DANSOL HIGH SCHOOL
SS 2 SECOND TERM SCHEME + NOTE

WEEK	TOPIC
1	Excretion
2	Tissues and Supporting Systems
3	Components of the Mammalian Skeleton
4	Joints / Supporting Tissues in Plants
5	Alimentary Canal / Digestive System
6	Practical on Digestion and Skeleton
7	Feeding Habits
8	Feeding Habits
9	Transport System
10	Circulatory System in Mammals
11	Transport System in Plants
12	Revision / Examination
13	Revision / Examination

EXCRETION

Excretion is the removal of metabolic waste products from the body of living organisms. These waste products are usually toxic and can harm the organism if not removed.

Note: Excretion is different from egestion/elimination and secretion.

- Egestion/Elimination: This is the removal of solid undigested food substances which are not by-products of metabolism from the body of living organisms.
- Secretion: This is the production of useful substances such as enzymes and hormones by metabolic processes in the body.

Waste substances may include-:

- By-products formed during metabolic processes in the body.
- Excess food substances which cannot be stored in the body.

Assignment - State Five Importance of Excretion

Excretory organs and waste products of some organisms.

	Organism	Excretory Organ	Waste Product
1 .	Protozoans e.g. Amoeba, Paramecium etc.	Body Surface, Contractile Vacuole	CO_2 , water, excess mineral salts.
2.	Flat worms, e.g. Tapeworm	Flame cells	Water, urea, CO_2 and nitrogenous waste.
3.	Earthworm	Nephridia	CO_2 , urea, nitrogenous waste
4.	Insects e.g. Cockroach	Malpighian tubules	CO_2 , water and uric acid
5.	Mammals	Lungs, skin, liver, kidney	Water, CO_2, mineral salts, sweat, nitrogenous waste.
6.	Flowering plants.	Stomata, lenticels	Water, gums, alkaloids, CO_2 oxygen, latex
7.	Crustaceans	Green glands	Nitrogenous waste

Excretory Mechanisms in Earthworm

In earthworm, carbon dioxide and nitrogenous wastes are the main waste materials. The carbon dioxide is excreted out from the body through its moist skin by the process of diffusion. The nitrogenous wastes are excreted out of the body by special excretory organs called *nephridia*(singular nephridium). A nephridium is a tubular coiled structure. It starts from a rounded funnel shaped structure called *nephrostome*. The nephrostome opens in a coiled tube called *nephridial tubule* which is lined with cilia. The nephridial tubule opens outside the body through a small opening called *nephridiopore*.

The body fluid of earthworm rich in nitrogenous wastes enters the nephridium through nephrostome and passes into nephridial tubule. In the nephridial tubule, the useful substances present in fluid are absorbed. The remaining fluid containing high percentage of nitrogenous wastes is excreted out of the body through nephridiopore with the help of movements of cilia.

***Assignment*:** Make a well labelled diagram of the nephridium

Excretion in Man

The kidneys are the main organs of excretion; however, the skin, lungs and liver also play vital roles in excretion in man. The skin has sweat glands through which we excrete small amounts of water, urea and salts. The liver helps in the removal of bile pigments. It also excretes cholesterol. The lungs help in getting rid of carbon dioxide (CO_2), formed as a result of cellular respiration, through exhalation.

The Kidneys

The paired kidneys are the excretory organs of humans. They remove unwanted nitrogenous substances like urea and other ammonium compounds from the blood. They also maintain the osmotic pressure of the blood by controlling the excretion of water and salts.

The kidney is supplied with blood vessels (renal artery and renal vein). The renal artery which arises directly from the dorsal aorta and brings oxygenated blood containing excretory products. The renal vein drains filtered deoxygenated blood from the kidney to the posterior vena cava. A narrow tube, the ureter, connects the kidney to the urinary bladder where urine is stored. The urinary bladder leads to the urethra which opens to the exterior.

The kidney has two distinct regions:

- an outer cortex, and
- an inner medulla

Urinary tubules (also called nephrons) pass through these regions and open at the tips of triangular-shaped masses of tissues called pyramids. The pyramids open into a funnel-shaped cavity called the pelvis. The pelvis is continuous with the ureter.

Assignment: Make well labelled diagrams of the kidney and nephron

Structure of a Urinary Tubule (Nephron)

The urinary tubule is the functional unit of the kidney. Each urinary tubule begins in the cortex as a cup-like structure called Bowman's capsule. The capsule opens into a short coiled tube called the proximal convoluted tubule. Then it straightens out as it passes into the medulla, where it makes a U-shaped loop, the Henle's loop, before re-entering the cortex. In the cortex, it becomes coiled again to form the distal convoluted tubule. This tubule pours it contents into wider main collecting ducts which eventually join up and open into the pelvis at the apices of the pyramids.

Summary of the sequence of movement:
Glomerulus --- Bowman's capsule --- Proximal convoluted --- Henle's loop --- Distal convoluted tubule --- Collecting ducts

The knot of capillaries in the Bowman's capsule is called the glomerulus. The capsule and glomerulus form the Malpighian corpuscle. {Malpighian corpuscle = Bowman's capsule + Glomerulus}

Formation of Urine

The processes involved in the formation of urine are as follows:

- Ultrafiltration
- Selective reabsorption
- Hormonal Secretion

Ultrafiltration

Here, blood is brought to the kidney by the renal artery. As this blood circulates through the capillaries of the glomerulus of each bowman's capsule, water, urea, nitrogenous compounds, mineral salts, sugar, glucose and plasma solutes are filtered into the capsule. This process of filtering materials from the glomerulus into the bowman capsule called ultrafiltration. The filtered product is called glomerular filtrate.

Selective Reabsorption

The glomerular filtrate containing absorbed food substances such as glucose, salts, water, urea and other excretory waste product flows through the convoluted tubules towards the pelvis, and the substances are selectively reabsorbed. In the proximal convoluted tubule, the glucose re-absorbed into the blood in the blood vessels creates a higher osmotic pressure and also causes water to be reabsorbed by osmosis. In the loop of Henle, the salts are also reabsorbed into the medulla by active transport. The process of reabsorbing useful materials into the blood is called selective reabsorption.

Hormonal Secretion

After re-absorption, the fluid in the tubules becomes more concentrated as it flows through the distal tubule where more water is re-absorbed by the action of the Anti-diuretic Hormone (ADH). The filtrate then moves into the last part of the tubule. Here, large waste molecules like creatinine are secreted into the tubules. The fluid that eventually remains in the tubules is concentrated and it is known as urine. The urine gradually trickles into the urethra and are collected into

the bladder. When the bladder is full, it contracts and discharges the urine out of the body through the urethra.

Excretion in Plants

Plants are autotrophic and stationary so their metabolic wastes are minimal. As a result, they do not need a special excretory system. Stomata and lenticels help in excretion in plants.

- In leaves and young stems, the gases pass through the stomata
- In old stems, gases escape through lenticels
- In roots, gases pass out through general root surface

The main waste products found in plants are water, CO_2 and oxygen. Excess water in plants is removed as water vapour through the process called *transpiration*. In certain plants, the excess water drops off in a process called *guttation* (this is a process by which droplets of water resembling dew drops enlarge and eventually drop off)

Other excretory products in plants are:

- Oils and Resins
- Alkaloids
- Latex
- Tannins
- Mucilage
- Gum crystals
- Anthocyannin

Differences between Excretion in plants and animal:

	Excretion in animals	Excretion in plants
1.	Animals do not usually store excretory products	Plants store excretory products for long period and eventually remove them by shedding of leaves or death
2.	There are special organs for excretion in animals	There are no special organs
3.	Animals produce excretory substances quickly	Plants produce excretory substances slowly
4.	Animals do not excrete tannins, alkaloids and other waste products in plants	Plants excrete tannins, alkaloids, and others that are needed by man.

Assignment: Briefly explain the following (i) transpiration (ii) guttation

TISSUES AND SUPPORTING SYSTEMS

Skeleton

Skeleton is the structural framework of an organism which gives the organism shape, strength and support.

Biological Significance / Functions of Skeleton

- Protects vital organs
- Aids movement
- Gives support
- Gives shape
- Enables the attachment of tissues
- Aids breathing
- Responsible for the development of blood cells

Skeletal Materials

There are three main types of materials found in the skeleton of animals, and they are chitin, cartilage and bone.

- Chitin: It is a tough, light and flexible material and it is the major component of the skeletons of arthropods. It is a non-living material composed of a carbohydrate and it is freely permeable to water

- Cartilage: This is a tissue found in the skeleton of complex vertebrates. It consists of living cells (chondroblasts), carbohydrates and protein fibres. It has great tensile stress and acts as a shock absorber to cushion the effect of bones moving against each other during movement.

  Cartilage forms the entire skeletal systems of sharks and rays. In mammals, there are three types of cartilage: hyaline cartilage, fibro-cartilage and elastic cartilage. Hyaline cartilage makes up the rings which support the trachea and bronchi; covers the surface of movable joints; and supports the protruding part of the nose. Fibro-cartilage is found in the discs between the small bones of the vertebral column. Elastic cartilage is present in the external ear and the epiglottis. Cartilage does not have its own blood supply.

- Bone: This tissue is the major component of the vertebral skeleton. It consists of living bone cells (osteocytes), protein fibres (collagen) and minerals, mainly calcium phosphate and calcium carbonate. The minerals make up 2/3 of the mass of the bone. This makes a bone stronger and more rigid than a cartilage. Bones

also have their own supply of blood to nourish them.

In a young vertebrate embryo, the skeleton is made up of cartilage. As the embryo grows, bone cells replace cartilage cells. This causes the cartilage tissue to harden into bone through the addition of minerals. This process is known as *ossification*.

Assignment: Discuss briefly (i) Osteocytes (ii) Chondroblasts (iii) Ossification

Types of Skeleton

There are three main types of skeleton namely:

- Hydrostatic skeleton
- Exoskeleton
- Endoskeleton

Hydrostatic Skeleton

This is the type of skeleton possessed by soft- bodied animals like earthworm. They have fluid pressure to provide support. Fluid is secreted to fill the spaces in the body. The fluid presses against the muscular body wall, causing the muscles to contract, exerting a force against the fluid.

Exoskeleton

This type of skeleton is found on the external part of the body of organisms like arthropods. The main component is chitin which is often strengthened by deposits of protein and minerals, especially calcium carbonate. Animals with exoskeletons moult periodically. They shed their old exoskeletons and grow rapidly in size, while the new exoskeletons are still soft and extensible. Moulting is also known as ecdysis.

Endoskeleton

This is an internal skeleton found in all vertebrates. With the exception of cartilaginous fishes, the endoskeletons of vertebrates are composed mainly of bones. These bones are attached together at movable joints by ligaments. Bones are attached to muscles by tendons.

Components of the mammalian skeleton

The mammalian skeleton is composed of two main components which are:

- Axial skeleton
- Appendicular skeleton

Axial Skeleton

The skull, vertebral column, and ribs and sternum (breastbone) make up the axial skeleton.

The Skull:

This is made of several flat bones which are joined together to form:

- Brain box or Cranium which covers the brain protectively
- Upper jaw or maxilla and the cavities for the main sense organ
- Lower jaw or mandible which is a single bone that hinges with the rest of the skull in such a way that it can move up and down.

Vertebral Column

This is also known as the backbone or spinal column and it is the central supporting structure of the skeleton. In humans, it consists of 33 vertebrae stacked to form a flexible column with a central canal for the spinal cord.

A typical vertebra has the following:

- Neural canal which is for the passage of spinal cord
- Neural spine which projects upward (dorsal view)
- A centrum which is a solid piece of bone below the neural canal
- A transverse process: This projects from each side of the vertebrae
- Facets which fit into the adjacent vertebrae

The vertebrae are of five different types which are:

- Cervical Vertebrae
- Thoracic Vertebrae
- Lumbar Vertebrae
- Sacral Vertebrae
- Caudal Vertebrae

Assignment: Make well labelled diagrams of atlas, axis, cervical, thoracic, lumbar, sacral and caudal vertebrae

The first and second vertebrae of the column are the atlas and the axis respectively. They are cervical vertebrae. The atlas, first bone, permits nodding of the head while the axis, second bone, permits the head to turn from side to side. The axis has a large centrum which projects forward as the odontoid process.

Type of vertebrae	Body region	Number in man	Number in Rabbit	Characteristic Features and Functions
Cervical	Neck	7	7	They have a very short neural spine, large neural canal. It has a large and broad transverse process and a very short or no neural spine. **Function**: It supports the head and allows for the turning and twisting of the head.
Thoracic	Chest	12	12	Presence of a large centrum and a large neural canal. Long neural spine. Presence of facets on each side for articulating with a rib. **Functions**: -It forms the thoracic cage for the protection of the heart. - It assists in breathing alongside with the ribs.
Lumbar	Loin	5	7	It has short neural spine which projects from upward and forward. It has large and thick centrum. **Function**: It supports the body weight of the animal.
Sacral	Hip	5	3-4	They fuse together to form the sacrum (waist). It has a narrow neural canal and a reduced spine. **Function**: They are joined to the pelvic girdle to provide support.
Caudal Vertebrae	Tail	4	16	They are fused and reduced to small centrum bone called coccyx. **Function**: The tail helps in balancing.

Ribs and sternum

Twelve pairs of ribs and the sternum form the rib cage. In humans, the sternum is a single bone, while that in rabbits consists of seven small bones. Also, only the first ten pairs are attached to the sternum. The last two pairs remain free and are known as floating ribs.

Appendicular Skeleton

This is composed of the limb girdles (shoulder and hip) and the limbs.

The Limb Girdles

The limb girdles are divided into the pelvic and pectoral girdles.

1. Pectoral girdle: In humans, the pectoral girdle holds the upper limb of the hand to the axial skeleton. It consists of four separate bones: two shoulder-blades called scapulae and two collar-bones called clavicles. Each scapula has a depression called **glenoid cavity** into which the head of the humerus fits to form the shoulder joint. The clavicles are attached to the scapula at one end and to the sternum at the other end.

2. Pelvic girdle: The pelvic girdle or hips consists of two bones, the right and left pelvis. On the outer edge of each pelvis is a deep cavity, the **acetabulum**, into which the head of the thigh bone or femur fits to form the hip joint.

The Limbs

The limbs are divided into Fore and Hind limbs. The forelimb is made up of:

- Humerus: This is the upper arm whose head articulates with the scapula
- Lower arm: This is made up of the radius and the ulna which can partly rotate so that the hand can be held either upward or downward.
- Wrist: This is made up of eight small bones called carpals.
- Hand: The hand is made up of five rod-like bones of the palm called metacarpals. Jointed bones from the fingers and the thumb are known as phalanges.

The hindlimb is made up of:

- Femur: This is the thigh bone whose head articulates with the acetabulum of the pelvis. It is the strongest and largest bone in the body.
- Lower leg: This is made up of tibia and fibula
- Ankle: This is made up of small bones called tarsals
- Feet: This is made up of rod- like bones called metatarsals.

Assignment: Briefly explain (i) glenoid cavity (ii) acetabulum (iii) odontoid process

Joints

A joint is a place where two or more bones meet or articulate. Bones meeting at a joint are held together by strong ligament which prevents dislocation during movement. The degree of movement of a joint varies with the particular joint. The shoulder joint is the most mobile joint of the body while the joints of the bones that form the cranium are immovable. A slightly movable joint is at the sacrum which is found at the hip region.

Types of Joints

There are two main types of joints which are movable joints and immovable joints. There are four main kinds of movable joints which are:

- Ball and socket joint
- Hinge joint
- Gliding and sliding joint
- Pivot joint

1. Ball and socket joint: This joint allows movement in almost all directions. For example: the shoulder and the hip joint.
2. Hinge joint: This type of joint allows free movement in one direction only. Example of hinge joint can be found at the elbow, knees and fingers.
3. Pivot joint: The pivot joint allows rotation of one part of the body on another (rotatory movements). It is found in the neck where the atlas rotates on the odontoid process of the axis.
4. Gliding or sliding joint: This allows the sliding of bones over one another. It occurs at the wrist and ankle. It allows the hand and foot to be moved up and down or slide and rotate.

Assignment: Make a well labelled diagram of ball and socket joint.

Note:

Synovial cavity: These contain the end of the bones.
Synovial membrane: This secretes the synovial fluid.
Synovial fluid: The fluid helps in the lubrication and thus prevention of friction. It also acts as a cushion to prevent shock.

Muscles

Muscles are attached to bones by means of strong whitish substance called tendons. Muscles contract and relax so as to bring about movement in animals. This means that skeletal and muscular system work together to produce movement in animals. There are three types of muscles in animals:

1. Voluntary muscles: These muscles are known as skeletal muscles. They are concerned with movement of hands and limbs; they are under

the control of our will. Examples are found in the muscles of the hands and legs.

2. Involuntary muscles: These muscles are not under the control of will. They make up part of the digestive, reproductive, excretory system and walls of the blood vessels.
3. Cardiac muscles: They are voluntary muscles that make up the walls of the heart. Regular exercises promote good development of our muscles.

How muscles bring about movement in animals.
The voluntary muscles work together (contracting and relaxing) to bring about movement. The flexor muscles (biceps) one on top of the humerus while the extensor muscles (triceps) are below the humerus. For an individual to bend his hand, the bicep muscles will contract while the tricep muscles will relax. In order to straighten the hand, the tricep muscles will contract while bicep muscles will relax.

Supporting Tissues in Plants
Types of supporting tissues in plants include:

- Turgid parenchyma
- Collenchymas
- Sclerenchyma
- Xylem

Internal structure of herbaceous roots
Internally, a root consists of an outer cylinder and an inner central cylinder or stele. A transverse section of a root shows the following arrangement of tissues from the circumference to the centre:

- Piliferous layer } Outer
- Cortex (including the endodermis) } cylinder
- Pericycle
- Vascular tissue } Inner cylinder/stele
- Pith

The outer cylinder consists of the piliferous layer. Root hairs arise from the young cells of the piliferous layer. The endodermis is the innermost layer of the cortex.

The stele consists of vascular tissue, made up of alternate phloem and xylem bundles arranged in a ring. Usually, there are more vascular bundles in a monocotyledonous root than a dicotyledonous one. The pericycle bounds the vascular tissue on the outer side. The pith which is large in monocotyledonous roots is composed of thin-walled parenchyma. In most dicotyledonous roots, the xylem fills up the centre of the stele, forming a centrally supporting column.

Assignment: Make well labelled diagrams of dicotyledonous root and monocotyledonous root

Note:

- The main supporting tissues in roots are xylem and turgid parenchyma which makes up the cortex.
- The cambium, a meristematic tissue which gives rise to secondary growth, appears in older dicotyledonous roots but is completely absent in monocotyledonous roots.

Internal structure of herbaceous stems
A stem has more supporting tissues than a root. A transverse section of a dicotyledonous stem shows the following arrangement of tissues from the circumference to the centre:

- Epidermis } Outer
- Cortex (including the endodermis) } cylinder
- Pericycle
- Vascular bundles } Inner cylinder/stele
- Pith and medullary rays

The epidermis is made up of closely packed rectangular cells. The cells are thickened on the outer walls by cutin, a waterproof material which forms an outer skin or cuticle. Stomata and lenticels are found between the epidermal cells. The cortex is made up of collenchymas and parenchyma. The collenchyma forms a strengthening hollow cylinder down the length of the stem. The innermost layer of the cortex is bound by the endodermis.

The pericycle, found just above the vascular bundles, is composed mainly of sclerenchyma (for strength). The vascular bundles are arranged in a ring within the pericycle. Each bundle is composed of phloem, cambium and xylem. The pith consists of thin-walled parenchyma, which extends between the vascular bundles as medullary rays.

A transverse section of a monocotyledonous stem shows an epidermis and a ground tissue with vascular bundles scattered in it. The vascular bundles are surrounded by sclerenchyma which forms hollow strengthening cylinders that run down the length of the stem. **Cortex, pith and cambium are absent.** The collenchyma, sclerenchyma and xylem are the main supporting tissues in the stem.

Assignment: Make well labelled diagrams of dicotyledonous stem and monocotyledonous stem

Note:

- Turgid parenchyma is an important supporting tissue in herbaceous stems. In woody stems, however, secondary xylem or wood is the main supporting tissue.
- Ground tissue includes all plant tissues, except the dermal and vascular tissues. Thus, the cortex, pith and medullary rays are part of the ground tissue. In monocotyledons, the cambium is absent in the vascular bundle.

Assignment: Briefly explain the roles of a leaf
Make a well labelled diagram of a leaf

Main Features of Supporting Tissues

Turgid parenchyma

Parenchyma is a tissue made up of living unspecialized plant cells that are roughly spherical in shape. A parenchymatous cell has a thin but fairly rigid cell wall composed mainly of cellulose, and a large vacuole containing cell sap. Cell sap is a concentrated solution and has a high osmotic pressure. Water enters the cell and passes into the vacuole by osmosis. The cell vacuole increases in volume causing the cytoplasm to press against the cell wall. The cell wall only expands slightly and resists the internal water pressure. This is known as **turgor pressure**. In herbaceous plants, turgid parenchyma provides the main support.

Collenchyma

This tissue consists of living cells that are thickened at the corners by the deposition of extra cellulose to provide support and mechanical strength. Collenchymas is an important supporting tissue in young plants, herbaceous plants, and plants or plant organs, such as leaves, in which secondary growth does not occur. In these plants, it supplements the strengthening effect of the turgid parenchyma. Collenchyma is usually found below the epidermis in stems and in the midrib of leaves.

Sclerenchyma

This tissue is composed of two types of cells fibres and sclereids. Both are dead cells in which the cell walls are heavily thickened with deposits of lignin, a hard substance that provide mechanical strength. (A dead cell has a cell wall enclosing a space or lumen instead of protoplasm). Sclerenchyma fibres are arranged in bundles in the outer regions of the cortex and pericycle of stems, and in vascular tissue. Sclereids or stone cells are heavily lignified cells and are scattered in the cortex, pith, phloem, fruit and seed coat.

Xylem

This is the water conducting tissue which also has a strengthening function, especially in plants that undergo secondary growth. Four types of cells make up the xylem tissue: tracheids, vessels, fibres and parenchyma. Of these, the first three are lignified and so provide mechanical support. In plants where secondary growth occurs, secondary xylem or wood takes over the mechanical function from sclerenchyma and collenchyma.

DIGESTIVE SYSTEM

Digestion

This is the breakdown of food into simple, soluble and diffusible substances by chemical and mechanical means. Animals have different types of alimentary tract which vary in size, mode of feeding or the type of diet. The major form of alimentary tracts have some evolutionary trend as complexity tends to increase from simple unicellular animals like the protozoa to the complex multi-cellular, animal like the mammals.

In most holozoic animals, digestion and absorption of food take place in the alimentary canal or gut. A simple unicellular animal does not have an alimentary canal. Digestion takes place inside the cell within a food vacuole. This is known as intracellular digestion. Digestion in the gut is said to be extracellular.

Alimentary Tract of Invertebrates

Planaria (Flatworm)

A planaria is a free living flatworm that feeds on small animals in the water (zooplankton). Planaria has a simple alimentary canal with one opening that is, the mouth on the ventral side of the flat body. The mouth opens into a short buccal cavity which leads into a large muscular pharynx. Digestion is partly extracellular and partly intracellular as in the case of hydra, the branched intestine enables the digested food to diffuse to all parts of the body while the undigested food is egested from the mouth.

Annelids (Earthworm)

The earthworm feeds on soil containing small organisms and dead organic matter. The alimentary canal is a tube that runs through the whole length of the body. It is a

tube with two-openings, the mouth through which the food enters and the anus through which undigested food leave the body. Soil is taken into the mouth which is in the first segment. The mouth leads into the buccal cavity from where it passes into the pharynx. This contracts and relaxes forcing the food through the oesophagus into the crop (a temporary store where food is moistened) then into the muscular gizzard where the food is grounded up. An earthworm feeds mainly on vegetable matter found in the soil that it swallows as it burrows. In the intestine, a long tube, digestion is completed and food is absorbed by the body of the organism. The unabsorbed material is passed out through the anus as a "worm cast"

Note: Food is moved through the alimentary system by the contraction of the body wall.

Grasshopper (Arthropod)

Grasshopper feeds on leaves of grasses and other plants. The alimentary canal is divided into three: the foregut, midgut and hindgut. The foregut begins with a mouth part for biting and grinding leaves. Salivary gland secretes saliva into the mouth. From the mouth, the food passes through the oesophagus into the crop, where it is held and softened before it goes into the gizzard for crushing. Digestion and absorption occur in the mid-gut. Water is absorbed in the hindgut. Faeces are stored for a time in the rectum and passed out through the anus.

Alimentary Tract of Vertebrates

Birds (Vertebrates)

Birds use their beaks for feeding. The beaks show adaptations according to the types of food the birds eat. The alimentary canal of the bird consists of the pharynx, oesophagus, crop, gizzard, intestine, anus and cloaca. Birds swallow their food whole and store it in the crop where it is softened by secretions from the walls of the crop. It then passes into the gizzard, a strong muscular bag. The muscles of the gizzard and the gastric juice churn and break up the food into small pieces. Small stones (which the bird swallow from time to time) in the gizzard also help to grind the food. Chemical digestion also begins here.

Digestion is completed in the small intestine by the action of the pancreatic juice and intestinal secretions. Absorption also takes place here. In the rectum, most of the water is reabsorbed. Solid waste is egested through the anus into the cloaca and out of the body. Body waste from the kidneys, and eggs and sperms also leave the body through the cloaca.

Assignment: Draw the alimentary tract of the bird

Rabbit

The teeth of herbivores are adapted for cropping grass and grinding plant matter to break down the cellulose cell walls. The incisors of a rabbit are long and chisel-shaped. They bite against each other to chop off pieces of grass. The incisors wear away fast but the teeth can grow continuously because of a good supply of blood into the pulp cavity. Hence, these teeth that grow continuously are known as open teeth.

There are no canines in herbivores. Instead, between the incisors and premolars there is a gap called diastema. The premolars and molars, which have broad and ridged surfaces, grind the food into fine particles.

Plant matter contains a lot of cellulose which has to be broken down to glucose before it can be made use of. Rabbits cannot make cellulose, the enzyme needed to digest cellulose. Instead, the rabbit has cellulase-producing bacteria in its gut. This is an example of a mutualistic (symbiotic) relationship. The bacteria are found in the caecum which lies between the small and large intestines.

One problem arises during the digestion of food in the rabbit. By the time cellulose digestion is completed, the contents would have moved past the small intestine where absorption can take place. The food is then passed out as soft, mucus-covered pellets. The rabbit quickly eats the pellets and the glucose they contain is absorbed in the small intestine. The intestine of the rabbit is quite long because the food needs a longer time to digest.

Assignment: Draw the alimentary tract of a rabbit

Differences between the Alimentary Canal of Insects and Birds

Alimentary canal of insect	**Alimentary canal of bird**
Tongue is absent	Tongue is present in the mouth
Mouth is modified into mandible and maxillae for chewing and grinding	Mouth is modified into beak
Duodenum is not	Duodenum is present

present	
It has relatively short alimentary canal	It has a long alimentary canal
Hind gut end in anus distinct from the reproductive tract	Hind gut ends in the cloaca

Malpighian tubules are present	Malpighian tubules are absent
Pancreas is absent	Pancreas is present

Alimentary Canal and Digestion of Food in Humans

The alimentary canal is a long tube stretching from the mouth to the anus. Most of it is coiled up in the abdominal cavity. It is divided into several regions: mouth, oesophagus, stomach, intestines. Each region plays a role in the digestion and/or absorption of food.

Site of digestion	**Secretion**	**Medium**	**Enzymes present**	**Digestion**
Mouth	Saliva	Alkaline	Ptyalin	Cooked starch → maltose
Stomach	Gastric juice	Acidic	(i) Rennin (ii) Pepsin	(i) Caseinogen → casein (coagulation of milk) (ii) Proteins → polypeptides
Duodenum (Small intestine)	Pancreatic juice	Alkaline	(i) Amylopsin/amylase (ii) Trypsin (iii) Lipase	(i) Starch → maltose (ii) Proteins → polypeptides (iii) Fats → carboxylic acid + glycerol
Ileum (Small intestine)	Intestinal juice	Alkaline	(i) Maltase (ii) Lactase (iii) Sucrase (iv) Erepsin (v) Lipase	(i) Maltose → glucose + glucose (ii) Lactose → glucose + galactose (iii) Sucrose → glucose + fructose (iv) Polypeptides → amino acids (v) Fats → carboxylic acid + glycerol

Alongside the table, note the following:

- In the mouth, the tongue mixes the food with saliva and rolls it into a ball or bolus.
- During swallowing, the epiglottis flaps down to cover the trachea and prevent food from entering.
- In the oesophagus, bands of muscles contract and relax alternately to push the bolus downwards. This process is called peristalsis. Sometimes food moves backward and this is called anti-peristalsis.
- At the entrance of the stomach is a ring of muscles called sphincter.
- All enzymes that act on proteins are called proteases. Examples are pepsin, trypsin and erepsin.
- The bolus turns to chime in the stomach and chyle in the duodenum.
- The three sections of the small intestine are duodenum, jejunum and ileum.
- Bile, produced by the liver and stored in the gall bladder, reduces the surface tension of fats and emulsifies them.

Absorptin of Digested Food

Glucose, amino acids, fatty or carboxylic acids and glycerol, as well as, vitamins and mineral salts are absorbed in the small intestine. The walls of small intestine are specially adapted to carry out this function.

For efficient absorption, a large surface area is necessary. The walls of the small intestine have folds and furrows which serve to increase its surface area. In addition, there are small finger-like projections called villi (singular: villus) which increase the surface area even more. The inner surface layer of each villus is thin; this allows the absorption of the end-products by either diffusion or active transport through it.

Undigested food passes into the colon (large intestine). Here, water is absorbed. This concentrates the waste products and makes them semi-solid. In this state, the waste products are called faeces. Faeces pass into the rectum and out of the body through the anus. If there is insufficient roughage in the diet, constipation will result. Constipation is difficulty in removing bowels.

Modification/Mechanism Of Feeding In Some Animals

There are four (4) mechanisms of feeding in animals which are:

- Absorbing Mechanism e.g. *Ascaris lumbricoides*, tapeworm
- Biting and Chewing Mechanism e.g. Insect
- Sucking Mechanism e.g. Mosquito
- Grinding Mechanism e.g. Human being

Absorbing Mechanism

The tapeworm (a flatworm) is an endoparasite which absorbs digested food from the animals. It carries out parasitic feeding on its own. The body of tapeworm is modified and adapted for parasitic feeding. The following are the adaptations of tapeworm to its feeding mechanism:

- The alimentary canal is absent. Hence, food is absorbed through the entire body
- The tapeworm has hooks and suckers which are used for attachment to the intestine of the host to avoid falling off.
- The flat body surface of tapeworm provides a large surface area for the absorption of already digested food.

Assignment: Draw the head section of the tapeworm

Biting and Chewing Mechanism

These insects, grasshoppers and cockroaches, have mouthparts adapted for biting and chewing. They have four different mouth parts which are modified and adapted for biting and chewing food. They are:

- The Labrum (upper lip): This mouth part prevents food from falling off the mouth.
- Mandibles: Insects have a pair of mandibles which are heavy tooth and jaw-like structure. Used for cutting and chewing food materials.
- Maxillae: Insects have a pair of maxillae which is also used for biting. It breaks down the food with the mandible.
- Labium (lower lip): It prevents wastage of food from the mouth.

Sucking Mechanism

There are three main organisms which exhibit sucking mechanism and they are mosquito, butterfly and housefly.

Mosquito: The mosquito possesses a piercing mouth part called the proboscis which is used for sucking the blood of man and animals. The mouth part altogether forms a strong stylet capable of penetrating the skin to suck blood. The stylet is sharp and pointed to ease the penetration into the skin. The mouth can produce saliva to prevent blood from clotting while it is being sucked in. It has the ability to fold back the labium easily so as to allow the stylet to perform its work of penetration of the skin to suck blood.

Butterfly: Butterfly feed on liquid food like nectars of flower. It has its mouth part modified into a long coiled proboscis for sucking nectar. It is capable of re-coiling the long proboscis under the head when it is not in use. There is no functioning of the other mouth parts due to the type of food taken by the insect.

Housefly: The housefly feeds on liquid food materials and has mouth part modified into the following

- Possession of a large labella which are sucking structures for liquid food
- Ability to feed on solid food and bring out their saliva to change the food into a liquid state.

Assignment: Draw the mouthpart of a grasshopper

Grinding Mechanism

This is common among mammals e.g. cattle, goat, man etc. These animals are capable of grinding the food before swallowing. This grinding habit is aided by hard and strong teeth made of enamel and dentine. The animals are adapted to the grinding mechanism by the following features.

- They possess different sets of teeth.
- The teeth are hard and strong to withstand biting, chewing and grinding.
- They have incisors which are sharp and flat and are used for cutting food.
- They have canine which are used for tearing food, premolars and molars which are used for grinding and chewing food.

Trapping Mechanism

This is common to insectivorous or carnivorous plants such as bladderwort and sundew. They have structures that enable them to adapt to this mode of feeding.

Sundew: This plant traps insect by undergoing a nastic movement in response to touch from the body of the insect. The sundew leaf has long hairs which carries digestive gland. Insects on landing on the hair, causes the hair to coil over the insect and cover it. The sundew is capable of secreting fluid rich in enzymes to digest the insect externally. The protein synthesized is easily absorbed by the carnivorous plant.

Feeding Habits

Animals exhibit different feeding habits. These habits include:

Filter Feeding

They are mainly aquatic animals and they wallow in water using a sieve-like structure which they use to collect reasonable quantity of their prey/food. Examples of filter feeders are mosquito larva, ducks and prawns.

Fluid Feeding

Fluid feeders are of two types: the wallowers and the Suckers

The Wallowers: These are organisms that wallow in their food. Example is tapeworm in the intestine of man. The tapeworm lives within the digested food of its host and absorbs the food directly into its body. They have no alimentary canal.

The Suckers: These are organisms that feed by sucking fluid from plants and animals. Examples are insects like butterfly, mosquitoes, aphid, bugs, tsetse fly and housefly.

Saprophytic Feeding

Saprophytes are organisms that feed on dead or decaying matter. E.g rhizopus, mucor, mushrooms. Their body is adapted to the feeding habit in the following ways:

- They have hyphae instead of root through which they pour out enzymes for digestion.
- They are capable of carrying out extracellular digestion.

Parasitic Feeding

This is found in both plants and animals. The animal parasites are tapeworms, roundworms, liver fluke, louse, tick, guinea worm etc. Plant parasites include cassytha, dodder plant, mistletoe etc. Parasites are structurally modified organisms that depend on other organisms wholly or partially for their food and survival.

Dentition

Dentition is the number and kinds of teeth and their arrangement in the lower and upper jawbones. There are two types of dentition namely: homodont and heterodont

Homodont Dentition: This is the dentition in which organisms have the same set and types of teeth. No set of teeth is specialized for a particular function. This can be found in fishes, amphibians and reptiles.

Heterodont Dentition: This is a type of dentition in which organisms possess teeth of different shapes, sizes and functions. This can be found in man, dog, cat etc.

Types of Teeth

There are two types of teeth in humans which are:

- Milk teeth: This is also called temporary and it is the first set of teeth that grows when the child is a few months old and ready to feed on solid food. It lasts for only a short time. There are 20 milk teeth
- Permanent teeth: This is the second set of teeth which grows after the milk teeth. There are 32 permanent teeth. The permanent teeth are made up of four different types of teeth; the incisors, canines, premolars and molars. In humans, the incisors are chisel-shaped and are used for biting off pieces of food. The canines have pointed tips and are used for tearing. The premolars and molars have broad surfaces for grinding food.

Dental Formula

Dental formula shows the number and types of teeth an animal has in one half of each jaw.

The dental formula for man is

$$I=\frac{2}{2} \quad C=\frac{1}{1} \quad P=\frac{2}{2} \quad M=\frac{3}{3} = 32$$

The dental formula for a dog is

$$I=\frac{3}{3} \quad C=\frac{1}{1} \quad P=\frac{4}{4} \quad M=\frac{2}{3} = 42$$

Dog is a carnivorous animal and it is adapted to the kind of food it eats. It uses its teeth for different functions:

- Incisors: - They are used for cutting small pieces of meat from bone.
- Canine: - They are long, large, curved and pointed. They are used to attack, defend, as well as, tear flesh from bone.
- Pre-molars and molars: - They have sharp edges. The largest ones are called carnassial teeth. They are used to cut off meat and tear it away from bones and they are also used for cracking bones.

The dental formula for rabbit is

$$I=\frac{2}{1} \quad C=\frac{0}{0} \quad P=\frac{3}{2} \quad M=\frac{3}{3} =28$$

The rabbit is an herbivorous animal and the teeth are adapted to the kind of food it eats.

Structure of a Tooth

All teeth have the same basic structure. The crown projects above the gums. The root lies embedded in the jawbone. The neck is the junction of the crown and root.

The centre of the tooth consists of pulp cavity which contains blood vessels and nerves which are extremely sensitive to heat and cold. Enclosing the pulp is a layer of dentine, a hard and bone-like material. The dentine contains some living cytoplasm. A hole at the tip of each root allows the blood vessels and nerves of the pulp to be connected to those of the bones and gums.

Covering the dentine is a white layer, the enamel. Enamel is the hardest material made by animals. It protects the pulp and dentine within. Enamel is not present in the root region. Instead, a thin layer of cement covers the dentine. The cement is, in turn, surrounded by the periodontal membrane which fixes the tooth to the jawbone. However, the tooth is not fixed rigidly to the jawbone but can move slightly during biting and chewing.

Assignment: Make a well labelled diagram of a human tooth

TRANSPORT SYSTEM

Animals need to take in food and oxygen from the external environment. Plants need to take in the raw materials necessary to carry out photosynthesis, as well as, mineral nutrients and oxygen from the external environment. Both plants and animals have to get rid of waste products from their bodies to the exterior. All these are brought about by an efficient transport system. The basic function of a transport system is to bring about rapid mass flow of materials, such as soluble food, excretory products and oxygen, throughout the body.

Need for Transport System in Organisms

- To obtain the materials such as water from the environment.
- For the removal of waste products of metabolism.
- To ensure the movement of digested foods to where they are required.
- To ensure the movement of gases around the body of an organism.

Surface Area to Volume Ratio

A simple unicellular organism, like the amoeba, carries out these material exchanges through its external body surfaces by diffusion. The surface area to volume ratio becomes a limiting factor as an organism increases in size. As the size of amoeba increases, the surface area to volume ratio decreases. So, beyond a particular size, the external body surface of amoeba cannot cope with its material exchange requirements. When this happens, the amoeba stops growing and divides into two.

In complex multicellular organisms such as rats, elephants, cow etc., diffusion alone is not enough to take gases or other materials from the environment to all the cells in their body or to take excretory products from all living cells out of the body. This is because they have small surface area to volume ratio and the distance through which diffusion has to operate is too great or thick for diffusion to be effective. Therefore, they require specialized transport system.

Materials Transported in Organisms

- Glucose
- Oxygen
- Amino acids
- Urea
- Fatty acids and glycerol
- Carbon dioxide
- Hormones
- Water
- Mineral salts
- Vitamins

Transport in Animals

Simple multicellular animals do not have transport systems. Such animals are small and have a large surface area to volume ratio, so diffusion is sufficient to meet their needs. Other animals have a mass flow system to bring about transport and distribution of materials.

All materials are transported within an animal in the form of an aqueous solution. Transport media are therefore, fluids. In simple animals, cytoplasm and water act as transport media. In most animals, however, blood is the main medium of transport. Intercellular fluid and lymph are part of blood and play an important role in the transport of materials to the individual body cells.

Features of a Transport System

In most animals, a transport system, also called circulatory system, usually has three features which are:

- A circulating fluid, which is usually blood
- A pumping device or heart
- A system of branched vessels connected to the heart.

Types of Circulatory Systems

In animals, there are two types of circulatory systems: the open and the closed circulatory systems

- Open Circulatory System: Here, the heart pumps blood out into a blood vessel which branches and opens into spaces in the body cavity called haemocoel. This can be found in insects and molluscs.
- Closed Circulatory System: Here, blood is contained in closed vessels as it can be found in higher animals. Blood vessels leading away from the heart are called arteries. These divide into smaller vessels called arterioles which form fine vessels called capillaries. Capillaries are found in between all body cells. Exchange of materials between the cells and the capillaries occur through the walls of the vessels and cell membranes by diffusion. Capillaries unite to form venules which join to form veins, the blood vessels that transport blood back to the heart. The blood leaving the heart is at high pressure while that returning to the heart is at low pressure.

Circulation in Vertebrates

All vertebrates have closed circulatory systems. The closed circulatory system shows distinct modification as the vertebrates evolved from fishes to mammals. Hence, the closed circulatory system can be classified into: single circulation and double circulation.

- Single Circulation: This is a type of circulation in which blood only passes through the heart once every time it makes a complete circuit through the body. In a fish, the heart chamber is divided into two main chambers – an atrium and a ventricle. Blood from the body enters the atrium, passes into the ventricle and out of the heart via the aorta to the gills for oxygenation. From the gills, the blood is taken to different parts of the body of the fish.
- Double Circulation: This is the type of circulation where blood passes through the heart twice before it completes one circuit through the body. Amphibians, reptiles, aves and mammals exhibit this kind of circulation. Deoxygenated blood is pumped from the heart to the lungs where gaseous exchange occurs. Oxygenated blood from the lungs is returned to the heart, from where it is pumped to the other organs and tissues of the body. The blood circulation from the heart to the lungs and back to the heart is called **pulmonary circulation**. The circulation from the heart to all other parts of the body and back to the heart is called **systemic circulation**.

  In the frog, since the ventricle is not divided, there is tendency for both oxygenated and deoxygenated blood to become mixed. However, there are ridges and valves which keep the oxygenated and deoxygenated blood separate. The frog is said to exhibit a **partial double circulation** since the oxygenated and deoxygenated blood are not completely separated as in mammals.

Transport in Mammals

Mammals have a rapid and efficient transport system.

Components and Structure of Blood

An average adult has about 5.5 litres of blood. There are two components of blood which are:

- Blood Plasma
- Blood Cells/Corpuscles.

Blood Plasma

This is a pale yellow liquid made up mainly of water. It constitutes about 55% of the blood and many substances are dissolved in it including plasma proteins, antibodies, hormones, enzymes, gases, salts, digested food materials and waste materials. The main function of the blood plasma is to transport the substances that are dissolved in it, as well as, the cells that float in it.

Blood Cells

There are three components of blood cells namely:

- Red blood cells (erythrocytes)
- White blood cells (leucocytes)
- Platelets (thrombocytes)

Red Blood Cells

- The red blood cells are also known as erythrocytes.
- They are flat and circular with a depression on each side
- They have no nucleus.
- They appear to be yellow when viewed singly but dark red when they are viewed together.

- The red colour is due to the presence of haemoglobin which readily combines with oxygen to form oxyhaemoglobin.
- Haemoglobin is broken down to bilirubin and ferritin.
- They have a life span of 120 days and are formed in the marrow of bones.
- Main function is to transport oxygen from the lungs to the body cells

Note: Adaptation of red blood cells:

- Its shape gives a high surface area to volume ratio enabling it to absorb large amounts of oxygen
- It contains a pigment which has a high affinity for oxygen

White blood Cells

- They are fewer in number compared to the red blood cells but larger in size.
- They possess nucleus
- They are produced in some lymph nodes and in bone marrow
- They last just for a few days
- Main function is to help defend the body against diseases.

Assignment: In a tabular form, state five differences between red blood cells and white blood cells

Platelets

- These are very tiny, irregular cell fragments
- They are non-nucleated
- They are formed in large bone marrow cells
- Main function is to initiate blood clotting process

Functions of Blood

- Transport of oxygen
- Transport of carbon dioxide
- Transport of urea
- Transport of digested food
- Transport of hormones
- Transport of waste materials
- Heat distribution
- Aid blood clotting
- Defend the body against diseases

The Heart

The human heart is a conical, hollow, muscular organ which works continuously throughout the life of a person. It lies in the chest just behind the breastbone and between the two lungs. It is enveloped in a two-layered tough membranous bag called pericardium. The space between the two-layers is filled with fluid. This reduces the friction, caused by the pumping movements of the heart, between the heart wall and the surrounding tissues.

When at rest, the average human heart beats about 70 times per minute and pumps about 14000 litres of blood a day. During exercise, this rate goes up to over 100, thereby increasing the supply of oxygen and food to the body cells. To carry out such hard work, the wall of the heart is made up of a special muscle, the cardiac muscle, found only in the heart.

Structure of the Heart

The heart has four chambers: two upper thin-walled auricles and two lower thick-walled ventricles. The right side of the heart is completely separated from the left side by a wall called the septum. Two large veins, the superior (anterior) and inferior (posterior) vena cavae, bringing dark red, deoxygenated blood from the various parts of the body (except the lungs), open into the right auricle. The pulmonary veins bringing bright red, oxygenated blood from the lungs open into the left auricle.

The right auricle opens into the right ventricle. This opening is guarded by the tricuspid valve. This valve has three flaps which are attached by cord-like tendons (chordae tendinae) to the walls of the right ventricle. The valves only allow movement of blood from the auricle to the ventricle. The opening of the left auricle into the left ventricle is guarded by the bicuspid valve. This valve has two flaps.

The right ventricle opens out into the pulmonary artery, which branches into two, one leading to the right lung and the other to the left lung. These carry deoxygenated blood to the lungs. The left ventricle opens into the large aorta which branches to distribute oxygenated blood to all parts of the body except the lungs. Semi-lunar valves in these arteries prevent backflow of blood from the arteries into the ventricles.

The wall of the left ventricle is at least three times thicker than that of the right ventricle. This is because the contraction of the left ventricle must send the blood round the much longer systemic circulation. Thus, blood entering the aorta is of a very high pressure.

Assignment: Draw the mammalian heart

Heartbeat

The two sides of the heart work together. The relaxed or resting period of the heart chambers, especially the ventricles, is known as **diastole**. The period when the chambers, especially the ventricles, contract is known as **systole**. Thus, one complete heartbeat consists of one contraction (systole) and one relaxation (diastole) of the ventricles, and lasts for about 0.8 second.

Arteries, Veins and Capillaries

Artery	Capillary	Vein
Carries blood away from the heart	Links arterioles and venules	Carries blood to the heart
Thick, muscular, elastic wall	One-cell thick wall	Fairly thick, slightly elastic wall
Blood is at high pressure and flows rapidly	Blood pressure is higher at arteriole end than at venule end of capillary network; flows smoothly	Blood pressure is low and flows slowly and smoothly
Valves absent (except semi-lunar valves)	Valves absent	Valves present
Blood is oxygenated (except that in the pulmonary arteries)	Blood is oxygenated at arteriole end and deoxygenated at venule end (except that in the lung capillaries)	Blood is deoxygenated (except that in the pulmonary veins)

Transport in Plants

The major materials transported within plants are the gases, carbon dioxide and oxygen, water, mineral salts, manufactured food and essential chemicals such as hormones and pigments.

Plant saps, cell saps and cytoplasm are the main transport media. Plant saps are the fluids in the vascular tissues and latex tubes. The cell sap helps in the uptake of water from the soil by the root hairs and its transport to the vascular tissues in the root.

Vascular Tissues

In higher plants, mass flow of food and water occurs within vascular tissues to all parts of the plant. This movement of substances is known as **translocation**. There are two main vascular tissues: xylem and phloem. Xylem conducts water and mineral salts from the roots to the leaves and the rest of the plants. Phloem conducts manufactured food from the leaves to the rest of the plant for assimilation and storage (in the case of excess food).

Gases enter and leave the plant through openings called stomata (singular: stoma) on leaves, and lenticels on stems and roots.

Absorption of Water and Mineral Salts

Root hairs absorb water from the soil by osmosis. The cell sap of the root hair cell is a solution of higher concentration than the soil solution. The cell membrane of the root hair acts as a selectively permeable membrane. So water enters the sap of the root hair cell from the soil.

Plants also absorb mineral salts through root hairs. The concentration of ions in the cell sap of the root cells is high, while that in the soil solution is low. Here, simple diffusion cannot explain the uptake of mineral ions into the root cells. Active transport is involved. The energy needed in this process is obtained by the oxidative breakdown of glucose in the root cells.

Transport of Water in the Xylem Tissue

Transport of water in xylem tissue is due to:

- Root pressure
- Capillary action
- Transpiration pull

Root pressure is the force that helps to drive fluids upward into the water-conducting vessels (xylem). It is primarily generated by osmotic pressure in the cells of the roots and can be demonstrated by exudation of fluid when the stem is cut off just aboveground. Capillary action is the process that plants use to pull water up from the ground. Transpiration pull is a passive process that functions without any energy input from the plant. However, it is a critical process and it is the strongest force that pulls and transports water to the leaves of all plants.

Assignment: Describe an experiment to show that the xylem tissue conducts water upwards from the roots.