

Lesson Overview

7.3 Cell Transport

Lesson Overview Cell Transport

THINK ABOUT IT

When thinking about how cells move materials in and out, it can be helpful to think of a cell as a nation. The boundaries of a nation are its borders, and nearly every country tries to regulate and control the goods that move across those borders.

Cells have their own borders, which separate the cell from its surroundings and also determine what comes in and what goes out.

How can a cell separate itself from its environment and still allow material to enter and leave?

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Passive Transport

What is passive transport?

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Passive Transport

What is passive transport?

The movement of materials across the cell membrane without using cellular energy is called passive transport.

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Passive Transport

Every living cell exists in a liquid environment.

One of the most important functions of the cell membrane is to keep the cell's internal conditions relatively constant. It does this by regulating the movement of molecules from one side of the membrane to the other side.

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Diffusion

The cytoplasm of a cell is a solution of many different substances dissolved in water.

In any solution, solute particles tend to move from an area where they are more concentrated to an area where they are less concentrated.

The process by which particles move from an area of high concentration to an area of lower concentration is known as **diffusion**.

Diffusion is the driving force behind the movement of many substances across the cell membrane.

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Diffusion

Suppose a substance is present in unequal concentrations on either side of a cell membrane.

There is a higher concentration of solute on one side of the membrane than on the other.

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Diffusion

If the substance can cross the cell membrane, its particles will tend to move toward the area where it is less concentrated until it is evenly distributed.

Diffusion causes a net movement of solute particles from the side of the membrane with the higher solute concentration to the side with the lower solute concentration.

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Diffusion

At that point, the concentration of the substance on both sides of the cell membrane is the same, and equilibrium is reached.

Once equilibrium is reached, solute particles continue to diffuse across the membrane in both directions but at approximately equal rates, so there is no net change in solute concentration.

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Diffusion

Even when equilibrium is reached, particles of a solution will continue to move across the membrane in both directions.

Because almost equal numbers of particles move in each direction, there is no net change in the concentration on either side.

Once equilibrium is reached, solute particles continue to diffuse across the membrane in both directions but at approximately equal rates, so there is no net change in solute concentration.

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Diffusion

Diffusion depends upon random particle movements. Substances diffuse across membranes without requiring the cell to use additional energy.

The movement of materials across the cell membrane without using cellular energy is called passive transport.

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Facilitated Diffusion

Cell membranes have proteins that act as carriers, or channels, making it easy for certain molecules to cross.

Molecules that cannot directly diffuse across the membrane pass through special protein channels in a process known as **facilitated diffusion**.

Hundreds of different proteins have been found that allow particular substances to cross cell membranes.

The movement of molecules by facilitated diffusion does not require any additional use of the cell's energy.

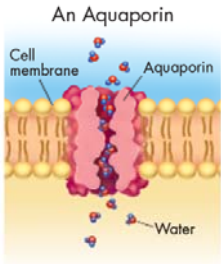
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Osmosis: An Example of Facilitated Diffusion

The inside of a cell's lipid bilayer is hydrophobic—or "water-hating." Because of this, water molecules have a tough time passing through the cell membrane.

Many cells contain water channel proteins, known as **aquaporins**, that allow water to pass right through them. Without aquaporins, water would diffuse in and out of cells very slowly.

The movement of water through cell membranes by facilitated diffusion is an extremely important biological process—the process of osmosis.



An Aquaporin

Cell membrane

Aquaporin

Water

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Osmosis: An Example of Facilitated Diffusion

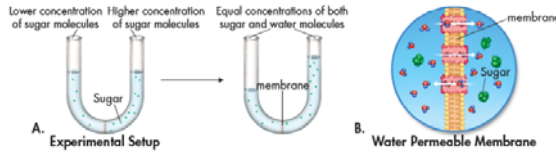
Osmosis is the diffusion of water through a selectively permeable membrane.

Osmosis involves the movement of water molecules from an area of higher concentration to an area of lower concentration.

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How Osmosis Works

In the experimental setup below, the barrier is permeable to water but not to sugar. This means that water molecules can pass through the barrier, but the solute, sugar, cannot.



Lower concentration of sugar molecules

Higher concentration of sugar molecules

Equal concentrations of both sugar and water molecules

A. Experimental Setup

B. Water Permeable Membrane

Sugar

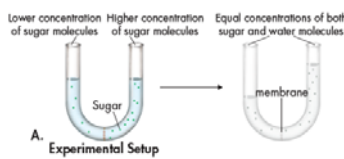
membrane

Sugar

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How Osmosis Works

There are more sugar molecules on the right side of the barrier than on the left side. Therefore, the concentration of water is lower on the right, where more of the solution is made of sugar.



Lower concentration of sugar molecules

Higher concentration of sugar molecules

Equal concentrations of both sugar and water molecules

A. Experimental Setup

Sugar

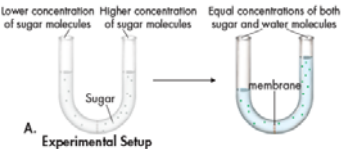
membrane

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How Osmosis Works

There is a net movement of water into the compartment containing the concentrated sugar solution.

Water will tend to move across the barrier until equilibrium is reached. At that point, the concentrations of water and sugar will be the same on both sides.



Lower concentration of sugar molecules

Higher concentration of sugar molecules

Equal concentrations of both sugar and water molecules

A. Experimental Setup

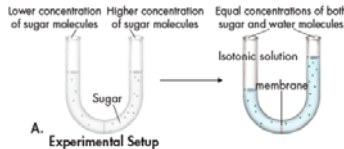
Sugar

membrane

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How Osmosis Works

When the concentration is the same on both sides of the membrane, the two solutions will be **isotonic**, which means "same strength."



Lower concentration of sugar molecules

Higher concentration of sugar molecules

Equal concentrations of both sugar and water molecules

A. Experimental Setup

Sugar

membrane

Isotonic solution

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How Osmosis Works

The more concentrated sugar solution at the start of the experiment was **hypertonic**, or "above strength," compared to the dilute sugar solution.

The dilute sugar solution was **hypotonic**, or "below strength."

A. Experimental Setup

B. Water Permeable Membrane

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Osmotic Pressure

For organisms to survive, they must have a way to balance the intake and loss of water.

The net movement of water out of or into a cell exerts a force known as **osmotic pressure**.

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Osmotic Pressure

Because the cell is filled with salts, sugars, proteins, and other molecules, it is almost always hypertonic to fresh water.

As a result, water tends to move quickly into a cell surrounded by fresh water, causing it to swell. Eventually, the cell may burst.

The Effects of Osmosis on Cells			
Solution	Isotonic: The concentration of solutes is the same inside and outside the cell. Water molecules move equally in both directions.	Hypertonic: The solution has a higher solute concentration than the cell. A net movement of water molecules out of the cell causes it to shrink.	Hypotonic: The solution has a lower solute concentration than the cell. A net movement of water molecules into the cell causes it to swell.
Animal Cell	Water in and out	Water out	Water in
Plant Cell	Water in and out	Water out	Water in

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Osmotic Pressure

In plants, the movement of water into the cell causes the central vacuole to swell, pushing cell contents out against the cell wall.

Since most cells in large organisms do not come in contact with fresh water, they are not in danger of bursting.

The Effects of Osmosis on Cells			
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Osmotic Pressure

Instead, the cells are bathed in fluids, such as blood, that are isotonic and have concentrations of dissolved materials roughly equal to those in the cells.

Cells placed in an isotonic solution neither gain nor lose water.

The Effects of Osmosis on Cells			
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Osmotic Pressure

In a hypertonic solution, water rushes out of the cell, causing animal cells to shrink and plant cell vacuoles to collapse.

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Osmotic Pressure

Some cells, such as the eggs laid by fish and frogs, must come into contact with fresh water. These types of cells tend to lack water channels.

As a result, water moves into them so slowly that osmotic pressure does not become a problem.

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Osmotic Pressure

Other cells, including those of plants and bacteria, that come into contact with fresh water are surrounded by tough cell walls that prevent the cells from expanding, even under tremendous osmotic pressure.

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Osmotic Pressure

Notice how the plant cell holds its shape in hypotonic solution, while the animal red blood cell does not.

However, the increased osmotic pressure makes such cells extremely vulnerable to injuries to their cell walls.

The Effects of Osmosis on Cells			
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Active Transport

What is active transport?

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Active Transport

What is active transport?

The movement of materials against a concentration difference is known as active transport. Active transport requires energy.

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Active Transport

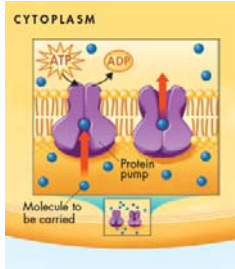
Cells sometimes must move materials against a concentration difference.

The movement of material against a concentration difference is known as active transport. Active transport requires energy.

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Active Transport

The active transport of small molecules or ions across a cell membrane is generally carried out by transport proteins, or protein "pumps," that are found in the membrane itself.



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Active Transport

Larger molecules and clumps of material can also be actively transported across the cell membrane by processes known as endocytosis and exocytosis.

The transport of these larger materials sometimes involves changes in the shape of the cell membrane.

Endocytosis
The membrane forms a pocket around a particle. The pocket then breaks loose from the outer portion of the cell membrane and forms a vesicle within the cytoplasm.

Exocytosis
The membrane of a vesicle surrounds the material then fuses with the cell membrane. The contents are forced out of the cell.



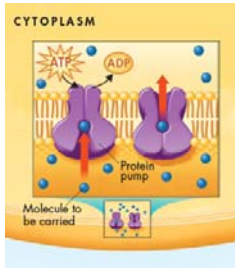
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Molecular Transport

Small molecules and ions are carried across membranes by proteins in the membrane that act like pumps.

Many cells use such proteins to move calcium, potassium, and sodium ions across cell membranes.

Changes in protein shape seem to play an important role in the pumping process.



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Molecular Transport

A considerable portion of the energy used by cells in their daily activities is devoted to providing the energy to keep this form of active transport working.

The use of energy in these systems enables cells to concentrate substances in a particular location, even when the forces of diffusion might tend to move these substances in the opposite direction.

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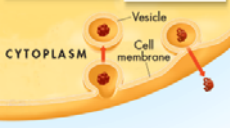
Bulk Transport

Larger molecules and even solid clumps of material may be transported by movements of the cell membrane known as bulk transport.

Bulk transport can take several forms, depending on the size and shape of the material moved into or out of the cell.

Endocytosis
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Exocytosis
The membrane of a vesicle surrounds the material then fuses with the cell membrane. The contents are forced out of the cell.



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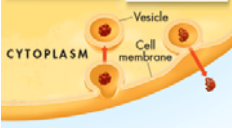
Endocytosis

Endocytosis is the process of taking material into the cell by means of infoldings, or pockets, of the cell membrane.

The pocket that results breaks loose from the outer portion of the cell membrane and forms a vesicle or vacuole within the cytoplasm.

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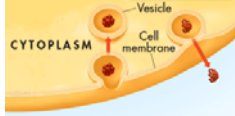
Endocytosis

Large molecules, clumps of food, and even whole cells can be taken up by endocytosis.

Two examples of endocytosis are phagocytosis and pinocytosis.

Endocytosis
The membrane forms a pocket around a particle. The pocket then breaks loose from the outer portion of the cell membrane and forms a vesicle within the cytoplasm.

Exocytosis
The membrane of a vesicle surrounds the material then fuses with the cell membrane. The contents are forced out of the cell.



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Endocytosis

In phagocytosis, extensions of cytoplasm surround a particle and package it within a food vacuole. The cell then engulfs it.

Amoebas use this method for taking in food.

Engulfing material in this way requires a considerable amount of energy and, therefore, is a form of active transport.

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Endocytosis

In pinocytosis, cells take up liquid from the surrounding environment by forming tiny pockets along the cell membrane.

The pockets fill with liquid and pinch off to form vacuoles within the cell.

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Exocytosis

Many cells also release large amounts of material from the cell, a process known as exocytosis.

During exocytosis, the membrane of the vacuole surrounding the material fuses with the cell membrane, forcing the contents out of the cell.

Endocytosis
The membrane forms a pocket around a particle. The pocket then breaks loose from the outer portion of the cell membrane and forms a vesicle within the cytoplasm.

Exocytosis
The membrane of a vesicle surrounds the material then fuses with the cell membrane. The contents are forced out of the cell.

