PEARSON EDEXCEL IAL BIOLOGY · YBI11

BIOLOGY



EXAM QUESTION PACK

UNIT 2: CELL STRUCTURE, REPRODUCTION AND DEVELOPMENT

SCORE	PERCENTAGE
/497	%

STEMUP

These questions belong to Pearson Edexcel, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by Pearson Edexcel. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with Pearson Edexcel and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. Pearson Edexcel has not endorsed, approved or been involved in the production of it. Pearson Edexcel and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

Pearson Edexcel publishes its past papers, mark schemes and examiner reports free of charge. Always check the current specification at qualifications.pearson.com before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Q1.

The photograph shows a Venus fly trap (*Dionaea muscipula*), a plant native to North and South Carolina in the United States.



This plant is found in nitrogen and phosphorus poor environments, such as a bog. The plant catches and digests insects and spiders and absorbs compounds containing nitrogen.

(a) Explain why the Venus fly trap needs compounds containing nitrogen.

(2)

.....

.....

.....

.....

.....

.....

(b) The Venus fly trap secretes extracellular enzymes that digest the insects and spiders it catches.

Describe the role of the Golgi apparatus in forming these extracellular enzymes.

(2)

.....

.....

.....

.....

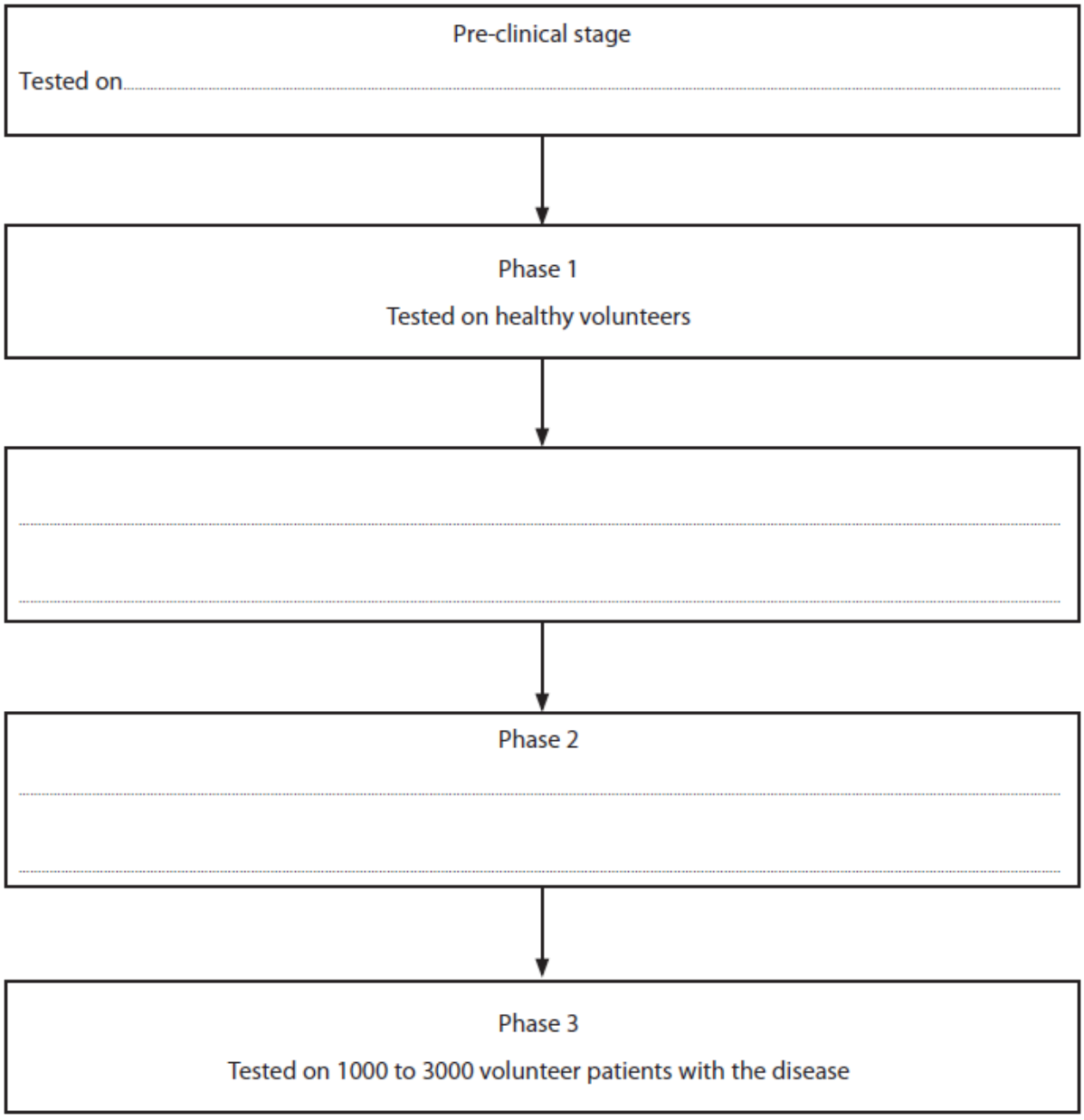
.....

.....

(c) Extracts from Venus fly trap plants are used in some alternative medicines as a treatment for HIV and some cancers.

Complete the diagram to show how an extract could be tested as part of the initial stages of a drug trial.

(3)



(Total for question = 7 marks)

Q2.

Many female organisms produce egg cells containing cortical granules.

(a) Explain how cortical granules ensure that the egg cell is diploid after fertilisation.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

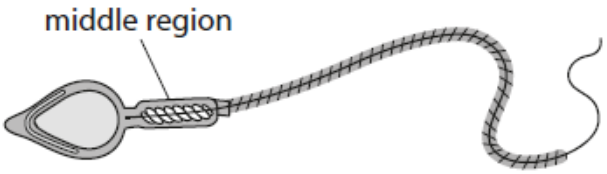
.....

.....

.....

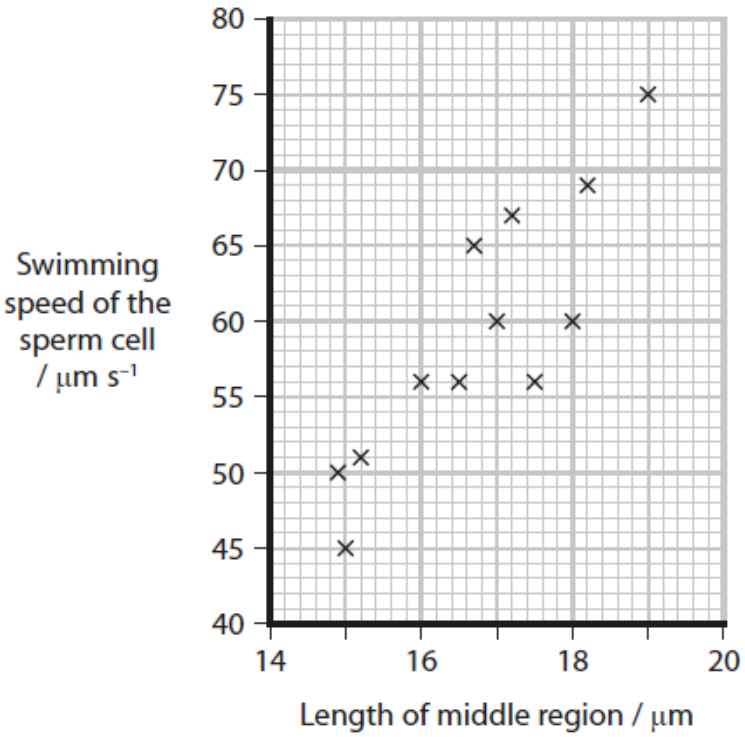
*(b) Organisms have evolved different mating strategies such as:

- Some male animals have sperm cells with longer middle regions, as shown in the diagram.



The females of these species produce multiple egg cells and mate with many males in a short period of time.

The graph shows the effect of the length of the middle region on the swimming speed of the sperm cell.



- Some male animals, such as the zebra longwing butterfly, produce spermatophores that remain inside the reproductive system of the female after mating.

  The spermatophore contains sperm cells and nutrients for the female. The spermatophore also releases chemicals that reduce the attractiveness of this female butterfly to other males.

- Some female animals, such as the eastern box turtle, mate with numerous males and then store the sperm for a number of years. This allows fertilised egg cells to be laid even when the female has not mated in that year.

Comment on the effect that these three mating strategies would have on the reproductive success of the males and females, and the genetic diversity of the offspring.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

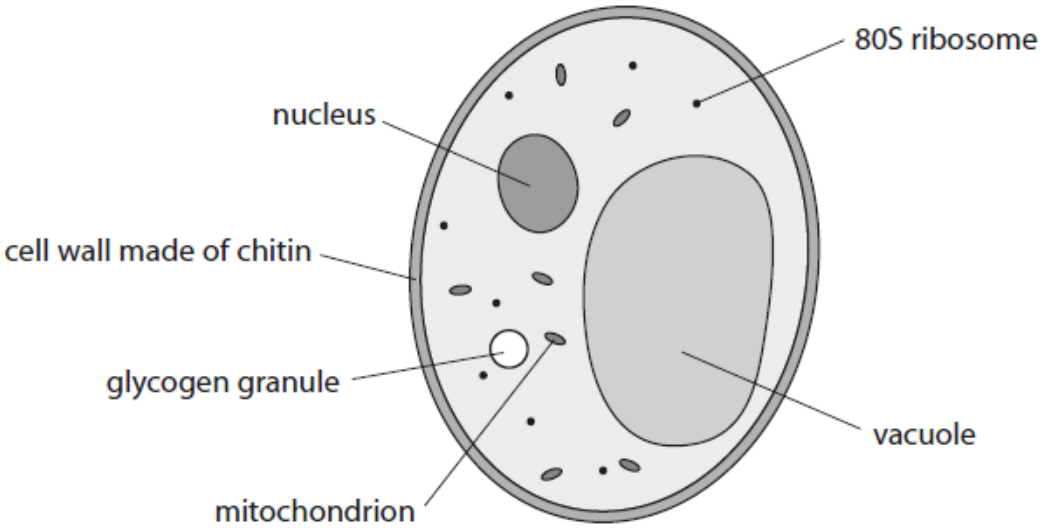
.....

(Total for question = 10 marks)

Q3.

Some fungi infect plants and affect the expression of the plant genes.

(a) A student drew and labelled a fungal cell.



Compare and contrast the structure of this fungal cell and a plant cell.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) The photograph shows darnel, a species of grass.



© blickwinkel / Alamy Stock Photo

The fungus *Epichloë festucae* lives within darnel for part of its life cycle.

The fungus influenced the expression of certain genes in the plant cells.

- There was reduced expression of some genes involved in DNA synthesis.
- There was reduced expression of some genes involved with the synthesis of phospholipids, starch and sucrose.

(i) Explain the effect of this fungal infection on the growth of the plant.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

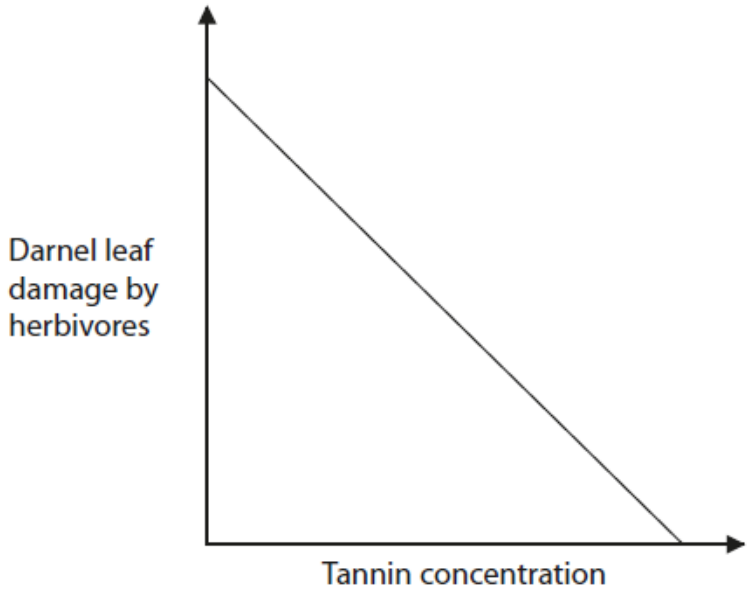
*(ii) The fungus and the plant both benefit from this relationship.

The fungus absorbs nutrients from the plant.

The expression of certain genes in the plant cells is increased when infected with the fungus.

These genes are involved in the synthesis of tannin and flavonoids.

The graph shows the relationship between tannin concentration and the degree of darnel leaf damage by herbivores (grazing animals).



The table shows the antimicrobial effect of different concentrations of flavonoids on cultures of the bacterium *Pseudomonas aeruginosa*. This bacterium causes disease in plants.

Flavonoid concentration / $\mu g\ cm^{-3}$	Diameter of inhibition zone / mm
500	7.0
666	8.0
1000	9.0

The fungus increases the expression of the genes involved in the synthesis of tannin and flavonoids.

Discuss the advantages and disadvantages of this for the fungus and for the infected plants.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(iii) The bacterium *Pseudomonas aeruginosa* causes lung infections in humans.

Describe how a drug containing flavonoids could be tested in a stage II drug trial.

(2)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

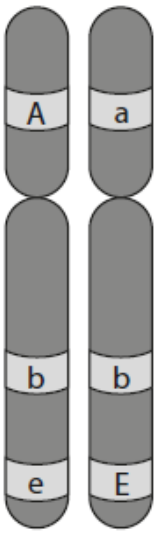
(Total for question = 15 marks)

Q4.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

The nucleus of a cell contains chromosomes.

The diagram shows three genes present on a pair of chromosomes.



(a) (i) How many of the following statements about this diagram are correct?

- there are three gene loci
- the pair of chromosomes will be separated into different cells following mitosis
- one chromosome was inherited from the mother and one chromosome was inherited from the father

(1)

☒ **A** none

☒ **B** one

☒ **C** two

☒ **D** three

(ii) Describe what will happen to these chromosomes when they enter the interphase stage of the cell cycle.

(2)

.....

.....

.....

.....

.....

.....

(b) Crossing over between pairs of chromosomes increases genetic variation.

(i) Name the stage of meiosis in which crossing over begins.

(1)

.....

(ii) How many of the following combinations could result from one crossover of the chromosomes shown in the diagram?

- AbE
- ABe
- abE
- abe

(1)

☒ **A** one

☒ **B** two

☒ **C** three

☒ **D** four

(iii) Explain why alleles b and e are more likely to be inherited together than alleles A and e.

(2)

.....

.....

.....

.....

.....

.....

.....

(Total for question = 7 marks)

Q5.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

The number and size of Golgi apparatus vary depending on the type of cell.

(a) (i) Draw a labelled diagram of the Golgi apparatus.

(4)

(ii) How many of the following are functions of the Golgi apparatus?

- formation of extracellular enzymes
- modification of proteins
- formation of peptide bonds through condensation reactions

(1)

☒ **A** none

☒ **B** one

☒ **C** two

☒ **D** three

(iii) A cell was supplied with radioactive amino acids. The cell took in these amino acids and

used them in protein synthesis.

Which structure in the cell would become radioactive first?

(1)

☒ **A** centrioles

☒ **B** Golgi apparatus

☒ **C** lysosomes

☒ **D** ribosomes

(b) In a mammalian cell, there was one Golgi apparatus with a diameter of 1.1 µm.

In a maize cell, there were 600 Golgi apparatus. The largest diameter of Golgi apparatus in the maize cell was 0.5 µm.

(i) Calculate the percentage difference in these diameters.

(1)

Answer ..... %

(ii) The number and size of the Golgi apparatus in the maize cell increases during one stage of the cell cycle.

In which stage of the cell cycle would the number and size of the Golgi apparatus increase?

(1)

☒ **A** anaphase

☒ **B** interphase

☒ **C** prophase

☒ **D** telophase

(iii) Suggest why the number and size of the Golgi apparatus change during the cell cycle.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

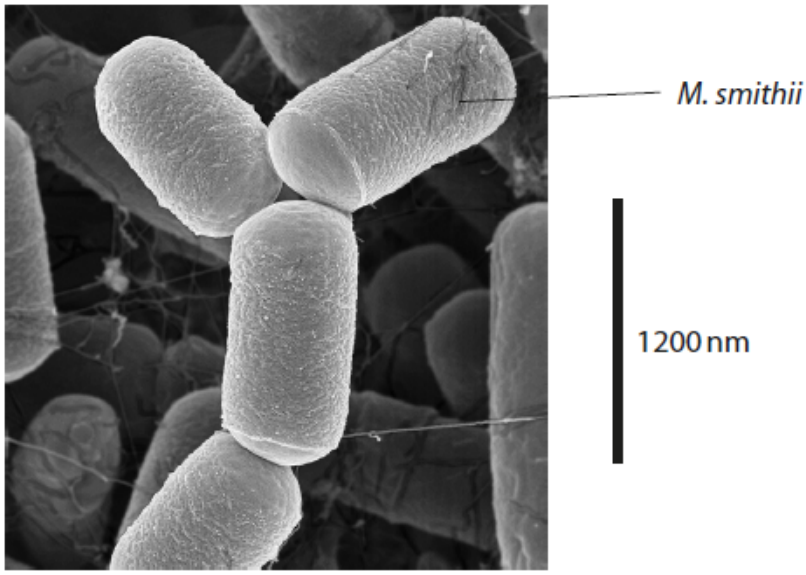
.....

(Total for question = 12 marks)

Q6.

Methanobrevibacter smithii (*M. smithii*) is a single-celled microorganism found in the human intestine.

The photograph shows *M. smithii*.



(© DENNIS KUNKEL MICROSCOPY / SCIENCE PHOTO LIBRARY)

(a) (i) Calculate the magnification of this photograph.

Give your answer in standard form to two significant figures.

(2)

Answer .....

(ii) Explain which type of microscope was used to take this photograph.

(2)

.....

.....

.....

.....

.....

.....

(b) Scientists classified this microorganism as a species in the domain Archaea.

(i) Describe the information the scientists would have used to classify *M. smithii* into the Archaea domain.

(2)

.....

.....

.....

.....

.....

.....

(ii) Scientists have identified a similar microorganism in the human mouth.

This microorganism is called *Methanobrevibacter oralis* (*M. oralis*).

Explain how the scientists could confirm that *M. smithii* and *M. oralis* are different species of Archaea.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

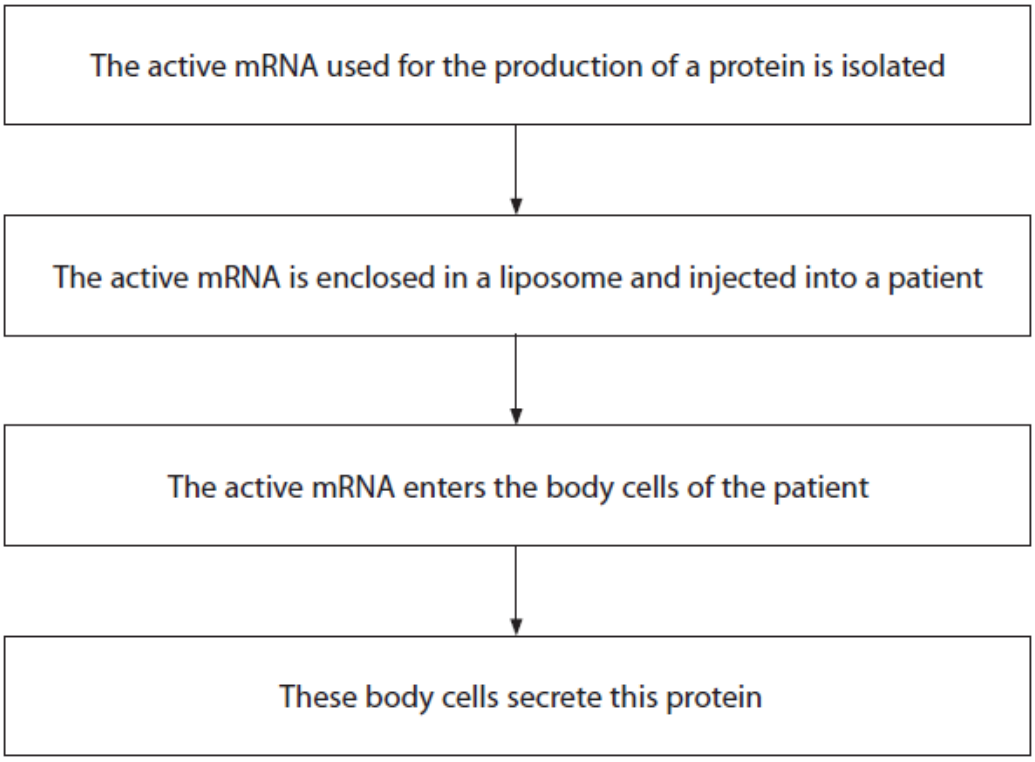
.....

(Total for question = 9 marks)

Q7.

A new vaccine has been developed that contains active mRNA.

The flow diagram shows how this vaccine causes body cells to produce a new protein.



(a) The diameter of one spherical liposome was 75 nm.

Calculate the volume of this liposome using the formula:

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

Give your answer in standard form.

(2)

Answer ..... nm^3

(b) Active mRNA is formed after post-transcriptional modification of pre-mRNA.

The structure of pre-mRNA produced from transcription is different from the structure of active mRNA.

Compare and contrast the structures of pre-mRNA and active mRNA.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 6 marks)

Q8.

The scientist Carl Woese proposed the three-domain system of classification.

The photograph shows *Haemanthus albiflos*, a flowering plant native to South Africa.



(Source: © COULANGES/Shutterstock)

(a) (i) Which of the following is the domain for this plant?

(1)

☒ **A** Archaea

☒ **B** Bacteria

☒ **C** Eukarya

☒ **D** Prokaryota

(ii) Describe the evidence that Carl Woese used to support his system of classification.

(2)

.....

.....

.....

.....

.....

.....

(b) A pollen grain can germinate on the stigma of a flower.

After germination, a pollen tube grows through the style.

Explain the function of a pollen tube in the fertilisation of flowering plants.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

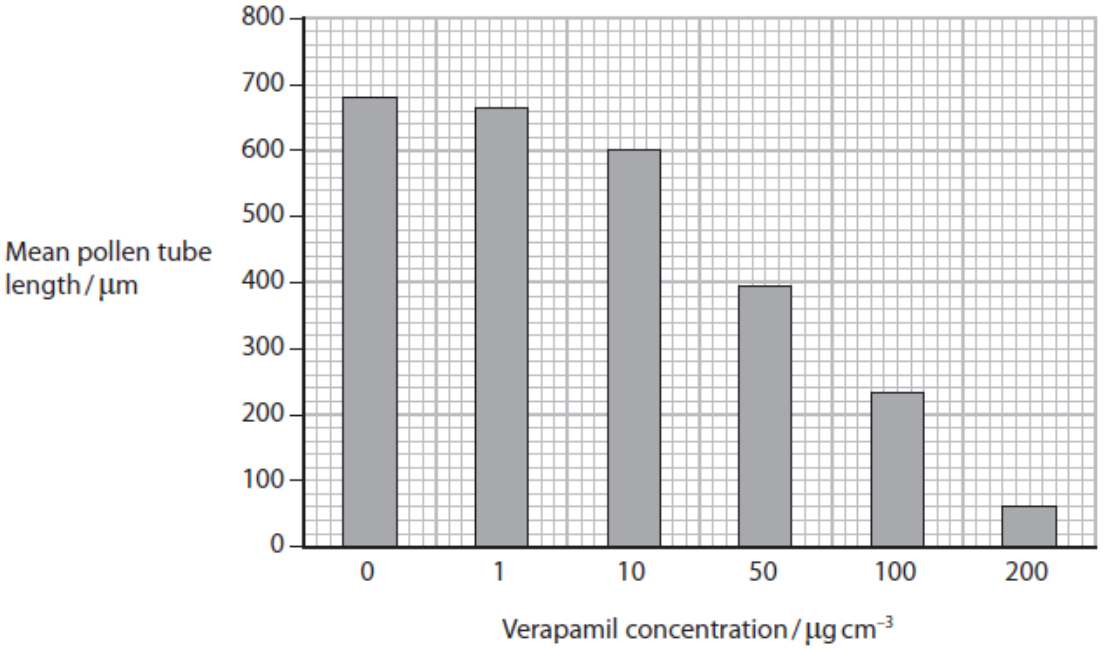
(c) Verapamil is a substance that inhibits the uptake of calcium ions by the pollen tube.

An investigation was carried out to study the effect of Verapamil on the growth of pollen tubes.

Each pollen sample was exposed to a different concentration of Verapamil solution.

The lengths of the pollen tubes in each sample were measured after one hour.

The graph shows the mean length of the pollen tubes after one hour in each concentration of Verapamil.



(i) Determine the effect of Verapamil concentration on the growth of pollen tubes.

(2)

.....

.....

.....

.....

.....

.....

(ii) Explain why Verapamil can reduce the strength of cell walls.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 11 marks)

Q9.

The photograph shows the caterpillar of a moth from Costa Rica.

The caterpillar looks like a pit viper snake. It will try to strike potential predators.



(Source: © Avalon/Photoshot License / Alamy Stock Photo)

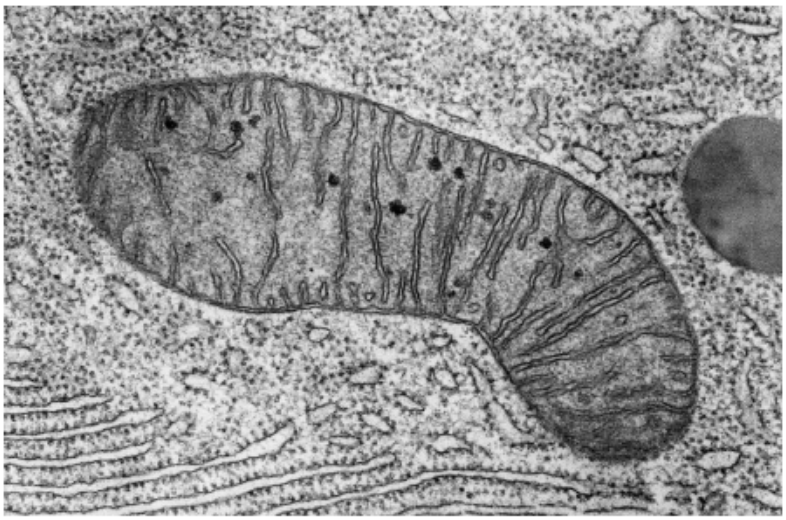
(a) This caterpillar is adapted to its niche.

Complete the table to show the type of adaptations shown by this caterpillar.

(2)

Feature	Type of adaptation
looks like a pit viper snake	.....
tries to strike potential predators	.....

(b) The photograph shows an organelle that can be found in caterpillar cells, as seen using a microscope.



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

Magnification × 72 500

(i) State the type of microscope used to view this organelle.

(1)

.....

(ii) Describe the function of this organelle.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) Rough endoplasmic reticulum is another organelle found in caterpillar cells.

Draw a labelled diagram of rough endoplasmic reticulum.

(3)

(Total for question = 9 marks)

Q10.

All organisms contain one or more cells.

(a) (i) In which of the following is a cell membrane present?

(1)

☒ **A** animal cells only

☒ **B** animal and plant cells only

☒ **C** plant and prokaryotic cells only

☒ **D** animal, plant and prokaryotic cells

(ii) In which of the following is a cell wall present?

(1)

☒ **A** plant cells only

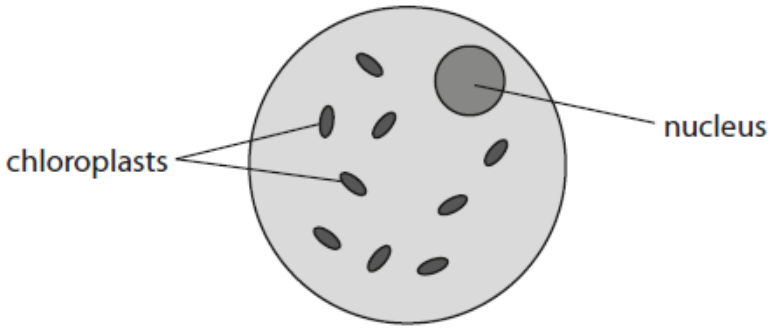
☒ **B** animal and plant cells only

☒ **C** plant and prokaryotic cells only

☒ **D** animal, plant and prokaryotic cells

(b) Sailor's eyeball (*Valonia ventricosa*) is a single-celled, spherical organism.

The diagram shows one of these cells.



(i) The diameter of this cell is 25 µm.

Calculate the magnification of the diagram.

(2)

Answer .....

(ii) This cell contains chloroplasts.

State the function of these chloroplasts.

(1)

.....

.....

.....

(iii) This cell is not a prokaryotic cell as it contains chloroplasts.

Give **one** other reason why this organism is not a prokaryotic cell.

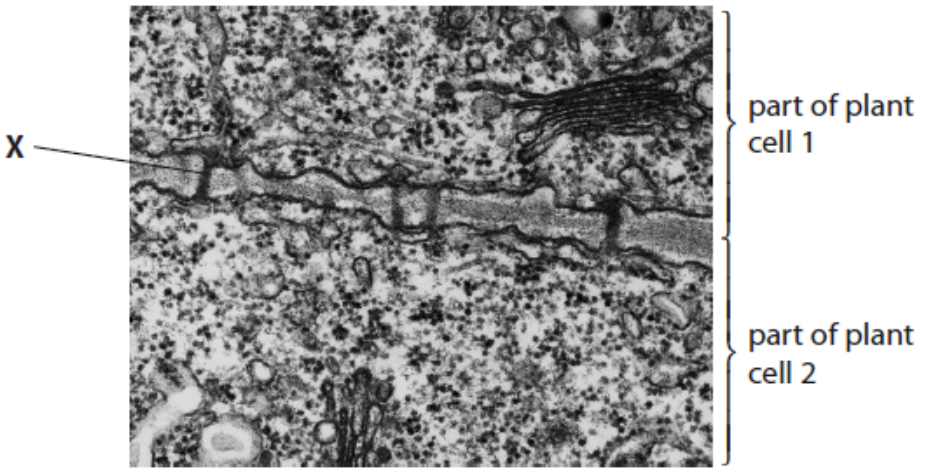
(1)

.....

.....

.....

(c) The photograph shows part of two adjoining plant cells, as seen using an electron microscope.



(Source: © biophoto associates/Getty Images)

(i) Name the part labelled **X**.

(1)

.....

(ii) Explain the function of the part labelled **X**.

(2)

.....

.....

.....

.....

.....

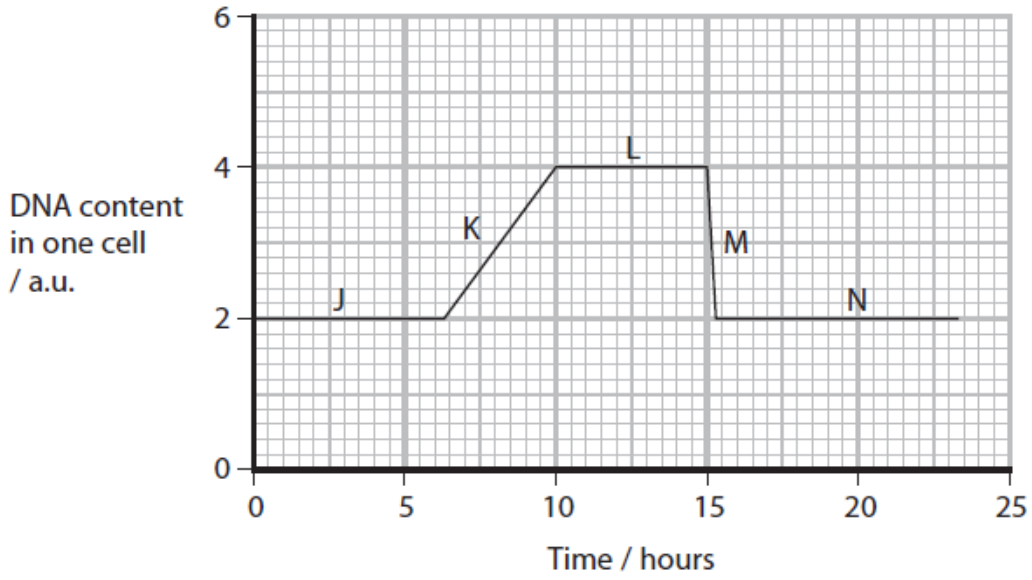
.....

(Total for question = 9 marks)

Q11.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The graph shows the changes in the DNA content of one cell during one cell cycle.



(a) (i) In which part of the graph is the DNA being replicated?

(1)

☒ **A** J

☒ **B** K

☒ **C** L

☒ **D** M

(ii) In which part of the graph would the condensation of chromosomes be completed?

(1)

☒ **A** J

☒ **B** L

☒ **C** M

☒ **D** N

(b) Centrioles are involved in spindle formation.

(i) Name the stage of mitosis when spindle fibres begin to form.

(1)

.....

(ii) Explain the role of the spindle in mitosis.

(2)

.....

.....

.....

.....

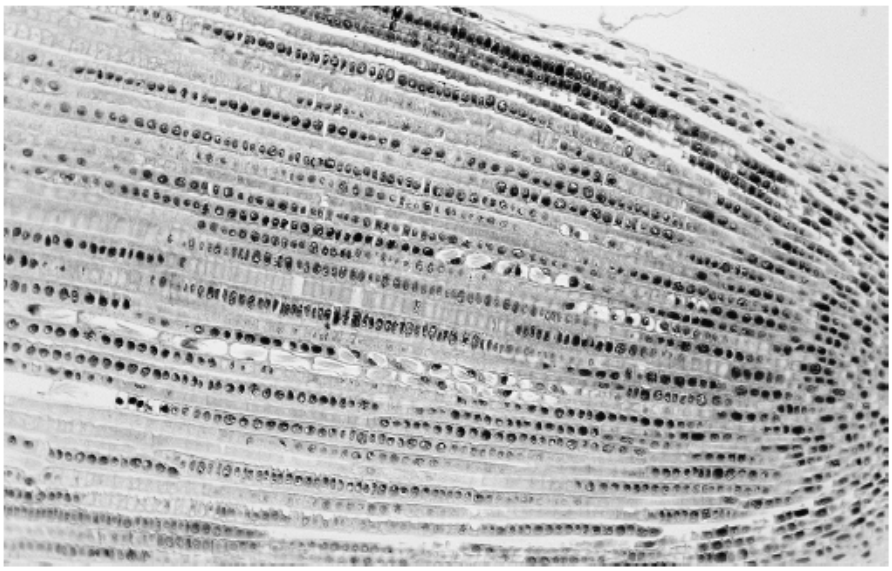
.....

.....

(iii) Draw a plant cell undergoing cell division, after mitosis has just finished.

(2)

(c) The photograph shows a section through a root tip, as seen using a microscope.



(Source: © agefotostock / Alamy Stock Photo)

Describe how to determine the mitotic index of this tissue.

(2)

.....

.....

.....

.....

.....

.....

(Total for question = 9 marks)

Q12.

Stomach ulcers are sores that develop in the lining of the stomach.

The mucus produced by the stomach prevents bacteria from reaching the lining of the stomach.

Stomach ulcers can be caused by infection with the bacterium *Helicobacter pylori*.

These bacteria reproduce in the stomach as it provides all the conditions required for the growth of bacteria.

(a) Explain the conditions needed for the growth of bacteria.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) The plant *Cibotium barometz* is native to several countries in East Asia.

The photograph shows hairs on the surface of this plant.



(Source: © Mauro Rodrigues/123RF)

Extracts from the hairs on this plant have antimicrobial properties.

An investigation compared the use of this extract and the drug omeprazole to treat stomach ulcers in rats.

The mass of mucus and the area of ulcer were measured in five groups of rats.

The table shows the treatments and the results of this investigation.

Group	Treatment / mg kg^{-1}	Mean mass of mucus / g	Mean area of ulcer / mm^2
Control rats with no ulcer	0.00	2.28	0.00
Control rats with ulcer	0.00	0.75	802.71
Rats with ulcer treated with omeprazole	20.00	1.92	95.71
Rats with ulcer treated with extract	125.00	1.87	202.80
Rats with ulcer treated with extract	500.00	2.17	172.80

(Source: adapted from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5244617/)

(i) Calculate the percentage decrease in the mean areas of ulcer of the rats treated with omeprazole compared with
the control rats with ulcer.

(2)

Answer ..... %

*(ii) Explain the results of this investigation.

Use all the information in Question 6 to support your answer.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 12 marks)

Q13.

The five stages of cancer are used to describe the size and spread of a cancer in a human body.

(a) The mitotic index of a tissue can be used to determine the stage of cancer.

A higher mitotic index is usually linked to a later stage of cancer.

The mitotic index is calculated using the formula

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

Tests were performed on three patients, P, Q and R, who had cancer.

The table shows the number of cells that were counted in each stage of the cell cycle per mm2 of tissue, taken from the same organ in each patient.

Patient	Interphase	Prophase	Metaphase	Anaphase	Telophase
P	16	1	3	0	0
Q	14	2	1	1	2
R	11	2	2	3	2

(i) State what is meant by the term **tissue**.

(1)

.....

.....

.....

(ii) Using the data in the table, determine the stages of cancer in patients P and R.

(3)

.....

.....

.....

.....

.....

.....

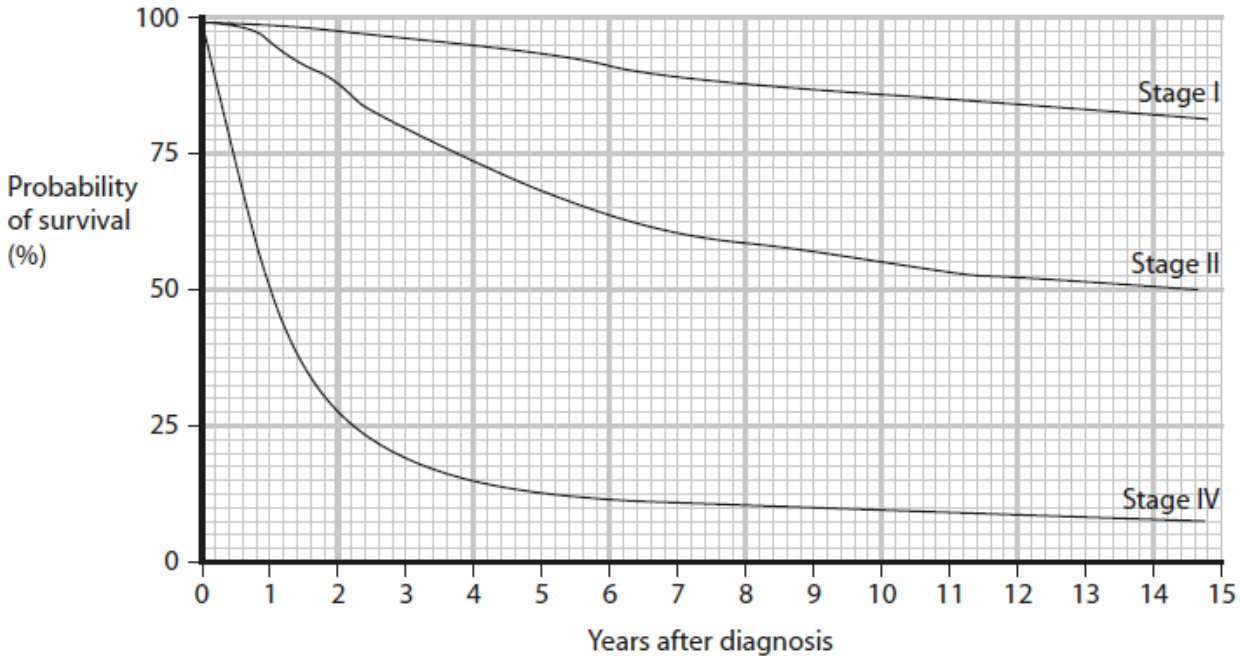
.....

.....

.....

.....

(b) The graph shows the probability of survival for different stages of a cancer, after diagnosis.



(Source: http://www.mmmp.org/MMMP/import.mmmp?page=tnm_staging.mmmp)

Compare and contrast the probabilities of survival for the different stages of this cancer, as shown by the graph.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) Anticancer drugs have to undergo double-blind trials before they are used to treat patients.

Describe how a placebo is used in a double-blind trial.

(2)

.....

.....

.....

.....

.....

.....

(Total for question = 9 marks)

Q14.

The photograph shows a Baird's tapir.



Source: https://www.biolib.cz/IMG/GAL/171566.jpg

(a) Baird's tapir is endemic to countries in Central America.

State what is meant by the term **endemic**.

(1)

.....

.....

.....

(b) Baird's tapir is classified as endangered.

In 2006, it was estimated that there were 5500 Baird's tapirs. This number had fallen to 3000 in 2016.

(i) Calculate the percentage decrease in the number of Baird's tapirs from 2006 to 2016.

(2)

Answer ..... %

(ii) Explain how human activity, other than hunting, could have caused this decrease in the

number of Baird's tapirs.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) Preservation of sperm collected from Baird's tapir may help captive breeding programmes.

Scientists investigated the effect of freezing on sperm from Baird's tapir.

The sperm were frozen and then thawed.

The results of this investigation are shown in the table.

Sperm	Percentage of sperm capable of moving (%)	Ability of sperm to swim in a straight line / a.u.	Percentage of sperm with an undamaged acrosome (%)
Freshly collected	63	3.5	80
Frozen and then thawed	38	2.5	48

(i) Describe how each of these effects of freezing could be determined.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(ii) Explain how freezing sperm could affect the success of captive breeding programmes.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 13 marks)

Q15.

All living organisms are made of cells.

Eukaryotic cells and prokaryotic cells have some features in common and some differences.

(a) (i) Which cells have a cell wall?

(1)

☒ **A** plant cells only

☒ **B** animal cells and prokaryotic cells

☒ **C** plant cells and prokaryotic cells

☒ **D** animal cells, plant cells and prokaryotic cells

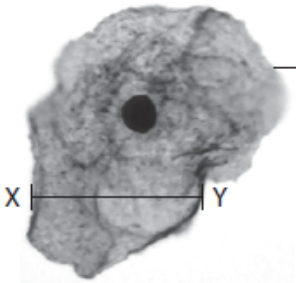
(ii) Eukaryotic cells contain a nucleus.

Draw a labelled diagram of a nucleus, as seen using an electron microscope.

(4)

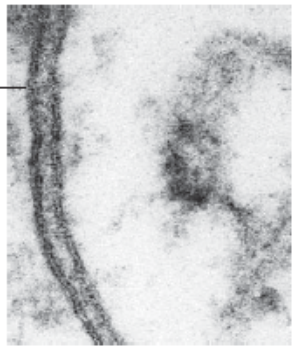
(b) The photographs show a cell as seen using a light microscope and part of two cells using an electron microscope.

The bilayer structure of the cell surface membrane can be seen only with an electron microscope.



(Source: © Komsan Loonprom/Shutterstock)

Cell seen using a light microscope



(Source: © Dennis Kunkel Microscopy /Science Photo Library)

Part of cells seen using an electron microscope

(i) Explain why the bilayer structure of the cell surface membrane could not be seen using a light microscope.

(2)

.....

.....

.....

.....

.....

.....

(ii) The light microscope magnified the cell 200 times.

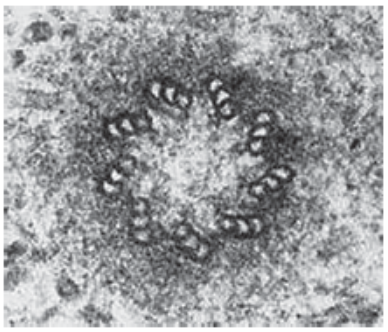
Calculate the actual width of this cell by measuring the line XY.

Give your answer in µm.

(3)

Answer ..... µm

(iii) The photograph shows an organelle that can be found in a eukaryotic cell, as seen using an electron microscope.



Describe the function of this organelle.

(2)

.....

.....

.....

.....

.....

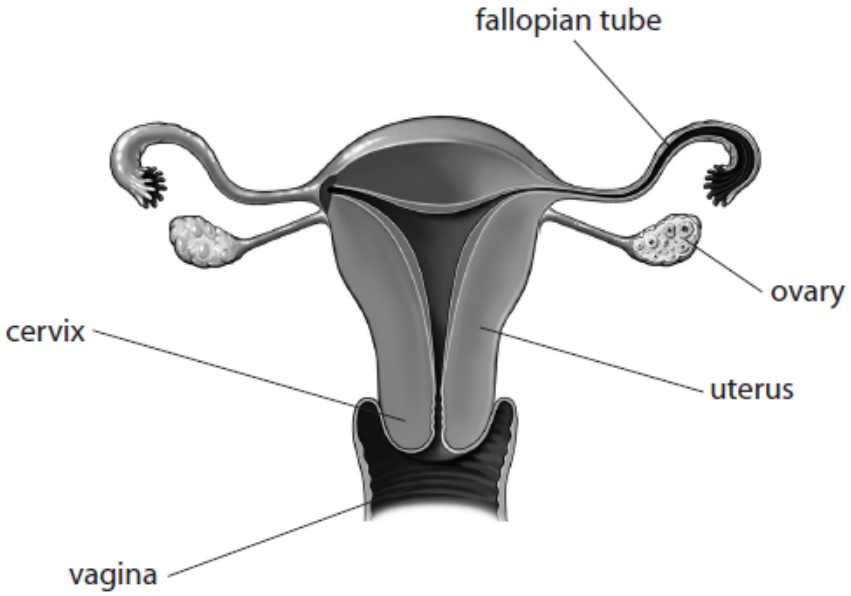
.....

(Total for question = 12 marks)

Q16.

Answer the questions with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The diagram shows an organ system of a human female.



(Source: © Nucleus Medical Media Inc / Alamy Stock Photo)

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

(1)

.....

.....

.....

(b) Gametes are produced in one of the tissues in the ovary.

(i) State what is meant by the term **tissue**.

(1)

.....

.....

.....

(ii) Gametes are specialised for their functions.

Complete the table to show the correct statement for each structure found in gametes.

(4)

Structure	Propels male gamete towards female gamete	Modified by the action of cortical granules	Produces ATP by respiration	Contains linear DNA
flagellum	☒ A	☒ B	☐ C	☐ D
mitochondria	☒ A	☒ B	☐ C	☐ D
nucleus	☒ A	☒ B	☐ C	☐ D
zona pellucida	☒ A	☒ B	☐ C	☐ D

(Total for question = 6 marks)

Q17.

Fertilisation in mammals, such as the African northern white rhino, results in the fusion of gamete nuclei.

The photograph shows the last two remaining northern white rhinos.

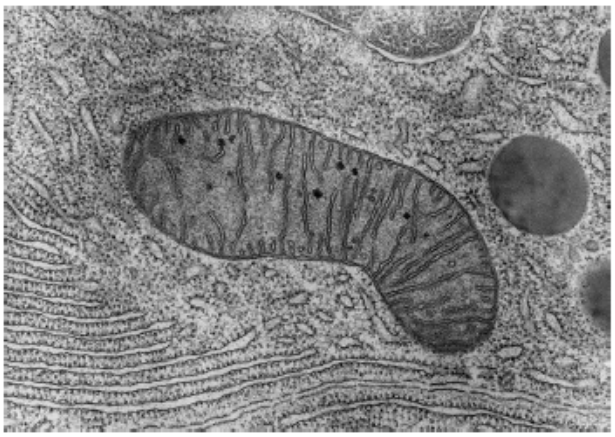
Both of these rhinos are female.

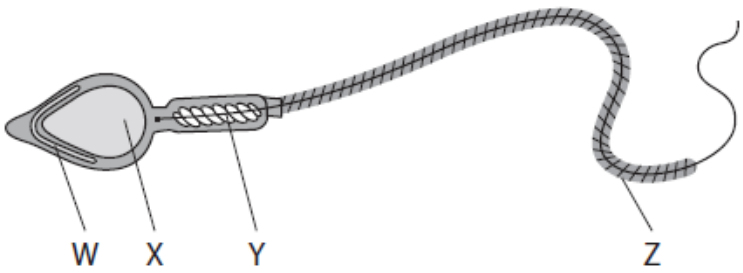


(Source: © Xinhua/Alamy Stock Photo)

Sperm and tissue samples were taken from the last few male northern white rhinos before they died. The sperm samples were frozen.

(a) The photograph shows an organelle taken from a sperm cell, as seen using an electron microscope. The diagram shows a sperm cell.





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

In which part of this sperm cell would this organelle be found?

(1)

☒ **A** W

☒ **B** X

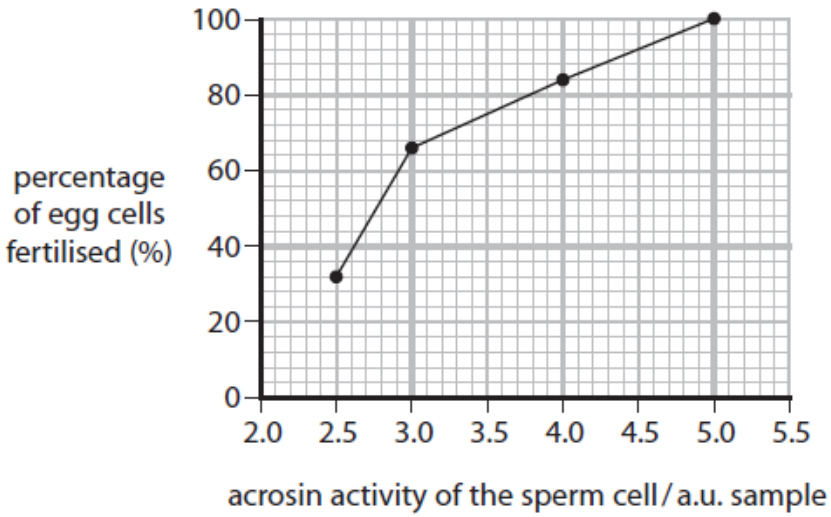
☒ **C** Y

☒ **D** Z

(b) Sperm cells contain a digestive enzyme called acrosin.

The effect of acrosin activity of samples of sperm cells on the percentage of egg cells fertilised was investigated.

The graph shows the results of this investigation.



(i) Describe the role of **one** organelle involved in the production of this enzyme.

Organelle

.....

Role

.....

.....

.....

(ii) The investigation used 2500 egg cells for each sample of sperm cells.

Calculate the number of egg cells that would have been fertilised by sperm cells with 2.5 a.u. acrosin activity.

(1)

Answer .....

(iii) Explain why a higher activity of the digestive enzyme acrosin resulted in a higher percentage of egg cells being fertilised.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

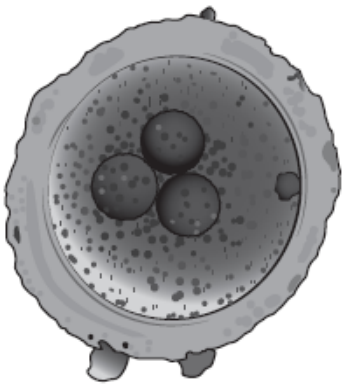
.....

.....

(c) In vitro fertilisation (IVF) has been used to fertilise northern white rhino egg cells using the frozen sperm samples.

The zona pellucida of some egg cells were damaged when they were removed from the ovaries of the females.

The drawing shows a fertilised egg cell with three nuclei.



magnification ×200

(i) State how to calculate the actual size of this egg cell.

(1)

.....

.....

(ii) Suggest why this fertilised egg cell has three nuclei.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 12 marks)

Q18.

Egg cells are produced by many organisms.

The development of fish embryos can be studied using fertilised egg cells.
The photograph shows part of a beluga fish from the Caspian Sea.



(Source: © Design Pics / Alamy Stock Photo)

(a) Explain how an egg cell is specialised for its function.

(2)

.....

.....

.....

.....

.....

.....

(b) A student studied beluga fish cells undergoing mitosis and meiosis.

(i) Compare and contrast metaphase in mitosis and meiosis.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(ii) Some of the cells undergoing mitosis were from a beluga morula whereas some of the cells were from a beluga blastocyst.

Explain how the cells of the beluga morula change as they develop into the cells of the blastocyst.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) Chickens produce eggs.
The effect of the age of a chicken on the mass of the eggs it laid was investigated.

A statistical test can be used to see if there is a significant correlation between the age of a chicken and the mass of her eggs.

The value generated by this statistical test will always be between −1.0 to +1.0.

The table shows the mass of eggs collected from chickens of different ages.

Age / weeks	Rank of age	Mass of egg / g	Rank of mass of egg	D	D^2
36	1	2.27	8	−7	49
39	2	1.91			
42	3	2.18	5.5	−2.5	6.25
45	4	2.28	9	−5	25
48	5	2.12	4	1	1
51	6	2.19	7	−1	1
54	7	2.18	5.5	1.5	2.25
57	8	2.09	3	5	25
60	9	2.03	2		

(i) Calculate the value for $\sum D^2$.
Use the table to help you.

(2)

$\sum D^2 =$ .....

(ii) Calculate the correlation coefficient, r_s value, for this data using the formula:

(2)

$$r_s = 1 - \frac{6\left(\sum D^2\right)}{n\left(n^2 - 1\right)}$$

Answer .....

(iii) The null hypothesis is that there was no significant correlation between the age of the chicken and the mass of the eggs laid.
Another scientist replicated this study and gained a correlation coefficient value of 0.38.
The table shows the critical values at the 95% probability level.

Number of pairs of data	Critical values at the 0.05 % probability level
8	0.738
9	0.683
10	0.648

Explain whether the null hypothesis should be accepted or rejected.

(2)

.....

.....

.....

.....

.....

.....

(Total for question = 15 marks)

Q19.

The photograph shows a species of harvest mouse native to countries in Asia.



(Source: © Mark Bridger/Shutterstock)

(a) The body of this species of harvest mouse is 55 mm to 75 mm long and its tail is 50 mm to 75 mm long.

The body of the Indian flat-haired mouse is 10 cm to 12 cm long and its tail is 7 cm to 8 cm long.

Calculate the percentage difference in **minimum** total length of the Indian flat-haired mouse compared with the **minimum** total length of the harvest mouse.

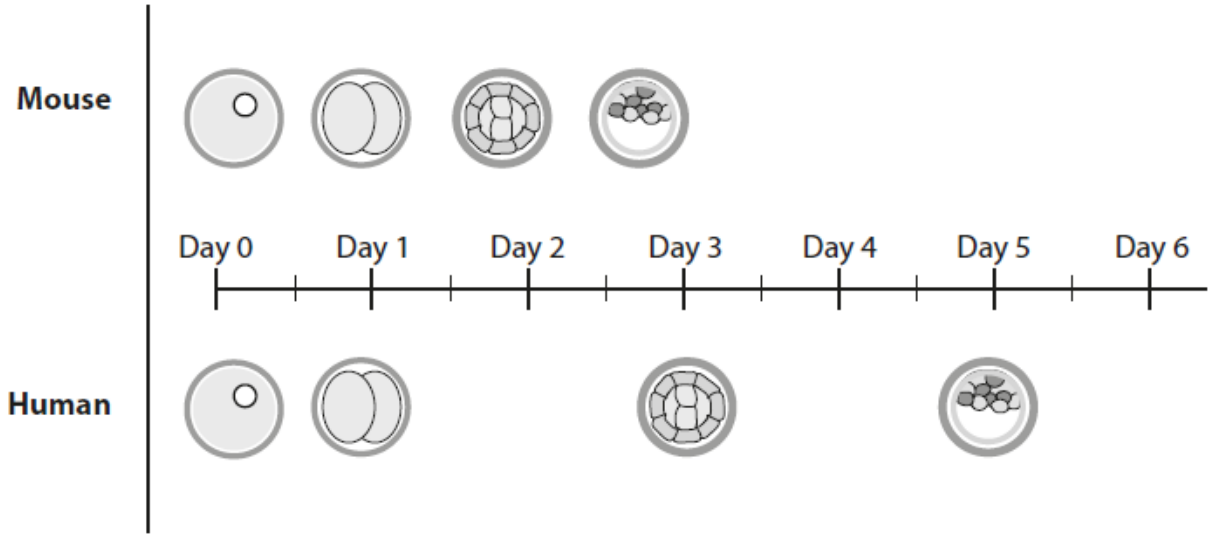
Give your answer to **two** significant figures.

(2)

Answer ..... %

(b) The diagram shows the timeline for the structures formed after fertilisation in a mouse and in a human.

A fertilised egg cell is called a zygote.



(i) As mouse egg cells develop they accumulate small spherical lipid droplets.

These lipid droplets have a mean radius of 88 μm.

The volume of a sphere (V) is calculated using the formula

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

Which of the following gives the mean volume of a lipid droplet in **mm^3**?

(1)

☒ **A** 2.85×10^{-6}

☒ **B** 2.85×10^{-3}

☒ **C** 2.85×10^{3}

☒ **D** 2.85×10^{6}

(ii) Draw a circle around the part of the diagram that is a mouse morula. Label the circle 'morula'.

(1)

(iii) Describe the events that occur after a sperm cell enters an egg cell, until a zygote is formed.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) Analysis of some mouse egg cells showed that the lipid droplets were located within 10 nm of mitochondria.

Suggest why mitochondria were located within 10 nm of the lipid droplets.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

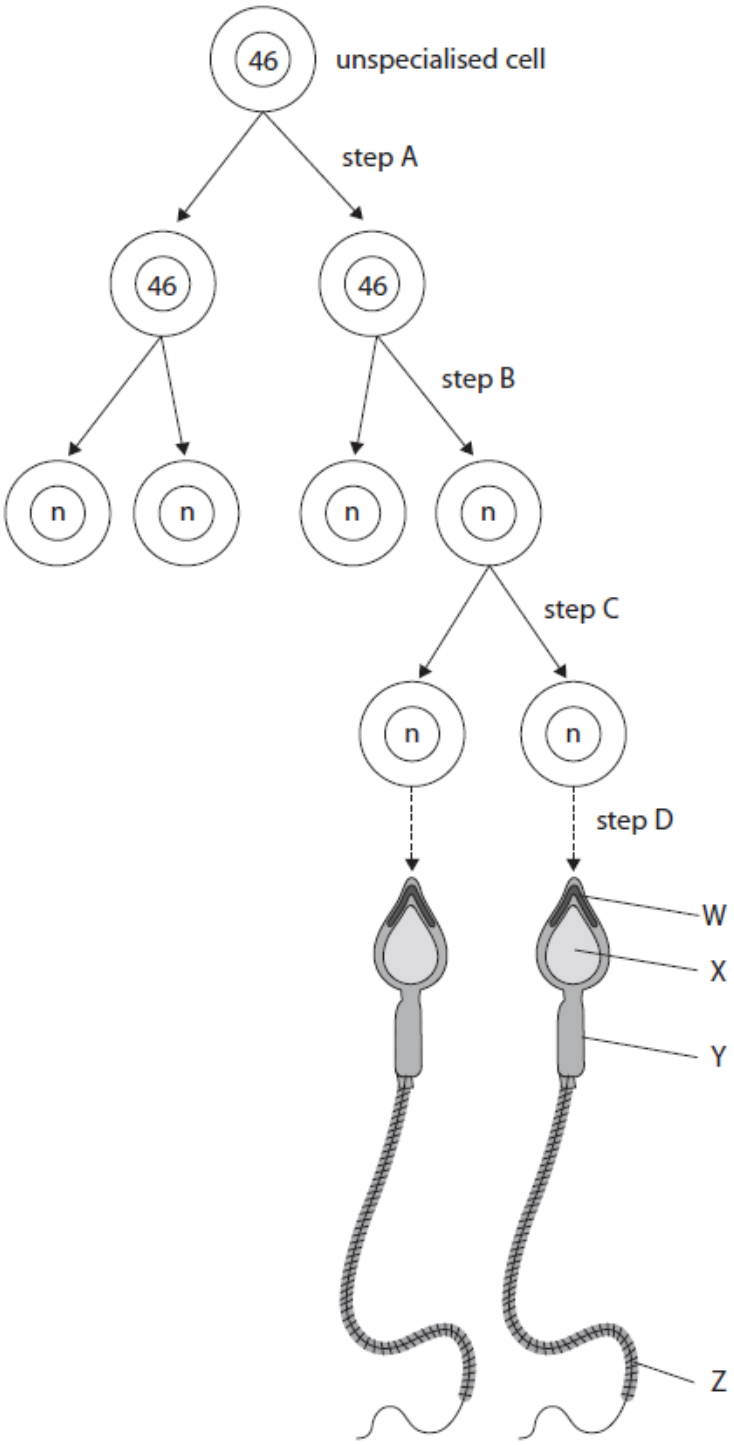
.....

(Total for question = 10 marks)

Q20.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The diagram shows some of the steps involved in the production of human sperm cells from an unspecialised cell. This process involves both mitosis and meiosis.



(a) (i) The unspecialised cell is diploid.

State the types of division occurring at step A and step B.

(2)

step A .....

step B .....

(ii) Which part of the sperm cell contains enzymes that are released to break down the zona pellucida?

(1)

☒ **A** W

☒ **B** X

☒ **C** Y

☒ **D** Z

(b) A sperm cell is a specialised cell.

Explain what happens at step D for the cell to become a specialised sperm cell.

(5)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) The nucleus of a sperm cell fuses with the nucleus of an egg cell to form a zygote. The zygote develops into a blastocyst.

(i) Draw a diagram to show the arrangement of the cells of a blastocyst.

(2)

(ii) The blastocyst contains some pluripotent stem cells.

Which of the following describes these pluripotent stem cells?

(1)

☒ **A** adult stem cells that can give rise to most types of cell in the body, including totipotent

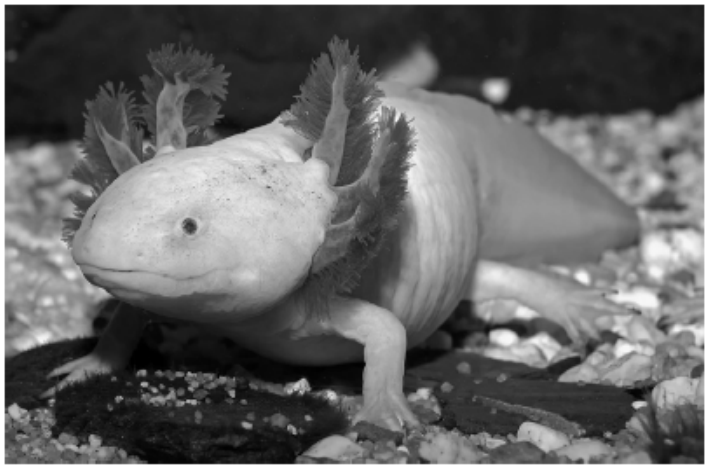
cells

☒ **B** adult stem cells that can give rise to most types of cell in the body, excluding totipotent cells

☒ **C** embryonic stem cells that can give rise to most types of cell in the body, including totipotent cells

☒ **D** embryonic stem cells that can give rise to most types of cell in the body, excluding totipotent cells

(d) The photograph shows a Mexican salamander.



(Source: © Imagebroker/Alamy Stock Photo)

Salamanders can regenerate damaged limbs and organs throughout their lives.

An ethics committee has approved the use of stem cells taken from salamanders.

Suggest why the use of stem cells taken from salamander embryos was approved.

(2)

.....

.....

.....

.....

.....

.....

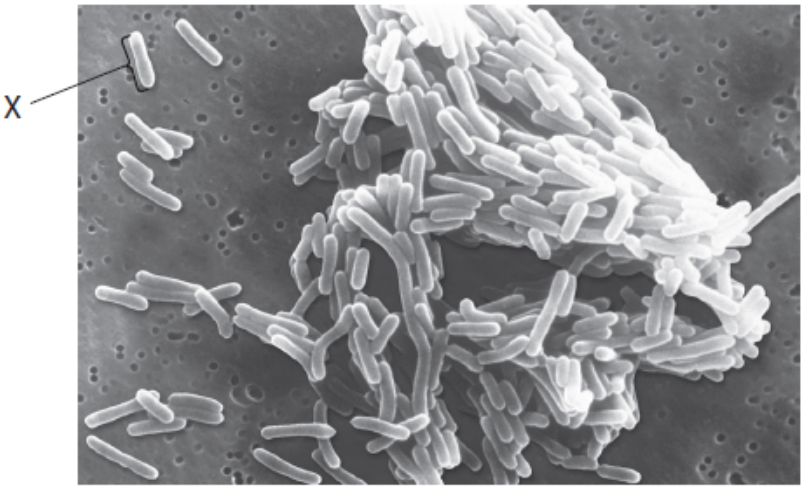
(Total for question = 13 marks)

Q21.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Listeria monocytogenes is a bacterium that contaminates food and causes the disease listeriosis.

The photograph shows a colony of these bacteria, as seen using an electron microscope.



(Source: © BSIP SA / Alamy Stock Photo)

(a) The bacterium labelled X on the photograph is 0.5 µm in length.

(i) Calculate the magnification of this image.

(1)

Answer .....

(ii) State why a light microscope cannot be used to view these bacteria.

(1)

.....

.....

.....

(b) The photograph shows a bottle of oil extracted from the plant oregano. This plant is native to Mediterranean and western Asian countries.



(Source: © Frank Hecker / Alamy Stock Photo)

Oregano oil contains antimicrobial substances.

This oil can be used in the production of plastic used to package food.

Explain why this packaging may be chosen over traditional oil-based plastic packaging.

(2)

.....

.....

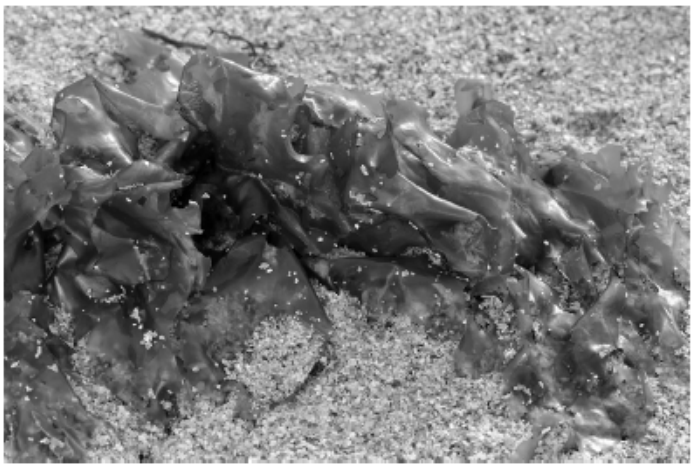
.....

.....

.....

.....

(c) The photograph shows green algae called sea lettuce (Ulva lactuca).



(Source: © Arterra Picture Library / Alamy Stock Photo)

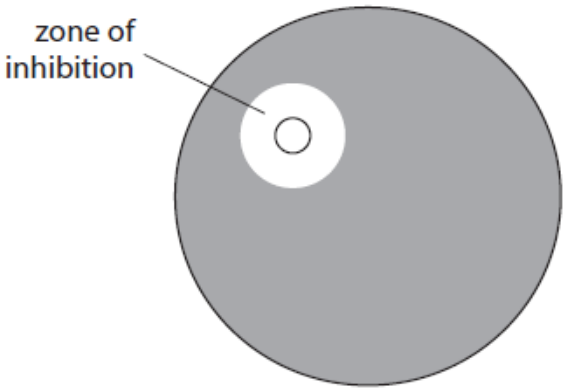
Sea lettuce contains chemicals called fucoxanthins that have antimicrobial properties.

The antimicrobial properties of these chemicals were investigated.

Discs containing fucoxanthin chemical were placed onto four agar plates each seeded with a different type of bacteria.

These plates were then incubated for 24 hours at 25 °C and the zone of inhibition measured.

The diagram shows the zone of inhibition.



The table shows the results of this investigation.

Type of bacteria	Mean diameter of the zone of inhibition / mm	Range / mm
E. coli	10.2	±0.72
S. aureus	11.1	±0.63
L. monocytogenes	6.0	±0.41
P. aeruginosa	7.5	±0.55

(i) Which type of bacteria was least affected by fucoxanthin?

(1)

☒ **A** *E. coli*

☒ **B** *S. aureus*

☒

C *L. monocytogenes*

☒ **D** *P. aeruginosa*

(ii) The table shows the mean and the range of the diameter of the zone of inhibition for each type of bacteria.

Calculate the maximum difference in the diameter of the largest and smallest zones of inhibition.

(1)

Answer ..... mm

(d) Drugs containing these chemicals must be tested for safety before they can be approved and used to treat humans.

Three-phase testing can be used to check for the safety and effectiveness of these chemicals.

Describe the roles of phase I and phase II.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 9 marks)

Q22.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Brazil is the largest producer of sugarcane.

The photograph shows sugarcane plants growing in Brazil.



(Source: © jeep2499/Shutterstock)

(a) Products from sugarcane, such as starch and cellulose, are used to make bioplastic.

(i) How many of the following statements about **starch** are correct?

- contains α-glucose and β-glucose molecules
- contains amylose and amylopectin
- stored in the tonoplast

(1)

☒ **A** none

☒ **B** one

☒ **C** two

☒ **D** three

(ii) How many of the following statements about a **cellulose** molecule are correct?

- contains α-glucose and β-glucose molecules
- contains 1,4 glycosidic bonds
- forms hydrogen bonds with other cellulose molecules

(1)

☒ **A** none

☒ **B** one

☒ **C** two

☒ **D** three

(b) Bioplastic bags made from sugarcane take up to six months to decompose.

Bacteria secrete enzymes onto the bags during the process of decomposition.

(i) Name **two** structures found in bacterial cells that are involved in the synthesis of these enzymes.

(1)

1 .....

2 .....

(ii) Decomposition of bioplastic bags occurs faster if there is increased bacterial growth.

Explain the conditions needed for increased bacterial growth.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

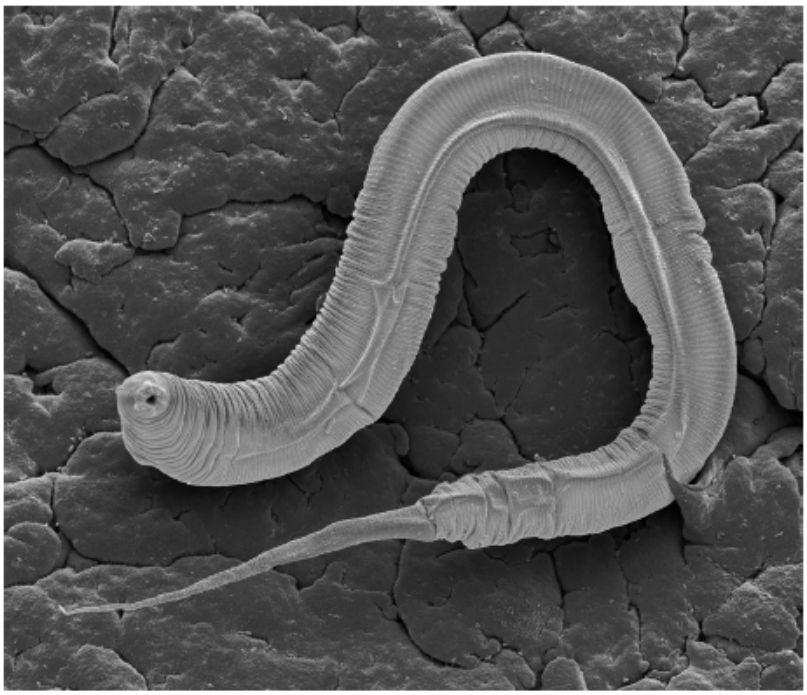
.....

(Total for question = 6 marks)

Q23.

Variation between organisms occurs as a result of sexual reproduction and epigenetic modification.

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



(Source: © Leonid Serebrennikov / Alamy Stock Photo)

* (a) Animals of this species are either male or hermaphrodites.

Nematodes that inherit one sex chromosome are male.

Nematodes that inherit two sex chromosomes are hermaphrodites.

Hermaphrodites can produce both egg cells and sperm. Approximately 300 sperm are produced first and stored inside the nematode. After this, egg cells are produced.

The sperm of a hermaphrodite nematode can fertilise its own egg cells. This is called self-fertilisation.

However, when a hermaphrodite nematode mates with a male nematode, the sperm of the male fertilises the egg cells. This results in 700 more egg cells being fertilised than when a hermaphrodite self-fertilises. Half of these fertilised egg cells will result in male offspring.

Explain how the reproductive behaviour of these nematodes increases their chance of survival.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

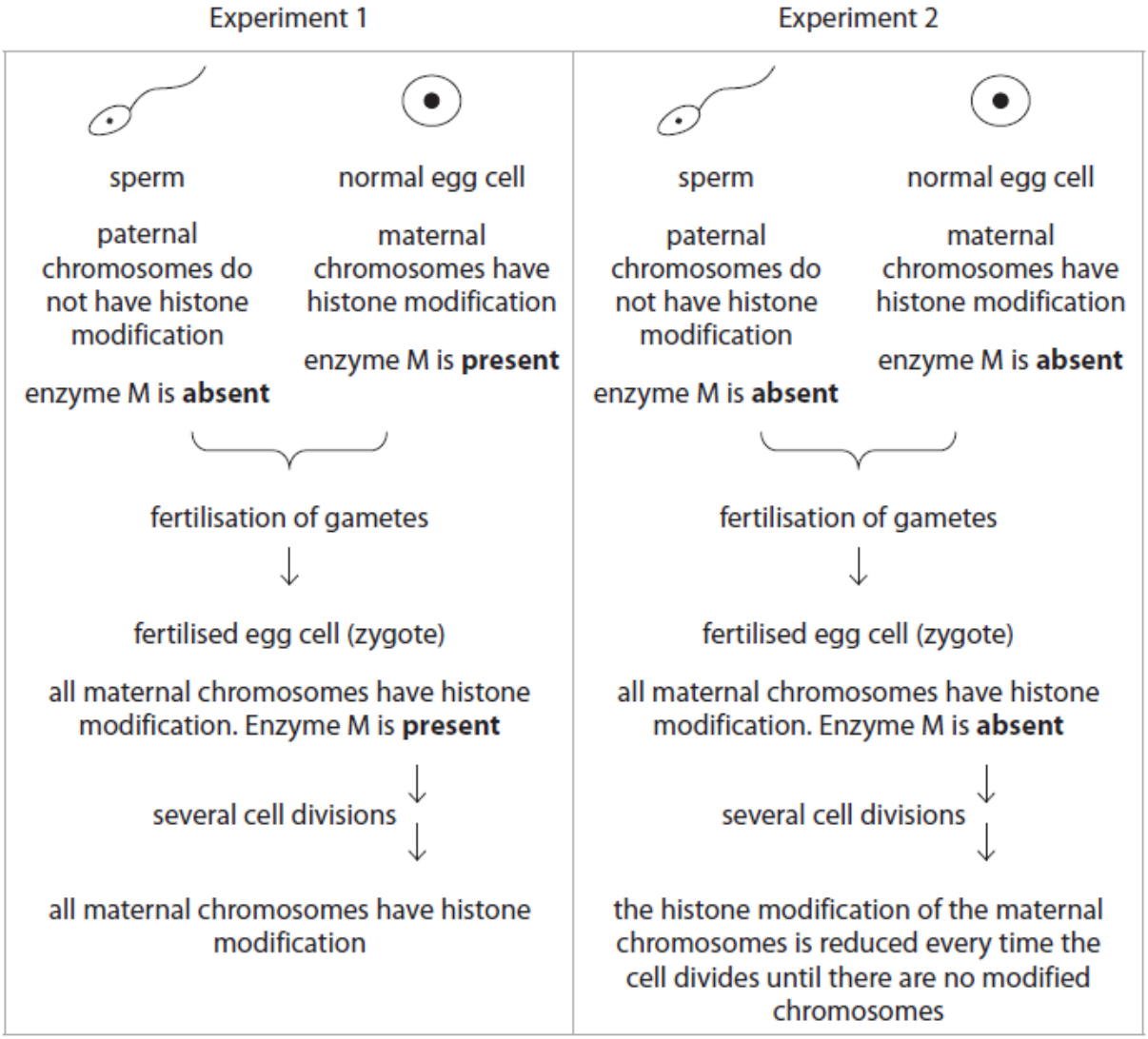
.....

.....

.....

.....

(b) In nematodes, histone modification can be passed onto embryos.
Enzyme M causes this modification.
The diagram shows two experiments that demonstrated this.



Deduce how histone modification can be passed onto embryos.

(5)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 11 marks)

Q24.

Meiosis increases genetic variation through independent assortment and crossing over.

(a) (i) In which stage of meiosis does independent assortment occur?

(1)

☒ **A** metaphase I

☒ **B** metaphase II

☒ **C** telophase I

☒ **D** telophase II

(ii) In which stage of meiosis does crossing over occur?

(1)

☒ **A** metaphase I

☒

B metaphase II

☒ **C** prophase I

☒ **D** prophase II

(b) Genetic variation increases due to the production of new combinations of alleles.

A cell has gene A and gene B with alleles A, a and B, b.

Meiosis could produce the following percentages of gametes containing the combinations of alleles shown in the table.

Combination of alleles	Percentage of total gametes produced (%)
AB	48
Ab	2
aB	2
ab	48

Explain why the percentages are not 25% for each combination of alleles.

(3)

.....

.....

.....

.....

.....

.....

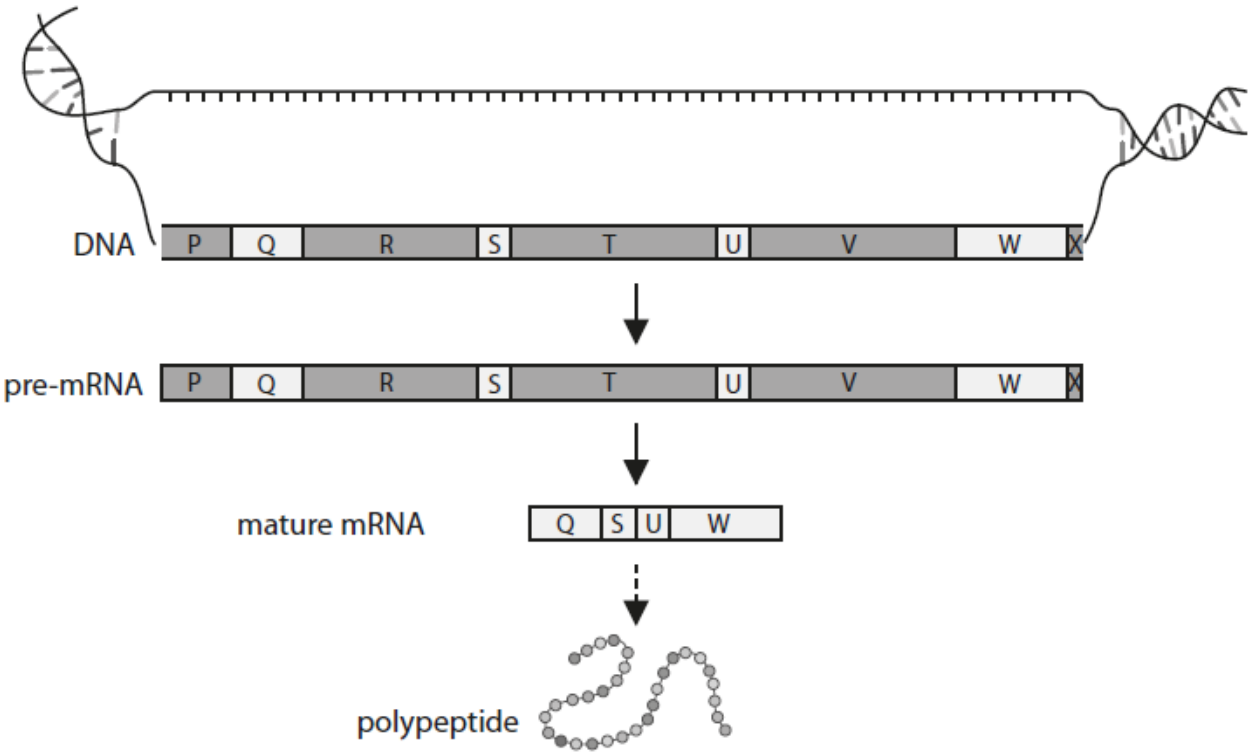
.....

.....

.....

(c) More than one type of protein can be synthesised from the RNA produced from one gene.

The diagram shows parts of this process.



Describe how more than one type of protein can be synthesised from the RNA produced from one gene.

Use the information in the diagram to support your answer.

(5)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

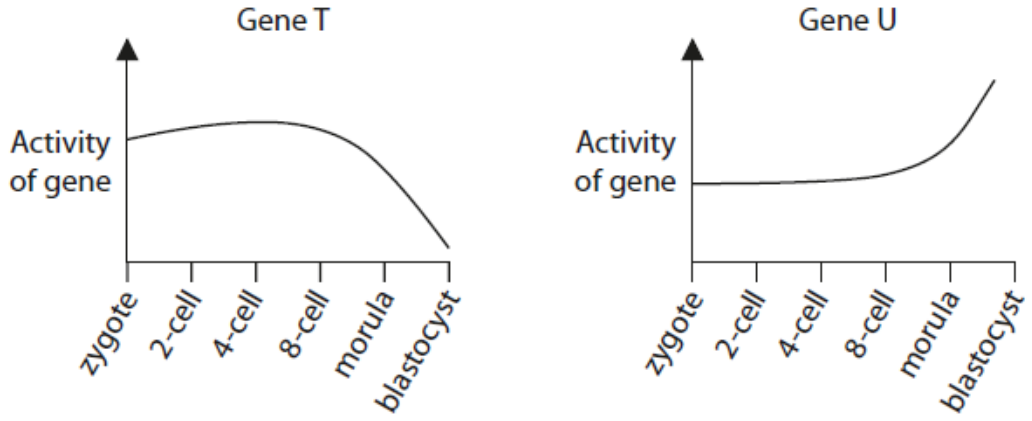
.....

.....

.....

.....

(d) The graphs show the activity of two genes, T and U, as a mouse zygote (fertilised egg cell) develops into a blastocyst.



Comment on the changes in the activity of these two genes.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 13 marks)

Q25.

Mitosis and the cell cycle are involved in producing new cells.

(a) Describe the role of the cell cycle in producing new cells.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) Uncontrolled cell division can result in the formation of a tumour.

The RB gene is a tumour suppressor gene.

The RB protein produced from this gene inhibits tumour growth.

Lung cancer can occur when this gene has increased methylation compared with the RB gene in normal lung cells.

Explain why increased methylation of this gene could cause the growth of a tumour.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) The cell cycle can be affected by various chemicals.

One drug, used to treat various types of cancer, prevents the shortening of spindle fibres.

Explain how preventing the shortening of spindle fibres affects mitosis.

(2)

.....

.....

.....

.....

.....

.....

* (d) Paclitaxel is a drug used to treat some tumours.

In one study, the effect of paclitaxel on the cell cycle in human lung tumours was investigated.

The table shows the results of this study.

Concentration of paclitaxel / nmol dm^{-3}	Duration of mitosis / hours	Mitotic index of cancerous cells in lung tissue (%)
0	1	2
10	4	17
100	9	38
1 000	21	48
10 000	24	59

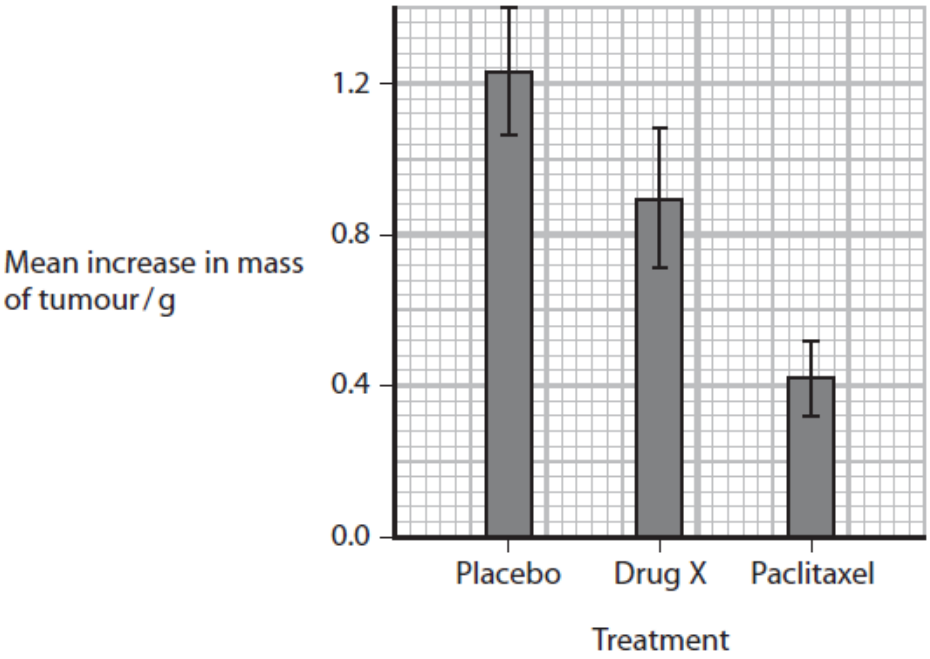
In another study, the effect of paclitaxel on the growth of breast tumours in mice was investigated. The effect of paclitaxel was compared with drug X and with a placebo.

For each group the increase in mass of the tumour was measured 21 days after starting treatment.

Three groups of mice with breast tumours were given the following treatments:

- Group 1 received a placebo
- Group 2 received drug X
- Group 3 received paclitaxel.

The graph shows the results from this study.



Evaluate the effectiveness of paclitaxel.

Use the information given to support your answer.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 15 marks)

Q1.

The phenotype of an organism is affected by a number of factors.

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

(1)

.....

.....

.....

(b) Coat colour in rabbits is determined by multiple alleles.

The table gives some information about coat colour in rabbits.

Type of rabbit	Coat colour of rabbit	.....
Black 	black all over	CC
Chinchilla 	grey all over	$c^{ch}c^{ch}$
Himalayan 	white body black ears, face, feet and tail	$c^{h}c^{h}$
Albino 	white all over	cc

(i) Complete this table by writing a suitable heading for the right-hand column.

(1)

(ii) Which row of the table gives the correct number of genes and alleles for coat colour in these rabbits?

(1)

	Number of genes for coat colour	Number of alleles for coat colour
☒ A	1	1
☒ B	1	4
☒ C	4	1
☒ D	4	4

(c) Height is one phenotype of an elephant.

The photograph shows an African elephant.



Source: Caroline Wilcox

Male African elephants range in height from 3.2 m to 4.0 m.

Female African elephants range in height from 2.2 m to 2.6 m.

(i) Which row of the table names the types of graph that should be drawn to show sex and height variation in a population of African elephants?

(1)

	Sex	Height
☒ A	bar chart	bar chart
☒ B	bar chart	histogram
☒ C	histogram	bar chart
☒ D	histogram	histogram

(ii) Calculate how many times bigger the male African elephant is than the female African elephant.

(2)

Answer .....

(Total for question = 6 marks)

Q2.

The phenotype of an organism is the result of interactions between the genotype and the environment.

Phenotypes can show continuous or discontinuous variation in a population.

(a) Sketch a graph to show the distribution for a phenotype showing continuous variation in a population.

(2)

(b) The presence or absence of teeth in chickens is one example of a discontinuous phenotype.

Chicken genomes contain the genes for tooth production, but chickens do not normally develop teeth.

These genes are switched off as the embryo develops.

Explain how a mutation could cause the development of teeth in a chicken embryo.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) The photograph shows two Himalayan goats.



(Source: © Rainer Pauschert / Alamy Stock Photo)

The fur colour of a goat depends on its genotype.

Gene B controls fur colour in these goats.

The allele for brown fur is dominant to the allele for white fur in goats.

The allele **B** codes for brown fur and the allele **b** codes for white fur.

In one population, there were 470 brown goats and 140 white goats.

Calculate the frequency of the allele **B** in this population, using the equation

$$p^2 + 2pq + q^2 = 1$$

Give your answer to **two** decimal places.

(3)

Answer .....

(Total for question = 9 marks)

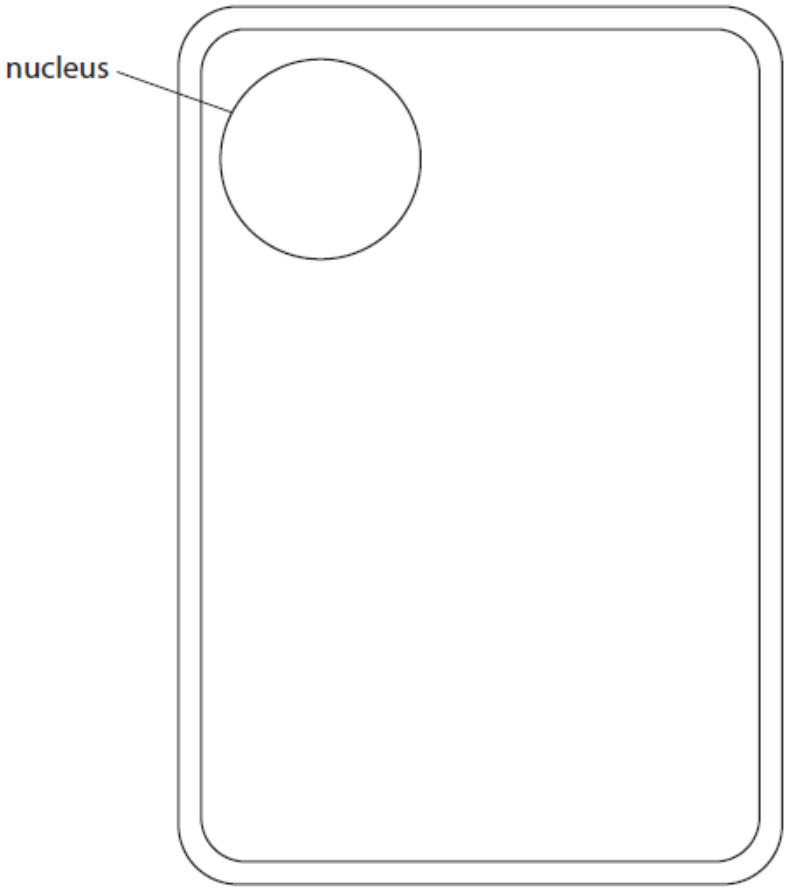
Q3.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Woese classified organisms into a three-domain system.

Plant cells were classified into the Eukarya domain.

The diagram shows an incomplete cell from a plant.

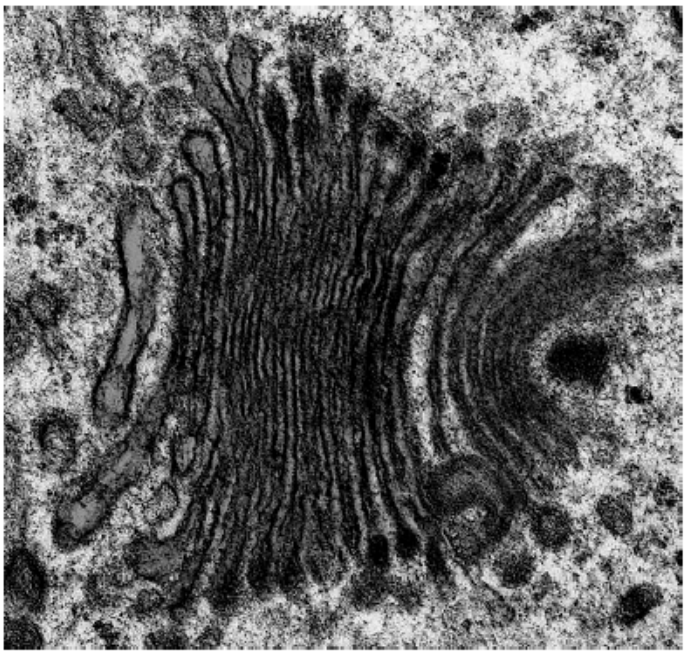


(a) Complete the diagram by drawing an amyloplast, a chloroplast and the tonoplast to show their location and relative size in this cell.

Label these three structures.

(3)

(b) The photograph shows an organelle found in a plant cell, as seen using an electron microscope.



(Source: © SCIENCE PHOTO LIBRARY)

State the function of this organelle.

(1)

.....

.....

.....

(c) The other domains in the three-domain system are Archaea and Bacteria. Complete the table to show in which of the domains the following structures would be found.

(4)

Structure	Archaea only	Bacteria only	Eukarya only	More than one domain
cell membrane	☒	☒	☒	☒
nucleolus	☒	☒	☒	☒
cell wall	☒	☒	☒	☒
70S (small) ribosome	☒	☒	☒	☒

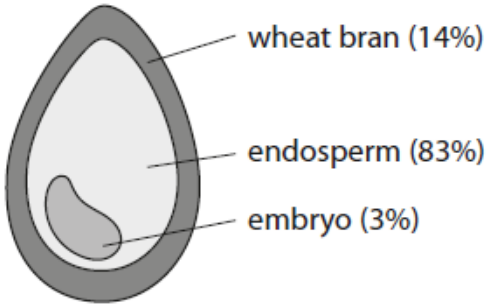
(Total for question = 8 marks)

Q4.

Plant-based products can replace plastics produced from oil.

Wheat bran comes from the outer layers of grains of wheat.

(a) The diagram shows the structure and composition of a grain of wheat.



Wheat bran contains 43% fibre.

A grain of wheat has a mass of 48 mg.

Calculate the mass of fibre in the wheat bran of this grain of wheat.

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

(3)

Answer ..... mg

(b) Disposable plates and cutlery can be made from either plant-based products or from oil-based plastics.

The photograph shows cutlery and a plate made from wheat bran.



(Source: © Konektus Photo/Shutterstock)

Explain the advantages of using cutlery and plates made from wheat bran instead of oil-based plastics.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) The endosperm of a grain of wheat develops from the endosperm nucleus, formed during fertilisation.

Explain the role of the pollen tube and nuclei in the formation of the endosperm nucleus.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 9 marks)

Q5.

Abaca plants are found in the Philippines.

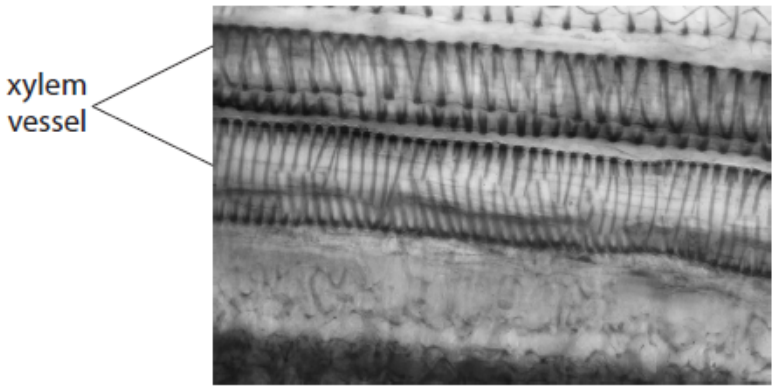
The photograph shows a mat made from abaca plant fibres.



(Source: © Mehmet Çetin / Alamy Stock Photo)

Plant fibres include xylem vessels.

(a) The photograph shows some xylem vessels, as seen using a light microscope.



(Source: © STEVE GSCHMEISSNER / SCIENCE PHOTO LIBRARY)

A stain was added to the xylem before viewing using a microscope.

Give a reason why it is usual to stain specimens in microscopy.

(1)

.....

.....

.....

(b) Explain how the arrangement of cellulose molecules and secondary thickening in xylem vessels contributes to the physical properties of the cell wall.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 5 marks)

Q6.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Some of the characteristics of an organism are due to polygenic inheritance.

(a) Every person has a Rhesus characteristic.

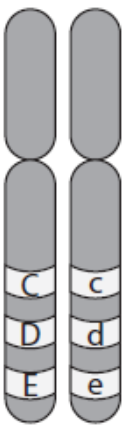
People who are Rhesus positive have one or more of three types of Rhesus antigen C, D or E, on the cell surface membrane of their red blood cells.

Each Rhesus antigen is coded by a dominant allele of gene C or gene D or gene E.

People who are Rhesus negative for one of these genes will have two recessive alleles.

For example, a person who is Rhesus D negative will have inherited two recessive d alleles.

The diagram shows the loci of these three genes on a pair of chromosomes.



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

(1)

.....

.....

.....

(ii) Which of the following is the genotype of a person who is Rhesus negative for all three genes?

(1)

☒ **A** ccddee

☒ **B** ccddEe

☒ **C** CcDdEe

☒ **D** CCDDEE

(iii) Rhesus antigens are glycoproteins.

Describe how a Rhesus antigen would be produced from its polypeptide chain and transported to the cell surface membrane.

(5)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) Seed colour in wheat is an example of polygenic inheritance. There are three genes thought to affect
seed colour (A, B, C). Each gene has a dominant and recessive allele.

A cross between two heterozygous plants (AaBbCc) was carried out.

The seed colour of the offspring was recorded.

The table below shows the phenotype of the wheat seed colour, the number of recessive alleles and the frequency of seed colour in the offspring.

Colour of wheat seed	Number of recessive alleles	Frequency of seed colour
White	6	1
Very light red	5	6
Light red	4	15
Intermediate red	3	20
Red	2	15
Moderate red	1	6
Dark red	0	1

Explain this variation in the colour of wheat seeds.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 10 marks)

Q7.

Some of the characteristics of an organism are due to polygenic inheritance.

(a) The photograph shows some Chinese white kidney beans.



The mass of individual Chinese white kidney beans varies. This is partly due to polygenic inheritance.

(i) State what is meant by the term **polygenic inheritance**.

(2)

.....

.....

.....

.....

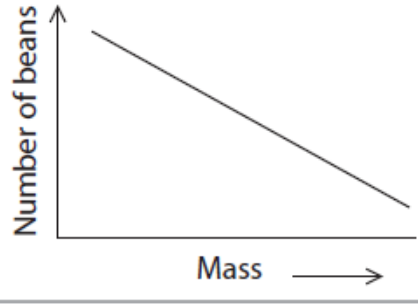
.....

.....

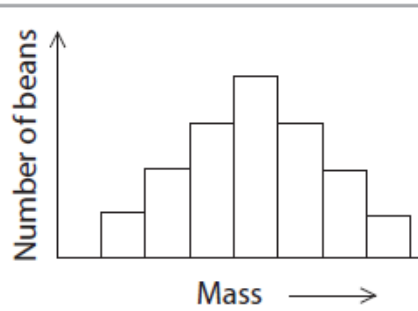
(ii) Which of the following graphs represents the distribution of mass of these beans?

(1)

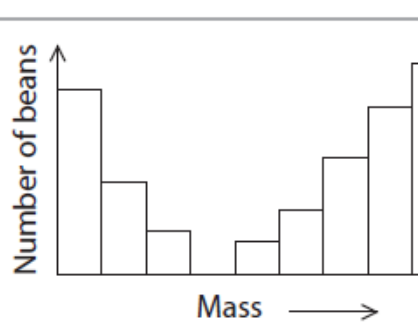
☒ A



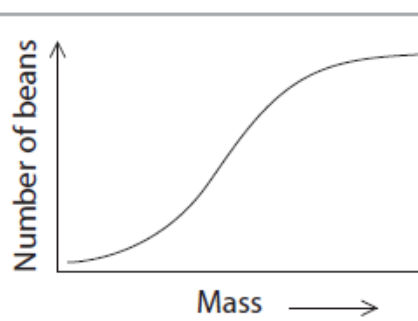
☒ B



☒ C



☒ D



(b) The inheritance of height is another example of polygenic inheritance.

It is possible to predict how tall children could become when they reach adulthood.

The prediction uses the following steps.

1. Add the mother's height (cm) to the father's height (cm).
2. Add 13 cm if the child is a boy or subtract 13 cm if the child is a girl.
3. Divide by two.

(i) A woman with a height of 1.59 m has a daughter. The father is 1.76 m tall.

Calculate the predicted adult height of their daughter.

(1)

Answer ..... m

(ii) Explain why their daughter may not grow to be this height.

(3)

.....

.....

.....

.....

.....

.....

.....

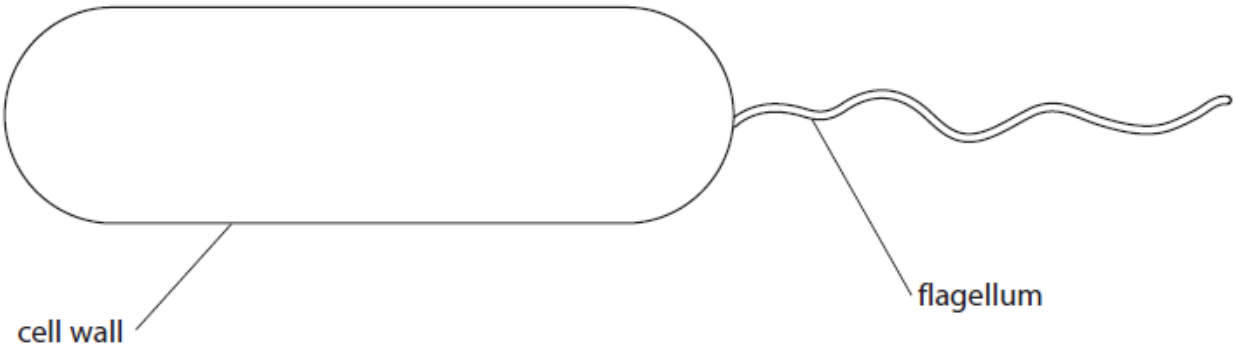
.....

.....

(Total for question = 7 marks)

Q8.

The diagram shows part of a prokaryotic cell, as drawn by a student.



(a) Draw **and** label a capsule and two pili on the diagram.

(2)

(b) The effect of concentrations of sodium chloride solution on the growth of bacteria was investigated.

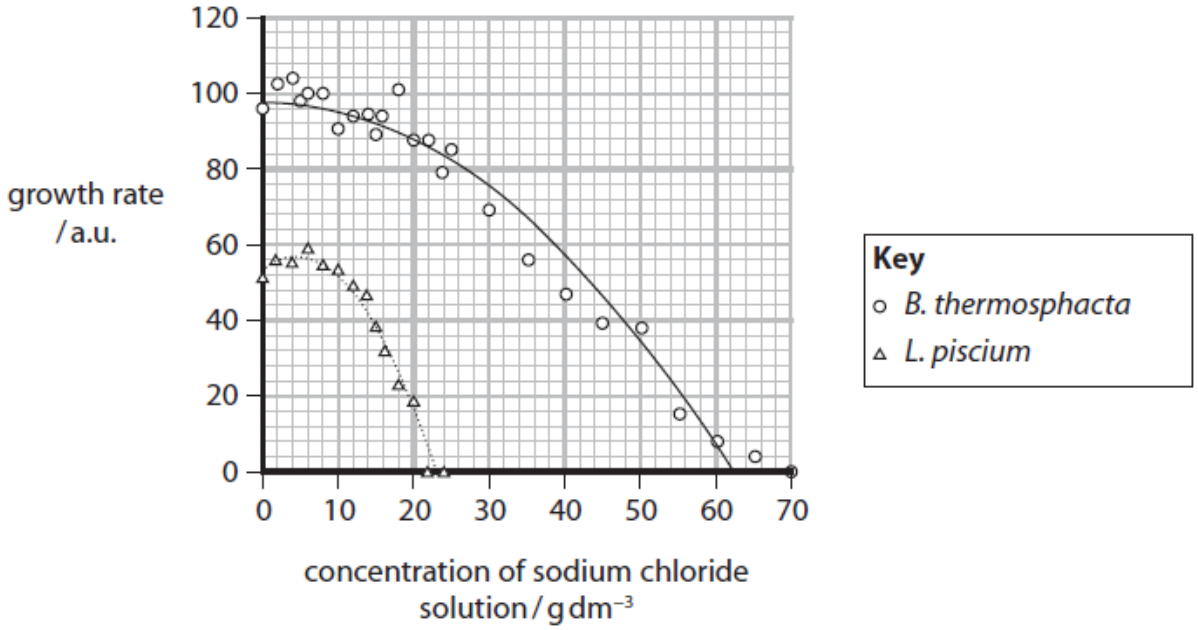
The same number of *L. piscium* bacteria were added to test tubes containing different concentrations of sodium chloride solution.

The volume of sodium chloride solution was the same in each test tube.

The growth rates of the bacteria were recorded after a set period of time.

The investigation was repeated with *B. thermosphacta* bacteria.

The graph shows the results of this investigation.



Comment on the results of this investigation.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 6 marks)

Q9.

Answer the questions with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Woese classified organisms into a system with three domains.

(a) How many of the domains contain prokaryotic organisms?

(1)

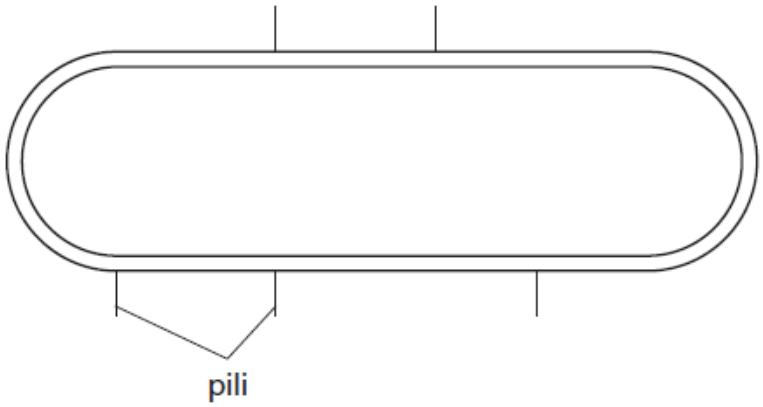
☒ **A** none

☒ **B** one

☒ **C** two

☒ **D** three

(b) The diagram shows part of a prokaryotic cell, as drawn by a student.



(i) Complete the diagram by drawing and labelling a flagellum and a plasmid.

(2)

(ii) State the function of a plasmid.

(1)

.....

.....

.....

(c) (i) The ribosomes in prokaryotic cells are different from the ribosomes in eukaryotic cells.

Give **one** difference between prokaryotic ribosomes and eukaryotic ribosomes.

(1)

.....

.....

.....

(ii) How many of the following statements about eukaryotic ribosomes are correct?

- ribosomes are located on the surface of both types of endoplasmic reticulum
- ribosomes are located inside chloroplasts and mitochondria
- ribosomes are involved in the process of transcription

(1)

☒ **A** none

☒ **B** one

☒ **C** two

☒ **D** three

(Total for question = 6 marks)

Q10.

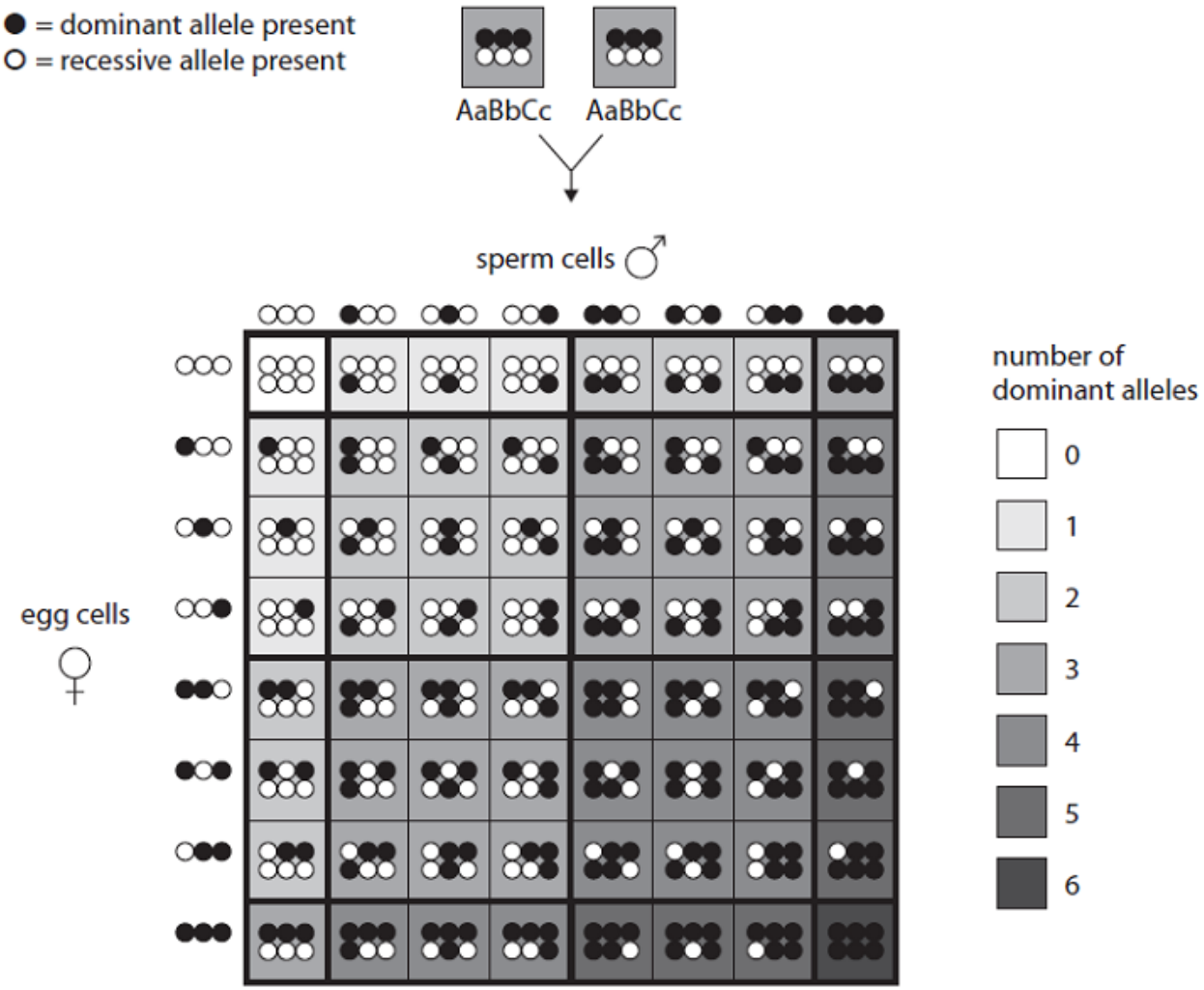
Skin colour is an example of continuous variation in some species.

In one species skin colour is polygenic and controlled by three genes: A, B, and C.

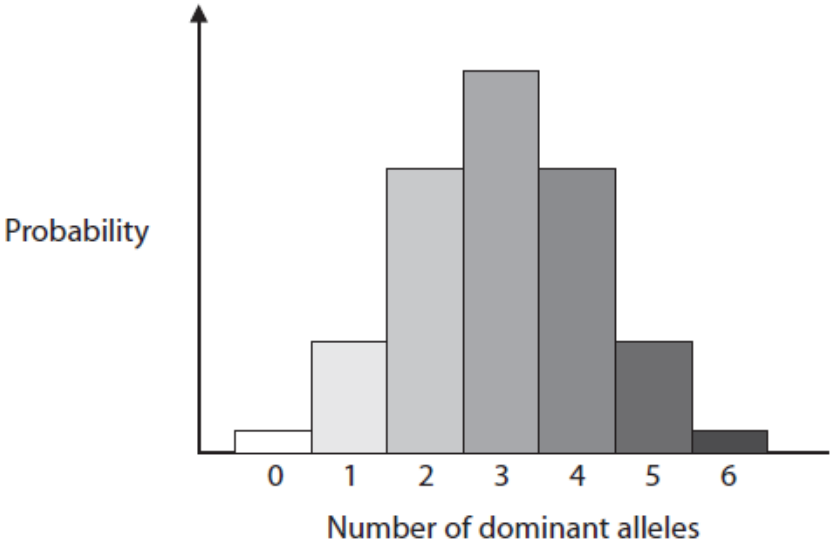
Two individuals heterozygous for each of these three genes were crossed.

The diagram shows the possible allele combinations present in the gametes and the offspring produced in this cross.

The shading indicates the darkness of the skin colour of the offspring.



The graph shows the probability of the skin colours of the offspring from this cross.



*(a) Explain why there is a large variation in the skin colour of the offspring produced from this cross.

Use information from the question, and your own knowledge, to help support your answer.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) Suggest **two** reasons why individuals that have inherited the genotype AaBbCc, may have a darker skin colour than other individuals with the same genotype.

(2)

1 .....

.....

.....

.....

2 .....

.....

.....

.....

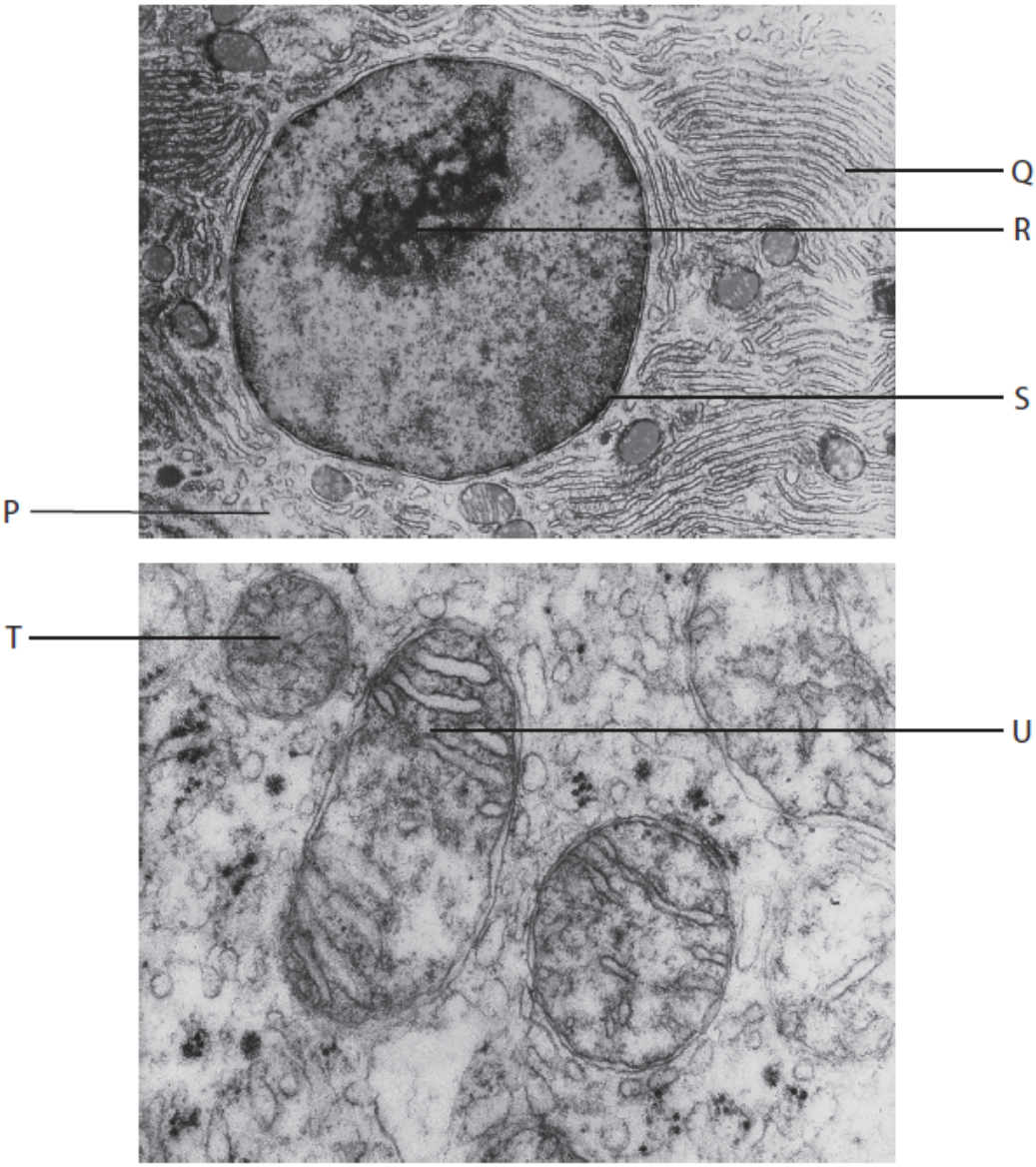
(Total for question = 8 marks)

Q11.

Insulin is a protein produced in beta cells in the pancreas.

Ribosomes are involved in the production of insulin.

(a) The photographs show part of a beta cell from the pancreas, as seen using an electron microscope.



(Source: © Don Fawcett/Science Photo Library
© Martin M. Rotker/Science Photo Library)

(i) Which labelled structure produces ribosomes?

(1)

☒ **A** P

☒ **B** Q

☒ **C** R

☒ **D** S

(ii) The structures labelled T and U are the same type of organelle.

Suggest why these structures look different in this photograph.

(2)

.....

.....

.....

.....

.....

.....

(iii) A student measured the length of the structure labelled U as 52 mm.

The actual length of this structure is 3.0 µm.

Calculate the magnification of this electron microscope image.

(2)

Answer .....

(b) Describe how the protein insulin is transported from the ribosomes and then secreted by a beta cell.

(5)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) Explain why beta cells can produce insulin but other cells in the pancreas do not.

(5)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 15 marks)

Q12.

The common wombat is endemic to Australia and Tasmania.

The photograph shows a common wombat.



(Source: © Albert Ziraj / Alamy Stock Photo)

magnification × 0.1

(a) Common wombats mark areas of their habitat to signal to other wombats of the same species that they are living there. These marked areas are called territories.

Common wombats produce cube-shaped faeces. It is thought that these cubes can be stacked to mark territory without rolling away.

(i) Calculate the surface area : volume ratio of one cube with a length of 2.5 cm.

(2)

Answer .....

(ii) State what is meant by the term **habitat**.

(1)

.....

.....

.....

(iii) State what is meant by the term **species**.

(1)

.....

.....

.....

(b) The height of a wombat is a result of polygenic inheritance.

State what is meant by the term **polygenic inheritance** with reference to wombat height.

(1)

.....

.....

.....

(c) Common wombats dig burrows to live in. They have adaptations to help them to do this successfully.

Describe **two** anatomical adaptations of a common wombat that help it to dig burrows to live in.

Use the information in the photograph to support your answer.

(2)

1 .....

.....

.....

2 .....

.....

.....

(Total for question = 7 marks)

Q13.

Egg cells vary in size.

(a) The table shows the size of egg cells from three species of animal.

Species	Diameter of egg cell / µm
Orb weaver spider	10
Human	150
Blue poison dart frog	1600

(i) Which of the following shows the diameter, in standard form, of the egg cell of a blue poison dart frog?

(1)

☒ **A** 1.6×10^{-2} μm

☒ **B** 1.6×10^{2} μm

☒ **C** 1.6×10^{-3} μm

☒ **D** 1.6×10^{3} μm

(ii) The egg cells of humans and blue poison dart frogs are approximately spherical.

The volume of a sphere (V) is calculated using the formula

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

The volume of the human egg cell is 1.8×10^{6} μm^3.

Calculate how many times larger the volume of the blue poison dart frog egg cell is than the volume of a human egg cell.

Give your answer to two significant figures.

(3)

Answer .....

(b) An egg cell and a skin cell were removed from a female human.

Both cells contained a nucleus.

The skin cell contained 46 chromosomes.

Explain the differences between the genetic material from these two cells.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 8 marks)

Q14.

Red blood cells are produced from pluripotent stem cells found in bone marrow.

(a) Which statement about these stem cells is correct?

(1)

☒ **A** they can produce all types of cell

☒ **B** they can produce all types of cell except extraembryonic cells

☒ **C** they can produce some types of cell

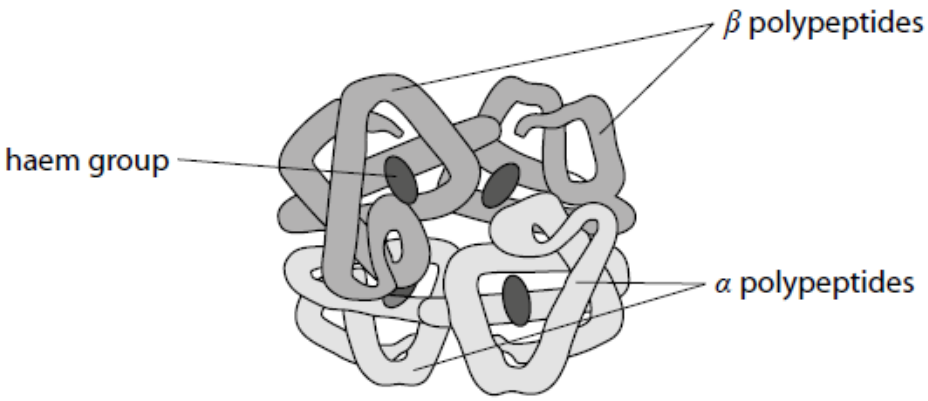
☒ **D** they can produce red blood cells only

(b) Red blood cells contain haemoglobin.

A molecule of haemoglobin is made of four polypeptides. Each polypeptide has a haem group attached to it. The haem group is **not** made of amino acids.

In most adult haemoglobin, there are two α polypeptides and two β polypeptides.

The diagram shows the structure of adult haemoglobin.



Describe the role of the rough endoplasmic reticulum in the synthesis of haemoglobin.

(3)

.....

.....

.....

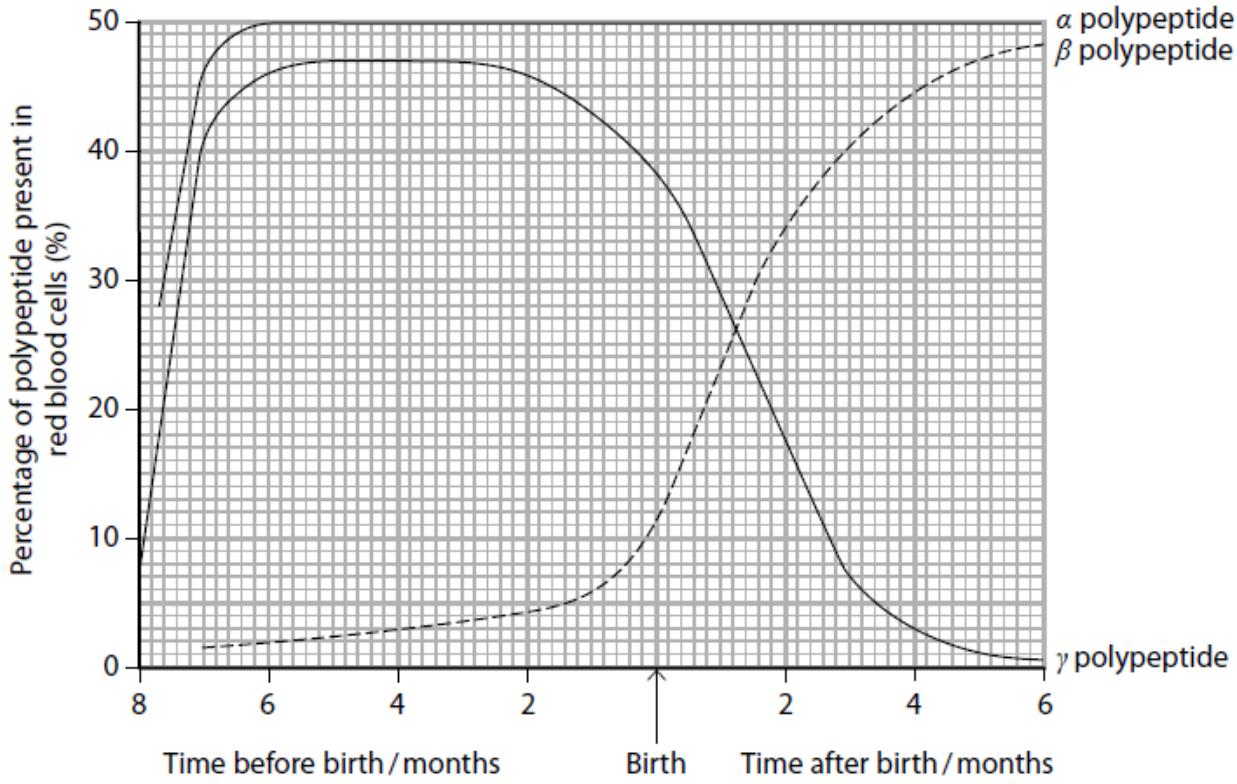
.....

.....

.....

(c) Fetal haemoglobin has a similar structure to adult haemoglobin. Fetal haemoglobin has two α polypeptides and two γ polypeptides.

The graph shows the percentage of each polypeptide present in red blood cells in an individual before and after birth.



(i) Describe the changes in the percentages of polypeptides present in red blood cells. Use the information in the graph to support your answer.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(ii) Explain how epigenetic modification could result in these changes.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 11 marks)

Q15.

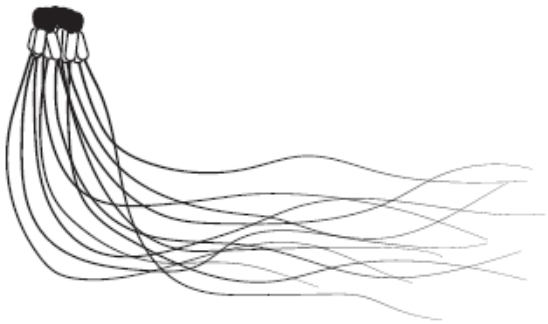
Gametes are specialised for their function.

Egyptian female desert ants (*Cataglyphis savignyi*) mate with more than one male.

A male desert ant has an adaptation to improve the chances of his sperm fertilising a female's egg cell.

The sperm are released in bundles with the heads held together by a sticky protein.

The diagram shows a bundle of desert ant sperm.



(a) Suggest how the sticky proteins would have been secreted.

(2)

.....

.....

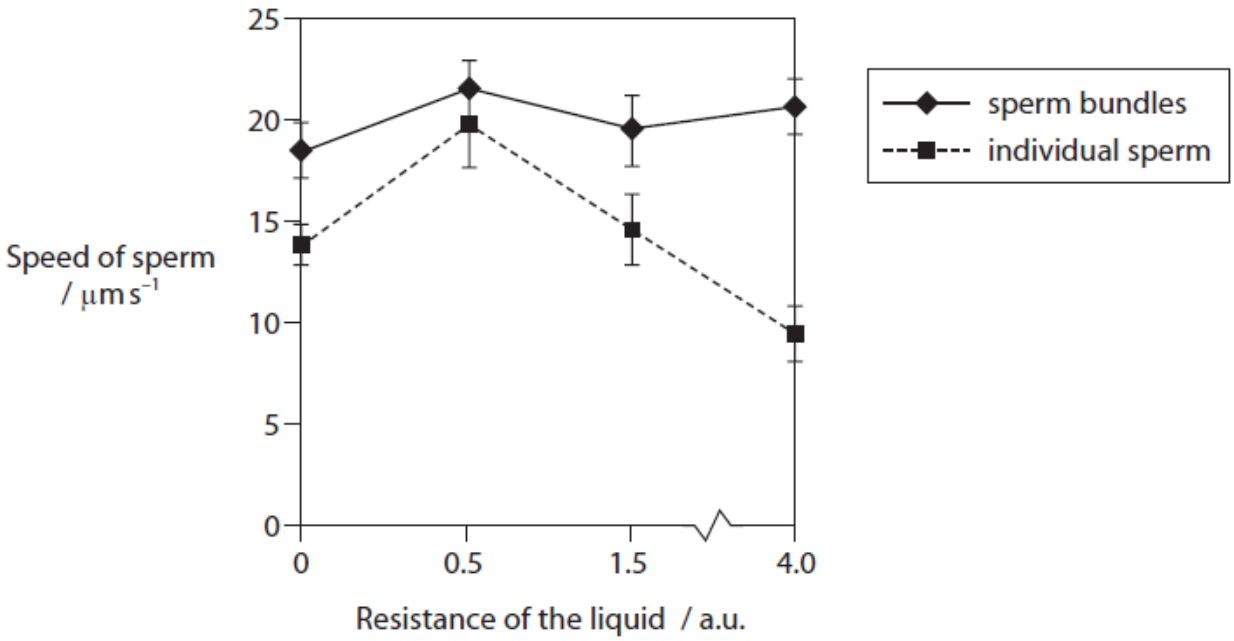
.....

.....

.....

.....

(b) The graph shows the speed of individual sperm compared with bundles of sperm in liquids of different resistance.



Comment on the results of this investigation.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) The photograph shows an Amur leopard found in southeastern Russia and northern China.

In-vitro fertilisation (IVF) techniques are being developed to help conserve this endangered species of leopard.



(Source: © NaturaLight / Alamy Stock Photo)

These techniques are being developed using mice.

IVF involves the removal of egg cells from the female mice. The zona pellucida can be damaged during this process.

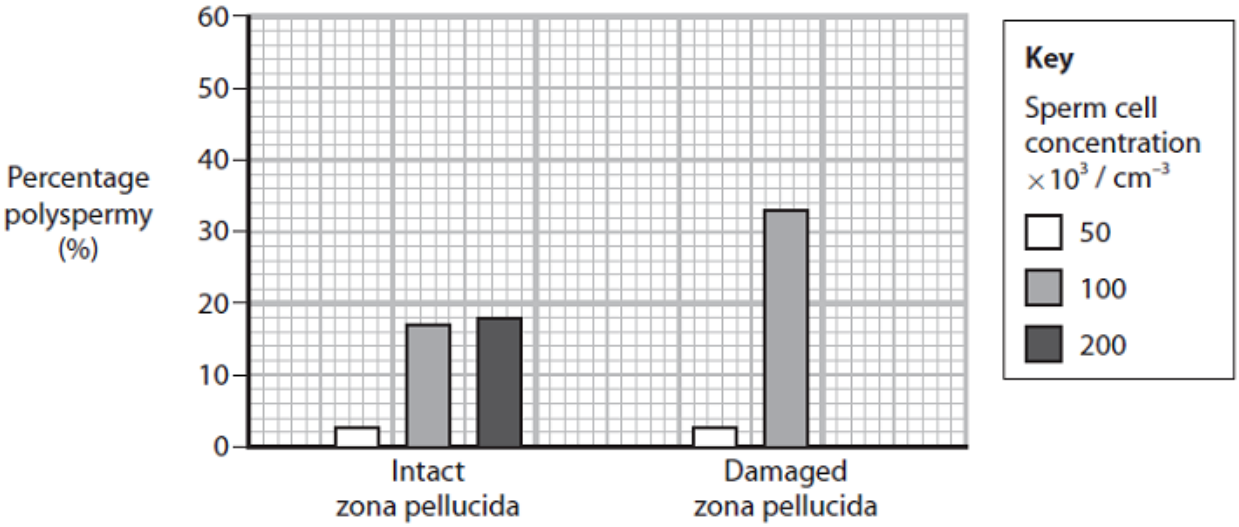
The effect of damaging the zona pellucida was investigated.

Three hundred mouse egg cells were distributed equally in three Petri dishes containing nutrient solutions.

Samples of sperm of different concentrations were added to each Petri dish. The volume of each sample added was the same.

The experiment was repeated for egg cells which had their zona pellucida damaged.

The graph shows the percentage of egg cells fertilised by more than one sperm (percentage polyspermy).



(i) When the highest sperm concentration was added to the egg cells with damaged zona pellucida, the percentage polyspermy was 52%.

Plot this result on the graph.

(1)

(ii) Explain the results of this investigation.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

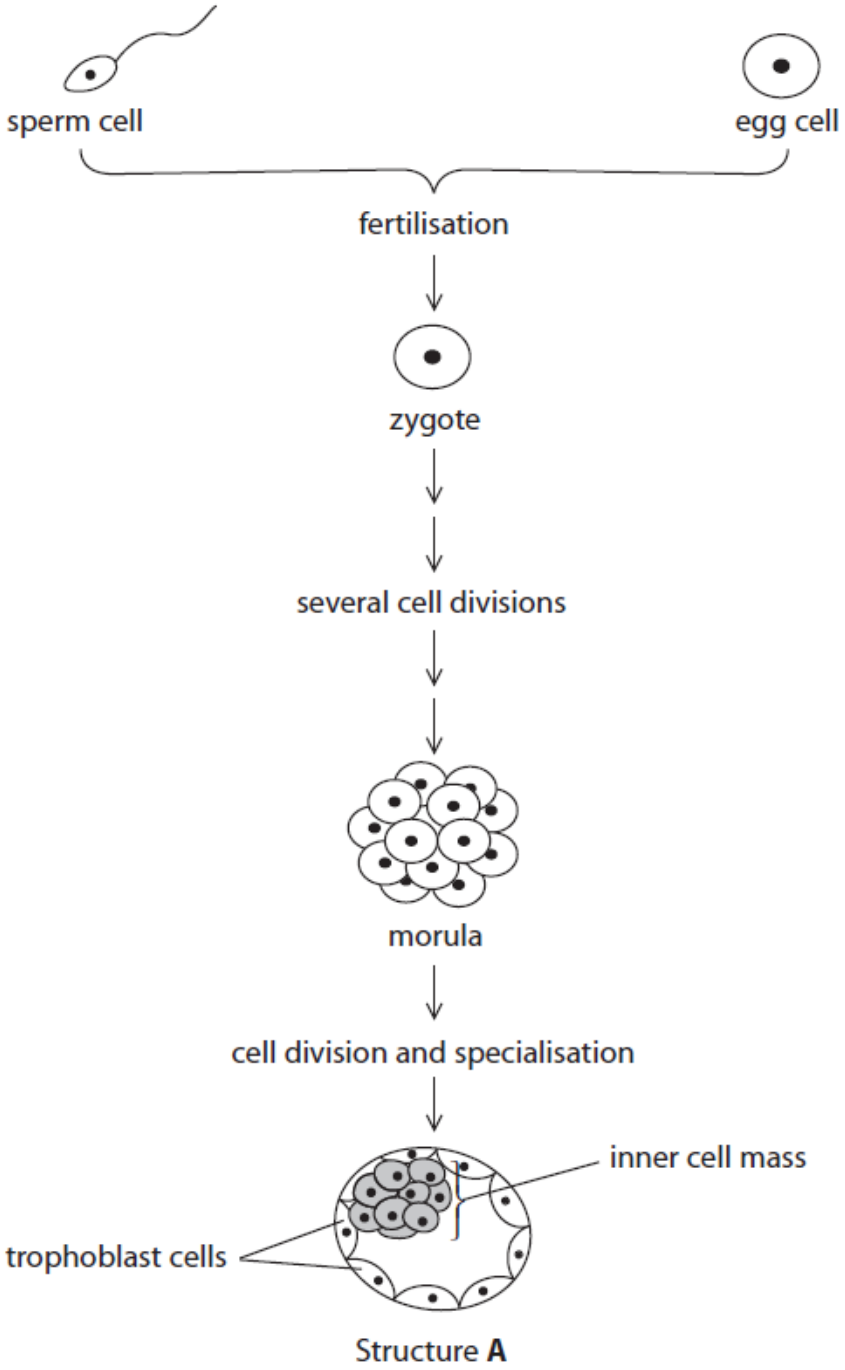
.....

.....

(Total for question = 11 marks)

Q16.

The diagram shows three structures that form after the fertilisation of an egg cell.



(a) Explain why the cells in the morula are genetically identical.

(2)

.....

.....

.....

.....

.....

.....

(b) Structure **A** can be used as a source of pluripotent stem cells.

(i) Name structure **A**.

(1)

.....

(ii) Stem cells can be used as a medical treatment when a patient has had a severe heart attack.

A severe heart attack can cause the death of heart muscle cells.

The medical treatment involves injecting stem cells into damaged areas of the heart muscle.

Suggest why injecting pluripotent stem cells may benefit a person who has had a severe heart attack.

(2)

.....

.....

.....

.....

.....

.....

(Total for question = 5 marks)

Q17.

Sweet pea plants were originally found in Sicily and southern Italy.

They are used to investigate genetic inheritance and linkage.

The photograph shows a flowering sweet pea plant.



(Source: © Tim Gainey/Alamy Stock Photo)

Sweet pea plant flowers can be different colours and have a variety of pollen grain shapes.

(a) (i) How many of the following statements about a pollen grain are correct?

- contains a tube nucleus and a generative nucleus
- the generative nucleus divides by mitosis to form two female gametes
- can produce diploid gametes

(1)

☒ **A** none

☒ **B** one

☒ **C** two

☒ **D** three

(ii) The table gives information about the surface area and volume of round and long pollen grains.

Pollen grain shape	Surface area	Volume / μm^3	Surface area to volume ratio
round	5.03	33.5	0.150
long		25.8	0.160

Calculate the difference in surface area between round and long pollen grains.

Give your answer in standard form with appropriate units.

(2)

Answer .....

(b) Plants that grow from a sweet pea seed contain stem cells.

Describe how a stem cell in a plant can become a sclerenchyma cell.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

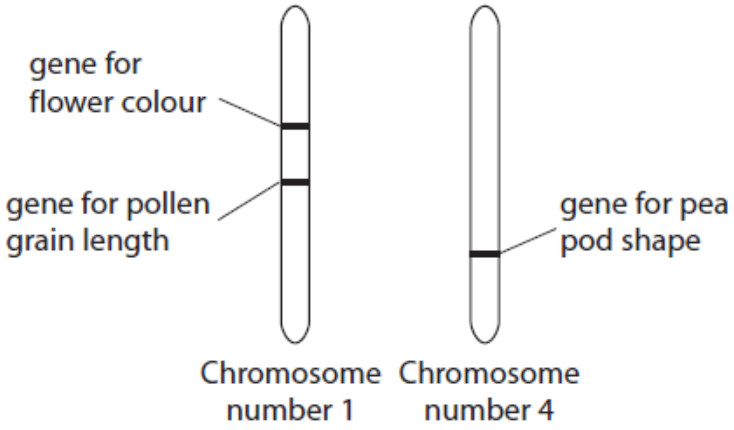
.....

.....

(c) Sweet pea plants were used in an investigation into the inheritance of flower colour, pollen grain length and pea pod shape.

Each of these traits is controlled by a single gene. Sweet peas have seven pairs of chromosomes.

The arrangement of these three genes on sweet pea chromosomes is shown in the diagram.



Comment on the role of meiosis in the inheritance of these traits.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 11 marks)

Q18.

Tendrils are produced by climbing plants, such as pea plants.

The photograph shows the tendrils on a growing pea shoot.



(Source: © Jerry Lin/Shutterstock)

A tendril is a modified leaf that can coil around anything it touches.

Cells in the tip of the tendril divide by mitosis.

(a) A student investigated the mitotic index of cells in the tips of tendrils.

Acetic orcein stain was added to the tissues from the tips of the tendrils.

(i) Give **one** reason why the cells were stained in this investigation.

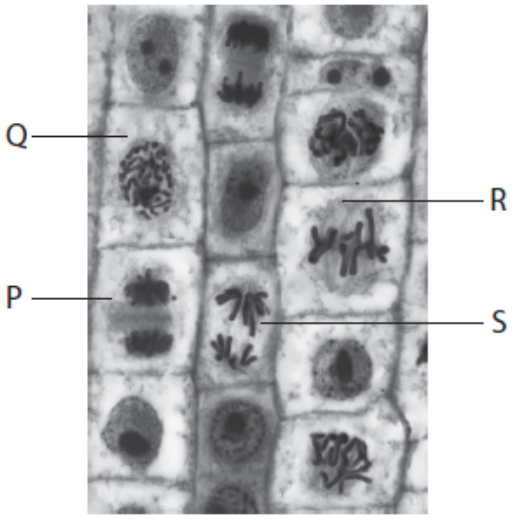
(1)

.....

.....

.....

(ii) The photograph shows these cells, as seen using a light microscope.



(Source: © Steve Gschmeissner/Science Photo Library)

Which labelled cell is in the metaphase stage of mitosis?

(1)

☒ **A** P

☒ **B** Q

☒ **C** R

☒ **D** S

(iii) The table shows the results of this investigation.

Stage	Number of cells
Interphase	117
Prophase	15
Metaphase	3
Anaphase	10
Telophase	5

Calculate the mitotic index.

(2)

Answer .....

(b) Suggest the advantages of tendrils for the pea plant.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) Pea plants produce flowers.

Some cells in the flowers undergo meiosis.

Explain how the separation of chromosomes in meiosis gives rise to genetic variation in the offspring of pea plants.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 10 marks)

Q19.

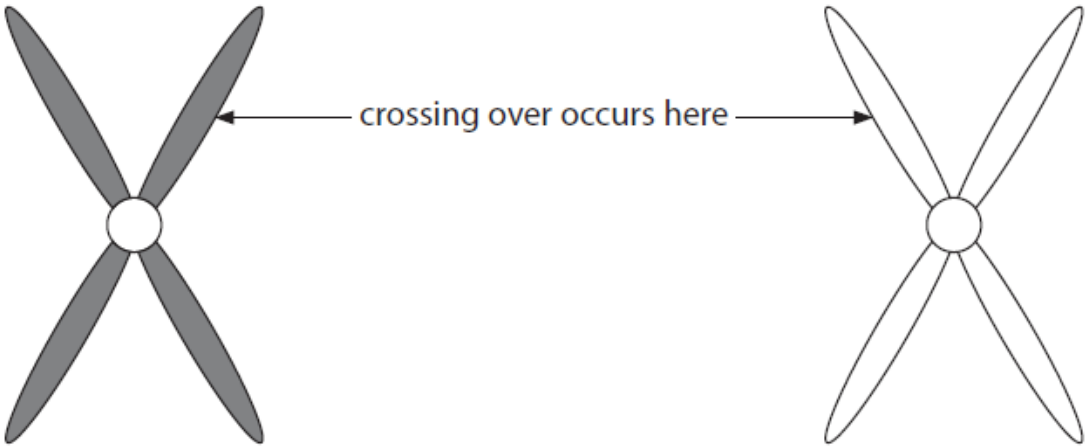
Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Meiosis and mitosis are involved in cell division.

(a) Meiosis produces gametes that are genetically different.

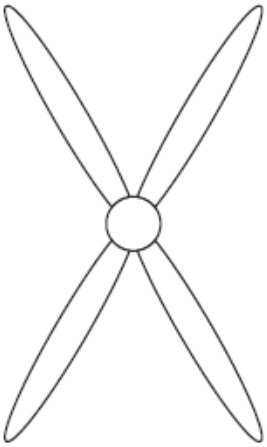
Crossing over is important to increase genetic variation.

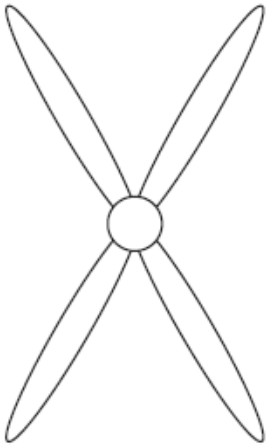
The diagram shows one pair of homologous chromosomes during early meiosis.



Complete the diagram below to show these chromosomes after crossing over has occurred.

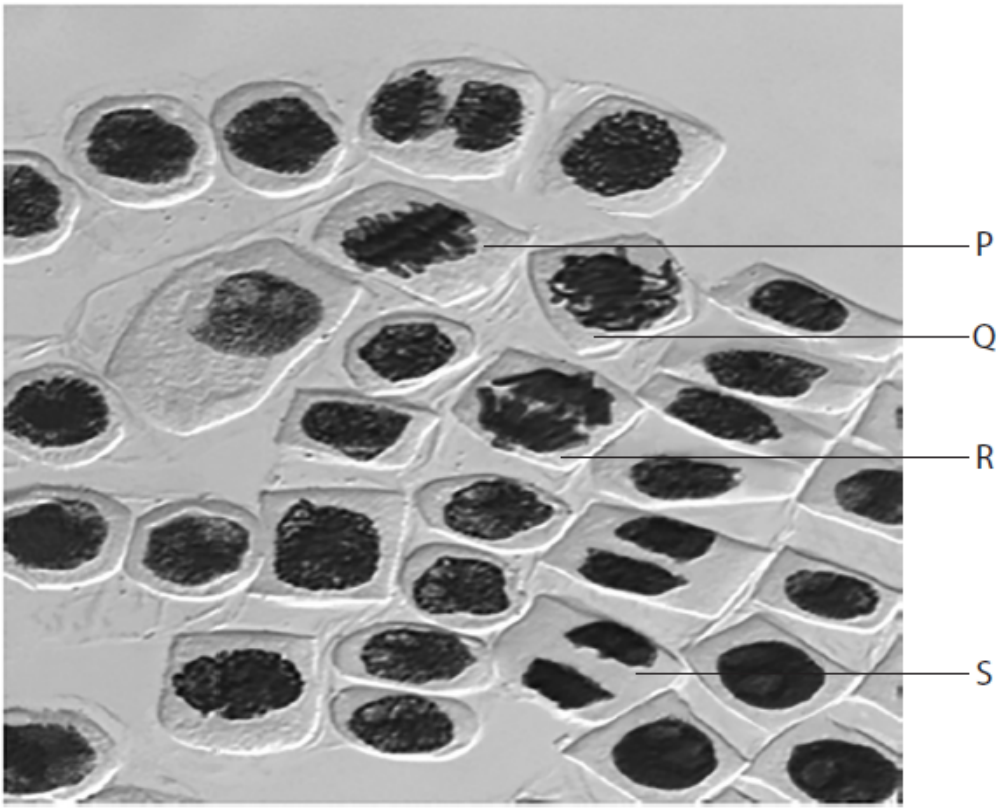
(2)





(b) The photograph shows some cells undergoing mitosis.

Each labelled cell is in a different stage of mitosis.



(i) Which cell is in prophase?

(1)

☒ **A** P

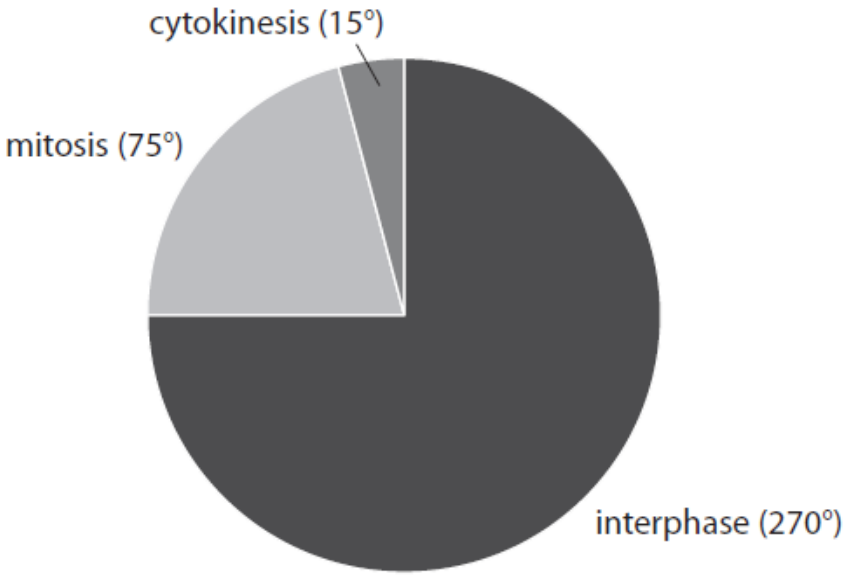
☒ **B** Q

☒ **C** R

☒ **D** S

(ii) In some embryo cells, interphase can last an average of nine hours.

The diagram shows the relative proportions of time spent in each part of the cell cycle.



Calculate how long cytokinesis would take in these embryo cells.

(1)

Answer ..... hours

(iii) Calculate the total number of cells resulting from one cell dividing by mitosis eight times.

(1)

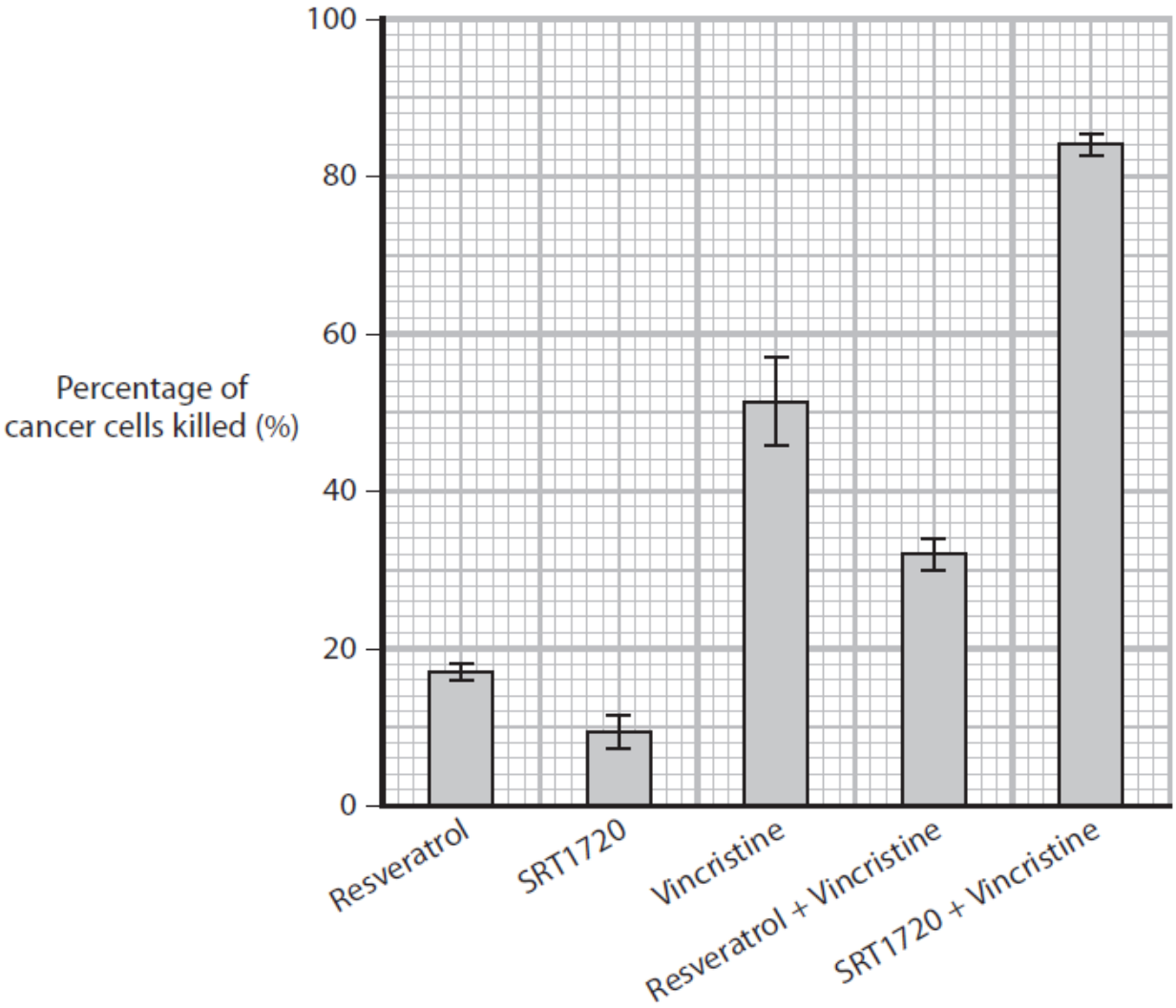
Answer .....

(c) Ewing's sarcoma is a type of cancer.

Resveratrol, SRT1720 and Vincristine are drugs used to kill cancer cells.

An investigation was carried out to determine the most effective treatment for patients with Ewing's sarcoma.

The graph shows the results of this investigation.



(i) Vincristine prevents spindle fibres from shortening during mitosis.

This leads to the death of the cell.

At which stage of mitosis do the spindle fibres contract?

(1)

☒ **A** anaphase

☒ **B** metaphase

☒ **C** prophase

☒ **D** telophase

(ii) Evaluate the effectiveness of the three drugs used in this investigation.

Use the information in the graph to support your answer.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 10 marks)

Q20.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

There are more than 100 species of trees and shrubs around the world with the common name of 'ironwood'.

One type of ironwood tree, *Tabebuia avellanedae*, is native to South America.

Chemicals from these trees have antibacterial properties.

(a) (i) State the genus to which this plant belongs.

(1)

.....

(ii) Which structure in the cells of this plant stores starch?

(1)

☒ **A** amyloplast

☒ **B** middle lamella

☒ **C** plasmodesmata

☒ **D** tonoplast

(b) Plague is a disease caused by *Yersinia pestis* bacteria.

Every year, thousands of people around the world are infected with these bacteria.

These bacteria have a thick slime capsule and many pili.

(i) State the function of each of these structures.

(2)

Slime capsule .....

.....

.....

.....

Pili .....

.....

.....

.....

*(ii) The ironwood tree has wood containing chemical compounds called

naphthoquinones. These compounds have antibacterial properties.

Scientists are investigating whether these compounds could be used to develop a drug to treat people infected with *Y. pestis*.

Describe the methods that would be used to trial a drug containing these compounds.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 10 marks)

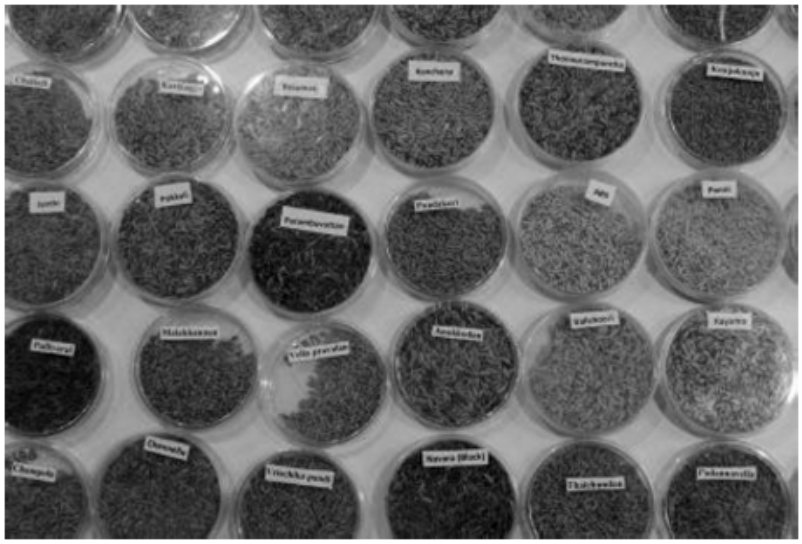
Q21.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

One of the aims of seed banks is to maintain genetic diversity.

Seeds are stored in the Navdanya Seed Vault, one of over a hundred seed banks in India. This seed bank stores over 4000 varieties of rice.

The photograph shows some of these varieties of rice.



(a) (i) Which of the following can be used to calculate genetic diversity?

(1)

☒ **A** Hardy–Weinberg equation

☒ **B** heterozygosity index

☒ **C** index of diversity

☒ **D** mitotic index

(ii) Give **two** differences between genetic diversity and species richness.

(2)

1 .....

.....

2 .....

.....

(b) Suggest **two** reasons why seed banks store seeds instead of growing whole plants.

(2)

1 .....

.....

.....

.....

.....

2 .....

.....

.....

.....

.....

(c) Bananas are a popular food and seed banks are involved in the development of disease-resistant varieties.

The table shows the mass of bananas imported by three countries in 2007 and in 2011.

Country	Mass imported in 2007 / tonnes × 10^5	Mass imported in 2011 / tonnes × 10^5
China	3.3	8.2
Iran	6.3	6.2
Japan	9.8	1.1

(i) Calculate the percentage increase in the mass of bananas imported by China.

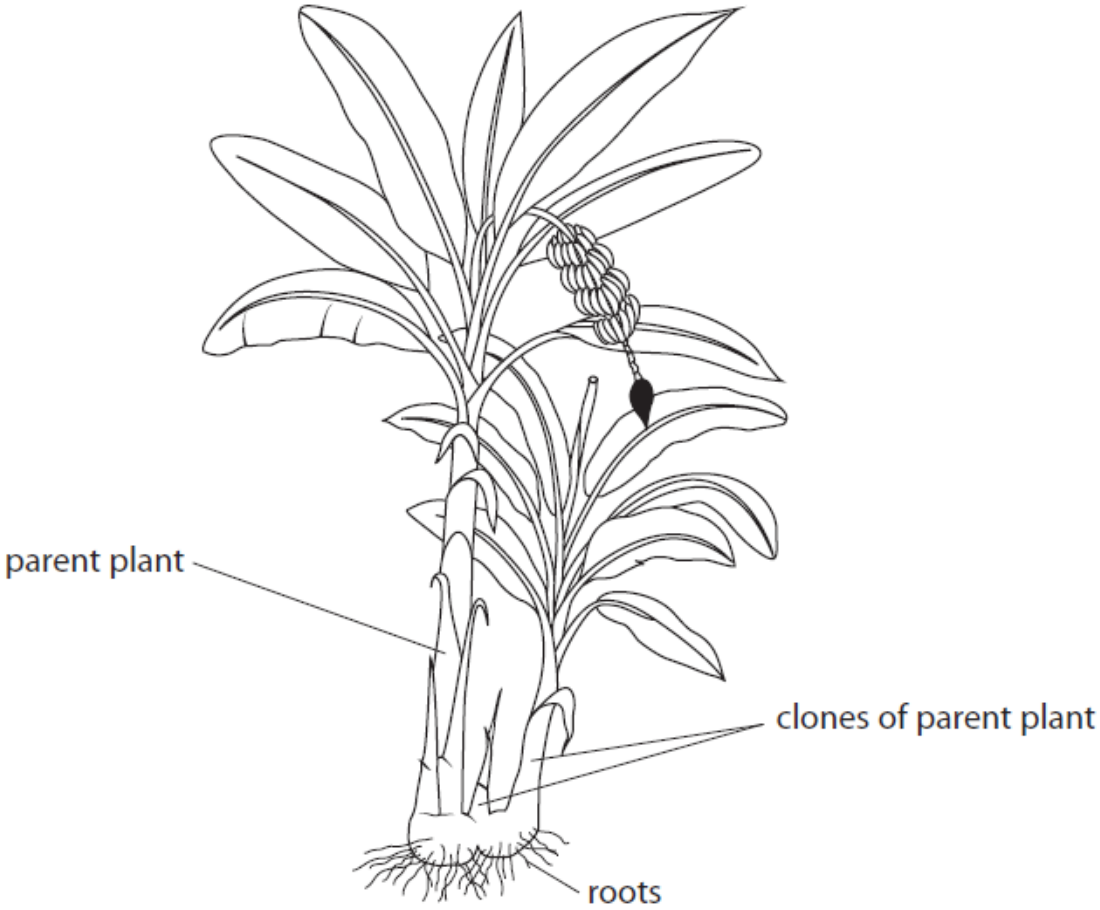
(2)

Answer ..... %

(ii) Banana plants can reproduce asexually.

Most of the bananas grown by farmers around the world are clones from a single parent banana plant called 'The Cavendish'.

The diagram shows a parent banana plant and two clones of this parent plant.



These clones can be removed from the parent plant and grown into new banana plants.

Panama disease is caused by a fungus. It has destroyed Cavendish banana plants in the Philippines. Cavendish banana plants are not resistant to this fungus.

Seed banks around the world have seeds from different varieties of banana.

Scientists are trying to improve the Cavendish banana by breeding it with different varieties of banana.

Explain why scientists are breeding the Cavendish banana with different varieties of banana.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

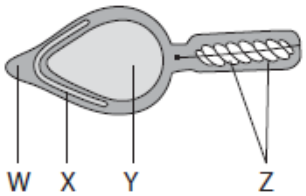
(Total for question = 11 marks)

Q22.

The phenotype of a rabbit is affected by its genotype.

Rabbit sperm cells contain genetic information that will become part of the genotype of the offspring.

The diagram shows part of a rabbit sperm cell.



(a) Which labelled structure contains the genetic information used in the synthesis of acrosomal enzymes?

(1)

☒ **A** W

☒ **B** X

☒ **C** Y

☒ **D** Z

(b) A fertilised rabbit egg cell will divide by mitosis to form a solid ball of genetically identical cells.

Name this solid ball of cells.

(1)

.....

(c) The genetically identical cells in a developing rabbit embryo will continue to divide by mitosis.

Some of the cells produced can undergo epigenetic modification as they develop into specialised cells.

(i) Epigenetic modification can alter the activation of certain genes.

Describe **one** form of epigenetic modification that could occur in the rabbit cells.

(2)

.....

.....

.....

.....

.....

.....

(ii) Explain how cells in the rabbit embryo become specialised after epigenetic modification.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

* (d) The table shows information about three types of rabbit.

Type of rabbit	Black 	Himalayan 	Albino 
Colour of fur	Solid black all over	White fur with black ears, nose, paws and tail	White all over
Allele combination(s)	CC, Cc^{ch}, Cc^{a}	$c^{h}c^{h}$, $c^{h}c^{a}$	$c^{a}c^{a}$

Enzymes produced by the rabbits control the production of pigments in the fur.

One type of rabbit produces an enzyme that is inactive at the core body temperature of the rabbit.

Discuss how genes and the environment interact to produce the fur colour of these three types of rabbit.

Use the information in the question to support your answer.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 13 marks)

Q23.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The pancreas is an organ with many functions.

A student observed some cells of the pancreas using an electron microscope.

The student described one organelle that was seen as

> "several curved membrane-bound sacs of decreasing size".

(a) (i) Which organelle was seen?

(1)

☒ **A** centriole

☒ **B** Golgi apparatus

☒ **C** rough endoplasmic reticulum

☒ **D** smooth endoplasmic reticulum

(ii) Explain why this organelle cannot be seen using a light microscope.

(2)

.....

.....

.....

.....

.....

.....

(iii) Give **two** differences between an organ and a tissue.

(2)

1 .....

.....

.....

2 .....

.....

.....

(b) Plant cells can also be studied using an electron microscope.

Name **two** structures present in animal cells that are not present in a plant cell.

(2)

1 .....

2 .....

(c) Cells in the pancreas use amino acids to synthesise polypeptides.

These cells also secrete enzymes and glycoproteins into the small intestine.

Cells from the pancreas, containing amino acids labelled with a fluorescent marker, were used in an investigation. The fluorescent marker looked green when seen with a special microscope.

The percentage of green fluorescence inside and outside the cells was measured at the start and after 60 minutes.

The results of this investigation are shown in the table.

Time / min	Percentage of green fluorescence (%)	
	Inside the cells	Outside the cells
0	100	0
60	38	62

Explain the results of this investigation.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 11 marks)

Q24.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Organisms can be classified using the three-domain system.

Molecular evidence is used to place an organism into one of the three domains.

(a) (i) Give **one** example of the molecular evidence used to support the three-domain system.

(1)

.....

.....

.....

(ii) Describe the role of the scientific community in evaluating the evidence for this system of classification.

(2)

.....

.....

.....

.....

.....

.....

(b) The table shows some features of living organisms.

Which box in each row shows whether the feature is found in these domains?

(4)

Feature	Archaea only	Archaea and Bacteria only	Archaea and Eukarya only	Archaea and Bacteria and Eukarya
absence of a nuclear envelope	☐	☐	☐	☐
presence of circular DNA	☐	☐	☐	☐
presence of a cell membrane	☐	☐	☐	☐
presence of ribosomes	☐	☐	☐	☐

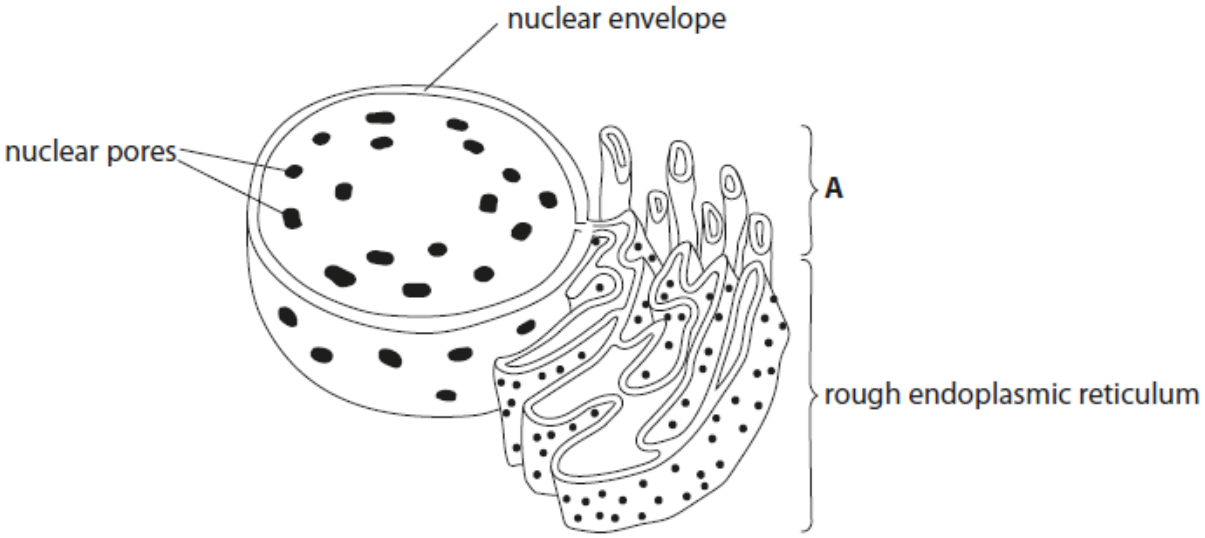
(Total for question = 7 marks)

Q25.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Eukaryotic cells contain cell organelles.

(a) The diagram shows part of a eukaryotic cell, as drawn by a student.
The nuclear envelope, nuclear pores and rough endoplasmic reticulum are labelled.



(i) Which of the following is a correct statement about rough endoplasmic reticulum?

(1)

☒ **A** it has 70S (small) ribosomes

☒ **B** it has 80S (large) ribosomes

☒ **C** it forms vesicles surrounding phospholipids only

☒ **D** it forms vesicles surrounding polysaccharides only

(ii) Name a substance synthesised by the organelle labelled **A** in the diagram.

(1)

.....

(iii) Name **two** structures that could be present inside the nucleus in the diagram.

(2)

1 .....

.....

2 .....

.....

(b) After cell division, the plant cells produced increase in size.
Explain how these plant cells increase in size.

(3)

.....

.....

.....

.....

.....

.....

.....

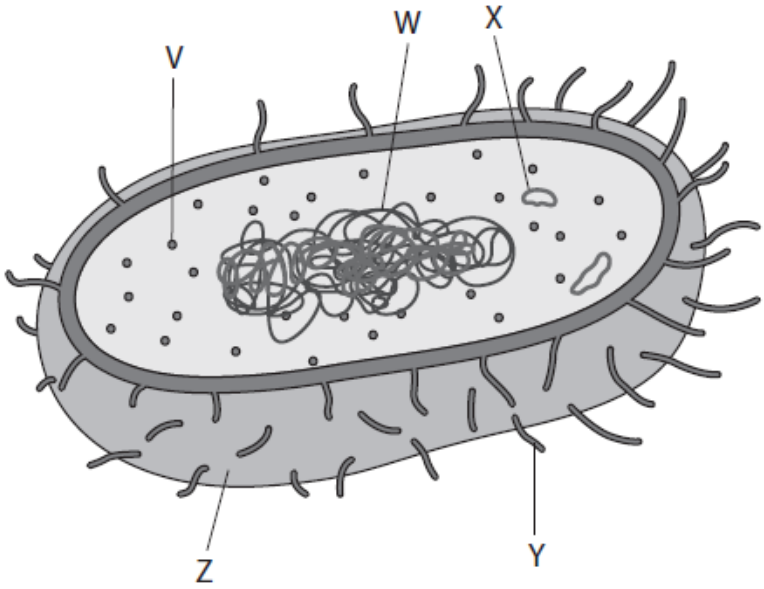
.....

.....

(Total for question = 7 marks)

Q26.

The diagram shows a prokaryotic cell, drawn by a student.



(a) (i) Which labelled structure is a plasmid?

(1)

☒ **A** W

☒ **B** X

☒ **C** Y

☒ **D** Z

(ii) Which labelled structure enables this cell to adhere to other bacterial cells in conjugation?

(1)

☒ **A** V

☒ **B** X

☒ **C** Y

☒ **D** Z

(iii) State how ribosomes in prokaryotic cells are different from those in eukaryotic cells.

(1)

.....

.....

.....

(b) Prokaryotic cells may also have a capsule and a flagellum.

State **one** function of each of these structures.

(2)

Capsule

.....

.....

.....

Flagellum

.....

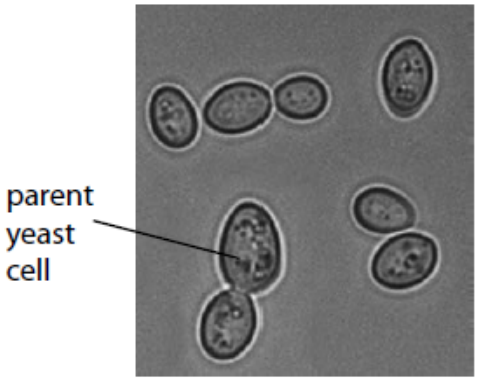
.....

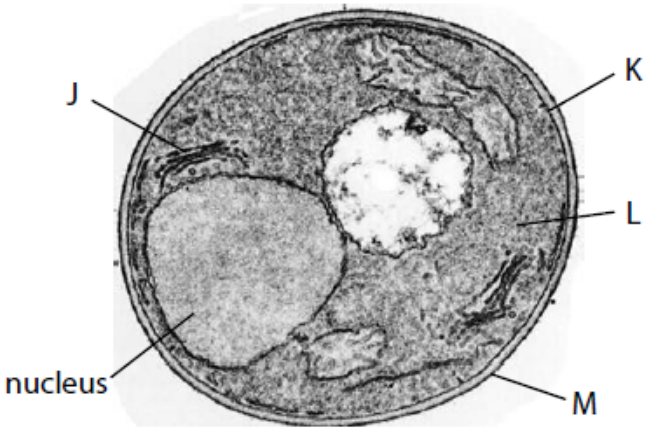
.....

(Total for question = 5 marks)

Q27.

The photographs show yeast cells, seen using a light microscope and an electron microscope.





Yeast cells seen using a light microscope Yeast cell seen using an electron microscope

Used under CC License from: https://commons.wikimedia.org/wiki/File:Zygosaccharomyces_bailii_cells.jpg

(a) Which structure identifies yeast as a eukaryotic organism?

(1)

☒ **A** J

☒ **B** K

☒ **C** L

☒ **D** M

(b) Explain why structure J can be seen using the electron microscope but not the light microscope.

(2)

.....

.....

.....

.....

.....

.....

(c) Explain why the nuclear envelope cannot be seen as two membranes using this electron microscope.

(2)

.....

.....

.....

.....

.....

.....

(d) Yeast cells reproduce asexually by a process called budding.

The parent yeast cell produces a bud.

(i) Explain the importance of mitosis in budding.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(ii) Once the bud is large enough, it separates from the parent yeast cell.

The rate at which budding happens depends on the availability of oxygen and nutrients.

Suggest why the availability of oxygen and nutrients determines the rate of budding.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 11 marks)