

Cell Transport

Notes 7.2

Objectives

1. Describe how materials move into and out of the cell through the cell membrane.
2. Explain how energy is involved in transporting some materials.
3. Describe why cells are small.

Some materials move by diffusion

Consider the following situations. You wake up in the morning to the smell of bacon sizzling on a skillet. You add a powder mix to a glass of water. You smell perfume someone put on in another room. What do all of these have in common? All of these are examples of diffusion.

Diffusion is the process by which molecules move spread out. The particles spread out in a certain way, however. In diffusion, particles always spread from an area of high concentration to an area of low concentration. This means the particles spread from where there are many of them to where there are few of them.

This movement occurs because the molecules in gases, liquids, and even solids are in constant motion in all directions. This random movement of molecules tends to spread them out until they are evenly distributed.

Diffusion only happens when there is a difference in concentration. The concentration of a substance is the number of particles of that substance in a specific volume. An example of concentration would be 5g/L. You might be asking, "how is 5g the number of particles?" Scientists know the mass of the particles. Therefore, we know how many particles are in 5g. It's just easier to write 5g versus how many particles there actually are. (The number would be huge!)

When there is a difference in concentration, diffusion occurs. For example, if you add blue dye to water, there is a high concentration of blue dye in the water where you added it, but a very, very low concentration of dye in the rest of the water. Therefore, the dye will spread quickly through the water.

This diffusion occurs regardless of other substances. For example, the blue dye spreads regardless of the concentration of water in the container or any other substance in there. the blue dye diffuses because there is fewer blue dye particles in the rest of the water.

The greater the difference in concentration, the faster diffusion will occur. For example, if we have 100mL of water and add one drop of blue dye in it, the dye will diffuse fast. This is because there is no dye in the water when we started. If that we add another drop to the same water, this drop of dye will diffuse more slowly. This is because the concentration of dye particles is higher than it was before. The greater the difference, the faster diffusion

occurs.

As the concentration gets closer to equilibrium, or being equal, the rate of diffusion slows down. Again, let's look at our dye example. When we first add the blue dye to the water, the dye moves quickly through the water. As the dye becomes more evenly spread, it begins to slow down.

Eventually, the concentrations will be the same all throughout the water, and diffusion will stop. Once the concentration is unequal, diffusion will begin again! (Even though we say diffusion has stopped, it doesn't! The particles are constantly in motion making it near impossible for there to be equilibrium.)

In this section, I made reference to water a lot. Particles don't just diffuse in water. They can diffuse in many substances such as air, other gases, and other liquids.

Diffusion occurs in cells

Now that we have an understanding of diffusion, we can see its importance to cells. Diffusion is just one way in which materials can move in and out of cells. Diffusion is important to cells because it is a form of passive transport. In passive transport, materials move in and out of the cell without using the cell's energy. This would be like someone giving you a paycheck each week even though you haven't done any work!

Not all particles will be able to enter or leave the cell, however. This is because the cell is surrounded by a protective layer called the cell membrane. The cell membrane is semipermeable (or selectively permeable). This means that only certain materials can pass through the cell membrane while others cannot.

Certain substances, such as oxygen, can easily pass through the cell membrane. If a material does not easily pass through the membrane, the cell may have a protein channel for it. A protein channel is an opening in the cell membrane designed only for a certain substance to pass through it. For example, some protein channels exist for water, glucose, salt, and some amino acids. Each of these can only pass through the protein channel designed for it. Glucose cannot go through the protein channel for water. Glucose can only go through its own protein channel.

All of this affects the cell. The cell can have concentrations of particles in it different than outside it. For example, if there is a high concentration of oxygen outside the cell than inside the cell, the oxygen will move into the cell until the concentrations are equal. This is important to the cell because it can obtain oxygen in this way. The best part is the cell doesn't have to use any of its energy for this to happen!

The same process of diffusion that causes particles to enter the cell also causes particles to leave the cell. As we will learn in notes 7.3, the cell uses oxygen to obtain energy. As a result, it produces carbon dioxide, which the cell does not need. Eventually, there is a higher concentration of carbon dioxide inside the cell than outside the cell. Therefore, the carbon dioxide will diffuse out of the cell.

Osmosis occurs in cells

Diffusion is the movement of particles from higher to lower concentration with one exception: water. If the water is diffusing, it receives a special name: osmosis. Osmosis is the diffusion of water across a cell membrane. Osmosis works in the exact same way as diffusion. If there is a higher concentration of water outside the cell than inside the cell, the water will move into the cell. Osmosis, like diffusion, is a form of passive transport. The cell does not use any energy to have water enter or leave it.

Unfortunately, water cannot easily move across the membrane on its own. This is because the inside of the membrane is hydrophobic. This causes water particles to move very slowly through the membrane. However, the surface of the cell is covered in protein channels that allow water to quickly enter the cell.

Maintaining correct water balance in the cell is important to the cell. Remember, the cell's survival depends on how much water it has. Scientists have observed three situations that affect the amount of the water in a cell. These situations refer to environments that the cells are placed in. There are three environments a cell can be in: hypertonic, isotonic, or hypotonic.

- In a hypertonic solution, the concentration of water inside the cell is greater than the concentration outside the cell. This causes the water in the cell to leave the cell. The result is a cell that shrinks.
- In an isotonic environment, the concentration of water in the cell is equal to the concentration outside the cell. The result is that water freely moves in and out of the cell. Our cells prefer this environment.
- In a hypotonic environment, the concentration of water outside the cell is greater than the concentration inside the cell. This causes water to enter the cell. In animal cells, this can cause the cells to lyse, or break. In plant cells, this environment causes the plant to become more firm and give it the support it needs to stand upright (so it doesn't wilt).

Some transport requires energy.

As long as particles are moving from high concentration to low concentration, the cell does not have to use any of its own energy. This is because particles naturally move from high to low concentration. However, there are several situations in which the cell must use its own energy.

For example, if the cell must move materials against the natural concentration, it must use energy. This means that the cell must move particles from a low concentration to a high concentration. This is the opposite of what naturally happens. This occurs when the cell has a high concentration of a particle and obtains more of that particle from a low concentration. This is like you walking up a hill. *Falling* (not walking or running) down a hill you don't have to use your own energy. However, if you want to go back up the hill by walking, you must use your energy to do so.

When the cell uses energy to transport materials, it is called active transport. Cells use active transport to perform important life functions. For example, the cell uses active

transport to keep or obtain materials it has a higher concentration of already. The cell can also force out materials it does not need even if there is a higher concentration of that material outside the cell.

The cell can also use active transport when it uses transport proteins. Transport proteins are different than protein channels. Remember, protein channels are openings in the cell that allow certain materials to enter without using the cell's energy. Transport proteins are also openings in the cell, but in order to get a particle through them, the cell must use its energy. Think of it like an automatic revolving door. A person can enter it, but in order to get in, power must be supplied to the door.

The cell must also use energy if it needs to obtain or release a particle that is too big to easily pass through the cell membrane. This is a process known as endocytosis or exocytosis.

Endocytosis is the process of obtaining materials that are too large to fit through the cell membrane or protein channel by using energy. There are three basic steps to endocytosis.

1. The cell membrane folds inward to create a space for the material that needs to enter the cell.
2. The particle moves into the space and the membrane closes around it forming a package.
3. The package breaks away from the membrane forming a vesicle.

Exocytosis is the process of removing materials that are too large to fit through the cell membrane or protein channel by using energy. Notice that this is the opposite of endocytosis. Therefore, the steps of exocytosis are those of endocytosis in reverse.

1. The vesicle (containing wastes or particles the cell does not need) approaches the cell membrane.
2. The vesicle and membrane fuse together.
3. The vesicle becomes part of the cell membrane and forces the material out.

These processes use energy when the vesicles are transported in the cell. Special proteins carry the vesicles along the cytoskeleton. The proteins carry the vesicles much like a car carries a person. The car cannot move without energy just as the protein cannot move without energy.

Let's recap. There are several ways a cell can use energy to move materials:

- When the cell needs to obtain materials it already has a higher concentration of (moving materials against the natural concentration).
- When the cell needs to prevent materials entering or leaving the cell.
- When the cell uses endo- or exocytosis.
- When the cell uses its transport proteins.
- When the cell moves materials within the cell.

Cell size affects cell survival

Cells are small for a reason. As cells grow and become larger, their volume quickly increases. Unfortunately, their surface area does not increase as fast. This is important because the surface area determines how many materials can enter the cell. Imagine if the United Center only had one set of doors everyone could get through. It would be chaos!

The larger cell also means that materials must travel a greater distance within the cell. If the organelle in the center of a cell needs a material, it won't be able to reach it in time if it is too big. Therefore, cells remain small so they can transport materials within them quickly enough for them to survive.

The smaller the cell, the faster the cell can transport materials within it. The larger the cell, the longer it takes materials to move in to and out of the cell AND the longer it takes the materials to move within the cell. Therefore, the cell stays small.

Practice Questions

Answer the following questions for review.

1. What is diffusion?
2. What are two examples of diffusion that you have personally observed?
3. What about the particles causes diffusion to occur?
4. What is concentration?
5. How does concentration affect diffusion?
6. How does the rate of diffusion change as concentrations reach equilibrium?
7. What happens to the rate of diffusion when the concentrations are equal?
8. What is passive transport?
9. What is osmosis?
10. How is osmosis different or similar to diffusion?
11. What causes osmosis to occur?
12. What happens to the water in or out of a cell in a hypertonic, isotonic, and hypotonic environment?
13. What is active transport?
14. What are endocytosis and exocytosis? Why does each occur? How does each happen?
15. List a few situations in which a cell would need to use energy in transport.

Resources

Need some more help? Want to review more information? Check out the following:

- <http://www.biologycorner.com/bio1/diffusion.html>
- <http://www.biologycorner.com/bio1/active.html>
- http://www.biology4kids.com/files/cell2_passivetrans.html
- http://www.biology4kids.com/files/cell2_activetrans.html