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CLASSIFICATION II

- Classification, in biology is the identification, naming, and grouping of organisms into a formal system based on similarities such as **internal and external anatomy, physiological functions, genetic makeup, or evolutionary history.**

Study Question 1

General Principles of Classification

Organisms that have similar and common features are grouped together while those that have different features are grouped separately.

Taxonomy is the study of grouping of organisms according to their relationship. There are seven major taxonomic units (taxa).

- Kingdom
- Phylum (phyla) or Division in plants
- Class
- Order
- Family
- Genus Species

❖ As you move from the kingdom to the species the differences decrease as the similarities increases.

❖ **Species** is a group of organisms that can freely interbreed to give rise to viable/fertile offsprings.

❖ Sometime members of different species may interbreed to give an offspring which is sterile. E.g. a donkey and a horse can interbreed to give rise to a mule which is infertile.

Binomial Nomenclature

This is the double naming system of organisms where organisms are assigned two names i.e. the generic name and the specific name.

Examples

In binomial nomenclature the following rules are observed.

i.) Generic name is written first followed by the specific name.

ii.) First letter in the generic name is in capital and the rest are in small letters. **iii.)** Specific name is written in small letters. **iv.)** The two names are underlined separately when handwritten or italicized when printed.

Study Question 2

The Five Kingdoms of Classification

Carolus Linnaeus initially introduced the two kingdom system of classification. However many new life forms have been discovered which are neither animals nor plants. This has led to a more accepted classification system that adopts five kingdoms. These are;

- Monera

- Protoctista
- Fungi
- Plantae
- Animalia. **Fig. 1.2**

Kingdom Monera

The kingdom is made up of mainly the bacteria e.g. nitrobacter, azotobacter. Vibrio cholerae etc.

General characteristics

i.) They are unicellular and microscopic. Some are single cells while others are in colonies. They have different body shapes.

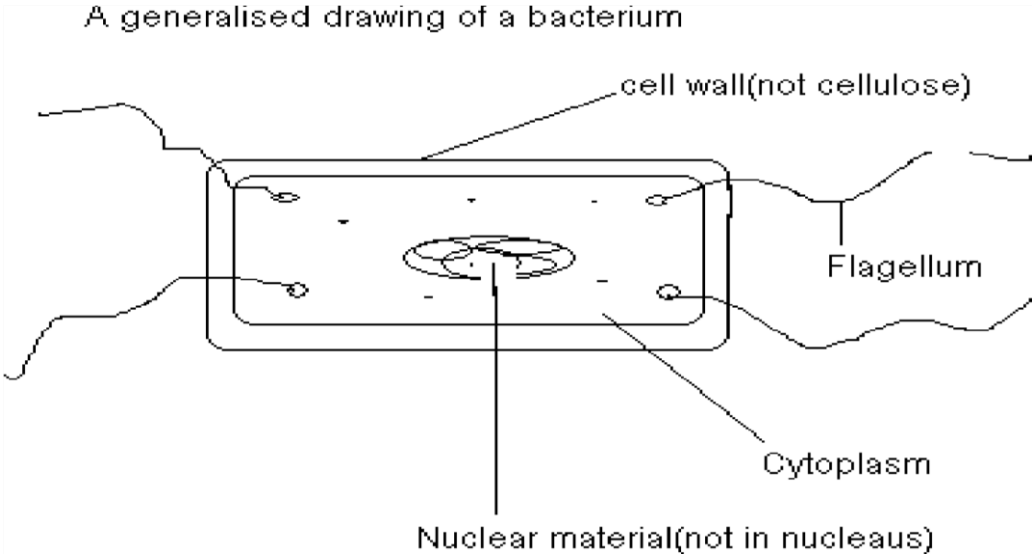


Fig. 1.4 ii.) Most are heterotrophic, feeding either saprophytically or parasitically. Some areautotrophic. **iii.)**They are prokaryotic i.e. their nuclear material is not enclosed by a nuclear membrane.

iv.) They have few organelles which are not membrane bound. They don't have mitochondria.

v.) They have a cell wall though not made of cellulose.

vi.) They reproduce asexually mainly through binary fission. **vii.)**Most of them respire an-aerobically but some respireaerobically. **viii.)**Most of them move by use of flagella.

Study question 3

Kingdom Protoctista

Examples include paramecium, amoeba, plasmodium, chlamydomonas, euglena, spirogyra, and trypanosome.

General characteristics

i.) They are eukaryotic whereby their nuclei is bound by a nuclear membrane.

ii.) Some are heterotrophic while others are autotrophic. **iii.)**They have may organelles including mitochondria all of which are membrane bound. **iv.)** They have different body forms; some are unicellular or colonial while others are multicellular. **v.)** Reproduction is mainly asexual by fission, fragmentation or sporulation. Some reproduce sexually by conjugation.

vi.) They are mobile and move by means of cilia, flagella or pseudopodia.

vii.) Some may have specialized structures that perform specific functions such as contractile vacuole for osmoregulation.

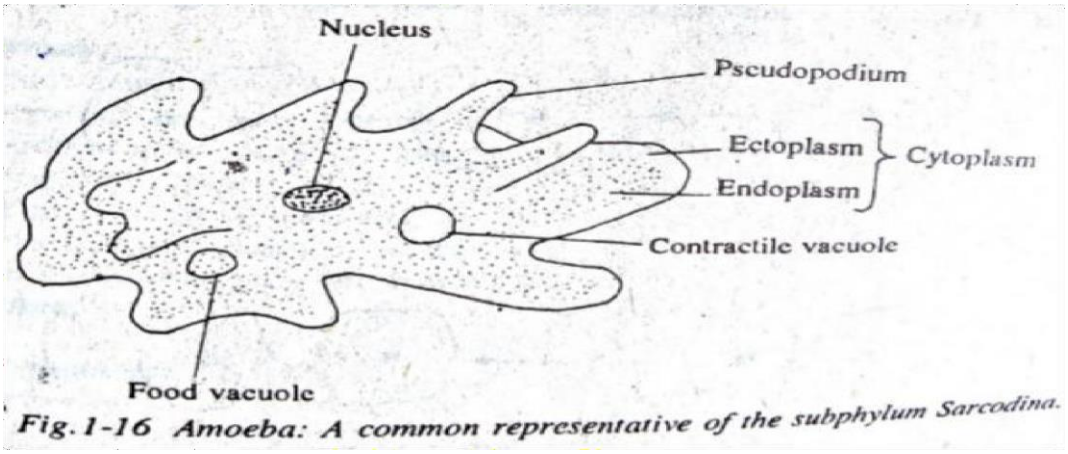


Fig. 1-16 Amoeba: A common representative of the subphylum Sarcodina.

Practical Activities 1 and 2

Kingdom Fungi

Examples

- Saprophytic ones include mushrooms, toadstools, bread moulds, penicilia, yeast etc.
- Parasitic ones cause plant diseases such as wheat rust, potato and tomato blight and animal diseases such as athlete's foot and ringworm.

General characteristics

i.) They are eukaryotic.

ii.) Most have cell walls made of chitin but a few have cellulose cell walls. **iii.)**They store food particles in their cytoplasm in the form of glycogen or oil droplets but not starch.

iv.) The basic unit is the **hyphae**. Hyphae are thin filaments and many of them make up structures called **mycelium**.

v.) Fungihave neither the chloroplasts nor thechlorophyll. They feed on already manufactured food. Hyphae act as the roots and are sent into the food material to obtain nutrients. In saprophytic fungi the hyphae are referred to as **rhizoids** and *in parasitic ones as **haustoria**.*

vi.) They reproduce **sexually** (fusion of nuclei in hyphal branches) and **asexually** (spores and budding).

Kingdom Plantae

General Characteristics

i.) They are eukaryotic and multicellular.

ii.) In most their body is differentiated into leaves, stem and roots. **iii.)**They reproduce both sexually and asexually.

iv.) Their cells have cellulose cell walls

v.) They have photosynthetic pigment hence are autotrophic.

vi.) Majority have a transport system **vii.)**They show alternation of generation.

The kingdom Plantae is divided into ***three main divisions.***

- Bryophyta.
- Pteridophyta.
- Spermatophyta.

Division Bryophyta

These are the mosses and the liverworts.

General Characteristics

i.) The lack the vascular system **ii.)** Contain chlorophyll and are therefore photosynthetic. iii.) They have rhizoids for anchorage and water and mineral salts absorption. **iv.)** They show alternation of generations.

v.) Fertilisation depends of availability of water. Male gametes are produced by the **antheridia** and female gametes by the *archegonia.*

vi.) They grow on damp substratum such as walls, rocks and marshes.

vii.) They are **thalloid** as in liverworts or differentiated into simple leaf like and stem like structures as in mosses.

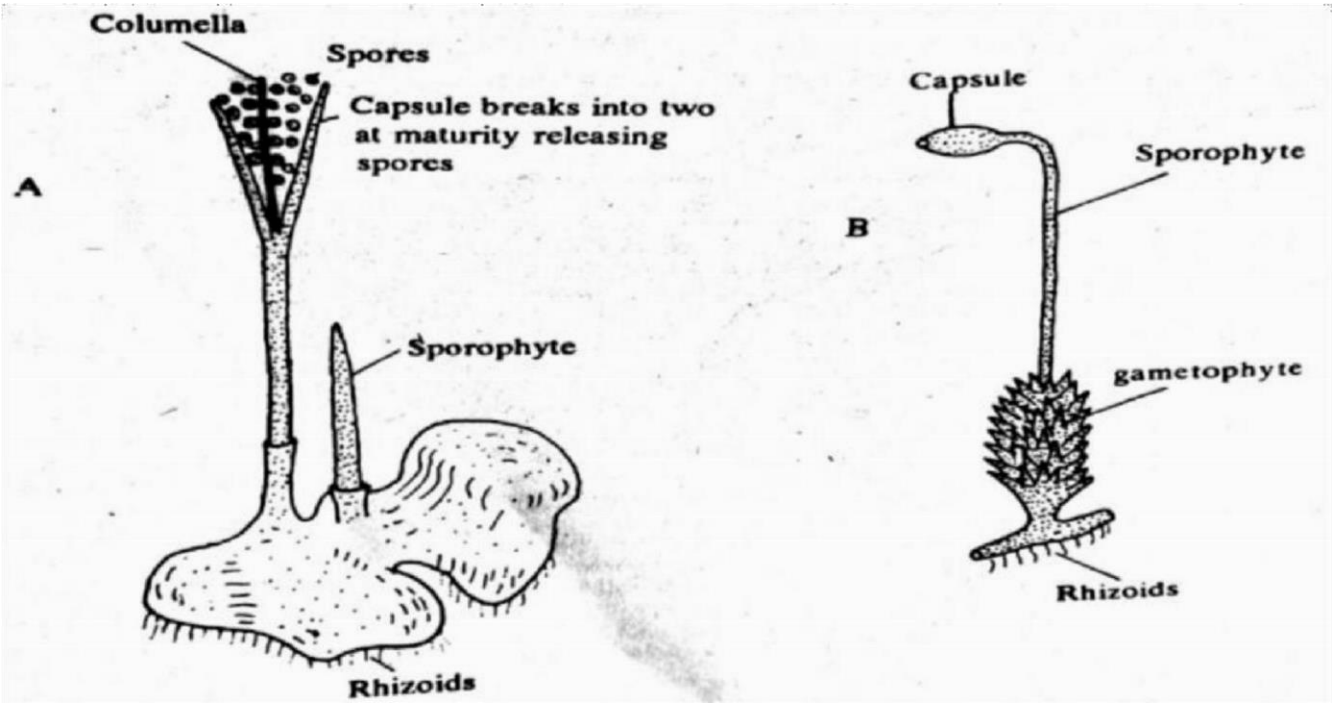


Fig. 1-11 Representatives of the division bryophyta: A, horned liverwort (Anthroceros); B, Moss (Funaria).

Division Pteridophyta

This includes ferns and horsetails.

They are more advanced compared to the bryophytes.

General Characteristics

i.) They have leaves, stems and roots but no flowers.

ii.) They are photosynthetic. **iii.)**They have a clearly defined vascular system made of xylem and phloem. **iv.)** They have compound leaves with leaflets called **pinna.**

v.) On the lower side of mature leaves are the spores bearing structures (sporangia) which occur in groups called **sori** (**sorus-singular**). see diagram.

vi.) They show alternation of generations where the sporophyte (fern plant) is the dominant one while the gametophyte is a heart shaped structure called **Prothallus**. See diagram.

vii.) They have sexual reproduction which is dependent of water.

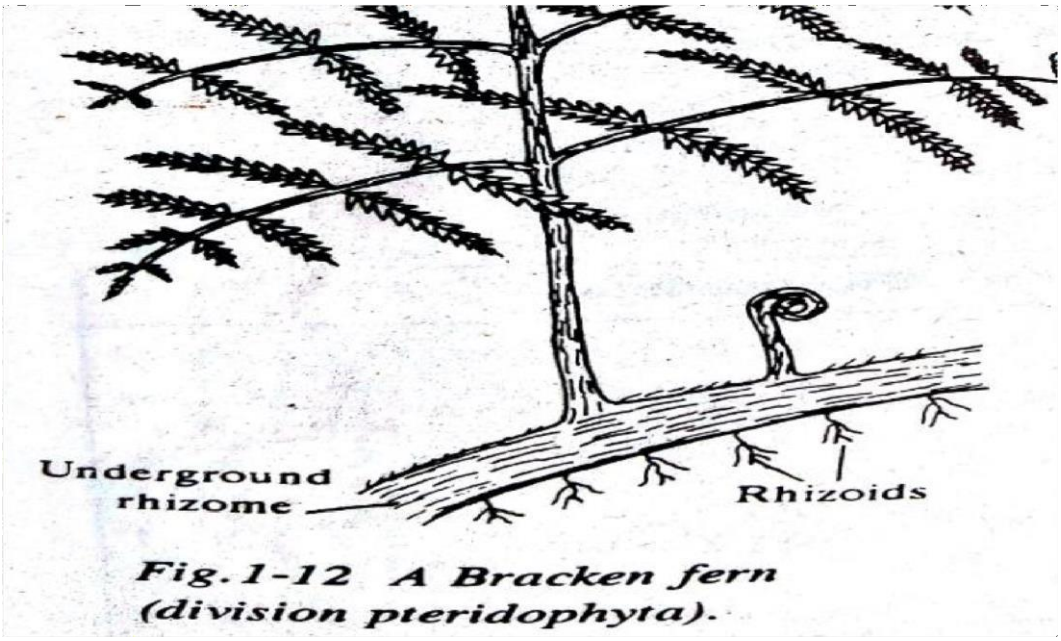


Fig. 1-12 A Bracken fern (division pteridophyta).

Study Question 6
Practical Activity 4
Study Question 7
Practical Activity 5

Division Spermatophyta

This comprises of all the seed bearing plants.

General Characteristics

i.) They contain chloroplasts hence are photosynthetic.

ii.) The plant body is differentiated into roots, stems, leaves and seed bearing structures.

iii.) Vascular system is highly developed with xylem tissue consisting of both xylem vessels and tracheids.

iv.) Sexual reproduction is well defined.

v.) Seeds are produced after fertilisation. **vi.)**
They show alternation of generation.

The division Spermatophyta is made up of two main subdivisions i.e.

- **Gymnospermaphyta**
- **Angiospermaphyta**

Gymnospermaphyta

General Characteristics

- They bear male and female cones.
- After fertilisation seeds are borne on the female cones and they are naked i.e. they are not enclosed in a fruit wall.
- They show xerophytic characteristics such as needle like leaves, rolled leaves, thick waxy cuticle and sunken stomata.
- Phloem doesn't contain companion cells and xylem mainly consists of tracheids.

This subdivision has three main classes.

- Coniferales
- Cycadales Ginkgoales

Class Coniferales

- These include all the common gymnosperms.
- They are found in areas of little water.
- They have small needle-shaped leaves with waxy cuticle.
- They have cones and most of them are ever green.

Male cones are inform of clusters at the**base of the terminal bud**.

- **Female cones are on lateral buds** of young shoots and they contain naked seeds. **Diagrams.**

Class Cycadales

- They resemble the palm trees by appearance.
- They have long compound leaves which are clustered at the apex of a thick short un-branched stem.
- They bear cones at the apex of the trunk.

Class Ginkgoales

- Members here are very rare.
- They include the **Ginkgo biloba** of China. • They are deciduous with fan like leaves.

Angiospermaphyta

General characteristics

- Are usually bisexual and flower bearing.
- Seeds are enclosed in an ovary which develops into a fruit.
- Xylem has tracheids and vessels while the phloem has companion cells.
- They have double fertilisation.

This subdivision is divided into two classes.

 Monocotyledonae. – examples Dicotyledonae. – **examples**

Class Monocotyledonae	**Class Dicotyledonae.**
They have seeds with one cotyledon.	Have two cotyledons.
They have narrow-long leaves with parallel venation.	Broad leaves with reticulate venation.
Most of their leaves have a modified petiole to form a leaf sheath.	Leaves have distinct petioles.
Their stems have scattered vascular bundle.	Vascular bundles are arranged to form a concentric ring.
Pith is usually absent.	Pith is present.
Vascular cambium is usually absent hence no secondary growth.	Vascular cambium is present hence there is secondary growth.
They have a fibrous root system	They have a tap root system

Floral parts are in threes or in multiples of three.	Floral parts are in fours, fives or their multiples.
In the root vascular bundles are arranged in a ring with phloem and xylem alternating.	In roots, the xylem is centrally placed and star shaped with the phloem alternating with the arms of the xylem.

Study question 8

Practical activity 6

v.)Kingdom Animalia

General characteristics

i.) Most show locomotion but a few are sessile **ii.)** Most reproduce sexually and a few asexually **iii.)** They are eukaryotic and multicellular **iv.)** All are heterotrophic

v.) Their cells have no cell walls

Kingdom Animalia has nine phyla but only two will be discussed i.e. Arthropoda and chordata.

Phylum Arthropoda

General Characteristics

i.) They are segmented.

ii.) They are bilaterally symmetrical. **iii.)**They have open circulatory system where blood flows in open cavities called **haemocoel. iv.)** Head is well developed with eyes, sensory structures and a fairly developed brain.

v.) Gaseous exchange is through the tracheal system which opens through the spiracles to the outside. Some aquatic ones use gills.

vi.) Reproduction is mostlysexual with internal fertilization.They have different sexes.

vii.) They have jointed appendages hence the name arthropoda. V **viii.)**They have a body covered with exoskeleton made of chitin.This provides a surface for muscle attachment. It is

shed periodically to allow growth through a process called **moulting**. **ix.)** Most have their body divided into head, thorax and abdomen.

In some, the head and the thorax are fused to form **Cephalothorax**. Thethorax andthe abdomen are all segmented.

The phylum arthropoda is divided into five classes.

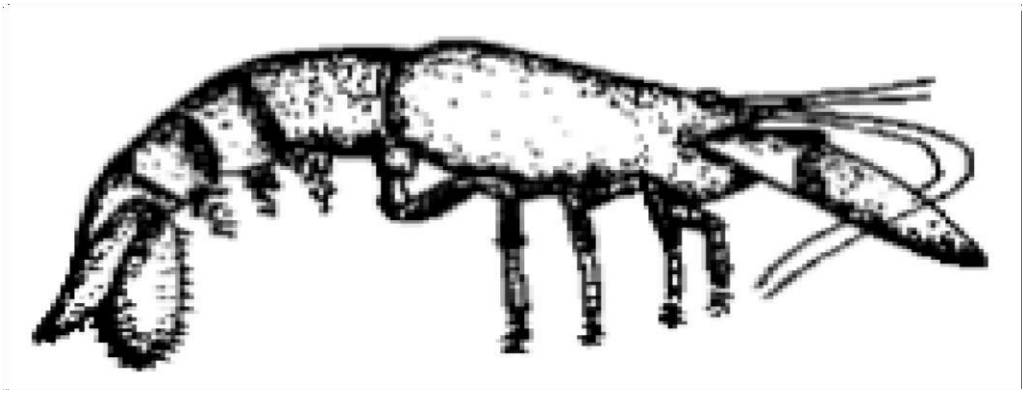
- Crustacea
- Chilopoda Diplopoda Arachnida.
- Insecta.

Different members of the phylum are placed to their respective classes based on;

- Number of limbs
- Presence and number of antennae
- Number of body parts.

Class Crustacea

Examples. Daphnia, crayfish. Crab and prawn.



General Characteristics

i.) Head and thorax are fused to form cephalothorax.

ii.) They have two pairs of antennae.

iii.) They have between five and twenty pairs of limbs modified for different functions e.g. locomotion defence and feeding. **iv.)** They have a pair of compound eyes.

v.) Gaseous exchange is through the gills.

vi.) They have three pairs of mouth parts made of one pair of mandibles (lower) and two pairs of maxillae (upper).

Class Chilopoda

These are the centipedes.

General Characteristics

i.) Body is divided into two parts, the head and the trunk.

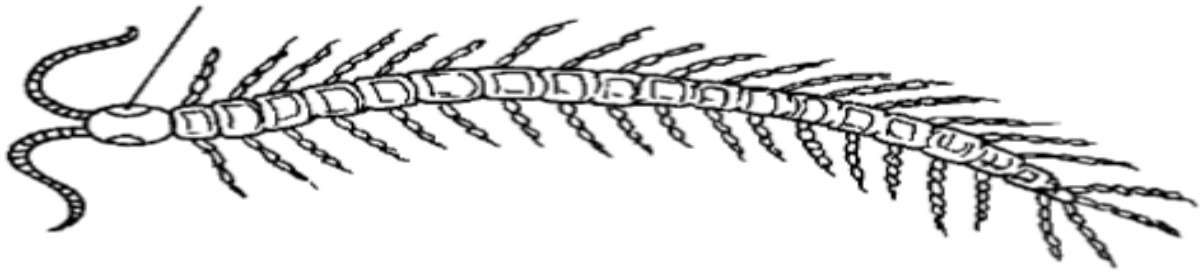
ii.) The body is dorsa-ventrally flattened.
iii.) Body is made up of 15 or more segments.
iv.) Head has a pair of simple eyes.

v.) segment has a pair of walking legs.

vi.) Head has a pair of antennae. **vii.)**Have poison claws n the head and are therefore carnivorous. **viii.)**Have a tracheal system for gaseous exchange. **ix.)** Have separate sexes.

Class Diplopoda

Theseare the millipedes. **Diagram**



General Characteristics

i.) They have cylindrical body.

ii.) Have three body parts, head, and thorax and body trunk. **iii.)**They have two clumps of many simple eyes. **iv.)** They have no poison claws and are therefore herbivorous. **v.)** Heads has a pair of short antennae and mandibles.

vi.) Each body segment has a pair of spiracles for breathing. **vii.)**Body has between 9-100segments. **viii.)**Each segment has two pairs of walking legs except the first thoracic segment.

Class Arachnida

These include the scorpions, spiders, ticks and mites. **Diagrams**

General Characteristics

i.) Body has two parts, cephalothorax and abdomen.

ii.) Cephalothorax has two chelicerae which produce poison to paralyse the prey. **iii.)**Cephalothorax has four pairs of walking legs each having seven joints. **iv.)** At the end of each leg are two toothed claws. **v.)** Cephalothorax has eight simple eyes. **vii.)**They have no antennae but have a pair of pedipalps which are sensitive to touch.

Class Insecta

- ❖ They include grasshoppers, bees, houseflies, butterflies, termites, beetles etc.
- ❖ Insects form half the population of animals on earth. They occupy all habitats i.e. air, water, and land. Their food is varied such as plant tissues, animal fluids, dead animals and excretions of animals making them to be found almost everywhere on earth.

General Characteristics

i.) Body is divided into three parts, head, thorax and abdomen. **ii.)** Thorax is made up of three segments with three pairs of legs.

Some have one or two pairs of wings on the thorax.

iii.) Head has one pair of antennae. **iv.)** They undergo complete or incomplete metamorphosis.

v.) Excretion is through the malpighian tubules which remove uric acid.

vi.) Gaseous exchange is through the tracheal system but they breathe through thespiracles. **vii.)**The head a pair of compound eyes and several simple eyes.

viii.) Abdomen is made up of 11 or fewer segments. The terminal segments are modified for reproduction.

ix.) Mouth parts consist of the mandibles, maxillae and labium.

The mouth parts are modified according to their feeding habits such as sucking, biting, chewing etc.

Assignment

Discuss the economic importance of arthropods. Study Question 10

Phylum Chordata

- Chordate, common name for animals of the phylum Chordata, which includes vertebrates as well as some invertebrates that possess, at least for some time in their lives, a stiff rod called a notochord lying above the gut. About 43,700 living species are known, making the chordates the third largest animal phylum.

- In animals such as the **Amphioxus** the notochord persists but in others it is replaced at later stages of development by the vertebral column.

- Members in this phylum inhabit both aquatic (marine and fresh water) and terrestrial(burrowers and arboreal) environments.

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General Characteristics

i.) Members have a notochord at some stage of their development.

ii.) They are bilaterally symmetrical.

iii.) Heart is ventrally placed. Blood flows from the heart through the arteries and gets back to the heart through the veins. **iv.)** They have a post anal tail although it is greatly reduced in some. **v.)** They have an endoskeleton.

vi.) They have a closed circulatory system.

vii.) They have visceral clefts where in fish they become the gills in higher chordates they are only present in the embryo.

viii.) They have a tubular dorsal nerve cord. It develops anteriorly into brain and posteriorly as the spinal cord. Spinal cord is enclosed by the vertebral column.

ix.) They have segmented muscle blocks called **myotomes** on either side of the body.

The main classes of the phylum chordata are;

- Pisces
- Amphibia Reptilia.
- Aves.
- Mammalia

Pisces

Diagram

These are the fishes. They include those with a skeleton made of cartilage e.g. shark and those with a bony skeleton such as the tilapia, Nile perch, lung fish, dog fish, and cat fish etc.

General Characteristics

i.) The move by fins **ii.)** Bodies are covered with scales **iii.)**Have gills for gaseous exchange in water. **iv.)** They don't have a middle or inner ear.

v.) They have streamlined bodies.

vi.) They have a lateral line for sensitivity.

vii.) Their heart has two main chambers i.e. the auricle and the ventricle. **viii.)**They are poikilothermic/ectothermic. **ix.)** Eyes are covered by a nictating membrane.

Amphibia

They include the toads, newts, salamanders and frogs.

The toad is the most advanced amphibian. Its skin is less moist and therefore uses the lungs more for gaseous exchange. They therefore stay mostly on land and only return to the ponds during reproduction.

Diagrams

General Characteristics

i.) They have a double circulatory system.

ii.) They have a three chambered heart with two atria and one ventricle. **iii.)**Fertilisation is external and they breed in water. **iv.)** Gaseous exchange is through the skin, lungs and gills. **iv.)** They have two eyes and an eardrum behind the eyes. **v.)** They are ectothermic.

vii.) They have 4 well developed limbs. The hind limbs are more muscular than theforelimbs.

Reptilia

Examples include tortoise, turtles, snakes, crocodiles, lizards and chameleons.

General Characteristics

i.) They are ectothermic.

ii.) They have a well developed lung for gaseous exchange. **iii.)**They have double circulatory system with the heart having three chambers i.e.two atria and apartially dividedventricle. Crocodiles however have a four chambered heart. **iv.)** The body is covered with a dry scaly skin reducing desiccation.

v.) Some have four limbs while others don't have any limbs such as the snakes.

vi.) Fertilisation is internal. They lay eggs with a leathery shell to avoid desiccation. Some species of chameleons give birth to young ones.

Aves

Examples include doves, chicken, hawks, eagles and turkeys. They are terrestrial and arboreal while some have been adapted for aquatic life.

General Characteristics

i.) Bodies are covered with feathers for in insulation.
ii.) They have beaks.

iii.) They internal auditory canal/ meatus **iv.)** Fertilisation is internal and they lay hard calcareous eggs. **v.)** They have lungs for gaseousexchange.

vi.) They have air sacs which store air in them reducing their body density for flight. **vii.)**They are endothermic. **viii.)**They have hollow bones. **ix.)** They have scales on their hind limbs.

x.) They have double circulatory system with a four chambered heart.
xi.) The sternum is enlarged to form keel for attachment of flight muscles.

Mammalia

Study Question 11

- Some are arboreal such as the tree squirrels, and some monkeys.

- Some are terrestrial either on the surface of the earth or in tunnels.

- Some are aquatic such as the dolphins and whales.

General Characteristics

i.) They have double circulatory system **ii.)** They have mammary glands hence the name Mammalia. **iii.)**Their body is usually covered with fur or hair.

iv.) They have two eternal ears (pinna) **v.)** They have sweat glands.

vi.) They have lungs for gaseous exchange. **vii.)**They have four limbs. **viii.)**They have a diaphragm which separates the body cavity into thoracic and abdominalcavities.. **ix.)** The brain is highly developed.

x.) They have seven cervical vertebrae at their neck.

xi.) They are endothermic.

xii.) They have heterodont type of dentition where the teeth are differentiated into four types, incisors, canines, pre-molars and molars. The number varies in relation to feeding habits.

- **Although most mammals give birth to live young ones, some are egg laying such as the duck billed platypus. After hatching, the young ones are fed on milk.**

Practical Activity 9

Practical Activity 10.

The Dichotomous Key

- The word dichotomous means separating into two. I.e. Separation ofdifferentorcontradictory things: a separation into two divisions that differ widely from or contradict eachother.

❖ As you move down the key you progress from general characteristics to more specific characteristics. The last single choice reveals the identity of the unknown organism.

Rules Used in Constructing a Dichotomous Key

i.) Use morphological features as far as possible.

ii.) Start with the major characteristics and proceed to lesser variations that separate the organisms into smaller groups.E.g. in leaves start with type of leaf i.e. simple or compound.

iii.) Select a single characteristic at a time and identify it by a number such as.

- Type of leaf
- Type of venation **iv.) Use** identical forms of words for the two contrasting statements e.g.

1. a) leaf simple.

b) Leaf compound 2.

a) Leaf net veined.

b) Leaf parallel veined.

v.) The statements should always be written in positive form.

Where a negative statement cannot be avoided, thefirst statement must be in the positive form e.g.

a) Animal with wings

b) Animal without wings vi.) Avoid overlapping statements or generalizations such as

- Short plants
- Tall plants

Be very specific in your description such as

- Plant I metre tall and above. • Plant 15cm to 60cmtall.

Some common Featres Used For Identification.

- **In animals**

i.) Locomotory structures (legs, wings and fins) **iv.)** Number of bodyparts **v.)** Body segmentation **vi.)** Type of skeleton present **vii.)**Feeding structures

viii.) Presence of hair, fur, scales or feathers on the body **In plants**

Part of plant	Some characteristics.
Leaf	• Phylotaxy • Leaf type • Leaf venation • Margin • Lamina - Colour
Flower	• Inflorescence • Flower shape - Number of floral
Stem	• Type of stem(woody, herbaceous or fleshy) • Shape (rectangular or cylindrical) - Texture of the stem (smooth or spiny/thorny)

Roots	Root system (taproot or fibrous) Storage roots.

ECOLOGY

Introduction

Ecology is the study of the interrelationships of organisms to each other and to their environment (biotic and Abiotic factors). **Autecology**; study of single species within a community and how it relates with both the biotic and Abiotic factors.

Synecology. This is the study of many different species of organisms' interacting among themselves within an ecosystem. Ecology helps to address the following issues.

- Sustainable food production
- Pollution control
- Natural resources conservation
- Pest and disease control
- Population control
- Eco-tourism

- Prediction of adverse weather conditions

Concepts of ecology

- **Biosphere/ecosphere.** This is the part of the earth and atmosphere inhabited by living organisms.

- **Habitat.** This is a specific locality with a particular set of conditions where an organism lives.

  Habitats can be terrestrial or aquatic.

- **Ecological niche.** This is the position occupied by an organism in a habitat. It includes the **physical space** where an organism is found and **its role** in the habitat.

- **Population.** This refers to all members of a given species in particular habitat.
- **Community.** This refers to all organisms belonging to different species interacting in the same habitat. Many populations make up a community.

- **Ecosystem.** This is a natural unit made of biotic and Abiotic factors whose interactions lead to a self sustaining system.

E.g. a tropical rain forest, a small pond etc.

- **Biomass.** This is the total dry weight of living organisms at a particular Trophic (feeding) level or per unit area.

- **Carrying capacity.** This is the maximum number of organisms an area can comfortably support without depletion of the available resources. E.g. the maximum number of cows a pasture land can comfortably hold without overgrazing.

Study Question 1

Factors in an Ecosystem They are divided into two:

1. Abiotic factors or the non living factors

2. Biotic or the living factors

Abiotic Factors

- **Light.** This is required by plants and photosynthetic bacteria to manufacture food. The sun is the source of light energy. Light intensity and quality (wavelength) affects the rate of photosynthesis, flowering and germination in plants, while in animals it affects migration, hibernation and reproduction. Light intensity is measured using a **Photographic Light meter** while a **Seechi disc** measures light penetration in water.

- **Atmospheric pressure.** Variation in atmospheric pressure affects the availability of oxygen and carbon (IV) dioxide in the atmosphere. These two gases in turn affect the distribution of living organisms. Low atmospheric pressure increases the rate of transpiration. Barometer is used to measure it.

- **Humidity.** This is the amount of water vapour in the atmosphere. It affects the rate of water loss from plants and animals surfaces through transpiration and sweating respectively. The higherthe humidity the lower the rate of loss and vice versa. It is measured using the **hygrometer.**

- **Salinity.** This refers to the salt concentration of the water. This divides the aquatic environment into **marine, estuarine and fresh water**. Only organisms with adaptable osmoregulatory features can comfortably occupy such habitats. In estuaries, there are fluctuations of salt concentrations at different times. When the sea tide is low, the salt concentrations are low due to the greater diluting effect of the fresh water being discharged. High tide raises the salt level. Estuarine organisms must therefore be adapted to cope with such wide salt variations.

- **Wind.** This is moving air. It increases the rate of water loss from organisms affecting their distribution. It also influences rain formation. It helps in formation of sand dunes in deserts which become habitats for the growth of deserts plants. Its an agent of seed and fruit dispersal

- **Temperature.** This affects the distribution of organisms in any habitat. Very low temperature may inactivate enzymes whilevery high temperatures denature them. Temperature varies due to seasons, altitude, and latitude and diurnally in hot deserts.

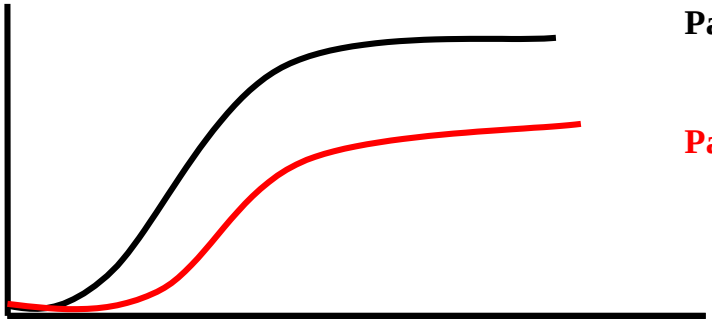
- **pH (hydrogen ion concentration.)**

This is the measure of acidity or alkalinity of water in aquatic habitats or soil solution. This influences the distribution of plants and animals in soil and aquatic habitats. Different organisms have different pH requirements. pH is determined using the pH meter.

Biotic Inter-Relationships Competition

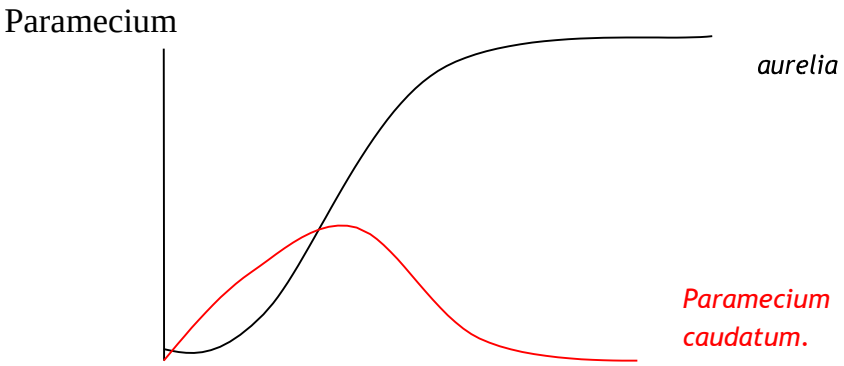
Living organisms compete for resources such as nutrients, space,light and mates. There are two types of competition.

i.) Inter-specific competition. This is the competition between individuals of different species for the same resources. For example. An experiment6 was carried out on two closely related species of paramecia- Paramecium caudatum and Paramecium aurelia. It was observed that when each species is grown separately in controlled cultures with constant food supply, they show normal population growth. When they are grown together in the same culture, thre is competition and Paramecium caudatum is eliminated. See graphs.



Paramecium aurelia

Paramecium caudatum.



However, closely related species can live together without competition. For example, when Paramecium caudatum and Paramecium bursoria are grown in the same culture, there is no competition because each species occupies a different part of the culture. Similarly, browsers and grazers can occupy same habitat without competitionbecause theyfeed at differentlevels of the same plants. For example, the zebras eat the softer shoots, followed by the wild beasts, and the gazelles which eat the fibrous left over of the same grass. **Study Question 4** ii.) **Intra-specific competition.** This is the competition between members of the same species for the same resources. When there is competition the best adapted organisms survive while the less adapted ones may die or be forced to migrate.

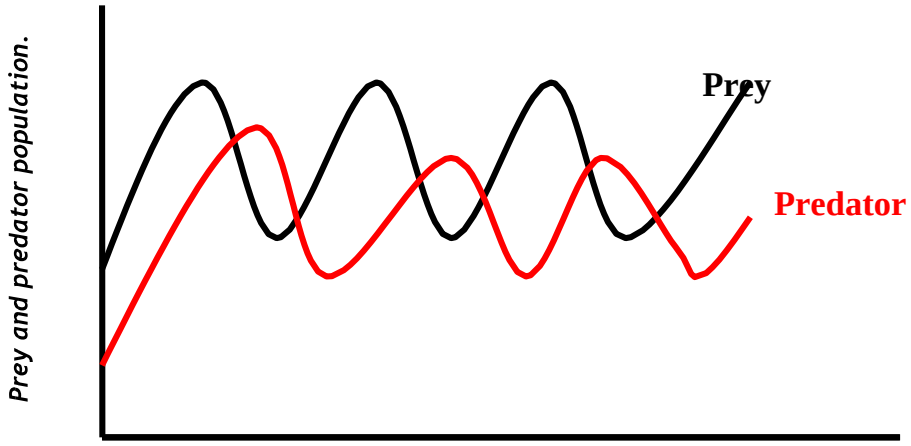
Predation

This is the relationship where one organism kills another for food and feed on it either as a whole or a part of it. The **predator** is the one which kills while the **prey** is the one being killed for food.

Predators have various adaptations to enable them to be efficient in capturing the prey. These include;

- Sharp eyesight as in eagles, kites and hawk
- Fast flight,
- Modified beaks
- Strong jaws with carnassial's teeth as in leopards and lions. ❖ Large claws on strong forelimbs.
- Colour camouflage such as the spotted pattern of theleopard blends well with the background colour of the bushes and trees.
- Moving against the wind while stalking the prey. Preys also have structural and behavioural adaptations. These include:
- Swift movement e.g. the antelope and gazelle

See the graph below.



Parasitism

- ❖ Camouflage e.g. in gazelles and stripes of the zebra.
- ❖ Large eyes on the sides of the head to giving them a wide field of view ❖ Confrontational display in porcupine

NB/. When the numberof the prey increases that of thepredators also increases. An increase in the number of predators leads to a decrease in the population of the prey. This decrease in prey population leads to a fall in predatorpopulation which in turn givesspace for the increase in the population of the prey. This is **the basis of biological control.**

Time

This is the relationship where an organism **[parasite**] obtains nutrients from another live organism **[host]** without killing it. The parasite obtains food and shelter from the host causing some harmful effects. Parasites may weaken the host and also transmit diseases which may kill their host thus reducing their number an d distribution. There are two types of parasites;

- ☐ **Ecto-parasites**
- ☐ **Endo-parasites**

Symbiosis

This is an association between two of different species in which both benefit. For example the association of colon bacteria with humans and other animals, especially plant-eating animals, the ox-pecker bird and the ox etc.

The **Rhizobium** bacteria help the leguminous plants to fix nitrogen while the bacteria obtain shelter and carbohydrates from the plants.

Saprophytism

This is where organisms obtain nutrients from dead organisms causing decomposition hence releasing nutrients into the ecosystem. Saprophytes include the bacteria and fungi.

The Nitrogen Cycle

- This refers to the cycling of nitrogen and its compounds in the natural environment.
- Although nitrogen is abundant in the atmosphere as nirtogen gas, it cannot be utilised by plants. It has to be converted into a form that can be absorbed by plants through a process called **nitrogen fixation.**
- Nitrogen fixation is done in two ways;
- **Biological fixation**. This can occur in two forms

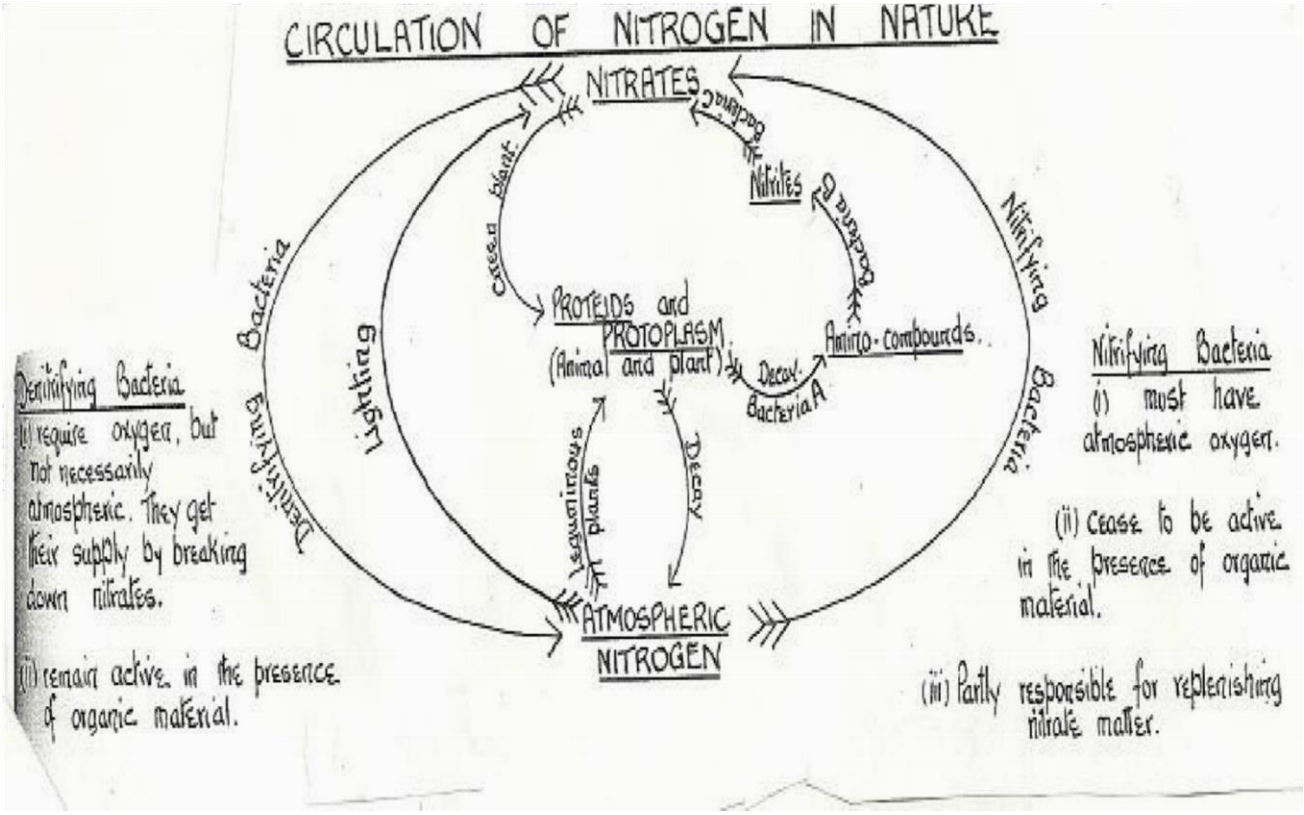
1. **Nitrogen fixation by symbiotic bacteria** such as **Rhizobium spp.** They are found in the root nodules of legumes. They convert nitrogen gas into ammonia which is then converted into nitrates for plant utilisation.

2. **Nitrogen fixation by free living bacteria e.g. Clostridium, Azotobacter, and** some algae such as **Anabaena, chlorella andNostoc.**

- **Non-Biological nitrogen fixation**. This is done by lightning.
- During thunderstorms, lightning energy combines atmospheric nitrogen gas with oxygen to form nitrous and nitric acid. These are then converted into nitrates.
- Plants absorb nitrates and convert them into plant proteins. Animals feed onthese plantsand obtain the proteins. They are then digested into amino acids andbecome assimilated into animal proteins.
- When living organisms die, saprophytic bacteria and fungi break down the proteins in their bodies into ammonia.
- Nitrifying bacteria convert this ammonia into nitrates thorough a process called **nitrification. Nitrosomonas and Nitrococcus** convert ammonia into nitrites and **Nitrobacter** convert nitrites into Nitrates.

- Some soil micro organisms such as **Pseudomonas denitrificans & Thiobacillus denitrificans** utilize the oxygen in the nitrates reducing it to nitrites, ammonia and eventually into nitrogen gas. This is called **de-nitrification.**

This reduces the amount of nitrogen available to plants buit frees the nitrogen so that it becomes *available for the cycle to continue.*



Energy Flow in an Ecosystem

The sun is the natural source of energy. This energy is transferred to the following feeding levels;

- Producers
- Primary consumers
- Secondary consumers

- Tertiary consumers
- Quaternary consumers
- These feeding levels are called **Trophic levels**

Decomposers

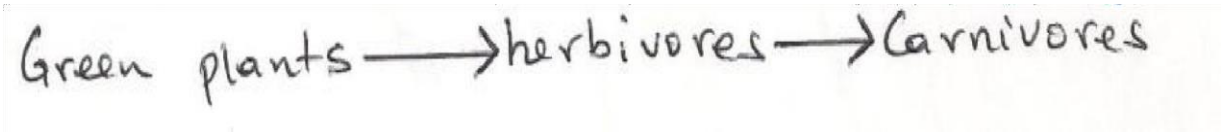
They break down organic materials into simple substances which are made available for re-use by other organisms.

Decomposers are mainly fungi and bacteria. **Food Chains**

This is the representation of energy flow from a producer to other organisms linearly. Green plants are eaten by herbivores which are eaten by carnivores.

Producers' ▶ Primary consumers ▶ Secondary consumers ▶ Tertiary consumers ▶ Quaternary consumers

Some energy is lost as it is moved from one trophic level to the next. This is through respiration, defecation, excretion and in form of heat.



Examples

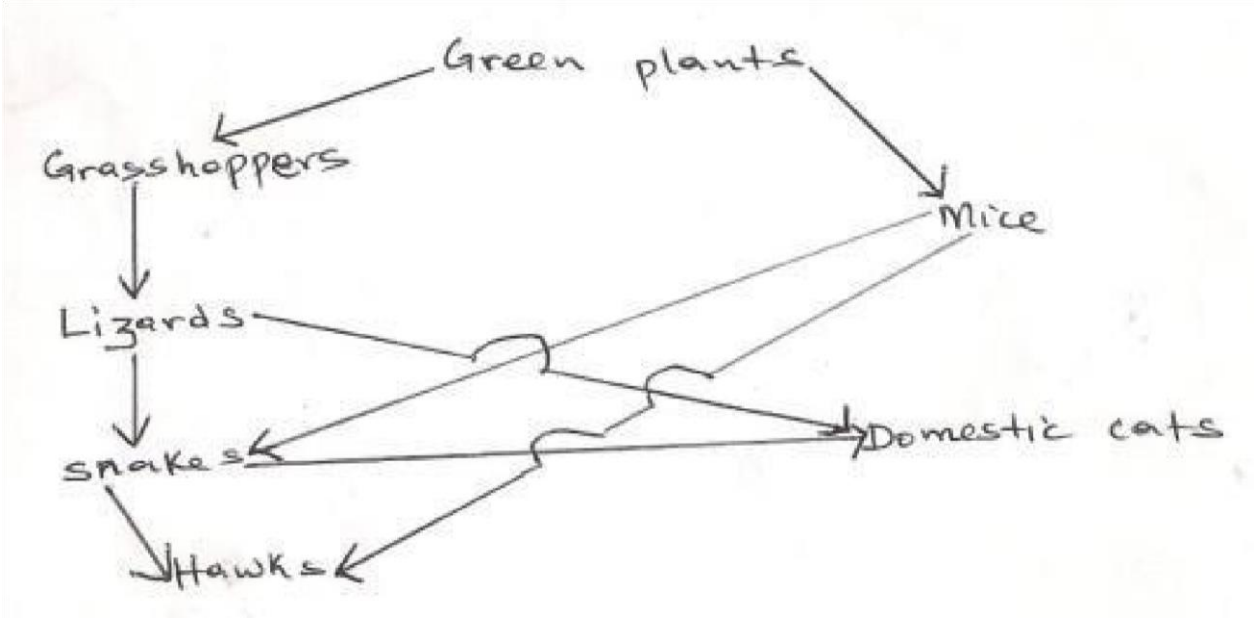
When the decomposers are included in a food chain, they are placed at theend.

Food Webs

These are several interconnected food chains. Simple food chains rarely exist since in any ecosystem, many populations interact.

Examples

Study Question 8



Ecological Pyramids

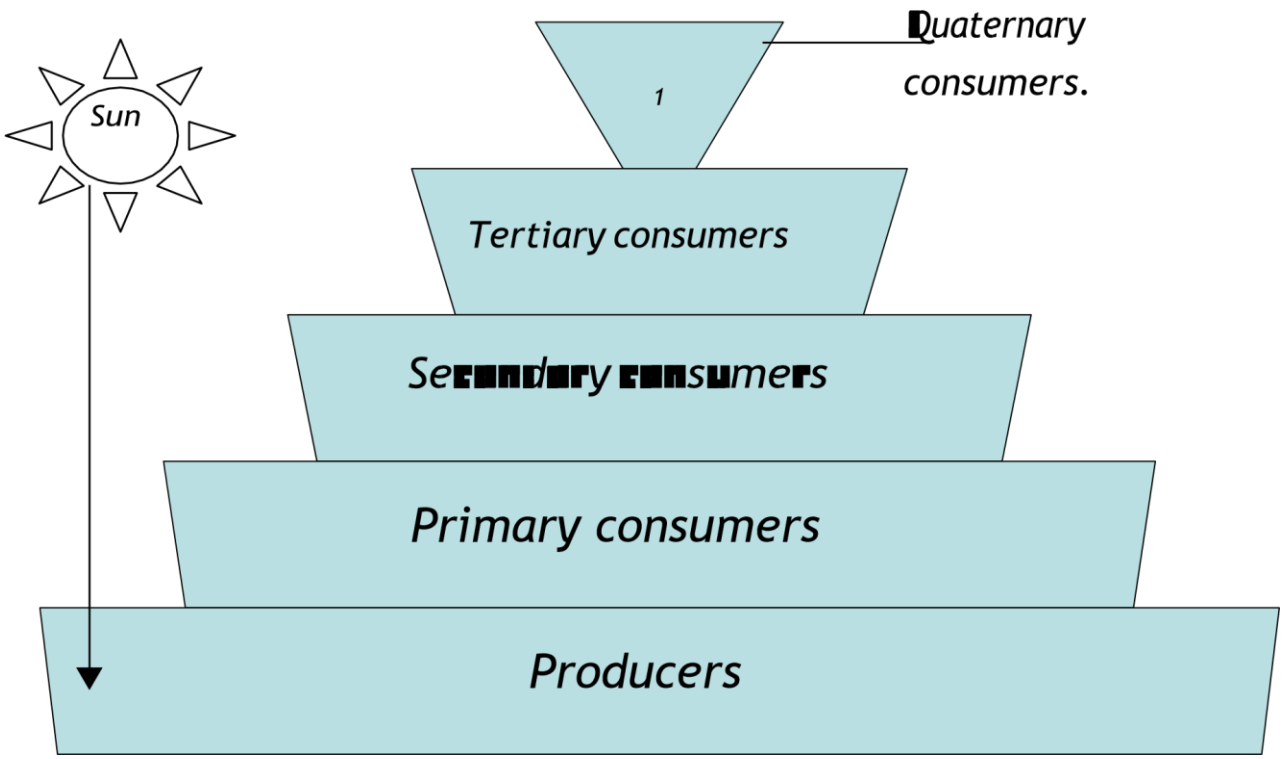
These give a simplified representation of feeding relationships and energy flow in an ecosystem.

They are of three types.

- **Pyramid of numbers**
- **Pyramid of biomass**
- **Pyramid of energy**

Pyramid of Numbers

There is a progress decrease in the number of organisms as one move from the producers all the way to the quaternary consumers. Producers have the greatest number followed in a decreasing order by primary, secondary, tertiary and quaternary consumers.



Construction of Pyramid of Numbers

i.) Use data provided or collected.

ii.) From the data, identify and draw the most suitable food chain. **iii.)**Indicate the numbers at each trophic level in the food chain. **iv.)** Choose a suitable scale for the data.

v.) Using the chosen scale draw a horizontal rectangular bar to represent the number of the producers as the base of the pyramid.

vi.) Progressively draw horizontal bars of the other trophic levels in their ascendingorder.

Ensure that the width ofthe bars is uniform. Study Question 9

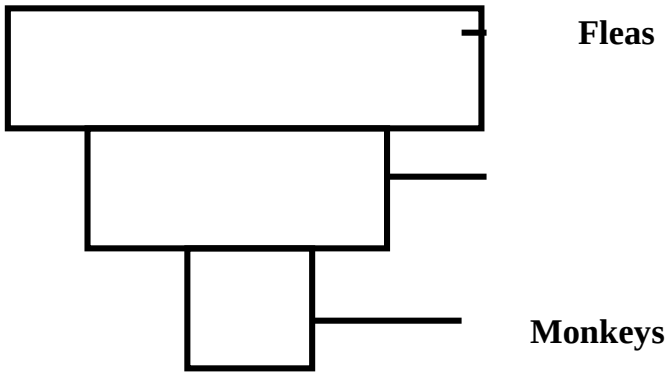
Interpretation of Pyramid of Numbers

- Generally the body size of organisms increases at each trophic level from the base to the apex of the pyramid as their number decreases.

- At each trophic level much energy is lost through respiration, excretion, sweating, defecation etc.

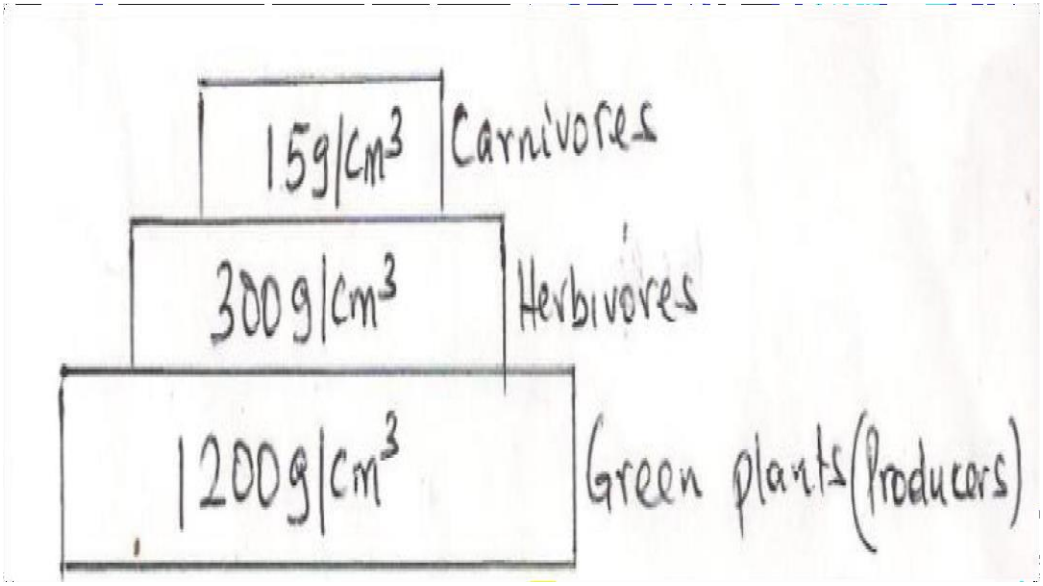
  therefore less energy is transmitted to the succeeding trophic level. Fewer organisms can therefore besupported.

- Inverted pyramid of numbers also exist. For example where one mango tree supports several monkeys each being fed on by several fleas.



Pyramid of Biomass

Biomass of an organism is its constant dry weight. In an ecosystem, the producers have the highest biomass followed in decreasing order by primary, secondary, tertiary and quaternary consumers.



Population

Populations change in size, structure and organisation.

Characteristics of apopulation.

- **Density.** This is the number of individuals per unit area. E.g. 50 gazelles per Km^2.
- **Dispersion.** This is the distribution or spread of organisms in a habitat.
- **Population growth.** This refers to the rate of increase in numbers.

Population Estimation Methods

Usually a representative sample is used to estimate the population of organism in a big habitat. A sample is a small number of individuals taken from the habitat that is a representative of the whole population. The following methods are used when sampling.

- Quadrat method.
- Line transect.
- Belt transect.
- Capture-recapture method.

Quadrat Method

- A Quadrat is a square, made of woos metal/hard plastic.
- It can also be established on the ground using pegs, rope/permanent coloured ink, using metre rule or measuring tape.
- The size is usually one square metre ($1M^2$), in grassland.
- In wooded or forest habitat it is usually larger, and can reach upto 20 m^2 depending on particular species under investigation.
- The number of each species found within the quadrat is counted and recorded.
- Total number of organisms is then calculated by, finding the average quadrats and multiplying it with the total area of the whole habitat.
- The number of quadrats and their positions is determined by the type of vegetation studied.
- In a grassland, the quadrat frame can be thrown at random.
- In other habitats of forest, random numbers that determine the locus at which to establish a quadrat are used.

Line Transect

- A line transect is a string or rope that is stretched along across the area in which all the plants that are touched are counted.
- It is tied on to a pole or tent peg.
- It is particularly useful where there is change of populations traversing through grassland, to woodland to forest land.
- This method can also be used in studying the changes in growth patterns in plants over a period of time.

Belt Transect

- Two line transects are set parallel to each other to enclose a strip through the habitat to be studied.
- The width is determined by the type of habitat, i.e., grass or forest and by the nature of investigation.
- In grassland it can be 0.5 m or 1 m.
- Sometimes it can be 20 metres or more especially when counting large herbivores.
- The number of organisms within the belt is counted and recorded.

Capture-recapture method

- This is used for animals such as fish, rodents, arthropods and birds.
- The animals are caught, marked, counted and released.
- For example, grasshoppers can be caught with a net and marked using permanent ink.
- After sometime, the same area is sampled again, i.e., the grasshoppers are caught again.
- The total number caught during the second catch is recorded.

The number of marked ones is also recorded:

- Let the number caught and marked be a.
- The total number in the second catch be b.
- The number of marked ones in the second catch be c.
- The total number of grasshoppers in the area be T.

The total number T can be estimated using the following formula: Total Number =

$$\frac{\text{Number caught during the first catch} \times \text{number caught in the second catch}}{\text{Number marked in second catch}}$$

$$\text{OR } T = \frac{a \times b}{c}$$

The following assumptions are made:

- No migration, i.e., no movement in and out of the study area.

- There is even distribution of the organisms in the study area.
- There is random distribution of the organisms after the first capture.
- No births or deaths during the activity.

After the estimation, the results can be used to show anyone of the following population characteristics:

Density:

- Density is calculated by dividing the number of organisms by the size of the area studied.

Frequency:

- Frequency is the number of times that a species occurs in the area beingstudied.

Percentage Cover:

- This is the proportion of the area covered by a particular species.
- For example, a given plant species may cover the whole. of a given area.
- In this case the plant is said to have 100% cover.

Dominance:

- This is the term used to describe a species that exerts the most effect on others.
- The dominance may be in terms of high frequency or high density.

Adaptations of plants to various Habitats

An adaptation is a **change to suit environment:** the development of physical, physiological or behavioural characteristics that allow organisms to survive and reproduce in their habitats. There are four main groups of plants namely; Xerophytes.

- Mesophytes.
- Hydrophytes.
- Halophytes.

Xerophytes

These are plants adapted to survive in the dry habitats. These habitats have the following characteristics.

i.) Unpredictable and poorly distributed rainfall between 250- 350mm per year.

ii.) Very high day temperatures and very low night temperatures hence high diurnal temperature range.

iii.) They are very windy. **iv.)**
Low humidity.

Adaptations of Xerophytes

i.) Shedding of leaves during the dry season to reduce the surface exposed totranspiration.

ii.) Reduced leaves in size such as in pine or modified into spines as in cactus. This reduces the surface area over which transpiration occurs.

iii.) Leaves have a thick waxy cuticle to reduce the rate of transpiration. **iv.)** Some store water in large parenchyma cells contained in succulent stems and leaves. **v.)** Some have reversed stomatal rhythm**.**

vi.) Sunken stomata **vii.)**Folded leaves

reduced the surface area.

viii.) Reduced number of stomata **ix.)** Some have deep roots to

absorb water from deep in the soil.

Others have superficial roots growing horizontally close to the surface to absorb water after a light

Mesophytes

These are plants growing in well watered areas. Such habitats have the following general **characteristics.**

- Adequate rainfall; 950-1800mmthat is well distributed throughout the year.
- Relatively high humidity
- Thick clouds

- Moderate to high temperatures
- Shallow water table
- Less windy

Adaptations of Mesophytes

They show various adaptations depending on where they grow. Some of these adaptations are for reduction of water loss, others for increased water, loss and some are also adapted to light conditions.

Forest Ecosystem

i.) Vegetation grows fast to compete for light. ii.) Trees grow very tall to compete for light.
iii.) Some develop buttress roots or prop roots for extra support *such as the* ***Ficus natalensis.***
iv.) Climbers such as lianas support themselves on stems of tall trees to reach light.

v.) Epiphytes support themselves on the branches of tall trees. vi.) Others are adapted to carry out photosynthesis under low light intensity by having many chloroplasts that are sensitive to low lightintensity. **vii.)** They show leaf mosaic pattern to minimise overlapping enhancing trapping of light for photosynthesis.

- **Those in areas with a lot of water have broad leaves, thin cuticle and many stomata on both surfaces to encourage high rate oftranspiration.**

- Those in dry areas have waxy and shinycuticle toreflect light. Others are deeprooted to obtainwater fromdeep in the soil.

Hydrophytes

These are plants growing in fresh water either partially or wholly. Such habitats have the following general characteristics.

- Low concentration of dissolved gases such as oxygen
- Presence of waves andcurrents
- Inadequate light in water

Hydrophytes (Water plants) are either submerged, emergent or floating.

Submerged Plants

- The leaves have an epidermis with very thin walls and a delicate cuticle.
- They have no stomata.
- Water is excreted from special glands and pores at the tips.
- Other adaptations include the following:
- Presence of large air spaces and canals (aerenchyma) for gaseous exchange and buoyancy.
- Some plants have filamentous leaves In order to increase the surface area for absorption of light, gases and mineral salts.
- Some plants are rootless, hence support provided by water.
- Mineral salts and water absorbed by all plant surfaces.
- In some plants, the stem and leaves are covered with a waxy substance to reduce absorption of water. e.g. Ceratophyllum and Elodea sp.

Floating Plants

- Their structure is similar to that of mesophytes.
- The leaves are broad to increase the surface area for water loss.
- They have more stomata on the upper surface than on the lower surface to increase rate of water loss.
- Examples are Pistia sp. (water lettuce), Salvinia and **Nymphea.**

Halophytes

These are plants which are able to tolerate very salty conditions in soil and marine water. Such habitats have the following general characteristics.

- High concentration of mineral salts
- Low concentration of dissolved gases
- Low light intensity in marine water
- Presence of waves and currents in marine water

Adaptations of Halophytes

i.) They root cells which concentrate a lot of salts to enable them to absorb water by osmosis.

ii.) Some have salt glands that secrete excess salts.
iii.) Many have water storage tissues.

iv.) Some like the mangroves have breathing roots called **pneumatophores.** These rise above the water surface to obtain oxygen from the atmosphere.

v.) Mangroves growing on mud flats have buttress roots for support.

vi.) Submerged halophytes are adapted to photosynthesise under low light intensity.

vii.) Their fruits are adapted for dispersal by having ***aerenchymatous*** *tissue for air storage to make them buoyant.*

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