HELICATE · A-LEVEL BIOLOGY · TOPIC BANK

3.8.2 Gene expression is controlled by a number of features

Topic question bank

Version 1 · 16 October 2026

Name

Date

QUESTIONS	TOTAL MARKS	TIME	YOUR SCORE
11	83	No time limit	/ 83

Contents

Subtopic	Questions	Marks
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Total		**83**

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 3.8.2. Not affiliated with or endorsed by AQA.

Do not write outside the box

Stem cells and cell specialisation 3.8.2.1

0 1 . 1 Which row correctly describes a type of stem cell in mammals?
Tick (✓) one box.

[1 mark]

Type of stem cell	Where it is found	Cell types it can produce	
Totipotent	Early embryo, for a limited time only	Any type of body cell	☐
Pluripotent	Mature mammals only	Only one type of cell	☐
Multipotent	Early embryo only	Any type of body cell	☐
Unipotent	Embryos only	Many different types of cell	☐

0 1 . 2 During the development of a mammalian embryo, totipotent cells give rise to specialised cells such as muscle cells and nerve cells.
Explain how totipotent cells become specialised.

[2 marks]

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Question 1 continues on the next page

Do not write outside the box

0 1 . 3 Describe how induced pluripotent stem cells (iPS cells) are produced.

[2 marks]

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5

Turn over for the next question

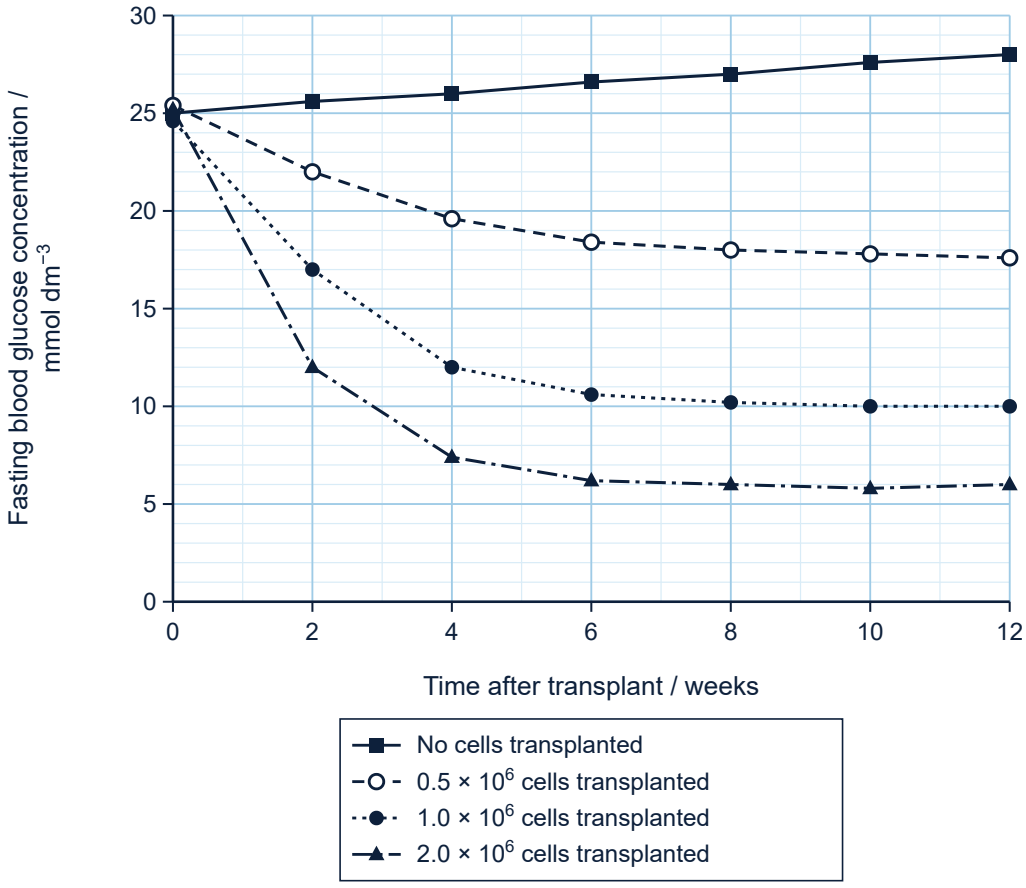
Do not write outside the box

Type 1 diabetes is caused by the loss of the insulin-secreting cells of the pancreas.

Scientists made mice diabetic using a chemical that destroys their insulin-secreting cells. For each mouse, they produced iPS cells from the mouse's own skin cells, caused these iPS cells to differentiate into insulin-secreting cells, and transplanted the insulin-secreting cells back into the same mouse.

The scientists gave groups of 10 diabetic mice different numbers of cells. Figure 1 shows the mean fasting blood glucose concentration of each group. In healthy mice, the fasting blood glucose concentration is 4.5–6.5 mmol dm^{-3}.

Figure 1



Question 2 continues on the next page

Do not write outside the box

0 2 . 1 Use Figure 1 to calculate the percentage decrease in the mean fasting blood glucose concentration at week 12 for mice given 1.0×10^6 cells, compared with mice given no cells.

[2 marks]

Answer _____ **%**

0 2 . 2 The scientists made the insulin-secreting cells from each mouse's own skin cells, rather than from the cells of a different mouse.
Explain the advantage of this.

[2 marks]

0 2 . 3 Before transplanting the insulin-secreting cells, the scientists checked that none of the cells were still pluripotent.
Suggest why.

[2 marks]

Question 2 continues on the next page

Do not write outside the box

At week 12, the scientists examined each mouse for a tumour at the transplant site. Table 1 shows their results.

Table 1

Number of cells transplanted	Number of mice with a tumour (out of 10)
0	0
0.5×10^6	0
1.0×10^6	1
2.0×10^6	3

0 2 . 4 A scientist suggested using 2.0×10^6 cells in all future work on this treatment. Use all the information to evaluate this suggestion.

[5 marks]

11

Turn over for the next question

Do not write outside the box

A student produced tissue cultures of cauliflower. She cut small pieces of tissue, called explants, from the florets and from the stalk of a cauliflower. She:

- soaked the explants in dilute bleach solution for 15 minutes
- rinsed the explants three times in sterile water
- placed each explant on sterile nutrient agar containing plant growth factors in a sealed tube
- kept the tubes at 25 °C in the light for six weeks.

Table 2 shows her results.

Table 2

Source of explants	Number of explants set up	Number of explants contaminated by microorganisms	Number of explants that formed shoots
Floret tips	40	3	31
Stalk	40	4	9

0 3 . 1 Explain why the student soaked the explants in bleach solution and then rinsed them in sterile water.

[2 marks]

0 3 . 2 Calculate the percentage of the uncontaminated explants from the floret tips that formed shoots.
Give your answer to the nearest whole number.

[2 marks]

Answer ..... **%**

Question 3 continues on the next page

Do not write outside the box

0 3 . 3 Explants from the floret tips grew into small plants with both shoots and roots.
Few explants from the stalk formed shoots.
Use your knowledge of gene expression to suggest an explanation for these results.

[2 marks]

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Turn over for the next question

Do not write outside the box

Transcription factors and oestrogen 3.8.2.2

0 4 . 1 Which statement about transcription factors in eukaryotic cells is correct?
Tick (✓) one box.

[1 mark]

They bind to mRNA in the cytoplasm and stimulate translation. ☐

They move from the cytoplasm into the nucleus and can stimulate or inhibit transcription. ☐

They join RNA nucleotides together to form a pre-mRNA molecule. ☐

They change the base sequence of the promoter of a target gene. ☐

0 4 . 2 Oestrogen is a steroid hormone. It diffuses through the cell-surface membrane of its target cells.
Describe how oestrogen then initiates transcription of a target gene.

[4 marks]

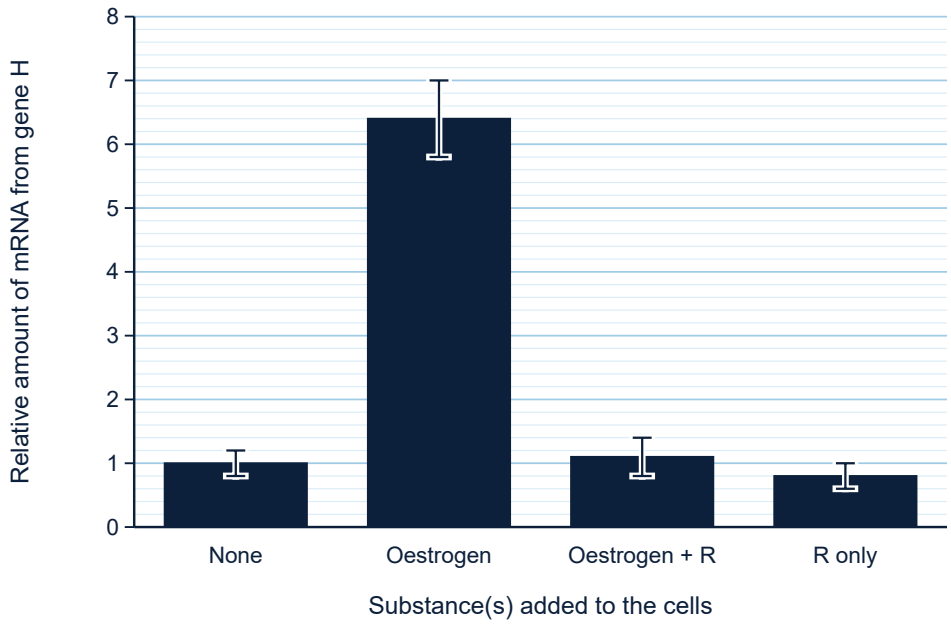
Question 4 continues on the next page

Do not write outside the box

Scientists investigated the effect of oestrogen on transcription of a gene, gene H, in human breast cells grown in culture. Substance R has a similar shape to oestrogen. The scientists set up 5 cultures for each treatment and measured the relative amount of mRNA from gene H after 24 hours.

Figure 2 shows their results. The error bars show ±1 standard deviation.

Figure 2



0 4 . 3 Use Figure 2 to calculate the percentage decrease in the amount of mRNA from gene H when substance R was added with oestrogen, compared with oestrogen alone.

[2 marks]

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Answer ..... **%**

Question 4 continues on the next page

Do not write outside the box

0 4 . 4 Use the information in Figure 2 and your knowledge of transcription factors to explain the results for substance R.

[3 marks]

0 4 . 5 A student concluded that substance R completely prevents the effect of oestrogen on transcription of gene H.
Use Figure 2 to evaluate this conclusion.

[2 marks]

12

Turn over for the next question

Do not write outside the box

Epigenetics and RNA interference 3.8.2.2

0 5 . 1 Which epigenetic change would inhibit transcription of a gene?
Tick (✓) one box.

[1 mark]

- Decreased methylation of the DNA of the gene ☐
- Increased acetylation of the histones associated with the gene ☐
- Increased methylation of the DNA of the gene ☐
- Increased acetylation of the DNA of the gene ☐

0 5 . 2 Explain how decreased acetylation of histones can inhibit transcription of a gene.

[2 marks]

3

Turn over for the next question

Do not write outside the box

Identical twins develop from the same fertilised egg. Non-identical twins develop from two different fertilised eggs.

Scientists measured the methylation at 1200 sites in the DNA of white blood cells from pairs of twins. For each pair, they recorded the percentage of these sites at which the twins' DNA was methylated differently. Table 3 shows their results.

Table 3

Type of twins	Age / years	Where the twins lived	Number of pairs	Mean percentage of sites with different methylation
Identical	3–10	Together	20	1.8
Identical	50–60	Together all their lives	18	6.3
Identical	50–60	Apart for more than 30 years	12	10.5
Non-identical	3–10	Together	20	7.4

0 6 . 1 Explain why studying identical twins allows scientists to investigate the effect of the environment on methylation of DNA.

[2 marks]

Question 6 continues on the next page

Do not write outside the box

0 6 . 2 What do the data in Table 3 suggest about the relative influences of genetic and environmental factors on methylation of DNA?
Use the data in your answer.

[4 marks]

6

Turn over for the next question

Do not write outside the box

Gene W is a tumour suppressor gene. Histone deacetylase is an enzyme that removes acetyl groups from histones. Drug V is an inhibitor of histone deacetylase.

Scientists studied two lines of colon cancer cells, line P and line Q. In both lines, histone deacetylase activity is high and gene W is rarely transcribed. In line Q, gene W also has one base deleted.

The scientists grew each line of cells with different concentrations of drug V. Each well contained 1.0×10^5 cells at the start. After 72 hours, they measured the relative amount of mRNA from gene W and the number of cells in each well. Table 4 shows their results.

Table 4

Concentration of drug V / μmol dm^{-3}	Line P		Line Q	
	Relative amount of mRNA from gene W	Cells per well / $\times 10^4$	Relative amount of mRNA from gene W	Cells per well / $\times 10^4$
0	1.0	52	1.0	55
0.5	1.8	41	1.9	54
1.0	3.1	29	3.3	52
2.0	4.6	18	4.4	53
4.0	4.9	16	4.8	51

0 7 . 1 Drug V was dissolved in a solvent.
Suggest what the scientists should have added to the cells in the wells with no drug V.

[1 mark]

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Question 7 continues on the next page

Do not write outside the box

0 7 . 2 Use Table 4 and your knowledge of epigenetics to explain the effect of drug V on the number of cells of line P.

[4 marks]

0 7 . 3 Calculate the percentage decrease in the number of cells per well of line P at 2.0 μmol dm^{-3} of drug V compared with no drug V.

[2 marks]

Answer ..... **%**

0 7 . 4 Suggest an explanation for the results for line Q.

[2 marks]

Question 7 continues on the next page

Do not write outside the box

0 7 . 5 A doctor is considering using drug V to treat patients with colon cancer.
Use the information about lines P and Q to suggest how the doctor could decide which patients are likely to benefit. Explain your answer.

[3 marks]

12

Turn over for the next question

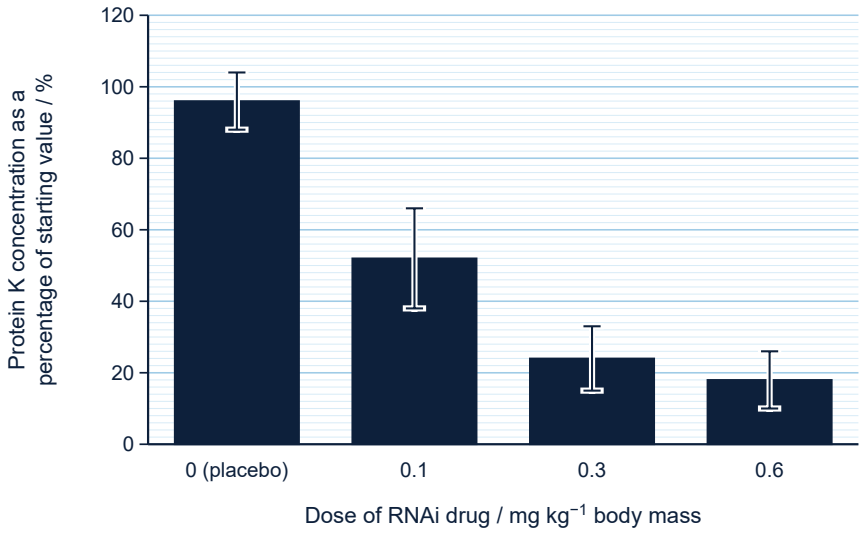
Do not write outside the box

Protein K is made in liver cells and secreted into the blood. In one inherited condition, a faulty form of protein K builds up in the body and damages nerves.

Scientists developed a drug that uses RNA interference (RNAi). The drug contains short, double-stranded RNA molecules. Inside liver cells, the two strands separate and one strand joins a protein complex.

In a clinical trial, patients with the condition were given a placebo or one of three doses of the RNAi drug for 18 weeks. There were 10 patients in each group. Figure 3 shows the concentration of protein K in their blood after 18 weeks, as a percentage of the concentration at the start. The error bars show ±1 standard deviation.

Figure 3



0 8 . 1 Explain how this RNAi drug reduces the production of protein K.

[2 marks]

Question 8 continues on the next page

Do not write outside the box

0 8 . 2 Use Figure 3 to calculate the percentage decrease in the mean protein K concentration at a dose of 0.3 mg kg^{-1} compared with the placebo.

[2 marks]

Answer _____ **%**

0 8 . 3 A doctor suggested that patients should be given the dose of 0.6 mg kg^{-1} rather than 0.3 mg kg^{-1}.
Use Figure 3 to evaluate this suggestion.

[2 marks]

0 8 . 4 After the trial, the patients stopped taking the drug. Within a few months, their protein K concentrations had returned to the starting values.
Explain why.

[2 marks]

8

Turn over for the next question

Do not write outside the box

Gene expression and cancer 3.8.2.3

0 9 . 1 Which row correctly describes a tumour?
Tick (✓) one box.

[1 mark]

Type of tumour	Rate of growth	Appearance of cells	Spreads to other parts of the body	
Benign	Slow	Similar to normal cells	No	☐
Benign	Fast	Unspecialised	No	☐
Malignant	Slow	Similar to normal cells	Yes	☐
Malignant	Fast	Similar to normal cells	No	☐

0 9 . 2 In some breast tumours, the cells have many more oestrogen receptors than normal breast cells.
Suggest how an increased concentration of oestrogen in the blood could lead to the development of this type of tumour.

[2 marks]

3

Turn over for the next question

Do not write outside the box

Gene T is a tumour suppressor gene. Gene G codes for protein G, a receptor protein that stimulates cell division when a growth factor binds to it.

Scientists compared normal cells and tumour cells from the colon of one patient. Table 5 shows their results.

Table 5

Feature	Normal colon cells	Tumour cells
Percentage of the promoter of gene T that is methylated	4%	78%
Relative amount of mRNA from gene T	1.00	0.08
Base sequence of gene G	Normal sequence	One base substituted
Relative amount of mRNA from gene G	1.00	1.05
Activity of protein G	Active only when a growth factor binds	Active all the time, even with no growth factor

1 0 . 1 Use the information in Table 5 and your knowledge to explain how the changes to gene T and gene G could have led to the development of this tumour.

[6 marks]

Question 10 continues on the next page

Do not write outside the box

1 0 . 2 Drug Y binds to protein G and stops it stimulating cell division.
Suggest why drug Y could treat the tumour described in Table 5 but would be less effective against a tumour in which gene G is normal and gene T is heavily methylated. Suggest a different type of drug that could treat this second tumour.

[3 marks]

9

Turn over for the next question

Do not write outside the box

Gene N codes for an enzyme in the liver. This enzyme converts some chemicals that form when red meat is cooked at high temperatures into carcinogens. The fast allele of gene N codes for a form of the enzyme that works faster than the form coded for by the slow allele.

Scientists followed 48 000 adults for 12 years. At the start, they identified each person's alleles of gene N and recorded the mass of red meat the person usually ate each day. They then recorded who developed colorectal cancer.

Table 6 shows the relative risk of colorectal cancer for different groups. A relative risk of 2.0 means a risk twice that of the reference group. The *P* values compare each group with the reference group.

Table 6

Alleles of gene N	Red meat eaten per day	Relative risk of colorectal cancer	*P* value
Two slow alleles	Less than 50 g	1.00 (reference group)	–
Two slow alleles	More than 100 g	1.18	0.21
At least one fast allele	Less than 50 g	1.09	0.48
At least one fast allele	More than 100 g	1.87	0.003

1 1 . 1 Explain what the *P* value of 0.003 shows about the relative risk for people with at least one fast allele who ate more than 100 g of red meat per day.

[2 marks]

Question 11 continues on the next page

Do not write outside the box

1 1 . 2 A newspaper headline stated: ‘Fast allele raises colorectal cancer risk.’
Use the information to evaluate this headline.

[4 marks]

1 1 . 3 Suggest how the results of this study could be used to help prevent colorectal cancer.

[2 marks]

8

END OF QUESTIONS

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