Thi- Qar University - College of Science

Pathological Analysis Department

Environment & pollution- Third stage

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Lecturer : AFAQ T. FARHOOD

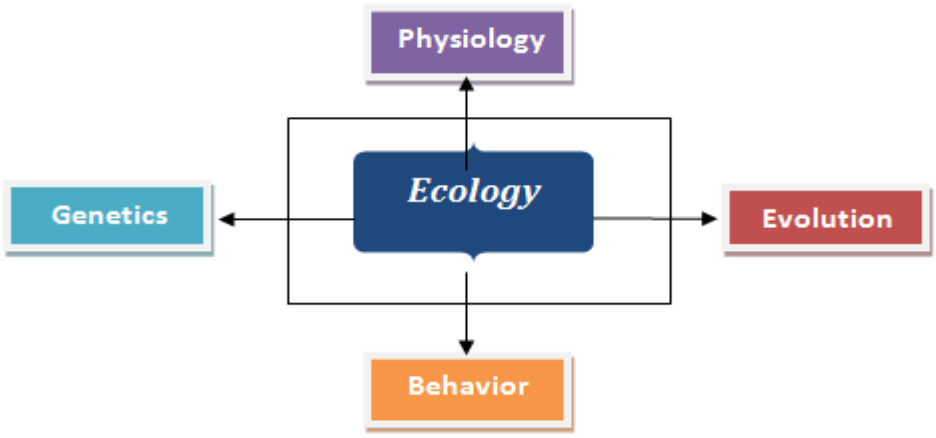
Ecology :

Ecology (from Greek: οἶκος, "house", or "environment"; -λογία, "study of") is the scientific analysis and study of interactions that (biotic components) organisms have with each other, other organisms, and with (abiotic components) of their environment , it is an interdisciplinary (mix) field that includes biology, geography, chemistry and Earth science (geology).

Ecology is **not synonymous** with environment , It is closely related to evolutionary biology, genetics, and ethology (the science of animal behavior).

The word "ecology" ("Ökologie") was coined in 1866 by the German scientist Ernst Haeckel (1834–1919) , Modern ecology become a much more rigorous science in the late 19th century , evolutionary concepts relating to adaptation and natural selection became the cornerstones of modern ecological theory .

Can us Summery the relation of ecology with other sciences in this scheme :



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1- Ecology affects genetics where genetic mutations get due to the influence of the environment , thus produce a new science called (**Evolution**) .

2. Each organism has a particular **Physiology** towards the it environment resulting in a particular behavior, thus produce a new science called **(Behavior)** .

Branches of Ecology :

First : **Aquatic Ecology** : include :

A- **Marine Ecology :** The study of the aquatic environment includes sea and ocean waters, which are characterized by salinity, where this water contains salinity estimated at **0.035=3.5% =35 ppt** , cover approximately 71% of the Earth's surface and contain approximately 97% of the planet's water. They generate 32% of the world's net primary production .They are **distinguished from freshwater ecosystems** by the **presence of dissolved compounds**, especially salts, in the water. Approximately 85% of the dissolved materials in seawater are sodium and chlorine.

B- Estuarine (Brackish water) Ecology : Study of the estuarine environment, which is the region of the **convergence** of fresh river water when it flows to the sea, where it mixes with the salty sea water, so that the salinity of the water sea is diluted , more salinity than fresh water , where this water contains salinity estimated at **0.019 = 1.9%=19ppt** .

C- Fresh water (Inland water) Ecology : Study of Internal water environment include water of Rivers, streams , Marshes and lakes **, can us called (Limnology) ,** where this water contains salinity estimated at **0.0005 = 0.05% = 0.5 ppt** , cover 0.78% of the Earth's surface and inhabit 0.009% of its total water. They generate nearly 3% of its net primary production , contain 41% of the world's known fish species , divided to :

There are **three basic types** of freshwater ecosystems:

1- **Lentic** (**Standing** water) : slow moving water, including pools, ponds, and lakes.
2- **Lotic** (**Running** water): faster moving water, for example streams and rivers.
3- **Wetlands**: areas where the soil is saturated or inundated for at least part of the time.

Second : **Terrestrial Ecology** :

A- Division of ecology depending the **Environment** .

1- Mountain Envir.

2 - Plateau Envir.

3- Plainland Envir.

4- Hill Envir..

5- Desert Envir.

B- Division of ecology depending on the(**Organism type and number**) :

1- Individual Eco.

2- Population Eco.

3- Community Eco.

4- Biosphere Eco.

C- Division of Ecology depend (**Type** or **group of types of organisms**) :

1- Autecology :

Study of **one organism** or **group of organisms** dating back to the **same species** , and it relation to the different environmental factors.

2- Synecology:

Studying the **different life groups** of **different species in a specific area** , and it relation to the different environmental factors .

Ecosystem :

History of Ecosystem :

the term "ecosystem" was first used in 1935 in a publication by British ecologist **Arthur Tansley** , its devised the concept to the importance of transfers of materials between organisms and their environment. He later , describing it as (**The whole system) .**

Ecosystem :

It is the structural and functional and a balanced organizational unit of ecology , it is community composed of two aspects , **biotic** (living organisms) components , include **plants, animals,** and **micro-organisms**.. in conjunction with the non-living **(abiotic**) components includes (the physical and chemical components of the around environment also air, water and mineral soil) . The two sides are interconnected on the basis of **energy flow** and are **sustainable** , (Inorganic substances become organic and then become inorganic again by living or sometimes non-living factors such as : Biogeochemical cycles) .

As ecosystems are defined by the network of **interactions among organisms**, and between organisms and their environment, they can be of any size but usually **encompass specific, limited spaces** (although some scientists say that the **entire planet** is an ecosystem called **Biosphere** or **Ecosphere**) .

Energy flow and sustainability of Ecosystem :

Energy, water, nitrogen and soil minerals are other essential abiotic components of an ecosystem.

1- The energy that flows through ecosystems is **obtained primarily from the sun**. It generally **enters the system** through **photosynthesis** .
2- A process that also captures carbon dioxide from the **atmosphere**.
3- By **feeding on plants** and on one another, animals play an important role in the **movement of matter and energy through the system**. They also influence the **quantity** of **plant** and **microbial biomass** present.

4- By **breaking down dead organic** matter, **decomposers** (**Bacteria** and **fungi**) release carbon **back to the atmosphere** and **facilitate nutrient cycling** by converting nutrients stored in **dead biomass** back to a form that can be **readily used** by plants and other microbes , Most mineral nutrients released , are **recycled within** ecosystems **.**

Ecosystems are controlled both by **external** and **internal factors**. Internal factors include **(Organisms**) ,External factors such **as climate**, the **parent material** that forms the **soil**, and **topography** control the overall structure of an ecosystem and the way things work within it .

Structure of the Ecosystem :

1- Abiotic Components of Environment

Abiotic components refer to the nonliving components of the environment. Chemical and geological factors like rocks, soil, rivers, lakes, oceans, minerals, and pH, physical factors like temperature, weather, humidity, sunlight are referred to as the abiotic components of the ecosystem.

The abiotic components of an ecosystem are the non-living components of the ecosystem on which the living organisms depend on. Every abiotic factor influences the variety of plants that grow in the ecosystem which in turn influences the variety of animals that live in the ecosystem. The abiotic factors in an ecosystem are not identical in the whole region. This influences the distribution of plants in the ecosystem. All abiotic factors affect different organisms to different extents.

Major abiotic components of environment and their influence on the Ecosystem:

Light :

Sunlight is the primary source of energy in almost all the ecosystems. Light energy is used by green plants for the process of **photosynthesis**.

Temperature :

The distribution of the biotic factors is influenced by temperature. For example: The opening of flowers of some plants is often due to the temperature difference between the day and night. Seasonal temperature changes have great influence of the animal ecosystem.

Water (Hydrosphere) :

Water is essential for life and all living organisms depend on water to survive. Habitats of plants and animals vary from aquatic environments to dry deserts.

Atmospheric Gases :

Gases like oxygen, carbon dioxide and nitrogen are used by plants and animals for respiration, photosynthesis.

Soil (Lithosphere) :

The edaphic factors of the ecosystem include the texture of soil, soil temperature, water retention capacity, porosity, pH which influence the soil organisms, plants and the decomposers.

Climate :

Climate includes the rainfall, temperature and wind patterns that happens in an ecosystem and is one of the most important abiotic factors.

Topography :

Topography is the landscape like slopes, elevation aspects in an ecosystem . also influence the ecosystem and the biotic components.

Natural Disturbances :

Factors like annual flooding, fire, storm, lightning also influence the ecosystem and the biotic components.

pH value :

Most of the organisms live in neutral and nearly neutral conditions. Some plants grow well in acidic condition and some plants grow well in alkaline conditions.

Humidity :

The humidity in air affects the rate of transpiration in plants and animals. In low level humidity water evaporates faster. Humidity is lower during the day and higher during the night.

2- Biotic components :

Are the living things that form an ecosystem , usually include:

A- Producers Organisms (Autotrophs Organism , Self nourishments): e.g. plants, Algae **(phytoplankton**) convert the energy [from photosynthesis (the transfer of sunlight, water, and carbon dioxide into energy), or other sources such as hydrothermal vents] into food.

$$Co_2 + H_2o \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}o_6 + Co_2 + H_2o$$

There are, however, different types and types of organisms that have the potential to use the energy **emitted from oxidation of chemicals**, as in some types of bacteria such as sulfur bacteria and **exploitation in the manufacture** of food itself called **Chemosynthetic Bacteria .**

B- Consumers Organisms (Heterotrophs Organisms): e.g. animals, depend upon producers (occasionally other consumers) for food.

Include :

1- Herbivores : is a form of consumers organisms in which an organism principally eats autotrophs, anatomically and physiologically adapted to eating plant material .

2- **Carnivores** : is an organism that derives its energy and nutrient requirements from a diet consisting **mainly or exclusively of animal tissue**, whether through **predation** or **scavenging.**

Animals that **depend solely on animal flesh** for their nutrient requirements are called **: Obligate carnivores**

while those that **also consume non-animal** food are called: **Facultative carnivores.**

3-Omnivores: organism that derives its energy and nutrient requirements from chemical energy and nutrients from **plant and animal origin .**

C- Decomposers (**Osmotrophs) Organisms** : are organisms that break down **dead** or **decaying organisms**, and in doing so, they **carry out the natural process of decomposition**.

Like **herbivores** and **carnivores**, **decomposers** are **heterotrophic**, meaning that they **use organic substrates to get their energy**, **carbon** and **nutrients** for **growth** and **development**.

While the **terms decomposer** and **detritivores** are often interchangeably used, detritivores must **ingest** and **digest dead matter** via **internal processes** while decomposers **can directly absorb nutrients through chemical and biological processes** hence **breaking down matter without ingesting it**. e.g.(**fungi** and **bacteria**) , called **Saprophytic organisms** are when they live on **dead organic matter**, or **Parasitic organisms**, when they rely **on living organisms** .

The **primary decomposers** in many ecosystems are **fungi . Unlike bacteria**, which are **unicellular organisms**, most fungi **grow as a branching network of hyphae**. While bacteria are **restricted to growing and feeding on the exposed surfaces** of organic matter, fungi can use their **hyphae to penetrate larger pieces of organic matter**. Additionally, fungi **have evolved their enzymes necessary to decomposition** . These **two factors make** fungi the primary decomposers in many Ecosystem .

Ecosystem configuration condition :

1- Presence **community** .(**Producers , Consumers , Decomposers**)
2- **Energy flow** clearly in different levels trophic for this community .
3- Presence **biodiversity** in this community.
4- Occur **recycling for elements and necessary nutrients** for life and exchange between biotic & abiotic and its environment .

Principle Processes of Ecosystem :

1- Autotrophs are primary producers .
2- Energy supplied by the sun .
3- Pedogenesis chemical energy (Changing energy from sunlight into chemical energy that plants and animals can use as food)
4- Energy flow is one way (Regulate the flux of energy and matter through an environment) .
5- Materials and nutrient are recycled .

Linking Ecosystem Components:

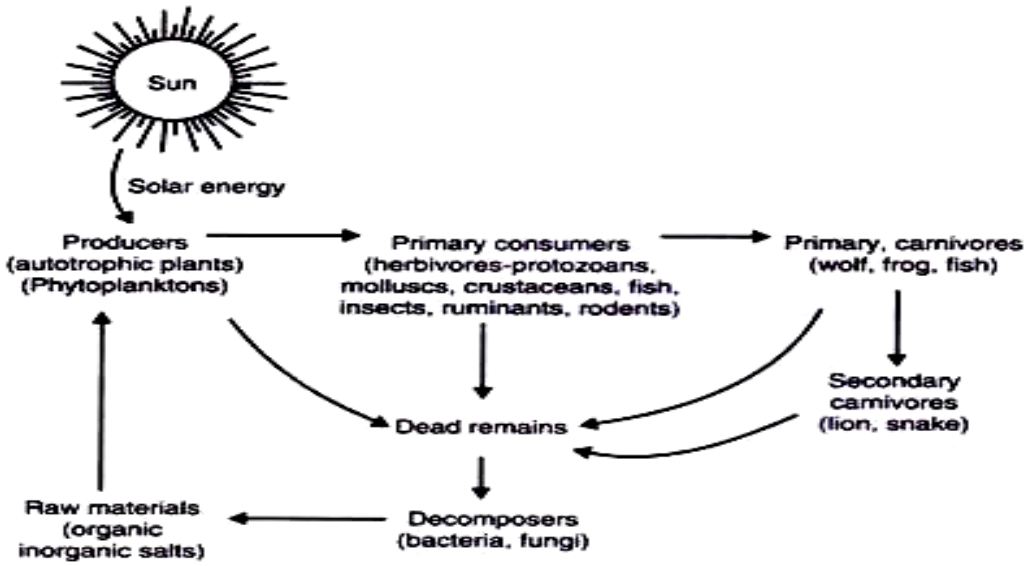
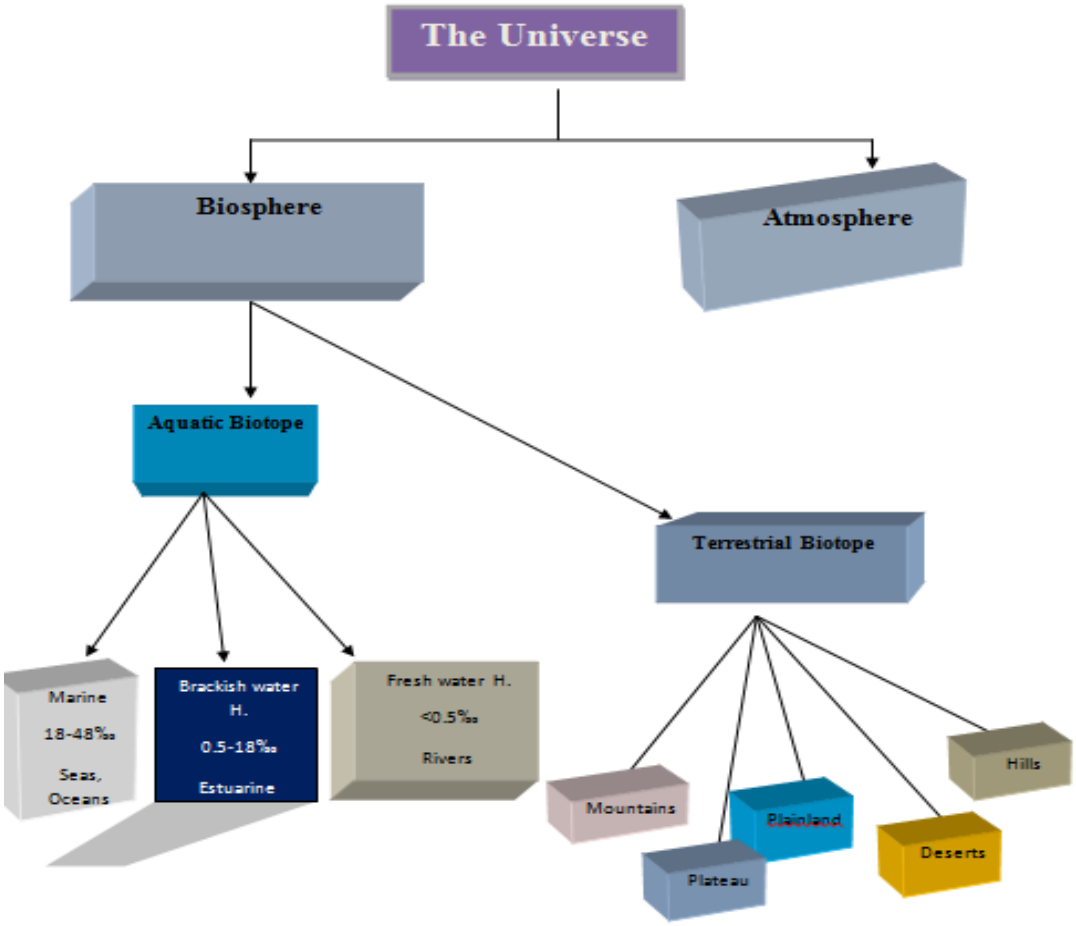


Fig. 3.7. Flow of energy at different levels of ecosystem.

Type of Ecosystem :

1- **Complete Ecosystem** . Presence all its components , Ex : **The Universe** .



2- **Incomplete Ecosystem** . Complete Ecosystem absent one or more from its essential part of components .

3- **Micro Ecosystem** . Ex : Small ecosystem it has distinct limits , can us influence it's in any time . Ex: Ornamental aquarium .

4- **Artificial Ecosystem** . Ex: Fish Farming aquarium .

Habitat and Ecological niche :

1- **Habitat** : refers to any part of the biosphere where a species can successfully live and reproduce .

2- **Ecological niche** : describes a species' ecological role within a community.

The Ratios of the elements of the human body :

Q: Why studying the elements is very important ?

Oxygen: It forms **65%** , which is present in the **lungs** and is an **essential element** of the **breathing process**.

Carbon: 18%, is present in **every organic part of the body**, and is present as a product of the breathing process, in the form of carbon dioxide.

Hydrogen: It forms **10%**, a component of water.

Nitrogen: forms **3%,** enters into the **synthesis of nucleic acids**, proteins, and organic compounds.

Calcium: forms **1.5%, forms 99% of the bone structure**, and the teeth .

Phosphorus: 1%, enters the synthesis of nucleic acids responsible for the transfer of genetic traits**.**

Iron: forms **0.006%,** enters the **structure of hemoglobin**, and **myoglobin**.

Chlorine: **0.15%,** is **present in the stomach as part of hydrochloric acid**, used in digestion, and is present in the form of ion in body fluids.

Iodine: constitutes **0.000016%,** enters the **synthesis of thyroxine**, necessary to stimulate chemical reactions within the body.

Sulfur: forms **0.25%,** enters into the **synthesis of hormones**, some **vitamins**, **amino acids**, and proteins.

It also consists of **lead**, **aluminum**, **lithium**, **vanadium**, **silicon**, **in small quantities.**

Biogeochemical cycles : include

1- Hydrologic cycle . Ex : Water cycle .

2- Gaseous cycle . Ex : Carbon cycle , Nitrogen cycle

3- Sedimentary cycle . Ex : Sulfur cycle , Phosphor cycle**.**

1-Hydrologic cycle (Water cycle) :

Water covers **about three-quarters** of Earth's surface and is a **necessary element for life**. water molecules pass repeatedly through **solid, liquid,** and **gaseous phases** (**ice**, **liquid water,** and **water vapor**), but the **total supply remains fairly constant**. A water molecule **can travel to many parts of the globe as it cycles**.

water vapor **redistributes energy** from the sun **around the globe** through **atmospheric circulation**. This happens **because water absorbs a lot of energy** when it **changes its state from liquid to gas**.

Even though the temperature of the water vapor **may not increase** when it evaporates from liquid water, this vapor **now contains more energy**, which is referred to as (**latent heat)**

Atmospheric circulation moves this latent heat around Earth , and when water vapor **condenses** and **produces rain** , **the latent heat is released.**

Very little water is consumed in the sense of actually taking it **out of the water cycle permanently**, and unlike energy resources such **as oil, water** is not lost as a consequence of being used .

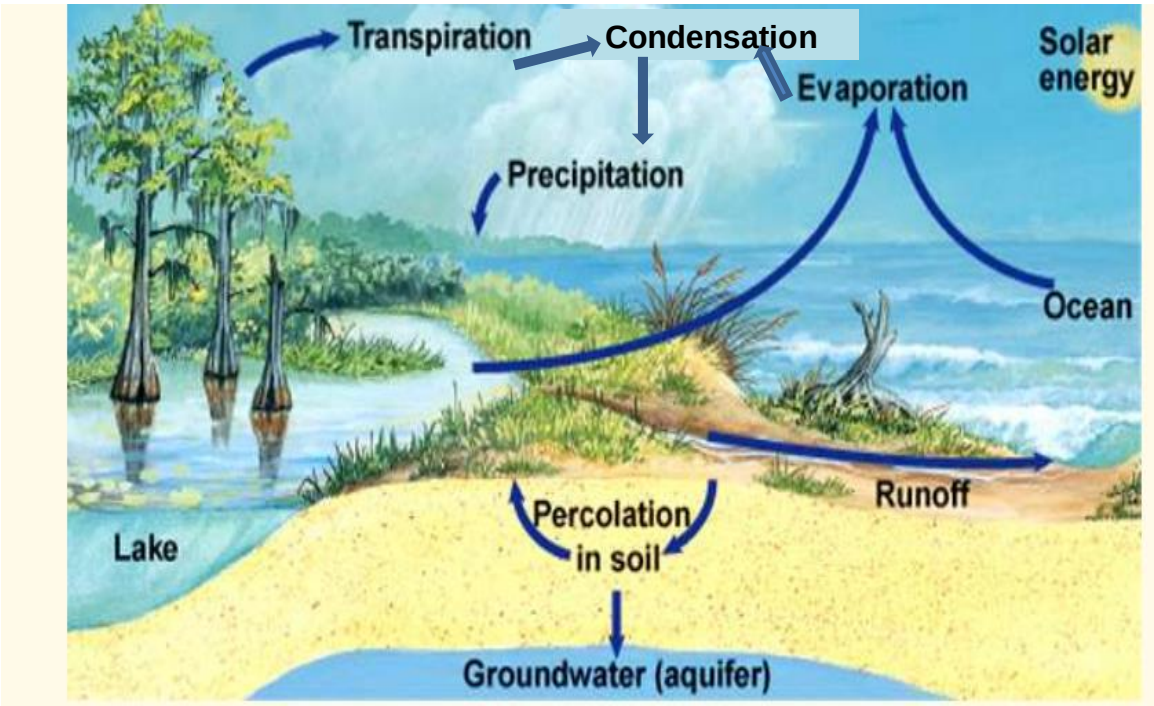
There are **three basic steps in the global water** cycle:

1- Water precipitates from the atmosphere.
2- Travels on the surface and through groundwater to the oceans.
3- Evaporates or transpires back to the atmosphere from land or evaporates from the oceans.

- Approximately 90 percent of water vapor evaporates from oceans, lakes, and rivers;

- 10 percent evaporates from the surface of plants through a process called transpiration .

Water cycle:



2- Gaseous cycle (The Carbon cycle) :

Carbon element :

The human body consists of water, which forms about 65% to 90% of the mass of cells forming the body, and water is composed of two essential elements: hydrogen, oxygen, so these two elements, a key component of the human body, and oxygen is the most abundant element, despite The presence of two hydrogen atoms in the water molecule, because the mass of oxygen is higher than the mass of hydrogen atoms, and carbon is the second most abundant element, to contain most of the members of the human body, and then comes hydrogen, and also exists in the human body many elements, different rates, depending on the need her body, make up about 7% of the body mass.

Carbon is a very important element. It is not the most abundant element in the universe or even on the Earth, but it is the second most common element in the human body. You could not live without carbon. If something you eat has protein or carbohydrates or fats, then it contains carbon. When your body breaks down that food to produce energy, you breathe out carbon dioxide. Carbon is also a very important element on Earth. Carbon is provided by the environment, moves through organisms and then returns to the environment again. When all this happens in balance, the ecosystem remains in balance .

let's follow the path of a carbon atom over many years and see what happens.

The Carbon cycle :

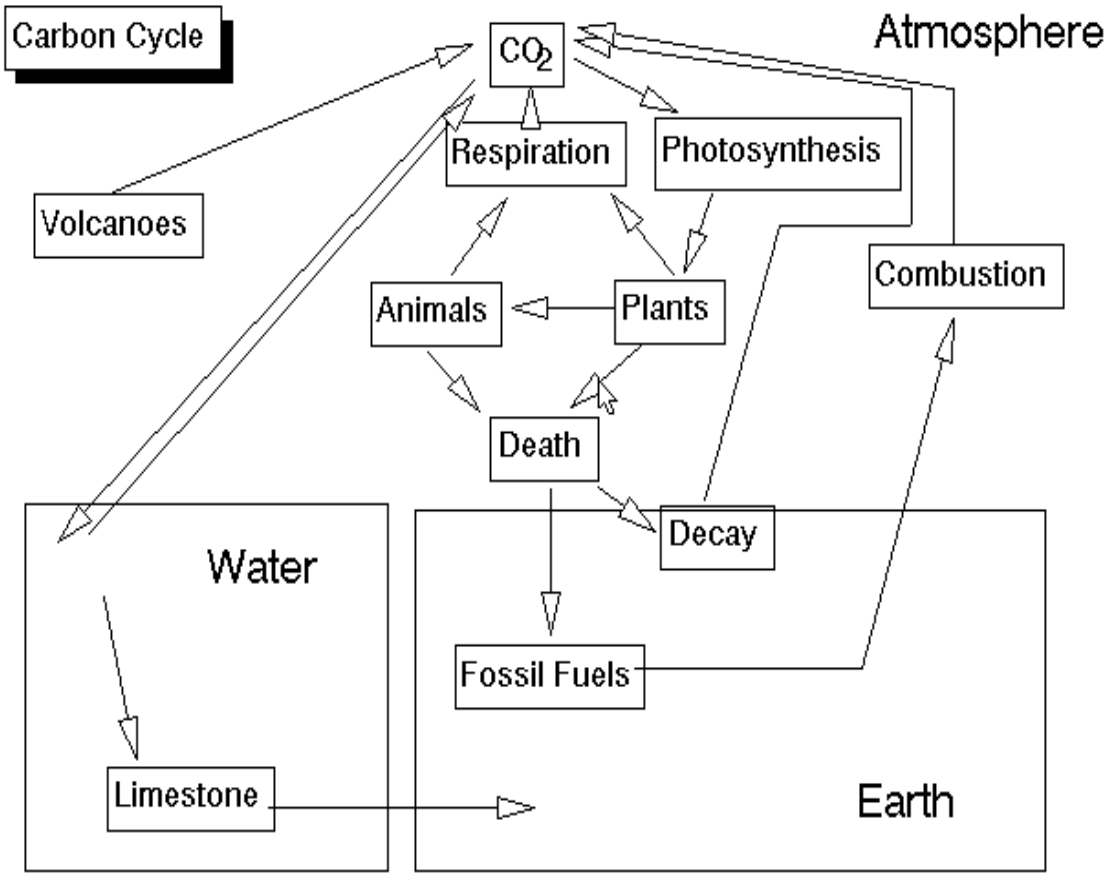
The short term cycling of carbon begins with carbon dioxide and the process of photosynthesis. Our atmosphere is mostly made of nitrogen and oxygen, but there is a small amount of carbon dioxide in the air too. Plants and algae use this carbon dioxide, along with water and energy from sunlight to produce their own food. Plants and algae have the ability to take the inorganic carbon in carbon dioxide and make it into organic carbon, which is food .

Through photosynthesis, carbon dioxide plus water and energy from sunlight is transformed into food with oxygen given off as a waste product **.**

$6CO_2 + 6H_2O$ + energy from sunlight → $C_6H_{12}O_6 + 6O_2$

Other times , the organic material of the organism is buried and transformed over millions of years into coal, oil, or natural gas. When this happens, it can take millions of years before the carbon becomes available again .

Another way that carbon is stored for long periods of time happens when carbon is used by ocean organisms. Many ocean creatures use calcium carbonate ($CaCO_3$) When algae die, their organic material becomes part of the ocean sediments, which may stay at the bottom of the ocean for many, many years. Over millions of years, . As the ocean sediments melt and form magma, carbon dioxide is eventually released when volcanoes erupt.

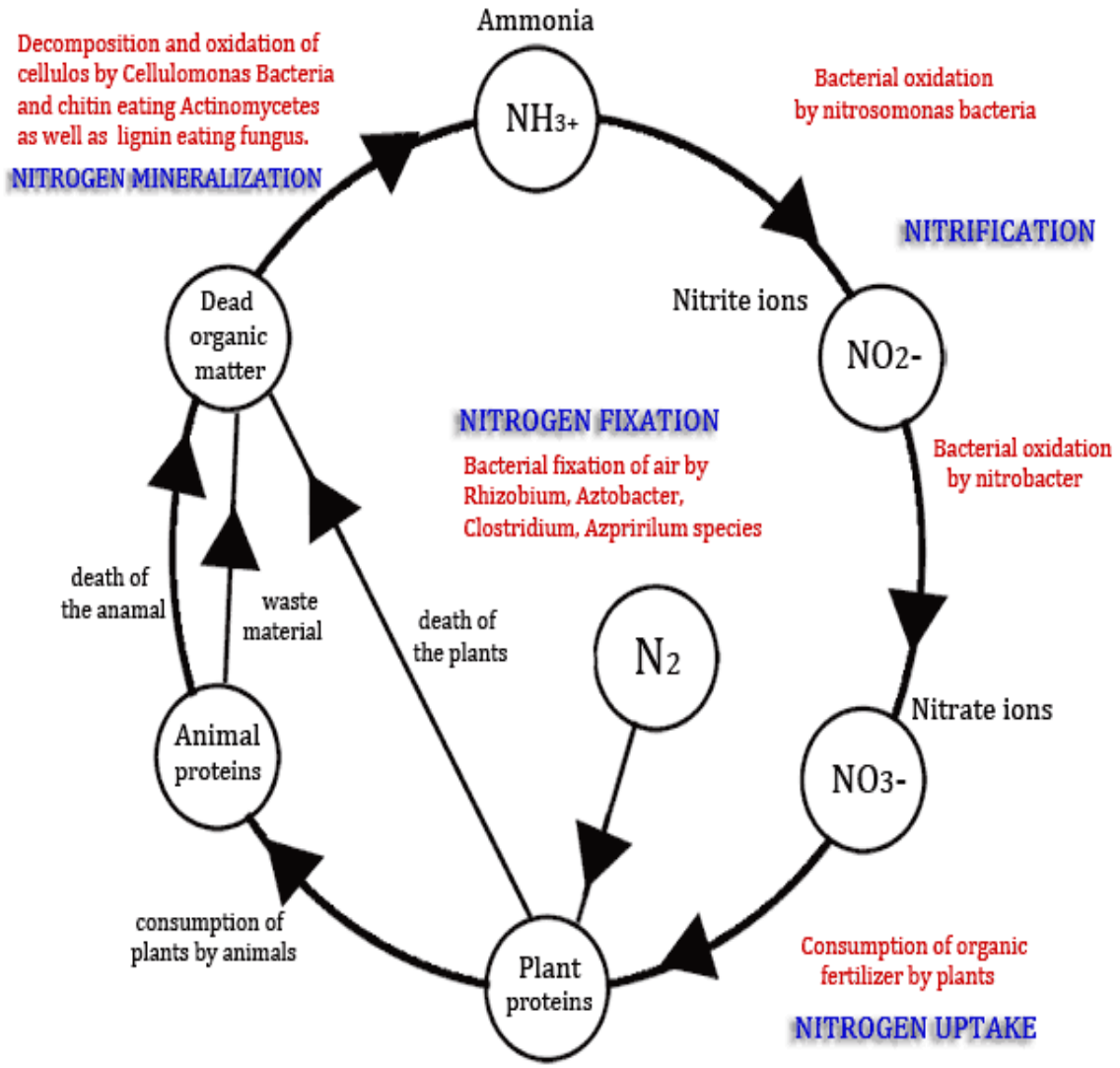


The Nitrogen cycle:

The **important steps** of nitrogen cycle :

1- Nitrogen from atmosphere (78%) is fixed by prokaryotes . (fixing bacteria either live free or in a symbiotic relationship with leguminous plants) .
2- NH4 in soil is converted by nitrifying bacteria to NO_2- and NO_3- .
3- NO3 is taken up by plant roots and also denitrified by bacteria back to N_2
4- Found in all amino acids, proteins, and nucleic acids such as DNA and RNA, Chlorophyll molecules in plants . also animals molecules (above)
5- Death of plants and animals returns some ammonia to the soil .
6- Soil nitrogen limits plant growth .

NITROGEN CYCLE



Sedimentary cycles :

Sulphur Cycle :

Sulphur is an important component of **most proteins**, few **vitamins** and **enzymes**. Though sulphur occurs in gaseous form, as hydrogen sulphide **(H2S)** and sulphur dioxide **(SO2),** the residence time of sulphur in atmosphere is **very small** and **its main reservoir pool** is the **soil sulphides** and **organic sulphur** .

So, sulphur cycle is **classified under sedimentary cycles** .

Steps of Sulfur cycle:

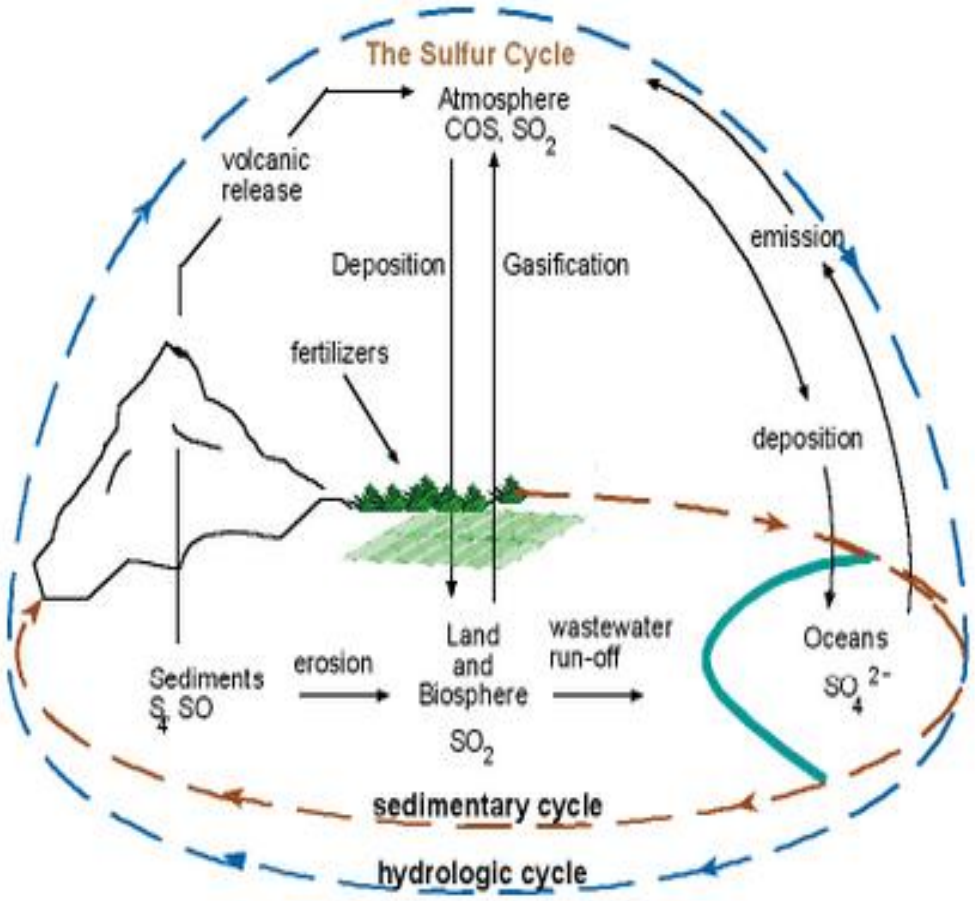
The sulfur cycle contains both atmospheric and terrestrial processes. Within the terrestrial portion.

1 - The cycle begins with the weathering of rocks ،
2- Releasing the stored sulfur .
3 -The sulfur then comes into contact with air where it is converted into sulfate (SO4).
4- The sulfate is taken up by plants and microorganisms and is converted into organic forms; animals then consume these organic forms through foods they eat,
5- Thereby moving the sulfur through the food chain.
6- As organisms die and decompose, some of the sulfur is again released as a sulfate and some enters the tissues of microorganisms.

There are also a variety of natural sources that **emit sulfur directly into the atmosphere**, including **volcanic eruptions**, the **breakdown of organic matter in swamps** and **tidal flats**, and **the evaporation of water** into organic sulfur form.

Sources of Sulphur:

a) Soil, water and rocks containing sulphates, sulphides and organic sulphur, and also body of living organisms.
b) Oxides of sulphur in the atmosphere due to the burning of fossil fuels and volcanic emissions.
c) Sulphur occurs as elemental sulphur also.



Phosphor Cycle :

Phosphorus is an important element for all forms of life. As phosphate (PO4), it makes up an important part of the structural framework that holds DNA and RNA together. Phosphates are also a critical component of ATP—the cellular energy carrier—as they serve as an energy ?release' for organisms to use in building proteins or contacting muscles. Like calcium, phosphorus is important to vertebrates; in the human body, 80% of phosphorous is found in teeth and bones.

The phosphorus cycle **differs from the other major biogeochemical cycles** in that it does **not include a gas phase**; although small amounts of phosphoric acid (H3PO4) may make their way into the atmosphere, contributing—in some cases—to acid rain. The water, carbon, nitrogen and sulfur cycles **all include at least one phase in which the element is in its gaseous state**. The largest reservoir of phosphorus is in **sedimentary rock.**

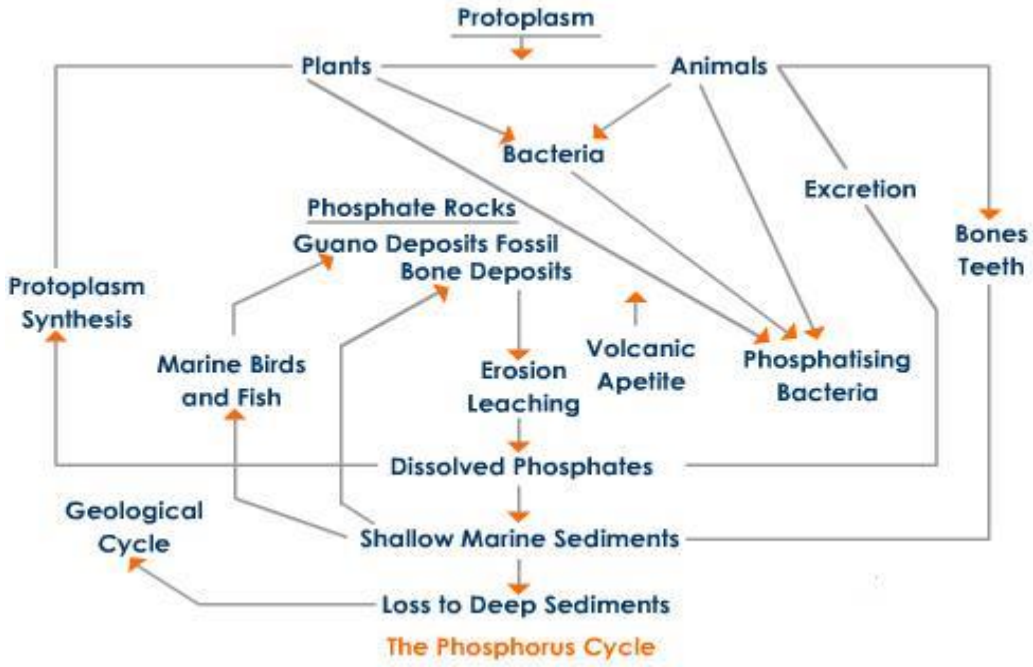
Very **little phosphorus circulates** in the atmosphere **because:**

1- At Earth's **normal temperatures** and **pressures,** phosphorus .
2- Its various compounds **are not gases**.

Phosphorus moves in a cycle through rocks, water, soil and sediments and organisms.

Here are **the key steps of the phosphorus cycle** :

1- Over time, rain and weathering cause rocks to release phosphate ions and other minerals. This inorganic phosphate is then distributed in soils and water.
2- Plants take up inorganic phosphate from the soil. The plants may then be consumed by animals. Once in the plant or animal, the phosphate is incorporated into organic molecules such as DNA. When the plant or animal dies, it decays, and the organic phosphate is returned to the soil.
3- Within the soil, organic forms of phosphate can be made available to plants by bacteria that break down organic matter to inorganic forms of phosphorus. This process is known as mineralisation.
4- Phosphorus in soil can end up in waterways and eventually oceans. Once there, it can be incorporated into sediments over time.



Eutrophication

Eutrophication is when the environment becomes enriched with nutrients such as (P , N) . This can be a problem in marine habitats such as lakes as it can cause algal blooms.

1- Fertilisers are often used in farming, sometimes these fertilisers run-off into nearby water causing an increase in nutrient levels.
2- This causes phytoplankton to grow and reproduce more rapidly, resulting in algal blooms.
3- This bloom of algae disrupts normal ecosystem functioning and causes many problems.
4- The algae may use up all the oxygen in the water, leaving none for other marine life. This results in the death of many aquatic organisms such as fish, which need the oxygen in the water to live.
5- The bloom of algae may also block sunlight from photosynthetic marine plants under the water surface.
6- Some algae even produce toxins that are harmful to higher forms of life. This can cause problems along the food chain and affect any animal that feeds on them.

ECOSYSTEM ENERGY FLOW :

Nearly all of the energy that drives ecosystems ultimately comes from the sun. Solar energy, which is an abiotic factor, by the way, enters the ecosystem through the process of photosynthesis. The organisms in an ecosystem that capture the sun's electromagnetic energy and convert it into chemical energy are called producers.

Primary consumers only obtain a fraction of the total solar energy—about 10%—captured by the producers they eat. The other 90% is used by the producer for growth, reproduction, and survival, or it is lost as heat .

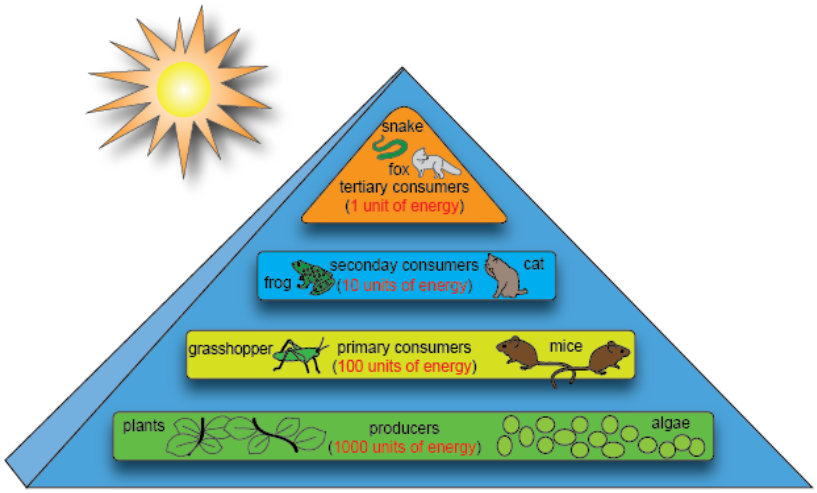
Primary consumers are eaten by secondary consumers. An example would be birds that eat bugs that eat leaves. Secondary consumers are eaten by tertiary consumers. Cats that eat birds that eat bugs that eat leaves, for instance.

At each level, called a trophic level, about 90% of the energy is lost. , if a plant captures 1000 calories of solar energy, a bug that eats the plant will only obtain 100 calories of energy. A chicken that eats the bug will only obtain 10 calories, and a human that eats the chicken will only obtain 1 calorie of the original 1000 calories of solar energy captured by the plant. When you think about this way, it would take 100 1000-calorie plants—those would be enormo plants, by the way—to produce a single 100-calorie piece of free-range chicken.

The relationships among producers, primary consumers, secondary consumers, and tertiary consumers is usually drawn as a pyramid, known as an energy pyramid, with producers at the bottom and tertiary consumers at the top. You can see from the example above why producers are at the bottom of this pyramid.

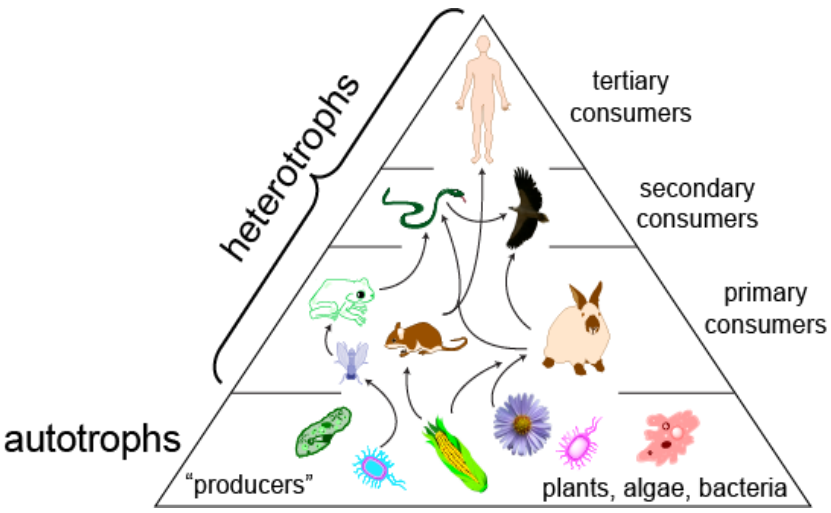
It takes a lot of producers for higher trophic level consumers, like humans, to obtain the energy they need to grow and reproduce.

This is the answer to the great mystery as to why there are so many plants on Earth. We will even spell it out for you because it is so important to understand: there are so many plants on Earth because energy flow through ecosystems is inefficient. Only 10% of the energy in one trophic level is ever passed to the next.



in addition to energy pyramid diagrams, ecosystem ecologists sometimes depict the relationship between trophic groups in a linear way, If there is only one producer, one primary consumer, one secondary consumer, and one tertiary consumer, this linear diagram is called a food chain.

In fact, trophic interactions among organisms in an ecosystem are often really complex. It's rare that an ecosystem only has one species at each trophic level. Usually, there are multiple producers that are eaten by multiple primary consumers. Some consumers eat differ In any case, uncovering food webs goes a long way to understanding the first half of an ecosystem, the community.ent kinds of producers. These complex relationships a called a food web.



Food chains are of three types:

1- Grazing food chain:

The grazing food chain starts from green plants and from autotrophs it goes to herbivores (primary consumers) to primary carnivores (secondary consumers) and then to secondary carnivores (tertiary consumers) and so on .

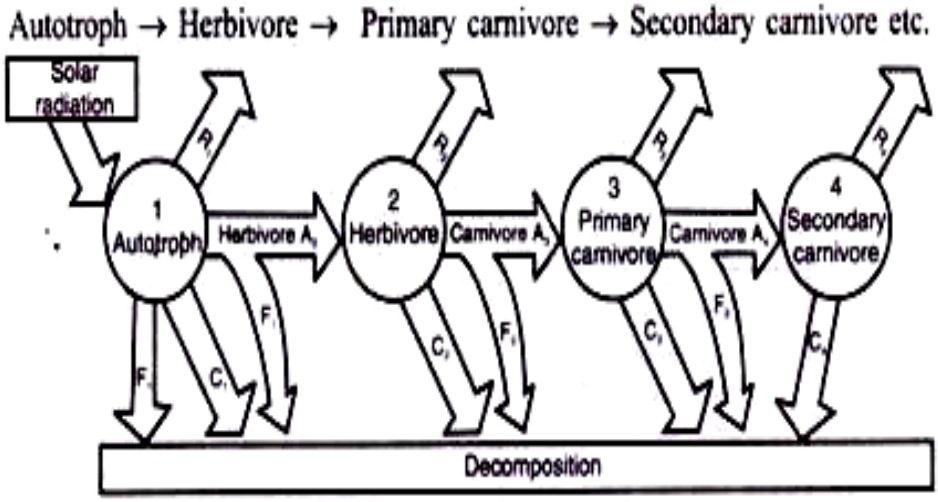


Fig. 3.8. Diagrammatic representation of a grazing food chain showing input and losses of energy at each trophic level. Trophic levels are numbered and used as subscripts to letters indicating energy transfer. A—assimilation of food by the organisms at the trophic level; F—energy lost in the form of faeces and other excretory products; C—energy lost through decay; and R—energy lost to respiration.

A schematic representation of grazing food chain showing input and losses of energy

2- Parasitic food chain:

It goes from large organisms to smaller ones without outright killing as in the case of predator.

3- Detritus food chain:

The dead organic remains including metabolic wastes and exudates derived from grazing food chain are generally termed detritus. The energy contained in detritus is not lost in ecosystem as a whole, rather it serves as a source of energy for a group of organisms called detritivores that are separate from the grazing food chain. The food chain so formed is called detritus food chain. **The organisms in the detritus food chain are many and include** algae, fungi, bacteria, actinomycetes, protozoa, etc

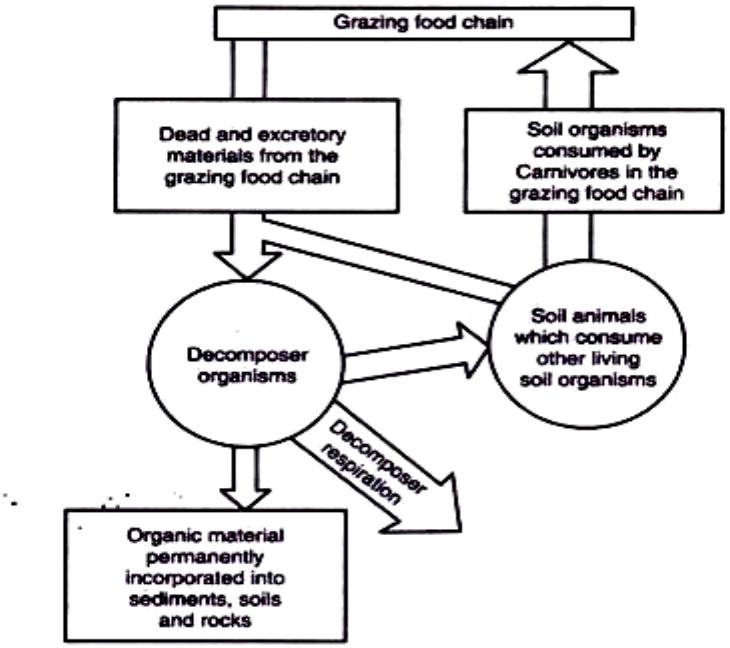


Fig. 3.9. Diagrammatic representation of the detritus food chain showing energy transfers between it and the grazing food chain, as well as energy losses to the detritus food chain.

Food web:

Similarly, in the food chain grass → mouse → snakes → owls, sometimes mice are not eaten by snakes but directly by owls.

This type of interrelationship interlinks the individuals of the whole community. In this way, food chains become interlinked. A complex of interrelated food chains makes up a food web. Food web maintains the stability of the ecosystem. The greater the number of alternative pathways the more stable is the community of living things.

Fig. below. illustrates a food web in ecosystem.

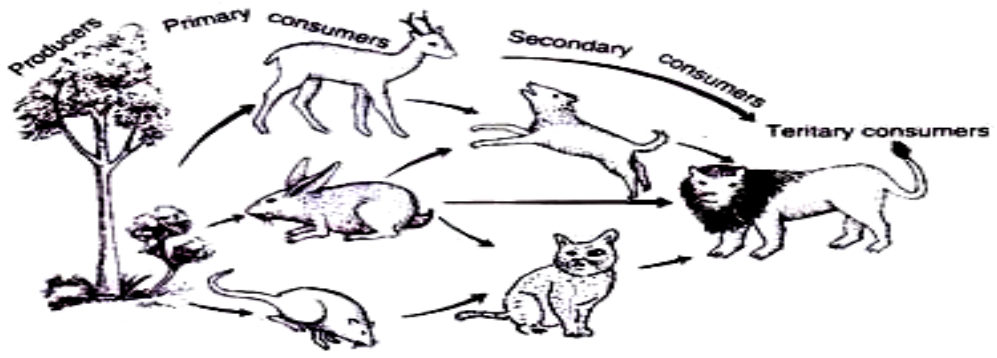


Fig. 3.10. Food web in an ecosystem.

Ecological pyramid:

The trophic structure of an ecosystem can be indicated by means of ecological pyramid. At each step in the food chain a considerable fraction of the potential energy is lost as heat. As a result, organisms in each trophic level pass on lesser energy to the next trophic level than they actually receive. This limits the number of steps in any food chain to 4 or 5. Longer the food chain the lesser energy is available for final members. Because of this tapering off of available energy in the food chain a pyramid is formed that is known as ecological pyramid. **The higher the steps in the ecological pyramid the lower will be the number of individuals and the larger their size.**

The idea of ecological pyramids was advanced by C.E. Elton (1927). There are different types of ecological pyramids. In each ecological pyramid, producer level forms the base and successive levels make up the apex. Three types of pyramidal relations may be found among the organisms at different levels in the ecosystem.

These are as follows:

1- .Pyramid of number 2-. Pyramid of biomass (**biomass is the weight of living organisms**), 3- Pyramid of energy.

1- Pyramid of numbers:

It depicts the numbers of individuals in producers and in different orders of consumers in an ecosystem. The base of pyramid is represented by producers which are the most abundant. In the successive levels of consumers, the number of organisms goes on decreasing rapidly until there are a few carnivores.

The pyramid of numbers of an ecosystem indicates that the producers are ingested in large numbers by smaller numbers of primary consumers. These primary consumers are eaten by relatively smaller number of secondary consumers and these secondary consumers, in turn, are consumed by only a few tertiary consumers .

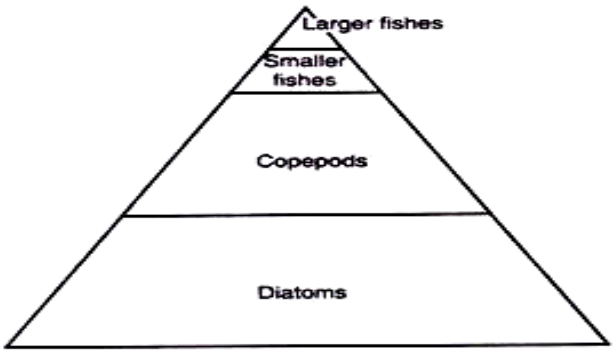


Fig. 3.11. A pyramid of numbers of a lake ecosystem.

This type of pyramid is best presented by taking an example of Lake Ecosystem. in the ecological pyramid of numbers there is a relative reduction in number of organisms and an increase in the size of body from base to apex of the pyramid. In parasitic food chain starting from tree, **the pyramid of numbers will be inverted** .

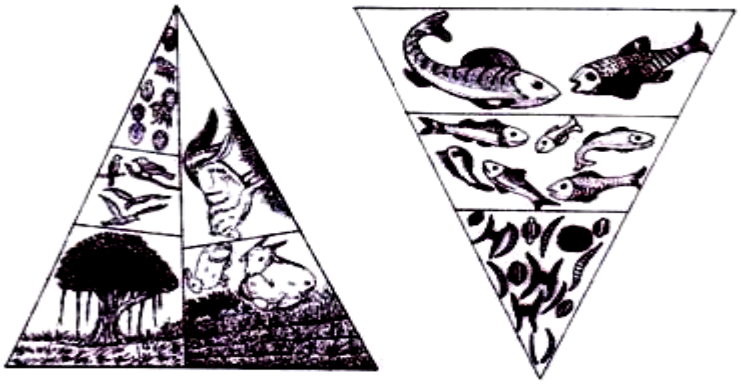


Fig. 3.12 (*a* & *b*). Pyramids of number
(*a*) Fig. 3.12 a & b. Up-right Pyramids of numbers in a grassland and cultivated field
(*b*) Pyramid of numbers (inverted) of diseased tree (Parasitic ecosystem)

2- **Pyramid of biomass of organisms:**

The living weights or biomass of the members of the food chain present at any one time form the pyramid of biomass of organisms. This indicates, by weight or other means of measuring materials, the total bulk of organisms or fixed energy present at one time. Pyramid of biomass indicates the decrease of biomass in each tropic level from base to apex, e.g., total biomass of producers is more than the total biomass of the herbivores.

Likewise, the total biomass of secondary consumers will be lesser than that of herbivores and so on , This usually gives sloping pyramid for most of the communities in terrestrial

and shallow water ecosystems. The pyramid of biomass in a pond ecosystem will be inverted as shown in Fig. 3.13 b.

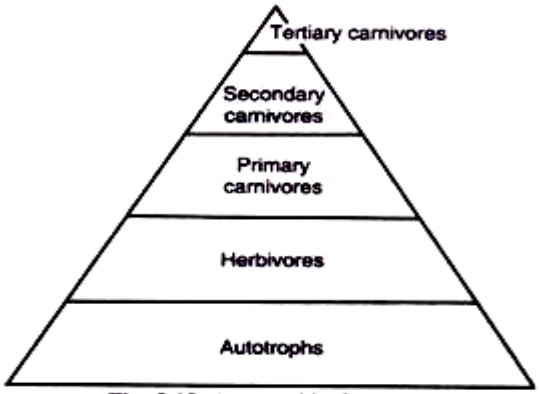


Fig. 3.13. A pyramid of biomass

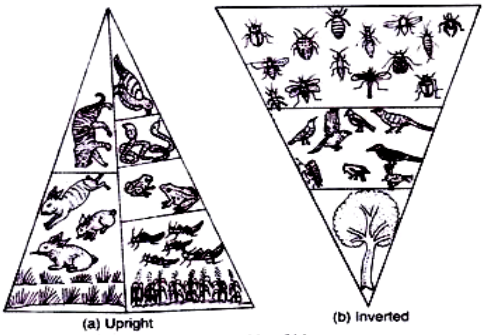


Fig. 3.14. (*a* & *b*). Pyramids of biomass
(*a*) A grassland ecosystems showing upright-triangular
(*b*) Inverted pyramid of biomass of an aquatic ecosystem.

3- Pyramid of energy:

This Pyramid not only the amount of total energy utilized by the organisms at each trophic level of food chain but more important, the actual role of various organisms in transfer of energy. At the producer level the total energy will be much greater than the energy at the successive higher trophic level.

Some producer organisms may have small biomass but the total energy they assimilate and pass on to consumers may be greater than that of organisms with much larger biomass. Higher trophic levels are more efficient in energy utilization but much heat is lost in energy transfer. Energy loss by respiration also increases from lower to higher trophic states (Fig.

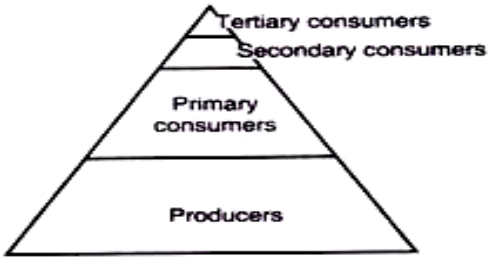


Fig. 3.15. A pyramid of energy

in the energy flow process, two things become obvious. Firstly there is one way along which energy moves i.e. unidirectional flow of energy. Energy comes in the ecosystem from outside source i.e. sun. The energy captured by autotrophs does not go back to the sun, the energy that passes from autotrophs to herbivores does not revert back and as it

moves progressively through the various trophic levels, it is no longer available to the previous levels.

Productivity:

The relationship between the amount of energy accumulated and the amount of energy utilized within one trophic level of food chain has an important bearing on how much energy from one trophic level passes on to the next trophic level in the food chain.

Primary Productivity:

The fraction of fixed energy a trophic level passes on to the next trophic level is called production .

Green plants fix solar energy and accumulate it in organic forms as chemical energy. Since it is the first and basic form of energy storage, the rate at which the energy accumulates in the green plants or producers is known as primary productivity.

Primary productivity is the rate at which energy is bound or organic material is created by photosynthesis per unit area of earth's surface per unit time. It is most often expressed as energy in calories / cm2 / yr or dry organic matter in g / m2 / yr , quite different from biomass , The total solar energy trapped in the food material by photosynthesis is referred to as gross primary productivity (G.P.P.).

A good fraction of gross primary production is utilized in respiration of green plants. The amount of energy bound in organic matter(per unit area and time) that is left after respiration in plants is net primary production (N.P.P)

Net productivity of energy = gross productivity—energy lost in respiration.

Secondary Productivity:

Secondary productivities are the productivities of animals (heterotrophic organisms) in communities.

Ecological (Symbiotic) Relationships :

Ecological relationships are relations between two different organisms. **There are five** different types of ecological relationships**: mutualism**, **competition, parasitism**, .**neutralism**, and **commensalism .**

Mutualism :

Mutualism is when two different species have an ecological relationship that **they both benefit from**.. This is a positive relationship , patterns occur in two forms:

1- Obligate mutualism :For example**, lichens**, which consist of **fungi** and either **algae** , The fungi's partners **provide sugar from photosynthesis** and the fungi **provide nutrients** from decomposition organic matter . **Thus, both organisms benefit from this relationship**.

1- **Facultative mutualism** : is when one species **can survive on its own under certain conditions.** :For example **: Zebras** and **wild birds** in the **grasslands of Africa**. Wild birds follow herds of zebras and feed off the bugs that are in the zebra's fur. This helps the zebras because the bugs can be harmful to them and bite them and it is also helpful to the birds because the bugs they eat from the zebra's fur are their main source of food .

Commensalism :

Commensalism is a relationship in which one organism benefits from another organism that is not affected. **This is a positive relationship**, occur in two forms : **Obligate , Facultative** . For example, a small fish called the remora Fish follows underneath a shark and when the shark eats something the remora fish eats the scrap pieces of the shark original kill .

Competition :

Competition occurs in virtually every ecosystem in nature. This type of relationship develops when more than one organism in an environment requires the same thing in order to survive. These individuals compete for limited resources such as : food, shelter and mates.When food and shelter are plentiful, there is no competition--it only takes place when there is not enough to go around. Competition often results in the survival of the fittest, **This is a negative relationship**, occur in two forms :

Intraspecies competition :

Organisms competing can be from within **the same species** for example, two male elk fighting for a female mate .

Interspecies competition :

Competition can be also **found in two different species**. A lizard and a frog can compete for a similar food they eat such as a small insect. This type of competition is only found when two different species share an ecological niche that they must compete over.

Competitive exclusion principle :

Direct competition **between different species** almost always produces **a winner** and a **loser**- and the **losing species dies out**," or is **forced to migrate to another ecosystem** which can support them

This is the **competitive exclusion principle**. This principle says that two species **that need** the same resources cannot survive together in the same habitat. One organism will eventually die off.

Parasitism :

Parasitism is when one organism in the relationship **benefits from the (the parasite**) relationship, and when the other organism **(the host) is harmed**. This usually happens when a small organism lives inside or on a larger organism and feeds off of it.This is a **negative relationship** ,occur in two forms : **1- Temporary 2- Permanent**

Although some parasitic **organisms can kill their host** (the organism that they feed on) **but not always killed** . These parasitic organisms **use the host as their main food source** and a **place to live**. Also, the host organism **can spread the offspring of the parasitic organism** if it is in contact with other individuals of its **own species**.

Parasitic organisms include **lice, fleas, ticks, and hookworms**. **Most feed** on the **outside** of the organism, but hookworms and other specialized parasites **live inside their host**.

For example, mosquito is a parasite, feeding on a human while transferring the disease called **Malaria.**

Predation :

This is where one organism **captures, kills** and **eats** the other organism. The organism hunting is called the **predator**, while the organism being hunted is called the **prey** .

A predator is usually a **carnivore that hunts**, **kills** and **eats other animals**. For example, a **snake eating a mouse**: the snake is considered the predator because it is **consuming** the mouse.

However, a predator can **become the prey of another larger predator**; for instance, a snake may become a **meal for a hawk**.

"In ecology, predation is a **mechanism of population control**. Thus, balanced between the number of predators and , the number of prey .

Because of this, predation is called a "**positive-negative" relationship. a positve - negative relationship (for individials)** , a **positve** (**for Population , Community**) .