CELLS

Learning outcome:

The learner should be able to analyse the ultrastructure of animal/plant cells, bacterial cells and the plasma membrane to distinguish prokaryotic and eukaryotic cell characteristics.

Outline

Ultrastructure of
- Animal cell
- Plant cell
- Bacterial cell

Eukaryotes and prokaryotes

Groups / Domains of prokaryotes

Comparision of plant/animal with bacterial cell

Structure and function of cell membrane (fluid mosaic)

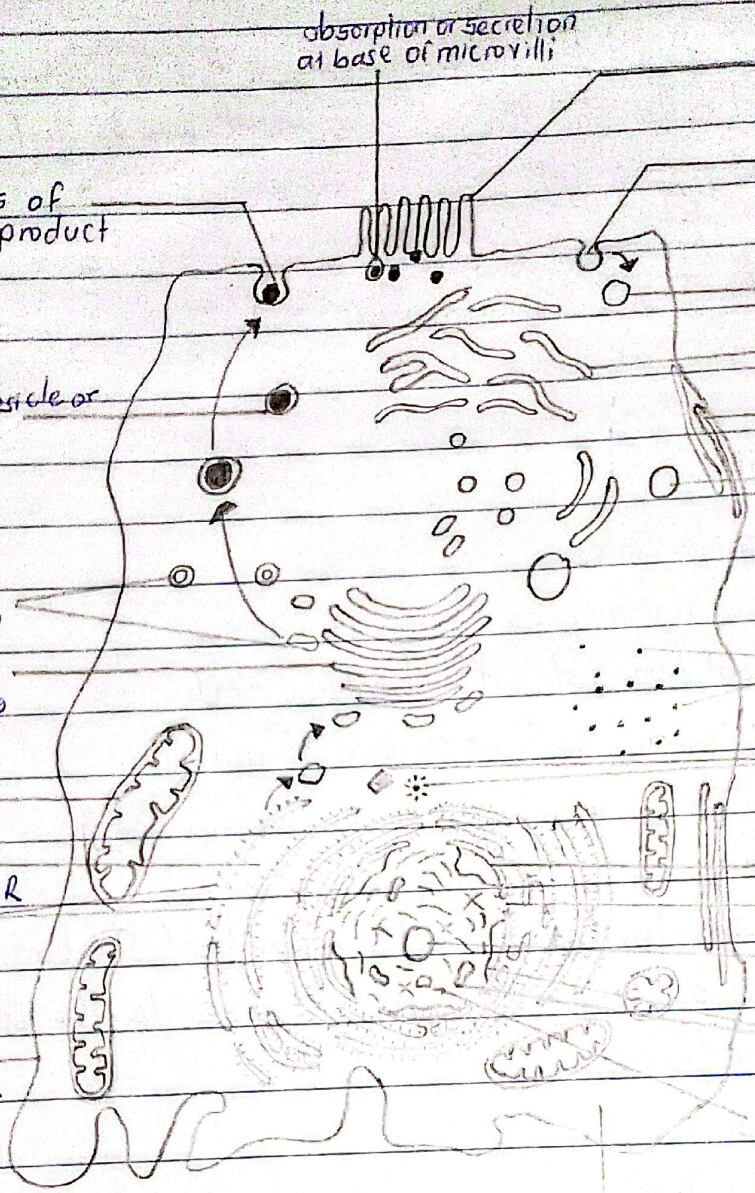
Cells

A cell is a basic structural and functional unit of life (an organism).

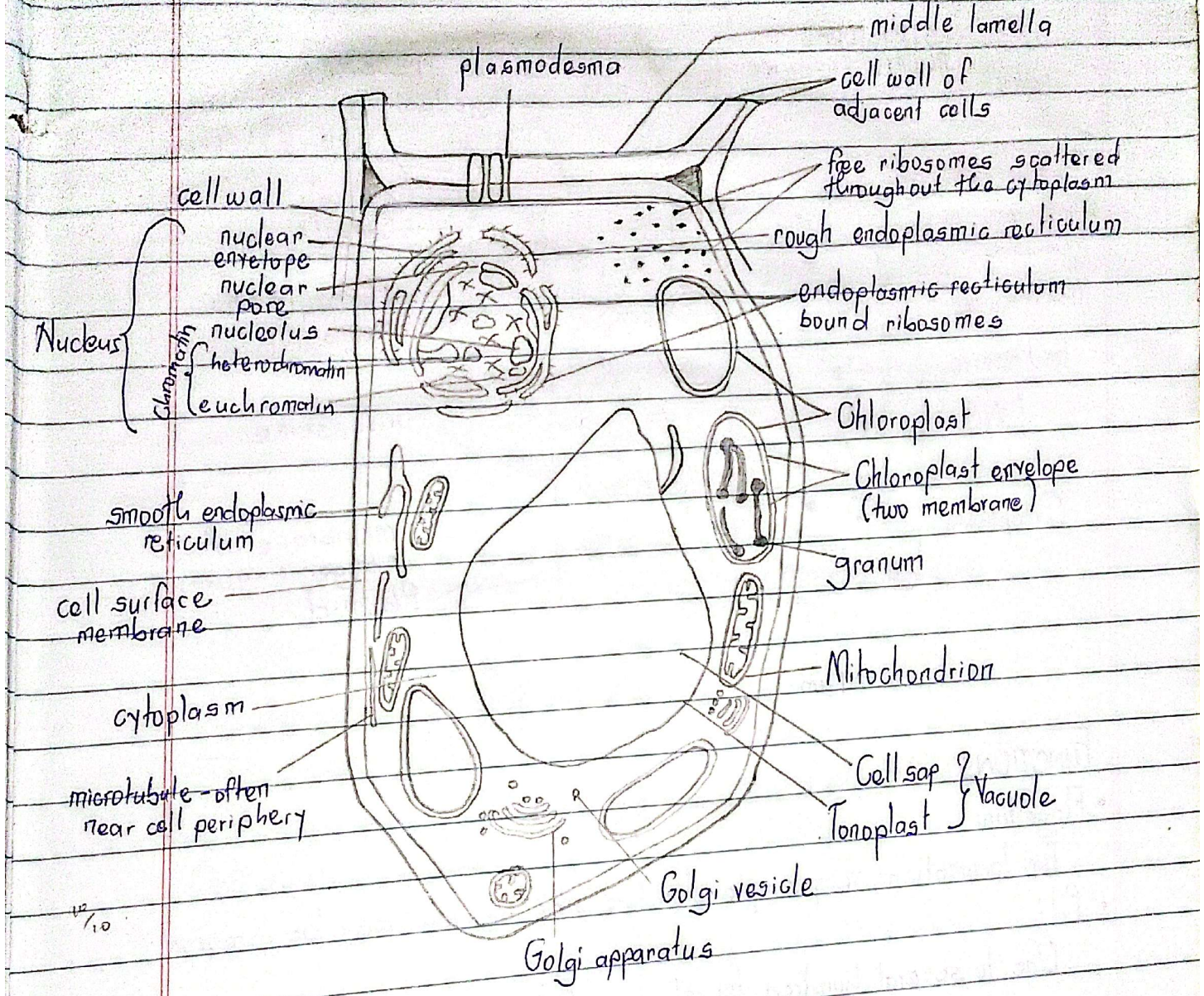
Numerous biochemical processes take place inside the cell

e.g.
- Protein synthesis
- Respiration
- DNA replication
- Photosynthesis in autotrophs.

Ultrastructure of an animal cell.



Ultrastructure of a generalised plant cell.



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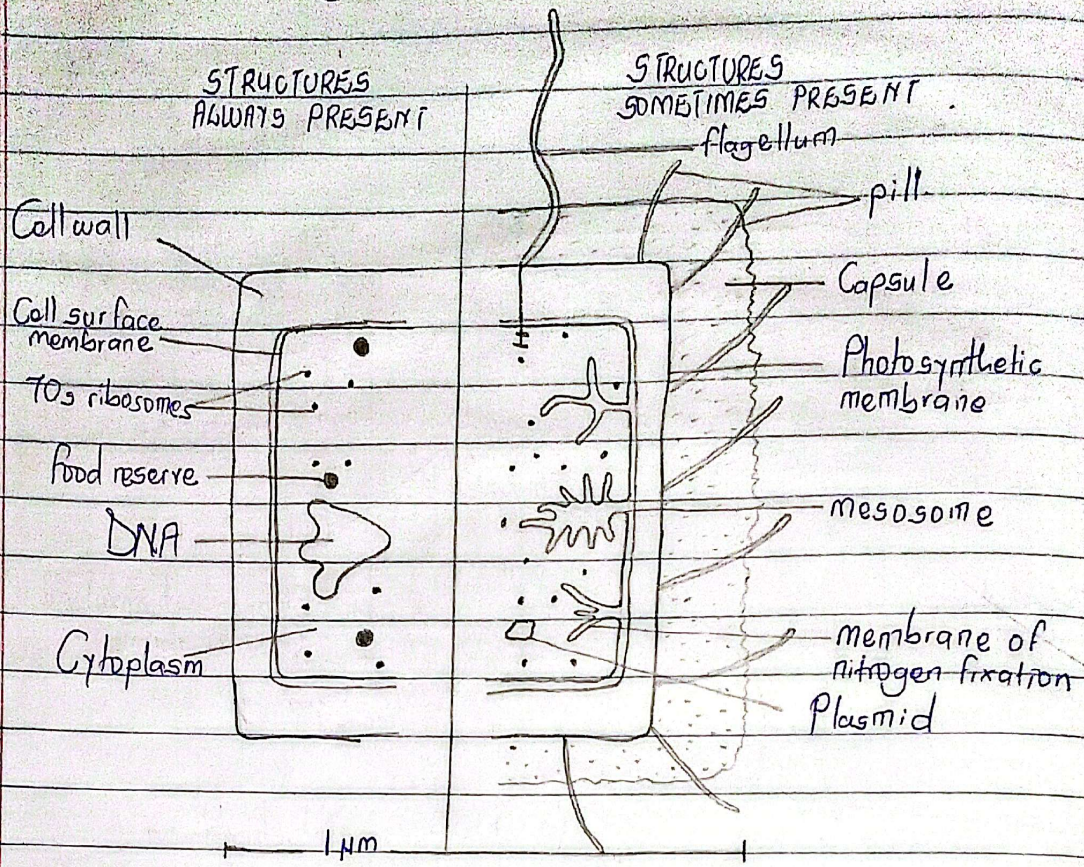
Structure of a generalised bacterial cell:

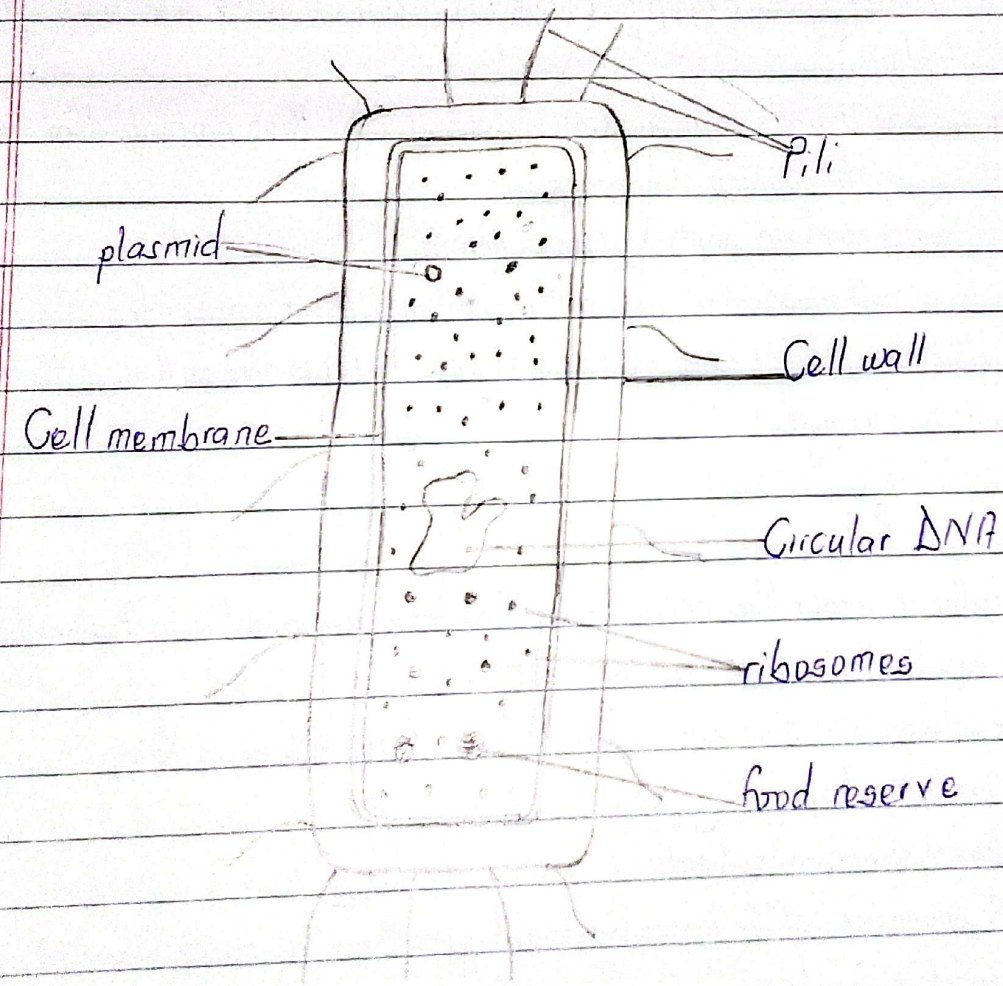


FUNCTIONS:

- **Flagellum**
  For locomotion, very simple structure, one or more may be present.
- **Pili**
  One to several hundred for attachment to other cells or surface involved in sexual reproduction
- **Capsule**
  For additional protection
- **Photosynthetic membrane**
  Possesses pigments, spread throughout cell
- **Mesosome**
  Intensely folded, associated with DNA during cell division and helps with formation of new cell wall.
- **Plasmid**
  Small circle of DNA, several may be present. Infoldings of cell surface membrane.

CamScanner

- Cell wall
  Rigid strengthening material is murein.
- 70s ribosomes
  Slightly smaller than 80s eukaryote ribosomes.
- DNA
  Circular molecule usually referred to as a chromosome, although it is not associated with protein unlike eurokaryatic chromosomes; often the cytoplasm ~~and~~ around it is clear, forming an area called the nucleoid.
- Cytoplasm.



PROKARYOTES

These are unicellular organisms that lack a nucleus and double membraned organelles. They range in size from 1-5 micrometres making them much smaller than most eukaryotic cells. Most prokaryotes were called bacteria.

Formally, all prokaryotes were placed in a single kingdom Monera however, they are now divided in classes / groups ie Eubacteria and Archaeabacteria.

Each of the two groups above is now considered to be a separate kingdom.

Eubacteria

This is the largest of the two kingdoms of prokaryotes

They live almost everywhere ie in fresh water, salty water, on land and on and within the human body for example Escherichia coli (E coli) ~~ben~~ lives in the human gut (intestines).

Eubacteria are usually surrounded by a cell wall that protects the cell from injury and damage, determines its shape.

Their cell walls contain peptidoglycan which is a carbohydrate.

They have a cell membrane inside the cell wall that surrounds the cytoplasm. Some have a second membrane called capsule outside the cell wall that makes them resistant to damage.

Archaeabacteria

Structurally ie under the microscope, they look very similar to Eubacteria ie they are also small, lack nuclei and have cell wall.

However, chemically they are different from Eubacteria in that

- Their cell walls lack peptidoglycan
- Have different membrane lipids.
- The DNA sequence of Archaea bacterial genes are more like those of eukaryotes than those of eubacteria.

Many Archaeabacteria live in extremely harsh environments e.g methanogens (groups of prokaryotes that produce methane gas) live in oxygen free environments eg thick mud and digestive tracts of animals.

Others live in extremely salty environments or in hotsprings

Structural differences between Eubacteria and Archaebacteria.

Feature	Eubacteria	Archaebacteria
Cell wall composition	Cell wall are composed of peptidoglycan	Cell wall lack peptidoglycan but contain other polysaccharide or pseudo peptidoglycan
Cell membrane Composition (membrane lipids)	Their cell membranes have ester-linked lipids where the fatty acids are linked to glycerol by ester bonds.	Their cell membranes have ether-linked lipids where branched isoprenoid chains are linked to glycerol by ether bonds.
Ribosomal RNA and Proteins	Are more similar to those of bacteria	Are more similar to those of eukaryotes than those of Eubacteria.
Examples	• Escherichia coil (E.coil) • Clostridium botulinum • Streptococci pyogenes • Bacillus thuringiensis • Rhizobium spp.	• Euryarchaeota • Methano brevibacter smithii • Bathyarchaeota • Nitrososphaerota • Thermoproteota • Methano sarcina • Lokiarchaeota • Proteoarchaeota. barker fusaro • Thermophiles • Hyperthermophiles e.g Pyrolobus fumani • Sulfolobus Acibocamborius

Non-structural differences between Eubacteria and Archaebacteria.

i) Metabolic Pathways

Eubacteria utilize a wide range of metabolic pathways including fermentation and respiration while Archaebacteria often have unique metabolic pathways such as methanogenesis (respire in absence of oxygen and methane gas is the by product)

2) Environmental Adaptations.

Eubacteria can be found in various environments including soil and water, while Archaebacteria are often extremophiles, thriving in extreme conditions such as high salinity, temperature or acidity.

3) Susceptibility to Antibiotics:
Eubacteria are susceptible to antibiotics while archaebacteria are not.

4) Growth and Reproduction.
Archaebacteria: Asexual reproduction (binary fission, fragmentation and budding)
Eubacteria: In addition to other asexual methods they also produce spores in order to remain dormant during unfavorable conditions.

Archaebacteria	Eubacteria.
General resistance to antibiotics	Susceptible to antibiotics.
They are halophiles, methanogens and thermoacidophiles	They are chemosynthetic, photosynthetic and heterotrophic.
Intermidates btn prokaryotes and Eukaryotes	Prokaryotes
Enzymes are often adapted to extreme conditions.	Enzymes are prone to extreme conditions.
Trive in places with high pressure.	Sensitive to rise in pressure.

Archaebacteria.
The discovery of archaebacteria (ancient and ~~bact~~ bakterion, mod) in the late 1970s left many biologists incredulous. These bacteria were found thriving in extreme environments where few other organisms survive:

- Methanogenic archaebacteria.

They inhabit anaerobic habitats and give off methane as a product of their metabolism. They live in the guts of cattle and are responsible for the intestinal gases that cattle produce. A cow can belch out 200-400 dm^3 of methane each day

- Extremely halophilic (salt-loving) archaebacteria.

They live only in very salty conditions such as salt flats, where heat from the sun has evaporated sea water. They will grow in salt concentrations

approaching saturation, about ten times as salty as oceanic sea water.

- Thermoacidophilic (heat and acid loving) archaebacteria.

They can live in hot acidic springs where temperatures may exceed 100°C and the pH may be as low as 2.

Because they tolerate extreme conditions similar to those that are thought to have existed at the dawn of life, archaebacteria are believed to have been the first forms of life on Earth. Also, some features of their ultrastructure and metabolism suggest that they are the ancestors of both eubacteria and eukaryotes.

EUKARYOTES:

Plants, animals, fungi and protocists all have cells contain double membraned structures and have genetic material enclosed within the nucleus. These are known as Eukaryotes and are made up of eukaryotic cells.

Differences btn Eukaryotes and Prokaryotes:

Features	Prokaryotes (bacteria)	Eukaryotes
Cell size	Average diameter 0.5-10μm	10-100μm diameter common, commonly 1000-10000 times volume of prokaryotic cell
Form	Mainly unicellular	Mainly multicellular except protoctista
Evolutionary origin	3.5 thousand million years ago.	1.2 thousand million years ago, evolved from prokaryotes.
Cell division	Mostly binary fission, no spindle	Mitosis, meiosis or both; spindle formed
Genetic material	DNA is circular and lies free in cytoplasm (no true nucleus). DNA is naked (not associated with proteins or RNA to form chromosomes)	DNA is linear and contained in nucleus. DNA is associated with proteins and RNA to form chromosomes.
Protein synthesis	70s ribosomes (smaller). No endoplasmic reticulum present. Susceptibility to antibiotics e.g prokaryotes inhibited by streptomycin	80s ribosomes (larger). Ribosomes may be attached to endoplasmic reticulum.
Organelles	Few organelles. None are surrounded by an envelope (two membranes)	Many organelles. Envelope-bound organelles present e.g mitochondria.
Cell walls	Rigid and contain polysaccharides with amino acids; murein is main strengthening compound.	Cell walls of green plants and fungi rigid and contain polysaccharides; cellulose for plant walls, chitin of fungal walls (none in animal cells).
Flagella	Simple, lacking microtubules; extracellular (not enclosed by cell surface membrane); 20nm diameter.	Complex with '9+2' arrangement of microtubules; intracellular (surrounded by cell surface membrane) 200 nm diameter
Respiration	Mesosomes in bacteria except cytoplasmic membranes in blue green	Mitochondria for aerobic respiration

Photosynthesis	No chloroplasts; takes place on membranes which show no stacking	Chloroplasts containing membranes which are usually stacked into lamellae or grana
Nitrogen fixation	Some have the ability	None have the ability.

Similarities btn animal cell and bacterial cell.

Both have cytoplasm.
Both have DNA
Both have cell membrane
Both have ribosomes.

Differences between animal cell and bacterial cell.

Animal cell	Bacterial cell.
Lacks a cell wall	Has a cell wall
Has double membraned organelles	Lacks double membraned organelles.
DNA is linear	DNA is circular
DNA located in nucleus	DNA located freely in cytoplasm.
Has a nucleus	Lacks no nucleus
Has more organelles	Has few organelles.
Has 80's ribosomes	Has 70's ribosomes.
Has mitochondria for respiration	Has mesosomes for respiration.

Similarities between plant cell and bacterial cell.

Both have cell wall
Both have cytoplasm.
Both have cell membrane
Both have ribosomes.
Both have DNA.

Differences between plant cell and bacterial cell.

Plant cell	Bacterial cell
Cell wall made up of cellulose	Cell wall made up of murein.
Has 80's ribosomes	Has 70's ribosomes.
Has double membraned organelles	Lacks double membraned organelles.
Has more organelles	Has few organelles.
DNA is linear	DNA is circular
DNA located in nucleus	DNA is free in the cytoplasm
Has a nucleus	Lacks a nucleus
Has mitochondria for respiration	Has mesosomes for respiration.
Has plasmodesmata	Lacks plasmodesma
Has endoplasmic reticulum	Lacks endoplasmic reticulum.

STRUCTURE OF THE CELL MEMBRANE.

According to S.J. Singer and G.L. Nicholson (1972), the structure of the cell membrane is a fluid-mosaic model. It is described as:

Fluid because the individual phospholipid and protein molecules can move laterally giving the membrane a flexible or dynamic structure that is constantly changing in shap

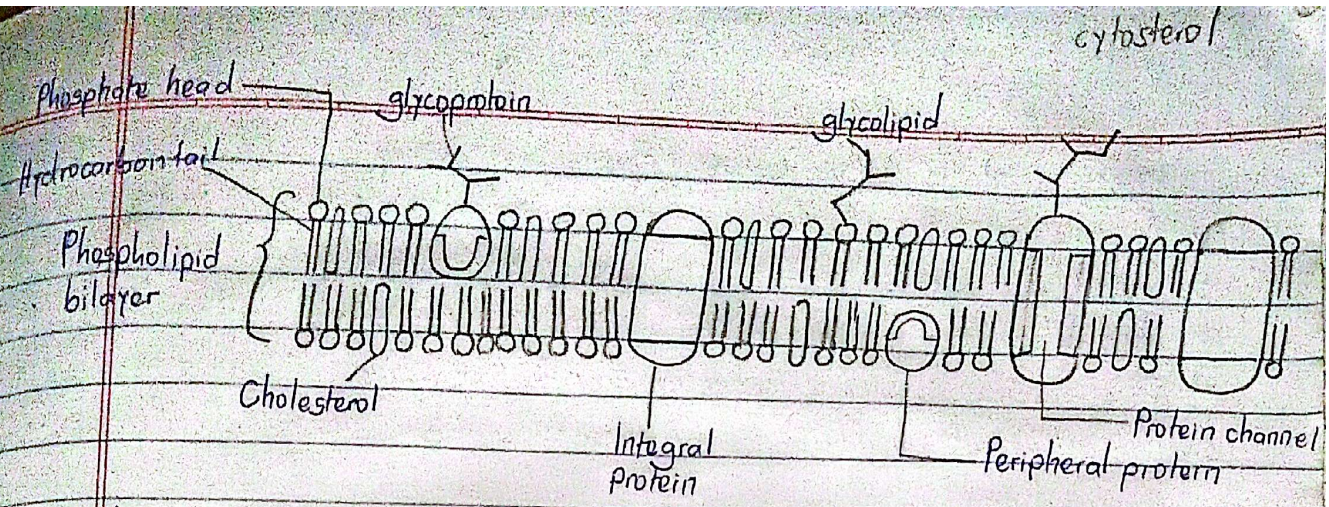
Mosaic because the proteins that are embedded in the phospholipid bilayer vary in size, shape and pattern of arrangement. OR.

Proteins are dotted or scattered throughout the phospholipid bilayer.

The main components of the cell membrane are:

- Phospholipids
- Proteins
- Carbohydrates
- Cholesterol

FLUID MOSAIC MODEL



Description of the fluid mosaic model.

The plasma membrane is made up of two layers of phospholipids (Phospholipid bilayer), whose lipid tails face inwards of the membrane while phosphate heads face outwards.

Phosphate heads are polar, hydrophilic or water loving and form hydrogen bonds with water.

Lipid tails are non-polar, hydrophobic or water hating and are attracted/attached to each other by hydrophobic interactions and Van-der-Waals forces.

Extrinsic (peripheral proteins) are found at the inner and outer surfaces.

Some intrinsic proteins are partly embedded in any one of the phospholipid layers while other span across the two phospholipid layers (trans-membrane proteins)

Some trans-membrane proteins are porous (channel proteins)

Some proteins conjugate with short branched carbohydrates to form glycoproteins.

Some phospholipids conjugate with short branched carbohydrates to form glycolipids.

In animal cells, cholesterol ~~are~~ molecules squeeze btn the phospholipid molecules. Plant cells do not contain cholesterol in their membranes. They utilize a variety of other sterols such as sitosterol and stigmasterol to maintain membrane fluidity and function.

Research

Functions of the cell membrane / Plasma membrane:

1. Controls movement of substances in and out of the cell.
2. Important in cell recognition
3. They act as hormonal and neurotransmitter binding site.
4. Enables cells to adhere to one another to form tissues.
5. They act as cell identity markers / antigens enables cells to behave in an organised way.
6. In animal cells, it may be folded to form microvilli providing a large surface area for absorption of substances.
7. Proteins on membranes sometimes act as enzymes
8. Transmission of nerve impulses.
9. For mechanical support.

FUNCTIONS OF THE CELL MEMBRANE:

General functions:

Forms a protective barrier between the inside and outside of the cell.

Controls exchange of materials btn the cell and its envt.

Component functions:

1. Phospholipids:

Affect the fluidity of the membrane due to their constant motion relative to one another

Contribute to the selelive permeability of the membrane since their tails are lipid in nature, they can only allow diffusion of lipid soluble molecules but will not allow diffusion of water soluble (polar) molecules.

2. Proteins:

- Transport proteins:

Channel proteins have water filled ~~hydrophob~~ hydrophilic channels that are specific and allow diffusion of particular ions and polar molecules across the membrane.

Carrier proteins move ions or solutes by active transport e.g sodium ions or by facilitated diffusion e.g. glucose, amino acids, etc across the membrane.

NOTE:

Once attached, the proteins change shape / configuration so as to move the substance

Myelinated Schwann cell

across the membrane.

The carrier proteins involved in facilitated diffusion don't need an energy supply to change shape unlike those involved in active transport.

→ Other membrane proteins.

Some provide structural support to the membrane ie provide sites for cytoskeleton filaments to anchor to support and maintain cell shape.

Some membrane proteins work as electron carriers in the electron transport chains e.g those embedded in the inner mitochondria membrane.

Some membrane proteins have enzymatic ~~prote~~ properties e.g ATP-synthase for ATP synthesis.

Some embedded proteins act as energy transducer.

3. Glycoproteins.

Glycoproteins work as antigens in immunity.

Membrane proteins join cells together forming tissues which perform specific functions. (adhesion)

Cell surface receptor proteins are involved in signal-transduction by converting an extracellular signal to an intracellular one.

4. Glycolipids.

Are involved in cell to cell recognition.

May act as receptor sites for chemical (substances) signals.

Together with glycoproteins they are involved in sticking the correct cells together in tissues.

5. Cholesterol.

Makes the membrane less fluid at higher temperatures and more fluid at lower temperatures; thus stabilizing the membrane.

It also contributes to the selective permeability of the membrane by acting as a plug. It prevents the leakage of ions, water or any other polar molecules since cholesterol molecules are hydrophobic in nature.

How Cholesterol Maintains Membrane Fluidity:

At low temperatures, cholesterol increases membrane fluidity by preventing fatty acid hydrocarbon chains from coming together and crystallizing thereby inhibiting the transition from liquid to solid (decreases the membrane freezing point).

At warm temperatures e.g 37°C, cholesterol decreases membrane fluidity by interacting with lipid tails to reduce their mobility, thereby increasing the melting point.

At high concentrations, cholesterol also prevents fatty acid hydrocarbon chains from coming together and crystallizing.

The partial permeability of the plasma membrane:

The plasma membrane is partially permeable ie it allows the passage of some materials while restricting others. This is because;

It is made up of hydrophobic regions composed of fatty acid chains (lipid tails) that allow passage of lipid-soluble / non polar molecules while repelling the polar molecules / ionic substances.

It is also composed of cholesterol that is majorly hydrophobic allowing the diffusion of non polar molecules across the membrane.

The plasma membrane is also made up of channel proteins; whose channels are water filled (hydrophilic) and specific; allowing the diffusion of specific polar molecules / ions (water-soluble substances) into or out of the cell.

The membrane contains very tiny pores between the phospholipid molecules thereby allowing diffusion of only very small sized molecules like gases and lipid soluble substances.

Various Roles of Membranes in Cells.

Membranes of cells not only include the cell membrane / plasma membrane but also other membranes enclosing some organelles and some cytoplasmic inclusions within cell. They include the following;

1. Control of entry and exit of substances ie selective permeability.
2. Bulk transport (cytosis (endocytosis and exocytosis): In endocytosis, the plasma membranes form an infolding / ~~in~~ invagination through which fluid or solid materials may be enclosed; a vesicle is formed and the material moved inside the cell.

In exocytosis, the plasma membrane (vesicles formed internally within the cell usually pinching off from the Golgi body) move towards the plasma membrane, fuse with it, releasing their contents to the outside of the cell.

Isolation of reaction sites. Membranes of various organelles play an important role in isolating regions within the cell where specific enzyme catalyzed reactions can take place without interference with those occuring within other organelles.

Isolation of lytic enzymes. Lysosomes contain enzymes for destruction of foreign materials and worn out organelles. These enzymes must be isolated or else they will digest the entire cell. Peroxisomes isolate enzyme catalase that catalyzes the breakdown of hydrogen peroxide into harmless products.

Packaging and isolation. Membranes of the Golgi apparatus isolate compartments in which sorting, modification and packaging of proteins into vesicles occurs. The packaging material is moved to the cell surface membrane for secretion

Providing surface area for protein synthesis. The membrane of rough endoplasmic reticulum provides a large surface area onto which ribosomes are attached. The ribosomes synthesize and secrete proteins directly into the space enclosed by the rough endoplasmic reticulum membrane.

Containment of DNA (genes). The nuclear envelope forms a separate compartment that houses the cells' genetic material.

Isolation of storage sites e.g membrane of plant cell vacuole.

Protection e.g the plasma membrane protects internal organelles.

Energy transfer e.g the inner mitochondrion membrane and the chloroplast thylakoid membranes have proteins embedded in them which act as electron carriers. The electrons are moved along proteins from a high energy to a low energy level with release of energy that is subsequently used in synthesis of ATP from ADP and an inorganic solvent phosphate via chemiosmosis.

Cell recognition, identification and communication

Describe the distribution and function of the membranes of cells.

Plasma membrane around each cell; controls exchange of materials btn the cell and env't; maintains cell shape and limits cytoplasm and organelles;

Nuclear membrane (envelope); isolates DNA from cytoplasm around the nucleus, allows exit of messenger RNA (mRNA) through nuclear pores

Outer mitochondrial membrane; allows entry of glycolytic products into the matrix of the mitochondrion.

Thylakoid membrane of the chloroplast; store photosynthetic pigments e.g chlorophyll and are a site for light reactions of photosynthesis

Lysosomal membrane; isolates hydrolytic enzymes.

Tonoplast; isolates cell sap within the vacuole

Rough endoplasmic reticulum membrane; for attachment of ribosomes and intracellular transport of proteins.

Golgi complex membrane; for synthesis of cell wall polysaccharides; formation of lysosomes.

Smooth endoplasmic reticulum membrane; for intracellular transport of lipids and steroids.

Myelin sheath membrane; insulate nerve fibres increasing speed of transmission of nerve impulses.

Membrane around vesicles; isolate contents within it e.g neurotransmitter substance until they are ready for exit.

MEMBRANE FLUIDITY

This refers to the viscosity of the lipid bilayer of the cell membrane.

Membrane fluidity is important because;

- It has to be regulated in order for the membrane to be fluid, to work properly.
- Also biological process stop when the bilayer fluidity reduces too much e.g membrane transport and enzyme activity.

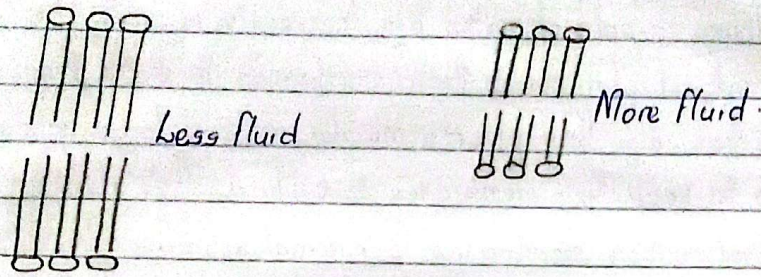
Factors that affect membrane fluidity.

> Length of phospholipids (lipid tails)

Membrane fluidity decreases with increase in length of fatty acid tails and increases with decrease in length of the tails. Longer phospholipids are more rigid, have higher

molecular masses than shorter ones and so are less easily moved. The intermolecular interactions btn the longer tails add rigidity to the membrane. The longer the lipid tails, the more the interactions btn the tails and the less fluid the membrane becomes

Illustration.



② Temperature

Increase in temperature increases membrane fluidity while lowering temp reduces fluidity. In low temp, phospholipids in the bilayer donot have much kinetic energy and they cluster together more easily / closely increasing the intermolecular interactions btn them, this decreases membrane fluidity.

In high temp, phospholipids have enough kinetic energy to overcome intermolecular forces holding them together which increases membrane fluidity.

3. Presence / absence of multiple bonds btn carbon atoms of the fatty acid tails (saturation / unsaturation)

Saturated fatty acids are arranged in a way that maximises interactions btn the tails as they are more closely packed. This decreases membrane fluidity. Unsaturated fatty acids have more distance between them and fewer intermolecular interactions. This is because the presence of multiple bonds btn fatty acids causes some bends / kinks at points where multiple bonds occur. This disrupts close packing and this makes the membrane more fluid (thus more permeable)

4. Presence / absence of cholesterol (Amount of cholesterol)

At low temperatures, cholesterol increases fluidity by the preventing the fatty acid hydrocarbon chains from coming together and crystalizing thereby inhibiting the transition from liquid to solid.

At warm (high) temperature, cholesterol reduces membrane fluidity by interacting

with lipid tails to reduce their mobility thereby increasing the melting point

At high concentration, cholesterol prevents fatty acid hydrocarbon chains from coming together and crystalizing.

NOTE: Animals living in cold climates e.g temperate regions like South Africa have evolved adaptations in their membranes to make them survive well in such extremes e.g their plasma membrane have large amounts of unsaturated fatty acids to keep their membranes more fluid. They also have large amounts of cholesterol in their membranes to prevent solidification of membranes in extremely low temperatures.

Describe how the structure of the cell membrane is related to its functions.

Cell membrane is thin; allowing rapid transport (diffusion) of substances across i

It contains phospholipids; which are fluid making it flexible and hence preventing it from breaking down.

Cholesterol and phospholipids in the cell membrane; are hydrophobic providing selective permeability to the membrane and thus controlling the entry and exit of materials in the cell.

Cholesterol in the membrane prevents the close packing of the membrane, keeping them more fluid such that the membrane does not solidify at low temperature

Proteins are embedded in the phospholipid bilayer to provide structural suppor to the membrane (by providing attachment to cytoskeleton filament).

Some proteins in the membranes are enzymes; making the membrane metabolically active.

Cholesterol in the membrane increases the flexibility and stability of the membrane such that it does not break up.

Short carbohydrate chains attach to phospholipids and proteins are involved in sticking cells together to form tissues and in cell to cell recognition.

ANIMAL TISSUES.

There are 4 major categories of tissues in vertebrates. They include the following. - Epithelial tissue
- Connective tissue
- Muscular tissue
- Nervous tissue

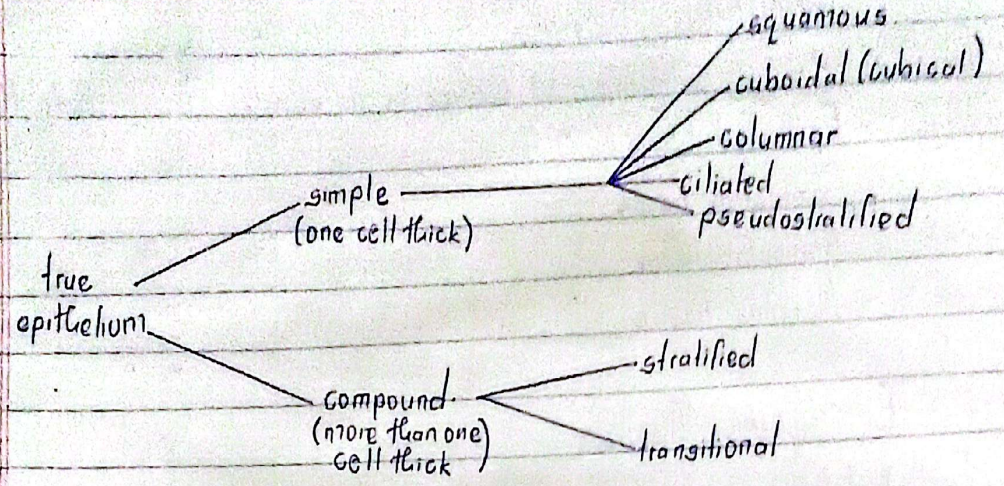
EPITHELIAL TISSUES.

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

General structure / features 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 (carbohydrate-based). The bottom layer of epithelial cells rest 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 neighbouring structures and serves as board upon which new cells attach during healing of injured epithelia.
- The free surface is highly specialized depending on its location e.g may be modified into cilia or microvilli.
- There are no blood vessels in epithelial tissues.
- Epithelial tissues are innervated, ie nerve ending may occur in the epithelium or the epithelium itself may be specialized for reception of stimuli.
- Epithelial tissues have a high regeneration capacity due to rapid cell division by mitosis. This helps epithelial tissue to recover fast after any injury / abrasion.

SUMMARY OF EPITHELIAL TISSUES.



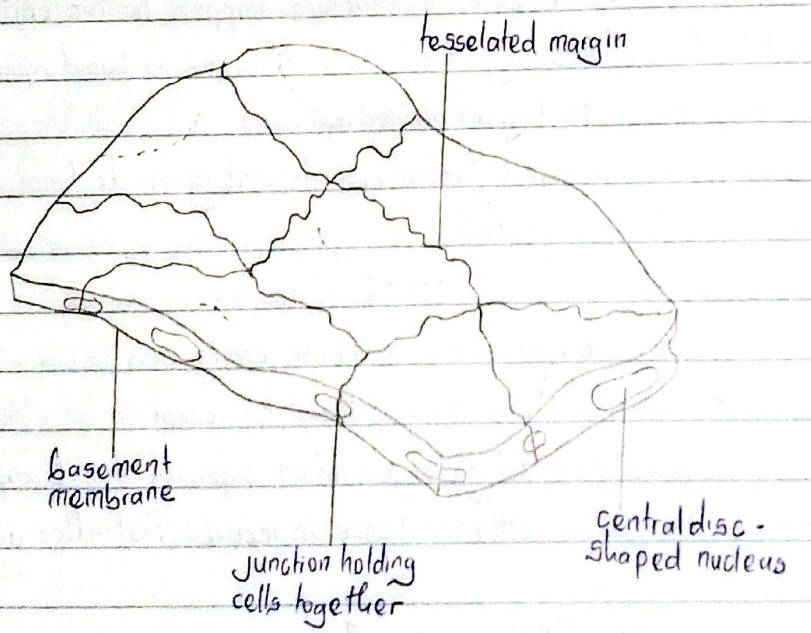
A. Simple Epithelial Tissues.

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 and flattened.

Diagram of simple squamous epithelium.



Location.

- Alveolar lining of the lungs.
- Inner lining of blood vessels where it is referred to as endothelium.
- Lining of blood capillaries.

• Bowman's capsule of kidneys

Functions

> Diffusion of materials and gaseous exchange across membranes.

> 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 which reduces resistance to blood flow.

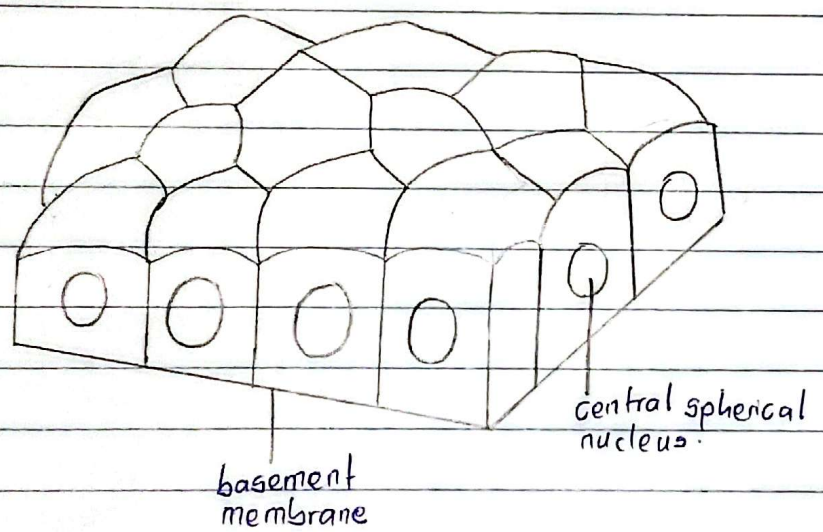
2. Cuboidal epithelial tissue.

Its cells are roughly cube-shaped and possess a central spherical nucleus.

The cells form a single layer attached to a basement membrane.

In surface view, the cells appear pentagonal or hexagonal in outline.

Structure of cuboidal epithelium.



Location.

• Lining of salivary and pancreatic ducts.

• Lining of proximal and distal convoluted tubules and collecting ducts of kidneys.

• Salivary, sweat and thyroid glands.

Functions

• Secretion

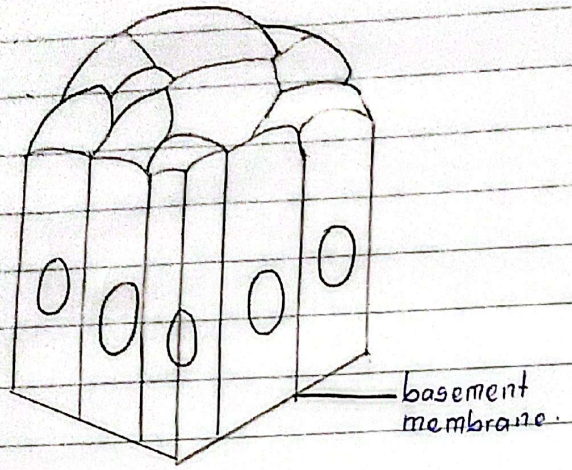
• Reabsorption of materials e.g in distal and proximal tubules where the free cell surfaces have numerous microvilli to increase the surface area for reabsorption

of materials.

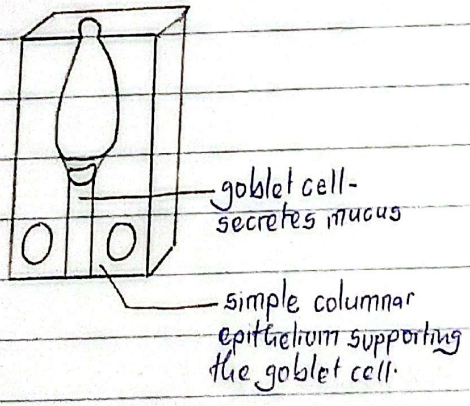
3. Simple columnar epithelium.

Cells are tall, column like and narrow with nucleas at the basal end. It is often interspered by goblet cells.

Structure of simple columnar epithelium.



Structure of goblet cell.



Location.

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

Functions.

- Secretion and absorption.
- Side view of simple columnar
- Mucus protects the lining from the acidic content in the stomach and from digestion

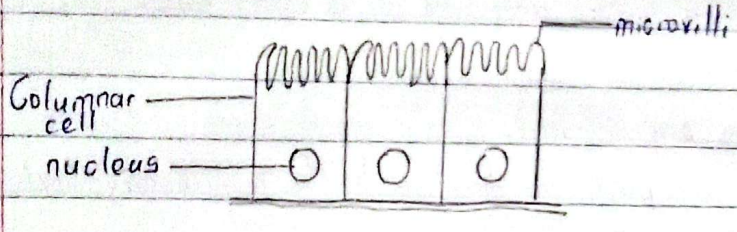
by enzymes and also lubricates the passage for food.

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.

Structure of side view of brush bordered columnar epithelium.



Location.

Intestinal mucosa

Function

Increase the surface area for absorption of nutrients.

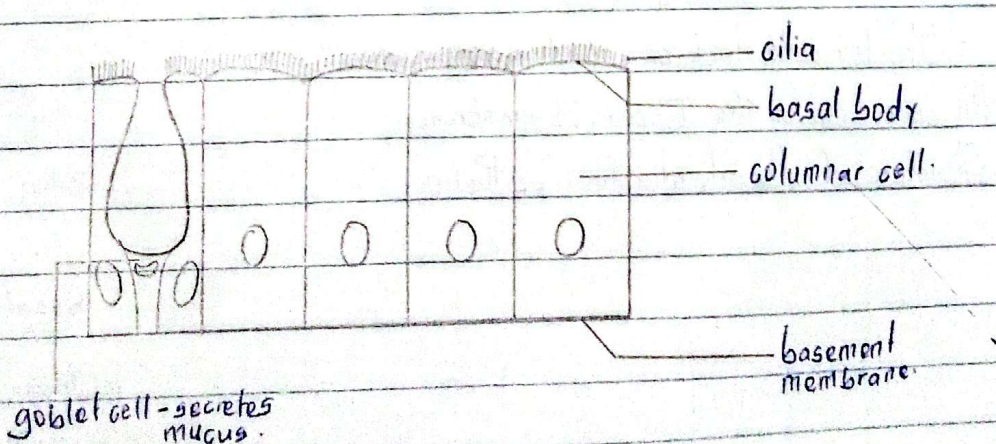
Adaptations.

- Have microvilli at free surface increase surface area for absorption of nutrients.
- Contain secretory goblet cells for secretion of mucus.

5. Ciliated epithelium (columnar)

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

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



Location:

Ciliated epithelium lines:

- The insides of the oviducts.
- ventricles of the brain
- The spinal cord.
- The respiratory passages (trachea, bronchi and bronchioles) where it serves to move materials from one location to another.
- In flat worms like planaria, it lines underside of the body where they aid locomotion.

Functions.

pssr

> Locomotion in flatworms e.g planaria.
> Movement of materials in a particular direction. In the respiractory tract, for example cilia waft mucus up to the throat for swallowing.
The cilia set up currents to move materials from one point to another.
> The mucus traps bacteria, dust and other small particles, preventing it from reaching the lungs.
> The mucus also lubricates the passage

6. Pseudostratified epithelium.

Consist of one layer of columnar cells that appear to be at several different levels due to:

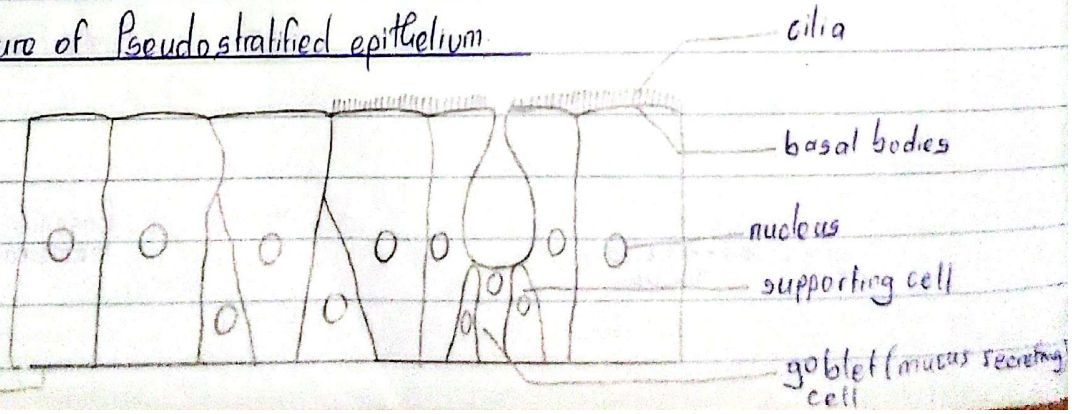
- Nuclei at different levels
- All cells do not reach the surface.

Has two types of cells:

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

All cells rest on the basement membrane.

Structure of Pseudostratified epithelium



Location.

- Lining of respiratory passages i.e trachea, bronchi and bronchioles.
- Lining of urinary tract.

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.

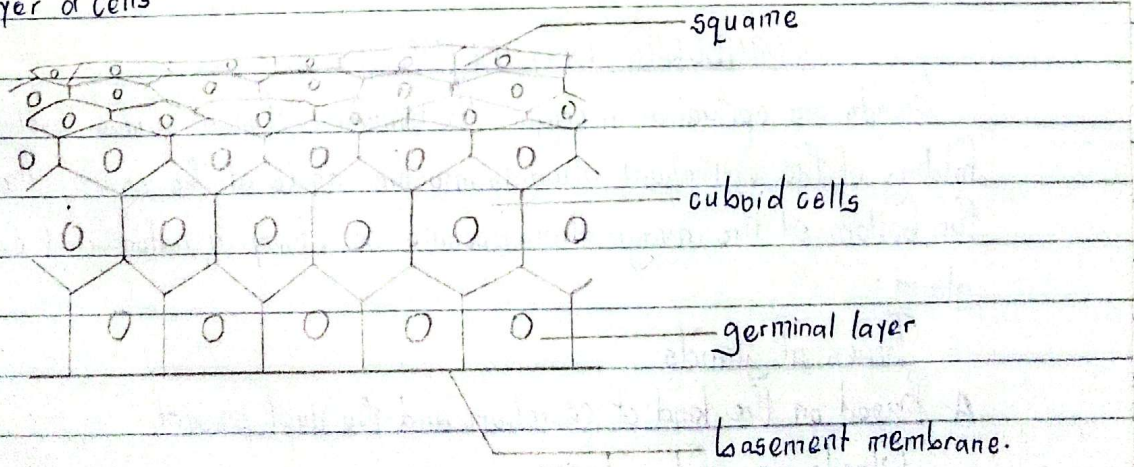
1. Stratified epithelium

It is made of many layers of cells and therefore thicker than the simple epithelium.

The tissue forms a relatively tough impervious barrier.

The cells are formed by mitotic division of the germinal layer which rests on the basement membrane. The first formed cells are cuboid in shape but as new cells form, older ones are pushed near to the surface changing shape and flattening to form squames.

In some areas the squames may remain unkeratinized as in the oesophagus or may be heavily thickened with keratin (cornified) e.g the skin where there is a dead layer of cells.



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.

Functions
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.

2. Transitional epithelium:
It comprises of 3-4 layers of cells which may be flattened towards the surface, are not shed but can modify their shape when placed under differing conditions thus allowing stretching.

Location:
It is found in structures which are subjected to considerable stretching e.g the urinary bladder, ureter and urethra.

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

GLANDULAR EPITHELIUM.

Glands are epithelial in origin. The formation of most glands involves extensive folding of the epithelium inwards into the inside of the organ. The cells lining the bottom of the invagination become secretory in nature and evolves into a gland.

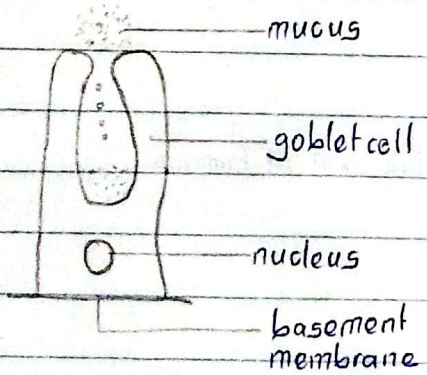
Types of glands:
A. Based on the kind of secretion and the duct present.
Glands are of two types;
1) Exocrine glands.

These produce their secretions that move through ducts to their respective sites of action e.g. salivary, tear, intestinal and gastric glands.
Their secretions are called enzymes.

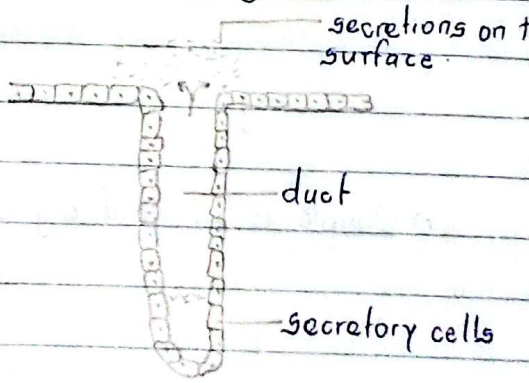
ii) Endocrine glands.
These do not possess ducts and pour their secretions directly into the blood stream. Their secretions are known as hormones. These include adrenal gland, pituary gland, pancreas.

B. Based on number of cells, the glands are of 2 types;
i) Unicellular.
An individual epithelial cell is modified into a glandular cell as seen in goblet cells.
ii) Multicellular
Number of glandular cells aggregate to form a multicellular gland.
Illustration.

Unicellular gland.



Multicellular gland



Multicellular glands can further be sub-divided into simple or compound glands e.g. sweat glands.

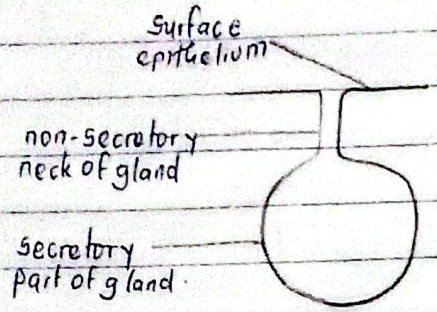
C. Based on the shape and complexity
The exocrine glands are of 2 main types; simple and compound glands which may further be modified by branching.
NOTE: The branching of the tube or sac increases suiface area for secretion.

1) Simple glands:

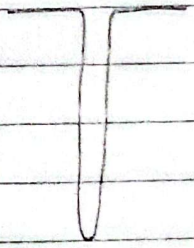
These have a single unbranched duct. The secretory part could be in the form of tube (tubular) or sacs (alveolar (saccular). These could be coiled or uncoiled, branched or unbranched.

Forms of simple exocrine glands:

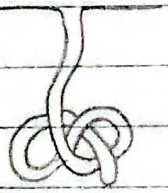
=> Simple alveolar (saccular) gland e.g mucous secreting glands in frog skin and other amphibians:



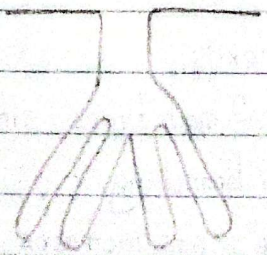
=> Simple tubular gland e.g crypts of Lieburkuhn in the wall of the mammalian small intestines.



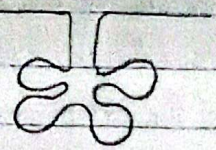
=> Simple coiled gland e.g. sweat glands in the skin of humans.



=> Simple branched tubular gland e.g gastric glands and simple Brunner's glands of the mammalian small intestine.



- Simple branched saccular gland where a number of sacs open into the same duct e.g. sebaceous glands in mammalian skin.

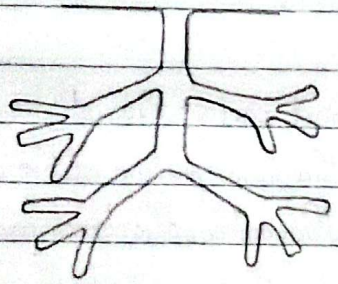


ii) Compound glands.

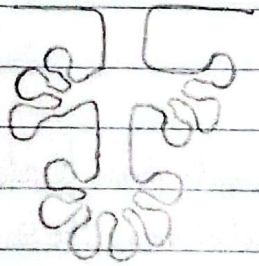
These have a number of ducts forming a branching pattern ie the duct is branched.

Forms of compound exocrine glands

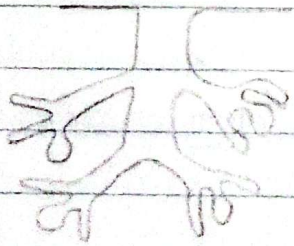
- Compound tubular glands e.g. salivary glands.



- Compound saccular gland eg mammary glands, pancreatic glands.



- Compound tubulair alveolar e.g. parts of salivary and mammary glands



D. Based on mode of secretion:

1. Merocrine glands:

In this case, the secretion accumulates below the free surface of the cell and is then released through the plasma membrane either by exocytosis or by diffusion

Merocrine secretion does not involve loss of the cytoplasm

Examples of merocrine secretion:

Secretion of mucus by goblet cells

Secretion of sweat by sweat glands.

Secretion of pancreatic juice by pancreas

Secretion of steroid hormones (lipid soluble hormones) e.g progesterone, oestrogen testosterone by their respective endocrine glands.

2. Apocrine glands:

These are glands where the upper most part of the cell once it has been loaded with the secretions breaks away from the lower portion of the cell releasing the contents.

It involves loss of some cytoplasm. Meanwhile, the lower portion of the cell develops a new top which then becomes recharged with new secretions ie mammary glands

Example of apocrine secretion

Secretion of milk by mammary glands.

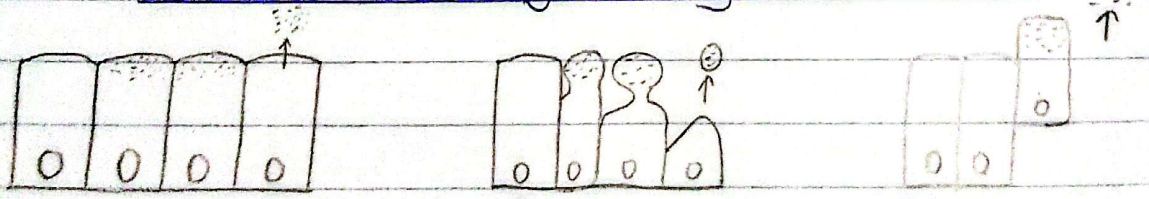
3. Holocrine glands

These are glands where the entire cell breaks down to release its secretory product

The cell is therefore lost from the epithelial area. The lost cell is replaced through mitosis of the cell remaining in the epithelium e.g sebaceous glands in mammalian skin

Holocrine secretion involves complete loss of the cytoplasm of the cell e.g secretion of oil (sebum) from the sebaceous glands.

Illustration of the different glands basing on mode of secretion.



Merocrine secretion (Most exocrine glands)

Apocrine secretion (mammary glands)

Holocrine secretion (sebaceous glands)

Functions of the Epithelial Tissues.

Epithelial tissues serve the following functions, protection, secretion, absorption, exchange of materials, tissue replacement, sensory.

1. Protection

Epithelial tissues protect underlying tissues from injury, 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 abrasion.

Columnar epithelium lining the stomach is interspered with goblet cells which secrete mucus.

Mucus protects the lining of the stomach from acid contents of the stomach and from digestive juices.

Mucus lubricates the passage of food thereby protecting the lining from abrasion.

The short 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 longer cells beat expelling them in the outward direction.

Melanin in the deeper layer of the skin prevents penetration of dangerous ultra violet radiations.

2. Absorption.

Cuboidal and columnar epithelia are modified for absorption.

Adaptations.

Columnar epithelium lining kidney tubules poccess microvilli on the free surface which increase surface area for selective reabsorption.

Columnar epithelium lining the small intestine poccess microvilli which increase the surface area for absorption of nutrients.

3. Secretion.

A number of epithelial cells are modified to produce secretions e.g mucus, enzymes

or hormones e.g columnar epithelium lining the stomach is interspersed with goblet cells which secrete mucus.

4. Movement of materials along cavity of tubules.

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 flat worms, ciliated epithelium lines the underside of the body where it aids locomotion

6. Tissue Replacement.

Replacement of worn out cells through rapid mitosis 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 envt.

9. Exchange of materials.

Squamous epithelium which lies the alveoli of the lungs and in the blood capillary wall is extremely thin and flattened to reduce diffusion distance

CONNECTIVE TISSUE

Connective tissue is the major supporting tissue of the body. It includes the skeletal tissue, bone and cartilage and in addition it binds other tissues together. Connective tissue is a composite tissue and has three basic components;

Cells; they are the living components that are widely separated from each other. They originate from the embryonic mesoderm.

Fibres; there are several types of fibres scattered in btn the cells. They form the extracellular material. They do not contain blood.

Matrix; it forms the basic ground tissue/substance in which both the cells and fibres are suspended. It is ~~more~~ non-living, transparent, fluid or semi-fluid in nature. It contains various organic and inorganic substances. The kind of matrix varies in different tissues.

Location of connective tissue.

- It is present in btn 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 packing tissue but has many other important functions as well ie;

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 packing tissue.

The areolar tissue protects the body against wounds and infection.

The adipose tissue stores fats and insulates the body against heat loss.

The supportive tissue forms shape and the framework of the body.

The haemopoietic tissue produces blood.

The lymphatic tissue helps the body to build immunity by producing antibodies.

Types / Various forms of Connective tissue.

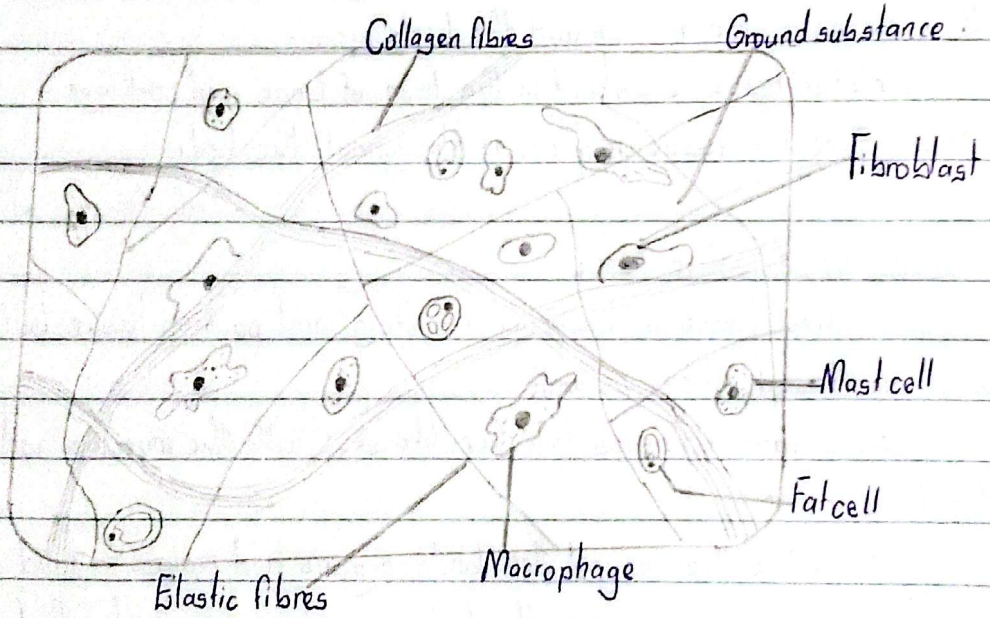
FA 36

- Connective tissue
  - Loose connective tissue (Areolar tissue)
  - Dense fibrous connective tissue
    - White fibrous
    - Yellow elastic
  - Adipose tissue
  - Skeletal tissue
    - Cartilage
      - Hyaline cartilage
      - Yellow elastic cartilage
      - White fibrous cartilage
    - Bone
      - Spongy bone (Trabecular bone)
      - Membrane bone (dermal bone)
      - Compact bone (dense bone)
  - Dentine tissue (Teeth)
  - Haemopoietic tissue
    - Myeloid tissue (Bone marrow)
    - Lymphoid tissue

A. AREOLAR TISSUE

It is the simplest form of connective tissue and it is found all over the body. It lies beneath the skin, binds / connects organs together and fills spaces btn other tissues.

Note; For this function, it is similar to parenchyma tissues in plants



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 the ground substance and an anticoagulant
Fat cell; which stores fat
Macrophage; a large amoeboid cell which ingests a wide variety of foreign particles

and is important in defending the body against disease.
Elastic fibres; form a loose network of stretchable fibres.

The matrix of areolar tissue is transparent and jelly-like. It contains a mixture of chemical substances such as mucin, hyaluronic acid, chondroitin sulphate.
Scattered through this matrix are numerous cells and fibres. The cells in the matrix include;

① Fibroblasts (Fibrocytes)
These are large blood cells which produce the collagen and elastic fibres. They are spindle shaped and contain an oval nucleus.
They lay close to the fibres which they produce
At times, they migrate towards wounded tissues and secrete more fibres in this regions to effectively seal off the wounded area

② Fat cells.
These store fat

③ Macrophage
These are amoeboid like in shape and their role is to ingest any foreign material like bacteria by phagocytosis.
They are important in defending the body (tissue) against diseases.

vasodilation ↓ increasing lumen size

④ Mast cells.
They are small and oval shaped and contain glandular cytoplasm. They secrete the fluid like matrix as well as heparin and histamine
Heparin is an anticoagulant that neutralises the action of thrombine preventing the conversion of fibrinogen to fibrin.
Histamine is released from tissues when they are injured or disorganised in any way. It causes local vasodilation (it is responsible for inflammatory response).

The fibres in the matrix of areolar tissue include;
1. Collagen (White fibres)
These are unbranched fibres running parallel to each other within a bundle. The bundles are wavy like.

Collagen fibres are flexible but inelastic

ii) Elastic fibres (Yellow fibres)

These are branched fibres forming a network in the matrix. They are thin and do not occur in bundles. They are flexible and elastic.

Together with collagen fibres, elastic fibres give the tissue considerable tensile strength and make it resiliant

Comparison btn elastic and collagen fibres.

Similarities.

Both are fibrous proteins.

Both are flexible

Differences

Collagen fibres	Elastic fibres.
Are white	Are yellow
Occur in bundles	Don't occur in bundles (occur singly)
Are not branched	Are branched to form a network in the matrix
Are inelastic	Are elastic
Have higher tensile strength	Have lower tensile strength
Easily digestible by pepsin	Are resistant to digestion by pepsin.

Compare the structure of collagen and cellulose.

Similarities.

Both are fibrous

Both have cross-bridges.

Both are elongated

Both are polymers ie consist of repeating units.

Both are not branched

In both, the structures have high tensile strength

Differences.

Cellulose	Collagen
Repeating unit is β-glucose	Repeating units are glycine, proline, alanine
Does not form a helix	Forms a triple helix
Monomers are linked by glycocidic bonds	The amino acid units are linked by peptide bonds.
It has one type of repeating unit	Has three types of repeating units.
Is a carbohydrate	Is a protein
Not digestible by protein enzyme pepsin.	Digestible by pepsin

NOTE: The suffixes 'blast' and 'cyte' refer to the same cell but at different stages of development.

- 'blast' is used to refer to a cell that is not yet fully developed and is still capable of producing its product e.g fibroblasts secretes fibres, osteoblasts secrete bone matrix, chondioblasts synthesis cartilage matrix, haemocytoblasts synthesize blood cells.
- 'cyte' is used when the cell has fully matured and is nolonger capable of synthesizing its products e.g fibrocyte, osteocyte, chondiocyte, haemocytocyte

B. DENSE FIBROUS CONNECTIVE TISSUE:

✓ White fibrous connective tissue (Collagen)

It's matrix consts of glycoprotein in which collagen fibres are densely packed and organised in bundles running parallel to each other.

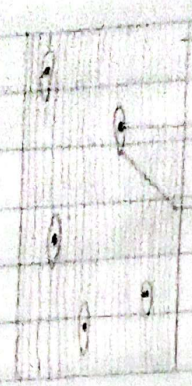
Rows of fibroblasts are interspersed among the collagen fibres and run alongside the bundles. This type of tissue is very strong, flexible but relatively inextensible / unstretchable due to the presence of densely packed collagen fibres

Location

It is abundant in tendons which attach muscles to bones. It also forms the outer covering of cartilage (perichondrium) and bone (periosteum

Sclera and cornea of the eye and kidney capsule

Longitudinal section through a tendon



Explain why it is difficult for physically tear a tendon.

A tendon consists of very many; closely packed; and inelastic collagen fibres; hence cannot be easily stretched and torn. The closely packing of the collagen fibres is due to the interspersed fibroblasts in the collagen tissue.

✓ Yellow Elastic Tissue

In contrast to collagen tissue, yellow elastic tissue possesses a loose network of irregularly arranged and branched yellow elastic fibres. The tissue is elastic and flexible. It is more stretchable than collagen tissue.

It is however not as strong as collagen tissue.

Like collagen tissue, it is also composed of a glycoprotein matrix and fibroblasts which produce the fibres.

Location.

It is located in ligaments which join borne to bone at a joint.

In the walls of the urinary bladder where it allows the bladder to stretch as it fills with urine.

In the walls of the arteries

C. ADIPOSE TISSUE (FAT TISSUE).

It has no specific matrix on its own. It is a modification of areolar tissue. It contains large numbers of closely packed fat cells within a network of elastic fibres and some few collagen fibres.

The fat cells are usually filled with a lot of fat making adipose tissue an important energy store.

The large amount of fat in cell squeezes the cytoplasm and nucleus to the periphery or sides.

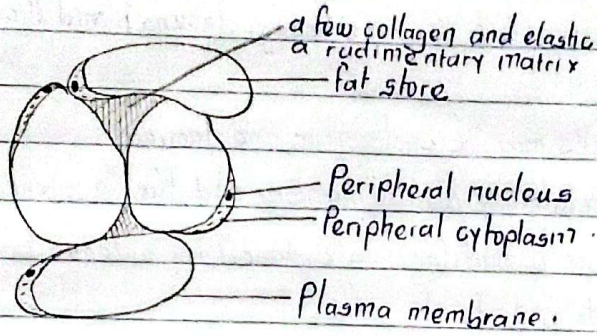
Location.

In the dermis of the skin where it performs an insulation role.

In the mesenteries linking the folds of the intestines.

Around organs e.g kidney and the heart where it acts as shock absorber (cushion).

Transverse section through adipose tissue.



D. SKELETAL TISSUE (CARTILAGE AND BONE)

It consists of cells embedded in the matrix which is relatively hard / dense compared to the matrices of other connective tissues except dentine tissue.

The matrix of bone is harder than that of cartilage due to deposition of more inorganic minerals in the bone matrix.

Skeletal tissue is responsible for supporting the body and providing it with a rigid framework upon which movement can occur.

Bone also provides sites where skeletal muscles attach to give the body shape.

In all vertebrate embryos, the main skeletal material is cartilage which is gradually replaced by bone during the process of ossification.

In some vertebrates however for example cartilagenous fish (sharks, dogfish, rays) embryonic cartilage is not replaced and so adults entirely have cartilagenous skeleton.

In adult mammals, cartilage occurs in a few places in the skeleton for example, at the ends of bones, external ears, at the end of the nose, at the trachea as rings, in the voice box as larynx, in between the bones of the vertebral column where it exists as intervertebral discs.

Cartilage.

The general structure of cartilage

Cartilage consist of cells embedded in a relatively dense matrix made of chondrin.

Chondrin is a mucopolysaccharide made from chondroitin sulphate.

The matrix is deposited by cells called chondroblasts.

The matrix also consist of collagen and elastic fibres which occur in varying amounts depending on the location and type of cartilage

Once the chondroblasts have finished depositing the matrix, they gradually become enclosed in spaces called lacunae (sing. lacuna) and they now become known as chondrocytes

Two or more cells may be enclosed in one lacuna.

The cells are relatively few in number and the biggest proportion of the tissue is the matrix

The outer margin of cartilage is enclosed by a dense layer of collagen tissue called perichondrium which protects it.

Just beneath the perichondrium, new chondroblasts are produced which are constantly added to the internal matrix of the cartilage.

The fibres in the matrix of the cartilage are produced by fibroblast.

Cartilage is hard but flexible. The matrix compressible and elastic and is able to absorb mechanical shock.

NOTE: Cartilage is avascular tissue (lacks blood vessels) and this causes it to have a slower growth rate than bone since the exchange of materials is purely by diffusion

Types of Cartilage.

1. Hyaline Cartilage.

It is the most simplest type with very little or no collagen fibres in the matrix.

It consists mainly of the matrix chondrin and the cells which secrete the matrix (chondroblasts).

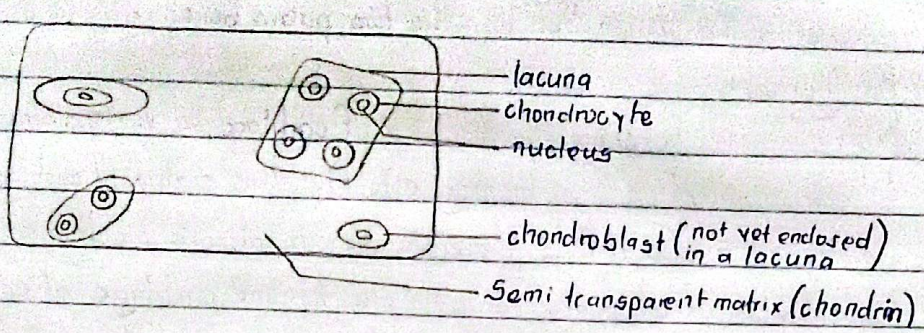
The matrix is semi-transparent and the chondroblasts or chondrocytes are ~~seen~~ scattered within it. Some of these cells are enclosed in spaces (Lacunae)

The cells may occur singly or in small groups.

Fibrils or fibres if any are very fine collagen fibrils

Hyaline cartilage is elastic and compressible.

Transverse Section through hyaline cartilage.



Location

Skeleton of cartilagenous fish e.g shark.

At the ends of the bones

Skeleton of vertebrate embryos

Respiratory passages of mammals ie trachea, bronchi and large bronchioles. In these passages, it appears as C-shaped rings and prevents them from collapsing.

At the distal end of the nose

2. Yellow Elastic Cartilage.

Its matrix is semi-opaque and contains a network of yellow elastic fibres.

These fibres make it have greater elasicity and also flexibility than is found in hyaline cartilage.

The tissue readily recovers its shape soon after being distorted

Location

External ears (pinna)

Ear canal (auditory canal)

Epiglottis

Eustachian tube

Cartilages of the pharynx

3. White Fibrous Cartilage.

Its matrix is more dense compared to the other two cartilage types

The matrix is densely packed with large numbers or bundles of white collagen fibres.

These proride it with greater tensile strength and with a small degree of flexibility.

Location

Intervertebral discs where it provides cushioning effect between the vertebra. It is formed in the region between the two pubic bones of the pelvis (symphysis pubis). In the ligaments.

With examples, explain the functions of cartilage in vertebrates.

Shock absorption (Cushioning effect); the matrix of cartilage is generally compressible and elastic and is therefore able to absorb mechanical shock especially those that frequently occur at joints for example hyaline cartilage at ends of limb bones, white fibrous cartilage that forms intervertebral discs between adjacent vertebrae.

Formation of skeletons in vertebrate embryos and cartilagenous fish thus providing support. This is done by hyaline cartilage.

Supports ventilation of lungs by preventing respiratory tubes from collapsing under low pressure during breathing in. This is achieved by hyaline cartilage being organised in C-shaped rings.

Hyaline cartilage reduces friction between long bones allowing movement to occur.

Yellow elastic cartilage supports the external ear keeping it in a funnel-shape to collect and direct soundwaves towards the eardrum

White fibrous cartilage in the symphysis pubis allows female mammals to give birth without breakages.

Bone.

Structure

Bone is much more dense than cartilage. Its matrix is made up of collagen fibres and inorganic substances.

The main inorganic substance is calcium hydroxyapatite $[Ca_{10}(PO_4)_6(OH)_2]$.

Other inorganic substances that may be present in the bone matrix include calcium carbonate, sodium, magnesium, potassium, fluoride, chloride, hydrogen carbonate or citrate ions in varying amounts.

The inorganic components of the bone make up 70% of the bone.

Bone cells (osteoblasts) are contained in lacula which are present throughout the matrix

These cells lay down the inorganic compounds of the bone.

Fine canals containing cytoplasm connect the lacunae to each other and blood vessels passing through them provide the means by which the osteoblasts exchange materials.

canaliculus

These small canals / projections are called canaliculi.

The fine canals may also link up with the central canal called Haversian canal

This canal contains main ~~many~~ blood vessels, lymph vessels and nerve fibres from which smaller branches branch to supply the rest of the bone.

The transverse section through a compact bone shows that it consists of numerous cylinders of concentric lamellae ie the components of bone are arranged in concentric circles around the Haversian canal. A system of such concentric circles around the Haversian canal is called an osteon / Haversian system

In the peripheral of each bone lays a layer of ~~nerve~~ tough fibres called the periosteum ~~collagen fibres~~

This layer protects the bone and also forms new oesteoblasts as bone grows.

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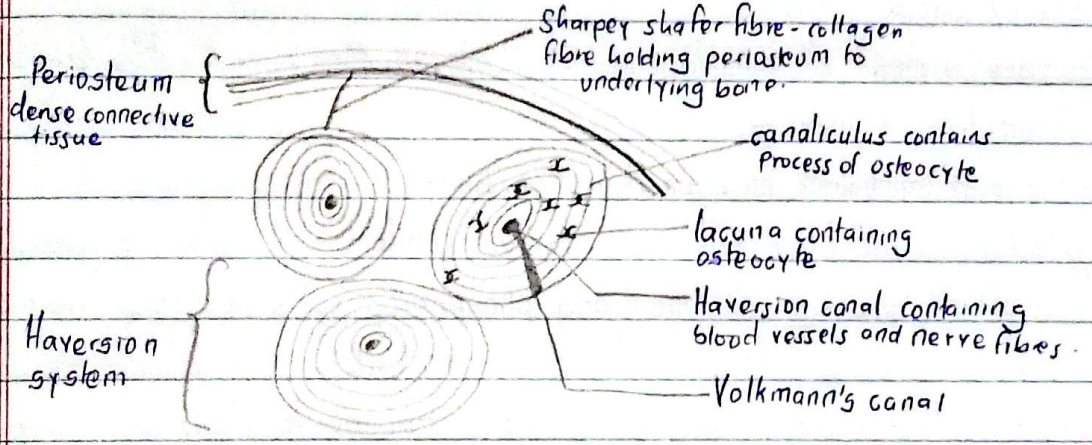
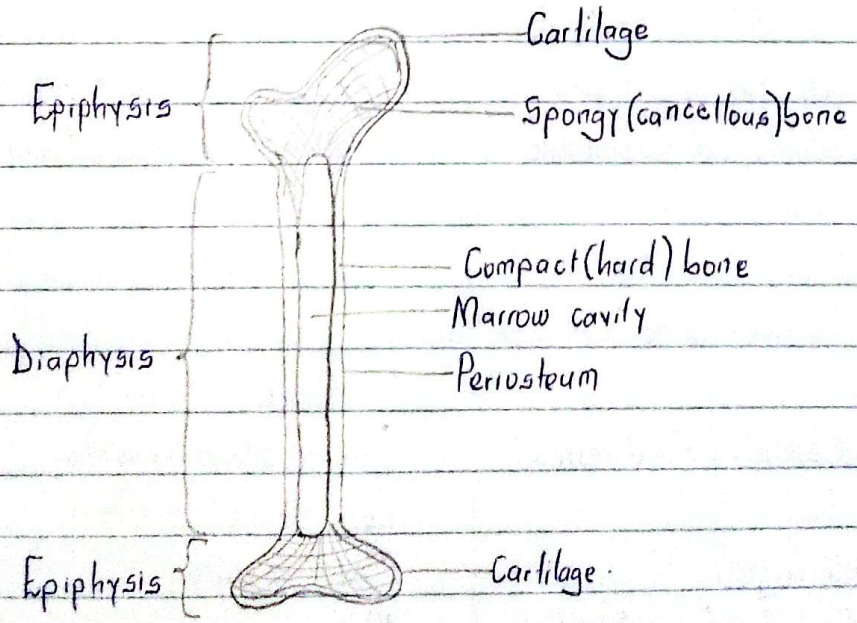
Transverse Section from Compact Bone.



A Vertical Section through a femur.



Differences between compact and spongy bone:

Compact bone	Spongy bone
Contains more inorganic material	Contains less inorganic material
Is very hard	Is less hard
Is more dense	Is less dense.
Components are arranged in concentric circles called lamellae	Components are arranged in mesh-work of thin interconnected bars called trabeculae
Encloses yellow bone marrow	Has mainly ~~red blood cells~~ red blood and encloses red bone marrow
Found in shafts of long bones	Found at the ends of long bones.

Functions of bones.

Provides a mean of muscle attachment which then operates the bones to bring about locomotion or movement.

Provides a framework for supporting the body

Production of red blood cells and certain white blood cells e.g granulocytes

They act as reserves of calcium and phosphorus salts or phosphate ions helping to maintain their constant levels in blood stream. Calcium and phosphate ions may be released into blood when needed under the control of two hormones ie parathormone and calcitonin.

Protection of delicate body parts or organs e.g the skull protects the brain, vertebra protects the spinal cord and rib cage protects the heart and lungs.

Note: Osteoclasts in bone are responsible for resorption of the calcified matrix as and when necessary.

Comparison between bone and cartilage.

Bone	Cartilage
Has blood supply (blood vessels)	Has no blood vessels
More dense	Less dense
Not flexible (rigid)	More flexible
Matrix is deposited by osteoblasts	Matrix is deposited by chondroblasts

CamScanner

Consist of calcium phosphate / calcium hydroxyapatite (calcified matrix)	Consist of mucopolysaccharide (chondroitin sulphate)
Fine projections called canaliculi extend from.	Lacunae have no fine canals projecting from them
Less compressible	More compressible.

How the structure is related to function in compact bone

Bone matrix is made up of organic substances mainly collagen fibres and inorganic materials which provide great tensile strength.

Haversian canal contain blood vessels for efficient supply of nutrients to and draining of wastes from ~~blo~~ bone cells.

Osteocytes bear many canaliculi that span across lacunae to improve on material exchange the bone cells.

Bundles of collagen fibres originate from the bone surface and act as a firm base for tendon insertion.

There is regular / continual remondeling which enables compact bone to respond to mechanical strength of varying loads pressed on it.

E: DENTINE TISSUE

It is similar to bone but harden because it has highly mineral content.
It is found between enamel and pulp cavity in teeth

F: HAEMOPOIETIC TISSUE:

This tissue forms red blood cells and white blood cells. It is located in the red bone marrow and lymphoid tissue of adult mammals.

Bone marrow tissue (myeloid) produces red blood cells and granulocytes.
Lymphoid tissue is responsible for differentiation / maturation of lymphocytes

MUSCLE TISSUE:

Muscle tissue has a unique property of the cells being able to contract. It is excitable. This makes it possible by the presence of thick myosin and thin actin filament which slide past each other to cause contraction / shortening.

The ability of muscle tissue to contract allows it to change in length or develop tension.

It also enables it to move the body or its parts

Types of Muscle Tissue.

Smooth / unstriated / unstriped / involuntary muscle.
Cardiac / heart muscle
Skeletal / striated / striped / voluntary muscle

✓ Smooth Muscle

Location.

Occurs in the walls of alimentary canal, blood vessels, iris of the eye, urinary bladder, erector pili muscle in the skin, ciliary muscle that support the eye lace, uterus lining and other cavities or tubes in the body.

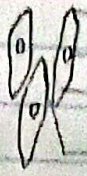
It is found in places where slow involuntary movements are required

Contraction.

It's contraction is controlled by the involuntary nervous system (autonomic)

Structure.

The cells are spindle shaped (fusiform)
The cells are numerous, slender, elongated and are parallel to each other.
The cells are densely packed and bound together by connective tissue.
Each muscle fibre is a single cell with a single nucleus centrally positioned.
The nucleus may be elongated or oval shaped
The cytoplasm consist of many mitochondria to provide the energy required for contraction.
It also consist of actin and myosin filaments.
The myofibrils are inconspicuous (not easily visible) and therefore there are no stations



The smooth muscle fibres may be organised into circular and longitudinal layers.
Contraction of fibres in circular layer causes the organ to lengthen and the lumen to reduce (become close) while contraction of longitudinal layer causes the organ to shorten and widen

✓ Cardiac Muscle.

Located in the heart.

Contraction

Involves involuntary contraction. The wave of contraction is initiated by the from the heart itself in the wall of the right atrium of heart called the Sino-atrial node (SAN) / Pace maker.

For this reason, the ~~fat~~ heart tissue is described as myogenic. The cardiac muscle is innervated by the vagus (parasympathetic) nerve and sympathetic nerve

The cardiac muscle contracts rapidly and never faligues.

Structure.

It consists of irregularly shaped cells which are branched to form a network.

The muscle fibres of cells appear stripped under the light microscope.

Muscle cells are joined to each other by highly folded plasma membranes called intercalated discs / junctions.

These discs allow the impulse to easily spread from one cell to another such that the cells in one region such as Arches can contract simultaneously

The branching of fibres or cells also ensures that the impulse or wave of excitation can spread from one cell to another very fast.

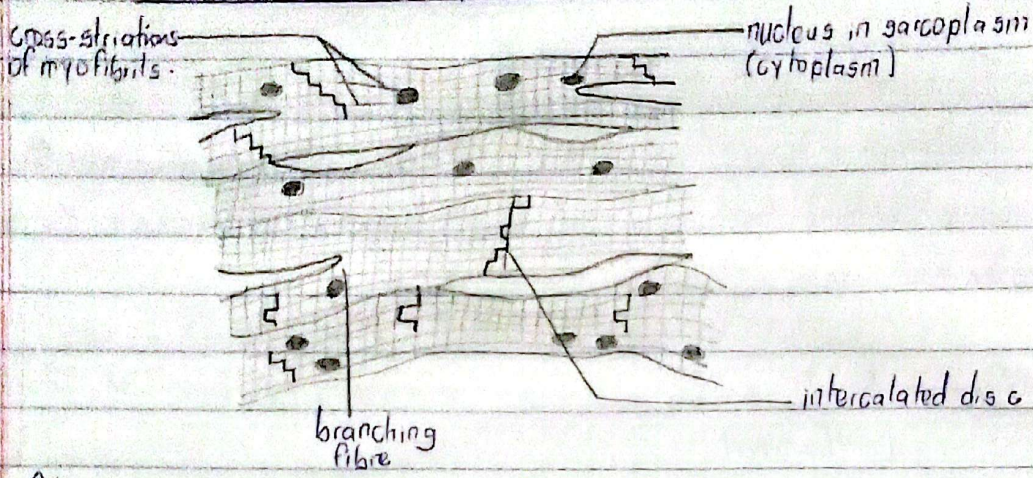
Each muscle fibre possesses one or two large prominent nuclei which are centrally located.

Within the cells are numerous large mitochondria.

The myofibrils in the cells are conspicuous and cross striations or strips exist.

The contraction of the muscle is brought about by action of the myosin and actin filaments.

Illustration of Cardiac Muscle.



Adaptations of Cardiac Muscle

The cells possess many large mitochondria to provide sufficient ATP for muscle contraction.

The presence of a large prominent nucleus to effectively control cell activities.

The highly folded intercalated discs between the fibres increase the surface area over which the impulse passes. And also possess gap junctions that allow passage of the impulse or ions from one cell to another to bring about simultaneous contraction of the cells.

~~Posit~~ Possession of branching fibres for easy spread of impulses from cell to cell

Presence of many myofibrils consisting of actin and myosin filaments to bring about the contraction of muscle

The presence of special sino-atrial node (SAN) to initiate and set the basic rhythm / pace for contraction of the muscle

✓Skeletal Muscle.

Muscle attached to bone either directly or indirectly via tendons Its movts are under voluntary control It is innervated by nerves or neurones from conscious centers of the central nervous system (voluntary nervous system)

Functions of the Skeletal Muscle

Maintenance of the posture of the body.

Aiding locomotion

Releases heat during contraction that contributes to maintenance of body temp.

As a component of sphincter muscles, it regulates the passage of materials through organs like urinary bladder and alimentary canal.

Structure of skeletal muscle

An individual muscle fibre is formed by fusion of special cells called myoblasts. Therefore, a skeletal muscle fibre is multinucleated and the nuclei lie in the periphery.

The fibre also has several mitochondria, numerous myofibrils and modified form of endoplasmic reticulum called sarcoplasmic reticulum. which stores a lot of calcium ions which are involved in the process of muscle contraction.

Each myofibril consists of thin actin filaments and thin myosin filaments. These bring about muscle contraction by sliding past one another.

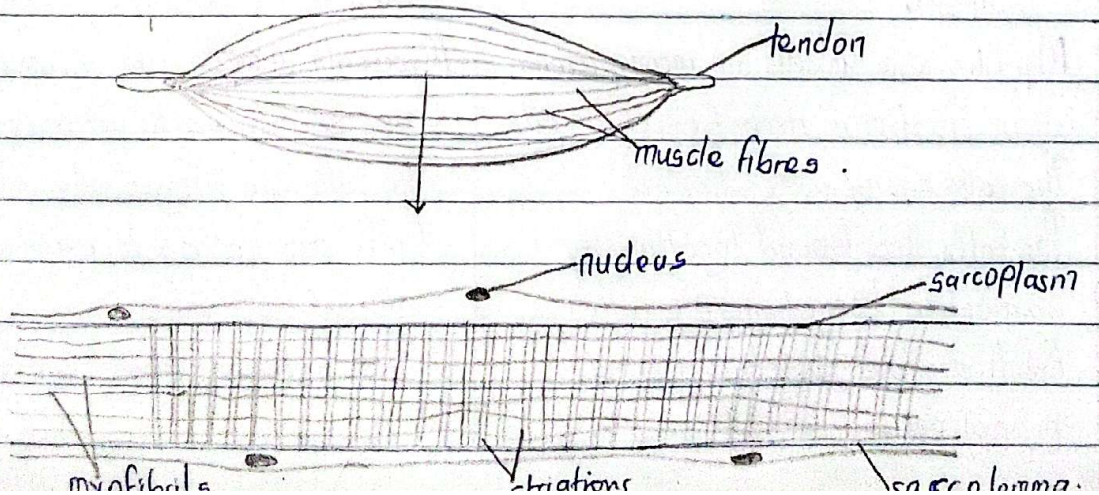
They are properly organised into units called sarcomeres. which are responsible for the striated / stripped appearance of the skeleton muscle by fibre.

The plasma membrane of the skeletal muscle fibre is called sarcolemma and the cytoplasm it encloses is called sarcoplasm.

The skeleton muscle contracts and fatigues rapidly.

Several muscle fibres may be grouped together to form a bundle surrounded by connective tissue and supplied with blood vessels and nerves.

Illustration



i) ~~Smooth~~ Skeletal and Cardiac muscle.

Similarities

Both have their cells containing a lot of mitochondria.
Both have myofilament (actin and myosin)
Both are striped
Both have more than one nucleus.
Both are bound by connective tissue.
Both have modified sarcoplasm
Both can contract rapidly.

Differences.

Skeletal	Cardiac
Muscle fibres are not branched.	Muscle fibres are branched.
Cells are longer	Cells are shorter
Intercalated discs absent	Intercalated discs present.
Nuclei located at the periphery	Nuclei are centrally located
Each muscle fibre has many nuclei	Each muscle fibre has one or two nuclei
It is heavily / densely striped	Lightly striped.

ii) Smooth and cardiac muscle.

Similarities.

Both have their cells containing numerous mitochondria
Both have myofilament (actin and myosin)
Both are innervated

Differences.

Smooth	Cardiac
Myofibrils in the cells are inconspicious	Myofibrils in cells are conspicuous.
Cross striations do not exist in cells	Cross striations exist in cells.
The cells are spindle shaped	The cells are irregularly shaped.
The cells are bound together by connective tissue (muscle cells)	Cells are joined to each other by intercalated discs.
Each muscle fibre has a single branched	The muscle fibres are branched

Smooth and Skeletal muscles.

Similarities.

Both consist of myofibrils in their cells.

Both have a nucleus ie one for smooth muscle which numerous in skeletal muscle.

Differences.

Smooth	Skeletal
No sarcolemma	Cells are cylindrical shaped
Has a connective tissue binding the cells together.	Has no connective tissue
Cells are not striated.	Cells are striated.
Nucleus is centrally located	Nuclei are located at the periphery of the fibres.