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EB Education Revision Guide

How to work with Required Practicals: Part 5
Triple (AQA Biology Paper 1& 2 2022)

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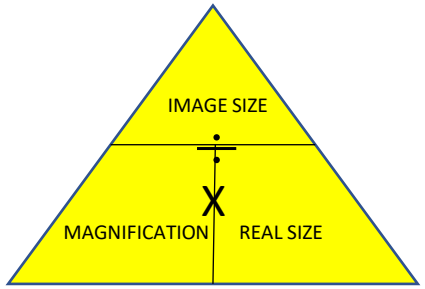
Assessed Required Practical Activities
Paper 1
Foundation

Required practical activity 1: how a light microscope is used to observe plant cells.
Required practical activity 3: investigate the effect of a range of concentrations of salt solution on the mass of plant tissue.
Required practical activity 4: use qualitative reagents to test for a range of carbohydrates, lipids and proteins.
Required practical activity 6: investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed.

Higher

Required practical activity 1: how a light microscope is used to observe plant cells.
Required practical activity 3: investigate the effect of a range of concentrations of salt solution on the mass of plant tissue.
Required practical activity 4: use qualitative reagents to test for a range of carbohydrates, lipids and proteins.

Practical 1: Using a Microscope



What you need to know

- Be able to label a light microscope (see diagram)
- Be able to explain how to set up a microscope slide and look at it under a microscope (always start with the lowest magnification).
- Remember and rearrange the equation
- Know the units and how to convert between them

  1m = 1000mm

  1mm = 1000µm

  1µm = 1000nm

You may need a ruler to measure the size of images and work out their real size.

- Explain that we can see the nucleus and cell wall but not the mitochondria as they're far too small and not stained.
- Explain how we could see smaller parts of cells by using an electron microscope which has much more resolution and magnification.

REMEMBER:
Use a stain to make things visible.
Get the specimen as flat and thin as possible.
Start on the smallest lens, focus, then move up a lens.

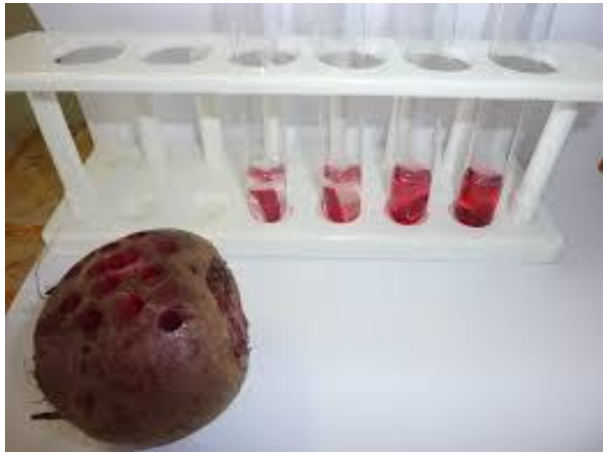
Practical 3: Investigating Osmosis

What you need to know

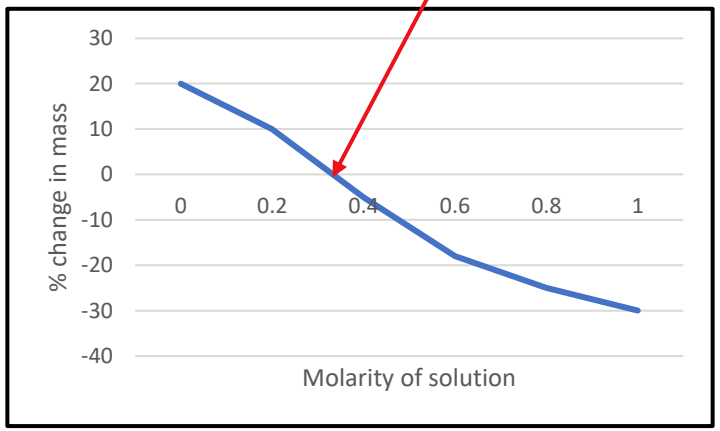
- Be able to explain that osmosis is the movement of water through a partially permeable membrane. The water moves from an area of high concentration of water to an area of lower concentration of water.
- Explain that vegetables placed in a concentrated sugar solution will lose weight as water moves out of the cells into the solution.
- Explain that vegetables placed in a dilute solution will gain weight as water moves into them from the solution.
- Explain that the vegetables will remain the same weight if the concentration of the solution is the same as inside the potato.
- Be able to work out percentage change

$$\frac{change\ in\ mass}{original\ mass} \times 100\%$$

- Explain that only the water can move through the partially permeable membrane, as the sugar molecules are too big.



Where there is no mass change the concentration in the solution is equal to the concentration in the vegetable



You may need to answer questions about the control variables (e.g. temperature, volume of solution, amount of time)

You may need to explain how to make sure measurements are accurate e.g. removing excess water with a paper towel

You may need to interpret a graph to find the concentration inside a vegetable cell

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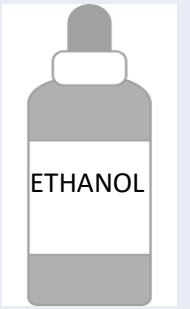
Practical 4: Food Tests

What you need to know

- Be able to describe how to test foods for the presence of starch, protein, reducing sugars (glucose) or fats.
- To explain whether the test is qualitative or quantitative. Most food tests are qualitative – they tell you whether it contains the substance, but do not tell you how much there is. The reducing sugar test will give you an indication of how much sugar is in the food – because of the different colour in the results.
- You may get asked questions on the difficulty of judging colour changes, or how you could make mistakes during the experiments.

Chemical	Tests for:	Method	Result	Chemical	Tests for:	Method	Result
	Starch	Add iodine solution directly to the substance	Turns blue black if starch is present		Protein	Add Biuret's solution to the sample (liquid)	Turns purple if protein present
	Reducing sugar	Add Benedict's solution to the sample (liquid) Heat for 2 minutes in a water bath	Turns brick red (green, yellow orange if less sugar)		Lipid	Add ethanol to the liquid sample and shake Add water	Turns cloudy, milky if lipid present

Practical 6: Photosynthesis

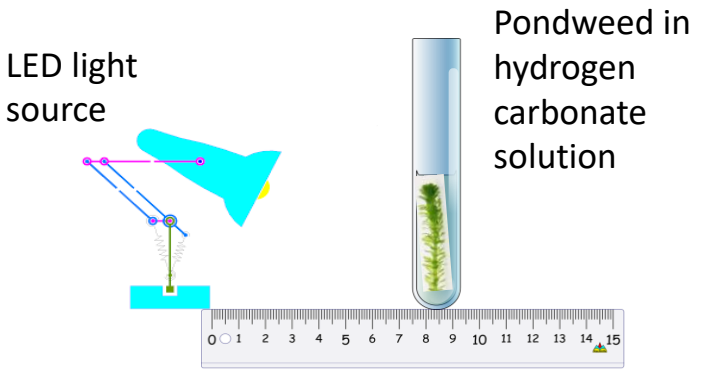
What you need to know

- Photosynthesis takes place in the chloroplasts and needs light energy to take place.
- You need to explain how light intensity affects the rate of photosynthesis.
- You may need to explain how to make the results more accurate. This could be done by using a gas syringe to measure the volume of oxygen produced in a given time, as it is difficult to count very small bubbles, and the bubbles could be different sizes. The heat produced by the lamp could also affect the number of bubbles produced. You could place a glass screen in front of the pondweed to prevent the heat getting through.
- You may also be asked to discuss why the rate of photosynthesis will not increase indefinitely even if you keep increasing the light intensity. This is because there are other limiting factors such as carbon dioxide concentration and temperature.

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

Carbon dioxide + water → glucose + oxygen

Diagram



The lamp is placed at different distances away from the pondweed, and the number of oxygen bubbles produced is counted. The closer the lamp is, the higher the light intensity, and the faster the bubbles are produced – meaning the rate of photosynthesis is higher.

Your turn:

1. The diagram below shows human cheek cells seen under a light microscope.

a) Label a nucleus and a cell membrane on the diagram.

b) Mitochondria and ribosomes cannot be seen in the cells pictured above.

What type of microscope is needed to see mitochondria and ribosomes?

……

c) What is an advantage to using this type of microscope?

……

d) The cheek cells are magnified 250 times. The width of the image of the cell is 45mm.

Calculate the actual width of the cell in µm.

……

……

e) A bacterial cell is 40 times smaller than a red blood cell, which has a diameter of 8µm.

Calculate the diameter of the bacterial cell.

……

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……

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Your turn:

2. A student completed a practical investigating the effect of different concentration sugar solutions on sweet potato.

She used the method below.

- Place 40 cm^3 of 0.8 mol dm^{-3} sugar solution to a boiling tube.
- Repeat this step with 30 cm^3 of water, 0.2, 0.4 and 0.6 mol dm^{-3} solutions.
- Cut five cylinders of the same size using a cork borer.
- Weigh each cylinder using a top-pan balance. Place a cylinder into each tube.
- Remove the cylinders from the test tubes after 24 hours and pat dry with a paper towel.
- Reweigh each cylinder.

The table shows the results.

Concentration of sugar solution (mol dm^{-3})	Starting mass (g)	Final mass (g)	Change of mass (g)	% change in mass
0.0	1.28	1.49	0.21	16.4
0.2	1.34	1.49	0.15	11.2
0.4	1.29	1.35	0.06	X
0.6	1.32	1.27	-0.05	-3.8
0.8	1.20	1.09	-0.11	-9.2

a) Calculate the % change X.

……

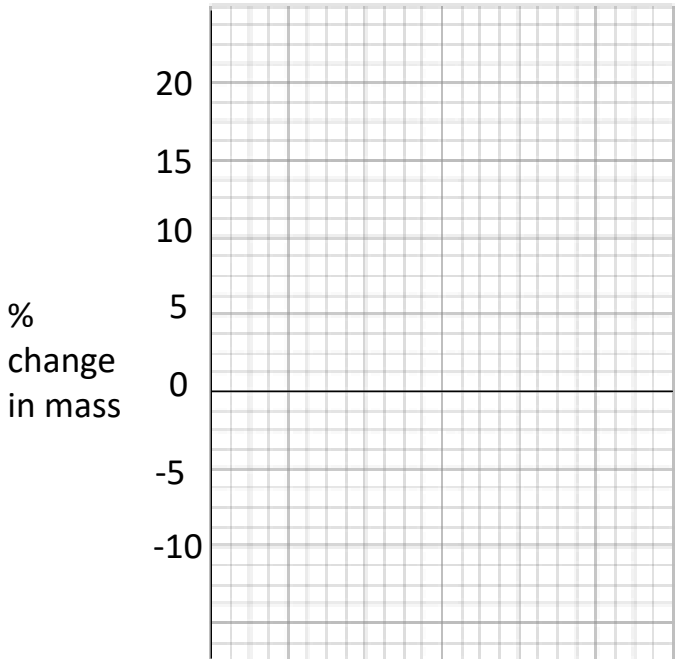
b) Explain why she calculated the % change in mass.

……

c) Complete the graph using results from the table, including:

- A suitable scale.
- Plotting the % change in mass.
- A line of best fit.

Your turn:



d) Use the graph to estimate the concentration of solution inside the sweet potato cells.

……

e) Explain why there are positive and negative percentage changes.

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……

……

f) Give two suggestions for errors in the method.

1……

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2……

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Your turn:

3. Isobel is analysing the content of egg whites.
Describe fully an investigation she could carry out to find out if there is protein present in the egg whites.

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4. Rosie was provided with some test tubes containing samples of glucose at different concentrations:
0M , 0.03M, 0.1M, 1M
She was asked to investigate which test tube contained which glucose solution.
Describe the tests she could carry out.

……
……
……
……

The table below shows what she observed.
Complete the table.

	Tube 1	Tube 2	Tube 3	Tube 4
Observation	Yellow precipitate	Blue solution	Red precipitate	Green precipitate
Glucose concentration (M)				

Your turn:

5a) Plants require light to carry out photosynthesis.
What is the correct equation for photosynthesis?

glucose + oxygen	→	carbon dioxide + water
carbon dioxide + glucose	→	oxygen + water
water + carbon dioxide	→	oxygen + glucose
oxygen + water	→	carbon dioxide + glucose

b) The apparatus below can be used to measure the rate of photosynthesis

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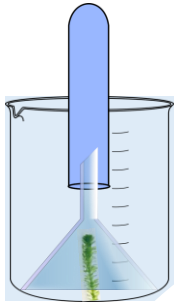
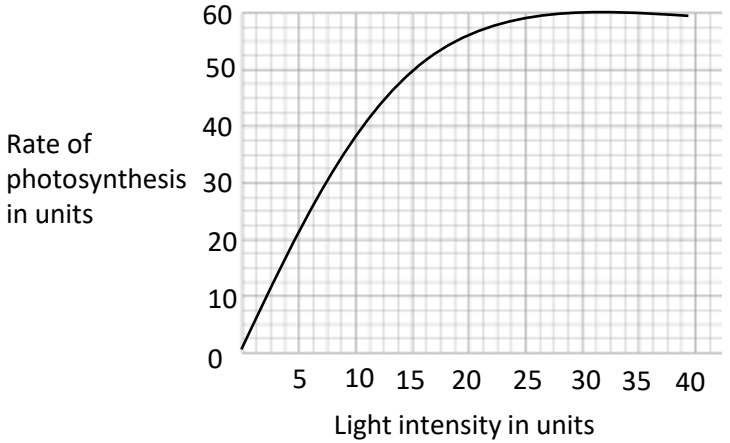


Light intensity affects the rate of photosynthesis.
Describe a method to investigate this.

b) Results from a similar investigation are below.



The scientist concluded that “light stops being a limiting factor at a light intensity of 25 units.”
What evidence supports this conclusion.

What could be a limiting factor at 25 units?

……

Answers:

1. The diagram below shows human cheek cells seen under a light microscope.

a) Label a nucleus and a cell membrane on the diagram.

b) Mitochondria and ribosomes cannot be seen in the cells pictured above.

What type of microscope is needed to see mitochondria and ribosomes?

Electron

c) What is an advantage to using this type of microscope?

Higher magnification/higher resolution

d) The cheek cells are magnified 250 times. The width of image of the cell is 45mm.

Calculate the actual width of the cell in µm.

45/250 = 0.18

180 µm

e) A bacterial cell is 40 times smaller than a red blood cell, which has a diameter of 8µm.

Calculate the diameter of the bacterial cell.

8/40 = 0.2 µm

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Answers:

2. A student completed a practical investigating the effect of different concentration sugar solutions on sweet potato.

She used the method below.

- Place 40 cm^3 of 0.8 mol dm^{-3} sugar solution to a boiling tube.
- Repeat this step with 30 cm^3 of water, 0.2, 0.4 and 0.6 mol dm^{-3} solutions.
- Cut five cylinders of the same size using a cork borer.
- Weigh each cylinder using a top-pan balance. Place a cylinder into each tube.
- Remove the cylinders from the test tubes after 24 hours and pat dry with a paper towel.
- Reweigh each cylinder.

The table below shows the results.

Concentration of sugar solution (mol dm^{-3})	Starting mass (g)	Final mass (g)	Change of mass (g)	% change in mass
0.0	1.28	1.49	0.21	16.4
0.2	1.34	1.49	0.15	11.2
0.4	1.29	1.35	0.06	X
0.6	1.32	1.27	-0.05	-3.8
0.8	1.20	1.09	-0.11	-9.2

a) Calculate the % change X.

0.06/1.29 x 100 = 4.7%

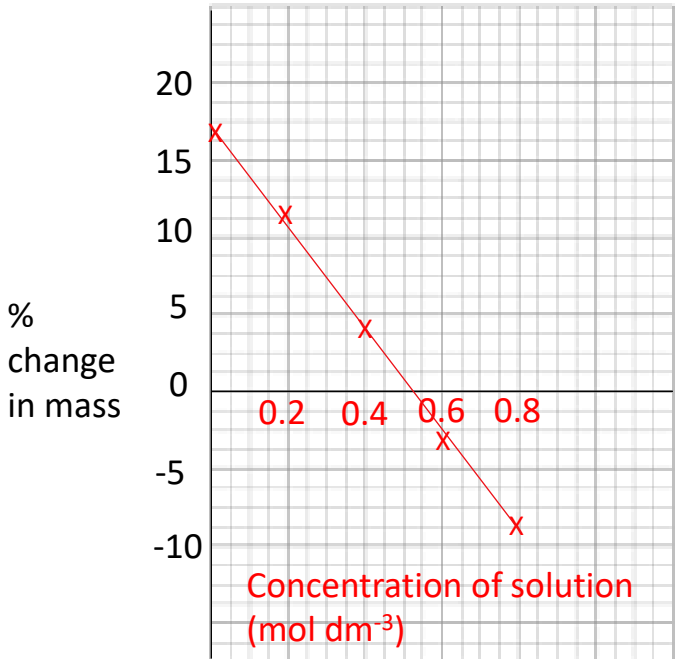
b) Explain why she calculated the % change in mass.

They had different starting masses/allows them to be compared

c) Complete the graph using results from the table, including:

- A suitable scale.
- Plotting the % change in mass.
- A line of best fit.

Answers:



Axis labelled
Correct scale
Correct plotting
Line through points

d) Use the graph to estimate the concentration of solution inside the sweet potato cells.

0.45 – 0.55mol dm^{-3}

e) Explain why there are positive and negative percentage changes.

0 – 0.4 – water moves into cells by osmosis and they gain mass. 0-6 – 0.8 water moves out of cells by osmosis and they lose mass.

f) Give two suggestions for errors in the method.

1. Concentration of solution

2. Drying of chips
   Also – accuracy of balance/evaporation

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Answers:

3. Isobel is analysing the contents of egg whites.
Describe fully an investigation she could carry out to find out if there is protein present in the egg whites.

Add 2cm³ of Biurets reagent to a test tube. This will be blue.
Add some of the egg white to the Biurets solution in the test tube and mix thoroughly.. The blue colour will change to violet if protein is present. If protein is not present, the blue colour will remain.

4. Rosie was provided with some test tubes containing samples of glucose at different concentrations:
0M , 0.03M, 0.1M, 1M
She was asked to investigate which test tube contained which glucose solution.
Describe the tests she could carry out.

Warm the glucose solutions individually with Benedict's solution in a water bath and leave for 5 minutes. If the colour remains blue – no glucose present, there will be a range of colours to indicate how much glucose is in the others (green – red)

The table below shows what she observed.
Complete the table.

	Tube 1	Tube 2	Tube 3	Tube 4
Observation	Yellow precipitate	Blue solution	Red precipitate	Green precipitate
Glucose concentration (M)	0.1M	0M	1M	0.03M

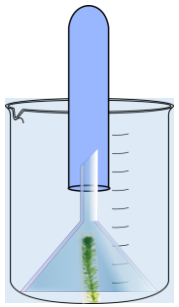
Answers:

5a) Plants require light to carry out photosynthesis.
What is the correct equation for photosynthesis?

glucose + oxygen	→	carbon dioxide + water
carbon dioxide + glucose	→	oxygen + water
water + carbon dioxide	→	oxygen + glucose
oxygen + water	→	carbon dioxide + glucose

b) The apparatus below can be used to measure the rate of photosynthesis

.

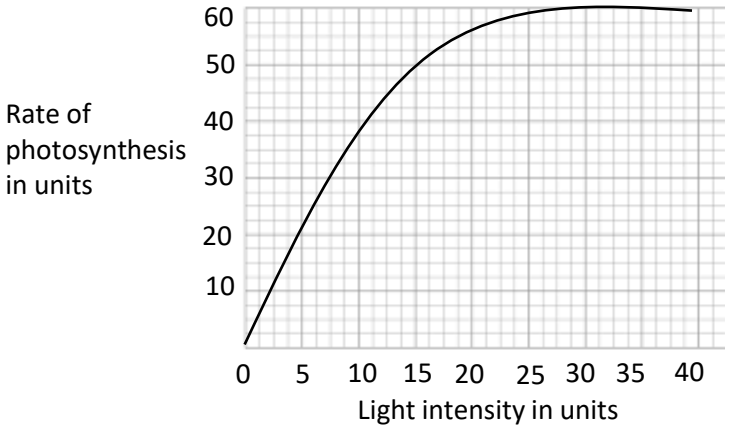


Light intensity affects the rate of photosynthesis.
Describe a method to investigate this.

- Place the lamp at different distances from the pondweed and measure the distances using a ruler. Count the number of bubbles of oxygen produced by the pondweed OR measure the amount of gas produced using a gas syringe at each distance in a given time.
- Keep the same lamp with the same colour light.
- Place a heat filter in front of the lamp to ensure the temperature does not increase.
- Control the supply of carbon dioxide in the water – and ensure the same in each experiment.
- Use the same size and type of pondweed for each experiment.
- Repeat each experiment at least 3 times.
- Calculate the mean from each experiment.

Your turn:

b) Results from a similar investigation are below.



The scientist concluded that "light stops being a limiting factor at a light intensity of 25 units."

What evidence supports this conclusion.

Rate does not increase further when light intensity increases beyond 25 units

What could be a limiting factor at 25 units?

Carbon dioxide concentration or temperature or amount of chlorophyll

Assessed Required Practical Activities
Paper 2
Foundation

Required practical activity 7: carry out an investigation into human reaction times.
Required practical activity 8: investigate the effect of light on the growth of newly germinated seedlings.
Required practical activity 9: measure the population size of a common species in a habitat.

Higher

Required practical activity 8: investigate the effect of light on the growth of newly germinated seedlings.
Required practical activity 9: measure the population size of a common species in a habitat.

Practical 7: Reaction Times

What you need to know

To be able to investigate how different variables affect reaction time.

Messages travel very quickly around your body through the nervous system. This is so that you are able to respond to changes in the environment. The time it takes for you to respond to such a change is called your reaction time.

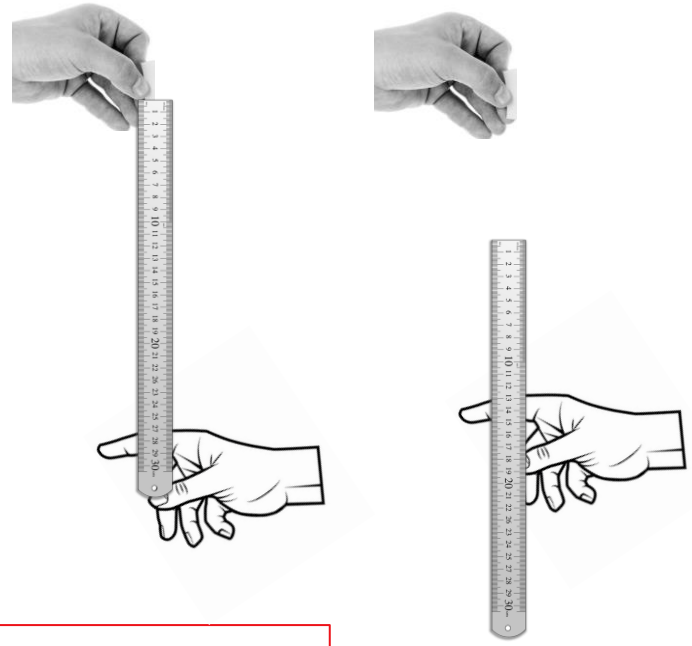
Athletes spend hours practicing to try and to reduce their reaction time. This is to help them improve their performance in their particular sport.

To measure reaction time you could:

- drop a ruler and catch as quickly as you can
- complete an online reaction test

You may be asked about:

- Control variables –e.g. dropping the ruler from the same height, positioning the arm in the same place, using the same hand to catch
- Repeats and calculating the mean
- Control groups – e.g. comparing a group who has taken a stimulant, against a group who hasn't



Possible independent variables:
Practice
Gender
Age
Taking caffeine/alcohol/drugs
Listening to music

Practical 8: Plant responses

KEY WORDS:
Auxin: plant hormone responsible for growth
Tropism: The ability for parts of a plant to move either towards or away from a stimulus
Geotropism: The ability for parts of a plant to move either towards or away from gravity
Phototropism: The ability for parts of a plant to move either towards or away from light

What you need to know

To be able to investigate the effect of light or gravity on the growth of newly germinated seedlings.

- The same number of cress seeds are added to cotton wool in three petri dishes and the same volume of water added to each dish. These are then kept in a warm place to germinate. (Extra water should be added if the cotton wool dries out, but this needs to be consistent across all three dishes).
- Once the seeds have germinated, one dish is placed in full light on a windowsill, the second in a dark cupboard and the final dish will be placed in partial light. (Alternatively cardboard boxes can be used with holes in allowing light to shine in from either side/above/all angles).
- The height of each seedling is measured each day for a week and observations recorded.
- The mean height of the seedlings is calculated.

You may be asked about why the seedlings grow towards the light. You will need to explain how auxins diffuse to the shaded part of the stem and increase the growth rate in the shaded part.

What you will find:

Seeds in full light: These have the least growth but will appear the healthiest.

Seed in partial light: These will grow taller and will move towards the light (positive phototropism). They grow taller than those in light, as they are growing faster on one side in order to reach the light,

No light: These will grow much taller in order to get to light. If they are left longer without light, they will die, as no photosynthesis can take place and they will run out of stores of carbohydrate.

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KEY WORDS:
Population: Total number of individuals in a species living in a particular area
Abiotic: Non-living factors e.g. temperature, pH
Biotic: Living factors e.g. predators, disease

Practical 9:Investigating Population Size

What you need to know

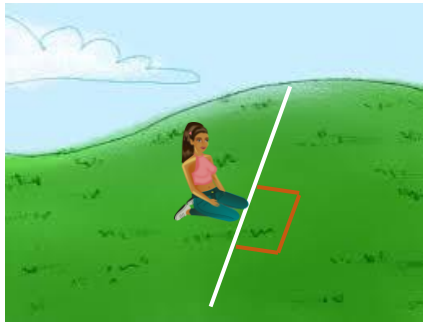
To be able to investigate how different factors affect the distribution of species.

The size of a population of animals or plants in a habitat can be estimated by taking samples of the organisms from the habitat. The larger the sample, the more accurate the estimate of the population size is likely to be. Plants can be sampled more easily than animals because they are unable to move around within the habitat. By sampling, population sizes can be compared between different areas.

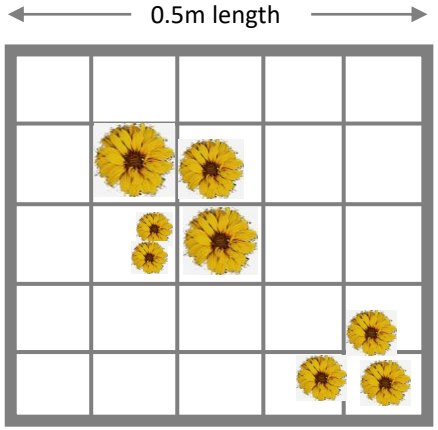
- Random sampling – used when you want to know how the organisms are spread out across an area. You would place the quadrats at random coordinates.
- Line transect – used when you want to see how one particular feature (e.g. a river/road/building) affects an area. You take samples in a line (called a transect) and repeat to compare the difference near and far from the feature.

You will need to be able to calculate the mean and work out an estimate of the total number of a particular species which are present:

Estimated population size = (Area of field ÷ area of quadrat) × mean number of specific individual organisms per quadrat



You would use a quadrat (diagram below) and count the number of individuals within it.



Your turn:

1. Cerys investigated her reaction time.
She used a computer, which measured how quickly she clicked the mouse when she detected each of three different stimuli. These are shown in the diagram below.

She felt a bar vibrate in her hand

She saw a star appear on the screen

She heard a woman shout “Help”

a) What stimulus did each sense organ detect?

Receptors in the skin detected ……
Receptors in the ears detected ……..
Receptors in the eyes detected ……

b) Cerys tested each sense organ 4 times and calculated the mean reaction times.
The results are shown below.

	Reaction time for each sense organ (seconds)		
	Skin	Ears	Eyes
Test 1	0.16	0.15	0.26
Test 2	0.18	0.14	0.23
Test 3	0.17	0.17	0.27
Test 4	0.35	0.14	0.24
Mean reaction time	0.17	0.15	

i) Draw a ring around the anomalous result in the table.

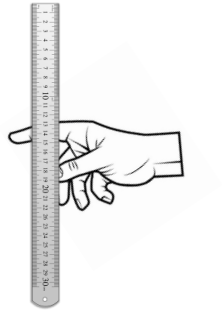
ii) Calculate the mean reaction time for the eyes.
……
……

iii) Give one conclusion from these results.
……

Your turn:

2. Elle and Melanie decided to investigate reflex action times.
Their method is detailed below.

1. Elle sits with her elbow resting on the edge of the table.
2. Melanie holds the ruler making sure the bottom of the ruler is level with Elle's thumb.
3. Melanie drops the ruler.
4. Elle catches the ruler and records the distance the ruler dropped.
5. These steps were repeated 7 times.



a) How could they improve their method to ensure that the test gives valid results?

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Test number	Distance ruler dropped in mm
1	116
2	121
3	115
4	107
5	122
6	126
7	104

b) What is the median result?

c) The mean distance the ruler was dropped is 116mm.

Using the equation below, calculate the mean reaction time.

Reaction time (s) = $\sqrt{\frac{mean\ drop\ distance\ (cm)}{490}}$

……

……

Your turn:

d) Elle's reaction time was then measured using a computer programme.
The method they used is below.

1. A green box is shown on the computer.
2. As soon as the box turns red, Elle has to press any key on the keyboard as fast as she can.
3. She repeats this 5 times and the mean reaction time is shown on the screen.

Her mean reaction time was 105ms.

This method is likely to be more valid than using a dropped ruler.

Suggest two reasons why.

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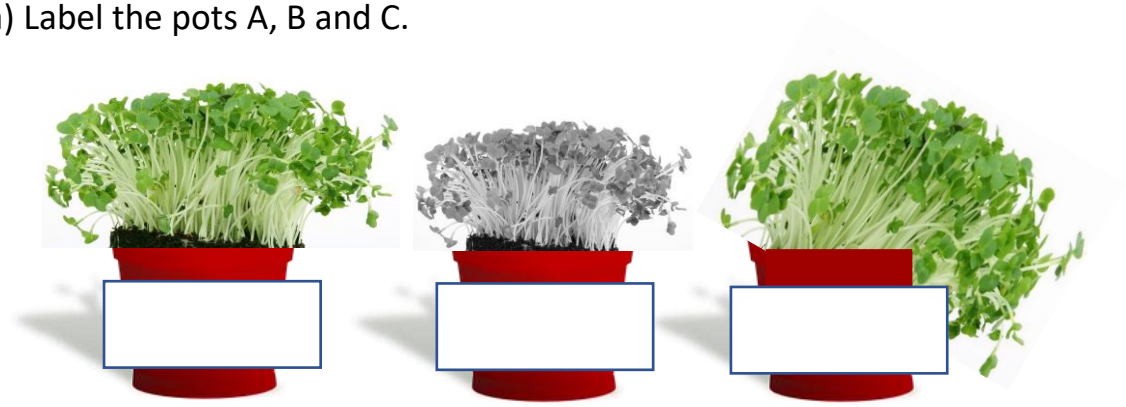
Your turn:

3. Charlie wanted to investigate the effect of light on the growth of cress seedlings.
She had 3 pots of seedlings which she grew in different conditions.
She placed Pot A in a cupboard with no light.
She placed Pot B in a window with light from one direction only.
She placed Pot C with light from above.

Below is a diagram of the seedlings at the end of the investigation.
a) Label the pots A, B and C.



b) Name the response shown by the cress seedlings in Pot B.
……

c) What plant hormone causes the cress seedlings to grow towards the light?
……
……

d) Charlie wanted to investigate where the hormone causing the cress to grow towards the light was found.
She placed two growing plant shoots in a window with light coming from one direction.
Describe a method Charlie could use to show that the hormone was found in the tip of the plant shoot.
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Your turn:

4. Auxins are plant hormones.

a) Explain how auxins cause the shoot of a plant to grow towards the light.

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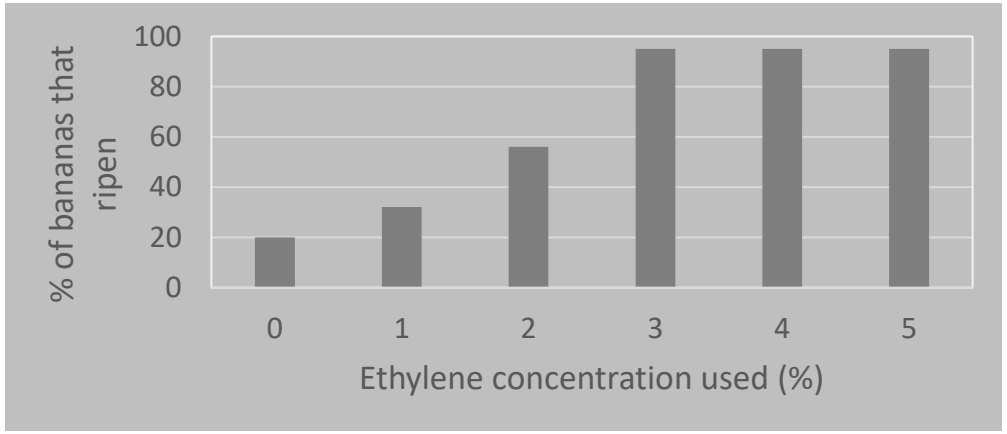
b) A plant hormone called ethylene (ethene) can stimulate fruit to ripen.

The graph below shows the effect of ethylene concentration on the ripening of bananas after 4 days.



i) Describe the effect ethylene has on the ripening of bananas

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ii) Explain which concentration of ethylene should be used by a supermarket to be most cost effective when ripening bananas.

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……

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Your turn:

5. Josh used quadrats to estimate the population of dandelion plants in a field.

a) Describe how Josh should use the quadrats to estimate the number of dandelion plants in the field.

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b) Josh used 0.25m^2 quadrats. The field measured 30m by 155 m.
He found a mean of 0.48 dandelions per quadrat.

Estimate the population of dandelions in the field.

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c) In a corner of the field, there is a lot of grass growing.
Suggest why the dandelions may not grow as well in this area.

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Answers:

1. Cerys investigated her reaction time.
She used a computer, which measured how quickly she clicked the mouse when she detected each of three different stimuli. These are shown in the diagram below.

She felt a bar vibrate in her hand

She saw a star appear on the screen

She heard a woman shout “Help”

a) What stimulus did each sense organ detect?

Receptors in the skin detected ..... Touch
Receptors in the ears detected ..... Sound
Receptors in the eyes detected ..... Light

b) Cerys tested each sense organ 4 times and calculated the mean reaction times.
The results are shown below.

	Reaction time for each sense organ (seconds)		
	Skin	Ears	Eyes
Test 1	0.16	0.15	0.26
Test 2	0.18	0.14	0.23
Test 3	0.17	0.17	0.27
Test 4	0.35	0.14	0.24
Mean reaction time	0.17	0.15	

i) Draw a ring around the anomalous result in the table.

ii) Calculate the mean reaction time for the eyes.

0.26 + 0.23 + 0.27 + 0.24 ÷ 4 = 0.25 seconds

iii) Give one conclusion from these results.

the ears/sound had the shortest/fastest reaction time
the eyes/light had the longest/slowest reaction time
ears/sound and skin/touch had similar reaction times

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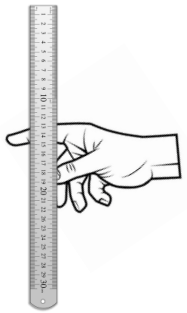
Answers:

2. Elle and Melanie decided to investigate reflex action times.
Their method is detailed below.

1. Elle sits with her elbow resting on the edge of the table.
2. Melanie holds the ruler, making sure the bottom of the ruler is level with Elle's thumb.
3. Melanie drops the ruler.
4. Elle catches the ruler and records the distance the ruler dropped.
5. These steps were repeated 7 times.



a) How could they improve their method to ensure that the test gives valid results?

Drop the ruler from the same height each time
Let the ruler drop without using force
Same type/weight of ruler
Keep thumb in same place at start
Rest arm the same way on the table
Use the same hand to catch the ruler each time

Test number	Distance ruler dropped in mm
1	116
2	121
3	115
4	107
5	122
6	126
7	104

b) What is the median result? 116mm

c) The mean distance the ruler was dropped is 116mm.

Using the equation below, calculate the mean reaction time.

Reaction time (s) = $\sqrt{\frac{mean\ drop\ distance\ (cm)}{490}}$

$\sqrt{11.6/490}$ (change from mm to cm)
= 0.154 seconds

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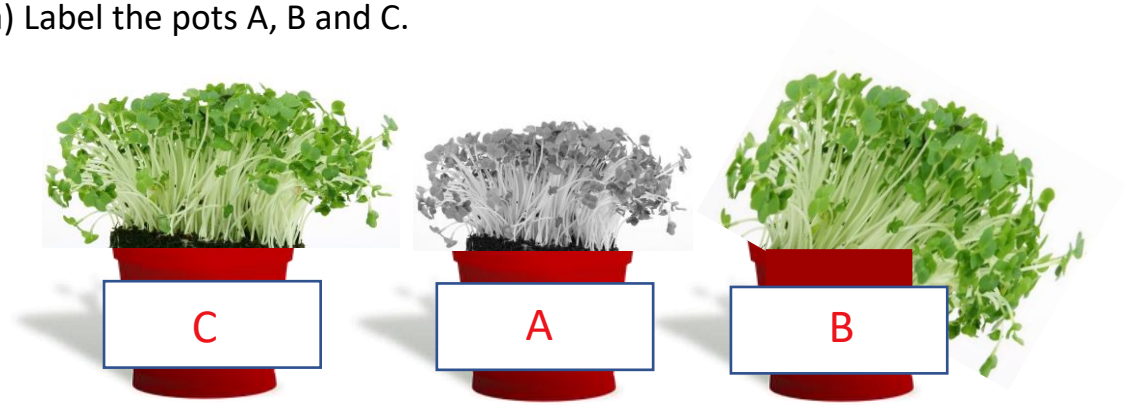
Answers:

3. Charlie wanted to investigate the effect of light on the growth of cress seedlings.
She had 3 pots of seedlings which she grew in different conditions.
She placed Pot A in a cupboard with no light.
She placed Pot B in a window with light from one direction only.
She placed Pot C with light from above.

Below is a diagram of the seedlings at the end of the investigation.
a) Label the pots A, B and C.



b) Name the response shown by the cress seedlings in Pot B.
Positive phototropism

c) What plant hormone causes the cress seedlings to grow towards the light?
Auxin

d) Charlie wanted to investigate where the hormone causing the cress to grow towards the light was found.
She placed two growing plant shoots in a window with light coming from one direction.
Describe a method Charlie could use to show that the hormone was found in the tip of the plant shoot.

Remove the tip from one of the plant shoots and leave the other.
Measure the changes in growth and direction of movement

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Answers:

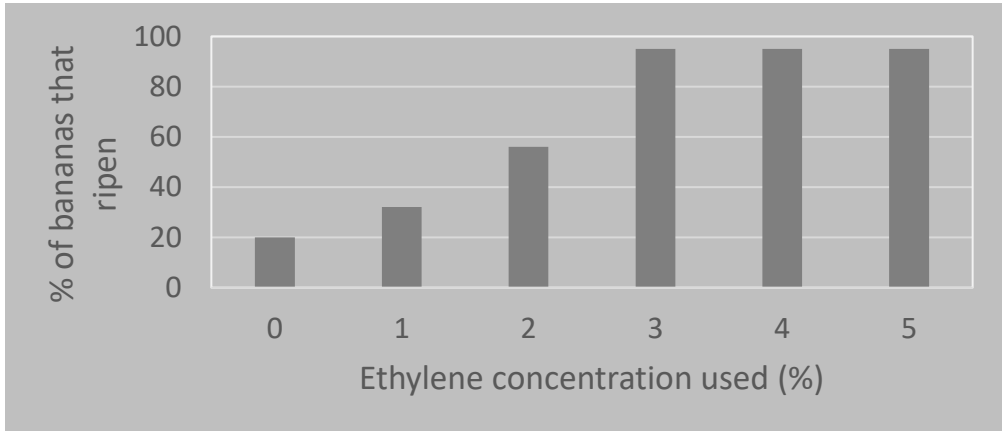
4. Auxins are plant hormones.

a) Explain how auxins cause the shoot of a plant to grow towards the light.

Auxins move to the shaded side of the shoot, causing the cells on the shaded side to elongate

b) A plant hormone called ethylene (ethene) can stimulate fruit to ripen.

The graph below shows the effect of ethylene concentration on the ripening of bananas after 4 days.



i) Describe the effect ethylene has on the ripening of bananas

There is an increase in the % bananas that ripen as the ethylene concentration increases

ii) Explain which concentration of ethylene should be used by a supermarket to be most cost effective when ripening bananas.

3%. It would be more expensive to increase above this when there is no added benefit. Below 3% not all the bananas are ripe

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Answers:

5. Josh used quadrats to estimate the population of dandelion plants in a field.

a) Describe how Josh should use the quadrats to estimate the number of dandelion plants in the field.

Place (a sufficient number of) quadrats randomly in the field.
Count the number of dandelions in each quadrat.
Calculate the mean number of dandelions per quadrat.
Divide the area of the field by the area of the quadrat, then multiply by the mean number of dandelions per quadrat to estimate population

b) Josh used 0.25m^2 quadrats. The field measured 30m by 155 m.
He found a mean of 0.48 dandelions per quadrat.

Estimate the population of dandelions in the field.

(30 × 155) ÷ 0.25 = 18 600

(0.48 × 18 600) = 8928

c) In a corner of the field, there is a lot of grass growing.
Suggest why the dandelions may not grow as well in this area.

Competition for resources including:
- light, water, space, mineral ions (nutrients/salts/ions)

Reference to why growth may be limited:
- less (light) energy for photosynthesis
- less water as a raw material for photosynthesis / support
- less surface area exposed to light
- less sugar / glucose produced in photosynthesis
- less (space) to grow bigger
- less (space) for growth of root system
- less (mineral ions) for growth
- less (mineral ions / sugar) for production of larger molecules

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