The Genetic Code

Lecture Objectives

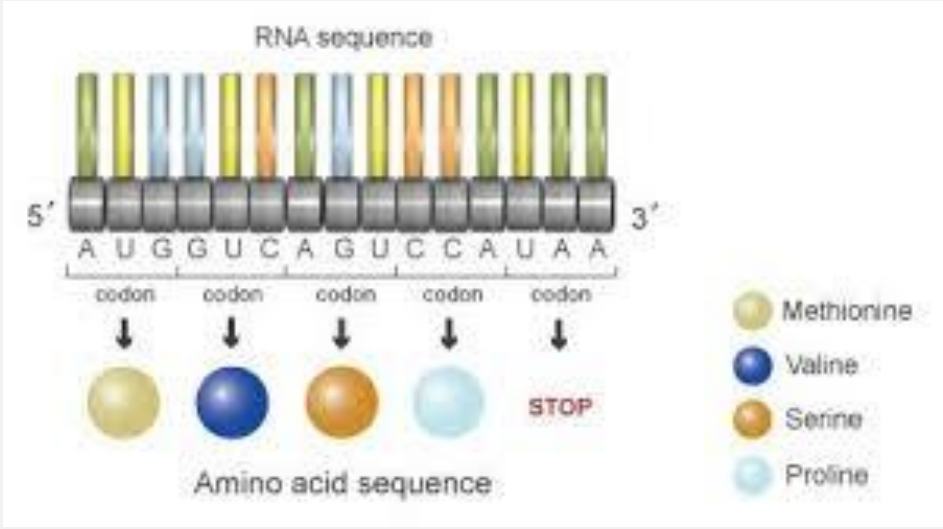
- **What is genetic code?**
- **Explain Properties of genetic code**
- **Understand amino acids codons**

What is Genetic Code

The genetic code is the set of rules by which information encoded in genetic material (DNA or RNA sequences) is translated into proteins (amino acid sequences) by living cells.

- DNA could be read by Bases
- Proteins could be read by Amino Acids
- mRNA could be read by ?

  –It will be read by codon



The Genetic Code

- Genetic code is established to have an understanding of **molecular language.**
- The sequence of codons in the **mRNA** defines the primary structure of the final protein.
- A codon is made up of 3 bases also called **triplet codon**
- Therefore three nucleotides in mRNA (a codon) specify one amino acid in a protein.

Properties of the Genetic Code

- The code is triplet
- The code is degenerate
- The code is non-overlapping
- The code is commaless (comma-free).
- Organized by start and stop codons.
- The code is universal.

The code is triplet

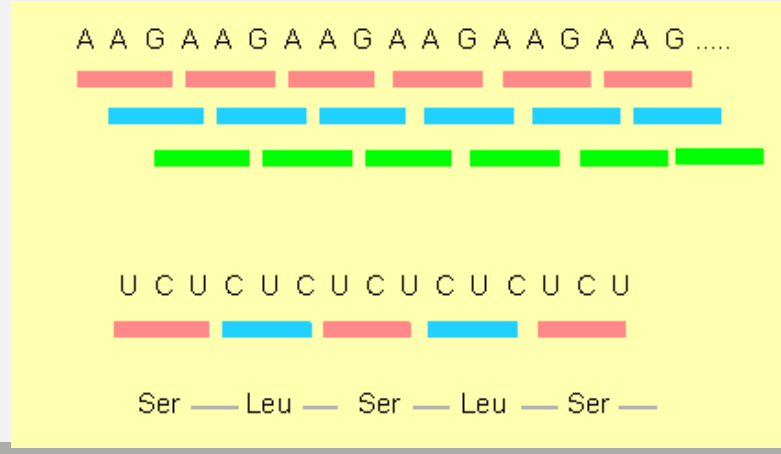
❖**The triplet sequence** of mRNA that specify certain amino acid.

❖**There are 64 different codons**, but only 20 amino acids. (So, there may be more than one codon for an amino acid)

❖**Stop Codons:** 3 codons (UUA, UGA, UAG) in the genetic code used to terminate translation.

❖**Start Codon:** the codon (AUG) used to signify the start of translation

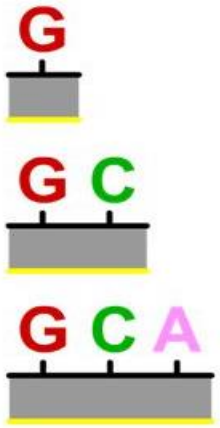
❖**The remainder of the code is degenerate** meaning that some amino acids are specified by more than one codon.



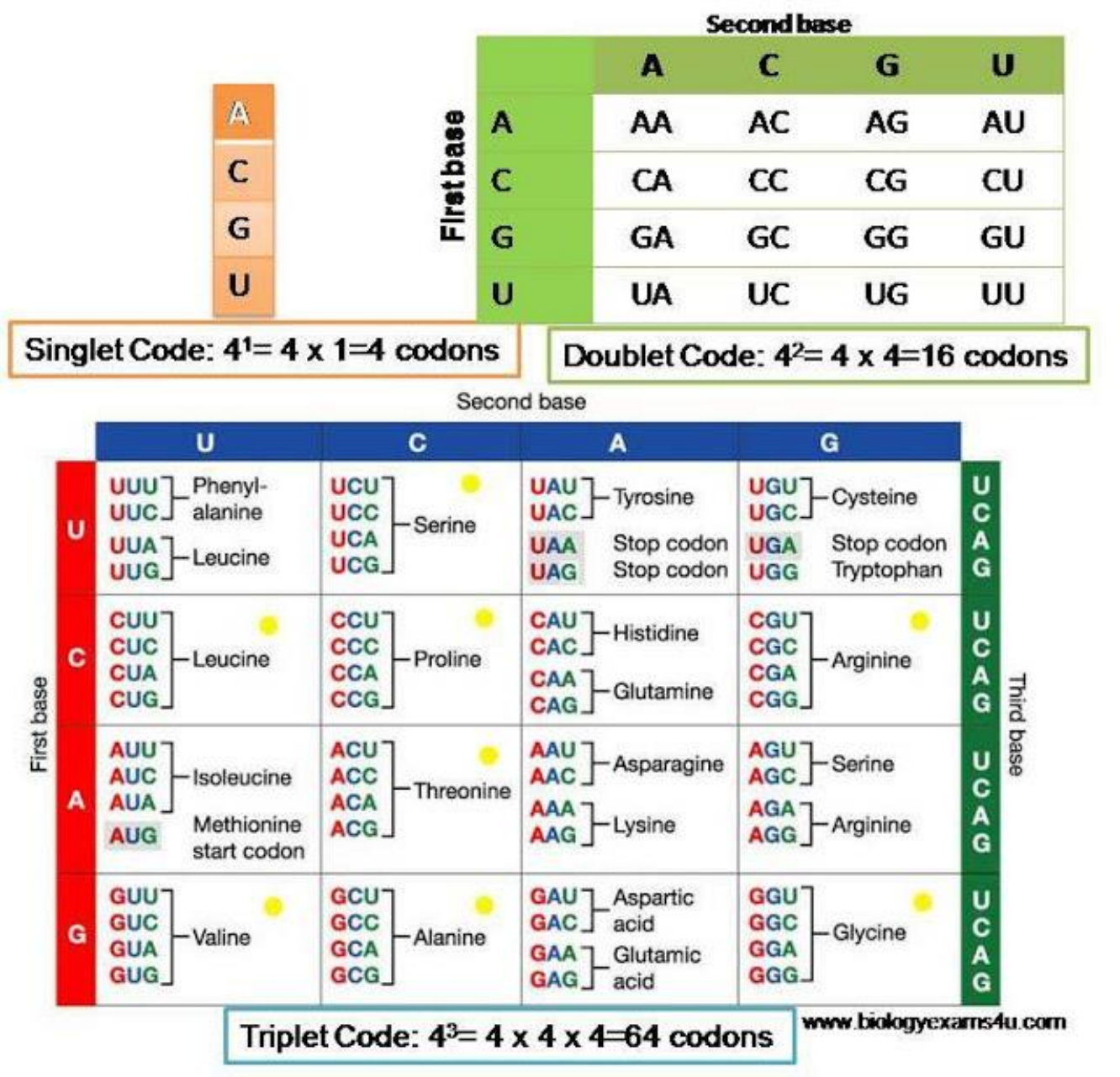
Evidence for the Triplet Code

Given that there are four bases in DNA, and these code for 20 Amino acids, what is the basis for the genetic code?

- If **one** base = one amino acid, possible amino acids = **4**
- If **two** bases = one amino acid, possible amino acids = **16** (4×4)
- If **three** bases = one amino acid, possible amino acids = **64** (4×4×4)



The existence of a three- base (triplet) code was confirmed by experiments by Francis Crick and his colleagues in 1961.


Second base
A
C
G
U
First base
A
C
G
U
AA AC AG AU
CA CC CG CU
GA GC GG GU
UA UC UG UU
Singlet Code: 4¹= 4 x 1=4 codons
Doublet Code: 4²= 4 x 4=16 codons
Second base
U C A G
First base
U
UUU Phenyl-alanine
UUC
UUA Leucine
UUG
UCU Serine
UCC
UCA
UCG
UAU Tyrosine
UAC
UAA Stop codon
UAG Stop codon
UGU Cysteine
UGC
UGA Stop codon
UGG Tryptophan
C
CUU Leucine
CUC
CUA
CUG
CCU Proplne
CCC
CCA
CCG
CAU Histidine
CAC
CAA Glutamine
CAG
CGU Arginine
CGC
CGA
CGG
A
AUU Isoleucine
AUC
AUA
AUG Methionine start codon
ACU Threonine
ACC
ACA
ACG
AAU Asparagine
AAC
AAA Lysine
AAG
AGU Serine
AGC
AGA Arginine
AGG
G
GUU Valine
GUC
GUA
GUG
GCU Alanine
GCC
GCA
GCG
GAU Aspartic acid
GAC
GAA Glutamic acid
GAG
GGU Glycine
GGC
GGA
GGG
Third base
U C A G
Triplet Code: 4³= 4 x 4 x 4=64 codons
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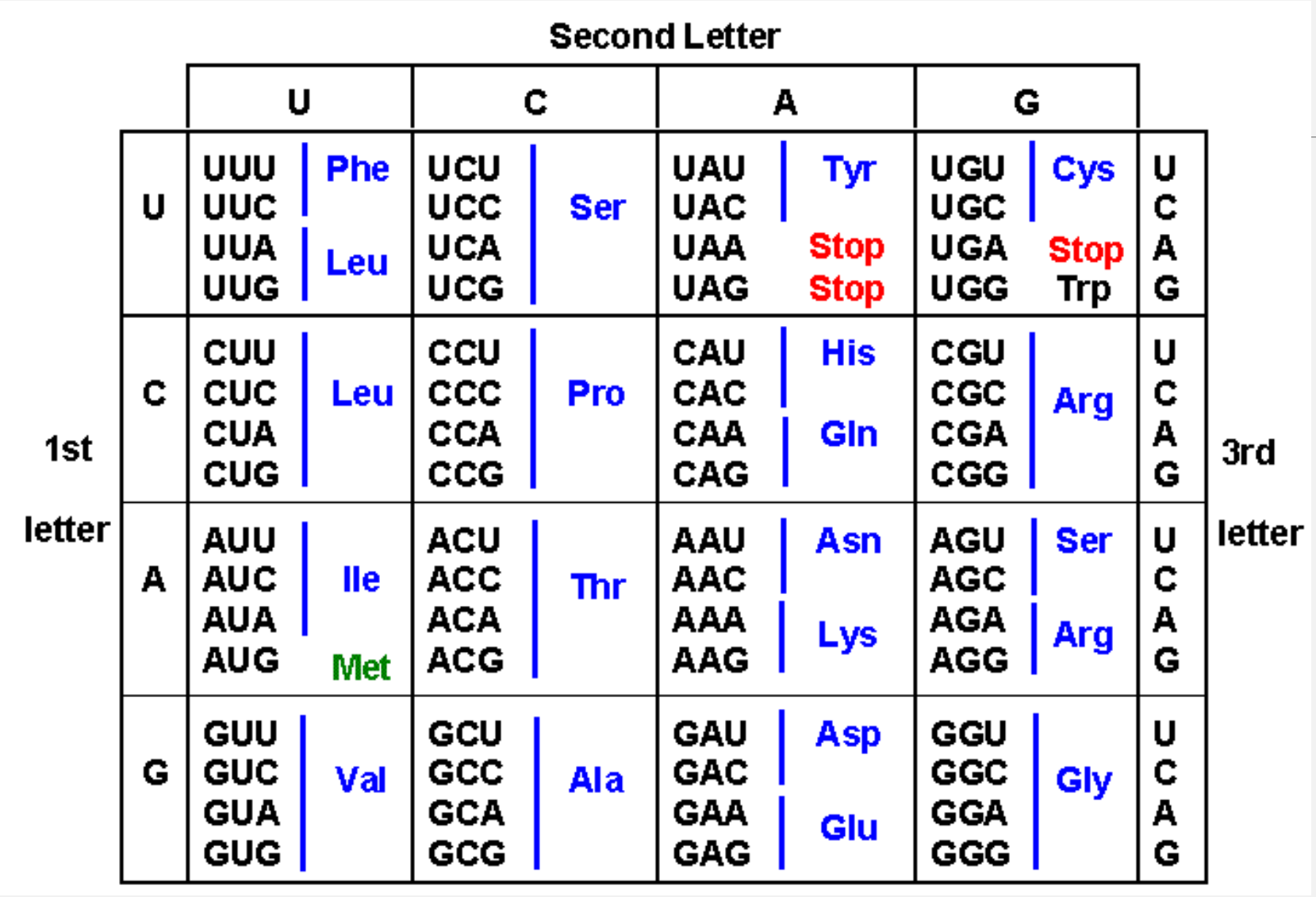
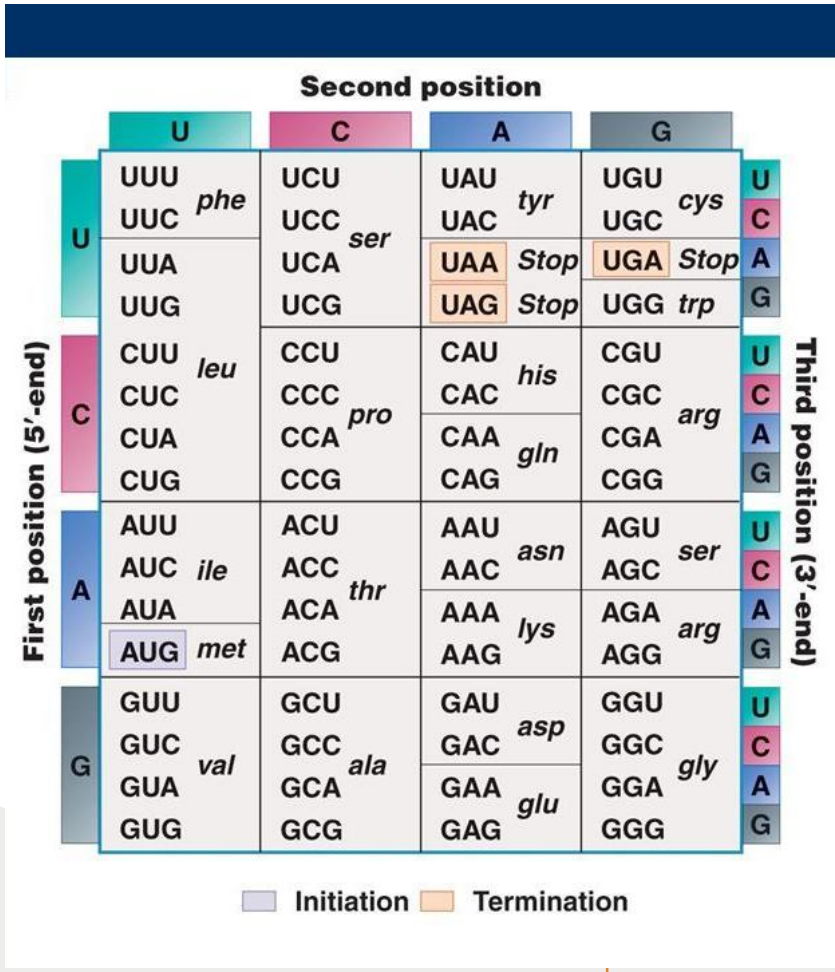
Codons


Second Letter
U
C
A
G
1st letter
3rd letter
U
UUU Phe
UUC
UUA Leu
UUG
UCU
UCC
UCA
UCG Ser
UAU Tyr
UAC
UAA Stop
UAG Stop
UGU Cys
UGC
UGA Stop
UGG Trp
C
CUU
CUC
CUA
CUG Leu
CCU
CCC
CCA
CCG Pro
CAU His
CAC
CAA
CAG Gln
CGU
CGC
CGA
CGG Arg
A
AUU
AUC
AUA Ile
AUG Met
ACU
ACC
ACA
ACG Thr
AAU Asn
AAC
AAA
AAG Lys
AGU Ser
AGC
AGA
AGG Arg
G
GUU
GUC
GUA
GUG Val
GCU
GCC
GCA
GCG Ala
GAU Asp
GAC
GAA
GAG Glu
GGU
GGC
GGA
GGG Gly

The table shows the 64 codons and the amino acid for each. The direction of the mRNA is 5' to 3'.					
1st Base	2nd base				3rd Base
	U	C	A	G	
U	UUU (Phe/F)Phenylalanine UUC (Phe/F)Phenylalanine UUA (Leu/L)Leucine UUG (Leu/L)Leucine	UCU (Ser/S)Serine UCC (Ser/S)Serine UCA (Ser/S)Serine UCG (Ser/S)Serine	UAU (Tyr/Y)Tyrosine UAC (Tyr/Y)Tyrosine UAA Ochre (Stop) UAG Amber (Stop)	UGU (Cys/C)Cysteine UGC (Cys/C)Cysteine UGA Opal (Stop) UGG (Trp/W)Tryptophan	U C A G
C	CUU (Leu/L)Leucine CUC (Leu/L)Leucine CUA (Leu/L)Leucine CUG (Leu/L)Leucine	CCU (Pro/P)Proline CCC (Pro/P)Proline CCA (Pro/P)Proline CCG (Pro/P)Proline	CAU (His/H)Histidine CAC (His/H)Histidine CAA (Gln/Q)Glutamine CAG (Gln/Q)Glutamine	CGU (Arg/R)Arginine CGC (Arg/R)Arginine CGA (Arg/R)Arginine CGG (Arg/R)Arginine	U C A G
A	AUU (Ile/I)Isoleucine AUC (Ile/I)Isoleucine AUA (Ile/I)Isoleucine AUG (Met/M)Methionine	ACU (Thr/T)Threonine ACC (Thr/T)Threonine ACA (Thr/T)Threonine ACG (Thr/T)Threonine	AAU(Asn/N)Asparagine AAC (Asn/N)Asparagine AAA (Lys/K)Lysine AAG (Lys/K)Lysine	AGU (Ser/S)Serine AGC (Ser/S)Serine AGA (Arg/R)Arginine AGG (Arg/R)Arginine	U C A G
G	GUU (Val/V)Valine GUC (Val/V)Valine GUA (Val/V)Valine GUG (Val/V)Valine	GCU (Ala/A)Alanine GCC (Ala/A)Alanine GCA (Ala/A)Alanine GCG (Ala/A)Alanine	GAU (Asp/D)Aspartic acid GAC (Asp/D)Aspartic acid GAA (Glu/E)Glutamic acid GAG (Glu/E)Glutamic acid	GGU (Gly/G)Glycine GGC (Gly/G)Glycine GGA (Gly/G)Glycine GGG (Gly/G)Glycine	U C A G

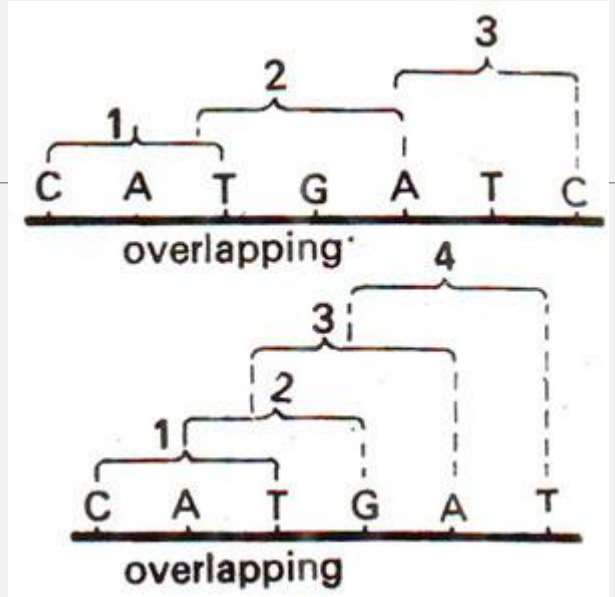
The code is degenerate

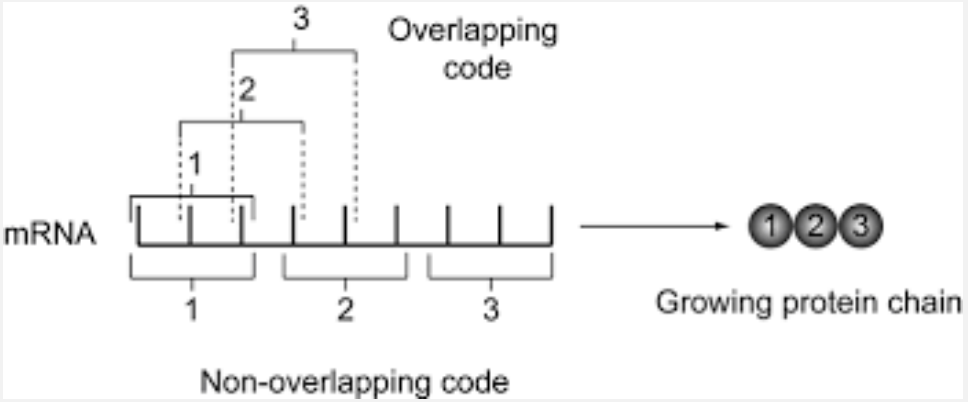
- In the genetic code there are 64 codons. Three of them are stop codons (UAA, UAG & UGA).
- Remaining 61 codons code for 20 amino acids.
- Thus there are more than one codon for one amino acid. This is called degeneracy of genetic code.
- Methionine and tryptophan are the only two amino acids that are coded for by just a single codon (AUG and UGG, respectively).
- The other 18 amino acids are coded for by two to six codons. Because most of the 20 amino acids are coded for by more than one codon, the code is called degenerate.



Non Overlapping

- Non-overlapping code means that a base in a mRNA is not used for two different codons.
- Not used in the formation of more than one codon.
- In Figure : it is shown that an overlapping code can mean coding for four amino acids from six bases. In actual practice six bases code for not more than two amino acids.

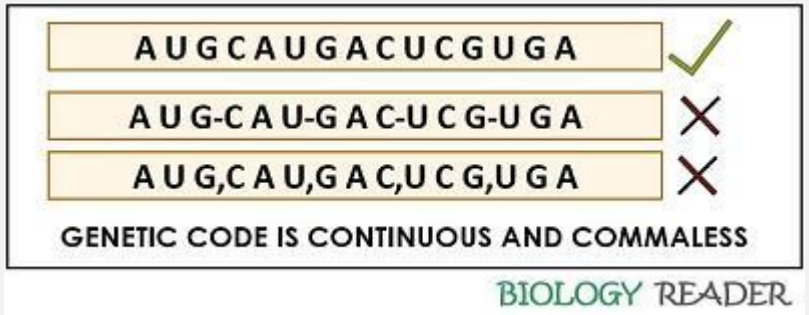




A commaless code

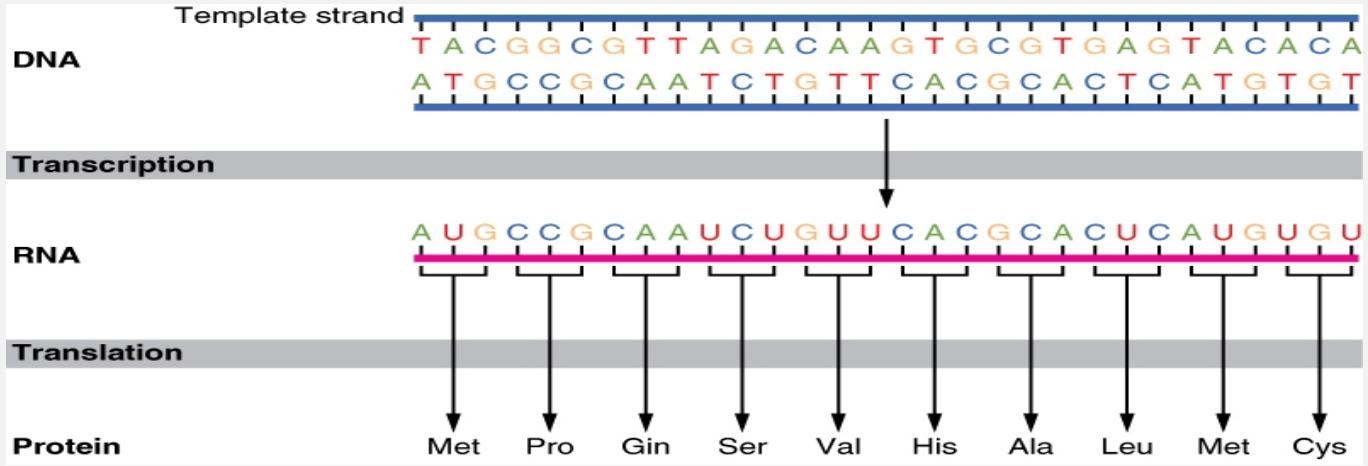
Means that no punctuations are needed between any two words. In other words, we can say that after one amino acid is coded, the second amino acid will be automatically coded by the next three letters

- Genetic code is non punctuating
- The reading frame of mRNA could not have any break during translation
- Punctuation in codon may be lethal
- It is called as comma less language that means within the coding regions of mRNA molecules there are no commas so that during translation, the codons are read consecutively.



The code is universal

All kinds of living organisms, micro or macro, plants or animals, the same genetic code is used.



Amino acids codons

There are 64 possible codons, three of which do not code for amino acids but indicate the end of a protein. The remaining 61 codons specify the 20 amino acids that make up proteins. The AUG codon, in addition to coding for methionine, is found at the beginning of every mRNA and indicates the start of a protein..

Organized by start and stop codons

Types of codons:

1- Sense Codons:

The codon that code for amino acid are called sense codon.

2- Signal Codons: Start codons • Stop codons

Those codons that code for signal during protein synthesis are called signal codons.

For Example: AUG, UAA, UAG & UGA.

There are Two types of signal codons:

**Terminating Codon **Initiating Codon

“Terminating Codons” • UAA, UAG & UGA are termination codons

“Initiating codon” • AUG is the initiation codon. It codes for the first amino acid in all proteins.

Reading the Genetic Code

Suppose we want to determine the amino acids coded for in the following section of a mRNA

5’—CCU —AGC—GGA—CUU—3’

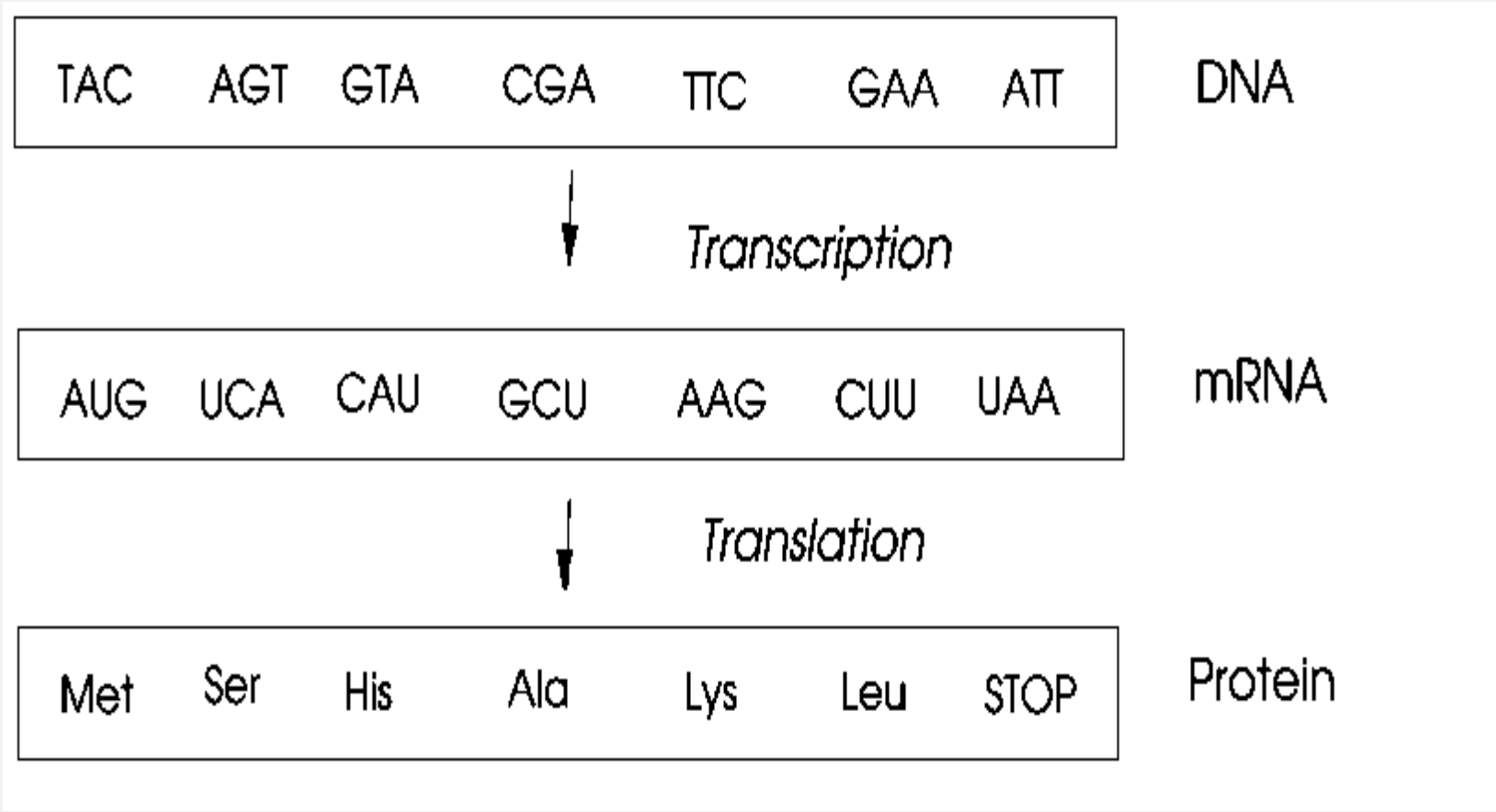
According to the genetic code, the amino acids for these codons are:

CCU = Proline AGC = Serine

GGA = Glycine CUU = Leucine

The mRNA section codes for the amino acid sequence of Pro—Ser—Gly—Leu

Construction of a Protein



https://www.youtube.com/watch?v=LsEYgwuP6ko