

Investigation into the permeability of cell membranes using beetroot

Specification reference:

AS Component: 1.3

A level Component: Core concepts 3

Cell membranes and transport

Introduction

Cell membranes are fluid structures which control the exit and entry of materials into cells. Some substances cross the membrane through proteins, others diffuse through the phospholipid layer. The molecules within the membrane are constantly moving and their movement is greatly affected by temperature. Heating the membrane can cause gaps to form between the phospholipid molecules and the membrane will become more permeable. The protein in the membrane can be denatured by heat.

Beetroot cells contain betalain, a bright red, water soluble pigment, in the cell vacuoles. If the cell membranes are damaged the pigment can escape from the cells and can be detected in an aqueous medium around the tissue. Beetroot grows in soil at a temperature of between 10–15°C.

Apparatus

Beetroot cylinders

White tile

10 test tubes

Scalpel

250 cm³ beaker

Forceps

Water baths at (25, 35,45,55,65 °C)

Thermometer

Stop clock

Colorimeter with a blue filter / colour chart

Method

1. Cut 5 pieces of beetroot, 1 cm long, from the cylinders provided.
2. Wash under running water to remove the pigment released from cells during cutting.
3. Place a test tube containing 5 cm³ of distilled water into each water bath to equilibrate for 5 minutes.
4. Place 1 piece of beetroot into each test tube for 30 minutes.
5. After 30 minutes, shake the test tubes gently to make sure any pigment is well-mixed into the water, then remove the beetroot cores.

6. Describe the depth of colour in each test tube. A piece of white card behind the tubes will make this easier to see. Arrange the tubes in order of temperature of the water bath.
7. If you have access to a colorimeter, set it to respond to a blue/ green filter (or wavelength of 530 nm) and to measure absorbance. Check the colorimeter reading for distilled water.
8. Measure the absorbance/percentage transmission of each tube and plot a graph of absorbance/percentage transmission against temperature.

Risk Assessment

Hazard	Risk	Control measure
Scalpels are sharp	Could cut skin when cutting cylinders	Cut away from body onto white tile

Teacher/ Technicians notes

Beetroot must be raw, not cooked. Use a size 4 cork borer and cut with care using a cutting board. Cut enough cores to make eight 2 cm lengths per working group. Leave the cores overnight in a beaker of distilled water. The pigment from any cells that have been cut by the cork borer will leak into the water. Rinse away any pigmented water in the morning and replace with fresh water.

Each student should be given cylinders of the same diameter (5 – 8 mm. diameter) and enough to be able to cut 5 x 1cm cylinders.

Thermostatically controlled water baths could be set up at the required temperatures or students could be given equipment to enable them to make their own water baths (tripod, gauze, beaker, Bunsen burner and thermometer).

If students are using a colorimeter it would be an advantage to have a simple set of printed instructions by the instrument.

Further details are available from:

<http://www.nuffieldfoundation.org/practical-biology/investigating-effect-temperature-plant-cell-membranes>

Sample results

Here is a sample of results obtained with a colorimeter – measuring transmission of light at 530 nm (rather than absorbance).

Temperature (°C)	Observation	Colorimeter reading (%transmission of light)			
		Repeat 1	Repeat 2	Repeat 3	Mean
0	clear	100	98.5	99.0	99.2
22	very pale pink	93.9	95.0	96.0	95.0
42	very pale pink	80.1	77.0	76.9	78.0
63	pink	26.3	29.9	31.0	29.1
87	dark pink	0.7	0.7	1.0	0.8
93	red	0.0	0.1	0.0	0.0

Further work

- Students could extend their investigation by finding the effect of alcohol or detergents on membrane permeability.
- The procedure allows for students to identify systematic and random variables. It is a good opportunity to practice graphical treatment of results, including range bars to assess the variation in repeats.

Practical Techniques

- use appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length and pH)
- use appropriate instrumentation to record quantitative measurements, such as a colorimeter or potometer