CELL BIOLOGY

Ultra structure of cells and Diversity of tissues

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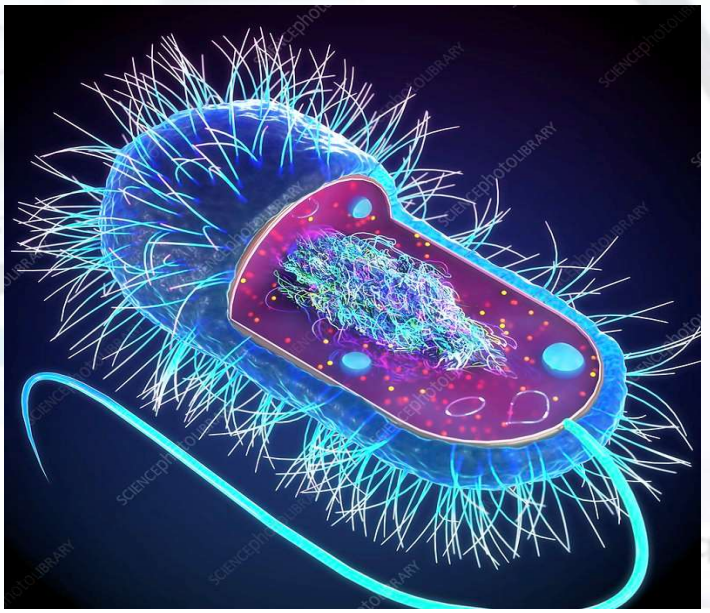
LEARNING OUTCOMES.

The learner should be able to:

- Analyze the ultrastructure of animal/ plant cells, bacterial cells, and the plasma membrane, to distinguish prokaryotic and eukaryotic cell characteristics. (s, gs)

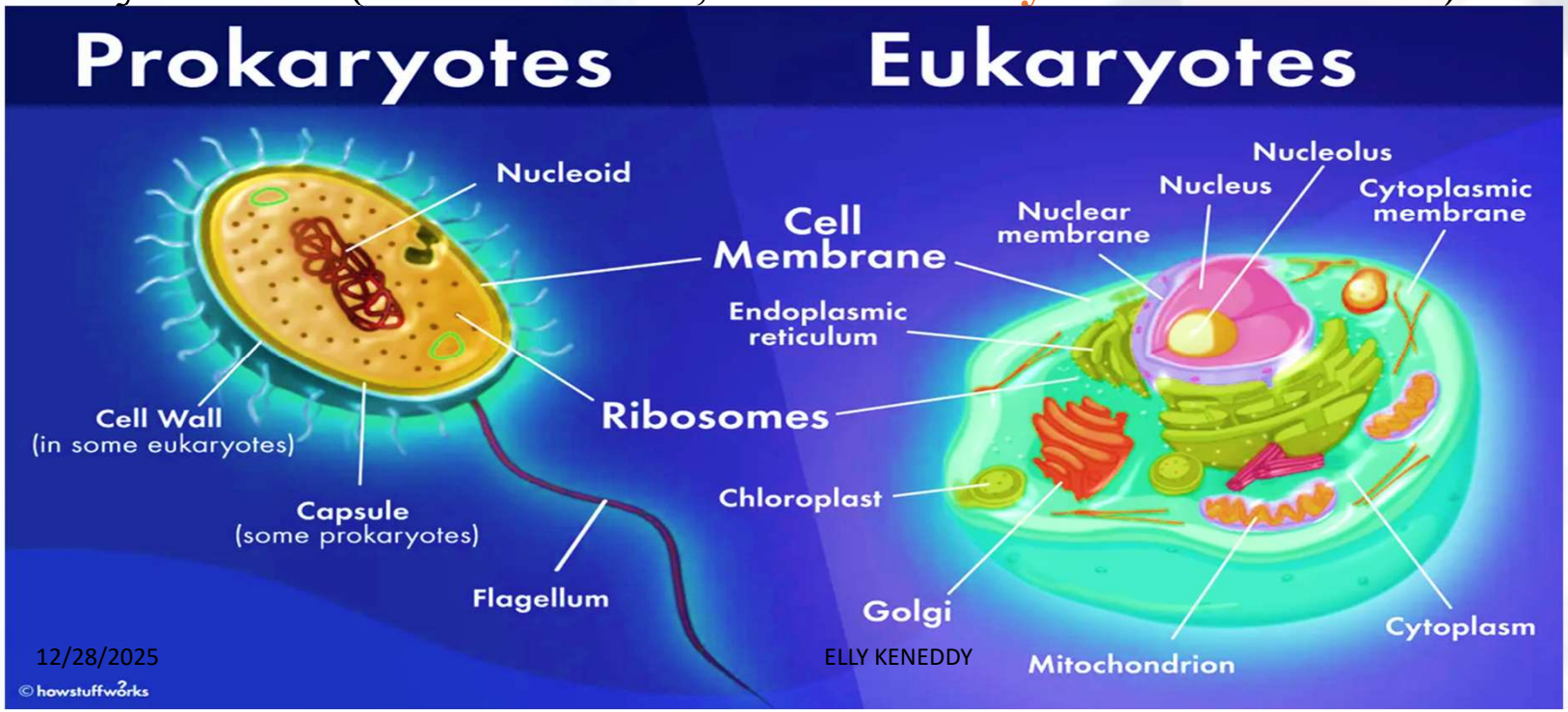


INTRODUCTION.

- **Cytology** deals with the **study of structure, function and physiology** of a cell.
- Cytology, is part of a **major branch of biology** known as **cell biology**.
- The cell is **a basic unit of life**.
- The cell is the ***smallest unit of an organism that still retains the characteristics of life***.
- **Identify the 7 characteristics of life mentioning the relevancy of each.**
- All cells are self-contained and self-sufficient units i.e. survive independent from one another.
- A cell carries out a number of activities including protein synthesis, cell division and it is where the hereditary material is contained.

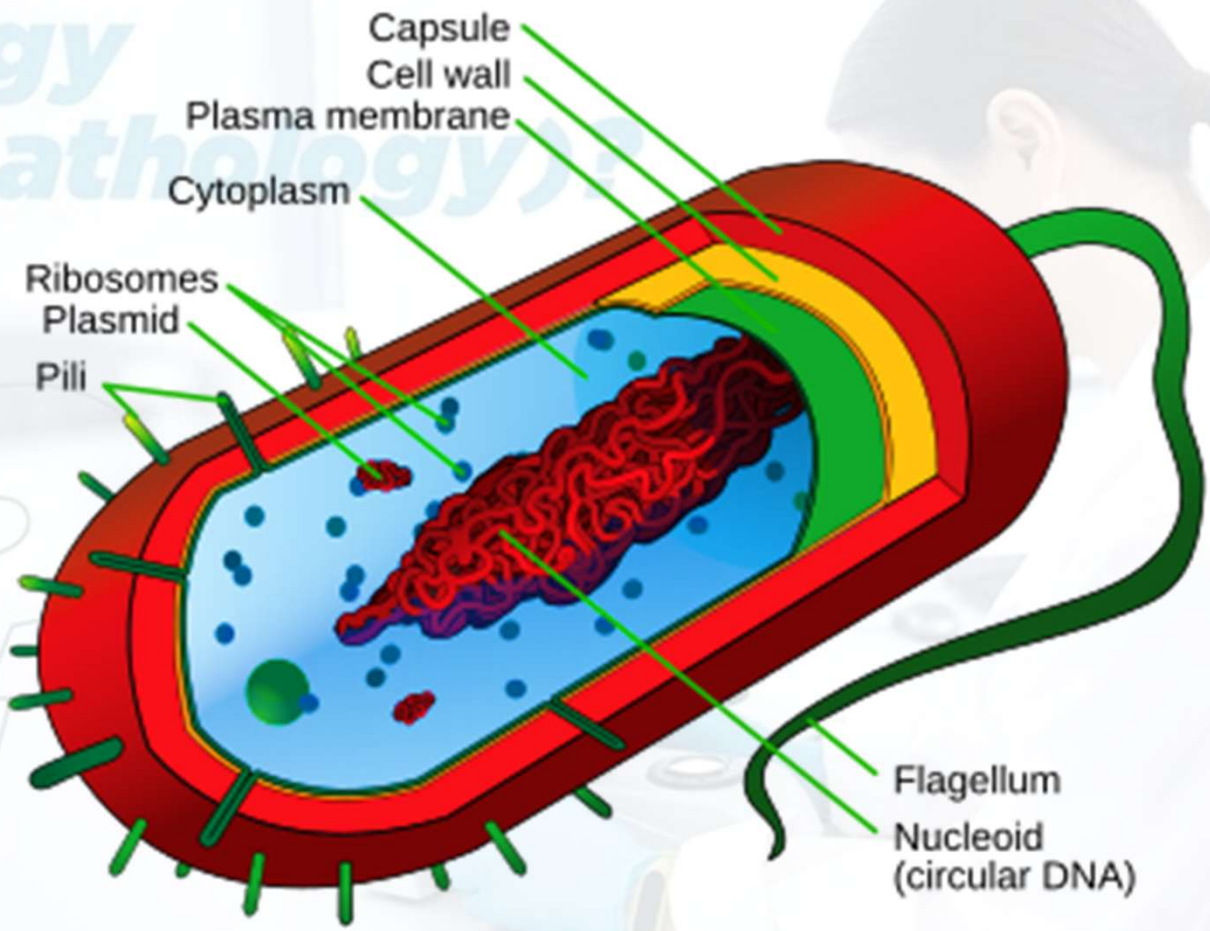
TYPES OF CELLS

- There are **two** fundamentally different types of cells, the **prokaryote** cell and **eukaryote** cell.
- Prokaryote cell (**Pro** ⟶ **before**; **karyon** ⟶ nucleus)
- Eukaryote cell. (**Eu** ⟶ **true**; **Karyon** ⟶ Nucleus)



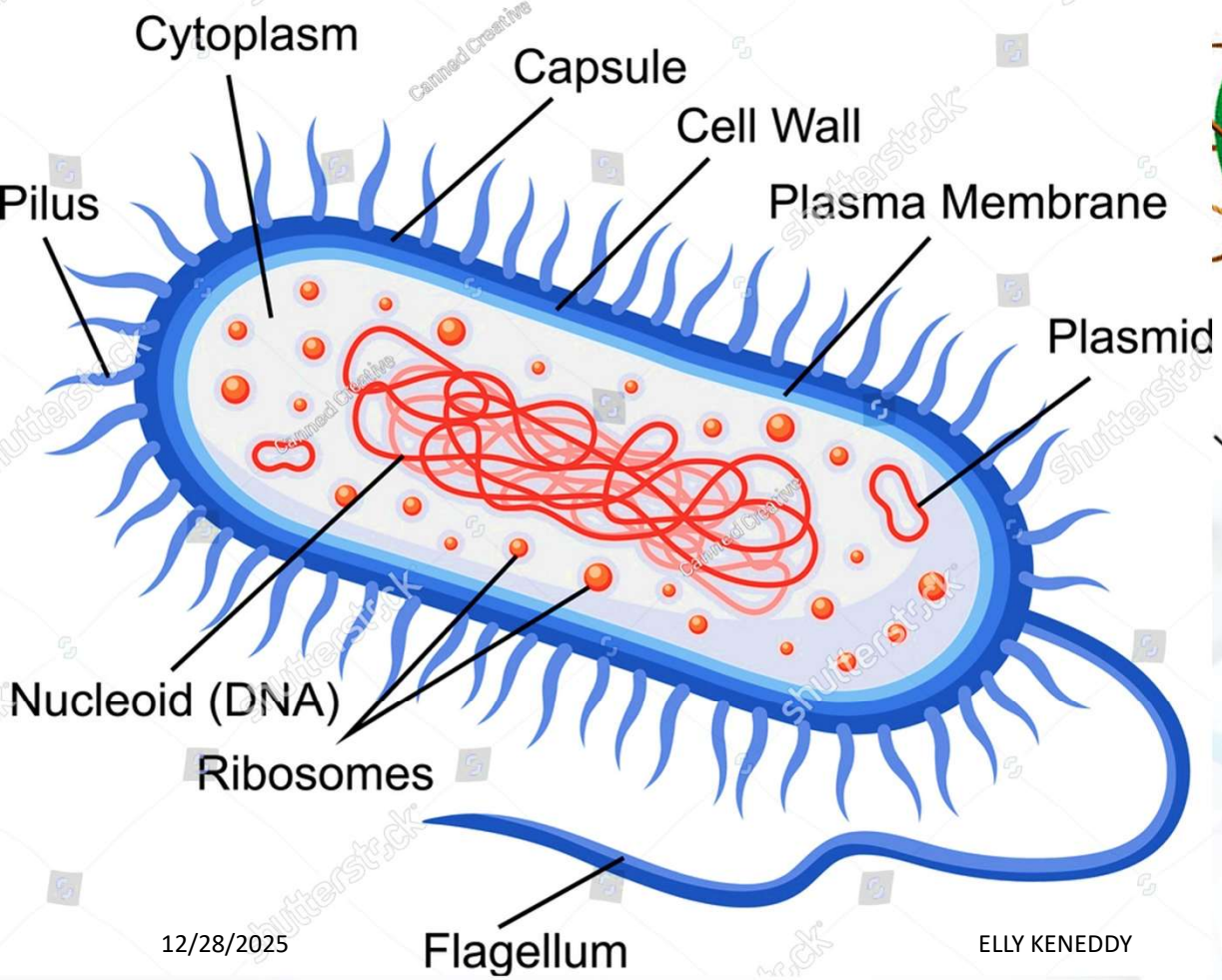
TYPES OF CELLS.

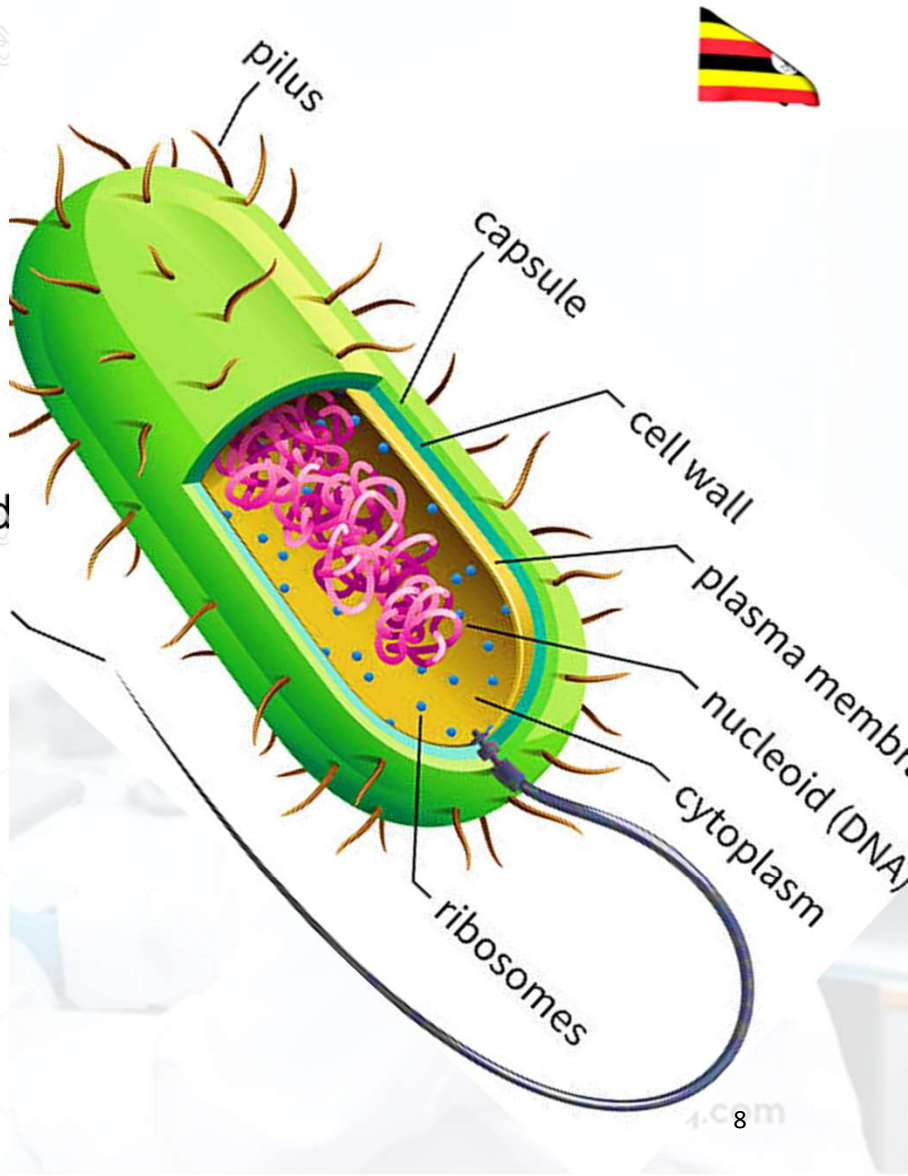
OBSERVE THE CELL BELOW CAREFULLY



STRUCTURE OF PROKARYOTIC CELL.

PROKARYOTIC CELL





CHARACTERISTICS OF PROKARYOTIC CELLS

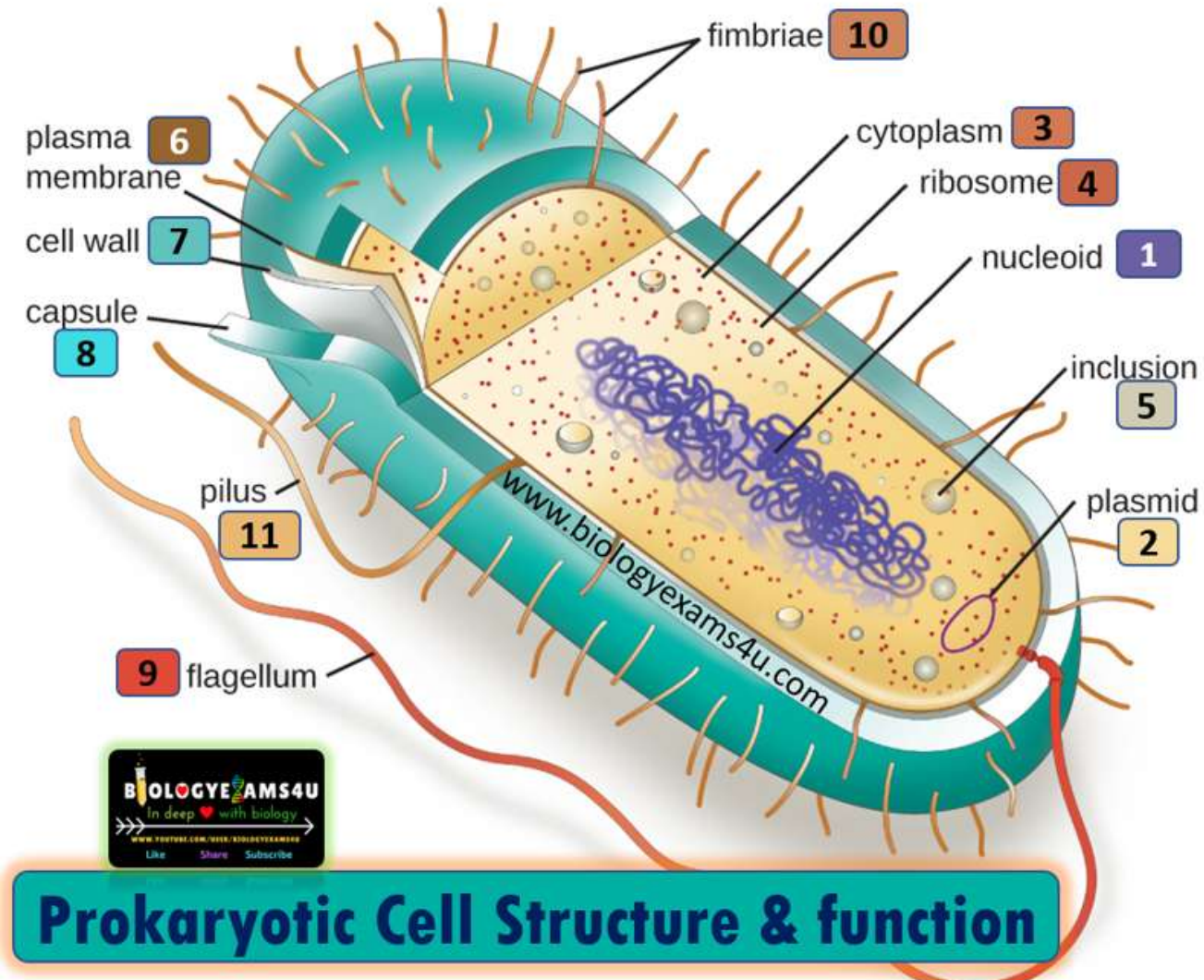
- They were probably the first organisms on earth
- These are cells that **do not have a true nucleus**.
- They **have no membrane bound organelles**. e.g. they do lack the **chloroplasts** and **mitochondria**

N.B.

- An **organelle** can be defined as a **membrane-enclosed structure with specialized functions, suspended in the cytosol** of eukaryotic cells.
- Their nuclear material lies in a free region known as a nucleoid e.g. in bacteria.
- They contain a flagellum used for movement.

CONT.....

- The cell has a single circular chromosome in the form of a ring, of **Deoxyribonucleic Acid (DNA)** in the cytoplasm, not contained in a nuclear membrane
- They are extremely **small**, ranging in size between 1-10milimetres in diameter
- Duplication of the chromosomes occurs but not on the spindle i.e. their cells are capable of multiplication
- The cell has got a unique cell wall containing a polysaccharide called **murein**.



Prokaryotic Cell Structure & function

1. Nucleoid: region of cytoplasm where prokaryotic DNA is located
2. Plasmid: extrachromosomal ds circular DNA; encodes genes for fertility
3. Cytoplasm: gel-like matrix with water, enzymes & cell structures
4. Ribosome 70S: site protein synthesis
5. Inclusions: storage reserves
6. Plasma membrane: made up of phospholipid bilayer and proteins
7. Cell wall: made up of peptidoglycan
8. Capsule: extra envelope made up of polysaccharides
9. Flagella: structure for locomotion
10. Fimbriae: structures for attachment
11. Pilus: attachment for conjugation

Cell wall

This lies external to the cell membrane, it's rigid and strengthened by presence of murein

- Protects the internal parts from mechanical damage
- Prevents the cell bursting when it takes in water by osmosis

Cell membrane

- It lies immediately below the cell wall. It has enzymes involved in the synthesis of the capsid and cell wall components. Enzymes for respiration and those which facilitate flagella mobility.

Ribosomes

- Prokaryotes have 70S ribosomes which are slightly smaller. Ribosomes are site of protein synthesis.

DNA

- The DNA comprises of a single circular molecule possessing the genetic information needed to replicate new cells

Flagellum (Plural. flagella)

- They are hair like helical appendages protruding through the cell wall. They are used for propulsion. Bacterial flagella are smaller, thinner and simpler than eukaryotic flagella.

Pili

- Pili are numerous fine protein rods projecting from the walls of some bacteria. The pili are for attachment to specific cells or surfaces.

Capsule

- This is an enveloping layer of viscous substances around the cell wall. This layer can be detected under the light microscope after staining the bacteria with Indian ink. Its uses include;

❑Protecting against infecting phages

❑Resist engulfment by white blood cells

❑Prevents agglutination of bacteria

❑Used by bacteria to stick firmly onto substances e.g. bacteria on teeth

Plasmids

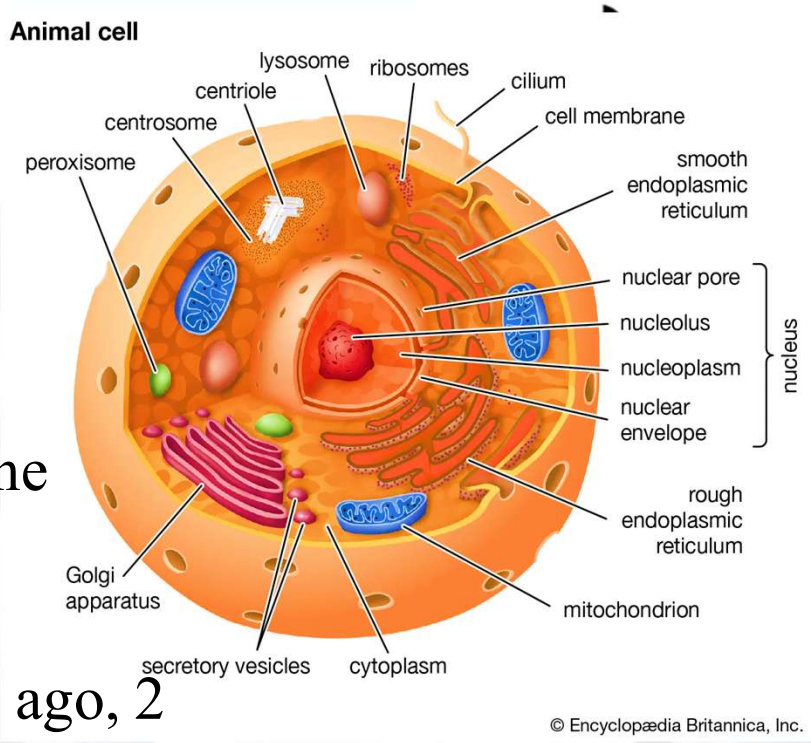
- Plasmids are small self-replicating strands of extra DNA. Plasmids possess only a few genes, and are generally concerned with survival in adverse conditions.
- Plasmids are known which; ***Confer resistance to antibiotics and disinfectants*** ,**ability to cause disease** ,**responsible for fermentation of milk to cheese**

Mesosomes

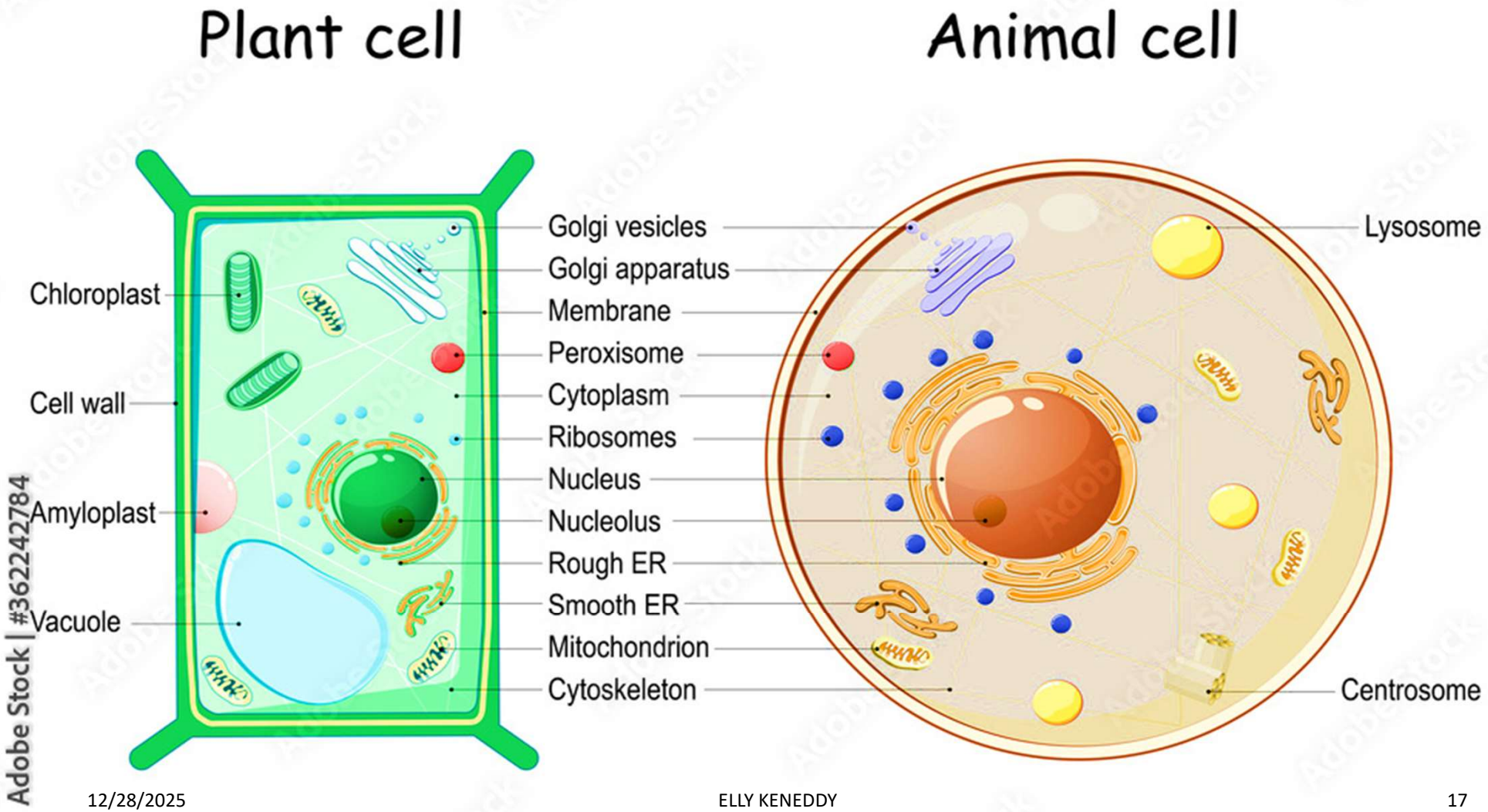
- Bacteria lack membrane bound organelles such as mitochondria and chloroplasts.
- Instead, they have invaginations of cell membranes forming a system referred to as **mesosomes**.
- They are associated with export of secretions such as cellular secretions or enzymes. They are site of respiration.

EUKARYOTIC CELL

- Cells as seen with the light microscope
- These are cells with a true nucleus.
- Their nuclear materials(DNA) are found inside the nucleus surrounded by two membranes.
- They probably evolved about 1000 million years ago, 2 million years after the prokaryotes.
- There are 2 main types of eukaryotic cells; the **plant cell** and the **animal cell.**



WHAT ARE THE COMPONENTS OF THE CELL AND FUNCTIONS OF EACH


Plant cell
Animal cell
Chloroplast
Cell wall
Amyloplast
Vacuole
Golgi vesicles
Golgi apparatus
Membrane
Peroxisome
Cytoplasm
Ribosomes
Nucleus
Nucleolus
Rough ER
Smooth ER
Mitochondrion
Cytoskeleton
Lysosome
Centrosome
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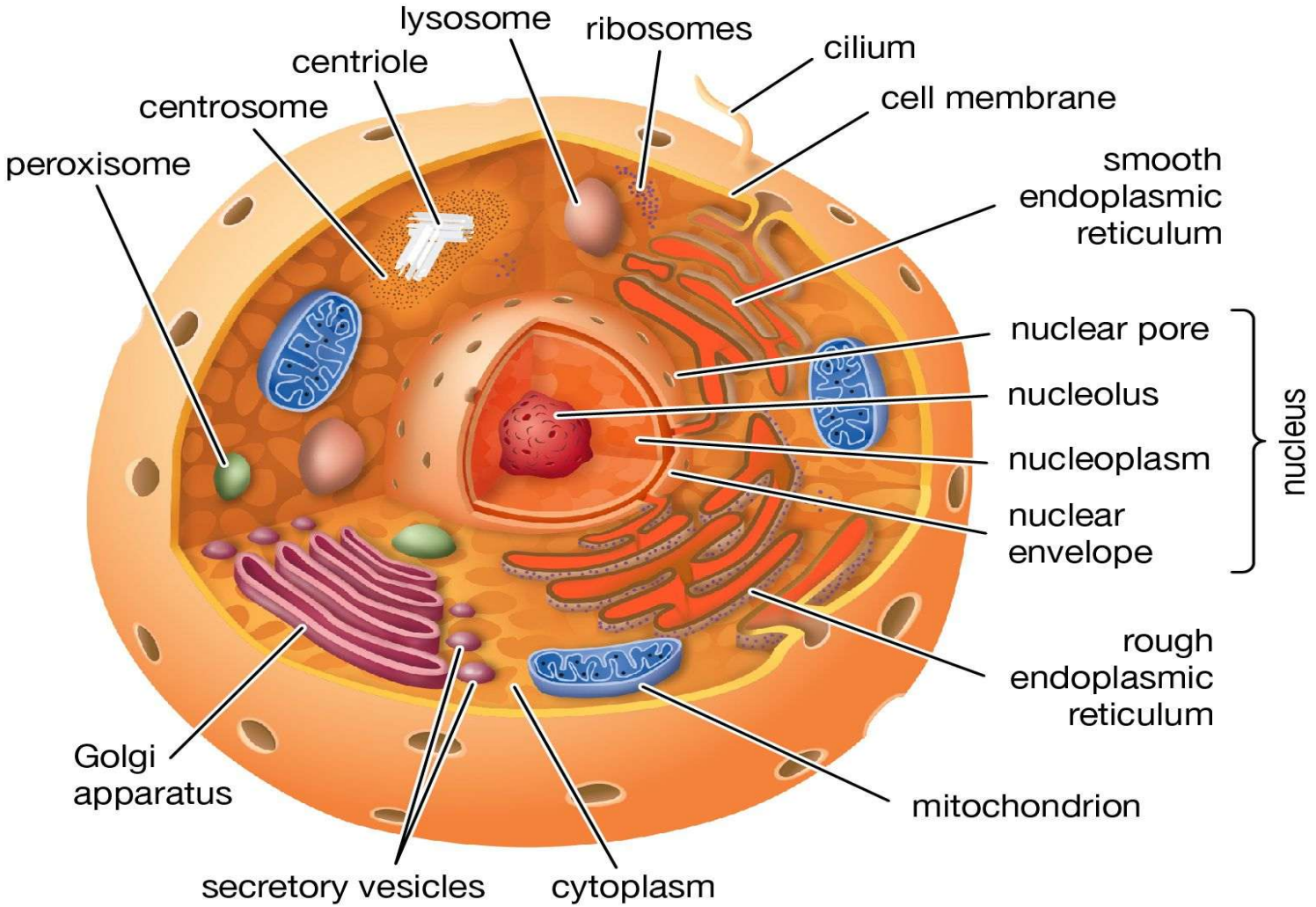
STRUCTURE OF A EUKARYOTIC CELL

- The most conspicuous structure of the cell is the **nucleus** which contains chromatin.
- Chromatin is the **loosely coiled form of chromosomes**. Chromosomes contain genetic material in the form of DNA.
- The nucleus is separated from the cytoplasm by its nuclear membrane
- The **cytoplasm contains organelles**. These include Nucleus ,Mitochondria ,Ribosomes ,Endoplasmic Reticulum, Golgi Apparatus.
- Plant cells have unique organelles such as chloroplasts, a cell wall, and a large central vacuole, while animal cells often include lysosomes and centrioles

Animal cell



ANIMAL CELL.

- An animal cell as seen in a light microscope contains protoplasm (nucleus and cytoplasm) surrounded by a thin plasma membrane.
- Each cell has a relatively **large central nucleus** surrounded by the cytoplasm.
- The nucleus contains coiled threads called chromatin.
- Chromatin contains DNA which together condense to form chromosome during cell division.
- DNA carries genetic material which controls cell activities and determines the organism's characteristics.
- The cytoplasm **contains organelles suspended within**.

Cell part	Description	Function
Cell Membrane	Is the outer living part of a cell and it is found in all cells. Its semi permeable i.e. has tiny holes through which only very small molecules like water can pass through	• It allows movement of materials in and out of the cell. • It regulates the shape and strength of a cell. • Offers protection to the inner parts of the cell. • Binds protoplasm/ cytoplasm
Cell Walls	It is found in plant cells and it is made up of cellulose (a nonliving substance) which gives it its rigid tough nature.	• It gives the plant cell its shape. • Protects the inner parts of the cell. • Allows movement of materials in and out of the cell.
Nucleus	It is surrounded by double membrane, consists of nucleolus and nucleoplasm called the nuclear membrane.	• Controls cell activities. • Controls cell division • Stores the genetic material of a cell

Cell Vacuole	Contains a watery substance called cell sap and is surrounded by a single membrane called the tonoplast.	• Stores waste materials before they are expelled. • It is a temporary food store. • Gives shape to the cell.
Chloroplast	Found in only plant cells only.	• Contains a green pigment called chlorophyll that traps sunlight for photosynthesis.
Cytoplasm	It is a fluid material that contains cell organelles e.g. mitochondria, nucleus etc.	• Site for cell activities i.e. metabolic reactions. • Site for storage of energy producing materials e.g. starch and glycogen.
Mitochondria	This is the cell 'power house'. It is found in both plant and animal cells	• It manufactures and releases energy through respiration.

Cytoplasm	It is a fluid material that contains many organelles e.g. Mitochondria, nucleus etc.	• Site for cell activities i.e. metabolic reactions. • Site for storage of energy producing materials e.g. starch and glycogen.
Golgi body	Made up of flattened saclike structures and found in both plants and animals	• Involved in cell secretions i.e. secretes enzymes. • It transports materials in cells

EUKARYOTIC VS PROKARYOTIC CELL.

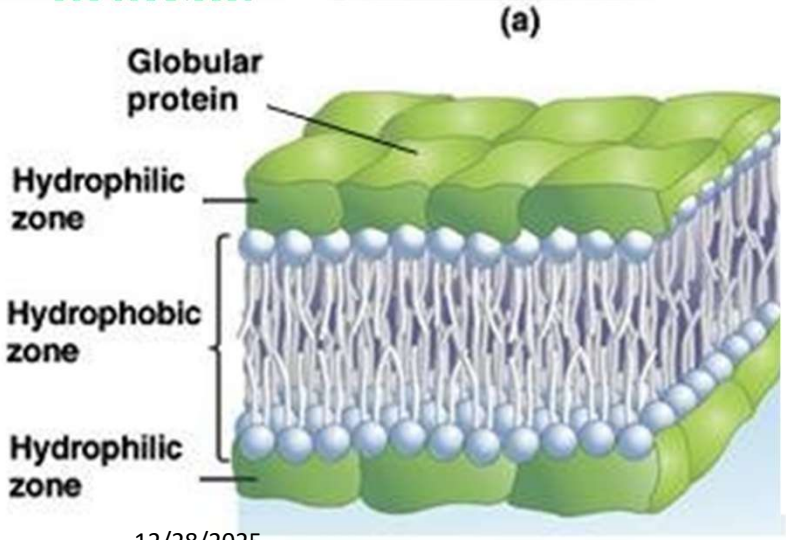
Eukaryotic Cells	Prokaryotic Cells
➢ True nucleus enclosed in a nuclear membrane	➢ No nucleus; genetic material is in nucleoid
➢ Larger in size(10–100 μm)	➢ Smaller in size (0.1–5 μm)
➢ Have membrane-bound organelles (e.g., mitochondria, ER)	➢ Have no membrane-bound organelles
➢ Plasmids are absent.	➢ Some bacteria have small circular DNA plasmids
➢ There's spindle formation	➢ No spindle formation occurs

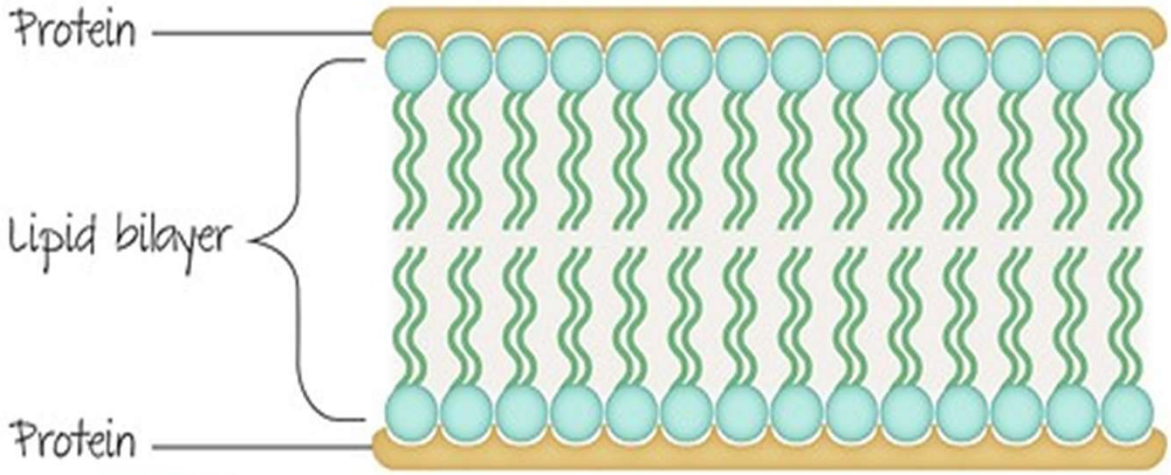
CONT.....

➢ Genetic material is circular double strand of DNA	➢ Most DNA is linear and associated with histones proteins to form chromosomes
➢ DNA is linear and associated with histone proteins	➢ Circular DNA, not associated with histones
➢ Mitosis and meiosis occurs	➢ Mitosis or meiosis doesn't occur
➢ Large ribosomes (80S)	➢ Smaller ribosomes(70S)
➢ If present cell wall is made of cellulose (plants) or chitin (fungi)	➢ Present, made of peptidoglycan (murein)

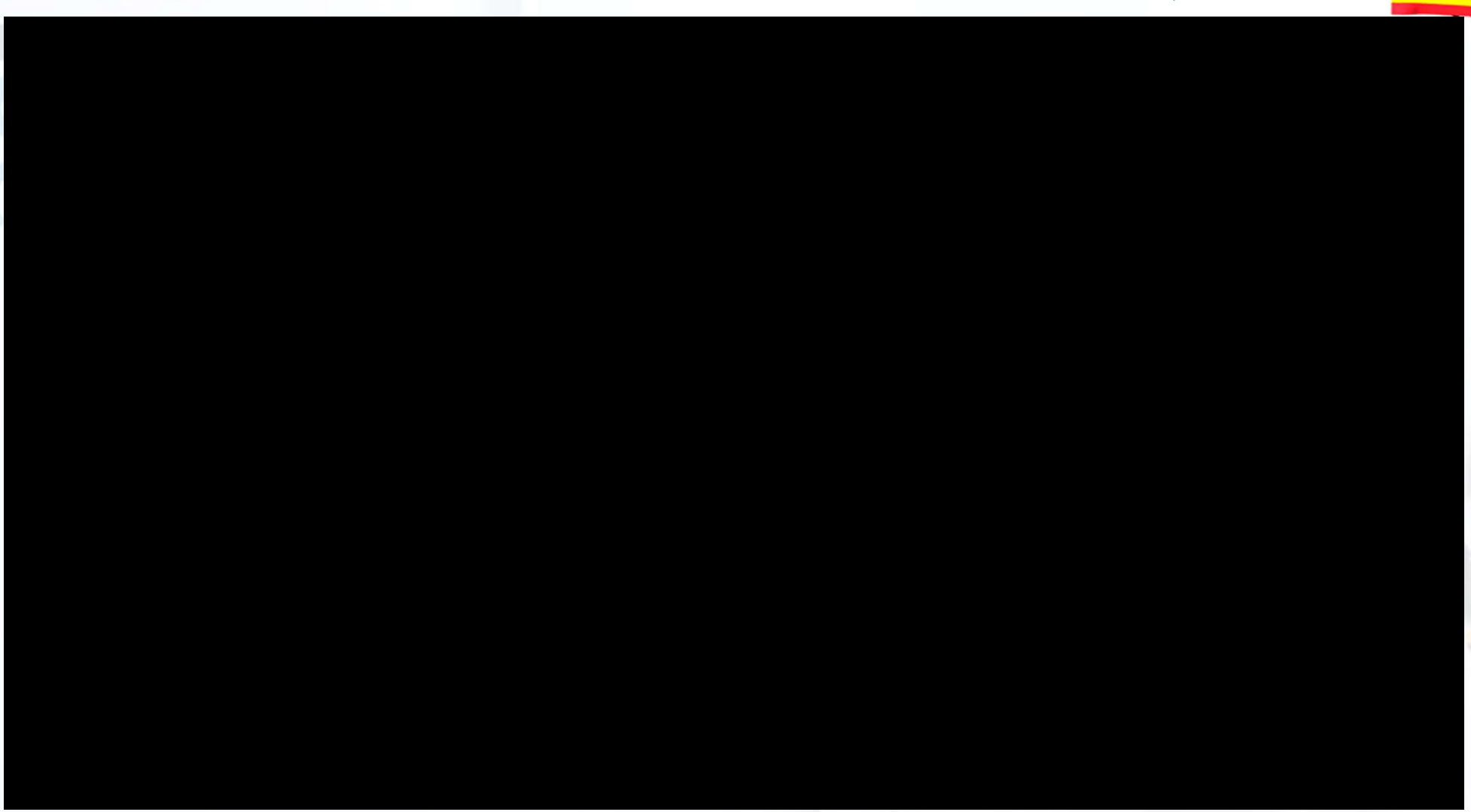
PLASMA MEMBRANE

- The cell membrane is invisible with a light microscope.
- **Danielli and Davison** proposed a membrane structure in which a lipid bilayer was coated on either side with a protein.
- This hypothesis proposes that the ***plasma membrane is made up of***
- ***three layers***: a ***bimolecular layer of lipid sandwiched*** between **two layers of protein.**



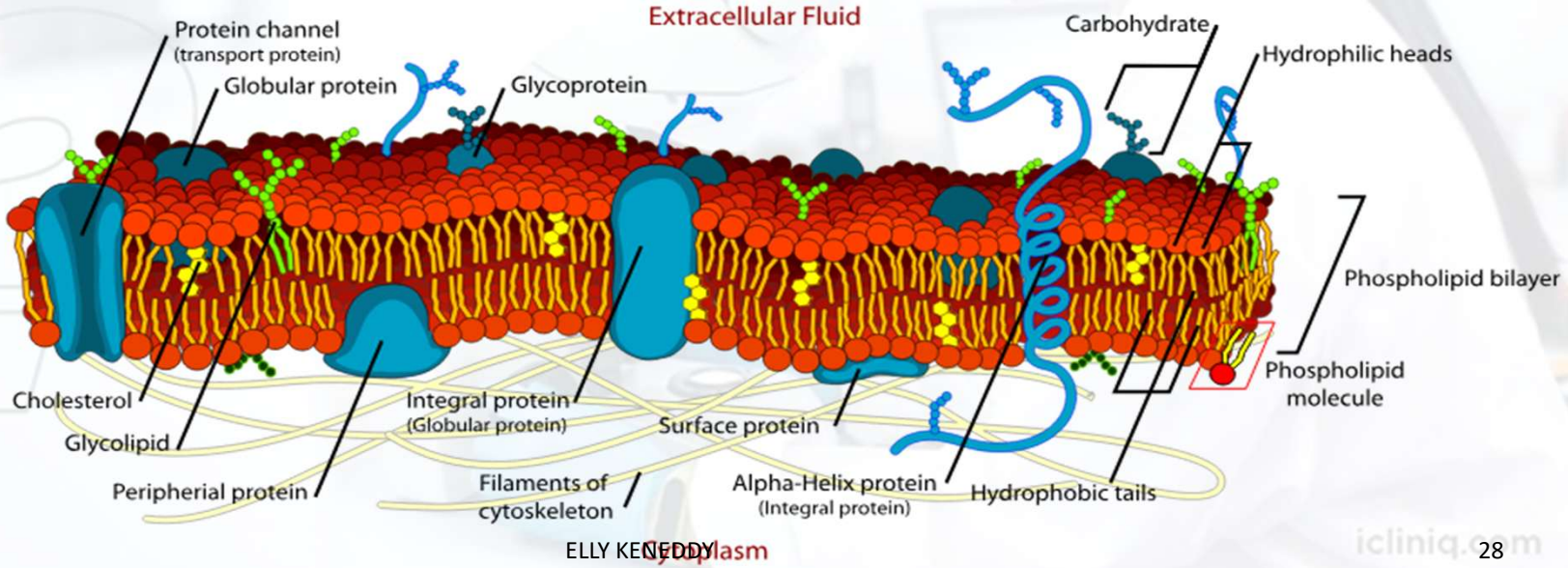


FLUID MOSAIC MODEL OF CELL MEMBRANE.

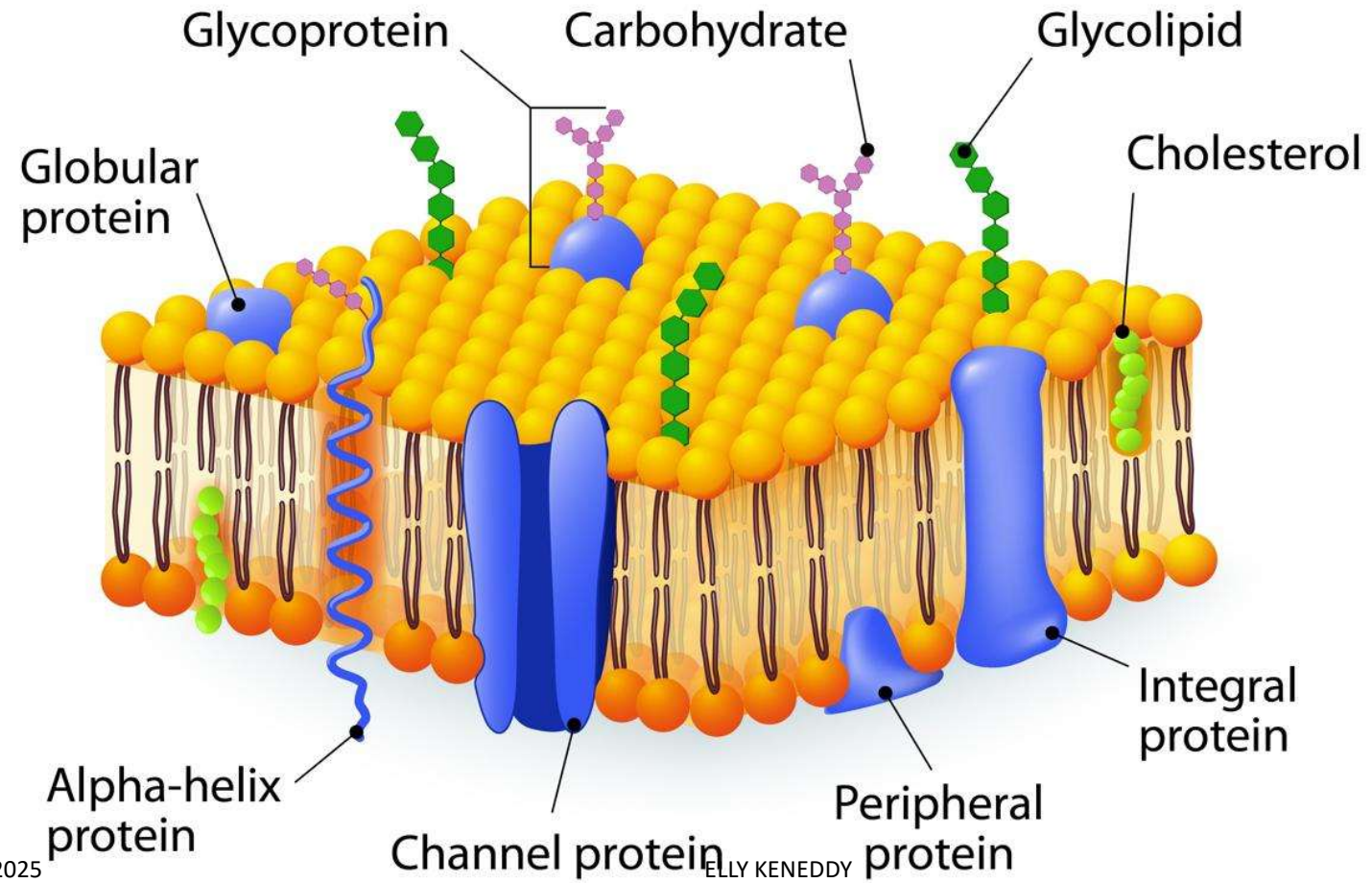


FLUID MOSAIC MODEL.

- In 1972 Singer and Nicolson suggested that the unit membrane has a fluid mosaic model.
- The fluid mosaic model proposes that the basic structure for the unit membrane is a **phospholipid bilayer with various protein molecules** embedded and attached to it.
- Each phospholipid molecule has two ends, **an outer head hydrophilic** i.e. water attracting, and the **inner tail pointing centrally hydrophobic**, i.e. water repelling

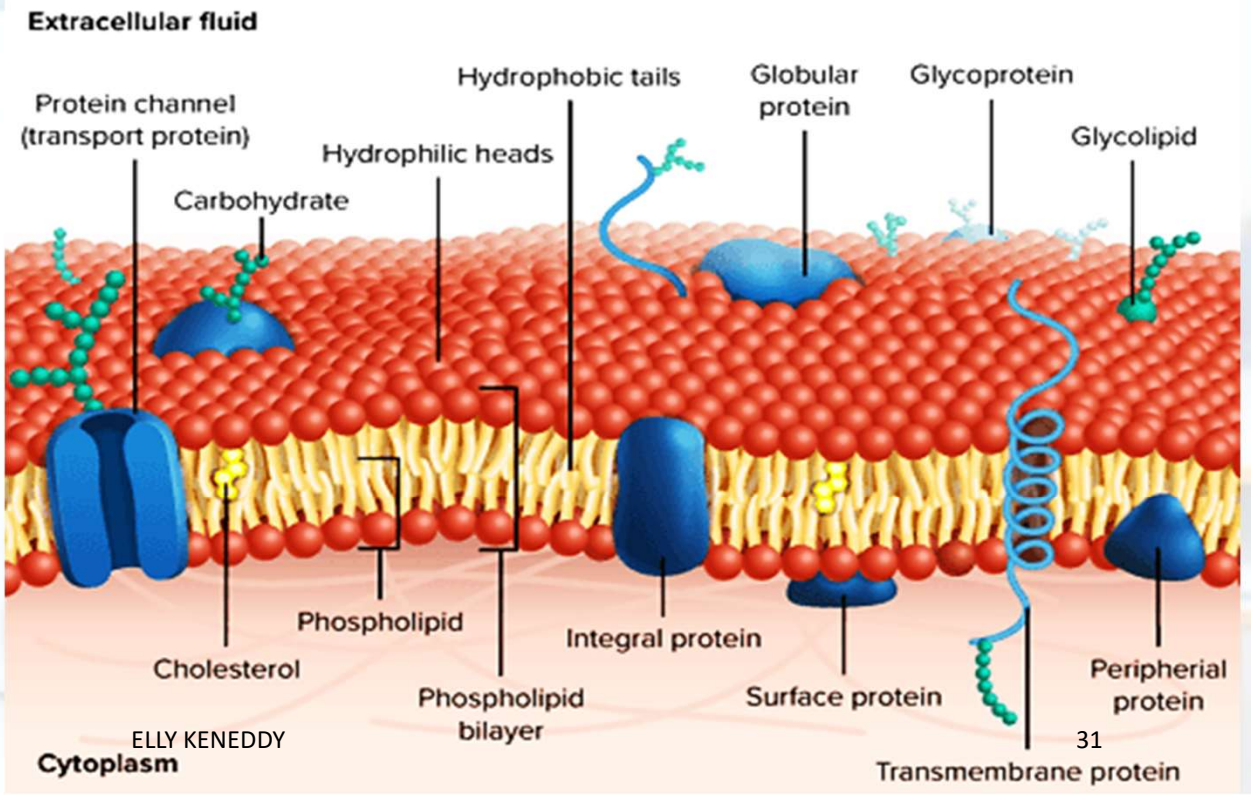


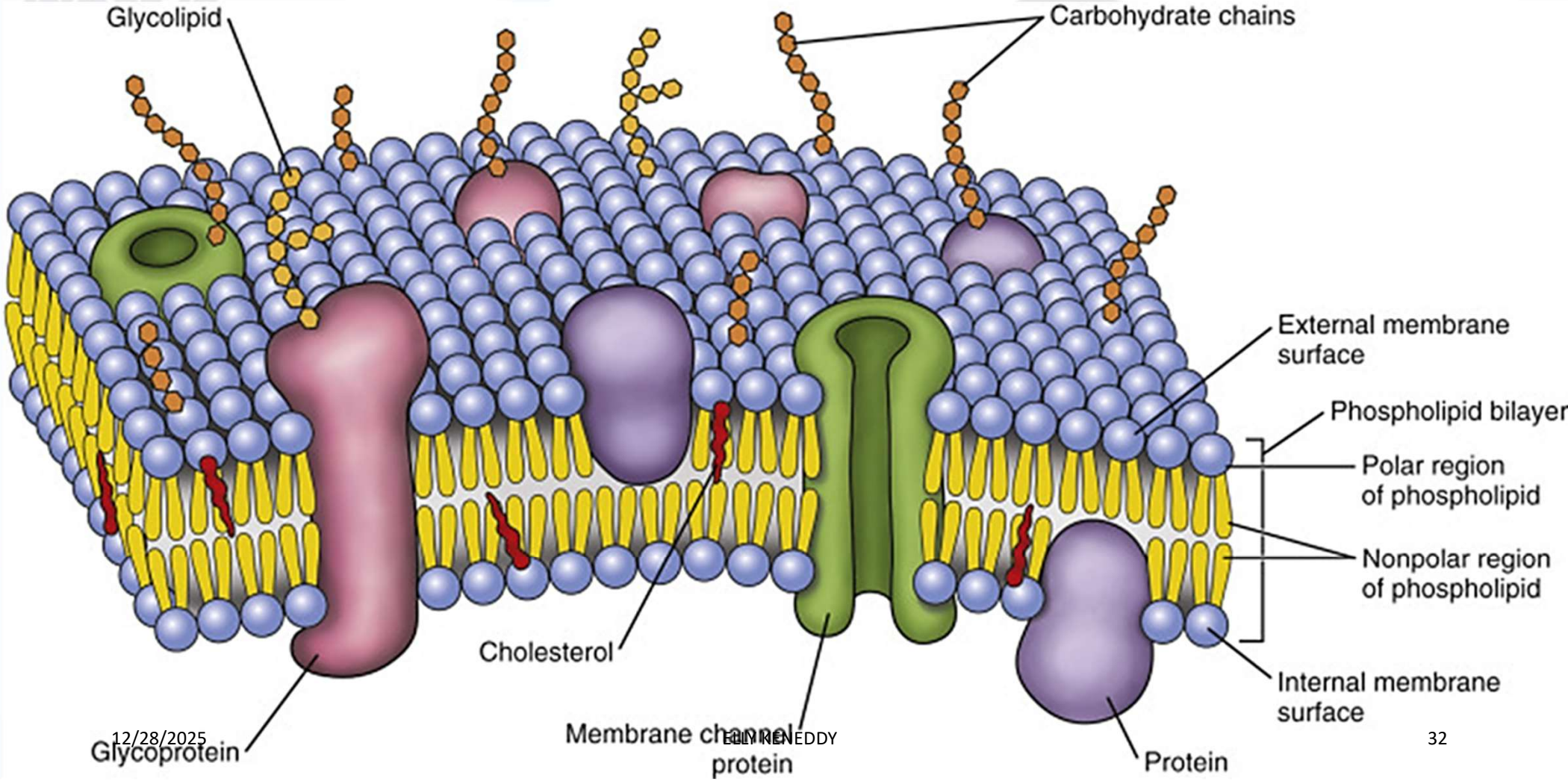
FLUID MOSAIC MODEL



- The **hydrophilic phosphate heads of the phospholipids face outwards** into the aqueous environments inside and outside the cell and form hydrogen bonds with water molecules
- The ***hydrocarbon tails face inwards and create a hydrophobic interior*** through Van der Waal forces and hydrophobic interactions.
- The **phospholipids are fluid** because they move **rapidly laterally in their own layers.**
- Some of the **fatty acid tails are saturated and some are unsaturated**. Unsaturated tails are bent and fit together more loosely.
- Most protein molecules ***float and scattered through out the phospholipid bilayer*** forming a **fluid mosaic pattern** and these **proteins stay in the membrane** because **they have regions of hydrophobic amino acids which interact with the fatty acid tails to exclude water.**
- The **membrane proteins** most of which **float individually in the fluid bilayer, form the mosaic part** of the fluid mosaic model.

- The rest of the protein is hydrophilic and faces into the cell or out into the external environment, both of which are aqueous.
- Some proteins **penetrate only part of the way** into the membrane (**extrinsic proteins**) while **others penetrate all the way through** (**intrinsic proteins**).




Glycolipid
Carbohydrate chains
External membrane surface
Phospholipid bilayer
Polar region of phospholipid
Nonpolar region of phospholipid
Internal membrane surface
Cholesterol
Glycoprotein
Membrane channel protein
Protein

CONT.....

Some proteins and lipids (phospholipids) have ***short branching carbohydrate (oligosaccharides) chains*** forming **glycoproteins** and **glycolipids** respectively, more glycoproteins are formed than glycolipids. **These are important for cell recognition**.

- Membranes also contain **cholesterol** which ***disturbs the close parking of phospholipids thus regulates membrane fluidity***.
- This is important for organisms living at **low temperatures where membranes can solidify.**
- Cholesterol also increases flexibility and stability of membranes, without it, membranes break up.
- The protein molecules are arranged in two different ways:

✓**Peripheral proteins or extrinsic proteins**: these proteins are present on the outer and inner surfaces of lipid bilayer.

✓**Integral proteins or intrinsic proteins**: These proteins penetrate the lipid bilayer partially or wholly.

ROLE OF PROTEINS WITHIN THE PLASMA MEMBRANE

- ✓Membrane proteins **form channels that allow selective passage of ions** for example, carrier proteins during facilitated diffusion. Some carrier proteins pump solutes across membranes by active transport
- ✓Some **membrane proteins are enzymes** that catalyze reactions ***that occur within or along the surface of the membrane.***
- ✓**Receptor proteins** bind with signal molecules such as hormones and neurotransmitters, and ***transmit information into the cell***
- ✓**Cell recognition**. Proteins function as identification tags for cells
- ✓In photosynthesis and respiration, membrane proteins take part in energy transfer
- ✓The various proteins dotted throughout the phospholipid bi-layer **provide structural support to the cell membrane.**

FUNCTIONS OF THE UNIT MEMBRANE

- **Anchoring cells**. Membrane proteins anchor cells to the cuticle membrane, and also to microfilaments within the cell.
- **Transport**. Membrane proteins form channels that allow selective passage of ions or molecules, for example carrier proteins during facilitated diffusion. Some carrier proteins pump solutes across membranes by active transport
- **Enzyme activity**. Some membrane proteins are enzymes that catalyze reactions that are placed within or along the surface of the membrane.
- **Signal transduction**. Receptor proteins bind with signal molecules such as hormones and neurotransmitters, and transmit information into the cell
- **Cell recognition**. Proteins function as identification tags for cells

CONT.....

- **Junction between cells**. Cell adhesion proteins of different cells together
- **Energy transducers and electron carriers.** In photosynthesis and respiration, membrane proteins take part in energy transfer
- **Structural support**. The various proteins dotted throughout the phospholipid bi-layer provide structural support to the cell membrane

TRANSPORT OF SMALL MOLECULES

- Small molecules can be transported across the plasma membrane by any one of the following three methods:
- **Diffusion**: molecules of substances move from their region of higher concentration to the regions of lower concentration. This does not require energy.
- **Osmosis**: movement of water molecules from the region of their higher concentration to the region of their lower concentration through a semipermeable membrane. There is no expenditure of energy in osmosis.
- **Active Transport**: the direction of movement of a certain molecule is opposite to that of diffusion i.e. from region of their lower concentration towards the region of their higher concentration

- This energy is provided by ATP (adenosine triphosphate).
- The active transport may also be through a carrier molecule Transport of large molecules (bulk transport)
- During bulk transport the membrane changes its form and shape. It occurs in two ways:

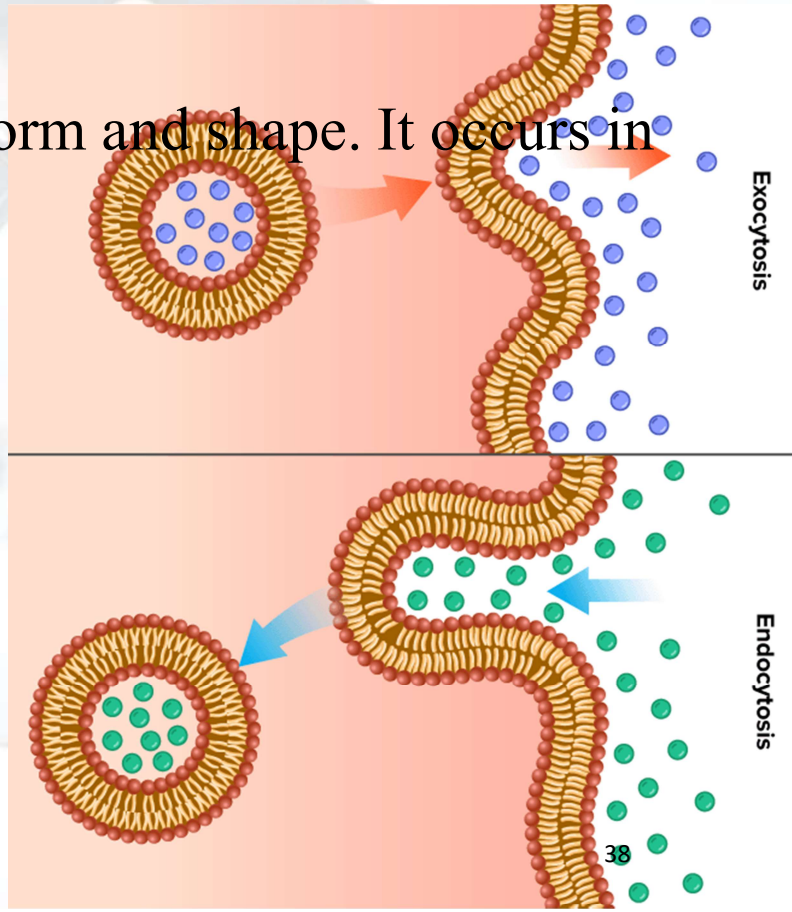
➢**Endocytosis** (taking the substance in)

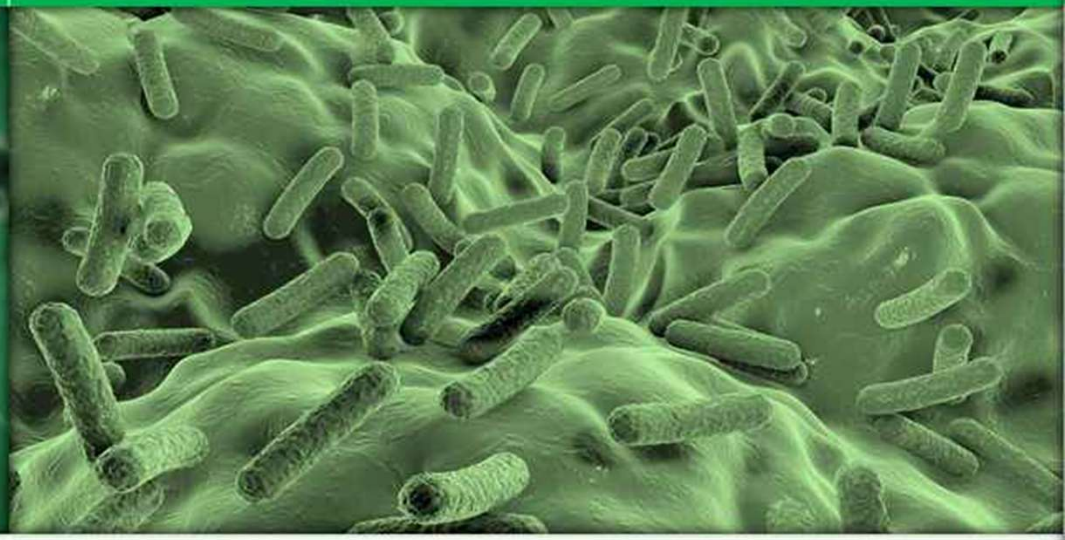
➢**Exocytosis** (passing the substance out)

- Endocytosis is of two types:

❑Phagocytosis

❑Pinocytosis



ARCHAEBACTERIA	EUBACTERIA
	
✓ Cell walls lack peptidoglycan	✓ Cell walls contain peptidoglycan
✓ Found in extreme environment	✓ Found everywhere in the environment
✓ These are primitive and oldest bacteria	✓ These are advanced or true bacteria
✓ They are always aerobic	✓ They may be aerobic or anaerobic
✓ Less sensitive to antibiotics	✓ May show sensitivity or resistance to antibiotics

ARCHAEA VS EUBACTERIA

DOMAIN ARCHAEA (KINGDOM: ARCHAEBACTERIA)

- These are unicellular prokaryotic organisms that before the rise of three domain systems. ***resemble bacteria in their appearance, and hence were fallaciously placed under bacteria***

Characteristics of Archaebacteria

- Archaebacteria are **obligate or facultative anaerobes**, i.e., they survive in the absence of oxygen and that is why only they can undergo methanogenesis.
- The **cell membranes of the Archaebacteria are composed of lipids**.
- The **cell wall is composed of Pseudomurein**, which prevents archaebacteria from the effects of Lysozyme.
- These **do not possess membrane-bound organelles** such as nuclei, endoplasmic reticulum, mitochondria, lysosomes or chloroplast.

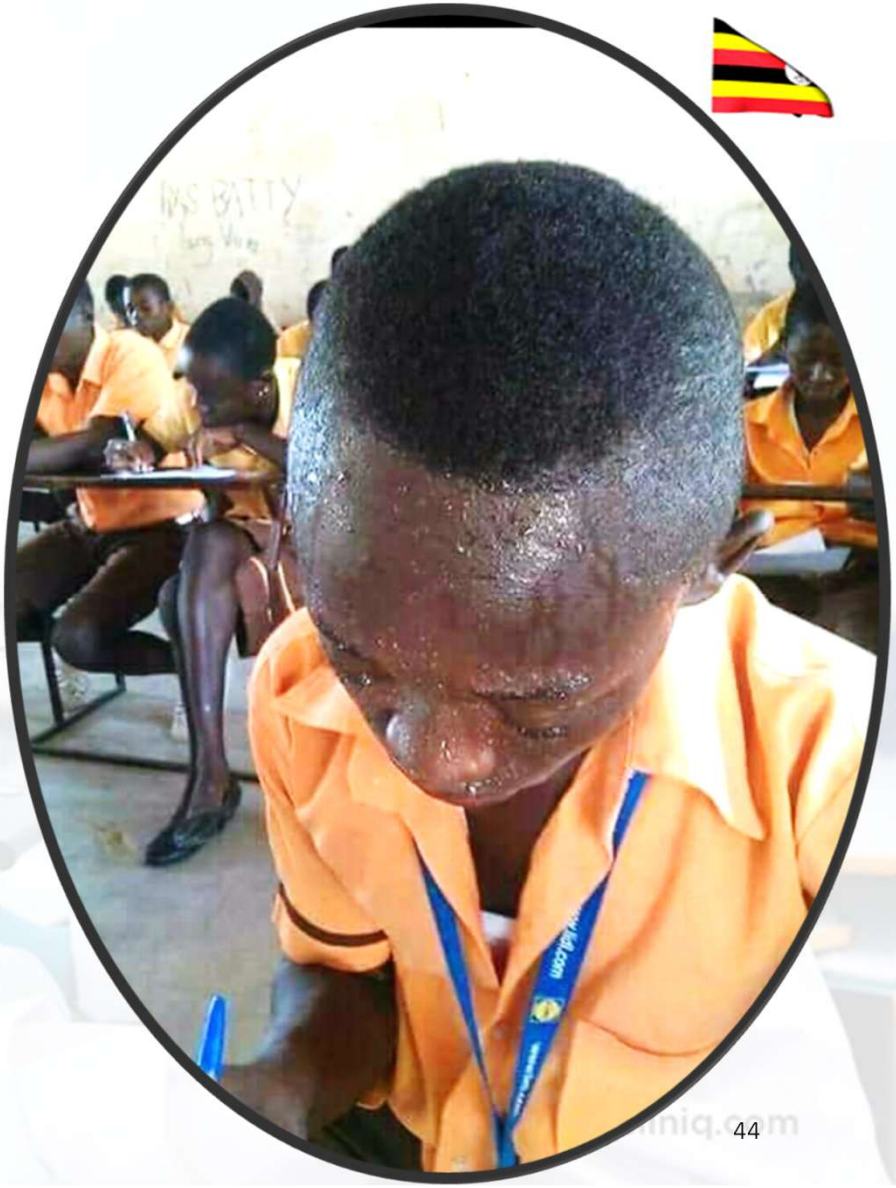
- They **can live in a variety of environments** and are hence called ***extremophiles***. They can survive in acidic and alkaline aquatic regions, and also in temperature above boiling point.
- They can withstand a very high pressure of more than 200 atmospheres.
- Archaebacteria are **resistant towards major antibiotics** because they contain plasmids which have antibiotic resistance enzymes.
- The **mode of reproduction is asexual**, known as binary fission.
- They perform unique gene transcription.
- The differences in their ribosomal RNA suggest that they diverged from both prokaryotes and eukaryotes

EUBACTERIA (TRUE BACTERIA)

- Bacteria are unicellular prokaryotic microscopic organisms.
- Their unique feature covers the presence of peptidoglycan in the cell wall unlike the Archaea and Eukarya, membrane composed of unbranched fatty acid chains attached to glycerol by ester linkages. Examples: ***Cyanobacteria, Mycoplasmas, Gram-Positive bacteria, and Gram-negative bacteria.***
- These are sensitive to most antibacterial antibiotics however show resistance against antibiotics.
- They show the asexual mode of reproduction.
- Generally, these are pathogenic but some are part of essential microbiota such as
- commensals. Such commensals play a vital role in digestion and absorption of foods, preventing pathogen colonization, activation of the immune system, and many etc.
- Bacteria are considered to be the primary decomposers of the natural ecosystem.

ACTIVITY

1. How is the structure of the plasma membrane related to function? (**08** marks)
2. How do properties of phospholipids maintain cell membrane structure (**06** marks)

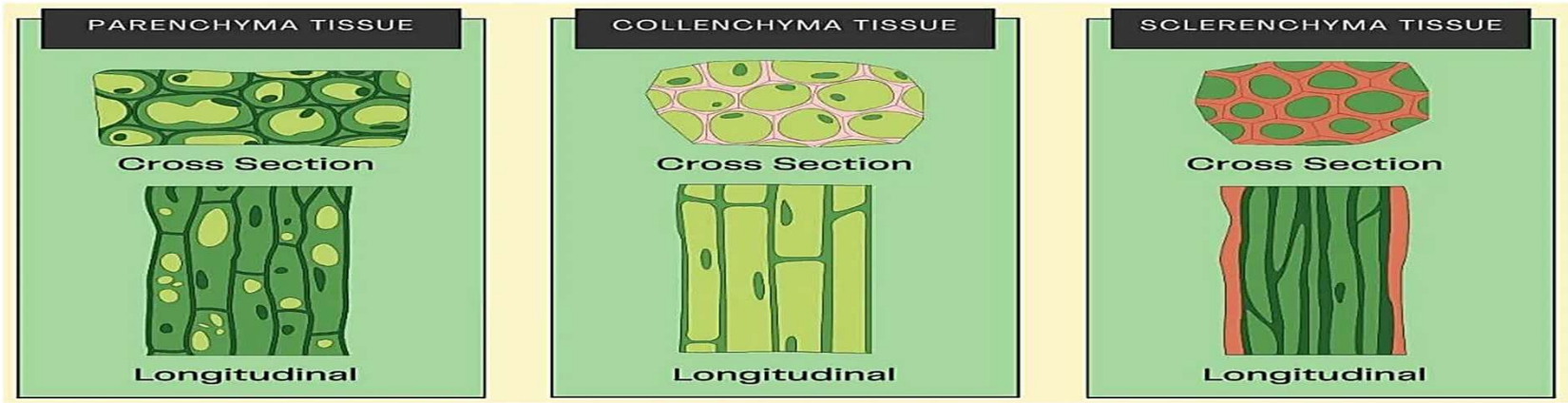


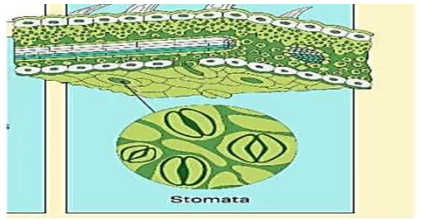
ASSIGNMENT.

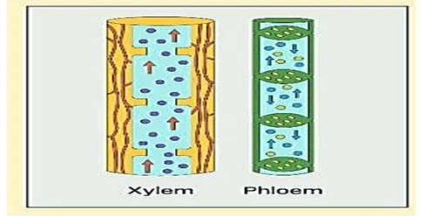
1. How is the structure of a prokaryotic cell like bacteria related to function (**10** marks)
2. Describe the various ways in which the plasma membrane permits interactions with the outside environment (**06** marks)
3. How are the Parenchyma tissues related to functions (**09** marks)
4. Discuss the relevancy of bacteria to survival of organisms in the ecosystem. (**10** marks)

RESPONSES.

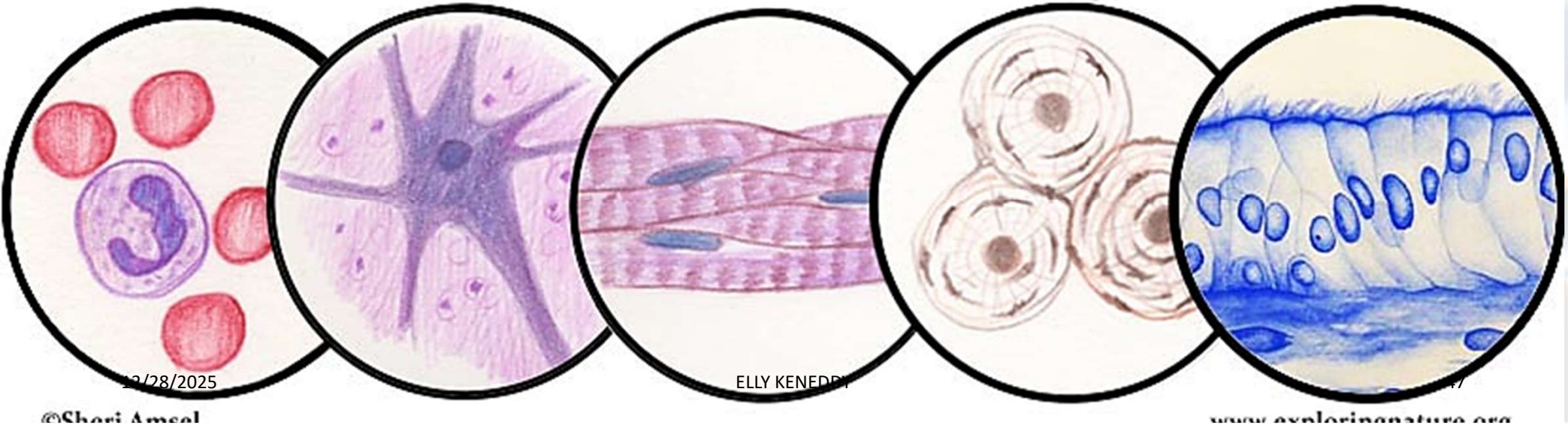
- Nutrient Recycling: Bacteria decompose organic matter, breaking down dead plants and animals into nutrients like nitrogen, phosphorus, and carbon. This process enriches the soil and makes these nutrients available for plants, which form the base of most food chains.
- Nitrogen Fixation: Certain bacteria, like those in the roots of legumes, convert atmospheric nitrogen into forms that plants can absorb and use. Nitrogen is essential for producing proteins and DNA, making these bacteria vital for life on Earth.
- Symbiotic Relationships: Many organisms rely on bacteria for survival. For instance, humans and animals have gut bacteria that help digest food and produce essential vitamins like B12 and K. Similarly, some insects depend on bacteria for nutrients or protection from pathogens.
- Disease Prevention and Balance: While some bacteria cause diseases, many beneficial bacteria compete with harmful ones, preventing their overgrowth and maintaining health in organisms and ecosystems.
- Photosynthesis and Oxygen Production: Cyanobacteria are capable of photosynthesis and played a historic role in producing oxygen for Earth's atmosphere. They continue to contribute to oxygen levels, supporting life.
- Bioremediation: Bacteria are used to clean up pollution, such as oil spills or chemical contamination, by breaking down harmful substances into less toxic forms, thus restoring ecosystems.
- Food Chain Support: Bacteria are foundational in aquatic ecosystems, forming the base of food chains as part of plankton communities. They support larger organisms like fish and whales.







TISSUES-HISTOLOGY.

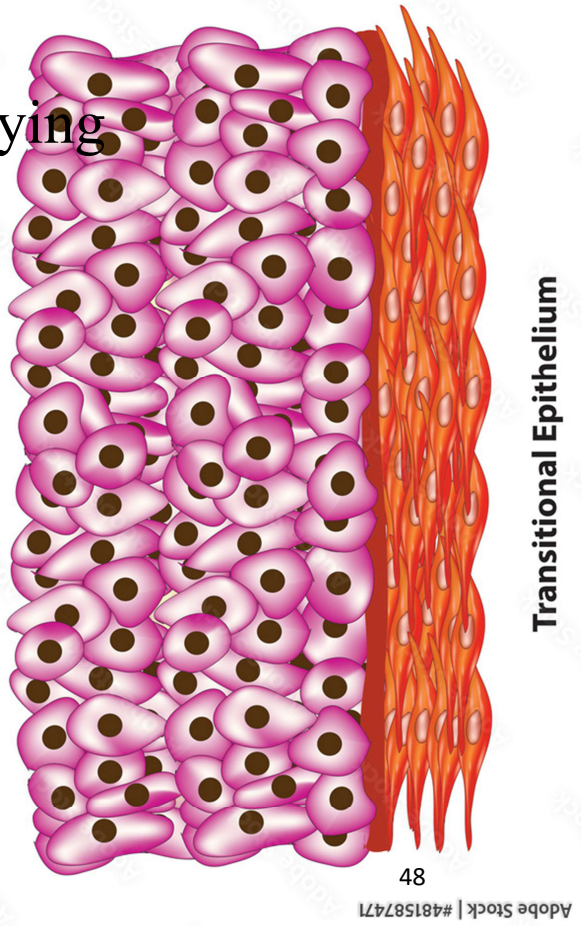


HISTOLOGY

- Histology is the study of tissues. A tissue is a group of similar physically linked cells organized into a structural and functional unit.
- It is a group of cells of similar structure organized for carrying out a particular function(s).

Characteristics of tissues

- Cells of a tissue are physically linked.
- The cells of a tissue may be interspersed with intercellular substances.
- A tissue may comprise one or more types of cells.
- A tissue is specialized to perform a particular function(s).

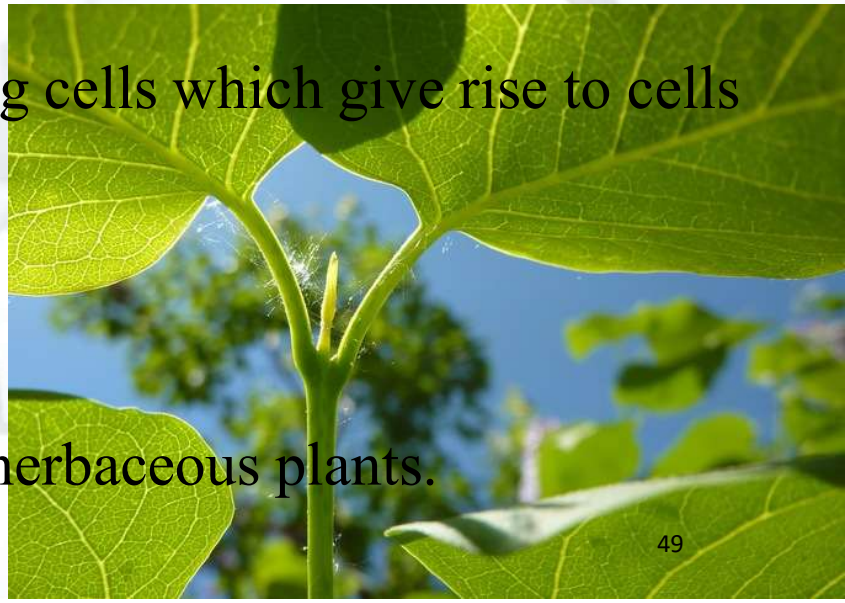


PLANT TISSUES

- 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.

Temporary tissues (meristematic tissues)

- It is a plant tissue consisting of actively dividing cells which give rise to cells that differentiate into new tissues of the plant.



Permanent tissues

- These replace the temporary tissues in all non-herbaceous plants.


MERISTEMATIC TISSUE

MERISTEM

A meristem is a group of plant cells which remain with the ability to divide by mitosis producing daughter cells which grow to form the rest of the plant body.

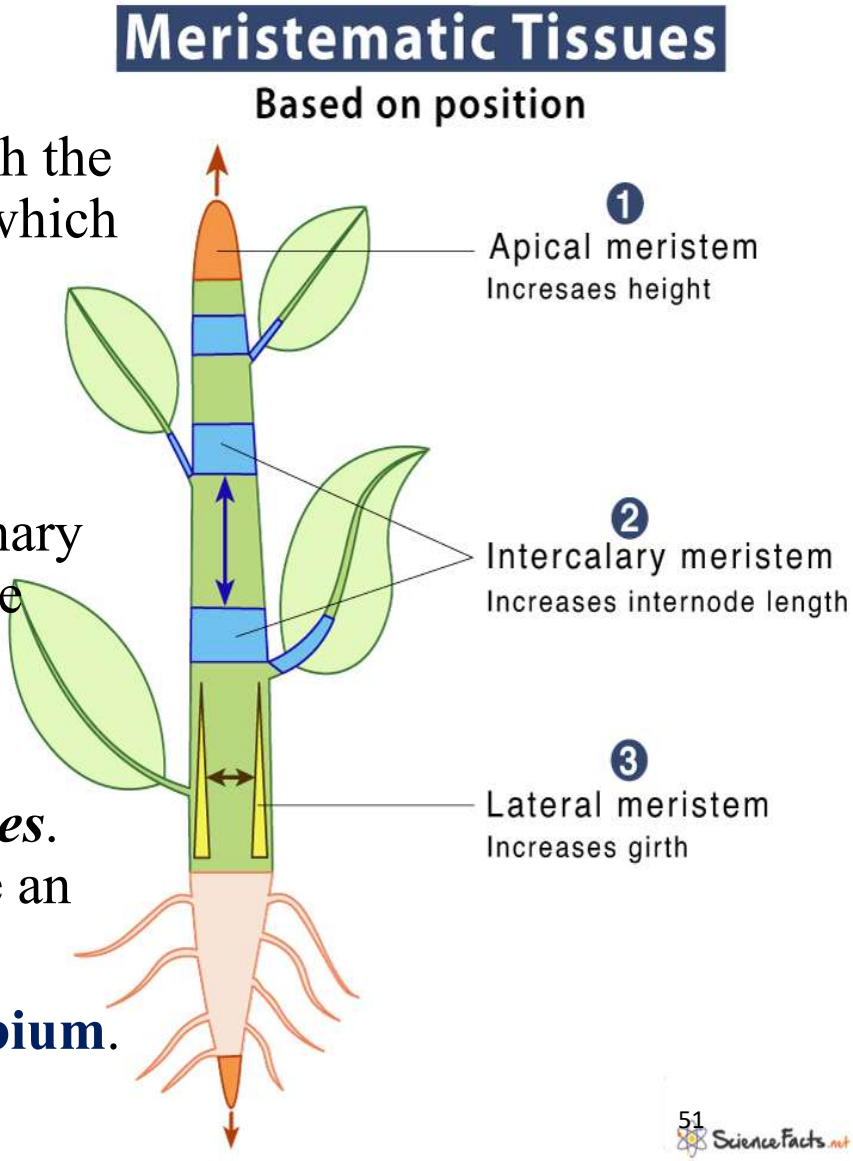
Apical meristems

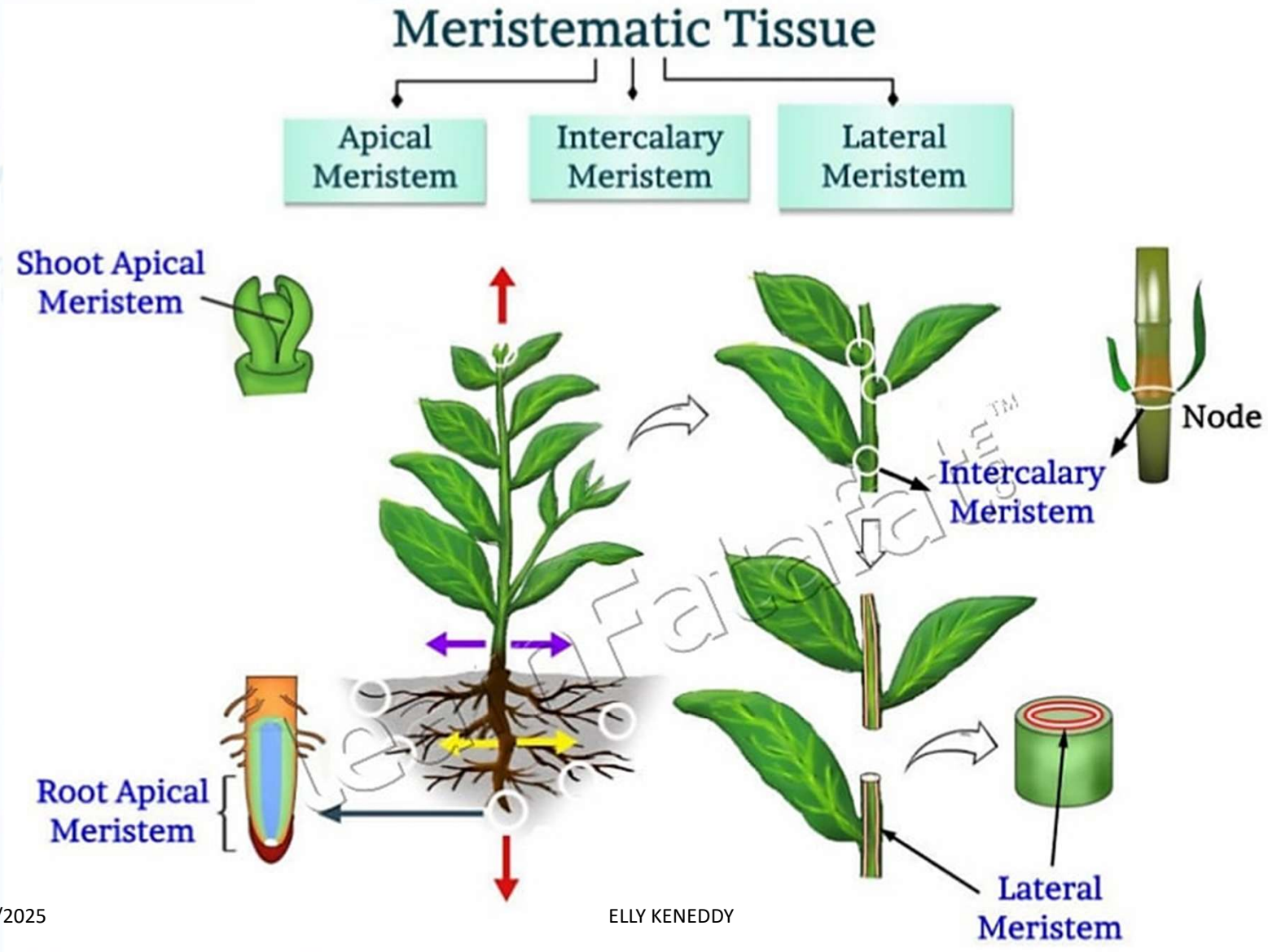
- They are found at the shoot tip and root tip.
- They divide continuously by mitosis leading to primary growth of the plant body **i.e**. increase in length of the shoot or root.

Lateral meristems (**cambium**)

These are ***found in a cylinder between vascular tissues***. They are responsible for **secondary** growth and cause an increase in **girth**.

They include the **Vascular cambium** and **Cork cambium**.




Meristematic Tissue
Apical Meristem
Intercalary Meristem
Lateral Meristem
Shoot Apical Meristem
Node
Intercalary Meristem
Root Apical Meristem
Lateral Meristem

Intercalary meristems:

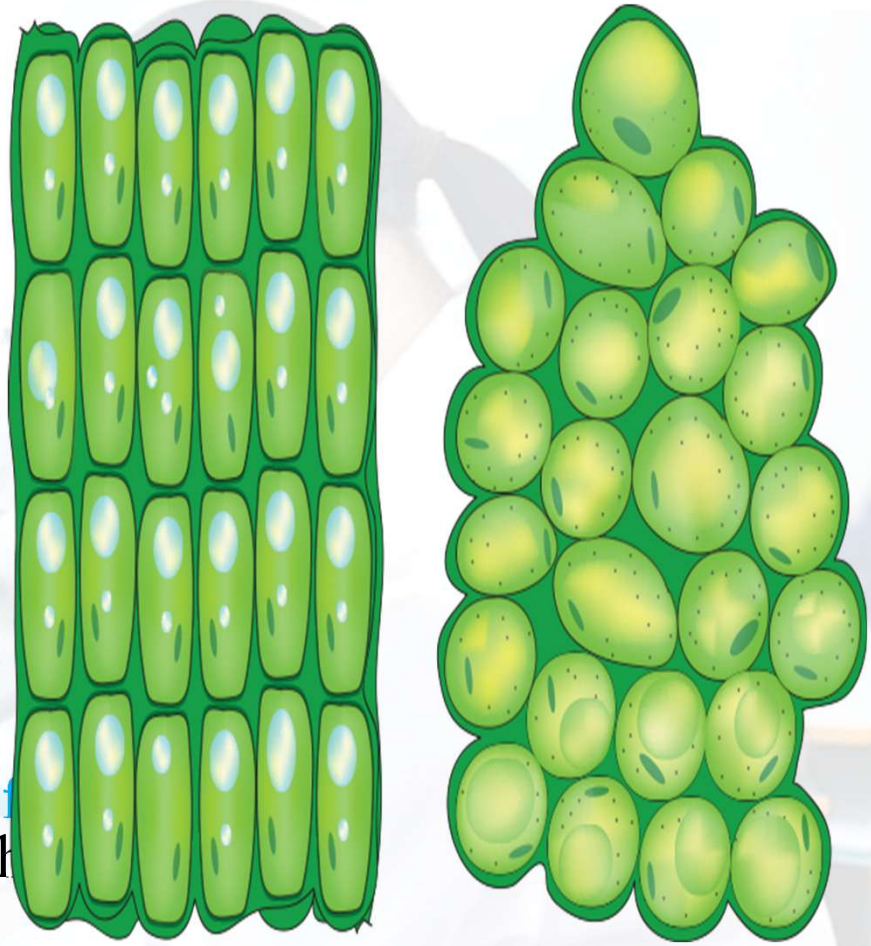
- These are found at the **nodes in monocotyledonous** plants. They allow an increase in length in positions other than the tip. Ensures continued growth.

Permanent plant tissues are of two categories;

- **Simple plant Tissues** -These are made up of one type of cell, including Parenchyma, Collenchyma and Sclerenchyma.
- **Compound plant Tissues**-These are made up of more than one cell type, include Vascular tissues which consist of Xylem and phloem

PARENCHYMA

- It consists of ***living cells*** which are ***relatively undifferentiated.***
- The cells are either roughly ***spherical*** or elongated.
- The cells ***have thin cell walls*** made up of **cellulose**, **pectin** and **hemicelluloses**.
- The cells also have large sap vacuoles with dense but peripheral cytoplasm.



Location

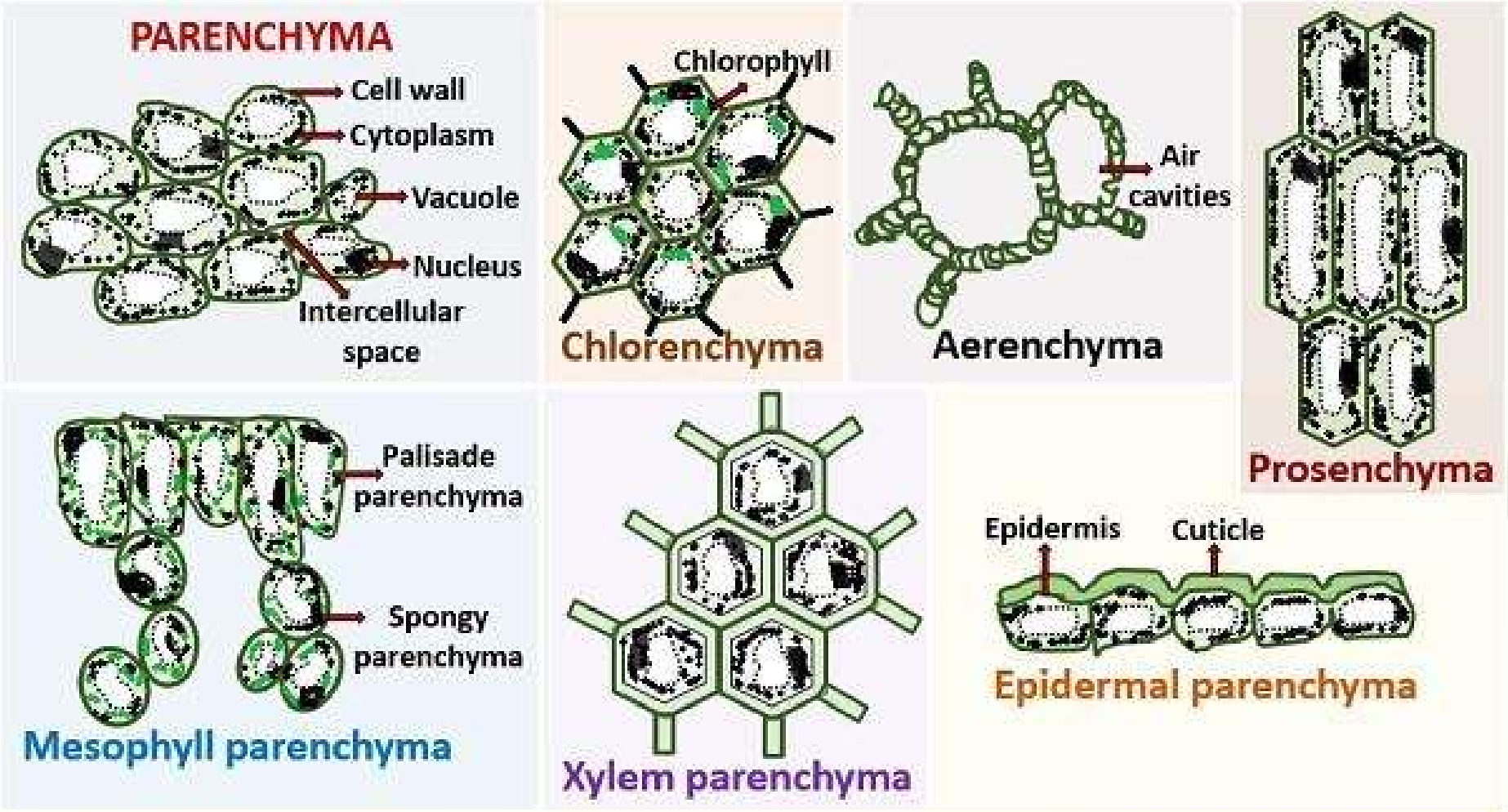
They form the ***packing tissues between more specialized tissues*** such as **pith, cortex and medullary rays**, also found in the **periphery of stems, roots and leaves** and all soft parts which appear fleshy.

FUNCTIONS OF THE PARENCHYMA TISSUE

- ✓***Acts as a packing tissue*** i.e. cells of the parenchyma fill spaces between other specialized tissues e.g. in the cortex, pith, between the xylem vessels and phloem.
- ✓When they are turgid, parenchyma cells become closely packed thus ***provide support for the organs in which they occur.*** E.g the leaves and in stems of herbaceous plants.
- ✓It is ***a storage tissue*** due to ***possession of starch granules and large food vacuoles***. Therefore, the tissue is abundant in storage organs eg the Irish potato.
- ✓It allows ***transportation of materials*** through cells by symplast pathway or apoplast pathway.

CONT.....

- The parenchyma tissue is metabolically active as it is composed of living cells for example some ***parenchyma are photosynthetic***.
- Growth of the pericycle in the roots where it retains the meristematic activity producing lateral roots and ***contributing to secondary growth***.
- In the endodermis, cells are covered by a fatty substance (suberin) that forms the Casparian strip that prevents apoplast transportation of water through the root thus ***directing the flow of water into xylem***.
- It contains intercellular air spaces which ***allow gaseous exchange***.


PARENCHYMA
Cell wall
Cytoplasm
Vacuole
Nucleus
Intercellular space
Chlorophyll
Chlorenchyma
Air cavities
Aerenchyma
Prosenchyma
Palisade parenchyma
Spongy parenchyma
Mesophyll parenchyma
Xylem parenchyma
Epidermis
Cuticle
Epidermal parenchyma
TYPES OF PARENCHYMA

ADAPTATIONS OF THE PARENCHYMA TISSUE

- The cells are **unspecialized** to **perform a variety of functions**.
- Posses many **intercellular spaces** to **increase surface area for diffusion and exchange of gases.**
- **Thin cellulose cell walls** to **allow passage of materials for transport**.
- **Transparent cell walls** to **allow easy light penetration for photosynthesis**.
- The cells are large and contain **large vacuoles** with a thin layer of cytoplasm to **provide storage space for materials** of the plant.
- Have **isodiametric**, roughly spherical or elongated cells to ***serve as a packing material between specialized cells.***
- Cells have **transparent walls** to allow ***easy penetration of light for photosynthesis.***

CONT……..

- Cells have **leucoplasts** such as amyloplasts ***to store food such as starch***.
- **Cells have numerous chloroplasts** which ***increase the surface area for photosynthesis.***
- ***Cell walls contain cellulose, pectin*** and ***hemicelluloses*** which ***increase mechanical strength for support.***
- The cells have **chromoplasts** such as in petals to ***provide bright colour to attract insects for pollination.***

Modified parenchyma

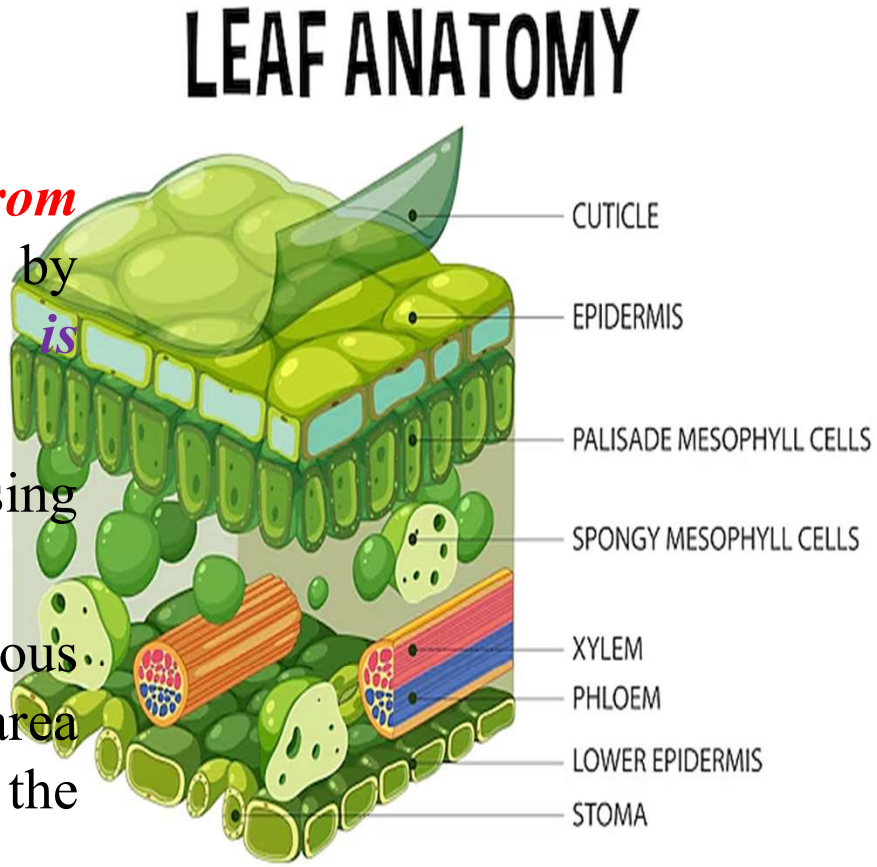
They include; **epidermis**, **mesophyll**, **endodermis**, **pericycle**, **companion cells and transfer cells**.

EPIDERMIS/EPIDERMAL CELLS

- It is a layer of one cell thick that covers the whole primary plant body.

Functions

- The basic function is to ***protect the plant body from desiccation and infection***. This is achieved by secreting **cutin** and forms the ***cuticle that is impervious to water.***
- The guard cells are important in opening and closing of stomata.
- Hairlike structures on epidermis serve various purposes e.g. root hairs increase on the surface area for absorption of water and mineral salts by the roots.

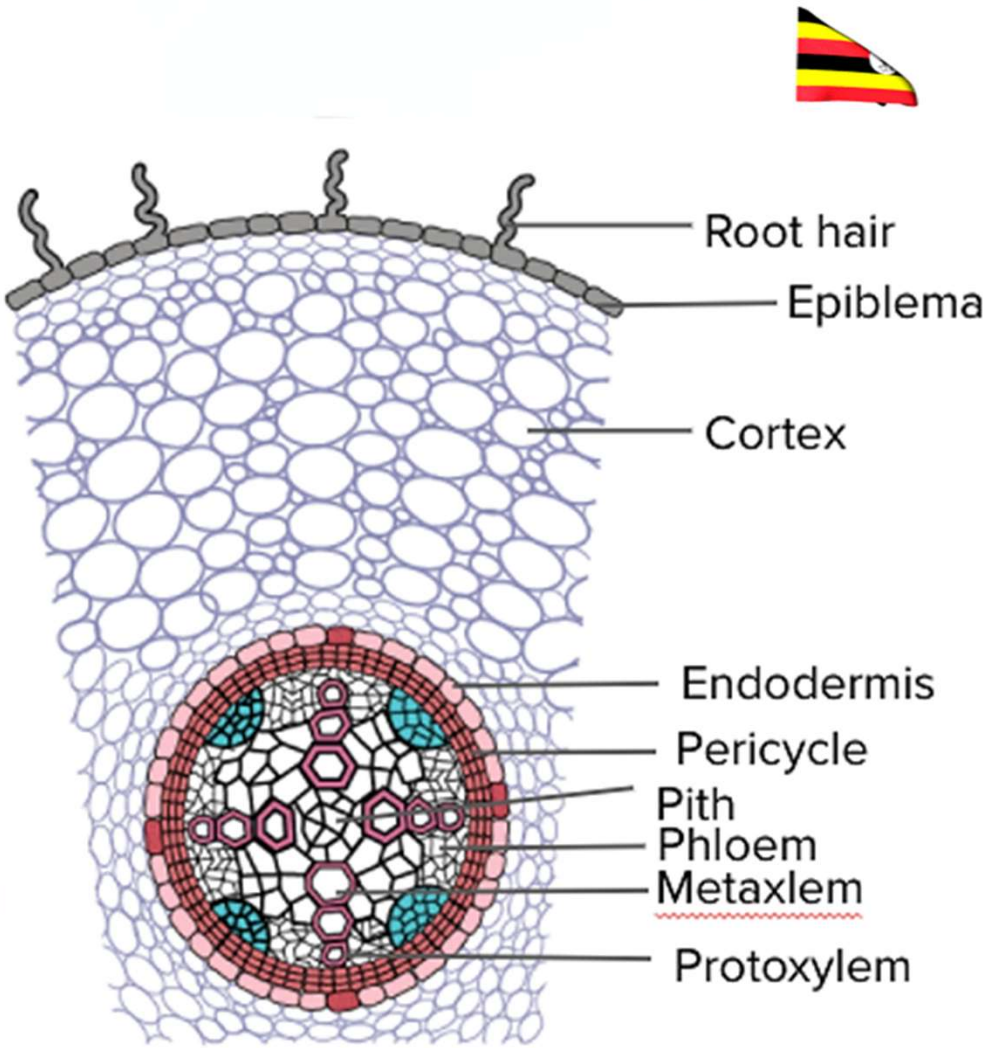


Pericycle

- This is made up of one to several layers of parenchyma cells. Pericycle is found between the endodermis and central vascular tissues.
- It can divide to produce the lateral roots and it is involved in the secondary growth of roots.

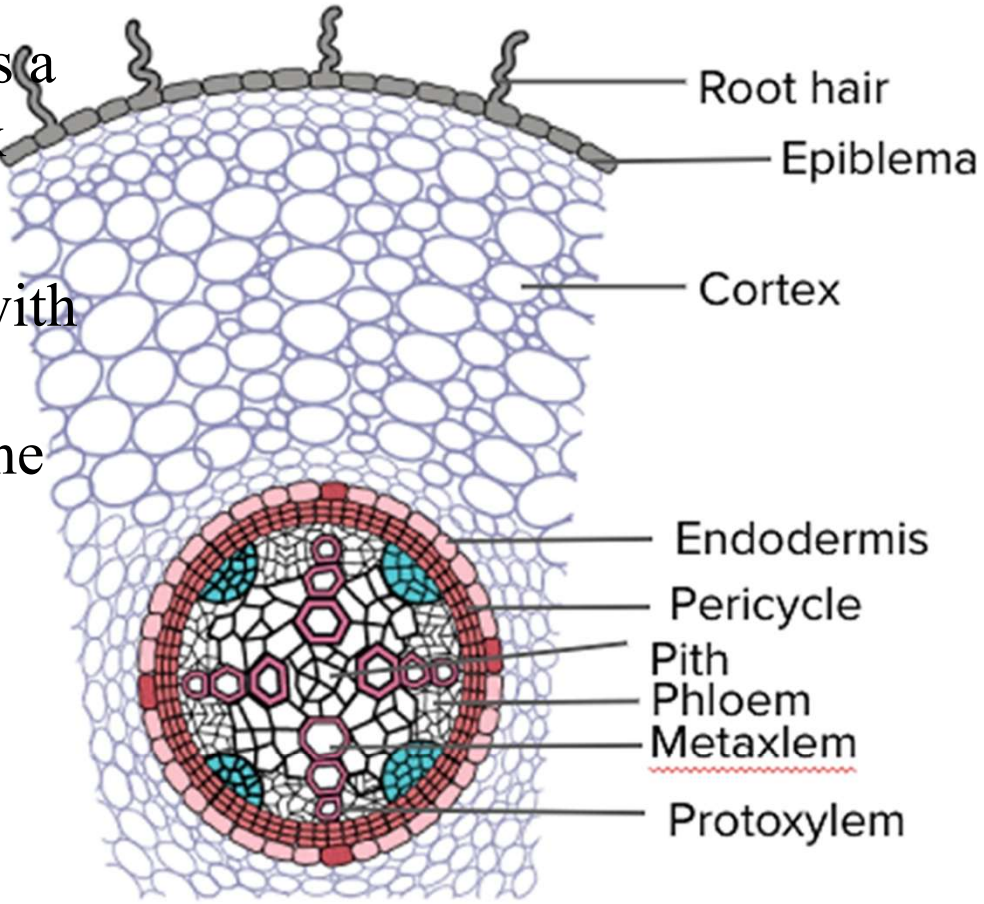
Palisade mesophyll

- This is made up of column shaped cells and it's found below the upper epidermis.
- Function: It contains many chloroplasts that enable a leaf to carry out photosynthesis.



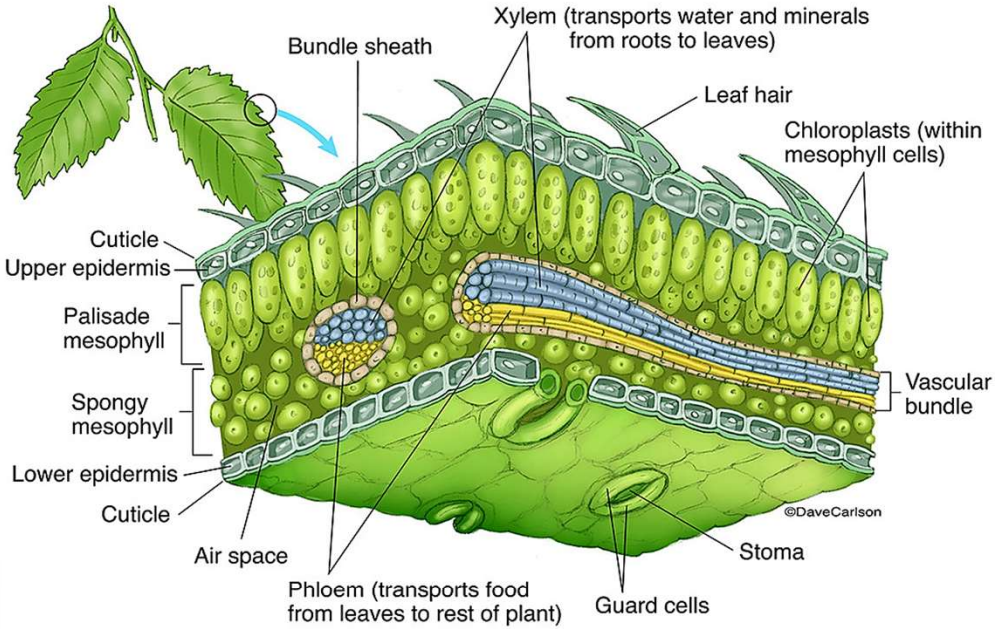
Endodermis

- It consists of a single-celled ring which is a selective barrier between the outer cortex and the inner pericycle tissues.
- In roots the endodermis is impregnated with suberin to form a distinct Casparian strip and prevent the movement of water via the apoplast pathway.
- Non-suberized passage cells in the endodermis permit lateral movement of water and mineral salts.



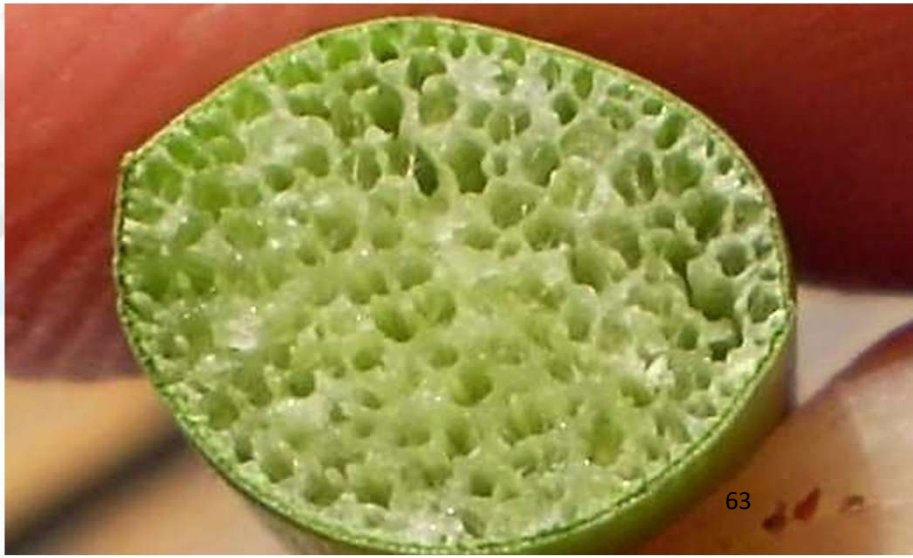
Spongy mesophyll

- It has isodiametric or irregular shaped cells.
- They are loosely packed with many intracellular space for gaseous exchange.
- They have fewer chloroplasts than the palisade cells to carry out photosynthesis



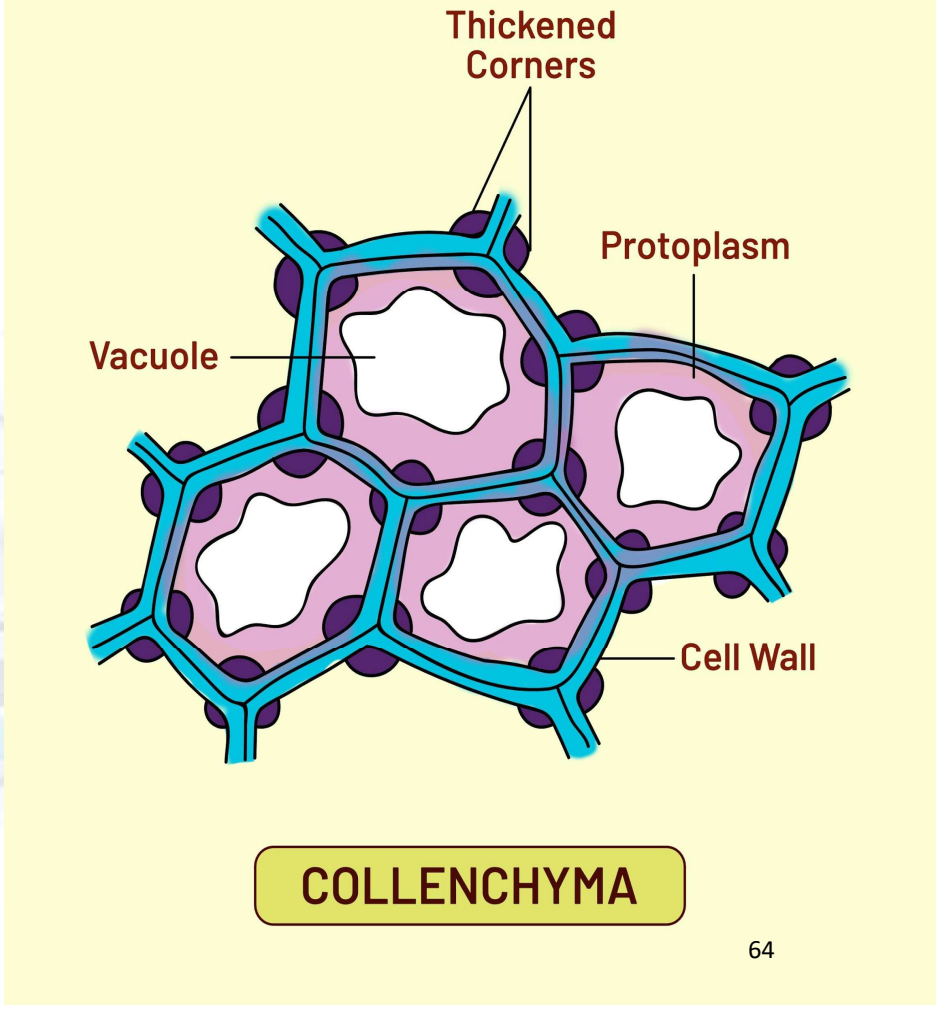
Aerenchyma

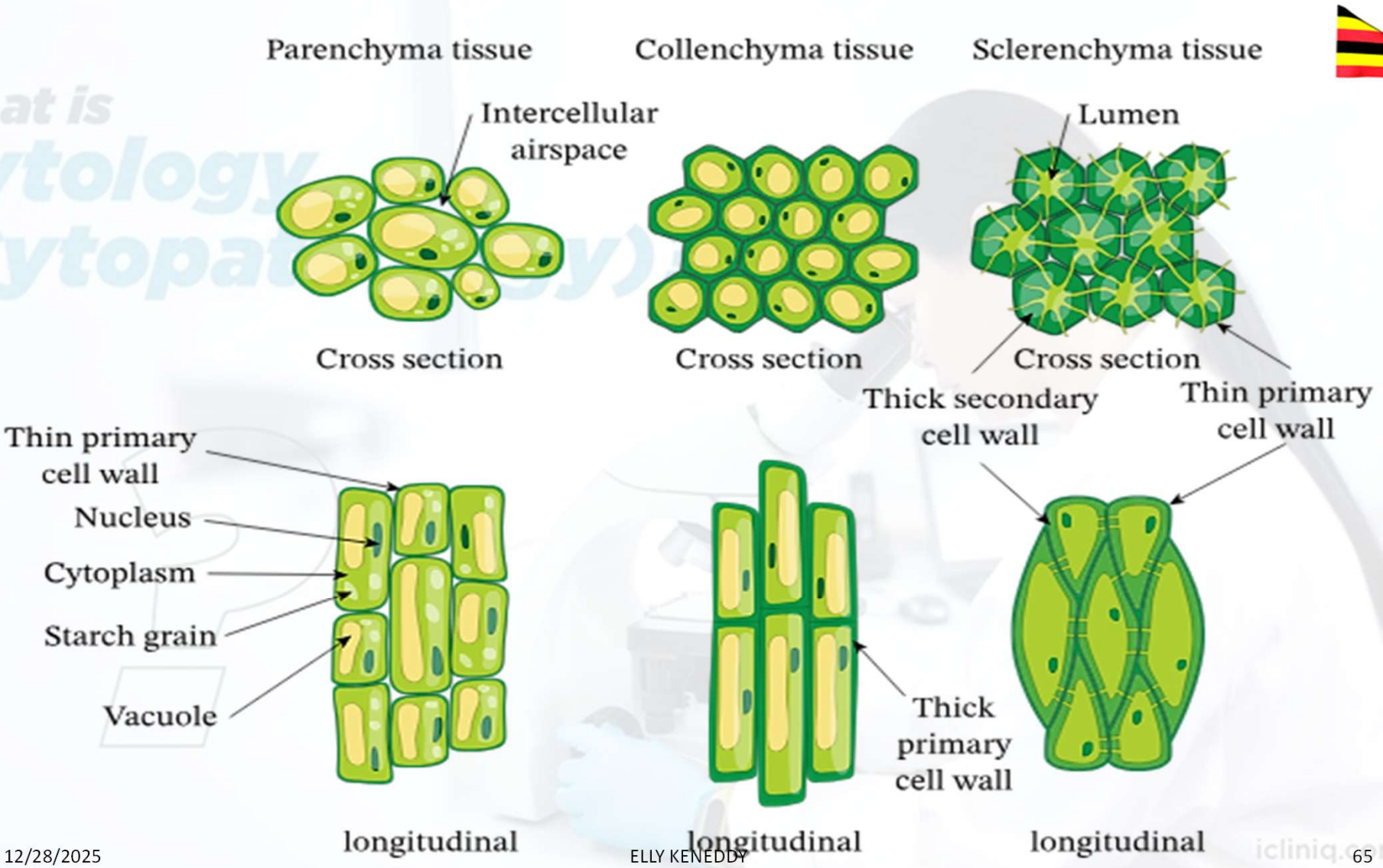
- Parenchyma tissues that surround large air spaces form reservoirs of oxygen and permit gaseous exchange in submerged parts.
- The large air spaces also provide buoyancy.



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



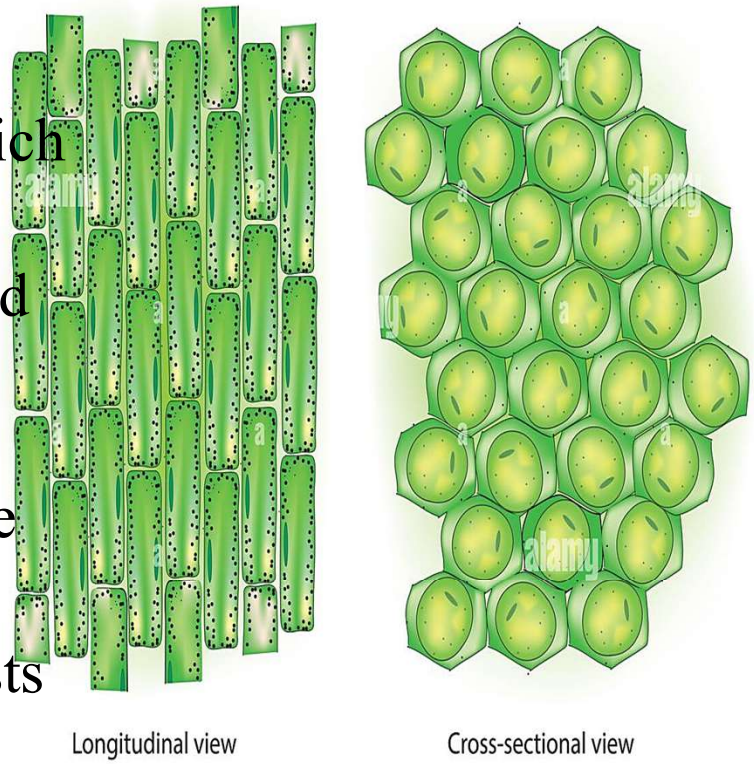

Parenchyma tissue
Collenchyma tissue
Sclerenchyma tissue
Intercellular airspace
Lumen
Cross section
Cross section
Cross section
Thick secondary cell wall
Thin primary cell wall
Thin primary cell wall
Nucleus
Cytoplasm
Starch grain
Vacuole
Thick primary cell wall
longitudinal
longitudinal
longitudinal

Location

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

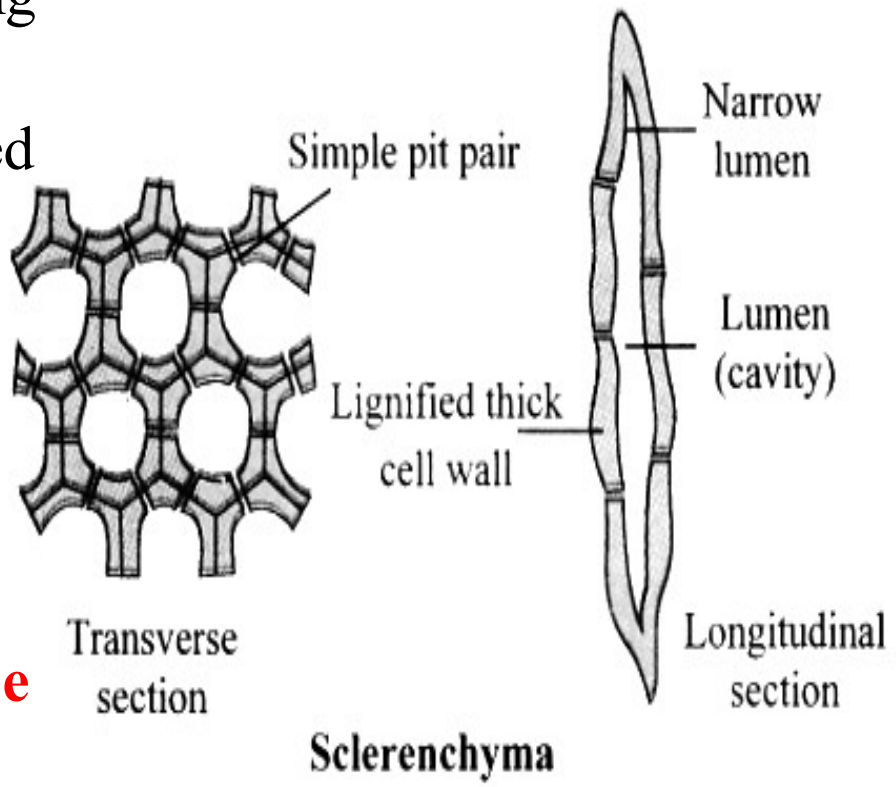
Functions

- 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.
- It allows the cell to expand and be stretched as the young stem grows.
- Some of the collenchyma cells contain chloroplasts which carry out photosynthesis



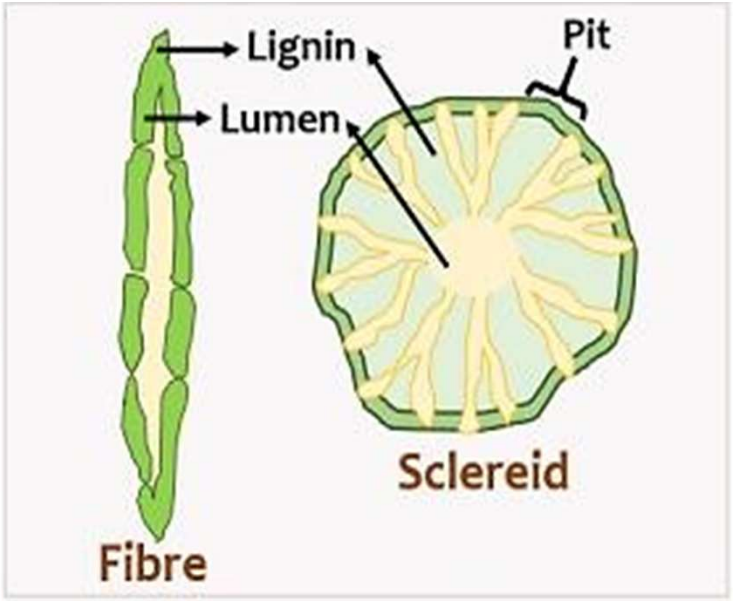
SCLERENCHYMA FIBERS

- These are polygonal shaped cells with tapering ends.
- Mature sclerenchyma cells have thick lignified secondary cell wall impermeable to water, solutes and gases.
- The cells have protoplast with narrow empty lumen.
- Pits are present in cell walls.
- Sclerenchyma fibers are **found below the epidermis** of the stems or roots or **around the vascular bundles** and **in the midrib of the leaves**.



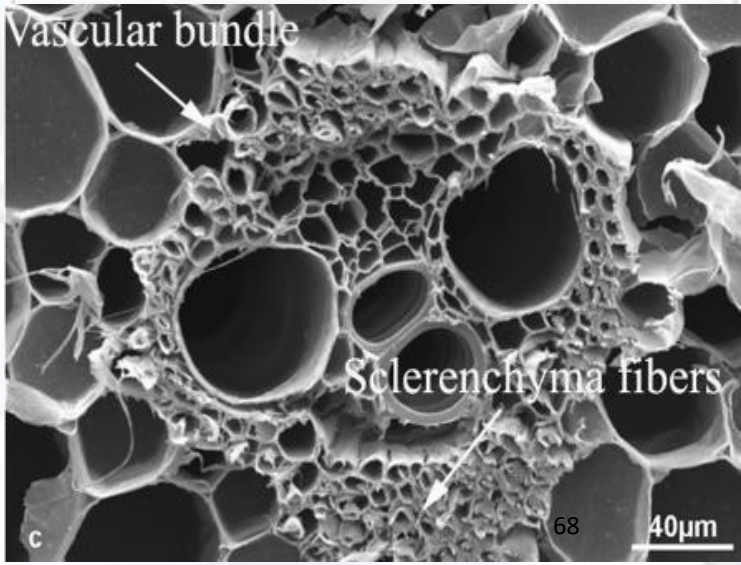
They are two types of sclerenchyma

- ❖Sclerenchyma fibers
- ❖Sclereids (stone cells)



Functions

- ❑It acts as a supporting tissue. Collectively the tightly packed sclerenchyma fibers with thick lignified walls provide the plant with mechanical strength and rigidity.
- ❑The tapering ends of sclerenchyma fibers overlap and interlock with one another, further increasing their combined strength



ADAPTATIONS OF SCLERENCHYMA FIBERS TO ITS FUNCTIONS

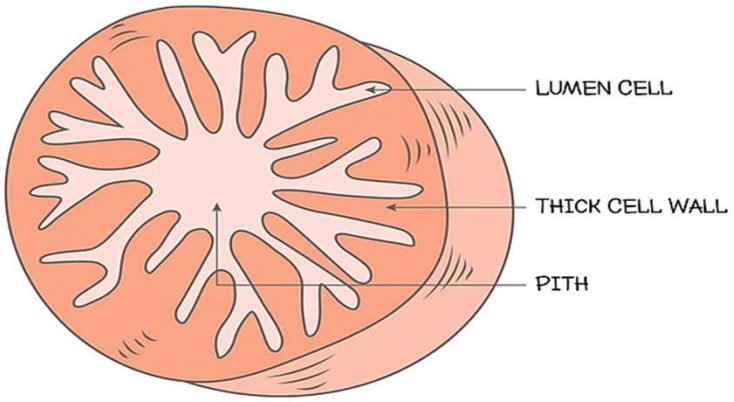
- Cells have highly lignified thick walls to provide enough resistance to forces of the environment.
- Cells are dead and therefore take no extra metabolic demand on the plant.
- Fibers are elongated and arranged in sheets/strands to increase strength.
- Fibers are interlocked to enhance their combined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

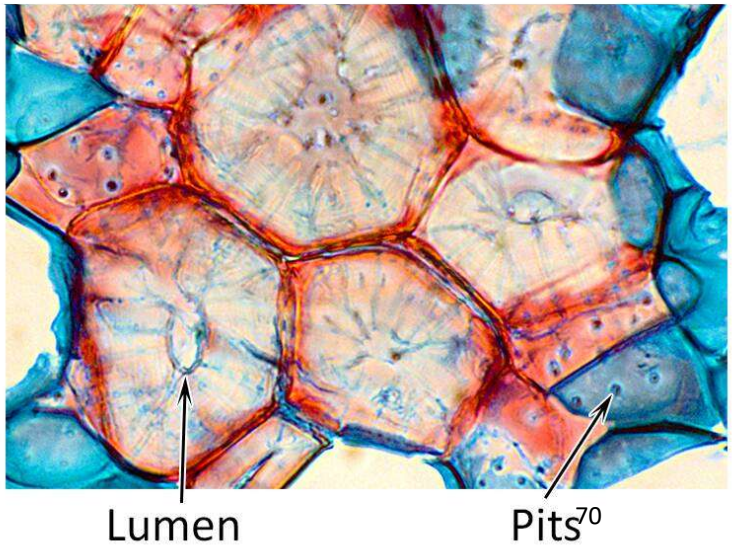
SCLEREIDS (STONE CELLS)

- They consist of dead cells with thicker lignified walls.
- These are dead cells irregular in shape.
- They have a narrow lumen and simple branched pits.
- Simple branching pit are present in the walls.

Functions

- Provide support, firmness and hardness where they occur.
- Responsible for grittiness when the fruit is eaten.
- ***Location***: ***In the cortex, phloem of woody plants. Endocarps of seeds like coconut.***



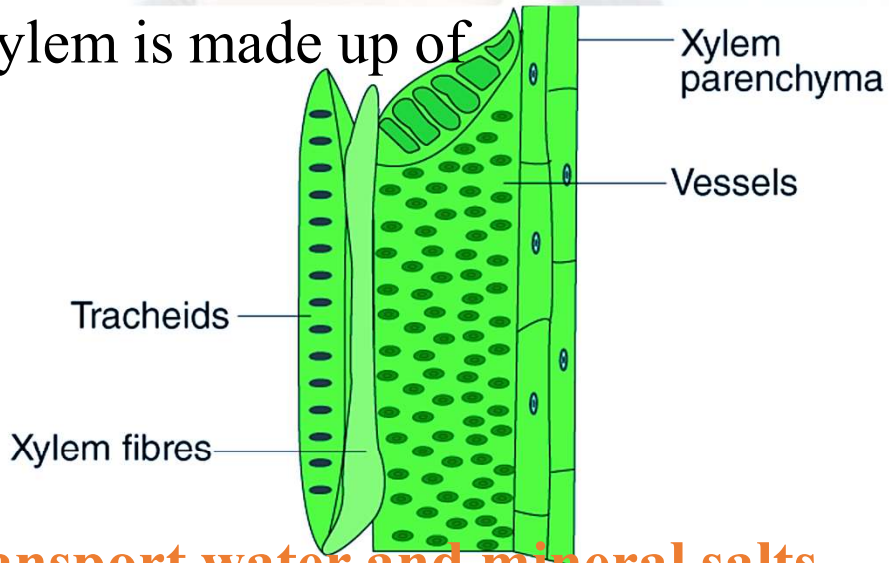


THE VASCULAR TISSUE

- Vascular tissue consists of **xylem** and **phloem** which are specialized for the internal transport of substances in the plant.

Xylem tissue

- Xylem tissue is commonly called wood. Xylem is made up of
  - ➢Xylem tracheids
  - ➢Xylem vessels
  - ➢Parenchyma cells
  - ➢Xylem fibers.

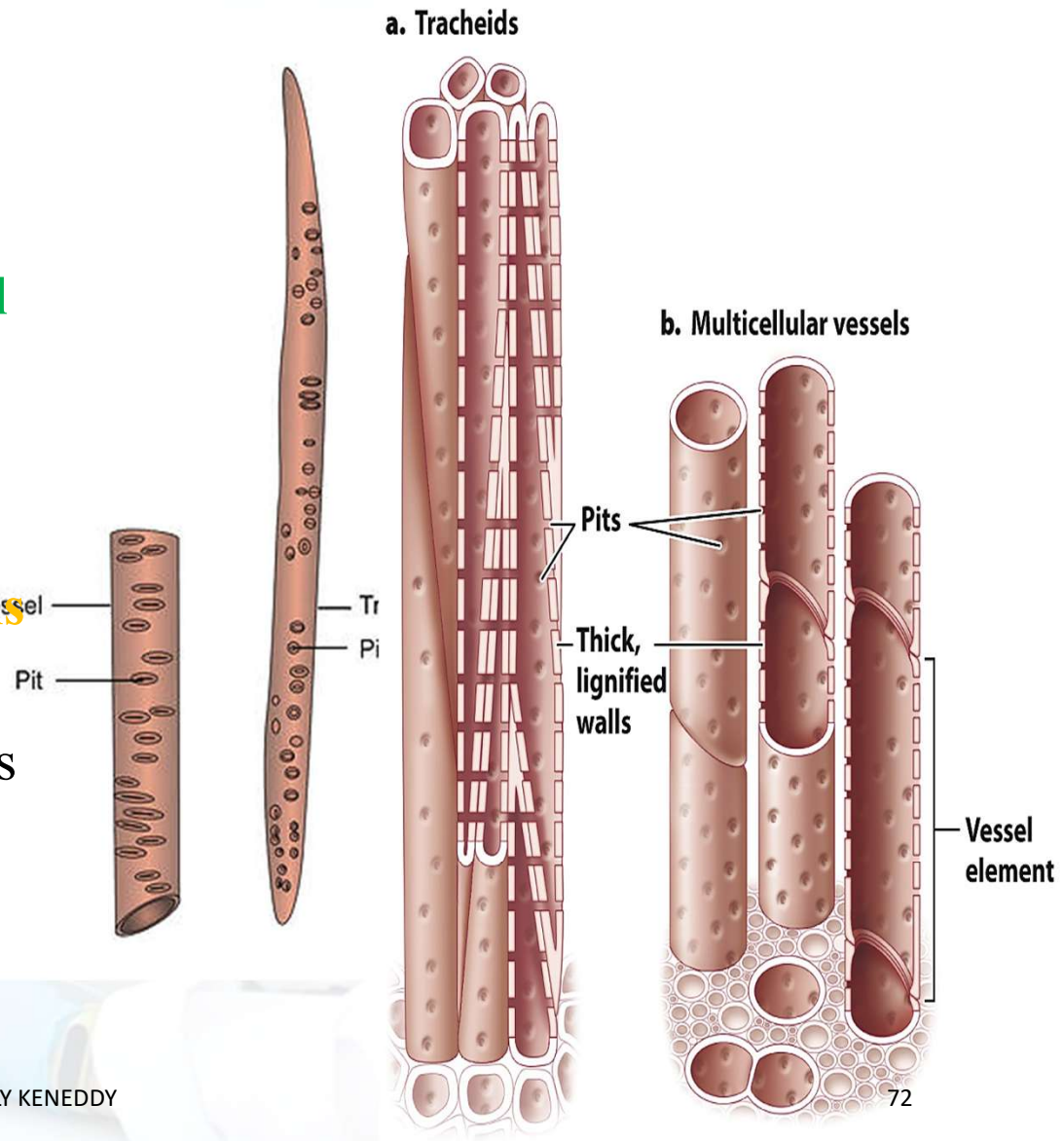


- The primary function of the xylem is to **transport water and mineral salts from roots to leaves.**

XYLEM TRACHEID

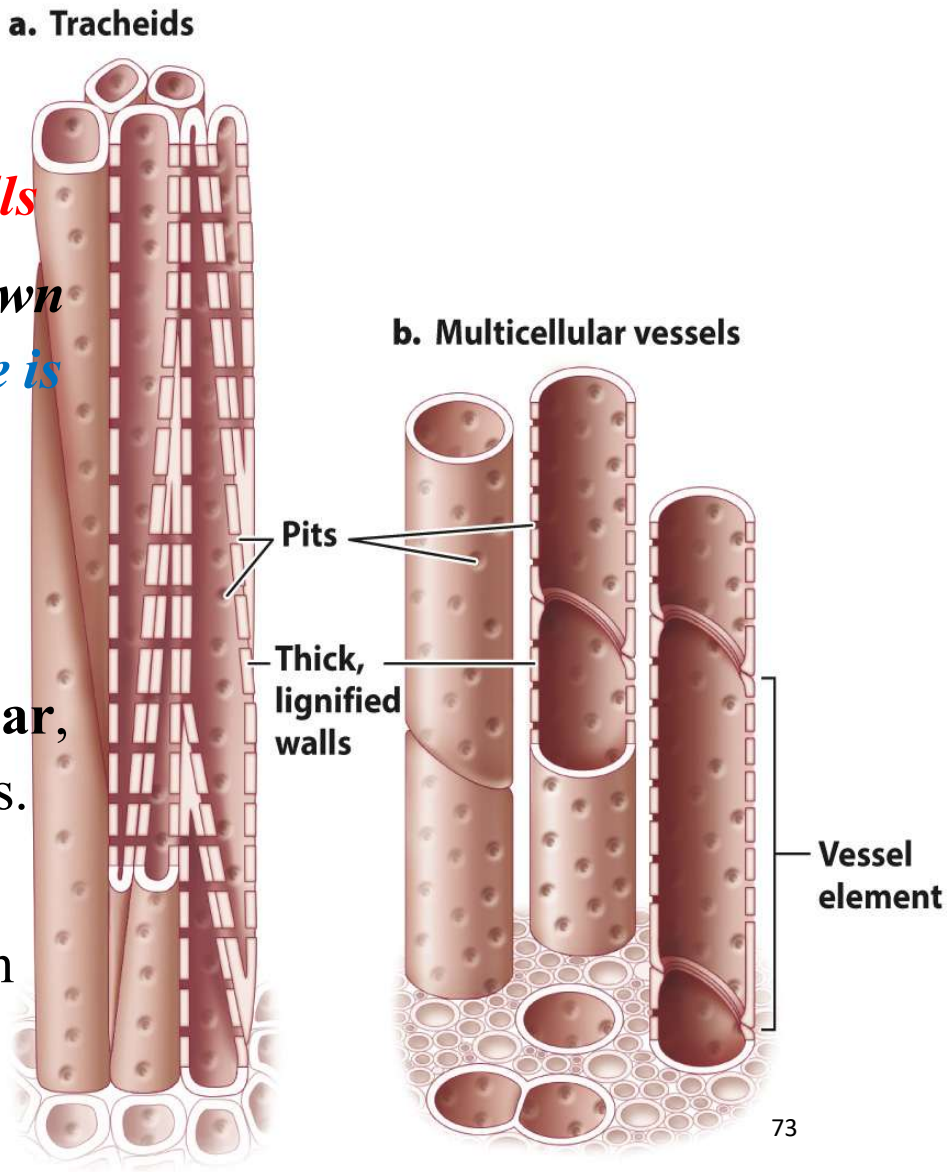
- These ***consist of dead cells*** which **are elongated and tubular.**
- They have **hard**, **thick** and **lignified cell walls.**
- Cell walls also contain cellulose, hemicellulose and pectin.
- The single cells **have tapering end walls** that ***overlap with adjacent tracheids.***
- The walls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

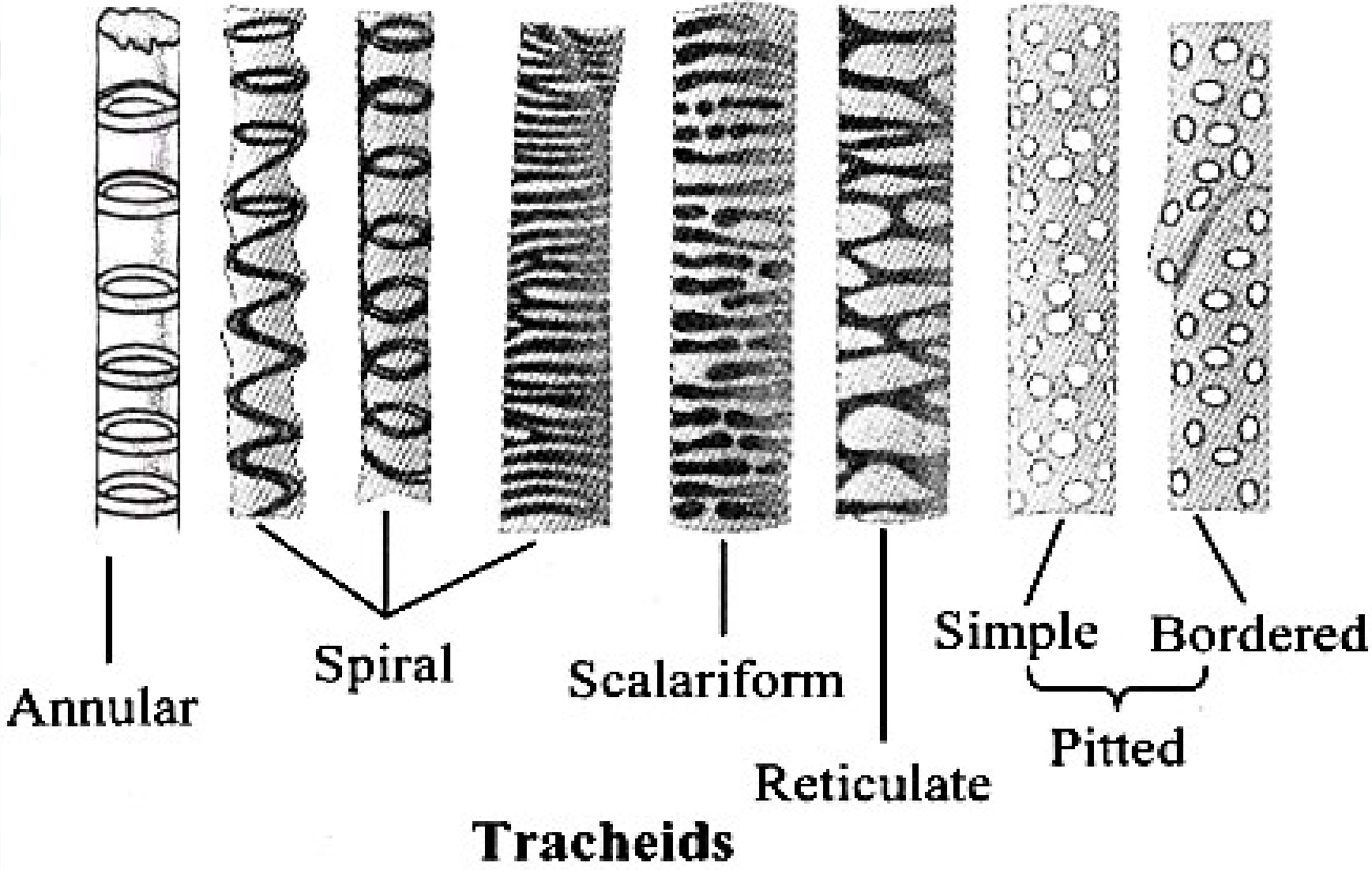
Location: They are predominant in **lower vascular plants of ferns** and ***gymnosperms***.



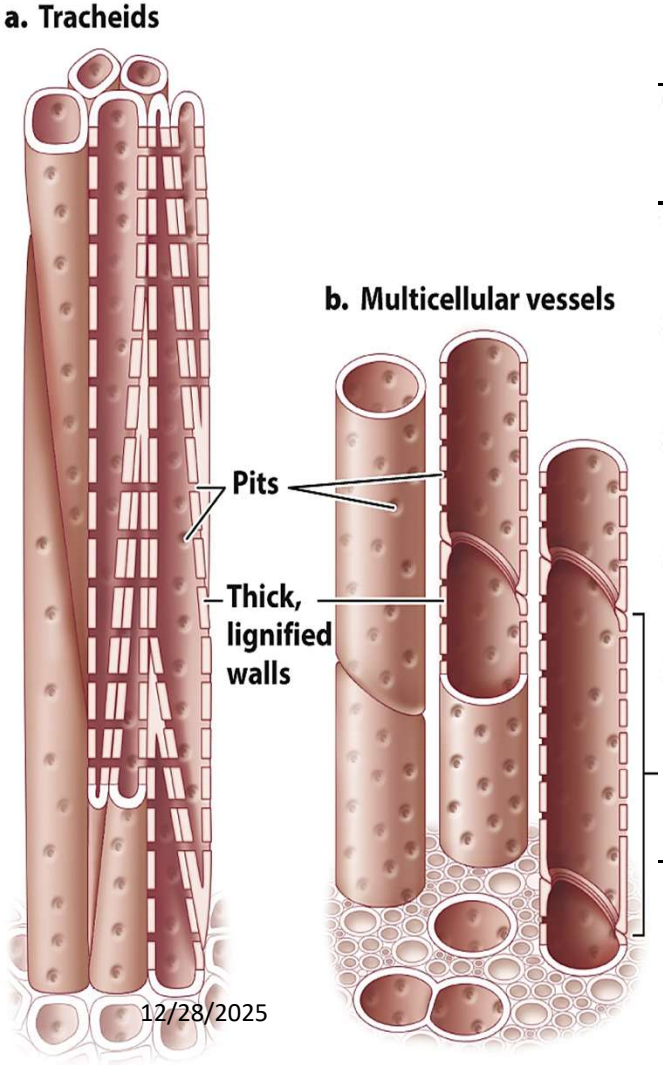
XYLEM VESSELS

- They are made up of ***elongated cylindrical cells***
- 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**. Cells are **dead**
- 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.




Annular
Spiral
Scalariform
Reticulate
Simple
Bordered
Pitted
Tracheids

COMPARISON.



Differences	
Xylem vessels	**Tracheids**
Cylindrical shape	Are 5 to 6 sided in cross section
Have open ends at their sides	Perforated end walls
Have non tapering (pointed) ends	Have tapering ends
Offers less resistance towards water passage	Offer more resistance towards water passage

ACTIVITY.

- In your respective groups, discuss how the structure of xylem is related to its function

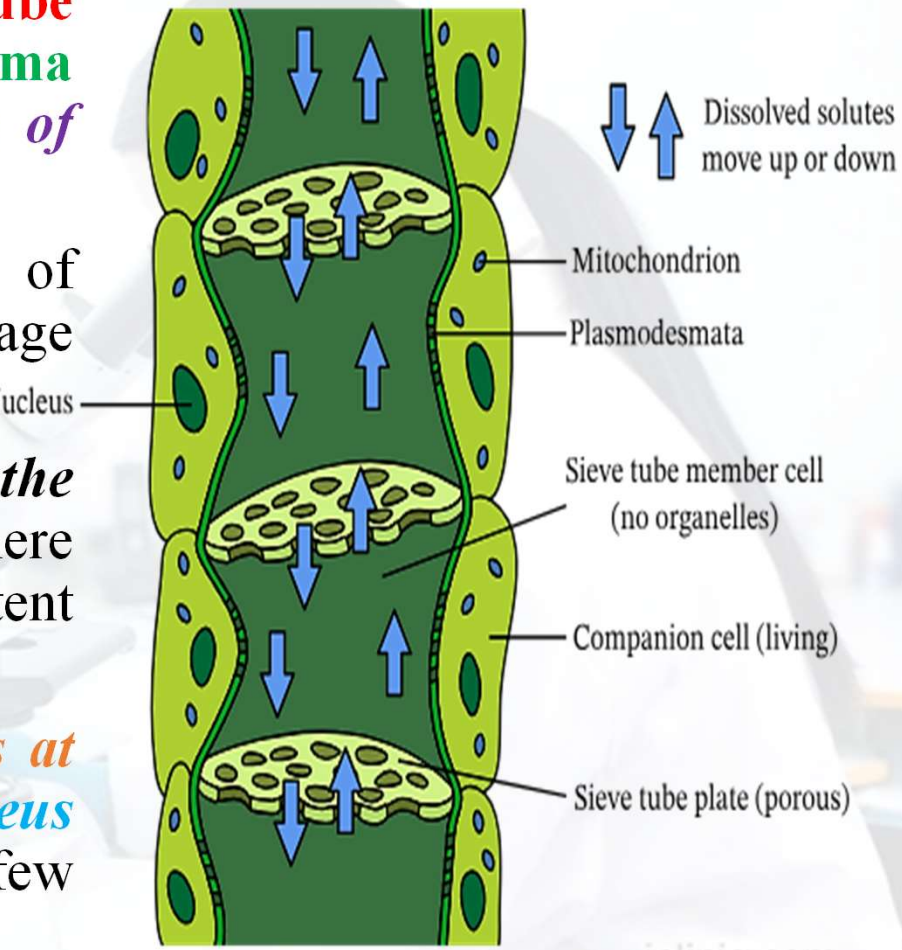
SAMPLE OF RESPONSES.

- Xylem vessels have a narrow lumen which enables the upward movement of water from roots to leaves due to the high capillarity
- Xylem vessels and tracheids have lignified cell walls which prevents curving in of the walls due its tension created by water strength
- They are lignified making the xylem water proof which minimizes resistance to waterflow up the plant.
- Xylem vessels and tracheids lack living protoplasmic contents which enable them to remain hollow so that they allow water to move through with minimum resistance.
- Xylem vessels and tracheids have partially or completely broken down to allow open communication of one cell to another such that there's free passage of water through them.
- Xylem vessels and tracheids side walls are perforated by lateral pits to allow horizontal movement of water in and out of the xylem tubes.
- In some plants like conifers, the bordered pits of the tracheids have a plug-like torus which controls the lateral passage of water through the pits
- The xylem is lignified hence

- Cell walls of vessels are impregnated with lignin; increase adhesion for upward movement of water
- • Tracheids and xylem vessels are placed end to end; to allow continuity of flow.
- • Broken end walls of the xylem vessels; permit continuity of water flow.
- • Xylem vessel is hollow; allows water to move freely without any obstruction
- • Xylem vessels are woody; enables them provide support.
- • The side walls of vessels & tracheids are perforated to allow side way movement of water between cells
- • Tracheids tapering/ elongated ends with bordered pits; to allow water pass from one cell to another.
- • Elongated and narrow tubes of tracheids increase capillarity

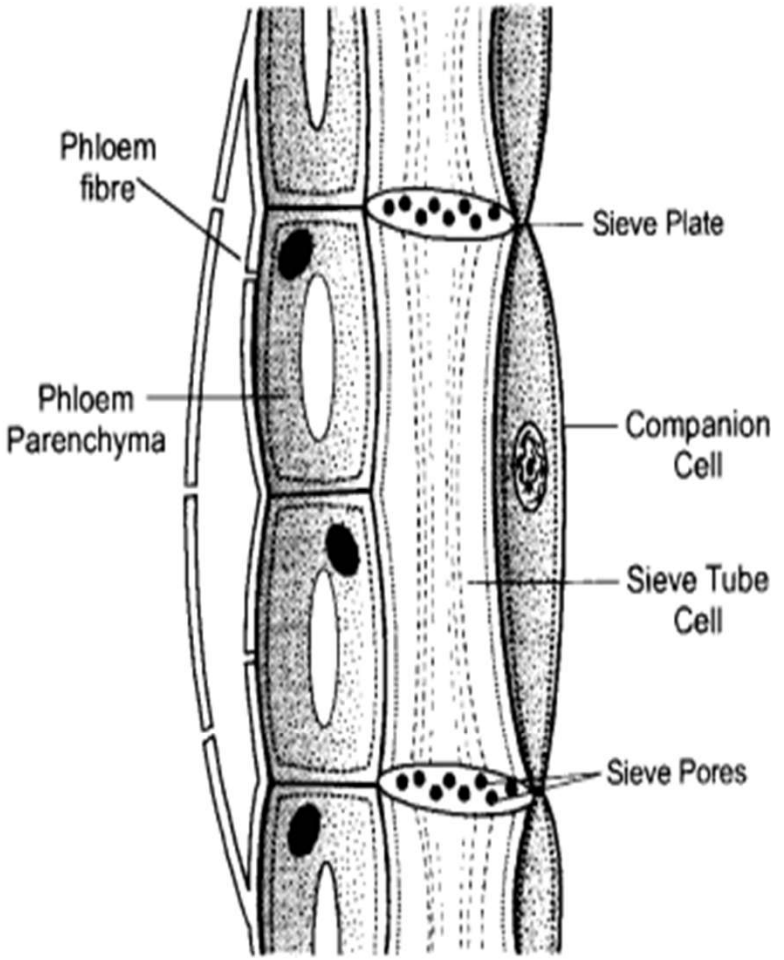
PHLOEM.

- The phloem tissue consists of **sieve tube elements**, **companion** cells and **parenchyma cells.** The phloem is used for ***translocation of materials.***
- The phloem is responsible for translocation of organic food molecules from the leaves to storage and metabolic sites.
- The sieve tubes are ***long tubes formed from the fusion of end-to-end sieve tube elements***, where end walls break down to a greater or lesser extent to allow the passage of materials.
- Sieve tube contain a ***nucleus and organelles at the young stage*** but ***on maturity, the nucleus and organelles degenerate*** though some few adjacent to cell wall persist.



Companion cells

- Alongside each sieve tube element is one or more ***companion cells*** made of thin cellulose walls, enclosing a protoplast.
- The companion cells are ***the metabolically active cells of this tissue*** with a prominent nucleus, numerous mitochondria, ribosomes and many other organelles.
- Active metabolism are conducted within the companion cells.
- All the required materials for these processes are passed via plasmodesmata from the companion cells or to the sieve tube elements and vice versa.

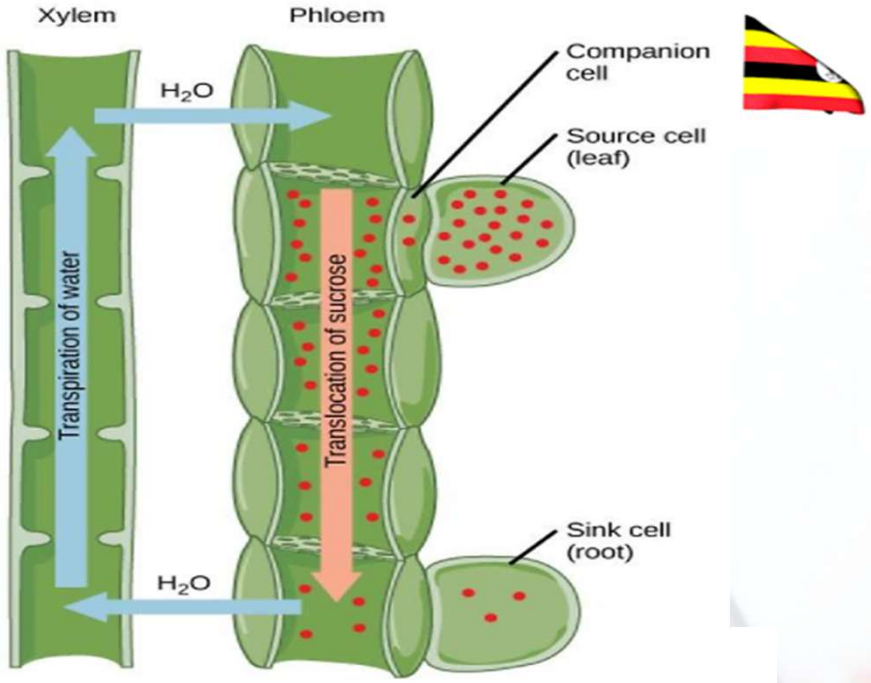


HOW THE PHLOEM IS SUITED TO THE FUNCTION.

- It has sieve plates which are perforated to enable a continuous flow of sugars.
- The sieve tubes have large pits (plasmodesmata) for lateral movement of organic substances.
- Companion cells have numerous mitochondria so as to produce large quantities of energy in form of ATP needed for transport of food.
- Sieve tube elements have fewer cell organelles so as to provide more space for the flow of food materials
- Some sieve tube elements have cytoplasmic strands or filaments (trans-cellular strands) which allow peristaltic movement of food through the sieve tubes
- The walls contain cellulose microfibrils that run around cells, giving strength and preventing the tubes bursting under pressure
- The walls are thin to allow easy entry of water at the source so as to build up pressure

Similarities

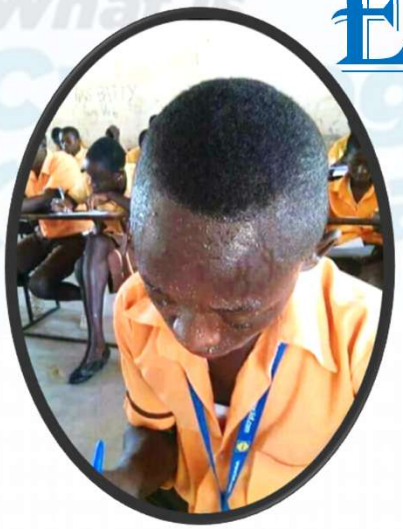
- Both have perforated cells.
- Both are surrounded by parenchyma cells.
- Both are conducting tissues.
- Both have cells that lack a nucleus.



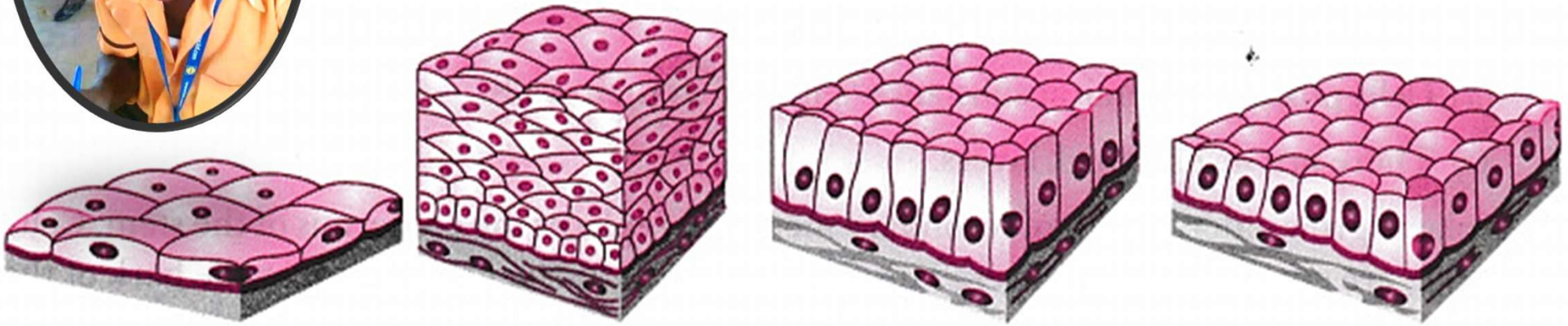
Differences:

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.

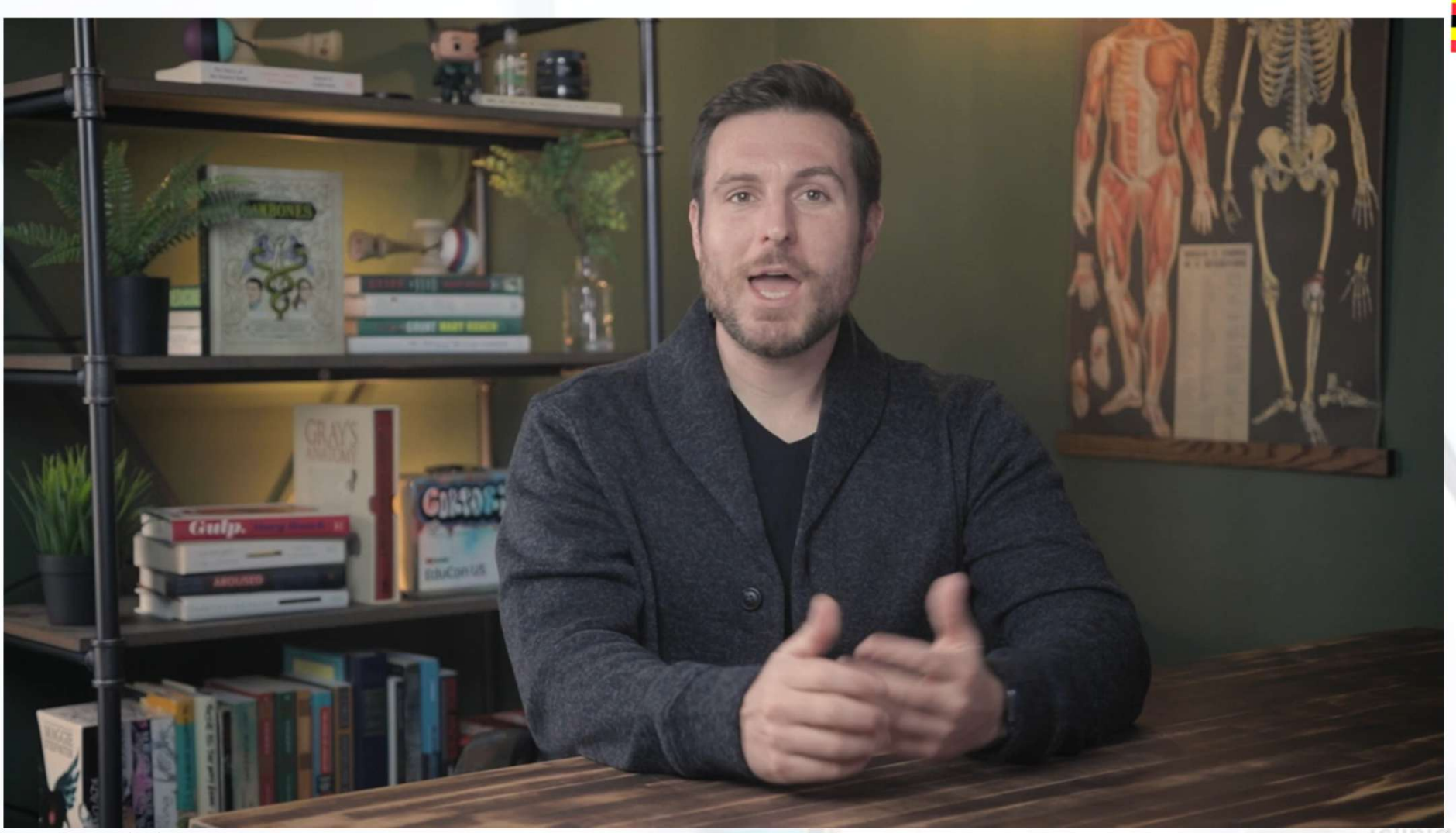
EPITHELIAL TISSUES



ANIMAL TISSUES



Different types of epithelial tissues

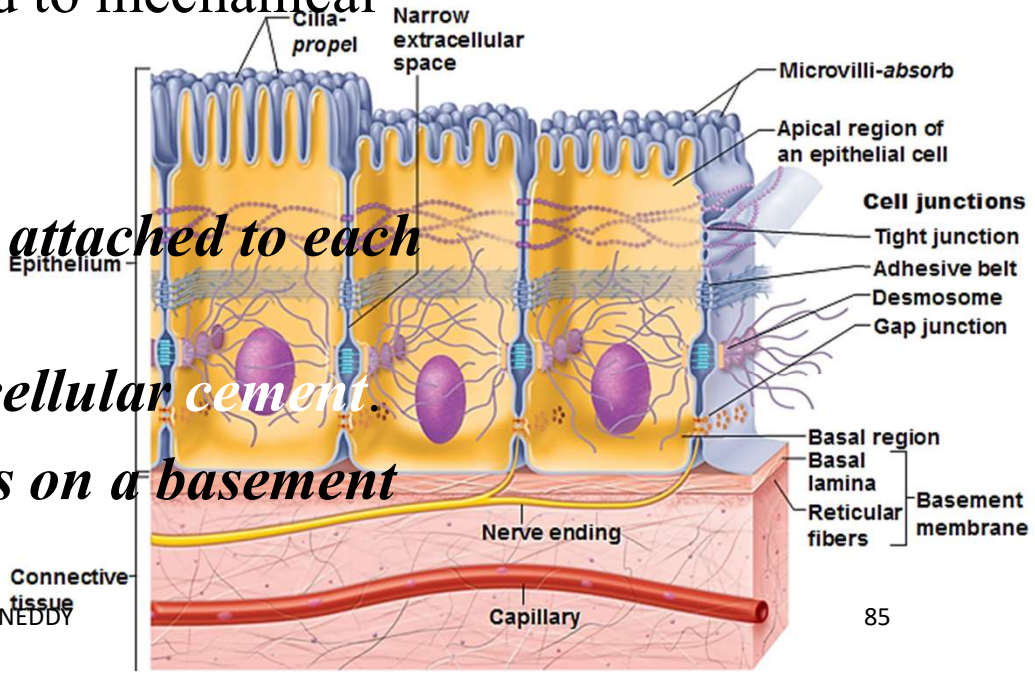

BONES
GRAY'S
Gulp.

INTRODUCTION.

- Epithelial tissues ***consist of a single or many layers of closely packed cells.***
- They cover of external body surface or lining of inner body cavities.
- Epithelial tissues cover tissues subjected to mechanical damage.

General structure of epithelial tissues

- The cells are ***closely packed and firmly attached to each other.***
- Adjacent cells ***joined together by intercellular cement.***
- The bottom layer of epithelial cells ***rests on a basement membrane.***



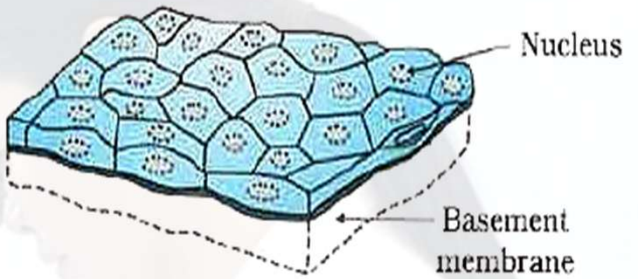
SIMPLE EPITHELIAL TISSUES

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

Squamous epithelium.

- **Structure:** Cells form a single layer attached to a basement membrane. The cells are thin, shallow and flattened.
- In surface view, the cell outlines are irregular and closely packed. Adjacent cells may be joined by strands of cytoplasm.
- **Location**: Alveolar lining, Inner lining of blood vessels and lining of blood capillaries.
- **Functions**: Diffusion of materials, provides a friction free lining for blood flow.

Ans.



(a) : Squamous epithelium |

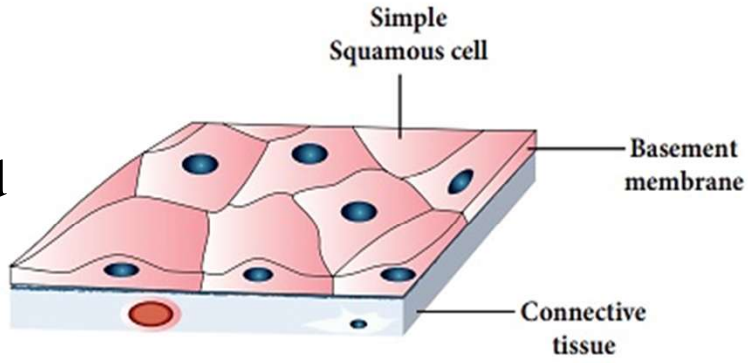


Figure 7.7 Squamous Epithelium

EPITHELIAL TISSUES.

CUBOIDAL EPITHELIAL TISSUE

➢**Structure**: Its cells are ***cuboidal*** and ***form a single layer*** attached to a basement membrane.

- The nuclei are ***spherical and centrally located***.
- **Location**: Lining of salivary, collecting and pancreatic ducts (kidneys).

Functions

- Secretion, the ciliated cuboidal epithelium lining the salivary glands.
- The brush bordered cuboidal are for reabsorption of materials from fluid.

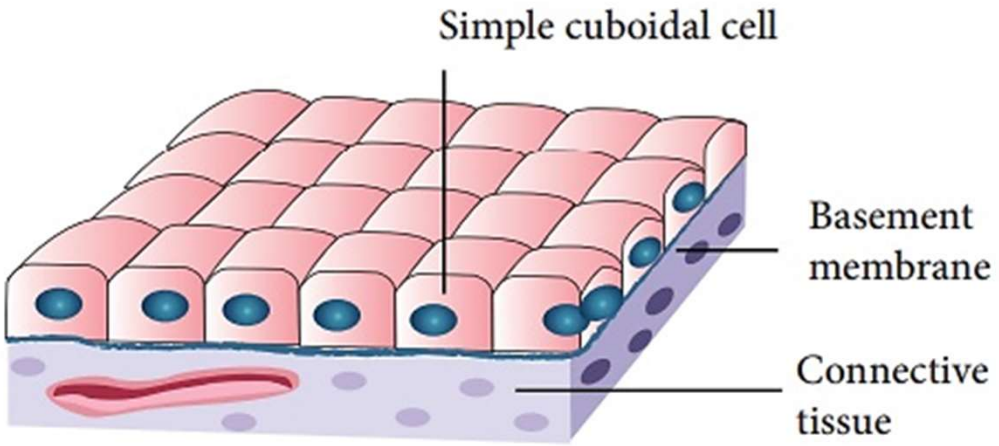
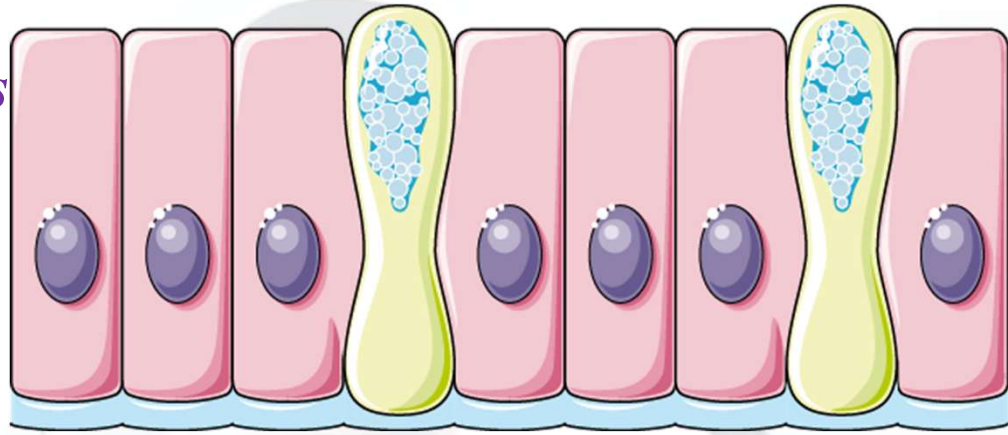


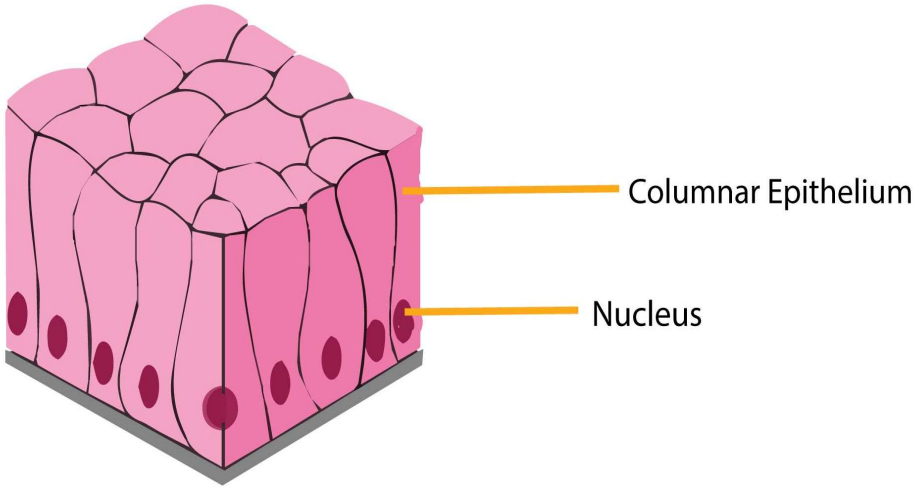
Figure 7.8 Cuboidal Epithelium

SIMPLE COLUMNAR EPITHELIUM



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

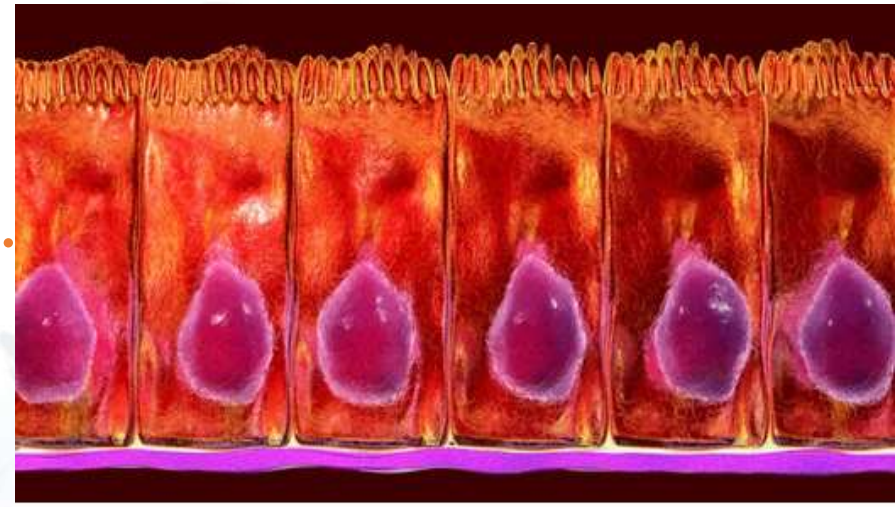
- Location: Lining of stomach, intestine, gall bladder and gastric glands.
- Functions:
- **Secretion** and **absorption**. (*Mucus secreted protects the lining from the acidic content in the stomach and from digestion by enzymes and also lubricates the passage*)



MODIFIED COLUMNAR EPITHELIAL TISSUE

Brush bordered columnar epithelium

- They are found in the ***gut*** and ***kidney nephrons***. These **contain micro villi at the free end** which **increases surface area for diffusion of materials.**
- Secretory **goblet cells** are for ***secretion of mucus*** which ***protects the gut walls from HCL*** and **digestive enzymes** ***and trap pathogens from entering the alveolus***.



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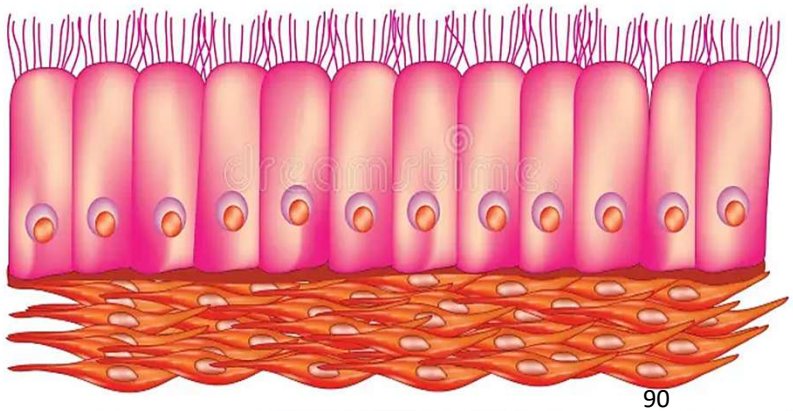
Simple Columnar Epithelium

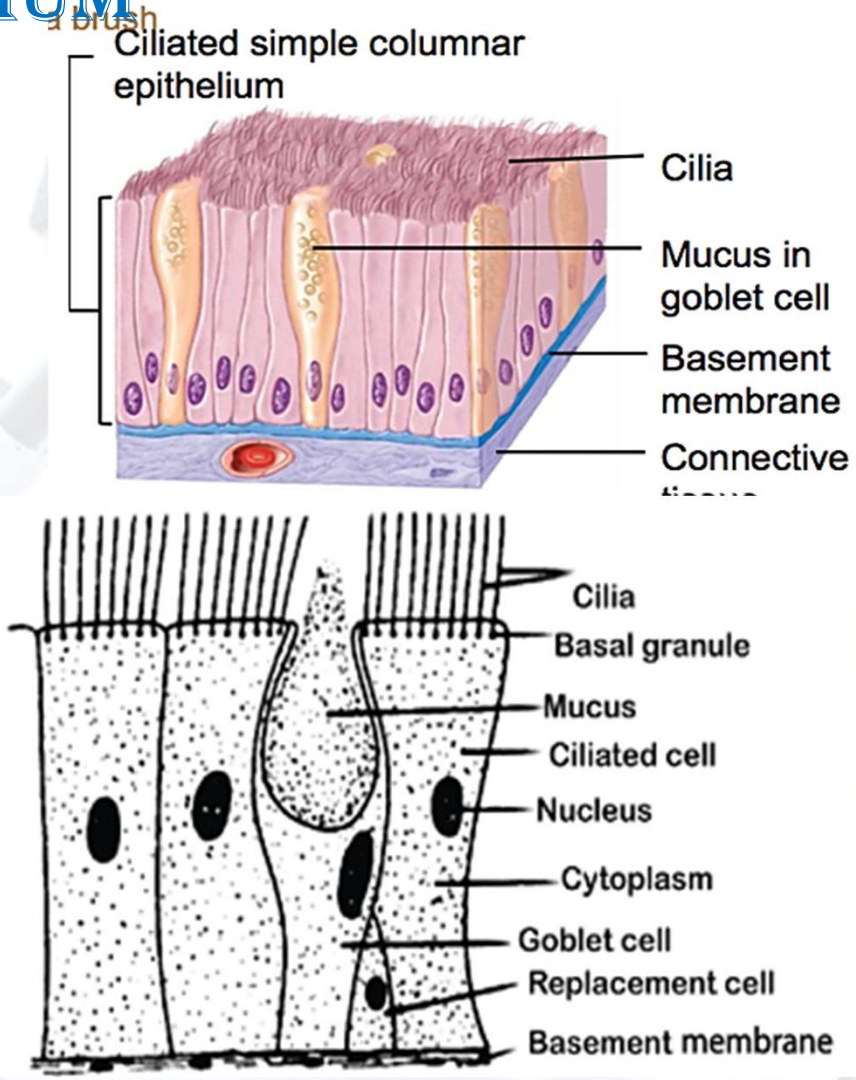
Ciliated columnar epithelium

- It comprises of columnar cells with ***cilia at their free edges.***
- **Location**: Oviducts, respiratory passage (bronchioles) and spinal canal. They ***aid in movement of materials in a particular direction.***



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***.
- They are found lining the trachea and bronchi and mainly have two types of cells: ***longer cells*** have cilia and ***shorter cells*** lacking cilia but with goblet cells.
- **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 or spitting.

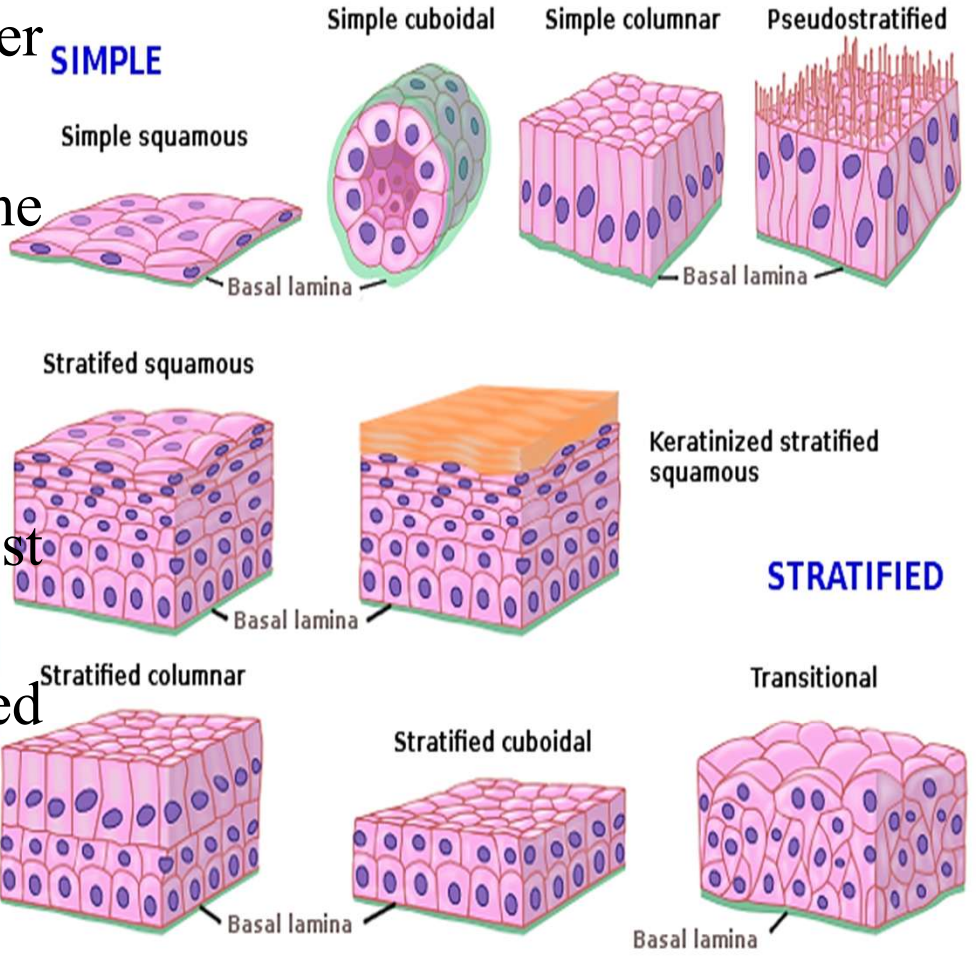


COMPOUND EPITHELIAL TISSUES

- These consist of cells form the germ layer which continue to divide by mitosis.
- They are primarily found in areas where the epithelium has protective functions.

They have the following 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.



STRATIFIED EPITHELIUM

- It is made of many layers of cells. The cells are formed by division of the germinal layer resting on the basement membrane.
- As new cells form, older ones are pushed near to the surface changing shape ie become flattened.
- Some cells may remain un keratinized as in the oesophagus or may be heavily thickened with keratin (cornified) e.g. the skin

Location: External skin surface, lining of buccal cavity and vagina & lining of pharynx and oesophagus where they :

✓Protection from abrasion to areas exposed to wear and tear.

✓Protection of the tissue from mechanical damage by the food that is swallowed.

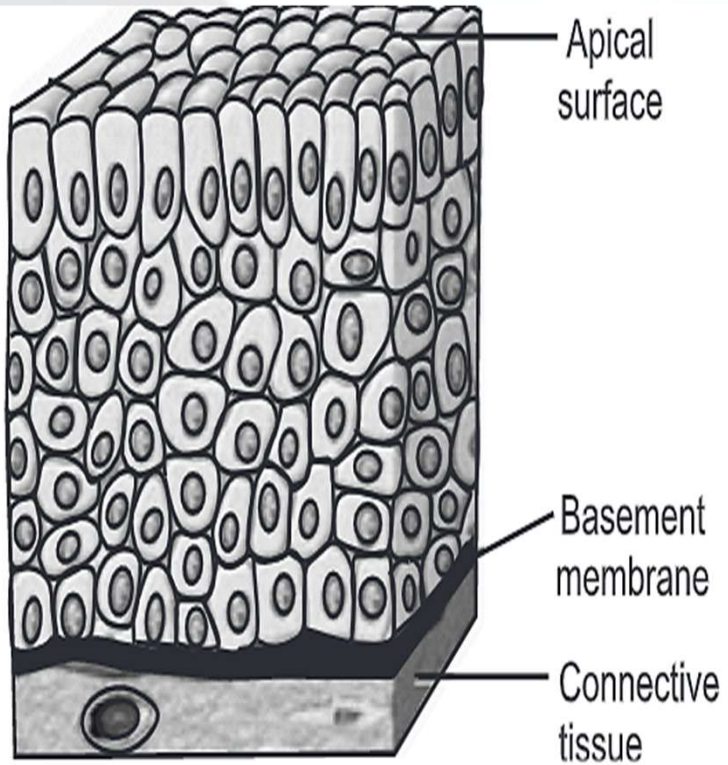


Fig. : Stratified columnar epithelium

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.

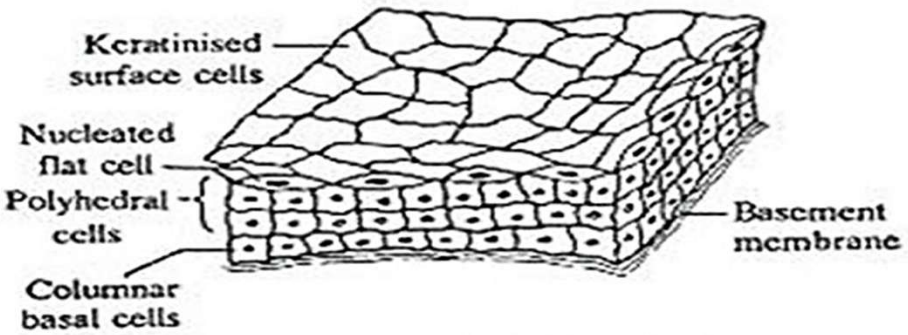


Fig. 4-6–(a)–Keratinised stratified squamous epithelium

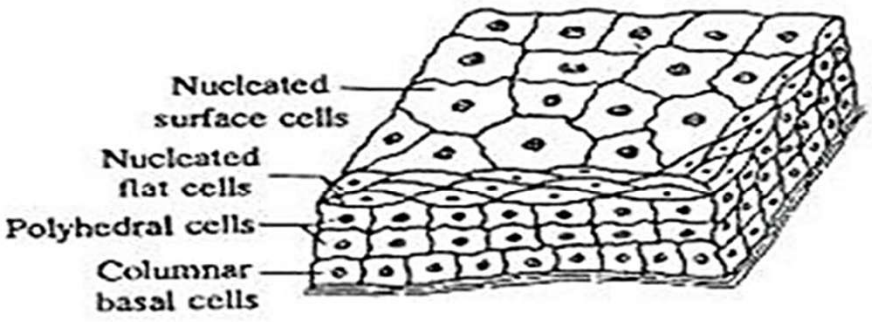
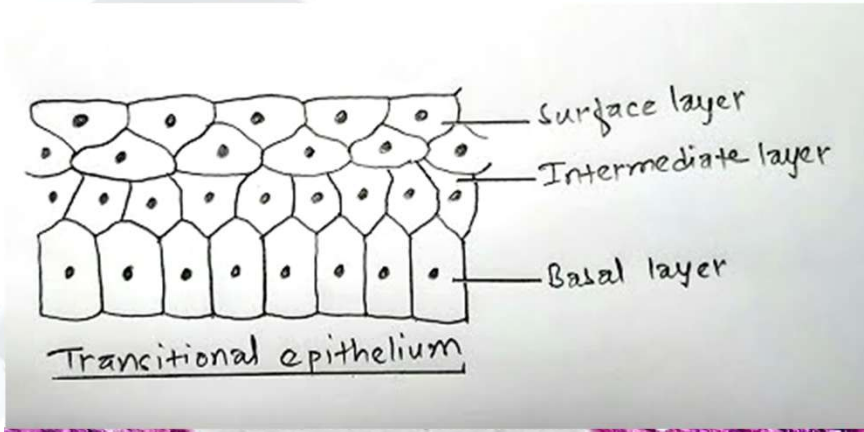


Fig. 4-6–(b)–Non-Keratinised stratified squamous epithelium

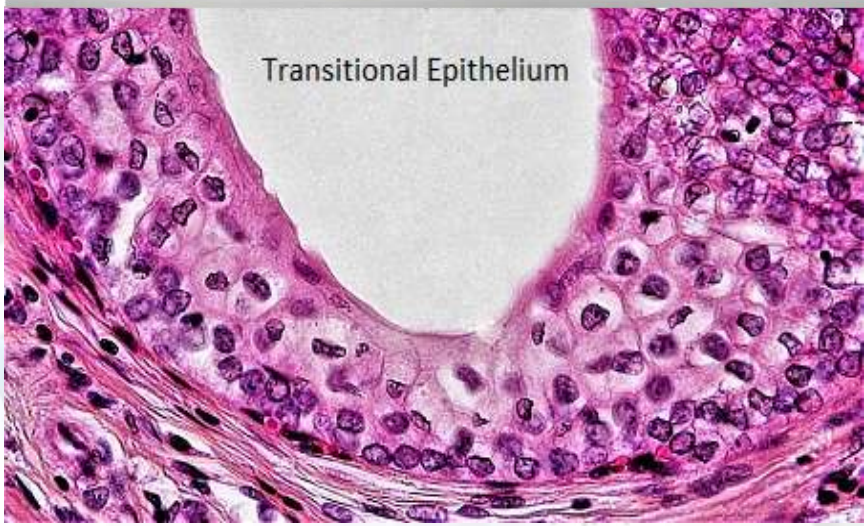
TRANSITIONAL EPITHELIUM

- It is found in structures which ***experience tension and stretching*** e.g. the urinary bladder, ureter and urethra.
- It comprises of 3 or 4 layers of cells which ***may be flattened towards the surface*** but ***can change their shape thus allowing stretching***.

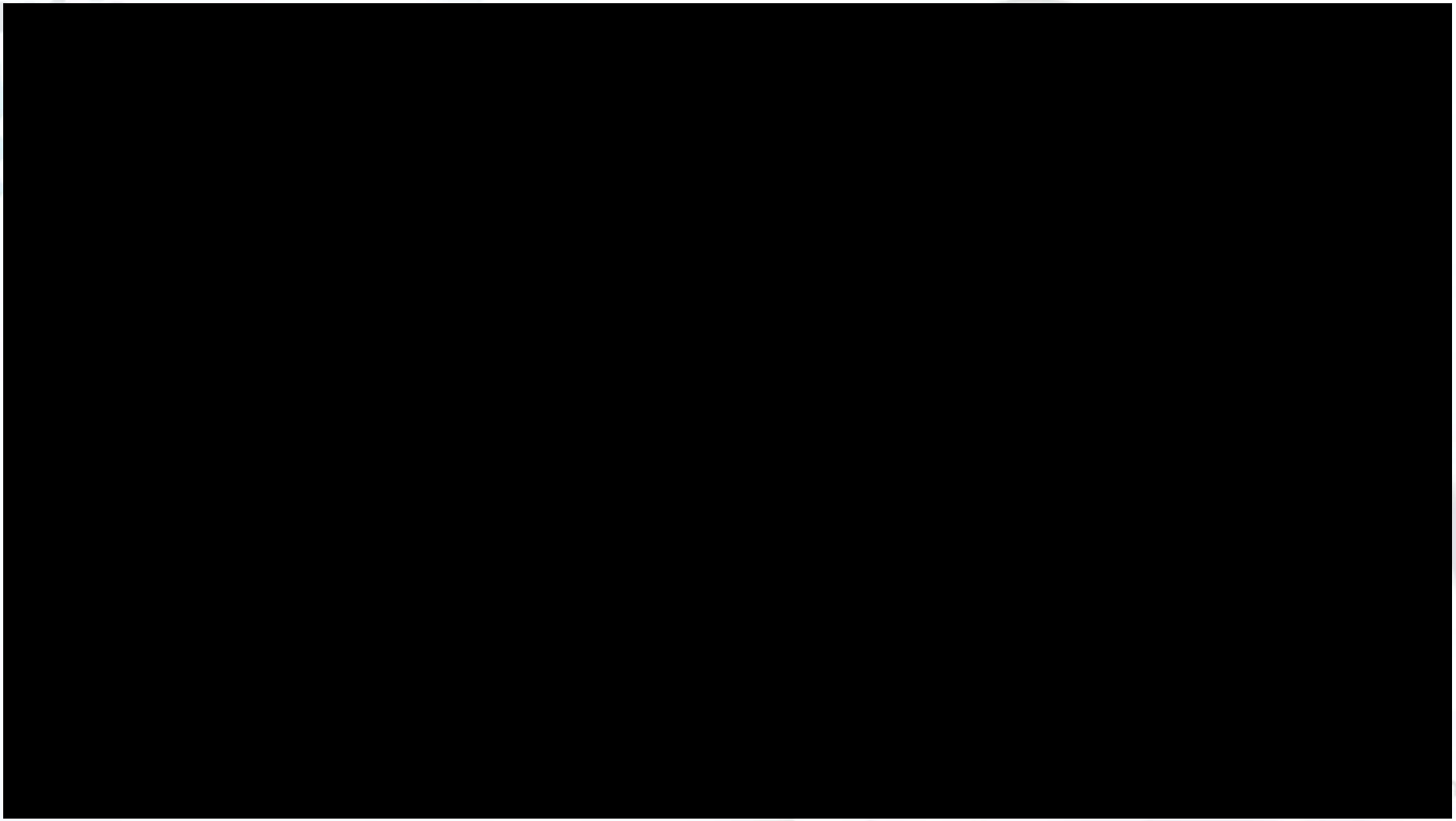


Functions

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



CARDIAC MUSCLE

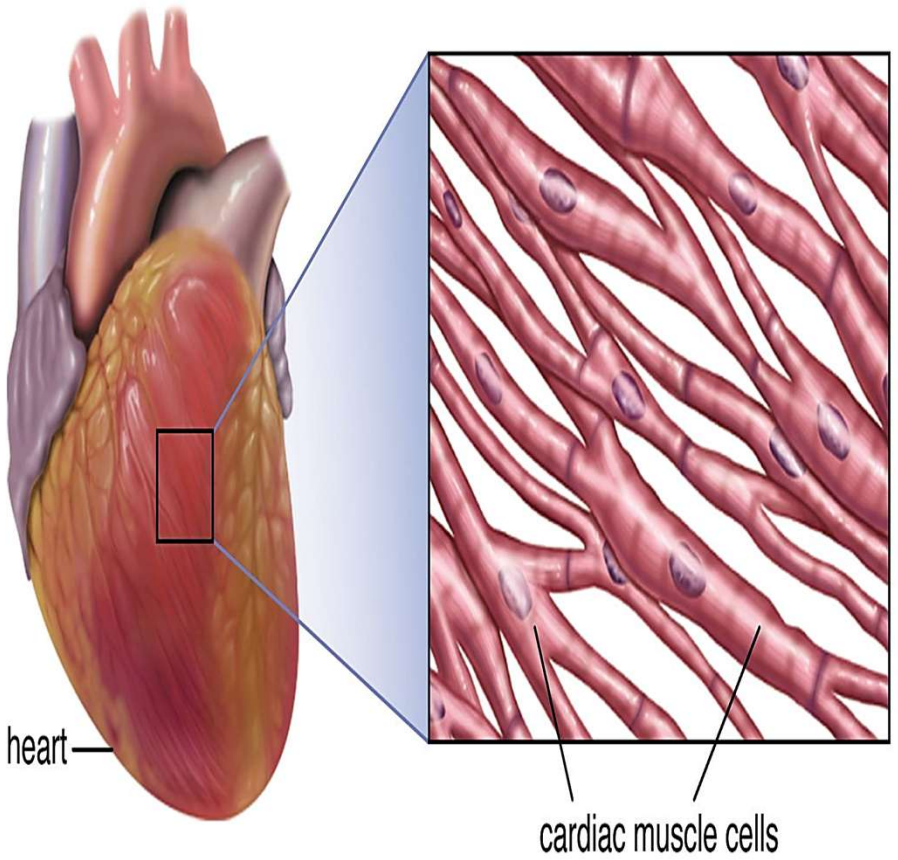


CARDIAC TISSUE

- The cardiac muscles are found only in the heart and are **myogenic** i.e. the contractions are generated within the muscle itself.

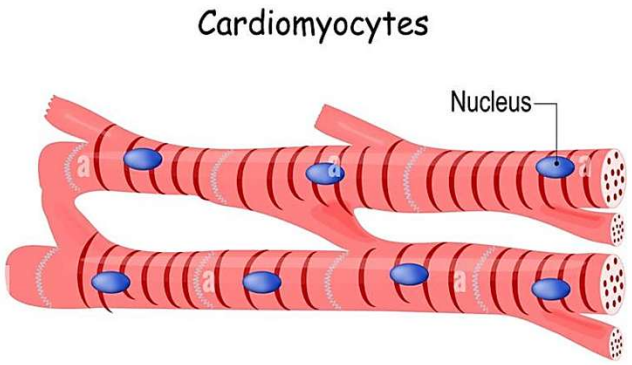
Structure f the cardiac muscle.

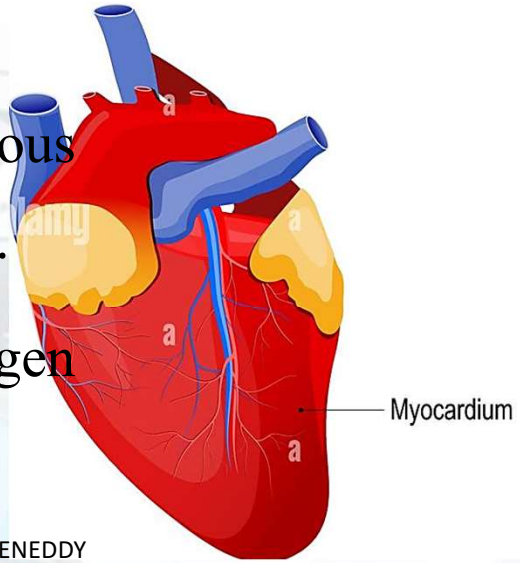
- The muscle cells are **short**, **cylindrical** and **branched**, **multinucleated**, cells **joined end to end** to form rows.
- The cells are connected to each other by special zigzag junctions called **intercalated** discs.

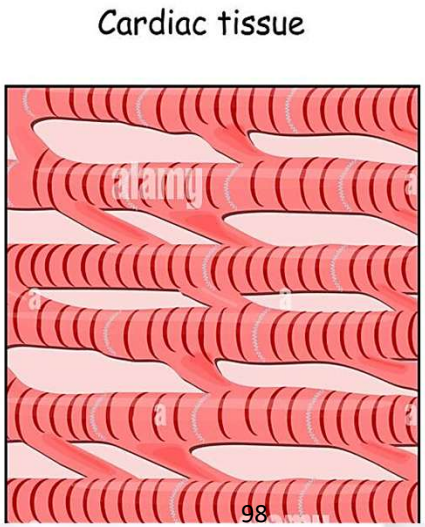


Cardiac muscle

- In between such discs generally one nucleus is present.
- The cells show faint, but regular cross striations (regular arrangement of myosin and actin filaments to form light and dark bands).
- Each muscle fiber has numerous mitochondria, myofibrils with sarcomeres.
- It has abundant cytoplasm and glycogen granules.





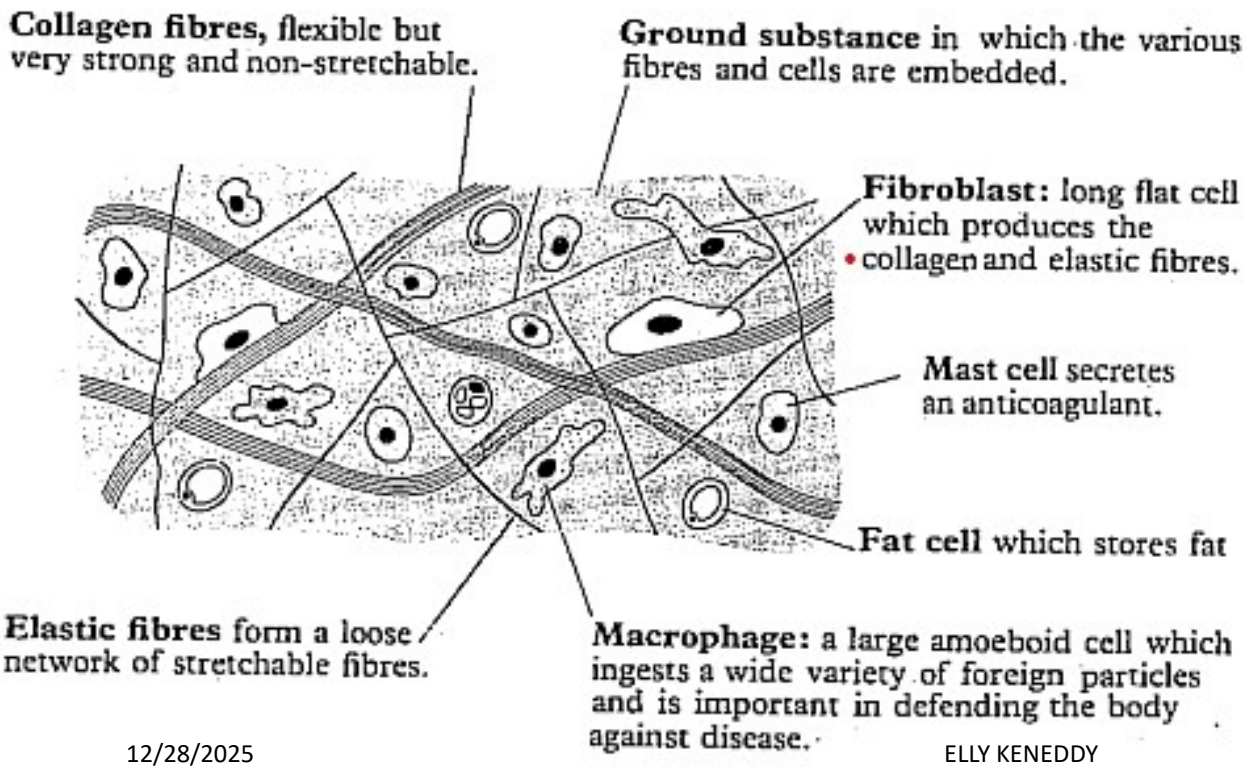


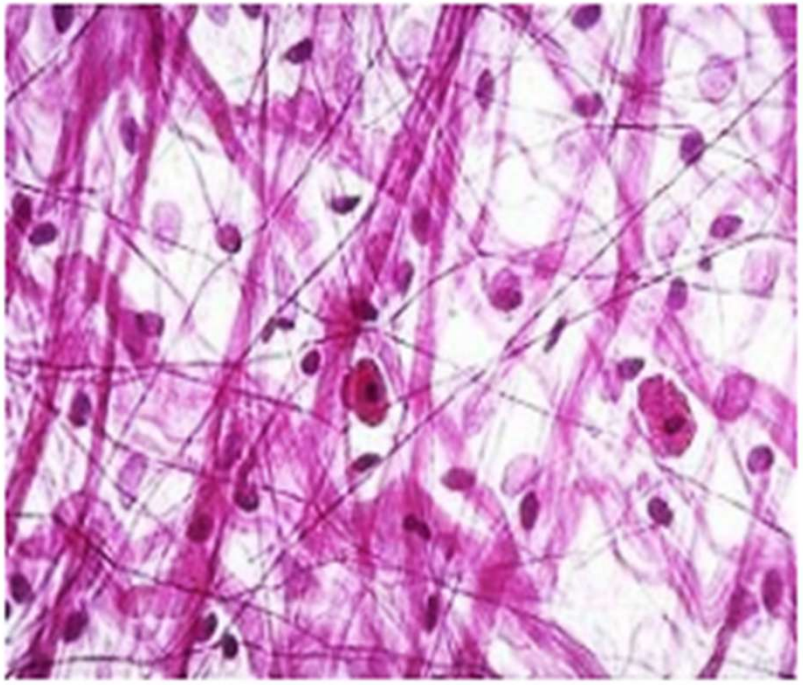
ADAPTATIONS OF THE CARDIAC MUSCLE TO ITS FUNCTION

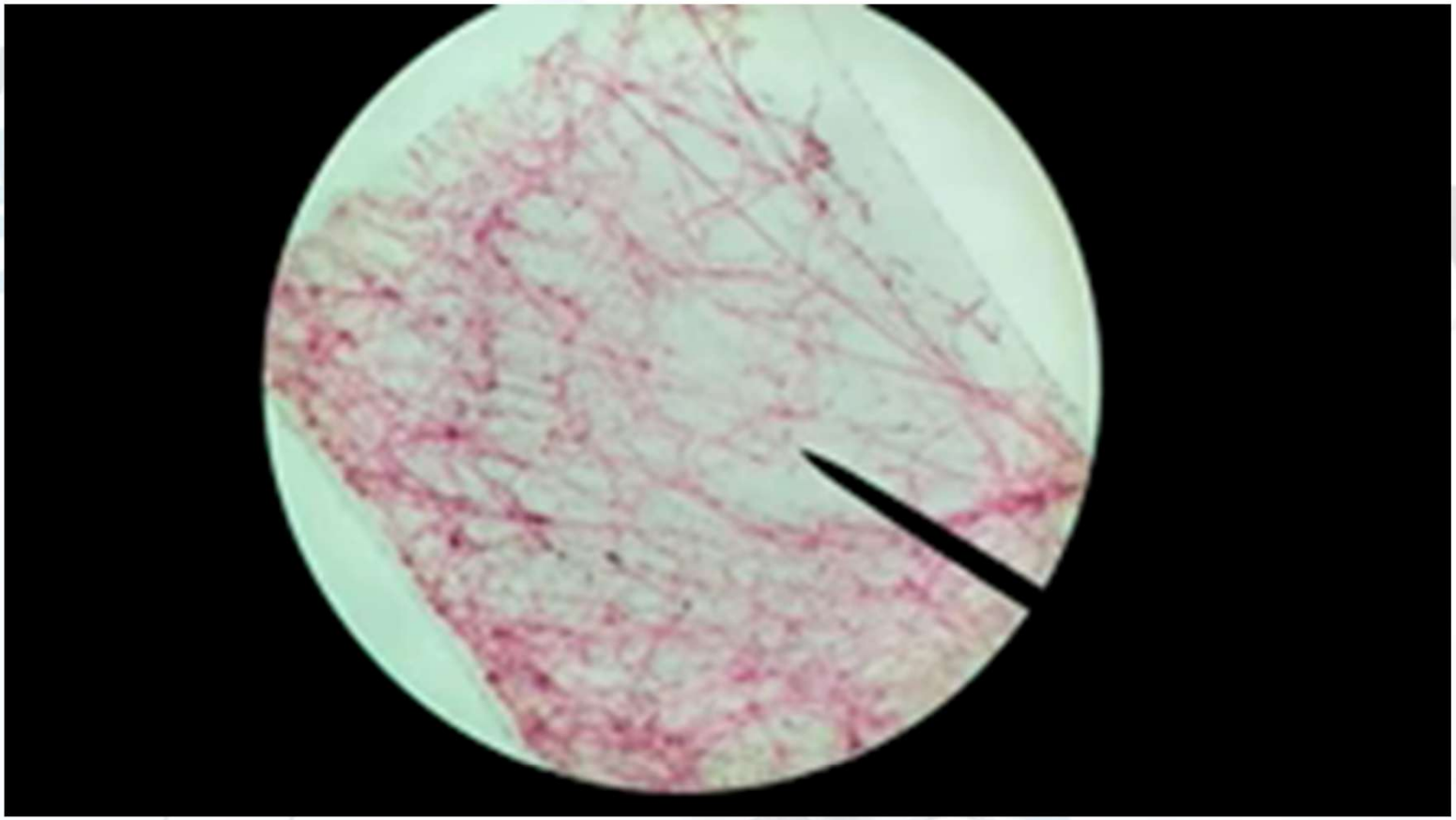
- Dense network of blood capillaries ensures adequate supply of oxygen and food nutrients, for fast production of adequate ATP, for continuous rapid muscle contraction and rapid removal of carbon dioxide and other metabolic wastes.
- Numerous large mitochondria and glycogen granules rapidly provide adequate ATP for rapid contraction without fatigue.
- Has the Sino atrial node (SAN) which emits waves of electrical excitation that initiate continuous and rhythmic contraction.
- Have long refractory periods and thus does not fatigue.
- Well-developed T-system for rapid transmission of impulses thus rapid contraction and relaxation.
- Branched muscle fibers offer a large surface area for fast spread of waves of electrical excitation for continuous contraction hence continuous heartbeat

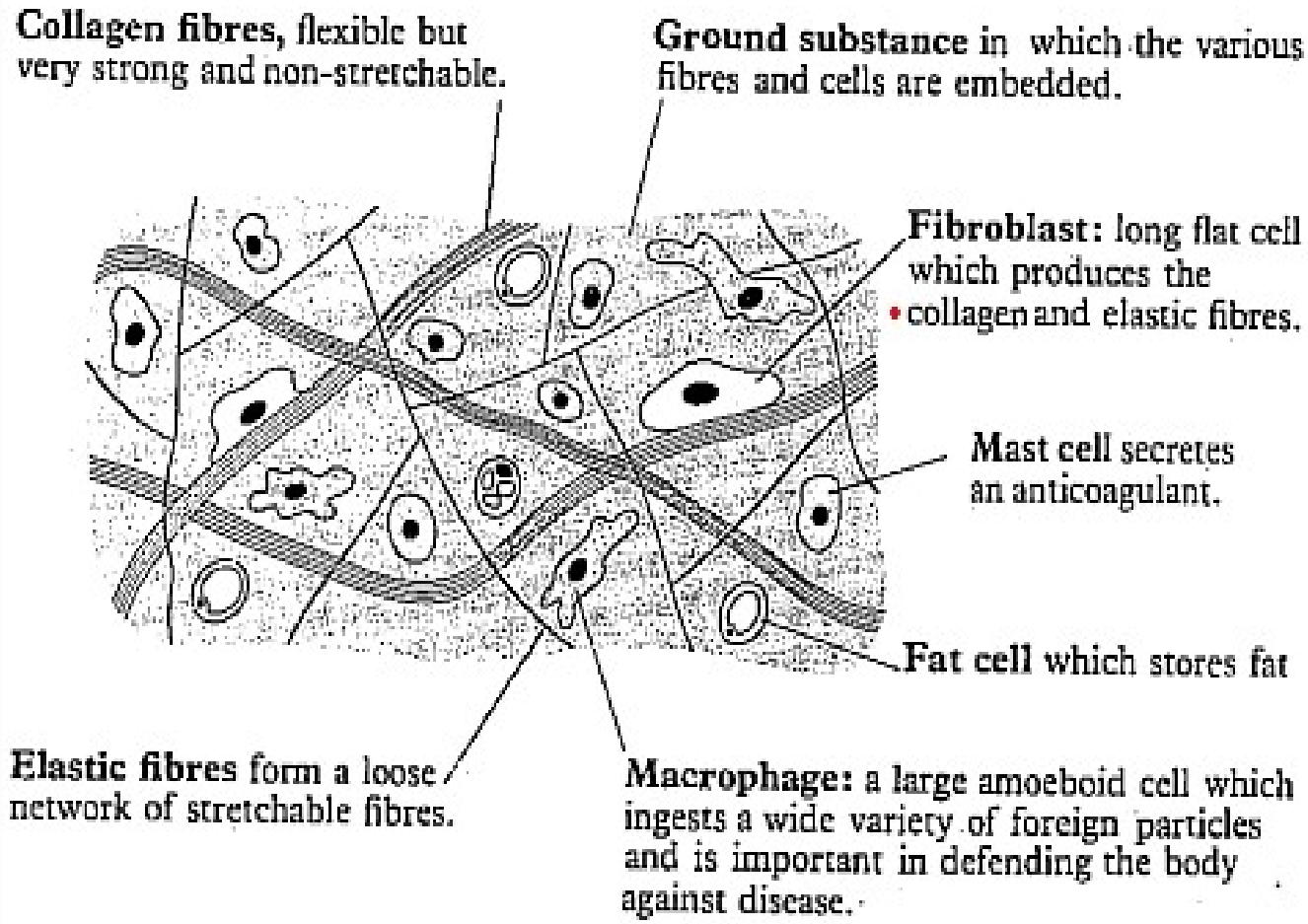
AREOLAR TISSUE

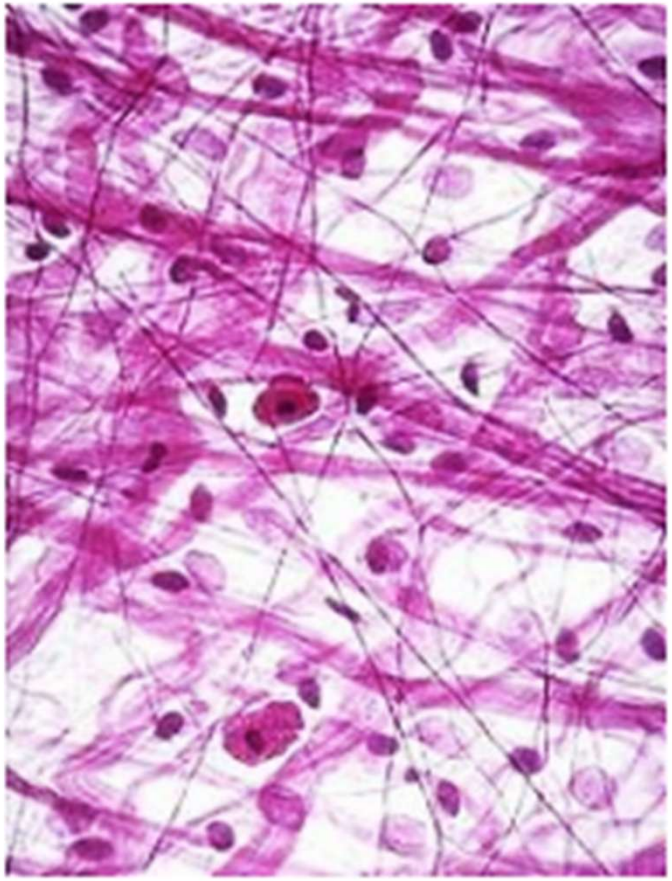
- This is most abundant type of connective tissue found all over the body beneath the skin, ***connecting organs together*** and ***filling spaces between adjacent tissues***. It consists of a semi-fluid matrix containing a variety of cells and fibers.








Collagen fibres, flexible but very strong and non-stretchable.
Ground substance in which the various fibres and cells are embedded.
Fibroblast: long flat cell which produces the collagen and elastic fibres.
Mast cell secretes an anticoagulant.
Fat cell which stores fat
Elastic fibres form a loose network of stretchable fibres.
Macrophage: a large amoeboid cell which ingests a wide variety of foreign particles and is important in defending the body against disease.



It consists of the following types of cells.

- **Fibroblasts**: These are spindle shaped flattened cells with an oval nucleus. They produce fibers 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 substance
- **Macrophage** or **histocytes**: These are large amoeboid cells with a kidney shaped nucleus. They engulf bacteria or other foreign particles.
- **Plasma cells**: these are small round or irregular cells. They produce antibodies that help in self-defense.
- **Fat cells** :They are mainly store lipid droplets. The cytoplasm and nucleus of a fat cell are confined to the margins of the periphery

There are **two types** of fibers in areolar tissue:

- ***Collagen/white fibers***: these are long, wavy and unbranched fibers present in bundles. They are flexible but inelastic.
- ***Elastic/yellow fibers***: these are long, straight and branched fibers arranged singly. They are flexible and elastic as they contain protein elastin

Functions of the areolar connective tissue

- Binds tissues and organs together.
- Serves as a packing tissue filling spaces between adjacent tissues.
- Support various tissues.
- Provide tissues which resist strain and displacement.
- Provides protection against wounds and infections.

FIBROUS TISSUE.

It consists of contains tightly packed collagen fibers making it stronger than the lose connective tissue There are two forms of fibrous tissue.

White fibrous tissue.

This consists of glycoprotein matrix containing ***densely packed collagen fibers***. The collagen fibers are **strong**, **flexible, inelastic** and have a high tensile strength. They are abundant in **tendons** and **ligaments**.

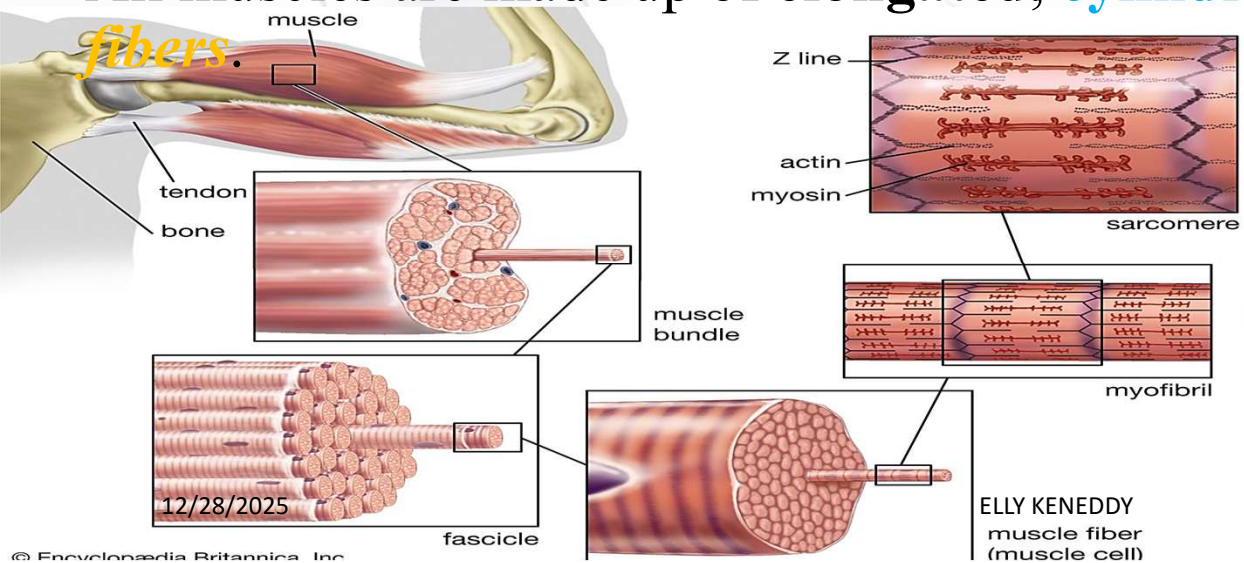
Yellow elastic fibrous tissue.

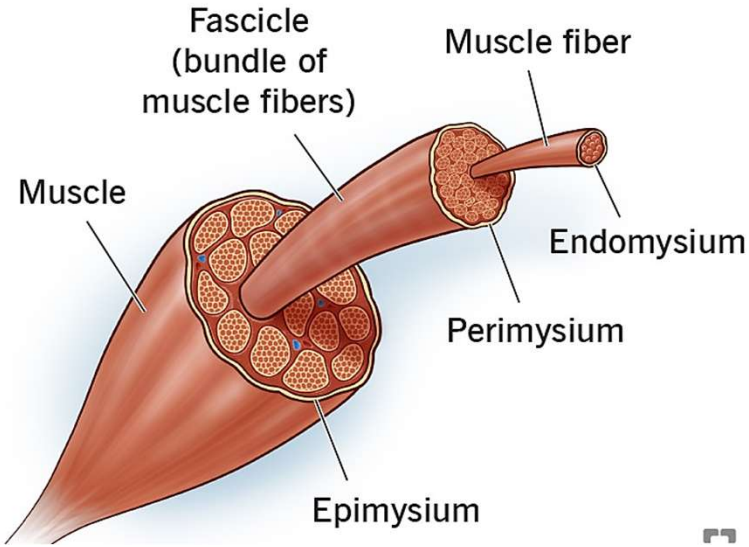
This consists of a glycoprotein matrix containing ***loose network of fibers***. It is **strong** and **elastic**. Such tissue is found in **ligaments** where it binds bones to other bones.

It is also found around **the walls of arteries** and it is also found as a **component of the lungs** and associated air passages.

SKELETAL MUSCLE

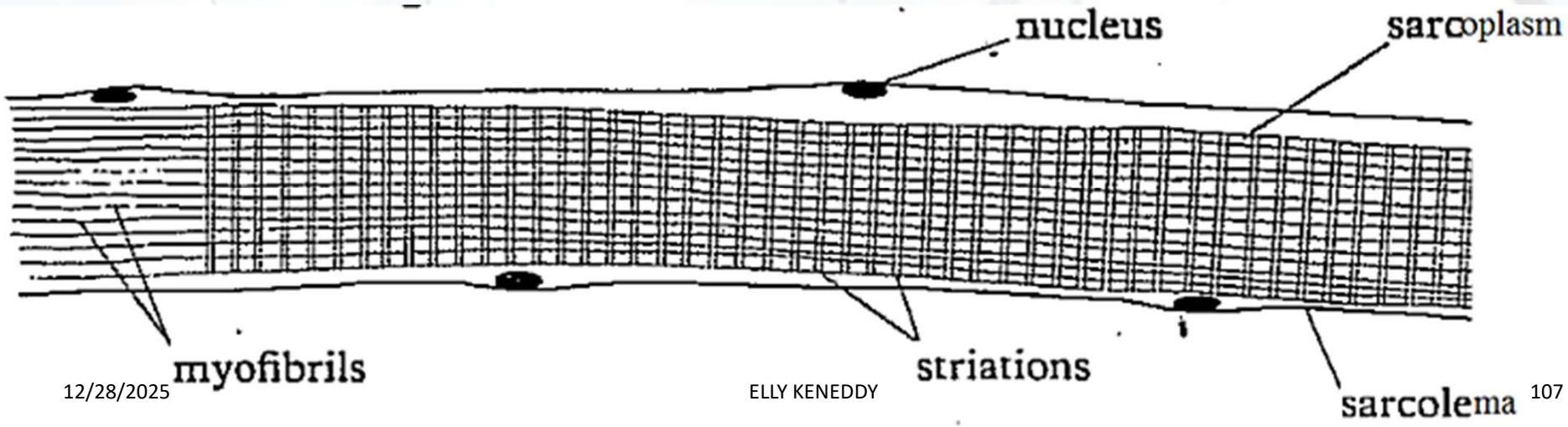
- This is also known as **voluntary**, **striated** or **striped** muscle
- It is said to be striated because ***its muscle cells have transverse stripes*** when viewed in longitudinal section.
- It is found *attached to the skeleton* in the **head**, **trunk** and **limbs** hence the name ***skeletal muscle***.
- All muscles are made up of **elongated**, **cylindrical** and **thin** cells called ***muscle fibers***.

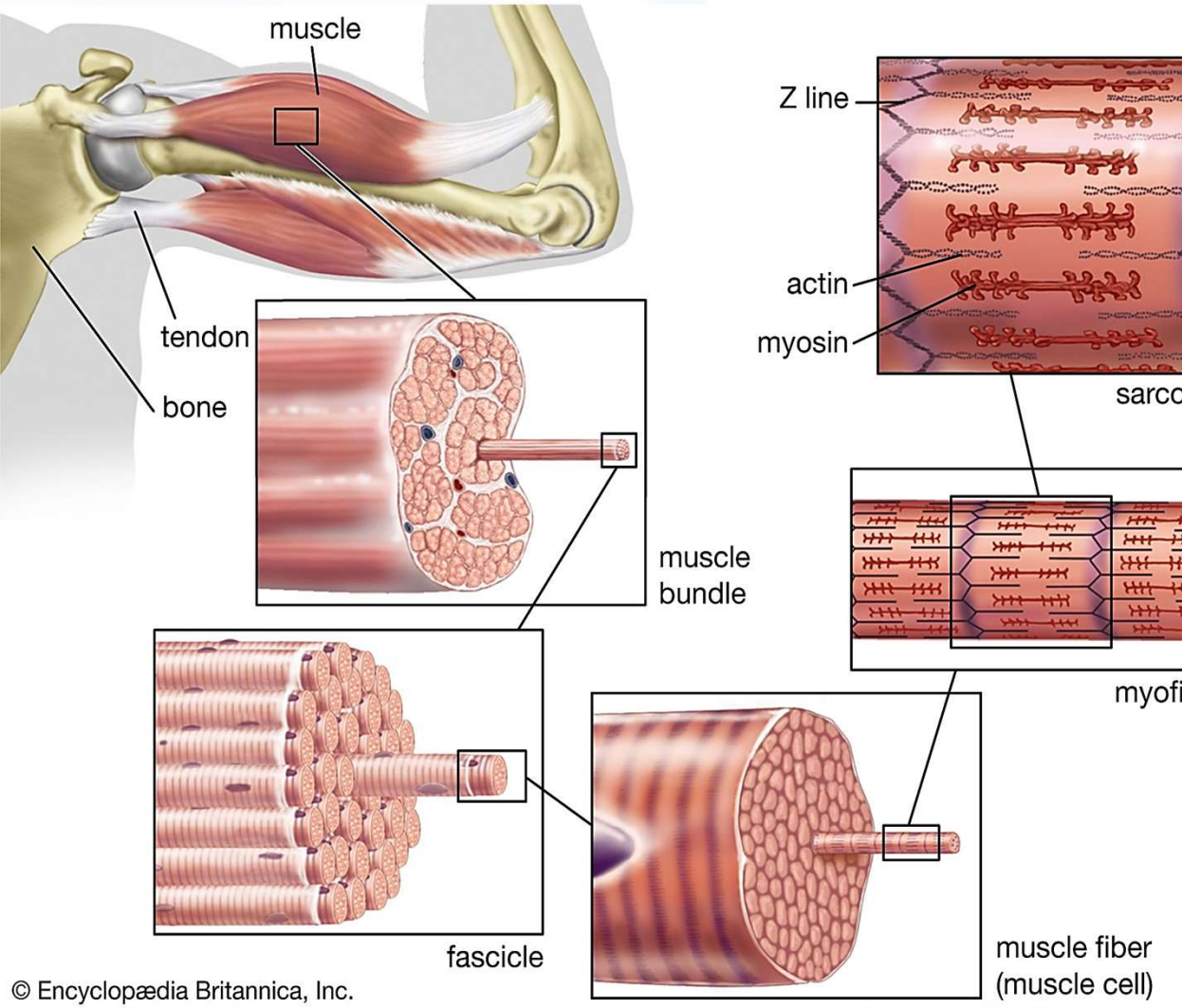


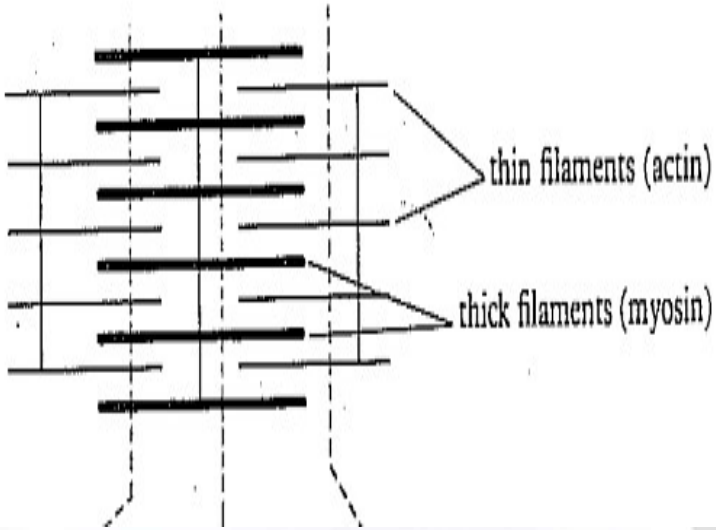


- Muscle fibers are be bound by a cell membrane called **sarcolemma**.
- The muscle fibers contain a specialized cytoplasm called **sarcoplasm** that contains a network of membranes called **sarcoplasmic reticulum**.
- Each muscle may contain ***numerous thin myofibrils*** i.e. **Actin** and **Myosin** filaments regularly arranged to form striations.
- The cells are multinucleated, nuclei are located on peripheral ends of the cell, have numerous mitochondria, highly supplied by blood capillaries

Structure of muscle fiber.




muscle
tendon
bone
muscle bundle
fascicle
muscle fiber (muscle cell)
Z line
actin
myosin
sarcomere
myofibril
© Encyclopædia Britannica, Inc.


thin filaments (actin)
thick filaments (myosin)

- ✓Each myofibril is divided into ***light*** and ***dark*** bands. The **dark** band has a comparatively ***light region in the middle*** called **H- zone**. In the middle of the H- zone is a dark line called the ***M- line***.
- ✓Running through the ***light bands in the middle*** is the **Z- line.** The dark and light bands are called A and I bands respectively.
- ✓**I** means isotropic, as it allows light to pass through and so appears lighter.
- ✓**A** means anisotropic as it does not allow light to pass through, so it appears darker.
- ✓The region of a myofibril between two Z-lines is called **a sarcomere** and the basic functional unit of a muscle.
- ✓The ***thick myosin filaments are confined*** to the **dark band** and the ***thin actin protein filaments*** occur in the **light band** but extend in between the thick myosin filaments within the dark band.

ADAPTATION OF SKELETAL MUSCLE TISSUE FOR ITS FUNCTION.

- It consists of elongated fibers, allowing considerable contractile length.
- Its fibers are parallel to give it maximum contractile effect and to allow each fiber to be controlled individually necessary for proper control of skeletal movement.
- The ends of the muscle fiber are tapered and interwoven with each other to provide adequate mechanical strength during muscle contraction.
- Its cells contain a large number of mitochondria to provide large amounts of ATP for muscle contraction.
- The actin and myosin filaments fit into each other to allow them slide over each other to cause contraction.
- The cells have a rich blood supply to provide adequate supply of oxygen.

Research for more

SMOOTH UNSTRIATED/INVOLUNTARY MUSCLES.

- Smooth muscles ***are involuntary in action*** and ***cannot be moved by one's own will***.

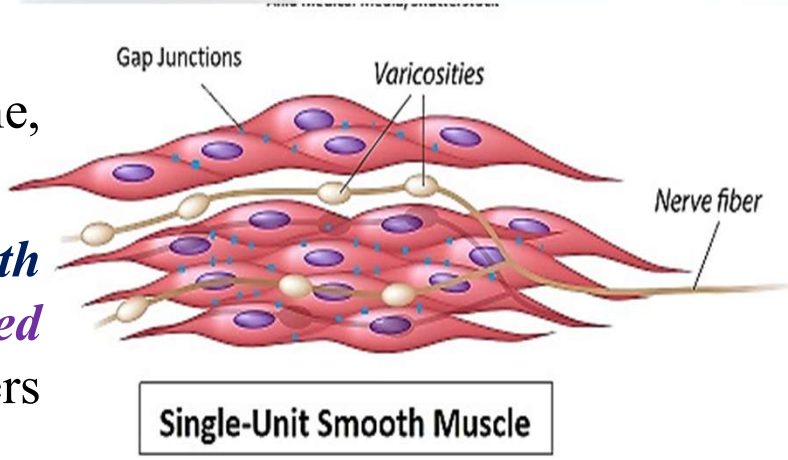
Location: walls of visceral organs like stomach, intestine, ureters, kidneys, blood vessels, etc.

✓Muscle cells are ***spindle shaped*** and ***tapering at both ends*** and **uninucleated**. The nucleus is, ***centrally placed*** and surrounded by little **sarcoplasm** and muscle fibers **lack a sarcolemma**.

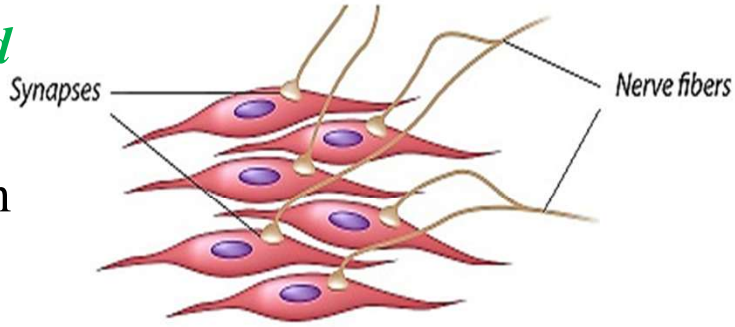
✓The actin and myosin filaments are ***evenly distributed hence there are no striations*** or light and dark bands.

✓Has sarcoplasmic reticulum but less extensive than in striated muscle.

✓Has prominent mitochondria but less numerous than in striated muscle.



Single-Unit Smooth Muscle

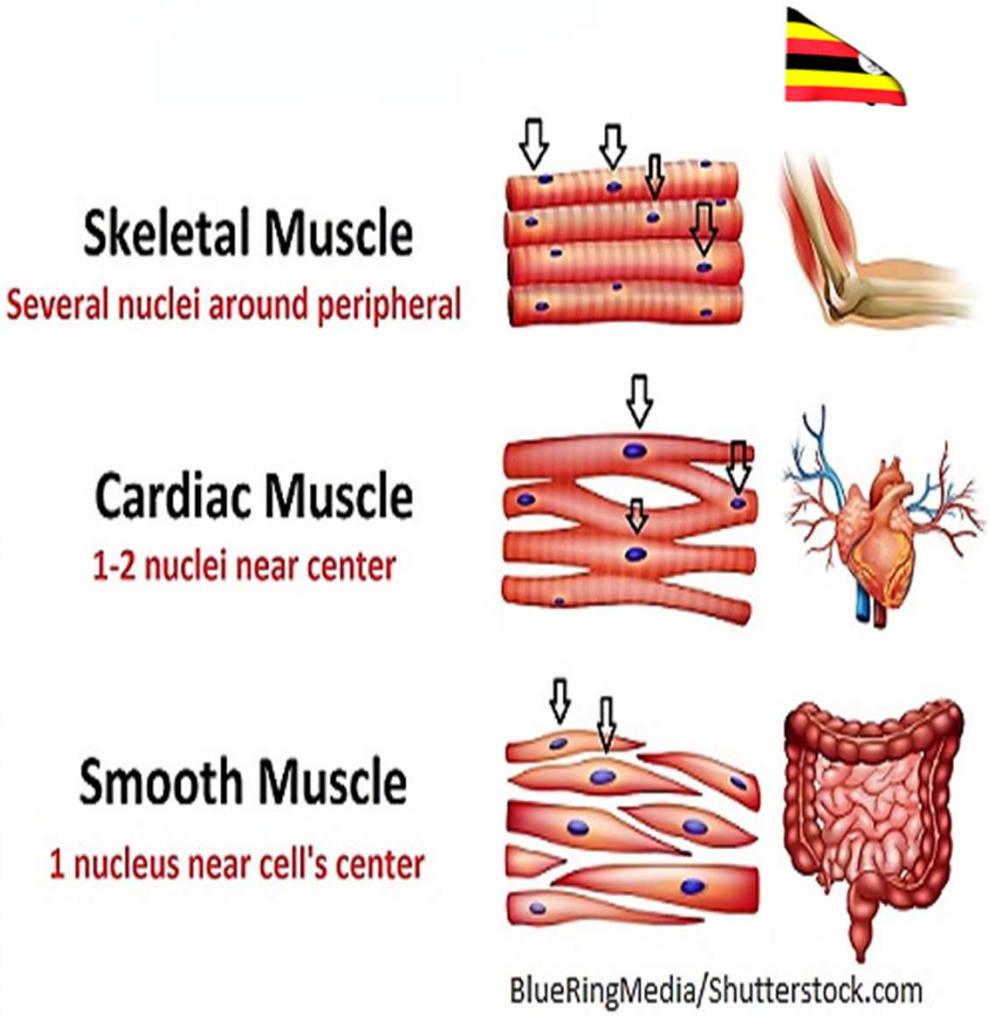


Multi-Unit Smooth Muscle

- It has less mitochondria and other organelles and much less extensive sarcoplasmic reticulum.

Functions of the smooth muscle

- ➢The anal sphincter controls the elimination of feaces from the body.
- ➢The pyloric sphincter controls passage of food from the stomach to the duodenum.
- ➢Small sphincter muscle surrounds some blood vessels to control the distribution of blood and regulation of blood pressure.



ORGANISMS AT THE ORGAN LEVEL ARE MORE EFFICIENT THAN THOSE AT THE CELLULAR AND TISSUE LEVEL

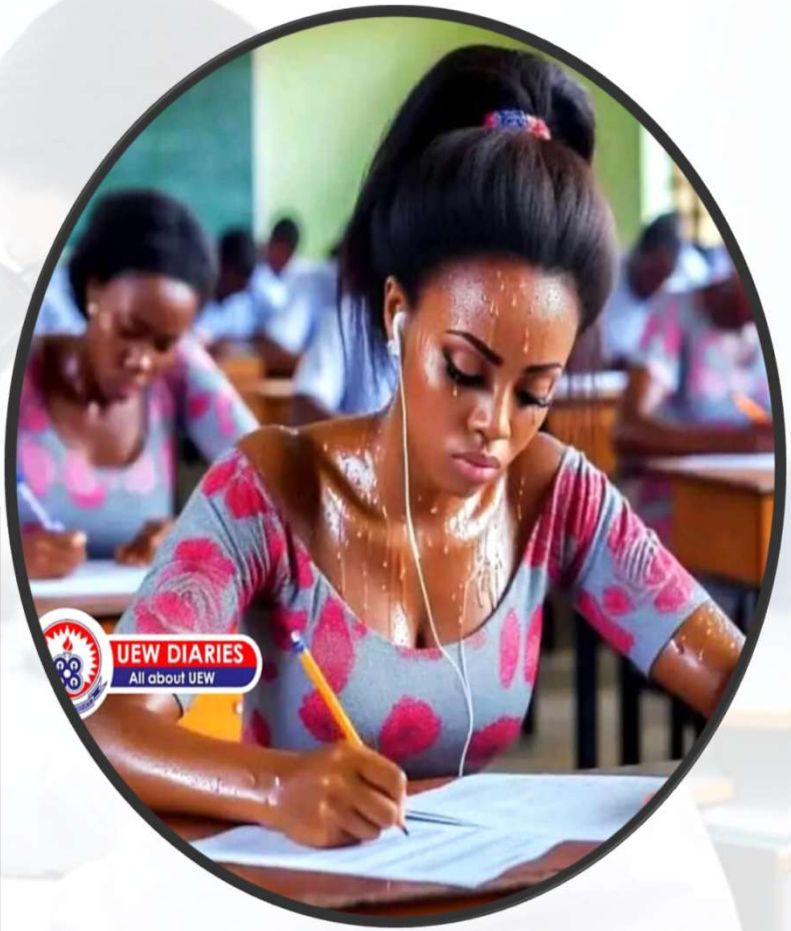
CHAIRPERSON:
SECRETARIES:

Proposers

Opposers

BRAIN TEASER.

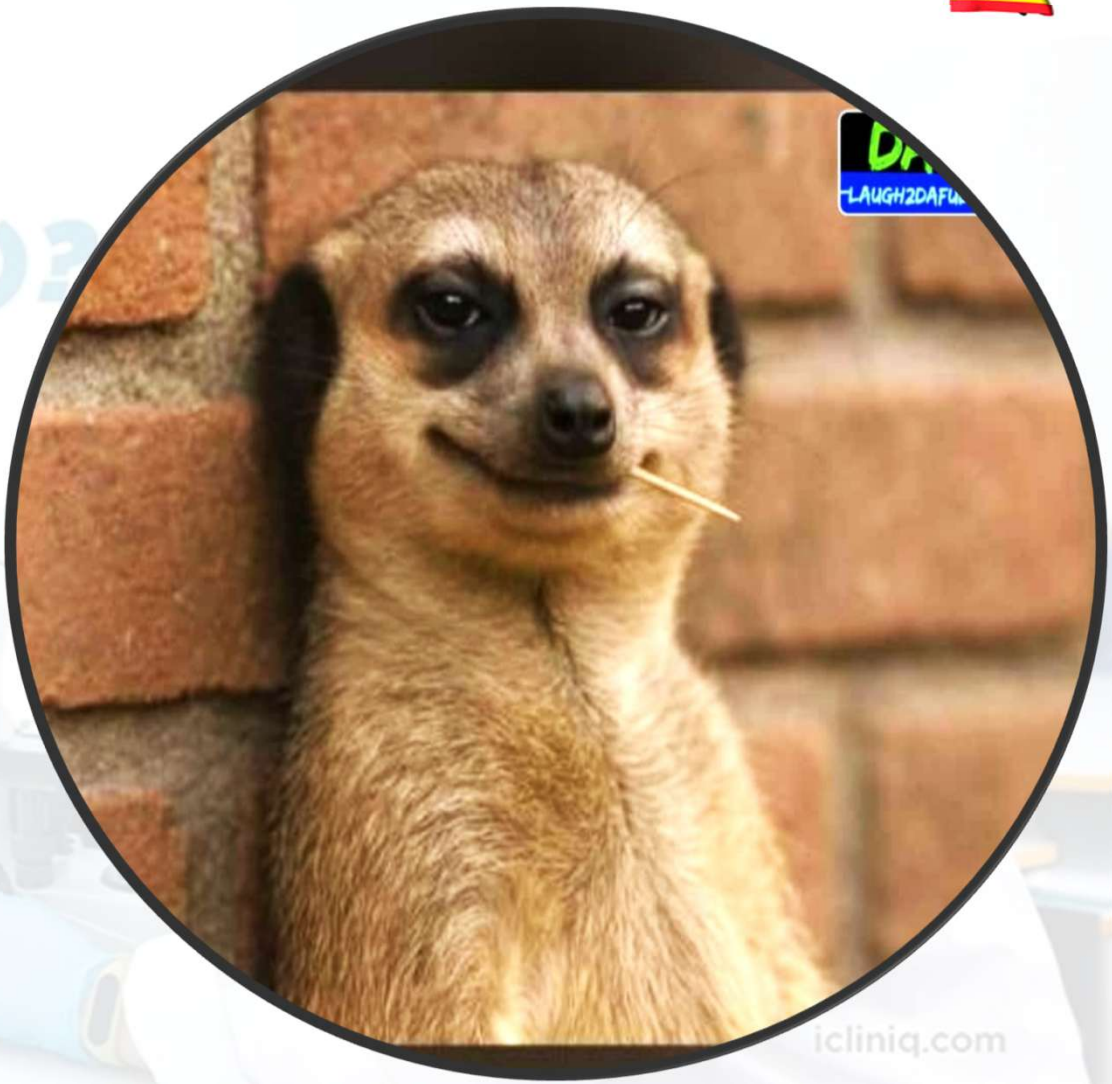
- Analyze the structure and arrangement of cells in different tissues covered.
- Identify the advantages of each level of organization.



THANKS FOR ATTENDING

Aim for the best always.

ELLY KENEDDY NALITSO



ALWAYS AIM FOR EXCELLENCE

BY *ELLY KENEDDY NALITSO*

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