Effect of temperature on permeability of red cabbage

The aim of the experiment was to investigate the effect of temperature on the membrane permeability in red cabbage. The permeability wound be estimated by the amount of red pigment diffusing out of the red cabbage.

Introduction

They are both bounded by membranes. Red cabbage appears as a purple colour since it contains a class of reddish purple pigment called anthocyanin within the vacuole of red cabbage cells. The anthocyanins are responsible for the red, purple and blue colours of plant’s leaves, flowers and fruits (Biologymad, nd).

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Like other eukaryotic cells, red cabbage cells have different organelles. They are both bounded by membranes. Cell membranes can provide structural support and control the transport of substances moving through the cells. As Figure 1 shows, the cell membrane is made up of a phospholipid bilayer, cholesterol, proteins, glycolipids and glycoproteins. Without the cell membrane, cells would not be able to carry out the multiple functions for the activities of organisms.

Figure 1. The Structure of Membrane ï¼ˆClick4 Biology, 2002ï¼‰

The basic structure of the membrane is phospholipids (Figure 2). They are composed of a phosphate group chemically linked to a three- carbon glycerol molecule and two fatty acids (Ucl. nd). As a result, the phospholipids have a hydrophilic (loving water) head and two hydrophobic (hating water) tails (Lane, 2009).

Figure 2. Phospholipid Structure (University of Florida, nd)

Cytochemistry (2007) reports that the temperatures can affect the packing of the hydrocarbons. As Figure 3 shows, the phosphlipid is tightly packed and have a gel state at low temperatures (Cytochemistry, 2007). A higher temperature can make the lipids ‘ melt’ and become more fluid, which allow the phosphlipid to move or rotate (Cytochemistry, 2007). This leads to the membranes become more unstable and fragile (Ucl. nd). Although having hydrophilic heads, phospholipids are still a barrier to water (polar) molecules because of the hydrophobic tails.

Figure 3. Phospholipids at Different Temperatures (Cytochemistry, 2007)

The coiled and folded strings of amino-acids can form variable structures of proteins. These amino-acids are also held together by hydrogen bonds and disulphide bridges (Losos, Mason and Singer, 2008). With weak interactions, such as hydrogen bonds, the secondary and tertiary structure of proteins can be disrupted and become denatured. Denaturation is the structure of a protein is charged, leading to the loss of proteins’ biological properties (Clik4 Biology, 2008). Heating increases the kinetic energy and causes the molecules to vibrate. Therefore, the interactions can be weakened and broken. Temperatures above 41â„ ƒ will break the interactions in many proteins and denature them (Chemistry Explained, nd).

Proteins can act as a passage way for ions and polar molecules to diffuse through the membrane. The plasma membrane is a selectively permeable barrier because of protein carriers can control certain substances to enter or leave (Losos, Mason and Singer, 2008).

The substances can transport across the membrane by diffusion. The movement is from high concentration to low concentration. For hydrophobic substances, they can move by simple diffusion. They directly pass through the membrane and no energy is required (Losos, Mason and Singer, 2008). As Figure 3 shows, facilitated diffusion occurs when channel proteins binding to specific molecules ï¼ˆClick4 Biology, 2002ï¼‰.

Figure 3. Facilitated Diffusion ï¼ˆClick4 Biology, 2002ï¼‰

The diffusion of water molecules from high water concentration to low water concentration is called osmosis (Lane, 2009). Active transport and cytosis can also move certain things through cell membranes.

Method

In this experiment, red cabbage, test tubes, beakers, cork borer, a cylinder, a mounted needle and spirit lamp were provided.

The practical was done as following steps (Lane, 2010). To begin with, cylinders of red cabbage tissue were cut and placed on a tile. The red cabbage discs were then washed under a running tap for 5 minutes. Using the cylinder, 6 cm3 cold water was separately added to seven test tubes labeled 30â„ ƒ, 40â„ ƒ, 50â„ ƒ, 60â„ ƒ, 70â„ ƒ, 80â„ ƒ, and 90â„ ƒ. Using a large beaker, tripod and gauze and spirit lamp, a water bath was set up. Six red cabbage discs were impaled on a mounted needle. The water bath was heated to 30â„ ƒ. The burner was then removed and the discs were placed in the water bath for 1 minute. These discs were push off and dropped into the test tube with cold water (5 cm3). The procedures of heating at varying temperatures, placing the discs into the water bath and then removing them to the test tubes were repeated. The start time was recorded. The discs were left in the test tubes for 20 minutes. The tubes were shaken and observed.

Results

Discussion

In the experiment, the diffusion between the red cabbage membrane and the cold water in the test tubes is passive transport. As mentioned before, osmosis occurs from the higher water concentration in cold water to the discs. The lower concentration outside the pigment can make the pigment diffuse out from the red cabbage disc. However, the proteins within the red cabbage membrane can help a selective transport.

The clear water in the test tubes labeled 30â„ ƒ to 60â„ ƒ can be explained, the red pigments found within the vacuole of red cabbage cells are good for the red cabbage. Even though they have different concentration, there are no carrier proteins allowing pigment to be transported. The sky blue colour in other test tubes indicates that the proteins or the phospholipids in the cell membrane have become denatured and lost the integrity, which cause the pigments to diffuse out. With the similar reasons, the movement of water into the red cabbage discs make the discs swell at low temperature (30â„ ƒ to 60â„ ƒ). The shrunken discs might be caused by the loss of membrane integrity. It cannot resist the osmotic forces.

The results indicate the phospholipids or the proteins become denatured when heated with the temperature higher 60â„ ƒ. Compared with above 41â„ ƒ, the temperature making denatured proteins is higher in the experiment. This might be caused by the time heating the discs in the water bath is too short. Or the temperature cannot maintain a constant temperature and falls, because in this experiment, the burner was removed when placing the discs in the water bath.

It can be deduced that as the temperature rises, the cell membrane will become more and more permeable. Therefore, all content within the cell will spill out at the end. With such reason, the water colour would have become more and more blue from 70â„ ƒ to 90â„ ƒ. The results are different from the expected ones. Errors may have arisen in the measurement of water used in each test tube. The water was measured using a cylinder rather than a graduated pipette. It obviously causes the different volumes of water and different concentrations have different colours. Another reason might be part of pigments diffuse into the heating water before placed into the test tube, especially at higher temperatures. Or higher temperatures destabilize the anthocynin molecules and decompose the pigments to colourless.

This experiment just investigates the effect of temperature. Therefore, other variables need to be controlled. They are also the modifications need to improve the experiment. For example, using the same sized cork borer cutting the red cabbages having the same thickness can make sure the same surface area and the same dry weight of the discs. It is possible a wide range of temperatures were used. If more reduplicate procedures had been done at smaller intervals, the results would be more accurate.

Conclusion

Temperatures have a significant effect on the cell membranes permeability and integrity. Low temperatures make the discs swollen, but have not obvious colour change. At around 70 â„ ƒ, colour begins to increase. The denatured anthocyanin molecules cause a decrease in colour at higher temperature.