

Cell membranes and transport

Membranes and passive transport

The membrane is selectively permeable

A cell membrane separates the cell's interior from its surroundings. Its phospholipid bilayer has water-attracting heads facing the watery environments and water-repelling tails facing inward. Small nonpolar molecules such as oxygen can cross the bilayer relatively easily. Ions and many polar molecules need membrane transport proteins. Selectively permeable means that some substances cross more readily than others; it does not mean the membrane is a completely sealed wall.

Diffusion follows a gradient

Diffusion is the net movement of particles from a region of higher concentration to a region of lower concentration because of random molecular motion. At equilibrium, molecules still move, but there is no net movement in either direction. Simple diffusion crosses the lipid bilayer directly. Facilitated diffusion uses a channel or carrier protein. Both are passive transport: movement down the relevant concentration or electrochemical gradient does not require a direct input of cellular energy. A protein's involvement alone does not make transport active.

Osmosis is the movement of water

Osmosis is the net movement of water across a selectively permeable membrane. In a simple system where the solute cannot cross, water moves toward the side with the higher concentration of that solute. Suppose a membrane separates a dilute sugar solution from a more concentrated sugar solution, and only water can cross. Water moves toward the more concentrated sugar solution. Aquaporin channels can speed water movement; they do not pump water using ATP.

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Active transport and applying the ideas

Active transport requires energy

Active transport can move a substance against its concentration or electrochemical gradient. Primary active transport couples this movement directly to an energy source such as ATP hydrolysis. For example, the sodium-potassium pump uses ATP to move three sodium ions out of a cell and two potassium ions into it per cycle. Secondary active transport uses energy stored in another substance's gradient. In a sodium-glucose cotransporter, sodium moving down its gradient can drive glucose movement against its gradient. The cotransporter does not directly hydrolyze ATP, but maintaining the sodium gradient depends on energy-consuming processes.

Compare the transport mechanisms

Simple diffusion: oxygen crosses the lipid bilayer down its concentration gradient. Facilitated diffusion: a carrier moves glucose down its gradient without a direct energy input. Osmosis: water crosses a selectively permeable membrane toward a higher concentration of nonpenetrating solute. Primary active transport: the sodium-potassium pump directly uses ATP. Secondary active transport: one substance moving down its gradient drives another substance uphill. To classify a mechanism, ask what moves, which way it moves relative to its gradient, and where any required energy comes from.

Check your understanding

A channel allows an ion to move down its electrochemical gradient. This is facilitated diffusion, even though a protein is involved. If ATP production stops, existing gradients do not disappear instantly: some passive transport may continue while gradients last, but ATP-dependent pumping cannot be sustained. A sugar solution example predicts net water movement only when the membrane's permeability is known. Always distinguish particle movement from net movement, and distinguish a protein's presence from an energy requirement.