UNIT 1: CELL BIOLOGY

TOPIC F: CELL MEMBRANE STRUCTURE

Essential Idea(s)
- The structure of biological membranes makes them fluid and dynamic.

IB Assessment Statements and Class Objectives:

1.3 U1 Phospholipids form bilayers in water due to the amphipathic properties of phospholipid molecules.
   - Draw a simplified diagram of the structure of the phospholipid, including a phosphate-glycerol head and two fatty acid tails.
   - Define hydrophilic and hydrophobic.
   - Define amphipathic and outline the amphipathic properties of phospholipids.
   - Explain why phospholipids form bilayers in water, with reference to hydrophilic phosphate heads and two hydrophobic hydrocarbon tails.

1.3 NOS1 Using models as representations of the real world—there are alternative models of membrane structures.
   - Explain what models are and their purposes in science.
   - Describe the observations and conclusions drawn by Gorter and Grendel in discovering the structure of cell membranes.

1.3 S2 Analysis of evidence from electron microscopy that led to the proposal of the Davson-Danielli model.
   - Describe the observations and conclusions drawn by Davson and Danielli in discovering the structure of cell membranes.

1.3 S3 Analysis of the falsification of the Davson-Danielli model that led to the Singer-Nicolson model.
   - Describe conclusions about cell membrane structure drawn from freeze-etched electron micrograph images of the cell membrane.
   - Describe conclusions about cell membrane structure drawn from cell fusion experiments.
   - Describe conclusions about cell membrane structure drawn from improvements in techniques for determining the structure of membrane proteins.
   - Compare the Davson-Danielli model of membrane structure with the Singer-Nicolson model.

1.3 NOS2 Falsification of theories with one theory being superseded by another—evidence falsified the Davson-Danielli model.
   - Describe why the understanding of cell membrane structure has changed over time.

1.3 S1 Drawing of the fluid mosaic model.
   - Draw and label the structure of membranes - include phospholipid bilayer, integral proteins, peripheral proteins, protein channels with a pore, glycoproteins, cholesterol, and an indication of thickness (10nm)

1.3 U2 Membrane proteins are diverse in terms of structure, position in the membranes and function.
   - State the primary function of the cell membrane.
   - Contrast the structure of integral and peripheral proteins.
   - List at least four functions (with examples) of membrane bound proteins
   - Contrast the two types of transport proteins: pumps and channels.

1.3 U3 Cholesterol is a component of animal cell membranes
   - Identify the structure of cholesterol in molecular diagrams.
   - Describe the structural placement of cholesterol within the cell membrane.

1.3 A1 Cholesterol in mammalian membranes reduces membrane fluidity and permeability to some solutes
   - Describe the function of cholesterol molecules in the cell membrane.
UNIT 1: CELL BIOLOGY  TOPIC F: CELL MEMBRANE STRUCTURE

PHOSPHOLIPIDS

*AMPHIPATHIC*  +
both hydrophobic +
hydrophilic

**Head is:** phosphate bonded to glycerol
**Structure:** 

**Tails are:** fatty acids
**Structure:** hydrocarbon chain

Hydrocarbon tail can be saturated or unsaturated

Unsaturated:
- some C's lack max H's
- some double bonds
- kinked chain
- increases fluidity

Saturated:
- all C's have max # of H's
- lack double bonds
- straight chain
- decreases fluidity

Structure of a Phospholipid
MODELS OF MEMBRANE STRUCTURE

Gorter and Grendel (1920's)
extracted phospholipids from cell membrane of red blood cells

<table>
<thead>
<tr>
<th>Observation</th>
<th>Deduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>calculated SA of monolayer is 2x SA of intact cell</td>
<td>bilayer!</td>
</tr>
</tbody>
</table>

Davson and Danielli (1930’s)
discovered cell membrane is made of phospholipids AND proteins

<table>
<thead>
<tr>
<th>Observation</th>
<th>Deduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proteins show up dark with lipids clear.</td>
<td>proteins sandwich lipids</td>
</tr>
</tbody>
</table>

PROBLEMS WITH THE DAVSON-DANIELLI MODEL

<table>
<thead>
<tr>
<th>Freeze-etched micrographs</th>
<th>Structure of membrane proteins</th>
<th>Fluorescent antibody tagging</th>
</tr>
</thead>
<tbody>
<tr>
<td>freezing + fracturing along points weak points</td>
<td>proteins extracted varied in size + globular</td>
<td>red/green markers attached to antibodies for membrane proteins</td>
</tr>
<tr>
<td>globular structures throughout - transmembrane proteins</td>
<td>hydrophobic - attracted to tails</td>
<td>cells fused together</td>
</tr>
<tr>
<td></td>
<td></td>
<td>red/green markers mixed throughout fused cells</td>
</tr>
</tbody>
</table>
Singer and Nicolson (1960's) **FLUID MOSAIC MODEL**

<table>
<thead>
<tr>
<th><strong>Observation</strong></th>
<th><strong>Deduction</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>membranes vary in function</td>
<td>structure not rigid/fixed, but flows</td>
</tr>
<tr>
<td>lipid soluble materials pass through</td>
<td>no solid protein cap</td>
</tr>
<tr>
<td></td>
<td>proteins dispersed throughout</td>
</tr>
<tr>
<td></td>
<td>membrane some parts bare- allow</td>
</tr>
<tr>
<td></td>
<td>lipid soluble molecules</td>
</tr>
</tbody>
</table>

**BIG IDEA:** Membranes are “**Fluid Mosaics**” in which proteins move within layers of fluid phospholipids

- **Why called a FLUID?**
  - Phospholipid bilayer is flexible, allowing for cellular shape changes.
  - Membrane lipids (and some proteins) can drift laterally within the membrane.
  - Individual phospholipid molecules are not bonded to one another.
  - Proteins drift more slowly than lipids.
  - Some membrane proteins are tethered to the cytoskeleton and cannot move far.

- **Why called a MOSAIC?**
  - A **mosaic of proteins** is embedded in the membrane.

**THE PLASMA MEMBRANE**

- **Integral:**
  - Span entire membrane permanently attached

- **Peripheral:**
  - Attached to 1 side temp. attached attach to integral
### Roles of Membrane Bound Proteins:

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>DESCRIPTION</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Proteins</td>
<td>binds to specific molecule outside cell which triggers chain inside cell or action</td>
<td>insulin receptor protein</td>
</tr>
<tr>
<td>I/P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enzyme Proteins</td>
<td>promote chemical reactions that synthesize or break apart molecules</td>
<td>ATP synthase</td>
</tr>
<tr>
<td>I/P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adhesion Proteins</td>
<td>anchors cell membrane to cytoskeleton, proteins, other cells</td>
<td>cadherins</td>
</tr>
<tr>
<td>I/P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recognition Proteins</td>
<td>1D tags on surface of cell glycoproteins - protein + sugar)</td>
<td>MHC proteins</td>
</tr>
<tr>
<td><em>glycoproteins</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I/P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Channel Proteins</td>
<td>pores/tunnels for large/hydrophilic molecules to be transported passively</td>
<td>glucose channel</td>
</tr>
<tr>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump Proteins</td>
<td>pores/tunnels for large/hydrophilic molecules to be transported actively</td>
<td>Na/K pump</td>
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### Role of Cholesterol

**What is cholesterol?**

fat molecules

**What types of cells have cholesterol?**

animal cells

(especially cold-blooded)

**What does cholesterol do in the cell membrane?**

↓ fluid at warm temps

↑ fluid at low temps