Rewarding Learning

ADVANCED
General Certificate of Education
2025

Centre Number

Candidate Number

Life and Health Sciences

Assessment Unit A2 5
assessing
Genetics, Stem Cell Research and Cloning

MV18

[AZ051]

THURSDAY 12 JUNE, MORNING

Time

1 hour 45 minutes, plus your additional time allowance.

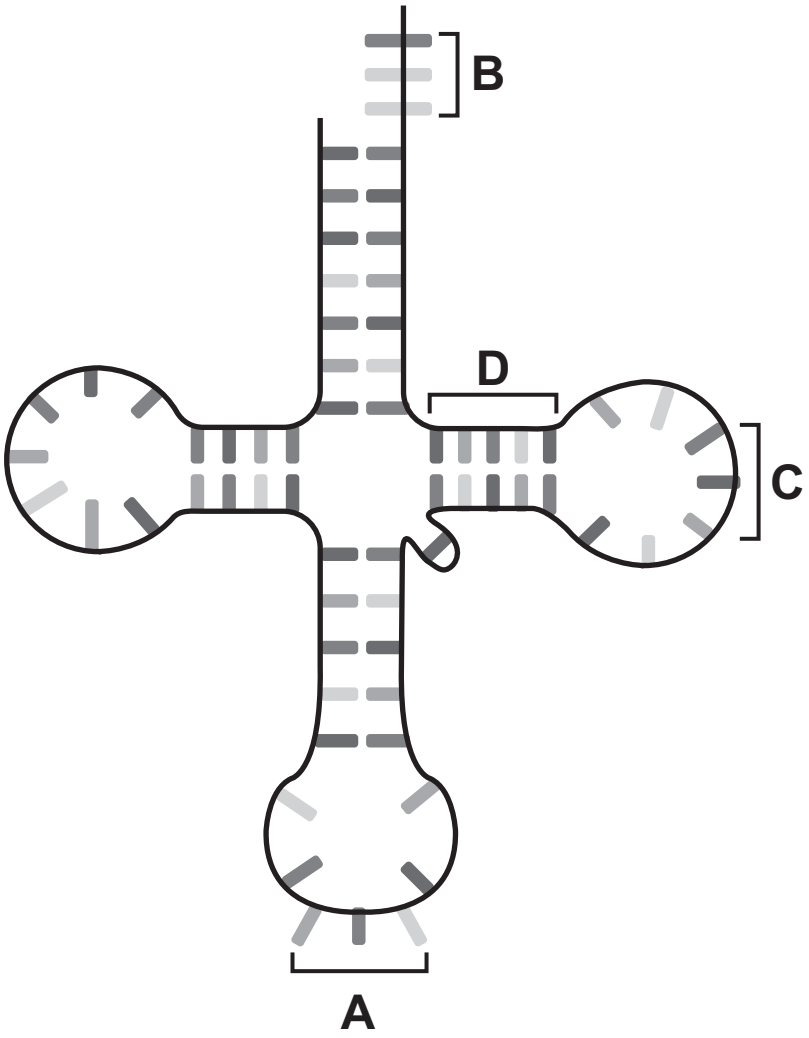
Instructions to Candidates

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
You must answer the questions in the spaces provided.
Do not write on blank pages.
Complete in black ink and use a dark HB pencil for drawings and graphs.
Do not write with a gel pen.
Answer **all nine** questions.

Information for Candidates

The total mark for this paper is **100**.
Figures in brackets printed at the end of each question indicate the marks awarded to each question or part question.
You may use a scientific calculator.
Quality of written communication will be assessed in Question **7(b)**.

1 The diagram below shows a molecule involved in the process of protein synthesis.



(a) Identify the molecule shown above. [1 mark]

_____

(b) (i) Identify the region labelled **A**. [1 mark]

_____

(ii) State what happens at region **B**. [1 mark]

_____

(iii) Use the diagram to describe the difference between **C** and **D**. [1 mark]

_____

_____

(c) Uracil is found in RNA.
Name the base, found in DNA, that uracil **replaces**.
[1 mark]

_____

2 **(a)** Nucleotides are made up of three components.
In the space below, **draw** a DNA nucleotide and **label** each component. [6 marks]

(b) Erwin Chargaff carried out several experiments that examined the relationship between bases in different organisms.
A summary of the results is shown in the table below.

	Organism /percentage (%) of each base	
Base	**Human**	**Bacterium**
Adenine	29.8	36.6
Cytosine	20.4	
Thymine	29.8	36.6
Guanine	20.4	

(i) Calculate the values for cytosine and guanine in the bacterium. [3 marks]
Show your working out.

Cytosine _____

Guanine _____

(ii) State two conclusions that Chargaff could have made from this experimental data. [2 marks]

1. _____

_____

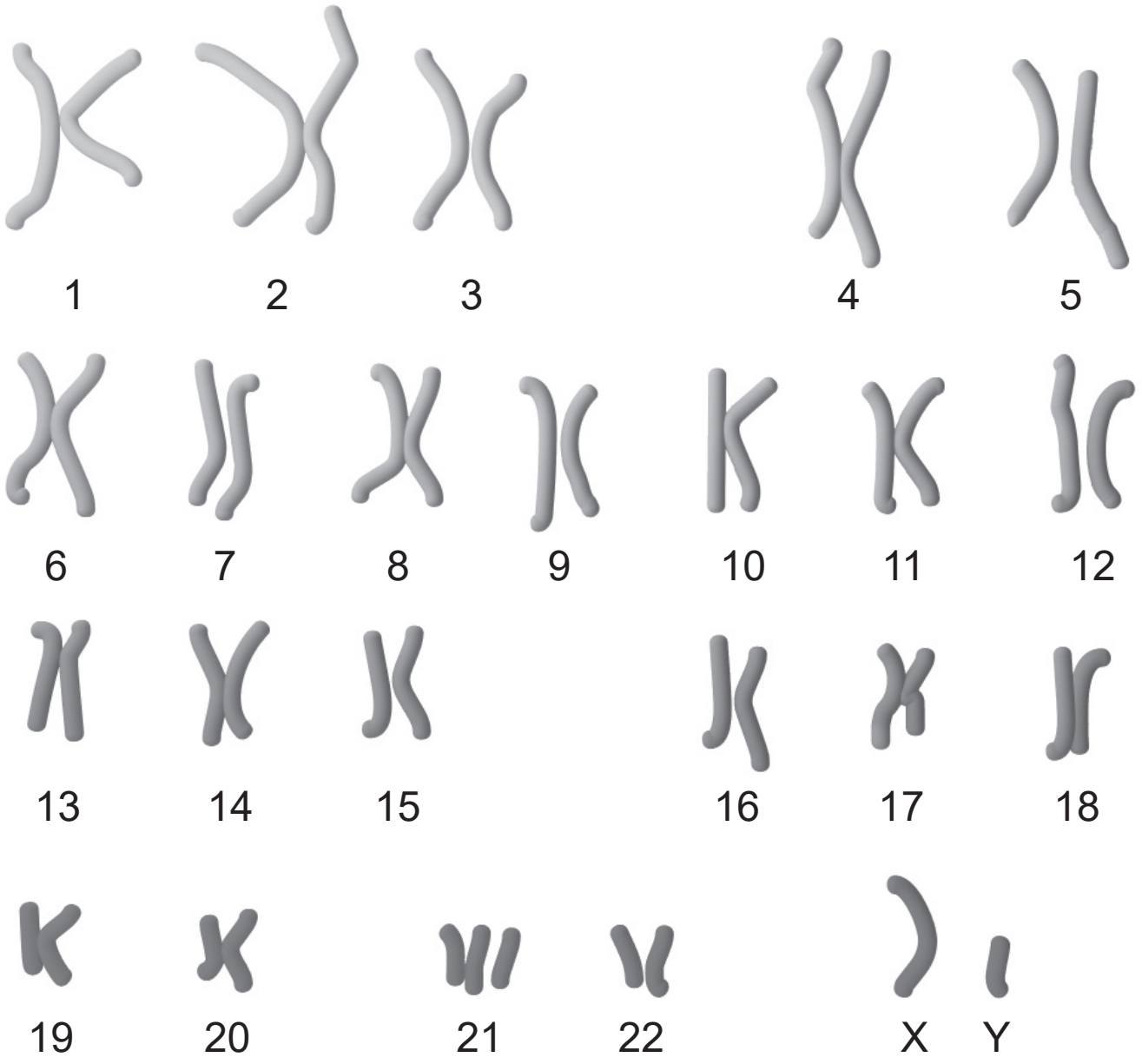
_____

2. _____

_____

_____

3 **(a)** The diagram below (known as a karyotype) shows the arrangement of chromosomes from a single human cell.



Study the diagram carefully and then answer the questions below.

(i) State the total number of chromosomes present in the karyotype opposite. [1 mark]

_____

(ii) State how you can tell this individual is male. [1 mark]

_____

(iii) Identify the difference between the karyotype opposite and a normal karyotype. [2 marks]

_____

_____

_____

(iv) This type of mutation is termed aneuploidy. Define the term **aneuploidy**. [1 mark]

_____

_____

_____

Meiosis is a type of cell division described as 'reduction division'.
Gametes are produced during meiotic cell division.

(b) Two important properties of gametes are:

- they are haploid; and
- there is genetic variation among all gametes of an individual.

(i) Suggest why it is important for gametes to be haploid. [2 marks]

_____

_____

_____

(ii) There are two ways in which genetic variation arises during meiosis. In each process, explain how the variation occurs. [1 mark for each]

Process: Recombination or crossing over

Explanation _____

_____

_____

_____

Process: Independent assortment

Explanation _____

_____

_____

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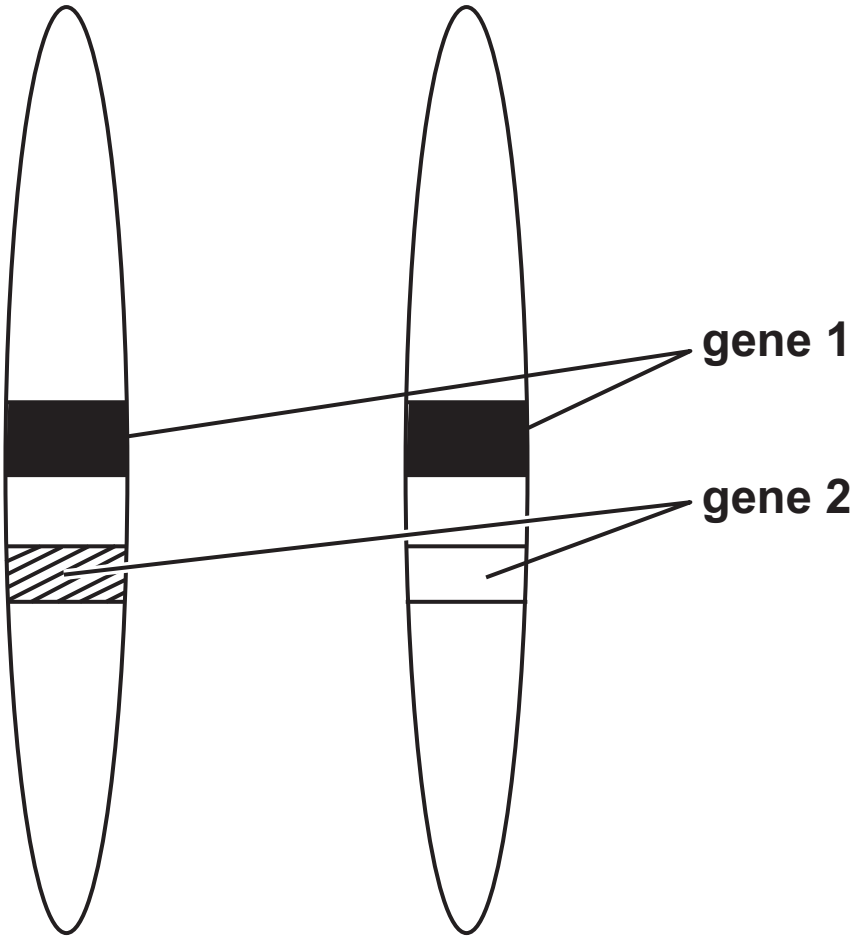
(Questions continue overleaf)

4 **(a)** The diagram below shows a pair of homologous chromosomes.
Different alleles are represented by changes in the shading on the diagram.



(i) Explain what is meant by the term **locus**.
[2 marks]

(ii) What terms are used to describe the pair of alleles for **gene 1** and **gene 2** as shown opposite?
[2 marks]

gene 1 _____

gene 2 _____

(b) Alleles can be described as dominant or recessive in simple interactions.

When considering blood groups, the I^A and the I^B alleles are both dominant to the I^O allele.

An individual who possesses both the I^A and the I^B alleles has a phenotypic blood group AB.

(i) Explain how this allele arrangement (I^A and I^B) gives rise to an individual with blood group AB.
[2 marks]

_____

_____

_____

(ii) Explain how an individual can have blood group O.
[1 mark]

_____

_____

_____

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5 **(a)** Stem cell technology and its potential use in treating certain diseases is proving to be very promising.

(i) State the name of the process that allows a stem cell to become a specific cell type and explain how this occurs. [2 marks]

_____

_____

_____

_____

(ii) Name another type of cell produced by dividing stem cells. [1 mark]

_____

(b) The graph opposite shows the results of a poll carried out in America.
Over a period of several years, people were asked the same question,
'Are you in favour of using embryonic stem cells to treat medical conditions?'

A line of best fit has been drawn on the graph for those against using embryonic stem cells.

(i) Draw a line of best fit on the graph for those 'in favour'. [1 mark]

(ii) Describe three trends shown in the data sets. [3 marks]

1. _____

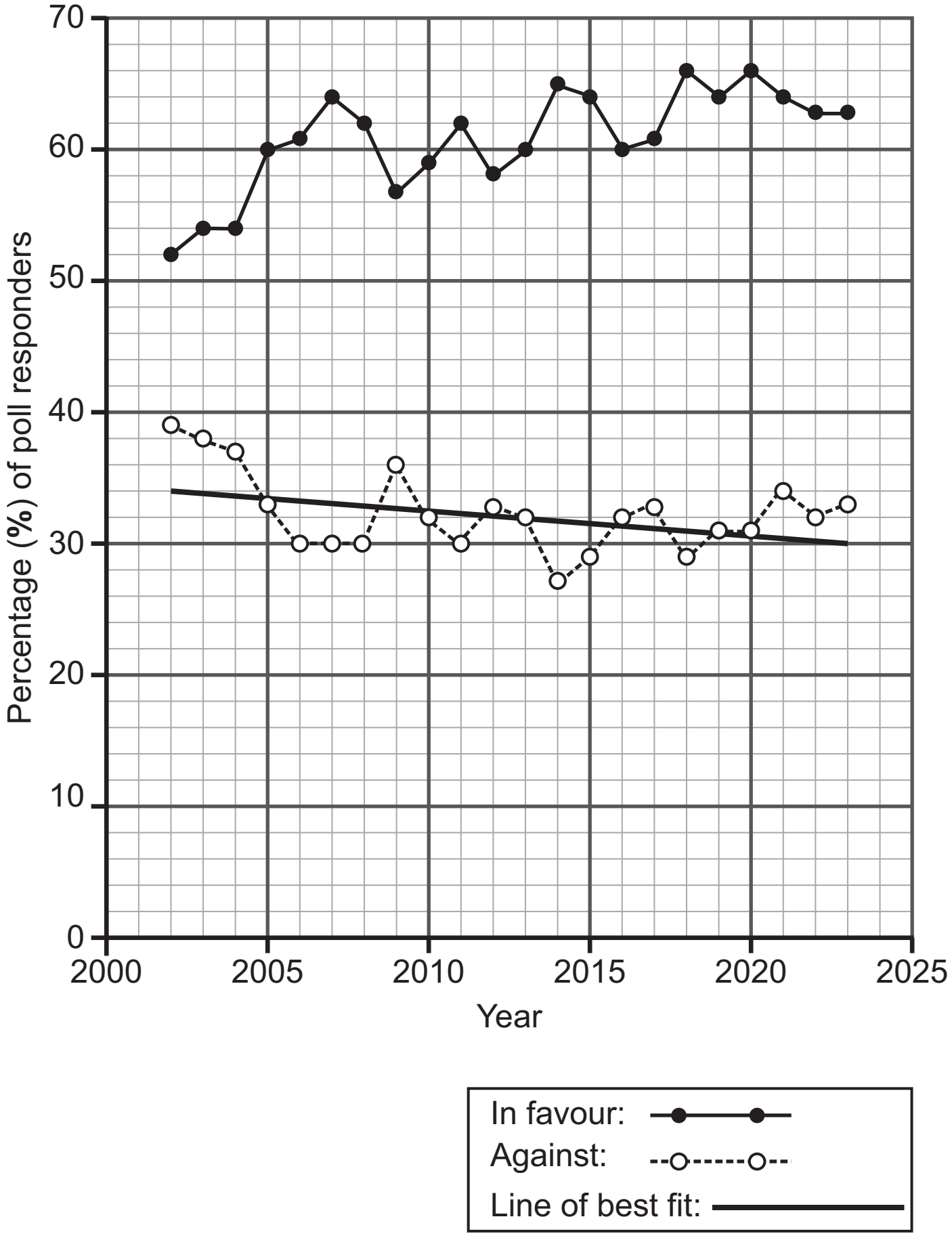
_____

2. _____

_____

3. _____

_____


70
60
50
40
30
20
10
0
Percentage (%) of poll responders
2000
2005
2010
2015
2020
2025
Year
In favour:
Against:
Line of best fit:

(iii) **In 2009**, President Obama decided to fund embryonic stem cell research. Using the data sets **from 2009–2011**, suggest why this appeared to be a popular decision with the American public. [2 marks]

(c) Recent advances in stem cell research have resulted in the production of a new type of stem cell.
These new cells are called induced pluripotent stem cells (iPS).
They can be produced from an individual's specialised cells, such as skin cells.

(i) What are pluripotent stem cells? [1 mark]

(ii) Suggest **two** advantages in the use of induced pluripotent stem cells. [2 marks]

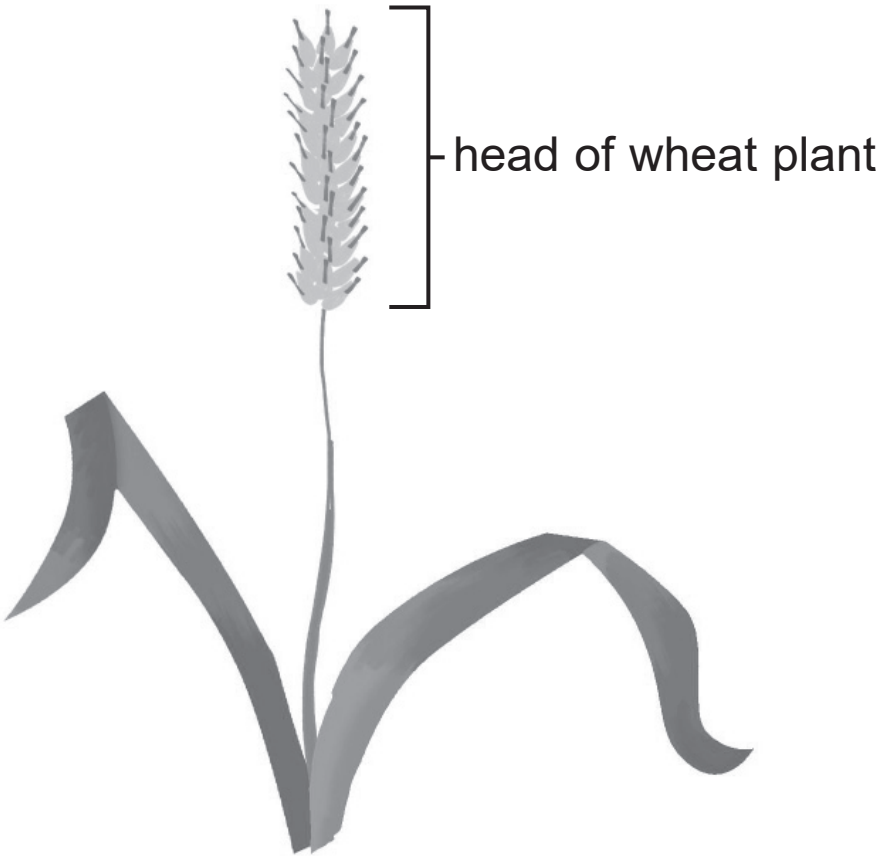
1.

2.

6 Traditional breeding methods have been used for thousands of years to improve the quality of domestic animals and plants.
This is known as selective breeding.

(a) Explain the process of selective breeding. [3 marks]

(b) Modern wheat (**T. aestivum**) is an example of a plant bred by traditional breeding methods.
Wheat grains are found on the head of the wheat plant.
The head is supported by the stem.
If a head is too large or a stem is too long, this will make harvesting more difficult, and reduce the yield of wheat grains collected.



The table below shows data from older wheat varieties and the modern variety bred from these.

Age	**Variety**	**Mean number of grains per head**	**Mean stem length /cm**
Older	Variety 1	67	71.6
Older	Variety 2	18	35.2
Modern	**T. aestivum**	45	48.1

(i) Using data from the table, explain why modern wheat was bred from the two older wheat varieties. [2 marks]

(ii) Suggest why growing modern wheat shows an increased yield at harvest. [2 marks]

(c) More commonly now, genetic engineering can be used to improve the quality of crop plants.

(i) State two advantages of genetic engineering of crop plants compared to traditional methods of breeding. [2 marks]

1.

2.

(ii) Suggest one improvement in the quality of a genetically modified (GM) crop and explain the benefit of this improvement. [2 marks]

Improvement

_____

_____

_____

Benefit

_____

_____

_____

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(Questions continue overleaf)

7 **(a)** Insulin is produced in the pancreas and is an important homeostatic hormone.

(i) State the role of insulin in the body. [1 mark]

_____

When the insulin protein is produced it consists of three sections, an A-section (21 amino acids), a B-section (30 amino acids) and a C-section (33 amino acids).

(ii) Calculate the number of bases in the insulin gene required to code for the number of amino acids in the insulin protein. [3 marks]

Show your working out.

_____ bases

(iii) Explain why the insulin gene is likely to contain more bases than the calculated number of bases in **(a)(ii)**. [2 marks]

(b) Describe the role of rRNA and mRNA in the production of a protein such as insulin. [6 marks]

In this question you will be assessed on the quality of your written communication skills, including the use of specialist scientific terms.

rRNA

mRNA

8 Dystrophin is a muscle protein.
The condition Duchenne Muscular Dystrophy (DMD) can occur if there is a mutation in the dystrophin gene.

The diagram below shows a DNA sequence in the gene.

A mutation occurred in this gene.
The diagram below shows the DNA sequence with the mutation.

(a) (i) Describe this mutation and explain the effect this may have on the protein coded for by this gene. [3 marks]

(ii) Explain how genetic fingerprinting could be used to diagnose DMD. [2 marks]

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DMD is a recessive condition.

The gene for dystrophin is located on the X chromosome.

(b) (i) Explain why a female can be a DMD carrier, but not suffer from it. [2 marks]

(ii) Explain why DMD is a more common disorder in males. [2 marks]

(c) A female carrier of DMD and a normal male have a family.

(i) Complete the following genetic diagram to show the probability of their first child being a male suffering from DMD.
Use the following symbols to show the parental genotypes and gametes. [4 marks]

- XX female
- XY male
- D normal dystrophin
- d abnormal dystrophin

Parental phenotype: carrier female × normal male

Parental genotype _____ _____

Gametes _____ _____ _____ _____

(ii) Complete the following Punnett square to show the probability of their child being a male suffering from DMD. [2 marks]

Gametes		

(iii) Circle the genotype of any male sufferer of DMD on the Punnett square. [1 mark]

(iv) Give the probability of a child being male and a sufferer of DMD. [1 mark]

_____

(d) State and explain the probability that their next child will also be male and a sufferer of DMD. [2 marks]

Probability _____

Explanation _____

_____

_____

9 A genetic study involving two characteristics, body colour and wing type, in fruit flies was carried out.

Body colour was controlled by one pair of alleles.
A resulted in a fruit fly with a grey body and **a** resulted in a fruit fly with a black body.

Wing size was controlled by **another** pair of alleles.
B resulted in normal wings and **b** resulted in small wings.

(a) Using the information above, state how a scientist would know that a black body is recessive to a grey body.
[1 mark]

_____

When heterozygous flies were crossed, the following offspring ratios were observed.

Offspring phenotype	Grey body normal wing	Grey body small wing	Black body normal wing	Black body small wing
Expected ratio	9	3	3	1
Observed ratio	4	1	1	4

The expected ratio of 9:3:3:1 was not observed, indicating the genes were not on separate chromosomes.

Ten flies were counted in total for this cross.

(b) A chi-squared (χ^2) test was applied to the results obtained in the cross.

(i) State an appropriate null hypothesis for this test. [2 marks]

_____

_____

_____

(ii) State the number of degrees of freedom (d.f.) for this test and explain how you decided on this value. [2 marks]

Degrees of freedom _____

Explanation _____

_____

The formula for the χ^2 test is:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

where O = observed frequency
E = expected frequency
Σ = sum of

(iii) Complete the table below and then calculate the χ^2 value for these results. [4 marks]

Phenotypes	**O**	**E**	**O–E**	**$(O–E)^2$**	**$(O–E)^2$ / E**
Grey/normal	4	5.625	–1.625	2.641	0.469
Grey/small	1	1.875	–0.875	0.766	0.409
Black/normal	1	1.875	–0.875	0.766	0.409
Black/small	4	0.625			

Calculated χ^2 value _____

The table below states the range of probability values for use in a chi-squared test.

χ^2 values

	Probability						
d.f.	**0.900**	**0.500**	**0.100**	**0.050**	**0.010**	**0.001**	**0.0005**
1	0.016	0.455	2.706	3.841	6.635	7.879	14.116
2	0.211	1.392	4.605	5.991	9.210	10.597	16.202
3	0.584	2.375	6.251	7.815	11.345	12.838	19.997
4	1.060	3.361	7.779	9.488	13.277	14.860	22.105
5	1.610	4.358	9.236	11.070	15.086	16.750	24.103
6	2.200	5.356	10.645	12.592	16.812	22.458	27.868
7	2.830	6.352	12.017	14.067	18.475	24.323	29.666
8	3.490	7.344	13.362	15.507	20.090	26.124	31.420
9	4.170	8.340	15.987	16.919	21.666	27.877	33.137

(iv) Between what range of probability values does the χ^2 value fit? [1 mark]
Use the table **above** to assist you.

between _____ and _____

(v) State your decision regarding the null hypothesis and give a reason for your answer. [2 marks]

_____

_____

_____

(vi) Suggest what this data indicates about the genes controlling body colour and wing type. [2 marks]

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Question Number	**Marks**
1	
2	
3	
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5	
6	
7	
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9	
Total Marks	

Examiner Number