Contents

LESSON 2

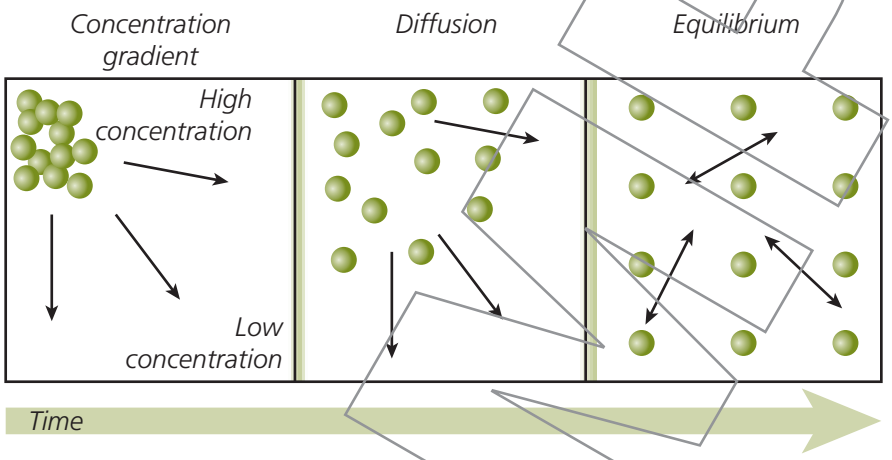
Passive Transport

BIO.A.4.1.2

The plasma membrane is an area of constant movement as molecules are shuttled back and forth in a variety of ways. Without this movement of molecules, wastes would build up inside the cell and needed materials would not enter it. The movement of substances may be driven by differences in their **concentration** inside and outside the cell.

Concentration Gradient

When a dissolved substance is more concentrated in one area than in an adjacent area, it forms a **concentration gradient**. For example, in the diagram below, there is more dissolved solute at one corner of the solvent, and far less everywhere else. Notice how the concentration changes over time.



Diffusion moves a dissolved substance *down* its concentration gradient.

Molecules and ions in a solution are constantly in motion. Because of this, they will naturally move from the more-concentrated region to the less-concentrated regions. This movement "down" the concentration gradient is called **diffusion.** Diffusion does not require any energy *input* to occur. It happens whenever a concentration gradient exists.

Eventually, enough of the substance will have diffused that its concentration is equal everywhere throughout the solution. It has reached a state of *equilibrium*. Even though molecules may move in any direction, there is no overall movement in any single direction.

In addition to the plasma membrane, cell membranes surround the organelles of eukaryotic cells and make up most of the ER and Golgi apparatus. Transport processes are therefore important within the cell.

Concentration refers to the amount of a substance (a solute) dissolved in a given volume of water or other solvent.

A **concentration gradient** is a gradual difference in the concentration of a substance in a solution as a function of distance.

Because the particles that make up a substance have energy, they are always in motion.

Diffusion is the movement of molecules or ions *down* a concentration gradient. It stops when *equilibrium* is reached.

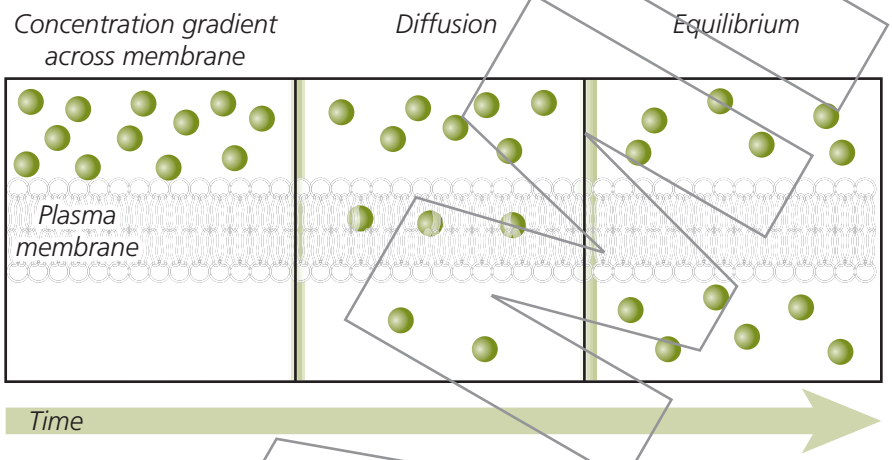
Glucose is added to water and the solution is stirred until the glucose is evenly distributed throughout. Will diffusion occur within the solution? Explain.

Diffusion will not occur in the solution once its concentration is equal throughout. Diffusion requires a concentration gradient to occur.

Passive Transport

What happens when a concentration gradient occurs across a cell membrane? If the membrane is permeable to the substance, the substance will move across the membrane, toward the side of lower concentration, due to simple diffusion. Recall that diffusion requires no energy input, and that the net movement of particles stops once equilibrium is reached.

Any type of cellular transport that does not require some form of energy input is called **passive transport.** There are several types of passive transport. Diffusion across a membrane is the simplest type. Small, nonpolar molecules cross the phospholipid bilayer most easily, slipping between the phospholipids and crossing into or out of the cell.



Diffusion *down* a concentration gradient can cause a substance to cross a plasma membrane. Diffusion is a form of passive transport.

However, the plasma membrane is impermeable to certain substances. Recall that large molecules, charged ions, and polar molecules do not readily cross the phospholipid bilayer. In this case, membrane **transport proteins** can provide a way for the substance to enter or exit the cell. This type of transport is called **facilitated diffusion** because it is facilitated, or helped, by proteins. Even though they are helping move molecules that normally would not be able to move across the cellular membrane, they are still using no ATP (energy). Therefore, facilitated diffusion is a form of passive transport.

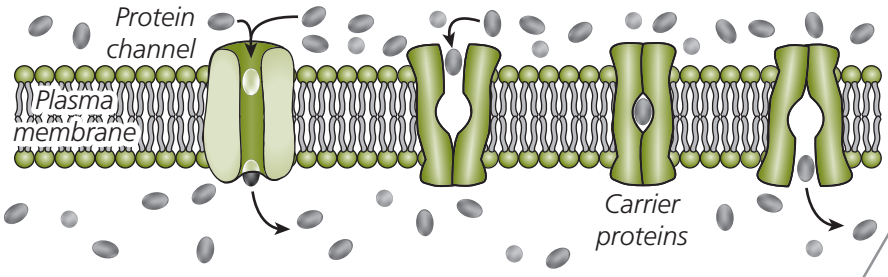
Passive transport is the movement of a substance across the plasma membrane without any input of energy.

Simple **diffusion** and **facilitated diffusion** are both types of passive transport.

Small, nonpolar molecules, such as oxygen and carbon dioxide, can easily pass between the phospholipids of plasma membranes. Ions and large or polar molecules are repelled by the nonpolar phospholipid tails, and do not cross as easily.

A **transport protein** is a protein built into the plasma membrane that helps certain kinds of molecules or ions pass through.

Facilitated diffusion relies on membrane proteins to help molecules cross a cell membrane.



Facilitated diffusion uses transport proteins to move a substance *down* its concentration gradient.

Transport proteins include *protein channels* and *carrier proteins.* Many transport proteins are so specific that they help move only a single type of molecule across the membrane.

Channel proteins, with their tubelike openings, allow specific substances to enter or exit freely. Aquaporins are protein channels through which water molecules enter and exit the cell. *Carrier proteins* bind to molecules or ions and carry them to the other side of the membrane. Glucose, for example, needs the help of a transport protein to enter cells. Without this transport protein, your cells would not receive enough glucose to power cellular respiration.

Which is **not** an example of passive transport?

A Carbon dioxide in a capillary crosses the alveoli membranes of the lungs.

B Oxygen dissolved in the blood crosses the phospholipid portion of the membrane of a red blood cell.

C Glucose molecules are transported by a carrier protein until its concentration on both sides of the membrane is equal.

D Sodium ions move through a protein channel until there is a higher concentration in extracellular fluid than the cytoplasm.

Choices A and B describe simple diffusion through membranes; this is a form of passive transport. Choice C describes facilitated transport, which occurs until equilibrium is reached. Choice D describes the transport of sodium *against* its concentration gradient. This requires energy and is therefore not a form of passive transport.

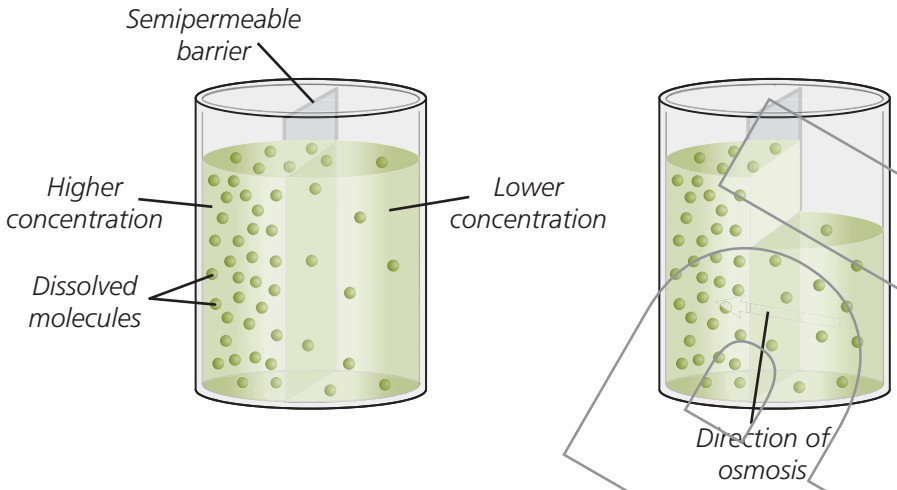
Osmosis

Diffusion involves the movement of molecules or ions that are dissolved in water. However, the movement of water itself is so important in biology that it is given its own term: osmosis. **Osmosis** refers to the movement of water from areas of higher *water* concentration to areas of lower *water* concentration. The concentration of water is high wherever the concentration of dissolved substances is low. So, the direction of osmosis is usually opposite the direction of diffusion.

Osmosis refers to the movement of water from where dissolved substances are *less* concentrated to where they are *more* concentrated. The identity of the solute does not matter.

Osmosis is a form of passive transport. It requires no energy.

Because a plasma membrane may be impermeable to some solutes, osmosis can change the volume of fluid inside a cell. Consider the semipermeable membrane in the diagram below. Water can move across it, but the solute cannot. Water will move from the side with the *lower solute* concentration to the side with the *higher solute* concentration. This net movement of water down *its own* concentration gradient results in unequal volumes in the two halves of the beaker. Equilibrium is reached when the solute concentration is equal on both sides of the membrane.



In osmosis, water moves from an area of higher *water* concentration (the right side of the beaker) to an area of *lower* water concentration (the left side of the beaker).

The fluids inside and outside of a cell can be compared in terms of solute concentration. The terms *hypotonic*, *isotonic*, and *hypertonic* refer to extracellular fluid that is less, equal, and more concentrated than the cell's interior (cytoplasm). For example, fresh water is hypotonic to cells' cytoplasm, while the extremely salty water of Utah's Great Salt Lake is hypertonic to most cells. Due to osmosis, hypotonic and hypertonic fluids can result in changes to a cell's volume.

A *solute* is a dissolved substance. In osmosis, water "follows" the solute.

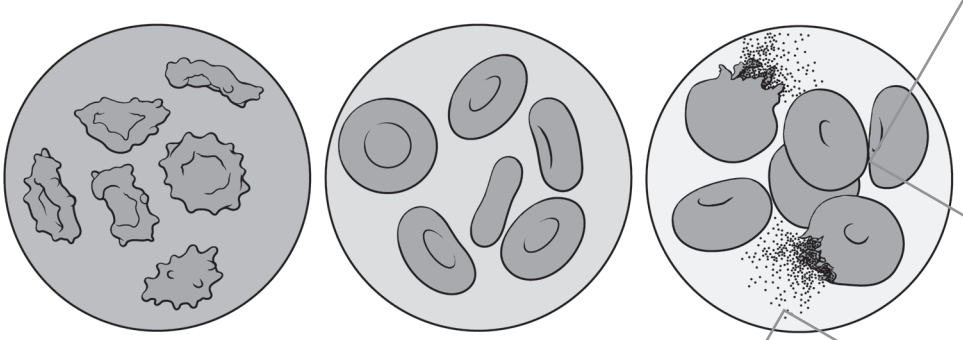
Osmosis can result in changes in volume.

A *hypotonic* fluid has a lower concentration of dissolved substances than a cell's interior. An *isotonic* fluid has an equal concentration. A *hypertonic* fluid has a greater concentration.

The cell walls of plant cells allow them to survive in a hypotonic freshwater environment.

Microbes that live in the Great Salt Lake maintain water balance by maintaining high solute concentrations in the cytoplasm.

The diagram shows changes to red blood cells placed in solutions of varying concentrations. Identify the solutions as hypotonic, isotonic, or hypertonic to the cells. Explain your responses.



The cells in image A are in a hypertonic solution. Water moves where the solute concentration is higher, that is, out of the cytoplasm and into the extracellular fluid. The cells in image B are in an isotonic solution. They are healthy red blood cells because the solute is equal inside and outside the cell. The cells in image C are in a hypotonic solution. Water moves where the solute concentration is higher, from the extracellular fluid and into the cytoplasm. This causes some of the cells to burst.

IT'S YOUR TURN

Please read each question carefully. For a multiple-choice question, circle the letter of the correct response. For a constructed-response question, write your answers on the lines.

1 Which of the following is **not** involved in the transport of molecules by facilitated diffusion?

A ATP

B phospholipids

C protein channels

D concentration gradient

2 What is one way that facilitated diffusion differs from simple diffusion?

A Facilitated diffusion requires energy input.

B Facilitated diffusion requires membrane proteins.

C Facilitated diffusion requires a concentration gradient.

D Facilitated diffusion requires small, nonpolar molecules.

3 A pipe carries excess rainwater into a lake. The rainwater has picked up dissolved nitrates from surrounding lawns. Which of the following is a consequence of simple diffusion of the nitrates in the lake?

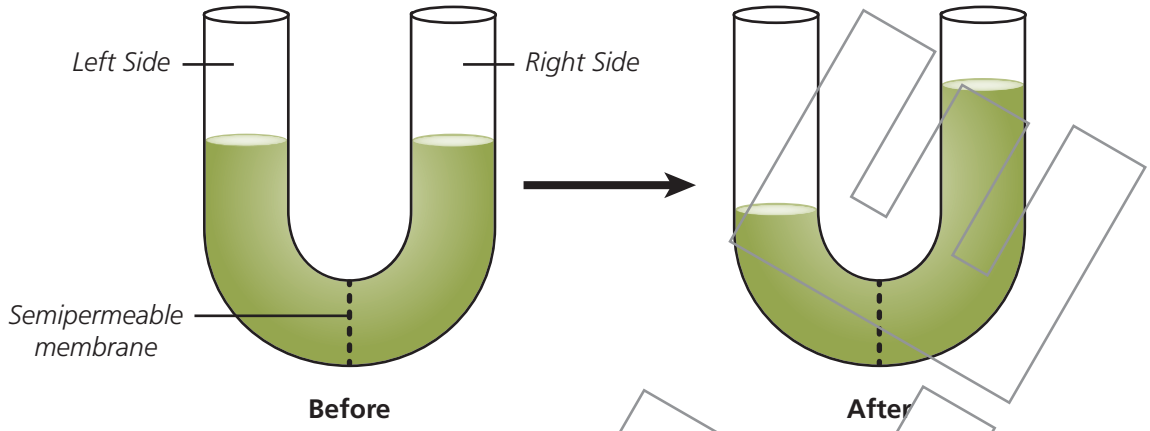
A A concentration gradient of nitrates is created and maintained.

B The total amount of dissolved nitrate in the lake water decreases.

C Nitrate concentration decreases in some places and increases in others.

D Energy is required to move the nitrates from one end of the lake to the other.

Use the image below to answer question 4.



4 The image shows a U-shaped tube with a semipermeable membrane separating the right and left sides. Each side is filled with equal volumes of water and different concentrations of solute. Which statement explains the change in water volume?

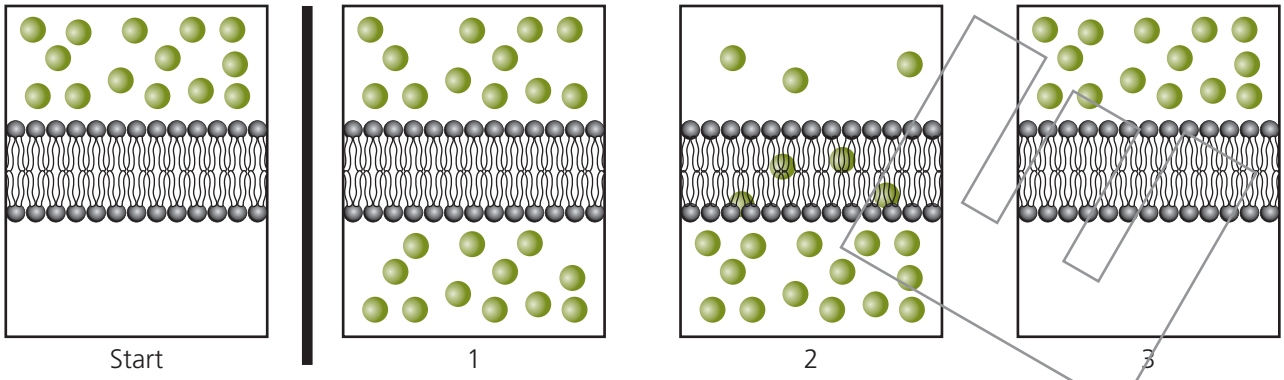
A Water moved to the right side, where solute concentration was originally lower.

B Water moved to the right side, where solute concentration was originally higher.

C Water and solute moved to the right side, where solute concentration was originally lower.

D Water and solute moved to the right side, where solute concentration was originally higher.

Use the images below to answer question 5.



5 The diagram labeled *Start* shows the distribution of a dissolved material near a plasma membrane at a point in time. The concentration is high in the extracellular fluid and the only available method of transport is passive transport. The diagrams numbered 1, 2, and 3 depict possible outcomes after some time has passed.

A Does diagram 1 show a possible outcome of the original situation? Explain your reasoning.

B Does diagram 2 show a possible outcome of the original situation? Explain your reasoning.

C Does diagram 3 show a possible outcome of the original situation? Explain your reasoning.