BIOL 258 PRINCIPLES OF ECOLOGY I

3 CREDIT HOURS

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Course outline

- Basic definitions and concepts
- Introduction to ecosystems
- Ecological concepts
- Dynamic interrelationships of plant and animal communities with their environments
- Primary and secondary production in plants and animals.
- Ecological energetics

Course outline Cont'd.

- Introduction to population ecology
- Man and his habitat
- Habitat fragmentation and edge effects
- Biogeochemical cycles

Recommended text books and websites

- Cunningham Saigo. 1997. **Environmental Science: a global concern**. Fourth Edition.
- Fred Van Dyke.2003. **Conservation Biology: foundations, concepts, application.** McGraw-Hill Company Inc.
- Manuel C. Molles Jr. 1999. **Ecology: concepts and applications**. McGraw-Hill Company Inc.
- Gutierrez, Kenneth, Marlon Amador, Eli Gonzalez, and Stephanie M. **Tropical dry forest biome**." *tropical dry forest biome*. N.p., n.d. Web. 15 oct 2013. http://www.slideshare.net/mdonohue/tropical-dry-forest biome.
- Leo Robert Smith. 1990. **Ecology and field biology.**
- Bush Mark B.2003. **Ecology of a changing planet.** Third Edition.

BASIC DEFINITIONS AND CONCEPTS

What is Ecology?

- Ecology is the study of the relationships and interactions among living organisms as well as the relationships and interactions between them and their environment.

- The interactions and relationships revolve around individuals, species, populations, communities, ecosystems, and even the planet.

- The study of ecological relationships can be achieved using two main approaches; autecology and synecology.

Basic Definitions and Concepts Cont'd.

- Ecology is a multidisciplinary course.

- The study of these ecological relationships from the point of view of a single species or individual is called autecology.

- If all the species living together are studied as a community, then this study is called synecology.

Basic Definitions and Concepts Cont'd.

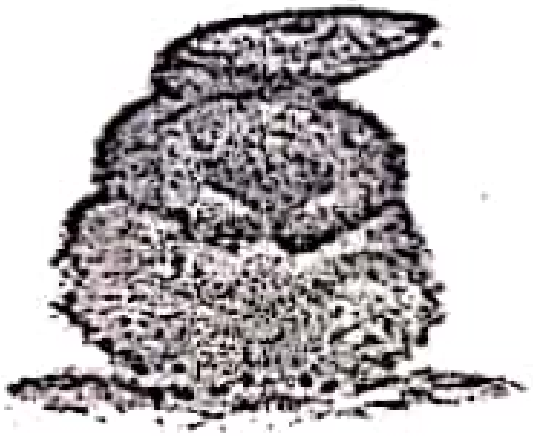
Concepts of ecology

- All living organisms affect their environment and vice versa.
- Environment plays an important role in the critical stages of the life cycle of species.
- Species react to changes the environment, and they may adjust structurally and physiologically to the changes.
- The activities of species also cause changes in the environment e.g. growth, dispersal, reproduction, death, decay, etc.

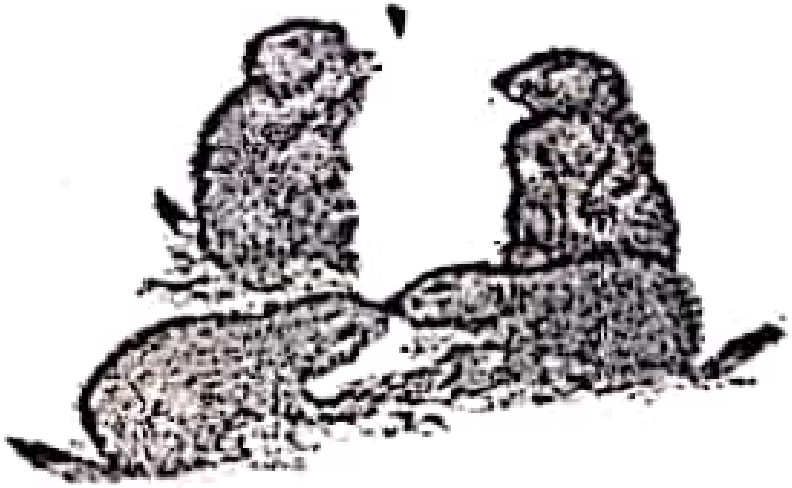
Basic Definitions and Concepts Cont'd.

Under similar climatic conditions, two or more communities can develop simultaneously; some may reach climax stage, and others under different stages of succession.

Ecological levels of organisation



Individual



Population/species

Community

Ecosystem

INTRODUCTION TO ECOSYSTEMS

- An ecosystem is a community of living organisms in conjunction with their non-living environment, which interact as a system or ecological unit.

- Therefore, an ecosystem is made up of biotic and abiotic components which are interrelated and interact with each other.

- Energy flow and nutrient cycling occur within ecosystems.

Introduction To Ecosystems Cont'd.

Concepts of an ecosystem

- There is the presence of positive, negative and neutral interactions among organisms at both inter- and intra-specific levels.

- The chemical components of an ecosystem move in a defined path called biogeochemical cycles.

- There are some limiting factors that control survival and growth of organisms. The minimum and maximum levels of tolerance for all species vary seasonally, geographically and according to the population.

Introduction To Ecosystems Cont'd.

Concepts of an ecosystem

- Different kinds of populations undergo succession.

- Two main groups of organisms exist in ecosystems: native and non-native (exotic/alien) species.

- There exist certain important species referred to as keystone species.

- They are species that have strong effects on biological communities, with the effects being disproportionately large compared to their abundance and biomass.

Introduction To Ecosystems Cont'd.

Concepts of ecosystems

- Many populations exhibit viability despite the presence of ecological processes such as disturbance.

- Ecosystems may exhibit ecological resilience.

- Disturbance forms an integral part of many ecosystems in the world.

Introduction To Ecosystems Cont'd.

Components of ecosystems

(1) Biotic component

- This is made up of two groups of organisms namely, autotrophs and heterotrophs.

(a) Autotrophs

- They comprise of organisms which are capable of using simple inorganic materials from the abiotic environment and with the energy from the sun, build up complex organic substances.

- Autotrophs are known as producers and form the base of food chains.

Introduction To Ecosystems Cont'd.

(b) Heterotrophs

- Heterotrophs utilise, re-arrange and decompose the complex organic substances produced by the autotrophic organisms.

- Two types of heterotrophs exist within ecosystems:

(i) Consumers

- These are organisms that feed on other organisms. E.g. Animals and parasitic plants (*Dionea*, Venus fly trap & *Nepenthes*, Pitcher plant)

Introduction To Ecosystems Cont'd.

(ii) Decomposers

- Decomposers break down non-living organic matter and convert them to simpler substances.

- Decomposers are referred to as saprotrophs. E.g. fungi, some bacteria.

Introduction To Ecosystems Cont'd.

(2) Abiotic component

- This is made up of the non-living physical and chemical factors of the ecosystem that influence living organisms and ecosystem functioning.

Examples

- Rainfall
- Sunlight
- Temperature
- Soil water/moisture
- Altitude
- Slope angle
- Oxygen
- Carbon dioxide

Ecological principles

- Protection of species and species' subdivisions will conserve genetic diversity.

- Protecting habitat is fundamental to conserving species.

- Large areas usually contain more species than smaller areas with similar habitats.

- All species interact but the nature and strength differ.

- Climate influences terrestrial, freshwater and marine ecosystems.

Types of Ecosystems

Two main types of ecosystems namely, aquatic and terrestrial ecosystems exist.

Aquatic ecosystem

- This is the type of ecosystem in which water serves as the habitat for living organisms.

- Aquatic ecosystem comprises of fresh water and marine (salt) water types.

Fresh water ecosystem

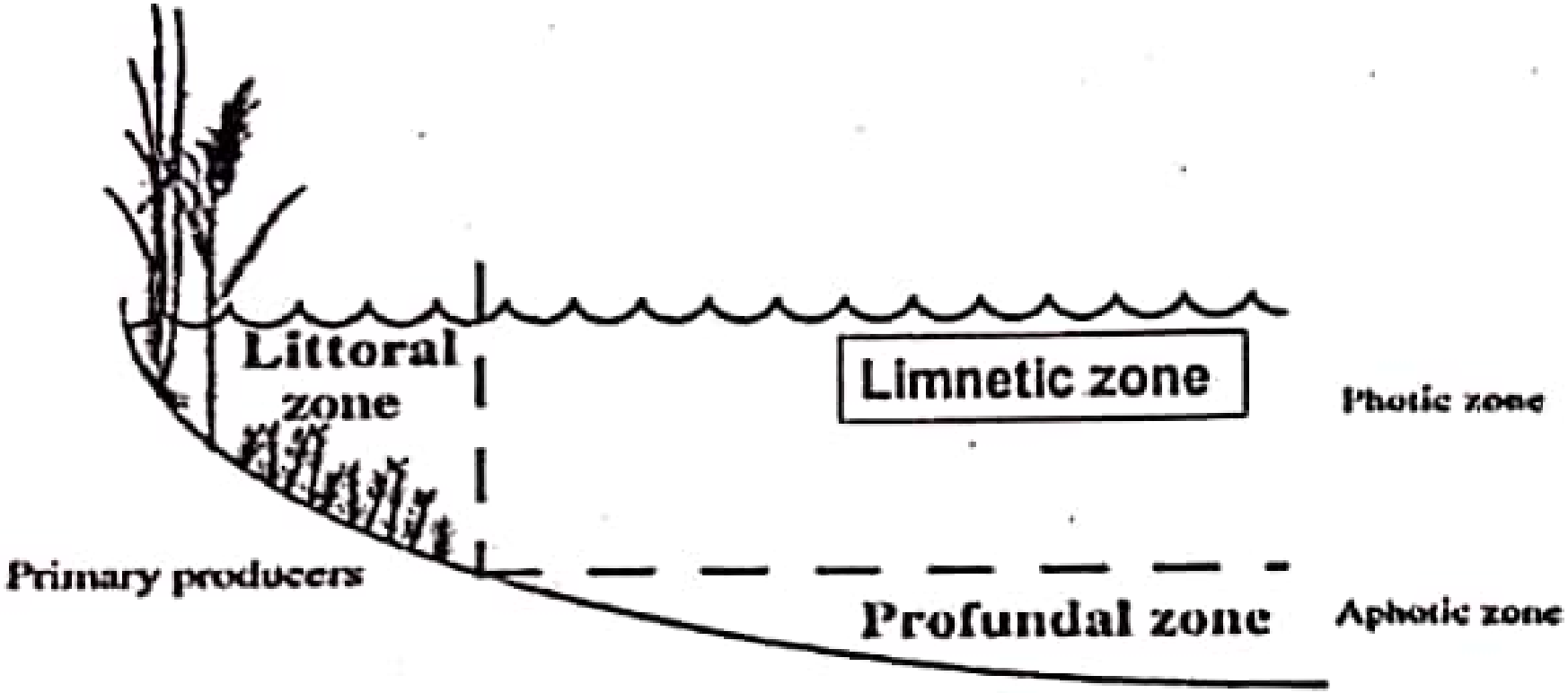
- Fresh water ecosystem is subdivided into standing- and lowing-water ecosystems on the basis of water movement.

Standing-water ecosystem

- In this ecosystem water tends to remain in the same eneral area for a longer period of time.

- Examples include lakes, ponds.

Zones of Standing-water ecosystem



Different zones of lakes and ponds, including the 'open water' (pelagic) zone and the nearshore littoral zone, where the primary production at the sediment surface is high. Water and sediment below the compensation depth (i.e. where the amount of oxygen produced by photosynthesis equals that consumed by respiration) is called the profundal zone.

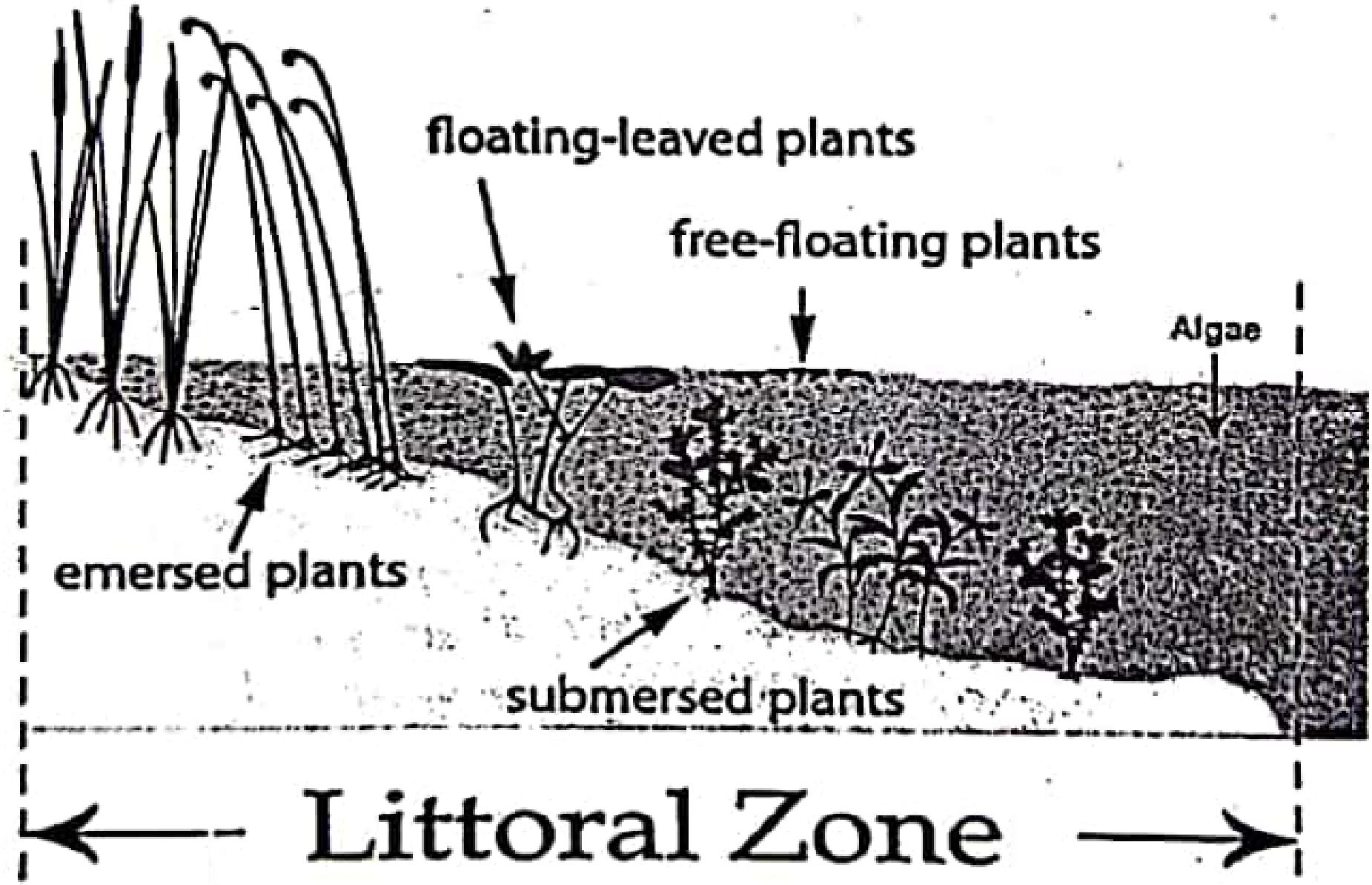
Zones of Standing-water ecosystem

Littoral zone

- This is the shallow water portions along the edge of a pond or lake.

- Light penetrates to the bottom of the littoral zone and hence photosynthetic organisms are abundant there.

Plants of littoral zone



Animals of littoral zone

- The littoral zone supports different kinds of fauna.

- It provides food and shelter for animals such as crabs, water birds, fishes etc.

Limnetic (pelagic) zone

- This is the open water area where light penetrates.

Plants of limnetic zone

- Plants in this zone are floating algae known as phytoplankton.
- The phytoplankton occupy upper parts of the limnetic zone so that they can receive enough sunlight for photosynthesis.
- Rooted plants (macrophytes) are absent in this zone.

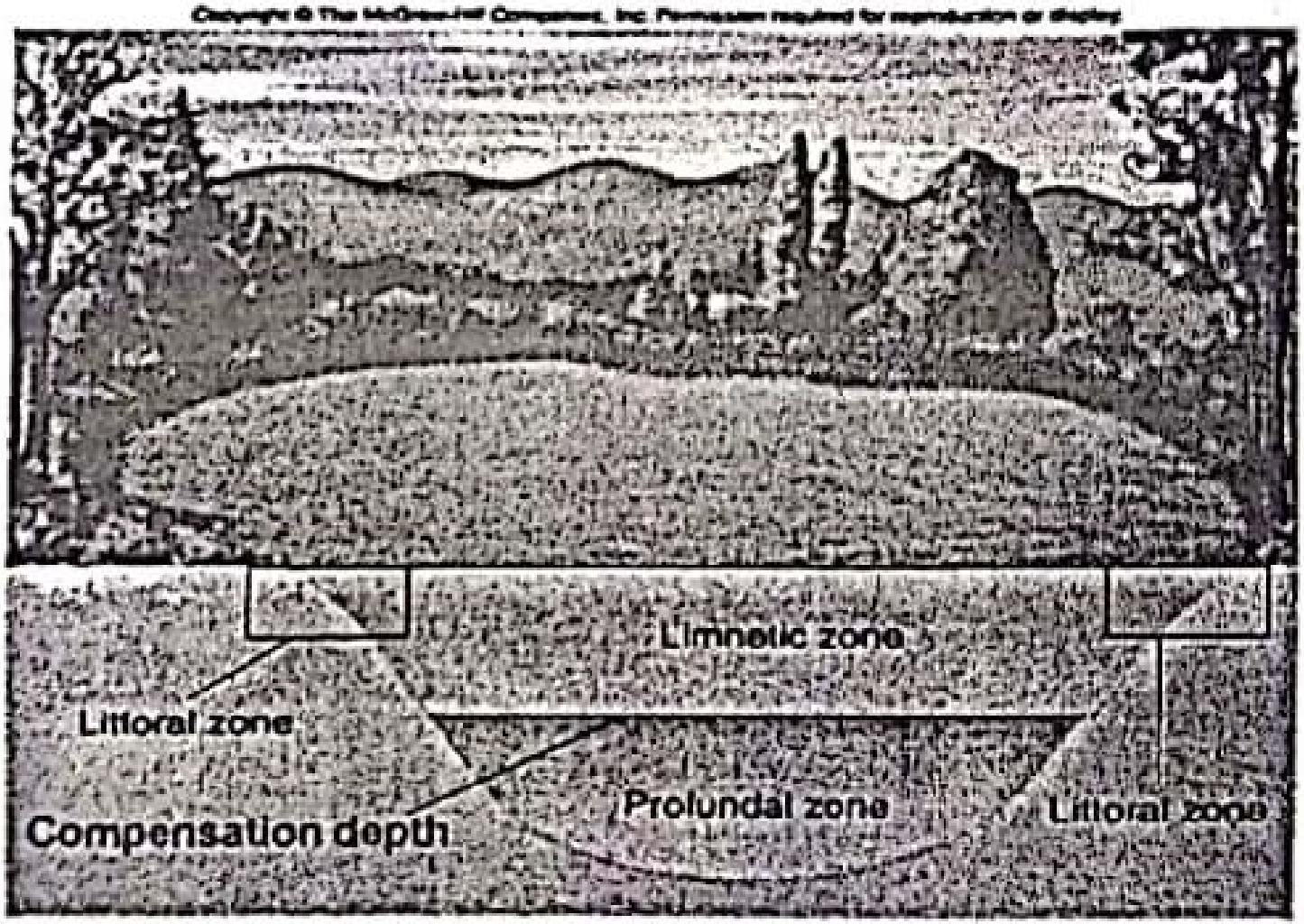
Animals of limnetic zone

- Primary consumers such as microscopic crustaceans and rotifers occur in this zone.

- Secondary consumers include swimming insects and fish. These animals usually swim between the littoral and limnetic zones. Thus, they are able to feed on plants in the littoral zone as well.

- some animals in the limnetic zone camouflage themselves so that they become difficult to see from above and below.

Profundal zone



- This is a zone located beyond the depth of effective light.

- Diversity and abundance of life are limited by oxygen and temperature.

- Animals in this zone are therefore adapted to low oxygen concentration.

- Animals here depend on organic materials from littoral and limnetic zones.

- Some animals may occupy this zone during some part of the day, but migrate upward to the surface to feed.

- The profundal zone supports large population of bacteria and fungi which break down organic matter and release inorganic nutrients for recycling.

Flowing-water ecosystem

- A flowing-water ecosystem is any type of water body that flows constantly over land surface.

E.g. streams, rivers, creeks, waterfall etc.

- Velocity of water determines the type of ecological community in the water.

Plants of flowing-water ecosystem

- Producers of fast-flowing water ecosystem are mainly algae and grasses.

- Algae form an important component of the diet of fast-flowing water animals.

Animals of flowing-water ecosystem

- As a result of strong water movement in flowing-water ecosystem, fauna communities are limited to animals that are able to withstand water movement.

- Examples: fish, insects, amphibians, reptiles etc.

- Fish will generally hide beneath or beside rock to avoid being moved down stream.

- Some insects attach themselves to aquatic plants so as to avoid being washed away by water.

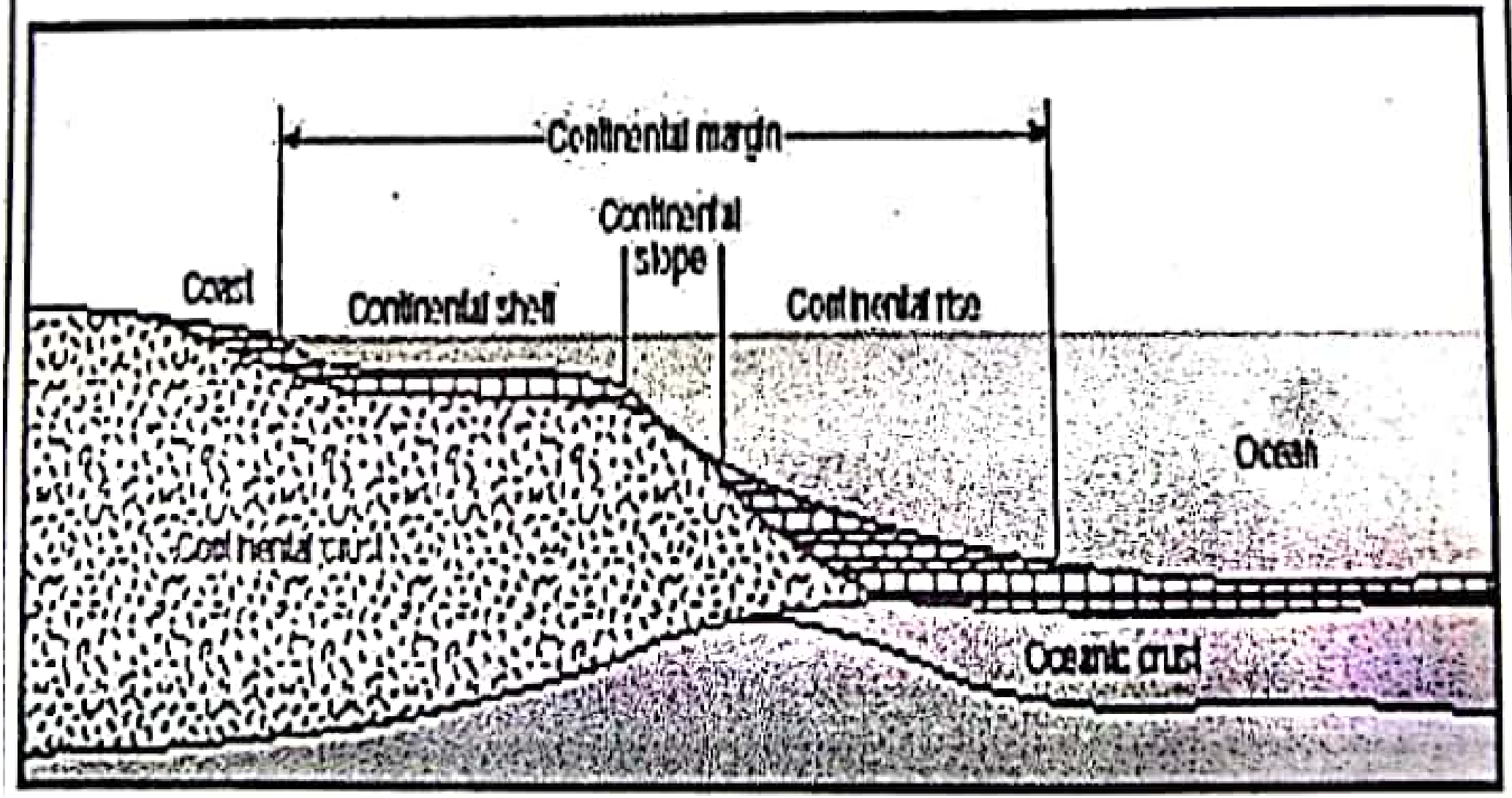
- Carnivorous animals such as crocodiles, alligators, birds also live in some fast-flowing waters.

- Omnivorous animals include bears.

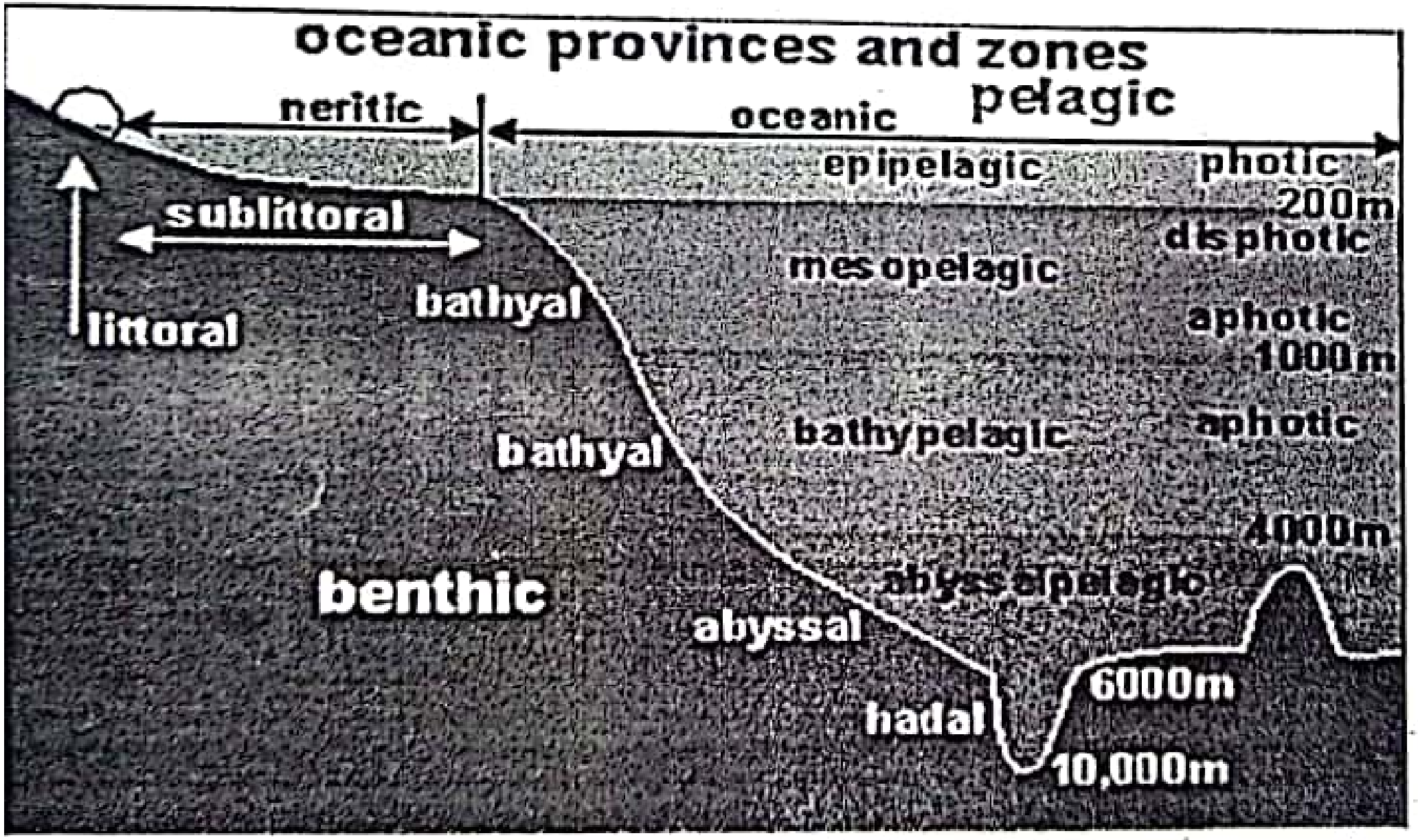
Characteristics of flowing-water ecosystem

- Existence of water currents.
- Close association of water with surrounding land area.
- Constant high oxygen concentration.
- Negligible thermal and chemical stratification.

Marine water ecosystem (Oceans)



Divisions of the ocean



Provinces of the ocean

(1) Benthic province – includes all of the ocean bottoms

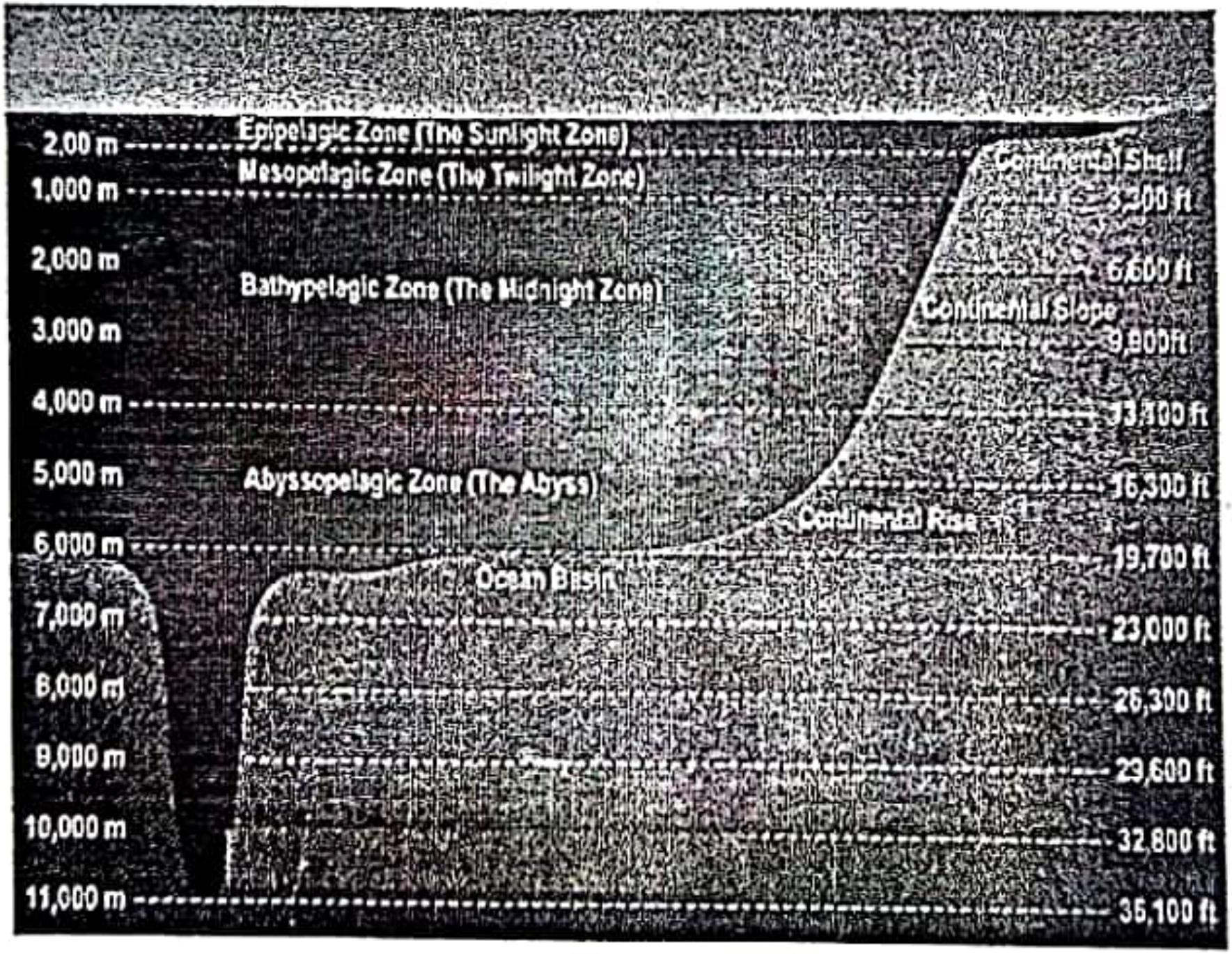
(2) Pelagic province – includes the entire volume of ocean water

- The pelagic province in turn consists of two zones; neritic and oceanic zones

(a) Neritic zone – the relatively shallow water overlying the continental shelves.

(b) Oceanic zone – the water over the ocean basins; photosynthesis is restricted to the surface.

Zones of the ocean



Epipelagic Zone (surface/sunlight zone)

- The illuminated surface zone where there is enough sunlight for photosynthesis. Due to this, plants and animals are largely concentrated in this zone.

Mesopelagic Zone (twilight zone)

- This zone occurs just beneath the epipelagic zone. Light penetrates to this zone but it is very faint.

- Many animals spend daylight hours within the mesopelagic zone and then move towards the surface during evening hours.

- In this way, they can feed on the phytoplankton and zooplankton available near the surface of the water while avoiding predators during the day.

Bathypelagic Zone (midnight/dark zone)

- This zone is found beneath the mesopelagic zone.

- Sunlight does not reach this zone. The only light present at this zone is the light produced by some organisms living in this zone.

- Because sunlight does not get to this zone, many organisms that live at this point are either black or red in colour.

- Pressure at this zone is very high but many organisms are able to live there. E.g. Sperm whales move to this zone in search of food.

Abyssopelagic Zone

- The water temperature is near freezing, and there is no light at all.

- Only a few organisms with adaptations to the harsh conditions of this zone are able to live there. E.g. many invertebrates including basket stars and tiny squids.

Terrestrial ecosystem

- A terrestrial ecosystem is the type of ecosystem that is located on land.

- Examples of terrestrial ecosystem are taiga, tundra, deciduous forest, savanna, tropical rain forests, and deserts.

Factors that govern terrestrial ecosystem

(a) Temperature

- Organisms need optimum temperature for germination, growth and reproduction.

- Outside the optimum temperature, the germination, growth and reproduction of some species can be impaired.

(b) Water (moisture)

- Water is important for photosynthesis and transport of nutrients within plants.

- Thus, it is essential in germination, growth and reproduction of plant species.

(c) Soil

- Soil is the medium for plant growth. The type of soil determines the vegetation types in a terrestrial ecosystem.

- E.g. loamy soil supports more diverse vegetation than sandy soil.

(d) Topography

- Topographic variables such as altitude, slope angle and slope aspect affect life in terrestrial ecosystems.

- Thus, it is essential in germination, growth and reproduction plant species.

Producers in terrestrial ecosystem

- Flowering plants (angiosperms) constitute the major group of terrestrial plants.

- Other groups of plant include gymnosperms, mosses, and ferns.

- The principal role of terrestrial plants is the provision of food for animals but they also serve as habitats for some animals.

- Terrestrial plants play a major role in nutrient recycling.

Consumers in terrestrial ecosystem

- Many different kinds of animals feed on plants of terrestrial ecosystem, and therefore constitute consumers of this ecosystem. E.g. insects, snails, mammals, birds etc.

- There are also some animals that feed on other animals in terrestrial ecosytem. E.g. lion, preying mantis, man etc.

Decomposers in terrestrial ecosystem

- These are mostly fungi and bacteria. They decay dead organic matter and release nutrients into the soil.

- That is, terrestrial decomposers help in nutrient cycling.

Dynamic interrelationships of organisms with one another and with their environments

- The various interrelationships in ecosystems take the form of energy flow and nutrient cycling.

- Energy flow within an ecosystem can be expressed in food chains.

- A food chain is a feeding relationship in which a preceding organism is fed upon by a succeeding organism, which in turn is fed upon by another organism and so on.

- By so doing, energy is transferred from one organism to another.

Types of food chains

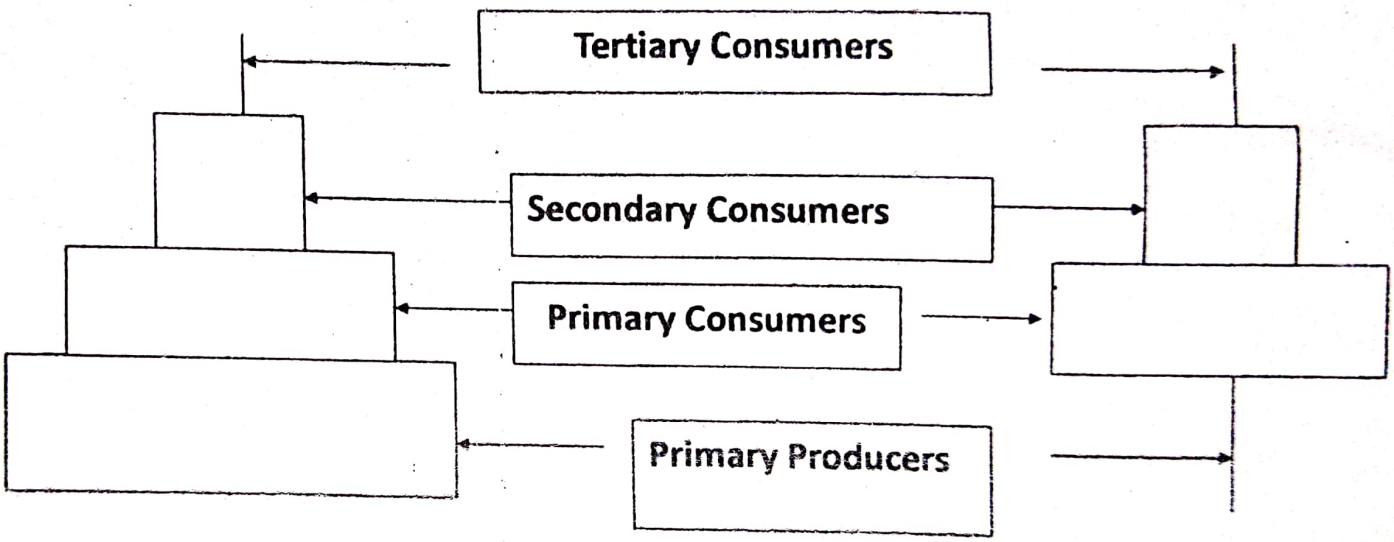
(a) Grazing (predator) food chain

- Plants form the base of the predator or grazing food chain. The plants are consumed by primary consumers, which in turn are fed on by secondary consumers and so on.

- Grazing food chain thus depends on sunlight energy captured by plants, and then the movement of the captured energy from plants to herbivores, and so on.

Plants ⟶ Herbivores ⟶ Primary carnivores ⟶ Secondary carnivores

Pyramid of numbers of grazing (predator) food chain



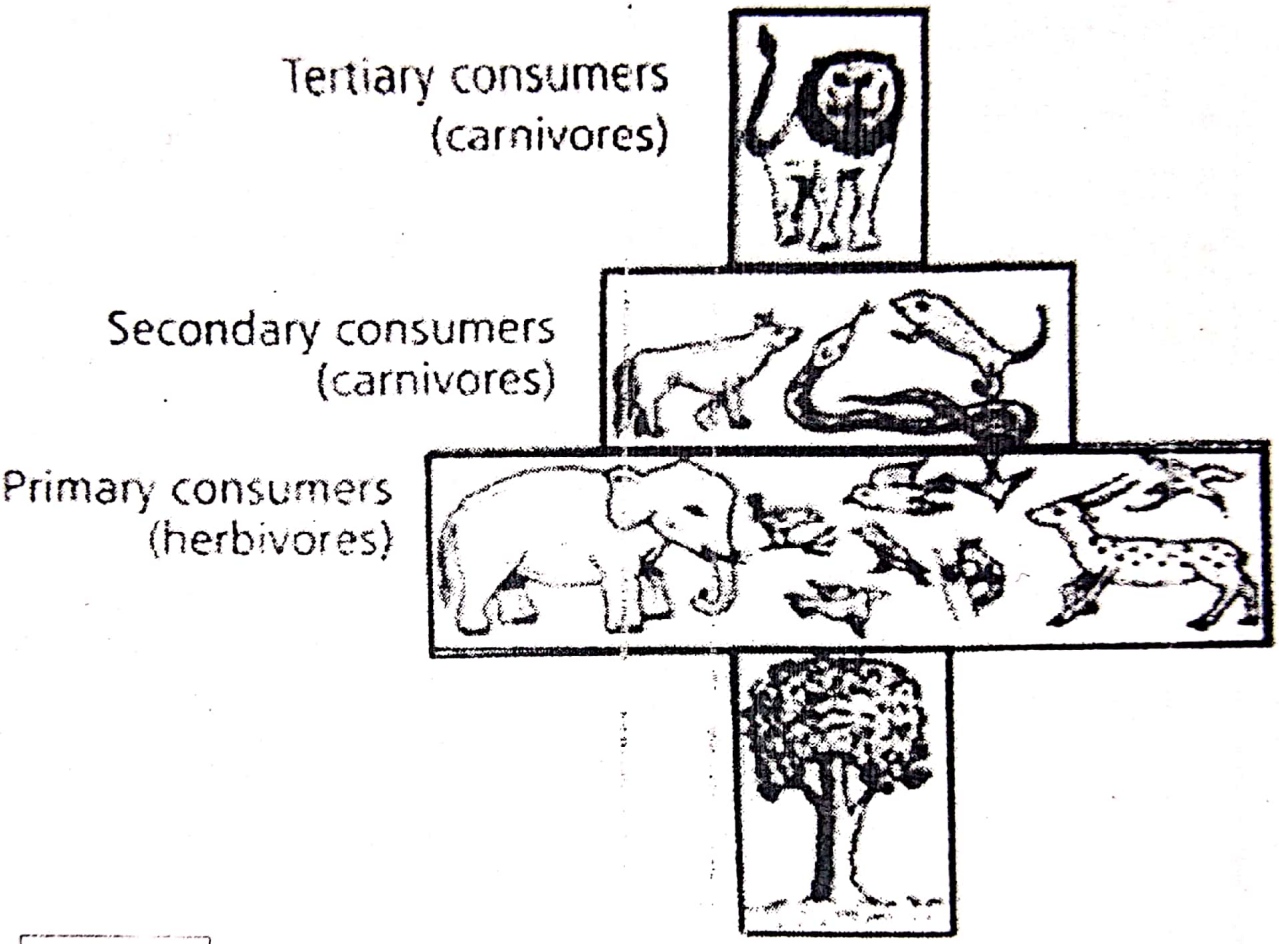


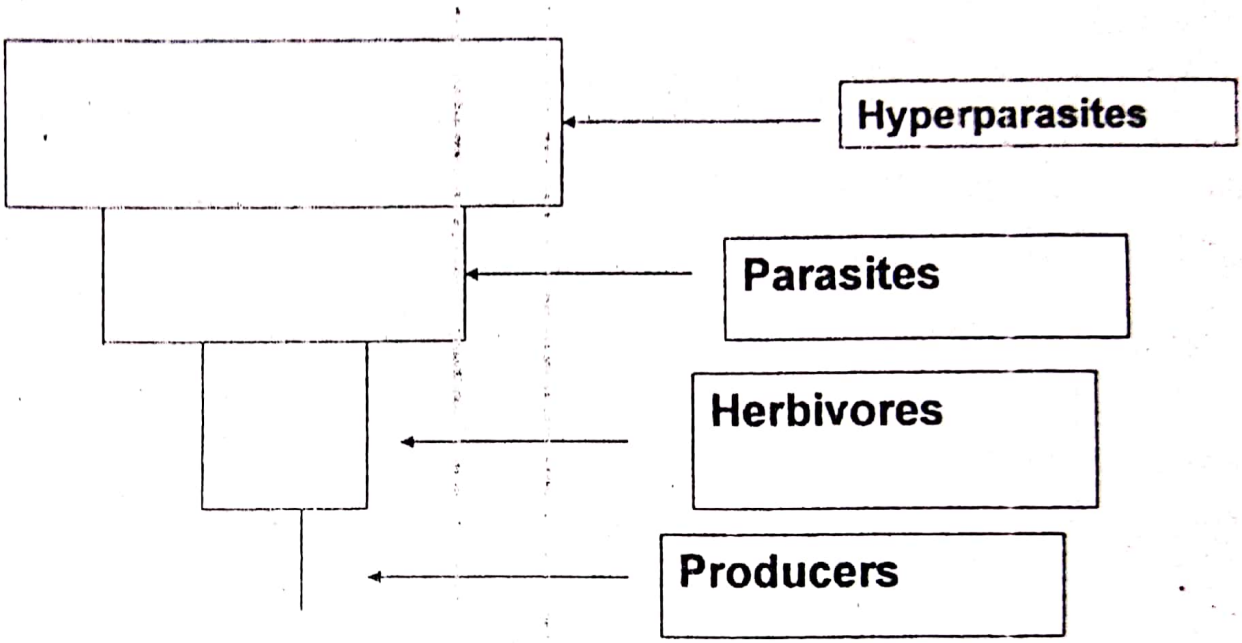
Fig.: Pyramid of numbers in forest ecosystem

(b) Parasitic food chain

- This is where many herbivores feed on a single plant, and each herbivore is fed on by several parasites. The parasites may be consumed by many higher parasites (hyperparasites).

- The number of organisms at each trophic level increases progressively. Thus, pyramid of numbers in parasitic food chain is always inverted.

Pyramid of numbers for parasitic food chain



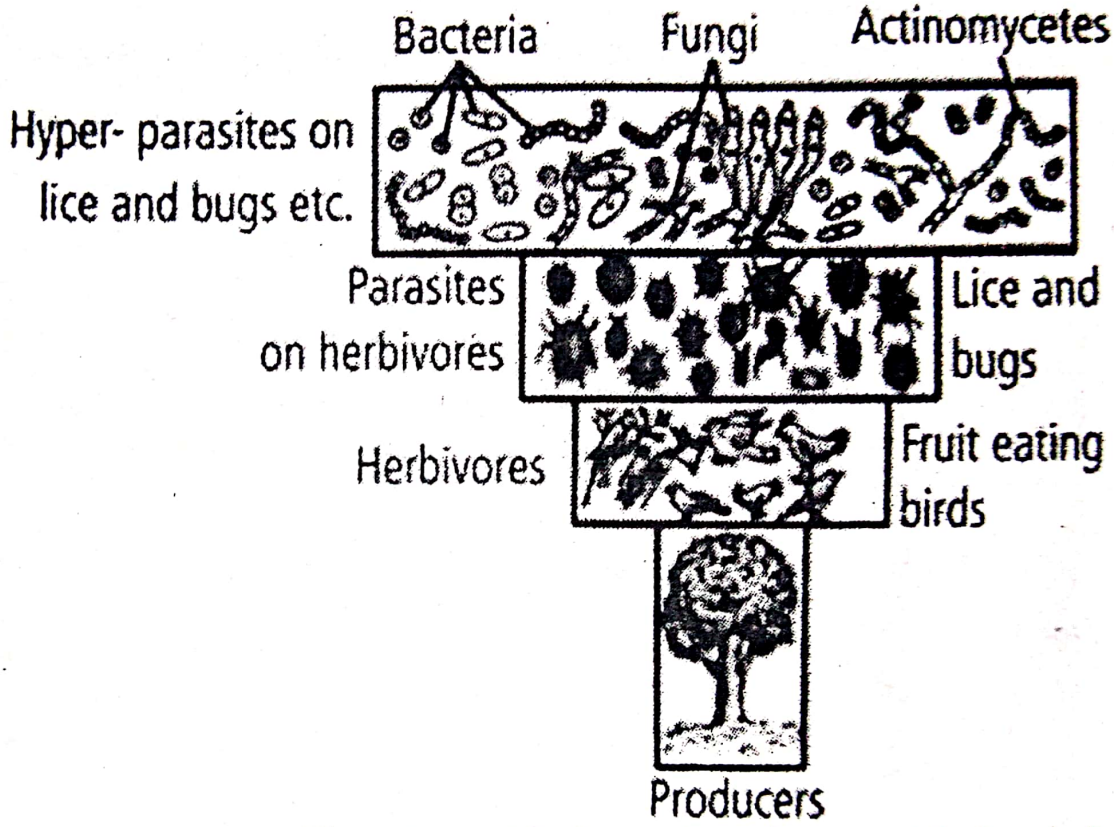


Fig.: Pyramid of numbers in parasitic food chain

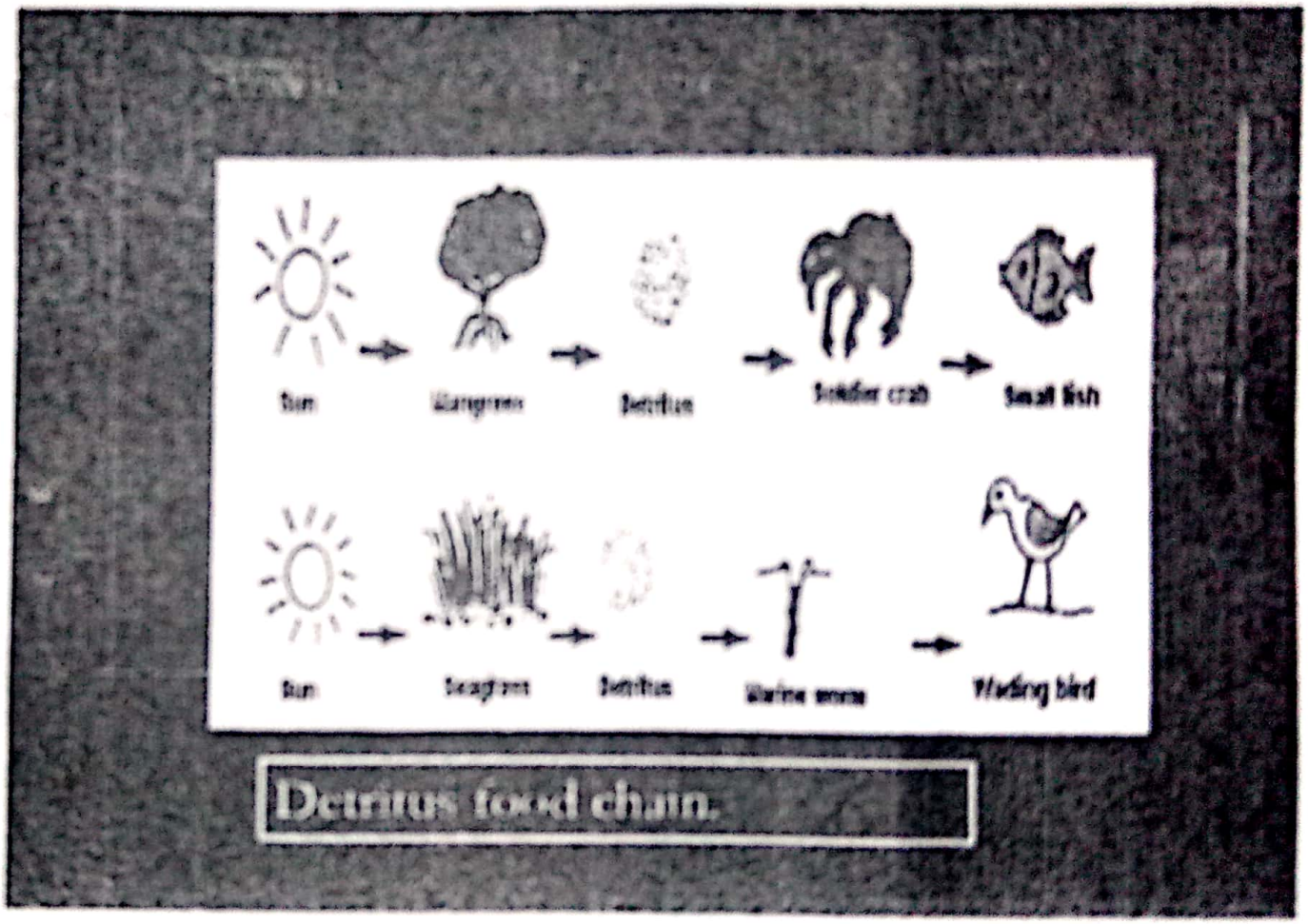
(c) Detritus/decomposer/saprophytic food chain

- Dead plants and animals form the base of detritus food chain.

- This type of food chain begins with fungi and bacteria feeding on dead plants and animals to release nutrients into the soil.

- Detritivores such as earthworms, termites, beetles etc. feed on the detritus formed as a result of fungi and bacteria actions to speed up the decay process. The detritivores may be fed upon by larger animals like moles.

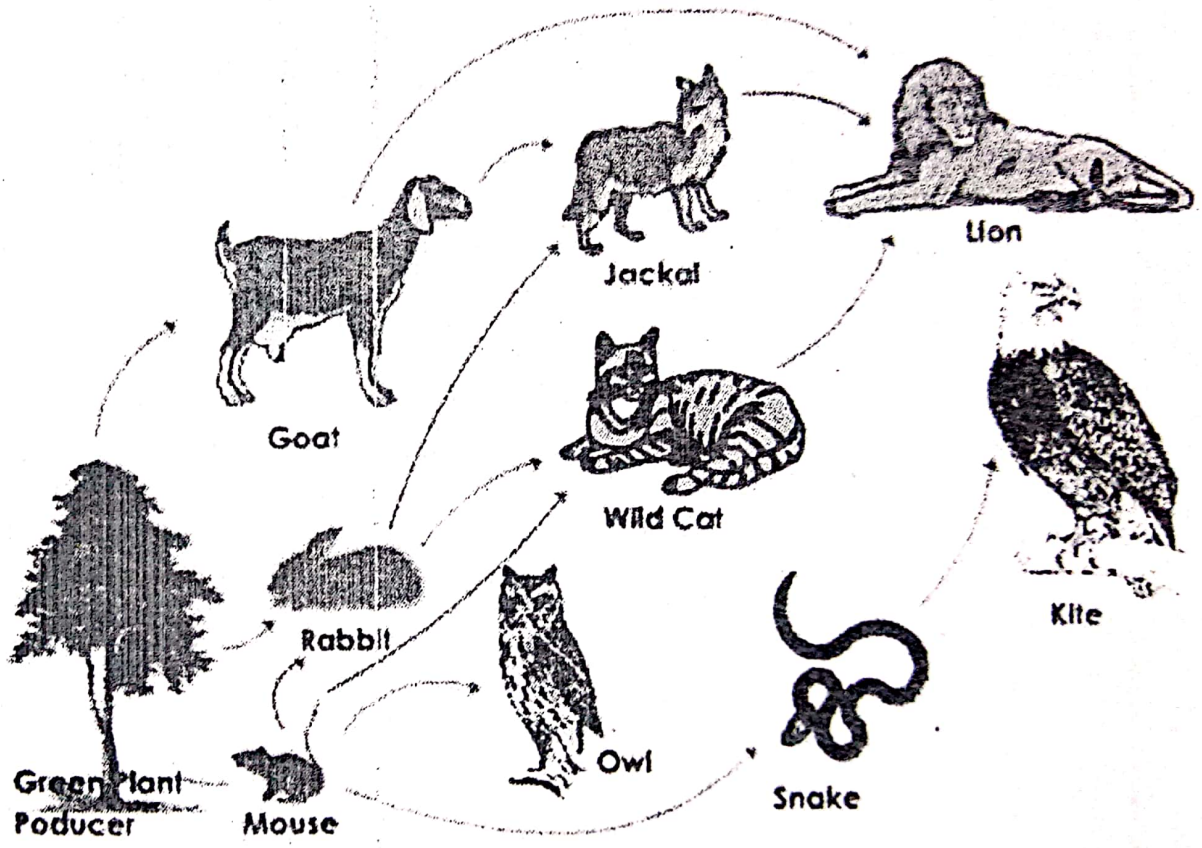
- The fungi and bacteria can also be acted upon by several small animals like protozoans, which in turn, may have small carnivores feeding on them. Larger carnivores can still feed on the small carnivores.



Detritus food chain.

Food webs

- Reading assignment



Food Web In a Forest

Methods of assessing food chains

- Gut contents analysis
- Faecal analysis
- Direct observation in the field and/or laboratory
- Radiotracer

Ecological pyramids

- Ecological pyramids are quantitative ways of representing feeding relationships and energy transfer between organisms in an ecosystem.

- They usually take the form of bars stacked on each another.

- Ecological pyramids enable us to easily assess energy flow and losses within ecosystems.

- Construction of ecological pyramids makes it possible to compare different ecosystems or seasons within the same ecosystem.

Types of ecological pyramids

Pyramid of numbers

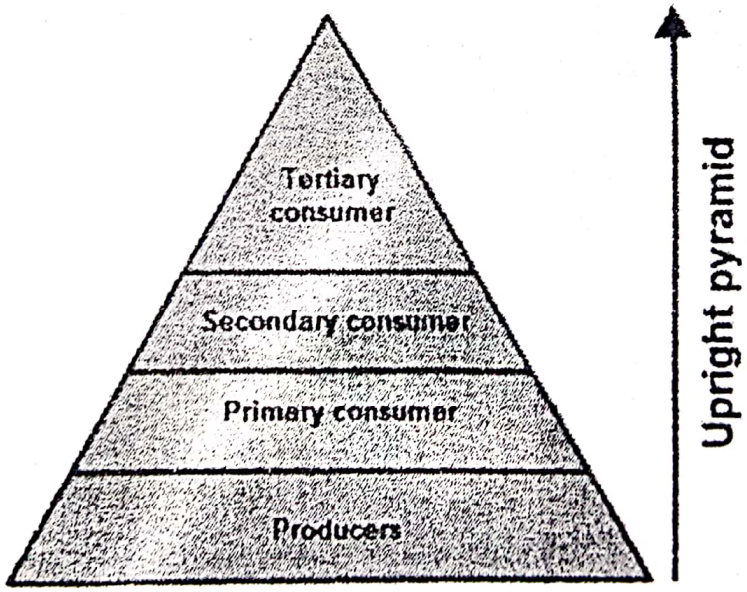
- Pyramid of numbers shows the relationship in terms of number of organisms (producers, herbivores and carnivores) at their successive trophic levels.

- There is a decrease in the number of individuals from lower to higher trophic levels. Pyramid of numbers varies from one ecosystem to another.

- Three types of pyramid of numbers exists: upright, partially upright and inverted.

Upright pyramid of numbers

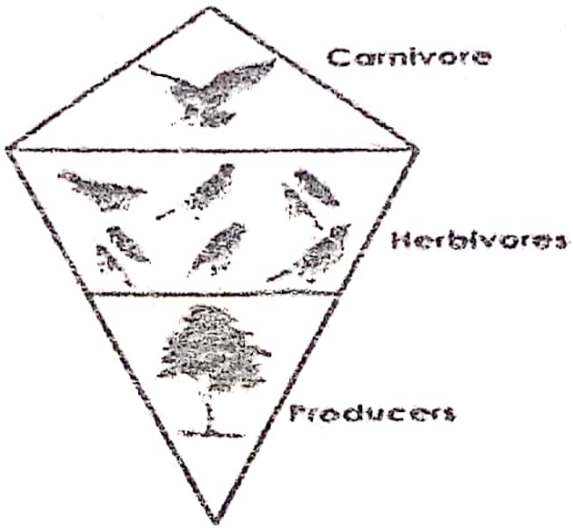
- **The body size of the producers are so small that many of them are needed to support lesser number of primary consumers, which in turn support smaller number of secondary consumers, etc.**



Pyramid of Number

Partially upright pyramid of numbers

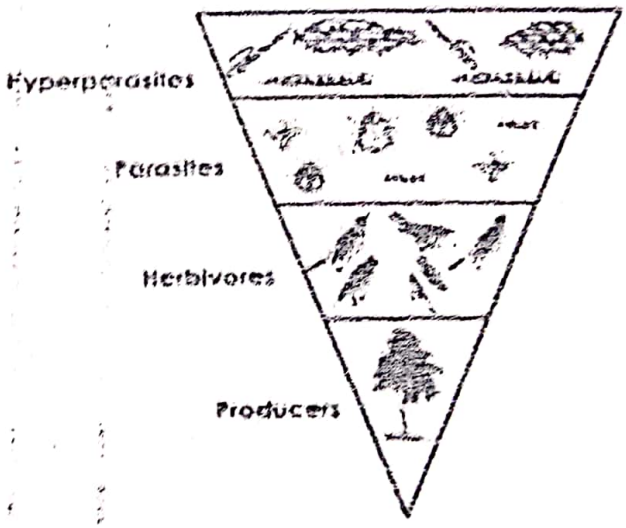
- Due to large body size of producers, a smaller number of them is needed to feed a higher number of primary consumers, which in turn support a smaller number of secondary consumers, etc.



Partly Upright
Pyramid of Number

Inverted pyramid of numbers

- This occurs where one primary producer supports numerous herbivores and the herbivores support more number of parasites, which in turn support more hyperparasites.



Inverted pyramid of number

Advantage of pyramid of numbers

- It is easy to collect data for the construction of pyramid of numbers.

Disadvantages of pyramid of numbers

- In some cases, it is not easy to decide which trophic level an organism belongs to.

- All organisms are included regardless of their sizes, and as a result organisms of different sizes are given the same status. This could lead to different shapes of pyramid of numbers.

- Numbers of organisms can be too great to represent accurately.

Pyramid of biomass

- This is the representation of the total mass of organisms at each trophic level.

- Pyramid of biomass gives a better diagram than pyramid of numbers because it shows the loss of mass from producers to consumers, and among consumers in a food chain.

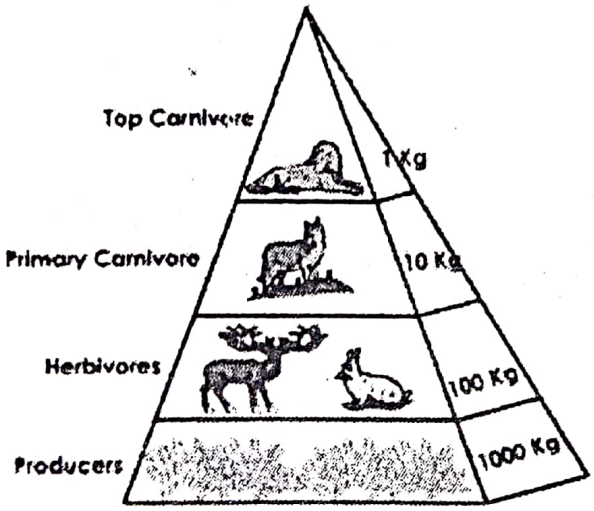
- That is, there is a gradual decrease in mass with increasing trophic level.

- The biomass of trophic levels is obtained by collecting, drying and taking the final weight of organisms.

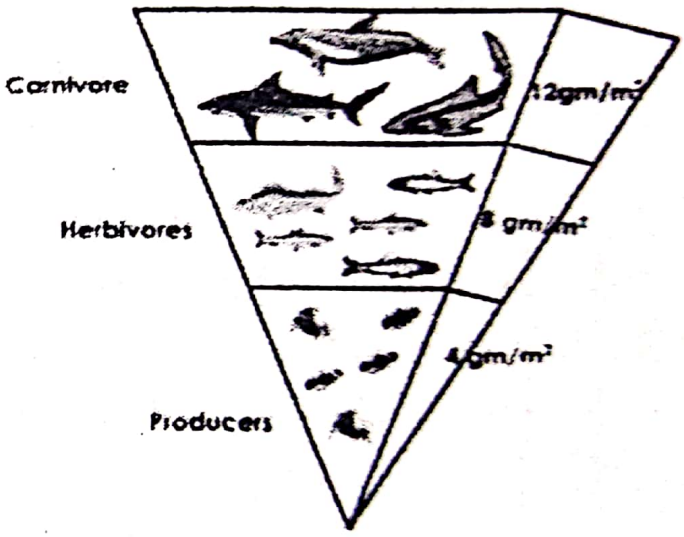
- The biomass of trophic levels at a given time is known as standing crop biomass or standing biomass.

- This dry weight which represents biomass, gives the amount of energy available in the form of living organic matter of the organisms.

- There are two types of pyramid of biomass namely, upright and inverted pyramids of biomass.



Upright Pyramid of biomass in a Terrestrial Ecosystem



Inverted Pyramid in an Aquatic Ecosystem

Advantages of pyramid of biomass

- It produces more accurate data.
- It eliminates the misleading problem of size differences associated with pyramid of numbers.

Disadvantages of pyramid of numbers

- It is more laborious and expensive than pyramid of numbers.
- It destroys biodiversity because organisms must be killed before their biomass can be measured.
- There is a difficulty in assigning organisms to specific trophic levels.

- Biomass of organisms is affected by seasons. That is, the time of the year in which biomass is measured could influence the values obtained.

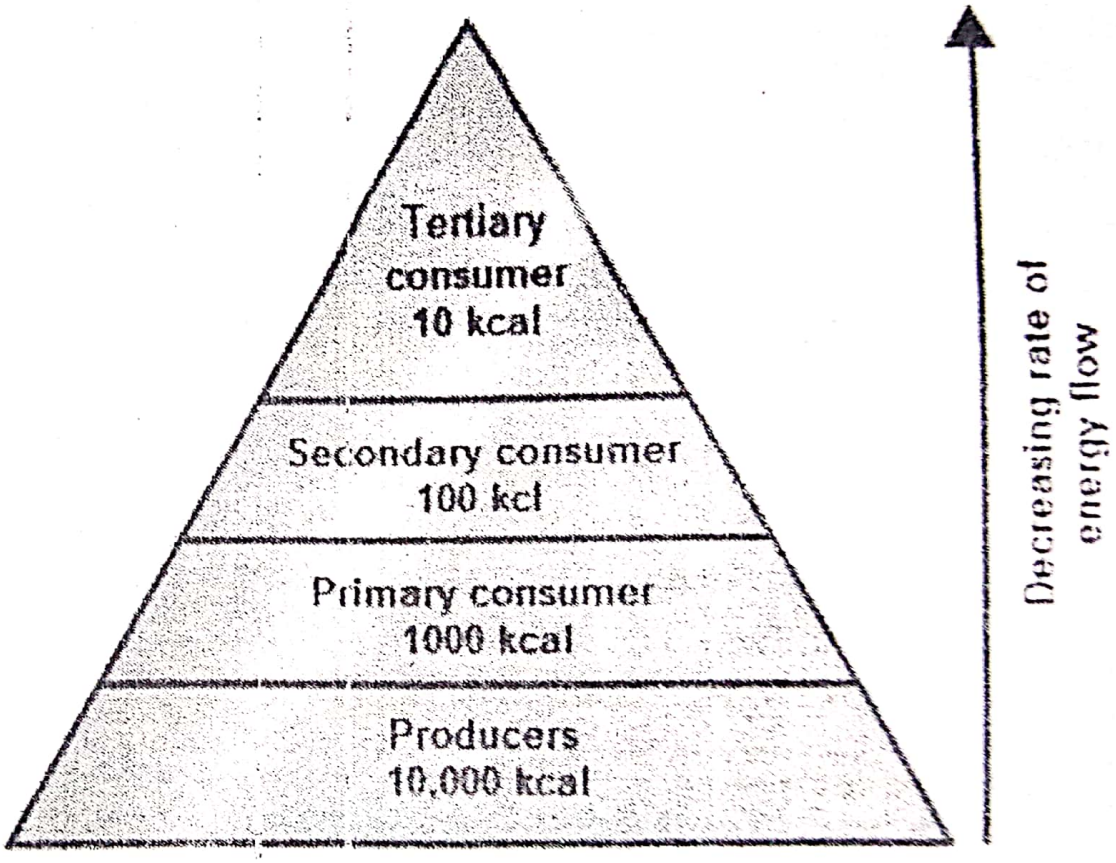
- Pyramid of biomass only measures standing crop biomass but not rate of production (productivity).

Pyramid of energy

- Pyramid of energy is a representation of the amount of energy trapped per unit time and area in different trophic levels of a food chain.

- It is the most accurate way of representing feeding relationships of organisms at different trophic levels. This is because it takes into account energy gains and losses over time.

- Thus, it truly measures energy flow at different trophic levels. Each bar represents the amount of energy per unit area/volume flowing through a trophic level in a given time period.



Pyramid of Energy

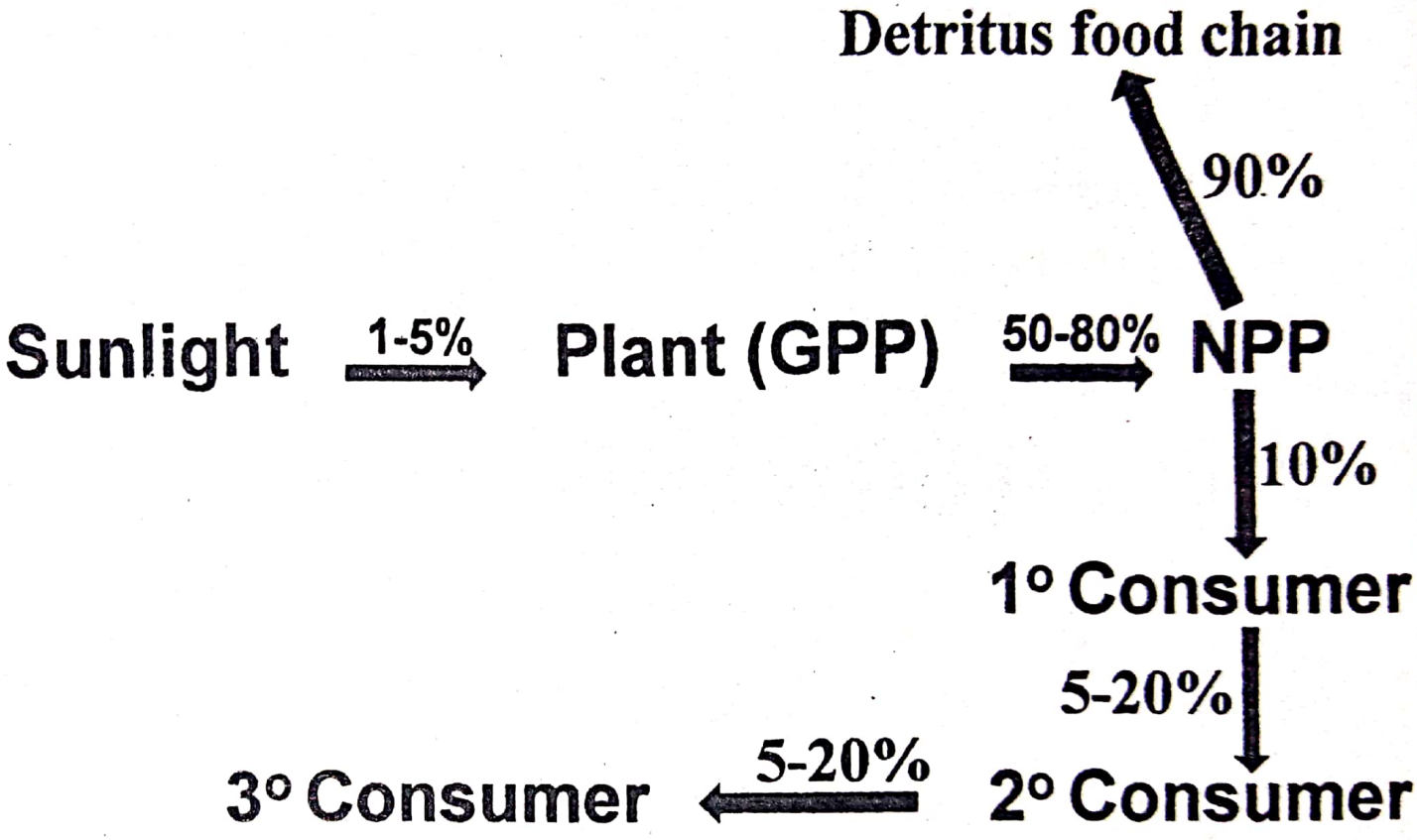
Advantages of pyramid of energy

- **It takes into account the rate of production.**
- **The energy content of organisms with different weight can be directly compared using pyramid of energy.**
- **Beside making it possible to compare different ecosystems, pyramid of energy also enables the relative energy flow of populations within an ecosystem to be compared.**

Disadvantages of pyramid of energy

- It is most laborious and expensive.
- It is difficult and complex to collect energy data; it requires combustion of organisms.
- It destroys biodiversity.
- There is still the difficulty of assigning organisms to specific trophic levels.
- About 80% of energy fixed by producers may be passed on to detritivores and decomposers and yet pyramid of energy does not include dead organic mater.

ENERGY TRANSFER AND EFFICIENCY IN ECOSYSTEMS



Energy transfer efficiency

- Ecological efficiency describes the efficiency with which energy is transferred from one trophic level to another.

- Only about 1-5 % of sunlight energy that reaches plants is used in photosynthesis. The remaining percentage is lost from the plant through reflection, radiation and heat evaporation.

- Through photosynthesis, light energy is converted to chemical energy and stored in plants. The total amount of chemical energy stored by plants is referred to as gross primary productivity (GPP).

- Part of the GPP (usually 20-50 %) is used by the plants themselves through respiration and photorespiration. The remaining percentage stored in the plant is referred to as net primary productivity (NPP).

- Consequently, NPP forms about 50-80 % of GPP. This amount is usually about 1-2 % of sunlight energy absorbed by plants.

- When animals feed on producers, they obtain part of the NPP in the plants. Thus, the NPP in plants is what is potentially available to animals.

- About 10 % of the NPP in plants become available to primary consumers for production (i.e. growth, repair, reproduction). This is referred to as secondary production.

- The remaining percentage of NPP (90 %) is lost via detritus food chain to detritivores and decomposers through litter fall and death.

- In turn, about 80-95 % of the secondary production in the primary consumers are lost through respiration, excretion and defaecation, leaving only 5-20 % available for use by secondary consumers.

- Tertiary consumers also obtain only up to 20 % of the secondary production in secondary consumers as least 80 % of this energy is lost in the secondary consumers in the form of respiration, excretion and defaecation.

Ecological tithe (The 10 % law)

- This law shows the general level of energy transfer efficiency in ecosystems.

- It states that only about 10 % (1/10) of the amount of energy in a trophic level is passed on to another trophic level. That is, energy available at a trophic level is about 10 % (1/10) of the energy present at a previous trophic level.

- Per this law, the number of trophic levels in food chains of ecosystems is limited by the amount of energy available for transfer.

Factors that limit primary production

Aquatic ecosystems

- Light limits primary production greatly in aquatic ecosystem because sunlight energy can only penetrate to a certain depth, beyond which there is no plant life.

- Nutrient availability can also limit production in aquatic ecosystem.

- E.g. in oceans, nitrogen and phosphorus deficiency may limit phytoplankton growth.

- However, in fresh water ecosystem, high levels of these nutrients may cause eutrophication, which changes lakes from phytoplankton communities dominated by diatoms and green algae to communities dominated by cyanobacteria.

Terrestrial ecosystems

- Terrestrial ecosystems' productivity is limited by temperature and moisture.

- Terrestrial ecosystems that possess warm and moist conditions are the most productive. E.g. Tropical rain forests.

- On the contrary, terrestrial ecosystems that are either dry or dry and cold have low productivity. E.g.s desert (dry condition), tundra (dry and cold).

Methods of measuring plant productivity

Relative growth rate (RGR)

- It is the gain in dry mass in unit time per dry mass of plant.

- i.e., $RGR = \frac{(M2-M1)/(T2-T1)}{M1} = \frac{M2-M1}{T2-T1} \times \frac{1}{M1}$

Where, M1 = Initial mass, M2 = Final mass, T1 = Initial time, T2 = Final time

- It is photosynthesis which leads to an increase in dry mass of plants.

- Increase in dry mass is obtained by deducting dry mass loss due to respiration from GPP.

Biomass

- Productivity can be measured as dry weight of organic matter of an organism.

- This is known as the biomass of the organism.

- It is usuálly expressed as gram, kilogram or megagram (tonne, metric ton).

Food chain concentration (biological magnification)

- This is the build-up of toxic substances, (e.g. DDT, heavy metals) in the bodies of organisms at higher trophic levels of food webs.

- Usually, organisms at lower trophic levels accumulate small amounts of the toxic substances. However, organisms at higher trophic levels accumulate larger amounts of the toxic substances because they eat many of the lower-level organisms.

- At the highest trophic levels the increased concentrations in tissues may become toxic.

Introduction to population ecology

What is a population?

- Population is a group of individuals of the same species that live in the same area and share a common gene pool.

- The above definition means that a population has the following features:

1) Abundance (density)
2) Boundaries
3) sex and age
4) Dynamic (change over time)
5) Distribution (pattern and scale)

What is population ecology?

- It is the study of structure and dynamics of populations, and how populations interact with the environment.

Interactions within and among populations

- Population interactions may take the form of competition; intra-specific and interspecific competition

(1) Intra-specific (intra-population) interactions

Resource competition

- This is a negative interaction that occurs among organisms where two or more organisms require the same limited resources, and therefore compete for it.

- The following mechanisms underlie resource competition:

i) acquisition of resources (or structures) by individuals.

ii) interference in resource acquisition by other members of the population.

iii) Resultant limited availability or supply of the resources.

- Resource competition is a density dependent process.

Consequences of resource competition

(i) Extinction

- Where all individuals of a population use the same amount of resources at the same rate, competition between them can cause steady decrease in the population size.

- Eventually, all the individuals will start to die at the same time.

- This rather extreme case of overcompensation is called scramble, and always leads to extinction.

(ii) Decreased population growth rate

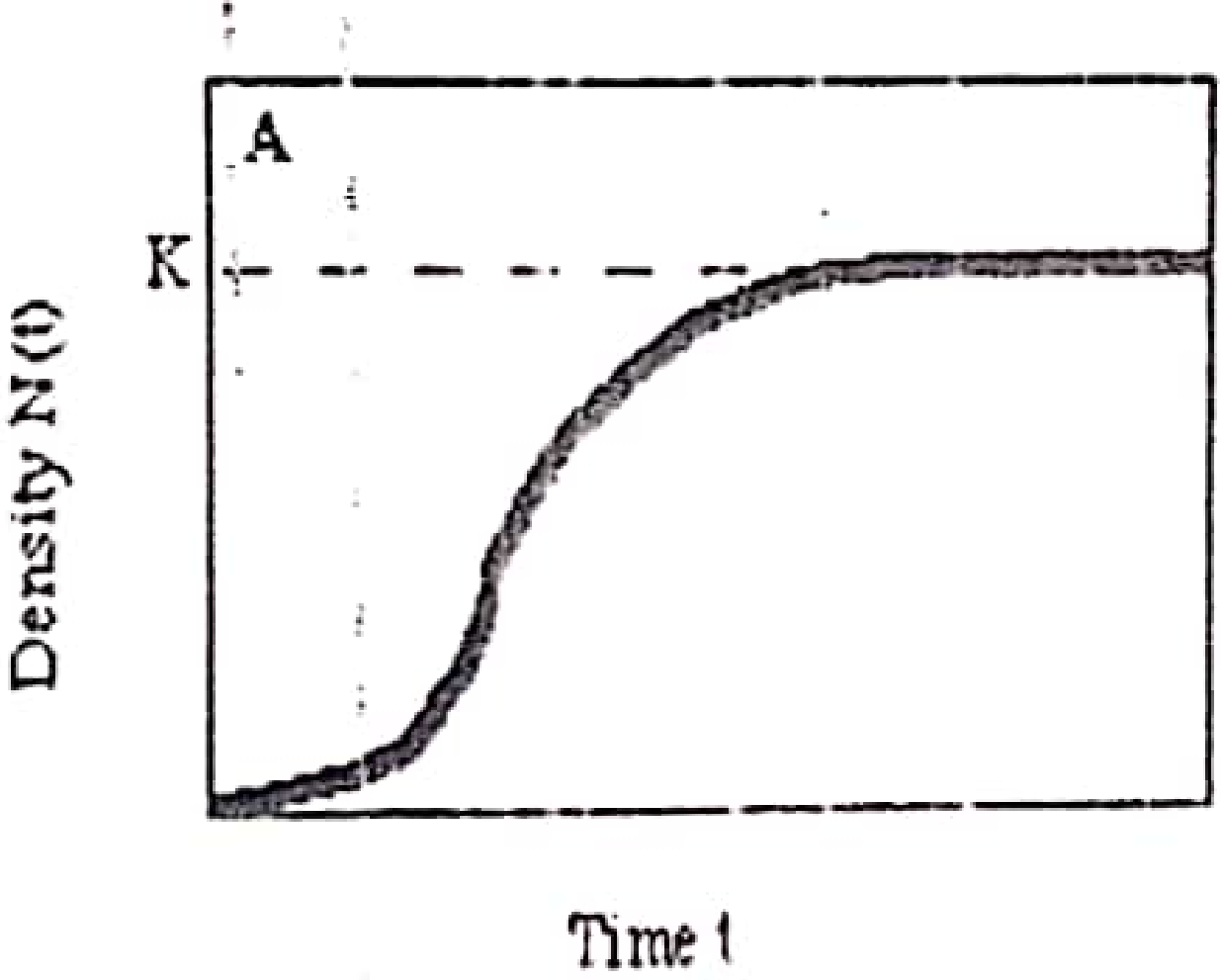
- Where individuals of a population use resources at different rates, competition does not impact on the individuals equally.

- When differences occur in resource acquisition between individuals, some of the individuals will win while others will not.

- The survivors grow and/or reproduce well, and the losers are suppressed in growth and may suffer increased mortality.

- The population growth rate decreases till it becomes constant at the carrying capacity of the ecosystem.

- At the carrying capacity, resources are sufficient for only a certain maximum number of individuals.



- Can the carrying capacity of an ecosystem be altered?

Causes of differences in resource acquisition

Timing of recruitment, establishment and growth

Variation in site quality

Genetic differences between individuals

(2) Interspecific Interactions

- Interspecific interactions may occur through competition between populations of different species for limited resources such as nutrient, light, structural support, space, food etc.

- Interspecific competition is less intense than intraspecific competition because in interspecific competition, requirements are less similar between the competitors.

Consequences of interspecific competition

(i) Coexistence

- Different competing species can coexist in the same environment due to niche differentiation.

- Niche differentiation occurs when species undergo specialisation that enables them to partition (subdivide) available resources.

- E.g. stingless bees; one species feeds in groups in high density forest patches whereas the other species feeds singly in less dense forest patches.

- E.g. African ungulates feed in different plant species and different parts of forests.

- Coexistence of different competing species can also occur due to character displacement.

- Character displacement is a phenomenon where two species living apart have similar traits but when they live together they compete and therefore develop different traits.

- Thus, character displacement allows for resource partitioning.

(ii) Competitive exclusion

The competitive exclusio n principle (Gause's principle)

- If there is no niche dif erentiation, then one competing species will eliminate or e xclu de the other.

- Thus exclusion occurs when the realised niche of the superior competitor completely fills those parts of the inferior competitor's fundamental niche which the habitat provides.

(3) Symbiotic interactions

- Symbiosis refers to two or more organisms of different species living together in a close association.

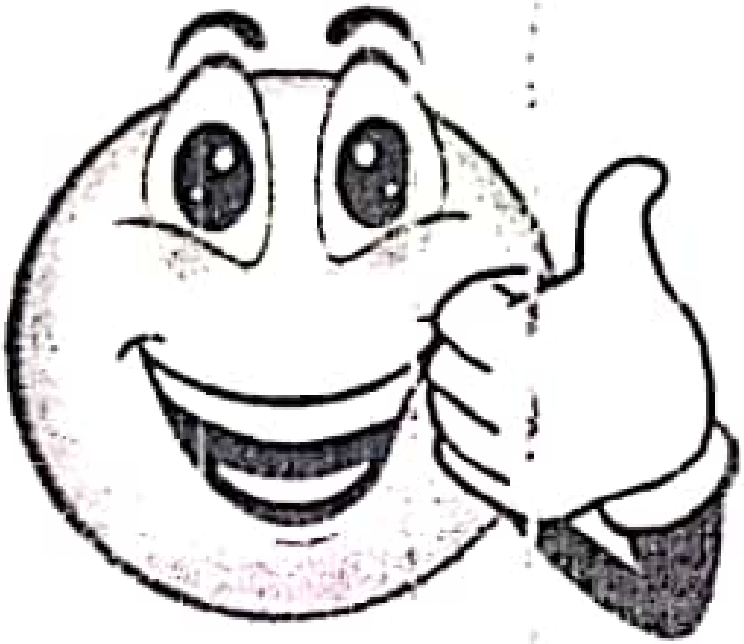
- If two populations show no interaction or have no effect on each other they exhibit neutralism.

- Some categories of interactions between organisms of different species include mutualism, commensalism, parasitism and predation.

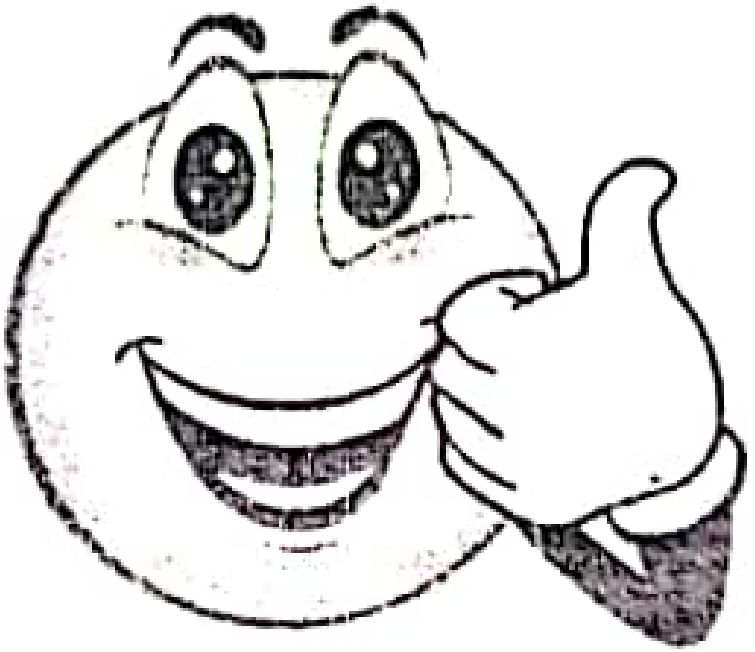
Mutualism	Commensalism	Parasitism/predation
Both organisms benefit	✓ One organism benefits ✓ The other organism is not affected in any way	✓ One organism benefits ✓ The other organism is affected by being harmed

Mutualism

Organism *A*



Organism *B*



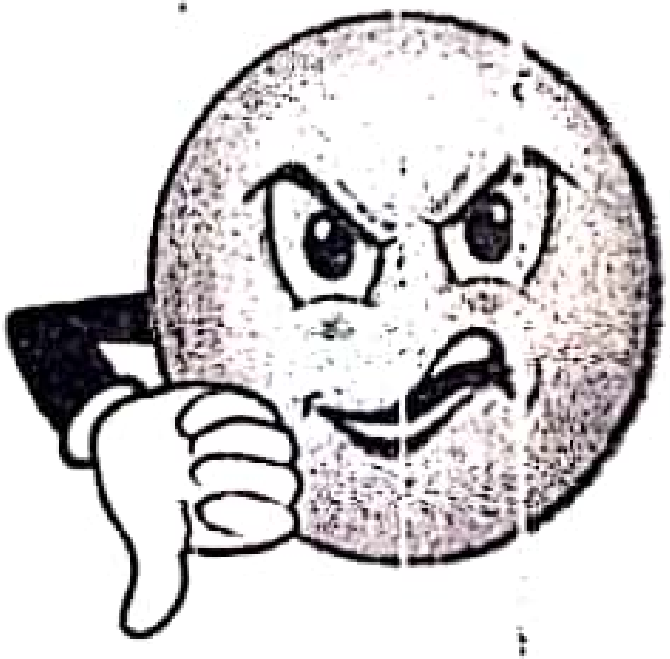
Commensalism

Organism *A*

Organism *B*

Parasitism/predation

Organism *A*

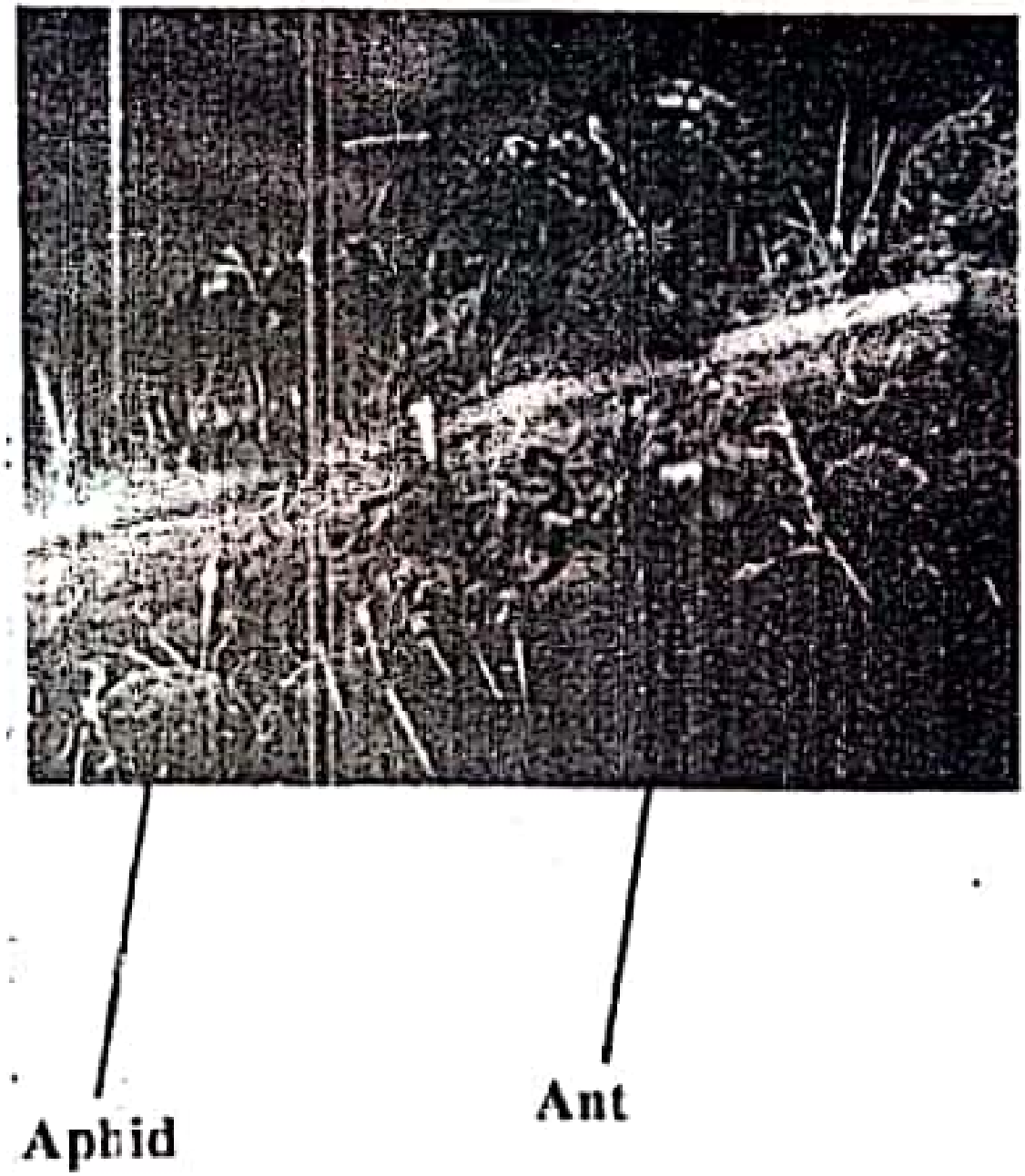


Organism *B*

Examples of mutualism

- Aphids and ants. Both organisms can live independently, but when they are together, the ants protect the aphids against predation and in return, the aphids provide the ants with sugary fluid.

Facultative mutualism

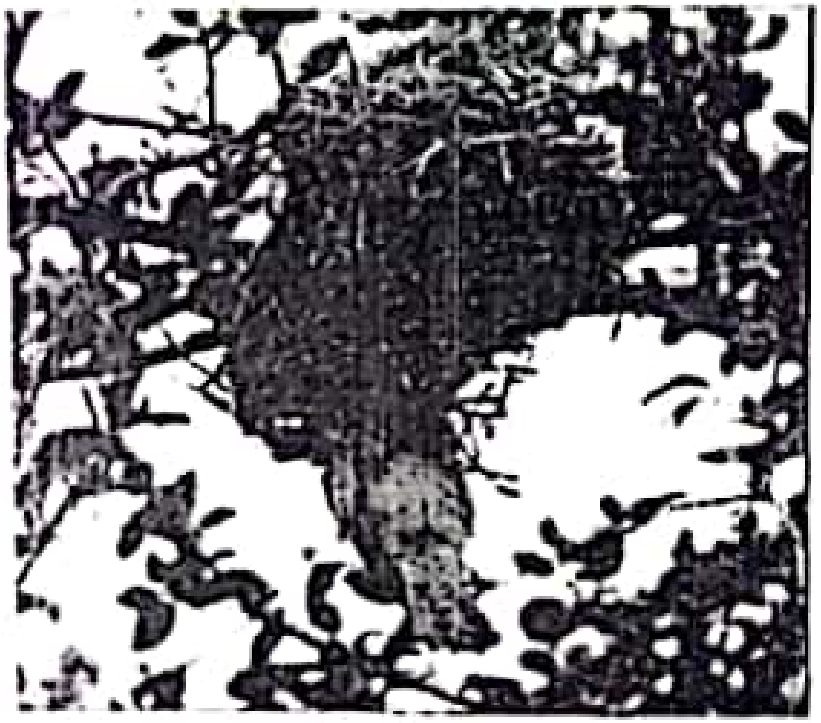


Cellulose digesting bacteria live in the gut of ruminants. They feed on cellulose in the host's diet and convert it into simple forms which the ruminant can digest, absorb and assimilate. In return, the bacteria get food from the gut.

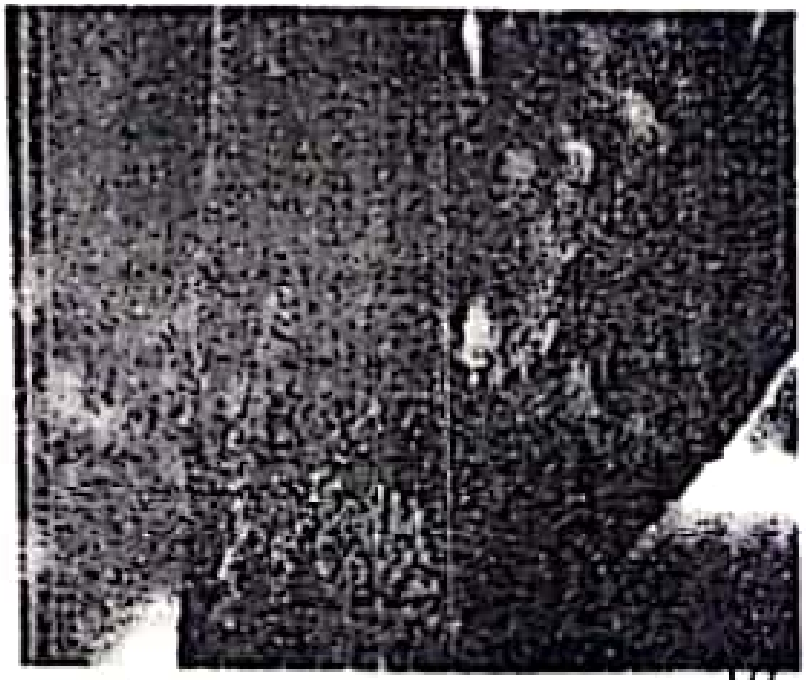
Obligate mutualism

Examples of commensalism

1. Birds benefit from trees by constructing their nests on trees but they trees are not harmed and do not benefit from the bird.



2. Lichens attach themselves to tree barks and obtain water and nutrients from them. However, trees do not benefit from the presence of lichens and they are not harmed by them.



Examples of parasitism

- Fungi that parasitise trees. E.g. *Armillaria* sp.
- *Candida albicans* in humans.
- Facultative parasites

- Flatworm, *tapeworm*, roundworm, flea etc.
- Obligate parasites

Adaptations of parasites

1) Some have structures that enable them to penetrate into hosts.

2) Endo-parasites have adhesive structures like hooks, suckers etc.

3) The presence of resistant body cover. E.g. nematodes body surface is covered with cuticle.

4) Some intestinal parasites produce anti-enzymes to neutralise digestive enzymes of hosts.

5) Some parasites living in certain parts of the body with low oxygen content are able to live as facultative anaerobes. E.g. *Ascaris lumbricoides*

6) Parasites have high reproductive potential. E.g. *Ascaris lumbricoides* lays about 200,000 eggs per day.

Predation

- Predation occurs when a species (predator) eats another species (prey).

- The predatory activity of predators results in a reduction in the fitness of preys.

- Predator-prey relationships are essential to maintaining the balance of organisms in an ecosystem.

- Is there any ecological significance of predation?

Types of predation

(a) True predation

- This is where a predator kills and eats its prey.

E.g snakes, lions, cat

b) Grazing predation

- This is where a predator eats part of the prey without killing it.

E.g herbivores such as goats, sheep, cattle

- Herbivores feed on grasses but the grasses do not die, and they regrow.

Ecological importance of predation

(For class discussion)

Population growth dynamics

- Populations fluctuate in size in characteristic ways due to intrinsic and extrinsic factors.

- Population size, which refers to the number of individuals of a species within a specific area, is partly governed by reproductive potential of individuals.

- If environmental resources within ecosystems are unlimited, the rate of reproduction in organisms would be maximum. That is, the maximum reproductive potential (biotic potential) of organisms would be realised.

- However, in reality, full biotic potential is unattainable due to environmental resistance.

- Consequently, reproductive potential of organisms is one of the factors that affects the growth rates of their populations.

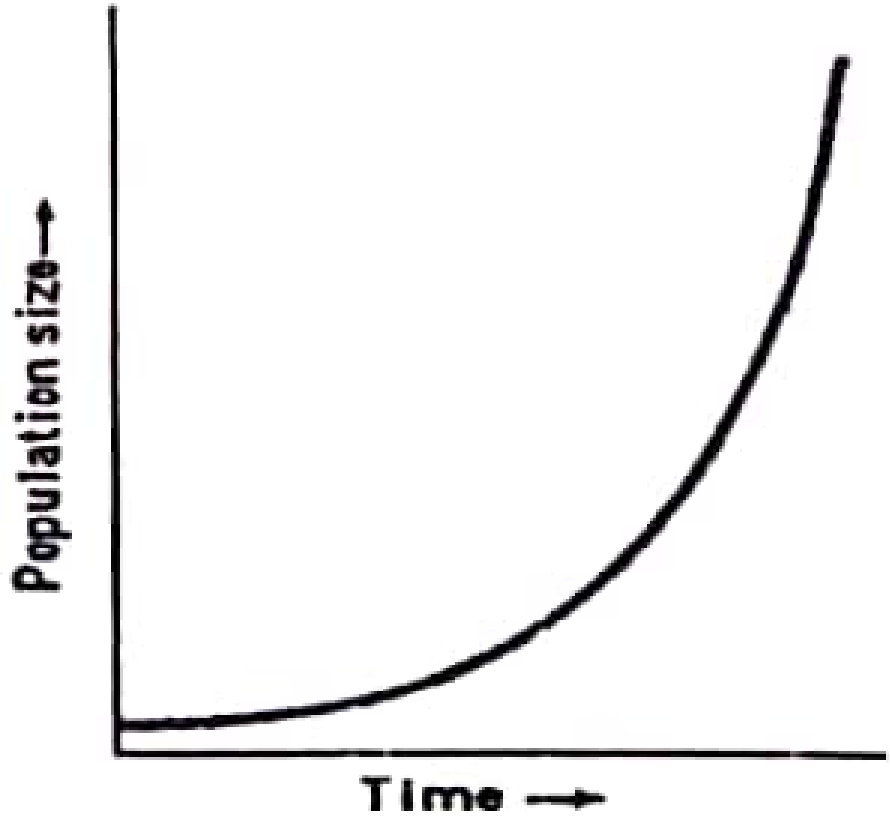
- Apart from reproductive potential (birth rate), there are other factors that affect population growth rate: death rate, immigration and emigration.

- There are environmental resistance factors that affect the number of individuals that can survive and reproduce as well as migrate in a habitat.

Population growth curves

Exponential growth rate

- If birth rate and immigration exceed death rate and emigration, then a population grows exponentially resulting in a characteristic J-curve.



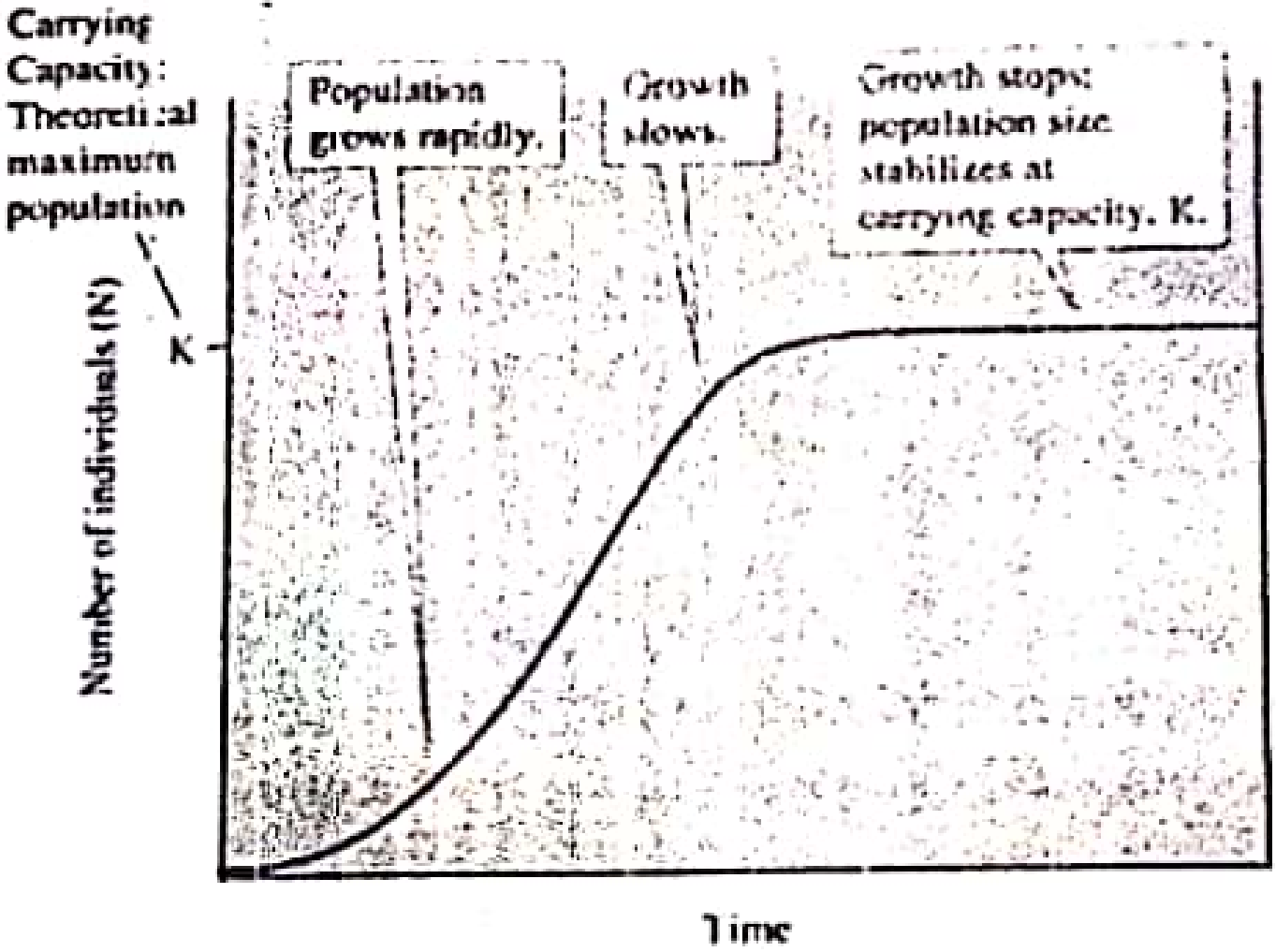
- This type of growth is very characteristic of small populations.

- It can only occur in an ecosystem where environmental resources are not limited.

- However, since in reality resources in ecosystems are limited, then this type of growth rate would hardly ever occur in nature. Where it occurs, it can only exist for a short time.

- The J-curve growth type is density independent.

Logistic growth rate



- As indicated earlier, exponential growth cannot continue forever due to limited resources.

- In the logistic growth rate, the population density of a species increases slowly initially, and then increases rapidly, approaching exponential growth rate.

- As the population size increases, growth rate eventually slows down until a zero population growth rate occurs. At this point, rate of reproduction balances rate of mortality. And it is at this point that maximum carrying capacity occurs.

- This type of growth rate is density dependent because as the population density increases, competition for resources increases, resulting in increased mortality and reduced biotic potential, that eventually brings growth rate to zero.

- The shape of the graph produced from the logistic growth rate is S-shaped.

MAN AND HIS ENVIRONMENT

- Human beings impact on the environment in two main ways namely, land use and pollution.

LAND USE

Deforestation

- It is one of the main land use practices that adversely impacts on the environment.

- Deforestation is the permanent destruction of forests in order to extract timber or use the land for other purposes.

Effects of deforestation on the environment

- Deforestation contributes to increased atmospheric CO_2, leading to global warming.

- Deforested areas experience soil erosion frequently because they become exposed to rain and wind.

- Soils lost during erosion may end up in rivers, filling up river beds and causing flooding.

- It leads to a reduction in the amount of rainfall and changes rainfall patterns.

- Deforestation causes biodiversity loss because it leads to species death, species extinction and habitat loss.

Logging

- Logging is the felling of trees for timber.
- Logging can be selective or indiscriminate (clear-cutting).

Effects of logging on the environment

- Forests serve as a buffer zone to filter water and hold soil in place. They sustain water and soil resources through recycling of nutrients.
- In watersheds where forests are destroyed, the buffer zone function is lost. This causes reduction in water movement into rivers during the dry season (leading to drought), while flooding and soil erosion increase during the wet season.

- Logging can exacerbate forest fires.

- Logging also affects rainfall patterns and amount; rainfall becomes more erratic and dry periods become prolonged.

- Unsustainable logging mobilises debris that finds its way into the marine environment, where it damages mangroves and coral reefs, and habitats crucial for aquatic life.

- It also causes biodiversity loss as a result of species death, species extinction and habitat loss.

Monoculture (forest plantation)

- This is the planting of only one species of tree on a piece of land.

Effects of monoculture on the environment

- Increase in pest diversity and abundance due to continuous supply of food.

- The same species draws particular soil nutrients from the soil for a long time and so the soil becomes deficient in particular soil nutrients.

POLLUTION

- Pollution is the release of substances or energy into the environment in such quantities and for such duration that they can have detrimental effects on the environment and organisms living in it.

- The substances which cause pollution are known as pollutants.

- There are four main forms of pollution: land, air, water and noise.

LAND POLLUTION

Sources

- Domestic wastes
- Agricultural wastes
- Industrial wastes

Domestic wastes

- Solid wastes such as paper, food, metals, glass, wood, plastics, clothes, rags are generated in homes.

- These are disposed off in the open, landfills, or are burnt. The organic part of domestic waste can be composted.

Environmental effects

- Gives off bad smell and attracts pests.

- Plastics and metals cannot degrade and therefore require a lot of space for land filling.

- Open dump burning contributes to air pollution.

Agricultural wastes

- They include fertilisers, pesticides, animal mannure.

Environmental effects

- Residues of fertilisers and pesticides remain in the soil and crops. This can cause biological magnification when animals feed on the plants.

- Fertilisers usually contain nitrates, phosphates, potassium compounds etc. Animals can take in these components which can be toxic to them.

Industrial wastes

- These are wastes generated from manufacturing processes of industries. Some of these wastes find their way directly into the soil.

- Mining is a major source of industrial wastes. E.g. Petroleum extraction and manufacturing contaminate the soil with bitumen, gasoline, kerosene and mining brine solutions. Opencast mining contaminates soil with toxic metals (Hg, Pb, As) and chemicals (Cyanide).

- Other industries also contaminate land with chemicals, paints, foundry wastes etc.

Environmental effects

- Chemicals released into soils end up in the food chain, causing biological magnification.

- The chemicals cause pollution in the soil which destroys vegetation.

- People who come into contact with such polluted soils may have health related problems.

AIR POLLUTION

1) Smoke and exhaust fumes

a) Carbon monoxide

Environmental effects

- Carbon monoxide combines with haemoglobin to form *carboxyhaemoglobin* which reduces oxygen carrying capacity of the blood.

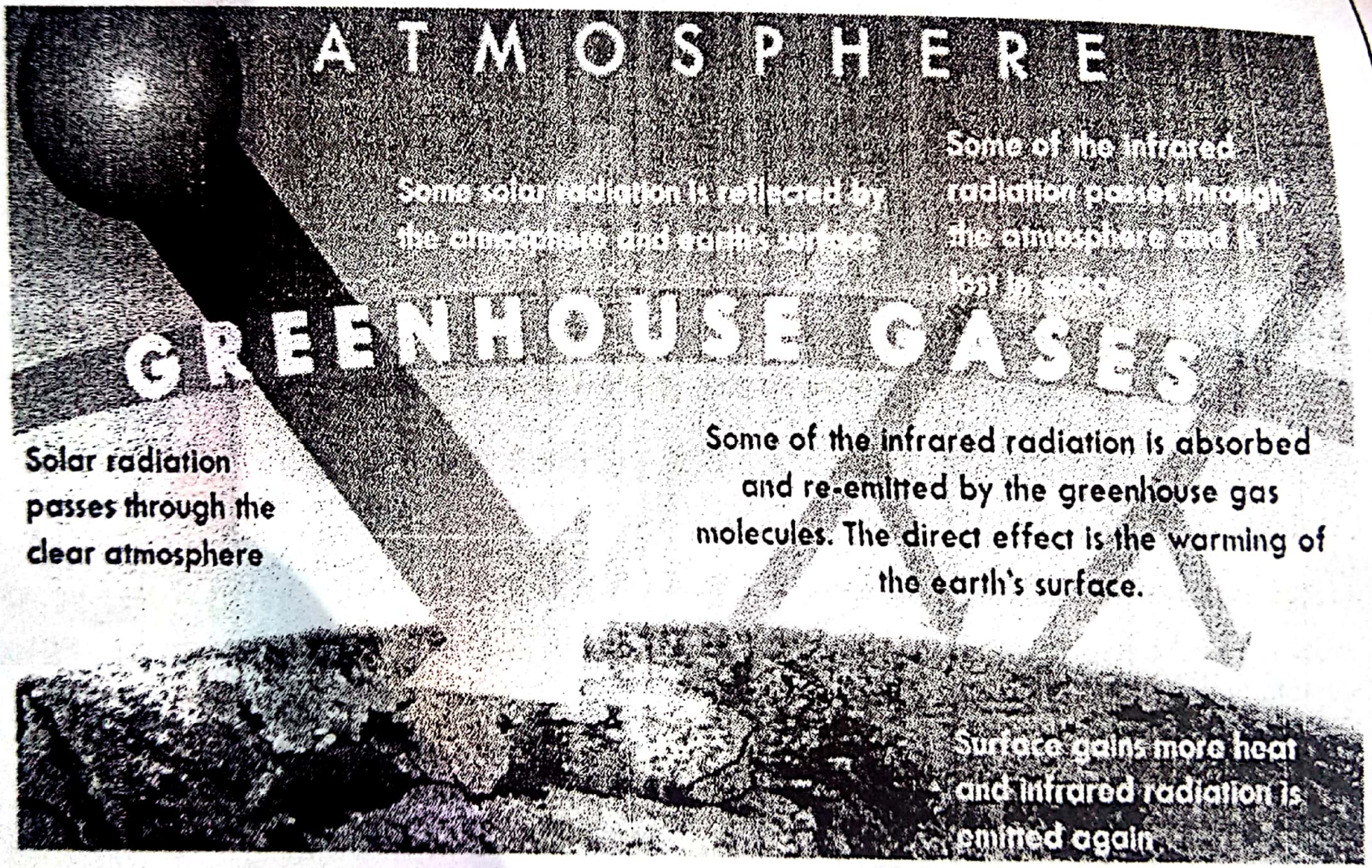
- This condition causes weakness, fainting and death.

b) Carbon dioxide

- It is the primary greenhouse gas produced from human activities.

- As a greenhouse gas, it contributes to greenhouse effect leading to global warming, increase in sea level due to melting of polar ice, and subsequently flooding.

Greenhouse effect



c) Carbon particles

Environmental effects

- They block stomata of plants, making it impossible for them to undergo gaseous exchange and photosynthesis.

- Carbon particles cause respiratory diseases in man.

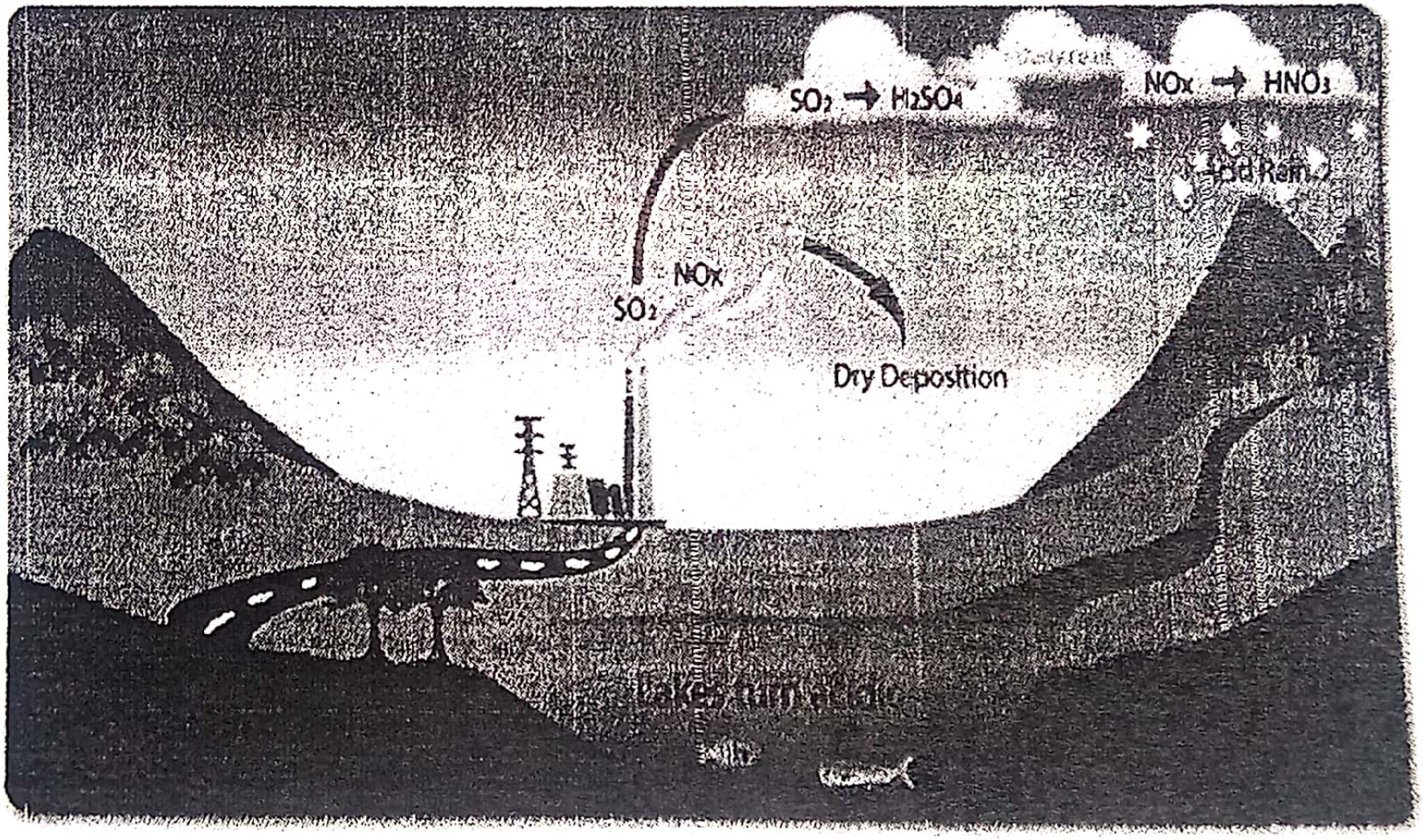
d) Lead

Environmental effects

- **Affects mental development of children.**
- **Causes headache, fatigue, depression and irritability.**

2) Sulphur dioxide & nitrogen dioxide

- They cause acid rain.



Environmental effects

- Acid rain is corrosive to buildings and metals.

- Acid rain causes leaf blotching and wilting of plants.

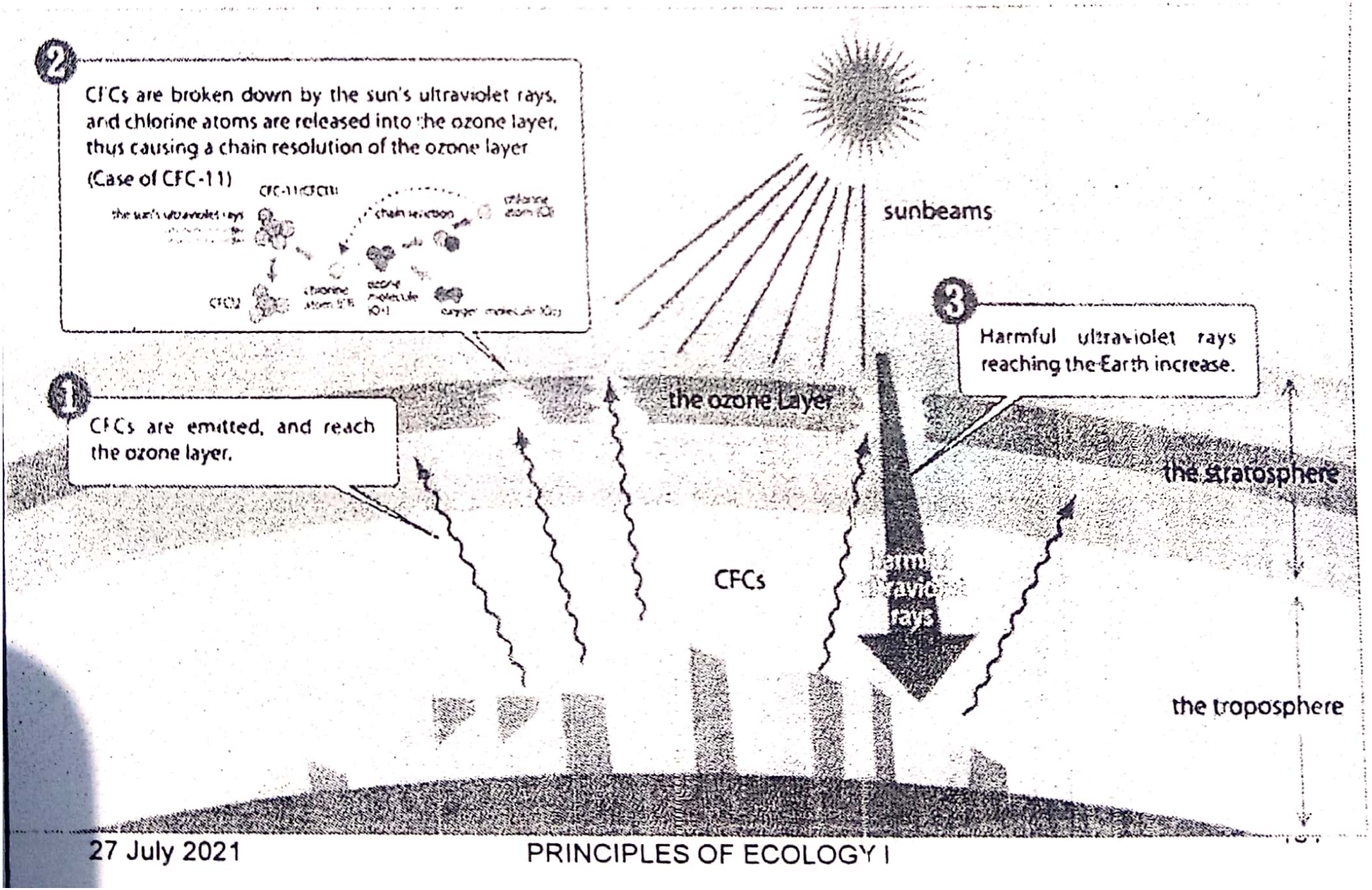
- Deposition of SO_2, NO_2 and acid rain in water bodies kills aquatic life.

- They also find their way in soils, making them acidic. This phenomenon:

(a) reduces plant growth and can ultimately kill forests.

(b) reduces soil microbial diversity and activity.

3) Chlorofluorocarbons (CFCs)



- CFCs emanate from refrigerators, aerosol sprays, foam industries etc.

Environmental effects

- They cause the breakdown of the ozone layer which protects the earth from UV radiation of the sun.

- This phenomenon increases the amount of UV radiation that reaches the earth.

WATER POLLUTION

Hot water (Thermal pollution)

- This is the release of hot water produced from industria processes into water bodies.

Environmental effects

- It decreases solubility of oxygen in water thereby reducing dissolved oxygen concentration of water bodies.

- Consequently, organisms living in affected water bodies become suffocated.

- High temperature can hamper digestion and reproduction of organisms.

Crude oil from spillage

Environmental effects

- The oil covers the surface of the ocean and reduces sunlight penetration and dissolved oxygen concentration.

- The oil can stick to the feathers of birds and prevent them from flying.

Sewage

- Wastewater from drains and sewers such as soaps, detergents etc. are often released into water bodies.

Environmental effects

- It causes high nutrient enrichment in water bodies which can eventually lead to eutrophication.

- It increases BOD of water thereby reducing the amount of dissolved oxygen of water bodies.

- The release of wastewater into water bodies introduces disease causing organisms in them.

Sediment

- Soil erosion from agricultural lands, forest soils exposed by logging and deforestation, degraded stream banks, overgrazed rangelands, strip mines, and construction sites can release large amount of sediments into water bodies.

Environmental effects

- It decreases water transparency and hence reduces light penetration.
- Sediments can cover aquatic organisms and impede their growth and affect their survival.
- Sediments can carry insoluble toxins into river bodies.

Agricultural wastes

- Agricultural wastes including manure, animal and plant residues, pesticide and fertiliser residues can be washed into streams, rivers, lakes etc.

Environmental effects

- Eutrophication may occur.
- These residues may become toxic to aquatic organisms.
- They can enter food chains and cause biological magnification.

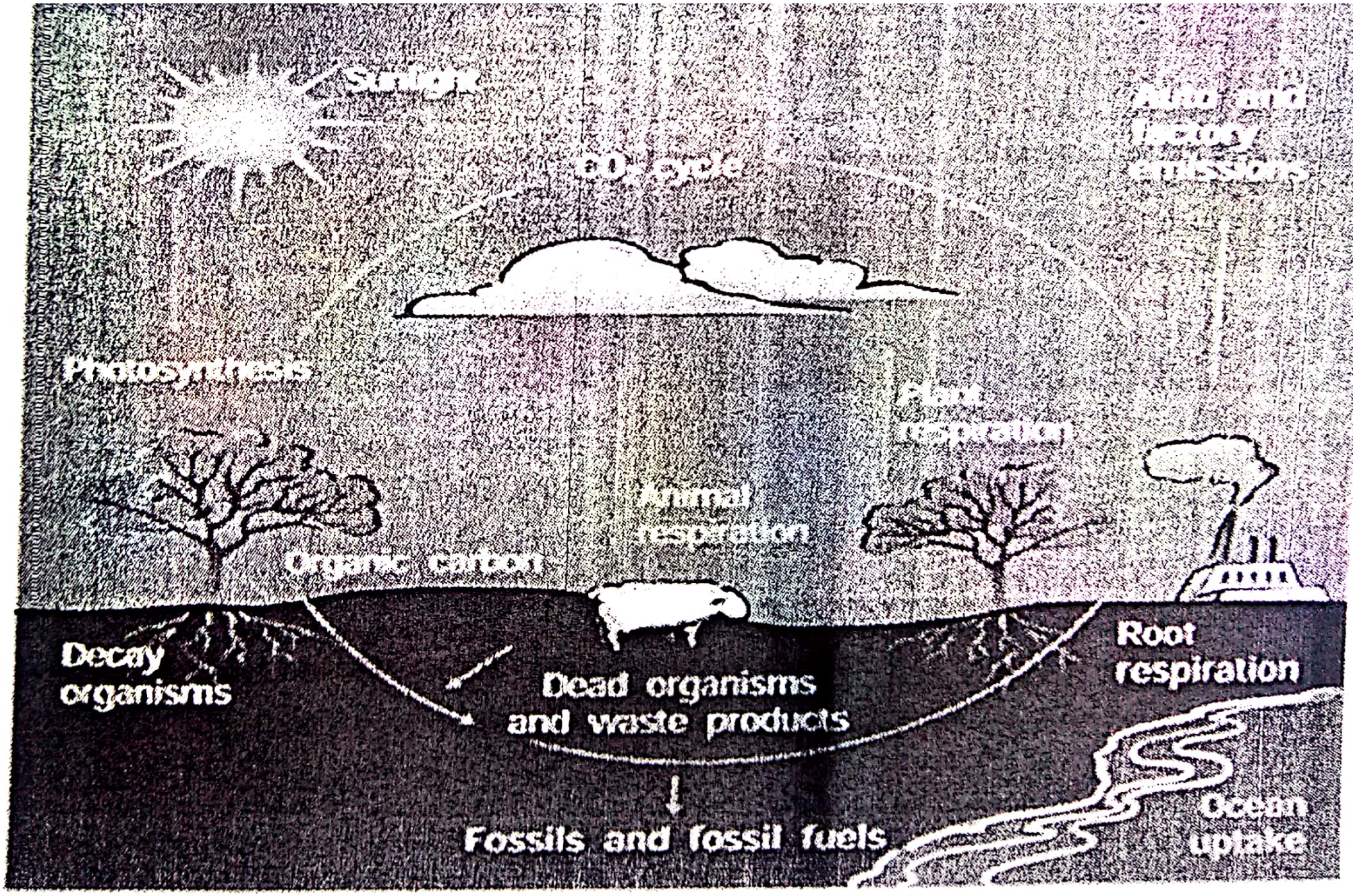
BIOGEOCHEMICAL CYCLES

- A biogeochemical cycle is a pathway by which a chemical substance moves through biotic and abiotic components of the earth.

- Every biogeochemical cycles is made up of an active or cycling pool and a reservoir pool.

Types of biogeochemical cycles

- The major types of elements involved in biogeochemical cycles include carbon, nitrogen, sulphur, phosphorus, water.



Nitrogen cycle