Questions

Q1.

At the start of fertilisation, many sperm cells will surround the ovum.

Fertilisation begins with the acrosome reaction.

(i) Which of the following describes the acrosome reaction?

(1)

☒ **A** the ovum releases enzymes that digest the egg cell membrane

☒ **B** the ovum releases enzymes that digest the zona pellucida

☒ **C** the sperm cell releases enzymes that digest the egg cell membrane

☒ **D** the sperm cell releases enzymes that digest the zona pellucida

(ii) Which of the following statements describes the genetic content of a sperm cell?

(1)

	Each sperm cell will contain	Different sperm cells will contain
☒ **A**	one copy of each gene	different alleles of some genes
☒ **B**	one copy of each gene	the same alleles for all genes
☒ **C**	two copies of each gene	different alleles of some genes
☒ **D**	two copies of each gene	the same alleles for all genes

(Total for question = 2 marks)

Q2.

Cell division can be affected by various chemicals. The effects of these chemicals can be studied by observing tissues.

Herbicides are chemicals used to kill weeds. Some herbicides work by disrupting the cell cycle.

An investigation was carried out to study the effect of different concentrations of the herbicide Agil on mitosis in onion root tips.

The roots of onions were exposed to different concentrations of Agil for 24 hours.

Root tip squashes were then prepared and the mean mitotic index was calculated for each Agil concentration.

The results are shown in the table.

Agil concentration / ppm	Mean mitotic index (% ± SE)
0.0	40.7 ± 0.22
0.5	33.7 ± 0.32
1.0	31.1 ± 0.15
1.5	30.8 ± 0.19

(i) Describe the effects of Agil concentration on mitosis in onion root tips.

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(ii) Devise an investigation to determine the effect of exposure time to Agil on the rate of mitosis in onion root tips.

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(Total for question = 8 marks)

Q3.

Cigarette smoking is associated with several medical problems.

In an investigation, some female mice were exposed to cigarette smoke during pregnancy.

The ability of their male offspring to produce sperm and the activity of the sperm were investigated.

The results of this investigation are shown in the table.

Group	Percentage of sperm that are motile (%)	Ability of sperm to cross the zona pellucida of an egg cell	Percentage of stem cells producing sperm in the testes (%)
Offspring of control mice	68	Good	100
Offspring of mice exposed to cigarette smoke	45	Poor	40

Analyse the data to explain why exposing pregnant mice to cigarette smoke affects the fertility of their male offspring.

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(Total for question = 3 marks)

Q4.

Egg cells vary in size between different species of animal.

Egg cells from different animals were measured and some further information about each species was recorded. The data are shown in the table.

Animal	Diameter of egg cell	Mass of adult / kg	Site of fertilisation	Site of offspring development
Domestic cow (mammal)	85 μm	540	inside the body	in the uterus
Human (mammal)	150 μm	62	inside the body	in the uterus
American eel (fish)	1.1 mm	6.8	in the sea	floating in the sea
Hermann's tortoise (reptile)	2.3 cm	3.4	inside the body	inside an egg shell, in a nest
Great spotted kiwi (bird)	7.8 cm	2.3	inside the body	inside an egg shell, in a nest

(a) The human egg cell and the eel egg cell are approximately spherical. The formula for the volume of a sphere is

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

where V is the volume and r is the radius of the sphere.
The volume of the human egg cell is 1.8×10^6 μm^3.
Calculate how many times larger the volume of the eel egg cell is than the volume of the human egg cell.

(3)

Answer ..... times larger

(b) The eel egg cell is larger than the human egg cell, yet an adult eel is smaller than an adult human.

Analyse the data in the table to explain why it is advantageous for the eel to have a larger egg cell.

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(c) (i) Deduce the relationship between egg cell diameter and the mass of the adult animal shown by the data.

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(ii) Criticise this data set as evidence for a relationship between egg cell diameter and the mass of the adult.

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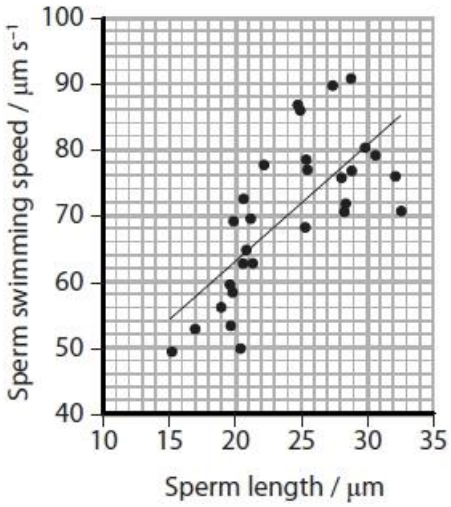
(Total for question = 10 marks)

Q5.

The relationship between the length of a sperm cell and the speed at which it can swim was investigated.

The data collected are shown in the graph.



(i) Calculate the swimming speed of a sperm cell that is 40 μm long, as predicted by the line shown on the graph.

(2)

Answer .....

(ii) Explain the limitations of using the line on the graph to predict the swimming speed of sperm cells.

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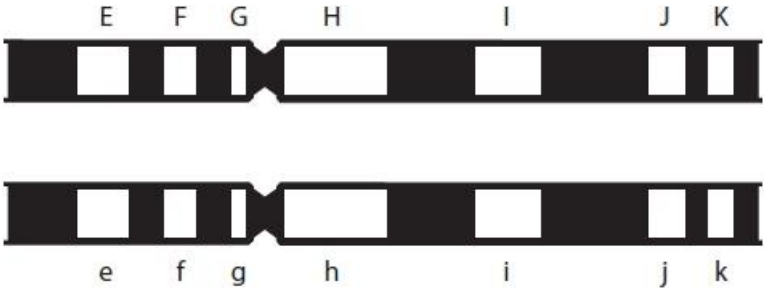
(Total for question = 4 marks)

Q6.

The diagram shows two homologous chromosomes from a man.



The white regions are the loci of seven genes involved in different phenotypic traits.
The letters E-K and e-k represent the alleles present at each locus.

Alleles F and G are

(1)

- ☒ **A** autosomal and complementary
- ☒ **B** autosomal and linked
- ☒ **C** sex-linked and dominant
- ☒ **D** sex-linked and epigenetic

(Total for question = 1 mark)

Q7.

Cell division in a plant such as an onion can be observed using a light microscope.

Explain why the following techniques are used when producing a root tip squash to observe cell division.

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Adding hydrochloric acid to the root tip

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Adding a stain to the root tip

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(Total for question = 4 marks)

Q8.

Cell division can be affected by various chemicals. The effects of these chemicals can be studied by observing tissues.

Chemotherapy is used to treat cancer. Cancer involves uncontrolled cell division. Some chemotherapy treatments have an effect on mitosis.

Paclitaxel is a chemical used in chemotherapy to treat various types of cancer. It works by preventing the shortening of spindle fibres.

Explain how preventing the shortening of spindle fibres affects mitosis.

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(Total for question = 2 marks)

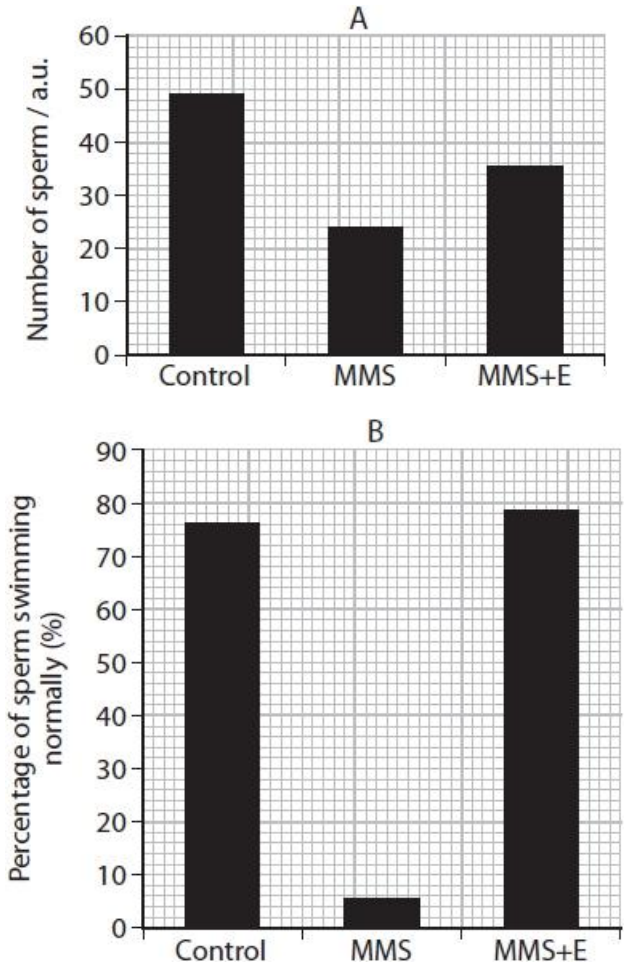
Q9.

Methyl methanesulfonate (MMS) can be used as a cancer treatment. One side effect associated with MMS is teratozoospermia.

Three groups of rats were exposed to the following additives to their diet as shown in the table.

Group	Additive to diet
Control	distilled water
MMS	methyl methanesulfonate
MMS+E	methyl methanesulfonate followed by vitamin E

The graphs show the results of the study of the sperm cells produced by these three groups of rats.



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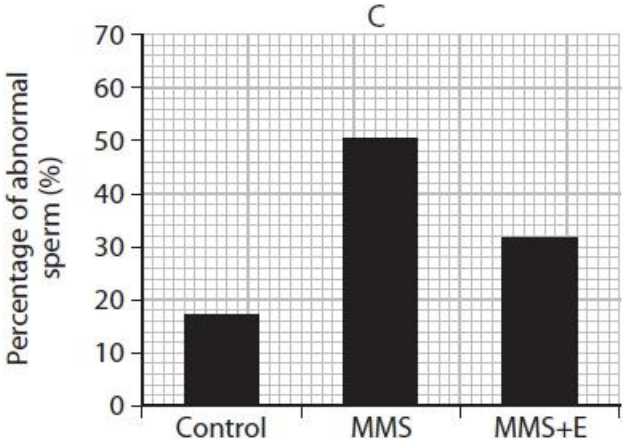

Deduce the effects of MMS on the production of sperm cells in rats.

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(Total for question = 3 marks)

Q10.

Seed banks store seeds to conserve different varieties of plants.

Seeds are stored for long periods of time in conditions that allow them to be germinated when required.

It is claimed that the percentage of cells in a root tip undergoing mitosis during the day is different from the percentage during the night.

Devise an investigation to test this hypothesis.

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(Total for question = 5 marks)

Q11.

Discuss the potential use of vitamin E as a fertility treatment for people with teratozoospermia.

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(Total for question = 6 marks)

Q12.

At the start of fertilisation, many sperm cells will surround the ovum.

Describe the events of fertilisation that occur after the acrosome reaction.

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(Total for question = 3 marks)

Q13.

The saiga antelope is found in the grasslands of Eurasia. In the 1970s its population was 1 250 000. The population has decreased due to loss of habitat and a disease outbreak in 2015.

Population estimates suggest as few as 50 000 individuals remain.

Conservation efforts aim to ensure that the population recovers to previous levels.

The population may recover quickly as saiga antelopes usually produce twins.

(i) Even though both offspring are from the same father and the same mother, they may be genetically different.

Explain why the offspring may be genetically different.

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(ii) During fertilisation, only one sperm cell can fertilise an egg cell.

Explain why a second sperm cell cannot fertilise the egg cell.

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(Total for question = 5 marks)

Q14.

Duchenne muscular dystrophy (DMD) is a sex-linked disorder.

(i) Explain what is meant by the term sex-linked disorder.

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(ii) Explain why the genotype frequency for males with DMD cannot be calculated using this Hardy-Weinberg equation.

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(iii) Dystrophin is a protein needed to maintain the structure of muscle cells.

In DMD the affected allele prevents the production of this protein, leading to symptoms that include a progressive effect on muscle tissue.
Stem cells are a potential treatment for DMD.
Explain why stem cells from a healthy donor may provide a treatment for this disorder.

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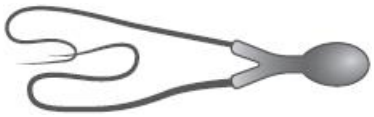
(Total for question = 7 marks)

Q15.

Teratozoospermia is a condition that causes sperm cells to have an abnormal structure. This condition reduces fertility.

The diagram shows an abnormal sperm cell with two flagella.



Explain why the production of these abnormal sperm cells may reduce fertility.

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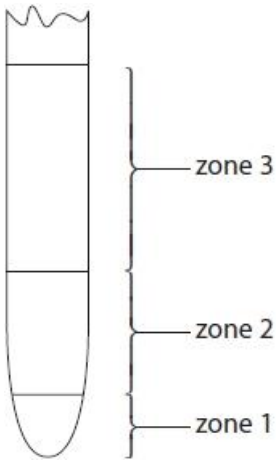
(Total for question = 3 marks)

Q16.

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 diagram shows three different zones found in a plant root.



Cells in zone 1 carry out interphase, mitosis and cytokinesis.

A student stated the hypothesis that:

In zone 1, the percentage of cells carrying out mitosis decreases from the tip to the start of zone 2.

(i) Which one of the following would be the correct null hypothesis?

(1)

☒ **A** the percentage of cells carrying out mitosis increases from the tip to the start of zone 2

☒ **B** the percentage of cells in interphase decreases from the tip to the start of zone 2

☒ **C** there is no change in the percentage of cells carrying out mitosis from the tip to the start of zone 2

☒ **D** there is no change in the percentage of cells in interphase from the tip to the start of zone 2

(ii) Devise an investigation to test this hypothesis.

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(Total for question = 6 marks)

Q17.

Children are different from their parents due to genetic variation and other factors.

Genetic variation can be the result of meiosis and random fertilisation of gametes.

During random fertilisation, only one sperm cell fuses with the cell surface membrane of an egg cell. Vesicles play an important role in this process.

Explain how vesicles are involved in the successful fertilisation of an egg cell by only one sperm.

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(Total for question = 2 marks)

Q18.

Children are different from their parents due to genetic variation and other factors.

Genetic variation can be the result of meiosis and random fertilisation of gametes.

Describe how meiosis leads to genetic variation in the gametes produced.

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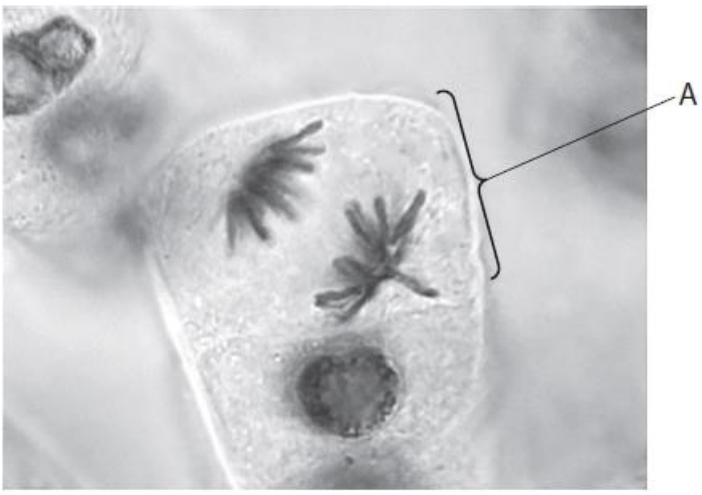
(Total for question = 2 marks)

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 ☒.

Plants have areas of undifferentiated cells called meristems. Cells in these areas divide rapidly during plant growth.

The photograph shows a cell undergoing nuclear division, as seen using a light microscope.



Magnification ×800

(i) Which stage of nuclear division is shown in cell A?

(1)

- ☒ **A** anaphase
- ☒ **B** metaphase
- ☒ **C** prophase
- ☒ **D** telophase

(ii) The mean distance between the two sets of chromatids in the photograph of cell A is 1.5 cm.

Calculate the actual distance in μm.

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(iii) Devise an investigation to study the effect of temperature on the rate of nuclear division in a plant meristem.

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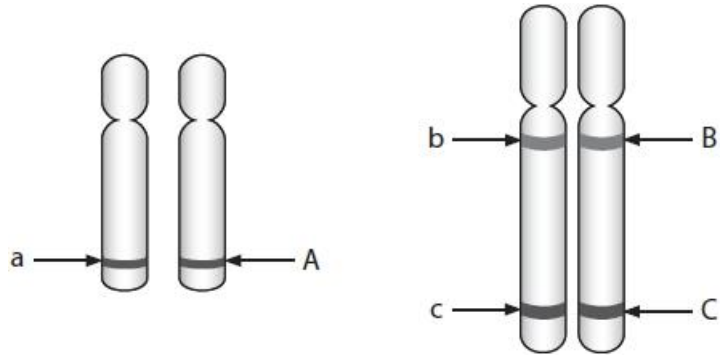
(Total for question = 8 marks)

Q20.

Linked genes are usually inherited together.

The process of meiosis gives rise to genetic variation. Genes A, B and C are located on two different pairs of chromosomes, as shown in the diagram.



Which combination of alleles could only be present if crossing over has occurred?

(1)

- ☒ **A** ABC
- ☒ **B** aBC
- ☒ **C** ABc
- ☒ **D** Abc

(Total for question = 1 mark)

Q21.

Children are different from their parents due to genetic variation and other factors.

Genetic variation can be the result of meiosis and random fertilisation of gametes.

Variation between children and their parents is affected by linkage of genes.

Explain why some genes show linkage and others show sex-linkage.

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(Total for question = 3 marks)

Q22.

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 ☒.

Fertilisation in humans involves the fusion of a sperm cell with an egg cell.

(i) After the sperm cell nucleus fuses with the egg cell nucleus, the single fertilised cell is described as a

(1)

- ☐ **A** diploid gamete
- ☐ **B** diploid zygote
- ☐ **C** haploid gamete
- ☐ **D** haploid zygote

(ii) The fertilised cell then divides by

(1)

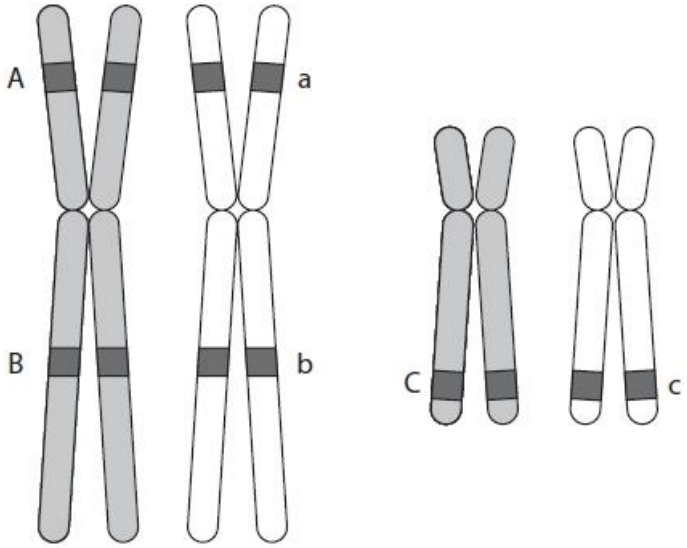
- ☐ **A** meiosis to produce genetically different cells
- ☐ **B** meiosis to produce genetically identical cells
- ☐ **C** mitosis to produce genetically different cells
- ☐ **D** mitosis to produce genetically identical cells

(Total for question = 2 marks)

Q23.

Homologous chromosomes pair up during meiosis.

The diagram shows the loci of three genes on two pairs of homologous chromosomes.



(i) Draw a diagram to show a crossover for chromosome 1 during meiosis.

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(ii) Explain how crossing over and independent assortment can produce gametes with new combinations of the alleles shown on the diagram of the two pairs of chromosomes.

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Crossing over

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Independent assortment

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(Total for question = 6 marks)

Q24.

Explain how crossing over may differ in sex chromosomes.

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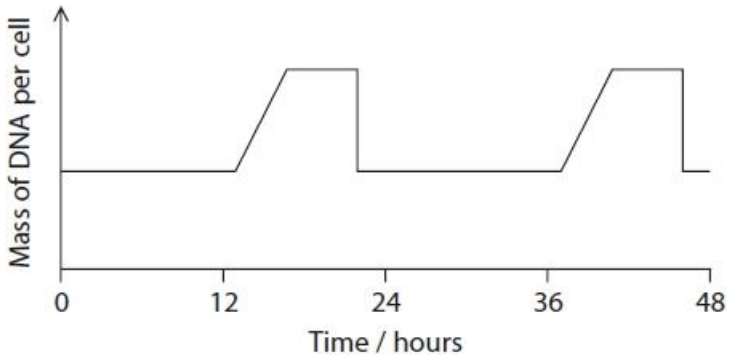
(Total for question = 2 marks)

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 ☒.

Some plants use asexual reproduction to produce offspring.

The graph shows how the mass of DNA changes in dividing cells.



(i) Mitosis is occurring between

(1)

- ☒ **A** 0 and 12 hours
- ☒ **B** 12 and 16 hours
- ☒ **C** 16 and 20 hours
- ☒ **D** 24 and 36 hours

(ii) Explain why DNA is replicated before mitosis begins.

(2)

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(iii) Explain how large numbers of cells with the same phenotype can be produced in a tissue.

(2)

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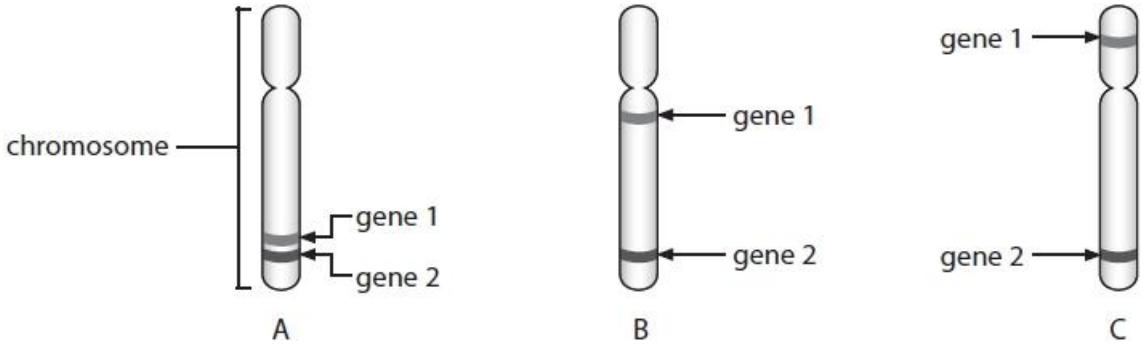
(Total for question = 5 marks)

Q26.

Linked genes are usually inherited together.

The diagram shows the position of two genes on three chromosomes, A, B and C.



(i) Name the part of a chromosome that is occupied by a gene.

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(ii) Explain which chromosome shows the weakest linkage between genes 1 and 2.

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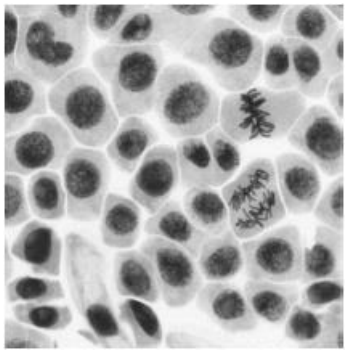
(Total for question = 4 marks)

Q27.

Cell division can be affected by various chemicals. The effects of these chemicals can be studied by observing tissues.

The photograph shows onion root cells undergoing mitosis.



(i) Draw a line labelled **M** to one cell at metaphase and a line labelled **A** to one cell at anaphase.

(2)

(ii) The rate at which cells are dividing can be determined by calculating the mitotic index.

The mitotic index is the percentage of cells in a sample undergoing mitosis.
The table shows the number of cells at different stages of the cell cycle in one sample.

Stage	Number of cells
Interphase	462
Prophase	23
Metaphase	24
Anaphase	4
Telophase	16

Calculate the mitotic index for the sample of cells shown in the table.

(2)

Answer ..... %

(Total for question = 4 marks)

Q28.

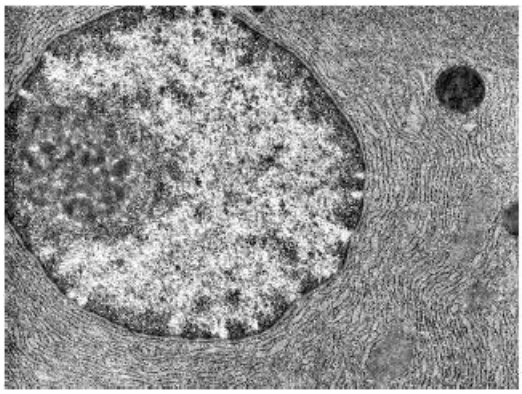
Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

An electron microscope can be used to identify organelles in eukaryotic cells.

The photograph shows part of a eukaryotic cell.

(i) Label the nucleolus on the photograph.

(1)



(Source: AL1379899 – Jose Luis Calvo / Shutterstock / PAL)

(ii) The nucleolus is not found in prokaryotic cells because they

(1)

- ☒ **A** do not contain DNA
- ☒ **B** do not have a nucleus
- ☒ **C** only contain RNA
- ☒ **D** only contain single-stranded DNA

(iii) Explain why the nucleus cannot be observed at the end of prophase in a eukaryotic cell.

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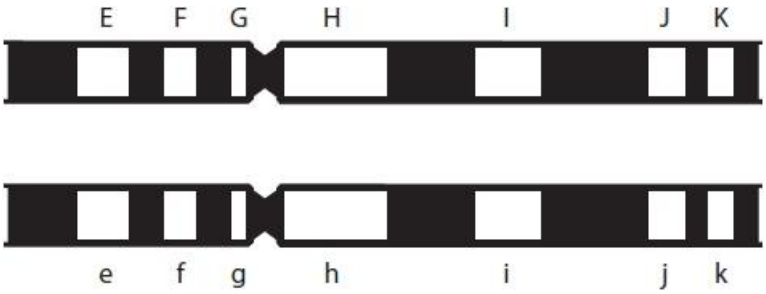
(Total for question = 4 marks)

Q29.

The diagram shows two homologous chromosomes from a man.



The white regions are the loci of seven genes involved in different phenotypic traits.
The letters E-K and e-k represent the alleles present at each locus.

This man produces gametes. Each gamete contains only one allele of each gene.

Describe how each gamete receives only one allele of each gene.

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(Total for question = 2 marks)

Q30.

Sperm cells have adaptations for their function as male gametes.

Describe how the acrosome is involved in the digestion of the zona pellucida.

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(Total for question = 2 marks)

Q31.

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 ☒.

A sperm cell must reach the egg cell membrane for fertilisation to occur.

The surface area of an egg cell with a diameter of 120 μm was calculated using the formula $4\ \pi r^2$.

Which of the following is the correct surface area of this egg cell to two significant figures?

(1)

- ☐ **A** 45 000 μm^2
- ☐ **B** 180 000 μm^2
- ☐ **C** 570 000 μm^2
- ☐ **D** 2 300 000 μm^2

(Total for question = 1 mark)

Q32.

Polyspermy occurs when more than one sperm cell enters the egg.

This is usually prevented by the hardening of the zona pellucida shortly after the arrival of the first sperm cell.

In an investigation, the effects of varying sperm cell concentrations on the fertilisation of eggs was measured. This was repeated using egg cells with the zona pellucida removed.

The table shows the results of these investigations.

Sperm cell concentration / $\times 10^3$ cm^{-3}	Zona pellucida intact		Zona pellucida removed	
	Percentage fertilisation (%)	Percentage polyspermy (%)	Percentage fertilisation (%)	Percentage polyspermy (%)
50	84	3	94	3
100	99	17	95	33
200	99	18	98	52

(i) In the investigation using egg cells without a zona pellucida, 15 egg cells were used for each sperm cell concentration.

Calculate how many of these egg cells were entered by more than one sperm cell when the sperm cell concentration was 100 × 10^3 cm^{-3}.

(2)

Answer .....

(ii) Deduce the effect of sperm cell concentration on the chance of polyspermy when the zona pellucida is removed.

(1)

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*(iii) During IVF treatment, egg cells are extracted from the ovaries.

Large numbers of sperm cells can be added to these egg cells in a Petri dish to increase the chances of successful fertilisation.
In a study of 200 extracted egg cells, there was damage to the zona pellucida of 13 of these egg cells.
Comment on the frequency of polyspermy due to IVF procedures.

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(Total for question = 9 marks)

Q33.

Studies have provided evidence for a link between heart rate when a person is at rest and various medical conditions.

Cancer can be due to body cells continuing to undergo mitosis and cell division. Prophase is one stage of mitosis.

Describe the events that occur during prophase in an animal cell.

(3)

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(Total for question = 3 marks)

Q34.

Which adaptation allows a sperm cell to digest the zona pellucida?

(1)

- ☒ **A** acrosome
- ☒ **B** flagellum
- ☒ **C** haploid nucleus
- ☒ **D** streamlined shape

(Total for question = 1 mark)

Q35.

Gametes are specialised for their role in sexual reproduction.

The purpose of the cortical reaction is to

(1)

- ☒ **A** allow the haploid nuclei to fuse
- ☒ **B** attract the sperm towards the egg cell
- ☒ **C** cause the sperm cell membrane to fuse with the egg cell membrane
- ☒ **D** ensure that only one sperm fertilises the egg

(Total for question = 1 mark)

Q36.

Give a reason for the high density of mitochondria found in the midpiece of a sperm cell.

(1)

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(Total for question = 1 mark)

Q37.

The sex of a mammal is determined by a pair of sex chromosomes. There are two types of sex chromosome known as X and Y.

(i) Which row in the table correctly shows the sex chromosomes found in the male and female gametes of mammals?

(1)

	Present in egg	Present in sperm
☒ **A**	Y	either X or Y
☒ **B**	either X or Y	X
☒ **C**	either X or Y	Y
☒ **D**	X	either X or Y

(ii) Explain why genes found on the sex chromosome pair have a pattern of inheritance that is different from genes found on other chromosome pairs.

(2)

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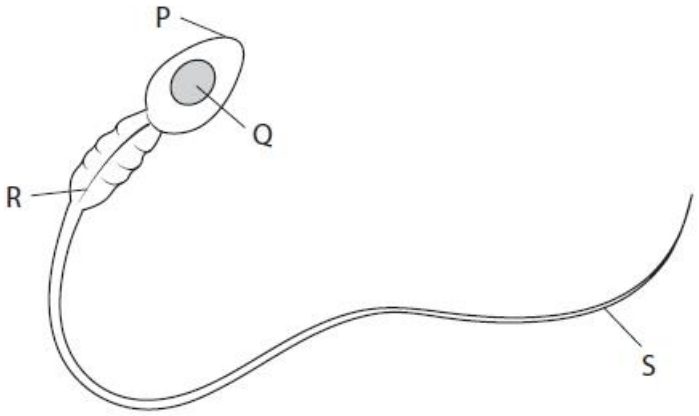
(Total for question = 3 marks)

Q38.

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 ☒.

Human fertility may be affected by chemicals in the environment such as polychlorinated biphenyls (PCBs). It is thought PCBs affect the functioning of the mitochondria.

(i) The diagram shows the structure of a sperm cell.



Which labelled part of the sperm cell contains mitochondria?

(1)

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

(ii) The table shows the effect of different concentrations of PCB on the speed of movement of sperm cells.

PCB concentration / mg dm^{-3}	Mean speed of sperm / $\mu m\ s^{-1}$
0	37
1	35
5	29
25	28

Calculate the percentage decrease in the mean speed of sperm in 25 mg dm^{-3} of PCB compared with the control.

(2)

Answer .....

(iii) Deduce how PCBs could affect the speed of movement of sperm.

(2)

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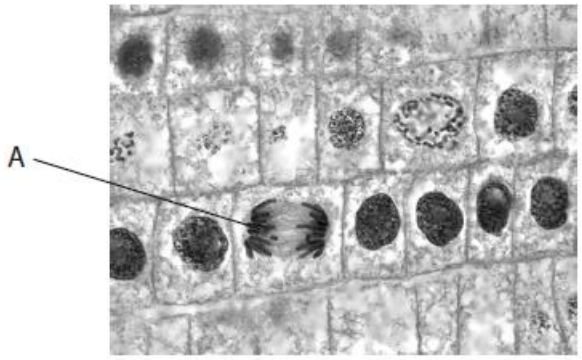
(Total for question = 5 mark)

Q39.

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 ☒.

Stages of cell division in plant tissue can be observed using a light microscope.

The image shows the result of a root tip squash.



(Source: AL1323910 – Jose Luis Calvo / Shutterstock / PAL)

(i) Which stage of cell division is shown by cell A?

(1)

- ☒ **A** anaphase
- ☒ **B** interphase
- ☒ **C** metaphase
- ☒ **D** prophase

(ii) The cells shown in the image are dividing by

(1)

- ☒ **A** meiosis to enable sexual reproduction
- ☒ **B** meiosis to enable growth
- ☒ **C** mitosis to enable sexual reproduction
- ☒ **D** mitosis to enable growth

(iii) Describe how a slide can be prepared from a root tip sample to produce this image.

(3)

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(iv) The mitotic index gives the percentage of cells in a sample undergoing mitosis.
Calculate the mitotic index for the 30 cells in this image.

(2)

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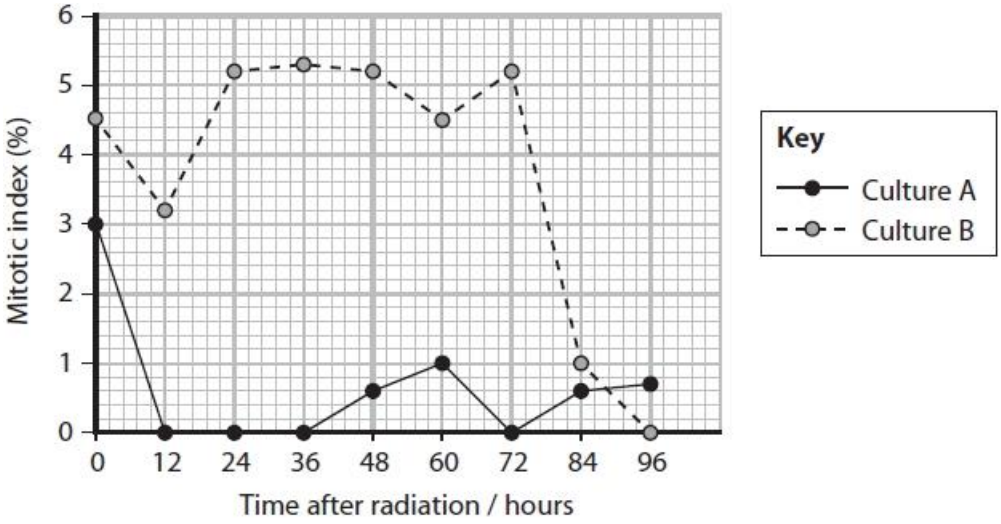
(Total for question = 7 marks)

Q40.

Two cultures of cells were used to investigate the cell cycle.
The cells in culture A have a functioning gene called P21.
The cells in culture B have no functioning P21 gene.

Both cultures were treated with gamma radiation that can cause damage to DNA.
They were then sampled at intervals of 12 hours and the mitotic index calculated.
The results are shown in the graph below.



Deduce the effect of the P21 gene on the cell cycle when cells are treated with gamma radiation.

(4)

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(Total for question = 4 marks)

Q41.

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 ☒.

Reproduction in mammals involves specialised cells called gametes. The production and structure of the gametes can be affected by chemicals in the environment.

(i) A sperm cell contains a specialised lysosome called the acrosome.

Describe the role of the acrosome in fertilisation.

(3)

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(ii) Following fertilisation a zygote is formed.

The zygote then divides by

(1)

- ☐ **A** meiosis to produce diploid cells
- ☐ **B** meiosis to produce haploid cells
- ☐ **C** mitosis to produce diploid cells
- ☐ **D** mitosis to produce haploid cells

(Total for question = 4 marks)

Q42.

Cell division during the production of gametes produces genetic variation.

This type of cell division involves

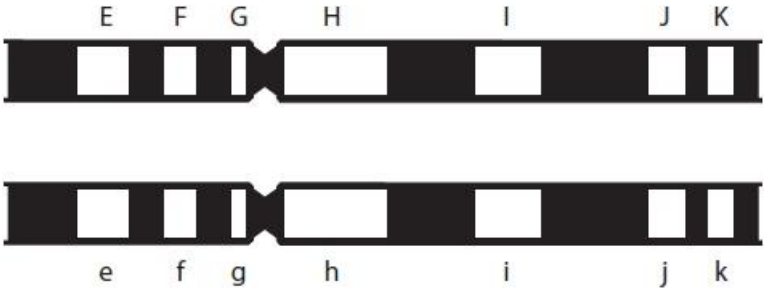
(1)

- ☒ **A** one division to produce diploid cells
- ☒ **B** one division to produce haploid cells
- ☒ **C** two divisions to produce diploid cells
- ☒ **D** two divisions to produce haploid cells

(Total for question = 1 mark)

Q43.

The diagram shows two homologous chromosomes from a man.



The white regions are the loci of seven genes involved in different phenotypic traits.
The letters E-K and e-k represent the alleles present at each locus.

The gametes produced by this man may have different combinations of alleles. Possible combinations of alleles are:

- E and K
- e and K
- h and i
- H and i

Assess the relative chances of this man's gametes containing these combinations of alleles.

(4)

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(Total for question = 4 marks)

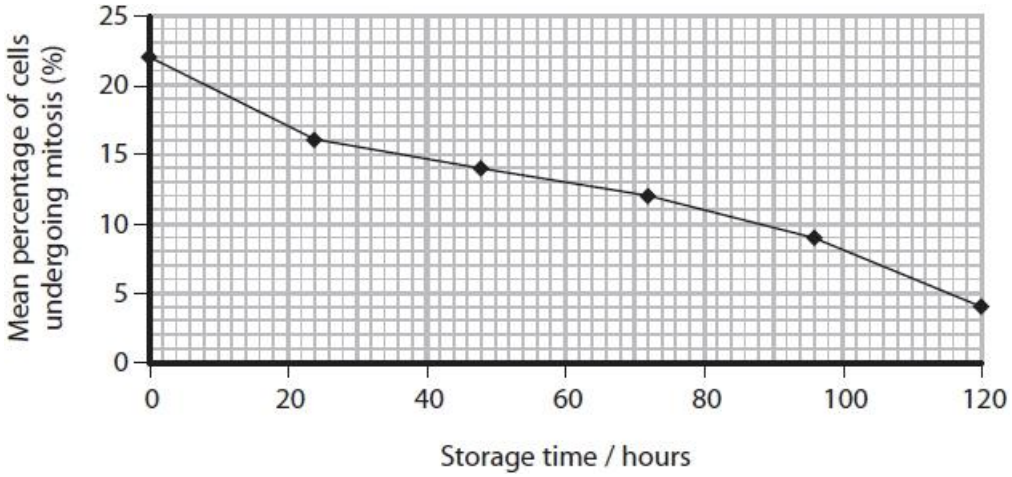
Q44.

Seed banks store seeds to conserve different varieties of plants.

Seeds are stored for long periods of time in conditions that allow them to be germinated when required.

Root tips were removed from the seedlings of variety Q. The percentage of cells from these root tips undergoing mitosis was recorded.

The results are shown in the graph.



(i) Describe the appearance of the chromosomes in the cells undergoing the metaphase stage of mitosis.

(3)

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(ii) Analyse the data to explain how storage time affects the growth of the seedlings of variety Q.

(2)

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(Total for question = 5 marks)

Mark Scheme

Q1.

Question Number	Answer	Mark
(i)	**The only correct answer is D – the sperm cell releases enzymes that digest the zona pellucida** A is not correct because the enzymes are released by the sperm and digest the zona pellucida B is not correct because enzymes are released by the sperm C is not correct because the enzymes digest the zona pellucida	1

Question Number	Answer	Mark
(ii)	**The only correct answer is A –** one copy of each gene | different alleles of some genes B is not correct because sperm can contain a different allele of a gene C is not correct because sperm will contain one copy of each gene D is not correct because sperm contain one copy of each gene and can have a different allele of some genes	1

Q2.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to the following: • negative correlation between Agil concentration and {number of cells undergoing mitosis / mitotic index} **(1)** • no significant difference between 1.0 and 1.5 ppm Agil **(1)**	ALLOW description ALLOW overlap between Agil concentrations of 1.0 and 1.5 ppm	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following: • controlled concentration of Agil **(1)** • one other variable controlled **(1)** • roots exposed (to Agil) for a range of time intervals **(1)** • details of root tip squash procedure **(1)** • an appropriate named stain **(1)** • counting number of cells undergoing mitosis (to calculate mitotic index) **(1)**	e.g. temperature / onions of same type – age, source ALLOW root tips e.g. correct use of hydrochloric acid or maceration procedure e.g. toluidine blue / (acetic) orcein / Schiff's /methylene blue	**(6)**

Q3.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: • fewer stem cells producing sperm (therefore fewer sperm cells produced) • fewer motile sperm therefore fewer sperm will reach the egg • {poor ability to cross the zona pellucida / acrosome reaction inhibited} therefore sperm will not reach the egg cell (membrane) • therefore reducing chance of fertilisation (1)	ALLOW 'mobile' sperm ALLOW fusing with egg cell membrane / fusion of nuclei in place of reaching egg cell	**(3)**

Q4.

Question Number	Answer	Additional Guidance	Mark
(a)	• conversion of eel data to µm (1) • calculation of volume of eel egg (1) • correct answer (1)	Example of calculation 1.1 mm = 1100 µm / 0.55 mm = 550 µm OR 0.70 mm^3= 7.0 x 10^8 $µm^3$ V = 4/3 π 550^3 = 7.0 x 10^8 ($µm^3$) OR V = 4/3 π 0.55^3 = 0.70 (mm^3) ALLOW 6.9 x 10^8 OR 0.69 7.0 x 10^8 / 1.8 x 10^6 = **389 (times larger)** **ALLOW 385 to 395 (times larger)** ALLOW ECF: division of candidate's calculated volume, as long as eel egg volume is larger Correct answer with no working gains full marks	(3)

Question Number	Answer	Additional Guidance	Mark
(b)	An explanation that makes reference to the following: • a larger egg will contain more lipid droplets (1) • therefore will provide more energy for the development of the embryo (1) • the eel's larger egg is a bigger target for sperm to hit, aiding fertilisation in open water (1)	 ALLOW more resources for the embryo ALLOW greater chance of fertilisation	(2)

Question Number	Answer	Additional Guidance	Mark
(c)(i)	• as adult mass increases, egg diameter decreases OR there is a negative correlation (between adult mass and egg diameter) (1)	ACCEPT converse	(1)

Question Number	Answer	Additional Guidance	Mark
(c)(ii)	An answer that makes reference to four of the following: • this data set includes only a few { species / animals } (1) • the species in the data are from different taxonomic groups (1) • there is no (evidence of) repeats / data for these individuals may not be representative (1) • the reproductive strategy of the species { is likely to influence egg size / should be controlled } (1) • there are other factors that { may affect the egg cell / may affect adult mass / should be controlled } (1)	ALLOW small sample size ALLOW more species needed NOT more groups / amphibians IGNORE ref to different species (alone) ALLOW similar species should be used NOT different kingdoms / phyla ALLOW an example e.g. site of fertilisation, where the embryo develops ALLOW an example of a relevant factor e.g. maternal diet, health, predation risk, age IGNORE height	(4)

Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	• correct extrapolation to find the speed for 40µm (1) • correct units (1)	<u>Example of calculation</u> 18 ÷ 10 = 1.8 (ALLOW 1.75 to 1.85) 84 + (1.8 x 8) = 98.4 µm/s ALLOW **98 to 99 µm/s** µm/s OR µm s^{-1} NOT $µm^{s-1}$	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation making reference to the following points: • there is variation about the line / few data points lie exactly on the line (therefore the prediction will not be exact) (1) • the gradient of the line may not remain the same (1)	ALLOW a suggested reason for variation about the line e.g. different numbers of mitochondria in the sperm	(2)

Q6.

Question Number	Answer	Mark
	B – autosomal and linked	(1)

Q7.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to four of the following: **Adding hydrochloric acid** • **breaks down middle lamella (1)** • **allowing cells to be separated / produce a thin layer (of cells)(1)** • **to allow light** **to pass through (1)** **Adding stain** • **makes the chromosomes visible (1)** • **so that stages of mitosis can be identified (1)**	**ALLOW one cell can be observed at a time**	**(4)**

Q8.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to two of the following: • (sister) chromatids cannot be separated / centromere cannot be split **(1)** • mitosis stops at metaphase / anaphase cannot occur / chromosomes remain at equator **(1)** • (daughter) cells produced with incorrect numbers of chromosomes **(1)**		**(2)**

Q9.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: • MMS reduces {sperm count / number of sperm cells} (1) • MMS increases percentage of sperm cells with abnormalities (1) • (as the greatest effect is on percentage of sperm swimming normally) MMS is likely to affect production of {flagella / mitochondria} (1)		**(3)**

Q10.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: • description of how {day and night / light and dark } conditions provided / collect root tips { during day and night / from plants grown in light and dark conditions } (1) Plus four of the following: • use same source of root tips (1) • controlled environmental variable in which plants grown (1) • use of appropriate named stain (1) • squash { under a coverslip / on a microscope slide } (1) • description of how comparison considered (1)	 ALLOW same species / same variety / type Q / same plant / same age of plant e.g. temperature, humidity, mineral ion concentration e.g. (propionic) orcein, toluidine blue, Schiff's reagent, Feulgen's reagent ALLOW macerated or a description of maceration e.g. percentage of cells undergoing mitosis, mitotic index calculated	**(5)**

Q11.

Question Number	Answer
	Answers will be credited according to candidate's knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • There is a positive effect of vitamin E shown from the trial on reducing number of abnormal sperm and improved motility • Reference to data from graphs to compare results with vitamin E and control groups • Increased motility will increase probability that sperm will reach the egg • Increases in sperm count will increase the chance of fertilisation • The low numbers of sperm may not be the reason for infertility • Trials conducted on rats not humans therefore results may not be the same in people • The trial only involved examples of teratozoospermia that are caused by MMS • Other causes of teratozoospermia may not respond to Vitamin E **(6)**

Level 0	**0**	No awardable content	
Level 1	**1-2**	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.	Description of positive effect of vitamin E e.g. reference to an improvement such as improved sperm motility, reduced abnormalities
Level 2	**3-4**	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.	Discussion of how specific effects of vitamin E treatment would improve fertility or analysis of data from graphs, e.g. comparing vitamin E treatment data with control groups. Reference to tests only being carried out on rats or results from trials on humans necessary. Other causes of teratozoospermia apart from MMS not considered.

Level 3	**5-6**	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Full discussion of evidence for potential use of vitamin E to treat infertility. Detailed discussion of limitations due to experimental design or other causes of infertility.

Q12.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to three of the following: • fusion of sperm cell (membrane) with egg cell membrane (1) • cortical granules release contents (into zona pellucida) (1) • contents of cortical granules react with the zona pellucida / zona pellucida { thickens / hardens } (1) • fusion of { sperm and egg / haploid } nuclei (1)	ALLOW sperm cell binds to egg cell membrane	**3**

Q13.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation which makes reference to two of the following: • (each zygote is formed) from different gametes / random fertilisation (1) • each gamete contains different combinations of alleles (1) • (different combination of alleles due to) { independent assortment / crossing over } (during meiosis) (1)	ALLOW not monozygotic twins	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation which makes reference to the following: • cortical reaction / fusion of cortical granules with egg cell (surface) membrane (1) • resulting in { thickening / hardening } of the zona pellucida (1) • therefore (other) sperm cells cannot reach egg cell (surface) membrane (1)		(3)

Q14.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to two of the following: • (a disorder caused by) a {mutated / faulty } gene (1) • located on the { X / Y } chromosome (1) • therefore (the disorder) is more likely in one gender than another (1)	ALLOW allele for gene ALLOW located on sex chromosome	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to two of the following: • males only have one allele for this gene (1) • males cannot be heterozygous (1) • the Hardy-Weinberg equation assumes all individuals have two alleles for the gene (1)	ALLOW males do not have two alleles for the gene ALLOW males cannot be carriers ALLOW 2pq cannot be calculated	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to the following: • stem cells can differentiate into muscle cells (1) • these cells will not have the affected allele (1) • {the protein / dystrophin} will be produced (1)	ALLOW 'specialise' instead of 'differentiate' ALLOW will have normal allele for dystrophin	(3)

Q15.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: • (presence of two flagella) would affect {motility / ability of sperm to propel itself} (1) • this may prevent sperm from reaching the egg (1) • preventing fertilisation (1)	ALLOW would affect ability of sperm to {swim / move} / affect direction of movement	(3)

Q16.

Question Number	Answer	Mark
(i)	***The only correct answer is C*** - there is no change in the percentage of cells carrying out mitosis from the tip to the start of zone 2. ***A*** *is incorrect as it is the alternate and not the null hypothesis* ***B*** *is incorrect as the null hypothesis must refer to mitosis and not interphase* ***D*** *is incorrect as the null hypothesis must refer to mitosis and not interphase*	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to five of the following: • samples from different regions of zone 1 / samples from zone 1 and (start of) zone 2 (1) • details of root tip squash procedure (1) • use of an appropriate named stain (1) • detail of how to assess percentage of cells undergoing mitosis (1) • use of a named appropriate statistical test (1) • comparison of calculated value to critical value (to accept or reject the student's hypothesis) (1)	e.g. correct use of hydrochloric acid, maceration procedure, squashing to produce single layer of cells e.g. toluidine blue, (ethanoic) orcein e.g. number of cells with visible chromosomes compared to the total or use of mitotic index e.g. Spearman's rank correlation, or (Student's) T test (to compare two different regions)	(5)

Q17.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following: • cortical granules fuse with the egg cell (surface) membrane (1) • releasing {contents / enzyme} that {harden / thicken}zona pellucida (1)	ALLOW exocytosis ALLOW alter the polarity of the egg cell surfacemembrane	(2)

Q18.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to the following: • (produces non-identical gametes due to) independentassortment (of chromosomes) (1) • crossing over between (non-sister) chromatids (of homologous chromosomes) (1)	ALLOW description of independent assortment e.g. random which chromosome of each pair moves to which pole ALLOW description of crossing over e.g. swapping of alleles between (non-sister) chromatids	(2)

Q19.

Question Number	Answer	Mark
(i)	***A*** *– anaphase* ***The only correct answer is A*** ***B*** *is not correct because chromosomes are not pulled apart in metaphase* ***C*** *is not correct because chromosomes are not pulled apart in prophase* ***D*** *is not correct because chromosomes are not pulled apart in telophase*	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	• correct conversion of units (1) • image size divided by magnification (1)	<u>Example of calculation</u> 15 (mm) x 1000 = 15000 (µm) 15000 ÷ 800 = 18.75 (µm) ALLOW 18.8 Correct answer with no working gains full marks	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to five of the following: • grow plant in a suitable range of temperatures (1) • description of a suitable named variable to be controlled when growing the plants(1) • sample meristem tissue from same area of plant (1) • an appropriately named stain (1) • details of root tip squash procedure (1) • detail of how to compare number of cells undergoing nuclear division / calculate mitotic index (1)	 e.g. a range up to 40°C e.g. plant {species / age } / growing conditions such as light, mineral ions, water, pH e.g. either root tips / shoot tips e.g. toluidine blue, (ethanoic) orcein e.g. use of hydrochloric acid to prepare tissue sample, maceration procedure, squashing under cover slip e.g. number of cells with {visible / condensed} chromosomes compared to the total	(5)

Q20.

Question Number	Answer	Mark
	C –ABc *The only correct answer is C* *A is not correct because B and C are on the same chromosome* *B is not correct because B and C are on the same chromosome* *D is not correct because b and c are on the same chromosome*	**(1)**

Q21.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following: • there are more genes than there are chromosomes (1) • linkage relates to genes (for different characteristics)located on the same (non-sex) chromosome (1) • sex-linkage relates to genes on the {sex / X / Y} chromosome (1)	ALLOW many genes on each chromosome	**(3)**

Q22.

Question Number	Answer	Mark
(i)	**The only correct answer is B – a diploid zygote** ***A*** *is incorrect because it is not a gamete* ***C*** *is incorrect because it is not haploid* ***D*** *is incorrect because it is not haploid*	**(1)**

Question Number	Answer	Mark
(ii)	**The only correct answer is D- mitosis to produce genetically identical cells** ***A*** *is incorrect because the division is not meiosis* ***B*** *is incorrect because the division is not meiosis* ***C*** *is incorrect because the cells are not genetically different*	**(1)**

Q23.

Question Number	Answer	Additional guidance	Mark
(i)	An answer that includes the following: • a diagram showing a pair of homologous chromosomes with a crossover between two chromatids (1) • crossing of non-sister chromatids (1)	ALLOW correct products of crossover.	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to the following: Crossing over • chromatids are produced with different combinations of alleles (1) • for example { Ab/aB } (1) Independent Assortment • different combinations of chromosomes (1 and 2) are produced (1) • therefore the alleles for A and B could be in the same gamete as C or c (1)		(4)

Q24.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following: • crossovers cannot form between (some sections of) the X and Y chromosome (1) • because { they are not homologous chromosomes / the Y chromosome is shorter / there are alleles on the X chromosome that are not on the Y chromosome } (1)	ALLOW crossovers unlikely to form between the X and Y chromosome ALLOW reference to difference in size of the X and Y chromosomes	(2)

Q25.

Question Number	Answer	Mark
(i)	The only correct answer is – C 16 and 20 hours A is incorrect because cells are in early interphase B is incorrect because cells are replicating DNA from 12 hours D is incorrect because cells are in interphase from 24 to 36 hours	**(1)**

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to the following: • to ensure that {diploid number of chromosomes / one copy of each chromosome } in each daughter cell (1) • to ensure daughter cells are genetically identical (1)	ALLOW correct number of chromosomes in each cell	**(2)**

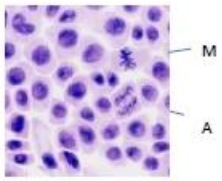
Question Number	Answer	Additional guidance	Mark
(iii)	An explanation that makes reference to the following: • phenotype is determined by the genotype and the effect of the environment (1) • mitosis produces cells with the same genotype (1)	ALLOW mitosis produces genetically identical cells	**(2)**

Q26.

Question Number	Answer	Additional Guidance	Mark
(i)	• locus (1)	ALLOW loci	(1)

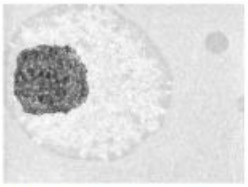
Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation which makes reference to the following: • (diagram / chromosome) C (1) • because the genes are furthest apart (1) • more likely { to be separated during crossing over / chiasmata forming between the two genes } (1)	ALLOW genes are further apart	(3)

Q27.

Question Number	Answer	Additional Guidance	Mark
(i)	• cell correctly labelled M **(1)** • cell correctly labelled A **(1)**		(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	• correct number of cells undergoing mitosis and correct total number of cells calculated • correct answer	<u>Example of calculation</u> 67 and 529 Correct % calculated = 12.665(%) / 12.67(%) / 12.7(%) Correct answer with no working gains full marks	(2)

Q28.

Question Number	Answer	Additional guidance	Mark
(i)	• nucleolus correctly labelled	 within area shown	**(1)**

Question Number	Answer	Mark
(ii)	The only correct answer is – B prokaryotic cells do not have a nucleus A is incorrect because prokaryotic cells do contain DNA C is incorrect because prokaryotic cells do not only contain RNA D is incorrect because prokaryotic cells do not only contain single-stranded DNA	**(1)**

Question Number	Answer	Additional guidance	Mark
(iii)	An explanation that makes reference to the following: • because the nuclear membrane is broken down (1) • because DNA is { coiled / condensed } into individual chromosomes (1)		**(2)**

Q29.

Question Number	Answer	Additional Guidance	Mark
	A description making reference to two of the following: • (in meiosis) homologous chromosomes (carrying alleles for the same genes) are separated from one another (1) • sister chromatids (containing copies of the same alleles) are (also) separated from one another (1) • spindle (fibres) pull the { chromosomes / chromatids } to opposite poles of the cell (1)	IGNORE crossing over IGNORE independent assortment IGNORE reference to stages of meiosis ALLOW split for separated	**(2)**

Q30.

Question Number	Answer	Additional guidance	Mark
	A description that makes reference to two of the following: • **the membrane of the acrosome fuses with the (plasma) membrane (of the sperm cell) (1)** • **releasing enzymes (from the acrosome) (1)** • **by exocytosis (1)**	**ALLOW acrosin**	**(2)**

Q31.

Question Number	Answer	Mark
	The only correct answer is – A 45000 μm² **B is incorrect because the diameter was used instead of the radius** **C is incorrect because 4πr was calculated before squaring** **D is incorrect because 4π × diameter was calculated before squaring**	**(1)**

Q32.

Question Number	Answer	Additional guidance	Mark
(i)	• correct percentage selected (1) • correct calculation of number of eggs rounded up to whole number of eggs (1)	**Example of calculation** 33% 0.33 x 15 = 4.95 = 5 (eggs) **One mark for 4.95** Correct answer without working gains full marks	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to the following: • as sperm cell concentration increases so does the risk of polyspermy (1)	ALLOW positive correlation	(1)

Question Number	Indicative content
*(iii)	Answers will be credited according to candidate's knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • {removing the zona pellucida causes an increase in polyspermy • because it prevents a physical barrier being formed • the effect is increased at higher sperm cell concentrations • because more sperm cells reach the (egg cell) membrane at the same time. • there is an increased concentration of sperm around the egg in IVF • due to shorter distance that the sperm have to swim / fewer sperm die on the way to the egg • even with zona pellucida intact there are some incidences of polyspermy • there is a delay while the cortical reaction takes place • physical damage to zona pellucida can prevent effectiveness of cortical reaction

Level	Marks		Additional Guidance
0	0	No awardable content	
1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Damage to zona pellucida increases risk of polyspermy OR increased number of sperm increase risk of polyspermy
2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.	Reference made to data showing polyspermy increases with increase in sperm 'concentration' OR increases when zona pellucida removed. Link made to either lack of hardening of zona pellucida or increased probability to more than one sperm entering if there are more of them.
3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Reference to data on both sperm 'concentration' and presence of zona pellucida, linked to cortical reaction which would otherwise prevent polyspermy. Answer links all the data and makes reference to reasons why IVF could result in increased risk of polyspermy.

Q33.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to three of the following: • {nucleus / nuclear envelope / nucleous} breaks down **(1)** • spindle (fibres) formed **(1)** • {chromosomes / chromatids} condense **(1)** • Centrioles migrate to (opposite) poles of the cell **(1)**	IGNORE chromatin ALLOW become visible ALLOW opposite ends	**(3)**

Q34.

Question Number	Answer	Mark
	A the acrosome	**(1)**

Q35.

Question Number	Answer	Mark
	D to ensure that only one sperm fertilises the egg	**(1)**

Q36.

Question Number	Answer	Additional Guidance	Mark
	An answer making reference to the following point: • { energy / ATP } for movement of flagellum (1)	ALLOW (to release) energy for the sperm to swim ALLOW **provide** energy IGNORE 'move' alone NOT **produce** energy NOT energy **for** respiration	**(1)**

Q37.

Question number	Answer	Mark
(i)	**The only correct answer is D -** X | either X or Y ***A** is not correct because eggs do not contain a Y chromosome* ***B** is not correct because eggs do not contain a Y chromosome and sperm do not always contain X* ***C** is not correct because eggs do not contain a Y chromosome*	(1)

Question number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to two of the following points: • X chromosome carries { genes / loci } not present on the Y chromosome (1) • males have only one { copy / allele } of some genes (1) • (if only one allele inherited) it will be expressed (1)	ALLOW Y chromosome does not carry { a copy /alleles } of some genes	(2)

Q38.

Question Number	Answer	Mark
(i)	The only correct answer is C – R *A is not correct because P is the site of the acrosome* *B is not correct because Q is the nucleus* *D is not correct because S is the flagellum*	(1)

Question Number	Answer	Additional guidance	Mark
(ii)	• correct calculation of difference (1) • correct calculation of % decrease (1)	Example of calculation 37-28=9 (9÷37)x100=24.32 ALLOW 24 24.3 Correct answer without working gains full marks	(2)

Question Number	Answer	Additional guidance	Mark
(iii)	An answer that makes reference to two of the following • PCBs reduce (aerobic) respiration (1) • therefore less ATP is produced (1) • sperm need ATP to move the flagellum (1)	ALLOW energy for ATP ALLOW tail for flagellum	(2)

Q39.

Question Number	Answer	Mark
(i)	The only correct answer is – A anaphase B is incorrect because the cell is not in interphase C is incorrect because the cell is not in metaphase D is incorrect because the cell is not in telophase	**(1)**

Question Number	Answer	Mark
(ii)	The only correct answer is – D A is incorrect because root tips are not involved with reproduction B is incorrect because root tip cells do not divide by meiosis C is incorrect because root tips are not involved with reproduction	**(1)**

Question Number	Answer	Additional guidance	Mark
(iii)	A description that makes reference to the following: • description of use of appropriate part of the root tip (1) • an appropriately named stain (1) • details of root tip squash procedure (1)	e.g. toluidine blue, (ethanoic) orcein e.g. use of hydrochloric acid to prepare tissue sample, maceration procedure, squashing under cover slip	**(3)**

Question Number	Answer	Additional guidance	Mark
(iv)	• number of cells undergoing mitosis divided by total number of cells (1) • correct answer given as a percentage (1)	Example of calculation 7 ÷ 30 = 23.3% Correct answer with no working gains full marks	**(2)**

Q40.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to the following: • radiation can cause damage to chromosomes (1) • cells with (a functioning) P21 gene show reduced cell division (1) • with faulty P21 gene cell division remains high (1) • suggests P21 prevents cell progressing through mitosis if DNA damaged (1)	ALLOW after 72 hours mitosis is reduced as cells are not viable ALLOW P21 regulates the cell cycle	(4)

Q41.

Question Number	Answer	Additional guidance	Mark
(i)	A description that makes reference to the following • it fuses with the cell (surface) membrane of the sperm cell (1) • (digestive) enzymes are released (1) • to break down the zona pellucida (1)	DO NOT ALLOW lysozyme	(3)

Question Number	Answer	Mark
(ii)	The only correct answer is C- mitosis to produce diploid cells *A is incorrect because the division is not meiosis* *B is incorrect because meiosis does not produce diploid cells* *D is incorrect because mitosis does not produce haploid cells*	(1)

Q42.

Question Number	Answer	Mark
	D - two divisions to produce haploid cells ***The only correct answer is D*** ***A*** *is not correct because diploid cells are not produced* ***B*** *is not correct because there are two divisions not one* ***C*** *is not correct because diploid cells are not produced*	**(1)**

Q43.

Question Number	Answer	Additional Guidance	Mark
	An answer making reference to four of the following points: • combination on same chromosome more likely (1) • but { e+K / H+i } can result from crossing over (1) • H+i are closer together than e+K (1) • greater distance between loci gives greater likelihood of { crossing over / e+K } (1) • the relative chances, from most likely to least likely, are: h+i, E+K, e+K, H+i (1)	ALLOW converse ALLOW E+K / h+i > e+K / H+i	**(4)**

Q44.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to three of the following: • condensed / visible (1) • seen as pairs of chromatids (held together by a centromere) (1) • joined to the spindle (fibres) (1) • aligned on the equator of the cell (1)	ALLOW from annotated drawing ALLOW thickened /shortened ALLOW correct reference to sister chromatids ALLOW middle for equator	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to two of the following: • with longer storage time growth (of the seedling) will be slower (1) • as there is less { mitosis / cell division } (after increased storage time) (1) • because storage conditions lead to { enzymes being denatured / (stem) cell death / fungal growth } (1)	ALLOW less or decreased growth ALLOW decrease in percentage undergoing mitosis of 18% after 120 hours	(2)