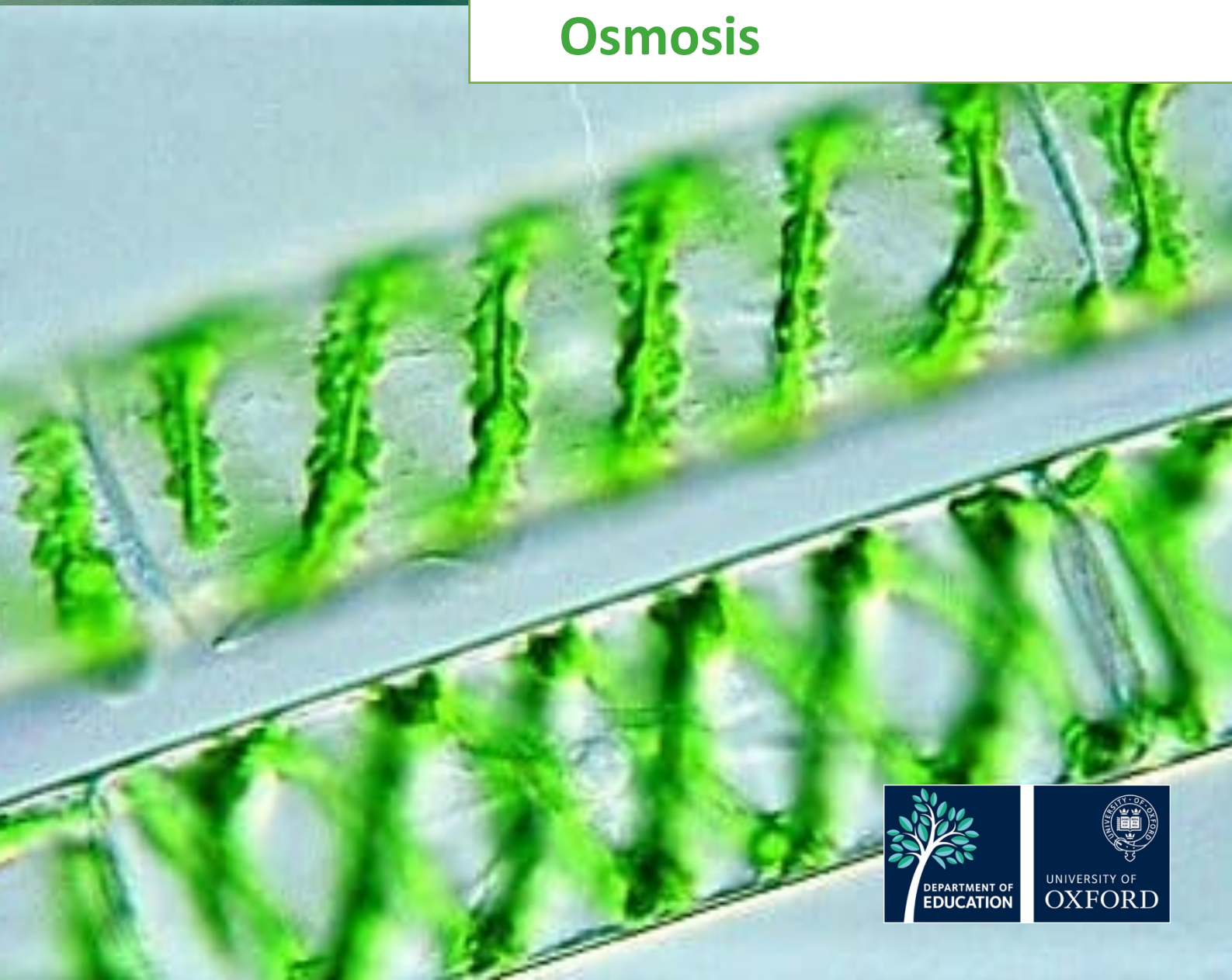


# Summative Assessment Resources for Practical Science

## Biology

### Osmosis



## About Project Calibrate

Project Calibrate is a research and development collaboration between University of Oxford and AQA, and aims to foster effective teaching, learning and assessment of practical science. The resource pack contains five summative assessments developed as part of the project to assess learners' understanding of and skills in GCSE practical science. The underlying framework of practical science is Brandon's matrix which highlights a variety of methods used in science. According to Brandon, there are four main categories of scientific methods (described on the next page). Four assessment tasks were designed using each category. The fifth assessment task includes all four categories and engages the learners in an evaluation of the different scientific methods.

## Principal Investigator

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## Project team

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Project Calibrate (2020). *Summative Assessment Resources for Practical Science: Osmosis*. Oxford: University of Oxford.

## Brandon’s Matrix

Brandon provides an account of diversity in scientific methods. His framework has been adapted by Project Calibrate (see Table 1) and illustrates that not all experiments rely on hypothesis testing, and that not all descriptive work is non-manipulative. Brandon represents the connections between experiments and observations in terms of a matrix (i.e. two-by-two table) in which an investigation (experiment/observation) is related to whether or not it involves manipulation, and whether or not it involves hypothesis testing or parameter measurement.

**Table 1.** Adaptation of Brandon’s matrix

		Experiment or observation	
		Change variable	Don’t change variable
Test hypothesis	Manipulative hypothesis testing		Non-manipulative hypothesis testing
	Describe or measure	Manipulative description or parameter measurement	Non-manipulative description or parameter measurement

The importance of the matrix is that it challenges the traditional linear model of the scientific method in the science curriculum. A fairly typical depiction in school of how science is done involves the so-called ‘scientific method’, which is described as a process through which scientists produce robust evidence by applying procedures such as experimentation and observation. According to this model, scientists begin with a question they want to answer. They then design an experiment and, by carefully tracing independent and dependent variables, they produce findings that help them answer the question. However, such a step-wise and linear description of the scientific method is simplistic and hardly a realistic representation of how scientists actually do science. Rather, scientists engage in a wide array of methods some of which include hypothesis testing, and some other approaches including those where there is no manipulation of variables (Erduran & Dagher, 2014).

A contemporary example about Brandon’s matrix involves the Covid-19 pandemic (Erduran, Childs & Baird, 2020). Scientists collect data on how the virus might be influencing a patient’s breathing over a period of time. Such observation is simply based on the recording of parameters where there is no manipulation of variables in the sense of an experimental design. Sometimes the data might be subjected to hypothesis testing about correlation between incubation period and extent of lung disease, but without an experiment resulting in non-manipulative hypothesis testing. Scientists may conduct randomised control trials in which a drug could be treated as a variable in interventions that also include control groups to test the placebo effect. All of these different approaches are used in science, and there is no one single method but rather a diversity of scientific methods.

## References

Brandon, R. (1994). Theory and experiment in evolutionary biology. *Synthese*, 99, 59-73.

Erduran, S., Childs, A., & Baird, J. (2020). Practical science and pandemics. <https://www.bera.ac.uk/blog/practical-science-and-pandemics>

Erduran, S., & Dagher, Z. (2014). *Reconceptualising the nature of science for science education: Scientific knowledge, practices and other family categories*. Dordrecht: Springer.

## Biology: Osmosis

### Question 1 [manipulative hypothesis testing]

A student investigated how temperature affects the rate of osmosis in potato cells. This is the method used:

1. Fill a beaker with distilled water at 50°C.
2. Cut a piece of potato to 2 cm long.
3. Put the piece of potato in the beaker of water for 45 minutes.
4. After 45 minutes, remove the potato and measure its length.
5. Calculate the percentage change in length.
6. Repeat steps 1 to 5 at 10°C, 20°C, 30°C and 40°C.

All the potatoes increased in length due to osmosis.

**Table 1** shows the results.

**Table 1**

Temperature in °C	10	20	30	40	50
Percentage change in length	5	18	22	24	16

1.1 Describe the results shown in **Table 1**.

[2 marks]

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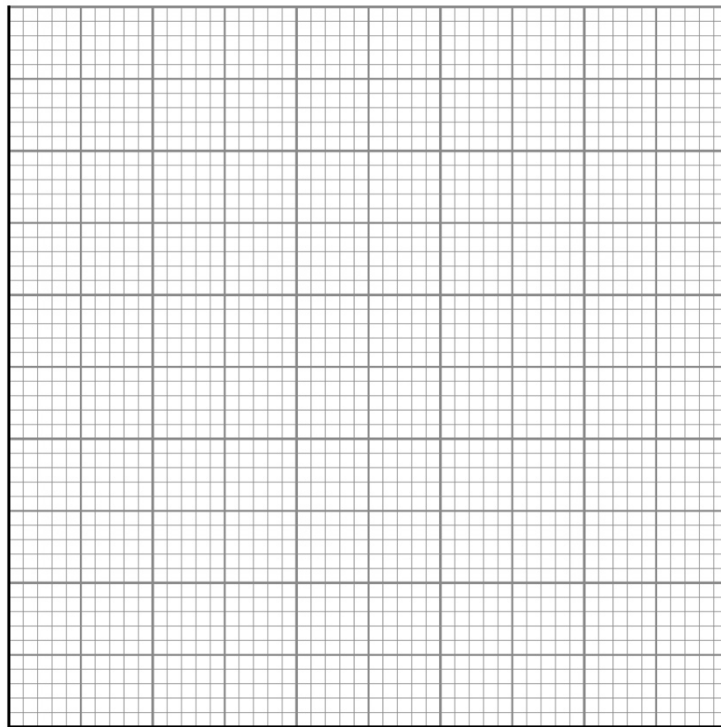
1.2 Draw a graph of the results in **Table 1** on **Figure 1**:

You should:

- label each axis
- choose a suitable scale for each axis
- plot the results
- draw a line of best fit.

[5 marks]

**Figure 1**



The student's hypothesis was 'temperature speeds up the rate of osmosis.'  
Do the data support the student's hypothesis?

1.3 Use your graph in **Figure 1** to justify your answer.

[2 marks]

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1.4 Predict the percentage change in length at 60°C.

[1 mark]

Prediction \_\_\_\_\_ %

1.5 The student repeated the investigation at each temperature.  
How does repeating an investigation improve the results?

Tick (✓) **one** box.

[1 mark]

- Makes the measurements more accurate
- Makes the measurements repeatable
- Makes the measurements more precise

1.6 Which statement best describes what the student did in his experiment?

Tick (✓) **one** box.

[1 mark]

- Tested a hypothesis and did **not** change any variables
- Tested a hypothesis and changed **at least one** variable
- Did **not** test any hypothesis and did **not** change any variables
- Did **not** test any hypothesis but changed **at least one** variable

**Question 2 [non-manipulative parameter measurement]**

A student observed what happened when blood was placed in distilled water.

**2.1** The student thought that the red blood cells would burst.  
Which word describes this sentence?

Tick (✓) **one** box.

**[1 mark]**

- Prediction
- Observation
- Classification
- Communication

**2.1** Suggest what would happen if a plant cell were placed in distilled water. Give a reason for your answer.

**[2 marks]**

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**2.2** A student said: 'This practical activity was **not** scientific because no variables were altered'.  
Why is this statement incorrect?

**[1 mark]**

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**2.3** Suggest one way the student could adapt this experiment to make another observation.

**[1 mark]**

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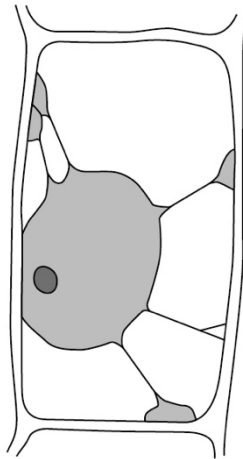
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**Question 3 [non – manipulative hypothesis testing]**

A student investigated the effect of concentrated sugar solution on onion cells. The student said that the plant cells would absorb the sugar solution and swell up.

**Figure 2** shows a magnified image of one of the onion cells that had been in a concentrated sugar solution for 10 minutes.

**Figure 2**



**3.1** Explain what has happened to the onion cell shown in **Figure 2**.

**[4 marks]**

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**3.2** Which statement best describes what the student did in his experiment.

Tick (✓) **one** box.

**[1 mark]**

- Tested a hypothesis and did **not** change any variables
- Tested a hypothesis and changed **at least one** variable
- Did **not** test any hypothesis and did **not** change any variables
- Did **not** test any hypothesis but changed **at least one** variable

#### Question 4 [manipulative parameter measurement]

A student investigated the effect of placing potato chips in different concentrations of sugar solutions.

This is the method he used:

1. Prepare six different concentrations of sugar solution in separate boiling tubes.
2. Cut six equal sized pieces of potato.
3. Dry each potato chip and record its mass.
4. Place one potato chip in each boiling tube and leave for 2 hours.
5. Remove the potato chips and dry them before recording the final mass.

4.1 Give **two** variables the student should control in this investigation.

[2 marks]

1. \_\_\_\_\_
2. \_\_\_\_\_

4.2 What was the independent variable in this investigation?

\_\_\_\_\_ [1 mark]

4.3 The mass of one of the potato chips was 4.1g at the start and 4.5g after being in the sugar solution.

Calculate the percentage increase in mass of this potato chip.

[2 marks]

\_\_\_\_\_  
\_\_\_\_\_

Percentage increase in mass = \_\_\_\_\_ %

Table 2 shows the results of the student's investigation.

Table 2

Concentration of sugar solution in mol/dm <sup>3</sup>	Percentage change in mass
0.0	+23
0.2	+10
0.4	+1
0.6	-10
0.8	-15
1.0	-19

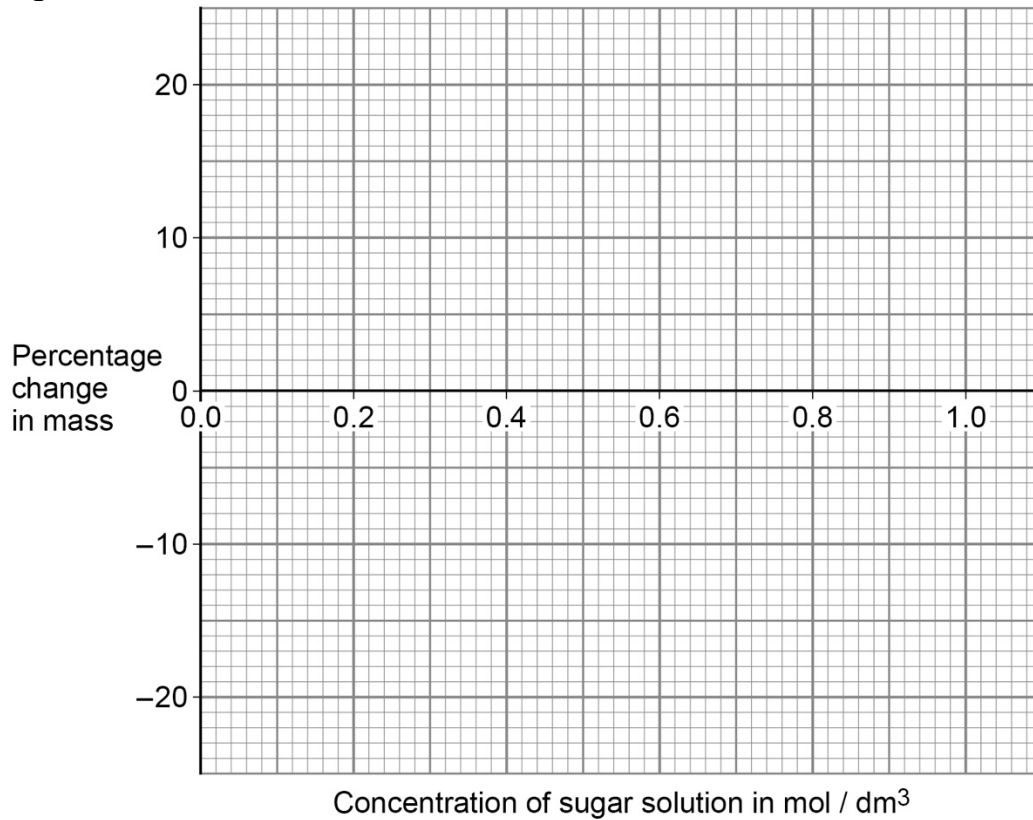
4.4 Use data from **Table 2** to complete the graph in **Figure 3**

You should:

- plot the data
- draw a line of best fit.

[3 marks]

**Figure 3**



4.5 Use your graph to determine the concentration of sugar solution inside the potato chips.

[1 mark]

Concentration = \_\_\_\_\_ mol/dm<sup>3</sup>

### Question 5 [combined task]

Jacob, Lucy, Ella and Riley are studying osmosis.

The sentences below show five different scenarios. Read the scenarios and answer the questions that follow:

- Jacob investigated how temperature affects the rate of osmosis in potato cells. He placed potato pieces in distilled water at different temperatures and calculated their change in mass.
- Lucy observed what happened when a red blood cell was placed in distilled water.
- Ella tested whether plants absorbed sugar through their cell membranes by observing what happened when a plant cell was placed in a concentrated sucrose solution.
- Riley determined the concentration of sugar solution inside potato chips by placing the potato chips in different concentrations of sugar solutions and using a graph of the results to find his desired concentration.

5.1 Name **one** student who tested a hypothesis and justify your answer.

[2 marks]

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5.2 Name **one** student who tested a hypothesis but did **not** change any variable. Justify your answer.

[2 marks]

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5.3 Name **one** student who did not test a hypothesis but changed variables and collected data.

[1 mark]

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5.4 Name **one** student who did not test a hypothesis and did **not** change any variables.

[1 mark]

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## Mark scheme

### Question 1

Question	Answers	Extra Information	Mark	AO/Spec. Ref
1.1	Change in mass increases and decreases as temperature increases  Decrease is at 40°C		1  1	AO2 / WS3.2
1.2	Each axis correctly labelled  Suitable scale on each axis  All points correctly plotted  Line of best fit	Allow 1 mark for 3 correct points	1  1  2  1	AO2 / WS3.1 WS3.2
1.3	Hypothesis is correct until 40°C  Above 40 °C the trend does not follow the hypothesis		1  1	AO2 / AO3 WS3.6
1.4	Extrapolation on graph		1	AO3 / WS3.4
1.5	Makes the measurements repeatable		1	AO2 / WS3.7
1.6	Tested a hypothesis and changed <b>at least one</b> variable		1	AO2 / WS2.2 WS2.7
<b>Total</b>			<b>12</b>	

## Question 2

Question	Answers	Extra Information	Mark	AO / Spec. Ref
2.1	Prediction		1	AO1
2.2	The plant cell would get bigger but not burst  The cell wall would prevent it bursting	Allow ref to turgidity	1  1	AO3
2.3	Because scientists use observations as evidence to draw conclusions		1	AO1 / WS2.7
2.4	Any 2 from  Use other animal cells / named  Use a plant cell / named  Investigate cells in different sugar / salt concentrations	Allow any sensible suggestion	2	AO3 / WS2.7
<b>Total</b>			<b>6</b>	

### Question 3

Question	Answers	Extra Information	Mark	AO/Spec. Ref
3.1	Contents of the cell have shrunk/ pulled away from the cell wall		1	AO2 / WS2.2 WS3.2
	The cell is plasmolysed/ flaccid		1	
	There is a higher concentration of water in the cell		1	
	So water moves out the cell by osmosis		1	
3.2	Tested a hypothesis but did not change any variables		1	AO2 WS2.7
<b>Total</b>			<b>5</b>	

### Question 4

Question	Answers	Extra Information	Mark	AO/Spec. Ref
4.1	Any two from:	Allow any correct control variable	2	AO3 / WS2.2
	Keep the temperature the same for each concentration			
	Equal length of potato			
	Keep the same time for each one in the solution			
4.2	Concentration of sugar solution		1	AO3
4.3	10%	Allow 1 mark for 0.4/4.1	2	AO2 / WS3.5
4.4	Data plotted correctly		1	AO2 / WS3.1 WS3.2
	Line of best fit		1	
4.5	Correct value from student's graph		1	AO3 / WS3.5
<b>Total</b>			<b>8</b>	

**Question 5**

<b>Question</b>	<b>Answers</b>	<b>Extra Information</b>	<b>Mark</b>	<b>AO/Spec. Ref</b>
5.1	Jacob OR Ella  Jacob tested whether temperature affected the rate of osmosis  OR  Ella tested whether plant cells absorb sugar through their membrane		<b>1</b>  <b>1</b>	AO1 / AO3 / WS2.7
5.2	Ella  Ella tested whether plant cells absorbed sugar without changing any variables		<b>1</b>  <b>1</b>	AO1 / AO3 / WS2.7
5.3	Riley		<b>1</b>	AO1 / AO3 / WS2.7
5.4	Lucy		<b>1</b>	AO1 / AO3 / WS2.7
<b>Total</b>			<b>6</b>	

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