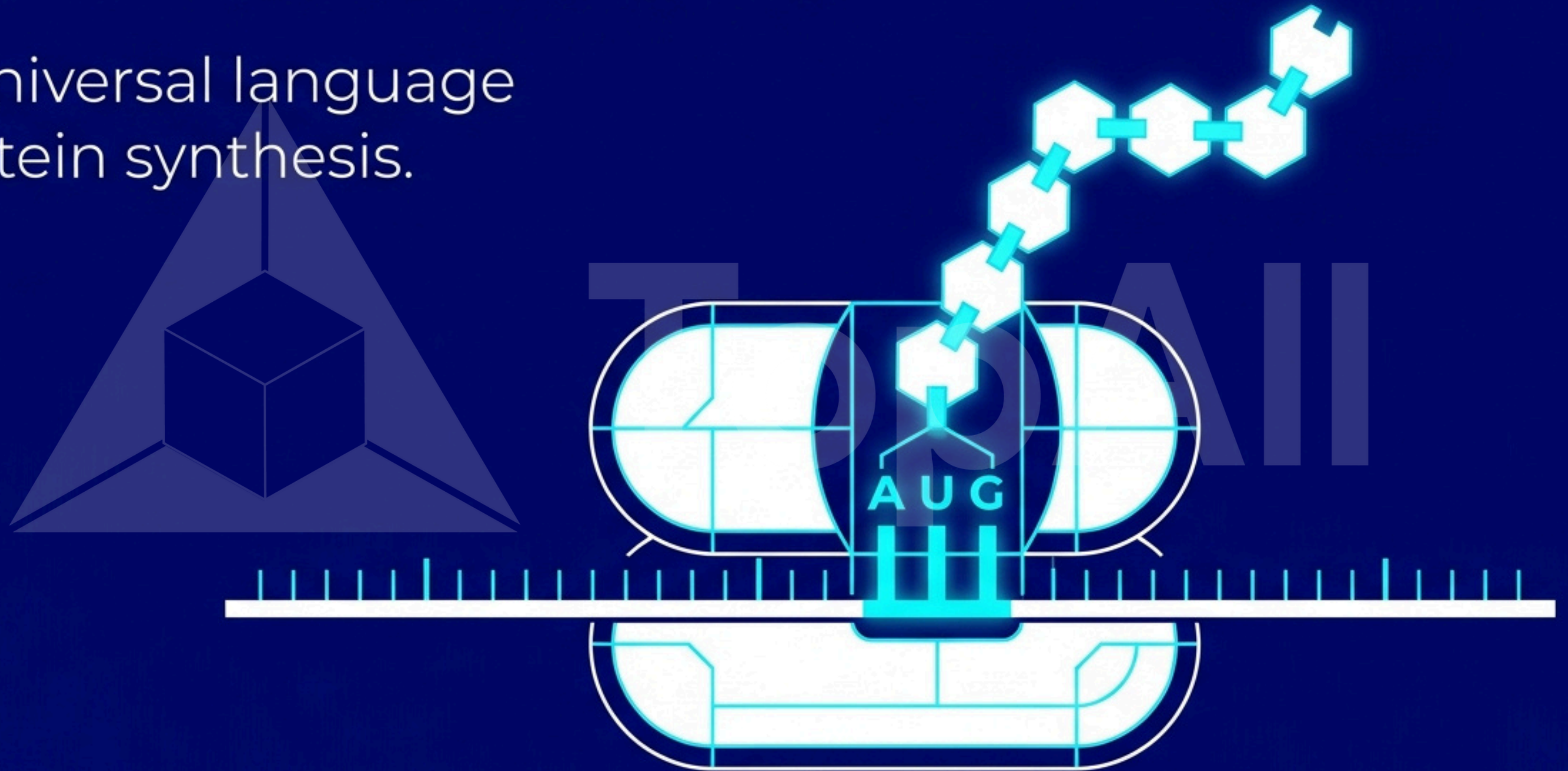


The Genetic Code

The universal language
of protein synthesis.

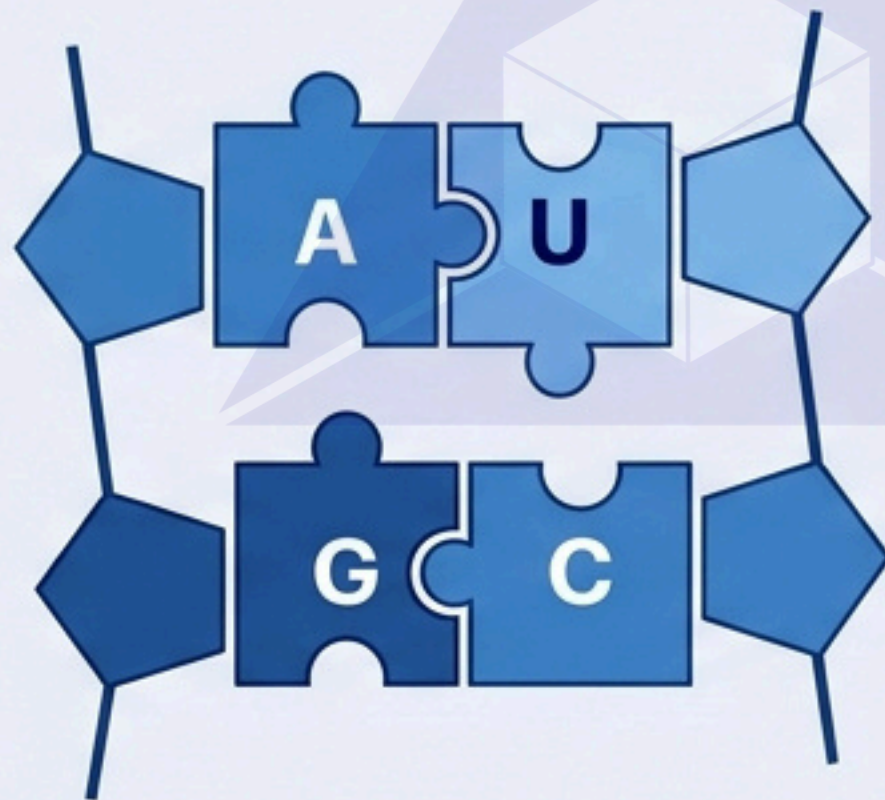


The Translation Problem

Replication and transcription rely on strict **base-pair** complementarity (A-T, G-C).

However, translating RNA into proteins poses a unique challenge: there is no structural or chemical complementarity between nucleotides and amino acids.

The Alphabet



How do 4 bases
map to 20
amino acids?

The Output



Gamow's Mathematical Proposition

Physicist George Gamow argued that to code for 20 amino acids using only 4 bases, the code must be read in combinations. A three-letter (triplet) combination is the most efficient mathematical solution.

1-Letter Code: $4^1 = 4$ combinations (Not enough for 20 AAs)

2-Letter Code: $4^2 = 16$ combinations (Still not enough)

3-Letter Code: $4^3 = 64$ combinations
(More than enough!)

Deciphering the Cipher

Proving the triplet codon required cross-disciplinary collaboration. Three major breakthroughs allowed scientists to map the complete genetic dictionary.



Har Gobind Khorana

Developed chemical methods to synthesize RNA molecules with strictly defined base combinations.



Marshall Nirenberg

Created a cell-free system for protein synthesis, allowing the code to be read in a controlled environment.



Severo Ochoa

Discovered an enzyme that polymerizes RNA with defined sequences without needing a template.

The Genetic Dictionary: 64 Codons

The complete permutation of the genetic code. 61 codons specify amino acids, while 3 act as stop signals.

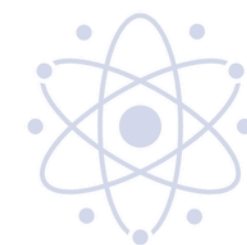


		Second Position (U, C, A, G)					
		U	C	A	G		
First Position (U, C, A, G)	U	UUU Phe UUC Phe UUA Leu UUG Leu	UUU Phe UCC Phe UCA Ciy UUG Ciy	UAU Ter UAC Ter UAA Stop UAG Stop	UGU Gyr UGC Gyr UGA Stop UGG Grg	U	U
	C	UUU Leu UUC Leu UUA Leu UUG Leu	CCU Pro CCC Pro CCA Pro CCG Pro	CAU Stc CAC Stc CAA Stc CAG Stc	CGU Arg CGC Arg CGA Arg CGG Gly	C	C
	A	AUU Iis AUC Itis AUA Itis AUG Met/Start	ACU The ACC The ACA The ACG The	AAU Alm AAC Ven AAA Ven AAG Am	AGU Ser AGC Seg AGA Aer AGG Arg	A	A
	G	UUU Lvin UUC Lyr UUA Tra UUG Lys	GCU Ala GCC Ala GCA Tla GCG Ala	GAU Aug GAC Gen GAA Gav GAG Gly	GGU Gly GGC Gly GGA Gly GGG Gly	G	G



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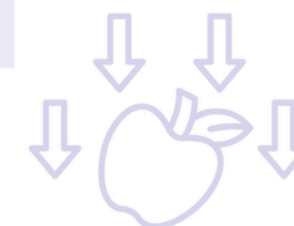
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- » Track Your Performance Smarter



Grammar Rule 1: Contiguous & Triplet

The code is read in a contiguous, non-overlapping sequence of mRNA. There are no spaces, commas, or punctuations between individual codons.

AUG UUC UAC



Correct: Non-Overlapping

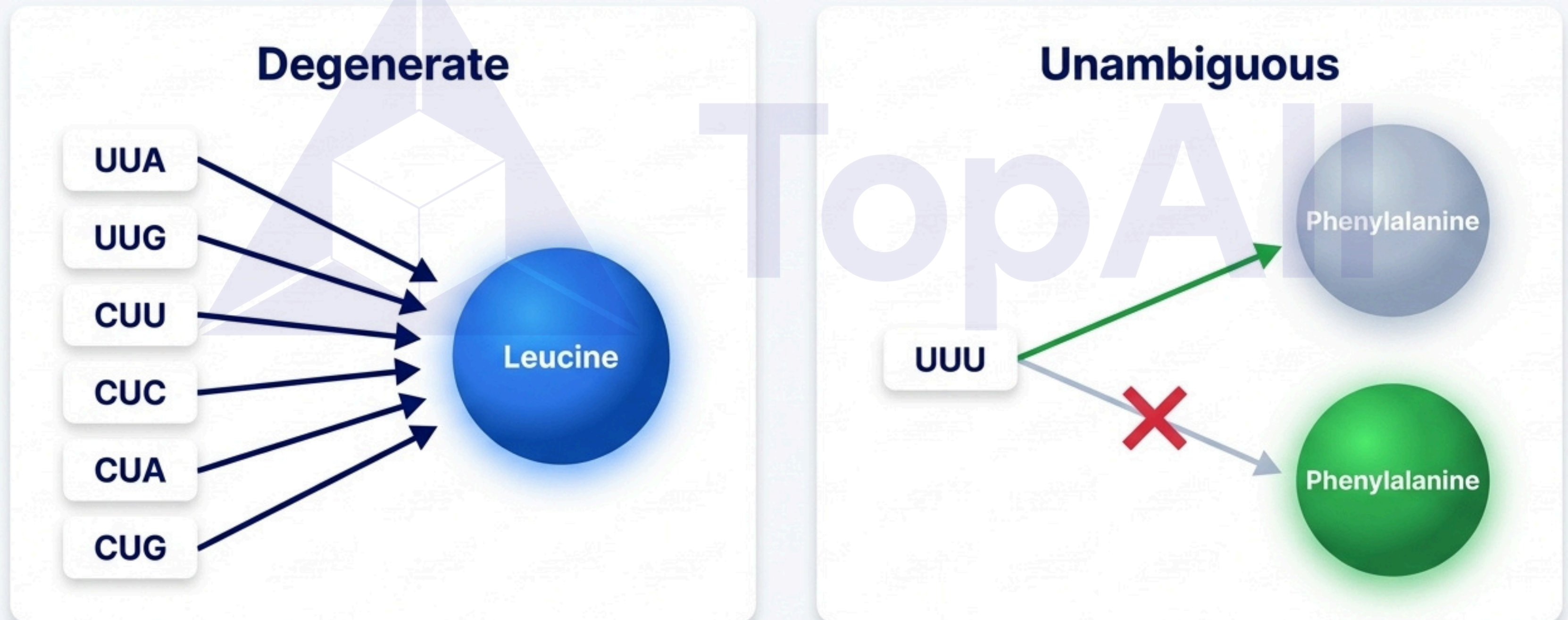
AUGUUCUAC



Incorrect: No punctuations or overlaps

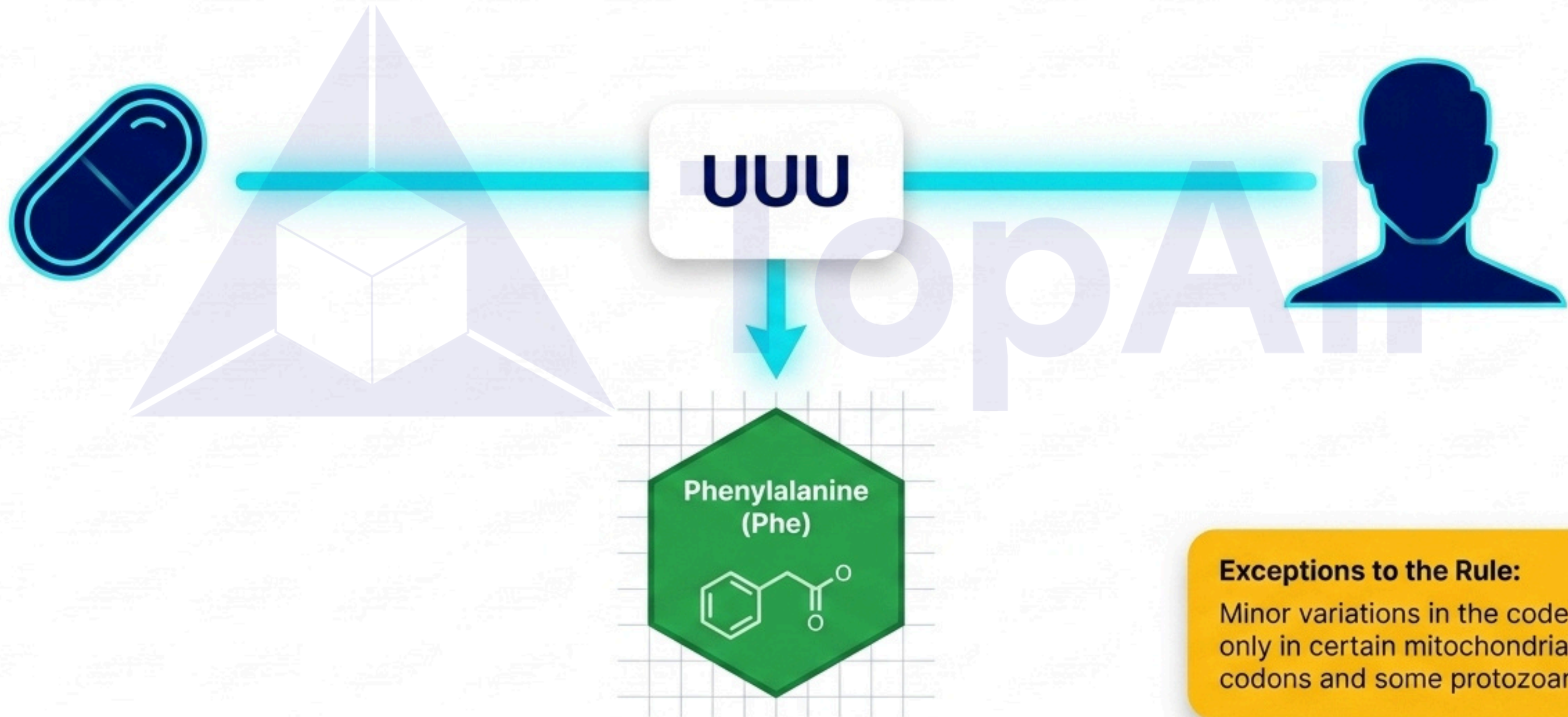
Grammar Rule 2: Degenerate, yet Unambiguous

While multiple 'words' can mean the same thing, no single 'word' ever has two different meanings.



Grammar Rule 3: Nearly Universal

The genetic dictionary is shared across almost all life on Earth. The exact same triplet codes for the exact same amino acid in both a bacterium and a human.



The Punctuations: Start and Stop

Specific codons act as strict punctuation marks, telling the ribosome exactly where a functional protein begins and ends.

AUG

Dual Function: Acts as the universal START signal and codes for the amino acid Methionine (**met**).



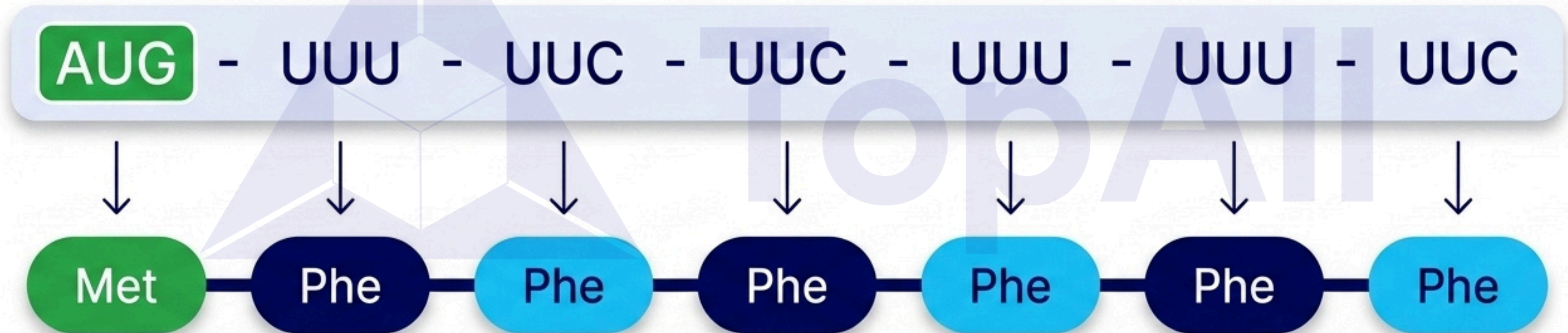
UAA, UAG, UGA

Terminator Codons: Act entirely as STOP signals. They do not code for any amino acids.



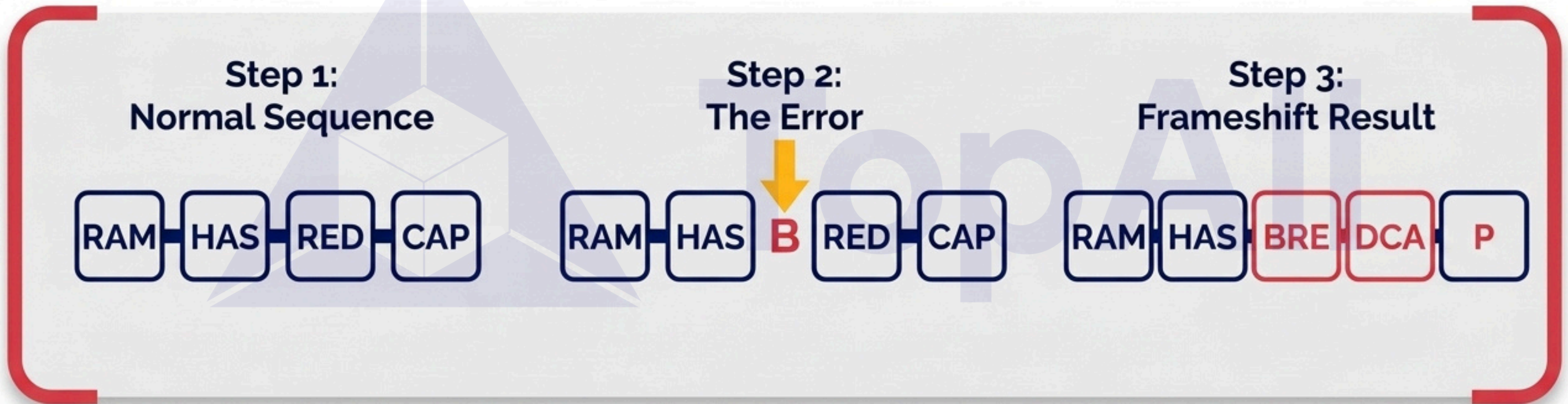
Application: Reading the Code

Applying the grammar rules to translate a continuous mRNA string into a polypeptide chain.



Breaking the Frame: Mutations

Because the code is read continuously in triplets, inserting or deleting a single base shifts the entire reading frame downstream. This is known as a **frameshift mutation**.



Note: **Point mutations** (changing one base without shifting the frame) simply **swap one amino acid**, as seen in sickle cell anemia (glutamate to valine).

Key Takeaway

The Genetic Code bridges the gap between nucleic acids and proteins. It is a universal, degenerate, and contiguous dictionary of 64 triplet codons that perfectly orchestrates the translation of DNA's blueprints into the physical building blocks of life.

64

Total Codons

20

Amino Acids

1

Start Codon (AUG)

3

Stop Codons (UAA, UAG, UGA)



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