Chapter 4 – Membrane Structure & Function

Plasma membrane Structure & Function

What molecules make up the plasma membrane?

**Phopholipids, Glycolipids, Proteins, Glycoproteins, Cholesterol**

How are the phospholipids arranged to form the plasma membrane?

**As a bilayer**

What characteristics of the phospholipid allow this arrangement?

**Amphipathic** nature – possessing both **hydrophilic & hydrophobic** regions

![Phospholipid Bilayer](image)
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Proteins embedded in the membrane can either be **peripheral or integral**.

Peripheral proteins may either be on the **outside or inside surface** of the membrane; they do not span it.

Integral membrane proteins **span the width** of the plasma membrane coming in contact with both the cytoplasm & external environments.

Now that you see the plasma membrane, what kind of consistency do you think it possesses?

It’s **fluid**

Why do you think it’s called a mosaic?

Because it contains a diverse number of **proteins**
Chapter 4 – Membrane Structure & Function

Experiment to Demonstrate Lateral Drifting of Plasma Proteins
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Membrane proteins

We can see from the picture that membrane proteins can interact with the lipid bilayer.

The question is how can proteins interact with the bilayer given that it's made up of phospholipids (i.e. fats)
Chapter 4 – Membrane Structure & Function

Membrane proteins

Proteins can be **amphipathic** just like phospholipids
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Functions of membrane proteins

What could be a function of the integral membrane proteins?

What could be a function of peripheral proteins?
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Membrane Protein Diversity
— Channel Protein

Channel Protein

Allows a particular molecule or ion to cross the plasma membrane freely. Cystic fibrosis, an inherited disorder, is caused by faulty chloride (Cl-) channel; a thick mucus collects in airways and in pancreatic and liver ducts.
Membrane Protein Diversity — Carrier Protein

Carrier Protein

Selectively interacts with a specific molecule or ion so that it can cross the plasma membrane. The inability of some persons to use energy for sodium-potassium (Na\(^+\)-K\(^+\)) transport has been suggested as the cause of their obesity.
Membrane Protein Diversity — Cell Recognition Protein

Cell Recognition Protein

The MHC (major histocompatibility complex) glycoproteins are different for each person, so organ transplants are difficult to achieve. Cells with foreign MHC glycoproteins are attacked by blood cells responsible for immunity.
Membrane Protein Diversity — Receptor Protein

Receptor Protein

Is shaped in such a way that a specific molecule can bind to it. Pygmies are short, not because they do not produce enough growth hormone, but because their plasma membrane growth hormone receptors are faulty and cannot interact with growth hormone.
Membrane Protein Diversity — Cell Recognition Protein

Cell Recognition Protein

The MHC (major histocompatibility complex) glycoproteins are different for each person, so organ transplants are difficult to achieve. Cells with foreign MHC glycoproteins are attacked by blood cells responsible for immunity.
Membrane Protein Diversity — Enzymatic Protein

Enzymatic Protein

Catalyzes a specific reaction. The membrane protein, adenylate cyclase, is involved in ATP metabolism. Cholera bacteria release a toxin that interferes with the proper functioning of adenylate cyclase; sodium ions and water leave intestinal cells and the individual dies from severe diarrhea.
Cell to Cell Connections

Cell junctions are the points of contact between adjacent plasma membranes via membrane proteins.

**Tight** Form fluid tight seals between cells

**Anchoring** Fasten cells to one another or to the extracellular material

**Gap** Permit electrical or chemical signals to pass from cell to cell
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Junctions Between Cells of the Intestinal Wall – Tight Junctions

- Plasma membranes
- Tight junction proteins
- Intercellular space
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Junctions Between Cells of the Intestinal Wall – Gap Junction

- Plasma membranes
- Membrane channels
- Intercellular space
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Permeability of the Plasma Membrane

Do you think that the membrane is permeable to every molecule?

How does the membrane selectively allow molecules to cross it?

Well, the lipid bilayer is nothing more than a big hydrophobic barrier!

Based on this, what kind of molecules could easily cross and not cross?

**Non-polar or hydrophobic molecules** can cross

**Polar or hydrophilic molecules** can’t cross
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Permeability of the Plasma Membrane

Based on the picture then, why can water cross the lipid bilayer even though it’s a polar molecule!

**It’s small**

What other molecular characteristics could the membrane select for?

**SIZE!**

How then do these other molecules cross this hydrophobic barrier?

**Via protein carriers or vesicle formation**
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Membrane Transport Mechanisms

Why would we want molecules to cross the membrane?

Do you think that energy is needed to cross the membrane?

**YES!** But it exists in two forms: **passive & chemical energy**

What happens over time, when you place a drop of dye in a glass of water?

Eventually, the glass of water will have a **homogenous (consistent) red color**

Why does this happen?

Every element, ion, molecule, etc. has **inherent molecular motion** (passive energy) & they will **bump off** of each other, eventually spreading out evenly in their environment.

How fast the molecules spread out is dependent on how many molecules are in the given environment – **MORE** molecules = **MORE** bumping = **MORE** movement

This is quantified as the **concentration gradient** – if more molecules are in a given area versus another, a concentration gradient exists & the molecules will move from an area of **higher** concentration to an area of **lower** concentration.
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Simple Diffusion

Movement of molecules from a region of high concentration to an area of low concentration: does not require an input of chemical energy, a cell membrane, or transport/carrier proteins.
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Osmosis – Diffusion of Water across a semi-permeable (selectively permeable) membrane

Since it’s defined as the diffusion of water, what direction is water moving? Does it require an input of chemical energy? Does it require a transport/membrane protein?

Movement of water molecules or solvent molecules from a region of high water concentration to an area of low water concentration: does not require an input of chemical energy, does not require pores in the cell membrane

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[Diagram of Osmosis demonstration]
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Osmosis – Diffusion of Water across a semi-permeable (selectively permeable) membrane

The key point to this picture is the fact that the membrane is semi-permeable or selectively permeable.

What would happen if this membrane were permeable to the solute as well as water?

The solution would not rise in the thistle tube.

As the solute diffuses down its concentration gradient, the water’s concentration gradient is being reduced.

Eventually to zero – no NET movement of water can be occurring.
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Osmosis – Diffusion of Water across a semi-permeable membrane

As you can see water also has a concentration gradient to follow. This gradient is referred to as the osmotic pressure gradient – the pressure that develops in a system due to osmosis.

In this case, a solution with more dissolved solute (less water) has a higher osmotic pressure & will draw water from a solution with less dissolved solute (more water).

Simple terms to describe how water will move between two solutions separated by a membrane:

- **Isotonic** solutions – two solutions in which they possess the same amount of dissolved solute.
- **Hypotonic** solution – a solution containing less dissolved solutes than another solution.
- **Hypertonic** solution – a solution containing more dissolve solutes than another solution.

Given that solution A is a 25% glucose solution & solution B is a 30% glucose solution, use the above terms to describe their relationship.

If they were separated by a membrane that was only permeable to water which direction would the net flow of water be? A to B or B to A!
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Osmosis in animal and plant cells

Animal Cells
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Osmosis in animal and plant cells

Plant Cells
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Facilitated diffusion

Since part of its name is diffusion, what direction are the molecules moving? Does it require an input of chemical energy? What does the word facilitated mean to you?

Movement of molecules from a region of high concentration to an area of low concentration: does not require an input of chemical energy, but does require transport/carrier proteins in the cell membrane.
Chapter 4 – Membrane Structure & Function

Active Transport

Since the other transport mechanisms are classified as passive transport mechanisms, how do you think that active transport differs from them?

Movement of molecules from a region of low concentration to an area of high concentration: does require an input of energy, as well as transport/carrier proteins in the cell membrane.
Chapter 4 – Membrane Structure & Function

Endocytosis & exocytosis – movement of large molecules via vesicle formation

**Endocytosis**

Transport of *large molecules* into the cell due to the “engulfing” action of the cell membrane & the subsequent formation of a *membrane bound vesicle*

**Phagocytosis** - “cellular eating” of *solid* matter

**Pinocytosis** - “cellular drinking” of predominantly *extracellular fluid*

**Receptor-mediated endocytosis** - a specific pathway in which a molecule must bind to a *specific receptor* in the cell membrane to initiate an *endocytic* event. Once within the cell, the receptors & molecules separate with the receptors returning to the cell membrane, while the specific molecules are processed

**Exocytosis**

Reverse of endocytosis - secretory vesicles formed within the cell *fuse with the cell membrane*, emptying their contents into the *extracellular* environment
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Three methods of endocytosis

- Phagocytosis
Three methods of endocytosis

Pinocytosis
Three methods of endocytosis

- Receptor-mediated endocytosis
- vesicle
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Exocytosis

plasma membrane
vesicle
substance
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PRACTICE QUESTIONS

1. Define amphipathic

2. What are the functions of proteins embedded in the cell membrane?

3. What is the difference between an anchoring junction & a tight junction?

4. What are the similarities & differences between simple diffusion, osmosis, facilitated diffusion, & active transport