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EDEXCEL A LEVEL BIOLOGY B: QUESTIONS BY TOPIC

Cells, Viruses and Reproduction of Living Things (2)

A Level Biology B Topic 2

84 questions · 799 marks · Mark schemes included

Pearson Edexcel AS (8BI0) and A Level (9BI0) Biology B, June 2016 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.
Click any heading or question row below to jump straight to it.
On every question page, click ANSWER in the top-right corner to jump to its mark scheme.
Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

84 questions · 799 marks · grouped by sub-topic, lowest tariff first

SUB-TOPIC 2(a)

CELL STRUCTURE AND MICROSCOPY

30 questions in this sub-topic · 281 marks · lowest tariff first

1 Plant and animal cells contain a number of organelles.

The table gives information about some of these organelles.

Organelle	Information about the organelle
P	10^{-9} m in size involved in translation
Q	contains thylakoids
R	involved in aerobic respiration
S	2500 nm in size involved in protein modification
T	6 μm in size has a double membrane
U	has a single membrane

(a) Which of the following describes the structure of organelle **S**?

(1)

☒ **A** network of interconnecting tubules

☒ **B** pair of cylinders at right angles to one another

☒ **C** stacks of curved cisternae

☒ **D** two subunits with a groove

(b) Which row of the table is correct for organelles **Q** and **R** ?

(1)

	Found in animals cells	Found in plant cells
☒ **A**	**Q** and **R**	**Q** and **R**
☒ **B**	**Q**	**R**
☒ **C**	**R**	**Q** and **R**
☒ **D**	**Q** and **R**	**Q**

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

(1)

☒ **A** **P S T**

☒ **B** **P T S**

☒ **C** **S T P**

☒ **D** **T S P**

(d) The number of organelles in the table which contain DNA is

(1)

☒ **A** one

☒ **B** two

☒ **C** three

☒ **D** four

(e) The DNA of organelle **R** contains 37 genes. Thirteen of these genes code for proteins involved in part of aerobic respiration.

Calculate the percentage of genes coding for these proteins.

(1)

Answer ..... %

(Total for Question 1 = 5 marks)

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

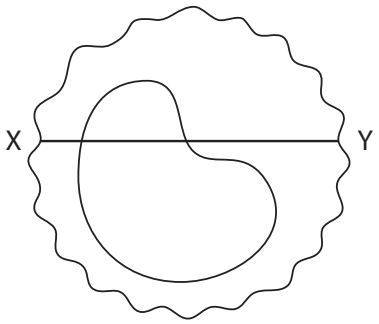
☒ **B** Q P S

☒ **C** Q S P

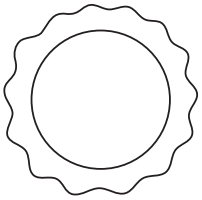
☒ **D** S P Q

(Total for Question 1 = 5 marks)

1 A student drew two types of white blood cell, from a slide viewed using a light microscope.



Cell A



Cell B

The student used the internet to research the actual diameter of these two types of cell.

The student found several values for the diameters of cell A and cell B. They used the mean value for the diameter of cell B to calculate the magnification of the drawing of cell B.

The student calculated the magnification of the drawing of cell B to be ×1571.

The student found the following values for the diameter of cell A:
0.016 mm, 0.022 mm, 0.019 mm, 0.021 mm, 0.017 mm.

(a) Calculate the magnification of the drawing of cell A, using the mean diameter of this cell.

Measure the diameter of cell A between the points X and Y on the diagram.

(2)

Answer .....

(b) This method of calculating the magnification of these drawings is not accurate.

Describe a method that the student could use to calculate the magnification accurately.

(3)

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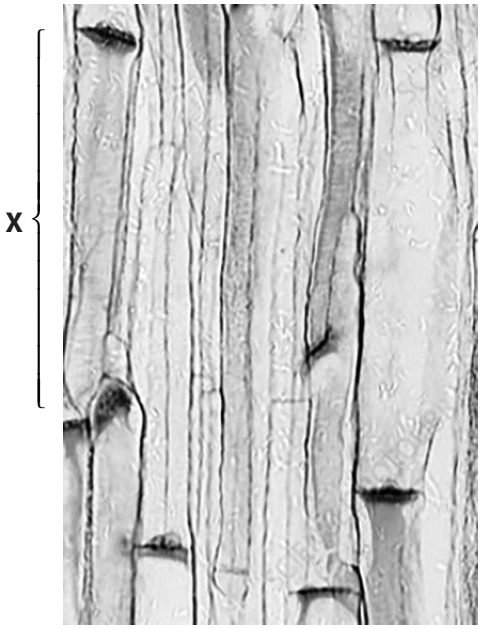
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1 Plant stems contain xylem and phloem, tissues specialised for transport.

The photomicrograph shows a longitudinal section of phloem tissue.



(a) (i) Draw the cell labelled **X**.

(2)

(ii) Explain how phloem tissue is adapted for its function.

(3)

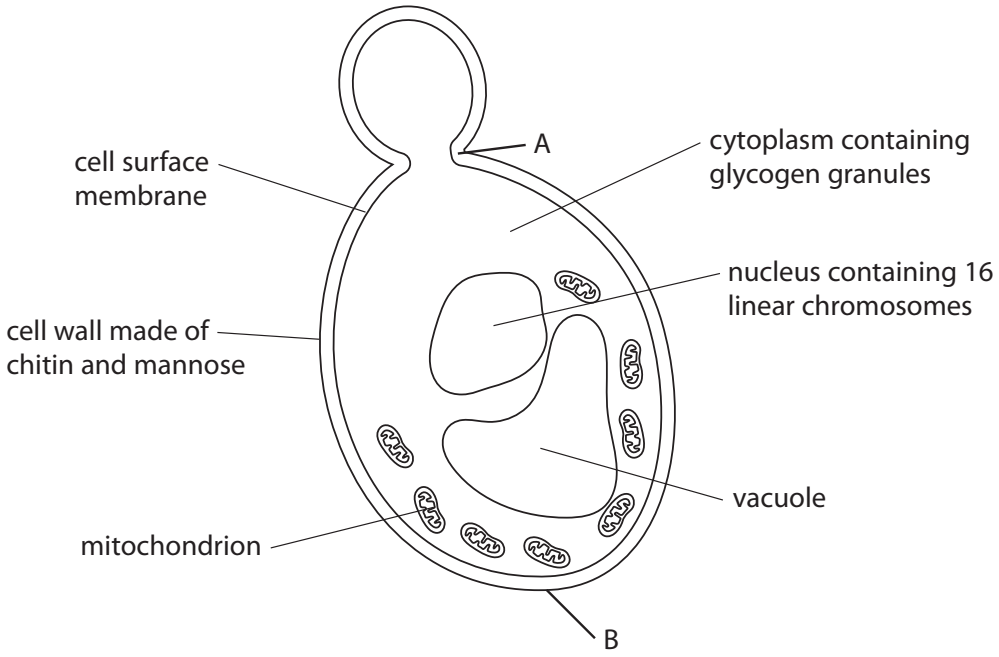
(b) State why stains, such as methylene blue, are sometimes used when preparing a microscope slide.

(1)

(Total for Question 1 = 6 marks)

1 *Saccharomyces cerevisiae* (yeast) is a single-celled organism widely used in brewing and baking.

The diagram shows a drawing of a yeast cell, as seen using an electron microscope.



(a) The actual size of the cell measured from point A to point B is 6 μm.

Calculate the magnification of this yeast cell.

Give your answer to the **nearest whole number**.

(2)

Answer .....

(b) Draw this yeast cell as it would be seen using a light microscope at high magnification.

Labels are not required.

(2)

(c) The information in the diagram can be used to classify yeast.

(i) State why yeast is classified as eukaryotic not prokaryotic.

(1)

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(ii) State why yeast is not classified as a plant.

(1)

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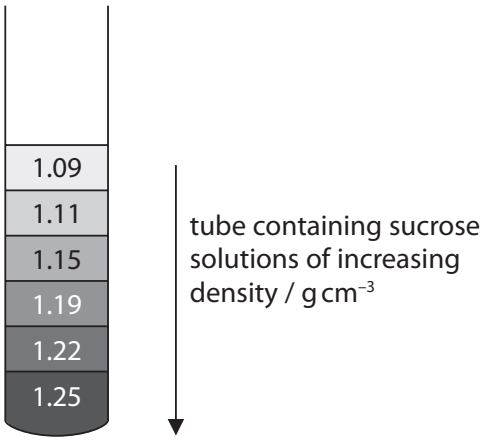
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(Total for Question 1 = 6 marks)

5 A scientist separated the components of animal cells using density gradient centrifugation.

The density gradient is made by layering sucrose solutions of different density on top of each other in a tube, as shown in the diagram.

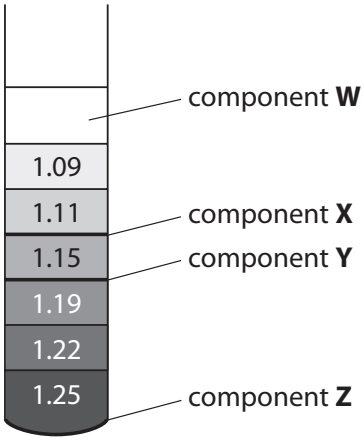


The animal cells were broken up in a salt solution which was then placed on top of the sucrose column.

The tube was then spun in a centrifuge.

This caused the cell components to move different distances down through the sucrose column according to their density.

The diagram shows the position of some cell components in the sucrose column after centrifugation.



The table shows the density of some cell organelles.

Organelle	Density / g cm^{-3}
endoplasmic reticulum	1.16
Golgi apparatus	1.15 to 1.16
lysosome	1.12
mitochondrion	1.19

(a) Component **W** was present after centrifugation.

Explain what might be present in component **W** other than water and salt.

(2)

(b) Which row correctly identifies the organelles present in component **X** and component **Y**?

(1)

	Component X	Component Y
☒ **A**	endoplasmic reticulum	mitochondrion
☒ **B**	Golgi apparatus	lysosome
☒ **C**	lysosome	Golgi apparatus
☒ **D**	mitochondrion	Golgi apparatus

(c) Explain which other organelle would be present in component **Z**.

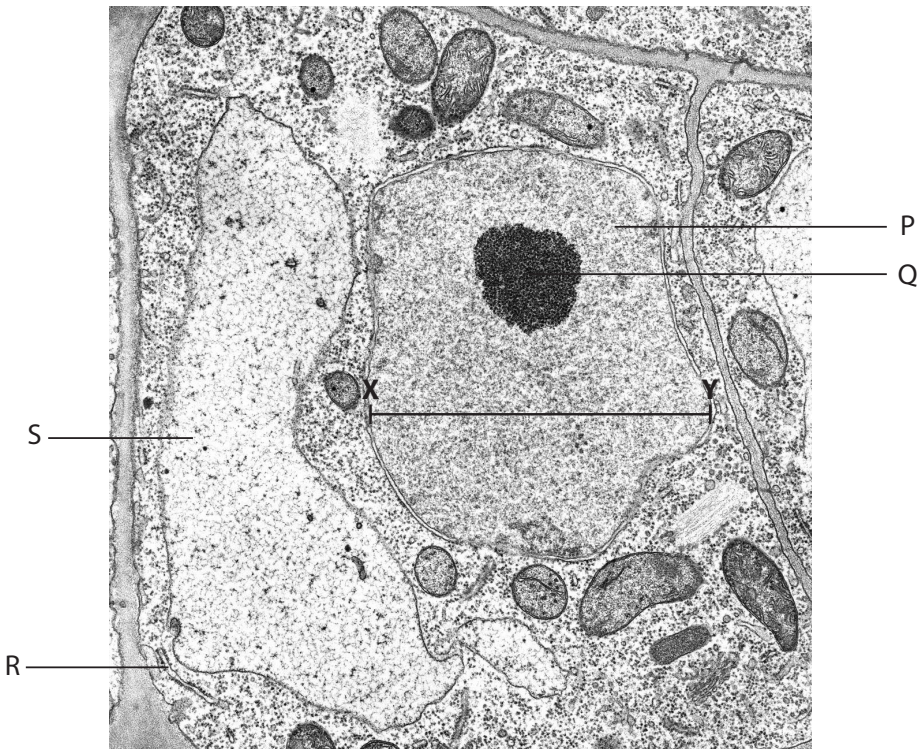
(2)

(d) Explain how rough endoplasmic reticulum can be separated from smooth endoplasmic reticulum using density gradient centrifugation.

(2)

(Total for Question 5 = 7 marks)

1 The photograph shows part of a root tip cell, as seen with an electron microscope.



(Source: © BIOPHOTO ASSOCIATES / SCIENCE PHOTO LIBRARY)

(a) (i) Which of the following structures is surrounded by a tonoplast?

(1)

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

(ii) In which of the following structures does the process of translation occur?

(1)

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

(iii) How many of the labelled structures in this cell will be present in a cell of an organism in the domain Archaea?

(1)

- ☒ **A** 0
- ☒ **B** 1
- ☒ **C** 2
- ☒ **D** 3

(b) The width of structure P, measured between X and Y, is 36 μm.

Calculate the magnification of this photograph.

Give your answer in **standard form**.

(2)

Answer .....

(c) Some plants have adaptations that prevent them being eaten by animals.

Sorghum is a plant that stores a substance called dhurrin inside leaf cells in the structures labelled S in the photograph.

Dhurrin is broken down by the enzyme glucosidase to release hydrogen cyanide.

Glucosidase is stored within the chloroplasts of leaf cells.

Hydrogen cyanide inhibits aerobic respiration.

Explain why dhurrin is stored within structure S, and glucosidase is stored separately in the chloroplasts.

(2)

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5 Leigh syndrome is a genetic disorder inherited from the mother. The mother carries genes for the disorder in her mitochondrial DNA.

(a) Draw and label a mitochondrion.

(4)

(b) Scientists have developed a technique for producing 'three-parent' babies.

This ensures that a mother with Leigh syndrome will not pass on the genes for this disorder to her baby.

The technique involves:

- removing the nucleus from the ovum of the mother
- removing the nucleus from the ovum of a donor female to produce an enucleated ovum
- inserting the nucleus from the ovum of the mother into the enucleated donor ovum
- fertilising this ovum with the sperm of the father to produce a zygote
- implanting the resulting embryo into the uterus of the mother.

(i) The 'three-parent' baby produced by this technique will inherit mitochondrial DNA from the

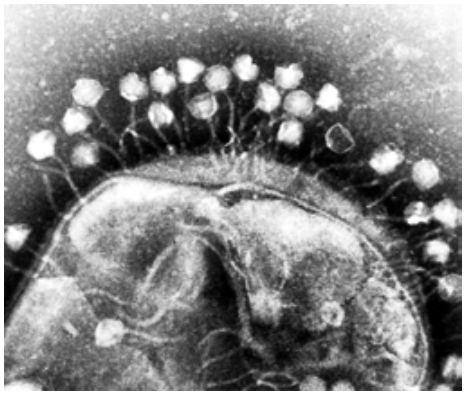
(1)

- ☒ **A** donor female
- ☒ **B** donor female and father
- ☒ **C** mother
- ☒ **D** mother and father

(ii) Explain the importance of DNA replication during the development of this zygote into a blastocyst.

(3)

4 The photograph shows part of a bacterial cell surrounded by viruses, as seen using an electron microscope.



(a) (i) Which of these structures would be present in a bacterial cell but absent in a palisade mesophyll cell?

(1)

- ☒ **A** cellulose cell wall and nucleoid
- ☒ **B** cellulose cell wall and nucleolus
- ☒ **C** peptidoglycan cell wall and nucleoid
- ☒ **D** peptidoglycan cell wall and nucleolus

(ii) Which virus contains DNA?

(1)

- ☒ **A** Ebola
- ☒ **B** HIV
- ☒ **C** λ (lambda) phage
- ☒ **D** tobacco mosaic

(iii) Explain why an electron microscope, rather than a light microscope, was used to produce this photograph.

(2)

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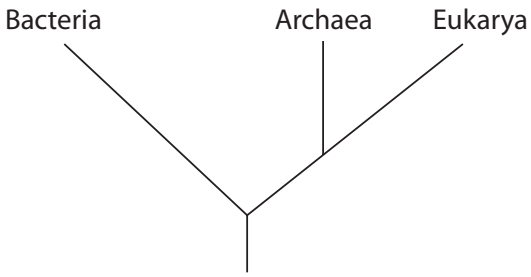
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(b) The diagram shows the three-domain model of classification as suggested by Carl Woese.



This model was based on the comparison of many different characteristics.

Some of the characteristics used by Woese are shown in the table.

Characteristic	Archaea	Bacteria	Eukarya
Membrane lipids	branched carbon chains attached to glycerol by **ether** linkage	straight carbon chains attached to glycerol by **ester** linkage	straight carbon chains attached to glycerol by **ester** linkage
First amino acid in protein synthesis	methionine	formylmethionine	methionine
Antibiotic sensitivity	no	yes	no
rRNA loop sequence	absent	present	absent
Ribosome size	70 S	70 S	80 S

(i) Analyse the information to explain the evidence for the three-domain model of classification.

(3)

(ii) Many scientists agree with this three-domain model.

State how these scientists would have reached agreement about this model.

(1)

(Total for Question 4 = 8 marks)

4 Cells and some cell organelles are surrounded by a membrane.

(a) Explain the arrangement of phospholipids in a membrane.

(2)

(b) The photograph shows part of a mitochondrion, as seen using an electron microscope.



(Source: © DON W. FAWCETT/SCIENCE PHOTO LIBRARY)

(i) State why the intermembrane space can be seen in this photograph, when it is not always visible in photographs of mitochondria using other electron microscopes.

(1)

(ii) The width of each membrane in this photograph is 6 nm.

Calculate the actual width of the intermembrane space in the region labelled on this photograph.

(2)

Answer ..... nm

(c) The table shows the percentage of some types of membrane in one cell from a liver and one cell from a pancreas.

Type of membrane	Percentage of total membranes (%)	
	Cell from a liver	Cell from a pancreas
Plasma cell membrane	2	5
Rough endoplasmic reticulum	35	60
Smooth endoplasmic reticulum	16	<1
Golgi apparatus	7	10
Mitochondria	39	21
Secretory vesicle	not determined	3
Other	1	between 0 and 1

Analyse the data to explain three differences in the percentages of these types of membrane in these two cells.

(3)

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3 *Bacillus subtilis* and *Pseudomonas aeruginosa* are two types of bacteria.

(a) (i) Which pair of structures is found in these bacteria?

(1)

- ☒ **A** nucleoid and 70S ribosomes
- ☒ **B** nucleoid and 80S ribosomes
- ☒ **C** nucleus and 70S ribosomes
- ☒ **D** nucleus and 80S ribosomes

(ii) Name **three other** structures that are surrounded by the cell wall of bacteria.

(2)

1 .....

2 .....

3 .....

(b) A scientist determined the thickness of the cell wall of these bacteria.

The thickness of the cell wall of *B. subtilis* is 55.4 nm and the thickness of the cell wall of *P. aeruginosa* is 2.4 nm.

(i) Calculate the ratio of the thickness of the cell wall of *B. subtilis* to that of *P. aeruginosa*.

Give your values to **two** significant figures.

(1)

Answer .....

(ii) Some antibiotics affect only Gram positive bacteria.

Explain which of *B. subtilis* or *P. aeruginosa* will be affected by these types of antibiotics.

(2)

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(c) *Bacillus subtilis* was grown in a culture. At the start the culture contained 6×10^3 cells and after two hours the culture contained 1.7×10^5 cells.

Calculate the mean rate of increase in the number of bacteria in this culture.

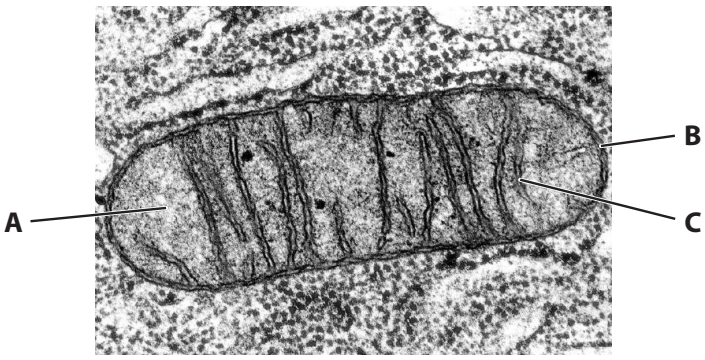
Give your answer in cells per minute.

(2)

Answer ..... cells per minute

(Total for Question 3 = 8 marks)

5 The photograph shows a mitochondrion, as seen using an electron microscope.



(Source: © CNRI/SCIENCE PHOTO LIBRARY)

(a) Name the parts labelled **A**, **B** and **C**.

(2)

A .....

B .....

C .....

(b) Draw a diagram of this mitochondrion.

(2)

(c) The actual length of this mitochondrion is 0.9 µm.

(i) What is the magnification of this photograph?

(1)

☒ **A** ×1200

☒ **B** ×8200

☒ **C** ×12 000

☒ **D** ×82 000

(ii) The magnification of this photograph can be shown as a scale bar.

Complete the 1 cm scale bar for this photograph.

(1)

1 cm scale bar ⟷

Answer ..... µm

(d) Explain why specimens have to be stained with coloured dyes when viewed using a light microscope and not when using an electron microscope.

(2)

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1 The photograph shows part of a liver cell, as seen using an electron microscope.



(Source: © Keith R. Porter/SCIENCE PHOTO LIBRARY)

(a) Describe the roles of the labelled organelles in a liver cell.

(3)

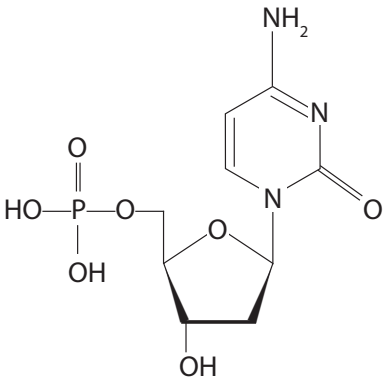
(b) Hepatitis B is a DNA virus that infects liver cells. The DNA of the virus replicates inside liver cells.

(i) Describe the process of DNA replication.

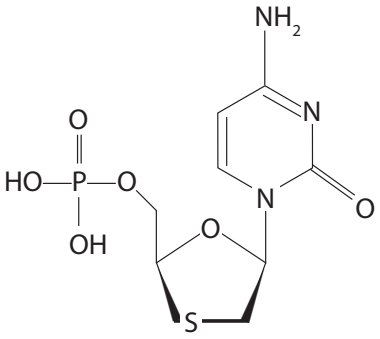
(3)

(ii) The drug lamivudine is used to treat infections by the hepatitis B virus. It causes the production of altered nucleotides containing cytosine.

The diagram shows a normal nucleotide and an altered nucleotide.



normal nucleotide



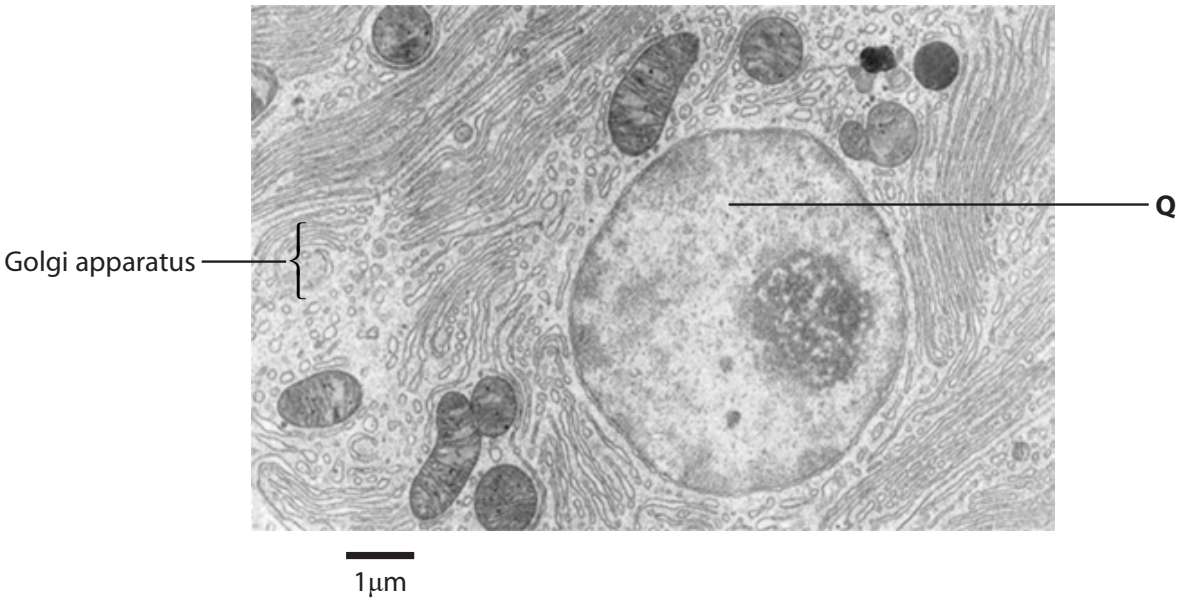
altered nucleotide

Explain how lamivudine reduces replication of the hepatitis B virus in liver cells.

(2)

6 The pancreas is an organ that secretes digestive enzymes.

The electron micrograph shows part of a secretory cell from a human pancreas.



(a) Name organelle **Q**.

(1)

.....

(b) Calculate the maximum diameter of organelle **Q**.

(2)

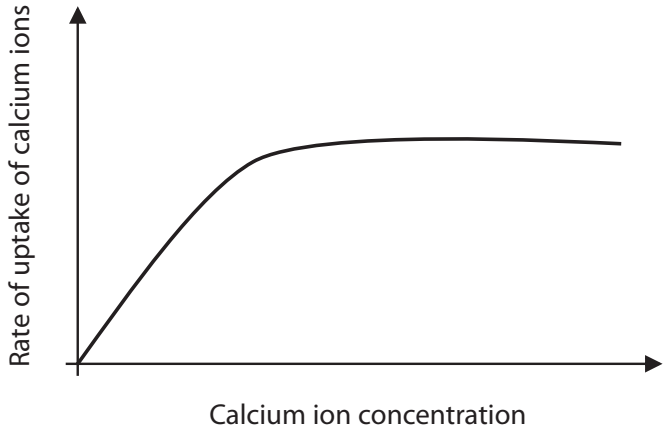
Answer .....

(c) Describe the role of the Golgi apparatus in producing secreted enzymes.

(3)

(d) Calcium ions are needed for the secretion of enzymes from pancreatic cells.

The graph shows the effect of increasing calcium ion concentration on the uptake of calcium ions by pancreatic cells.



Explain the effects of calcium ion concentration on the rate of uptake of calcium ions through the pancreatic cell membrane.

(3)

5 Cattle with bovine spongiform encephalopathy (BSE) have microscopic holes in their brain tissue.

This disease involves the misfolding of proteins which then form clumps.

Clumps of misfolded proteins can be seen with an electron microscope.

(a) BSE is diagnosed by examination of brain tissue.

(i) Explain why the clumps of misfolded proteins can be seen with an electron microscope, but not with a light microscope.

(2)

(ii) Explain why stains are used when preparing tissue for examination using a light microscope.

(2)

(b) The misfolded proteins have a changed secondary structure. Therefore they cannot be digested by some protease enzymes.

(i) Describe what is meant by the secondary structure of a protein.

(2)

(ii) Explain why the misfolded protein cannot be digested by some protease enzymes.

(3)

4 (a) Photographs **P** and **Q** are electron micrographs of mitochondria.

Each photograph was taken using a different electron microscope.

Photograph **P**



Sourced from: http://book.bionumbers.org/how-big-are-mitochondria/

Photograph **Q**



Source: Cellupedia

(i) What is the structure labelled **S**?

(1)

- ☒ **A** crista
- ☒ **B** matrix
- ☒ **C** stroma
- ☒ **D** thylakoid

(ii) Explain the difference in appearance of the parts labelled **C** using the two different electron microscopes.

(2)

*(b) The table shows the protein : lipid ratio of the inner and outer membrane of a mitochondrion.

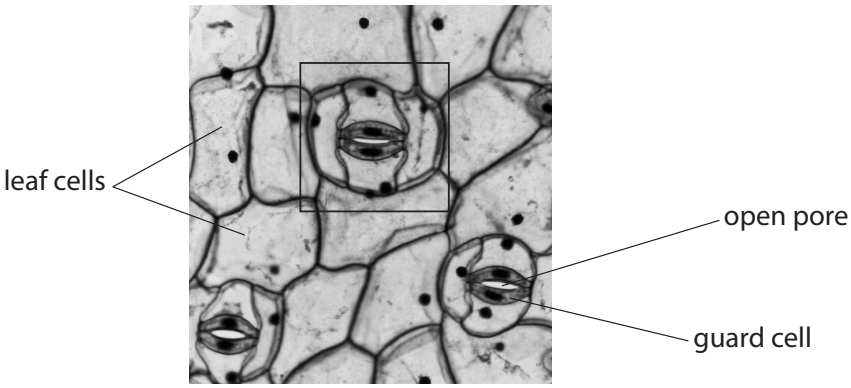
Membrane of mitochondrion	Protein : lipid ratio
inner	3:2
outer	1:1

Explain the difference in the protein : lipid ratio of the inner and outer membrane of a mitochondrion.

(6)

4 Stomata are pores found on the under-surfaces of leaves. They are surrounded by a pair of guard cells.

The photograph shows three stomata, as seen using a light microscope.



(Source: © Science History Images/Alamy Stock Photo)

(a) Draw the cells in the box on the photograph, at a magnification × 2 of the photograph.

(3)

*(b) The pores are closed in the dark and open in the light.

When the pores are open, the width of the pores increases.

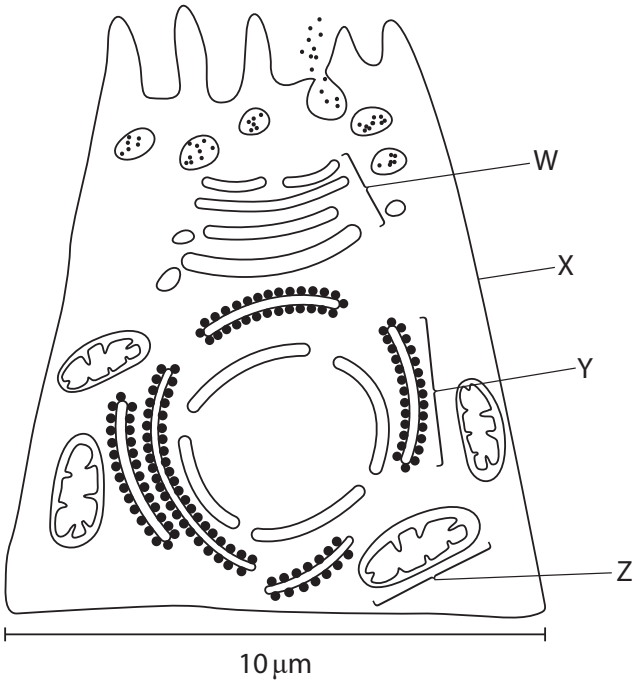
Potassium ions are involved in the opening of the pores.

Devise an investigation to determine the effect of potassium ion concentration on the width of the pores of stomata.

(6)

6 Some of the cells in the pancreas secrete proteins.

The diagram represents a pancreatic cell.



(a) (i) The structure labelled **Y** represents the

(1)

- ☒ **A** centrioles
- ☒ **B** Golgi apparatus
- ☒ **C** rough endoplasmic reticulum
- ☒ **D** smooth endoplasmic reticulum

(ii) The structure also found in a prokaryotic cell is labelled

(1)

- ☒ **A** W
- ☒ **B** X
- ☒ **C** Y
- ☒ **D** Z

(iii) Calculate the magnification of this cell.

(2)

Answer.....

(iv) Explain why these pancreatic cells contain large numbers of organelle **Z**.

(3)

.....

.....

.....

.....

.....

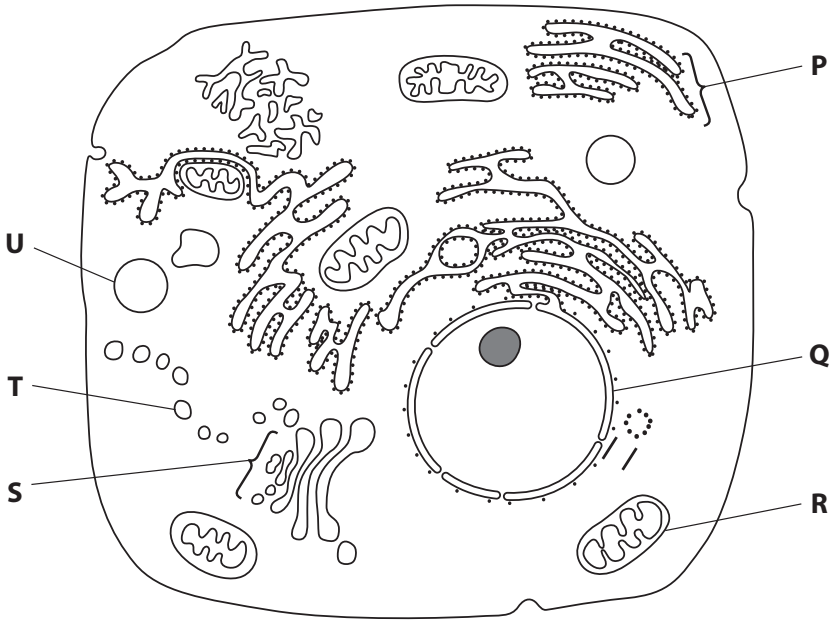
(b) The secreted proteins are made from amino acids.

Two amino acids join together to form a dipeptide.

Draw a diagram to show the structure of a dipeptide.

(3)

2 The diagram shows the ultrastructure of an animal cell.



Magnification ×9000

(a) (i) The structure labelled **R** on the diagram represents a

(1)

- ☒ **A** chloroplast
- ☒ **B** lysosome
- ☒ **C** mitochondrion
- ☒ **D** ribosome

(ii) The structure labelled **Q** on the diagram represents the

(1)

- ☒ **A** cell surface membrane
- ☒ **B** nuclear envelope
- ☒ **C** rough endoplasmic reticulum
- ☒ **D** smooth endoplasmic reticulum

(iii) Calculate the actual diameter of the structure labelled **U**.

(2)

Answer .....

(iv) Describe how the structures labelled **P**, **S** and **T** are involved in the production and secretion of molecules from this cell.

(3)

(b) Which row in the table is correct for structures found in animal cells and prokaryotic cells?

(1)

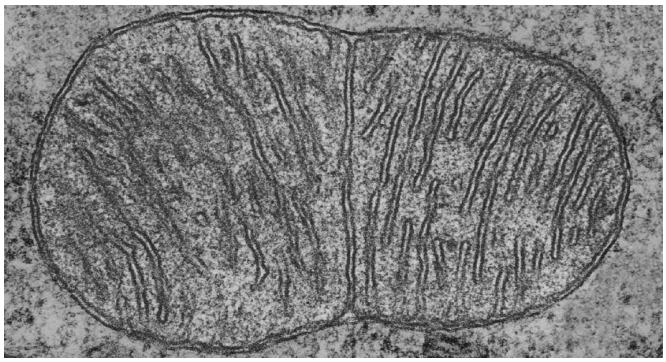
	Nucleolus		Plasmid		Ribosome	
	Animal cell	**Prokaryotic cell**	**Animal cell**	**Prokaryotic cell**	**Animal cell**	**Prokaryotic cell**
☒ **A**	✓	×	✓	✓	✓	✓
☒ **B**	×	✓	✓	✓	×	✓
☒ **C**	✓	×	×	✓	✓	✓
☒ **D**	✓	✓	✓	×	✓	×

(c) Explain why it is possible to see the detailed structure of a prokaryotic cell with an electron microscope but not with a light microscope.

(2)

3 Mitochondria are organelles surrounded by a double membrane.

The photograph shows a dividing mitochondrion, as seen using an electron microscope.



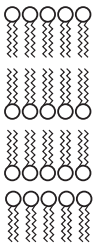
(Source: © DON W. FAWCETT / SCIENCE PHOTO LIBRARY)

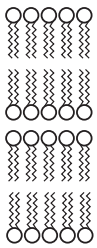
(a) The inner and outer membrane of a mitochondrion each consist of a phospholipid bilayer.

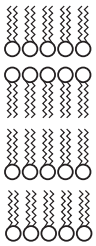
A phospholipid can be represented as 

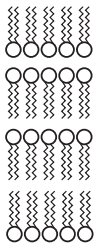
(i) Which of the following shows the arrangement of phospholipids in these two membranes?

(1)

☒ **A** 

☒ **C** 

☒ **B** 

☒ **D** 

(ii) The gap between these two membranes is called the intermembrane space.

The intermembrane space is 200 angstroms wide.

One angstrom = 0.1 nm

Which of the following is the width of the intermembrane space in μm?

(1)

- ☒ **A** 0.002
- ☒ **B** 0.020
- ☒ **C** 0.200
- ☒ **D** 2.000

(iii) Explain why the intermembrane space can be seen in this photograph.

(2)

(iv) Name **one** other organelle with a double membrane.

(1)

(b) (i) Explain why it is necessary for mitochondria to divide during the cell cycle.

(2)

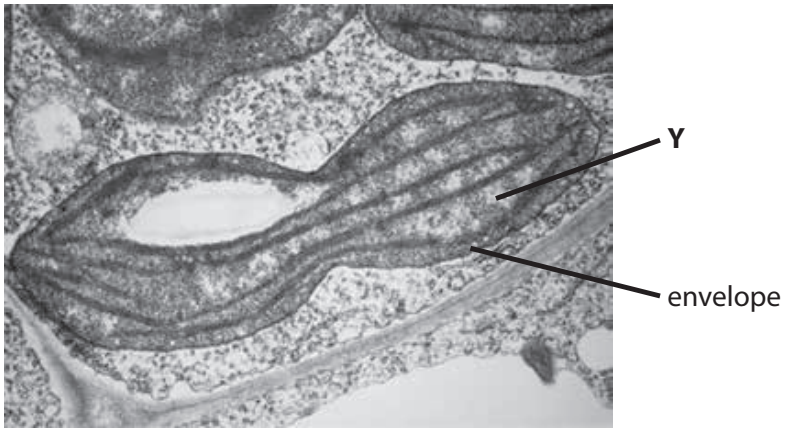
(ii) Describe how mitochondria divide.

Use the information in the photograph and your own knowledge to support your answer.

(3)

8 When a photosynthetic plant cell grows, the number of chloroplasts in the cell increases. This increase in the number of chloroplasts can result from the division of chloroplasts already present in the cell.

The electron micrograph shows a chloroplast dividing.



(a) What is the name of the part of the chloroplast labelled **Y**?

(1)

- ☒ **A** cytoplasm
- ☒ **B** matrix
- ☒ **C** nucleoplasm
- ☒ **D** stroma

(b) The envelope consists of two membranes. These membranes are separated by a gap of 10×10^{-3} to 20×10^{-3} μm.

The magnification of this electron micrograph is ×12 000.

(i) Calculate the maximum width of this gap in this electron micrograph.

(2)

Answer .....

(ii) Explain why the envelope in this electron micrograph cannot be seen as two separate membranes.

(2)

.....

.....

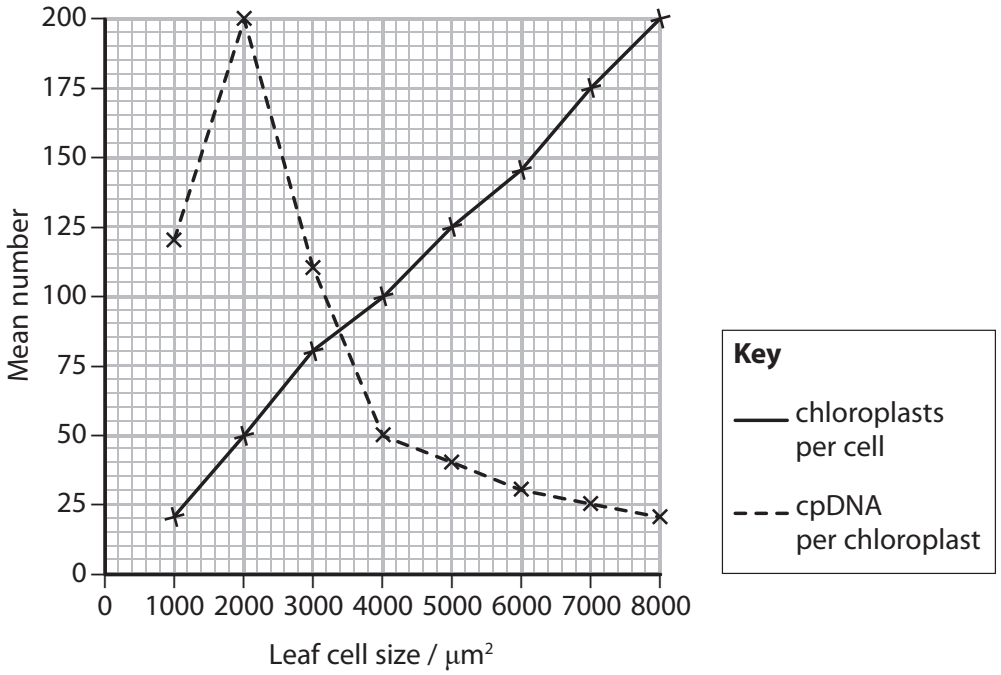
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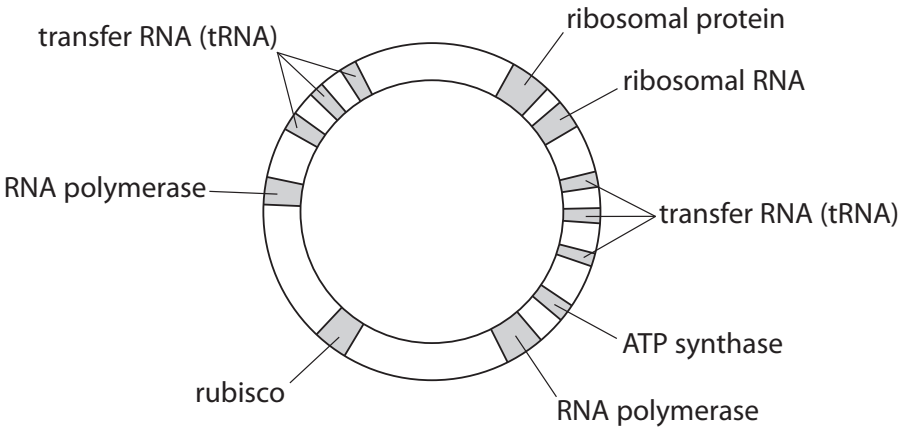
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*(c) In an investigation, the mean size of leaf cells was determined. The mean number of chloroplasts per cell and the mean number of DNA molecules (cpDNA) per chloroplast were also determined.

The graph shows the results of this investigation.



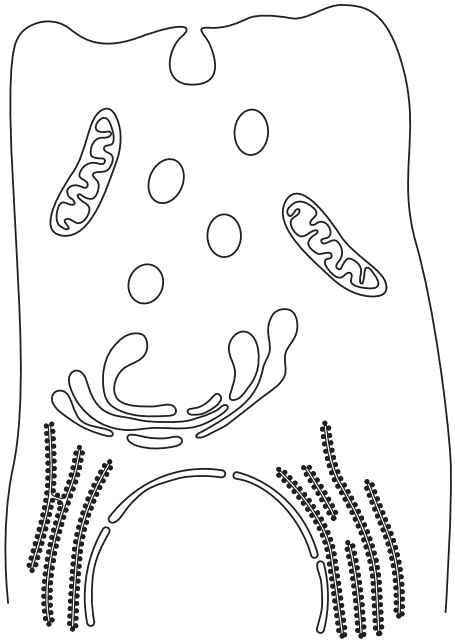
The diagram shows the location of some genes found in cpDNA.



Analyse the information to explain the changes that occur in a leaf cell as it grows.

(6)

5 The diagram shows part of a cell from the pancreas that produces enzymes for use in the digestion of food.



(a) State one way in which the structure of a prokaryotic cell would differ from the cell shown in this diagram.

(1)

.....

(b) In an investigation, cells from the pancreas were grown in a culture medium containing radioactive amino acids.

Samples of these cells were taken and the level of radioactivity in three organelles was measured.

The table shows the results of this investigation.

Time after radioactive amino acids were added to the culture medium / min	Level of radioactivity present / arbitrary units		
	Golgi apparatus	Rough endoplasmic reticulum	Vesicles
1	21	120	6
20	52	88	6
40	86	39	8
60	71	23	15
90	50	27	28
120	23	11	51

(i) Using the information in the table, draw arrows on the diagram showing the path of radioactivity through and out of the cell.

(2)

(ii) Comment on the results of this investigation.

(4)

(c) The diagram shows the position of the pancreas and the small intestine.



Lipase and protease enzymes produced by the pancreas are used in the small intestine during digestion.

Pancreatitis is a condition that occurs when the pancreatic duct becomes blocked.

(i) Explain how the contents of the small intestine in a patient with pancreatitis would differ from the contents of the small intestine in a healthy person.

(2)

(ii) Some of the enzymes are produced in an inactive form.

In patients with pancreatitis, these enzymes can become active in the pancreas.

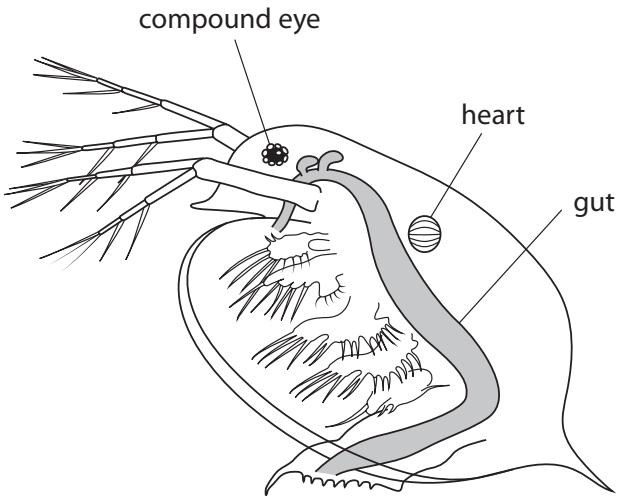
Explain how this activation could affect the pancreas.

(2)

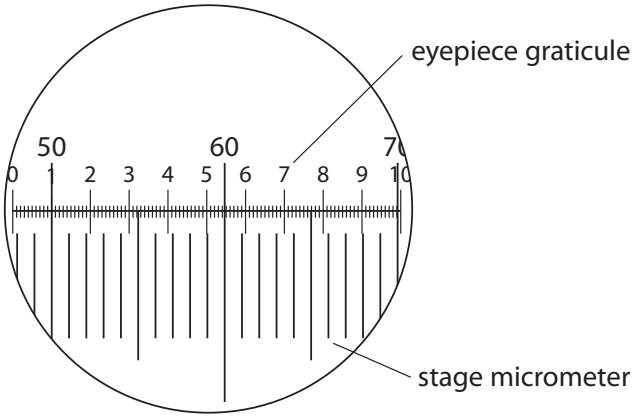
3 Water fleas are small animals that live in pond water.

A student observed a water flea using a light microscope.

The diagram shows the student's drawing of the water flea.



The diagram shows an eyepiece graticule and a stage micrometer used by the student to measure the diameter of the heart in this water flea.



(Source: http://biology4alevel.blogspot.com/2014/07/2-cell-structure-microscopy.html)

Each small division on the stage micrometer is 0.01 mm.

The diameter of the heart was found to be 0.2 mm.

(a) Determine the number of eyepiece units that equal the diameter of the water flea heart.

(1)

Answer .....

(b) The water flea has a spherical heart with a diameter of 0.2 mm.

Cardiac output is the volume of blood pumped out of a heart in one minute.

The resting heart rate of a water flea is 200 beats min^{-1}.

The volume of a sphere is calculated using the formula

$$\frac{4}{3}\pi r^3$$

where $\pi = 3.142$

(i) Calculate the cardiac output of a water flea at rest using the formula

cardiac output = stroke volume × heart rate

(3)

Answer ..... $dm^3\ min^{-1}$

(ii) The cardiac output of a human heart at rest is 5.0 $dm^3\ min^{-1}$.

Give one reason why the cardiac output of a human heart at rest needs to be greater than the cardiac output of a water flea at rest.

(1)

.....

.....

(c) A student investigated the effect of adrenaline and acetylcholine on the heart rate of water fleas using the following method:

- place a water flea in pond water on a microscope slide
- count the number of heart beats in one minute
- repeat with two other water fleas
- repeat this procedure using three water fleas placed in adrenaline solution and three water fleas placed in acetylcholine solution.

The table shows the results of this investigation.

Treatment	Heart rate / beats min^{-1}				Standard deviation (SD)
	Water flea 1	Water flea 2	Water flea 3	Mean	
Pond water	195	185	190	190	
Adrenaline solution	240	236	238	238	±2.0
Acetylcholine solution	116	120	118	118	±2.0

(i) Calculate the standard deviation for the mean heart rate in the pond water.

Use the formula

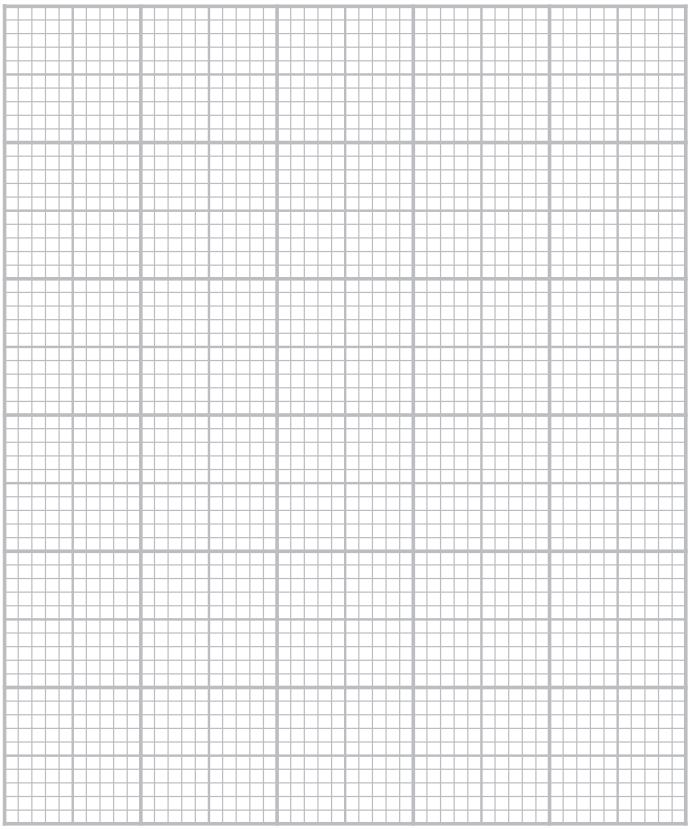
$$SD = \sqrt{\frac{\sum (X - \bar{X})^2}{n - 1}}$$

(2)

Answer .....

(ii) Plot a graph to show the data for the mean heart rate and SD in each treatment.

(2)

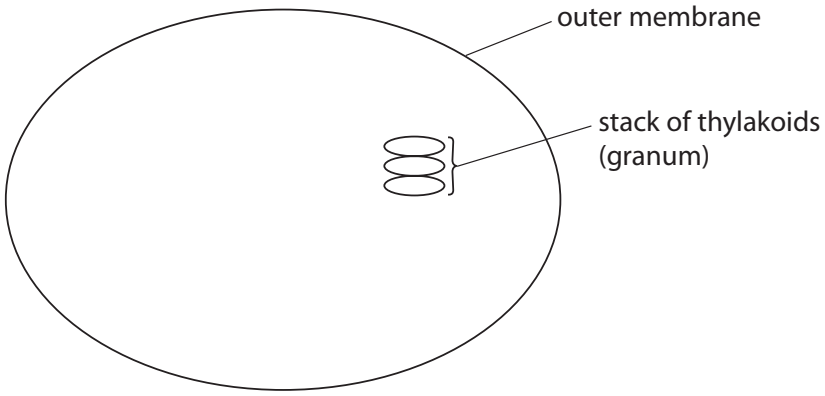


(iii) Explain why abiotic variables should be controlled in this investigation.

(2)

6 Scientists have removed thylakoids from chloroplasts to make artificial chloroplasts.

(a) The diagram shows part of a chloroplast.



(i) Draw and label **three** other structures found in a chloroplast.

(3)

(ii) Chloroplasts can be 3 μm in length.

Calculate the magnification of this diagram for a chloroplast that is 3 μm in length.

Give your answer to two significant figures.

(2)

Answer .....

(b) Explain the importance of the thylakoid membranes in the light-dependent stage of photosynthesis.

(4)

(c) The artificial chloroplasts made by the scientists consisted of thylakoids removed from spinach leaves, and enzymes involved in carbon fixation.

These components were put into water, forming a suspension.

This suspension was dropped into a medium containing oil.

The suspension formed cell-sized droplets of water containing the thylakoids and the enzymes.

(i) Name the enzyme that fixes carbon dioxide in the light-independent stage of photosynthesis.

(1)

(ii) Explain why it is necessary to keep the thylakoids and enzymes together within droplets.

(2)

5 (a) Bacteria are prokaryotes.

(i) Give **two** differences between the structures of a prokaryotic cell and a eukaryotic cell.

(2)

(ii) Gram staining is often used to help identify bacteria.

A sample of bacteria from an infected person was tested by using Gram staining.

The bacteria stained red.

Explain why the bacteria stained red **and** why this information is useful for treating the infected person.

(3)

(b) (i) Describe the method used to isolate individual species from a mixed culture of bacteria in nutrient broth.

(4)

(ii) Explain **three** precautions that would be taken to reduce the growth of pathogenic bacteria.

(3)

5 Eukaryotic cells and prokaryotic cells have similarities and differences in their ultrastructure.

(a) Compare and contrast the ultrastructures of eukaryotic cells and prokaryotic cells.

(4)

(b) Some antibiotics inhibit RNA synthesis and protein synthesis in cells.

Actinomycin D, Rifamycin and α-Amanitin are antibiotics that work by binding to molecules in a cell. This inhibits protein synthesis.

The scientists who developed these antibiotics had to find out which types of cell were affected and which molecule they were binding to.

The table shows the types of cell that these antibiotics affect and the molecule that they bind to.

Antibiotic	Type of cell affected	Molecule that the antibiotic binds to
Actinomycin D	Prokaryotic and eukaryotic	DNA
Rifamycin	Prokaryotic only	RNA polymerase
α-Amanitin	Eukaryotic only	RNA polymerase

(i) Describe the structure of a DNA molecule.

(3)

(ii) Explain the effect of Actinomycin D on protein synthesis.

(3)

(iii) Explain the effect of Rifamycin and α-Amanitin on protein synthesis.

(3)

6 Mitochondria and chloroplasts in eukaryotic cells are thought to have originated millions of years ago by a process called endosymbiosis.

In endosymbiosis, free-living prokaryotic organisms were engulfed by their new host cells.

(a) The table shows the lipid composition of the membranes of these two organelles.

Type of lipid	Percentage of total lipid composition of membranes (%)	
	In mitochondria	In chloroplasts
phosphatidyl A	43	0
phosphatidyl B	35	0
phosphatidyl C	6	1
phosphatidyl D	3	7
phosphatidyl E	13	0
monogalactosyldiacylglycerol F	0	55
digalactosyldiacylglycerol G	0	24
sulfolipid H	0	8

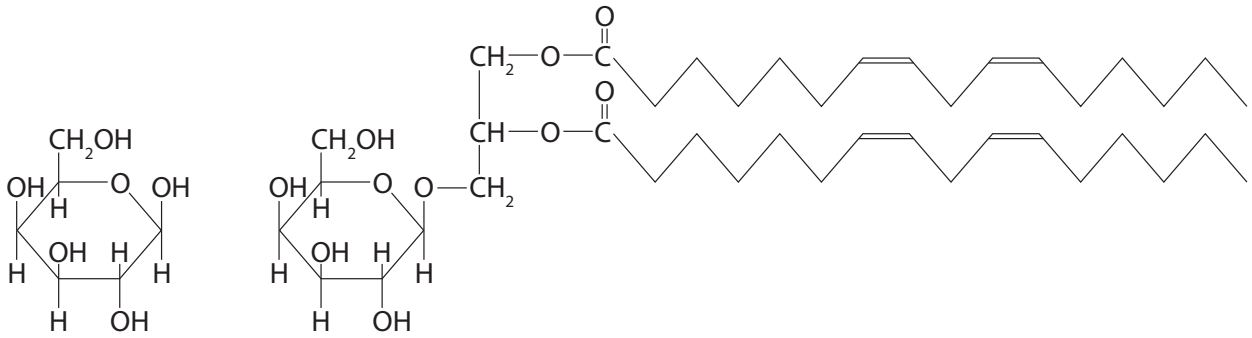
(i) Analyse the data and use your knowledge to explain why these two organelles are thought to have originated from different prokaryotic organisms.

(3)

(ii) Digalactosyldiacylglycerol (DGDG) is synthesised from galactose and monogalactosyldiacylglycerol (MGDG).

The galactose forms a 1,6 glycosidic bond with the MGDG.

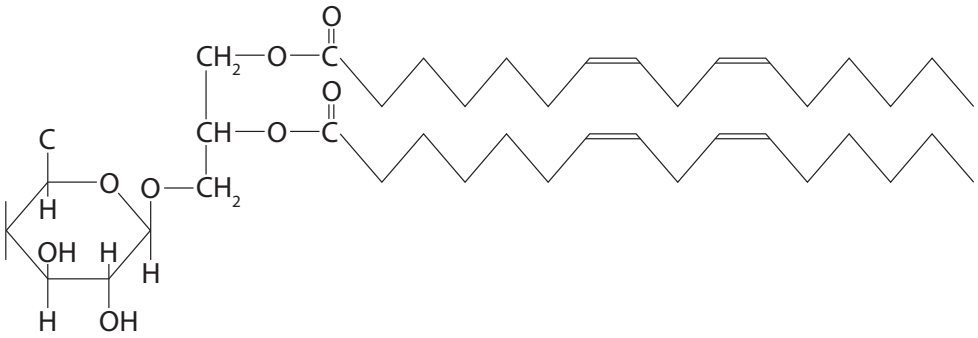
The diagram shows the structure of galactose and MGDG.



galactose MGDG

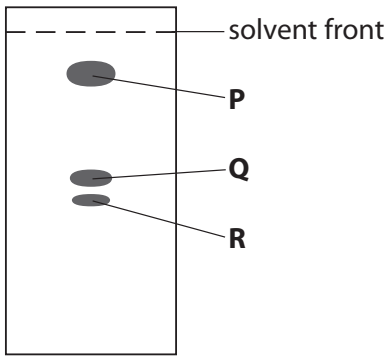
Complete the diagram below to show the structures of the products formed when DGDG is synthesised from galactose and MGDG.

(3)



(iii) Chromatography can be used to separate MGDG, DGDG and sulfolipid extracted from chloroplasts.

The diagram shows the position of these three lipids, **P**, **Q** and **R**, on a chromatogram.



Which row in the table identifies the position of these three lipids in this chromatogram ?

(1)

	Lipid in position P	Lipid in position Q	Lipid in position R
☒ **A**	DGDG	sulfolipid	MGDG
☒ **B**	MGDG	DGDG	sulfolipid
☒ **C**	sulfolipid	DGDG	MGDG
☒ **D**	sulfolipid	MGDG	DGDG

(b) Chloroplasts are thought to be derived from cyanobacteria.

It is estimated that there are 1×10^{10} carbon atoms in one cyanobacterial cell.

Ten photons of light are needed to fix one carbon atom.

(i) Calculate the number of photons of light needed to fix enough carbon to form one cyanobacterial cell.

(1)

(ii) Explain why the value calculated in (b)(i) is likely to be an underestimate.

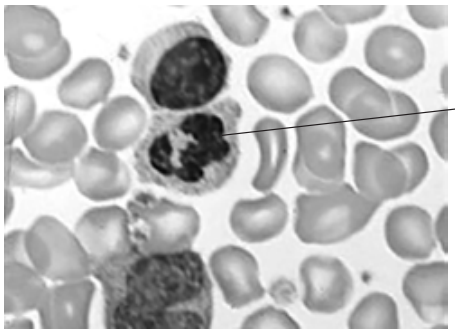
(2)

(iii) Describe how carbon fixation takes place in chloroplasts.

(3)

9 Microscopy is a technique used to study structures that are not within the resolution range of the human eye.

(a) The photograph shows cells in a blood smear, as seen using a light microscope.



(i) Draw the cell labelled **K**, as shown in the photograph. Your drawing should have a magnification ×2.

(4)

(ii) Describe how to use a micrometer to determine how many times bigger your drawing is than the actual cell in the blood smear.

(4)

*(b) A school wanted to buy some new microscope objective lenses that would give better resolution.

Several factors affect the resolution of a microscope.

The tables show some data that the school was given from a company selling microscope objective lenses.

Table 1

Magnification of objective lenses	Objective lenses P		Objective lenses Q		Objective lenses R	
	Numerical aperture	Resolution / μm	Numerical aperture	Resolution / μm	Numerical aperture	Resolution / μm
×4	0.10	2.75	0.13	2.12	0.20	1.38
×10	0.25	1.10	0.30	0.92	0.45	0.61
×40	0.65	0.42	0.75	0.37	0.95	0.29
×100	1.25	0.22	1.30	0.21	1.40	0.20

Table 2

Wavelength of light / nm	Resolution / μm
360	0.19
400	0.21
500	0.26
600	0.32
700	0.37

Analyse the data in Table 1 and Table 2 to determine the extent to which resolution is affected by magnification, numerical aperture and the wavelength of light.

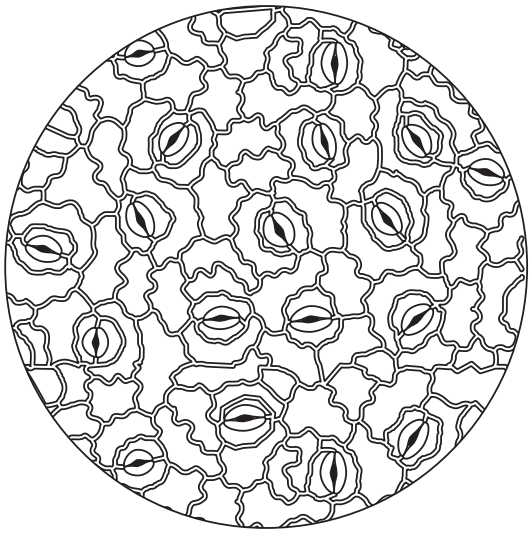
(6)

6 A student investigated the effect of light intensity on the development of stomata in coffee plant leaves.

The following method was used:

- young coffee seedlings were separated into two groups
- one group was grown in bright light and the other group was grown in dim light
- leaves were selected from each group and their surfaces were painted with nail varnish
- the nail varnish was allowed to dry and then peeled off the leaf surface
- each nail varnish peel was observed using a light microscope.

The diagram shows an example of the field of view seen by the student when using the high power lens.



(a) Describe how a microscope should be used to observe the stomata using the high power lens.

(3)

(b) The diameter of the field of view is 0.4 mm.

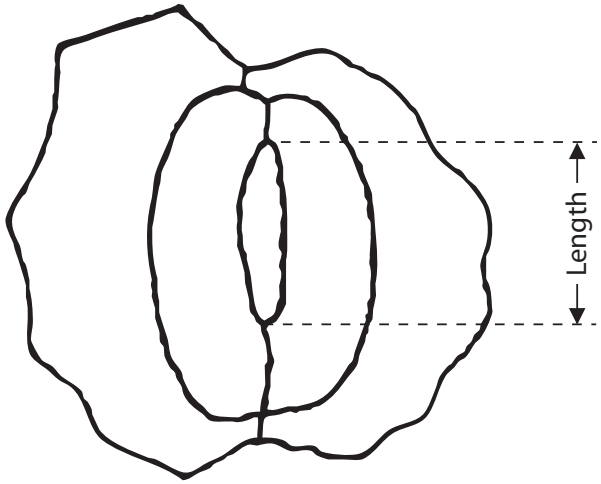
Calculate the number of stomata per mm^2 on the leaf surface.

The area of a circle is πr^2, where π is 3.142.

(2)

Answer ..... mm^{-2}

(c) The diagram shows one of the stomata drawn by the student.



The actual length of this stoma is 20 µm.

Calculate the magnification of this drawing.

(2)

Answer .....

(d) The results of this investigation are shown in the table.

Leaf sample	Number of stomata mm^{-2}	
	Leaves in bright light	Leaves in dim light
1	184	143
2	190	138
3	182	140
4	185	132
5	192	136
Mean ($\bar{x}$) and SD	186.6 ± 4.2	137.8

(i) Calculate the SD for the leaves in dim light.

Use the formula

$$SD = \sqrt{\frac{\Sigma(x - \bar{x})^2}{n - 1}}$$

(2)

Answer .....

(ii) Describe how these nail varnish peel samples should be taken to allow a valid comparison between the mean numbers of stomata.

(2)

(iii) Analyse the data to explain how fewer stomata might affect the growth of coffee plants.

(3)

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 μm to 100 μm.

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)

Answer .....

(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)

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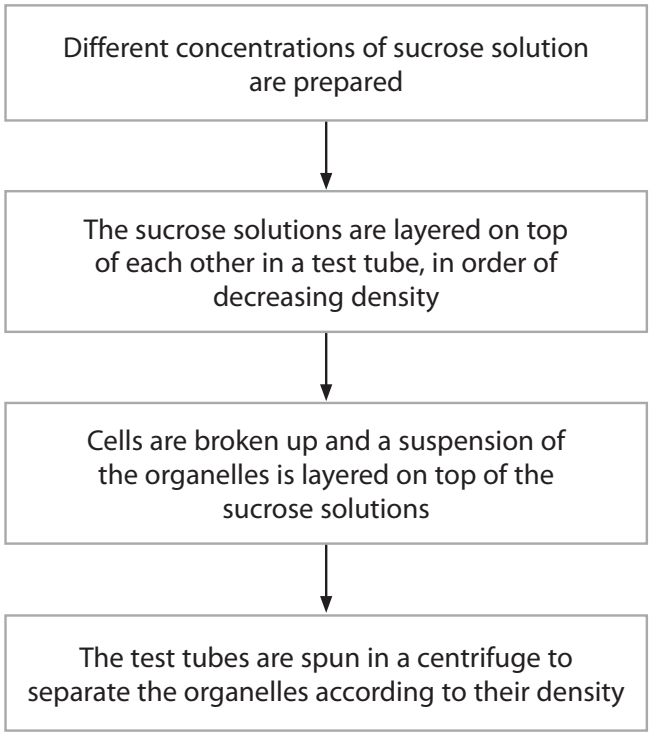
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(b) Cell organelles can be separated according to size using a sucrose density gradient.

The flow diagram shows how this can be done.



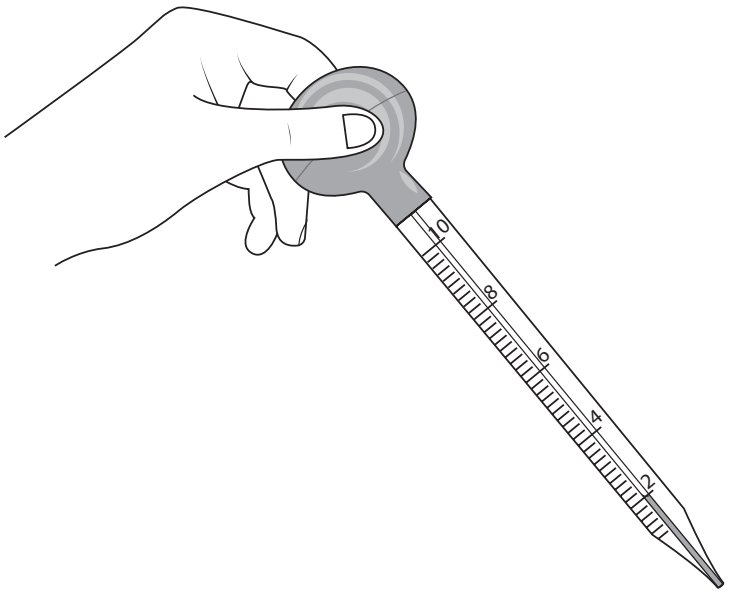
(i) A student prepared a 1.25 g cm^{-3} sucrose solution by diluting a sucrose solution with a concentration of 5 g cm^{-3}.

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

(2)

Answer .....

(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)

.....

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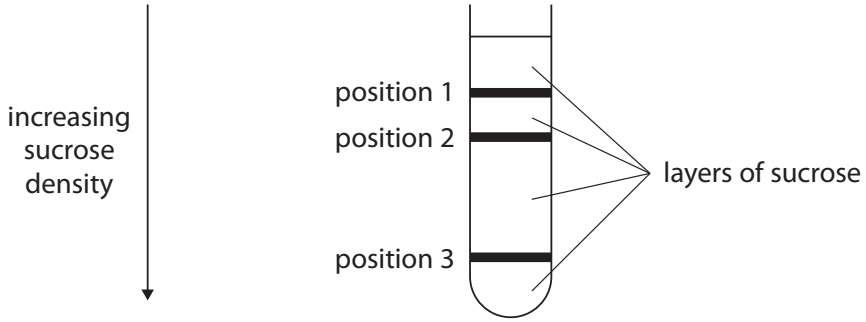
(iii) The student actually measured 2.01 cm^3 of the suspension using the method shown in this diagram.

Calculate the percentage error of this measurement.

(1)

Answer ..... %

(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)

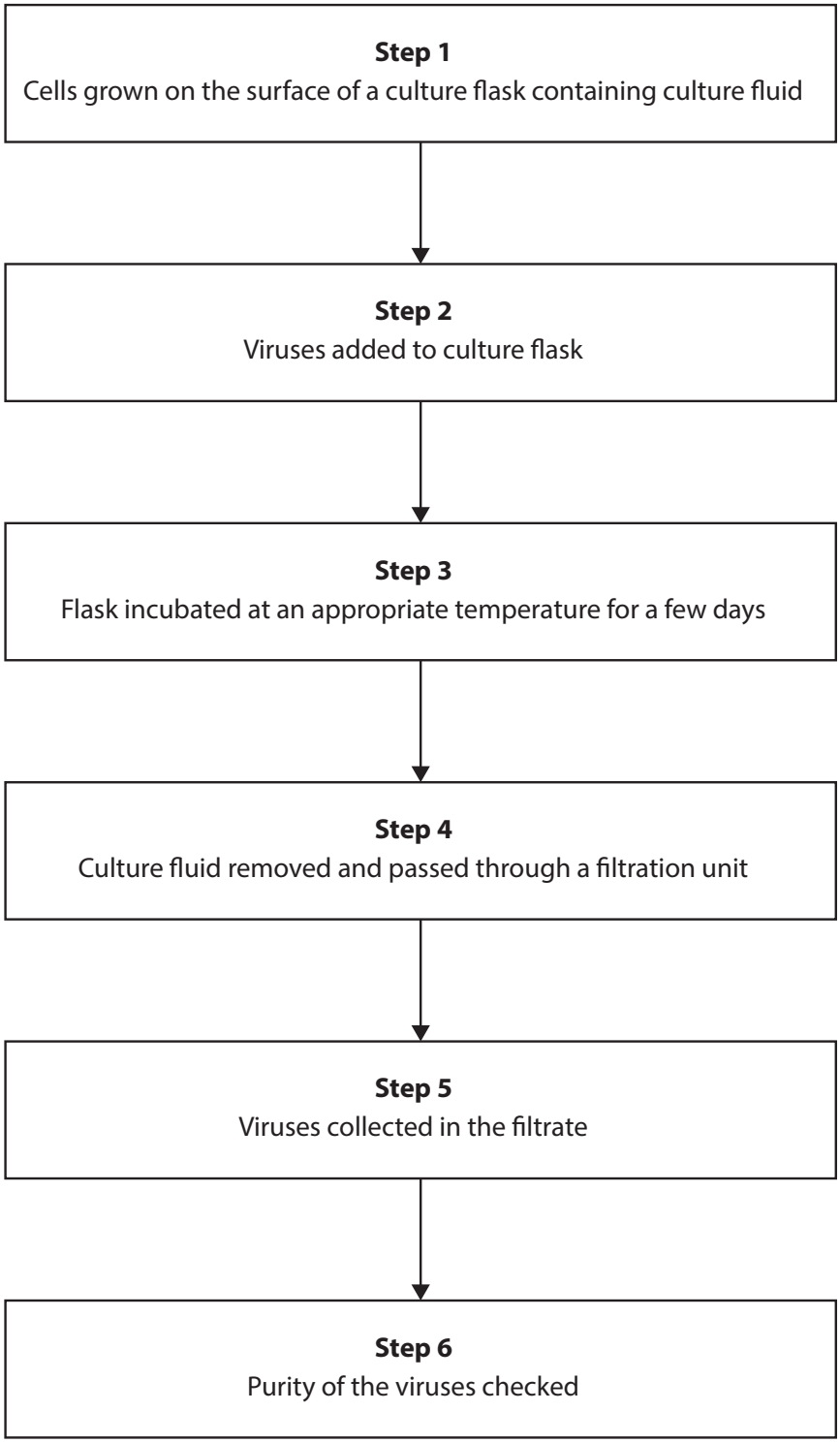
SUB-TOPIC 2(b)

VIRUSES

11 questions in this sub-topic · 115 marks · lowest tariff first

3 Viruses can be cultured and isolated in a laboratory.

The diagram shows the steps involved in culturing and isolating viruses.



(a) State why specifically-selected cell types have to be grown in **Step 1**.

(1)

(b) Explain why the flask has to be incubated at an appropriate temperature for a few days in **Step 3**.

(2)

(c) Explain why the viruses and not the cells will be present in the filtrate in **Step 5**.

(3)

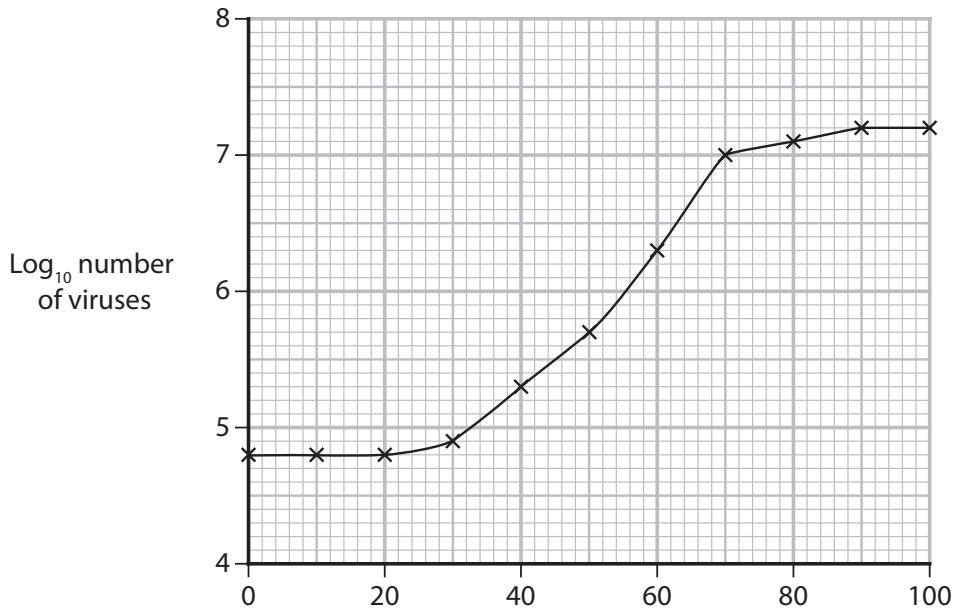
3 Viruses can replicate using the lytic cycle.

Viruses can be grown in a laboratory by culturing them with appropriate cells.

(a) Explain why viruses have to be cultured with 'appropriate cells'.

(2)

(b) The graph shows the changes in the number of viruses after they had been added to the cells.



(i) Explain why the number of viruses did not start to increase until after 20 minutes.

(3)

(ii) Calculate how many more viruses are present at 70 minutes than at 50 minutes.

Give your answer to **three significant figures**.

(2)

Answer .....

(Total for Question 3 = 7 marks)

6 (a) The classification of viruses is based on structure and nucleic acid types.

(i) Which of the following pairs of viruses both have an envelope?

(1)

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

(ii) Which of the following pairs of viruses both have a helical capsid?

(1)

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

(b) When a bacterial cell is infected with λ (lambda) phage, the virus will enter the lytic cycle.

(i) Describe the lytic cycle of a virus.

(3)

(ii) The multiplicity of infection (MOI) is one factor that determines whether a virus enters the lytic cycle or latency.

$$\text{MOI} = \frac{\text{number of infectious virus particles}}{\text{number of target cells present}}$$

A scientist needed to use a MOI of 0.5 for an investigation.

The virus particles were at a concentration of $2 \times 10^9\,\text{cm}^{-3}$ and the bacteria were at a concentration of $8 \times 10^8\,\text{cm}^{-3}$.

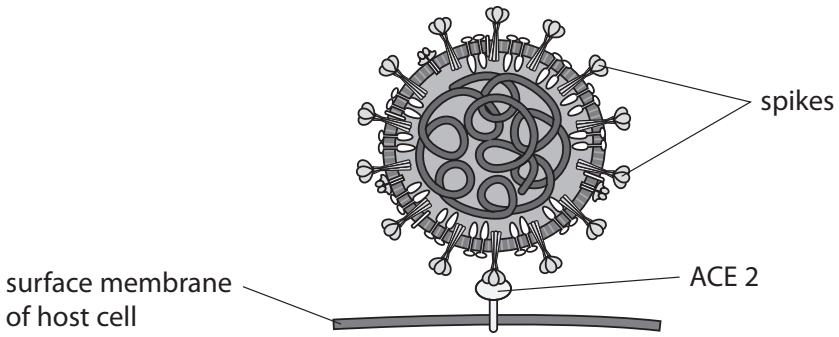
Calculate the volume of virus particles that should be added to $0.25\,\text{cm}^3$ of bacteria.

(3)

Answer ..... cm^3

(Total for Question 6 = 8 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)

(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)

3 In 2014 there was an Ebola virus outbreak in West Africa.

(a) Which of the following viruses contains RNA and the enzyme reverse transcriptase?

(1)

☒ **A** Ebola virus

☒ **B** human immunodeficiency virus (HIV)

☒ **C** λ (lambda) phage

☒ **D** tobacco mosaic virus

(b) Ebola virus begins its lytic cycle soon after the infection of body cells.

(i) Describe the lytic cycle of a virus.

(2)

(ii) Some doctors believe that the Ebola virus may undergo latency within body cells.

State what is meant by the term latency.

(2)

(c) An experimental drug called Zmapp was used to treat patients during this outbreak of Ebola virus.

Patients with Ebola virus were randomly split into two groups.

Both groups received standard medical treatment.

One group was also given Zmapp on days 1, 3 and 5.

Some of the patients suffered severe side effects after treatment with Zmapp and required additional medical care.

The results are shown in the table.

Day	Number of patients surviving		Number of patients with severe side effects after treatment with Zmapp on days 1, 3 and 5
	Without Zmapp	With Zmapp	
1	35	36	11
2	32	33	
3	31	31	7
4	30	29	
5	29	28	3
6	26	28	
7	23	28	
8	22	28	
9	22	28	

Analyse the data to assess the effectiveness of Zmapp to treat patients with Ebola virus.

(4)

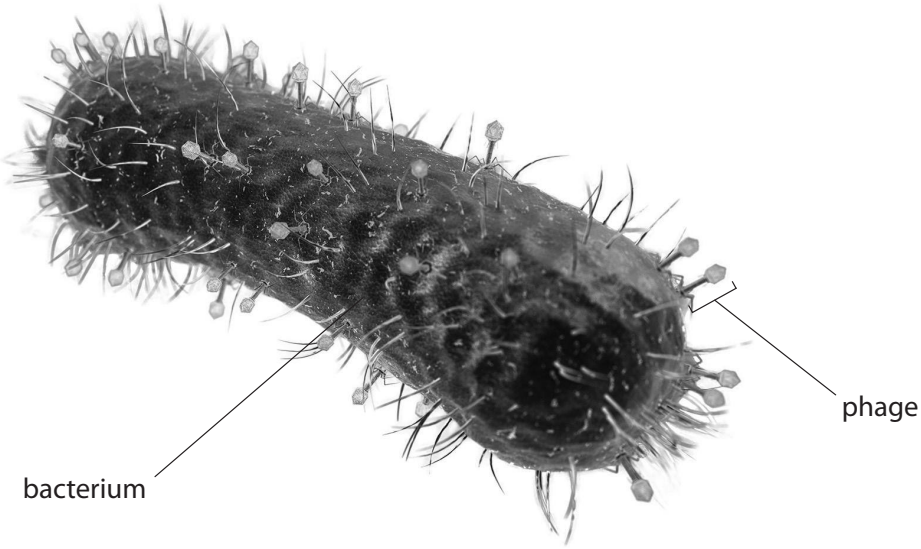
4 Bacteria are the host cells for λ (lambda) phage viruses.

(a) Which is a description of a λ phage?

(1)

- ☒ **A** DNA virus with a complex protein capsid
- ☒ **B** DNA virus with a helical protein capsid
- ☒ **C** RNA virus with a complex protein capsid
- ☒ **D** RNA virus with a helical protein capsid

(b) The image shows phage viruses attacking a bacterium.



(Source: © nobeastsofierce Science/Alamy Stock Photo)

The length of this bacterium is 1.7 µm.

Calculate the length of the labelled phage.

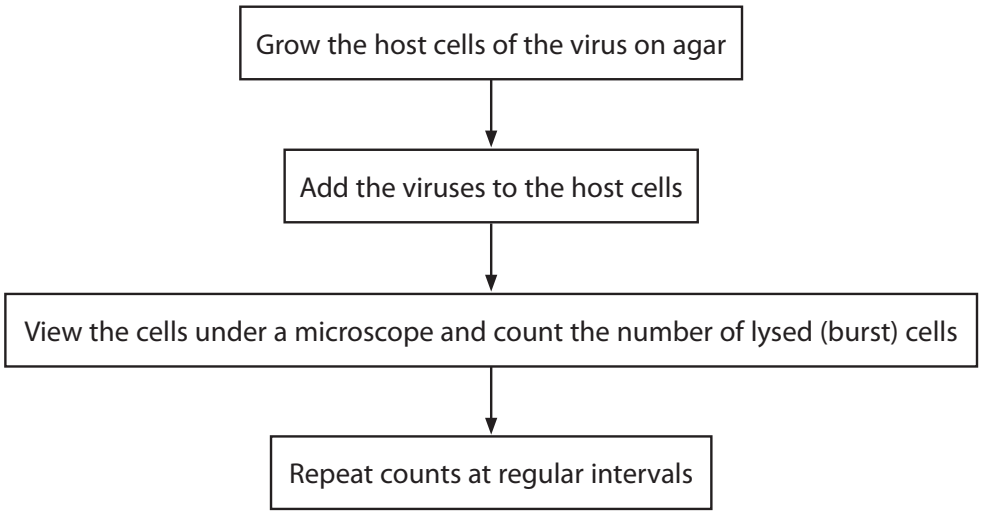
Give your answer in nanometres (nm).

(2)

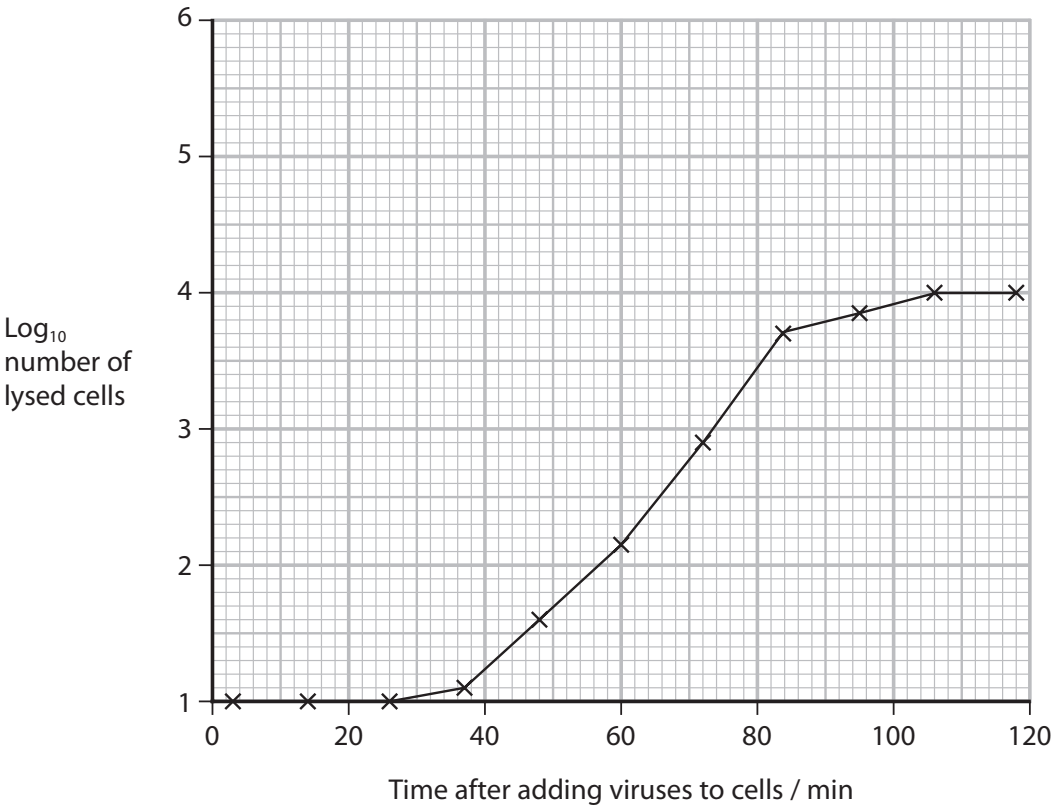
Answer ..... nm

(c) Viruses can be cultured and a growth curve can be produced.

The flow chart shows how this can be done.



The graph shows a growth curve for viruses.



(i) Explain why there was a delay before the number of lysed cells started to increase.

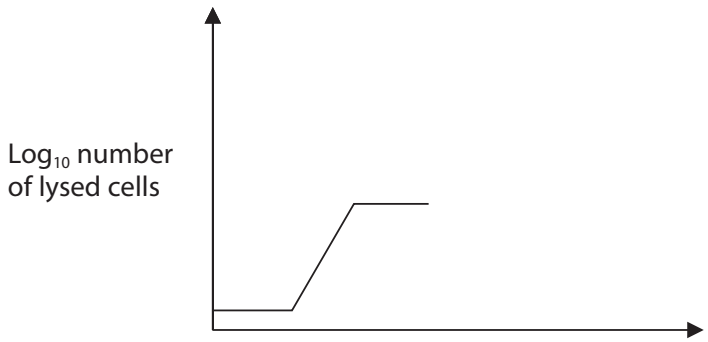
(3)

(ii) Calculate the mean rate of increase in the actual number of lysed cells between 50 minutes and 90 minutes.

(2)

Answer ..... cells min^{-1}

(iii) A sketch has been made of this growth curve.

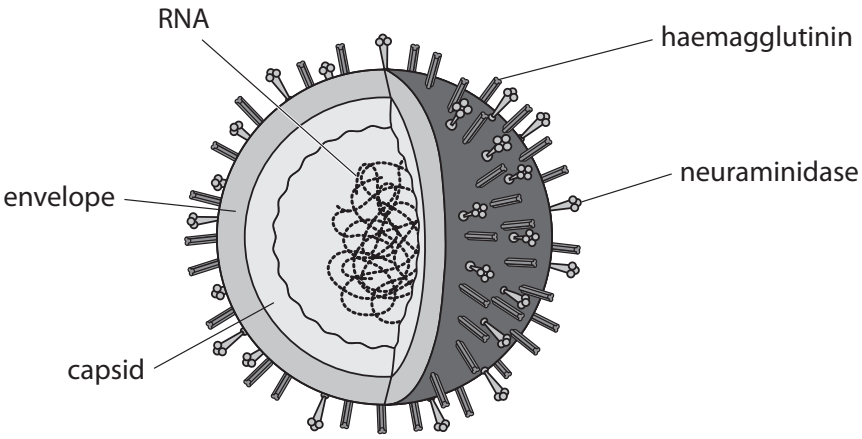


Complete this sketch to predict the shape of the growth curve after 120 minutes, assuming there is an excess of host cells.

(2)

(Total for Question 4 = 10 marks)

6 The diagram shows the structure of the influenza virus.



(a) The influenza virus has a helical capsid.

Which virus also has a helical capsid and an envelope?

(1)

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

(b) Neuraminidase is an enzyme.

Describe the structure of an enzyme.

(3)

*(c) The host cells of the influenza virus are the cells lining the airways. These cells are coated in mucus.

Neuraminidase and haemagglutinin are glycoproteins present in the envelope of the influenza virus.

Neuraminidase and haemagglutinin are important in the lytic cycle of this virus.

Neuraminidase breaks bonds between sialic acid groups and other molecules.

Sialic acid is found on glycoproteins present in the cell membrane, mucus and the envelope of the virus.

Haemagglutinin is a glycoprotein that binds to sialic acid groups.

The lytic cycle of the influenza virus includes the following steps:

1 the virus attaches to a cell

2 the virus moves until it attaches to the correct cell surface receptor

3 new virus particles are made inside the host cell

4 new virus particles bud from the host cell

5 new virus particles are attached to the outside of the host cell membrane and to each other

6 new virus particles infect new host cells.

Explain the importance of neuraminidase and haemagglutinin in the spread of infection of the influenza virus in the body.

(6)

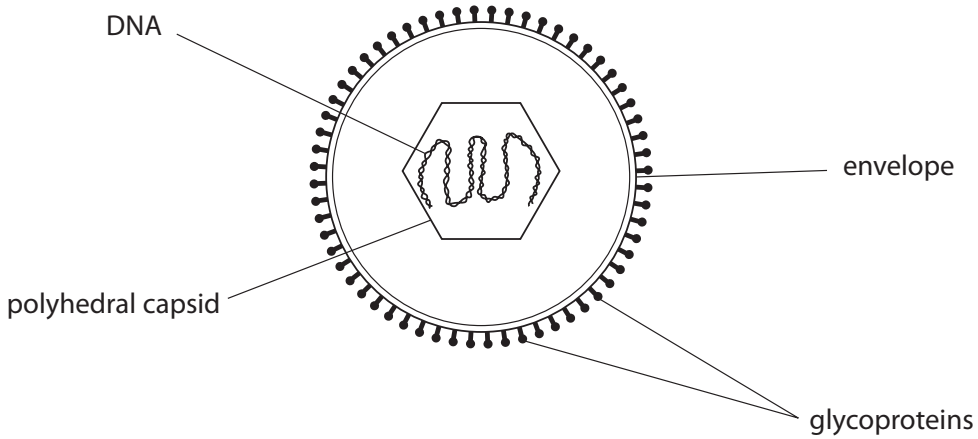
5 Glandular fever is caused by infection with the Epstein–Barr virus (EBV).

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)

.....

.....

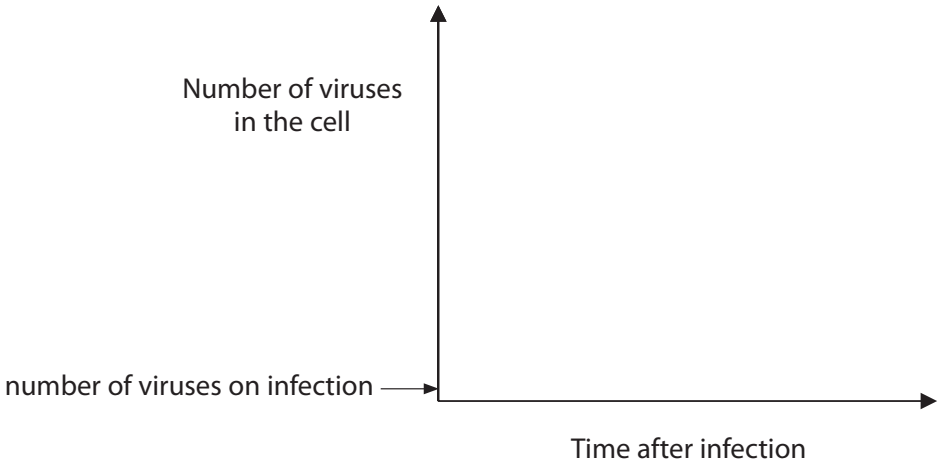
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(iii) Describe the role of the glycoproteins in EBV.

(2)

(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.

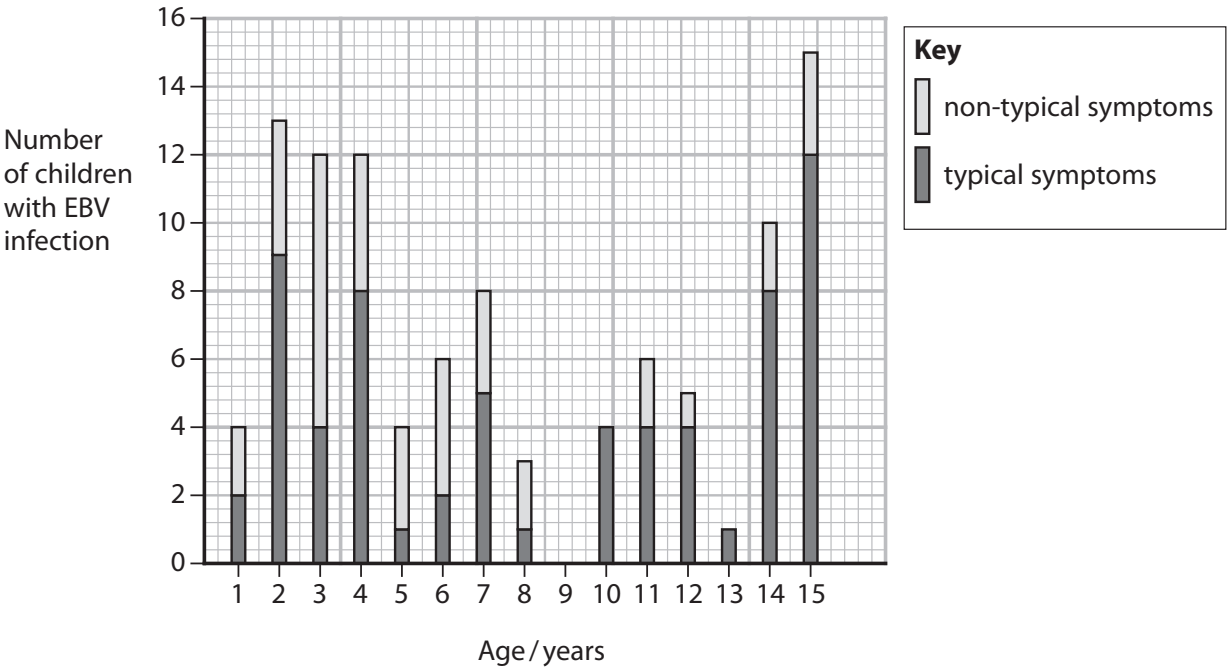
(2)



(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)

Answer .....

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

(2)

(iii) Describe how this investigation could be improved.

(3)

6 Norovirus is a single-stranded RNA, non-enveloped virus.

Norovirus is the most common cause of gastroenteritis.

(a) The table shows some features used to classify viruses.

Which box in each row shows how these viruses are classified?

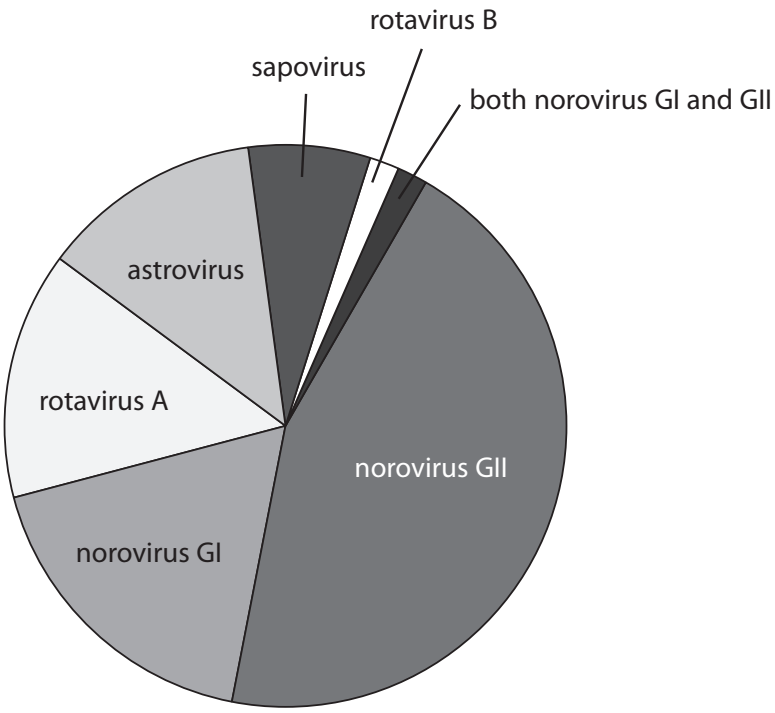
(3)

Virus	Classification of viruses			
	DNA enveloped	**DNA non-enveloped**	**RNA enveloped**	**RNA non-enveloped**
Ebola	☒	☒	☒	☒
λ (lambda) phage	☒	☒	☒	☒
Tobacco mosaic	☒	☒	☒	☒

(b) One study into the causes of gastroenteritis involved 162 patients.

This study found that 24.7% of these gastroenteritis cases were caused by viruses.

The pie chart shows the proportion of the different types of virus identified as causing these gastroenteritis cases.



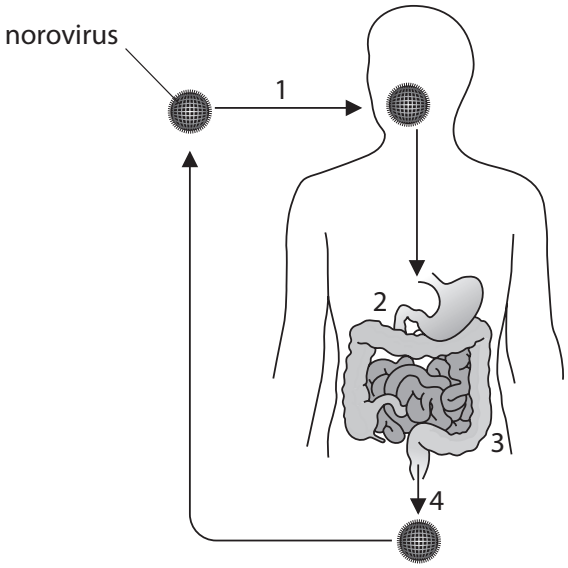
Estimate the total number of gastroenteritis cases caused by noroviruses.

(3)

Answer .....

(c) Norovirus is usually spread through the faecal-oral route.

The diagram shows the pathway that norovirus takes through the body.



1 The norovirus is transmitted in contaminated food or water.

2 The norovirus passes through the stomach and into the small intestine.

3 Some noroviruses are taken up by the cells of the small intestine.

4 Some noroviruses pass out of the body in the faeces.

This process only takes a few hours.

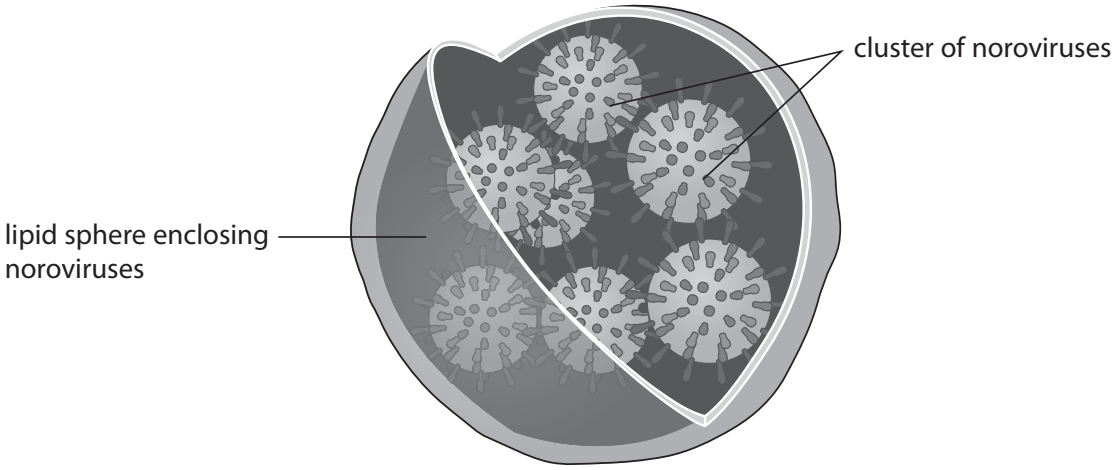
Describe what happens inside the cells of the small intestine that have taken up the norovirus.

(3)

(d) Noroviruses can infect an animal as individual viruses or as a cluster of viruses inside a lipid sphere.

A cluster of viruses inside a lipid sphere is called a stealth sphere.

The diagram shows a stealth sphere.



(i) Animals infected with stealth spheres develop gastroenteritis very quickly and with severe symptoms.

Animals infected with individual noroviruses develop gastroenteritis more slowly and with less severe symptoms.

Analyse the information to explain these findings.

(3)

(ii) Scientists are hoping that new treatments for norovirus infections can be developed to target the stealth sphere.

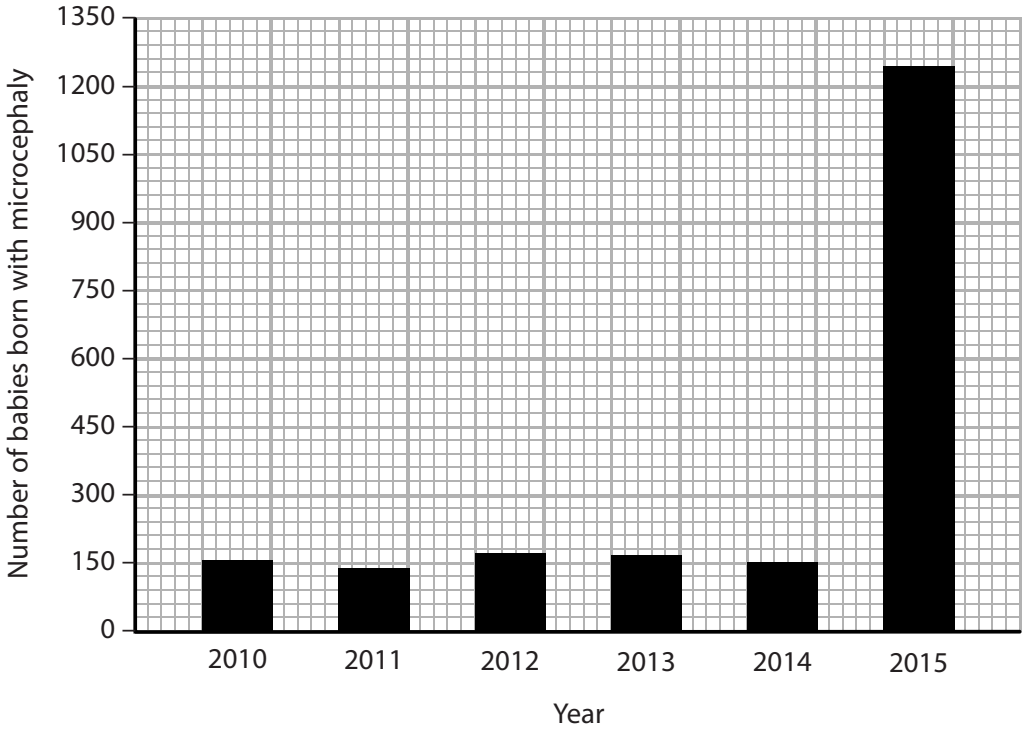
Analyse the information to explain how targeting the stealth sphere could be used to treat these infections.

(2)

6 In February 2016, the World Health Organisation (WHO) declared a public health emergency because of the spread of the Zika virus.

The mild symptoms, such as joint pains, headaches and a slight temperature increase lasted only a few days. However, Zika virus has been linked to a birth defect called microcephaly.

The graph shows the number of babies born with microcephaly in Brazil from 2010 to 2015.



(a) Calculate the percentage increase in the number of babies born with microcephaly in 2015 compared with 2014.

(2)

Answer ..... %

(b) Zika virus is transmitted to humans by infected mosquitoes.

(i) Explain why another type of drug, rather than antibiotics, has to be used to treat Zika virus infections.

(2)

(ii) Scientists have suggested that genetically modified (GM) mosquitoes could be used to help combat the spread of the Zika virus.

Mosquito eggs are injected with DNA, from GM mosquitoes. This DNA contains a gene for fluorescence. However, only one in a few thousand injected eggs results in a GM mosquito.

Explain how this procedure could help in the production of large numbers of GM mosquitoes.

(4)

(iii) Explain why the Brazilian government has advised people to use mosquito nets, even if they have already contracted the Zika virus.

(2)

(c) Scientists have discovered that the Zika virus genome is made of RNA.

This RNA codes for:

- capsid protein with 105 amino acids
- pre-membrane protein with 187 amino acids
- envelope protein with 505 amino acids
- seven nonstructural proteins

(i) State how many bases are needed to code for the capsid protein.

(1)

(ii) Unlike human immunodeficiency virus (HIV), Zika is not a retrovirus.

Describe what happens to the Zika RNA once it is in the cell.

(2)

(d) During the replication of the Zika virus, the ten proteins that are coded for in the RNA are produced as a single polyprotein molecule.

Explain how this polyprotein molecule is converted into ten separate protein molecules.

(2)

(Total for Question 6 = 15 marks)

8 Infections caused by *Chlamydia* and human papillomavirus (HPV) are sexually transmitted.

The HPV is a non-enveloped DNA virus.

Chlamydia infection is caused by the bacterium, *Chlamydia trachomatis*.

(a) Compare and contrast the structure of a bacterial cell with the structure of HPV.

(3)

(b) Some people with HPV infections have no symptoms but others develop warts and some types of cancer.

Over 99% of cervical cancers are caused by HPV.

Girls in the UK are offered an HPV vaccine.

(i) Explain how an HPV vaccine protects girls from developing cervical cancer.

(3)

(ii) Explain why the HPV vaccine will not protect girls from infection with *Chlamydia*.

(3)

*(iii) The HPV vaccination programme is being extended to boys.

Explain the advantages of offering the HPV vaccine to boys, as well as girls, in schools.

(6)

SUB-TOPIC 2(c)

CELL CYCLE, MITOSIS AND MEIOSIS

22 questions in this sub-topic · 207 marks · lowest tariff first

2 A student investigated the number of dividing cells in an onion root tip.

The student made a root tip squash and counted the number of cells at each stage of the cell cycle. The table shows the results.

Number of cells at each stage of the cell cycle				
Prophase	**Metaphase**	**Anaphase**	**Telophase**	**Interphase**
4	2	1	1	90

(a) (i) Calculate the mitotic index for these results using the formula

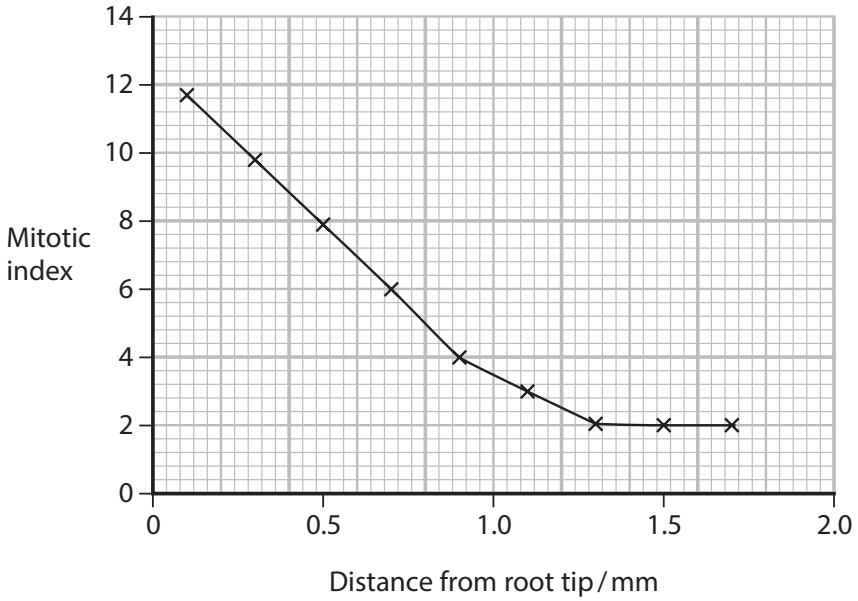
$$\text{Mitotic index} = \frac{\text{number of actively dividing cells}}{\text{total number of cells}} \times 100$$

(2)

Answer .....

(ii) The mitotic index depends on the distance from the root tip.

The graph shows the relationship between the mitotic index and the distance from the root tip.



Explain the relationship shown in the graph.

(2)

(b) The student used the following method to prepare the root tip squash.

1. Cut a small piece from the tip of a growing onion root and place it in weak acid.
2. Transfer the root tip to a microscope slide.
3. Add a drop of stain.
4. Use a mounted needle to flatten the piece of root and place a coverslip on top.
5. View using low power objective lens of a microscope.
6. Count the cells at each stage of the cell cycle.

Justify two improvements to this method.

(2)

1 A student made a root tip squash to observe the stages of mitosis.

(a) Name the region of the root tip where cells are actively dividing.

(1)

.....

(b) Give **one** reason for each of the following:

(i) Treating the root tip with strong acid

(1)

.....

.....

.....

(ii) Adding a stain to the root tip

(1)

.....

.....

.....

(iii) Pressing lightly on the coverslip

(1)

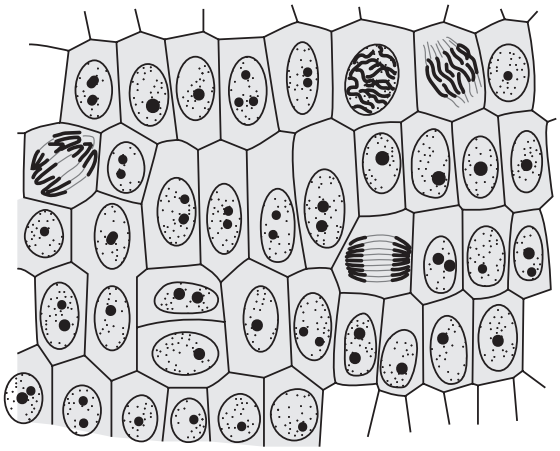
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(c) The diagram shows cells from a root tip squash.

The total number of cells is 39.



Calculate the mitotic index for this root tip squash.

Use the formula

$$\text{Mitotic index} = \frac{\text{number of cells in mitosis}}{\text{total number of cells}} \times 100$$

Give your answer to **one decimal place**.

(2)

Answer .....

(Total for Question 1 = 6 marks)

3 A student made a squash preparation of a root tip to observe the stages of mitosis.

(a) The student used the following statements to identify cells in metaphase.

- Pairs of homologous chromosomes lined up along the equator of each cell.
- Crossing over taking place.
- Chromatids visible.

The number of correct statements about metaphase in root tip cells is

(1)

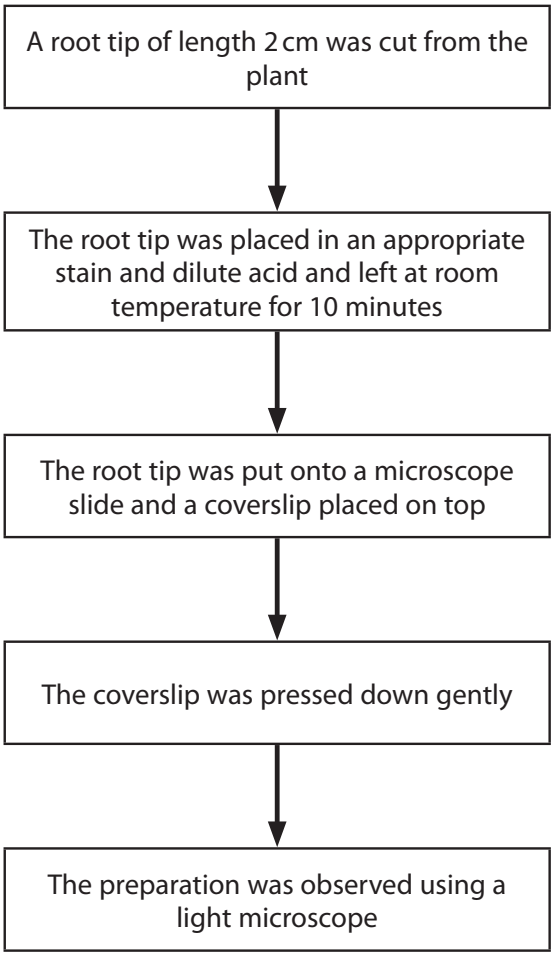
☒ **A** none

☒ **B** one

☒ **C** two

☒ **D** three

(b) The diagram shows the method that the student used.



The student was disappointed with the slide that had been prepared because the nuclei were poorly stained and no stages of mitosis could be seen.

(i) Explain why the student had to make sure that an appropriate stain was used.

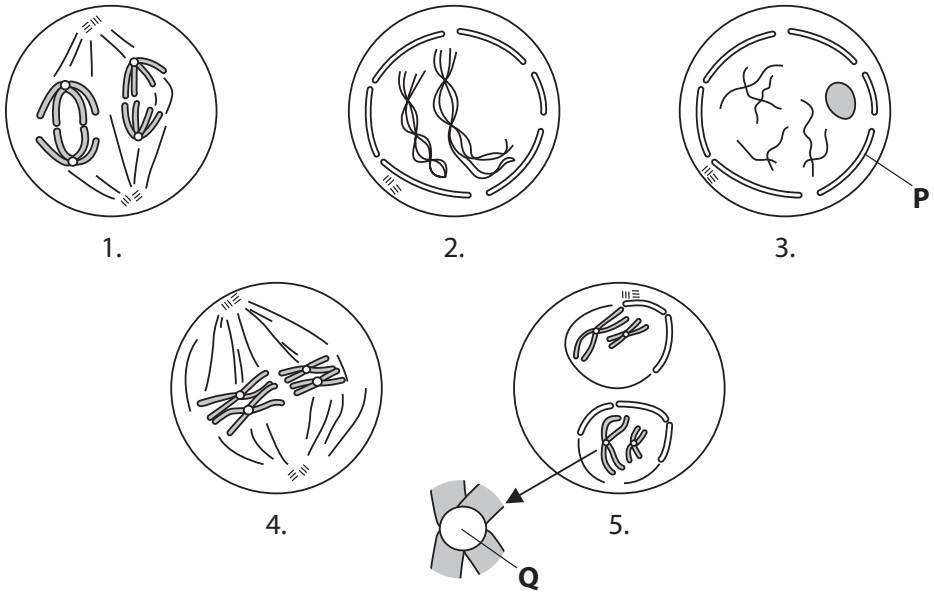
(2)

(ii) Describe the changes that need to be made to this method to allow stages of mitosis to be seen.

(4)

1 In some diploid organisms, haploid cells are produced by meiosis.

The diagram shows an animal cell at various stages during the first division of meiosis.



(a) (i) Identify the correct sequence in the diagram that shows the first division of meiosis.

(1)

☒ **A** 1, 2, 3, 4, 5

☒ **B** 2, 5, 4, 1, 3

☒ **C** 3, 2, 4, 1, 5

☒ **D** 5, 4, 1, 2, 3

(ii) Identify the parts labelled P and Q.

(2)

P .....

Q .....

(b) In mammals, meiosis occurs during oogenesis and spermatogenesis.

Describe how the products of oogenesis differ from the products of spermatogenesis in mammals.

(4)

.....

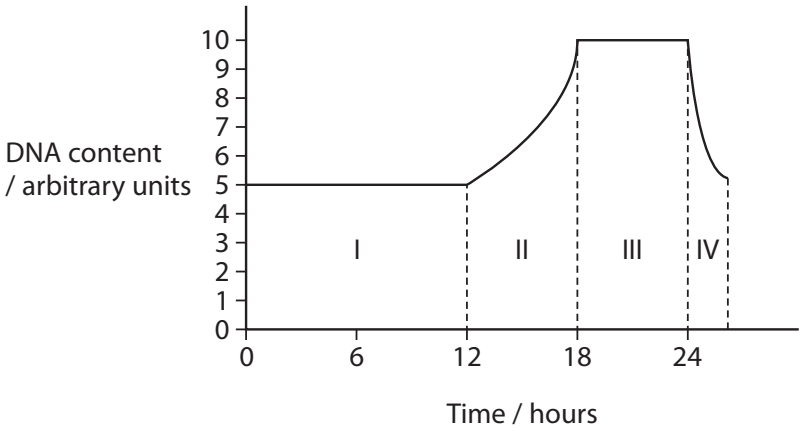
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2 The graph shows the DNA content of a cell during four stages, I, II, III and IV, of one cell cycle.



(a) (i) In which stage does DNA replication take place?

(1)

- ☒ **A** stage I
- ☒ **B** stage II
- ☒ **C** stage III
- ☒ **D** stage IV

(ii) Explain the role of the enzyme ligase in DNA replication.

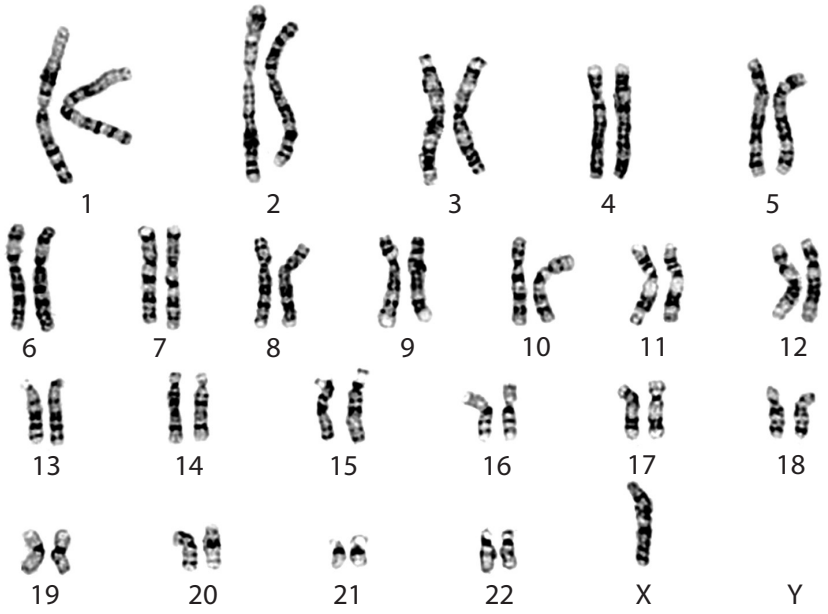
(3)

(b) Describe what is happening during stage IV in the cell cycle.

(3)

1 A karyotype shows the chromosomes found in the cells of an individual.

The photograph shows a karyotype from a child with a genetic condition.



(Source: © Dept. of Clinical Cytogenetics, Addenbrookes Hospital / Science Photo Library)

(a) (i) Which of the following identifies the genetic condition shown in the photograph?

(1)

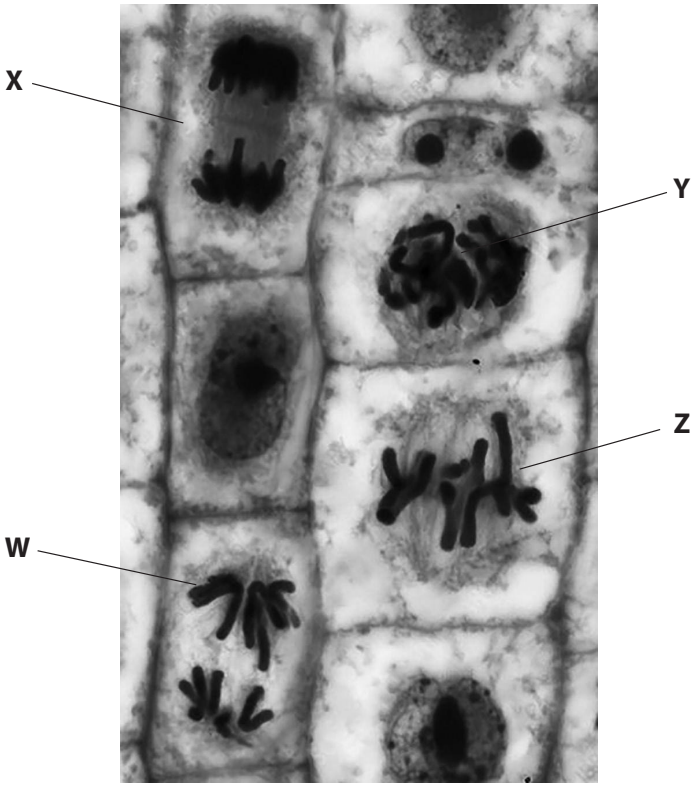
- ☒ **A** Down's syndrome due to monosomy
- ☒ **B** Down's syndrome due to polysomy
- ☒ **C** Turner's syndrome due to monosomy
- ☒ **D** Turner's syndrome due to polysomy

(ii) Which process would have caused the genetic condition shown by this karyotype?

(1)

- ☒ **A** base insertion
- ☒ **B** base substitution
- ☒ **C** non-disjunction
- ☒ **D** translocation

(b) The photograph shows cells in different stages of mitosis.



(Source: © STEVE GSCHMEISSNER / Science Photo Library)

(i) Which of the following correctly identifies the stages shown in the photograph?

(1)

	W	X	Y	Z
☒ A	anaphase	telophase	prophase	metaphase
☒ B	anaphase	prophase	telophase	metaphase
☒ C	prophase	anaphase	metaphase	telophase
☒ D	telophase	metaphase	anaphase	prophase

(ii) Colchicine is a chemical that inhibits mitosis.

A student investigated the effect of colchicine on mitosis.

Two sets of genetically identical cells were grown in culture. Colchicine was added to one culture of cells but not to the other culture of cells.

Six hours after treatment, the mean percentages of cells in each stage of mitosis were determined.

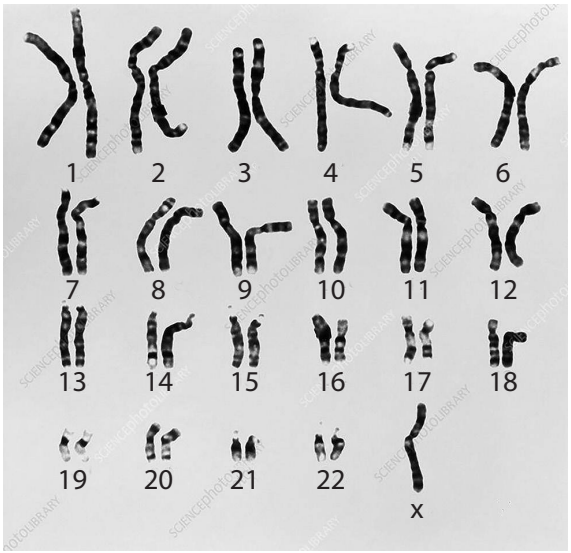
The results are shown in the table.

Mitosis stage	Mean percentage of cells in stage ± Standard Deviation	
	cells cultured without colchicine	cells cultured with colchicine
interphase	84.8 ± 4.2	82.8 ± 3.2
prophase	10.2 ± 2.2	16.3 ± 3.1
metaphase	1.8 ± 0.4	0.8 ± 0.2
anaphase	1.8 ± 0.2	0.7 ± 0.1
telophase	1.4 ± 0.3	0.4 ± 0.1

Analyse the data to comment on how colchicine affects mitosis.

(4)

2 (a) The diagram shows a human karyotype.



(Source: © DEPT. OF CLINICAL CYTOGENETICS, ADDENBROOKES HOSPITAL/SCIENCE PHOTO LIBRARY)

(i) Which of the following identifies the human with this karyotype?

(1)

- ☒ **A** female with Down's syndrome
- ☒ **B** female with Turner's syndrome
- ☒ **C** male with Down's syndrome
- ☒ **D** male with Turner's syndrome

(ii) Which of the following would cause the karyotype in the diagram?

(1)

- ☒ **A** non-disjunction producing a monosomy
- ☒ **B** non-disjunction producing a polysomy
- ☒ **C** translocation producing a monosomy
- ☒ **D** translocation producing a polysomy

(b) (i) The table shows the chromosome number and chromatid number of some of the cells formed during oogenesis in humans.

Cell type	Chromosome number	Chromatid number
ovum	23	23
primary oocyte	46	92
secondary oocyte	23	46

Which of the cells are haploid?

(1)

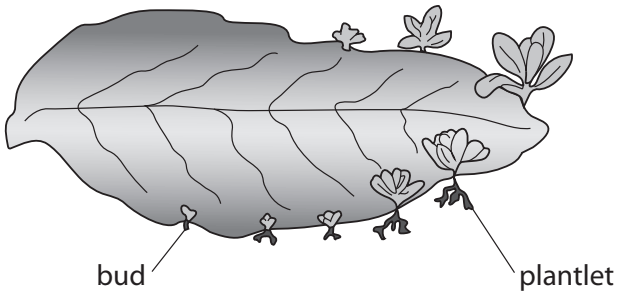
- ☒ **A** ovum and primary oocyte
- ☒ **B** ovum and secondary oocyte
- ☒ **C** primary oocyte and secondary oocyte
- ☒ **D** ovum alone

(ii) Explain how meiosis produces new combinations of alleles in gametes.

(4)

4 The diagram shows a leaf of *Bryophyllum*.

Some of the cells at the edges of the leaf divide to form buds. These buds can develop into individual plantlets.



(a) (i) Name the type of nuclear division that produces the plantlets.

(1)

.....

(ii) State **two** advantages of this type of reproduction.

(2)

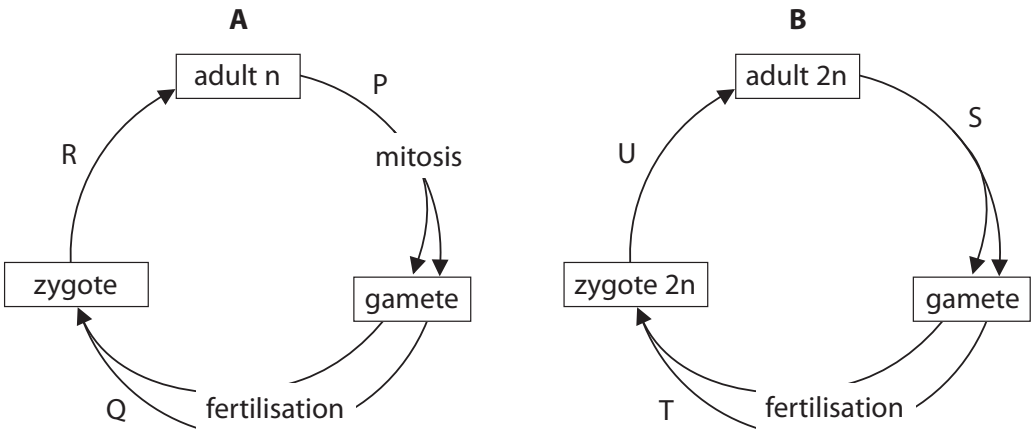
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(b) The diagrams show the life cycles of two organisms, **A** and **B**.



(i) Which row of the table correctly describes the zygote of organism **A** and the gametes of organism **B**?

(1)

		Zygote of organism A	Gametes of organism B
☒	**A**	diploid	diploid
☒	**B**	diploid	haploid
☒	**C**	haploid	diploid
☒	**D**	haploid	haploid

(ii) Which row in the table shows where meiosis occurs in each life cycle?

(1)

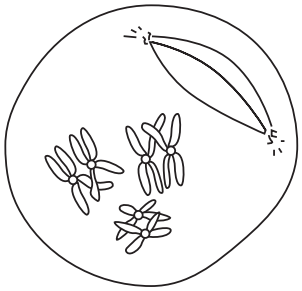
	Life cycle A	Life cycle B
☒ **A**	P	T
☒ **B**	Q	U
☒ **C**	R	S
☒ **D**	R	T

(iii) Explain the significance of meiosis in living organisms.

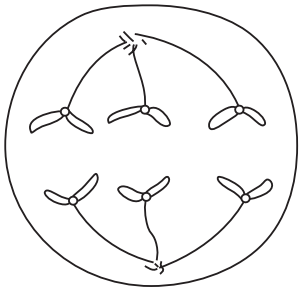
(3)

6 (a) Mosquitoes have cells with a diploid number (2n) of six.

The diagram shows two cells from a male mosquito at different stages of meiosis.



P



Q

(i) Which row of the table shows the stages of meiosis of cells P and Q?

(1)

		P	Q
☒	**A**	anaphase II	anaphase I
☒	**B**	metaphase I	prophase I
☒	**C**	prophase I	anaphase II
☒	**D**	prophase II	metaphase II

(ii) Non-disjunction occurred during meiosis I.

Which of the following shows the number of chromosomes in each of the four sperm cells produced?

(1)

☒ **A** 4, 3, 3, 2

☒ **B** 4, 4, 2, 2

☒ **C** 6, 6, 7, 5

☒ **D** 7, 7, 5, 5

(b) Down's syndrome in humans is caused by non-disjunction.

The chance of having a baby with Down's syndrome increases as the age of the mother increases.

At age 40, the probability of having a baby with Down's syndrome is 0.018.

In 2016 the number of women aged 40 in the UK was estimated to be 500 000.

The pregnancy rate for women in the UK aged 40 is 14 pregnancies per 1000 women per year.

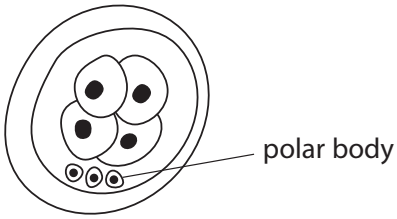
Calculate the number of babies with Down's syndrome that were expected in 2016 in the UK.

(2)

Answer .....

(c) *In vitro* fertilisation (IVF) is a technique in which eggs are taken from the ovaries and fertilised with sperm in a laboratory.

The resulting embryos are cultured until the four-cell stage, as shown in the diagram.



Two screening techniques used to identify embryos with chromosomal abnormalities are:

- polar body biopsy in which the polar bodies are removed and the chromosomes analysed
- pre-implantation genetic diagnosis (PGD) in which one cell from the four-cell stage embryo is removed and the chromosomes analysed.

Embryos without chromosome abnormalities are placed into the mother's uterus.

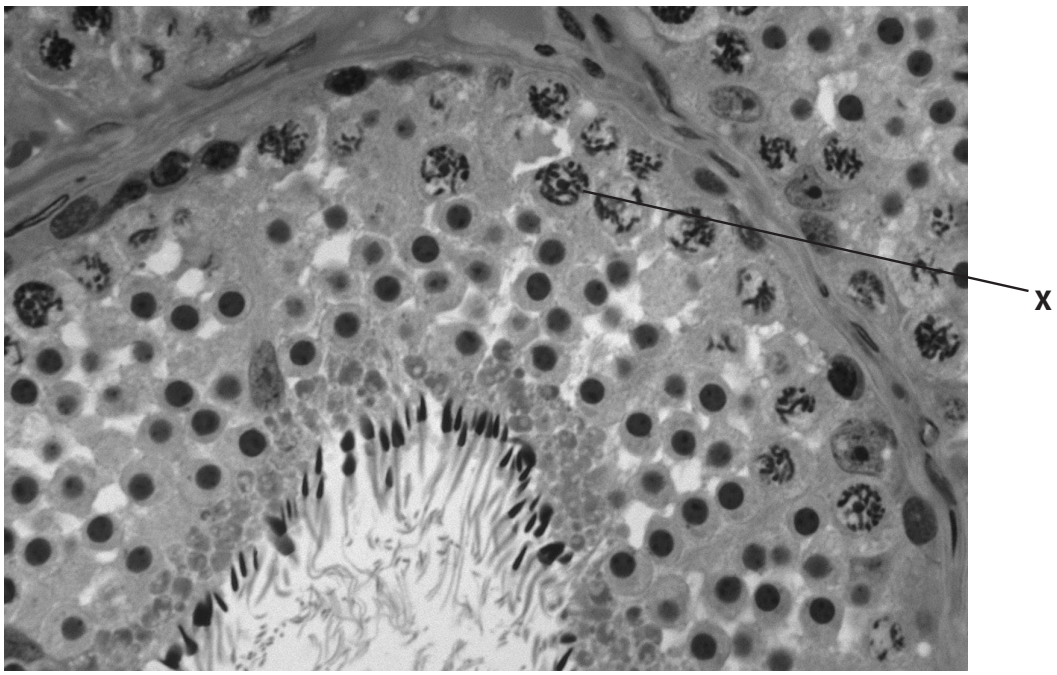
The success rates of both techniques are shown in the table.

Technique	Percentage of embryos that survive screening (%)	Percentage of embryos transferred to the uterus that lead to the birth of baby (%)
Polar body biopsy	87	21
PGD	74	29
Control	IVF with no screening	16

Analyse the data to comment on the effectiveness of the two techniques.

(4)

3 The photograph shows part of a testis, as seen using a light microscope.



(Source: © M. I. WALKER / SCIENCE PHOTO LIBRARY)

(a) The cell labelled X is a primary spermatocyte.

(i) At which stage of cell division is cell X?

(1)

- ☒ **A** prophase I of meiosis
- ☒ **B** prophase II of meiosis
- ☒ **C** prophase I of mitosis
- ☒ **D** prophase II of mitosis

(ii) In the photograph, cell X has a width of 0.8 cm.

The magnification of the photograph is ×1500.

Calculate the actual width, in micrometres (μm), of cell X.

Give your answer to one decimal place.

(2)

Answer ..... μm

(b) Some pregnancies do not develop to full term, so no baby is born.

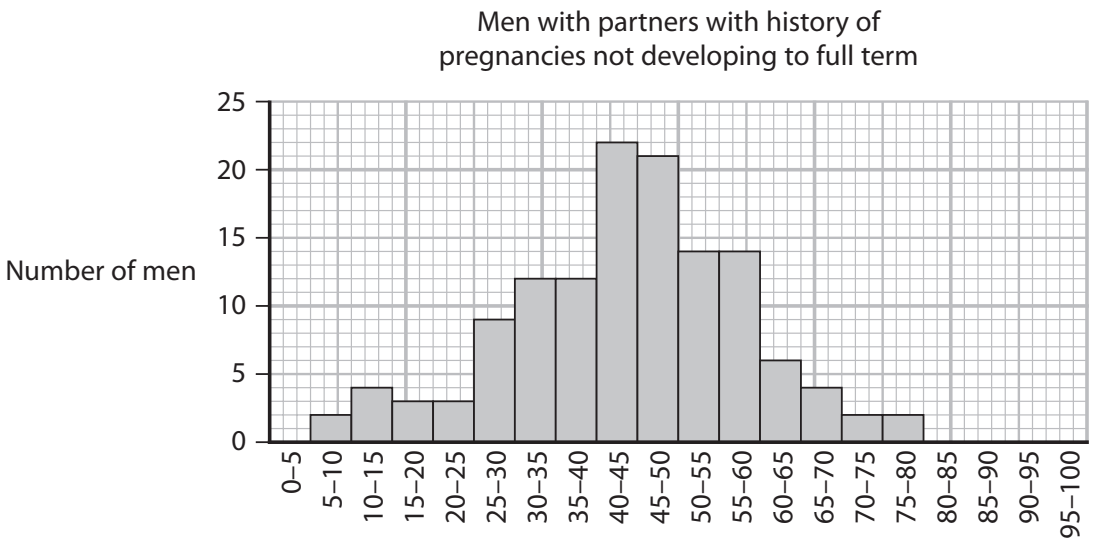
Damage to the DNA of sperm is thought to be one cause of pregnancies not developing to full term.

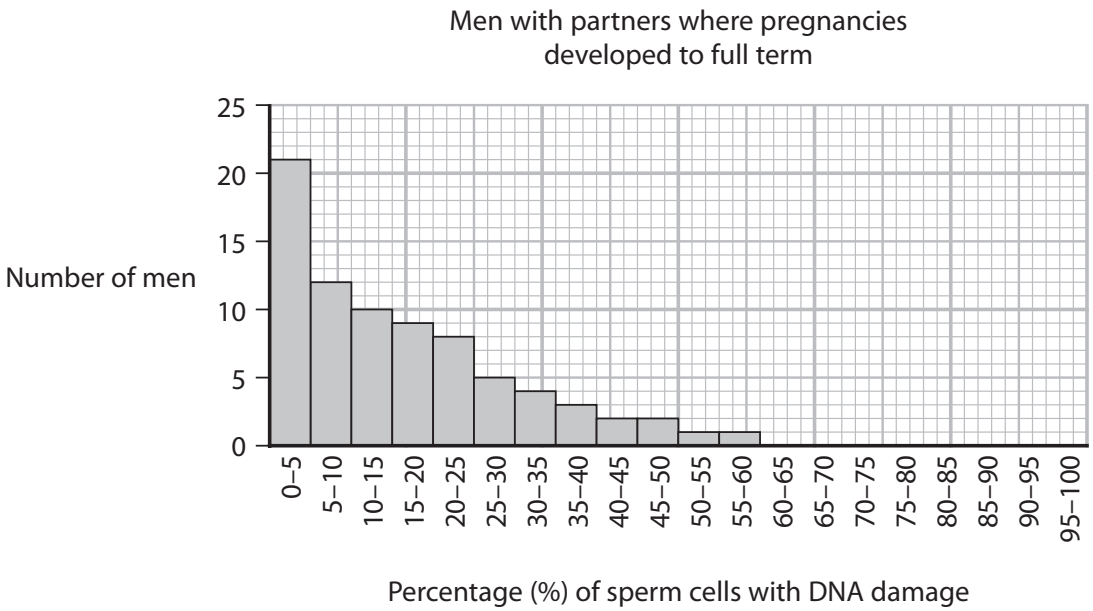
Scientists investigated if there is an association between the production of sperm with damaged DNA and the risk of pregnancies not developing to full term.

The percentage of sperm cells with DNA damage was determined for 130 men where there was a history of pregnancies not developing to full term.

The percentage of sperm cells with DNA damage was measured for 78 men where pregnancies developed to full term.

The graphs show the results of this investigation.





(i) Calculate the number of men with partners that have a history of pregnancies not developing to full term that had 25% or less of sperm with DNA damage.

(1)

Answer .....

(ii) The scientists concluded that having more than 25% of sperm with damaged DNA leads to a high risk of pregnancies not developing to full term.

Analyse the data to evaluate this conclusion.

(4)

.....

.....

.....

.....

.....

8 Genetic variation results from the recombination of alleles during meiosis.

(a) State what is meant by the term **allele**.

(1)

(b) (i) Which row of the table correctly shows when independent assortment and crossing over take place during meiosis?

(1)

		Independent assortment	Crossing over
☒	**A**	metaphase I	anaphase I
☒	**B**	metaphase I	prophase I
☒	**C**	prophase I	anaphase I
☒	**D**	prophase I	metaphase I

(ii) Describe the process of crossing over that occurs during meiosis.

(3)

(c) The table shows some data on the genome size, haploid number of chromosomes and the recombination rate of several species of animals.

Species	Genome size / Mb	Haploid number of chromosomes	Recombination rate / au
Dog	2500	39	1.6
Human	3000	23	1.2
Sheep	3000	27	1.2
Cow	3000	30	1.1
Macaque	3100	21	0.7
Baboon	3100	21	0.6
Opossum	3500	11	0.2
Wallaby	3700	8	0.2

Analyse the data to comment on the relationship between genome size, haploid number of chromosomes and recombination rate.

(4)

(Total for Question 8 = 9 marks)

4 (a) A queen bee can lay both fertilised and unfertilised eggs.

Fertilised eggs develop into diploid females.

Unfertilised eggs develop into haploid males.

(i) Explain which type of cell division produces gametes in female bees.

(2)

(ii) Explain which type of cell division produces gametes in male bees.

(2)

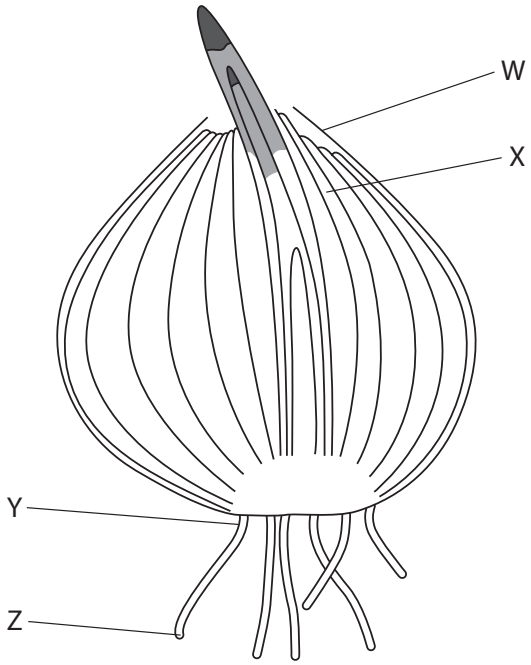
(iii) Which row identifies the features that contribute to genetic variation in the offspring of bees?

(1)

	Random fusion of gametes		Independent assortment of chromosomes		Crossing over	
	Female offspring	Male offspring	Female offspring	Male offspring	Female offspring	Male offspring
☒ **A**	✓	✓	✓	✓	✓	✓
☒ **B**	✓	×	×	✓	×	✓
☒ **C**	✓	×	✓	×	✓	×
☒ **D**	×	×	✓	×	✓	×

(b) Onion bulbs that are growing can be used to make slides of plant tissue to observe the stages of mitosis.

The diagram shows a section through an onion bulb that is starting to grow.



(i) Which of the parts, W, X, Y or Z, should be used to prepare a slide showing mitosis?

(1)

- ☒ **A** W
- ☒ **B** X
- ☒ **C** Y
- ☒ **D** Z

(ii) Name a stain that can be used to show the stages of mitosis.

(1)

.....

(iii) Explain how to make a temporary preparation to show the stages of mitosis, after adding the stain to the slide.

(2)

.....

.....

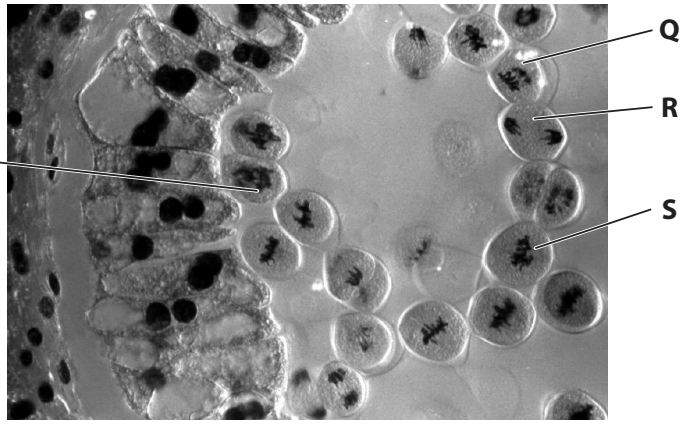
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4 Sexual reproduction occurs in flowering plants.

(a) The photograph shows meiosis in a bluebell plant.



(Source: SCIENCE PICTURES LTD/SCIENCE PHOTO LIBRARY)

(i) Which cell is in the latest stage of meiosis?

(1)

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

(ii) Devise a practical procedure to determine the total percentage of cells in both metaphase I and metaphase II in a bluebell.

(5)

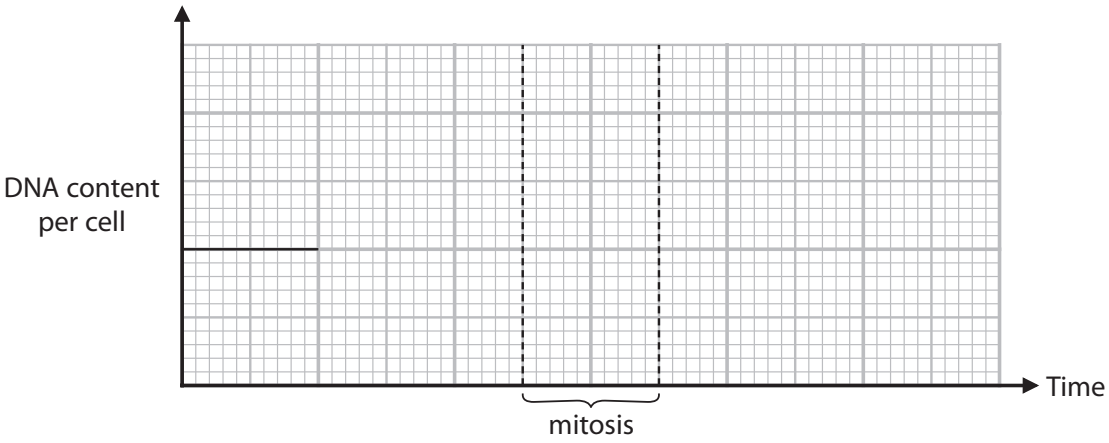
(b) Explain how meiosis results in genetic variation in a flowering plant.

(3)

7 The synthesis of DNA takes place during the cell cycle.

(a) Sketch a graph to show how the DNA content of a cell changes during one cell cycle that includes mitosis.

(3)



*(b) The experiments of Meselson and Stahl contributed to our current understanding of DNA replication.

The diagram shows the stages involved in one experiment.

Stage 1

Bacteria grown for several generations in a culture medium containing heavy nitrogen (^{15}N)

↓

Stage 2

Bacteria from stage 1 grown for one generation in a culture medium containing light nitrogen (^{14}N)

↓

Stage 3

Bacteria from stage 2 grown for one generation in a culture medium containing light nitrogen (^{14}N)

↓

Stage 4

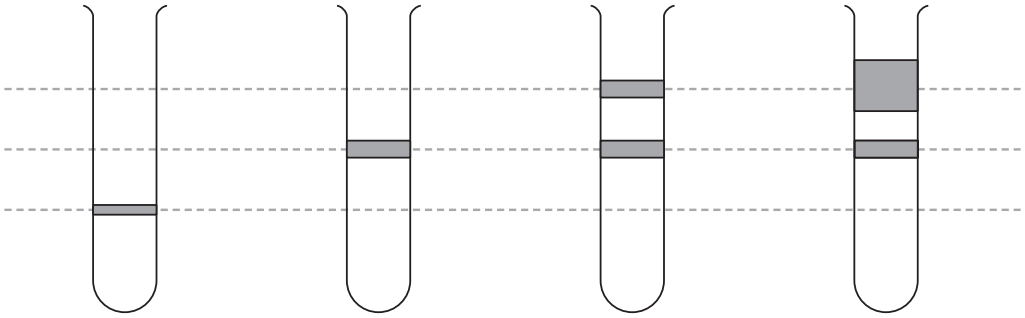
Bacteria from stage 3 grown for one generation in a culture medium containing light nitrogen (^{14}N)

After each stage, a sample of DNA was taken from the bacteria and the DNA molecules separated using a density gradient in a tube.

The heavier DNA molecules form bands lower down the gradient than lighter DNA molecules.

The size of each band is proportional to the percentage of DNA molecules in the sample.

The diagram shows the results of this experiment.



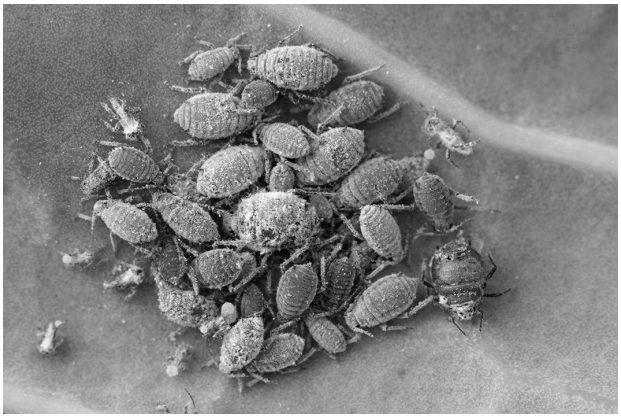
DNA taken after stage 1 | DNA taken after stage 2 | DNA taken after stage 3 | DNA taken after stage 4

Analyse the data to explain the results of this experiment and how it contributed to our current understanding of DNA replication.

(6)

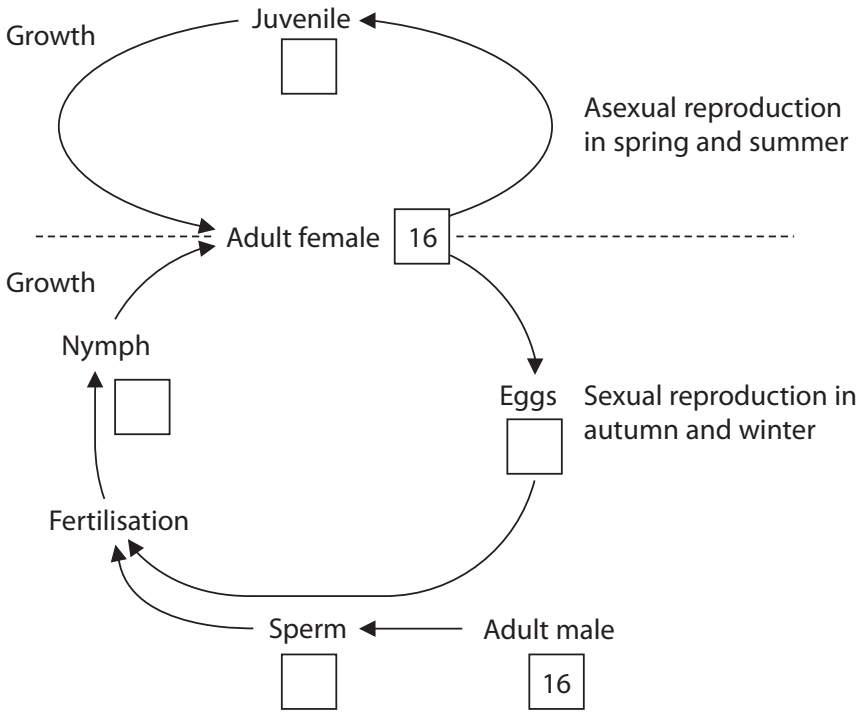
3 Adult female cabbage aphids (*Brevicoryne brassicae*) undergo either asexual reproduction or sexual reproduction depending on the time of year.

The photograph shows some cabbage aphids on a cabbage leaf.



Source: © Denis Crawford/Alamy Stock Photo

Some of the boxes in the diagram show the number of chromosomes present in a single cell from a particular stage of each of the alternative methods of reproduction.



(a) (i) Complete the empty boxes in the diagram to show the number of chromosomes present in a single cell at that stage of reproduction.

(2)

(ii) Label the arrows on the diagram with the letter **M** to show where meiosis takes place.

(1)

(b) Explain why a juvenile aphid is genetically identical to its parent.

(3)

(c) (i) Complete the table with a ✓ or ✕ to compare the events during mitosis and meiosis. The first row in the table has been completed for you.

(3)

Event	Mitosis	Meiosis I	Meiosis II
chromosomes shorten and thicken	✓	✓	✕
homologous chromosomes pair together			
crossing over can cause genetic variation			
homologous chromosomes separate			
sister chromatids separate			

(ii) Which of the following increases the number of different alleles in a population?

(1)

- ☒ **A** crossing over
- ☒ **B** gene mutation
- ☒ **C** independent assortment of chromosomes during nuclear division
- ☒ **D** random fusion of gametes

(Total for Question 3 = 10 marks)

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?

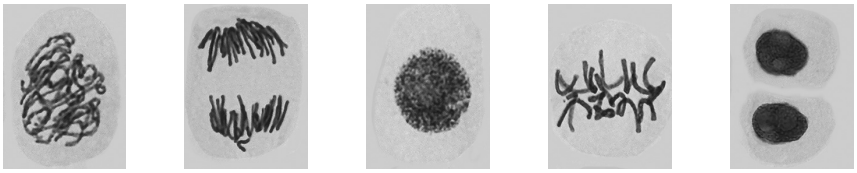
(1)

- ☒ **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)

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



J K L M N

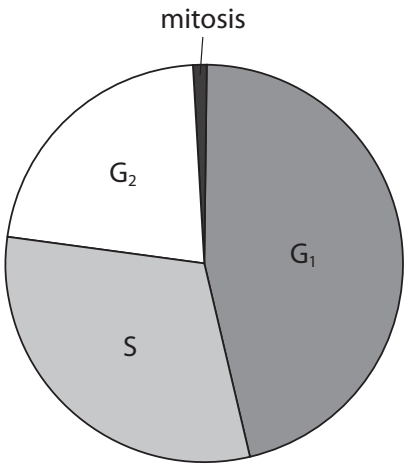
(Source: © STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY)

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.



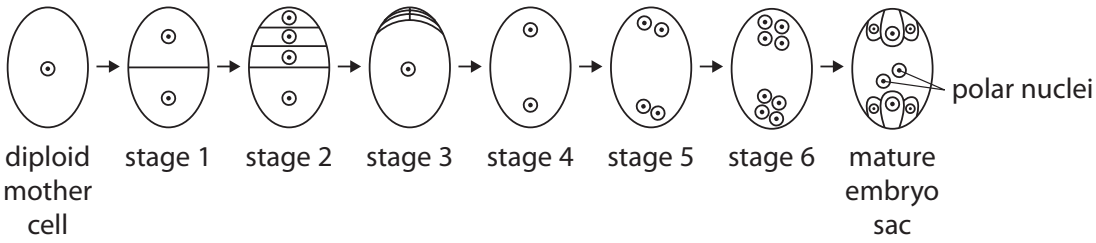
The cell cycle in this plant lasts 22 hours.

Give an estimate of the duration of S.

(1)

Answer ..... 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?

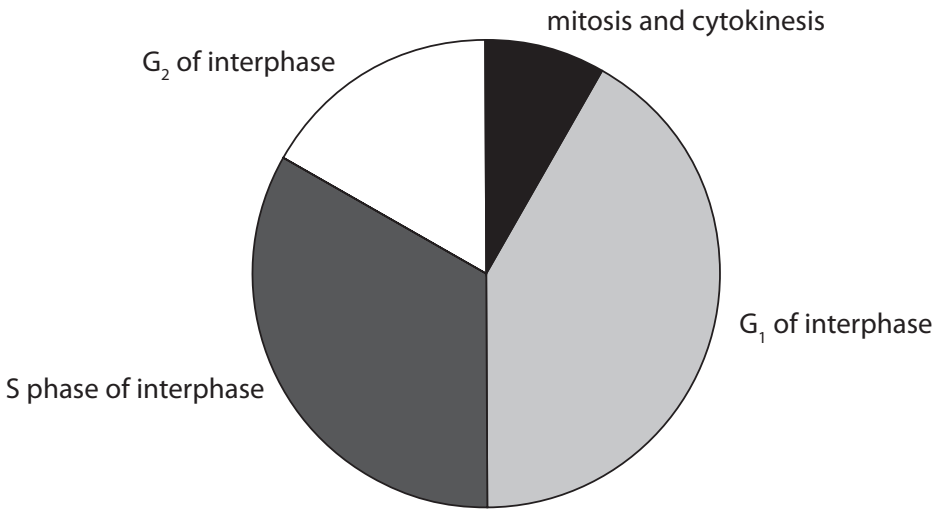
(1)

- ☒ **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)

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	
G_1 of interphase	
S phase of interphase	
G_2 of interphase	

(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)

(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)

6 Mitosis is involved in growth and repair of tissues and organs.

(a) Describe the differences between a tissue and an organ.

(2)

(b) Metaphase is one stage of mitosis.

(i) Draw and label the parts of a chromosome, as it would appear during metaphase of mitosis.

(2)

(ii) Describe the events that take place during metaphase of mitosis.

(2)

(c) In cancers, cells divide uncontrollably.

Colchicine is an anti-cancer drug that inhibits mitosis.

The effects of treating cells with colchicine were investigated.

Animal cells were cultured in a single layer in plastic dishes.

Colchicine was added to the culture and the mean number of cells in three stages of mitosis was determined over a period of 192 hours.

The table shows the results of this investigation.

Time after treating cells with colchicine / hours	Mean number of cells		
	Prophase	Metaphase	Anaphase
0	11.7	33.3	15.3
6	9.3	41.3	9.3
12	3.0	41.7	3.0
24	3.7	49.0	0.0
48	4.3	68.7	0.0
96	2.3	80.0	0.0
192	0.7	86.3	0.0

(i) Explain the results shown in the table.

(3)

(ii) Describe how these results could have been obtained.

(3)

.....

.....

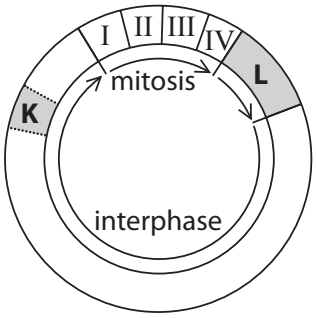
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6 Mitosis is one of the stages of the cell cycle.

The diagram represents some of the stages in the cell cycle.



(a) Explain why cells carry out mitosis.

(2)

(b) Explain what happens to the DNA content and the number of chromosomes in the stage labelled **K**.

(4)

(c) Name the stage of the cell cycle labelled **L**.

(1)

.....

(d) The duration of each stage of the cell cycle is directly proportional to the number of cells in that stage.

A student made a squash preparation of a root tip and counted the number of cells in each stage of the cell cycle.

The results are shown in the table.

Stage of cell cycle	Number of cells
Interphase	169
Prophase	5
Metaphase	8
Anaphase	2
Telophase	62

(i) The cells in this root tip had a cell cycle time of 23 hours.

Calculate the time, in minutes, that these cells spent in anaphase.

(2)

Answer ..... mins

(ii) The student then used the same method to study mitosis in a root tip from another plant of the same species.

The student worked out that the cells spent 8% less time in anaphase.

Calculate the time, in minutes, that these cells spent in anaphase.

(2)

Answer ..... mins

(iii) Explain why these two calculated values are not identical.

(2)

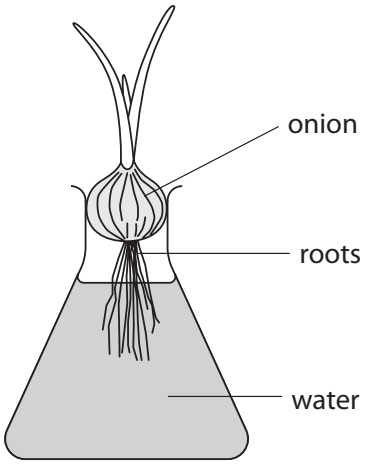
(Total for Question 6 = 13 marks)

5 A student read that some plants do not grow well in waterlogged soil.

The student formed the following hypothesis:

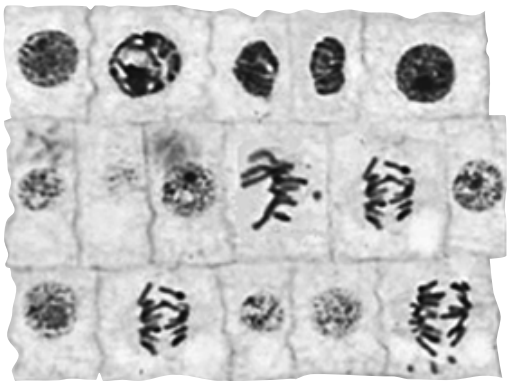
Adding water to soil inhibits mitosis in root cells.

To test this hypothesis, the student grew onion roots in the apparatus shown.



The tips of the onion roots were removed and observed for stages of mitosis.

The photomicrograph shows a preparation from one onion root tip.



(a) Calculate the percentage of cells in this photomicrograph in anaphase.

(2)

Answer .....

(b) Describe how to prepare a microscope slide of root tissue to show stages of mitosis.

(4)

(c) Devise a method the student should use to investigate the effect of waterlogged soil on mitosis in root cells.

(4)

(d) Waterlogged soil lacks oxygen.

Explain why a lack of oxygen in waterlogged soil could reduce the growth of a plant.

(4)

8 During mitosis, microtubules form the spindle.

These microtubules are made of a protein called tubulin.

Individual tubulin molecules are globular with a diameter of 25 nm.

Thousands of tubulin molecules are assembled together to form long, hollow microtubules.

(a) (i) Describe the differences between a fibrous protein and an individual tubulin molecule.

(2)

(ii) A microtubule is 40 μm in length.

Calculate how many times longer this microtubule is than a single tubulin molecule.

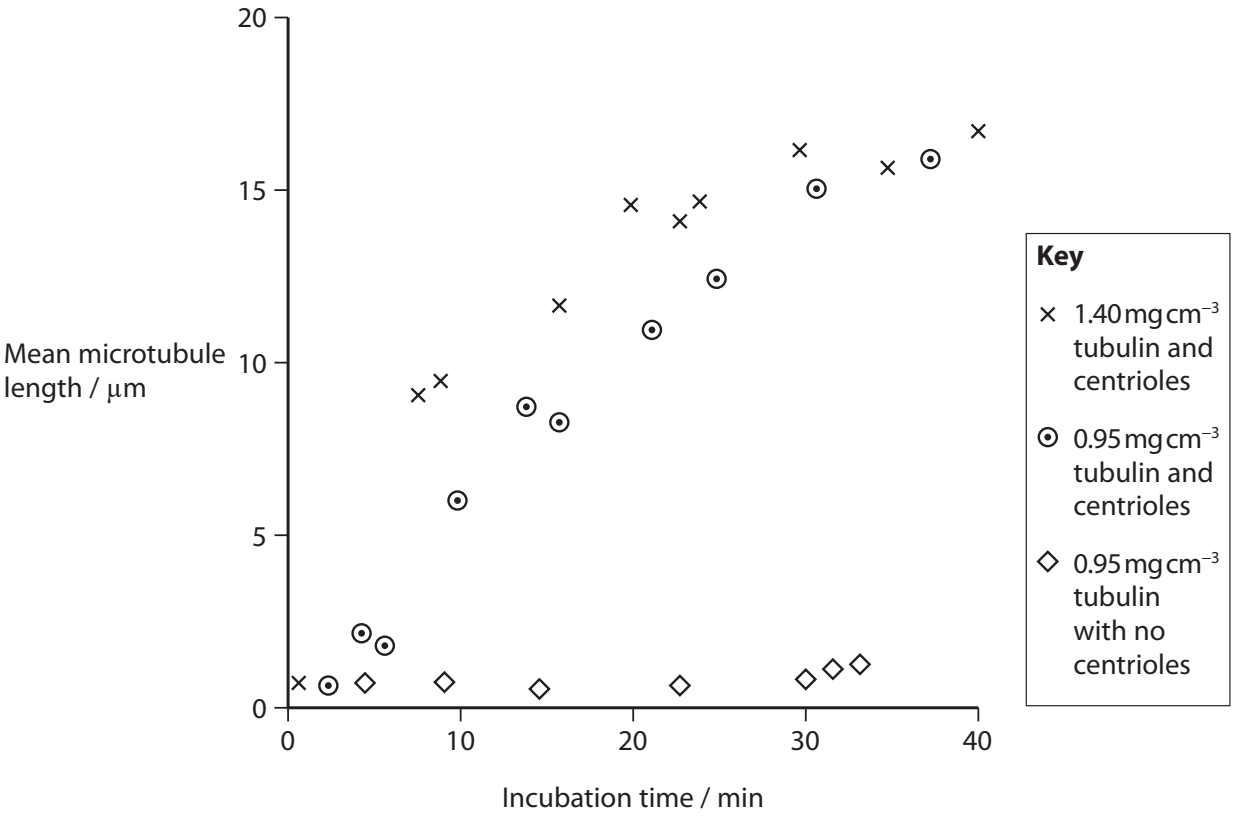
(2)

Answer .....

(b) The involvement of centrioles in spindle formation was investigated using the following method:

- in the first experiment, purified tubulin at a concentration of 1.40 mg cm^{-3} was mixed with centriole fragments
- the mixture was incubated at 35 °C
- every few minutes, the length of any microtubules formed was measured
- in a second experiment, a mixture containing 0.95 mg cm^{-3} tubulin and centriole fragments was used
- in a third experiment, 0.95 mg cm^{-3} tubulin with no centriole fragments present was used
- each of these three experiments was repeated several times.

The graph shows the results of this investigation.



(i) Analyse the data to comment on the relationship between centrioles and tubulin in the production of microtubules.

(4)

(ii) Explain why the centriole fragments and tubulin were each in a buffer solution at 35 °C before being used in these experiments.

(4)

(c) It was observed that for the mixture of 1.40 mg cm^{-3} tubulin with centriole fragments the mean length of microtubules decreased after 40 minutes.

Explain why the microtubule length decreased after 40 minutes.

(2)

9 Doxorubicin (Dox) is a drug used to treat cancer.

(a) Cancer is caused when cells divide uncontrollably.

This drug works in two ways:

- it becomes inserted into the DNA and holds the two strands together.
- it binds to an enzyme that repairs DNA.

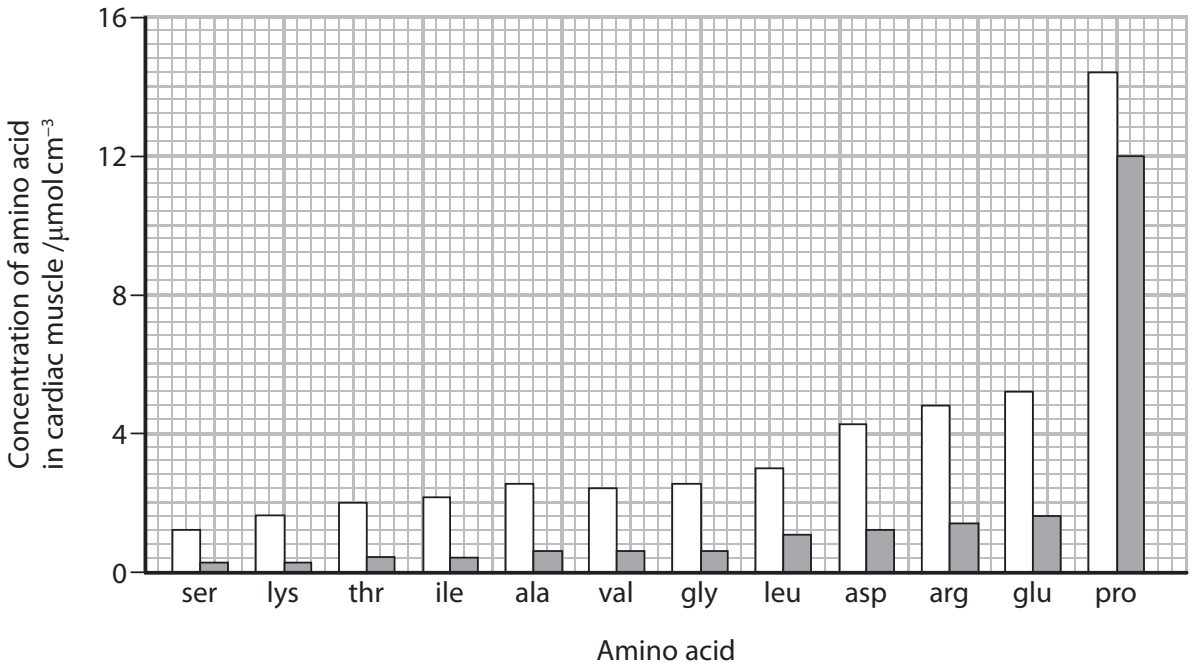
Explain how Dox prevents cancer cells from dividing.

(5)

(b) Weakening of the cardiac muscle is one side effect of using Dox.

The effect of Dox on the concentration of several amino acids in cardiac muscle was investigated.

The graph shows the results of this investigation.



The table shows some non-polar and polar amino acids.

Type	Amino acids
non-polar	ala, gly, ile, leu, pro, val
polar	arg, asp, glu, lys, ser, thr

*(i) Analyse the information to determine the effect of Dox on the concentration of these types of amino acid in cardiac muscle.

(6)

(ii) Explain why a change in the concentration of amino acids results in the weakening of cardiac muscle.

(2)

(iii) Explain how weakening of the cardiac muscle could affect a person.

(3)

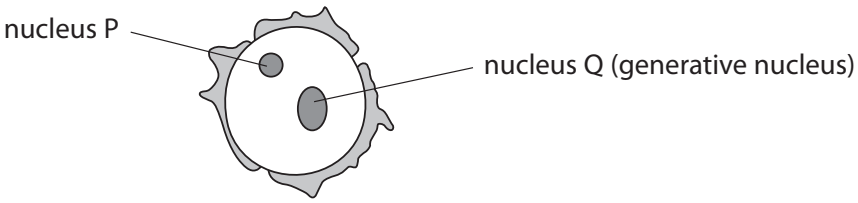
SUB-TOPIC 2(d)

SEXUAL REPRODUCTION IN MAMMALS AND PLANTS

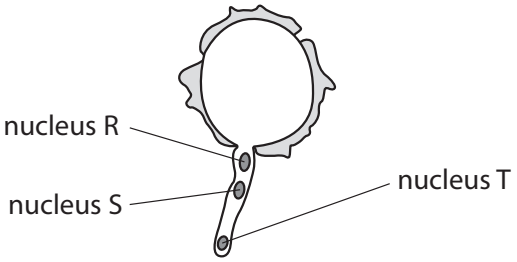
17 questions in this sub-topic · 161 marks · lowest tariff first

1 The diagram shows a pollen grain, before and after germination.

Before germination



After germination



(a) In which part of the plant are pollen grains made?

(1)

☒ **A** anther

☒ **B** embryo sac

☒ **C** filament

☒ **D** stigma

(b) One species of grass has a diploid number of 14 chromosomes.

Which row of the table is correct for this species of grass?

(1)

	Chromosome number	
	Nucleus P	**Nucleus Q**
☒ **A**	14	14
☒ **B**	14	7
☒ **C**	7	14
☒ **D**	7	7

(c) Which of the following is a correct statement?

(1)

☒ **A** nucleus P divides by meiosis to form nuclei R and S

☒ **B** nucleus P divides by mitosis to form nuclei R and S

☒ **C** nucleus Q divides by meiosis to form nuclei R and S

☒ **D** nucleus Q divides by mitosis to form nuclei R and S

(d) The following three statements were made by a student:

- nucleus R and S will fertilise the endosperm nucleus
- the genetic material in nucleus R or S could become part of the zygote
- nucleus T will fertilise the female gamete

The number of correct statements is

(1)

☒ **A** none

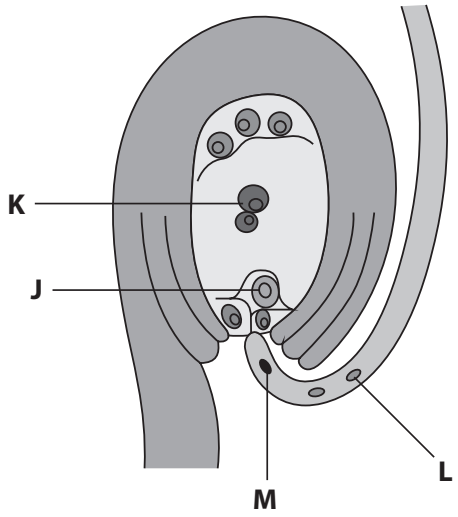
☒ **B** one

☒ **C** two

☒ **D** three

(Total for Question 1 = 4 marks)

1 The diagram shows a pollen tube entering the embryo sac of a flowering plant.



Complete the table to give the name of each labelled structure and the number of sets of chromosomes that each structure contains.

(4)

Structure	Name of structure	Number of sets of chromosomes
J		
K		
L		
M		

(Total for Question 1 = 4 marks)

2 A zygote is formed when gametes fuse at fertilisation.

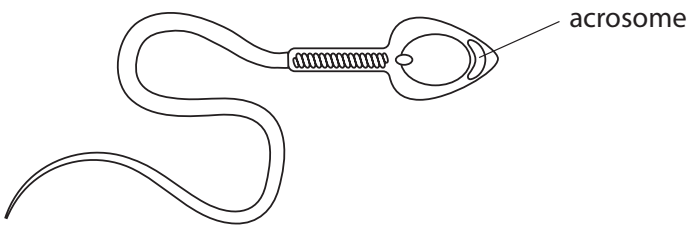
(a) Explain how meiosis results in genetic variation in the gametes.

(2)

(b) Describe how the process of fertilisation results in the formation of a zygote from the gametes in humans.

(3)

2 The diagram shows a mature sperm cell.



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

(2)

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

(3)

3 In flowering plants, pollen grains grow pollen tubes that are involved in fertilisation, producing a zygote and endosperm.

(a) (i) Which row of the table shows the correct description for these nuclei?

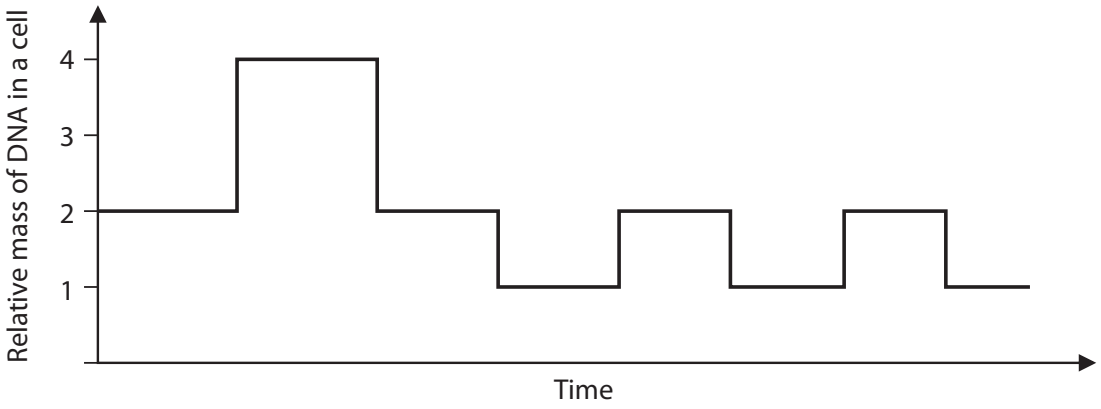
(1)

	Zygote nucleus	Endosperm nucleus	Pollen tube nucleus
☒ **A**	diploid	diploid	haploid
☒ **B**	diploid	triploid	haploid
☒ **C**	diploid	triploid	diploid
☒ **D**	haploid	triploid	diploid

(ii) The production of plant gamete cells involves both mitosis and meiosis.

The graph shows the DNA content of a cell during the production of a pollen grain.

(1)



The order of nuclear divisions shown in the graph is

☒ **A** meiosis, mitosis, mitosis

☒ **B** meiosis, mitosis, meiosis

☒ **C** mitosis, meiosis, meiosis

☒ **D** mitosis, mitosis, meiosis

(b) A scientist investigated the effects of chemical A and chemical B on pollen tube growth.

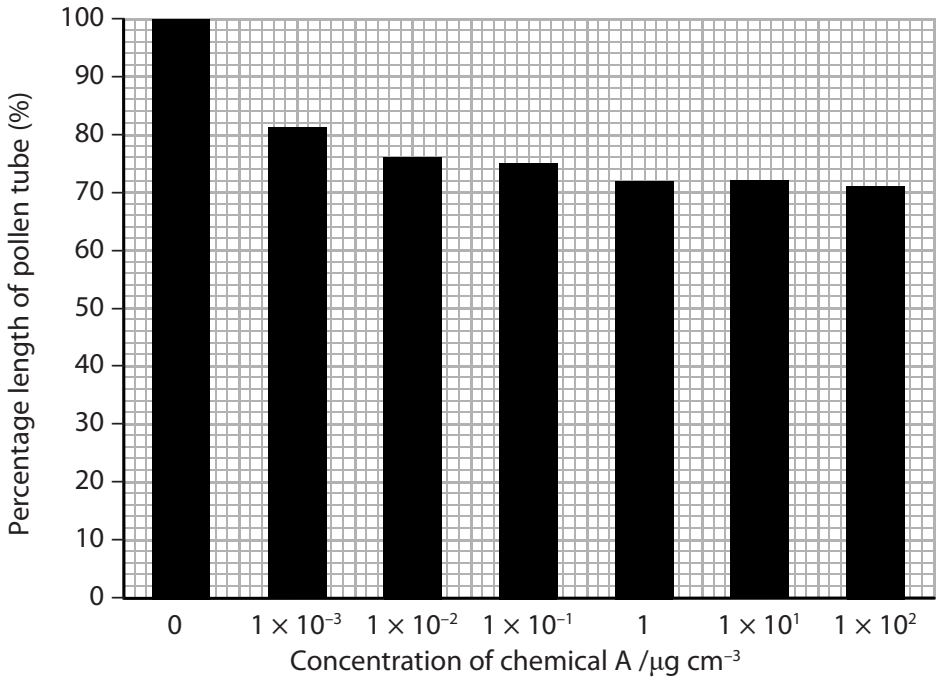
Chemical A prevents transcription.

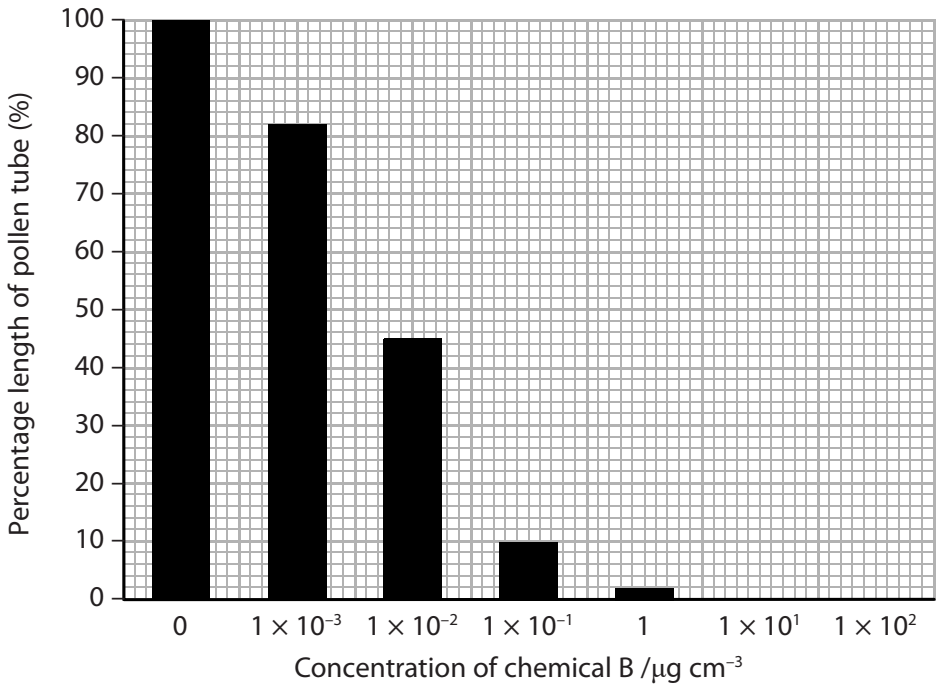
Chemical B prevents translation.

Pollen grains were treated with different concentrations of these two chemicals. The lengths of the pollen tubes they produced were compared with a control group of pollen grains.

The lengths of the pollen tubes were measured and expressed as a percentage of the control group.

The results are shown in the graphs.





(i) The mean length of the pollen tubes in the control group was 7.5 mm.

Calculate the mean length of the pollen tubes after adding 0.010 μg cm^{-3} of chemical A.

(2)

Answer .....

(ii) Analyse the data to comment on the effects of chemical A and chemical B on the roles of transcription and translation in pollen tube growth.

(4)

.....

.....

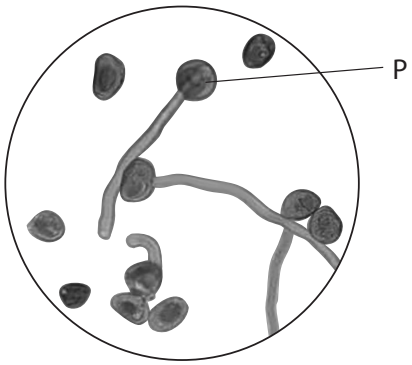
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3 A student used a light microscope to determine the mean percentage germination of pollen grains.

The photograph shows one high power field of view observed by the student.



(a) The student used a paintbrush to obtain pollen grains from a flower.

Describe the steps taken by the student to see these pollen grains using a microscope.

(3)

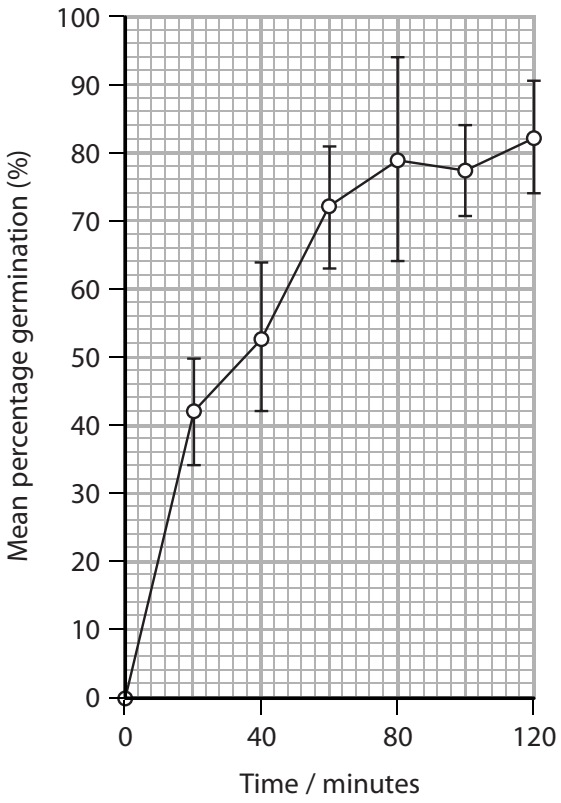
(b) The actual diameter of pollen grain P is 30 μm.

Calculate the magnification of pollen grain P.

(2)

Answer .....

(c) The graph shows the results of the investigation.



(i) Explain why the student plotted standard deviation bars on the graph.

(2)

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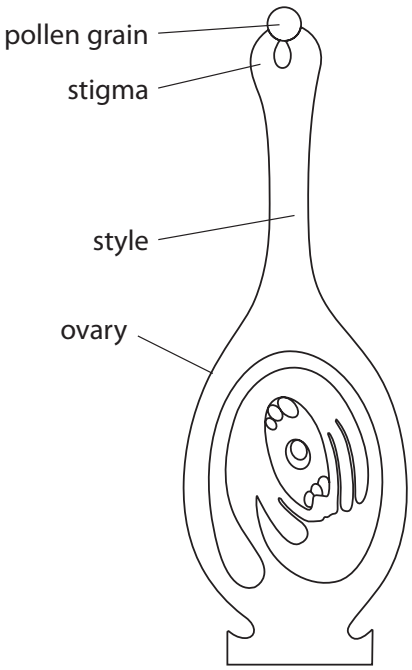
(ii) Determine the time when the photograph was taken.

(2)

Answer ..... minutes

(Total for Question 3 = 9 marks)

5 The diagram illustrates part of a flowering plant when pollination has just taken place.



(a) Describe the role of enzymes in the growth of the pollen tube.

(3)

(b) The styles of some plants secrete RNAase enzymes when pollen from the same flower germinates on the stigma.

Explain how these RNAase enzymes affect the growth of the pollen tube.

(3)

(c) Explain the role of double fertilisation in flowering plants.

(4)

6 Male fertility can be determined by a number of different factors.

(a) Describe the process of spermatogenesis.

(4)

(b) The mean volume of the semen produced by a male ejaculation is 3.4 cm^3.

This contains a mean concentration of 17 000 sperm mm^{-3}.

Calculate the mean total number of sperm in a single ejaculation.

Give your answer in standard form.

(2)

Answer .....

(c) The distance from the point of ejaculation in the vagina to the upper end of the fallopian tube (where fertilisation takes place) is 19 cm.

Some sperm travel this distance in three hours.

Calculate the mean speed of these sperm in cm min^{-1}.

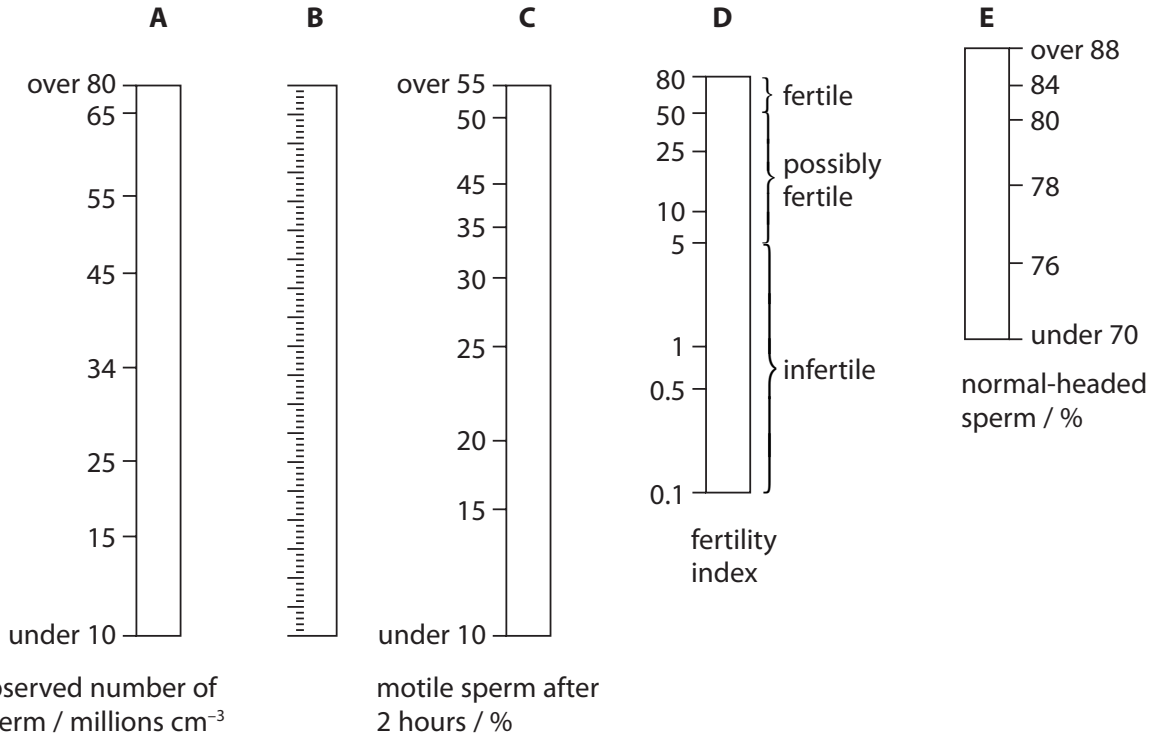
(1)

Answer .....

(d) Male fertility can be estimated using scales that take into account the number of sperm, their mobility and the percentage with a normal 'head'.

To calculate male fertility using these scales:

- draw a straight line between the observed number of sperm (scale A) and the percentage of sperm motile after 2 hours (scale C)
- from the intersection of this line with scale B, draw another straight line to scale E (the percentage of normal-headed sperm)
- the point where this second line crosses scale D (the fertility index), provides a relative assessment of fertility.



(i) Estimate the fertility of a man who produces a semen sample with:

- 25 million sperm per cm^3
- 35% of which are motile after 2 hours and
- 84% of which have normal heads.

(2)

Answer .....

(ii) Deduce why fertilisation is unlikely to occur if there are 5 million spermatozoa per cm^3.

(1)

.....

.....

.....

.....

.....

2 The photograph shows tomato flowers.



(Source: © NIGEL CATTLIN / HOLT STUDIOS / SCIENCE PHOTO LIBRARY)

(a) (i) Describe how an embryo sac, containing eight haploid nuclei, is formed inside the ovary of a flower.

(3)

(ii) Which row gives the correct chromosome number in these structures?

(1)

	endosperm cell	generative nucleus of pollen grain	embryo cell
☒ **A**	n	n	2n
☒ **B**	2n	2n	2n
☒ **C**	3n	n	2n
☒ **D**	3n	2n	n

(b) Cereal grains, such as barley, start to germinate after exposure to water.

Which growth substance is released by the embryo during germination to stimulate enzyme production?

(1)

☒ **A** auxin

☒ **B** cytokinin

☒ **C** gibberellin

☒ **D** phytochrome

(c) The colour of tomato fruits is controlled by two genes, each on a different chromosome.

- The flesh colour gene has two alleles, a dominant allele for red flesh (**R**) and a recessive allele for white flesh (**r**).
- The skin colour gene has two alleles, a dominant allele for yellow skin (**T**) and a recessive allele for white skin (**t**).

If a tomato plant has an allele for red flesh (**R**), the tomatoes will always have a red colour regardless of the skin colour.

(i) Which are the possible genotypes for a yellow-coloured tomato?

(1)

☒ **A** **RrTT** only

☒ **B** **rrTt** only

☒ **C** **rrtt** only

☒ **D** **rrTt** and **rrTT**

(ii) A tomato breeder crosses a yellow tomato plant with a red tomato plant that is heterozygous for both genes.

Some of the F1 generation tomatoes are white.

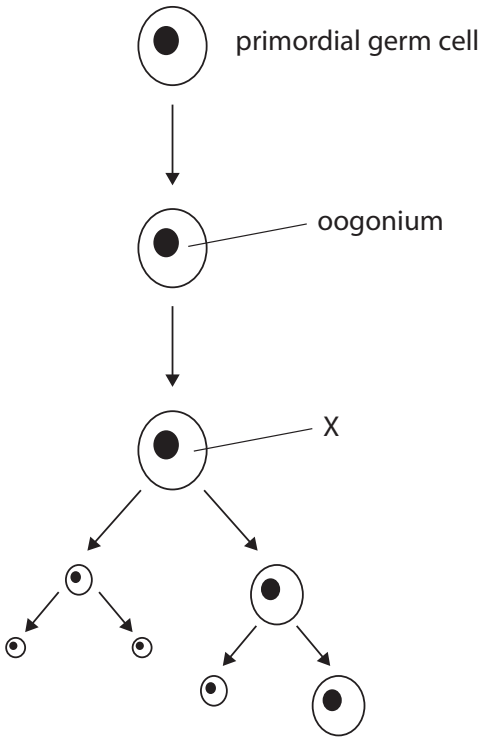
Determine the expected ratios of all the phenotypes of the F1 generation, using a genetic diagram.

(4)

Answer .....

(Total for Question 2 = 10 marks)

2 The diagram shows the process of oogenesis.



(a) (i) Which is the name of the cell labelled X?

(1)

- ☒ **A** ovule
- ☒ **B** ovum
- ☒ **C** primary oocyte
- ☒ **D** secondary oocyte

(ii) Meiosis is involved in oogenesis.

Describe the events of prophase I during oogenesis.

(3)

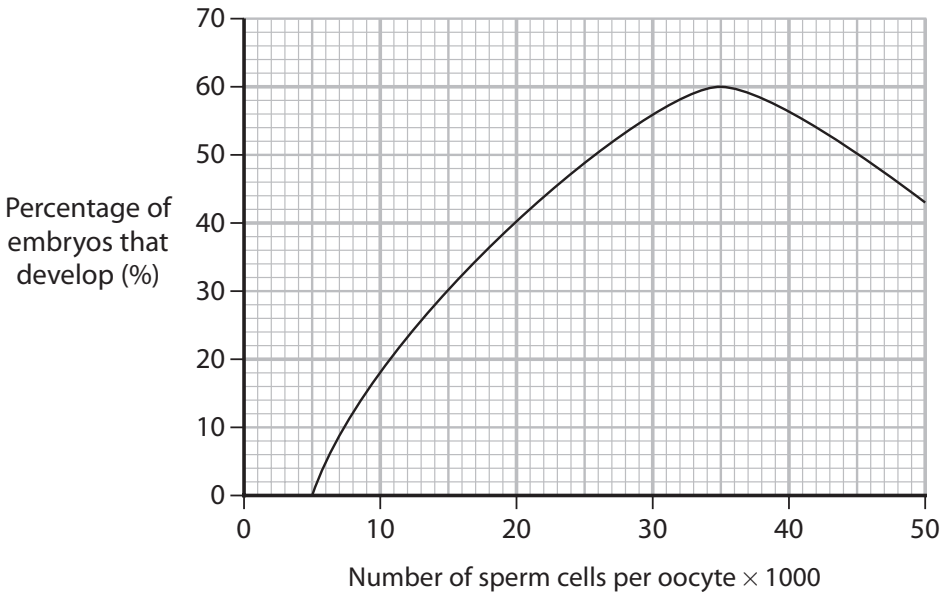
(iii) Compare and contrast the process of oogenesis with spermatogenesis.

(3)

(b) During in vitro fertilisation (IVF), oocytes are fertilised with sperm cells in a culture medium.

If more than one sperm cell fertilises an oocyte, the embryos do not develop.

The graph shows the effect on the production of embryos that develop when different numbers of sperm cells are added to oocytes during IVF.



(i) Calculate the number of sperm cells that need to be added to four oocytes so that 60% of embryos develop.

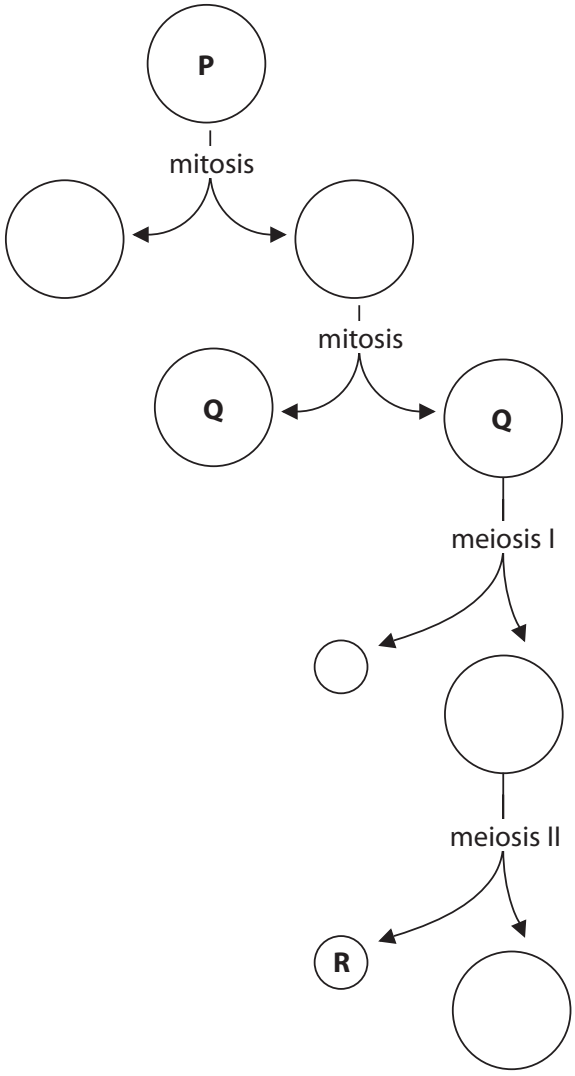
(1)

Answer .....

(ii) Analyse the data to explain the effects of increasing the number of sperm cells per oocyte on the percentage of embryos that develop.

(2)

6 The diagram summarises the process of oogenesis in humans.



(a) Which row contains the names for cells **P**, **Q** and **R**?

(1)

	P	Q	R
☒ **A**	germ cell	oocyte	polar body
☒ **B**	germ cell	polar body	ovum
☒ **C**	oocyte	polar body	ovum
☒ **D**	ovum	germ cell	oocyte

(b) A study determined the number of oocytes in human females of different ages.

The table shows the results of this study.

Age / years	Mean number of oocytes per female
at birth	733 000
4 to 10	499 200
11 to 17	389 300
18 to 24	161 800
25 to 31	80 200
32 to 38	32 500
39 to 45	10 900

(i) Calculate the percentage change in the mean oocyte numbers between birth and 11 to 17 years.

(2)

Answer .....

(ii) Deduce when oocytes are produced in a female human.

(1)

.....

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.....

(c) Some men are infertile due to a condition called azoospermia.

Men with this condition produce semen that contains spermatids instead of mature spermatozoa.

(i) State one structural difference between a spermatid and a mature spermatozoon.

(1)

(ii) Explain why men with azoospermia are infertile.

(2)

(iii) Infertility caused by azoospermia can be treated by using intracytoplasmic sperm injection (ICSI).

This procedure injects a single spermatid directly into an ooctye.

One concern about this procedure is that it uses selected spermatids. This eliminates the normal competition between sperm that precedes fertilisation.

Explain the advantage of competition between sperm.

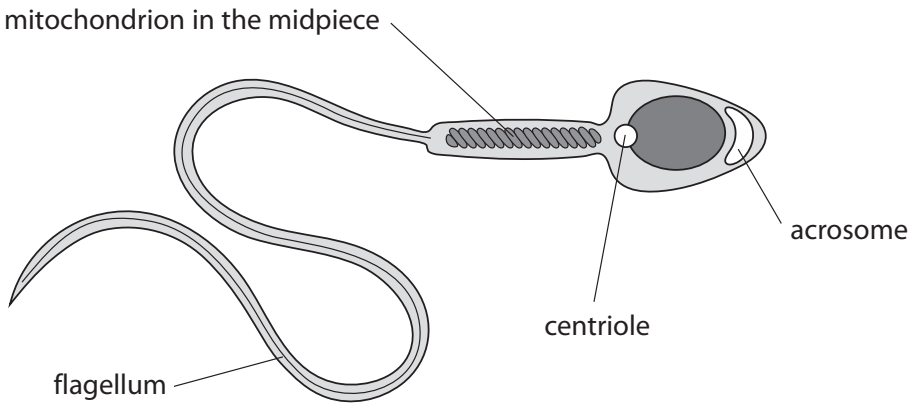
(2)

(iv) Describe two ethical implications of the use of ICSI.

(2)

9 Spermatogenesis is the process that results in the production of sperm cells.

The diagram shows a mature human sperm cell.



(a) (i) Which row of the table shows the type of nuclear division that takes place in spermatogonia and in primary spermatocytes?

(1)

		Spermatogonia	Primary spermatocytes
☒	**A**	meiosis I	meiosis II
☒	**B**	meiosis I	mitosis
☒	**C**	mitosis	mitosis
☒	**D**	mitosis	meiosis I

(ii) Which of the following pairs of cells are haploid?

(1)

☒ **A** primary spermatocytes and secondary spermatocytes

☒ **B** primary spermatocytes and spermatids

☒ **C** secondary spermatocytes and spermatids

☒ **D** spermatogonia and primary spermatocytes

(b) Human sperm cells contain centrioles but human egg cells do not.

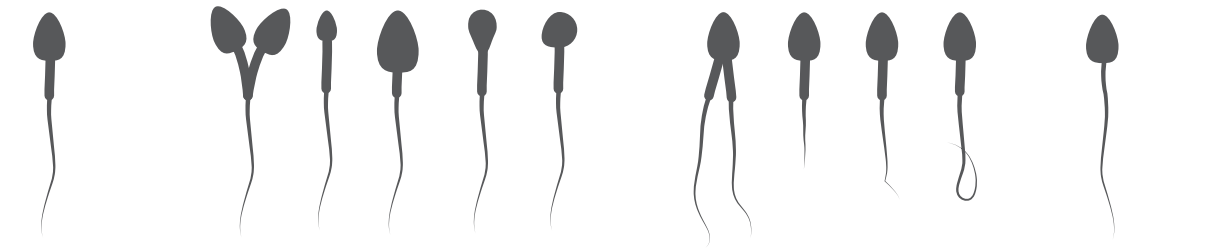
Explain the role of the centrioles in sperm cells following fertilisation.

(3)

*(c) Male infertility can be caused by a number of factors related to sperm cells:

- low sperm count
- structural defects of sperm cells
- absence of an acrosome
- mutations in the mitochondrial DNA
- chromosome mutations.

The diagrams show a normal sperm cell and some sperm cells with structural defects.



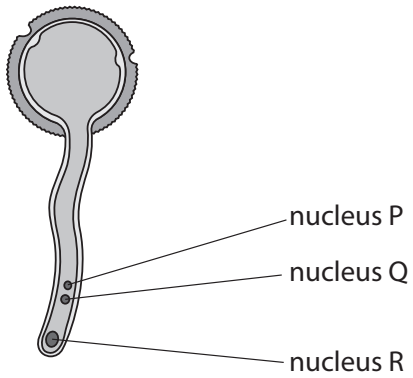
Normal | Head defects | Flagellum defects | Midpiece defects

Comment on how each of these five factors could result in male infertility.

(6)

6 In sexual reproduction in plants, a pollen grain lands on the stigma of a flower. The pollen grain germinates and a pollen tube grows.

(a) The diagram shows a germinated pollen grain.



(i) Which row of the table shows the role of each of these nuclei?

(1)

		Role of nucleus		
		P	**Q**	**R**
☒	**A**	control pollen tube growth	fertilise the female nucleus	fertilise the endosperm nucleus
☒	**B**	control pollen tube growth	fertilise the endosperm nucleus	fertilise the female nucleus
☒	**C**	fertilise the endosperm nucleus	control pollen tube growth	fertilise the female nucleus
☒	**D**	fertilise the endosperm nucleus	fertilise the female nucleus	control pollen tube growth

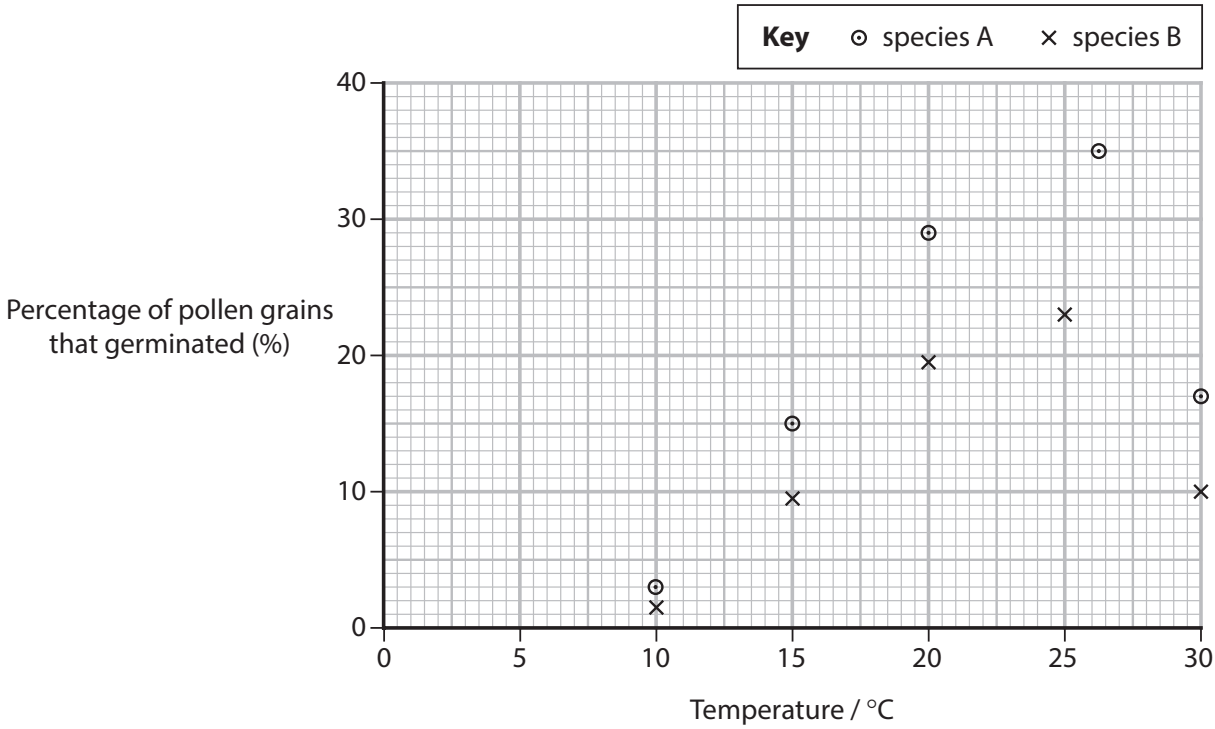
(ii) Which row of the table shows the number of sets of chromosomes each nucleus contains?

(1)

		Number of sets of chromosomes		
		P	**Q**	**R**
☒	**A**	n	n	n
☒	**B**	n	2n	2n
☒	**C**	2n	n	2n
☒	**D**	2n	2n	n

(b) The effect of temperature on the germination of pollen grains from two species of plant was investigated.

The graph shows the results of this investigation.



A student made two conclusions from these results.

(i) Conclusion 1: species A has a wider range of temperatures for pollen grain germination.

Comment on this conclusion.

(3)

(ii) Conclusion 2: species A has a higher optimum temperature for germination than species B.

Devise an investigation to confirm conclusion 2.

(4)

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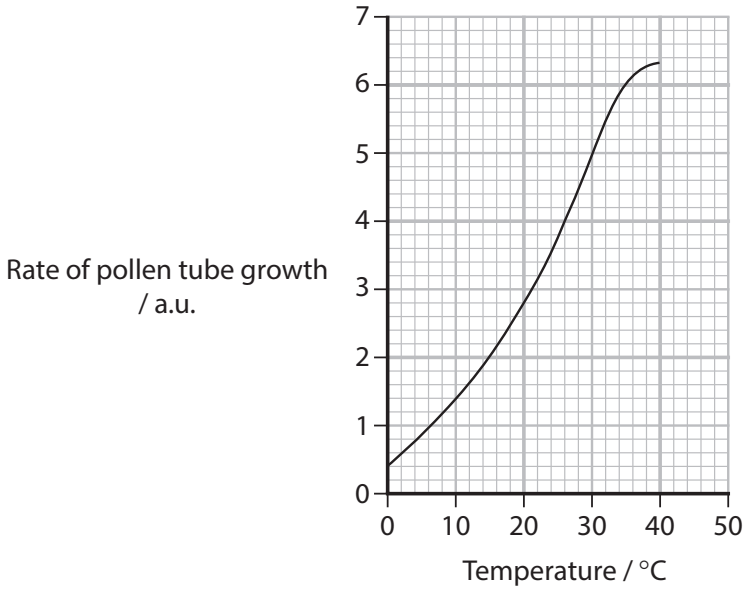
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(c) In another investigation, the rate of pollen tube growth at different temperatures was determined.

The graph shows the results of this investigation.



Pollen tube growth is controlled by enzymes.

The temperature coefficient (Q_{10}) describes the increase in rate of reaction as a result of increasing the temperature by 10 °C.

Calculate the Q_{10} for a temperature rise from 10 °C to 20 °C.

Use the formula:

$$Q_{10} = \frac{R_{(t+10)}}{R_t}$$

where R_t is the rate of reaction at 10 °C.

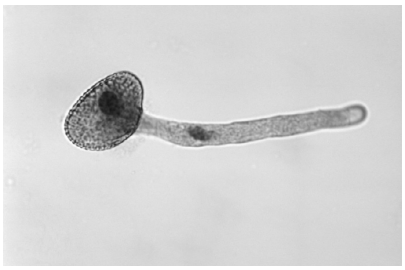
Give your answer to one decimal place.

(2)

Answer .....

(Total for Question 6 = 11 marks)

5 The photograph shows a germinating pollen grain, on a slide, as seen using a light microscope.



(Source: CAROLINA BIOLOGICAL SUPPLY COMPANY/SCIENCE PHOTO LIBRARY)

(a) Describe how you would use a light microscope to measure the actual length of this pollen tube.

(2)

(b) A scientist investigated the effect of concentration of calcium ions on the germination and growth of pollen grains.

The tables show the results from this investigation.

Concentration of calcium nitrate / mg dm^{-3}	Percentage germination of pollen grains after each hour (%)			
	1	2	3	4
0	0	0	0	0
300	50	55	65	65
400	50	58	60	69
500	50	65	70	79

Concentration of calcium nitrate / mg dm^{-3}	Mean pollen tube length after each hour / μm			
	1	2	3	4
0	0	0	0	0
300	120	261	284	355
400	256	284	355	426
500	341	412	455	547

(i) Calculate the mean rate of growth of the pollen tube in the 500 mg dm^{-3} calcium nitrate solution.

Give your answer in μm per minute, to **two decimal places**.

(2)

Answer ..... μm $minute^{-1}$

(ii) Give **three** conclusions that can be drawn from this investigation.

(3)

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(c) Devise a method that could have been used to collect valid data in this investigation.

(4)

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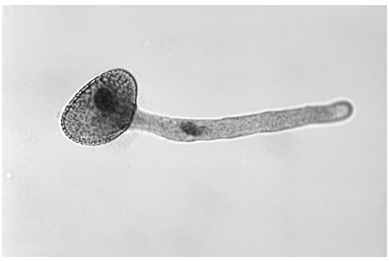
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5 (a) The photograph shows a germinating pollen grain as seen through a light microscope.



(Source: © CAROLINA BIOLOGICAL SUPPLY COMPANY/SCIENCE PHOTO LIBRARY)

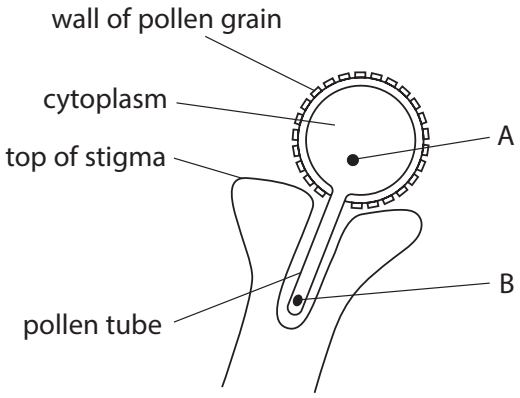
The actual length of this pollen tube is 136 μm.

Calculate the magnification of this photograph.

(2)

Answer .....

(b) (i) The diagram shows a pollen grain that has begun to germinate after landing on the surface of the stigma of a flower.



Identify the structures labelled A and B.

(2)

A .....

B .....

(ii) Describe the process of double fertilisation in flowering plants.

(3)

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(c) Devise an investigation to determine the effect of pH on the rate of growth of pollen tubes.

(5)

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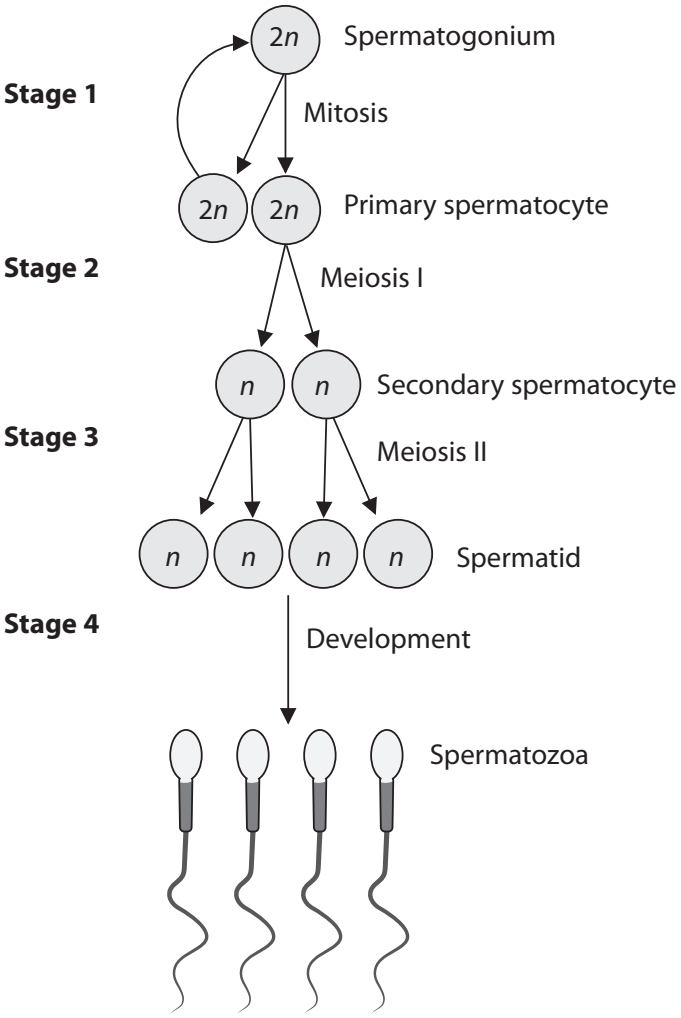
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8 In mammals, gametes are produced by spermatogenesis and oogenesis.

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



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

(2)

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

(4)

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

(3)

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

(2)

(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)

8 Changes must occur to mammalian sperm cells as they pass through the female reproductive tract, if successful fertilisation is to take place.

Capacitation results in changes to the sperm cell membrane and increased motility.

The acrosome reaction (AR) must follow capacitation but not too soon nor too late.

(a) Explain why the timing of the AR is important for successful fertilisation.

(3)

(b) A protein is involved in the timings of capacitation and the AR.

This protein exists in two forms: protein G and protein G-P.

Protein G-P results in the stimulation of capacitation and protein G results in the inhibition of the AR.

Protein G-P is located in the midpiece (neck) and flagellum of the sperm.

Protein G is located in the head region of the sperm.

The levels of these two forms of protein change just before capacitation, during capacitation and just before the AR.

Complete the table to show which form of protein is present and which is absent.

If the protein is present put a tick (✓) in the box and if the protein is absent put a cross (✗) in the box.

(4)

Event	Presence of protein G		Presence of protein G-P	
	Head region	Midpiece and flagellum	Head region	Midpiece and flagellum
Just before capacitation				
During capacitation				
Just before the AR				

(c) In some infertile males, the gene coding for protein G is methylated.

Explain why DNA-methylation of this gene could result in infertility.

(3)

(d) Scientists have used 'knockout' mice to investigate the effect of protein G on fertility.

(i) State the meaning of the term 'knockout' mice, as used in this context.

(2)

(ii) In an investigation, female mice and 'knockout' mice were housed together.

Describe how this investigation should be designed to confirm that protein G affects fertility.

(3)

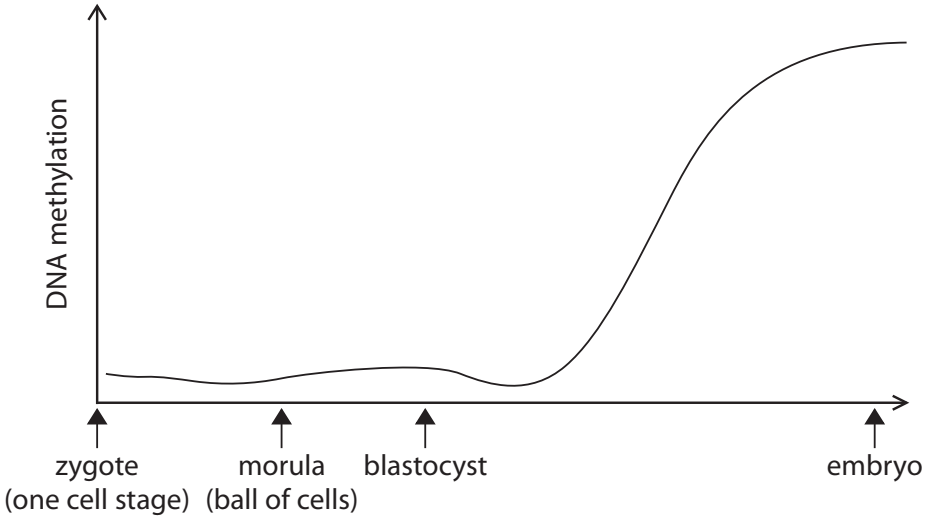
SUB-TOPIC 2(e)

CELL DIFFERENTIATION AND STEM CELLS

4 questions in this sub-topic · 35 marks · lowest tariff first

5 (a) Epigenetic modifications are involved in the development of an embryo.

The graph shows the changes in DNA methylation during the development of an embryo from a zygote.



(i) State the meaning of the term DNA methylation.

(1)

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(ii) Describe the differences between totipotent, pluripotent and multipotent stem cells during the development of an embryo.

(3)

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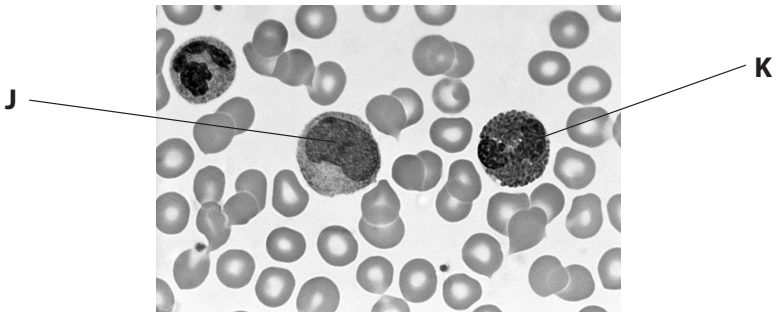
(iii) Analyse the graph to explain why DNA methylation is involved in the development of an embryo.

(2)

(b) Explain why some cells are not able to become other cell types.

(2)

4 The photograph shows a blood smear from a healthy person, as seen using a light microscope.



Source: © biophoto associates/science photo library

(a) (i) Which row of the table identifies the cells labelled **J** and **K**?

(1)

	Cell J	Cell K
☒ **A**	eosinophil	lymphocyte
☒ **B**	lymphocyte	neutrophil
☒ **C**	monocyte	eosinophil
☒ **D**	neutrophil	monocyte

(ii) Which is the approximate ratio of erythrocytes to leucocytes in this blood smear?

(1)

☒ **A** 1:50

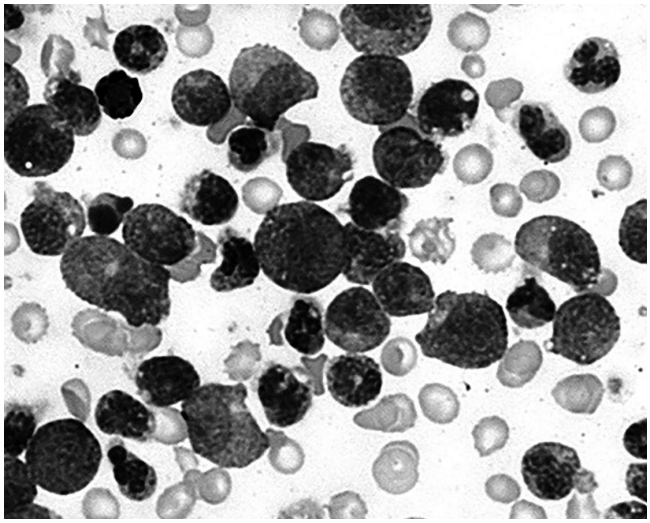
☒ **B** 3:50

☒ **C** 50:1

☒ **D** 50:3

(b) Chronic myelogenous leukaemia (CML) is a blood disorder.

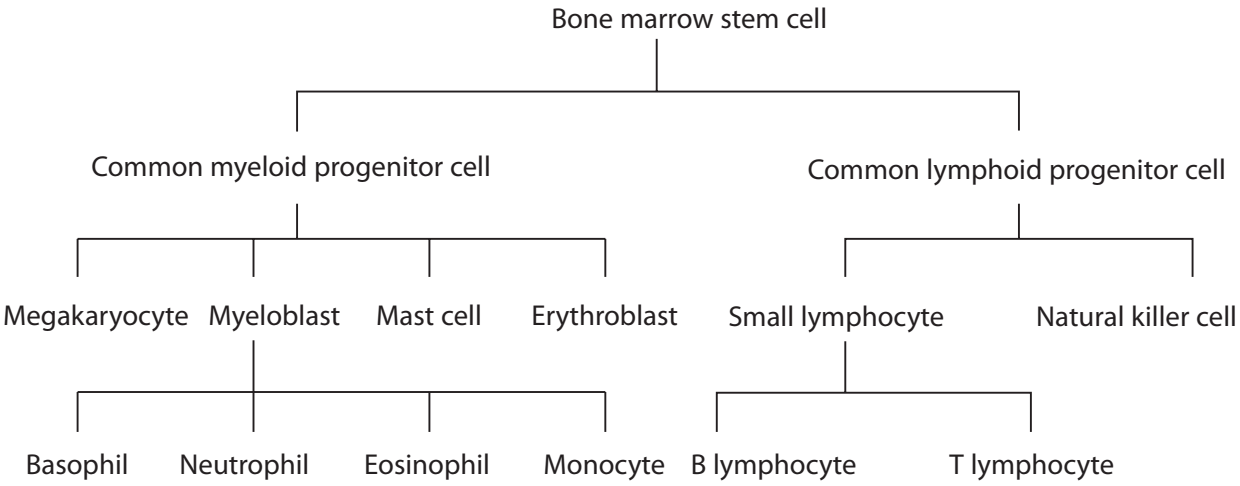
The photograph shows a blood smear from a person with CML, as seen using a light microscope.



Explain why a blood smear can be used to diagnose CML.

(2)

(c) The diagram shows some stages in the production of blood cells from bone marrow stem cells.



Explain how a bone marrow stem cell differentiates into either a common myeloid progenitor cell or a common lymphoid progenitor cell.

(4)

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4 Scientists are developing ways of using stem cells to replace heart cells that have been damaged as a result of heart disease.

(a) The table shows the results of a survey of the incidence of heart disease.

Age / years	Incidence of heart disease per 1000 population	
	In women	In men
18 to 44	3	5
45 to 64	118	138
65 to 74	220	305
75 and older	358	422

Analyse the data to explain the factors affecting the incidence of heart disease.

(2)

(b) Explain why heart cells are damaged as a result of heart disease.

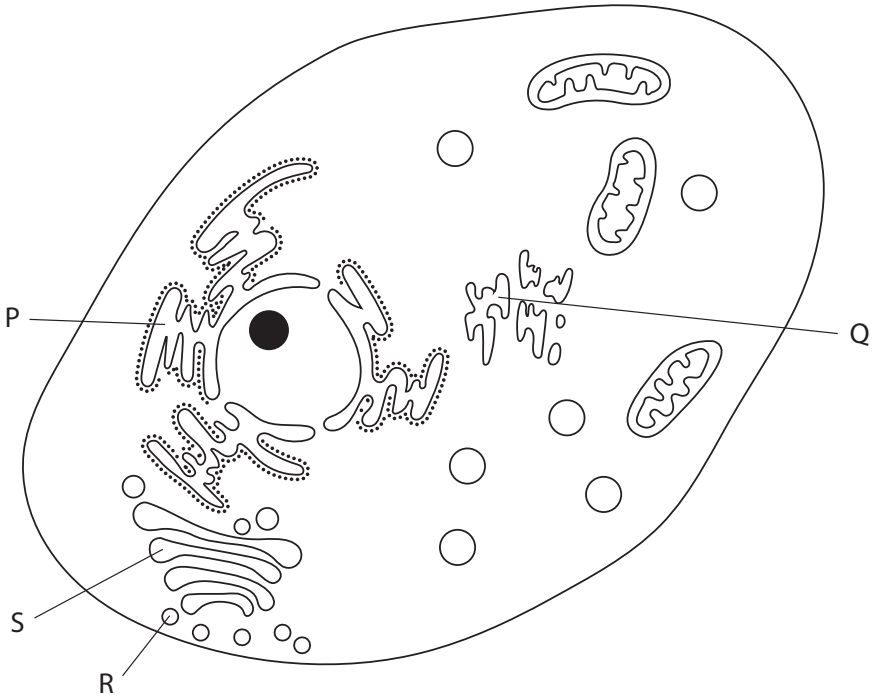
(2)

(c) Both embryonic stem cells and induced pluripotent stem cells (iPS cells) can be used to create new heart cells.

Compare and contrast the properties and uses of embryonic stem cells with those of iPS cells.

(5)

3 The diagram shows the structure of an animal cell.



(a) (i) Which of the following is the name of the structure labelled Q?

(1)

- ☒ **A** centriole
- ☒ **B** nucleus
- ☒ **C** rough endoplasmic reticulum
- ☒ **D** smooth endoplasmic reticulum

(ii) These cells were cultured in radioactively-labelled amino acids.

In which sequence would the cell structures in the diagram become radioactive during protein synthesis?

(1)

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

(iii) Explain one function of lysosomes.

(2)

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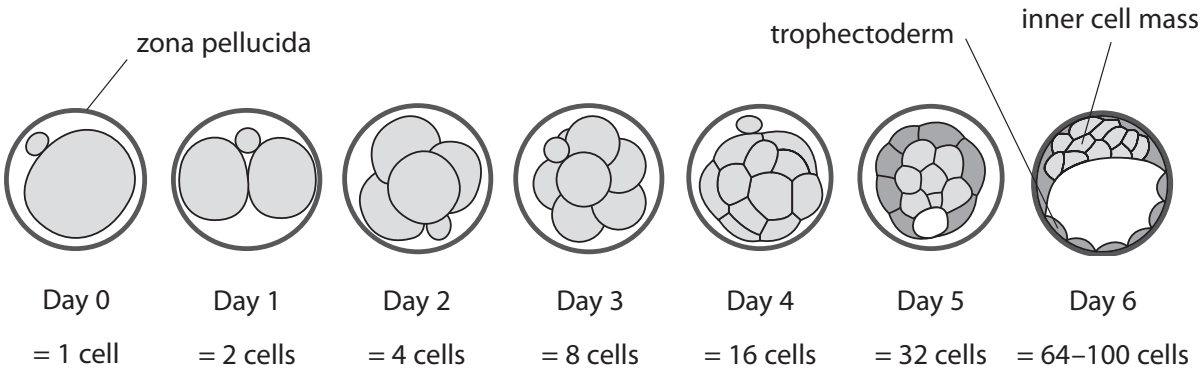
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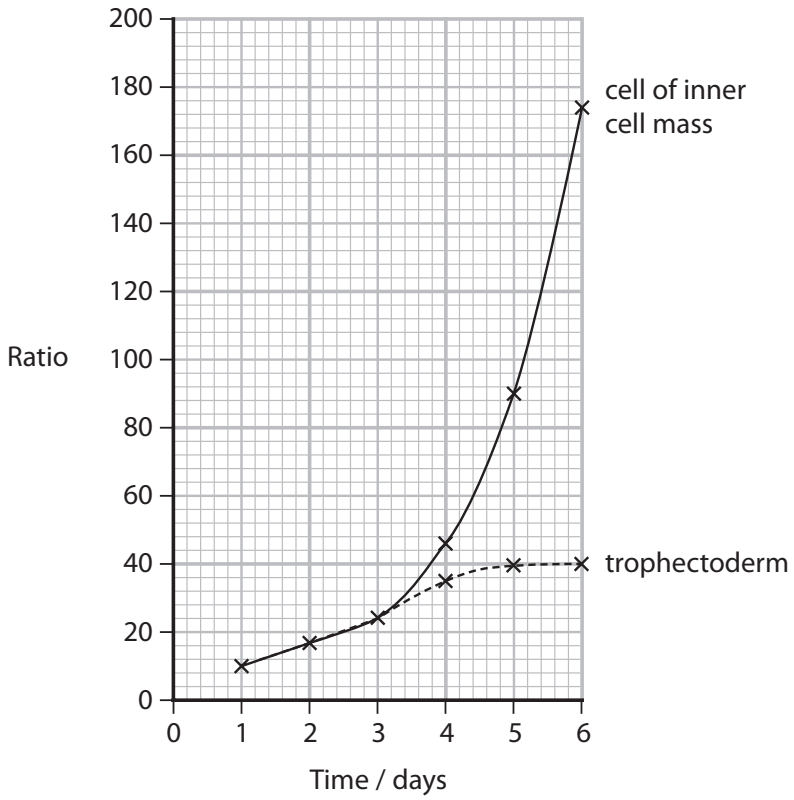
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(b) The diagram shows the development of a zygote into a blastocyst.



The graph shows how the ratio of the volume of the nucleus to the volume of the cytoplasm of each embryonic cell changes as the blastocyst develops.



(i) The ratio shown in the graph can be calculated using the formula

$$\text{ratio} = \frac{\text{volume of nucleus}}{\text{total volume of cell} - \text{volume of nucleus}}$$

On day 2, the volume of the cell nucleus was 900 μm^3.

Calculate the total volume of this cell on day 2.

Give your answer to two significant figures.

(3)

Answer ..... μm^3

(ii) Comment on the changes in the ratios as the zygote develops into a blastocyst.

(3)

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MARK SCHEMES

official Pearson Edexcel mark schemes

Question Number	Answer	Mark
1(a)	**1(a). The only correct answer is C** ***A*** *is not correct because this describes Endoplasmic reticulum which is involved in protein synthesis not modification* ***B*** *is not correct because this describes centrioles* ***D*** *is not correct because this describes a ribosome which is involved in synthesis (not modification) and is much smaller*	**(1)**

Question Number	Answer	Mark
1(b)	**1(b). The only correct answer is C** ***A*** *is not correct because Q describes a chloroplast which is not found in an animal cell* ***B*** *is not correct because chloroplasts are not found in animal cells, but they are found in plant cells, animal cells would also contain mitochondria (R)* ***D*** *is not correct because chloroplasts are not found in animal cells, plant cells would also contain mitochondria (R)*	**(1)**

Question Number	Answer	Mark
1(c)	**1(c).The only correct answer is A** ***B*** *is not correct because 6 μm is 6000 nm which is bigger than 2500nm* ***C*** *is not correct because* 10^{-9} *m is a nanometer so the smallest not the largest organelle* ***D*** *is not correct because they are listed from largest to smallest in this sequence*	**(1)**

Question Number	Answer	Mark
1(d)	**1(d). The only correct answer is C** ***A*** *is not correct because Q (chloroplast), R (mitochondria) and T (nucleus) all have DNA* ***B*** *is not correct because Q (chloroplast), R (mitochondria) and T (nucleus) all have DNA* ***D*** *is not correct because because only Q (chloroplast), R (mitochondria) and T (nucleus) have DNA. P is a ribosome, S is the Golgi and each of the organelles containing DNA each has a double membrane*	**(1)**

Question Number	Answer		Mark
1(e)	Correct calculation	<u>Example of calculation</u> (13 ÷ 37) x 100 = 35.1 **ACCEPT** 35 or 35.14	**(1)**

Total for Question 1 = 5 MARKS

1(a)	D	**(1) comp**

Question Number	Answer	Mark
1(b)	A	**(1) comp**

Question Number	Answer	Mark
1(c)		**(2) clerical**

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

Question Number	Answer	Mark
1(d)	C	**(1) comp**

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following:		

Question Number			
1(a)	• diameter measured and mean value calculated (1) • 2 000 / 2 300 / 2 320 / 2 316 (1)	Example of calculation: 44 (mm) / 4.4 (cm) and 0.019 (mm) ecf if either 44 (mm) or 0.019 used and answer rounded up to whole number correctly e.g. (45 and 0.019 =) 2 368 Correct answer with no working gets 2 marks	(2)

Question Number	Answer	Additional Guidance	Mark
1(b)	A description that makes reference to three of the following: • use an (eye piece) graticule to measure the diameter (1) • take several measurements and calculate the mean (for each cell) (1) • calibrate the (eye piece) graticule (1) • using a stage micrometer (1)	**ACCEPT** length / size **ACCEPT** a description of how this is done	(3)

Number	Answer	Additional Guidance	Mark
1 (a)(i)	An answer that makes reference to the following: • one cell drawn with correct shape / proportion (1) • clear lines used to represent correct shape of cell, with no shading of any feature (1)	Must be a drawing not a diagram	**(2)**

Question Number	Answer	Additional Guidance	Mark
1 (a)(ii)	An explanation that makes reference to three of the following: • companion cells for ATP production (1) • because sieve tubes are for transport of organic molecules (1) • because energy is needed for transport (both up and down the stem) (1) • sieve tubes have no organelles, so less barriers to transport (1)	Allow named organic molecule eg {sugar / sucrose} Allow energy needed for active transport (of sugars) Allow sieve tubes have {sieve plates / plasmodesmata} so less barriers to transport	**(3)**

Question Number	Answer	Additional Guidance	Mark
1(b)	An answer that makes reference to the following: • so that some organelles are clearly visible (1)	**Accept** converse Allow named organelles	**(1)**

Number	Answer	Additional Guidance	Mark
1(a)	An answer that includes the following: • conversion of actual size and correct measured size to same units (1) • correct answer to nearest whole number (1)	Sample calculation Accept 64 000 to 66 000 (for measured size in µm) 6×10^{-4} (for actual size in cm) 6×10^{-3} (for actual size in mm) Accept answers in range **10 667 to 11 000** **Do not allow** units Correct answer with no working gains 2 marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
1(b)	An answer that includes the following: • cell drawn correct shape with clear lines and no {shading / hatching} (1) • {nucleus / vacuole} (1)	Ignore cell wall if drawn **Do not allow** mitochondria **Do not allow** anything smaller eg ribosomes	**(2)**

Question Number	Answer	Additional Guidance	Mark
1(c)(i)	• (presence of) {membrane-bound organelles / named organelle} / nucleus / linear chromosomes / 16 chromosomes / cell wall made of {chitin / mannose} (1)	Accept does not have a nucleoid / Accept does not have a looped {chromosome / DNA} Ignore has a cell wall unqualified	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(c)(ii)	• cell wall not made of cellulose / glycogen granules present / no chloroplasts present / it is single celled / does not have {roots / a stem / leaves} (1)	Accept only what can be seen in the diagram Accept cell wall made of chitin and / or mannose Ignore refs to chlorophyll / photosynthesis Accept not multicellular	**(1)**

(Total for Question 1 = 6 marks)

swer	Additional Guidance	Mark
e to the following:		
(1)	e.g. glucose, enzymes, ATP, amino acids, protein, lipids, vitamins, mineral ions and fragments of cell membrane Allow oxygen / carbon dioxide if qualified	
n 1.09 (gcm^{-3}) (1)	Ignore sodium chloride, sucrose, sugar and salt	(2)

Additional Guidance	Mark
	(1)

swer	Additional Guidance	Mark
e to the following:		
(1)	Reject nucleolus	
(1)	Allow more dense than 1.22 or more dense than mitochondria or similar Allow contains very dense material Must be in context of an organelle not listed on the table	(2)

Question Number	Answer	Mark
1(a)(i)	The only correct answer is D (S) *A is incorrect as P is the nucleus* *B is incorrect as Q is a mitochondrion* *C is incorrect as R is rER*	**(1)**

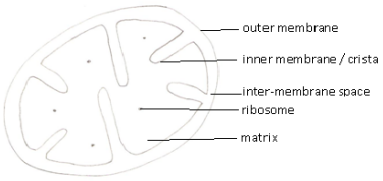
Question Number	Answer	Mark
1(a)(ii)	The only correct answer is C (R) *A is incorrect as translation does not occur in P* *B is incorrect as translation does not occur in Q* *D is incorrect as translation does not occur in S*	**(1)**

Question Number	Answer	Mark
1(a)(iii)	The only correct answer is A (0) *B is incorrect as none of the structures are present in Archaea* *C is incorrect as none of the structures are present in Archaea* *D is incorrect as none of the structures are present in Archaea*	**(1)**

Question Number	Answer	Additional guidance	Mark
1(b)	• correct calculation of magnification (1) • answer given in standard form (1)	**one mark** for answer between 1361 up to 1417 Correct answer but with wrong standard for e.g. between 13.6 x 10^2 up to 14 x 10^2 = **one mark** **two marks** for answer between 1.36 x 10^3 up to 1.42 x 10^3 **(2)** **Accept** any number of decimal places **Correct answer gains both marks**	**(2)**

Question Number	Answer	Additional guidance	Mark
1(c)	An explanation that makes reference to two of the following: • to prevent enzyme and substrate reacting / do not form E-S complexes / hydrogen cyanide is not produced (1) • react when {cell damaged / vacuole and chloroplast break} / so dhurrin and glucosidase only come into contact when cell is {eaten / damaged} (1) • so plant (cell) does not die / stop growing (1)	**Accept** stop dhurrin and glucosidase reacting **Accept** if together would produce hydrogen cyanide	**(2)**

(Total for Question 1 = 7 marks)

Question Number	Answer	Additional Guidance	Mark
5(a)	A drawing that shows the following: Drawing marks : • 2 membranes drawn (1) • (continuous) inner membrane (of two) folded (1) Label marks : Any **two** from • {inner membrane / crista} and outer membrane (1) • inter-membrane space (1) • matrix (1) • ribosome (1)		**(4)**

Question Number	Answer	Mark
5(b)(i)	**The only correct answer is A** ***B*** *is not correct because the father's mitochondria do not enter the ovum on fertilisation* ***C*** *is not correct because only the nucleus was used from the mother* ***D*** *is not correct because only the nucleus was used from the mother and the father's mitochondria do not enter the ovum on fertilisation*	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	An explanation that makes reference to three of the following: • zygote divides by mitosis (several times to form blastocyst) (1) • to make identical copies of the {DNA (molecules) / chromatids} (1) • so that all cells (in the blastocyst) {will be diploid / have two copies of each chromosome} (1) • so that when the mitochondria divide they will have a copy of the DNA (1)	 **ACCEPT** genetically-identical (daughter) cells / same genetic information **ACCEPT** correct number of chromosome / 46 chromosomes / 23 pairs **ACCEPT** mitochondrial DNA divides	**(3)**

Number	Answer	Mark
4(a)(i)	**The only correct answer is C** ***A*** *is not correct because cellulose is not found in a bacterial cell* ***B*** *is not correct because cellulose and nucleoli are not found in a bacterial cell* ***D*** is not correct because nucleoli are not found in a bacterial cell	**(1)**

Question Number	Answer	Mark
4(a)(ii)	**The only correct answer is C** ***A*** *is not correct because Ebola contains RNA* ***B*** *is not correct because HIV contains RNA* ***D*** *is not correct because tobacco mosaic virus contains RNA*	**(1)**

Question Number	Answer	Additional Guidance	Mark
4(a)(iii)	An explanation that makes reference to the following: • the resolution is higher / better (1) • because wavelength of electrons is short(er) (1)	**ACCEPT** converse **ACCEPT** smaller wavelength	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(b)(i)	An explanation that makes reference to three of the following: • each domain has unique characteristics (1) • Archaea and Eukarya share three characteristics (1) • Archaea and Eukarya are more closely related / have a more recent common ancestor (1) • differences in {membrane lipids / ribosome size} evolved after Archaea and Eukarya split (1)	**ACCEPT** Archaea and Eukarya share more characteristics / share no rRNA loop, no antibiotic sensitivity and methionine **ACCEPT** branched carbon chains / ether linkage / 80 S	**(3)**

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	• peer review / (scientific) paper / (scientific) journal / (scientific) conference		**(1)**

Question	Answer	Additional Guidance	Mark

Question Number	Answer	Additional Guidance	Mark
4(a)	An explanation that makes reference to the following: • arranged in a bilayer (1) • {phosphate / polar / hydrophilic} heads orientated outside as they can interact with aqueous environment (on both sides of membrane) (1) • {fatty acid / non polar / hydrophobic} tails within membrane because they turn away from the water (1)	**ACCEPT** phosphate heads on outside and fatty acid tails inside from labelled diagram **ACCEPT** description of aqueous environment **ACCEPT** water repels phospholipids / phospholipids repel water	(2)

Question Number	Answer	Additional Guidance	Mark
4(b)(i)	• the resolution of the (electron) microscope was good (to see the two membranes as separate structures)		(1)

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	• magnification of photograph calculated / ratio of membrane to space given (1) • value 12 (nm) (1)	100 000 OR in the range of space : membrane = 1 : 1.5 to 1 : 2.5 or 0.4 : 1 to 0.67 : 1 **ACCEPT** any value between 9 and 15 to one decimal place max **ECF** for 1 mark if numerical value falls in our range and answer is given to one decimal place max but order of magnitude is wrong Correct answer only = 2 marks	(2)

Question Number	Answer	Additional Guidance	Mark
4(c)	An explanation that makes reference to three of the following: • liver has smaller percentage of cell membrane as there are more organelles inside it (1) • liver has less RER (membrane) because it is {making / transporting} less protein OR liver has more SER (membrane) as it is {making / transporting} more lipid (1) OR liver has more RER (membrane) as it makes steroids and pancreas has more SER (membrane) as it makes insulin • liver has more mitochondria (membrane) as it is more metabolically active (1) • liver has less Golgi as it is {modifying / secreting} fewer proteins OR pancreas {may have more / has} secretory granules for exocytosis of proteins (1)	**ACCEPT** converse throughout for pancreas correctly named proteins throughout e.g. pancreas - insulin **ACCEPT** because of liver's role in producing lipids and pancreas' role in producing proteins **ACCEPT** stores lipid steroids / cholesterol metabolism of toxins **ACCEPT** requires more energy / more (aerobic) respiration	(3)

Question Number	Answer	Additional Guidance	Mark
3(a)(i)	**The only correct answer is A** **B** is incorrect because bacteria have 70S ribosomes **C** is incorrect because bacteria do not have a nucleus **D** is incorrect because bacteria do not have a nucleus or 80S ribosomes		(1)

Question Number	Answer	Additional Guidance	Mark
3(a)(ii)	An answer that makes reference to the following: • cytoplasm • plasmids • cell membrane	3 correct = 2 marks 1 or 2 correct = 1 mark **ACCEPT** glycogen granules / lipid droplets /mesosome	(2)

Question Number	Answer	Additional Guidance	Mark
3(b)(i)	• 23 : 1.0	**Accept** 23 : 1 **Accept** 1.0 : 0.043 **Accept** 1 : 0.043	(1)

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	An explanation that makes reference to the following: • *B. subtilis*, because it {is Gram positive / has a thick peptidoglycan cell wall} (1) • antibiotics interfere with the synthesis of peptidoglycan (crosslinks) / inhibit formation of peptidoglycan (1)		(2)

Question Number	Answer	Additional Guidance	Mark
3(c)	An answer that makes reference to the following: • increase in cell number calculated (1) • rate calculated (1)	$(1.7 \times 10^5 - 6 \times 10^3 =)$ 164 000 1367 / 1366.7 / 1366.67 / 1366 recurring (cells per minute) 1366(.66) gains 1 mark Correct answer with no working gains 2 marks	(2)

Question Number	Answer	Additional Guidance	Mark
5(a)	An answer that makes reference to the following: **A** : matrix (space) **B** : outer membrane / envelope **C** : crista / cristae / (folded) inner membrane	 **Accept** intermembrane space / double membrane All three correct = 2 marks 1 or 2 correct = 1 mark	(2)

Question Number	Answer	Additional Guidance	Mark
5(b)	An answer that makes reference to the following: • diagram that (roughly) shows the shape and position of the cristae (minimum of 7 cristae at least half width of drawing) (1) • diagram that has no overlapping lines, breaks in lines, shading (1)		(2)

Question Number	Answer	Additional Guidance	Mark
5(c)(i)	**The only correct answer is D** **A** is incorrect because 74 000 ÷ 0.9 = 82 222 **B** is incorrect because 74 000 ÷ 0.9 = 82 222 **C** is incorrect because 74 000 ÷ 0.9 = 82 222		(1)

Question Number	Answer	Additional Guidance	Mark
5(c)(ii)	An answer that makes reference to the following: • 0.12 (195...) or 0.12 (162…) μm (1)	**Accept** ECF from Q5ci) A 8.33(3333) μm B 1.21(951…) or 1.21(621…) μm C 0.83(3333) μm	(1)

Question Number	Answer	Additional Guidance	Mark
5(d)	An explanation that makes reference to the following: • because (many) specimens / cells, will be colourless / not be visible (without a stain) (1) • because electron microscope uses electrons to show (electron) dense areas (1)	 **Accept** stains provide a contrast **Accept** electrons are not absorbed/scattered by coloured stains / electron microscopes need to use heavy metals	(2)

Question Number	Answer	Additional guidance	Mark
1(a)	A description that makes reference to the following: • (rough endoplasmic reticulum) performs {polypeptide synthesis / translation / protein synthesis} (1) • (Golgi apparatus) {modifies proteins / glycosylates proteins / adds carbohydrates to proteins / packages proteins / forms quaternary structure of proteins / produces lysosomes / modifies lipids / forms glycolipids} (1) • (mitochondria) {makes ATP / performs respiration} (1)	**Allow** makes proteins **Allow** forms {primary / secondary / tertiary structure} **Do not accept** forms quaternary structure **Do not accept** forms cell walls **Do not accept** anaerobic respiration	**3**

Question Number	Answer	Additional guidance	Mark
1 (b)(i)	A description that makes reference to three of the following: • (DNA) helicase {breaks hydrogen bonds / separates strands / unzips the two strands / unzips the DNA} (1) • complementary {nucleotides / bases} pair up (1) • (DNA) polymerase forms {phosphodiester bonds / forms sugar-phosphate backbone} (between nucleotides bound to strand) (1) • (DNA) ligase {joins (Okazaki) fragments} (1)	**Allow** adenine pairs with thymine **and** cytosine pairs with guanine **Allow** A,T,C,G for names **Do not accept** polymerase forms hydrogen bonds **Allow** joins breaks in DNA strands	**3**

Question Number	Answer	Additional guidance	Mark
1(b)(ii)	An explanation that makes reference to two of the following: • altered form {has a missing OH group / has sulfur instead of carbon}(1) • so phosphodiester bonds cannot form (between neighbouring / adjacent nucleotides) (1) • (and) **sugar phosphate backbone** cannot form (1)	**Allow** S instead of C-OH **Do not accept** S instead of OH	**2**

(Total for Question 1 = 8 marks)

	Additional Guidance	Mark
hree of the {move to / fuse arbohydrates /)	**Accept** quarternary structure formed / conjugated protein formed **Accept** package into vesicles	**(3)**

	Additional Guidance	Mark
the following: {increased diffusion / calcium ion channels oteins} limit rate (1) acilitated diffusion	**Accept** all calcium ion channels are being used	**(3)**

	Additional Guidance	Mar
	Do not accept nucleolus	**(1**

	Additional Guidance	Mar
	<u>Example of calculation:</u> magnification: 10 000 μm ÷ 1 μm = × 10 000 diameter: 54 mm ÷ 10 000 = 5.4 μm **Accept** range between 5.3 μm to 5.5 μm Correct answer with units gains full marks	**(2**

Number	Answer	Additional Guidance	Mark
5ai	An explanation that makes reference to two of the following: • a light microscope has limited (useful) magnification (1) • because a light microscope has limited resolution (1) • because the wavelength of visible light is more than a beam of electrons (1)	accept converse for electron microscope	**(2)**

Question Number	Answer	Additional Guidance	Mark
5aii	An explanation that makes reference to the following: • provides greater contrast (1) • because the stain {attaches to / is taken up by} specific {parts / types of}cell (1)		**(2)**

Question Number	Answer	Additional Guidance	Mark
5bi	A description that makes reference to two of the following: • folding of the {primary structure / polypeptide chain } (1) • into α-helix or β pleated sheet (1) • due to formation of hydrogen bonds (1)		**(2)**

Question Number	Answer	Additional Guidance	Mark
5bii	An explanation that makes reference to the following: • protease enzymes have an active site specific to certain amino acid sequences (1) • so the misfolded protein will not fit in the active site (of the protease enzyme) (1) • therefore enzyme is unable to hydrolyse peptide bond (1)		**(3)**

Question Number	Answer	Additional Guidance	Mark
4(a)(i)	**B** matrix	**A** is incorrect because crista are folds in the membrane **C** is incorrect because stroma is in chloroplasts **D** is incorrect because thylakoids are in chloroplasts	

Question Number	Answer	Additional Guidance	Mark
4(a)(ii)	An explanation that makes reference to the following: • because the resolution of the microscope used for **P** is {lower / worse} (1) • to distinguish {the small distance between the two membranes / the membranes as separate structures} (1)	**ACCEPT** converse for **Q** throughout **DO NOT ACCEPT** magnification **ACCEPT** (inter membrane) space can be seen between membranes / the inner and outer membrane can be seen/ two lines can be seen	

Question Number	Indicative content
***4(b)**	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content: • membranes both made of phospholipid bilayer with embedded proteins • lipid content is the phospholipid bilayer • phospholipids needed for {fluidity / compartmentalisation} • higher protein : lipid ratio in the inner membrane / more protein compared to lipid in the inner membrane • protein content equals lipid content in outer membrane • role of inner membrane is oxidative phosphorylation / chemiosmosis / synthesise ATP • inner membrane contains proteins involved in electron transport • inner membrane contains ATPase channels • movement of protons through ATPase channels results in ATP formation • proteins in outer membrane to allow pyruvate to pass through

Level 0	Marks	No awardable content
Level 1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain description of membrane structure 1 mark = 2 points 2 marks = 3 points
Level 2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages between the two membranes and their lipid and protein content 3 marks = explanation of ATPase or electron transport proteins or outer membrane 4 marks = explanation of two from ATPase, electron transport proteins, outer membrane
Level 3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which relates named protein molecules to the high protein content of the inner membrane 5 marks = explanation of ATPase, electron transport proteins and outer membrane 6 marks = clear, accurate account of oxidative phosphorylation

Question Number	Answer	Additional Guidance	Mark
4(a)	An answer that makes reference to the following: • all cells drawn with no extra details (1) • in correct proportions and twice as big (at least 4.4 cm) (1) • visible nuclei shown in correct positions (1)	No shading/feathered lines	**(3)**

Question Number	Indicative content	
***4(b)**	**Indicative content:** **1. Method for soaking stomata in potassium ions:** • leaf / leaf sections / epidermal strips taken • kept in dark (until all stomata are closed) • soaked in potassium ions/solution containing K^+ • of at least {five different concentrations / four different concentrations + water control) • left for a period of time • several leaf samples used /repeats, at each concentration **2. Control variables:** • leaves from same plant/same species of plant • all, kept in dark / exposed to same light intensity • other control variable, such as temperature / CO_2 concentration / windspeed / humidity / other (named) ions • same period of time **3. Visualising stomata:** • use a (light) microscope / description indicating microscope use • use, leaves / section/ strip, thin enough for light to penetrate through • use a, stain / named stain, to show stomata • nail varnish peel method • suitable plant leaf type eg: Tradescantia **4. Measurements made:** • use of an eye piece graticule • measure width of stomata • several stomata measured • eye piece graticule calibrated • using a stage micrometer **5. Data handling:** • calculate means • standard deviation / statistical analysis • graph plotted of width of stomata against potassium ion concentration	**Level 1** 1 mark : one relevant comment made 2 marks : Any 2 comments made from any aspect **Level 2 :** 3 marks : 3 comments made from at least two aspects 4 marks : 4 comments made from at least three aspects **Level 3 :** 5 marks : 4 comments made from at least four aspects 6 marks : at least 5 comments made from all aspects ACCEPT use of correlation coefficient test

Question Number	Answer	Additional Guidance	Mark
6ai	**C** rough endoplasmic reticulum		**(1)**

Question Number	Answer	Additional Guidance	Mark
6aii	**B** X		**(1)**

Question Number	Answer	Additional Guidance	Mark
6aiii	To check on typeset version of the paper working shown (1) (1)	correct answer	**(2)**

Question Number	Answer	Additional Guidance	Mark
6aiv	An explanation that makes reference to the following: • organelle Z produces ATP (1) • which supplies the energy for the synthesis of proteins (1) • which supplies energy for {modification / transport / secretion} of proteins (1)	 accept enzymes / hormones accept active transport / exocytosis	**(3)**

Question Number	Answer	Additional Guidance	Mark
6b	A diagram that includes the following: • amino group and carboxyl group shown (1) • a carbon attached to H and R on each side of (1) • a peptide bond shown (1)	 accept reasonable example of an R group	**(3)**

Question Number	Answer	Additional Guidance	Mark

Number	Answer	Mark
2(a)(i)	**The only correct answer is C** ***A*** *is not correct because there are no chloroplasts in an animal cell* ***B*** *is not correct because lysosomes do not have a folded inner membrane* ***D*** *is not correct because ribosomes are much smaller and do not have a membrane*	**(1)**

Question Number	Answer	Mark
2(a)(ii)	**The only correct answer is B** ***A*** *is not correct because it is not at the cell surface* ***C*** *is not correct because the rough endoplasmic reticulum is irregular in shape and is labelled P in the diagram* ***D*** *is not correct because the structure has ribosomes on the surface*	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(a)(iii)	A calculation that shows: • image size measured correctly (1) • image size / 9000 with suitable units (1)	<u>Example of calculation</u> 8mm 8/9000 = 0.00089mm / / 0.0009mm / 0.89µm / 0.9µm / 889nm / 8.9 x10^{-7} Allow ECF from image size +/- 1mm for one mark correct answer gets both marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(a)(iv)	A description that makes reference to the following: • P is (rough endoplasmic reticulum) where {translation / protein synthesis} takes place (1) • S is (Golgi apparatus) where protein is {packaged / sorted / quaternary structure produced} (1) • T are (vesicles) in which {proteins / enzymes} are transported to the cell membrane (1)	**Allow** exocytosis	**(3)**

Question Number	Answer	Mark
2(b)	**The only correct answer is C** ***A*** *is not correct because there are no plasmids in an animal cell* ***B*** *is not correct because Prokaryotes do not have a nucleolus* ***D*** *is not correct because Prokaryotes do have ribosomes and plasmids*	**(1)**

Question Number	Answer	Additional Guidance	Mark
2 (c)	An explanation that makes reference to two of the following: • light has a longer wavelength than electrons (1) • therefore a light microscope has a lower resolution (than the electron microscope) (1)		**(2)**

Question	Answer	Additional Guidance	Mark

Question Number	Answer	Additional Guidance	Mark
3(a)(i)	**The only correct answer is C** *A is incorrect because the second and third layer cannot line up with polar heads adjacent to non-polar tails* **B** *is incorrect because the non-polar tails cannot interact with the aqueous environment on either side of membrane* **D** *is incorrect because the non-polar tails cannot interact with the aqueous environment + the second and third layer cannot line up with polar heads adjacent to non-polar tails*		**(1)**

Question Number	Answer	Additional Guidance	Mark
3(a)(ii)	**The only correct answer is B** *A is incorrect because the answer is 0.02* **C** *is incorrect because the answer is 0.02* **D** *is incorrect because the answer is 0.02*		**(1)**

Question Number	Answer	Additional Guidance	Mark
3(a)(iii)	An explanation that makes reference to the following: • the resolution is higher (enough to see the space between the two membranes) (1) • because the wavelength of electrons is short(er) (1)	ACCEPT electron microscope uses electrons not light	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(a)(iv)	• chloroplast / nucleus (1)	ACCEPT amyloplast	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(b)(i)	An explanation that makes reference to one of the following: • because one cell divides into two cells (1) **OR** • and therefore each new cell would, only have half the number of / not enough, mitochondria (1) plus • and therefore would not be able to, provide sufficient energy / produce enough ATP(1)	ACCEPT two (daughter) cells produced ACCEPT mitochondria shared between the two cells ACCEPT ORA	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	A description that makes reference to three of the following: • DNA replication takes place (1) • the inner membrane extends through the matrix (1) • a second membrane would form around each half of the mitochondria (1) • synthesis of any other named component that would be found in mitochondria (1)	ACCEPT (inner) membrane pinches together in the middle (of mitochondria) ACCEPT outer membrane forms /encloses each half e.g. matrix, ribosomes	**(3)**

Question Number	Answer	Mark
8(a)	**8(a). The only correct answer is D** ***A*** *is not correct because there is no cytoplasm inside the chloroplast* ***B*** *is not correct because the matrix is found inside mitochondria* ***C*** *is not correct because nucleoplasm is found inside the nucleus*	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	• maximum width × magnification **(1)** • correct gap width with appropriate units **(1)**	$20 \times 10^{-3} \times 12\,000 = 240$ = 0.24 mm / 240 µm / 240 000 nm / 24 × 10^4 nm **Accept** correct minimum gap width with appropriate units for 1 mark	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	An explanation that makes reference to the following: • because the resolution of the microscope is {not high enough / is too low} **(1)** • as the membranes are too close together to be distinguished as separate structures **(1)**	**Do not accept** magnification **Accept** as separate lines **Do not accept** magnification	**(2)**

Question Number	Indicative content
*8(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Descriptions of graph or diagram:** • as the leaf size increases so does the number of chloroplasts per cell • as the leaf size increases cpDNA per chloroplast increases then decreases • as the leaf continues to grow the number of chloroplasts per cell continues to increase but the number of cpDNA per cell drops **Explanations of graph or diagram:** • as the leaf increases in size more chloroplasts needed for photosynthesis • cpDNA replicates to provide the cpDNA for newly made chloroplasts • this ensures that the new chloroplasts have identical genetic information • the cpDNA per chloroplast begins to drop as the leaf cells get older, since there are more chloroplasts per cell **Interpretation of the genes found in the cpDNA :** • cpDNA codes for RNAs and ribosomal proteins that will be needed for transcription and translation of proteins needed in the new chloroplasts • cpDNA codes for proteins needed in photosynthesis e.g.RUBISCO

Level 0	Marks	No awardable content
Level 1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. **Description given of the changes shown in the graph in the number of chloroplasts, cpDNA and increase in leaf size**
Level 2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure. **An explanation given for these changes**
Level 3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. **Links made between the genes in the cpDNA and the processes of photosynthesis and protein synthesis**

Total for Question 8 = 11 MARKS

Additional Guidance	Mark
converse	(4)

Additional Guidance	Mark
e named organelle e.g lope / mitochondria / Golgi aller ribosomes / cell wall /	(1)

Additional Guidance	Mark
	(2)

Additional Guidance	Mark
ACCEPT prevents enzymes going to the small intestine ACCEPT more {undigested food / protein / starch / polysaccharides} ACCEPT lower concentration of { amino acids / sugars / glucose }	EXP

Additional Guidance	Mark
ACCEPT pancreatic duct damaged ACCEPT digests insulin (in the pancreas)	(2)

Number	Answer	Additional Guidance	Mark
3(a)	9 / 90		(1)

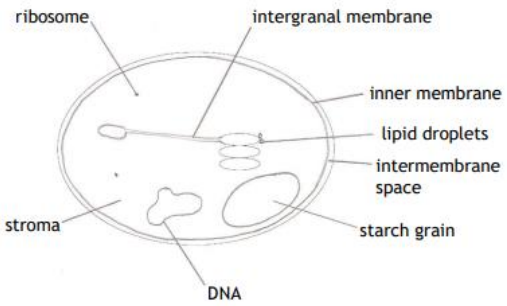
Question Number	Answer	Additional Guidance	Mark
3(b)(i)	• calculation of volume (1) • calculation of cardiac output (1) • conversion to $dm^3\ min^{-1}$ (1) OR • change units for radius (1) • calculation of volume (1) • calculation of cardiac output (1)	= $\frac{4}{3}$ x 3.142 x 0.001 = 0.004189 x 200 = 0.0000008379 ($dm^3\ min^{-1}$) **Accept** 8 x 10^{-7} / 8.4 x 10^{-7} / 8.38 x 10^{-7} / 8.379 x 10^{-7} / 0.0000008 / 0.00000084 / 0.000000838 Correct answer gains full marks, with no working shown. 8 / 8.4 / 8.38 / 8.379 to wrong power of 10 gets 2 marks Ecf if diameter used instead of radius 0.1mm = 0.001 dm = $\frac{4}{3}$ x 3.142 x 0.001 = 4.189 x 10^{-9} x 200 ($dm^3\ min^{-1}$) = 8.38 x 10^{-7} **Accept** 8 x 10^{-7} / 8.4 x 10^{-7} / 8.379 x 10^{-7} / 0.0000008 / 0.00000084 / 0.000000838 / 0.0000008379	(3)

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	more cells that need supply of {glucose / oxygen} (1)		(1)

Question Number	Answer	Additional Guidance	Mark
3(c)(i)	• calculate sum of d^2 and divide (1) • calculate square root (1)	50 ÷ 2 = 25 5.0 Correct answer gains full marks, with no working shown.	(2)

Question Number	Answer	Additional Guidance	Mark
3(c)(ii)	An answer that makes reference to the following: • one axis labelled mean heart rate with units, linear scale starting at 0 (not broken scale), bars labelled and covers at least half the grid (1) • accurate plot and standard deviations (1)		(2)

Question Number	Answer	Additional Guidance	Mark
3(c)(iii)	An answer that makes reference to two of the following: • for valid comparison / to get a valid result (1) **and any one from the following**: • temperature because {water fleas are ectotherms / affects heart rate} (1) • {carbon dioxide / pH} affects heart rate (1) • time of measuring because water fleas may fatigue (1) • acclimatisation to allow equal time for substances to take effect (1)	Accept to ensure the treatment is the only factor affecting heartrate	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(a)(i)	A drawing that labels three of the following: • DNA (loop) (1) • stroma (1) • starch {grain / granule} (1) • inner membrane / envelope (1) • inter membrane space (1) • intergranal membrane / (stromal) lamellae / intergranal thylakoid (1) • (small / 70S) ribosome (1) • lipid droplets **IGNORE** thylakoid membrane / lumen of thylakoid / grana drawing quality, unless completely wrong e.g. strand of DNA	**DO NOT ACCEPT** if drawn as linear DNA **DO NOT ACCEPT** stoma  **NB** 1 correct + 1 or 2 wrong = 1 mark 1 correct + 3 wrong = 0 marks 2 correct + 1 wrong = 2 marks 2 correct + 2 or 3 wrong = 1 mark 3 correct + 1 wrong = 2 marks 3 correct + 2 wrong = 1 mark 3 correct + 3 wrong = 0 marks	(3)

Question Number	Answer	Additional Guidance	Mark
6(a)(ii)	• length measured and converted to μm / length measured and actual chloroplast length converted into same units (1) • (magnification given to 2 significant figures, with no units) 27 000 (1)	80 000 / 81 000 / 82 000 + 3 80 / 81 / 82 + 0.003 8.0 / 8.1 / 8.2 + 0.0003 80 000 ÷ 3 = 26,666.66 81 000 ÷ 3 = 27,000 82 000 ÷ 3 = 27,333.3333 ECF figures of 27 given but wrong order of magnitude **NB** Correct answer with no working = 2 marks Correct answer with too many sig figs = 1 mark Figures of 27 given but wrong order of magnitude = 1 mark	(2)

Question Number	Answer	Additional Guidance	Mark
6(b)	An explanation that makes reference to four of the following: • (contain) {photosystems / PSI / PSII / chlorophyll / named pigment} so that {light / photons} can be <u>absorbed</u> (1) • (contain) electron {carrier proteins / carriers / transport chain} so that {reduced NADPH is formed / hydrogen is pumped into thylakoid (space) / so that a series of redox reactions can take place} (1) • (contain) ATP synthase so that hydrogen ions can pass through (1) • membranes {enclose a space / form a barrier} so that hydrogen ions can accumulate (1) • membranes are the site of {photolysis / chemiosmosis / photophosphorylation} (1)	**ACCEPT** ETC **ACCEPT** ATPase **ACCEPT** membranes trap hydrogen ions protons **ACCEPT** compartmentalisation / description of	(4)

Question Number	Answer	Additional Guidance	Mark
6(c)(i)	• RUBISCO / ribulose bisphosphate carboxylase / ribulose bisphosphate oxygenase	**ACCEPT** ribulose biphosphate carboxylase / ribulose biphosphate oxygenase RUBISCO in capitals / lowercase / mixture	(1)

Question Number	Answer	Additional Guidance	Mark
6(c)(ii)	An explanation that makes reference to two of the following: • keep the thylakoids and enzymes <u>close</u> together (1) • so that products of the light-dependent stage {are not lost / can collide with enzymes more frequently} (1) • because enzymes need to be in solution to function (1)	**ACCEPT** other terms meaning close e.g. nearby, constant contact, touching, small distance {products / named products} of light-dependent stage needed in {light-independent stage / Calvin cycle / carbon fixation / by enzymes} **ACCEPT** easier for collisions to occur	(2)

Number	Answer	Additional Guidance	Mark
5(a)(i)	A description that includes two of the following: • prokaryotes have a loop of DNA but eukaryotes have linear chromosomes (1)	Accept prokaryotes have one {piece of DNA / chromosome}, but eukaryotes have several chromosomes Accept in eukaryotes DNA is associated with histone proteins but not in prokaryotes Ignore references to plasmids	**(2)**
	• prokaryote cell wall contains {peptidoglycan / teichoic acid / murein}, but eukaryote cell wall does not (1)	Accept eukaryote cell wall (if present) contains {cellulose / chitin}, but prokaryote cell wall does not Accept all prokaryotic cells have a cell wall but some eukaryotic cells do not have a cell wall	
	• prokaryotes do not have a nucleus but eukaryotes do (1)	Accept eukaryotes have a nucleus but prokaryotes have {a nucleoid / DNA in cytoplasm}	
	• prokaryotes do not contain membrane-bound organelles, but eukaryotes do (1)	Accept named organelle eg mitochondria / chloroplasts / Golgi body	
	• prokaryotic cells (only) have 70S ribosomes, but eukaryotic cells have {80S ribosomes / have both 70S and 80S} (1)	Accept prokaryotic ribosomes are smaller than those in eukaryotic cells / prokaryotic ribosomes have subunits 30S and 50S, but eukaryotic ribosomes have subunits 40S and 60S	

Question Number	Answer	Additional Guidance	Mark
5(a)(ii)	An explanation including **two** of the following • bacteria are Gram negative	Accept - ve	**(3)**
	• (the cell wall has) {a thin peptidoglycan layer / an outer membrane / lipopolysaccharide layer} (1)	Accept {less / little} peptidoglycan	
	• so it does not retain violet / blue stain (but picks up red stain) (1)	Accept {primary stain / crystal violet} for blue stain	
	and • so helps to determine which **antibiotics** {are used / will be most effective} (to treat infection (1)	Accept {outer membrane / lipopolysaccharide} is a barrier to some antibiotics Ignore ref to {bactericidal / bacteriostatic / exotoxins / endotoxins} and focus on choosing antibiotic Ignore determining dose of antibiotics	

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	A description including four of the following • use of inoculating loop to transfer bacteria (to nutrient agar) (1) • {description / diagram} of streak plating (1) • incubation for suitable period (1) • incubation at suitable temperature (1) • identification of {bacteria / colonies} by {colour / shape} (1) • transfer to separate agar plates (1)	Accept description of loop eg wire Accept use of loop to transfer from {culture / broth} Accept {24-48 hours / stated time in range} Accept {20-37 °C / stated temperature in range / below 37°C / below 30°C / stated temperature below this value} Accept identification of {colonies / bacteria} by microscopy Accept use of selective media to identify {colonies / bacteria} Accept description of transfer	**(4)**

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	An explanation including three of the following • use of **aseptic technique** to prevent {contamination / growth of pathogens} (1) • **example of** aseptic technique with appropriate explanation (1) • incubation below 30 °C, as {this is below optimum for pathogens / pathogens are more likely to grow at 37 °C} (1) • use of cross tape between lid and base, to {allow air to enter / prevent growth of anaerobes} (1)	Accept example of aseptic technique eg • autoclaving {to kill bacteria / so no pathogens present} • use of sterile equipment to prevent contamination • flaming {inoculation loops / neck of bottle} to kill bacteria • working near lit Bunsen to {create an updraft / carry bacteria away from plate} • partially opening lids of plates to prevent entry of bacteria • disinfection of surfaces to {kill / remove} bacteria Accept stated temperature below 30 °C Accept not sealing lid to base of plate to {allow air to enter / prevent growth of anaerobes}	**(3)**

(Total for Question 5 = 12 marks)

Number	Answer	Additional Guidance	Mark
5(a)	An answer that makes reference to the following: **Similarities** • cytoplasm **(1)** • cell membrane **(1)** • ribosomes **(1)** **Differences** • eukaryotic cells contain {Membrane-bound organelles / named example e.g. mitochondria }, prokaryotic cells do not **(1)** • eukaryotic cells have 80S ribosomes, prokaryotic cells have 70S ribosomes **(1)** • eukaryotic cells have {a nucleus / nuclear envelope }, prokaryotic cells {have a nucleoid / do not have a nucleus} **(1)** • some eukaryotic cells have a cellulose cell wall and prokaryotic cells have a {murein / peptidoglycan} cell wall **(1)**	Max of 3 marks if only differences given **ACCEPT** eukaryotic cells have larger ribosomes **ACCEPT** as comparison: prokaryotes have free-floating genetic material (in the cytoplasm)	**(4)**

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	A description that makes reference to three of the following: • composed of nucleotides / nucleotides described **(1)** • nucleotides held together by phosphodiester bonds **(1)** • complementary base pairs held together by hydrogen bonds **(1)** • two {sugar phosphate backbones / polynucleotide chains / DNA strands} that form a double helix **(1)**	**ACCEPT** description e.g. between named base pairs	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	An explanation that makes reference to the following: • the DNA strands will not be able to separate / no template strand will be available **(1)** • leading to inhibition of {transcription / mRNA synthesis / RNA polymerase binding to DNA} **(1)** • DNA of both cell types are the same (structure) so both cell types affected **(1)**	**ACCEPT** DNA can't be unzipped	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(b)(iii)	An explanation that makes reference to the following: • will inhibit {transcription / mRNA synthesis} **(1)** • because the RNA polymerase {will be inhibited / will not be able to bind to the DNA} **(1)** • each antibiotic affects different cell types because the (structure of) RNA polymerases are different **(1)**	**ACCEPT** cannot catalyse the reaction, prevent enzyme-substrate complex formation	**(3)**

Total for Question 5 = 13 MARKS

Question Number	Answer	Additional Guidance	Mark
6(a)(i)	An explanation that makes reference to the following: • because different types of lipid are found in the mitochondria and chloroplasts **(1)** • because mitochondria are associated with { respiration / oxidative phosphorylation} whereas chloroplasts are associated with {photosynthesis / light-dependent reactions / photophosphorylation} **(1)** • because mitochondria contain {electron transport proteins / cytochromes / cristae / stalked particles} whereas chloroplasts contain {grana / chlorophyll / photosystems / carotenoids} **(1)**	**Accept** a description of the differences e.g. a lipid high in mitochondria is low in chloroplast, only two of the lipids are found in both organelles **Do not accept** a list of values from the table without some sort of comparison **Accept** any other membrane difference	**(3)**

Question Number	Answer	Additional Guidance	Mark
6(a)(ii)	A diagram that shows the following: • a glycosidic bond between C 1 on galactose and C 6 on MGDG **(1)** • rest of molecules complete **(1)** • water molecule **(1)**	ecf if glycosidic bond drawn between C1 and C 4 **Accept** H_20 / water	**(3)**

Question Number	Answer	Mark
6(a)(iii)	**6(a)(iii). The only correct answer is B** ***A*** *is not correct because DGDG is larger than MGDG so will not travel as far and sulfolipid is the smallest quantity so will be the smallest spot* ***C*** *is not correct because DGDG is larger than MGDG so will not travel as far and sulfolipid is the smallest quantity so will be the smallest spot* ***D*** *is not correct because sulfolipid is the smallest quantity so will be the smallest spot*	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	1×10^{11}	**Accept** 10^{11} / 100 000 000 000 / 10×10^{10} / any other equivalent ways of expressing this answer	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	An explanation that makes reference to two of the following: • because the number of carbon (atoms) in the cell has been under-estimated (1) • because not all the ATP is used in (light-dependent reaction / Calvin cycle / carbon fixation} (1) • because {photons differ in energy / not all wavelengths of light are absorbed by the plant} **(1)**	**Accept** there are more carbons in the cell **Accept** cyclic photophosphorylation is happening **Accept** process is not 100% efficient / some light is reflected / not all photons of light are absorbed	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(b)(iii)	A description that makes reference to three of the following: • carbon dioxide diffuses into stroma **(1)** • carbon dioxide binds to {ribulose bisphosphate / RuBP} **(1)** • using {ribulose bisphosphate carboxylase / RUBISCO} **(1)** • resulting in the formation of {(intermediate) 6C compound / GP} **(1)**	**Accept** attaches / joins / reacts / added to **Accept** rubisco	**(3)**

Total for Question 6 = 13 MARKS

Number	Answer	Additional Guidance	Mark
9(a)(i)	A drawing that includes the following: • only cell K drawn **(1)** • the shape of the cell and its nuclei are representative of those in the photograph **(1)** • there is no sketching or other structures shown **(1)** • drawn cell is twice the size of cell in the photograph **(1)**		**(4)**

Question Number	Answer	Additional Guidance	Mark
9(a)(ii)	A description that makes reference to the following: • measure the length of the blood cells using an {eye piece / stage } micrometer **(1)** • divide the length by the magnification of the objective / calibrate the graticule using a stage micrometer **(1)** • more than one measurement taken **(1)** • divide this value into the length of the blood cells in the drawing **(1)**	**ACCEPT** use an eyepiece graticule E.g. repeats, length and breadth	**(4)**

Question Number	Answer
9*(b)	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • data used to support trends e.g. figures quoted / calculation done • table 1 shows that resolution increases with an increase in numerical aperture • table 2 shows an increase in wavelength decreases the resolution • table 1 suggests an increase in magnification increases the resolution • comparison of objectives with the same magnification shows that increase in numerical aperture increases resolution • at higher magnifications shorter wavelengths of light would need to be used to achieve maximum resolution

Level	Marks	
0	0	No awardable content
1	1-2	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. **Attempts to comment on each of the factors but fails to understand that a small value represents better resolution**
2	3-4	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. **Understands that a small value means better resolution and correct comments made about two variables using quoted data.**
3	5-6	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. **Correct comments made about the interaction of the three variables on resolution.**

Total for Question 9 = 14 MARKS

TOTAL FOR PAPER = 80 MARKS

Number	Answer	Additional Guidance	Mark
6(a)	A description that makes reference to three of the following: • locate specimen by using {low power / medium power} objective lens (1) • (focus) using {low power / medium power} objective lens before the high power objective lens (1) • only use fine focus with high power lens (1)		(3)

Question Number	Answer	Additional Guidance	Mark
6(b)	• multiplication (1) • division (1)	3.142 x 0.2^2 / 3.142 x 0.04 = 0.126 / 0.1257 / 0.12568 18 ÷ 0.126 = 143 Allow one mark if answer is 142.857 / 143.198 / 143.220 Correct answer gains full marks, with no working shown	(2)

Question Number	Answer	Additional Guidance	Mark
6(c)	conversion of mm into µm conversion of µm into mm conversion of µm into cm (1) divide image size by actual size (1)	Correct answer gains full marks, with no working shown 27 mm = 27 000 µm / 20 ÷ 1000 = 0.02 mm / 20 ÷ 10 000 = 0.002 cm 27 000 ÷ 20 = (×) 1350 / 13.5 x 10^2 / 1.35 x 10^3	(2)

Question Number	Answer	Additional Guidance	Mark
6(d)(i)	• calculate sum of d^2 and divide (1) • calculate square root (1)	Correct answer gains full marks, with no working shown 68.8 ÷ 4 = 17.2 square root of 17.2 = 4.1 / 4.147 / 4.15 One mark for 17.2 / 68.8	(2)

Question Number	Answer	Additional Guidance	Mark
6(d)(ii)	A description that makes reference to two of the following: • leaves at {same height / same age} on stem (1) • sample at same stated position of leaf (1) • same surface of leaf (1)	**DO NOT ACCEPT** same location / same part / same place **DO NOT ACCEPT** same area / same part / same place	(2)

Question Number	Answer	Additional Guidance	Mark
6(d)(iii)	An answer that makes reference to three of the following: • (reduced growth) because less carbon dioxide absorbed (1) • therefore less {GP / GALP / glucose / sucrose} (1) • less transpiration so less mineral ions (1) • therefore less named product (1)	**ACCEPT** converse **ACCEPT** cellulose / amino acids / protein / chlorophyll / DNA **DO NOT ACCEPT** starch	(3)

Question Number			
6(a)(i)	• 1000 / 1 x 10^3 (1)	**DO NOT ACCEPT** if units given	(1)

Question Number	Answer	Additional Guidance	Mark
6(a)(ii)	An explanation that makes reference to two of the following: • to keep the enzymes and their substrates close together (1) • so that the (enzyme) reactions are faster (1)	**ACCEPT** converse throughout **ACCEPT** compartmentalisation **ACCEPT** respiration reaction is faster	

	• because bacteria {have mesosomes / can use their cell membranes} (1)		(2)

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	• volumes of sucrose solution and water calculated (1) • 0.3 : 1 / 0.33 : 1 (1)	e.g. 1.25 cm^3 sucrose and 3.75 cm^3 water **ACCEPT** 1 : 3 **DO NOT ACCEPT** 0.3 recurring **ACCEPT** CE for incorrect volumes Correct answer = 2 marks	(2)

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	An explanation that makes reference to two of the following: • because the pipette needs to be held {vertically /at eye level / kept steady} (1) • so that the (bottom of the) meniscus (of the suspension) is sitting on the line (of the pipette) (1) • (slightly) squeezing it will lose liquid (1) • pipette too large for this volume to be measured (1)	**ACCEPT** to avoid a parallax measurement	(2)

Question Number	Answer	Additional Guidance	Mark
6(b)(iii)	• 0.5 / ½ (%) (1)		(1)

Question Number	Answer	Additional Guidance	Mark
6(b)(iv)	**The only correct answer is D** *A is incorrect because the mitochondria are bigger than ribosomes* **B** *is incorrect because nuclei are the largest so will be at the bottom* **C** *is incorrect because nuclei are the largest so will be at the bottom*		(1)

Question Number	Indicative content	
*6(c)	**Indicative content:** **Lumen of smooth endoplasmic reticulum** • no radioactivity as the SER is not involved in protein synthesis • as it transports lipids **Ribosomes** • level of radioactivity high in first 10 minutes as the amino acids are incorporated into the polypeptide chain • during translation • level then falls as polypeptide chain leaves the ribosomes • and protein synthesis ends **Lumen of rough endoplasmic reticulum** • level rises as RER is also site of protein synthesis • the polypeptide chains are transported through the cell • level falls to zero once all polypeptide chains have left the RER **Golgi apparatus** • level of radioactivity rises as the proteins are transferred into the Golgi • by vesicles from the RER • level of radioactivity drops once the proteins have been modified • and packaged into vesicles / lysosomes **Vesicles** • level rises as the vesicles are formed from the Golgi that contains radioactive proteins • level falls as proteins are released from the cell • by exocytosis **Unaccounted for radioactivity** • some radioactive amino acids were present in the cytoplasm as not all the radioactivity is in the organelles	**Level 1** 1 mark : description of changes in levels of radioactivity in two organelles 2 marks : description of changes in levels of radioactivity in four organelles **OR** explanation for one organelle **Level 2 :** 3 marks : explanation for two organelles 4 marks : explanation for three organelles **Level 3 :** 5 marks : explanation for four organelles, which includes at least one increase and one decrease explained for one of the organelles 6 marks : explanation for four organelles + an explanation for the unaccounted radioactivity
	• these amino acids were not used in protein synthesis • not all the proteins were packaged into vesicles • because the proteins were going to be used by the cell itself	

Question Number	Answer	Additional Guidance	Mark
3(a)	• viruses can only {attach to/bind /infect} specific (host) cells / viruses are not living so can only replicate inside cells (1)	Do NOT accept viruses reproduce	(1)

Question Number	Answer	Additional Guidance	Mark
3(b)	An explanation that makes reference to the following: • because the temperature has to be suitable for the enzymes of the cells to function (1) • because enough time has to be allowed for {viral replication / lytic cycle/lysis} (1)	So that the enzymes in the cell do not denature Ignore reproduce	(2)

Question Number	Answer	Additional Guidance	Mark
3(c)	An explanation that makes reference to the following: • because viruses burst out of their (host) cells into the culture fluid (1) • a filter will be selected that allows the viruses through and not the cells (1) • most of the host cells will be attached to the culture flask (1)	Accept the cells have been lysed/fragmented Accept cells are too big (to pass through the filter/filtration unit)	(3)

Question Number	Answer	Additional Guidance	Mark
3(a)	An explanation that makes reference to two of the following: • because viruses can only bind to {one type / limited number of types} of cell (1) • due to receptors on {their capsid / the surface of the cells} (1) • because they cannot replicate without host cell	**ACCEPT** specific cells bind	(2)

Question Number	Answer	Additional Guidance	Mark
3(b)(i)	An explanation that makes reference to three of the following: • because time was needed for the {(viral) DNA / (viral) RNA} to enter the cell (1) • because time needed for {nucleic acid / protein} synthesis (1) • because time needed for assembly of viruses (1) • numbers only increase once (host) cells have been lysed (1)	**ACCEPT** genetic material **ACCEPT** time for transcription or translation	(3)

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	• correct values read from the graph (1) • correct answer given to 3 sig figs (1)	70 : $\log_{10}$ 7 50 : $\log_{10}$ 5.7 10 000 000 – 501 187 = 9 498 813 = 9 500 000 more particles /or 10 000 000 ÷ 501 187 = 19.95 = 20.0 x 7 – 5.7 = 1.3 = 20.0 x 9500000 = 2 marks 9498813 = 1 mark	(2)

Number	Answer	Mark
6(a)(i)	**6(a)(i). The only correct answer is B** ***A*** *is not correct because lambda phage does not have an envelope* ***C*** *is not correct because both lambda phage and tobacco mosaic virus do not have envelopes* ***D*** *is not correct because tobacco mosaic virus does not have an envelope*	**(1)**

Question Number	Answer	Mark
6(a)(ii)	**6(a)(ii). The only correct answer is A** ***B*** *is not correct because lambda phage does not have a helical capsid* ***C*** *is not correct because neither HIV or lambda phage have a helical capsid* ***D*** *is not correct because HIV does not have a helical capsid*	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	A description that makes reference to the following: • virus {attaches to / penetrates} host cell **(1)** • assembly of virus particles from synthesised {DNA / RNA} and proteins **(1)** • (immediate) lysis of the host cell **(1)**	**ACCEPT** virus genetic material goes into the cell **ACCEPT** virus replicates **DO NOT ACCEPT** exocytosis	**(3)**

Question Number	Answer	Additional Guidance	Mark
6(b) (ii)	• number of bacteria in 0.25 cm^3 **(1)** • number of phage needed to give MOI of 0.5 **(1)** • answer = volume of phage needed **(1)**	<u>Example of calculation</u> $8 \times 10^8 \div 4 = 2 \times 10^8$ $0.5 \times 2 \times 10^8 = 1 \times 10^8$ $1 \times 10^8 \div 2 \times 10^9 = 0.05\,cm^3$ **ACCEPT** 1 mark for calculation of MOI as 2.5 for using equal volumes of the concentrations given Correct answer with no working gains full marks	**(3)**

Total for Question 6 = 8 MARKS

Question Number	Answer	Additional Guidance	Mark
4(a)	**The only correct answer is A** ***B*** *is incorrect because human immunodeficiency virus is polyhedral* **C** *is incorrect because λ (lambda) phage is non-enveloped, complex in structure and has DNA* **D** *is incorrect because tobacco mosaic virus does not have an envelope*		(1)

Question Number	Answer	Additional Guidance	Mark
4(b)	**The only correct answer is A** ***B*** *is incorrect because hydrolysis uses water not produces it* **C** *is incorrect because hydrolysis splits bonds not forms them* **D** *is incorrect because hydrolysis splits bonds not forms them*		(1)

Question Number	Answer	Additional Guidance	Mark
4(c)(i)	An answer that makes reference to three of the following, that includes the similarity: **Similarities** • both contain carbon, hydrogen and oxygen (1) **Differences** • polysaccharides are made up of monosaccharides but the primary structures of proteins are made up of amino acids (1) • polysaccharides contain glycosidic bonds but the primary structures of proteins contain peptide bonds (1) • polysaccharides do not contain {nitrogen / sulfur} but primary structures of proteins do contain {nitrogen / sulfur} (1) • polysaccharides may be branched but primary structures of proteins are linear (1)	**DO NOT PIECE TOGETHER** **ACCEPT** glucoses	(3)

Question Number	Answer	Additional Guidance	Mark
4(c)(ii)	An explanation that makes reference to the following: • because (if lectins bind to the {spike / polysaccharide) then the virus will not be able to attach to the {ACE 2 / enzyme / (host) cell} (1) • and therefore will not be able to {infect / enter} the cell (1) • new virus particles will not be made (1)	**ACCEPT** {genetic material / RNA} cannot enter cell **ACCEPT** virus cannot replicate lytic cycle will be prevented **DO NOT ACCEPT** latency / lysogenic cycle	(3)

	Additional Guidance	Mark
	ACCEPT deaths with Zmapp level off at 28 **ACCEPT** no more deaths after 3 doses **ACCEPT** converse	**4**

Additional Guidance	Mark
us is not virulent al RNA is not translated al DNA is replicated when host replicated	**2**

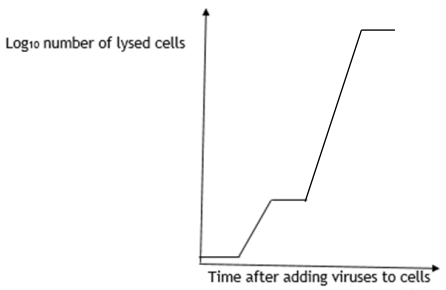
wer	Additional Guidance
ency virus (HIV) *nscriptase* *in reverse transcriptase*	
eplicate} n cell} (1)	**ACCEPT** viral RNA is translated

Question Number	Answer	Additional Guidance	Mark
4(a)	**The only correct answer is A** **B** is incorrect because the capsid is complex not helical **C** is incorrect because DNA is the genetic material not RNA **D** is incorrect because DNA is the genetic material not RNA		(1)

Question Number	Answer	Additional Guidance	Mark
4(b)	• drawing length of bacteria given in μm or nm / drawing length of virus given in μm or nm **OR** • ratio of drawing length (1) • actual length of virus given in nm, to the nearest whole number, value between 103 and 143 (1)	**ACCEPT** between 95 000 μm / 95 000 000 nm and 115 000 μm / 115 000 000 nm for bacteria between 7 000 μm / 7 000 000 nm and 8 000 μm / 8 000 000 nm for virus **ACCEPT** between 95 mm and 115 mm for bacteria and between 7 mm and 8 mm for virus ecf if numerals correct but order of magnitude wrong	(2)

Question Number	Answer	Additional Guidance	Mark
4(c)(i)	An explanation that makes reference to three of the following: • virus to attach to host cells / {genetic material / DNA} to enter host cells (1) • synthesis of DNA (1) • {protein synthesis / transcription and translation} (1) • assembly of new viruses (1)	**ACCEPT** virus {enters / infects} **DO NOT ACCEPT** RNA **DO NOT ACCEPT** RNA unless already penalised in mp 1 / in the context of {proviruses / latency} **ACCEPT** capsid / capsomeres / tail / base plate / tail (fibres) / collar / J protein / enzymes / protease / permease / other named proteins will need to be checked **DO NOT ACCEPT** reverse transcriptase / integrase **NB ACCEPT** (time for) {replication / multiplication} of the virus in correct context if no other marks awarded.	(3)

Question Number	Answer	Additional Guidance	Mark
4(c)(ii)	• correct values read from graph and divided by the time (1) • mean rate calculated (1)	3.8 and 1.7 and a division by 40 156 ecf wrong time value but correct answer to whole number e.g.(30 mins) 209 Correct answer only = 2 marks	(2)

Question Number	Answer	Additional Guidance	Mark
4(c)(iii)	• line going up and (generally) levelling off (1) • increase greater than the first increase (1)		(2)

Question Number	Answer	Additional Guidance	Mark
6(a)	**The only correct answer is A** **B** is incorrect because Ebola has a helical capsid and an envelope whereas HIV has a polyhedral capsid **C** is incorrect because Ebola has a helical capsid and an envelope whereas λ (lambda) phage does not have an envelope and has a complex capsid **D** is incorrect because Ebola has a helical capsid and an envelope whereas TMV does not have an envelope		(1)

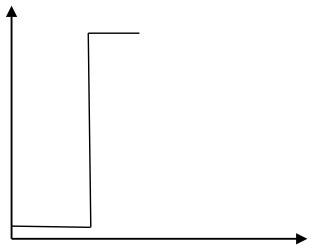
Question Number	Answer	Additional Guidance	Mark
6(b)	A description that makes reference to two of the following: • globular / 3D / tertiary protein (1) • held together by {hydrogen bonds / disulfide bridges / ionic bonds/hydrophobic (interactions)} (1) • between R groups (1) • has an active site (1)	**Accept** hydrophobic R groups on inside /hydrophilic R groups on outside = mp 2 & 3	(3) EXP

Question Number	Indicative content	
***6(c)**	Indicative content: Lytic Cycle **(L)** • virus attaches/binds to (host) cells • (viral) genetic material / provirus, inserted (into host cell) • viral proteins/capsid made • **genetic material /(viral) RNA**, replicates • new viral particles assembled • cell ruptures/viral particles, released Haemagglutinin **(H)** • binds to sialic acid groups on the {glycoproteins / cell membrane / host cell / mucus} • so that it can infect host cell • needed by new virus particles to attach to more (host) cells Neuraminidase **(N)** • needed to separate virus particles from the {(non-host) cells / membrane} that they attach to • breaks down mucus • cleave the haemagglutinin from the sialic acid group on cell • needed to separate the new virus particles from each other • needed to separate the new virus particles from the host cell membrane (that they have budded out of) • needed to release the new virus particles from mucus • so that they are free to attach to new host cells • so that the infection is spread	**Level 1:** 1 mark = 1 point from L, H or N 2 marks = 2 points from L, H or N **Level 2 :** 3 marks = 3 points from at least two of L, H or N 4 marks = 4 points from at least two of L, H or N **Level 3 :** 5 marks = 5 points from L, H and N 6 marks = 6 points from L, H and N

5(a)(i)	B		**(1)** **comp**

Question Number	Answer	Additional Guidance	Mark
5(a)(ii)	• (protein) capsid / protein coat		**(1)** **GRAD**

Question Number	Answer	Additional Guidance	Mark
5(a)(iii)	A description that makes reference to the following: • attach the virus to {receptors / attachment molecules} (1) • on the {epithelial cells / B lymphocytes} (1)		**(2)** **EXP**

Question Number	Answer	Additional Guidance	Mark
5(b)	An answer that makes reference to the following: • the delay before number of viruses increase (1) • the one step growth curve (1)	**ACCEPT** steep line / ignore steep downward line after peak due to cell bursting 	**(2)** **EXP**

Question Number	Answer	Additional Guidance	Mark
5(c)(i)	An answer that makes reference to the following: • number of boys calculated (1) • number of girls calculated and given as a whole number (1)	47 % of 103 = 48.41 (103 - 48.41 =) 55 Correct answer with no working gains both marks	**(2)** **EXP**

Question Number	Answer	Additional Guidance	Mark
5(c)(ii)	An answer that makes reference to the following: • as age increases the proportion of children with non-typical symptoms get lower / decreases (1) • credit calculation to illustrate this (1)	e.g. 50% in children aged 1 but 20% in children aged 15	**(2)** **EXP**

Question Number	Answer	Additional Guidance	Mark
5(c)(iii)	A description that makes reference to the following: • increase the sample size (1) • ensure there is data for all age groups (1) • investigate older teenagers (1)	e.g. studying other towns **ACCEPT** increase age range	**(3)** **EXP**

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following:		

6(a)

Virus	Classification of viruses			
	DNA enveloped	DNA non-enveloped	RNA enveloped	RNA non-enveloped
Ebola	☐	☐	X	☐
λ (lambda) phage	☐	X	☐	☐
Tobacco mosaic	☐	☐	☐	X

(3)

Question Number	Answer	Additional Guidance	Mark
6(b)	• number of patients with gastroenteritis caused by viruses (1) • pie chart used to estimate proportion of cases caused by noroviruses (1) • total number of gastroenteritis cases caused by noroviruses (1)	Example of calculation: 162 × 24.7 ÷ 100 = 40 (40.014) 60 - 70 % 24, 25, 26, 27, 28 people Correct answer with no working gains full marks	(3)

Question Number	Answer	Additional Guidance	Mark
6(c)	A description that makes reference to the following: • (viral) RNA made (1) • (viral) {capsid / protein} made (1) • assembly of viruses (1)	**ACCEPT** new virus particles made	(3)

Question Number	Answer	Additional Guidance	Mark
6(d)(i)	An explanation that makes reference to three of the following: • because more viruses delivered (1) • because {lipid / sphere} can pass through cell membrane / no need to bind to (cell) receptors / can bind to any cell (1) • because {lipid / sphere} protects viruses from {enzymes / stomach acid / phagocytes / immune system} (1) • credit a link between one reason and the information given (1)	e.g. more cells infected so symptoms develop faster	(3)
		more cells infected so symptoms are worse virus particles not destroyed so more cells infected	

Question Number	Answer	Additional Guidance	Mark
6(d)(ii)	An explanation that makes reference to two of the following: • because the lipids could be {targetted / broken down} (1) • by an enzyme (that breaks down lipid) (1) • resulting in {fewer virus particles arriving at cells (in one go) / exposure to immune system} (1)	**ACCEPT** using a drug that can penetrate the lipid **ACCEPT** therefore destroying the viruses **ACCEPT** {fewer / no} viruses (arriving at the cells)	(2)

Answer	Additional Guidance	Mark
es reference to the following: / have no metabolism / hesis organelles / lack a cell wall / (1) ecause they inhibit replication (1)		**(2)**

Answer	Additional Guidance	Mark
es reference to four of the at fluoresce (1) itoes are / contain the gene} (1) resce / GM mosquitoes} to interbreed erations (1) e for fluorescence are selected to of GM mosquitoes (1)	**Do not accept** eggs	**(4)**

Answer	Additional Guidance	Mark
ference to the following: 14 and 2015 (1) crease calculated (1)	Example of calculation: 150 and 1240 to 1245 1240 – 150 = 1090 (1090 ÷ 150) ×100 = 727 1245 – 150 = 1095 (1095 ÷ 150) ×100 = 730 **Accept** range 727 to 730 Correct answer with no working gains full marks	**(2)**

Answer	Additional Guidance	Mark
es reference to two of the th Zika) being bitten (1) g uninfected people / nosquitoes} (1) her diseases (1)		(2)

Answer	Additional Guidance	Mark
		(1)

Answer	Additional Guidance	Mark
reference to the following: make (viral) protein (1) d (1)		(2)

Mark
(4)

Answer	Additional Guidance	Mark
es reference to the following: g} of peptide bonds (1)		(2)

Mark
(4)

Question Number	Answer	Additional Guidance	Mark
8(a)	An answer that makes reference to the following: **Similarities** • both contain DNA (1) **Differences** • HPV is surrounded by {protein / capsid} and chlamydia by {a cell wall / peptidoglycan} (1) • HPV is hollow and chlamydia has {cell membrane / cytoplasm / ribosomes / glycogen granules / lipid droplets / plasmids} (1)	**ACCEPT** DNA strands in HPV **ACCEPT** chlamydia has {cell membrane / cytoplasm / ribosomes / glycogen granules / lipid droplets / plasmids} but HPV does not	(3)

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	An explanation that makes reference to the following: • vaccine contains the HPV antigens (1) • which stimulates the production of memory cells (1) • therefore (secondary) immune response destroys HPV before it causes cancer (1)	**ACCEPT** {attenuated / inactive / harmless / fragments of} {virus / pathogen **DO NOT ACCEPT** contains dead virus **ACCEPT** a description e.g. antibodies released faster so macrophages destroy HPV before it damages cells **DO NOT ACCEPT** antibodies destroy virus virus is killed	(3)

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	An explanation that makes reference to the following: • because the immune response is specific (1) • so on infection with Chlamydia there will not be memory cells present (specific to Chlamydia) (1) • and another (primary) immune response will need to be initiated (1) • therefore the Chlamydia will not be destroyed before it causes disease (1)	**ACCEPT** Chlamydia has different antigen to {HPV / the virus / the vaccine} **ACCEPT** no antibodies (against Chlamydia) present	(3)

Question Number	Indicative content	
***8(b)(iii)**	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content: Advantages of vaccinating girls and boys • protects students from becoming infected • virus less likely to get passed on • as there will be no virus to pass on during intercourse • because the virus will be destroyed before infections caused • the more girls vaccinated the fewer cases of cervical cancer and other conditions caused by HPV in girls • the more boys vaccinated the fewer cases of other conditions caused by HPV in boys because of {memory cells / active immunity} Advantages of vaccination in schools • more {boys / girls} likely to be vaccinated • because they are not reliant on a doctor's appointment being {made / available} • do not have to miss school for the appointment • seeing others being vaccinated might encourage others to get vaccinated • inoculating school children is likely to be before they become sexually active Points that can apply in either context (but only creditable once) • greater chance of developing herd immunity • therefore fewer infected people to pass virus onto uninfected people • help to protect those who cannot be infected	**Level 1** 1 mark = 1 comment 2 marks = 3 comments **Level 2 :** 3 marks = 4 comments 4 marks = 5 comments **Level 3** **NB** must include points on advantages of vaccinating boys **AND** vaccinating in school 5 marks = 5 comments 6 marks = 6 comments

Number	Answer	Additional Guidance	Mark
2(a)(i)	Calculation of number of dividing cells (1) Calculation of mitotic index (1)	8 8.2 / 8.16 (%) Correct answer with no working gains 2 marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	An explanation that includes the following • as distance (from root tip) increases, mitotic index decreases (1) • (because) cells {differentiate / become specialised / elongate} further from the root tip (1)	 Allow negative correlation between mitotic index and distance from root tip Accept converse Accept {meristem / stem cells} are close to tip	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(b)	An answer including two of the following: • use {strong / concentrated} acid to {break down middle lamella / break down pectins / separate layers of cells} (1) • heat to intensify effect of {acid / stain} (1) • press (on cover slip) to form a single layer of cells (1) • view at high power to see details (of chromosomes) (1)	 Accept use of standardised length of root tip to ensure you include just the dividing area Accept view at high power to see chromosomes (clearly)	**(2)**

Total for Question 2 = 6 marks

Number	Answer	Additional Guidance	
1(a)	An answer that includes the following • meristem (1)		**(1)**

Question Number	Answer	Additional Guidance	Mark
1(b)(i)	An answer that includes the following: • to {break down middle lamella / break down pectins / separate layers of cells} (1)	Accept calcium pectate separate cells	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(b)(ii)	An answer that includes the following: • to make the {chromosomes / DNA} visible (1)	Accept to dye / colour the chromosomes / DNA	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(b)(iii)	An answer that includes the following: • to form a single layer of cells (1)	Accept to separate layers of cells / form a thin layer of cells	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(c)	An answer that includes the following: • number of actively dividing cells counted (1) • mitotic index calculated to 1dp (1)	4 10.3 Correct answer with no working gains full marks	**(2)**

(Total for Question 1 = 6 marks)

Number	Answer	Mark
3 (a)	**3(a). The only correct answer is B** ***A*** *is not correct because chromatids are visible in metaphase* ***C*** *is not correct because the first two statements only occur in meiosis not mitosis* ***D*** *is not correct because the first two statements only occur in meiosis not mitosis*	**(1)**

Question Number	Answer	Additional Guidance	Mark
3 (b)(i)	An explanation that makes reference to the following: • a stain is needed to see chromosomes that would not be clearly visible **(1)** • because the stain must attach to {chromosomes / DNA / histone} **(1)**	**ACCEPT** can see chromatids, nucleus **ACCEPT** {take up / absorb} stain	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	A description that makes reference to four of the following: • use {5 mm / shorter} piece of root tip **(1)** • add acid and then stain separately **(1)** • heat the root tip in { acid / stain } **(1)** • tease the cells apart before staining **(1)** • intensify the stain by warming (after squashing) **(1)**	**ACCEPT** use more concentrated acid **ACCEPT** maceration	**(4)**

Total for Question 3 = 7 MARKS

Number	Answer	Additional Guidance	Mark
1ai	C 3, 2, 4, 1, 5		(1)

Question Number	Answer	Additional Guidance	Mark
1aii	P – nuclear envelope (1) Q– centromere (1)	accept nuclear membrane, nucleus membrane	(2)

Question Number	Answer	Additional Guidance	Mark
1b	A description that makes reference to four of the following: • ova { are larger cells / contain more food stores / contain more cytoplasm } (1) • spermatozoa contain an acrosome, ova do not (1) • spermatozoa has a {tail / flagellum / microtubules}, ova do not (1) • ova are surrounded by the {zona pellucida / other cells}, spermatozoa are not (1) • oogenesis produces polar bodies, spermatogenesis does not (1)	accept references to egg and sperm accept sperm are motile while ova are not accept each spermatid may produce a spermatozoa / the number of spermatozoa produced are much higher than the number of ova	(4)

Guidance	Mark
spindle fibres push rane contracts at	(3)

	Mark
ide chain rboxyl group at the de of an amino acid	(1)

	Mark
ɔ.u. s not increases	(1)

Additional Guidance	Mark
ACCEPT join Okazaki fragments / joins fragments produced from copying the lagging strand / needed for working in 3' to 5' direction ACCEPT between (mono) nucleotides	(3)

1(a)(i)	C *Turner's syndrome due to monosomy* *A is incorrect because there are not three copies of chromosome number 21* *B is incorrect because there are not three copies of chromosome number 21* *D is incorrect because Turner's syndrome is a monosomy*		**1**

Question Number	Answer	Additional Guidance	Mark
1 (a)(ii)	C non-disjunction *A because it is not a gene mutation* *B is incorrect because it is not a gene mutation* *D because there is a missing chromosome is incorrect*		**1**

Question Number	Answer	Additional Guidance	Mark
1 (b) (i)	A ☒ **A** anaphase | telophase | prophase | metaphase *B is incorrect because X is not prophase* *C is incorrect because W is not prophase* *D is incorrect because W is not telophase*		**1**

Question Number	Answer	Additional Guidance	Mark
1 (b) (ii)	An answer that makes reference to four of the following: • colchicine has no effect on the percentage of cells in interphase (1) • colchicine arrests cells at prophase (1) • colchicine inhibits spindle (formation) (1) • fewer cells reach {metaphase / anaphase / telophase} with colchicine / more cells reach {metaphase / anaphase / telophase} without colchicine / more cells at prophase with colchicine /fewer cells at all phases except prophase (1) • correct reference to overlapping of standard deviations (1)	**Accept** colchicine stops (many) cells at prophase / cells can only reach prophase with colchicine **Accept** converse **Accept** converse	**4**

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to four of the following:		

Number	Answer	Additional Guidance	Mark
2(a)(i)	B Female with Turner's syndrome *A is incorrect because the human has one X* *B is incorrect because the human is female* *C is incorrect because the human is female*		1

Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	A Non-disjunction producing a monosomy B is incorrect because it is a monosomy C is incorrect because it is due to non-disjunction C is incorrect because it is due to non-disjunction		1

Question Number	Answer	Additional Guidance	Mark
2 (b)(i)	B ovum and secondary oocyte A is incorrect because secondary oocyte is diploid C is incorrect because the secondary oocyte is diploid D is incorrect because the primary oocyte is diploid		1

Question Number	Answer	Additional Guidance	Mark
2(b)(ii)	*An explanation that makes reference to:* • crossing over (1) • which swaps {alleles / DNA / genes} between {homologous chromosomes} (1) • independent / random assortment (1) • because it is random movement of homologous chromosomes to poles (1)	**Allow** random movement of paternal and maternal chromosomes / random combinations of paternal and maternal chromosomes	4

Question Number	Answer	Additional Guidance	Mark
	A CH_3		

Number	Answer	Additional Guidance	Mark
4ai	mitosis	accept mitotic	(1)

Question Number	Answer	Additional Guidance	Mark
4aii	An answer that make reference to two of the following: • can produce large numbers of offspring (1) • can reproduce rapidly (1) • does not need another plant (1)		(2)

Question Number	Answer	Additional Guidance	Mark
4bi	B diploid and haploid		(1)

Question Number	Answer	Additional Guidance	Mark
4bii	C - R S		(1)

Question Number	Answer	Additional Guidance	Mark
4biii	An explanation that refers to three of the following: • source of genetic variation (1) • because it involves random {assortment / fertilisation / crossing over } (1) • because it enables contribution of {DNA / genes / alleles } from two individuals (1) • because it produces new combinations of alleles (1) • genetic variation allows organisms to adapt to environmental change (1)		(3)

Question	Answer	Additional Guidance	Mark

Number	Answer	Mark
6(a)(i)	**The only correct answer is C** ***A*** *is not correct because P is in prophase I and Q is in metaphase II* ***B*** *is not correct because P is in prophase I and Q is in metaphase II* ***D*** *is not correct because P is in prophase I and Q is in metaphase II*	**(1)**

Question Number	Answer	Mark
6(a)(ii)	**The only correct answer is B** ***A*** *is not correct because if non-disjunction occurred in meiosis I, it would generate one cell with four chromosomes (each composed of two chromatids) and one cell with two chromosomes (each composed of two chromatids). These cells would divide in meiosis II to generate two cells with four chromosomes and two cells with two chromosomes.* ***C*** *is not correct because if non-disjunction occurred in meiosis I, it would generate one cell with four chromosomes (each composed of two chromatids) and one cell with two chromosomes (each composed of two chromatids). These cells would divide in meiosis II to generate two cells with four chromosomes and two cells with two chromosomes.* ***D*** *is not correct because if non-disjunction occurred in meiosis I, it would generate one cell with four chromosomes (each composed of two chromatids) and one cell with two chromosomes (each composed of two chromatids). These cells would divide in meiosis II to generate two cells with four chromosomes and two cells with two chromosomes.*	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(b)	An answer that makes reference to the following: • number of pregnancies calculated (1) • number of babies calculated (1)	Correct answer gains full marks (500 000 ÷1000) x 14 = 7 000 (1.8 ÷ 100) x 7 000 = 126 or 14 x 500 = 7000 and then 7000 x 0.018 = 126	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(c)	An answer that makes reference to four of the following: • {screening / both techniques} are {more effective / produce more births} than control (1) • more embryos survive screening with polar body biopsy than PGD / polar body biopsy is less damaging than PGD (1) • PGD more effective (than polar body biopsy) / PGD produces more births (than polar body biopsy) (1) • (because) PGD produces 21% births compared to 18% with polar body (1) • PGD detects abnormalities in both paternal and maternal chromosomes / polar body biopsy only checks for maternal chromosome abnormalities (1)	**ACCEPT** converse **ACCEPT** converse **ACCEPT** converse **ACCEPT** 21.46 / 21.5 / 18.27 /18.3 **ACCEPT** 0.21 /0.215 / 0.18 / 0.183 / 0.1827 **DO NOT ACCEPT** just 21% alone **ACCEPT** ideas that polar body biopsy only screens for abnormalities from mother / PGD screens both parents	**(4)**

Question Number	Answer	Mark
3(a)(i)	The only correct answer is A (Prophase I of meiosis) *B is incorrect as the primary spermatocytes do not have prophase II stage* *C is incorrect as primary spermatocytes do not perform mitosis* *D is incorrect as primary spermatocytes do not perform mitosis*	**1**

Question Number	Answer	Additional guidance	Mark
3(a)(ii)	• correct division of 0.8 cm by 1500 • correct conversion to micrometres and to one decimal place	÷1500 **or** 5.333… = **one mark** 5.3 = **2 marks** **correct answer with no working gains full marks**	**2**

Question Number	Answer	Additional guidance	Mark
3(b)(i)	• 12		**1**

Question Number	Answer	Additional guidance	Mark
3(b)(ii)	An answer that makes reference to four of the following: Support • for pregnancies not going full term there are {more men with sperm with greater than 25% DNA damage / few men have less than 25 % DNA damage} (1) • no men where pregnancies go full term have more than 60% damage / no men with 0-5% DNA damage where pregnancies do not go full term (1) Against • some men had partners with pregnancies that go full term with high % DNA damage (1) • small sample size / uneven group sizes (1) • other factors of men not accounted for e.g. age / diet / genetic conditions (1) • maternal factors affect pregnancy (1)	**At least one from support and at least one from against** **Allow** the majority of men (with pregnancies going full term) had less than 25% damage **Allow** correct numerical comparison e.g only 12(%) of men have less then 25(%) **Allow** converse **Allow** most men with pregnancies that go full term have between 0-5% damage **Allow** description (e.g. some with 55-60%, some with >25%)	**4**

	Additional Guidance	Mar
(1)	Ignore different type of gene Allow found at the same locus on a chromosome Ignore sequence of DNA that codes for a protein	(1)

	Additional Guidance	Mar
		(1)

	Additional Guidance	Mar
he following:	Ignore crossing over and prophase I	
(1)	Allow reference to bivalent	
(1)	Allow description of chiasmata e.g. chromatids overlap	
occurs (1)		
omatids} (1)		(3)

k	dditional Guidance	Mark
	ls with genome size of 3000 reatest variability in ne number	(4)

Mark
(1)

	Mark
roduce a haploid male nosomes and crossing over can occur in the ıle) l occur to form a fertilised egg (a female)	(1)

	Mark
	(1)

	Additional Guidance	Mark
		(2)

	Additional Guidance	Mark
	ACCEPT haploid cells can only divide by mitosis / do not need reduction division	(2)

Mark	(2)
ce	

Question Number	Answer	Additional Guidance	Mark
4(a)(i)	**The only correct answer is C** **A** is incorrect because P is in prophase which comes before R which is in late anaphase **B** is incorrect because Q is in early anaphase which comes before R which is in late anaphase **D** is incorrect because S is in metaphase which comes before R which is in late anaphase		(1)

Question Number	Answer	Additional Guidance	Mark
4(a)(ii)	An answer that makes reference to the following: • select the { anther / filament / carpel / ovary / embryo sac } (1) **and** any four from: • place in {acid / HCl} and {heat / place in hot / warm water bath} (1) • add acetic orcein (1) • tease the cells apart (with a mounted needle) / macerate (1) • place a coverslip on top and gently squash the preparation (1) • count total number of cells in each stage (of meiosis) / count (all) cells and count number of cells at metaphase I and metaphase II (1) • divide the number of cells in metaphase (multiplied by 100) by the total number of cells (1)	Sequence should be logical **Accept** stated temperature **Accept** other appropriate named stains e.g. Feulgen's, Toluene blue	(5)

Question Number	Answer	Additional Guidance	Mark
4(b)	An explanation that makes reference to the following: • independent assortment (1) • crossing over between homologous chromosomes (1) • different combinations of alleles (in the gametes) / different combinations of maternal and paternal chromosomes (1)		(3)

Question Number	Answer	Additional Guidance	Mark
7(a)	An answer that makes reference to the following: • a {vertical / upward sloping} line that shows the DNA content increasing (before mitosis) **and** a {vertical / downward sloping} line that shows the DNA content decreasing (after/towards end of mitosis) (1) • a horizontal line extending across all of mitosis (1) • DNA doubles after replication and returns to same level indicated at start (halves) (1)		(3)

Question Number	Indicative content	
***7(b)**	Indicative content: DNA replication **(D)** • reference to semi-conservative replication • helicase {separates the DNA strands / break hydrogen bonds between DNA strands} • each DNA strand acts as a template • bases complementary base pair with the exposed bases (on template strands) • DNA polymerase joins together (adjacent) DNA nucleotides • each new molecule (of DNA) has one old strand and one new strand • number of molecules doubles each time so total width of bands doubles each time Stage 1 **(S1)** • bases contain {heavy nitrogen / 15 N } • only one band near bottom of tube, as all the DNA has {heavy nitrogen / ^{15}N } Stage 2 **(S2)** • DNA replication occurs using the { light nitrogen / ^{14}N } • new strands will contain light nitrogen / ^{14}N } • only one band as all new molecules / DNA have one heavy and one light strand • band higher up in the tube as it is lighter than the {original / stage 1} DNA Stage 3 **(S3)** • new strands will contain { light nitrogen / ^{14}N } • (two bands because) {original / stage 1 / heavy nitrogen / ^{15}N strands} will bind with lighter strands to form {medium weight DNA molecules / band in same position as stage 2 } • (two bands because) light strands from stage 2 molecules will bind with new light strands to form lightest molecules, so will be higher up the tube • bands of equal widths as equal number of light and heavy strands in stage 2 DNA	**Level 1:** 1 mark = 2 details from D, S1, S2, S3 or S4 2 marks = 3 details from D, S1, S2, S3 or S4 **Level 2:** 3 marks = 4 details from **two** of D, S1, S2 S3 or S4 4 marks = 4 details from **three** of D, S1, S2 S3 or S4 **Level 3:** 5 marks = 5 details from **four** of D, S1, S2 S3 or S4 6 marks = 5 details from **all** of D, S1, S2 S3 and S4

	Stage 4 **(S4)** • all new strands contain { light nitrogen / ^{14}N } • (two bands because) {original / stage 1 / heavy nitrogen / ^{15}N strands} will bind with lighter strands to form {medium weight DNA molecules / band in same position as stage 2 / band in same position as the last stage} • (two bands because) light strands from stage 2 molecules will bind with new light strands to form lightest molecules, so will be { higher up the tube / in same position as the last stage } • more light strands in stage 3 DNA that heavy strands so the width of band for lightest DNA will be wider • in a ratio of 3 : 1	

Number	Answer	Additional Guidance	Mark
3(a)(i)	• juvenile and nymph both 16 (1) • eggs and sperm both 8 (1)		(2)

Question Number	Answer	Additional Guidance	Mark
3(a)(ii)	M on arrows before eggs and sperm		(1)

Question Number	Answer	Additional Guidance	Mark
3(b)	An explanation that makes reference to the three from the following: • Asexual reproduction occurs due to mitosis (1) • when DNA replication takes place (1) • so that, mitosis can divide sister chromatids equally into each cell (1) • therefore cells produced have no genetic variation (1)	**Allow** Cells receive identical chromosomes / {chromosomes or DNA } from only one parent **Allow** no {independent assortment of chromosomes or random fusion of gametes or crossing over} takes place	(3)

Question Number	Answer	Additional Guidance	Mark
3(c) (i)	<table><tr><th>Feature</th><th>Mitosis</th><th>Meiosis I</th><th>Meiosis II</th></tr><tr><td>homologous chromosomes pair together</td><td>×</td><td>✓</td><td>×</td></tr><tr><td>crossing over can cause genetic variation</td><td>×</td><td>✓</td><td>×</td></tr><tr><td>homologous chromosomes separate</td><td>×</td><td>✓</td><td>×</td></tr><tr><td>sister chromatids separate</td><td>✓</td><td>×</td><td>✓</td></tr><tr><td></td><td>(1)</td><td>(1)</td><td>(1)</td></tr></table>		(3)

Question Number	Answer	Mark
3 (c) (ii)	**The only correct answer is B** ***A*** *is not correct because crossing over does not alter the DNA sequence of a gene to produce new alleles* ***C*** *is not correct because independent assortment does not alter the DNA sequence* ***D*** *is not correct because random fusion of gametes does not alter the DNA sequence*	(1)

Question Number	Answer	Additional Guidance	Mark
5(a)(i)	**The only correct answer is C** *A is incorrect because the tips need heating in acid before acetic orcein* **B** *is incorrect because the tips need heating in acid before acetic acid* **D** *is incorrect because the cells need teasing apart and the cover slip placed on top before the preparation is squashed*		(1)

Question Number	Answer	Additional Guidance	Mark
5(a)(ii)	An explanation that makes reference to the following: • because this is (the only part of the root) where mitosis takes place (1) • because the tips are the only part of the root {that grows / where cell division takes place} (1) • because the tips contain {meristem / stem cells} (1)		(2)

Question Number	Answer	Additional Guidance	Mark
5(a)(iii)	**The only correct answer is B** *A is incorrect because L comes before J* **C** *is incorrect because M comes after J and L* **D** *is incorrect because N is the last stage*		(1)

Question Number	Answer	Additional Guidance	Mark
5(b)			(1)
	• estimate between 6 and 7.5 to one decimal place max (hours) (1)		

Question Number	Answer	Additional Guidance	Mark
5(c)(i)	**The only correct answer is D** *A is incorrect because meiosis is involved in the formation of stage 1* **B** *is incorrect because meiosis is involved in the formation of stage 1 and 2* **C** *is incorrect because meiosis is involved in the formation of stage 2*		(1)

Question Number	Answer	Additional Guidance	Mark
5(c)(ii)	**The only correct answer is A** *B is incorrect because the ovary is at the bottom of the style* **C** *is incorrect because the stigma is at the top of the style* **D** *is incorrect because the stigma is at the top of the style*		(1)

Question Number	Answer	Additional Guidance	Mark
5(c)(iii)	A description that makes reference to three of the following: • polar nuclei fuse (1) • to form a {diploid nucleus / primary endosperm nucleus} (1) • which is then fertilised by one of the male {nuclei / gametes} (1) • to form a (triploid) endosperm nucleus / which will result in the formation of {endosperm / nutrients} (1)	**ACCEPT** fuses / join together sperm **ACCEPT** (triploid) endosperm cell	(3)

	Answer	Additional Guidance	Mark

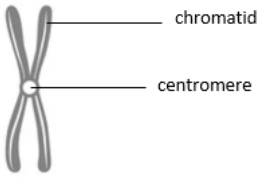
6(a)	<table><tr><th>Stage of cell cycle</th><th>Estimated length of time cell spends in this stage / hours</th></tr><tr><td>mitosis and cytokinesis</td><td>2</td></tr><tr><td>G_1 of interphase</td><td>10</td></tr><tr><td>S phase of interphase</td><td>8</td></tr><tr><td>G_2 of interphase</td><td>4</td></tr></table>	All correct = 2 marks G_2 and S / mitosis and G_1= 12 hours total = 1 mark	**(2)** **EXP**

Question Number	Answer	Additional Guidance	Mark
6(b)	A description that makes reference to the following: • use a method similar to a root tip squash to stain the cells (1) • count the number of cells in mitosis (and cytokinesis) (1) • divide the number of cells in mitosis by the total number of cells counted (1) • and work out as a proportion of 24 hours (1)	**ACCEPT** description of technique that includes at least relevant two steps e.g. heating in acid and staining with acetic orcein	**(4)** **EXP**

Question Number	Answer	Additional Guidance	Mark
6(c)	An explanation that makes reference to five of the following: • DNA content will double by the end of {S phase / interphase} (1) • because DNA synthesis takes place (before mitosis) (1) • the chromosomes will now consist of pairs of chromatids joined together at the centromere (1) • During mitosis the chromatids separate and chromosomes now consist of one DNA molecule (by the end of mitosis (1) • DNA content will return to normal by the end of cytokinesis (1) • because chromatids are separated into (two new) daughter cells (1)	**ACCEPT** increase to 136 arbitrary units of DNA **ACCEPT** (return to) 68 arbitrary units of DNA	**(5)** **EXP**

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following:		

Question Number	Answer	Additional Guidance	Mark
6(a)	A description that makes reference to the following: • a tissue is (a group of) similar cells (1) • an organ is tissues working together to perform {one / several} functions (1)		(2)

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	A drawing that shows the following: • {one / two} chromatids drawn and labelled (1) • joined at the centromere, which is labelled (1)		(2)

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	A description that makes reference to the following: • chromosomes line up along the equator (of the cell) (1) • spindle fibres (from the centrioles) attach to the {centromere / chromosome} (1)	**ACCEPT** middle / metaphase plate pairs of chromatids **DO NOT ACCEPT** chromatids **DO NOT ACCEPT** chromatids	(2)

Question Number	Answer	Additional Guidance	Mark
6(c)(i)	An explanation that makes reference to the following: • the number of cells in metaphase increases because colchicine stops the cells from moving out of this phase (1) • the number of cells in anaphase {decreases / goes to zero} as the cells are not moving out of metaphase (1) • because colchicine {interferes with spindle fibres / stops centromeres being split / stops chromatids being pulled apart} (1) • number of cells in prophase decreases as there are fewer cells to pass through the cell cycle (1)	**ACCEPT** stuck in metaphase **ACCEPT** stuck in metaphase **ACCEPT** going into mitosis	(3)

Question Number	Answer	Additional Guidance	Mark
6(c)(ii)	A description that makes reference to three of the following: • cells grown with colchicine for a period of time (1) • minimum of three plastic dishes sampled at each of the time intervals (shown in the table) (1) • cells stained with (acetic / propionic / ethano) orcein (1) • cells observed under a microscope and the number of cells in each stage of the cell cycle counted (1)	**ACCEPT** treated **DO NOT ACCEPT** plant cells **ACCEPT** acetocarmine, Giemsa, methylene blue, toluidine blue **ACCEPT** observe how many	(3)

rk	Additional Guidance	Mark
	lifferent growing conditions e.g. :emperature	
	e anaphase can be confused ırly telophase, early anaphase confused with metaphase	
	nly two cells found in anaphase / ample size	
		(2)

)

rk

)

	Additional Guidance	Mark
	Example of calculation	
(1)	2 ÷ 246	
(1)	1380 x (2 ÷ 246) = 11.22 minutes Allow 11 / 11.2 Correct answer with no working gains full marks	(2)

	Additional Guidance	Mark
	Allow ecf from 6(d) (i) Example of calculation	
(1)	(11.22 x 8) ÷ 100 (11.2 x 8) ÷ 100 (11 x 8) ÷ 100	
(1)	11.22 - 0.898 = 10.32 / 10.3 / 10 11.2 – 0.896 = 10.30 / 10.3 / 10 11 – 0.88 = 10.12 / 10.1 / 10 Correct answer with no working gains full marks	(2)

	Additional Guidance	Ma
e following:		
(1)	Ignore repair damaged cells or cell growth (unless qualified by a suitable cell type such as a muscle cell) Allow replace cells	
al cells / clones / somes } (1)		(2

	Additional Guidance	Ma
e following:		
(1)		
(1)		
(1)		
the same (1)		

	Additional Guidance	Ma
		(

Number	Answer	Additional Guidance	Mark
5(a)	• division (1) • multiplication (1)	3 ÷ 16 = 0.1875 0.1875 × 100 = 18.75 / 18.8 /19	(2)

Question Number	Answer	Additional Guidance	Mark
5(b)	A description that makes reference to four of the following: • use warm acid (1) • remove acid using water (1) • add named stain (1) • macerate or tease with needle (1) • use coverslip and squash (1)	**e.g.** acetic orcein / toluidine blue / Schiff's / Giemsa / Feulgen / (aceto) carmine	(4)

Question Number	Answer	Additional Guidance	Mark
5(c)	An answer that makes reference to four of the following: • use waterlogged soil and non-waterlogged soil / range of water content (1) • use same plant variety / type / species / age / size (1) • control {temperature / light / soil type / mineral ions / pH} (1) • leave for same stated time (1) • take cells from same part of root tips (1)	**DO NOT ACCEPT** nutrients **DO NOT ACCEPT** less than 24 hours **e.g** both cut at 2mm	(4)

Question Number	Answer	Additional Guidance	Mark
5(d)	An explanation that makes reference to four of the following: • aerobic respiration inhibited / anaerobic respiration occurs (1) • therefore {electron transport chain / oxidative phosphorylation} inhibited / therefore {glycolysis occurs / ethanol produced} (1) • less {ATP synthesis / reduced NAD} (1) • (less) active transport (of mineral ions) (1) • less {GP / GALP / IAA pumping / spindle fibre contraction / protein synthesis} (1)	**ACCEPT** valid substances / energy requiring processes **DO NOT ACCEPT** starch	(4)

	Additional Guidance	Mark
rence to two of the or no tertiary (1) ole whereas tubulin ater) (1) of long polypeptide) whereas tubulin is e (1)	ACCEPT fibrous proteins have hydrophobic groups on the outside / converse ACCEPT fibrous proteins are {longer / tougher}	**(2)**

	Additional Guidance	Mark
(1) (1)	<u>Example of calculation</u> • 40 µm = 40000 nm / 25 nm = 0.025 µm ACCEPT correct standard form • 40000/ 25 = 1600 correct answer gains both marks	**(2)**

Additional Guidance	Mark
ACCEPT greater concentration of tubulin produces onger microtubules	**(4)**

nal Guidance	Mark
equilibration onding between {tubulin d centrioles}	(4)

:e	Mark
forming and ached at	(2)

Question Number	Answer	Additional Guidance	Mark
9(a)	An explanation that makes reference to five of the following: • DNA synthesis is needed for {mitosis / cell division} (1) • Dox prevents {DNA synthesis / DNA strands separating / promotors binding} (1) • because the strands are not available (for nucleotides to align) (1) • Dox prevents {transcription / transcription factors from binding} (1) • so no proteins synthesised (1) • repair enzyme will not be able to remove the drug (1)	**ACCEPT** without DNA synthesis the cell will remain in interphase **ACCEPT** mRNA cannot be made **ACCEPT** {cell cycle stops / cells destroyed} if damaged DNA is not repaired	

Question Number	Indicative content
***9(b)(i)**	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. <u>Indicative content</u> • Dox decreases the concentration of (all) amino acids shown • largest actual decrease is glu and asp (3.6 μmol cm^{-3}) • smallest actual decrease is ser (0.9 μmol cm^{-3})) • relative decrease is least for pro (16.67%) • relative decrease is greatest for asp (85.71%) • data not available for all amino acids • polar and non-polar amino acids are affected • polar amino acids affected most (total 14.4 μmol cm^{-3} compared to total 11.7 μmol cm^{-3} / mean 2.4 μmol cm^{-3} compared to mean 1.95 μmol cm^{-3}) • effect on non-polar amino acids is within a {narrower range for actual decrease / wider range for percentage decrease}

	Level 1 : comments on overall effect of Dox 1 mark = level 1 comment only 2 marks = level 1 comment backed up with figures / level 2 comment but no figures given **Level 2 : comments on effect of Dox on polar and non-polar amino acids** 3 marks = level 2 comment only / level 1 comment with a level 2 calculation (= actual decrease in concentration) 4 marks = level 2 comment backed up with a level 2 calculation **Level 3 : comments about amino acids within the group of polar / non-polar amino acids** 5 marks = level 3 comment / level 2 comment with a level 3 calculation (= percentage decrease in calculation) 6 marks = comment backed up with a level 3 calculation	
Level 0	Marks	No awardable content
Level 1	1-2	An **answer** may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The **answer** will contain basic information with some attempt to describe the data shown in the graph
Level 2	3-4	An **answer** will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The **answer** shows some linkages and lines of scientific reasoning with some structure between the graph and the different types of amino acids
Level 3	5-6	An **answer** is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The **answer** shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.

Question Number	Answer	Additional Guidance	Mark
9(b)(ii)	An explanation that makes reference to the following: • a decrease in some amino acids may mean that {certain proteins cannot be formed / less protein made} (1) • if these proteins are involved in heart muscle structure then it will be weaker (1) • these proteins may affect heart muscle function (1)	**ACCEPT** named example e.g. actin, myosin, collagen **ACCEPT** named example e.g. collagen, haemoglobin, myoglobin, cytochromes	

Question Number	Answer	Additional Guidance	Mark
9(b)(iii)	An explanation that makes reference to the following: • heart will not be able to pump as well (1) • so less {oxygenated blood / oxygen} will be delivered to the {cells / tissues / organs / named example} (1) • example of a consequence of this (1)	**ACCEPT** less carbon dioxide removed / lowers blood pH **e.g.** less aerobic respiration, build-up of lactic acid / fatigue / breathlessness	

Additional Guidance
Additional Guidance
Additional Guidance
Additional Guidance

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>1</td><td>
<table>
<tr><th>Structure</th><th>Name of structure</th><th>Number of sets of chromosomes</th></tr>
<tr><td>J</td><td>egg cell / female gamete</td><td>one / haploid / n (1)</td></tr>
<tr><td>K</td><td>polar nucleus / nucleus that forms the endosperm nucleus</td><td>one / haploid / n (1)</td></tr>
<tr><td>L</td><td>male gamete</td><td>one / haploid / n (1)</td></tr>
<tr><td>M</td><td>(pollen) tube nucleus</td><td>one / haploid / n (1)</td></tr>
</table>
</td><td>NB Any two correct cells = 1 mark

ACCEPT ovum / ova

ACCEPT pleural

ACCEPT male / sperm nucleus
pleurals

DO NOT ACCEPT generative nucleus</td><td>(4)</td></tr>
</table>

Question Number	Answer	Additional Guidance	Mark
2(a)	An explanation that makes reference to two of the following: • meiosis results in recombination of alleles (1) • due to {independent / random} assortment (of chromosomes) (1) • (and) due to crossing over between chromatids (between the same homologous chromosomes) (1)	**ACCEPT** description e.g. pairs of homologous chromosomes line up (on the equator) randomly **ACCEPT** description e.g. genetic material is swapped between chromatids (between the same homologous chromosomes) **DO NOT ACCEPT** wrong description/ wrong stage	(2)

Question Number	Answer	Additional Guidance	Mark
2(b)	A description that makes reference to three of the following: • (contact between sperm and secondary oocyte results in) <u>acrosome</u> reaction (1) • meiosis is completed (1) • <u>cortical</u> reaction takes place (1) • fusion of sperm {nucleus / genetic material} with {nucleus genetic material} of ovum (1)	**ACCEPT** ovum / egg cell / female gamete description e.g. enzymes are released from the <u>acrosome</u> **DO NOT ACCEPT** if described after cortical reaction or fusion of two cells **ACCEPT** description e.g. <u>cortical</u> granules are released that {hardens the membrane / forms a fertilisation membrane} **ACCEPT** egg cell / nuclei of the gametes	(3)

Question Number	Answer	Additional Guidance	Mark
2(a)	A description that makes reference to the following: • to {digest / breakdown} the {egg cell / ovum / secondary oocyte} membrane (1) • so that the sperm {nucleus / genetic material} can enter the {egg cell / ovum / secondary oocyte} (1)	**ACCEPT** zona pellucida	(2)

Question Number	Answer	Additional Guidance	Mark
2(b)	A description that makes reference to three of the following: • transcription of the genes coding for the (acrosome) enzymes (1) • translation (of the mRNA) (to synthesise the enzymes) (1) • transported in the RER (to the Golgi) (1) • {modification / processing / packaging} (of the enzymes) in the Golgi (1) • packaging (by the Golgi of the enzymes) into {the membrane / vesicles} (of the acrosome) (1)	**ACCEPT** description of transcription e.g. mRNA copy of gene coding for enzyme made **ACCEPT** description of translation e.g. amino acids joined by peptide bonds **DO NOT ACCEPT** for exocytosis	(3)

	Additional Guidance	Mark
ving:		
ffect /	**Accept** converse for chemical B / stopping translation	
growth ncreases	**Accept** correct mathematical comparison e.g. overall chemical A causes a 29% drop and chemical B causes a 100 % drop **Accept** transcription occurred before chemical A added	
proteins /	**Accept** pollen tube cannot grow without synthesis of new proteins	**(4)**

nal Guidance	Mark
ation:	
m = 5.7 mm	
ding from graph A ains full marks	
= maximum 1	**(2)**

r	Additional Guidance	M
id , triploid, haploid)		
perm nucleus is not diploid		
tube nucleus is not diploid		
e nucleus is not haploid but is not diploid but haploid		

r	Additional Guidance	M
osis, mitosis, mitosis)		
division is not meiosis but the same		
ivision is not mitosis as the and third divisions are both the same and does not		
nuclear division halves the vision does not halve the		(

Ma	(1

Ma	(1

nswer	Additional Guidance	Mark
ce to the following: ean / mean / nean / n of significant difference / ignificant difference (1)	**ACCEPT** average	**(2)**

Additional Guidance
culation
n
)
gains full marks, with no working
ark in working ÷ 30

	Additio

wer
ing:
solution (1)
overslip (1)
ation (1)

er	Additional Guidance	Mark
by total number (1) e (1)	Example of calculation 4 ÷ 11 = 36.36 / 36 / 36.4 36.36 is 16 to 18 minutes **ACCEPT** one mark for 12 to 14 if 3 ÷ 11 seen in working	**(2)**

Number	Answer	Additional Guidance	Mark
5(a)	A description that includes: • enzymes {hydrolyse / digest} the tissue (of the style) (1) • provides {nutrients / energy /ATP} for pollen tube growth (1) • clears path for pollen tube growth / allows pollen tube to enter ovule (1)	**Allow** enzymes {regulate the production of growth hormones / extend the cytoskeleton / are involved in aerobic respiration / produce new cell membranes} **Allow** provides cell structures needed for growth	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(b)	An explanation that includes: • enzymes {hydrolyse / digest} the (m)RNA (1) • this prevents {translation / protein synthesis / enzyme synthesis} (1) • which prevents {digestion of style / pollen tube growth / pollen tube reaching ovule / prevents self-pollination} (1)		**(3)**

Question Number	Answer	Additional Guidance	Mark
5(c)	An explanation that includes four of the following: • one (male nucleus) fuses with two polar nuclei (1) • which produces a triploid (endosperm) nucleus (1) • which therefore, provides nutrients (for germination) (1) • one (male nucleus) fuses with the female gamete nucleus (1) • which produces the diploid zygote (1)	**Allow** pollen/egg/ova/fertilises	**(4)**

Number	Answer	Additional Guidance	Mark
6(a)	An description that makes reference to four of the following: • germ cells divide by mitosis / form {spermatogonia / primary spermatocytes} (1) • which divide by meiosis to form secondary spermatocytes (1) • which divide to form spermatids / 2nd meiotic division forms haploid spermatids (1) • which develop into {(mature) spermatozoa / sperm} (1) • which includes {an acrosome / flagellum} (1)	**Allow** differentiate	**(4)**

Question Number	Answer	Additional Guidance	Mark
6(b)	A calculation that shows: • total number of spermatozoa calculated (1) • answer given in standard form (1)	Example of calculation • 3400 × 17000 • = 5.8×10^7 **Allow** 5.78×10^7	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(c)	A calculation that shows: • speed of sperm travel = 0.11 cm min^{-1}	Example of calculation 3 × 60 = 180 19 ÷ 180 = 0.11 / 0.106	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(d)(i)	• two correct straight lines drawn (1) • possibly fertile (1)	**Allow** 11 - 13	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(d)(ii)	• off the bottom of the scale therefore person is infertile	**Allow** infertile (on the scale)	**(1)**

Question Number	Answer	Additional guidance	Mark
2(a)(i)	A description that makes reference to the following: • (megaspore mother cell) meiosis producing <u>four</u> {haploid / n} {<u>nuclei / megaspores</u>} (1) • three (nuclei / megaspores) disintegrate / disappear (1) • only one (nucleus / megaspore) then undergoes mitosis (1) • <u>three</u> (mitotic) divisions occur (to produce 8 nuclei) (1)	penalise cells **once** e.g. meiosis makes four haploid cells but three cells disintegrate = one mark Award marks from correct labelled diagrams	**(3)**

Question Number	Answer	Mark
2(a)(ii)	The only correct answer is C *A is incorrect as endosperm cells are 3n* *B is incorrect as endosperm cells are 3n* *D is incorrect as embryo cells are 2n*	**(1)**

Question Number	Answer	Mark
2(b)	The only correct answer is C (gibberellin) *A is incorrect as auxin does not stimulate enzyme production* *B is incorrect as cytokinin does not stimulate enzyme production* *D is incorrect as phytochrome does not stimulate enzyme production*	**(1)**

Question Number	Answer	Mark
2(c)(i)	The only correct answer is D (rrTt and rrTT) *A is incorrect as RrTT is red* *B is incorrect as rrTT is also yellow* *C is incorrect as rrtt is white*	**(1)**

Question Number	Answer	Additional guidance	Mark
2(c)(ii)	An answer that makes reference to the following: • correct parent genotypes (rrTt, RrTt) (1) • correct gametes (rT, rt **AND** RT, Rt, rT, rt) (1) • correct genotypes of offspring (RrTT, RrTt, Rrtt, rrTT, rrTt, rrtt) (1) • correct ratios of phenotypes (4 red : 3 yellow : 1 white **OR** 8 red : 6 yellow : 2 white) (1)	**Allow ECF** for mp2 **ONLY** if wrong parental genotypes have been stated (max 1) **Allow** mp1,2,3 from Punnet square The **three** phenotype colours must be shown somewhere for mp4	**(4)**

(Total for Question 2 = 10 marks)

Question Number	Answer	Mark
2 (a)(i)	The only correct answer is C (primary oocyte) *A is incorrect as ovule is not part of oogenesis* *B is incorrect as an ovum is not formed at this stage* *D is incorrect as X is not a secondary oocyte*	**1**

Question Number	Answer	Additional guidance	Mark
2(a)(ii)	A description that makes reference to three of the following: • nuclear membrane disintegrates / nucleolus disintegrates (1) • centrioles move to poles / begin to form spindle (1) • chromosomes condense / chromosomes become visible (1) • **homologous chromosomes** {pair up / form bivalent} (1) • {chiasmata form / crossing over occurs} {between chromosomes / between (non-sister) chromatids} (1)	**Allow** alternatives to disintegrate **Allow** chromatin condenses **Allow** description of DNA coiling around histones **Allow** recombination occurs between homologous chromosomes	**3**

Question Number	Answer	Additional guidance	Mark
2(a)(iii)	An answer that makes reference to three of the following: Similarities (**max 2**): 1. both begin with {stem cells / primordial germ cells} (1) 2. both involve mitosis and meiosis (1) 3. both produce **haploid {**cells / gametes} (1) 4. both produce {gametes / cells} with genetic variation (1) Differences (**max 2**): 5. oogenesis produces one (gamete) **and** spermatogenesis produces {four / more than one} (gametes) (1) 6. oogenesis begins before birth **and** spermatogenesis starts at puberty (1) 7. oogenesis {pauses / arrests / is blocked at} {at prophase I / metaphase II} and spermatogenesis has no pause / arrests (1)	**At least one similarity and one difference** **Allow** oogenesis produces polar bodies **but** spermatogenesis does not **Allow** oocytes present {before / at} birth **but** sperm are {not present / only made after puberty} **Allow** oogenesis is only completed at fertilisation **but** spermatogenesis is continuous (1)	**3**

Question Number	Answer	Additional guidance	Mark
2(b)(i)	• 35 x 1 000 ×4 = 140 000 (1)	**Allow** answers between 136 000 and 144 000	**1**

Question Number	Answer	Additional guidance	Mark
2(b)(ii)	An explanation that makes reference to the following: • percentage that develop increase up to **35 000** sperm (per oocyte) **and** then decrease (1) • so that (at low ratios) zona (pellucida) cannot be digested / not enough enzymes from acrosomes (1) • at higher ratios {several sperm fertilise egg / zygote is polyploid / has too many sets of chromosomes} (1)	**Allow** 35x1000 **Allow** more digestion of zona as sperm concentration increases **Allow** polyspermy occurs	**2**

(Total for Question 2 = 10 marks)

Answer	Mark
is A *s not a polar body* *'s a germ cell not an oocyte* *'s a germ cell not an ovum*	**(1)**

Additional Guidance	Mark
ᵖT stationary ᵖT so no fusion with the oocyte occurs / no ɔme reaction / unable to fertilise the egg	**(2)**

Additional Guidance	Mark
ᵖT converse ᵖT natural selection can take place	**(2)**

ver	Additional Guidance	Mark
d subtracted (1) ulated (1)	Example of calculation • 733000 – 389300 = 343700 • 343700 / 733000 X 100/1 = 46.9% ACCEPT both positive and negative answers correct answer gets both marks ACCEPT 47% and 46.89%	**(2)**

ver	Additional Guidance	Mark
(1)	ACCEPT during gestation, pregnancy	**(1)**

ver	Additional Guidance	Mark
flagellum / acrosome}	ACCEPT converse / spermatids have fewer {enzymes / mitochondria }	**(1)**

Mark	(2)
nal Guidance	

Question Number	Answer	Mark
9(a)(i)	**The only correct answer is D** ***A** is incorrect because spermatogonia divide by mitosis and primary spermatocytes divide in meiosis I to form secondary spermatocytes* ***B** is incorrect because spermatogonia divide by mitosis and primary spermatocytes divide in meiosis I to form secondary spermatocytes* ***C** is incorrect because spermatogonia divide by mitosis and primary spermatocytes divide in meiosis I to form secondary spermatocytes*	(1)

Question Number	Answer	Mark
9(a)(ii)	**The only correct answer is C** ***A** is incorrect because primary spermatocytes are diploid* ***B** is incorrect because primary spermatocytes are diploid* ***D** is incorrect because primary spermatocytes are diploid*	(1)

Question Number	Answer	Additional Guidance	Mark
9(b)	An explanation that makes reference to the following: • to be the source of centrioles in the zygote (1) • so that the spindle (fibres) can be synthesised (in the zygote / embryo) (1) • so that the (fertilised egg cell /zygote) can divide by mitosis (to form the embryo) (1)	**ACCEPT** fertilised egg cell / cell resulting from fertilisation **DO NOT ACCEPT** meiosis	(3)

Question Number	Indicative content	
***9(c)**	Low sperm counts: • fewer sperm arriving at the egg cell, reducing the likelihood of fertilisation • not enough enzymes released for fertilisation Absence of an acrosome: • sperm will not be able to digest through (the outer membrane of egg cell) • therefore {nucleus / genetic material} will not be released inside the egg cell Mutations in the mitochondrial DNA: • less energy available for flagellum • without energy sperm will not be able to swim (through female) Chromosomal mutations: • could result in {lack of / too much} genetic material • cell division maybe affected • embryo maybe defective and not develop Structural defects: • defect in head may prevent penetration of sperm into egg cell • defects in flagellum could prevent motility • two heads might prevent entry into egg cell* • small head may not contain {an acrosome / a nucleus}* • misshapen head may {not be able to penetrate egg cell / impair motility}* • two flagella may {get tangled up together / not receive sufficient energy for swimming}* • short flagella may not provide enough motility* • no mid piece would mean no energy for swimming*	**Level 1:** 1 mark = effect of one factor commented on 2 marks = effects of two factors commented on **Level 2:** 3 marks = effects of three factors commented on 4 marks = effects of four factors commented on **Level 3:** 5 marks = effects of all five factors commented on 6 marks = effects of all five factors commented on but includes **one** specific types of structural defects*

Question Number	Answer	Additional Guidance	Mark
6(a)(i)	**The only correct answer is D** *A is incorrect because R guides pollen tube growth* **B** *is incorrect because R guides pollen tube growth* **C** *is incorrect because both P and Q are involved in fertilisation*		**(1)**

Question Number	Answer	Additional Guidance	Mark
6(a)(ii)	**The only correct answer is A** ***B** is incorrect because all three nuclei are haploid* **C** *is incorrect because all three nuclei are haploid* **C** *is incorrect because all three nuclei are haploid*		**(1)**

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	An answer that makes reference to three of the following: • conclusion is not, justified / correct (1) • (from the data provided) they both have the same range of temperatures (1) • there is no data available for below 10 °C and above 30 °C (1) • percentage germination for species A is dropping more steeply so range could be narrower (1) • percentage germination for species A is always higher so could show some germination at lower and higher temperatures (1) • Not very accurate /large gaps between temperatures/needs to have smaller increases between temperatures (1) • no idea of sample size / no standard deviations calculated (1) • low percentage germination for each species (at each temperature) (1)	ACCEPT same/similar temperatures ACCEPT needs more temperatures below 10°C and above 30 °C	**(3)**

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	An answer that makes reference to four of the following: • carry out the investigation using the same two species of plant (1) • investigate more temperatures between 20 °C and 30 °C (1) • at, smaller increments / increments of {1 / 2} °C (1) • credit named control variable (1) • place slides in petri dish, with a humid atmosphere / AW (1) • count the number of pollen grains and the number of pollen grains that have germinated to calculate the percentage (1) • repeats / calculate {mean / standard deviations} (1)	Eg: same, sucrose concentration / mineral salt concentration / volume of sucrose / mineral salt solution / time period ACCEPT appropriate statistical test	**(4)**

Question Number	Answer	Additional Guidance	Mark
6(c)	• correct calculation (1) • correct answer given to one dp (1)	1 mark: 2.8 ÷ 1.4 = 2 2 marks: 2.8 ÷ 1.4 = 2.0	**(2)**

Number	Answer	Additional Guidance	Mark
5(a)	A description that includes the following: • calibrate eyepiece graticule using stage micrometer (1) • measure (pollen tube) using eyepiece graticule (1)	 Accept description eg calculate how many EG units are in one stage micrometer unit / convert EG units into stage micrometer units Allow measure the pollen tube in eyepiece units	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	An answer that includes the following: • calculation of mean growth per hour (1) • calculation of mean growth per minute to 2dp (1)	Example calculation calculate mean per hour from 4 hour data 547 / 4 hours = 136.75 in 1 hour 136.75 divided by 60 = **2.28 (µm per minute)** Correct answer with no working gains full marks 1 mark for correct value to wrong dp	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	A description that includes three of the following: • if no calcium ions are present, pollen {grains / tubes} will not {germinate / grow} (1) • as concentration of calcium ions increases, (percentage) pollen tube germination increases (1) • above 300 mg dm^{-3}, increasing calcium ion concentration makes no difference to **initial** percentage germination (1) • as concentration of calcium ions increases (above 300 mg dm^{-3}) pollen tube {length increases / grows more} • most germination happens in the first hour / pollen tube growth is fastest in the first hour	Allow calcium nitrate for calcium ions Ignore limiting factors / optimum levels of Ca $(NO_3)_2$ Accept calcium ions are needed for pollen tube germination / growth Allow **rate** of pollen tube germination increases Allow above 300 mg dm^{-3}, increasing calcium ion concentration makes no difference to percentage germination in the first hour Accept as concentration of calcium ions increases (above 300 mg dm^{-3}) **rate** of pollen tube growth increases (1) Accept rate of pollen tube growth slows at higher levels of calcium nitrate	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(c)	An answer that includes four of the following:		
	• collect pollen from {one species of plant / same age anthers} (1)	Allow named species Allow same plant / same source	
	• (add pollen to) additional concentrations of calcium ions /	Accept add to solutions of calcium nitrate at concentrations of 0, 300, 400, 500 (mg dm^{-3}) / carry out at **each** concentration of calcium ions	
	measurements at {shorter / intermediate} intervals to record percentage germination / pollen tube length (1)	Allow observe each hour for 4 hours to record percentage germination / pollen tube length Ignore measuring growth	
	• add sucrose (solution) of same concentration (1)		
	• control temperature by keeping tubes in a {thermostatically controlled water bath / incubator} (1)	Accept a maximum of 40°C (if given)	
	• control pH by adding buffer to the tubes (1)		
	• {use / measure} several grains (at each concentration) to calculate {mean / SD} values (for germination / growth rate / length) (1)	Allow multiple grains / minimum 3 Ignore "repeat" unless qualified	**(4)**

(Total for Question 5 = 11 marks)

Number	Answer	Additional Guidance	Mark
5(a)	• length of pollen tube measured from photo (1) • magnification calculated (1)	Example calculation Length = 33 (mm) Accept 31 – 34 (mm) / 3.1 – 3.4 (cm) Magnification = $\frac{\text{photo size}}{\text{actual size}} = \frac{33\,000}{136}$ = 243 / 242.7 / 242.65x Accept values in the range 227.9 to 250.0 x Do not accept units Correct answer with no working gains 2 marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	A: generative nucleus (1) B: (pollen) tube nucleus (1)		**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	A description including three of the following • {one male nucleus / one male gamete} fuses with the two polar nuclei • to form a {triploid / 3n} nucleus (1) • {one male nucleus / one male gamete} fuses with the {egg cell / ovum / female gamete / female nucleus} • to form a {diploid / 2n} zygote (1)	Do not accept polar bodies Do not accept fertilises Accept triploid endosperm **nucleus** Accept fertilises	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(c)	An answer that includes five of the following: • at least 5 different pH values tested (1) • sucrose solution added (1) • suitable time before pollen tube measured (1) • method of measurement of pollen tube with a microscope described (1) • method of calculation of rate of growth (1) • method of control of one relevant variable (1) • a repeat at each pH and calculate {mean / standard deviation} (1)	If intervals eg every 10 minutes or single measurement. If single measurement must be minimum of 30 mins and max of 24 hours eg use of stage micrometer and {graticule / scale bar} / calibrated graticule eg length divided by time / gradient on a graph eg. (temperature) – use of waterbath / incubator sucrose concentration – described / named (humidity) - environmental chamber / lid on petri dish / coverslip on cavity slide (species) of flower – collect from same flower / plant (ripeness of pollen) – collect from same anther mineral salt concentration – stock solution / named	**(5)**

Total for Question 5 = 12 marks

8(a)(i)	• to produce several diploid primary spermatocytes (1) • so that lots of sperm can be produced from a single spermatogonium (1) • to replace the spermatogonia (1)		**(2)** **EXP**

Question Number	Answer	Additional Guidance	Mark
8(a)(ii)	An explanation that makes reference to the following: • crossing over (in prophase I) (1) • to produce new combinations of alleles on a chromatid (1) • independent assortment (in metaphase I) (1) • to increase the combination of chromosomes in each daughter cell (1)	increase variety of combinations of maternal and paternal chromatids / alleles	**(4)** **EXP**

Question Number	Answer	Additional Guidance	Mark
8(a)(iii)	An answer that makes reference to one similarity and two differences : **Similarities** • haploid cells produced from diploid cells in both (1) **Differences** • {stage 2 / meiosis I} results in two secondary spermatocytes but only one secondary oocyte (1) • {stage 3 / meiosis II} results in four spermatids but one {ovum / egg cell} (1) • polar bodies are produced in oogenesis but not in spermatogenesis (1)		**(3)** **EXP**

Question Number	Answer	Additional Guidance	Mark
8(a)(iv)	An explanation that makes reference to the following: • Contains enzymes (1) • to enable the sperm to digest through the membrane of the (secondary oocyte) (1)		**(2)** **EXP**

Question Number	Answer	Additional Guidance	Mark
8(a)	An explanation that makes reference to the following: • if AR is too early then there will not be the enzymes available for fertilisation (1) • and it will not be able to digest through the zona pellucida/jelly coat (1) • if AR is too late then {the egg/sperm (cell) may have died / the sperm have swam past the egg (cell)} (1)		(3)

Question Number	Answer	Additional Guidance	Mark
8(b)	<table><tr><th rowspan="2">Event</th><th colspan="2">Presence of protein G</th><th colspan="2">Presence of protein G-P</th></tr><tr><th>Head region</th><th>Mid piece and flagellum</th><th>Head region</th><th>Mid piece and flagellum</th></tr><tr><td>Just before capacitation</td><td>✓</td><td>×</td><td>×</td><td>✓</td></tr><tr><td>During capacitation</td><td>✓</td><td>×</td><td>×</td><td>✓</td></tr><tr><td>Just before the AR</td><td>×</td><td>×</td><td>✓</td><td>✓</td></tr></table>		(4)

Question Number	Answer	Additional Guidance	Mark
8(c)	An explanation that makes reference to the following: • DNA methylation {silences / switches off} a gene (1) • Because is a form of epigenetic modification (1) • therefore the gene cannot be transcribed / therefore no protein G will be produced (1) • without protein G the timings of capacitation and AR will be wrong (1)	**ACCEPT** Transcription factors cannot bind to DNA **ACCEPT** If AR not inhibited, AR will happen too soon	(3)

Question Number	Answer	Additional Guidance	Mark
8(d)(i)	An answer that makes reference to the following: • genetically-modified (laboratory) mice (1) • that have had the gene coding for protein G {inactivated / replaced} (1)	**ACCEPT** genes coding for protein G prevented from being expressed	(2)

Question Number	Answer	Additional Guidance	Mark
8(d)(ii)	A description that makes reference to three of the following: • all female mice would have to be fertile (1) • fertile males used as a control (1) • pregnancy rate measured (1) • Same species/age of mouse/diet (1)	**ACCEPT** Control group that have not had gene modified **ACCEPT** Number of offspring produced	(3)

Question Number	Answer	Additional Guidance	Mark
5(a)(i)	{methyl group / CH_3} added to a {base (cytosine or adenine) / cytosine / adenine / CpG site}	**DO NOT ACCEPT** between cytosine and guanine **ACCEPT** A for adenine, C for cytosine, G for guanine	

Question Number	Answer	Additional Guidance	Mark
5(a)(ii)	A description that makes reference to the following: • {zygote / morula} are totipotent stem cells as they give rise to all cell types (1) • {blastocyst / inner cell mass} contains pluripotent cells that give rise to the cells of the embryo (and not the extra embryonic tissue) / most cell types (1) • cells in the developing embryo are multipotent as they become only some cell types (1)	**ACCEPT** references to early and late stages of development if clear from description which stages are being referred to **ACCEPT** cleavage cells **ACCEPT** {trophoblastic cells / cells around the outside of the blastocyst} as they become extra embryonic tissue **N.B.** If correct description given for 2 or more types of stem cell but no reference to embryo, award 1 mark	

Question Number	Answer	Additional Guidance	Mark
5(a)(iii)	An explanation that makes reference to two of the following: • level of DNA methylation increases after the blastocyst stage} (1) • because genes {switched off / silenced / inactivated / cannot be transcribed / cannot be expressed} (1) • causing cells to become {specialised / differentiated} (1)		

Question Number	Answer	Additional Guidance	Mark
5(b)	An explanation that makes reference to two of the following: • because they are (fully) differentiated cells (1) • therefore genes needed (for other cell types) are (permanently) {switched off / silenced} (1) • therefore proteins needed by other cell types cannot be produced (1)	**ACCEPT** specialised **ACCEPT** not able to express certain genes	

Question Number	Answer	Additional Guidance	Mark
4(a)(i)	**C** monocyte | eosinophil	**A** is incorrect because cell J is not an eosinophil and cell K is not a lymphocyte **B** is incorrect because cell J is not a lymphocyte and cell K is not a neutrophil **D** is incorrect because cell J is not a neutrophil and cell K is not a monocyte	(1)

Question Number	Answer	Additional Guidance	Mark
4(a)(ii)	**D** 50 : 3	**A** is incorrect because there are about 50 erythrocytes and 3 leukocytes **B** is incorrect because there are about 50 erythrocytes and 3 leukocytes ie the ratio is the wrong way round **C** is incorrect because there are 3 leucocytes	(1)

Question Number	Answer	Additional Guidance	Mark
4(b)	An explanation that makes reference to the following: • because the numbers of erythrocytes to leucocytes can be determined (1) • and compared to the {normal / healthy / known CML} (smear) (1)	**ACCEPT** red blood cells to white blood cells named white blood cell	(2)

Question Number	Answer	Additional Guidance	Mark
4(c)	An explanation that makes reference to four of the following: • by epigenetic modification (1) • for example by {DNA methylation / histone methylation / histone acetylation} (1) • {house-keeping genes / genes needed in both cell types} remain switched on (1) • genes needed in {common lymphoid progenitor / lymphoid} cells become (permanently) switched off (1) • causing {proteins / named protein} to be made that are specific to the {cell type / named cell} (1)	**ACCEPT** descriptions / post-transcriptional modification transcription of genes switched on / no transcription of genes switched off **ACCEPT** converse **ACCEPT** converse credit a named example of a gene which may be switched {on / off} e.g. gene coding for cytokines in T lymphocytes **NB** genes become switched on or off = 1 mark, if no other marks awarded	(4)

Question Number	Indicative content
***5(a)**	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content: • IgM produced early in response (D) • has multiple antigen-binding sites (D) • involved in agglutination of the viruses (R) • IgA produced early in response (D) • can bind two antigens (D) • so involved in agglutination of the viruses (R) • involved in opsonisation (R) • to enhance phagocytosis by phagocytes (R) • is present in {eyes / nasal passages} (D) • to prevent entry of pathogen through {eyes / nose} (R) • can provide passive immunity to newborn baby (R) • IgG persists in body for a few months (D) • providing immunity to virus (R) • has two antigen-binding sites (D) • involved in agglutination of the viruses (R) • involved in opsonisation (R) • to enhance phagocytosis (R) • can cross the placenta to provide passive immunity to the fetus (R) • IgD will be involved in B cell activation (R) • as it will bind virus to B cell (R) • activated B cells will differentiate into plasma cells that will produce antibody (R) • IgE not involved as Rubella infection {is not a parasitic infection / does not result in an allergic response} (R) **Level 1 :** 1 mark = description of antibodies from either the graph or the table 2 marks = description of antibodies from both the graph and the table / role of one class of antibody described **Level 2 :** 3 marks = role of two classes of antibody described 4 marks = role of three classes of antibody described **Level 3 :** 5 marks = role of four classes of antibody described 6 marks = role of all five classes of antibody described

Level	Marks	
0	0	No awardable content
1	1-2 (1-3)	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.
2	3-4 (4-6)	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.
3	5-6 (7-9)	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.

Question Number	Answer	Additional Guidance	Mark
4(a)	An explanation that makes reference to two of the following: • more men than women are affected and heart disease increases with age **(1)** • gender because {presence of oestrogen in women / more men than women smoke} **(1)** • age because {more time to develop atherosclerosis / less active lifestyle / higher blood pressure / less elastic arteries} **(1)**	**Accept** pieced together answer	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(b)	An explanation that makes reference to two of the following: • the { atheroma / plaque / (blood) clot} blocks the (coronary) artery **(1)** • therefore the heart {cells / muscle} are deprived of {oxygen / glucose} **(1)** • therefore respiration cannot take place **(1)**	**Accept** atherosclerosis results in the (coronary) artery being blocked **Accept** they (heart cells) are deprived of oxygen / less oxygen {reaches / transported to} the cells / ischaemia / reduction in flow of oxygenated blood	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(c)	An answer that makes reference to five of the following, including at least one similarity or one difference : <u>Similarities</u>: • both have the potential to divide indefinitely **(1)** • both have the potential to differentiate into a number of cell types **(1)** <u>Differences</u>: • iPS cells were {adult cells / named example of adult cell} but embryonic stem cells are cells taken from the {morula / inner cell mass} **(1)** • iPS have a {gene / named gene} added but embryonic cells do not **(1)** • there are {no / less / different} ethical issues surrounding the use of iPS cells **(1)** • iPS cells can form adult cells whereas embryonic cells form younger cells **(1)** • iPS cells will produce patient-matched cells but embryonic stem cells will be antigenic **(1)**	**NB** do not piece together **Accept** have no Hayflick limit **Accept** to specialise e.g. fibroblasts, keratinocytes, kidney epithelium, blood cells **Accept** blastomeres / early embryo (up to 14 days) e.g. Oct4, Sox2, cMyc, KIf4 **Accept** there will be rejection issues using embryonic stem cells but not using iPS cells	**(5)**

Total for Question 4 = 9 MARKS

3 (a) (i)	The only correct answer is: **D** smooth endoplasmic reticulum *A is incorrect as centriole has microtubules* *B is incorrect as a nucleus has a nucleolus* *C is incorrect as there are no ribosomes*		**(1)**

Question Number	Answer	Additional Guidance	Mark
3 (a)(ii)	The only correct answer is: **D** P S R *A is incorrect because the SER is not involved in protein synthesis* *B is incorrect because Golgi should be after the RER* *C is incorrect because the SER is not involved in protein synthesis*		**(1)**

Question Number	Answer	Additional Guidance	Mark
3(a)(iii)	An explanation that makes reference to the following: • (because lysosomes) contain enzymes (1) and **one** from • to {digest / hydrolyse} {pathogens / bacteria / viruses / proteins / antigens} (1) • to digest (old) organelles (1) • for apoptosis / autolysis of cells (1)	**Accept** correct named hydrolytic enzyme, e.g. protease / lysozyme **Accept** other correct biological molecules **Accept** breakdown pathogens / bacteria / viruses / proteins / antigens **with** hydrolytic / digestive enzymes for **2 marks** **Accept** self-digest (damaged) cell	**(2)**

Question Number	Answer	Additional Guidance	Mark
3 (b)(i)	• correct reading from graph (1) • correct calculation of mean total cell volume (1) • correct conversion into two significant figures (1)	Example: 17 or 16 952.94 or 956.25 (ignore dps) **950** or **960** (952.94 or 956.25 gains **two marks)** (950 or 960 gains **three marks**) Correct answer with no working gains full marks	**(3)**

Question Number	Answer	Additional Guidance	Mark
3 (b)(ii)	An answer that makes reference to three of the following points: • (ratio) ICM increases up to 3/4 days (at a steady rate) / trophectoderm cells increase up to 3/4/5 days (1) • (after 3/4 days) ratios increases more steeply for ICM cells / (after 3/4/5 days) levels off for trophectoderm cells (1) • (as ratio increases) {volume of cytoplasm / volume of cells} decreases (over time) (for ICM cells) (1) • cells are differentiating (1)	**Accept** ratio increases up to 3 days **Accept** faster increase for ICM cells **Accept** ICM divide faster than trophectoderm cells	**(3)**

Question	Answer	Additional Guidance	Mark