3.1 Genes & Chromosomes

Question Paper

Course	DP IB Biology
Section	3. Genetics
Topic	3.1 Genes & Chromosomes
Difficulty	Hard

Time allowed: 60

Score: /45

Percentage: /100

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Question 1a

a)
Part of the gene coding for a specific polypeptide contains the following base sequence:

CATAGTTGGCCA

The following table contains some of the codons on messenger RNA and the amino acids that they code for:

Codons	Amino acid coded for by codons
AUU / AUC / AUA	Isoleucine (Ile)
UUA / UUG / CUU / CUC / CUA / CUG	Leucine (Leu)
GGU / GGC / GGA / GGG	Glycine (Gly)
ACU / ACC / ACA / ACG	Threonine (Thr)
UCU / UCC / UCA / UCG	Serine (Ser)
GUU / GUC / GUA / GUG	Valine (Val)
UAA / UAG / UGA	STOP

Using the information provided, identify the amino acid sequence for this part of the polypeptide.

[3 marks]

[3 marks]

Question 1b

b)
The cells that synthesise this polypeptide was exposed to a mutagen that caused a substitution mutation that changed the DNA base sequence in the following way:

CATACTTGGCCA

Using the table from part a), explain the effect this mutation will have on the polypeptide produced.

[3 marks]

[3 marks]

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Question 1c

c)
This polypeptide forms part of the active site of an enzyme that catalyses a metabolic reaction.

Suggest the effect that the mutation mentioned in part b) would have on the enzyme.

[2 marks]

[2 marks]

Question 1d

d)
Based on the information provided in part a), explain how it could be possible for a mutation to have no effect on the polypeptide.

[1 mark]

[1 mark]

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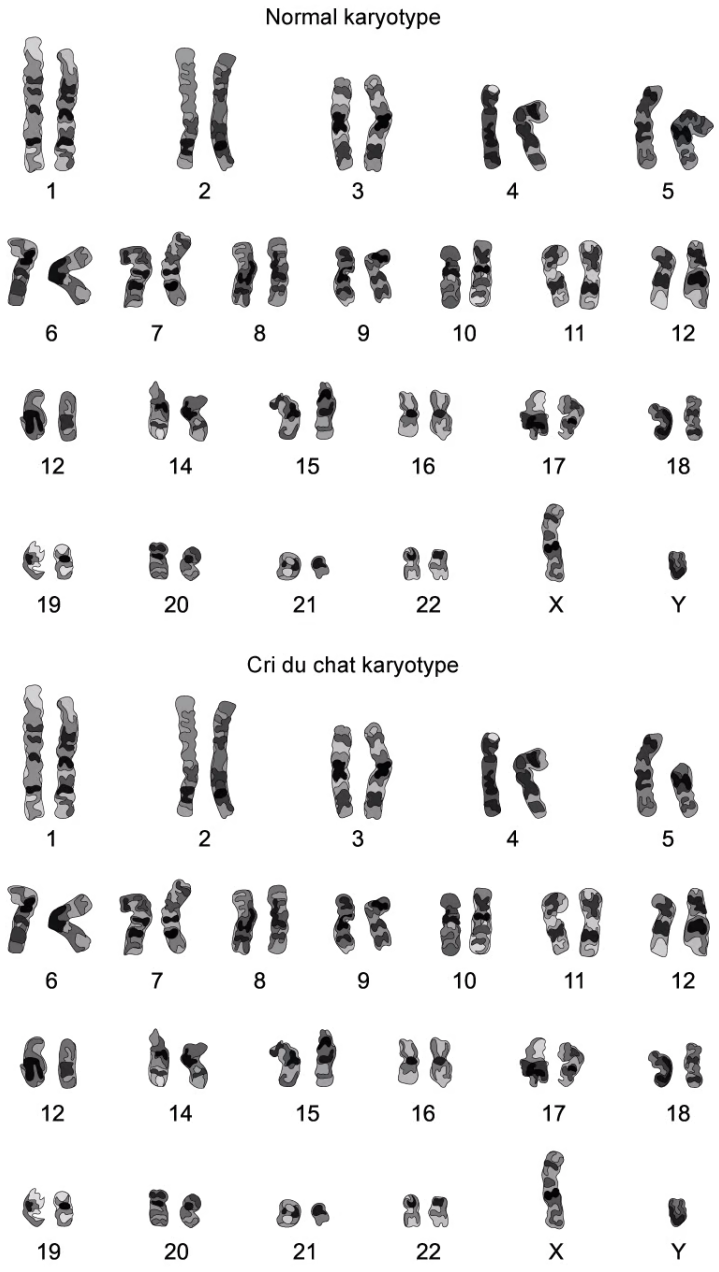
Question 2a

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.

[1 mark]

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[1 mark]

Question 2b

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.

[2 marks]

[2 marks]

Question 2c

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.

[2 marks]

[2 marks]

Question 2d

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.

[1 mark]

[1 mark]

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Question 3a

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.

[2 marks]

[2 marks]

Question 3b

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.

[2 marks]

[2 marks]

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Question 3c

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).

[3 marks]

[3 marks]

Question 3d

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.

[1 mark]

[1 mark]

Question 4a

a)
Wilson's disease is a condition caused by a mutation of gene ATP7B located on chromosome 13, which codes for an ion transport enzyme. This enzyme is responsible for transporting copper ions (Cu^{2+}) into bile so that it can be removed from the body through the digestive tract. There are several mutations which may lead to Wilson's disease; one of these mutations involves the replacement of the amino acid histidine by glutamine.

Describe the type of mutation that could have led to this disease.

[2 marks]

[2 marks]

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Question 4b

b)
Based on the information provided in part a), explain the effect this mutation would have on the transport of copper ions.

[2 marks]

[2 marks]

Question 4c

c)
In most cases of Wilson's disease, a sufferer must have two copies of the mutated ATP7B allele before the disease is present.

Suggest what this may indicate about the dominance of the ATP7B allele.

[1 mark]

[1 mark]

Question 4d

d)
People suffering from Wilson's disease have high levels of free copper in their bloodstream which have been shown to cause damage to the cell membranes of red blood cells.

Explain the consequences of this to the sufferer.

[2 marks]

[2 marks]

Question 5a

One mark is available for clarity of communication throughout this question.

a)
Compare and contrast the X and Y chromosome.

[5 marks]

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[5 marks]

Question 5b

b)
The sex of a foetus is determined by the father.

Explain this statement.

[3 marks]

[3 marks]

Question 5c

c)
Outline how a substitution mutation can alter the amino acid sequence of a polypeptide by using sickle cell anaemia as an example.

[7 marks]

[7 marks]

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