ECOLOGY

Definition;

- ✓ Is the scientific study of the complex relationships between organisms and their environment.
- ✓ These interactions determine the distribution and abundance of organisms within a particular environment.
- ✓ ***Environment*** is the immediate surroundings of an organism.

❖ Organisms live within a relatively narrow sphere (land, water and air) and the earth's surface and this is known as **Biosphere/ecosphere** .

❖ The biosphere is divided into two major regions namely;

i. Aquatic regions; made up of fresh water(lakes and ponds, rivers and streams, wetlands), marine water(oceans) , and estuaries.

ii. Terrestrial regions covering a few meters deep in the soil and a few kilometers into the atmosphere.

❖ On land, there are several biogeographical areas, each with specific conditions that support distinct species of plants and animals. Such areas include the present day continents.

❖ Some of these areas may possess similar physical conditions, therefore supporting similar plants and animals; these areas are collectively called **Biomes**.(*a large ecological area on earth's surface with distinctive plant and animal groups which are adapted to that particular environment*)

Biomes include ; ***tropical rain forests***, ***tundra regions*** (ground is frozen much of the year and vegetation is sparse), ***Hot and dry desert regions*** (evaporation is high and there is too much heat), ***cold deserts***(precipitation coming from colder water sources than rain, such as snow or ice), ***temperate region*** (winters and summers).

❖ Organisms have developed adaptations to live in each of the biomes e.g desert organisms offer the most extreme adaptations to live in both intensive hot and drought condtions i.e desert animals are able to feed less often, thus conserving energy both by slowly metabolizing food and by not frequently hunting or foraging; while marine organisms are adapted to osmo regulate in highly saline environment.

❖ Biomes are further divided into zones,each with its unique properties e.g

i. A forest biome is divided into **ground zone**(consisting of millipedes & earthworms) , and **canopy zone/aerial zone;** (consisting of birds & monkeys); with each of these zones supporting different animals that are adapted to the conditions within them.

ii. Aquatic biome divided into **surface** , **intertidal** ,& **benthic zones;** with the organisms in the intertidal zone withstanding wave action e.g snakes, snails, those in benthic zone not able to withstand wave action e.g sponges, while organisms requiring much air supply e.g photosynthetic algae inhabiting surface zone.

iii. Desert biome divide into **surface** and **subterranean zones**; with those in surface zone adapted to withstand extreme heat, while those in subterranean able to survive in low oxygen content.

NB The zones in a biome are subdivided into **habitats**(***specific locality where an organism normally lives within the environment)*** with set physical conditions that support specific organisms

Examples of habitats include; leaf litter for earthworms, intestines of man for tapeworms, ponds for frogs, beside the water storage tanks for toads, kitchen for cockroaches, etc.

ECOLOGICAL NICHE*:*

- ♣ Is the role and position any species has within its habitat, and its interactions with living and non-living environment.
- ♣ Describes how an organism meets its need for food and shelter, how it survives, and how it reproduces; therefore reduces intra specific competition for resources.

Example.

Consider a forest habitat, with leaves scattered on the ground; an old rotting log sitting on a forest floor; earthworms may be seen under the soil feeding on decaying organic matter; with centipedes eating small beetles and other organisms; colony of ants working and feeding on dead insects; millipedes strolling around feeding on decaying leaves; therefore all these organisms are filling an ecological niche looking at where they live, how they survive and how they reproduce.

Types of ecological niche.

- ➢ Realized niche;
  Occurs in the presence of predators, competitors, and parasites; limiting the habitat and roles performed by an organism, Its smaller in size.
- ➢ Fundamental niche;
  Occurs in the absence of predators, competitors, and parasites; allowing the organism experience a larger habitat and perform a variety of roles .

ECOSYSTEM

- ✓ it is natural unit of environment composed of living (biotic) and non-living (abiotic) components whose interactions lead to a self-sustaining system.

  (i) Water (aquatic) ecosystems may be fresh water bodies (e.g. lakes, ponds, rivers) or marine water bodies (e.g. sea, ocean).

  Organisms in water may be of large size (nektons) e.g. fish, whales, turtles or very tiny (planktons) e.g. phytoplanktons and zooplanktons.

  (ii) Land (terrestrial) ecosystems include forests, deserts, savanna, etc

THE MAJOR COMPONENTS OF AN ECOSYSTEM

a) Abiotic / non living things: these are physical and chemical factors that influence living organisms on land (terrestrial) ecosystems

and in water (aquatic).

Examples of abiotic components:

i. climatic factors, which include; Temperature, Light, Wind, Humidity, rainfall etc
ii. soil (edaphic) factors e.g. Soil pH, Soil air, Inorganic particles, Soil water , Organic matter (dead organic matter and living organisms), Soil temperature etc
iii. Topography
iv. Other physical factors e.g fire and wave action etc

Question. How do abiotic factors affect the distribution and abundance of organisms?

(i) ***Climatic factors***

Temperature

- Affects physiological processes (respiration, photosynthesis, and growth etc) in organisms which in turn influence their distribution.
- Ultimate heating and cooling of rocks cause air to break and crack into small pieces and finally form soil.
- These changes in turn may result into migration of organisms e.g birds to avoid over heating or freezing.
- Low temperatures inactivate enzymes while excessive temperatures denature enzymes.
- High temperature increase transpiration and sweating
- Low temperatures break dormancy of some plants.
- Temperatures stimulate flowering in some plants e.g cabbage (vernalisation)
- Exposure to low temperature(stratification) stimulate germination in some seeds after imbibitions.

Organisms have evolved to have structural, physiological and behavioral adaptations to maintain their temperature in an optimum range.

(i) ***adaptations of animals for life in hot and dry deserts***.

Structural adaptations,

- Large body extremities e.g ear lobes ; to increase surface area over which heat is lost.
- Small sized; to increase the surface area to volume ratio, for heat loss
- Some animals like the camel, have long skinny non fatty legs to increase heat loss during locomotion
- Little or no fur to reduce on insulation, and increase amount of heat lost
- Thin subcutaneous fat layer under the skin to increase heat loss from the body
- Have tissues tolerant to extreme temperature changes, maintaining the body's main functions

Physiological adaptations

- Enzymes work under a high optimum temperature range to maintain metabolism during day and night.

Behavioral adaptations

- Most are nocturnal, i.e most active at night, when temperatures are relatively low
- Aestivation(seasonal response by animals to drought or excessive heat during which they become dormant, and the metabolic rate followed by body temperature fall to the minimum required for maintaining the vital activities of the body) ; allows them to survive extremes of hot temperatures e E.g. African lungfish burrows into mud till the dry season ends, earthworms , garden snails , desert rats, termites also aestivate
- Movement with some body parts raised to minimize direct contact with hot grounds e.g desert snakes
- Salivation of the neck and legs ; increasing heat loss by evaporation e.g in tortoise

(ii).***adaptations of animals for life in cold environments***

Structural adaptations

- Thick layer of fat under the skin; to increase on insulation by avoiding heat loss
- Small body extremities to reduce the surface area over which heat is lost
- Large sized; thus small surface area to volume ratio; reducing amount of heat lost to the surrounding
- Thick fur; to increase on insulation
- Tissues tolerant to extreme changes in temperature; maintaining their normal functions in the body

Physiological adaptations

- Enzymes work under a high optimum temperature range to maintain metabolism during day and night

Behavioral adaptations

- Hibernation(is seasonal response by animals to cold temperature during which they become dormant, body temperature and metabolic rate fall to the minimum required for maintaining the vital activities of the body) The animals, said to be in 'deep sleep' ably reduce energy needs to survive the winter when food is scarce allowing them survive extreme cold conditions eg in polar bears.
- Gathering in groups to warm themselves e.g penguins

Rain fall;

- Amount of rainfall in a given area determines the abundance, distribution and types of plants in the area

Ecological significances of water

- ✓ Habitat for many aquatic organisms e.g frogs, fish etc
- ✓ Raw material for photosynthesis; main energy source for body processes of other organisms
- ✓ High thermal capacities ; acting as cooling agent for terrestrial organisms e.g plants during transpiration, some animals during sweating.
- ✓ Agent for fruit, seed, spore, larva and gamete dispersal
- ✓ Condition for germination
- ✓ Highly transparent; therefore allowing light to reach acquatic organisms, for photosynthesis; and aquatic predators to locate their prey
- ✓ Important factor in decay and decomposition ; therefore increases in recycling of nutrients in an ecosystem.

Humidity;

Amount of water in the atmosphere;

- affects the rate at which water evaporates from organisms i.e Low humidity results to increasing evaporation while high humidity causes low rate of evaporation; through stomata of leaves in plants.

Accordingly , organisms within areas of low humidity are adapted to avoid excessive loss of water by;

- ✓ Having reduced number of sweat glands e.g in kangaroo rat
- ✓ Presence of leaf spines in cactus plants; to reduce surface area over which water is lost through transpiration.

- o Controls other activities of animals like feeding, hunting, and movements e.g earth worms experience a larger ecological niche when the environment is humid.
- o Controls opening and closure of stomata; therefore affecting rate of photosynthesis and transpiration.

Wind / air currents;

It influences the following ,

- o dispersal or migration of flying mammals, winged insects; thus reducing the level of competition.
- o Pollination
- o Dispersal of seeds and spores; increasing the spread of non-motile organisms e.g fungi and some bacteria.
- o Takes part in rain formation
- o Current and wave formation in seas and lakes enables distribution of mineral salts.
- o Increase transpiration; thus promoting water and mineral salt uptake from the soil by plant roots
- o Increases evaporation and reduces sweating.
- o Causes physical damage to vegetation and soils e.g soil erosion.
- o Increases dissolution of oxygen in aquatic bodies; thereby increasing aerobic activities of organisms.

Light (intensity, quality, and duration)

Influences many physiological activities of organisms ie

- ✓ It is a source of energy for photolysis (breakdown of water during photosynthesis.).
- ✓ Absence of light causes etiolation (elongation of shoot inter nodes).
- ✓ Induces flowering in long-day plants e.g. barley, but inhibits flowering in short day plants.
- ✓ Phototropism, by redistributing auxins on the darker sides of shoots and roots, with cells on darker side elongating more than those on illuminated side.
- ✓ Germination ; some seeds are positively photoblastic; germination only in presence of light while other do not require light to germinate.(are negatively photoblastic)
- ✓ Stomatal opening and closure; with most plant species opening their stomata during day(when there is light) and closing during night (in absence of light/darkness).
- ✓ Predation ; (hunting and killing of prey by predators require certain levels of illumination and visiblility)
- ✓ Courtship; with some animals preferring light so as to carry out courtship while others prefer darkness
- ✓ Light breaks dormancy of seeds.
- ✓ Stimulates synthesis of vitamin D in mammals; where lipids(sterols) in the dermis are converted to vitamin D by uv light
- ✓ It enables the mechanisms photoreceptions in eyes
- ✓ Absence of light results in failure of chlorophyll formation in plants i.e. plant remains yellow, and leaves fail to expand.
- ✓ Photoperiod affects migratory and reproductive behaviour in various animals e.g. sunlight polarised by water acts as a compass for migration of salmon fish.
- ✓ Necessary for the germination of certain seeds e.g. lettuce

(ii) ***Topography***.;

- o Refers to the nature of the landscape, which includes features like mountains, valleys, lakes etc.
- o High altitude is associated with, low atmospheric pressure; low average temperatures,; increased wind speed; decreased partial pressures of oxygen, thus few organisms live permanently here.
- o Slope reduces water logging and there is a lot of soil erosion preventing proper plant establishment especially at steep slopes
- o At low altitudes, average temperatures are high, high atmospheric pressure, partial pressures of oxygen are high, and in some places there is water logging.

Assignment. Describe different adaptations of organisms that live in high altitude.

(iii). *Edaphic(soil) factors*,

- o Soil formed by chemical and physical weathering of rocks, possess both **living components**(living organisms like bacteria, fungi, algae and animals like protozoans, nematodes earthworms, insects, burrowing mammals) and **non living components (**particles of various sizes)
- o Also present are; mineral salts, water, organic matter, and grasses.

Soil Ph

- ❖ Influences physical properties of soil and availability of certain minerals to plants, thus affecting their distribution in soil; i.e tea and coffee plants thrive well in acidic soils
- ❖ Affects activity of decomposers e.g in acidic medium, the rate of decomposition is reduced, subsequently recycling of matter in an ecosystem reduced.

Water content;

- ❖ Varies markedly in any well defined soil,
- ❖ Any finely drained soil holding much water as possible is said to be at full capacity
- ❖ Addition of more water which cannot be drained away leads to water logging; and anaerobic conditions , affecting mineral ion uptake by active transport, subsequently affecting osmotic uptake of water , due to decreased osmotic potential gradient, causing plants to dry out.
- ❖ Plants like rice, marshes, and sedges have developed air spaces among root tissues , allowing some diffusion of oxygen from aerial parts to help supply the roots.

Biotic content;

- Microorganisms like bacteria and fungi carry out decomposition of dead organic material, therefore recycling nutrients back

to the soil.
- Burrowing organisms e..g earthworms improve drainage and aeration by forming air spaces in the soil.
- Earthworms also improve soil fertility by mixing of soil, as they bring leached minerals from lower layers within reach of plant roots.
- They also improve humus content , by pulling leaves into their burrows
- Also press soil through their bodies making its texture fine.

Air content;
- Spaces between soil particles is filled with air from which plant roots obtain oxygen by diffusion for aerobic respiration,
- Also essential for aerobic respiration by micro organisms in the soil that decompose the humus.

(iv) *Salinity*;
- ♣ Is the measure of salt concentration in aquatic bodies and soil water.
- ♣ Determines the osmotic pressure of water; therefore the organisms have developed structural, behavioral, and physiological adaptations to osmo regulate in the respective salt concentration, **(read adaptations of fresh water fish, marine water fish and migratory fish to their osmo regulatory problems**).
- ♣ Mineral salts in water affect the distribution of plant species, which in turn affects the animals that depend on plants for food.
- ♣ Plants growing in soils deficient of certain salts, e.g insectivorous plants in nitrogen deficient soils, obtain nitrogen feeding on insects.

Significances of mineral salts to plants
- ✓ Mineral salts together with other solutes determine the osmotic pressure of cells and body fluids
- ✓ Determinants in anion and cation balance in cells, e.g Na^+ and Cl^-, involved in transmission of nerve impulses
- ✓ Constituents of certain pigments like haemoglobin, and chlorophyll containing iron and magnesium respectively.
- ✓ Metabolic activators; some ions activate enzymes, e.g chloride ions activate salivary amylase, magnesium activate enzymes in phosphate metabolism, and phosphorus as phosphate is required in activation of sugars during Glycolysis in tissue respiration.
- ✓ Mineral salts like potassium are involved in formation of cell membrane and opening of stomata;
- ✓ Development of stem and root e.g. calcium pectate in formation of plant cell wall. Etc

(v) Fire;

Types of fire
- ➢ Natural fires; are set up by natural causes like lightening, volcanic eruptions etc
- ➢ Artificial fires; are set up by man either intensionally or carelessly
- ➢ Wild fires; burn in the direction of wind
- ➢ Early fires; set up at beginning of dry season
- ➢ Prescribed fires; under ecological management where prevention measures are taken when stting up the fire.

Properties of fire
- ➢ Fire intensity;

  Is the heat content of the fire,

  Depends on environmental factors such as wind, temperature as well as the amount and type of vegetation.
- ➢ Fire duration;

  Is the time taken by the fire to destroy a given area.
- ➢ Fire severity; is measured in terms of major vegetation destroyed by the fire.

Ecological effects of fire

Positive effects
- ✓ Removes old leaves and stimulates trees and grasses to produce new buds.
- ✓ Breaks dormancy (seed dormancy), incase seed coats are hard and impermeable.
- ✓ Causes release of mineral nutrients in form ash; on burning organic matter, releasing nitrate and phosphate compounds into soil, and subsequently improving on soil fertility.
- ✓ Improves on visibility of organisms such as predators, prey, mates allowing them easily carry out their activities.
- ✓ Improves on food productivity in terms of quality, quantity and productivity, because after burning new species with high protein content grows.
- ✓ Destroys pests
- ✓ Controls undesirable plant species and weeds

Negative effects
- ✓ Increase soil erosion; leading soil infertility
- ✓ Kills slow moving animals e.g snails, earthworms
- ✓ Destruction of habitat for most of the animal species may leading migration or extinction
- ✓ Increases fire resistant species.
- ✓ Reduction in population density and biodiversity.
- ✓ Destroys food for animals like herbivores which may lead to starvation and eventually death.
- ✓ Air pollution by products such as carbon monoxide and carbon dioxide, increasing on global warmimg.

Adaptations of plants to fire

Thick succulent shoot system to reduce the effects of heat.

Grasses grow in tussocks to protect the young growing buds.

Some tree stems are succulent i.e. store water in parenchyma cells to reduce on the effects of fire heat.

Many plants are annuals to avoid fire severity in form of seeds, which may be underground.

Some trees have heat resistant tissues.

(b). ***Biotic / living components:*** these are the plants, animals and decomposers.

THE MAJOR BIOTIC / LIVING COMPONENTS OF ECOSYSTEMS

1. Producer: ,

- are autotrophs capable of synthesizing complex organic food materials from simple inorganic food raw materials e.g carbon dioxide and water.
- Examples include; large green terrestrial plants e.g trees, shrubs, grass. For aquatic ecosystem, the producers are microscopic algae, blue green bacteria. Others are flagellates like euglena, volvox, chlamydomonas etc. They are collectively called **Phytoplanktons (**microscopic marine producers)

NB; Some producers use chemical energy derived from breakdown of chemical compounds like sulphur to convert carbon dioxide and water into high energy compounds like carbohydrates e.g sulphur bacteria i.e they are **chemosynthetic**.

2. Consumer:

- Are organisms that get energy and nutrients by feeding on other organisms or their remains .
- Are classified as;

(i) **Primary consumers(Herbivore):**

- ✓ A consumer that eats plants.
- ✓ E.g. insects, birds, most mammals(grazers),
- ✓ In aquatic ecosystem, they include; water fleas, fish, crabs, mollusks, and protozoans, collectively known as **zooplanktons**(microscopic marine consumers).

(ii) **Secondary consumers(Carnivore):**

- ✓ A consumer that eats other animals.
- ✓ E.g. birds of prey like eagle, kites, kingfishers; and lions, cheetahs, tigers, hyenas, snakes, big fish,

(iii) **Tertiary consumers**:

- ✓ These feed on both primary and secondary consumers
- ✓ Can be predators that hunt and kill others for food or scavengers(animals that feed on dead organisms but do not kill them.
- ✓ E.g. vultures, hyenas, marabou stocks etc

(iv) **Omnivore**: A consumer that eats both plants and animals .e.g. man, pigs,etc

3. Decomposer:

- ✓ An organism that feeds on dead organic matter.
- ✓ Classified into;

(i) **Detrivore/ macro decomposers**;

- ✓ An animal that eats detritus.(dead and waste matter not eaten by consumers)
- ✓ E.g earth worms, rag worms, mites, maggots, wood lice, termites etc.

(ii) **Saprophyte**:

- ✓ A microbe (bacterium or fungus) that lives on detritus.

Importance of decomposition:

(1) It enables dead bodies to be disposed off which, if left would accumulate everywhere.
(2) Recycles nutrients to be used by other organisms e.g. Mineral salts are released from dead bodies into soil for plant growth.
(3) Unlocks trapped energy in the body of dead organisms.

ENERGY FLOW THROUGH AN ECOSYSTEM

- The sun is the primary source of energy in the ecosystem.
- Light energy is trapped by photosynthetic organisms (green plants, algae, and some bacteria); converted into chemical energy by during photosynthesis.
- It is then transferred from one feeding level to another through feeding relationships like ***food chains*** or ***food webs.***
- Most of the energy from sun getting the earth's surface is reflected by vegetation, soil, and water or absorbed and radiated to atmosphere; leaving only between 5%-10% for the producers to make use of.
- Along the food chain, only a small proportion of the available energy is transferred from one feeding level to another; much energy is lost as heat during ***sweating and evaporation***, ***excretion*** , ***respiration***, **egestion,** and some remains locked up in indigestible parts of the plant like cellulose, or bones, hooves, hair, skin etc of animals.
- The number of organisms decrease at each successive feeding level because of the great energy losses, so the energy left in organisms is little to support large numbers of top consumers; limiting the length of food chain(not exceeding five trophic levels(feeding level in a food chain containing given amount of energy).

TROPHIC EFFICIENCY/ ECOLOGICAL EFFICIENCY

- Is the percentage of energy at one trophic level that is converted into organic substances at the next trophic level.

Productivity in ecosystem

- ✓ Is the amount of organic material manufactured by organisms.

Can be measured using several methods i.e

-Harvest crop
-Through oxygen production of the given area of the ecosystem.
-Amount of carbon dioxide consumed during photosynthesis.
.-Rate of consumption or use of raw materials

- ✓ Can be divided into;

(i) **Gross productivity**; is the total amount of energy and organic matter stored in an organism over a period of time.
(ii) Net productivity; is the amount of energy and organic matter stored in an organism and passed onto the next trophic level.
(iii) Primary productivity; Is the amount of energy and organic material stored in primary producers.

Measured in **mass per unit area per unit time** (kilogram per unit area per year, $Kg/M^2/yr.$)

The initial amount of energy incorporated into primary producers during photosynthesis is called **Gross primary productivity (G.P.P)** .

The amount of energy transferred from primary producers to primary consumers is called **Net Primary Productivity (N.P.P).** It can as well be called dry mass of the harvest crop**.**

Therefore, GPP- assimilation (respiration & metabolism) =NPP

(iv**). Secondary productivity**; Is the amount of energy incorporated into the body of consumers . Also known as **Gross secondary productivity.**

Net secondary productivity; is the amount of energy that can successfully be transferred from one consumer to another.

Carnivores have a higher secondary productivity than herbivores because ;

- ♣ Diet of carnivores is rich in proteins; easily digestible and therefore absorbed efficiently, allowing little energy to be lost. Herbivores their diet mainly consists of plant materials which are not easily digested.
- ♣ Carnivores do not have symbiotic microbes to consume part of the energy of their diet in their digestive tracts,
- ♣ Their faeces contain much less undigested matter.

Net secondary productivity is higher in exotherms than in endotherms, because;

- ♣ Energy from absorbed food, is used in replace the lost heat to their surrounding, inorder to maintain a constant body temperature, unlike exotherms that depend mostly on behavioral means to maintain their body temperature.

FOOD CHAIN AND FOOD WEB.

FOOD CHAIN

- ❖ A linear sequence of energy flow from producers through a series of organisms in which there is repeated eating and being eaten.

  Two types exist i.e

  (i) Grazing food chain (ii) Detritus food chain

(i). Grazer food chain,

- ♣ starts with autotrophs (producers)/ green plants which convert carbon dioxide & water into chemical compounds.
- ♣ These are grazed upon by herbivores.
- ♣ Energy is further transferred to carnivores. It can be in grass land or water body (aquatic). E.g.

  Grass→millipedes→toads→snakes→hawks

  Green algae→haplochromics→tilapia→kingfisher

(ii) Detritus food chain

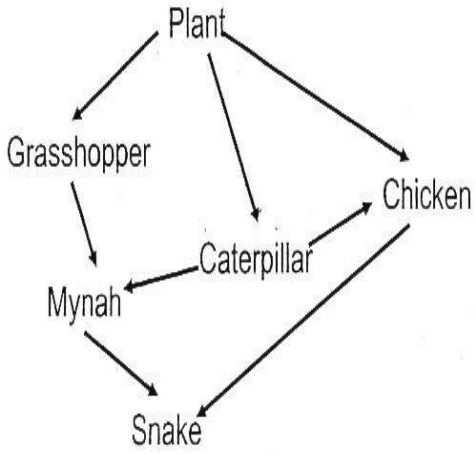
- ♣ is the one where the consumers obtain energy from fragments of dead decaying organic matter.
- ♣ exists in both aquatic and terrestrial habiats.
- ♣ 1st trophic level is occupied by a decomposing organic matter
- ♣ E.g Tree log → wood lice → toad → python

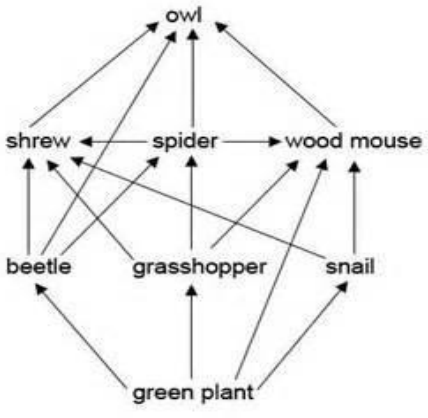
  Dead animal→ maggot→birds→ python

FOOD WEB

- ♣ is a complex nutritional interrelationship that illustrates alternative food sources and predator for each organism.
- ♣ In a food web, there are several food chains.

Examples of food webs in a grassland





EXERCISE

1. Construct a food web using the following organisms: phytoplanktons, mosquito larvae, small fish, large fish, and crocodiles.
2. (a) With reference to a **named** ecosystem, what is meant by the following terms;
   (i)energy flow (ii) trophic levels (iii) food web
   (b). Discuss the interactions between the living and non living components of such an ecosystem.
3. (a) What is an ecosystem?

NB. Techniques used in constructing food webs and food chains

- ❖ Direct observation of organisms as it feeds so as to establish the organisms prey.
- ❖ Examination of stomach content through dissecting the animals' stomach
- ❖ Faecal method; observation of faecal materials egested by an animal.
- ❖ Use of radioactive tracers to label the environment from which organisms obtain their food and then trace them in the organisms gut.

Assignment. **State the advantages and limitations of the above methods**

ECOLOGICAL PYRAMIDS

- ❖ These are histograms that provide information about feeding (trophic) levels in ecosystems.

Three types exist i.e

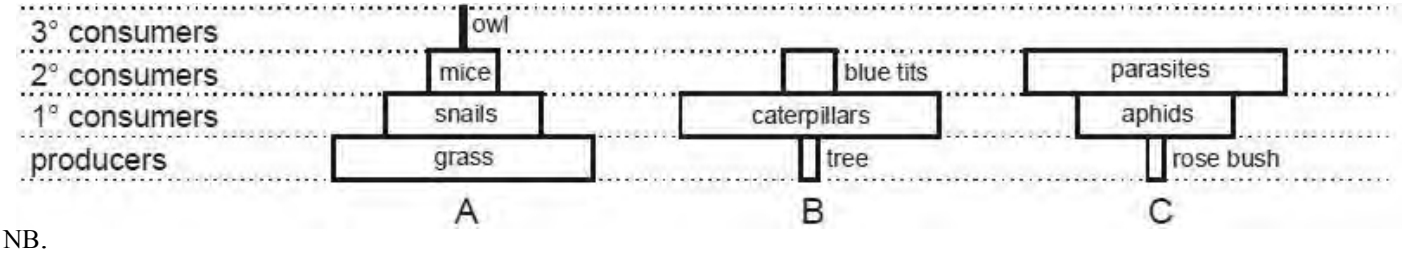
(i).pyramid of numbers

(ii) pyramid of biomass

(iii) pyramid of energy

NB. ***Length of a given bar is proportional to the number, energy or biomass at a given trophic level in a given area.***

(i) **pyramid of numbers.** It is a histogram representing the numbers of different organisms at each trophic level in an ecosystem at any one time.



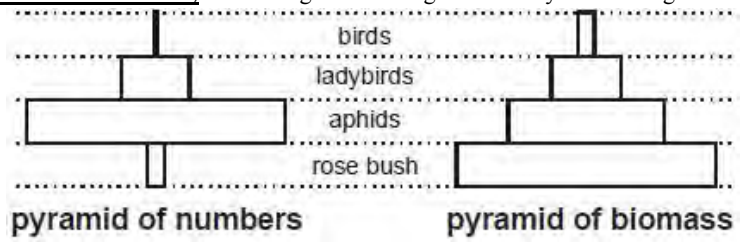
NB.

- o As a pyramid is ascended, the number of organisms decreases but the size of each individual increases.
- o In some cases, the consumers may be more than the producers e.g in a parasitic food chain, inverted pyramids **B** & **C** are obtained, because parasites progressively become smaller and many along a food chain.

Limitations of pyramid of number

- o Drawing the pyramid accurately to scale may be difficult e.g where there a million plants.
- o Pyramids may be inverted
- o The trophic level of an organism may be difficult to ascertain.
- o The young forms of species may have a different diet from adults.

(ii) **pyramid of biomass;** is a histogram showing the total dry mass of organisms present at each feeding level



Advantages

- ✓ Reduces the possibility of forming inverted pyramids because its construction depends n biomass of organisms

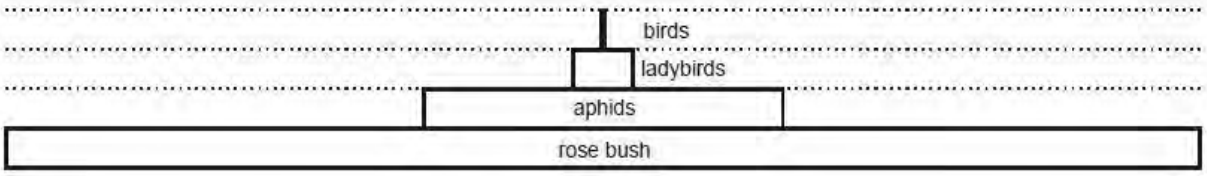
NB. Inverted pyramid of biomass is typical of an aquatic ecosystem,because diatoms(phytoplankton) have a lower biomass but with higher productive rate(caused by so rapid turnover rate), therefore capable of supporting a larger biomass of zooplanktons.

Disadvantages/limitations of pyramid of biomass

- ✓ Does not allow for changes in biomass at different times of the year e,g deciduous trees have larger biomass in summer than in winter when they shed off leaves.
- ✓ Does not take into account rate at which biomass accumulates e.g a mature tree has a large biomass which increases over many years.
- ✓ Impossible to measure exactly biomass of the organisms in an ecosystem, because the sample used may not true representation of the whole population.
- ✓ Results may not be accurate, e.g where killing is not allowed, the results are obtained by estimating the fresh mass.

(iii) **pyramid of energy flow** it is a histogram showing the total amount of energy present at each feeding level.

- ✓ Because only a proportion of energy is in a trophic level is transferred to the next, energy pyramids are never inverted nor do they have a central bulge.
- ✓ More informative than than pyramids of numbers and biomass because it shows the amount of energy required to support each trophic level.
- ✓ Energy values may be expressed variously as kJ/ m^2 / yr^1 or kCal /m^2/ yr^1.
- ✓ explains why the earth can support more people if they eat at lower trophic level (by consuming grains, vegetables and fruits directly rather than passing such crops through another trophic level and eating grain eaters.



Advantages

- ✓ It compares productivity because a time factor is incorporated.
- ✓ Biomass may not be equivalent to energy value, e.g. 1g of fat has many more kJ than 1g of cellulose or lignin.
- ✓ No inverted pyramids are obtained because of the automatic degradation of energy quality.
- ✓ The solar input of energy may be included as an extra rectangle at the base.

Disadvantage:

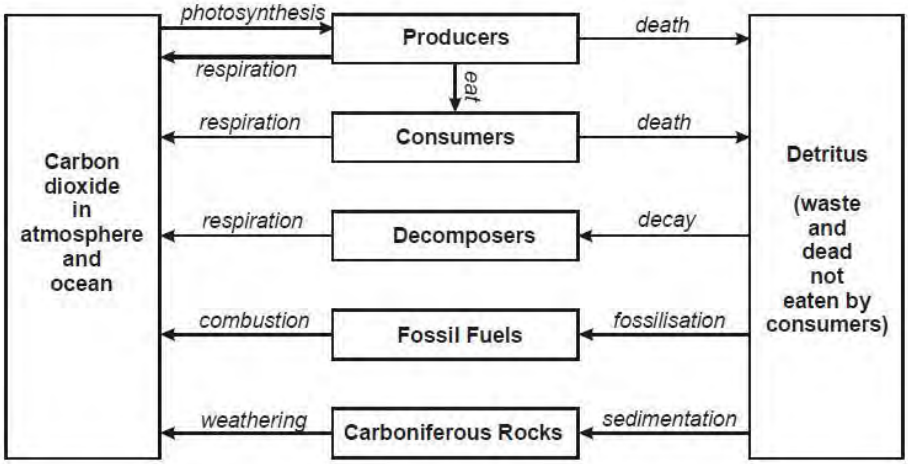
- ✓ Obtaining the necessary data required in constructing pyramids of energy flow is difficult.

MATERIAL CYCLING/BIOGEOCHEMICAL CYCLING (NUTRIENT CYCLING)

- ✓ process by which chemical compounds of a particular element that constitutes living matter are transferred between living organisms (biotic phase) and non-living environment (abiotic phase).
- ✓ Are driven directly or indirectly by incoming solar energy and gravity

(a). **CARBON CYCLE**

- ❖ Based on carbon dioxide gas, making up 0.036% of the volume of the troposphere and is also dissolved in water.
- ❖ Carbon fixation involves the reduction of carbon dioxide to large organic molecules during photosynthesis and chemosynthesis.
- ❖ During aerobic respiration by all organisms, carbon dioxide is returned to the atmosphere or dissolves in water.
- ❖ Over millions of years, buried deposits of dead plant debris and bacteria are compressed between layers of sediment to form the carbon-containing fossil fuels e.g. coal, oil and natural gas, which when burnt release carbon dioxide into air.
- ❖ In aquatic ecosystems, carbon dioxide may (i) remain dissolved (ii) be utilised in photosynthesis (iii) react with water to form carbonate ions and bicarbonate ions . As water warms, more dissolved carbon dioxide returns to the atmosphere.
- ❖ In marine ecosystems, some organisms take up dissolved carbon dioxide molecules, carbonate ions and bicarbonate ions and these ions react with calcium ions to form calcium carbonate (CaCO3) to build their shells and skeletons.
- ❖ When the animals with calcium in shells and skeletons die and drift into deep bottom sediments of oceans, immense pressure causes limestone and chalk to form after a very long period of time.
- ❖ Weathering processes release a small percentage of carbon dioxide from limestone into the atmosphere.



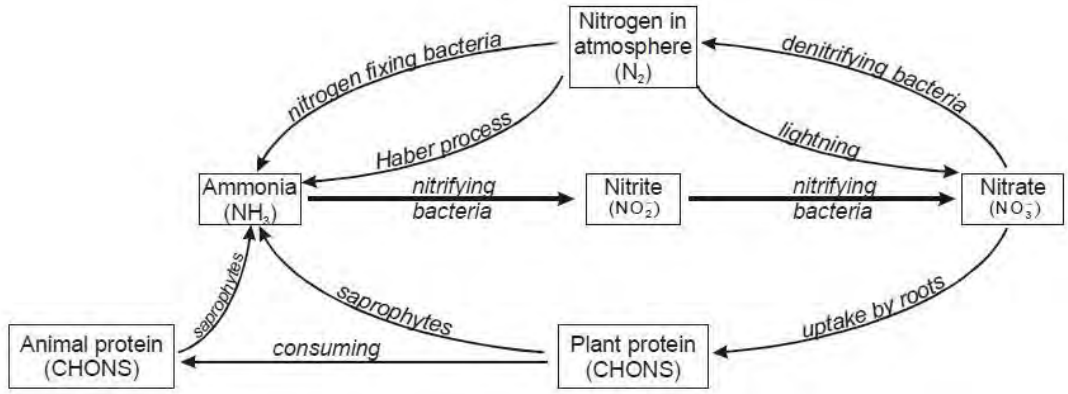
How human activities affect the carbon cycle

i) Cutting trees and other plants that absorb CO_2 through photosynthesis increases carbon dioxide in the atmosphere.
ii) Burning of fossil fuels like coal, petroleum oil etc and wood adds large amounts of CO_2 into the troposphere.

(b) **NITROGEN CYCLE**

- ❖ Nitrogen is the atmosphere's most abundant element, with chemically unreactive nitrogen gas making up 78% of the volume of the troposphere. However, N2 cannot be absorbed and metabolized directly by multicellular plants and animals.
- ❖ Atmospheric electrical discharges in the form of **lightning** causes nitrogen and oxygen in the atmosphere to react and produce oxides of nitrogen, which dissolve in rainwater and fall to the ground as weakly acidic solutions .
- ❖ **Nitrogen fixation** occurs when the nitrogen in soil is reduced to ammonium ions, catalysed by(i) nitrogen-fixing bacteria which may be free-living e.g. **Azotobacter** and **Clostridium**; **symbiotic bacteria in root nodules** e.g. **Rhizobium or blue- green algae** e.g. Nostoc.
- ❖ **Nitrification** occurs when ammonium compounds in soil are converted first to nitrite ions(highly toxic to plants) by ***Nitrosomonas* bacteria** and later to nitrate ions by ***Nitrobacter* bacteria**.
- ❖ **Ammonification** (putrefaction) occurs when decomposers e.g. saprophytic bacteria and fungi convert nitrogen-rich organic compounds, wastes like urea and dead bodies of organisms into ammonia and ammonium ion-containing salts.
- ❖ **Assimilation** occurs when inorganic ammonia, ammonium and nitrate ions are absorbed by plant roots to make nucleic acids, amino acids and protein.
- ❖ **Denitrification** occurs when mostly anaerobic bacteria e.g. ***Pseudomonas denitrificans*** and ***Thiobacillus denitrificans*** in water logged soil and deep in ocean, lake and swamp bottoms convert ammonia and ammonium ions back into nitrite and nitrate ions, and

then into nitrogen gas and oxygen. Nitrogen gas is released into the atmosphere while oxygen is used for the respiration of these bacteria.



How human activities affect the nitrogen cycle

1. Burning of fuels forms nitric oxide, which reacts with atmospheric oxygen to form nitrogen dioxide gas that reacts with water vapour to form acid rain containing nitric acid. Nitric acid together with other air pollutants (i) damages trees (ii) corrodes metals (iii) upsets aquatic ecosystems.
2. The inorganic fertilizers applied to soil are acted upon by anaerobic bacteria to release nitrous oxide into the stratosphere, where it (i) contributes to ozone depletion (ii) contributes to green house effect.
3. Nitrogen is removed from top soil when we (i) harvest nitrogen-rich crops (ii) irrigate crops (iii) burn or clear grasslands and forests before planting crops
4. Adding nitrogen compounds to aquatic ecosystems e.g. sewage algal blooming, which upon death, their decomposition causes oxygen shortage resulting into death of aerobic organisms e.g. some fish.
5. The accelerated deposition of acidic nitrogen containing compounds e.g. NO2 and HNO3 onto terrestrial ecosystems stimulates growth of weeds, which outcompsete other plants that cannot take up nitrogen as efficiently.

Qn**. (a) Describe the flow of energy and the cycling of carbon and nitrogen in any named ecosystem.**

(b). Suggest reasons why felling and removal of forest trees result in changes in the levels of nutrients in the soil.

(c**) WATER CYCLE/ HYDROLOGICAL CYCLE**

- is powered by energy from the sun and by gravity, and it involves;
- evaporation(conversion of water into water vapour)
- Transpiration (evaporation from leaves of the water extracted from soil by roots and transported throughout the plant)
- Condensation (conversion of water vapour into droplets of liquid water)
- Precipitation (rain, hail, snow and sleet/freezing rain)
- Infiltration (movement of water into soil)
- Percolation (downward flow of water through soil and permeable rocks to ground storage areas called aquifers)
- Runoff (down slope surface movement back to the sea to resume the cycle)

Further reading Advanced Biology by simpkins & Williams page 674-675

HOW BIOTIC FACTORS AFFECT THE DISTRIBUTION AND ABUNDANCY OF ORGANISMS

NB. Biotic factors are those that arise in organisms interacting with each other.

Examples include (i) diseases (ii) competition ,(iii) parasitism, (iv) pollution,(v) pollination &dispersal,(vi) anti biosis(vii) mimicry.

(a**) Human influence**.

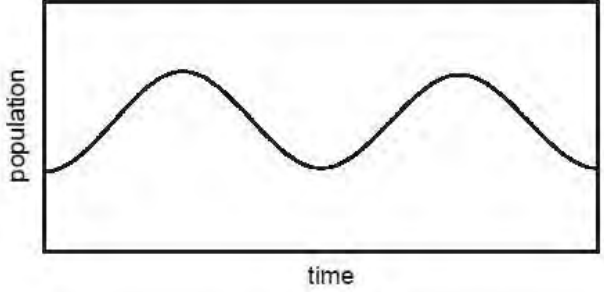
- Of all living organisms, humans exert most influence on the distribution and survival of other species through a multitude of activities like pollution, deforestation, farming, construction etc
- Man is also a predator hunting down many animals to a point of extinction.

(b**) Competition**

- This is a relationship whereby two individuals of the same species or different species struggle to obtain resources which are in limited supply.
- E.g plants competing for light, carbin dioxide, water, minerals, pollinators , and sites for spores and seeds to germinate while animals compete for food, mates, breeding sites and shelter from predators.

(i) intraspecific competition

- ✓ is the competition between members of the same species for the same resources.
- ✓ Intraspecific competition tends to have a stabilising influence on population size.
- ✓ If the population gets too big, intraspecific population increases, so the population falls again.
- ✓ If the population gets too small, intraspecific population decreases, so the population increases again.



Explanation:

(ii) **Interspecific competition**

- ✓ is the competition between members of two or more different species for food, space, good hiding place, water, sunlight, nesting sites or any other limited resource.

Competition is very intense when there is significant overlap of niches, and in this case one of the competing species must;

(i) migrate to another area if possible
(ii) shift its feeding habits or behaviour through natural selection and evolution
(iii) suffer a sharp population decline or
(iv) become extinct in that area, otherwise two species can never occupy exactly the same ecological niche.

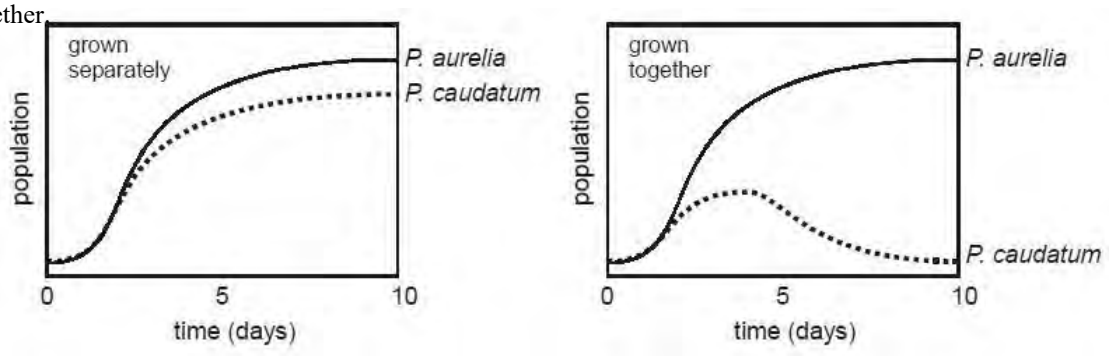
According to **Gause's (Russian biologist) competive exclusion principle** " no two species can occupy the same ecological niche"

e.g (i). Two species of flour beetles, *Tribolium castenum* and *T. confusum* were kept in the laboratory in bottles of flour acting as a habitat and providing food for them, under variable temperature conditions(24-34) and humid condtions(very humid , 70%RH& 30% RH).

Observation. At high temperatures and in veryhumid conditions, *Tribolium castenum* succeded better , while at low temperatures and very dry conditions *T. confusum* did better.

Whatever the conditions, only one of the species eventually survived.

(ii). Two species of *Paramecium Aurelia* and *P.caudatum* were grown separately in the same culture, then later cultured together.



Observation (i)When cultured separately, each specie has maximum population, only coming almost constant with time due to;

-Presence of toxic wastes which can poison paramecium.
-Heat generated during respiration may kill some paramecium.
-Decrease in food measures.

(ii)When the two species of paramecium are cultured together, *paramecium aurelia* gets competitive advantage over *P. caudatum* and after several days , *P. caudatum* gradually decreases and later decreases rapidly until its excluded hence competitive exclusion principle. *P.caudatum* therefore,goes to extinction.

Competitive advantages of *P.aurelia* are;

- High rate of reproduction.
- High growth rate.
- Good nutrient absorptive capacity/greater efficiency in obtaining food.
- Being small, it requires less food hence can easily survive when food is scarce.
- Survivorship, long life span.

HOW SPECIES REDUCE OR AVOID COMPETITION THROUGH RESOURCE PARTITIONING

Resource partitioning is the dividing up of scarce resources so that species with similar needs use them (i) at different times (ii) in different ways or (iii) in different places.

- ➢ Some species that are in competition for the same resources have evolved adaptations that reduce or avoid competition or an overlap of their fundamental niches.
- ➢ Resource partitioning decreases competition between two species leading to increased niche specialisation

Examples of resource partitioning:

(i).When living in the same area, lions prey mostly on larger animals while leopards on smaller ones.

(ii)Hawks and owls feed on similar prey, but hawks hunt during the day and owls hunt at night.

(iii)Each of the five species of common warblers (insect-eating birds) minimises competition with the others by (i) spending atleast half its feeding time in a different part of spruce tree branches e.g. some hunt at the extreme top, others at the lower portion, some mid way etc (ii) Consuming somewhat different insect species.

(iv)Different species of eagles in a forest feed at different times of the day e.g. bald headed eagles are most active early mornings and evenings while the white-breasted eagles feed vigorously towards noon.

(v)When three species of ground finches of Galapagos Islands occur on separate islands, their bills tend to be the same intermediate size, enabling each to feed on a wider range of seeds, but where they co-occur, there is divergence in beak size to suit each finch species to feeding on seeds of either small, medium or large size, but not all sizes.

(vi).In an abandoned field, drought tolerant grasses with shallow, fibrous root system grow near the soil surface to absorb moisture; plants with a taproot system grow in deeper soil while those with a taproot system that even branches to the topsoil and below the roots of other species grow where soil is continuously moist.

NB:

i) The more that two species in the same habitat differ in their use of resources, the more likely they can coexist.

ii) Two competing species also may coexist by sharing the same resource in different ways or at different times.

iii) The tendency for characteristics to be more divergent when populations belong to the same community than when they are isolated is termed **character displacement** e.g Galapagos finches.

Question.

1.(a). Explain the role of competition in regulating the size of population.

(b). Duck weed grows on or near the surface of ponds. Its growth can be measured by counting the number of fronds. Two species of duckweed , *Lemna trisulca* and *Lemna minor* were grown separately, and together , in identical beakers in the laboratory

	Total number of fronds.			
	Species grown separately		**Species grown together**	
Days	***L. trisulca***	***L. minor***	***L. trisulca***	***L. minor***
0	30	30	30	30
16	63	78	48	105
36	126	142	84	234
46	177	225	84	324
54	165	276	48	360
60	129	219	45	354

(i).Draw graphs to compare the rates of growth of the two species when grown separately and when grown together.

(ii) What do the graphs suggest about the growth rate of the two species grown separately?

(iii)Account for this difference.

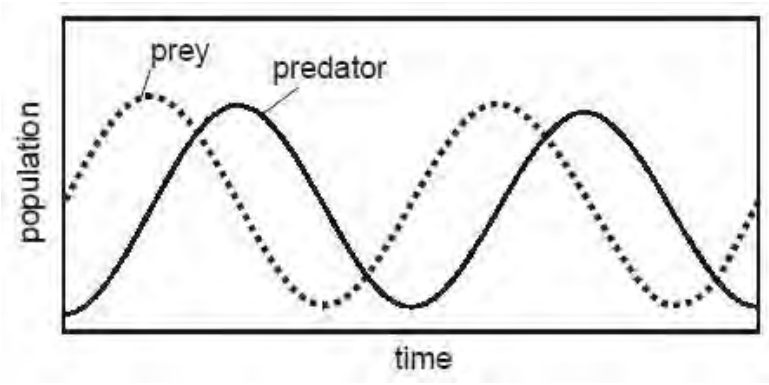
(iv)Offer an explanation for the interaction of the two species when grown together.

(v).Account for the changes in the growth rate between 46 and 60 days for *Lemna trisulca.*

(c.) **Predation.** This is a relationship whereby members of one species (the predator) feed on all or part of a living organism of another species (the prey). Therefore, predators are only found where there is prey e.g. herbivores are found where there is suitable plant material.

A predator is an animal that feeds on another live organism. A prey is the live organism that is fed on by the predator.

PREDATOR-PREY INTERACTIONS IN ECOSYSTEMS



Description of the changes in population numbers:

Initially, the population of the prey is higher that the population of the predator.

Within a short time, both populations of prey and predator increase rapidly.

The population of the prey reaches a maximum earlier the predator.

As the prey population decreases rapidly, the predator population continues to increase gradually for a short than time to a maximum then also decreases rapidly.

As the predator population continues to decrease, the prey population starts to increase rapidly, followed by a rapid increase in predator population. The cycle is repeated.

Explanation for the observed changes in populations:

At the beginning ,there are more prey than predator to provide food to the predators.

When the predator population is low, they get enough food and few preys are eaten so they both increase rapidly.

The large number of preys provides food to predators, so they reproduce fast and increase in numbers.

The increased predator population eats many preys and the prey population crashes.

The decrease in prey numbers causes the predators to starve and even their reproduction reduces, so the predator numbers crash.

Finally, the very low number of predators allows the prey population to recover, causing the cycle to start again.

Evolutionary significance of predator –prey

- Predation usually eliminates the unfit (aged, sick, weak). This gives the remaining prey access to the available food supply and also improves their genetic stock hence, enhances the chances of reproductive success and long time survival, thus pass on their good traits to their off springs which can improve their evolution.

How are the predation suited for capturing prey?

- Have keen eyes for locating prey eg wolves, African lions hunt in groups.
- Preying mantis, chameleon have cryptic coloration/camouflage that enable them to walk to prey unnoticed..
- Nocturnal predators eg bats have highly developed sense for detecting sound made by prey.
- Some snakes which have glands to secrete poison (venom) which the fangs inject into prey to immobilize it (prey).
- Web-spinning spiders use their silky cob webs to catch small sized ground walking or flying insects.
- Ant-lions lay traps by making pits in the ground where preys fall
- Some have soft pads at the bottom of their feet so that they are not easily detected as they walk towards prey
- Some of stinging cells which paralyse their prey e.g sea anemones
- Have long and sharp canines which pierce and kill prey
- Well developed limbs which increase the speed of locomotion to chase and capture prey.

How are prey species suited to avoid predation?

- Ability to run, swim or fly faster.
- Possession of highly developed sense of sight or smell alerting the presence of predators.

- Possession of protective shells eg in tortoise and snails for rolling into armour-plated ball
- Possession of spines to prick the predators.
- In some lizards, the tail breaks off when attacked giving the animal (lizard) time to escape.
- Possession of spines (porcupines) or thorns (cacti and rose-bushes) for pricking predators.
- In some lizards tails break off when attacked, giving the animal enough time to escape.
- Some prey **camouflage** by changing colour e.g. chameleon and cuttlefish, or having deceptive colours that blend with the background e.g. arctic hare in its winter fur blends into snow.

  NB. Camouflage is the ***use of any combination of materials, coloration, or illumination for concealment, either by making animals difficult to see, or by disguising them as something else***.

  Exists in various forms;

  (i) **warning colouration** , conspicuous colouring that warns a predator that an animal is unplalable or poisonous e.g poisonous frogs, some snakes, monarch butterflies, and some grasshoppers(ii) **disruptive colouration/patterning** , works by breaking up the outlines of an animal with a strongly contrasting pattern, thus decreasing detectabilitye.g. group of zebras **(iii) cryptic colouration** allows an organism to match its background and hence become less vulnerable to predation e.g chameleon.
- Some prey species discourage predators with chemicals that are poisonous (e.g. oleander plants), irritating (e.g. bombardier beetles), foul smelling (e.g. stinkbugs and skunk cabbages) or bad tasting (e.g. monarch butterflies and buttercups)
- Some prey species have evolved warning colouration – contrasting pattern of advertising colours that enable predators to recognise and avoid such prey e.g. the poisonous frogs, some snakes, monarch butterflies and some grasshoppers.
- Some species gain protection to avoid predation by mimicking (looking and acting like) other species that are distasteful to the predator e.g. the non-poisonous viceroy butterfly mimics the poisonous monarch butterfly. **Batesian mimicry** occurs when the palatable species mimics other distasteful species e.g . viceroy butterfly mimics the poisonous monarch butterfly, the harmless hoverfly mimics the painful stinging wasp while **Mullerian mimicry** occurs when both the mimic and mimicked are unpalatable or dangerous e.g. the five spot Burnet and related moths.
- Other preys gain some protection by living in large groups e.g. schools of fish, herd of antelope, flocks of birds.
- Some prey scare predators by puffing up e.g. blowfish, or spreading wings e.g. peacock.
- The flesh of some slow-moving fish is poisonous e.g. porcupine fish.
- Some preys secrete poisonous or repellant substances e.g. scorpions, caterpillars, some grasshoppers, culex mosquito eggs
- The electric fish Malapterurus (a cat fish) produces high voltage discharge of up to 350v that shocks any predator that makes contact with it.
- Other preys employ alarm signals and calls e.g. ants, various fish, small birds and mammals.
- Group defense, occurring among those that live and feed in herds

NB Predation

-Determines distribution and abundance of the prey because (i) an increase in the number of predators results into decrease in the number of prey.(ii) predators will always be found in places of their potential prey.

-leads to dispersal of animals which reduces competition, since it involves movement of animals from place to place.

-is a biological control method.

(d) **<u>Pollination and dispersal</u>**

- Pollination is an ecological interaction because plants and animals interact with each other. Insects transfer pollen grains from anthers to stigma.
- Dispersal of seeds and fruits introduces new plants to new habitats and this minimizes competition among species.
- Both interactions between the flowering plants and animals like insects , birds & bats may be highly elaborate and species specific.
- This co- evolution ensures that the distribution of the plants with their pollinations or agents of dispersal are related.e.g arum lily flowers are pollinated by dung flies.

  NB. ***Co evolution is a long term evolutionary adjustment of two or more groups of organisms that facilitate those organisms living with one another.***

  Examples include; (i) Many features of flowering plants have evolved as a result of dispersal of plant's gametes by insects and insects have in turn evolved special traits for obtaining nectar (ii) Grasses have evolved the ability to deposit silica in their leaves and stems to reduce their risks of being grazed, large herbivores have in turn evolved complex molars with enamel ridges for grinding up grass.

(e) **<u>Antibiosis;</u>** is the secretion by organisms chemical substances into their surrounding that may be repellant to members of the same species or different species e.g. penicillium (a fungus) secretes antibiotics that inhibit bacterial growth, ants release pheromones to warn off other members of a species in case of danger.

Two types exist i.e(i) **intraspecific antibiosis** secretion by organisms chemical substances into their surrounding that may be repellant to members of the same species e,g male rabbits secrete pheromones from their submandibular salivary glands that are used to mark territory as a warning to other bucks that the territory is occupied.(ii)**interspecific antibiosis** secretion by organisms chemical substances into their surrounding that may be repellant to members of the different species e.g penicillium (a fungus) secretes antibiotics that kill or prevent the bacterial growth.

(f) **<u>Parasitism</u>**

An organism called **<u>parasite</u>** obtains part or all its nutrients from the body of another organism of different species called **<u>host.</u>**

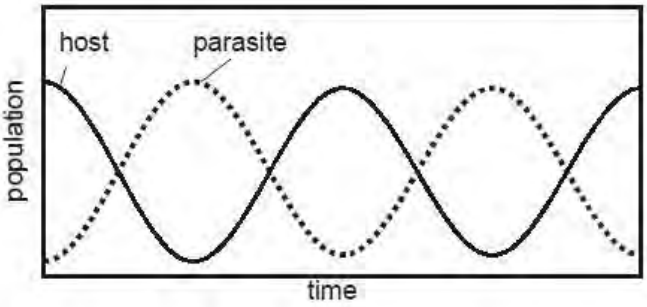
The parasite is usually smaller than its host in size.

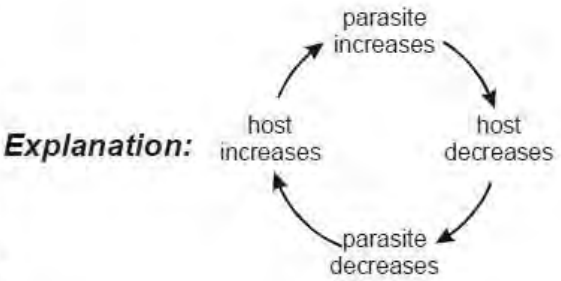
Parasites do not usually kill their hosts, but the host suffers harm.

Many parasites live permanently on (ectoparasites) or in their hosts(endo parasite) while some visit their hosts only to feed.

Some parasites are **facultative**, live on or in the host for some time e.g.Pythium(a fungus) that causes damping off seedlings, on

killing the seedlings, lives as a saprophyte on their dead remains and others are **obligat**e (live on or in the host for their entire lives.)





(g**) Mutualism.** Is an interspecific association in which both organisms benefit.
Examples include.(i) cellulose digesting bacteria in gut of ruminants such as goats, cattle& sheep.Ruminants obtain sugars, aminoacids while bacteria obtains shelter and food.(ii)leguminous plants e.g clover and nitrogen fixing bacteria(rhizobium). The plants obtain nitrates while bacteria obtains shelter, sugars, vitamins.(iii) mycorrhizae(fungus and root of higher plants) .In **ectotrophic mycorrhiza** , the fungus forms a sheath covering lateral roots of forest trees such as oaks, beech , conifers, while depending on photosynthesis by the tree to provide organic materials. **Endotrophic mycorrhiza** involves most of fungi inside the root of orchids with the fungi digesting lignin and cellulose in the soil; and passing the end products into the roots of plants.(iv)lichens; algae and fungus. Algae carries out photosynthesis, providing nutrients to the fungus while the fungi it is protected by the fungi from intense sunlight and dessication, minerals absorbed by the fungus are passed onto it.(v)hermit crab and sea anemones , with the hermit crab(*Eupagurus berhardu)s* obtaining defence from the stinging cells of anemones(*Adamsia)* & camouflaging from its predators. Sea anemones feed on food remains of the crab & obtains free transport from one area to another.
(h) **Commensalism** Is an association between organisms of different species in which one benefits while the other neither benefits nor its harmed.e.g (i)cow and white egrets, epiphytes and host plant.
Question**. Explain what is meant by the terms parasitism, mutualism and predation, indicating with the help of suitable examples how they differ from one another.**

ECOLOGICAL SUCCESSION

- This is a long- term directional change in the composition of a community from its origin to its climax through a number of stages brought about by the actions of the organisms themselves.
- It is a process by which plants and animal communities in a given area change gradually over time, becoming replaced by different and usually more complex communities.
- Pioneers are first sets of organisms to occupy the area, collectively such organisms constitute the **pioneer community**.
- The process of succession continues through stages known as **seral** stages and there are a number of **sere** (complete succession) according to the environment being colonized.
  (i) **hydrosere**; succession in aquatic environment (ii)**halosere**;succession in salty environment(iii)**xerosere**; succession dry envirionments e.g deserts(iv**) lithosere**; succession on a rocky surface
- The first seral stage has pioneers and the final stage has a climax community, a final stable community at the end of succession, which a particular environment can sustain.
- Climax community is characterized by by (i) diverse species (ii) complex feeding relationships and (iii) progressive increases in biomass.

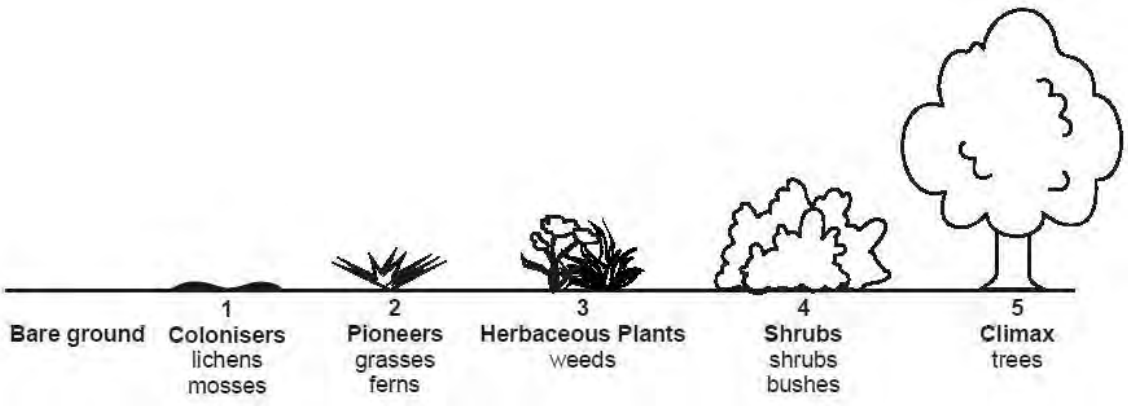
Types of succession

a) Primary succession
b) Secondary succession

a) Primary succession

This is the gradual change in species composition of an area that has never had any vegetation growing on it.
It occurs on Bare rocks exposed by erosion, Newly cooled lava, Newly created shallow ponds ,Sand dunes , Abandoned highway or parking yard.

An example of primary succession on land



Description of Primary succession on land

- Lichens and mosses attach to bare rocks and start forming soil by trapping wind- blown soil particles, producing tiny bits of organic matter and secreting mild acids that slowly breakdown the rock. Alternate heating and cooling also causes break down of rocks.
- As patches of soil build up and spread, eventually the pioneer species are replaced by the early successional plants like small grasses and ferns, whose seeds and spores respectively germinate after arriving by wind or in droppings of birds.
- Some of their roots penetrate and break rocks into soil particles, and death and decay of small grasses and ferns increases nutrients in soil.
- After a long period of time, the soil becomes deep, moist and fertile enough to support the growth of mid successional plant species like herbs, large grasses, low shrubs and small trees that need a lot of sunlight.
- Late successional plant species (mostly trees that tolerate shade) later replace the mid successional plant species.
- Unless natural or human processes disturb the area, a complex forest community remains

(b) **Secondary succession**.

This is the gradual change in species composition of an area where the natural community of organisms has been disturbed, removed or destroyed but some soil or bottom sediment remains.
It occurs on abandoned farmlands, burnt or cut forests, heavily polluted streams, flooded land.
Due to some soil or sediment present, vegetation usually begins to germinate within a few weeks.
Seeds and spores can be present in the soil and can be carried from nearby plants by wind, birds and insects.
The ground may even contain resistant plants/vegetative organs of the colonizing plants that survived the changes.

Characteristics of the stages of primary succession*;*

a) Early succession

- Species grow very close to the ground and have low biomass.
- Species have short life span.
- Species are simple and small sized.
- Species diversity (number of species present in a habitat) is very low.
- Community is open ie allows space for other colonizers.
- Species may show symbiotic relationships to aid their establishment.
- Species are poor competitors and hence get replaced by higher, more demanding plants like grasses ,shrubs and trees.
- The community is mostly is mostly composed of producers and a few decomposers.
- Net productivity is high.
- Feeding relationships are simple, mostly herbivores feeding on plant with few decomposers.

b) Late succession

- Plants are of large size and complex.
- Species diversity is high
- Community is a mixture of producers, consumers and decomposers.
- Biomass is high
- Net productivity is low
- Community takes a longtime to establish.
- climax community is often determined by one dominant species.
- There is increased soil depth and nutrients.
- Interspecific competition is very high.
- There is little space for new species
- The climax community is stable and is in equilibrium with its environment.
- Feeding relationships are complex, dominated by decomposers.

POPULATION DYNAMICS

These are changes in population in response to environmental stress or environmental conditions.
A population is a group of organisms of the same species living together in a given place at a particular time.

TERMS USED IN POPULATION STUDIES:

Population size: Number of individuals in a population.
Population density: Total number of organisms of a species per unit area (land) or per unit volume (water)
Population growth: A change in the number of individuals (increase-positive or decrease-negative)
Population growth rate; Change in number of individuals per unit time
Birth rate (natality): Number of new individuals produced by one organism per unit time (Humans: per year). Expressed as the number of individuals born in a given period for every 1000 individuals e.g 36 births per 1000 people per year.
Death rate (mortality): Number of individuals dying per unit of time per unit of population (humans: number of deaths per 1000 per year e.g. 20 deaths per 1000 people per year)
Environmental resistance: All the environmental factors acting jointly to limit the growth of a population.
Carrying capacity: Maximum number of individuals of a given species that can be sustained indefinitely in a given area of land or volume of water.
Age structure/distribution*;* is the proportion of individuals of each age in a population.
The young-age group before reproduction
Middle age- reproductive age
Old age-age after reproductive stage
Biotic potential*,* rmaximum rate at which the members of a given population can reproduce given unlimited resources and favourable environmental conditions.

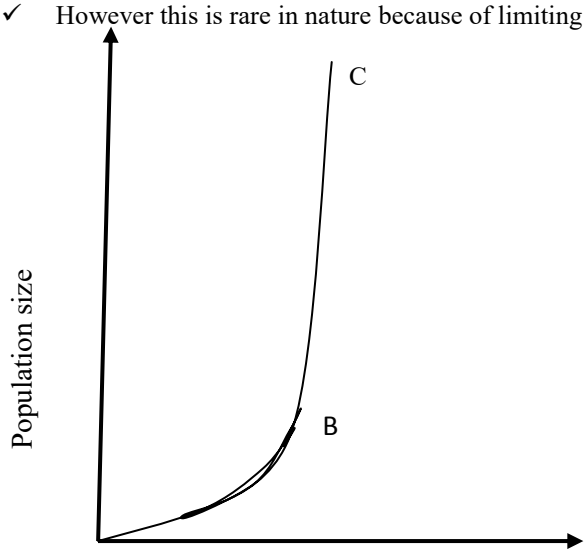
Immigration: Movement of individuals into a population from neighboring populations.
Emigration: Departure of individuals from a population.
Rare species: Species with small populations either restricted geographically with localized habitats or with widely scattered individuals.
Endangered species: Species with low population numbers that are in considerable danger of becoming extinct.
Extinct species: Species, which cannot be found in areas they previously inhabited nor in other likely habitats
Population distribution/dispersion - distribution of organisms in a habitat. Three main types exist i.e (i) **uniform distribution** organisms are equidistantly placed due to severe struggle for resources in the environment.(ii)***Random distribution*** organisms are dispersed by chance with neither forces of attraction nor repulsion and the environment provides uniform factors.(iii) **clumped distribution** organisms aggregate into groups to gain better protection, feeding, reproduction etc. Clumped dispersion is the most common pattern of population distribution.
NB. Main characteristics of a population are (i)density(ii) dispersion(iii)age structure(iv) natality (v) mortality (vi) population size.

POPULATION GROWTH PATTERNS

- Population grows when(i) natality is greater than mortality (ii) immigration is greater than emigration
- Population growth may form a curve which is either (i) exponential population growth curve (J-shaped) (ii) logistic population growth curve(Sigmoid/S-shaped)

(i) **Exponential population growth (J-shaped curve)**

- ✓ It is a theoretical population growth curve in which the population growth rate increases with time indefinitely.
- ✓ Population growth starts out slowly and then proceeds faster and faster as the population increases.
- ✓ It occurs when resources are unlimited and the population can grow at its intrinsic rate of growth.(rate at which a population would grow if it had unlimited resources)
- ✓ However this is rare in nature because of limiting factors (environmental resistance).

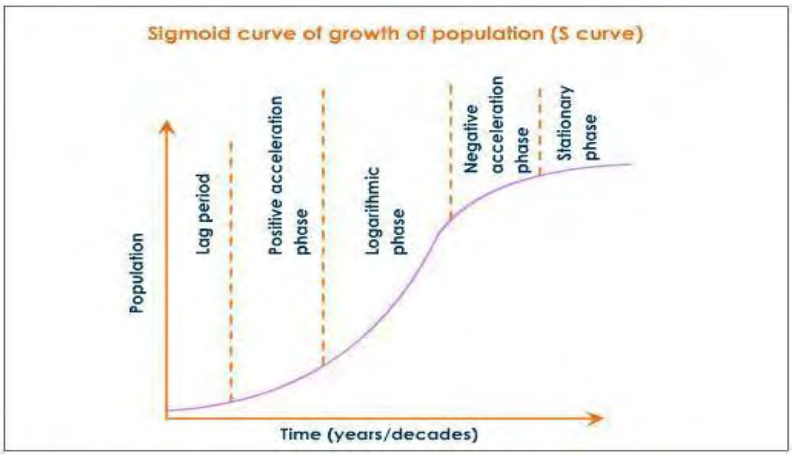


Description
Number of individuals(population) is small. Their number increases gradually/slowly with time along AB. Later thw population size increases rapidly/sharply/drastically with time along CB

Explanation
Initially , the number of individuals increases gradually with time because the population size is small, thus few reproducing individuals, ,reproducing individuals are scattered within the environment, some may not have reached reproductive age, organisms are still getting used to their environment. Later on, number of individuals increases rapidly because many individuals have now reached reproductive age, & number of reproducing individuals now gets bigger

(ii) **Logistic population growth curve sigmoid / s-shaped) .**

- Population growth starts out slowly and then proceeds faster to a maximum (carrying capacity) and then levels off.
- Population then fluctuates slightly above and below the carrying capacity with time.
- The population stabilises at or near the carrying capacity (K) of its environment due to environmental resistance(any factors that may prevent a population from increasing as expected eg predation, parasitism, and accumulation of toxic substances)



The actual factors responsible for the shape of each phase depend on the ecosystem, and this can be illustrated by considering two contrasting examples: **yeast** in a flask (reproducing asexually), and **rabbits** in a field (reproducing sexually).

PHASES	**YEAST IN A FLASK**	**RABBITS IN GRASSLAND**
Lag phase	Little growth while yeast starts synthesizing appropriate enzymes for new conditions.	Little growth due to small population. Individuals may rarely meet, so few matings. Long gestation so few births.
Acceleration phase	Slow growth because cells are getting used to conditions in the environment	Slow growth because of few reproducing individuals
Log phase (Logarithmic phase)	Rapid exponential growth. No limiting factors since relatively low density.	Rapid growth. Few limiting factors since relatively low density.
Deceleration phase (Negative acceleration phase)	Slow growth due to accumulation of toxic waste products (e.g. ethanol) or lack of sugar.	Slow growth due to intraspecific competition for food/territory, predation, etc.
Stationary phase	Population is stable (fluctuates slightly above and below the carrying capacity). Cell death is equivalent to cells formed	Population is stable (fluctuates slightly above and below the carrying capacity). Death rate is equivalent to the birth rate

How Population Density Affects Population Growth

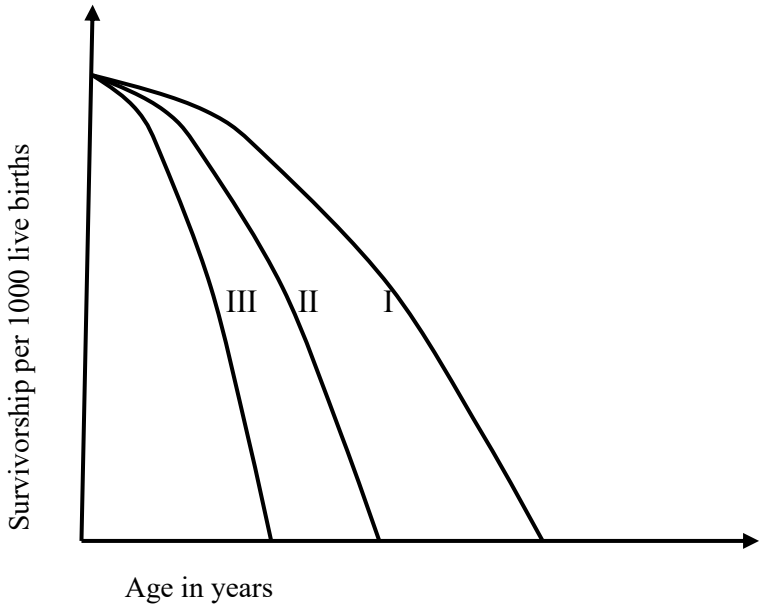
(a) Density dependent factors, are those factors whose effectiveness depends on number of individuals present in a unit space. The more individuals there are in the population, the greater the percentage of population that dies or fails to reproduce. These include; diseases, predation, competition for food, parasitism, pollution (accumulation of wastes etc.

(b) Density independent factors, are those whose effectiveness is not related to the density of the population. Any change in the factor affects the same proportion of the population regardless of population density. They include; temperature, rainfall, light, floods, soil nutrients, fires, drought, hurricanes and habitat destruction e.g. clearing a forest or fishing in a wetland, pesticide spraying. They are mainly abiotic factors.

SURVIVORSHIP

This is the percentage of an original population that survives to a given age.

Survivorship curve: is a graph which shows the number (or percentage) of surviving individuals of each age group of a population for a particular species.



(I) **Late loss curves**

Occurs in Humans, elephants, rhinoceroses, mountain sheep

These are organisms with stable populations close to carrying capacity of the environment (K).

They produce few young ones which are cared for until reproductive age, thus reducing juvenile mortality and therefore enabling high survivorship to a certain age, then high mortality at later age in life.

(II)**Early loss curves**

Occurs in annual plants, most invertebrates and most bony fish species; with a high intrinsic rate of increase.

They produce many offspring which are poorly cared for resulting into high juvenile mortality.

There is high survivorship once the surviving young reach a certain age and size.

(III) **Constant loss**

Many song birds, lizards, small mammals and hydra

This is characteristic of species with intermediate reproductive patterns with a fairly constant rate of mortality in all age classes and thus a steadily declining survivorship curve.

There is an equal chance of dying at all ages.

These organisms face a fairly constant threat from starvation, predation and disease throughout their lives.

Importance of plotting survivorship curves:

- Enables determination of mortality rates of individuals of different ages and hence to determine at which age they are most vulnerable.
- Enables identification of factors causing death at different ages so as to plan regulation of population size

DETERMINATION OF POPULATION SIZE OF ORGANISMS

Importance of estimating population size

- Enables monitoring of population growth
- Enables determination of habitat requirements of species.
- Enables determination of carrying capacity in the area. i.e determine whether existing population are likely to be sustainable.
- Enables determination of age structure, and sometimes sex ratio of a population.
- It enables projection of how population size is likely to change with time for proper planning eg determining the peak populations of organisms e.g mosquitoes enables control measures to be prepared.

FACTORS TO CONSIDER BEFORE COUNTING ORGANISMS

- The area of land or volume of water or air under study should be determined.
- The nature of vegetation cover of the habitat.
- Size of organisms under study.
- Facilitation in terms of equipment to be used.

- Behavior of the organism e.g. their level of hostility and excitement when disturbed.
- Topography of the area
- Type of habitat, terrestrial/aquatic.
- Risks involved during the exercise.
- Seasonal changes and its effect on organisms.

METHODS OF DETERMINING POPULATION SIZE OF ORGANISMS

(a)Total count:

This is the physical counting of every individual of a population in a specified area of ground.

It is effective for large animals living in unconcealed (exposed) habitats. It includes; (i) **Direct counting method** (using a low flying aircraft) (ii)**Aerial photography** (iii)**Drive and count** (iv)**Strip census** (v)**Removal method**

(i)Direct counting method using a low flying aircraft

Used to determine population of large animals.

Requirements

(i)An air craft e.g. a helicopter(ii) Survey map of the area (iii)Stationary (iv) binoculars

Procedure

An air craft is flown at low altitude over the study area a long several strips of known area

The number of organisms of given species under study is obtained by direct counting and recorded.

This is repeated several times. The average population density for all the sample is then calculated.

Advantages

- It gives a quick estimate of the population size
- Other studies on the population such as feeding habits, reproductive behavior, and predation can be carried out simultaneously.
- It reduces the risk of attacks from aggressive animals eg lions, buffalos, etc

Disadvantages

- It is expensive since it requires sophisticated air craft and skilled man power
- The sound made by the air craft may scare some animals which may hide in concealed areas e.g. under the trees.
- It's greatly hampered by some weather conditions e.g fog, misty or cloudy weather.
- Can only be used on large animals and those in open grass lands
- Not easy in very hilly areas.
- calculations involved may cause inaccuracy

(ii) Aerial photography.

Requirements

(i) Low flying air craft (ii) Good camera

Procedure

Photographs are taken from a low flying air craft over the whole study area.

Photographs are then developed, printed and number of animals in each photograph counted

Population density is then expressed as number per unit area

NB; **advantages and disadvantages are as seen above (direct counting)**

(iii) Drive and count method

Requirements

(i)Man power (ii)Stationary

Procedure

A number of people drive animals into a particular space/area and count them.

Advantages

i. It is quick and more accurate especially for slow moving animals and those that live in herds e.g. antelopes.
ii. There is reduced likelihood of not counting an animal or counting a given animal more than once.

Disadvantages

-It cannot be applied to aggressive animals e.g. lions, tigers, etc

-Limited to slow moving animals

-Restricted to animals moving in herds

(iv) Stripe census

Requirements

(i) Map of the area (ii) Vehicle

Procedure

- While driving , animals are counted in a given strip /besides the road.
- The number of organisms in each strip is obtained by direct counting and the population density of the strip is obtained.
- Such is repeated for several strips and the average population density for the strips is calculated.
- The population of total population of the area given is calculated as ; **average population area of each strip x total area**.

Advantages

- It's quick
- It's cheap compared to aerial means

Disadvantages

- Moving vehicles scare away animals that may run into hiding
- Some animals avoid roads and paths commonly used by man in the park.
- There is increased likelihood of counting fast moving animals more than once.

- ❖ Very many counts have to be made so as to come out with a reliable number.

(b) <u>Counting by sampling</u>

- ❖ This is when the number of organisms is determined in several sample plots that represent a known fraction of the total area under investigation from which estimation of the total population size of the whole area is made by simple calculations
- ❖ sample counting is applied when the number of the organisms is large, covers a large area or where the behavior of organisms does not allow easy contact.

(i) <u>Capture mark Release recapture method (Lincoln Index).</u>

This method is used on highly mobile animals like fish, small animals like mammals e.g. rats, birds, ,arthropods eg insects like butterflies, moth, grass hoppers.

Requirements

(i) Suitable traps (ii) Suitable tags/label e.g. aluminum discs for fish, permanent ink for rats/mice

Procedure

- ❖ Traps are set up randomly over study area.
- ❖ After some time, the traps are observed for any captures made , a count is made for all animals captured in this first occasion., noted as **N1**.
- ❖ They are all marked using a suitable label or tag e.g. placing an aluminum disc on the ear of a mammal (rat).
- ❖ These animals are then released back to their natural environment.
- ❖ After allowing sufficient time for the population to mix thoroughly, the traps are set up again all over the study area.
- ❖ A count is made of all animals captured on the second catch noted as **N2**.
- ❖ A count is made of how many animals captured on the second catch have marks /labels; i.e. those that have been recaptured. Noted as **N3**.
- ❖ The estimated total population**(P)** of animals in the area is then estimated using the Lincoln index as follows;

$$P = \frac{N_1 \times N_2}{N_3}$$

Where P-estimated total population of the area
N1- number of individuals captured on the first occasion.
N2- number of individuals captured on the second catch.
N3- number of individuals recaptured on the second catch.

<u>Assumptions made when using the capture mark Release recapture method</u>

- That organisms mix randomly within the population.
- That the time allowed for random mixing is enough.
- That changes in population size due to immigration, emigration, death and birth are negligible.
- That the movement of organisms is restricted geographically.
- That there is even dispersing of organisms within the study area.
- That the mark does not hinder the movement of organisms or make them conspicuous to predators.

Disadvantages/limitations

- It's only reliable when the organisms' range of movement is relatively restricted and defined.
- Animals often move in groups whose members recognize one another and avoid mixing with those of other groups.
- Many animals have particular localities where they confine, so the marked animals may not spread widely.
- Loss of marked individuals reduces those recaptured and this causes inaccuracy.
- The label may psychologically or physically disturb the organism.

Example

In an attempt to estimate the number of tilapia in a small lake, 625 tilapia were netted, marked and released. One week later, 873 were netted of which 129 tilapia had been marked. What is the estimated population size of tilapia?

$$P = \frac{N1 \times N2}{N3}$$

$$P = \frac{625 \times 873}{129}$$

P=4230 tilapia

ASSIGNMENT. In an investigation of a fresh water pond, 35 water bugs(**Notonecta**) were caught, marked and released . Three days later 35 water bugs were caught and 7 were found to be marked.

(a) What is the approximate size of population of water bugs in the pond? Show your working.

(b) Give three reasons why capture-recapture is unlikely to be an accurate way of assessing the size of water bugs.

(ii) <u>Use of quadrat</u>

This is suitable for slow moving animals and grass.

Requirements

(i)Metallic, plastic or wooden frame of a known area e.g. $1m^2$ (ii) Stationary

Procedure

The frame is randomly thrown several times in an area under investigation.
All individual within a quadrat are counted each time.
Population density is expressed as the average figure per metre squared.
Total population is got by multiplying the average with the total area under investigation.

Advantages

(i) It's accurate (ii) It enables comparison of different areas and species. (iii) It provides an absolute measure of abundance.

Disadvantages

(i)Its time consuming. (ii) It's not suitable for first moving animals. (iii) It's not suitable for large sized animals. (iv) some plants e.g. grass species are indistinguishable and may disturb.

(iii**) Removal method**

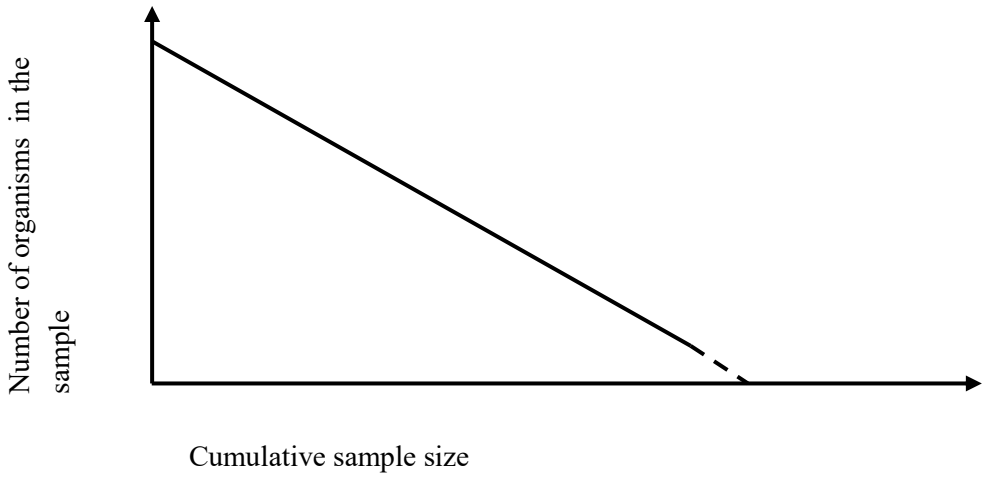
This is suitable for small organisms like insects and rats within a known area of grassland or volume of water.

After sweeping with a heavy net, counting and recording of the animals captured is done without replacement.

The procedure is repeated several times and gradually decreasing numbers of organisms and cumulative number of organisms captured is noted.

A graph of number of animals captured per sample against the previous cumulative number of animals captured is plotted and extrapolation of the line of the graph is made to the point at which no further animals would be captured, from which the population is estimated. E.g.

Sample no	Number of organisms in the sample	Cumulative sample size
1	120	120
2	93	213
3	60	273
4	35	328



Assignment

Suggest and describe the suitable methods for estimating the population size of the organisms below. Give reasons for your choice of each method and outline the associated limitations.

a) Fish in a pond (b) Terrestrial plant (c) Large mammals

REGULATION OF POPULATION SIZE

Population size is naturally maintained at their normal carrying capacity depending on the resources in a given habitat. These populations are controlled by homeostatic means depending on the density controlled factors e.g. food, pests, diseases, predators etc.

The population itself initiates the control measure i.e an increase in population stimulates environmental resistance which brings the population back to normal, and a decrease in population below carrying capacity, environmental resistance decreases, thus causing an increase in the number of organisms e.g. predator –prey relationship.

Methods of population control

(a) Biological control method

This is the eating or weakening of a pest species or weeds using other organisms called **control agents** e.g. natural predator, parasite or pathogen .E.g.. (i) Using cats to eat rats, (ii) using beetles to feed on the water hyacinth on Lake Victoria, (iii) placing fish in ponds to eat mosquito larvae.

Biological control aims at bringing the pest population to a level where they are economically un harmful.

Biological control method can be used to; (i) control of vector population (ii) control of parasites (iii) control of pathogens (bacteria& virus) (iv)control of some plants e.g. weeds (v) control of pests.

Steps involved in biological pest control:

- Identifying the pest and tracing its origins, i.e. where it came from.
- Investigating the original site of the pest and identifying natural predators, parasites or pathogens of the pest.
- Testing the potential control agent under careful quarantine to ensure its specificity.
- Mass culturing of the control agent.
- Development of the most effective distribution / release method for the control agent.

NB. Biological control of population is very specific, thus useful organisms are not affected.

(b) Chemical method.

Involves use of chemicals by humans to eradicate harmful organisms

Are named according to the target organisms e.g. herbicides kill weeds, insecticides kill insects, fungicides kill fungi.

Properties of an ideal pesticide:

- Should be biodegradable / non-persistent so that toxic products are not left in or on crop plants.
- Should be specific so that only pest species is killed.

- ❖ Should not accumulate either in specific parts of an organism or as it passes along food chains.
- ❖ Should effectively control the pest under field growing conditions
- ❖ Should be easy to apply at the correct dosage.

Problems of using insecticides:

- ❖ Accidental misuse of toxic chemicals results in death of humans and domestic animal.
- ❖ Many are non-specific, killing non-target species, particularly natural predators of the pest species.
- ❖ Pest resistance occurs i.e. genetic variation enables a few individuals in the pest population to survive and may quickly reproduce.
- ❖ There is pest replacement i.e. since most crop are susceptible to attack by more than one pest species, and the pesticide may be more deadly to one species than another, elimination of one species may simply allow another species to assume major pest proportions.
- ❖ Pest resurgence may occur i.e. non-specific pesticides may kill natural predators as well as pests, and so a small residual pest population may multiply quickly without being checked.
- ❖ **Bioaccumulation** (some molecules of the pesticide may be stored in specific organs or tissues at levels higher than would be expected) and **biological magnification** (the pesticide may get more concentrated as it passes along the food chains and webs) may occur. E.g. If Dichlorodiphenyl trichloroethane, DDT is sprayed on plants, to kill green flies, some survive, and absorb the chemical into their bodies. When eaten by small birds, DDT accumulates and when birds are eaten by other predators, e.g birds of prey, the accumulation of DDT reaches a level which burns up and kills the final consumer.

Questions

1. (a) What is a biological pest control?
(b). What consideration must be made before application of biological pest control method?
(c.) State two ways in which the chemical control method can upset an ecosystem
(d) Suggest three characteristics of a good pesticide.

2. The table shows the amount of DDT in plants per million found in a variety of organisms associated with fresh water lake.

Site of DDT measurement	Amount of DDT in parts per million
water	0.0003
phytoplankton	0.002
zooplankton	0.004
Herbivorous fish	0.39
Carnivorous fish	0.89
Fish eating birds	14.2

(a) (i). Calculate how many times DDT is more concentrated in carnivorous fish compared with its concentration in water
(ii) what do the results in a(i) show?
(b)Explain why the concentration of DDT changes from water to carnivorous fish?
c) Explain how a pest sprayed with a pesticide may flourish afterwards?.

3. In an aquatic ecosystem which was affected by an insecticide, analysis of energy flow and concentration of the insecticide in each trophic level in a food chain was made. The results were shown in the table below.

Energy flow	pesticide
Producers	0.04
Herbivores	10
Carnivore 1	50
Carnivore 2	75

(a)Explain why from producers to consumers,(i) level of insectide increases(ii) the flow of energy decreases.(b) Give three ecological problems that may arise from the use of pesticides.

NATURAL RESOURCES

- ❖ A natural resource is anything not made by man obtained from the environment to meet human needs and wants
- ❖ While some resources are directly available for use e.g. solar energy, fresh air, wind, fresh surface water, fertile soil, wild edible plants others, become available after processing has been done e.g. petroleum, metallic elements like iron, ground water, modern crops.

CLASSIFICATION OF NATURAL RESOURCES

Type of natural resource & its definition	Examples
(i) ***Perpetual resources***. Resources that are replaced (renewed) continuously on human time scale.	(i) Solar energy (ii) wind (iii) tides.
(ii) ***Renewable resources*** Resources that are replenished (replaced) fairly rapidly (hours to decades) through natural processes as long as the usage is not faster than the replacement.	(i) Fresh water (ii) fresh air (iii) fertile soil (iv) animals and plants (Forests, grasslands)
(iii) ***Nonrenewable resources*** Resources that exist in a fixed quantity or stock in the earth's crust. On the shorter human time scale, they are depleted much faster than they are formed.	(i) Fossil fuels (e.g. coal, oil, natural gas) (ii) metallic minerals (e.g. copper, iron, aluminium) (iii) non-metallic minerals (e.g. salt, clay, sand, phosphates).

Further terms associated with natural resource.

Term and definition	Examples and/or comments
(i) *Sustainable yield* The highest rate at which a renewable resource can be used indefinitely without reducing its availability supply.	In spite of the renewability, renewable resources can be depleted or degraded.
(ii) *Environmental degradation* The process when the resources natural replacement rate is exceeded resulting into a decline in its availability.	Urbanization of productive land, excessive soil erosion, deforestation, ground water depletion, over grazing of grass lands by livestock, reduction in the earth forms of wild life by elimination of habitats and species, pollution, water logging and salt build up in the soil

(iii) ***Recycling of resources*** This is the reprocessing of a resource into new products	Old aluminum saucepans and copper items can be recycled
(iv) ***Reusing of resources*** Using of resources over and over in the same form.	Glass bottles of alcoholic and soft drinks can be collected washed and refilled many times
(v) Wild life This includes plants and animals that occur in their natural environment	Forests and wild animals

POLLUTION

- It is the release of substances or energy into the external environment in such quantities and for such duration that may cause harm to living organisms or their environment.
- **Pollutants** include; noise, heat and radiation as different forms of energy, many chemical compounds and elements and excretory products.
- The parts of external environment affected include air, water and land.

Harm cause by pollutants.

- Disruption of life support systems for living organisms.
- Damage to wild life, human health and property.
- Nuisances such as noise and unpleasant smells, tastes and sights.

Categorisation of pollutants basing on their persistence in the environment

(a) Degradable (non-persistent) pollutants: Are the pollutants that are broken down completely or reduced to acceptable levels by natural physical, chemical and biological processes.

Biodegradation: is the breakdown of complex chemical pollutants into simpler chemicals by living organisms (usually specialised bacteria) e.g. sewage is a biodegradable pollutant.

(b) Slowly degradable (persistent pollutants): Are those that take a longer time to degrade e.g. DDT - an insecticide, and **plastics e.g. plastic bags.**

c) Non-degradable pollutants: these cannot be broken down by natural processes e.g. the toxic elements lead, mercury, arsenic, selenium

TYPES OF POLLUTION

(a) AIR POLLUTION

Pollutant	Source(s)	Effects/ consequences	Control measures
(i) ***Carbonmonoxide***	(i)Motor vehicle exhausts ii) Incomplete combustion of fossil fuels (iii) tobacco smoking	(i) Prevents oxygen usage by blood by forming carboxy-haemoglobin, which may cause death.(ii) Small concentrations cause dizziness and headache	(i)Efficient combustion of fuels in industry an homes(ii) Avoid smoking.(iii) Vehicle exhausts gas control e.g. in USA.
(ii) ***Sulphurdioxide***	(i) Combustion of Sulphur containing fuels, oil, coal gas	(i) Causes lung diseases, irritation of eye surface, and asthma resulting into death if in high concentrations.(ii) Forms acid rain which increases soil PH.(iii) Reduces growth of plants and kills lichens. NB. *Lichens are indicator species for sulphurdioxide pollution.* *The presence of many lichen species indicates low level of sulphurdioxide pollution in that area.*	i) Use of Sulphur free fuel e.g. natural gas.(ii) Installation of Sulphurdioxide extraction units in industrial fluels and chimneys.
(iii) ***Ozone***	(i) Motor vehicle exhausts ii) combustion of fossil fuels to form nitrogen dioxide which decomposes to form oxygen atoms that combine with oxygen molecules to form ozone.	***Low level (tropospheric) ozone*** causes: (i) Internal damage to leaves hence reducing photosynthesis.(ii)Eye, throat and lung irritation which may result into death.(iii)Internal damage to leaves which severely reduces photosynthesis. (iv) Green house effect by absorbing and radiating heat which raises the temperature at the earth's surface. ***High level (stratospheric) ozone offers*** protection against excessive solar heat by absorbing solar ultraviolet radiation which would reach the earth's surface.	(i) Vehicle exhausts gas control e.g. in USA
(iv) Smoke	(i) House coal, smoke, soot ii)Motor vehicle exhausts iii) tobacco smocking iv) Incomplete combustion of refuse in incinerators and bonfires.	(i) Causes lung diseases when inhaled (ii) Sunlight barrier, hence reducing photosynthesis.(iii)Stunted growth of plants (iv) Stomatal blockage hence reducing photosynthesis	(i)Usage of smokeless fuels (ii)Efficient combustion iii)No smoking iv) Vehicle exhausts gas control
(v) ***Dust***	(i) Solid fuel ash (ii) soil (iii) quarrying (iv) mining, etc	i)Lung diseases(ii) stomatal blockage iii) Stunted growth of plants.(iv) Smog –	i)Installation of dust precipitators in industrial chimneys.

		forms when temperature inversion occurs (layer of warm air traps cool air containing dust and smoke close to the earth' surface)	ii) Efficient combustion. iii) Wearing of face masks by factory workers.
(vi) ***Carbondioxide***	(i)Motor vehicle exhausts ii) combustion of fossil fuels	Increased carbon dioxide causes Green house effect – warming up of the earth's atmosphere as a result of the blanket of carbon dioxide, preventing escape of solar radiation higher into space.	(i)Planting more green plants, (ii0 reduction in combustion of fossil fuels by relying on alternative sources of energy e.g. solar energy.
(vii) ***Nitrogen oxides* (*nitric oxide & nitrogen dioxide)***	(i) Car exhaust emissions (ii) industrial fuel gases	(i)Acid rain formation(ii) contribute to green house effect	(i) Car exhaust control
Viii)Chlorofluorocarbons CFCs	(i)Aerosol propellants, (ii) refrigerator (iii) air conditioner coolants (iv) expanded plastics. E.g. bubbles in plastic foam used for insulation and packaging **(polyurethane form)**	Enters stratosphere, the chlorine reacts with ozone hence reducing the ozone layer and permitting greater penetration of UV light to cause global warming.	Ban on the use of CFCs
(ix) ***Noise***	(i) Discos (ii) road traffic, (iii0 engines (iv) machines, (v) aeroplanes(vi) firearms	(i) Hearing impairment,(ii) total deafness (iii) nervous disorders	(i) Effect laws against excessive noise(ii)put on ear muffs and plugs while in industry
(x) ***Radioactive*** *fallout from explosion*	(i) Nuclear weapons(ii) nuclear power fuels.	Ionizing radiation causes cancer	Nuclear power controls

GREENHOUSE EFFECT AND GLOBAL WARMING

Greenhouse effect

- This is a description of the condition which results when greenhouse gases i.e. gases in the troposphere (atmosphere's inner most layer extending about 17km above sea level) like carbon dioxide, water vapor, methane and nitrous oxide allow mostly visible light, some infrared radiation and ultraviolent radiation from the sun to pass through the troposphere to the earth, which transforms this solar energy to longer-wave lengths-infrared radiation (heat) which then rises into the atmosphere.
- Molecules of greenhouse gases absorb and emit this heat into the troposphere as even longer-wave-length infrared radiation, which causes a warming effect of the earth's surface and air.

The tropospheric gases act like a glass of large green house surrounding the earth.

Global warming

This is the observed average global temperature rise of 0.8oC since 1900 as result of the enhanced natural greenhouse effect.

The origins of greenhouse gases are;

- ✓ Combustion of fossil fuels by motor engines and industries releases carbon dioxide and methane into the troposphere.
- ✓ Deforestation and clearing of grasslands reduces the uptake of carbon dioxide in photosynthesis.
- ✓ Ruminant fermentation produces methane, which is released into troposphere.
- ✓ Use of aerosol propellants, which contain CFCs that are 105 times worse than carbon dioxide as greenhouse gases
- ✓ Cultivation of rice in swamps and paddy fields causes anaerobic fermentation, which produces methane.
- ✓ Use of inorganic fertilizers cause the release of nitrous oxide.

Effects of global warming.

- ✓ Rise in sea level due to melting of polar ice and thermal expansion of seas.
- ✓ Altered temperature gradients cause cyclones and heavy rains as water evaporates quicker.
- ✓ Species migration which are likely to cause pests/diseases to extend their ranges.
- ✓ Reduced cropped fields due to drier weather.
- ✓ Increased crop yields because of more rainfall and longer growing seasons in some regions.
- ✓ Flooding low-lying islands and coastal cities.
- ✓ Extinction of some animal and plant species.
- ✓ Increased death of human population.
- ✓ Greatly increased wild fires in areas where the climate becomes drier.

ACID RAIN

Formation

Combustion of fossil fuels releases sulphur dioxide and nitrogen oxides into the atmosphere.

Catalyzed by ammonia and unburnt hydrocarbons, these oxides react with water in the clouds to form solutions of **sulphuric acid** and **nitric acid**, which make up acid rain.

Effects

- ✓ Hydrogen ions bound to soil particles are displaced into runoff water by the $SO4^{2-}$ ions from sulphuric acid, causing formation of soft exoskeletons, which results into death of invertebrates.

- ✓ Aluminum ions are displaced from soil by $SO4^{2-}$ ions into water where it interferes with gill functioning in fish causing their death.
- ✓ Aluminum ions are displaced from soil by $SO4^{2-}$ ions into water are toxic when absorbed by plants.
- ✓ The leaching action of acid rain removes calcium and magnesium ions from soil causing poor formation of middle lamella and chlorophyll in leaves.
- ✓ Contributes to humans respiratory diseases such as bronchitis and asthma.
- ✓ Can leach toxic metals such as lead and copper from water pipes into drinking water.
- ✓ Damages statues and buildings.
- ✓ Decreases atmospheric visibility, mostly because of sulphate particles.
- ✓ Promotes the growth of acid-loving mosses that can kill trees.
- ✓ Loss of fish population when the pH lowers below 4.5

Prevention

- ✓ Installation of SO2 extraction units (wet scrubbers) in chimneys of industries.
- ✓ Cleaning up of exhaust emissions by encouraging several pollutants to react with one another to give less harmful products in catalytic converters.
- ✓ Reduce coal use.
- ✓ Increase use of renewable resources.
- ✓ Tax emissions of sulphur dioxide, "polluter pays principle" should be adopted everywhere.

Why high-altitude lakes quickly become acidic than low- altitude lakes?

Low- altitude lakes are richer than high-altitude lakes in limestone which buffers against the effects of acid rain, and also the surrounding soils to low-altitude lakes are deeper.

(b) **WATER POLLUTION**

MAJOR CATEGORIES OF WATER POLLUTION

(A) *SEWAGE DISCHARGE INTO RIVERS*

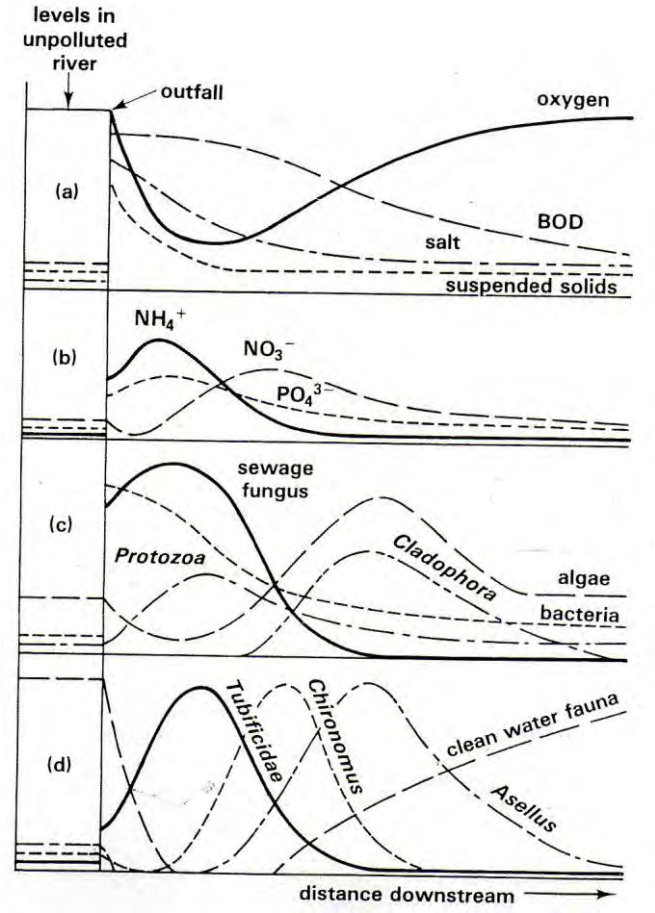
Sewage is liquid waste (composed of faeces, urine, water, detergents and other substances) from industries and/ or homes carried through pipes called **sewers**.

Effects of untreated sewage discharge into rivers

Discharge of untreated sewage into a river has an immediate effect on the aquatic environment, causing many changes in both the **abiotic** and **biotic components**.

Some of these changes are due to specific chemical pollutants (e.g. heavy metals such as cadmium from industrial processes, and pesticides from agriculture, with the effects varying according to the chemicals present in the discharge.

Variation of components in a river on discharge of untreated sewage



(a) What is meant by the term biochemical oxygen demand(BOD)?

(b). Explain the changes in BOD shown in the diagram

(c.) (i) Explain the changes in nitrate level shown in the diagram.

(ii). Compare and comment on the curves for the sewage fungus and the algae in the diagram.

(d). Using evidence from the diagram, suggest a method by which an organism might be used as a pollution indicator.(Your answer should include practical details of your method)

(e) Suppose that the chemical works also discharged thermal pollution. Suggest one possible effect on the river's chemical content and one possible effect on its biological content.

Component(s)	Variation down stream	Explanation
(i) *Dissolved oxygen and B.O.D (Biological or biochemical oxygen demand)* NB. BOD is mass of oxygen consumed by microorganisms in a sample of water in a given time - usually measured as the mass (in mg) of oxygen used by $1dm^3$ of water stored in darkness at 20degrees Celsius for 5 days. B.O.D indicates the oxygen not available to more advanced organisms. Therefore a high B.O.D indicates anaerobic conditions (low oxygen availability).	-Dissolved oxygen level is high in unpolluted water; decreases rapidly at sewage discharge to the minimum; and then increases gradually downstream, returning to a normal level further downstream. - B.O.D is very low in unpolluted water, increases rapidly at sewage discharge then decreases gradually downstream.	-Decomposition of organic components of sewage by aerobic bacteria coupled with reduced photosynthesis because of low illumination caused by suspended solids in sewage rapidly reduce oxygen (cause oxygen sag) and create a high BOD at outfall. -The gradual increase of dissolved oxygen downstream is because of increased photosynthesis and dissolution from atmosphere. -The death of aerobic bacteria due to reduction in organic substances decreases BOD down stream.
(ii) *suspended solids*	-Suspended solids are very few before outfall, increase rapidly at the sewage discharge but progressively decrease downstream.	-Sewage discharge adds decomposable organic matter into the water at the point of discharge, the progressive decrease downstream is due to bacterial consumption and dilution by water.
(iii*) Living organisms* e.g Aerobic bacteria, sewage fungus((filamentous bacteria), algae(cladophora) and higher plants.	-Aerobic bacteria are very few before, but very many at outfall, then their population decreases rapidly immediately and gradually after out fall downstream. -Sewage fungus is contained in sewage population; increases to a maximum immediately after outfall, but decreases rapidly downstream to very low level. -Algae and higher plant populations decrease rapidly to a minimum at outfall but increase rapidly a short distance downstream and return to normal further downstream.	-Sewage contains aerobic bacteria that feed on organic substances, but population falls as availability of oxygen and nutrients diminishes. -Population increases at outfall because the sewage fungus thrives in anaerobic conditions and is very tolerant at high ammonia concentrations. -The rapid decrease in population results from reduced photosynthesis because of the turbidity caused by suspended solids, the rapid increase is because of the high concentrations of nitrate ions and increased illumination because suspended solids reduce and water becomes clearer.
(iv) *Ammonium, nitrate and phosphate ions.*	-Ammonium, nitrate and phosphate ions concentration is very low before out fall. -NH_4^+ ions increase rapidly at discharge; more rapidly to a maximum just after outfall; then decreases first rapidly and later gradually to a very low level downstream. -NO_3^- ions first decrease gradually to a minimum concentration after outfall, gradually increase to a maximum a short distance downstream, then decreases gradually further downstream. -PO_4^{3-} ion concentration increases (1) rapidly at discharge, (2) gradually just after outfall to a maximum, then decreases gradually to a very low level downstream.	-Sewage contains NH_4^+ ions. Putrefying (ammonifying) bacteria convert organic nitrogen-containing compounds in sewage to NH_4^+ just after outfall. Downstream, NH_4^+ ions are converted to NO_3^- by nitrifying bacteria and further downstream there is dilution by water. -NO_3^- ions first decrease due to consumption by sewage fungus abundant at outfall, then gradually increase because NH_4^+ ions are converted to NO_3^- by nitrifying bacteria, then decrease gradually due to consumption by plants and algae. Sewage contains PO_4^{3-} ions from (1) detergents and (2) decomposition of organic matter, yet the consumption by autotrophs is very low at outfall, accounting for the high PO_4^{3-} ion concentration. PO_4^{3-} ion gradual decline downstream is caused by (1) absorption by the progressively increasing populations of autotrophs (2) storage in sediments.
v) *Clean water fauna (e.g. stonefly nymphs, mayfly larvae, Caddis fly*	-The populations of clean water fauna are high before outfall, decrease rapidly to zero	-Clean water species cannot tolerate anaerobic conditions at outfall, populations

larvae) Asellus (fresh water louse), Chironomus(bloodworm), Tubifex and rat –tailed maggots(not indicated on the graph but it can be sketched basing on tolerance to pollution) **NB-** organisms above are **indicator species** of un polluted, well oxygenated water.	at outfall only appearing and increasing to normal with distance downstream. -*Asellus* population decreases rapidly to zero at outfall, only appearing and increasing rapidly to a maximum a short distance downstream after which it decreases rapidly. -Tubifex population increases rapidly to a maximum at outfall and then decreases rapidly downstream. - Chironomus population increases rapidly to a maximum at a slightly longer distance from outfall and then decreases rapidly downstream.	increase downstream because oxygen and food become available. -*Asellus* cannot tolerate anaerobic conditions at outfall and therefore dies and migrates to the relatively less polluted water downstream where it shrives. -The increase in population of Tubifex, and Chironomus is because they are (i) relatively inactive to reduce oxygen demand and (ii) have haemoglobin with very high affinity for oxygen enabling them to be tolerant to anaerobic conditions. The increase in their population downstream indicates the level of pollution in the water. Tubifex, is the most tolerant to anaerobic conditions, followed by rat tailed maggots and Chironomus. The decrease in population downstream is partly due to predation.

NB. (a) Flowing rivers naturally undergo self-purification to recover from pollution through a combination of dilution and biodegradation, but the recovery time and distance depend on (1) ***volume of incoming degradable wastes in sewage*** (2) ***flow rate of the river*** (3) ***temperature of the water*** (4) ***pH level of the water.(5)existing population of microorganisms.***

(b) Indicator species ***are organisms requiring particular environmental conditions or set of conditions in order to survive and provide information about the environment e.g. can be used in ecological investigations to find out about both the present and past conditions of soil and climate.***

(B) *ADDITION OF INORGANIC CHEMICALS, PLANT NUTRIENTS AND SEDIMENTS INTO LAKES.*

Pollutant	Examples	Main human sources	Harmful effects
(i) ***Plant nutrients***	(i)Nitrate (NO_3^-) (ii) phosphate (PO_43-) and (iii) ammonium (NH_4^+) ions. The nutrient enrichment of water bodies is termed ***eutrophication***	-Raw sewage discharge, detergents and other chemical release from industries, leaching of inorganic fertilizers e.g. NPK from farmland.	(i)Rapid growth of algae and green protists (algal blooming/dramatic first growth of algae) (ii) reduces light penetration in water leading to (iii) Death and decay of algae, which depletes water of dissolved oxygen, killing fish and other aerobic animals. (iv) Excessive levels of NO_3^- if drank in water lowers the oxygen carrying capacity of blood and kill unborn children and infants **("blue baby syndrome").**
(ii) ***Sediment***	(i) soil (ii) silt	Land erosion	Can (i) cause turbidity / cloudiness in water; light penetration is reduced therefore reduce photosynthesis, (ii) settle and destroy feeding and spawning grounds of fish, (iii) clog and fill water bodies, shortening their lifespan (iv) disrupt aquatic ecosystems (v) carry pesticides, bacteria and other harmful substances into water.
(iii***) Inorganic chemicals***	(i) acids, (ii) compounds of toxic metals like lead (Pb), mercury (Hg), arsenic (As) and selenium (Se) and (iii) salts e.g. NaCl in ocean water	Surface runoff, industrial effluents and household cleaners	(i)Drinking water becomes unusable for drinking and irrigation (ii) Lead and Arsenic damage the nervous system, liver and kidneys (iii) they harm fish and other aquatic life (iv) they lower crop yields (v) they accelerate corrosion of metals exposed to such water.

C. *HEAT (THERMAL) POLLUTION*

Main human sources

Use of water as a coolant in industrial processes e.g. electricity generating plants.

Harmful effects

1) Lowers dissolved oxygen levels since solubility of most gases reduces with temperature.
2) Make aquatic organisms more vulnerable to disease, parasites, and toxic chemicals.
3) When a power plant shuts down for repair or opens, fish and other aquatic organisms adopted to a particular temperature range can be killed by the abrupt change in water temperature. This is known as **thermal shock**.
4) Some aquatic animals may migrate to water with favorable temperature.

Note:

Effects of eutrophication are more severe in water bodies where thermal pollution occurs because of;

1) Increased decomposition of organic matter and metabolism, which raise the demand for oxygen by higher organisms.
2) Reduced dissolved oxygen levels in water.

Questions

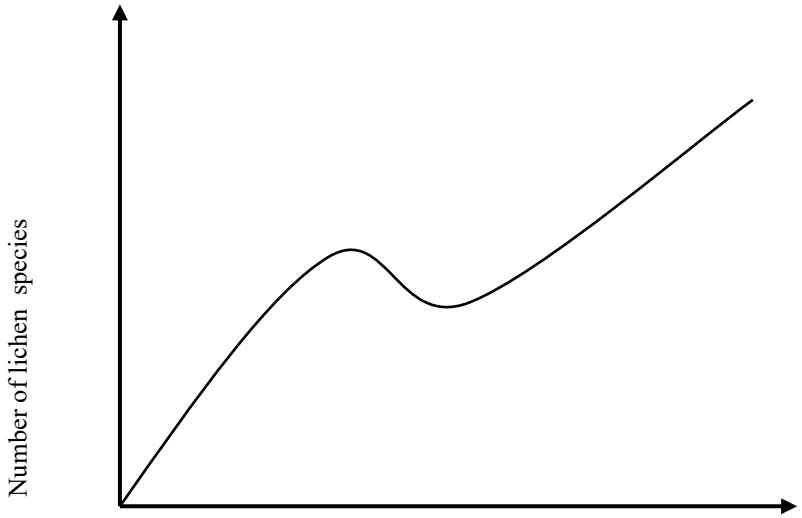
1.What are advantages and disadvantages of biological rather than chemical control of eutrophication?

Organisms live in their environment all the time; their presence (or absence) reflects the suitability of that environment for their living requirements at all times. A short-lived but severe pollution incident occurring at night would be reflected by the absence of sensitive organisms long after visible and chemical evidence of the pollution incident had disappeared. Biological indicators can therefore be a more sensitive and representative reflection of environmental conditions. Chemical monitoring all the time can only be done for small water courses e.g small rivers , streams and remote areas. It also requires much time-consuming and, in the long term, expensive laboratory analysis Biological control requires reasonable expertise at identification and is also affected by seasonal factors.

2.(a) **State three ecological problems which arise from accumulation of domestic waste in urban communities.**

(b) Give two ways of reducing domestic waste in urban communities

(c.) The figure below shows the lichen species along 20km transect from the urban centre.



(i) Explain the trend in the lichen species with distance from the urban centre.

(ii) Suggest an explanation for the observed number of lichen species at a distance of 10km from the urban centre.

3. (a). **Describe the factors which influence the concentration of dissolved oxygen in a river.**

(b). Explain the presence nor absence of those organisms may be used as indicators of the concentration of dissolved oxygen