The Permeability of the Beet Root Membrane

Grade 12 University Preparation Biology

Performed: ___________________________ Due: ___________________________

Foreword

Permeability of a cell to solutes in an aqueous solution depends upon the physical and chemical make-up of the membrane. The maintenance of the living cell depends upon the continued presence and functioning of a selectively permeable membrane. If the nature of the membrane is altered in any way, this may affect it’s permeability and thus the properties of the cell of which it is a part. Irreversible changes in the permeability of the membrane usually lead to the death of the cell. In this experiment, we will study the effects of changes in the environmental conditions on the permeability of living beet root cells.

Roots of beet (Beta vulgaris) contain large amounts of a reddish pigment called betacyanin, localized almost entirely in the large central vacuoles of the cells. Betacyanin in healthy cells remains inside the vacuoles, surrounded by a vacuolar membrane called a tonoplast. The entire cell is surrounded by a cellular or plasma membrane. Environmental stresses can damage the membranes, allowing betacyanin to leak through the tonoplast and plasma membrane. This leakage of betacyanin will produce a red colour in the water surrounding the stressed beet. Thus the degree of membrane damage can be determined by monitoring the intensity of the colour leakage resulting from a treatment.

Objectives

By the end of this investigation the student should be able to:

1. Describe the effect of heat on the permeability of beet root tissue.

2. Relate the theory of membrane structure as considered in class, with the observations made during this activity.

Introduction:

Discuss the structure of the cell membrane as it relates to its permeability. You may use figures or diagrams if they will aid in illustrating this structure [all figures must be numbered, titled and referred to in the text of your work]. Include relevant research information concerning the affect of the experimental treatments on the permeability of plasma membranes. When referring to facts which are not general knowledge, use the MLA style to cite the source of the information [i.e. The cell membrane consists of protein molecules embedded in a phospholipid bilayer (Bretscher, 1985)]. There is no word minimum. (4 marks)
Purpose: (2 marks)

Hypothesis: (2 marks)

Materials and Apparatus: (each pair needs the following)

<table>
<thead>
<tr>
<th>Item</th>
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<tbody>
<tr>
<td>12 test tubes</td>
<td>masking tape</td>
<td>thermometer</td>
</tr>
<tr>
<td>1 test tube holder</td>
<td>50 ml beaker</td>
<td>10 ml pipette</td>
</tr>
<tr>
<td>1 test tube rack</td>
<td>beets</td>
<td>pipette pump</td>
</tr>
<tr>
<td>6 thermostatic water bath</td>
<td>scalpel</td>
<td>glass stirring rod</td>
</tr>
<tr>
<td>safety goggles</td>
<td>watch/clock</td>
<td>colorimeter</td>
</tr>
<tr>
<td>distilled water</td>
<td>3 cuvettes</td>
<td>GLX data recorder</td>
</tr>
</tbody>
</table>

Procedure: (refer to procedure below and make note of changes only) (2 marks)

**Preparation of Beet Root Sections**

With the aid of a scalpel, remove both top vegetative potions and the base of a beet root (See Figure 1). Carefully bore out several cores of beet root tissue using a cork borer. Use a scalpel to slice the cylindrical cores into 5 mm sections. You will need a total of 3 sections for each temperature used in the lab. (Make every effort to cut the sections accurately). All of the sections should be placed in a beaker of distilled water at room temperature to remove the betacyanin from the injured cells on the surface.

**Note:** 6 water baths will be set at different temperatures (room temperature (___ ° C), 30° C, 40° C, 50°C, 60 °C and 70° C). One member of each group will be responsible for cutting the beet discs while the others will measure 10.0 ml of distilled water at the appropriate temperature into the labelled test tubes used. One labelled test tube is placed into each of the 6 water baths for each group. Be sure that you can identify your group’s test tubes.
1. Six water baths have been prepared at the following temperatures (___ °C), 30°C, 40°C, 50°C, 60°C and 70°C.

2. Each water bath contains beakers filled with distilled water (this water is at the same temperature as the water bath).

3. At each water bath measure 10.0 ml of water into a labelled test tube (be sure the label clearly indicates your group and the temperature of the water), and place the test tube into the rack located in the water bath.

4. Place three (3) beetroot sections into each of your prepared test tubes. Leave the beet tissue in each water bath for 20 minutes. It is unlikely that you will be able to place the beet discs into all the test tubes at the same time so it makes sense to separate the time that each test tube receives the beet discs by a minute. Keep track of the time so that each test tube only remains in its water bath for 20 minutes.

5. Label a second set of empty test tubes (one for each water temperature), and place these in your group’s test tube rack (on the counter, at your lab station).

6. After 20 minutes, remove each test tube from the water bath. Stir the solution with a glass rod, to disperse the dye. Then pour the liquid only into a clean labelled test tube (these are the test tubes that you prepared in step 5), leaving the beet discs in the first test tube. The beet discs are to be discarded (in the garbage).

7. Measure 5.0 ml of the room temperature solution into a clean cuvette.

8. Using a colorimeter and a calibrated GLX data recorder, collect the absorbance value for light of wavelength 565 nm (green). Refer to the procedure for using the colorimeter on the white board. Always use the same colorimeter.

9. Repeat this procedure for each of the other 5 solutions. At the end of day one you should have 6 values for absorbance, one for each water bath temperature (trial 1).

10. On day two of the lab, repeat the procedure to obtain a second set of data (trial 2).

11. In your observations section, record the all data in a well labelled raw data table. Your table must have a descriptive title, and labelled columns with appropriate units. Also include qualitative observations, below your raw data table. (3 marks)

11. For each temperature, find the average absorbance value (from the two trials). Show these values in a separate, well-labelled processed data table. Show a sample calculation for one of the temperature treatments before the table. (3 marks)

12. Using this averaged data, make a scatter plot of the overall relationship that exists between temperature of water and the amount of damage done to the membrane (as indicated by the amount of dye leakage). Use a trend line (or curve) to clearly show the relationship (if you know how to use Excel you can get the software to calculate and plot the trend line, if not you should draw it by hand). (6 marks)
Discussion Questions:

1. What characteristics of beets make them useful experimental models for studying cellular membranes? (i.e. why don’t we use potatoes instead?)  
   (1 mark)

2. Suggest 2 ways that heat can affect the permeability of a membrane. Be specific about the major membrane component(s) that is/are affected.  
   (2 marks)

3. Discuss one possible source of error in the laboratory procedure. Suggest a practical improvement in procedure or equipment that will eliminate or reduce the error. We should be able to implement this suggestion for next year. Do not include human error.  
   (2 marks)

Conclusion:

Summarize your results in paragraph form and explain your findings in terms of how changes in temperature affect the component(s) of the membrane (that is, suggest the mechanism of damage). The conclusion should address the purpose of the lab and your hypothesis (i.e. do the results support or refute your conclusion). Be sure to refer to the scatter plot when writing your conclusion. The text of the conclusion should be in the same style as that of the introduction (reference research material used).  
(4 marks)

Work cited: Use MLA style (minimum of 3 sources)  
(2 marks)

Permeability of Beet Root Lab – Rating Scale

| Introduction: | 0 | 1 | 2 | 3 | 4 |
| Purpose: | 0 | 1 | 2 |
| Hypothesis: | 0 | 1 | 2 |
| Method: | 0 | 1 | 2 |
| Observations: | 0 | 1 | 2 | 3 |
| Raw Data Table: | 0 | 1 | 2 |
| Processed Data Table: | 0 | 1 | 2 | 3 |
| Scatter plot (Trend): | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| Discussion Questions: | 0 | 1 | 2 | 3 | 4 | 5 |
| Conclusion: | 0 | 1 | 2 | 3 | 4 |
| Work cited: | 0 | 1 | 2 |