STRUCTURE AND FUNCTION OF CELL MEMBRANE

1. What is a cell membrane?

Ans – All the cells are surrounded by a biological membrane called a cell membrane. It is a highly viscous structure which is known as the plasma membrane in the animal cells. All biological membranes are made up of proteins, lipids and carbohydrates.

2. What are the functions of the cell membrane?

Ans – The functions of the cell membrane are as follows:

- To maintain the physical integrity of the cell – especially in the case of animal cell, the cell membrane holds the cell together by enclosing the cytoplasm and organelles within it.
- The cell membrane forms a barrier between the inside of the cell and the environment outside the cell.
- Protection
  - The cell membrane protects the cell from some harmful chemicals in its external environment.
  - It also protects the cell from loss of useful biological macromolecules held within the cell by its plasma membrane.
- The cell membranes that enclose cells are selectively permeable. That is, the structure of these membranes is such that they allow certain particles, e.g. molecules, - but not others - to pass through the membrane, hence into or out of the cell.
- They allow active transport of specific molecules across the cell membrane in either direction, i.e. either into or out of the cell (movement against the concentration gradient).
- Bulk transport through exocytosis and endocytosis.
- Metabolic activities – Certain proteins and enzymes which form a component of the cell membrane are involved in metabolic activities.

3. What are the components of a phospholipid bilayer?

Ans – The three main components of a phospholipid bilayer are – phospholipids, carbohydrates and proteins.

4. Give a diagram to show the various components of the fluid mosaic model.

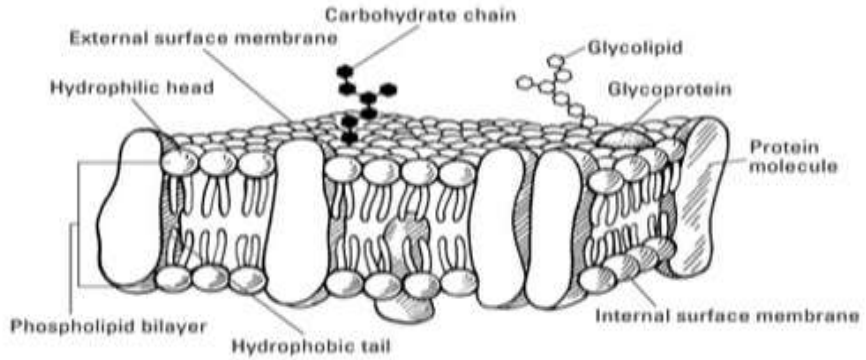


Figure 1: Components of the Fluid Mosaic Model

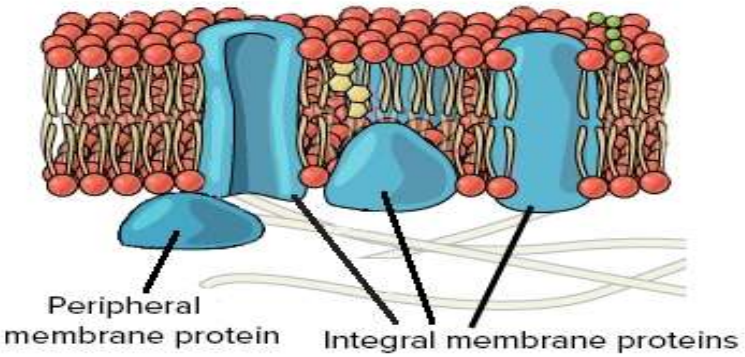
5. What are the three domains of integral proteins?

Ans – Integral proteins are the proteins that lie immersed in the Lipid bilayer. The three domains of this protein are:

- A sequence exterior to the cell (Containing amino terminal end)
- A trans-membrane sequence
- A sequence extending into the cell (containing –COOH terminal end)

6. What are peripheral proteins?

Ans – Peripheral membrane proteins are membrane proteins that adhere only temporarily to the biological membrane with which they are associated.



7. How do carbohydrates help the cell membrane?

Ans – They help in the cell to cell recognition. Also, the carbohydrates of the cell membrane form a “sugar coating” called glycocalyx which is hydrophilic (water-loving). Glycocalyx helps in the interaction with the water present in the external environment. As a result, cell can take the dissolved substances present in the water easily.

8. What are tight junctions and what are they made up of?

Ans – They are specialized sites of contact that block solutes from diffusing between the cells in the epithelium. The strands of the tight junctions are made up two types of proteins called claudins and occludins.

9. What are the functions of tight junctions?

- They create a barrier and do not allow unwanted substances to pass through the epithelium.
- Involved in the regulation of signaling pathways.

10. What is a cytoskeleton? Name the three major filaments that make up the cytoskeleton.

Ans – The cytoskeleton is a system of microscopic molecular filaments, present in the cytoplasm of all the cells. The cytoskeleton provides an architectural framework upon which the cell can organize the subcellar organelles and the metabolic machinery. The three major types of filaments that make up the cytoskeleton are; microtubules, intermediate filaments and microfilaments.

11. What are the functions of the cytoskeleton?

Ans – The functions are:

1. It provides structural support
2. It functions as an internal framework.
3. Provides the network of materials that directs the movement of materials
4. It functions as a force generating apparatus.
5. Plays a role in cell division (helps in the movement of chromosomes during cell division and cytokinesis)

12. What are microtubules made up of and what is their function?

Ans – Microtubules are long, hollow tubular structures made of globular monomeric proteins called alpha and beta tubulins. Microtubules are more rigid than other filaments. They are stiff, tubular structures that are arranged in longitudinal rows and are also called proto-filaments They help in determining the shape of the cell and maintaining position of organelles such as endoplasmic reticulum and Golgi Complex. They play a vital role in moving the split chromatids to the newly forming daughter cells during mitosis. Collections of microtubules also form cilia and flagella found in protozoans and other organs of some multicellular animals.

13. What are intermediate filaments and what is their function?

Ans – Intermediate filaments are strong rope like fibres which come in several types. They are made up of globular proteins but the variety of global proteins subunits is different in different cell types. All the cells have intermediate filaments but the protein subunits of these structures vary. The primary function of intermediate filaments is to provide mechanical stability to cells that may be required for specialised tissue specific functions. Some of the examples of intermediate filaments are neurofilaments which are found in neurons (most prominent prominently in long axons of the neuron cells) and keratin that is found in hair, nails, etc.

14. What are microfilaments made up of and what is their function?

Ans – Microfilaments or actin filaments are the thinnest elements of the cytoskeleton that are found in the cytoplasm of Eukaryotic cells. They are formed by the polymerization of actin proteins in the presence of a ATP. Actin filaments play a key role in all types of contractility and motility within the cell, for example microfilaments are responsible for the movement, change of shape in Amoeba, etc.

15. What are the three mechanisms of passive transport?

Ans – Diffusion, Osmosis and facilitated diffusion.

16. Explain diffusion with the help of an example.

Ans – Diffusion is the net movement of a substance (liquid or gas) from an area of higher concentration to one of lower concentration. A drop of dye in water is concentrated but then begins to disperse throughout the water moving from an area of high to an area of low concentration. During passive diffusion or simple diffusion the solutes move down the electrochemical gradient. Small in organic solutes such as oxygen, carbon dioxide, water penetrate the lipid bilayer readily as do the lipids with high solubility.

17. What is osmosis?

Ans - It is a type of simple diffusion in which water molecules diffuse through the selectively permeable membrane.

18. Why is the membrane known to be selectively permeable?

Ans- Water moves much rapidly than the dissolved irons or small polar organic molecules, which are essentially non-penetrating. Because of this difference in the permeability of water *vs* solutes, membranes are said to be semipermeable.

19. What do you mean by hyper tonic and hypotonic solution?

Ans - A hyper tonic solution has more solute and less water and a hypotonic solution solution has less solutes and more water.

20. What happens to the cell when it is placed in a hypertonic or hypotonic solution?

Ans- When a cell is placed into a hypotonic solution, it rapidly gains water by osmosis and swells. Conversely when the cell is placed in a hypertonic solution, it loses water by osmosis and shrinks. This shows that volume of the cell is controlled by the difference between the solute concentrations inside the cell and extracellular medium.

21. What is an isotonic solution?

Ans - When the internal solute concentration is equal to the external solute concentration the internal and external fluids are said to be iso tonic or iso osmotic. At this stage, no movement of water into our out of the cell occurs.

22. What are aquaphorins?

Ans - They are a family of small integral proteins which allow passive movement of water from one side of the plasma membrane to another. They are particularly prominent in cell such as kidneys tubules where passage of water plays a crucial role in physiological activities of the tissue.

23. How does the facilitated diffusion take place?

Ans - In facilitated diffusion, substances move into or out of cells down their concentration gradient with the help of cell membrane proteins called carrier proteins. These carrier proteins are also known as transporters.

24. What is the similarity and difference between a simple diffusion and a facilitated diffusion?

Ans -Simple diffusion and facilitated diffusion are similar in that both involve movement down the concentration gradient. The difference is how the substance gets through the cell membrane. In simple diffusion, the substance passes between the phospholipids; in facilitated diffusion there are a specialized membrane channels. Charged or polar molecules that cannot fit between the phospholipids generally enter and leave cells through facilitated diffusion.

25. What is the function of a glucose transporter?

Ans – A glucose transporter is a facilitative transporter which is present in the plasma membrane. It gets stimulated with the increase in the insulin levels.

26. What are protein channels? What are the three different types of protein channels?

Ans - Some integral proteins of the lipid bilayer allow the passage of certain charged molecules like Na^+, K^+, Ca^+, Cl^-. These proteins are known as the protein channels. They are specific to certain ions. They are also known as gated channels as they exist either in the open or closed confirmation. Three major categories of protein channels are:

- Voltage gated channels –
- Ligand gated channels
- Mechano gated channels

27. Is filtration a passive mechanism. How does it help in the transport of solutes?

Ans - Filtration is movement of water and solute molecules across the cell membrane due to hydrostatic pressure generated by the cardiovascular system. Depending on the size of the membrane pores, only solutes of a certain size may pass through it. For example, the membrane pores of the Bowman's capsule in the kidneys are very small, and only albumins, the smallest of the proteins, have any chance of being filtered through. On the other hand, the membrane pores of liver cells are extremely large, but not forgetting cells are extremely small to allow a variety of solutes to pass through and be metabolized.

28. What is active transport?

Ans – it involves the movement of ions and solutes against the concentration gradient with the input of energy. Proteins that carry out active transport are known as active transporters or pumps.

29. How are the active transporters classified?

Ans - The active transporters are of two types: primary active transporters and secondary active transporters.

30. What are primary active transporters? What are its types?

Ans – These transporter proteins are present in all the living organisms. The energy source is ATP that is used for the translocation of cations. They are of three types:

1. P-type transporters

These transport proteins get phosphorylated and de phosphorylated during the transport of cations. Example – Na^+/K^+- ATPase (also known as sodium potassium pump)

2. V-type transporters

They occur in the membranes of organelles like lysosomes, golgi vesicles, secretory granules, etc. They help to transport hydrogen ions (protons) across the walls. The proton pump present in the kidney tubules helps in maintaining the acid base balance by eliminating excess protons in the urine.

3. F-type transporters

They are present in the mitochondria, chloroplasts, etc. They translocate protons at the expense of ATP. (In addition, they can also synthesize ATP through reverse process.)

31. What are secondary active transporters?

Ans – They utilize secondary source of energy for example transmembrane electro-chemical gradient to translocate small organic molecules like glucose and amino acids. For example – Na^+- glucose transporter.

32. What is an acid?

Ans – An acid is a substance that dissociates in water to release hydrogen ions. It is also known as a proton donor.

HA----→ H^+ (proton) + A^-(conjugate base)

33. What is a base?

Ans – A base is any substance that releases hydroxyl (OH^-) ions in an aqueous solution. It decreases the concentration of H^+.

34. Give examples of a strong base and a strong acid

Ans – Hydrochloric Acid (HCl) is a strong acid and sodium hydroxide (NaOH) is a strong base.

35. What is an amphoteric substance?

Ans – Some substances such as amino acids and proteins can act both as a acid and a base. Such substances are known as amphoteric substances. Example: glycine

36. What is a buffer?

Ans - A buffer is a solution that can resist changes in pH. It minimises the change in H^+ ion concentration following the addition of an acid or a base. It can be prepared by mixing a weak acid (HA) and its conjugate base (A^-). A buffer has maximum buffering capacity when acidic and basic forms are present in equal concentrations.

37. Why are buffers required in our blood?

Ans - Metabolism of various constituents of foods result in the production of acids as well as carbon dioxide in the body. But the blood has to be constantly maintained at particular pH that ranges between 7.35 to 7.45. This balance is done by buffers.

38. What are the two main mechanisms involved in the maintenance of acid base balance?

Ans - The first mechanism involves chemical buffers which are present in the extracellular and intracellular fluids

The second mechanism involves lungs that maintain the pH by disposing of excess of carbon dioxide.

39. What are the three main blood buffers?

Ans - The 3 main blood buffers are:

- Protein buffers
- Phosphate buffer
- Bicarbonate/carbon dioxide buffer

40. How does a protein buffer function?

Ans – The proteins (particularly albumin) is present in the plasma and haemoglobin in RBCs. Proteins have several ionizable groups because of the presence of several amino acids that can either donate or accept protons.

41. What are the components of phosphate buffer?

Ans - The phosphate buffer consists of phosphoric acid (H_3PO_4) and its conjugate base ($H_2PO_4^-$)

42. Why is a bicarbonate or carbon dioxide buffer most important mechanism of maintenance of acid-base balance in the blood?

Ans – Bicarbonate or carbon dioxide buffer is important because the components of this buffer system, that is, the bicarbonate ($HCO3^-$) and carbon dioxide, are present in large

quantities, as they are the end products of metabolism. Secondly, this buffer acts as an open system which means either of its components can be added or removed from the system.

43. How do lungs help in the maintenance of acid base balance?

Ans - The respiratory system controls partial pressure of carbon dioxide (pCO_2) and thus minimises changes in pH in arterial blood. Normally, CO_2 is expired at the same rate at which it is produced and the partial pressure of carbon dioxide (pCO_2) is maintained. If blood becomes acidic by the addition of acids, hyperventilation takes place. As a result, carbon dioxide is flushed out at a greater rate than the rate at which it is produced. Thus, the partial pressure of carbon dioxide (pCO_2) falls. This reductions in arterial pressure results in the fall in H^+ concentration of blood.

On the reverse, if blood pH increases, changes occur in opposite direction. Hypo ventilation takes place and blood (pCO_2) rises. This in turn leads to an increase in the carbonic acid concentration in the blood.

44. How do the kidneys help in the maintenance of acid base balance?

Ans - Renal response to acid base disturbance is slow but more accurate. Kidneys regulate acid base balance by

- controlling bicarbonate reabsorption
- secreting H^+

Both these processes depend upon the formation of H^+ and $HCO3^-$ from carbon dioxide and water within the tubule cells. Normally, H^+ formed in the reaction is actively secreted into the lumen in exchange for sodium ions. So, within the tubule cells, both Na^+ as well as HCO_3^- ions are pumped out to the blood, while H^+ is secreted into the lumen.

45. What happens to the H^+ ions after secretion into the lumen?

Ans – The H^+ ions adopt three different pathways:

1. By filtered Bicarbonate - H^+ ions that are secreted into the lumen may combine with HCO_3^- . This in turn, leads to the formation of carbonic acid which is subsequently dissociated to water and carbon dioxide.
2. Excretion as titratable acids: On secreted into the lumen, the H^+ ions maybe taken up by phosphate buffer. This results into a drop in pH. Thus, the excess of acid is released as a component of the urinary buffer.
3. Excretion as NH_4^+ ions – Ammonia (NH_3) is naturally synthesized in the proximal convoluted tubule of the kidneys from amino acids. This ammonia (NH_3) gas combines with hydrogen ions (H^+ ions) to form NH_4^+ ions. The NH_4^+ ions combine with Cl^- ions to form as NH_4Cl that gets excreted out in urine.

46. What is acidosis and alkalosis?

Ans – Acidosis is a clinical condition that arises due to the excess of acids or deficiency of an alkali.

Alkalosis is a clinical condition that results due to the excess of alkali or deficiency of an acid.

47. Name the four different types of acid base disturbances.

Ans – They are:

- Respiratory alkalosis
- Respiratory acidosis
- Metabolic acidosis
- Metabolic alkalosis

48. What are the different diagnostic tests used to assess acid base balance disorders?

Ans – The diagnostic tests are:

- Blood gas analysis (BGA) - Acid base balance disorders are usually diagnosed by blood gas analysis which commonly includes blood pH, pCO_2 and HCO_3^-.
- Base excess - The amount of acid required to return the pH of blood to 7.35 when pCO_2 is adjusted to normal is known as base excess.
- Anion gap = $(Na^+ + K^+) – (Cl^- + HCO3^-)$ Normal values vary between 12-16meq/L.