

Please check the examination details below before entering your candidate information

Candidate surname <i>StemUp Model Solution</i>		Other names
Centre Number	Candidate Number	

Pearson Edexcel Level 3 GCE

Monday 15 May 2023

Morning (Time: 1 hour 30 minutes)

Paper reference **8BI0/01**

Biology B

Advanced Subsidiary

PAPER 1: Core Cellular Biology and Microbiology

You must have:
Scientific calculator, HB pencil, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
– *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- In question(s) marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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Answer ALL questions.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

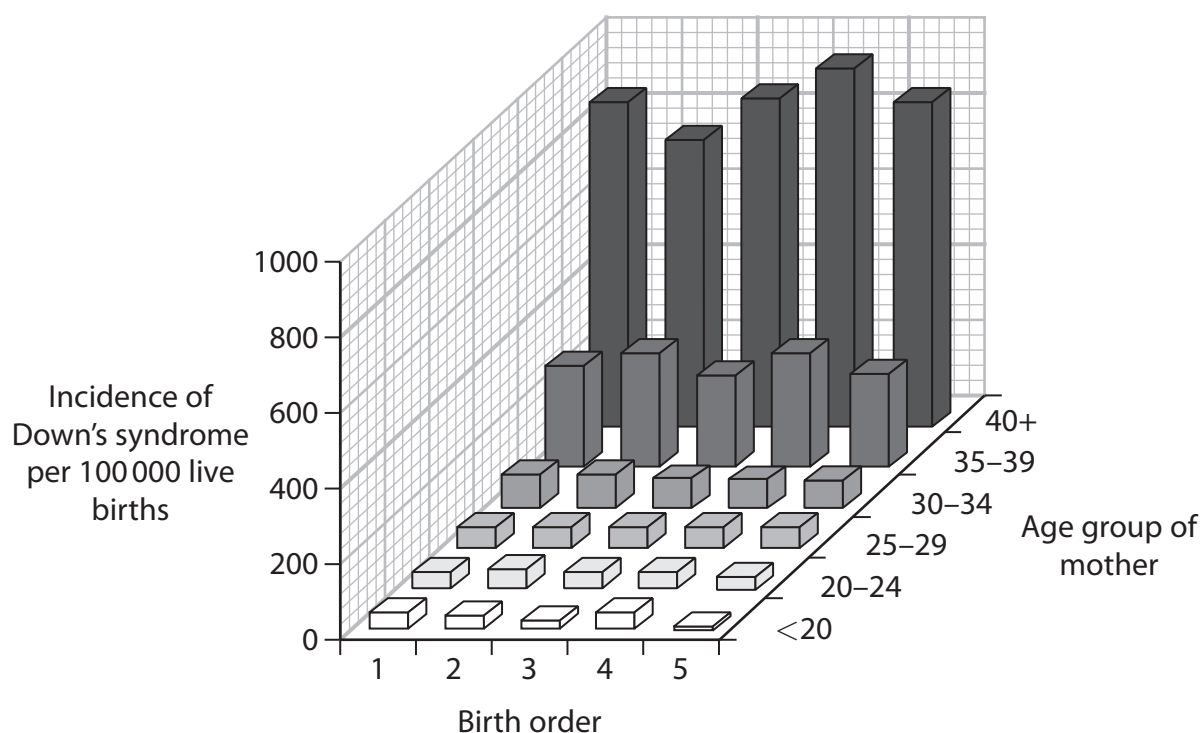
1 Down's syndrome is a genetic condition.

(a) Which row in the table describes the cause of Down's syndrome?

(1)

	Type of mutation	Result of non-disjunction
☐ A	chromosome	monosomy
☒ B	chromosome	polysomy
☐ C	gene	monosomy
☐ D	gene	polysomy

(b) The graph shows the effect of the age of the mother and the order in which babies are born in a family (birth order) on the incidence of Down's syndrome.



Determine the effects of birth order and age of the mother on the incidence of Down's syndrome.

(3)

Birth order has no effect on the incidence of Down's syndrome: there is no pattern, as the incidence is about the same for the 1st to 5th baby within each age group.

The incidence increases as the age of the mother increases, slowly up to 30-34 and then very steeply from 35 onwards.

A mother over 40 has about 80 times greater chance than a mother under 20, and about 4 times greater chance than a mother aged 35-39 (about 500 per 100 000 more births).

(Total for Question 1 = 4 marks)

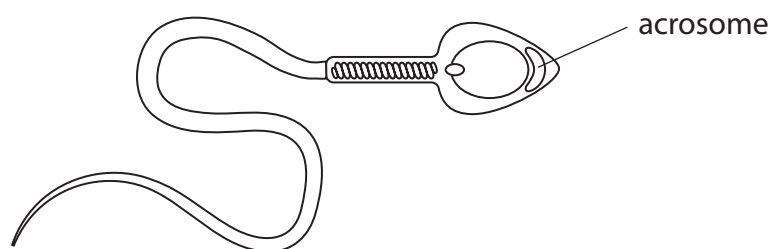
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2 The diagram shows a mature sperm cell.



(a) Describe the role of the acrosome in fertilisation.

(2)

The acrosome releases enzymes that digest (break down) the zona pellucida and the membrane of the egg cell (secondary oocyte).

This allows the sperm nucleus (genetic material) to enter the egg cell.

(b) Describe how the enzymes are synthesised and packaged during the development of the acrosome.

(3)

The genes coding for the acrosome enzymes are transcribed; an mRNA copy is made in the nucleus and leaves through a nuclear pore.

The mRNA is translated at ribosomes on the RER, where amino acids are joined by peptide bonds to synthesise the enzymes.

The enzymes are transported through the RER and then in vesicles to the Golgi apparatus.

The enzymes are modified, processed and packaged in the Golgi into vesicles (membrane), which fuse to form the acrosome.

(Total for Question 2 = 5 marks)



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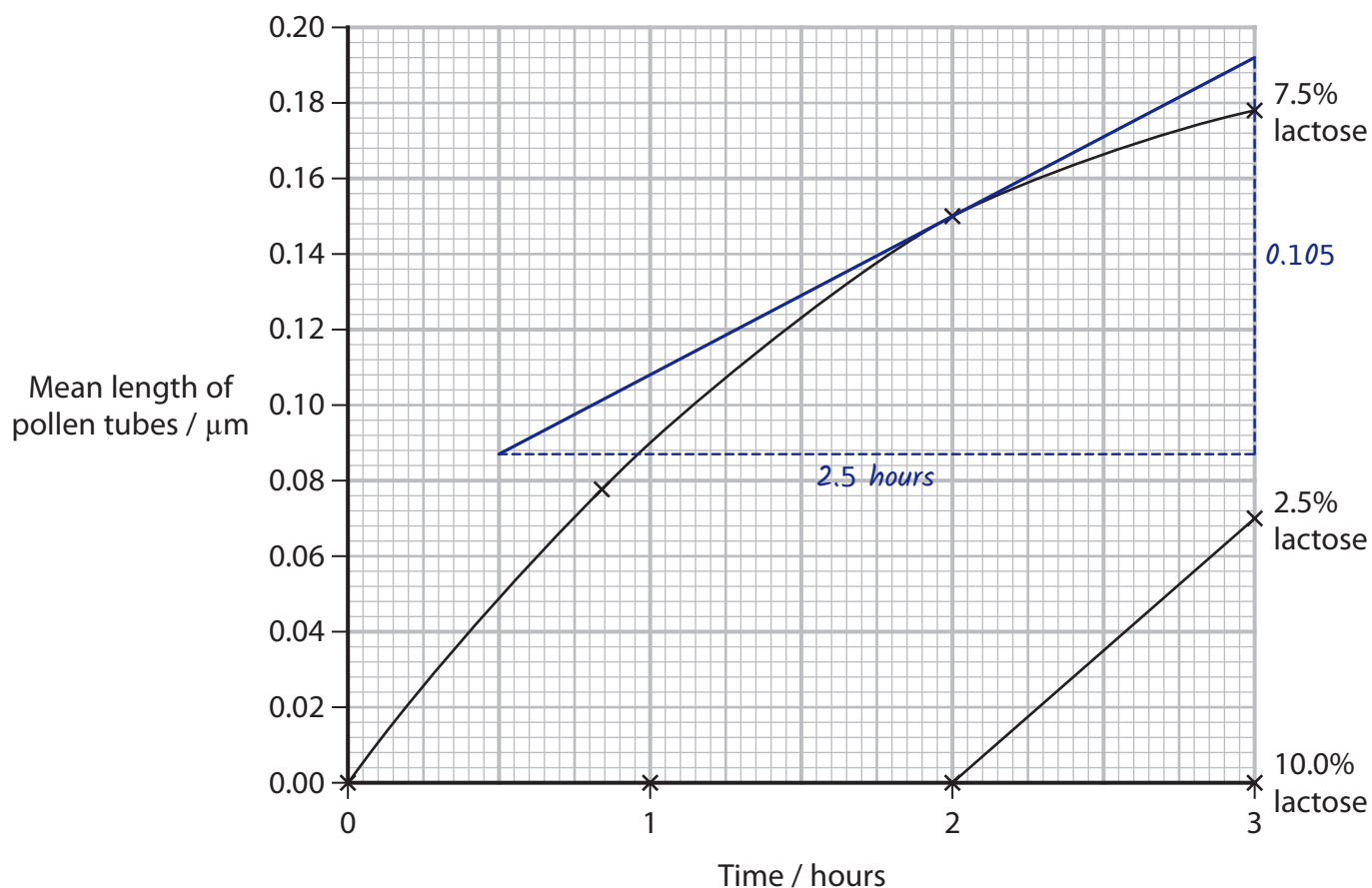
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3 The effect of lactose concentration on the growth of pollen tubes was investigated.

The graph shows the results of this investigation.



(a) Describe the structure of lactose.

(2)

Lactose is a disaccharide made of two monosaccharides: one glucose and one galactose.

They are joined by a 1-4 glycosidic bond, formed in a condensation reaction.

(b) Calculate the rate of growth of the pollen tubes, at 2 hours, for the 7.5 % lactose.

Use a tangent to help you with your calculation.

(2)

$$\text{rate} = (0.192 - 0.087) \div (3.0 - 0.5) = 0.105 \div 2.5$$

Answer 0.042 $\mu\text{m hour}^{-1}$



(c) Describe **three** conclusions that can be made from the results of this investigation.

(3)

Lactose at 2.5% and 7.5% stimulates the growth of the pollen tubes, so pollen tubes can grow in lactose.

The effect is dose-dependent: growth depends on the concentration, with 7.5% giving faster growth that starts straight away, while at 2.5% growth only starts after 2 hours.

High concentrations inhibit pollen tube growth: at 10.0% lactose the pollen tubes did not grow at all, as it was too concentrated.

(d) Give **two** reasons why lactose was an unusual choice of sugar to investigate.

(2)

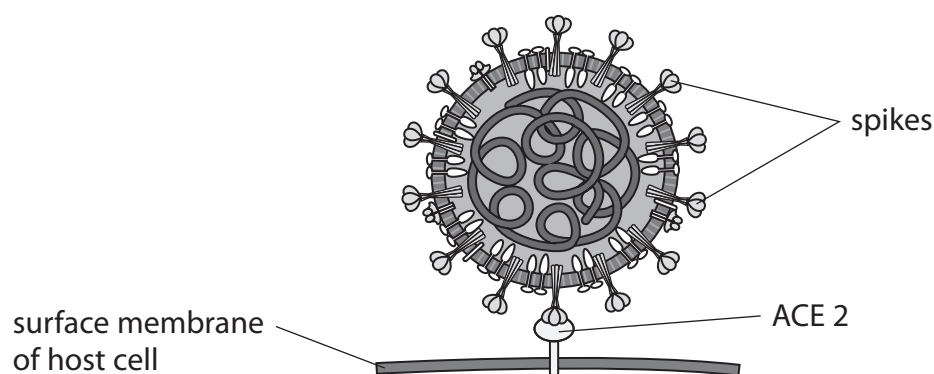
Lactose is the sugar found in milk; it is not produced by (not found in) plants.

Sucrose is the sugar produced and secreted by the stigma (carpel) of the plant, so sucrose would be the natural sugar for pollen tubes to grow in.

(Total for Question 3 = 9 marks)



- 4 The diagram shows a virus attached to the enzyme ACE 2, on the surface membrane of its host cell.



- (a) This virus is classified as an enveloped RNA virus with a helical capsid structure.

Which virus is also classified in the same way?

(1)

- ☒ **A** Ebola
- ☐ **B** human immunodeficiency virus
- ☐ **C** λ (lambda) phage
- ☐ **D** tobacco mosaic virus

- (b) The enzyme ACE 2 catalyses the hydrolysis of angiotensin II into angiotensin.

Which of the following describes hydrolysis by ACE 2?

(1)

- ☒ **A** a bond is split to produce angiotensin, using water
- ☐ **B** a bond is split to produce angiotensin, producing water
- ☐ **C** a bond is formed to produce angiotensin, using water
- ☐ **D** a bond is formed to produce angiotensin, producing water

(c) The spikes are proteins with polysaccharide molecules attached.

- (i) Compare and contrast the structure of polysaccharides with the primary structure of proteins.

(3)

Similarity: both polysaccharides and proteins contain carbon, hydrogen and oxygen.

Polysaccharides are made of monosaccharides (e.g. glucose), but the primary structure of a protein is made of amino acids.

Polysaccharides contain glycosidic bonds, but the primary structure of proteins contains peptide bonds.

Polysaccharides do not contain nitrogen or sulfur, but proteins do contain nitrogen (and sulfur).

Polysaccharides may be branched, but the primary structure of a protein is linear.

- (ii) Lectins are molecules that bind to polysaccharides.

Some lectins bind to the spikes of this virus.

Explain why scientists are hoping that lectins can be used to prevent disease caused by this virus.

(3)

If lectins bind to the polysaccharides on the spikes, the virus will not be able to attach to the ACE 2 enzyme on the host cell.

Therefore the virus will not be able to infect (enter) the host cell, so its RNA cannot enter the cell.

So new virus particles will not be made: the virus cannot replicate, so the lytic cycle is prevented and disease is prevented.

(Total for Question 4 = 8 marks)



P 7 1 9 2 4 A 0 9 2 8

5 Mitosis occurs in plant roots, plant shoots and during the formation of gametes.

(a) A squash preparation of a root tip can be used to show the stages of mitosis.

The statements below describe some of the steps in a squash preparation.

They are **not** listed in the correct order.

1. Use needles to tease cells apart.
2. Soak root tip in acetic orcein stain.
3. Heat root tip in acid.
4. Warm gently to intensify staining.
5. Gently squash cells with a thumb.
6. Place a cover slip on top of the cells.

(i) Which is the correct order for these steps?

(1)

- ☐ A 2, 3, 1, 6, 5, 4
- ☐ B 2, 3, 5, 1, 4, 6
- ☒ C 3, 2, 1, 6, 5, 4
- ☐ D 3, 2, 5, 1, 4, 6

(ii) Explain why the tip from a growing root is used in this preparation.

(2)

The tip of a growing root contains meristem (stem cells), and it is the only part of the root where cell division takes place and the root grows.

So this is where mitosis takes place, and many cells in the stages of mitosis can be seen.



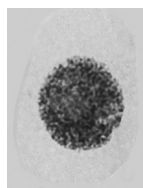
(iii) The photographs J to N show stages of mitosis.



J



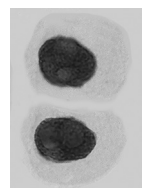
K



L



M



N

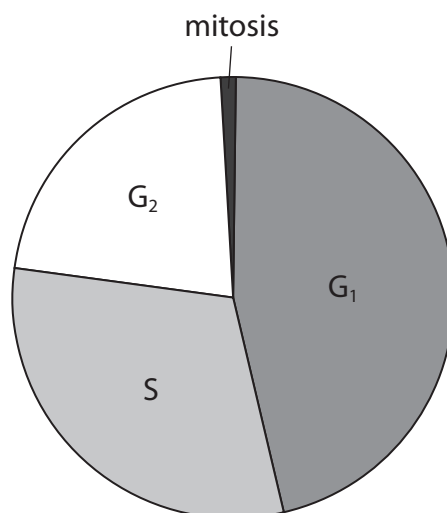
(Source: © STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY)

Which is the correct order of these stages?

(1)

- ☐ A J, L, M, K, N
- ☒ B L, J, M, K, N
- ☐ C M, J, L, N, K
- ☐ D N, K, J, M, L

(b) The pie chart shows the proportion of time that cells spend in the cell cycle in one species of plant.



The cell cycle in this plant lasts 22 hours.

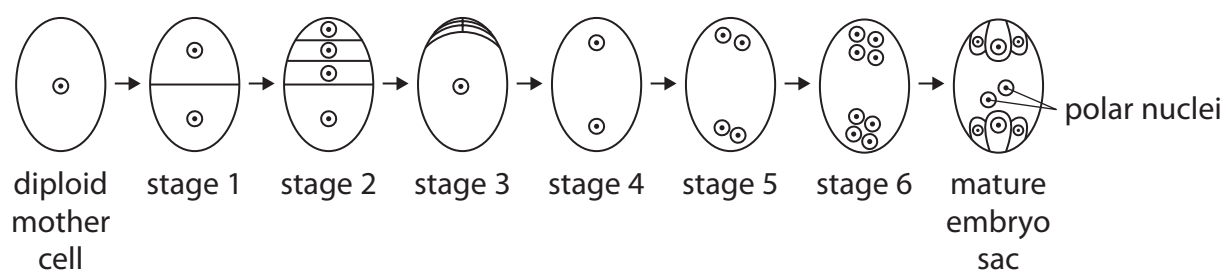
Give an estimate of the duration of S.

(1)

$$S = 111^\circ \div 360^\circ \times 22 \text{ hours} = 6.8$$

Answer 6.8 hours

- (c) The diagram shows the stages in the formation of an embryo sac in a flowering plant.



- (i) When does mitosis take place?

(1)

- ☐ **A** in the formation of stages 1, 4 and 6
- ☐ **B** in the formation of stages 1, 2 and 5
- ☐ **C** in the formation of stages 2, 4 and 5
- ☒ **D** in the formation of stages 4, 5 and 6

- (ii) Which shows the order of tissues that the pollen tube grows through to reach the embryo sac?

(1)

- ☒ **A** stigma style ovary
- ☐ **B** stigma ovary style
- ☐ **C** style ovary stigma
- ☐ **D** style stigma ovary

- (iii) Describe what happens to the polar nuclei once the pollen tube has grown into the embryo sac.

(3)

The two polar nuclei fuse together to form a diploid nucleus (the primary endosperm nucleus).

This diploid nucleus is then fertilised by (fuses with) one of the male nuclei (male gametes) from the pollen tube.

This forms a triploid endosperm nucleus, which divides to form the endosperm, a store of nutrients for the embryo.

(Total for Question 5 = 10 marks)

6 Eukaryotic cells contain a number of organelles that are absent in prokaryotic cells.

- (a) (i) The size of a typical eukaryotic cell is in the range $10\text{ }\mu\text{m}$ to $100\text{ }\mu\text{m}$.

The size of a typical prokaryotic cell is in the range 100 nm to 5000 nm .

Calculate how many times bigger the largest eukaryotic cell is than the smallest prokaryotic cell.

(1)

$$100\text{ }\mu\text{m} = 100\text{ }000\text{ nm}$$

$$100\text{ }000\text{ nm} \div 100\text{ nm} = 1000$$

Answer 1000

- (ii) Eukaryotic cells and prokaryotic cells both respire aerobically.

Only eukaryotic cells have mitochondria.

A number of enzyme reactions involved in aerobic respiration take place in mitochondria.

Explain why eukaryotic cells need mitochondria whereas prokaryotic cells do not need them.

(2)

Mitochondria compartmentalise the enzymes, keeping the enzymes and their substrates

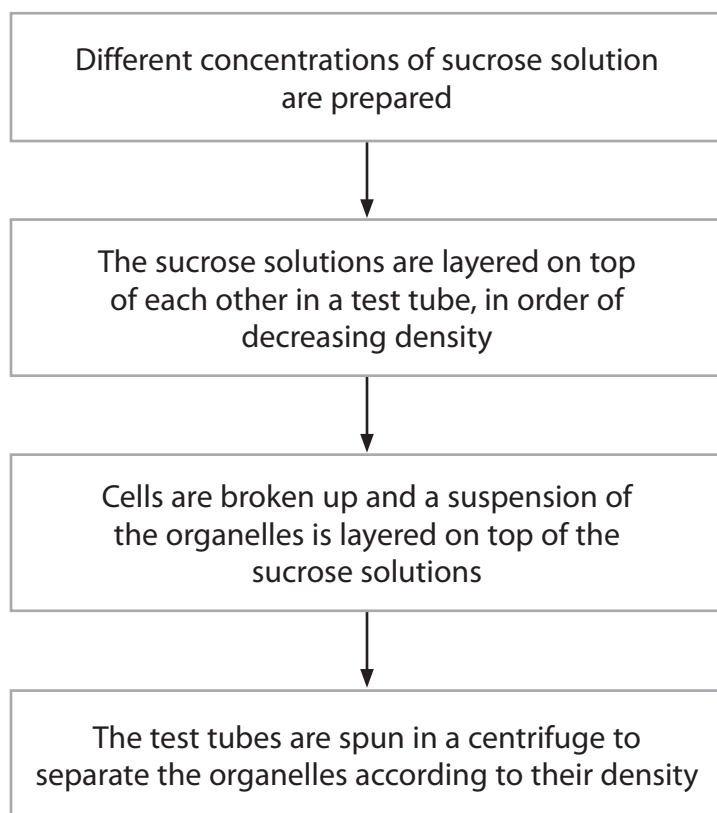
close together, so the respiration reactions are faster in the large eukaryotic cell.

Prokaryotic cells are small and do not need them, because bacteria can use their cell membranes (mesosomes) for these enzymes.



- (b) Cell organelles can be separated according to size using a sucrose density gradient.

The flow diagram shows how this can be done.



- (i) A student prepared a 1.25 g cm^{-3} sucrose solution by diluting a sucrose solution with a concentration of 5 g cm^{-3} .

Calculate the ratio of sucrose solution to water that would be needed to make this dilution.

(2)

$1.25 \div 5 = 0.25$, so the sucrose solution is diluted 4 times

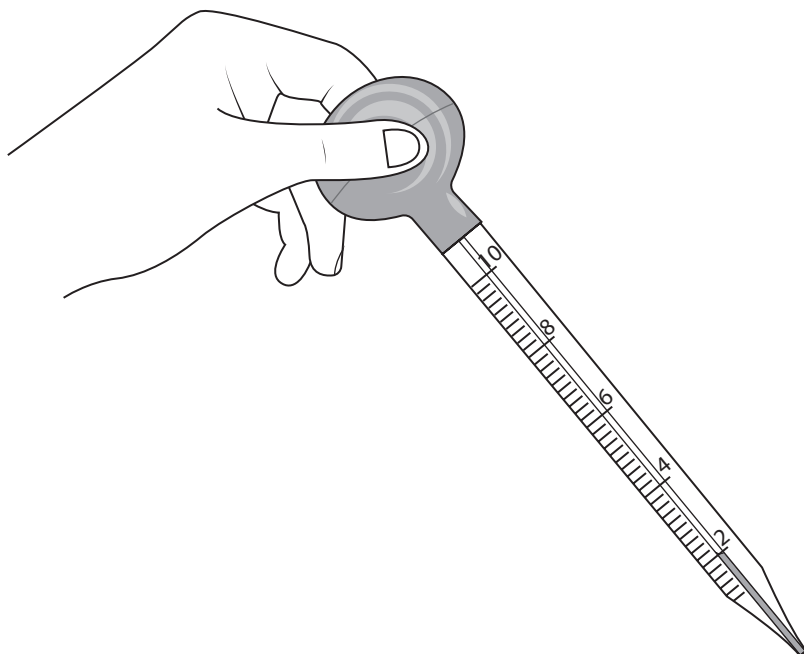
e.g. 1.25 cm^3 sucrose solution + 3.75 cm^3 water = 5 cm^3

ratio = $1.25 : 3.75$

Answer 1 : 3 (0.33 : 1)



- (ii) The diagram shows the student measuring 2.00 cm^3 of the organelle suspension using a pipette.



Analyse the diagram to explain why this method will produce an inaccurate measurement of volume.

(2)

The pipette is held at an angle, not vertically at eye level, so the bottom of the meniscus is not sitting on the line (parallax error).

Squeezing the bulb slightly will lose liquid, and the 10 cm^3 pipette is too large to measure 2.00 cm^3 accurately.

- (iii) The student actually measured 2.01 cm^3 of the suspension using the method shown in this diagram.

Calculate the percentage error of this measurement.

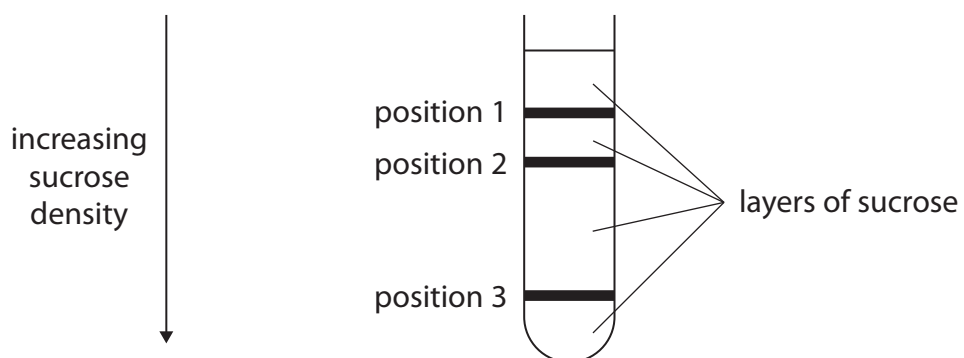
(1)

$$(2.01 - 2.00) \div 2.00 \times 100$$

Answer 0.5 %



- (iv) The diagram shows the positions of three organelles in a sucrose density gradient after centrifuging.



Which row of the table identifies the organelles found at each position?

(1)

	Position 1	Position 2	Position 3
☐ A	mitochondria	ribosomes	nuclei
☐ B	nuclei	ribosomes	mitochondria
☐ C	nuclei	mitochondria	ribosomes
☒ D	ribosomes	mitochondria	nuclei



*(c) Cells can be grown in media containing radioactively-labelled amino acids.

In an investigation, scientists grew cells in the media and removed a sample of cells every five minutes.

The organelles were separated and the radioactivity measured.

The table shows the results of this investigation.

Time / mins	Percentage of radioactivity found in different parts of the cells (%)					
	Smooth endoplasmic reticulum	Ribosomes	Rough endoplasmic reticulum	Golgi apparatus	Vesicles	Other
5	0	67	2	0	0	31
10	0	70	16	4	0	10
15	0	16	60	12	2	10
20	0	2	20	55	13	10
25	0	0	2	10	78	10
30	0	0	0	2	88	10
35	0	0	0	0	45	10



Explain the changes in the levels of radioactivity in the different parts of these cells.

(6)

Ribosomes: radioactivity is high in the first 10 minutes (67–70%) because the radioactive amino acids are incorporated into polypeptide chains during translation. It then falls (to 0% by 25 minutes) as the polypeptide chains leave the ribosomes and protein synthesis ends.

RER: the level rises to 60% at 15 minutes because the RER is also a site of protein synthesis and the polypeptides are transported through it. It falls to zero once all the polypeptide chains have left the RER.

Golgi apparatus: the level rises to 55% at 20 minutes as the proteins are transferred into the Golgi by vesicles from the RER. It then drops once the proteins have been modified and packaged into vesicles.

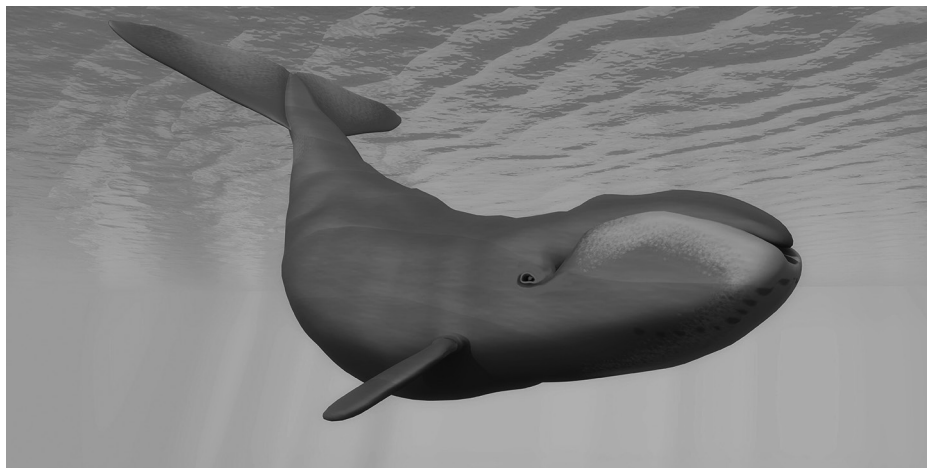
Vesicles: the level rises to 88% at 30 minutes as vesicles containing the radioactive proteins form from the Golgi, then falls to 45% as the proteins are released from the cell by exocytosis.

SER: no radioactivity at any time, as the SER is not involved in protein synthesis; it makes and transports lipids.

The 10% unaccounted for is radioactive amino acids in the cytoplasm that were not used in protein synthesis, or proteins not packaged into vesicles because they are used by the cell itself.

(Total for Question 6 = 15 marks)

7 The image shows a bowhead whale.



(Source: © Panther Media GmbH/Alamy Stock Photo)

These marine mammals have a thick layer of blubber beneath their skin that acts as an energy store and an insulator.

Blubber is composed of fat cells and fibrous tissue.

- (a) The lipids in blubber contain mostly unsaturated fatty acids.
- (i) Describe **two** differences between the structure of an unsaturated fatty acid and a saturated fatty acid.

(2)

An unsaturated fatty acid has at least one carbon-carbon double bond ($C=C$), whereas a saturated fatty acid has only single carbon-carbon bonds.

An unsaturated fatty acid has fewer hydrogens and has kinks in its chain, whereas a saturated fatty acid has more hydrogens and no kinks.

(ii) Explain why lipids are used for energy storage and insulation.

(3)

Lipids are used for energy storage because they are insoluble (hydrophobic, non-polar), so they do not affect the water potential of cells.

Lipids are used for energy storage as they have a high content of hydrogen, so they release a lot of energy per gram.

Lipids are used for insulation as they are poor conductors of heat, because they are large molecules that are loosely packed.

(b) The effect of seasonal feeding and age on the blubber of bowhead whales was investigated.

Samples were removed from three layers in the blubber and analysed for the:

- mean number of fat cells
- mean area of the sample of blubber occupied by fat cells
- mean area of fibrous tissue.

(i) Describe how a light microscope can be used to determine the area of one fat cell.

Assume that a fat cell is circular in shape.

(3)

Stain the fat cells and view them under the light microscope.

Use an eyepiece graticule to measure the diameter of the cell, calibrated with a stage micrometer to find the actual diameter.

Take several measurements and calculate a mean diameter, then calculate the area using

$A = \pi r^2$, where $r = d \div 2$.

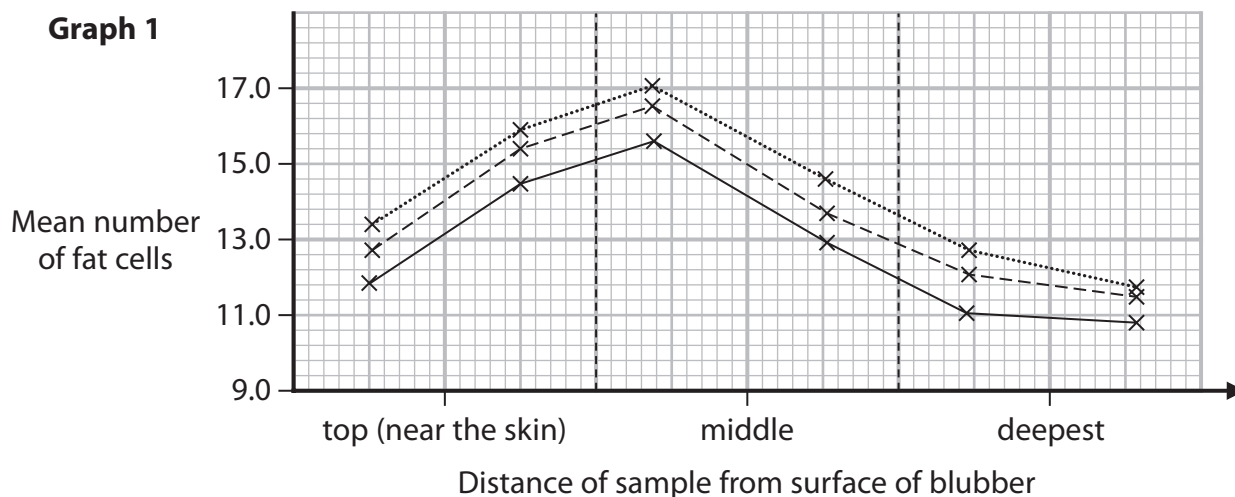
*(ii) The graphs show the results of this investigation.

Key: young whales feeding from mother

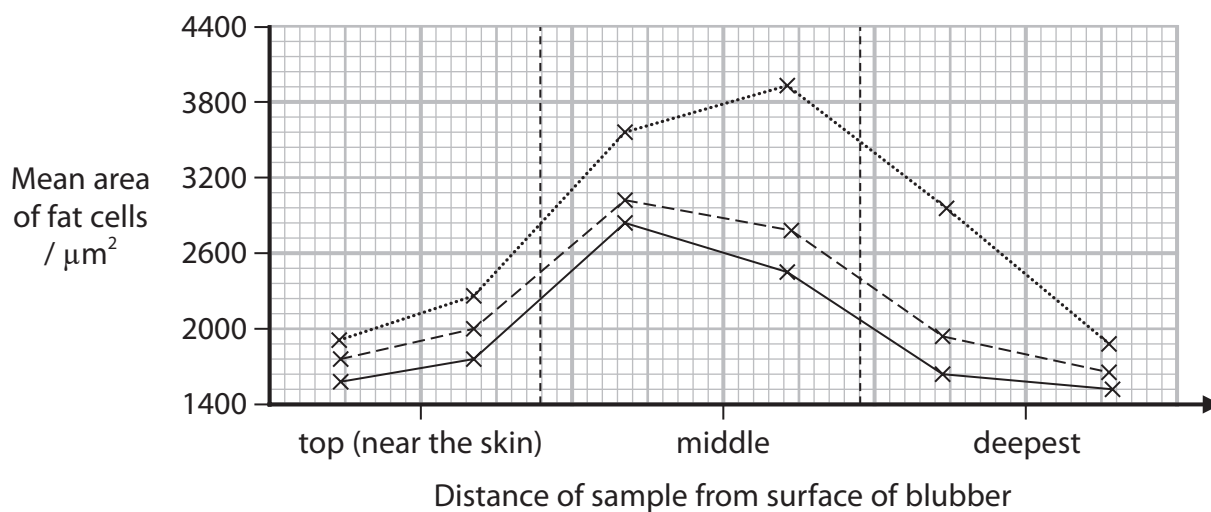
adult whales feeding

adult whales after a
winter of fasting

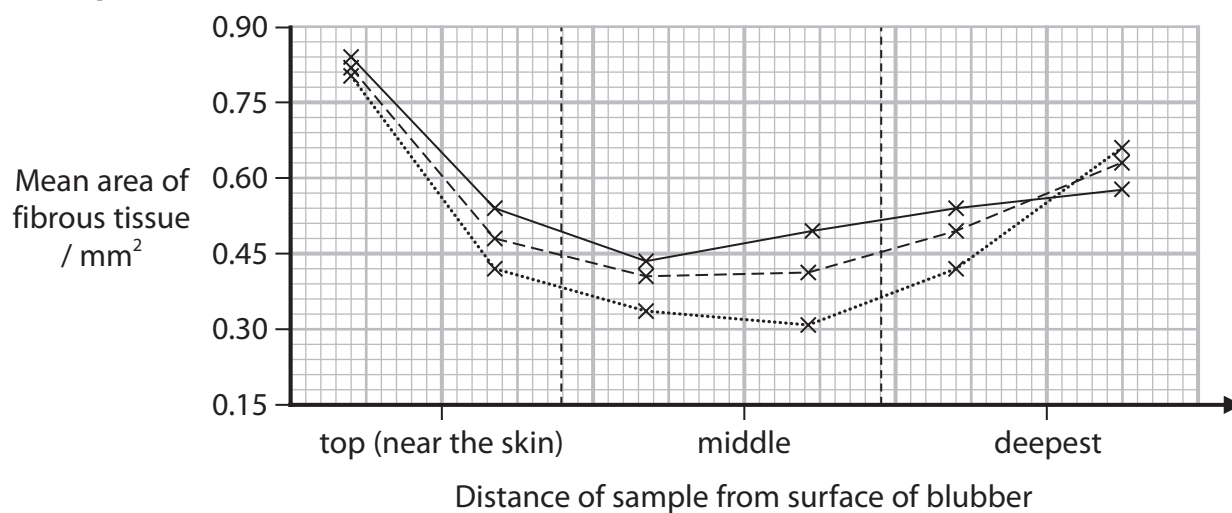
Graph 1



Graph 2



Graph 3



Analyse the data to explain the results of this investigation.

(6)

Graph 1: young whales have more fat cells at all depths than adult whales, because they are fed energy-rich, high quality milk by their mothers. They need a thick insulating layer because they are small with a larger surface area to volume ratio, so they lose more heat.

Adult whales feeding have fewer fat cells than young whales because their diet is not so energy-rich, and females use their reserves feeding their young.

Fasting whales have the fewest fat cells at all depths because their fat reserves have been used up over the winter for respiration.

Fat cells are present in all layers, most in the middle, to provide a thick insulating layer because the whales live in cold water.

Graph 2: young whales have the largest area of fat cells at all depths (about 3900 μm^2 in the middle), because of the high quality milk from their mothers. Adult whales have a smaller area, as their diet is not so energy-rich.

Fasting whales have the smallest area of fat cells at all depths, as stored fat has been used up. The highest area of fat cells is in the middle layer for all whales.

Graph 3: young whales have the lowest area of fibrous tissue in the top and middle layers, and fasting whales have the highest area of fibrous tissue, because fibrous tissue is formed to replace the area filled by fat cells as the fat cells shrink.

(Total for Question 7 = 14 marks)

- 8 Some microorganisms can break down plastics, including polyesters.

Cows are a group of plant-eating mammals that have bacteria living in one of their four stomachs.

These bacteria play a role in the digestion of the plant material consumed by the cow.

Scientists have studied these bacteria to see if they can break down polyesters.

- (a) Polyesters account for 15 % of the 25.8 million US tons of plastic waste accumulated in Europe.

Calculate the mass, in kilograms, of polyester in this accumulated plastic waste.

$$1 \text{ US ton} = 907.185 \text{ kg}$$

(2)

$$25.8 \times 10^6 \times 907.185 = 2.34 \times 10^{10} \text{ kg of plastic}$$

$$0.15 \times 2.34054 \times 10^{10} = 3\,510\,805\,950 \text{ kg}$$

Answer 3.51×10^9 kg

- (b) State why scientists think that these bacteria might be able to break down polyesters.

(1)

The bacteria produce enzymes that can digest plant material (polymers such as cellulose).

- (c) The bacteria were incubated with polyester at 40 °C in a pH 7 buffer solution.

Explain why these conditions were used.

(2)

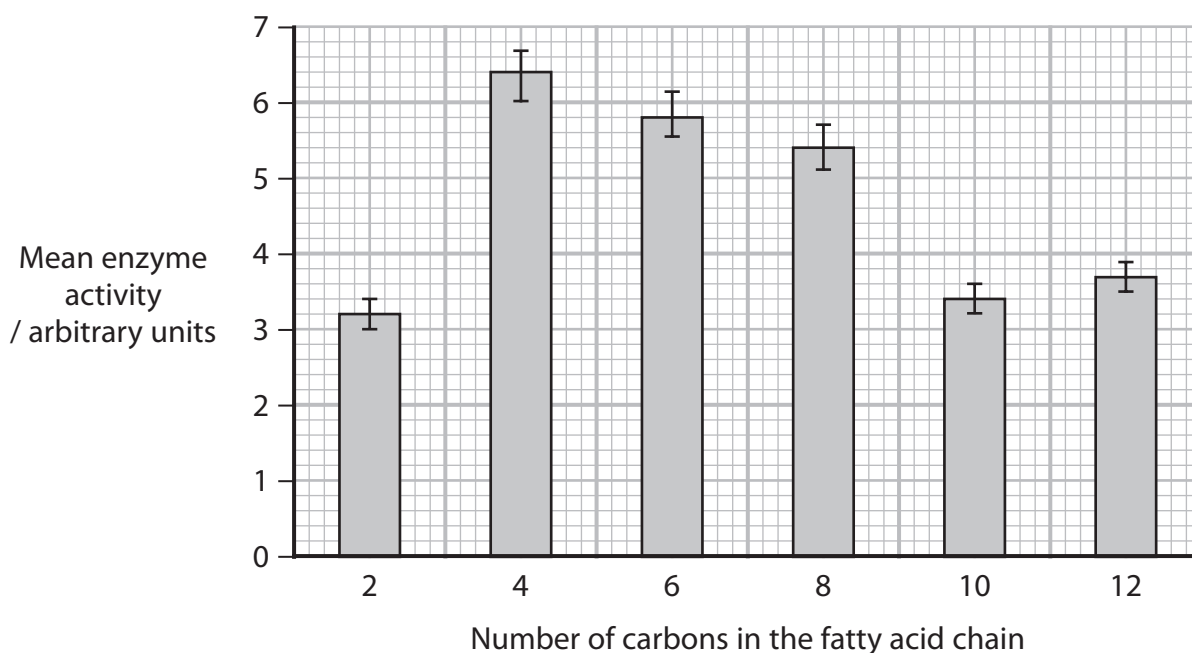
40 °C and pH 7 are the temperature and pH of the cow's stomach, so they are the optimum temperature and pH of the bacterial enzymes, so the enzymes work fastest.

The buffer is used to keep the pH constant.



- (d) One study investigated the breakdown of one type of polyester with different fatty acid chain lengths.

The graph shows the mean enzyme activities and standard deviations from this study.



- (i) Analyse the data to comment on these results.

(3)

There is no correlation between mean enzyme activity and the number of carbons in the fatty acid chain; the activity is not proportional to chain length.

The optimum number appears to be 4 carbons (6.4 units) and the least activity is with 2 carbons (3.2 units).

But the optimum could be between 4 and 6 carbons, as the standard deviation bars for 4 and 6 carbons overlap.

The standard deviations are small, indicating that the variability within each data set is low.

(ii) Devise an experiment to confirm these results.

(5)

Use the same type of polyester with fatty acid chains containing 2, 4, 6, 8, 10 or 12 carbons.

Add the same volume and concentration of bacterial enzyme extract to the same mass (concentration) of each polyester, in the same volume of pH 7 buffer.

Carry out the experiment at 40 °C in a thermostatically controlled water bath.

Monitor the reaction by measuring the pH change (fall in pH as fatty acids are released) with a pH meter, or the loss in mass of polyester, at regular intervals.

Measure the initial rate of reaction from the gradient at the start.

Repeat the experiment several times for each chain length to calculate a mean and standard deviation.

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(e) In another study, scientists measured the concentration of the breakdown products from two types of polyester, P1 and P2, using bacteria.

The table shows the results of this study.

Breakdown product	Concentration of breakdown products / arbitrary units	
	from P1	from P2
A	38	68
B	30	0
C	5	0
D	0	20
E	0	30

Explain why the scientists thought that the bacteria were producing more than one type of enzyme.

(2)

There were two different types of polyester and enzymes are specific, so the two polyesters must have different bonds that need breaking, needing different enzymes.

The two polyesters produced different products: B and C only came from P1, while D and E only came from P2.

(Total for Question 8 = 15 marks)

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