The Cell – Membrane Structure and Function

Biology In Focus Ch 5

Things to Know

- Why membranes are selectively permeable
- The role of phospholipids, proteins, and carbohydrates in membranes
- How water will move if a cell is placed in an isotonic, hypertonic, or hypotonic solution and be able to predict the effect of different environments on the organism
- How electrochemical gradients and proton gradients are formed and function in cells

Cellular membranes are fluid mosaics of lipids and proteins

- Plasma membrane is selectively permeable (allows some substances to cross more easily than others)
- Predominantly composed of phospholipids and proteins held together by weak interactions that cause the membrane to be fluid.

Cellular membranes are fluid mosaics of lipids and proteins

- Phospholipids provide a hydrophobic barrier that separates the cell from its liquid environment
  - Hydrophilic phosphate heads are oriented toward the aqueous inside and outside environments of cells
  - hydrophobic fatty acids face each other in a double layer (the bilayer) in the interior
- Hydrophilic molecules cannot easily enter the cell
- Hydrophobic molecules can enter much more easily

Cellular membranes are fluid mosaics of lipids and proteins

- There are proteins completely embedded in the membrane
  - Some span the entire width of the membrane
    - Serving as transport channels to move materials across the hydrophobic interior
    - Or, as molecular receptors to bind to signaling molecules **(ligands)**
    - Peripheral proteins are loosely bound to the membranes surface
      - Ex) G protein which can move along the membrane when a ligand binds a G-protein coupled receptor

Cellular membranes are fluid mosaics of lipids and proteins

- Carbohydrates on the membrane are crucial in cell-cell recognition (which is necessary for proper immune function) and in developing organisms (for tissue differentiation)
- Cell surface carbohydrates vary from tissue to tissue and are the reason that blood transfusions must be type-specific

Membrane structure results in selective permeability

- Nonpolar molecules are hydrophobic and can dissolve in the hydrophobic interior of the phospholipid bilayer and cross the membrane easily
  - Ex) hydrocarbons, carbon dioxide, and oxygen
- Hydrophobic core of the membrane impedes the passage of ions and polar molecules, which are hydrophilic
- Hydrophilic substances can avoid the phospholipid bilayer by passing through transport proteins that span the membrane

Membrane structure results in selective permeability

- Most important molecule to move across the membrane is water.
  - Water moves through special transport proteins called **aquaporins**
  - Aquaporins greatly accelerate the speed at which water can cross membranes (3 billion water molecules per aquaporin per second)

Passive transport is diffusion of a substance across a membrane with no energy investment

- A substance travels from where it is more concentrated to where it is less concentrated, diffusing down its **concentration gradient**
  - Hydrocarbons, CO_2, and O_2 are all hydrophobic substances that can pass easily across the cell membrane by passive transport
- Passive diffusion requires no work thus no energy. The cell expends no energy in moving the substances

Passive transport is diffusion of a substance across a membrane with no energy investment

- The diffusion of water across a selectively permeable membrane is osmosis.
- A cell has one of three water relationships with the environment around it
  - Isotonic
  - Hypertonic
  - hypotonic

Passive transport is diffusion of a substance across a membrane with no energy investment

- In an **isotonic solution**, there will be no net movement of water across the plasma membrane.
  - Water crosses the membrane but at the same rate in both directions

Passive transport is diffusion of a substance across a membrane with no energy investment

- In a **hypertonic solution**, the cell will lose water to its surroundings. Cell will shrivel and may die
  - Hyper means more solutes in the water around the cell hence the movement of water to the higher concentration of solutes.

Passive transport is diffusion of a substance across a membrane with no energy investment

- In a **hypotonic solution**, water will enter the cell faster than it can leave. Cell will swell and may burst.
  - Hypo means fewer solutes in the water around the cell hence the movement of water into the cell where solutes are more heavily concentrated.

Passive transport is diffusion of a substance across a membrane with no energy investment

- Be sure to watch the wording. Is the cell hypertonic to the solution it is placed in, or is the surrounding solution hypertonic to the cell?
  - In the first example, water moves into the cell.
  - In the second example, water moves out of the cell

- *Remember – water moves from a hypotonic solution to a hypertonic solution. Hypo → Hyper*

Passive transport is diffusion of a substance across a membrane with no energy investment

- Ions and polar molecules cannot pass easily across the membrane
- The process by which ions and hydrophilic substances diffuse across the cell membrane with the help of transport proteins is called **facilitated diffusion**
- Transport proteins are specific (like enzymes) for the substances they transport and work in 1 of 2 ways
  - Provide a hydrophilic channel through which the molecules in question can pass
  - They bind loosely to the molecules in question and carry them through the membrane

Active transport uses energy to move solutes against their gradients

- In active transport, substances are moved against their concentration gradient (from the region that is less concentrated to the area that is more concentrated)
- This type of transport requires energy, usually in the form of ATP
- Common example is the sodium-potassium pump
  - Transmembrane protein pumps sodium out of the cell and potassium into the cell
  - Sodium-potassium pump is necessary for proper nerve transmission and is a major energy consumer in your body

Active transport uses energy to move solutes against their gradients

- The inside of the cell is negatively charged compared with the outside of the cell
- The difference in electric charge across a membrane is expressed in voltage and termed membrane potential
  - Because the inside of the cell is negatively charged, a positively charged ion on the outside, like sodium, is attracted to the negative charges inside the cell. Thus the two forces drive the diffusion of ions across a membrane
    - A chemical force which is the ions concentration gradient
    - A voltage gradient across the membrane, which attracts positively charged ions and repeals negatively charged ions
- The combination of forces acting on an ion forms an electrochemical gradient.

Bulk transport across the plasma membrane occurs by exocytosis and endocytosis

- Large molecules are moved across the cell membrane through exocytosis and endocytosis
  - In **exocytosis**, vesicles from the cell's interior fuse with the cell membrane expelling their contents
  - In **endocytosis**, the cell forms new vesicles from the plasma membrane
    - Basically the reverse of exocytosis
    - Allows the cell to take in macromolecules
      - Ex) engulfing of foreign particles by white blood cells