Past-paper walk-through

Feedback ▪ 4.4

eXercise

Questions in this set

- 2025 Q5
- 2019 Q1
- 2018 Q8

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 5

2025 ▪ Q5

Figure 1 shows the reactions of the metabolic pathway used to synthesize amino acid B from amino acid A in cells.

Figure 1. Synthesis of amino acid B from amino acid A

[Diagram of a linear metabolic pathway with feedback inhibition. Left to right: a triangle labeled "Amino Acid A" is converted by "Enzyme 1" (shown as a shape resembling a Pac-Man/wedge with a notch) into an intermediate; an arrow leads to a shape converted by "Enzyme 2" (a chevron/arrow shape, drawn shaded/filled darker to indicate it is the enzyme being asked about) producing "Intermediate X" (small triangle shape); an arrow leads to a shape converted further to produce "Intermediate Y" (a half-circle/D shape); an arrow leads through "Enzyme 3" (a half-circle notch shape) producing the final product, a rectangle labeled "Amino Acid B". Below the pathway, a curved arrow leads from "Amino Acid B" back down and around to

Question 5

"Enzyme 1", terminating in a flat bar (inhibition symbol, T-bar) pointing into the Enzyme 1 / Amino Acid A binding site, indicating that Amino Acid B feedback-inhibits Enzyme 1's binding of Amino Acid A.]

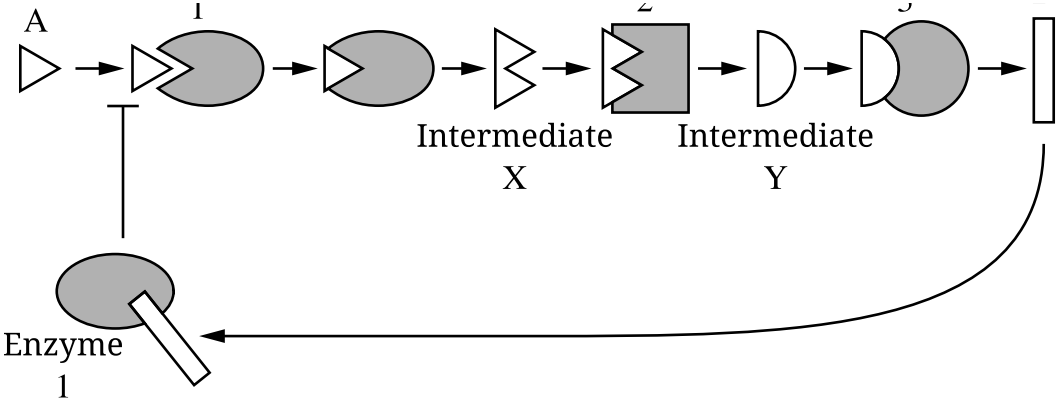
(a) Describe a characteristic of an enzyme's active site that allows it to catalyze a specific chemical reaction.

(b) Based on Figure 1, explain how the binding of amino acid A to enzyme 1 is regulated by amino acid B.

(c) Using the information in Figure 1, identify the product of the reaction catalyzed by enzyme 2: intermediate X, intermediate Y, or amino acid B.

(d) Based on Figure 1, explain how a change in pH could affect enzyme 3 in such a way that amino acid B cannot be produced.

Question 5



Solution 5

(a)

Mark scheme

- The active site's shape/charge is complementary/compatible with a specific substrate/amino acid, letting the enzyme bind only that substrate; the active site also positions the substrate in a way that makes the reaction more likely (induced fit stresses bonds, increasing the reaction's likelihood).

Solution 5

(b)

Mark scheme

- Amino acid B (the pathway's end product) inhibits the binding of amino acid A to enzyme 1 — it binds to an allosteric site on enzyme 1, causing the enzyme to change shape and preventing amino acid A from binding at the active site. This is feedback inhibition, shown in Figure 1 by the arrow from amino acid B back to enzyme 1.

Solution 5

(c)

Mark scheme

- Intermediate Y is the product of the reaction catalyzed by enzyme 2 (enzyme 2 converts intermediate X into intermediate Y in the pathway shown in Figure 1).

Solution 5

(d)

Mark scheme

- A change in pH could alter the structure/active site/shape of enzyme 3 (e.g., by disrupting the ionic and hydrogen bonds that maintain its 3D structure) so that intermediate Y/the substrate can no longer bind to it, or could denature enzyme 3 entirely so intermediate Y cannot bind and be converted into amino acid B.

Question 1

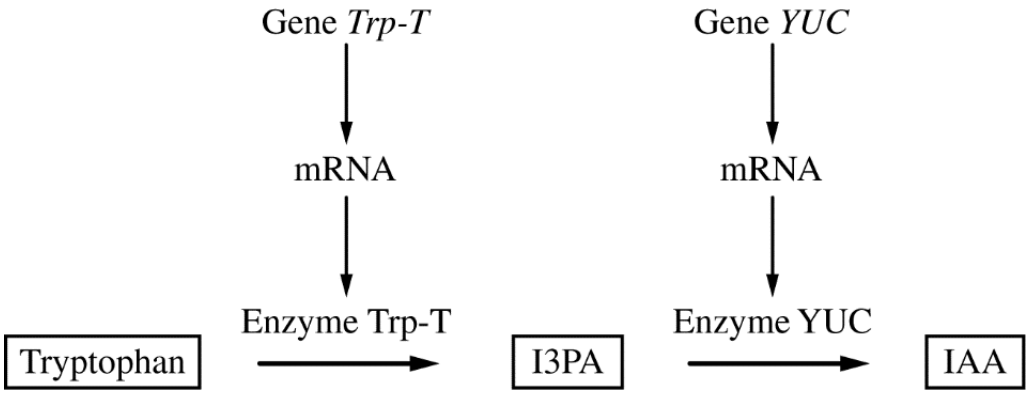
2019 ▪ Q1

[Figure 1. Model of two-step enzymatic plant pathway for synthesis of IAA from tryptophan: Gene Trp-T -> (arrow down) mRNA -> (arrow down) Enzyme Trp-T; Tryptophan –(Enzyme Trp-T)–> I3PA. Gene YUC -> (arrow down) mRNA -> (arrow down) Enzyme YUC; I3PA –(Enzyme YUC)–> IAA.]

Auxins are plant hormones that coordinate several aspects of root growth and development. Indole-3-acetic acid (IAA) is an auxin that is usually synthesized from the amino acid tryptophan (Figure 1). Gene *Trp-T* encodes an enzyme that converts tryptophan to indole-3-pyruvic acid (I3PA), which is then converted to IAA by an enzyme encoded by the gene *YUC*.

(a) Circle ONE arrow that represents transcription on the template pathway. **Identify** the molecule that would be absent if enzyme YUC is nonfunctional.

Question 1


Gene *Trp-T*
mRNA
Enzyme Trp-T
Tryptophan
I3PA
Gene *YUC*
mRNA
Enzyme YUC
IAA

Question 1

2019 ▪ Q1

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(b) Predict how the deletion of one base pair in the fourth codon of the coding region of gene *Trp-T* would most likely affect the production of IAA. **Justify** your prediction.

Question 1

2019 ▪ Q1

[Figure 1. Model of two-step enzymatic plant pathway for synthesis of IAA from tryptophan: Gene Trp-T -> (arrow down) mRNA -> (arrow down) Enzyme Trp-T; Tryptophan –(Enzyme Trp-T)–> I3PA. Gene YUC -> (arrow down) mRNA -> (arrow down) Enzyme YUC; I3PA –(Enzyme YUC)–> IAA.]

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(c) Explain one feedback mechanism by which a cell could prevent production of too much IAA without limiting I3PA production.

Question 1

2019 ▪ Q1

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(d) Rhizobacteria are a group of bacteria that live in nodules on plant roots. Rhizobacteria can produce IAA and convert atmospheric nitrogen into forms that can be used by plants. Plants release carbon-containing molecules into the nodules. Based

Question 1

on this information, **identify** the most likely ecological relationship between plants and rhizobacteria. **Describe** ONE advantage to the bacteria of producing IAA.

Question 1

2019 ▪ Q1

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(e) A researcher removed a plant nodule and identified several "cheater" rhizobacteria that do not produce IAA or fix nitrogen. **Describe** the evolutionary advantage of being a bacterial cheater in a population composed predominantly of noncheater bacteria.

Question 1

Plants can adjust the amount of carbon-containing molecules released into nodules in response to the amount of nitrogen fixed in the nodule. **Predict** the change in the bacterial population that would cause the plant to reduce the amount of carbon-containing molecules provided to the nodule.

Solution 1

(a)

Mark scheme

- Circle: Circle either arrow that points from a gene (Trp-T or YUC) to its mRNA — this represents transcription. [1 point] Identify: If enzyme YUC is nonfunctional, the molecule IAA would be absent, because YUC catalyzes the conversion of I3PA to IAA (the final step of the pathway); with no functional YUC, I3PA cannot be converted to IAA. [1 point]

Solution 1

(b)

Mark scheme

- Prediction: Deletion of one base pair in the fourth codon of the Trp-T coding region would most likely reduce IAA production, or result in no IAA production. [1 point] Justification (any one): the frameshift mutation results in translation of an inactive/nonfunctional Trp-T enzyme; OR the mutation results in no translation of the Trp-T enzyme (e.g., a premature stop codon); OR the mutation results in no/reduced production of I3PA (since Trp-T is needed to convert tryptophan to I3PA, and I3PA is the precursor for IAA). [1 point]

Solution 1

(c)

Mark scheme

- This is a negative feedback (feedback inhibition) mechanism: as IAA accumulates, increasing amounts of IAA inhibit the pathway that produces it. [1 point] Specifically, the rising IAA level inhibits production of the YUC enzyme, or inhibits YUC enzyme activity — this blocks only the second step (I3PA $\rightarrow$ IAA), so I3PA production (via Trp-T, the first step) is not limited. [1 point]

Solution 1

(d)

Mark scheme

- Identification: The relationship between plants and rhizobacteria is mutualism — both organisms benefit. [1 point] Description: One advantage to the bacteria of producing IAA is that IAA promotes root growth, which increases the plant's habitat/number of nodules available to house the rhizobacteria; in exchange, the bacteria receive carbon-containing molecules released by the plant (as a result of the increased plant growth). [1 point]

Solution 1

(e)

Mark scheme

- Description: 'Cheater' bacteria that benefit from nodule resources without expending energy to produce IAA or fix nitrogen have more energy available for their own reproduction, giving them a reproductive/evolutionary advantage over noncheater bacteria as long as cheaters remain a minority. [1 point]
  Prediction: A decrease in the nitrogen-fixing/noncheater bacteria (or a decrease in the total amount of nitrogen fixed in the nodule) would cause the plant to reduce the amount of carbon-containing molecules it releases into that nodule. [1 point]

Question 8

2018 ▪ Q8

Acetylcholine receptor (AChR) proteins are found at the synapse between neurons and skeletal muscle cells. Acetylcholine released from neurons binds to a specific site on the receptor proteins, which causes an ion channel in the receptors to open and allow sodium ions (Na^+) to enter muscle cells. The resulting depolarization of muscle cells initiates muscle contractions. Another molecule, nicotine, can also bind to certain types of AChR proteins and activate the receptors.

Question 8

A researcher is investigating two different types of AChR proteins: type 1 and type 2. To determine which stimuli activate the receptors, the researcher exposes muscle cells expressing the different types of receptor proteins to stimuli and observes the results indicated in Table 1.

TABLE 1. RESPONSE OF AChR PROTEINS TO DIFFERENT STIMULI

AChR Protein Type	**Acetylcholine**	**Nicotine**
Type 1	+	+
Type 2	+	–

Question 8

- indicates activation; – indicates no activation

(a) Describe the difference in the structure AND function between AChR type 1 and AChR type 2.

(b) Acetylcholinesterase is an enzyme that breaks down acetylcholine in the synapse. **Describe** the effect of inhibiting acetylcholinesterase on the muscle cells with AChR type 2.

Question 8

AChR Protein Type	Acetylcholine	Nicotine
Type 1	+	+
Type 2	+	–

+ indicates activation
– indicates no activation

Solution 8

(a) Mark scheme

- Structure (1 pt, any one of, from Table 1 where type 1 responds to both ACh (+) and nicotine (+) but type 2 responds to ACh (+) only and not nicotine (–)): binding sites on type 1 and type 2 differ in shape/specificity/number; OR there is differential binding of molecules to type 1 vs type 2 receptors; OR the receptors are activated by one (ACh) or both (ACh and nicotine) molecules. Function (1 pt, matched to the same row/structure statement): differential binding of molecules to type 1 and type 2 receptors; OR activated by one or both molecules; OR no difference in response once activated (both open a sodium channel, cause depolarization, and cause muscle contraction). Fullest correct pairing: structurally the receptors' binding sites differ (type 2 can't bind nicotine, type 1 can);

Solution 8

functionally, once either IS activated there is no difference in the resulting muscle-cell response. Points may be earned from only one row of the table — don't mix statements across rows.

Solution 8

(b)

Mark scheme

- Acetylcholinesterase normally breaks down acetylcholine in the synapse to end receptor activation. If it is inhibited, acetylcholine is not broken down and remains in the synapse, causing continued/prolonged activation of AChR type 2 (1 pt) — leading to repeated opening of sodium channels, repeated depolarization, and/or muscle spasms.