

# Effect of temperature on membrane permeability



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The purpose of this practical is to investigate the effect that an increase in the surrounding temperature has on the selectively permeability of a plant membrane

## **Introduction**

The cell membrane is crucial for the cell's interaction such as protection and regulation of materials passage. According to Plantcellstructures (2008), the cell membrane consists of primarily phospholipids, proteins and other biological molecules such as carbohydrates.

Providing structural support for the membrane, phospholipid occupies a significant area in the membrane. Glycerol linking to two fatty acids and one phosphate group makes a phospholipid (Losos, Manson & Singer, 2008a).

The phosphate proportion group is more polar and hence water loving while the fatty acids hate water. This results in phospholipid spontaneously forming a bilayer when it meets water (Losos, Manson & Singer, 2008a). The hydrophilic heads are closer to water while the hydrophobic tails will be away from water (Web-book, n. d.). Due to this property, hydrophobic material such as polar ions will be unable to cross the phospholipid. Therefore, phospholipid is an important barrier to polar molecules transport through the membrane. According to Zona Land (2006), temperature in Kelvin is proportional to kinetic energy. Thus, if the surrounding temperature increases, the kinetic energy of molecules increases as well. This leads to increased motion of phospholipids, resulting in greater permeability.

Protein functions mainly as transporter, receptor and enzyme in the membrane (Rsc, 2010a). Playing a vital role in passive transport, proteins

assist polar materials to get in and out of the cell. Passive transport, without the need for the cell to expend energy, is usually carried out as diffusion (Farabee, 2007). Diffusion is the tendency of substance moving from a high concentration to a low concentration (Gregory, n. d.). The concentration gradient has been believed to be the main driving force of transport through membrane, stated Bariyanga (2008). In passive transport, proteins act as aqueous channels for polar particles. This is because charged ions have polarity, which interacts with water easily (Losos, Manson & Singer, 2008c). Proteins also act as carriers that bind to particular molecules to help them cross the membrane (Losos, Manson & Singer, 2008c). This is called facilitated diffusion. Due to the important role protein plays in transport, once the structure of protein is affected, the function of protein is lost. There are essential forces within the protein structure that hold it stable, including hydrogen bonds and ionic bonds (Rsc, 2010b). According to Lane (2009a), boiling point is a great indicator for forces, because at this point all interactions are broken. Since hydrogen bonding is the main force within protein structures, temperature change will affect the structure of proteins, or denature them, by breaking hydrogen bonds. Therefore, an increase in temperature can denature proteins and make polar molecules move in or out of the cell freely.

Inside the red cabbage leaf there are anthocyanins, pigments that are responsible for light absorbing and red or purple colour of leaves (Horbowicz, et al, 2008). They exist in the cell sap of epidermis and mesophyll cells (Lane, 2009b). Anthocyanins solution is often used as an indicator since it will turn red when meets acid while appear purple in water (Helmenstein, n.

d.). Since anthocyanins are polar molecules, they get in and out of the cell through ion channels or by facilitated diffusion (Commandini, et al, 2008). Therefore, once proteins are affected by temperature change, the anthocyanins inside the red cabbage cells will leak out.

Another kind of passive transport is osmosis. According to Bailey (n. d.), osmosis is the diffusion of water from low solute concentrated to high solute concentrated side. It will not stop until the equilibrium of concentration is reached. Plant cells are not likely to rupture even its maximum volume is reached during osmosis. The turgid cell wall has the ability to stop osmosis by rising up osmotic pressure of the cell (Purchon, 2006), the force required to unable osmosis to happen (Losos, Manson and Singer, 2008e). The cell wall is freely permeable (Rsc, 2010a). Therefore, it is not a factor affected by temperature in terms of permeability. However, temperature can accelerate osmosis by increasing kinetic energy.

It is possible that an increase in temperature will lead to an increase in permeability of the membrane by rising up kinetic energy and denaturing proteins

## **Method**

Materials needed for this experiment: 7 test tubes, test tube rack, medium size cork borer, small beakers, mounted needle, large beaker, thermometer, alcohol burner, tripod, gauze, measure cylinder, tongs and red cabbage leaves.

The experiment was conducted following these steps modified from Land (2010b)

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42 discs of fresh red cabbage leaf were cut using a medium size cork borer. Every 6 discs were put in a small beaker and washed under a running tap for 5 minutes.

7 test tubes were labelled as 30°C, 40°C, 50°C, 60°C, 70°C, 80°C, 90°C. Approximately 6 cm<sup>3</sup> of cold water was added to each tube, using measure cylinder.

Using a large beaker, a tripod, a piece of gauze and a Bunsen burner, water bath was prepared. The water in the beaker was heated to 30°C and the burner was removed.

6 red cabbage discs were impaled on the mounted needle with space between each disc. The needle was put in the water bath for exactly 1 minute. The discs were pushed off, using tongs, and dropped into the test tube labelled 30°C.

The water bath was heated to 40°C and gently and 6 more discs were placed on to the needle. These discs were put into the water bath for 1 minute, then the discs were pushed off into the test tube labelled 40°C.

The procedure was repeated for the other 4 tubes. The discs were left for 20 minutes.

Finally, the tubes were shaken and placed on the test tube rack. The tubes were held to the light and observed.

## Discussion

The result of this practical shows the influence of temperature on permeability. As it suggests, there are mainly three appearances.

There was almost no obvious change of red cabbage discs at 30°C and 40°C. The temperature was still too low to have a significant effect on components of the cell membrane.

Then, at 50°C and 60°C, the discs swelled, which indicates water had got in the cells. This is due to the increase in temperature. As Zona Land (2006) suggested, molecules would vibrate or move more frequently and violently with the increase of kinetic energy as temperature arise. Water has a bigger chance to get in or out of the cell, following the concentration gradient. As Purchon (2006) stated, plant cells will not rupture due to the existence of cell wall. Hence, because the equilibrium of concentration was reached, the volume of each cell increased and the whole disc became bigger in size and thicker.

Finally, the purple colour of red cabbage discs was gone, resulting in a colour change of the solution. This indicates the cell membrane almost became freely permeable at over 70°C. The anthocyanins had come out of the cells and dissolved in the solution. The leak of anthocyanins is evidence that proteins structures had changed. Proteins control anthocyanin getting in and out of the cell. Heat can change the structure of protein by breaking hydrogen bonds (Lane, 2009a). During the experiment, once the temperature of protein was reached, proteins vibrated and their hydrogen bonds were broken, denaturing proteins to function as carriers or channels

for anthocyanin. Therefore, due to low concentration outside but high inside the cell, anthocyanin moved into the water solution outside and dissolved in it. The result also suggests that there were some purple colour remaining in the discs. There might be two possible reasons. One is the maximum amount was reached, or not all cell membranes were destroyed and some anthocyanins remained inside the cells. In addition, in 70°, 80°, 90° tubes, there was no size change of the discs. Although the cell wall does prevent the cell from rupture, the membrane structure of the cell might be totally destroyed by high temperature, as with the vacuole membrane (Purchon, 2006). Hence the water that went in the cell previously might have passed out again. As a result, the cell became freely permeable. Also, anthocyanin was not concentrated enough within such a large amount of water. Thus, the solutions appeared to be light blue.

Errors that have taken place during this experiment might influence the result. First of all, measure cylinder was used to measure the amount of water being poured into the 7 tubes. There would not be exactly the right amount of water being poured into the tubes due to the water residue in the cylinder. Thus, the amount of water in each tube was not equal, resulting in different concentrations of colour. Another factor that was missed during the experiment is the accurate control of temperature and time. The red cabbage discs being placed under a running water tap were not staying for exactly 5 minutes. Temperature was not accurately reached during this experiment as required, resulting in lower or higher temperature affecting the membrane permeability. Some of them had a longer or shorter wait time.

For future experiment, more comprehensive preparation should be done.

Initially, precise measurement equipment such as graduated pipette should be used. Then, precise control of temperature should be done for accurate recording temperature. Thirdly, exact timing should be carried out by using a timer or watch.

## **Conclusion**

An increase in temperature will affect the permeability of the cell membrane.

Low surrounding temperature such as 30°C and 40°C does not have a significant effect on permeability. At 50°C and 60°C, permeability starts to increase while at over 70°C the cell membrane becomes freely permeable due to protein structure destruction. Meanwhile, according to the result of this experiment, the temperature to denature the function of protein is approximately at 70°C.