5.2.2

Facilitated Diffusion

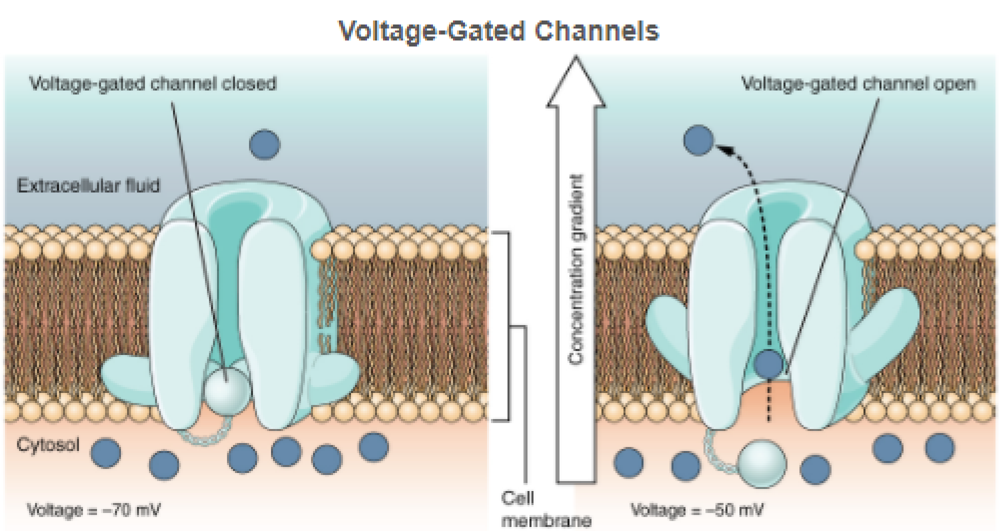
Not all solutes can pass directly through cell membranes. Molecules that are large, or that have an electrical charge, generally are prevented from moving through the membrane. However, many of these solutes need to be able to enter or leave the cell. So, how does the cell solve this dilemma? Recall that embedded in the cell membrane are several types of proteins that pass completely through the membrane (the integral membrane proteins). There are several specialized integral proteins that assist in the diffusion of solutes across the membrane. This type of diffusion is referred to as **facilitated diffusion.** Facilitated diffusion can occur in two different ways, through channel proteins and carrier proteins. Below are two links to videos that demonstrate the properties of these two passive processes that will discuss in more detail below.

https://books.byui.edu/-YRw (Transcription Available)

https://books.byui.edu/-HXs (Transcription Available)

Channel Proteins

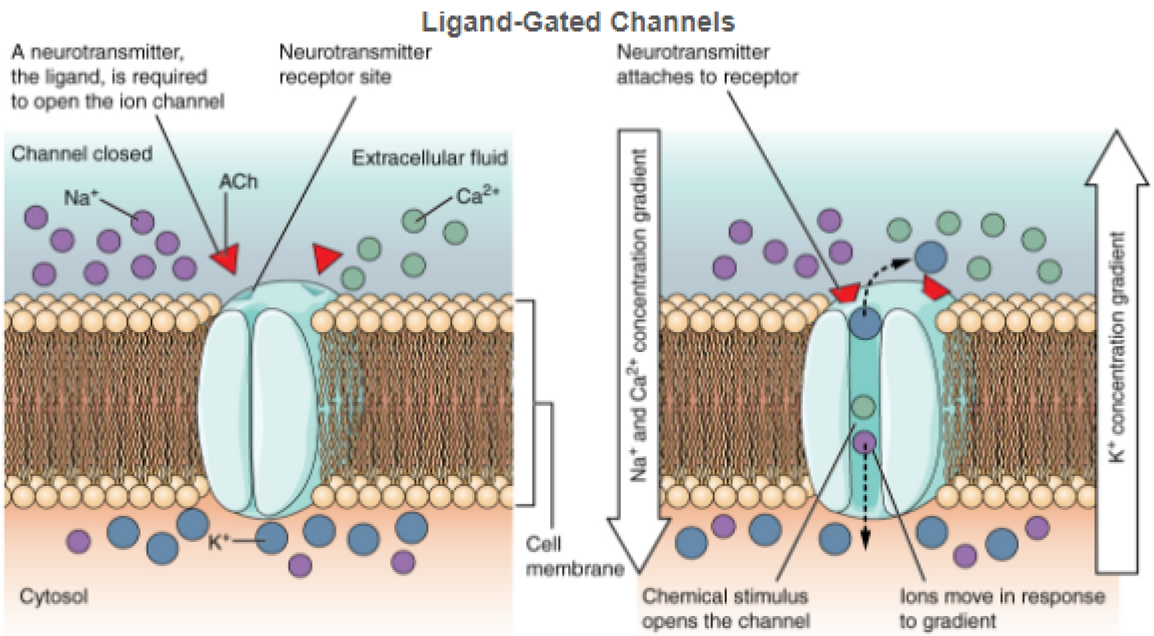
The first is via **channel proteins**. These channel proteins resemble fluid filled tubes through which the solutes can move down their concentration gradients across the membrane. These channels are often responsible for helping ions, such as Na^+, K^+, Ca^{2+}, and Cl^-, cross the membranes. Even though they are open tubes, they often only allow very specific ions to pass through them. For instance, a K^+ channel may allow K^+ to pass through but not Na^+ or Cl^-. Also, as we shall learn later, the regulation of the movement of the various ions across the membranes is crucial for many important cellular functions. These channels, therefore, are often gated (they have doors or gates that can be opened or closed). Depending on the channel, these gates may respond to voltage differences across the membrane (**voltage-gated channels**), specific signal molecules (**ligand-gated channels**), or even stretching or compressing of the membrane (**mechanically-gated channels**).



Voltage Gated Channel. *Author: OpenStax College; Site: https://books.byui.edu/-yThl License: Licensed under a Creative Commons Attribution 4.0 License*

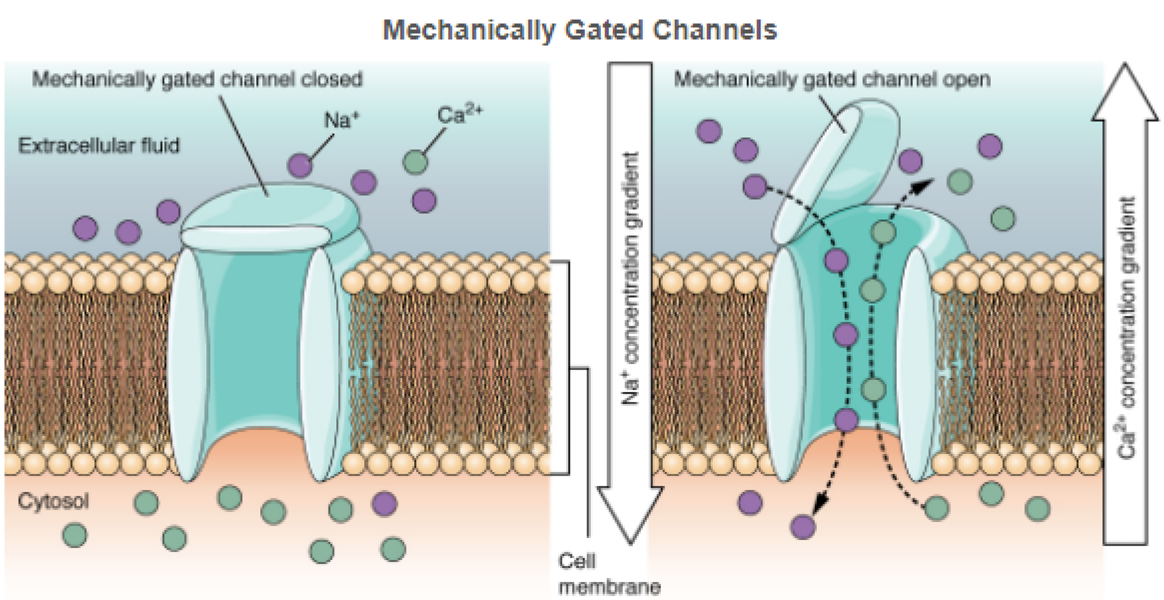
Voltage-gated channels (shown above) open when membrane voltage changes. We will discuss electrophysiology later on in this chapter but understand now that the concentration of ions (charged particles) in the intracellular fluid relative to the extracellular fluid creates a voltage (difference in charge). Amino acids comprising the channel protein are sensitive to changes in voltage which can cause the channel to open for a specific ion.

In ligand-gated channels the pore opens when the ligand binds to a specific location on the extracellular surface of the channel protein. Acetylcholine is the ligand shown in the example below.



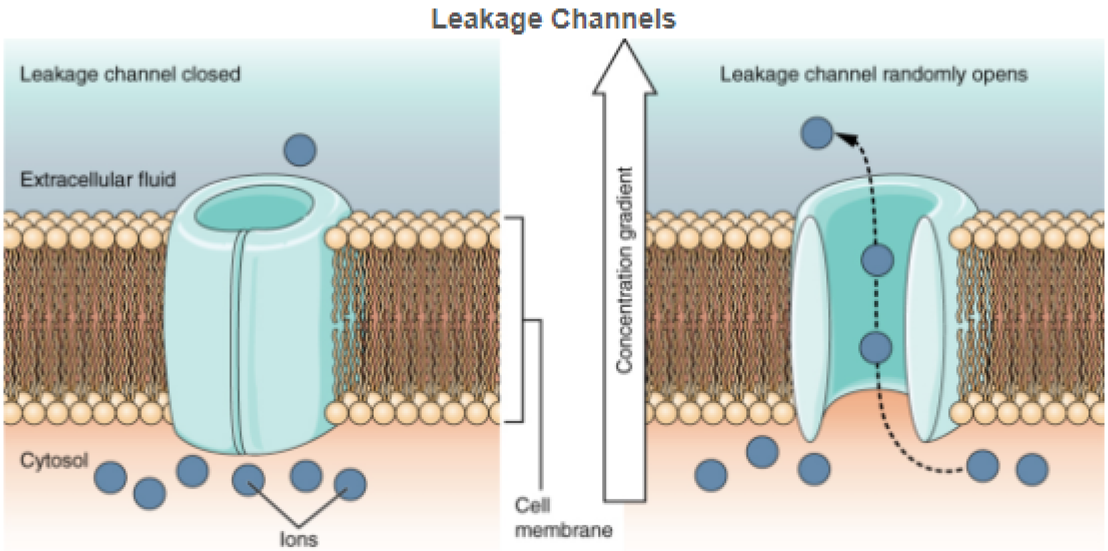
Ligand-Gated Channels. Author: OpenStax College; Site: https://books.byui.edu/-dfk License: Licensed under a Creative Commons Attribution 4.0 License

When a mechanical change happens such as pressure (e.g. touch), or a change in temperature, mechanically-gated channels open.



Mechanical-Gated Channels. Author: OpenStax College; Site: https://books.byui.edu/-ULoF License: Licensed under a Creative Commons Attribution 4.0 License

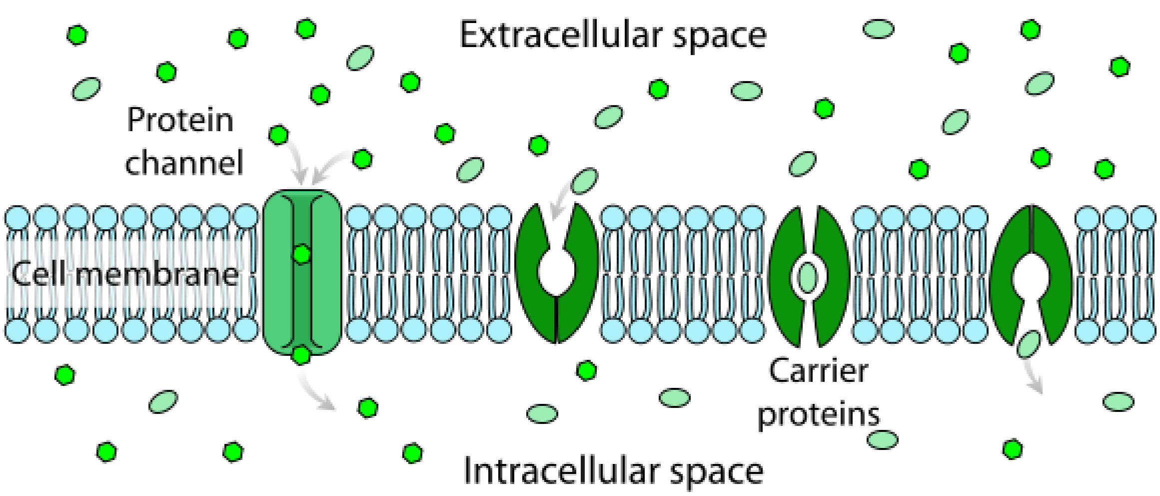
Some channels are not gated and are always open. These channels are called passive or leak channels. Perhaps the most well-known leak channel is the K^+ leak channel which contributes significantly to the resting membrane voltage.



Leak Channel. Author: OpenStax College; Site: https://books.byui.edu/-Mpz License: Licensed under a Creative Commons Attribution 4.0 License

Carrier Proteins

The second type of facilitated diffusion utilizes carrier proteins in the membrane and is known as carrier-mediated transport. Unlike the channel proteins, carriers bind to a specific solute on one side of the membrane which causes the carrier to change shape, allowing solute access to the other side of the membrane (think of a revolving door).



Carrier Proteins. By LadyofHats Mariana Ruiz Villarreal [Public domain], via Wikimedia Commons

Like the channel proteins, these carriers can be very specific for the solute they transport since the solute must bind to a receptor site within the carrier protein before it changes shape. Another interesting characteristic of these carriers is that they have a maximum rate of transport and can thus become saturated if the solute concentration is high enough.

Just as a revolving door can only allow a so many people to enter a building at one time, a carrier protein can only transport a specific amount of solute into the cell in a given time. Here is an example:

An important family of carrier proteins transport glucose across cell membranes. They are called glucose transporters (or GLUTs). There are 12 GLUTs that have been identified. Their distribution and specificity vary. For example, **GLUT2** is found in the kidney, liver, and pancreatic islets while **GLUT4** is found in skeletal muscle and fat tissue. GLUT2 and other glucose carriers expressed in the kidney enable the reabsorption of glucose that gets filtered out of the blood by the kidney. In the case of uncontrolled diabetes where blood glucose levels are super high, the kidney GLUT2 proteins become saturated with glucose and are unable to fully reabsorb the glucose back into the blood. As a result, glucose is lost in the urine, a condition known as glucosuria. Observe the graph below. Read the x and y axis labels. Can you determine which lines represent channel-mediated, carrier-mediated, and simple diffusion?