Cambridge Assessment International Education

Practical Booklet 3
Investigating osmosis

Cambridge International AS & A Level
Biology 9700

Version 2.0

Cambridge Pathway

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Introduction

Practical work is an essential part of science. Scientists use evidence gained from prior observations and experiments to build models and theories. Their predictions are tested with practical work to check that they are consistent with the behaviour of the real world. Learners who are well trained and experienced in practical skills will be more confident in their own abilities. The skills developed through practical work provide a good foundation for those wishing to pursue science further, as well as for those entering employment or a non-science career.

The science syllabuses address practical skills that contribute to the overall understanding of scientific methodology. Learners should be able to:

1. plan experiments and investigations
2. collect, record and present observations, measurements and estimates
3. analyse and interpret data to reach conclusions
4. evaluate methods and quality of data, and suggest improvements.

The practical skills established at AS Level are extended further in the full A Level. Learners will need to have practised basic skills from the AS Level experiments before using these skills to tackle the more demanding A Level exercises. Although A Level practical skills are assessed by a timetabled written paper, the best preparation for this paper is through extensive hands-on experience in the laboratory.

The example experiments suggested here can form the basis of a well-structured scheme of practical work for the teaching of AS and A Level science. The experiments have been carefully selected to reinforce theory and to develop learners' practical skills. The syllabus, scheme of work and past papers also provide a useful guide to the type of practical skills that learners might be expected to develop further. About 20% of teaching time should be allocated to practical work (not including the time spent observing teacher demonstrations), so this set of experiments provides only the starting point for a much more extensive scheme of practical work.

Guidance for teachers

Aim

To determine the concentration of potato cell content using sucrose solutions of known concentration.

Outcomes

Syllabus section 4.2 (e)

Skills included in the practical

AS Level skills	How learners develop the skills
MMO decisions	Carry out a simple dilution of the 1 mol dm^{-3} sucrose solution
MMO collection	Take quantitative readings of the mass of potato cylinders using a balance
PDO recording	Record quantitative results appropriately in a table
PDO display	Show all steps in the calculation of percentage change in mass
PDO layout	Draw a graph of concentration of sucrose solution against percentage change in mass using processed data
ACE analysis	Find the zero percentage change in mass from the graph drawn
ACE conclusions	Explain the trend shown by the graph and the reason why zero percentage change in mass shows the sucrose concentration with the same water potential as the potato cells

Method

- Learners will need an understanding of the process of osmosis and the concept of water potential before carrying out this practical. It is important that they understand how the net movement of water molecules into or out of a cell is affected by the water potential gradient between the cytoplasm of the cell and its environment. They should also have been taught that when the water potential of the cytoplasm in a cell is equal to that in its environment there will be no net movement of water molecules by osmosis.
- Learners are supplied with a 1 mol dm^{-3} sucrose solution. They are asked to carry out a simple dilution to produce 6 concentrations between 1 mol dm^{-3} and 0 mol dm^{-3}. They will need 25 cm^3 of each concentration. This task gives learners the opportunity to make decisions about which concentrations they should select and the volumes of sucrose solution and distilled water that they need in order to make these solutions. The solutions can be made directly into test-tubes which have been labelled by the learner.
- Learners are asked to cut 6 cylinders from a fresh potato; each should be 5 cm long. This could be done using a cork borer or chips could be made using a sharp knife. It is important that the surface area of the potato cylinders is constant and that the potato skin has been removed.
- The potato cylinders should be gently blotted dry with a paper towel. This will remove any liquid which has leaked out of cells that were damaged when the cylinders were cut.
- The learners will measure the mass of a potato cylinder. The mass should then be recorded in their results table. The potato cylinders are unlikely to start at the same mass so it is important that the starting mass of each potato cylinder is recorded next to the appropriate concentration of sucrose solution into which the potato will be placed. This will allow the starting mass of a cylinder to be compared to the final mass of the same cylinder after it has been soaked in a sucrose solution.

Guidance for teachers, *continued*

- Each potato cylinder should be put into the appropriate sucrose solution using forceps. The learner should place a bung into each test-tube. The potatoes should then be left to soak for one hour. The importance of the bung can be discussed with learners. It prevents evaporation which could cause a change in concentration of the solution. In this experiment this would be unlikely to be a significant error as the tubes are only left for an hour. However, if they were to be left overnight, the error due to evaporation would become more significant.
- After an hour the potatoes should be removed from the solutions. Learners should gently blot each potato dry. This is important as it removes the solution that is clinging to the outside of the potato cylinder. If blotting is not done then this would be an error as the volume of solution on the outside of the cylinder would vary between cylinders. The mass is being recorded to give an indication of the volume of water in the cytoplasm of the cells in the potato.
- Learners will then measure the final mass of the cylinders. Again it is important that the final mass of each cylinder is recorded in the table next to the concentration of solution that the potato was removed from.

Results

Learners should have prepared a table similar to the one below. They should be reminded that this is an appropriate results table because the:

- table has been drawn with lines separating each of the columns and rows
- independent variable is in the first column
- column headings are descriptive
- units are included in the column headings, not next to each result recorded in the table.

concentration of sucrose solution / mol dm^{-3}	**start mass of potato cylinder / g**	**final mass of potato cylinder / g**
0.0		
1.0		

The need to record the same number of significant figures for each measurement should be emphasised.

Interpretation and evaluation

- As each potato cylinder started with a different mass it is not possible to draw conclusions from the raw data, so it must be processed to allow the cylinders to be compared.
- Learners are asked to calculate the percentage change in mass of each cylinder and they should be encouraged to show each step in one worked example. They should draw a new table to record the processed data. The need to record the same number of significant figures for each calculation should be emphasised.

Guidance for teachers, *continued*

- The results of the experiment will be used to plot a graph to show the relationship between the concentration of sucrose solution and the percentage change in mass of the cylinder. This provides an opportunity to plot a graph which has both positive and negative values on the *y*-axis. When drawing the graph it would be helpful to re-enforce the following points:
  - the independent variable should be on the *x*-axis and the dependent variable on the *y*-axis
  - the axes should have descriptive labels, including units
  - the scale should enable more than half the graph paper to be used for plotting points
  - the points should be drawn with a sharp pencil, as a small cross or a small dot in a circle
  - the points should be connected with straight lines drawn with a ruler from the centre of each cross.
- Learners are then asked to read from their graph the concentration of sucrose solution at which the percentage change in mass of the potato cylinder is zero. This is the sucrose solution which has the same concentration as the contents of the cytoplasm within the cells in the potato cylinders.
- Learners will write a conclusion explaining the trend shown by the graph using their knowledge of osmosis and water potential. They should be able to explain why:
  - some potato cylinders gained mass
  - some potato cylinders lost mass.
- Learners should conclude that a potato with a zero percentage change in mass was in a sucrose solution with the same water potential as the potato cells.

Information for technicians

Each learner will require:

- at least 100 cm^3 1.0 mol dm^{-3} sucrose solution
- at least 100 cm^3 distilled water
- 2 × 10cm^3 syringes
- 6 × large test-tubes (boiling tubes) and bungs
- 1 × test-tube rack to hold large test-tubes
- 1 × marker pen
- 1 × potato
- 1 × cork borer
- 1 × white tile
- 1 × knife
- 1 × ruler
- 4 × paper towels
- access to a balance
- 1 × stopwatch
- 1 × glass rod
- 1 × forceps

There are no specific hazards for this investigation.

Worksheet

Aim

To determine the concentration of potato cell content using sucrose solutions of known concentration.

Method

You need to carry out a simple dilution of the 1.0 mol dm^{-3} sucrose solution to produce 6 different concentrations of sucrose solution ranging from 1.0 mol dm^{-3} to 0.0 mol dm^{-3}.

1. Complete the table below by writing in the concentration of sucrose solutions you will prepare.
2. Decide the volumes of 1.0 mol dm^{-3} sucrose solution and distilled water you will need to make 25 cm^3 of each of the concentrations of sucrose shown in the table below. Record these in the table.

concentration of sucrose solution / mol dm^{-3}	**volume of 1 mol dm^{-3} sucrose solution / cm^3**	**volume of distilled water / cm^3**
1.0	25	0
0.0	0	25

3. Label large test-tubes with these concentrations.
4. Prepare the 6 concentrations of sucrose solutions in the labelled test-tubes.
5. Cut 6 cylinders of potato using a cork borer, each should be 5 cm long.
6. Each cylinder should be gently blotted with a paper towel.
7. Measure the mass of one of the potato cylinders.

   Note: This potato cylinder is going to be soaked in 1.0 mol dm^{-3} sucrose solution.
8. Record the mass of this potato cylinder in a results table.
9. Put the potato into the test-tube containing the 1.0 mol dm^{-3} sucrose solution.
10. Repeat steps **7** to **9** for each of the other sucrose solutions you have prepared.
11. Leave the potato cylinders to soak for one hour.
12. After one hour, remove the potato cylinder from the 1.0 mol dm^{-3} sucrose solution.
13. Gently blot the cylinder with a paper towel.
14. Measure the mass of the potato cylinder and record its mass in a results table.
15. Repeat steps **12** to **14** with each of the other potato cylinders. You should remove them from their solutions in the same order that you put them in.

Worksheet, *continued*

Results

Record your results in an appropriate table. When drawing a results table remember that you should:

- put the independent variable in the first column
- use descriptive column headings
- include units in the column headings only.

Interpretation and evaluation

1. Calculate the percentage change in mass of each cylinder. You should show all the steps in your calculation for one cylinder. Record these processed results in a table.
2. Plot a graph to show the relationship between the concentration of sucrose solution and the percentage change in mass of the cylinders.
3. Use your graph to find the concentration of sucrose at which the percentage change in mass of the potato cylinder is zero.
4. Explain the trend shown by the graph using your knowledge of osmosis and water potential. You should be able to explain why:
    - some potato cylinders gain mass
    - some potato cylinders lose mass
    - there is a concentration of sucrose at which there is no percentage change in mass of the potato cylinder.

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