Teacher Tune-up

Quick Content Refresher for Busy Professionals

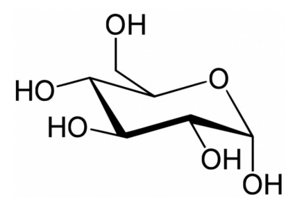
How does the cell move large particles through the cell membrane?

While small molecules, like oxygen, carbon dioxide, and water, can pass through the cell membrane on their own with diffusion and osmosis, large molecules and highly-charged molecules can't make it through. They are either too large to fit, or their electrical charges interact with the molecules of the membrane, preventing them from flowing easily through. Some of these substances, like sugars, proteins, or salts, are critical for cell survival. In order to get them inside, cells have proteins embedded in the cell membrane that act as carriers and gatekeepers.

Facilitated Diffusion

Proteins in the membrane act as passageways for large molecules and charged particles, or ions, that can't cross the membrane directly. Some of these proteins recognize a specific substance, and upon recognition, change shape to form a tunnel into the cell. Scientists call them carrier proteins. Once the tunnel is open, the substance can pass from areas of high concentration to low concentration. Because this kind of movement happens without any extra energy from the cell, it is known as passive transport. When cells use membrane proteins to allow large molecules or ions through based on concentration differences, we call this movement facilitated diffusion, since the proteins are facilitating the passage of substances.

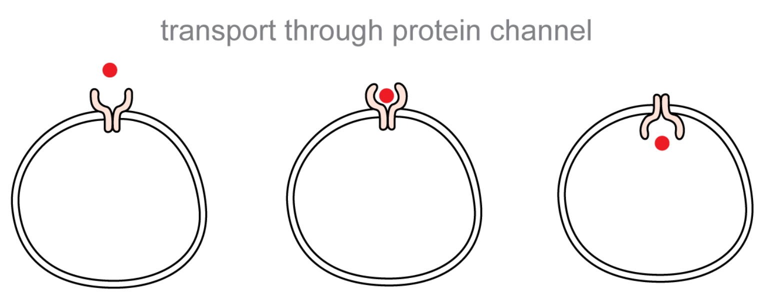
One of the most common molecules that uses facilitated diffusion is glucose. Glucose is an important sugar for the body, and cells break it down to get energy. Most cells in the body transport glucose using carrier proteins. In most parts of the body, glucose tends to be most concentrated outside of the cell, because the glucose inside the cells is taken apart for energy, thus making the concentration of glucose lower on the inside. Cells don't need extra energy to get the glucose to travel this concentration gradient, but they do need carrier proteins to form a tunnel for this large molecule to pass through.



Active Transport

What if cells want to move something in a different direction? Sometimes cells need to move substances across the membrane from an area of low concentration to an area of high concentration, so diffusion, whether it is simply through the membrane or facilitated by proteins, just won't work. To move against the concentration gradient, cells still use membrane proteins, but these proteins use extra energy to drag materials where they don't naturally want to go. This process is known as active transport.

Consider the case of the membrane of your gut. After you've eaten a full meal, your body needs to move glucose, or the food, out of the highly concentrated gut and into blood, which has a lower concentration of glucose. This kind of movement follows the concentration gradient, high to low. Since glucose is a large molecule, it needs a protein to help it through, so we might expect cells to use passive transport here, as most cells in the body do.



If these cells used passive transport to move glucose, however, the body would run into a big problem a few hours later. Once you start to get hungry again, your gut would be empty, or have an even lower concentration of glucose than your blood. If glucose could just diffuse across the membrane using a protein, you would start to lose glucose from your blood to refill your gut! Your body solves this problem by using active transport in the gut, with proteins carrying glucose in only one direction, regardless of the concentration differences.

Active transport has to fight against a concentration gradient, so it requires energy. Imagine a metaphor: the cell is a closet filled with balloons (or molecules). If you just open the door (or a channel protein) to your closet, all the balloons will fall out, moving from an area of high concentration to low concentration and spilling out on your floor. But if you are planning a special birthday party, you may want to store even more balloons in that closet. Getting them in there is going to take some extra energy, coupled with a specialized door that opens to the right size and crams the balloons through without letting any escape. That's exactly what's needed to move substances across cell membranes when you're acting against a concentration gradient: energy and a membrane protein that not only forms a tunnel into the cell, but also actively selects a specific molecule and gives it a push in the right direction.

Both active and passive transport are critical to the body maintaining homeostasis, or balance, among of all of its components. It's dangerous for the body to have too much or too little of critical substances, and membrane proteins help transport materials into and out of cells to keep things in balance and to help cells function correctly.

How do cells know when to open up their passageways?

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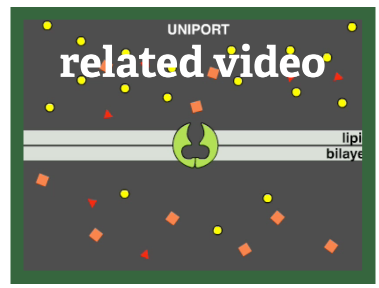

The key to membrane proteins is that they only open for certain molecules, some at certain times. You can imagine that opening a large passageway into the cell could let in lots of undesirable substances, so membrane proteins are specialized: they generally only work for one kind of molecule or ion. In addition, many of these membrane proteins do not need to be open at all times. For example, when cells in the brain send signals to each other, they open channel proteins that let ions pass through, helping to set off a chain of events that cause signals to be passed through the cell. Since cells only want to send signals some of the time, they only open their protein channels some of the time. How do they know when to open?

Membrane proteins often act as receptors for specific substances, binding to a molecule that acts as a signal telling it to open up. In the brain cell mentioned above, a molecule released from another cell, known as a neurotransmitter, will bind to a membrane protein. This neurotransmitter acts as a chemical signal to tell the protein to open and let ions pass through.

Cell membrane proteins recognize molecular signals by matching shapes, like two puzzle pieces fitting together or a specific key fitting into a specific lock. Scientists like the latter metaphor so much that they coined the phrase, "lock and key model." Molecules on the outside of the cell are bumping into the membrane all the time, hitting many different types of proteins embedded there. When a specific signal comes along that matches the shape of a specific membrane protein, the protein responds by moving into action, opening up a channel or bending itself to drag something into or out of the cell. In the body, signals that affect these membrane proteins include substances like neurotransmitters and hormones. These substances tell cells to change what goes in and out of the cell, which helps maintain homeostasis for the body.