Membrane Structure and Function
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Any plasma membrane has as its infrastructure a phospholipid bilayer arranged with the hydrophobic tails of one layer meeting the tails of the other layer, and the hydrophilic heads of each layer facing the watery surface either inside or outside the cell.

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A complete plasma membrane has various particles embedded in the phospholipid bilayer. Among these other particles are various kinds of proteins. A protein is not covalently bonded to the phospholipids; rather it remains part of the membrane, because hydrophobic parts of the protein easily remain next to the hydrophobic tails of the phospholipids while avoiding the hydrophilic heads.

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Freeze-fracturing of a plasma membrane shows that the majority of a membrane's proteins are associated with the inner phospholipid layer.

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The plasma membrane is a highly dynamic structure that not only changes its composition but whose components are continuously moving. This is described by the fluid mosaic model of membrane structure. Phospholipids in the membrane are not covalently bonded to each other, so they are free to change positions, like people within a crowd. The fluidity of the membrane can be adjusted by changing the relative abundance of phospholipids having unsaturated tails or (in animals) by increasing or decreasing the amount of cholesterol in the membrane.

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Dramatic evidence for the fluid mosaic nature of plasma membranes is seen in the results of an experiment in which a human cell and a mouse cell were fused into a single cell. At first, the fused cell was polarized, with human proteins on one side of the cell and mouse proteins on the other. Later, the two types of proteins are found dispersed throughout the entire membrane, indicating that the proteins and phospholipids are changing positions.

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Proteins are found within the cell (including as part of the cytoskeleton), outside the cell (as part of the extracellular matrix), and within the membrane (as membrane-bound proteins). Membrane-bound proteins come in two varieties:

- Peripheral proteins are connected to only one of the two layers of phospholipids.
- Integral proteins are associated with both layers of phospholipids. Integral proteins that extend through the entire thickness of the membrane are called transmembrane proteins.

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A transmembrane protein is built with a hydrophobic portion that stays next to phospholipid tails and hydrophilic portions that stay next to the phospholipid heads. Some transmembrane proteins feature a hollow center, allowing them to function as channels.

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Membrane-bound proteins perform six classes of functions:

- Transport proteins allow certain particles to pass through the membrane to either enter or exit the cell.
- Enzymatic proteins function as catalysts.
- Signal-transduction proteins operate as receptors for signals that are not able to pass through the membrane (e.g., protein hormones). These signals bind to the signal-transduction protein, and the shape of that protein is changed, including the part of the protein that is in contact with the cell's interior. Therefore, the binding of the signal outside of the cell can cause a change within the cell.
- Some membrane-bound glycoproteins function in cell-cell recognition, allowing one cell of a multicellular organism to recognize another cell as being part of the same organism.
- Some membrane-bound proteins in adjacent cells can form bonds, keeping the two cells connected to each other.
- Some membrane-bound proteins can form structural connections with proteins of the cytoskeleton, proteins of the extracellular matrix, or both.

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Part of the dynamism of the plasma membrane is explained by the fact that pieces of membrane are continuously being moved from organelle to organelle (including the plasma membrane), primarily through the pinching off of vesicles from organelles and the fusion of those vesicles with other organelles.

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Transmembrane transport is movement of particles through a plasma membrane (either into or out of the cell). Transport mechanisms can be classified as either passive (requiring no input of additional energy) or active (requiring additional energy). Diffusion is a passive transport process. A concentration gradient is a difference in concentration that exists between two spaces. If a concentration gradient exists for a type of particle (and if there is nothing impeding the movement of that type of particle), then diffusion will move the particles from the space having a higher concentration to the space having the lower concentration. Diffusion can occur whether or not a membrane occurs between the two spaces, as long as any such membrane is permeable to that type of particle. As diffusion proceeds, the gradient is diminished, and eventually equilibrium will be attained. At equilibrium, there is still movement of particles, but there is no longer any net diffusion, because movement of particles occurs in both directions at equal rates. When multiple types of solutes are present, the diffusion of each type will depend only on its own gradient.

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Osmosis is a special case of diffusion. Specifically, osmosis is the diffusion of solvent (rather than solute) particles through a selectively permeable membrane that allows that solvent through but blocks the solutes from passing through. The solvent (which is water for biological systems) osmoses down its own gradient. Since a space with a high solute concentration is less watery, and a space with a low solute concentration is more watery, osmosis will move water from the space with low solute concentration to the space with high solute concentration. In other words, water will move to where it is less watery.

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Tonicity is a property of a solution, and it refers to the tendency for osmosis to occur when a cell is surrounded by that solution. There are three classes of tonicity. Each of these terms should be used to describe the solution surrounding the cell; they should not be used to describe the cell.

- A hypotonic solution is one that has an overall solute concentration that is lower than the overall solute concentration of the cell's contents. An animal cell in a hypotonic medium will take on water via osmosis, causing the cell to swell. In extreme conditions, the cell will burst. This is called lysis. A plant cell in a hypotonic medium will also take on water via osmosis, but the cell wall of the plant cell will withstand the pressure and remain turgid.
- An isotonic solution is one that has an overall solute concentration that is equal to the overall solute concentration of the cell's contents (though the types of solutes outside the cell might be different from the types inside the cell). There will therefore be no net osmosis, because there is no gradient. This is the ideal condition for an animal cell, but a plant cell is flaccid in an isotonic medium, which is not as healthy for the plant cell as being turgid.
- A hypertonic solution is one that has an overall solute concentration that is higher than the overall solute concentration of the cell's contents. A cell in a hypertonic medium will lose water via osmosis. For an animal cell, this causes shrinkage, called crenation. For a plant cell, this causes peeling of the plasma membrane away from the interior surface of the cell wall. This is called plasmolysis.

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An aquatic protist lives in a hypotonic environment, which means that osmosis continuously moves water into the cell. Since the cell has no cell wall to withstand the pressure, the cell faces lysis. An aquatic protist has a contractile vacuole that gradually fills with water until stretching causes it to contract, pumping the water back out to the surroundings.

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Any particle that is either too large or too polar (or both) to be able to pass directly through the phospholipid bilayer requires the help of a membrane-bound transport protein to get through the membrane. There are two classes of transport proteins:

- A channel protein features a hollow core and functions as a tiny tunnel through with particles of the correct type can pass by diffusion. The direction of transport (into or out of the cell) depends on the direction of the gradient for that type of particle. This diffusion (as for all diffusion) is passive, but because it requires a transport protein, it is called facilitated diffusion.
- A carrier protein is a transport protein that operates by changing its conformation. A specific type of particle is able to bind to the protein on one side of the membrane, and the resulting conformational change moves the particle through the membrane to the other side. A carrier protein can operate either passively (for facilitated diffusion) or for active transport (as long as energy is supplied).

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A carrier protein that operates for active transport is called a pump. Pumps (active transporters) move particles against the gradient, taking them from where they are already at low concentration and putting them where they are already at high concentration. This requires input of additional energy, often in the form of ATP. The sodium-potassium exchange pump actively transports sodium ions out of a cell (against the gradient) and potassium ions into the cell (against the gradient).

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Passive transmembrane transport includes simple diffusion of small, nonpolar particles directly through the phospholipid bilayer, facilitated diffusion using a channel protein, and facilitated diffusion using a carrier protein. Active transport requires a carrier protein and a source of additional energy.

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In primary active transport (usually just called active transport), energy in the form of ATP or a similar molecule is used to cause a carrier protein to bind to a particle and drag it against its gradient, through the membrane. This stockpiles that type of particle on one side of the membrane and makes the gradient steeper.

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Secondary active transport requires two different carrier proteins. The first carrier protein operates by primary active transport (and directly uses the ATP) to create a gradient for one type of particle (like the hydrogen ions in this example). A gradient is itself a source of energy, so the energy of the gradient can be used to actively transport a second kind of particle (like the sucrose in this example). The hydrogen ions will diffuse back into the cell (down their gradient), as long as they are able to get through the membrane. But because they are ions, they can't pass directly through the phospholipid bilayer. They diffuse back into the cell with the help of the second carrier protein, but when the hydrogen ions diffuse, the conformational change of the carrier protein drags sucrose along for the ride (against sucrose's gradient).

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Particles that cannot be transported through the membrane via either passive or active transport can be moved into or out of a cell via vesicular transport (i.e., transport via a vesicle). There are two primary classes of vesicular transport:

- Exocytosis is vesicular transport that moves particles out of the cell.
- Endocytosis is vesicular transport that moves particles into the cell. Endocytosis can be classified as either phagocytosis (inward movement of solid particles) or pinocytosis (inward movement of liquid particles).