IB · DP · Biology

2 hours 15 questions

Structured Questions: Paper 2

3.2 Meiosis

3.2.1 Meiosis / 3.2.2 Stages of Meiosis / 3.2.3 Genetic Variation / 3.2.4 Non-disjunction / 3.2.5 Skills: Meiosis

Easy (5 questions)	/36
Medium (5 questions)	/45
Hard (5 questions)	/54
Total Marks	**/135**

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Easy Questions

1 (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.

.....

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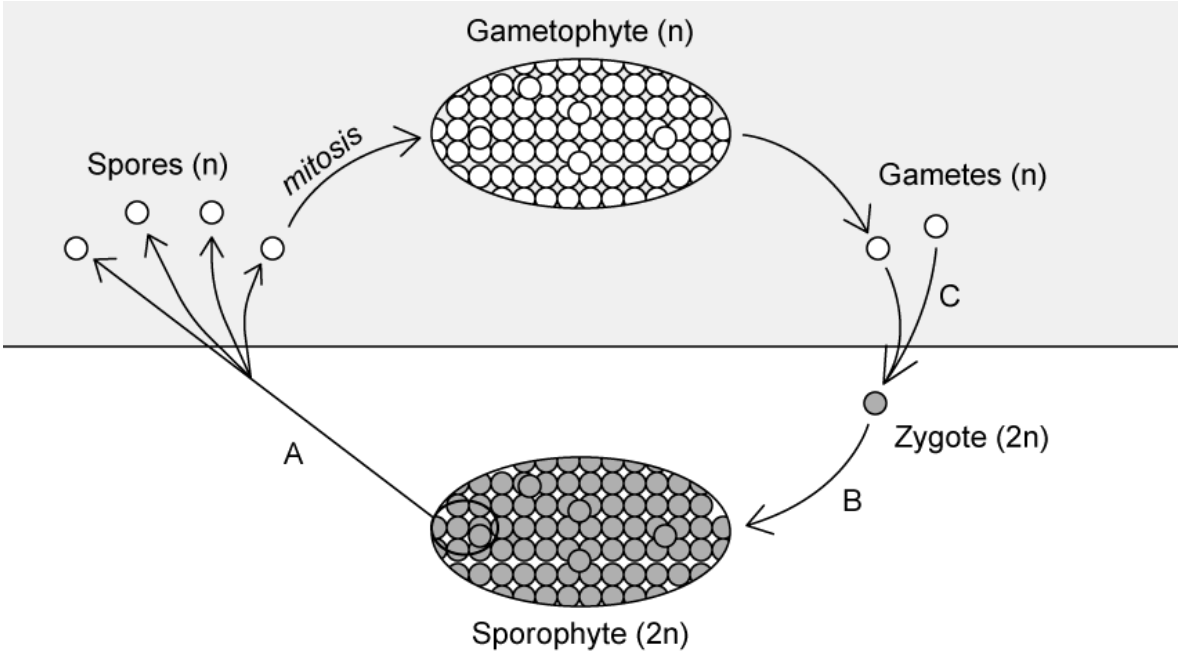
(2 marks)

(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)

2 (a) The process of meiosis was discovered in the late 1800s.

(i) State **one** challenge that would have been faced by the scientists studying cell division at this time.

(ii) Describe an observation that would have led to the discovery of meiosis.

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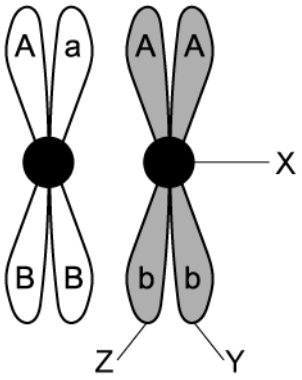
(2 marks)

(b) 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]

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(3 marks)

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

Define the term **homologous chromosome**.

.....

.....

(2 marks)

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

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

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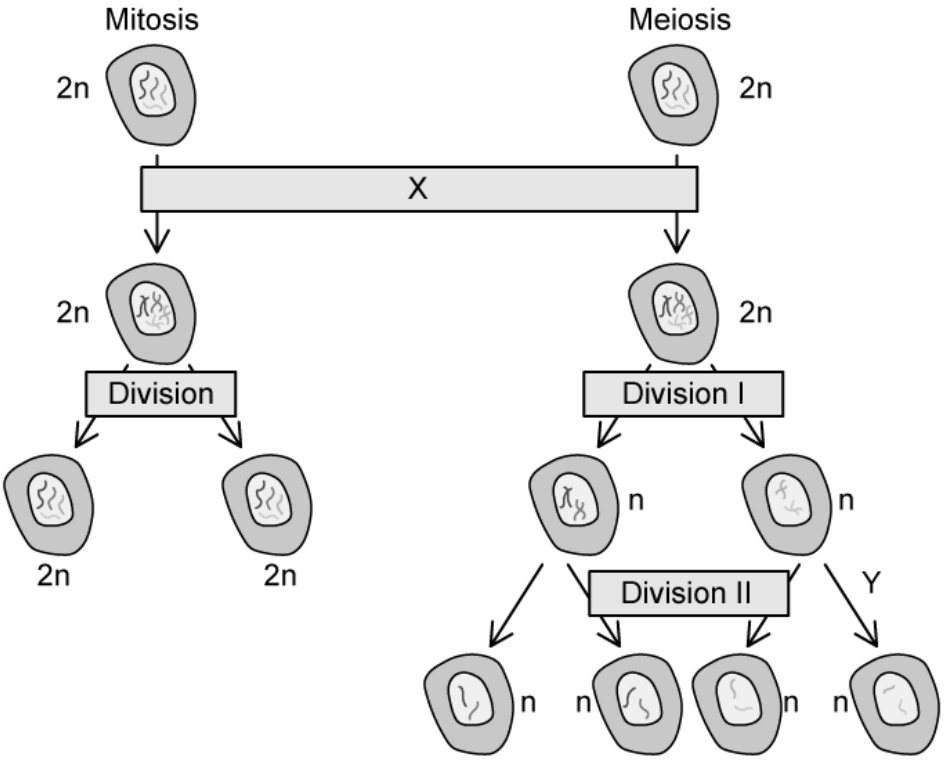
(1 mark)

3 (a) The image below shows a summary of the events during mitosis and meiosis.



Identify the process taking place at the stage marked **X**.

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(1 mark)

(b) The stage marked **Y** on the image in part a) shows a change in the amount of genetic material in the cells.

Describe the events that take place in order for this change to occur.

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.....

(2 marks)

(c) During division 1 shown in the image in part a) a process known as crossing over takes place.

Outline the events that take place during crossing over.

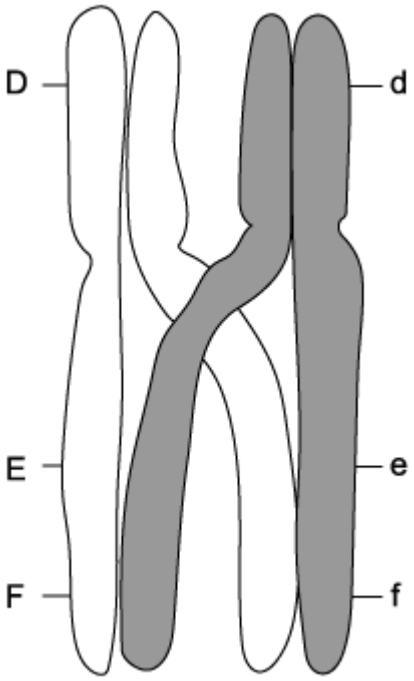
(2 marks)

(d) Crossing over generates genetic variation.

Other than crossing over, identify **one** other process that generates genetic variation during sexual reproduction.

(1 mark)

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



(i) Identify the process taking place in the image.

[1]

(ii) Label the image with an **X** to show the location of the chiasmata.

[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.

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.....

(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]

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.....

(2 marks)

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

Draw an annotated diagram of a cell in telophase I. The chromosomes should be clearly defined in your diagram.

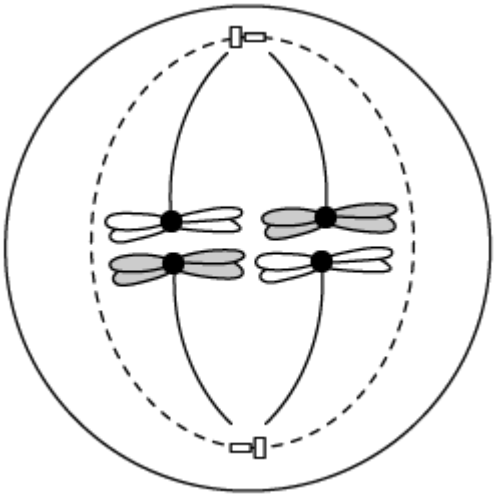
(3 marks)

(b) Outline the production of a karyogram for the purpose of screening the chromosomes of a developing embryo.

(5 marks)

Medium Questions

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



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(2 marks)

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

Calculate how many different chromosomal combinations can result during meiosis, assuming no crossing over occurs.

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(1 mark)

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

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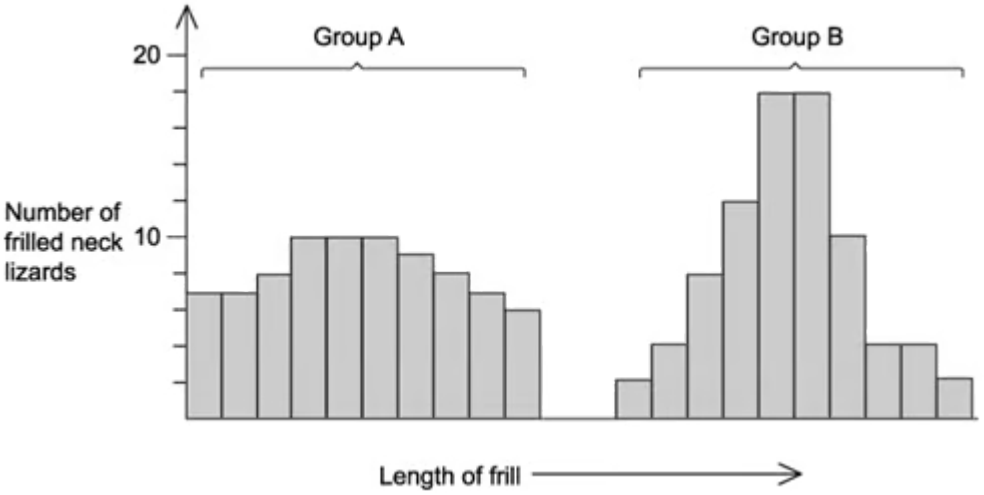
.....

(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.

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.....

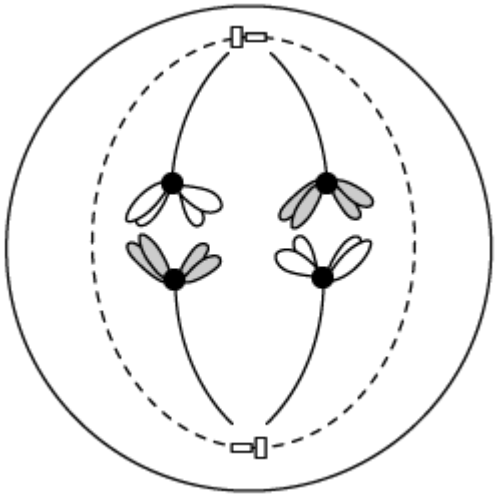
(2 marks)

2 (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		

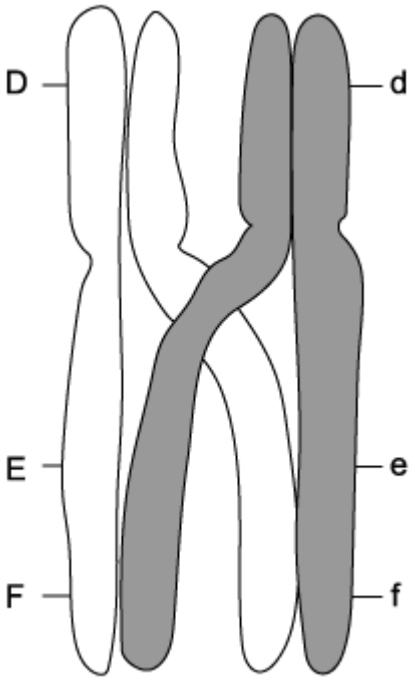
(2 marks)

(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)

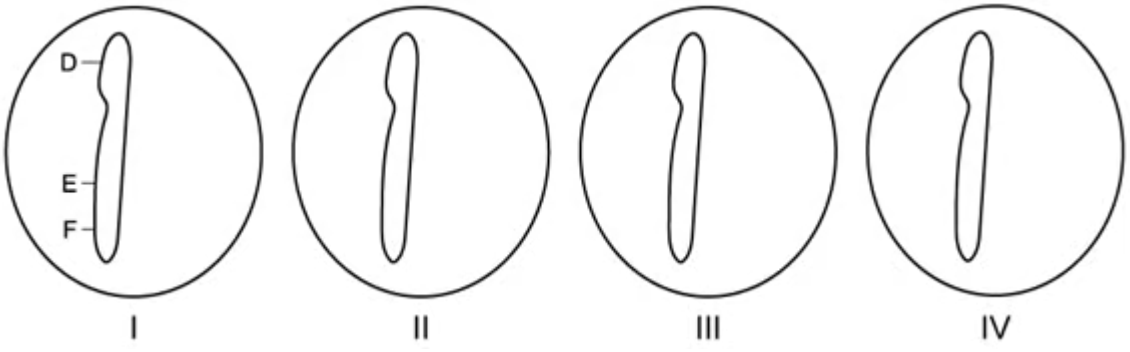
(c) The diagram below shows a pair of chromosomes during meiosis in a cell in a *Drosophila melanogaster* (fruit fly) testis. The position of the alleles of some genes is indicated.



Explain whether the chromosomes are homologous or non-homologous.

(2 marks)

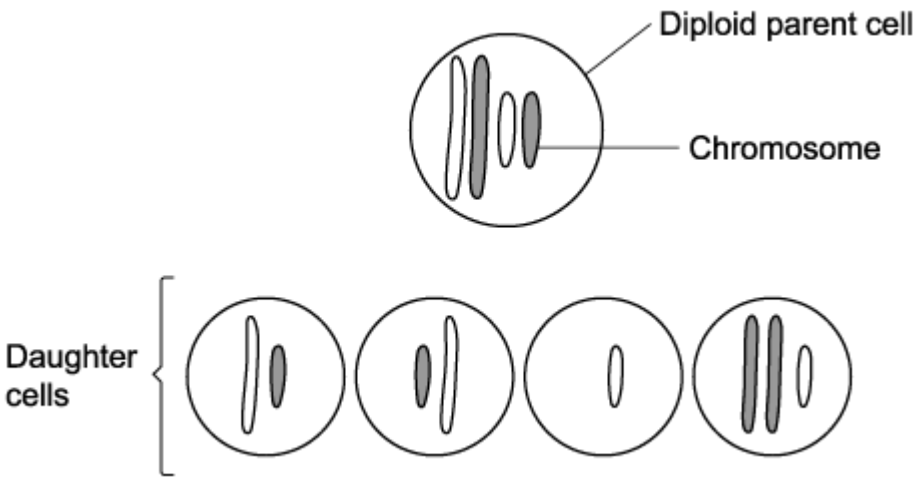
(d) At the end of meiosis, each of the chromosomes shown in the diagram from part (c) will be in a different haploid cell.



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

(3 marks)

3 (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

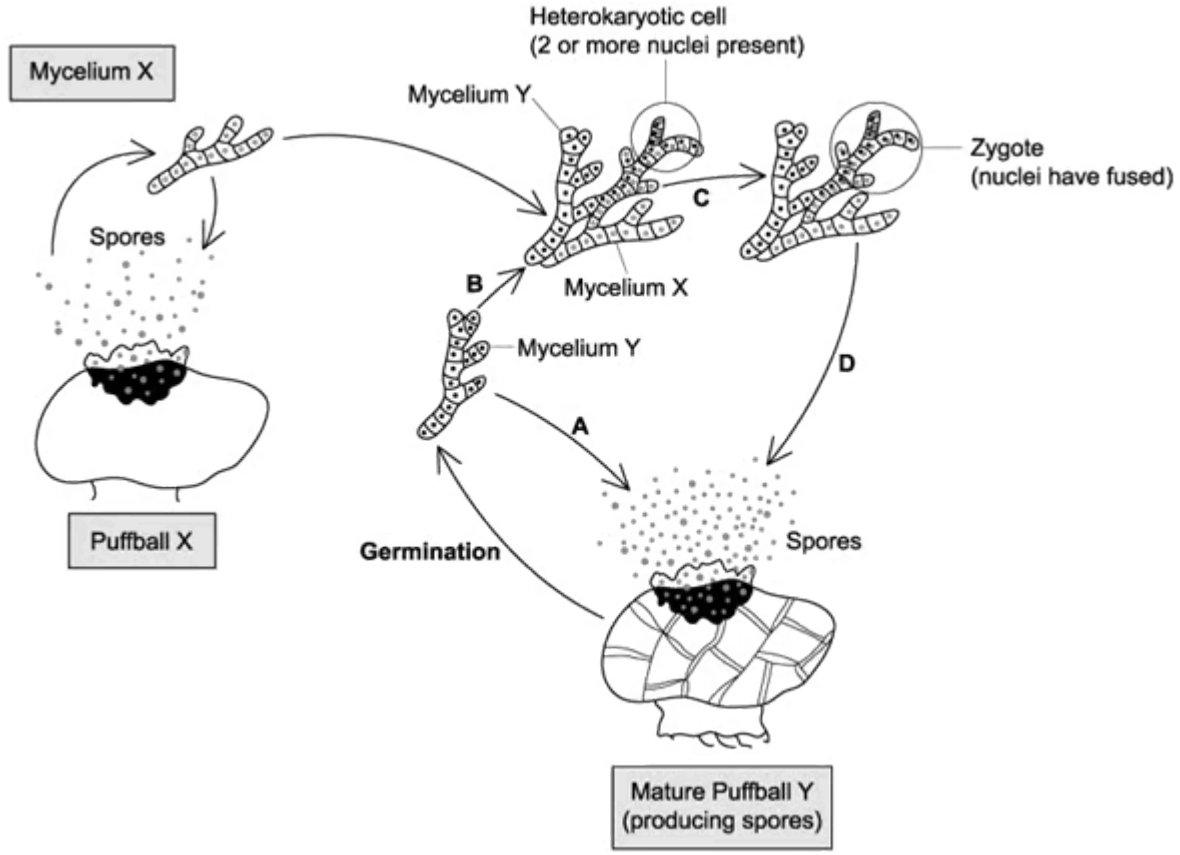
Calculate how much more likely it is that a child is conceived with Down Syndrome for a mother who is 41 compared to a mother who is 26.

(1 mark)

(d) Describe how the process of amniocentesis can be used to obtain cells which can be used for chromosome analysis.

(3 marks)

4 (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*

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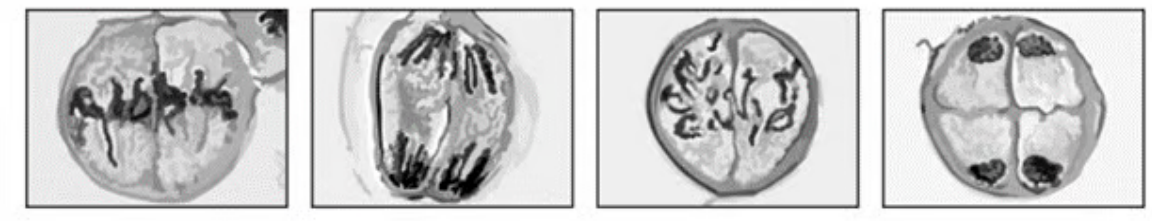
(1 mark)

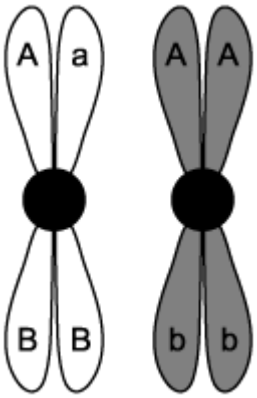
(b) The micrographs below show cells undergoing meiosis.



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

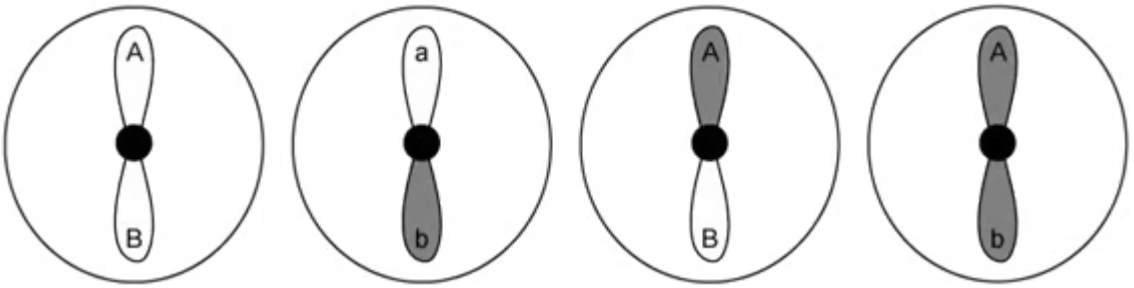
(4 marks)

(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)

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

Draw a labelled diagram to show a cell in the following stages of meiosis:

- Metaphase I
- Prophase I

(4 marks)

(b) Outline how developments in scientific methods facilitated the discovery of meiosis.

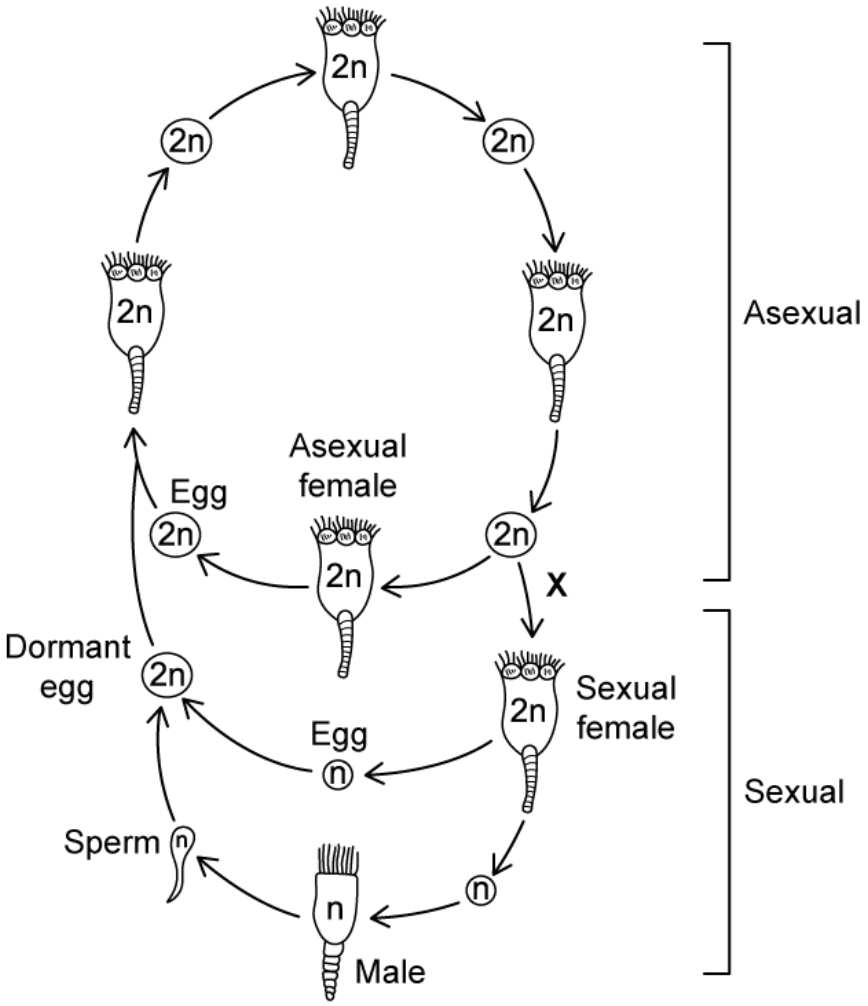
(4 marks)

(c) Explain how genetic variation may be introduced into a population.

(7 marks)

Hard Questions

1 (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.

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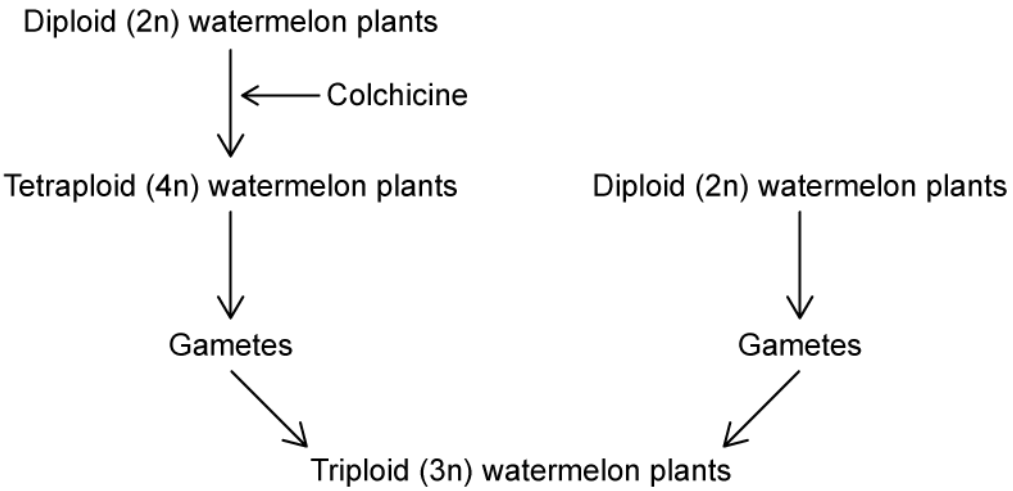
(1 mark)

2 (a) Polyploidy is a condition in which cells have a chromosome number that is greater than the normal diploid (2n) number. Polyploidy is considered to be a useful characteristic in crop plants as it gives rise to bigger plant organs and provides cells which contain a larger variety of alleles for breeding programmes. While polyploidy can occur naturally in plants, it can also be induced artificially using a chemical called colchicine. Colchicine works by preventing the formation of the microtubules that make up the spindle fibres inside cells.

Suggest how colchicine gives rise to tetraploid (4n) cells after **mitosis** in plants.

(2 marks)

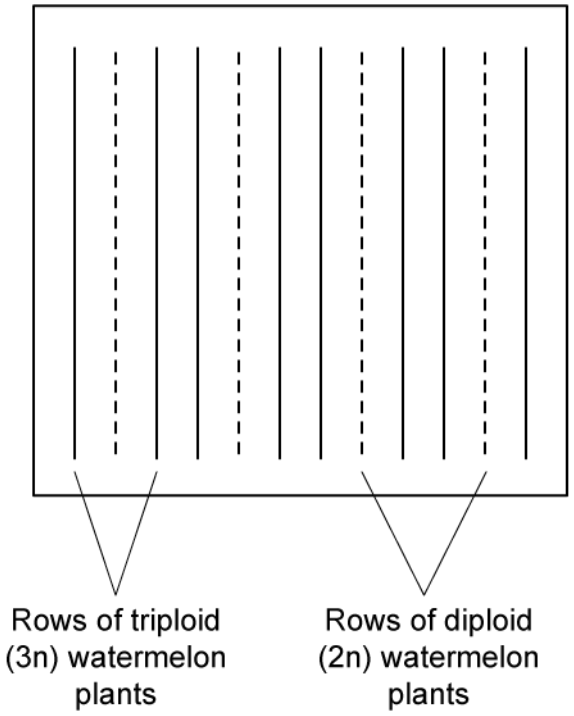
(b) Plant scientists have been able to breed seedless watermelons by crossing tetraploid watermelons with regular, diploid plants to produce infertile, triploid (3n) plants. The diagram below illustrates this process. Note that diploid watermelons contain 22 chromosomes.



Suggest why the offspring of the tetraploid-diploid cross are infertile.

(3 marks)

(c) For the triploid offspring shown in part b) to start producing fruits, the triploid plants must be pollinated with pollen from diploid plants. Pollination involves the transfer of a plant gamete, pollen, from the flower of one plant to the flower of another. While the diploid pollen does not *fertilise* the triploid plants (they are infertile), it does trigger fruit production, and the resulting watermelon fruits are seedless. The graphic below shows a recommended planting plan for farmers that will ensure pollination of the triploid plants with pollen from diploid plants.



(i) State why diploid plants need to be used for pollination rather than other triploid plants.

[1]

(ii) Suggest **two** disadvantages to farmers of the method described here and in part b) for growing seedless watermelons.

[2]

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.....

.....

(3 marks)

(d) A watermelon variety that naturally produces fewer seeds has been identified by scientists, and observation of its cells indicates that an event known as reciprocal translocation of chromosomes occurs in the cells of the watermelon variety. Reciprocal translocation of chromosomes involves the exchange of entire sections of chromosomes between non-homologous chromosomes during meiosis.

(i) Contrast reciprocal translocation of chromosomes and crossing over with each other.

[1]

(ii) Suggest how reciprocal translocation of chromosomes could result in a watermelon plant that produces fruits containing fewer seeds.

[2]

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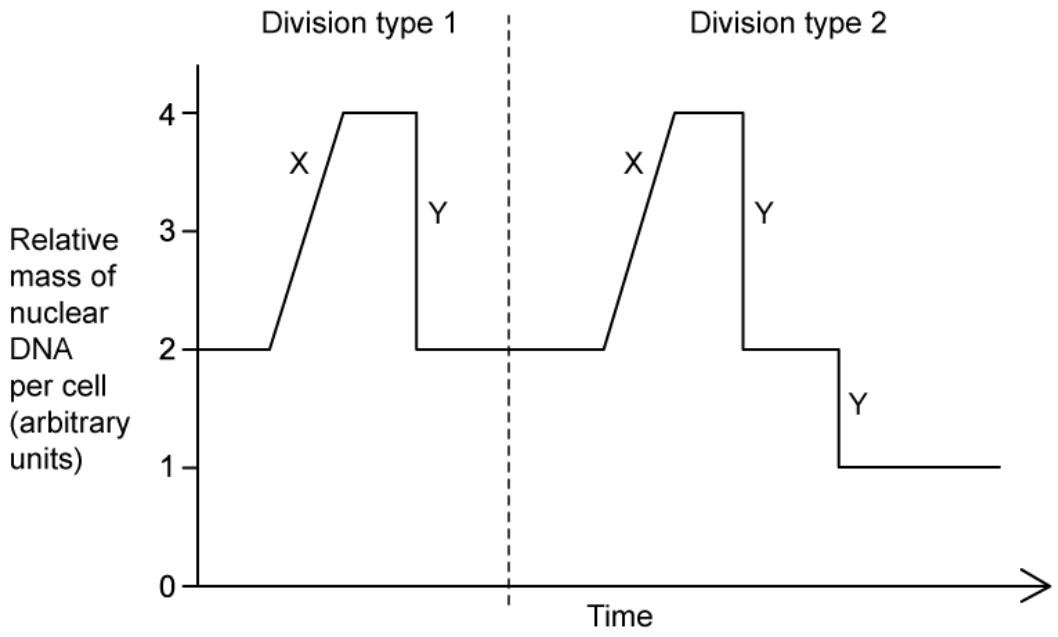
(3 marks)

3 (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**.

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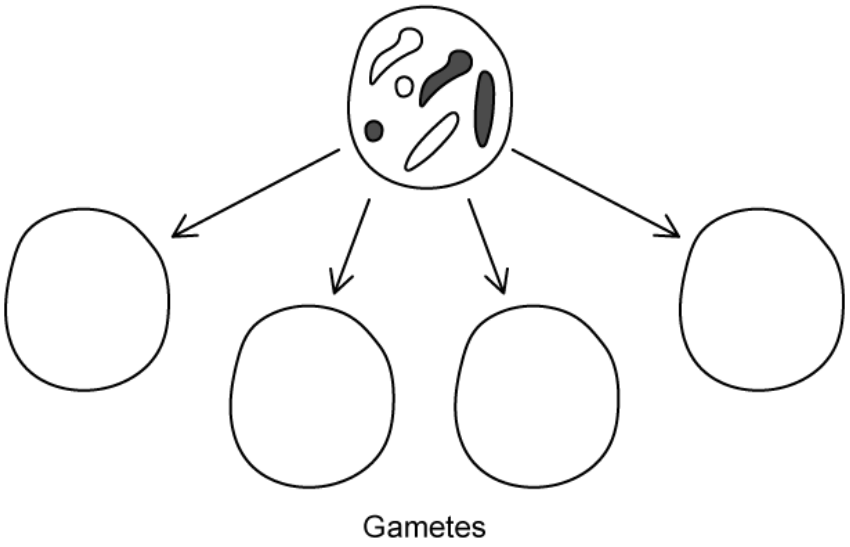
(2 marks)

(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.

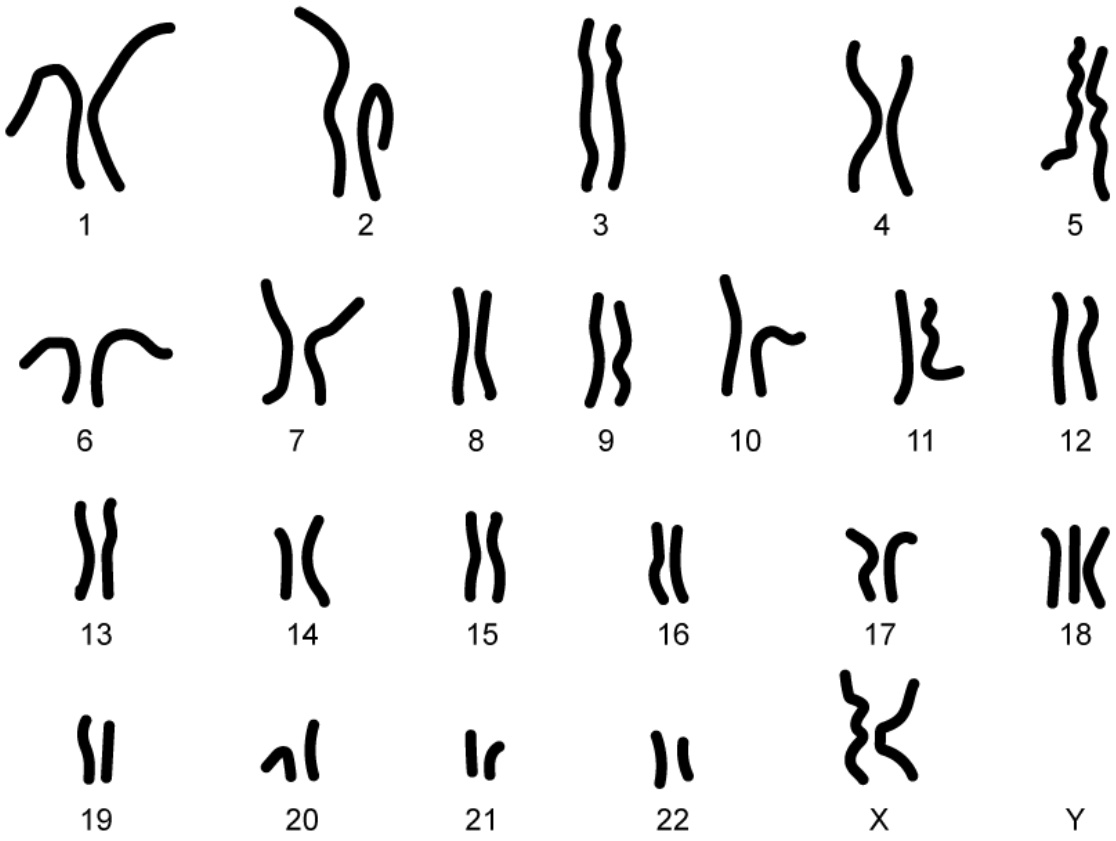
[1]

(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)

4 (a) Edwards syndrome is a rare but serious condition that influences birth weight and development. Death rates during infancy are high. The image below shows the karyogram of an individual with Edwards syndrome.



(i) Use the karyogram to suggest the cause of Edwards syndrome.

[1]

(ii) Describe the events that have led to the feature noted in part i).

[2]

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(3 marks)

(b) Edwards syndrome affects every cell in the body.

Explain why this is the case.

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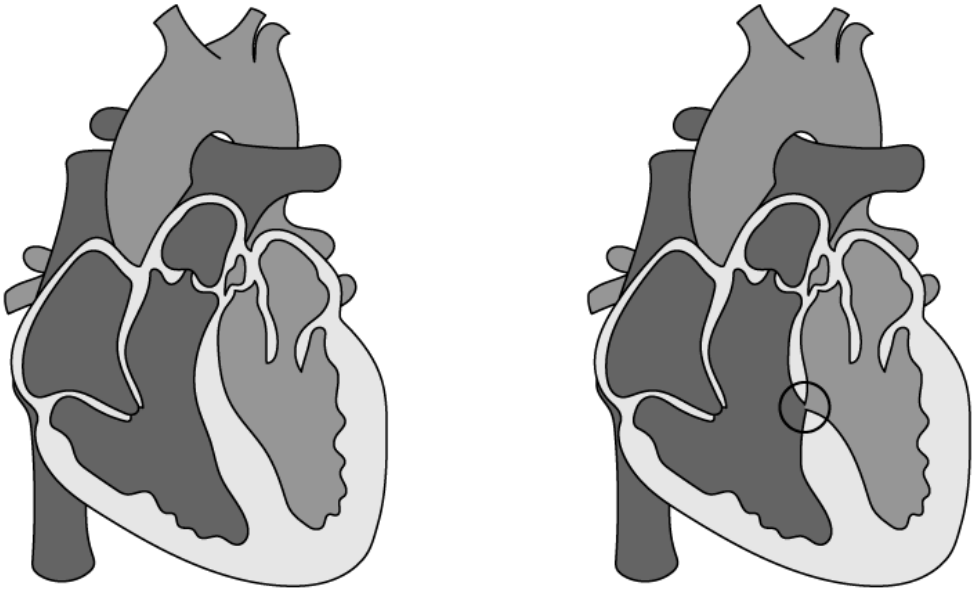
(2 marks)

(c) One of the life-threatening complications that babies with Edwards syndrome can be born with is a structural abnormality in the heart. The image below shows a heart abnormality that can be seen in babies born with Edwards syndrome.



Explain why the abnormality shown in the image can be life-threatening.

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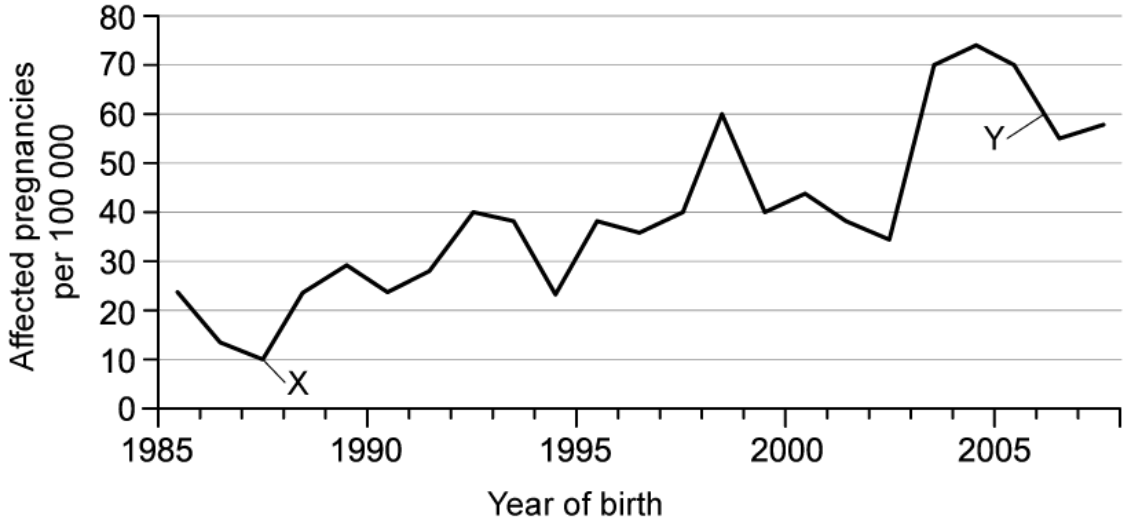
(3 marks)

(d) The graph below shows the number of pregnancies affected by Edwards syndrome between 1985 and 2008.



(i) In the year marked **X** there were 1 100 000 pregnancies, and in the year marked **Y** there were 700 000 pregnancies.

Calculate the number of affected pregnancies at the times marked **X** and **Y**.

[2]

(ii) Suggest **one** reason for the difference in affected pregnancies between times **X** and **Y**.

[1]

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(3 marks)

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

Describe the process of meiosis.

(8 marks)

(b) Explain the link between meiosis and evolution.

(5 marks)