

Mutations and Reading Frame

Decoding the mechanics of point and frameshift errors in DNA.

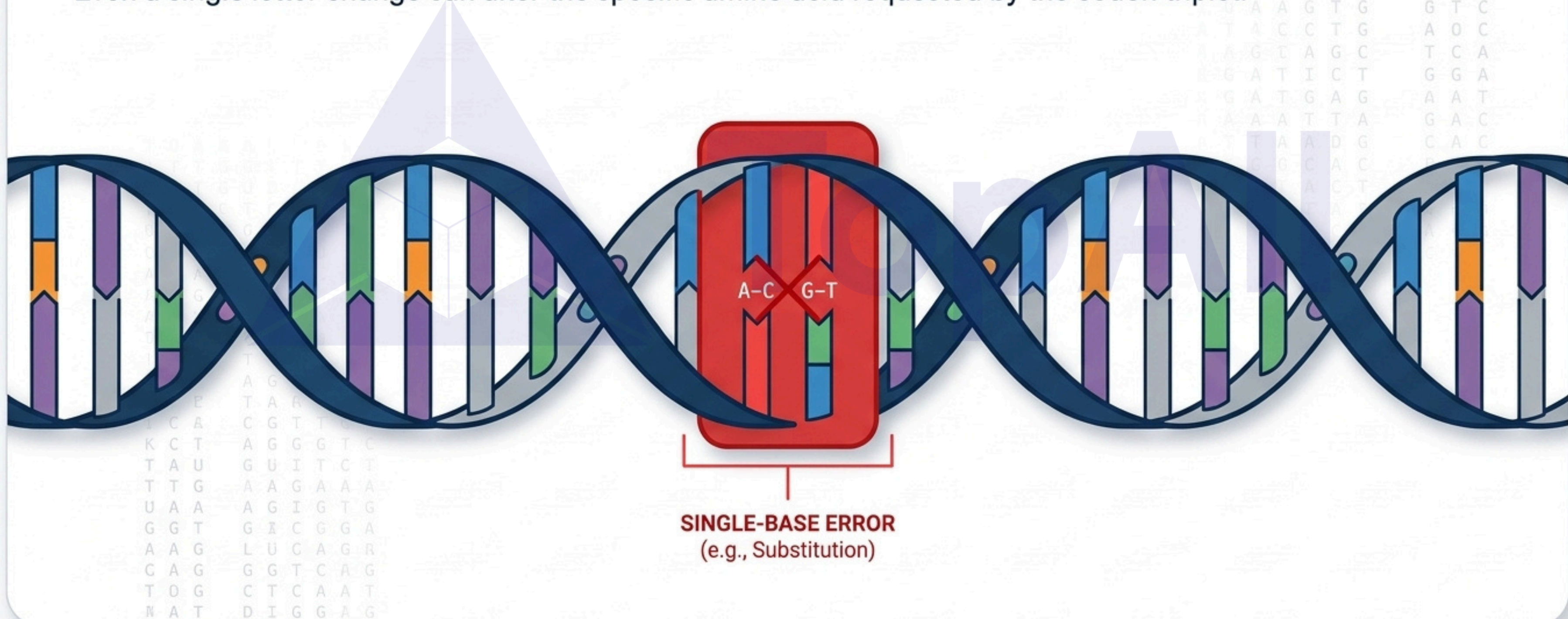
The Origin of Genetic Variation

Mutations alter the fundamental base sequence of DNA. Because the genetic code directs the synthesis of amino acids, a localized change in DNA can cascade into a structural change in the resulting protein.



Point Mutation: The Single-Base Error

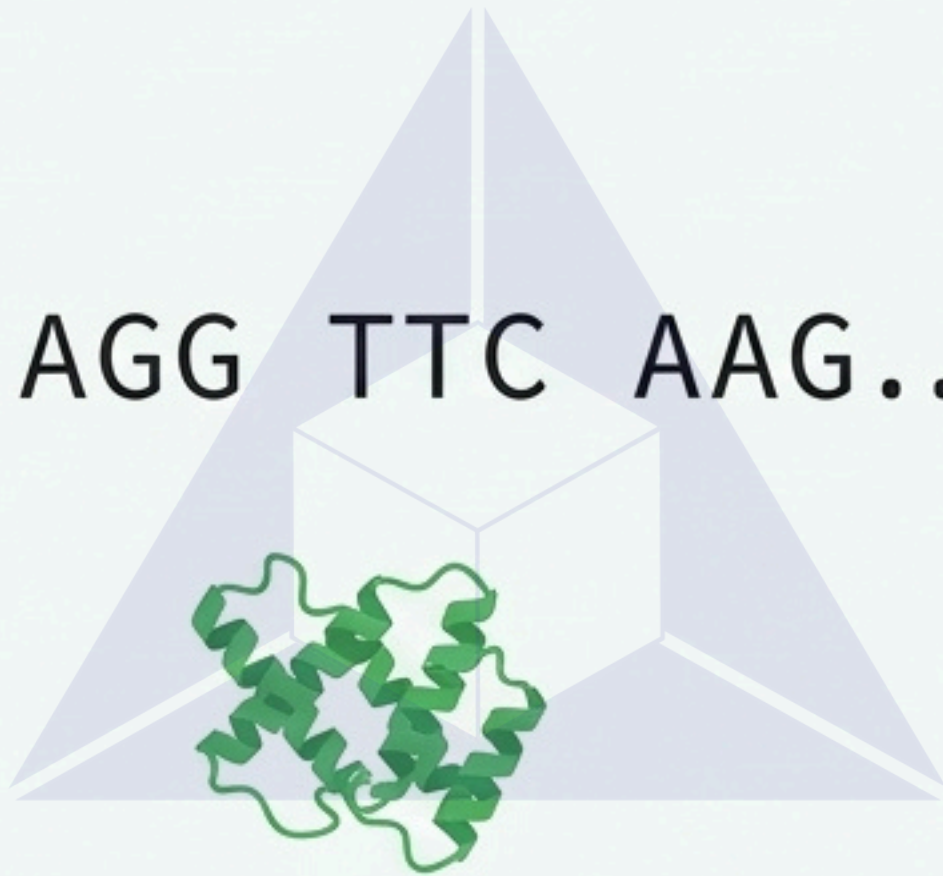
A point mutation is the substitution, insertion, or deletion of a single base pair in the structural gene. Even a single letter change can alter the specific amino acid requested by the codon triplet.



Cause & Effect

NORMAL STATE

GTC AGG TTC AAG...



Normal Gene → Glutamate

MUTATED STATE (POINT MUTATION)

GTC AGG **A**TC AAG...

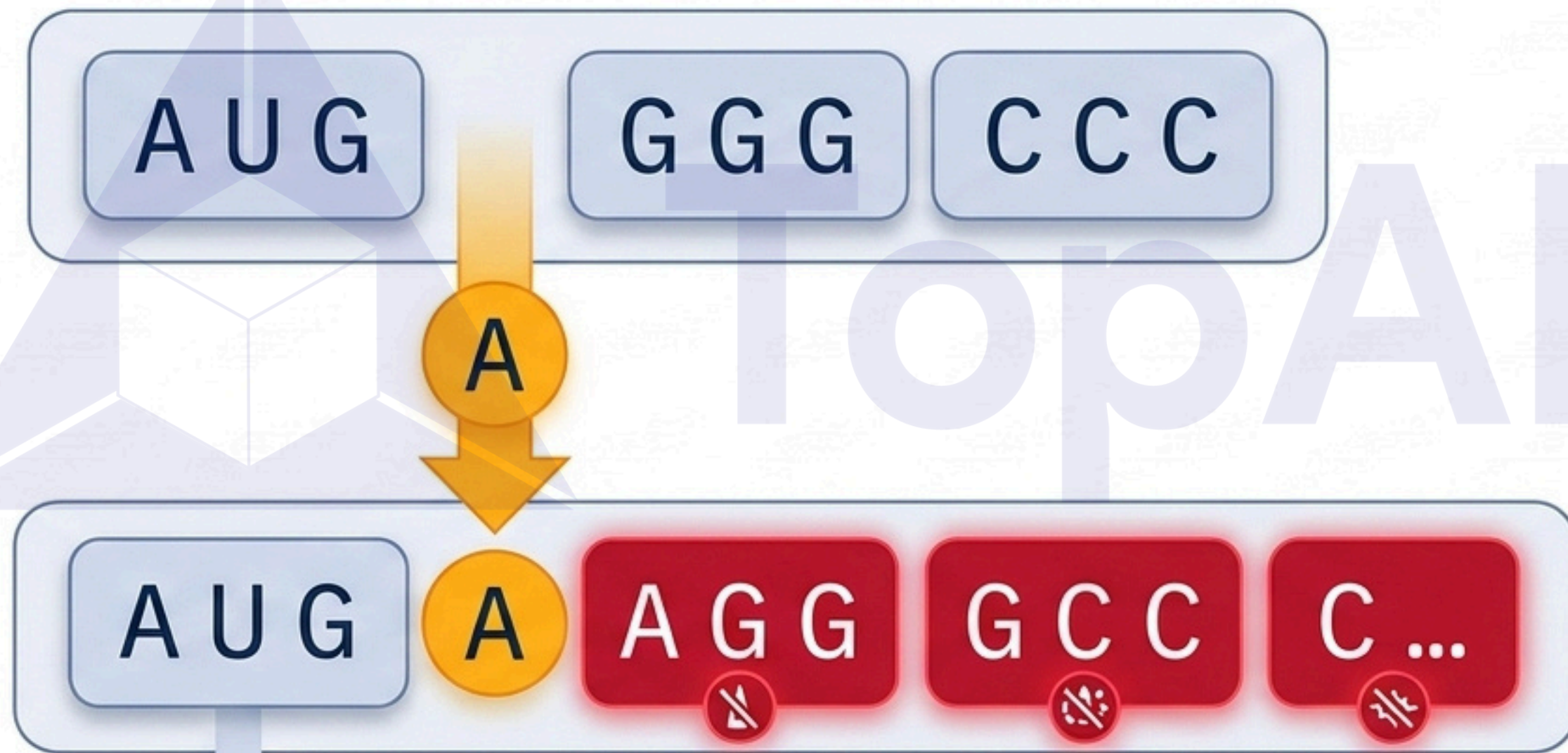


Point Mutation → Valine

Sickle-Cell Anaemia: A classic diseased condition caused entirely by a single base pair substitution in the beta-globin chain gene.

Frameshift Mutation: The Systemic Disruption

Unlike a substitution, inserting or deleting bases shifts the **entire reading frame of the sequence**, altering every single downstream codon.

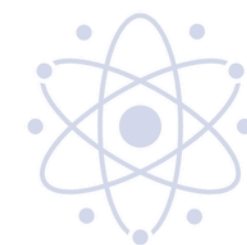


Resulting in a non-functional or harmful protein downstream.



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$$E=mc^2$$



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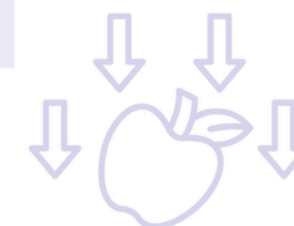
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The Triplet Mental Model

Consider a genetic sequence as a sentence made entirely of three-letter words. The **reading frame** reads **exactly three letters at a time**, with no **punctuation**.

RAM HAS RED CAP

Mechanical Progression of a Frameshift

+1 Insertion

Insert 1 Base ('B')
Reading frame shifts by one.

RAM HAS **B** RE **DCA** P

+2 Insertion

Insert 2 Bases ('BI')
Reading frame shifts by two.

RAM HAS **BI** R **EDC** AP

The +3 Restoration

Inserting exactly three letters creates a new word, but leaves the reading frame unaltered from that point onwards.

RAM HAS

BIG

RED

CAP

Deletion Follows the Same Rule

Deleting one or two bases corrupts the frame. Deleting three bases removes an entire codon, but saves the rest of the sequence.

Delete 1: RAM HAS **EDC** AP

Delete 2: RAM HAS **DCA** P

Delete 3: RAM HAS RED **CAP**

Point vs. Frameshift Disruptions

	Point Mutation	Frameshift Mutation
Mechanism	Substitution of 1 base	Insertion/Deletion of bases
Reading Frame Impact	Frame remains unaltered	Entire frame shifts from point of mutation
Downstream Effect	Single amino acid change (e.g., Sickle-cell)	Entire downstream sequence altered into gibberish

Key Takeaway

The Rule of Multiples

- Insertion or deletion of one or two bases results in a frameshift mutation.
- Insertion or deletion of three (or its multiples) adds or removes specific amino acids, but the reading frame remains functionally unaltered from that point onwards.



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