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VCE Biology ¾
CRISPR-Cas9 & Bioethics [1.6]
Homework

Homework Outline:

Compulsory Questions	Pg 1 – Pg 21

Section A: Compulsory Questions (41 Marks)

Sub-Section [1.6.1]: Describe the Function and the Process of CRISPR-Cas9 as an Adaptive Defense Against Viruses in Bacteria

Question 1

a. CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats):

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_____

b. Cas Proteins:

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c. Spacer DNA:

_____

_____

d. Guide RNA (gRNA):

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e. Adaptive Immunity:

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Question 2 (1 mark)

What is the primary function of CRISPR-Cas9 in bacteria?

A. To synthesise proteins for metabolic processes.

B. To act as an adaptive defense against viral infections.

C. To enable bacterial conjugation.

D. To promote genetic variation through mutations.

Question 3 (1 mark)

How does the CRISPR-Cas9 system recognises and targets viral DNA?

A. It binds randomly to any DNA in the cell.

B. It synthesises new RNA molecules that directly destroy viral DNA.

C. It uses RNA sequences transcribed from CRISPR arrays to guide the Cas9 protein to complementary viral DNA.

D. It relies on physical contact with viral proteins to detect and target viral DNA.

Question 4 (5 marks)

a. A student states that Cas9 is involved in incorporating a proto spacer into the CRISPR array in bacteria. Explain where the student has gone wrong, and correctly describe the function of the Cas9 enzyme. (2 marks)

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b. Alternatively, describe how the CRISPR-Cas9 functions as a defense system in bacteria. (3 marks)

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Sub-Section [1.6.2]: Explain the Process of Using CRISPR-Cas9 as a Gene Editing Tool, Including Silencing, Knock-Ins & Knock-Outs

Question 5

a. Gene editing:

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b. Knock in:

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c. Knock out:

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d. Mutation:

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Question 6 (1 mark)

What is a knock-out in the context of CRISPR-Cas9 gene editing?

A. Inserting a new gene into a specific location in the genome.

B. Silencing gene expression by targeting RNA.

C. Disrupting a gene's function by introducing a mutation or deletion.

D. Replacing a defective gene with a functional one.

Question 7 (1 mark)

How does CRISPR-Cas9 facilitate gene knock-ins?

A. By silencing genes through blocking transcription.

B. By cutting DNA and inserting new genetic material during repair.

C. By using guide RNA to degrade messenger RNA before translation.

D. By introducing random mutations to alter gene expression.

Question 8 (2 marks)

Researchers used CRISPR-Cas9 to modify the GROW1 gene, which regulates plant height. They designed a guide RNA targeting the gene's coding region but did not provide a donor DNA template for repair. After the experiment, the plants showed no detectable GROW1 protein, and their growth was significantly stunted compared to controls.

Which CRISPR-Cas9 technique was likely used in this experiment? Justify.

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Sub-Section [1.6.3]: Describe & Compare the Function of the PAM Sequence in Bacteria & Gene Editing Applications of CRISPR-Cas9 Technology

Question 9

Protospacer Adjacent Motif (PAM):

_____

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Question 10 (1 mark)

What is the primary function of the PAM sequence in the natural bacterial CRISPR-Cas system?

A. To prevent Cas9 from cutting bacterial DNA by recognising self-DNA.

B. To allow Cas9 to bind any DNA sequence, regardless of its origin.

C. To direct the synthesis of guide RNA (gRNA) for Cas9.

D. To recruit repair enzymes after DNA cutting.

Question 11 (1 mark)

How does the PAM sequence influence the application of CRISPR-Cas9 in gene editing?

A. It ensures Cas9 can bind any DNA sequence, enhancing versatility.

B. It limits the sequences Cas9 can target by requiring a PAM near the target site.

C. It eliminates the need for guide RNA (gRNA) in targeting specific DNA.

D. It repairs DNA after Cas9 introduces a double-stranded break.

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Question 12 (3 marks)

a. Compare and contrast the role of the PAM sequence in both bacteria and in gene editing. (2 marks)

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b. Other than preventing self-harm to the bacteria, what role does the PAM sequence play naturally? (1 mark)

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Sub-Section [1.6.4]: Describe the Function & Compare the Guide RNA (gRNA) & Single Guide RNA (sgRNA)

Question 13

a. sgRNA:

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b. CRISPR RNA (crRNA):

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c. Trans-activating CRISPR RNA (tracrRNA):

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_____

Question 14 (1 mark)

What is the primary difference between guide RNA (gRNA) and single guide RNA (sgRNA)?

A. gRNA is made purely from RNA nucleotides, while sgRNA is composed of both RNA and DNA components.

B. gRNA is naturally occurring in bacteria, while sgRNA is artificially engineered.

C. gRNA is used only in gene editing, while sgRNA is used only in bacteria.

D. gRNA has higher specificity than sgRNA.

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Question 15 (1 mark)

How may sgRNA be designed to minimise the chance of offsite cuts?

A. By designing a shorter spacer region in the sgRNA to increase flexibility in target binding.

B. By avoiding the inclusion of a PAM sequence in the sgRNA.

C. By designing a longer spacer region in the sgRNA to maximise specificity in target binding.

D. By eliminating the scaffold region of the sgRNA to reduce binding efficiency.

Question 16 (2 marks)

Provide one structural and one functional difference between gRNA and sgRNA.

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Sub-Section [1.6.5]: Apply Bioethical Principles to the Use of CRISPR-Cas9 Technology

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Sub-Section [1.6.6]: Define & Describe the Bioethical Concepts of Integrity, Respect, Beneficence, Non-Maleficence & Justice as Elaborated in the VCAA Study Design

Question 17

a. Beneficence:

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b. Non-Maleficence:

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c. Respect:

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d. Justice:

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e. Integrity:

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Question 18 (1 mark)

A pharmaceutical company develops a CRISPR-Cas9 therapy to cure a life-threatening genetic disorder. While the therapy shows promising results, it is priced so high that only wealthier patients can afford it. Advocacy groups raise concerns about equitable access to the therapy, arguing that it should be made available to all affected individuals, regardless of their financial situation. Which ethical principle is most relevant in addressing these concerns?

A. Non-maleficence - ensuring the therapy does not cause harm to patients.

B. Justice - ensuring fair and equitable access to the therapy.

C. Beneficence - maximising positive outcomes for patients who can afford it.

D. Integrity - maintaining honesty in reporting the benefits of the therapy.

Question 19 (1 mark)

A CRISPR-Cas9 clinical trial aims to modify the germline DNA of embryos to prevent a heritable genetic disease. Although the researchers have obtained proper regulatory approval and documented short-term safety, there is significant uncertainty about how these genetic modifications might affect future generations. Critics argue that the potential risks outweigh the benefits. Which ethical principle is primarily being questioned in this scenario?

A. Beneficence - ensuring the research provides significant benefits.

B. Respect - acknowledging the autonomy of the individuals involved.

C. Non-maleficence - avoiding harm, particularly to future generations.

D. Justice - ensuring equal access to the trial for affected families.

Question 20 (1 mark)

A team of scientists uses CRISPR-Cas9 to study a genetic mutation by editing the genomes of laboratory animals. They ensure that the research is carefully designed to minimise suffering, obtain the maximum amount of useful data, and contribute to life-saving therapies. However, animal rights activists challenge the experiment, claiming it violates ethical standards. The researchers defend their work by emphasising that all animals are treated humanely, and their study is aimed at improving human health. Which ethical principle best supports the researchers' position?

A. Respect - ensuring the humane treatment of animals in the experiment.

B. Justice - ensuring the benefits of the study are shared across populations.

C. Integrity - conducting the research honestly and transparently.

D. Beneficence - ensuring the research maximises potential benefits for society.

Question 21 (4 marks)

Scientists are exploring the use of CRISPR-Cas9 technology to modify the genes of livestock to enhance meat production efficiency. For example, CRISPR could be used to increase muscle growth or disease resistance in cattle. However, concerns have been raised about the long-term welfare of the animals and the potential ecological consequences of releasing genetically modified organisms into the environment.

Discuss an ethical concern that could be raised about the use of CRISPR-Cas9 technology in livestock. Propose a feasible solution to this ethical concern. State the ethical concept or approach that has been addressed in your discussion.

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

Question 22

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 23 (1 mark)

A biotechnology company proposes using CRISPR-Cas9 to engineer crops that are more resistant to drought and pests. While there are concerns about the long-term environmental impact of genetically modified organisms, the company justifies its decision by highlighting the potential to address food shortages in drought-prone regions and reduce reliance on harmful pesticides.

What ethical approach is primarily guiding the company's decision?

A. Duty-based approach - prioritising adherence to ethical rules about environmental protection.

B. Consequences-based approach - focusing on maximising benefits like food security.

C. Virtues-based approach - emphasising compassion for affected communities.

D. Respect-based approach - ensuring the autonomy of farmers to choose improved crops.

Question 24 (1 mark)

A research team refuses to edit human embryos with CRISPR-Cas9 despite significant funding and pressure from investors. They argue that doing so would prioritise financial gain over ethical responsibility. Instead, they focus on projects that reflect their values of integrity and respect for human life, even though these projects may have less immediate impact.

What ethical approach is primarily guiding the research team's decision?

A. Consequences-based approach - weighing financial risks and potential benefits.

B. Justice-based approach - ensuring fairness in research funding allocation.

C. Duty-based approach - adhering to rules against germline editing.

D. Virtues-based approach - prioritising ethical character and moral values.

Question 25 (1 mark)

An international organisation bans the use of CRISPR-Cas9 to create genetically modified organisms in agriculture, citing an obligation to follow global agreements that prohibit certain forms of genetic modification until further studies confirm safety. The decision is made without considering specific potential benefits or risks in individual cases.

What ethical approach is primarily reflected in this decision?

A. Virtues-based approach - demonstrating a commitment to caution and responsibility.

B. Consequences-based approach - ensuring the technology benefits the majority.

C. Duty-based approach - adhering to established ethical rules and guidelines.

D. Justice-based approach - promoting fairness in decision-making.

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Question 26 (4 marks)

A research team is considering the use of CRISPR-Cas9 to modify the genes of crops to improve drought resistance. Some team members argue that the potential to reduce global hunger justifies the risks of unintended ecological consequences, while others prioritise strict adherence to existing regulations that limit genetic modification.

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

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

Question 27

a. Crop Productivity:

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b. Disease Resistance:

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Question 28 (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.

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Question 29 (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 30

You are a plant geneticist working to help tomato farmers combat devastating losses caused by fungal infections from Fusarium oxysporum. Research shows that the **S (Susceptibility) gene SITOM1** plays a critical role in facilitating fungal infections in tomatoes. By editing this gene using CRISPR-Cas9, you aim to reduce the plant's susceptibility to fungal pathogens.

Describe how you would use CRISPR-Cas9 to modify the SITOM1 gene to enhance fungal resistance in tomatoes.

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

Question 31

a. Transgenic Organism:

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b. Cisgenic Organism:

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c. Genetically Modified Organism (GMO):

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Question 32 (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.

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Question 33 (1 mark)

A farmer grows a new type of wheat that has been genetically modified to resist fungal infections by introducing a gene from a bacterium. 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 34 (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 35 (2 marks)

A group of scientists develops a new variety of apples that are resistant to fungal infections. To achieve this, they introduce a gene from a wild apple species into a commercial apple variety that is sexually compatible. The gene enhances the plant's ability to produce antifungal compounds.

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

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