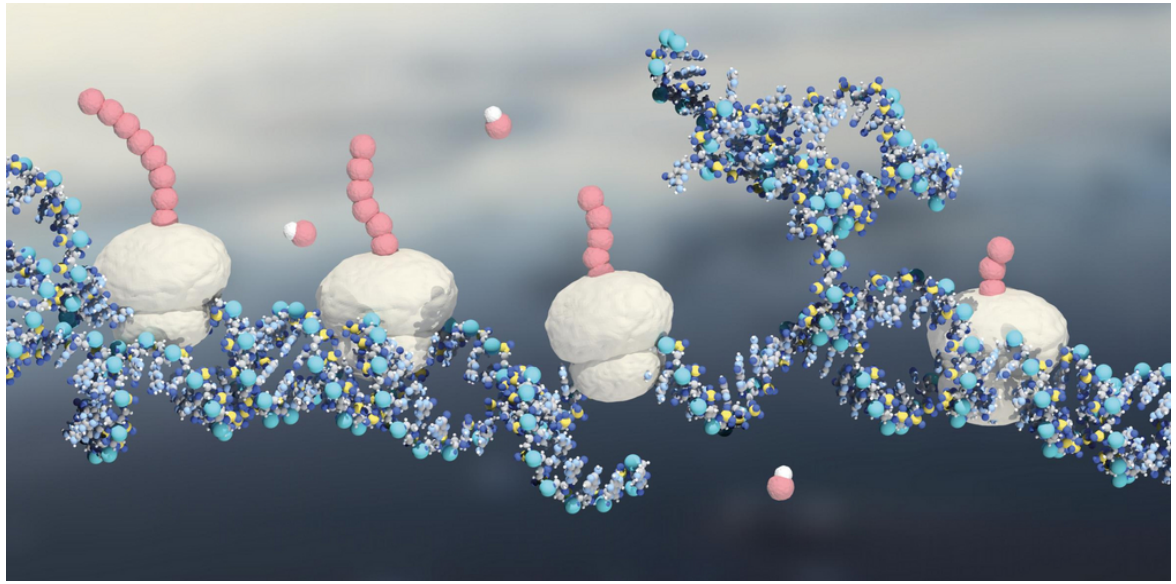
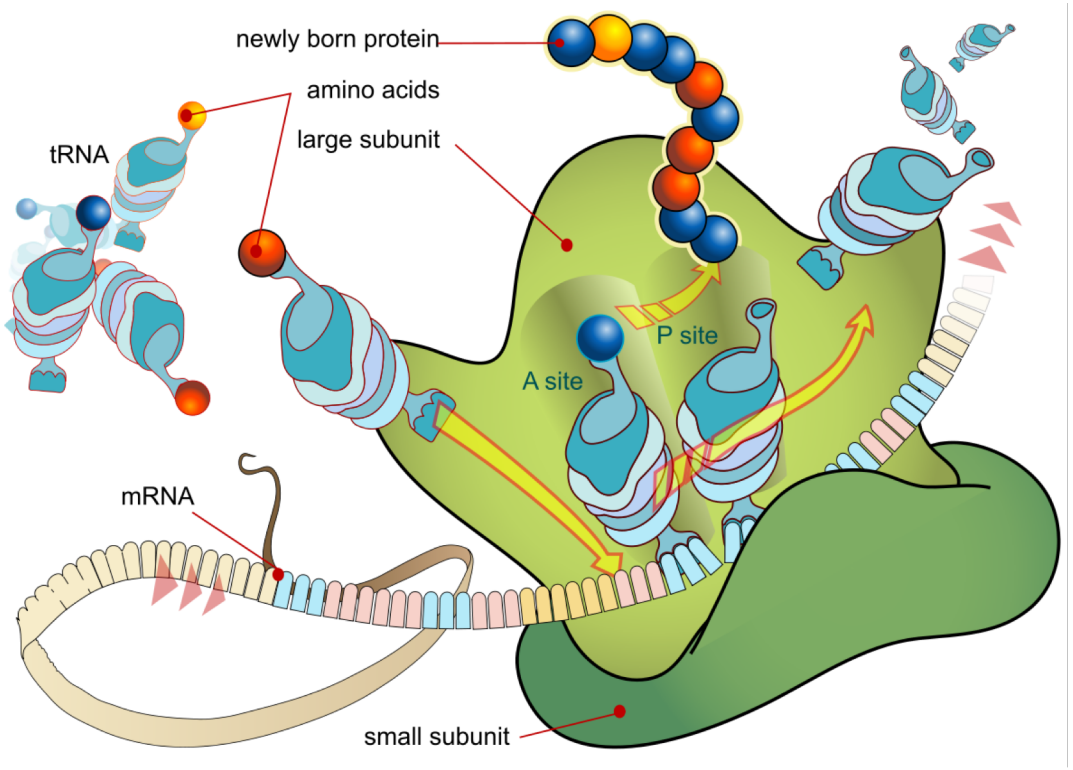
Lesson 12
RNA translation (protein synthesis)



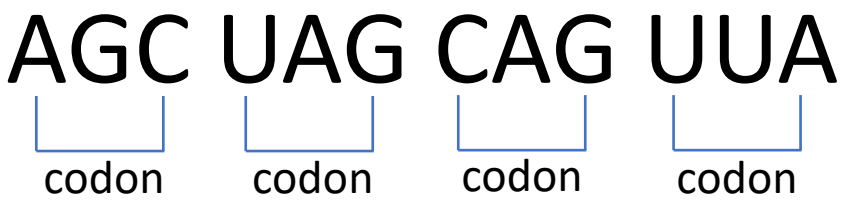
RNA translation

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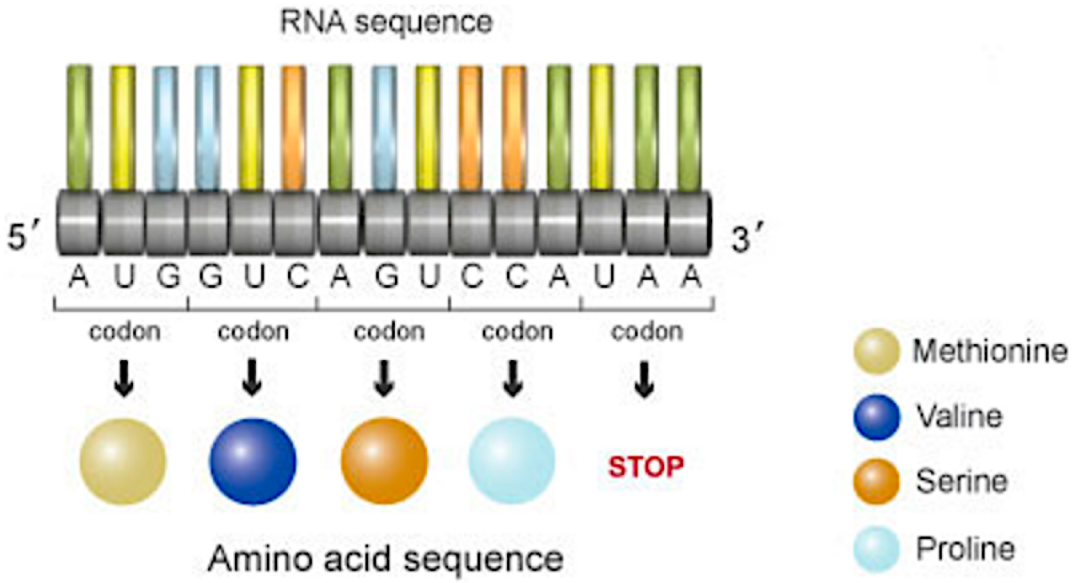
- **Each codon** encodes **1 amino acid**



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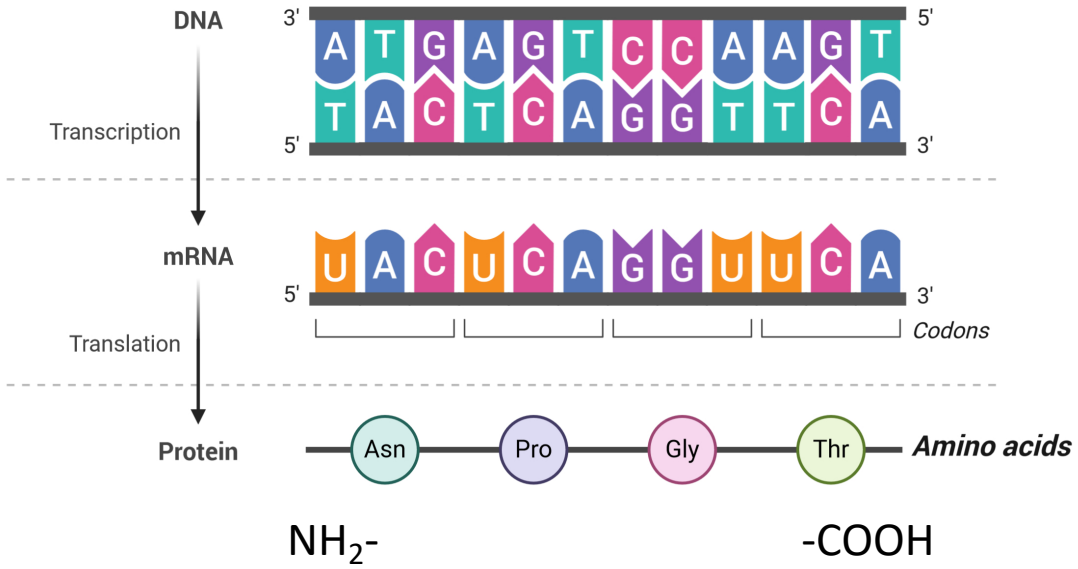
- mRNA is read from 5’ to 3’
- The protein is made from the -NH_2 end to the COOH end
  - Each new amino acid is added to the C end of the preceding one (discussed in Lesson 3)



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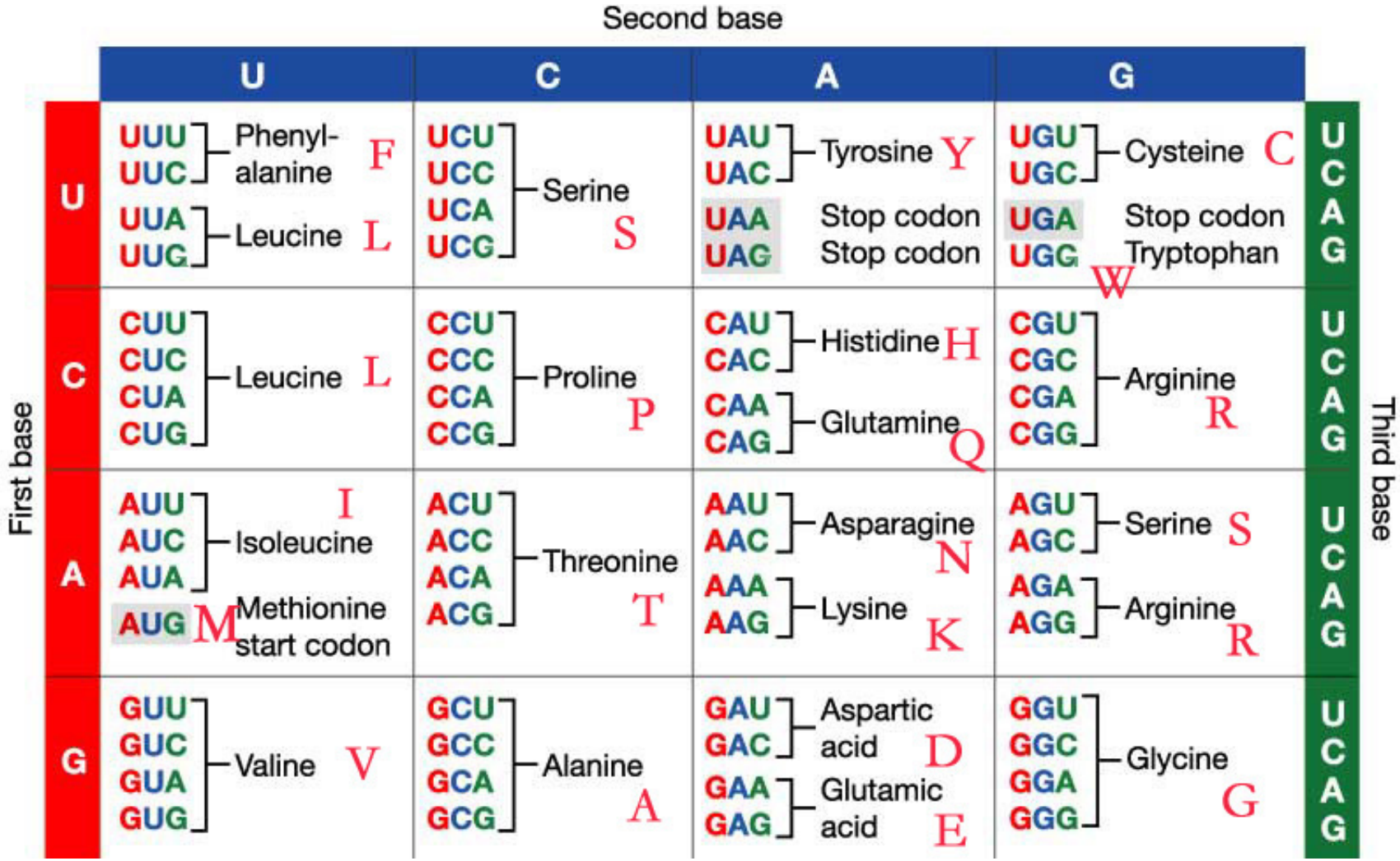

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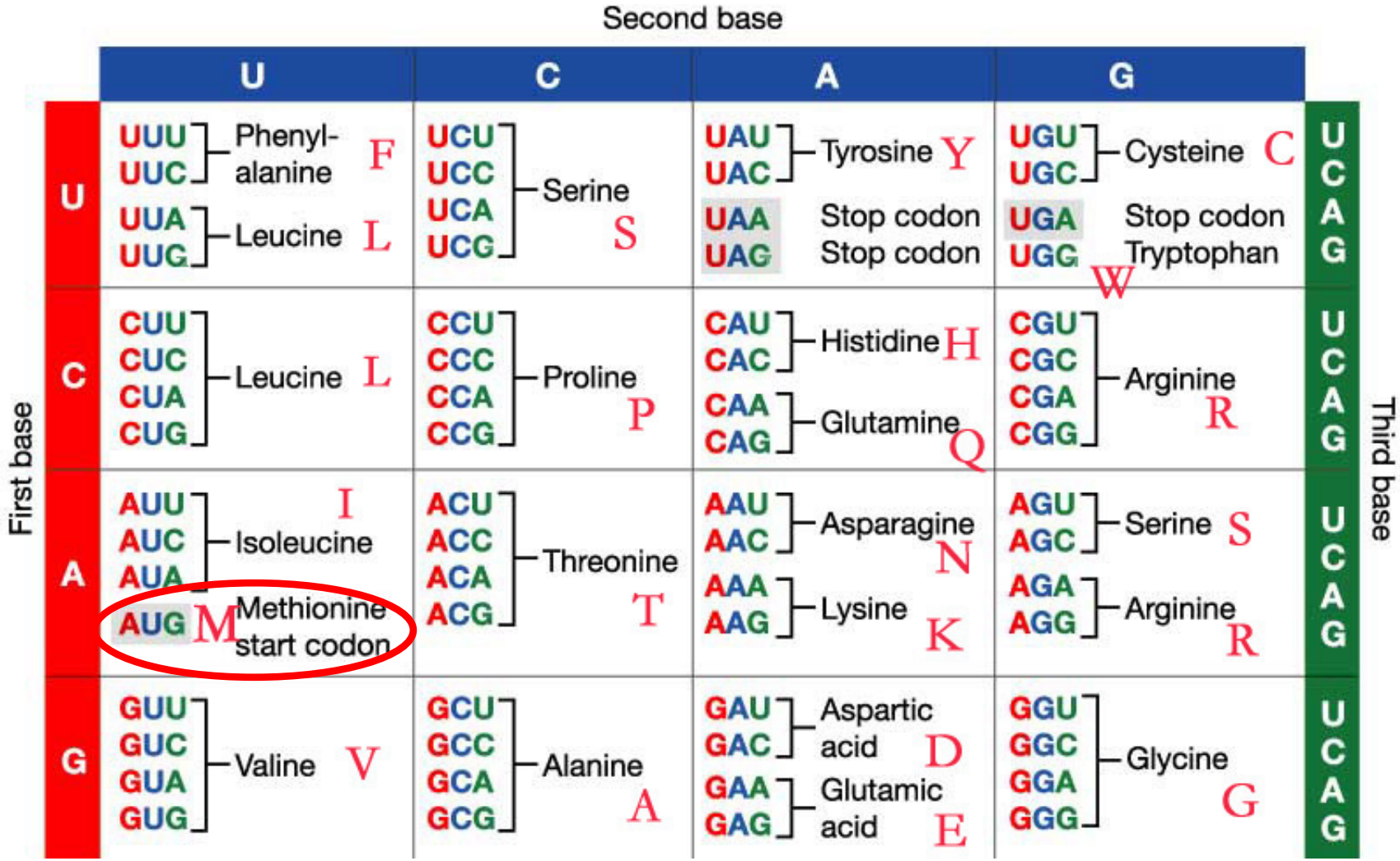

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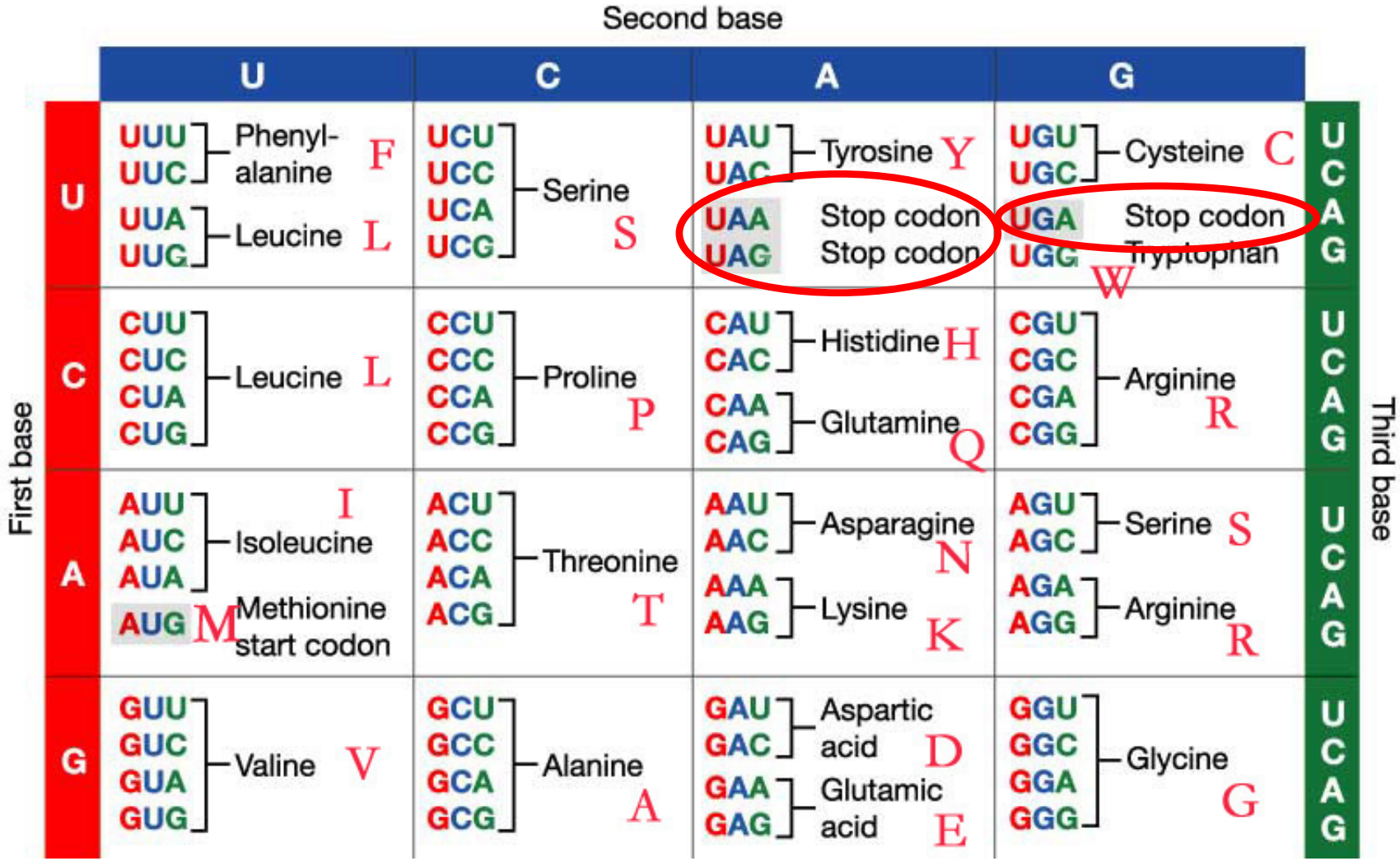

t-RNA

- 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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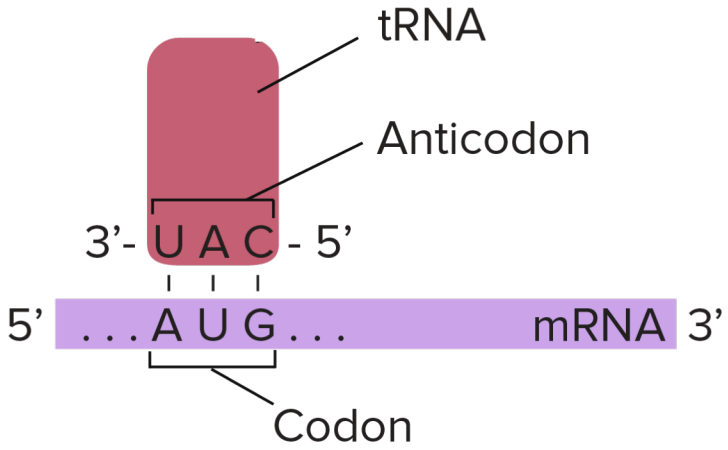

- After codon-anticodon matching, the tRNA covalently binds the correct amino acid and carries it to the ribosome for the protein synthesis

- 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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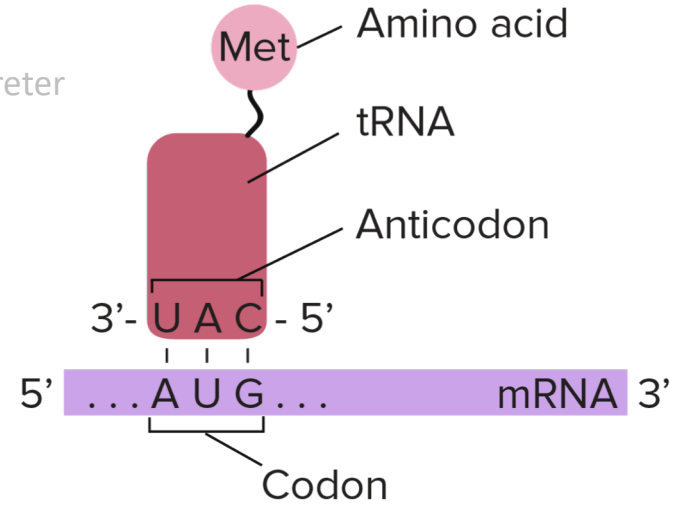


- After codon-anticodon matching, the tRNA covalently binds the correct amino acid and carries it to the ribosome for the protein synthesis
- For example: the mRNA codon 5'AUG3' encodes for the amino acid methionine, then:
  1. the particular tRNA that has the anticodon 3'UAC5' base-pairs with this codon
  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'

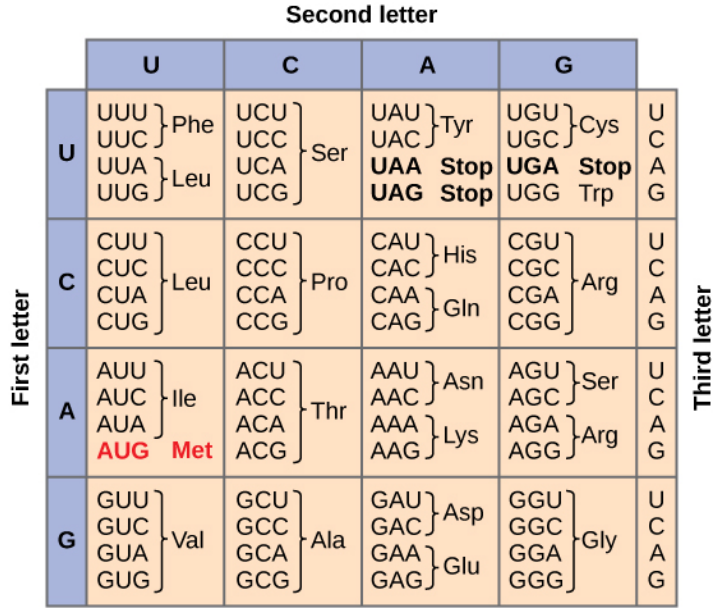
tRNA anticodon 3'UAC5'

- 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

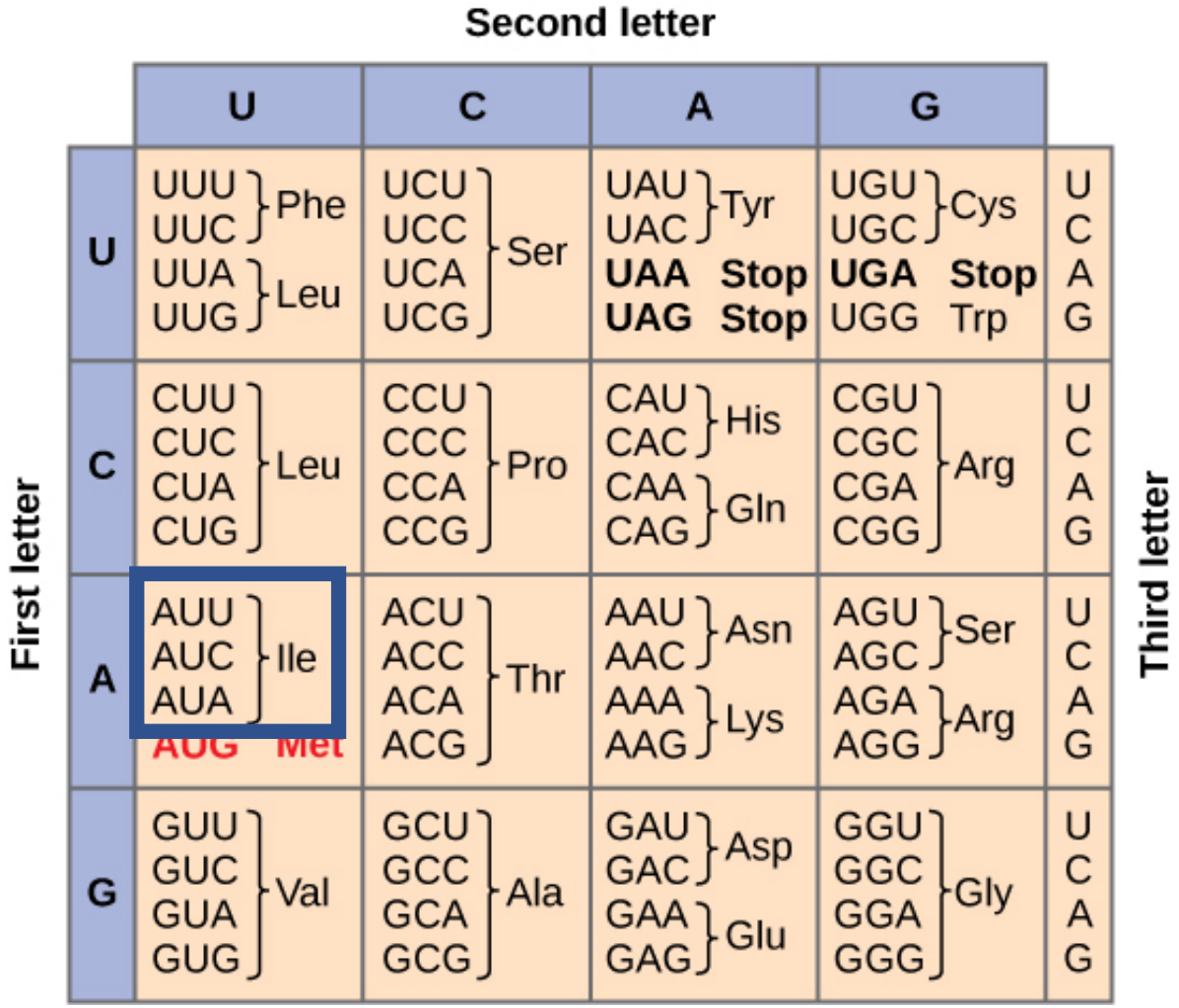
From mRNA to protein

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)

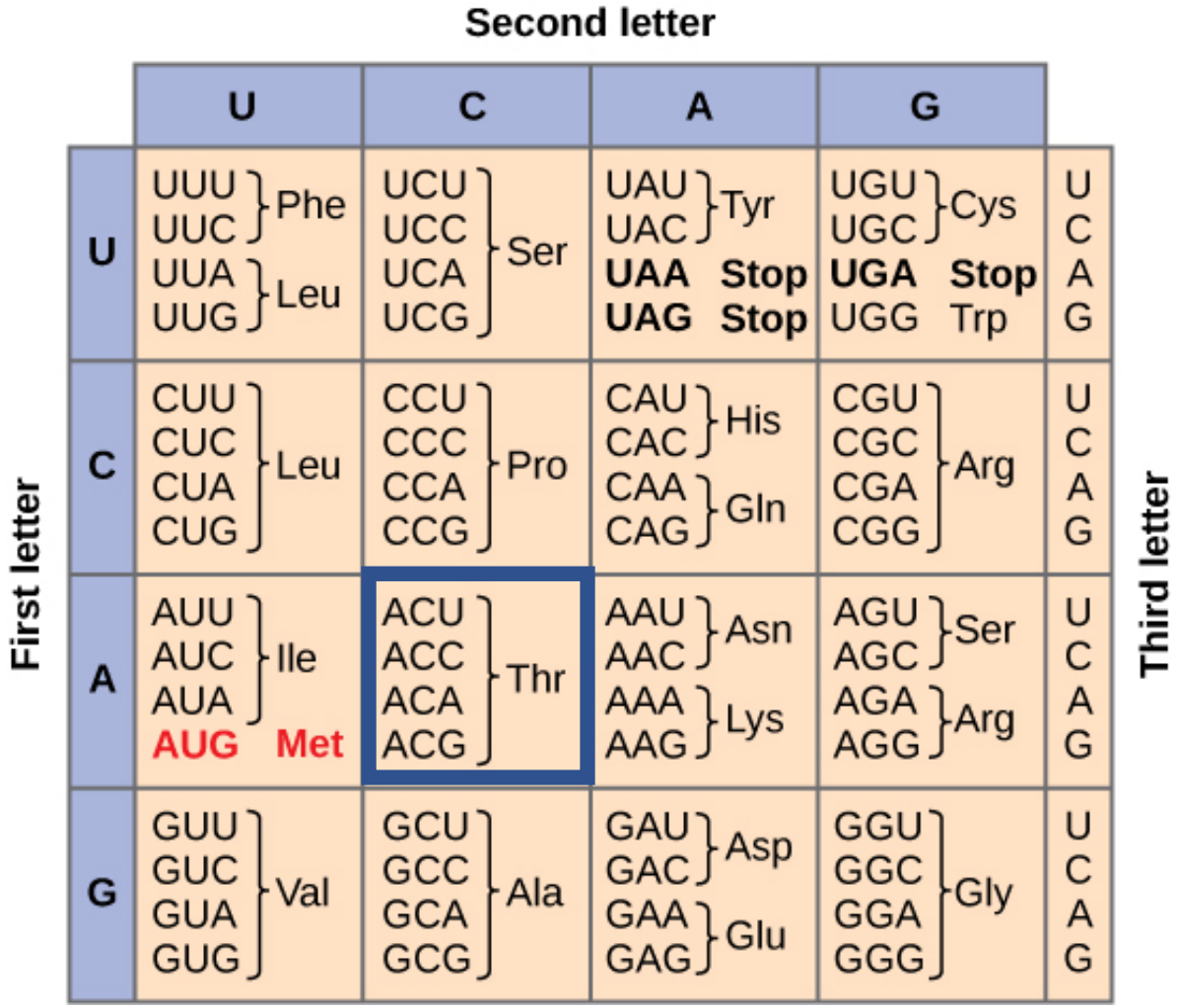
Note: stop codons do not code for any amino acid; they just stop translation



The genetic code again

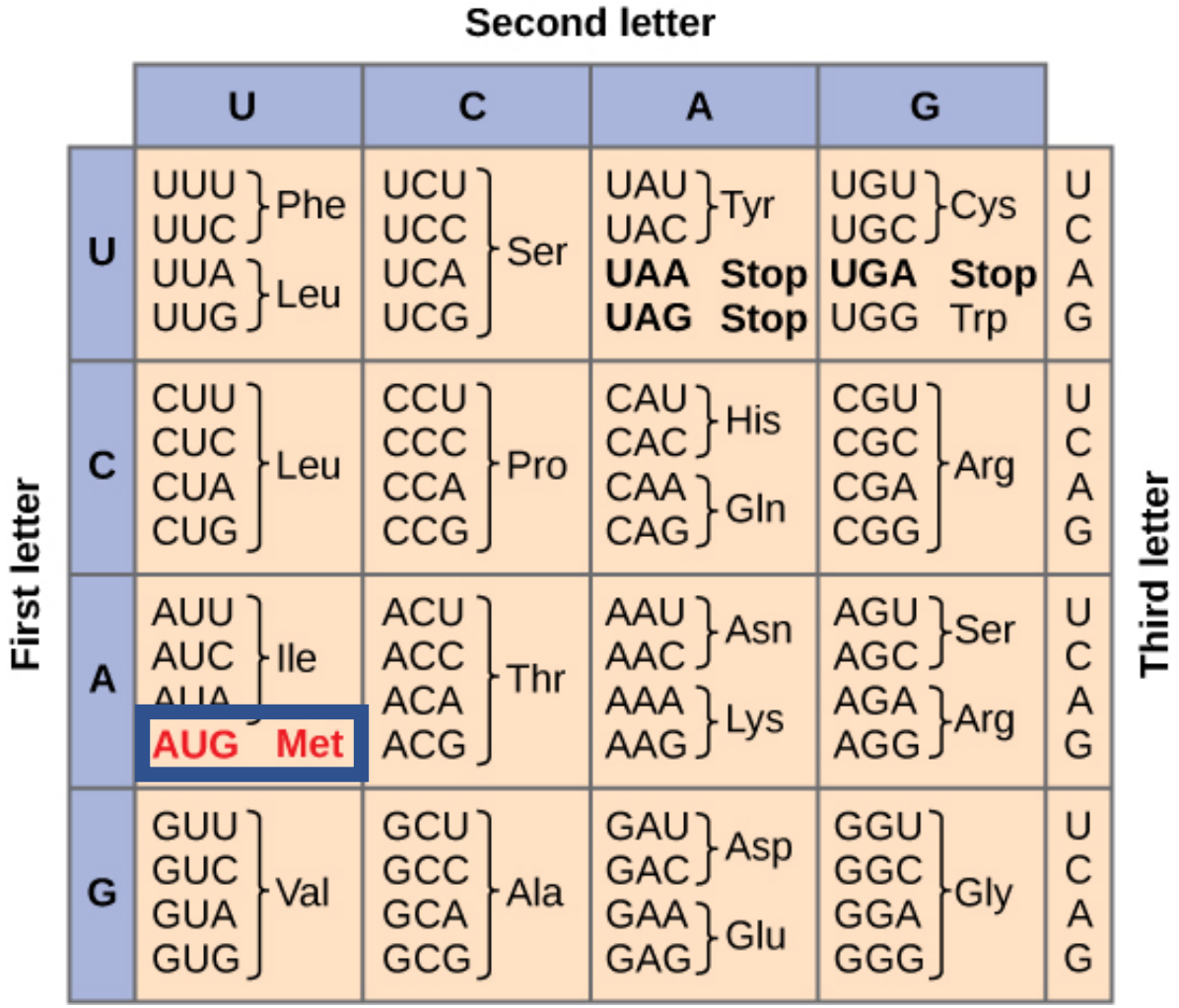


The genetic code again



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

The genetic code again



“Cracking” the genetic code

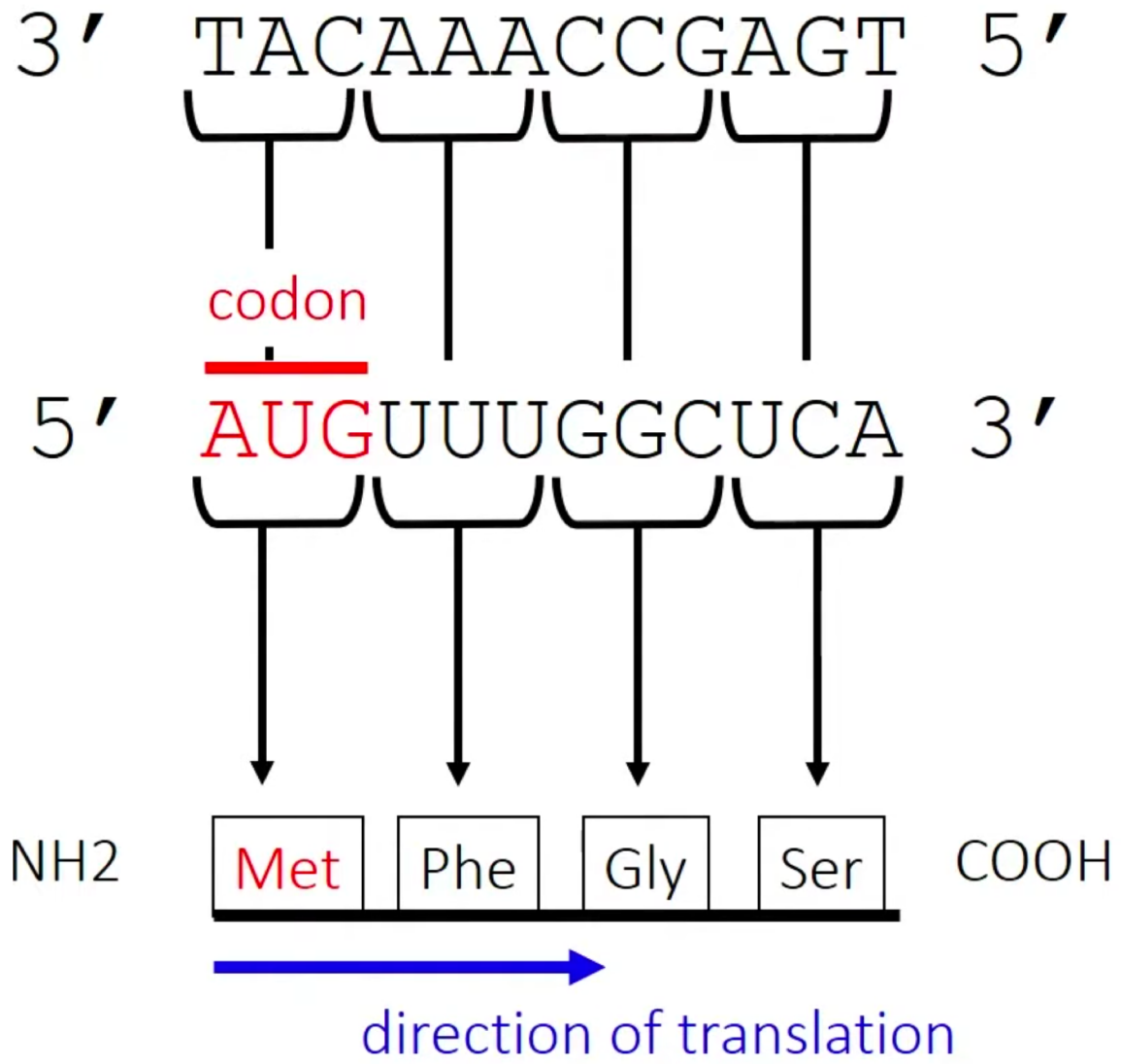
DNA template strand

transcription

mRNA

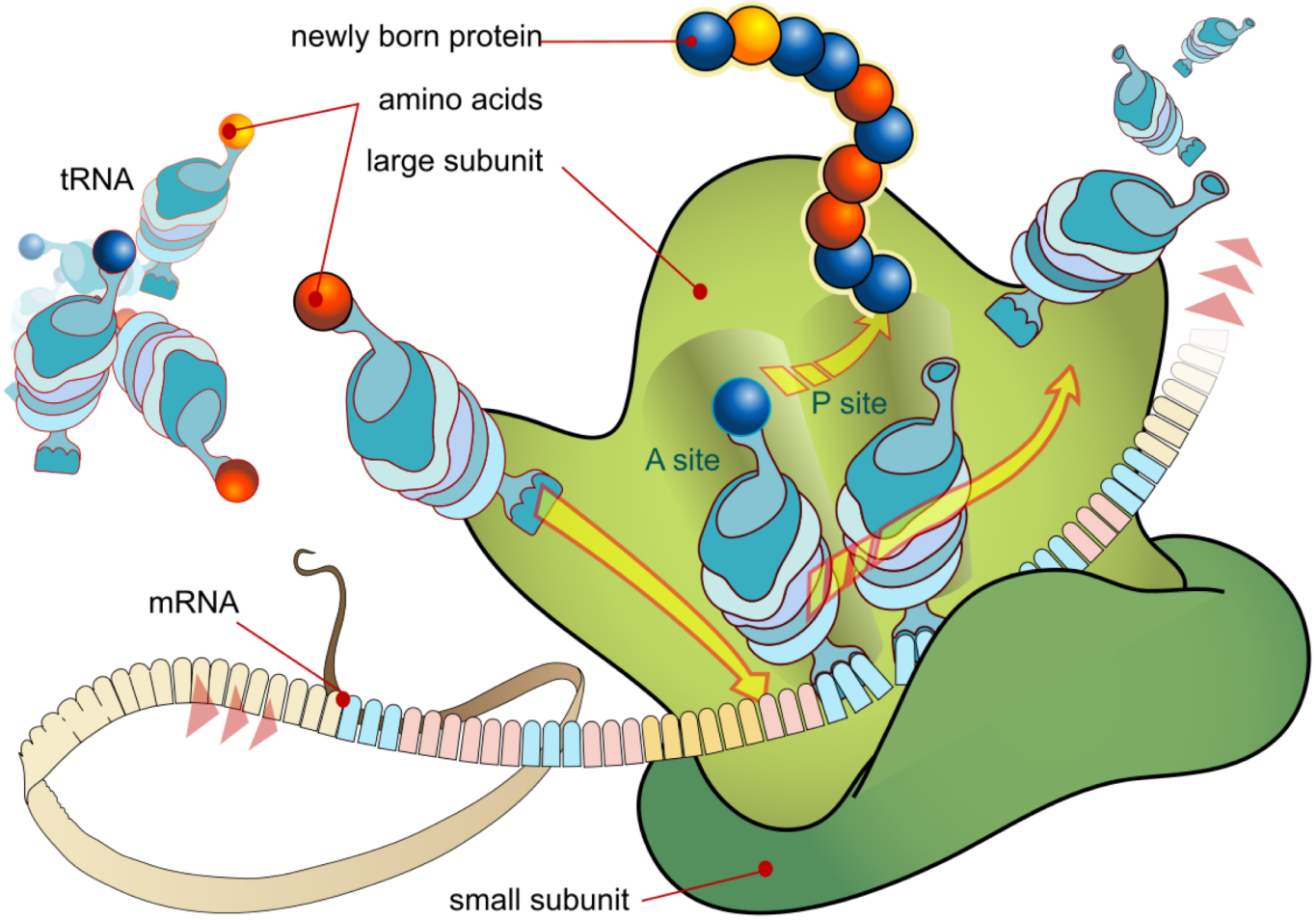
translation (via tRNA)

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



RNA translation

- Take assignment 12: RNA translation