CELL SPECIALIZATION IN MULTICELLULAR ORGANISMS

A multicellular organism is one whose body is made up of more than one cell. However these organisms develop from a single cell by sexual reproduction or as part of another organism by asexual reproduction.

Advantages of being multicellular

- It allows an organism to exceed the size limits normally imposed by diffusion. Single cells with increased size have decreased surface to volume ratio and hence difficulty absorbing sufficient nutrients and transporting them throughout the cells. Multicellular organism therefore have a competitive advantage of increase in size without its limitations.
- Multicellularity also permits increasing complexity by allowing differentiation of cell types within one organism.
- Multicellular organisms have a longer lifespan as they can continue living when individual cells die.
- Worn out cells are easily replaced by cell division.
- It allows tissue specialization which increases efficiency in performing body functions.

Disadvantages of being multicellular

- More energy/food is needed for normal functioning since multicellular organisms require more energy to feed multiple cells.
- The increased energy consumption also leads to an increase of waste created. This waste can at times be difficult to eliminate and can cause toxicity to the organism.
- When an organism requires much food to function correctly it will need to expend further energy in the search for food sources.
- Infection becomes a possibility when multicellular. Infection becomes impossible as a single celled organism since there is nothing smaller to cause infection. For multicellular organism, infection becomes a real risk from unicellular organisms that take advantage of larger organisms.
- Takes longer to reach maturity and to breed.
- If one cell group fails, they can all fail because they rely on each other to perform certain tasks to help with survival.
- They require specialized locomotory structures to enable motion.

In multicellular organisms, the cells undergo division producing a number of cells whose functions may vary depending on the need of the organism. This is called cell specialization.

Examples of specialized cells in plants:

- Parenchyma cells
- Collenchyma cells
- Sclerenchyma cells
- Epidermal cells
- Palisade cells
- Meristematic cells

Examples of specialized cells in animals:

- Red and white blood cells
- Osteoblasts and Chondroblasts
- Epithelial cells
- Muscle cells
- Nerve cells
- Egg cells and sperm cells.

The cells above and others do come together to perform specialized functions which sustain the life of an organism. This constitutes cell organization as:

Cell ⇨ Tissue ⇨ Organ ⇨ Organ system ⇨ Organism

A **tissue** is a group of physically linked cells and their associated intercellular substances which are specialized to carry out a specific function(s).

Examples of tissues in animals:

- Epithelial tissues.
- Connective tissues i.e. adipose tissues and blood.
- Support tissues i.e. bone and cartilage.
- Muscle tissues and nerve tissues.

Plant tissues:

- Meristematic tissues
- Epidermis tissues.
- Vascular tissues.
- Photosynthesis tissues and support tissues.

An **organ** is a collection of tissues working together as a functional unit e.g. nose, eye, skin and heart.

An **organ system** is a collection of organs and associated tissues working together as a functional unit. E.g. digestive system, respiratory system, circulatory system, etc.

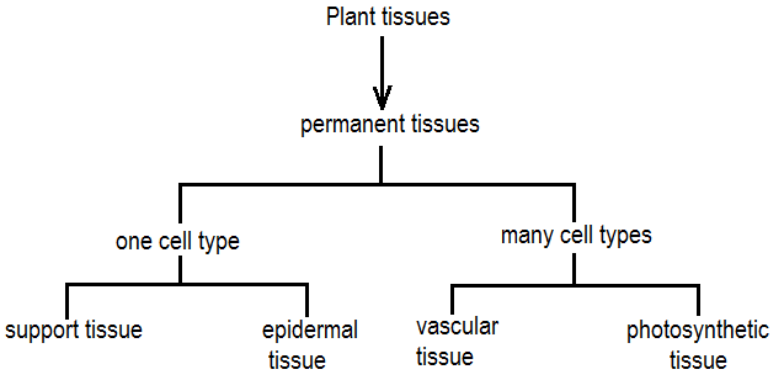
PLANT TISSUES

The type of tissues in plants varies depending on the age of the plant and the cell types that make up the tissue.

Depending on age, the plant tissues are grouped into two i.e.

i) **Temporary tissues (meristematic tissues):** These exist at the time of germination and they are replaced by other tissues in woody plants only. The remaining are the growing points of the shoot and root.
ii) **Permanent tissues:** These replace the temporary tissues in all non-herbaceous plants.

The tissues may be made up of one cell types or many cell types as shown below:



Plant tissues consisting of one type of cells

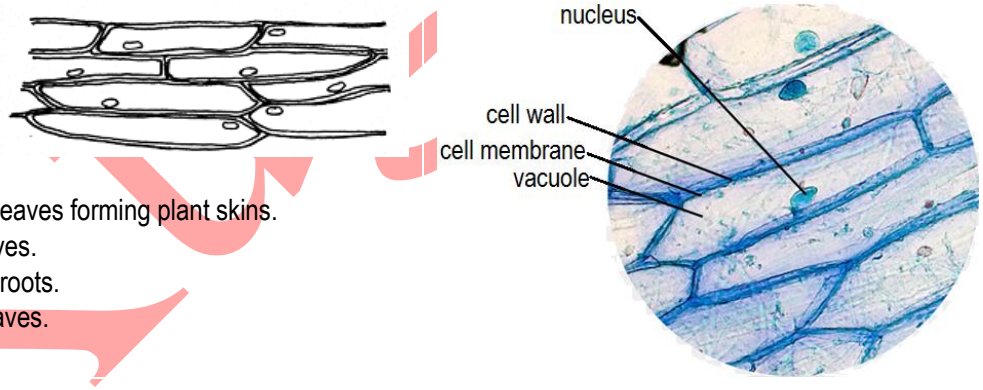
1) Epidermal tissue:

The epidermis forms the outermost layer of the primary plant body like young stems, roots, leaves and flowers. In roots, the outermost layer is called **piliferous layer**.

Characteristics:

- Cells are flattened and one cell thick.
- Cells are irregular in shape without intercellular spaces.
- The cells have no chloroplasts with exception to guard cells.
- The outer cellulose cell wall may be coated with a thick layer of cuticle.
- They may bear unicellular or multicellular hair.

Epidermal tissue/cells as seen in a light microscope



Location:

- In young stems and leaves forming plant skins.
- As guard cells in leaves.
- As piliferous layer in roots.
- The outer layer of leaves.

Functions:

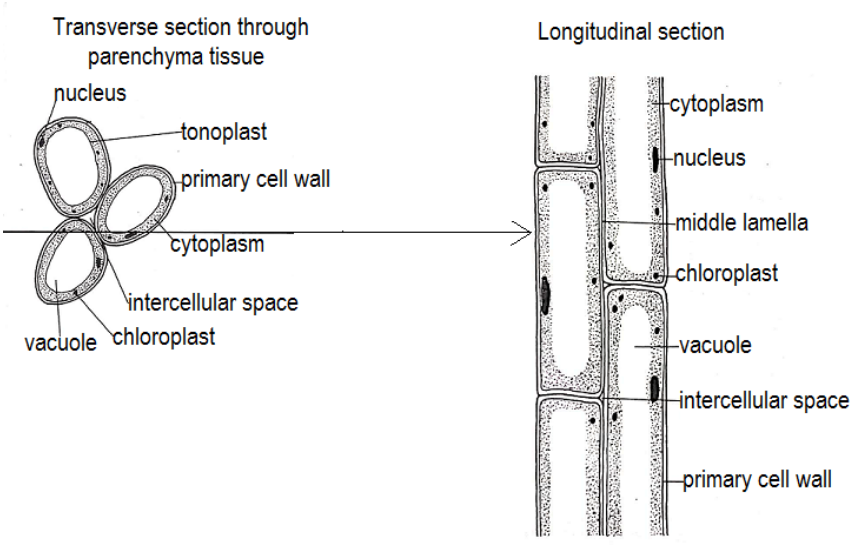
- The epidermis acts as a protective layer covering the plant body.
- The cuticle reduces excessive loss of water by evaporation from the plant body.
- The stomata allow exchange of gases and transpiration.
- It protects the plant from excessive heat or cold and from attack of parasitic fungi and bacteria.
- The piliferous layer forms the root hairs important in the absorption of water and mineral salts from the soil. It has no cuticle.

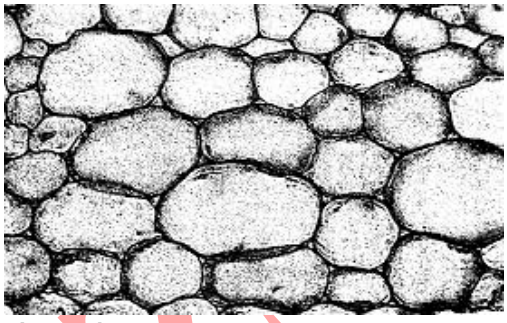
2) Support tissues (ground tissues):

These are parenchyma tissue, collenchyma tissue and sclerenchyma tissue.

Parenchyma tissue

It is the most common plant tissue made up of unspecialized cells which act as storage tissue between specialized tissues. It is the main tissue in young stems of herbaceous plants.





Characteristics and structure of the parenchyma tissue

- Cells are spherical in shape.
- They have thin transparent cell walls and large vacuole and therefore the cells can easily change their turgidity as a result of the osmotic uptake of water.
- Among the cells are large intercellular spaces.
- In aquatic plants they are modified as **aerenchyma**. They are star shaped and have a number of air cavities in between.

Location:

- They form the packing tissues between more specialized tissues such as pith, cortex and medullary rays.
- They are also found in the periphery of stems, roots and leaves.
- They are found in all soft parts which appear fleshy.

Functions of the parenchyma tissue

- They fill spaces between other tissues and hence acting as packing tissues.
- They offer support when they become fully turgid as a result of osmotic uptake of water especially in herbaceous plants.
- They are metabolically active carrying out biochemical reactions of plants like photosynthesis.
- Some may have air spaces between them to allow gaseous exchange.
- Food storage like the parenchyma cells of potato tubers.
- Their cell walls allow water transport by Apoplast pathways.
- Mesophyll cells are sites of photosynthesis.

Adaptations of parenchyma tissues to its functions

- Have unspecialized cells to carry out a variety of functions.
- Have many intercellular spaces to allow gaseous exchange/diffusion.
- Have thin cellulose cell walls to allow passage of materials.
- Have transparent cell wall to allow easy entry of light for photosynthesis.
- Large cells with large vacuoles for storage of food.
- Cells are closely packaged to provide support when they become fully turgid because of osmotic uptake of water.

Modifications of parenchyma tissues

The tissues may become specialized in certain parts. In such parts, they are modified to suit their functions. The modified forms include mesophyll, cortex and pericycle.

i) Mesophyll tissue:

This is made up of spherical, irregular or columnar cells. Their cell walls contains cellulose, pectin and hemicellulose.

Function:

- It facilitates gaseous exchange. This is aided by the large intercellular spaces which exist between the cells especially in the spongy mesophyll layer.
- It carries out photosynthesis. This is because they contain chloroplasts with chlorophyll. This type of parenchyma is called **chlorenchyma** due to the chloroplasts in their cytoplasm.

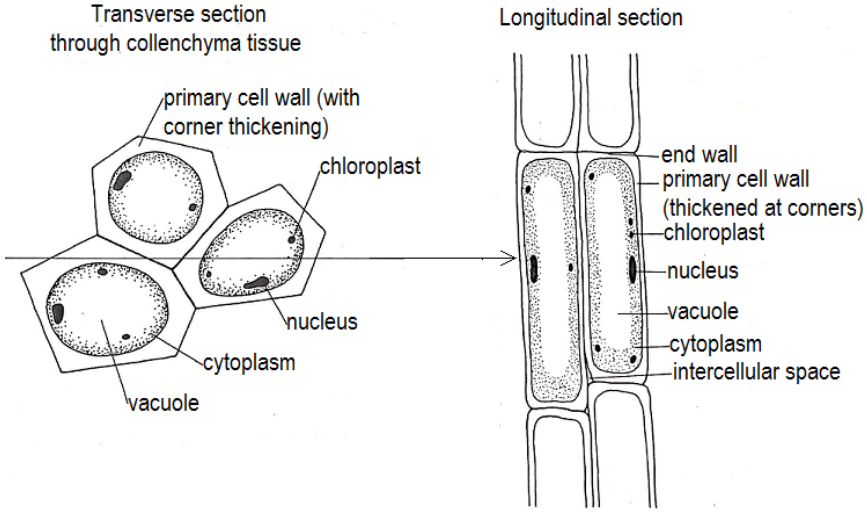
ii) Pericycle:
This is a living tissue which forms parts of the plant body. It is made up of polygonal cells in the outline. Sometimes the cells are spherical or elongated with cell walls containing pectin and hemicellulose.
Location: It is found in roots and stems between vascular tissues and endodermis.
Function: produce lateral roots and help in secondary growth. It is strong enough to provide tensile strength to the roots.

iii) Endodermis:
This is made up of parenchyma cells forming a selective barrier to movement of water and mineral salts between cortex and xylem.

Functions:
- The endodermal cell walls in the roots have **casparian strip** made of suberin which prevents movement of water along the cell walls of the cells by the Apoplast pathway.
- In the roots, the epidermal cells generate root pressure when they actively secrete salts into the xylem tissue creating a low water potential in the xylem. This draws water into the xylem by osmosis which causes a pressure in the roots that pushes water up the xylem.
- In the stems of dicots, the endodermis surrounds the vascular bundles and stores starch.

Adaptations of the endodermal cells to their function
- Cells have an impermeable strip of suberin the casparian strip which controls the passage of water into the xylem.
- In-folding of the cell wall which increases surface area of the cell membrane for transfer of solutes.
- Numerous mitochondria to provide energy for active transport.
- Numerous starch grains in endodermal cells which act as energy source.

Collenchyma tissue
It consists of living cells with the following characteristics:
- Cells are elongated, parallel to the longitudinal axis of the organ where they occur and appear polygonal in the transverse section.
- Cells have thick cellulose cell walls.
- The corners of the cells are thickened with extra cellulose.
- They have large vacuoles and little cytoplasm.



Location:
- In the cortex of the stems and roots.
- In the petiole and midribs of leaves.

Functions:
- Provides mechanical support to the organs on which they are located.
- It is the main supporting tissue in young stems and organs such as fruits and leaves and stems of herbaceous plants.

Sclerenchyma tissue
When mature, this tissue consists of dead cells. The tissue has cells with highly lignified cell walls and because of this, the tissue has a high tensile strength able to stretch without breaking.
As lignification continues in the cellulose cell wall, small pits are formed. There are areas of plasmadesmata. At maturity (when dead) these cells lose their living content.

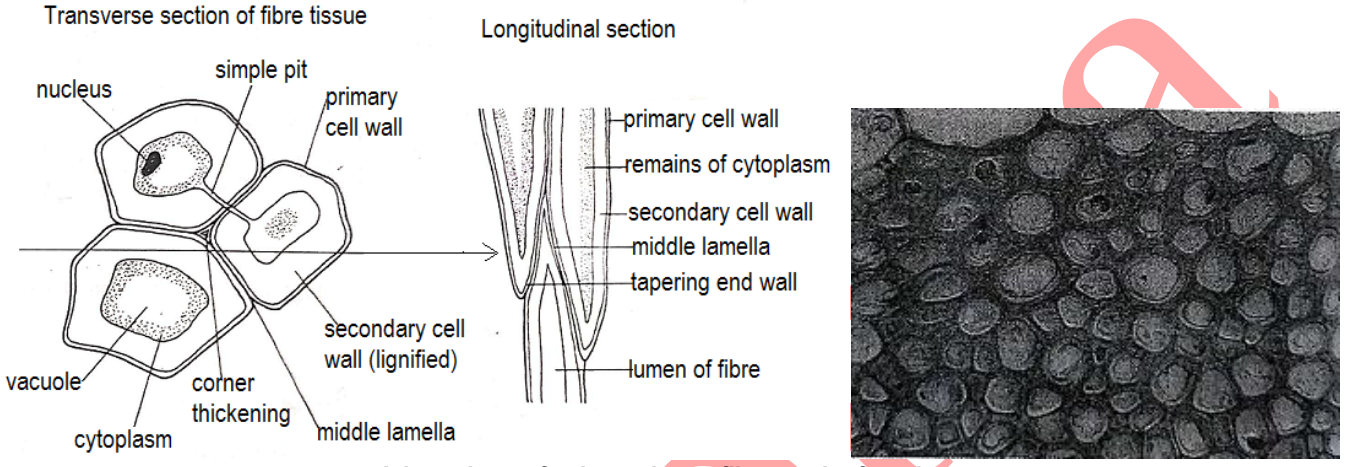
Types of sclerenchyma tissues

1) **Fibres:** This is made up of elongated polygonal cells with:
   - Their cell wall is deposited with lignin in addition to pectin, hemicellulose and cellulose.
   - The cells are densely packed without air spaces within them.
   - The cell walls of these cells have some parts without lignin forming pits. This allows movement of materials from one cell to another.

Location:

They are located in the xylem, phloem and pericycle.

They are also found in the outer region of the cortex and the epidermis of especially fibrous plants.



Adaptations of sclerenchyma fibres to its functions

- Cells have highly lignified thick walls to provide enough resistance to forces of the environment.
- Cells are dead and therefore take no extra metabolic demand on the plant.
- Fibres are elongated and arranged in sheets/strands to increase strength.
- Fibres are interlocked to enhance their combined strength.

2) **Sclereids (stone cells):**

These are dead cells irregular in shape.

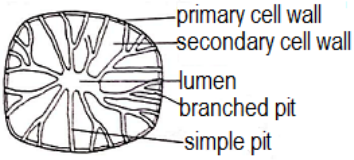
Their cell walls are highly lignified.

They have a narrow lumen and simple branched pits.

Location:

- In the cortex, phloem of woody plants.
- Endocarps of seeds like coconut.
- Shells of nuts.
- Stones of fruits.
- Flesh of fruits like guava and pea.

A sclereid tissue



Functions:

- Provide support, firmness and hardness where they occur.
- Responsible for grittiness when the fruit is eaten.

Differences between fibres and sclereids

Fibres	Sclereids
Cells are elongated and polygonal.	Cells are broad/isodiametric (roughly spherical).
The pits are narrow and unbranched.	The pits are deep and branched.
Have tapering interlocking ends.	Have blunt broad ends.

Differences between collenchyma and sclerenchyma tissues

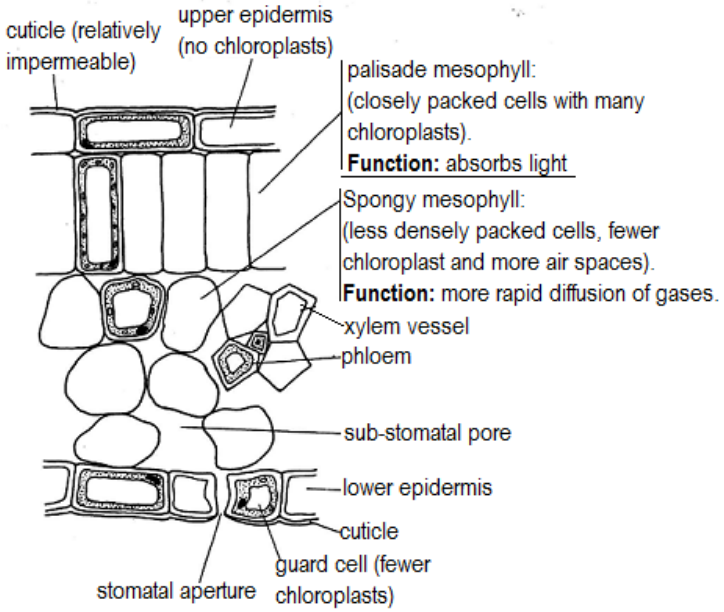
Collenchyma	Sclerenchyma
Consists of living cells	Consists of dead cells.
Cell wall thickened with cellulose.	Thickened with lignin.
Cell wall thickening is non-uniform.	Thickening is uniform.
Contain chloroplasts.	Don't contain chloroplasts.
It has no pores.	Has pores.
It has a wide cell cavity.	Cell cavity is narrow.

Plant tissues consisting of more than one type of cells

1) Photosynthetic tissues:

This has specialized cells for photosynthesis.
The cells have a lot of chloroplasts which store chlorophyll.
It occurs in the **palisade** and **spongy mesophyll** layers of the leaf.

Structure of a leaf showing the photosynthetic tissue



2) Vascular tissues:

These are tissues responsible for transport and translocation of materials from one part of the plant to another. They consist of the **xylem** and **phloem** tissues.

Xylem tissue

Structure:

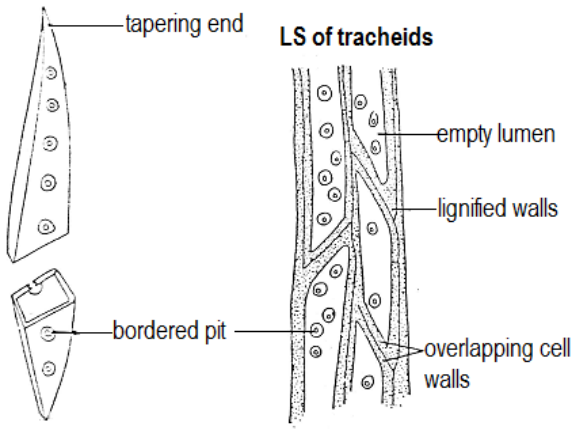
Xylem is made up of ***tracheids, xylem vessels, parenchyma cells*** and ***fibres***.
The cell walls of these tissues have lignin and bordered pits. Xylem tissue is commonly called wood.
Function: Primary function is to transport water and mineral salts from roots to leaves.

a) Tracheids:

These consist of dead cells which are elongated and tubular.
They have hard, thick and lignified cell walls.
The cell walls also contain lignin, cellulose, hemicellulose and pectin.
The single cells have tapering end walls that overlap with adjacent tracheids.
The walls usually have one or more rows of bordered pits.

Location and distribution: They are predominant in lower vascular plants of ferns and gymnosperms.

Structure of tracheid



Functions:

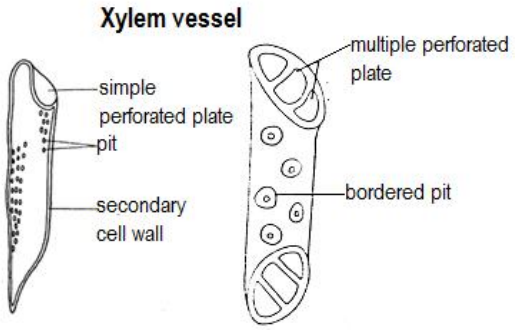
- They form primitive water conducting tissues of gymnosperms and ferns.
- They provide mechanical support.

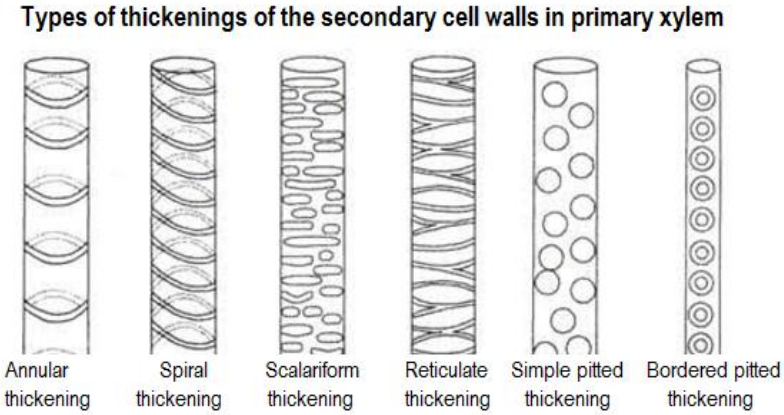
Adaptations:

- Tracheids have tapering end that interlock with the neighboring tracheids for firm support.
- They have empty lumens without any living tissues which allows smooth flow of water without any obstruction.
- They have pits through which water and mineral salts pass from one tracheid to another.

b) Xylem vessels:

These are made up of elongated cylindrical cells called xylem elements placed end to end.
The end walls of the vessel elements break down during development so that a continuous tube is made for flow of water.
The walls are impregnated with lignin for support with bordered pits.
The end wall may have a single opening called a **simple perforation plate** or many openings called **multiple perforation plate**.
The thickenings on the vessels could be ***annular, spiral, scalariform, reticulate or pitted*** forms.
Thickening/lignification gives the vessels additional strength and prevents the walls from curving in.





Formation and development of a xylem vessel element

The cells of the procambium strand divide by mitosis. The cell formed elongates/enlarges and the vacuoles appear in the cytoplasm. The horizontal end walls between adjacent cells breakdown/disintegrate forming perforation which is continuous with that of adjacent cells. A secondary wall is formed by addition of extra cellulose and lignin. Lignification causes the protoplasmic contents die leaving a hollow tube known as a vessel. The lignified walls are perforated with pits where lignin fails to be deposited.

Functions of xylem vessels

- They conduct water and dissolved mineral salts in angiosperms.
- They provide mechanical support to the plant due to their being lignified.

Adaptation of the xylem tissues for transport of water and mineral salts

- Tracheids and xylem vessels are placed end to end, the end wall of the vessel elements breakdown during development so that a continuous tube is made for flow of water.
- The walls are impregnated with lignin for support which increase adhesive force for upward movement of water.
- A xylem vessel is hollow allowing water to move freely without any obstruction.
- The side walls of the vessels and tracheids are perforated (has pits) to allow water and salts to move sideways between cells.
- The tracheids have elongated, tapering (sloping) end walls containing cellulose-lined pits that allow water to pass from one cell to another.
- Narrow lumen of tracheids and vessels enhances the upward movement of water by capillarity.

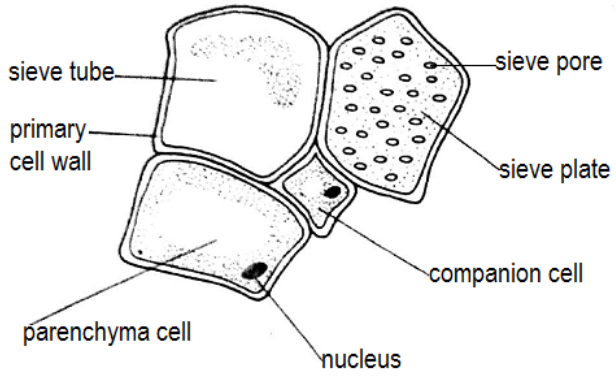
Differences between tracheids and vessels

Tracheids	Vessels
Single elongated cells	It is formed by fusion of several cells with dissolution of end walls.
Very short	Are medium in length.
End walls are not perforated and water moves through bordered pits on the walls	End walls may have one or several openings/perforations.
They are the only cells present in lower plants and predominant in gymnosperms for transportation of water and mineral salts.	Are predominant in angiosperms for transportation of water and mineral salts.
They have a narrow lumen.	They have a wider lumen.

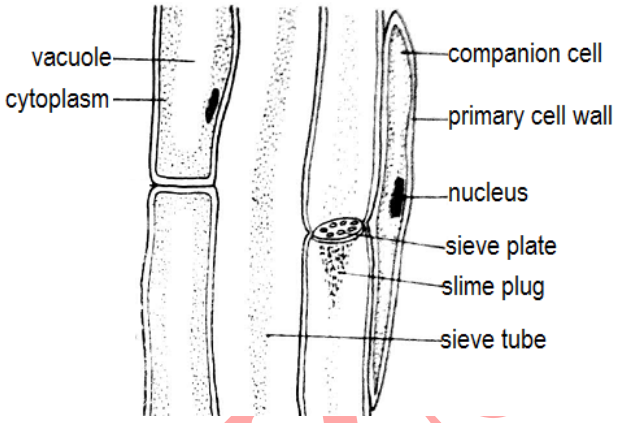
Phloem tissue

It is made up of three types of cells; **sieve tube elements**, **companion cells** and **phloem parenchyma** (in dicots only).

Transverse section of phloem tissue



Longitudinal section



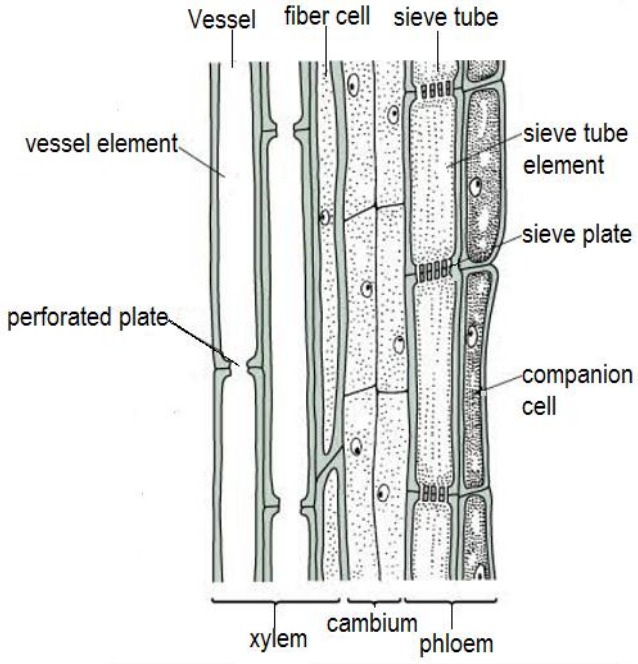
a) Sieve tubes:

These are made up of tubular and elongated cells called sieve tube elements.
They have thin walls made of pectin, cellulose and hemicellulose.
They are formed by fusion of cells called sieve tube elements which lie to one another end to end.
The cells lack a nucleus when mature. However they are living cells even at maturity.
When mature, they remain with very little cytoplasm in form of strands called cytoplasmic strands.
At the end walls, there exist pores which connect adjacent cells. The perforated end walls form one sieve element to the next.
Function: Translocation of organic solutes e.g. sucrose, amino acids and other organic substances like growth hormones.

b) Companion cells

These cells are living cells found adjacent to the sieve tubes connected by simple pits.
They contain dense cytoplasm and have a prominent nucleus.
They contain numerous mitochondria for provision of energy to enable the process of translocation.
They are connected to sieve tubes by simple pits and are present in angiosperms only.
Function:
They are metabolically active and they therefore provide the sieve tube elements with the necessary energy for translocation of organic solutes.

The relationship between xylem tissue and phloem tissue



Comparison between xylem and phloem tissues

Similarities:

- Both have perforated cells.
- Both are surrounded by parenchyma cells.
- Both are conducting tissues.
- Both have cells that lack a nucleus.

Differences:

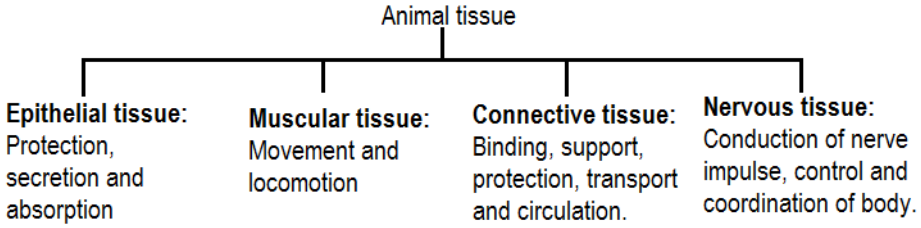
Xylem	Phloem
Has dead cells.	Has living cells
Made up of xylem vessels, tracheids, fibres and parenchyma cells.	Made up sieve tube elements, companion cells, parenchyma cells and fibres.
Have lignified walls	Walls made of cellulose.
They transport water and mineral salts.	For translocation of organic solutes.

Assignment:

1. *What is a tissue?*
2. *Make a labelled drawing of a living parenchyma cell of a plant.*
3. *How do the following structures differ from a parenchyma cell?*
   i) The leaf epidermal cell.
   ii) Apical meristem
   iii) Xylem tracheid
4. *How are the parenchyma cells adapted to their functions?*
5. *Describe structural adaptations of vascular tissues for support.*

ANIMAL TISSUES

There are 4 major groups of animal tissues i.e. epithelial tissue, connective tissue, muscular tissue and nervous tissue.



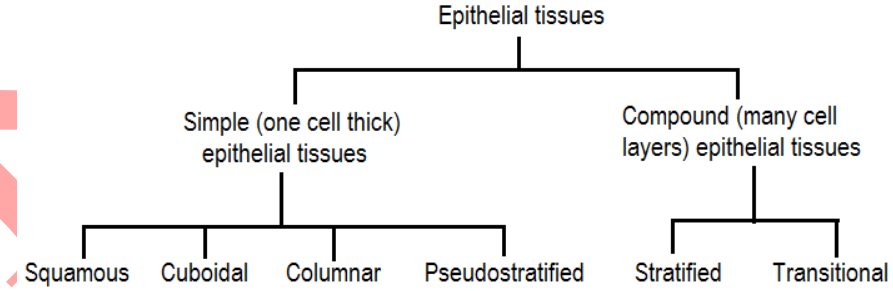
EPITHELIAL TISSUES

Epithelial tissues consist of a single or many layers of closely packed cells specialized to form the covering of external body surface or lining of inner body cavities.
Epithelial tissues cover tissues subject to mechanical damage.

General structure of epithelial tissues

The cells are closely packed and firmly attached to each other. They lack intercellular space.
Adjacent cells joined together by intercellular cement.
The bottom layer of epithelial cells rests on a basement membrane composed of a network of collagenous fibres. The basement membrane provides structural support for the epithelium and also binds it to the neighboring structures and serves as scaffolding/board upon which new cells attach during healing of injured epithelia.
The free surfaces may be modified into cilia and microvilli.
There are no blood vessels in epithelial tissues. However nerve ending may occur in the epithelium.
Epithelial tissues have a high regeneration capacity due to rapid cell division. This helps epithelial tissue to recover fast after any injury or abrasion.

Summary of epithelial tissues



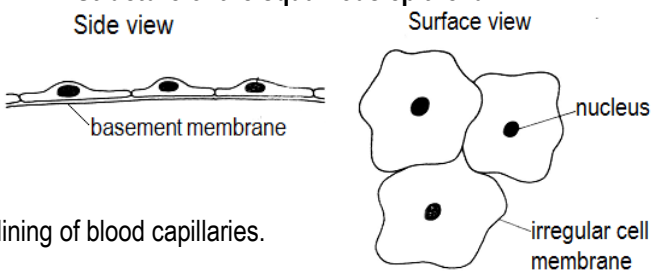
SIMPLE EPITHELIAL TISSUES

Simple epithelial tissue consists of a single layer of cells. All the cells rest on basement membrane. They include the following types:

1. Squamous epithelium (pavement epithelial):

Cells form a single layer attached to a basement membrane. In surface view, the cell outlines are irregular and closely packed. The cells are thin, shallow and flattened.
Adjacent cells may be joined by strands of cytoplasm.

Structure of the squamous epithelium



Location:
- Alveolar lining of the lungs.
- Inner lining of blood vessels and lining of blood capillaries.
- Bowman's capsule of kidney.

Functions:
- Diffusion of materials and gaseous exchange across the membrane.
- Provides a friction free lining for blood flow in blood vessels

Adaptations:
- Made up of thin flattened cells to reduce diffusion distance across tissues.
- Their smooth surface provides a friction free lining for blood flow in blood vessels.

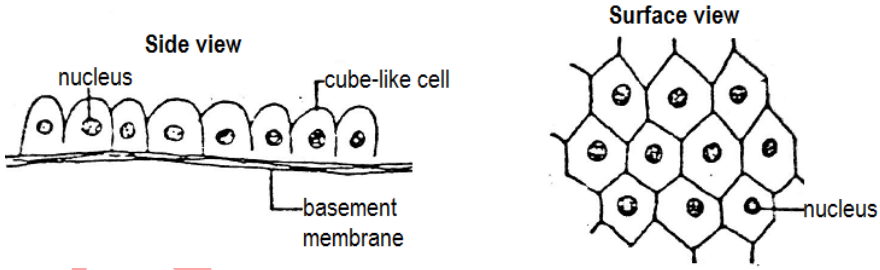
2. Cuboidal epithelial tissue:

Its cells are cuboidal and form a single layer attached to a basement membrane. The nuclei are spherical and centrally located. The cells appear pentagonal or hexagonal in surface view.

Location:
- Lining of salivary, collecting and pancreatic ducts (kidneys).
- Salivary, sweat and thyroid glands.

Functions:
- Secretion
- The ciliated cuboidal epithelium are for flow of nephric filtrate.

Structure of cuboidal epithelium



- The brush bordered cuboidal are for reabsorption of materials from fluid in tubules with microvilli which increase surface area.

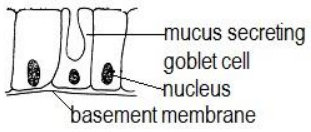
3. Simple columnar epithelium

Tall, column like narrow cells with nucleus at the basal end. It is often interspersed by goblet cells.

Location:
- Lining of stomach, intestine and gall bladder.
- Intestinal and gastric glands.

Functions:
- Secretion and/or absorption.
- Mucus protects the lining from the acidic content in the stomach and from digestion by enzymes and also lubricates the passage.

Side view of simple columnar



4. Brush bordered columnar epithelium

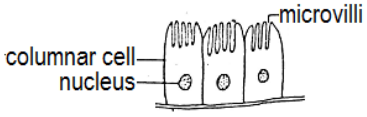
These are tall and narrow cells with a nucleus near their base.
The surface area is increased by micro villi at the free end.
Secretory goblet cells are found within the columnar cells.

Location:
Intestinal mucosa

Function:
Increased surface area for absorption of nutrients.

Adaptations:
- Microvilli at free surface increase surface area for absorption of nutrients.
- Secretory goblet cells for secretion of mucus.

Side view of brush border columnar epithelium



5. Ciliated columnar epithelium

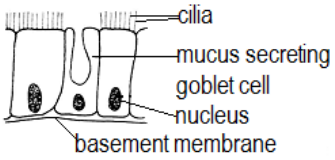
It comprises of columnar cells with cilia at their free edges.

They have many mucus secreting goblet cells in between the cells.

Location:

- Oviducts, respiratory passage (bronchioles) and spinal canal.
- In flat worms, lines underside of the body where they aid locomotion.

Side view of ciliated columnar epithelium



Functions:

- Locomotion in flatworms.
- Movement of materials in a particular direction. The cilia sets up currents to move materials in a particular direction.
- The mucus protects the lining and lubricates the passage.

6. Pseudostratified epithelium

Consist of one layer of columnar cells that appear to be in two layers due to:

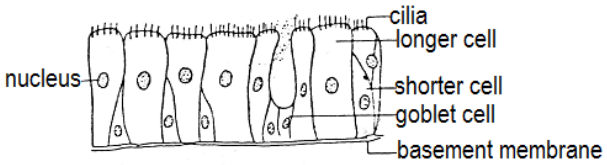
- Nuclei at different levels and
- All cells do not reach the surface.

Has two types of cells:

- Longer cells have cilia
- Shorter cells lack cilia and secrete mucus.

All cells rest on the basement membrane.

Side of pseudostratified epithelium



Location:

- Lining of trachea and primary bronchi.
- Part of the nasal epithelium.

Functions:

- Mucus traps bacteria and dust particles and prevent them from reaching the lungs.
- Cilia move mucus with trapped foreign particles up to the throat for swallowing.

COMPOUND EPITHELIAL TISSUES

Characteristics:

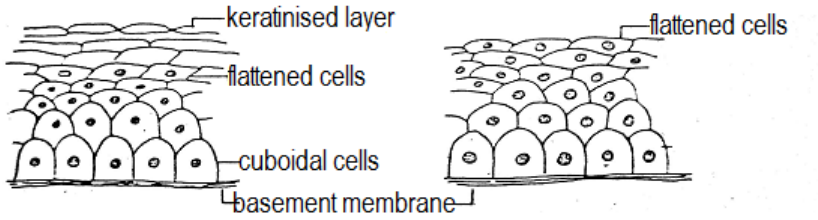
Consist of many layers of cells.
Only the lower most layer of cells rest on the basement membrane.
Compound epithelial may be stratified or transitional.

Types of compound epithelial tissues

1. Stratified epithelium

It is made of many layers of cells and therefore thicker than the simple epithelium.
The cells are formed by mitotic division of the germinal layer which rests on the basement membrane.
As new cells form, older ones are pushed near to the surface changing shape and flattening to form squamous.
In some areas the squamous cells may remain un keratinized as in the oesophagus or may be heavily thickened with keratin (cornified) e.g. the skin where there is a dead layer of cells.

Keratinised stratified epithelium **Non-keratinised stratified epithelium**



Location:

- Areas or ducts that are delicate or have large flow of fluids.
- External skin surface, lining of buccal cavity and vagina.
- Lining of pharynx and oesophagus.

Function:

- Protection from abrasion to areas exposed to wear and tear.
- Protection of the tissue from mechanical damage by the food that is swallowed.
- Protection of the underlying tissue from mechanical damage.

Adaptations of stratified epithelium

- It is composed of several layers of cells which are tough impervious and some cells keratinized/cornified for protection against mechanical abrasions.
- Cells of germinal layer divide repeatedly by mitosis to replace the cells that are breaking off wearing off at the surface.
- Some cells can change their shape when subjected to tension to allow stretching where they are located e.g. in urinary bladder.

Practical check: An experiment to study the squamous epithelium from a temporary mount of check epithelium.

Procedure:

- *Take a tooth pick or sterilized spatula and scrape the mucous membrane from inner lining of mouth very lightly.*
- *Put the scrapings on a glass slide and add a drop of 0.9% NaCl solution (isotonic to mammalian tissue).*
- *Place the coverslip and put a drop of 1% methylene blue solution at the edge of coverslip. (Methylene blue stains the nucleus blue).*
- *Wipe off the excess dye with a blotting paper and observe the slide under the microscope.*
- *Draw and label at least 4 cells observed.*

2. Transitional epithelium.

It comprises of 3 or 4 layers of cells which may be flattened towards the surface which are not shed but can change their shape thus allowing stretching. Transitional epithelium lacks a basement membrane.

Location:

It is found in structures which must stretch e.g. the urinary bladder, ureter and urethra.

Function:

- By changing the shape, the transitional epithelium allows the expansion of the organ.
- It prevents the loss of water from blood to urine.
- Due to its thickness, it prevents the urine from escaping into the surrounding tissue.

Typical examination question

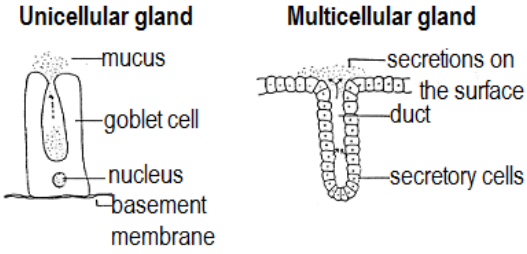
a) What is a tissue?

b) Give one characteristic feature and one location of each of the following tissues in a mammal in the table below:

Tissue	*Characteristic feature*	*Location*
Squamous epithelium		
Columnar epithelium		
Stratified epithelium		

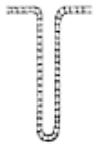
GLANDULAR EPITHELIUM

1. **Based on the kind of secretion and the duct present, glands are of two types;**
   i) **Exocrine glands**: these pour their secretions through the ducts to their respective sites of action e.g. salivary, tear intestinal and gastric glands. Their secretions are called enzymes.
   ii) **Endocrine glands:** these do not possess ducts and pour their secretions directly into the blood stream. Their secretions are known as hormones.
2. **Based on number of cells, the glands are of 2 types;**
   i) **Unicellular:** an individual epithelial cell is modified into a glandular cell as in goblet cells.
   ii) **Multicellular:** number of glandular cells aggregate to form a multicellular gland. Multicellular glands can further be divided into simple or compound glands e.g. sweat glands.



3. **Based on the shape and complexity, the exocrine glands are of 2 main types**; simple and compound glands which may further be modified.
   i) **Simple glands:** these have a single unbranched duct. The secretory part could be in the form of tube (called tubules) or sacs (alveolar/saccular). These could be coiled or uncoiled, branched or unbranched.

Various forms of simple exocrine glands

Simple tubular e.g. crypts of Lieburkuhn in intestine	Simple coiled e.g. sweat glands	Simple branched tubular e.g. gastric glands and Brunner's glands of intestine.	Simple alveolar e.g. mucous secreting glands in frog skin.	Simple branched alveolar gland where a number of sacs open into the same duct e.g. sebaceous glands.
				

ii) **Compound glands**: these have number of ducts forming a branching pattern.

Compound tubular glands e.g. salivary glands.	**Compound alveolar** e.g. mammary glands, pancreatic glands.	**Compound tubular alveolar** e.g. parts of salivary and mammary glands.
		

4. **Based on the mode of secretions, the exocrine glands are of 3 types;**
   i) **Merocrine glands**: the secretions produced within the cell are discharged on its cell surface without losing any of its cytoplasm. E.g. goblet cells, pancreatic glands and sweat glands.
   ii) **Apocrine glands**: in these glands, the cell loses a part of its cytoplasm while releasing its secretions. The secretions are stored in the apical part of the cell which bursts open to release the contents e.g. mammary glands.
   iii) **Holocrine glands:** the entire cell breaks down in order to release its secretions which extrude from the epithelial surface e.g. sebaceous glands.
5. **Based on the form of secretion, glands are of 3 types.**
   i) Mucous glands: secretion is in form of viscous mucous fluid. They are called mucocytes.
   ii) Serous glands: secretion is clear, watery fluid containing enzymes. They are called serocytes.
   iii) Mixed glands: secret both.

Functions of epithelial tissues

The epithelial tissues serve the following functions; protection, secretion, absorption, exchange of materials/gases and sensory.

1) Protection:

Epithelial tissues protect underlying tissues from injury by chemicals, pressure, abrasion and infection.

Adaptations:

- Stratified epithelium is composed of several layers of cells which are tough, impervious and some cells keratinized/cornified for protection against mechanical abrasions.
- Columnar epithelium lining the stomach is interspersed with goblet cells which secret mucus.
- The mucus protects the lining of the stomach from acidic contents of the stomach and from digestive juices.
- The mucus also lubricates the passage of food thereby protecting the lining from abrasion.
- The shorter cells of the pseudo stratified epithelium lining the trachea and bronchi secrete mucus which traps bacteria and dust particles in incoming air and the cilia on the longer cells beat expelling them in the outward direction.
- Melanin in deeper layer of the skin prevents penetration of dangerous ultra violet radiations.

2) Absorption:

Cuboidal and columnar epithelia are modified for absorption

Adaptations:

- Columnar epithelial cells lining kidney possess microvilli on free surface which increase surface area for selective reabsorption.
- Columnar epithelium lining the small intestine possesses microvilli which increase the surface area for absorption of nutrients.

3) Secretion:

A number of epithelia cells are modified to produce secretions such as mucus, enzymes or hormones. E.g. the columnar epithelium lining the stomach is interspersed with goblet cells which secrete mucus.

4) **Movement of materials along a cavity of tubule:**
Ciliated epithelium lining the inside of respiratory passage eliminates small particles of dust and other foreign materials which have got trapped in mucus secreted by goblet cells.
In oviducts, rhythmic beating of cilia moves the ovum towards the uterus along the fallopian tube.
5) **Locomotion:**
In flatworms, ciliated epithelium lines underside of the body where they aid locomotion.
6) **Tissue replacement:**
Replacement of worn out cells through rapid mitotic division of cells of germinal layer.
7) **Reduction of friction:**
The smooth, tightly interlocking epithelial cells that line endothelium of blood vessels reduce friction during blood flow.
8) **Sensory function:**
Epithelial tissues in the skin contains receptors which detect changes in the environment.
9) **Exchange of materials:**
Squamous epithelium which lines the alveoli of the lungs and the blood capillary walls is extremely thin and flattened to reduce diffusion distance.

CONNECTIVE TISSUE

Connective tissue is a composite tissue and has three basic components.

i) **Cells:** they are the living components that are widely separated from each other. They originate from the embryonic mesoderm.
ii) **Fibres:** there are several types of fibres scattered in between the cells. They form the extracellular material. Blood is devoid of any fibres.
iii) **Matrix:** tit forms the basic ground tissue in which both the cells and the fibres are suspended. It is nonliving, transparent, fluid or semi fluid in nature. It contains various organic and inorganic substances, the most important being hyaluronic acid. The kind of matrix varies in different tissues.

Location of connective tissue

- It is present in between different tissues and organs.
- It is present inside and around the body organs.
- The skeletal tissue is present in the form of bone and cartilage.
- Fluid connective tissue is present throughout the body.

Functions of connective tissue

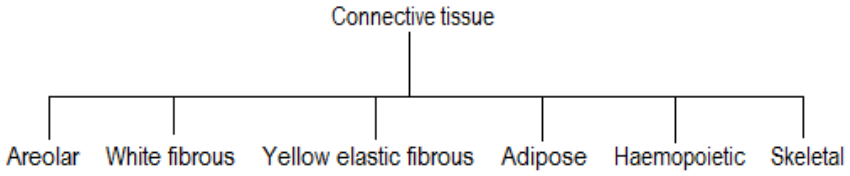
Connective tissue is basically a binding and packaging tissue but has many other important functions as well.

- It binds various tissues together like skin with the muscles and muscles with the bones.
- It forms sheaths around the body organs and makes a kind of packaging tissue.
- The areolar tissue protects the body against wounds and infection.
- The adipose tissue stores fat and insulates the body against heat loss.
- The supportive tissue forms shape and the frame work of the body.
- The haemopoietic tissue produces blood.
- The lymphatic tissue helps the body to build immunity by producing antibodies.

Types of connective tissue

The type depends on the kind of matrix present. They include connective tissues proper, skeletal tissue and vascular (fluid/haemopoietic) tissue as summarized below

Summary of the connective tissue



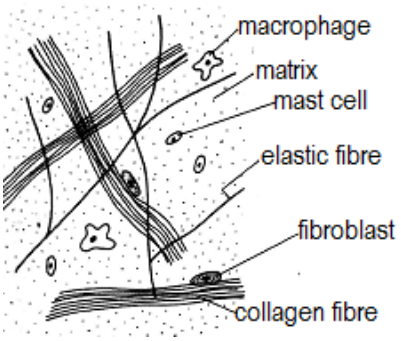
1) **Areolar tissue**

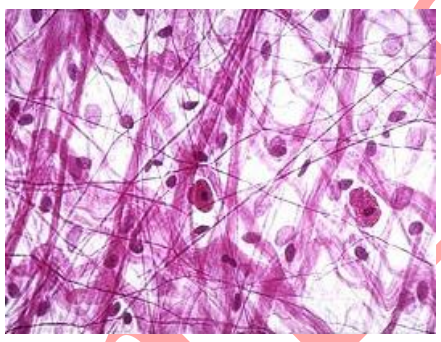
This is found around all organs in the body. It consists of a semi-fluid matrix containing a variety of cells and fibres.
The cells are:
Fibroblasts: These are spindle shaped flattened cells with an oval nucleus. *They produce fibres* and so are generally seen close to them.

Mast cells: These are large oval shaped cells and contain granular cytoplasm. They secrete the matrix and chemicals heparin and histamine. ***Heparin*** is an anticoagulant while ***histamine*** is anti-inflammatory and is released from tissue when they are injured.
Macrophage or histocytes: These are large amoeboid cells with a kidney shaped nucleus. They engulf bacteria or other foreign particles. They are capable of amoeboid movement and can ingest damaged cell tissues.
Plasma cells: these are small round or irregular cells. They produce antibodies that help in self-defense.

There are two types of fibres in areolar tissue:
The **collagen/white fibres:** these are long, wavy and unbranched fibres present in bundles. They are flexible but inelastic.
The **elastic/yellow fibres:** these are long, straight and branched fibres arranged singly. They are flexible and elastic as they contain protein elastin.

Transverse section of areolar



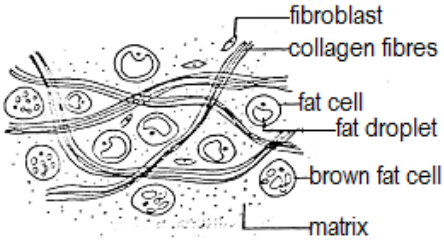


2) White fibrous tissue:
This consists of glycoprotein matrix containing densely packed collagen fibres. The collagen fibres are strong, flexible yet inelastic and have a high tensile strength. They are abundant in tendons and ligaments.

3) Yellow elastic fibrous tissue:
This consists of a glycoprotein matrix containing loose network of fibres. It is strong and elastic. Such tissue is found in ligaments where it binds bones to other bones. It is also found around the walls of arteries and it is also found as a component of the lungs and associated air passages as well as in the great cords of the neck.

4) Adipose tissue (fatty tissue):
This is areolar tissue containing many **fat cells** which act as an energy reserve, for insulation and also act as a shock absorber.
There are two types of adipose tissue;

Adipose tissue structure



i) **White adipose tissue:**
The white adipose tissue is called so because the cells appear white due to accumulation of fats. It is distributed throughout the body particularly the deep layers of the skin.

ii) **Brown/yellow adipose tissue:**
This is commonly in young mammals and some hibernating mammals. It is important in temperature regulation.
It is supplied within blood capillaries and appears red. It differs from the white because of;
- It's coloured and has limited location in the body e.g. it is found around the neck.
- The fats in brown remain as small droplets i.e. do not form big globules.
- The nucleus of the brown remains centrally placed.

5) Haemopoietic tissue:
This forms the red and white blood cells and is located in the red bone marrow and lymphoid tissue of mammals.

6) Skeletal connective tissue:
This is made up of cartilage and bone.

i) Cartilage:
Cartilage is a tough, hard but flexible connective tissue. It can resist strain and can absorb the mechanical shock. It consists of solid or semi-solid **matrix** in which are embedded the cartilage cells called **chondrocytes** and the **fibres**.

Structure:
- The cartilage is enclosed in a sheath of white fibrous tissue called **perichondrin**.
- Next to perichondrin is a layer of **chondroblasts** which eventually form the chondrocytes.

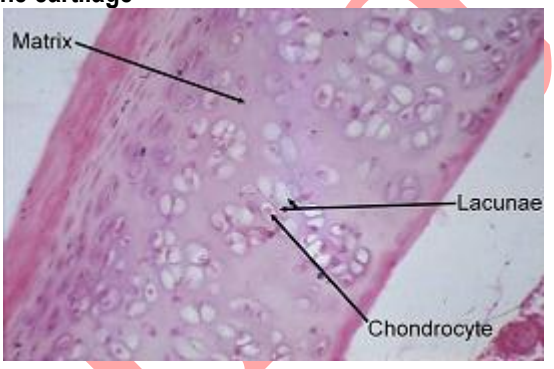
- The **chondrocytes** are dispersed in the matrix and occur in the fluid filled spaces called **lacunae**.
- Each lacuna contains two to three chondrocytes.
- Each chondrocyte is a large, angular cartilage cell with a distinct nucleus.
- The matrix has a protein **chondrin** and lacks blood vessels.

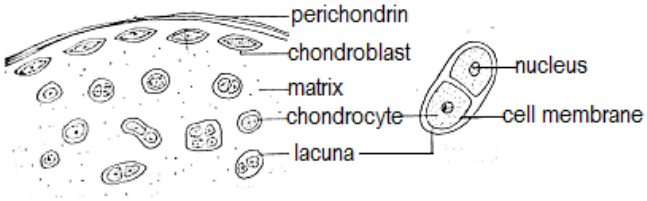
Types of cartilage

a) Hyaline cartilage

The simplest form of cartilage is known as hyaline cartilage which consists of only chondrin matrix and chondroblasts which secret it. It is glassy and semi-transparent in appearance and has very few or no fibres. It is slightly elastic and compressible. It is found at the ends of the bones, larynx (voice box) and trachea. It forms the skeleton of cartilage fish.

Section through hyaline cartilage

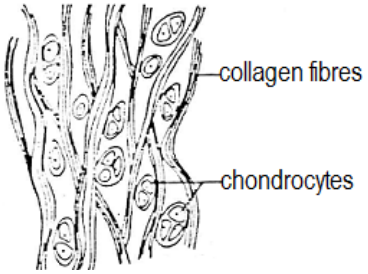




b) White fibrous cartilage

The matrix has bundles of densely packed white collagen fibres. It provides great strength and a little degree of flexibility. It acts as a shock absorber by giving a cushioning effect.
It is found between the adjacent vertebrae.

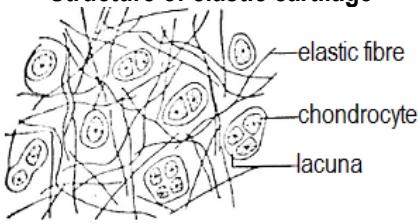
Structure of white fibrous cartilage



c) Elastic cartilage

This has a semi-opaque matrix with many yellow elastic fibres. It is highly flexible and elastic. The tissue recovers the shape quickly. It is found in external ear, eustachian tube, nose and the epiglottis.

Structure of elastic cartilage



ii) Bone:

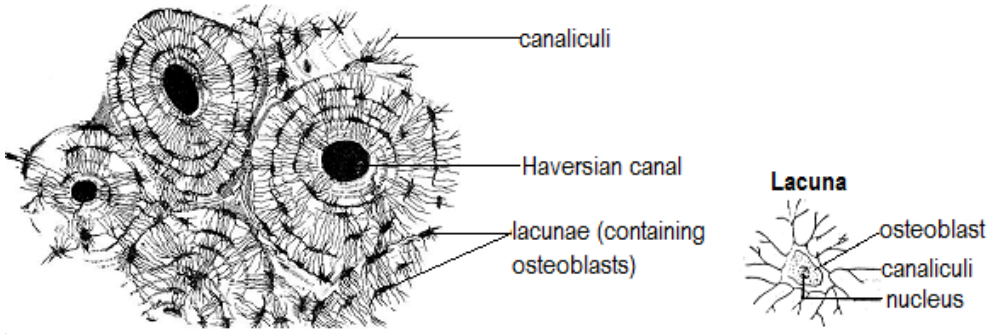
Bone is a supportive and protective tissue. The matrix is solid and **calcified**. Most bone mass consist of salts of calcium and phosphate. Small amounts of sodium, magnesium, potassium, chloride and fluoride are also present. The phosphates and carbonates of calcium and magnesium give hardness and strength to the bone. The matrix contains protein **ostein**. In the matrix are embedded the bone cells osteocytes and mainly the **collagen fibres.**

Structure of a bone:

- Each bone is enclosed in a layer of white fibrous connective tissue called the **Periosteum**. It is through the Periosteum, the blood vessels and nerves pierce in.
- In a bone, the matrix is arranged in concentric circles called **lamellae.**
- In between the lamellae are present, a number of living bone cells called **osteoblasts** or **osteocytes**, in the fluid-filled cavities called **lacunae**. Osteoblasts are active bone cells while osteocytes are inactive osteoblasts.

- Each lacuna has fine cytoplasmic extensions called **canaliculi** which pass through lamellae and make connections with other lacunae.

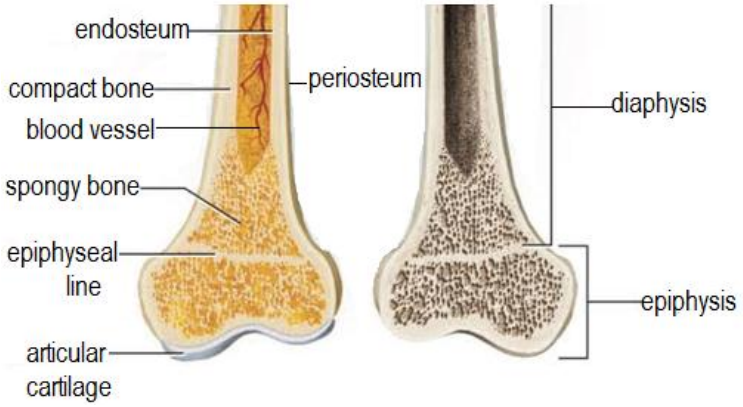
Transverse section through a bone



Structure of a compact bone:

- A compact bone consists of concentric cylinders of bony lamellae surrounding a central **Haversian canal** with an artery and vein.
- Osteoblasts interspersed between the lamellae aid bone deposition.
- A layer of dense connective tissue, the **periosteum** covers the surface of the bone.
- In the centre of a compact bone is present a bone marrow cavity lined by **endosteum**.
- Throughout the bone, the lamellae are present in concentric circles except at the periphery where they are arranged circumferentially.

Longitudinal section of a long bone



Differences between bone and cartilage

Bones	Cartilage
Matrix is ostein	Matrix is chondrin.
Matrix is firm, inelastic and rigid.	Matrix is firm, elastic and flexible.
Surrounded by periosteum.	Surrounded by perichondria.
Blood vessels and nerves present.	Blood vessels and nerves absent.
Have osteoblasts that form the osteocytes.	Has chondroblasts that form the chondrocytes.
Osteoblasts form the ostein matrix.	Chondrocytes form the chondrin matrix.
Have inorganic materials like Ca and P ions.	Lacks the inorganic molecules.
Marrow cavity is present in long bones.	Marrow cavities absent.
Have concentric circles of lamellae with lacunae and canalicunae.	Lacks the lamellae, lacunae and canalicunae.
Osteoblasts are star shaped.	Chondroblasts are spherical.
Relatively metabolically active.	Not metabolically active.
Osteoblasts are arranged in concentric circles.	Chondroblasts are scattered randomly in the matrix.
Can manufacture blood cells from the bone marrow.	Cannot manufacture blood cells.
Matrix has haversian canals.	Matrix has no canals.
Has a secretory function.	No secretory function.

MUSCULAR TISSUE

This is composed of specialized thin and elongated cells called muscle fibres. These muscle fibres have the capability to contract and relax. This property of contractility is due to presence of protein filaments myosin and actin present in their cytoplasm.

Basic structure:

- All muscles are made up of elongated and thin cells called **muscle fibres.**

- The muscle fibres contain specialized cytoplasm called **sarcoplasm** that contains a network of membranes called **sarcoplasmic reticulum.**
- The muscle fibre may be bound by a cell membrane called **sarcolemma.**
- Each muscle fibre may contain numerous thin **myofibrils.**

Types of muscles

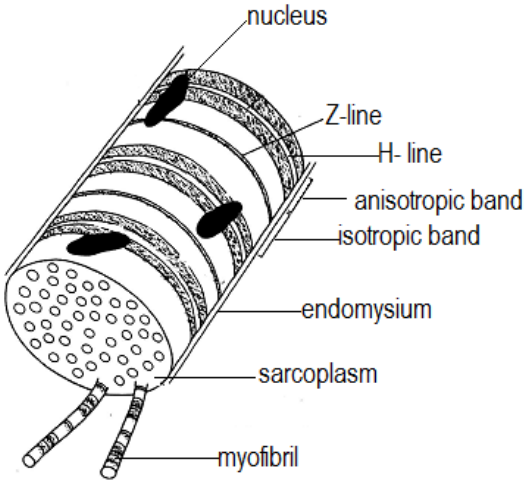
1. Skeletal (striated/stripped/voluntary) muscles.
2. Smooth (involuntary/unstriated/unstripped) muscles.
3. Cardiac muscles.

1) Skeletal/striated muscles

These are voluntary in action i.e. they work under one's own will.
They bring about the movement of the organs and the locomotion of the body.
They undergo powerful and rapid contractions with short rest periods and hence get fatigued easily.
Location: attached to the skeleton in the head, trunk and limb region.

Structure:
A skeletal muscle possesses distinct **cross-striations** in the form of light and dark bands or **I** and **A** bands respectively. **I** means **isotropic** i.e. that allows the light to pass through and so appears **lighter** while **A** means **Anisotropic** i.e. that does not allow light to pass through and so appears **darker.**
A muscle is composed of a number of multi-nucleate cylindrical **muscle fibres**. Each muscle fibre further consists of numerous thin **myofibrils.**

Skeletal muscle fibre

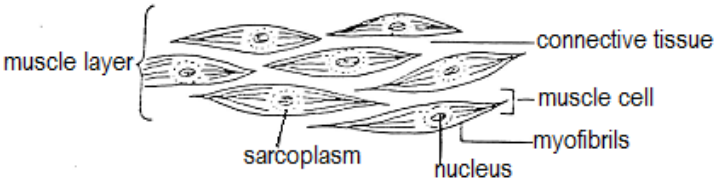


2) Smooth or unstriated/involuntary muscles

Smooth muscles are involuntary in action and cannot be moved by one's own will. The cells undergo prolonged and slow contractions and relaxations.
Location: walls of visceral organs like stomach, intestine, ureters, kidneys, blood vessels, etc.
Structure:

- A smooth muscle consists of sheets of densely packed elongated fibres running parallel to each other, bound together by connective tissue.
- Each muscle fibre is spindle shaped, tapering at both ends and uninucleate. It lacks sarcolemma.
- Each muscle fibre contains numerous fine contractile myofibrils arranged longitudinally.
- The nucleus is centrally placed and is surrounded by little sarcoplasm.
- The actin and myosin filaments are randomly distributed and hence there are no striations or light and dark bands.
- It is shorter than skeletal muscle
- It has less mitochondria and other organelles and much less extensive sarcoplasmic reticulum.

Longitudinal section of the smooth muscle from the alimentary canal



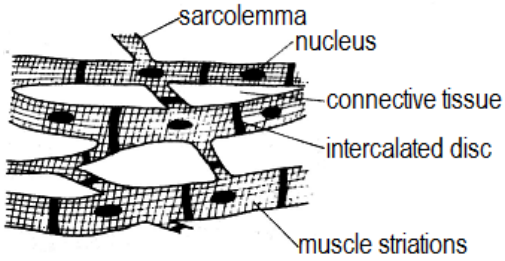
3) Cardiac muscle

The cardiac muscles are **myogenic** meaning the contractions are generated within the muscle itself. They do not have to be initiated by the nervous system.
The rate of contraction can be influenced by the autonomic nervous system.
The cardiac muscles have rhythmical contractions and relaxations and do not get fatigued. They need a constant supply of a large amount of energy.
Location: Found only in the heart.

Structure:

- The muscle cells are short, cylindrical and branched cells joined end to end to form rows.
- They show faint, but regular cross striations (light and dark bands) indicating a regular arrangement of myosin and actin filaments.
- Each muscle fibre has numerous mitochondria, myofibrils with sarcomeres and many nuclei. It has abundant cytoplasm and glycogen granules.
- The cells are connected to each other by special zigzag junctions called **intercalated discs.**
- In between such discs generally one nucleus is present.

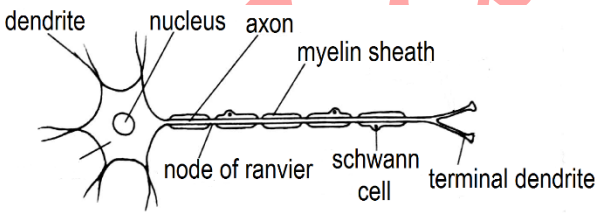
Structure of a cardiac muscle



Nervous tissue

The nerve tissue is made up of millions of nerve cells called **neurons**. The neurons are highly specialized cells and form the nervous system of the body.
They provide the quickest mean of communication within the body and help the body give response to the external stimuli.
The nervous tissue does not regenerate when damaged.

Structure of a neuron



Roles played by dead cells in multicellular organisms

i) Support and protection:
   - Nails, horns, hooves, down feathers and dead skin cells in animals.
   - Sclerenchyma has thick walls for mechanical support.
   - Heart wood gives a strong internal support.

ii) Protection from loss of fluids and invasion of harmful microbes in:
   - The outer layer of skin in animals.
   - The cork and bark of the tree.

iii) Create channels for conducting without leakage. Xylem vessels have dead walls which help conduct water and minerals to great heights without leakage.

iv) Development of other organs:
   - During metamorphosis many tissues and organs like gills and tail in tadpole stage die and help it to become a frog.
   - During maturation of xylem in cells of flowering plants, the cross walls dissolve giving rise to long columns to help in the conduction of water and minerals.

Biological life fact on death:

Death is a biological phenomenon which is a part of an organism's lifecycle. Each organism has a certain length of time for which he will survive. This is called its lifespan. It is a period from birth to death. It is different for all species. Even if an organism does not meet an accident, does not suffer from a disease, does not fall prey to predators, death comes as a last event of aging.

Aging is a prerequisite for natural death. The deterioration in the structure and of body cells starts after adulthood where there is a gradual degeneration of organs. This is the final stopping of the vital organs like heartbeat and respiration of the body.

It is an irreversible process. It is necessary for the continuity of life on earth. Some of the advantages of death are:

- *The cells that die over a period of time play very important roles.*
- *Helps to regulate the number of individuals in a population. It prevents overcrowding and so maintains an ecological balance.*
- *The decomposers (microbes) act on dead and decaying organisms. They convert the complex organic molecules into simple forms like C, H, O, N, S, etc. these are returned to soil, air and water. The recycling of minerals helps in maintaining a balance in nature.*

WORKED OUT SAMPLE EXAMINATION QUESTIONS

1. Describe how the structures of the following tissues are adapted to their functions:

i) Striated (skeletal) muscular tissue

ii) Parenchyma tissue in plants.

Note: In each instance it is essential to show clearly how the structure permits a specific function to be carried out efficiently. You ***do not*** have to present your answers in table format.

a) Skeletal muscle.

Structure	***Function***
Elongated fibres	*Allow considerable contraction.*
Parallel fibres	*Give maximum contractile effect*
Fibre ends tapered and interwoven	*Provide strength*
Large number of mitochondria	*Provide large amount of ATP*
Actin and myosin arrangement in sarcomere	*Allows contraction by filament sliding over each other*
Rich supply of blood vessels	*Provide adequate supply of oxygen and glucose.*
Myoglobin present	*To store oxygen for release when blood oxygen levels are low.*
Motor end plates	*Allow muscle stimulation*
Fibres arranged in motor units	*To allow variable degrees of contraction.*

b) **Parenchyma tissue**

Structure	**Function**
Unspecialized tissue	*Variety of functions*
Many intercellular spaces	*Diffusion of gases*
Isodiametric cells	*Packing material*
Thin cellulose cell walls	*Permit passage of materials*
Transparent cell wall	*Permits entry of light for photosynthesis*
Permeable walls	*Allow water entry for turgidity*
Large cells/large vacuoles	*Provide storage space*
Chloroplasts present	*Allow photosynthesis*
Leucoplasts present	*To store starch*

2. Describe the structural adaptations of vascular tissues for support.

Note: this question requires you to know the **structural** appearance and composition of all the tissues that make up the vascular tissues in plants and describe how they are adapted for support. You should not limit yourself to the **vascular system** i.e. xylem vessels and phloem vessels but all tissues in the system. The vascular tissues in plants are the phloem parenchyma, parenchyma, collenchyma, sclerenchyma, sclereids and tracheids.

- *Phloem parenchyma tissue has spherical/polygonal cells that form radial sheets/medullary rays for support.*
- *Parenchyma tissue has cells with a flexible membrane that allow the cells to expand and become turgid with cells closely packed hence offering hydrostatic support.*
- *Collenchyma tissue has polygonal/rectangular cells that have cellulose cell wall to offer tensile strength and compressional strength for extra support.*
- *Sclerenchyma tissue in the form of fibres is lignified, elongated and longitudinally arranged in sheets/bundles for support.*
- *Stone cells/sclereids are also a form of sclerenchyma which are also lignified, spherical and arranged in groups to offer firmness.*
- *Xylem also comprises of the tracheids and vessel elements that are also lignified to offer strength.*
- *In stems, vessels are at the peripheral of the stem for support.*
- *Tracheids have tapering ends that interlock with neighboring tracheids for firm support.*
- *Mature xylem completes development by annular or spiral or reticulate lignification to increase support.*

3. Describe the structure of the vascular system in higher plants.

Note: The vascular system in higher plants consists of two types of vascular tissue, the xylem and phloem.

- The xylem contains two types of conducting cells: tracheids and vessel elements. Both types of conducting cells are hollow, non-living and lack end walls. They are connected end to end to form a continuous pipeline for water and mineral transport. The xylem

elements have lignified side walls which are perforated by numerous bordered pits.
- The conducting cells of phloem are the sieve-tubes, each associated with a companion cell. Sieve-tube cells contain cytoplasm but no nuclei. Strands of cytoplasm, called plasmadesmata extend from one cell to another through the sieve plates (perforated cell end walls).
- The vascular system extends from the roots to the leaves and vice versa. In the roots, the vascular tissue is located in the vascular cylinder. In the stem, it forms vascular bundles and in the leaves, it is found in leaf veins.

4. How is the vascular system in plants adapted to its function?

Note: The vascular system in higher plants consists of two types of vascular tissue, the xylem and phloem.

Adaptations of xylem for its function.
- *Its cells have no end walls and so allow unimpeded flow of water.*
- *Lignin in the cellulose side walls makes it impermeable to water and solutes. This prevents wastage during transport.*
- *Having spiral and annular thickening gives it a high tensile strength and prevents the vessel from collapsing.*
- *Presence of pits allows passage of water in and out of the lumen.*
- *Lignin also strengthens the vessels in order to give structural support to the plant.*
- *Have elongated cylindrical cells for continuous flow of water.*
- *The torus in bordered pits acts as a plug for controlling passage of water in some plants.*

Adaptations of phloem for its function:
- *The sieve tubes are elongated, cylindrical cells connected end to end. Their end walls have sieve plates perforated with pores to allow continuous flow of materials.*
- *The sieve tubes have no nucleus, to create more room for movement of materials.*
- *Within the lumen of the sieve elements are cytoplasmic filaments/strands which are continuous from cell to cell to enable continuous flow of materials.*
- *The companion cells have nuclei and other organelles. They control the flow of materials through the phloem sieve tubes.*

5. How is support achieved in woody plants?

Note: state how the tissues in plants provide support to plants.
- *By use of turgid cells in young parts of the plant*
- *Collenchyma tissues with cell walls thickened with cellulose.*
- *By use of sclerenchyma tissues and xylem tissues in which cell walls are strengthened with deposition of lignin.*

6. Describe the changes that take place in a cell that eventually develops into a xylem vessel element.

Note: describe how xylem vessel element is formed from a single cell.

The cells of the procambium strand divide by mitosis. The cell formed elongates/ enlarges and vacuoles appear in cytoplasm. Cross walls between adjacent cells' cross wall disintegrate forming perforation which is continuous with that of adjacent cells. A secondary wall is formed by addition of extra cellulose and lignin. This results in death of the cells leaving the cell with an empty lumen/ hollow.

7. Make a labelled drawing of a living parenchyma cell of a plant.

Note: Only one cell of a parenchyma tissue is essential information to the question above. Note that 'living' means you restrict yourself to structures visible using a light microscope since electron microscope specimens are dead already.

8. a) How do the structure of the following differ from the parenchyma cell?
- **i) A leaf epidermal cell**
- **ii) An apical meristem cell and**
- **iii) A xylem tracheid**

Note: The following table forms a basis for comparison but each cell type should be dealt with in turn and a structure should only be included where it differs from the parenchyma cell.

Structure	***Parenchyma cell***	***Leaf epidermal cell***	***Apical meristem cell***	***Xylem tracheid***
Shape	*Isodiametric*	*Flat and thin*	*Isodiametric*	*Long and cylindrical*
Vacuole	*Large*	*Small*	*Very small if present*	*None*
Cytoplasm	*Little*	*More present*	*Much and dense*	*None*

Cell wall	*Thin cellulose*	*Thick outer walls of cellulose and cutin.*	*Very thin with cellulose*	*Very thick and impregnated with lignin.*
Nucleus	*Small and at the peripheral*	*Fairly small and at the peripheral*	*Large and central*	*None*
Pits	*Few*	*Few*	*None*	*Many*
Storage granules	*Common*	*Few*	*None*	*None*
Chloroplast	*Sometimes*	*Rarely*	*None*	*None*

b) For each of the cells above in 8 (a), give an example of a cell or groups of cells which perform similar functions in a mammal. Comment on their differences.

Note: for any of the cells above, equate them to mammalian cells or tissues which perform similar roles. Compare them and write a brief comment on the difference stated. They are equated as follows:

Plant	Mammal
Leaf epidermis	**Stratified epithelium cells** of the skin
Apical meristem	Rapidly dividing tissue such as germinative cells of the **Malpighian layer** of the skin.
Xylem tracheid	• For transport (artery/vein as these contain muscular, connective and epithelial tissues. capillaries contain squamous epithelial cells). • For support (**bone tissue**).

Answer plan:

Leaf epidermis cell	*Stratified epithelium*	*Comment*
Has cellulose wall, vacuole and starch	*Not present*	*Plant/animal cell difference*
One cell thick	*Multiple celled layer*	*Animals move, more abrasion.*
Cutin present	*Keratin present*	*Cutin waterproof, keratin gives mechanical protection.*
Transparent	*Opaque*	*Light must penetrate for photosynthesis.*

Apical meristem	*Malpighian layer*	*Comment*
Restricted to apices	*Covers whole body*	*Plants grow at apices, animals all over.*

Xylem tracheid	*Bone*	*Comment*
Strengthened with lignin	*Strengthened with calcium salts*	*More rigidity in animals, flexibility at joints only. Slightly flexibility throughout plants.*
No nucleus or cytoplasm	*Nucleus and cytoplasm*	*Xylem dead, bone living*
Hollow with pits in wall	*Canals within bone but largely solid*	*Xylem also used to transport water.*

"Every adversity, every failure and every heart-ache carries with it the seed of an equivalent or a greater benefit"
Team #make sure it hurts