Objective 29

CELL TRANSPORT AND HOMEOSTASIS

B.5 *The student will analyze the transport of materials through cell membranes.*

B.6 *The student will explain homeostasis.*

Living things must maintain a stable environment. This need for a stable relationship between the organism and the environment is called **homeostasis**. Temperature regulation is an example of homeostasis functioning in the human body. When the body begins to get hotter than normal body temperature, the blood vessels near the skin will open wider to allow the "hot" blood to release some energy to the skin's surface. Conversely, the blood vessels will tighten when the body is too cold. Your body, as well as the cells of all living things, has many of ways to maintain homeostasis.

Define homeostasis.

The environment of the cell also must remain stable so that it can function. One example of how cells can maintain homeostasis is through the transport of materials through the cell membrane and within the cell. The function of the **cell membrane** is to control the passage of materials into and out of the cell. There are two main types of material transport, **passive** and **active**. Passive transport does not require the use of chemical energy to make it happen, similar to a ball rolling downhill. There is no need to put in extra energy, aside from the potential energy the ball already has, to make it roll. Active transport does require the cell to use chemical energy, similar to rolling a ball uphill. Active transport is used when something must be moved in the opposite direction from its natural tendency.

What is the difference between active and passive transport?

Passive Transport Mechanisms

The primary type of passive transport is **diffusion**, the movement of molecules from an area of greater concentration to an area of lesser concentration. Diffusion occurs because molecules are in constant motion (Fig. 29.1). The motion of the molecules causes them to move into areas in which the molecules are in smaller number. An example is when perfume is sprayed at one end of a room. Due to the motion of the perfume molecules, eventually the perfume can be smelled at the other end of the room.

Define diffusion.

The difference in concentration between two areas is the **concentration gradient**. When there is no difference in concentration, **equilibrium** exists. Although equilibrium occurs, the molecules still continue to move but the net effect is that the concentration on both sides stays the same; equilibrium is maintained. In other words, if five molecules move from right to left, then five molecules will move from left to right.

What is equilibrium?

In the cell, diffusion occurs when the cell wall is **permeable** to a particular substance, or will allow it to pass through. A cell membrane is not permeable to all substances, but rather **selectively permeable** (semipermeable) because all materials cannot diffuse through it, either because of size or identity.

Identify the difference between permeable and semipermeable.

What determines the direction of water movement?

When water is the material being diffused the process is termed **osmosis**. The direction in which the water moves is determined by the ratio of water to the ratio of materials dissolved in it. If the concentration of water is higher on the outside of the cell, then water will move inside. It is important to realize that the higher the water concentration is, the lower the solute concentration must be and vice versa. Three conditions can exist:

1. **Isotonic** - the concentration of solvent and solute is equal on both sides of the cell.

Iso- same
Hyper- above
hypo- below

2. **Hypertonic** environment / **hypotonic** cell - the concentration of solute is greater outside the cell than inside. Water will move out of the cell and will result in the cell shrivelling, a condition known as **plasmolysis**.

What is it called when a cell bursts because too much water has entered?

3. **Hypotonic** environment / **hypertonic** cell - the concentration of solute is greater inside the cell than outside. Water will move into the cell. If the cell takes in too much water it may burst, a condition known as **cytolysis**.

For example, blood cells must be put into a special solution once removed from the body. Since water flows toward the hypertonic solution and away from the hypotonic solution, if blood is put into a hypertonic solution, then the blood cells will shrivel. If the solution is hypotonic, then the blood cells can burst. For this reason, it is important to place blood cells into an isotonic solution so that the net amount of water inside the cell remains the same.

Two other types of passive transport are **facilitated diffusion** and **gated channels.** Facilitated diffusion is similar to simple diffusion except the materials being transported pass through at locations on the cell membrane that contain a special carrier molecule. The carrier molecules allow the material to be carried across the cell membrane faster. The number of carrier molecules in the cell membrane determines how much material can enter or exit. Glucose is an example of a molecule transported by facilitated diffusion. Although it can travel through the cell membrane without a carrier molecule, it is a slow process. The more carrier molecules present in the cell membrane, the more glucose will enter in a specific time. Gated channels are passageways made of proteins that allow the cell to become permeable to some substances as needed by the cell. Some are permanently open, while others open only as needed. An example of gated channels at work is the release of specific materials into and out of muscle cells when a contraction occurs.

Compare and contrast facilitated and simple diffusion.

Active Transport

It is sometimes necessary for a cell to move materials across the cell membrane against the concentration gradient from an area of lesser to higher concentration. Energy must be expended for this to occur. The primary example of active transport is the **sodium-potassium pump**. This mechanism uses carrier molecules that accept three sodium ions. The molecule then changes shape, releases the sodium ions onto the other side, and accepts two potassium ions. Again, the molecule changes shape and the potassium ions are transported to the opposite side. The sodium-potassium pump is important in the conduction of nerve impulses, muscle contraction, and other body processes.

Describe the function of a sodium-potassium pump.

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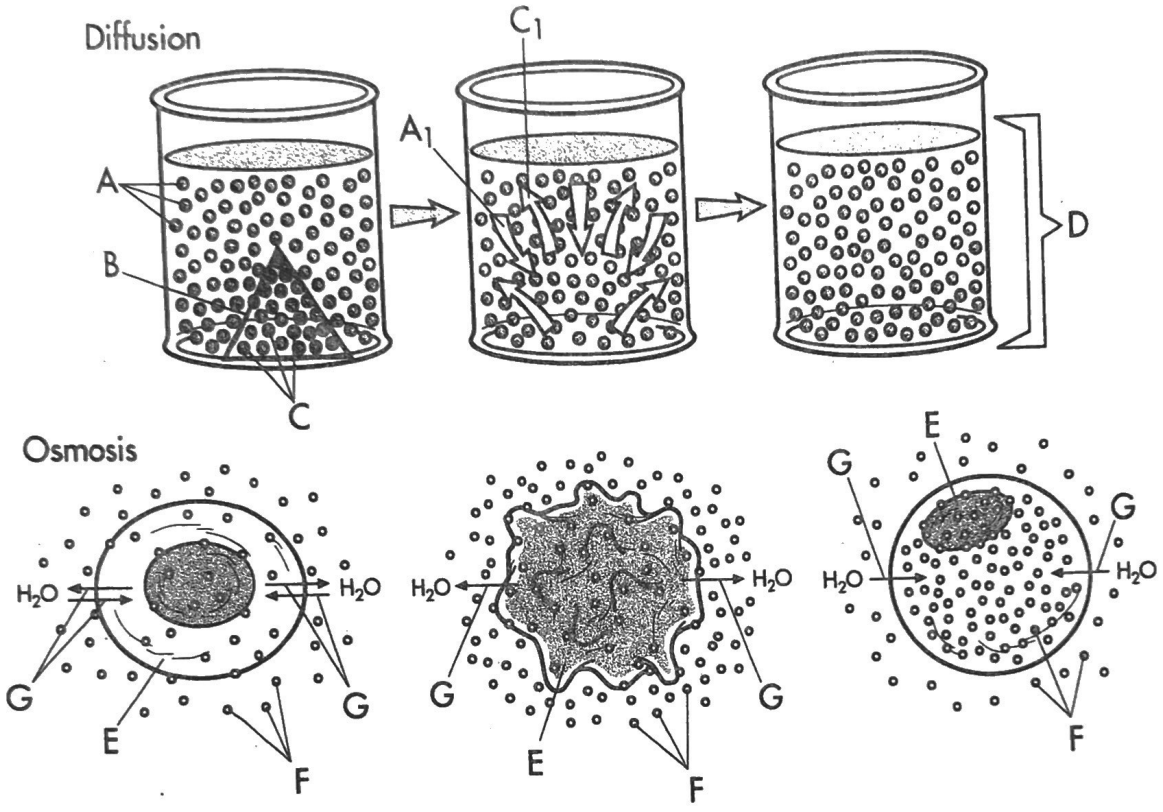

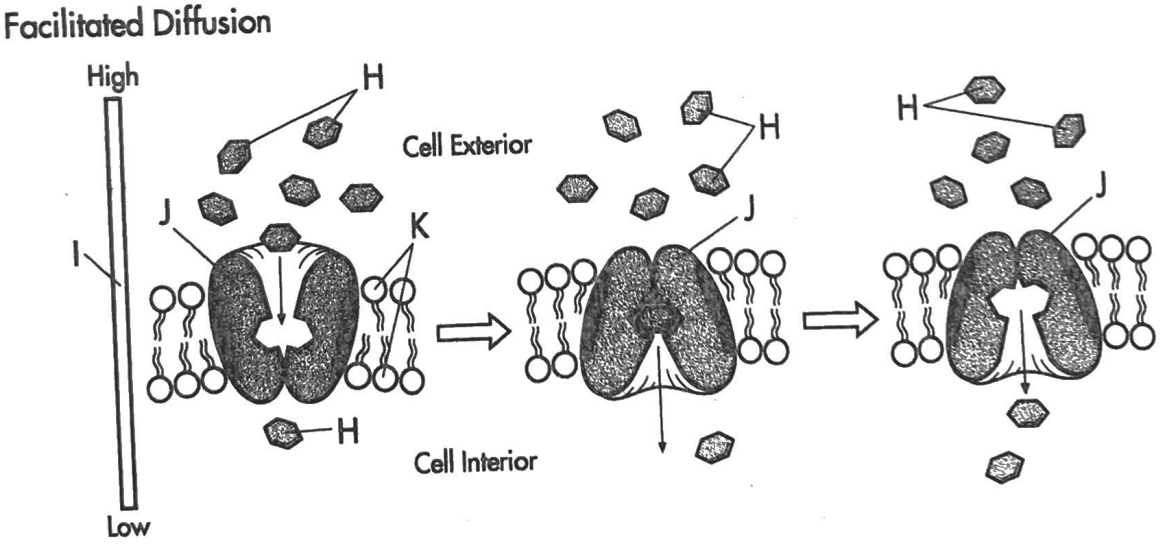

A: Water Molecules
A_1: Movement of Water Molecules
B: Crystal
C: Crystal Molecules
C_1: Movement of Crystal Molecules
D: Mixed Water and Crystal Molecules
E: Red Blood Cells
F: Water
G: Movement of Water
H: Carbohydrates
I: Concentration Gradient
J: Transport Protein
K: Cell Membrane

Fig. 29.1

Special Mechanisms

When molecules are too large to pass through the cell membrane, they will be packaged in a membrane called a **vesicle**. Two examples of this process exist, **endocytosis** and **exocytosis**. Endocytosis (*endo-* into, *cyto-* cell) occurs when the cell membrane itself is pinched off into the cell, "swallowing" materials with it. Once this occurs, the vesicle membrane and the contents are digested by the cellular enzymes. Two types of endocytosis are **pinocytosis**, the movement of fluids, and **phagocytosis**, the movement of solids. White blood cells are phagocytes that engulf bacteria and digest them. Exocytosis (*exo-* out, *cyto-* cell) is similar to endocytosis except the vesicle membrane is produced by the Golgi apparatus. It fuses with the cell membrane, causing its contents to be pushed out of the cell.

What is the difference between pinocytosis and phagocytosis?

FURTHER STUDY

homeostasis
diffusion
permeable
isotonic
plasmolysis
facilitated diffusion
exocytosis
sodium-potassium pump
passive transport
concentration gradient
selectively permeable
hypertonic
cytolysis
vesicle
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active transport
equilibrium
osmosis
hypotonic
gated channels
endocytosis
phagocytosis

QUESTIONS FOR REVIEW

1. What is the term used when a cell is attempting to maintain a balance with its environment?

2. Name and describe four types of passive transport.

3. What will occur if cells are placed in a hypertonic solution? Hypotonic? Isotonic?

4. Why is it sometimes necessary for a cell to expend energy to transport materials across the cell membrane?

5. What type of transport would be necessary for extremely large molecules?

6. Describe endocytosis and exocytosis with a drawing.

Transport through the Cell Membrane

TYPE OF TRANSPORT		DIRECTION Do molecules move from high to low concentration, or low to high concentration?	ENERGY Does the cell use energy to transport molecules this way?	MOVEMENT Does it move molecules through the lipid bilayer or through proteins?	MOLECULES What type of molecules move through the membrane in this way?
Passive Transport	Diffusion				
	Osmosis				
	Facilitated Diffusion				
Active Transport	Protein Pump				
	Exocytosis				
	Endocytosis