

Model Answers: Medium

1a

a) i) Lactase can be considered an inducible enzyme because...

- It is only synthesised in the presence of lactose/its substrate; [1 mark]

a) ii) Inducible enzymes are important because...

- (The ability to induce enzyme production when needed) prevents the wastage of energy in producing enzymes/molecules that are not required; [1 mark]

[Total: 2 marks]

1b

b) i) The structural genes are transcribed in the presence of lactose because...

Any **three** of the following:

- Lactose is taken up by the *E. coli* / bacterial cells; [1 mark]
- Lactose binds to the repressor protein; [1 mark]
- This distorts / changes the shape of the repressor protein; [1 mark]
- The repressor protein cannot bind to the operator (meaning that RNA polymerase can bind to the promoter); [1 mark]

Ignore references to RNA polymerase and transcription as this information has already been given in the question.

b) ii) If *E. coli* was grown in a medium containing both glucose and lactose...

Any **three** of the following:

- cAMP would not be produced (due to the presence of glucose) **AND** would not bind to CAP; [1 mark]
- CAP would not be activated **AND** would not bind to the CAP site; [1 mark]
- The transcription rate (of structural genes) would be low (since RNA polymerase would not bind very well to the promoter); [1 mark]
- A small amount of lactase would be produced; [1 mark]

[Total: 6 marks]

This is a tricky question that requires you to use your knowledge of the effect of lactose on the lac operon at the same as applying new information about the effects of glucose.

You know that in the presence of lactose the repressor protein cannot bind to the operator and RNA polymerase can therefore bind to the promoter and initiate transcription of the structural genes.

However, at the same time as these familiar events, you have also been told that the presence or absence of glucose can affect this process. The presence of glucose means that cAMP is not produced and that CAP is not activated. The absence of CAP at the CAP site means that even though RNA polymerase is theoretically free to bind (due to the absence of the repressor protein) it actually cannot bind very well. This means that there will be some transcription of the structural genes but not very much, and only a small amount of lactase would be produced.

This is beneficial to the bacteria because it prevents them from producing too much lactase when glucose is available as a preferred energy source.

1c

c) The role of the operator region in the absence of lactose is...

- (This is where) the repressor protein binds (and prevents RNA polymerase from

binding to the promoter); [1 mark]

[Total: 1 mark]

2a

a) Gibberellin controls gene expression in a germinating seed as follows...

- Gibberellin binds to a gibberellin receptor associated with / attached to an enzyme; [1 mark]
- The enzyme will start the breakdown of DELLA (repressor proteins); [1 mark]
- (Transcription factor) PIF is no longer bound to DELLA protein **AND** is able to bind to the promoter; [1 mark]
- Transcription of amylase gene; [1 mark]
- Amylase is produced (to break down stored starch as an energy source); [1 mark]

[Total: 5 marks]

Make sure that you understand the way in which gibberellin facilitates germination in seeds. By breaking down the DELLA repressor protein the transcription factor can stimulate the transcription of the amylase gene. This enzyme is important to break down starch reserves in the seed and provide the energy that is needed for growth and development of the plant embryo.

2b

b) The importance of RNA analysis in studying gene expression is...

Any **two** of the following:

- During gene expression (m)RNA is produced during transcription; [1 mark]
- The (m)RNA present in a cell can be matched to specific genes; [1 mark]
- This can provide information about / show which genes are being expressed (in the cell); [1 mark]
- This can be useful in diagnosing genetic disorders / determining whether or not a cell is cancerous; [1 mark]

[Total: 2 marks]

Cells express different genes at different levels from each other. Analysing the mRNA present in a cell can give a good indication of the specific genes that are being expressed in that cell at a particular time. This can be useful when diagnosing the cause of cell problems, or in determining whether a cell is expressing cancer genes.

2c

c) The importance of controlling seed germination includes...

Any **two** of the following:

- To ensure that seeds germinate when conditions are favourable **OR** to prevent seeds from germinating when conditions are unfavourable; [1 mark]
- Water/carbon dioxide availability for photosynthesis / temperature is suitable for enzyme activity / oxygen availability for respiration / soil mineral content for production of new molecules; [1 mark]
- To avoid wasting energy / death of the embryo/young plant if germination occurs under unfavourable conditions; [1 mark]

***Accept** other correctly described example of an environmental variable that affects plant growth for mark point 2.*

[Total: 2 marks]

It is important that seeds germinate when conditions are favourable for their growth and development. A lack of water, nutrients, or cold temperatures could all cause the developing embryo to die, which would result in the wastage of energy and materials used during germination.

3

Genetic control of protein production in a prokaryote using the lac operon involves...

Any **seven** of the following:

- (The lac operon contains a) regulatory gene; [1 mark]
- (The regulatory gene) codes for a repressor protein; [1 mark]
- (The repressor protein) binds to the operator; [1 mark]

In the presence of lactose:

- Lactose binds to the repressor protein; [1 mark]
- (The repressor protein) changes shape; [1 mark]
- (The repressor protein) moves away from the operator; [1 mark]

In the absence of lactose;

- (The repressor protein) covers/binds to (part of) the promoter; [1 mark]
- RNA polymerase cannot bind to the promoter; [1 mark]
- Structural genes cannot be transcribed / mRNA is not synthesised; [1 mark]
- (Named) enzymes cannot be synthesised; [1 mark]

Accept reverse answers for the events that occur in the **presence** of lactose for marking points 7-10, e.g. "in the presence of lactose..."

- For marking point 7 "...the promoter region is unblocked/exposed".
- For marking point 8 "...RNA polymerase can then bind to the promoter".
- For marking point 9 "...structural genes are transcribed".
- For marking point 10 "...enzymes can be synthesised"

[Total: 7 marks]

Make sure here that it is very clear whether you are describing the events in the **presence** or **absence** of lactose.

4a

a) i) The completed table is as follows...

Any **two** of the following:

structural gene	name of gene product
<i>lacZ</i>	β -galactosidase / lactase; [1 mark]
<i>lacY</i>	(lactose / β -galactoside) permease; [1 mark]
<i>lacA</i>	transacetylase; [1 mark]

a) ii) Some genes show constitutive expression because...

- Gene products/enzyme/protein needed all the time; [1 mark]

a) iii) The effect of the product of gene I on the functioning of the *lac* operon is...

Any **two** of the following:

- (Repressor protein/gene product) binds to the operator; [1 mark]

- Blocks promoter; [1 mark]
- RNA polymerase unable to bind to promoter; [1 mark]
- No transcription / expression / activation / mRNA synthesis of (named) structural genes; [1 mark]

[Total: 5 marks]

Make sure to check your spelling carefully, for example if you spell β -galactosidase incorrectly you cannot get the mark.

4b

b) i) A inducible enzyme is...

- Only produced when substrate/inducer/lactose is present; [1 mark]
- (Substrate/inducer/lactose) causes gene expression / gene activation / transcription / mRNA synthesis; [1 mark]

b) ii) This is beneficial to *E. coli* because...

- (There is) no waste of amino acids/ATP/nucleotides/energy; [1 mark]

[Total: 3 marks]