

BIOLOGY

Unit 3 – Written examination



2023 Trial Examination

SOLUTIONS

SECTION A: Multiple-choice questions (1 mark each)

Question 1

Answer: C

Explanation:

Ribosomal RNA forms part of the structural component of ribosomes. mRNA carries the genetic code from the nucleus, and tRNA carries amino acids.

Question 2

Answer: D

Explanation:

Regulatory genes produce repressor proteins and attenuation creates truncated proteins. Prokaryotes do not undergo RNA processing. The operator allows the repressor protein to bind, inhibiting transcription from occurring.

Question 3

Answer: B

Explanation:

As the students had the same DNA sample and the same restriction enzymes, the factor that would affect the position of the bands is the current applied, with a higher current causing the fragments to move through the gel faster than a lower current.

Question 4

Answer: C

Explanation:

The H⁺ ions from water bind to the co-enzyme NADP⁺ and move from the grana to the stroma. The matrix and cristae are in the mitochondria, and Rubisco is responsible for carbon fixation.

Question 5

Answer: C

Explanation

The protein is synthesized at the ribosome, folding occurs at the rough endoplasmic reticulum. The protein is then placed in a transport vesicle and sent to the Golgi body for further modification. Finally, the protein is placed in a secretory vesicle for export from the cell.

Question 6

Answer: B

Explanation

Photorespiration occurs in C₃ plants, whereas C₄ and CAM (including cacti) have adaptations to minimize photorespiration. As water is available, the plant is most likely to be C₄ as CAM plants are adapted to arid regions.

Question 7

Answer: A

Explanation

As the B galactosidase gene is part of the lac operon, it contains a promoter region. As such, by inserting the gene for insulin within this gene, the insulin will be transcribed and translated. Different endonucleases have different recognition sequences and antibiotic resistance is in another gene.

Question 8

Answer: B

Explanation

Viral DNA is stored as a spacer, with the repeats separating the sequences stored from different viral genomes.

Question 9

Answer: A

Explanation

The coding strand is complementary to the template strand from which mRNA is read. If the coding strand is TTA, the template strand would be AAT and the complementary mRNA would be UUA. As the anticodon is complementary to the mRNA, this would be UUA.

Question 10

Answer: B

Explanation

As Methionine and Tryptophan are only coded for one codon, they are not degenerate. Degenerate means that multiple codons will code for one amino acid. Enzymes are catalysts, and co-enzymes increase the affinity of an enzyme to a substrate.

Question 11

Answer: D

Explanation

A competitive inhibitor binds to the active site of an enzyme, whereas a non-competitive inhibitor binds to the allosteric site. Adding more substrate increases the probability of the substrate binding to the enzyme, rather than the inhibitor, reducing the impact on the rate of reaction.

Question 12

Answer: A

Explanation

Oxygen is the final acceptor in the electron transport chain, with NAD accepting H^+ ions in glycolysis and the Krebs cycle, and FAD accepting H^+ ions in the Krebs cycle only. $NADP^+$ is a H^+ acceptor in photosynthesis.

Question 13

Answer: B

Explanation

PCR uses Taq or DNA polymerase, not RNA polymerase, which is why the DNA sample would not amplify. If there was a low number of free nucleotides, it would still be expected that the initial DNA sample would somewhat increase in volume.

Question 14

Answer: A

Explanation

At a pH level above and below the optimum, and a temperature above the optimum, the rate of reaction decreased as the enzyme denatures. Substrate is converted to product when the enzyme is at the optimal level.

Question 15

Answer: B

Explanation

The net ATP in glycolysis is 2, however 4 are produced in total. 26 ATP are produced in the electron transport chain, and a total of 30 ATP is produced in aerobic respiration.

Question 16

Answer: C

Explanation

The first stage, denaturation, occurs at 95°C. The second stage, annealing, occurs at 55°C and the final stage, elongation; occurs at 72°C.

Question 17

Answer: B

Explanation

Initial folding occurs at the rough endoplasmic reticulum, with further modification at the Golgi body. Post transcriptional modification occurs within the nucleus, and the smooth endoplasmic reticulum is the site of lipid synthesis.

Question 18

Answer: C

Explanation

Enzymatic hydrolysis is the process of using enzymes and the addition of a water molecule to convert chains of stored sugars into monomers. Chitin is found in fungal cell walls, and as such, is not used to produce bioethanol.

Question 19

Answer: B

Explanation

The x axis could be either substrate concentration or enzyme concentration, however the rate of reaction is the only option for the y axis. A pH or temperature graph would show a decline following the optimum value.

Question 20

Answer: D

Explanation

The Cas9 enzyme binds to the PAM sequence and cuts 2-5 nucleotides upstream. Endonucleases search for a specific palindromic sequence.

Question 21

Answer: A

Explanation

RNA processing removes introns and splices exons together. The methyl cap is added to the 5' end and the poly A tail is added to the 3' end.

Question 22

Answer: D

Explanation

Initially aerobic respiration would occur, increasing carbon dioxide and decreasing oxygen levels. When oxygen resources have been depleted, anaerobic respiration would occur, increasing carbon dioxide and ethanol levels.

Question 23

Answer: D

Explanation

As oxygen levels would have been depleted, the yeast would then undergo anaerobic respiration.

Question 24

Answer: B

Explanation

As oxygen would still be present, aerobic respiration would still be occurring. Carbon dioxide is produced in both glycolysis and the Krebs cycle, and oxygen is the final acceptor in the electron transport chain.

Question 25

Answer: A

Explanation

The volume of yeast should be the same for any repetitions of the experiment. Oxygen, ethanol and carbon dioxide levels all changed and were measured.

SECTION B Short-answer questions

Question 1 (7 marks)

- a. Tryptophan is an amino acid and amino acids are the monomers of proteins (1). If tryptophan was unavailable, the bacterium may not be able to produce all required proteins OR energy would be wasted transcribing mRNA that could not be translated (1)
2 marks
- b. The attenuator region contains domains which will control the expression of the trp genes (1). These domains can create loops which either cause a terminator hairpin loop to form – stopping translation (1) or a non-terminator hairpin loop – allowing translation to continue (1)
3 marks
- c. One of
Protein synthesis is faster in prokaryotes than eukaryotes as transcription and translation occur simultaneously.
Eukaryotes have RNA processing whereas prokaryotes do not.
Eukaryotes have introns and exons whereas prokaryotes have only exons.
1 mark
- d. More than one codon codes for the same amino acid.
1 mark

Question 2 (7 marks)

- a. Transgenic
1 mark
- b. DNA is universal (1) with the same DNA triplet coding for the same amino acid in all organisms (1)
2 marks
- c. Two of:
DNA ligase (1) restores phosphodiester bonds in DNA (1)
Taq/DNA polymerase (1) catalyses the addition of free nucleotides (1)
Endonucleases (1) cut DNA at a specific recognition sequence (1)
4 marks

Question 3 (17 marks)

- a. Light dependent stage in the grana/thylakoid (1) and light independent in the stroma (1)
- b. Chlorophyll is a protein(1) at high temp it will denature(1) and the tertiary structure will irreversibly change(1)

c. Carbon fixation in maize would occur in the bundle sheath, whereas in C3 it occurs in the mesophyll (1). C3 plants produce a 3-carbon molecule whereas C4 plants produce a 4-carbon molecule (1). C4 plants are more efficient than C3 plants at high temperatures (1).

d.6 of: Isolate the gene of interest (1). Create a single guide RNA sequence complementary to the target DNA sequence, with a PAM sequence adjacent to the target DNA (1). Add the sgRNA to the cell with the Cas9 enzyme (1). Cas9 binds to the PAM sequence and unzips the target DNA (1). sgRNA binds to the target sequence (1). Cas9 moves 3-5 nucleotides upstream of PAM and cuts the sequence (1) Sequence can be modified by disrupting, adding or deleting DNA bases (1)

e. Respect (1) – does wheat have an intrinsic value? (1). Wheat plants must be respected and their role in the ecosystem considered (1)

Non-maleficence (1) – Is there harm being done? (1). No other organisms should be harmed when using CRISPR technology (1)

Justice (1) – consider competing claims (1). Do all farmers have access to the technology? (1)

Integrity (1) – Is all data accurately reported (1). Data from trials must be available publicly (1)

Beneficence (1) – Is there maximise benefits and minimise risk when considering outcomes? (1).

More people/organisms should benefit from the technology with the cost being minimal (1)

Or any other suitable issue, definition, and consideration

Question 4 (9 marks)

a. Plant matter/plants (1)

b.

Stage	Key event
Pre-treatment	Biomass is mechanically broken down into smaller pieces
Enzymatic hydrolysis	Enzymes are used to break polymers into monomers
Fermentation	Yeast and sugars are added to allow fermentation, and production of ethanol to occur
Distillation	Molecular sieve used to remove any impurities

1 mark per correct cell

c. If the temperature is below the optimum, there is low kinetic energy and the rate of reaction would be lower (1). Above the optimum temperature, enzymes would denature lowering the rate of reaction (1).

If the pH is above or below the optimum, the enzymes denature, lowering the rate of reaction (1).

At the optimal pH and temperature, the rate of reaction is greatest (1).

Question 5 (10 marks)

a. Krebs cycle (1) that occurs in the mitochondrial matrix (1). It can only by Krebs as the coenzyme FAD⁺ is only found in the Krebs cycle (1).

b. (i) Competitive inhibitors bind to the active site of an enzyme (1) preventing the substrate from binding (1). Increasing substrate can increase the rate of reaction OR increase in competitive inhibitors can decrease reaction rate (1).

(ii) Non-competitive inhibitors bind to the allosteric site of an enzyme (1) causing a conformational change in the shape of the active site – preventing the substrate from binding (1). Adding more substrates will not change the rate of reaction (1)

c. 2 ATP