

Highlights of Membrane Transport

1. Proteins that move more than one chemical in the same direction across a membrane are called symports (synports). Those that move them in opposite directions are called antiports. If a net charge difference arises as a result of the movement, the system is referred to as electrogenic. If no charge difference arises, they are called electroneutral.
2. Nerve cells use the gradient of Na^+ and K^+ built up by the Na^+/K^+ pump to transmit signals. In nerve transmission, special "gates" open and close to allow Na^+ to diffuse into nerve cells and K^+ to diffuse out of nerve cells.
3. The first step in nerve transmission involves opening of Na^+ gates. These allow Na^+ to diffuse into the cell, since Na^+ concentration is higher outside of cells than inside. Movement of the positively charged sodium ion causes a change in the electrical potential of the cell near the Na^+ gate. To compensate for the voltage change, the K^+ gates open and Na^+ gates close, allowing K^+ to flow out of the cell. This results in an overcompensation of the voltage. The K^+ gates close and the region where the original movement of ions occurred recovers. During this time, no nerve signal can be transmitted at that point.
4. The nerve signal is transmitted as a consequence of the initial movement of Na^+ into the cell. Before it can be pumped out, some of the sodium diffuses down to the next Na^+ gate and the change in the voltage environment causes it to open and trigger the same events as occurred in the last step. Thus, the signal moves from one junction to another to another, ultimately arriving at the end of the axon.
5. Tetrodotoxin is a neurotoxin because it inhibits the action of nerve cells. It is found in the puffer fish and it blocks the Na^+ gates.
6. Channels (gates) are made by protein molecules in the membranes of cells. Channels are generally very specific for what they will allow to pass through them. Glucose channels, for example are fairly specific for glucose. Sodium and potassium channels are very specific for each respective ion.
7. Ion specificity is accomplished by two mechanisms. The first is physical. If an ion is too big to fit in a channel, it is excluded. This is the case of the sodium channel, which excludes potassium ions because they are too big.
8. The second mechanism of specificity is energy. An example is the potassium channel, which excludes sodium ions. In this case, the channel allows larger ions (potassium) to pass through, but blocks smaller ions, like sodium ions.
9. The mechanism of exclusion of the potassium channel relates to the energies of solvation of

each ion. For potassium ions, the energy of desolvation of the ion as it enters the channel is overcome by the energy of resolvation as it enters the channel. Thus, entry of potassium ions is energetically favored. This is due to the geometry of the potassium channel closely matching the dimensions of the potassium ion.

10. When sodium ions try to enter the channel, their energy of desolvation is greater than is realized by their resolvation in the channel. Thus, they do not enter. Their energy of resolvation not as favorable due to their ion sizes not matching the dimensions of the potassium channel.

11. After the nerve has "fired" the gradient must be restored and this is the job again of the Na/K ATPase.

12. After a nerve "signal" has moved along the entire length of a nerve cell, it must move to the adjacent cell. This requires a neurotransmitter. Neurotransmitters are small molecules encapsulated in vesicles (synaptic vesicles) that are released from the nerve cell carrying the signal (presynaptic membrane) to the adjacent nerve cell (postsynaptic membrane). The example I showed as acetylcholine, which is released in presynaptic vesicles and when the contents (acetylcholine) bind receptors on the postsynaptic membrane, channels open to allow sodium and potassium ions to move as before, causing the next nerve cell to start an action potential.

13. Mitochondria are the locations in cells where oxidation/reduction and ATP synthesis occurs, along with metabolism. Mitochondria have distinctive structural features, including an inner membrane that is impermeable to protons, infoldings of the inner membrane called cristae, an outer membrane that is not very impermeable, an intermembrane space between the inner and outer membrane, and the matrix. This last "structure" is simply the fluid in the inner mitochondrion and it is here where the enzymes of the citric acid cycle and fatty acid oxidation are found.

14. Remember that for every oxidation, there is an equal and Loss of electrons by one molecule means gain of them by another one. Oxidation is a process that involves the loss of electrons. Reduction is a process that involves the gain of electrons.

15. Electrons are carried to the electron transport system in the mitochondria by NADH and FADH₂.

16. Mitochondria are the site of electron transport and oxidative phosphorylation.

17. The compound 2,4 DNP (dinitrophenol) was marketed as a miracle diet drug about a century ago. It kills because it destroys the proton gradient of mitochondria without allowing sythesis of ATP. I'll have more to say about it later.