Topic 1.4 Membrane Transport

1.4.U1 Particles move across membranes by simple diffusion, facilitated diffusion, osmosis and active transport.

- **Describe simple diffusion.**
  - Net movement of molecules from areas of higher concentration to areas of lower concentration, without the input of energy (passive).
- **List two examples of simple diffusion of molecules into and out of cells.**
  - 1. Gas exchange by diffusion in lung alveoli cells.
  - 2. Gas exchange by diffusion through eye cornea cells.
- **Outline factors that regulate the rate of diffusion.**
  - Concentration of the diffusing molecule; increase concentration gradient, increase diffusion rate
  - Temperature; increase temperature, increase diffusion rate
  - Pressure; increase pressure, increase diffusion rate
- **Describe facilitated diffusion.**
  - Movement of molecules from higher to lower concentration through a transport protein without the input of energy.
- **Describe one example of facilitated diffusion through a protein channel.**
  - The CFTR protein is a channel protein that controls the flow of H2O and Cl- ions into and out of cells inside the lungs. When the CFTR protein is working correctly, as shown in Panel 1, ions freely flow in and out of the cells. However, when the CFTR protein is malfunctioning as in Panel 2, these ions cannot flow out of the cell due to a blocked channel. This causes Cystic Fibrosis, characterized by the buildup of thick mucus in the lungs.
- **Define osmosis.**
  - The movement of water by diffusion across a membrane.
- **Predict the direction of water movement based upon differences in solute concentration.**
  - Water moves from hypotonic solutions into hypertonic solutions.
- **Compare active transport and passive transport.**
  - Passive Transport
    - Does not require energy input
    - Molecules move from high to low concentration, "with" the gradient.
  - Active Transport

        - Requires energy input
        - Molecules move from low to high concentration, "against" the gradient.
- **Explain one example of active transport of molecules into and out of cells through protein pumps.**
    - Pumps are proteins that actively transport other molecules using ATP as an energy source.
    - For example, the proton pump is used in photosynthesis and respiration.

1.4.U2 The fluidity of membranes allows materials to be taken into cells by endocytosis or released by exocytosis. Vesicles move materials within cells.

- **Describe the fluid properties of the cell membrane and vesicles.**
    - Fluidity refers to the viscous flow of phospholipids in the cell membrane and organelles of the endomembrane system (including vesicles).
    - Fluidity is affected by:
        - fatty acid length
        - fatty acid saturation
        - presence of cholesterol
- **Explain vesicle formation via endocytosis.**
    - In endocytosis, the cell activity transports molecules into the cell by engulfing them into vesicles formed from the cell membrane.
- **Outline two examples of materials brought into the cell via endocytosis.**
    - White blood cells can engulf bacteria when fighting infection.
    - Single celled organism like amoeba can engulf bacteria as a food source.
- **Explain release of materials from cells via exocytosis.**
    - A secretory vesicle moves towards the cell membrane, fuses with the membrane and releases its contents into the extracellular space.
- **Outline two examples of materials released from a cell via exocytosis.**
    - Secretion of neurotransmitter at synaptic terminus.
    - Secretion of digestive juices from exocrine glands.

1.4.U3 Vesicles move materials within cells.

- **List two reasons for vesicle movement.**
    - Transport vesicles can move molecules between locations inside the cell (e.g. proteins from the ER to the Golgi).

- Secretory vesicles can move molecules from inside the cell to outside of the cells (e.g. to secrete a protein hormone).

- **Describe how organelles of the endomembrane system function together to produce and secrete proteins (rough ER, smooth ER, Golgi and vesicles).**
  - 1. In the nucleus, transcription of DNA, creating mRNA.
  - 2. Translation of mRNA at a ribosome on the *Rough ER*, creating a protein.
  - 3. Packaging of the protein into a *transport vesicle*.
  - 4. Transport of the protein inside the vesicle to the *Golgi*.
  - 5. Modification of the protein within the Golgi.
  - 6. Packaging of the protein into a *secretory vesicle*.
  - 7. Secretion of the protein when the vesicle fuses with the *cell membrane* during exocytosis.
- **Outline how phospholipids and membrane bound proteins are synthesized and transported to the cell membrane.**
  - Phospholipids are synthesized in the ER. The phospholipids become part of the ER membrane.
  - When a transport vesicle buds off the ER, the newly made phospholipid will be part of the vesicle. There may also be proteins (made at a ribosome on the ER) than embed in the vesicle.
  - As the vesicle moves through the cell towards the Golgi and then towards the cell membrane, the new phospholipid and protein are also transported.
  - When the vesicle fuses with the cell membrane, the new phospholipid and protein will become part of the cell membrane.

1.4.A1 Structure and function of the sodium-potassium pumps for active transport and potassium channels for facilitated diffusion in axons.

- **Describe the structure of the sodium-potassium pump.**
  - The sodium-potassium pump is an integral membrane protein. It had binding sites for three sodium ions, two potassium ions and an inorganic phosphate group (which comes from ATP).
- **Describe the role of the sodium-potassium pump in maintaining neuronal resting potential.**
  - The sodium-potassium pump is found in many cell (plasma) membranes. Powered by ATP, the pump moves sodium and potassium ions in opposite directions, each against its concentration gradient. In a single cycle of the pump, three sodium ions are extruded from and two potassium ions are imported into the cell. The rest of the ion movement is a net negative charge in the cell, called the resting potential.
- **Outline the six steps of sodium-potassium pump action.**

    - Three sodium ions bind with the protein pump inside the cell.
    - The pump protein is phosphorylated by ATP and changes shape.
    - By changing shape, the three sodium ions are released out of the cell.
    - At that point, two potassium ions from outside the cell bind to the protein pump.
    - The inorganic phosphate (which came from the ATP) is released from the pump, restoring the original shape of the protein.
    - The potassium ions are then released into the cell, and the process repeats.
- **Describe the structure of the potassium channel.**
    - The potassium channel is an integral membrane protein that facilitates the diffusion of potassium ions out of the cell.
- **Describe the mechanism of potassium movement through the potassium channel.**
    - The channel has a "ball and chain" gate mechanism that will only open the channel for potassium movement when a specific cell voltage is reached.
- **Explain the specificity of the potassium channel.**
    - Potassium channels are designed to allow the flow of potassium ions across the membrane, but to block the flow of other ions--in particular, sodium ions.
- **Describe the action of the "voltage gate" of the potassium channel.**
    - When a neuron is firing, the voltage of the cell changes. The potassium channel will only open when the voltage of the cell has reached its peak (of about 30mv).

[1.4.A2 Tissues or organs to be used in medical procedures must be bathed in a solution with the same osmolarity as the cytoplasm to prevent osmosis.]()

- **Explain what happens to cells when placed in solutions of the same osmolarity, higher osmolarity and lower osmolarity.**
    - Isotonic solutions are solutions that have the same osmolarity. Water moves into and out of the cell equally, resulting in no NET movement of water.
    - Hypertonic solutions are solutions that have more solutes than the cell. Water will move out of the cell and as a result the cell will shrivel (animal) or plasmolyze (plant).
    - Hypotonic solutions are solutions that have fewer solutes than the cell. Water will move into the cell. Animal cells will swell and may burst. Plant cells will become turgid with a vacuole full of water and pressure on the cell wall.

- **Outline the use of normal saline in medical procedures.**
  - Normal saline is a solution of water and salt ions that is isotonic to human blood. It is used as an eye wash, to flush wounds and intravenously to rehydrate patients. During organ transplant, while out of a body the organs are bathed in normal saline.
  - Because the solution is isotonic to body cells, the cells will not shrink or swell when exposed to the saline solution.

1.4.S1 Estimation of osmolarity in tissues by bathing samples in hypotonic and hypertonic solutions. (Practical 2)

- **Define osmolarity, isotonic, hypotonic and hypertonic.**
  - Osmolarity: the concentration of solutes in a solution.
  - Isotonic: the osmolarity of two solutions is the same.
  - Hypotonic: a solution with a lower osmolarity (fewer solutes) compared to another solution.
  - Hypertonic: a solution with a higher osmolarity (more solutes) compared to another solution.
- **Calculate the percentage change between measurement values.**
  - Calculate the difference between the two numbers you are comparing. Then, divide the increase by the original number and multiply the answer by 100.
- **Calculate the mean value of a data set.**
  - The mean is the average of the numbers. It is easy to calculate: add up all the numbers, then divide by how many numbers there are. In other words it is the sum divided by the count.
- **Calculate the standard deviation value of a data set.**
  - To calculate the standard deviation of those numbers:
    - Work out the mean (the simple average of the numbers)
    - Then for each number: subtract the mean and square the result
    - Then work out the mean of those squared differences
    - Take the square root of that and you are done!
- **State that the term standard deviation is used to summarize the spread of values around the mean, and that 68% of the values fall within one standard deviation of the mean.**
  - The Standard Deviation is a measure of how spread out numbers are relative to the mean.
  - 68% of the values in a sample will fall within 1 standard deviation (+/- 1 SD) of the mean.
- **Explain how the standard deviation is useful for comparing the means and the spread of data between two or more samples.**

    - The smaller the standard deviation, the more closely the data cluster about the mean. This information is useful in comparison to other datasets using a T-test.
- **State that error bars are a graphical representation of the variability of data.**
    - Error bars are graphical representations of the variability of data and used on graphs to indicate the variation or uncertainty in a reported measurement.
    - They give a general idea of how precise a measurement is, or conversely, how far from the reported value the true value might be.
- **Determine osmolarity of a sample given changes in mass when placed in solutions of various tonicities.**
    - Samples will gain mass when placed in a hypotonic solution (as water moves into the sample). Samples will lose mass when placed in a hypertonic solution (as water moves out of the sample). There will be zero change in mass when the sample is placed in an isotonic solution.
    - The osmolarity of a sample is the point at which there is no net movement between the sample and the solution in which it is placed.

1.4.NOS Experimental design- accurate quantitative measurements in osmosis experiments are essential.

- **Define quantitative and qualitative.**
    - Quantitative: data that is in the form of a *number* obtained in a count or measurement.
    - Qualitative: data that is descriptive or subjective.
- **Determine measurement uncertainty of a measurement tool.**
    - All measurements have uncertainties and are only as accurate as the tool being used to make the measurement.
    - For general purposes, the accuracy of a measurement device is one half of the smallest measurement possible with the device.
    - To determine uncertainty:
        - Find the smallest increment of measurement on your measurement device
        - Divide it by two
        - Round to the first non-zero number
- **Explain the need for repeated measurements (multiple trials) in experimental design.**
    - Multiple trials allows one to see if the results of each measurement show consistency. Consistent findings reinforce the strength of the conclusion.
- **Explain the need to controlled variables in experimental design.**

- A controlled experiment is an experiment in which all factors are held constant except for one: the manipulated variable.
- A common type of controlled experiment compares a control group against an experimental group. All variables are identical between the two groups except the variable being tested.
- The advantage of a controlled experiment is that it makes it easier to eliminate uncertainty about the significance of the results.