IB · HL · Biology

1 hour 9 questions

Structured Questions

Diversity of Organisms

Biological Species Concept / Chromosome Number / Karyograms: Skills / Genomes / Comparing Genome Sizes: Skills / Uses of Genome Sequencing / Biological Species Concept: Challenges (HL) / Chromosome Number: Cross-Breeding (HL) / Dichotomous Keys: Skills (HL) / Environmental DNA & Barcodes (HL)

Easy (1 question)	/6
Medium (3 questions)	/31
Hard (5 questions)	/31
Total Marks	**/68**

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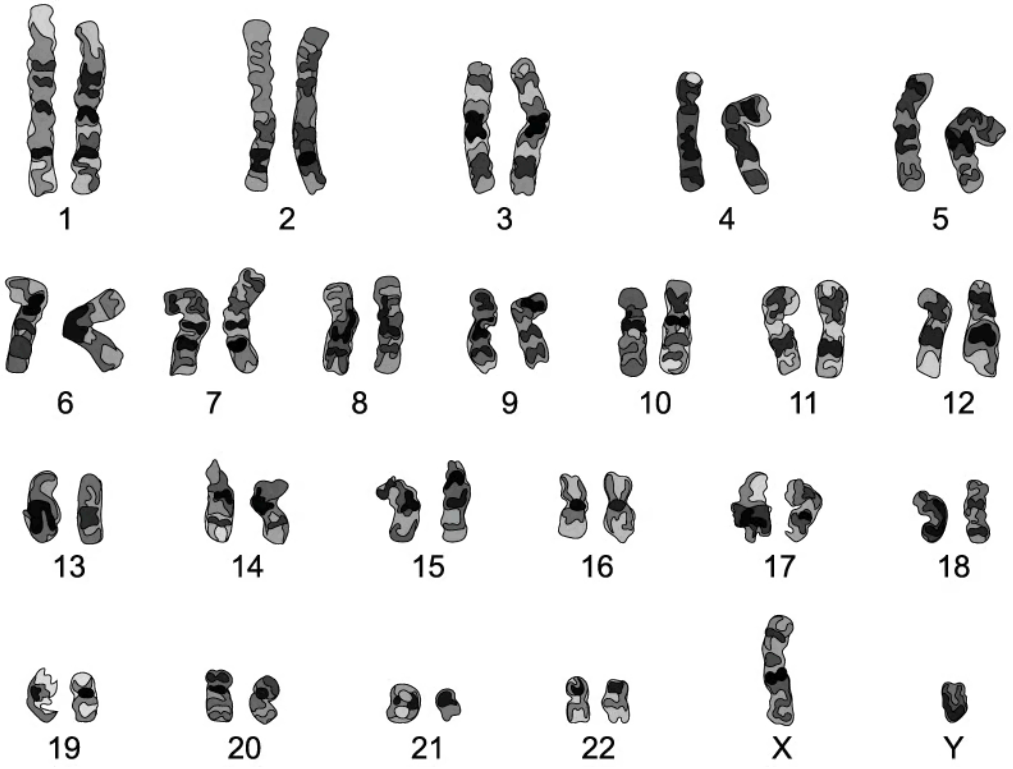
Easy Questions

1 (a) The following diagram shows the karyogram of an individual.



(i) Identify the sex of this individual.

[1]

(ii) State a reason for your answer in part i).

[1]

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(2 marks)

(b) Cells in metaphase of mitosis were used to construct the karyogram from part a).

Explain the reason for this.

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(1 mark)

(c) List **two** characteristics of the chromosomes that are used to arrange them in a karyogram.

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(2 marks)

(d) Apart from sex determination, state **one other** use of studying the karyotype of an individual.

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(1 mark)

Medium Questions

1 (a) The table below shows the genome sizes of several different plant species.

Organism	Common name	Genome size (million base pairs)
Paris japonica	Japanese canopy plant	149,890
Tmesipteris obliqua	Long fork-fern	147,290
Viscum album	Mistletoe	90,000
Galanthus nivalis	Snowdrop	61,089
Arabidopsis thaliana	Thale cress	135
Genlisea margaretae	Corkscrew plant	63

(i) Calculate how many times bigger the genome of *Paris japonica* is in comparison with *Genlisea margaretae*.

[1]

(ii) Mistletoe is a diploid plant with 10 pairs of homologous chromosomes.

Calculate the average size of one of these chromosomes.

[1]

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(2 marks)

(b) State the best method that can be used to compile the information found in the table in part (a).

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(1 mark)

(c) In comparison to the plant genomes in the table, the size of the human genome, *Homo sapiens*, is 3000 mbp.

Using information from the question and your own knowledge, discuss the relationship between genome size and the complexity of organisms.

(4 marks)

(d) Many plants with very large genomes do not have a significantly larger proteome as a result of this. Instead, these plants have a larger proportion of non-coding DNA.

State three uses of non-coding DNA.

(3 marks)

2 (a) Define the term DNA barcode.

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(1 mark)

(b) Researchers in Paris, France were monitoring the species richness of fish species living in two rivers, the Marne and the Seine, over a period of several years.

Since 1990 these researchers have been carrying out a technique called electrofishing (EF) which involves stunning the fish with mild electric current and then recording the species of the stunned fish before releasing them back into the water.

In 2017 and 2018 the researchers trialled using eDNA samples in nine different sites to determine species richness in the area and compare the results to the existing EF method.

Describe the method used by these researchers to collect the eDNA data.

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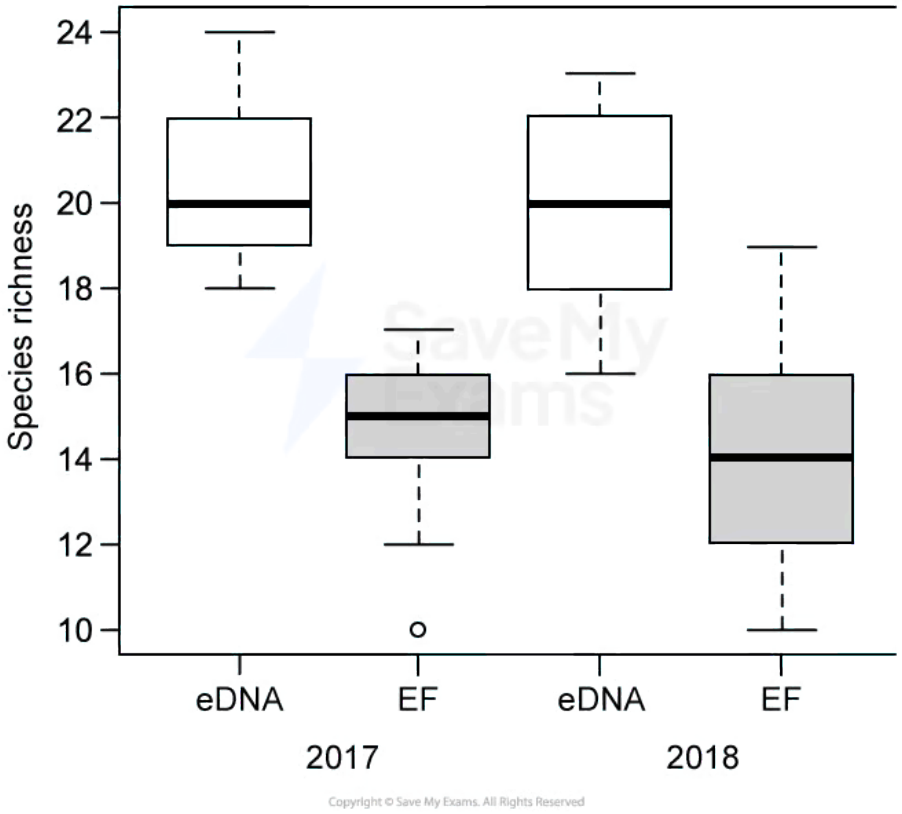
(3 marks)

(c) The results of this experiment are shown in the graph.



Use the data in the graph to evaluate the use of the eDNA and the electrofishing (EF) methods for recording species richness in the two rivers.

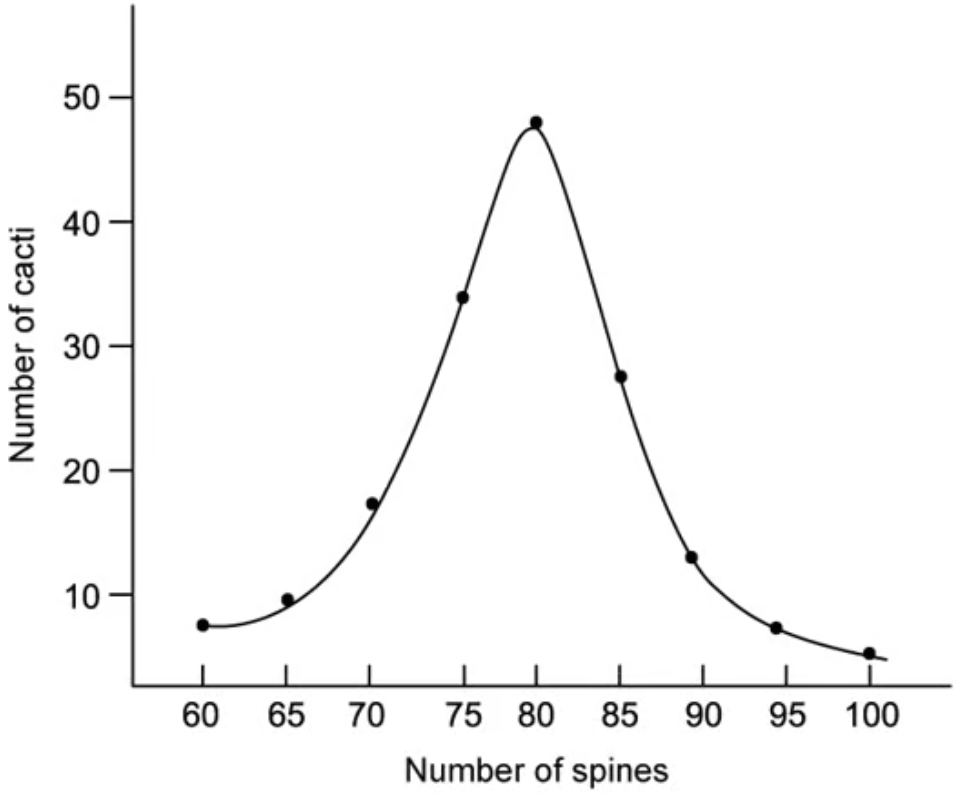
(4 marks)

(d) Suggest three reasons why the scientists might prefer to use eDNA in this specific circumstance compared to electrofishing.

(3 marks)

3 (a) Prickly pear cacti are plants that are adapted to live in arid conditions. They store water in thick stems which are protected from grazing by herbivores through the presence of multiple spines. The number of spines that are present on the prickly pear cacti may vary greatly, depending on the frequency of grazing that they experience.

The graph shows the number of spines present in a species of prickly pear cacti, *Opuntia ficus-indica.*



State the type of variation that is represented by the graph and provide **two** reasons for your answer.

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(3 marks)

(b) Suggest the possible impact of environmental factors on the variation observed in the graph, with regards to the number of spines on prickly pear cacti.

(2 marks)

(c) The prickly pear, *Opuntia ficus-indica*, is native to Mexico in Central America.

(i) State the genus and the species of the prickly pear.

[2]

(ii) The prickly pear can be grown on an agricultural scale for use in food types all over the world.

Suggest why the binomial name assists with the international trade of this cactus.

[1]

(3 marks)

(d) Since the 19th Century there have been cultivars of *Opuntia ficus-indica* that have been artificially selected to have no spines.

These species have been used for agricultural uses by humans and are kept separately from the wild *Opuntia ficus-indica* populations.

Scientists studying these plants want to determine if these two groups are still the same species.

Explain why this process can present a challenge to these scientists.

(2 marks)

Hard Questions

1 (a) The table below shows the genome size and haploid chromosome number of different organisms.

Organism	Genome size / base pairs	Chromosome number / n
Polychaos dubium (single celled eukaryote)	6.7×10^{11}	> 100
Trumpet lily (plant)	9.0×10^{10}	12
Mouse	3.5×10^{9}	20
Human	3.2×10^{9}	23
Carp (fish)	1.7×10^{9}	49
Chicken	1.2×10^{9}	39
Housefly	9.0×10^{8}	6
Tomato plant	6.6×10^{8}	12

Calculate the percentage difference in the chromosome number found in the zygotes of chickens compared to those of humans.

Show your working and give your answer to three significant figures.

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(2 marks)

(b) The diploid number in an organism is always an even number.

Using your knowledge on the behaviour of chromosomes during meiosis, explain the importance of the diploid number in an organism.

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(2 marks)

(c) Scientists hypothesised that a high chromosome number leads to the development of a more complex organism.

Discuss this hypothesis using the data provided in part a).

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(3 marks)

(d) Based on your knowledge of chromosomes, suggest a reason why the genome size of a species does not always seem to correlate with the chromosome number.

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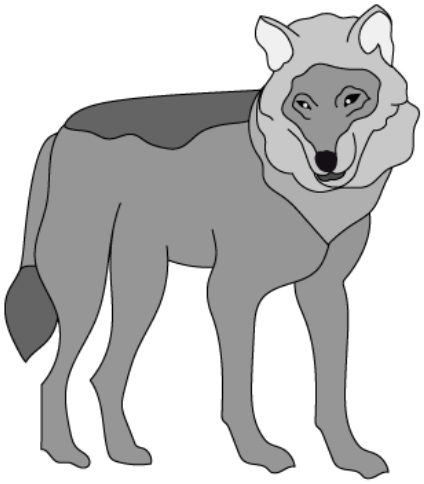
(1 mark)

2 (a) The images show two organisms from the genus *Canis*.

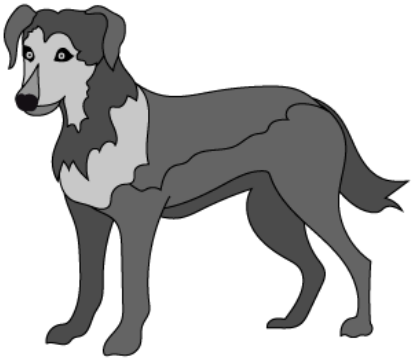
Grey wolves, *Canis lupus,* are wild animals native to Eurasia and North America.

Domestic dogs, *Canis familiaris,* descended from wolves and became domesticated over many years.

Canis lupus



Canis familiaris



A wolfdog is a hybrid produced when a domesticated dog (*Canis familiaris*) breeds with a wolf (*Canis lupus*). Genetically, dogs and wolves are very similar and the resulting offspring are fertile. Wolfdog hybrids are rare as natural habitats and territorial behaviours isolate wolves from domestic dogs.

Using the information provided, discuss the validity of the claim that wolves and dogs are the same species.

(4 marks)

(b) A taxonomist suggested that the wolf and the domestic dog should be re-categorised as follows:

- *Canis lupus familiaris*
- *Canis lupus lupus*

Identify the genus name and the species name for the wolf and the domestic dog under this re-categorisation.

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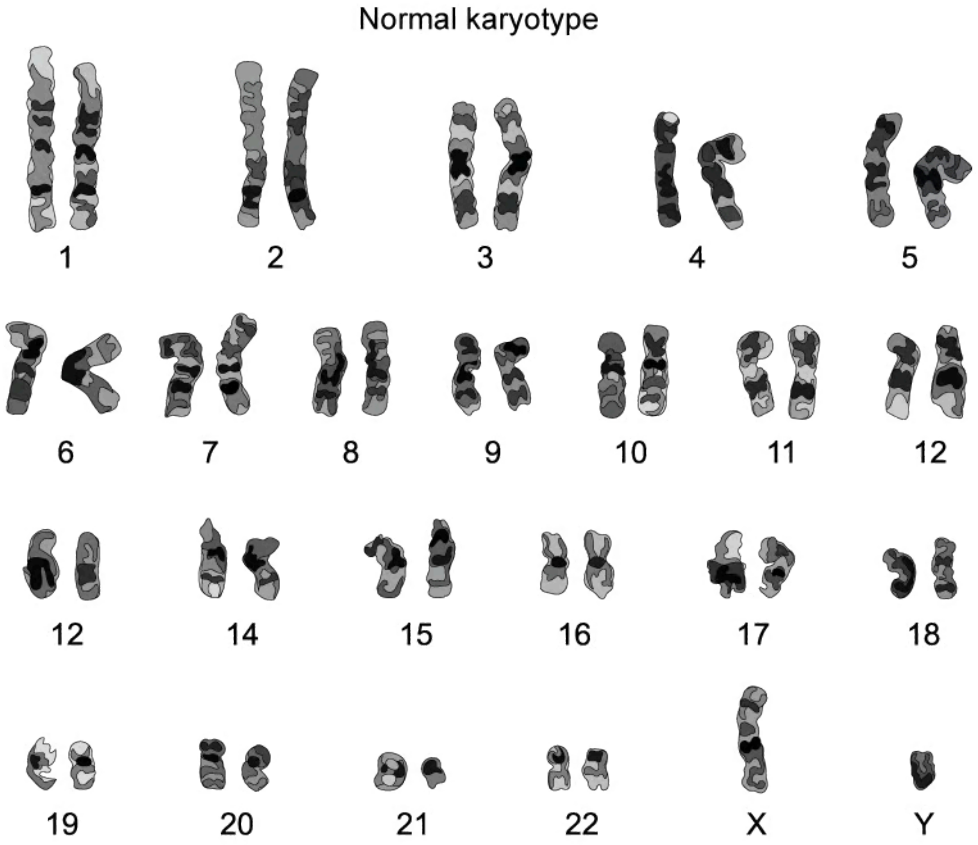
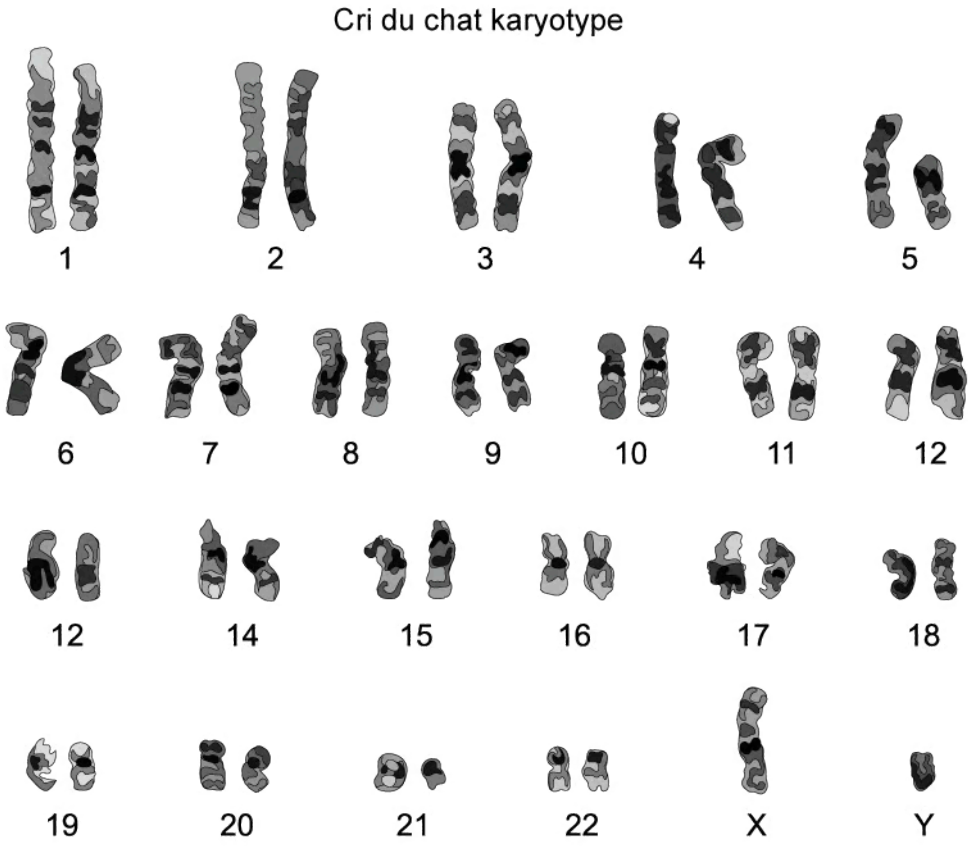
(2 marks)

3 (a) Cri du chat syndrome is a rare genetic disorder caused by a chromosomal abnormality that occurs very early in embryonic development. Babies born with cri du chat syndrome suffer from a variety of symptoms and have a characteristic cry which sounds like the meowing of a cat.

The karyograms below compare the karyotype of a normal child with one that suffers from cri du chat syndrome.





Contrast the karyotype of a normal child with that of a child suffering from cri du chat syndrome.

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(1 mark)

(b) Two genes, SEMA5A and CTNND2, are believed to be involved with brain development in a foetus. These genes are missing from children suffering from cri du chat syndrome.

Suggest **two** possible symptoms of children with cri du chat syndrome as a result of this.

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(2 marks)

(c) There are some individuals with cri du chat syndrome that do not differ developmentally from their peers in a significant way.

Based on the information provided in the karyograms at part a), explain this occurrence.

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(2 marks)

(d) Most of the people affected by cri du chat syndrome do not have a family history of the condition.

Suggest what this means in terms of the heritability of the syndrome.

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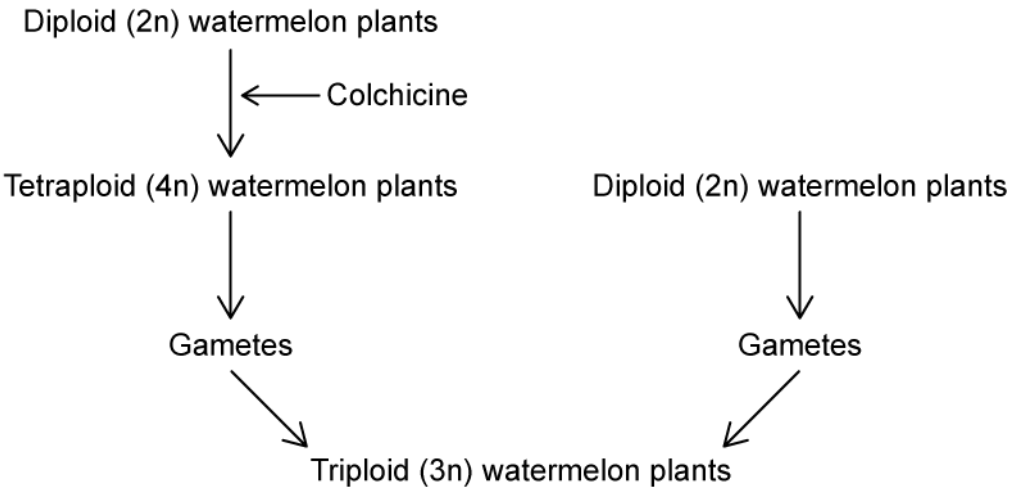
(1 mark)

4 (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) 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)

5 The binomial naming system is an important tool to facilitate cooperation and collaboration between groups of scientists.

Discuss how the binomial system will facilitate cooperation and collaboration between scientists.

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(3 marks)