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Friend, Philosopher, Guide

Ecosystems & Ecology

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Ecosystems And Ecology

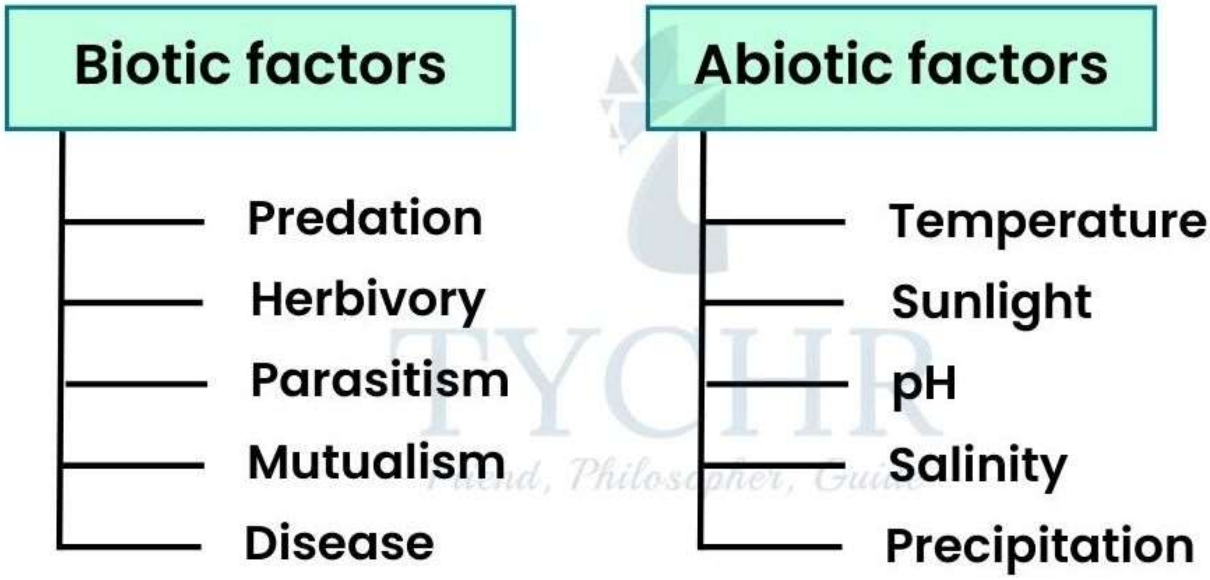


Figure 1 The Illustrates interactions between the organisms (Biotic Factors) & factors that influence the organisms and ecosystems (Abiotic Factors).

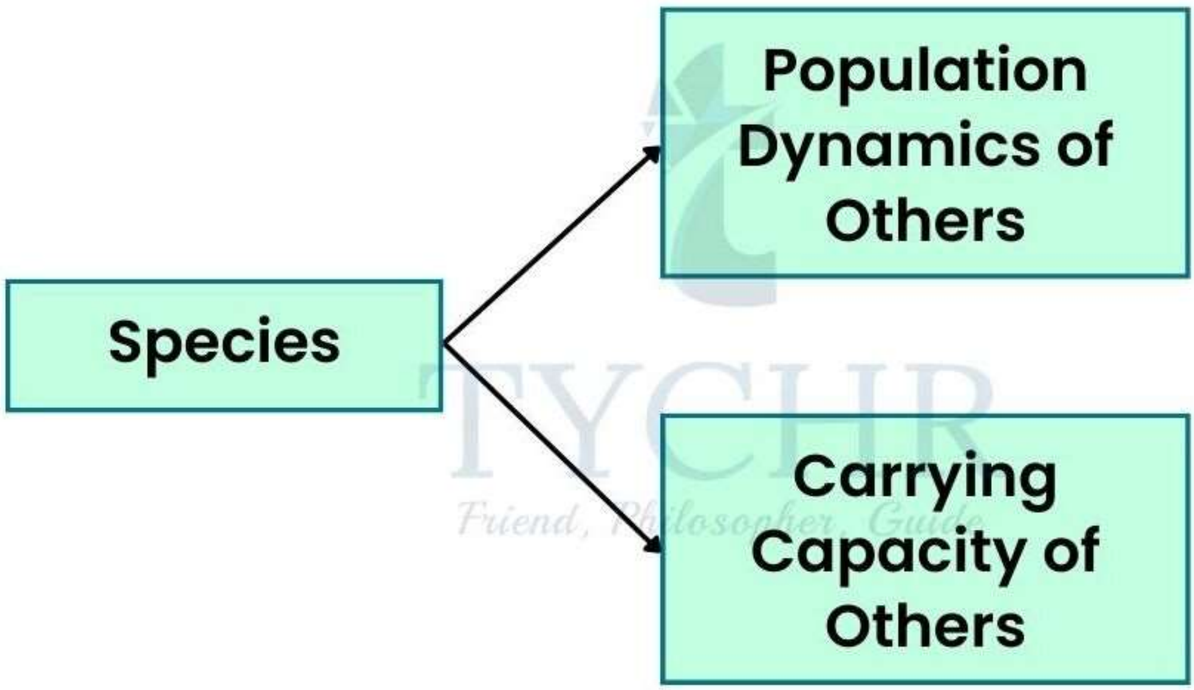


Figure 2 Illustrates the influences a species has on members of its own species as well as other species.

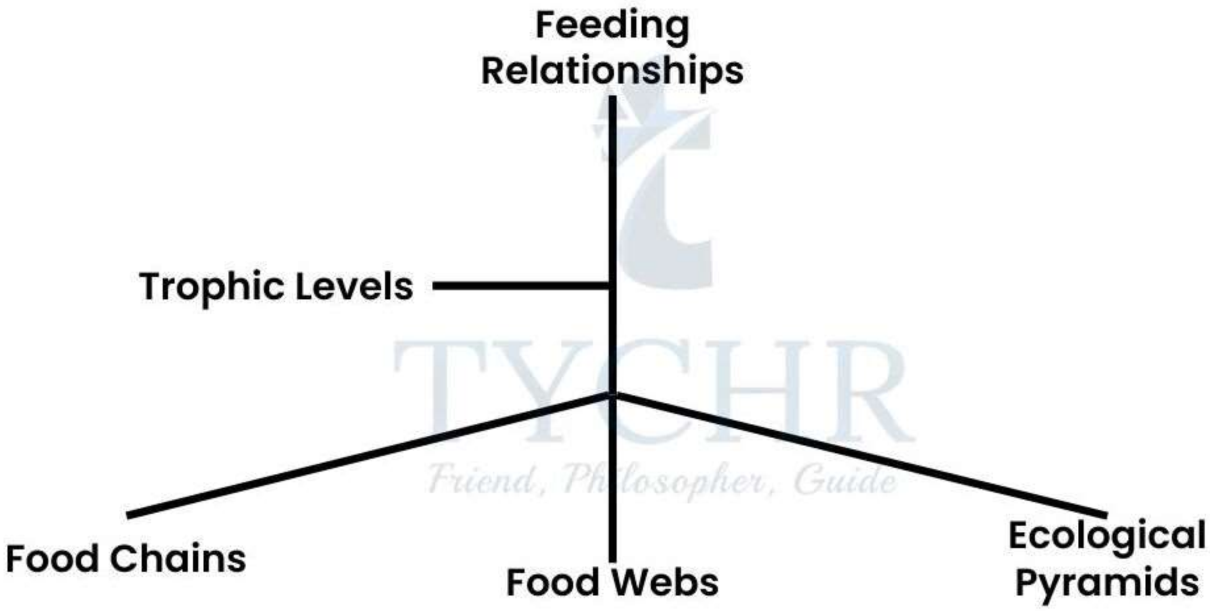


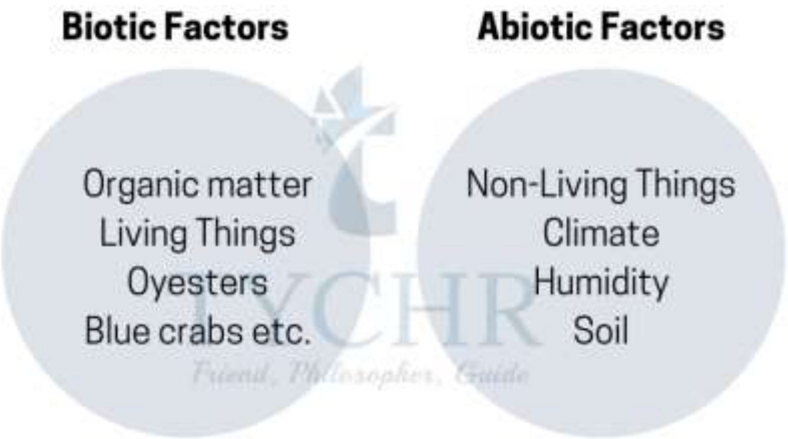
Figure 3 Explores different feeding relationships which can be divided into different trophic levels, which can be modelled using food chains, food webs, and ecological pyramids.

2.1 Species And Populations

2.1.1 Species, Habitat, Niche

- Species- A species can be defined as a group of organisms that interbreed and produce fertile offspring. An example of a species is the lion, Panthera leo.
- Habitat- A species' typical biotic and abiotic environment is known as its habitat. Lions, for instance, can be found in open woodland, grassland, savanna, and dense scrub.
- Niche- An ecological niche is best described as where, when, and how an organism lives. An organism's niche depends not only on where it lives (its habitat) but also on what it does. A niche is the particular collection of biotic and abiotic conditions and resources to which an organism or population responds.
    - Fundamental niche- Can be simply defined as where and how an organism could live.
    - Realised niche- Is where and how an organism does live.
- Abiotic Factors- Are non-living parts of the environment and these factors determine the fundamental and realised niche of species.
- Biotic Factors- Are the living part of the environment. Interactions between organisms are also biotic factors. Ecosystems contain

numerous populations with complex interactions between them. The nature of the interactions varies.



2.1.2 Population Interactions

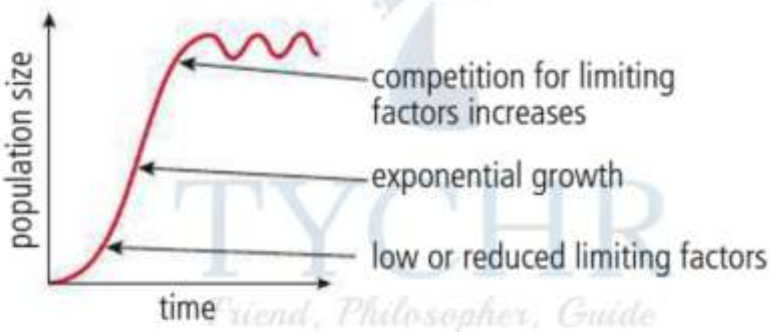
Predation	Herbivory	Parasitism	Mutualism	Disease
Predation occurs when one animal hunts and eats another organism.	Herbivory is an interaction where an animal feeds on a plant.	One organism gets its food from another organism that does not benefit from the relationship.	Mutualism is an interaction in which both species benefit.	An organism that causes disease is known as a pathogen.
are frequently governed by population densities-controlling negative feedback mechanisms. The carrying capacity of the prey and predator is affected	The carrying capacity of herbivores is affected by the quantity of the plant they feed on. An area with more abundant plant resources will have a	The organism that benefits is called the parasite. The organism from which the parasite gets its food is called the host. The carrying capacity of the host may be reduced	This is a symbiotic relationship.	The disease-causing species may reduce the carrying capacity of the organism it is infecting. Changes in disease can also cause populations to increase

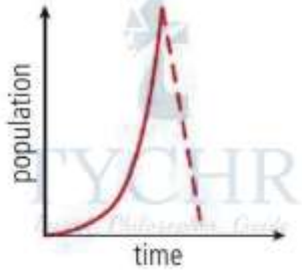
because of the negative feedback.	higher carrying capacity.	because of the harm caused by the parasite.		and decrease around the carrying capacity.
Eg: Lion that kills a deer.	Eg: Caterpillar feeding, eating a leaf.	Eg: Rafflesia.	Eg: Corals and unicellular algae.	Eg: Dutch elm disease caused by fungus.

2.1.3 Competition

When resources are limited, individuals must compete in order to survive. This competition can be either within a species or between individuals of different species. When competition is within a species it is called intraspecific competition. When competition is between different species it is called interspecific competition.

2.1.4 Population Growth

S Population Curve	**J Population Curve**
In such a population, there is an initial rapid growth (exponential growth) which then slows down as the carrying capacity is reached.  	In some populations, exponential growth is at an increasing or accelerating rate of growth. Growth is initially slow but becomes increasingly rapid, a



nd does not slow down
as population Growth .

2.1.5 Limiting Factors

For plants: light, nutrients, water, carbon dioxide, and temperature. For animals: space, food, mates, nesting sites, and water. The carrying capacity of a population is affected by various limiting factors, such as:

- The availability of food and water
- Territorial space
- Predation
- Disease
- Availability of mates

2.2 Communities And Ecosystem

A community is many species living together, whereas the term population refers to just one species.
Communities include all biotic parts of the ecosystem, both plants and animals.
An ecosystem is a community of interdependent organisms and their physical environment, or abiotic component. There are three kinds of ecosystems: freshwater, marine, and terrestrial

2.2.1 Photosynthesis And Respiration

Photosynthesis converts light energy to chemical energy, which is stored in biomass.

Respiration releases energy from glucose and other organic molecules inside all living cells. It begins as an anaerobic process in the cytoplasm of cells, and is completed inside mitochondria with aerobic chemical reactions occurring. The process is controlled by enzymes.

$Glucose + Oxygen \rightarrow Carbon\ Dioxide + Water$

2.2.2 Feeding Relationships

Producers	Consumers	Decomposers
Producers are organisms in an ecosystem which convert abiotic components into living matter. They support the ecosystem by constant input of energy and new biological matter. Also called **autotrophs.**	Because they lack photosynthetic pigments like chlorophyll, consumers are organisms that consume other organisms for energy and matter. These organisms cannot produce their own food. Also called **heterotrophs.**	Decomposers obtain their food and nutrients from the breakdown of dead organic matter. Decomposers also contribute to the build-up of humus in soil.

2.2.3 Trophic Levels, Food Chains And Food Webs

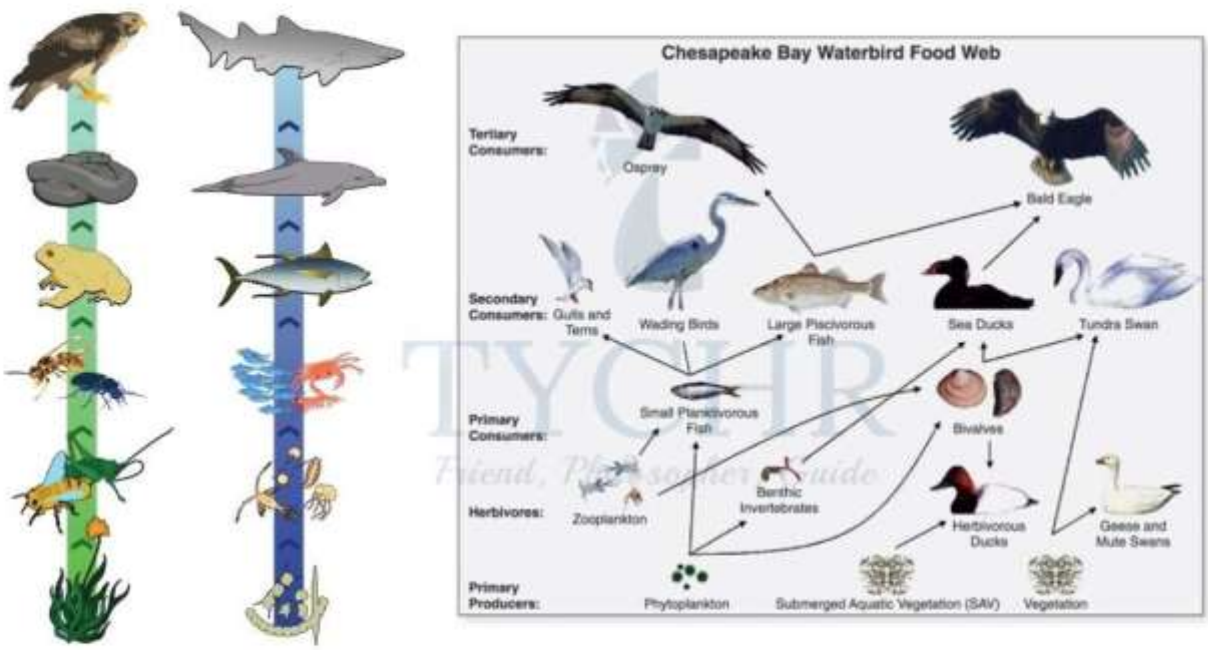


Figure 4 The flow of energy and matter from organism to organism can be

shown in a food chain. The position that an organism occupies in a food chain is called the trophic level Ecosystems contain many interconnected food chains that form food webs.

Let's Revise

Fundamental niche- The full range of conditions and resources in which a species could survive and reproduce.
Realized niche- The actual conditions and resources in which a species exists due to biotic interactions.
Niche- The abiotic and biotic conditions and resources to which an organism or pop

2.2.4 Pyramids Of Numbers, Biomass, And Productivity

- A pyramid of numbers represents the number of organisms (producers and consumers) coexisting in an ecosystem.
- A pyramid of biomass represents the quantities of matter and energy stored at each trophic level, such as grams of biomass per square meter (gm–2)
- Pyramids of biomass represent the momentary stock, whereas pyramids of productivity show the rate at which that stock is being generated.
  Pyramid Structure and Ecosystem Functioning
- The second law of thermodynamics states that biomass tends to decrease along food chains, so pyramids narrow as trophic levels rise because energy decreases along food chains.
- A reduction in the numbers of producers or primary consumers can threaten the existence of the top carnivores when there are not enough of the producers or primary consumers (and therefore energy and biomass) to support the top carnivores.
- Because of their relatively small populations, top carnivores may be the first population we notice to suffer through ecosystem disruption.

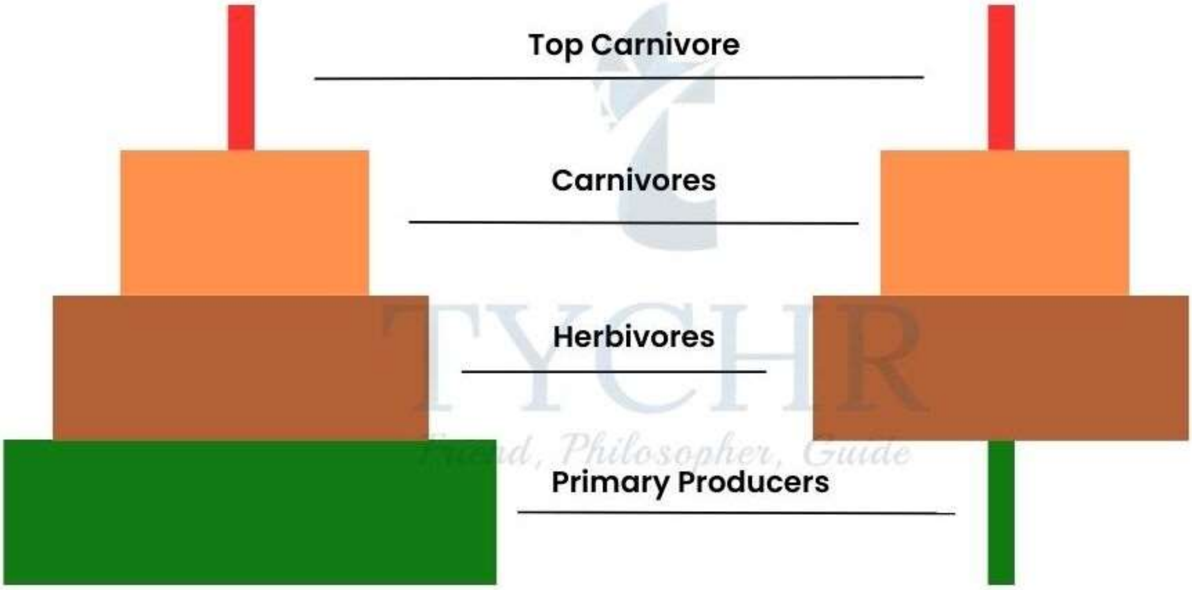


Figure 5 Pyramid of numbers. (a) A typical pyramid where the number of producers is high. (b) A limitation of number pyramids is that they are inverted when

2.3 Flows Of Energy And Matter

2.3.1 Transfer And Transformation Of Energy

Pathways of Radiation through the Atmosphere
Not all sunlight emitted by the Sun is used by plants for photosynthesis.

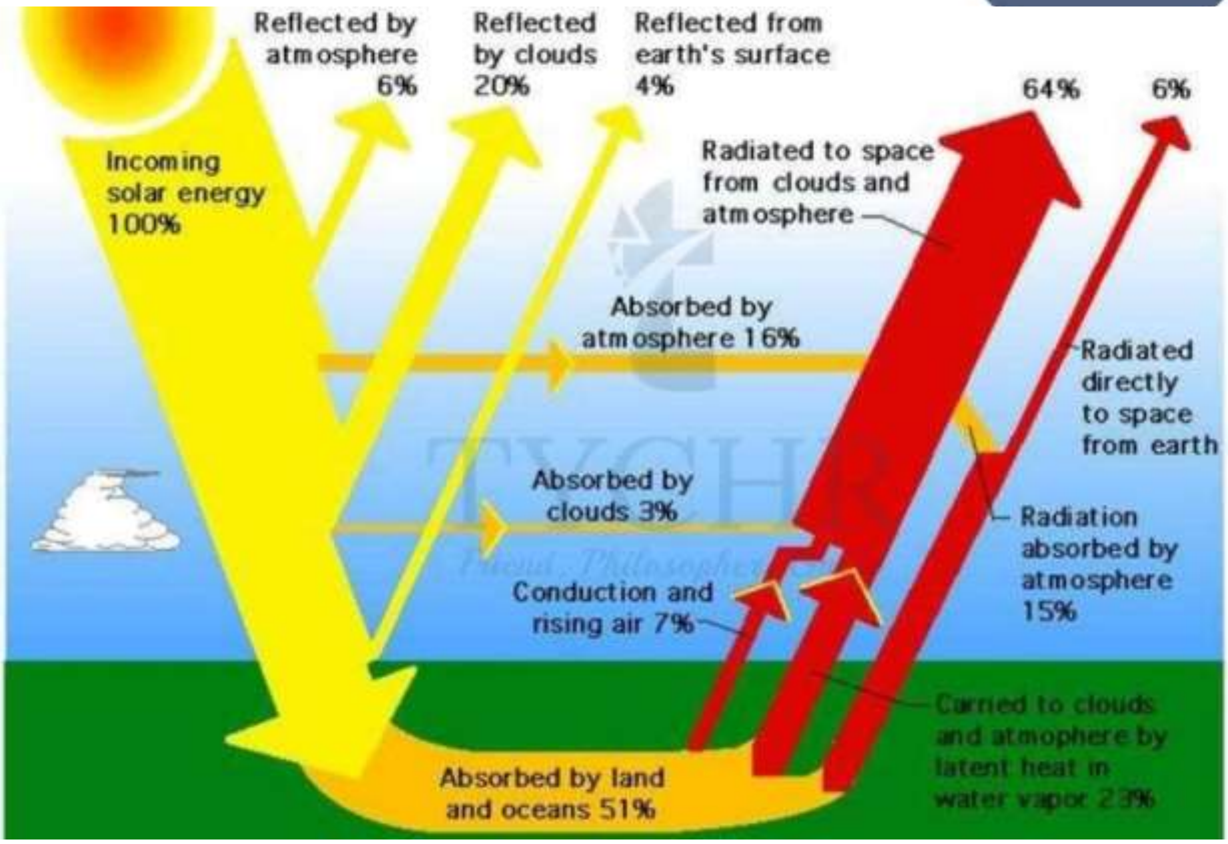


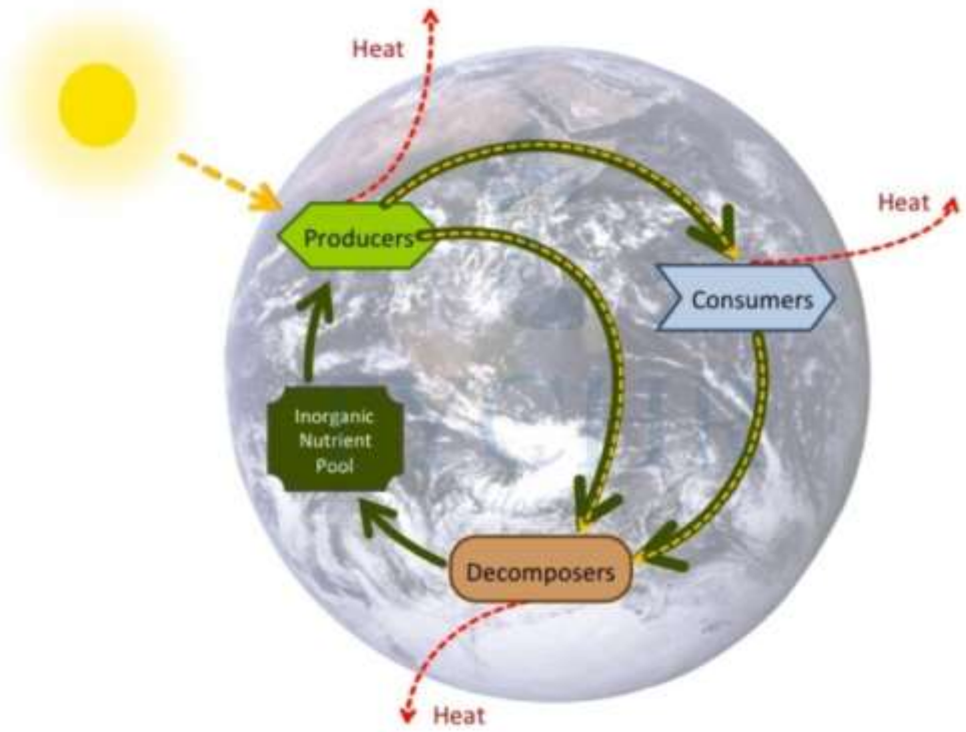
Figure 6 The Pathways of radiation through the atmosphere involve a loss of radiation through reflection and absorption.

2.3.2 Primary And Secondary Productivity

- Primary Productivity – the gain by producers (autotrophs) in energy or biomass per unit area per unit time.
  o Gross Primary Productivity (GPP)-is equivalent to the mass of glucose produced per unit area and time by primary producers through photosynthesis.
- Net Primary Productivity (NPP)- is the addition by makers in energy or biomass per unit region per unit time staying subsequent to considering respiratory misfortunes (R). In an ecosystem, this might be available to customers.
  NPP = GPP – R
- Secondary Productivity – the biomass gained by heterotrophic organisms, through feeding and absorption, measured in units of mass or energy per unit area per unit time.
  - Gross Secondary Productivity (GSP)- is the total energy or biomass assimilated by consumers and is calculated by

subtracting the mass of faecal loss from the mass of food consumed. GSP is the total energy gained through absorption in consumers.
GSP = food eaten – faecal loss

- Net Secondary Productivity (NSP)is calculated by subtracting the GSP's respiratory losses (R):
GSP – R = NSP
- Net Secondary Production (NSP)- is the gain by consumers in energy or biomass per unit area per unit period left after permitting for respiratory losses (R).
NSP = GSP – R



Systems diagram showing nutrient cycles

2.3.4 Cycles

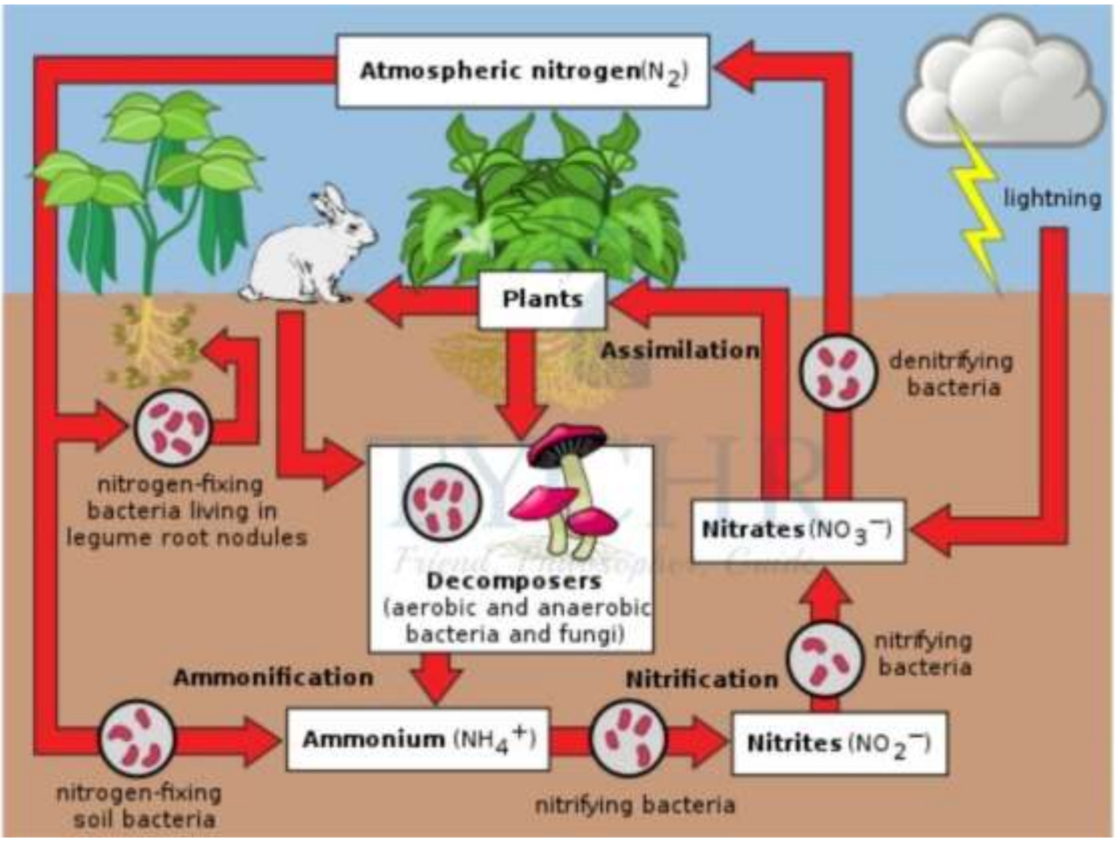
Carbon Cycle

Transfers In The Carbon Cycle	Transformations In The Carbon
• Herbivores feeding on producers	• Photosynthesis, which converts inorganic materials into organic matter.

- Carnivores feeding on herbivores
- Decomposers feeding on dead organic matter
- Carbon dioxide from the atmosphere dissolves in rainwater oceans.

- Photosynthesis transforms carbon dioxide and water into glucose using sunlight
- energy trapped by chlorophyll. Respiration converts organic storage into inorganic matter.
- Respiration transforms
- organic matter such as glucose into carbon dioxide and water.
- Combustion transforms biomass into carbon dioxide and water.
- Fossilization transforms organic matter in dead organisms into fossil fuels through incomplete decay and pressure.

Nitrogen Cycle



2.3.5 The Impact Of Human Activities On Energy Flows And Matter Cycles

Energy Flows	Matter Cycles
• The combustion of fossil fuels has altered the way in which energy from the Sun interacts with the atmosphere and the surface of our planet. • Increased carbon dioxide levels, and the corresponding increase in temperatures have led to the reduction in Arctic land and sea ice, reducing the amount of reflected sunlight energy.	• Timber harvesting (i.e. logging) interferes with nutrient cycling. • Adding fertilisers, such as those containing nitrates, can cause eutrophication in nearby bodies of water when nitrates run-off from soils, causing disruption to ecosystems. • When crops are harvested and transported to be sold at a market usually some distance away, the nitrogen they contain is also transported. These changes to the location of the nitrogen storages alter the nitrogen cycle and can

2.4 Biomes, Zonation, And Succession

2.4.1 Biomes

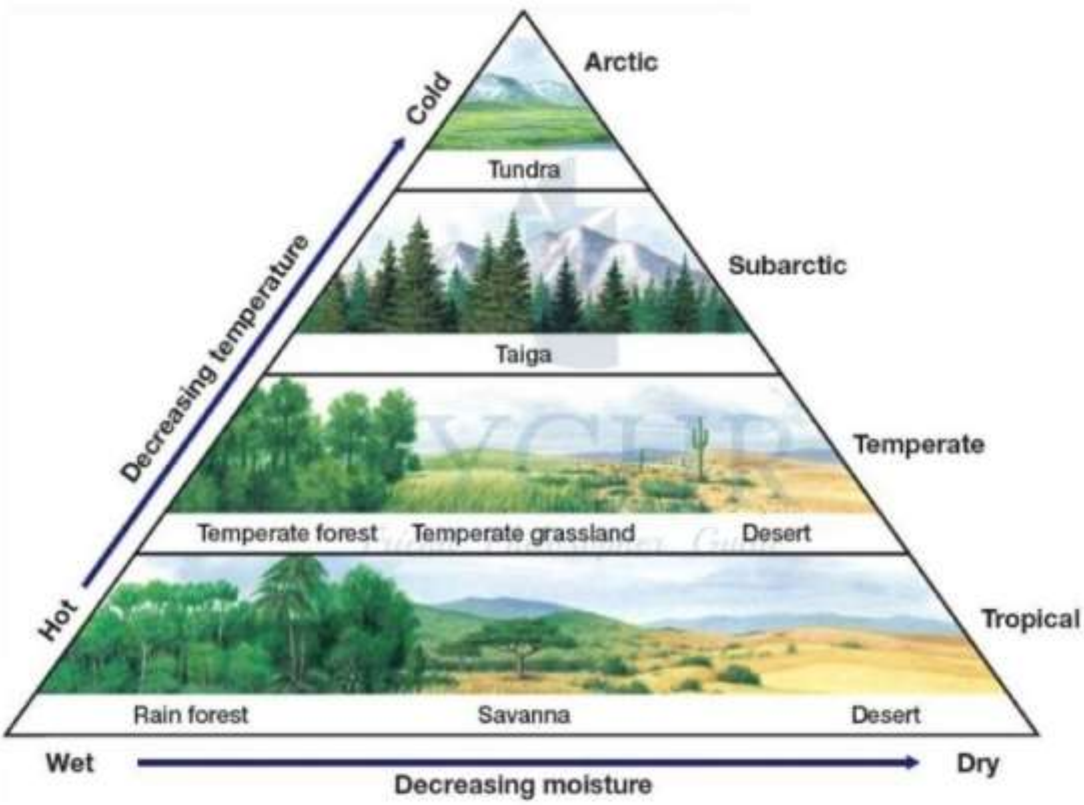


Figure 8 Temperature and precipitation determine biome distribution around the globe. Levels of insolation also play an important role, which correlates broadly with temperature (areas with higher levels of light tend to have higher temperatures).

Biome Distribution

Biome distribution depends on levels of insolation (sunlight), temperature and precipitation (rainfall). Some key factors that also affect biome distribution:

- Distribution
- Structure
- Relative Productivity

2.4.2 Zonation

Zonation refers to changes in communities in space, along an environmental gradient. Altitude, latitude, tidal level, and distance from the shore are all factors that contribute to zoning. An example of zonation is the rocky shore which can be divided into zones from the lower to upper shore. Seaweeds show distinct zonation patterns.

2.4.3 Succession

Succession happens when species change the habitat they have colonised and make it more suitable for new species. Succession causes changes in the biotic and abiotic conditions:

- It increases levels of vegetation.
- It causes an increase in soil aeration.
- Decaying vegetation improves the soil fertility.
- The soil & vegetation provide habitats for other organisms.
- This leads to increased biodiversity.

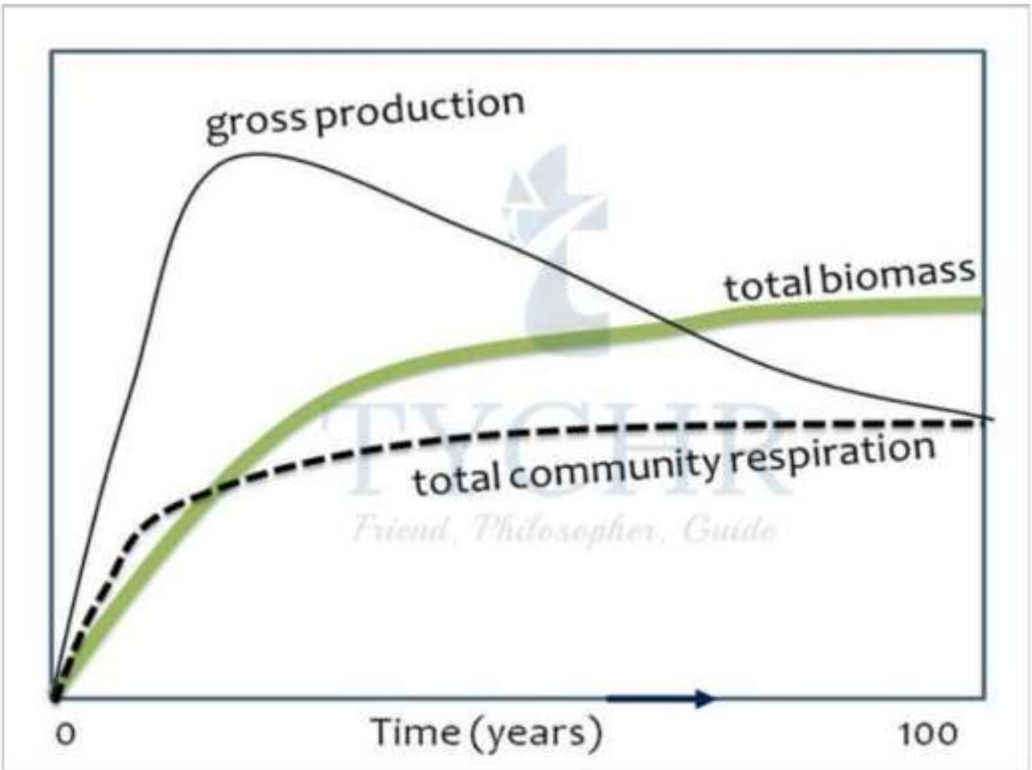


Figure 9 Due to high NPP and relatively low community respiration in the pre-climax successional stages, gross productivity remains high and the P:R ratio therefore remains more than 1. There is high community respiration in the climax stage and so the P:R ratio equals 1 (P : R = 1)

Climax Community

In a climax community there are continuing inputs and outputs of matter and energy, but the system as a whole remains in a more or less constant state (steady-state equilibrium).
Features: Better soil structure, more species diversity, better soil conditions, and increased biomass

2.4.4 R- And K-Strategist Species

Species can be classified as r-strategist or K-strategist.

R Strategist	K Strategist
• Are pioneers and can reach new areas that need colonisation • Are involved in the initial colonisation of a piece of land or water • Have rapid growth • Can get through the lifecycle quickly • Have many offspring • Are generally small in size • Cannot compete in later stages of a succession.	• Occur in climax communities • Are large organisms that need a developed soil and food web • Are slow growers • Outperform other organisms for light and nutrients • Have few offspring • Can only grow to maturity when a space appears in the ecosystem.

Figure: Survivorship curves for different types of species. Factors that influence survivorship rates include:

- Competition for resources
- Reproductive strategy
- Adverse environmental conditions

- Predator–prey relationships.

2.4.4 The Effect Of Climate Change On Biome Distribution

The distribution of biomes is controlled by a combination of temperature, insolation, and precipitation. Increases in carbon dioxide and other greenhouse gases lead to an increase in mean global temperature which in turn affects rainfall patterns. These changes in climate affect the distribution of biomes.

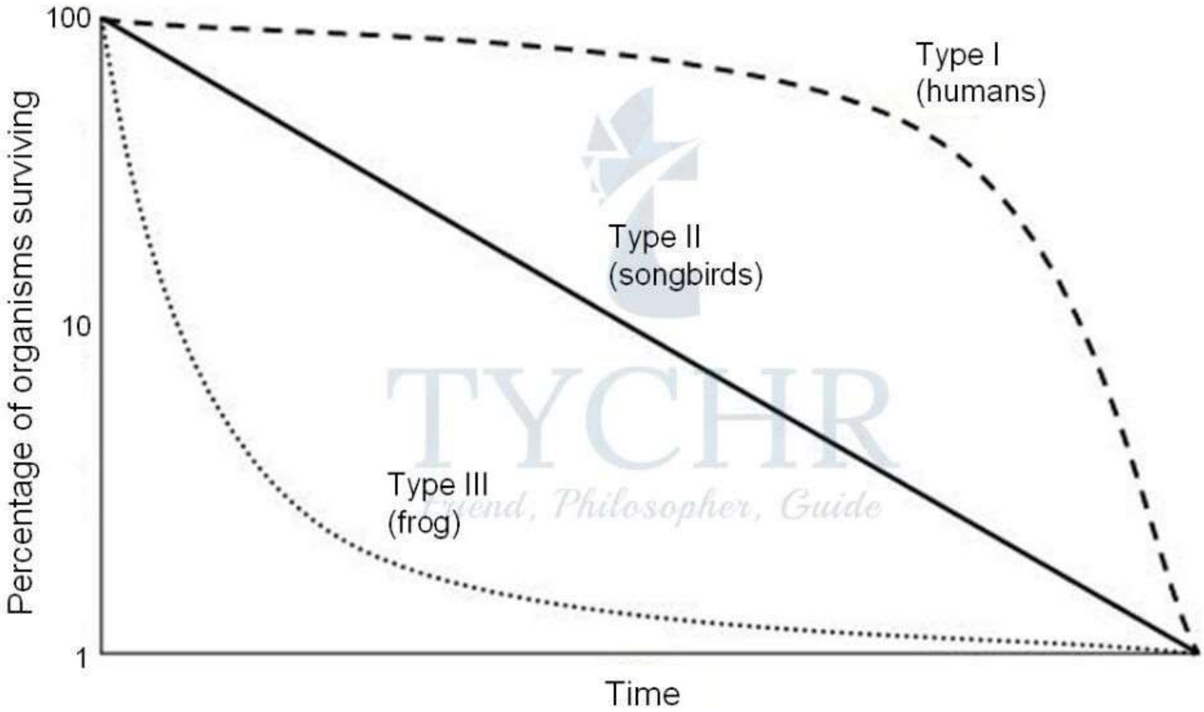


Figure 10 Survivorship curves for different types of species.

2.4.5 The Impact Of Human Activities On Succession

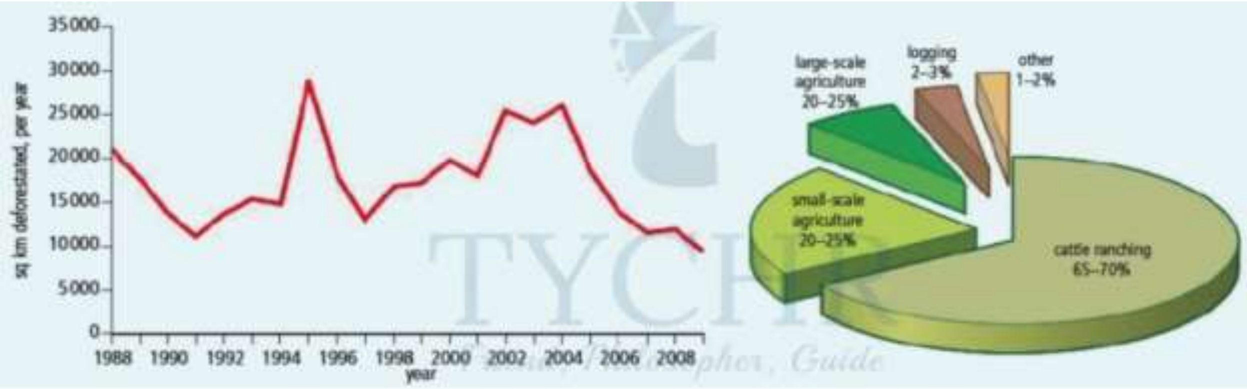


Figure 11 Figure on the Left: Deforestation in the Brazilian Amazon basin fluctuates but remains high despite warnings about the consequences for the planet. The loss of the highly diverse climax community and its replacement by agricultural or grazing ecosystems affects global biodiversity, regional weather, the water cycle and sedimentation patterns. Figure on the Right: Deforestation in the Brazilian Amazon basin, 2000–05 – the reasons land is deforested. The high percentage of meat in western diet, and the increasing consumption of beef in the developing world, demand land for cattle ranching. This is the main driver of human impact on the ecology of the Amazon

Human Factors Affecting Climatic and Edaphic Factors

The characteristics of a climax community are determined by climate and edaphic (relating to soil) factors. This process is frequently disrupted by human factors. A different stable state, rather than the climax community, is reached as a result of the interference or disturbance, which stops and redirects the succession process. Plagioclimax refers to this abrupt sequence. For instance, the effect of persistent foot traffic on footpath erosion.

2.5 Investigating Ecosystems

2.5.1 Organisms In Ecosystems

A dichotomous key is a handy tool for identification of organisms that one is not familiar with. Dichotomous means ‘divided into two parts’. The key is written so that identification is done in steps. At each step, one has a choice of two options, based on different possible characteristics of the organism one is looking at.

2.5.2 Measuring Abiotic & Biotic Components Of The Ecosystem

Measuring Abiotic Factors	**Measuring Biotic Factors**
Ecosystems can be divided into three types: marine, freshwater, and terrestrial. • Abiotic components of a **marine ecosystem** include: salinity, pH, temperature, dissolved oxygen, and wave action. • Abiotic components of a **freshwater ecosystem** include: turbidity, temperature, flow velocity, dissolved oxygen, and pH. • Abiotic components of a **terrestrial ecosystem** include: temperature, light intensity, wind speed, soil particle size, amount and angle of slope, soil moisture, drainage, and mineral content. • Each type of ecosystem has its own specific abiotic components as well as factors that they share with other types of ecosystems.	**Quadrats**: Biotic factors can be measured using quadrats. Quadrats can be used to measure percentage cover, population density and percentage frequency. Quadrats are suitable for measuring vegetation and non-motile animals. *Total Number of a species in all quadrats* *Population Density = Area of one quadrat × Total number of quadrats* Lincoln Index: The Lincoln Index is also known as the capture-mark-release-recapture method. Animals are captured, marked, and then released. After a specific amount of time the animal population is resampled. The total population size of the animal is estimated using this equation: N = (n1 x n2)/ nm N is the total estimated population size; n1 is the number caught in the first sample; n2 is the number caught in the second sample; nm is the number caught in the second sample that were marked.

2.5.3 Ways For Removing An Estimate Of The Biomass Of Trophic Levels

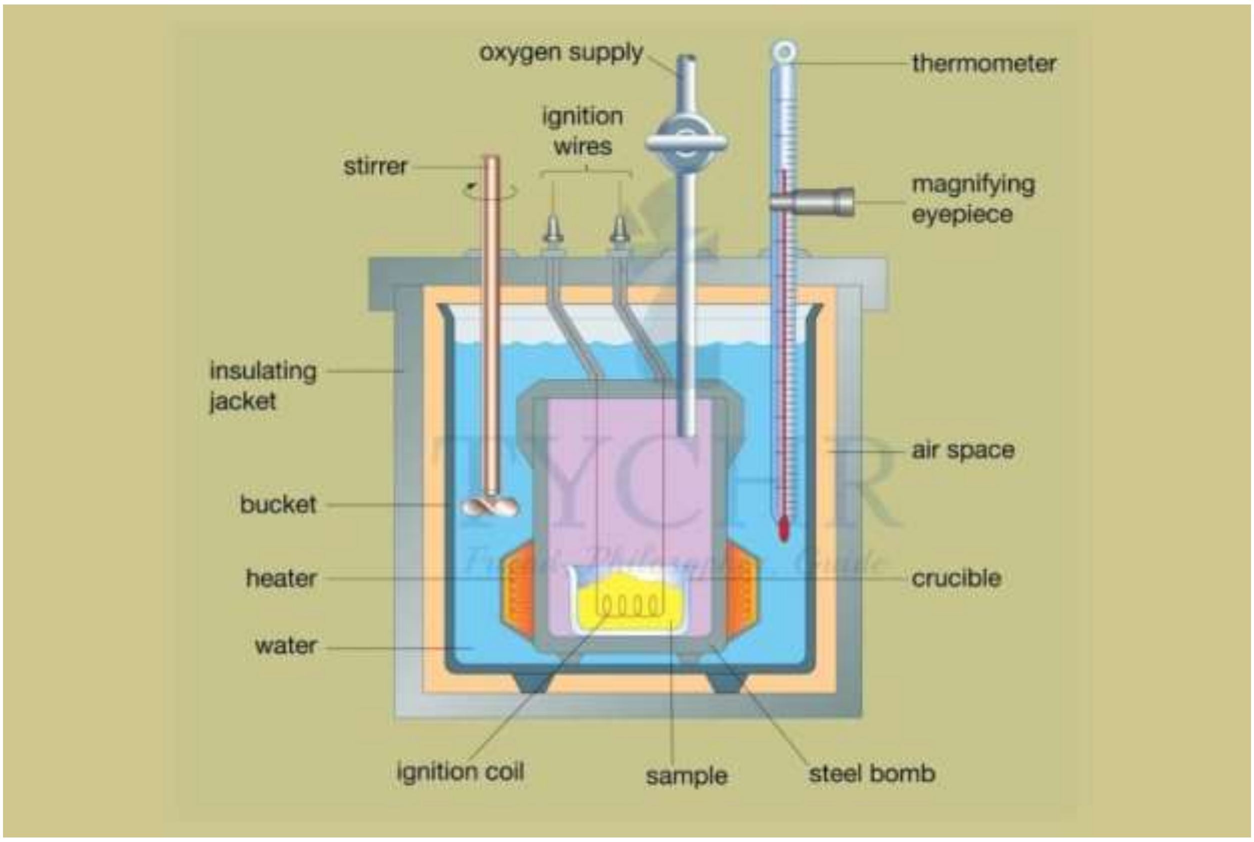


Figure 12 A calorimeter – used to calculate the energy content of biomass
The sample of the organism whose biomass is being determined is weighed in a container of known mass. The sample is put in a hot oven at around 80°C and left for a specific length of time. The sample is reweighed and replaced in the oven. This is repeated until the same mass is obtained on two subsequent weigh-ins; no further loss in mass is recorded, as no further water is present.
To estimate the biomass of a primary producer within a study area the following is done:

- All the vegetation is collected within a series of quadrats. The vegetation includes roots, stems and leaves.
- Dry biomass measurements of sample areas are extrapolated to estimate total biomass over the whole area being considered by the study.
- The mass of one organism, or the average mass of several organisms, is taken.
  - o This mass is multiplied by the total number of organisms to estimate total biomass

2.5.4 Species Richness And Diversity

Two factors are taken into consideration when assessing species diversity: the variety of species and the proportion of individuals belonging to each species.
Simpson's diversity index- $D = (N(N-1)/\Sigma n(n-1))$
Where D = diversity index, N = no of species found in total, n = number of individuals of a particular species.

2.5.5 Measuring Changes In Ecosystems

There are a variety of methods you can use to study the effect of human activities:

- Carry out capture–mark–release–recapture methods on invertebrate species in disturbed and undisturbed sites.
- Measure species diversity using the Simpson's index.
- Use indicator species.
- Measure variables such as light levels, temperature and wind speed. One can also calculate the average width of tree stems at breast height and the degree of canopy openness which would give measures of tree biomass and leaf cover.
- Measuring soil erosion – in areas with high precipitation this can be simply calculated by measuring the depth of soil remaining under free-standing rocks and stones, where soil around these solid objects has been eroded away.
- Measure soil variables such as soil structure, nutrient content, pH, compaction levels, and soil moisture.

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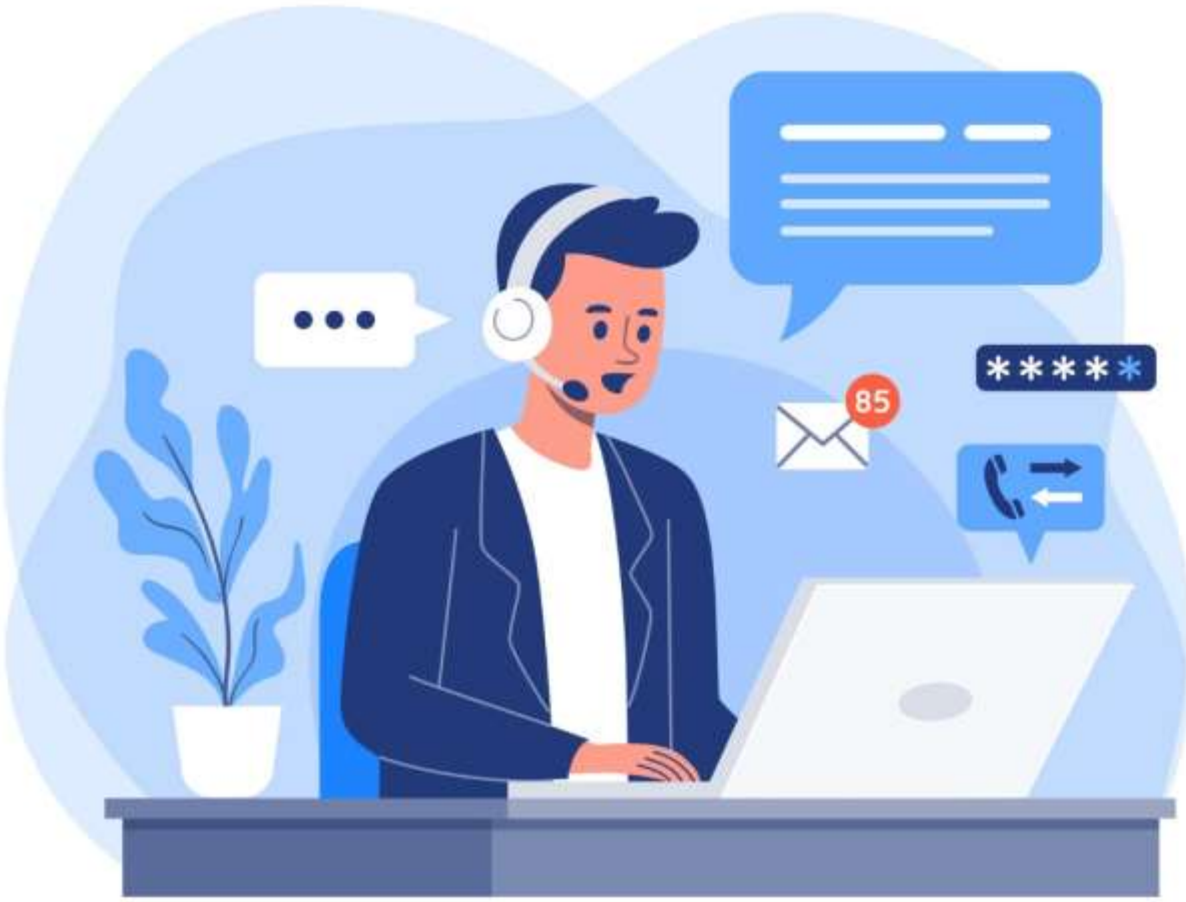

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