Helicate

HELICATE · A-LEVEL BIOLOGY · TOPIC BANK

3.8.4 Gene technologies (part 2)

Topic question bank

Version 1 · 22 October 2026

Name

Date

QUESTIONS	TOTAL MARKS	TIME	YOUR SCORE
8	68	No time limit	/ 68

Contents

Subtopic	Questions	Marks
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Screening, genetic counselling and personalised medicine Specification 3.8.4.2	05–06	15
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Total		**68**

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.

Do not write outside the box

Making genes and amplifying them in host cells 3.8.4.1

Phytase is an enzyme that hydrolyses phytate, a phosphate-containing compound found in plant seeds. Farmers add phytase to pig and chicken feed so that the animals can absorb more phosphate from their food.

The feed is heated to 85 °C when it is pressed into pellets, and this denatures the phytase made by a fungus. Scientists designed a modified phytase in which six amino acids are different. The modified phytase is not denatured at 85 °C.

The scientists made a gene for the modified phytase in a gene machine. They then inserted the gene into plasmids and put the plasmids into bacteria.

0 1 . 1 Describe how the scientists could use a gene machine to make the gene for the modified phytase.

[4 marks]

Question 1 continues on the next page

Do not write outside the box

0 1 . 2 Which enzyme would the scientists **not** need to use to produce bacteria containing the gene for the modified phytase?
Tick (✓) one box.

[1 mark]

DNA ligase ☐

Restriction endonuclease ☐

Reverse transcriptase ☐

None of these; all three enzymes are needed ☐

0 1 . 3 Suggest why the scientists made the gene in a gene machine, rather than obtaining the phytase gene from the fungus.

[2 marks]

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Turn over for the next question

Do not write outside the box

The plasmid the scientists used also contained two marker genes:

- gene R, which gives resistance to antibiotic K
- gene G, which codes for a protein that fluoresces green under ultraviolet light. The promoter of gene G allows transcription only when sugar A is present.

The scientists mixed plasmids with bacteria and treated the mixture so that some bacteria took up a plasmid. They treated another sample of the same bacteria in the same way, but without plasmids. They spread 0.10 cm^3 of bacteria on each of four agar plates and incubated the plates. Table 1 shows their results.

Table 1

Plate	Bacteria mixed with plasmids?	Substances in the agar	Result after incubation
1	No	Nutrients only	Bacteria grew over the whole surface; no fluorescence
2	No	Nutrients and antibiotic K	No colonies
3	Yes	Nutrients and antibiotic K	84 colonies; none fluoresced
4	Yes	Nutrients, antibiotic K and sugar A	81 colonies; all fluoresced

0 2 . 1 Explain why the scientists included plates 1 and 2.

[2 marks]

Question 2 continues on the next page

Do not write outside the box

0 2 . 2 Explain why the colonies on plate 4 fluoresced but the colonies on plate 3 did not.

[2 marks]

Transformation efficiency is the number of transformed colonies produced per µg of plasmid DNA. The scientists added 0.050 µg of plasmid DNA to the bacteria. The final volume of this mixture was 0.50 cm^3.

0 2 . 3 Use this information and the result for plate 4 to calculate the transformation efficiency.
Give your answer in standard form.

[3 marks]

Answer _____ **colonies per µg**

Question 2 continues on the next page

Do not write outside the box

0 2 . 4 Give **two** aseptic techniques the scientists should use while transferring and spreading the bacteria on the agar plates.
Explain why poor aseptic technique could give a transformation efficiency that is too high.

[3 marks]

The scientists transferred one fluorescent colony from plate 4 into a flask of nutrient broth containing antibiotic K. They incubated the flask for 24 hours.

0 2 . 5 Explain how culturing these bacteria produces many copies of the gene for the modified phytase.

[3 marks]

13

Turn over for the next question

Do not write outside the box

Evaluating recombinant DNA technology 3.8.4.1

Cowpea is a bean crop grown by many small farmers in West Africa. The larvae of an insect, the pod borer, can destroy much of a cowpea crop. Scientists produced a genetically modified (GM) cowpea, variety P, that contains a gene from a bacterium. This gene codes for a protein that is toxic to pod borer larvae.

0 3 . 1 The scientists used a gene for resistance to an antibiotic as the marker gene when they made variety P. Some environmentalists objected to this.
Suggest why they objected, **and** suggest one advantage of using a gene coding for a fluorescent protein as the marker gene instead.

[2 marks]

Question 3 continues on the next page

Do not write outside the box

Cowpea farmers usually keep some of their beans to plant the next season. Variety P is owned by a large international company. Farmers who grow variety P agree to buy new seed from the company every season. Wild relatives of cowpea grow in the same region.

Scientists collected data from 60 farms growing non-GM cowpea and 60 farms growing variety P, over three seasons. Each farmer chose which type of cowpea to grow. Farmers sold the beans for 0.50 dollars per kg. Table 2 shows the results.

Table 2

	Non-GM cowpea	GM variety P
Mean yield of beans / kg per hectare	640	904
Mean number of insecticide sprays per season	6	2
Mean cost of seed / dollars per hectare	15	42
Mean cost of insecticide / dollars per hectare	48	16
Mean income from beans sold / dollars per hectare	320	452

0 3 . 2 Calculate the percentage increase in mean yield of beans for farms growing variety P compared with farms growing non-GM cowpea.

[2 marks]

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Answer ..... **%**

Question 3 continues on the next page

Do not write outside the box

0 3 . 3 Use all the information about variety P and Table 2 to evaluate the growing of variety P by small farmers in West Africa.
In your answer, consider its humanitarian benefits and the concerns of environmentalists and anti-globalisation activists.

[6 marks]

10

Turn over for the next question

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Gene therapy 3.8.4.1

Condition R is an inherited condition that causes gradual loss of sight. It is caused by a recessive allele of a gene that codes for an enzyme in cells of the retina. Without the functional enzyme, the light-sensitive cells of the retina die.

In a gene therapy, scientists inserted the functional, dominant allele of this gene into a harmless virus. The virus is used as a vector. It was injected into the space behind the retina of each eye, where it delivered the functional allele into retina cells.

0 4 . 1 Explain how the functional allele could stop the light-sensitive cells of the retina from dying.

[2 marks]

0 4 . 2 A woman with condition R was treated successfully with this gene therapy. Explain why her children could still inherit the allele for condition R from her.

[2 marks]

Question 4 continues on the next page

Do not write outside the box

0 4 . 3 Another inherited condition of the retina is caused by a dominant allele. This dominant allele codes for a protein that damages retina cells.
Suggest why this type of gene therapy would **not** be effective for this condition.

[2 marks]

Question 4 continues on the next page

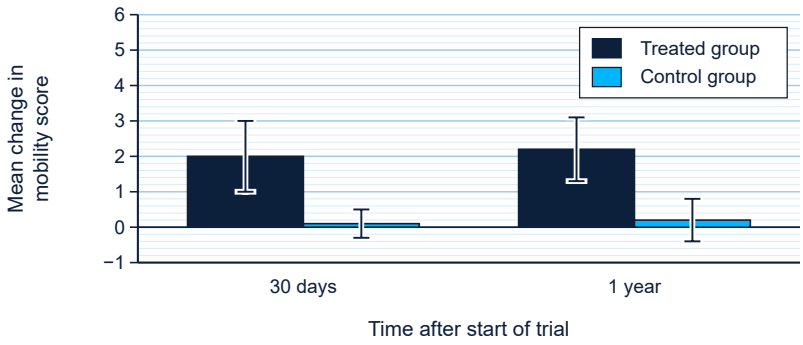
Do not write outside the box

Scientists tested this gene therapy in a trial with 31 patients with condition R.

- 20 patients (the treated group) received the injection.
- 11 patients (the control group) did not receive an injection during the first year. They were offered the treatment after one year.
- Each patient walked a course at seven light levels, from bright to very dim. Their mobility score was the number of light levels at which they completed the course without error.
- 4 patients in the treated group developed raised pressure in the eye. This was treated with drugs.

Figure 1 shows the mean change in mobility score from the start of the trial. The error bars show ± 1 standard deviation.

Figure 1



0 4 . 4 Evaluate whether this trial shows that the gene therapy is an effective and safe treatment for condition R. Use Figure 1 and the information given.

[5 marks]

11

Turn over for the next question

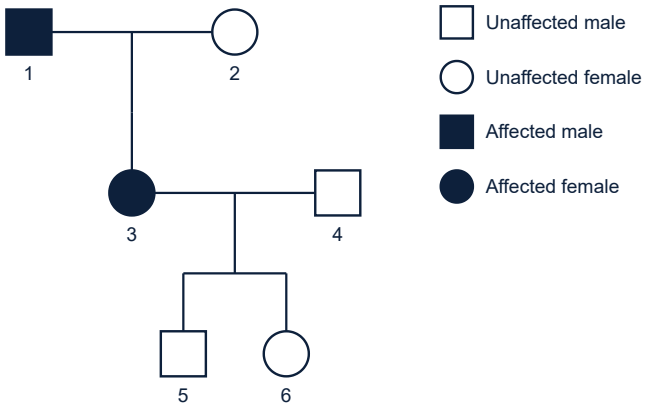
Screening, genetic counselling and personalised medicine 3.8.4.2

Condition H is a disorder of the nervous system caused by a dominant allele, **H**, of a gene. Symptoms usually first appear between the ages of 35 and 50.

Within the gene is a section in which the base sequence CAG is repeated. Allele **H** has 40 or more repeats. The recessive allele, **h**, has fewer than 27 repeats; the number of repeats differs between different copies of allele **h**.

Figure 2 shows the inheritance of condition H in one family. Person 5 is aged 24 and person 6 is aged 21. Neither has any symptoms.

Figure 2



0 5 . 1 Before deciding whether to be tested for allele **H**, persons 5 and 6 each met a genetic counsellor.
Suggest what the genetic counsellor would discuss with them.

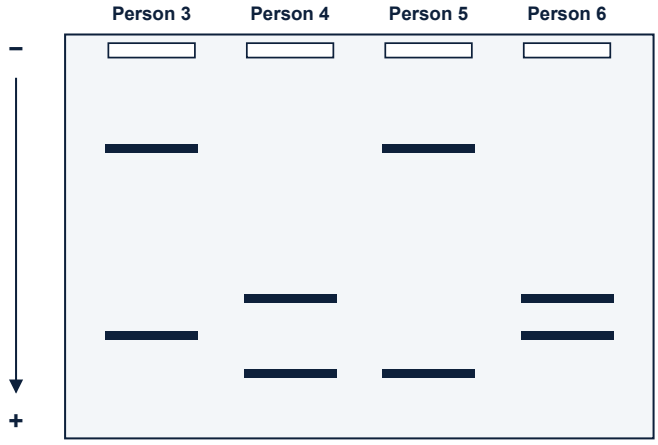
[3 marks]

Question 5 continues on the next page

Do not write outside the box

Persons 5 and 6 decided to be tested. Doctors used the polymerase chain reaction (PCR) to copy the section of the gene containing the repeats from the DNA of persons 3, 4, 5 and 6. They separated the copies by gel electrophoresis and used a labelled DNA probe to locate them. Figure 3 shows the results.

Figure 3



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

0 5 . 2 Which of persons 5 and 6 has inherited allele **H**?
Use Figure 2 and Figure 3 to explain how you reached your answer.

[4 marks]

Question 5 continues on the next page

Do not write outside the box

0 5 . 3 Person 5 plans to have children with a partner who does not have allele **H**.
What is the probability that their first child will inherit allele **H**?

[1 mark]

Answer .....

8

Turn over for the next question

Do not write outside the box

Some lung cancers are caused by mutations in a gene coding for a receptor protein, receptor T, in the cell-surface membrane. Allele **M** of this gene codes for a form of receptor T that is always active and stimulates cells to divide. Drug K inhibits receptor T.

Doctors used a labelled DNA probe to find out whether the tumour cells of patients with advanced lung cancer contained allele **M**. They then randomly allocated patients to receive drug K or standard chemotherapy. Table 3 shows their results.

Table 3

Allele **M** in tumour cells	Treatment	Number of patients	Percentage of patients whose tumour became smaller	Median time before the tumour started to grow again / months
Present	Drug K	118	68	10.2
	Standard chemotherapy	121	45	6.0
Absent	Drug K	84	2	1.8
	Standard chemotherapy	90	22	5.0

0 6 . 1 Choosing a drug by screening a patient's DNA is an example of personalised medicine.
What is meant by personalised medicine?

[1 mark]

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Question 6 continues on the next page

Do not write outside the box

0 6 . 2 Which conclusion is supported by the data in Table 3?
Tick (✓) one box.

[1 mark]

Tumours with allele **M** started to grow again sooner with drug K than with standard chemotherapy. ☐

Standard chemotherapy is more effective in patients with allele **M** than in patients without allele **M**. ☐

Allele **M** makes tumour cells resistant to standard chemotherapy. ☐

Drug K causes more side effects in patients without allele **M**. ☐

A hospital treats 400 patients with advanced lung cancer each year. The tumour cells of 35% of these patients contain allele **M**.

0 6 . 3 Use Table 3 to calculate how many more of these patients each year would have a tumour that became smaller if every patient were tested, and patients with allele **M** were given drug K and other patients were given standard chemotherapy, rather than every patient being given drug K without testing.

[2 marks]

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Answer ..... **patients**

Question 6 continues on the next page

Do not write outside the box

0 6 . 4 A newspaper article about this trial said: 'Drug K is a better treatment for lung cancer than standard chemotherapy.'
Use Table 3 to evaluate this statement.

[3 marks]

7

Turn over for the next question

Do not write outside the box

Genetic fingerprinting 3.8.4.3

0 7 . 1 Which statement about variable number tandem repeats (VNTRs) is correct?
Tick (✓) one box.

[1 mark]

Each VNTR has the same number of repeats in every member of a species. ☐

VNTRs are found only in the DNA of white blood cells. ☐

The number of times the base sequence is repeated at a VNTR varies between individuals. ☐

Identical twins have different VNTRs. ☐

A laboratory compares the VNTRs at 10 different sites in the genome. Each site is on a different chromosome. At each site, the probability that two unrelated people have the same pair of VNTRs is 0.07.

0 7 . 2 Calculate the probability that two unrelated people have the same VNTRs at all 10 sites.
Give your answer in standard form.

[2 marks]

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Answer .....

Question 7 continues on the next page

Do not write outside the box

0 7 . 3 The probability that two full brothers have the same VNTRs at all 10 sites is much higher.
Explain why.

[2 marks]

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0 7 . 4 Which is a use of genetic fingerprinting in plant breeding?
Tick (✓) one box.

[1 mark]

Inserting a gene for pest resistance into a crop plant ☐

Checking that seeds sold as a new variety really are that variety ☐

Making many copies of a gene for drought tolerance ☐

Increasing the number of VNTRs in the genome of a crop plant ☐

6

Turn over for the next question

Do not write outside the box

Leukaemia is a cancer of white blood cells. A man with leukaemia was given treatment that destroyed his bone marrow, which contains the stem cells that produce blood cells. He then received a bone marrow transplant from his brother.

Doctors used genetic fingerprinting to find out whether the man's blood cells came from his own cells or from his brother's cells. They used DNA from four samples:

- A: cheek cells from the man before the transplant
- B: blood from his brother (the donor)
- C: blood from the man 1 month after the transplant
- D: blood from the man 6 months after the transplant.

The doctors used PCR to copy the DNA fragments containing VNTRs, then separated the fragments by gel electrophoresis. Figure 4 shows their results.

Figure 4



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

0 8 . 1 Explain why the doctors used PCR before electrophoresis.

[2 marks]

Question 8 continues on the next page

Do not write outside the box

0 8 . 2 What do the results for sample C show? Explain your answer.

[2 marks]

0 8 . 3 Suggest why the doctors were concerned by the results for sample D.

[2 marks]

6

END OF QUESTIONS

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