

Please check the examination details below before entering your candidate information

Candidate surname <i>StemUp Model Solution</i>		Other names	
Pearson Edexcel Level 3 GCE		Centre Number 	Candidate Number
Time 1 hour 30 minutes		Paper reference	8BI0/01
Biology B Advanced Subsidiary PAPER 1: Core Cellular Biology and Microbiology			
You must have: 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 questions 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.
- Good luck with your examination.

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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 Prokaryotic cells and eukaryotic cells contain a number of organelles.

The table gives information about some organelles.

Organelle	Information about each organelle
P	10^{-9} m in diameter involved in translation
Q	5000 nm in diameter contains thylakoids
R	stack of curved cisternae involved in protein modification
S	1.2×10^{-3} mm in diameter has a single membrane

- (a) Which of the following is a lysosome?

(1)

- ☐ A P
☐ B Q
☐ C R
☒ D S

- (b) How many of the organelles in the table contain DNA?

(1)

- ☒ A 1
☐ B 2
☐ C 3
☐ D 4



(c) The table gives information about organelles found in prokaryotic cells and animal cells.

For each organelle, put **one** cross ☒ in the appropriate box in each row to show which cells contain these organelles.

(2)

Organelle	Organelle found in			
	both prokaryotic cells and animal cells	prokaryotic cells only	animal cells only	neither prokaryotic cells nor animal cells
P	☒	☐	☐	☐
Q	☐	☐	☐	☒

(d) Which of the following shows the organelles in order of size from largest to smallest?

(1)

- ☐ **A** P S Q
- ☐ **B** Q P S
- ☒ **C** Q S P
- ☐ **D** S P Q

(Total for Question 1 = 5 marks)



2 Mineral ions are needed for plant growth.

A student had a plant that had been kept in the same soil for a long time.

The growth of the plant had slowed down and the leaves were pale green.

The student decided to add fertiliser to the plant and measure the increase in height of the plant.

The student made two predictions:

- the leaves would gradually become greener
- the plant would not start growing until the leaves were greener.

(a) Explain why the student made these predictions.

(3)

Magnesium ions are needed to make chlorophyll, so as the plant absorbs magnesium

from the fertiliser, chlorophyll is made and the leaves become greener.

This happens gradually because it takes a while for the chlorophyll to be made.

Nitrate ions are needed to make amino acids and proteins, which are needed for growth.

There is a delay in growth because the plant needs chlorophyll to photosynthesise before it can grow (photosynthesis and protein synthesis are needed for growth).

(b) The student used a stock fertiliser solution at a concentration of $500 \mu\text{g cm}^{-3}$.

Calculate the volumes of stock fertiliser solution and water that had to be mixed together to produce 100 cm^3 of fertiliser solution at a concentration of $50 \mu\text{g cm}^{-3}$.

(1)

Volume of stock fertiliser solution 10 cm^3

Volume of water 90 cm^3



(c) When the fertiliser was added to the plant, the height of the plant was 130 cm.

Six weeks after the fertiliser was added, the plant had grown to a height of 155 cm.

Calculate the mean growth rate for this plant, in centimetres per day, in this six-week period.

(1)

$$\text{increase in height} = 155 - 130 = 25 \text{ cm}$$

$$6 \text{ weeks} = 6 \times 7 = 42 \text{ days}$$

$$\text{rate} = 25 \div 42 = 0.595 \text{ cm day}^{-1}$$

Answer 0.6 cm day⁻¹

(Total for Question 2 = 5 marks)



(c) The table shows the composition of some of the different types of lipid in milk from cows.

Type of lipid	Composition of lipids in milk from cows (%)
monoacylglycerols	0.027
diacylglycerols	0.360
triacylglycerols	97.500
free fatty acids	0.027
phospholipids	0.600

Which row of the table shows the types of lipids that are the median and mode for this set of data? (1)

	Median	Mode
☒ A	diacylglycerols	monoacylglycerols
☐ B	diacylglycerols	triacylglycerols
☐ C	monoacylglycerols	diacylglycerols
☐ D	monoacylglycerols	triacylglycerols

(d) Phospholipids have a different structure from other lipids, such as triglycerides. Give one difference in the properties of phospholipids and triglycerides. (1)

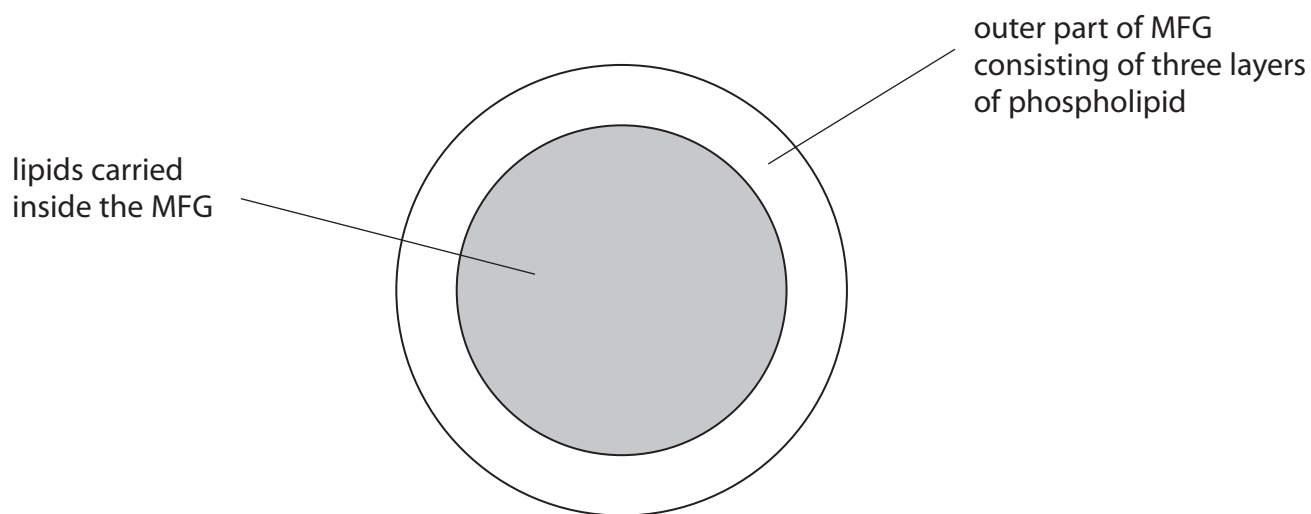
Phospholipids are polar, whereas triglycerides are non-polar.



(e) Milk from cows also contains a solution of proteins, lactose and mineral ions.

The lipids in milk are carried inside milk fat globules (MFG).

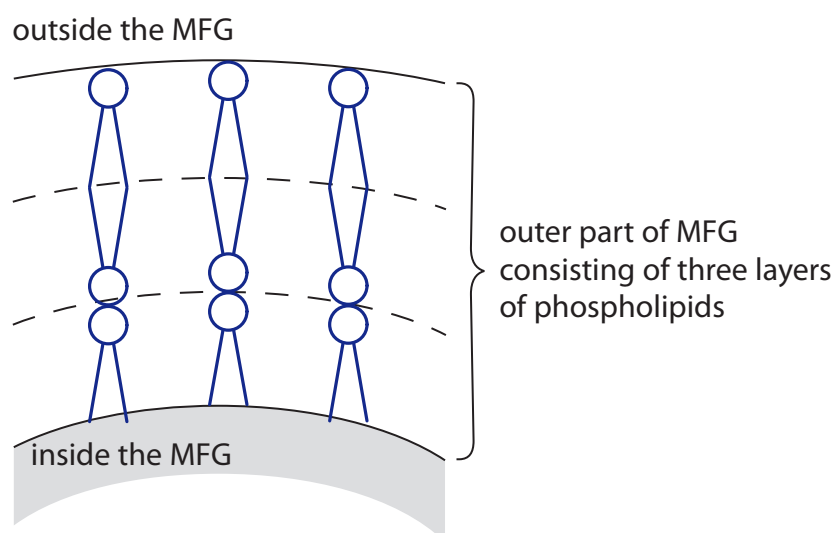
The diagram shows an MFG.



- (i) Complete the diagram to show how nine phospholipid molecules would be arranged in the outer part of an MFG.

Use this shape to draw each phospholipid:

(2)



(ii) Explain the structure of an MFG.

(3)

Lipids are non-polar (hydrophobic), so they cannot be carried in the watery solution of the milk.

The non-polar fatty acid tails of the inner phospholipid layer face inwards and enclose the lipids.

The phosphate heads are polar (hydrophilic), so the heads of the outer layer can interact with the water in the milk solution.

The heads of the two adjoining layers also face each other and interact with each other, and the tails of the outer two layers face each other, holding the three layers together.

(Total for Question 3 = 9 marks)



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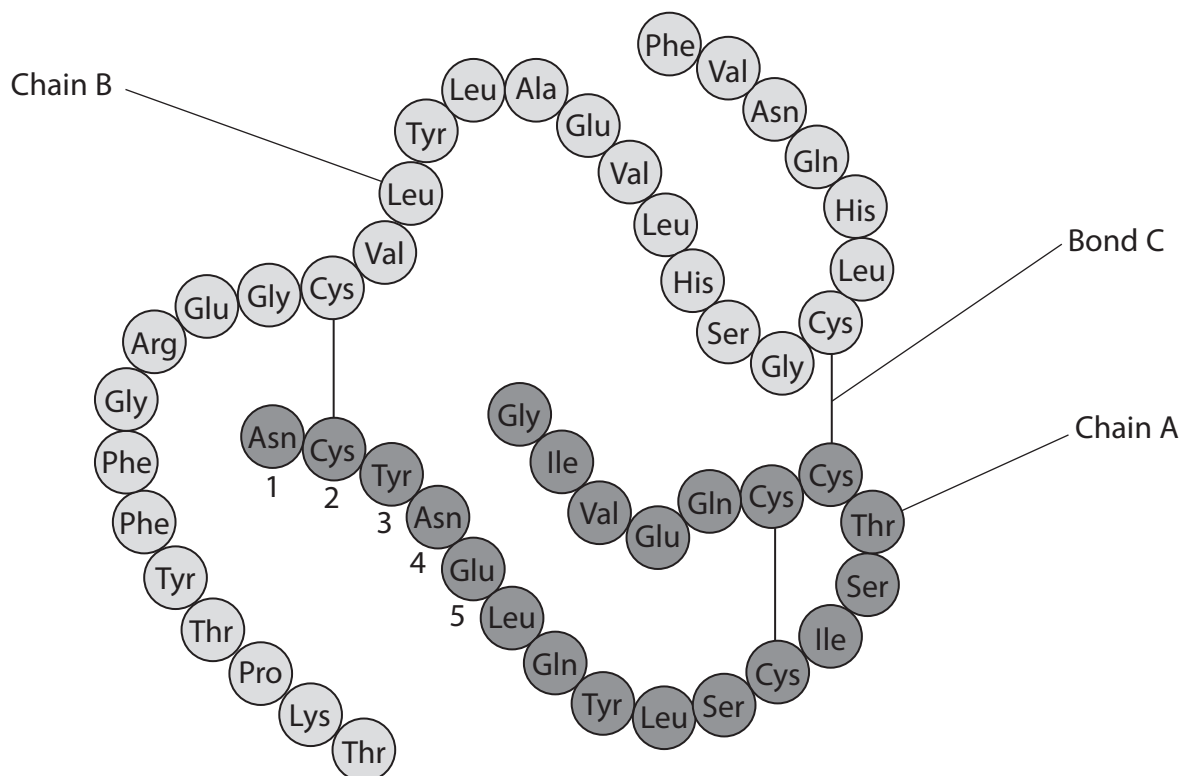
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- 4 Insulin is a protein that is composed of two polypeptide chains, chain A and chain B.

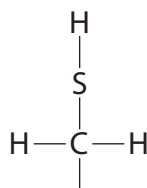
The diagram shows the amino acid sequence of these two polypeptide chains and some of the bonds involved in the folding of this protein.



- (a) Cysteine (Cys) is one type of amino acid found in insulin.

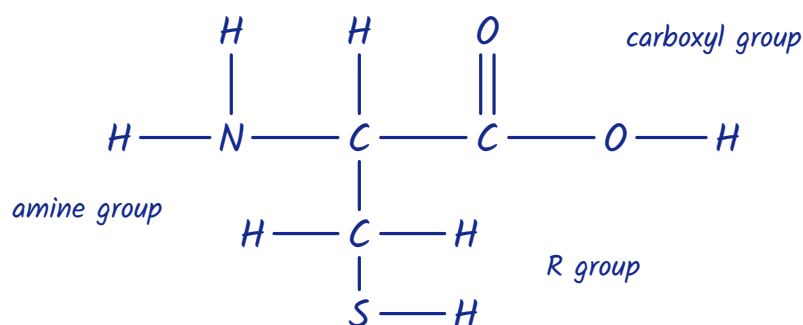
The presence of cysteine in insulin is important in determining the structure of this protein.

The R group of cysteine is:



- (i) Draw a diagram to show the structure of the amino acid cysteine.

(3)



(ii) Name the covalent bond labelled C in the diagram.

(1)

Disulfide bond (disulfide bridge).

(b) The table shows the DNA genetic codes on the anti-sense DNA strand (template strand) for amino acids.

Genetic code	Amino acid	Genetic code	Amino acid	Genetic code	Amino acid	Genetic code	Amino acid
AAA AAG	Lys	CAA CAG	Gln	GAA GAG	Glu	TAC TAT	Tyr
AAC AAT	Asn	CAT CAC	His	GAC GAT	Asn	TCA TCC TCG TCT	Ser
ACA ACC ACG ACT	Thr	CCA CCC CCG CCT	Pro	GCA GCC GCG GCT	Ala	TGG	Try
AGA AGG	Arg	CGA CGC CGG CGT	Arg	GGA GGC GGG GGT	Gly	TGC TGT	Cys
AGC AGT	Ser	CTA CTC CTG CTT	Leu	GTA GTC GTG GTT	Val	TTA TTG	Leu
ATA ATC ATT	Ile					TTC TTT	Phe
ATG	Met						

The genetic codes TAA, TAG and TGA are stop codons.

(i) Complete the diagram to show one base sequence in the antisense DNA strand (template strand) coding for the five amino acids numbered in the diagram of insulin.

(1)

Amino acid number	1	2	3	4	5
Amino acid abbreviation	Asn	Cys	Tyr	Asn	Glu
Base sequence on the antisense DNA strand	AAC	TGT	TAC	AAT	GAA



- * (ii) Analyse the information to deduce how gene mutations in the DNA base sequence for Cys (amino acid number 2) could affect the structure of insulin.

(6)

The DNA code for Cys (amino acid 2) is TGT. A substitution mutation of the third base may not change the amino acid, e.g. TGT to TGC still codes for Cys, so there is no effect on the structure of insulin.

A substitution may change the amino acid, e.g. TGT to TGG would insert Try instead of Cys. TGT to TGA gives a stop codon, so chain A would be shorter.

Without Cys at position 2, no disulfide bond can form joining chain A and chain B together at that point.

An insertion or deletion of a base causes a frame shift, changing the amino acid sequence from that point onwards, so Cys is no longer present in that position and the disulfide bond with chain B is lost.

A Cys may be coded further down the chain, so a disulfide bond could form in the wrong place, or a stop codon could form so chain A is shorter.

The change in bonding will change how the polypeptide chains fold, affecting the tertiary and quaternary structure of insulin, so its 3D shape changes and it may not bind to its receptor.

(Total for Question 4 = 11 marks)



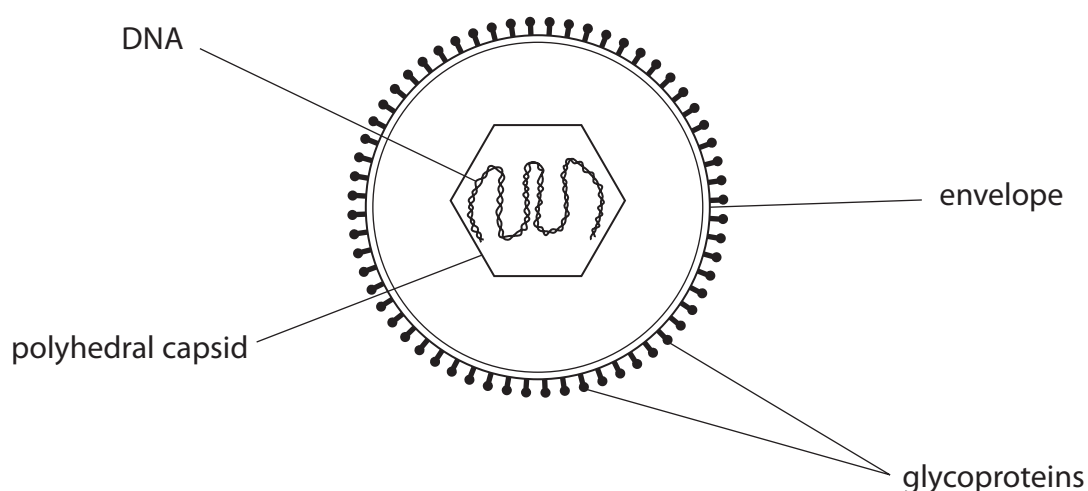
5 Glandular fever is caused by infection with the Epstein–Barr virus (EBV).

The virus infects B lymphocytes and epithelial cells.

On infection of these cells, the virus enters the lytic cycle.

After the lytic cycle is brought under control by the immune system of the body, latency takes place.

(a) The diagram shows the structure of EBV.



Source from: <https://www.hindawi.com/journals/jir/2012/370516/>

(i) Which virus has both a polyhedral capsid and an envelope?

(1)

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

(ii) State what the genes in the DNA of EBV code for, other than glycoproteins.

(1)

The proteins of the capsid (protein coat), and enzymes needed for replication.



(iii) Describe the role of the glycoproteins in EBV.

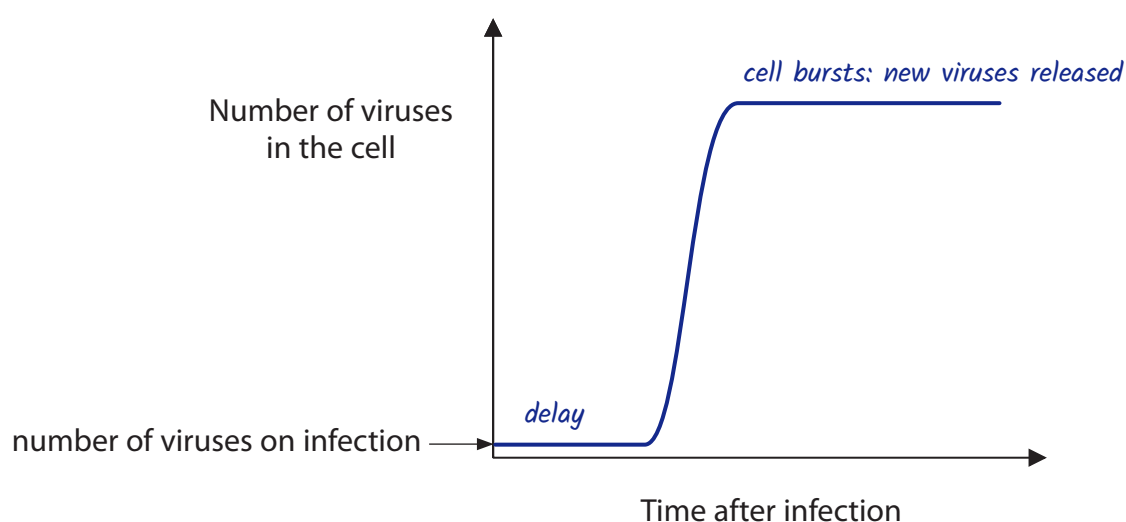
(2)

The glycoproteins attach the virus to specific receptors (attachment molecules) on the cell surface membrane of the host cells.

These are on the epithelial cells and the B lymphocytes, allowing the virus to enter these cells.

(b) Complete the graph to show the shape of the growth curve of EBV as a result of one lytic cycle after infection of a cell.

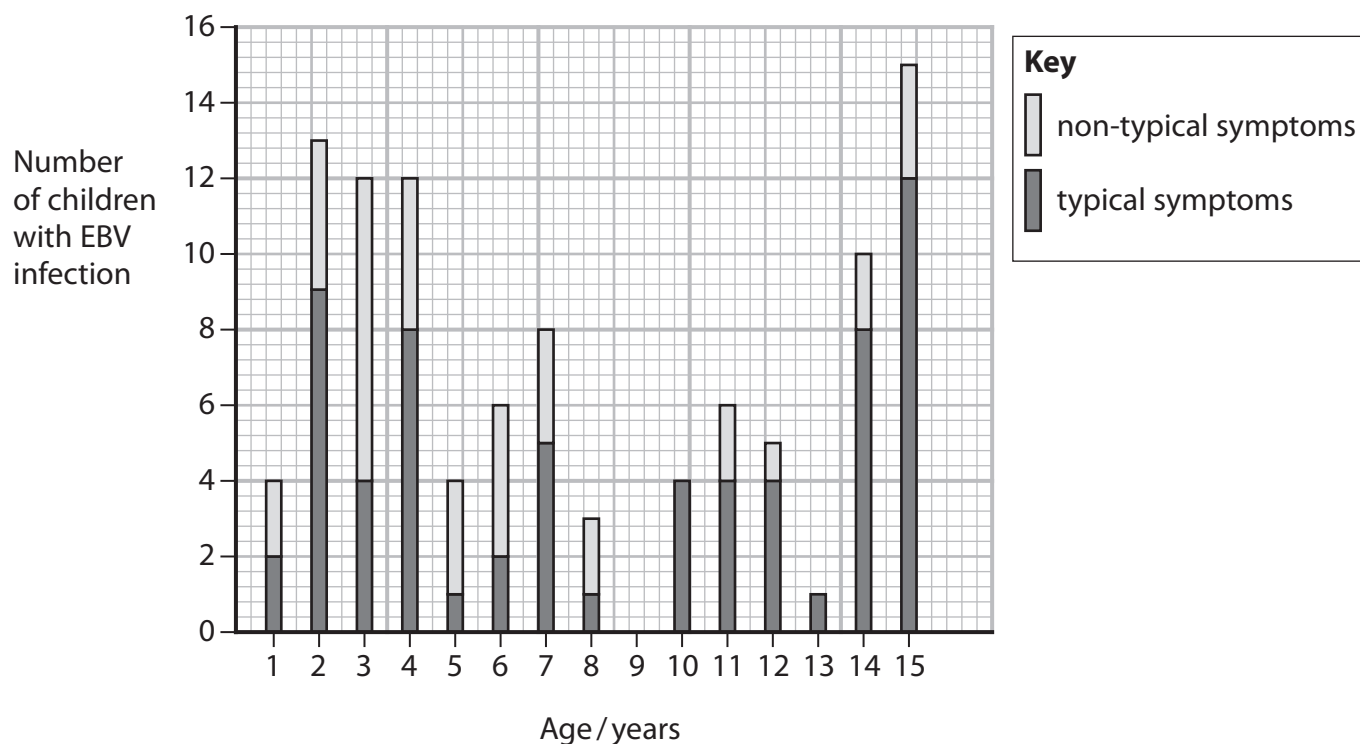
(2)



(c) An investigation studied a group of 103 children infected with EBV, in one town.

The number of children with typical symptoms of EBV infection and the number of children with non-typical symptoms of EBV infection were recorded.

The graph shows the results of this investigation.



(i) There were 47% boys in this group of children.

Calculate the number of girls in this group of children.

(2)

$$\text{boys} = 47\% \text{ of } 103 = 0.47 \times 103 = 48.41$$

$$\text{girls} = 103 - 48.41 = 54.59$$

so 55 girls

Answer 55



- (ii) Determine the effect of age on the proportion of children with non-typical symptoms of EBV.

(2)

As age increases, the proportion of children with non-typical symptoms decreases.

e.g. at age 1, 2 out of 4 = 50% have non-typical symptoms, but at age 15, 3 out of 15 = 20%.

- (iii) Describe how this investigation could be improved.

(3)

Increase the sample size, e.g. by studying children in other towns, so the results are more representative.

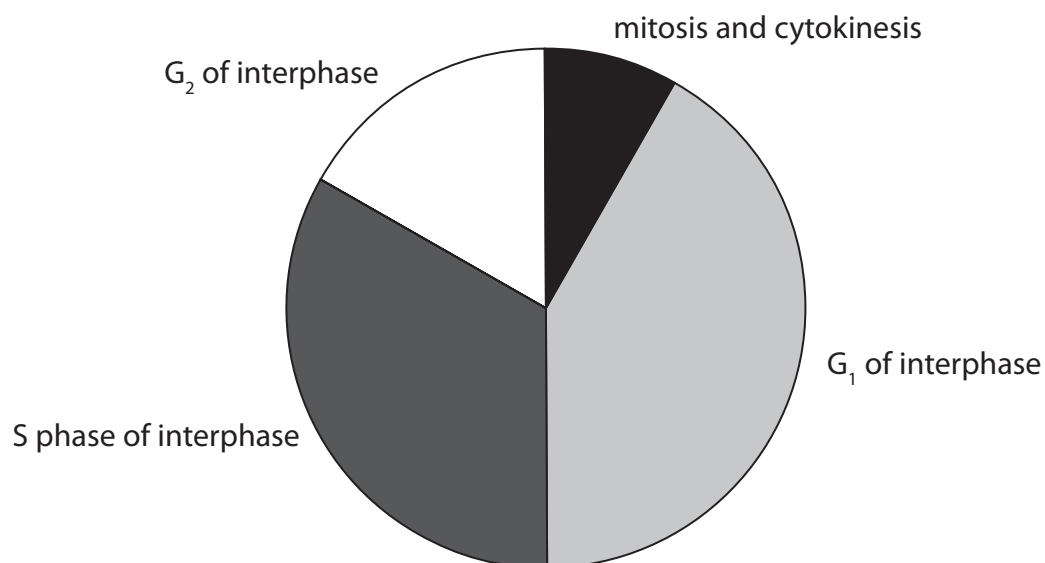
Ensure there is data for all age groups, as there are no children aged 9 or 14 in this sample.

Increase the age range to investigate older teenagers (and adults), e.g. ages 16 to 19.

(Total for Question 5 = 13 marks)



- 6 The diagram shows four stages in a human cell cycle.



- (a) The cell cycle time for this cell is 24 hours.

Give an estimate for the length of time that this cell spends in each of the four stages of the cell cycle.

(2)

Stage of cell cycle	Estimate for the length of time that this cell spends in each stage / hours
mitosis and cytokinesis	2
G ₁ of interphase	10
S phase of interphase	8
G ₂ of interphase	4

- (b) The percentage of cells in any one stage is proportional to the length of time of that stage.

Describe an investigation that could be carried out to confirm the length of time of mitosis and cytokinesis for these human cells.

(4)

Take tissue from a region of these human cells where division is occurring and use a method similar to a root tip squash.

Heat the tissue in hydrochloric acid (to separate the cells), then stain it with acetic orcein (or toluidine blue) to stain the chromosomes, squash it under a cover slip and view it with a light microscope.



Count the number of cells in mitosis (and cytokinesis) and the total number of cells in several fields of view.

Divide the number of cells in mitosis by the total number of cells counted, then multiply this proportion by 24 hours to find the length of mitosis and cytokinesis.

(c) A cell in G_1 of interphase contains 68 arbitrary units of DNA.

Explain how the DNA content and the structure of the chromosomes of this cell will change during the cell cycle.

(5)

During interphase, in the S phase, DNA replication (DNA synthesis) takes place before mitosis.

So by the end of S phase (interphase) the DNA content will double, from 68 to 136 arbitrary units.

Each chromosome will now consist of a pair of identical sister chromatids joined together at the centromere.

During mitosis (anaphase) the chromatids separate and move to opposite poles, so each chromosome now consists of one DNA molecule.

By the end of cytokinesis the DNA content will return to normal, 68 arbitrary units in each cell.

This is because the chromatids are separated into two new daughter cells.

(Total for Question 6 = 11 marks)



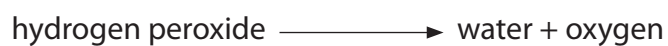
- 7 The photograph shows sweet red peppers growing on a plant.



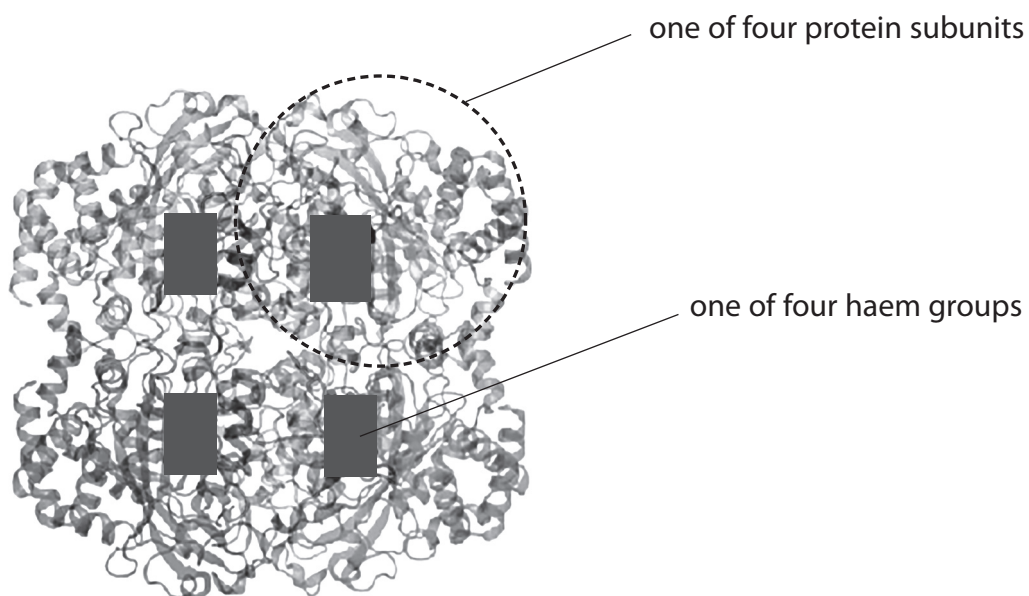
© Janet Horton / Alamy Stock Photo

Unripe sweet red peppers contain the enzyme catalase. As these peppers ripen, the activity of catalase decreases.

The equation summarises the reaction catalysed by catalase.



- (a) The diagram shows the structure of catalase.



Explain why the enzyme catalase is described as having a tertiary and quaternary structure.

(3)

Catalase is made of polypeptide chains, which fold because of bonds (hydrogen, ionic and disulfide bonds) between the R groups to form a 3D globular tertiary structure.

Catalase has four subunits, so it is made of more than one polypeptide chain, so it has a quaternary structure.

It also has quaternary structure because it is a protein with non-protein haem groups attached.

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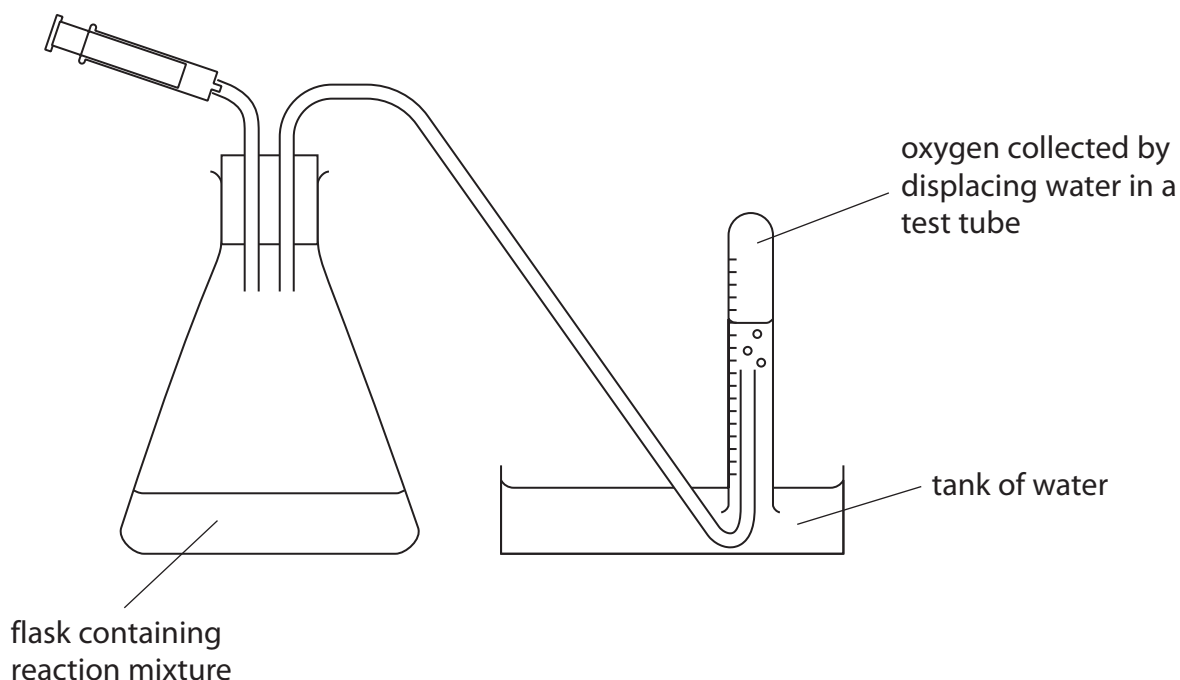
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P 6 7 1 5 1 A 0 2 1 2 8

- (b) The activity of catalase can be measured by collecting the oxygen produced during the reaction.

The diagram shows apparatus that can be used to collect the oxygen produced.



- (i) When measuring the activity of enzymes, the initial rate of reaction should be measured.

Explain why the initial rate of reaction should be measured.

(2)

As soon as the reaction starts the substrate (hydrogen peroxide) is broken down, so its concentration decreases and is no longer controlled.

At the start the substrate concentration is known and does not limit the rate of reaction.

- * (ii) Devise an investigation, using this apparatus, to show that as sweet red peppers ripen the activity of catalase decreases.

(6)

Use red peppers at various stages of ripeness, e.g. green (unripe), part ripe and fully red. Use the same type of pepper and the same mass (e.g. 5 g) of pieces or extract of each pepper.

Add the pepper to a flask containing the same volume and concentration of hydrogen peroxide (e.g. 20 cm³ of 3%), and quickly connect the delivery tube to the test tube full of water in the tank.

Control the temperature using a water bath (e.g. 30 °C) and control the pH using a buffer.

Record the volume of oxygen collected at regular short time intervals, e.g. every 30 seconds for 5 minutes.

Plot a graph of the volume of oxygen collected against time for each pepper, and draw a tangent at the start of the curve to work out the initial rate of reaction in cm³ per minute.

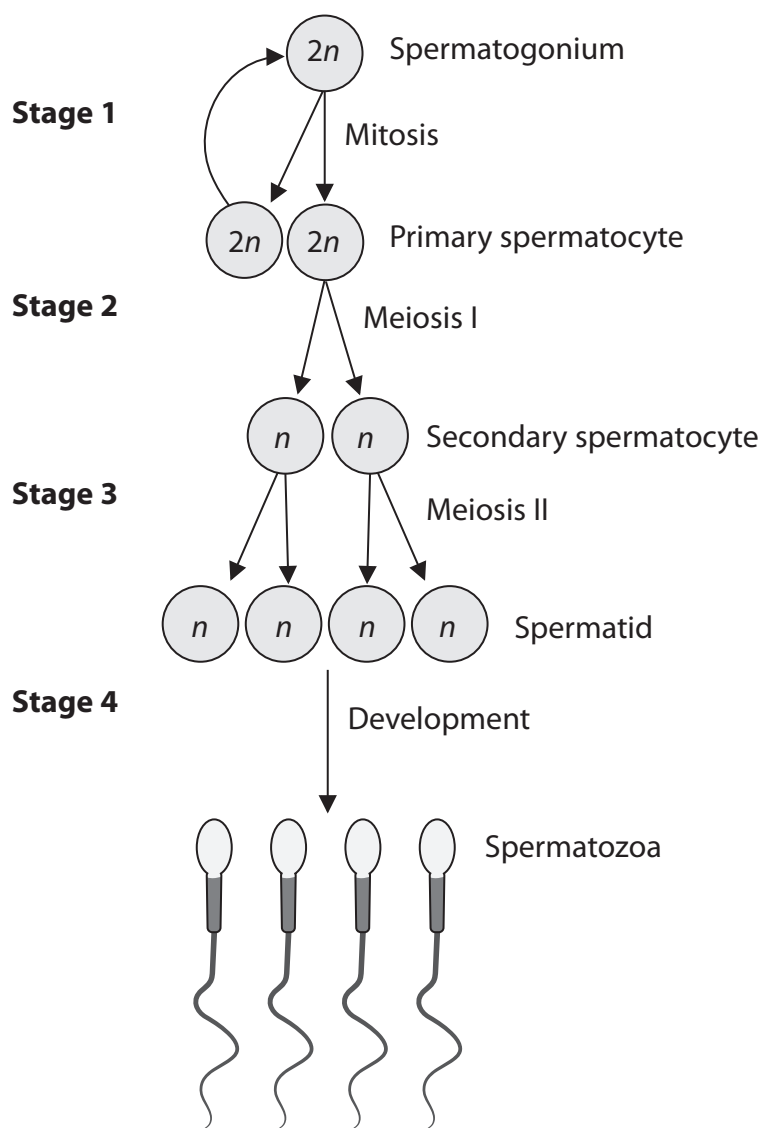
Repeat with different red peppers at each stage of ripeness and calculate a mean. Plot a graph of initial rate against ripeness; the initial rate should decrease as the peppers ripen.

(Total for Question 7 = 11 marks)



8 In mammals, gametes are produced by spermatogenesis and oogenesis.

(a) The diagram shows some of the stages in spermatogenesis.



(i) Explain the significance of mitosis in stage 1 of spermatogenesis.

(2)

Mitosis produces several genetically identical diploid primary spermatocytes, so lots of sperm can be produced from a single spermatogonium.

It also replaces the spermatogonia, so sperm production can continue.



(ii) Explain the events that take place in stage 2, that result in genetic variation.

(4)

Crossing over takes place in prophase I between non-sister chromatids of homologous chromosomes, exchanging sections of DNA.

This produces new combinations of alleles on a chromatid.

Independent assortment takes place in metaphase I, as homologous pairs line up randomly on the equator.

This increases the variety of combinations of maternal and paternal chromosomes (and alleles) in each daughter cell.

(iii) Compare and contrast the products of stage 2 and stage 3 in spermatogenesis with the products from these stages in oogenesis.

(3)

Similarity: in both, haploid cells are produced from diploid cells.

Differences: in spermatogenesis stage 2 (meiosis I) results in two secondary spermatocytes, but in oogenesis only one secondary oocyte.

Stage 3 (meiosis II) results in four spermatids, but in oogenesis only one ovum (egg cell).

Polar bodies are produced in oogenesis but not in spermatogenesis.

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(iv) Explain the importance of the acrosome that develops during stage 4.

(2)

The acrosome contains (digestive) enzymes.

These enable the sperm to digest through the zona pellucida and membrane of the secondary oocyte, so fertilisation can occur.

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(b) The effect of storage time on sperm was investigated.

The table shows some results of this investigation.

Storage time / hours	Percentage of sperm with structural defects (%)	Percentage of sperm that could swim (%)
0	8.2 ± 3.9	85.0 ± 5.7
6	9.5 ± 3.1	67.5 ± 11.0
12	18.0 ± 3.9	66.3 ± 7.5
18	21.3 ± 6.1	67.5 ± 2.8
24	19.5 ± 3.1	58.8 ± 8.5
30	26.5 ± 3.1	41.3 ± 7.5

Analyse the data to comment on conclusions that can be made from this investigation.

(4)

As storage time increases, the percentage of sperm with structural defects increases, from 8.2% at 0 hours to 26.5% at 30 hours.

As storage time increases, the percentage of sperm that can swim decreases, from 85.0% to 41.3%.

These differences are significant because the error bars for no storage and 30 hours of storage do not overlap.

However, increase in storage time may not always correlate with a change, e.g. defects fall from 21.3% at 18 hours to 19.5% at 24 hours, and swimming stays about 67% from 6 to 18 hours.

Many of the error bars overlap or are large, e.g. at 6, 12 and 18 hours, so these differences may not be significant.

(Total for Question 8 = 15 marks)

TOTAL FOR PAPER = 80 MARKS



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