IB · DP · Biology

2 hours 15 questions

Structured Questions: Paper 2

10.1 Meiosis

10.1.1 The Process of Meiosis / 10.1.2 Crossing Over / 10.1.3 Meiosis I / 10.1.4 Meiosis II / 10.1.5 Skills: Drawing Chiasmata

Easy (5 questions)	/38
Medium (5 questions)	/44
Hard (5 questions)	/55
Total Marks	**/137**

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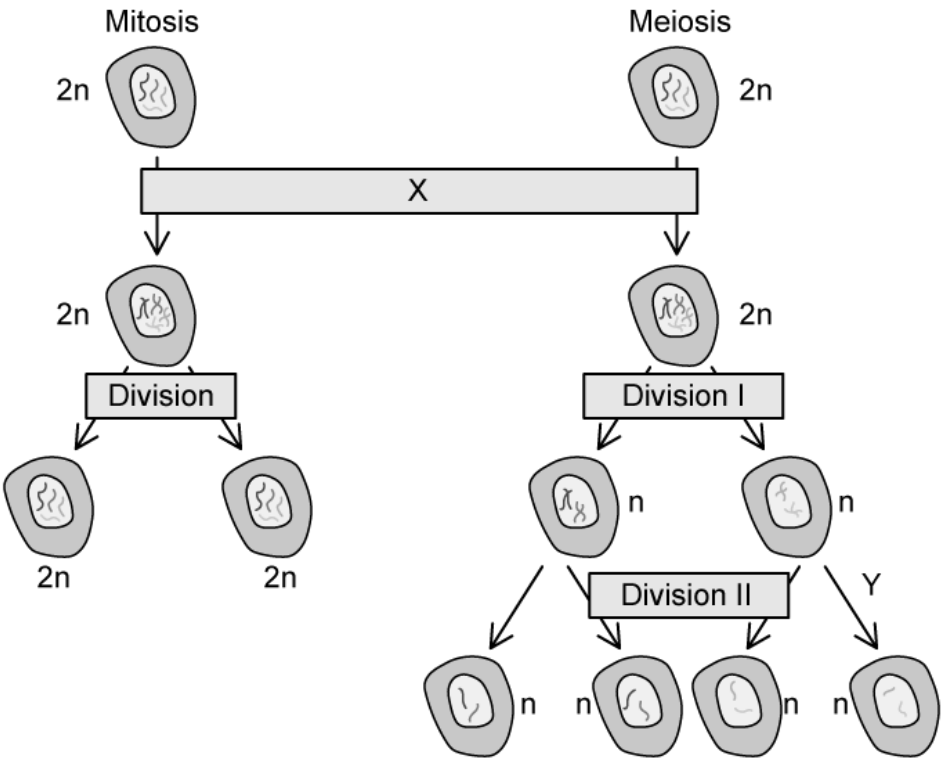
Easy Questions

1 (a) The diagram below summarises the processes of mitosis and meiosis.



Identify the process marked **X** in the diagram.

.....

(1 mark)

(b) Identify the stage of the cell cycle during which the process marked **X** in part a) takes place.

.....

(1 mark)

(c) Describe **one** way in which the process marked **X** in part a) can increase genetic variation.

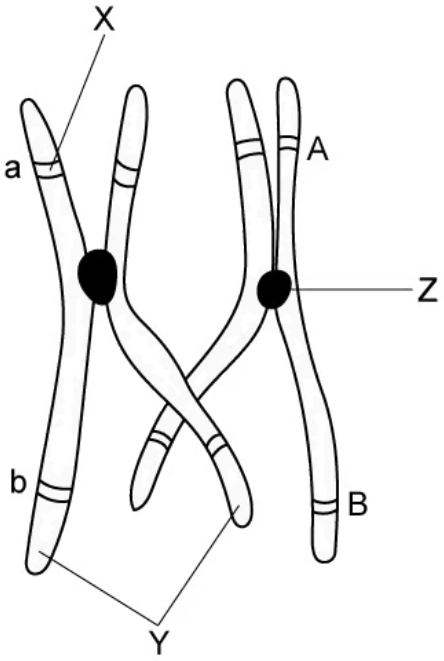
.....

(2 marks)

(d) Describe the chromosome activity taking place at the stage marked **Y** in the diagram in part a).

(2 marks)

2 (a) The diagram below shows two chromosomes during meiosis.



Identify structures **X**-**Z**.

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(3 marks)

(b) Outline the events shown in the diagram in part a).

.....

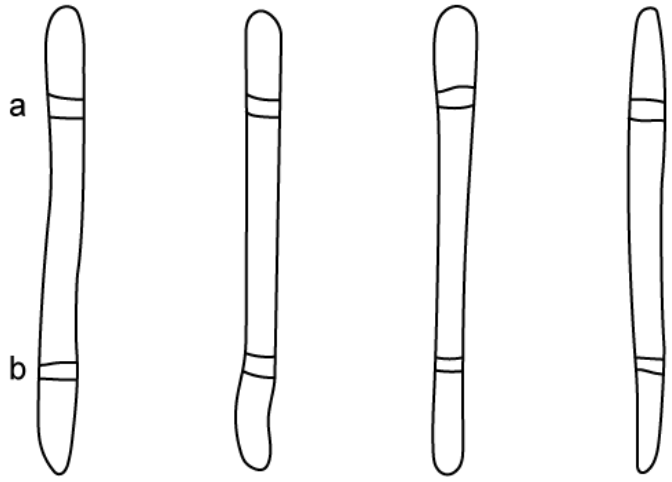
.....

.....

(3 marks)

(c) At the end of meiosis the chromosomes shown in part a) form four new chromosomes, as illustrated in the diagram below.

Annotate the four new chromosomes below to show the results of the events shown in part a). The first chromosome has been annotated for you.

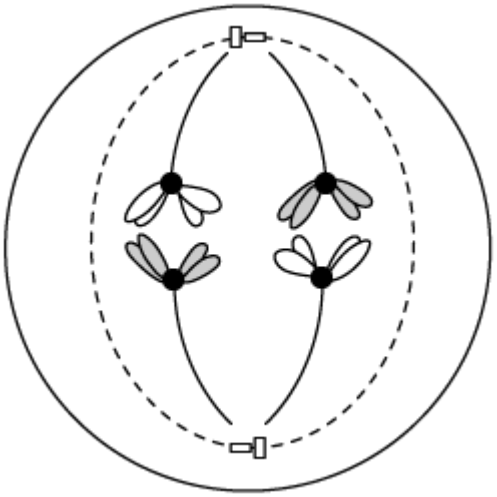


(3 marks)

(d) Outline the importance of the process shown in part a) to living organisms.

(2 marks)

3 (a) The diagram below shows a cell in anaphase of meiosis I.



State how it is possible to know the following:

(i) That the cell is in anaphase.

[1]

(ii) That the cell is in meiosis I.

[1]

.....

.....

(2 marks)

(b) Meiosis I is described as **reduction** division.

State why this is the case.

.....

(1 mark)

(c) Meiosis I generates genetic variation due to the process of crossing over.

Outline **one other** process during meiosis I that generates genetic variation.

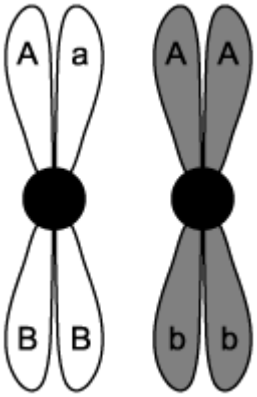
(2 marks)

(d) Rice, *Oryza sativa*, has a chromosome number of 24.

Use the formula 2^n to calculate the number of different chromosome combinations that can be generated when rice cells undergo meiosis I. Note that the term *n* here denotes the number of pairs of chromosomes.

(2 marks)

4 (a) The diagram below shows chromosomes from a garden pea plant, *Pisum sativum*, during meiosis.



Identify, with a reason, the meiotic division that is occurring in the diagram.

.....

.....

(2 marks)

(b) Mendel's law of independent assortment states that:

'Characteristics are inherited completely independently of each other'

While the chromosomes in part a) will undergo independent assortment during meiosis, this law of Mendel's cannot be correctly applied to the characteristics for which genes A and B code.

Explain why this is the case.

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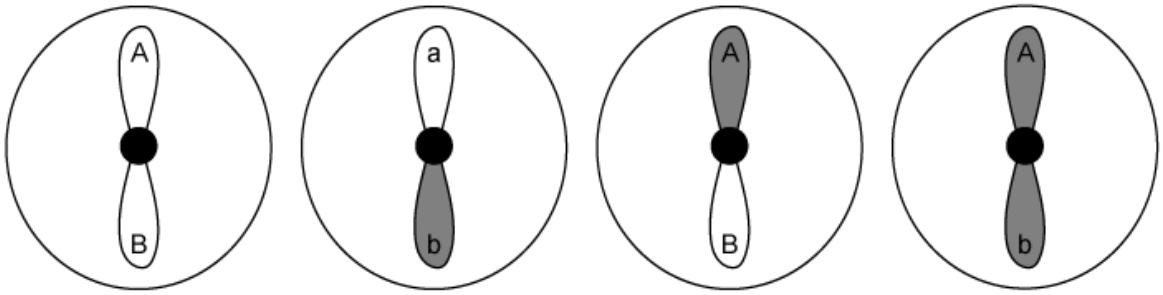
(1 mark)

(c) At the end of meiosis, the chromosomes were distributed to the pea plant pollen grains as shown below.



Explain how the chromosomes in part a) gave rise to the new allele combinations shown above.

.....

.....

(2 marks)

(d) The process in part c) and independent assortment both contribute to genetic variation.

State **one other** process that contributes to genetic variation.

.....

(1 mark)

5 (a) *One mark is available for clarity of communication throughout this question.*

Draw an annotated diagram of chromosomal synapsis.

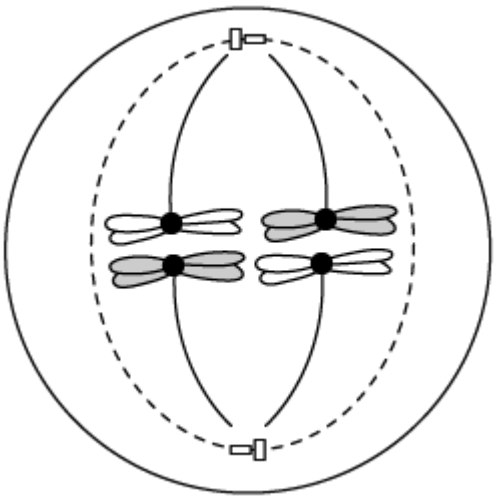
(3 marks)

(b) Outline the events that take place during the second division of meiosis.

(5 marks)

Medium Questions

1 (a) The following image shows a cell undergoing cell division.



Identify, with a reason, the type of cell division shown in the image.

.....

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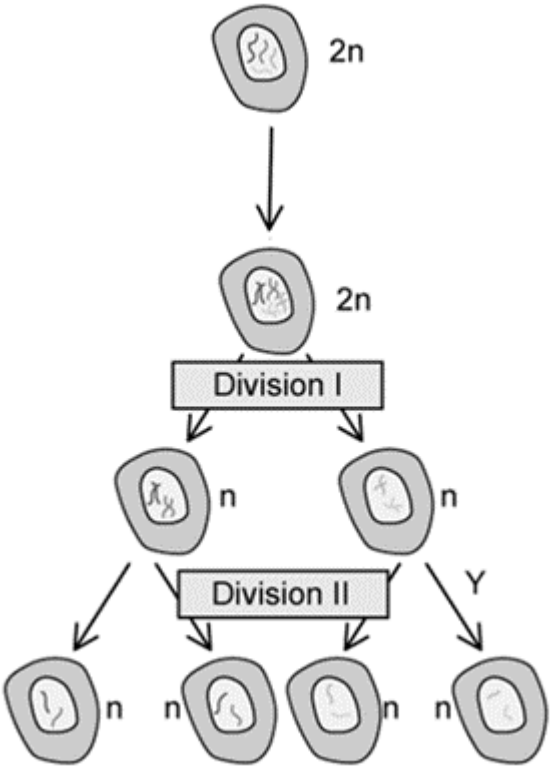
(2 marks)

(b) The image below illustrates the formation of sperm cells, also known as spermatozoa.



State and explain the change in chromosome number taking place during division **I**.

.....

.....

(2 marks)

(c) A sperm-producing cell in the testes has 46 chromosomes in its nucleus.

Calculate the number of **chromatids** that would be in the nucleus of this cell after it has undergone meiosis I.

.....

.....

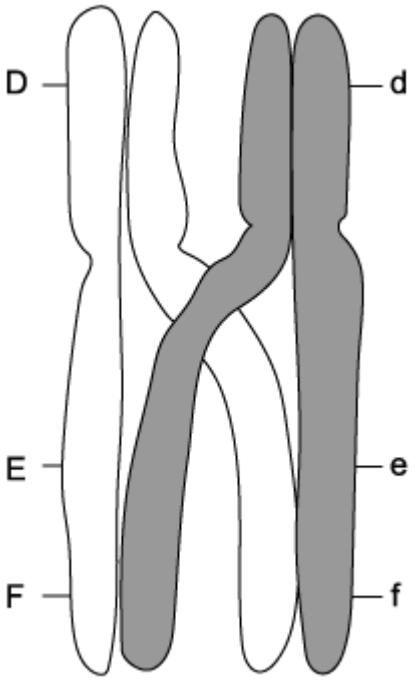
(2 marks)

(d) Outline the first steps in the process of meiosis, known as prophase I.

.....

(2 marks)

2 (a) The image below shows a pair of chromosomes during meiosis, taking place in a testis of *Drosophila melanogaster* (a fruit fly). The position of the alleles of some genes is indicated.



State the name of the arrangement of chromosomes shown in the image above.

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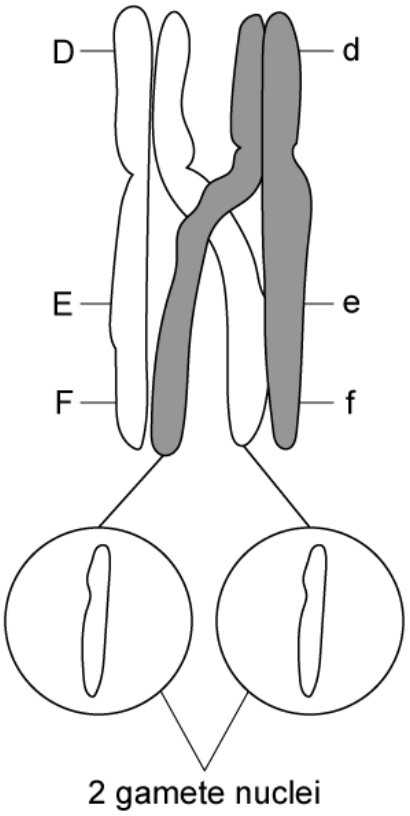
(1 mark)

(b) The diagram below shows two of the gamete nuclei that formed at the end of the meiosis process shown in part a). Assume that the parent cell only contains 2 chromosomes.



Draw the chromosomes in each of the nuclei shown in the diagram to give their appearance at the end of meiosis.

(2 marks)

(c) Outline the events that occur during anaphase I of meiosis.

(2 marks)

(d) Explain how independent assortment contributes to genetic variation in gametes.

(2 marks)

3 (a) European rabbits (*Oryctolagus cuniculus*) have a diploid (2n) chromosome number of 44.

The number of possible chromosome combinations that are possible as the result of independent assortment can be calculated using the formula 2^n, where n is the haploid chromosome number.

Calculate the number of different possible chromosome combinations in the gametes of rabbits.

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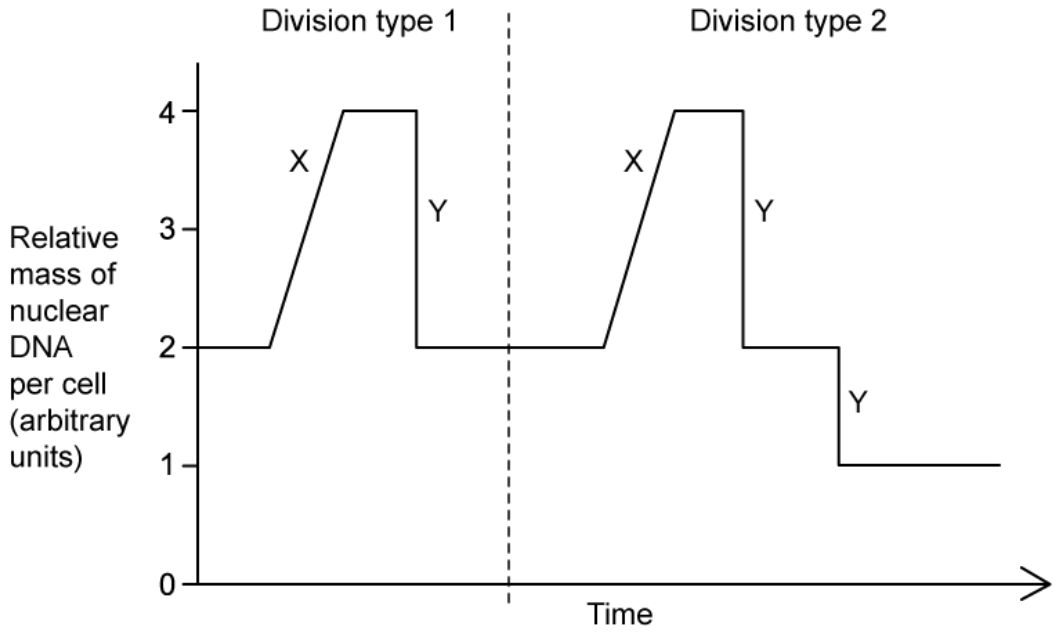
(2 marks)

(b) The graph below shows how the mass of DNA changes over time during two different types of cell division of a diploid organism.



Identify, with a reason, which of the division types represents meiosis.

.....

.....

(2 marks)

(c) Describe the two processes represented by the letters **X** and **Y** in the graph in part b).

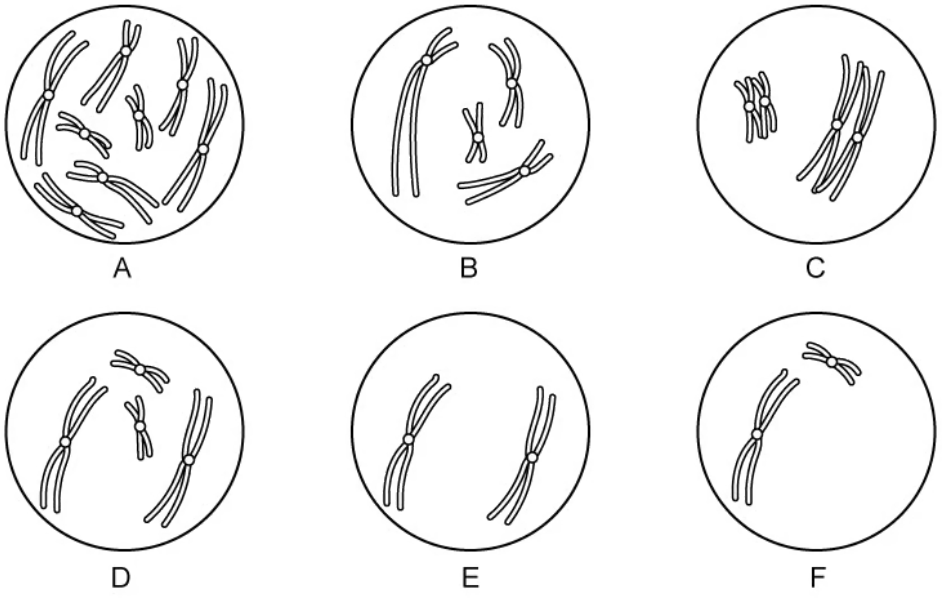
.....

.....

(2 marks)

(d) The fruit fly (*Drosophila melanogaster*) has a diploid number (2n) of 8.

The image below shows some cells from different organisms undergoing cell division.



Identify, with a reason, the cell which would represent a fruit fly cell that has just completed meiosis I.

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(2 marks)

4 (a) Explain what is meant by the phrase 'non-Mendelian ratio'.

.....

.....

(2 marks)

(b) Explain how the work of Thomas Hunt Morgan provided a possible explanation for non-Mendelian ratios.

.....

.....

(2 marks)

(c) Hydra are small, freshwater invertebrates that can reproduce by forming buds on their cylinder-shaped bodies. These buds grow over time, developing tentacles like the adult hydra, and eventually detaching from the parent hydra's body.

Suggest why meiosis would not occur in Hydra during the process described above.

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.....

(2 marks)

5 (a) *One mark is available for clarity of communication throughout this question.*

Describe the process of crossing over in prophase I.

(7 marks)

(b) Compare and contrast meiosis II and mitosis.

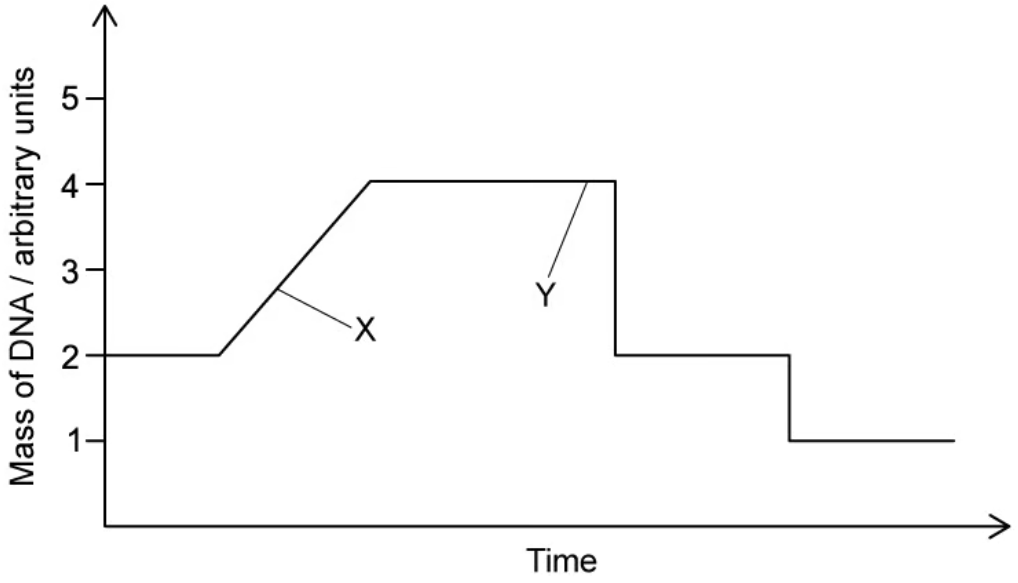
(5 marks)

(c) Draw a diagram to show how chiasmata are formed.

(3 marks)

Hard Questions

1 (a) The graph below shows changes in the mass of DNA over the course of a cell cycle.



Explain the role of the process, represented by this graph, in living organisms.

(3 marks)

(b) Annotate the graph in part a) to show the approximate points at which the following events are taking place:

(i) G2

[1]

(ii) Cytokinesis I

[1]

(iii) Metaphase II

[1]

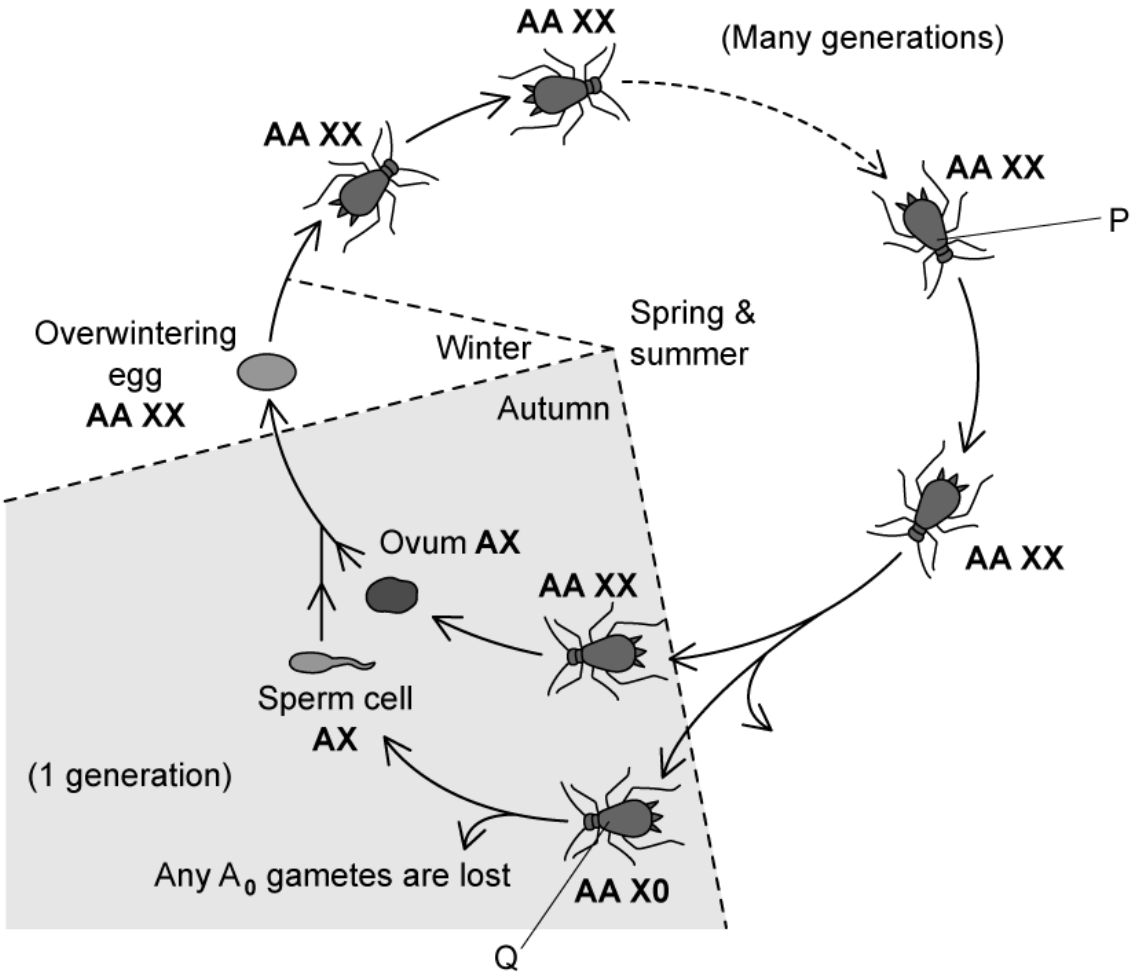
(3 marks)

(c) Variation is introduced at the points labelled **X** and **Y** in the graph in part a).

Identify processes that could introduce variation at points **X** and **Y**.

(2 marks)

2 (a) The diagram below illustrates the life cycle of the pea aphid, *Acyrthosiphon pisum*. Note that the term **autosome** refers to any chromosome that is not a sex chromosome.



Key: **A** = a single set ot autosomes
X = female sex chromosome
0 = absence of female sex chromosome

Identify the biological sex of the individuals labelled **P** and **Q**.

.....

(1 mark)

(b) The diagram in part a) shows that aphids use a different type of reproduction in the spring and summer to the type used in the autumn.

(i) Identify the type of reproduction used by aphids in the spring and summer, and in the autumn.

[1]

(ii) Explain your answer to part i).

[2]

(iii) Suggest the advantage to the aphids of switching their method of reproduction in the autumn.

[1]

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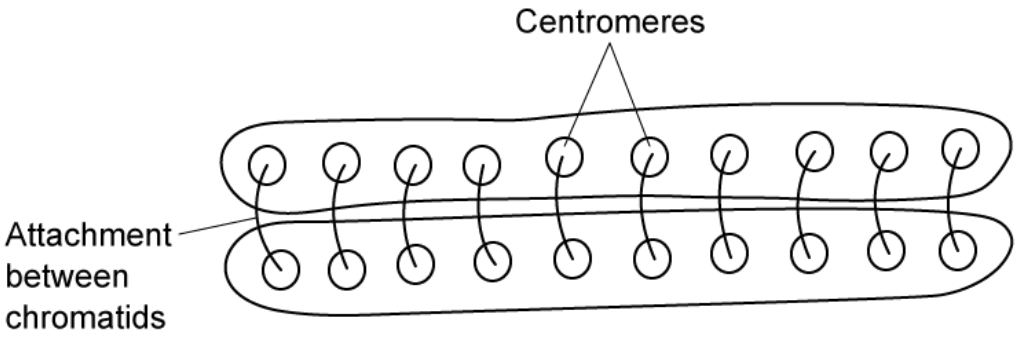
(4 marks)

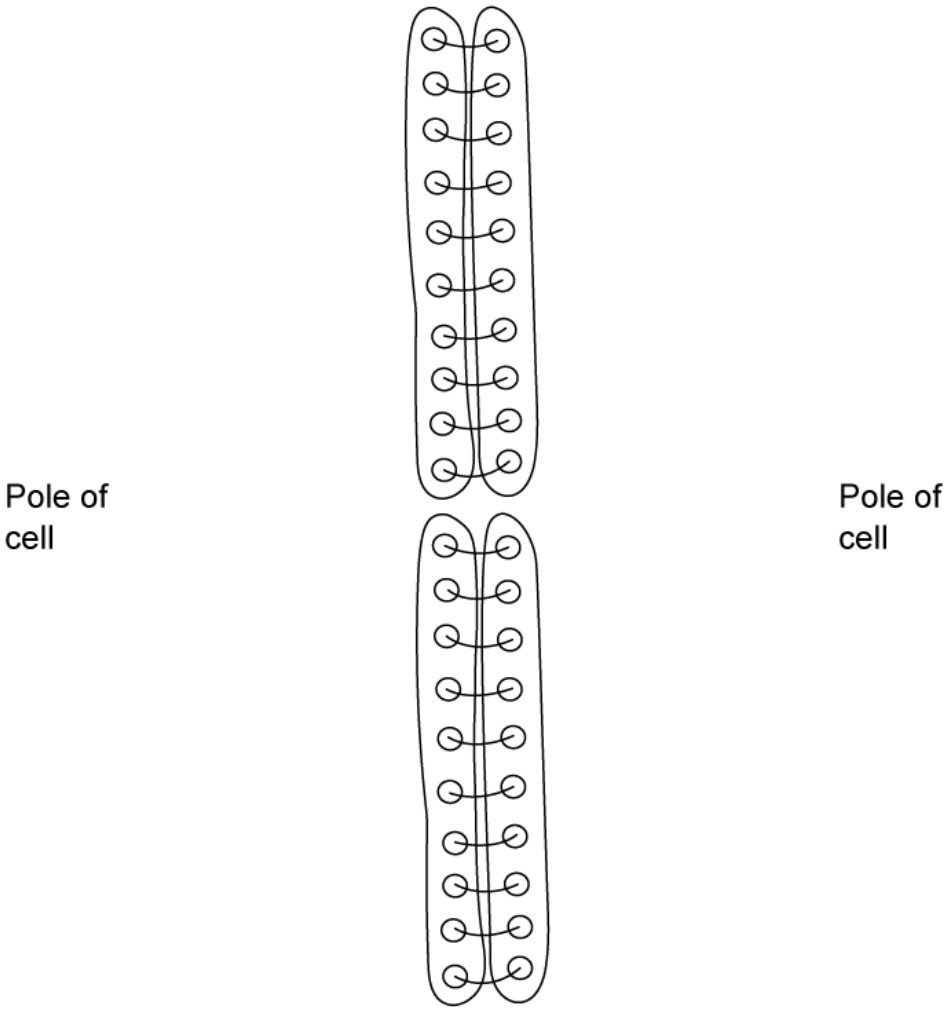
(c) Most eukaryotic chromosomes are described as being monocentric. Aphids have unusual chromosomes known as **holocentric** chromosomes. A holocentric chromosome after DNA replication is shown in the diagram below.



Contrast holocentric chromosomes with normal monocentric chromosomes.

(2 marks)

(d) While scientific understanding of aphid meiosis is still limited, the holocentric nature of their chromosomes means that aphids are thought to carry out a form of meiosis known as inverted meiosis. The possible behaviour of a homologous pair of aphid chromosomes during metaphase I is shown in the diagram below.

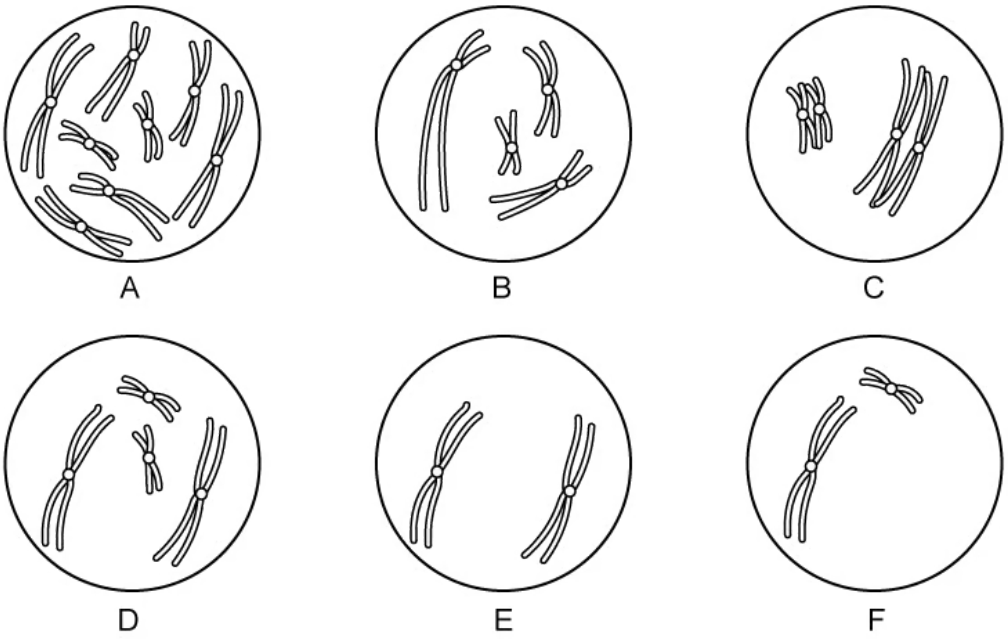


Suggest, with reasons, **two** ways in which meiosis in aphids could be different to conventional meiosis.

(4 marks)

3 (a) The spider mite *Eutetranychus africanus* has very few chromosomes (2n = 4).

The diagram below shows a series of cells undergoing cell division.



Identify, with reasons, which of the cells in the diagram above belong to *E. africanus.*

(3 marks)

(b) A sample of cells was taken from the reproductive organs of *E. africanus* and the mass of DNA in each cell was determined. Some of the cells' DNA had a mass of 1.7 arbitrary units (a.u.) whilst other cells' DNA had a mass of 3.4 or 6.8 a.u..

Use your knowledge of the cell cycle to explain this observation.

(3 marks)

(c) A species of false spider mite, *Brevipalpus phoenicis*, is the only animal to have so far been identified as having exclusively haploid cells throughout its life cycle. *B. phoenicis* populations are entirely female, producing eggs which hatch into more females.

The discovery of the haploid nature of *B. phoenicis* was a surprise to scientists, who believed that being diploid was essential due to the evolutionary advantage that it provides.

(i) Identify the type of cell division by which *B. pheonicis* produces eggs.

[1]

(ii) Suggest why scientists might think that diploidy provides an evolutionary advantage.

[1]

(iii) *B. phoenicis* is a highly successful pest of citrus, tea, and palm plantations. Suggest how *B. phoenicis* might have evolved to become such a successful pest despite the points covered in parts i) and ii) above.

[1]

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(3 marks)

(d) While studying the cells of *B. phoenicis* scientists discovered that the cells of all individuals contained bacteria. Treatment with antibiotics caused female *B. phoenicis* to lay eggs that hatched into haploid males.

(i) Suggest the experimental measure that the scientists would need to take in order to demonstrate that the link between antibiotic treatment and male egg development is causal.

[1]

(ii) Suggest why treatment with antibiotics might have enabled the production of male offspring.

[2]

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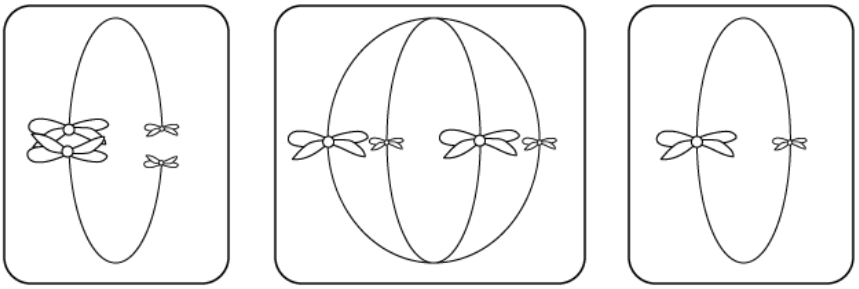
(3 marks)

4 (a) The diagram below shows three cells in different stages of cell division. Note that all of the cells shown have the same 2n chromosome number.



Cell Q Cell R Cell S

Identify the cell(s) in the diagram above that show the following:

(i) Homologous chromosomes

[1]

(ii) Meiosis

[1]

(iii) Reduction division

[1]

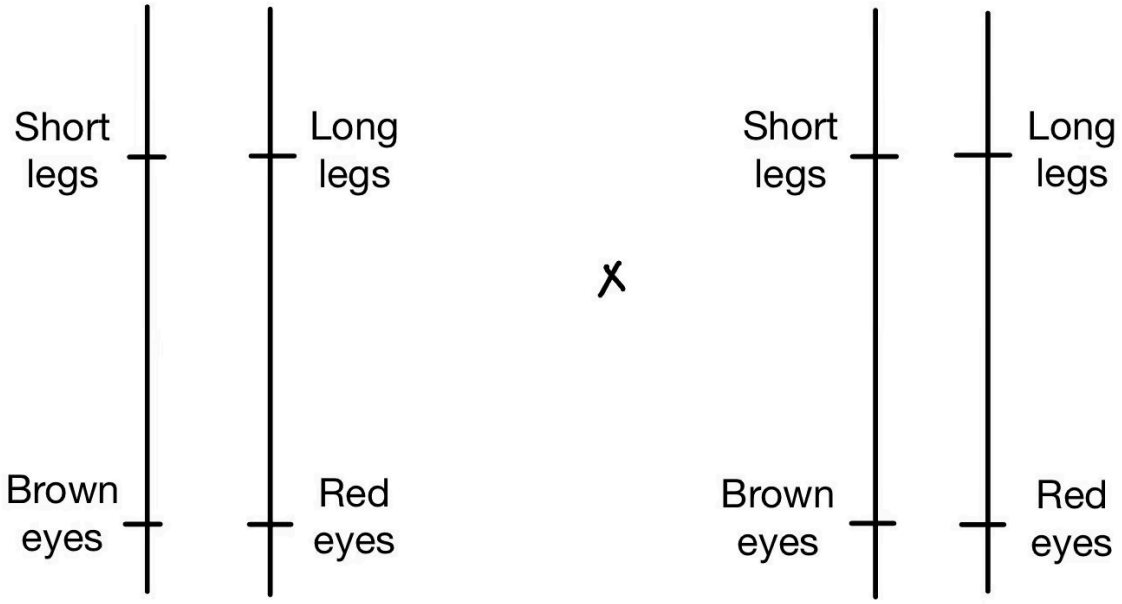
.....

.....

.....

(3 marks)

(b) Fruit flies, *Drosophila melanogaster*, are frequently used in scientific studies. The diagram below shows the gene loci and alleles of two genes on a pair of chromosomes in a male and female *D. melanogaster* individual. Note that the dominant alleles are long legs and red eyes.



A cross was carried out between the two individuals shown above. The table below shows the number of offspring with short/long legs and brown/red eyes produced from the cross.

Characteristics	Number of offspring
Short legs and brown eyes	545
Long legs and red eyes	182
Short legs and red eyes	14
Long legs and brown eyes	12

Calculate the offspring ratios for the cross shown. Give your answers to the nearest whole number.

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.....

(2 marks)

(c) Explain the offspring ratios shown in part b).

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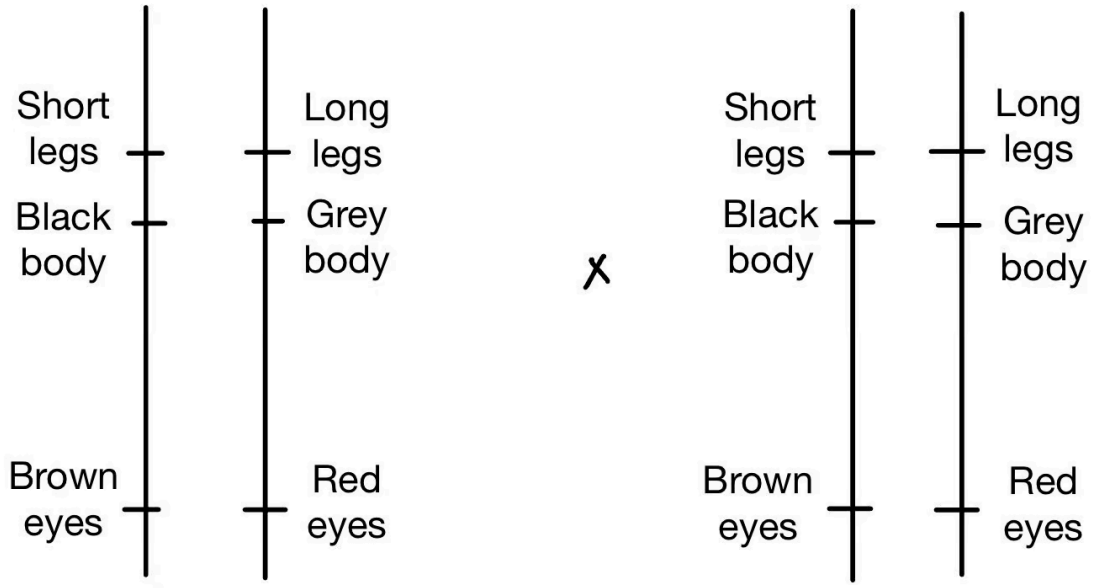
(3 marks)

(d) The diagram below shows the gene loci and alleles for a third gene on the chromosomes of the individuals in part b). Note that the grey body allele is dominant to the black body allele.



Suggest, with a reason, how the numbers of offspring with short/long legs and black/grey bodies would differ from the numbers with short/long legs and brown/red eyes shown in part b).

(2 marks)

5 (a) *One mark is available for clarity of communication throughout this question.*

Compare and contrast meiosis I and meiosis II.

(8 marks)

(b) Use named examples to describe the roles of mitosis and meiosis in living organisms.

(6 marks)