An experiment to investigate how the temperature affects the diffusion rate of beetroot

Aim

The aim of this experiment is to investigate how the temperature will affect the absorbance or transmission of light by diffusion through the phospholipid bi-layer of beetroot.

Hypothesis

I predict that as the temperature increases, the light absorbance will increase because the heated up temperature will provide more kinetic energy for the pigments in order to collide more. However, the light absorbance will start to decrease when the temperature has reached a certain level as the carrier proteins and the protein channels would be denatured and slow down the facilitated diffusion.

Scientific knowledge and understanding

Facilitated diffusion is a process of diffusion, a form of passive transport, via which molecules diffuse across membranes, with the assistance of transport proteins. This diffusion will be affected by serveral varibles. They are temperature, pH, surface area of the beetroot, time and the surrounding concentration. I have chosen temperature as my varible. Temperature will affect the rate of diffusion effectively because the temperature will create a force of kinetic energy which provide a greater rate for the pigments to collide in which speed up the reaction through the phospholipuid bi-layer. However, if the temperatrue is too high, the proteins will be denatured and as a result the process will stop.

Method

I have decided to use 6 different temperatures to test the rate of diffusion of pigments in beetroot. The range is 40℃ to 90℃.

Apparatus

1. A size 4 cork borer
2. 6 boiling-tubes rack
3. A kettle
4. A colorimeter
5. A Stop Clock
6. A Thermometer
7. A Scalpel
8. A Cutting board
9. A Beaker
10. A Test -tube
11. A Syringe
12. A rule

I have first of all heat up the water with a kettle. While it is heating, I used a size 4-cork borer to cut out a part of the beetroot on the cutting board. Then, I cut it int o 6

pieces with 1 cm long each. When the water is ready, I poured it into my beaker and test the temperature. However, the temperature was too high, so I added some distill water to cool it down. Once the temperature is ideal, I then put the beetroot into a test tube with 7cm^2 water in it. I measured the water by using the syringe. After that, I started my stop clock and wait for 5 minutes. After 5 mins, I got rid of the piece of beetroot and poured some of the sample out and measured the light absorbance using a colorimeter.

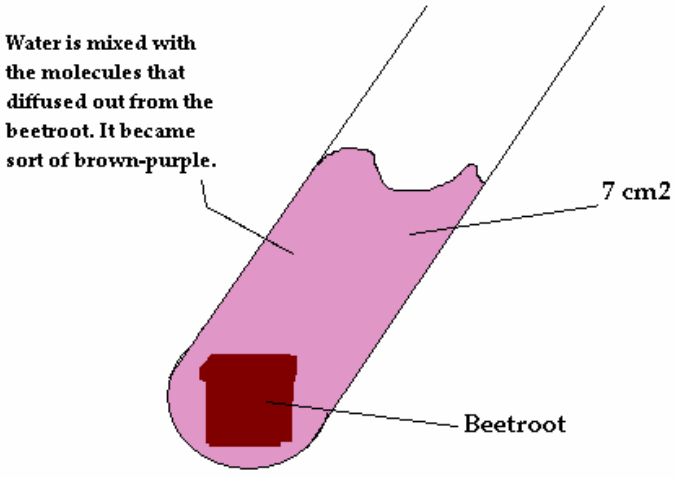
I then repeat these again but using different temperatures. If the water is too cold I then added some hot water to sustain the temperatures. Finally, I repeat the whole experiment 3 times for each temperature to increase its reliability.

Fair test

In order to produce a fair test, I must ensure that the size of beetroot and the amount of water I used are the same throughout the whole experiment because the surface area of the beetroot and the volume of the water will affect the results as well. Therefore, these are the factors that I have to keep constant.

Preliminary work

From the preliminary experiment, I have got some odd results. This can help me to improve the quality of the actual experiment and let me learn from the mistakes such as reset the colorimeter with distill water before testing my samples.



Using the above apparatus, I managed to get all my results apart from one. The purpose of this experiment is to measure the diffusion rate in the cell membrane by

changing the temperature. Therefore, I can measure the light absorbance by using a colorimeter and I hope this will provide me a sufficient evidence of the changes. The light absorbance can tell me how much light the substance absorbs. The higher the light absorbance, the high the diffusion rate, as there will be more particles in the substance.

Temperature (℃)	40	50	60	70	80	90
Light Abs (P.E.)	0.63	0.51	1.09	0.81	N/A	N/A
Light Abs 1	0.39	0.36	0.40	0.52	0.61	0.79
Light Abs 2	0.39	0.40	0.46	0.66	0.89	0.94
Light Abs 3	0.38	N/A	0.43	0.56	0.82	0.92
Average	**0.39**	**0.38**	**0.43**	**0.58**	**0.77**	**0.88**

As the temperature is increase, the light absorbance will increase as well. However, in my preliminary experiment, my second test which is 50℃ has gone slightly wrong and on the 3rd one, it went up to 1.09 abs which is an unusual result. I have stopped after the 4th test, as the time is not enough.

Therefore, on the actual experiment, I have been more careful on the time allowance, but unfortunately I did not have enough time to finish the 3rd 50℃ result. In this case, I have then average up the values that I have got.

p.s. graph at the next page

I have drawn a graph with a best-fit line from my results. It shows that the higher the temperature is, the higher the rate of diffusion, which is light absorbency. (This is shown by the graph below.) The light absorbency means that there is more pigment in the water and will absorb more light.

Conclusion

As the evidence has shown, when I rise the temperature to 90℃, there is more pigment diffused in the boiling tube since the concentration in the boiling tube is lower. Diffusion is the movement of particles from higher concentration to lower concentration. This proves if I increase the temperature, the diffusion rate of pigment increases because more kinetic energy is produced which encourage more collision between particles. All small particles will diffuse through the cell membrane (a phospholipid bi-layer), however, some larger molecules such as glucose and pigment, they cannot diffuse out through the plasma membrane. Alternatively, a carrier protein

will be formed and will transport the pigments through the plasma membrane in which it is embedded and into the cell. This is called facilitated diffusion.

Lastly, I conclude that if the temperature increases the rate of diffusion increases at a constant rate as well. This is due to the kinetic energy produced by the form of heat energy encourage the movement of the pigments in and out the plasma membrane. This conclusion I made has fitted my prediction, which I stated in my hypothesis. However, part of my hypothesis stated that when the reaction reached a certain temperature, the rate of diffusion will start to decrease as the protein channel and the carrier protein would be denatured. On my result, it did not show the decreasing of the reaction. This might be because that the range of temperatures that I have got is not high enough to denature the protein.

Evaluation

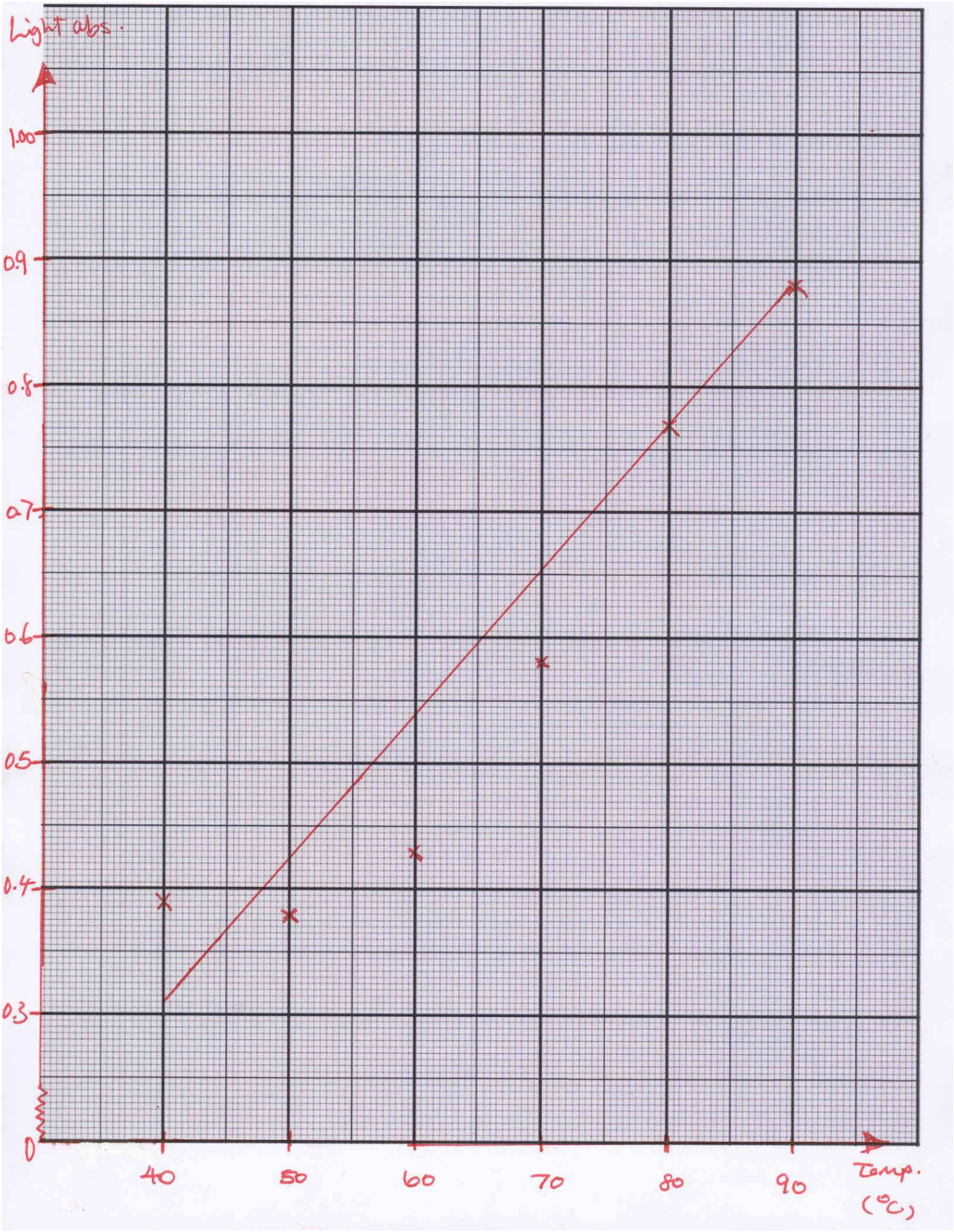
I think the evidence I have obtained is not as accurate, as it is not close to the best-fit line. This may due to the slightly strange result on the graph, which does not suit my pattern. I think this is partly because I have not got enough time to finish my 3rd repeat for 50℃. Therefore, when I averaged my data, it went a bit wrong. The anomaly results might also cause by me forgetting to reset the colorimeter with distilled water before testing my results. Alternatively, I think my trend of the graph can be explained in other way. The carrier protein and the protein channel is working normally at the rate of 40°C to 60°C but when it go beyond 60°C, the carrier protein and the protein channel start to denature and which encourage the speed of the diffusion for the pigments to diffuse out.

To maintain the suitable temperature, I have used a kettle to boil water. However, as I cannot control the exact temperature I want, I sometimes have a different of 1 or 2 ℃. This might have caused some inaccuracy. To improve that, I can use a Bunsen burner next time so I can maintain the temperature by myself, not relying on the kettle. In additional, a thermostatically controlled water baths would be a good idea to maintain the temperature as well as it can sustain the exact temperature I want which will increase the accuracy.

In improve this experiment, I can try and alter the method slightly by using a larger range of temperature. Moreover I can also take the time more carefully in case I run out of time like this time. If I can re-do the experiment again, I will obtain a room temperature as my range of temperature as well because my pattern of graph shows the gradual increasing of temperature from 40°C to 60°C. The trend would be more

perfect as it can show the gradual increase from 40˚C to 60˚C and a rapid increase from 60°C to 90°C.

Graph



The graph is originally produced by hand and scanned in this document