

Various Models of Plasma Membrane

Introduction

The plasma membrane (cell membrane) is a thin, living, flexible boundary that surrounds the cell. It controls the movement of substances into and out of the cell and maintains the internal environment. Over time, several models have been proposed to explain its structure.

1. Lipid Monolayer Model (Overton, 1895)

Proposed by:

Charles Overton

Main Features:

- Based on permeability experiments.
- Suggested that the plasma membrane is composed mainly of **lipids**.
- Lipid-soluble substances enter the cell more easily than water-soluble substances.

Merits:

- First model to suggest lipid nature of the membrane.
- Explained selective permeability to some extent.

Demerits:

- Could not explain:
 - Protein presence
 - Active transport
 - Electrical properties of membranes

2. Lipid Bilayer Model (Gorter and Grendel, 1925)

Proposed by:

Evert Gorter and François Grendel

Main Features:

- Membrane consists of a **double layer of phospholipids**.
- Hydrophilic heads face outward.
- Hydrophobic tails face inward.
- Based on experiments with red blood cells.

Merits:

- Correctly explained the bilayer nature of membrane.
- Basis for all future membrane models.

Demerits:

- Did not include proteins.
- Could not explain membrane functions like transport and enzymatic activity.

3. Sandwich Model / Protein–Lipid–Protein Model (Danielli and Davson, 1935)

Proposed by:

Hugh Davson and James Danielli

Main Features:

- Lipid bilayer is **sandwiched between two layers of proteins**.
- Proteins are present on both outer and inner surfaces.
- Provided a stable structure to the membrane.

Merits:

- Included both lipids and proteins.
- Explained low surface tension of membrane.
- Accepted for many years.

Demerits:

- Assumed proteins are continuous layers (which is incorrect).
- Could not explain selective permeability and transport proteins.
- Failed to explain dynamic nature of membrane.

4. Unit Membrane Model (Robertson, 1959)

Proposed by:

J. David Robertson

Main Features:

- Plasma membrane has a **trilaminar structure**:
 - Two electron-dense outer layers (proteins)
 - One electron-lucent middle layer (lipid)
- Thickness ~7.5–10 nm.
- Observed under electron microscope.

Merits:

- Provided ultrastructural evidence.
- Suggested all biological membranes have similar structure.

Demerits:

- Did not explain molecular organization.
- Ignored membrane fluidity and functional diversity.

5. Fluid Mosaic Model (Singer and Nicolson, 1972) – Most Accepted Model

Proposed by:

S. J. Singer and G. L. Nicolson

Main Features:

- Membrane is a **fluid phospholipid bilayer**.
- Proteins are embedded within the lipid bilayer like a mosaic.
- Lipids and proteins can move laterally.
- Two types of proteins:
 - **Integral (intrinsic) proteins**
 - **Peripheral (extrinsic) proteins**
- Carbohydrates are present as:

- Glycoproteins
- Glycolipids (mainly on outer surface)

Merits:

- Explains:
 - Selective permeability
 - Transport mechanisms
 - Enzyme activity
 - Cell recognition
- Supported by experimental evidence.
- Explains dynamic nature of membrane.

Demerits:

- Does not fully explain membrane asymmetry in all cases.
- Some membrane regions are less fluid than proposed.

Conclusion

Among all the proposed models, the **Fluid Mosaic Model** is the most widely accepted as it explains both the **structure and functions** of the plasma membrane accurately.