**MEKDELA AMBA UNIVERSITY**

**MEKANESELSM CAMPUS**

**COLLEGE OF SOCIAL SCIENCE AND HUMANITIES**

**COURSE OUTLINE FOR UNDERGRADUATE PROGRAM**

**Department of Geography and Environmental Studies**

Course Title: *Biogeography*

Course code: *GeES3102*

COURSE INFORMATION

Academic year, *2012 E.C*

Year /Semester:- *Year III/ Semester II*

Instructor Name: Yeshalem A.

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Status of Course - Compulsory

**Course description**

This course offers a broad introduction to the field of biogeography, exploring key concepts, theories, and practices employed by biogeographers. Past and present distribution of plants and animals will be described through systematic and integrative studies, and factors of location including geographical, environmental, and historical will be discussed. The ultimate goal of biogeography is to provide baseline information about the environment, which can be used as a guideline for the development of policies to manage our natural environment better for sustainable use.

**Course objective**

The course equips students to interpret and analyze the current issues in the social and economical activities of the society. Merely focuses to give brief knowledge on the relationship between man and the environment.

**At the end of the course students will be able to**:

* Demonstrate an understanding of basic biogeographical concepts and processes
* Describe and explain the sources of biological diversity on our planet.
* Develop literacy in biogeographical concepts as they apply to current environmental and ecological issues.
* Articulate how biogeography has relevance to cultural, social, and economic systems.
* Apply concepts to decisions regarding human use of the environment.
* Plan for future changes in species distributions and diversity as a result of environmental and human-induced pressures
* Integrate biogeographic perspectives with their personal view of the world to become a more informed global citizen.
* Based on the skill of analyses, students can apply in various scientific researches in their field of study.

**Chapter One**

**1**. Introduction

1.1. The Meaning and scope of biogeography

1.2. History of Biogeography

1.3. Origin and evolution of life

1.4. Classification and organization of life

**Chapter Two**

2. Energy controls of ecosystems

2.1. Forms of energy

2.2. Source of energy

2.3. Energy transformations

2.4. Food chains and food webs

2.5. Ecological pyramids

2.6. Biological productivity

**Chapter Three**

3. Element exchanges of ecosystems

3.1 Essential elements

3.2 Elements in living organisms

Biogeochemical cycles

**Chapter Four**

4. Living organisms and the environmental factors

4.1 Climatic factors

4.2 Topographic factors

4.3 Edaphic checks

4.4 Biotic restrictions

4.5 Anthropogenic factors

**Chapter five**

5. **World Biomes**

**5.1 Terrestrial Biomes**

5.1.1. Tropical Broadleaf Evergreen Forest

5.1.2. Savanna/Tropical Seasonal Forests

5.1.3. Desert scrub

5.1.4 Temperate Broadleaf Deciduous Forest

5.1.5 Mid-latitude Grasslands

5.1.6. Mediterranean Vegetation

5.1.7 Boreal Forest or Taiga

5.1.8 Tundra

**5.2. Aquatic Biomes**

5.2.1 Fresh water

5.2.2.Marine biome

**Chapter Six**

**6. Important Biogeography Processes**

6.1. Evolution, Adaptation

6.2. Speciation

6.3. Extinction

6.4. Geographical Dispersal and Colonization

6.5. Ecosystem stability, diversity and ecological succession

**Assessment /evaluation techniques**

Test1…………………….…………………10

Test 2……………………………………….10

Project report……………..…………………10

Group assignment & presentation…………...20

Final exam………………...............................50%

Total....................................................100%

**Course Policy**

Students are expected to attend classes regularly. Students that do not attend 15% of the classes will not sit for the final exam. Students are urged to be in lecture room at least 5 minutes before the starting time of the lecture. Cell phones must be turned off during lecture hours. Students are obliged to behave properly. Smoking, chewing chat and insulting each other during class hours is strictly forbidden

***References***

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**UNIT ONE**

**STUDYING BIOGEOGRAPHY**

**1. Introduction**

This chapter refers to the meaning, scope, sub divisions and the historical development of biogeography. It also gives a detailed expiation on origin, organization and classification of life in different environment.

**1.1. Meaning and Scope of Biogeography**

Biogeography is the science that attempts to document and understand spatial patterns of biodiversity. It is the study of distribution of organisms, both past and present, and of related patterns of variation over the earth in the numbers and kinds of living. Biogeography is the study of the distribution of plants and animals over the surface of the Earth in both a spatial and temporal context. The discipline is important because it study the Earth, its environs and its organisms, to have better manage the future to ensure its wellbeing.

Biogeography is a broad field. To be a complete biogeography, one must acquire and synthesize a tremendous amount of information. Notice both “spatial” and “temporal” contexts are mentioned, because biogeography is concerned with the analysis and explanation of patterns of distribution, and with the understanding of changes in these distributions that have taken place in the past and which are taking place today.

**The principal processes in biogeography**

There are **three** fundamental processes in biogeography: evolution, extinction, and dispersal.

**Evolution**: any irreversible chance in the genetic composition of a population.

**Extinction**: the process of a species becoming permanently eliminated with no more living individuals on earth.

**Dispersal**: the movement of organisms away from their point of origin

**1.2. Themes of Biogeography**

* **Ecosystems:** the interactions between the biotic and abiotic worlds within and between these communities. These concepts fall within the field known as Ecological Biogeography.
* **Community:** Includes all of the populations occupying a given area. They are animal and plant components of an ecosystem, which usually show some stability in space and time.

Species can come and go within communities over time, yet the community as a whole persists. In general, communities are less fragile and more flexible than some earlier concepts would suggest.

* **Populations:** collective groups of organisms of the same species occupying a particular space. It is consisted of a group of organisms of any one kind that are not able to cross-breed with others. Each individual member of a population is called the individual.
* **Organism:** is the individual entity (plant or animal) of a population.
* **Species:** are the different kinds of organisms found on the Earth. A more exact definition of species is a group of interbreeding organisms that do not ordinarily breed with members of other groups. If a species interbreeds freely with other species, it would no longer be a distinctive kind of organism.
  1. **Scope of Biogeography**

Like geography, there is no clear demarcation of the scope of biogeography. Some limit its content to the study of plant and animal geography with emphasis upon the former; others would broaden its scope to include the study of soils and some aspects of human geography.

In simple and narrower sense, Biogeography is defined as the study of the origin, distributes adaptation and association of plants and animals. However, the scope of biogeography extend across the fields of plant and animal geography, with many overlaps in genetics, human geography, anthropology, and the social sciences. All of these together form the domain of biogeography.

Biogeography deals with the geography, ecology and history of life-where it lives, how it lives there, and how it came to live there. It has three main branches-analytical biogeography, ecological geography and historical biogeography.

**1.4.1. Plant and Animal Geography**

The geography of plant life, **Phytogeography**, deals with the distribution of plants, more particularly the vascular plants (i.e plants that have vessels in their bodies, which transmit liquids) and the mutual influence of environment and plants each other. It has long been a subject of intensive study and research-mainly by biologists-and accordingly has developed highly specialized fields of study especially in its historical and ecological aspects.

In addition to this, **Zoogeography**, which corresponds to phytogeography , studies the distribution of animal life and the interaction of environment and animals upon each other, has been less fully studied and developed. There are also different reactions of animals with the environment are less direct and obvious than in the case of plants, have made zoogeography a more difficult, if not less easily resolved.

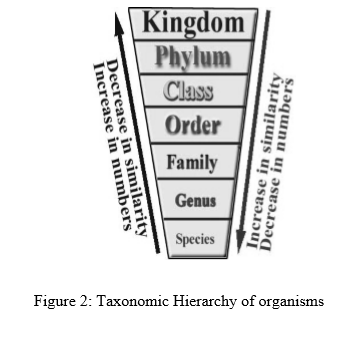
Although the two twin’s aspects of plant and animal geography, in practice, form biogeography, it is more concerned with the world of plants than animals. This is partly because animals, like man, are ultimately dependent on plants for their existence; and it is partly because animals, unlike plants, do not exhibit the same close relationship to environmental conditions. Largely for this reason, animal ecology as a branch of zoology has progressed on very different lines from those of plant ecology on which biogeography greatly depends.

**A biogeography may specialize and become a:**

* Phylogeographers, studying plants:
* Zoogeographer, studying animals;
* Ecological geographer, studying the present distributions of plants and animals in relation to their physical environment; and
* Historical biogeography, attempting to reconstruct the origin, dispersal and extinction of taxa and biotas.

**1.5. Taxonomic Hierarchy of organisms**

Estimates of the total number of living species greatly vary. Most scientists agree that the actual number is in the order of 13 million to 14 million, with most being insects and microscopic life forms. However, it appears that we may never know how many there are because many of them will become extinct before being counted and described. The great diversity of life is largely a result of branching evolution or adaptive radiation, i.e., diversification of species to adapt to different ecological riches.

With so many organisms in the world, it is important to be able to classify them to make it easier for sorting and description. The science of classifying organisms is **called taxonomy**. There are seven classification levels or taxa (singular = taxon), from kingdom, the most inclusive (many organisms) to species: the most exclusive (only one type organism). Organisms, which have certain basic features in common, are grouped together into kingdom. Kingdom is split into smaller units called phyla (singular= phylum). Phyla are again split into classes; classes into orders, orders into families and families into genera (singular= genus) while genera are finally divided into species. 

As shown in the diagram above, the various units of classification ranging from kingdom down to species make up the taxonomic hierarchy. It follows that the number of organisms decreases but their similarity increases as we go down the hierarchy. This means that kingdom contains a large number of organisms that share general common features but display quite a wide range of forms. A species is a group of organisms which have numerous detailed features in common and which do not normally breed with other species. Sometimes species are split into sub-species or varieties. These are capable of interbreeding but can be distinguished by slight structural differences.

Classification of the prokaryotes, protests, and fungi. In 1969 the American ecologist named Whittaker instituted a new five-kingdom system of classification, as shown below:

**Kingdom Animalia (Animals):** The defining characteristic is that all organisms develop from an embryo with a blastula stage. They also have senses and nervous systems, to aid in locomotion and searching for food. All are heterotrophic organisms.

**Kingdom Plantae (Plants):** The main characteristic is that plants develop from an embryo without a blastula stage and have cellulose in their cell walls. Almost all of them are autotrophs, organisms that can make their own food. Plants produce food through photosynthesis, and have chloroplasts for this purpose. Most are immobile. A few eat insects for extra nutrients, such as the Venus flytrap. **Kingdom Fungi:** These heterotrophic organisms develop from spores and have chitin in their cell walls. They are mostly immobile. Most are decomposers. Examples are mushrooms, molds and bracket fungus.

**Protista:** The Protista are basically a various category, with no defining characteristic. The only real similarity is that they are all eukaryotes (cells have nucleus). Some are autotrophs, some heterotrophs, and some are decomposers. They can be single celled or multi celled. Examples are slime molds, algae, protozoa, and amoebas.

**Kingdom Monera (prokaryote):** includes bacteria and all prokaryotes. Prokaryotes are organisms with cells that have no nucleus or membrane-enclosed organelles. Monera is the only kingdom, which includes prokaryotes, so, that is the determining, factor for inclusion in this kingdom. Most are single-celled organisms. In terms of number of species and places where they live, bacteria are the most diverse group of the organisms.

**1.5.1. Metabolism:** Living things have the ability to take energy of food from their environment and change it from one form to another. This energy is usually used to facilitate their growth and reproduction. We call the process that allows for this facilitation metabolism. These metabolic reactions are of two kinds: **Anabolism** or constructive metabolism: process resulting in the building up of rather complex materials from simple ones. E.g. photosynthesis in plants, muscle building or wound healing in animals. Thus, anabolism involves an increase in volume or storage of energy.

**Catabolism:** is an energy releasing process that results in tearing down or changing of more complex substances in to simpler ones. E.g. respiration.

Nutrition, the most important of the anabolic processes, is the process where by the organism assimilates or absorbs into its system substances which it converts into paganisms, i.e. its own body substance. Protoplasm is the living substance of all organisms, whether plant or animal, contains, and is built up from, water and such elements as carbon, oxygen, nitrogen, iron, sulfur calcium, phosphorus, etc: these elements are in very unstable combination and constant changes take place in the living substance.

**1.6. Historical Development of Biogeography**

Biogeography has had a long history that is inseparably woven into the development of evolutionary biology and ecology. The problems of distribution and variation on geographic scales were matters of primary interest to evolutionary biologists, including the distinguished “fathers” of the field such as Lamarck, Darwin, and Wallace.

The development of biogeography, evolution, and ecology is tied to the exploration. Early European explorers and naturalists did far more than just label catalogue their specimens. They immediately, perhaps irresistibly, took to the comparing biotas across regions and developing explanations for the similarity differences they observed.

The comparative method served these early naturalists and by the eighteenth century, the study of biogeography began to crystallize are fundamental patterns of distribution and geographic variation. We here trace development of biogeography from the age of exploration to its current status mature and respected science.

**1.6.1. The Age of Exploration**

Biologists the prevailing belief was that the secrecies of creation would be reveal these naturalist/explorers developed more complete catalogues of the diversity of life until the mid-eighteenth century the prevailing world view was one of stasis- the earth, its climate and its species were immutable. However, as the early biogeography’s (then called naturalists or simply geologists) returned with their growing wealth of specimens and accounts, two things became clear

These are:

1. Biologists needed to develop a standardized and systematic scheme to classify the rapidly growing wealth of specimens; and
2. It was becoming increasingly obvious that there were too many species to have been accommodated.

It was just difficult for these early biologists to explain how animals and plants now isolated and perfectly adapted to dramatically different climates and environments, could have coexisted at the landing site of ark before they spread to populate all regions of the globe. One of the most ambitious and visionary of these eighteenth – century biologists was Carolus Linnaeus (1707-1778). He developed a scheme to classify all life- the system of binomial taxonomy that we continue to use today.

Linnaeus reasons that each of these elevation zones harbored a different assemblage of species each immutable but perfectly adapted to that environment. Once the Flood receded, these species migrated down from the mountain and spread to eventually colonize and inhabit their respective environments in different regions of the globe.

Comte de Buffon (1707-1788) was a contemporary of Linnaeus, but his studies of living and fossil mammals led him to a very different view of the origin and spread of life.

Buffon noted two problems with Linnaeus’s explanation.

First, he observed that different portions of the glob, even those with the same climatic and environmental conditions were often inhabited by distinct kinds of plants and animals. The tropics, in particular contained a great diversity of unusual organisms.

Second, Buffon reasoned that Linnaeus’s view of the spread of life required that species migrate a cross inhospitable habitats following the Flood. Species adapted to Montana forests, for example, would have had to migrate across deserts before they could colonize deciduous and coniferous forests to the north. It species environmental barriers would have blocked their spread.

Moreover, Button’s observation that environmentally similar but isolated regions have distinct assemblages of mammals and birds became the first principle of biogeography, known as Buffons law. From 1750 to the early 1800s, many of Button’s colleagues continued to explore the diversity of nature and to write catalogues and general syntheses of their work. One of the most prominent naturalist/collectors of this period was Sir Joseph Banks, who, during a 3-year voyage around the world with Captain James cook on the Endeavor (1768-1771), collected some 3600 plant specimens, including over 1000 species not known to science (i.e.., in addition to the 6000 species described by Linnaeus in his species plant arum).

The efforts of Banks and many other naturalist/explorers resulted in two important developments. First, they affirmed and generalized Button’s law. Second, they developed a much more thorough understanding of and appreciation for the complexity of the natural world.

Banks and his colleagues discovered some interesting exceptions to Button’s law specifically, cosmopolitan species. Moreover, they noted other biogeography patterns, which in their own right would become major themes as biogeography developed.

In the latter part of the eighteenth century, Johann Reinhold Forster (1729-1798) made many important contributions to phytogeography in particular and to biogeography in general. In his account of his circumnavigation of the globe, he presented one of the first systematic worldviews of biotic regions, each defined by its distinct plant assemblages.

He found that Button’s law applied to plants well as to mammals and birds, and to all regions of the world, not just the tropics. Forster also described the relationship between regional floras and environmental conditions and, how animal associons changed with those of plants.

**1.7. Origin of Life**

It is generally accepted that life first began in the sea but exactly when is not known. We know little about organisms living in pre-Cambrian time, i.e. earlier than about 6000 million years ago. Traces of life are rare because soft- bodied organism did not lend themselves of preservation. It has been suggested that some forms of life go back approximately 2,000 million years.

It is therefore possible that certain algae, fungi and unicellular organisms, comparable with simple plant forms, existed fully 1,000 million years before Cambrian times. Traces of animal life, as distinct from plant life, are uncommon still in pre-cambrian times although there are a few indications that primitive animal forms did exist.

Evidence for this rests on the fact that scientists have been able to perform such syntheses in the laboratory under supposedly primitive Earth conditions. These laboratory syntheses do not, of course, prove that similar events took place billions of years ago, but they did and do show that such events could have taken place.

Assuming that the synthesis of organic molecules took place in the atmosphere, it is thought that they were subsequently brought down to the Earth's surface in heavy rains and that, in the course of time, they accumulated in the primitive ocean and lakes.

One can imagine that these great bodies of water must have been teaming with organic molecules of a kind of 'organic soup. It is generally believed that the first organism was generated spontaneously from non-living matter, thus, the theory of spontaneous generation. Somehow or other, certain of these organic compounds came together to form the first organism, i.e., they must have combined in such a way as to produce a stable and integrated chemical system capable of releasing energy and replicating itself.

First, it must have been able to obtain energy, presumably by the breakdown of organic molecules. Since there was not oxygen present at this time, its respiration must have been anaerobic. With respiration proceeding all the time, it would need some way of replenishing its supplies of organic compounds. The possibility that it could synthesize these for itself (autotrophic nutrition) is hardly acceptable.

Secondly, it must have been able to reproduce itself. Most probably at this early stage of evolution, reproduction must have been a simple asexual process involving nothing more than the replication of macromolecules. Once the first reproducing organisms had originated, rapid evolution would be expected to have produced more complex and better-adapted forms. Further variation would result from sexual reproduction, and we must assume that sex, involving the transfer of genetic material from one individual to another, arose at a very early stage of evolution.

**1.8. The Evolution and distribution of Life**

The diversity of plant and animal life has been recognized from the very earliest times. Man has long considered upon the variety and organic life. Traditionally most people, at least in the western world, believed that living organisms could be spontaneously produced from dead or inorganic matter. Such belief is no longer generally held, and the scientist has been able to show that all living forms have depended from previously living forms.

Darwin’s great book on the origin of species (1859) dealt with the theme of evolutionary development. Along with Wallace, he put forward the idea that species originate as a result of natural section or survival of the fittest. Darwin argued that individuals of a species vary and that this variability through small was significant. Particular characteristics might make certain individuals more efficient and better able to stand up on to conditions in their struggle for life.

Any advantageous characteristics that an organism possessed would give it a better chance of survival and reproduction. Such advantageous characteristics, if transmitted to and through the organism’s offspring, would give succeeding generations, superiority in the struggle of existence.

**UNIT TWO: Energy Controls of Ecosystems**

**Introduction**: This chapter exclusively devotes itself to the examination of the transfer of energy in ecosystems. It deals with sources of energy, conversions and transfer of energy, food chain, food web and biological production of world ecosystems.

**2.1. Ecosystem**

An ecosystem is a community of living things and their non-living environment. It is a basic functional unit of biosphere, consisting of organisms (plants and animals) and their environment (air, water, soil and rock). The non-living features of the environment are the abiotic factors, and the organisms in the environment. All ecosystems require energy in order to exist. This is provided by sunlight, with only minor contributions from other sources.

**2.2. Forms of Energy**

Energy is defined as the capacity to do work. Energy varies in quality or ability to do useful work. Hence, energy quality is a measure of energy usefulness. High quality energy is organized, concentrated and has great ability to perform useful work. By contrast, low quality energy is disorganized, weak and has little ability to do useful work. There are different forms of energy in the natural world, but those of great importance to living organisms are radiant, chemical, mechanical and heat energy.

**2.3.1. Radiant Energy:** is the form of energy, which the sun produces by the nuclear transmutation in space to the Earth in the form of rays. It comes in the form of short (ultra -violet), medium (visible light) and long waves (infrared) rays. Solar radiation, as it is also called, is energy in the form of electromagnetic waves involving a regular exchange between potential and kinetic energy. It is upon this energy that life on Earth depends.

When these rays reach the Earth, they are transformed into other forms, one form of which is heat, which warms the Earth and atmosphere, driving the water cycle, and causing air movements. The range of wavelengths between 400 and 700mm, known photochemical as active radiation is absorbed by green plants during photosynthesis and changed into chemical energy, which becomes the source of energy for all living organisms on Earth.

**2.3.2. Chemical Energy:** is the form of energy contained in the covalent atomic bond of chemical substances such as those found in food. In fact, the source of potential energy for all living organisms is found in the chemical energy of food. Potential energy, in this sense, is the stored energy in the food, which can be converted to kinetic energy through the process of respiration.

**2.1.3. Mechanical Energy:** is free or useful energy, which a body possess by quality of its motion or other biological activities. In other words, this is the form of energy which living organisms use to conduct the various life activities. After living organisms use this energy to perform different kinds of work, it is ultimately converted into heat energy whereby it is once and for all lost from their system.

**2.1.4. Heat Energy:** is a special form of energy resulting from the random motion of atoms and molecules in a body.

**2.2. Sources of Energy**

Many of the most important relationships between living organisms and the environment are ultimately controlled by the amount of available incoming energy received at the Earth's surface. It is this energy, which helps to derive the complicated mechanisms of the biosphere and shape the growth of ecosystems. There are a variety of direct sources of energy. These include the direct inputs of energy including wind, hydropower (falling and flowing water) biomass (solar energy converted into chemical energy in trees and other plants), fossil fuels (partially decomposed remains of ancient life in the form of coal, oil and natural gas) as well as other minerals and elements.

The main source of energy, however, is the sun. Most of the sources of energy mentioned above directly or indirectly obtained their energy primarily from the sun. And their total contribution to the overall demand of living organisms is less than 1%. More than 99% of the requirement of energy of living organisms is directly or indirectly obtained from the sun. Thus, the Earth can be thought of as an open system with a single source of energy, i.e., the sun.

In fact, actual quantities of incident radiation that are received at any place on the surface of the Earth can considerably vary on latitudinal basis. Once incident radiant energy has reached the surface and becomes available for ecosystems, a further 95-99% of it may be lost immediately from the plant and rock surfaces by reflection and in the form of sensible heart and the heat of evaporation. Finally it is only between 1-5% of the energy received at the ground, which is absorbed by the plants and so used in the process of photosynthesis to replenish the chemical energy of plant tissues and other organisms.

**2.3. Laws of Energy Transformation**

The basic relationship between organisms and their environment is reflected in the maintenance of life through various kinds of energy exchanges. All forms of energy are inter-convertible and when conversions occur, they do so according to rigorous laws of exchange known as the Laws of Thermodynamics. This idea of thermodynamics says that plants transform sun light energy into

chemical energy of food by the process of photosynthesis for their own use but the other organisms use the mass of organic energy stored in the plant tissues for their use.

It suggests that the total biomass in an ecosystem is a function of the total energy entering the system, the number of transformations it is subjected to, and the relative efficiency of these transformations. We have already seen that the total energy entering the system depends on the incident energy, which is greater at the equator than at the poles.

The number of transformations depends on the trophic levels represented and the efficiency is determined by both the adaptations of individual populations and its requirement for life.

**There are two laws of thermodynamics.**

**The first** law of thermodynamics, also known as the Law of conservation of Energy, states that energy may be converted from one form in to another but on this process of conversion it is neither created nor destroyed. This means that organisms are limited by the amount of energy that already exists. They cannot magically create energy; they can only change it into different forms and use them. Indeed, transformations of energy from one state to another are taking place continuously in the biosphere such that incoming radiant energy during photosynthesis by green plants is converted to chemical energy of plant food, which is converted into chemical energy of animal food when animals consume plants.

**The second** law of thermodynamics also called the Law of Degradation of Energy, states that although energy is neither created nor destroyed during its transformations, there is always a

degradation or decrease in energy quality or amount of useful energy. According to this law, therefore, we cannot recycle or reuse high-quality energy to perform useful work. For instance, once the concentrated high-quality energy in a piece of wood is released, it is degraded into low quality heat energy that flows into the environment.

In other words, according to this law, no energy transfer is 100% efficient. Most transfers of energy in the ecosystems are inefficient. Energy degradation is encountered at every stage of its transformation. Hence, plants don't trap all the energy coming from the sun, and they don't incorporate all that they trap into chemical bonds of food. Likewise, animals don't incorporate all the energy they consume from the plants. The biosphere, therefore, is a complex web of energy exchanges, each of which encounters loss.

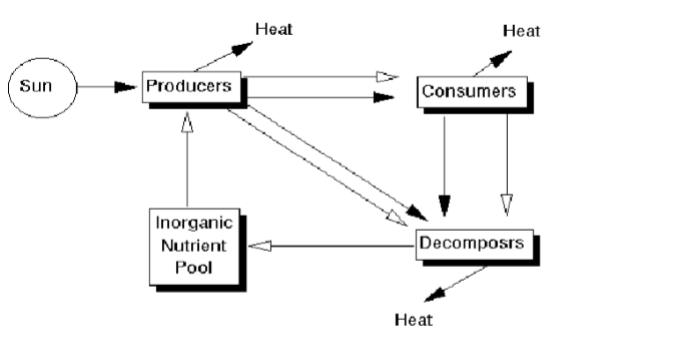
As explained above, of the total incoming solar energy potentially available to green plants only 1% to 5% will be finally converted into chemical energy and tied up in foods in plants. 

Figure 2.1: Energy and Nutrient flow through Ecosystem.

Similarly, when herbivores feed on green plants and convert plant starch and protein into animal energy and protein, another high percentage of energy escapes. During the digestion of the food by the animals, the complex organic molecules are broken down to simpler molecules and new compounds are synthesized. As a result a large part of the energy is again lost as heat and a small portion is stored in the animal tissues.

Likewise, when carnivores feed on herbivores, there is again inefficiency in energy transfer. Thus, as one goes up the food chain, the limits of available energy are reached.

This degradation of energy, therefore, explains the reason why in any ecosystem the amount of green plants is ultimately limited by the amount of sunlight energy and the efficiency of plants in converting it into a useful form.

In a similar way, the final limit of the number of animals in certain areas is determined by the amount of energy available to them in green plants and the efficiency of the animals in converging this to useful form for their maintenance, growth and reproduction.

It is already shown that only green plants are equipped with the mechanisms of utilizing solar (sunlight) energy for the synthesis of foodstuffs (chemical energy) upon which all other organisms (both green plants and animals) depend. The presence of the pigment called chlorophyll in the cells of plant leaves makes it possible for photosynthesis to take place.

The process of photosynthesis uses light energy used in building plant foods (primarily glucose) from simple inorganic compounds of CO2 from the air and H2O from the soil. Later, from glucose with the addition of other simple inorganic chemical compounds obtained from the soil and the atmosphere or hydrosphere, plants build more complex foods in the form of complex carbohydrates, proteins, fats and vitamins.

Based on food synthesis, organisms, hence, can be divided in to two groups:

**1. Producers:** Organisms, such as a variety of bacteria, many varieties of blue-green algae and nearly all plants that produce their own food are called autotrophs. The autotrophs, as mentioned before, convert inorganic compounds into organic compounds. They posses the green pigment known as chlorophyll and in its presence organic materials of food can be synthesized from water and carbon dioxide, provided that a source of sunlight energy is available. They are called producers because all of the species of the ecosystem depend on them.

**2. Consumers:** They include fungi, many varieties of bacteria, a few varieties of flowering plants and all animals. All of these organisms can not make their own food (and need producers) are called heterotrophs. In an ecosystem heterotrophs are called consumers because they depend on others. They obtain food by eating other organisms. These are, hence, organisms that can only exist in biologically modified environments.

There are different levels of consumers. Those that feed directly from producers, i.e. organisms that eat plant or plant products are called primary consumers. In the figure below the grasshopper is a primary consumer.



Organisms that feed on primary consumers are called secondary consumers. Those who feed on secondary consumers are tertiary consumers. In the figure above the snake acts as a secondary consumer and the hawk as a tertiary consumer. Consumers are also classified depending on what they eat.

**Herbivores:** are those that eat only plants or plant products. Examples are grasshoppers, mice, rabbits, deer, beavers, moose, cows, sheep, goats and groundhogs.

**Carnivores:** on the other hand, are those that eat only other animals. Examples of carnivores are foxes, frogs, snakes, hawks, and spiders.

**Omnivores:** are the last types and eat both plants (acting as primary consumers) and meat (acting as secondary or tertiary consumers). Examples of omnivores are:

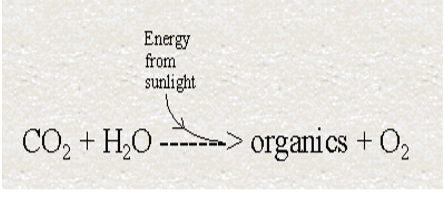
Bears: They eat insects, fish, moose, elk, deer, sheep as well as honey, grass, and sedges.

Turtles: They eat snails, crayfish, crickets, earthworms, but also lettuce, small plants, and algae. Monkeys: They eat frogs and lizards as well as fruits, flowers, and leaves.

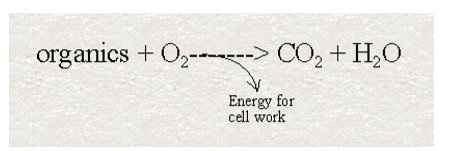
Squirrels: They eat insects, moths, bird eggs and nestling birds and also seeds, fruits, acorns.

**2.4. Ecosystem Structure**

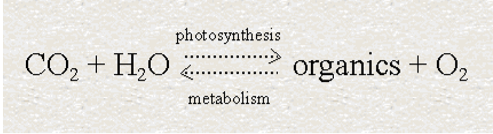
One way of describing an ecosystem is according to its trophic structure. The trophic structure constitutes the levels of feeding (trophic = food) and the feeding relationships of the components of the ecosystem. All ecosystems must be based upon autotrophs. Autotrophs (literally self feeders) produce organic food for themselves and all members of their community. A few types of bacteria are able to harness chemical energy to produce food, but mostly autotrophs are green plants which utilize photosynthesis to harness energy from sunlight to produce organic materials, such as carbohydrates, plus oxygen. The chemical reaction for this process is shown below.



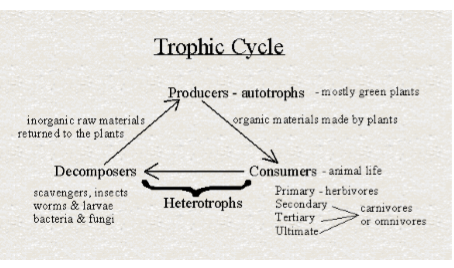
The inorganic materials water and carbon dioxide are the raw materials for photosynthesis. Plants take them in from the environment and, using the energy from sunlight, assemble the large macromolecules virtually all organisms depend on for food energy. In addition the oxygen produced is necessary for the cell metabolism (respiration) carried on by animal cells (and plant cells too, in the dark). The macromolecules plants produce include not only carbohydrates (sugars, starches, etc.) but also fats, proteins and vitamins. In order to produce these substances other minerals such as nitrates and phosphorus must also be present. In fact a whole spectrum of trace minerals is necessary for healthy plant growth.



Animals which consume these plant products as they eat the plants and breathe in oxygen do the reverse reaction: They use the energy now contained in the organic molecules together with the oxygen, and produce carbon dioxide and water as waste products. This process is known as cell respiration or metabolism. The relationship between photosynthesis and metabolism is shown below.



As you can see this clearly shows the complementarity between animals and plants. Therefore, from this we can understand that we would have neither the organic foods nor the oxygen that we need without them. The organic food consumed (and its energy along with it) is not broken down all at once. It travels through many levels of consumers and decomposers, allowing each to obtain some of the benefit of the food the green plants have produced.



Consumers live in levels according to whether they eat the green plants directly (herbivore = plant eater), or whether they get the plant food second hand by eating another animal (carnivore = meat eater, omnivore = eats all). Human beings are omnivores because sometimes we eat the plants directly and sometimes we eat animals who have eaten plants, or even animals who have eaten other animals.

**2.5. Photosynthesis**

Photosynthesis is the process of converting water and carbon dioxide into chemical energy of food and oxygen with the help of sunlight energy. It chemically unites two common inorganic compounds to form organic matter with the release of oxygen. Plants use six molecules of carbon dioxide, twelve molecules of water and 763 kilo calories of light energy to produce one molecule of glucose

6CO2 + 12H2O + light energy ===> C6H12O6 + 6O2 + 6H2O

Virtually all the energy available for life in the Earth's biosphere is made available through photosynthesis. It is, thus, the most important biological process on Earth. Although plants draw necessary materials from the soil and carbon dioxide from the air, their energy needs is obtained from the sun.

**2.6. Respiration**

While photosynthesis builds up chemical energy in food, respiration is the process by which organisms break down the complex food stuff with the help of oxygen, thus, releasing the atomic bond energy to be used as source of kinetic energy for the organisms to perform their life activities. During plant respiration, carbohydrates combine with oxygen and are reduced to carbon dioxide, water, and heat.

While photosynthesis operates only during day when sunshine is available, respiration goes on both night and day. Plant growth occurs so long as photosynthesis exceeds respiration.

The compounds, which plants produce from the chemical reactions of inorganic materials with the help of light energy, are called organic materials. Forms of matter not formed by living things are termed inorganic. Compounds and molecules constructed in living tissues are commonly called organic. Photosynthesis supplies the glucose, which through combining with nitrogen, phosphorus, sulfur, and magnesium produces four general categories of organic compounds:

lipids, carbohydrates, proteins, and nucleic acids. Lipids: are composed of carbon atoms that have two hydrogen atoms attached. Lipids are commonly known as fats and oils, and belong to the family of molecules known as hydrocarbons. Carbohydrates: are composed of carbon, oxygen, and hydrogen atoms. Some examples are sugars, starch, and cellulose. Proteins: are organic compounds that are made primarily of carbon, hydrogen, oxygen, nitrogen, and some other minor elements that are arranged into 20 different compounds known as amino acids. Nucleic acids: are composed primarily of different combinations of carbon, hydrogen, nitrogen, oxygen, and phosphorus. The primary types of organisms that produce such kinds of materials are, as indicated above, green plants (thus, primary producers).

Green plants are, therefore, organisms that can exist in purely physical environments, provided that these inorganic substances are obtained in the presence of light energy. It is stated above that green plants trap solar energy by the process of photosynthesis to form the essential food sources sustaining all the Organisms supported by the system. This means that all forms of life are sustained by the transference of energy from one level of life to another in the system i.e., energy passes from its source in green plants to herbivores (plant eating animals) and from the latter to carnivores (flesh eaters) and then to decomposers (decaying organisms. In other words, organisms of a certain ecosystem involve food chain.

**2.7. Food Chain**

Food chain refers to the transfer of energy and chemicals through a series of organisms involving eating and being eaten. It represents the different links along which chemical energy and other materials pass from organism to the other. Each link in the food chain feeds on and obtains energy from the one preceding it and in turn is eaten by and provides energy for the one following it. Thus, food energy and chemical substances move up the food chain from the lowest level, i.e., green plants, to the highest level i.e., carnivores and decomposers.

Each of the separate level in food chain is known as trophic level. A trophic level consists of, hence, all organisms that share the same general type of food. In this form of transfer of food energy from one trophic level to another (producers or plants to consumers or animals), considerable energy is used up, lost and returned to the environment in the form of low quality heat energy.

As much of the energy is lost in this process of transfer, fewer organisms can be supported at the succeeding level. Hence, the number of links in the food chain is usually three or four and rarely exceeds five. Due to this considerable loss of energy at each trophic level, the producers contain the greatest amount of mass and energy. Consequently, many organisms at lower feeding levels are required to furnish sufficient food energy for a single organism at a higher level.

Plant =====> herbivore====>carnivore1==>Carnivore2====>Carnivore3

Primary Primary Secondary Tertiary Quaternary

Producer Consumer Consumer Consumer Consumer

I II III IV V

Relationships in food chains are, however, rarely as obvious as those presented above and are rarely more than three or four trophic levels. For that matter most herbivores do not feed on just one kind of plant nor are they eaten by only one type of carnivore. Rather, most organisms consume a variety of organisms and are in turn eaten themselves by several other species so that simple food chains usually comprise of parts of a large food web and a much more complex arrangement of energy movement.

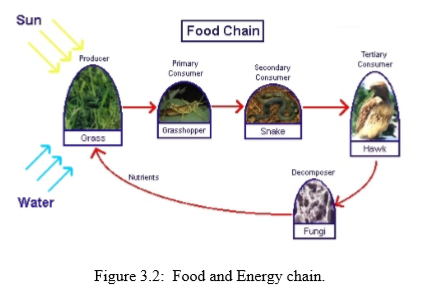
Within natural ecosystems, two major types of food chains may exist either separately or in conjunction with each other: the grazing food chain and detritus food chain.

**2.7.1. Grazing Food Chain**: Involves a fairly direct and rapid transfer of energy from living plants through grazing herbivores to carnivores. In this case, the term grazing herbivore may be taken to mean any primary consumer, from large animals to minute ones.

**2.7.2. Detritus Food Chain:** Transmits energy much more slowly through the decomposing elements of dead plant and animal materials to other living organisms that feed on them.

Food chains may also be differentiated into predator chains, in which energy moves from smaller organisms to larger animals or from stronger and bigger ones to more tactful and biological more adapted organisms.

This chain of energy transferring from one species to another can continue several more times, but it eventually ends. It ends with the dead animals that are broken down and used as food or nutrition by bacteria and fungi. As these organisms, referred to as decomposers, feed from the dead animals, they break down the complex organic compounds into simple nutrients. Decomposers play a very important role in this world because they take care of breaking down (cleaning) many dead material. These simpler nutrients are returned to the soil and can be used again by the plants. The energy transformation chain starts all over again.



Food chains, also called, food networks and/or trophic social networks, describe the eating relationships between species within an ecosystem. Organisms are connected to the organisms they consume by lines representing the direction of organism or energy transfer.

**2.8. Food Webs:** In looking at the previous picture, the concept of food chain looks very simple, but in reality it is more complex. One doesn't find simple independent food chains in an ecosystem, but many interdependent and complex food chains that look more like a web and are therefore called food webs. A food web that shows the energy transformations in an ecosystem is shown below.

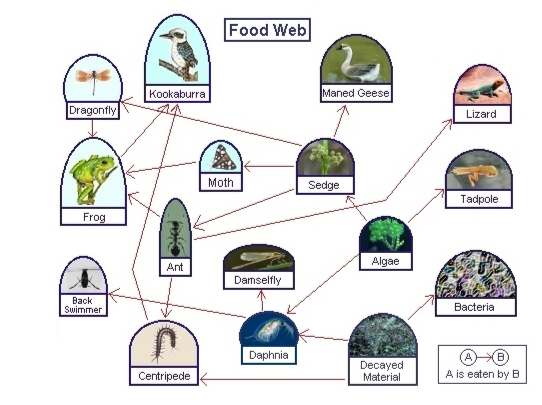


Figure 2.3: A food web showing the energy transformations in an ecosystem.

As you can see from this figure, food webs, with all their dependencies, can be very complex.

**2.9. The Ecological Pyramids**

To examine the patterns of energy exchange and to study the establishment of organisms within the food chains and webs, we use ecological pyramids of numbers, biomass and energy.

In a food chain the number of individuals decreases at each trophic level ( a trophic level refers to an organisms position in the food chain) with huge number of tiny individuals at the base and a few large individuals at the top. This formation is known as Ecological pyramid.

The base of the pyramid represents the producer trophic level, and from there the consumer trophic level is stacked, with the apex representing the highest consumer trophic level.

The pyramid of numbers is based on the number of organisms at each trophic level, constructed by placing the number of the producers at the base of the pyramid and the top carnivores at the apex. As stated above, normally the number of organisms decrease up the food chain and the pyramid constructed will be normal. The normal pyramid is one in which many small primary producers support a relatively large number of herbivores and carnivores.

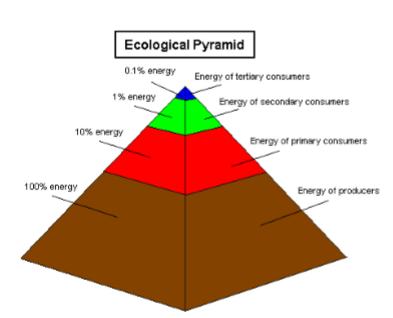


Figure 2.4: The Ecological Pyramid.

**2.10. Biological productivity**

It is mentioned time and again that in passing through the ecosystem much energy is degraded to heat, therefore, becoming unavailable for growth process within it. This is particularly important as it is related to the rate of production of organic matter or biological productivity. **Primary production of World Ecosystems:** refers to the energy accumulated by green plants. The most productive terrestrial ecosystem is the equatorial rain forest with high rainfall and high temperature throughout the year (net primary productivity ranging between 1000 to 3500 g/ m2/yr). Temperate forests range between 600-2500 g/ m2/yr) while shrub lands and grasslands have values ranging between 700-1500 g/ m2/yr and deserts and the tundra range between 100-250 g/ m2/yr.

**The Secondary Production of World Ecosystems:** refers to the amount of energy transfer from primary producers to consumers. It is the energy available to the heterotrophic component of the ecosystem. The secondary productivity of individual organisms within limited ecosystems may range from between 6% and 37%. Thus, while the secondary producers depend ultimately on the primary producers for food, they can influence the rate and form of primary producers for food, they can influence the rate and form of primary production, for instance, by defoliating leaves so that the synthetic efficiency of plants is reduced, and this, in turn, can then rest upon the secondary producers themselves.

**UNIT THREE: Element Exchanges of Ecosystems**

**Introduction:** In this chapter you will learn about the chemical elements in living organisms, biogeochemical cycles and the structure of biogeochemical cycles. The cycles of elements such as oxygen, carbon, nitrogen, phosphorus and sulfur.

**3.1. Chemical Elements in Living organisms**

The chemical elements essential to life may be obtained from any one of pool areas to be found in the atmosphere, ocean, soil and bedrock and, furthermore, are continually re-circulated among ecosystems, so being reused forever.

all the known natural elements very essentials to living organisms. After hydrogen, carbon and oxygen the elements required in greatest quantity by living organisms are nitrogen, phosphorus, sulfur, potassium, calcium, magnesium and iron. Elements in the list are derived ultimately from the atmospheric sources, from the soil and from the bedrock or seas.

Although all of the know elements are capable of being absorbed by living organism, usually oxygen, carbon and hydrogen are found in appreciable quantities within living organism.

It must be noted here that both the manufacture of cells and their component substances depend upon the adequate circulation of many chemical elements, the most abundant being oxygen, carbon and hydrogen. These three are important constituents of not only cell structures, but they are also major components in fats and carbohydrates. Moreover, with nitrogen and phosphorus, they create many of the nucleic acids and much of the cytoplasm materials.

Of course, the presence of several other elements may at time be critical for the healthy development of organisms. For instance, sulfur, although needed in small quantities, is required for the formation of amino acids, without which proteins couldn't be synthesized. Calcium is needed in the strengthening of cell walls. Although their precise functions have not been fully known, several other elements such as phosphorus, iron, manganese, copper, zinc, molybdenum, chlorine, etc, appear to act as catalysts, which speed up many of the complex chemical changes within cells. As shown above, when assimilated by organisms, chemical elements usually combine to form complex mixtures of substance within living cells.

**3.2. The Biogeochemical Cycles**

The chemical elements tend to circulate in the biosphere in characteristic paths from the environment to organisms and back to the environment. This more or less circular path is known as biogeochemical cycle. The movement of these elements and inorganic and organic compounds that are essential to life is termed nutrient cycle.

Another component of ecosystem structure is the pathway of each chemical element through the components of the biosphere. Every element that is used by living organisms passes between the biotic (living) and abiotic (non-living) components of the biosphere.

**These cycles fall into two categories:**

**1. The gaseous cycles:** include all gaseous elements whose reservoir is the atmosphere or hydrosphere and for that reason, such elements have global circulation patterns. The elements falling into this category are carbon, nitrogen, and oxygen. Carbon is found in the atmosphere in carbon dioxide (CO2), nitrogen as nitrogen gas (N2), and oxygen as oxygen gas (O2). The carbon and nitrogen cycles are shown below.

Carbon is found in the atmosphere as carbon dioxide which is taken into plants to become plant tissues. The plant tissues are consumed and either metabolized to CO2 (and water) or turned into animal tissues. The animal tissues become detritus eventually most of which will ultimately revert to the inorganic forms. But over time small amounts of detritus have built up in the form of coal, oil, gas, and peat, the fossil fuels. These fossil fuels have been built up very slowly over long periods of time, literally millions of years, as incompletely decomposed detritus was covered by other materials and subjected to heat and pressure.

The carbon cycle begins with the fixation of atmospheric carbon dioxide directly from the atmosphere through the process of photosynthesis by green plants and certain microorganisms (refer to the figure shown below). During this process carbon dioxide reacts with water to form carbohydrates with the simultaneous release of free oxygen to the atmosphere. Plants use some of the carbohydrate directly to supply themselves with energy. Hence, some of the CO2 so generated is released into the atmosphere through plant respiration.

Animals, a portion of which is again released into the atmosphere directly during animal respiration, later consume part of the carbon dioxide fixed in plant tissues. Again, some portion of the carbon dioxide fixed during photosynthesis is secreted to the soil, part of which is again lost by soil respiration. Finally, plants and animals die and are decomposed by microorganisms in the soil and, hence, the carbon in their tissues is oxidized to form CO2 which moves back to the atmospheric reservoir.

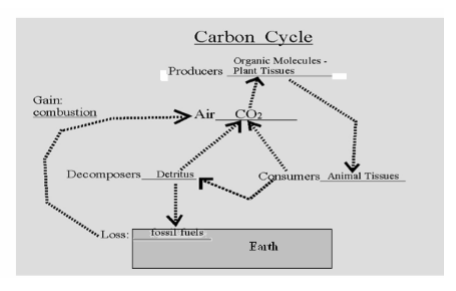


Figure 3.1: Carbon cycle.

The nitrogen cycle also uses the atmosphere as a component, but plants don't get their nitrogen from the atmosphere. Nitrogen gas is mostly inert, while plants obtain needed nitrogen from soluble nitrates in the soil. These nitrates are produced from the decomposition of detritus, i.e. composting.

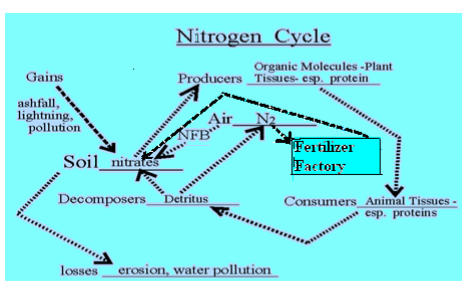


Figure 3.2: Nitrogen cycle.

Plants absorb soluble nitrates, along with other minerals, and use them to make plant tissues. It's proteins that especially require nitrates, making the nitrogen cycle (the nitrogen budget) so critical for nutritious crops. The plant protein is passed on to animals to be made into animal protein. Animals metabolize some of the protein for energy, excreting urea in the process. Urea can be used by plants, but most of the nitrogen is converted to the soluble forms by the decomposers. Soil organisms such as worms, fungi, and bacteria are essential to the normal recycling of minerals and nutrients for continued plant growth.

Among the important soil organisms are those indicated in the above figure by NFB ( Nitrogen Fixing Bacteria) and other organisms which convert gaseous nitrogen to soluble forms useful to plants. These organisms take the nitrogen found in the small air pockets in the soil and fix it, turning it into a form plants can absorb.

Nitrogen fixing bacteria live frequently in the company of legumes, a family of plants which includes peas, beans, clover, alfalfa, and many others. In the process of fixing nitrogen the soils are built up and that makes possible the growth of other plants. Organic gardeners take advantage of nitrogen fixing.

bacteria by growing legumes in an area which will later be given over to corn or some other nitrogen consuming crop. They also utilize the abundant nitrogen available in compost and manure, including human manure.

The growth of all organisms depends on the availability of mineral nutrients, and none is more important than nitrogen, which is required in large amounts as amino acids, proteins, and nucleic acids and other cellular constituents. In order for nitrogen to be used for growth it must be "fixed" and be present in the soil (combined) in the form of ammonium (NH4) or nitrate (NO3).

**Phosphorus cycle:** Phosphorus is derived from the soil and weathered bedrock. It is essential for the healthy growth of living organisms; and available in relatively short supply in terms of its biological demand. It is indispensable in the formation of nucleic acids and nucleo-proteins. It is the key to energy in living organisms, for it is it that moves energy from ATP to another molecule, driving an enzymatic reaction, or cellular transport. Phosphorus is also the glue that holds DNA and RNA together, binding deoxyribose sugars together.

Phosphorus supplies may be present in the soil either organically as chemical compounds, or inorganically as mineral salts. Phosphorus in elemental form, like nitrogen, is inert, i.e., cannot be directly used by living organisms. These supplies of phosphorus should undergo several changes (see figure below), acted upon by several groups of bacteria, to produce the final compound form which living organisms can use. The final compound of phosphorus, which plants utilize, is orthophosphate (H2PO4-). Initially, phosphate weathers from rocks.

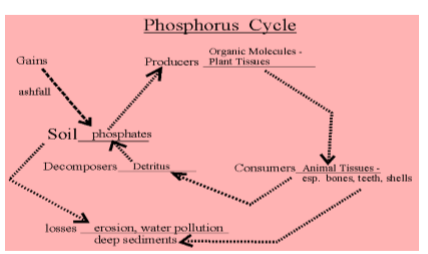


Figure 3.3: phosphorus cycle.

**The sulfur cycle:** Sulfur is important in the formation of amino acids, cysteine and methionine. Most elemental sulfur is present in the form of inorganic compounds developed from weathered rock materials. Under anaerobic soil conditions, these are converted to H2S and sulfides following which they are oxidized to sulfates (SO4) and only then are they absorbed by plant roots in solution. The chemical reactions needed to create sulfides and microorganisms, which include fungi, bacteria and others, all of which tend to be widespread in anaerobic soils of low pH values, stimulate sulfates from inorganic and organic sources.

Like phosphorus exchanges, those of sulfur are frequently not entirely complete since, despite the presence of bacteria, much of the H2S may never be oxidized, even under aerobic conditions.

Biogeochemical exchanges require the presence of a wide variety of living organisms, whose patterns of birth, life and death all encourage the movement of chemical elements. Therefore, one may expect biogeochemical cycles to occur at every level of the biosphere and, indeed, some very minor exchanges have been detected not only in the upper troposphere, but also in the bedrock several thousand meters below ground surface, where some micro-organisms live off oily liquids.

**The Oxygen Cycle:** The atmosphere under which life arose on the Earth was almost certainly of free oxygen. Through evolution, however, autotrophs evolved and became capable of manufacturing their own food. These autotrophic organisms started photosynthetic activities, thus, releasing free oxygen into the atmosphere.

From that time onwards, oxygen became one of the most important elements that play a fundamental role in aerobic respiration that allowed organisms to extract more energy from organic matter they consumed. Generally speaking, one can say that differentiated multi-cellular life (consisting of tissues and organs) evolved after free oxygen appeared in the atmosphere through obtaining their energy by breaking down organic materials (produced originally by photosynthesis) in the presence of oxygen in the process of respiration.

During respiration, organisms remove oxygen from the air and allow it to react with the chemicals in the food at inside the cells and release CO2. For organisms to release the energy in reduced carbon, it must be oxidized. So, while photosynthesis adds electrons to carbon dioxide (and removes the oxygen), respiration removes the electron (and adds oxygen). Photosynthesis requires a photon, carbon dioxide and water; it produces a hydrocarbon and oxygen. Respiration requires a hydrocarbon and oxygen; it produces carbon dioxide and water. So, there is a complete circle, with photosynthesis satisfying the needs of respiration and respiration satisfying the needs of photosynthesis.

For the use of organisms, oxygen, of course, comes directly form the air, of which it constitutes roughly 21%. Ultimately, however, it originates with the decomposition of water molecules by light energy during photosynthesis.

**CHAPTER FOUR**

**LIVING ORGANISMS AND THE ENVIRONMENTAL FACTORS**

4.1. Factors Affecting Geographic distributions of living organisms

**Environmental Factors**

Environment is defined as the totality of things that in any way may affect organism. Landforms, soils and nutrients, weather and climate all comprise an organism’s environment.

As indicated time and again, living organisms require a variety of materials and conditions such as water, soil nutrients, light, heat, oxygen and other gases to survive.

**4.1.1. Climatic Factors**

This relationship between climatic conditions and number of species can be illustrated in a broad way. In the first place there is a clearly recognizable decrease in the number of species of both flora and fauna between the tropics and the Polar Regions. One can compare, for instance, the thousands of species of trees found in tropical forests with those found in the northern forest which amount only to a few dozen.

Similarly, there is a much more varied fauna in the plant formation type, such as the coniferous forest, one finds a reduction in the number of species of trees as one goes towards the poles. In like manner there is a general decline in the variety of animal life in the forest. Generally the impact of climate upon the distribution of living organisms can be described in to different climatic groups as follows.

**Light**: Certain characteristics of the solar radiation may be responsible for shaping (and sometimes limiting) the growth of organisms within ecosystems. Thus, the presence and intensity of light are the most important single factors which stimulate the process of photosynthesis and the production of chlorophyll, the opening and closing of stomata (leaf-pores) and the formation of auxins (growth forming substances) in green plants. Recent experiments have shown that many plants can vary their physiology and morphology very quickly to adapt to changing light conditions (E.g. the changing of leaf-pores which respond to falling light intensities so changing the rate of photosynthesis).Taken as a whole, three aspects of light income: intensity, quality and photoperiod are significant to plant growth, and each of these may vary diurnally and seasonally according to latitude. For many species organisms, the **photoperiod** (or duration of sunshine) is a further critical factor in successful growth.

Even though physiological reactions among some seedlings are sufficiently sensitive to be stimulated by moon light, most plants require either direct or diffuse sunlight for their healthy development, so that differences in the length of the day according to latitude, ranging from the constant 12 hours at the equator to the 6 months of 24 hours day light or darkness period at the poles, may be expected to produce some modifications to growth patterns.

**Heat and Temperature:** an adequate supply of heat is essential to the growth of organisms, all of which have their own maximum, minimum and optimum temperature requirements. The most favorable temperature for photosynthesis are usually lower than those for respiration, a feature which may give rise to some physiological problems since the rate of photosynthesis will fall appreciably should the temperature rise to the optimum for respiration. Differential patterns of temperature over the surface of the Earth can be accounted for largely in terms of variations in latitude, altitude, and distance from the sea and ocean currents.

**Humidity and Moisture**: Water is essential not only to the maintenance of many physiological and chemical processes within organisms but also as a carrier of their nutrient food supply in solution. Water is taken into green plants largely through root hairs and lost through transpiration in the leaves and barks. Complex mechanisms are required to aid its transportation through the plant and these must be extremely efficient in the case of vary tall trees.

It must be understood that not all of the water which reaches the vegetation canopy or surface ultimately becomes available to plants. Plant communities may intercept some precipitation before it reaches the ground to return to the atmosphere as water vapor by means of evaporation from the intercepting plant surfaces. The amount of water lost by interception varies from place to place and also seasonally. In all cases, whether precipitation is in the form of rain or snow interception becomes high or low depending on the duration of precipitation. If the duration is high, there will be low interception (i.e. more will move down by means of direct through fall in the atmosphere or by indirect flow along branches, trunks and leaves).

On the basis of tolerance to water, plants, for example, can be broadly classified into:

* **Hydrophytes:** moisture loving plants. They can have their roots in water or are present in soil with above normal quantities of water within it.
* **Xerophytes:** plants adapted to drought conditions. They are able to withstand long periods and even years of atmospheric and soil drought by means of specific physiological and morphological adaptations, some of which are the following:
* Storing water in stems or leaves (e.g. cactus
* Limiting the growth period (e.g. Perennial grasses
* Developing extensive and long root systems to reach deep soil water (e.g. Mesquite)
* Widely spacing to increase the supply of water (e.g. the creosote bush
* Postponement of the permanent wilting phase by decreasing transpiration by developing grey pigmentation in the leaves, or possessing thorny leaves, or leaves with hard-circularized layer.
* Mesophytes: show a wide range of adaptation to life in environments, which are neither too wet nor too dry and form a group, which include most of the plant species to be found in terrestrial ecosystems.

**Wind:** Strong and persistent winds can restrict growth within ecosystems either by means of abrasive action and mechanical injury or through altering the rates of transpiration or the effective temperature. Cases in which physical damage to plant structure results from wind action are most often seen on exposed mountain ridges, open plains or land close to the sea.

Usually, however, it is more common for vegetation growth to be restrained by wind less directly as when wind speeds coupled with high temperatures increase the transpiration rates so steeply that many species can no longer extract sufficient water from the soil to keep pace with their output, a situation which may lead to visible effects such as browning of needle leaves in conifers, and eventually wilting, cell damage, or at times, death. On high mountain ridges or in exposed situations at high latitudes, where wind effects may induce not only physiological drought, but also an above normal degree of cold penetration into plant tissues (Wind-chill), plants may eventually be killed off completely (wind kill) or restricted to much lower altitudes or the sheltered valleys than would usually be the case. In coastal areas, due to strong winds and salt spray there is wind-beveling (a process that smoothly molds the top of shrub or tree canopies at their upper limits as they rise away from windward shores. Distinctive patterns of vegetation zonation may be present on coastlands as a direct reaction to the differing degree of tolerance to salt spray, which is found among dissimilar plant species.

**4.2. TOPOGRAPHIC INFLUENCES:**

The three major topographic influences, which may sometimes act as limiting factors, are altitude, aspect and relative steepness of slope.

**Altitude:** refers to the height or elevation of land in reference to mean sea level. Generally, air temperature decreases and rainfall increases, at least to a certain height, with an increase in altitude. Those changes of temperature and rainfall conditions result in the occurrence of different zones of climate at different altitudes along the slopes of highlands. These conditions are, therefore, responsible for the well-known development of altitudinal zonation patterns in animal and plant communities of major mountain ranges as when rainforest gives way upslope to cloud forest, dwarfed forest, and finally to alpine scrub and grasses in the tropics.

Besides, at higher altitudes, solar radiation during clearing weather is intense, winds are stronger, soil temperature is lower, and the atmosphere is less dense with a decrease in carbon dioxide, than at lower altitudes. This makes the plant incapable of absorbing and retaining much heat. The combination of all these results in slow and stunted growth of vegetation. Moreover, mountains act as major barriers to the spread of organisms as well as defined lines or division between regions of broadly dissimilar climates and ecosystems on different sides.

**Aspect:** refers to the face of the slope of land in relation to the sun. Local variations in aspect also give rise to some restrictions on plant growth in mountain and hilly regions of the mid and high latitudes, where the angle of incidence of the solar radiation is relatively low, especially during the winter months. Because of this, the intensity, quality and duration of insulation in these areas may be dissimilar on different sides of certain valleys as to give rise to major alterations in the general vegetation pattern. Usually the sun facing slopes can support communities that are more diverse.

**Slope:** refers to the gradient or degree of steepness of the land. On occasions, the relative steepness of slope is also important. Its importance is in its effect on drainage and runoff and consequently upon the depth of soil as well as the water and nutrient content of the soil. Owing to variations in slope, drainage is modified, in that it increases with increasing slope. As a general rule, steeper slopes are, therefore, drier than more gentle ones, so that the vegetation communities developed upon them can be expected to be of a more xerophytic nature than elsewhere. Besides, owing to the higher degree of slope there is more removal of not only water, but also of plant nutrients. Thus, the steep slopes, unlike gentle lands, are usually covered with stunted and short vegetation. The shallow soils do not allow plants with long roots to grow here.

**4.3. THE INFLUENCE OF SOIL (EDAPHIC FACTOR)**

The influence of soil upon plant distribution is both know and appreciated, but little is known of the effects of soils upon animal life. Apart from such as many characteristics certain burrowing or soils living creatures, soil conditions usually exert their influences indirectly through plant life.

Although the porosity and thickness of soil may influence plant growth, the most important property affecting the distribution of plants is probably the chemical composition of the soil.

Soil microorganisms often play a significance role in plant soil relationship. Animals, like plants, require a variety of chemicals, most of which are obtained indirectly through plants on which they feed. Even where an animal appears to be restricted to a particular kind of soil, it is rather probable that the restriction is a reflection of the nature of the plant cover rather than a specific relationship with the soil, although it is possible to see a clear association between animals and soil in some cases. As an environmental medium, soil must be capable of providing plants with four essentials: waterfronts for plant roots, supply of water, supply of adequate amounts of chemical elements in nutrient form, and providing enough space for air circulation.

**4.5**. **ANTHROPOGENIC Factors**

Anthropogenic impact on the distribution of other species has become increasingly intense use and pervasive. This is due in part to the massive diversion of natural resources to human use and the anthropogenic creation of barriers to dispersal and migration instances of environmental deterioration have also multiplied. Not every human intervention in the natural scheme of things is always or necessarily bad: changes are inevitable, for the world is not and cannot remain static. The creation of man-made lakes provides a good example of man’s intervention in nature upon a large scale. Such lakes bring obvious benefits to man in addition to creating problems. The main influences relate to climate, water supply, fisheries, forests, agriculture, transport human health and amenity.

CHAPTER FIVE

TERRESTRIAL AND AQUATIC BIOMES

A biome can be defined as a major regional community of plants and animals with similar life forms and environmental conditions or it is simply a large area with similar flora, fauna, and microorganisms. It is the largest geographical biotic unit, across which the interactions of climate, soil and topography are uniform to permit the development of similar life forms or types of vegetation. The biosphere is divided into two general ecosystems: terrestrial (land) and aquatic (water), each of which is further subdivided into smaller formations that we have already termed biomes. A biome can be defined as various similar ecosystems throughout the World grouped together.

**5.1.Terrestrial Ecosystem**

The terrestrial ecosystem is further classified into four main biomes: Forest, grassland, tundra and desert biomes

**5.1.1. Forest biomes**

They occur in areas where mean annual precipitation, temperatures, and conditions of soils and other factors permit the growth of predominantly various species of trees and few lower forms of vegetation. Forests are made up of tree associations that grow close together, with their canopies so interlocked that the light of the sun does not normally reach the forest floor.

Due to variations in temperature and precipitation both spatially and temporally, forests also exhibit wide variations and are, thus, subdivided into various groups.

**Equatorial Forests:** They occur in lowlands, coastal plains and valleys near the equator, mainly within the area bounded by latitudes 10 degrees N and 10 degrees S. The most extensive forests of this type are found in the Amazon and Zaire basins, with some patches scattered in the islands and peninsulas of Southeast Asia.

Day lengths are essentially the same all year round. Temperature is on average 20-25° C and varies little throughout the year: the average temperatures of the three warmest and three coldest months do not differ by more than 5 degrees. Precipitation is almost evenly distributed throughout the year, with annual rainfall exceeding 2000mm. There may be one or more relatively dry months (with less than 100 mm rainfall) almost anywhere in the zone, but there is no moisture stress in the region. These are complex forests with as many as five moderately well defined layers- emergent, upper canopy, lower canopy, under-story and shrub/herb.

* + A layer/ emergent: the emergent. Widely spaced trees 100 to 120 feet tall and with umbrella-shaped canopies extend above the general canopy of the forest. Since they must contend with drying winds, they tend to have small leaves and some species are deciduous during the brief dry season.
  + B layer/ upper canopy: a closed canopy of 80-foot trees. Light is readily available at the top of this layer, but greatly reduced below it.
  + C layer/ lower canopy: a closed canopy of 60-foot trees. There is little air movement in this zone and consequently humidity is constantly high.
  + Ground / shrub or herb layer: sparse plant growth. Less than 1 percent of the light that strikes the top of the forest penetrates to the forest floor. In such darkness few green plants grow. The canopy above also reduces moisture: one third of the precipitation is intercepted before it reaches the ground. Most plant species are evergreen, their leaves elliptic, often with an elongate tip.

Animal life is highly diverse. Common characteristics found among mammals and birds (and reptiles and amphibians, too) include adaptations to an arboreal life.

Tropical forests, covering 7% of the Earth's surface area, contain perhaps 50% of the world's species. This forest is the most complex ecosystem on Earth. Animal diversity is also of the highest in the world, with almost incomprehensible variety of insects. As in plants, animal species are never in pure stands, i.e., many species live together.

However, many large mammals are not diverse in primary forests: as the dense vegetation hinders locomotion, but a few orders of arboreal primates are especially well represented. Birds reach their greatest diversity in this forest. Lizards, snakes, and frogs also exhibit their greatest diversity in this forest. Amphibians of great diversity also abound the biome.

**Tropical Dry Forest:** Normally, is found in a broad zone extending between the equatorial rain forest and the savanna. Here temperatures are high all year, but there is well-developed alternate long dry season and short wet season. Soils are essentially like those of tropical rain forests with similar processes.

The deciduousness of most tree species is a significant difference from the tropical rain forest. Many evergreen tree species of the rain forest become deciduous in this zone. Growing conditions are not so optimal, thus the tree canopy is lower (10-30m) than in the rain forest and the trees are less dense where drought is more extreme. The undergrowth is often dense and tangled because of greater light penetration.

Species diversity is high on a world scale, but most of the taxonomic groups in the dry forest are less diverse than in the rain forest. Dry forest is important as habitat for migratory birds in their non-breeding season (Central America, India). Trees have thicker bark (anti-fire adaptation), thicker and smaller leaves (anti-desiccations adaptation), thorns (anti-herbivore adaptation), longer roots (to reach deeper water table), and other features along a gradient toward the well-developed drought adaptations of woody plants of the savanna and desert zones. With more space between trees, larger mammals are more prominent in the environment.

**Mediterranean Shrub Lands:** occur roughly between 30° and 40° latitude on the west coasts of continents, where offshore there are cold ocean currents. The Mediterranean Climate is unique in that the wet season coincides with the low sun or winter period. Summers are dry. Temperatures are those of the subtropics moderated by maritime influence and fogs associated with the cold ocean currents. The result is a very limited, but predictable, growing season when there is both sufficient soil moisture and adequately warm temperatures.

Many plants are adapted to withstand drought. Shrubs characterize the Mediterranean biome. In most regions these shrubs are evergreen and have small, leathery leaves with thick cuticles. Sometimes the leaves are so reduced as to appear needle-like. Many typical members of the shrub flora are aromatic (for example, sage, rosemary, and oregano) and contain highly flammable oils.

The fauna of the various expressions of this biome are characterized by endemism that seems more a product of isolation than of peculiar adaptations to the Mediterranean environment. There is close convergence in the bird species found in California and those in Chile in terms of morphology, ecological niche, and even color.

**Temperate Broadleaf Deciduous Forest:** The region is characterized by warm summers and cold winters, with precipitation often spread throughout the year. Snow is common in the northern part of the zone but decreases to the south end of it. The non-growing season is due to temperature-induced drought during the cold winters. Brown, fertile forest soils develop under the Temperate Broadleaf Deciduous Forest. Broadleaf trees tend to be nutrient demanding and their leaves bind the major nutrient bases.

Thus the litter under this forest is not as acidic as under the needle leaf trees and aluminum and iron are not mobilized from the A-horizon. The Autumn leaf fall provides for abundant and rich humus that begins to decay rapidly in spring just as the growing season begins. The humus content gives both A and B-horizons a brown color. Many have been under continuous cultivation since a long time ago. There are many types of seasonal adaptations in the fauna as well as in the flora. A large proportion of the birds and many bats migrate south in winter, while the remainder of the bats and some other mammals hibernate during this period of greatly reduced food supply and adverse climatic conditions.

**Boreal or Taiga Forests:** The climatic conditions under which these forests grow are very severe. The taiga corresponds with regions of sub-arctic and cold continental climate. Long, severe winters (up to six months with mean temperatures below freezing) and short summers are characteristic of the region. Mean annual precipitation is scanty to moderate, ranging between nearly 300mm to 750mm, but low evaporation rates make this a humid climate.

The low temperatures inhibit bacterial and fungal action, so the decomposition rate is low and leaf litter relatively deep. Needle leaf, coniferous trees are the dominant plants of the taiga biome. A very few species in four main genera are found: the evergreen spruce, fir, and pine, and the deciduous larch or tamarack. In North America, one or two species of fir and one or two species of spruce are dominant. The conical or spire-shaped needle leaf trees common to the taiga are adapted to the cold and the physiological drought of winter and to the short-growing season.

Species diversity is considerably lower than in the temperate deciduous forests; some of the northern coniferous forests may feature only one to three dominant species, even where the most highly developed and productive. Carnivorous mammals are moderately diverse, probably because rodents are abundant, if not diverse, in this zone. Some migratory bird species are also diverse.

**5.1.2. GRASSLANDS**

Grasslands are characterized as lands dominated by grasses rather than large shrubs or trees. There are two main divisions of grasslands: tropical grasslands, called savannas, and temperate grasslands.

**Savanna:** Savannas or Tropical grasslands are associated with the tropical wet and dry climate type., savannas develop in regions where the climax community should be some form of seasonal forest or woodland, but edaphic conditions or disturbances prevent the establishment of those species of trees associated with the climax community.

A tropical wet and dry climate predominates in areas covered by savanna growth. Mean monthly temperatures are at or above 64° F and annual precipitation averages between 30 and 50 inches. For at least five months of the year, during the dry season, less than 4 inches a month are received. The dry season is associated with the low sun period.

The savanna actually encompasses a broad spectrum of vegetation types from pure grasses and forbs at one end through trees and shrubs at variable densities to thorn bush at the other end, which in turn grades to tropical dry forests in areas of higher rainfall. Tree growth is controlled not only by rainfall, but also by soil type.

Large areas of hardpan soils allow no trees to penetrate except through cracks, and the cracks determine tree distribution. Tree growth is also often controlled by the nearness of the water table, with trees always along water bodies, grading into gallery forests.

**Temperate grasslands:** These grasslands have hot summers and cold winters. The temperature range is very large over the course of the year. Rainfall is moderate and usually occurs in the late spring and early summer. The soil of the temperate grasslands from the growth and decay of deep, many-branched grass roots. The rotted roots hold the soil together and provide a food source for living plants. This fertile soil is called chernozem, soil that is more of alkaline nature because net water movement within it.

This zone is largely dominated by grasses, but with annual and perennial forbs intermingled in different proportions in different areas. As in the savanna, seasonal drought and occasional fires are very important to biodiversity. The seasonal drought, occasional fires, and grazing by large mammals all prevent woody shrubs and trees from invading and becoming established. However, a few trees grow among the grasses. Plant and animal diversity is rather low in this structurally simple, temperate climate. in the northern hemisphere.

**Desert Scrubs:** develop under four distinct geographic conditions:

* Under zones of high atmospheric pressure associated with the subtropics and centered near 30° latitude. Air descending from the upper atmosphere at these latitudes causes evaporation to exceed precipitation. Much of the Sahara and the Australian desert can be associated with this phenomenon.
* Interiors of continents where usually, in combination with the rain shadow effect, distance from a major source of moist air results in dry climates in the interior of a landmass.

Desert climates are those, which average less than 250mm of precipitation a year. Potential evaporation exceeds precipitation in the annual water budget. Furthermore, rainfall is highly localized and relatively unpredictable in terms of when it will occur, although usually there are seasons of highest probability for precipitation.

Temperatures are also variable. Winters are cool to cold: Calcification is the dominant soil-forming process. There is poor development of horizons, with accumulation of calcium carbonate at or near the surface. Sparse vegetative cover and tiny leaves results in little humus and soils typically have a light gray color.

Shrubs are the dominant growth form of deserts. They may be evergreen or deciduous; typically have small leaves; and frequently have spines or thorns and/or aromatic oils. Shallow but extensive root systems procure rainwater from well beyond the canopy of the shrub whenever it does rain. These are the true xerophytes adapted to tolerate extreme drought.

5.1.3. **THE Tundra**

The word tundra derives from the Finnish for barren or treeless land. Tundra is the simplest biome in terms of species composition and food chains. It is restricted to the high latitudes of the northern hemisphere in a belt around the Arctic Ocean. Many of its species, both plant and animal, have circumpolar distribution areas. The high latitude conditions of climate type that impact life

• Extremely short growing season (6 to 10 weeks)

• Long, cold, dark winters (6 to 10 months

• Low precipitation, coupled with strong, drying winds. Snowfall is actually advantageous to plant and animal life as it provides an insulating layer on the ground surface.

small-mammal prey.

**UNIT SIX: Important Biogeographic Processes**

Introduction: This chapter addresses various topics of ecosystem dynamics at different spatial and temporal scales. Due emphasis is given to the discussion on the responses of living organisms to the influences of environmental factors in the forms of evolution and adaptation, species diversity

***6.1. Evolution, Adaptation***   
***6.1.1.*** ***Evolution***

*Evolution* is a process that results in changes in the genetic content of a population over time. There are two general classes of evolutionary change: microevolution and macroevolution. Micro evolutionary processes are changes in allele frequencies in a population over time. Three main mechanisms cause allele frequency change: natural selection, genetic drift, and gene flow. Macroevolution, on the other hand, refers to change at or above the level of the species.   
Advances in technology have given us tools that have dramatically advanced our understanding of how evolution occurs. In addition to its implication for human health, advances in these fields have benefited ecological studies as well.

onservationists in South Africa have used DNA technology to learn about more about genetic diversity in cheetahs, and are using this information to help keep cheetahs from becoming extinct. Further advances will bring wide applications in agriculture, conservation, and environmental restoration efforts.

***6.1.2.*** ***Adaptation***

*Adaptation* is primarily a process rather than a physical form or part of a body. An internal [parasite](https://en.wikipedia.org/wiki/Parasite) (such as a [liver fluke](https://en.wikipedia.org/wiki/Liver_fluke)) can illustrate the distinction: such a parasite may have a very simple bodily structure, but nevertheless the organism is highly adapted to its specific environment. From this we see that adaptation is not just a matter of visible traits: in such parasites critical adaptations take place in the [life cycle](https://en.wikipedia.org/wiki/Biological_life_cycle), which is often quite complex. However, as a practical term, ***"adaptation" often refers*** to a *product*: those features of a [species](https://en.wikipedia.org/wiki/Species) which result from the process.

Many aspects of an animal or plant can be correctly called adaptations, though there are always some features whose function remains in doubt. By using the term *adaptation* for the evolutionary process, and adaptive trait for the bodily part or function (the product), one may distinguish the two different senses of the word.

Adaptation is not always a simple matter where the ideal phenotype evolves for a given external environment. An organism must be viable at all stages of its development and at all stages of its evolution. This places *constraints* on the evolution of development, behavior, and structure of organisms. The main constraint, over which there has been much debate, is the requirement that each [genetic](https://en.wikipedia.org/wiki/Genetics) and phenotypic change during evolution should be relatively small, because developmental systems are so complex and interlinked.

All adaptations help organisms survive in their [ecological niches](https://en.wikipedia.org/wiki/Ecological_niche). The adaptive traits may be structural, behavioral or [physiological](https://en.wikipedia.org/wiki/Physiology). Structural adaptations are physical features of an organism, such as shape, body covering, armament, and [internal organization](https://en.wikipedia.org/wiki/Comparative_anatomy). [Behavioral](https://en.wikipedia.org/wiki/Ethology) adaptations are inherited systems of behavior, whether inherited in detail as [instincts](https://en.wikipedia.org/wiki/Instinct), or as a [neuropsychological](https://en.wikipedia.org/wiki/Neuropsychology) capacity for [learning](https://en.wikipedia.org/wiki/Learning). Examples include [searching for food](https://en.wikipedia.org/wiki/Foraging), [mating](https://en.wikipedia.org/wiki/Mating), and [vocalizations](https://en.wikipedia.org/wiki/Animal_communication).

Physiological adaptations permit the organism to perform special functions such as making [venom](https://en.wikipedia.org/wiki/Venom), secreting [slime](https://en.wikipedia.org/wiki/Snail_slime), and [phototropism](https://en.wikipedia.org/wiki/Phototropism)), but also involve more general functions such as [growth and development](https://en.wikipedia.org/wiki/Developmental_biology), [temperature regulation](https://en.wikipedia.org/wiki/Thermoregulation), [ionic](https://en.wikipedia.org/wiki/Ions) balance and other aspects of [homeostasis](https://en.wikipedia.org/wiki/Homeostasis). Adaptation affects all aspects of the life of an organism.

***The following definitions are given by the evolutionary biologist***[***Theodosius Dobzhansky***](https://en.wikipedia.org/wiki/Theodosius_Dobzhansky)***:***

1. *Adaptation* is the evolutionary process whereby an organism becomes better able to live in its [habitat](https://en.wikipedia.org/wiki/Habitat) or habitats.

2. *Adaptedness* is the state of being adapted: the degree to which an organism is able to live and reproduce in a given set of habitats.

3. An *adaptive trait* is an aspect of the developmental pattern of the organism which enables or enhances the probability of that organism surviving and reproducing.

***6.2. Speciation***

**Speciation** is the [evolutionary](https://en.wikipedia.org/wiki/Evolution) process by which populations evolve to become distinct [species](https://en.wikipedia.org/wiki/Species). The biologist [Orator F. Cook](https://en.wikipedia.org/wiki/Orator_F._Cook) coined the term in 1906 for [cladogenesis](https://en.wikipedia.org/wiki/Cladogenesis), the splitting of lineages, as opposed to [anagenesis](https://en.wikipedia.org/wiki/Anagenesis), phyletic evolution within lineages [Charles Darwin](https://en.wikipedia.org/wiki/Charles_Darwin) was the first to describe the role of [natural selection](https://en.wikipedia.org/wiki/Natural_selection) in speciation in his 1859 book [On the Origin of Species](https://en.wikipedia.org/wiki/On_the_Origin_of_Species). He also identified [sexual selection](https://en.wikipedia.org/wiki/Sexual_selection) as a likely mechanism, but found it problematic.

There are four geographic modes of speciation in nature, based on the extent to which speciating populations are isolated from one another: [allopatric](https://en.wikipedia.org/wiki/Allopatric_speciation), [peripatric](https://en.wikipedia.org/wiki/Peripatric_speciation), [parapatric](https://en.wikipedia.org/wiki/Parapatric_speciation), and [sympatric](https://en.wikipedia.org/wiki/Sympatric_speciation). Speciation may also be induced artificially, through [animal husbandry](https://en.wikipedia.org/wiki/Animal_husbandry), agriculture, or [laboratory experiments](https://en.wikipedia.org/wiki/Laboratory_experiments_of_speciation). Rapid sympatric speciation can take place through [polyploidy](https://en.wikipedia.org/wiki/Polyploid), such as by doubling of chromosome number; the result is progeny which are immediately [reproductively isolated](https://en.wikipedia.org/wiki/Reproductive_isolation) from the parent population.

New species can also be created through [hybridization](https://en.wikipedia.org/wiki/Hybrid_speciation) followed, if the hybrid is favored by natural selection, by reproductive isolation.

***6.3. Extinction***

In [biology](https://en.wikipedia.org/wiki/Biology), **extinction** is the termination of an [organism](https://en.wikipedia.org/wiki/Organism) or of a group of organisms ([taxon](https://en.wikipedia.org/wiki/Taxon)), usually a [species](https://en.wikipedia.org/wiki/Species). The moment of extinction is generally considered to be the death of the [last individual](https://en.wikipedia.org/wiki/Endling) of the species, although the [capacity to breed and recover](https://en.wikipedia.org/wiki/Functional_extinction) may have been lost before this point. Because a species' potential [range](https://en.wikipedia.org/wiki/Range_(biology)) may be very large, determining this moment is difficult, and is usually done retrospectively.

More than 99 percent of all species, amounting to over five billion species, that ever [lived](https://en.wikipedia.org/wiki/Life) on Earth are estimated to have died out. Estimates on the number of Earth's current species range from 10 million to 14 million, of which about 1.2 million have been documented and over 86 percent have not yet been described. In 2016, scientists reported that 1 trillion species are estimated to be on Earth currently with only one thousandth of one percent described.

Through [evolution](https://en.wikipedia.org/wiki/Evolution), species arise through the process of [speciation](https://en.wikipedia.org/wiki/Speciation)—where new varieties of organisms arise and thrive when they are able to find and exploit an [ecological niche](https://en.wikipedia.org/wiki/Ecological_niche)—and species become extinct when they are no longer able to survive in changing conditions or against superior [competition](https://en.wikipedia.org/wiki/Competition_(biology)). The relationship between animals and their ecological niches has been firmly established. A typical species becomes extinct within 10 million years of its first appearance, although some species, called [living fossils](https://en.wikipedia.org/wiki/Living_fossil), survive with virtually no [morphological](https://en.wikipedia.org/wiki/Morphology_(biology)) change for hundreds of millions of years.

[Mass extinctions](https://en.wikipedia.org/wiki/Extinction_event) are relatively rare events; however, isolated extinctions are quite common. Only recently have extinctions been recorded and scientists have become alarmed at the [current high rate of extinctions](https://en.wikipedia.org/wiki/Holocene_extinction#Defaunation). Most species that become extinct are never scientifically documented. Some scientists estimate that up to half of presently existing plant and animal species may become extinct by 2100. According to the 2019 [Global Assessment Report on Biodiversity and Ecosystem Services](https://en.wikipedia.org/wiki/Global_Assessment_Report_on_Biodiversity_and_Ecosystem_Services) by [IPBES](https://en.wikipedia.org/wiki/IPBES), the biomass of wild mammals has fallen by 82%, natural ecosystems have lost about half their area and a million species are at risk of extinction—all largely as a result of human actions. Twenty-five percent of plant and animal species are threatened with extinction.

In June 2019, one million species of plants and animals were at risk of extinction. At least 571 species are lost since 1750 but likely many more. The main cause of the extinctions is the destruction of natural habitats by human activities, such as cutting down forests and converting land into fields for farming.

The extinction of one species' wild population can have knock-on effects, causing further extinctions. These are also called "chains of extinction". This is especially common with extinction of [keystone species](https://en.wikipedia.org/wiki/Keystone_species).

***6.4. Geographical Dispersal and Colonization***

**Biological dispersal** refers to both the movement of individuals ([animals](https://en.wikipedia.org/wiki/Animal), [plants](https://en.wikipedia.org/wiki/Plant), [fungi](https://en.wikipedia.org/wiki/Fungi), [bacteria](https://en.wikipedia.org/wiki/Bacteria), etc.) from their birth site to their breeding site ('natal dispersal'), as well as the movement from one breeding site to another ('breeding dispersal'). Dispersal is also used to describe the movement of [propagules](https://en.wikipedia.org/wiki/Propagule) such as [seeds](https://en.wikipedia.org/wiki/Seed) and [spores](https://en.wikipedia.org/wiki/Spore). Technically, dispersal is defined as any movement that has the potential to lead to [gene flow](https://en.wikipedia.org/wiki/Gene_flow). The act of dispersal involves three phases: departure, transfer, settlement and there are different fitness costs and benefits associated with each of these phases.

Through simply moving from one habitat [patch](https://en.wikipedia.org/wiki/Landscape_ecology#Patch_and_mosaic) to another, the dispersal of an individual has consequences not only for individual [fitness](https://en.wikipedia.org/wiki/Fitness_(biology)), but also for [population dynamics](https://en.wikipedia.org/wiki/Population_dynamics), [population genetics](https://en.wikipedia.org/wiki/Population_genetics), and [species distribution](https://en.wikipedia.org/wiki/Species_distribution). Understanding dispersal and the consequences both for evolutionary strategies at a species level, and for processes at an ecosystem level, requires understanding on the type of dispersal, the dispersal [range](https://en.wikipedia.org/wiki/Range_(biology)) of a given species, and the dispersal mechanisms involved.

***6.5. Ecosystem stability, diversity and ecological Succession***

***6.5.1. Ecological stability***

An [ecosystem](https://en.wikipedia.org/wiki/Ecosystem) is said to possess **ecological stability** (or **equilibrium**) if it is capable of returning to its equilibrium state after a perturbation (a capacity known as [resilience](https://en.wikipedia.org/wiki/Ecological_resilience)) or does not experience unexpected large changes in its characteristics across time. Although the terms **community stability** and ecological stability are sometimes used interchangeably, community stability refers only to the characteristics of [communities](https://en.wikipedia.org/wiki/Community_(ecology)).

It is possible for an ecosystem or a community to be stable in some of their properties and unstable in others. For example, a vegetation community in response to a drought might conserve [biomass](https://en.wikipedia.org/wiki/Biomass_(ecology)) but lose [biodiversity](https://en.wikipedia.org/wiki/Biodiversity).

Stable ecological systems abound in nature, and the scientific literature has documented them to a great extent. Scientific studies mainly describe grassland plant communities and microbial communities. Nevertheless, it is important to mention that not every community or ecosystem in nature is stable. Also, noise plays an important role on biological systems and, in some scenarios, it can fully determine their temporal dynamics.

***6.5.2.*** ***Ecosystem diversity***

Ecosystem diversity deals with the variations in ecosystems within a geographical location and its overall impact on human existence and the environment. **Ecosystem diversity** is a type of biodiversity. It is the variation in the **ecosystems** found in a region or the variation in **ecosystems** over the whole planet.

Ecosystem diversity is a type of [biodiversity](https://en.wikipedia.org/wiki/Biodiversity). It is the variation in the [ecosystems](https://en.wikipedia.org/wiki/Ecosystems) found in a region or the variation in ecosystems over the whole planet. Biodiversity is important because it clears out our water, changes out climate, and provides us with food. Ecological diversity includes the variation in both [terrestrial](https://en.wikipedia.org/wiki/Terrestrial_ecosystem) and [aquatic ecosystems](https://en.wikipedia.org/wiki/Aquatic_ecosystem).

Ecological diversity can also take into account the variation in the [complexity](https://en.wikipedia.org/wiki/Complexity) of a [biological community](https://en.wikipedia.org/wiki/Biological_community), including the number of different [niches](https://en.wikipedia.org/wiki/Ecological_niche), the number of [trophic levels](https://en.wikipedia.org/wiki/Trophic_level) and other ecological processes. An example of ecological diversity on a global scale would be the variation in ecosystems, such as [deserts](https://en.wikipedia.org/wiki/Desert), [forests](https://en.wikipedia.org/wiki/Forest), [grasslands](https://en.wikipedia.org/wiki/Grassland), [wetlands](https://en.wikipedia.org/wiki/Wetland) and [oceans](https://en.wikipedia.org/wiki/Ocean). Ecological diversity is the largest scale of biodiversity, and within each ecosystem, there is a great deal of both [species](https://en.wikipedia.org/wiki/Species_diversity) and [genetic diversity](https://en.wikipedia.org/wiki/Genetic_diversity).

Diversity in the ecosystem is significant to human existence for a variety of reasons. Ecosystem diversity boosts the availability of [oxygen](https://en.wikipedia.org/wiki/Oxygen) via the process of [photosynthesis](https://en.wikipedia.org/wiki/Photosynthesis) amongst plant organisms domiciled in the habitat. Diversity In an aquatic environment helps in the [purification of water](https://en.wikipedia.org/wiki/Water_purification) by plant varieties for use by humans. Diversity increases plant varieties which serves as a good source for medicines and [herbs](https://en.wikipedia.org/wiki/Herb) for human use. A lack of diversity in the ecosystem produces an opposite result.

***6.5.3.*** ***Ecological succession***

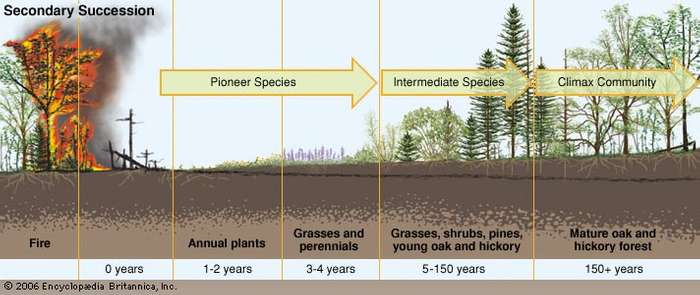
Ecological succession the process by which the structure of a biological [community](https://www.britannica.com/science/community-biology) evolves over time. Two different types of succession—primary and secondary—have been distinguished.

[Primary succession](https://www.britannica.com/science/primary-succession) occurs in essentially lifeless areas—regions in which the soil is incapable of sustaining [life](https://www.britannica.com/science/life) as a result of such factors as [lava](https://www.britannica.com/science/lava-volcanic-ejecta) flows, newly formed [sand dunes](https://www.britannica.com/science/sand-dune), or [rocks](https://www.britannica.com/science/rock-geology) left from a retreating [glacier](https://www.britannica.com/science/glacier).

[Secondary succession](https://www.britannica.com/science/secondary-succession) occurs in areas where a [community](https://www.merriam-webster.com/dictionary/community) that previously existed has been removed; it is typified by smaller-scale disturbances that do not eliminate all life and [nutrients](https://www.britannica.com/science/nutrient) from the [environment](https://www.britannica.com/science/environment). Primary and secondary succession both create a continually changing mix of [species](https://www.britannica.com/science/species-taxon) within [communities](https://www.merriam-webster.com/dictionary/communities) as disturbances of different intensities, sizes, and frequencies alter the landscape.

The sequential progression of species during succession, however, is not random. At every stage certain species have evolved life histories to exploit the particular conditions of the community. This situation imposes a partially predictable sequence of change in the species [composition](https://www.merriam-webster.com/dictionary/composition) of communities during succession. Initially only a small number of species from surrounding [habitats](https://www.britannica.com/science/habitat-biology) are capable of thriving in a disturbed [habitat](https://www.britannica.com/science/habitat-biology).

As new [plant](https://www.britannica.com/plant/plant) species take hold, they modify the habitat by altering such things as the amount of shade on the ground or the mineral composition of the soil. These changes allow other species that are better suited to this modified habitat to succeed the old species. These newer species are superseded, in turn, by still newer species. A similar succession of [animal](https://www.britannica.com/animal/animal) species occurs, and interactions between plants, animals, and [environment](https://www.merriam-webster.com/dictionary/environment) influence the pattern and rate of successional change.

[[](https://www.britannica.com/science/ecological-succession/media/1/178264/125659)](https://www.britannica.com/science/ecological-succession/media/1/178264/125659)

**[Secondary succession](https://www.britannica.com/science/ecological-succession/media/1/178264/125659)** [Secondary succession follows a major disturbance, such as a fire or a flood. The stages of secondary succession are similar to those of primary succession; however, primary succession always begins on a barren surface, whereas secondary succession begins in environments that already possess soil. In addition, through a process called old-field succession, farmland that has been abandoned may undergo secondary succession](https://www.britannica.com/science/ecological-succession/media/1/178264/125659)*[.](https://www.britannica.com/science/ecological-succession/media/1/178264/125659)*

In some [environments](https://www.merriam-webster.com/dictionary/environments), succession reaches a climax, which produces a stable community dominated by a small number of prominent species. This state of [equilibrium](https://www.merriam-webster.com/dictionary/equilibrium), called the [climax community](https://www.britannica.com/science/climax-ecology), is thought to result when the web of biotic interactions becomes so intricate that no other species can be admitted. In other environments, continual small-scale disturbances produce communities that are a [diverse](https://www.merriam-webster.com/dictionary/diverse) mix of species, and any species may become dominant.

**UNIT SEVEN: Distribution Areas/Patterns**

***7.1. Endemism***

**Endemism** is the [ecological](https://en.wikipedia.org/wiki/Ecological) state of a [species](https://en.wikipedia.org/wiki/Species) being unique to a defined geographic location, such as an island, nation, country or other defined zone, or [habitat](https://en.wikipedia.org/wiki/Habitat_(ecology)) type; organisms that are [indigenous](https://en.wikipedia.org/wiki/Indigenous_(ecology)) to a place are not endemic to it if they are also found elsewhere. The extreme opposite of endemism is [cosmopolitan distribution](https://en.wikipedia.org/wiki/Cosmopolitan_distribution). An alternative term for a species that is endemic is **precinctive**, which applies to species (and subspecific categories) that are restricted to a defined geographical area.

There are two subcategories of endemism: [paleo endemism](https://en.wikipedia.org/wiki/Paleoendemism) and [neoendemism](https://en.wikipedia.org/wiki/Neoendemism). Paleo endemism refers to species that were formerly widespread but are now restricted to a smaller area. Neoendemism refers to species that have recently arisen, such as through divergence and reproductive isolation or through hybridization and [polyploidy](https://en.wikipedia.org/wiki/Polyploidy) in plants.

Endemic types or species are especially likely to develop on geographically and biologically isolated areas such as islands and remote island groups, such as [Hawaii](https://en.wikipedia.org/wiki/Endemism_in_the_Hawaiian_Islands), the [Galápagos Islands](https://en.wikipedia.org/wiki/Gal%C3%A1pagos_Islands), and [Socotra](https://en.wikipedia.org/wiki/Socotra); they can equally develop in biologically isolated areas such as the [highlands](https://en.wikipedia.org/wiki/Ethiopian_Highlands) of [Ethiopia](https://en.wikipedia.org/wiki/Ethiopia), or large bodies of water far from other lakes, like [Lake Baikal](https://en.wikipedia.org/wiki/Lake_Baikal). [*Hydrangea hirta*](https://en.wikipedia.org/wiki/Hydrangea_hirta) is an example of an endemic species found in [Japan](https://en.wikipedia.org/wiki/Japan). Endemics can easily become [endangered](https://en.wikipedia.org/wiki/Endangered) or [extinct](https://en.wikipedia.org/wiki/Extinct_species) if their restricted habitat changes, particularly—but not only—due to human actions, including the [introduction of new organisms](https://en.wikipedia.org/wiki/Introduced_species).

***7.2. Relicts***

In [biogeography](https://en.wikipedia.org/wiki/Biogeography) and [paleontology](https://en.wikipedia.org/wiki/Paleontology) a **relict** is a [population](https://en.wikipedia.org/wiki/Population) or [taxon](https://en.wikipedia.org/wiki/Taxon) of organisms that was more widespread or more diverse in the past. A **relictual population** is a population that presently occurs in a restricted area, but whose original [range](https://en.wikipedia.org/wiki/Range_(biology)) was far wider during a previous [geologic epoch](https://en.wikipedia.org/wiki/Geologic_time_scale). Similarly, a **relictual taxon** is a taxon (e.g. species or other lineage) that is the sole surviving representative of a formerly diverse group. These **ecosystems** typically arise due to unusual environmental conditions, are mostly small (<1 to 1000 ha) and non-forested, and often support unique biodiversity.

A relict (or relic) plant or animal is a [taxon](https://en.wikipedia.org/wiki/Taxon) that persists as a remnant of what was once a diverse and widespread population. Relictualism occurs when a widespread habitat or range changes and a small area becomes cut off from the whole. A subset of the population is then confined to the available hospitable area, and survives there while the broader population either shrinks or [evolves divergently](https://en.wikipedia.org/wiki/Divergent_evolution). This phenomenon differs from [endemism](https://en.wikipedia.org/wiki/Endemism) in that the range of the population was not always restricted to the local region. In other words, the species or group did not necessarily arise in that small area, but rather was stranded, or insularized, by changes over time. The agent of change could be anything from [competition](https://en.wikipedia.org/wiki/Competition_(biology)) from other organisms, [continental drift](https://en.wikipedia.org/wiki/Continental_drift), or [climate change](https://en.wikipedia.org/wiki/Climate_change) such as an [ice age](https://en.wikipedia.org/wiki/Ice_age).

The concept of Relictualism is useful in understanding the ecology and [conservation](https://en.wikipedia.org/wiki/Conservation_biology) status of populations that have become insularized, meaning confined to one small area or multiple small areas with no chance of movement between populations.

***7.3. Boreal*** ***Distribution Patterns***

A **boreal ecosystem** is an [ecosystem](https://en.wikipedia.org/wiki/Ecosystem) with a [subarctic climate](https://en.wikipedia.org/wiki/Subarctic_climate) located in the [Northern Hemisphere](https://en.wikipedia.org/wiki/Northern_Hemisphere), approximately between 50° to 70°N [latitude](https://en.wikipedia.org/wiki/Latitude). These ecosystems are located in [Boreal forests](https://en.wikipedia.org/wiki/Boreal_forests) which are commonly known as the [taiga](https://en.wikipedia.org/wiki/Taiga), particularly in [Europe](https://en.wikipedia.org/wiki/Europe) and [Asia](https://en.wikipedia.org/wiki/Asia). The ecosystems that lie immediately to the south of boreal zones are often called [hem boreal](https://en.wikipedia.org/wiki/Hemiboreal).

Boreal ecosystems display high sensitivity towards both natural and anthropogenic climate change, atmospheric warming due to greenhouse gas emissions ultimately leads to a chain reaction of climatic and ecological effects. The initial effects of climate change on the boreal ecosystem can include, but are not limited to, changes in temperature, rainfall, and growing season.

Based on studies from the boreal ecosystems in the [Yukon](https://en.wikipedia.org/wiki/Yukon), a territory in northwestern Canada, climate change is having an impact on these abiotic factors. As a consequence, these effects drive changes in forest [ecotone](https://en.wikipedia.org/wiki/Ecotone) as well as marshlands or lakes in boreal ecosystems. This also concerns plant productivity and predator-prey interactions, which ultimately leads to habitat loss, fragmentation, and threatens biodiversity.

***7.4. Disjunct patterns***

A [taxon](https://en.wikipedia.org/wiki/Taxon) with a **disjunct distribution** is one that has two or more groups that are related but considerably separated from each other geographically. The causes are varied and might demonstrate either the expansion or contraction of a species range. Disjunct distributions may be caused by changes in the environment, such as [mountain building](https://en.wikipedia.org/wiki/Orogeny) and [continental drift](https://en.wikipedia.org/wiki/Continental_drift) or rising [sea levels](https://en.wikipedia.org/wiki/Sea_level); it may also be due to an [organism](https://en.wikipedia.org/wiki/Organism) expanding its range into new areas, by such means as [rafting](https://en.wikipedia.org/wiki/Oceanic_dispersal), or other animals transporting an organism to a new location (plant seeds consumed by birds and animals, can be moved to new locations during bird or animals migrations, and those seeds can be deposited in new locations in fecal matter).

Other conditions that can produce disjunct distributions include: flooding, or changes in wind, stream, and current flows, plus others such as anthropogenic introduction of alien [introduced species](https://en.wikipedia.org/wiki/Introduced_species) either accidentally or deliberately (agriculture and horticulture).

Disjunct distributions can occur when suitable [habitat](https://en.wikipedia.org/wiki/Habitat) is [fragmented](https://en.wikipedia.org/wiki/Habitat_fragmentation), which produces fragmented populations, and when that fragmentation becomes so divergent that species movement between one suitable habitat to the next is disrupted, isolated population can be produced.

Extinctions can cause disjunct distribution, especially in areas where only scattered areas are habitable by a species; for instance, island chains or specific elevations along a mountain range or areas along a coast or between bodies of water like streams, lakes and ponds.

***7.5. Rarity***

A **rare species** is a group of [organisms](https://en.m.wikipedia.org/wiki/Organisms) that are very uncommon, scarce, or infrequently encountered. This designation may be applied to either a plant or animal [taxon](https://en.m.wikipedia.org/wiki/Taxon), and is distinct from the term [endangered](https://en.m.wikipedia.org/wiki/Endangered_species) or [threatened](https://en.m.wikipedia.org/wiki/Threatened_species)*.* An official body, such as a national government, state, or province, may make designation of a rare species. The term more commonly appears without reference to specific criteria. The [IUCN](https://en.m.wikipedia.org/wiki/IUCN) does not normally make such designations, but may use the term in scientific discussion.

Rarity rests on a specific species being represented by a small number of organisms worldwide, usually fewer than 10,000. However, a species having a very narrow [endemic](https://en.m.wikipedia.org/wiki/Endemic_(ecology)) range or [fragmented habitat](https://en.m.wikipedia.org/wiki/Habitat_fragmentation) also influences the concept. Almost 75% of known species can be classified as "rare." The International Union for Conservation of Nature uses the term "rare" as a designation for species found in isolated geographical locations. They are not endangered but classified as "at risk."

A species may be endangered or vulnerable, but not considered rare if it has a large, dispersed population. Rare species are generally considered threatened because a [small population size](https://en.m.wikipedia.org/wiki/Small_population_size) is more likely to not recover from [ecological disasters](https://en.m.wikipedia.org/wiki/Environmental_disaster).

Rare species are species with small populations. Many moves into the endangered or vulnerable category if the negative factors affecting them continue to operate. Examples of rare species include the [Himalayan brown bear](https://en.m.wikipedia.org/wiki/Himalayan_brown_bear), [Fennec fox](https://en.m.wikipedia.org/wiki/Fennec_fox), [Wild Asiatic buffalo](https://en.m.wikipedia.org/wiki/Wild_Asiatic_buffalo) and [Hornbill](https://en.m.wikipedia.org/wiki/Hornbill).

***7.6. Biodiversity***

[Biodiversity](https://www.greenfacts.org/glossary/abc/biodiversity.htm) is defined as “the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic [ecosystems](https://www.greenfacts.org/glossary/def/ecosystem.htm) and the ecological complexes of which they are part; this includes [diversity](https://www.greenfacts.org/glossary/def/diversity.htm) within [species](https://www.greenfacts.org/glossary/pqrs/species.htm), between species and of **ecosystems.”** The importance of this definition is that it draws attention to the many dimensions of biodiversity. It explicitly recognizes that every biota can be characterized by its taxonomic, ecological, and [genetic diversity](https://www.greenfacts.org/glossary/ghi/genetic-diversity.htm) and that the way these dimensions of diversity vary over space and time is a key feature of biodiversity. Thus only a multidimensional assessment of biodiversity can provide insights into the relationship between changes in biodiversity and changes in [ecosystem](https://www.greenfacts.org/glossary/def/ecosystem.htm) functioning and [ecosystem services](https://www.greenfacts.org/glossary/def/ecosystem-services.htm).

[**Biodiversity**](https://www.greenfacts.org/glossary/abc/biodiversity.htm)**includes all ecosystems—managed or unmanaged.** Sometimes biodiversity is presumed to be a relevant feature of only unmanaged [ecosystems](https://www.greenfacts.org/glossary/def/ecosystem.htm), such as wildlands, nature preserves, or national parks. This is incorrect. Managed systems—be they planta­tions, farms, croplands, [aquaculture](https://www.greenfacts.org/glossary/abc/aquaculture.htm) sites, rangelands, or even urban parks and urban ecosystems—have their own biodiversity.

Given that cultivated systems alone now account for more than 24% of Earth’s terrestrial surface, it is critical that any decision concerning biodiversity or [ecosystem services](https://www.greenfacts.org/glossary/def/ecosystem-services.htm) address the maintenance of biodi­versity in these largely anthropogenic systems ([C26.1](https://www.greenfacts.org/en/biodiversity/figtableboxes/table-crossreferences.htm#ac)).

[Biodiversity](https://www.greenfacts.org/glossary/abc/biodiversity.htm) is the foundation of [ecosystem services](https://www.greenfacts.org/glossary/def/ecosystem-services.htm) to which human [well-being](https://www.greenfacts.org/glossary/wxyz/well-being.htm) is intimately linked.  This layer of living organisms—the biosphere—through the collective metabolic activities of its innumerable plants, animals, and microbes physically and chemically unites the atmosphere, geosphere, and hydrosphere into one environmental system within which millions of [species](https://www.greenfacts.org/glossary/pqrs/species.htm), including humans, have thrived. Breathable air, potable water, fertile soils, productive lands, bountiful seas, the equitable climate of Earth’s recent history, and other ecosystem services are manifestations of the workings of life.

***7.6.1. Important of Biodiversity***

Biodiversity is important to most aspects of our lives. We value biodiversity for many reasons, some utilitarian, some intrinsic. This means we value biodiversity both for what it provides to humans, and for the value it has in its own right. Utilitarian values include the many basic needs humans obtain from biodiversity such as food, fuel, shelter, and medicine.

Further, ecosystems provide crucial services such as pollination, seed dispersal, climate regulation, water purification, nutrient cycling, and control of agricultural pests. Biodiversity also holds value for potential benefits not yet recognized, such as new medicines and other possible unknown services. Biodiversity has cultural value to humans as well, for spiritual or religious reasons for instance. The intrinsic value of biodiversity refers to its inherent worth, which is independent of its value to anyone or anything else.

This is more of a philosophical concept, which can be thought of as the inalienable right to exist. Finally, the value of biodiversity can also be understood through the lens of the relationships we form and strive for with each other and the rest of nature. We may value biodiversity because of how it shapes who we are, our relationships to each other, and social norms. These relational values are part of peoples’ individual or collective sense of wellbeing, responsibility for, and connection with the environment. The different values placed on biodiversity are important because they can influence the conservation decisions people make every day.

***7.6.2. Threats to Biodiversity***

Over the last century, humans have come to dominate the planet, causing rapid ecosystem change and massive loss of biodiversity across the planet. This has led some people to refer to the time we now live in as the “Anthropocene.” While the Earth has always experienced changes and extinctions, today they are occurring at an unprecedented rate.

Major direct threats to biodiversity include habitat loss and fragmentation, unsustainable resource use, invasive species, pollution, and global climate change. The underlying causes of biodiversity loss, such as a growing human population and overconsumption are often complex and stem from many interrelated factors.

The good news is that it is within our power to change our actions to help ensure the survival of species and the health and integrity of ecological systems. By understanding threats to biodiversity, and how they play out in context, we can be best prepared to manage conservation challenges. The conservation efforts of the last decades have made a significant difference in the state of biodiversity today. Over 100,000 protected areas—including national parks, wildlife refuges, game reserves, and marine protected areas, managed both by governments and local communities—provide habitat for wildlife, and help keep deforestation in check. When protecting habitat is not enough, other types of conservation actions such as restoration, reintroduction, and the control of invasive species, have had positive impacts.

These efforts have been bolstered by continuous efforts to improve environmental policies at local, regional, and global scales. Finally, the lifestyle choices of individuals and communities can have a large effect on their impacts on biodiversity and the environment. While we might not be able to prevent all negative human impacts on biodiversity, with knowledge we can work to change the direction and shape of our effects on the rest of life on Earth.