

Genetic Engineering

Mark Scheme



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1. Genetic engineering is a way scientists change the DNA of living things to give them new traits, like making crops resistant to pests or helping cure diseases.

- a) A gene for insulin is taken from a human cell and placed in a bacterium.
The bacterium can then make human insulin. What is this process called?

C – is the only correct answer.	1 mark
	Total: 1 mark

- b) Which of the following is a primary reason for using bacteria in the process of genetic engineering to produce human insulin?

C – is the only correct answer.	1 mark
	Total: 1 mark

- c) A scientist wants to insert a gene for human growth hormone into a bacterial plasmid. Which enzyme would be essential for cutting the plasmid DNA at a specific sequence to make space for the new gene?

C – is the only correct answer.	1 mark
	Total: 1 mark

- d) When genetic engineering is used to produce human insulin, the gene for human insulin is inserted into a bacterial plasmid.

What is this modified plasmid, now containing DNA from two different species, referred to as?

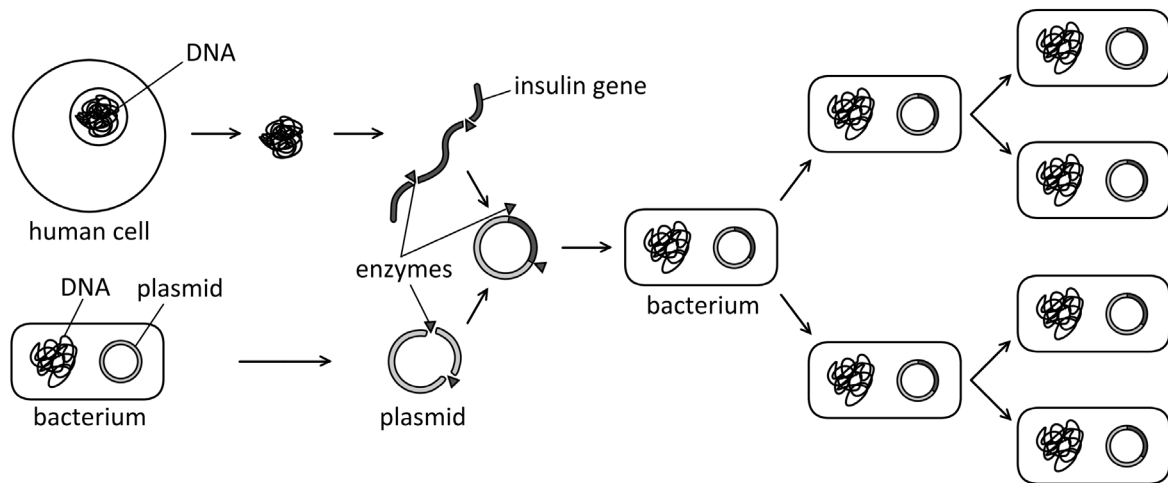
D – is the only correct answer.	1 mark
	Total: 1 mark

- e) In genetic engineering, after bacterial cells have been mixed with recombinant plasmids, not all bacteria will take up a plasmid. To identify the bacteria that have successfully incorporated the plasmid, what is commonly included on the plasmid alongside the desired gene?

B – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 5 marks)

2. The figure below shows some of the stages involved in the genetic engineering of bacteria to produce human insulin.



- a) From which type of cell is the gene for human insulin initially obtained? (1 mark)

Human cell.	1 mark
	Total: 1 mark

- b) Name the small, circular piece of DNA that is extracted from the bacterium.

Plasmid.	1 mark
	Total: 1 mark

- c) An enzyme is used to cut the human DNA to isolate the insulin gene, and also to cut open the plasmid. What is the specific name for this type of enzyme?

Restriction enzyme.	1 mark
	Total: 1 mark

- d) Another enzyme is then used to join the insulin gene into the cut plasmid. What is this enzyme called?

DNA Ligase.	1 mark
	Total: 1 mark

- e) The plasmid containing the human insulin gene is then inserted into a host bacterium.

Recombinant DNA.	1 mark
	Total: 1 mark

- f) The diagram shows the host bacterium reproducing. Explain one advantage of using bacteria in this process of producing human insulin.

Bacteria reproduce rapidly / at a fast rate.	1 mark
So a large amount of insulin can be produced quickly / in a short time.	1 mark
	Total: 2 marks

- g) Suggest why the bacteria that take up the modified plasmid might also contain a gene for antibiotic resistance.

It is used as a marker gene.	1 mark
It allows scientists to identify/select the bacteria that have successfully taken up the plasmid by growing them in the presence of the antibiotic.	1 mark
	Total: 2 marks

- h) Scientists who develop genetically engineered varieties of crop plants often breed them for several generations before releasing them for farmers to use. Suggest why the scientists do this.

Any three from:	
To check that the new trait is stable / inherited by offspring.	1 mark
To check for any unforeseen / negative side effects on the plant (e.g., on health, yield).	1 mark
To multiply the stock / produce a large number of seeds to be sold to farmers.	1 mark
To produce a true-breeding / homozygous strain.	1 mark
	Total: 3 marks

(Total for Question 2 is 12 marks)

3. To produce human insulin, bacterial plasmids are genetically modified.

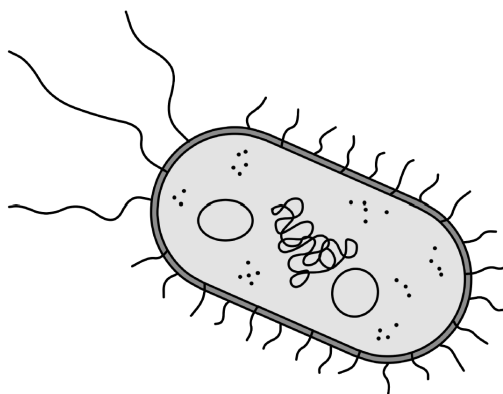
Describe the specific roles of two different types of enzymes in cutting a target gene (like the insulin gene) and a bacterial plasmid, and then joining them together to create a recombinant plasmid.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	Simple statements are made about the enzymes' roles. May name one or both enzymes correctly but with a very limited description of their function (e.g., "one cuts and one sticks").
Level 2	3 - 4	A good description of the roles of both enzymes, but may lack detail or clarity in some areas. May name both enzymes but the explanation of their function might be less precise (e.g., just says 'cuts' and 'joins').
Level 3	5 - 6	A detailed and coherent description of the roles of both enzymes. Correctly names both restriction enzymes and ligase and explains their specific functions in a logical sequence. Explains the concept of using the same restriction enzyme and the formation of complementary sticky ends, leading to successful joining. Clear and appropriate scientific terminology is used throughout.

Indicative Content:	
Restriction Enzyme: - A restriction enzyme is used to cut DNA. - It is used to cut the target gene (e.g., insulin gene) from the human chromosome/DNA. - The same restriction enzyme is used to cut open the bacterial plasmid. - The enzyme cuts at specific recognition sites / base sequences. - This creates 'sticky ends' (short sections of unpaired bases). - The sticky ends on the gene are complementary to the sticky ends on the plasmid. Ligase Enzyme: - Ligase is the enzyme used to join the DNA fragments. - It joins the target gene into the plasmid. - It does this by forming bonds in the sugar-phosphate backbone. - This creates a single, continuous piece of recombinant DNA / a recombinant plasmid.	
	Total: 6 marks

(Total for Question 3 is 6 marks)

4. Chymosin is an enzyme used in cheese making. It can be produced by genetically modified bacteria. The figure below shows a typical bacterial cell.



Explain how to genetically modify a bacterial cell to produce chymosin.

An explanation to include any three of the following:	
The gene for chymosin is isolated / cut from the DNA of the source organism using a restriction enzyme.	1 mark
A plasmid is removed from a bacterium and cut open with the same restriction enzyme.	1 mark
The chymosin gene is joined into the plasmid using a ligase enzyme (to form a recombinant plasmid).	1 mark
The recombinant plasmid is inserted into a host bacterium.	1 mark
	Total: 3 marks

(Total for Question 4 is 3 marks)

5. The figure below shows some of the stages involved in creating a genetically modified bacterial cell.

- a) The diagram states "enzymes cut out human gene" and "enzymes cut open plasmid".
Name the specific type of enzyme used to perform these cutting actions.

Restriction enzyme.	1 mark
	Total: 1 mark

- b) Why is it important to use the **same enzyme** to cut both the human DNA and the plasmid?

To create sticky ends.	1 mark
That are complementary (to each other), allowing the gene to join the plasmid.	1 mark
	Total: 2 marks

- c) The diagram also states enzymes "stick in new gene".

Name the specific type of enzyme that performs this 'sticking' action.

(DNA) Ligase	1 mark
	Total: 1 mark

- d) When the enzyme named in (a) cuts DNA, it can create 'sticky ends'.

Explain what is meant by the term 'sticky ends'.

A short section of single-stranded DNA / unpaired bases.	1 mark
At the end of a DNA fragment after it has been cut.	1 mark
	Total: 2 marks

- e) Human Growth Hormone (HGH) can be produced by genetically modified bacteria.

Outline the main steps involved in genetically modifying bacteria so that they can produce human growth hormone.

Any three of the following:	
The HGH gene is cut from human DNA using a restriction enzyme.	1 mark
A plasmid is removed from a bacterium and cut with the same restriction enzyme.	1 mark
The HGH gene is inserted into the plasmid using a ligase enzyme.	1 mark
The recombinant plasmid is put into a host bacterium.	1 mark
	Total: 3 marks

- f) Describe **one** medical condition that can be treated using the human growth hormone produced in this way.

Dwarfism / Growth hormone deficiency.	1 mark
	Total: 1 mark

(Total for Question 5 is 10 marks)

6. Genetic engineering can be used to modify plants to give them desirable characteristics.

a) A scientist wants to create a tomato plant that is resistant to a particular herbicide.

State **one** type of vector that could be used to transfer the herbicide resistance gene into the tomato plant cells.

A plasmid / <i>Agrobacterium tumefaciens</i> .	1 mark
	Total: 1 mark

b) Describe the main stages involved in producing the genetically modified herbicide resistant tomato plant, starting from isolating the herbicide resistance gene.

A description to include any four of the following:	
The herbicide resistance gene is cut from its source DNA using a restriction enzyme.	1 mark
A plasmid is removed from a bacterium and cut open with the same restriction enzyme.	1 mark
A ligase enzyme is used to join the gene into the plasmid.	1 mark
This creates a recombinant plasmid.	1 mark
The recombinant plasmid is inserted into the plant cells.	1 mark
The modified plant cells are grown / cloned into a whole plant.	1 mark
	Total: 4 marks

c) Other than herbicide resistance, state one other characteristic that plants can be genetically modified to have, and explain one benefit of this modification.

Characteristic (1 mark) and linked Benefit (2 marks)	
Characteristic: Resistance to insect pests. Benefit: Leads to increased crop yield because fewer plants are damaged/eaten. Reduces the need for chemical pesticides which is better for the environment.	
Characteristic: Increased nutritional value (e.g., Golden Rice). Benefit: Can help prevent deficiency diseases, for example, Vitamin A deficiency leading to blindness.	
Characteristic: Frost resistance. Benefit: Allows crops to be grown in colder climates, increasing the range of food production.	
	Total: 3 marks

d) The use of genetically modified (GM) crops can be controversial. Describe two concerns that some people have about the widespread cultivation of GM crops.

Any two from:	
Concern about the transfer of the modified gene to wild plants / creating 'superweeds'.	1 mark
Possible harm to other organisms (e.g., non-pest insects that eat the plant).	1 mark
Concern over long-term effects on human health / potential for allergies.	1 mark
Reduction in biodiversity if everyone grows the same few GM varieties.	1 mark
Ethical concerns about large corporations controlling the food supply.	1 mark
	Total: 2 marks

- e) Explain how growing GM crops that are resistant to insect pests could lead to an increase in the yield of the crop.

Fewer plants are damaged or eaten by insect pests.	1 mark
Therefore, a larger proportion of the crop survives to be harvested, increasing the overall yield.	1 mark
	Total: 2 marks

(Total for Question 6 is 12 marks)