01 / LEARN THE METHOD

Osmosis Prediction Lab

Permeable solutes and cell-volume reasoning

For biology and anatomy/physiology foundations. These are simplified model-cell exercises, not clinical fluid-selection instructions. Assume a large external reservoir, water permeability, and no solute transport unless stated.

Keep these distinctions clear

1. Osmolarity counts dissolved particles. Tonicity predicts sustained cell-volume change and depends on solutes that effectively cannot cross the membrane under the stated conditions.

2. If only water crosses, a cell swells in a hypotonic external solution and shrinks in a hypertonic one. Equal effective nonpenetrating-solute concentrations give no sustained volume change.

3. An iso-osmotic solution need not be isotonic if its solute enters the cell. Always identify permeability and the time scale before predicting volume.

4. For a conserved intracellular nonpenetrating solute in a flexible model cell, use $C_{initial} * V_{initial} = C_{final} * V_{final}$. Ignore pressure effects and rupture only when a question explicitly allows it.

Worked example: concentration and final volume

A model cell initially has volume 1.0 unit and 300 mOsm/L nonpenetrating solute. Outside is a large 200 mOsm/L nonpenetrating-solute reservoir.

Only water crosses, and the cell is allowed to expand without rupture. At equilibrium the internal concentration approaches 200 mOsm/L.

$300 * 1.0 = 200 * V_{final}$, so $V_{final} = 1.5$ units: a 50% increase.

The equation conserves internal solute amount. It does not imply that water creates new solute.

02 / TRY IT WITHOUT THE KEY

Practice set

Write the reasoning, not only the answer.

1. A cell contains 300 mOsm/L nonpenetrating solute; outside is 450 mOsm/L nonpenetrating solute. Predict water movement and volume change.

2. Repeat with 150 mOsm/L outside. Describe the direction without assuming the cell cannot rupture.

3. Both sides contain 300 mOsm/L nonpenetrating solute. Is water motion absent, or only net motion absent?

4. A cell contains 300 mOsm/L nonpenetrating solute; outside initially contains 300 mOsm/L urea that can enter the cell. Explain why equal osmolarity does not guarantee stable volume.

5. A flexible model cell starts at volume 2.0 units and 300 mOsm/L. Only water crosses; the outside is 400 mOsm/L nonpenetrating solute. Find final volume, ignoring pressure effects.

6. A model tissue sample changes from 8.0 g to 9.2 g. Calculate percentage mass change relative to its initial mass.

7. A graph of percentage mass change versus external sucrose concentration crosses zero near 0.28 mol/L. What does this estimate tell you, and what assumption is needed?

8. A student says facilitated diffusion requires ATP because it uses a membrane protein. Correct this claim and distinguish it from primary active transport.

03 / CHECK AND CORRECT

Answers with reasoning

1. Net water leaves the cell; it shrinks. The outside is hypertonic under the specified permeability assumptions.

2. Net water enters and the cell swells. A real cell may rupture if it cannot tolerate the expansion; the question does not guarantee a safe final volume.

3. Water molecules still move in both directions. At equilibrium there is no net movement caused by an osmotic imbalance.

4. Urea can enter, changing the distribution over time; it is not a sustained extracellular nonpenetrating solute. The model predicts swelling rather than stable volume. The short-term direction depends on relative water and urea transport rates.

5. 300 * 2.0 = 400 * V_final gives 1.5 volume units, a 25% decrease.

6. 100 * (9.2 - 8.0)/8.0 = +15%. Use the initial, not final, mass as the denominator.

7. It estimates the external concentration giving no net mass change in that experimental system. Interpreting it as isotonic requires sucrose to be effectively nonpenetrating and other mass-changing processes to be negligible.

8. Facilitated diffusion moves solute down its electrochemical gradient without direct ATP use. Primary active transport directly couples an energy source such as ATP hydrolysis to transport against a gradient.

Reference reading

OpenStax Anatomy and Physiology 2e, The Cell Membrane

OpenStax Biology 2e, Passive Transport

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