Questions

Q1.

The scientific article you have studied is adapted from several sources.

Use the information from the scientific article and your own knowledge to answer the following questions.

Tabor used enzymes to genetically modify a 'harmless species of *Escherichia coli*' (paragraph 26).

Describe the functions of the enzymes used to genetically modify bacteria.

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(Total for question = 4 marks)

Q2.

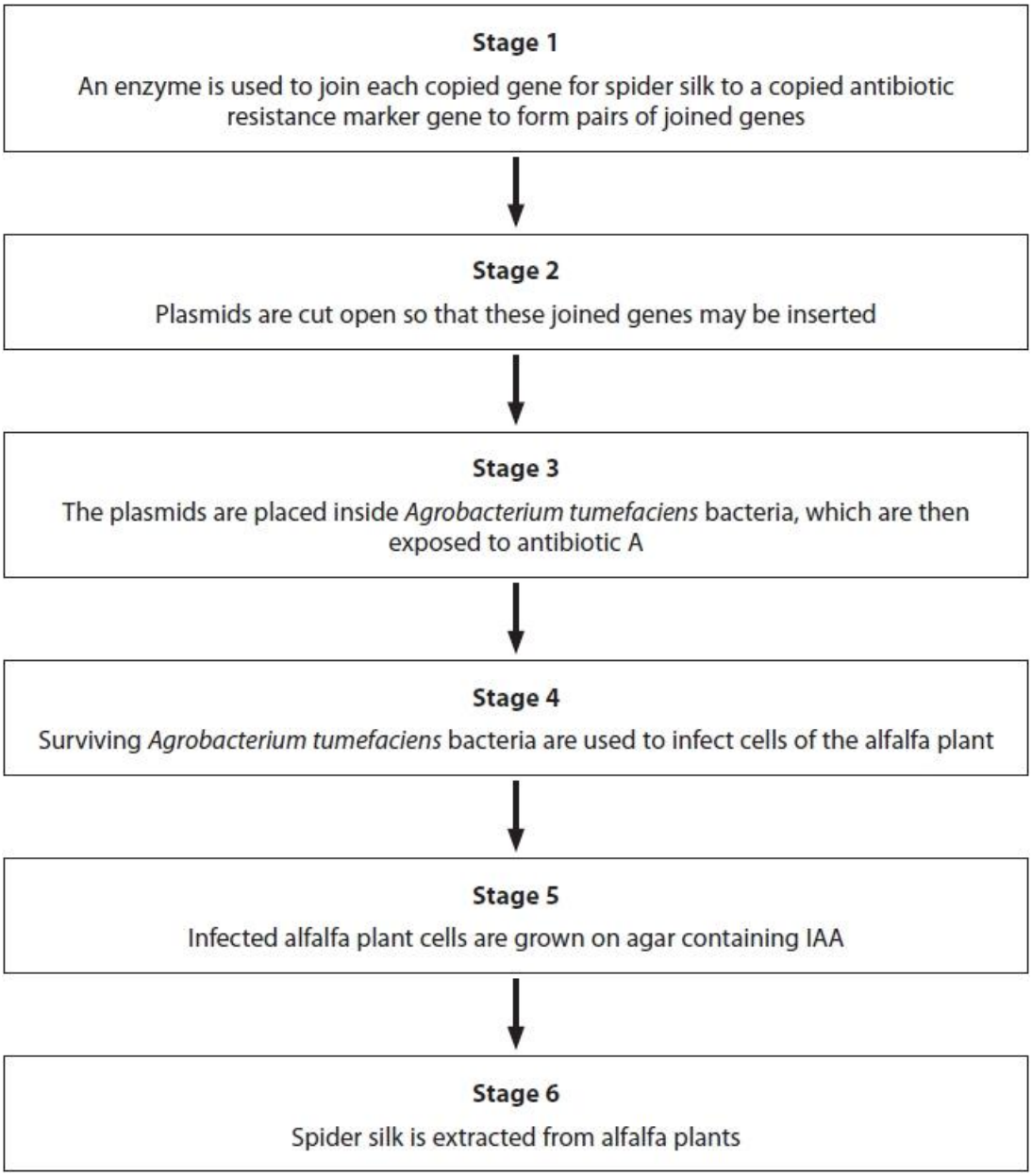
Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Spider silk is a very strong and flexible natural fibre. It is of interest to humans as a possible fibre for protective clothing.

Scientists have genetically modified a range of organisms to produce spider silk, including goats and plants such as alfalfa.

A gene for spider silk is copied. A gene for resistance to antibiotic A is also copied.

The flow diagram shows some of the stages in genetically modifying alfalfa plants to produce spider silk using the copied genes.



(i) Explain how an enzyme is involved in joining the two different genes together in stage 1.

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(ii) Which one of the following enzymes can be used to cut open the plasmids in stage 2?

(1)

- ☒ **A** DNA polymerase
- ☒ **B** RNA ligase
- ☒ **C** RNA polymerase
- ☒ **D** restriction endonuclease

(iii) Explain why antibiotic A is used in stage 3.

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(iv) Give reasons why the infected alfalfa plant cells are grown on agar containing IAA in stage 5.

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(v) The table shows the mass of spider silk produced from the genetically modified alfalfa in stage 6. It also shows the mass of spider silk produced from the genetically modified goats.

Organism	Mass of spider silk produced per year
Alfalfa	218 kg per acre
Goat	10 kg per goat

A typical number of goats that can be kept on one acre of land is 12.
Calculate the percentage increase in spider silk produced by the alfalfa plants compared with the goats.

(3)

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(Total for question = 11 marks)

Q3.

The modern bread wheat plant (*Triticum aestivum*) has been developed from other plant species that have different genomes.

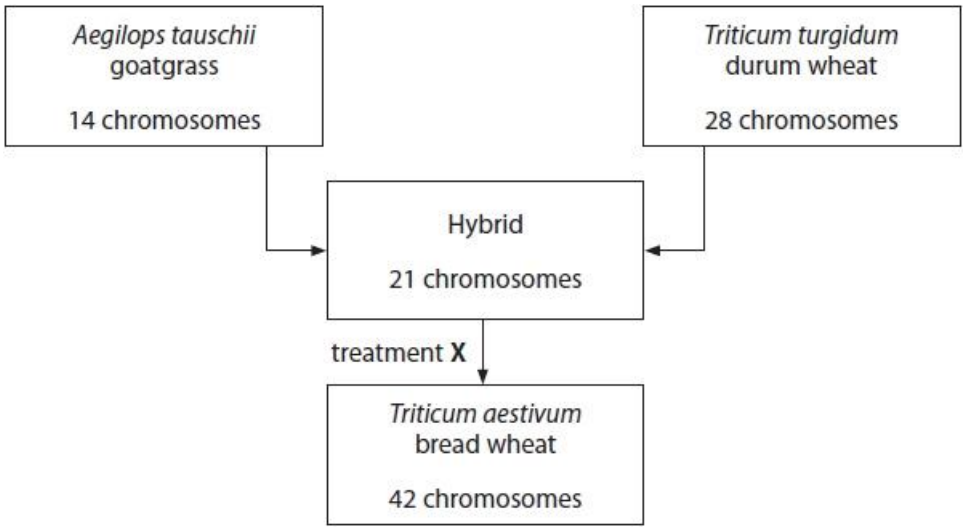
Three species of plant and their genomes are shown in the images.

Triticum aestivum
Genomes A, B and D

Triticum turgidum
Genomes A and B

Aegilops tauschii
Genome D

The diagram shows how chromosomes from different species have combined to produce the bread wheat species used to produce flour.



* New varieties of plants with desirable combinations of characteristics can be produced using the methods shown in the table.

Method	Example
Formation of hybrids	In wheat, genome D includes genes for a tolerance of harsh conditions and genome A promotes large starch stores in seeds.
Genetic modification	Production of specific molecules in plant cells.
Selective breeding	Plants with desired characteristics can be used for breeding to produce plants with combinations of desired characteristics.

Evaluate the risks and benefits of producing varieties of plants using these methods.

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(Total for question = 6 marks)

Q4.

Glucosaminoglycans (GAGs) are the by-products of chemical reactions inside cells. GAGs are broken down by enzymes inside lysosomes in cells.

Mucopolysaccharidosis type I (MPS I) is a genetic condition that results in the build-up of GAGs inside cells.

MPS I affects the production of enzyme G that breaks down GAGs inside lysosomes.

More than 50 different mutations in the gene for enzyme G have been found to result in MPS I. Most of these mutations involve changing a single base in the gene.

(i) Explain how a single base mutation can lead to an altered primary structure of enzyme G.

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(ii) Explain how human genome sequencing can be used to identify the mutations associated with MPS I.

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(Total for question = 6 marks)

Q5.

The scientific article you have studied is adapted from several sources.

Use the information from the scientific article and your own knowledge to answer the following questions.

Explain why genetically modified bacteria delivering drugs 'to the exact tissue in the body where they're needed and nowhere else' would decrease side effects (paragraph 34).

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(Total for question = 2 marks)

Q6.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Genome sequencing and genetic modification (GM) can be used to develop proteins as personalised medicines.

(i) Which of the following correctly describes the genome of an adult male?

(1)

- ☐ **A** all of his alleles plus all of his genes
- ☐ **B** all of his exons minus all of his introns
- ☐ **C** all of his introns minus all of his exons
- ☐ **D** all of his introns plus all of his exons

(ii) Which row correctly identifies all the types of organism that can be both genetically modified and be a

source of a gene to be used in GM?

(1)

	Animal	Bacterium	Plant
☐ **A**	no	no	yes
☐ **B**	no	yes	yes
☐ **C**	yes	yes	no
☐ **D**	yes	yes	yes

(Total for question = 2 marks)

Q7.

The neurones of the central nervous system contain TAU proteins. These proteins help to maintain cell structure.

In humans, six different TAU proteins can be produced from a single gene.

Parkinson's disease has been linked to the different forms of the TAU proteins present in neurones.

Scientists are studying the effect of these different TAU proteins in animal models.

One model used is the fruit fly, *Drosophila*.

Describe how *Drosophila* flies could be genetically modified to produce one form of the human TAU protein.

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(Total for question = 4 marks)

Q8.

The scientific article you have studied is from *Scientific American*.

Use the information from the scientific article and your own knowledge to answer the following question.

Describe how bacteria can be genetically modified to produce a cytokine for the treatment of neurological and mental disorders (paragraph 24).

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(Total for question = 4 marks)

Q9.

Spider silk is a very strong and flexible natural fibre. It is of interest to humans as a possible fibre for protective clothing.

Scientists have genetically modified a range of organisms to produce spider silk, including goats and plants such as alfalfa.

Give two reasons why some people may be concerned about the use of genetically modified alfalfa as a source of spider silk.

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(Total for question = 2 marks)

Q10.

Glucosaminoglycans (GAGs) are the by-products of chemical reactions inside cells. GAGs are broken down by enzymes inside lysosomes in cells.

Mucopolysaccharidosis type I (MPS I) is a genetic condition that results in the build-up of GAGs inside cells.

MPS I affects the production of enzyme G that breaks down GAGs inside lysosomes.

More than 50 different mutations in the gene for enzyme G have been found to result in MPS I. Most of these mutations involve changing a single base in the gene.

A biotechnology company is developing a method of repairing the mutations in the gene for enzyme G.

The method being developed is called CRISPR-Cas9.

In this method, a short sequence of RNA binds to the DNA containing the mutation responsible for MPS I.

This RNA acts as a guide to enable the Cas9 enzyme to bind to DNA.

This enzyme can then cut and repair the DNA, removing the mutation.

(i) Describe how scientists could produce this short sequence of RNA needed to treat someone with MPS I.

(2)

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(ii) Explain why the use of CRISPR-Cas9 technology can be described as personalised medicine.

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(Total for question = 4 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to four of the following: • restriction endonuclease used to { cut plasmid / isolate gene } (1) • forming sticky ends (1) • ligase enzymes used to add isolated gene to plasmid (1) • (ligase) forms phosphodiester bonds (between nucleotides) (1) • recombinant { DNA / plasmid } produced (1)	ALLOW 'endonuclease' or 'restriction enzyme' ALLOW 'sticky ends' in context of the DNA or plasmid being cut by enzymes if restriction enzymes not specified ALLOW integrase for ligase	**(4)**

Q2.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to three of the following: • (DNA) ligase (joins the two genes) (1) • by joining phosphate to sugar / forming phosphodiester bonds (1) • by condensation reactions (1) • description of role of active site of enzyme (1)		**(3)**

Question Number	Answer	Mark
(ii)	**The only correct answer is D restriction endonuclease** ***A*** *is not correct because DNA polymerase catalyses the formation of new DNA strands* ***B*** *is not correct because RNA ligase joins sections of RNA* ***C*** *is not correct because RNA polymerase catalyses the formation of pre-mRNA*	**(1)**

Question Number	Answer	Additional guidance	Mark
(iii)	An explanation that makes reference to the following: • so that only bacteria with the antibiotic resistance gene survive (1) • therefore, these bacteria will also have the genefor spider silk (1)		**(2)**

Question Number	Answer	Additional guidance	Mark
(iv)	An answer that makes reference to two of the following: • IAA to cause cell elongation (1) • detail of how IAA affects plant cells (1) • to grow plants that produce spider silk (1)	ALLOW alters pH of cell wall / makes cellulose cellwall more plastic / effect on transcription ALLOW stimulates roots to grow	**(2)**

Question Number	Answer	Additional guidance	Mark
(v)	An answer that makes reference to the following: • mass per acre per year for goats (1) • correct calculation of difference in mass of spider silk produced (1) • correct percentage increase (1)	Example of calculation 10 x 12 = 120 (kg per acre per year)218-120 = 98 (kg per acre per year) 81.66 / 81.7 / 82 (%) Correct answer with no working gains fullmarks	**(3)**

Q3.

Question number	Answer
	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. Indicative content: Benefits Described: • crops have increased yield due to pest control or resistance to disease • reduced need to use pesticides • crops can be grown in a wider range of conditions, e.g. harsh conditions, drought etc Discussed: • hybridisation could allow crop plants to have genes for tolerance to harsh conditions from genome D • crops have higher nutrient content, or produce a greater range of useful chemicals e.g. pharmaceutical products • genetic modification can be beneficial if crops are resistant to herbicides - crops can be sprayed with herbicide without { being harmed / causing reduction in yield } Risks Hybridisation: • hybridisation can lead to pest species which have ability to grow in wide range of conditions • hybridisation could allow genes for tolerance to harsh conditions from genome D to enter pest species GM: • genetic modification may result in genes entering pest species, making control difficult or into food chains • GM can introduce antibiotic resistant genes to other species Selective breeding • selective breeding reduces { genetic diversity / size of gene pool }, or causes genetic drift • leading to loss of useful alleles / reducing the ability of the crops to adapt to environmental change

Level	Mark	Descriptor	Additional Guidance
0	0	No awardable content	
1	1-2	Limited scientific judgement made with a focus on **one** side of the argument only. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	Only considered one benefit **or** one risk without further explanation beyond a brief description.
2	3-4	A scientific judgement is made through the application of relevant evidence to **both** sides of the argument. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	Considers at least one risk **and** one benefit with some discussion.
3	5-6	A scientific judgement is made, which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	Benefits generally described and specific risks discussed. Conclusions described for each of the three methods – hybrids, GM and selective breeding.

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following: • changing a base results in a change in the triplet code • this changes the codon(s) in the mRNA • resulting in a different { amino acid / amino acid sequence } (in the primary structure)	ALLOW deletion / substitution / insertion / frameshift. ALLOW illustration of change in triplet code e.g. ATT to ATG ALLOW introducing a stop codon / terminating translation	**(3)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: • sequence the genome of people with MPS1 • sequence the genome of a number of people without the condition • compare the base sequences to identify mutations found only in individuals with the condition	ALLOW comparison of base sequences of people with MPS1 and people without MPS1	**(3)**

Q5.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: • drugs not delivered to { other / healthy} tissues (1) • overall dosage needed is less (1)	ALLOW drug does not {affect / reach} other tissues, drug not delivered to the whole body ALLOW converse ALLOW {higher concentration / more of the drug} delivered to area where needed	**(2)**

Q6.

Question Number	Answer	Mark
(i)	The only correct answer is **D** – all of his introns plus all of his exons ***A*** *is incorrect because it does not describe the genome of the adult male* ***B*** *is incorrect because it does not describe the genome of the adult male* ***C*** *is incorrect because it does not describe the genome of the adult male*	**(1)**

Question Number	Answer	Mark
(ii)	The only correct answer is **D** – yes for animal, bacterium and plant ***A*** *is incorrect because animals and bacteria can also be genetically modified and be a source of a gene* ***B*** *is incorrect because animals can be genetically modified and be a source of a gene* ***C*** *is incorrect because plants can be genetically modified and be a source of a gene*	**(1)**

Q7.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to four of the following: • extract mRNA for one form of the (tau protein) (1) • copy mRNA into DNA (1) • use restriction enzymes {to create sticky ends) / cut theDNA and a vector} (1) • {ligate / insert / integrate} the TAU DNA into the vector(DNA) (1) • introduce vector into {fertilised egg / embryonic stem /zygote / cells / neural cell stem cells} (1)	IGNORE cut / remove TAU gene from a humanALLOW synthesis DNA sequence for one form e.g. use code specific for one of the tau proteins ALLOW insert gene into fertilised egg cell /embryonic stem cell ALLOW egg cell fertilised after inserting gene	Choose an item. (4)

Q8.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to four of the following: • (isolate) the gene for ~~the~~ cytokine (from human DNA) (1) • use a bacterial plasmid (as a vector) (1) • cut the human DNA and the plasmid using the same restriction enzyme (1) • splice the gene and plasmid together using (DNA) ligase (1) • put the (modified) plasmids into bacterial cells (1)	e.g. ue a restriction enzyme to cut the DNA and the plasmid ALLOW 'join' for 'splice' ALLOW produce lots of bacteria {with the plasmid / expressing the cytokine gene}	**(4)**

Q9.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to the following: • transfer of antibiotic-resistance gene to other microorganisms (1) • a reason associated with health (1)	e.g. pathogenic bacteria developingresistance to antibiotics	**(2)**

Q10.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to two of the following: • transcription (of the DNA containing the mutation) / transcribe to produce { mRNA / RNA } • using { RNA nucleotides / RNA polymerase }	IGNORE translation	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: • individuals have different mutations / targets an individual's specific mutation • the RNA molecule used will be specific to { each mutation / individual }	ALLOW mutations at different loci	**(2)**