Name: _____

Biology

Question and Answer Book

Unit 3 Trial Exam

- Reading time is **10 minutes**
- Writing time is **90 minutes**

Materials supplied

- Question and Answer Book of 19 pages

Instructions

- Follow the instructions outlined at the beginning of Section A and Section B.

Students are **not** permitted to bring mobile phones and/or any unauthorised electronic devices into the examination room.

Contents pages

Section A - Multiple-choice questions

Instructions

- Answer all questions in pencil on the Multiple-Choice Answer Sheet.
- Choose the response that is correct or that best answers the question
- A correct answer scores 1; an incorrect answer scores 0.
- Marks will not be deducted for incorrect answers.
- No marks will be given if more than one answer is completed for any question.
- Unless otherwise indicated, the diagrams in this book are not drawn to scale.

Question 1

Which sugar is present in RNA but not in DNA?

A. Deoxyribose

B. Ribose

C. Glucose

D. Fructose

Second letter

First letter	U	C	A	G	Third letter
U	UUU, UUC: Phe UUA, UUG: Leu	UCU, UCC, UCA, UCG: Ser	UAU, UAC: Tyr **UAA Stop** **UAG Stop**	UGU, UGC: Cys **UGA Stop** UGG Trp	U C A G
C	CUU, CUC, CUA, CUG: Leu	CCU, CCC, CCA, CCG: Pro	CAU, CAC: His CAA, CAG: Gln	CGU, CGC, CGA, CGG: Arg	U C A G
A	AUU, AUC, AUA: Ile **AUG Met**	ACU, ACC, ACA, ACG: Thr	AAU, AAC: Asn AAA, AAG: Lys	AGU, AGC: Ser AGA, AGG: Arg	U C A G
G	GUU, GUC, GUA, GUG: Val	GCU, GCC, GCA, GCG: Ala	GAU, GAC: Asp GAA, GAG: Glu	GGU, GGC, GGA, GGG: Gly	U C A G

Source Khan Academy, Codon Table, Khan Academy, viewed 7 August 2025

Question 2

A mutation changes an mRNA codon from UAG to UAA. What would be the most likely result of this change?

A. The amino acid sequence would remain unchanged due to code degeneracy.

B. Translation would prematurely stop, producing a truncated, non-functional protein.

C. The mutation would only affect RNA processing, not translation.

D. The ribosome would correct the mutation during translation.

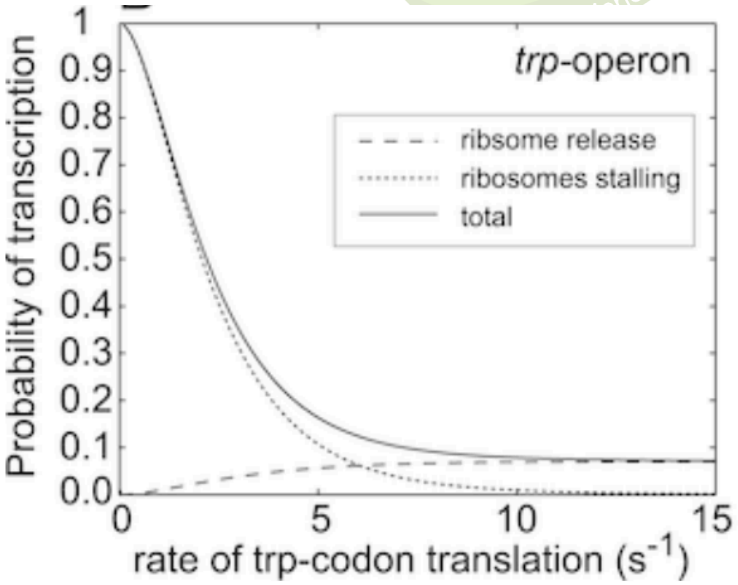
Question 3
Why does adding a 5' guanine cap to mRNA improve translation efficiency in eukaryotic cells?
A. It prevents degradation by ribosomes.
B. It helps ribosomes recognize and bind to the mRNA.
C. It lengthens the poly-A tail to stabilize the mRNA.
D. It allows tRNA molecules to bind more easily during translation.

Question 4
An mRNA molecule contains a premature stop codon due to a mutation. What is the most likely consequence?
A. A longer-than-normal protein would be produced.
B. No protein would be produced at all.
C. A truncated protein would be produced, likely affecting its function.
D. The ribosome would skip the stop codon and continue translation.

Question 5
The transcription of the trp operon doesn't occur when:
A. Activator proteins are bound to the promoter
B. Repressor proteins are bound to the operator
C. Repressor proteins are bound to the promoter
D. RNA polymerase is phosphorylated

Question 6
Which factor most directly determines the primary structure of a protein?
A. Hydrogen bonding between side chains
B. The genetic code in mRNA
C. Hydrophobic interactions during folding
D. Chaperone proteins during translation

Use the following information to answer questions 7 - 9



Source: What Makes Ribosome-Mediated Transcriptional Attenuation Sensitive to Amino Acid Limitation? - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Attenuation-Control-of-the-his-and-trp-Operons-A-The-trp-and-his-attenuation-leader_fig7_7656561 [accessed 9 Jul 2025]

Question 7
In the context of attenuation in the trp operon, which process is being **directly** regulated?
A. Translation of the structural genes
B. mRNA synthesis
C. DNA replication of the operon region
D. Activation of the repressor protein

Question 8
The main purpose of the leader sequence in attenuation is to
A. encode an enzyme for tryptophan synthesis.
B. regulate transcription based on translation speed.
C. promote translation of downstream structural genes.
D. recruit RNA polymerase to the promoter region.

Question 9
What does a high rate of trp-codon translation most likely indicate about tryptophan availability?
A. Tryptophan is low.
B. Tryptophan levels are high.
C. The repressor is inactive.
D. The operon is being induced.

Question 10
Which of the following best describes an organism's proteome?
A. The sequence of nucleotides in the genome.
B. The complete set of proteins expressed by a cell or organism.
C. The enzymes produced by ribosomes during translation.
D. The carbohydrates and lipids found in the plasma membrane.

Use the following information to answer questions 11 and 12

Proteins are synthesized and processed within a cell through a sequence of organelles before being secreted.

Organelle	Protein Quantity (arbitrary units)
Ribosome	10
Rough ER	55
Golgi apparatus	75
Vesicles near membrane	90
Plasma membrane	5

Question 11
Where is most of this protein likely to move next?
A. Ribosome
B. Rough ER
C. Vesicles near membrane
D. Plasma membrane

Question 12
Which type of error would cause all protein quantity readings to be consistently higher than the true value?
A. Random error
B. Personal error
C. Systematic error
D. No error

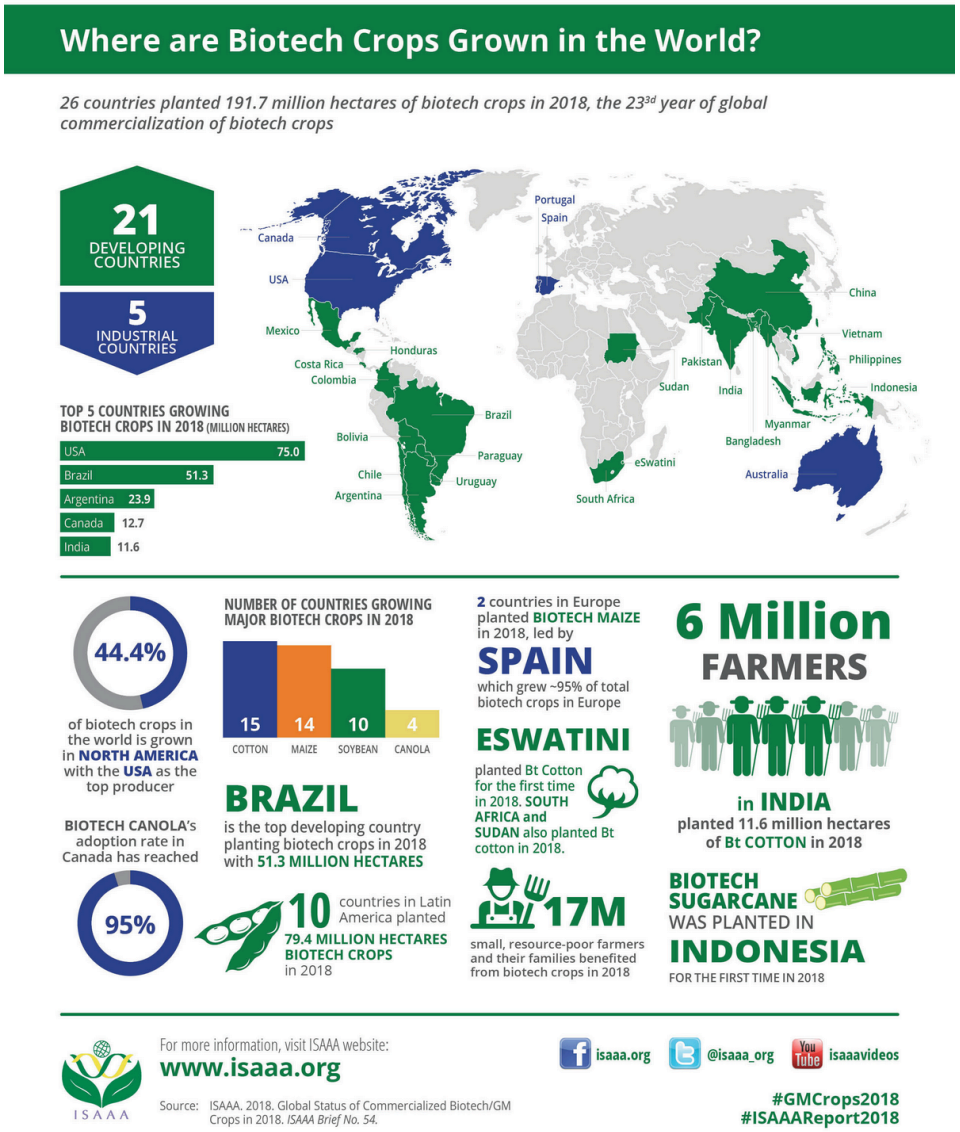
Question 13
Why does enzyme activity decrease as the concentration of the competitive inhibitor increases?
A. The inhibitor binds irreversibly, destroying the enzyme.
B. The inhibitor reduces substrate binding to the active site.
C. The enzyme becomes denatured by the inhibitor.
D. The inhibitor changes the pH of the solution.

In cells, enzymes must operate effectively in their specific surroundings, such as acidic or basic environments, to maintain proper metabolic processes.

pH Level	Enzyme X Activity (units)	Enzyme Y Activity (units)
4	10	2
5	15	5
6	20	10
7	25	30
8	18	35

Question 14
Which enzyme is likely adapted to function best in slightly basic conditions?
A. Enzyme X
B. Enzyme Y
C. Both equally
D. Neither enzyme

Use the following information and your own knowledge to answer Questions 15 and 16



Source: ISAAA 2018, Where are Biotech Crops Grown in the World? [infographic], ISAAA, viewed 7 August 2025,

Question 15

The ISAAA infographic shows high biotech crop production in countries like the USA and Brazil. One likely reason for this is

A. favorable government policies supporting gene technologies.
B. limited access to advanced farming equipment.
C. poor soil conditions restricting non-GMO crops.
D. low demand for food exports from these countries.

Question 16

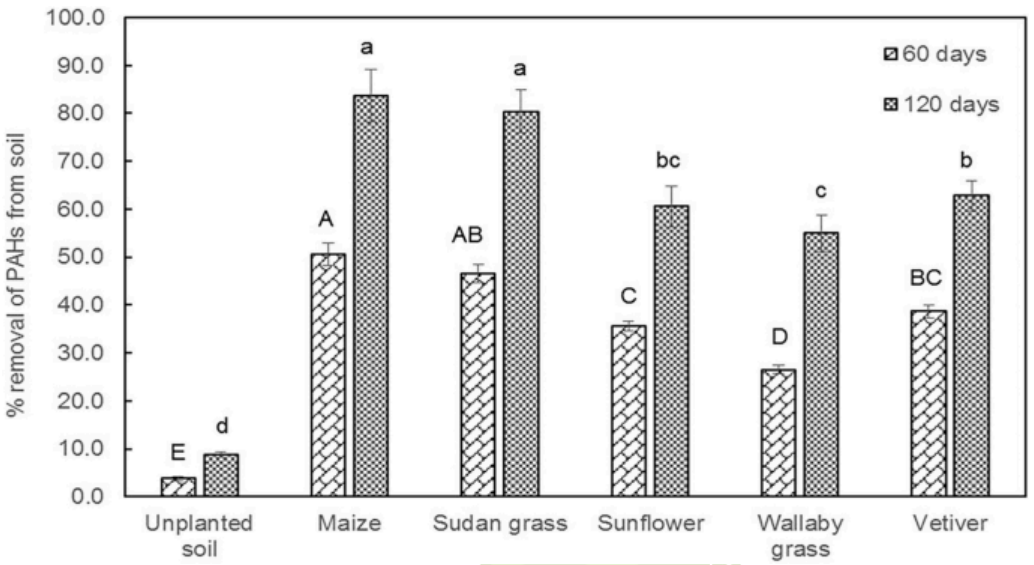
CRISPR-Cas9 enables plant scientists to improve non-photosynthetic traits as well, such as

A. increasing susceptibility to pests.
B. enhancing resistance to drought or salinity.
C. preventing leaf growth entirely.
D. reducing the need for sunlight in photosynthesis.

Use the following information and your own knowledge to answer questions 17 to 24

Polycyclic aromatic hydrocarbons (PAHs) are among the most persistent and toxic organic pollutants identified by the US EPA. They originate from natural sources such as volcanic eruptions and forest fires, as well as human activities like wood burning, gas production, and vehicle exhausts. Various remediation strategies exist, but phytoremediation, using plants and their root-associated microorganisms, has gained significant attention for being sustainable, cost-effective, and environmentally friendly. The rhizosphere effect, driven by root exudates, enhances the breakdown of PAHs by enriching PAH-degrading microbes in the root zone. The rhizosphere is the narrow region of soil that surrounds and is directly influenced by a plant's roots.

In a study comparing C3 and C4 plants, PAH removal was measured after 60 and 120 days. Planted treatments outperformed unplanted controls, with C4 plants such as maize and Sudan grass showing notably higher PAH removal than C3 plants like sunflower, wallaby grass, and vetiver. The findings highlight the potential of C4 plants in effective phytoremediation of PAH-contaminated soils.



Source: Sivaram, AK, Subashchandrabose, SR, Logeshwaran, P, Lockington, R, Naidu, R & Megharaj, M 2020, Rhizodegradation of PAHs differentially altered by C3 and C4 plants [figure 1], Scientific Reports, vol. 10

Question 17

According to the PAH study, which plants showed the highest PAH removal after 120 days?

A. Sunflower and Vetiver.
B. Maize and Sudan grass.
C. Wallaby grass and Sunflower.
D. Unplanted control soils.

Question 18

The dependent variable in the PAH case study is

A. plant height.
B. PAH concentration remaining in soil.
C. root length.
D. number of leaves.

Question 19
Which of the following is a likely controlled variable?
A. Plant species.
B. Soil type and volume.
C. Microbial inoculant type.
D. PAH removal rate.

Question 20
In the PAH case study, higher PAH removal by C4 plants may relate to
A. lower root biomass.
B. increased rhizosphere microbial activity.
C. decreased photosynthetic efficiency.
D. reduced stomatal density.

Question 21
To improve the accuracy of the PAH concentration measurements in this study, the researchers should
A. use a calibrated and sensitive chemical analysis method.
B. collect soil samples from random locations in the pot.
C. change plant species between sampling points.
D. increase the number of trials without altering the method.

Question 22
In the context of phytoremediation, place for Torres Strait Islander Peoples refers to
A. An abstract scientific term for land area.
B. Spaces with spiritual meaning and community connection beyond physical boundaries.
C. Commercial zones mapped for environmental projects.
D. Only the islands themselves, excluding surrounding waters.

Question 23
Why is it important to involve Aboriginal and Torres Strait Islander communities in environmental remediation projects, such as this study with PAH removal, on their traditional lands?
A. They have legal ownership but no cultural connection to the land.
B. They bring unique cultural perspectives and knowledge about local ecosystems and sustainable land management.
C. They provide a good source of labour.
D. They prefer to relocate away from contaminated areas.

Question 24
Respect, in the context of environmental remediation on Aboriginal Country includes
A. consulting and involving Aboriginal and Torres Strait Islander communities in decision-making.
B. assuming science alone can solve environmental problems without cultural input.
C. limiting information sharing with Indigenous communities to protect scientific data.
D. prioritising industrial development over cultural concerns.

Question 25
Which one of the following statements about the Krebs cycle is **correct**?
A. It is anaerobic (does not require oxygen).
B. It directly produces large amounts of ATP.
C. It releases carbon dioxide as a by-product.
D. It only occurs when glucose is absent.

Question 26
Which molecules are directly required for the electron transport chain to function?
A. oxygen, ADP and NADH
B. carbon dioxide, ATP and NADPH
C. glucose, ADP and NADH
D. carbon dioxide, ATP and $FADH_2$

Question 27
During fermentation, NADH is converted back into NAD+ to
A. allow glycolysis to continue producing ATP
B. synthesize more glucose
C. generate oxygen molecules
D. decrease lactic acid production

Question 28
Increasing glucose concentration beyond a certain point does NOT further increase respiration rate because
A. enzymes become saturated with substrate
B. oxygen concentration drops too low
C. ATP inhibits all enzyme activity
D. temperature becomes limiting

Question 29
You observe a yeast culture fermenting glucose at a constant temperature but with increasing glucose concentrations. At what point would oxygen concentration begin to affect the rate of fermentation, and why?
A. Immediately, because oxygen competes with glucose for enzyme binding
B. Never, because fermentation is an anaerobic process independent of oxygen
C. At high glucose levels, oxygen presence inhibits fermentation enzymes, slowing the process
D. At low oxygen levels, yeast may shift to aerobic respiration if glucose is high

Question 30
In photosynthesis, the enzyme Rubisco can be inhibited by
A. oxygen acting as a competitive inhibitor.
B. carbon dioxide acting as a non-competitive inhibitor.
C. water acting as a competitive inhibitor.
D. glucose acting as a non-competitive inhibitor.

End of Section A

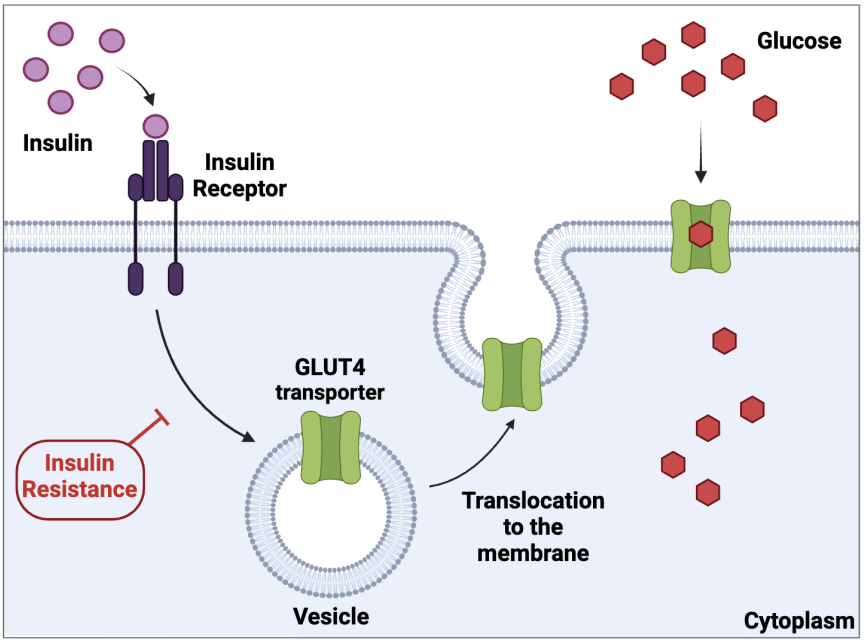
Section B

Instructions

- Answer all questions in the space provided.
- Write your responses in English.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1 (12 marks)

GLUT4 is a glucose transporter found in fat and muscle cells. Without insulin, GLUT4 is stored inside cells in GLUT4 storage vesicles (GSVs). After eating, insulin is released and binds to receptors on fat and muscle cells, activating the PI3K–AKT pathway. This triggers GSVs to rapidly fuse with the plasma membrane, increasing glucose uptake into the cell. In continued insulin presence, GLUT4 is recycled back to the membrane through different vesicles. Insulin can increase glucose transport into these tissues by 10- to 30-fold within minutes. This process ensures cells absorb glucose efficiently after meals for energy use or storage.



Source: Stöckli, J., Fazakerley, D. J., & James, D. E. (2011). GLUT4 exocytosis. Journal of Cell Science, 124(24), 4147–4159. https://doi.org/10.1242/jcs.097063

a. What nucleic acid is present at the ribosome and contains the instructions to produce the GLUT4 protein? 1 mark

b. Describe the steps of transcription to create a functional GLUT4 mRNA transcript in a human cell. 3 marks

c. Explain why the primary structure of GLUT4 is critical for its function in glucose transport.

3 marks

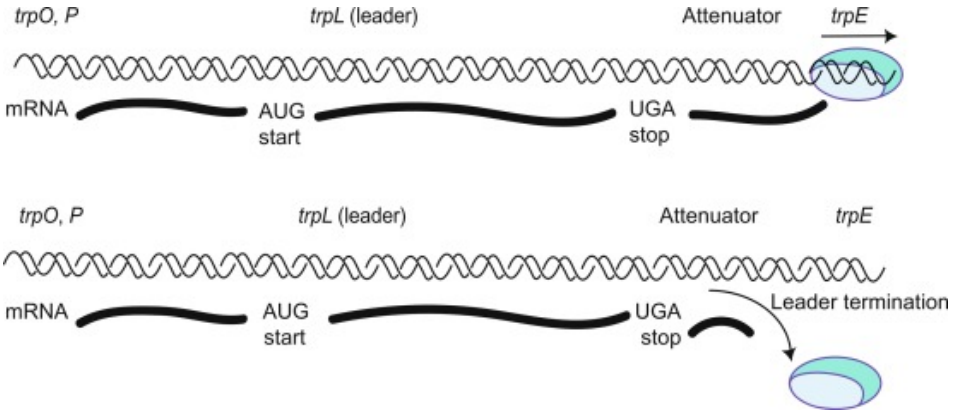
d. Describe the role of the Golgi apparatus in this cell. 3 marks

e. The proteome is often described as the full set of proteins a cell produces. Identify a limitation of this definition and suggest an improvement in this definition to better represent protein diversity.

2 marks

Question 2 (10 marks)

The synthesis of tryptophan in prokaryotic cells such as *Escherichia coli* is highly regulated. One such mechanism is attenuation.



Source: https://www.sciencedirect.com/science/article/pii/B9780128028230000031

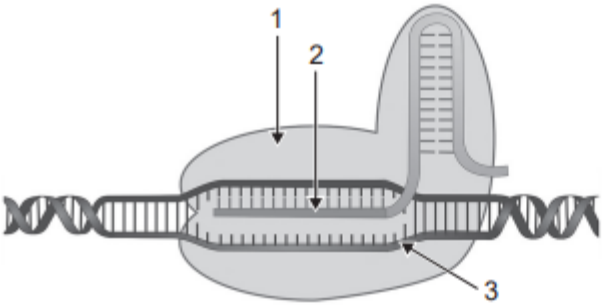
a. Compare the cell's response from attenuation during high levels of trp versus low levels of trp. Refer to the diagram in your answer. 4 marks

b. Explain why attenuation would not be an effective regulatory mechanism in eukaryotic cells. 2 marks

c. Design an experiment to test how varying tryptophan concentrations affect the activity of the trp operon. 4 marks

Question 3 (12 marks)

At present, over 50 million people have dementia globally and this figure will be beyond 131 million by 2050 with a global cost of around USD$818 billion. Mutations or alterations in amyloid-b precursor protein (APP), presenilin-1 (PSEN1), or presenilin-2 (PSEN2) genes are known factors associated with the pathophysiology of dementia. Yet there are no effective and stable therapeutic strategies for dementia and the failure rate in clinical trials (99.5%) is higher than any other disease. Genome editing tool CRISPR-Cas9 has been emerging as a powerful technology to correct anomalous genetic functions and is now widely applied to the study of AD.



Source: Source: Barman, N. C., Khan, N. M., Islam, M., Nain, Z., Roy, R. K., Haque, A., & Barman, S. K. (2020). CRISPR-Cas9: A Promising Genome Editing Therapeutic Tool for Alzheimer's Disease—A Narrative Review. Neurology and Therapy, 9(2), 419–434. https://doi.org/10.1007/s40120-020-00218-z

a. Which arrow, 1, 2 or 3, correctly points to the position of the Cas9? 1 mark

b. Describe the function of Cas9. 2 marks

Scientists have recently tried to use CRISPR-Cas9 technology to inactivate genes involved in the development of dementia. One of the pathways in the development of dementia is summarised below.

Mutation in *PSEN1 gene*

↓

Faulty presenilin-1 protein produced

↓

Faulty presenilin-1 protein causes increased activation of *amyloid precursor gene*

↓

Overproduction of amyloid-beta (Aβ) peptides

↓

Amyloid plaque formation

↓

Cognitive decline & dementia symptoms

c. Using the information in the flow chart, explain how CRISPR-Cas9 technology could be used to treat dementia. 4 marks

Scientists have trialled CRISPR-Cas9 technology to target genes linked to early-onset dementia. In the initial study, two patients received treatment after having their brain cells modified to reduce the production of abnormal proteins linked to the disease. Both showed signs of improved cognitive function, but also experienced some adverse effects, including inflammation and headaches. Scientists are now planning to expand the trial to another 50 patients.

d. State the scientific investigation methodology used by these scientists. 1 mark

e. Identify an ethical concept that the scientists would need to consider before proceeding with the treatment of the additional 50 patients. How could they justify continuing the treatment in new patients? 2 marks

f. Identify how **one** factor could affect the validity of the CRISPR dementia trial when expanding from 2 to 50 patients. 2 marks

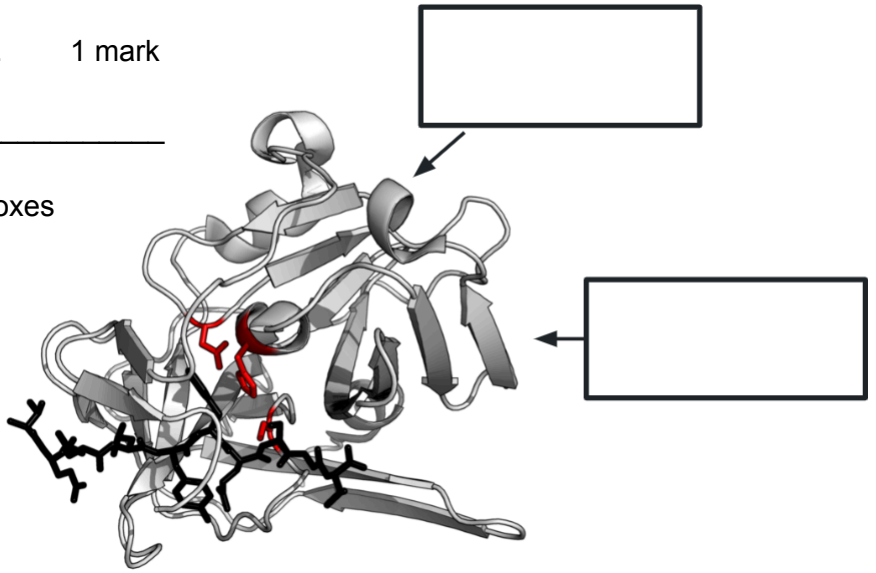
Question 4 (8 marks)

Proteases are enzymes found in all forms of life that help break down proteins into smaller molecules. Some proteases work inside cells, controlling key processes like protein recycling, enzyme activation, and cell development. Others act outside cells, breaking down external proteins so the cell can absorb and reuse the products.Bacterial proteases are especially valuable because they are stable, efficient, and suitable for many industrial uses. One important application is in silver recovery from waste X-ray films, where bacterial proteases digest the gelatin layer on the film, allowing silver to be reclaimed. These proteases often work best at high temperatures and in alkaline conditions (pH 8–10), making them ideal for industrial processes. However, different bacterial proteases have slightly different optimal conditions, such as temperature stability and pH tolerance. Industries are now seeking new, efficient, and eco-friendly enzymes like these to replace chemical methods for silver recovery, aiming to improve cost-effectiveness, reduce environmental impacts, and allow enzyme reuse.

a. Name the molecular monomer of proteases. 1 mark

_____

b. Provide the name of each structure in the boxes provided. 2 marks



c. What would occur if proteases are too far above their optimal temperature? 1 mark

S.no	Microbial	Optimum pH and Temperature	Application
1	*Bacillus licheniformis* KBDL	n.s*	Silver recovery
2	*Aspergillus Versicolor* PF/F/107	50°C (pH 9)	Silver recovery
3	*Bacillus sp. B21-2*	50°C (pH 9)	Silver recovery
4	*Bacillus subtillis* ATCC6633	50°C (pH 8)	Silver recovery
5	*Bacillus subtilis*	40°C (pH 10)	Silver recovery

d. Evaluate the following claim by a group of scientists: "The protease with the highest optimal temperature is always the best for silver recovery." 2 marks

e. How would you assess whether a new protease discovered from a sixth bacterial species is better than the current five for silver recovery? 2 marks

Question 5 (10 marks)
A scientist investigated the effect of oxygen concentration on the rate of cellular respiration in yeast cells over a 12-hour period. The yeast cells were grown under identical conditions in four sealed flasks, each containing a different percentage of oxygen gas. The amount of glucose consumed and carbon dioxide produced was measured for each flask.

Oxygen concentration (%)	Glucose consumed (micromoles/10^6 cells)	Carbon dioxide produced (micromoles/10^6 cells)
0	25.50	48.10
5	20.75	38.20
15	12.60	25.30
20	10.20	20.05

a. Describe the trends in the results. 2 marks

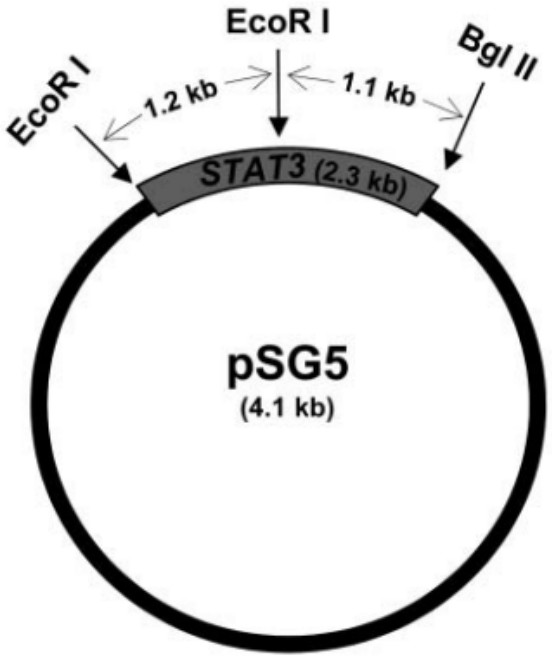
b. Explain how the yeast cells' energy production pathways are changing across the different oxygen conditions. 4 marks

c. Suggest **two** controlled variables that would be important to maintain in this experiment. 2 marks

d. State **two** reasons why yeast cells may not continue producing ethanol indefinitely during fermentation. 2 marks

Question 6 (8 marks)

The pSG5 plasmid is a circular DNA molecule commonly used in genetic engineering. It contains two recognition sites for the restriction enzyme EcoRI and one for BglII. When cut with EcoRI, the plasmid is cleaved into two fragments, which can be separated and visualized using gel electrophoresis. Scientists use enzymes like EcoRI to cut DNA at specific sites, polymerase to amplify DNA sequences via PCR, and ligase to join DNA fragments together. Recombinant plasmids carrying foreign genes can be introduced into bacterial cells to produce useful proteins, such as human insulin.



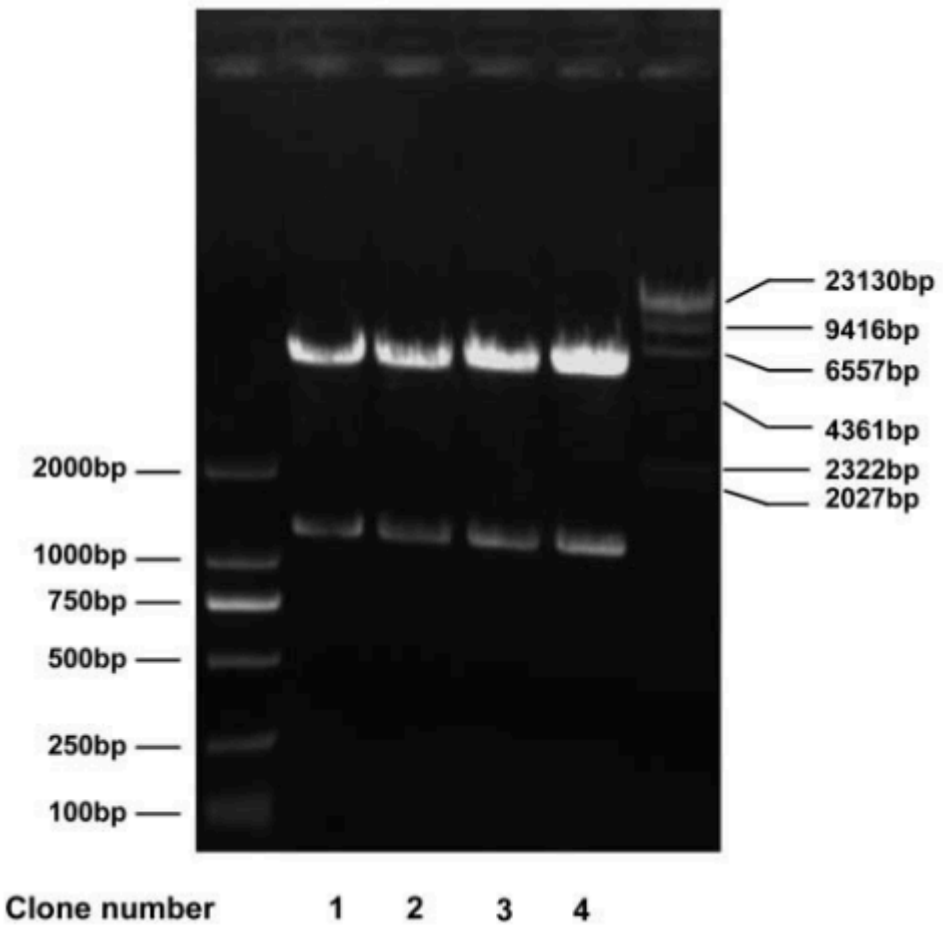
Source**:** Lou, Ye-jiang & Jin, Jie. (2017). Insert restriction enzyme cutting-free cloning strategy for expression plasmid construction. Biotechnology & Biotechnological Equipment. 31. 1-7. 10.1080/13102818.2017.1351310.

a. Which enzyme would be used to join DNA fragments after they are cut? 1 mark

b. Explain why plasmids are useful vectors for protein production. 2 marks

c. Often, plasmids will contain an antibiotic resistance gene. What is the purpose of an antibiotic resistance gene in a plasmid vector, such as the pSG5. 2 marks

Verification of the pSG5 plasmid by restriction endonuclease digestion. Four clones of pSG5 plasmids were digested with EcoRI and analyzed by agarose gel electrophoresis.



Source: Wang XP, Li FJ, Deng L, Nagano-Fujii M, Kitayama K, Hotta H. [Construction of pSG5/NS5A5BdeltaC and its expression in Huh7 cells]. Xi Bao Yu Fen Zi Mian Yi Xue Za Zhi. 2009 Jan;25(1):31-4. Chinese. PMID: 20104685.

d. What is the purpose of the DNA ladder? 1 mark

e. Why did the scientists use four clones in their verification process? 2 marks

End of examination questions

Extra space for responses
Clearly **number** all responses in this space.

ScienceLab Unit 3 Trial Exam 2 (2025)

Specific information
This report provides sample answers or an indication of what answers VCAA have accepted in the past.

Section A

Question	Correct answer	Comments
1	B	
2	A	
3	B	Degradation of mRNA does not occur due to the presence of the ribosome but other intracellular factors. It is important for students to recognise the multiple functions of both the methyl cap and the poly-A tail.
4	C	The term “truncated” has been used by VCAA in the past and is therefore assumed knowledge. Students should be aware of broader scientific terminology used in previous VCAA exams.
5	B	
6	B	As the primary structure is the **sequence** of amino acids making up a polypeptide chain, this will be determined by the codon sequence of the mRNA.
7	B	Repression directly impedes the coding of the structural genes
8	B	Attenuation is the process that involves the formation of hairpin loops. The type of hairpin loop that is formed is determined by the location of the ribosome (the translation speed).
9	B	
10	B	
11	D	
12	C	The terminology **“consistently higher”** refers to a constant variation from the true value.
13	B	It is important for students to be aware of the differences in competitive and non-competitive inhibition, including binding location and reversibility.
14	B	
15	A	The 2022-2026 Study Design emphasises the importance of students being able to identify ways that crop efficiency can be increased using gene editing and the ethical issues surrounding this.
16	B	
17	B	
18	B	
19	B	
20	B	
21	A	

22	B	The terms “Country” and “Place” are explicitly defined in the 2022-2026 study design.
23	B	
24	A	“Giving due regard to… beliefs, perceptions, customs and cultural heritage”
25	C	Krebs is classified as aerobic as it requires the process of NADH unloading to regenerate its inputs.
26	A	
27	A	
28	A	
29	D	
30	A	

Section B

Question 1 (12 marks)

a. What nucleic acid is present at the ribosome and contains the instructions to produce the GLUT4 protein?

• RNA	0 marks	1 mark

b. Describe the steps of transcription to create a functional GLUT4 mRNA transcript in a human cell.

• RNA polymerase binds to promoter region of the template strand • RNA polymerase begins creating a pre-mRNA strand using free complementary nucleotides, replacing thymine with uracil • RNA polymerase reaches a stop sequence and the pre-mRNA is released	0 marks	1 mark	2 marks	3 marks

c. Explain why the primary structure of GLUT4 is critical for its function in glucose transport.

• The amino acid sequence results in different folding • Different combinations of secondary structures • 3D functional shape allowing for glucose transport	0 marks	1 mark	2 marks	3 marks

d. Describe the role of the Golgi apparatus in this cell.

• Modify and package proteins from rough endoplasmic reticulum • Create secretory vesicles • Leading to export out of the cell / exocytosis	0 marks	1 mark	2 marks	3 marks

e. The proteome is often described as the full set of proteins a cell produces. Identify a limitation of this definition and suggest an improvement in this definition to better represent protein diversity.

• Oversimplification as the protein a cell produces will change over time (this is due to gene regulation) • Refine definition / provide further description	0 marks	1 mark	2 marks

Question 2 (10 marks)

a. Compare the cell's response from attenuation during high levels of trp versus low levels of trp. Refer to the diagram in your answer.

• High trp: attenuator/terminator loop forms • RNA polymerase detaches/no tryptophan produced whereas, • Low trp: anti-attenuator/anti-terminator loop forms • RNA polymerase does not detach and tryptophan can be produced	0 marks	1 mark	2 marks	3 marks	4 marks
Comment • Don't accept ribosome action as it is not present in diagram					

b. Explain why attenuation would not be an effective regulatory mechanism in eukaryotic cells.

• Attenuation requires transcription and translation to occur simultaneously Either of: • Contain a nucleus so stages are seperated • Transcription and translation do not occur simultaneously in eukaryotes • Eukaryotes have RNA processing	0 marks	1 mark	2 marks

c. Design an experiment to test how varying tryptophan concentrations affect the activity of the trp operon.

• DV: amount of tryptophan produced (%, mmol/L, ug, etc.) • CG: 0% tryptophan solution/no tryptophan present • CV: amount of tryptophan (ml, ul), time exposed to tryptophan (seconds/minutes) • Repeat at least 3x to increase accuracy	0 marks	1 mark	2 marks	3 marks	4 marks
Comments Do not accept IV as it is provided in the question stem					

Question 3 (12 marks)

a. Which arrow, 1, 2 or 3, correctly points to the position of the Cas9?

• 1	0 marks	1 mark

b. Describe the function of Cas9.

• Endonuclease: create a double strand break within the recognition sequence • Destruction / cutting / restriction of viral DNA	0 marks	1 mark	2 marks

c. Using the information in the flow chart, explain how CRISPR-Cas9 technology could be used to treat dementia.

Any 3 of: ● Lab made sgRNA with complementary spacer sequence to the amyloid precursor gene ● Cas9 enzyme is obtained with an appropriate target PAM sequence ● Cas9 and gRNA are added together in a mixture and bind together to create the CRISPR-Cas9 complex ● The Cas9 finds the target PAM sequence and checks whether the gRNA aligns with the DNA ● If complementary, Cas9 cuts the selected sequence of DNA inducing a mutation in the amyloid precursor gene, knocking the gene out AND ● Less amyloid plaque formed, reducing effects of dementia	0 marks	1 mark	2 marks	3 marks	4 marks

d. State the scientific investigation methodology used by these scientists.

● Controlled experiment	0 marks	1 mark

e. Identify an ethical concept that the scientists would need to consider before proceeding with the treatment of the additional 50 patients. How could they justify continuing the treatment in new patients?

● Non-maleficence ● Curing dementia outweighs the adverse effects OR ● Respect ● Allowing patients to take part despite side effects upholds individual autonomy OR ● Justice ● Access of trial to all demographics OR ● Integrity ● Adverse side effects have been advertised	0 marks	1 mark	2 marks

f. Identify how **one** factor could affect the validity of the CRISPR dementia trial when expanding from 2 to 50 patients.

● Larger sample size allows data to be expanded to a broader population / different demographics / ages / genders etc. ● Increasing validity	0 marks	1 mark	2 marks

Question 4 (8 marks)

a. Name the molecular monomer of proteases.

● Amino acid	0 marks	1 mark

b. Provide the name of each structure in the boxes provided

● Top = alpha helix ● Bottom = beta pleated sheet	0 marks	1 mark	2 marks

c. What would occur if proteases are too far above their optimal temperature?

● Denature	0 marks	1 mark

d. Evaluate the following claim by a group of scientists: "The protease with the highest optimal temperature is always the best for silver recovery."

• This claim is incorrect • Difficult/not cost effective to achieve high temperatures in a large commercial setting / not all bacteria have high optimal temps?	0 marks	1 mark	2 marks

e. How would you assess whether a new protease discovered from a sixth bacterial species is better than the current five for silver recovery?

• Compare rate of silver recovery in existing species and new proteases • If higher rate it is more effective	0 marks	1 mark	2 marks

Question 5 (10 marks)

a. Describe the trends in the results.

Either of: • As oxygen concentration increases the amount of glucose consumed decreases • As oxygen concentration increases the carbon dioxide produced decreases AND • Correct use of data	0 marks	1 mark	2 marks

b. Explain how the yeast cells' energy production pathways are changing across the different oxygen conditions.

• At 0% oxygen the cell is undertaking anaerobic fermentation • At 20% oxygen the cell is undertaking aerobic respiration • Aerobic respiration requires the presence of oxygen/ / Cell cannot undertake aerobic respiration in 0% oxygen • Anaerobic requires greater glucose uptake for similar yield of ATP	0 marks	1 mark	2 marks	3 marks	4 marks

c. Suggest **two** controlled variables that would be important to maintain in this experiment.

• Species of yeast • Amount of yeast (mg/g/kg)	0 marks	1 mark	2 marks

d. State **two** reasons why yeast cells may not continue producing ethanol indefinitely during fermentation.

Any 2 of: • Ethanol is poisonous to yeast and they die • Reach their energy requirements • Glucose runs out	0 marks	1 mark	2 marks

Question 6 (8 marks)

a. Which enzyme would be used to join DNA fragments after they are cut?

• DNA ligase	0 marks	1 mark

b. Explain why plasmids are useful vectors for protein production.

Any one of: • Plasmids can be inserted into bacteria • Bacteria replicate rapidly and one of: • Creating large quantities of the proteins encoded by the genes? • Don't need to kill animals to harvest proteins	0 marks	1 mark	2 marks

c. Often, plasmids will contain an antibiotic resistance gene. What is the purpose of an antibiotic resistance gene in a plasmid vector, such as the pSG5.

• Act as a selection agent • Allow scientists to select bacteria that have taken up the recombinant plasmid	0 marks	1 mark	2 marks

d. What is the purpose of the DNA ladder?

• To act as a control/point of comparison	0 marks	1 mark

e. Why did the scientists use four clones in their verification process?

Any two of: • Increased sample size / repetition • Can calculate average (reducing random error), closer to true value	0 marks	1 mark	2 marks