IB · SL · Biology

4 hours 39 questions

Structured Questions

Cell & Nuclear Division

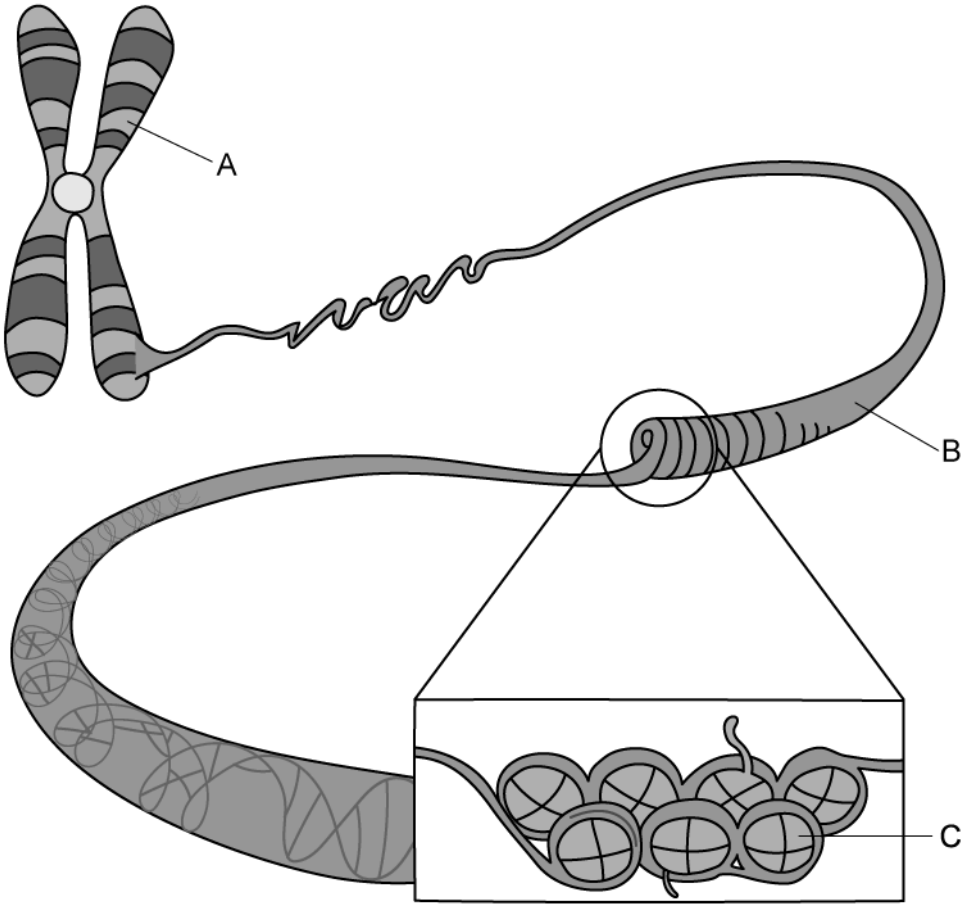
Cell Division / Nuclear Division / Mitosis / Mitosis: Skills / Meiosis

Easy (12 questions)	/73
Medium (15 questions)	/94
Hard (12 questions)	/79
Total Marks	**/246**

Scan here to return to the course
or visit savemyexams.com

Easy Questions

1 (a) The following diagram shows the arrangement of DNA in a eukaryotic chromosome.



(i) Label structure **A** in the diagram.

[1]

(ii) State what is represented by the banding pattern on structure **A**.

[1]

.....

.....

(2 marks)

(b) Use the information in the diagram in part a) to:

(i) Identify structures **B** and **C**.

[1]

(ii) Describe the relationship between structures **B** and **C**.

[1]

.....

.....

(2 marks)

(c) Chromosomes in diploid cells will occur in homologous pairs.

Define the term 'homologous chromosomes'.

.....

(1 mark)

2 (a) State the feature that forms in animal cells by the pinching of the plasma membrane during cytokinesis.

.....

(1 mark)

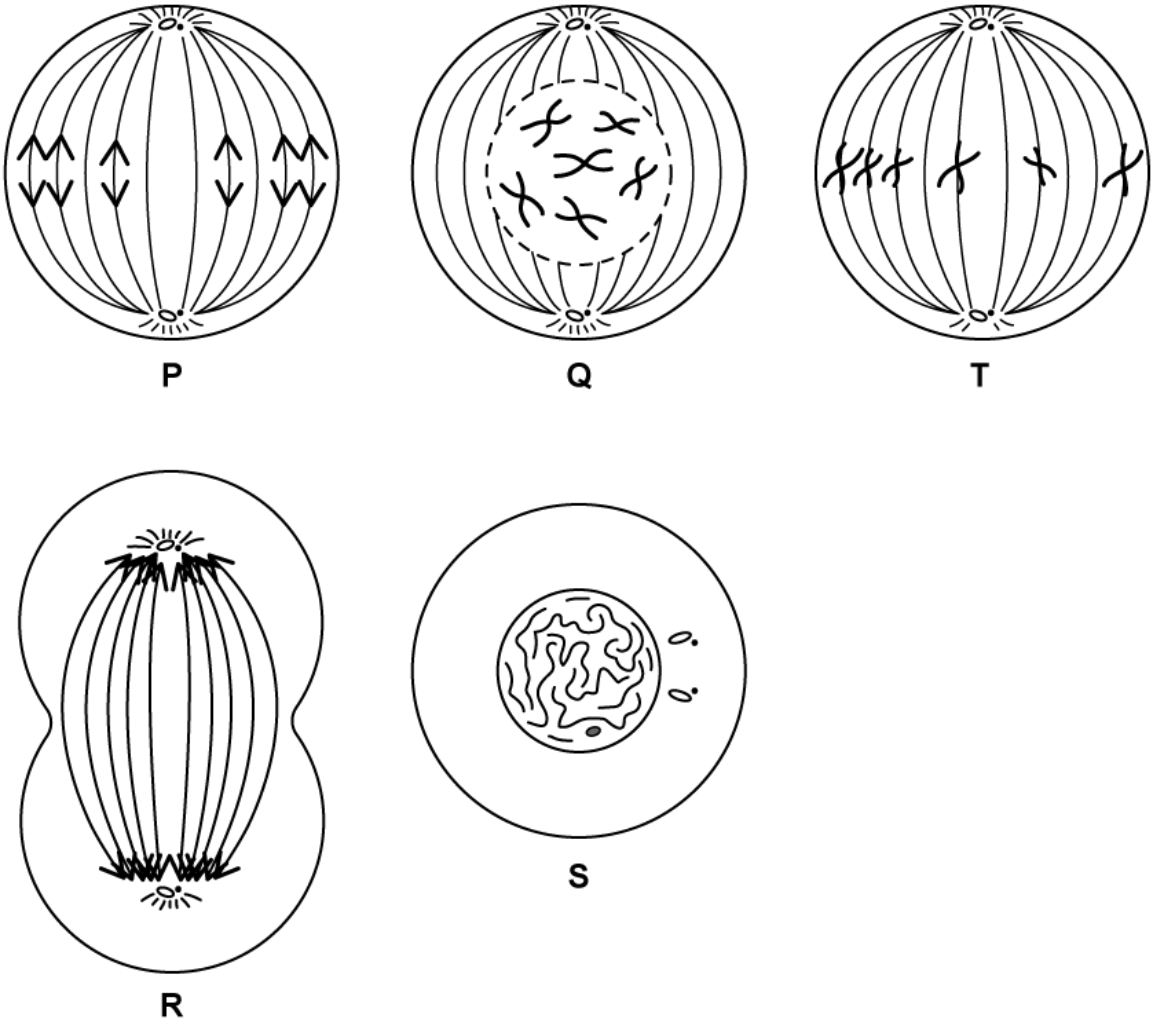
(b) Define the term **mitosis**.

.....

.....

(2 marks)

(c) The drawings below show a cell during different stages of mitosis.



List the stages **P**, **Q**, **R**, **S** and **T** in the correct sequence.

.....

.....

.....

(3 marks)

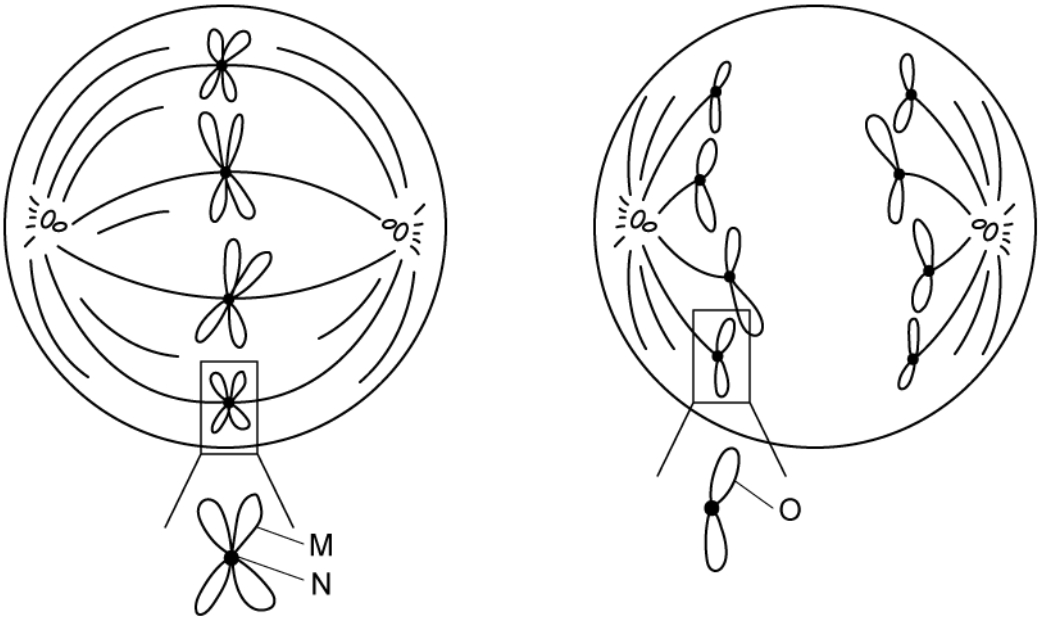
(d) Cell **M** contains 74 chromosomes. It divides by mitosis.

State the number of chromosomes that will be present in the new daughter cells.

.....

(1 mark)

3 (a) The diagram below shows two different stages of mitosis.



Identify structures **M**, **N** and **O**.

.....

.....

.....

(3 marks)

(b) List three reasons why cells will undergo mitosis.

.....

.....

.....

(3 marks)

(c) State the name of the process that occurs during prophase that causes the chromosomes to become visible as separate structures.

.....

(1 mark)

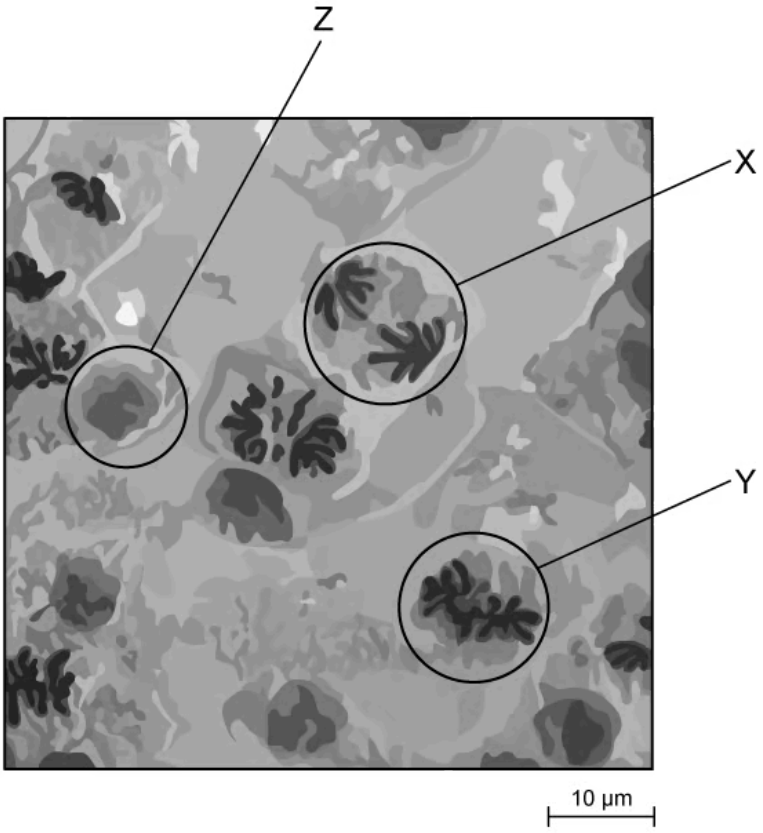
(d) List **two** examples of mutagens.

.....

.....

(2 marks)

4 The diagram below shows some grasshopper cells.



Identify the stages of mitosis taking place in cells **X** and **Y**.

.....

.....

(2 marks)

5 (a) Outline the purpose of meiosis in living organisms.

(2 marks)

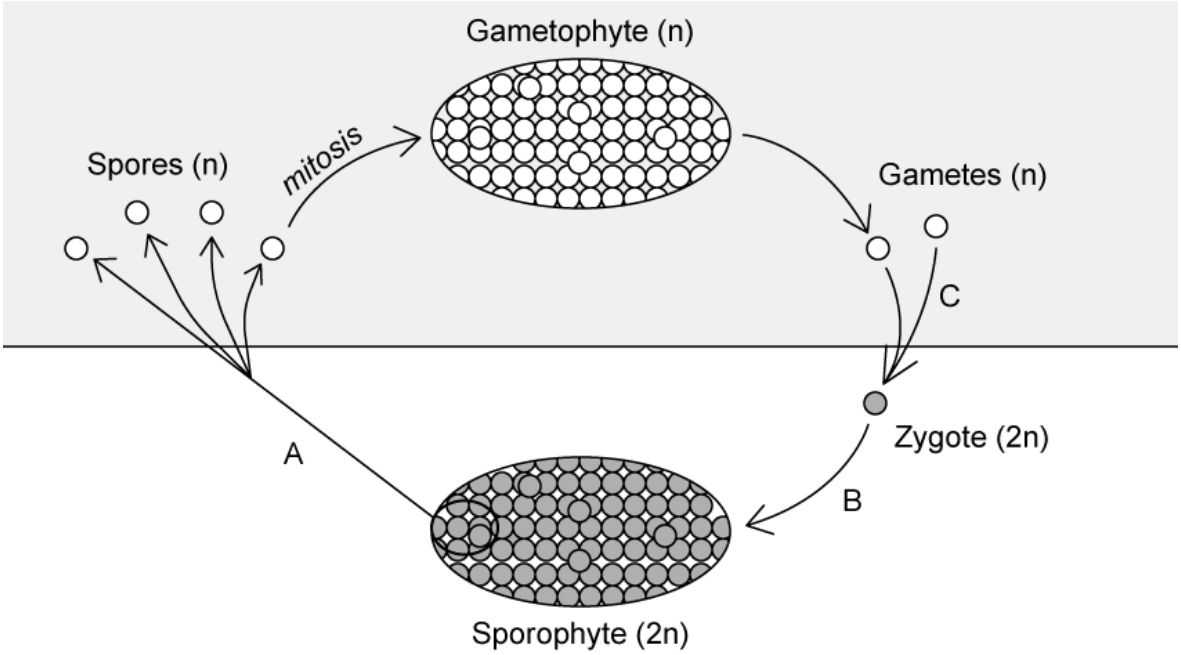
(b) The table below contains a series of statements about meiosis in human cells.

Statement	True / False
2 daughter cells are produced	False
Homologous pairs of chromosomes are separated	
Daughter cells have the full number of chromosomes	
Two cycles of division take place	
DNA replication occurs before the process begins	

Complete the table by indicating whether each statement is **true** or **false**. The first row has been completed for you.

(2 marks)

(c) The diagram below shows a simplified life cycle of a fern plant.



Identify the types of cell division taking place at the positions marked **A** and **B**.

.....

.....

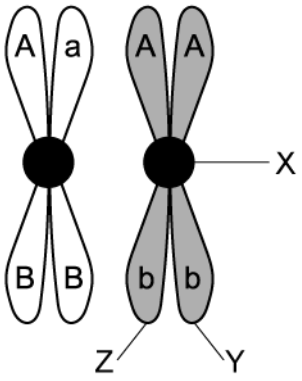
(2 marks)

(d) Identify the process taking place at the position marked **C** in the diagram in part c).

.....

(1 mark)

6 (a) The image below shows two chromosomes.



(i) Identify the structures labelled **X** and **Y**.

[2]

(ii) Structures **Y** and **Z** are identical.

State why this is the case.

[1]

.....

.....

.....

(3 marks)

(b) The two chromosomes shown in part b) can be described as homologous chromosomes.

Define the term **homologous chromosome**.

.....

.....

(2 marks)

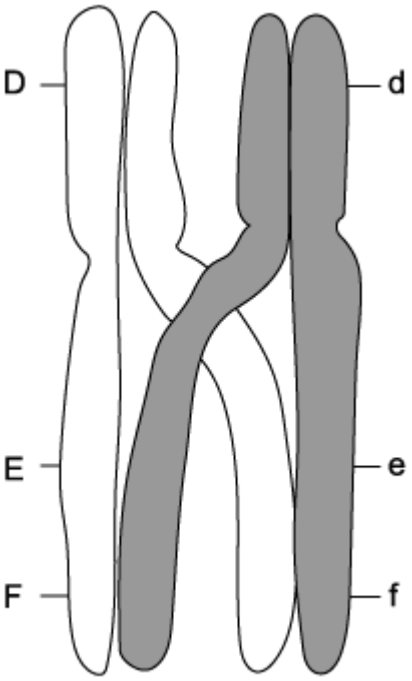
(c) During meiosis the homologous chromosomes shown in part b) are separated.

Identify the stage of meiosis during which the homologous chromosomes are separated.

.....

(1 mark)

7 (a) The image below shows a pair of chromosomes during meiosis.



Identify the process taking place in the image.

[1]

.....

(1 mark)

(b) State the alleles that will be present on each of the **grey** shaded chromatids at the end of the process shown in part a).

.....

.....

(2 marks)

(c) There are many different possible combinations of chromosomes that can be found in the daughter cells produced during meiosis.

Use the formula 2^n to calculate the number of possible chromosome combinations that can be generated in domestic cat gametes. Note that the adult cells of domestic cats contain 38 chromosomes.

.....

.....

(2 marks)

(d) Another source of variation during meiosis is a chromosome mutation that results from an event known as chromosome non-disjunction.

(i) State the meaning of the term **non-disjunction**.

[1]

(ii) Identify **one** factor that increases the risk of chromosome non-disjunction occurring during meiosis.

[1]

.....

.....

(2 marks)

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

.....

.....

(2 marks)

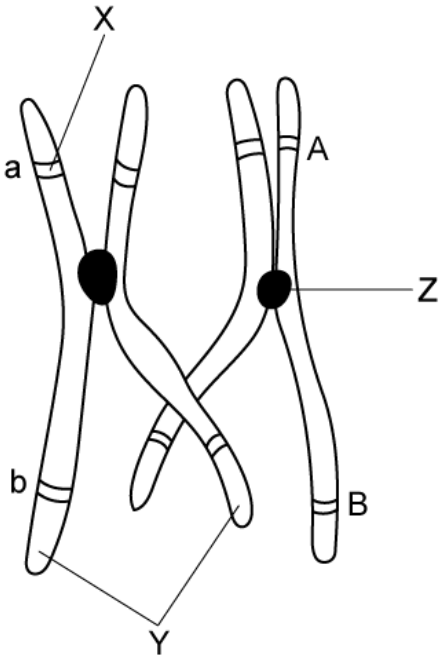
(b) Describe the chromosome activity taking place at the stage marked **Y** in the diagram in part a).

.....

.....

(2 marks)

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



Identify structures **X**, **Y** and **Z**.

.....

.....

.....

(3 marks)

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

.....

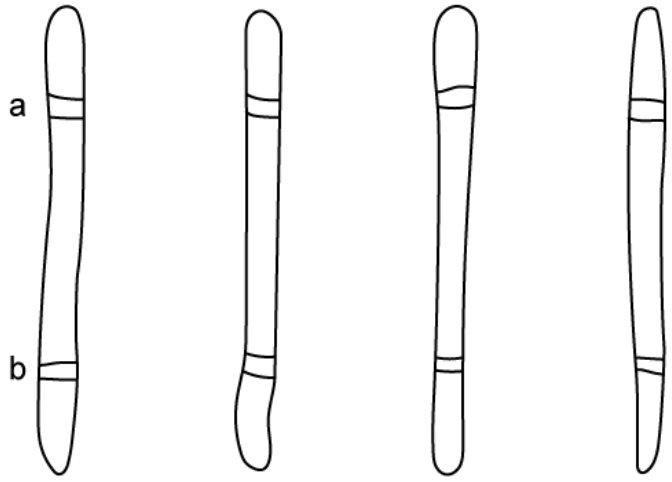
.....

.....

(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.

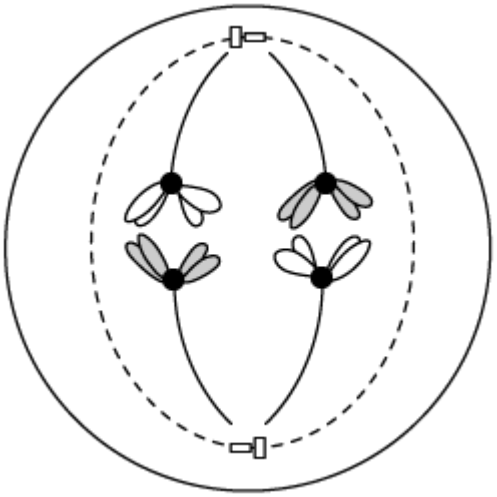


(3 marks)

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

(2 marks)

10 (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.

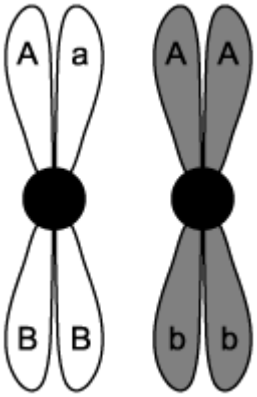
(2 marks)

(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)

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



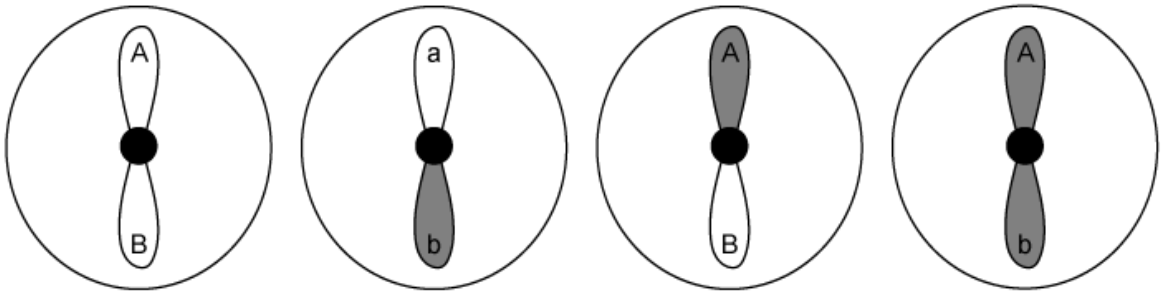
Identify, with a reason, the meiotic division that is occurring in the diagram.

.....

.....

(2 marks)

(b) 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)

(c) The process in part b) and random orientation both contribute to genetic variation.

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

.....

(1 mark)

12 Draw an annotated diagram to show how crossing over takes place during meiosis.

.....

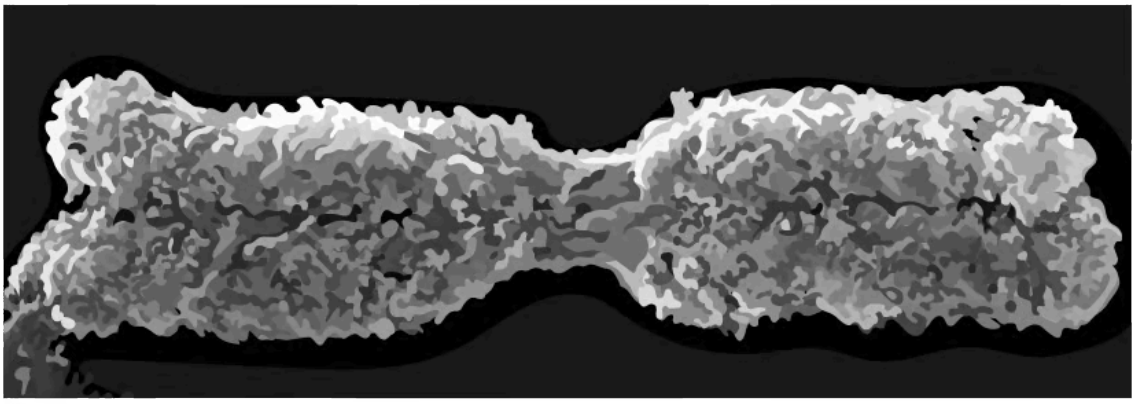
.....

.....

(3 marks)

Medium Questions

1 (a) Outline the process which leads to the production of a chromosome with the appearance shown in the image below.



(2 marks)

(b) In meiosis I, homologous chromosomes pair up before being separated during the first division.

Explain why these homologous chromosomes are not identical.

(2 marks)

2 (a) Distinguish between the terms chromosome and chromatid.

(2 marks)

(b) The following statements contain information about the stages of mitosis, with some details missing.

Stage 1: Chromosomes become shorter and thicker, and the nuclear membrane breaks down.

Stage 2: Chromosomes line up along the equator of the cell and ___(i)___,

Stage 3: ___(ii)___, causing the chromatids to separate and move towards ___(iii)___.

Stage 4: A new nuclear membrane forms around each group of chromosomes.

Complete **Stage 2** and **Stage 3** with appropriate statements.

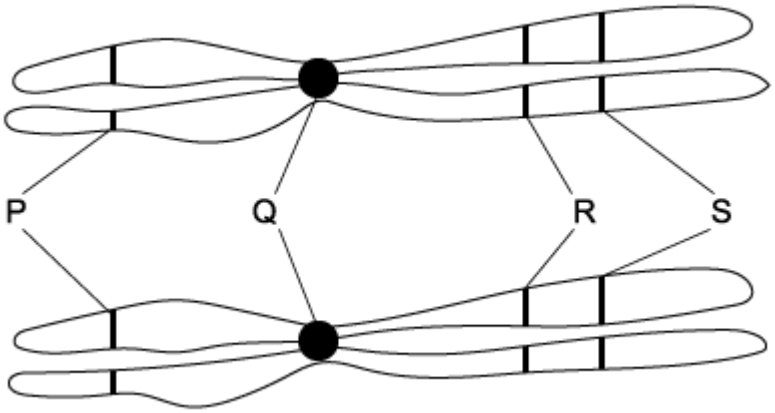
(3 marks)

3 Melanoma is a type of skin cancer that develops from pigment-producing cells in the skin known as melanocytes. Sun exposure is a risk factor in the development of melanoma.

Explain why sun exposure increases the risk of melanoma.

(2 marks)

4 (a) The diagram below shows two chromosomes in a cell that is undergoing mitosis.



Identify structure **Q** and explain what happens to it during anaphase.

.....

.....

(2 marks)

(b) After looking at the diagram in part **(a)**, a scientist concludes that the two chromosomes are homologous.

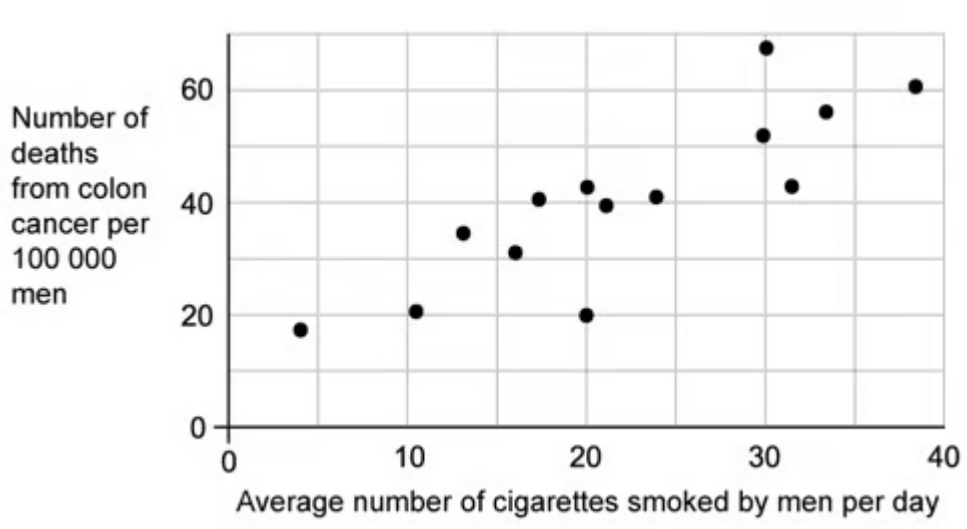
Use the diagram in part **(a)** to explain why the scientist has come to this conclusion.

.....

.....

(2 marks)

(c) A group of researchers investigated the relationship between the average number of cigarettes smoked by men per day and the number of men dying from colon cancer in 14 different countries. The data from the study is provided in the graph below.



A website reported the results of this investigation using the headline 'Smoking causes cancer'.

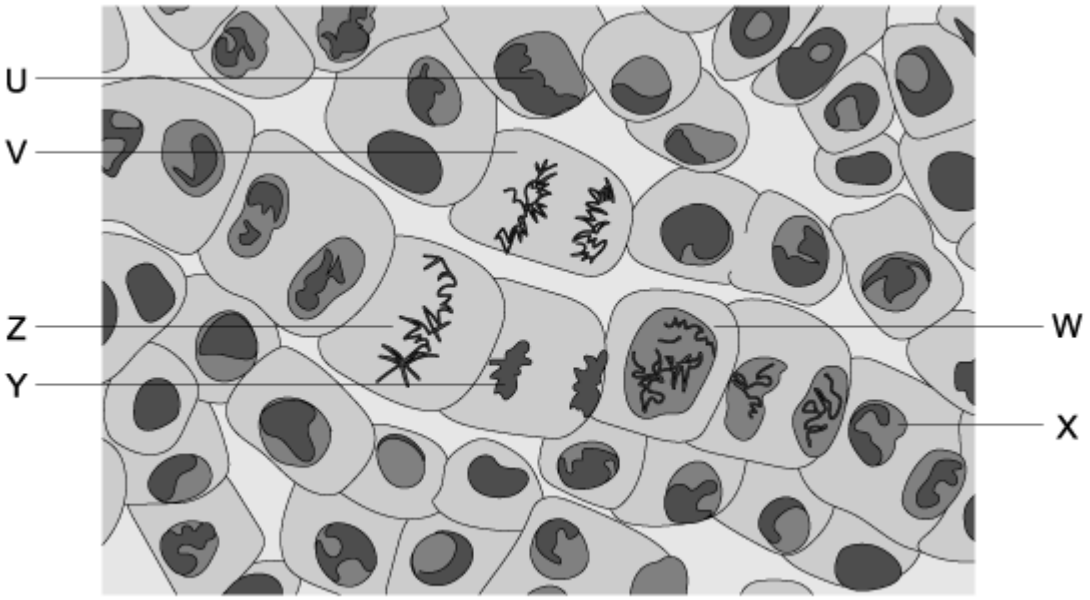
Explain why the researchers could not support this view based on the results of their investigation alone.

(4 marks)

(d) Explain why the death rate from colon cancer in part (c) is given per 100 000 men and not given as the total number of deaths.

(2 marks)

5 (a) The drawing below shows a micrograph of actively dividing cells in tissue taken from the tip of a plant root.



Complete the table to identify the stage of cell division visible in cells **W**, **V** and **Z**.

Cell	Stage of cell division
W	
V	
Z	

(3 marks)

(b) In which of the cells (**U**, **V**, **W**, **X**, **Y** or **Z**) in the micrograph drawing in part (a) can vesicles now fuse to form new cell membranes across the cytoplasm (in order to separate the cell into two daughter cells).

(1 mark)

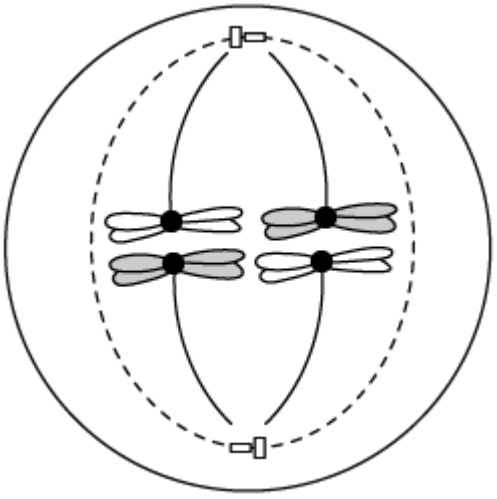
6 (a) Describe cytokinesis in animal cells and in plant cells.

(3 marks)

(b) Describe the events that take place during mitosis, including the name of the stage of mitosis during which each event occurs.

(7 marks)

7 (a) Identify, with a reason, the type of cell division shown in the diagram



.....

.....

(2 marks)

(b) *Pisum sativum* (garden pea) has a diploid chromosome number of 14.

Calculate the number of different chromosome combinations can result during meiosis, assuming no crossing over occurs.

.....

(1 mark)

(c) Discuss the significance of meiosis in the life cycle of *Pisum sativum* (garden pea).

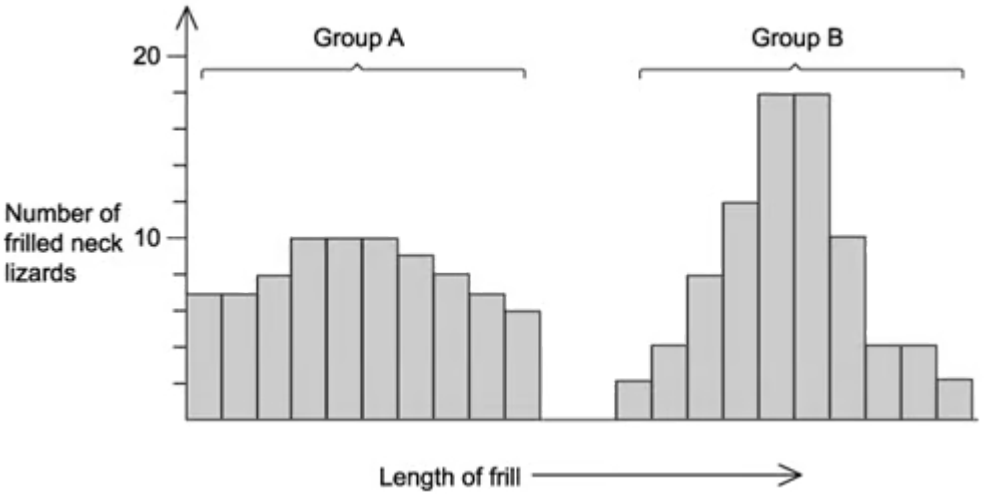
.....

.....

(2 marks)

(d) *Chlamydosaurus kingii* (Australian Frillneck lizard) is a diurnal (active during the day) lizard whose distribution extends across northern Australia and into Papua New Guinea. If the lizard is startled it opens its mouth and flexes the muscles in its frill (a large fold of skin surrounding its throat) causing it to be raised. Scientists believe that the frill is used to deter predators and to attract females.

The graphs below show the variation in the frill length of 164 male lizards from two different sites 150 km apart.



Explain how meiosis may have caused the variation shown in these graphs.

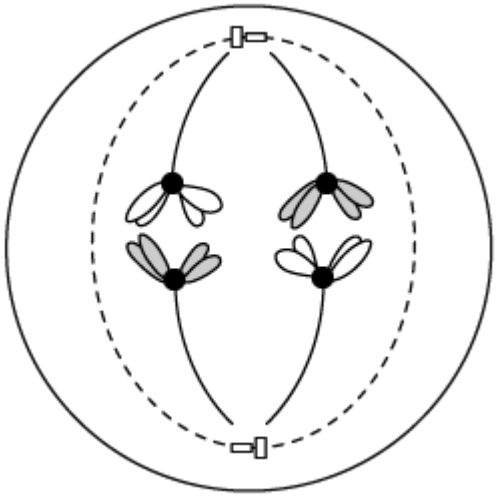
(2 marks)

8 (a) Complete the table using **'yes' / 'no'** or **numbers** to compare mitosis and meiosis.

Feature	Meiosis	Mitosis
Number of nuclear divisions		
Number of daughter cells produced		
Genetically different daughter cells are produced		
Crossing over occurs		
Homologous chromosomes pair up		

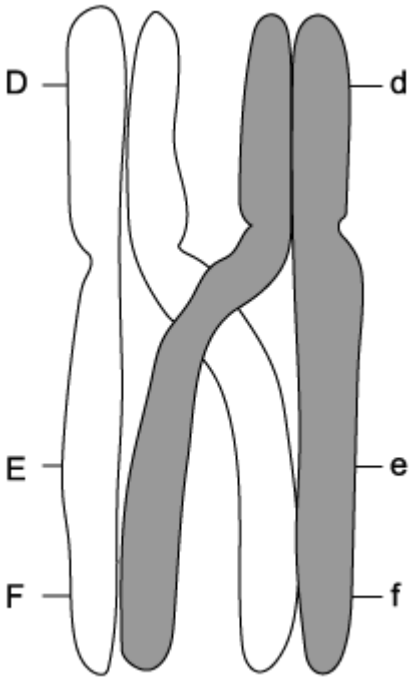
(2 marks)

(b) Explain how the diagram below illustrates that the resulting daughter cells will be genetically different. Give evidence from the diagram to support your answer



(2 marks)

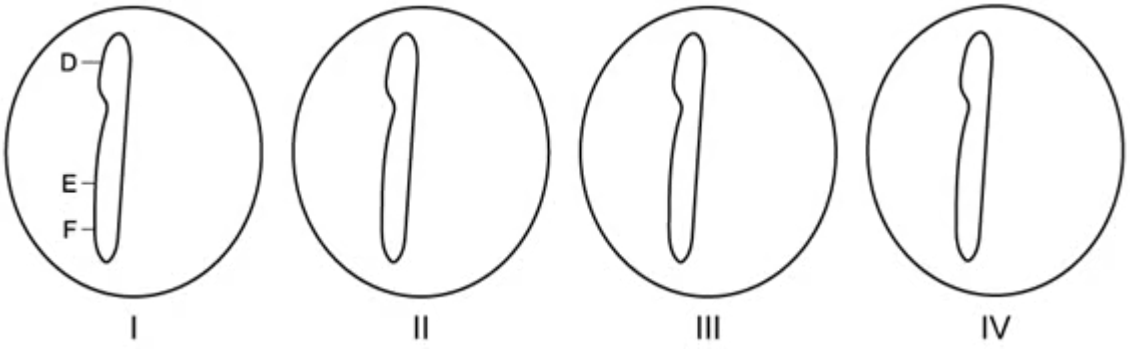
(c) The diagram below shows a pair of chromosomes during meiosis in a cell in a *Drosophila melanogaster* (fruit fly) testis. The position of the alleles of some genes is indicated.



Explain whether the chromosomes are homologous or non-homologous.

(2 marks)

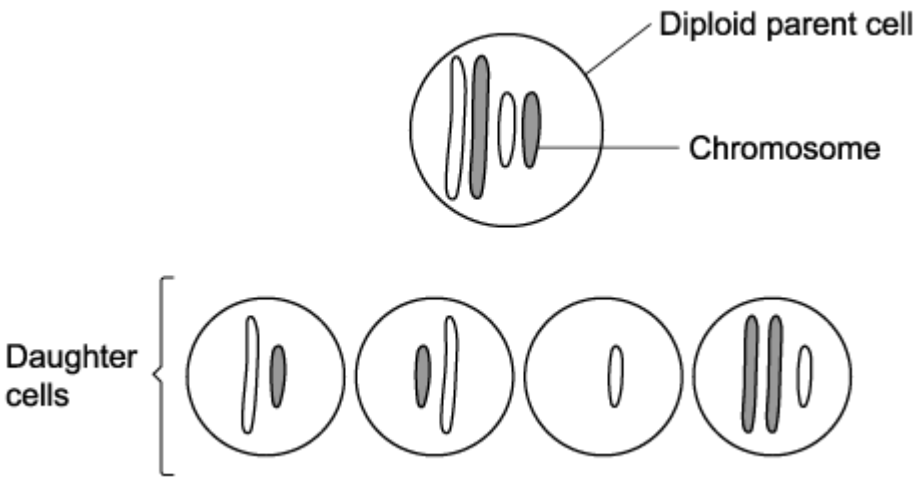
(d) At the end of meiosis, each of the chromosomes shown in the diagram from part (c) will be in a different haploid cell.



Label the diagram above to show the combinations of alleles that would be present on each chromosome inside the haploid daughter cells.

(3 marks)

9 (a) The diagram shows the chromosomes found in a parent cell and the daughter cells produced after meiosis



Identify the daughter cell(s) that contain a chromosome mutation by circling the cell(s).

(1 mark)

(b) Explain how the spontaneous chromosome mutation shown in part (a) arose in the daughter cells during meiosis.

(2 marks)

(c) The risk of a non-disjunction mutation increases with age. The table shows how the Down syndrome risk increases with age.

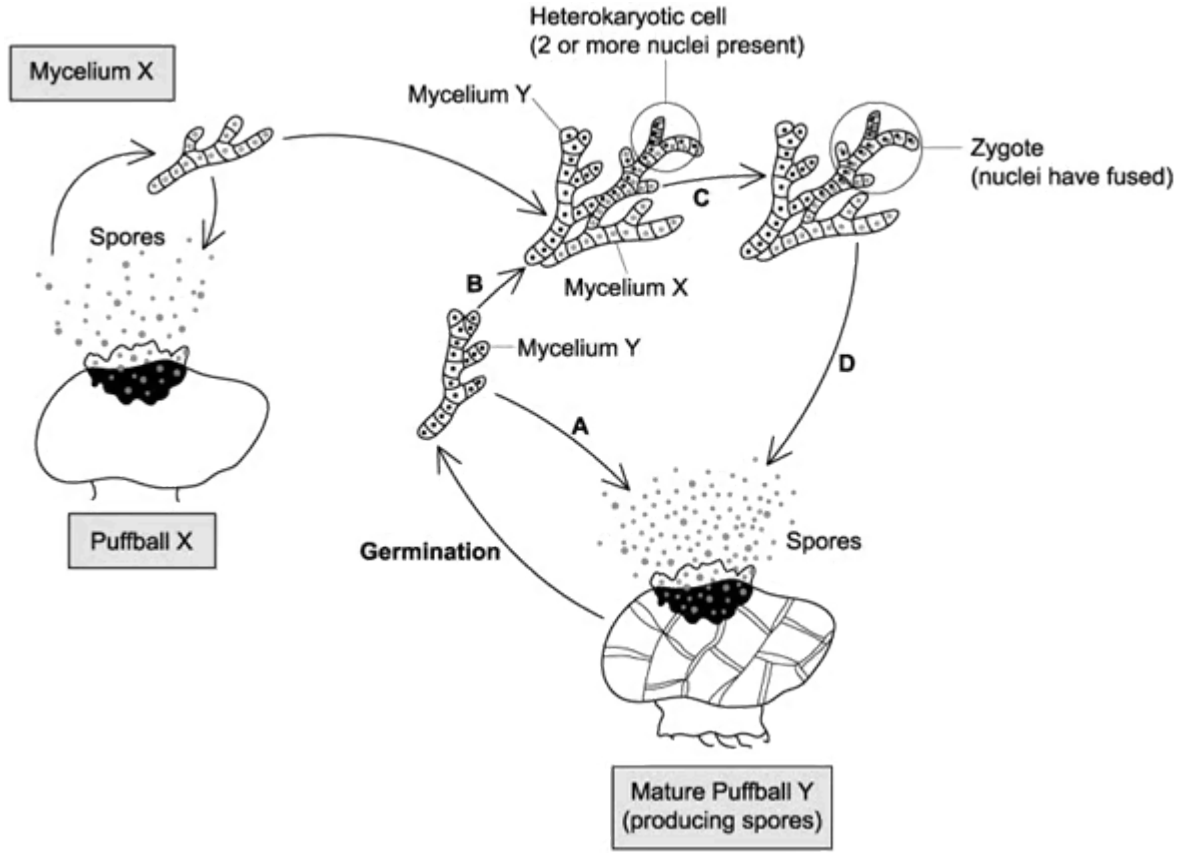
Mothers Age (Years)	Chance of conceiving a baby with Down syndrome
25-29	1 in 1250
30-34	1 in 1000
35-39	1 in 400
40-44	1 in 100
45+	1 in 30

Calculate how much more likely it is that a child is conceived with Down Syndrome for a mother who is 41 compared to a mother who is 26.

.....

(1 mark)

10 (a) The diagram below shows the life cycle of *Calvatia gigantea* (giant puffball). In this life cycle, only the zygote and mature puffball are diploid. All the cells in all the other stages of the life cycle of the puffball are haploid, including the spores.

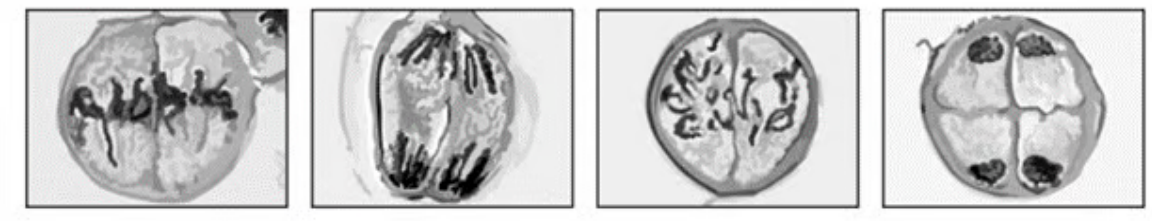


Identify which letter in the diagram shows where meiosis occurs in the life cycle of *Calvatia gigantea*

.....

(1 mark)

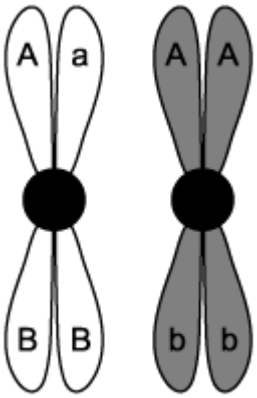
(b) The micrographs below show cells undergoing meiosis.



Identify, with a reason, the stages of meiosis shown in each micrograph.

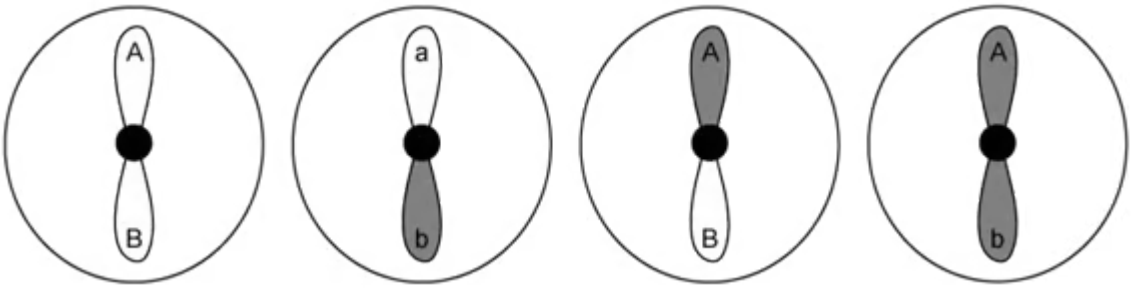
(4 marks)

(c) A *Pisum sativum* (garden pea) pollen cell is undergoing meiosis. During the initial phase of meiosis a pair of homologous chromosomes located in these cells can be represented by the chromosomes shown below. The two different letters represent two different genes.



At the end of meiosis the chromosomes were distributed to the four pollen grains as shown in the gametes below.

Figure 2



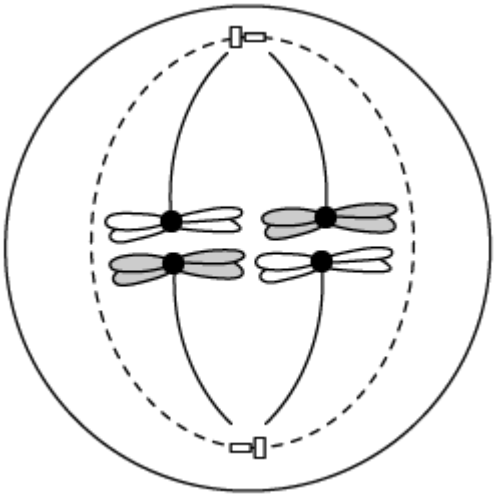
Describe how the new allele combinations seen in these gametes were formed during meiosis.

(2 marks)

11 Explain how genetic variation can be generated.

(7 marks)

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



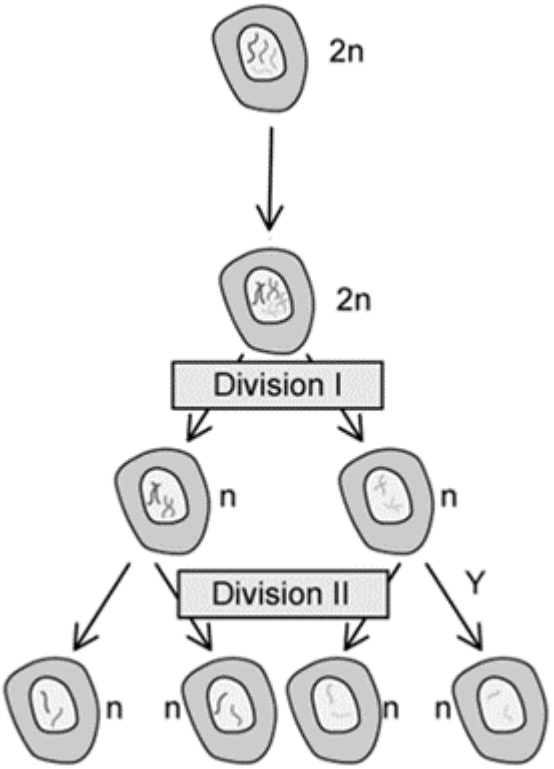
Identify, with a reason, the type of cell division shown in the image.

.....

.....

(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)

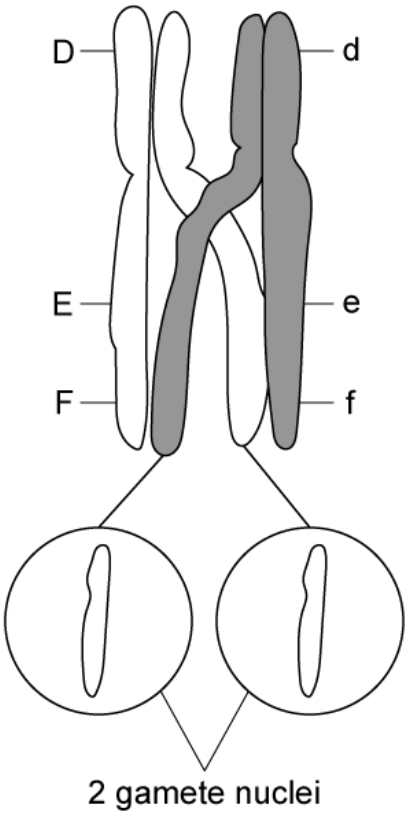
(d) Outline the first steps in the process of meiosis, known as prophase I.

.....

.....

(2 marks)

13 (a) The diagram below shows a homologous pair of chromosomes from a parent cell (top) and two gamete nuclei that form at the end of meiosis (bottom).



Draw the chromosomes present in each of the indicated gamete nuclei at the end of meiosis. Consider both shading and alleles in your answer.

(2 marks)

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

(2 marks)

(c) Explain how random orientation contributes to genetic variation in gametes.

.....

(2 marks)

14 (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 random orientation can be calculated using the formula 2^n, where *n* is the haploid chromosome number.

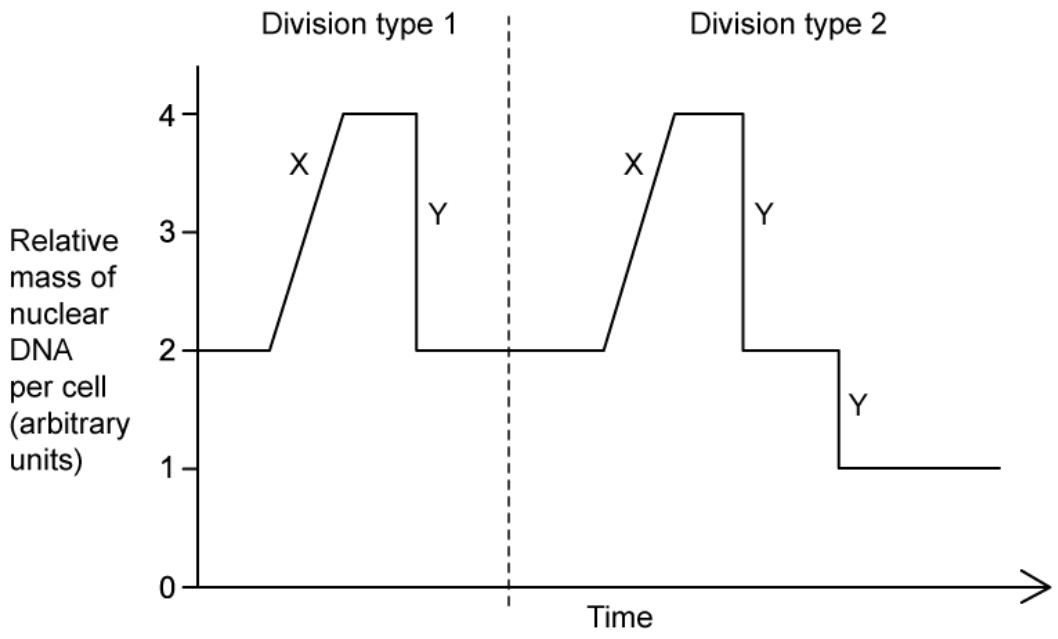
Calculate the number of different possible chromosome combinations in the gametes of rabbits.

.....

.....

(2 marks)

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



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

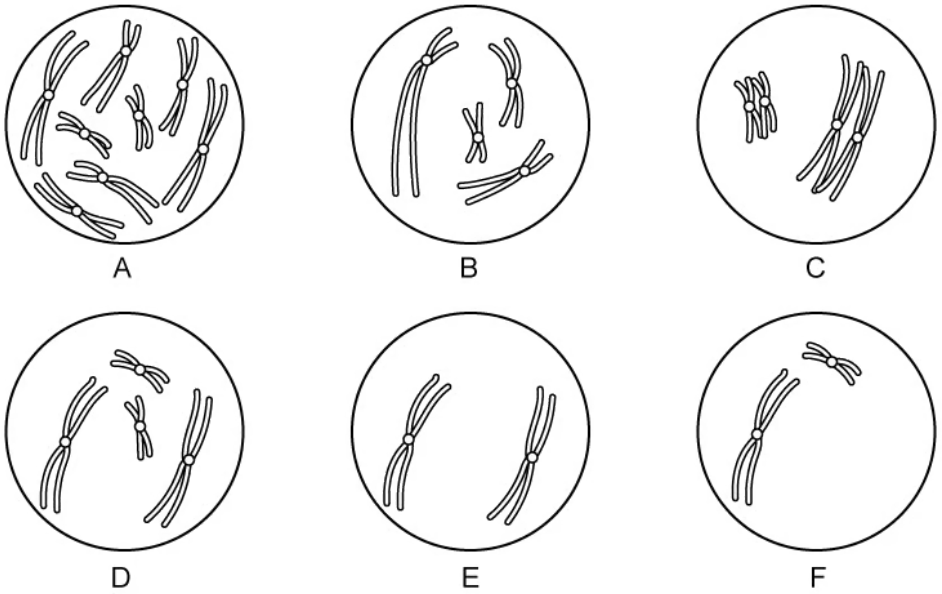
.....

.....

(2 marks)

(c) 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.

(2 marks)

15 Compare and contrast meiosis II and mitosis.

(5 marks)

Hard Questions

1 Compare and contrast the process of cytokinesis in plants and animals.

(3 marks)

2 (a) The biologists studying the *Saccharomyces cerevisiae* from part (a) hypothesised that when the yeast was exposed to stressful conditions, the growth rates were low.

Suggest, with a reason, which sample came from the nutrient-rich conditions.

.....

.....

(2 marks)

(b) The *Saccharomyces cerevisiae* nuclei are, on average, 2 μm in diameter, but the DNA molecules packed into them can be up to 355 μm in length.

Describe the process that enables the DNA molecules to be packed into the nuclei.

.....

.....

(2 marks)

3 (a) A student's research determined that the cell cycle in a similar root to that shown in part (a) was 1 560 minutes in length, and that on average, cells spent 5 hours in the visible stages of mitosis.

Calculate the percentage difference between the data gathered by the student and the mean length of the mitotic stages found by the researcher in part (a).

(2 marks)

(b) Suggest **two** possible reasons why there may have been differences in the mitotic index the researcher determined and the student's value.

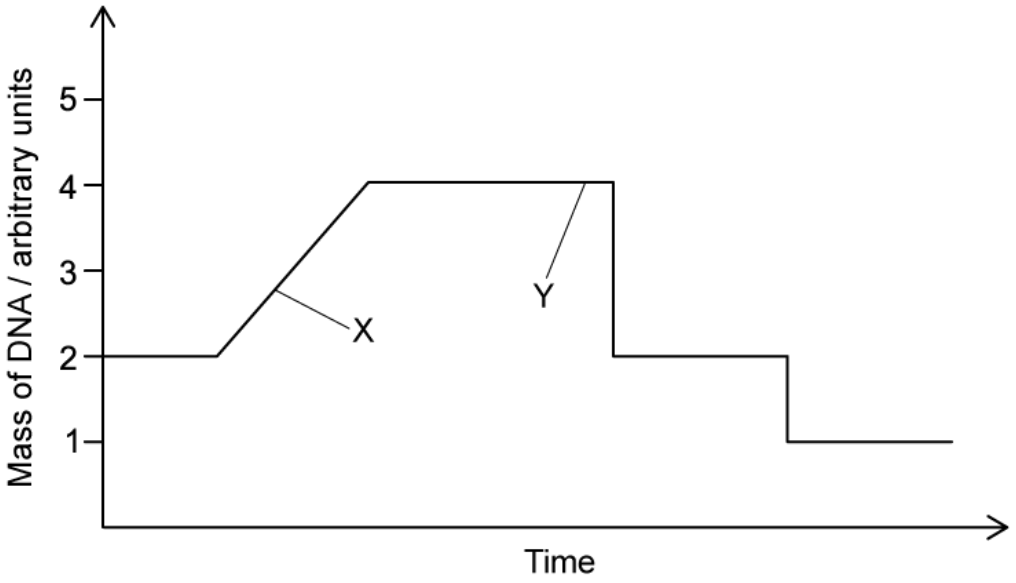
(2 marks)

4 Some cell biologists believe that the use of the term 'cell division' should be discontinued and replaced with 'cell multiplication'.

Evaluate this claim using your knowledge of the cell cycle.

(3 marks)

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

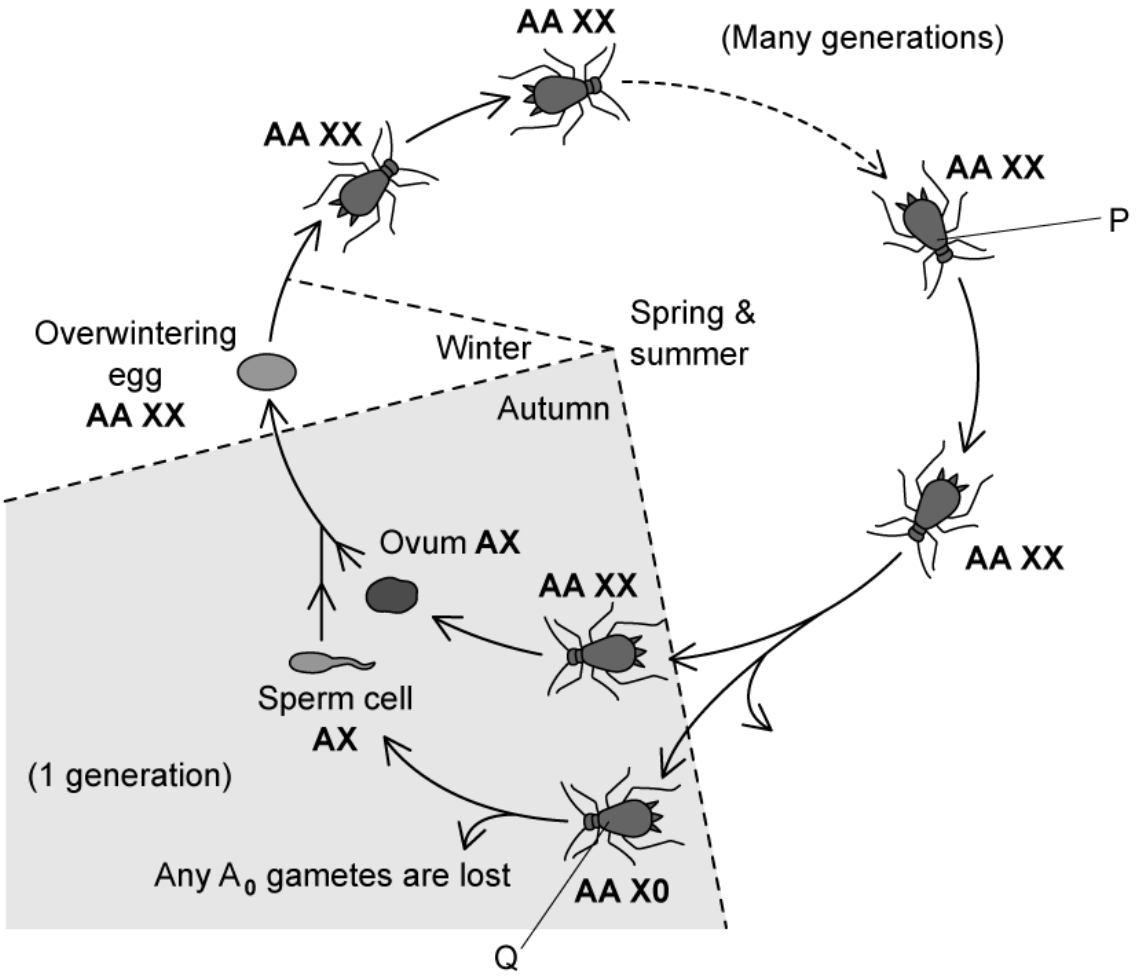
Identify processes that could introduce variation at points **X** and **Y**.

.....

.....

(2 marks)

6 (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]

.....

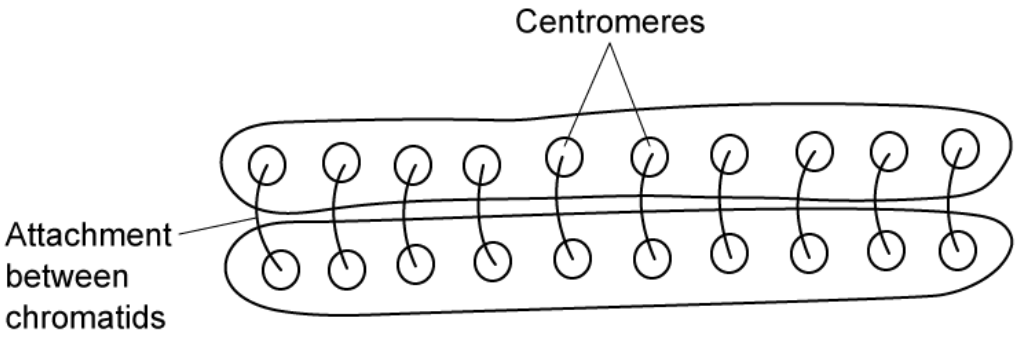
.....

.....

.....

(4 marks)

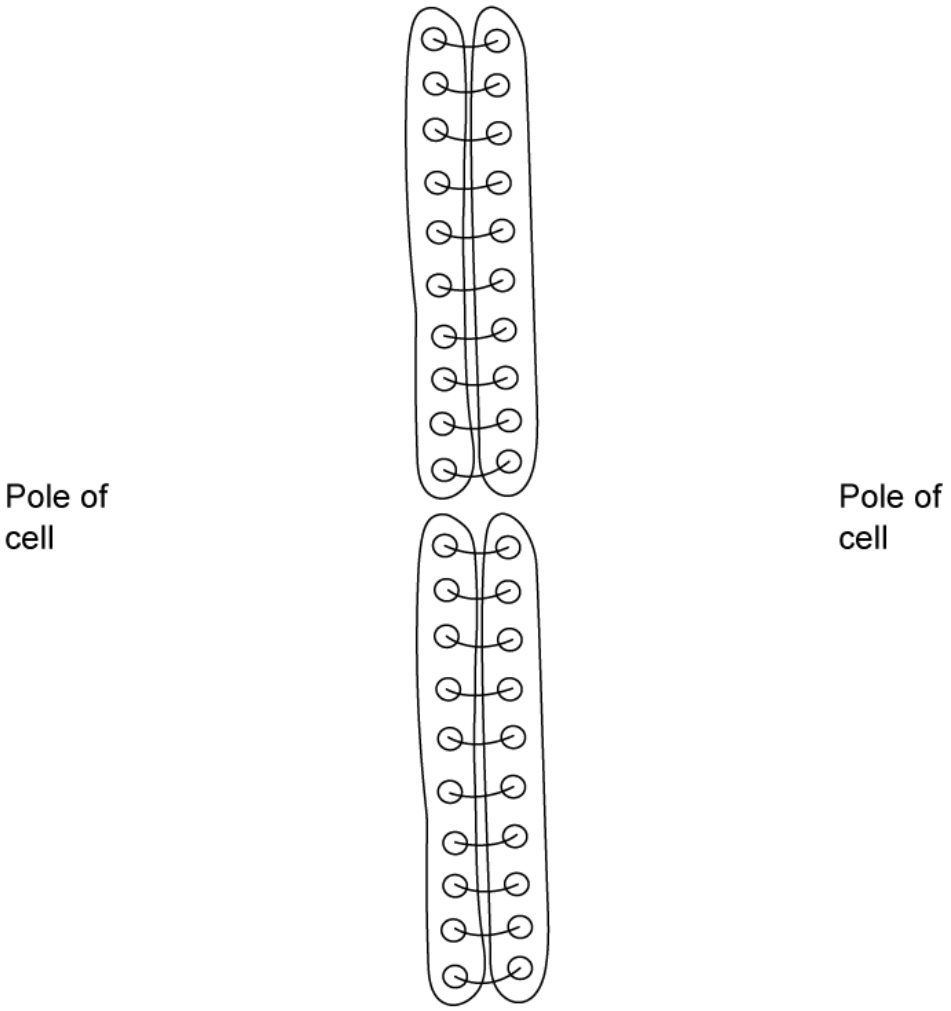
(c) Most eukaryotic chromosomes are described as being monocentric. Aphids have unusual chromosomes known as **holocentric** chromosomes. A holocentric chromosome after DNA replication is shown in the diagram below.



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.

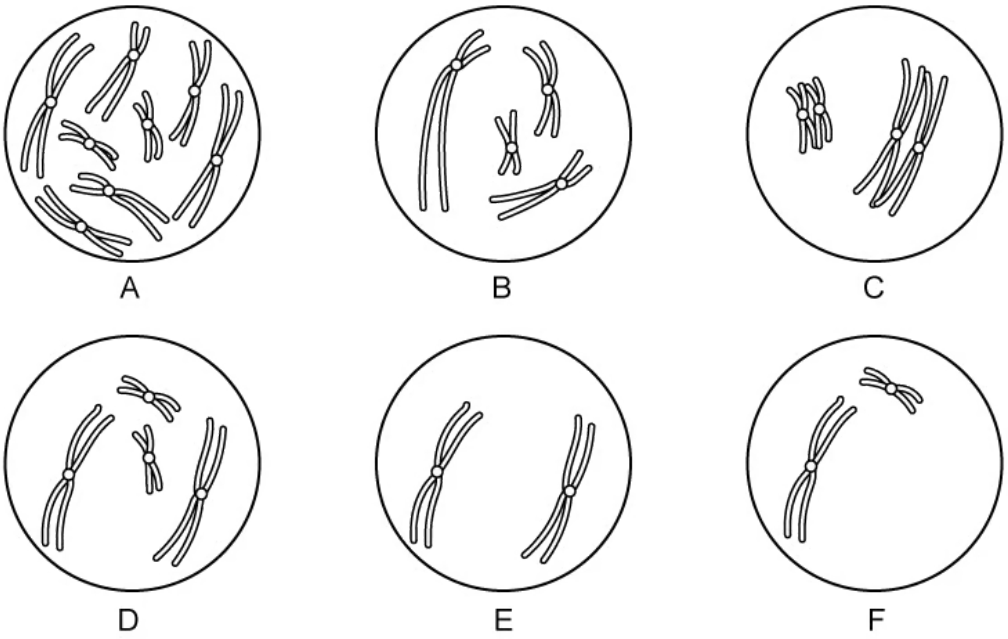


Suggest, with reasons, **two** ways in which meiosis in aphids might be different to conventional meiosis.

(4 marks)

7 (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 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]

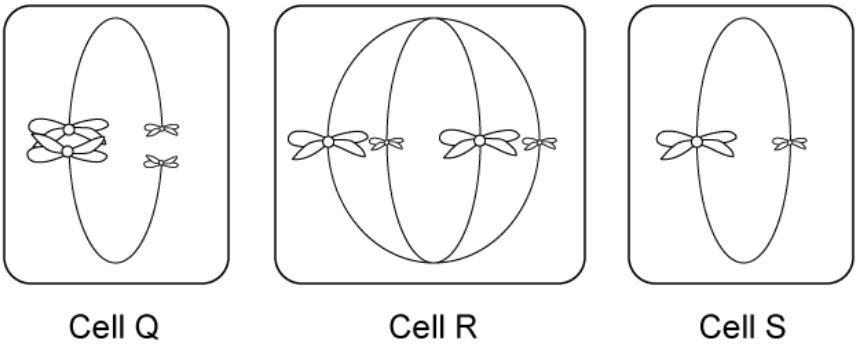
.....

.....

.....

(3 marks)

8 (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.



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

(i) Homologous chromosomes

[1]

(ii) Meiosis

[1]

(iii) Reduction division

[1]

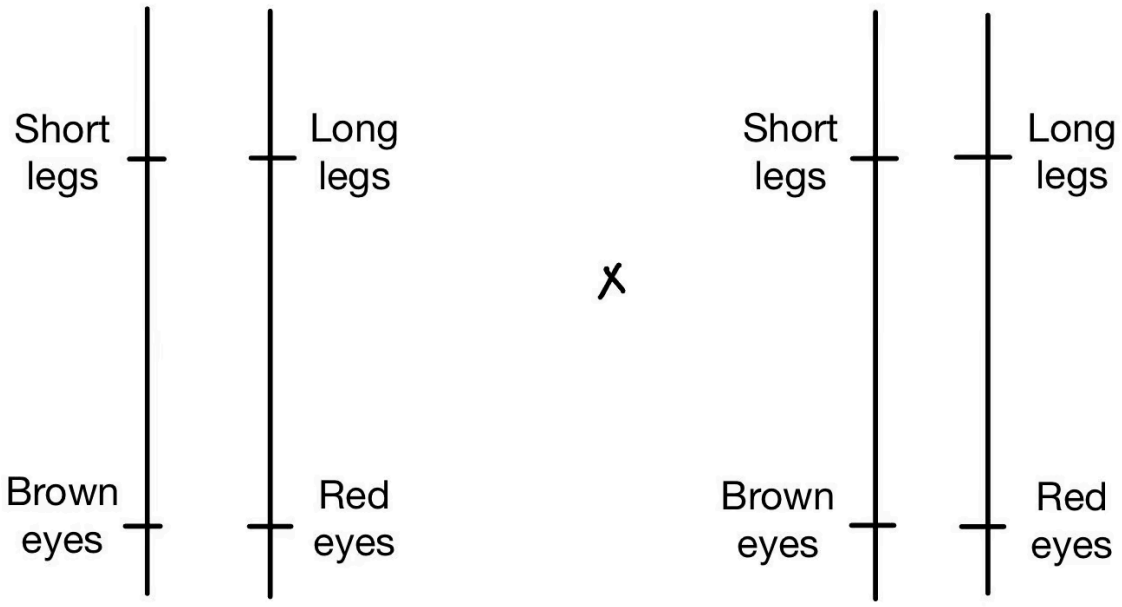
.....

.....

.....

(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.

.....

.....

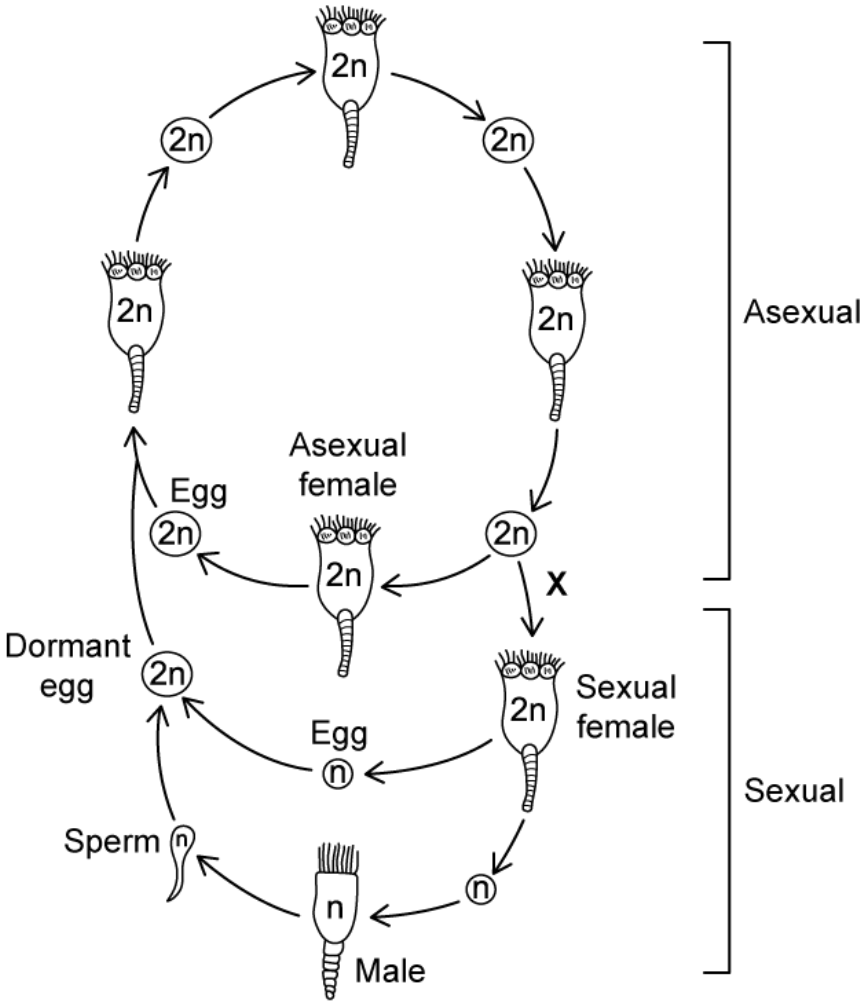
(2 marks)

9 Use named examples to describe the roles of mitosis and meiosis in living organisms.

.....

(6 marks)

10 (a) Rotifers are multicellular, aquatic animals that range in size from 50 μm to 3 mm. Their reproduction can be either asexual, resulting in the production of genetically identical females, or sexual, resulting in the production of eggs that can remain dormant for many years. A representation of a rotifer life cycle is shown in the diagram below.



Annotate the diagram as follows:

(i) Use the letter **A** to indicate **one** location within the **asexual** phase where mitosis is occurring.

[1]

(ii) Use the letter **B** to indicate **one** location within the **sexual** phase where mitosis is occurring.

[1]

(iii) Use the letter **C** to indicate **two** locations where meiosis is occurring.

[1]

(iv) Use the letter **D** to indicate **one** location where fertilisation is occurring.

[1]

(4 marks)

(b) Explain why meiosis is essential for sexual reproduction.

(2 marks)

(c) Rotifers mainly reproduce asexually, switching to sexual reproduction for brief periods. The **X** in the diagram in part a) indicates the occurrence of a stimulus that shifts the rotifers from asexual to sexual reproduction. This stimulus could be a change in the environmental conditions, such as a drought that reduces the size of their habitat.

Use the information provided here and in part a) to explain why it is advantageous to rotifers to switch to sexual reproduction when environmental conditions change.

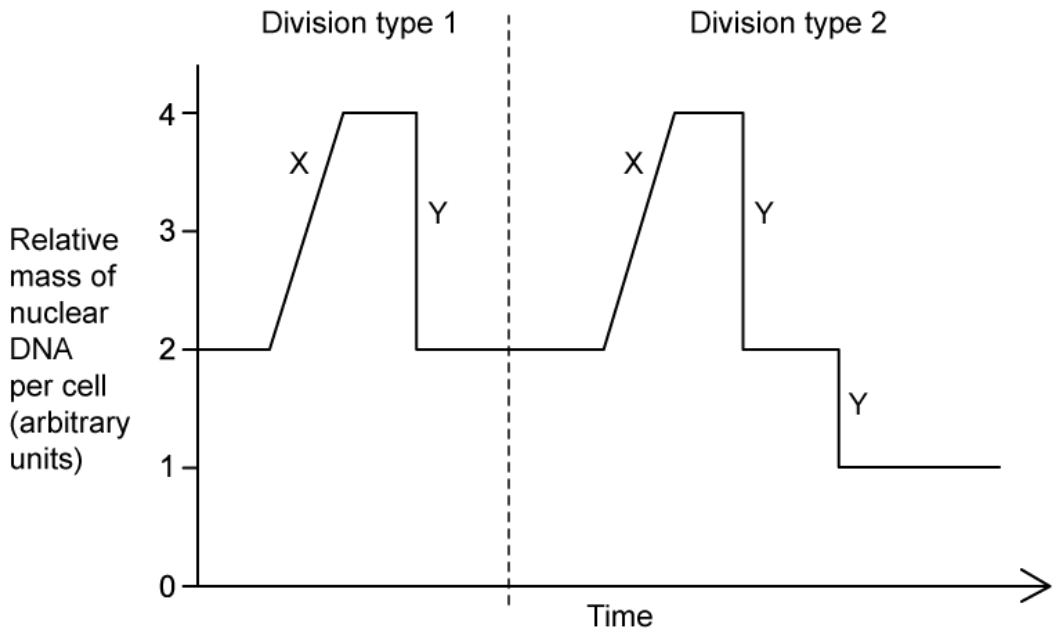
(3 marks)

(d) Rotifers can be observed using an optical microscope.

Explain why this is the case.

(1 mark)

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



State what is happening at the following stages in the graph:

(i) Stage **X**

[1]

(ii) Stage **Y**

[1]

.....

.....

(2 marks)

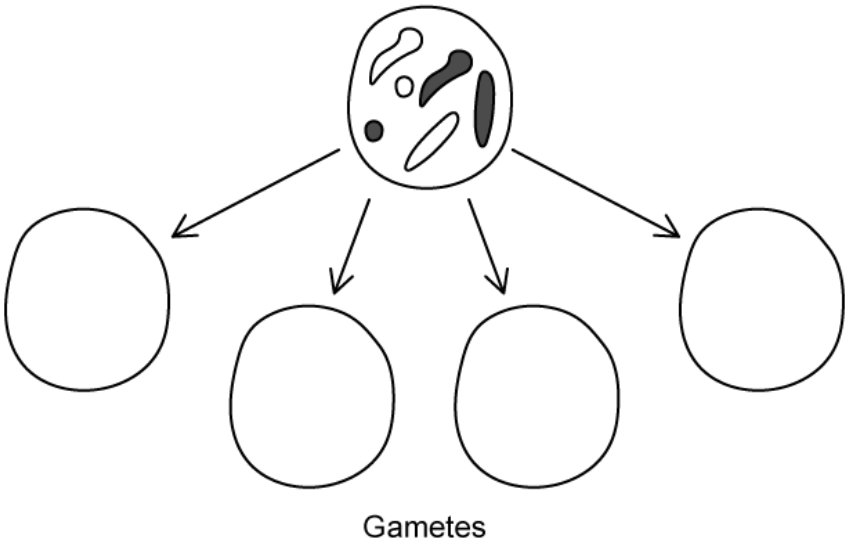
(b) Use the information provided in the graph in part a) to state, with a reason, which of the division types represents **meiosis**.

.....

.....

(2 marks)

(c) The image below shows a diploid cell containing several chromosomes.



Draw the possible appearance of **four** different gametes that could be produced from this diploid cell during meiosis.

(2 marks)

(d) A diploid cell contains 26 chromosomes.

(i) Calculate the number of different combinations of chromosomes that could be generated when this cell divides by meiosis.

[1]

(ii) Explain why the number calculated in part i) is not a true representation of the amount of genetic variation that can be generated from this cell during sexual reproduction.

[2]

(3 marks)

12 (a) Describe the process of meiosis.

(8 marks)

(b) Explain the link between meiosis and evolution.

(5 marks)