SCIENCE FOUNDATIONS

Mutations

Difficulty level: Advanced

Science Foundations

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Overview of the concept

This is how a single change in DNA can give a flower a new colour, make bacteria resist an antibiotic, or sometimes cause a disease that runs in a family. A breeder looking for a new flower colour is hoping for a mutation that changes the pigment. A doctor tracking an outbreak watches for mutations that let a virus spread more easily. Knowing mutations tells you where new traits come from, why most changes are harmless, and why a few of them matter a great deal.



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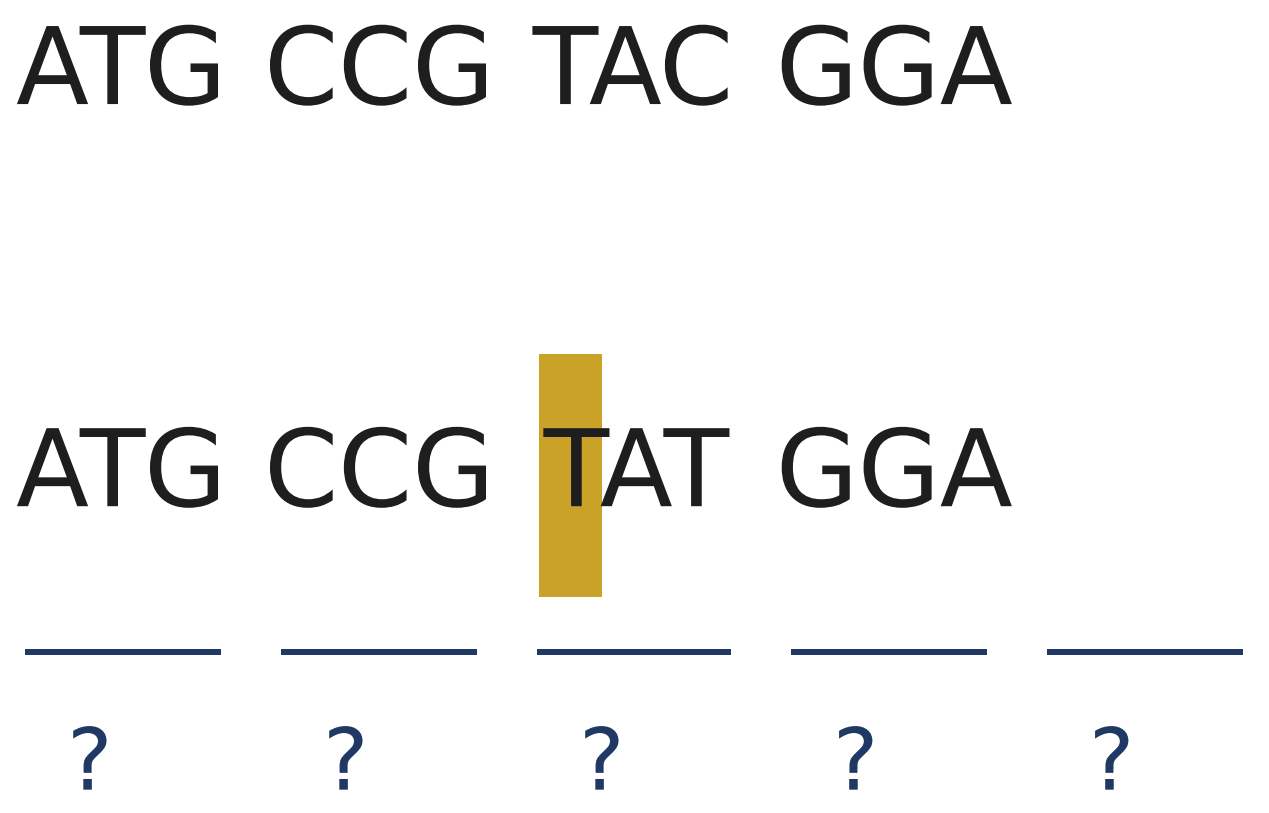
Worked examples

EXAMPLE 1

Q A substitution changes one base in a codon. What may happen?



SOLUTION

Read the codon before and after the swap.

Check the codon table: the new codon may call the same or a different amino acid.

Conclude: the protein may stay the same or change.

The result is same amino acid, or a different one, depending on the codon.

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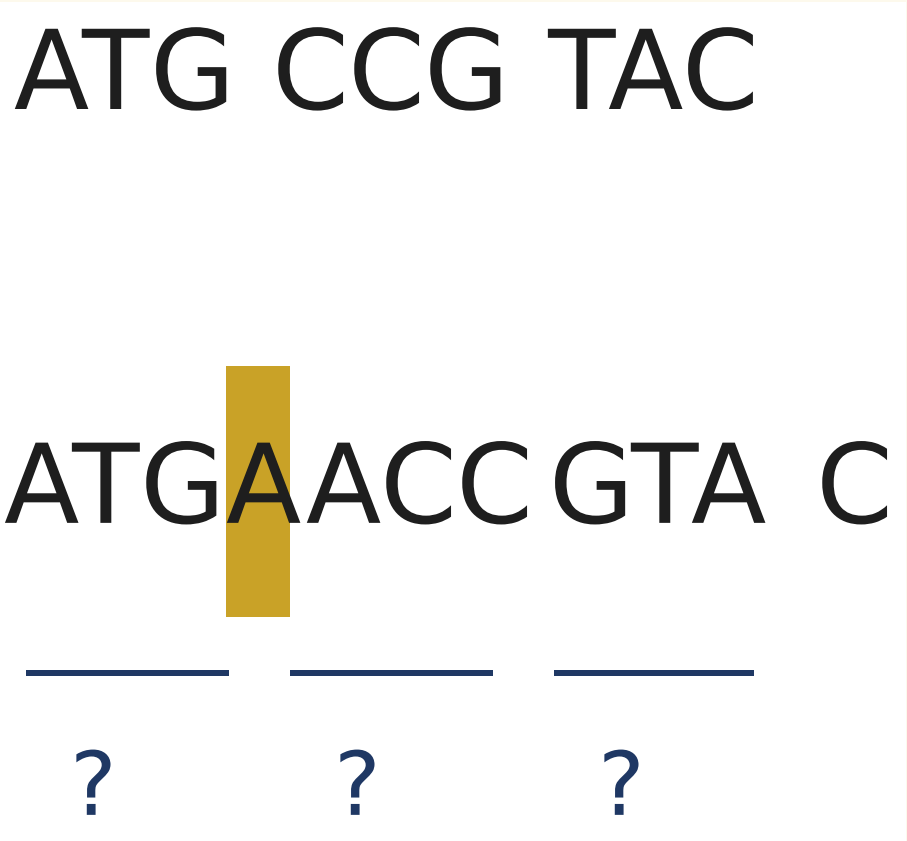
EXAMPLE 2

Q An insertion adds one base early in a gene. What may happen?



SOLUTION

Count the shift: every codon after the insertion moves by one base.

The reading frame shifts, so later amino acids change.

Conclude: the protein is often badly changed.

The result is frameshift, later amino acids mostly changed.

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Practice questions

1 **A substitution changes one base in a codon from CAA to CAG. What happens to the protein, and why?**

- **A** The protein changes, because every base change changes the amino acid
- **B** The protein stays the same, because CAA and CAG both call glutamine
- **C** The protein is cut short, because CAG is a stop codon
- **D** The protein stays the same, because the gene is no longer read

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2 A substitution changes one base in a codon, and the new codon still calls the same amino acid. What happens to the protein?

- **A** The protein stays the same.
- **B** The protein changes.
- **C** The protein is cut short.
- **D** The protein doubles.

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3 An insertion adds three bases in the middle of a gene. What happens to the reading frame and the protein?

- **A** The reading frame shifts, so later amino acids mostly change
- **B** The gene is cut short at the insertion
- **C** The reading frame stays in step, so one extra amino acid is added
- **D** The protein is unchanged

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4 A deletion removes one base early in a gene. What happens to the reading frame and the protein?

- **A** The reading frame shifts, so later amino acids mostly change
- **B** One amino acid changes and the rest stay the same
- **C** The protein is unchanged
- **D** The gene doubles in length

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5 What is a mutation?

- **A** A change in the cell wall
- **B** A change in the DNA sequence
- **C** A change in the ribosome
- **D** A change in the cytoplasm

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6 What is a substitution?

- A One base deleted
- B One base added
- C One base swapped for another
- D The whole gene doubled

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7 What is a frameshift?

- A A shift in the reading frame, caused by an insertion or deletion
- B A swap of one base for another
- C A change in the chromosome number
- D A doubling of the gene

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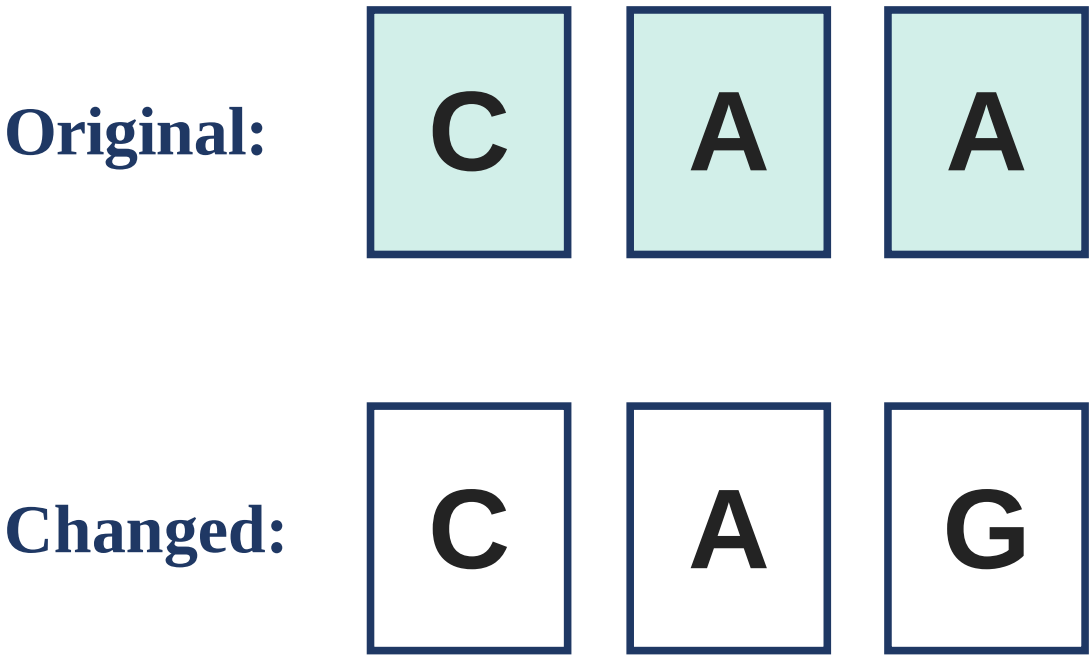
8 **Can a mutation be harmless? Give a reason. Use the codon-change diagram.**



A No, every mutation harms the protein

B Yes, if it deletes the whole gene

C No, mutations never change a protein

D Yes, if it does not change the amino acid

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9

Can a mutation ever be helpful?

A No, never

B Rarely, yes

C Yes, always

D Only in viruses

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10

A substitution changes a codon so it now calls a different amino acid. What happens to the protein?

A The protein stays the same.

B The protein is cut short.

C The whole protein is rebuilt.

D The protein changes at that position.

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ANSWER KEY

1. The protein stays the same, because CAA and CAG both call glutamine

2. The protein stays the same.

3. The reading frame stays in step, so one extra amino acid is added

4. The reading frame shifts, so later amino acids mostly change

5. A change in the DNA sequence

6. One base swapped for another

7. A shift in the reading frame, caused by an insertion or deletion

8. Yes, if it does not change the amino acid

9. Rarely, yes

10. The protein changes at that position.

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