

Cell Biology: Diffusion & Osmosis

AI-Generated Study Guide

(Based on [lectures delivered by Dr. Ty C.M. Hoffman](#))

I. Categories of Transport Processes

Cells utilize transport processes to move substances into or out of themselves. There are three major categories of transport:

1. Active Transport.
2. Passive Transport.
3. Vesicular Transport (which uses vesicles).

II. Active vs. Passive Transport

Active and passive transport are primarily distinguished based on their energy requirements.

A. Energy Requirements

- Energy is always required for movement. It is not true that passive transport requires no energy at all.
- **Passive Transport:** Does not require **additional** energy because the energy needed for movement is already **built into the system**.
- **Active Transport:** Requires **additional energy** to happen; otherwise, it will never occur.

B. The Role of the Gradient

- A **gradient** is defined generally as a difference in measurements at two different places.
- The gradient itself is the source of potential energy that drives passive transport.
- Examples of Gradients: Pressure gradient, voltage (a gradient of electrical potential energy).
- **Concentration Gradient:** The gradient relevant to cellular transport, involving differences in the concentration of solutes and solvents (water).
- If the concentration is the same at two points, the gradient is zero, and passive transport will cease.

III. Passive Transport and Diffusion

Passive transport is fundamentally based on diffusion.

A. Diffusion Mechanism

- Passive transport is based on random movement in all directions, known as **Brownian motion**.
- The net effect of this random movement is a directional movement: particles move **down the gradient** from an area of higher concentration to an area of lower concentration.
- Diffusion continues until the concentration gradient is eliminated (zero).

B. Diffusion of Solutes and Solvents

- In a simple solution (without a membrane), solutes (e.g., sugar) and solvents (e.g., water) diffuse **independently** down their own concentration gradients simultaneously.
- The solute moves from high solute concentration to low solute concentration.
- The solvent (water) moves from high water concentration to low water concentration.

C. Diffusion Through a Selectively Permeable Membrane (SPM)

- A **selectively permeable membrane** is a barrier that allows certain substances (permeable) to pass through but not others (impermeable).
- Two requirements must be met for diffusion through an SPM:
 1. A gradient must be in place (the tendency).
 2. The particle must have a way to pass through the membrane (permeability).
- If multiple permeable solutes are present, they diffuse **independently** down their own gradients.

IV. Osmosis: A Special Case of Diffusion

Osmosis is a special case of diffusion; all osmosis is diffusion, but not all diffusion is osmosis.

A. Requirements for Osmosis

For a diffusion process to be called osmosis, two conditions must be met:

1. The moving particle must be the **solvent** (water in biological systems).
2. Movement must occur through a **selectively permeable membrane**.

B. Direction and Driving Force

- Water moves **down its own concentration gradient**, from where the water concentration is high to where it is low.
- This is often described as movement from a place of **low solute concentration** to a place of **high solute concentration**.
- **Total Solute Concentration:** Only the water's concentration gradient matters. Measuring the total solute concentration is an indirect way of measuring the water concentration.

C. Osmotic Equilibrium

- Osmosis will stop (reach equilibrium) if the water concentration becomes equal on both sides (zero gradient).
- Equilibrium can also be reached when the force driving osmosis (osmotic pressure) is exactly balanced by an opposing force, such as gravity (in a U-tube setup).

V. Tonicity and Cell Environments

Tonicity refers to the tendency for osmosis to occur across a cell membrane. Tonicity terms must **only be used to describe the cell's surroundings or environment**, never the cell itself.

Tonicity Term	Environment Characteristics	Net Water Movement	Effects on Cells
Hypotonic (Hypo = Below)	Lower solute concentration; it is more watery than the cell.	Water moves into the cell.	• Animal Cells: Swell, may burst (Lysis). • Plant Cells: Swell, pressurized (Turgid); this is the ideal condition.

Hypertonic (Hyper = Above)	Higher solute concentration; it is less watery than the cell.	Water moves out of the cell.	• Animal Cells: Shivel (Crenation). • Plant Cells: Plasma membrane collapses away from the wall (Plasmolysis/Plasmolyzed); fatal.
Isotonic (Iso = Same)	Equal concentration; wateriness is the same.	Water enters and leaves at the same rate; no net volume change.	• Animal Cells: This is the ideal condition. • Plant Cells: Limp state (Flaccid); survivable but not ideal.