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VCE Biology ¾
AOS 1 Revision [1.0]
Contour Check (Part 2)

Sub-Section: [1.6.7] - Define & Describe the Three Ethical Approaches as Elaborated in the VCAA Study Design

Question 1

Definitions.

a. Consequences-Based Approach:

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b. Virtues-Based Approach:

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c. Duty-Based Approach:

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Question 2 (1 mark)

A company decides to use CRISPR-Cas9 to modify crops to improve yield but ignores potential long-term ecological effects. Which ethical approach is most relevant in questioning this decision?

A. Consequences-Based Approach – considering the overall benefits and risks.

B. Virtues-Based Approach – focusing on the company's moral responsibility.

C. Duty-Based Approach – ensuring compliance with environmental regulations.

D. Justice-Based Approach – ensuring fairness in ecological impacts.

Question 3 (1 mark)

A research team prioritises honesty and transparency in reporting their CRISPR-Cas9 trial results, even though the findings are unfavourable. Which ethical approach best describes this decision?

A. Duty-Based Approach – adhering to ethical guidelines for transparency.

B. Virtues-Based Approach – demonstrating integrity and moral responsibility.

C. Consequences-Based Approach – ensuring long-term benefits of accurate data.

D. Justice-Based Approach – providing equal access to the information.

Question 4 (1 mark)

What is the primary focus of a duty-based ethical approach in CRISPR-Cas9 research?

A. Considering the greatest good for the greatest number.

B. Ensuring compliance with established ethical guidelines and rules.

C. Evaluating the character of researchers involved in the study.

D. Maximising the positive outcomes for society.

Question 5 (1 mark)

A biotechnology company justifies using CRISPR-Cas9 to engineer pest-resistant crops because it will reduce pesticide use and increase food availability. Which ethical approach does this decision reflect?

A. Virtues-Based Approach

B. Duty-Based Approach

C. Consequences-Based Approach

D. Justice-Based Approach

Space for Personal Notes

Question 6 (1 mark)

A regulatory body prohibits germline editing with CRISPR-Cas9, citing adherence to global agreements, even though the technology could prevent genetic diseases. What ethical approach is primarily guiding this decision?

A. Consequences-Based Approach – assessing global impact.

B. Duty-Based Approach – following established ethical rules.

C. Virtues-Based Approach – valuing the integrity of genetic research.

D. Justice-Based Approach – ensuring fairness in decision-making.

Question 7 (4 marks)

A research team is considering the use of CRISPR-Cas9 to modify the genes of mosquitoes to reduce the spread of malaria. Some team members argue that modifying mosquitoes to reduce malaria transmission justifies the potential risks of ecological disruption, while others prioritise the ethical concerns regarding the manipulation of natural species.

Identify and explain two ethical approaches being debated by the research team. State how each approach influences the decision-making process.

Space for Personal Notes

Sub-Section: [1.6.8] - Describe Briefly How to Genetically Modify Organisms to Increase Crop Productivity & Disease Resistance, Using CRISPR-Cas9

Question 8

Definitions.

a. Crop Productivity:

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b. Disease Resistance:

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Question 9 (1 mark)

A scientist wants to increase drought tolerance in wheat using CRISPR-Cas9. What is the first step in the genetic modification process?

A. Introducing the CRISPR-Cas9 components into the plant cells using a gene gun.

B. Identifying the specific gene responsible for drought tolerance in wheat.

C. Regenerating modified plants using tissue culture techniques.

D. Designing a gRNA complementary to the plant's entire genome.

Space for Personal Notes

Question 10 (1 mark)

Which of the following best describes how CRISPR-Cas9 increases disease resistance in crops?

A. By eliminating the need for traditional pesticides through improved water uptake.

B. By creating a random mutation in the plant's genome to remove harmful traits.

C. By editing susceptibility genes or introducing new resistance genes into the plant genome.

D. By using Cas9 to repair DNA damage caused by environmental stresses.

Question 11

You are a plant geneticist working to help banana farmers combat devastating losses caused by fungal infections from *Fusarium oxysporum*. Research shows that the resistance gene RGA1 plays a critical role in protecting bananas from fungal infections. By editing this gene using CRISPR-Cas9, you aim to increase the banana plants' resistance to these pathogens.

Describe how you would use CRISPR-Cas9 to modify the RGA1 gene to enhance fungal resistance in bananas.

Space for Personal Notes

Sub-Section: [1.6.9] - Compare Transgenic, Cisgenic & Genetically Modified Organisms

Question 12

Definitions.

a. Transgenic Organism:

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b. Cisgenic Organism:

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c. Genetically Modified Organism (GMO):

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Question 13 (1 mark)

Which of the following best describes a **cisgenic organism**?

A. An organism modified with a gene from an unrelated species to introduce a new trait.

B. An organism modified with a gene from the same species or a closely related one.

C. An organism modified without introducing any new genetic material.

D. An organism modified with synthetic DNA sequences designed in the lab.

Space for Personal Notes

Question 14 (1 mark)

A farmer grows a new type of rice that has been genetically modified to resist drought by introducing a gene from a drought-resistant plant. This organism is an example of:

A. A genetically modified organism (GMO) only.

B. A cisgenic organism.

C. A transgenic organism.

D. A naturally bred organism.

Question 15 (1 mark)

Which of the following statements is true about genetically modified organisms (GMOs)?

A. All GMOs involve inserting genes from unrelated species.

B. GMOs only include cisgenic organisms.

C. GMOs encompass all organisms whose genetic material has been altered, including modifications to endogenous genes.

D. GMOs must always involve crossing natural species barriers.

Question 16 (2 marks)

A group of scientists develops a new variety of potatoes that are resistant to pests. To achieve this, they introduce a gene from a wild potato species into a commercial potato variety that is sexually compatible. The gene enhances the plant's ability to produce natural pesticides.

Based on the genetic modification described, determine whether this potato variety is transgenic or cisgenic.

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_____

Section A: [1.7] – Recombinant Plasmids (Checkpoints) (54 Marks)

Sub-Section: [1.7.1] - Describe the Role of Plasmids as a Vector to Transform Bacteria & Other Cells

Question 17

Definitions:

a. Plasmid:

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b. Vector:

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c. Transformation:

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d. Recombinant DNA:

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Space for Personal Notes

Question 18 (1 mark)

A researcher inserts a gene of interest into a plasmid containing a selectable marker for ampicillin resistance. After transforming bacterial cells with this plasmid, the cells are grown on an agar plate containing ampicillin. Which outcome confirms successful transformation?

A. All bacterial cells grow on the plate, regardless of whether they took up the plasmid.

B. Only bacterial cells containing the plasmid grow, as the plasmid confers ampicillin resistance.

C. No bacterial cells grow on the plate, indicating the plasmid does not function.

D. All bacterial cells produce the protein of interest, regardless of plasmid uptake.

Question 19 (1 mark)

In a transformation experiment, plasmids are introduced into bacterial cells by electroporation. What happens during this process?

A. The plasmid DNA is transcribed into mRNA before entering the cell.

B. An electric pulse creates temporary pores in the bacterial membrane, allowing plasmid uptake.

C. The plasmid DNA is incorporated into the bacterial chromosome.

D. The plasmid DNA is replicated outside the cell before transformation occurs.

Question 20 (1 mark)

A plasmid used as a vector contains an origin of replication (ORI), a multiple cloning site (MCS), and a selectable marker. What is the function of the MCS?

A. It allows the plasmid to replicate independently in the host cell.

B. It provides resistance to antibiotics, enabling selection of transformed cells.

C. It contains multiple restriction sites for inserting foreign DNA.

D. It ensures efficient transcription of the inserted gene.

Space for Personal Notes

Question 21 (1 mark)

A scientist uses a plasmid containing both an origin of replication and an antibiotic resistance gene for bacterial transformation. After transformation, why are antibiotic-free plates not useful for this experiment?

A. The plasmid cannot replicate without antibiotics present.

B. Non-transformed bacteria will grow alongside transformed bacteria, making it impossible to identify successful transformations.

C. Antibiotic-free plates inhibit the expression of the gene of interest.

D. Transformed bacteria will lose the plasmid in the absence of antibiotics.

Question 22 (1 mark)

What makes plasmids ideal vectors for introducing foreign DNA into bacterial cells?

A. They are linear DNA molecules that integrate into the bacterial genome.

B. They contain regions of non-coding RNA that improve transformation efficiency.

C. They replicate independently and can carry specific DNA sequences into host cells.

D. They are naturally resistant to restriction enzymes, ensuring stability.

Question 23 (8 marks)

You are a researcher working to produce insulin for diabetic patients using genetically modified *E. coli*. To achieve this, you need to transfer the human insulin gene into bacterial cells using a plasmid.

a. Define a plasmid and explain its role as a vector in bacterial transformation in this context. (2 marks)

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b. Describe two key features of a plasmid that make it suitable for use as a vector in genetic engineering for insulin production. (2 marks)

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c. During the transformation experiment, a plasmid containing an antibiotic resistance gene and a reporter gene was introduced into the bacterial culture.

i. Explain how the antibiotic resistance gene helps in selecting transformed bacteria. (1 mark)

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ii. Explain how the reporter gene distinguishes recombinant plasmids from non-recombinant plasmids in this experiment. (1 mark)

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d. Scientists are using heat shock to transform *E. coli* with the plasmid containing the human insulin gene. Briefly outline the heat shock method and explain how it facilitates DNA uptake. (2 marks)

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Space for Personal Notes

Sub-Section: [1.7.2] - Explain How a Gene of Interest is Isolated & Inserted Into a Plasmid

Question 24

Definitions:

a. Gene of Interest:

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b. Complementary DNA (cDNA):

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c. Restriction Enzyme (Restriction Endonuclease):

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d. Sticky Ends:

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e. DNA Ligase:

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Space for Personal Notes

Question 25 (1 mark)

During the isolation of a gene of interest, why is mRNA often used instead of genomic DNA in bacterial expression systems?

A. mRNA is more stable than genomic DNA.

B. mRNA does not contain introns, which bacteria cannot process.

C. mRNA is easier to amplify using PCR.

D. mRNA allows the gene to bypass transcriptional control in the host cell.

Question 26 (1 mark)

A researcher uses a restriction enzyme to cut both the plasmid and the gene of interest. Why must the same restriction enzyme be used?

A. To create compatible sticky ends for precise DNA insertion.

B. To prevent degradation of the plasmid and gene.

C. To increase the transformation efficiency of the plasmid.

D. To ensure the plasmid's origin of replication remains intact.

Question 27 (1 mark)

What is the role of reverse transcriptase in the preparation of a eukaryotic gene for insertion into a bacterial plasmid?

A. It cuts the gene into smaller fragments for easier insertion.

B. It synthesises cDNA from the mRNA, removing introns in the process.

C. It amplifies the DNA by generating multiple copies.

D. It prevents the gene from being degraded during transformation.

Space for Personal Notes

Question 28 (1 mark)

After a plasmid and the gene of interest are cut with a restriction enzyme, DNA ligase is used. What is the primary function of DNA ligase in this process?

A. To catalyse the insertion of the gene into the host cell's genome.

B. To form phosphodiester bonds between the plasmid and gene fragments.

C. To prevent the plasmid from being degraded during transformation.

D. To stabilise the plasmid's replication within the host cell.

Question 29 (8 marks)

a. Explain why scientists must remove introns from the insulin gene before inserting it into the plasmid. (2 marks)

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b. The scientists extract mRNA for the insulin protein from human pancreatic cells. Which enzyme will they use to create a DNA copy of the insulin gene, and why is this step necessary? (2 marks)

_____

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c. After obtaining the complementary DNA (cDNA) for insulin, the scientists cut both the plasmid and the cDNA using the same restriction enzyme. Explain the significance of using the same restriction enzyme for both. (2 marks)

_____

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d. The scientists now need to join the insulin cDNA to the plasmid to form a recombinant plasmid.

i. Which enzyme is used for this process? (1 mark)

_____

_____

ii. Describe the role of this enzyme in ensuring the stability of the recombinant plasmid. (1 mark)

_____

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Space for Personal Notes

Sub-Section: [1.7.3] - Explain Electroporation & Heat Shock as Methods to Transform Bacterial Cells

Question 30

Definitions:

a. Transformation:

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b. Electroporation:

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c. Heat Shock:

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Question 31 (1 mark)

During electroporation, what happens to the bacterial cell membrane?

A. It becomes denatured due to heat, allowing DNA to enter.

B. Temporary pores are formed due to an applied electric current, allowing DNA to pass through.

C. It is chemically altered, increasing the permeability to DNA.

D. It undergoes lysis, releasing internal components.

Space for Personal Notes

Question 32 (1 mark)

In a heat shock experiment, why are bacterial cells incubated on ice before being exposed to a high temperature?

A. To freeze the plasmid DNA for stability.

B. To stabilise the cell membrane and prepare it for heat-induced changes.

C. To increase the replication of bacterial DNA before transformation.

D. To chemically neutralise the DNA and membrane charges.

Question 33 (1 mark)

Why are calcium ions often used in the heat shock method?

A. To bind to plasmid DNA, increasing its stability.

B. To neutralise the negative charges on DNA and the bacterial membrane, improving DNA uptake.

C. To break the bacterial cell wall and allow DNA to enter directly.

D. To activate enzymes that facilitate DNA replication post-transformation.

Question 34 (1 mark)

Which of the following is an advantage of electroporation over the heat shock method?

A. Electroporation increases the likelihood of plasmid incorporation into the bacterial chromosome.

B. Electroporation is less expensive and requires no special equipment.

C. Electroporation achieves higher transformation efficiency by creating precise, uniform pores in the membrane.

D. Electroporation eliminates the need for plasmid preparation.

Space for Personal Notes

Question 35 (1 mark)

What is a key step common to both the heat shock and electroporation methods of transformation?

A. Chemical treatment to degrade the bacterial membrane.

B. Isolation of bacterial RNA prior to transformation.

C. Introduction of DNA into bacterial cells by altering the membrane's permeability.

D. Use of high-frequency sound waves to create membrane pores.

Space for Personal Notes

Sub-Section: [1.7.4] - Describe the Process by which Bacterial Cells can be Used to Produce Human Proteins, Including the Application of This to Human Insulin Production

Question 36

Definitions:

a. Human Insulin:

_____

_____

b. cDNA (Complementary DNA):

_____

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c. Recombinant Protein:

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_____

Question 37 (1 mark)

Why is cDNA used instead of genomic DNA for producing human insulin in bacteria?

A. cDNA lacks introns, allowing bacterial cells to transcribe and translate the insulin gene correctly.

B. cDNA includes antibiotic resistance genes for plasmid selection.

C. cDNA improves the stability of the plasmid in bacterial cells.

D. cDNA facilitates the binding of restriction enzymes to plasmid DNA.

Question 38 (1 mark)

Which of the following steps is essential in creating a recombinant plasmid for insulin production?

A. Isolation of genomic DNA from bacterial cells.

B. Amplification of intron-containing DNA.

C. Use of reverse transcriptase to synthesise cDNA from insulin mRNA.

D. Ligation of mRNA into the plasmid using DNA ligase.

Question 39 (1 mark)

How do scientists ensure the proper expression of the human insulin gene in bacterial cells?

A. By using a bacterial promoter sequence in the recombinant plasmid.

B. By inserting introns to stabilise the insulin gene.

C. By growing bacteria in the presence of insulin protein.

D. By using ribosomal RNA sequences in the plasmid.

Question 40 (1 mark)

After producing recombinant insulin, how is the protein purified from bacterial cells?

A. By extracting mRNA from the cells.

B. By using selective antibiotics to isolate insulin-secreting bacteria.

C. By lysing the cells and isolating the protein using chromatography.

D. By amplifying the insulin gene using PCR.

Space for Personal Notes

Question 41 (1 mark)

Which key enzyme is used to join the human insulin cDNA into a plasmid?

A. DNA polymerase.

B. DNA helicase.

C. DNA ligase.

D. Reverse transcriptase.

Question 42 (12 marks)

a. What is meant by recombinant DNA, and why was its development significant for the production of human insulin? (2 marks)

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b. Describe how the researchers addressed the challenges of producing the two polypeptide chains of insulin (*A* and *B*) in bacterial cells and ensuring their proper assembly into functional insulin. (2 marks)

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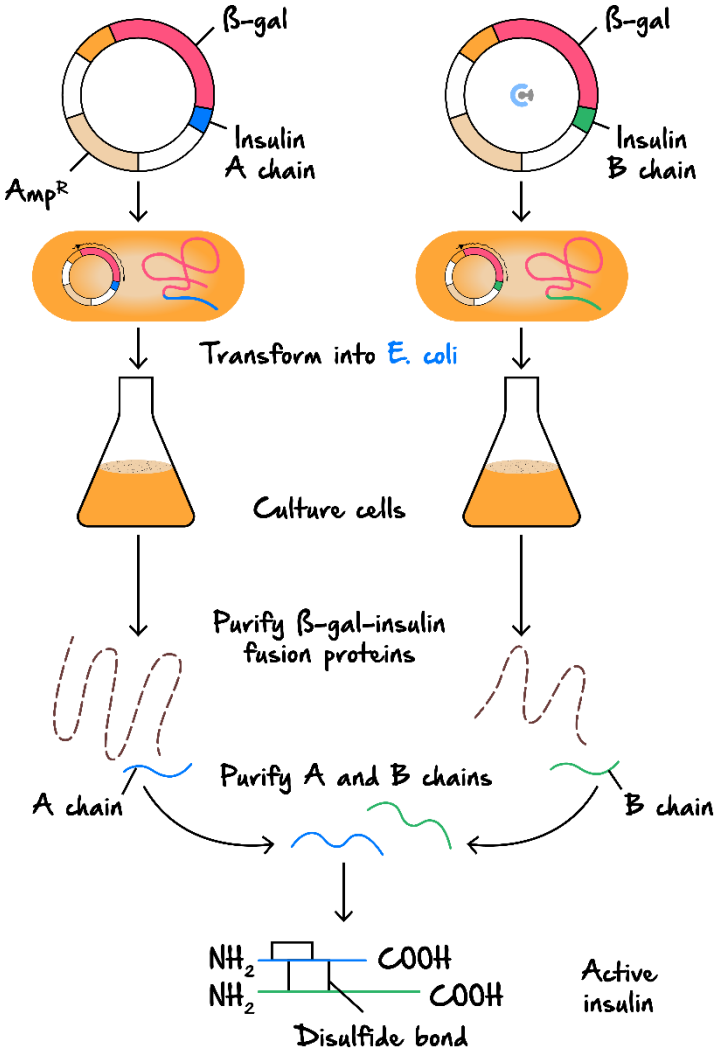
c. Outline the steps required to produce recombinant human insulin using bacterial cells. In your answer, include key enzymes, techniques, and processes. Use a flow chart to support your response. (6 marks)



d. When recombinant insulin was first developed, clinical trials confirmed its effectiveness and safety compared to animal-derived insulin. Explain one ethical consideration researchers and policymakers had to address when transitioning from animal-derived to recombinant insulin. (2 marks)

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Space for Personal Notes

Sub-Section [1.7.5]: Explain the Significance of Beta-Galactosidase, Other Reporter Genes, & Antibiotic Resistance Genes in the Selection of Transformed, Recombinant Bacterial Cells

Question 43

Definitions:

a. Beta-Galactosidase:

_____

_____

b. Reporter Gene:

_____

_____

c. Antibiotic Resistance Gene:

_____

_____

Question 44 (1 mark)

Which of the following best describes the role of an antibiotic-resistance gene in a plasmid vector?

A. It provides bacteria with the ability to survive in environments containing antibiotics, allowing the selection of transformed cells.

B. It disrupts the expression of beta-galactosidase to produce white colonies.

C. It ensures that recombinant plasmids are only expressed in eukaryotic cells.

D. It allows bacteria to metabolise lactose analogues such as X-gal.

Question 45 (1 mark)

Why is X-gal used in blue-white screening for bacterial transformation?

A. It is an antibiotic that kills non-transformed bacteria.

B. It allows the differentiation of recombinant and non-recombinant plasmids by producing a colour change.

C. It provides a source of energy for bacterial colonies on selective media.

D. It binds directly to the gene of interest, confirming its insertion.

Question 46 (1 mark)

Which of the following is a key characteristic of a reporter gene such as beta-galactosidase?

A. It enables bacteria to survive on antibiotic-containing media.

B. It produces a visible or measurable product that indicates gene expression or plasmid activity.

C. It enhances the replication of plasmids within bacterial cells.

D. It prevents non-recombinant plasmids from replicating in bacterial cells.

Space for Personal Notes

Question 47 (4 marks)

a. Explain how the lacZ gene and the use of X-gal allow scientists to identify recombinant bacterial colonies. (2 marks)

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b. Why is an antibiotic resistance gene included in the plasmid, and how does it assist in selecting transformed bacterial cells? (2 marks)

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Space for Personal Notes

Section B: [1.2 – 1.7] – Overall (Qs) (81 Marks)

Question 48 (1 mark)

Prokaryotes regulate gene expression through operon systems such as the *trp* operon.

In the *trp* operon, what happens when tryptophan levels are high in the cell?

A. RNA polymerase is prevented from binding to the promoter, and the operon is not transcribed.

B. The repressor protein binds to the *trp* operator, preventing transcription of the *trp* genes.

C. The genes *trpE*, *trpD*, *trpC*, *trpB*, and *trpA* are actively expressed to synthesise tryptophan.

D. The operon is fully transcribed, and enzymes for tryptophan synthesis are continuously produced.

Question 49 (1 mark)

The *trp* operon in prokaryotes uses attenuation as an additional method of regulating gene expression.

What happens during attenuation when tryptophan levels are high in the cell?

A. The ribosome stalls at the leader peptide region, allowing transcription of the *trp* structural genes to continue.

B. The repressor protein binds to the operator, completely halting transcription of the *trp* operon.

C. A terminator structure forms in the mRNA, causing RNA polymerase to stop transcription prematurely.

D. RNA polymerase bypasses the leader region and fully transcribes the operon, even in the presence of tryptophan.

Space for Personal Notes

Question 50 (1 mark)

The diagram below shows a eukaryotic organelle.

The correct function of the organelle shown in the diagram above is:

A. Process and package proteins and lipids.

B. Protein synthesis and lipid metabolism.

C. Aerobic cellular respiration.

D. The production of glucose in photosynthesis.

Question 51 (1 mark)

In the Polymerase Chain Reaction which of the following stages and temperatures is correct?

A. Denaturation - The DNA is heated to 72°C in order to separate the strands.

B. Annealing - The sample is cooled to 55°C and primers attach.

C. Extension - The sample is heated to 95°C to enable *taq* polymerase to add new primers.

D. Lysis - The sample is cooled to 40°C to allow restriction endonucleases to cut the DNA.

Space for Personal Notes

The following information applies to the two questions that follow.

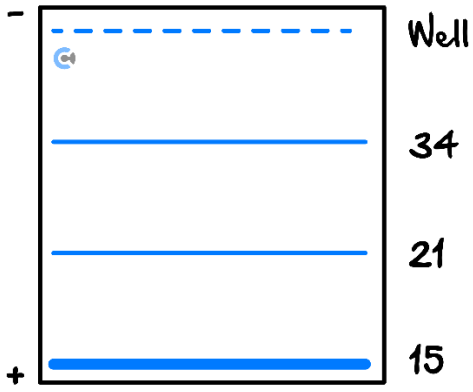
Restriction fragment length polymorphisms (RFLPs) are routinely used in genetic profiling cases where the identity of individuals is required, such as in criminal cases. The reason they are used is that individuals contain sections of DNA that vary in length when compared to other individuals. In the table below, four suspects were tested along with a sample of material from a crime scene. The numbers in the table represent the length of the DNA fragment at a particular locus.

	Length of DNA fragment (× 1000 of base pairs)				
Loci	**Suspect 1**	**Suspect 2**	**Suspect 3**	**Suspect 4**	**Suspect 5**
1	34	24	24	34	34
1	21	21	21	21	21
2	15	15	15	15	15
2	15	16	18	15	15

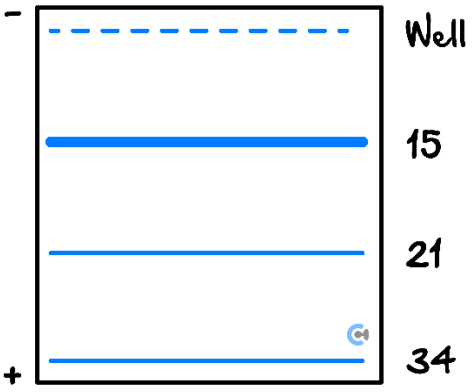
Question 52 (1 mark)

What would be the genetic profile of suspect 1 as seen after gel electrophoresis?

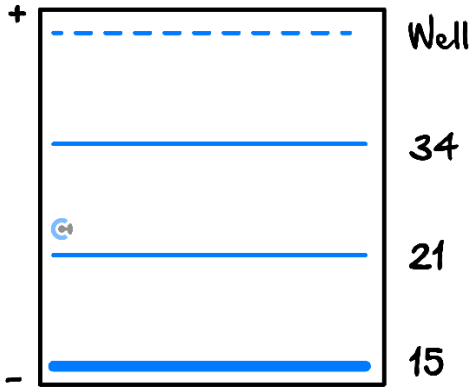
A.



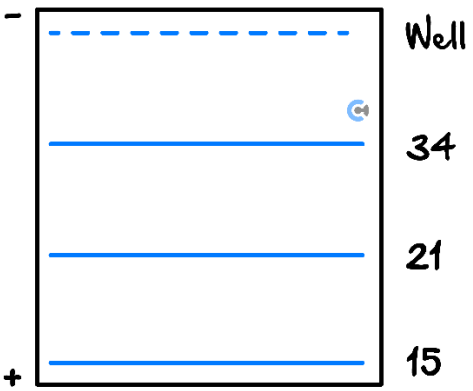
B.



C.



D.



Question 53 (1 mark)

What is a reasonable conclusion that could be made with respect to the criminal case in question?

A. In the general population, gene locus 2 would be less useful at determining uniqueness than gene locus 1.

B. More gene loci should be investigated to determine which suspect can be associated with the crime scene.

C. Suspect 1 and suspect 4 are identical twins who colluded together to commit a crime.

D. The risk of contamination at the crime scene would be too high to allow any reasonable conclusion to be made.

The following information applies to the three questions that follow.

A team of scientists is using CRISPR-Cas9 to develop a new strain of rice resistant to a fungal disease. The gene FRG1 (Fungal Resistance Gene 1) in rice is modified by introducing a mutation that enhances fungal resistance. After performing CRISPR-Cas9 editing, they grow modified and unmodified plants and expose them to fungal pathogens. The following table summarises their findings:

Plant Type	**Fungal Infection Rate (%)**	**Plant Survival Rate (%)**
Unmodified Rice Plants	80%	30%
CRISPR-Modified Plants	10%	90%

Question 54 (1 mark)

In this experiment, the scientists used CRISPR-Cas9 to target the FRG1 gene and introduce a mutation to enhance fungal resistance. Which of the following accurately describes the sequence of molecular events during CRISPR-Cas9 editing?

A. The guide RNA (gRNA) binds to the Cas9 protein, which then randomly scans the rice genome and cuts any DNA.

B. Cas9 binds to the protospacer adjacent motif (PAM) sequence, and the guide RNA directs Cas9 to cleave the target DNA at a specific location.

C. The guide RNA independently binds to the DNA, and Cas9 follows to cleave the DNA at a random location within the $FRG1$ gene.

D. Cas9 directly identifies the target DNA without needing a guide RNA and introduces a mutation to the FRG1 gene.

Question 55 (1 mark)

Which of the following steps would ensure that only the modified plants survive during the experiment?

A. Introduce an antibiotic resistance gene into the rice genome alongside the FRG1 mutation and grow the plants on an antibiotic-containing medium.

B. Allow the modified plants to self-pollinate to increase the mutation frequency in subsequent generations.

C. Grow the plants in a nutrient-deficient medium to promote fungal resistance.

D. Insert a fluorescent reporter gene to track the growth of modified plants.

Question 56 (1 mark) **Data Analysis.**

Based on the data in the table, what conclusion can be drawn about the effectiveness of CRISPR-Cas9 in modifying the FRG1 gene?

A. The unmodified plants show a higher fungal infection rate and survival rate compared to the modified plants, indicating CRISPR was ineffective.

B. CRISPR-modified plants show significantly lower fungal infection rates and higher survival rates, indicating the FRG1 mutation enhances fungal resistance.

C. Both unmodified and modified plants have similar fungal infection and survival rates, suggesting that CRISPR did not affect fungal resistance.

D. The CRISPR-modified plants are less resistant to fungal infection, but their survival rate remains higher due to increased nutrient absorption.

Question 57 (1 mark)

Scientists are able to produce functional insulin in a bacterium using human DNA. Before being inserted into the bacterium, the human DNA is spliced into plasmids.

This DNA:

A. Can be formed by isolating mRNA and transcribing it into DNA.

B. Is isolated from the nucleus of a human cell and inserted directly into the plasmid.

C. Is spliced into a plasmid that has had all of its introns removed.

D. Has blunt ends so it will join easily onto the plasmid.

Question 58 (1 mark)

A recombinant plasmid with a gene of interest and an ampicillin-resistant gene was copied and inserted into several bacteria, which were then placed in a growth medium at 37°C for 24 hours. This insertion technique was only 10% successful.

Which one of the following methods would give the best chance of selecting the transformed bacteria?

A. Growing the bacterium in a normal environment and placing 10% of the colonies in a different medium to continue growing.

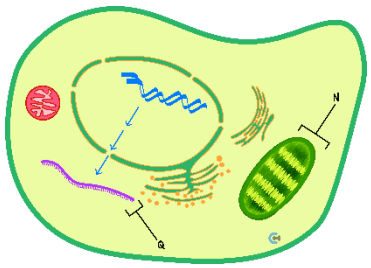
B. Increasing the temperature of the growth medium to 45°C so the ampicillin-resistant bacteria are more likely to survive.

C. Growing the bacteria in a medium that contains ampicillin so only the transformed bacteria will grow exposing the bacteria to heat shock or electroporation.

D. Growing the bacteria in a medium that contains ampicillin so only the transformed bacteria will grow.

Question 59 (4 marks)

The following figure represents a portion of a plant cell.

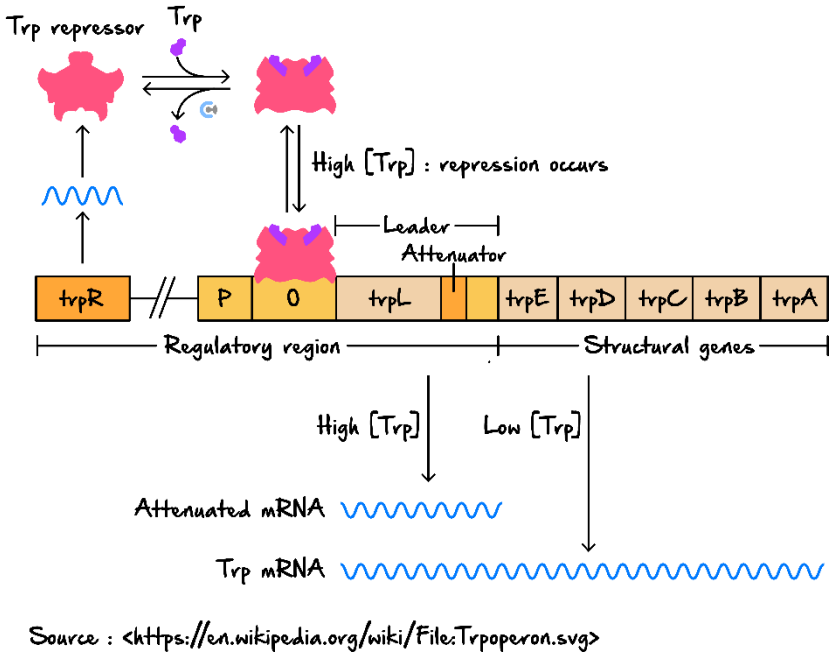


Examine the figure above and complete the following table.

	Type of Nucleic Acid Found in Structure	Specific Function of the Nucleic Acid
Structure N		
Structure Q		

Question 60 (9 marks)

The diagram below shows the *trp* operon.



Source : <https://en.wikipedia.org/wiki/File:Trpoperon.svg>

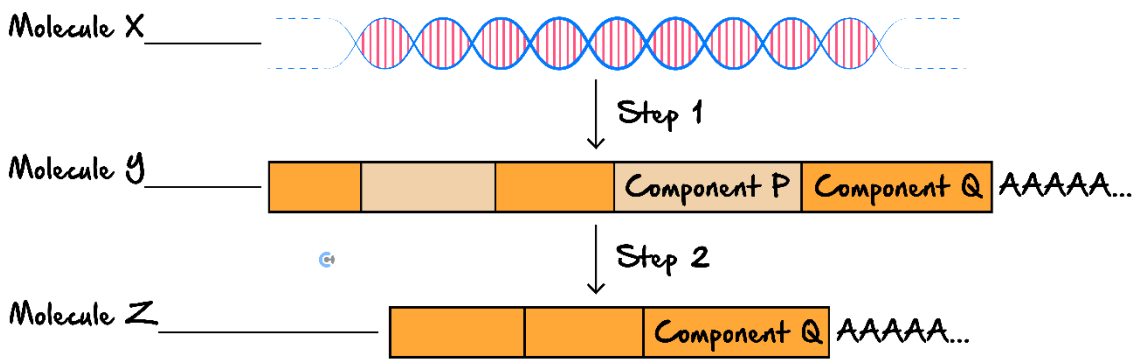
In *E.coli* there are two mechanisms that repress the genes E, D, C, B and A in the *trp* operon.

a. Explain how **one** of these mechanisms prevent the formation of tryptophan in a high tryptophan environment. (3 marks)

If the level of tryptophan is low, the *E.coli* will transcribe and translate the operon. Three forms of RNA are involved in these processes.

b. Describe the role of each type of RNA. (3 marks)

c. The diagram below shows RNA processing in eukaryotic cells. (3 marks)



Source : adapted from Maria Arsonova/dreamstime.com

i. In the diagram above, label the molecules X, Y and Z.

ii. Compare the roles of components P and Q in molecule Y.

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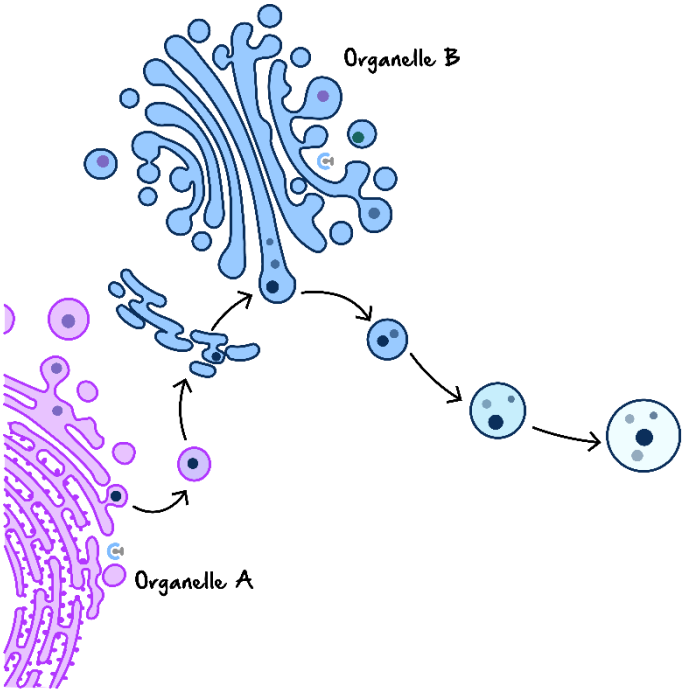
Question 61 (8 marks)

Many eukaryotic organisms are comprised of many different cells, with varying functions. Different cells produce different products that may be exported from the cell.

The diagram below shows a simplified overview of the protein secretory pathway.



Source: https://app.biorender.com/illustrations/63dlafff3ed616bf1730efa

a. Name and state the function of both Organelle *A* and Organelle *B* in the protein secretory pathway. (4 marks)

b. On the diagram above, circle a transport vesicle. (1 mark)

c. During the synthesis of a protein, a sequence of amino acids is joined together, forming the primary structure. After this initial structure has been created, further structural levels are required to produce a fully functional protein. Consider the protein **haemoglobin**.

Describe all the other structural hierarchical levels that are required to form a functional haemoglobin molecule. (3 marks)

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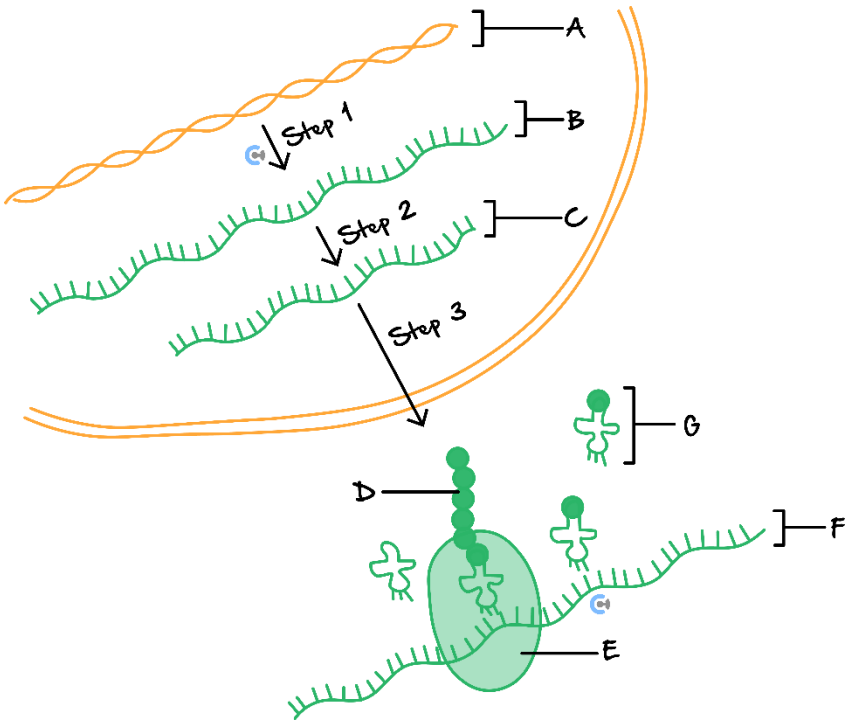
Question 62 (8 marks)

DNA provides a blueprint to manufacture protein, as shown in the diagram below.



a. Identify the names of step 1, molecule *B* and structure *E*. (3 marks)

b. Outline **two** differences between molecule *B* and molecule *F*. (2 marks)

c. Identify step 3 and describe how it uses molecule G to produce molecule D. (3 marks)

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Question 63 (11 marks)

Gene regulation ensures that the appropriate genes are expressed within specialised cells of a multicellular or single-celled organism.

a. Identify the advantage that gene regulation provides for the survival of an organism. (1 mark)

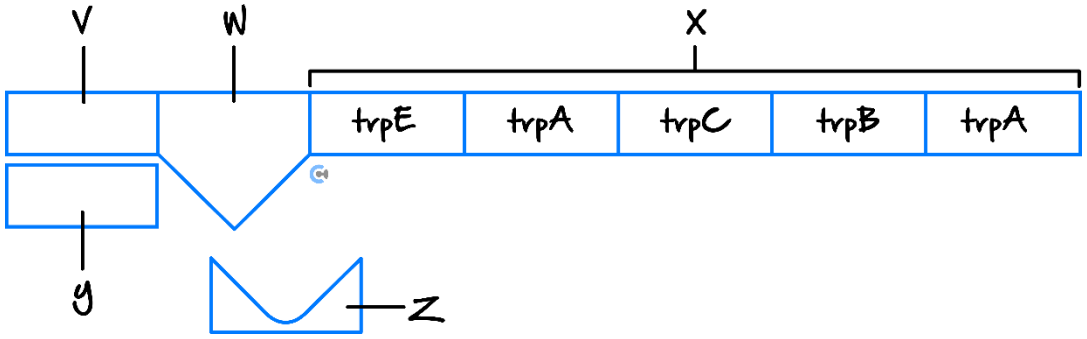
_____

_____

Tryptophan is an amino acid. Depending on the type of cell, tryptophan can be gained from the environment or synthesised in a cell.

b. Draw a diagram of the structure of an amino acid and indicate where tryptophan would differ from other amino acids. (2 marks)

c. *E. coli* is a type of bacteria. One of the amino acids that *E. coli* needs to survive is tryptophan. If tryptophan is available in the environment, E. coli will take it up. If it is not available, *E. coli* can make its own tryptophan using enzymes that are encoded by five genes (*trpA-trpE*), which are part of the trp operon. The diagram below represents this operon when the levels of tryptophan are low within *E. coli*. Labels *V-Z* represent different components of the *trp* operon.



i. Name components *V* and *X*. (2 marks)

ii. Explain how the *trp* operon would function when the levels of tryptophan in the environment are high with reference to both attenuation and repression. (6 marks)

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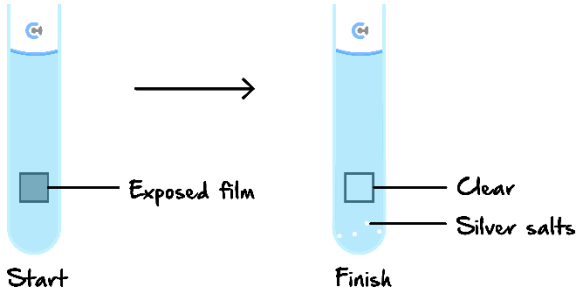
Question 64 (7 marks)

Exposed photographic film has black silver salts bonded to it by a thin layer of gelatin (a protein). In an investigation into the digestion of gelatin by the enzyme trypsin the end point is shown by the clearing of the film, as in the diagram below.



Seven test tubes, each with a different buffered pH solution and 1 cm^3 of 0.5% trypsin solution, were placed in a water bath at 35°C for five minutes. Small pieces of exposed film were simultaneously placed into each test tube and the time taken for the film to clear was noted.

pH	Time Taken to Clear in Minutes
6.0	30
6.5	20
7.0	13
8.0	5
9.0	8
9.5	20
10.0	35

a. What is the optimum pH for trypsin? (1 mark)

_____

_____

b. What control(s) would be required for this experiment? (1 mark)

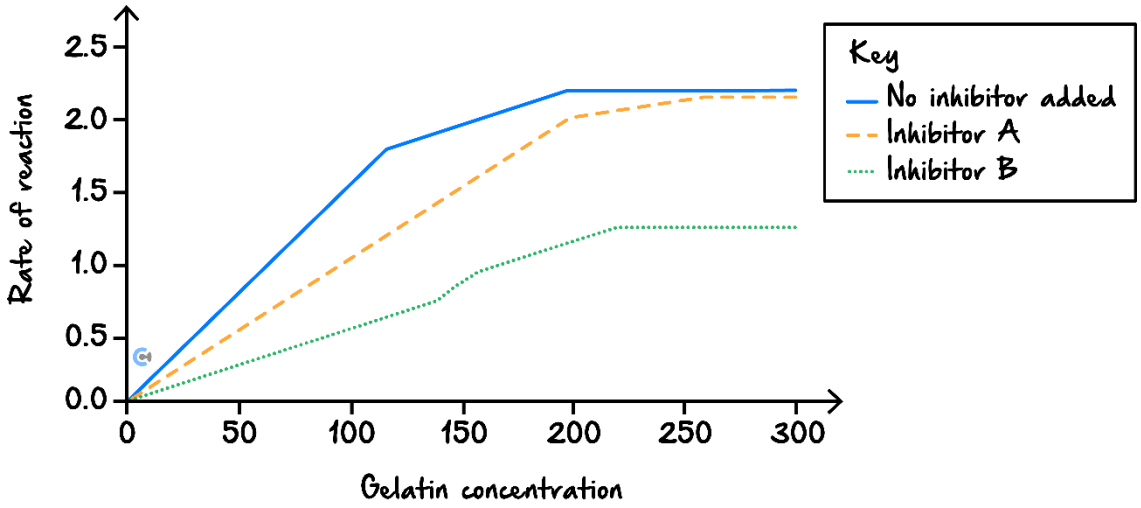
_____

_____

c. What would have happened to the 'time taken to clear' had the experiment been carried out at 70°C? Explain your answer. (1 mark)

d. Using your knowledge of the structure of enzymes, explain the pattern of results obtained for this experiment. (1 mark)

e. Another experiment was conducted involving the addition of chemicals (inhibitors *A* and *B*) that were thought to have an inhibitory effect on trypsin. The results gained from the experiment are shown in the graph below.



Compare the effects of inhibitors *A* and *B* on the biochemical pathway. (3 marks)

Question 65 (11 marks)

On a quiet Thursday evening, Contour Education's main office was broken into. Security footage revealed that an unidentified individual forced entry through the back door around 10: 30 PM. The perpetrator disabled the alarm system and stole several laptops containing sensitive student data, along with cash from the petty cash drawer.

The office manager discovered the break-in the following morning and immediately contacted the local police. A preliminary investigation revealed no signs of physical harm to any staff or visitors, but the theft raises concerns about data security and operational continuity.

Details:

- The security footage shows a masked individual wearing gloves, suggesting an intent to avoid leaving fingerprints.
- No external witnesses have come forward yet, but the nearby café's outdoor cameras might have captured the suspect fleeing the scene.
- The stolen laptops were encrypted, but there are concerns about potential attempts to bypass encryption.
- The estimated financial loss is $15,000, including equipment replacement costs.

Unfortunately, the image from the café looks like this:

Instead, the police must first rely upon the DNA that was left behind by the criminal!

They took that sample and then performed PCR, as shown below.

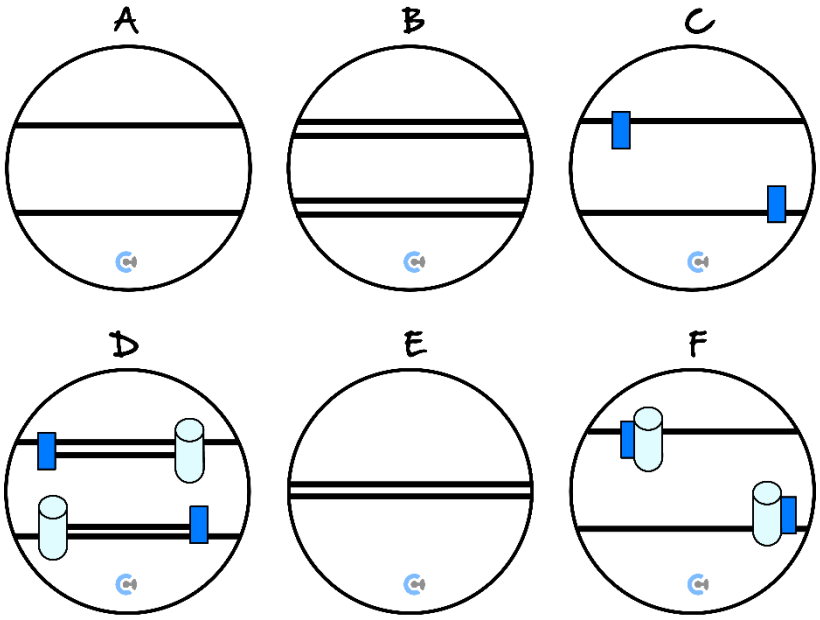


Figure 6

Figure 6 shows the different stages involved in one cycle of PCR.

a. What is meant by the term PCR? (1 mark)

_____

_____

b. Using the images shown in **Figure 6**, what is the correct sequence of images that would be seen in one cycle of PCR? (1 mark)

_____

_____

c. What name is given to the chemicals represented by the grey rectangles in images C, D and F in **Figure 6**? (1 mark)

_____

_____

d. Explain the key events which occur in the step of PCR outlined in image F as shown in **Figure 6**. (1 mark)

_____

_____

e. Name one other requirement for the process of PCR that is not shown in **Figure 6**. (1 mark)

_____

_____

f. The white cylinders shown in image *D* and *F*, represent a bacterial enzyme known as *Taq* DNA polymerase. Explain why *Taq* DNA polymerase is used during PCR rather than human polymerase. (1 mark)

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g. Outline how the gel electrophoresis could be used by law enforcement officials in a case where there are multiple suspects and a blood sample from the crime scene. (4 marks)

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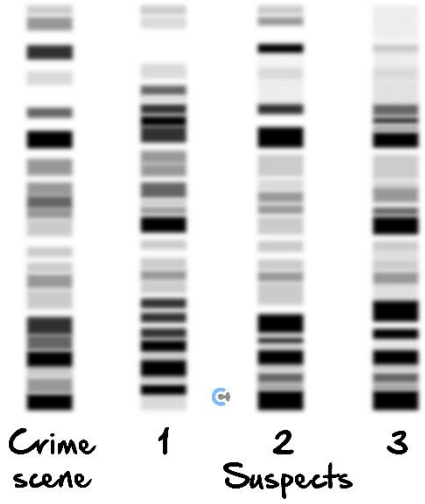
The results from the gel electrophoresis are below.



h. Use this information to identify the burglar. Justify your answer. (1 mark)

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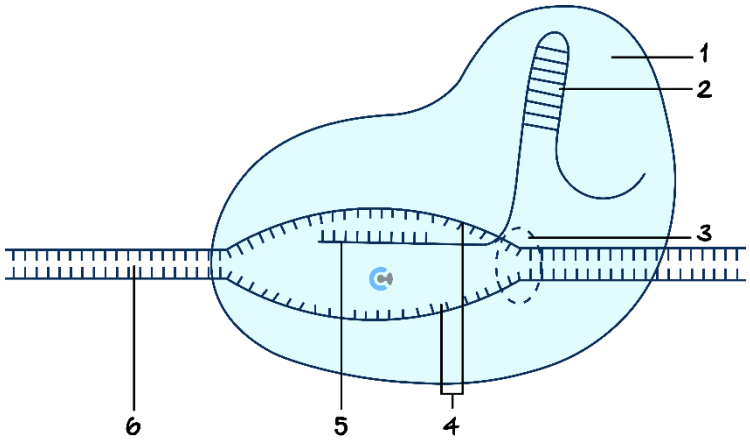
Question 66 (7 marks)

CRISPR-Cas9 technology has revolutionised modifying genes through the methods of disruption, correction or replacement. The diagram below shows a CRISPR-Cas9 complex and labels 1-6 represent different parts of the complex.



a. Complete the table below by stating the name and describing the function of the listed parts of the CRISPR-Cas9 complex. (3 marks)

Part	Name	Function
1		
5		
3		

b. Explain how CRISPR-Cas9 would be used to modify a gene to improve water retention in drought-resistant crops. (3 marks)

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c. Explain how the process described in your answer to **part b.** could be advantageous. (1 mark)

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Question 67 (5 marks)

Diabetes can be an autoimmune condition where the body is activated to destroy the boa cells in the pancreas that produce insulin. Human insulin is a polypeptide hormone. Insulin consists of two polypeptide chains, chain *A* (21 amino acids) and chain *B* (30 amino acids), connected by two disulphide bridges. Human insulin can be made using recombinant plasmids.

Outline how human insulin is made using recombinant plasmids.

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