

Questions

Q1.

Recombination of alleles can be due to the crossing over that occurs during meiosis. This process results in gametes with different combinations of alleles and genetic variation in the offspring.

Crossing over occurs between two genes found on the same chromosome.

The recombination frequency reflects the likelihood of crossing over occurring. It depends on how close the genes are on the chromosome.

Explain why crossing over between two different genes, located on a pair of homologous chromosomes, results in a maximum of 50% of gametes with the recombinant alleles.

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(Total for question = 3 marks)

Q2.

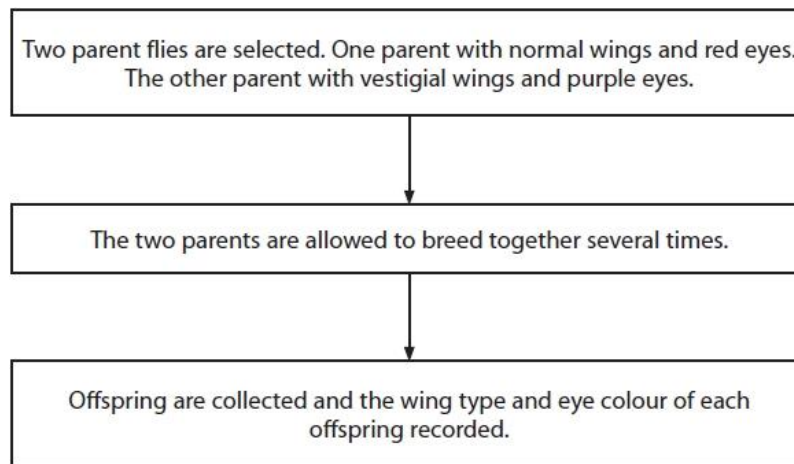
Recombination of alleles can be due to the crossing over that occurs during meiosis. This process results in gametes with different combinations of alleles and genetic variation in the offspring.

Crossing over occurs between two genes found on the same chromosome.

The recombination frequency reflects the likelihood of crossing over occurring. It depends on how close the genes are on the chromosome.

In fruit flies, the gene for wing type is located on the same chromosome as the gene for eye colour.

The flow diagram shows an experiment used to calculate the recombination frequency for these two genes.



The table shows the results of one experiment.

Description of offspring	Number recorded
Normal wings and red eyes	672
Vestigial wings and purple eyes	592
Normal wings and purple eyes	75
Vestigial wings and red eyes	69

The recombinant frequency is the percentage of offspring that have a different combination of characteristics compared with the parents. It is the proportion of the total number of offspring.

Calculate the recombinant frequency for this pair of genes.

Give your answer to three significant figures.

(1)

Answer

(Total for question = 1 mark)

Q3.

A zygote is formed when gametes fuse at fertilisation.

Explain how meiosis results in genetic variation in the gametes.

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(Total for question = 2 marks)

Q4.

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

Metaphase is one stage of mitosis.

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

(2)

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

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(Total for question = 4 marks)

Q5.

In cancers, cells divide uncontrollably.

Colchicine is an anti-cancer drug that inhibits mitosis.

The effects of treating cells with colchicine were investigated.

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

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

The table shows the results of this investigation.

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

(i) Explain the results shown in the table.

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

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(Total for question = 6 marks)

Q6.

Recombination of alleles can be due to the crossing over that occurs during meiosis. This process results in gametes with different combinations of alleles and genetic variation in the offspring.

When does crossing over first take place?

(1)

- A** metaphase I
- B** metaphase II
- C** prophase I
- D** prophase II

(Total for question = 1 mark)

Q7.

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

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

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

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

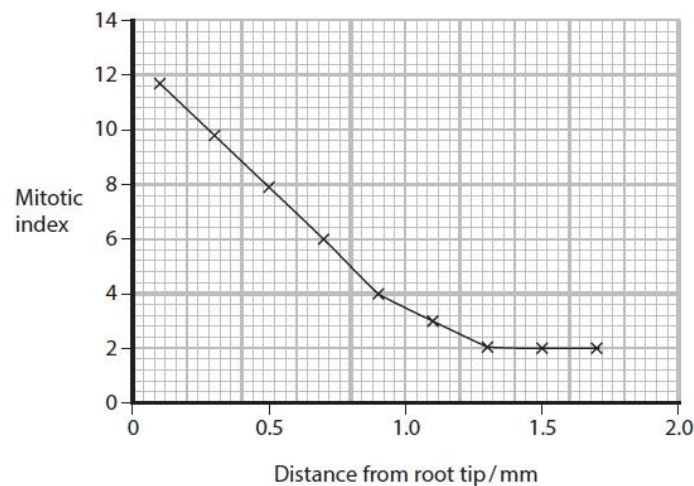
$$\text{Mitotic index} = \frac{\text{number of actively dividing cells}}{\text{total number of cells}} \times 100$$

(2)

Answer

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

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



Explain the relationship shown in the graph.

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(Total for question = 4 marks)

Q8.

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

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

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

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

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

Justify two improvements to this method.

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(Total for question = 2 marks)

Q9.

Recombination of alleles can be due to the crossing over that occurs during meiosis. This process results in gametes with different combinations of alleles and genetic variation in the offspring.

Crossing over occurs between two genes found on the same chromosome.

The recombination frequency reflects the likelihood of crossing over occurring. It depends on how close the genes are on the chromosome.

The table shows the recombinant frequencies between four genes, J, K, L and M, located on the same chromosome.

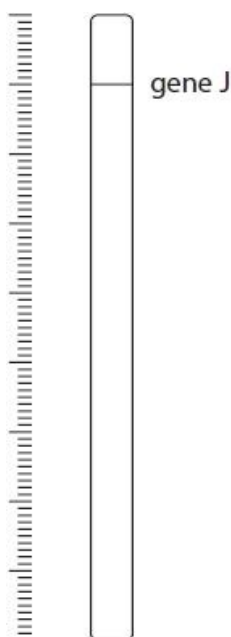
Pairs of genes	Recombinant frequency (%)
J and K	12.0
J and M	15.0
L and K	3.0
L and M	6.0

A genetic map can be produced by drawing a scale diagram to show the location of these genes.

The diagram shows the position of gene J on a chromosome.

Complete the diagram to show the position of genes K, L and M on this chromosome.

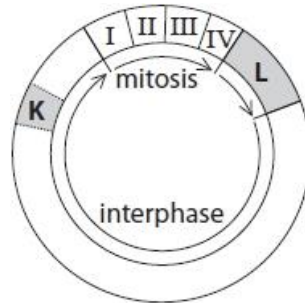
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**(Total for question = 3 marks)**

Q10.

Mitosis is one of the stages of the cell cycle.

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



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

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

The results are shown in the table.

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

- (i) The cells in this root tip had a cell cycle time of 23 hours.
Calculate the time, in minutes, that these cells spent in anaphase.

(2)

Answer mins

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

The student worked out that the cells spent 8% less time in anaphase.
Calculate the time, in minutes, that these cells spent in anaphase.

(2)

Answer mins

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

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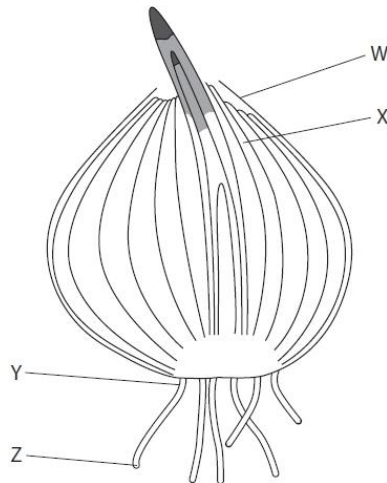
(Total for question = 6 marks)

Q11.

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 .

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

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



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

(1)

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

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

(1)

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

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(Total for question = 4 marks)

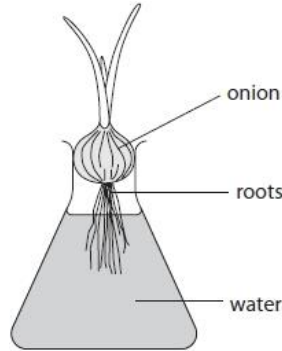
Q12.

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

The student formed the following hypothesis:

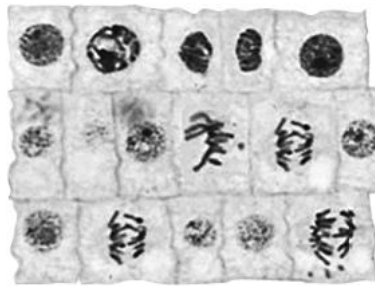
Adding water to soil inhibits mitosis in root cells.

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



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

The photomicrograph shows a preparation from one onion root tip.



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

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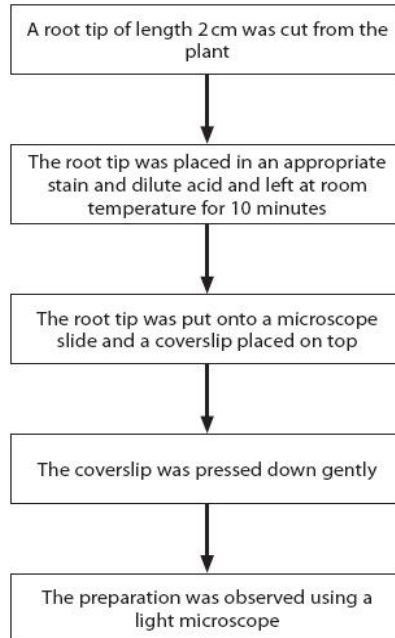
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(Total for question = 4 marks)

Q13.

A student made a squash preparation of a root tip to observe the stages of mitosis. The diagram shows the method that the student used.



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

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

(2)

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

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(Total for question = 6 marks)

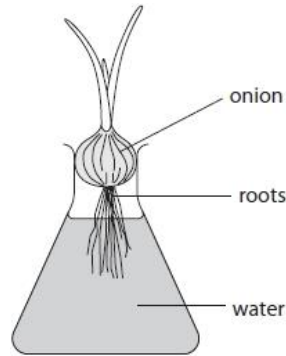
Q14.

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

The student formed the following hypothesis:

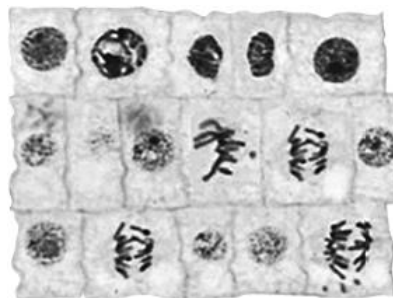
Adding water to soil inhibits mitosis in root cells.

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



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

The photomicrograph shows a preparation from one onion root tip.



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

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(Total for question = 4 marks)

Q15.

During mitosis, microtubules form the spindle.

These microtubules are made of a protein called tubulin.

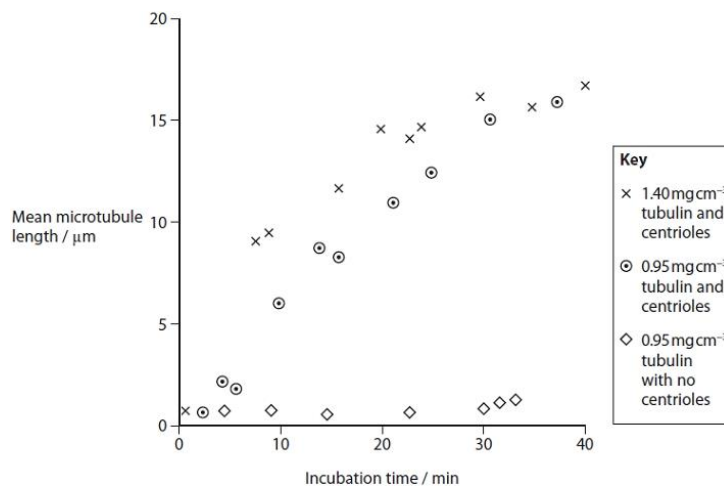
Individual tubulin molecules are globular with a diameter of 25 nm.

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

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

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

The graph shows the results of this investigation.



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

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

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(Total for question = 8 marks)

Q16.

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

The photograph shows some cabbage aphids on a cabbage leaf.



Source: © Denis Crawford/Alamy Stock Photo

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

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(Total for question = 3 marks)

Q17.

Some genetic disorders result from chromosome mutations.

Name the type of chromosome mutation that results in Down's syndrome.

(1)

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(Total for question = 1 mark)

Q18.

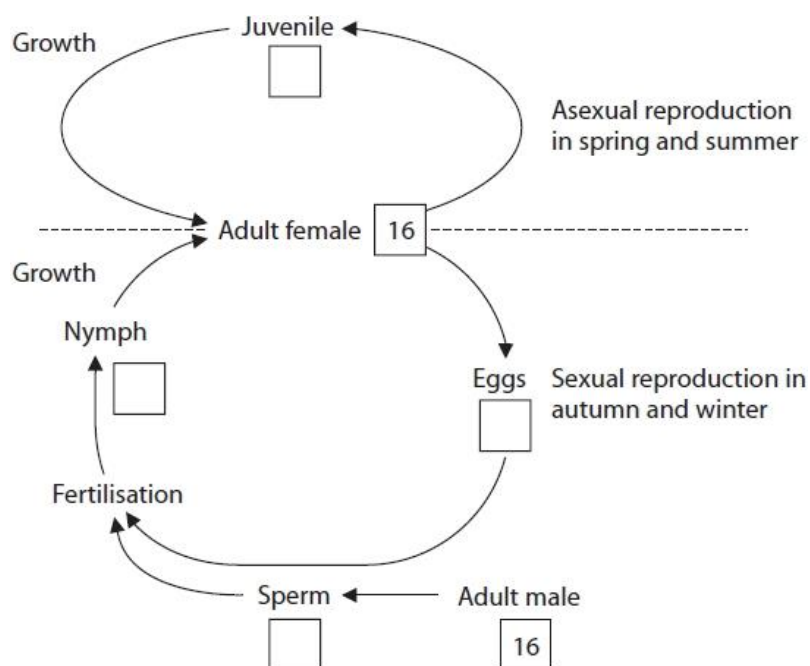
Adult female cabbage aphids (*Brevicoryne brassicae*) undergo either asexual reproduction or sexual reproduction depending on the time of year.

The photograph shows some cabbage aphids on a cabbage leaf.



Source: © Denis Crawford/Alamy Stock Photo

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



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

(2)

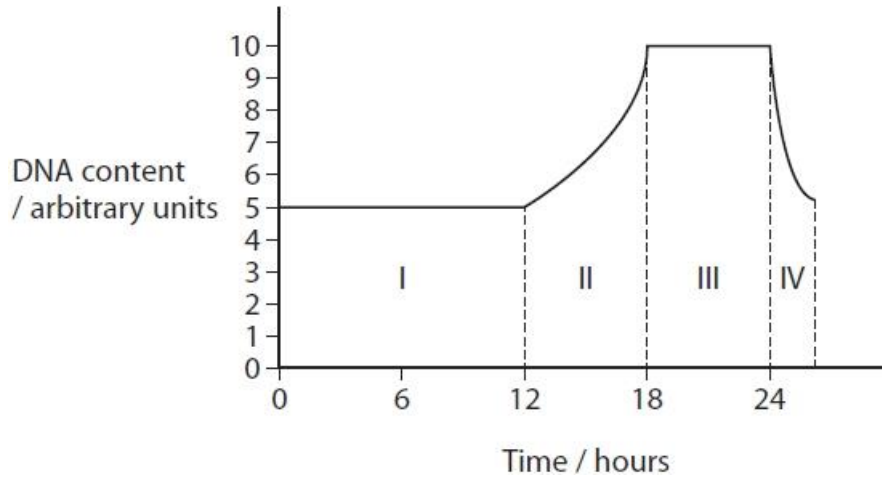
(ii) Label the arrows on the diagram with the letter **M** to show where meiosis takes place.

(1)

(Total for question = 3 marks)

Q19.

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



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

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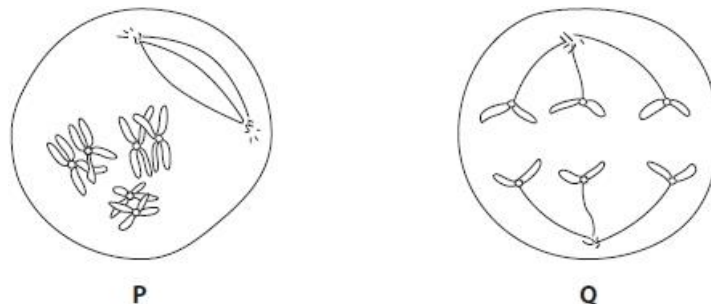
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(Total for question = 3 marks)

Q20.

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

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



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

(1)

	P	Q
<input type="checkbox"/> A	anaphase II	anaphase I
<input type="checkbox"/> B	metaphase I	prophase I
<input type="checkbox"/> C	prophase I	anaphase II
<input type="checkbox"/> D	prophase II	metaphase II

(ii) Non-disjunction occurred during meiosis I.

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

(1)

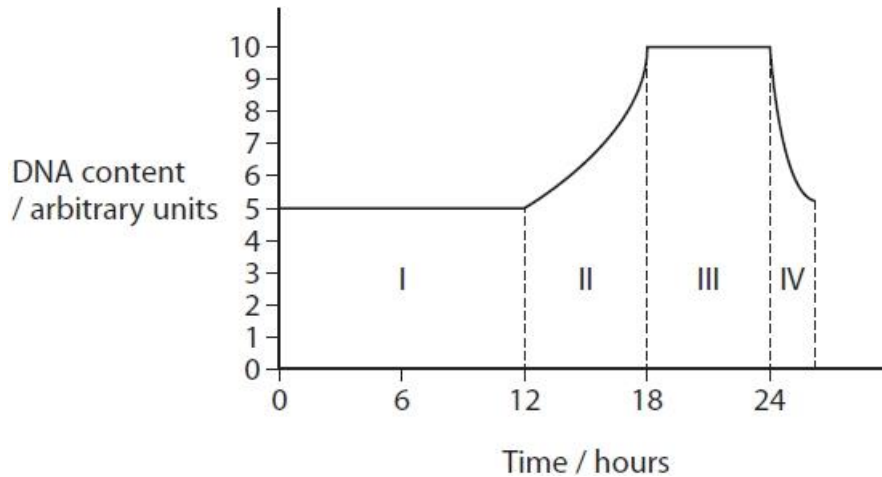
- A 4, 3, 3, 2
 B 4, 4, 2, 2
 C 6, 6, 7, 5
 D 7, 7, 5, 5

(Total for question = 2 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 .

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



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

(1)

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

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

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(Total for question = 4 marks)

Q22.

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

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

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

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

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

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

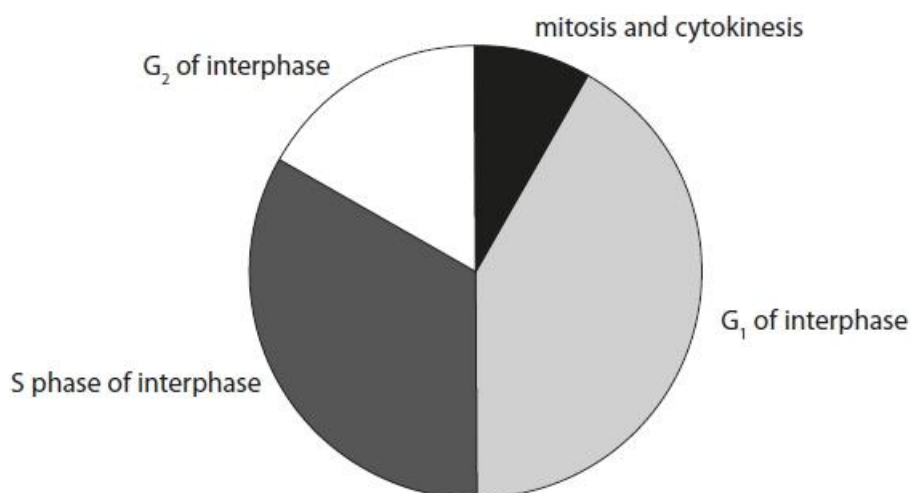
(2)

Answer

(Total for question = 2 marks)

Q23.

The diagram shows four stages in a human cell cycle.



The cell cycle time for this cell is 24 hours.

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

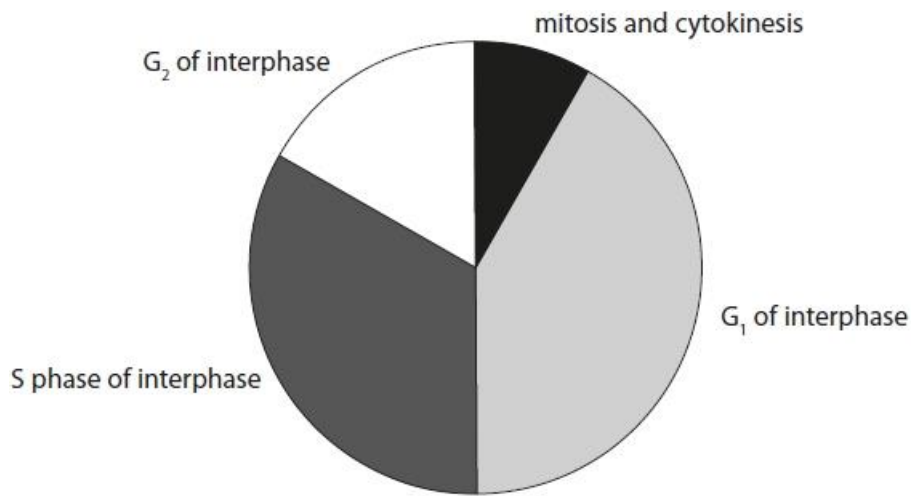
(2)

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

(Total for question = 2 marks)

Q24.

The diagram shows four stages in a human cell cycle.



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

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

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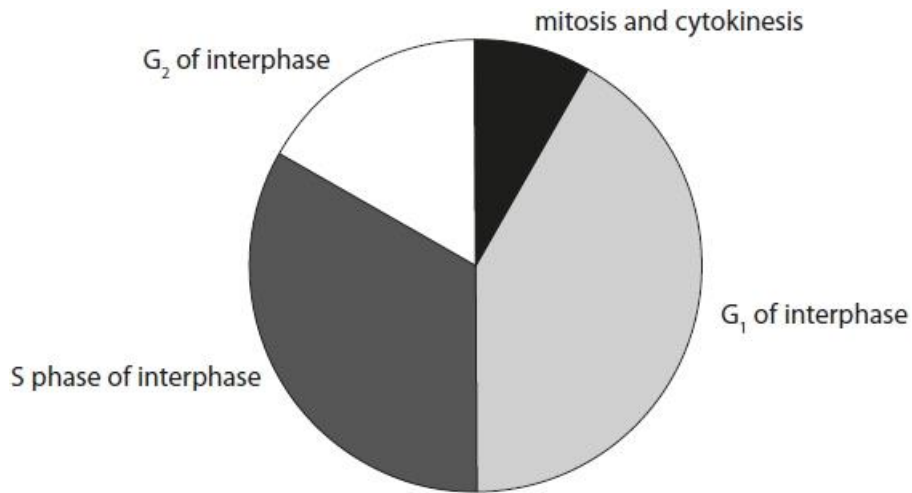
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(Total for question = 4 marks)

Q25.

The diagram shows four stages in a human cell cycle.



A cell in G₁ of interphase contains 68 arbitrary units of DNA.

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

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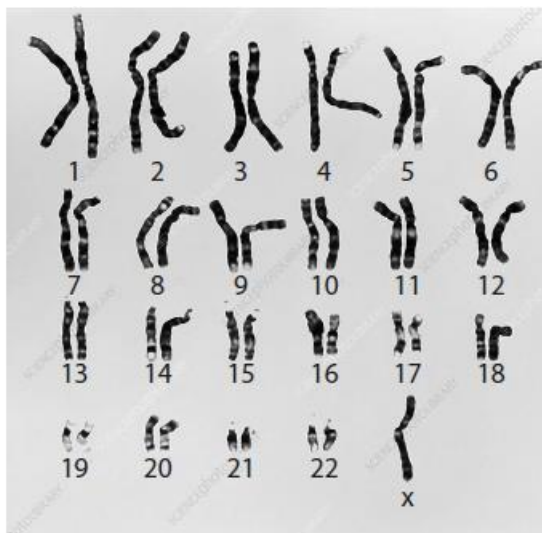
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(Total for question = 5 marks)

Q26.

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 a human karyotype.



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

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

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

(1)

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

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

(1)

(Total for question = 2 marks)

Q27.

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 queen bee can lay both fertilised and unfertilised eggs.

Fertilised eggs develop into diploid females.

Unfertilised eggs develop into haploid males.

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

(2)

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

(2)

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

(1)

		Random fusion of gametes		Independent assortment of chromosomes		Crossing over	
		Female offspring	Male offspring	Female offspring	Male offspring	Female offspring	Male offspring
<input type="checkbox"/>	A	✓	✓	✓	✓	✓	✓
<input type="checkbox"/>	B	✓	×	×	✓	×	✓
<input type="checkbox"/>	C	✓	×	✓	×	✓	×
<input type="checkbox"/>	D	×	×	✓	×	✓	×

(Total for question = 5 marks)

Q28.

During mitosis, microtubules form the spindle.

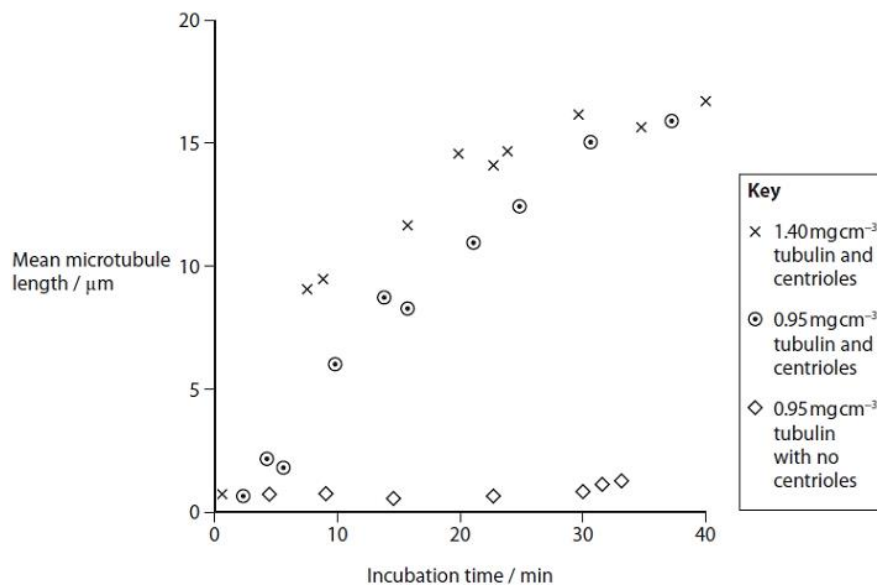
These microtubules are made of a protein called tubulin.

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

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

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

The graph shows the results of this investigation.



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

Explain why the microtubule length decreased after 40 minutes.

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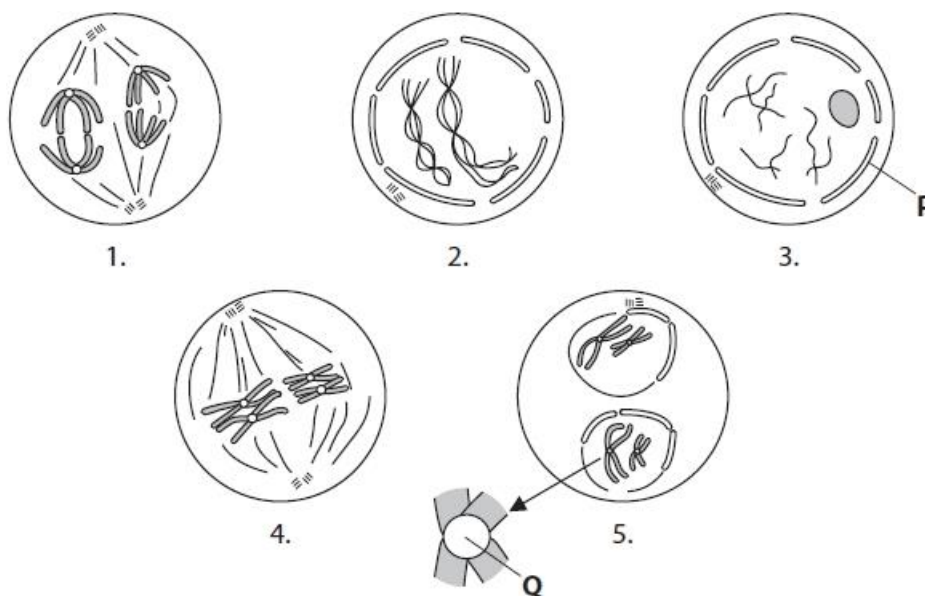
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(Total for question = 2 marks)

Q29.

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

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



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

- A 1, 2, 3, 4, 5
- B 2, 5, 4, 1, 3
- C 3, 2, 4, 1, 5
- D 5, 4, 1, 2, 3

(1)

(ii) Identify the parts labelled P and Q.

(2)

P

Q

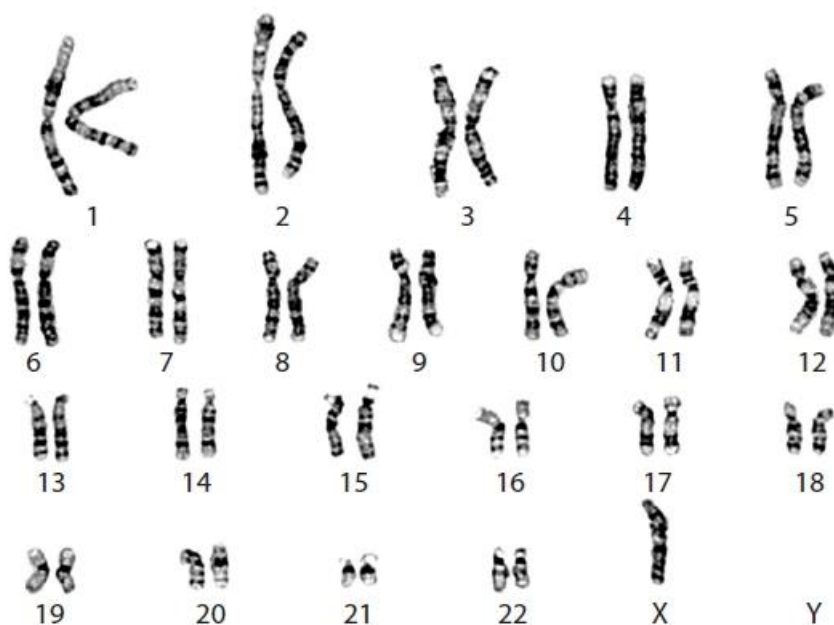
(Total for question = 3 marks)

Q30.

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 .

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

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



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

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

(1)

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

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

(1)

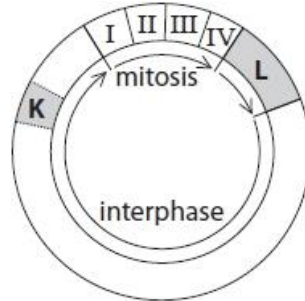
- A base insertion
 B base substitution
 C non-disjunction
 D translocation

(Total for question = 2 marks)

Q31.

Mitosis is one of the stages of the cell cycle.

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



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

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

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(Total for question = 5 marks)

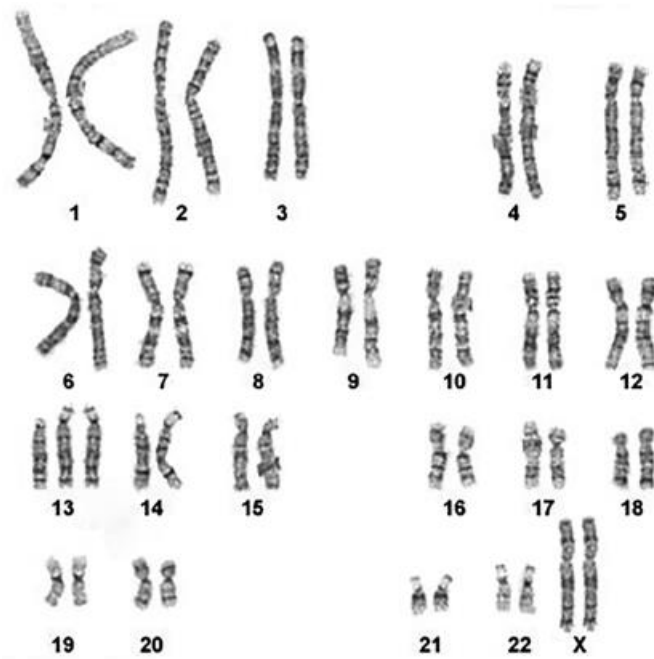
Q32.

Some genetic disorders result from chromosome mutations.

Genetic disorders can be diagnosed by looking at an individual's karyotype.

A karyotype shows the number of each type of chromosome present in a cell.

The diagram shows the karyotype of the cells taken from a female embryo.



Explain what conclusion can be made about this female embryo.

(2)

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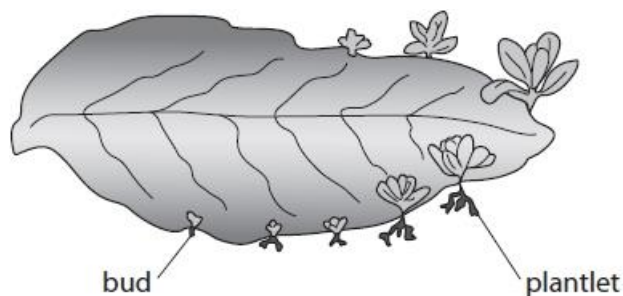
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(Total for question = 2 marks)

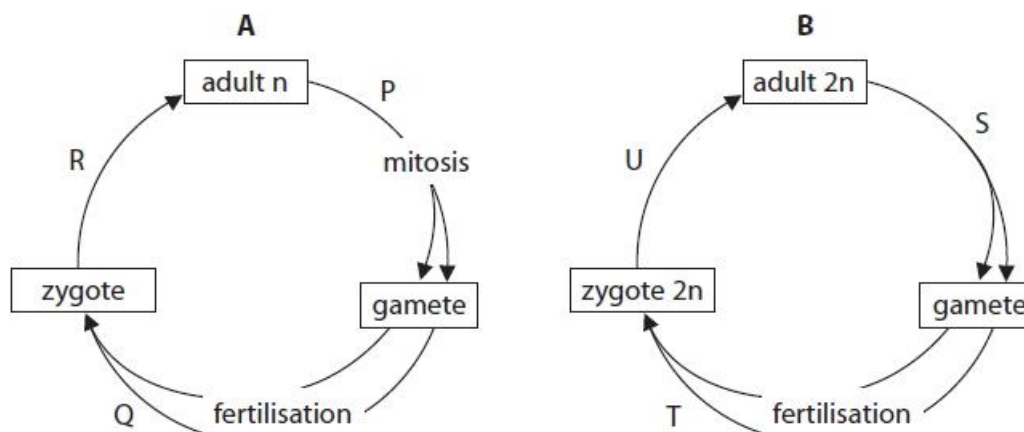
Q33.

The diagram shows a leaf of *Bryophyllum*.

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



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



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

(1)

	Zygote of organism A	Gametes of organism B
<input type="checkbox"/> A	diploid	diploid
<input type="checkbox"/> B	diploid	haploid
<input type="checkbox"/> C	haploid	diploid
<input type="checkbox"/> D	haploid	haploid

Q34.

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

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

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

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

(1)

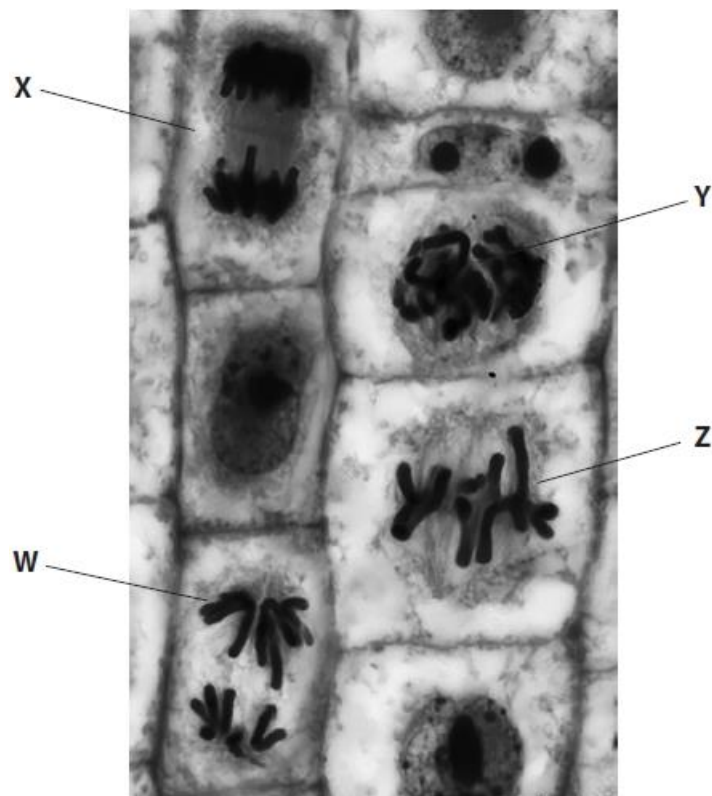
- A** none
- B** one
- C** two
- D** three

(Total for question = 1 mark)

Q35.

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 photograph shows cells in different stages of mitosis.



(Source: © STEVE GSCHMEISSNER / Science Photo Library)

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

(1)

	W	X	Y	Z
<input type="checkbox"/> A	anaphase	telophase	prophase	metaphase
<input type="checkbox"/> B	anaphase	prophase	telophase	metaphase
<input type="checkbox"/> C	prophase	anaphase	metaphase	telophase
<input type="checkbox"/> D	telophase	metaphase	anaphase	prophase

(ii) Colchicine is a chemical that inhibits mitosis.

A student investigated the effect of colchicine on mitosis.

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

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

The results are shown in the table.

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

Analyse the data to comment on how colchicine affects mitosis.

(4)

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(Total for question = 5 marks)

Q36.

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 .

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

(3)

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

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

(1)

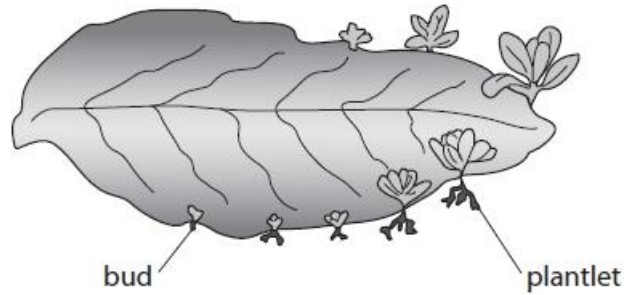
- A crossing over
 B gene mutation
 C independent assortment of chromosomes during nuclear division
 D random fusion of gametes

(Total for question = 4 marks)

Q37.

The diagram shows a leaf of *Bryophyllum*.

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



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

(1)

.....

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

(2)

.....

(Total for question = 3 marks)

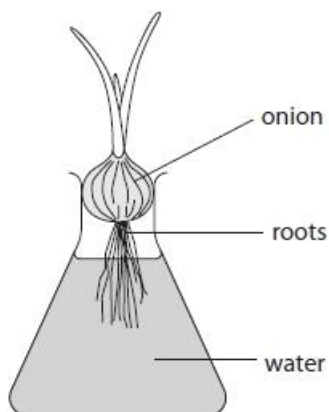
Q38.

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

The student formed the following hypothesis:

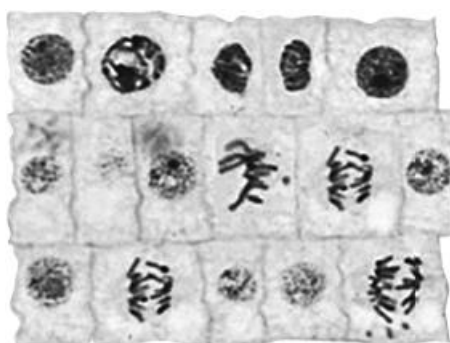
Adding water to soil inhibits mitosis in root cells.

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



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

The photomicrograph shows a preparation from one onion root tip.



Calculate the percentage of cells in this photomicrograph in anaphase.

(2)

Answer

(Total for question = 2 marks)

Q39.

Genetic variation results from the recombination of alleles during meiosis.

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

(1)

	Independent assortment	Crossing over
<input type="checkbox"/> A	metaphase I	anaphase I
<input type="checkbox"/> B	metaphase I	prophase I
<input type="checkbox"/> C	prophase I	anaphase I
<input type="checkbox"/> D	prophase I	metaphase I

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

(3)

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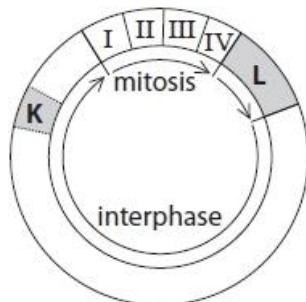
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(Total for question = 4 marks)

Q40.

Mitosis is one of the stages of the cell cycle.

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



Explain why cells carry out mitosis.

(2)

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(Total for question = 2 marks)

Q41.

Some genetic disorders result from chromosome mutations.

Translocation is one type of chromosome mutation.

Describe how translocation occurs.

(2)

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(Total for question = 2 marks)

Q42.

Genetic variation results from the recombination of alleles during meiosis.

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

(1)

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(Total for question = 1 mark)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> crossing over occurs between chromatids (between the same homologous chromosomes) (1) therefore (only) half the chromosomes (produced by anaphase II) will be recombinant chromosomes (so maximum of 50%) (1) crossing over does not always take place (so can be less than 50%) (1) 	ACCEPT will have recombinant {genes / alleles}	(3) Exp

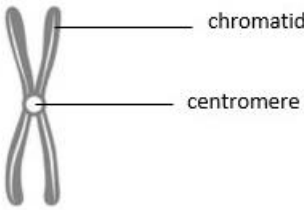
Q2.

Question Number	Answer	Additional Guidance	Mark
	<ul style="list-style-type: none"> 10.2 		(1) CLER

Q3.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> meiosis results in recombination of alleles (1) due to {independent / random} assortment (of chromosomes) (1) (and) due to crossing over between chromatids (between the same homologous chromosomes) (1) 	<p>IGNORE references to maternal and paternal chromosomes throughout</p> <p>ACCEPT description e.g. pairs of homologous chromosomes line up (on the equator) randomly</p> <p>ACCEPT description e.g. genetic material is swapped between chromatids (between the same homologous chromosomes)</p> <p>DO NOT ACCEPT wrong description/ wrong stage IGNORE mutations</p>	(2) Exp

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>A drawing that shows the following:</p> <ul style="list-style-type: none"> • {one / two} chromatids drawn and labelled (1) • joined at the centromere, which is labelled (1) 	 <p>1 correct label and 1 incorrect label = 1 mark 2 correct labels and 1 incorrect label = 1 mark 2 correct labels and 2 incorrect labels = 0 marks</p>	(2) EXP

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> • chromosomes line up along the equator (of the cell) (1) • spindle fibres (from the centrioles) attach to the {centromere / chromosome} (1) 	<p>ACCEPT middle / metaphase plate pairs of chromatids DO NOT ACCEPT chromatids</p> <p>IGNORE spindle fibres start to contract DO NOT ACCEPT chromatids</p>	(2) EXP

Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> the number of cells in metaphase increases because colchicine stops the cells from moving out of this phase (1) the number of cells in anaphase {decreases / goes to zero} as the cells are not moving out of metaphase (1) because colchicine {interferes with spindle fibres / stops centromeres being split / stops chromatids being pulled apart} (1) number of cells in prophase decreases as there are fewer cells to pass through the cell cycle (1) 	<p>ACCEPT stuck in metaphase</p> <p>ACCEPT stuck in metaphase</p> <p>ACCEPT going into mitosis</p>	(3) EXP

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>A description that makes reference to three of the following:</p> <ul style="list-style-type: none"> cells grown with colchicine for a period of time (1) minimum of three plastic dishes sampled at each of the time intervals (shown in the table) (1) cells stained with (acetic / propionic / ethano) orcein (1) cells observed under a microscope and the number of cells in each stage of the cell cycle counted (1) 	<p>ACCEPT treated DO NOT ACCEPT plant cells</p> <p>ACCEPT acetocarmine, Giemsa, methylene blue, toluidine blue</p> <p>ACCEPT observe how many IGNORE observe unqualified</p>	(3) EXP

Q6.

Question Number	Answer	Additional Guidance	Mark
	<p>The only correct answer is C</p> <p><i>A is incorrect because crossing over has taken place by metaphase I</i></p> <p><i>B is incorrect because crossing over takes place in meiosis I</i></p> <p><i>D is incorrect because crossing over takes place in meiosis I</i></p>		(1) COMP

Q7.

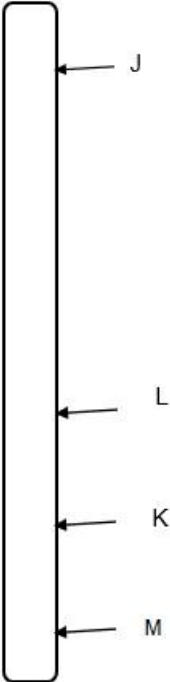
Question Number	Answer	Additional Guidance	Mark
(i)	<p>Calculation of number of dividing cells (1)</p> <p>Calculation of mitotic index (1)</p>	<p>8</p> <p>8.2% / 8.16%</p> <p>Correct answer with no working gains full marks</p>	Grad (2)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that includes the following</p> <ul style="list-style-type: none"> as distance (from root tip) increases, mitotic index decreases (1) (because) cells {differentiate / become specialised / elongate} further from the root tip (1) 	<p>Allow negative correlation between mitotic index and distance from root tip</p> <p>Accept converse</p> <p>Accept meristem is close to tip</p>	Exp (2)

Q8.

Question Number	Answer	Additional Guidance	Mark
	<p>An answer including two of the following:</p> <ul style="list-style-type: none"> • use {strong / concentrated} acid to {break down middle lamella / break down pectins / separate layers of cells} (1) • heat to intensify effect of {acid / stain} (1) • press (on cover slip) to form a single layer of cells (1) • view at high power to see details (of chromosomes) (1) 	<p>Accept use of standardised length of root tip to ensure you include just the dividing area</p> <p>Accept view at high power to see chromosomes (clearly)</p>	Exp (2)

Q9.

Question Number	Answer	Additional Guidance	Mark
	<p>A diagram that shows the following:</p> <ul style="list-style-type: none"> • L drawn below J (1) • K and M indicated correctly (1) • diagram drawn to (approximate) scale (9, 3, 3) (1) 	 <p>NB Everything must be correct to award all 3 marks</p>	(3) EXP

Q10.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	<ul style="list-style-type: none"> fraction of cells in anaphase (1) length of anaphase in minutes calculated (1) 	<p><u>Example of calculation</u></p> $2 \div 246$ $1380 \times (2 \div 246) = 11.22$ minutes Allow 11 / 11.2 Correct answer with no working gains full marks	(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	<ul style="list-style-type: none"> calculation of 8% (1) subtraction of calculated value from 11.22 (1) 	<p>Allow ecf from 6(d) (i) <u>Example of calculation</u> $(11.22 \times 8) \div 100$ $(11.2 \times 8) \div 100$ $(11 \times 8) \div 100$</p> $11.22 - 0.898 = 10.32 / 10.3 / 10$ $11.2 - 0.896 = 10.30 / 10.3 / 10$ $11 - 0.88 = 10.12 / 10.1 / 10$ Correct answer with no working gains full marks	(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> the student may have selected a different part of the root tip OR different plants had different {age / rates of growth / mitotic index / rates of respiration / genes} (1) it is difficult to identify the correct stage of mitosis (1) not many cells will be in anaphase OR variation due to {chance / error} will have a large effect on the calculated value (1) 	<p>Allow different growing conditions e.g. light , temperature</p> <p>e.g. late anaphase can be confused with early telophase, early anaphase can be confused with metaphase</p> <p>Allow only two cells found in anaphase / small sample size</p>	(2)

Q11.

Question Number	Answer	Mark
(i)	<p>The only correct answer is D</p> <p><i>A is not correct because W is not a meristem</i></p> <p><i>B is not correct because X is not a meristem</i></p> <p><i>C is not correct because Y is not a meristem</i></p>	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	(acetic) orcein	ACCEPT Feulgen, acetocarmine, toluidine blue	(1)

Question Number	Answer	Additional Guidance	Mark
(iii)	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> heat to intensify the stain (1) {squash / tease} the tissue to separate the cells (1) apply a coverslip {in order to view at high magnification / stop evaporation} (1) 		(2)

Q12.

Question Number	Answer	Additional Guidance	Mark
	<p>An answer that makes reference to four of the following:</p> <ul style="list-style-type: none"> • use waterlogged soil and non-waterlogged soil / range of water content (1) • use same plant variety / type / species / age / size (1) • control {temperature / light / soil type / mineral ions / pH} (1) • leave for same stated time (1) • take cells from same part of root tips (1) 	<p>DO NOT ACCEPT nutrients</p> <p>DO NOT ACCEPT less than 24 hours</p> <p>e.g both cut at 2mm</p>	(4)

Q13.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> • a stain is needed to see chromosomes that would not be clearly visible (1) • because the stain must attach to {chromosomes / DNA / histone} (1) 	<p>ACCEPT can see chromatids, nucleus</p> <p>ACCEPT {take up / absorb} stain</p>	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>A description that makes reference to four of the following:</p> <ul style="list-style-type: none"> • use {5 mm / shorter} piece of root tip (1) • add acid and then stain separately (1) • heat the root tip in { acid / stain } (1) • tease the cells apart before staining (1) • intensify the stain by warming (after squashing) (1) 	<p>ACCEPT use more concentrated acid</p> <p>ACCEPT maceration</p>	(4)

Q14.

Question Number	Answer	Additional Guidance	Mark
	<p>A description that makes reference to four of the following:</p> <ul style="list-style-type: none"> • use warm acid (1) • remove acid using water (1) • add named stain (1) • macerate or tease with needle (1) • use coverslip and squash (1) 	<p>e.g. acetic orcein / toluidine blue / Schiff's / Giemsa / Feulgen / (aceto) carmine</p>	(4)

Q15.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An evaluation that makes reference to four of the following:</p> <ul style="list-style-type: none"> centrioles are clearly needed because the microtubules did not increase in length (significantly) in the absence of centrioles (1) the concentration of tubulin is significant because 1.40 produced longer microtubules than 0.95 (in the first 30 minutes) (1) because the higher concentration of substrate increased {the number of collisions / rate of reaction} (1) the rate of increase of microtubule growth is non-linear / mean microtubule length appears to reach a maximum at {17 μm / after 30 min} (1) this suggests that there is another limiting factor (1) 	<p>ACCEPT greater concentration of tubulin produces longer microtubules</p>	(4)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> a buffer can prevent change to the pH (1) equilibrate because the experiment is carried out at 35°C (1) a change in {pH / too high temperature} may {denature / change the shape} of the {proteins / tubulin / centriole fragments} (1) because {hydrogen / ionic} bonds may be {changed / disrupted} (1) 	<p>ACCEPT description of equilibration</p> <p>ACCEPT may prevent bonding between {tubulin molecules / tubulin and centrioles}</p>	(4)

Q16.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to the three from the following:</p> <ul style="list-style-type: none"> • Asexual reproduction occurs due to mitosis (1) • when DNA replication takes place (1) • so that, mitosis can divide sister chromatids equally into each cell (1) • therefore cells produced have no genetic variation (1) 	<p>Allow Cells receive identical chromosomes / {chromosomes or DNA } from only one parent</p> <p>Allow no {independent assortment of chromosomes or random fusion of gametes or crossing over} takes place</p>	(3)

Q17.

Question Number	Answer	Additional Guidance	Mark
	Non-disjunction	ACCEPT Translocation, polysomy, aneuploidy, trisomy, partial trisomy, partial aneuploidy	(1)

Q18.

Question Number	Answer	Additional Guidance	Mark
(i)	<ul style="list-style-type: none"> • juvenile and nymph both 16 (1) • eggs and sperm both 8 (1) 		(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	M on arrows before eggs and sperm		(1)

Q19.

Question Number	Answer	Additional Guidance	Mark
	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> • DNA content halves (1) • cytoplasm is dividing / cytokinesis (1) • because two (daughter) cells are formed (1) 	<p>ACCEPT from 10 to 5 au</p> <p>ACCEPT cell elongates / spindle fibres push poles apart / cell membrane contracts at equator of the cell</p>	(3)

Q20.

Question Number	Answer	Mark
(i)	<p>The only correct answer is C</p> <p>A is not correct because P is in prophase I and Q is in metaphase II</p> <p>B is not correct because P is in prophase I and Q is in metaphase II</p> <p>D is not correct because P is in prophase I and Q is in metaphase II</p>	(1)

Question Number	Answer	Mark
(ii)	<p>The only correct answer is B</p> <p>A is not correct because if non-disjunction occurred in meiosis I, it would generate one cell with four chromosomes (each composed of two chromatids) and one cell with two chromosomes (each composed of two chromatids). These cells would divide in meiosis II to generate two cells with four chromosomes and two cells with two chromosomes.</p> <p>C is not correct because if non-disjunction occurred in meiosis I, it would generate one cell with four chromosomes (each composed of two chromatids) and one cell with two chromosomes (each composed of two chromatids). These cells would divide in meiosis II to generate two cells with four chromosomes and two cells with two chromosomes.</p> <p>D is not correct because if non-disjunction occurred in meiosis I, it would generate one cell with four chromosomes (each composed of two chromatids) and one cell with two chromosomes (each composed of two chromatids). These cells would divide in meiosis II to generate two cells with four chromosomes and two cells with two chromosomes.</p>	(1)

Q21.

Question Number	Answer	Mark
(i)	<p>The only correct answer is B</p> <p>A is not correct because in stage I the DNA remains at 5 a.u.</p> <p>C is not correct because in stage III the DNA remains at 10 a.u.</p> <p>D is not correct because in stage IV the DNA content reduces not increases</p>	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> joins sections of DNA together / repairs breaks in the phosphodiester backbone (1) by forming phosphodiester bonds (1) (forms bonds) between phosphate and {deoxyribose / sugar / pentose} (1) 	<p>ACCEPT join Okazaki fragments / joins fragments produced from copying the lagging strand / needed for working in 3' to 5' direction</p> <p>ACCEPT between (mono) nucleotides</p>	(3)

Q22.

Question Number	Answer	Additional Guidance	Mark
	<p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> number of pregnancies calculated (1) number of babies calculated (1) 	<p>Correct answer gains full marks</p> <p>$(500\ 000 \div 1000) \times 14 = 7\ 000$</p> <p>$(1.8 \div 100) \times 7\ 000 = 126$</p> <p>or</p> <p>$14 \times 500 = 7\ 000$ and then $7\ 000 \times 0.018 = 126$</p>	(2)

Q23.

Question Number	Answer	Additional Guidance	Mark										
	<p>An answer that makes reference to the following:</p> <table border="1"> <thead> <tr> <th>Stage of cell cycle</th> <th>Estimated length of time cell spends in this stage / hours</th> </tr> </thead> <tbody> <tr> <td>mitosis and cytokinesis</td> <td>2</td> </tr> <tr> <td>G₁ of interphase</td> <td>10</td> </tr> <tr> <td>S phase of interphase</td> <td>8</td> </tr> <tr> <td>G₂ of interphase</td> <td>4</td> </tr> </tbody> </table>	Stage of cell cycle	Estimated length of time cell spends in this stage / hours	mitosis and cytokinesis	2	G ₁ of interphase	10	S phase of interphase	8	G ₂ of interphase	4	<p>All correct = 2 marks</p> <p>G₂ and S / mitosis and G₁= 12 hours total =1 mark</p>	(2) EXP
Stage of cell cycle	Estimated length of time cell spends in this stage / hours												
mitosis and cytokinesis	2												
G ₁ of interphase	10												
S phase of interphase	8												
G ₂ of interphase	4												

Q24.

Question Number	Answer	Additional Guidance	Mark
	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> • use a method similar to a root tip squash to stain the cells (1) • count the number of cells in mitosis (and cytokinesis) (1) • divide the number of cells in mitosis by the total number of cells counted (1) • and work out as a proportion of 24 hours (1) 	<p>ACCEPT description of technique that includes at least relevant two steps e.g. heating in acid and staining with acetic orcein</p>	(4) EXP

Q25.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to five of the following:</p> <ul style="list-style-type: none"> • DNA content will double by the end of {S phase / interphase}(1) • because DNA synthesis takes place (before mitosis) (1) • the chromosomes will now consist of pairs of chromatids joined together at the centromere (1) • During mitosis the chromatids separate and chromosomes now consist of one DNA molecule (by the end of mitosis) (1) • DNA content will return to normal by the end of cytokinesis(1) • because chromatids are separated into (two new) daughter cells (1) 	<p>ACCEPT increase to 136 arbitrary units of DNA</p> <p>ACCEPT (return to) 68 arbitrary units of DNA</p>	(5) EXP

Q26.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>B Female with Turner's syndrome</p> <p><i>A is incorrect because the human has one X</i> <i>B is incorrect because the human is female</i> <i>C is incorrect because the human is female</i></p>		1
(ii)	<p>A Non-disjunction producing a monosomy</p> <p>B is incorrect because it is a monosomy C is incorrect because it is due to non-disjunction C is incorrect because it is due to non-disjunction</p>		1

Q27.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> meiosis (1) because haploid gametes produced from a diploid cell /number of chromosomes is halved (1) 		(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> mitosis (1) because the number of chromosomes remains the same (1) 	ACCEPT haploid cells can only divide by mitosis / do not need reduction division	(2)

Question Number	Answer	Mark
(iii)	<p>The only correct answer is C</p> <p>A is not correct because random fusion of gametes can't produce a haploid male</p> <p>B is not correct because independent assortment of chromosomes and crossing over can occur in the formation of gametes used to form a fertilised egg (a female)</p> <p>D is not correct because random fusion of gametes would occur to form a fertilised egg (a female)</p>	(1)

Q28.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> they shorten in the same way as they do during cell division (1) some of the microtubules may break / were shortened by the centriole (1) tubulin can detach from the microtubules as well as join (1) 	ACCEPT the {equilibrium between forming and breaking / optimum length} was reached at approximately 30 minutes	(2)

Q29.

Question Number	Answer	Additional Guidance	Mark
i	C 3, 2, 4, 1, 5		(1)

Question Number	Answer	Additional Guidance	Mark
ii	P – nuclear envelope (1) Q– centromere (1)	accept nuclear membrane, nucleus membrane	(2)

Q30.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>C Turner's syndrome due to monosomy</p> <p>A is incorrect because there are not three copies of chromosome number 21 B is incorrect because there are not three copies of chromosome number 21 D is incorrect because Turner's syndrome is a monosomy</p>		1

Question Number	Answer	Additional Guidance	Mark
(ii)	C non-disjunction <i>A because it is not a gene mutation B is incorrect because it is not a gene mutation D because there is a missing chromosome is incorrect</i>		1

Q31.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	An explanation that makes reference to the following: <ul style="list-style-type: none"> • DNA {synthesis / replication} (1) • therefore DNA (content) doubles (1) • (new) chromatids are formed (1) • but the number of chromosomes stays the same (1) 		(4) EXP

Question Number	Answer	Additional Guidance	Mark
(b)	• cytokinesis		(1)

Q32.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: <ul style="list-style-type: none"> • polysomy / not Down's Syndrome (1) • because {of chromosome 13 / more than two copies of one chromosome} (1) 	ACCEPT trisomy, aneuploidy DO NOT ACCEPT has {Turner's / Down's} Syndrome ACCEPT chromosome 21 only two copies ACCEPT extra chromatid	(2)

Q33.

Question Number	Answer	Additional Guidance	Mark
i	B diploid and haploid		(1)

Question Number	Answer	Additional Guidance	Mark
ii	C - R S		(1)

Question Number	Answer	Additional Guidance	Mark
iii	<p>An explanation that refers to three of the following:</p> <ul style="list-style-type: none"> • source of genetic variation (1) • because it involves random {assortment / fertilisation / crossing over } (1) • because it enables contribution of {DNA / genes / alleles } from two individuals (1) • because it produces new combinations of alleles (1) • genetic variation allows organisms to adapt to environmental change (1) 		(3)

Q34.

Question Number	Answer	Mark
	<p>The only correct answer is B</p> <p><i>A is not correct because chromatids are visible in metaphase</i></p> <p><i>C is not correct because the first two statements only occur in meiosis not mitosis</i></p> <p><i>D is not correct because the first two statements only occur in meiosis not mitosis</i></p>	(1)

Q35.

Question Number	Answer	Additional Guidance	Mark					
(i)	<p>A</p> <table border="1"> <tr> <td><input checked="" type="checkbox"/> A</td> <td>anaphase</td> <td>telophase</td> <td>prophase</td> <td>metaphase</td> </tr> </table> <p><i>B is incorrect because X is not prophase</i> <i>C is incorrect because W is not prophase</i> <i>D is incorrect because W is not telophase</i></p>	<input checked="" type="checkbox"/> A	anaphase	telophase	prophase	metaphase		1
<input checked="" type="checkbox"/> A	anaphase	telophase	prophase	metaphase				

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An answer that makes reference to four of the following:</p> <ul style="list-style-type: none"> colchicine has no effect on the percentage of cells in interphase (1) colchicine arrests cells at prophase (1) colchicine inhibits spindle (formation) (1) fewer cells reach {metaphase / anaphase / telophase} with colchicine / more cells reach {metaphase / anaphase / telophase} without colchicine / more cells at prophase with colchicine / fewer cells at all phases except prophase (1) correct reference to overlapping of standard deviations (1) 	<p>Accept colchicine stops (many) cells at prophase / cells can only reach prophase with colchicine</p> <p>Accept converse</p> <p>Accept converse</p>	4

Q36.

Question Number	Answer	Additional Guidance	Mark																								
(i)	<table border="1"> <thead> <tr> <th>Feature</th> <th>Mitosis</th> <th>Meiosis I</th> <th>Meiosis II</th> </tr> </thead> <tbody> <tr> <td>homologous chromosomes pair together</td> <td>x</td> <td>✓</td> <td>x</td> </tr> <tr> <td>crossing over can cause genetic variation</td> <td>x</td> <td>✓</td> <td>x</td> </tr> <tr> <td>homologous chromosomes separate</td> <td>x</td> <td>✓</td> <td>x</td> </tr> <tr> <td>sister chromatids separate</td> <td>✓</td> <td>x</td> <td>✓</td> </tr> <tr> <td></td> <td>(1)</td> <td>(1)</td> <td>(1)</td> </tr> </tbody> </table>	Feature	Mitosis	Meiosis I	Meiosis II	homologous chromosomes pair together	x	✓	x	crossing over can cause genetic variation	x	✓	x	homologous chromosomes separate	x	✓	x	sister chromatids separate	✓	x	✓		(1)	(1)	(1)		(3)
Feature	Mitosis	Meiosis I	Meiosis II																								
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crossing over can cause genetic variation	x	✓	x																								
homologous chromosomes separate	x	✓	x																								
sister chromatids separate	✓	x	✓																								
	(1)	(1)	(1)																								

Question Number	Answer	Mark
(ii)	<p>The only correct answer is B</p> <p>A is not correct because crossing over does not alter the DNA sequence of a gene to produce new alleles</p> <p>C is not correct because independent assortment does not alter the DNA sequence</p> <p>D is not correct because random fusion of gametes does not alter the DNA sequence</p>	(1)

Q37.

Question Number	Answer	Additional Guidance	Mark
i	mitosis	accept mitotic	(1)

Question Number	Answer	Additional Guidance	Mark
ii	<p>An answer that make reference to two of the following:</p> <ul style="list-style-type: none"> can produce large numbers of offspring (1) can reproduce rapidly (1) does not need another plant (1) 		(2)

Q38.

Question Number	Answer	Additional Guidance	Mark
	<ul style="list-style-type: none"> • division (1) • multiplication (1) 	$3 \div 16 = 0.1875$ $0.1875 \times 100 = 18.75 / 18.8 / 19$	(2)

Q39.

Question Number	Answer	Additional Guidance	Mark
(i)	B (metaphase I, prophase I)		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	<p>A description that makes reference to three of the following:</p> <ul style="list-style-type: none"> • homologous chromosomes line up (1) • chiasmata form (1) • break in {DNA / chromatid / chromosome } occurs (1) • genetic information exchanged between {chromatids} (1) 	<p>Ignore crossing over and prophase I</p> <p>Allow reference to bivalent</p> <p>Allow description of chiasmata e.g. chromatids overlap</p>	(3)

Q40.

Question Number	Acceptable Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> • growth / repair / asexual reproduction (1) • because this needs {genetically identical cells / clones / cells with the same number of chromosomes } (1) 	<p>Ignore repair damaged cells or cell growth (unless qualified by a suitable cell type such as a muscle cell) Allow replace cells</p>	(2)

Q41.

Question Number	Answer		Mark
	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> • part of a chromosome breaks off (1) • this then joins to another (non-homologous) chromosome (1) 	<p>ACCEPT one mark only for an answer that makes reference to {part of a chromosome / genes} being swapped between (non- homologous) chromosomes</p> <p>ACCEPT phosphodiester bonds break ACCEPT genes or section of DNA DO NOT ACCEPT parts of a gene</p> <p>DO NOT ACCEPT homologous chromosome</p>	(2)

Q42.

Question Number	Acceptable Answer	Additional Guidance	Mark
	<ul style="list-style-type: none"> • different {version of / form of} a gene (1) 	<p>Ignore different type of gene</p> <p>Allow found at the same locus on a chromosome</p> <p>Ignore sequence of DNA that codes for a protein</p>	(1)