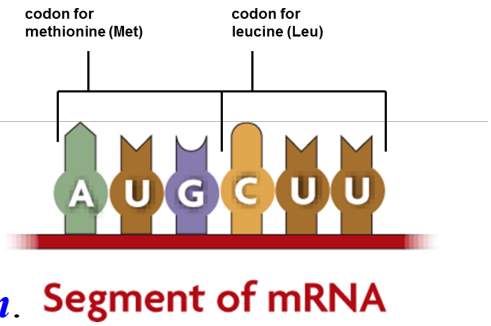
# 8.5 Translation

## III. The Genetic Code

### A. How can mRNA be translated into the sequence of amino acids that make up proteins?

**-Every *three*** nucleotides in mRNA specify a particular ***amino acid***. Each triplet in mRNA is called a ***codon*****.** The order of the *bases* in a codon determines which ***amino acid*** will be added to a growing protein chain. In turn, the order of amino acids will determine the structure and function of a ***protein***.



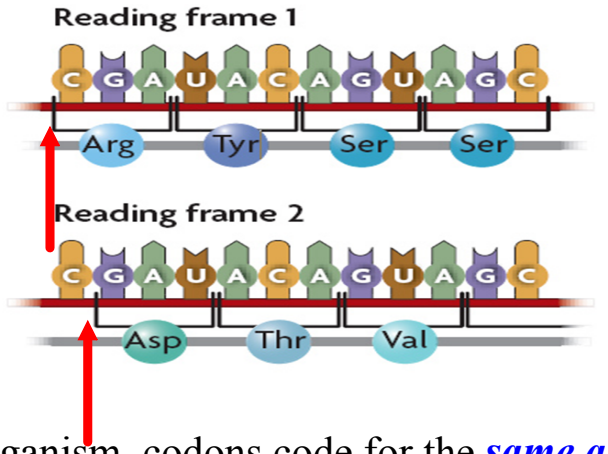

### B. The genetic code is the correspondence between nucleotide triplets in DNA and the amino acids in proteins.

- Since there are 20 different kinds of amino acids, there needs to be a least ***20 triplet codes***. You would need to group the bases (A,C,U,G) in three's, which gives you ***64*** possible combinations ($4^3 = 64$). If grouped in two's, you only get 16 combinations ($4^2 = 16$).

- Some codons do not code for an amino acid, but provide ***instructions*** for starting the protein chain (***AUG or methionine***) and stopping the chain because the protein is complete (***UAA, UAG, UGA***).

- The genetic code is the same in nearly all organisms, so it is said to be ***universal***. This provides evidence that ***all life*** on Earth evolved from a ***common origin***.

- A ***change in the order*** in which codons are read, ***changes the resulting protein.***

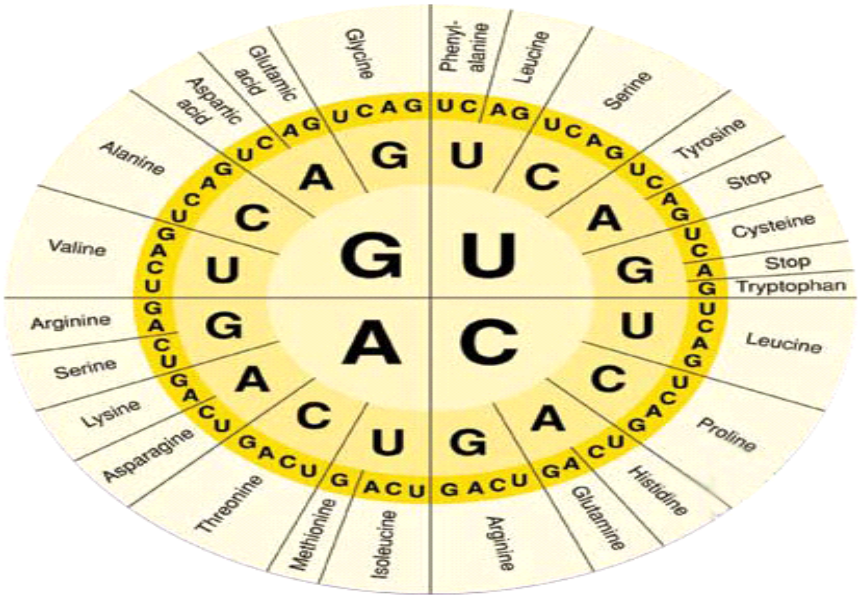



- Regardless of the organism, codons code for the ***same amino acid***.

The genetic code matches each RNA **codon** with its amino acid or function.

| First base | Second base U | | Second base C | | Second base A | | Second base G | | Third base |
|---|---|---|---|---|---|---|---|---|---|
| U | UUU | phenylalanine (Phe) | UCU | serine (Ser) | UAU | tyrosine (Tyr) | UGU | cysteine (Cys) | U |
| | UUC | | UCC | | UAC | | UGC | | C |
| | UUA | leucine (Leu) | UCA | | UAA | STOP | UGA | STOP | A |
| | UUG | | UCG | | UAG | STOP | UGG | tryptophan (Trp) | G |
| C | CUU | leucine (Leu) | CCU | proline (Pro) | CAU | histidine (His) | CGU | arginine (Arg) | U |
| | CUC | | CCC | | CAC | | CGC | | C |
| | CUA | | CCA | | CAA | glutamine (Gln) | CGA | | A |
| | CUG | | CCG | | CAG | | CGG | | G |
| A | AUU | isoleucine (Ile) | ACU | threonine (Thr) | AAU | asparagine (Asn) | AGU | serine (Ser) | U |
| | AUC | | ACC | | AAC | | AGC | | C |
| | AUA | | ACA | | AAA | lysine (Lys) | AGA | arginine (Arg) | A |
| | AUG | methionine (Met) | ACG | | AAG | | AGG | | G |
| G | GUU | valine (Val) | GCU | alanine (Ala) | GAU | aspartic acid (Asp) | GGU | glycine (Gly) | U |
| | GUC | | GCC | | GAC | | GGC | | C |
| | GUA | | GCA | | GAA | glutamic acid (Glu) | GGA | | A |
| | GUG | | GCG | | GAG | | GGG | | G |

1. Find the first base, C, in the left column.
2. Find the second base, A, in the top row. Find the box where these two intersect.
3. Find the third base, U, in the right column. CAU codes for histidine, abbreviated as His.

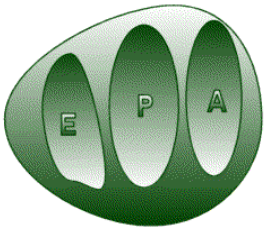


## I. How RNA Makes Proteins

-Translation = ***the process by which the genetic message is deciphered***.

**Steps in translation:**

1. A ribosome, which is composed of ***two subunits of rRNA and protein***, attaches to a strand of mRNA in the ***cytoplasm*** of the cell.




Ribosome has three sites -
***A site, P site, E site***
Initiate, Elongate, Terminate

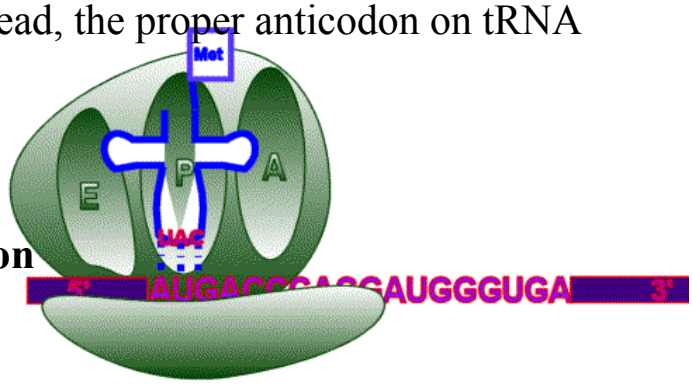

**Note location of the sugar**

2. Within the ribosome is another kind of RNA, ***tRNA***, which transfers in the amino acids as they are read on the mRNA.

-A tRNA molecule is about ***80 nucleotides*** long, folded into a compact shape. At one end is a three-nucleotide sequence called an ***anticodon***. At the opposite end is an ***amino acid***.

-As the codon on mRNA is read, the proper anticodon on tRNA ***matches*** to it.

***Initiation*** = **Ribosome + mRNA + tRNA come together at AUG start codon**



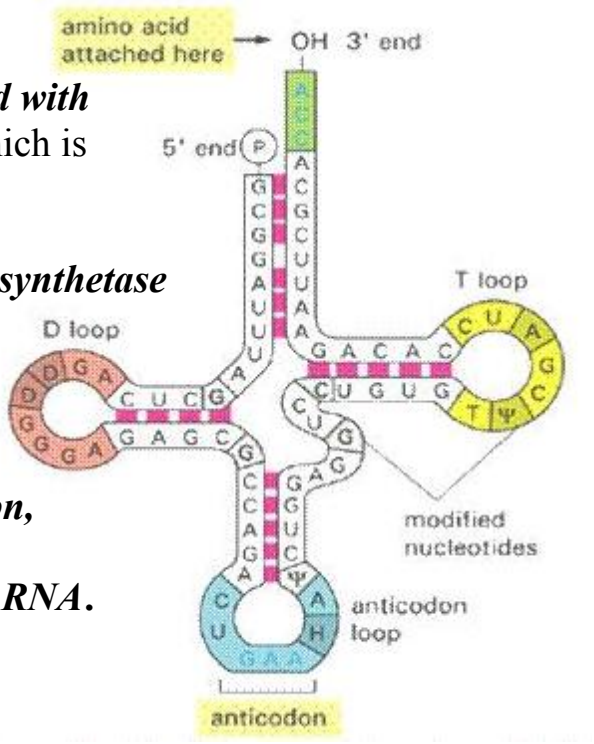
## FYI - Bases in tRNA

**A.** All tRNA molecules ***have a 3' end with the nucleotide sequence -- ACC,*** which is known as the ***acceptor stem.***

An enzyme, called ***aminoacyl tRNA synthetase attaches an amino acid*** by forming an ester bond with the free -- OH at the end of the acceptor stem.

**B.** Each tRNA contains an ***anticondon,*** which is a series of ***three bases that complements the three bases on a mRNA.***

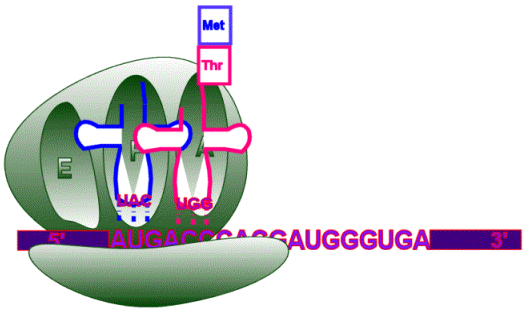
**B**

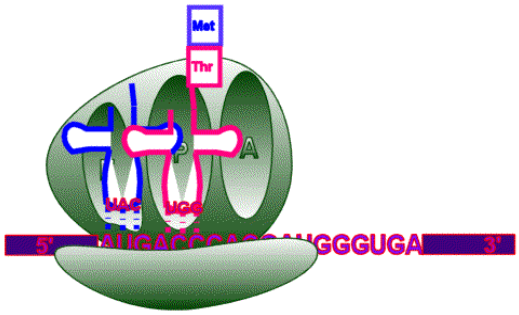



3. The anticodon ***binds*** to the codon, thus bringing in the proper amino acid.
4. The amino acid detaches from the *tRNA* molecule and attaches to the growing ***protein*** chain within the ribosome. A ***peptide*** bond is formed with the amino acid next to it. The empty tRNA molecule then ***leaves*** the ribosome to pick up another amino acid.


***Elongation*** **= tRNA with anticodon comes into A site**

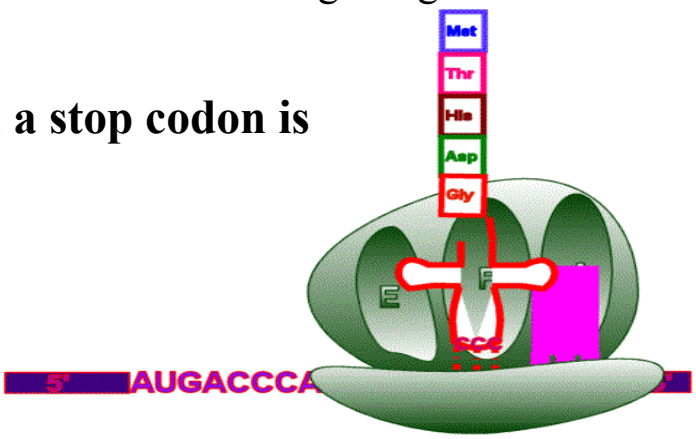
## *Translocation* - system ratchets down so that the tRNA formerly in the A site is now in the P site



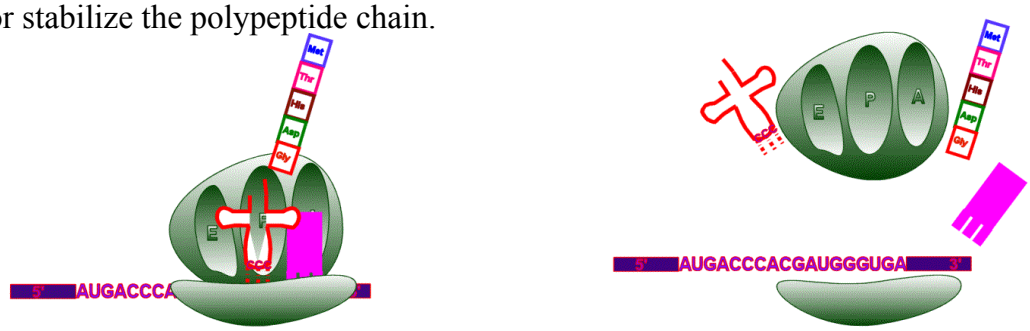

5. The ribosome moves along the ***mRNA*** strand to read the next ***codon***, and the whole process happens again.
6. At some point in the **mRNA** strand the ***"stop"*** codon occurs and the components of the ribosome ***separate and disengage*** the **mRNA**. The protein is then ***released*** into the cell. The **mRNA** returns to the nucleus, ***disassembles*** and begins again in the transcription process.

## *Termination* = when a stop codon is encountered

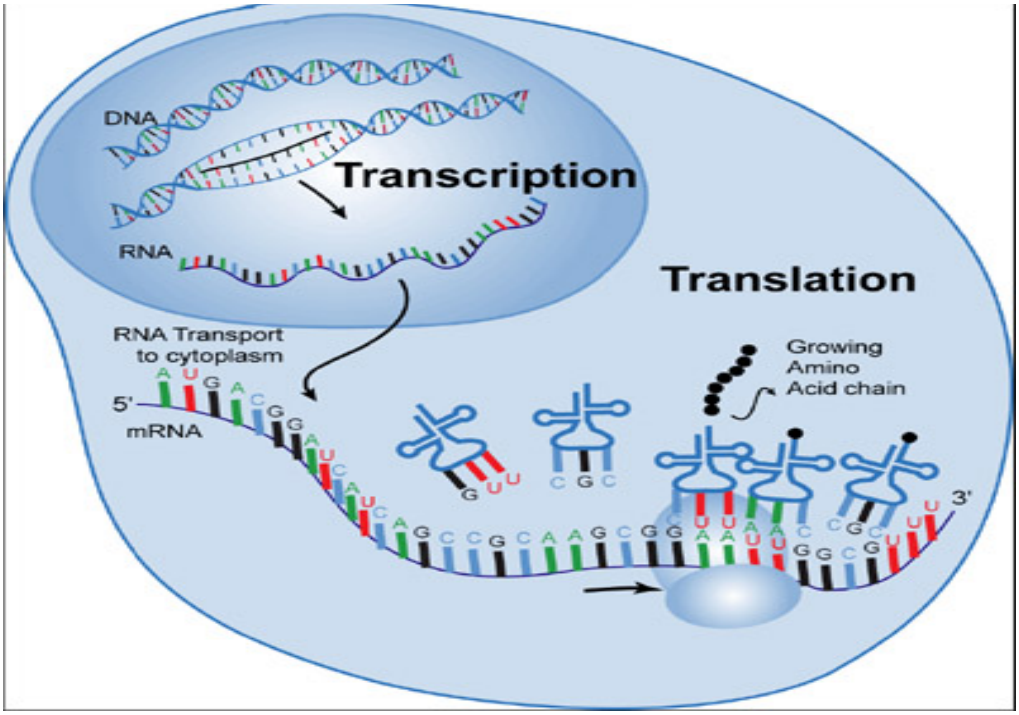


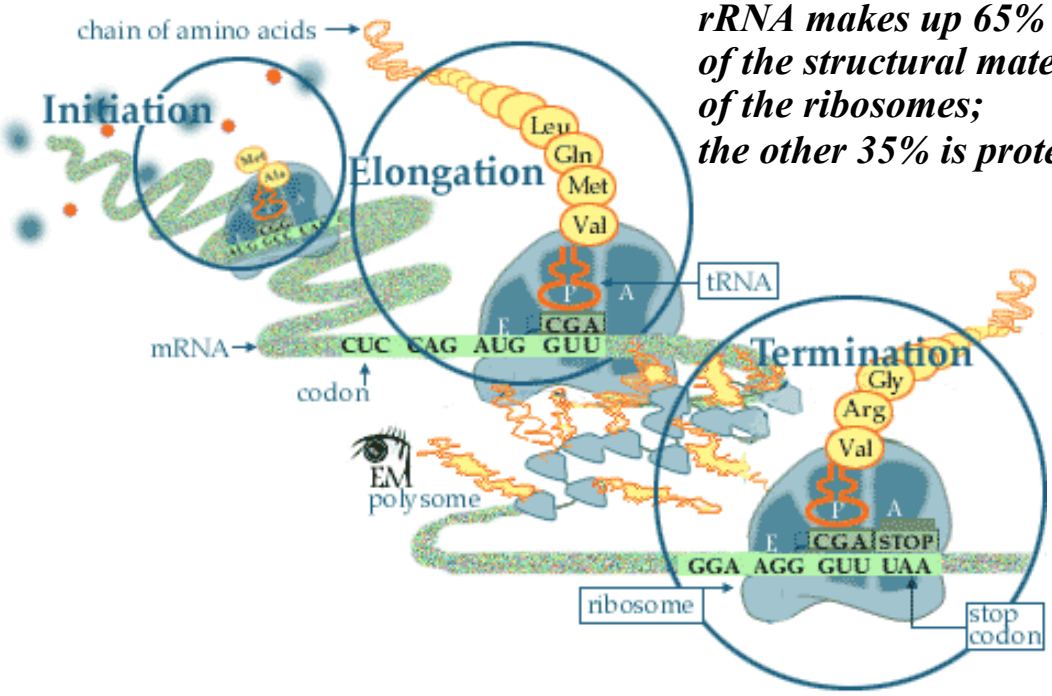
**HOW RIBOSOME OPENS** = ***Release factors*** bind to mRNA codon - since there is **not a tRNA anticodon** attaching to the **mRNA**"stop" codon

The release factor causes the ***addition of a water molecule*** instead of an amino acid to "***seal***" or stabilize the polypeptide chain.




Finally the ***whole polypeptide chain falls off*** & the remainder of the translation assembly then comes apart






***rRNA makes up 65% of the structural material of the ribosomes; the other 35% is protein.***