Chapter 5 (A Closer Look at the Plasma Membrane)

It Isn't Easy Being Single

A. Because the concentration of ions and other substances outside a cell may rapidly become too high or low, a mechanism is needed to selectively permit substances to enter or leave the cell.

B. The plasma membrane–a surface of lipids, proteins, and some carbohydrate groups–regulates exchange of materials between cytoplasm and surroundings.

C. Within the cytoplasm, exchanges are made across internal membranes of the organelles.

I. Membrane Structure and Function

A. The Lipid Bilayer of Cell Membranes

1. The "fluid" portion of the cell membrane is made of phospholipids.

a. A phospholipid molecule is composed of a hydrophilic head and two hydrophobic tails.

b. If phospholipid molecules are surrounded by water, their hydrophobic fatty acid tails cluster and a bilayer results; hydrophilic heads are at the outer faces of a two-layer sheet.

2. Bilayers of phospholipids are the structural foundation for all cell membranes.

B. Fluid Mosaic Model of Membrane Structure

1. Cell membranes are of mixed composition including the following:

a. Phospholipids differ in their hydrophilic heads and the length and saturation of their fatty acid tails.

b. Glycolipids have sugar monomers attached at the head end.

c. Cholesterol is abundant in animal membranes; phytosterols occur in plants.

2. Within a bilayer, phospholipids show quite a bit of movement; they diffuse sideways, spin, flex their tails to prevent close packing and promote fluidity,

which also results from short-tailed lipids and unsaturated tails (kink at double bonds).

3. The arrangement of molecules on one side of the membrane differs from that on the other side (asymmetrical).

C. Overview of Membrane Proteins

1. Transport proteins allow water-soluble substances to move through their interior, which opens on both sides of the bilayer.

2. Receptor proteins have binding sites for hormones (and like substances) that can trigger changes in cell action, as in growth processes.

3. Recognition proteins identify the cell as a certain type, help guide cells into becoming issues, and function in cell-to-cell recognition and coordination.

4. Adhesion proteins are glycoproteins that help cells stay connected to one another in a tissue.

II. Focus on Science: Testing Ideas About Cell Membranes

III. Crossing Selectively Permeable Membranes

A. All cell membranes show selective permeability, that is, some substances can cross, others cannot.

1. Gases and small electrically-neutral molecules can readily cross the lipid bilayer.

2. Glucose and other large, polar molecules cannot pass through the bilayer directly but must rely on passage through the interior of transport proteins.

B. Concentration Gradients and Diffusion

1. Concentration refers to the number of molecules (or ions) of a substance in a given volume of fluid.

a. Molecules constantly collide and tend to move down a concentration gradient (high to low).

b. The net movement of like molecules down a concentration gradient is called diffusion; each substance diffuses independently of other substances present as illustrated by dye molecules in water

2. Several factors influence the rate and direction of diffusion.

a. The rate of diffusion depends on concentration differences, temperature (higher = faster), molecular size (smaller = faster), electric gradients (a difference in charge), and pressure gradients .

b. When gradients no longer exist, there is no net movement (dynamic equilibrium).

C. Overview of Membarne Crossing Mechanisms

1. In passive transport, material passes through the interior of transport proteins without an energy boost; this is also known as "facilitated" diffusion.

2. In active transport, proteins become activated to move a solute against its concentration gradient.

3. Substances move in bulk across the cell membrane by exocytosis and endocytosis.

IV. Protein-Mediated Transport

A. When water-soluble molecules bind to transport proteins, they trigger changes in shape that "ease" the solute through the protein and hence through the membrane.

B. Passive Transport

1. A carrier protein that functions in passive transport (also called "facilitated diffusion") tends to move molecules to the side of the membrane where they are less concentrated.

2. Passive transport will continue until solute concentrations are equal on both sides of the membrane or other factors intervene.

C. Active Transport

1. To move ions and large molecules across a membrane against a concentration gradient, special proteins are induced to change shape (in a series), but only with an energy boost from ATP.

2. An example of active transport is the sodium-potassium pump of the neuron membrane, and the calcium pump of most cells.

V. Movement of Water Across Membranes

A. Osmosis

1. Bulk flow is the tendency of different substances in a fluid to move together in the same direction due to a pressure gradient (as in animal circulatory systems).

2. Osmosis is the passive movement of water across a differentially permeable membrane in response to solute concentration gradients, pressure gradients, or both.

3. For example, if a bag containing a sugar solution is placed in pure water, the water will diffuse inward (higher to lower).

B. Effects of Tonicity

1. Tonicity denotes the relative concentration of solutes in two fluids–extracellular fluid and cytoplasmic fluid, for example.

2. Three conditions are possible:

a. An isotonic fluid has the same concentration of solutes as the fluid in the cell; immersion in it causes no net movement of water.

b. A hypotonic fluid has a lower concentration of solutes than the fluid in the cell; cells immersed in it may swell.

c. A hypertonic fluid has a greater concentration of solutes than the fluid in the cell; cells in it may shrivel.

3. Cells either are dependent on relatively constant (isotonic) environments or are adapted to hypotonic and hypertonic ones.

C. Effects of Fluid Pressure

1. Hydrostatic pressure is a force directed against a membrane by a fluid; the greater the solute concentration, the greater will be the hydrostatic pressure it exerts.

2. This force is countered by osmotic pressure, which prevents any further increase in the volume of the solution.

3. When plants lose water, there is a shrinkage of the cytoplasm called plasmolysis.

VI. Bulk Transport Across Membranes

A. Exocytosis and Endocytosis

1. In exocytosis, a cytoplasmic vesicle moves substances from cytoplasm to plasma membrane where the membranes of the vesicle and cell fuse.

2. Endocytosis encloses particles in small portions of plasma membrane to form vesicles that then move into the cytoplasm.

a. In receptor-mediated endocytosis, specific molecules are brought into the cell by specialized regions of the plasma membranes that form coated pits which sink into the cytoplasm.

b. In bulk-phase endocytosis, a vesicle forms around a small volume of extracellular fluid without regard to what substances might be dissolved in it.

c. Phagocytosis, is an active form of endocytosis by which a cell engulfs microorganisms, particles, or other debris; this is seen in protistans and white blood cells.

B. Membrane Cycling

1. Even as exocytosis and endocytosis disrupt the plasma membrane, the rates are such that the plasma membrane is continually replaced.

2. For example in neurotransmitter release, an episode of exocytosis was immediately followed by counterbalancing endocytosis.