CELL AND MOLECULAR BIOLOGY
UNIT II
PLASMA MEMBRANE – FUNCTIONS AND SPECIALIZED STRUCTURES

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Specializations of Plasma membrane

The plasma membrane shows here and there specialised structures. These may be due to outgrowths or ingrowths or contact with adjacent membrane. Such structures include the following:

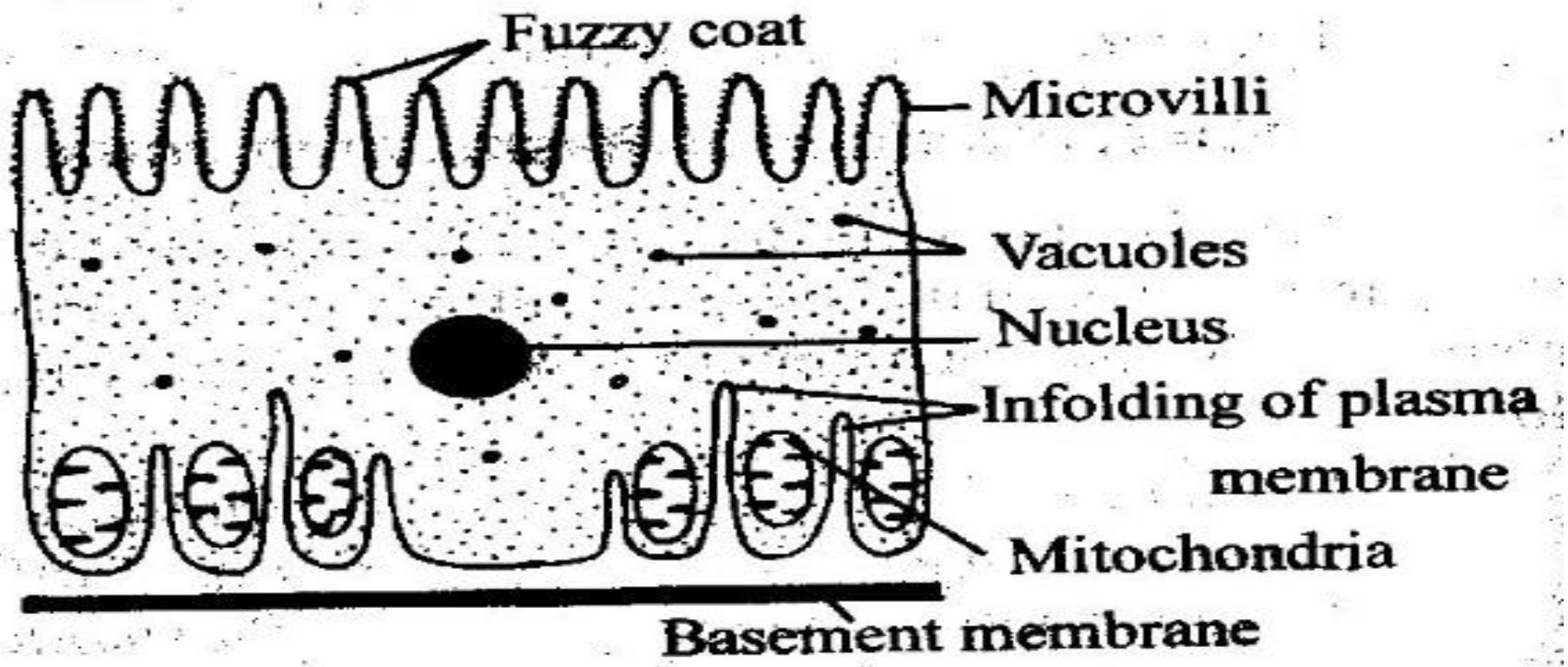
1. *Microvilli*
2. *Desmosomes*
3. *Gap junction (Nexus)*
4. *Tight junction(Zona occludens)*
5. *Interdigitations*
6. *Basal infoldings*
7. *Plasmodesmata*

An epithelial cell showing the differentiations of plasma membrane

Microvilli

Microvilli are minute finger-like projections arising from the surface of certain cells.

They are found on the epithelial cells of intestine, kidney tubules, gall bladder, uterus, hepatic cells and yolk cells. ‚A single cell contains about 3000 microvilli.



Kidney cell showing microvilli.

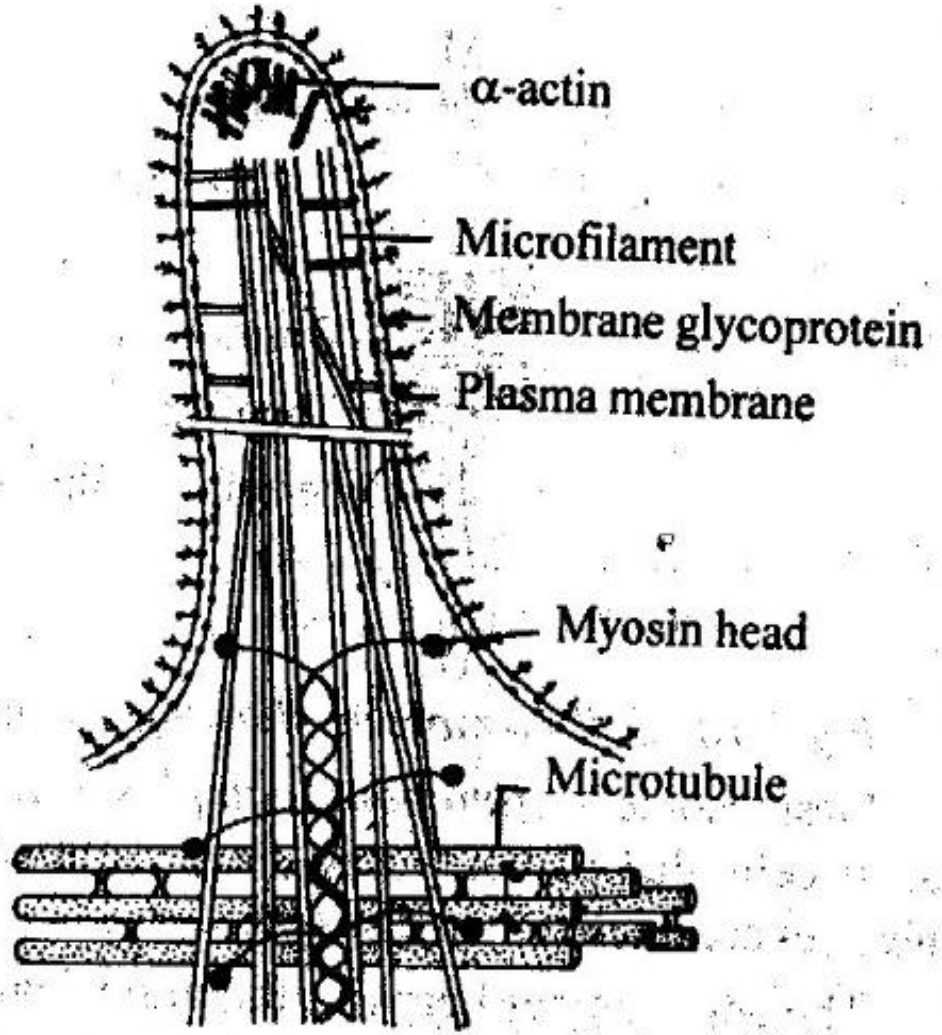
* Each microvillus is ***cylindrical*** in shape.

* The microvillus is 0.6 to 0.8 micrometer long and has a diameter of 0.1 micrometer.

* It has a core of ***cytoplasm*** enclosed by the ***plasma membrane.***

* The cytoplasmic core is traversed by fine ***micro-filaments*** made up of ***actin.*** The micro-filaments are attached to the tip of the microvillus by ***α - actin.*** The micro-filaments give rigidity to the microvilli.

The outer surface of the microvillus is covered by a coat of fine filaments called ***fuzzy coat.*** The fuzzy coat is composed of ***glycoprotein.***



Ultrastructure of a micro-villus.

At the base of microvillus the micro-filaments are joined to a transverse network of actin-myosin micro-tubules, that form the ***terminal web.***

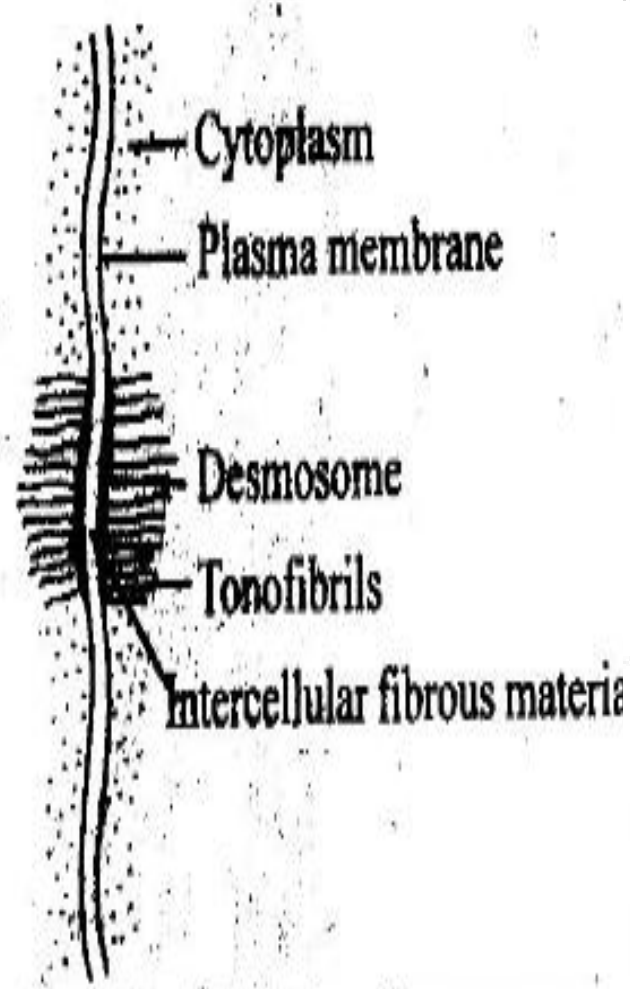
* ***Functions:*** 1. The microvilli increase the surface area of the cell and help in effective absorption.

2. The narrow spaces lying between the microvilli form a kind of sieve through which substances pass during the process of absorption.

Desmosomes

Desmosomes are thickened areas of plasma membranes of two adjacent cells, from which radiate fine ***tonofibrils.*** The desmosomes glue the adjacent cells.

Desmosomes are abundant in cardiac muscle and skin that are subject to severe mechanical stresses.



Cell membrane showing desmosome.

Desmosome is a ***junctional complex***, formed betwee adjacent cells due to contact. At the desmosome the ce membranes are thicker than else where.

The desmosomes bear fine radiating filaments calle ***tonofibrils*** into the cytoplasm of the cells. The tonofibril provide intracellular mechanical support.

In the desmosome, the intercellular gap is filled with dense fibrous material of acid mucosaccharides and protein This material helps to glue the cells together.

There are four types of desmosomes. They are th following:

1. *Belt desmosomes*
2. *Spot desmosomes*
3. *Hemi desmosomes*
4. *Septate desmosomes*

1. Belt desmosomes

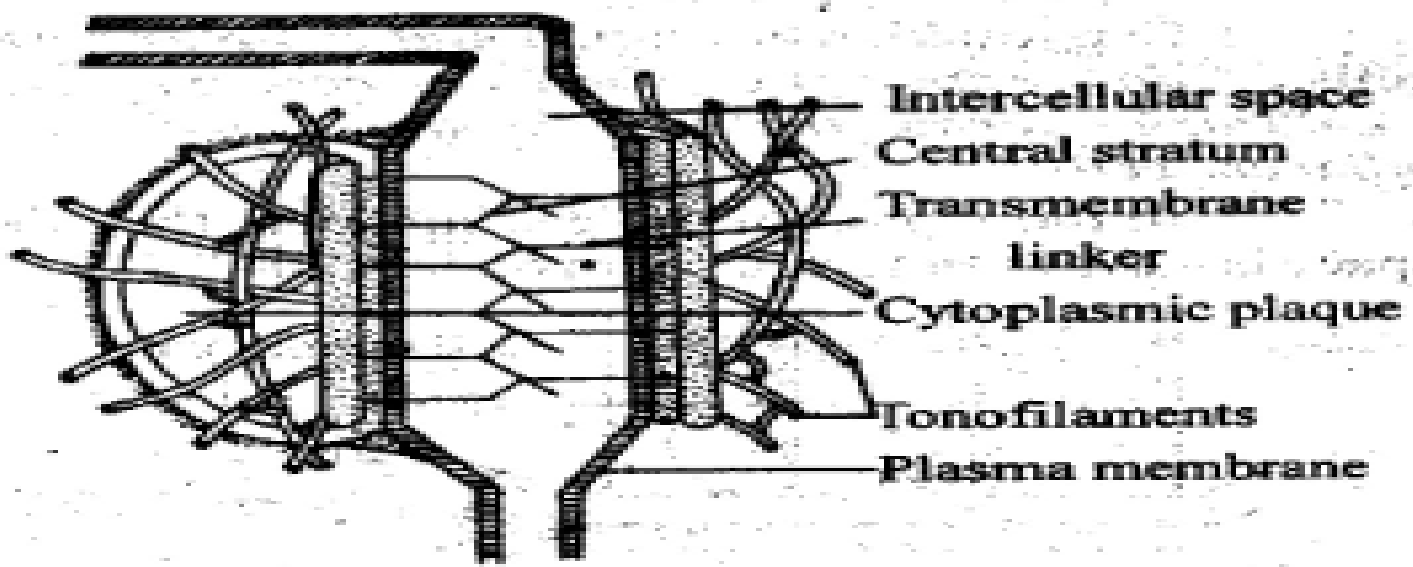
Belt desmosome is found just below the tight junctio It is in the form of a band on the inner side of the cell membra of epithelial cells. The intercellular space is filled with fi filaments. The belt desmosomes help to close gaps and al help in the movement and change in shape of embryoni epithelial cells.

2. Spot desmosomes

Spot desmosomes are disc-shaped points of contact between the plasma membrane of adjacent cells. The spot desmosome consists of an ***intercellular gap***, a disc-shaped ***intracellular plaque*** lying on the cytoplasmic surface of each cell membrane, ***tonofibrils*** and ***trans membrane linkers***, and a ***central stratum***.

The central stratum is the inter cellular core. The trans membrane linkers arise from the plaques and traverse the central stratum joining the plasma membranes.

The spot desmosome is meant for ***mechanical attachment***.



: A spot desmosome.

4. Septate desmosomes

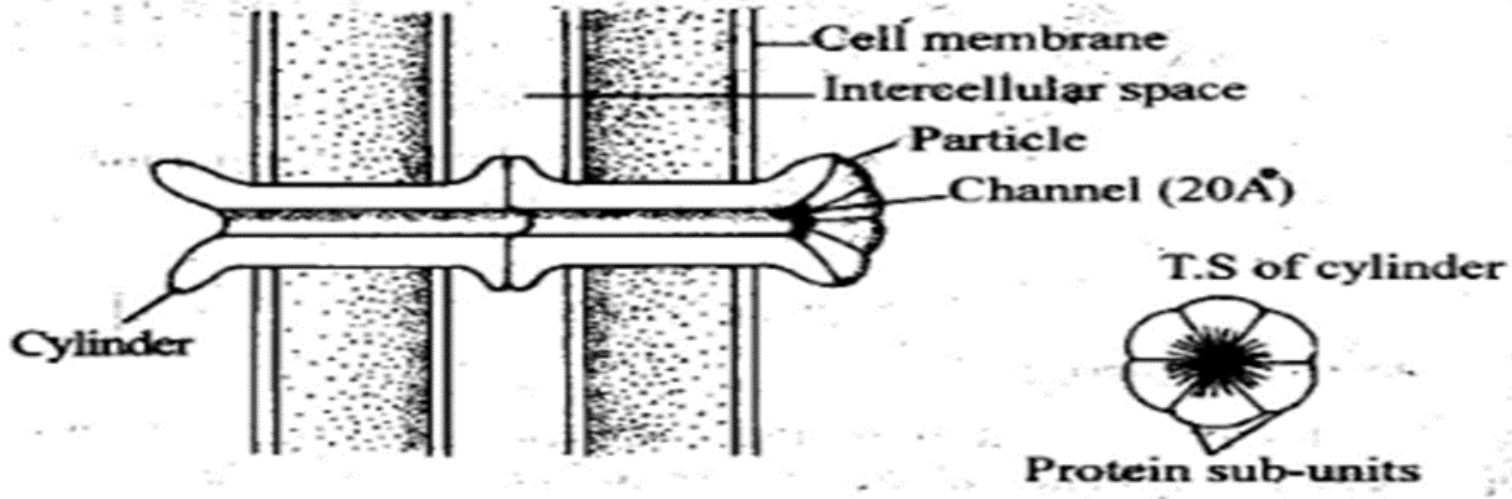
Septate desmosome is a desmosome containing many transverse septa between the plasma membranes in the intercellular space. It is found in the epithelial cells of invertebrates.

The septate desmosomes do not contain tono-fibrils and intercellular cementing substance. They help in the attachment of cells and intercellular communication.

Gap junction (Nexus)

* Gap junction is a ***junctional complex*** between two cells. *Gap junction is a channel or pore through two cell membranes across the intercellular space between two adjacent cells.*

* In the region of the gap junction, the intercellular space is narrow and has a width of only 20A°.



Gap junction showing a pair of cylinders and protein sub-units.

* The gap junction consists of a hollow containing a pair of hexagonal ***cylinders.*** Each plasma membrane contains one cylinder. The two cylinders are arranged end to end to form a channel or pipe between the two cells.

* Each cylinder is made up of six ***protein*** sub-units

* Calcium ions help to regulate the opening and closure of the gap junctions. When the intracellular calcium ion concentration increases, the channels are closed.

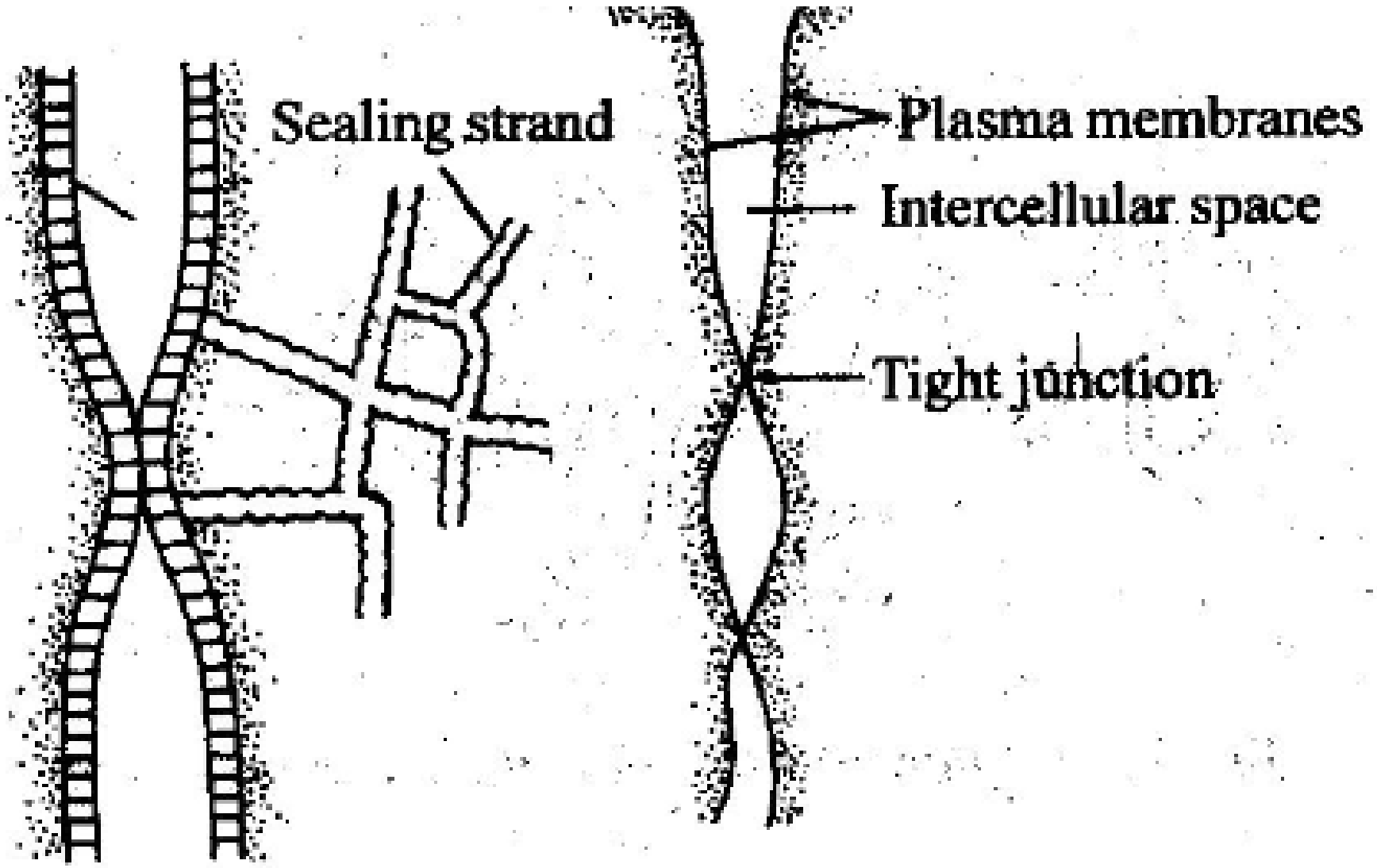
* ***Functions:*** 1. In cardiac muscles and synapses the gap junctions conduct electrical signals.

2. Gap junctions allow passage of ions, sugars, vitamins, nucleotides and metabolites between cells.

Tight Junction (Zona occludens)

Tight junction is a junctional complex where the plasma membranes of adjacent cells fuse together so intimately that the intercellular space disappears.

The tight junctions occur in intestinal cells, gland cells, gall bladder and brain cells.



: *Tight junction*

Tight junctions serve to seal the space between the cells and act as barriers for the diffusion of substances through these regions.

The tight junction consists of an interlocking network of ridges on the cytoplasmic face of plasma membrane. These ridges are called ***sealing strands.*** Each sealing strand is formed of a double row of protein particles.

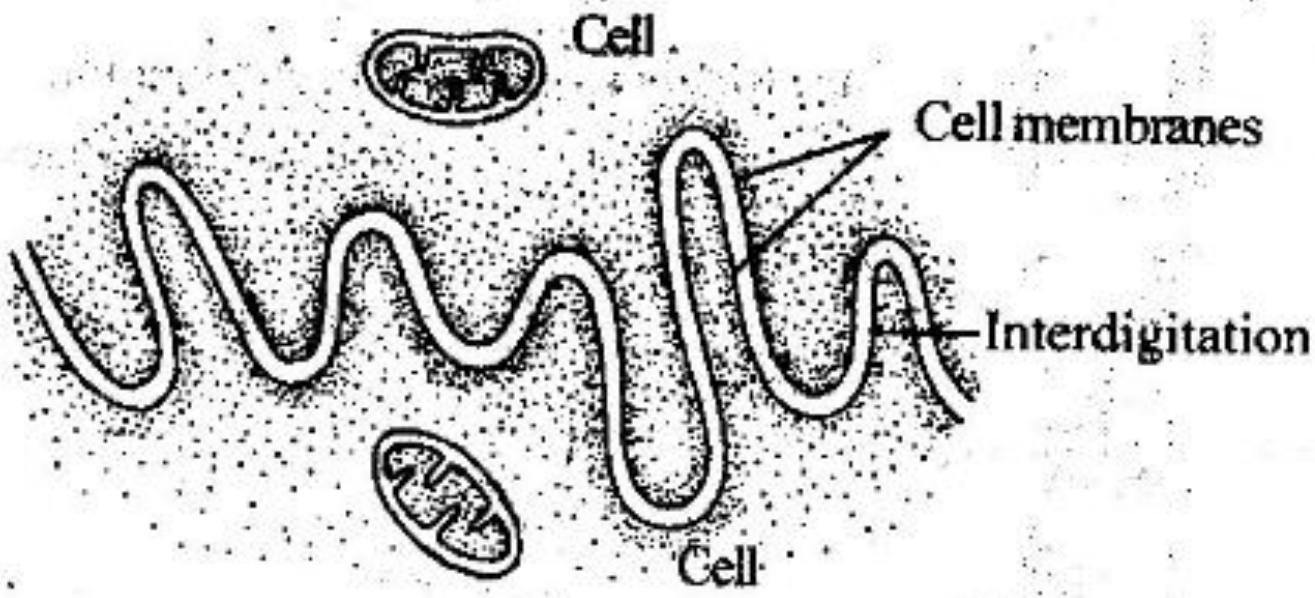
Function: 1. Tight junctions prevent the passage of materials to and from the cells.

2. They prevent the leakage of pancreatic secretory products into the blood.

Inter- digitations

The plasma membranes of adjacent cells project into the cytoplasm as finger-like projection called ***inter-digitations.***

The interdigitations help to compartmentalise the cytoplasm.



Interdigitation of plasma membrane.

Basal infoldings

Basal infoldings are finger-like invaginations of the plasma membrane into the cytoplasm from the base of the cell.

They are found in kidney cells

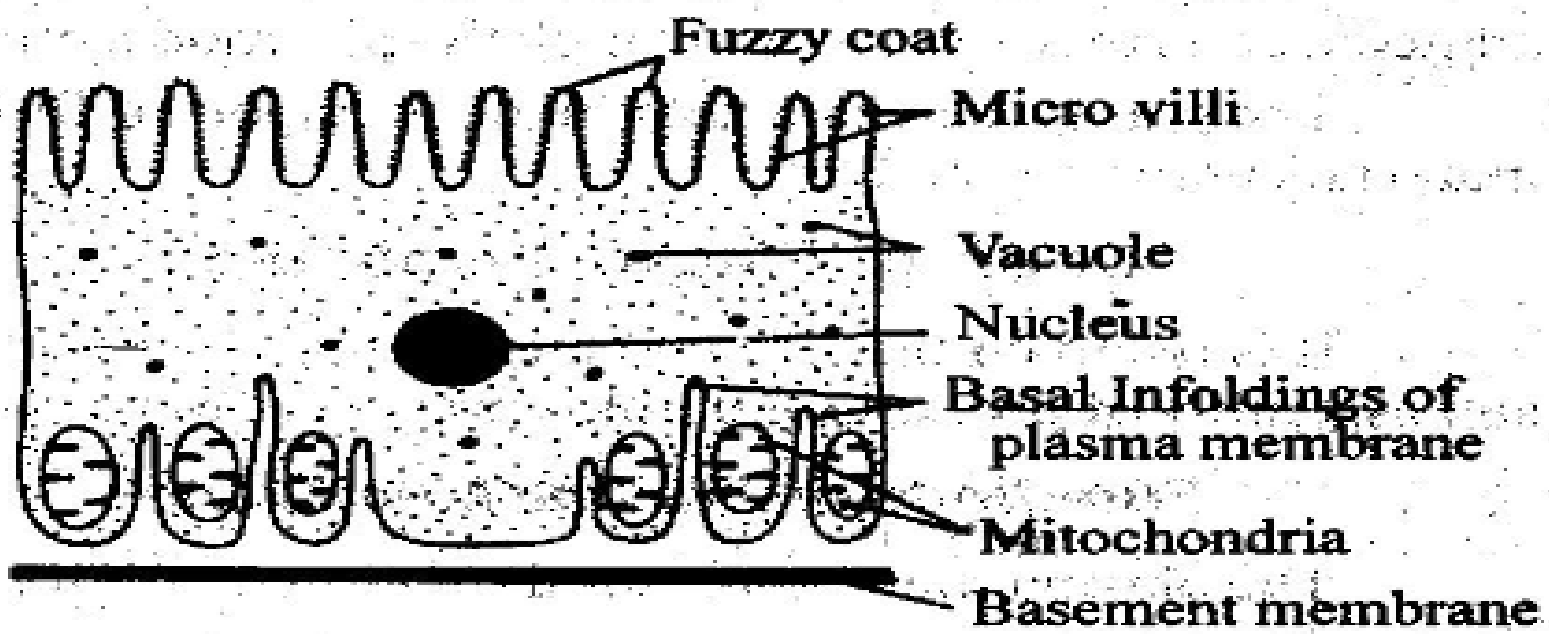


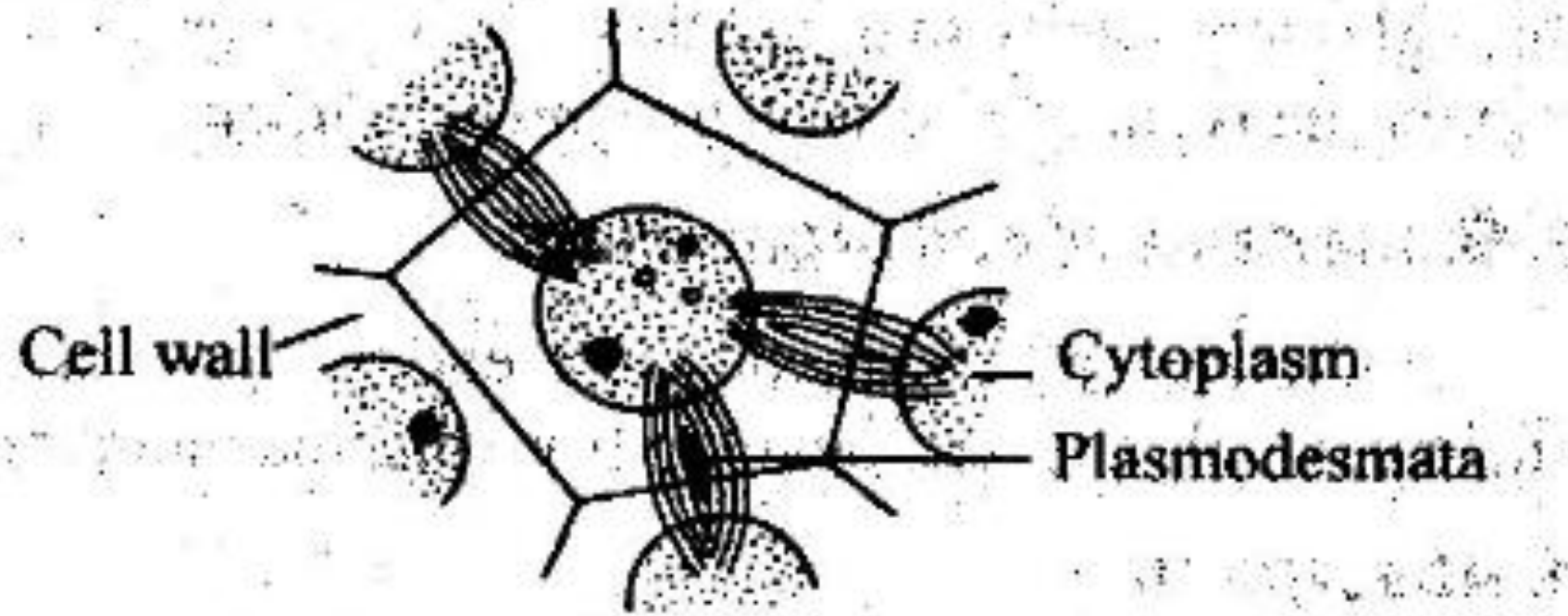
Fig. 5.15: Kidney cell showing basal infoldings.

The basal infoldings function as septa and they split the cytoplasm into compartments.

The basal infoldings enclose many mitochondria. They are concerned with the ***active transport*** of materials.

Plasmodesmata

Plasmodesma (singular) is a cytoplasmic bridge connecting adjacent cells.



Plant cells with plasmodesmata.

Origin of Plasma Membrane

It is believed that plasma membrane is formed by the self assembly of proteins and lipids present in the cytoplasm.

Functions of Plasma Membrane

The plasma membrane has the following functions

1. Mechanical support

Plasma membrane gives the shape to the cell. It protects the cell contents and keeps the cell contents in place.

2. Exchange of materials

Plasma membrane regulates the exchange of materials into and out of the cell. It allows the needed materials to enter the cell and sends out the unwanted materials from the cell. Hence the cell membrane allows one substance to pass through more easily than another. This property of the cell membrane is said to be *selective permeability.*

3. Biogenesis of cell organelles

Certain cell organelles like endoplasmic reticulum, nuclear membrane, etc. develop from plasma membrane.

4. Absorption

The microvilli of intestinal cells increase the surface area. Hence the rate of absorption increases.

5. Cell recognition

Mammalian leucocytes recognize foreign cells like bacteria and engulf them by phagocytosis. Similarly the macrophages of spleen can identify worn out RBCs from healthy RBCs and destroy them. The sites for cell recognition are located on the surface of the plasma membrane. The amino sugar *sialic acid* is involved in cell recognition.

6. Antigenic specificity

The antigen specificities of the cells are located on the surface of the plasma membrane. The antigenic determinants are the glycoproteins of plasma membrane.

The rejection of transplanted tissues is determined by antigens (glycoproteins) located on the cell membrane of implanted cells.

7. Transmission of impulses

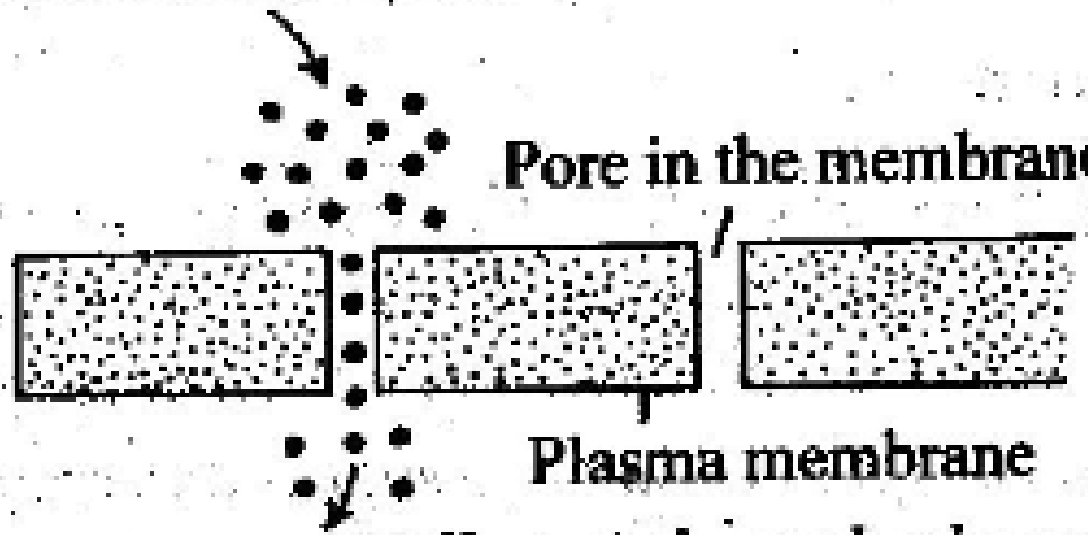
The plasma membrane of nerve fibres transmits nerve impulses.

8. Osmosis

The plasma membrane allows the free movement of water. The process of movement of water molecules from the region of higher water concentration to the region of lower water concentration is known as ***osmosis.*** The process in which the water molecules enter the cell is known as ***endosmosis*** and the reverse process is known as ***ex-osmosis.*** Due to endosmosis the pressure inside the cell increases. This pressure is termed ***hydrostatic pressure.*** Since this pressure is caused by osmosis, it is also termed ***osmotic pressure.*** The plasma membrane maintains a balance between the osmotic pressures of the inter and intracellular fluids.

9. *Passive transport or diffusion*

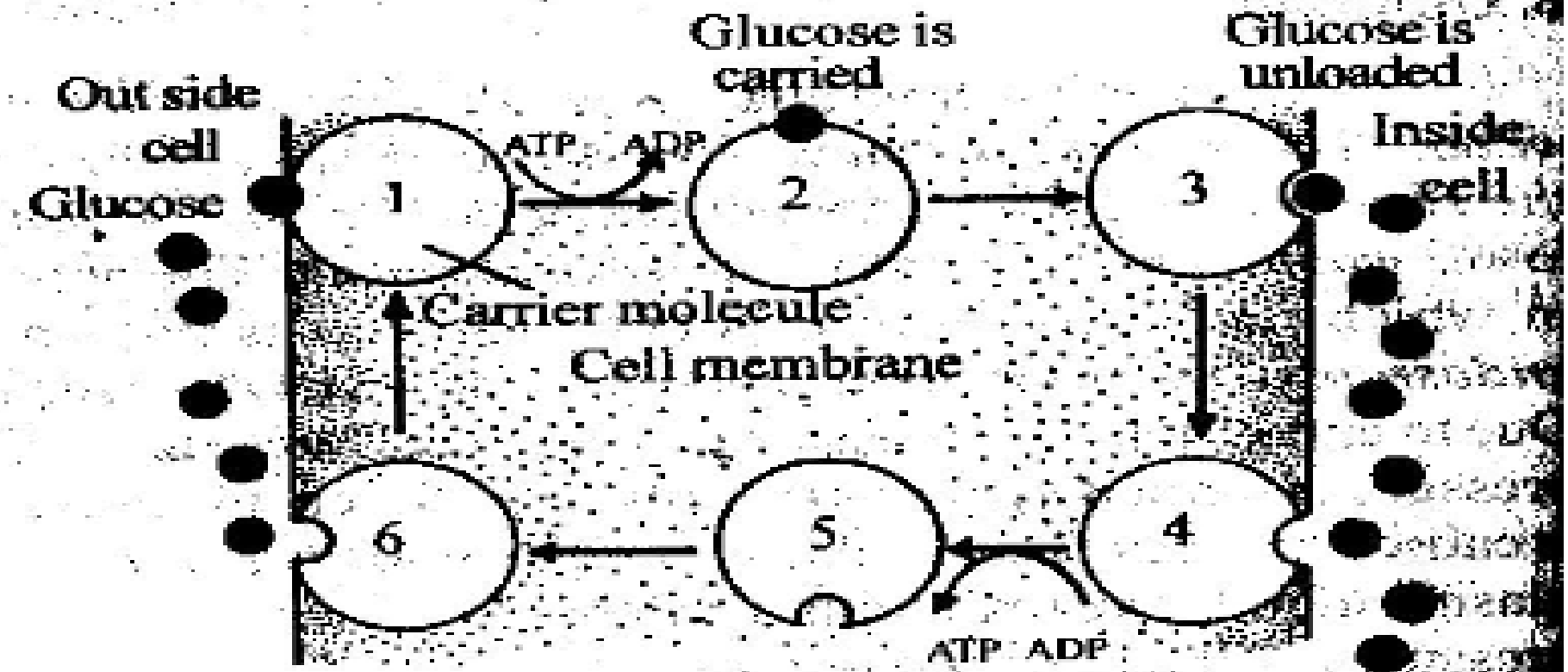
The movement of molecules across the plasma membrane from the region of higher concentration to a region of lower concentration is called ***passive transport*** or ***diffusion.*** Diffusion occurs through pores present in the cell membrane. This process does not utilize energy. Hence this process is also called ***down hill movement.***



Diffusion through plasma membrane

10. Active transport

The movement of molecules and ions from the region of lower concentration to the region of higher concentration, against the concentration gradient is called



: *Active transport.*

active transport. So it is compared to ***uphill movement.*** It needs energy. The energy is provided by the mitochondria. In this case, substances do not move by themselves, but they are carried by some agents present in the membrane. These carrying agents are mainly in the form of proteins called ***carrier proteins.***

Examples: 1. In kidney and nerve cells Na^+ ions are expelled outside and K^+ ions are accumulated inside. This phenomenon is called ***ionic pump.*** These cells actively pump these ions against the concentration gradient.

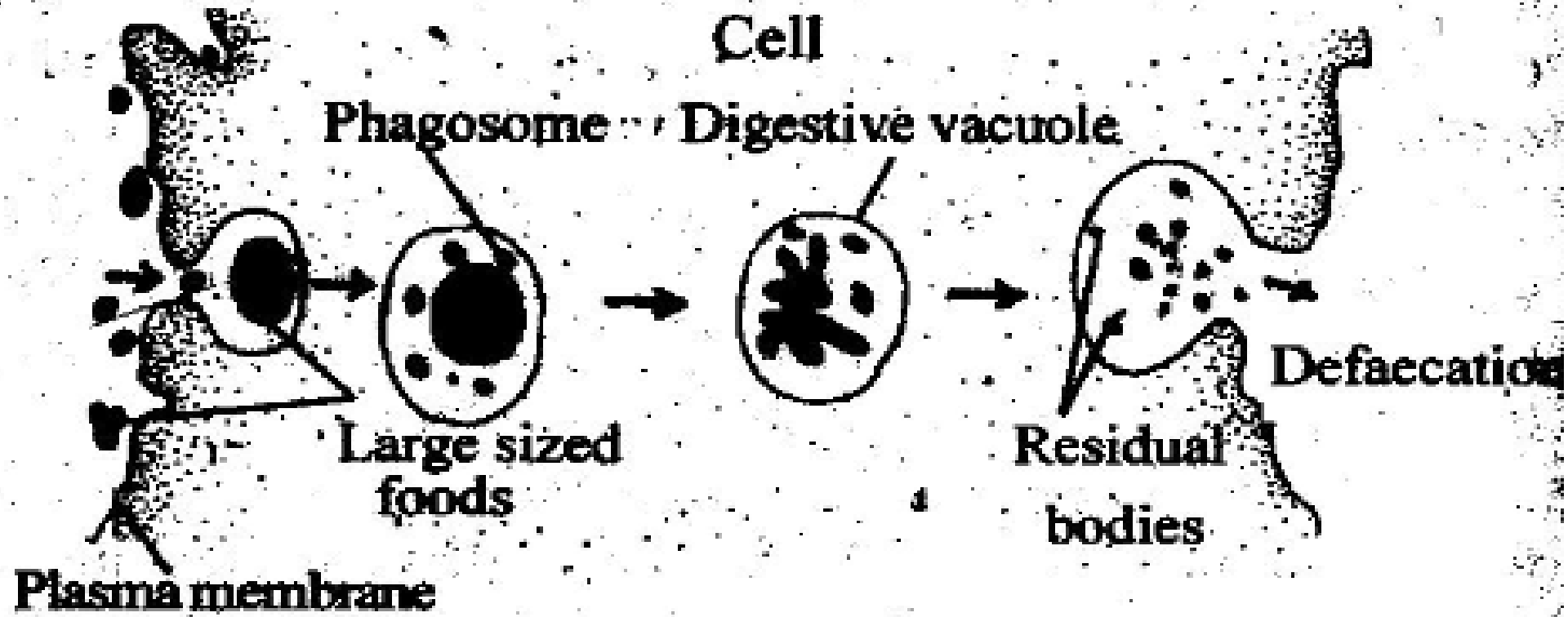
2. The blood contains 1 mg of glucose per 100ml. In the formation of urine, the glomerular filtrate present inside nephron also contains large amount of glucose. From this filtrate, the entire amount of glucose is actively reabsorbed into the blood, so that the urine is completely free from glucose.

11. Endocytosis

Endocytosis is the engulfing of food or foreign particles through the plasma membrane. The endocytosis can be differentiated into phagocytosis and pinocytosis.

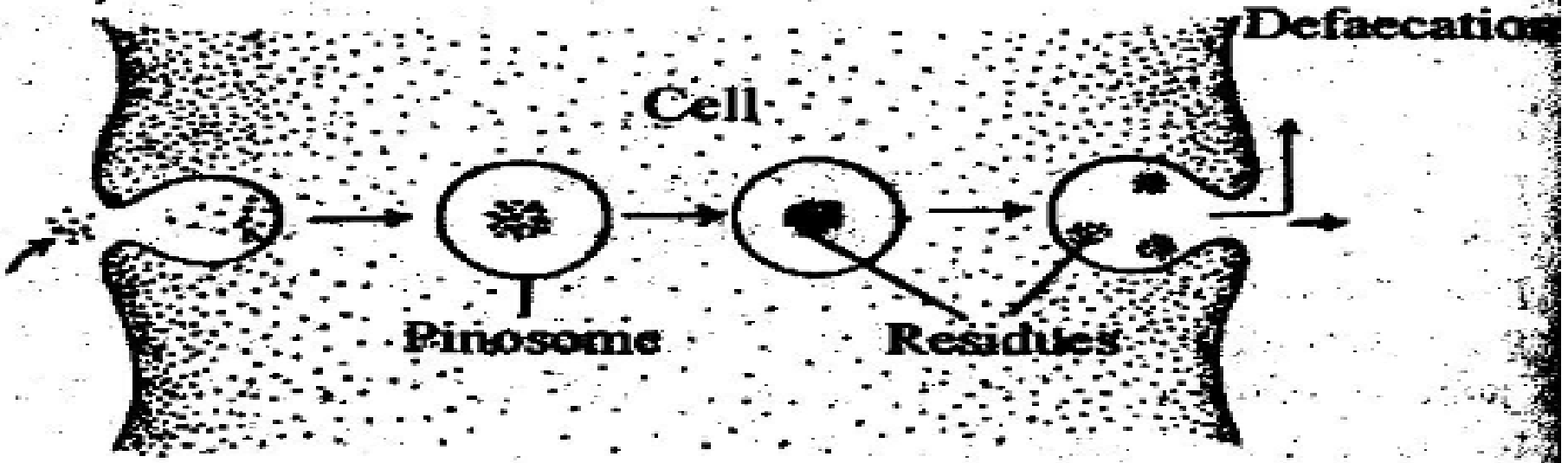
1. Phagocytosis or cell eating: ***Phagocytosis is the engulfing of solid particles through the plasma membrane.*** It is also called ***cell eating***. It is observed in a number of protozoans and leucocytes. The cells exhibiting phagocytosis are called ***phagocytes***. The term 'phagocytosis' was coined by ***Metchnikoff*** in 1885. During this process the food particles are adsorbed at the surface of the membrane. Later on they are taken into the cytoplasm by the infolding of the plasma membrane. The plasma membrane at the infoldings gets pinched off in the form of a small vesicle called ***phagosomes.*** Then the phagosomes fuse with lysosomes to form the ***digestive vacuoles.*** The food is digested inside the vacuole and the digested food diffuses into the cytoplasm.

Eg. 1. Capturing and ingestion of diatoms by *Amoeba*.
2. Devouring of disease causing germs by WBC, macrophages, etc.



: *Phagocytosis.*

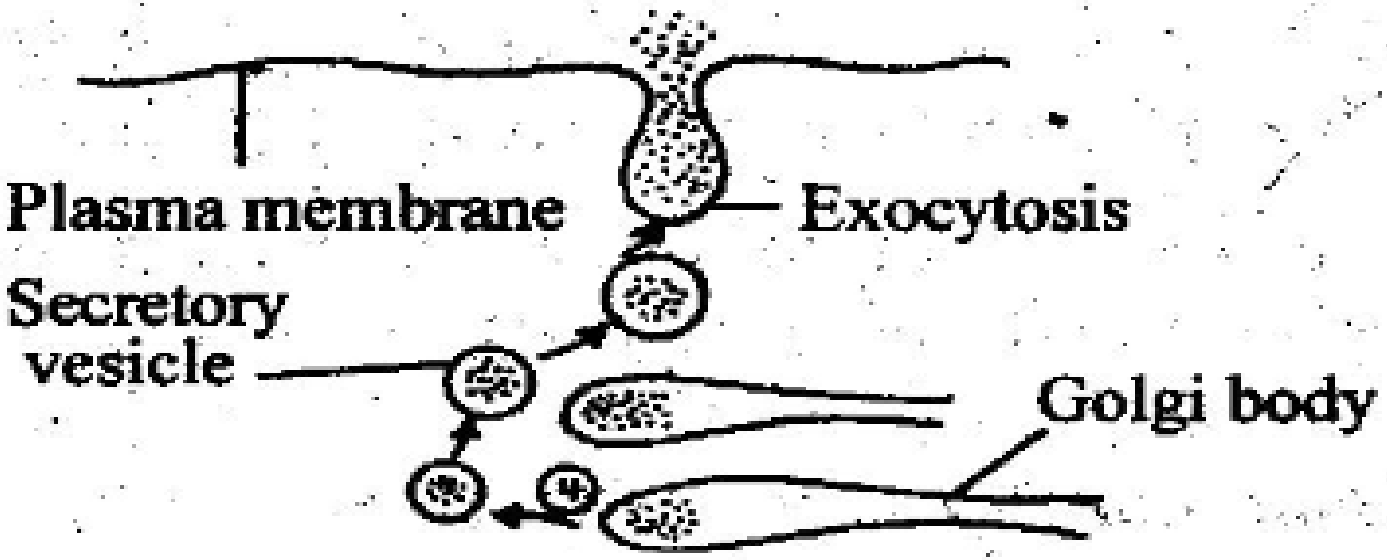
2. *Pinocytosis or Cell drinking:* Pinocytosis is the process of engulfing of ***fluid particles*** through the plasma membrane. It was first observed by ***Lewis.*** During pinocytosis, the plasma membrane is invaginated to form sac-like structures. The fluid food is drawn into the sac. Then the sac is pinched off from the plasma membrane, forming a vesicle called ***pinosome.*** The pinosome later fuses with lysosome. The food is digested by the enzymes of the lysosome. The digested food diffuses into the cytoplasm. Eg. Absorption of fat droplets by intestinal epithelial cells.



Pinocytosis.

12. Exocytosis or Cell vomiting

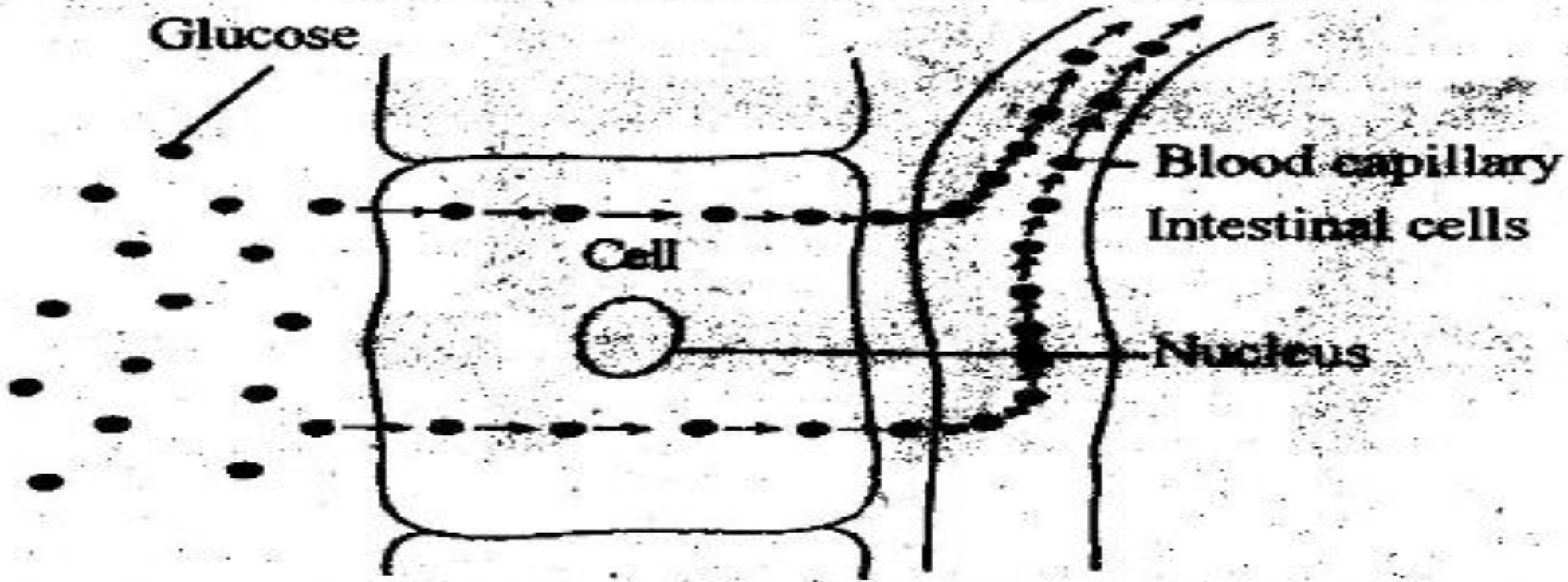
The process of exudating the secretory products from the secretory cells to the outside of the cell cytoplasm is known as ***exocytosis*** or ***cellvomiting.*** This process is also called ***emeiocytosis*** or ***reverse endocytosis.*** Eg: In panereatic cells, the enzymatie secretions are passed out with the help of the plasma membrane.



Exocytosis.

13. Cytopemphis

Cytopemphis is the transport of materials through a cell. The material passes into the cell by endocytosis and then it comes out of the cell by exocytosis without any change. Glucose molecules from the intestine move into the blood capillary through the epithelial cell by cytopemphis.



Cytopemphis.