BIOLOGY NOTES FOR S2

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Table of contents

TOPIC AREA 1: BIODIVERSITY AND CLASSIFICATION

Sub-topic Area: Classification of living things

Unit 1: Classification of kingdom Animalia

Key Unit Competence: To be able to classify animals into their main groups based on external features.

Knowledge and understanding	Skills	Attitudes and values
⁾ State the characteristics of all animals. ⁾ Identify the common features of chordates (fish, amphibians, reptiles, birds and mammals). ⁾ Explain adaptations of chordates, limited to fish and birds, to their environments. ⁾ State the classes of the phylum arthropod and outline their main characteristics. ⁾ Explain the economic importance of arthropods to humans. ⁾ State other phyla of kingdom Animalia and give examples of each. (Platyhelminthes; nematodes, annelids, molluscs, coelenterates / cnidarians, porifera/ sponges, echinoderms.)	⁾ Distinguish different groups of animals using observable features.	⁾ Appreciate the existence of animal diversity and increasing complexity from lower organisms to higher animal groups. ⁾ Appreciate the need for classification of animals.

ACTIVITY 1.1:

- In groups, learners observe different animals from their surrounding/field and record observable characteristics among them.
- In groups, observe external features of a fish, an amphibian, a reptile, a bird and a mammal and present what they observed.
- Engage the learners to discuss the adaptations of fish and birds to their environments.
- Learners collect or observe the provided specimens of arthropods to draw out differences among them.
- In groups, learners discuss the economic importance of arthropods to humans.
- Learners make research from the library or internet about different phyla in the kingdom Animalia and come up with examples in each group.

1.1.General characteristics of animals

- Animals are multicellular organisms
- Animals are heterotrophic organisms
- They are eukaryotic organisms.
- Cells do not have cell walls
- cells that are differentiated to form tissues and organs
- Cells do not have chloroplasts and cannotphotosynthesize
- Communication is by the nervous system
- Most animals reproduce sexually with the diploid stage usually dominating the life cycle.

1.2.The phylum chordata

The name chordate refers to the **notochord**: a firm, flexible rod of tissue located in the dorsal part of the body. At some stage of the development, all chordates have a notochord, as well as a **dorsal nerve cord**, **pharyngeal pouches** and a **post anal tail**.

The dorsal nerve cord is a hollow tube lying just above of the notochord. Pharyngeal pouches are small out pockets of the anterior part of the digestive tract. The post anal tail consists of muscle tissue and lies behind the posterior opening of the digestive tract.
A few chordate species retain their early chordate characteristics all their lives. In most vertebrates, a subphylum of the chordates, the dorsal nerve cord develops into the brain and spinal cord which runs within the hollow backbone. In aquatic vertebrates such as fishes, the pharyngeal pouches have evolved into gills which are used for breathing. In terrestrial chordates, the pouches evolved into a variety of structures including the jaws, inner ear, and tonsils.
The notochord or backbone extends into the post anal tail, and muscles in the tail can cause it to bend. The post anal tail provides much of the propulsion in many aquatic chordates. Invertebrates in other phyla lack this form of propulsion, because the anus, if present is located at the end of the body.

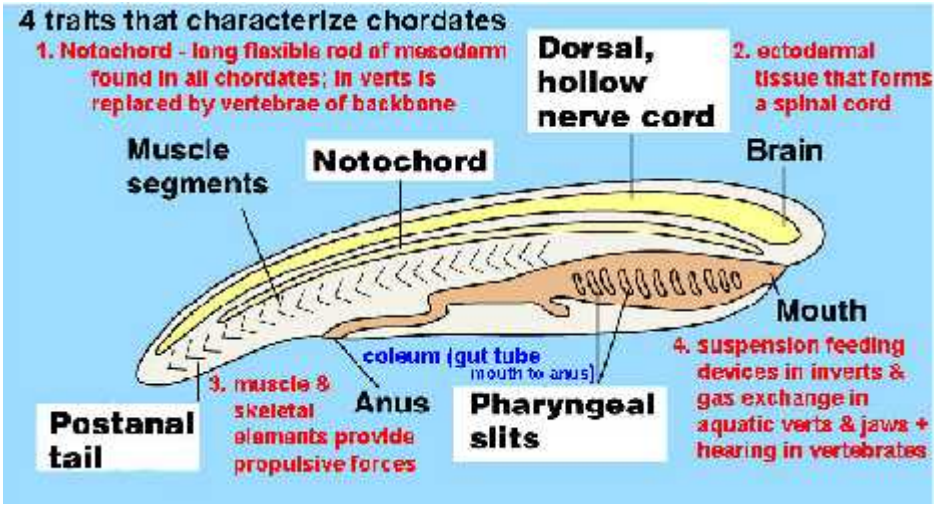


Fig 1.1: General structure of a chordate

In vertebrates, the nerve cord develops into the brain and spinal cord before birth. The notochord is a flexible rod right below the nerve cord. In most vertebrates, the notochord becomes the vertebral column that surrounds the spinal cord.

The pharyngeal pouches develop into gills, and disappear before birth in animals without gills. The post anal tail develops into a tail, or disappears before birth, as in the case of humans.

1.2.1. Classification of chordates

The phylum chordate is divided into **three subphyla**: **VERTEBRATA, CEPHALOCHORDATA** and **UROCHORDATA.**
Members of the subphylum vertebrata, vertebrates, constitute more than 95 % of all chordate species. Vertebrates will be described below.

1.2.2. Vertebrates

Although the vertebrates are not the largest or most abundant group of animals, they are the most familiar to us. This is partly because we are vertebrates. Vertebrates are also an important part of our diet.

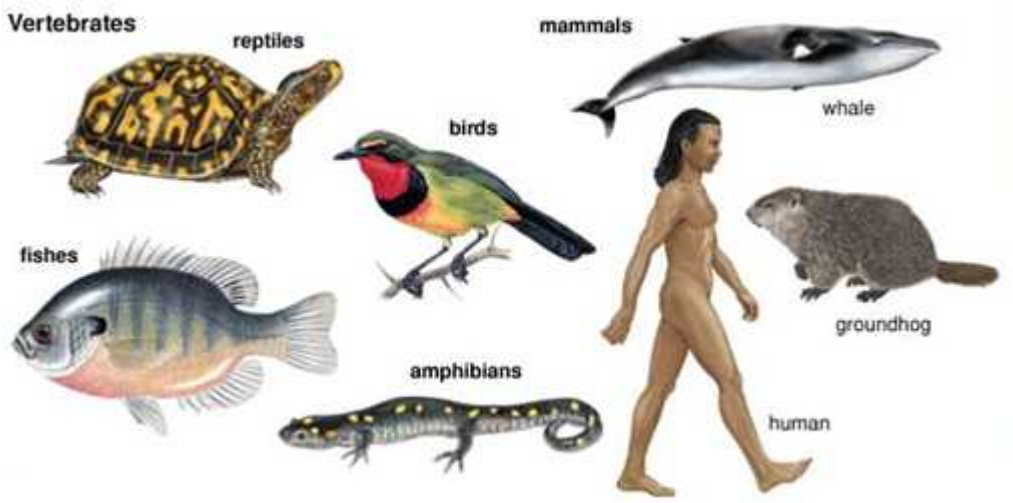


Fig 21.1: Some vertebrates

❯ *Characteristics of vertebrates*

Vertebtates are one subphylum within the phylum chordata. Like other chordates, vertebrates have at some stage of life a notochord, pharyngeal pouches and a post anal tail. Vertebrates are a distinct group because they have three characteristics that distinguish them from other chordates.

- First vertebrates have vertebrae, bones or cartilage that surround and protect the dorsal nerve cord. The vertebrae form the vertebral column or spine.
- Vertebrates have a cranium or skull that protects the brain.
- All vertebrates have an endoskeleton composed of bone or cartilage.

❯ *Classification of vertebrates*

Today, there are 45,000 species of vertebrates. They occupy the most extreme terrestrial habitats. More than 24,000 vertebrate species are fishes. Fishes are found in a wide range of water habitats. The major groups of vertebrates are summarized below:

- **CLASS FISHES**: most familiar fishes such as salmon, bass… All have jaws and most species have a skeleton composed of bone, a body covered by scales, move using fins, respiration through gills… There are over 23,000 species of fishes.

- **CLASS AMPHIBIA or AMPHIBIANS**: frogs, toads and salamanders belong to this group. Their skin is thin and is permeable to gases and water. Most species lay their eggs in water and pass through an aquatic larval stage.

- **CLASS REPTILIA or REPTILES**: This group includes turtles, crocodiles, lizards and snakes. The skin of reptiles is dry and scaly. The eggs of reptiles protect the embryo from drying out and can be laid on land. There about 6,000 species.

- **CLASS AVES or BIRD**S: Birds are characterized by adaptations that enable flight; including feathers, hollow bones, and a unique respiratory system. There are over 10,000 species.

- **CLASS MAMMALIA or MAMMALS**: humans, cats, mice and horses are among the members of this group. All these animals have hair and nurse their young with milk. There are about 4,000 species.

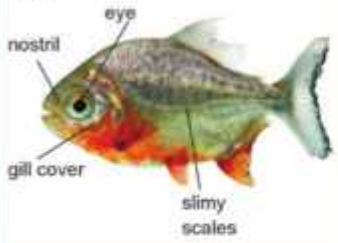
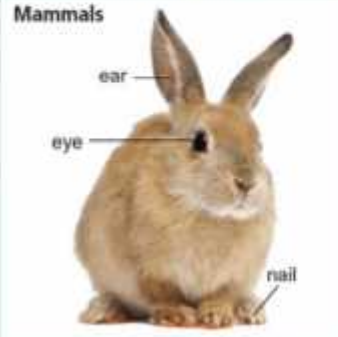
Classes of vertebrates	Characteristics
Fish  	• Live in fresh water or sea water. • Body is covered with **slimy scales**. • **Fins** and tails are used to swim and balance the body. • Breathe through **gills**. • **Cold-blooded** (poikilothermic). Body temperature changes according to the surrounding temperature. • **Lay eggs**. • Examples: Gold fish, eels, mackerels.
Amphibians  	• Can live on land and in the water. • Have **moist and exposed skin**. • **Cold-blooded** (poikilothermic). • **Lay eggs**. • Tadpoles breathe through gills and live in water while adult frogs live on land and breathe through **lungs** as well as moist skin. • Examples: Frogs, toads, salamanders, newts.
Reptiles  	• Have dry and scaly skin. • Mostly **lay eggs**. • **Cold-blooded** (poikilothermic). • Most have two pairs of legs except snakes. • Breathe through **lungs**. • Examples: Crocodiles, tortoises, turtles, lizards, snakes, monitor lizards.
Birds  	• Live on land. • Body is covered with **feathers**. • Have a pair of **wings** • Some birds can swim, such as ducks and penguins. • **Lay eggs** and eggs have hard shells. • **Warm-blooded** (homoiothermic). Body temperature remains constant and does not change with surrounding temperature. • Breathe through **lungs**. • Examples: Kiwis, pigeons, eagles, parrots.
Mammals  	• Most live on land, except whales and dolphins live in water. • Body is covered with **hair** or **fur**. • Skin has sweat glands. • **Warm-blooded** (homoiothermic). • Females have **mammary glands** to provide milk for the young. • The females give birth to live young except platypus which lay eggs. • Breathe through **lungs**. • Examples: Human, monkeys, rabbits, cows, giraffes, whales, bats.

Fig 1.2: The five classes of vertebrates

Table 1.1: A comparative summary of the vertebrate classes

FISHES	**CLASS AMPHIBIA (amphibians)**	**CLASS REPTILIA (reptiles)**	**CLASS AVES (birds)**	**CLASS MAMMALIA (mammals)**
Body covered by scales	Soft moist skin can be used for gaseous exchange to supplement lungs	Dry scaly skin with horny scales	Skin bears feathers, legs have scales	Skin bears hair with two types of glands, sebaceous and sweat
Paired pectoral and pelvic fins	Two pairs pentadactyl limbs	Two pairs pentadactyl limbs usually present	Two pairs pentadactyl limbs, front pair form wings	Two pairs pentadactyl limbs
No metamorphosis	Metamorphosis from larva to adult in life cycle	No metamorphosis	No metamorphosis	No metamorphosis
No external ear	No external ear	No external ear	No external ear	External ear (in addition to middle and inner ear)
Respiration by gills	Respiration by gills (tadpoles), lungs and skin (adults)	Respiration by lungs	Respiration by lungs	Respiration by lungs
Eggs produced, external fertilization	Eggs produced, external fertilization. Adults must return to water for reproduction	Fertilized yolk eggs laid on land or eggs retained until hatching. Eggs have a leathery skin. Internal fertilization	As reptiles but eggs in calcacerous shells, internal fertilization.	Embryo develops in mother. Mother has mammary glands which produce milk for the newborn. Internal fertilization.
Ectothermic	Ectothermic	Ectothermic	Endothermic	Endothermic
e.g. Tilapia, herring	e.g. Frogs, toads	e.g. Snakes, crocodiles, tortoises	e.g. Eagle, doves, chickens	e.g. Human, dogs, lions

1.3. Invertebrates

Invertebrates are animals without backbones. For example earthworms, crabs, houseflies and snails.

1.4. The phylum arthropoda

An **arthropod** is an invertebrate animal having an exoskeleton (external skeleton), a segmented body, and jointed appendages. Arthropods are members of the phylum **Arthropoda** (from Greek *árthron*, "joint", and *podós* "leg", which together mean "jointed leg"), and include the insects, arachnids, crustaceans, and others. Arthropods are characterized by their jointed limbs and cuticles, which are mainly made of chitin; the cuticles of crustaceans are also bio mineralized with calcium carbonate. The rigid cuticle inhibits growth, so arthropods replace it periodically by molting. The arthropod body plan consists of repeated segments, each with a pair of appendages.

Arthropods have adapted to life on land, at sea, and in the air. As plant pollinators, nutrient recyclers, and prey for other animals, they are essential members of the web of life. If all arthropods suddenly were to perish, thousands of animals and plants that depend on their services soon would vanish as well.

Many arthropods, including shrimp, lobsters, and crabs, are harvested as food for people throughout the world. Other arthropods provide the ingredients for fabric dyes, wood preservatives, and medicines. Members of one arthropod class in particular—insects—can be formidable pests, devouring crops, destroying wood structures, and spreading malaria and other life-threatening disease.

Characteristics of arthropods

The main features of arthropods are as follows:

- They are segmented and bilaterally animals.
- They have an exoskeleton made of chitin.
- They have an open circulatory system.
- Each segment has a pair of jointed appendages.
- Reproduction usually involves larval or immature forms

Classification of arthropods

Traditionally, living arthropods are classified among three subphyla: **the Chelicerata, Crustacea**, and **Uniramia.Trilobites,** a fourth subphylum, flourished during the Cambrian and Ordovician periods of the Paleozoic Era (570 million to 435 million years ago) but became

extinct by the mid-Permian Period (about 250 million years ago), for reasons that are not fully understood.

Chelicerata, named for their ***chelicerae***, or **specialized mouthparts**, include scorpions, spiders, ticks, mites, and horseshoe crabs. *These creatures have six pairs of appendages, one or two body regions, and lack wings and antennae.* Most live on land, although a few are aquatic.

With a few exceptions**, the Crustacea** are **aquatic**, occupying both freshwater and saltwater niches. Familiar crustaceans include shrimps, lobsters, and crabs. *All crustaceans have ten limbs, two body regions, and two pairs of antennae*. Many of the smallest crustaceans are zooplankton—drifting or weak-swimming animals that form the base of most marine food webs.

The Uniramia include centipedes, millipedes, and insects.*Centipedes have wingless, multisegmented bodies, with one pair of legs on each body segment*. *The bodies of millipedes are also wingless and multisegmented but have two pairs of legs per segment. Insects have three pairs of legs, one pair of antennae, and may be wingless or have one or two pairs of wings*. The majority of insects are land-dwellers, although some live in freshwater or marine environments.

Table 1.2: Classes of the phylum arthropoda and their characteristics

CLASS CRUSTACEA (crustaceans)	**CLASS INSECTA (insects)**	**CLASS CHILOPODA (centipedes)**	**CLASS DIPLOPODA (millipedes)**	**CLASS ARACHNIDA (arachnids)**
Mainly aquatic	Mainly terrestrial	Mainly terrestrial	Terrestrial	Terrestrial
2 body parts	3 body parts	2 body parts	2 body parts	2 body parts
Two pairs of antennae	One pair of antennae	One pair of antennae	One pair of antennae	No antennae
Larval forms occurs	Life cycle commonly involves metamorphosis with a larval stage	No larval form	No larval form	No larval form
Number of legs variable, sometimes 10	Three pairs of legs on thorax, one per segment	Numerous legs, all identical, one pair per segment.	Numerous legs, all identical, two pairs per	Four pairs of walking legs

			segment.	
Typical gas exchange by gills, outgrowths of the boy wall or limbs	No gill in adults. Gaseous exchange by tracheae	Gaseous exchange by tracheae	Gaseous exchange by tracheae	Gaseous exchange by book lungs or tracheae
Eg: crayfish, lobsters, barnacles, woodlice	Eg: Flies, grasshoppers, bees, earwings	Mainly carnivorous Eg: Lithobius (centipede)	Mainly herbivorous Eg:Iulus (millipede)	Eg:Scorpion, ticks, spider

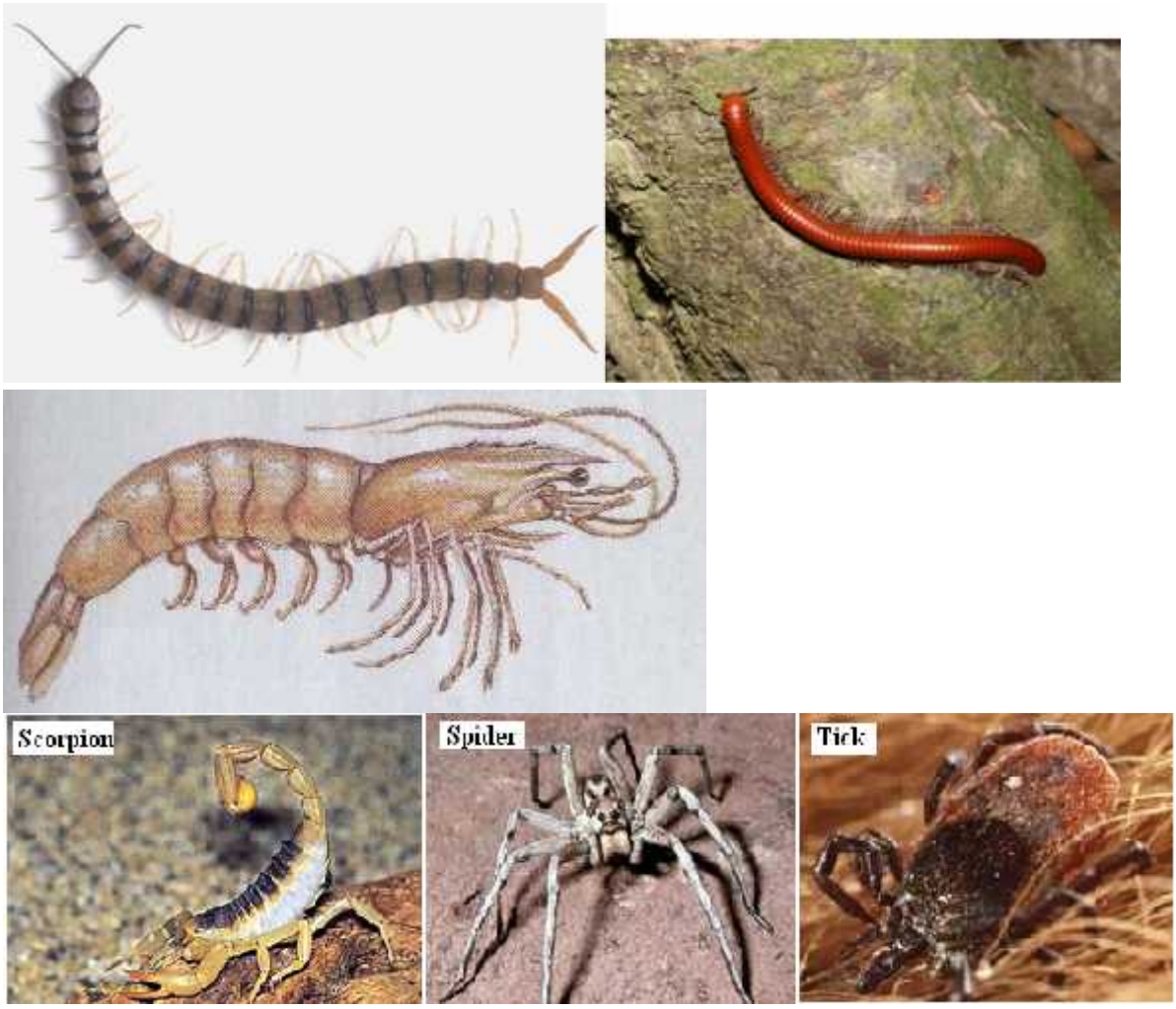


Fig 1.3: Arthropods

Importance of arthropods

Arthropods are of great direct and indirect importance to humans. The larger crustaceans—shrimps, lobsters, and crabs—are used **as food throughout the world**. Small planktonic crustaceans, such as copepods, water fleas, and krill, are a major link in the food chain between the photosynthetic phytoplankton and the larger carnivores, such as many fish and whales. Although many species of insects and mites attack food crops and timber, arthropods are of enormous benefit to human agriculture. Approximately **two-thirds of all flowering plants are pollinated by insects**, and soil and leaf-mold arthropods, which include insects, mites, myriapods, and some crustaceans (pill bugs), play an important role in the formation of humus from decomposed leaf litter and wood.

Thestings and bites of arthropods may be irritating or painful, but very few inject dangerous toxins. **Medically, arthropods are more significant as** carriers of diseases **such as malaria, yellow fever, dengue fever, and elephantiasis (via mosquitos), African sleeping sickness (via tsetse flies), typhus fever (via lice), bubonic plague (via fleas), and Rocky Mountain spotted fever and Lyme disease (via ticks). Many diseases of domesticated animals are also transmitted by arthropods.**

1.5. THE PHYLUM MOLLUSCA

Characteristics of mollusks

Molluscs have developed such a varied range of body structures that it is difficult to find defining characteristics that apply to all modern groups.The most general characteristic of molluscs is that they are unsegmented and bilaterally symmetrical.The following are present in all modern molluscs:

- They have soft and unsegmented body.
- Have complete digestive tract and nervous system.
- Some have protective shell made of calcium carbonate.
- Most have muscular foot for crawling.
- They carry out respiration by gills.
- Have sense organs for smell and taste
- The dorsal part of the body wall is a **mantle** (or pallium) which secretes calcareous spicules, plates or shells. It overlaps the body with enough spare room to form a **mantle cavity**.
- The anus and genitals open into the **mantle cavity**.
- There are two pairs of main nerve cords.

Examples of molluscs: snail, slug, octopus, squid…

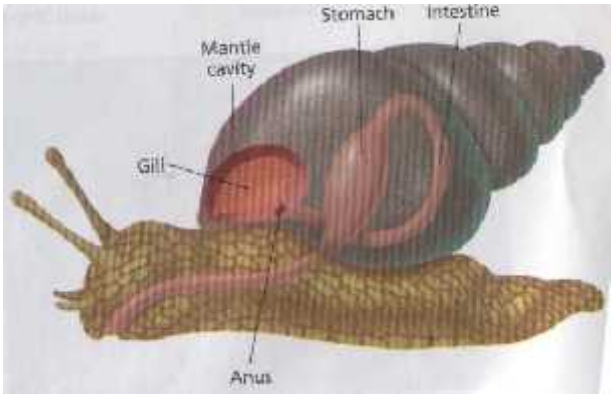


Fig 1.4: Molluscs

1.6. THE PHYLUM ANNELIDA

The main characteristics of annelids are as follows:

- They are triploblastic and
- They are coelomate animals.
- They are bilaterally symmetrical.
- They are segmented and the segments are separated from each other by septa.
- Most species have bristles (setae) made of chitin on each segment which they use to move.

Examples of annelids: earthworms, leeches

Fig 1.5: Annelids

1.7. THE PHYLUM NEMATODA

Characteristics of nematodes

- They are triploblastic
- They are bilaterally symmetrical.
- They are elongated and round with pointed ends, with some cephalization at the interior.
- They are not divided into segments.
- They have a true alimentary canal with a mouth and anus.
- There are two separate sexes.
- Some are free-living, but many are plant and animal parasites.

Examples of nematodes: ascaris, filarial, trichinella

Fig 1.6:Ascarislumbricoides, a nematode

1.8. THE PHYLUM PLATYHELMINTHES or FLATWORMS

The main characteristics of the flatworms are as follows:

- They are triploblastic
- They are bilaterally symmetrical
- They are unsegmented
- They are flattened dorso-ventrally
- They have a mouth but no anus
- They are hermaphrodites
- They usually have larval stages

Examples of flatworms: taenia, blood flukes and planaria

Fig 1.7: A planaria and a taenia worms

1.9. PHYLUM CNIDARIA

The main characteristics are as follows:

- They are diploblastic.
- There is some tissue differenciation.
- There is a single body opening for digestion and excretion.
- They have a radial symmetry.
- There are sedentary polyp forms which may be solitary or live in colonies and medusa forms which are free swimming and solitary.
- They reproduce asexually by budding.
- They reproduce sexually by sex organs which form when needed.

Examples of cnidarians: hydra, jellyfish

Fig 1.8: Cnidarians

1.10. Phylum PORIFERA (PARAZOA or SPONGES)

Characteristics of sponges

- Sponges have no true tissues
- Adults do not show locomotion
- Body has two layers of cells separated by a jelly like layer called the mesohyl
- Sponges are filter feeders
- Sponges are porous animals
- Sponges are asymmetrical animals or radially symmetrical animals
- Sponges are all marine
- Asexual reproduction takes place by budding and by regeneration

Examples: sponges

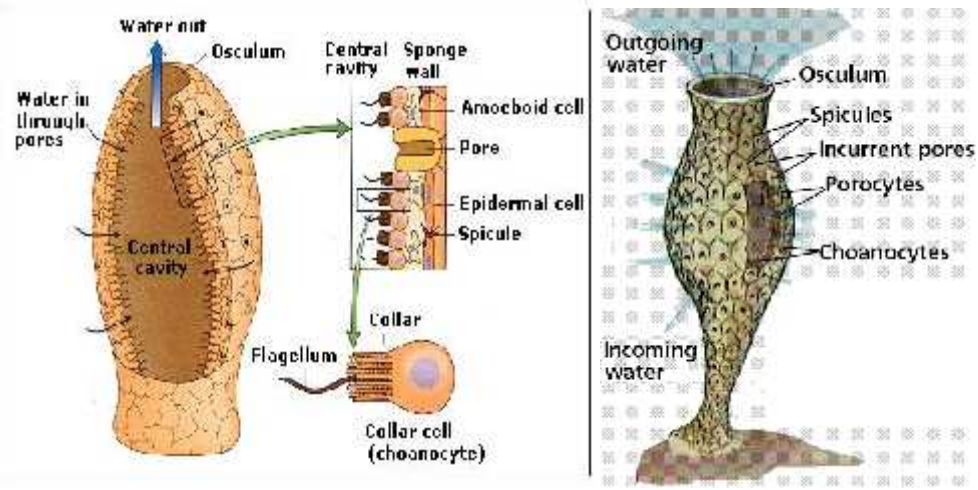


Fig 1.9: Sponges

1.11. ECHINODERMS

- They have an endoskeleton composed of calcium carbonate plates known as ossicles.
- They have a water-vascular system which is a network of water-filled canals inside their body.
- They have many small movable extension of the water vascular system called tube-feet, which aid in movement, respiration and excretion.
  Examples: starfish, sand dollars…

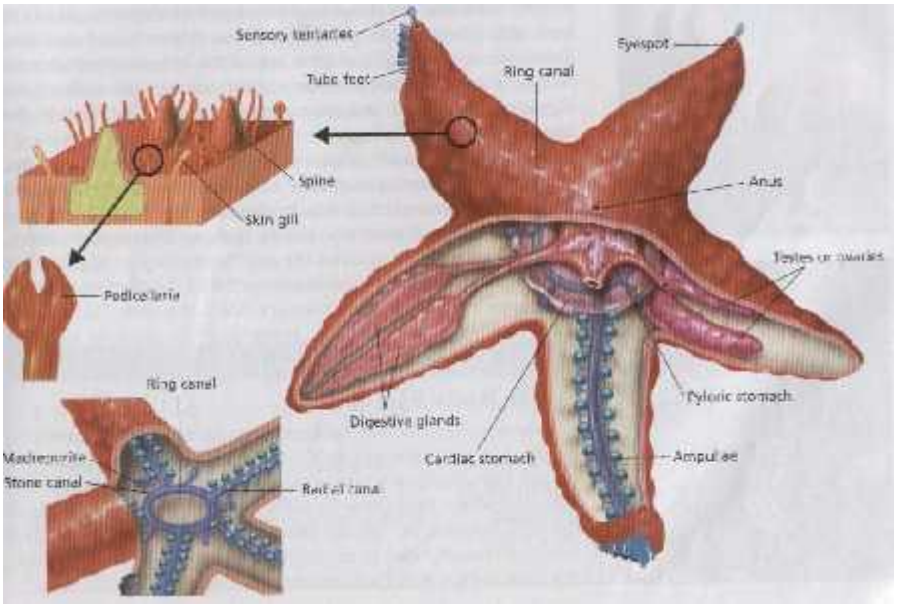


Fig 1.10: Internal structure of a starfish

TOPIC AREA 2: ECOLOGY AND CONSERVATION

Unit 2: Introduction to environmental biology

Key Unit Competence: To be able to explain the concepts applied in environmental biology including the interaction and interdependence of organisms.

Learning Objectives		
Knowledge and understanding	**Skills**	**Attitudes and values**
⁄ Define the following items: **Ecology**: a study of organisms in relation to the surroundings in which they live. **Population**: a group of individuals of the same species living in the same habitat at the same time. **Habitat**: a place where an organism lives. **Ecosystem**s: all the living organisms in a place and the interactions between them and their physical environment. **Niche**: the role of an organism in its habitat and how it makes it's living. **Bioticfactors**: as influences of other organisms on each other **Abiotic factors**: effects of non-biological surroundings of an organism such as temperature, light intensity and rainfall **Food chain**: showing the transfer of energy from one organism to the next beginning with the producers. **Food web**: the network of interconnected food chains. ⁄ Describe how energy is lost between trophic levels.	⁄ Construct and interpret simple food chains and food webs. ⁄ Construct pyramids of biomass and numbers. ⁄ Carry out analysis of the diagram showing a food chain.	⁄ Appreciate the role of green plants in terms of conversion and supply of energy to all living organisms. ⁄ Appreciate the interdependence of living organisms.

ACTIVITY 2.1:

- ⁄ Learners read in groups about ecological vocabulary.
- ⁄ Learners answer simple questions and make notes.
- ⁄ In groups, learners discover which non–living (abiotic) factors they interact with in their environment and ways that non-living things are essential to living organisms.
- ⁄ Learners, at different occasions, observe feeding relationships among wild and domestic animals.
- ⁄ Learners draw or model simple food chains and food webs.
- ⁄ Learners carry out analysis of the diagram showing a food chain and then find out the trophic level of each organism in the chain.
- ⁄ Construct pyramids of numbers and biomass on graph paper from given data. Argue why a pyramid of biomass is needed.
- ⁄ Learners watch an audio-visual of wildlife and appreciate the interdependence of different organisms.

The different populations that live together are interdependent on one another for survival. Therefore, the interdependence among living organisms and the environment creates a **balanced ecosystem**.

Definitions of some terms

- **Ecology:** the study of relationship between living organisms and their relationship with the environment.
- **Ecosystem:** interacting populations of organisms with biotic and abiotic factors.
- **Population:** all the members of the same group of organisms living in a particular area at a particular time.
- **Predator:** an animal that hunts and eats other animals.
- **Species:** Organisms that have common characteristic in common and that can produce fertile offspring.
- **Population:** A number of organisms of the same species living together.
- **A community:** Many populations living together in a particular place.

2.1. A balanced ecosystem

1. Living organisms are interdependent with one another for survival.
2. Examples of interdependence among living organisms:
    i. Plants are the main sources of food for animals and humans.
    ii. Animals, such as birds depend on plants for shelter.
    iii. Plants need animals such as insects for pollination.
3. Examples of interdependence between living things and non-living things:
    i. Plants need sunlight and carbon dioxide for photosynthesis.
    ii. Humans and animals need oxygen in the air for respiration.
4. Living things and non-living things interact with one another to create a balanced ecosystem.
5. A balanced ecosystem means a balanced environment that does not change very much over a period of time.

2.2. The Environment

To the ecologist, the **environment** of an organism includes both physical aspects and other organisms. These two components of the environment are called abiotic and biotic components, respectively.

- **Abiotic components**, or abiotic factors, are the non-living physical aspects of the environment. Examples include sunlight, soil, temperature, wind, water, and air.
- **Biotic components**, or biotic factors, are the living organisms in the environment. They include organisms of the same and different species.

2.3. Ecosystem

A community can also be defined as the biotic component of an ecosystem. An **ecosystem** is a natural unit consisting of all the living organisms in an area functioning together with all the nonliving physical factors of the environment. The concept of an ecosystem can apply to units of different sizes. For example, a large body of fresh water could be considered an ecosystem, and so could a small piece of dead wood. Both contain a community of species that interact with one another and with the abiotic components of their environment.

Like most natural systems, ecosystems are not closed, at least not in terms of energy. Ecosystems depend on continuous inputs of energy from outside the system. Most ecosystems obtain energy from sunlight. Some obtain energy from chemical compounds. In contrast to energy, matter is recycled in ecosystems. Elements such as carbon and nitrogen, which are needed by living organisms, are used over and over again.

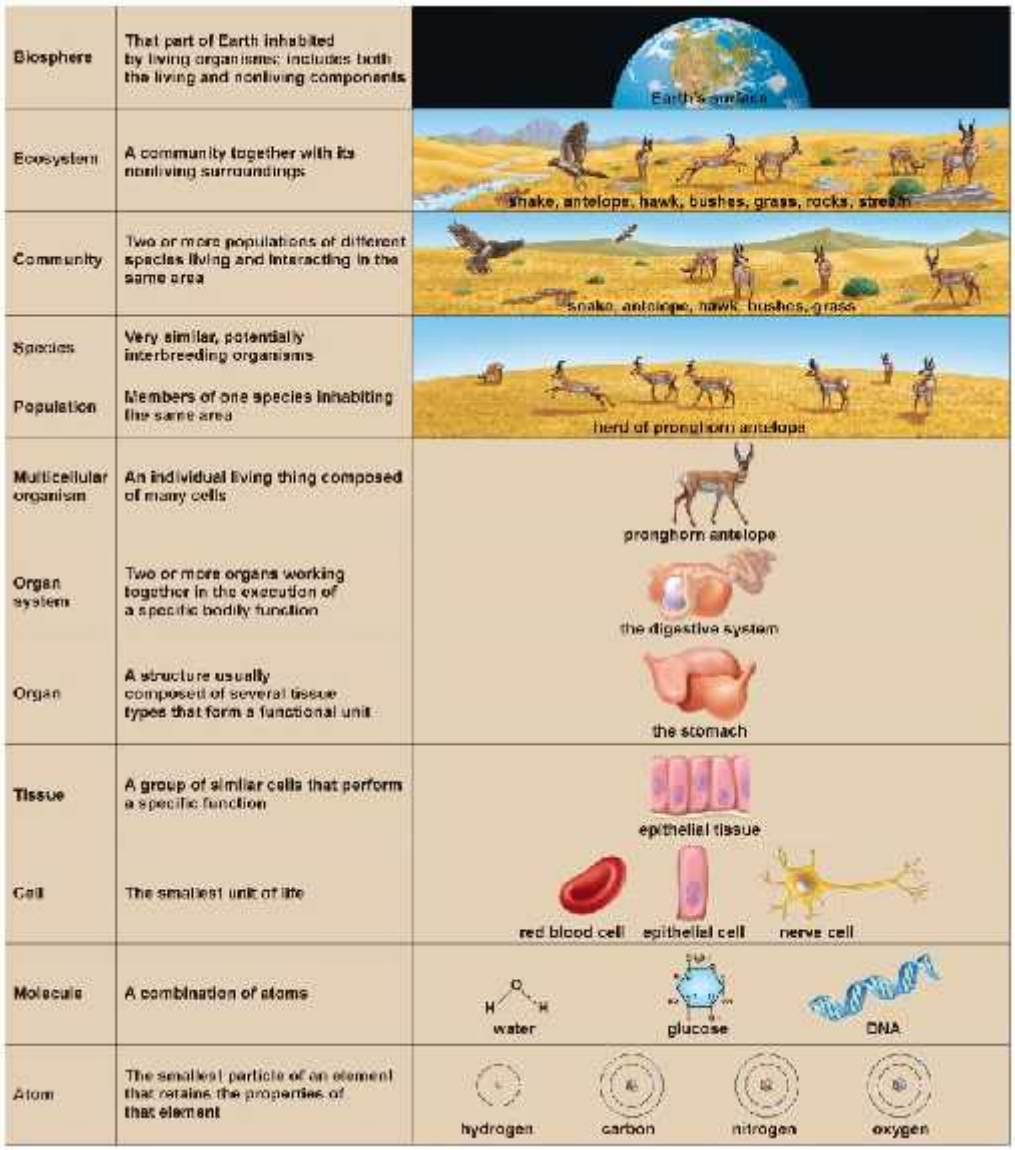


Fig 2.1: Levels of biological organization

2.4. Niche

One of the most important ideas associated with ecosystems is the niche concept. A **niche** refers to the **role of a species in its ecosystem.** It includes all the ways species' members interact with the abiotic and biotic components of the ecosystem.
Two important aspects of a species' niche include the food it eats and how it obtains the food.

2.5. Habitat

Another aspect of a species' niche is its habitat. A species' **habitat** is the physical environment to which it has become adapted and in which it can survive. A habitat is generally described in terms of abiotic factors, such as the average amount of sunlight received each day, the range of annual temperatures, and average yearly rainfall. These and other factors in a habitat determine many of the traits of the organisms that can survive there.

2.6. Food chains and food webs

Organisms can be classified as producers, consumers and decomposers, according to their relationships in terms of sources of food.

- **Producers** are organisms that can manufacture their own food. Example: green plants make their own food through photosynthesis.
- **Consumers** are organisms that obtain food from other organisms because they cannot make their own food.
- **Primary consumers** are consumers that feed directly on plants and are herbivorous or omnivorous animals.
- **Secondary consumers** are consumers that that feed directly on primary consumers and are carnivorous animals.
- **Tertiary consumers** are consumers that that feed directly on secondary consumers and are carnivorous or omnivorous animals.
- **Decomposers** are organisms that break down the tissues of dead organisms into simpler substances, for example bacteria and fungi. Fungi and bacteria break down dead plants and animals into compounds of carbon and nitrogen which are released into the soil to be used by plants and animals for growth.

Food chains

A **food chain** represents a simple linear pathway through which energy and materials are transferred from one species to another in an ecosystem. In general, food chains show how ***energy and materials flow from producers to consumers***. Energy and materials also flow from producers and consumers to decomposers, but this step usually is not included in food chains. Two examples of food chains are shown in the figure below:

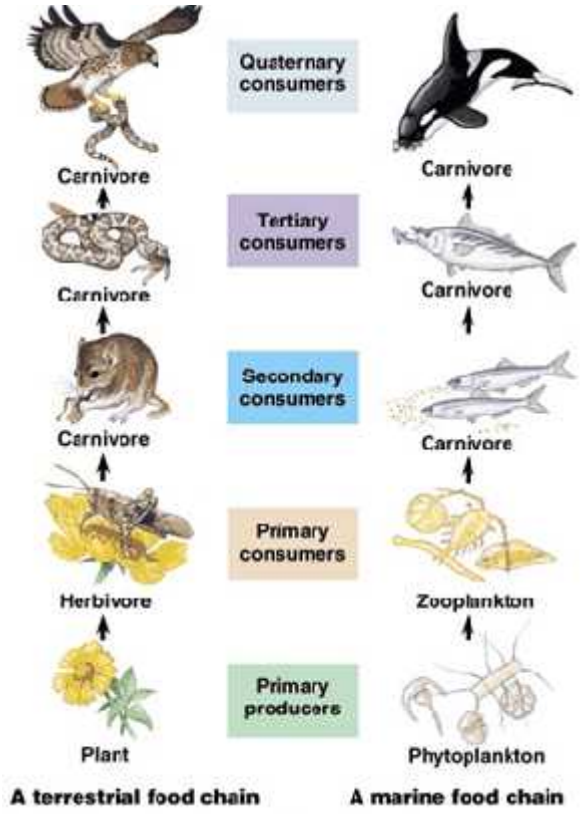


Fig 2.2: Food chains

In the terrestrial food chain on the left in, grasses are the producers. Grasses, in turn, are consumed by grasshoppers. Because grasshoppers directly consume producers, they are called primary consumers. At the next level of the food chain, grasshoppers are consumed by mice, which are called secondary consumers. Mice are consumed by snakes (called tertiary consumers), and snakes are consumed by hawks (called quaternary consumers).
In the aquatic food chain on the right, phytoplankton is the producer. Phytoplankton is eaten by zooplankton, which is the primary consumer. Zooplankton, in turn, is eaten by small fishes (secondary consumers). Small fishes are eaten by big fishes (tertiary consumers), and big fishes are eaten by whales (quaternary consumers).

Food Webs

Food chains tend to be overly simplistic representations of what really happens in nature. Most organisms consume multiple species and are, in turn, consumed by multiple other species. A food web represents these more complex interactions. A **food web**is a diagram of feeding relationships that includes multiple intersecting food chains. An example of a food web is shown below:

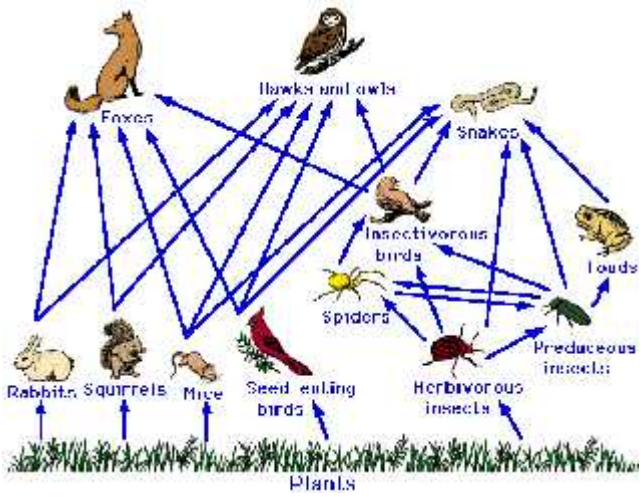


Fig 2.3: A food web

2.7. Trophic Levels and Energy Transfer

The different feeding positions in a food chain or web are called **trophic levels**. The first trophic level consists of producers, the second of primary consumers, the third of secondary consumers, and so on. There usually are no more than four or five trophic levels in a food chain or web. Humans may fall into second, third, and fourth trophic levels of food chains or webs. They eat producers such as grain, primary consumers such as cows, and tertiary consumers such as salmon.

Energy is passed up the food chain from one trophic level to the next. However, only ***about 10 percent of the total energy stored in organisms at one trophic level is actually transferred to organisms at the next trophic level***. The rest of the energy is used for metabolic processes or lost to the environment as heat. As a result, less energy is available to organisms at each successive trophic level. This explains why there are rarely more than four or five trophic levels.

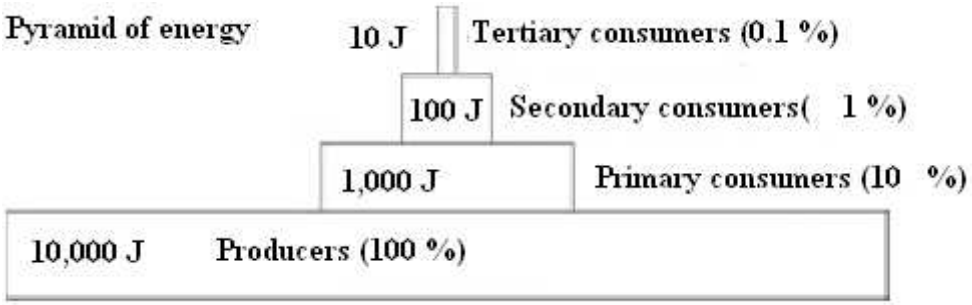
2.8. Ecological pyramids

Ecological pyramids are diagrams that represent each trophic level according to its energy, biomass or population.Three types of pyramids are used in ecology:

- **Pyramids of numbers,** based on counting **the number of organisms** at each trophic level;
- **Pyramids of biomass,** which note the **weight (usually dry weight)** of organisms at each trophic level;
- **Pyramids of energy,** which monitor **the energy content** of the organisms at each trophic level.

Energy pyramids are considered the most important since they deal directly with the fundamentals of food chains, the flow of energy.

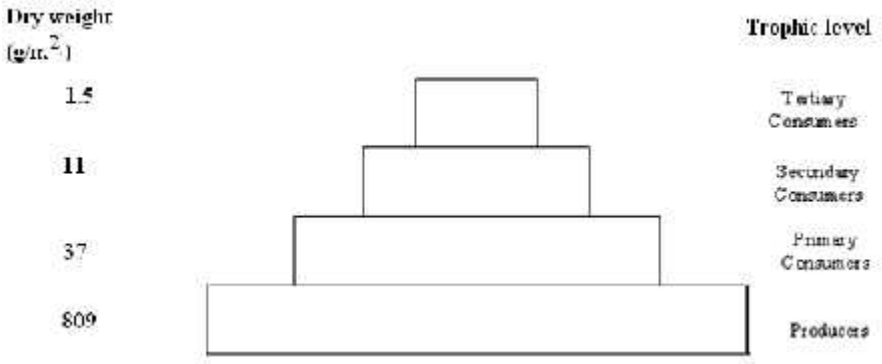
The amount of energy at different trophic levels can be represented by an energy pyramid like the one below.



This pyramid shows the total energy stored in organisms at each trophic level in an ecosystem. Starting with primary consumers, each trophic level in the food chain ***has only 10 percent of the energy of the level below it.*** The pyramid makes it clear why there can be only a limited number of trophic levels in a food chain or web.

One important ecological consequence of decreasing energy transfers through a food web can be represented in **a biomass pyramid**, in which each tier represents the standing crop biomass (the total dry weight of all organisms) in a trophic level. Biomass pyramids generally narrow sharply from producers at the base to top-level carnivores at the apex because energy transfers between trophic levels are so inefficient.

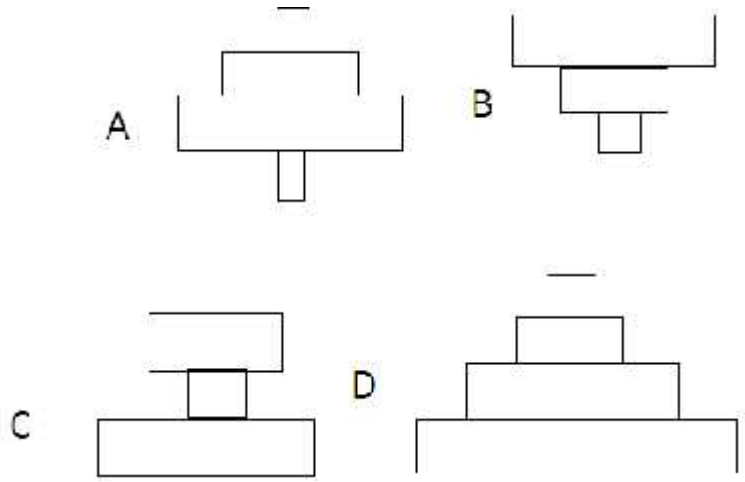
Pyramid of Biomass



The materials in dead organisms and wastes at all trophic levels are broken down by **decomposers**. Organisms such as detritivores and saprotrophs return needed elements to the ecosystem and use up most remaining energy. Because of the reduction in energy at each trophic

level, virtually no energy remains. Therefore, energy must be continuously added to ecosystems by producers.

Unusual pyramid of numbers



A: the producer is a single plant such as a tree.

B: the producer is a single plant which is infested with parasites (primary consumers) and the latter are parasitized by further parasites.

C: A large number of producers are eaten by a single primary consumer which is infested with parasites.

D: Normal pyramid for comparison.

TOPIC AREA 3: ORGANISATION AND MAINTENANCE OF LIFE

Unit 3: Passive movement of substances across the cell membrane

Key Unit Competence: To be able to explain and demonstrates the different processes of movement of water ions in and out of a cell.

Learning Objectives		
Knowledge and understanding	**Skills**	**Attitudes and values**
⁾Define diffusion as the movement of particles from the region of their higher concentration to the region of their lower concentration. ⁾State that substances move in and out of cells by diffusion through the cell membrane. ⁾Recall that energy in diffusion comes from the kinetic energy. ⁾Describe the importance of diffusion of gases and solutes and water as a solvent. ⁾Define osmosis as the net movement of water molecules from a region of higher water potential (dilute solution) to a region of low water potential (concentrated solution) through a partially permeable membrane. ⁾Describe the importance of osmosis in the uptake of water by plants and its effects on plant and animal tissues. ⁾Explain how plants are supported by pressure of water inside the cells (turgor pressure) pressing on their cell walls.	⁾Carry out an experiment to show that diffusion occurs in gases and liquids. ⁾Investigate the factors that influence diffusion; limited to surface area, temperature, concentration gradients and distance. ⁾Design an experiment to show that osmosis occurs in living tissues. ⁾Design an experiment to show how turgor pressure occurs.	⁾Appreciate the importance of turgidity in the supporting systems in plants.

ACTIVITY 3.1:

- Discuss the need for transport of substances in and out of the cell.
- Carry out an experiment to demonstrate diffusion in gas (e.g. spray perfume) and in in liquids (e.g. $KMnO_4$ crystals in water).
- Design and carry out investigations of factors likely to affect diffusion rates.
- Investigate that osmosis occurs only in living tissue using raw and boiled plant tissues.
- In groups, learners carry out an experiment to show turgor pressure in plants using solutions of different concentrations (e.g. sugar).

In S1, you saw that all living cells are surroundedby a very thin membrane, the cell surface membrane.This controls the exchange of materials such as nutrientsand wasteproducts between the cell and its environment.Inside cells, regulation of transport across the membranesof organelles is also vital. Membranes also have otherimportant functions. For example, they enable cells toreceive hormone messages.

Probably the most important feature of a cell's phospholipid membranes is that they are selectively permeable. A membrane that is **selectively permeable** has control over what molecules or ions can enter or leave the cell. The permeability of a membrane is dependent on the organization and characteristics of the membrane lipids and proteins. In this way cell membranes help maintain a state of homeostasis within cells (and tissues, organs, and organ systems) so that an organism can stay alive and healthy.

3.1. Transport across Membranes

The molecular make-up of the phospholipid bilayer limits the types of molecules that can pass through it. For example, hydrophobic (water-hating) molecules such as carbon dioxide (CO_2) and oxygen (O_2) can easily pass through the lipid bilayer, but ions such as calcium (Ca^{2+}) and polar molecules such as water (H_2O) cannot. The hydrophobic interior of the phospholipid does not allow ions or polar molecules through because they are hydrophilic, or water loving. In addition, large molecules such as sugars and proteins are too big to pass through the bilayer. Transport proteins within the membrane allow these molecules to cross the membrane and into or out of the cell. This way, polar molecules avoid contact with the nonpolar interior of the membrane, and large molecules are moved through large pores.

Every cell is contained within a membrane punctuated with transport proteins that act as channels or pumps to let in or force out certain molecules. The purpose of the transport proteins is to protect the cell's internal environment and to keep its balance of salts, nutrients, and proteins within a range that keeps the cell and the organism alive.

There are three main ways that molecules can pass through a phospholipid membrane. The first way requires no energy input by the cell and is called **passive transport**. The second way requires that the cell uses energy to pull in or pump out certain molecules and ions, and is called **active transport**. The third way is through vesicle transport, in which large molecules are moved across the membrane in bubble-like sacks that are made from pieces of the membrane.

3.1.1. Passive Transport

Passive transport is a way that small molecules or ions move across the cell membrane without input of energy by the cell. The three main kinds of passive transport are ***diffusion, osmosis, and facilitated diffusion.***

a) Diffusion

Diffusion is the movement of molecules from an area of high concentration of the molecules to an area with a lower concentration. The difference in the concentrations of the molecules in the two areas is called the **concentration gradient**. Diffusion will continue until this gradient has been eliminated. Since diffusion moves materials from an area of higher concentration to the lower, it is described as moving solutes "down the concentration gradient". The end result of diffusion is an equal concentration, or **equilibrium**, of molecules on both sides of the membrane.

If a molecule can pass freely through a cell membrane, it will cross the membrane by diffusion. The following figureshows how a molecule such as oxygen passes through the plasma membrane.

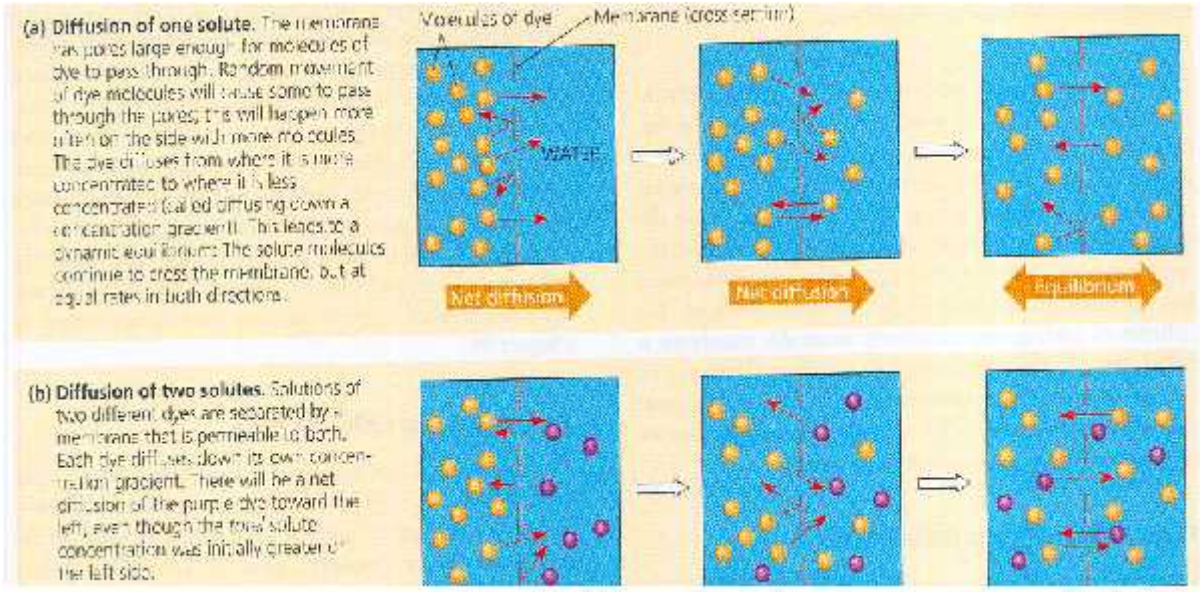


Fig 3.1: Diffusion

The importance of diffusion to organisms

Diffusion is a purely physical process which does not need energy from the cell to drive it. It is a very important process for all organisms. Lots of substances move in and out of cells by diffusion. For example:

- Oxygen and carbon dioxide move in and out of plant leaves through small pores called stomata by diffusion.
- Plant root hairs take up some salts from the soil by diffusion.

- Unicellular organisms, such as Amoeba, take in oxygen and get rid of carbon dioxide by diffusion across their cell surface membrane.
- Digested food, for example sugars and amino acids, enter your blood from your gut by diffusion. Once dissolved in your blood, these substances are transported around your body in solution and can diffuse out of your blood into cells where they are needed.
- Oxygen diffuses into the blood, and carbon dioxide diffuses out of the blood, in the lungs of mammals. The same thing happens in the gills of fish.
- Oxygen diffuses out of the blood, and carbon dioxide diffuses into the blood in the tissues of mammals.
- Waste products of metabolism, for example poisonous compounds containing nitrogen, diffuse out of animal cells and into the blood. They are then transported to an animal's kidney where they are removed from the blood and excreted in urine.

Factors that affect the rate of diffusion

- **Size of particles**

Small particles move faster than large ones so small particles will diffuse faster than large ones.

- **Temperature**

Increasing the temperature makes particles in a solution or a gas move faster. So increasing the temperature will increase the rate of diffusion.

- **Differences in concentration**

The bigger the difference in concentration between two points, that is the steeper the concentration gradient, the faster the rate of diffusion. This is really important in living organisms. Imagine a cell that is carrying out chemical reactions really quick. It uses some molecules, for example sugar, very rapidly. So the concentration of the sugar molecules in the cell is low and sugar molecules diffuse rapidly from the blood into the cells.

- **Surface area**

For a molecule to get into an organism's body it has through a cell membrane. The bigger the area of the cell membrane available for diffusion, the faster is the rate of diffusion. For example, such as Amoeba, this is not a problem. The area of their cell membrane is large enough to meet all their needs. However, for larger organisms this fact causes a problem.

b) Osmosis

Imagine you have a cup that has 100ml water, and you add 15 g of table sugar to the water. The sugar dissolves and the mixture that is now in the cup is made up of a solute (the sugar), that is dissolved in the solvent (the water). The mixture of a solute in a solvent is called a solution.
Imagine now that you have a second cup with 100ml of water, and you add 45 grams of table sugar to the water. Just like the first cup, the sugar is the solute, and the water is the solvent. But now you have two mixtures of different solute concentrations. In comparing two solutions of

unequal solute concentration, the solution with the higher solute concentration is **hypertonic**, and the solution with the lower concentration is **hypotonic**. Solutions of equal solute concentration are **isotonic**. The first sugar solution is hypotonic to the second solution. The second sugar solution is hypertonic to the first.
You now add the two solutions to a beaker that has been divided by a selectively permeable membrane. The pores in the membrane are too small for the sugar molecules to pass through, but are big enough for the water molecules to pass through. The hypertonic solution is on one side of the membrane and the hypotonic solution on the other. The hypertonic solution has a lower water concentration than the hypotonic solution does, so a concentration gradient of water now exists across the membrane. Water molecules will move from the side of higher water concentration to the side of lower concentration until both solutions are isotonic.

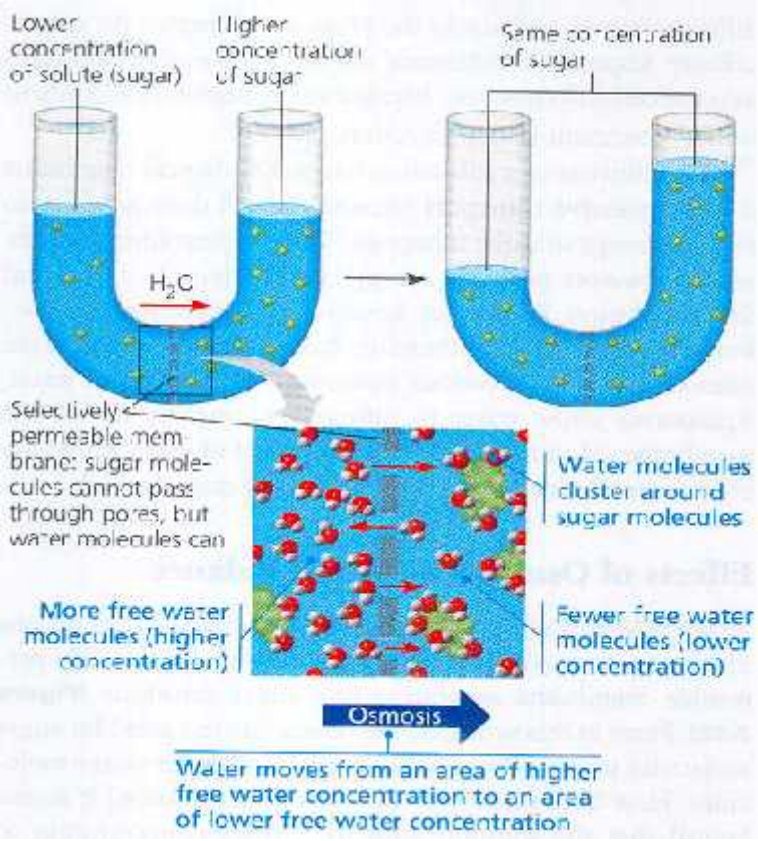


Fig 3.2: The process of osmosis

Osmosis is the diffusion of water molecules across a selectively permeable membrane from an area of higher concentration of water molecules to an area of lower concentration of water molecules. Water moves into and out of cells by osmosis. If a cell is in a hypertonic solution, the solution has a lower water concentration than the cell cytosol does, and water moves out of the cell until both solutions are isotonic. Cells placed in a hypotonic solution will take in water across their membrane until both the external solution and the cytosol are isotonic.
A cell that does not have a rigid cell wall (such as a red blood cell), will swell and lyse (burst) when placed in a hypotonic solution. Cells with a cell wall will swell when placed in a hypotonic solution, but once the cell is turgid (firm), the tough cell wall prevents any more water from

entering the cell. When placed in a hypertonic solution, a cell without a cell wall will lose water to the environment, shrivel, and probably die. In a hypertonic solution, a cell with a cell wall will lose water too. The plasma membrane pulls away from the cell wall as it shrivels. The cell becomes plasmolyzed. Animal cells tend to do best in an isotonic environment, plant cells tend to do best in a hypotonic environment. The figure below shows an animal cell and a plant cell in solutions of different concentrations.

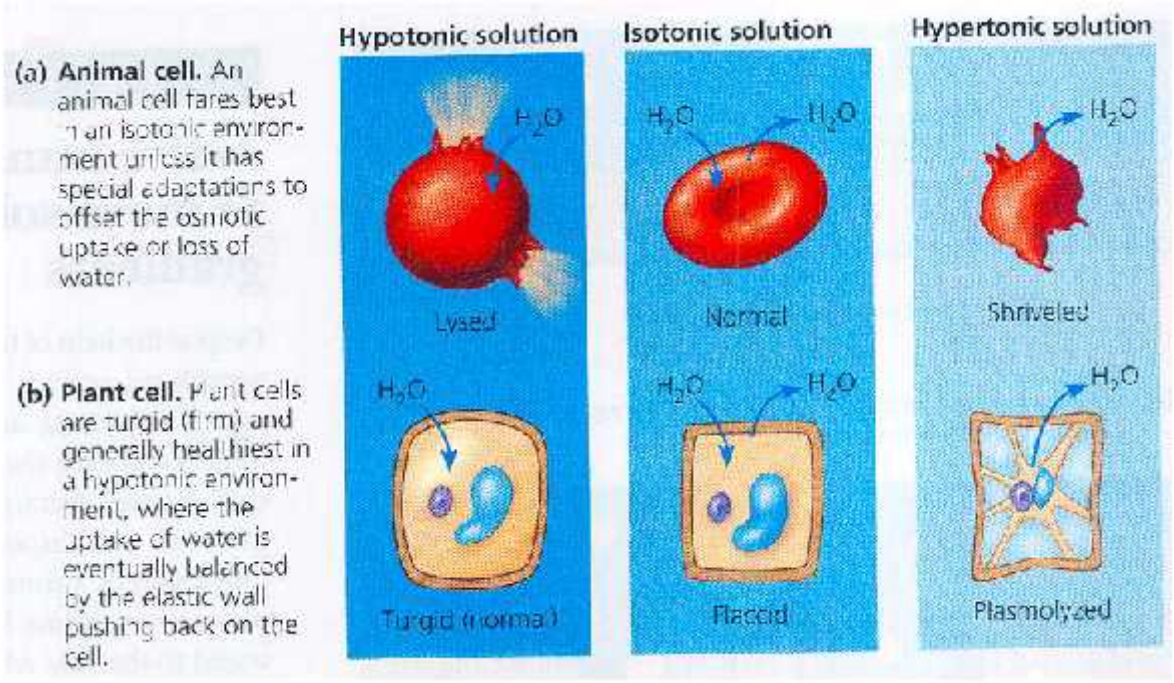


Figure 3.3: Plant cells and animal cells in solutions of different concentrations

The figure below shows how the process of osmosis can be demonstrated using an osmometer.

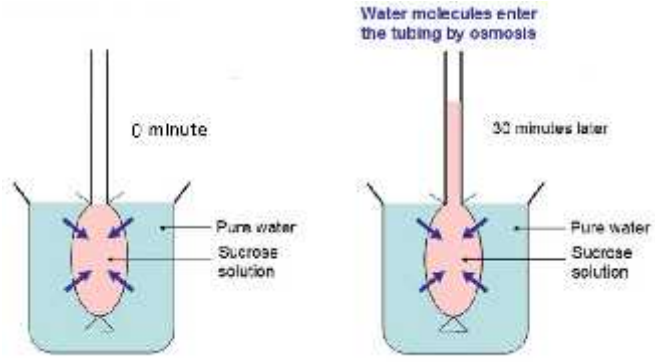


Fig 3.4: Demonstration of osmosis using an osmometer

c) Facilitated Diffusion

Facilitated diffusion is the diffusion of solutes through transport proteins in the plasma membrane. Facilitated diffusion is a type of passive transport. Even though facilitated diffusion involves transport proteins, it is still passive transport because the solute is moving down the concentration gradient.
As was mentioned earlier, small nonpolar molecules can easily diffuse across the cell membrane. However, due to the hydrophobic nature of the lipids that make up cell membranes, polar molecules (such as water) and ions cannot do so. Instead, they diffuse across the membrane through transport proteins. A **transport protein** completely spans the membrane, and allows certain molecules or ions to diffuse across the membrane. Channel proteins and carrier proteins are the types of transport proteins that are involved in facilitated diffusion.

A **channel protein**, (a type of transport protein), acts like a pore in the membrane that lets water molecules or small ions through quickly. Water channel proteins allow water to diffuse across the membrane at a very fast rate. Ion channel proteins allow ions to diffuse across the membrane.

A **carrier protein** is a transport protein that is specific for an ion, molecule, or group of substances. Carrier proteins "carry" the ion or molecule across the membrane by changing shape after the binding of the ion or molecule. Carrier proteins are involved in passive and active transport. The figure below shows a model of a channel protein and carrier proteins.

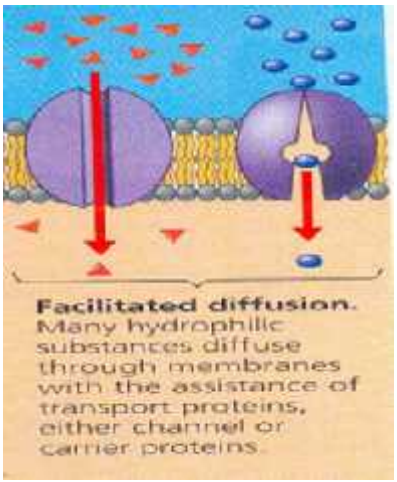


Fig 3.5: Facilitated transport

Unit 4: Active transport

Key Unit Competence: To be able to analyse and interpret the process of active transport and its significance to living organisms.

Learning Objectives		
Knowledge and understanding	**Skills**	**Attitudes and values**
⁃ Define active transport as the movement of particles through the cell membrane from a region of lower concentration to a region of high concentration using energy. ⁃ State locations in plant and animal tissues where active transport occurs. ⁃ State the factors affecting active transport. ⁃ Explain the importance of active transport as the process of movement across membranes limited to ion uptake by root hairs and uptake of glucose by epithelial cells of villi and kidney tubules. ⁃ Describe how carrier proteins move particles across membranes during active transport.	⁃ Compare passive and active transport. ⁃ Demonstrate active transport using charts and animations. ⁃ Use IT skills to carry out simulations of the process of endocytosis and exocytosis.	⁃ Appreciate the importance of active transport in plants and animals. ⁃ Acknowledge and support the role of energy in absorption of mineral salts in soils that support germinating and growing plants.

ACTIVITY 4.1:

- Make a group presentation to compare passive and active transport.
- Observe and interpret charts and animations of the active transport and list the sequence of stages in which ions are moved across the cell membrane.
- Research and present findings on the need energy in kidney tubules and intestinal epithelial cells in relation to their functions.
- Use animations, computer simulations or charts, and diagrams to illustrate the process of endocytosis and exocytosis.

Active Transport

In contrast to facilitated diffusion which does not require energy and carries molecules or ions down a concentration gradient, active transport pumps molecules and ions against a concentration gradient. Sometimes an organism needs to transport something against a concentration gradient. The only way this can be done is through active transport which uses energy that is produced by respiration (ATP). In active transport, the particles move across a cell membrane from a lower concentration to a higher concentration. **Active transport** is the energy-requiring process of pumping molecules and ions across membranes "uphill" against a gradient.

• The active transport of small molecules or ions across a cell membrane is generally carried out by transport proteins that are found in the membrane.

• Larger molecules such as starch can also be actively transported across the cell membrane by processes called endocytosis and exocytosis (discussed later).

a) Sodium-Potassium Pump

Carrier proteins can work with a concentration gradient (passive transport), but some carrier proteins can move solutes against the concentration gradient (from high concentration to low), with energy input from ATP. As in other types of cellular activities, ATP supplies the energy for most active transport. One way ATP powers active transport is by transferring a phosphate group directly to a carrier protein. This may cause the carrier protein to change its shape, which moves the molecule or ion to the other side of the membrane. An example of this type of active transport system, as shown below, is the **sodium-potassium pump**, which exchanges sodium ions for potassium ions across the plasma membrane of animal cells.

b) Vesicles and Active Transport

Some molecules or particles are just too large to pass through the plasma membrane or to move through a transport protein. So cells use two other methods to move these macromolecules (large molecules) into or out of the cell. Vesicles or other bodies in the cytoplasm move macromolecules or large particles across the plasma membrane. There are two types of vesicle transport, endocytosis and exocytosis.

c) Endocytosis

Endocytosis is the process of capturing a substance or particle from outside the cell by engulfing it with the cell membrane. The membrane folds over the substance and it becomes completely enclosed by the membrane. At this point a membrane-bound sac or vesicle pinches off and

moves the substance into the cytosol. There are two main kinds of endocytosis: **phagocytosis and pinocytosis**

• **Phagocytosis** or cellular eating occurs when the dissolved materials enter the cell. The plasma membrane engulfs the solid material, forming a phagocytic vesicle.

• **Pinocytosis** or "cellular drinking" occurs when the plasma membrane folds inward to form a channel allowing dissolved substances to enter the cell. When the channel is closed, the liquid is encircled within a pinocytic vesicle.

d) Exocytosis

Exocytosis describes the process of vesicles fusing with the plasma membrane and releasing their contents to the outside of the cell. Exocytosis occurs when a cell produces substances for export, such as a protein, or when the cell is getting rid of a waste product or a toxin. Newly made membrane proteins and membrane lipids are moved to the plasma membrane by exocytosis.

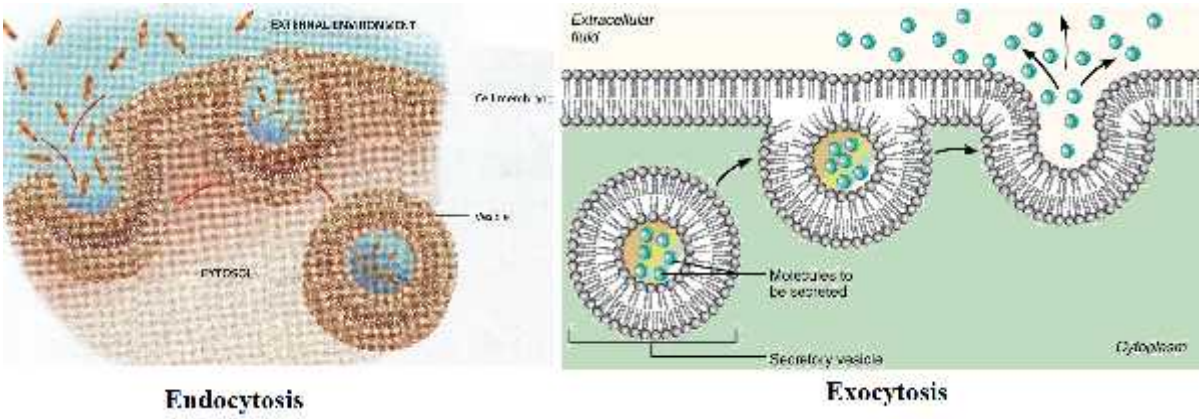


Fig 4.1: endocytosis and exocytosis

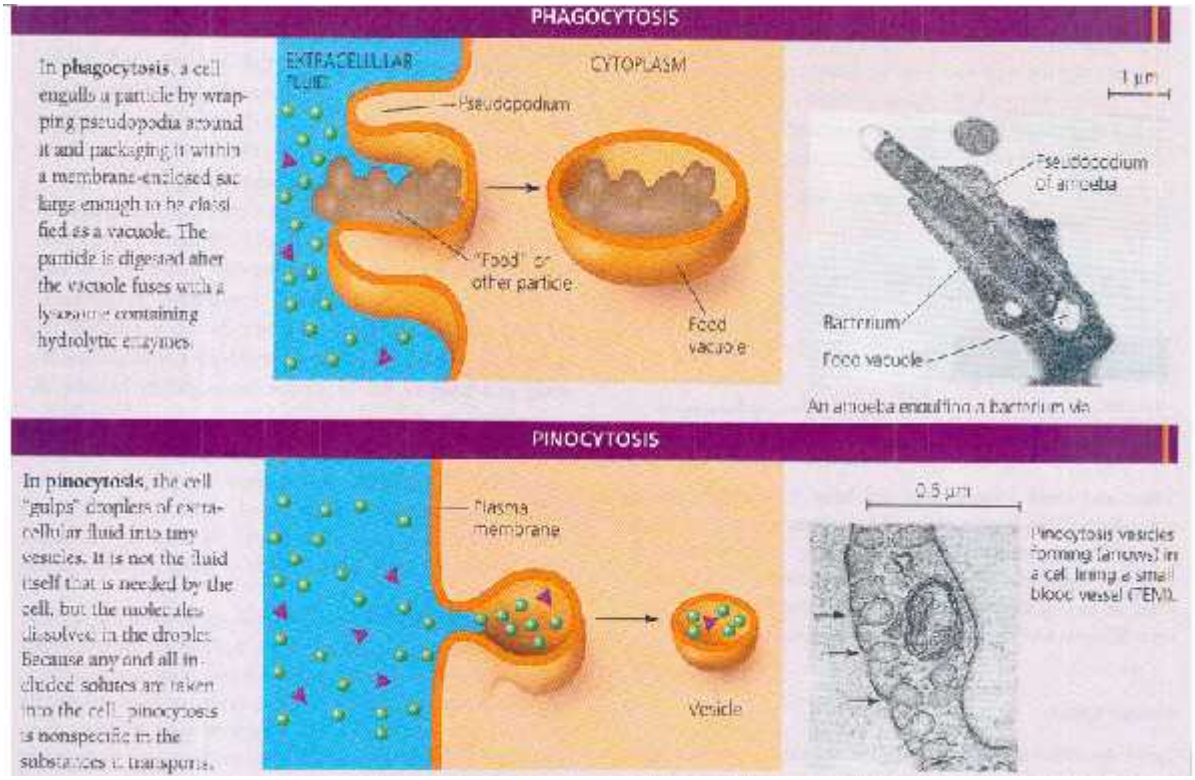


Fig 4.2: The two types of endocytosis

Factors affecting active transport

- O_2 concentration
- Temperature
- Availability of carriers protein
- Presence of energy

Importance of active transport in organisms

1. Uptake of mineral salts (ions such as nitrate, phosphate) from the soil by root hairs.
2. Uptake of glucose and other nutrients by epithelial cells of villi in the small intestines.

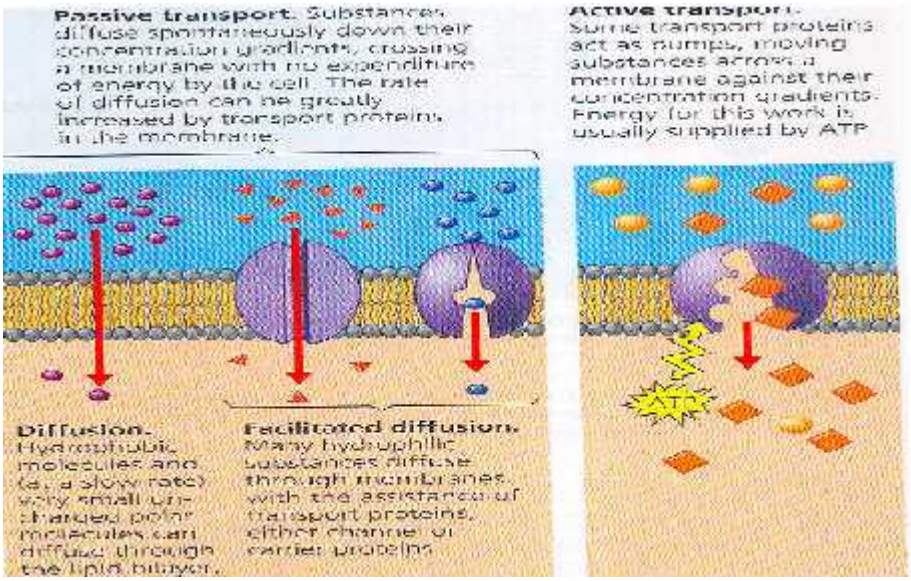


Fig 4.3: Passive and active transport compared

The table below shows the summary of transport methods

PASSIVE PROCESSES (i.e no energy input from ATP required)	**Diffusion**	Down a concentration gradient Lipid soluble or very small molecules through lipid bilayer
	Facilitated diffusion	Down a concentration gradient Charged or hydrophilic molecules or ions via channel or carrier proteins
	Osmosis	Down a water potential gradient through lipid bilayer or protein pores
ACTIVE PROCESSES (i.e energy input from ATP is required)	**Active transport**	Against a concentration gradient via carrier proteins that use energy from ATP in order to change shape
	Endocytosis and exocytosis	Bulk transport of materials via vesicles that can fuse with or break from the cell surface membrane

Table 4.1: Summary of transport methods

Unit 5: Identification of food components

Key Unit Competence: To be able to carry out chemical tests on a variety of foods to identify the nature of food substances.

Learning Objectives

Knowledge and understanding	Skills	Attitudes and values
⁄ State the chemical reagents used in the identification of each the classes of foods. ⁄ List the suitable apparatus required for the chemical test of a given food sample.	⁄ Practice designing a table including the procedure, observation and deductions for the tests made about the food samples. ⁄ Carry out tests to identify food substances in a given sample. ⁄ Carry out an investigation to determine the composition of an unknown food substance. ⁄ Observe changes in colour during food tests and relate them to the chemical reactions.	⁄ Appreciate the importance of different classes of food in one food substance. ⁄ Show perseverance when making observations for changes in colour during practical lessons. ⁄ Acknowledge the need to carry out practical activities with less supervision to develop independent mind and dealing with apparatus. ⁄ Show concern when carrying out practical work in groups. ⁄ Take care while carrying out an experiment involving heating to avoid burns.

ACTIVITY 5.1:

- With guided instructions, carry out a chemical test on starch using Iodine solution, on glucose solution using benedict's solution, on egg albumen using biuret reagent, cooking vegetable oil using ethanol and lemon juice using the DCPIP (Dichlorophenol- indol-phenol). Record in table form the observations.
- Devise an experiment to determine the composition of given food stuffs from the presence of reducing sugars, protein, lipid and vitamin C.
- Record your procedure, observation and deductions in a table form.

5.1.Test of Carbohydrates (Sugars and Starches)

- Reducing Sugars

The reducing sugars include all monosaccharides, such as glucose and fructose, and some disaccharides such as maltose.

a) Test for reducing sugar

Benedict's test: Add 1 cm^3 of a solution of the reducing sugar to a test tube. Add an equal volume of benedict's solution. Shake and bring gently to the boil, shaking continuously to minimise spitting.

Observation:The initial blue coloration of the mixture turns green, then yellowish and may finally form a brick red precipitate.

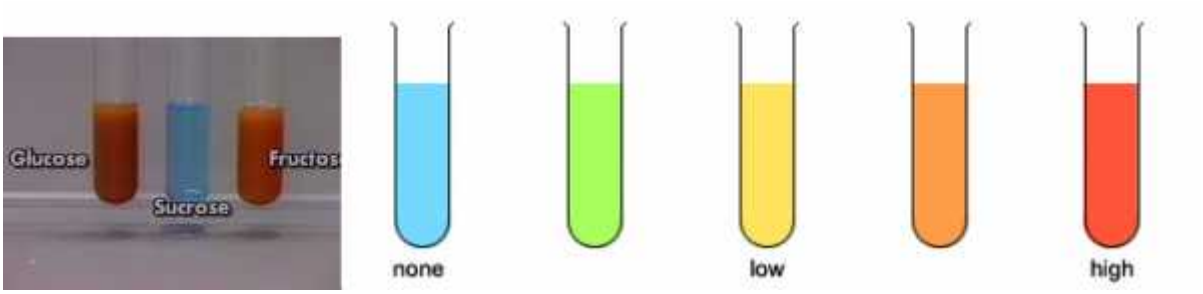


Fig 5.1: Test for reducing sugars

Basis of test*:* Benedict's solution contains copper sulphate. Reducing sugars reduce soluble blue copper sulphate containing copper (II) ions (Cu^{2+}) to insoluble red - brown copper oxide containing copper (I). The latter is seen as a precipitate.

- **Non- Reducing sugars**

The most common non reducing sugar is sucrose, a disaccharide. If reducing sugars have been shown to be absent (negative result in an above test) a brick red precipitate in the test below indicates the presence of a non reducing sugar. If reducing sugars have been shown to be present, a heavier precipitate will be observed in the following test than with the reducing test if non reducing sugar is also present.

Tests for non reducing sugar

To $1cm^3$ of the test solution, add $1cm^3$ of Benedict's solution and boil. The solution remains blue. To the mixture, add $1cm^3$ of dilute HCl and boil for 5 minutes. Cool the mixture, add $1cm^3$ of dilute NaOH solution followed by $1cm^3$ of Benedict's solution and boil.

Observation: As benedict's test.

***Basis of test*:**

Disaccharide can be hydrolysed to its monosaccharide constituents by boiling with dilute hydrochloric acid. Sucrose is hydrolysed to glucose and fructose, both of which are reducing sugars and give the reducing sugar result with the Benedict's test. NaOH is added in order to neutralize HCl because Benedict's solution works best in neutral PH.

- ***Test for starch:***

Add $1cm^3$ of starch solution to a test tube. Add 2 drops of iodine solution. The solution turns blue black.

Fig 5.2: Test for starch

5.2. Test for a lipid

Emulsion test: Add $1cm^3$ fat or oil to a test tube containing $1cm^3$ of absolute ethanol. Dissolve the lipid by shaking vigorously. Pour the solution into a boiling tube half filled with water. A white emulsion is formed.

Fig 5.3: Test for a lipid

Basis of test: Lipids are immiscible with water. Adding water to a solution of the lipid in alcohol results in emulsion of tiny droplets in the water which reflect light and give a white, opalescent appearance.

5.3. Test for a protein

Biuret test: To $1cm^3$ of the solution add $1cm^3$ of dilute sodium hydroxide solution followed by 2 drops of copper II sulphate solution and mix. No heating is required.

Fig 5.4: Test for proteins

Observation: A mauve or purple colour develops slowly.

Basis of test: A test for peptide bonds: in the presence of dilute copper sulphate in alkaline solution, nitrogen atoms in the peptide chain form a purple complex with copper (II) ions (Cu^{2+}). Biuret is a compound derived from urea which also contains the –COHN- group and gives positive results.

5.4. Test for the presence of vitamin C (Ascorbic acid)

To $1cm^3$ of DCPIP (Dichlorophenol Indophenol) solution in a test tube, add the test solution drop by drop. The blue DCPIP solution is decolourized.

Summary of food tests

Testing for	Description	Result (colour change)
Starch	Add a few drops of iodine solution	Brown to blue / Black
Reducing sugar	Add Benedict's solution and boil	Blue to orange-red
Non-reducing sugar	If reducing sugar is negative, boil with hydrochloric, cool and neutralize with sodium hydroxide; repeat Benedict's test	Blue to orange-red
Protein	Add biuret reagent	Blue to purple
Lipid	Add ethanol to extract (dissolve) lipid and pour alcohol into water in another test tube	White emulsion forms near the top of water

Table 7.1: Summary of food tests

Unit 6: Enzymes

Key Unit Competence: To be able to explain the role of enzymes in living organisms and how they are affected by temperature and pH.

Learning Objectives		
Knowledge and understanding	**Skills**	**Attitudes and values**
⁄ Define the term catalyst and enzyme. ⁄ Describe why enzymes are important in all living organisms in terms of reaction speed necessary to sustain life. ⁄ Explain the factors affecting enzyme activity limited to temperature and pH.	⁄ Apply knowledge of food tests to observe the changes and determine the effect of enzyme activity on substrates. ⁄ Conduct an experiment on the effect of temperature and pH on enzyme activity. ⁄ Draw and interpret graphs for the rate of enzyme activity on temperature and pH. ⁄ Illustrate enzyme action with reference to the complementary shape of an enzyme and its substrate and the formation of a product.	⁄ Appreciate the importance of enzymes in speeding up reactions to sustain life. ⁄ Appreciate the specificity of enzyme activity to substrates and with respect of the effect of temperature and pH

ACTIVITY 6.1:

- In groups, learners carry out an experiment to show the effect of amylase on starch.
- Independently, learners investigate the effect of temperature on enzyme activity using amylase on starch solution and carry out the test for presence or absence of the product of enzyme activity and present results in tabular form.
- In pairs, devise an experiment to find out the effect of pH on enzyme activity using amylase starch solution and carry out the test forpresence or absence of the product of enzyme activity and present results in tabular form.

Enzymes

6.1. Definition

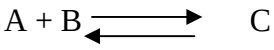
Enzymes are proteins that catalyse (i.e., increase the rates of) chemical reactions. In enzymatic reactions, the molecules at the beginning of the process, called **substrates**, are converted into different molecules, called**products**. Almost all chemical reactions in a biological cell need enzymes in order to occur at rates sufficient for life. Since enzymes are selective for their substrates and speed up only a few reactions from among many possibilities, the set of enzymes made in a cell determines which metabolic pathways occur in that cell.

Enzymes are proteins responsible for catalysing almost every metabolic reaction occurring in living organisms (**biological catalyst**). A catalyst is a substance which speeds up a chemical reaction but remains unchanged itself at the end.

6.2. Characteristics of enzymes

Enzymes are always proteins, and their characteristics therefore reflect the properties of proteins. Their main properties are as follows:

i. **Enzymes are not destroyed by the reaction** they catalyze and so can be used again.
ii. **An enzyme can work in either direction.** Metabolic reactions are reversible and the direction in which they proceed depends on the relative amounts of substrate and products present. The reaction will proceed from left to right until equilibrium between substrate and products is reached



iii. **Enzymes are inactivated by excessive heat**. This property of enzymes relates to the fact that they are proteins. The proteins (and therefore enzymes) are denatured at high temperatures. Few cells can tolerate temperatures higher than approximately 45°C.
iv. **Enzymes are sensitive to PH.** Every enzyme has its own range of PH in which it functions most efficiently. Most intracellular enzymes function best at or around neutral. Excessive acidity or alcalinity renders them inactive.
v. **Enzymes are specific** in the reaction they catalyze, much more than inorganic catalysts. Normally, a given enzyme will catalyze only one reaction or type of reaction. However, the degree of specificity varies from one enzyme to another.
vi. **Enzymes lower the activation energy of reactions they catalyze**. The activation energy is the energy necessary for a reaction to get started.
vii. **Enzymes possess active sites where the reaction takes place.** These sites have specific shapes.
viii. **All enzymes are globular proteins.**

In most metabolic reactions, the substrate must temporarily be provided with energy before it can change into a product. This is true for **endothermic** and **exothermic** reactions. This energy is called **activation energy**. Every chemical reaction involves both bond breaking and bond forming. The reactant molecules must absorb energy from their surroundings for their bond to break, and energy is released when the new bonds of the product molecule are formed. Enzymes reduce the activation energy needed to change a substrate into a product.

6.3. SPECIFICITY OF ENZYMES

Enzymes are usually very specific as to which reactions they catalyze and the substrates that are involved in these reactions. Enzymes are very specific, and it was suggested by the Nobel laureate organic chemist Emil Fischer in 1894 that this was because both the enzyme and the substrate possess specific complementary geometric shapes that fit exactly into one another. This

is often referred to "**the lock and key" model**. However, while this model explains enzyme specificity, it fails to explain the stabilization of the transition state that enzymes achieve.

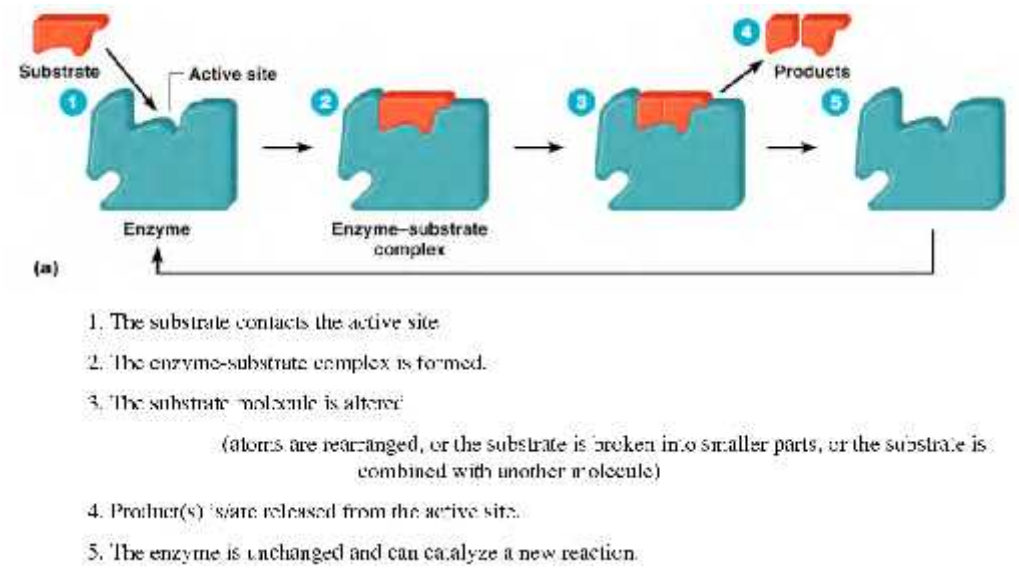
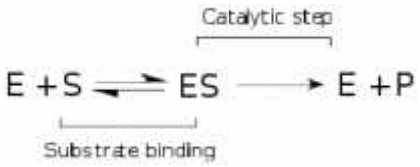


Fig 6.1: Mechanism of action of enzymes

How enzymes work

In an enzyme-controlled reaction, the substrate molecules combine with the enzyme to form an enzyme substrate complex. With their various bonds held in relation to each other by the enzyme, the substrate molecules react together to form an enzyme product complex. This splits into the enzyme and products. The enzyme, unchanged by the reaction can then be used again.



The high degree of specificity shown by enzymes suggests that the combination of substrate and enzymes is very exact. It is thought that each enzyme molecule has a precise place on its surface, the **active site**, to which the substrate molecules become attached. We can picture the active site of an enzyme molecule as having a distinctive configuration into which only certain specific substrate molecules will fit. Thus we have an explanation of the specificity of enzymes, enzyme and substrate fitting together like a lock and key. This explanation of enzyme action is known as **the lock-and-key hypothesis,** where the **substrate is imagined being like a key whose shape is complementary to the enzyme or lock.**

6.4. Factors affecting Enzyme Activity

The **activity** of an **enzyme** is affected by its **environmental conditions**. Changing these **alter** the **rate of reaction** caused by the enzyme. In nature, organisms **adjust** the **conditions** of their enzymes to produce an **optimum rate of reaction**, where **necessary**, or they may have enzymes which are **adapted** to **function well** in **extreme conditions** where they live.

⟩ Temperature

Increasing temperatureincreases the kinetic energy that molecules possess. In a fluid, this means that there are more random collisions between molecules.
Since enzymes catalyse reactions be randomly colliding with Substrate molecules, increasing temperature increases the rate of reaction, forming more product.
As temperature increases, more bonds, especially the weakerhydrogen and ionic bonds, will break as a result of this strain. Breaking bonds within the enzyme will cause the active site to change shape.
This change in shape means that the active site is less complementary to the shape of the Substrate, so that it is less likely to catalyse the reaction. Eventually, the enzyme will become denatured and will no longer function.
As temperature increases, more enzymes molecules' Active Sites' shapes will be less complementary to the shape of their Substrate, and more enzymes will be denatured. This will decrease the rate of reaction.

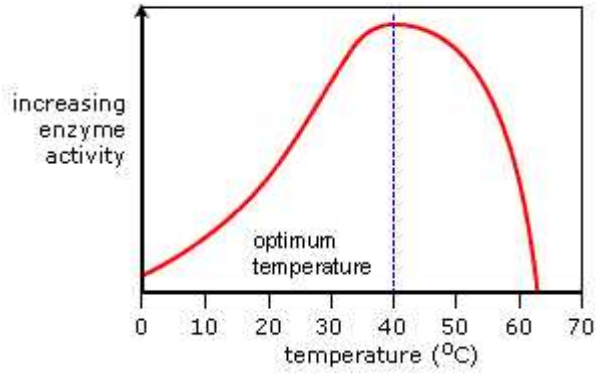


Fig 6.2: Effect of the temperature on an enzyme-controlled reaction

The temperature at which the **maximum rate** of reaction occurs is called the enzyme's **Optimum Temperature**. This is different for **different enzymes**. *Most enzymes in the human body have an Optimum Temperature of around 37.0 °C.*

⟩ pH - Acidity and Basicity

Acid solutions have pH values below 7, and Basic solutions (alkalis are bases) have pH values above 7. Deionised water is pH7, which is termed 'neutral'.
Different enzymes have different pH values at which the bonds within them are interfered with in such a way that the shape of their Active Site is the most Complementary to the shape of their Substrate. At the pH, the rate of reaction is at an Optimum, so this is the Optimum pH.

Any change in pHabove or below the Optimum will quickly cause a decrease in the rate of reaction, since more of the enzyme molecules will have Active Sites whose shapes are not, or at least less, Complementary to the shape of their Substrate.

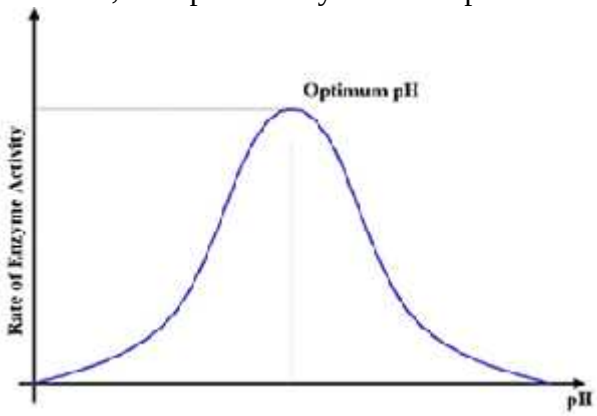


Fig 6.3: Effect of the pH on an enzyme-controlled reaction

Small changes in pH above or below the Optimum do not cause a permanent change to the enzyme, since the bonds can be reformed. However, extreme changes in pH can cause enzymes to denature and permanently lose their function.

Enzymes in different locations have different Optimum pH values since their environmental conditions may be different. ***For example, the enzyme Pepsin functions best at around pH2 and is found in the stomach, which contains Hydrochloric Acid (pH2).***

- **Concentration**

Changing the Enzyme and Substrateconcentrations affect the rate of reaction of an enzyme catalysed reaction. Controlling these factors in a cell is one way that an organism regulates its enzyme activity and so its metabolism.
Changing the concentration of a substanceonly affects the rate of reaction if it is the limiting factor: that is, it the factor that is stopping a reaction from proceeding at a higher rate.
If it is the limiting factor, increasing concentration will increase the rate of reaction up to a point, after which any increase will not affect the rate of reaction. This is because it will no longer be the limiting factor and another factor will be limiting the maximum rate of reaction.

- **Substrate Concentration**

Increasing Substrate Concentration increases the rate of reaction. This is because more substrate molecules will be colliding with enzyme molecules, so more product will be formed.
However, after a certain concentration, any increase will have no effect on the rate of reaction, since Substrate Concentration will no longer be the limiting factor. The enzymes will effectively become saturated, and will be working at their maximum possible rate.

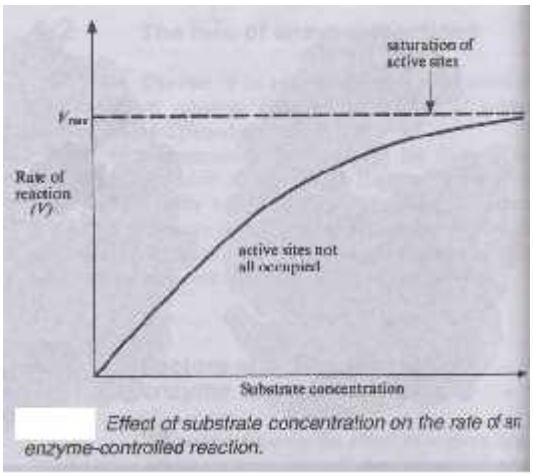


Fig 6.4: Effect of the substrate concentration on an enzyme-controlled reaction

- **Enzyme Concentration**

Increasing Enzyme Concentration will increase the rate of reaction, as more enzymes will be colliding with substrate molecules. However, this too will only have an effect up to a certain concentration, where the Enzyme Concentration is no longer the limiting factor.

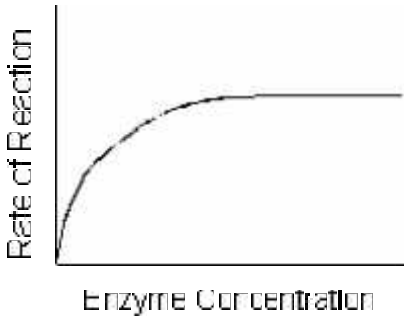


Fig 6.5: Effect of the enzyme concentration on an enzyme-controlled reaction

Unit 7: Photosynthesis

Key Unit Competence: To be able to explain the process of photosynthesis and how various environmental factors affect the rate at which photosynthesis occurs.

Learning Objectives		
Knowledge and understanding	**Skills**	**Attitudes and values**
) Recall the location of plastids and chloroplasts in plants cells.) Define photosynthesis and state the word equation for photosynthesis.) Identify the products of photosynthesis.) Identify and explain the limiting factors of photosynthesis in different environmental conditions.) Explain how the internal and external structures of a leaf are adapted for photosynthesis.) Describe the importance of nitrate and magnesium in chlorophyll synthesis.) Describe the uses, and dangers of nitrogen and other fertilisers.	) Carry out an experiment to test for starch in green leaves.) Interpret graphs about the variations in amount of carbon dioxide and light intensity on the rate of photosynthesis.) Investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis.) Conduct an experiment to show that oxygen is produced by plant leaves during photosynthesis.) Conduct experiment to find out the effects of nitrate and magnesium ions deficiency on plant growth.	) Appreciate the process of photosynthesis in the production of oxygen and reduction of carbon dioxide from the atmosphere.) Realise safety in handling flammable liquids (ethanol).) Express how plants have inhabited different geographical regions.

ACTIVITY 7.1:

- In pairs, carry out an experiment to test for the presence of starch in a leaf using iodine and ethanol and present the results.
- Interpret graphs provided on variation in the amount of carbon dioxide and light intensity affecting the rate of photosynthesis.
- Investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis.
- In groups, perform an experiment to show that oxygen is produced by plants during photosynthesis.
- Make research from the library or internet of internal and external adaptations of leaves for photosynthesis.
- Investigate the effects of varying light intensity, carbon dioxide concentration, temperature and light intensity on the rate of photosynthesis, e.g. in submerged aquatic plants.
- In groups learners isolate chlorophyll and discuss the importance of photosynthesis.
- Discuss case studies of examples of eutrophication from nitrogen and other fertilizers
- In groups, devise an experiment to find out the effects of nitrate and magnesium deficiency on plant growth and record the changes in leaves in tabular form.

Photosynthesis is a metabolic process by which green plants make (up synthesis) sugar (carbohydrates) from carbon dioxide (CO_2) and water, using sunlight energy absorbed by chlorophyll.

7.1. Internal and external adaptations of leaves for photosynthesis

Feature	Structure	Function
External shape and structure	Most plant leaves have numerous leaves, most leaves are thin with a large surface area and a flat leaf blade	Allows maximum absorption of incident light energy Facilitates inward diffusion of carbon dioxide in the mesophyll cells.
Epidermis	Modified parenchyma cells, with thick external wall with a waxy cuticle on the outer surface Epidermis has epidermal hairs (extensions of epidermis), particulate on young leaves.	Support protection of the leaf tissue. The epidermis protects leaf tissue from invasion by predators and from excessive water loss by evaporation.
Stomata	Pores in the leaf epidermis between two guard cells for gas exchange	Regulate entry of carbon dioxide and the loss of water vapor from the leaf.
Palisade mesophyll	Modified parenchyma cells with numerous chloroplasts in the cytoplasm; cells are elongated in shape and packed closely	Power house of the leaf; chloroplasts are the site of photosynthesis. Sugars and other substances are produced in the chloroplasts and oxygen is released.
Spongy mesophyll	Modified parenchyma cells with some chloroplasts in the cytoplasm; cells mostly more or less spherical or elongate, with large interconnecting air spaces between them	Facilitates gaseous exchange by diffusion
Veins containing vascular bundles	Network of small vascular bundles continuous with those of stem and root. Vascular bundles contain xylem vessels and phloem vessels.	Supports the leaf tissues as a large, thin, flexible organs Xylem delivers water to leaf cells Phloem transports the organic products of photosynthesis

7.2. Requirements for Photosynthesis: photosynthesis requires chlorophyll, carbon dioxide, water and sunlight.

a) **Chlorophyll:** Chlorophylls are green pigments found in all photosynthetic organisms and are responsible for their green colour. In plants, chlorophyll is mainly found in the leaves. Young stems and fruits may also have chlorophyll. In lower plants like algae, the whole plant is green and takes part in photosynthesis.

b) **Carbon dioxide:** Air contains about 0.03% of carbon dioxide. Terrestrial plants use atmospheric carbon dioxide in photosynthesis. Aquatic plants use the carbon dioxide dissolved in water. Plants obtain carbon dioxide through pores called stomata present on

the surfaces of leaves. The opening and closing of these pores are regulated by guard cells, which surround them.

c) **Water:** Water is an important raw material for photosynthesis. Plants absorb water from the soil through their root hairs. The water is then transported up to the leaves through the stem.

d) **Sunlight:** Light energy is used in splitting water molecules into hydrogen and oxygen. The splitting of water in the presence of light is called photolysis.

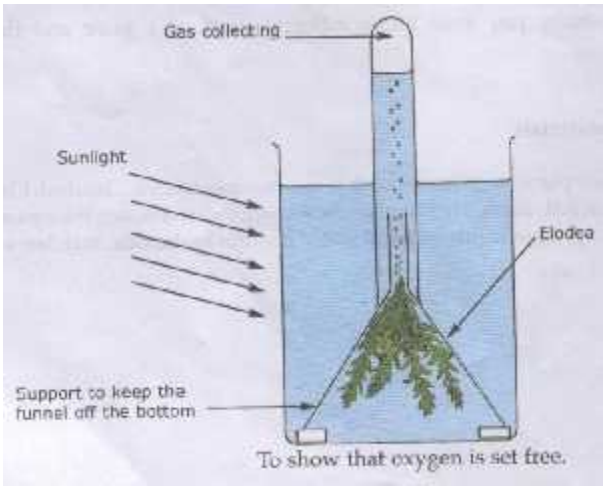


Fig 7.1: Demonstration of photosynthesis in an aquatic plant

7.3. Site of photosynthesis

Though all green parts of a plant are capable of performing photosynthesis, the leaves are the most suitable organs for this process. The cells of the leaves contain special organelles called chloroplasts, which are the main sites of photosynthesis. These are plastids which contain the light-absorbing green pigment chlorophyll. Most photosynthesis occurs in the palisade mesophyll of the leaf.

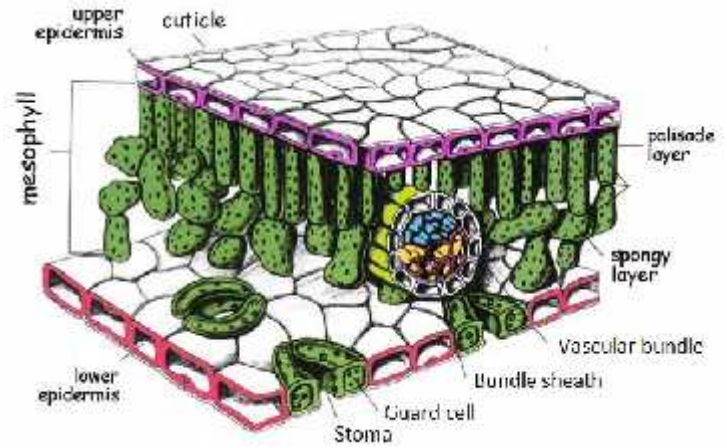
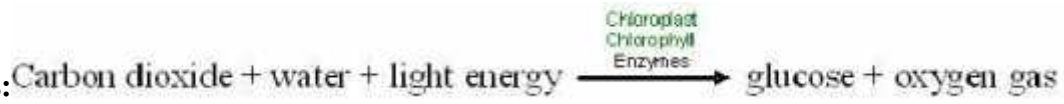
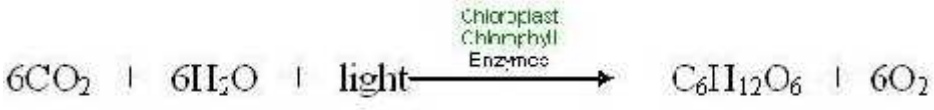


Fig 7.2: Internal structure of the leaf

7.4. Chemical reaction of Photosynthesis

In words: 

We can substitute symbols for the words. Then the above equation appears as:



7.5. Mechanism of Photosynthesis

There are two main stages in the entire process of photosynthesis. The first stage is dependent on light (light dependent reactions). The other stage does not require light (light independent reactions sometimes incorrectly called dark reactions).

During these two stages, the following events occur:

i. Light energy is first absorbed by chlorophyll molecules found inside the chloroplasts.
ii. The absorbed energy causes splitting of water molecules into hydrogen and oxygen. During this process the light energy gets converted into chemical energy.
iii. Finally, carbon dioxide is reduced to carbohydrate (the end product of photosynthesis).

7.6. Products of photosynthesis

Photosynthesis occurs mainly in green parts of the plant and this can be carried especially in leaf, stem, root, flower, etc. There are: primary and secondary products

Primary products

There are **sugars**: glucose and **oxygen**,

Secondary products

There are:

- **Starch**, reserve of glucose stored in different parts of plant. Ex: grain of maize, root of sweet potato, etc.
- **Lipids**, glucose is converted into lipids and stored in different parts of plant. Ex: in fruits of avocado, roots of groundnuts, fruits of fruits etc.
- **Proteins**, glucose is converted into proteins and stored in different parts of plant. Ex: fruits and seeds of bean, soya bean, peas, etc.

7.7. Some plant pigments

Chlorophylls: The major photosynthetic pigments are green and are located on the thylakoid membranes of the chloroplasts. In green plants there are two forms of chlorophyll a and b, which differ slightly in chemical makeup. Most chloroplasts have three times more chlorophyll a than

b. The absorption spectra of the chlorophylls show peak absorbencies in the red and blue-violet regions, with much of the yellow and green light reflected.

Carotenoids

These include the orange **carotenes** and yellow **xanthophylls,** which absorb light in the violet, blue, and blue green regions of the spectrum.

Roles of elaborated sap

Elaborated sap is the solution of water and organic maters (carbohydrates, proteins, lipids, vitamins, minerals) produced during photosynthesis. This solution called also **descendent** or organic or again photosynthetic sap is used for:

(1) Forming the new tissues allowing growth at the level of the roots, buds, flowers and fruits.
(2) Respiration, the function by which carbohydrates are destroyed (degraded) in the presence of oxygen to produce energy needed for plant.
(3) Accumulation of reserves that will be used by the plant

Note: There are two types of saps; **mineral sap** which is conducted by **xylem** from the soil by **absorption** through the roots and **elaborated** sap carried by **phloem** by **photosynthesis** in the leaves.

7.8. Importance of Photosynthesis for living world

(1) **Nutrition of all living organisms.**Green plants make the synthesis of organic matter that is necessary for them. However, these substances are used by both plants and animals. The herbivorous and Omnivorous animals feed directly on green plants and draw from them elaborated organic matter. By eating herbivorous, carnivorous, animals find elaborated matter.
(2) **Production of oxygen.** Atmospheric oxygen that is vital to respiration of living organisms is produced during photosynthesis.
(3) **Air cleaning up:** during photosynthesis, plants absorb carbon dioxide and decrease it in the air.

Note: By absorbing carbon dioxide, photosynthesis protects atmosphere against **pollution**.

(4) Formation of the ozone layer. In the upper layer of atmosphere, oxygen is transformed into ozone (O_3).

The ozone layer prevents some of the ultraviolet rays from the reaching Earth's surface. It plays an important role because the ultraviolet rays can cause skin cancer, eye disorders and destroy phytoplankton which is the main producer of aquatic ecosystems.

7.8. Factors affecting photosynthesis

Intensity of light, carbon dioxide concentration in the air, temperature and water are the important external factors that influence photosynthesis. Internal factors include chlorophyll content and the accumulation of the products of photosynthesis.

1. Experiment to demonstrate that starch is formed during photosynthesis

Pluck a healthy green leaf of a plant which was in the sunlight. Place it in a beaker containing boiling water for about two minutes. Now transfer the leaf to a beaker containing alcohol. Warm it over a water bath for a few minutes.
You will observe that the leaf turns white, indicating that the chlorophyll has been removed. Now wash the leaf carefully in water without damaging it. Place the leaf in a dilute solution of iodine. This will turn the leaf bluish black. The changing of the leaf's colour to bluish black after it has been treated with iodine solution shows that the leaf contains starch.

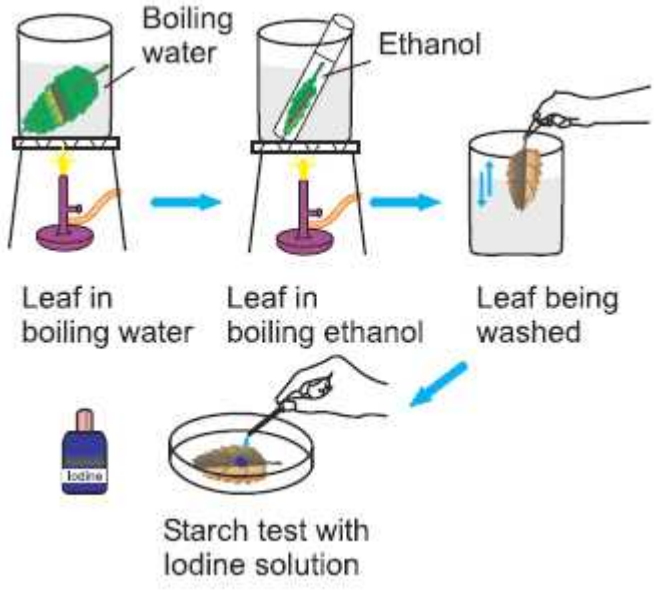


Fig 7.3: Testing a leaf for starch

2. Experiment to demonstrate that carbon dioxide is essential for photosynthesis:

Get two healthy potted plants of almost the same size and place them in the dark for 24 hours to destarch the leaves. Now place them on glass plates. Cover the plants with separate bell jars. Keep some crystals of potassium hydroxide (KOH) in a Petri dish and place it under one of the jars. Make the set-up airtight by applying Vaseline at the bottom of the bell jars.

Fig 7.4: Experiment to show that CO_2 is essential for photosynthesis

Keep the plants in sunlight for photosynthesis to take place. After 3 to 4 hours pluck a leaf from each plant. Boil the leaves in water and subsequently in alcohol, using a water bath, to remove chlorophyll. Now use a few drops of iodine to test for starch in each leaf.
Only one leaf turns blue-black showing the presence of starch. This happens because KOH absorbs the CO_2 present inside one bell jar. As a result, the leaves do not get CO_2 for photosynthesis. Thus the process of photosynthesis is inhibited and starch is not synthesized.

3. Experiment to show that sunlight is essential for photosynthesis:

Keep a potted plant in the dark for 24 hours. On one of the leaves, stick black paper strips (one below and one above the leaf) with the help of Sellotape. Now, place this plant in sunlight for a few hours. Pluck the leaf and remove the black strips.
Boil this leaf, first in water and then in alcohol, to remove chlorophyll. After washing the leaf with water, keep it in a Petri dish. Add a few drops of iodine solution. The leaf turns blue-black except in the region that had been covered. This region did not receive light and hence no starch was formed. The uncovered region received light and starch was formed due to photosynthesis.

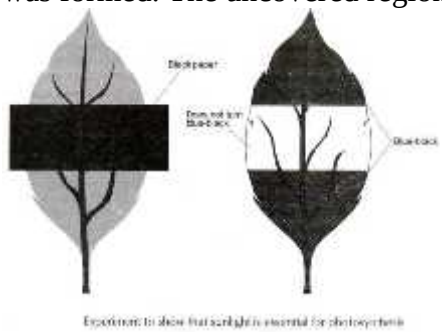


Fig 7.5: Experiment to show that sunlight is essential for photosynthesis

Plants take up different nutrients like nitrogen, phosphorus, iron, magnesium, etc., along with water through the root. These nutrients contribute not only to the process of photosynthesis but also to the general development of the plants. For example, nitrogen is used in the synthesis of proteins and other compounds.

Unit 8: Transport of water, mineral and organic foods in plants

Key Unit Competence: To be able to explain the process of uptake and transport of mineral and organic saps, transpiration and translocation and their roles in plants.

Learning Objectives		
Knowledge and understanding	**Skills**	**Attitudes and values**
⁾ State the functions of xylem and phloem. ⁾ Identify the positions of xylem and phloem tissues as seen in transverse sections of unthickened, herbaceous, dicotyledonous roots, stems and leaves. ⁾ Explain the mechanism by which water moves upwards in the xylem. ⁾ Explain the adaptations of plant leaves to controlling water loss. ⁾ Definetranspiration as loss of water vapour from plant leaves by evaporation of water at the surfaces of the mesophyll. ⁾ Describe the effects of variation of temperature and humidity on transpiration rate. ⁾ Explain how and why wilting occurs. ⁾ List ways in which desert plants are able to reduce water loss and conserve water. ⁾ Define translocation in terms of the movement of sucrose and amino acids in phloem. ⁾ Explain how some parts of a plant may act as a source and a sink for food stores at different times during the life of a plant.	⁾ Demonstrate how translocation takes place in plants. ⁾ Create a table to compare transpiration and translocation. ⁾ Use a potometer to measure the rate of water uptake of a given plant. ⁾ Demonstrate by practical evidence the process of translocation. ⁾ Compare the role of transpiration and translocation in transport of materials from sources to sinks, within a plant at different seasons.	⁾Appreciate the importance of absorption and transport of water in plants. ⁾Understand other perspectives related to transport like the absorption and transport of pesticides. ⁾Show concern for the control of aphid populations among plants since their feeding process on phloem content permits spread of viruses among plants.

ACTIVITY 8.1:

- Find out about the parts of the shoot system that carry out transpiration using branches with leaves.
- In pairs, set up a potometer to measure the rate of water uptake at various conditions of temperature and humidity.
- Discuss how some parts of a plant may act as a source and a sink at different times during the life of the plant.
- In pairs, discus reasons for the different modifications shown on plant shoot and root systems in desert and aquatic environments.
- Research from library or internet how systemic pesticides work to kill pests.

Unlike animals, plants make their own organic molecules, using the process of photosynthesis. Carbon dioxide gas is the source of carbon and light is the source of energy. The main photosynthetic organs are the leaves, which have evolved a large surface area: volume ratio for efficient capture of carbon dioxide and light. As a result, most plants do not have compact bodies like animals, but have extensive branching bodies with leaves above ground. In order to obtain the water and mineral salts also needed for nutrition, plants have extensive root systems below ground. The plant body therefore spreads out to obtain the carbon dioxide, light energy, water and inorganic mineral molecules like sugars and amino acids.

Transport systems are therefore needed for the following reasons:

- **To move substances from where they are absorbed to where they are needed** for example, water and mineral ions are absorbed by roots and transported in the xylem to other parts of the plant.
- **To move substances from where they are produced to where they are needed for metabolism.** For example sugars are produced in the leaves, but glucose is needed by all parts of the plant for respiration and converting to cellulose for making cell walls in areas for growth. Glucose can be moved in phloem as part of the sucrose molecule.
- **To move substances to a different part of the plant for storage** for example, to move sugars into a potato tuber for storage in the form of starch.

Unlike animals, plants do not have systems for transporting carbon dioxide and oxygen. Instead, these gases diffuse through air spaces within stems, roots and leaves.

- **Carbon dioxide:** Photosynthetic plant cells require a supply of carbon dioxide during daylight. Most photosynthetic tissue is in leaves, and most leaves have evolved thin, flat leaves with a large surface area ideal for absorbing as much carbon dioxide as possible. They obtain this by diffusion from the air.
- **Oxygen:** All plant cells require a supply of oxygen for respiration, but cells which are actively photosynthesizing produce more than enough oxygen for their own needs because oxygen is a waste product of photosynthesis. Cells which are not photosynthesizing need to take in oxygen from their environment. Plants have lower energy demands than animals, so they respire at much slower rates. They therefore do not need such a rapid supply of oxygen. The branching shape of plants and a network of air spaces in the plant body provide a large enough surface area for effective absorption of oxygen by diffusion.

To summarise, it is relatively easy for carbon dioxide and oxygen to diffuse into and out of the bodies of plants, reaching and leaving every cell quickly enough down diffusion gradients. Consequently, there is no need for a transport system for gases. However, transport systems are needed for distribution of water, inorganic and organic nutrients, as well as other substances such as plant hormones.

8.2. TRANSPORT OF XYLEM SAP

Water and mineral salts from the soil enters the plant through the epidermis of roots, cross the root cortex, pass into the stele and then flow up to the shoot system.
Root hairs which are extensions of epidermal cells and mycorrhyzae which are symbiotic associations of fungi and plant roots enhance water and mineral absorption. As much as 3 meters of hyphae can extend from each centimeter along the length of a root, reaching a far greater volume of soil than the root alone could penetrate. Mycorrhizae enable even older regions of roots, far from the abundance of root hairs near the root tips, to supply water and minerals to the plant. Xylem sap flows in vessels at rates of 15 meters per hour or faster. Veins branch throughout each leaf, placing xylem vessels close to every cell. Leaves depend on this efficient delivery system to their supply of water. Plants lose an astonishing amount of water by transpiration, the loss of water vapor from leaves and other aerial parts of the plant.

The ascent of ylem sap depends mainly on transpiration and the physical properties of water

1.1.1. Transpirationnal pull

Stomata, the microscopic pores on the surface of a leaf, lead to a maze of internal air spaces that expose the mesophyll cells to the carbon dioxide they need for photosynthesis. The air in these spaces is saturated with water vapor because it is in contact with the moist walls of the leaf.
On most days, the air outside the leaf is drier, that it is, it has a lower water potential than the air that is inside the leaf. Therefore, gaseous water, diffusing down its concentration gradient, exits the leaf via stomata. It is this loss of water vapor from the leaf that we call transpiration.
The water loss via stomata is replaced by water that is pulled out of the leaf xylem.

Importance of transpiration in plants

Water is important for the survival of a plant. Yet, transpiration is responsible for a large loss of water from a plant. Too much transpiration can be disadvantageous for the plant since it can lead to disruption of the different biological processes. Also, excessive water loss through transpiration can result in a decrease in cell turgidity, and consequent loss of mechanical support in the plant.
However, transpiration is useful to the plant because to the plant because it brings about:

i. **Transport of water**: due to transpirationnal pull, water is raised and rapidly distributed to all parts of the plants, where it performs various functions of the plant.

ii. **Cooling of the plant**: the heat which is generated within the plant during cell respiration and that which the plant receives directly from the sun (solar radiation) would cause the plant to reach high temperatures, thereby denaturing enzymes and killing the plant. Transpiration brings about the general cooling down of the plant since it draws heat (latent heat of vaporization) out of the plant itself as water evaporates from the leaves.

iii. **Distribution of minerals**: The movement of water and ions in the xylem vessels also brings about the distribution of mineral ions to all parts of the plant, especially to meristems where rapid growth takes place.

TRANSPIRATION AND MOVEMENT OF WATER THROUGH THE PLANT

Water normally leaves the plant as water vapour. The change from a liquid state to a vapour state requires the addition of energy which is provided by Sun, and it is this energy that maintains the flow of water through the entire plant. Transpiration may occur from the following three sites:

- **Stomata (stomatal transpiration):** by evaporation of water from cells and diffusion of the water vapour through stomata, the pores found in the epidermis of leaves and green stems. (About 90 % of the water is lost this way.)
- **Cuticle (cuticular transpiration):** by evaporation of water from the outer walls of epidermal cells through the waxy cuticle covering the epidermis of leaves and stems. (About 10 % of the water lost, varying with thickness of cuticle.)
- **Lenticels (lenticular transpiration):** by evaporation of water through lenticels. These are small slits in the stems and bark of trees for gas exchange. (Minute proportions, although this is the main method of water loss from deciduous trees after leaf fall.)

The quantities of water lost by transpiration can be very large. A herbaceous plant, such as cotton or sunflower, can lose 1-2 dm^3 of water per day, and a large oak tree may lose more than 600 dm^3 per day.

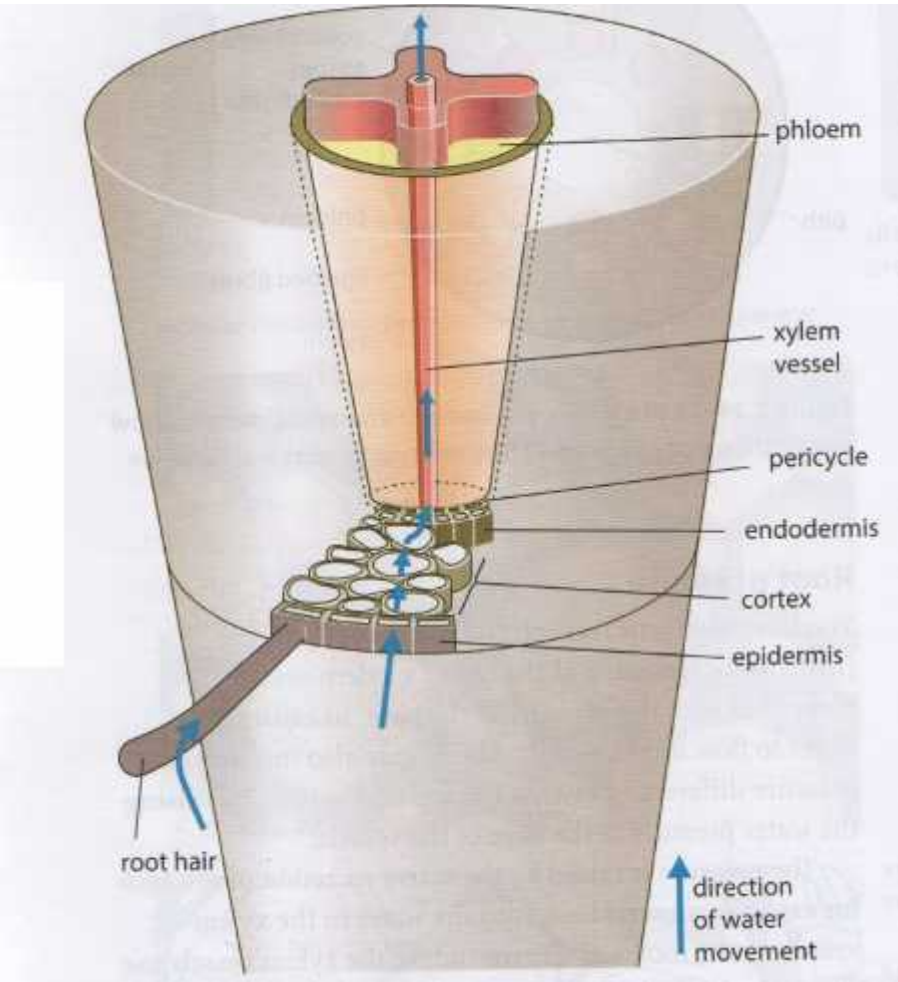


Fig 8.1: The pathway of water movement from root hair to xylem

8.3. FACTORS THAT AFFECT THE RATE OF TRANSPIRATION

The rate of water loss can be affected by many things. Some of these are to do with the plant, others are environmental. Anything that increases the gradient between the water vapour potential inside the leaf and that outside the leaf will increase water loss.

Feature that affect the rate of water loss	How it affects water loss
Number of leaves	A plant with more leaves has a large surface area over which water vapour can be lost.
Number, size and position of stomata	If the leaves have many large stomata, then water vapour is lost more quickly. If the stomata are on the lower surface, water vapour loss is slower.
Presence of cuticle	A waxy cuticle reduces evaporation from the leaf surface
Light	In light, the stomata open to allow gaseous exchange for photosynthesis
Water availability	If there is little water in the soil, then the plant cannot replace the water that is lost. Water loss in plants is reduced when stomata are closed or

	when the plants shed their leaves.
Temperature	A higher temperature will increase the rate of water loss in three ways. It will: - Increase the rate of evaporation from the cell surfaces so that the water vapour potential in the leaf rises. - Increase the rate of diffusion through the stomata because the water molecules have more kinetic energy. - Decrease the relative water vapour potential in the air, allowing more rapid diffusion of molecules out of the leaf.
Relative humidity	Higher relative humidity in the air will decrease the rate of water loss. This is because there will be a smaller water vapour potential gradient between the air spaces in the leaf and the air outside.
Air movement or wind	Air moving outside the leaf will carry away water vapour that has just diffused out of the leaf. This will maintain a high water vapour potential gradient.

Table 8.1: Factors that affect the transpiration rate

Measuring the rate of transpiration

It is common practice to use a potometer to measure transpiration (the loss of water vapor from the aerial system). In fact, the potometer measures water uptake by the leafy shoot. As the shoot transpires, the water vapor it has lost is replaced by liquid water drawn in from the potometer via the xylem of the stem. Water uptake is assumed to be the same as the water lost by the shoot due to transpiration.

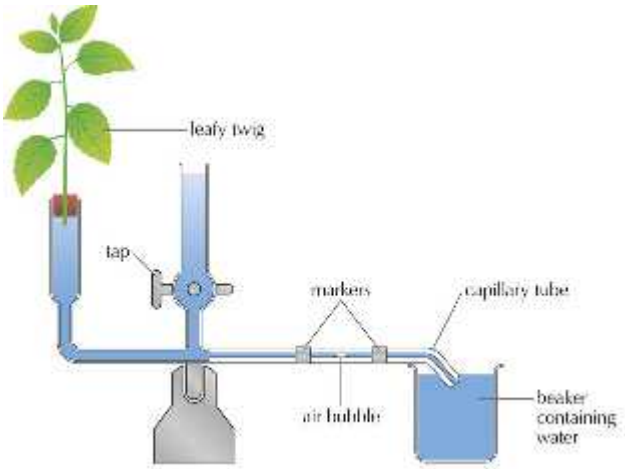


Fig 8.2: A simple potometer

Root pressure

Root pressure is generated by osmotic pressure within the root tissue. It pushes water into and up the xylem tissue. The existence of root pressure becomes evident when the main stem is cut a short distance above the soil surface.
Water oozes out of the exposed surface of the remaining intact stem. This water is forced out by pressure originating from the root system from the root system itself. This is why it is called root pressure.

Capillarity

This is the movement of liquids up of the fine bore of narrow tubes. Xylem vessels have very narrow bores and so can lift up water to a distance of 20 cm or more within a plant.

Cohesion and adhesion of water

The transpirational pull on xylem sap is transmitted all the way from the leaves to the root tips and even into the soil solution. The solution of water due to hydrogen bonding is possible to pull a column of sap from above without the water separating.
Water molecules exiting the xylem in the leaf tug on adjacent water molecules and this pull is relayed molecule by molecule down to the entire column of water in the xylem. Also helping to fight gravity is the strong adhesion of water molecules (again by hydrogen bonds) to the hydrophilic walls of the xylem cells.
The very small diameter of tracheids and vessel elements contribute to the importance of adhesion in overcoming the downward force of gravity.

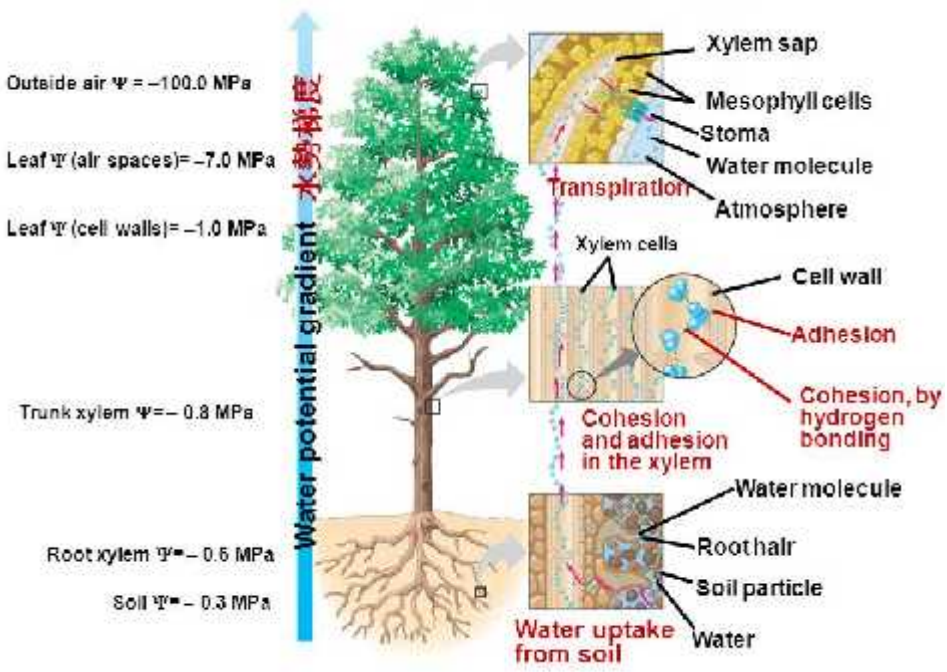


Fig 8.2: The ascent of xylem sap

Plant adaptations to avoid water loss (xeromorphic adaptations)

- Smaller leaves, particularly leaves shaped like needles. This reduces the total surface area of the leaves. The total leaf surface area is also reduced, so that less water is lost by transpiration.
- A thicker waxy cuticle reduces evaporation.
- Closing the stomata when water availability is low.
- Rolling the leaves so that the lower epidermis is not exposed to the atmosphere.
- Some plants have a low water potential inside their leaf cells. This is achieved by maintaining a high salt concentration inside their cells.
- Hairs on the surface of leaf trap a layer of air close to the surface. This air can become saturated with moisture and will reduce the diffusion of water vapor out through the stomata.
- Having tissues tolerant to water loss (desiccation).
- Some plants manage to live in dry places by having extremely deep roots which absorb water from deep the soil.
- Some plants store water in large parenchyma cells contained within swollen stems and leaves.
- Many plants survive dry periods as seeds or spores, a method of evading drought.
- Some plants pass unfavorable season as bulbs or tubers.
- Some plants shed their leaves in drought.

Fig 8.3: Some xerophytic plants

Note: the *Marram grass* plant is adapted to living in hot climates because it has many features that help to reduce water loss.

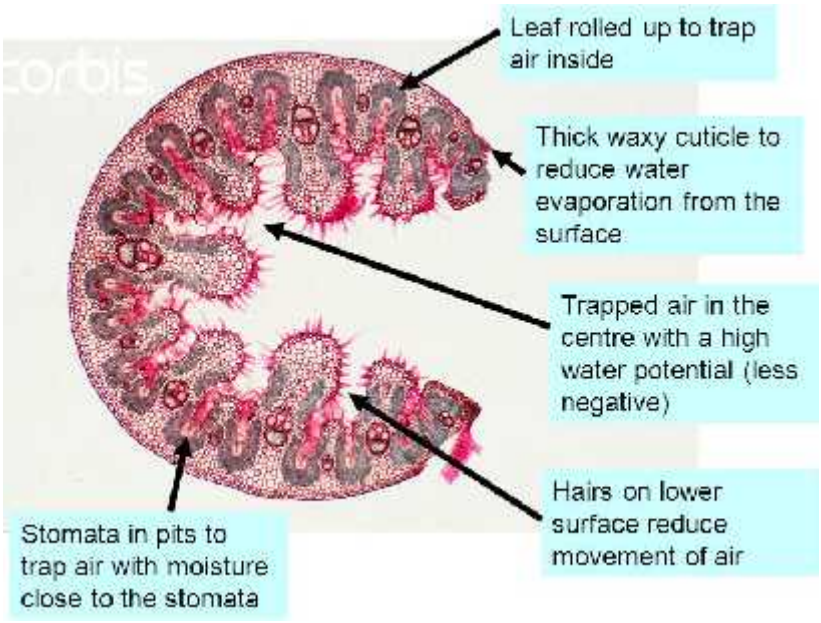


Fig 8.4: Marram grass

8.4.Transport of organic substances

Xylem sap generally flows in the wrong direction in exporting sugar from leaves to other parts of the plant. A second vascular tissue, the phloem, transports the organic products of photosynthesis throughout the plant. This transport of food in the plant is called ***translocation*.**
In angiosperms, the specialized cells of phloem that function in translocation are the sieve-tube members which are arranged end to end to form long sieve-tubes.

Between the members are sieve plates, porous cross walls that allow the flow of sap along the sieve tube. Phloem sap is an aqueous solution that differs markedly in composition from xylem sap. By far, the prevalent solute in phloem sap is sugar, primarily the disaccharide sucrose.
The sucrose concentration may be as high as 30 % by weight, giving the sap a syrupy thickness. Phloem sap may also contain minerals from one part of the plant to another.

a. Phloem tanslocates its sap from a sugar source to a sugar sink

In contrast to the unidirectional transport of xylem sap from roots to leaves, the direction that phloem sap travels is variable: the generalization that holds is that sieve tube carry food from a sugar source to a sugar sink.
A s**ugar source** is a place where sugar is produced by photosynthesis or by the breakdown of sugars. Mature leaves are the primary sugar sources.
A **sugar sink** is an organ which consumes or stores sugar. Growing roots, shoot tips, stems and fruits are sugar sinks supplied by the phloem.
A storage organ such as a tuber or a bulb may be either a source or a sink depending on the season. When the storage organ is stockpiling carbohydrates during the summer, it is a sugar sink. After breaking dormancy in the early spring, however, the storage organ becomes a source as its starch is broken down to sugar, which is carried away in the phloem to the growing buds of the shoot system.

Other solutes may be transported to sinks along with sugars. For example, minerals that reach leaves in xylem may later be transferred in the phloem to developing fruit. A sugar sink usually receives its sugar from the sources nearest to it.
The upper leaves on a branch may send sugar to the growing shoot tip, whereas the lower leaves export sugar to the roots. A growing fruit requires so much food that it may monopolize the sugar sources all around it. One sieve tube in a vascular bundle may carry phloem sap in one direction while sap in a different tube in the same bundle flows in the opposite direction.
For each sieve tube, the direction of transport depends only on the location of the source and sink connected by that tube, and the direction may change with the season or development stage of the plant.

b. Pressure flow is the mechanism of translocation in flowering plants

The **Pressure Flow Hypothesis**, also known as the **Mass Flow Hypothesis**, is the best-supported theory to explain the movement of sap through the phloem. It was proposed by **Ernst Munch, a German plant physiologist in 1930.** A high concentration of organic substances, particularly sugar, inside cells of the phloem at a source, such as a leaf, creates a diffusion gradient (osmotic gradient) that draws water into the cells from the adjacent xylem. This creates turgor pressure, also known as hydrostatic pressure, in the phloem. Movement of phloem sap occurs by **bulk flow (mass flow)** from *sugar sources* to *sugar sinks*. The movement in phloem is bidirectional, whereas, in xylem cells, it is unidirectional (upward).

Unit 9: Gaseous exchange in humans and plants

Key Unit Competence: To be able to explain gaseous exchange in humans and plants.

Learning Objectives		
Knowledge and understanding	**Skills**	**Attitudes and values**
⁄ State the characteristic features of respiratory surfaces. ⁄ Define gaseous exchange and state why it is an important process. ⁄ Explain the features or adaptations of gaseous exchange surfaces. ⁄ Describe the process by which air is moved into and out of the lungs during breathing. ⁄ Describe the process of gaseous exchange at the alveolus. ⁄ Identify common respiratory diseases and suggest their prevention and treatment. ⁄ Explain the process of gaseous exchange in plants.	⁄Demonstrate the processes of inspiration and expiration through deep breathing movements. ⁄Dissect a mammalian lung and arrive at its characteristic features related to gaseous exchange surfaces. ⁄Construct a bell-jar model apparatus from locally available materials. ⁄Design an experiment to show that expired air contains more carbon dioxide than inspired air. ⁄Observe stomata from epidermal leaf and use it to explain how gaseous exchange takes place. ⁄Compare the composition of inspired and expired air.	⁄Appreciate that learning can be enhanced by using readily available simple materials.

ACTIVITY 9.1:

- Learners discuss the importance of gaseous exchange by answering the teacher's probing questions.
- Learners observe the lungs of a dissected mammal and arrive at characteristic features of gaseous exchange surfaces.
- Learners make and use a model thorax to understand the mechanism of breathing.
- Set up experimentation to show that expired air contains more carbon dioxide than inspired air.
- Learners in groups use illustrations to explain gaseous exchange at the alveolus.
- Learners research common respiratory diseases, their prevention and treatment.
- Learners observe stomata from epidermal leaf and use it to explain how gaseous exchange takes place.

Gas exchange is the transport of oxygen from the outside air to the cells of the body, and the transport of carbon dioxide in the opposite direction. This is in contrast to the biochemical definition of cellular respiration, which refers to cellular respiration. **Cellular respiration** is the metabolic process by which an organism obtains energy by reacting oxygen with glucose to give water, carbon dioxide and ATP (energy). Although respiration is necessary to sustain cellular

respiration and thus life in animals, the processes are very different. Cellular respiration takes place in individual cells of the animal, while respiration involves the transport of metabolites between the organism and external environment.

9.1. Properties of gas exchange surfaces

All gas exchange surfaces have the following properties:

i. A **large surface area relative to the volume of the body**. If your lungs were laid out flat they would cover an area of between 50-100 m^2, almost the size of a volley ball court. Your skin has an area of about $2m^2$.
ii. They are **permeable to carbon dioxide and oxygen**. This also makes them permeable to water, which makes them moist.
iii. They are **thin.** In case of the gas exchange surface in human lungs, the distance gases have to diffuse from the air to the blood is less than 15µm.
iv. They often have a **ventilation mechanism** to ensure a continuous supply of air or water to the gas exchange surface.
v. Larger animals have a **circulation system to transport gases** to and from the gas exchange surfaces.

9.2. Structures of the Respiratory System

The nose and **nasal cavity** filter, warm, and moisten the inhaled air. The nose hairs and mucus produced by the epithelial cells in the nose catch airborne particles and prevent them from reaching the lungs. Behind the nasal cavity, air next passes through the **pharynx**, a long tube that is shared with the digestive system. Both food and air pass through the pharynx. A flap of connective tissue called the **epiglottis** closes over the trachea when food is swallowed to prevent choking or inhaling food. In humans the pharynx is important in vocalization. The **larynx**, also called the voicebox, is found just below the point at which the pharynx splits into the trachea and the esophagus. The voice is generated in the larynx. Air from the lungs is needed for the vocal folds to produce speech. The **trachea**, or wind pipe, is a long tube that leads down to the chest where it divides into the right and left **bronchi** in the lungs. The bronchi branch out into smaller bronchioles, which are the first airway passages that do not contain cartilage. The bronchioles lead into the **alveoli**, which are the multi-lobed sacs in which most of the gas exchange occurs.

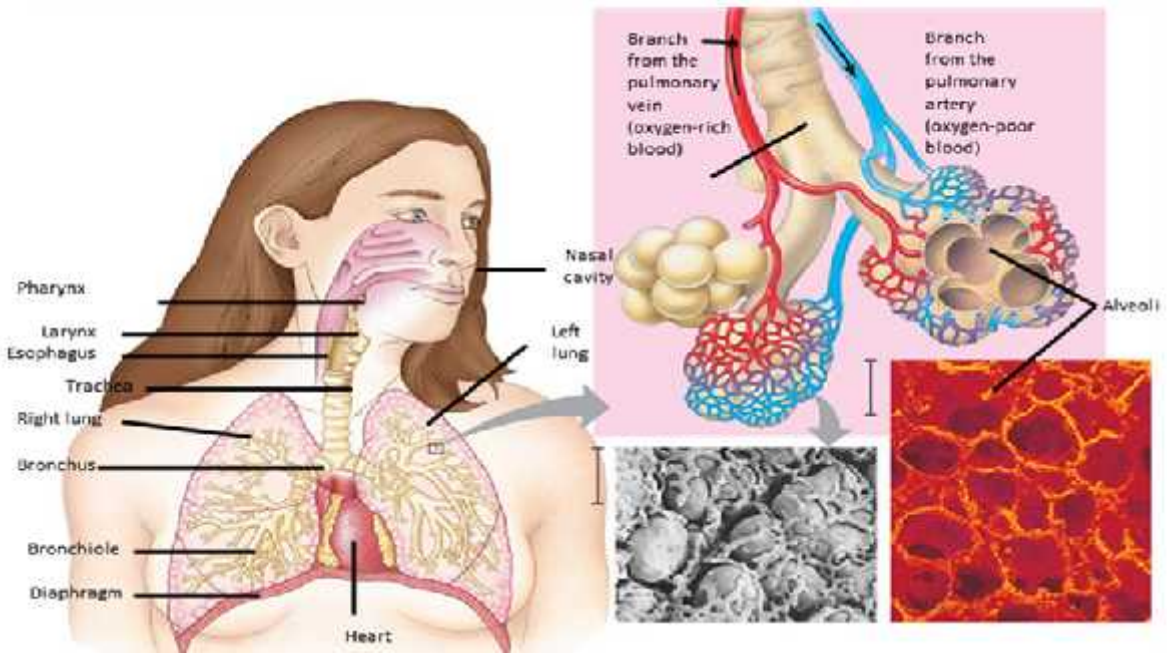


Fig 9.1: Human respiratory system

Ventilation: From the Air to the Alveoli

Air enters the body through the nose, is warmed, filtered, and passed through the nasal cavity. Air passes the pharynx (which has the epiglottis that prevents food from entering the trachea). The upper part of the trachea contains the larynx. The vocal cords are two bands of tissue that extend across the opening of the larynx. After passing the larynx, the air moves into the trachea. The trachea is a long tube that divides into two smaller tubes called bronchi which lead into each lung. Bronchi are reinforced to prevent their collapse and are lined with ciliated epithelium and mucus-producing cells. Bronchi branch into smaller and smaller tubes called bronchioles. Bronchioles end in grape-like clusters called alveoli. Alveoli are surrounded by a network of thin-walled capillaries. Breathing in, or inhaling, is usually an active movement, contraction of the diaphragm muscles uses ATP.

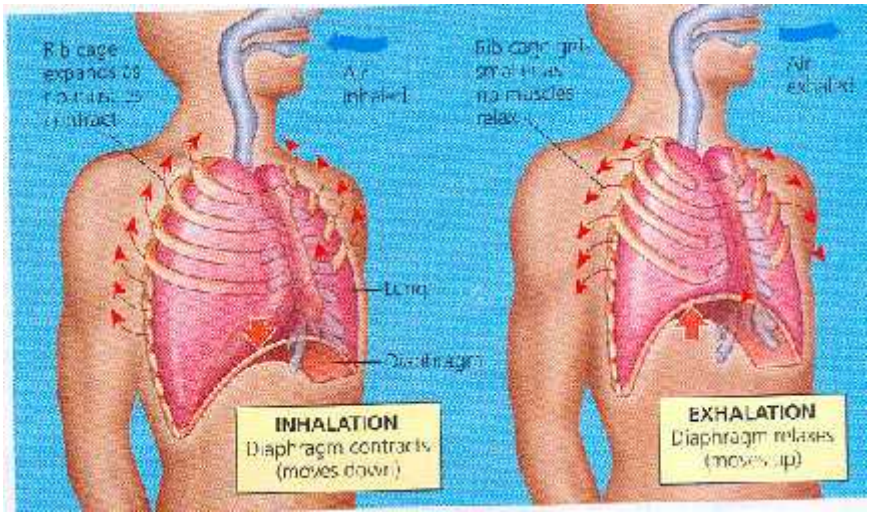


Fig 9.2: Breathing in a mammal

The **diaphragm** is a muscle that is found below the lungs. Contraction of the diaphragm causes the volume of the chest cavity to increase, and the air pressure within the lungs to decrease. The pressure difference causes air to rush into the lungs. Relaxation of the diaphragm causes the lungs to recoil and air is pushed out of the lungs. Breathing out, or exhaling, is normally a passive process powered by the elastic recoil of the chest, similar to letting the air out of a balloon.

Pulmonary Gas Exchange: From the Alveoli into the Pulmonary Capillaries

Breathing is only part of the process of delivering oxygen to where it is needed in the body. The process of **gas exchange** occurs in the alveoli by diffusion of gases between the alveoli and the blood passing in the lung capillaries. Recall that diffusion is the movement of substances from an area of higher concentration to an area of lower concentration. The difference between the high concentration of O_2 in the alveoli and the low O_2 concentration of the blood in the capillaries is enough to cause O_2 molecules to diffuse across the thin walls of the alveoli and capillaries and into the blood. CO_2 moves out of the blood and into the alveoli in a similar way. The greater the concentration difference, the greater the rate of diffusion.

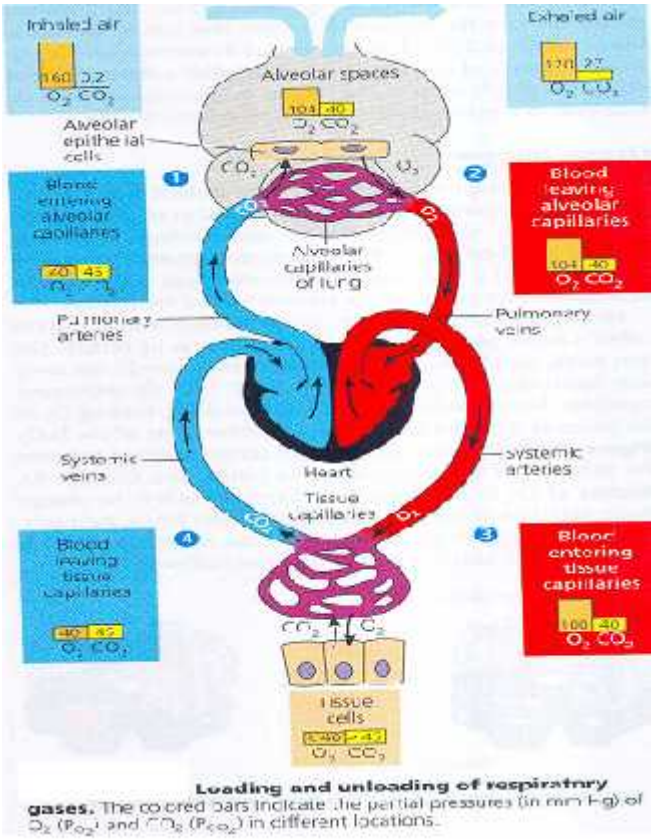


Fig 9.5: Gas exchange in the lungs and tissues

Breathing also results in loss of water from the body. Exhaled air has a relative humidity of 100 percent because of the diffusion of water that from the moist surface of the breathing passages and the alveoli into the warm exhaled air.

In the lungs, oxygen is transported across the thin membranes of the alveoli and the border of the capillary and attracted to the hemoglobin molecule within the red blood cell.

After leaving the lungs, the oxygenated blood returns to the heart to be pumped through the aorta and around the body. The oxygenated blood travels through the aorta, to the smaller arteries, arterioles, and finally to the peripheral capillaries where gas exchange occurs.

Diseases of the respiratory system, symptoms and prevention

Diseases	**Causal agent**	**Symptoms**	**Prevention**
Influenza (cold) infection of nasal passages	*Influenza virus*(more than 200 different viruses)	Nose color Difficult nasal breathing Cough, fever, sore, throat, sneezing	Avoid contacts with sick people Cover the nose and mouth in case of illness to avoid contaminating others
Asthma (lung inflammation)In	Many agents: cold: cold air, pollen or	Difficulty breathing,	Avoid home dust Avoid contact with

asthma, periodic constriction of the bronchi and bronchioles makes it more difficult to breathe in and, especially, out	allergens(dust, mites, cats, dogs, fungi, etc)	abdominal accumulation of blood in lung vessels of congestion	hairy pets, avoid smoking and smoke, identify and avoid causal agent
Pneumonia (lung inflammation especially of the alveoli) Tissue fluids accumulate in the alveoli reducing the surface area exposed to air. If enough alveoli are affected, the patient may need supplemental oxygen	*Streptococcuspneumoniae* Viruses Chemical products Carriers such as fungi	Fever, difficulty of breathing, pain in the chest, rapid and shallow breathing, wheezing, coughing, cold followed by fever	Vaccination Drink plenty of fluid, breath hot vapors, taking warm baths and messages. Pneumonia can kill within a very short period of time.
Lung cancer	Cigarette	Chronic coughing, hoarse voice, pain in the chest, fever	Avoid smoking, avoid inhaling polluted air, surgery, chemotherapy, radiation therapy, combination of surgery, chemotherapy and radiation
Emphysema In this disorder, the delicate walls of the alveoli break down, reducing the gas-exchange area of the lungs. The condition develops slowly and is seldom a direct cause of death. However, the gradual loss of gas-exchange area forces the heart to pump ever-larger volumes of blood to the lungs in order to satisfy the body's needs. The	Release of proteolytic enzymes as part of the inflammatory process that follows irritation of the lungs	Unable to carry a normal breathing,	Most people avoid this kind of damage during infections, etc. by producing an enzyme inhibitor called **alpha-1 antitrypsin**. Patients have to breathe from an oxygen cylinder to stay alive No cure for emphysema

added strain can lead to heart failure.			
Bronchitis This is serious inflammation of the **bronchi** caused by a virus	Cigarette smokers	Noisy cough, excess mucus secretion, fever	Avoid smoking and inhaling air from smokers Suppressants have been introduced to provide relief to patients
Tuberculosis (TB) A serious disease that attacks lungs but also attacks bones.	Bacillus of Koch (***Mycobacterium tuberculosis***)	Cough that lasts a long time, fever that is on and off, pale skin, enlarged glands easily felt beneath the skin, difficulty in breathing, loss of weight, Loss appetite, excessive sweating,	Immunization for children against TB with BCG The patient should avoid sharing utensils with other people, TB patients should sleep or stay in isolated rooms or houses, people should live and work in well ventilated rooms or houses, TB patients should cough while covering their mouth with cloth.
Bronchitis	Often due to the tobacco smoking	Respiratory insufficiency, noisy cough, excess mucus secretion, fever	Non-smokers should avoid smoking and inhaling air from smokers
Sinusitis Inflammation of sinus cavities usually that develop after cold or allergic reactions	The blockage of opening of the sinus cavities	Headache or facial pain, nasal congestion, green and yellow nasal mucus, cough, sore throat, fatigue	Avoid cigarette smoke and pollution, humidifiers, increased liquids, treat allergies and respiratory infections promptly, antibiotics, sinus surgery to drain sinus cavities.

STRUCTURE OF LEAVES

The leaf is the primary photosynthetic organ of most plants. Leaves are usually flattened blades that consist, internally, mostly of parenchyma tissue called the mesophyll, which is made up of

loosely arranged cells with spaces between them. The spaces are filled with air, from which the cells absorb carbon dioxide and into which they expel oxygen. The mesophyll is bounded by the upper and lower surface of the leaf blade, which is covered by epidermal tissue. A vascular network runs through the mesophyll, providing the cell walls with water and removing the food products of photosynthesis to other parts of the plants. The leaf blade is connected to the stem through a narrowed portion called the petiole, or stalk, which consists mostly of vascular tissue. Appendages called stipules are often present at the base of the petiole.

Many specialized forms of leaves occur. Some are modified as spines, which help protect plants from predators. Insectivorous plants possess highly modified leaves that trap and digest insects to obtain needed nutrients. Some leaves are brightly colored and petal-like, serving to attract pollinators to otherwise small, unattractive flowers. Perhaps the most highly modified leaves are flowers themselves. The individual parts of flowers—carpels, stamens, petals, and sepals—are all modified leaves that have taken on reproductive functions.

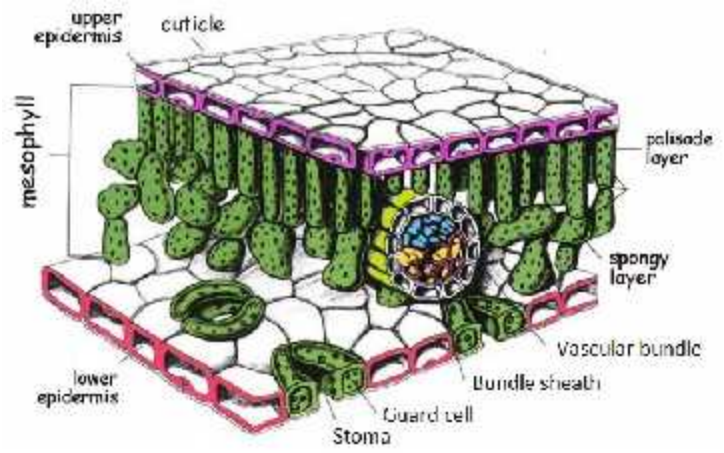


Fig 9.6: Internal structures of the leaf

The internal structure of a typical leaf is shown on the figure above. The vascular tissue of the leaf is located in the veins that run through the midrib and veins of the leaf. Just beneath the epidermal layer are two layers of **mesophyll.**
Mesophyll is the photosynthetic tissue of a leaf. It is usually made up two types of parenchyma cells: **palisade mesophyll** and **spongy mesophyll**.

The palisade mesophyll is made up of columnar shaped cells containing many chloroplasts. These cells are found under the upper epidermis, allowing for maximum exposure to the sun. **Most photosynthesis takes place in the palisade mesophyll.**

Below the palisade mesophyll is the spongy mesophyll, which is composed of loosely packed, irregular shaped cells. These cells are surrounded by many air spaces. These air spaces allow carbon dioxide, oxygen, and water vapor to freely flow around the cells. These gases can also move in and out of the stomata, which are located mainly on the lower epidermis.

The epidermis may contain **stomata,** openings through which gases are exchanged with the atmosphere. These openings are surrounded by specialized cells called **guard cells**, which, through changes in their size and shape, alter the size of the stomatal openings and thus regulate the gas exchange. The epidermis is covered with a waxy coating called the cuticle, which functions as a waterproofing layer and thus reduces water loss from the plant surface through evaporation.

Unit 10: Excretion in humans

Key Unit Competence: To be able to describe the structure and function of excretory organs and suggest good practices for healthy kidneys.

Learning Objectives

Knowledge and understanding	Skills	Attitudes and values
⁾ Define excretion as the removal from organism of toxic materials, the waste products of metabolism and substances in excess of requirements. ⁾ Explain the need for excretion, limited to toxicity of urea and carbon dioxide. ⁾ Name the excretory organs and excretory products of humans. ⁾ State that urea is formed in the liver from excess amino acids through the process of deamination. ⁾ Outline the structure of the kidney, limited to the cortex, medulla and ureter. ⁾ Describe a nephron as made of Bowman's capsule, proximal convoluted tubule, Loop of Henle, distal convoluted tubule, and collecting duct (no further details are required). ⁾ Describe the process of urine formation limited to ultra-filtration and selective re-absorption. ⁾ Explain that the volume and concentration of urine produced is affected by water intake, temperature and exercise.	⁾ Using a dissected mammal to identify parts of the urinary system. ⁾ Illustrate using diagrams the internal structure of a mammalian kidney limited to cortex, medulla and ureter. ⁾ Demonstrate that an individual may pass much dilute urine or little but concentrated urine. ⁾ Draw a well labelled structure of nephron.	⁾ Develop good habits to maintain a healthy urinary system.

ACTIVITY 10.1:

- Learners brainstorm why an individual would develop health problems if he/she does not urinate for a long period.
- Learners carry out research on different excretory organs and the respective secretions and present to the class.
- Learners observe the urinary system of a dissected mammal such as a rabbit or a photograph and identify the kidneys, ureters, bladder and urethra.
- Learners observe the internal structure of mammalian kidney and identify cortex, medulla and pelvis.
- Learners are provided with two unlabelled diagrams of the urinary system and human kidney and are requested to label them.
- Learners make research from textbook to identify parts of a nephron/kidney tubule and locate on it stages in urine formation.
- Learners make a research project on why an individual may pass much diluted urine or little but concentrated urine.
- Learners discuss in groups good habits that enhance healthy urinary system.

Excretion and osmoregulation

Excretion is the removal from the body of toxic wastes products of metabolism. The term is generally taken to mean nitrogenous wastes such as urea, ammonia and uric acid but other materials like carbon dioxide and the bile pigments are also waste products of metabolism, and their removal is as much a part of excretion as the elimination of urea.

Excretion is an essential process in all forms of life. When cells metabolize—or break down—nutrients, waste products are produced. For example, when cells metabolize amino acids, nitrogen wastes such as ammonia are produced. Ammonia is a toxic substance and must be removed from the blood and excreted from the body. Excretion is also necessary to remove excess water, salts, and many other substances from the body.

Although the kidneys are the main organs of excretion of wastes from the blood, several other organs are also involved in excretion, including the liver, skin, and lungs.

- The **liver** breaks down excess amino acids in the blood to form ammonia, and then converts the **ammonia to urea, a less toxic substance**. The liver also breaks down other toxic substances in the blood, including alcohol and drugs.
- The **skin** eliminates **water and salts in sweat**.
- The **lungs** exhale water **vapour** and **carbon dioxide.**

Osmoregulation is the process by which the osmotic pressure of the blood and tissue fluid is kept constant. Excretion and osmoregulation should be considered together and in the mammal, the same organ performs both functions.

Types of nitrogenous wastes

An animal's nitrogenous wastes reflect its phylogeny and habitat. Because most metabolic wastes must be dissolved in water to be excreted, the type and quantity of waste products may have a large impact on an animal's waste balance. In this regard, some of the most significant waste products are the nitrogenous breakdown products of proteins and nucleic acids. When proteins and nucleic acids are broken apart for energy or converted to carbohydrates or fats, enzymes remove nitrogen in the form of ammonia (NH_3)**. Ammonia is very toxic**, in part because its ion, ammonium (NH_4^+) interferes with oxidative phosphorylation. Although some animals excrete ammonia directly, many species expend energy to convert it to less toxic compounds prior to excretion. It is excreted by **most aquatic animals including most bony fishes.**

Urea is produced in the vertebrate liver. It is the product of a metabolic cycle that combines ammonia with carbon dioxide. **The main advantage of urea is its very low toxicity**. Animals can transport urea in the circulatory system and store it safely at high concentrations. Furthermore, **much less water is lost** when a given quantity of nitrogen is excreted in a concentrated solution of urea than would be in a dilute solution of ammonia. It is excreted by **mammals and most amphibians**.

Uric acid is relatively **non toxic and does not readily dissolve in water**. It therefore can be excreted as a semisolid paste. This is a great advantage for animals with little access to water, but there is a cost: uric acid is even more energetically expensive to produce than urea, requiring considerable ATP for synthesis from ammonia. It is excreted by many **reptiles, insects and land snails.**

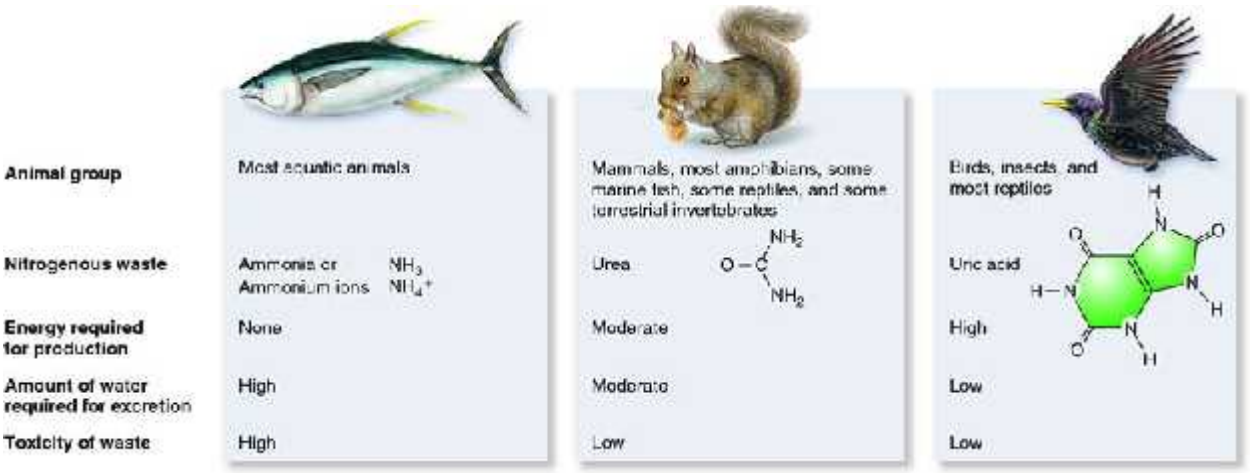


Fig 10.1: Types of nitrogenous wastes

Kidneys and Excretion

The kidneys are part of the urinary system. The kidneys work together with other urinary system organs in the function of excretion. The urinary system is shown in the figure below.

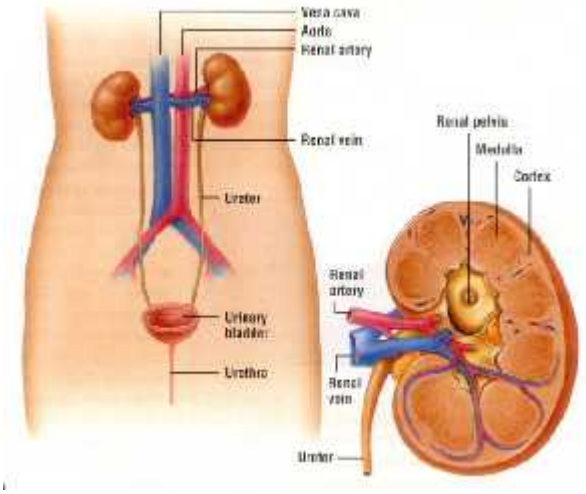


Fig 10.2: Urinary system

a) Urinary System

In addition to the kidneys, the urinary system includes the **ureters, bladder, and urethra**. The main function of the urinary system is to **filter waste products and excess water from the blood and remove them from the body.** The two kidneys, which are described in detail above, filter the blood and form urine. Urine is the liquid waste product of the body that is excreted by the urinary system.

From the kidneys, urine enters the ureters, which carry it to the bladder. Each ureter is a muscular tube about 25 centimeters long. Peristaltic movements of the muscles of the ureter send urine to the bladder in small spurts.

The bladder is a hollow organ that stores urine. It can stretch to hold up to 500 milliliters. When the bladder is about half full, the stretching of the bladder sends a nerve impulse to the sphincter that controls the opening to the urethra. In response to the impulse, the sphincter relaxes and lets urine flow into the urethra.
The urethra is a muscular tube that carries urine out of the body. Urine leaves the body through another sphincter in the process of urination. This sphincter and the process of urination are normally under conscious control.

- **Kidneys**

The kidneys are a pair of bean-shaped, reddish brown organs about the size of a fist. They are located just above the waist at the back of the abdominal cavity, on either side of the spine. The kidneys are protected by the ribcage. They are also protected by a covering of tough connective tissues and two layers of fat, which help cushion them.
Located on top of each kidney is an **adrenal gland**. The two adrenal glands **secrete several hormones.** Hormones are chemical messengers in the body that regulate many body functions. The adrenal hormone aldosterone helps regulate kidney functions.

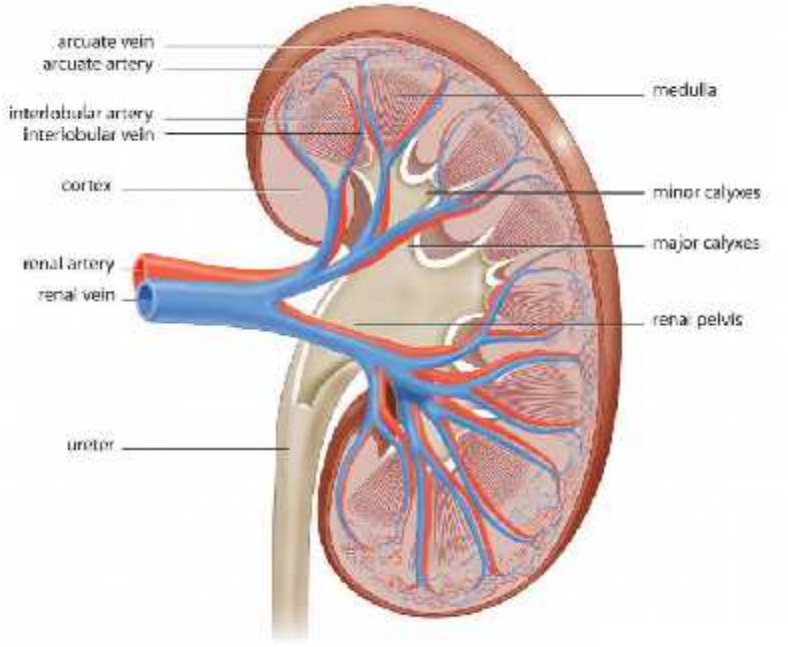


Fig 10.3: Human kidney

- **Nephrons**

Nephrons are the structural and functional units of the kidneys. A single kidney may have more than a million nephrons. The diagram below represents an individual nephron and shows its main structures and functions. The structures include the glomerulus, Bowman's capsule, and renal tubule.

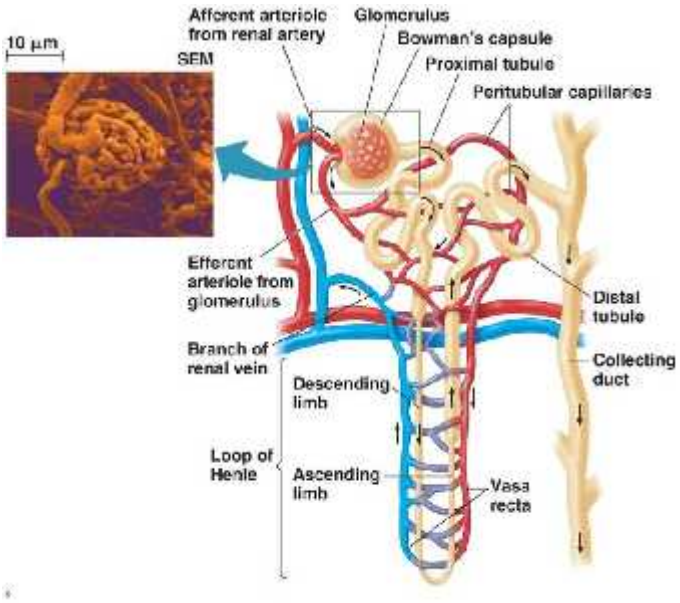


Fig 10.4: The nephron

Nephron structures and functions

• The glomerulus is a cluster of arteries that filters substances out of the blood.
• Bowman's capsule is a cup-shaped structure around the glomerulus that collects the filtered substances.
• The renal tubule is a long, narrow tube surrounded by capillaries that reabsorbs many of the filtered substances and secretes other substances.

- **Filtration, Reabsorption, and Secretion**

The renal arteries, which carry blood into the kidneys, branch into the capillaries of the glomerulus of each nephron. The pressure of blood moving through these capillaries forces some of the water and dissolved substances in the blood through the capillary walls and into Bowman's capsule. Bowman's capsule is composed of layers. The space between the layers, called Bowman's space, fills with the filtered substances.
The process **of filtering substances from blood in the glomerulus is called filtration**. The fluid that collects in Bowman's space is called **filtrate**. It is composed of water, salts, glucose, amino acids, and urea. Larger structures in the blood—including protein molecules, blood cells, and platelets—do not pass into Bowman's space. Instead, they return to the main circulation.

From Bowman's space, the filtrate passes into the renal tubule. **The main function of the renal tubule is reabsorption.** Reabsorption is the return of needed substances in the filtrate back to the bloodstream. It is necessary because some of the substances removed from the blood by filtration—including water, salts, glucose, and amino acids—are needed by the body. About 75 percent of these substances are reabsorbed in the renal tubule.

• Filtrate first enters the **proximal tubule**. This is where that most **reabsorption takes place**. Tiny projections called microvilli line the proximal tubule and increase the surface area for reabsorption. The proximal convoluted tubule cells are adapted for reabsorption as follows:

- ***Large surface area due to microvilli***
- ***Numerous mitochondria***
- ***Closeness of blood capillaries***

From the proximal tubule, the filtrate passes through the loop of Henle.

• The **loop of Henle** carries the filtrate from the cortex down into the medulla and then back up to the cortex again. **Its primary purpose is to reabsorb water and salt from the fluid**. The longer is the loop of Henle, the more concentrated urine that can be produced.
• The **distal tubule** carries the fluid, now called tubular fluid, from the loop of Henle to a collecting duct. As it transports the fluid, the distal tubule also **reabsorbs or secretes substances such as calcium and sodium**. The process of secreting substances into the tubular fluid is called secretion.

- **Urine Formation**

The collecting ducts are the site of urine formation. This process is crucial for water conservation in the body. The collecting ducts reabsorb water from tubular fluid and return it to the blood. The remaining fluid, called urine, has a smaller volume and a greater concentration than tubular fluid. From the collecting ducts, urine enters a ureter and is eventually excreted from the body.
The reabsorption of water by the collecting ducts is controlled by a negative feedback mechanism. The mechanism involves a hormone secreted by the pituitary gland, called antidiuretic **hormone (ADH).** ADH makes the collecting ducts **more permeable to water,** allowing more water to be reabsorbed from tubular fluid. When there is not enough water in the blood, more ADH is secreted, more water is reabsorbed from tubular fluid, and less water is excreted in urine. The opposite happens when there is too much water in the blood.

Diseases of urinary system

Disease	Characteristics
Kidney stones	There are hard solids deposited in the kidney. Are formed due to precipitation of calcium salts. The stones block urine tubes, which eventually interferes with the functioning of the kidney
Incontinence	Involuntary urination. Common in infants and children due to the predominance of the involuntary behavior- concentration and relaxation of sphincter muscles, over-conditioned contraction in early age. In old age, it can appear where the sphincter muscles fail to control the urethra opening. Incontinence can also be observed in women after child delivery.
Polyuria	An individual urinates large quantities. This is associated with dieresis. It is due to malfunctioning of the pituitary glands releasing

	less ADH.
Kidney failure	Due to the fall in the blood pressure, affecting the rate of filtration of blood plasma. This leaves the blood with a large amount of wastes, since blood filtration is favored by high blood pressure of blood.
Dysuria	Characterized by pain during urination. It normally occurs where there is a urinary infection resulting from bacteria and fungi.
Oedema	Results from the retention of watery fluid caused by excess NaCl that is not eliminated and spreads across the tissues.
Uraemia	Inflammations of kidneys due to the accumulation of urea in the blood
Gout	It is due to deposit of uric acid in the joints
Renal colic	Very painful, renal colic is caused by calculi- crystals that accumulate in the pelvis because of a low dilution of uric acid or salts.

IV.5. HEALTHY PRACTICES IN URINARY SYSTEM

(1) Drink enough water. This facilitates the process of dissolving wastes in large amounts and early filtration out of the blood.
(2) Avoid holding urine for a long time, since this overstretches the blood and weakens the sphincter muscles.
(3) Being mindful of diet in relation to age. For example, excessive proteins and salts in the meal of someone of old age may result in a worsening of conditions of the kidney.
(4) Toilet care at school and home

Unit 11: Joints and movement

Key Unit Competence: To be able to describe types of joints and relate their structures to their functions.

Learning Objectives		
Knowledge and understanding	**Skills**	**Attitudes and values**
⎫ Differentiate between hinge joint and ball and socket joint. ⎫ Outline the function of bones, ligaments, tendons, cartilage, nerves and synovial fluid in the joint.	⎫ Analyse the structure of immovable and movable joints. ⎫ Use acquired knowledge to classify joints in the human body as immovable or movable. ⎫ Draw and label a typical synovial joint. ⎫ Demonstrate by using a diagram how antagonistic muscles bring about movement at a hinge joint.	⎫ Appreciate the importance of link between skeletal muscles and bones in movement. ⎫ Develop good habits that maintain safety of the body joints.

ACTIVITY 11.1:

- Individually identify and locate immovable and movable joints.
- Investigate the location of immovable and movable joints in the body and the antagonistic actions of biceps and triceps (e.g. by using an arm model with elastic bands).
- Research about the effect of diet on healthy joints and bones
- In groups, discuss practices that maintain healthy bones and joints.

Joints

A **joint** (also called an **articulation**), is a point at which two or more bones make contact. They are constructed to allow movement and provide mechanical support for the body. Joints are a type of lever, which is a rigid object that is used to increase the mechanical force that can be applied to another object. This reduces the amount of energy that need to be spent in moving the body around. The articular surfaces of bones, which are the surfaces that meet at joints, are covered with a smooth layer of articular cartilage.

There are three types of joints: immovable, partly movable, and synovial.

• **Immovable Joint**: At an immovable joint (or a fixed joint), bones are connected by dense connective tissue, which is usually collagen. Immovable joints, like those connecting the cranial bones, have edges that tightly interlock, and do not allow movement. The connective tissue at immovable joints serves to absorb shock that might otherwise break the bone.

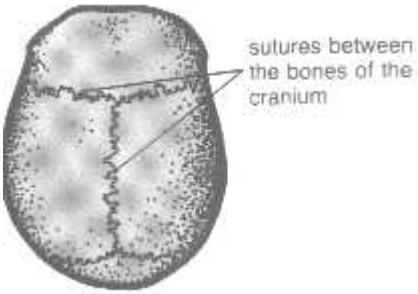


Fig 10.9: Fixed joints (sutures in the skull)

• **Partly Movable Joints**: At partly movable joints (or cartilaginous joints), bones are connected entirely by cartilage. Cartilaginous joints allow more movement between bones than a fibrous joint does, but much less than the highly mobile synovial joint. Examples of partly-movable joint include the ribs, the sternum and the vertebrae. Partly-movable joints also form the growth regions of immature long bones.

• **Synovial joints**: Synovial joints, also known as movable joints, are the most mobile joints of all. They are also the most common type of joint in the body. Synovial joints contain a space between the bones of the joint (the articulating bones), which is filled with synovial fluid. **Synovial fluid** is a thick, stringy fluid that has the consistency of egg albumin. The word "synovial" comes from the Latin word for "egg".
The fluid reduces friction between the articular cartilage and other tissues in joints and lubricates and cushions them during movement. There are many different types of synovial joints, and many different examples. A synovial joint is shown below:

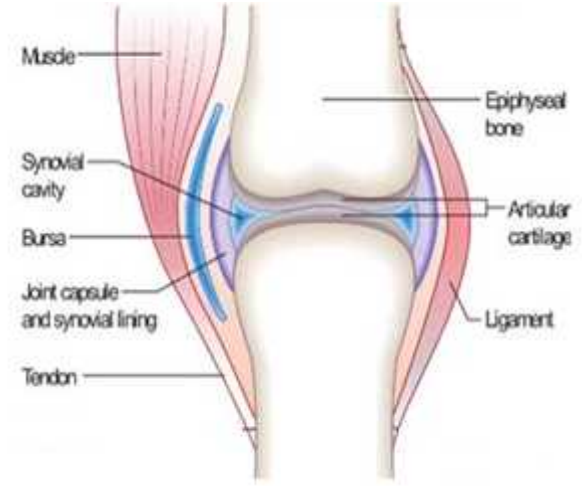


Fig 11.1: Diagram of a synovial joint

Synovial joints are the most common type of joint in the body, and allow a wide range of motions. Think of how difficult walking would be if your knees and hips were only partly movable, like your spine.
The outer surface of the synovial joint contains ligaments that strengthen joints and holds bones in position. The inner surface (the synovial membrane) has cells producing synovial fluid that lubricates the joint and prevents the two cartilage caps on the bones from rubbing together. Some joints also have tendons which are bands of connective tissue that link muscles to bones. **Bursae** are small sacs filled with synovial fluid that reduce friction in the joint. The knee joint contains 13 bursae.

Types of Synovial joints: These fully-movable joints between bones allow a wide range of motions by the body. They also help reduce the amount of energy that needs to move the body.

- In a **ball and socket joint** the ball-shaped surface of one bone fits into the cuplike depression of another. The ball-and-socket joint consists of one bone that is rounded and that fits within a cuplike bone. Examples of a ball and socket joint include the hip and shoulder.
- In a **saddle joint** the opposing bone surfaces are fit together like a person sitting in a saddle. The movements at a saddle joint are the same as in an ellipsoid joint. The best example of this form is the joint between the carpals and metacarpals of the thumb.

- In the **hinge joint,** the articular surfaces fit together in such a way as to permit motion only in one plane, forward and backward, the extent of motion at the same time being considerable. An example of a hinge joint is the elbow.
- The **pivot joint** is formed by a process that rotates within a ring, the ring being formed partly of bone, and partly of ligament. An example of a pivot joint is the joint between the radius and ulna that allows you to turn the palm of your hand up and down.
- A **gliding joint,** also known as a **plane joint**, is a joint which allows one bone to slide over another, such as between the carpels of the fingers. Gliding joints are also found in your wrists and ankles.

Category	Type and description	Examples
Immovable	**Sutures**	Between cranial bones
Slightly movable	**Symphysis**: disc of fibrous cartilage between bones	Between vertebrae; between pubic bones
Freely movable	**Ball-and-socket:** movement in all planes	Scapula and humerus; pelvic bone and femur
	Hinge: movement in one plane	Humerus and ulna; femur and tibia
	Pivot: rotation	Atlas and axis; radius and ulna

	Gliding: side-to-side movement	Between carplas
	Saddle: movement in several planes	Carpometacarpal of thumb

Table 11.1: Summary of the types of joints

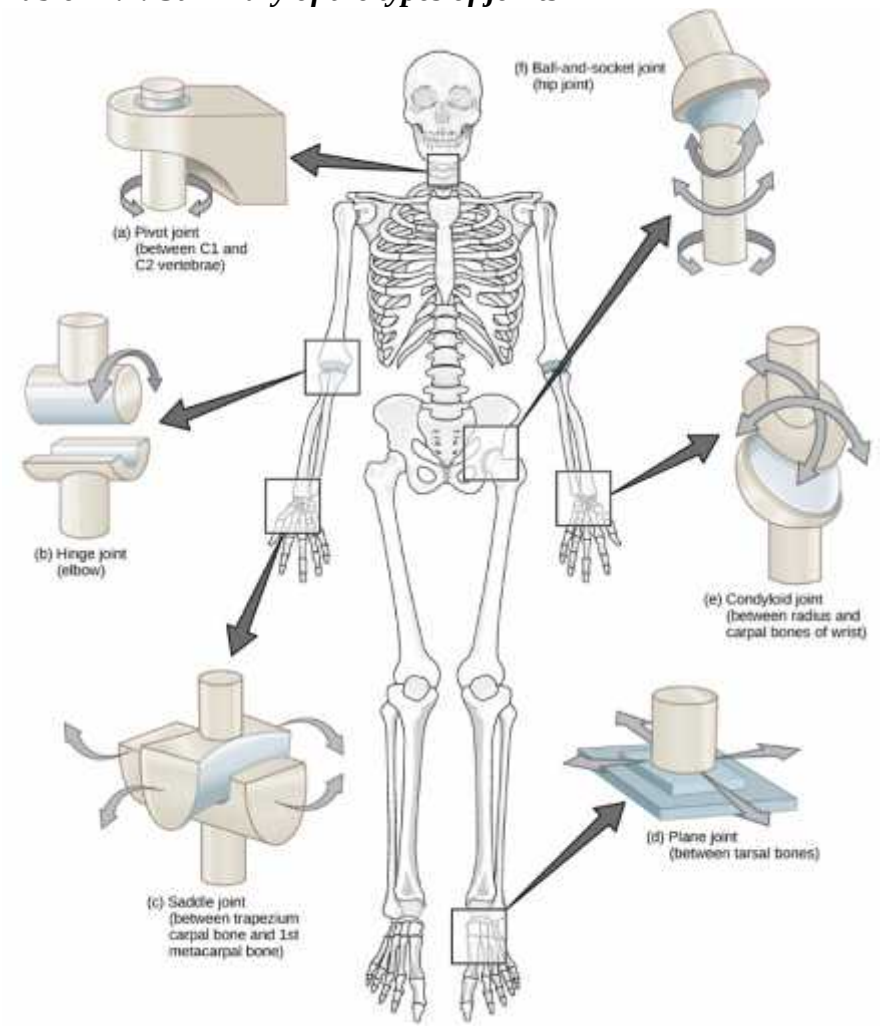


Fig 11.2: Types of synovial joints

Not all bones are interconnected directly: There are 6 bones in the middle ear called the ossicles (three on each side) that articulate only with each other. The hyoid bone which is located in the neck and serves as the point of attachment for the tongue, does not articulate with any other bones in the body, being supported by muscles and ligaments. ***The longest and heaviest bone in the body is the femur and the smallest is the stapes bone in the middle ear.*** *In an adult, the skeleton makes up around 20% of the total body weight.*

TOPIC AREA 4: HEALTH AND DISEASE

Sub-topic Area: Infectious and non-infectious diseases

Unit 12: Infectious diseases

Key Unit Competence: To be able to identify symptoms of common infectious diseases and their preventionand treatment.

Learning Objectives		
Knowledge and understanding	**Skills**	**Attitudes and values**
⁾ Define pathogen, transmissible disease and host. ⁾ State that the pathogen for a transmissible disease may be transmitted either through direct contact (e.g. through blood or other bodily fluids) or indirectly (e.g. from contaminated surfaces or food, from animals, or from the air). ⁾ State that the body has defences: mechanical barriers limited to skin and hairs in the nose; chemical barriers limited to mucus and stomach acid; cells, limited to phagocytosis and antibody production by white blood cells. ⁾ Explain that somebody defences can be enhanced by vaccinations. ⁾ Explain the symptoms, prevention and control of the following common diseases: malaria, Ebola and HIV/AIDS.	⁾Apply practices of hygienic food preparation, good personal hygiene, waste disposal and sewage treatment in controlling the spread of disease. ⁾Illustrate the danger of infectious diseases using a chart. ⁾Organise community campaigns on prevention and treatment of infectious diseases. ⁾Recognise individuals displaying symptoms of cholera, malaria, Ebola or HIV/AIDS.	⁾Campaign against the existence and spread of cholera, malaria, Ebola and, HIV/AIDS. ⁾Value the science of infectious diseases to avoid prejudice and discriminatio n

ACTIVITY 12.1:

- Learners carry out group research from the library or the internet to find out the definition and the role of pathogens.
- With reference to the spread of cholera, learners discuss ways by which infectious diseases are transmitted from one host to another and from one area to another.
- Learners are provided with worksheets containing a list of infectious diseases and blank columns for symptoms and prevention/control.
- Learners then work in groups to complete the table and present to the class.
- Research about ways by which the body defends itself from infections and then present their findings to class.

Health is a state of physical, mental, social and emotional well-being. This results from a steady state in the internal environment. Disturbance and interference of this steady state may cause ill health characterized by body disorders.

Definitions of some terms

- **Illness** is a general term used to mean a period of not being in good health.
- A **disease** is any physical or mental disorder or malfunction that affects a particular part of the body. It has characteristic set of signs and symptoms.
- **Pathogen** is an agent that can cause a disease
- **Sings:** this is an expression of a disease that can be observed by someone, for example a skin rash.
- **Symptoms:** these cannot be seen. It is experienced by someone affected by the disease for example anxiety and pain.
- A **condition** is a permanent health problem that affects a particular part of the body.
- An **infection** is an illness that is caused by microorganisms. It can affect one part of the body and spread from one person to another.

Importance of good health

- Good health helps people to grow and develop normally.
- A healthy person is able to work and earn a living as well as support other people.
- A healthy nation develops fast because most people are not sick. Healthy people work hard, and the country does not use a lot of money on medication. This brings about economic growth.
- Good reduces mortality (death rate). This ensures there is availability of labour.

Infectious diseases

They are also known as **communicable diseases**. These are diseases which can be transmitted from one person to another. They are usually caused by microorganisms like viruses, bacteria, fungi and protozoa. The diseases include cholera, malaria, typhoid, HIV and AIDS…

THE BODY'S DEFENSES

An animal must defend itself against unwelcome intruders, the many potentially dangerous viruses, bacteria, and other pathogens it encounters in the air, in food and in water. It must also deal with abnormal body cells, which, in some cases may develop into cancer. Three cooperative lines of defense that counter these threats have evolved.

Two of these are non specific; that is they do not distinguish one infectious agent from another.

The first line of non specificdefense is externalconsisting of ***epithelial tissues*** that cover and line our bodies (skin and mucous membranes) and the secretions they produce.

The second line of non specificdefense is internal: it is triggered by chemical signals and involves ***phagocytic cells*** and ***antimicrobial proteins*** that indiscriminately attack invaders that penetrate the body's outer barriers. The appearance of inflammation is a sign that this second line of defense has been deployed.
The third line is the immune system. The immune system comes into play simultaneously with the second line of defense, but ***it responds in a specific way to particular micro organisms***, aberrant body cells, toxins, and other substances marked by foreign molecules.

12.1. Non specificdefense against infection

An invading microbe must penetrate the external barrier formed by the skin and mucous membranes, which cover the surface and line the opening of an animal's body. If it succeeds in doing so, the pathogen encounters the second line of non specificdefense: interacting mechanisms that include phagocytosis, the inflammatory response and antimicrobial proteins.

a) The skin and mucous membranes provide first line barrier to infection

Intact skin is a barrier that cannot normally be penetrated by bacteria or viruses, even minute abrasions may allow their passage. Likewise, the mucous membranes that line the digestive, respiratory, and genitourinary tracts bar the entry of potentially harmful microbes. Beyond their role as a physical barrier, the skin and mucous membranes counter pathogens with chemical defenses. For example, secretions from sebaceous and skin glands give the skin a PH ranging from 3 to 5, which is acidic to prevent colonization by many microbes; the tears contain **lyzozyme**, an antimicrobial enzyme also present in saliva and mucous secretions

b) Phagocytic cells, inflammation, and antimicrobial proteins function early in infection

Microbes that penetrate the first line, such as those that enter through a break skin, face the second line of defense. The body's internal mechanisms of non specificdefenses depend mainly on phagocytosis, the ingestion of invading organisms by certain types of white blood cells. Phagocyte function is associated with an effective inflammatory response and also with certain antimicrobial proteins. These non specific mechanisms help limit the spread of microbes in advance of specific immune responses.

The phagocytic cells called neutrophils constitute about 60 % to 70% of all white blood cells (leucocytes). Cells damaged by invading microbes release chemical signals that attract neutrophils from the blood. The neutrophils enter the infected tissue, engulfing and destroying microbes there.

- **The inflammatory response**

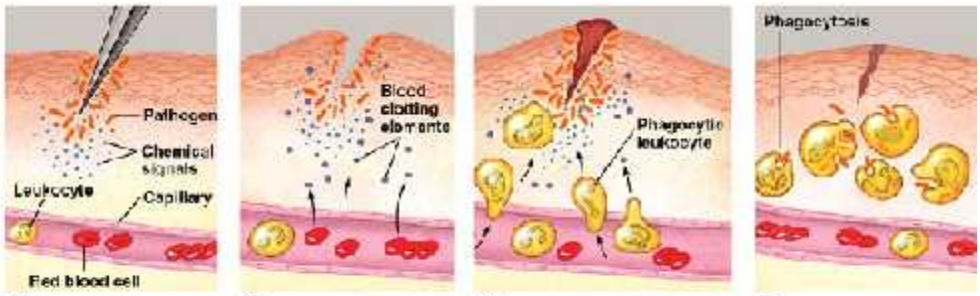
Inflammation is a local defensive response to tissue injury of any kind, including trauma and infection. Its general purposes are:

- To limit the spread of pathogens and ultimately destroy them,
- To remove the debris of damaged tissue, and
- To initiate tissue repair.

Inflammation is characterized by four cardinal signs: **redness, swelling, heat** and **pain.**

Damage to tissue by a physical injury (such as a cut) or by the entry of microorganisms triggers an inflammatory response. In the injured area, pre capillary arterioles dilate and post capillary veins constrict increasing the local blood supply. These events are responsible for the characteristic redness and heat of inflammation.

The localized response is triggered when cells of tissue injured by bacteria or physical damage release chemicals such as **histamine** and **prostaglandins**. The signals induce capillary dilation (leading to increased blood flow) and increased capillary permeability in the affected area. The tissue cells also release chemicals that attract phagocytic cells and lymphocytes. When phagocytes arrive at the site of injury, they consume pathogens and cell debris, and the tissue heals.



1. Damaged cells release chem signals (histamine, prostaglandins)
2. Nearby capillaries dilate & become more permeable; fluid and clotting agents move from the blood to the site
3. Chemokines & other chemotactic factors attract phagocytes from the blood
4. Phagocytes consume pathogens & cell debris, producing pus

Fig 12.1: The inflammatory response

- **Antimicrobial proteins**

Two groups of proteins, the **interferons** and the **complement system**, provide short-term, nonspecific resistance to viral and bacterial infections.

Interferons are proteins secreted by cells that have been invaded by viruses. They diffuse to neighbouring cells and stimulate them to produce antiviral proteins, which prevent viruses from multiplying within them. Interferons also activate natural killer cells and macrophages, which destroy infected host cells before they release more viruses. Interferons are non-specific for a particular virus but provide generalized protection. They also promote the destruction of cancer cells.

The **complement system** isa set of about 20 serum proteins that carry out a cascade of steps leading to the lysis of microbes. These proteins are continually present in the blood plasma but must be activated by pathogens to exert their effects.

12.2. How specific immunity arises

While microorganisms are under assault by phagocytic cells, the inflammatory response and antimicrobial proteins, they inevitably encounter ***lymphocytes***, the key cells of the **immune system**: ***the body's third line of defense***. The immune system is not an organ system but a group of widely distributed cells that recognize foreign substances and act to neutralize or destroy them. Two characteristics distinguish immunity from nonspecific resistance.

- **Specificity:** Immunity is directed against a particular pathogen. Immunity to one pathogen usually does not confer immunity to others.
- **Memory:** When reexposed to the same pathogen, the body reacts so quickly that there is no noticeable illness. The reaction time for inflammation and other nonspecific defences, by contrast, is just as long for later exposures as it was for the initial ones.

The major cells of the immune system are **lymphocytes** which are especially concentrated at strategic places such as the lymphatic organs and mucous membranes. Lymphocytes respond to infections by generating efficient and selective immune responses that work throughout the body to eliminate the particular invaders. Lymphocytes provide the specificity and diversity of the immune system. The vertebrate body is populated by two main types of lymphocytes: B lymphocytes (B cells) and T lymphocytes (T cells). The maturation of T lymphocytes takes place in the **thymus** whereas that of B lymphocytes takes place in the **bones**. T cells are involved in **cell-mediated immunity,** whereas B cells are primarily responsible for **humoral immunity** (relating to antibodies).
In cell-mediated immunity, the T lymphocytes bind to the surface of other cells that display the antigen and trigger a response; that is they fight against pathogens that have entered body cells, destroy virus infected cells and cancer cells. In humoral immunity, the antibodies dissolved in blood, lymph and other body fluids bind the antigen and trigger a response to it.

Like macrophages, both types of lymphocytes circulate throughout the blood and lymph and are concentrated in the spleen, lymph nodes and the lymphatic tissues. Because lymphocytes recognize and respond to particular microbes and foreign molecules, they are said to display specificity. A foreign molecule that elicits an immune response by lymphocytes is called an **antigen** (from **antibody generator**).

B cells and T cells specialize in different types of antigen, and they carry out different, but complementary and defensive actions. One way an antigen elicits an immune response is by activating B cells to secrete proteins called **antibodies** or**immunoglobulins (Ig)**. Each antigen has a particular molecular shape and stimulates certain B cells to secrete antibodies that interact specifically with it. In fact, B and T lymphocytes even distinguish among antigens with molecular shapes that are only slightly different. So, in contrast to the non specificdefenses, **the immune system targets specific invaders**. B cells and T cells recognize and inactivate foreign cells and molecules. Both types of cells also contribute to immunological memory, an enhanced response to a foreign molecule encountered previously.

The table below shows a summary of the body defenses.

NON SPECIFIC DEFENSE MECHANISMS		SPECIFIC DEFENSE MECHANISMS (IMMUNE SYSTEM)
First line of defense	**Second line of defense**	**Third line of defense**
⎫ Skin ⎫ Mucous membranes ⎫ Secretions of skin and mucous membranes	⎫ Phagocytic white blood cells ⎫ Antimicrobial proteins ⎫ The inflammatory response	⎫ Lymphocytes ⎫ Antibodies

Table 12.1: The summary of the three lines of defense of our body

CHOLERA

Cholera is an infection of the small intestine caused by the bacterium *Vibrio cholerae*. The main symptoms are watery diarrhoea and vomiting. Transmission occurs primarily by drinking water or eating food that has been contaminated by the feces (waste product) of an infected person, including one with no apparent symptoms. The severity of the diarrhea and vomiting can lead to rapid dehydration and electrolyte imbalance, and death in some cases. The primary treatment is oral rehydration therapy, typically with oral rehydration solution, to replace water and electrolytes. If this is not tolerated or does not provide improvement fast enough, intravenous fluids can also be used.

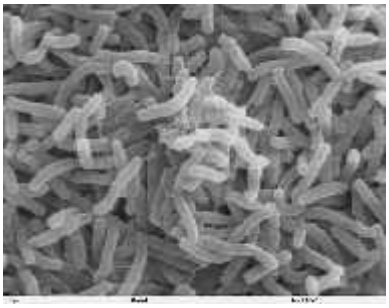


Fig 12.2: Scanning electron microscope image of Vibrio cholerae

TRANSMISSION, SIGNS AND SYMPTOMS

The organism which causes cholera is a comma shaped motile bacterium called ***Vibrio cholerae.***The main source of infection is water contaminated by feces from a sufferer of the disease or a carrier. The carrier is an individual infected with vibrios who does not develop the typical symptoms of cholera. It is estimated that only about one infected person in 50 develops the disease, the rest being carrier. Thus the feces containing vibrios are a considerable threat when the carriers are free moving in society. Drinking contaminated water, or washing food or utensils in it, is the most common means of transmission.

Direct contamination of food with feces as a result of poor hygiene is also possible.

Pathogen	*Vibrio cholerae*
Methods of transmission	Food-borne, water-borne
Global distribution	Asia, Africa, Latin America
Incubation period	Two hours to five days
Site of action of pathogen	Wall of small intestine
Clinical features	Severe diarrhoea (rice water), loss of water and salts, dehydration, weakness
Method of diagnosis	Microscopical analysis of faeces
Annual incidence worldwide	3-5 million
Annual mortality worldwide	100,000 – 120,000

Table 12.2: The features of cholera

TUBERCULOSIS (T.B)

Tuberculosis, **MTB**, or **TB** (short for *tubercle bacillus*) is a common, and in many cases lethal, infectious disease caused by various strains of mycobacteria, usually *Mycobacterium tuberculosis*. Tuberculosis typically attacks the lungs, but can also affect other parts of the body. It is spread through the air when people who have an active TB infection cough, sneeze, or otherwise transmit respiratory fluids through the air. Most infections are asymptomatic and latent, but about one in ten latent infections eventually progresses to active disease which, if left untreated, kills more than 50% of those so infected.

The classic symptoms of active TB infection are a chronic cough with blood-tinged sputum, fever, night sweats, and weight loss (the latter giving rise to the formerly prevalent term "consumption"). Infection of other organs causes a wide range of symptoms. Diagnosis of active TB relies on radiology (commonly chest X-rays), as well as microscopic examination and microbiological culture of body fluids. Diagnosis of latent TB relies on the tuberculin skin test and/or blood tests. Treatment is difficult and requires administration of multiple antibiotics over a long period of time. Social contacts are also screened and treated if necessary. Antibiotic resistance is a growing problem in multiple drug-resistant tuberculosis infections. Prevention relies on screening programs and vaccination with the bacillus Calmette–Guérin vaccine.

Fig 12.3: Mycobacterium tuberculosis (stained red) in sputum

Tuberculosis is caused by a bacterium called ***Mycobacterium tuberculosis,*** first discovered by Robert Koch in 1882. It is sometimes referred to as the tubercle bacillus, bacilli being rod-shaped bacteria. The common form is pulmonary T.B which infects the lungs, although other organs may be affected.

Two strains of the bacterium may cause the disease, the human and the bovine forms. The latter can be present in cattle and can enter the milk of cows. It is very resistant and can remain alive for long time in milk products.

Pathogen	*Mycobacterium tuberculosis, Mycobacterium bovis*
Methods of transmission	Air-borne droplets (*M. tuberculosis), via undercooked meat and unpasteurized milk (M. bovis)*
Global distribution	Worldwide
Incubation period	Few weeks up to several years
Site of action of pathogen	Primary infection in lungs; secondary infection in lymph nodes, bones and gut.
Clinical features	Racking cough, coughing blood, chest pain, shortness of breath, fever, sweating, and weight loss.
Method of diagnosis	Microscopic examination of sputum for bacteria, chest X-ray
Annual incidence worldwide in 2012	8.6 million
Annual mortality worldwide in 2012	1.3 million (Including 320,000 deaths of people who were HIV positive.

Table 12.3: The features of TB

THYPHOID AND PARATHYPHOID FEVERS

Typhoid and paratyphoid are caused by the bacteria *Salmonella typhi* and *Salmonella paratyphi*respectively. Paratyphoid is very similar to typhoid, but is usually milder in its symptoms.

Transmission, signs and symptoms

The bacteria are derived from the feces of a sufferer from the disease or from a carrier. The disease is spread by water or from contaminated food. Typhoid spread needs only a small number of organisms, and is therefore described as having **high infectivity**. Paratyphoid however, like food poisoning *(salmonellosis*) needs a larger dose of infecting organisms (low infectivity). Common source of infection are:

- Water supplies may be contaminated by human feces through seepage of sewage into a reservoir, leakage from defective underground sewers or discharge of sewage into a river.
- Serious epidemics have also been traced to food. Milk can be contaminated by a carrier or from dirty equipment which has been washed with contaminated water.
- Shellfish oysters and mussels are often responsible for transmitting typhoid, due to their filter method of feeding whereby pathogenic organisms are extracted from the surrounding water.

When the infecting organisms have been swallowed, they migrate to the lymph glands, where, they multiply during a ten-day incubation period. After this time, the organisms enter the bloodstream and the patient develops headache and muscular pains. A fever develops reaching its peak after about one week. A faint rash may appear. In the second week, diarrhea develops and the patient has mental confusion. The third week shows the peak of the illness and the patient deteriorates and may die.

Tetanus

Tetanus is a medical condition characterized by a prolonged contraction of skeletal muscle fibers. The primary symptoms are caused by tetanospasmin, a neurotoxin produced by the Gram-positive, rod-shaped, obligate anaerobic bacterium ***Clostridium tetani*.**

Infection generally occurs through wound contamination and often involves a cut or deep puncture wound. As the infection progresses, muscle spasms develop in the jaw (thus the name "lockjaw") and elsewhere in the body. Infection can be prevented by proper immunization and by post-exposure prophylaxis.

Signs and symptoms

Tetanus often begins with mild spasms in the jaw muscles (lockjaw). The spasms can also affect the chest, neck, back, abdominal muscles, and buttocks. Back muscle spasms often cause arching, called opisthotonos. Sometimes the spasms affect muscles that help with breathing, which can lead to breathing problems.

Prolonged muscular action causes sudden, powerful, and painful contractions of muscle groups. This is called tetany. These episodes can cause fractures and muscle tears. Other symptoms include drooling, excessive sweating, fever, hand or foot spasms, irritability, swallowing difficulty, and uncontrolled urination or defecation.

Mortality rates reported vary from 48% to 73%. In recent years, approximately 11% of reported tetanus cases have been fatal. The highest mortality rates are in unvaccinated people, people over 60 years of age or newborns.

AIDS – Acquired Immune Deficiency Syndrome

AIDS is a disorder which damages the human body's immune system. It is caused by the HIV virus (Human Immunodeficiency Virus). This is an RNA virus. The virus replicates inside **the T4 lymphocytes** or **helper T cells**. Thus these cells can no longer help or induce other T cells, called killer cells, to fight invaders. The body's immune system breaks down leaving the patient exposed to a variety of diseases called **opportunistic infections**. AIDS is not a disease; it is a

collection of these opportunistic diseases associated with immunodeficiency caused by HIV infection. It is important to realize, however, that the infection with the HIV virus does not necessarily result in AIDS. As with other diseases, some people remain symptomless and are therefore called carriers.

TRANSMISSION, SIGNS AND SYMPTOMS

The HIV virus can only survive in body fluids and is transmitted by blood or semen. In 90% of cases the transmission is achieved by sexual contact. People can contract the disease as follows:

- **Intimate sexual contact.** The most frequent mode of transmission of HIV is through sexual contact with an infected person. The majority of all transmissions worldwide occur through heterosexual contacts (i.e. sexual contacts between people of the opposite sex); however, the pattern of transmission varies significantly among countries. In the United States, as of 2009, most sexual transmission occurred in men who had sex with men (homosexual), with this population accounting for 64% of all new cases.
- **Infected blood entering bloodstream:** by means of unsterilized needles and syringes. Unfortunately the disease can be contracted after being given blood or blood products already infected with HIV. Close contact between infected and non infected people through cuts and open wounds has also been known to pass on the virus.
- **From mother to baby:** An infected pregnant woman can pass on the virus to her baby through the placenta, at birth or through breast milk during suckling. The chances of infection being transmitted from the mother to her baby are currently estimated to be 25-50%.

The virus binds to receptors present in the surface of the T4 lymphocytes. From here it enters the lymphocytes by endocytosis or by fusing with the cell surface membrane and injecting its viral RNA directly into the cell. The viral RNA is then copied into DNA by the activity of reverse transcriptase. The viral DNA enters the lymphocyte nucleus and becomes incorporated into the cell's own DNA. Thus it becomes a permanent part of the cells of an infected individual. Every time the human cell divides, so does the viral DNA, and thus spread of the viral genes is rapid. The viral DNA may remain dormant for at least six years, the so-called latency period. However, suddenly, for some unknown reason, the lymphocyte begins to make copies of the viral genes in the form of messenger RNA. These then migrate from the nucleus into the lymphocyte cytoplasm and direct the synthesis of viral proteins and RNA. These assemble to form new HIV viruses which leave the lymphocyte by budding out from underneath the cell surface membrane. The viruses spread and infect many other lymphocytes and brain cells. Eventually the cells in which the cell has multiplied are killed.

TEST FOR THE DISEASE

A blood test is used to tell whether or not a person has been infected by the HIV virus. Under normal circumstances the immune system reacts to infection by producing antibodies and when the HIV virus enters the body, anti-HIV antibodies are produced. The blood of the person being tested is added to HIV proteins which have been commercially prepared. If there are anti-HIV antibodies in the blood sample they will bind to the viral proteins and the person is described as

HIV positive. However, if the test proves negative that person may still be infected. This is because it takes up to three months or longer for HIV antibodies to be produced after infection.

PREVENTION OF THE DISEASE

There are many precautions which can be followed in trying to prevent the disease:

- The use of a barrier during intercourse can prevent the virus from infecting through blood or semen. Thus the use of a sheath or condom is recommended. This practice has been encouraged through many advertising campaigns throughout the world.
- Restriction to one sex partner and the absence of promiscuity will also clearly reduce the risk of infection.
- A reduction in the spread of HIV can be brought about by the use of clean needles and syringes by drugs addicts.
- The blood donated should be tested for the presence of antibodies to HIV which indicates whether or not the donor is infected. Blood containing these antibodies is not used.
- Educating the people about the disease.
- Taking antiretroviral during pregnancy and delivery.
- To avoid breastfeeding and to administer antiretroviral drugs to the newborn.

Pathogen	*Human immunodeficiency virus*
Methods of transmission	In semen and vaginal fluids during sexual intercourse, infected blood or blood products, contaminated hypodermic syringes, mother to fetus across the placenta, at birth, mother to infant in breast milk
Global distribution	Worldwide, especially in sub-Saharan Africa and South-East Asia
Incubation period	Initial incubation a few weeks, but up to ten years or more before symptoms of AIDS may develop
Site of action of pathogen	T helper lymphocytes, macrophages, brain cells
Clinical features	HIV infection-flu-like symptoms and then symptomless AIDS-opportunistic infections including pneumonia, TB and cancers; weight loss, diarrhoea, fever, sweating, dementia.
Method of diagnosis	Testing blood, saliva or urine for the presence of antibodies produced against HIV.
Estimated total number of people infected with HIV worldwide in 2012	35.5 million (69 % of these in sub-Saharan Africa)
Estimated number of new cases of HIV infection worldwide in 2012	2.3 million
Estimated number of deaths from AIDS-related diseases worldwide in 2012	1.6 million (UNAIDS estimate)

Table 12.4: The features of HIV/AIDS

Malaria

Malaria is a very serious disease characterized by severe chills, fever, sweating, fatigue and great thirst. Malaria is caused by a protozoan of the genus Plasmodium.
Victims die of anemia, kidney failure or brain damage. The genus Plasmodium infects humans, and all have life cycles that involve the female anopheles mosquito.

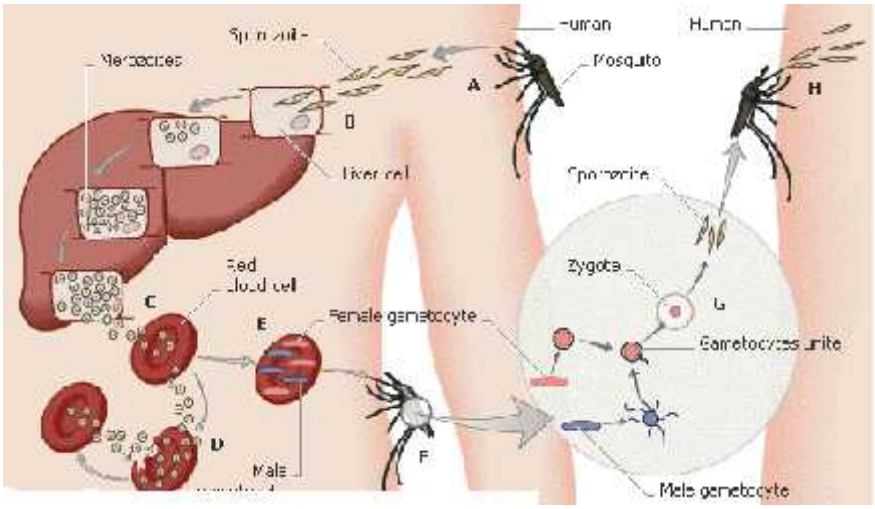


Fig 12.4: Life cycle of Plasmodium

When an infected mosquito bites a person, Plasmodium sporozoites enter the bloodstream and travel to liver cells, where they divide repeatedly.
New spores called merozoites emerge and infect red blood cells, where they reproduce asexually. At regular intervals, the merozoites burst out of the red blood cells and the release of toxins in the blood cause fever, anemia and other symptoms of malaria. The merozoites infect other red blood cells and again reproduce asexually. This asexual reproduction can happen many times over a long period of time. Merozoites of some species remain in the liver and do not come out for months or years. Thus, an infected person could take antimalaria drugs and cure the infection in the blood, only to become ill again when the merozoites leave the liver cells.

Some of the merozoites in the blood develop into specialized cells called gametocytes. When a female anopheles bites the infected person, it ingests these gametocytes. In the mosquito's digestive system, the sperm and eggs combine to form a zygote. The nucleus of the zygote divides repeatedly to form more sporozoites. When the zygote bursts, the sporozoites migrate to the body cavity and salivary glands of the mosquito. When the insect bites another person, the life cycle begins again.
One effective way to reduce human deaths from malaria is to control mosquito population. Without the mosquito hosts, the plasmodium cannot complete their life cycle.

The most common forms of human malaria are caused by *Plasmodium falciparum*, *P. vivax, P. knowlesi,* and *P. malariae*. ***Plasmodium falciparum*, common in sub-Saharan Africa, and *P. knowlesi*, common in Southeast Asia, are especially dangerous.**

Mosquitoes of the genera*Anopheles*, *Culiseta*, *Mansonia* and *Aedes* may act as vectors. The known vectors for human malaria (more than 100 species) belong **to the genus *Anopheles*. Only female mosquitoes bite. Aside from blood both sexes live on nectar, but one or more blood meals are needed by the female for egg laying, because there is very little protein in nectar.**

Eradication of malaria

- Drainage of stagnant water: The larval stages of the mosquito live in stagnant water, so drainage removes breeding sites. This has had some success.

- Destruction of the breeding sites of the mosquito: The larvae and pupae of mosquitoes obtain their oxygen by means of small tubes which are pushed through the water surface film. Thus any method of blocking these tubes will result in the death of the intermediate life stages of the mosquito (petrol, oil….)

- Destruction of the adult mosquitoes: This is aimed at killing the mosquitoes that enter houses. Thus, the indoor surfaces are sprayed with a persistent insecticide.

- Use of mosquito nets.

Pathogen	*Plasmodium falciparum, P. vivax, P. malariae*
Methods of transmission	Insect vector: female anopheles mosquito
Global distribution	Throughout the tropics and subtropics (endemic in 106 countries)
Incubation period	From a week to a year
Site of action of pathogen	Liver, red blood cells, brain
Clinical features	Fever, anemia, nausea, headache, muscle pain, shivering, sweating, enlarged spleen.
Method of diagnosis	Microscopic examination of blood; dip stick test for malaria antigens in blood.
Annual incidence worldwide	About 207 million cases of malaria in 2012 (about 80% are in Africa).
Annual mortality worldwide	About 630,000 deaths in 2012 (about 90 % are in Africa).

Table 12.5: The features of malaria

Unit 13: Immunity and vaccination

Key Unit Competence: To be able to describe natural and artificial methods that fight against infection.

Learning Objectives		
Knowledge and understanding	**Skills**	**Attitudes and values**
⁾Explain how each pathogen has its own antigens, which have specific shapes and specific antibodies which fit these are needed. ⁾State that antibodies lock on to antigens leading to direct destruction of pathogens, or marking of pathogens, for destruction by phagocytes. ⁾Define active immunity, pathogen and antibody production in the body. ⁾State that memory cells are not produced in passive immunity. ⁾Explain the importance of passive immunity for breast fed infants. ⁾State that some diseases are caused by the immune system targeting and destroying body cells, limited to Type 1 diabetes. ⁾Explain the process of vaccination. ⁾Explain the role of vaccination in controlling the spread of diseases.	⁾Use a diagram of mode of action of antibody – antigen to identify the antigen, the antibody and the binding site. ⁾Observe and differentiate the immune responses of an organism using computer aided simulation. ⁾Demonstrate the good practice for mothers in their families to breast feed the newborn baby for 1000 days.	⁾Advocate for vaccination and breast feeding as sustainable disease prevention. ⁾Aware of vaccination programs in their communities.

ACTIVITY 13.1:

- Learners are given a text paragraph about the discovery and chemical nature of both antibodies and antigens and how they react with each other. Thereafter, learners discuss the specificity and mode of action of an antibody and antigen.
- Using the diagram to comprehend the mode of action of antibody or antigen, learners identify the antigen, the antibody and the binding site.
- Learners use computer aided simulation to observe and differentiate the immune responses of an organism.
- Learners discuss how one's own immune system can bring about Type 1 diabetes.
- Learners research and present their findings on the background of the vaccination and its application as a means of preventing later/ present infections.
- Learners are engaged in the discussion that supports the practice of breastfeeding newborns and attending the vaccination campaign.

The major cells of the immune system are **lymphocytes** which are especially concentrated at strategic places such as the lymphatic organs and mucous membranes. Lymphocytes respond to infections by generating efficient and selective immune responses that work throughout the body to eliminate the particular invaders. Lymphocytes provide the specificity and diversity of the immune system. The vertebrate body is populated by two main types of lymphocytes: B lymphocytes (B cells) and T lymphocytes (T cells). The maturation of T lymphocytes takes place in the **thymus** whereas that of B lymphocytes takes place in the **bones**. T cells are involved in **cell-mediated immunity,** whereas B cells are primarily responsible for **humoral immunity** (relating to antibodies).
In cell-mediated immunity, the T lymphocytes bind to the surface of other cells that display the antigen and trigger a response; that is they fight against pathogens that have entered body cells, destroy virus infected cells and cancer cells. In humoral immunity, the antibodies dissolved in blood, lymph and other body fluids bind the antigen and trigger a response to it.

Like macrophages, both types of lymphocytes circulate throughout the blood and lymph and are concentrated in the spleen, lymph nodes and the lymphatic tissues. Because lymphocytes recognize and respond to particular microbes and foreign molecules, they are said to display specificity. A foreign molecule that elicits an immune response by lymphocytes is called an **antigen** (from **antibody generator**).

B cells and T cells specialize in different types of antigen, and they carry out different, but complementary and defensive actions. One way an antigen elicits an immune response is by activating B cells to secrete proteins called **antibodies** or**immunoglobulins (Ig)**. Each antigen has a particular molecular shape and stimulates certain B cells to secrete antibodies that interact specifically with it. In fact, B and T lymphocytes even distinguish among antigens with molecular shapes that are only slightly different. So, in contrast to the non specificdefenses, **the immune system targets specific invaders**. B cells and T cells recognize and inactivate foreign cells and molecules. Both types of cells also contribute to immunological memory, an enhanced response to a foreign molecule encountered previously.

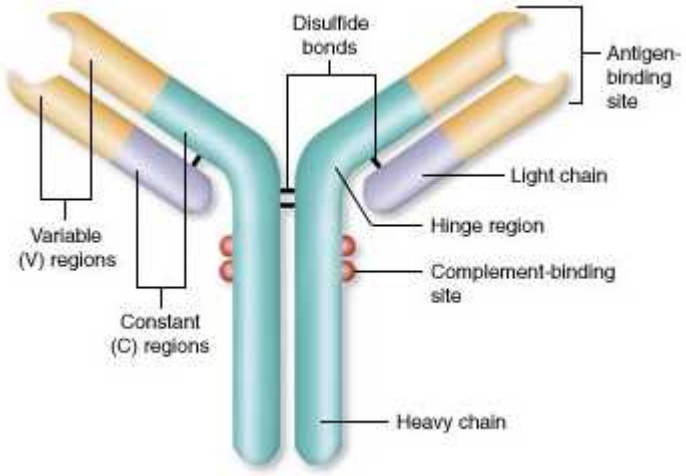


Fig 15.2: The structure of an antibody

The role of antibodies in immunity

The binding of antibodies to antigens can interfere with pathogen function in many ways. In the simplest of these, ***neutralization***, antibodies bind to surface proteins of a virus or bacterium, thereby blocking the pathogen's ability to infect a host cell. Similarly, antibodies sometimes bind to and neutralize toxins released in body fluids. In a process called ***opsonization***, the antibodies bound to antigens present a readily recognized structure for macrophages and therefore increase phagocytosis. Because each antibody has two antigen binding sites, antibodies can also facilitate phagocytosis by linking bacterial cells, virus particles, or antigens into aggregates.

Immunity conferred by recovering from an infectious disease such as chickenpox is called **active immunity** because it depends on the response of the infected person's immune system. As in the case with all such infections, this immunity is naturally acquired. Active immunity can also be acquired artificially by **IMMUNIZATION** also known as **VACCINATION.**

Vaccines include inactivated bacterial toxins, killed microbes, and viable but weakened microbes. These agents can no longer cause disease, but they retain the ability to act as antigens, stimulating an immune response, and more importantly, immunological memory. A vaccinated person who encounters the actual pathogen will have the same quick secondary response based on memory cells as a person who has had that disease.
Routine immunization of infants has dramatically reduced the incidence of infectious diseases such as measles, whooping cough, and has led to the eradication of smallpox, a disfiguring and often fatal disease. Unfortunately, not all infectious agents are easily managed by vaccination. For example, although researchers are working intensively to develop a vaccine for HIV, they face many problems, such as the antigenic variability of the virus.
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Antibodies can be transferred from one individual to another, providing **passive immunity**. This occurs when some antibodies of a pregnant woman cross the placenta to her fetus. Passive immunity persists only as long as these antibodies last (a few days to a few months), but it provides protection from infections until the baby's own immune system has matured.
Passive immunity can also be transferred artificially by injecting antibodies from an animal that is already immune to a disease into another animal, conferring short-term but immediate protection against that disease. Thus for example, a person bitten by a rabid animal may be injected with antibodies from other people who have been vaccinated against rabies.

Immunity can be active or passive. In active immunity, the body makes its own antibody against a pathogen whereas in passive immunity the body acquires antibodies produced by another person or an animal. Either type of immunity can occur ***naturally*** or, for treatment and prevention purposes, it can be induced ***artificially***. Thus we can recognize four classes of immunity under this scheme.

- **Natural active immunity:** This is the production of one's own antibodies as a result of infection or other natural exposure to an antigen.
- **Artificial active immunity:** This is the production of one's own antibodies as a result of vaccination against diseases such as smallpox, tetanus or influenza.
- **Natural passive immunity:** this is a temporary immunity that results from acquiring antibodies produced by another individual. The only natural way for this to happen is for a fetus to acquire antibodies from the mother through the placenta before birth or for a baby to acquire it through the colostrums or breast milk after birth.
- **Artificial passive immunity:** This is a temporary immunity that results from the injection of an immune serum obtained from another individual or from animals (such as horses) that produced antibodies against a certain pathogen. Immune serum is used for emergency treatment of snakebites, botulism, rabies, and other diseases.

	Natural	**Artificial**
Passive	Antibodies provided via the placenta or via breast milk. This makes the baby immune to diseases that the mother is immune to. It is very useful in the first year of the baby's life, when its immune system is developing	Immunity provided by injection of antibodies made by another individual (e.g. tetanus injections)
Active	Immunity provided by antibodies made in the immune system as a result of infection. The person suffers from the disease once and is then immune (e.g. immunity to chickenpox)	Immunity provided by antibodies in the immune system as a result of vaccination. A person is injected with a weakened, dead or similar pathogen, or with antigens, and this activates his/her immune system (e.g. Immunity to tuberculosis or influenza)

Table 3.9: types of immunities

ALLERGIES

Sometimes the immune system reacts to otherwise harmless antigens in ways that can be harmful. This inappropriate reaction to a harmless substance is called **allergy**. Antigens that can trigger allergic reactions include pollen, animal dander (flakes of skin), dust mites, food and fungal spores. Allergic reactions are characterized by watery eyes, wheezing, and sneezing. Many of the symptoms of allergy result from the release of histamine by cells that are exposed to the antigen. Drugs called antihistamines help counteract the effects of histamine and can relieve the symptoms of allergies. For most people, allergies are irritating and inconvenient but not life threatening. However, some people experience severe reactions that can be fatal.

AUTOIMMUNE DISEASES

Lymphocytes that recognize and react to the body's own cells are usually eliminated during development, before they become functional. This prevents an attack directed at the body's own

tissues. However, in rare cases the immune system does respond to the body's own cells, attacking them as if they were pathogens. Such a disorder is called an **autoimmune disease**. For example **multiple sclerosis** is an autoimmune disease of the nervous system that affects mainly young adults. In this disease, T cells attack and slowly destroys the insulating material that covers nerves. Although the severity of multiple sclerosis varies from individual to individual, the damage may progress to a point at which nerve transmission is interrupted. In severe cases, paralysis, blindness and even death can result. Another autoimmune disease is the **type 1 diabetes** in which the immune system mounts an attack on the cells of the pancreas that produce insulin.

Unit 14: Sexual behaviour and sexual response

Key Unit Competence: To be able to explain safe sex, sexuality and sexual behaviours and argue for control of sex violations.

Learning Objectives		
Knowledge and understanding	**Skills**	**Attitudes and values**
⎫ Discuss the concepts of physical and emotional maturity and what this implicates for forming sexual relationships. ⎫ Describe male and female responses to sexual stimulation. ⎫ Explain different ways couples can show love and affection. ⎫ Outline responses to sexual attraction and stimulation at puberty by boys and girls.	⎫ Share experience on the physical and emotional attraction to sexuality.	⎫ Recognise that sexual relationships require emotional and physical maturity. ⎫ Be sensitive that people have different feelings, beliefs and attitudes concerning sex. ⎫ Develop self-confidence and control towards sexual thoughts and feelings.

ACTIVITY 14.1:

- Learners discuss different ways of showing love and affection without engaging in sexual activity.
- Share experience on physical and emotional attraction to sexuality through role plays, games, drama and audio-visual material.
- Learners interact and reflect on sex harassment and coercion using information from internet and video animation, come up with a report to present to class their ideas for control.

14.1. Sexual stimulation

Sexual stimulation is any stimulus (including bodily contact) that leads to, enhances and maintains sexual arousal, and may lead to orgasm. Although sexual arousal may arise without physical stimulation, achieving orgasm usually requires physical sexual stimulation.

The term *sexual stimulation* often implies stimulation of the genitals, but may also include stimulation of other areas of the body, stimulation of the senses (such as sight or hearing) and mental stimulation (i.e. from reading or fantasizing). Sufficient stimulation of the penis in males

and the clitoris in females usually results in an orgasm. Stimulation can be by self (e.g., masturbation) or by a sexual partner (sexual intercourse or other sexual activity), by use of objects or tools, or by some combination of these methods.

Physical sexual stimulation

Genital

Physical sexual stimulation usually consists of touching the genitals or other erogenous zones. Masturbation, erotic massage, sexual intercourse, a fingering are types of physical sexual stimulation involving the genitals. Sexual arousal is usually triggered through sensitive nerves in these body parts, which cause the release of pleasure-causing chemicals (endorphins) that act as mental rewards to pursue such stimulation. A person may also become sexually aroused by touching another person's genitals or other body parts.

Non-genital stimulation

There are many areas through which a person can be sexually stimulated, other than the genitals. To name a few, the nipples, thighs, lips, and neck can all provide sexual stimulation when touched.

14.2. Puberty

Puberty is the period during which growing boys or girls undergo the process of sexual maturation. Puberty involves a series of physical stages or steps that lead to the achievement of fertility and the development of the so-called secondary sex characteristics, the physical features associated with adult males and females (such as the growth of pubic hair). While puberty involves a series of biological or physical transformations, the process can also have an effect on the psychosocial and emotional development of the adolescent.

- Puberty is the period of sexual maturation and achievement of fertility.
- The time when puberty begins varies greatly among individuals; however, puberty usually occurs in girls between the ages of 10 and 14 and between the ages of 12 and 16 in boys.
- Both genetic and environmental factors are involved in the timing of puberty.
- Body fat and/or body composition may play a role in regulating the onset of puberty.
- Puberty is associated with the development of secondary sex characteristics and rapid growth.
- Central precocious puberty (CPP) is puberty that occurs earlier than normal due to release of hormones from the hypothalamus of the brain.
- Girls are more likely than boys to have precocious puberty.
- Puberty may also be accompanied by emotional and mood changes.
- Some medical conditions may worsen or first become apparent at puberty.

When does puberty occur?

The onset of puberty varies among individuals. Puberty usually occurs in girls between the ages of 10 and 14, while in boys it generally occurs later, between the ages of 12 and 16. In some African-American girls, puberty begins earlier, at about age 9, meaning that puberty occurs from ages 9 to 14.

Adolescent girls reach puberty today at earlier ages than were ever recorded previously. Nutritional and other environmental influences may be responsible for this change. For example, the average age of the onset of menstrual periods in girls was 15 in 1900. By the 1990s, this average had dropped to 12 and a half years of age.

Common sexual disappointments

When you are first experimenting with sex, it's very common to experience some problems and disappointments. If you or your partner experience the problems listed below, **don't be afraid to go back a step and not have sex.** Think about ways to enhance your relationship without sex first. Get to know each other more and discuss your feelings about having sex. Learn what you each like as far as touching and get to know your bodies.

You can also talk with an adult and/or your doctor. If you are a minor and would prefer not to share this concern with your parents, ask your doctor to keep your discussion confidential before going into detail.

- No Orgasm
- Cuming Too Soon
- Losing the Erection
- Painful Vaginal Sex

No Orgasm

Most females and some males do not experience an orgasm the first time having sex. This may be in part due to the inexperience of you and/or your partner in the ways of touching and pleasing, nervousness, or worry about the relationship or about possible consequences – such as pregnancy, sexually transmitted infections (STIs), and your relationship with family.

Cuming Too Soon

Ejaculating (cuming) too soon the first time is a common complaint or fear for guys. Don't worry about it! If it happens to you or your partner, know that it doesn't mean this is how it will always

be. Nervousness for some guys can make them lose their erection or not have an orgasm, and for others, it can cause them to lose control in the excitement and cum too early or fast.

Feeling comfortable around each other will be vital if you feel you or your partner is cuming too soon. It helps for partners to work with each other, discussing feelings, and building confidence and trust.

Losing the Erection

Having difficulty keeping an erection or reaching orgasm for males is not uncommon. Nervousness and pressure to perform can easily make a guy lose his confidence or the mood. The more pressure a guy feels to perform, the higher the chance he will either lose his erection or ejaculate faster than he'd like to. The key is to take away the pressure of sex and involve each other in other activities, such as massage and touching.
Don't try remedies such as cock rings or penis lotions without consulting a doctor first. These solutions cause damage if not used properly.

Painful Vaginal Sex

Many of us hear that sex for the first time can be painful, especially for a female. But painful sex doesn't have to be the case at any time. The sections below discuss some ways that sexcan be painful or uncomfortable, and what you can do about it. If you are still finding sexpainful, consider talking to an adult or your doctor. Your doctor will have a betterunderstanding of your body and can give you helpful advice.

14.3. The sexual response

The sexual response cycle refers to the sequence of physical and emotional changes that occur as a person becomes sexually aroused and participates in sexually stimulating activities, including intercourse and masturbation. Knowing how your body responds during each phase of the cycle can enhance your relationship and help you pinpoint the cause of any sexual problems.

The sexual response cycle as has four distinct phases: **excitement, plateau, orgasm,** and **resolution.** Both males and females may experience these phases during sexual activity, but the duration of the phase may differ. This is why it is unlikely that sexual partners will experience

simultaneous orgasm or the same intensity levels at each of the phase. With communication, partners can better understand the differences in each other's sexual response cycles and enhance their sexual experiences.

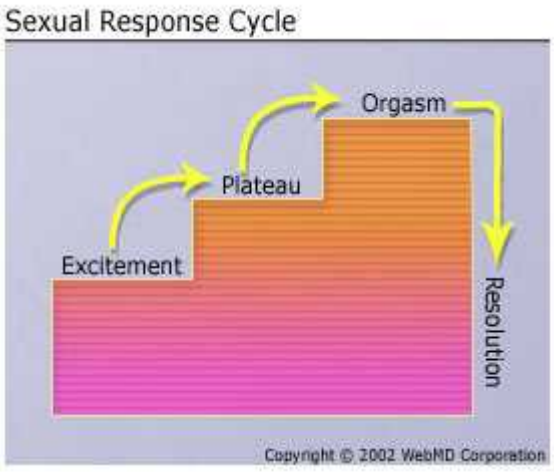

Fig 14.1: The sexual response cycle

Excitement

The excitement phase is the first phase of the sexual response cycle. Like all phases of the cycle, excitement varies from person to person and situation to situation. The characteristics of the excitement phase can last from less than a minute to several hours and include the following signs:

- Myotonia (muscle tension increases)
- Heart rate and blood pressure increase
- Breathing accelerates
- Skin becomes flushed, blotchiness may appear on the chest and back
- Nipples become erect
- Vasocongestion increased blood flow to the genitals, causes the swelling of the female clitoris and labia minora and the erection of the male's penis
- Vaginal lubrication begins and the labia majora begin to separate.
- Female breasts enlarge
- Male testes swell and the scrotum tightens

Plateau

In the plateau phase, sexual excitement continues to grow. This phase can be very brief, typically lasting only a few seconds to a few minutes. Many people find that extending the length of the plateau period can lead to more intense orgasms. There is no clear point at which a person visibly shifts from the excitement phase to the plateau phase. In the plateau phase, the general

characteristics of the excitement phase continue, but become more intensified. These characteristics include the following:

- Increases in muscle tension spasms of the feet, hands, and face
- Continued increase of heart rate, blood pressure, and breathing rate
- The female clitoris becomes highly sensitive and retracts under the clitoral hood to avoid direct stimulation or contact
- The male testes withdraw into the scrotum.
- The outer third of the vagina becomes especially engorged with blood and turns a dark purple color.

Orgasm

Orgasm is the climactic yet shortest phase of the sexual response cycle, typically lasting only several seconds. The general characteristics of this phase of the sexual response cycle include the following:

- Involuntary muscle contractions, including spasms of the feet.
- Peak in heart rate, blood pressure, and breathing rate.
- Flush may appear over the entire body.
- Sudden release of muscle tension.
- In a female, the vaginal muscles contract and the uterus undergoes repeated contractions.
- In a male, repeated contractions occur at the base of the penis and semen is ejaculated.

While females can have a longer orgasm than males, the sensations of orgasms do not seem to differ by gender; that is, males and females feel quite similar things during orgasm. In one study, college students provided descriptions of orgasms. Researchers compared the descriptions using a standard psychological rating scale, and there were no distinguishable differences between male and female descriptions. Both males and females tended to describe orgasms with similar words or phrases such as "waves of pleasure in my body," referring to the rhythmic muscle contractions that occur during orgasm. In an earlier study, 70 expert judges could not reliably differentiate between the orgasm reports of in males and females.

Resolution

In this phase, the body slowly returns to its original, unexcited state. Body parts return to their normal size and hue. Some of the changes occur rapidly, whereas others take more time. The resolution phase is often accompanied by a general sense of well-being, intimacy, and fatigue. The resolution phase begins immediately after orgasm if there is no additional stimulation.

Refractory Period

The refractory period is the one significant difference between the sexual response cycle of males and females. The refractory period occurs during the male's resolution phase. It is a length of time during which a male cannot become more aroused from any kind of sexual stimulation. This period can last from a few minutes to several days, depending on the male's age, frequency of sexual activity, and other things. Females do not experience a refractory period, and they are

capable of reaching orgasm again from any point during resolution. Females have the potential to experience multiple orgasms, but they may not always want to. Good communication can decrease the likelihood of misunderstanding occurring.

Unit 15: Pregnancy prevention

Key Unit Competence: To be able to apply knowledge of pregnancy prevention in sexual and reproductive decisions.

Learning Objectives		
Knowledge and understanding	**Skills**	**Attitudes and values**
) Identify effective ways of preventing unintended pregnancy.) Outline forms of contraceptive methods and their working mechanisms in the body, associated efficacy, benefits and side effects.) Describe benefits and possible side effects of available methods of contraception.	) Demonstrate confidence in discussing different contraceptive methods.) Design and illustrate a model that shows efficient use of male and female condoms.	) Appreciate the importance of making informed choices about reproduction and family size.) Recognise the benefits of child spacing.

ACTIVITY 15.1:

- Learners carry out research from the library or internet about contraceptive methods.
- In groups, learners discuss the advantage and disadvantages of using each contraceptive method.
- Learners research, in groups about the effective ways of preventing unintended pregnancy and present to class.
- In groups, learners discuss different forms of contraception and their working mechanism in the body, associated efficacy, benefits and side effects.
- Brainstorm on menopause and abortion related to the pregnancy conception
- Learners' observe models and discuss how they are used in relation to the real life situation.

Contraception is the prevention of conception that is preventing the fusion of the male gamete with the female gamete. Both natural and artificial methods exist.

About 85% of sexually active women who do not use contraceptives become pregnant within a year. A woman can become pregnant while breastfeeding, from about 10 days after childbirth, and even during her menstruation. Withdrawal of the penis prior to ejaculation and periodic abstinence does not prevent pregnancy or spread of sexually transmitted diseases. Here you can read more about several forms of contraceptives.

You can prevent an unwanted pregnancy with:

- Total Abstinence
- Use of contraceptives

If you are sexually active and do not want to get pregnant, always use contraception.

Methods of Contraception

No method of contraception gives 100% protection. The male latex condom is the only contraceptive method considered highly effective in reducing the risk of sexually transmitted diseases (STD's). Birth control pills, Implant and IUDs do not protect against STD infection.

Knowing how to prevent pregnancy can seem daunting, especially since there are so many birth control options to choose from. The birth control you use is a personal choice that should be carefully considered. Educating yourself on the various methods is the first step to finding the one that fits with your lifestyle and beliefs.

15.1. Barrier Methods

a) Condoms

Latex condoms are worn on the penis during intercourse. They prevent pregnancy by keeping semen from coming into contact with fertile eggs. Condoms are often given out for free at health clinics, and they're available for over-the-counter purchase for about $1.00 a piece at drug stores and grocery stores.

- An added benefit of condoms is that they protect both parties from sexually transmitted diseases (STDs) as well as pregnancy.
- Condoms are made from thin latex, so they occasionally tear during intercourse. When this happens, the chances of pregnancy go up.
- Some people have allergies to latex condoms, and choose condoms made of plastic instead.

b) Female condoms

Also made of latex, female condoms are shaped like a ring with a pouch. The pouch fits inside the vagina, while the ring stays outside the body to hold it in place. They collect semen during intercourse so it never has a chance to enter the woman's body.

- Female condoms reduce the risk of STDs by protecting the vagina from directly getting touched.
- Female condoms are slightly less effective than regular condoms, and some people say that they are less comfortable to use.

c) Diaphragms

These shallow cups made of silicone are inserted inside the vagina and over the cervix to prevent semen from contacting an egg. They are commonly used in combination with spermicidal jelly, which prevents sperm from moving, in order to increase efficacy.

- Since every woman's body is a slightly different shape, diaphragms must be fitted to make sure they're the right size. Talk to your gynecologist or health clinic worker about getting fitting for a diaphragm.
- Diaphragms are quite effective, but they don't prevent the transmission of STDs.

15.2. Hormonal Birth Control

a) Birth control pills

Birth control pills, often referred to in shorthand as "the Pill," consist of synthetic estrogen and progestin hormones that keep a woman's eggs from leaving her ovaries, so that pregnancy can't happen. When taken properly, they are extremely effective. Contraceptive pills are available on a prescription-only basis from your gynecologist or health care provider.

- The Pill must be taken every day, at the same time each day, to work properly. Skipping a few days could decrease its efficacy.
- The Pill causes some women to experience side effects. Different brands of pills have different levels of estrogen and progestin, so your doctor may prescribe a different brand if one seems to be causing negative side effects.

b) Other hormonal devices

The same hormones that make birth control pills effective can be distributed to the body by other means. If you don't like taking pills every day, consider these options:

- Depo-Provera, or the birth control shot. This shot is administered in the arm once every three months. The shot is very effective at preventing pregnancy, but it has been reported that side effects are possible.

- The birth control patch. The patch is usually placed on the arm, back or thigh. It distributes hormones through the skin and has to be replaced every few weeks.
- The birth control ring. The ring is inserted into the vagina once a month. It releases hormones to prevent pregnancy from occurring.
- The birth control implant. A small rod is inserted in the arm, and it releases hormones to prevent pregnancy for up to three years. It must be inserted and removed by a health care provider.

c) Intrauterine Devices (IUDs)

The IUD is a small metal device inserted in the uterus by a health care provider. One type of IUD works by releasing hormones, and another type is made of copper, which affects the mobility of sperm and stops them from fertilizing the egg.

- IUDs are extremely effective and last up to 12 years.
- If you're concerned about disrupting your menstrual cycle, consider the copper IUD, which doesn't interfere with your hormones or cause hormonal birth control-related side effects.

15.3. Behavioral Methods

a) Abstinence

Abstaining from vaginal intercourse prevents pregnancy by preventing the man's semen from coming into contact with the woman's egg. Abstinence is one hundred percent effective in preventing pregnancy when it is used continuously.

- Some people define abstinence as abstaining from all sexual contact, but in order to prevent pregnancy, only vaginal intercourse needs to be avoided.
- Abstinence requires strong willpower, and some people might find it difficult to rely on this birth control method for long periods of time.
- It's important to have another birth control method in place once abstinence is ended.

b) Fertility awareness

Also called natural family planning, this method of birth control requires having sex only during times of the menstrual cycle when the woman is not fertile. During times when pregnancy would be possible, periodic abstinence is employed. For fertility awareness to be effective, the practitioner must understand and respect the perimeters of her fertility.

- Fertility awareness often involves three different ways for calculating fertility: the calendar method, the mucus method, and the temperature method. Used together, these three methods are very effective at determining exactly when a woman is fertile.
- The calendar method requires tracking the different phases of the menstrual cycle on a calendar, then noticing patterns over time and using the patterns to predict when ovulation will occur.
- The mucus method involves checking vaginal mucus, which changes in color and consistency when a woman is fertile.
- The temperature method involves checking the body's basal temperature every day and noticing when it goes up a few tenths of degree, which signals that ovulation has occurred.
- The downside of fertility awareness is that it requires a lot of time and attention. If you forget to check mucus or temperature for a few days, you may miscalculate the days during which sex should be avoided.
- The upside of fertility awareness is that it its completely natural, requiring almost no money, no outside hormones, and no uncomfortable devices.

15.4. Surgical Methods

a) Female sterilization

Surgery is conducted to close off the fallopian tubes in a process called **tubal ligation**, preventing the possibility of pregnancy. This method is extremely effective at preventing pregnancy, but it is not to be taken lightly, since it is difficult or impossible to reverse.

b) Vasectomy

Men may choose to undergo a process that blocks their vas deferentia, through which sperm flow, preventing them from mixing with semen.When the man ejaculates, his semen does not contain sperm, making it impossible for him to get a woman pregnant. Vasectomy may be reversed in some cases, but it should not be considered unless the intention is to become permanently sterilized.

15.5. Preventing pregnancy after sex

a) Use emergency contraception

Also called Plan B, emergency contraception consists of two pills containing levonorgestrel that are ingested as soon as possible after sexual intercourse. The sooner they are taken, the more effective they are at preventing pregnancy.

- Emergency contraception is available at most pharmacies and from your healthcare provider.
- Emergency contraception should not be a replacement for regular birth control; it's a last resort to be taken after unprotected sex.

b) Abortion: Premature termination of pregnancy.

Contraceptives methods and birth control

Method	**Basis of action**	**Notes on use**	**Approximate failure rate**	**Relative advantages**
Barrier methods Condom Diaphragm	A thin, strong rubber sheath. Prevents sperm entering the vagina Flexible rubber dome which fits over the cervix and prevents entry of sperm to uterus.	Placed over erect penis just before sexual intercourse Inserted before intercourse. Must be left in place at least 6 hours after intercourse	3 % 3 – 15 %	Cheap, easy and convenient to use. Can be inserted a few hours before intercourse
Spermicide	Chemical kills sperm	Placed in vagina to cover the lining of vagina and cervix	10 – 25 %	Can be quite effective when used with condom or diaphragm
Hormonal methods Pill	Contains the female sex hormones estrogens and progesterone. Prevents development of eggs and ovulation by inhibiting secretion of FSH	One taken orally during the first 3 weeks of the cycle.	1 %	Very reliable. Woman has control. No interference with love making.
Preventing implantation IUD (Intra-uterine device)	Small device made of copper, plastic or stain less steel. Inserted into uterus by a doctor and		3 %	Can be left in place for long periods (up to 5 years). Suitable for women who

	left in place.			have had children.
Natural methods Abstinence Rhythm method Temperature method Coitus interruptus	 Avoid sexual intercourse Avoid sexual intercourse around the time of ovulation. Note rise in temperature at ovulation and avoid sexual intercourse at these times. Penis is withdrawn from vagina before ejaculation		 0 % 20 % Up to 20 % 60 %	 Effective Accepted by roman catholic church Accepted by roman catholic church Accepted by roman catholic church
Sterilization Vasectomy (male) Tying oviducts (in female)	 Cut each vas deferens Cut both oviducts		 Less than 1 % Less than 1 %	 Very reliable. No side effects. Very reliable
Termination Morning after pill Abortion	 Contains an anti-progesterone. Up to 24 weeks in UK	 Taken within 3 days of sexual intercourse Premature termination of pregnancy by surgical intervention.		

Table 15.1: Contraceptive methods

Unit 16: Reducing risk of STIs and HIV

Key Unit Competence: To be able to apply knowledge of STI and HIV transmission, prevention and treatment in sexual decision making.

Learning Objectives		
Knowledge and understanding	**Skills**	**Attitudes and values**
⁾ Explain how STIs and HIV are transmitted, treated and prevented. ⁾ Identify specific ways of reducing the risk of acquiring or transmitting HIV and other STIs, including the correct use of condoms. ⁾ State that abstinence is the most effective protection against HIV and other STIs. ⁾ State that age disparate/intergenerational relationship can increase the risk of acquiring HIV. ⁾ State that post-exposure prophylaxis (PEP), or short-term anti-retroviral therapy (ART), can reduce the likelihood of HIV infection after a potential exposure. ⁾ Explain that sexual health services, including voluntary counselling and testing (VCT) centres offering pre- and post-test counselling can help people to assess personal risk and perceived vulnerability and explore their attitudes about safer sexual practices. ⁾ State that culture, gender and peer norms can influence decision making about sexual behaviour. ⁾ Explain that alcohol and drug use can	⁾ Recognise symptoms and complications of STIs and HIV. ⁾ Demonstrate communication skills in negotiating safer sex and refusing unsafe sexual practices. ⁾ Explain how culture and gender affect personal decision making regarding sexual relationships. ⁾ Explain how STIs such as chlamydia, gonorrhoea, syphilis, HIV and HPV (genital human papilloma virus) can be prevented.	⁾ Appreciate behaviours that reduce the risk of STIs and HIV transmission . ⁾ Recognise the importance of getting tested and treated for STIs including HIV.

impair rational decision making and contribute to high-risk behaviours.		

ACTIVITY 16.1:

- Making posters presenting different topics related to STIs and HIV.
- Dramatize negotiation and refusal skills regarding sex.
- Demonstration and practice of correct use of condom.
- Watch movies relating risky behaviour and ways of reducing risk of STIs and HIV.
- Through drama and sketch,
- Learners reflect on the harmful effects on sexual behaviour of consuming drugs and alcohol.

16.1. Sexually transmitted diseases

Sexually transmitted diseases (**STD**), also referred to as **sexually transmitted infections** (**STI**) and **venereal diseases** (**VD**), are illnesses that have a significant probability of transmission between humans by means of sexual behavior, including vaginal intercourse, anal sex and oral sex. Some STIs can also be contracted by using drug needles after their use by an infected person, as well as through any incident involving the contact of a wound with contaminated blood or through childbirth or breastfeeding.

Sexually transmitted infections have been well known for hundreds of years, and **venereology** is the branch of medicine that studies these diseases. While in the past, these illnesses have mostly been referred to as STDs or VD, the term ***sexually transmitted infections*** (*STIs*) has been preferred by many up-to-date medical sources, as it has a broader range of meaning; a person may be *infected*, and may potentially infect others, without having a *disease*.

There are 19 million new cases of sexually transmitted infections every year in the United States, and, in 2005, the World Health Organization estimated that 448 million people aged 15–49 were being infected a year with curable STIs (such as syphilis, gonorrhea and chlamydia).

Until the 1990s, STIs were commonly known as ***venereal diseases***, the word venereal being derived from the Latin word venereus, and meaning relating to sexual intercourse or desire, ultimately derived from Venus, the Roman goddess of love.*Social disease* was a phrase used as a euphemism.

While many people with STDs show no signs or symptoms of their infection, when there are signs of STDs they are most likely to be in the genital area. The genital area in women includes the vulva (the area around the vagina including the lips), vagina (the opening where menstrual blood comes out), buttocks, urethra (the opening above the vagina where urine comes out) and anus (the opening where a bowel movement comes out). The genital area in men includes the penis, scrotum ("balls"), urethra, and anus.

What Are the Symptoms of STDs?

Sometimes, there are no symptoms of STDs. If symptoms are present, they may include one or more of the following:

- Bumps, sores, or warts near the mouth, anus, penis, or vagina.
- Swelling or redness near the penis or vagina.
- Skin rash.
- Painful urination.
- Weight loss, loose stools, night sweats.
- Aches, pains, fever, and chills.
- Yellowing of the skin (jaundice).
- Discharge from the penis or vagina. (Vaginal discharge may have an odor.)
- Bleeding from the vagina other than during a monthly period.
- Painful sex.
- Severe itching near the penis or vagina.

The table below shows some common sexually transmitted infections and their symptoms.

Table 16.1: **Sexually transmitted infections**

STI	SYMPTOMS
Chlamydia caused by a bacterium called *Chlamydia trachomatis*	Most women have no symptoms. Women with symptoms may have: - Abnormal vaginal discharge - Burning when urinating - Bleeding between periods Infections that are not treated, even if there are no symptoms, can lead to: - Lower abdominal pain - Low back pain - Nausea - Fever - Pain during sex
Genital herpes caused by a DNA virus	Some people may have no symptoms. During an "outbreak," the symptoms are clear: - Small red bumps, blisters, or open sores where the virus entered the body, such as on the penis, vagina, or mouth - Vaginal discharge - Fever - Headache - Muscle aches - Pain when urinating - Itching, burning, or swollen glands in genital area - Pain in legs, buttocks, or genital area Symptoms may go away and then come back. Sores heal after 2 to 4 weeks.
Gonorrhoea caused by a bacterium called *Neisseria*	Symptoms are often mild, but most women have no symptoms. If symptoms are present, they most often appear within 10 days of becoming infected. Symptoms are: - Pain or burning when urinating

gonorrhoea	⁾ Yellowish and sometimes bloody vaginal discharge ⁾ Bleeding between periods ⁾ Pain during sex ⁾ Heavy bleeding during periods Infection that occurs in the throat, eye, or anus also might have symptoms in these parts of the body.
AIDS caused by a retrovirus called HIV	Some women may have no symptoms for 10 years or more. About half of people with HIV get flu-like symptoms about 3 to 6 weeks after becoming infected. Symptoms people can have for months or even years before the onset of AIDS include: ⁾ Fevers and night sweats ⁾ Feeling very tired ⁾ Quick weight loss ⁾ Headache ⁾ Enlarged lymph nodes ⁾ Diarrhoea, vomiting, and upset stomach ⁾ Mouth, genital, or anal sores ⁾ Dry cough ⁾ Rash or flaky skin ⁾ Short-term memory loss
Syphilis caused by a bacterium called *Treponema pallidum*	Syphilis progresses in stages. Symptoms of the primary stage are: ⁾ A single, painless sore appearing 10 to 90 days after infection. It can appear in the genital area, mouth, or other parts of the body. The sore goes away on its own. If the infection is not treated, it moves to the secondary stage. This stage starts 3 to 6 weeks after the sore appears. Symptoms of the secondary stage are: ⁾ Skin rash with rough, red or reddish-brown spots on the hands and feet that usually does not itch and clears on its own ⁾ Fever ⁾ Sore throat and swollen glands ⁾ Patchy hair loss ⁾ Headaches and muscle aches ⁾ Weight loss ⁾ Tiredness
Trichomoniasis (sometimes called "trich") caused by a protozoan called *Trichomonas vaginalis*	Many women do not have symptoms. Symptoms usually appear 5 to 28 days after exposure and can include: ⁾ Yellow, green, or gray vaginal discharge (often foamy) with a strong odor ⁾ Discomfort during sex and when urinating ⁾ Itching or discomfort in the genital area ⁾ Lower abdominal pain (rarely)
Candidiasis caused by a fungus called *Candida albicans*	Severe irritation, extreme itching in the vaginal area, soreness and redness in the vaginal area, painful intercourse in females. In men the symptoms include: red rash on penis, itching or burning on the tip of the penis.

Chancroid is caused by a bacterium.	Symptoms may include genital sores, vaginal discharge, a burning feeling when urinating, and swollen lymph nodes in the groin. It can be spread by vaginal or anal sex or skin-to-skin contact with sores. Chancroid can be treated with antibiotics.

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