

Mutation and gene editing: practice questions

8 questions • 23 marks • mark scheme at the back

For IB Diploma Biology, Standard Level and Higher Level (first assessment 2025). **HL only** is additional higher level content, for HL students only.

Name

Total / 23

1 PAPER 1A STYLE

[1 mark]

Which mutation is most likely to cause a frameshift?

- A. ☐ Substitution of one base
- B. ☐ Deletion of three adjacent bases
- C. ☐ Insertion of one base
- D. ☐ Insertion of six adjacent bases

2 PAPER 1A STYLE

[1 mark]

A base substitution changes the codon GAA to GAG, but the polypeptide is unchanged. What explains this?

- A. ☐ The genetic code is universal.
- B. ☐ The genetic code is degenerate.
- C. ☐ The mutation occurred in an intron.
- D. ☐ Proofreading removed the change.

3 PAPER 1B STYLE

[6 marks]

Samples of the same bacterial culture were exposed to ultraviolet (UV) light for different times. After exposure, the frequency of mutants unable to make a particular amino acid was measured (practice data). (a) Describe the relationship between exposure time and mutant frequency. [2] (b) Calculate how many times greater the mutant frequency is at 40 s than at 0 s. [1] (c) Suggest why mutants occur in the sample with no UV exposure. [1] (d) Explain how UV light increases the frequency of mutation. [2]

Mutant frequency after UV exposure	
Exposure time / s	Mutants per 10 ⁶ surviving cells
0	2
10	15
20	38
30	61
40	80

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4 PAPER 2A STYLE

[2 marks]

Distinguish between the consequences of a mutation in a germ cell and in a somatic cell.

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PAPER 2B STYLE

Explain the role of gene mutation in evolution by natural selection.

PAPER 2A STYLE

HL only

Outline how CRISPR sequences and the enzyme Cas9 are used to edit a gene.

PAPER 2A STYLE

HL only

Some genes, such as those for histone proteins, have highly conserved sequences. (a) State what is meant by a highly conserved sequence. [1] (b) Outline two hypotheses to account for highly conserved sequences. [2]

HL only

What is the purpose of producing a knockout mouse?

- A. ☐ To increase the expression of a gene to study its product
- B. ☐ To investigate the function of a gene by making it inoperative
- C. ☐ To produce a clone of a mouse with a useful mutation
- D. ☐ To insert a human gene so the mouse makes a human protein

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [1]

C C;

2. [1]

B B;

3. [6]

- (a) mutant frequency increases as exposure time increases / positive correlation;
- (a) increase is roughly linear / steady between 10 and 40 s / rises from 2 to 80 per 10^6 cells; Accept use of data
- (b) $80 \div 2 = 40$ (times);
- (c) spontaneous mutations / errors in DNA replication or repair (not caused by UV);
- (d) UV is a mutagen / mutagenic radiation;
- (d) UV changes the structure of DNA / causes adjacent bases to bond together;
- (d) leading to incorrect base pairing / changed base sequence when DNA is replicated or repaired;
- (d) longer exposure causes more DNA damage, so more mutations;
- max 6

4. [2]

- germ-cell mutation can be inherited / passed to offspring, whereas somatic mutation is not inherited;
- germ-cell mutation will be in every cell of the offspring, whereas a somatic mutation is only in cells descended from the mutated cell;
- somatic mutation can cause cancer (in the individual);
- max 2

5. [5]

- mutation is the original source of all genetic variation;
- mutation creates new alleles;
- meiosis/sexual reproduction only recombines existing alleles;
- mutations occur at random / not in response to need;
- most mutations are harmful or neutral (for an individual);
- some mutations give an advantage in a particular environment;
- individuals with advantageous alleles are more likely to survive and reproduce;
- so these alleles increase in frequency in the population over generations;
- without mutation there would be no (new) variation for selection to act on;
- max 5

6. [4] HL only

- guide RNA made with a base sequence complementary to the target sequence;
- guide RNA combined with Cas9;
- guide RNA binds to the target DNA by complementary base pairing;
- Cas9 cuts (both strands of) DNA at the target site;
- repair of the cut can disable the gene / introduce small insertions or deletions;
- a supplied DNA template can be used in repair to insert/correct a sequence;
- named example, e.g. editing blood stem cells so they make fetal haemoglobin to treat sickle-cell disease;
- max 4

7. [3] HL only

- (a) a sequence that remains identical or similar over long periods of evolution / across distantly related groups;
- (b) the gene product has strict functional requirements, so mutations make it less functional;
- (b) (and) natural selection removes such mutations;
- (b) the sequence has a slower rate of mutation;
- max 3

8. [1] HL only

B B;