Gene Control (16.3): Cambridge (CIE) A Level Biology 9700 Exam Questions by Topic

22 questions · 60 marks · about 72 minutes. Answer in the spaces, then check the mark schemes at the end.

Question 1 · Paper 4 · May/June 2025 (44) · Q2(d) · 3 marks

(d) Some diseases are caused by mutations in regulatory genes.

Suggest how a mutation in a regulatory gene that codes for a repressor protein could cause a disease.

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Question 2 · Paper 4 · May/June 2022 (42) · Q7(a) · 2 marks

7 The bacterium, *Escherichia coli*, can use glucose or disaccharides, such as lactose, in its metabolism. Lactose needs to be hydrolysed by the enzyme β-galactosidase to form glucose and galactose, which can then be used by *E. coli*.

The production of β-galactosidase is controlled by a length of DNA called the *lac* operon.

(a) Fig. 7.1 shows the *lac* operon when lactose is **absent**.

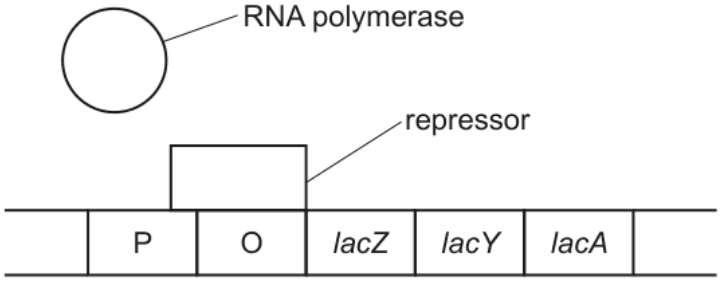


Fig. 7.1

On Fig. 7.2, draw the positions of RNA polymerase and the repressor molecule when lactose is **present**.

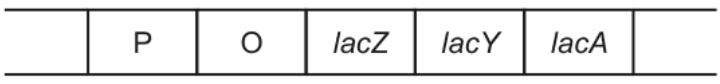


Fig. 7.2 [2]

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Question 3 · Paper 4 · May/June 2022 (42) · Q7(b)(i) · 1 mark

(b) The protein coded for by *lacY* is not involved in the control of gene expression.

(i) Name the type of gene represented by *lacY*.

Question 4 · Paper 4 · May/June 2022 (42) · Q7(b)(ii) · 2 marks

(ii) Name the protein product coded for by *lacY* **and** state the precise role of this protein.

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(c) In an investigation into the growth of *E. coli*, a sample of the bacterium was grown in a medium that contained limited concentrations of glucose and lactose. The population size of *E. coli* was measured at regular intervals.

Fig. 7.3 shows the population growth curve obtained for this investigation.

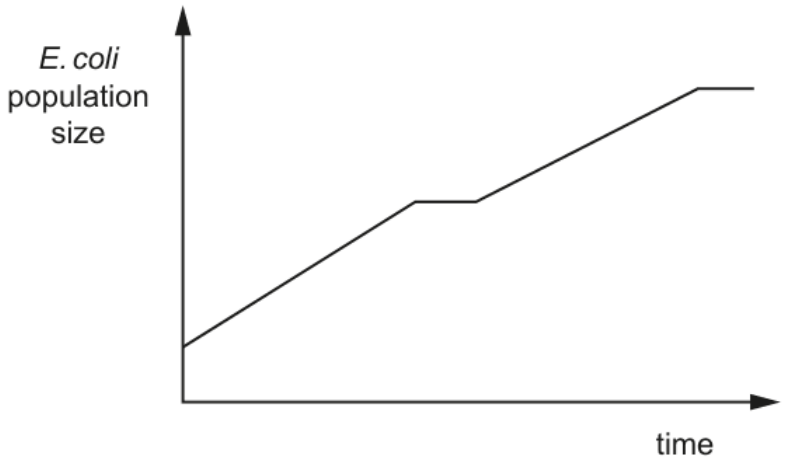


Fig. 7.3

Describe **and** suggest explanations for the population growth curve shown in Fig. 7.3.

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Question 6 · Paper 4 · May/June 2023 (43) · Q3(a)(i) · 3 marks

3 Gene expression in a cell is controlled. When a gene is expressed (switched on), the gene is transcribed. When a gene is **not** expressed (switched off), the gene is **not** transcribed.

Environmental changes can cause some genes to be switched on or switched off.

(a) An example of control of gene expression in prokaryotes is regulation in the *lac* operon.

The *lac* operon is a length of DNA that is made up of different parts.

Fig. 3.1 shows a simple diagram representing the *lacI* (regulatory) gene and the *lac* operon.

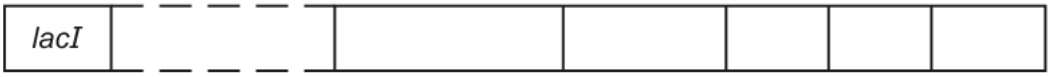


Fig. 3.1

(i) Outline the main features of the *lac* operon.

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Question 7 · Paper 4 · May/June 2023 (43) · Q3(a)(ii) · 4 marks

(ii) Explain the role of the *lacI* gene in the regulation of the *lac* operon.

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Question 8 · Paper 4 · May/June 2023 (43) · Q3(b) · 3 marks

(b) The *lac* operon codes for inducible enzymes. Repressible operons code for repressible enzymes.

Suggest **and** explain why it is an advantage to a prokaryote to have a repressible operon.

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3 The *lac* operon is present in the genome of the bacterium *Escherichia coli*.

When glucose is **not** available, the presence of lactose in the extracellular environment leads to the expression of the genes of the *lac* operon. This leads to an increase in the uptake and metabolism of lactose.

When glucose **and** lactose are available in the extracellular medium, lactose is prevented from entering the bacterial cell.

Fig. 3.1 shows what happens when glucose enters a bacterial cell.

- Glucose enters the bacterial cell using a transport protein, **A**.
- **B** is an enzyme found in the cytoplasm of the bacterial cell.
- **B** catalyses the phosphorylation of glucose to produce glucose 6-phosphate.

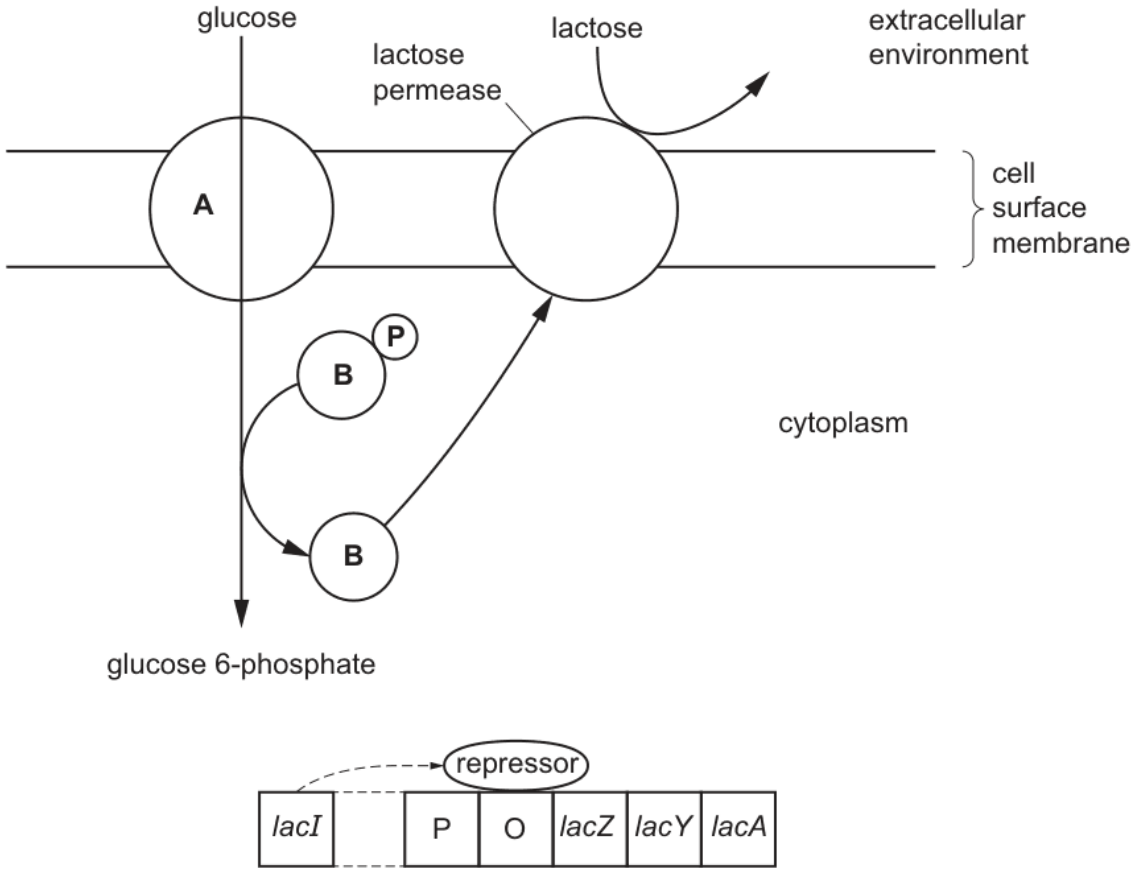


Fig. 3.1

(a) (i) With reference to Fig. 3.1, suggest **and** explain how the presence of glucose in the extracellular environment prevents lactose entering the bacterial cell.

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(ii) Suggest the advantages for the bacterial cell in preventing the entry of lactose when glucose is present in the extracellular environment.

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Question 11 · Paper 4 · October/November 2022 (42) · Q6(a)(i) · 3 marks

6 **(a)** The *lac* operon of prokaryotes contains a group of structural genes that are under the same control and are transcribed together.

Another operon found in prokaryotes is the *trp* operon.

Fig. 6.1 summarises the structure and control of the *trp* operon.

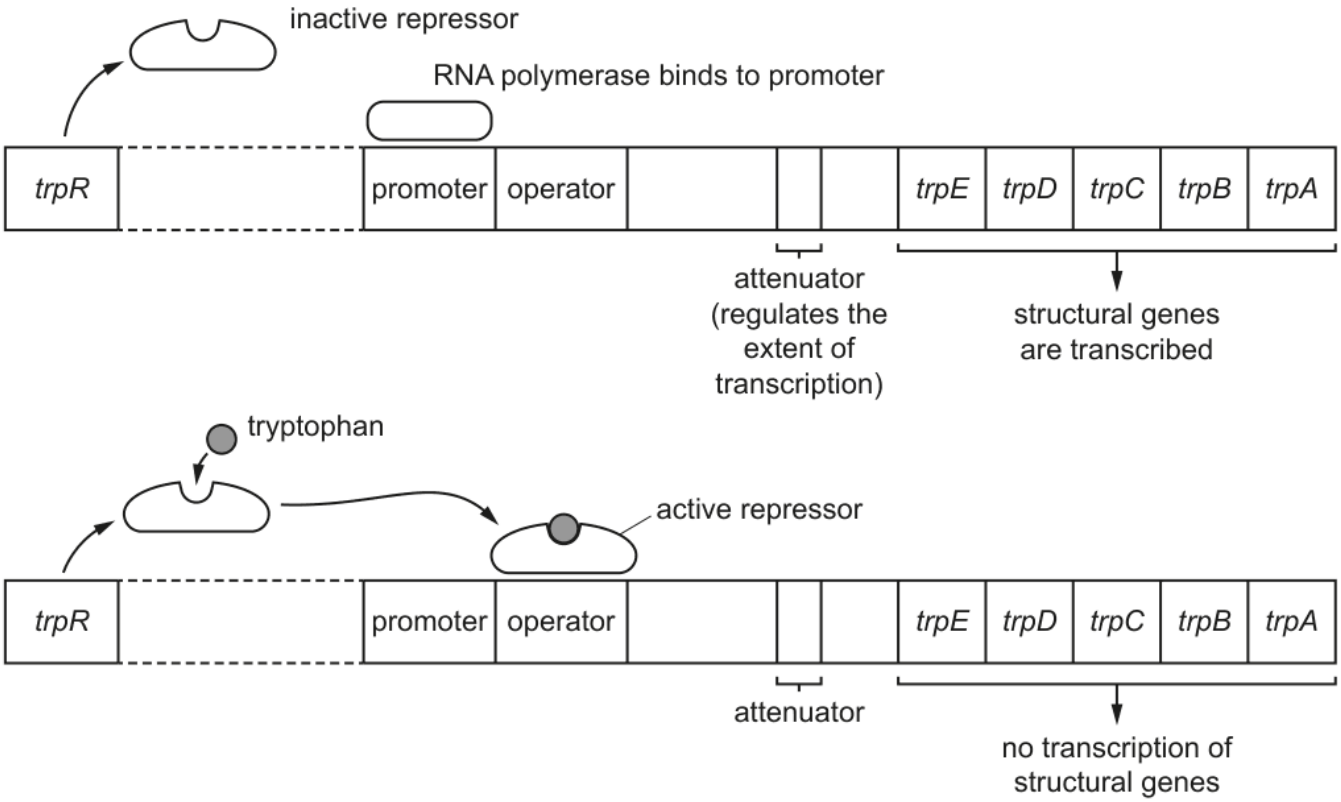


Fig. 6.1

(i) Describe the differences in structure **and** control between the *lac* operon and the *trp* operon.

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Question 12 · Paper 4 · October/November 2022 (42) · Q6(a)(ii) · 1 mark

(ii) Suggest why structural genes in operons are transcribed together.

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Question 13 · Paper 4 · October/November 2022 (42) · Q6(a)(iii) · 2 marks

(iii) *trpA* is an example of a structural gene and *trpR* is an example of a regulatory gene.

Describe the differences between the functions of structural genes and regulatory genes.

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Question 14 · Paper 4 · October/November 2022 (42) · Q6(a)(iv) · 2 marks

(iv) *trpA* codes for the enzyme tryptophan synthase.

Tryptophan synthase catalyses the formation of the amino acid tryptophan.

Explain why tryptophan synthase is an example of a repressible enzyme.

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Question 15 · Paper 4 · May/June 2019 (42) · Q2(c)(ii) · 4 marks

(ii) Explain how gene expression is controlled in eukaryotes such as fish.

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3 During an immune response, only B-lymphocytes with receptors that are specific to the antigens present are activated. Activation occurs when an antigen binds to a receptor of a B-lymphocyte.

Activated B-lymphocytes grow in size and then divide by mitosis. Many further mitotic cell divisions occur, increasing the number of B-lymphocytes with receptors specific to the antigen. Eventually, cells produced in this process will develop into either plasma cells that secrete antibodies or memory B-cells.

Fig. 3.1 is a summary of B-lymphocyte activation and the events that follow.

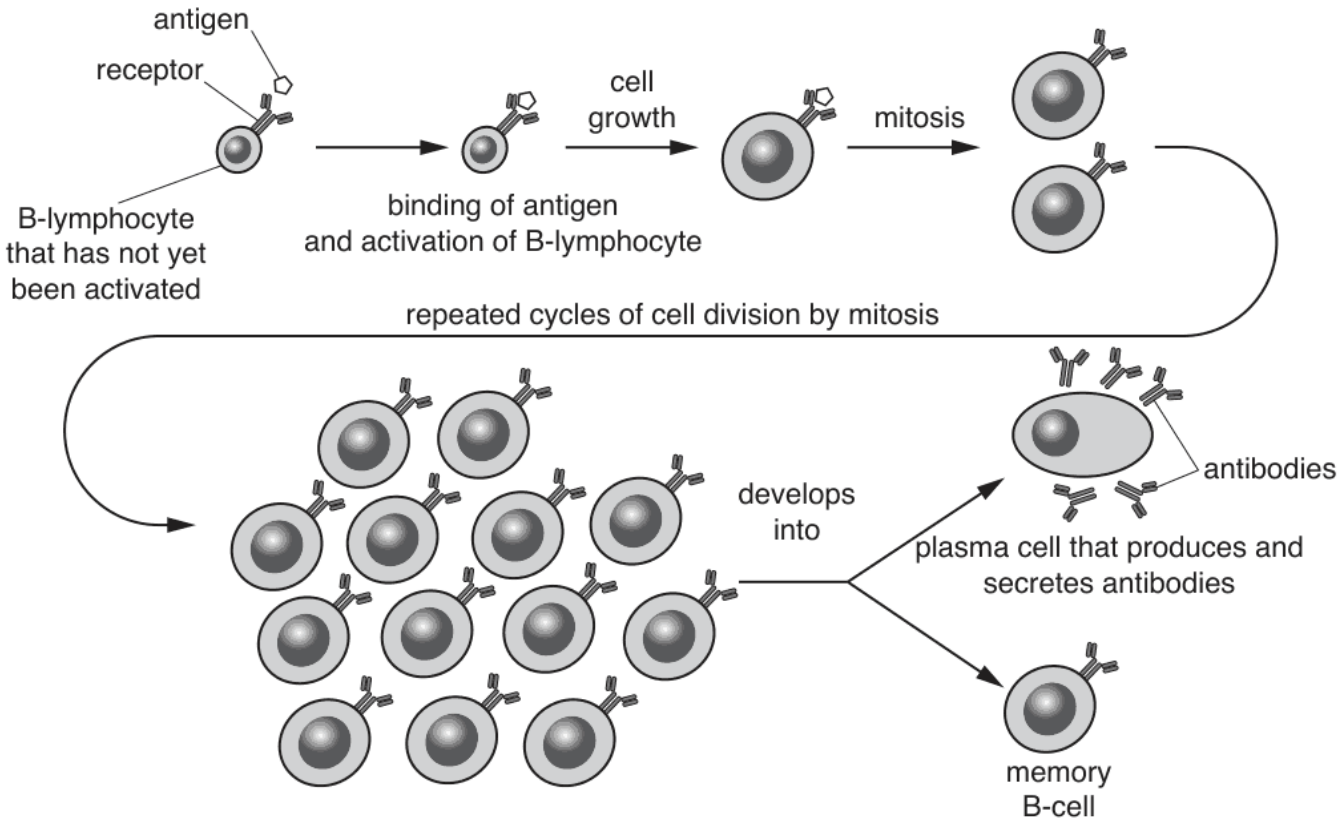


Fig. 3.1

The development of plasma cells and memory B-cells in this process depends on transcription factors.

(a) Explain the role of transcription factors in gene expression in eukaryotic cells.

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Question 17 · Paper 4 · May/June 2024 (41) · Q3(c) · 1 mark

(c) Some transcription factors increase the rate of transcription of genes involved in the closure of stomata.

State where transcription factors bind to cause an increase in the rate of transcription.

Question 18 · Paper 4 · October/November 2021 (42) · Q7(b)(ii) · 1 mark

(ii) State the term used to describe a protein that is involved in the control of gene expression in eukaryotes.

Question 19 · information from earlier in the question

3 Rice, *Oryza sativa*, is an important grain crop. A rice grain is a seed and can have a structure known as an awn, which projects from the tip of the grain.

Fig. 3.1 shows a rice grain with an awn present and a rice grain with no awn present.

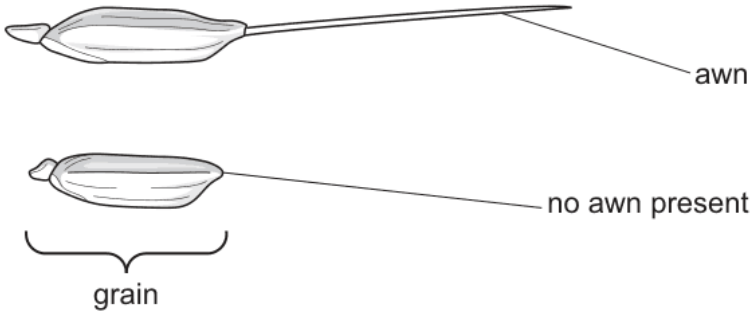


Fig. 3.1

(c) One of the changes that occurred during the domestication of wild rice to cultivated rice was the loss of the awns from rice grains.

Farmers found that long awns made storing and processing rice grains more difficult.

It was also observed that rice plants that have grains with no awns have an increased grain yield.

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Question 19 · Paper 4 · May/June 2025 (42) · Q3(c)(ii) · 3 marks

(ii) The normal allele for the gene *An-1* codes for a transcription factor that has a role in awn development and in the number of grains of rice produced.

When the transcription factor is present there is:

- an increase in the expression of genes involved in awn development (positive regulation)
- a decrease in the expression of genes involved in the number of grains produced (negative regulation).

Suggest **and** explain how changes at the *An-1* locus can cause rice plants to have grains with no awns and an increased grain yield.

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Question 20 · Paper 4 · October/November 2022 (42) · Q6(b)(i) · 4 marks

(b) Control of gene expression in eukaryotes is more complex than in prokaryotes.

In plants, the control of gene expression can involve plant hormones, such as gibberellin, and proteins known as JAZ and MYC.

(i) Describe how gibberellin activates genes in plant cells.

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Question 21 · Paper 4 · May/June 2024 (42) · Q4(c) · 3 marks

(c) Dwarf plants also occur if the genes controlling growth are not activated (switched on).

Explain how DELLA proteins act as repressors preventing gene expression.

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Question 22 · Paper 4 · May/June 2025 (41) · Q8 · 6 marks

8 The presence of gibberellins in a plant cell leads to the expression of genes involved in stem elongation.

Describe how gibberellin causes stem elongation in plants.

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Mark schemes

Question 1 · Paper 4 · May/June 2025 (44) · Q2(d) · 3 marks

2(d)	*any **three** from:* **1** no repressor produced / no repressor binds to operator **or** altered / faulty, repressor produced ; **2** (so) structural genes are, transcribed / expressed / switched on ; **3** (structural gene) proteins / enzymes, produced ; **4** (these) proteins / enzyme, damage cell / changes metabolism / causes disease ; **5** altered repressor, binds more tightly / AW, to operator ; **6** (so) structural genes, not transcribed / not expressed / switched off ; **7** (structural gene) proteins / enzymes, not produced ; **8** (so) lack of, protein / enzyme, causes, damage to cell / change to metabolism / disease ;	**3**

Question 2 · Paper 4 · May/June 2022 (42) · Q7(a) · 2 marks

7(a)	RNA polymerase attached to promoter ; repressor detached from operator ;	**2**

Question 3 · Paper 4 · May/June 2022 (42) · Q7(b)(i) · 1 mark

7(b)(i)	structural (gene) ;	**1**

Question 4 · Paper 4 · May/June 2022 (42) · Q7(b)(ii) · 2 marks

7(b)(ii)	lactose permease ; **A** beta-galactoside permease movement / transport, of lactose into cell **or** makes (cell surface) membrane (more) permeable to lactose ;	**2**

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Question 5 · Paper 4 · May/June 2022 (42) · Q7(c) · 4 marks

7(c)	1 population increases, then levels off, increases, then levels off / AW ;	**4**
	*any **three** from:*	
	2 (first increase) glucose, metabolised / respiration ;	
	3 (first levelling off) glucose has run out ;	
	4 (first levelling off) lactose, hydrolysed / broken down, into, glucose / galactose ;	
	5 (second increase) glucose / galactose, metabolised / respired ;	
	6 (second levelling off) lactose / glucose / galactose, has run out ;	
	7 AVP ; e.g. *idea of* time delay (for, lactose permease / beta galactosidase, to work)	

Question 6 · Paper 4 · May/June 2023 (43) · Q3(a)(i) · 3 marks

3(a)(i)	*the operon has:*	**3**
	promoter ;	
	operator ;	
	three structural genes / named three structural genes ;	

lacZ	**or**	β galactosidase gene
lacA	**or**	lactose / β galactoside, permease gene
lacY	**or**	transacetylase gene

***I** regulatory genes / order of named parts*

Question 7 · Paper 4 · May/June 2023 (43) · Q3(a)(ii) · 4 marks

3(a)(ii)	*any **four** from:*	**4**
	lacI gene	
	1 is always expressed ;	
	2 controls (structural) gene expression ;	
	3 codes for the repressor (protein) ;	
	4 repressor, binds to the operator / blocks the promoter ;	
	5 prevents, (structural) gene expression / RNA polymerase binding to promoter ;	
	6 lactose / allolactose, binds to repressor ;	
	7 (so) repressor cannot bind to operator / promoter unblocked / gene expression can occur ;	

Question 8 · Paper 4 · May/June 2023 (43) · Q3(b) · 3 marks

3(b)	1 enzymes / proteins, made continuously / all the time ;	**3**
	2 (because) enzymes / proteins, needed / necessary (for cell) ;	
	3 end product inhibition / made until product concentrations too high ;	

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Question 9 · Paper 4 · October/November 2025 (42) · Q3(a)(i) · 3 marks

3(a)(i)	*any **three** from:* 1 glucose diffuses into the cell (through, **A** / transport protein) ; 2 *idea that* the enzyme / **B**, loses phosphate group ; 3 (dephosphorylated) **B** binds to lactose permease ; 4 causes, shape change / allosteric change, to lactose permease ; 5 lactose permease cannot function (so lactose cannot enter) ;	**3**

Question 10 · Paper 4 · October/November 2025 (42) · Q3(a)(ii) · 2 marks

3(a)(ii)	*any **two** from:* 1 no / less, (protein) synthesis of, lactose permease / β-galactosidase / transacetylase **or** no / less, transcription / expression, of (named structural) genes (of lac operon) ; 2 no / less, ATP / energy, wasted ; 3 no / fewer, amino acids wasted ; 4 glucose is respired more easily / AW **or** fewer steps / less energy, required to break down glucose **or** lactose has to be broken down (to glucose and galactose) ;	**2**

Question 11 · Paper 4 · October/November 2022 (42) · Q6(a)(i) · 3 marks

6(a)(i)	*any **three** from:* 1 *trp* operon regulatory gene / *trpR*, codes for an inactive repressor **and** *lac* operon regulatory gene / *lacI*, codes for active repressor ; 2 *lac* operon does not have an attenuator ; **ora** 3 *lac* operon has fewer structural genes **or** 3 vs 5 structural genes ; 4 *lac* operon uses, an inducer / (allo)lactose **and** *trp* operon uses, a repressor / tryptophan ; 5 (allo)lactose, binds / inactivates, repressor, so repressor, leaves / cannot bind to, **operator** **and** tryptophan, binds / activates, repressor, so repressor can bind to **operator** ; 6 (allo)lactose causes genes to be, transcribed / switched on / expressed **and** tryptophan causes genes to be **not**, transcribed / switched on / expressed ;	**3**

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Question 12 · Paper 4 · October/November 2022 (42) · Q6(a)(ii) · 1 mark

6(a)(ii)	*any **one** from:* 1 (share) one promoter ; 2 all, enzymes / proteins / products, work together ;	**1**

Question 13 · Paper 4 · October/November 2022 (42) · Q6(a)(iii) · 2 marks

6(a)(iii)	*structural genes*: code for, enzymes / structural proteins / non-regulatory proteins / rRNA / tRNA ; *regulatory genes*: code for, proteins / products, that control, gene expression / transcription ; **A** code for, transcription factors / repressor proteins	**2**

Question 14 · Paper 4 · October/November 2022 (42) · Q6(a)(iv) · 2 marks

6(a)(iv)	*any **two** from:* 1 end-product inhibition / negative feedback / feedback inhibition ; 2 tryptophan, binds to / activates, repressor **or** tryptophan allows repressor to bind to operator ; 3 tryptophan, stops / reduces, *trpA or* gene transcription / *trpA or* gene expression / protein synthesis / tryptophan synthase being made ;	**2**

Question 15 · Paper 4 · May/June 2019 (42) · Q2(c)(ii) · 4 marks

2(c)(ii)	1 *ref. to* transcription factors ; *any **three** from:* 2 TF / gene product / protein, bind to DNA ; 3 (TF binds to) promoter ; 4 switches genes, on / off ; AW **I** genes, expressed / not expressed 5 *ref. to* binding of RNA polymerase ; **R** if operator mentioned 6 mRNA is made / transcription occurs ; **ora** 7 AVP ; e.g.(so that genes are expressed) at the correct time / in the correct context / in the correct cell type / in the correct order ;	**4**

Question 16 · Paper 4 · February/March 2019 (42) · Q3(a) · 3 marks

3(a)	*any **three** from:* 1 binds to DNA ; 2 at, promoter / enhancer ; 3 allows, RNA polymerase / other transcription factors, to bind (to, DNA / gene / promoter) ; 4 regulates / initiates / inhibits, gene expression / transcription ; **A** switches genes, on / off 5 (so that genes are expressed) at the correct time / in the correct context / in the correct cell type / in the correct order ;	**3**

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Question 17 · Paper 4 · May/June 2024 (41) · Q3(c) · 1 mark

3(c)	DNA / promoter ;	1

Question 18 · Paper 4 · October/November 2021 (42) · Q7(b)(ii) · 1 mark

7(b)(ii)	transcription factor ;	1

Question 19 · Paper 4 · May/June 2025 (42) · Q3(c)(ii) · 3 marks

3(c)(ii)	*any **three** from:* 1 mutation / change in base sequence, (in *An-1*) **or** *An-1* not expressed ; 2 transcription factor has different, primary structure / tertiary structure / 3D shape **or** transcription factor not, produced / functional **or** transcription factor faulty ; 3 transcription factor does not bind to, the promoter / DNA ; 4 decrease in expression of gene(s) for awn development ; 5 increase in expression of gene(s) for number of grains produced ;	3

Question 20 · Paper 4 · October/November 2022 (42) · Q6(b)(i) · 4 marks

6(b)(i)	*any **four** from:* 1 (gibberellin) binds to receptor ; 2 ref. enzyme ; 3 (enzyme causes) DELLA breakdown ; 4 DELLA no longer, binds to / inhibits, transcription factor / PIF ; 5 (so) transcription factor / PIF / RNA polymerase, binds to, DNA / promoter ; 6 (growth) genes, switched on / expressed / transcribed ;	4

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Question 21 · Paper 4 · May/June 2024 (42) · Q4(c) · 3 marks

4(c)	*any **three** from:* 1 (DELLA proteins) bind to, PIF / transcription factor ; 2 PIF / transcription factor, cannot bind to, DNA / promoter ; 3 RNA polymerase cannot bind to promoter ; 4 no transcription / mRNA not made ;	**3**

Question 22 · Paper 4 · May/June 2025 (41) · Q8 · 6 marks

8	*any **six** from:* **1** gibberellin binds to (gibberellin) receptor (-enzyme-complex) ; **2** DELLA (protein) destroyed ; **3** transcription factor / PIF, released / free / no longer bound to DELLA ; **4** transcription factor / PIF / RNA polymerase, binds to, DNA / promoter ; **5** growth / expansion / XET / xyloglucan endotransglucosylase, gene, switched on / expressed / transcribed ; **6** loosens cell walls / breaks bonds between cellulose ; **7** water enters (cells) by osmosis causing cell elongation ; **8** AVP ;	**6**

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