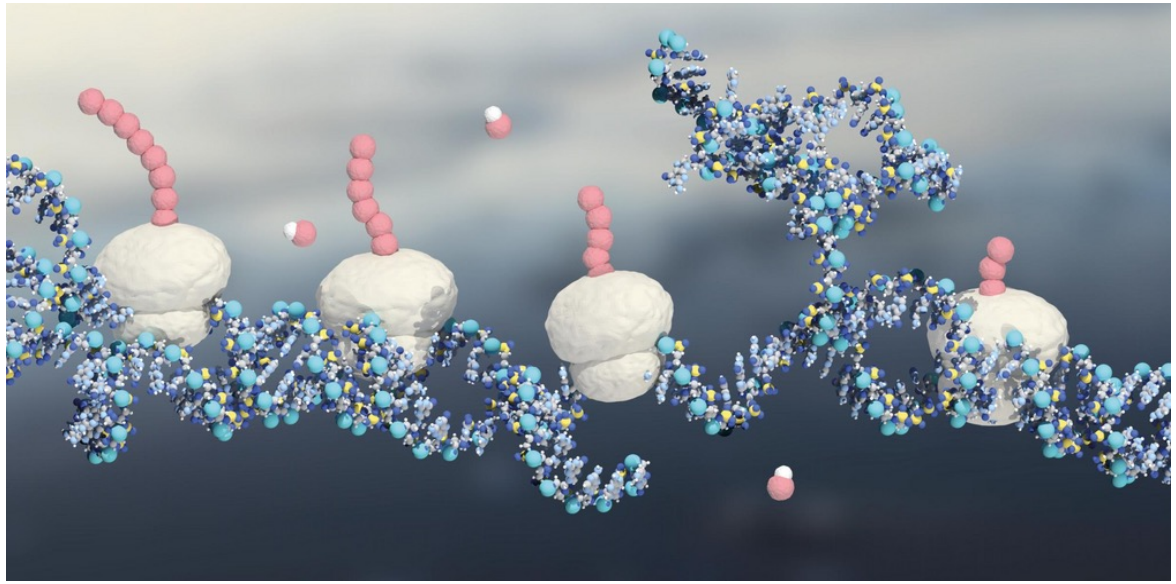
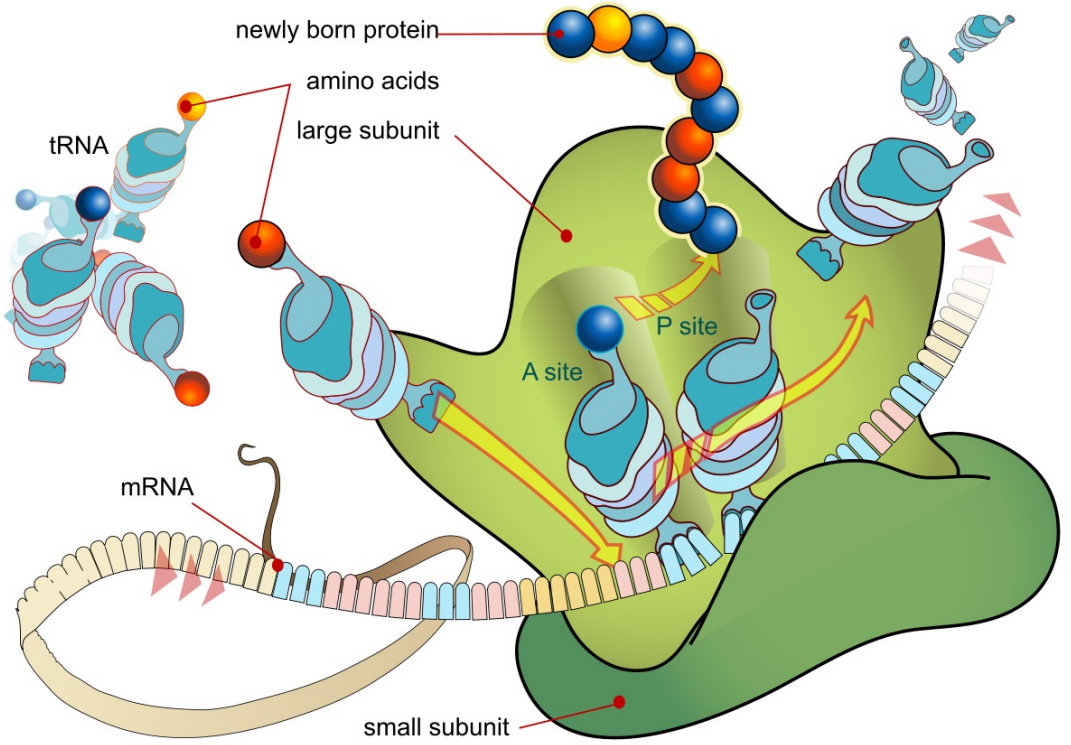
Lesson 12
RNA translation (protein synthesis)



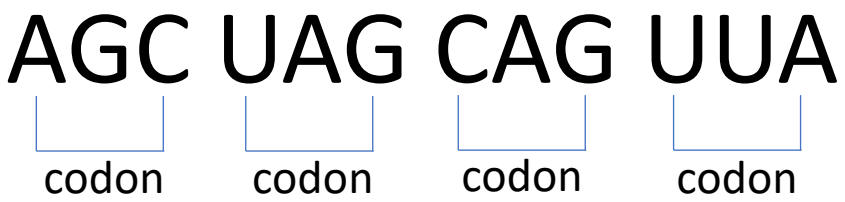
RNA translation

- **RNA translation** is a process that produces a **protein** from an mRNA template via the **genetic code**
- There is a change of language
  - From the language of nucleic acids (nucleotides) to the language of proteins (amino acids)
- The process takes place in the cytoplasm
- Requires another RNA, called **tRNA**
- Protein synthesis is operated by cell organelle called **ribosome**



The genetic code

- The **genetic code** = **triplets of RNA bases** (called **codons**)



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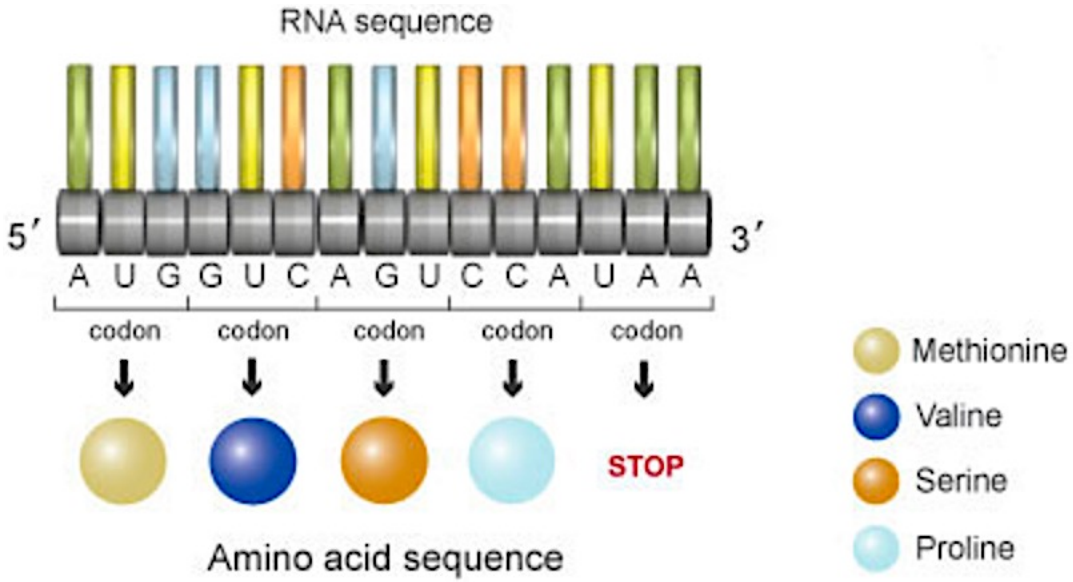
- **Each codon** encodes **1 amino acid**



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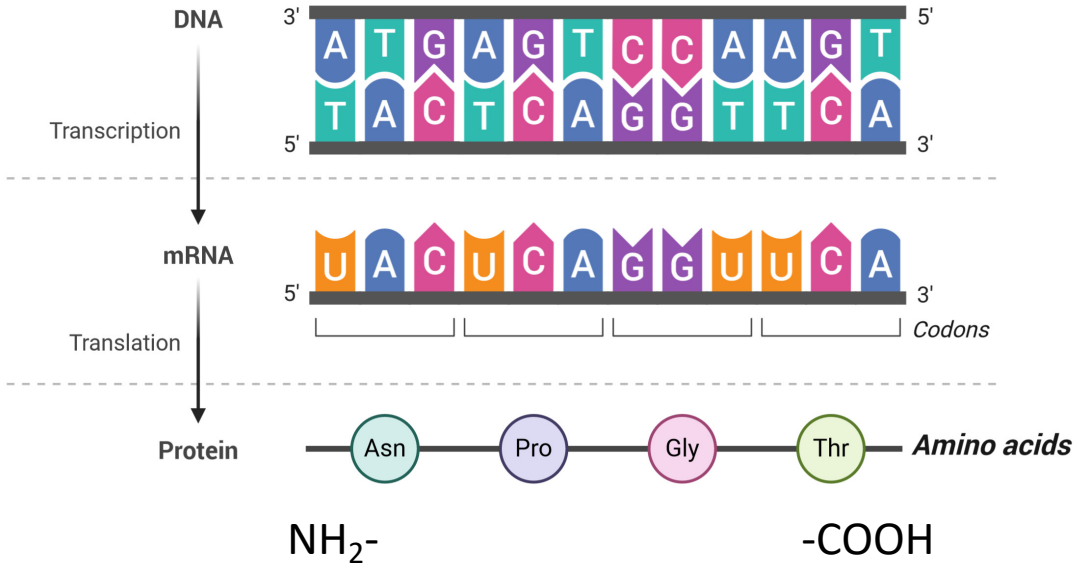
- mRNA is read from 5’ to 3’
- The protein is made from the -NH_2 end to the COOH end
  - Each new amino acid is added to the C end of the preceding one (discussed in Lesson 3)



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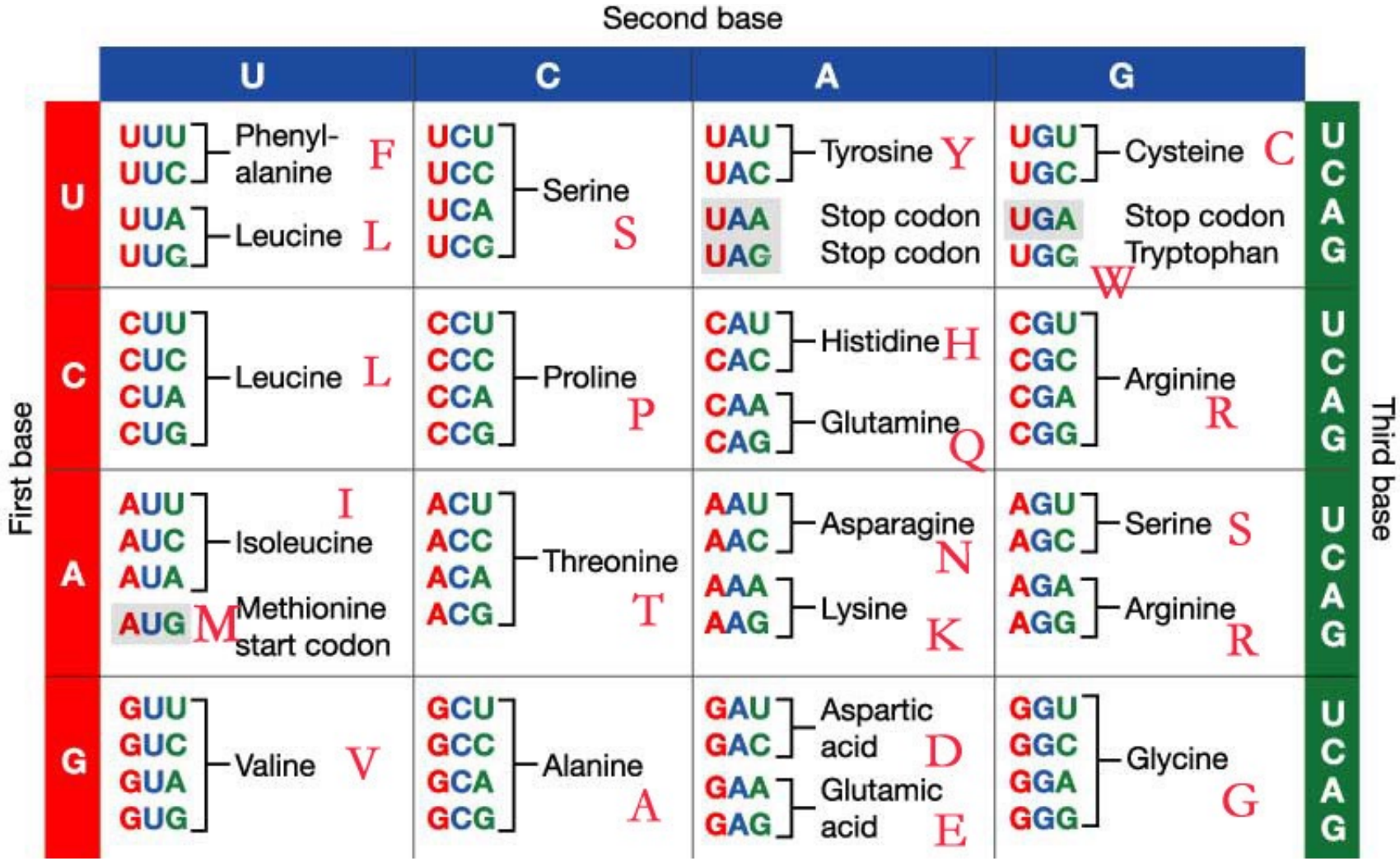

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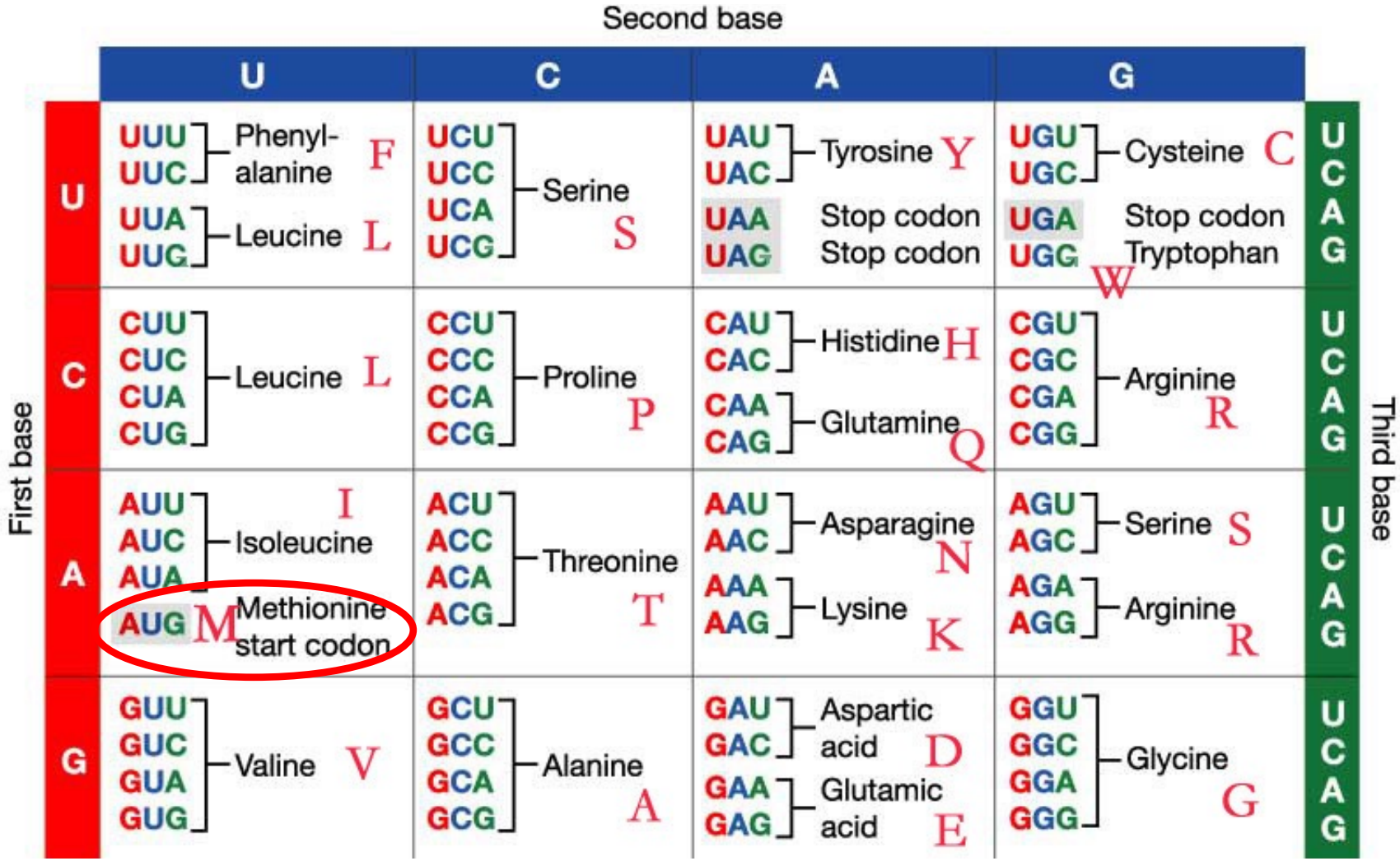

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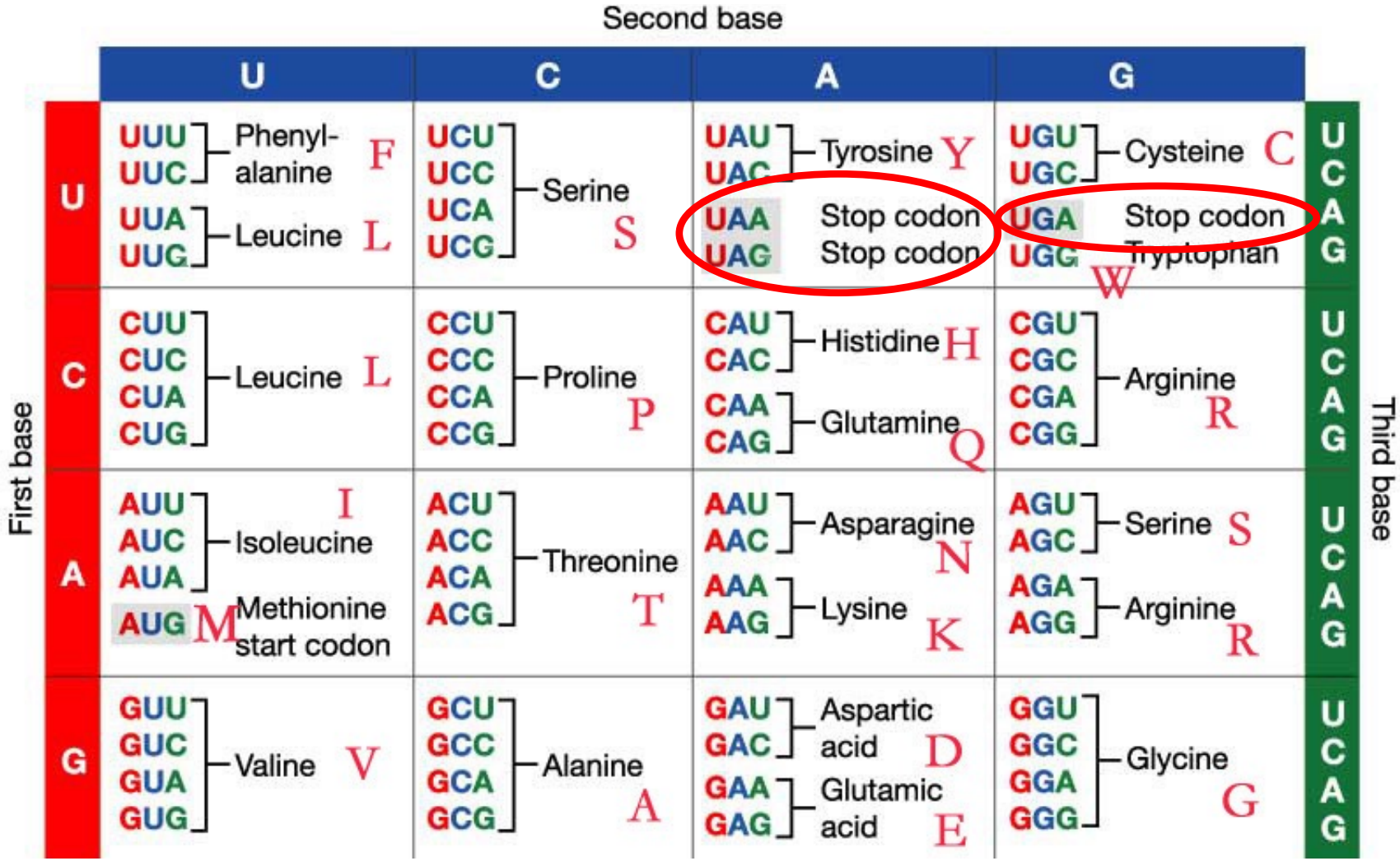

t-RNA

- In any case of unknown language change you need someone who understand both languages → interpreter
- In RNA translation you need an interpreter to translate CODONS into AMINOACIDS
- These interpreters are the **tRNAs** (small RNAs present throughout living cells)
- Each tRNA has a sequence called **ANTICODON** that base-pairs with a specific codon on a mRNA
- Each tRNA base-pairs with 1 mRNA codon a time

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- After codon-anticodon matching, the **tRNAs covalently binds the correct amino acid** and carries it to the ribosome for the protein synthesis

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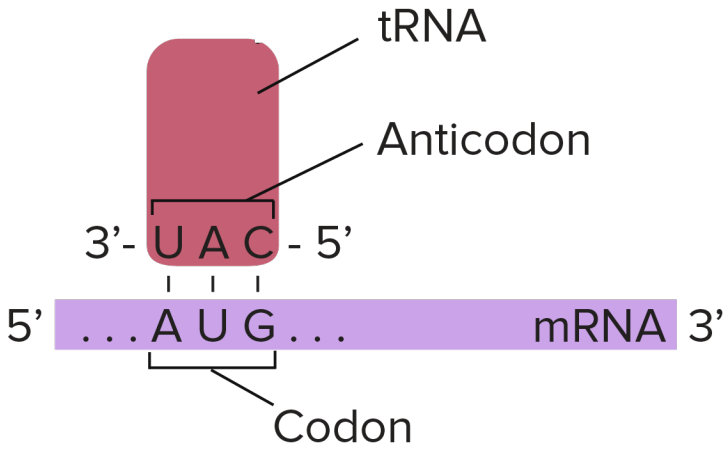

- After codon-anticodon matching, the tRNA covalently binds the correct amino acid and carries it to the ribosome for the protein synthesis

- For example: the mRNA codon 5'AUG3' encodes for the amino acid methionine, then:
  1. the particular tRNA that has the anticodon 3'UAC5' base-pairs with this codon

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- These interpreters are the tRNAs (small RNAs present throughout living cells)
- Each tRNA has a sequence called ANTICODON that base-pairs with a specific codon on a mRNA
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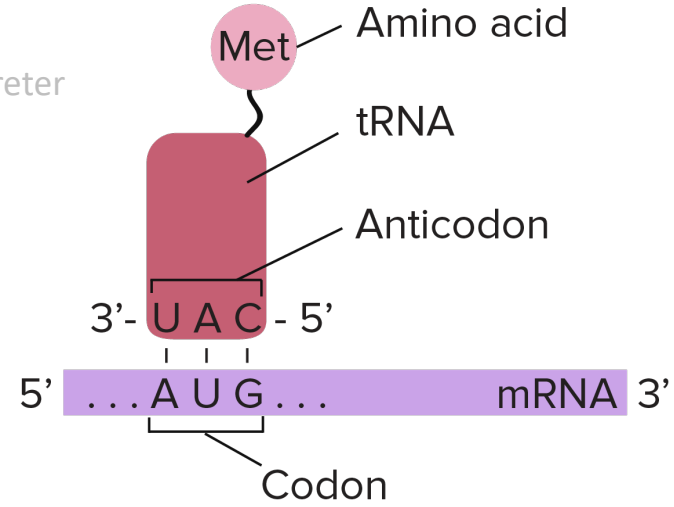


- After codon-anticodon matching, the tRNA covalently binds the correct amino acid and carries it to the ribosome for the protein synthesis
- For example: the mRNA codon 5'AUG3' encodes for the amino acid methionine, then:
  1. the particular tRNA that has the anticodon 3'UAC5' base-pairs with this codon
  2. It then covalently binds the amino acid Metionine ($tRNA^{MET}$)
  3. It finally shuttles to the ribosome where the amino acid will be released and added to the growing protein

t-RNA

- In any case of language change you need someone who understand both languages → interpreter
- In RNA translation you need an interpreter to translate CODONS into AMINOACIDS
- This interpreter is the tRNA (a small RNA present throughout living cells)
- A tRNA has a sequence called ANTICODON that base-pairs with a specific codon on a mRNA
- For example:

mRNA codon 5'AUG3'

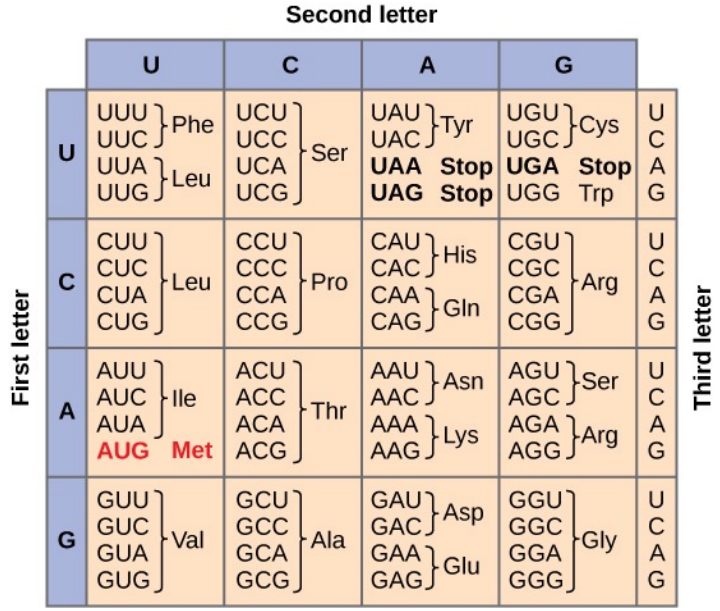
tRNA anticodon 3'UAC5'

- Each tRNAs carries the correct amino acid at the right moment to the ribosome for the protein synthesis
- For example: the mRNA codon 5'AUG3' encodes for the amino acid methionine, then:
  1. the particular tRNA that has the anticodon 3'UAC5' base-pairs with this codon
  2. It then covalently binds the amino acid Metionine ($tRNA^{MET}$)
  3. It finally shuttles to the ribosome where the amino acid will be released and added to the growing protein
- First codon = START codon
- Always 5'AUG3' codon = start codon for N-terminus Met

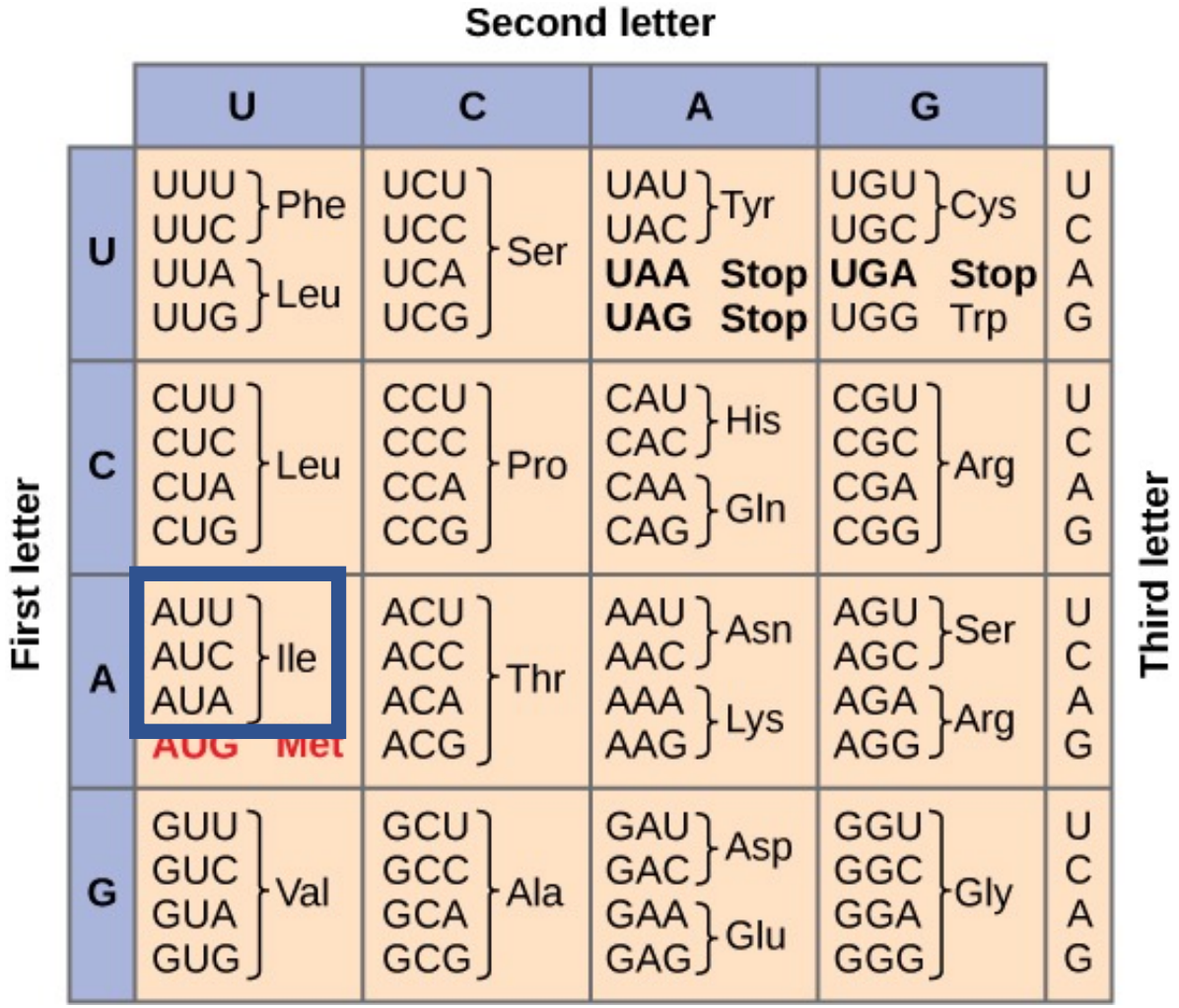
From mRNA to protein

1. Read mRNA sequence: 5’AUGAAAACU……3’
2. Identify codons: 5’AUG/AAA/ACU/……3’
3. Match codons with amino acids
   - AUG → Met (M)
   - AAA → Lys (K)
   - ACU → Thr (T)
   - …….
4. Continue until you find the stop codon (UAA or UAG or UGA)

Note: stop codons do not code for any amino acid; they just stop translation

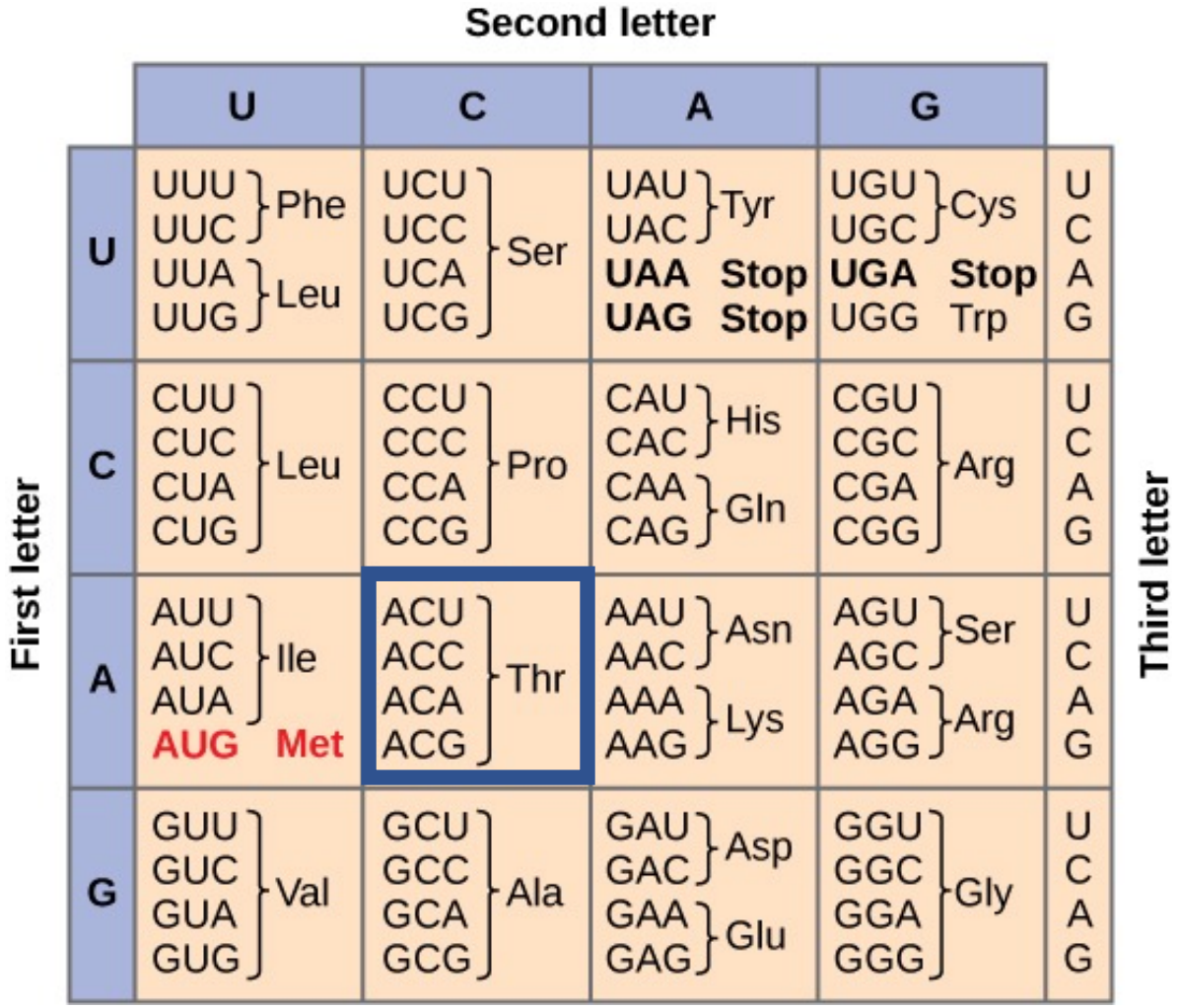


The genetic code again



First letter	Second letter: U	Second letter: C	Second letter: A	Second letter: G	Third letter
U	UUU, UUC: Phe; UUA, UUG: Leu	UCU, UCC, UCA, UCG: Ser	UAU, UAC: Tyr; **UAA Stop**; **UAG Stop**	UGU, UGC: Cys; **UGA Stop**; UGG Trp	U C A G
C	CUU, CUC, CUA, CUG: Leu	CCU, CCC, CCA, CCG: Pro	CAU, CAC: His; CAA, CAG: Gln	CGU, CGC, CGA, CGG: Arg	U C A G
A	AUU, AUC, AUA: Ile; AUG Met	ACU, ACC, ACA, ACG: Thr	AAU, AAC: Asn; AAA, AAG: Lys	AGU, AGC: Ser; AGA, AGG: Arg	U C A G
G	GUU, GUC, GUA, GUG: Val	GCU, GCC, GCA, GCG: Ala	GAU, GAC: Asp; GAA, GAG: Glu	GGU, GGC, GGA, GGG: Gly	U C A G

The genetic code again



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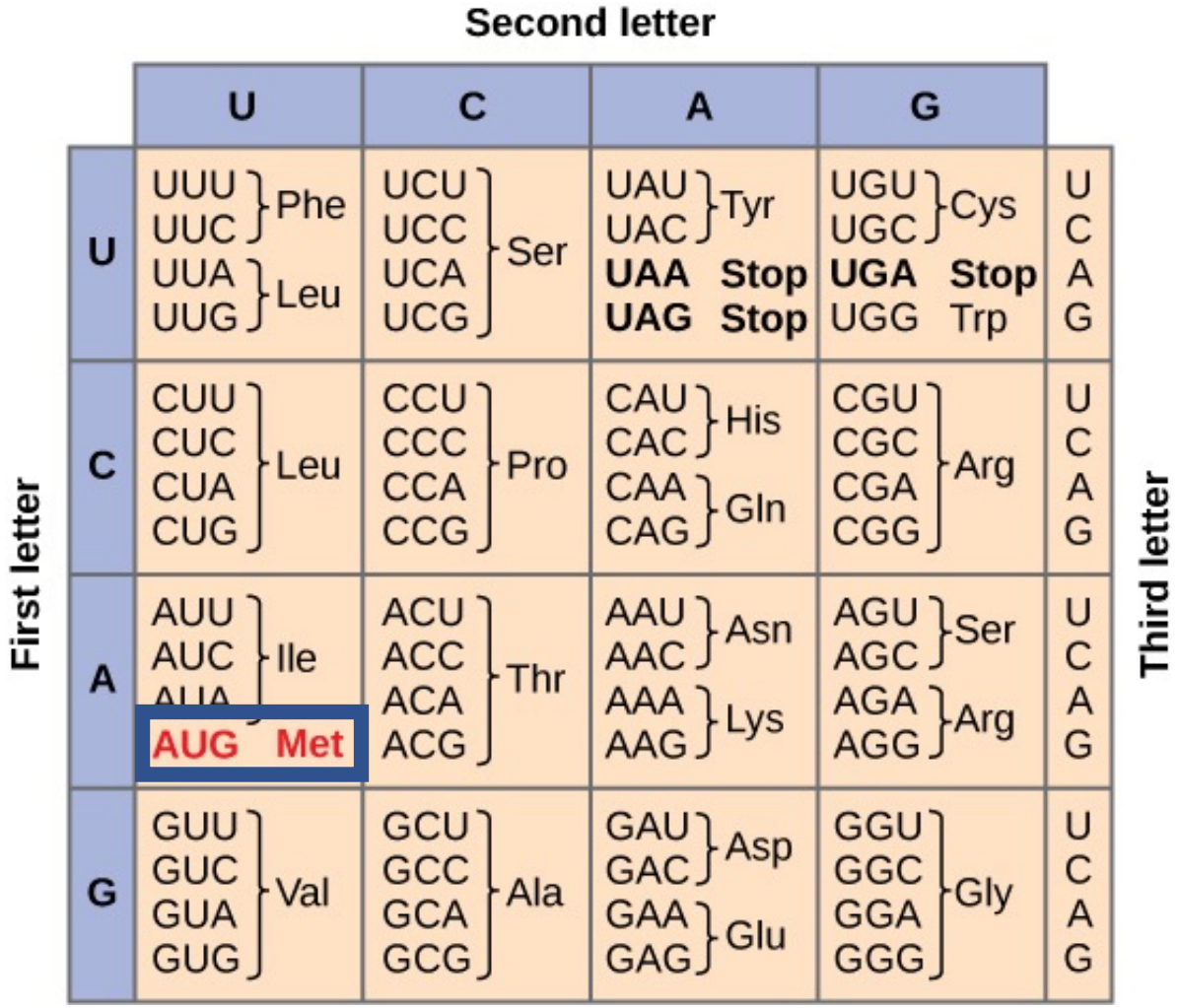

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A	AUU, AUC, AUA: Ile; **AUG Met**	ACU, ACC, ACA, ACG: Thr	AAU, AAC: Asn; AAA, AAG: Lys	AGU, AGC: Ser; AGA, AGG: Arg	U C A G
G	GUU, GUC, GUA, GUG: Val	GCU, GCC, GCA, GCG: Ala	GAU, GAC: Asp; GAA, GAG: Glu	GGU, GGC, GGA, GGG: Gly	U C A G

“Cracking” the genetic code

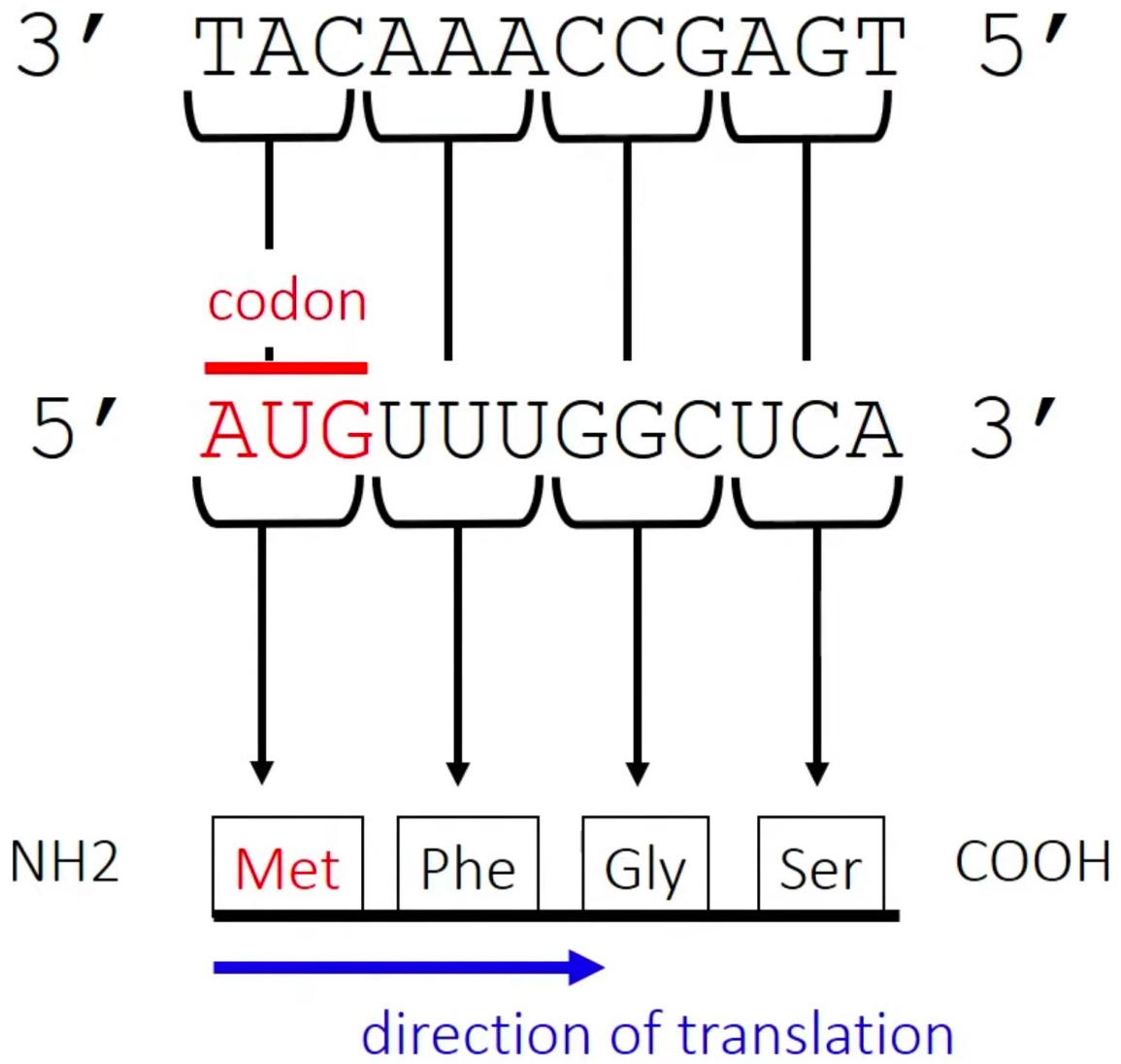
DNA template strand

transcription

mRNA

translation (via tRNA)

protein



tRNA - recap

- Each tRNA anticodon base-pairs with the corresponding mRNA codon
- Each tRNA binds the corresponding amino acid and delivers it to the ribosome
- The ribosome brings all amino acid together and join them covalently in the correct ordered sequence
- The tRNA is then released and can re-enter the translation loop when needed