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EDEXCEL A LEVEL BIOLOGY B: QUESTIONS BY TOPIC

Modern Genetics (7)

A Level Biology B Topic 7

24 questions · 264 marks · Mark schemes included

Pearson Edexcel AS (8BI0) and A Level (9BI0) Biology B, June 2016 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.

Click any heading or question row below to jump straight to it.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

24 questions · 264 marks · grouped by sub-topic, lowest tariff first



SUB-TOPIC 7(a)

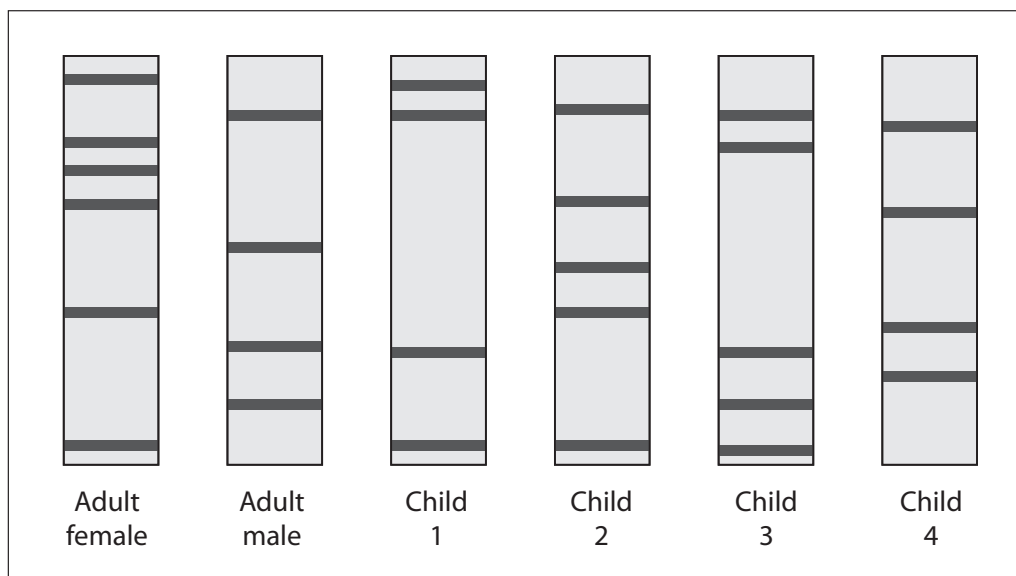
DNA PROFILING, PCR AND SEQUENCING

11 questions in this sub-topic · 108 marks · lowest tariff first



- 1 The polymerase chain reaction (PCR) and gel electrophoresis are used to produce DNA profiles.

The diagram shows DNA profiles, from an adult female, an adult male and each of four children.



- (a) Explain why PCR is used before gel electrophoresis to produce these DNA profiles.

(2)

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(b) Explain why gel electrophoresis produces individual DNA profiles.

(2)

(c) Which of the children have both of these adults as their parents?

(1)

- ☐ **A** child 1 and child 2
- ☐ **B** child 1 and child 3
- ☐ **C** child 2 and child 3
- ☐ **D** child 2 and child 4

(Total for Question 1 = 5 marks)

1 The nucleic acids, DNA and mRNA, are polymers.

(a) The table shows some components that may be found in a molecule of these nucleic acids.

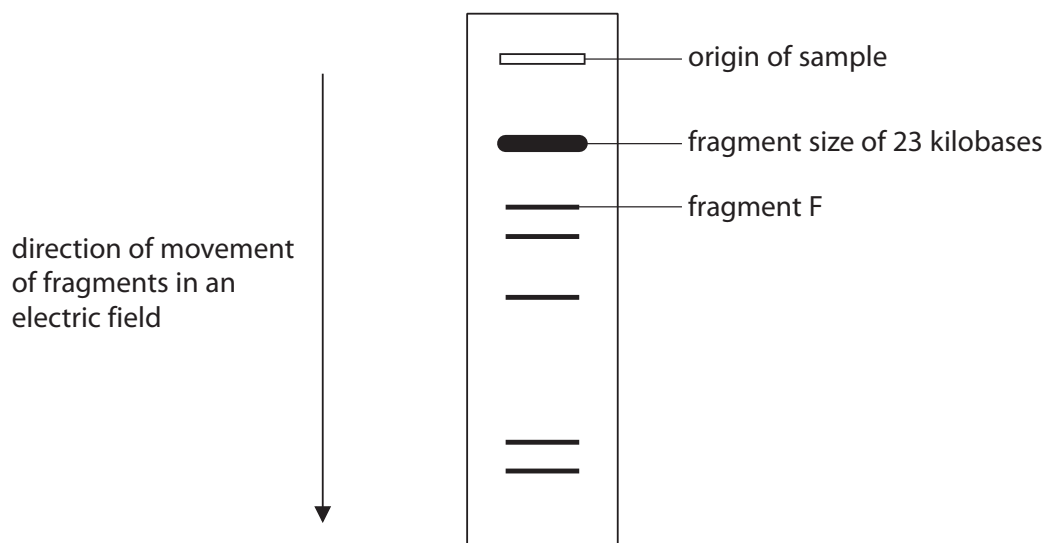
For each component, put **one** cross ☒ in the appropriate box, in each row, to show where these components can be found.

(4)

Component	Component found in a molecule of			
	both DNA and mRNA	DNA but not mRNA	mRNA but not DNA	neither DNA nor mRNA
Adenine	☒	☒	☒	☒
Hydrogen bonds	☒	☒	☒	☒
Pentose sugar	☒	☒	☒	☒
Uracil	☒	☒	☒	☒

(b) Fragments of DNA can be separated by gel electrophoresis to produce a DNA profile.

The diagram shows an example of a DNA profile.



(i) Explain why fragments of DNA can be separated by gel electrophoresis.

(2)

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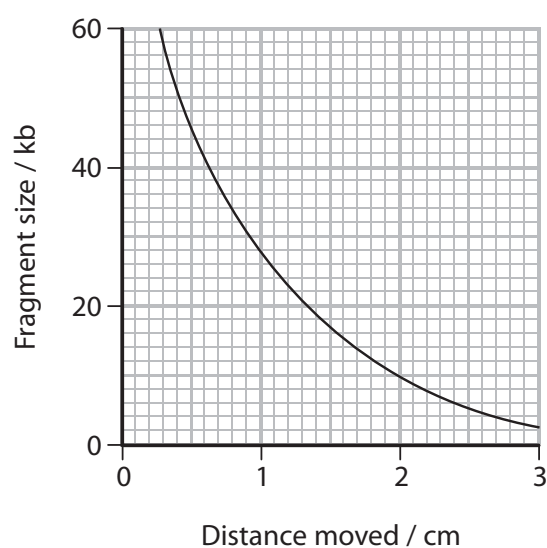
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(ii) The graph shows the relationship between the distance moved in a gel and the fragment size.



Determine the size of fragment F.

(1)

Answer kb

(Total for Question 1 = 7 marks)



- 6 The photograph shows a species of insect, *Gryllus pennsylvannicus*.



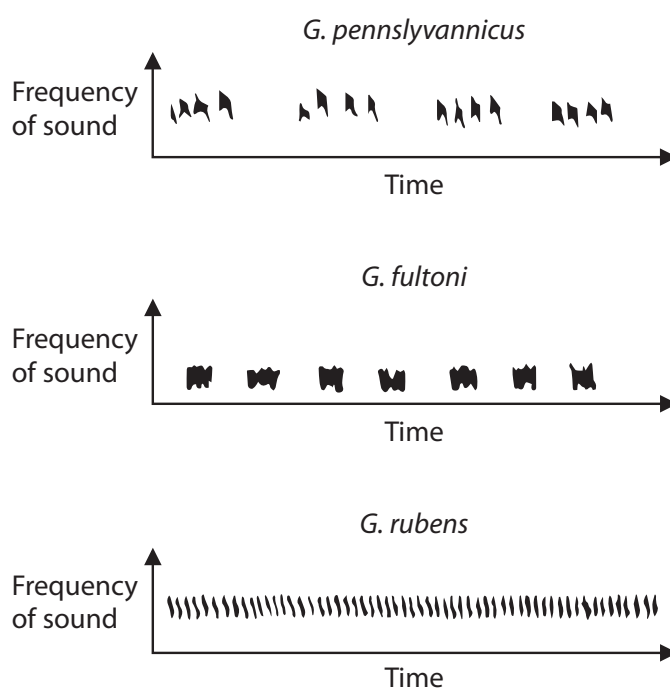
Scientists used to think that *G. pennsylvannicus* and two other species, *G. fultoni* and *G. rubens*, belonged to the same species.

The insects live in North Carolina in the USA.

Scientists have produced evidence that these insects have evolved into three distinct species from a common ancestor.

They recorded the male mating calls of each species and produced a graph representing the sound made. The graph is called a sonogram.

The diagram shows the sonogram for each species.



(a) Explain how the insects evolved from a common ancestor into three distinct species.

(4)

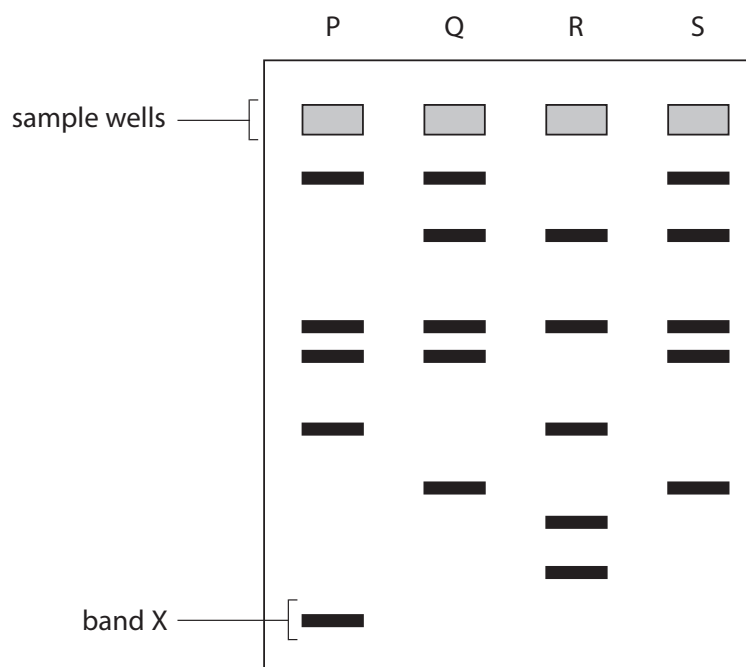
(b) Explain how gel electrophoresis could be used to identify which species is most closely related to the common ancestor.

(4)



3 Gel electrophoresis is a method used to analyse DNA fragments from different organisms.

(a) The diagram shows the results of gel electrophoresis of DNA samples from four organisms: P, Q, R and S.



What is shown by the band labelled X?

(1)

- ☐ **A** largest fragment of DNA that travelled the fastest
- ☐ **B** largest fragment of DNA that travelled the slowest
- ☐ **C** smallest fragment of DNA that travelled the fastest
- ☐ **D** smallest fragment of DNA that travelled the slowest

- (b) Gel electrophoresis of DNA can be used to study the evolutionary relationships between species.

Scientists used gel electrophoresis to examine the relationship between four species: A, B, C and D.

The diagram shows the results.

Related Species			
A (common ancestor)	B	C	D
—	— —	— —	—
— —		— —	— —
		—	—
— —	—	—	— —
—		—	
			—

Explain which species is most closely related to the common ancestor using these results.

(3)

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- (c) Describe evidence, other than the gel electrophoresis of DNA, that a scientist could use to establish the evolutionary relationships between species.

(4)

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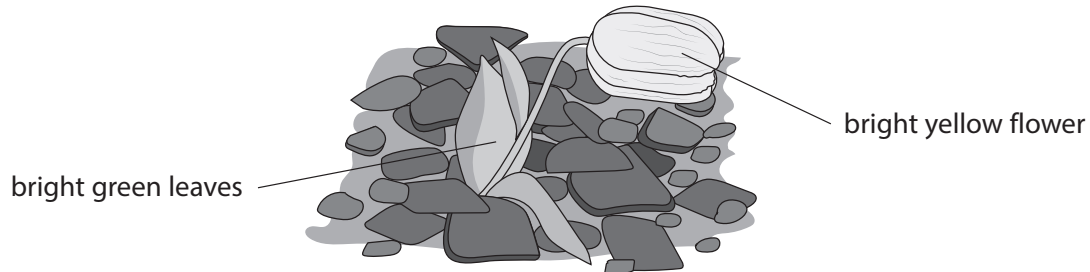
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- 6 *Fritillaria delavayi* is a small plant (height 7 cm), that grows on rocky slopes on mountains in China.

The image shows *Fritillaria delavayi*.



For at least 2 000 years, this plant has been collected and used in Chinese medicine. It is not known to be eaten by animals.

In less accessible regions, where few humans go, the plants are bright green with bright yellow flowers.

In locations where bulbs are collected in high numbers, most plants have greyish-brown leaves and flowers.

Scientists believe that the greyish-brown plants are the same species as the brightly-coloured plants.

- (a) Explain why most of the plants in areas where bulbs are collected in high numbers have greyish-brown leaves and flowers.

(4)

(b) (i) Describe how scientists can use gel electrophoresis to show that these plants belong to the same species.

(4)

(ii) Explain why the features of the brightly-coloured plants enable them to grow successfully in the areas where they are not collected by humans.

(2)



- 6 (a) A species may be defined as a group of organisms with similar characteristics that interbreed to produce fertile offspring.

Explain the limitations of this definition.

(3)

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- (b) The evolutionary relationship between species can be determined using gel electrophoresis.

Which of the following describes the movement of DNA fragments in gel electrophoresis?

(1)

- ☐ A all fragments travel the same distance
- ☐ B larger fragments travel faster than smaller fragments
- ☐ C larger fragments travel further than smaller fragments
- ☐ D smaller fragments travel further than larger fragments



- (c) Scientists discovered a new plant. They wanted to determine if this plant was a new species related to one or more of four known plant species.

The diagram shows the results of gel electrophoresis of DNA samples from the new plant and the four known plant species, A, B, C and D.

New plant	Species A	Species B	Species C	Species D
_____			_____	_____
_____	_____	_____	_____	_____
_____			_____	
_____		_____		
_____	_____	_____	_____	_____

- (i) Analyse the data to assess whether the new plant is a new species.

(4)

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- (ii) Describe **two** other pieces of information the scientists could use to confirm if the new plant is a new species.

(2)

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- 7** Scientists investigated the role of ex-situ conservation of plant species on genetic biodiversity.

The scientists investigated the variability of DNA sequences of 30 different genes for a number of species of plants in seed banks and in the wild.

- (a) (i) Which row gives correct statements about the genetic code in eukaryotes?

(1)

	Overlapping	Degenerate	Contains introns in genes
☐ A	yes	yes	yes
☐ B	yes	no	yes
☐ C	no	yes	no
☐ D	no	yes	yes

- (ii) Explain why the DNA sequences of genes are more variable than the sequences of amino acids in the proteins coded for by these genes.

(2)

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- (iii) Describe how the scientists could use technology to find out whether gene sequences of two species are similar.

(2)

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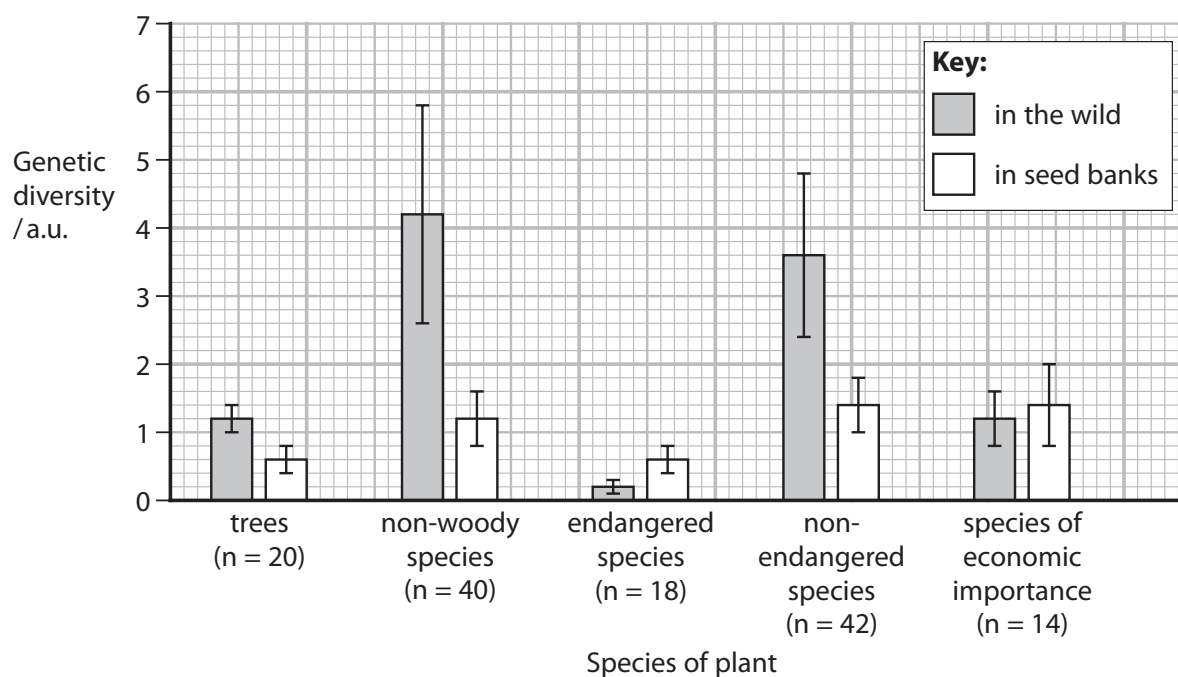
*(b) The scientists measured the mean genetic diversity of species in the wild and the mean genetic diversity of the same species in seed banks.

The species examined included:

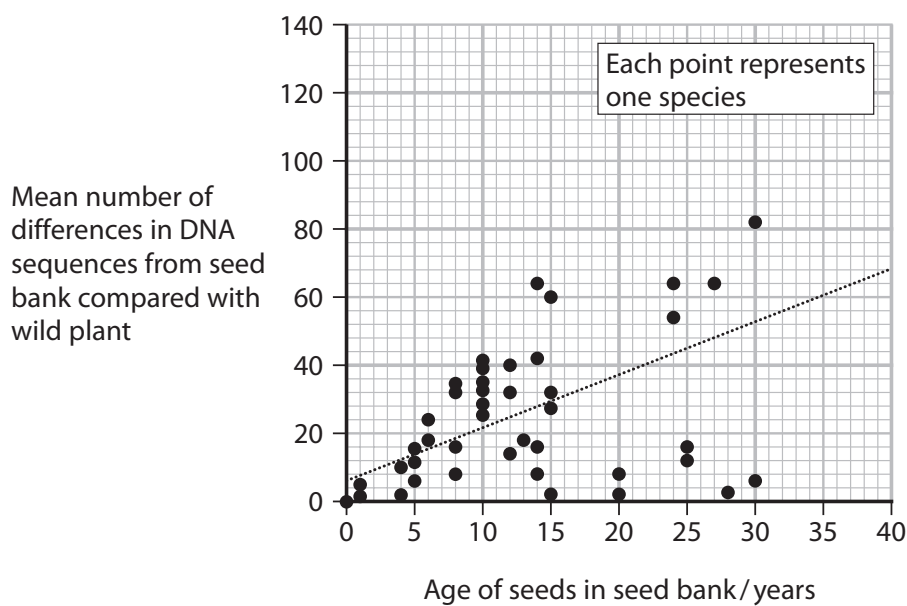
- trees
- non-woody species of plant
- plant species classed as endangered
- plant species classed as not endangered
- plants of economic importance that are harvested by people.

The scientists also measured the mean number of differences in the DNA sequences of the seeds that had been stored for different lengths of time compared with plants in the wild.

The graphs show the results.



Error bars represent ± 1 standard deviation
 n = number of different species



Analyse the data to discuss the results of this investigation.

(6)

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6 In a cell, DNA is found in both the nucleus and the mitochondria.

(a) Where is DNA found in mitochondria?

(1)

- ☐ A cytoplasm
- ☐ B intermembrane space
- ☐ C matrix
- ☐ D nucleus

(b) Which row of the table describes DNA found in the mitochondria?

(1)

	Shape	Ratio of phosphodiester bonds : pentose sugars
☐ A	circular	higher than nuclear DNA
☐ B	circular	lower than nuclear DNA
☐ C	linear	higher than nuclear DNA
☐ D	linear	lower than nuclear DNA



(c) Gel electrophoresis can be used to analyse the DNA of a person.

The diagram shows some of the bands produced when the DNA of a family was analysed using gel electrophoresis.



Analyse the information to explain the bands found at positions 1 to 5 in this family.

(4)

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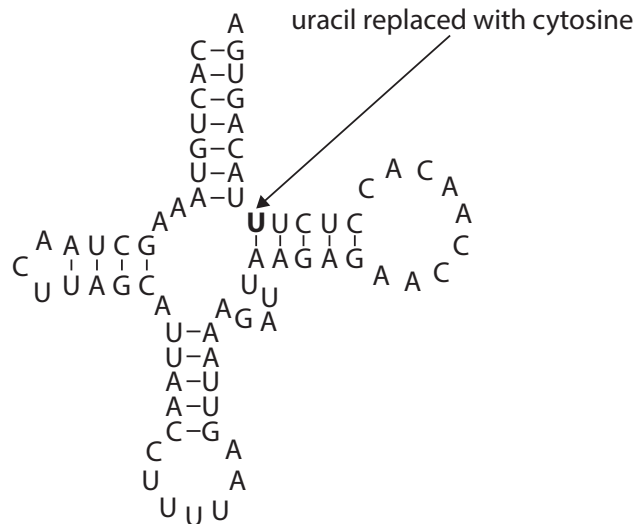
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- (d) A mutation in the tRNA^{Lys} gene in the mitochondria replaces one uracil with a cytosine in the resulting tRNA molecule.

The diagram shows the position of the uracil that is replaced with cytosine in a tRNA^{Lys} molecule.



- (i) Name this type of mutation.

(1)

- (ii) Explain how this mutation could affect the structure of the tRNA^{Lys} molecule shown in the diagram.

(2)

- (iii) Explain how this mutation could affect the role of the tRNA^{Lys} molecule.

(2)



5 Gel electrophoresis is used to separate biological molecules such as proteins.

(a) Explain how gel electrophoresis separates molecules.

(2)

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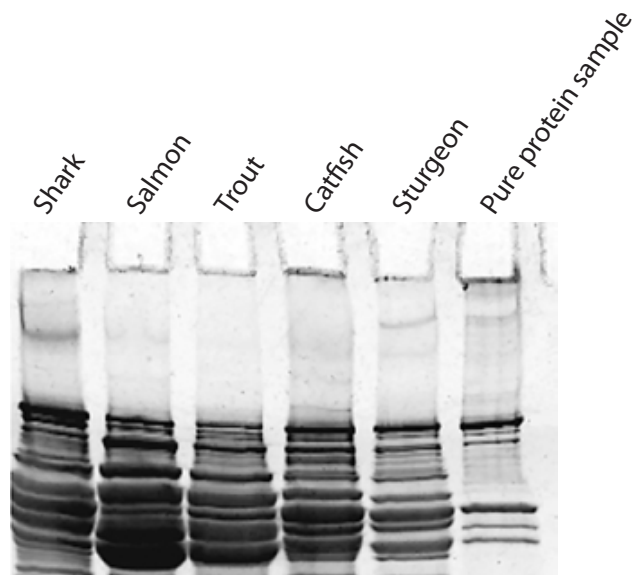
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(b) Proteomics is the study of proteins that are produced in different species.

Scientists used gel electrophoresis to separate muscle proteins from five species of fish and from a pure protein sample.

The photograph shows the results of a gel separation of proteins from these fish and from the pure protein sample.



- (i) Protein molecules in solution do not separate as easily as DNA fragments.

Explain how protein molecules in solution must be treated so that they can be separated by gel electrophoresis.

(2)

- (ii) Analyse the information shown in the photograph to explain how this banding pattern can be used to confirm that these are separate species of fish.

(4)

- (iii) Give a reason why pure protein samples were included in the gel.

(1)

- (iv) The bands in the photograph vary in thickness.

State what the thickness of the bands indicates.

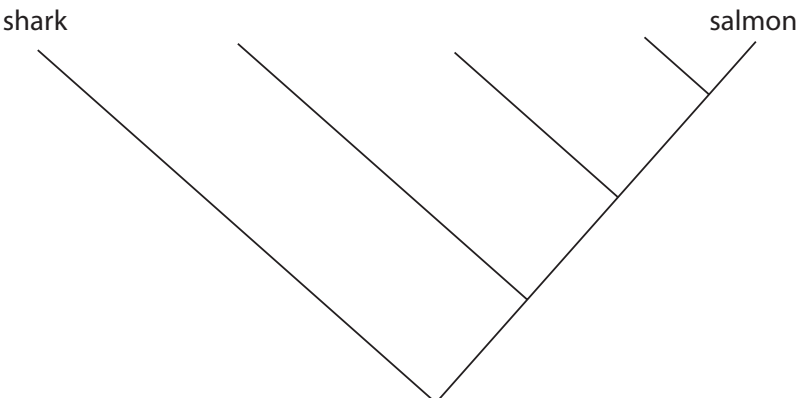
(1)

(c) The table shows the number of bands each fish has in common with the other species.

Species	Shark	Salmon	Trout	Catfish	Sturgeon
Shark	8	2	2	2	2
Salmon		10	10	5	3
Trout			13	5	4
Catfish				10	2
Sturgeon					12

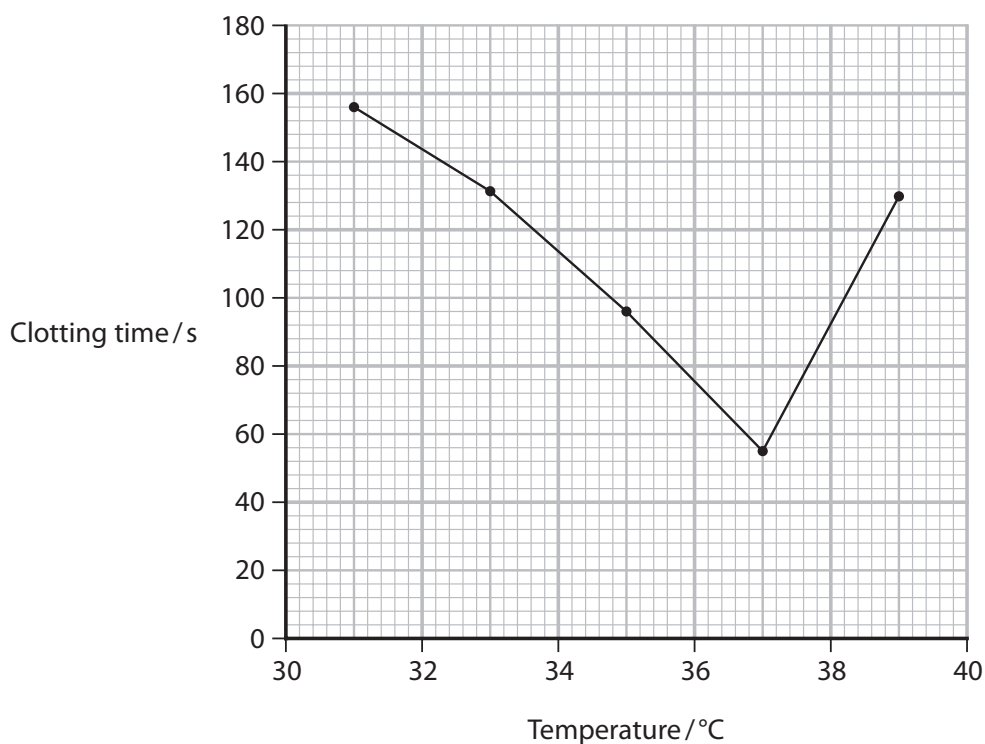
Analyse the data to complete the diagram showing the evolutionary relationships between these species of fish.

(2)



- 4 A scientist investigated the effect of temperature on the time it takes for blood to clot.

The graph shows the results of this investigation.



- (a) Explain how these results show that enzymes are involved in blood clotting.

(3)

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- (b) Prothrombin is involved in the blood clotting process.

The *F2* gene codes for the synthesis of prothrombin.

This gene is located from base pair 46 719 191 to base pair 46 739 504 on chromosome 11.

Determine the number of codons in this gene.

(1)

Answer

- (c) A mutation of the *F2* gene causes thrombophilia, a condition that results in the production of excess prothrombin.

In this gene mutation, guanine is replaced with adenine.

- (i) Name this type of mutation.

(1)

- (ii) People without this mutation have a 1 in 1000 risk of producing a blood clot in an artery.

The mutation increases this risk by 20 times.

State the probability of producing a blood clot for people with this mutation.

(1)

- (iii) Explain why thrombophilia increases the risk of producing a blood clot in an artery.

(3)



(d) A genetic test can be used to find out if a person has thrombophilia.

The test involves using a restriction endonuclease to obtain genetic material from white blood cells.

This genetic material is then used in the polymerase chain reaction (PCR).

(i) State the role of a restriction endonuclease.

(1)

(ii) Describe the process of PCR.

(3)

- 9 Aptamers are single-stranded DNA or RNA sequences that fold into specific three-dimensional structures.

Aptamers bind tightly to targets such as proteins and viruses.

- (a) Compare and contrast the structure of single-stranded DNA with that of single-stranded RNA.

(3)

- (b) Aptamers can be amplified using PCR.

To amplify an RNA aptamer, reverse transcription-PCR (RT-PCR) must be used.

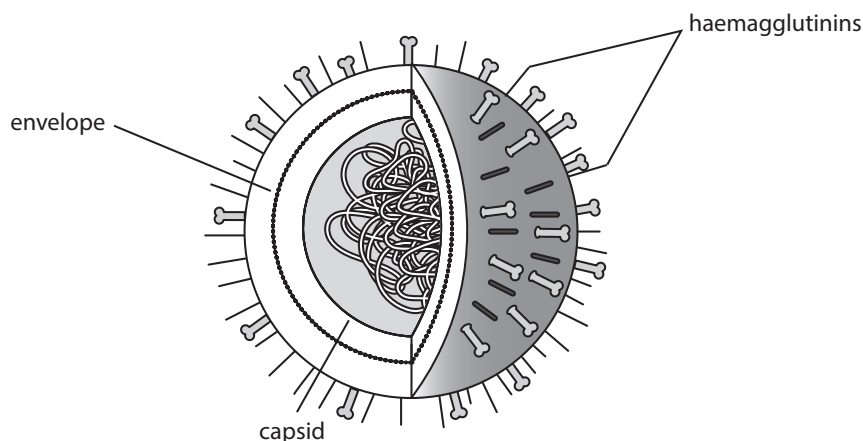
Describe how RT-PCR can be used to amplify RNA aptamers.

(4)

*(c) The diagram shows the structure of the influenza virus.

Haemagglutinin is a glycoprotein that binds to molecules on the cell membranes of the host cells of this virus.

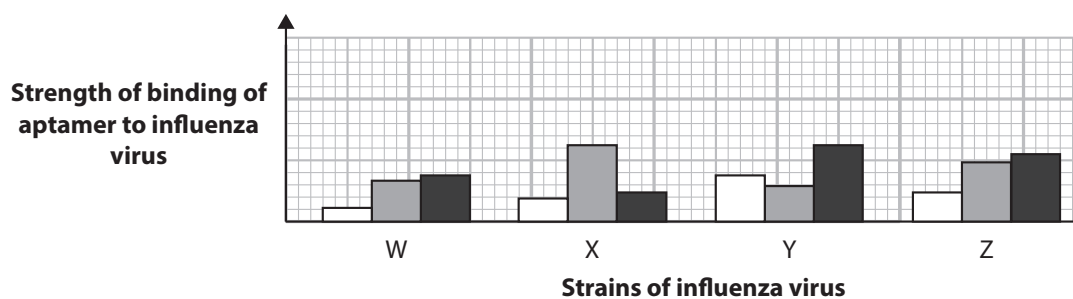
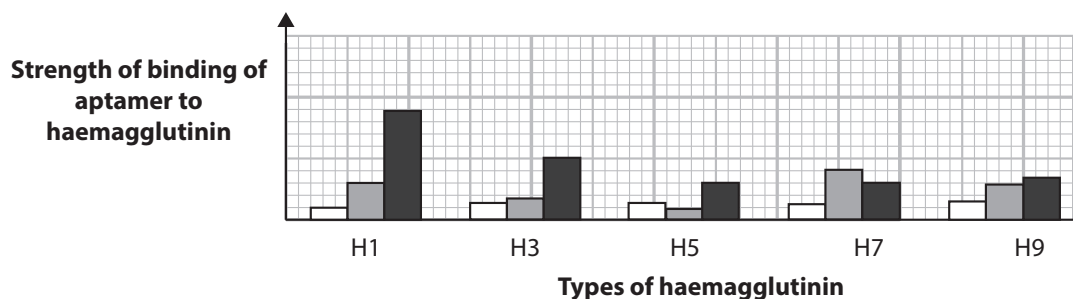
Strains of influenza virus have evolved that have haemagglutinins on their surface, with different antigenic properties.



Aptamers (AT1, AT2 and AT3) have been developed that bind to haemagglutinins (H1, H3, H5, H7 and H9).

The strength of binding of these aptamers to the haemagglutinins and to four strains of influenza virus (W, X, Y and Z) was investigated.

The graphs show the results of this investigation.



Key



AT1



AT2



AT3

Discuss the advantages and disadvantages of using aptamers to prevent infection with the influenza virus.

(6)



SUB-TOPIC 7(b)

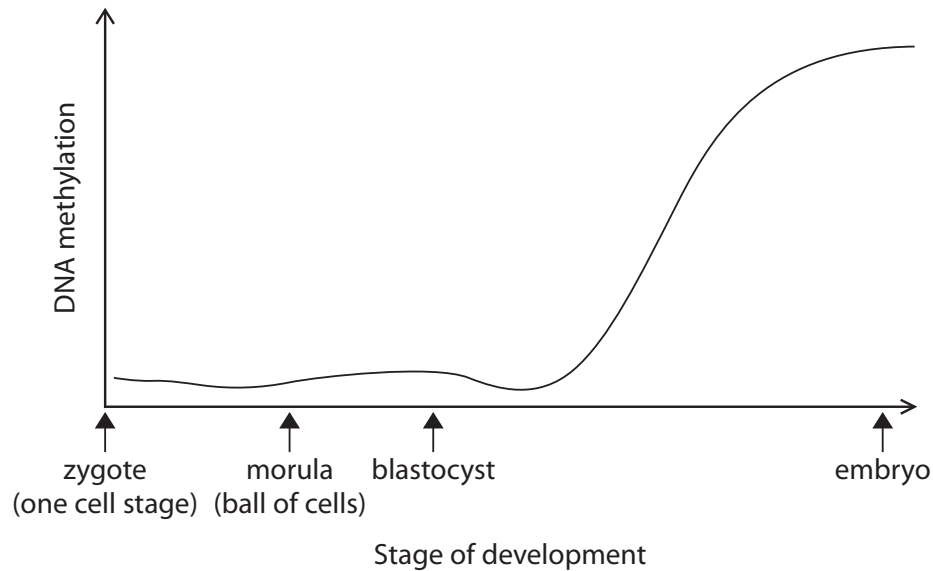
GENE EXPRESSION, REGULATION AND EPIGENETICS

6 questions in this sub-topic · 78 marks · lowest tariff first



- 5 (a) Epigenetic modifications are involved in the development of an embryo.

The graph shows the changes in DNA methylation during the development of an embryo from a zygote.



- (i) State the meaning of the term DNA methylation.

(1)

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- (ii) Describe the differences between totipotent, pluripotent and multipotent stem cells during the development of an embryo.

(3)

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(iii) Analyse the graph to explain why DNA methylation is involved in the development of an embryo.

(2)

(b) Explain why some cells are not able to become other cell types.

(2)



- 9 The photograph shows a shortfin molly.



(Source: © WILDLIFE GmbH/Alamy Stock Photo)

This fish has adapted to survive in environments where levels of hydrogen sulfide (H_2S) are toxic to other organisms.

- (a) Hydrogen sulfide can interrupt mitochondrial respiration by inactivating cytochrome c oxidase, one of the proteins in the electron transport chain.

- (i) Where is the electron transport chain located in mitochondria?

(1)

- ☐ **A** inner membrane
- ☐ **B** intermembrane space
- ☐ **C** matrix
- ☐ **D** outer membrane

- (ii) Explain why inactivating cytochrome c oxidase could be fatal.

(3)

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(b) The adaptation of these fish to H₂S in their environment is thought to be due to epigenetic modification by DNA methylation.

(i) State the meaning of the term epigenetic modification.

(1)

(ii) Which of the following is another type of **epigenetic** modification?

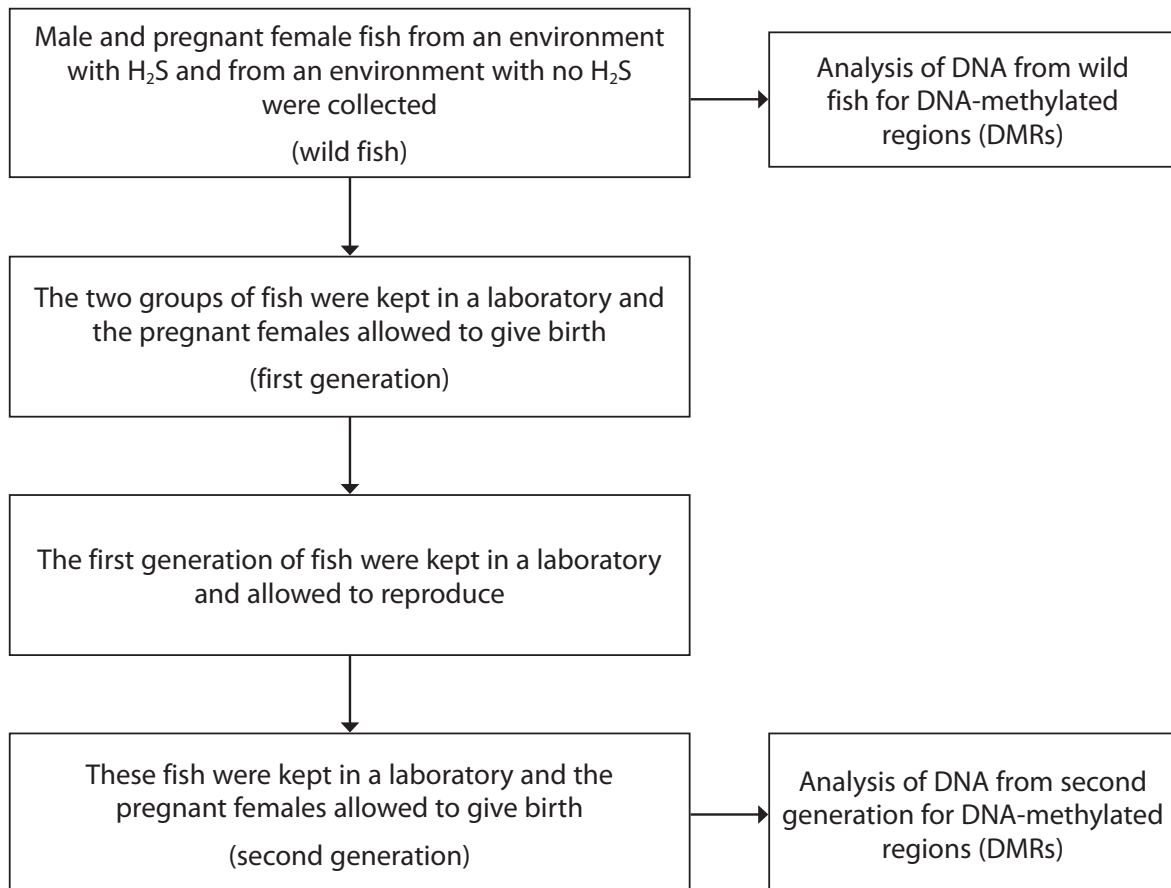
(1)

- ☐ **A** deletion mutation
- ☐ **B** histone modification
- ☐ **C** translation
- ☐ **D** translocation

*(c) The effect of hydrogen sulfide (H_2S) on DNA methylation in these fish was investigated.

The flow diagram shows part of the method used in this investigation.

All the fish kept in the laboratory were in water with no H_2S .



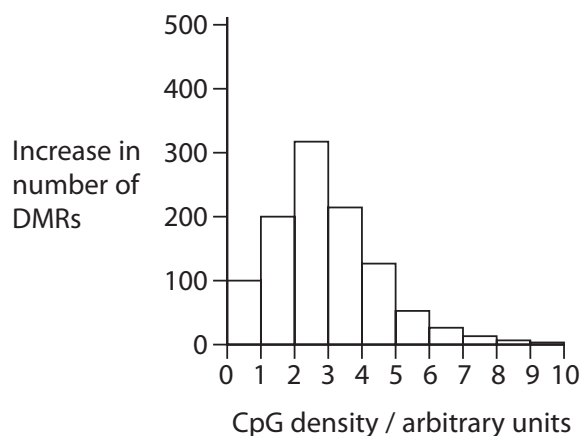
A CpG site is a region of DNA where a cytosine nucleotide is followed by a guanine nucleotide on the sense strand.

The DNA was analysed for the number of DNA-methylated regions (DMRs) at areas of DNA with different CpG densities. The numbers of DMRs for each group of fish were then compared.

The graphs show the increase in the number of DNA-methylated regions (DMRs) in each group of fish.

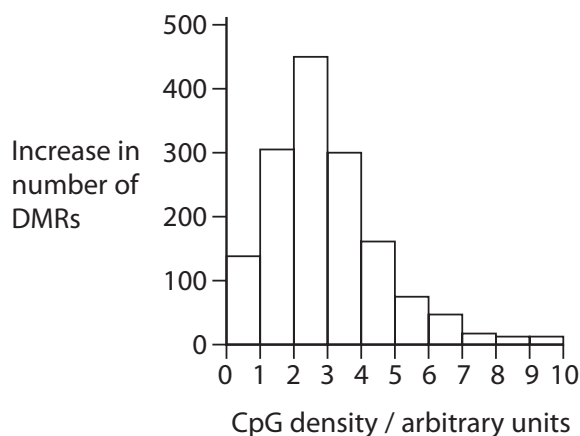
Graph 1: Wild male fish

fish from environment with H_2S compared with fish from environment with no H_2S



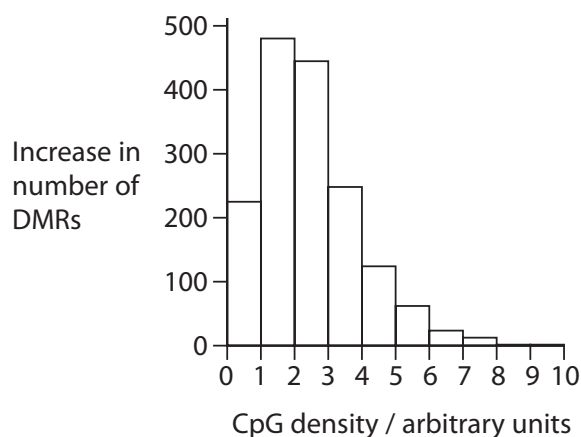
Graph 2: Wild female fish

fish from environment with H_2S compared with fish from environment with no H_2S



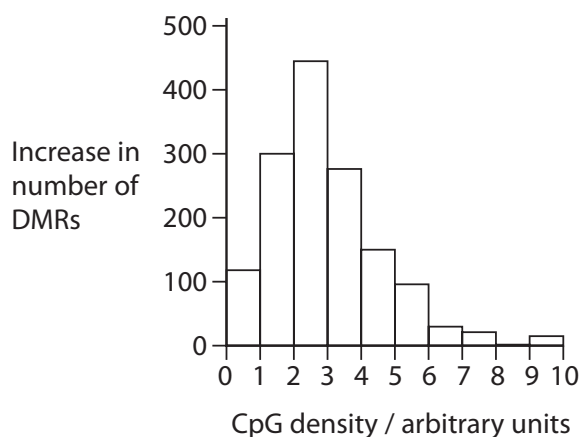
Graph 3: Second generation male fish

fish from environment with H_2S compared with fish from environment with no H_2S



Graph 4: Second generation female fish

fish from environment with H_2S compared with fish from environment with no H_2S



Discuss the results of this investigation.

(6)

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- 8 Hypoxia is an inadequate supply of oxygen to tissues and cells that restricts their function.

- (a) The normal partial pressures of oxygen vary from tissue to tissue.

The table shows the normal partial pressure of oxygen in two tissues.

Tissue	Partial pressure of oxygen / kPa
Pulmonary arterial blood	5.3
Other arterial blood	13.3

- (i) Calculate the ratio of the partial pressures of oxygen in these two tissues.
Give your answer to one decimal place.

(1)

Answer

- (ii) Explain why the partial pressures of oxygen in these two tissues are different.

(2)

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- (b) The body responds to hypoxia by releasing hypoxia-inducible transcription factors (HIF).

Investigations have shown that one effect of HIF is an increase in the rate of glycolysis in the affected cells.

- (i) Explain how HIF could result in an increase in the rate of glycolysis.

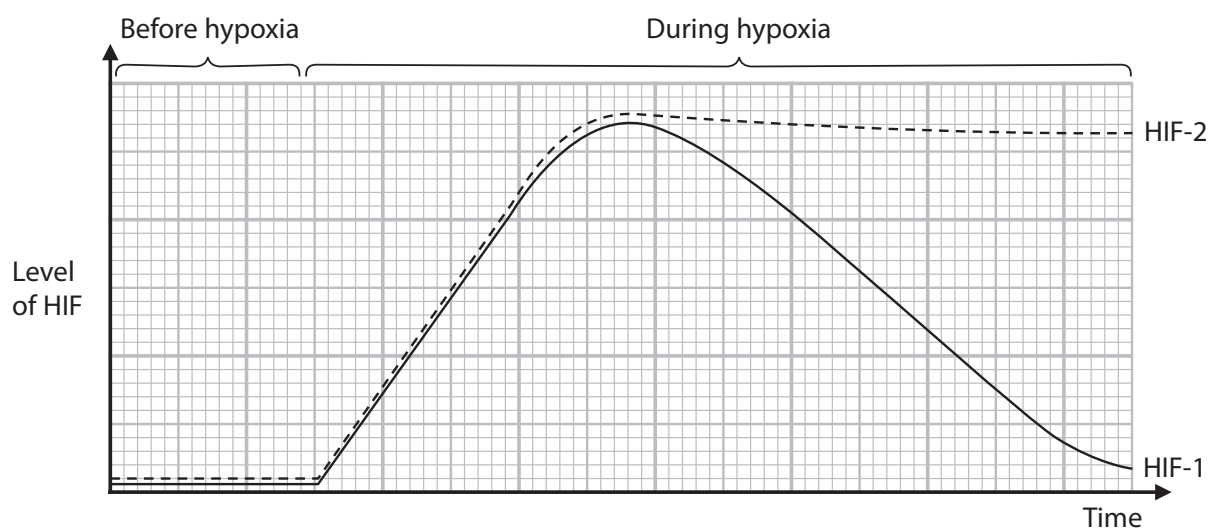
(2)

- (ii) Explain why cells need to respond to hypoxia with an increase in the rate of glycolysis.

(4)



(iii) The graph shows the changes in levels of two HIFs, HIF-1 and HIF-2, before and during hypoxia.



Compare and contrast the changes in the levels of HIF-1 and HIF-2 during hypoxia.

(2)

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(iv) Explain the changes in levels of HIF-1 and HIF-2 during hypoxia.

(2)

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- 8 The rate of photosynthesis in some plants can be affected by the level of nitrogen gas in the air.

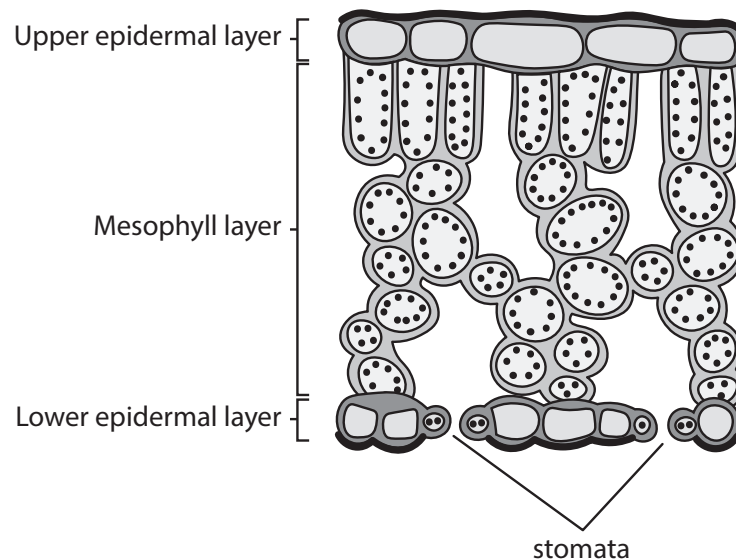
The effects of low, moderate and high nitrogen levels on leaf structure and molecules present in the leaves were investigated.

- (a) Which pair of molecules contains nitrogen atoms?

(1)

- ☐ A carbohydrates and lipids
- ☐ B lipids and nucleic acids
- ☐ C nucleic acids and proteins
- ☐ D proteins and carbohydrates

- (b) The diagram shows a section through a leaf.



- (i) Which is the main gas exchange surface in a leaf?

(1)

- ☐ A lower epidermal layer
- ☐ B mesophyll layers
- ☐ C stomata
- ☐ D upper epidermal layer

*(ii) The table shows some effects on the characteristics of leaves when plants are grown in low, moderate and high levels of nitrogen gas.

Characteristic	Effect compared with plants grown in moderate levels of nitrogen gas	
	Plants grown in low levels of nitrogen gas	Plants grown in high levels of nitrogen gas
Thickness of layers	smaller	larger
Size of chloroplasts	smaller	larger
Surface area of chloroplasts exposed to intercellular air space	lower	higher
RUBISCO activity	lower	lower

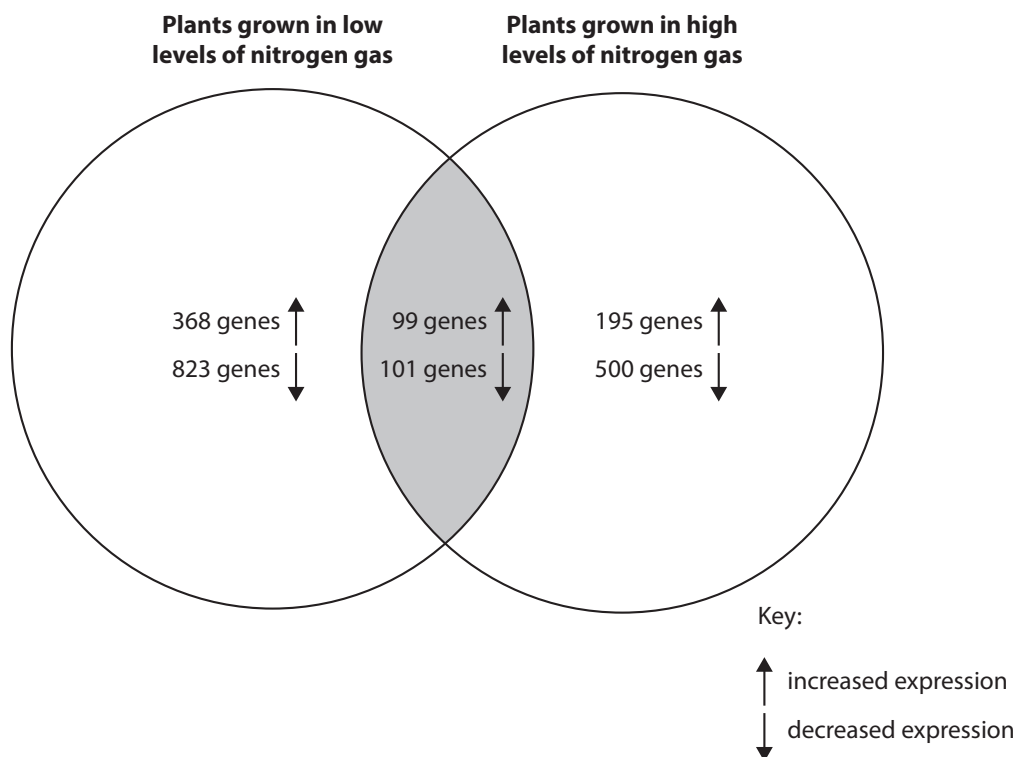
Discuss how growing plants in low levels and high levels of nitrogen gas affects the rate of photosynthesis.

(6)

- (c) This investigation also studied changes in gene expression in the plants grown in low levels and high levels of nitrogen gas compared with those grown in moderate levels.

The chart shows the results of this part of the investigation.

The shaded area shows the genes that were affected in both groups of plants.



- (i) Determine the effect of growing plants in low levels of nitrogen gas and in high levels of nitrogen gas on the changes in gene expression.

(3)

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(ii) Describe how gene expression can be changed.

(2)



- 8** Changes must occur to mammalian sperm cells as they pass through the female reproductive tract, if successful fertilisation is to take place.

Capacitation results in changes to the sperm cell membrane and increased motility.

The acrosome reaction (AR) must follow capacitation but not too soon nor too late.

- (a) Explain why the timing of the AR is important for successful fertilisation.

(3)

(b) A protein is involved in the timings of capacitation and the AR.

This protein exists in two forms: protein G and protein G-P.

Protein G-P results in the stimulation of capacitation and protein G results in the inhibition of the AR.

Protein G-P is located in the midpiece (neck) and flagellum of the sperm.

Protein G is located in the head region of the sperm.

The levels of these two forms of protein change just before capacitation, during capacitation and just before the AR.

Complete the table to show which form of protein is present and which is absent.

If the protein is present put a tick (✓) in the box and if the protein is absent put a cross (✗) in the box.

(4)

Event	Presence of protein G		Presence of protein G-P	
	Head region	Midpiece and flagellum	Head region	Midpiece and flagellum
Just before capacitation				
During capacitation				
Just before the AR				

(c) In some infertile males, the gene coding for protein G is methylated.

Explain why DNA-methylation of this gene could result in infertility.

(3)

(d) Scientists have used 'knockout' mice to investigate the effect of protein G on fertility.

(i) State the meaning of the term 'knockout' mice, as used in this context.

(2)

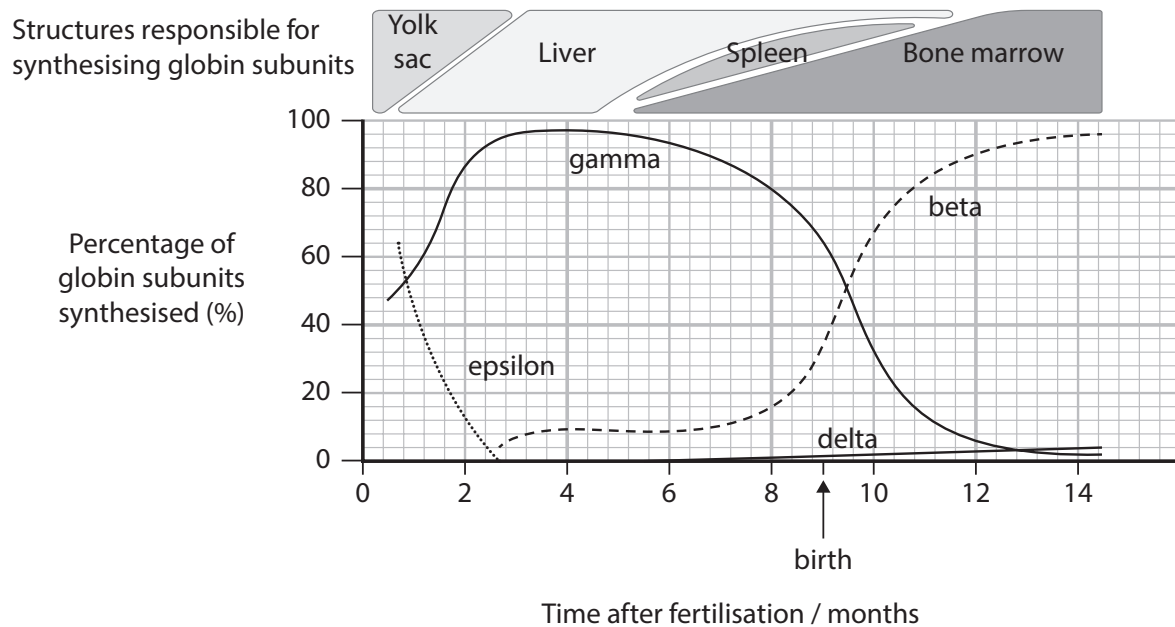
(ii) In an investigation, female mice and 'knockout' mice were housed together.

Describe how this investigation should be designed to confirm that protein G affects fertility.

(3)

9 The structure of haemoglobin changes as the embryo develops into a fetus and after the child is born.

(a) The graph shows the changes in the synthesis of four globin subunits (beta, gamma, delta, epsilon) during these stages of development.



(i) Explain why there is no synthesis of globin subunits in the first few days after fertilisation.

(3)

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- (ii) Analyse the data to describe conclusions that can be made about globin subunit synthesis during the 14 months following fertilisation.

(4)

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- (iii) Calculate the rate of decrease in percentage of gamma globin subunit synthesis from 7.6 to 10 months after fertilisation.

Give your answer to **two decimal places** with appropriate units.

(2)

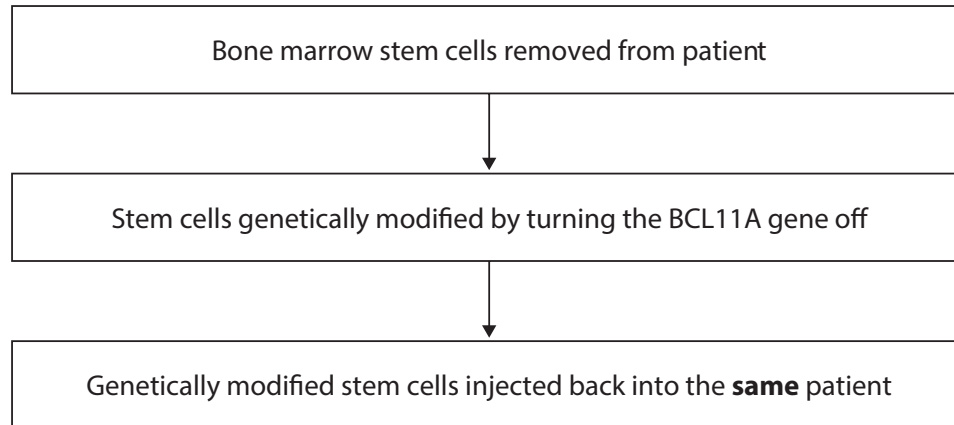
Answer



(b) Sickle cell disease (SCD) is an inherited disorder.

A new treatment for SCD is being developed that involves genetic modification.

The flowchart shows some of the stages in this process.



(i) There are approximately 67 million people in the UK, 15 000 of these people are affected by SCD.

Calculate the ratio of the number of people **without** SCD to the number of people **with** SCD in the UK.

Express your answer in **whole numbers**.

(2)

Answer

- *(ii) The product of the BCL11A gene regulates the switch from the synthesis of fetal to adult globin subunits.

Analyse all the information in this question to discuss how this approach could provide a cure for SCD and the ethical issues surrounding this treatment.

Use your own knowledge to support your answer.

(6)



SUB-TOPIC 7(c)

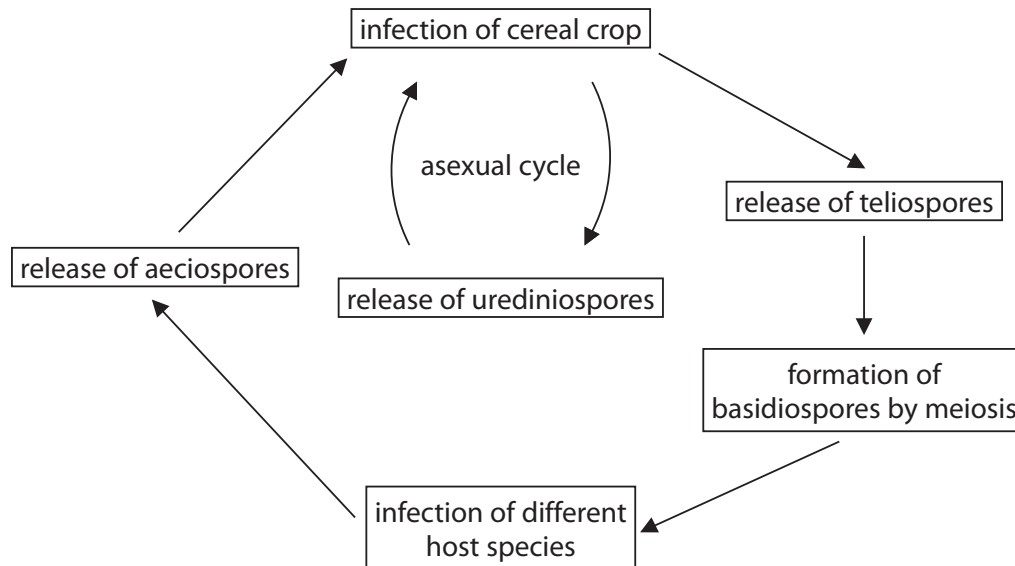
GENE TECHNOLOGY AND GENETIC MODIFICATION

7 questions in this sub-topic · 78 marks · lowest tariff first



- 3 The stem rust fungus is responsible for destroying cereal crops and reducing grain yield.

The diagram shows some stages in the life cycle of the stem rust fungus.



- (a) Which genus does the stem rust fungus belong to?

(1)

- ☐ A *Plasmodium*
- ☐ B *Puccinia*
- ☐ C *Salmonella*
- ☐ D *Staphylococcus*

(b) Explain how stem rust fungus results in a reduction in grain yield.

(3)

(c) Cereal crops have been genetically modified (GM) to produce plants that are resistant to stem rust fungus.

Analyse the diagram to deduce why the formation of basidiospores and urediniospores can produce a stem rust fungus to which these GM plants are no longer resistant.

(3)



3 Malaria is a serious and sometimes fatal disease.

Scientists are constantly looking for new ways of controlling this disease.

- (a) Which row of the table shows the name of the pathogen that causes malaria, and its classification group?

(1)

	Name of pathogen	Classification group
☐ A	<i>Plasmodium</i>	genus
☐ B	<i>Plasmodium</i>	species
☐ C	<i>Puccinia</i>	genus
☐ D	<i>Puccinia</i>	species

- (b) One group of scientists has genetically modified a fungus to produce a spider toxin that kills mosquitoes.

Describe how a fungus could be genetically modified to produce spider toxin.

(3)

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- (c) Another group of scientists has discovered a type of fungus that completely protects mosquitoes from infection by the pathogen that causes malaria.

This fungus does not kill the mosquitoes.

Explain why this approach is less controversial than the approach used by the scientists who are developing the genetically-modified fungus.

(3)

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- 3** In genetic modification, DNA from one species is joined to DNA from another species, to form recombinant DNA.

This recombinant DNA is inserted into the host organism using a vector.

The diagram shows a simplified sequence of events in the formation of herbicide-resistant, genetically modified (GM) soya beans.

Herbicides are chemicals that kill plants. They can be used to kill unwanted plants, such as weeds.

Step A Plasmids are extracted from *A. tumefaciens* bacteria



Step B Plasmids are cut using an enzyme



Step C The gene for herbicide-resistance is inserted into the plasmids.



Step D Plasmids are returned to *A. tumefaciens* bacteria



Step E A soya bean plant is infected with the modified *A. tumefaciens* bacteria



Step F Herbicide-resistant soya bean plants are cloned from the infected plant.

- (a) (i) Name the enzyme used in **Step C**.

(1)

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- (ii) Name the vector in this process.

(1)

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- (b) Explain why it is possible to clone many herbicide-resistant plants from one infected plant in **Step F**.

(2)

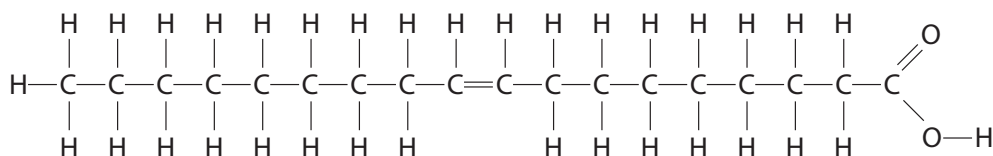
- (c) Explain how herbicide resistance would improve the yield of GM soya bean plants compared to non-GM soya bean plants.

(3)



- 7 Soya bean plants have been genetically modified (GM) to increase the concentration of certain organic molecules.

The diagram shows one of these molecules.



- (a) Explain what type of molecule is shown in the diagram.

(2)

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- (b) Describe how soya bean plants can be genetically modified to produce large numbers of GM soya bean plants.

(4)

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- (c) Some plants have been genetically modified to express viral antigens.

These plants are used as edible vaccines and stimulate immunity when eaten.

Devise an investigation that a scientist could use to measure the effectiveness of this vaccine in mice.

(5)

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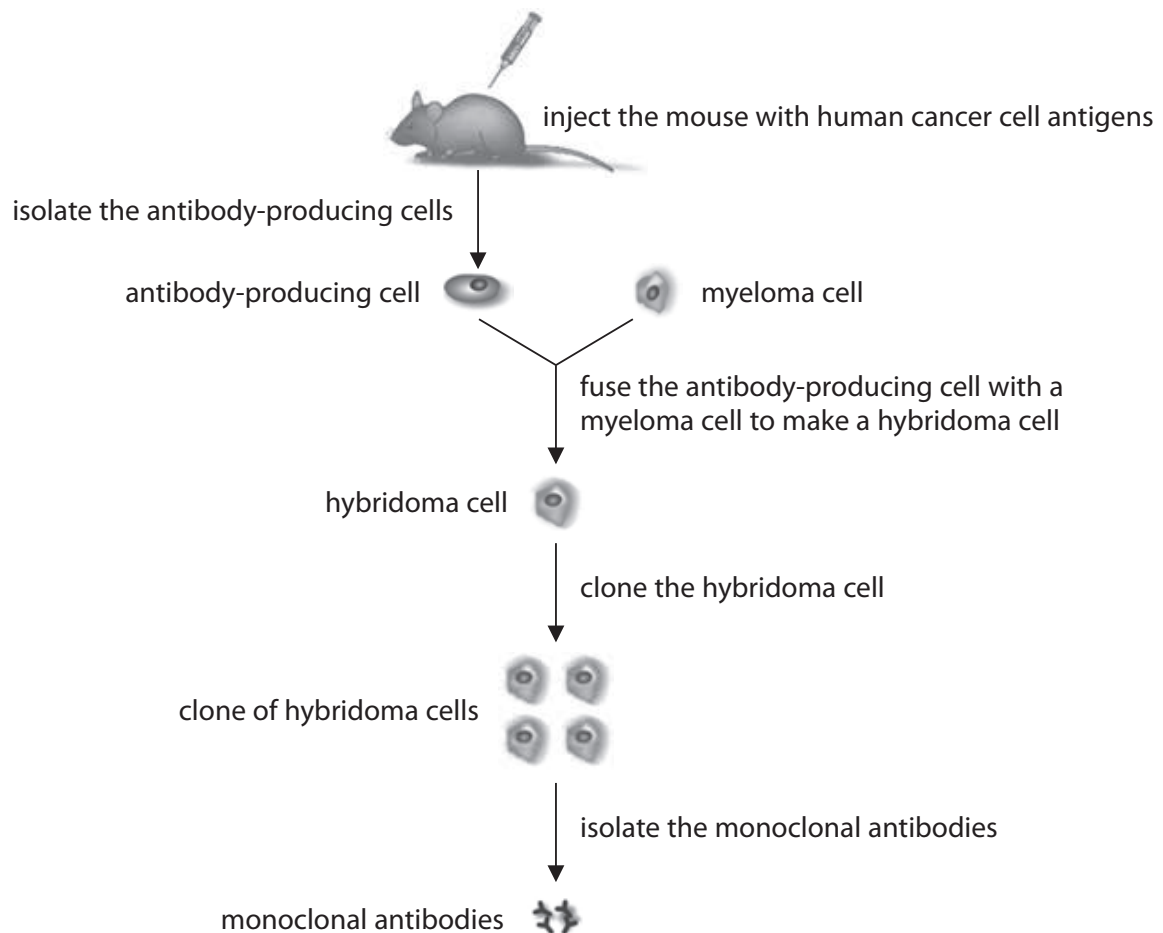
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- 9 Monoclonal antibodies can be made against a wide range of different antigens. They are used in research and medicine.

Monoclonal antibodies are made by fusing an antibody-producing cell with a myeloma cell.

The diagram shows some of the steps involved in making monoclonal antibodies against human cancer cell antigens.



(a) What is the name of the antibody-producing cell?

(1)

- ☐ A macrophage
- ☐ B memory cell
- ☐ C neutrophil
- ☐ D plasma cell

(b) Epigenetic modification is involved in the formation of the antibody-producing cells.

Describe epigenetic modification.

(3)

(c) Myeloma cells have the potential to divide indefinitely.

Explain why myeloma cells are used in the production of monoclonal antibodies.

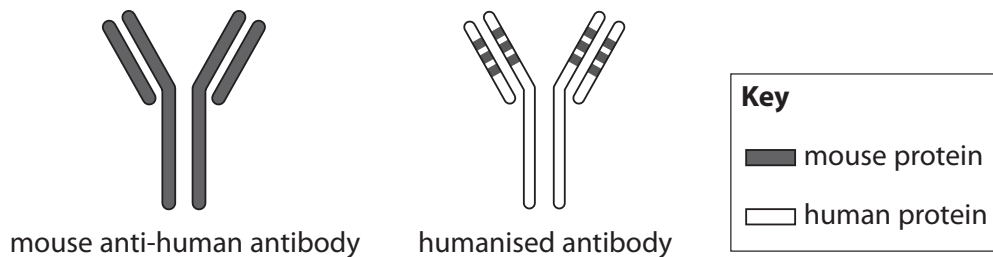
(2)



- (d) The antibodies made by this method are called 'mouse anti-human antibodies'. These antibodies are made by a mouse but are specific to human antigens.

Mouse anti-human antibodies are humanised using recombinant DNA methods.

The diagram shows a mouse anti-human antibody and a humanised antibody.



- (i) Explain the advantages of using humanised antibodies in the treatment of cancer.

(3)

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- *(ii) Explain why mouse anti-human antibodies need to be humanised in order to treat cancer.

(6)

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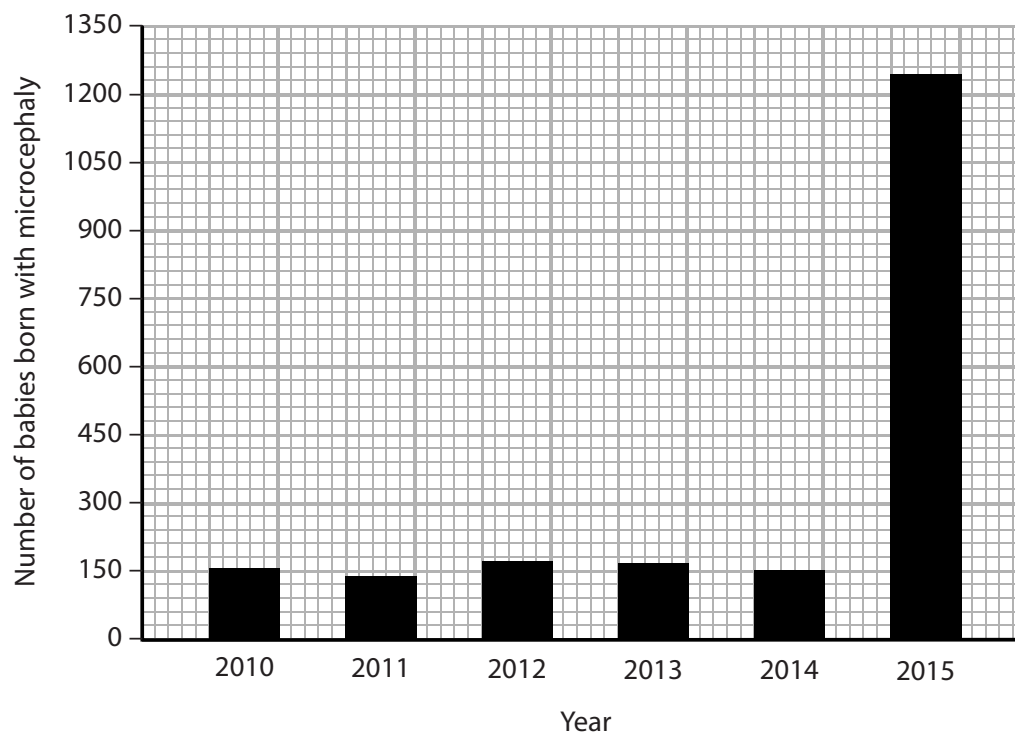
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- 6 In February 2016, the World Health Organisation (WHO) declared a public health emergency because of the spread of the Zika virus.

The mild symptoms, such as joint pains, headaches and a slight temperature increase lasted only a few days. However, Zika virus has been linked to a birth defect called microcephaly.

The graph shows the number of babies born with microcephaly in Brazil from 2010 to 2015.



- (a) Calculate the percentage increase in the number of babies born with microcephaly in 2015 compared with 2014.

(2)

Answer%



(b) Zika virus is transmitted to humans by infected mosquitoes.

- (i) Explain why another type of drug, rather than antibiotics, has to be used to treat Zika virus infections.

(2)

- (ii) Scientists have suggested that genetically modified (GM) mosquitoes could be used to help combat the spread of the Zika virus.

Mosquito eggs are injected with DNA, from GM mosquitoes. This DNA contains a gene for fluorescence. However, only one in a few thousand injected eggs results in a GM mosquito.

Explain how this procedure could help in the production of large numbers of GM mosquitoes.

(4)



(iii) Explain why the Brazilian government has advised people to use mosquito nets, even if they have already contracted the Zika virus.

(2)

(c) Scientists have discovered that the Zika virus genome is made of RNA.

This RNA codes for:

- capsid protein with 105 amino acids
- pre-membrane protein with 187 amino acids
- envelope protein with 505 amino acids
- seven nonstructural proteins

(i) State how many bases are needed to code for the capsid protein.

(1)

(ii) Unlike human immunodeficiency virus (HIV), Zika is not a retrovirus.

Describe what happens to the Zika RNA once it is in the cell.

(2)

(d) During the replication of the Zika virus, the ten proteins that are coded for in the RNA are produced as a single polyprotein molecule.

Explain how this polyprotein molecule is converted into ten separate protein molecules.

(2)

(Total for Question 6 = 15 marks)



9 Soya beans are an important crop for the production of food and oil.

- (a) In the 2012 to 2013 growing season, production of soya beans was highest in the United States and second highest in Brazil.

The United States produced 93 million tonnes of soya beans from 31 million hectares.

This was 9.4% more than Brazil produced from 28 million hectares.

Calculate the difference in the yield per hectare of soya beans from these two countries.

(3)

Answer



(b) Soya beans can be genetically modified to form transgenic plants.

A study of the nutritional content of soya beans from non-transgenic soya bean plants and from transgenic soya beans plants was carried out in two regions of Brazil.

The regions were Ponta Grossa and Londrina.

Tables 1 and 2 show the results of this study.

Table 1

Type of plant	Region	Mean mineral content / mg per 100 g dried soya beans		
		Iron	Copper	Manganese
Non-transgenic	Ponta Grossa	3.34	0.76	1.38
Transgenic	Ponta Grossa	3.44	0.86	1.40
Non-transgenic	Londrina	4.59	1.35	2.20
Transgenic	Londrina	4.15	1.25	2.02

Table 2

Type of plant	Region	Mean organic content / mg per 100 g dried soya beans		
		Protein	Lipid	Carbohydrate
Non-transgenic	Ponta Grossa	38.61	21.09	23.88
Transgenic	Ponta Grossa	38.80	21.19	23.41
Non-transgenic	Londrina	41.68	18.56	25.74
Transgenic	Londrina	40.62	19.87	25.26

*(i) Analyse the data to assess the nutritional content of soya beans from transgenic and from non-transgenic soya bean plants grown in these two regions.

(6)

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MARK SCHEMES

official Pearson Edexcel mark schemes



Question Number			
1(a)	An explanation that makes reference to two of the following: - because DNA needs to be {amplified / replicated} (1) - as only small samples are taken / to produce enough DNA (1) - all copies of the DNA need to be identical (to the original sample) (1)		(2)

Question Number	Answer	Additional Guidance	Mark
1(b)	An explanation that makes reference to two of the following: - because of the {differences in / hypervariable regions} (in each individual's DNA) (1) - so produce fragments of different lengths (1) OR - different {fragments / lengths} of DNA are separated out (1)	ACCEPT unique DNA ACCEPT each individual has different abundance of different sized DNA (fragments) OR ACCEPT fragments therefore move through gel at different rates / smaller fragments move {further / faster} / converse for larger	(2)

Question Number	Answer	Additional Guidance	Mark
1(c)	The only correct answer is B A is incorrect because child 2 has no matching bands with the father C is incorrect because child 2 has no matching bands with the father D is incorrect because child 4 has no matching bands with either adult		(1)



Question Number	Answer					Additional Guidance	Mark																													
1(a)	<table><tr><th rowspan="2">Component</th><th colspan="4">Component found in a molecule of</th></tr><tr><th>both DNA and mRNA</th><th>DNA but not mRNA</th><th>mRNA but not DNA</th><th>neither DNA nor mRNA</th></tr><tr><td>Adenine</td><td>X</td><td>☐</td><td>☐</td><td>☐</td></tr><tr><td>Hydrogen bonds</td><td>☐</td><td>X</td><td>☐</td><td>☐</td></tr><tr><td>Pentose sugar</td><td>X</td><td>☐</td><td>☐</td><td>☐</td></tr><tr><td>Uracil</td><td>☐</td><td>☐</td><td>X</td><td>☐</td></tr></table>	Component	Component found in a molecule of				both DNA and mRNA	DNA but not mRNA	mRNA but not DNA	neither DNA nor mRNA	Adenine	X	☐	☐	☐	Hydrogen bonds	☐	X	☐	☐	Pentose sugar	X	☐	☐	☐	Uracil	☐	☐	X	☐						
			Component	Component found in a molecule of																																
		both DNA and mRNA		DNA but not mRNA	mRNA but not DNA	neither DNA nor mRNA																														
		Adenine	X	☐	☐	☐																														
		Hydrogen bonds	☐	X	☐	☐																														
		Pentose sugar	X	☐	☐	☐																														
		Uracil	☐	☐	X	☐																														

Question Number	Answer	Additional Guidance	Mark
1(b)(i)	An explanation that makes reference to two of the following: {DNA / fragments} {are negatively charged / have a phosphate group} (1) - therefore the {DNA / fragments} move {when a potential difference is applied / towards the positive electrode} (1) {smaller / lighter} fragments move further / {larger / heavier} fragments move shorter distance (1)	ACCEPT current / charge / voltage / electric field towards (positive) anode ACCEPT small fragments faster / larger fragments slower	

Question Number	Answer	Additional Guidance	Mark
1(b)(ii)	7 / 7.0 / 8 / 8.0 / 9 / 9.0 (kb)		

ect geographic isolation ore no mating	
ect allopatric	(4)

Question Number	Answer	Mark
3(a)	The only correct answer is C smallest fragment of DNA that travelled the fastest A is not correct because it is not the largest fragment of DNA B is not correct because it is not the largest fragment of DNA D is not correct because smallest fragment of DNA does not travel the slowest	(1)

Question Number	Answer	Additional guidance	Mark
3(b)	An explanation that makes reference to three of the following points: - species C (is the most closely related) (1) - as the bands of DNA on the gel most closely match / align with / same pattern (1) - species C has 5 bands in same location (1) - species B has 2 bands and species D has 3 bands (1)	allow converse for least related	(3)

Question Number	Answer	Additional guidance	Mark
3(c)	A description that makes reference to four of the following: - using information about similar morphology / anatomy (1) - using information about reproduction such as the fertility of hybrids / mate recognition and behaviour (1) - using information about the similarity in proteins / molecular phylogeny (1) - looking at information about ecological niche and where species are found (1) - use of bioinformatics / sequence DNA / sequence amino acid / use genetic barcodes (1)	allow reference to sexual dimorphism noting that some species male and female have very different morphology allow look up in genetic databases	(4)

(Total for Question 3 = 8 marks)

Number	Answer	Additional Guidance	Mark
6(a)	An explanation that includes four of the following: - collection acts as a selection pressure (1) (random) mutation (in gene) for pigment / colour (1) - greyish brown plants are less likely to be (collected / found) as harder to see (1) - more likely to reproduce, passing on new allele (1) allele frequency increases (1)	Accept collection of plants results in natural selection Accept genetic variation for colour exists (in population) Accept greyish brown plants (better camouflaged / blend in) so not picked Accept converse for brightly coloured plants Accept more likely to pass on allele to offspring Accept converse for brightly coloured plants Accept allele increases in gene pool Accept converse for brightly coloured plants	(4)

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	A description that includes four of the following: - obtain DNA (from the two types of plants) (1) - use of {restriction enzymes / endonuclease} to cut DNA into fragments (1) {DNA / fragments} (loaded) on (agarose) gel with {current passed through / voltage or potential difference applied} (1) - fragments (of DNA) are separated (1) {same / similar} (banding) pattern suggests they are the same species (1)	Accept use of PCR to amplify DNA Accept use of {taq / DNA} polymerase to sequence DNA Accept movement of (negatively charged) DNA moves to positive electrode Accept description / diagram of banding pattern Accept shorter fragments travel further Accept converse Accept {same / similar} sequence suggests they are the same species	(4)

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	An explanation that includes two of the following: (if leaf is green it contains) chlorophyll / photosynthetic pigments (1) - so more light absorbed for photosynthesis (1) - so more glucose produced for growth (1) OR (if flower is brightly coloured) it attracts {pollinators / insects} (1) - so (more likely to) reproduce (successfully) (1) - to produce seeds / pass trait on (1)	Accept more wavelengths of light absorbed for photosynthesis Accept more light absorbed leads to higher rate of photosynthesis Accept more GALP / TP / GP for growth Accept so increased genetic variation (as less self-pollination) Accept asexual reproduction (through bulb) still possible if pollination does not occur	(2)

Total for Question 6 = 10 marks

Question Number	Answer	Additional guidance	Mark
6(a)	An explanation that includes three of the following: - because it does not allow for species with sexual dimorphism (1) - does not consider organisms in living different areas that cannot attempt to interbreed (1) - some species can produce hybrid offspring / plant species which can be fertile (1) - some species reproduce asexually (1)	allow examples	(3)

Question Number	Answer	Mark
6(b)	The only correct answer is D smaller fragments travel further A is not correct because all fragments do not travel the same distance B is not correct because larger fragments do not travel faster C is not correct because larger fragments do not travel further	(1)

Question Number	Answer	Additional guidance	Mark
6(c)(i)	An answer that includes four of the following points: - unknown species has 5 bands of DNA none of other species has 5 bands / has bands that don't match (1) - so is new species (1) 4 / most bands are in same position as species C (so most closely related to species C) (1) 3 bands in common with D (so next most related) / 2 bands in common with A (1) - least bands (only 1 band / no bands) in common with B (so least related) (1)	must indicate so is closely / less closely / less related once	(4)

Question Number	Answer	Mark
6(c)(ii)	A description that includes two of the following points: - examine protein biochemistry / proteomics/ (as similar species will have similar proteins coded for by similar DNA / genes) (1) - bioinformatics / DNA barcodes / CBOL (Consortium for the Barcode of Life) (1) - DNA sequencing / DNA profiling / molecular phylogeny (1) - examine ecology niche (to see if similar) (1) - look at morphology / anatomy / histology / structures (1) - examine shared evolutionary relationships (to see if evolved from common ancestor) (1)	(2)

(Total for Question 6 = 10 marks)

Question Number	Answer	Mark
7(a)(i)	The only correct answer is D (no yes yes) <i>A is incorrect as the genetic code is not overlapping</i> <i>B is incorrect as the genetic code is not overlapping</i> <i>C is incorrect as eukaryotes do have introns</i>	1

Question Number	Answer	Additional guidance	Mark
7(a)(ii)	An explanation that makes reference to two of the following: - because most amino acids have more than one triplet / code is degenerate (1) (genes contain) introns / non-coding DNA (1) - changing amino acid sequences affects {secondary structure / tertiary structure / quaternary structure / bonding / protein structure} (1)	Allow codon for triplet Allow converse	2

Question Number	Answer	Additional guidance	Mark
7 (a)(iii)	A description that makes reference to the following: DNA sequencing (1) - use gel electrophoresis (1) - comparing DNA band patterns / use bioinformatics to compare sequences in databases (1)	Allow Sangar sequencing Allow description of gel electrophoresis Allow fragments for bands Allow DNA hybridisation between two species	2

Question Number	Indicative content
7 *(b)	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Descriptions (D) • more diversity in wild for trees / non-woody species / non-endangered species / most species have higher diversity in wild / converse for seedbank • more diversity in seedbanks for endangered species / species of economic interest / converse for wild • non-woody species and non-endangered species have high variability / wide standard deviations • endangered species / trees how lower variability / lower standard deviations • the age in seed banks increases, the number of differences increases Explanations (E) • less breeding in seed banks / reproduction in wild increases variation • less gene flow in seed bank / more genetic drift occurs in wild • in wild more meiosis / crossing over / independent assortment / mutation / random breeding (to generate variation) • in the wild there is more selection pressure / natural selection • trees are slower growing / live longer, so less diversity • non-woody species have high reproduction rate so increased number of genetic changes • (for most) having fewer seeds stored means lower diversity • for endangered species there is inbreeding / genetic bottleneck / small gene pool (so lower diversity) • non-endangered species have high diversity due to higher numbers of each species / more breeding Validity of data and conservation role (V) • correct comment on whether differences are significant or not linked to overlapping error bars • (there is a correlation between genetic differences of seeds with age) but many outliers / less data for longer times • different group sizes so difficult to make (valid) comparisons / some groups have low numbers / low sample size (reduces validity) • shows need to keep rebreeding plants in seed banks to maintain diversity

		- show seedbanks play role in maintaining genetic diversity for conservation of endangered species (as more diversity in the seedbank) - no idea which dot is which species in scatter graph
Level	Marks	
0	0	No awardable content
1	1-2 (1-3)	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context. One mark: any one comment from D, E, or V Two marks: any two comments from D, E, or V
2	3-4 (4-6)	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure. Three marks: any three from two of D, E, or V Four marks: any four from two of D, E, or V
3	5-6 (7-9)	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. Five marks: any five from D, E <u>and</u> V Six marks: any six from D, E, <u>and</u> V and must relate to both graphs

Question Number	Answer	Additional Guidance	Mark
6(a)	The only correct answer is C A is incorrect because there is no cytoplasm in mitochondria B is incorrect because mitochondrial DNA is found in the matrix D is incorrect because mitochondria do not have a nucleus		(1)

Question Number	Answer	Additional Guidance	Mark
6(b)	The only correct answer is A B is incorrect because circular DNA has two more phosphodiester bonds than linear DNA with the same number of pentoses C is incorrect because mitochondrial DNA is circular D is incorrect because mitochondrial DNA is circular		(1)

Question Number	Answer	Additional Guidance	Mark
6(c)	An explanation that makes reference to four of the following: - position 1 : only the daughter has inherited this DNA from the mother (1) - position 2 : (genes located in) this DNA is common to all people (1) - position 3 : daughter and son 1 have inherited this DNA from their father but son 2 has not (1) - position 4 : this could be mitochondrial DNA as it is found in the mother and all children (1) - position 5 : this could be the mitochondrial DNA of the father as it is not present in any of the children (1)	IGNORE references to how the bands form Must refer to DNA in band at least once	(4)

Question number	Answer	Additional Guidance	Mark
6(d)(i)	substitution (1)	ACCEPT transition DO NOT ACCEPT insertion / addition / deletion / subtraction / chromosome mutation / frameshift / inversion / duplication / replacement	(1)

Question Number	Answer	Additional Guidance	Mark
6(d)(ii)	An explanation that makes reference to two of the following: - the cytosine will not bind with the adenine (1) - therefore the hydrogen bonds will not form (1) - so {the left hand loop will open up / other bonds may form} (1)	ACCEPT tRNA will be a different shape	(2)

Question Number	Answer	Additional Guidance	Mark
6(d)(iii)	An explanation that makes reference to two of the following: - the tRNA may not be able to bind with the ribosome (1) - and therefore not hold the amino acid in place (1) OR - the amino acid may not be able to bind to the tRNA (1) - and therefore {this amino acid cannot be / fewer of these amino acids} brought to the ribosome (1) OR - the anticodon may not be able to bind to the codon on the mRNA (1) - and therefore the amino acid will not be held in place (1)		(2)

Number	Answer	Additional Guidance	Mark
5(a)	An explanation that that makes reference to two the following: • using current / p.d. / electrodes (1) • because molecules are charged (1) • because {larger / longer / heavier} molecules move {shorter distance / move slower} (1)	ACCEPT Mps if reference is to DNA ACCEPT converse	(2)

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	An explanation that makes reference to two of the following points: • proteins digested / hydrolysed / digestive enzyme / protease (1) • therefore {smaller lengths / components / fragments / (poly)peptides} (1) • change pH / use buffer / use detergent (1) • therefore molecules charged / denatured / unfolded (1)		(2)

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	An explanation that that makes reference to four of the following: • the banding patterns are different (1) • different species have bands in different positions / different species have bands of different thickness (1) • because different fish or species have different proteins (1) • therefore different fish or species have different genetic material (1) • because DNA / genes code for protein (1)	ACCEPT converse ACCEPT converse ACCEPT converse	(4)

Question Number	Answer	Additional Guidance	Mark
5(b)(iii)	• identify the proteins (in the fish) / compare (pure protein sample) with fish protein		(1)

Question Number	Answer	Additional Guidance	Mark
5(b)(iv)	• amount / abundance (of protein / fragment)	ACCEPT mass / weight / concentration / density REJECT heaviness / size / charge	(1)

Question Number	Answer	Additional Guidance	Mark
5(c)		all correct = 2 one or two correct = 1	(2)

4 (a)	An explanation that makes reference to the following: - clotting takes longer at low temperature due to {low kinetic energy / fewer enzyme-substrate collisions} (1) - clotting time is least at {body/optimum} temperature (1) (clotting takes longer) at {temperatures above 37°C / high temperatures} (because) enzymes are denatured (1)	Accept clotting takes less time as temperature increases because {kinetic energy increases / more enzyme-substrate collisions}	(3)
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Question Number	Answer	Additional Guidance	Mark
4 (b)	6771		(1)

Question Number	Answer	Additional Guidance	Mark
4 (c)(i)	substitution	Accept point mutation	(1)
Question Number	Answer	Additional Guidance	Mark
4 (c)(ii)	1 in 50	Accept other correct probabilities e.g. 2% or 0.02	(1)

Question Number	Answer	Additional Guidance	Mark
4 (c)(iii)	An explanation that makes reference to the following: (excess prothrombin means) more thrombin (1) - therefore increased {conversion / catalysis} of fibrinogen to fibrin (1) - fibrin {is insoluble / traps blood cells / forms mesh / forms net} (1)	Accept if there is more fibrin it is more likely to clot	(3)

Question Number	Answer	Additional Guidance	Mark
4 (d)(i)	cut DNA to produce {short sections of DNA / short tandem repeats / mini satellites} (1)	Accept cut DNA into fragments / cut DNA to give sticky ends	(1)

Question Number	Answer	Additional Guidance	Mark
4 (d)(ii)	A description that makes reference to three of the following: - use (DNA) primers / nucleotides (1) - use {high temperature / 95 °C} for 30 seconds (to separate DNA strands) (1) - use {lower temperature / 55 °C} for 20 seconds (to bind primers) (1) - heat to 72°C with polymerase (to replicate DNA) (1) - repeat process (to obtain many copies of DNA) (1)		(3)

Question Number	Answer	Additional Guidance	Mark
9(a)	An answer that makes reference to three of the following: Similarities: - both consist of {(mono) nucleotides / adenine, guanine and cytosine} (1) - both contain phosphodiester bonds (1) Differences: - DNA has thymine whereas RNA has uracil (1) - DNA has deoxyribose whereas RNA has ribose (1)	DO NOT ACCEPT A,G,C DO NOT ACCEPT hydrogen bonds DO NOT ACCEPT T and U	(3)

Question Number	Answer	Additional Guidance	Mark
9(b)	A description that makes reference to four of the following: - use of reverse transcriptase to synthesise a DNA copy of the RNA strand (1) - details of the molecules needed in the PCR process (1) - details of the PCR process (1) - repeated cycles (1) {use of RNA polymerase / transcription} of DNA to make RNA (1)	Reverse transcription to convert RNA aptamer to DNA e.g. primers, buffers, DNA mononucleotides, DNA polymerase (2 of these) e.g. temperature cycles (high to break bonds, lower to synthesise DNA)	(4)

Question Number	Indicative content	
*9(c)	Indicative content: Graph 1: AT3 has the highest strength of binding of all with H1 AT1 binds the least except for H5 AT2 binds most to H7/least to H5 AT3 binds the most for all types apart from H7 All Aptamers bind to each haemagglutinin Graph 2: All Aptamers bind to all strains AT3 is binds strongest to W and Y and Z AT 2 binds strongest to X AT1 binds least to apart from Y Viral infections: - viruses attach to host cells - by attachment sites binding to receptor molecules - influenza uses haemagglutinin to bind to host cells Advantages of aptamers: - aptamer binding to haemagglutinin prevents attachment of influenza to host cell - virus cannot enter host cell and replicate - therefore viral infection will not spread - aptamers can bind to different strains of influenza and prevent infection by a range of strains - offering greater protection - aptamers can bind to a different types of haemagglutinin and therefore should prevent infection by a range of strains - offering greater protection - could bind to other {strains / haemagglutinins} that may result from mutations in the virus - offering further protection against new strains	Level 1 1 mark = any two comments 2 marks = 3 descriptions or 1 description and 2 adv/disadv or 2 descriptions and 1 adv/disadv Level 2 : Minimum 3 descriptions + 3 marks = 1 advantage / disadvantage 4 marks = 2 advantages / disadvantages Level 3 Minimum 3 descriptions + 5 marks = 3 statements that include at least one advantage and one disadvantage 6 marks = 4 statements that include at least one advantage

	Disadvantages of aptamers: • virus may mutate and aptamer may not be able to bind • not part of the immune system • not in immunological memory • so protection could be short-lived • new treatment so {long term / side effects} not known • no details on how long they last in the body • as they bind to a range of haemagglutinins they may bind to other molecules/cells • reference to lack of error bars and therefore cannot determine significance of results	and one disadvantage
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	Marks	AO2 discuss
0	0	No awardable content
1	1-2	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.

2	3-4	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.
3	5-6	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.

Question Number	Answer	Additional Guidance	Mark
5(a)(i)	{methyl group / CH ₃ } added to a {base (cytosine or adenine) / cytosine / adenine / CpG site}	DO NOT ACCEPT between cytosine and guanine ACCEPT A for adenine, C for cytosine, G for guanine	

Question Number	Answer	Additional Guidance	Mark
5(a)(ii)	A description that makes reference to the following: {zygote / morula} are totipotent stem cells as they give rise to all cell types (1) {blastocyst / inner cell mass} contains pluripotent cells that give rise to the cells of the embryo (and not the extra embryonic tissue) / most cell types (1) - cells in the developing embryo are multipotent as they become only some cell types (1)	ACCEPT references to early and late stages of development if clear from description which stages are being referred to ACCEPT cleavage cells ACCEPT {trophoblastic cells / cells around the outside of the blastocyst} as they become extra embryonic tissue N.B. If correct description given for 2 or more types of stem cell but no reference to embryo, award 1 mark	

Question Number	Answer	Additional Guidance	Mark
5(a)(iii)	An explanation that makes reference to two of the following: - level of DNA methylation increases after the blastocyst stage (1) - because genes {switched off / silenced / inactivated / cannot be transcribed / cannot be expressed} (1) - causing cells to become {specialised / differentiated} (1)		

Question Number	Answer	Additional Guidance	Mark
5(b)	An explanation that makes reference to two of the following: - because they are (fully) differentiated cells (1) - therefore genes needed (for other cell types) are (permanently) {switched off / silenced} (1) - therefore proteins needed by other cell types cannot be produced (1)	ACCEPT specialised ACCEPT not able to express certain genes	

Question Number	Answer	Additional Guidance	Mark
9(a)(i)	The only correct answer is A <i>B is incorrect because electron transport chain is located on the inner membrane</i> <i>C is incorrect because electron transport chain is located on the inner membrane</i> <i>D is incorrect because electron transport chain is located on the inner membrane</i>		(1)

Question Number	Answer	Additional Guidance	Mark
9(a)(ii)	An explanation that makes reference to the following: - because the electron transport chain can no longer function (1) - resulting in protein carriers / named carrier} becoming reduced (1) - therefore cells can only respire anaerobically (1) - therefore insufficient {ATP / energy} generated to sustain the fish (1)	ACCEPT {electrons transfer can no longer occur / electrons cannot flow through the cytochromes} slower / less DO NOT ACCEPT in context of no oxygen present ACCEPT cannot become oxidised / {NAD / FAD} cannot be regenerated / redox reactions cannot occur ACCEPT oxidative phosphorylation will be prevented / no protons pumped into intermembrane space / ATPase cannot synthesise ATP ACCEPT a reason for fish not being able to survive e.g. {heart / muscles} to contract, active transport, metabolism, chemical reactions lactic acid build up denaturing enzymes / stopping muscle contraction IGNORE no energy for respiration energy to swim too vague	(3)

Question Number	Answer	Additional Guidance	Mark
9(b)(i)	changes in {gene expression / phenotype} without a change in {base sequence / DNA / gene / genotype / genetic code} (1)	ACCEPT switching genes on or off DO NOT ACCEPT mutation	(1)

Question Number	Answer	Additional Guidance	Mark
9(b)(ii)	The only correct answer is B <i>A is incorrect because deletion mutation changes the base sequence</i> <i>C is incorrect because translation is the synthesis of a peptide chain</i> <i>D is incorrect because translocation affects the DNA base sequence</i>		(1)

Question number *9(c)	Data : <u>First generation fish</u> - male fish from environment with H₂S have more DMRs than male fish from environment without H₂S - female fish from environment with H₂S have more DMRs than female fish from environment without H₂S - number of DMRs increase up to a CpG density of 3 a.u. and then decrease - the number of female DMRs and male DMRs show a similar pattern - female fish have more DMRs than male fish <u>Second generation fish</u> - second generation fish show similar patterns of DMRs as the original fish - but there are differences e.g. male fish showing more DMRs at a CpG density of 2 than {original fish / female fish} - there are significant differences for the males at lower CpG densities, original females higher but 2nd gen females lower Lower level discussion points : recall of knowledge of epigenetics / experimental design : - DNA methylation of cytosine at CpG sites - Methylations adds a CH₃ - DNA methylation causes silencing of genes - by preventing transcription - epigenetic modifications are {inherited / passed down} - no details of experiment - no statistical analysis Higher level discussion points : - the presence of H₂S could be causing {DNA-methylation / epigenetic modification} - but no indication of other differences in the water that could be causing this (wild) males could be less susceptible to DNA-methylation than female fish (so increase not so great) / genetic effects - females have more methylation sites on second X chromosome - female fish already more adapted to toxic environment - DMRs have been retained by the second generation of fish - and stable / retained even after H₂S no longer present - but it appears that the laboratory conditions are also causing more DMRs to be formed in male fish - DNA methylation is a survival advantage - fish with more DNA methylation are better adapted to H₂S - as interruption to mitochondrial respiration is reduced / ETC can continue - DNA methylation can stimulate gene expression - so proteins synthesised that {inhibit H₂S / provide an alternative to cytochrome c oxidase}
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NB IGNORE all values given unless clearly wrong

Level 1 : Data commented on without any discussion

1 mark = any relevant comment

2 marks = some comparison of data

Level 2 : Some data discussed

3 marks = 1 discussion point

4 marks = 2 discussion points

Level 3 : Data discussed with some application of ideas

5 marks = comparisons described + 3 discussion points, including at least one higher level point

6 marks = comparisons described + 4 discussion points, including at least one higher level point



Question Number	Answer	Additional Guidance	Mark
8(a)(i)	(other : pulmonary) 2.5 : 1 / 2.5 / 1 : 0.4 / 0.4 (pulmonary : other) 1 : 2.5 / 2.5 / 0.4 : 1 / 0.4	DO NOT ACCEPT with units	(1)

Question Number	Answer	Additional Guidance	Mark
8(a)(ii)	An explanation that makes reference to the following: (partial pressure of oxygen is low in) pulmonary artery is carrying deoxygenated blood to lungs (1) (partial pressure of oxygen is high in) arterial blood is carrying oxygenated blood to the {body / cells / tissues} (1)	NB piece together ACCEPT deoxygenated as it has come back from the body ACCEPT oxygenated as it has been through lungs	(2)

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	An explanation that makes reference to two of the following: - because HIF can switch on gene (expression) (1) - bind to a promotor region / stimulate transcription / stimulate protein synthesis (1) - for {enzymes / proteins} involved in glycolysis (1)	ACCEPT increased gene expression ACCEPT increase rate of transcription IGNORE enzymes ACCEPT named {enzyme / protein} involved in glycolysis e.g. enzyme that makes NAD	(2)

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	An explanation that makes reference to the following: (because if conditions are hypoxic) there is not much oxygen available to act as a terminal electron acceptor (1) - therefore the electron transport chain will not operate (1) - therefore ATP production by oxidative phosphorylation will be reduced (1) - ATP is produced (directly / SLP) during glycolysis (during these anaerobic conditions) (1)	ACCEPT no oxygen	(4)

Question Number	Answer	Additional Guidance	Mark
8(b)(iii)	An answer that makes reference to the following: - both HIF-1 and HIF-2 increase (during hypoxia) (1) - levels of HIF-2 remain high (after a small decrease) but levels of HIF-1 fall (1)	DO NOT PIECE TOGETHER	(2)

Question Number	Answer	Additional Guidance	Mark
8(b)(iv)	An explanation that makes reference to two of the following: - HIF-1 and HIF-2 switch on different genes (1) {products / transcription of genes} resulting from the presence of both HIF-1 and HIF-2 are needed in the early stages of hypoxia (1) {products / transcription of gene} resulting from the presence of HIF-2 are needed {for longer periods of hypoxia / to sustain glycolysis} (1)	ACCEPT bind to different promotor regions ACCEPT converse for HIF-1	(2)



Question Number	Answer	Additional Guidance	Mark
8(a)	The only correct answer is C A is incorrect because neither carbohydrates nor lipids contain N B is incorrect because lipids do not contain N D is incorrect because carbohydrates do not contain N		(1)

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	The only correct answer is B A is incorrect because the mesophyll layer is the gas exchange surface C is incorrect because the mesophyll layer is the gas exchange surface D is incorrect because the mesophyll layer is the gas exchange surface		(1)

Question Number	Indicative content	
*8(b)(ii)	Indicative content: Depth of layers • smaller in low N (D)/(larger in high N (D)) • therefore mesophyll layer may be narrower (E) • therefore less chlorophyll for light-dependent stages (E) • therefore less stroma / RUBISCO for Calvin cycle (E) • therefore diffusion of gases will be higher (E) • therefore higher concentration of carbon dioxide for Calvin cycle (E) • Allow converse for all statements above (E) Size of chloroplasts • smaller in low N (D)/ (larger in high N (D)) • therefore less chlorophyll for light-dependent stages/less light absorbed (E) • therefore less ATP/NADPH (E) • less stroma / RUBISCO for Calvin cycle (E) • therefore RUBISCO maybe at a lower concentration • therefore Calvin cycle will be slower • Allow converse for all statements above (E) Surface area of chloroplasts exposed to intercellular air space • lower in low N plants (D)/ (higher in high N (D)) • therefore reduced gas exchange (E) • therefore lower concentration of carbon dioxide (E) • so Calvin cycle will be slower (E) • converse of statements above (E) RUBISCO activity • lower in low N (D) • lower in high N (D) • therefore Calvin cycle will be slower (E) • as RUBISCO catalyses carbon fixation (E) • and rate of reaction decreases with decrease in enzyme concentration (E)	Allow converse for all statements Level 1 1 mark = description of 2 characteristics 2 marks = explanation for 1 of the characteristics Level 2 : 3 marks = explanation for 2 of the characteristics 4 marks = explanation for 3 of the characteristics Level 3: 5 marks = extended explanation for 3 of the characteristics 6 marks = extended explanation for all 4 characteristics

	Marks	AO2 discuss
0	0	No awardable content
1	1-2	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.
2	3-4	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.



3	5-6	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.
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Question Number	Answer	Additional Guidance	Mark
8(c)(i)	An answer that makes reference to three of the following: Any two from - more {changes/increase/decrease} in gene expression in low levels of nitrogen (1) - more genes were not expressed in plants than expressed in both groups of plants (1) - some of the genes that were either expressed or not expressed were the same in both groups of plants (1) And - calculation used to illustrate at least one of the changes (1)	e.g Low levels 467 genes increased, 924 increased. High levels 294 genes increased, 601 decreased. Expression of 200 genes was similar in high and low levels of N. 496 more genes were affected in low levels than high levels.	(3)

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Question Number	Answer	Additional Guidance	Mark
8(c)(ii)	A description that makes reference to the following: - epigenetic modification (1) - credit example of epigenetic modification (1)	e.g. methylation, transcription factors, histone modification, acetylation	(2)

Question Number	Answer	Additional Guidance	Mark
8(a)	An explanation that makes reference to the following: - if AR is too early then there will not be the enzymes available for fertilisation (1) - and it will not be able to digest through the zona pellucida/jelly coat (1) - if AR is too late then {the egg/sperm (cell) may have died / the sperm have swam past the egg (cell)} (1)		(3)

Question Number	Answer					Additional Guidance	Mark																								
8(b)	<table><tr><th rowspan="2">Event</th><th colspan="2">Presence of protein G</th><th colspan="2">Presence of protein G-P</th></tr><tr><th>Head region</th><th>Mid piece and flagellum</th><th>Head region</th><th>Mid piece and flagellum</th></tr><tr><td>Just before capacitation</td><td>✓</td><td>✗</td><td>✗</td><td>✓</td></tr><tr><td>During capacitation</td><td>✓</td><td>✗</td><td>✗</td><td>✓</td></tr><tr><td>Just before the AR</td><td>✗</td><td>✗</td><td>✓</td><td>✓</td></tr></table>					Event	Presence of protein G		Presence of protein G-P		Head region	Mid piece and flagellum	Head region	Mid piece and flagellum	Just before capacitation	✓	✗	✗	✓	During capacitation	✓	✗	✗	✓	Just before the AR	✗	✗	✓	✓		(4)
							Event	Presence of protein G		Presence of protein G-P																					
						Head region		Mid piece and flagellum	Head region	Mid piece and flagellum																					
						Just before capacitation	✓	✗	✗	✓																					
						During capacitation	✓	✗	✗	✓																					
						Just before the AR	✗	✗	✓	✓																					

Question Number	Answer	Additional Guidance	Mark
8(c)	An explanation that makes reference to the following: - DNA methylation {silences / switches off} a gene (1) - Because is a form of epigenetic modification (1) - therefore the gene cannot be transcribed / therefore no protein G will be produced (1) - without protein G the timings of capacitation and AR will be wrong (1)	ACCEPT Transcription factors cannot bind to DNA ACCEPT If AR not inhibited, AR will happen too soon	(3)

Question Number	Answer	Additional Guidance	Mark
8(d)(i)	An answer that makes reference to the following: - genetically-modified (laboratory) mice (1) - that have had the gene coding for protein G {inactivated / replaced} (1)	ACCEPT genes coding for protein G prevented from being expressed	(2)

Question Number	Answer	Additional Guidance	Mark
8(d)(ii)	A description that makes reference to three of the following: - all female mice would have to be fertile (1) - fertile males used as a control (1) - pregnancy rate measured (1) - Same species/age of mouse/diet (1)	ACCEPT Control group that have not had gene modified ACCEPT Number of offspring produced	(3)

Question Number	Answer	Additional Guidance	Mark
9(a)(i)	An explanation that makes reference to three of the following: - because the embryo is increasing in cell number (1) - all the cells are unspecialised (1) - and have no genes switched on to produce the globin subunits (1) - no yolk sac has developed yet (1)	ACCEPT Mitosis is occurring ACCEPT Cells have not differentiated/are differentiating IGNORE genes haven't been switched off	(3)

Question Number	Answer	Additional Guidance	Mark
9(a)(ii)	An answer that makes reference to four of the following: - the structure responsible for synthesising the globin subunits changes with time after fertilisation (1) - the {embryo / fetus} contains gamma globin and either epsilon or beta globin (and some delta) (1) - the baby has increasing levels of beta (and delta globin) and decreasing levels of gamma globin (1) - yolk sac is responsible for synthesis of epsilon globin (1) - the liver synthesises mainly gamma globin (1) - bone marrow synthesises both components of adult haemoglobin (1)	ACCEPT Mainly gamma made before birth and mainly beta after birth ACCEPT Liver synthesises gamma and beta ACCEPT Bone marrow synthesises beta haemoglobin	(4)

Question Number	Answer	Additional Guidance	Mark
9(a)(iii)	- correct two values read from graph, subtracted and divided by 2.4 (1) - answer given to 2 decimal places + (decrease in percentage of γ globin synthesised) per month / (%) month⁻¹ (1)	$(84 - 32) \div 2.4 = 21.666667$ 21.67 month⁻¹ / month = 2 marks 21.66 month⁻¹ / month = 1 mark	(2)

Question Number	Answer	Additional Guidance	Mark
9(b)(i)	- number of people without sickle cell disease calculated (1) - ratio calculated (1)	67 million - 15 000 = 66 985 000 4466:1 = 2 marks 66 985 000 : 15 000 = 4 465.666666666666 : 1	(2)



Question Number	Indicative content	Mark
*9(b)(ii)	(1)Globin subunits and sickle cell disease : - sickle cell anaemia is caused by a mutation - in the gene coding for the beta globin subunit - which causes the red blood cells change shape - and reduces the blood supply to cells of the body - fetal haemoglobin contains gamma globin which is switched to beta globin at birth (2)BCL11A gene : - switch due to the presence of the gene product from the BCL11A gene - if BCL11A switched off there will be no transcription - therefore BCL11A will not be produced - and therefore gamma globin will still be produced (fetal) - which is not defective - therefore red blood cells will no longer be sickle shaped - haemoglobin affinity would be higher (3)Method used : - bone marrow stem cells used as these are the cells that produce haemoglobin in the fetus and the baby - stem cells will divide by mitosis - to produce genetically-identical cells - that will all contain the modified BCL11A gene - advantage of using own stem cells is that they will not cause an immune response when returned to body - as there will not be any (foreign) antigens for the immune system to recognise - and own stem cells will not be rejected - wont need immunosuppressants (4)Ethics: - new technology so little evidence on effect - e.g. that this will work in the long term - e.g. there are no unanticipated changes - relevant comment about cost - changes will not be inherited - painful to extract cells from patient	(6)
	- may become cancerous - Cells taken from patient not embryo - Treatment would save lives - If young, they cannot consent - Who will the treatment be available to - Don't know long term effects of GM	

			Additional guidance
Level 0	0	No awardable content	
Level 1	1-2	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.	Limited discussion about the treatment/SCD/ethics 1 mark = one comment made from any section 2 marks = two comments made from any section
Level 2	3-4	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts / concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.	Limited links made between treatment and SCD 3 marks = basic understanding of approach used 4 marks = understanding of method
Level 3	5-6	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant biological facts / concepts. Consequences are discussed which supported throughout by sustained linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Extended links made between treatment and SCD 5 marks = aspects from 3 sections discussed including the ethical issues 6 marks = detailed discussion including both the ethical issues and the significance of using own stem cells

Question Number	Answer	Additional Guidance	Mark
3(a)	B <i>Puccinia</i>	A is incorrect because <i>Plasmodium</i> is a protist that causes malaria C is incorrect because <i>Salmonella</i> is a bacteria that causes food poisoning D is incorrect because <i>Staphylococcus</i> is a bacteria that causes food poisoning	

Question Number	Answer	Additional Guidance	Mark
3(b)	An explanation that makes reference to three of the following: (stem rust) fungus {takes up / uses} {nutrients / glucose / amino acids} (1) - less {glucose to form starch / amino acids to form protein} (1) (stem rust) fungus interferes with vascular tissue (1) - consequence of damaged vascular tissue (1)	ACCEPT glucose for respiration (by the plant) e.g. weakened stems , less magnesium ions for chlorophyll, less sucrose to transport to roots	

Question Number	Answer	Additional Guidance	Mark
3(c)	An answer that makes reference to three of the following: - because {meiosis / sexual reproduction / basidiospore production} results in {genetically different fungi / variation} (1) - because of {crossing over / random assortment / independent assortment} (1) - because of mutation (in the DNA) (1) - the {asexual cycle / production of uredinospores} results in more stem rust fungus that plants are not resistant to (1)	ACCEPT recombinants ACCEPT only in the context of causing variation DO NOT ACCEPT meiosis causes mutation ACCEPT clones of stem rust fungus that plants are not resistant to	

Question Number	Answer	Additional Guidance	Mark
3(a)	The only correct answer is A B is incorrect because <i>Plasmodium</i> is the genus name not the species name C is incorrect because <i>Plasmodium</i> causes malaria not <i>Puccinia</i> D is incorrect because <i>Plasmodium</i> causes malaria not <i>Puccinia</i>		(1)

Question Number	Answer	Additional Guidance	Mark
3(b)	A description that makes reference to three of the following: • {gene / DNA / genetic material} coding for toxin isolated (from the spiders) (1) • using {restriction enzymes / (restriction) endonucleases} (1) • (spider) gene inserted into fungus using a {vector / named vector} (1) • genetically-modified fungi {identified / cloned / cultured} (1)	ACCEPT mRNA isolated and used to synthesise the gene / base sequence of gene determined and used to synthesise a gene ACCEPT in context of vector DNA e.g. virus / plasmid / gene gun / injection ACCEPT replicate / reproduce	(3)

Question Number	Answer	Additional Guidance	Mark
3(c)	An explanation that makes reference to three of the following: • not unethical as mosquitoes not killed (1) • risk of other organisms being affected by the genetically-modified fungus is avoided (1) • organisms that feed on mosquitoes will not lose their food supply (1) • some people believe that modifying DNA is {wrong / unethical} (1)	ACCEPT converse for other approach e.g. toxins could harm other organisms, transfer of genes into other organisms ACCEPT unknown risks ACCEPT biodiversity maintained / ecosystems not disrupted / food chain not disrupted	(3)

Number	Answer	Additional Guidance	Mark
3(a)(i)	(DNA) ligase (1)		(1)

Question Number	Answer	Additional Guidance	Mark
3(a)(ii)	<i>A. tumefaciens</i> (1)	Accept plasmid / bacterium Ignore any names of plasmids if given	(1)

Question Number	Answer	Additional Guidance	Mark
3(b)	An explanation including two of the following - plant cells are totipotent (1) - plant cells contain gene for herbicide resistance (1) - cells divide by mitosis (to produce genetically identical daughter cells) (1) - so (herbicide resistant) plants can be grown from {one / a few} plant cells (1)	Ignore references to sexual / asexual reproduction Accept cells from {crown gall / callus / tumour} are totipotent Accept plant cells contain {modified gene / recombinant DNA} Accept cells from {crown gall / callus / tumour} divide by mitosis	(2)

Question Number	Answer	Additional Guidance	Mark
3(c)	An explanation that includes three of the following: (in GM plants) herbicide {kills / removes} weeds but not crop plant (1) - so there is less competition (from weeds) (1) - for one named resource (1) - for second named resource (1) - so {more {light / water} for photosynthesis / more nitrates for {proteins / amino acids} / named mineral for appropriate function} (1)	Accept (for non-GM plants) herbicide would kill soya bean plants, so cannot be used to kill weeds Accept (in non-GM plants) weeds compete with soya bean plants Accept water / light / minerals / named mineral Ignore space / nutrients / CO₂ Accept so {less {light / water} for photosynthesis / less nitrates for {proteins / amino acids} / less named mineral for appropriate function in non-GM plants	(3)

(Total for Question 3 = 7 marks)

	Additional Guidance	Mark	Answer	Mark
placebo} / GM plant d cell} (1)	ACCEPT range of vaccine concentration if one is zero	(5)	re following: ylic acid / COOH / carboxyl group} (1) {a double bond / C=C / carbons with only one H} (1)	(2)
	ACCEPT (infection with virus and) {observe symptoms / ill / diseased / survive} DO NOT ACCEPT group			
			Answer	Mark
			ir of the following: ene / DNA / allele / plasmid} (1) 'DNA / allele} (1)	
			ne gun / virus / electroporation /	
			ACCEPT remove cell wall / produce a protoplast	(2)

Question Number	Answer	Mark
9(a)	9(a). The only correct answer is D <i>A is not correct because macrophages do not produce antibody</i> <i>B is not correct because memory cells do not produce antibody</i> <i>C is not correct because neutrophils do not produce antibody</i>	(1)

Question Number	Answer	Additional Guidance	Mark
9(b)	A description that makes reference to the following: - changes that affect gene {expression / activation} (1) - credit an example of epigenetic modification (1) - involved in {differentiation / change in function / change in proteins synthesised } (1)	Do not accept altering the DNA / base sequence / genetic code e.g. DNA methylation, histone {modification / methylation / acetylation} / chromatin remodelling / non-coding RNA / transcription factors Accept when a B cell becomes a plasma cell	(3)

Question Number	Answer	Additional Guidance	Mark
9(c)	An explanation that makes reference to two of the following: - to produce lots of {genetically identical / hybridoma} cells (1) - so that lots of antibodies (of one type) can be produced (by hybridoma cells) (1) - so that the hybridoma cells can divide (1)	Accept because a {fully-differentiated / antibody-producing / plasma} cell cannot divide	(2)

Question Number	Answer	Additional Guidance	Mark
9(d)(i)	An explanation that makes reference to the following: - humanised antibodies will not trigger an immune response / mouse antibodies could trigger an immune response (1) - antibodies would {bind to cancer cells so that macrophages could destroy the cancer cells / opsonise the cancer cells} (1) - the antibodies are target specific (1) - reducing the need for other {treatments / named treatment} (1)	Accept humanised antibodies will not be recognised as {foreign / as an antigen} / mouse antibodies could be recognised as {foreign / as an antigen} Accept antibodies will bind only to cancer cells Accept have less {side effects / named side effects}	(3)

Question Number	Indicative content
*9(d)(ii)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Description: - mouse antibody is made of all mouse components - humanised antibody consists mostly of human components - mouse antibody recognised by the patient's immune system (rejection) - mouse protein acts as an antigen Consequence: - mouse antibody could be destroyed - mouse antibodies would not persist in the body - macrophages may not bind to mouse antibody - so phagocytosis of the cancer cells would not be enhanced - humoral / B cell immune response could be initiated - macrophages may phagocytose the mouse antibody Immunology: - details of how macrophage destroys antibody - macrophage becomes an antigen-presenting cell - T helper cells become activated - antibodies against the mouse antibodies could be produced (by plasma cells) Accept converse for humanised antibody throughout

Level 0	0	No awardable content
Level 1	1-2	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. Description of mouse antibody resulting in rejection (Accept converse for humanised antibody throughout)
Level 2	3-4	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts to provide the explanation being presented. Lines of argument occasionally supported through the application of relevant evidence (scientific ideas, processes, techniques and procedures). The explanation shows some linkages and lines of reasoning with some structure. Details given on why the mouse antibodies may not be effective in treating the cancer (Accept converse for humanised antibody throughout)
Level 3	5-6	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts to provide the explanation being presented. Line(s) of argument supported throughout by sustained application of relevant evidence (scientific ideas, processes, techniques and procedures). The explanation shows a well-developed and sustained line of reasoning which is clear, coherent and logically structured. Explanation of how the mouse antibody could be destroyed by the immune system (Accept converse for humanised antibody throughout)

Total for Question 9 = 15 MARKS

TOTAL FOR PAPER = 90 MARKS



Answer	Additional Guidance	Mark
reference to the following: / have no metabolism / thesis organelles / lack a cell wall / (1) because they inhibit replication (1)		(2)

Answer	Additional Guidance	Mark
reference to four of the that fluoresce (1) mites are / contain the gene} (1) resce / GM mosquitoes} to interbreed erations (1) ie for fluorescence are selected to of GM mosquitoes (1)	Do not accept eggs	(4)

9B103

9B

Answer	Additional Guidance	Mark
reference to the following: 14 and 2015 (1) crease calculated (1)	<u>Example of calculation:</u> 150 and 1240 to 1245 1240 – 150 = 1090 (1090 ÷ 150) × 100 = 727 1245 – 150 = 1095 (1095 ÷ 150) × 100 = 730 Accept range 727 to 730 Correct answer with no working gains full marks	(2)

Mark	Answer	Additional Guidance	Mark
	es reference to the following: g} of peptide bonds (1)		(2)

Answer	Additional Guidance	Mark
es reference to two of the th Zika) being bitten (1) g uninfected people / nosquitoes} (1) her diseases (1)		(2)

(4)

Answer	Additional Guidance	Mark
		(1)

Mark

Answer	Additional Guidance	Mark
reference to the following: make (viral) protein (1) d (1)		(2)

(4)

9B103

Question Number	Answer	Additional Guidance	Mark
9(a)	- tonnes produced by Brazil calculated (1) - yield calculated for each country (1) - difference calculated (1)	ALLOW values that are correctly rounded up in the first two steps of the calculation (93 million $\times$ 100) $\div$ 109.4 = 85.00914077 (million tonnes) 93 million $\div$ 31 million = 3 (tonnes per hectare) and 85.00914077 million $\div$ 28 million = 3.036040742 (tonnes per hectare) 3.036 - 3 = {0.036 / 0.04} tonnes (per hectare less by US / more by Brazil) CE applies throughout	(3)

Question Number	Indicative content
*9(b)(i)	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. <u>Indicative content</u> Table 1 - Ponta Grossa: transgenic plants have higher mineral content than non-transgenic plants - Londrina: transgenic plants have lower mineral content than non-transgenic plants - Transgenic plants: plants grown in Ponta Grossa have lower mineral content than plants grown in Londrina - Non-transgenic plants: plants grown in Ponta Grossa have lower mineral content than plants grown in Londrina - Londrina: both types of soybean have more mineral content than both types in Ponta Grossa Table 2 - Ponta Grossa: transgenic plants have higher protein and lipid but lower carbohydrate content than non-transgenic plants - Londrina: transgenic plants have higher lipid but lower protein and carbohydrate content than non-transgenic plants - Transgenic plants: plants grown in Ponta Grossa have higher lipid but lower protein and carbohydrate content than plants grown in Londrina - Non-transgenic plants: plants grown in Ponta Grossa have higher lipid but lower protein and carbohydrate content than plants grown in Londrina - Londrina: both types of soybean have more protein and carbohydrate but lower lipid than both types in Ponta Grossa

	Examples of Conclusions	
	- Londrina soybeans are (generally) the most nutritious - In Londrina, non-transgenic soybeans are more nutritious - In Ponta Grossa, transgenic soybeans are more nutritious - Very little difference in nutritional content overall	
Level 0	Marks	No awardable content
Level 1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. 2 / 3 comparisons / conclusions
Level 2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure. 4 / 5 comparisons / conclusions
Level 3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. 6 / more comparisons and conclusions



Question Number	Answer	Additional Guidance	Mark
9(b)(ii)	An explanation that makes reference to five of the following: - Londrina (has a more fertile soil therefore the) soya beans will have a higher {mineral / mineral ion / ion / named mineral ion} content (1) - Londrina (has a more fertile soil therefore the) soya beans will have a higher protein content as there will be more nitrates (1) - Londrina has a higher temperature so {photosynthesis / Calvin cycle / carbon fixation} will be faster (1) - as {enzymes / RUBISCO} will {increase rate of reactions / have more kinetic energy} (1) - therefore making more {organic molecules / carbohydrate / named carbohydrate / protein} (1) - Londrina has a higher rainfall therefore more water for {photolysis / transport of minerals} (1)	ACCEPT {photosynthesise faster as more magnesium ions for chlorophyll / be stronger as more calcium ions for cell walls / more phosphate for ATP or nucleic acid synthesis} ACCEPT greater activity / work faster ACCEPT light-dependent reactions	(5)

Question Number	Answer	Additional Guidance	Mark
9(b)(iii)	An explanation that makes reference to the following: - to compare the fatty acids in the two types of soya bean (1) - so that {the (transgenic) soybeans will be less likely to increase the risk of heart disease / oxidation is less likely} (1)	ACCEPT to see if there were less saturated fatty acids / less linoleic acid / more oleic acid ACCEPT converse less likely to go rancid oleic acid less likely to oxidise than linoleic acid	(2)

