Helicate

HELICATE · A-LEVEL BIOLOGY · TOPIC BANK

3.8.4 Gene technologies

Topic question bank

Version 1 · 17 October 2026

Name

Date

QUESTIONS	TOTAL MARKS	TIME	YOUR SCORE
6	60	No time limit	/ 60

Contents

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Total		**60**

Instructions

- Answer the questions in the spaces provided. Show all your working.
- The marks for each question are shown in brackets. Use them to judge how much detail to give.
- Work through a subtopic at a time, then mark your answers with the matching mark scheme.

Original questions by Helicate for AQA A-level Biology (7402), specification section 3.8.4. Not affiliated with or endorsed by AQA.

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Producing DNA fragments and in vivo cloning 3.8.4.1

Human growth hormone is a protein made by cells in the pituitary gland. Children who do not make enough growth hormone can be treated with growth hormone made by genetically modified bacteria.

To make the growth hormone gene, scientists extracted mRNA from human pituitary cells. They used this mRNA to make complementary DNA (cDNA).

0 1 . 1 Which enzyme do scientists use to make cDNA from mRNA?
Tick (✓) one box.

[1 mark]

- DNA ligase ☐
- RNA polymerase ☐
- Restriction endonuclease ☐
- Reverse transcriptase ☐

0 1 . 2 The growth hormone gene could also have been cut out of the DNA of a pituitary cell using restriction endonucleases.
Suggest **two** reasons why the scientists made the gene from mRNA instead.

[2 marks]

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Question 1 continues on the next page

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0 1 . 3 Scientists can also make a gene in a gene machine.
Which information do the scientists need before they can make the growth hormone gene in a gene machine?
Tick (✓) one box.

[1 mark]

The base sequence of the gene ☐

The positions of the introns in the gene ☐

The recognition sites for restriction endonucleases near the gene ☐

The tertiary structure of growth hormone ☐

Before inserting the cDNA into a plasmid, the scientists added a promoter region to one end of the cDNA and a terminator region to the other end.

0 1 . 4 Explain why the scientists added a promoter region and a terminator region to the cDNA.

[2 marks]

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Question 1 continues on the next page

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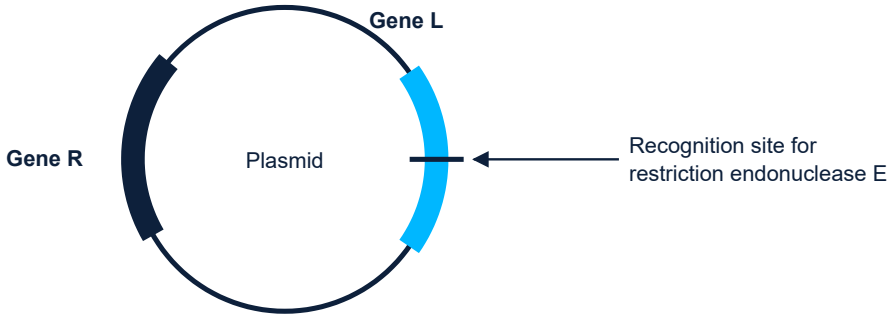
Figure 1 shows the plasmid the scientists used. It contains two marker genes.

- Gene R gives resistance to antibiotic A.
- Gene L codes for an enzyme that converts a colourless substance, X, into a blue product.

Figure 1



The scientists added short DNA sequences containing the recognition site for restriction endonuclease E to each end of the cDNA. They cut the cDNA and the plasmids with restriction endonuclease E, mixed them with DNA ligase, and then mixed the plasmids with bacteria.

They spread the bacteria on agar containing antibiotic A and substance X. Two types of colony grew: white colonies and blue colonies.

0 1 . 5 The scientists selected the white colonies to produce growth hormone. Explain why.

[3 marks]

Question 1 continues on the next page

Do not write outside the box

The scientists counted 138 white colonies and 462 blue colonies.

0 1 . 6 Calculate the percentage of colonies that contained bacteria with the plasmid that had the cDNA inserted.

[1 mark]

Answer ..... **%**

0 1 . 7 Explain why the scientists cut both the cDNA and the plasmids with the same restriction endonuclease.

[2 marks]

0 1 . 8 The growth hormone made by the bacteria had exactly the same amino acid sequence as growth hormone made in the human pituitary gland.
Explain why.

[2 marks]

14

Turn over for the next question

Do not write outside the box

The polymerase chain reaction 3.8.4.1

Scientists used the polymerase chain reaction (PCR) to make many copies of a section of DNA. The reaction mixture was taken through repeated cycles of three stages. Table 1 shows the temperature and the time of each stage.

Table 1

Stage of each cycle	Temperature / °C	Time at this temperature / s
Stage 1	95	30
Stage 2	55	30
Stage 3	72	60

0 2 . 1 Explain why the reaction mixture is held at a different temperature in each of the three stages shown in Table 1.

[3 marks]

Question 2 continues on the next page

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It took a total of 30 s to change between the three temperatures in each cycle. The reaction started with 120 copies of the section of DNA, and the PCR machine ran for 75 minutes.

0 2 . 2 Calculate the number of copies of the section of DNA present at the end of the run. Assume that the number of copies doubled in every cycle.
Give your answer in standard form.

[3 marks]

Answer ..... **copies**

0 2 . 3 Two different primers are added to the reaction mixture.
Explain why **two different** primers are needed.

[2 marks]

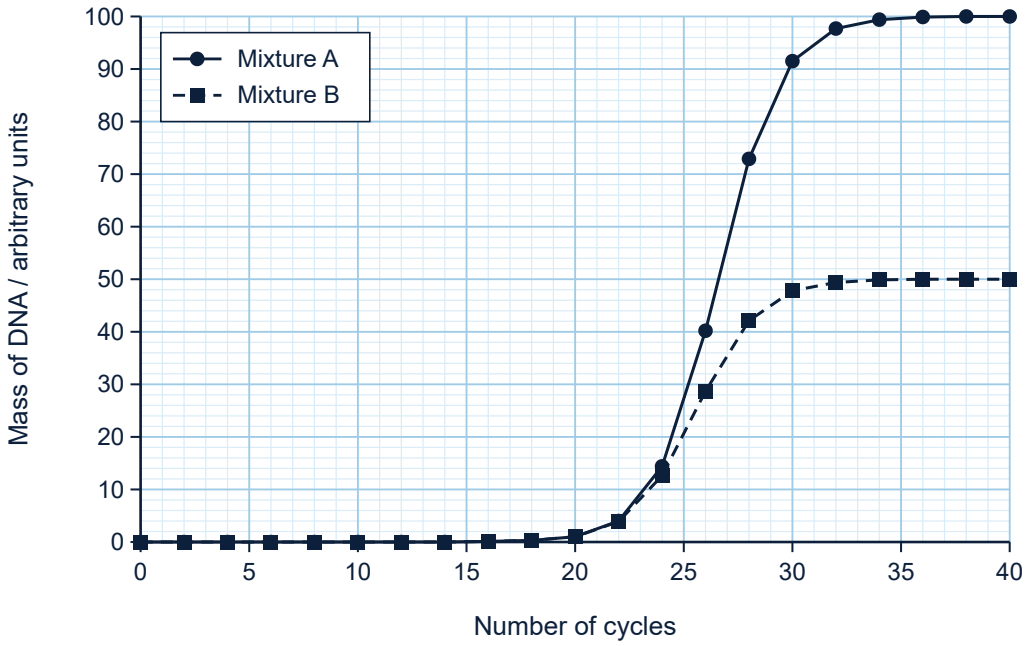
Question 2 continues on the next page

Do not write outside the box

The scientists then set up two reaction mixtures, A and B. Both mixtures started with the same mass of DNA. Mixture B contained half the concentration of DNA nucleotides in mixture A. Everything else was the same.

They measured the mass of DNA in each mixture after different numbers of cycles. Figure 2 shows their results.

Figure 2



0 2 . 4 A student predicted that, after 40 cycles, the mass of DNA in mixture A would be 2^{40} times greater than at the start.
Use Figure 2 to evaluate this prediction.

[3 marks]

Question 2 continues on the next page

Do not write outside the box

0 2 . 5 DNA fragments can also be copied in vivo by inserting them into plasmids and culturing transformed bacteria.
Which is an advantage of in vivo cloning compared with PCR?
Tick (✓) one box.

[1 mark]

It produces many copies of the DNA fragment more quickly. ☐

The transformed cells can also make the protein coded for by the gene. ☐

It does not need any enzymes to cut or join the DNA. ☐

It copies the DNA fragment without the need for a vector. ☐

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Turn over for the next question

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DNA probes, screening and personalised medicine 3.8.4.2

Condition T is a heritable condition caused by a recessive allele, **a**, of a gene. The dominant allele is **A**.

Scientists made two labelled DNA probes. Probe 1 binds only to allele **A**. Probe 2 binds only to allele **a**.

0 3 . 1 Alleles **A** and **a** differ by only one base.
Explain how probe 2 can bind to allele **a** but not to allele **A**.

[2 marks]

0 3 . 2 Before adding the probes, the scientists heated each sample of DNA to 95 °C.
Explain why.

[2 marks]

Question 3 continues on the next page

Do not write outside the box

Condition T is common in one community. Couples in this community who were planning to have children were offered screening with both probes. Table 2 shows the results for three couples.

Table 2

Couple	Partner	Probe 1 (allele A)	Probe 2 (allele a)
X	Woman	Bound	Did not bind
	Man	Bound	Bound
Y	Woman	Bound	Bound
	Man	Bound	Bound
Z	Woman	Bound	Did not bind
	Man	Bound	Did not bind

0 3 . 3 Use Table 2 to identify the couple who could have a child with condition T. Explain your answer.

[2 marks]

0 3 . 4 Suggest how a genetic counsellor could use these results to advise couple X and couple Y.

[2 marks]

8

Turn over for the next question

Do not write outside the box

Drug W reduces blood clotting. It is given to people at risk of harmful blood clots. If the concentration of drug W in the blood becomes too high, serious bleeding can occur.

Drug W is broken down in the liver by enzyme E. The gene for enzyme E has two alleles, **F** and **S**. Allele **S** codes for a form of enzyme E with lower activity.

Doctors used DNA probes to find the genotype for enzyme E of each patient in a large group. Every patient was given the same standard dose of drug W for the first month. After the first month, each patient's dose was adjusted until treatment was effective. Table 3 shows their results.

Table 3

Genotype for enzyme E	Number of patients	Number of patients with serious bleeding in the first month	Mean daily dose of drug W that gave effective treatment after adjustment / mg
FF	418	9	5.4
FS	236	14	3.9
SS	52	13	2.1

0 4 . 1 Calculate how many times more likely serious bleeding was in patients with genotype **SS** than in patients with genotype **FF** in the first month.

[2 marks]

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Answer ..... **times**

Question 4 continues on the next page

Do not write outside the box

0 4 . 2 Explain why patients with genotype **SS** are more likely to have serious bleeding when given the standard dose of drug W.

[2 marks]

0 4 . 3 A doctor suggested that every patient should be screened with a DNA probe for allele **S** before drug W is prescribed.
Use Table 3 to evaluate this suggestion.

[5 marks]

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Turn over for the next question

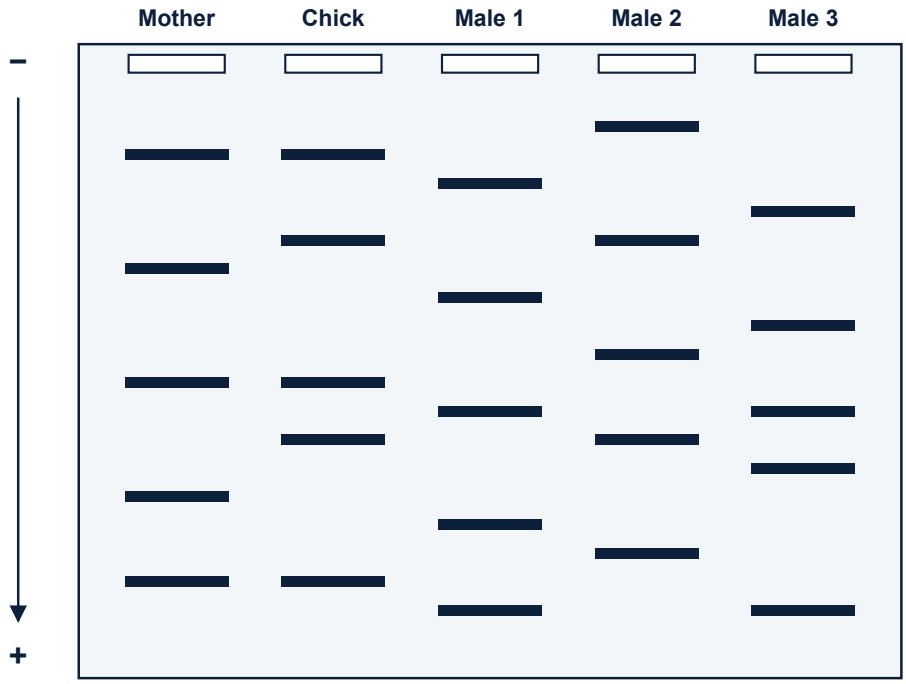
Do not write outside the box

Genetic fingerprinting 3.8.4.3

The genomes of birds contain many variable number tandem repeats (VNTRs). Scientists used genetic fingerprinting in a breeding programme for an endangered species of parrot.

They cut DNA from a female parrot, her chick and three males that could be the chick's father, using the same restriction endonuclease. They separated the DNA fragments containing VNTRs on one gel by electrophoresis. Figure 3 shows their results.

Figure 3



Wells are at the top. DNA fragments moved down the gel.

Question 5 continues on the next page

Do not write outside the box

0 5 . 1 Explain why the DNA fragments separate during gel electrophoresis.

[2 marks]

0 5 . 2 Which male is most likely to be the father of the chick?
Tick (✓) one box.

[1 mark]

Male 1 ☐

Male 2 ☐

Male 3 ☐

None of the males ☐

0 5 . 3 Explain why the scientists cut every DNA sample with the same restriction endonuclease and separated all the samples on the same gel.

[2 marks]

Question 5 continues on the next page

Do not write outside the box

The scientists want to choose a male to breed with another female, female F. They compared the fingerprint of female F with the fingerprints of four males. Table 4 shows their results.

Table 4

Male	Percentage of the bands in female F's fingerprint that are also in the male's fingerprint
P	64
Q	22
R	47
S	31

0 5 . 4 Which male should the scientists choose to breed with female F? Explain your answer.

[4 marks]

Question 5 continues on the next page

Do not write outside the box

The scientists also compared the fingerprints of pairs of birds chosen at random. In the captive population, pairs of birds shared a mean of 58% of their bands. In a wild population of the same species, pairs of birds shared a mean of 26% of their bands.

0 5 . 5 Suggest what these results show about the captive population. Suggest how the scientists could use this information.

[2 marks]

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Turn over for the next question

Do not write outside the box

A small spot of blood was found at the scene of a crime. Forensic scientists want to find out whether the blood came from a suspect.

0 6 Describe how the scientists could produce genetic fingerprints from the spot of blood and from the suspect. Explain why genetic fingerprinting can show whether the blood came from the suspect.

[6 marks]

6

END OF QUESTIONS

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