherent power of a population to increase in numbers when the age ratio is stable and all environmental conditions are optimal. The sum of the physical and biological factors which prevent a species from reproducing at its maximum rate is termed the environmental resistance.

6.1.2.3. Mortality

Mortality refer to death of individuals in the population. Mortality rate is equivalent to death rate in human demography. Like natality, mortality may be expressed as the number of individuals dying in a given period (deaths per time). Also there are two kinds of mortality:

1.**Ecological or realized mortality** – the loss of individuals under given environmental conditions- it's like ecological natality, not a constant but varies with population and environmental conditions.

2**. Minimum mortality -** a constant for a population, which represents the loss under ideal or non limiting conditions. that is even under the best conditions individuals would die of old age determined by there physiological age.

✓ ***Survivorship curves***

The survivorship curve is a graphical description of the survival of a group of individuals in a population from birth to the maximum age reached by any one member of the population. Therefore we can find three types of survivorship curves :

- Type I survivorship curve:

  Most individuals live out their life span and die of old age (e.g., humans).

- Type II survivorship curve:

Individuals die at a constant rate (e.g., birds, rodents, and perennial plants).

- Type III survivorship curve:

  Most individuals die early in life (e.g. fishes, invertebrates, and most plants).

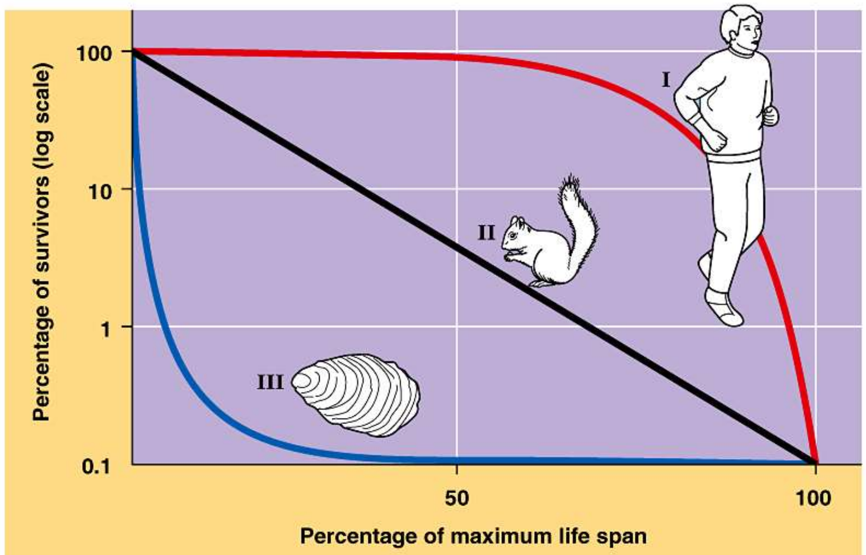


Figure 5: Survivorship curves

6.1.2.4: Population age distribution

Age structure (age distribution) - the ratio of one age class to another. Age pyramids, especially applicable to mammals and birds. Stable population of most mammals and birds has a ratio of young to adults of approximately 2:1.

Usually a rapidly expanding population will contain a large proportion of young individuals , a stationary population a more even distribution of age classes and a declining population a large proportion of old individuals.

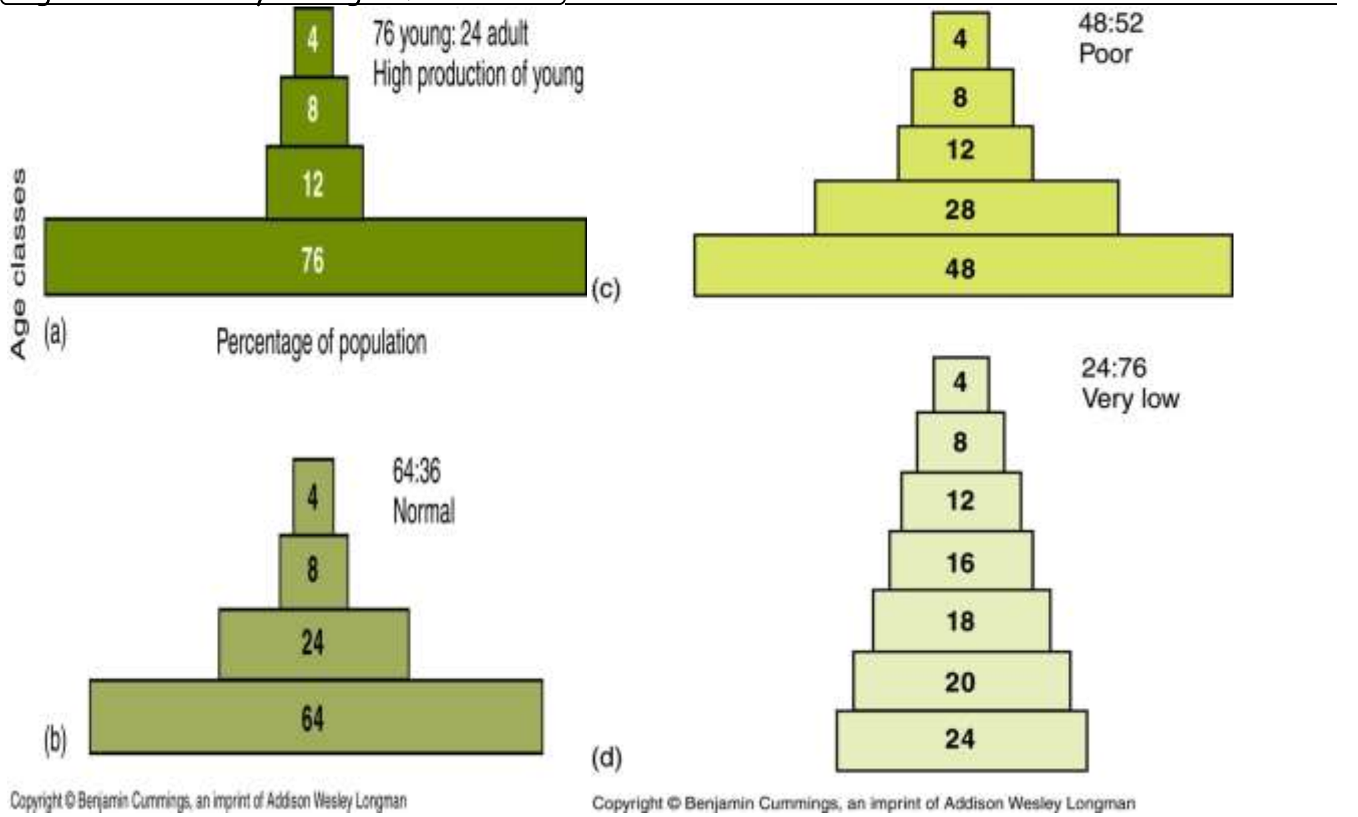


Figure 6: Age structure diagrams show how a population is distributed. The wider the base of the diagram the more individuals below the age of fifteen.

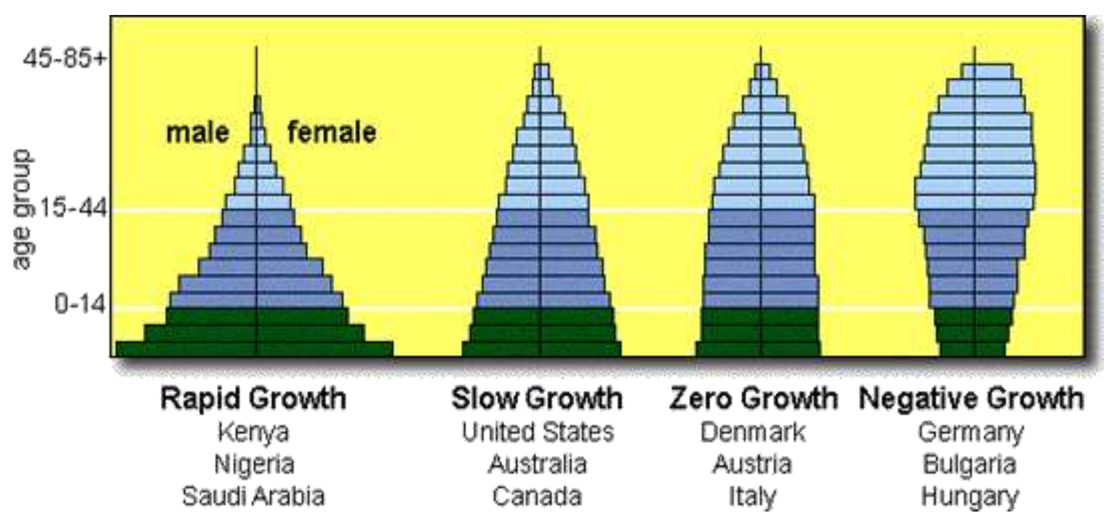


Figure 7: Age structure of the population for different countries

In so far as the population is concerned, there are three ecological ages : as pre-reproductive , reproductive, and post-reproductive. In modern man , the three ages are relatively equal in length, about a third of his life falling in each class. Many plants and animals have a vary long prereproductive period. Some animals, notably insects, have extremely long prereproductive periods, a very short reproductive period and no post reproductive period.

6.1.2.5: Population dispersal

Population dispersal is the movement of individuals or propaguls (seeds ,larvae, spores, etc.) into or out of the population or population area. It takes three forms:

1.***Emigration*** : One way out ward movement. Emigration decreases the size of local population, but the species spread to new areas.

2.***Immigration***: One way inward movement . It increases the size of local population.

3.***Migration***: Periodic departure and return. Among many animals the daily migrations in search of food and other necessities are more or less regular and well defined. Such seasonal migrations may be on any scale, ranging from the thousand-mile journeys of some birds, to the shorter journey made by aquatic worms and rotifers, when they migrate to the hot surface layers in ponds.

- ✓ ***Dispersal mechanisms***

Most animals are capable of locomotion and the basic mechanism of dispersal is movement from one place to another. Locomotion allows the organism to "test" new environments for their suitability, provided they are within the animal's range. Movements are usually guided by inherited behaviors.

1.Plant dispersal mechanisms

Seed dispersal is the movement or transport of seeds away from the parent plant. Plants have limited mobility and consequently rely upon a variety of dispersal vectors to transport their propagules, including both a biotic and biotic vectors. Seeds can be dispersed away from the parent plant individually or collectively, as well as dispersed in both space and time. The patterns of seed dispersal are determined in large part by the dispersal mechanism and this has important implications for the demographic and genetic structure of plant populations, as well as migration patterns and species interactions. There are four main modes of seed dispersal: gravity, wind, water and by animals.

2.Animals dispersal mechanisms

A: Non-motile animals

There are numerous animal forms that are non—motile, such as sponges, bryozoans, , sea anemones, corals, and oysters. In common, they are all either marine or aquatic. All of the marine and aquatic invertebrates whose lives are spent fixed to the bottom produce dispersal units. These may be specialized "buds", or motile sexual reproduction products, or even a sort of alteration of generations as in certain cnidaria. Corals provide a good example of how sedentary species achieve dispersion. Corals reproduce by releasing sperm and eggs directly into the water. The released eggs are fertilized, and the resulting zygote develops quickly into a multicellular *planula*. This motile stage then attempts to find a suitable substratum for settlement. Most are unsuccessful and die or are fed upon by zooplankton and bottom dwelling predators such as anemones and other corals. However, untold millions are produced, and a few do succeed in locating spots of bare limestone, where they settle and transform by growth into a ***polyp***. The single polyp grows into a coral head by budding off new polyps to form a colony.

B. Motile animals

The majority of all animals are motile. Although motile animals can, in theory, disperse themselves by their spontaneous and independent locomotive powers. Dispersal by water currents is especially associated with the physically small inhabitants of marine waters known as zooplankton.

C. Dispersal by dormant stages

Many animal species, especially invertebrates, are able to disperse by wind or by transfer with an aid of larger animals (birds, mammals or fishes) as dormant eggs, dormant embryos or, in some cases, dormant adult stages. Some rotifers and some copepods are able to withstand desiccation as adult dormant stages. Many other taxa (Cladocera, Bryozoa, Hydra, Copepoda and so on) can disperse as dormant eggs or embryos. Such dormant-resistant stages made possible the long-distance dispersal from one water body to another and broad distribution ranges of many freshwater animals.

6.1.2.6: Internal distribution patterns

Individuals in a population may be distributed according to three broad patterns: -

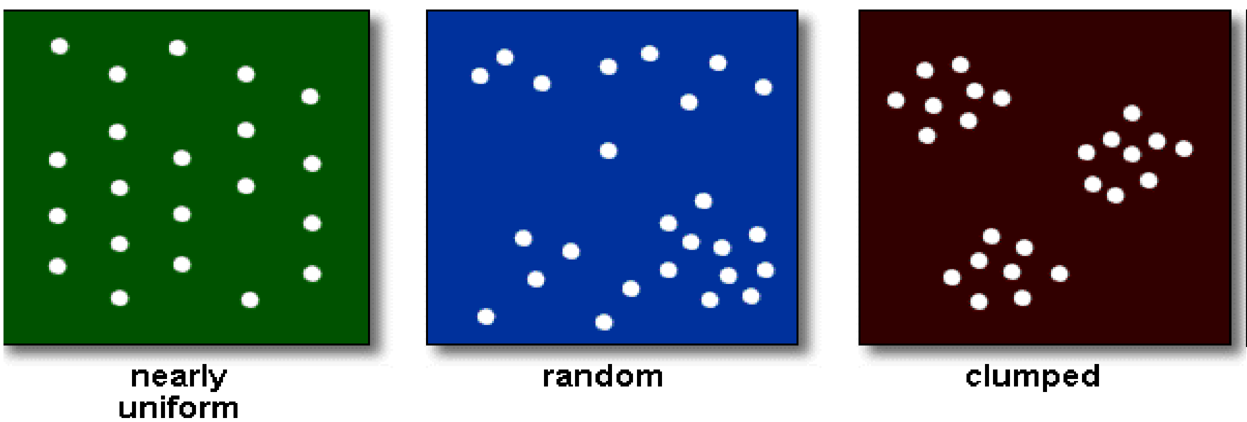
A. Clumping distribution

Clumping of varying degree represents by far the commonest pattern . All individuals of a population tend to form groups of a certain size –for example , pairs in animals ,or vegetative clones in plants. A strong tendency for plants and animals to aggregate for (or as a result of).

- In response to local habitat difference
- In response to daily and seasonal weather changes
- As a result of reproductive processes
- As the result of social attractions in higher animals

B. Uniform or regular

Regular patterns of distribution result from intraspecific competition among members of a population. However this pattern is rare in nature.



B. Random

The population is considered random if the position of each individual is independent of the others . In general, random distributions are rare, for they can occur only where:

1.The environment is uniform.

2.Resources are equally available throughout the year

3.And interaction among members of the population produces no patterns of attraction or avoidance.

Lecture 7:

7.1: Population growth models

The term population growth refers to how the number of individuals in a population increases or decreases with time. This growth is controlled by the rate at which new individuals are added to the population through the processes of birth and immigration and the rate at which individuals leave the population through the processes of death and emigration.

We refer to populations in which immigration and/or emigration occur as **open populations.** Those in which movement into and out of the population does not occur (or is not a significant influence on population growth) are referred to as **closed populations**.

- ✓ **Population growth reflects the difference between rates of birth and death**

Suppose we were to monitor a population of an organism that has a very simple life history, such as a population of freshwater hydra growing in an aquarium in the laboratory. We define the population size as $N(t)$, where t refers to time. Let us assume that the initial population is small, so that the food supply within the aquarium is much more than is needed to support the current population. How will the population change through time? Because no emigration or immigration is allowed by the lab setting, the population is closed. The number of hydra will increase as a result of new "births" (note that hydra reproduce asexually by budding). Additionally, the population will decrease as a result of some hydra dying. Because the processes of birth and death in this population are continuous ,we can define the proportion of hydra producing a new individual per unit of time as b, and the proportion of hydra dying per unit of time can be d. If we start with $N(t)$ hydra at time t, then to calculate the total number of hydra reproducing over a given time period, Δt (the symbol Δ refers to a "change"), we simply need to multiply the proportion reproducing per unit time by the total number of hydra and the length of the time period. However, the equation below represent the growth of population

$$\Delta N/\Delta t \text{ (growth)} = (b - d)\, N$$

Where , N is the initial population size

A. *Exponential Growth (J-shaped growth curve).*

If a population were suddenly presented with an unlimited environment, it would tend to expand exponentially. In other word the organisms reproduce continuously at a constant rate all the time – like humans.

The equation for population growth can be Written

$$\Delta N/\Delta t = r\,max\,N$$

Where:

ΔN = the change in number of individuals

Δt = the change in time

r = is the net reproductive rate =The difference between birth rate (b) and death rate (d).

b = the average of birth rate (includes immigrations)

d = the average of death rate (includes emigrations)

N=is the initial population size

When conditions are optimal, r is at its highest value (r max), called the specific rate of increase.

Real populations do not grow exponentially for long because of environmental limitations. This Environmental limitations include :

1.Food 2. Water 3.Space 4. Diseases 5. Density 6.Oxygen

The exponential growth model is applicable only to initial growth after colonization of an unexploited habitat so it is a transient phenomenon. Natural population growth more closely an S-shaped curve.

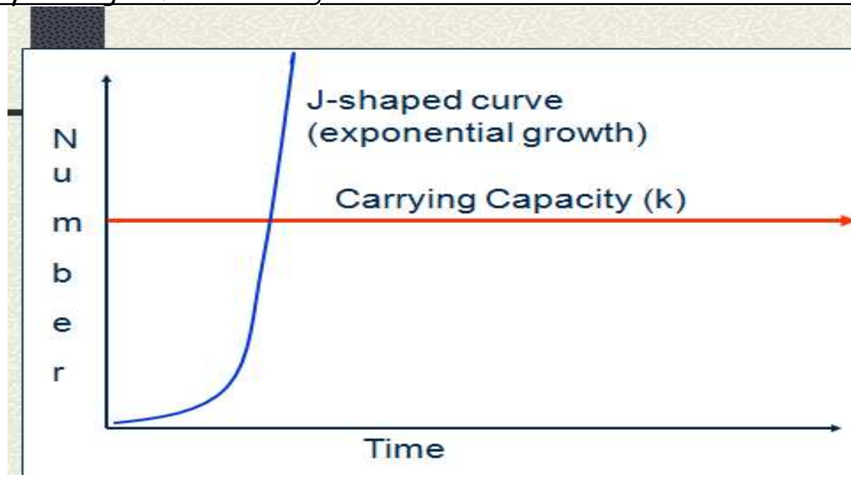


Figure 8: J-shaped growth curve

B. Logistic Growth (S-shaped growth curve)

The population in this pattern grows and then eventually levels off as the carrying capacity is reached. As population density increases, competition for available resources among its members increases (and disease etc). The effects of increasing competition on the population begin to slow the rate of growth until growth rate becomes zero and the population is at a theoretical equilibrium level with its environment. In general all populations will follow this pattern eventually. .

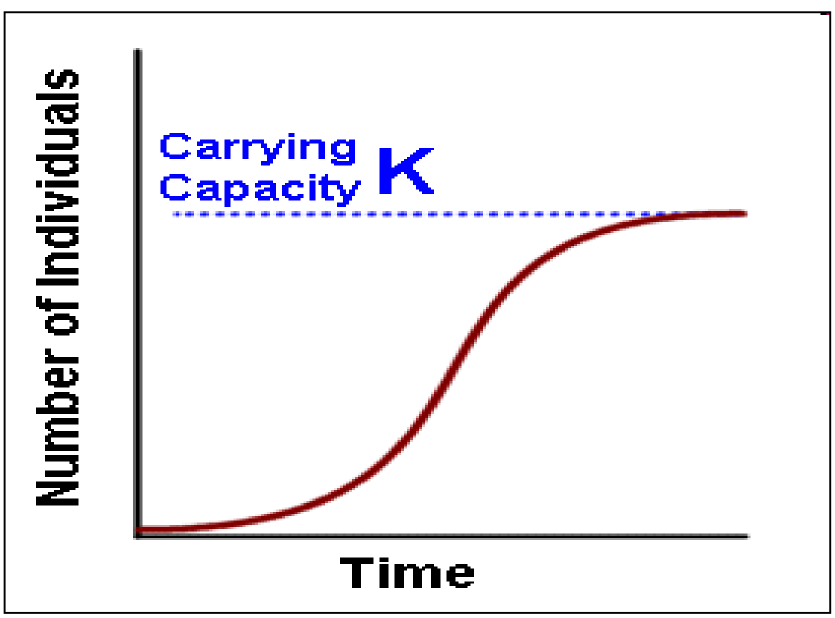


Figure 9: ***S***-shaped growth curve

Carrying Capacity (K) , is the maximum number of individuals that the environment can support. The logistic growth equation is:

$\Delta N/\Delta t = r\ max\ N\ (K-N/K)$

where:

r max = Maximum rate of increase under ideal conditions.

When N nears K, the right side of the equation nears zero.

- N/K = Environmental resistance.

7.2: Reproductive strategies

There are a wide range of reproductive strategies employed by different populations/species**.**

7.2.1: *r*/*K* selection theory

The terms *r-selection* and *K-selection* have been used by ecologists to describe the growth and reproductive strategies of various organisms.

1. *K-strategist*: They are called *k*-selected (for carrying capacity), because they are adapted to thrive when the population is near its carrying capacity. However, Population growth in *K*-selected species behaves according to the logistic growth equation. Species that follow this pattern usually.

1.Long life

2.Slower growth

3.Later maturity

4.Few, large offspring

5.High parental care and protection

6.Adapted to stable environment

7.High trophic level

***2.r-strategist*:** They are called *r*-selected species (for *rate* of increase). Population growth in *r*-selected species behaves according to the exponential growth equation. By contrast with k- selected when populations of are far below the carrying capacity, resources may be abundant. Costs of reproduction may be low , and selection will favor individuals with highest reproductive rates. Species that follow this pattern usually.

1. Short life 2.Rapid growth 3. Early maturity 4.Many small offspring
5.Little parental care and protection 6.Adapted to unstable environment
7.Low trophic level

7.3: Semelparity and Iteroparity

Semelparity and iteroparity refer to the reproductive strategy of an organism.

1.Semelparity –

The word semelparity comes from the Latin *semel* 'once, a single time' and *pario* 'to beget'. A species is considered semelparous if it is characterized by a single reproductive episode before death. A classic example of a semelparous organism is Pacific salmon which lives for many years in the ocean before swimming to the freshwater stream of its birth, spawning, and dying. Other semelparous animals include many insects, including some species of butterflies, and mayflies, and some molluscs such as octopus.

2.Iteroparity –

The term iteroparity comes from the Latin *itero*, to repeat, and *pario*, to beget. Individuals that normally experience several or many such reproductive events. During each period of reproductive activity the individual continues to survival and possibly growth, and beyond each it therefore has a chance of surviving to reproduce again. Results in overlapping generations. An example of an iteroparous organism is a human—though people may choose only to have one child, humans are biologically capable of having offspring many times over the course of their lives. Iteroparous vertebrates include all birds, most reptiles, virtually all mammals, and most fish. Among invertebrates, most mollusca and many insects (for example, mosquitoes) are iteroparous. This distinction is also related to the difference between annual and perennial plants. An annual is a plant that completes its life cycle in a single season, and is usually semelparous. Perennials live for more than one season and are usually (but not always) iteroparous.

Lecture 8:

8. Ecosystem structure: Biotic components of ecosystems

8.1: Biotic community

8.1.1 Meaning of biotic community

A biological community is a group of interacting populations that occupy the same geographic area. Also, community represent the living part of the ecosystem. There are certain features of the biotic community which include trophic organization, dominance, variety of species and the interactions between different species. Ecologists call relationships between species in a community **interspecific interactions**. Examples are competition, predation and symbiosis (parasitism, mutualism, and commensalism). Major communities are those which are sufficient size and completeness of organization that they are relatively independent, that is, they need only to receive sun energy from the outside. Minor communities are those which are more or less dependent on neighboring aggregations.

8.2.2: Concept of ecological dominance

Not all organisms in the community are equally important in determining the nature and function of the whole community of organisms. Out of the hundreds or thousands kinds that might be present in a community, a relatively certain species have a very large impact on community structure by their number, size, production or other activities. Such species are highly abundant or play a vital role in community dynamics which are called **Dominant species.** **Dominant species** are those that are most abundant or have the highest biomass and exert powerful control over the occurrence and distribution of other species. While the term **Keystone species** refer to the species which exert strong control on a community by their ecological roles. In contrast to dominant species, they are not necessarily abundant in a community.

8.2.3:Ecotone

An ecotone is a transitional area between two different ecosystems, such as a forest and grassland. In terrestrial ecology, an ecotone is the border area where two patches meet that has different ecological composition. The ecotone contains elements of both bordering communities as well as organisms which are characteristic and restricted to the ecotone. Ecotones can be a wide zone where two communities gradually change from one to another. Ecotones are not limited to terrestrial communities; for example, the transition from soft bottom to hard bottom marine communities is an aquatic ecotone. Ecotones often have a larger number of species and larger population densities than the communities on either side. This tendency for increased biodiversity within the ecotone is referred to as the "edge effect." Those species which occur most abundantly in the ecotones are called "edge" species. Because such an area contains habitats common to both communities as well as others unique to the transition zone itself, the edge effect is typically characterized by greater species diversity and population density than occur in either of the individual communities. Although ecotones support an increase in density for some species, other species need interior habitat to survive and show avoidance or poor survival on edges. An increase in anthropogenic fragmentation of land creates more ecotones, which may result in an increased occurrence of edge species, while in same time resulting in increased negative effects for interior species.

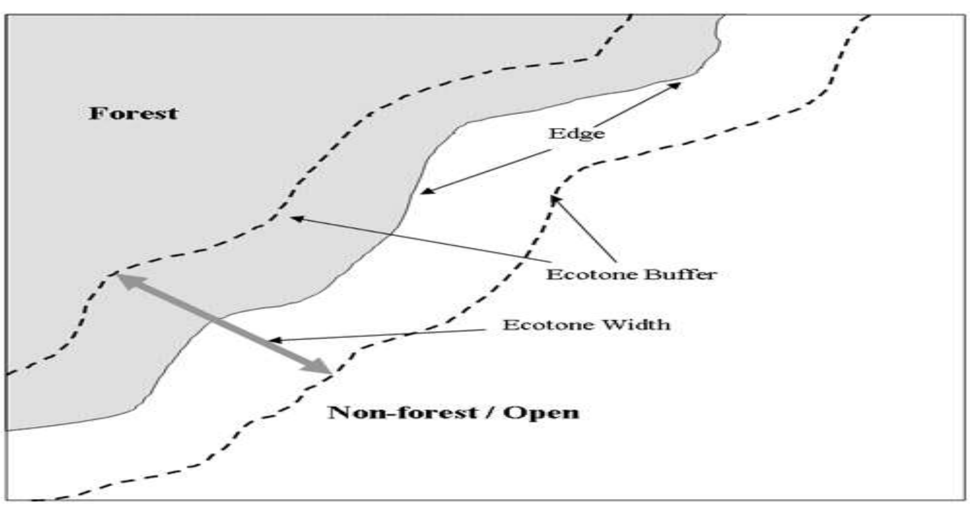


Figure 10: A transition zone or ecotone

8.2.4: Ecological Succession

Decades ago, most ecologists preferred the view that communities are in a state of equilibrium**.** Recent evidence of change has led to a nonequilibrium model, which describes communities as constantly changing after being affected by disturbances (is an event that changes a community, removes organisms from it, and alters resource availability).

Ecological succession is the sequence of community and ecosystem changes after a disturbance. There are two types of ecological succession – primary succession and secondary succession. The community begins with relatively few pioneering plants and animals and develops through increasing complexity until it becomes stable (climax community).

8.2.4.1: Pioneer species

Pioneer species are first organisms to become established in an ecosystem undergoing succession, for example, lichens and algae that colonize bare rocks. In general, pioneer species are autotrophs (like autotrophic bacteria, herbaceous plants, lichens). The pioneer community is formed of species able to survive under hostile environments. The presence of pioneer species helps to create soil by secreting acids that help to break down rocks. As the pioneer organisms die, their decaying organic materials, along with bits of sediment from the rocks, makeup the first stage of soil development. Therefore, they open the way to other species to establish in the place by the creation of new potential ecological niches.

8.2.4.2: *Primary ecological succession and secondary ecological succession*

Primary ecological succession is the establishment of a community in an area of exposed rock that does not have any top soil begins with colonization and establishment of pioneer species. Secondary ecological succession is the return of an area to its natural vegetation following a disruption or removal of the original climax community. Secondary Succession often occurs as a result of a natural disturbance, such as, fire, flood, or a wind storm. In this situation, organic matter and some organisms from the original community will remain; thus the successional process does not start from scratch. As a result, secondary succession is more rapid than primary. It is seen in areas burned by fire or cut by farmers for cultivation.

8.2.4.3:Climax Community

A climax community is the final stage of succession, remaining relatively unchanged until destroyed by an event such as fire or human interference. Altered ecosystems may reach a point of stability that can last for hundreds or thousands of years. A climax community persists until a catastrophic change of a major biotic or a biotic nature alters or destroys it (Ex. forest fires, floods, areas where the topsoil has been removed). **An ecosystem characteristics at immature and mature stages of ecological succession** are listed below

Characteristic	**Ecosystem (Early Successional Stage)**	**Ecosystem (Late Successional Stage)**
1.Plant size	Small	Large
2.Species diversity	Low	High
3.Trophic structure	Mostly producers, few decomposers	Mixture of producers, consumers, and decomposers
4.Ecological niches	Few, mostly generalized	Many, mostly specialized

8.3:Habitat and the ecological Niche

Every organism has a habitat and a niche. The habitat of an organism is the place where it lives, or the place where one would go to find it. The ecological niche on the other hand, is more inclusive term that includes not only the physical space occupied by an organism, but also its functional role in the community. In other word, a habitat is all aspects of the area in which an organism lives included biotic factors and a biotic factors, while the ecological niche of an organisms depends not only on where it lives but also what it does(how transforms energy, behaves, responds to and modifies its physical and biotic environment), and how it is constrained by other species. By analogy, it may said that the habitat is the organism's address and the niche is its profession in biological speaking. In general, the organisms that occupy the same or similar ecological niches in different ecological regions are known as **ecological equivalents**. Species that occupy equivalent niches tend to be closely related taxonomically in regions which are neighboring, but are often not closely related in regions which are widely separated or isolated from one another.

- ✓ ***The competitive exclusion and character displacement***

Species can share habitats and resources thus the competition occurs when two species use resources in the same way. Ecologically similar species can coexist in a community if there are one or more significant differences in their niches**.** Interspecific competition for resources can occur when resources are in short supply. The competitive exclusion principle can be restated to say that two species cannot coexist in a community if their niches are identical. Therefore the competitive exclusion principle demonstrate that the two species with similar needs for same limiting resources cannot coexist in the same place. One species is better suited to the niche and the other will either be pushed out or become extinct. One of the famous experimental studies of interspecific competition is that carried out in the laboratory of Dr. Thomas Park. Park and his students work with flour beetles , especially those belonging to the genus Tribolium. These small beetles can complete their life history in a very simple and homogenous habitat (a jar of flour or wheat bran). The investigators found that when two different species of Tribolium are placed in this homogeneous habitat one species is eliminated sooner or later while the other continues to thrive .One species always wins, or to put it another way, two species of Triboliumcan not survive in this particular ecosystem . One species (*T. castaneum*) always wins under conditions of high temperature and humidity, while the other (*T. confusum*) always wins under cool-dry conditions. Also, species that occur in different geographical regions(or separated by special barrier) are said to be allopatric , while those occurring in the same area (but not necessarily the same niche) are said to be sympatric species. Character displacement is the tendency for characteristics to be more divergent in sympatric populations of two species than in allopatric populations of the same two species. In the area of overlap, where the two species occur together, the populations are more divergent and easily distinguished one another in one or more characteristics such as morphological, ecological, behavioral or physiological, they are assumed to be genetically based. Character displacement has two adaptive values;

1. It enhances niche displacement, thus reducing competition
2. It enhances genetic isolation (i.e. preventing hybridization) and thereby maintains a greater species diversity in the community.

Lecture 9:

9: Ecosystem function– Energy flow through ecosystem

The ultimate source of energy for all ecological systems is the sun. The energy that enters the earth's atmosphere as heat and light is balanced by the energy that is absorbed by the biosphere, plus the amount that leaves the earth's surface as invisible heat radiation (first law of thermodynamics which refer to the energy can neither be created nor destroyed but only transformed from one form to another).

When solar energy strikes the earth, it tends to be degraded into heat energy. Only a very small part (about 10 per cent) of this energy gets absorbed by the green plants, and is subsequently transformed into food energy. The food energy then flows through a series of organisms in ecosystems. All organisms, dead or alive, are potential sources of food for other organisms. Food chains and energy flow are the functional properties of ecosystems which make them dynamic. The biotic and a biotic components of an ecosystem are linked through them.

9.1: Food Chain

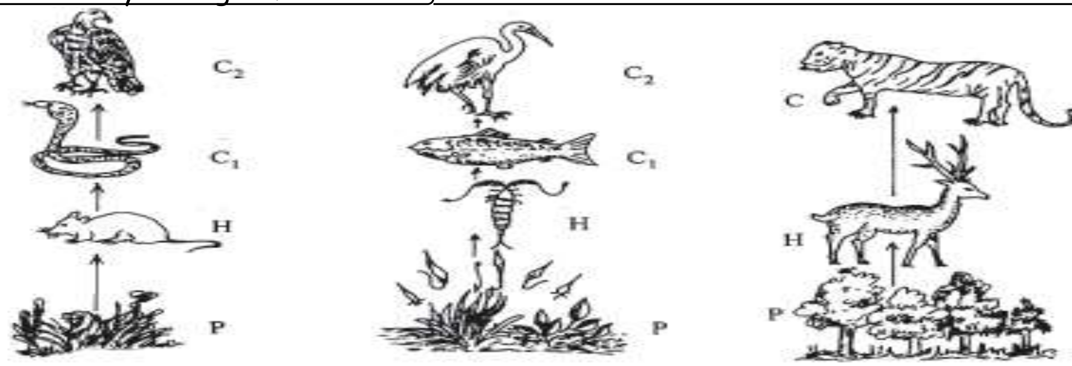
Transfer of food energy from green plants (producers) through a series of organisms with repeated eating and being eaten is called a food chain. e.g.

$Grasses \rightarrow Grasshopper \rightarrow Frog \longrightarrow Snake \rightarrow Eagle$

Each step in the food chain is called **trophic** .

In the above example grasses are 1st, and eagle represents the 5th trophic level.

Some more example of food chain are given in fig**ure** 11.



P = Producer, H = Herbivore, C = Carnivore, C1 = First level carnivore, C2 = Top Carnivore

Figure 11: shows some examples of food chain

During this process of transfer of energy some energy is lost into the system as heat energy and is not available to the next trophic level. Therefore, the number of steps are limited in a chain to 4 or 5.

Following trophic levels can be identified in a food chain.

(1) **Autotrophs:** They are the producers of food for all other organisms of the ecosystem. They are largely green plants and convert inorganic material in the presence of solar energy by the process of photosynthesis into the chemical energy (food). The total rate at which the radiant energy is stored by the process of photosynthesis in the green plants is called **Gross Primary Production** (GPP). This is also known as total photosynthesis or total assimilation. From the gross primary productivity a part is utilized by the plants for its own metabolism. The remaining amount is stored by the plant as **Net Primary Production** (NPP) which is available to consumers.

(2) **Herbivores:** The animals which eat the plants directly are called primary consumers or herbivores e.g. insects, birds, rodents and ruminants.

(3) **Carnivores:** They are secondary consumers if they feed on herbivores and tertiary consumers if they use carnivores as their food. e.g. frog, dog, cat and tiger.

(4) **Omnivores:** Animals that eat both plant and animals e.g. pig, bear and man

(5) **Decomposers:** They take care of the dead remains of organisms at each trophic level and help in recycling of the nutrients e.g. bacteria and fungi.

There are two types of food chains:

(i) **Grazing food chains:** which starts from the green plants that make food for herbivores and herbivores in turn for the carnivores.

(ii) **Detritus food chains:** start from the dead organic matter to the detrivore organisms which in turn make food for protozoan to carnivores etc.

In an ecosystem the two chains are interconnected and make y-shaped food chain. These two types of food chains are:-

(i) Producers → Herbivores → Carnivores

(ii) Producers → Detritus Feeders → Carnivores

The significance of studying food chains

1. It helps in understanding the feeding relations and interactions among different organisms of an ecosystem.
2. It explain the flow of energy and circulation of materials in ecosystems.
3. It help in understanding the concept of biomagnification in ecosystems.

9.2: Food web

Trophic levels in an ecosystem are not linear rather they are interconnected and make a food web. Thus food web is a network interconnected food chains existing in an ecosystem. One animal may be a member of several different food chains. Food webs are more realistic models of energy flow through an ecosystem .

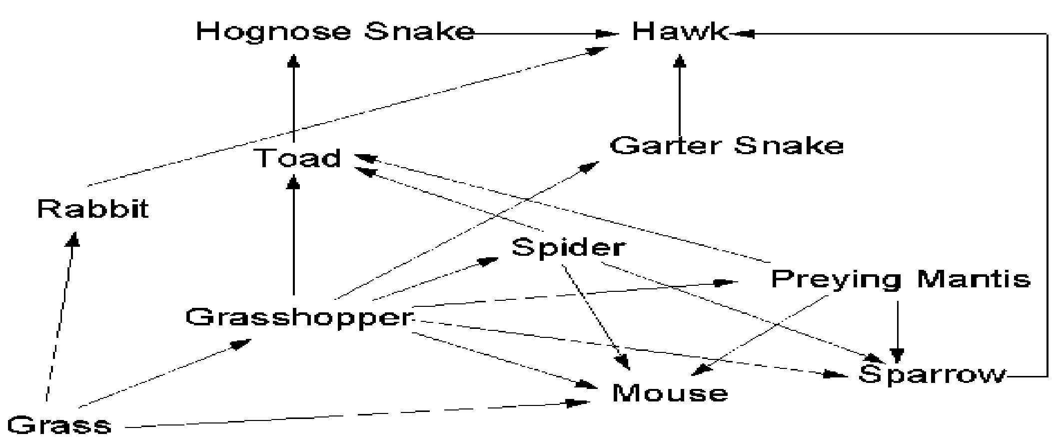


Figure 12: Simple food web

The flow of energy in an ecosystem is always linear or one way. The quantity of energy flowing through the successive trophic levels decreases as shown by the reduced sizes of boxes in figure 13. At every step in a food chain or web the energy received by the organism is used to sustain itself and the left over is passed on to the next trophic level.

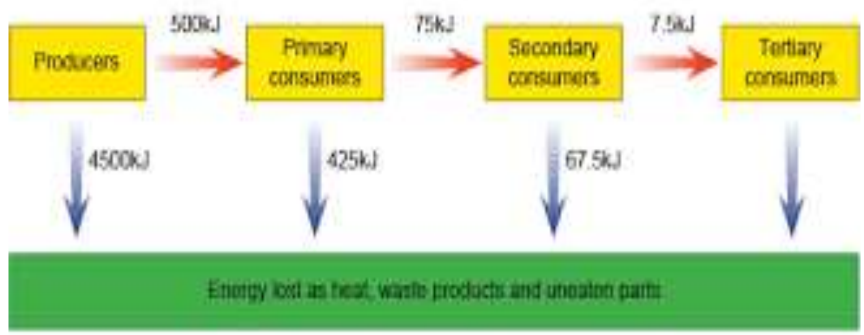


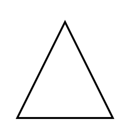
Figure 13: Model of energy flow through an ecosystem

9.3 Ecological pyramids

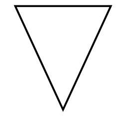
Ecological pyramids are the graphic representations of trophic levels in an ecosystem. They are pyramidal in shape and they are of three types: The producers make the base of the pyramid and the subsequent tiers of the pyramid represent herbivore, carnivore and top carnivore levels.

(1) **Pyramid of number:** This represents the number of organisms at each trophic level. For example in a grassland the number of grasses is more than the number of herbivores that feed on them and the number of herbivores is more than the number of carnivores.
In some instances the pyramid of number may be inverted, i.e herbivores are more than primary producers as you may observe that many caterpillars and insects feed on a single tree.

Therefore ,there are two kinds of this pyramid.

A- The primary producers are small in size with high numbers. 

B- The primary producers are large in size with few numbers.



(2) **Pyramid of biomass:** This represents the total standing crop biomass at each trophic level. **Standing crop biomass** is the amount of the living matter at any given time. It is expressed as gm/unit area or kilo cal/unit area. In most of the terrestrial ecosystems the pyramid of biomass is upright. However, in case of aquatic ecosystems the pyramid of biomass may be inverted e.g. in a pond phytoplankton are the main producers, they have very short life cycles and a rapid turn over rate (i.e. they are rapidly replaced by new plants). Therefore, their total biomass at any given time is less than the biomass of herbivores supported by them.

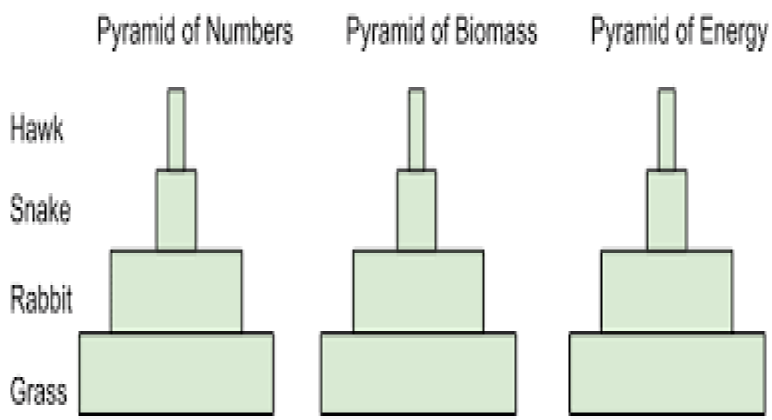


Figure14: Ecological pyramids

(3) **Pyramid of energy:** This pyramid represents the total amount of energy at each trophic level. Energy is expressed in terms of rate such as k cal/unit area /unit time or cal/unit area/unit time. eg. in a lake autotroph energy is 20810 kcal/m/year. Energy pyramids are never inverted.

It is clear from the trophic structure of an ecosystem that the amount of energy decreases at each subsequent trophic level. This is due to two reasons:

1. At each trophic a part of the available energy is lost in respiration or used up in metabolism.

2. A part of energy is lost at each transformation, i.e. when it moves from lower to higher trophic level as heat. The percentage of usable chemical energy transferred as biomass from one trophic level to the next is called **ecological efficiency.** It ranges from 2% to 40% (that is, a loss of 60–98%) depending on what types of species and ecosystems are involved, but 10% is typical.

Assuming 10% ecological efficiency (90% loss of usable energy) at each trophic transfer, if green plants in an area manage to capture 10,000 units of energy from the sun, then only about 1,000 units of chemical energy will be available to support herbivores, and only about 100 units will be available to support carnivores. The more trophic levels there are in a food chain or web, the greater is the cumulative loss of usable chemical energy as it flows through the trophic levels.

The **pyramid of energy flow** in Figure 15 illustrates this energy loss for a simple food chain, assuming a 90% energy loss with each transfer. The energy flow in ecosystem with one direction from solar energy to producers, consumers and at last to decomposers, in each step there is losing of this energy as heat.

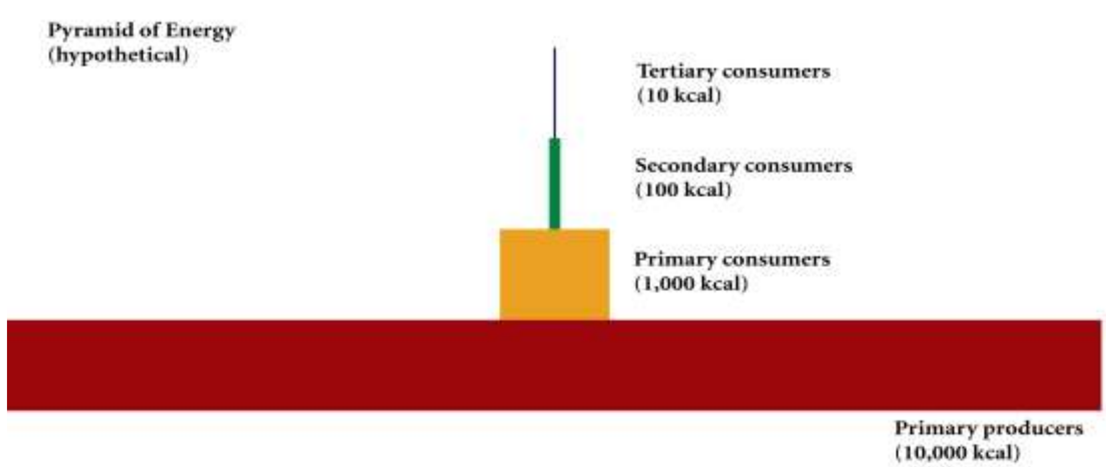


Figure 15: pyramid of energy

9.4: **Productivity of ecosystem: Primary, Secondary and Net Productivity**

Most solar energy occurs at wavelengths unsuitable for photosynthesis. Between 98 and 99 percent of solar energy reaching the Earth is reflected from leaves and other surfaces and absorbed by other molecules, which convert it to heat. Thus, only 1 to 2 percent is available to be captured by plants.

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:

1. **Primary productivity**

It is defined as the rate of which radiant energy is stored by the producers, most of which are photosynthetic, and to a much lesser extent the chemosynthetic microorganisms. Organisms responsible for primary production include land plants, marine algae and some bacteria (including cyanobacteria).

Primary productivity is of following types:

(a) Gross primary productivity:

It refers to the total rate of photosynthesis including the organic matter used up in respiration during the measurement period. Much of the energy assimilated by plants through photosynthesis is not stored as organic material but instead is used during cellular respiration. In this process organic compounds such as carbohydrates, proteins, and fats are broken down, or oxidized, to provide energy (in the form of adenosine triphosphate [ATP]) for the cell's metabolic needs.

(b) Net primary productivity (NPP):

Also known as apparent photosynthesis or net assimilation, it refers to the rate of storage of organic matter in plant tissues in excess of the respiratory utilisation by plants during the measurement period. Therefore, NPP = GPP - respiration [by plants]

About 40 to 85 percent of gross primary productivity is not used during respiration and becomes net primary productivity. Both gross and net primary productivity are in units of mass per unit area per unit time such as grams per square meter per year ($g/m^2/yr$).

2. Secondary productivity:

It is the rate of energy storage at consumer's levels-herbivores, carnivores and decomposers. Consumers tend to utilize already produced food materials in their respiration and also converts the food matter to different tissues by an overall process. Some ecologists such as Odum (1971) prefer to use the term assimilation rather than 'production' at this level-the consumer's level. It actually remains mobile (i.e., keeps on moving from one organism to another) and does not live in situ like the primary productivity.

3. Net Productivity:

It refers to the rate of storage of organic matter not used by the heterotrophs or consumers, i.e., equivalent to net primary production minus consumption by the heterotrophs during the unit period, as a season or year etc. It is thus the rate of increase of biomass of the primary producers which has been left over by the consumers.

Lecture 10:

10: Ecosystem function– Biogeochemical cycles (cycling of nutrients in ecosystem)

In ecosystems flow of energy is linear but that of nutrients is cyclical. This is because energy flows down hill i.e. it is utilized or lost as heat as it flows forward .The nutrients on the other hand cycle from dead remains of organisms released back into the soil by detrivores which are absorbed again i.e. nutrient absorbed from soil by the root of green plants are passed on to herbivores and then carnivores. The nutrients locked in the dead remains of organisms and released back into the soil by detrivores and decomposers. This recycling of the nutrients is called **biogeochemical or nutrient cycle** (Bio = living, geo = rock chemical = element). There are more than 40 elements required for the various life processes by plants and animals. The entire earth or biosphere is a closed system i.e. nutrients are neither imported nor exported from the biosphere.

There are two important components of a biogeochemical cycle

1. Reservoir pool – atmosphere or rock, which stores large amounts of nutrients.

2. **Cycling pool or compartments of cycle-** There are three kinds of these cycles:

1- **Hydrological cycle:** deal with the cycling of water in ecosystem.
2- **Gaseous cycle:** deals with gases cycling in ecosystem, the living organisms have a main role in it with it environment such as carbon and nitrogen.
3- **Sedimentary cycle:** deals with chemical elements cycling in ecosystem, also living organisms are with a main role in it with its environment such as sulfur and Phosphorus.

You shall now learn about the bio-geo chemical cycles carbon , nitrogen and phosphor

10.1: Gaseous cycles

10.1.1: Carbon cycle

The **carbon cycle** is the biogeochemical cycle by which carbon is exchanged among the biosphere, pedosphere, geosphere, hydrosphere, and atmosphere of the Earth. The source of all carbon is carbon dioxide present in the atmosphere. It is highly soluble in water; therefore, oceans also contain large quantities of dissolved carbon dioxide. The global carbon cycle consists of following steps-

• **Photosynthesis**

Green plants in the presence of sunlight utilize CO2 in the process of photosynthesis and convert the inorganic carbon into organic matter (food) and release oxygen. A part of the food made through photosynthesis is used by plants for their own metabolism and the rest is stored as their biomass which is available to various herbivores, heterotrophs, including human beings and microorganisms as food. Annually 4-9 $x10^{13}$ kg of CO2 is fixed by green plants of the entire biosphere. Forests acts as reservoirs of CO2 as carbon fixed by the trees remain stored in them for long due to their long life cycles. A very large amount of CO2 is released through forest fires.

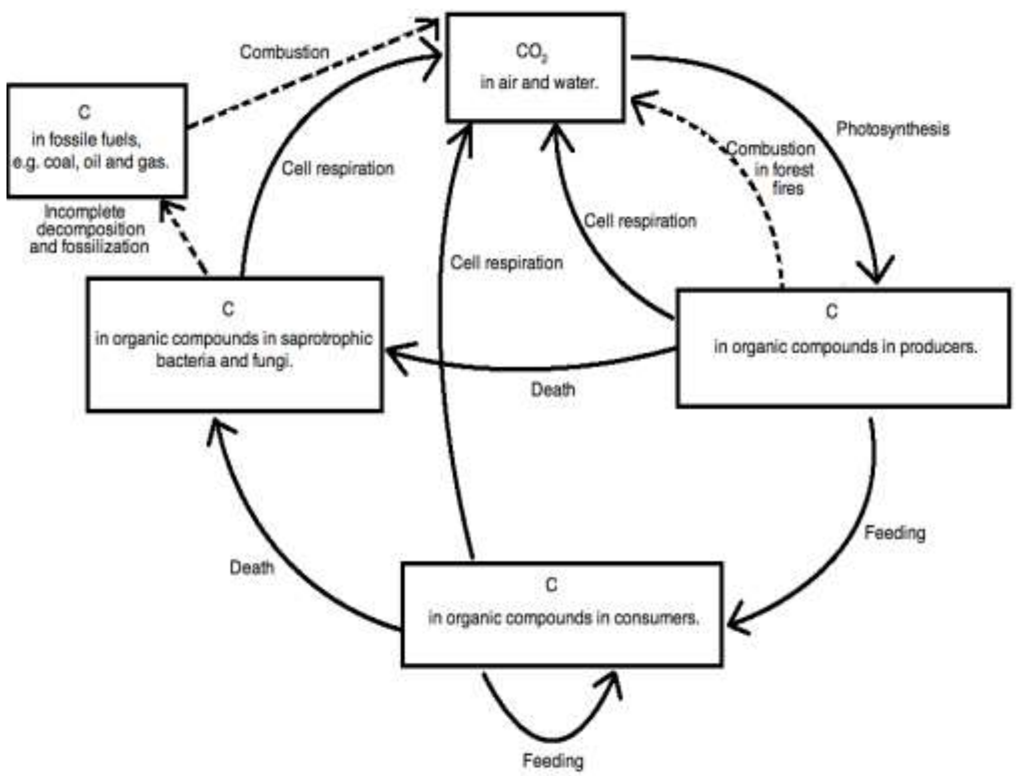


Figure 16: Carbon cycle

- **Respiration**

Respiration is carried out by all living organisms. It is a metabolic process where food is oxidized to liberate energy, CO_2 and water. The energy released from respiration is used for carrying out life processes by living organism (plants, animals, decomposers etc.).
Thus CO_2 is released into of the atmosphere through this process.

- **Decomposition**

All the food assimilated by animals or synthesized by plant is not metabolized by them completely. A major part is retained by them as their own biomass which becomes available to decomposers on their death. The dead organic matter is decomposed by microorganisms and CO_2 is released into the atmosphere by decomposers.

- **Combustion**

Burning of biomass releases carbon dioxide into the atmosphere.

✓ **Impact of human activities**

The global carbon cycle has been increasingly disturbed by human activities particularly since the beginning of industrial revolution . Large scale deforestation and ever growing consumption of fossil fuels by growing numbers of industries, power plants and automobiles are primarily responsible for increasing emission of carbon dioxide.
Carbon dioxide has been continuously increasing in the atmosphere due to human activities such as industrialization, urbanization and increasing use and number of automobiles. This is leading to increase concentration of CO_2 in the atmosphere, which is a major cause of global warming.

Lecture 11:

11.1: Nitrogen cycle

Nitrogen is an essential component of protein and required by all living organisms including human beings.

Our atmosphere contains nearly 79% of nitrogen but it can not be used directly by the majority of living organisms. Broadly like corbon dioxide, nitrogen also cycles from gaseous phase to solid phase then back to gaseous phase through the activity of a wide variety of organisms. Cycling of nitrogen is vitally important for all living organisms. There are five main processes which essential for nitrogen cycle are elaborated below.

(a) **Nitrogen fixation:** This process involves conversion of gaseous nitrogen into Ammonia, a form in which it can be used by plants. Atmospheric nitrogen can be fixed by the following three methods:-

(i) **Atmospheric fixation**: Lightening, combustion and volcanic activity help in the fixation of nitrogen.

(ii) **Industrial fixation**: At high temperature (400^{o}C) and high pressure (200 atm.), molecular nitrogen is broken into atomic nitrogen which then combines with hydrogen to form ammonia.

(iii) **Bacterial fixation**: There are two types of bacteria-

(i) Symbiotic bacteria e.g. Rhizobium in the root nodules of leguminous plants.

(ii) Freeliving or symbiotic e.g. 1. *Nostoc* 2. *Azobacter* 3. Cyanobacteria can combine atmospheric or dissolved nitrogen with hydrogen to form ammonia.

(b) **Nitrification:** It is a process by which ammonia is converted into nitrates or nitrites by *Nitrosomonas* and *Nitrococcus* bacteria respectively. Another soil bacteria *Nitrobacter* can covert nitrate into nitrite.

(c) **Assimilation:** In this process nitrogen fixed by plants is converted into organic molecules such as proteins, DNA, RNA etc. These molecules make the plant and animal tissue.

(d) **Ammonification** : Living organisms produce nitrogenous waste products such as urea and uric acid. These waste products as well as dead remains of organisms are converted back into inorganic ammonia by the bacteria This process is called ammonification. Ammonifying bacteria help in this process.

(e) **Denitrification:** Conversion of nitrates back into gaseous nitrogen is called denitrification. Denitrifying bacteria live deep in soil near the water table as they like to live in oxygen free medium. Denitrification is reverse of nitrogen fixation.

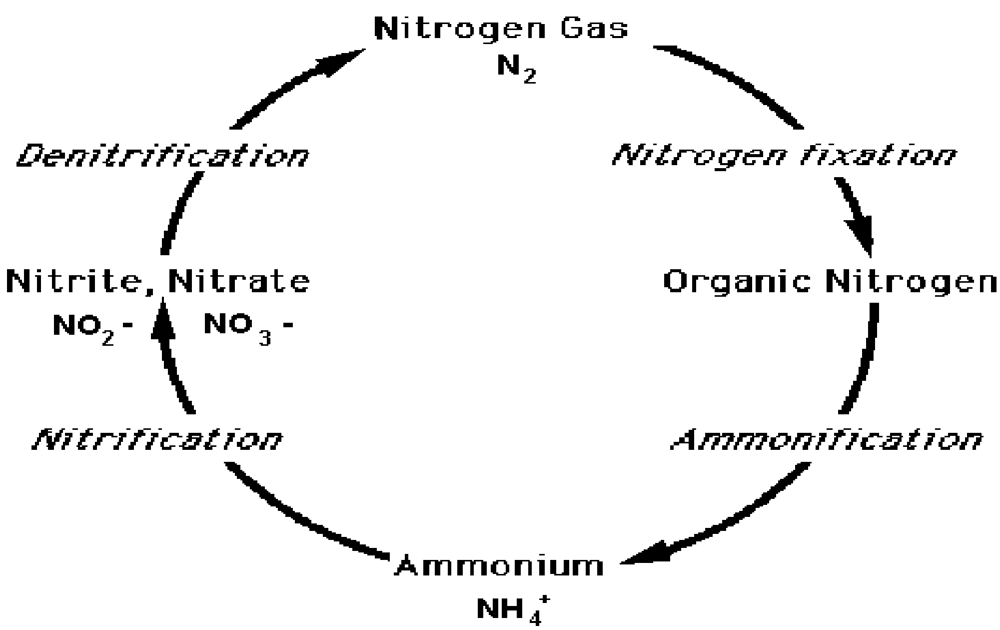


Figure 17: Nitrogen cycle

11.2: Sedimentary cycles

Usually the elements that contain in sedimentary cycle ended in milestones and then release with slowly transport, and is very difficult to close the cycle , so called **incomplete cycles**, while the elements in gaseous cycles and water cycle transport easy ,so it can considerable **complete cycles**.

11.2.1**: Phosphorus cycle:**

Phosphorus is an essential mineral nutrient for all plants and animals. Phosphorus forms the ions the of phosphates and hydrogen phosphates. These phosphates are important parts of DNA molecules and are also a part of energy storing molecules like the ATP and ADP and also fat molecules of the cell membranes. Phosphorus is also a building block of certain parts like bones and teeth in humans and animals. Phosphorus occurs most abundantly in nature as part of the orthophosphate ion $(PO_4)^{3-}$, consisting of a P atom and 4 oxygen atoms. On land most phosphorus is found in rocks and minerals.

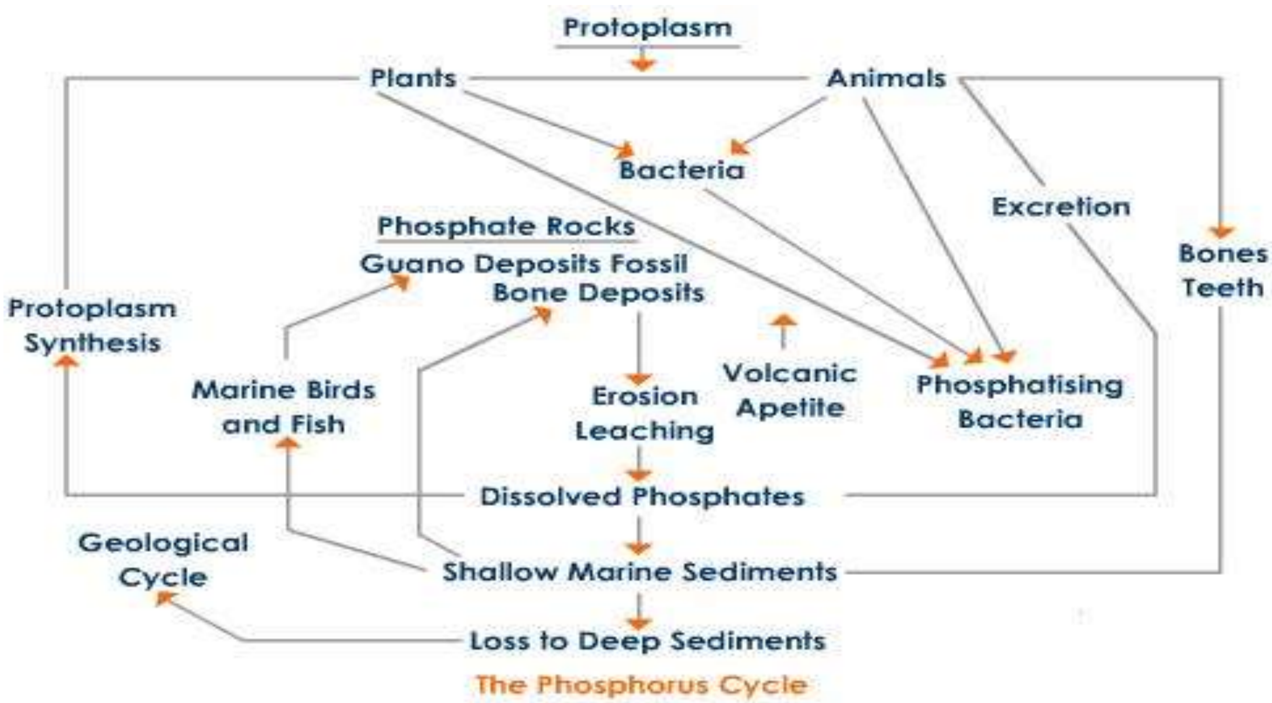


Figure 18: Phosphorus cycle

Phosphorus is found in water, soil and sediments, it cannot be found in air in the gaseous state like other compounds of matter cycles. It is found mainly cycling through soil, sediments and water. The phosphorus cycle is the slowest of the biogeochemical cycles. Phosphorus enters the environment from rocks and from deposits. Phosphate rock is commercially known as apatite and other deposits from the fossilized bone or bird droppings. Weathering of rocks releases phosphorus as ions which are soluble in water. Terrestrial plants need phosphate as fertilizers in the form of nutrients. Human influences on the phosphate cycle come mainly from the introduction and use of commercial synthetic fertilizers. The phosphate is obtained through mining of certain deposits of calcium phosphate called apatite. Huge quantities of sulfuric acid are used in the conversion of the phosphate rock into a fertilizer product called "super phosphate". Other human sources of phosphate are in the out flows from municipal sewage treatment plants. Without an expensive tertiary treatment, the phosphate in sewage is not removed during various treatment operations. Again an extra amount of phosphate enters the water.

Lecture 12:

12: Ecosystem diversity: Freshwater ecosystems

12.1:Introduction

Freshwater ecology is a specialized sub branch of the overall study of organisms and the environment. Unlike biology, ecology refers to the study of not just organisms but how they react, and are affected by the natural surrounding environment or ecosystem. Freshwater Ecology is a study of the interrelationships between freshwater organisms and their natural environments**.**

Fresh water habitats occupy a relatively small portion of the earth surface as compared to marine and terrestrial habitats, but the importance to man is far greater than their area for the following reasons

1. They are the most covenantal and cheapest sources of water for different domestic and industrial needs
2. The fresh water ecosystems the more convenient and cheapest waste disposal systems

There are generally three types of freshwater ecosystems: Lotic Systems, lentic systems, and freshwater wetlands.

12.2: Lentic systems (standing water)

Lentic systems include standing bodies of water, such as lakes and ponds. No sharp distinction between lakes and ponds. However, there are important ecological differences, other than overall size. In lake the limentic and profundal zones are relatively large, compared with littoral zone. The reverse is true in ponds, also continuous circulation of water in ponds, while the lakes tend to become stratified at certain seasons .

- ✓ ***Classification of Lakes***

Lakes may be classified according to their trophic status (i.e., their available phosphate content and biological productivity):

1. *Oligotrophic Lakes*—those with low phosphate concentrations and resulting low productivity.

2.*Mesotrophic Lakes*—those with moderate phosphate concentrations and resulting moderate productivity

3. *Eutrophic Lakes*—those with high phosphate concentrations and resulting high productivity.

4.Highly colored, low pH lakes resulting from high humic concentrations are termed *dystrophic lakes* .

- ✓ **Light penetration and thermal stratification**

Ponds or lakes are divided into two layers due to a decreases in light intensity with increasing depth - as light is absorbed by the water and suspended microorganisms.

- Upper **photic zone** is the layer where light is sufficient for photosynthesis.
- Lower **aphotic zone** receives little light and no photosynthesis occurs.

Temperature stratification also occurs in deeper ponds and lakes during summer in temperate zones. Over time, two distinctly different layers of water become established, separated by a large temperature difference and providing unique ecological niches for organisms. This process is called **stratification**.

The surface area is deemed the **epilimnion**, which is warmed water as a result of direct contact with sunlight. The lower layer is deemed the **hypolimnion,** found below the water surface, and due to increased depth, receives less heat from the sun, as a result only the warm top layer circulates, and does not mix with the more colder water, creating a zone with a steep temperature gradient in between called **thermocline**.

The oxygen supply becomes depleted in the hypolimnion since both the green plants and the surfaces sources is cut off. Distribution of plants and animals in a lake or pond shows stratification based on water depth and distance from the shore.

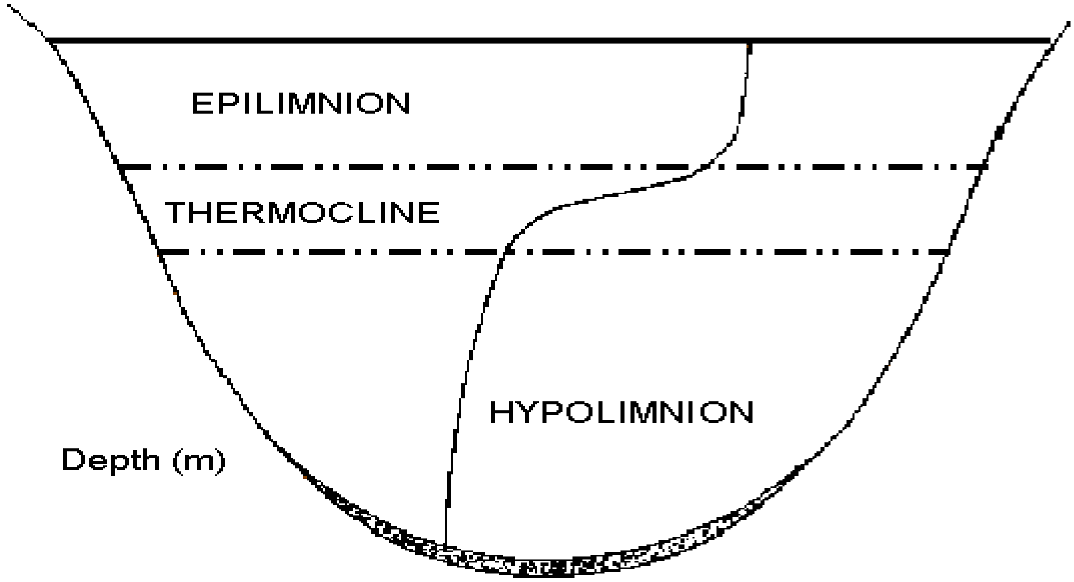


Figure 19: Thermal stratification in lake

✓ Still water animals

Through millions of years of evolution, animals living in an aquatic environment have diversified to occupy the ecological niches available in the ecosystem. When studying the habitats of these particular organisms, three main areas of the freshwater environment can be distinctly classified. Organisms may be classified as to region or sub habitat . In the ponds and lakes three zones are generally evident as shown in figure 20.

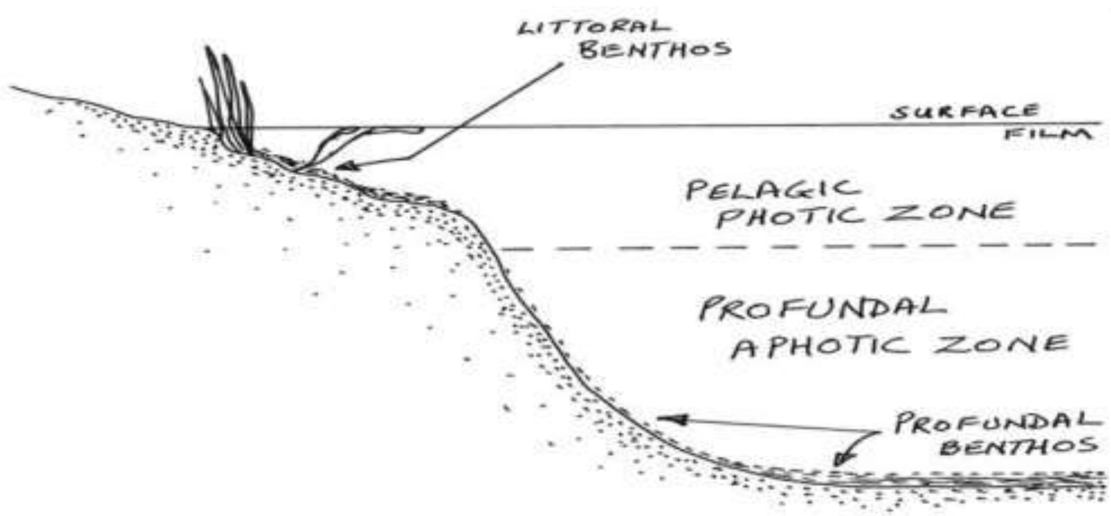


Figure 20: The major zones of Pond or Lake

1.**Littoral zone -**The shallow water region with light penetrations to the bottom typically occupied by rooted plants in ponds and lakes .

2.**The limentic zone** – the open water zone to the depth of effective light (pelagic zone). The community in this zone is composed only of plankton, nekton and some time neuston. This zone is absent in small shallow ponds.

3.**The profundal zone -** An area of still water that receives no sunlight therefore lacks autotrophic creatures. The animals in this zone rely on organic material as a means of food, which is sourced from the more energy rich areas above the profundal region.

12.3: Lotic systems (running water)

Lotic systems include flowing water, such as rivers and streams. Rivers and streams are places where water is being transported from one place to another. With few exceptions, rivers take the water that collects in a watershed and ultimately deposits that water in the ocean. Along the way, the river biome serves as an important life-giving source to many plants and animal. It seems that the currents factor is the most important factor that distinguishes lotic environments for the lentic environments, as well as other factors listed in the following table:

Characteristic	Streams (Lotic System)	Lakes (Lentic System)
Water flow	One direction of flow, upstream to downstream	Various flows, no particular direction
Oxygen content	Normally oxygen rich because of the constant mixing	Oxygen depletion exists at times in deeper water
General Depth	Shallower on average	Deeper as average
Size Description	Narrower and longer	Wider and shorter
Riparian Zone Description (the riparian zone is the land area along the banks of the body of water)	Various effects from different terrestrial environments along the stream's course. The shoreline has more potential to affect water quality because a larger portion of the water body is near shore.	Terrestrial environment similar all around the lake shore. A smaller portion of the water is in close proximity to the shore.
Changes in shape / depth over time	Stream continually cuts into the channel, making it longer, wider, and deeper	Lakes become shallower over time from depositing sediments
Water retention time (how long it holds water)	Shorter retention time for water (i.e. it's always flowing)	Longer retention time for water (because it stores water)
Temperature characteristics	Top and bottom waters generally have the same temperature (i.e of the constant mixing)	May have different temperatures from the top to bottom (i.e. it has layers based on density)

✓ Lotic Communities

Running water can bring many factors into play affecting the lives of the organisms in this particular environment:

1. Algae

In general the diversity of plant species in a lotic community is small compared to that of a still water (lentic) community although small parts of the lotic community host similar conditions to that of a lentic community. Most plants have went through evolutionary adaptations to cope with the force and different conditions that running water brings. Such adaptations have allowed a number of species to successfully take advantage of the lotic community as their ecological niche. As these conditions are more harsh for a typical species of plant, more notably larger plants, smaller species have found the conditions of the lotic community more favorable. This is due to the fact that they are more flexible in regards to the physical conditions of the water. Algae can grow in all sorts of different places and surfaces, and therefore are a successful constituent of the running water ecosystem. Most of these algae have developed evolutionary adaptations over times that prevent the water current sweeping them away.

There are many species of algae, all of which are capable of growing and reproducing at a quick rate. This consequence results in competition for niches in the freshwater environment. Algae are also the primary producers of this community, meaning they harness new energy into the ecosystem from the sun which provides the primary consumers with a valuable food source.

2.Plankton

Plankton are microscopic organisms that live suspended in the water environment, and form a very important part of the freshwater community. They move by currents. In almost every habitat of a freshwater ecosystem, thousands of these organisms can be found, and due to their small size and simplicity, they are capable of occupying large expanses of water and multiplying at an exponential rate.

Plankton can be subdivided into two categories.

a. Phytoplankton - Phytoplankton are microscopic plants which obtain their energy by photosynthesis. They are important to the ecosystem because they are part of the primary producing community and assist in recycling elements such as carbon and sulphur which are required elsewhere in the community.

b. Zooplankton - Zooplankton consist mainly of crustaceans and rotifers, and on the whole are relatively larger than their phytoplankton counterparts. Physiologically, there are many evolutionary adaptations that can be found that assist in the buoyancy of them, and prevent their deaths by allowing them to be suspended in the water .

3. Animals

The running water environment offers numerous microhabitats that simulate favorable conditions for many types of animals to successfully succeed the freshwater lotic community. As with plants, animals in this ecosystem have also undergone ongoing evolutionary adaptations to better suit this running water environment.

Some of these animals are sessile, meaning they are immobile and fixed to the one place. These animals are usually small, and include the protozoans and some freshwater sponges. These animals either remain attached to the mass of a plant or the water bank surface or rock.

Animals have developed some of the following adaptations over time that helps them cope with the conditions of lotic environment:

Suckers - These suckers attach themselves to a surface that leeches them into position and can also assist movement in any given direction.

Hooks / Claws - These sharp objects can dig into any given object and allow the animal to cling to a position or claw their way around the surface.

Body flattening - This adaptation can allow the animal in the water bear less of the brunt of the force of water moving downstream, therefore reducing it as an inhibitor of their movement. This also allows these animals to enter confined areas (such as under stones) that may present a useful environment for them to live in.

Streamlining - animals who have underwent streamlining adaptations on their external appearance means that less resistance is presented by the running water when the animal attempts to move.