Gene Expression

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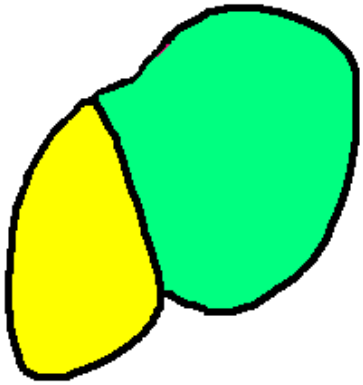
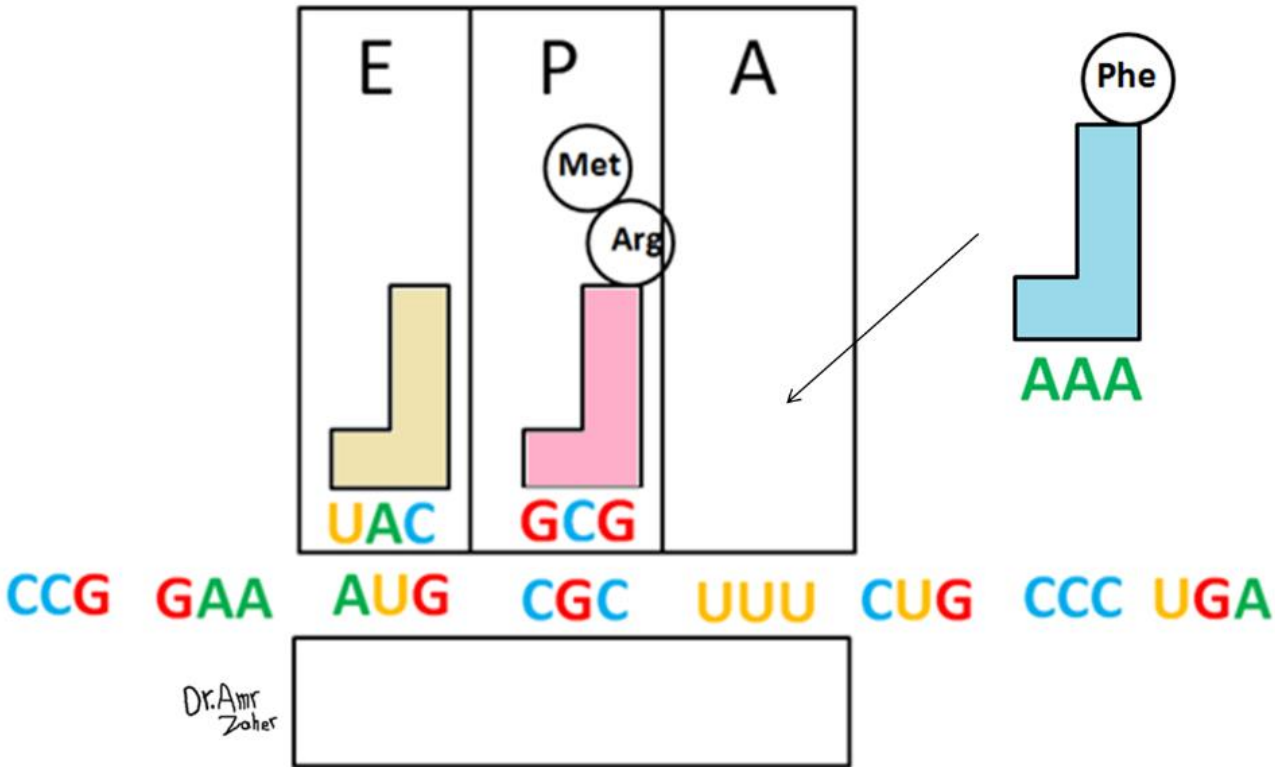
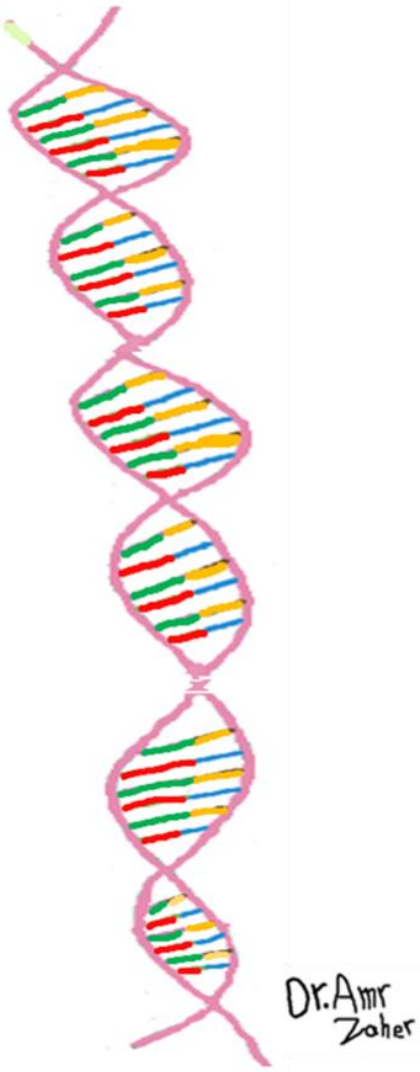
Gene expression

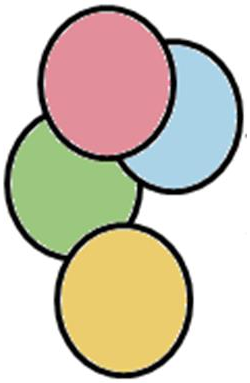
Dr. Amr Zaher
M.D., Ph.D., M.Sc., PGDip.





Gene expression is the process of which DNA directs the synthesis of proteins.





From DNA to protein

Transcription

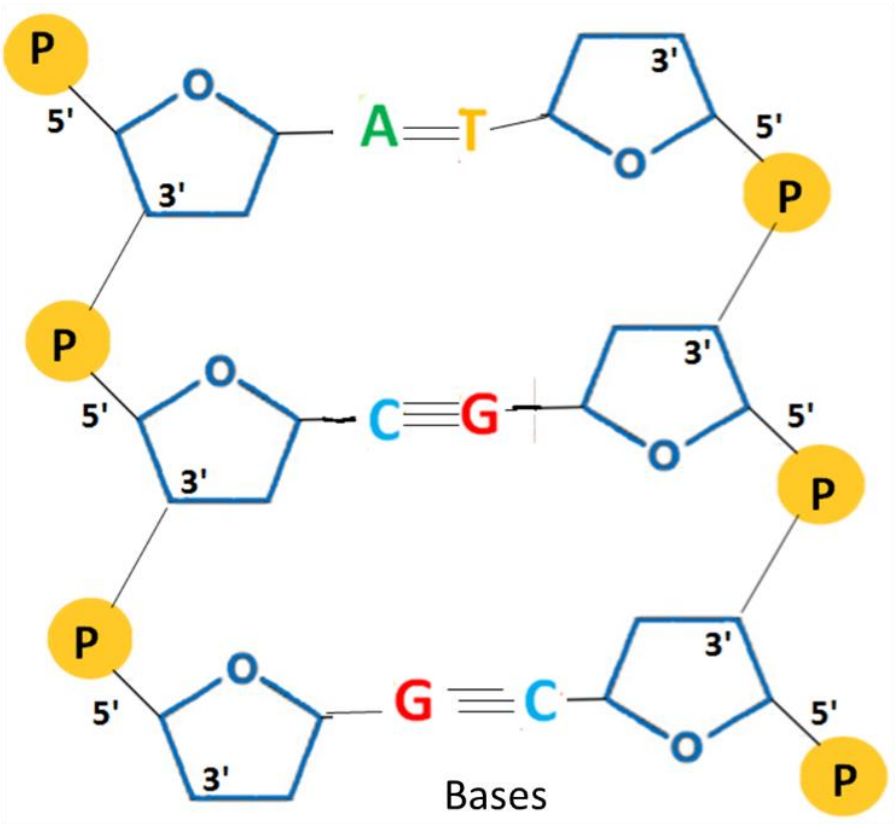
Translation

Folding

Transcription

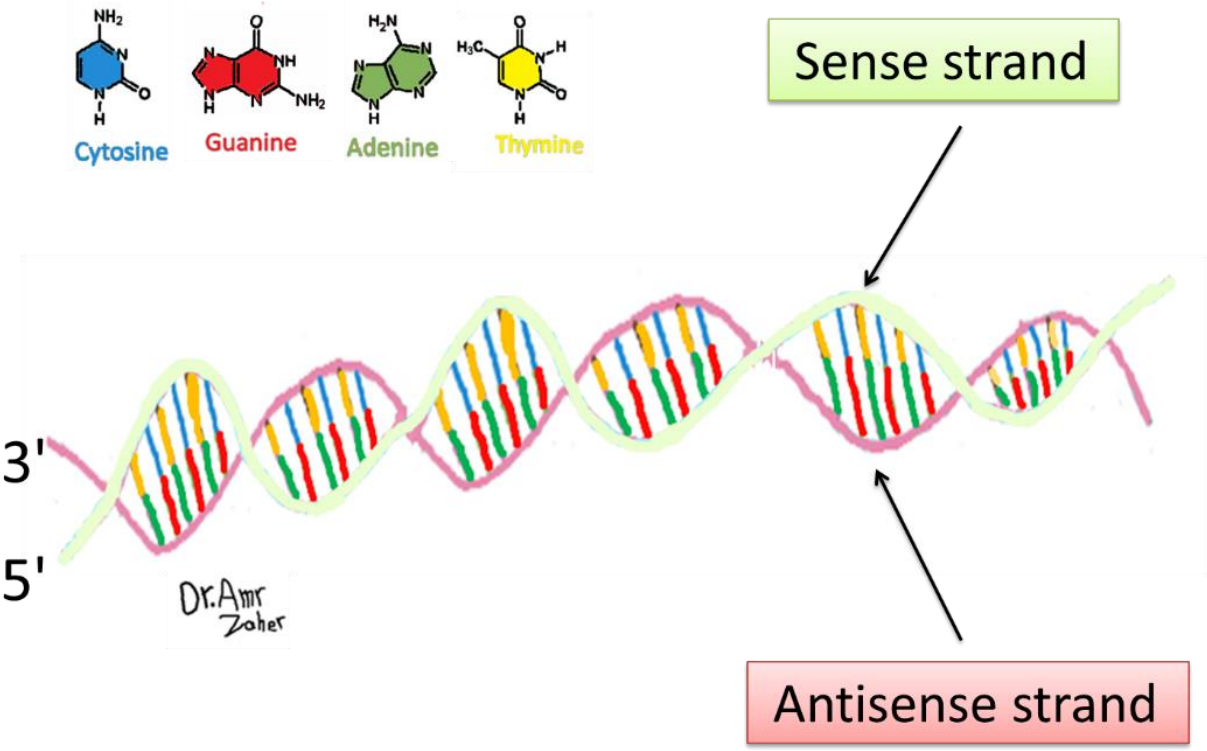
- Is the process by which DNA gets converted into mRNA.

- In genetics, a sense strand is the segment within double-stranded DNA that runs from 5' to 3', and which is complementary to the antisense strand of DNA, which runs from 3' to 5'.

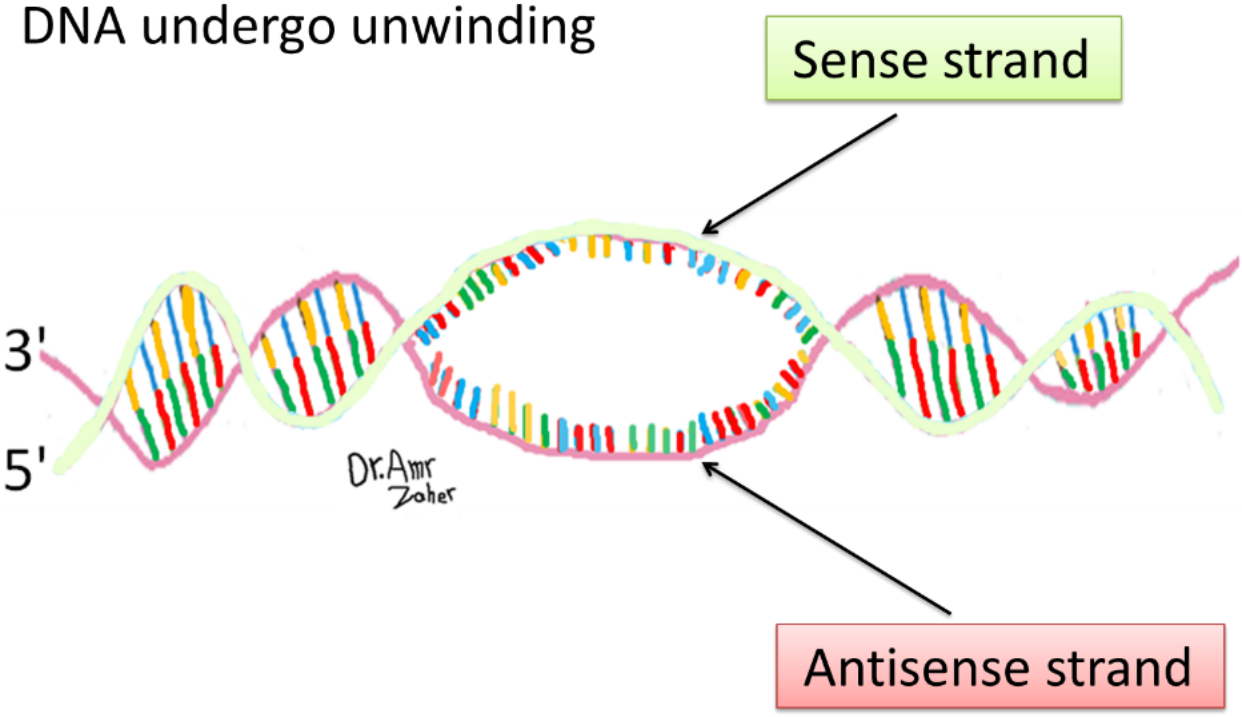


Sugar- phosphate backbone

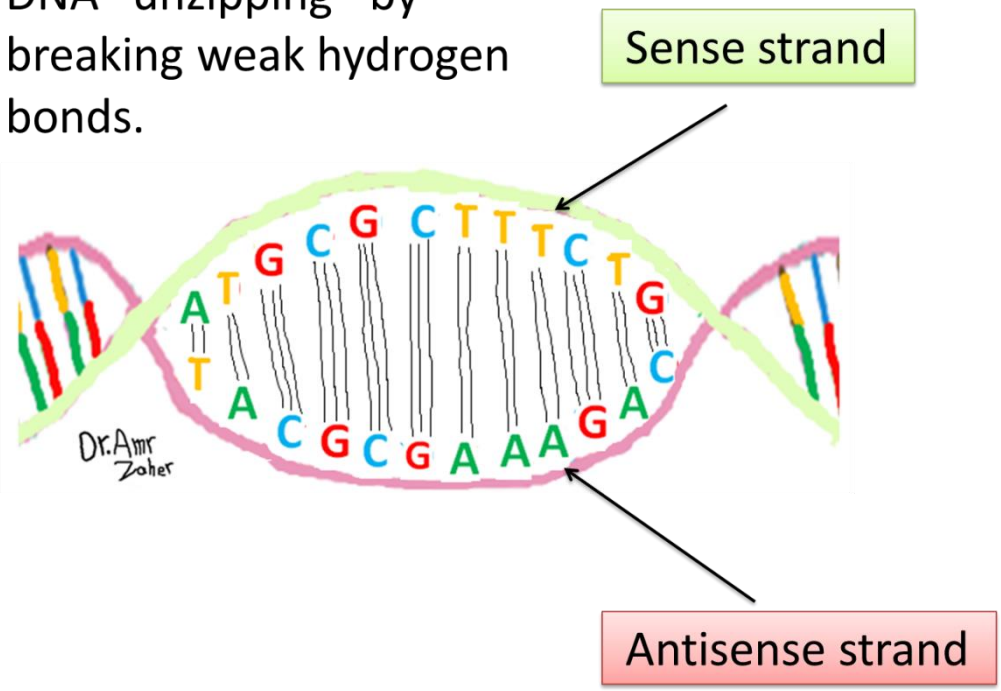
Sugar- phosphate backbone



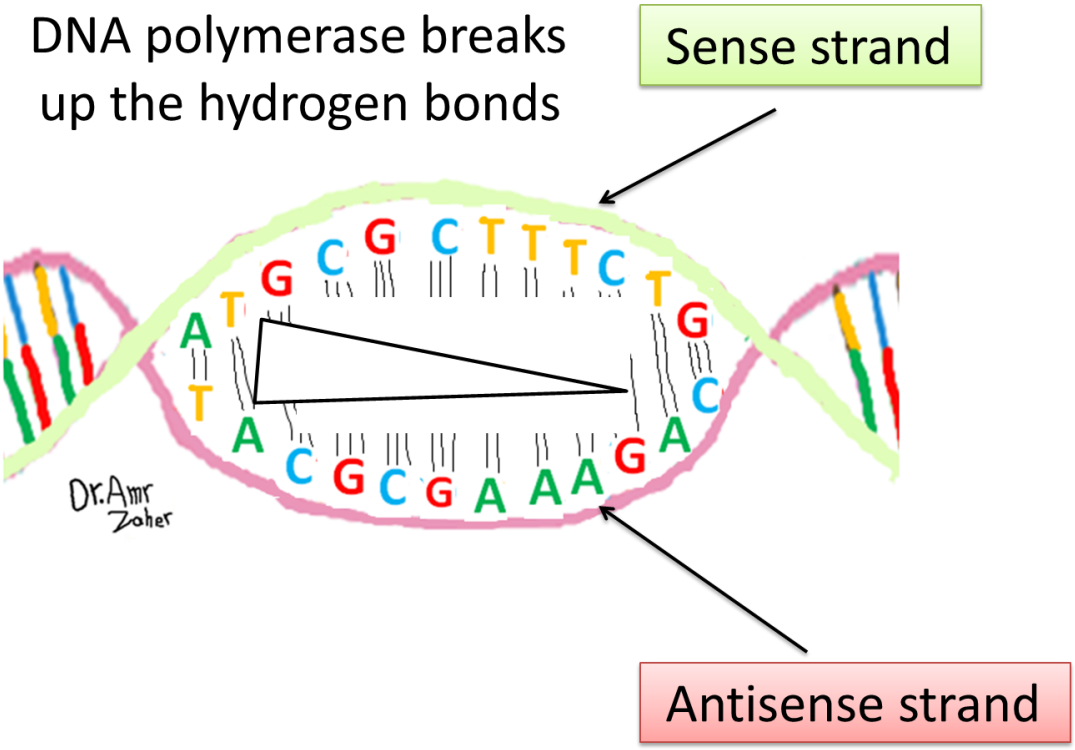
DNA undergo unwinding

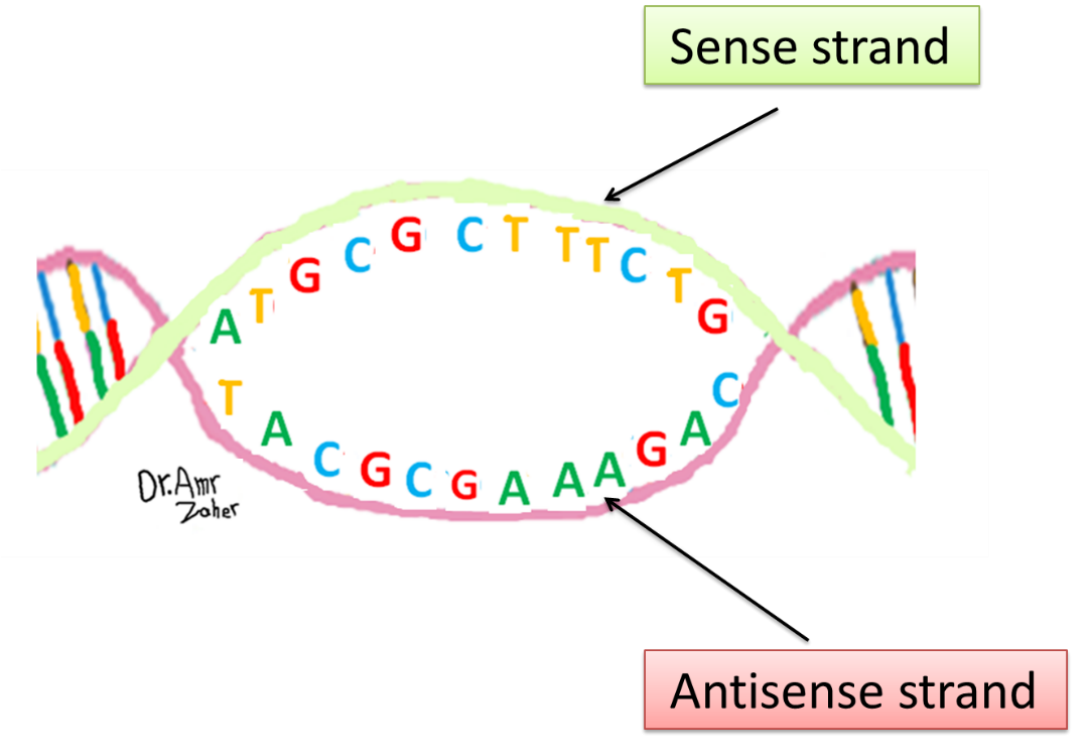


DNA “unzipping” by breaking weak hydrogen bonds.

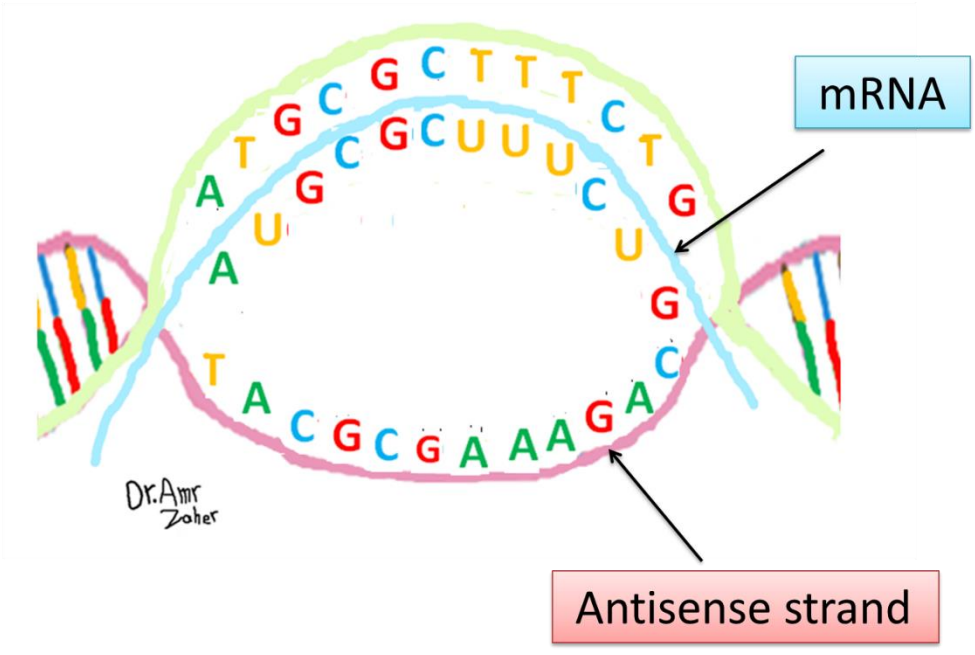


DNA polymerase breaks up the hydrogen bonds

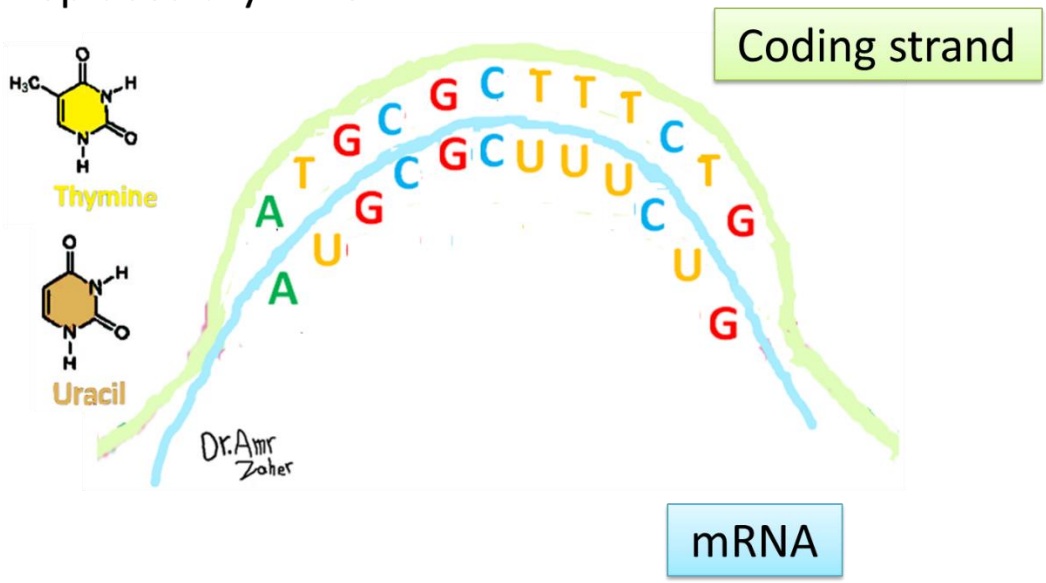




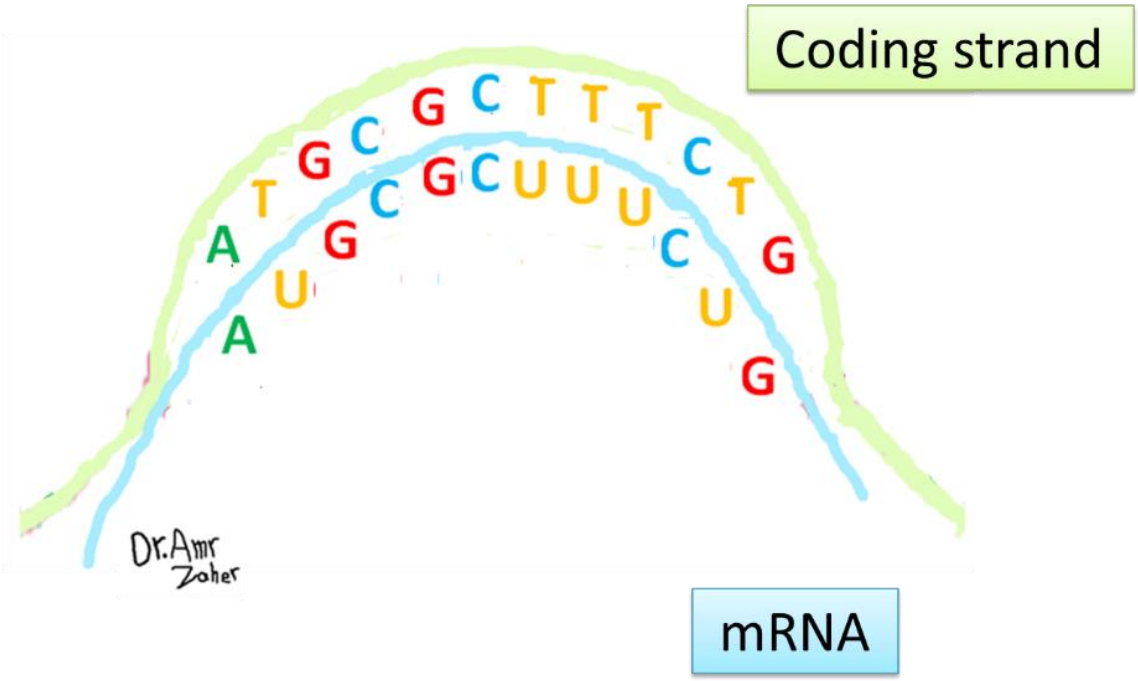
Antisense strand acts like a template for mRNA synthesis.



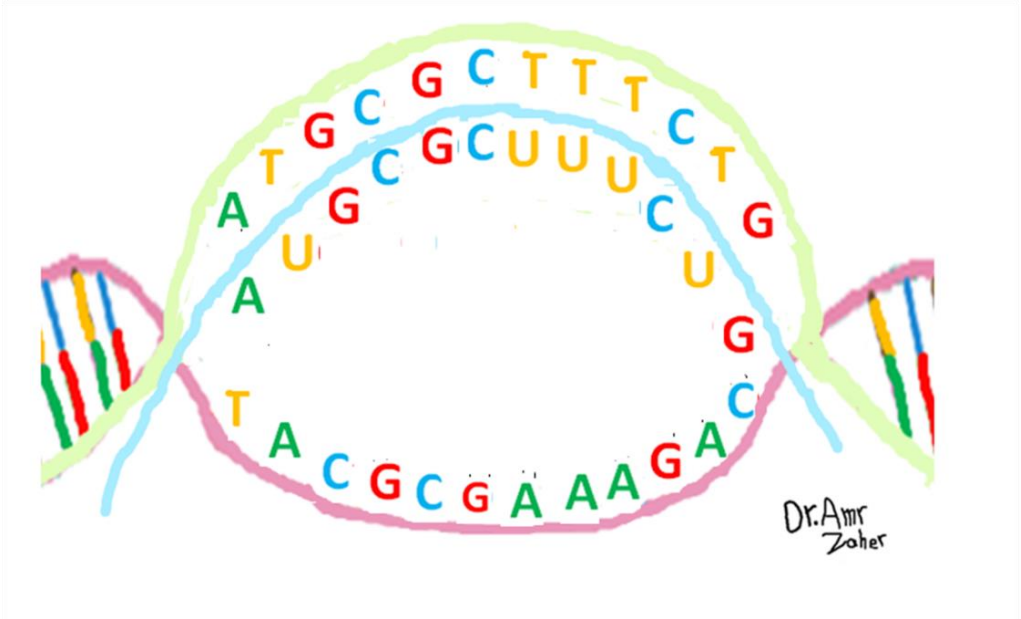
The sequence of nucleotides in the mRNA are the same like the sense strand except that uracil replaces thymine.



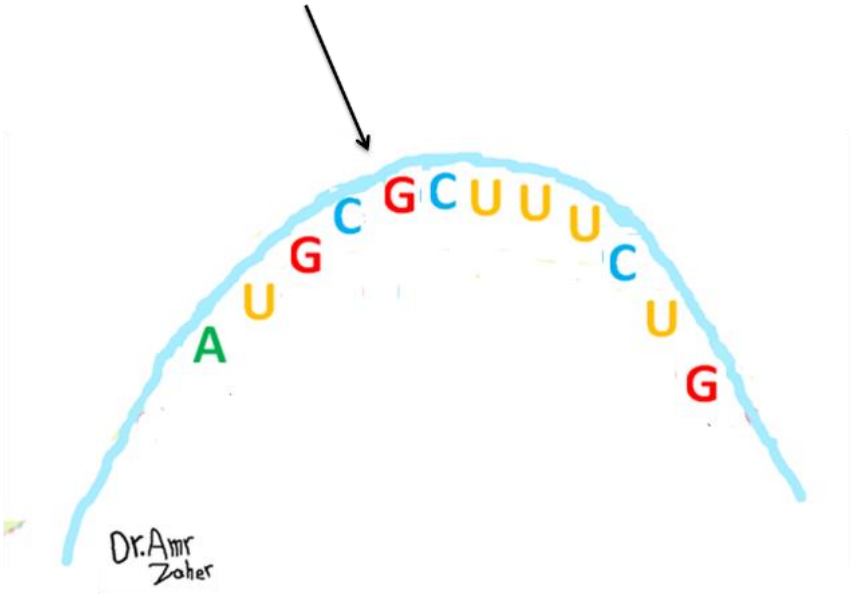
So it is the coding strand.



Messenger RNA carry the genetic information coded in the DNA.



- Back bone (phosphate group + sugar)

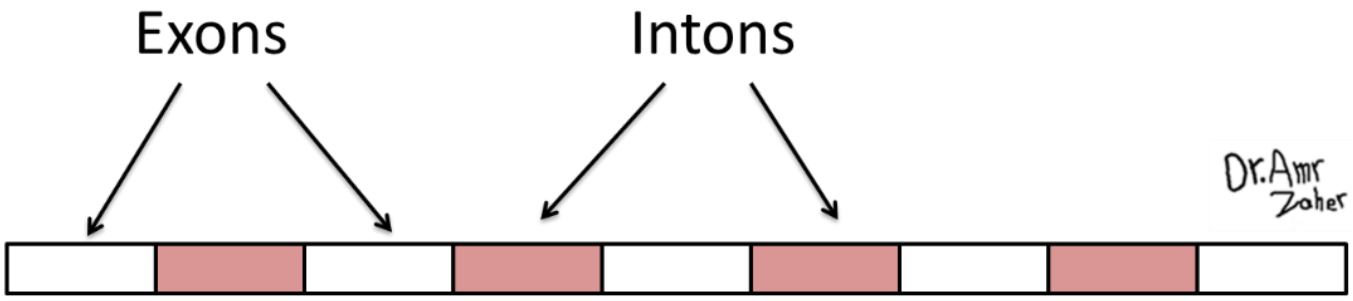


Pre-mRNA

Some noncoding DNA regions (junk DNA), called introns, are located within protein-coding genes but are removed before a protein is made.

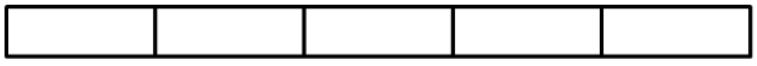
In humans, only about 2 percent of DNA actually codes for proteins.

- Introns (noncoding sections of an RNA) are spliced out before the RNA molecule is translated into a protein.
- The sections of RNA that code for proteins are called exons.



- Exons remain
- Intons removed

Pre-mRNA

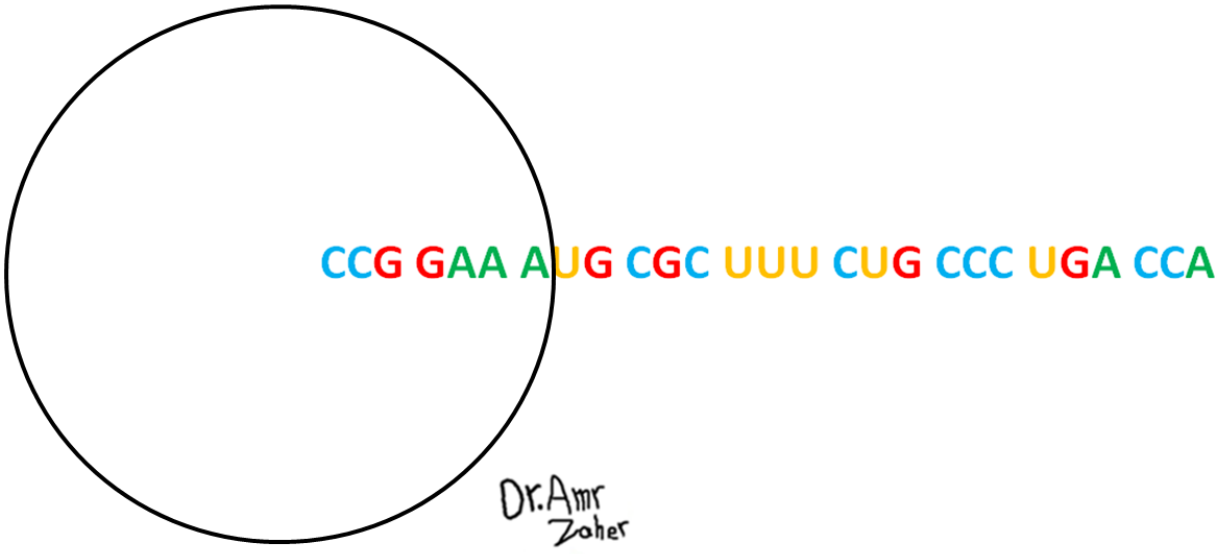


mRNA

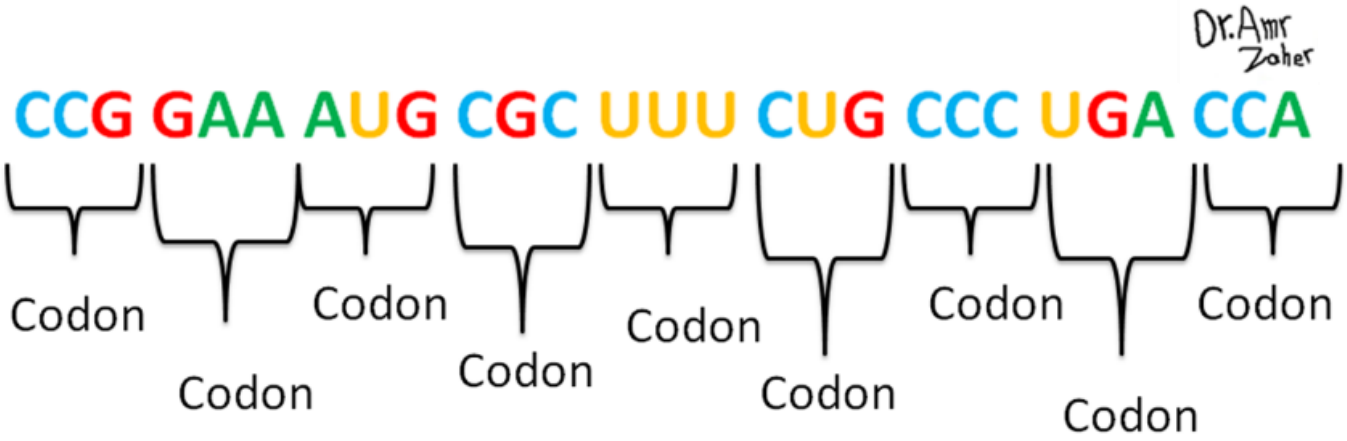
Translation

- Is the process of converting the information stored in mRNA, and using it to build a protein.

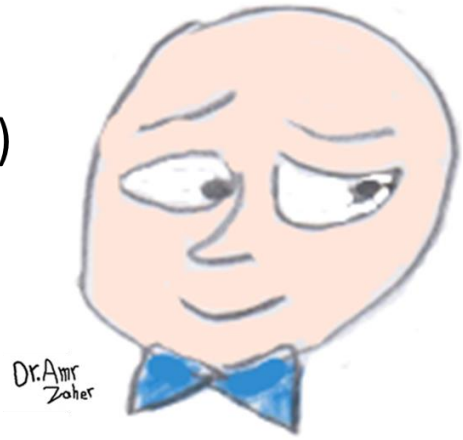
mRNA enter the cytoplasm



- Each three-letter sequence of mRNA (triplet) nucleotides are called a codon.



- Each codon (a group of three nucleotides) corresponds to a single amino acid.



- A codon either:
  - Codes for a particular amino acid.
  - Tells the ribosome to start or stop using the code.

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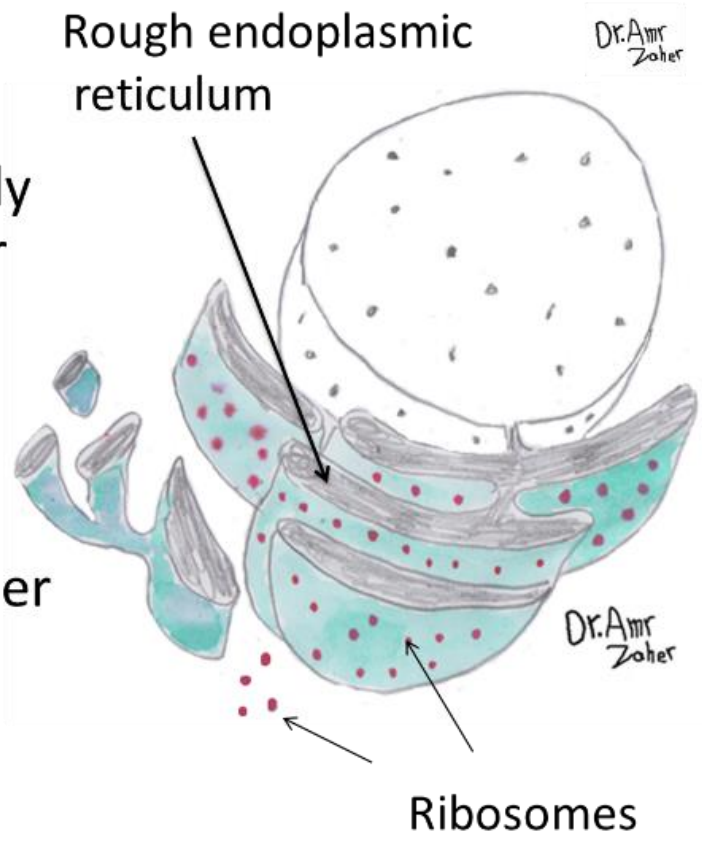
- 1 start codon — AUG
- 3 stop codons — UAA, UGA, UAG

- The start codon (AUG) is the codon for amino acid methionine.

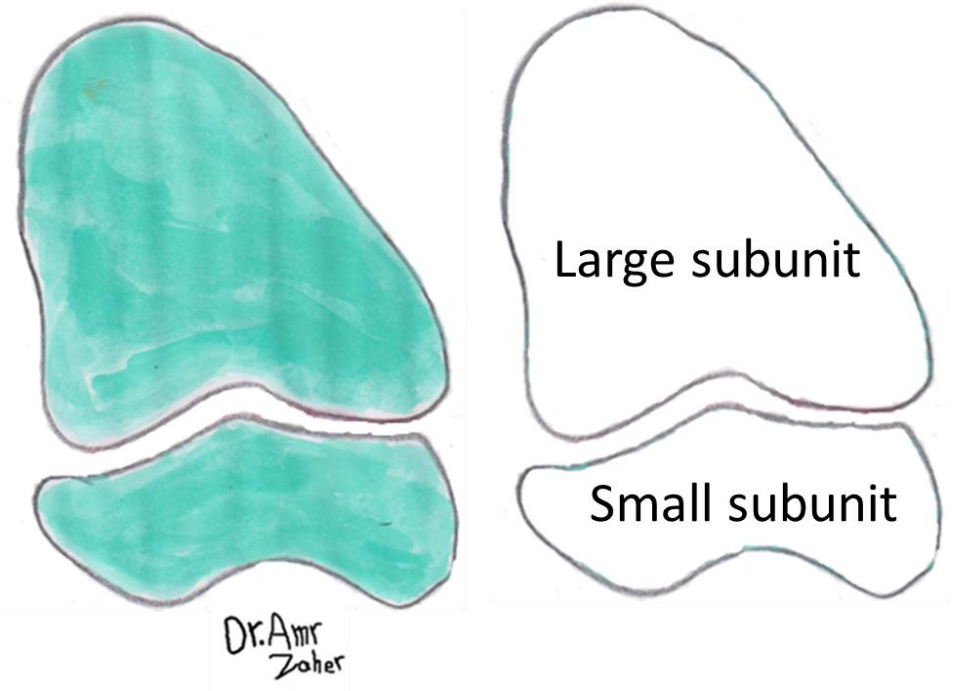
Ribosome

- Ribosomes can be found floating freely in the cytoplasm or attached to rough endoplasmic reticulum.
- Function: bringing amino acids together to form a protein.



- A ribosome consists of ribosomal RNA (rRNA) and a variety of ribosomal proteins.

- A ribosome consists of a large subunit and a small subunit.



Large subunit

Small subunit

- The small subunit of the ribosome will bind to the mRNA.

CCG GAA AUG CGC UUU CUG CCC UGA CCA

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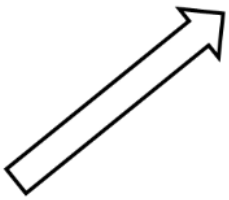
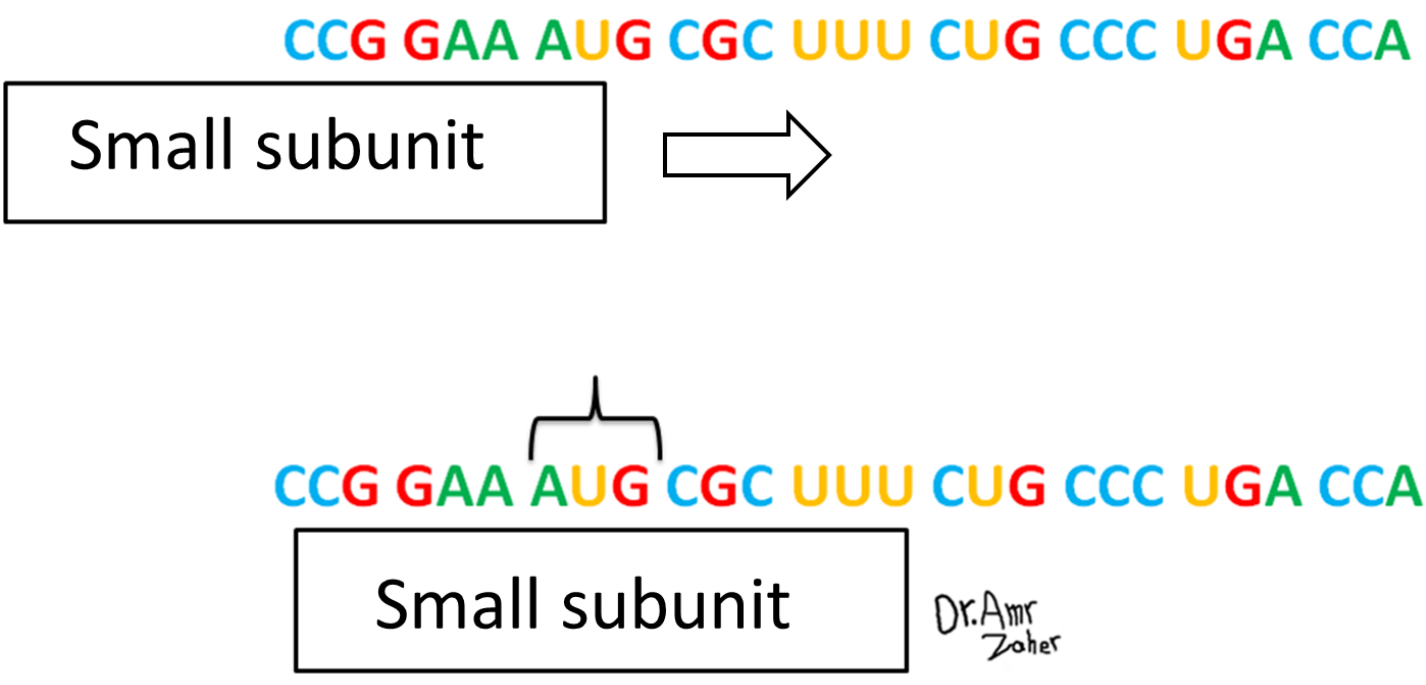
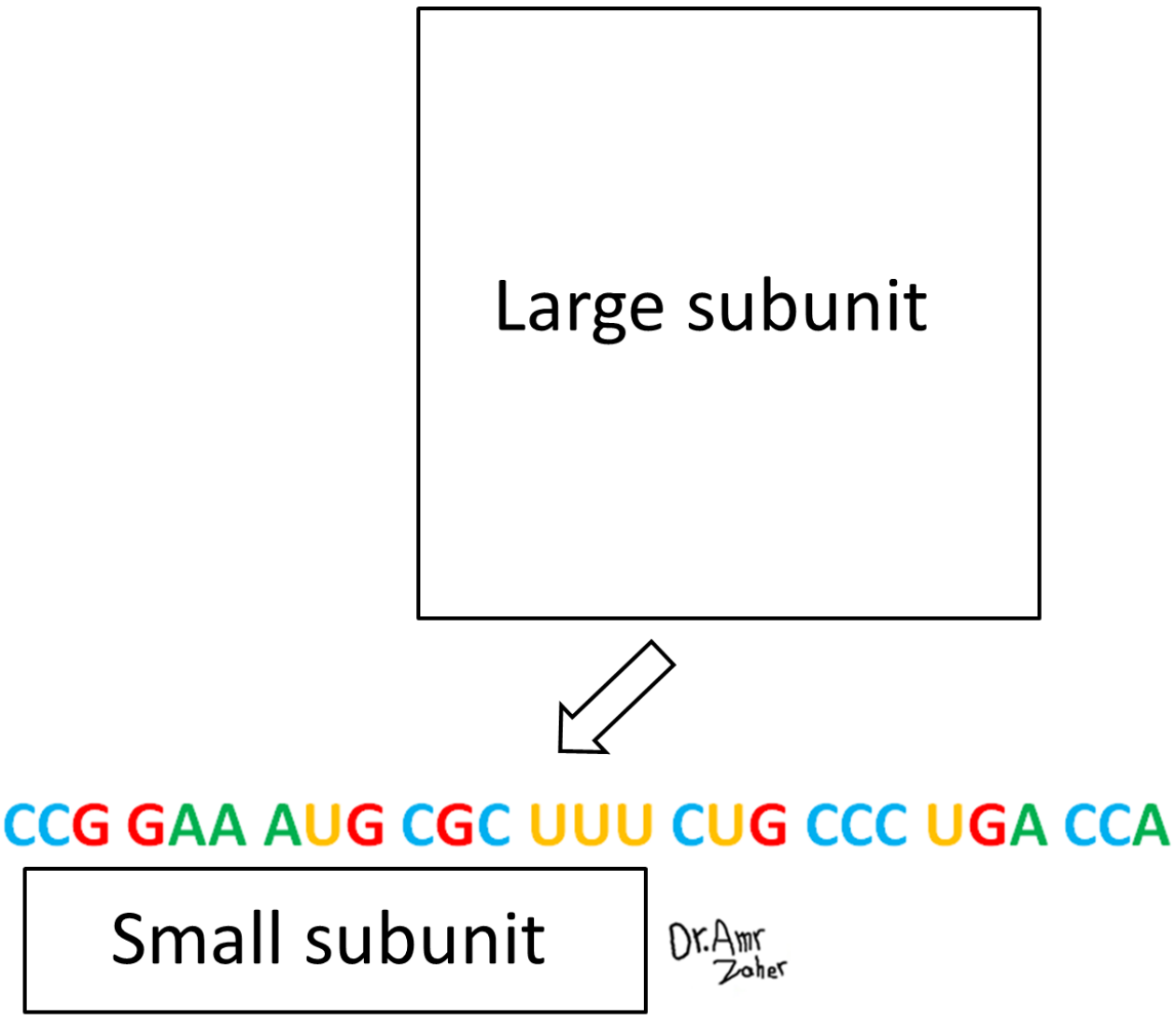


Small subunit

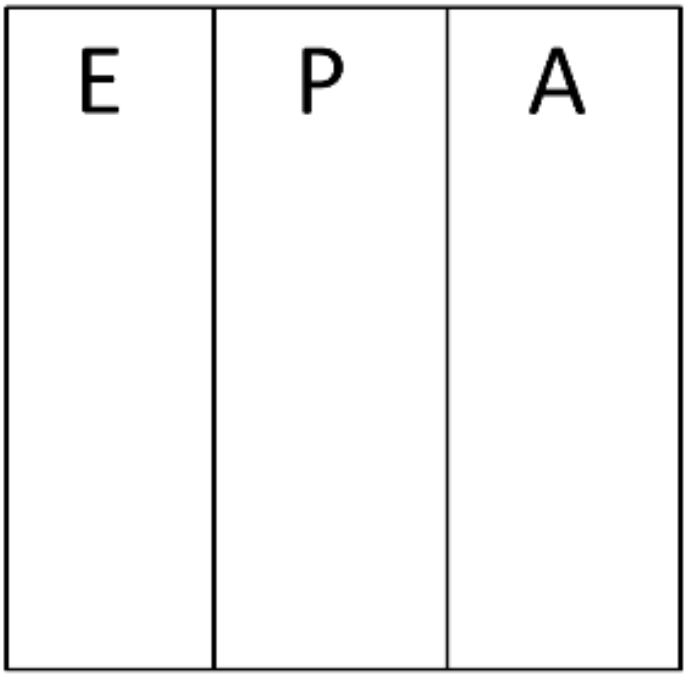
- Then it will scan along the mRNA until it finds the start codon (AUG).



- After it finds the start codon , the large subunit will attach to the complex.



- The large subunit consists of 3 sites.



CCG GAA AUG CGC UUU CUG CCC UGA CCA

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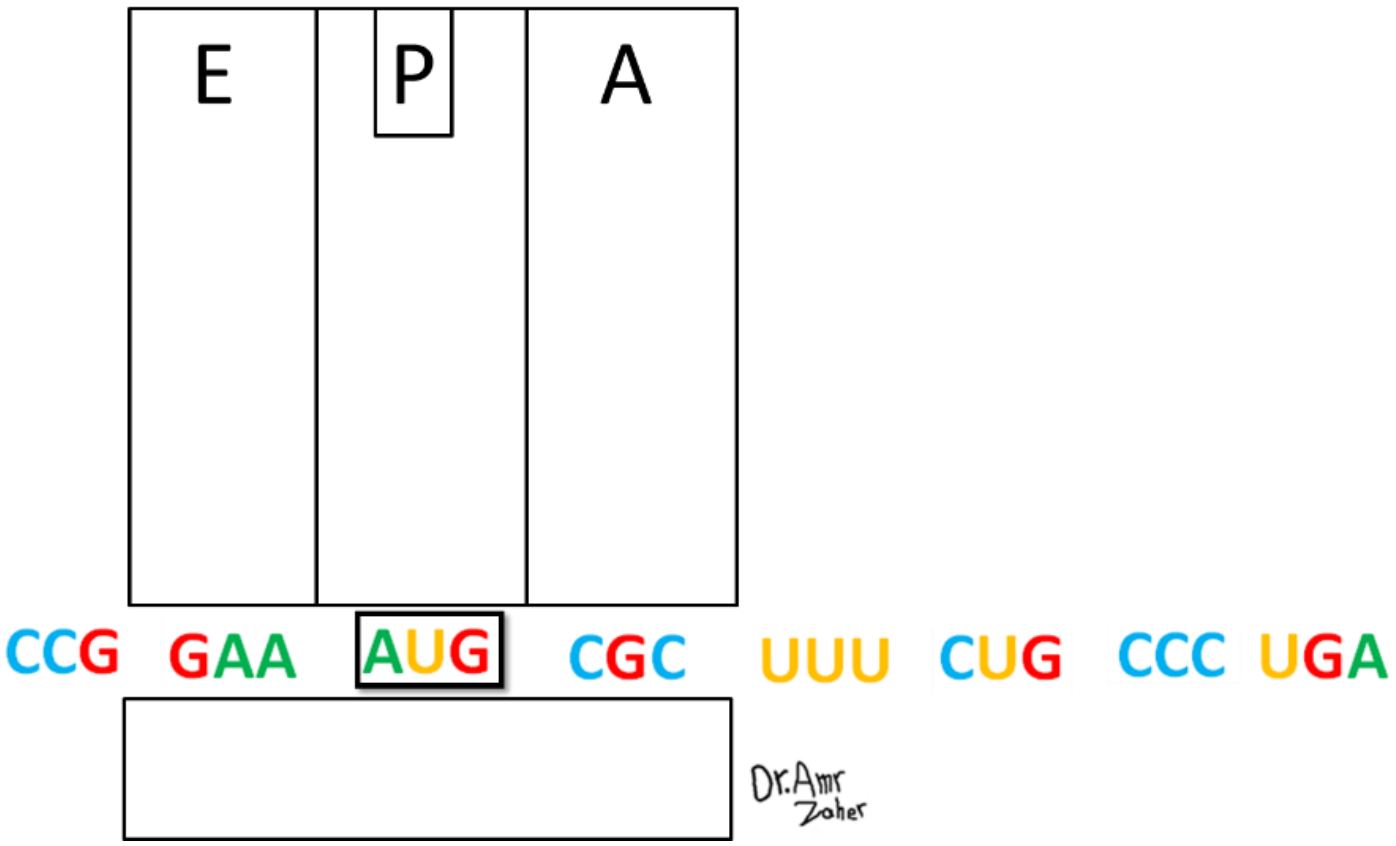
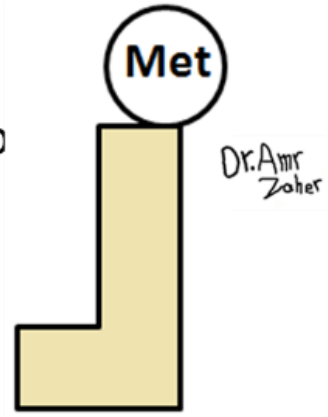
- The large subunit aligns the AUG codon (start codon) with in its P site location



- Then a transfer ribonucleic acid (tRNA) which has an anticodon complementary to the start codon will come into the P site in hydrogen bonds to that codon.

- But, what is a transfer ribonucleic acid (tRNA)?
- It is a type of RNA molecule that decodes a mRNA sequence into a protein.

- It carries a particular amino acid,

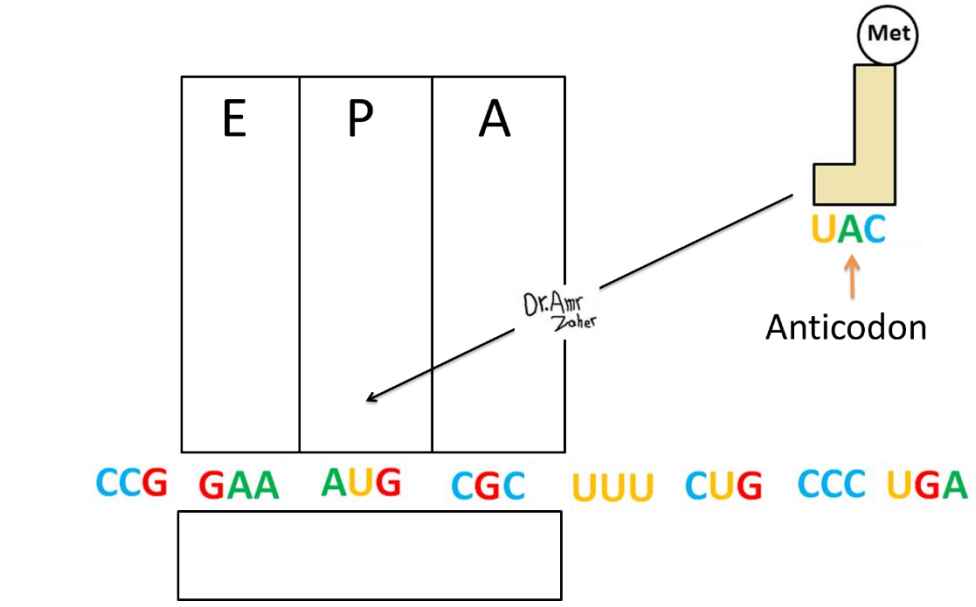


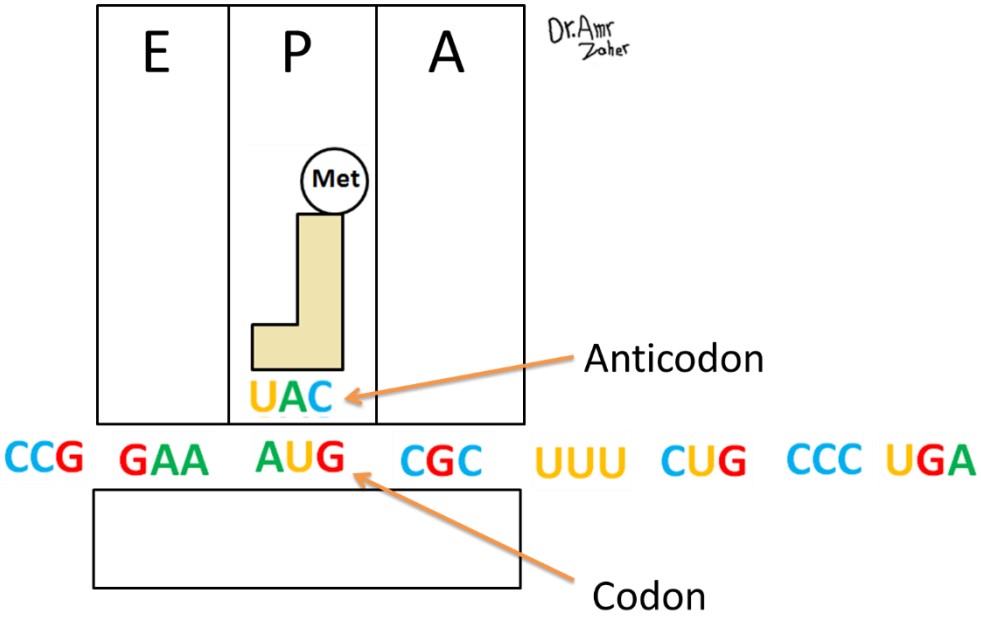
- It has anticodon complementary to codon on the mRNA.

- An anticodon is a three-base sequence on tRNA that matches a codon.

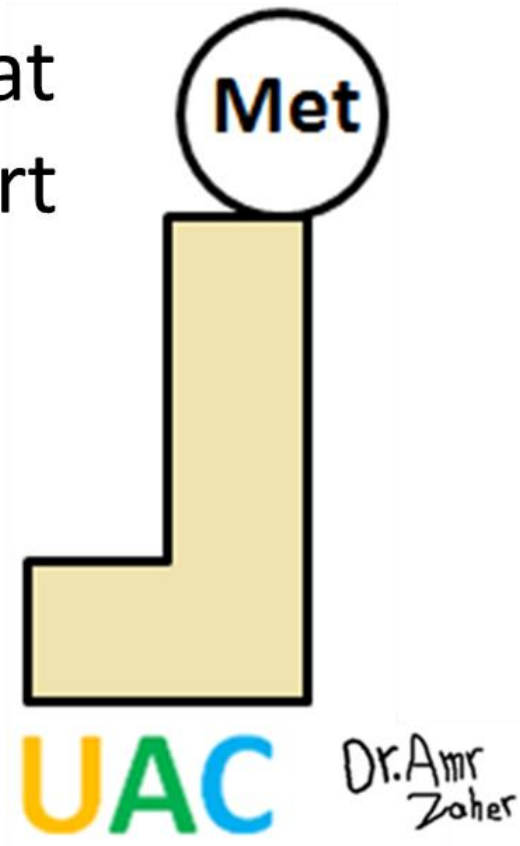
Anticodon	GCG	AAA
Codon	CGC	UUU

- Then a transfer ribonucleic acid (tRNA) which has an anticodon complementary to the start codon will come into the P site in hydrogen bonds to that codon.

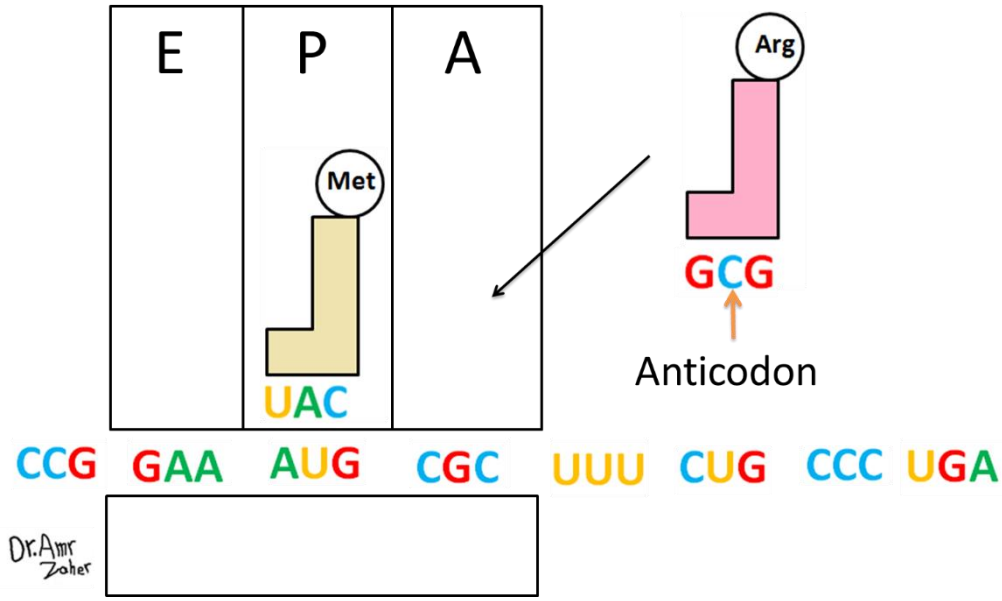




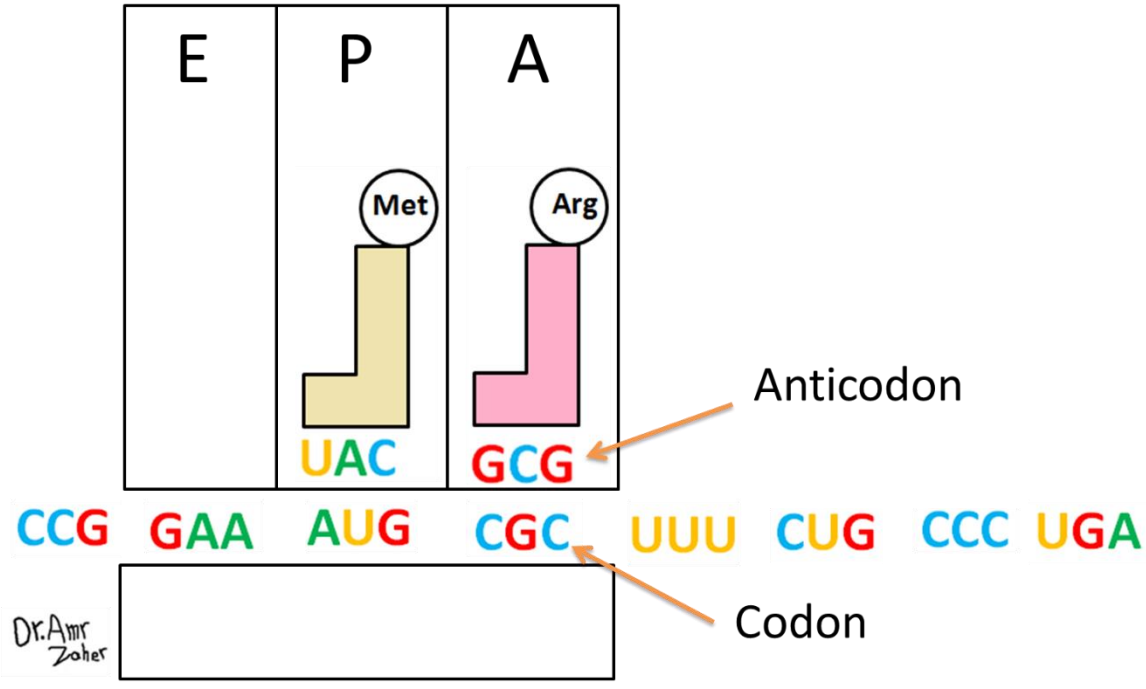
- The amino acid that attached to the start codon is always **methionine.**



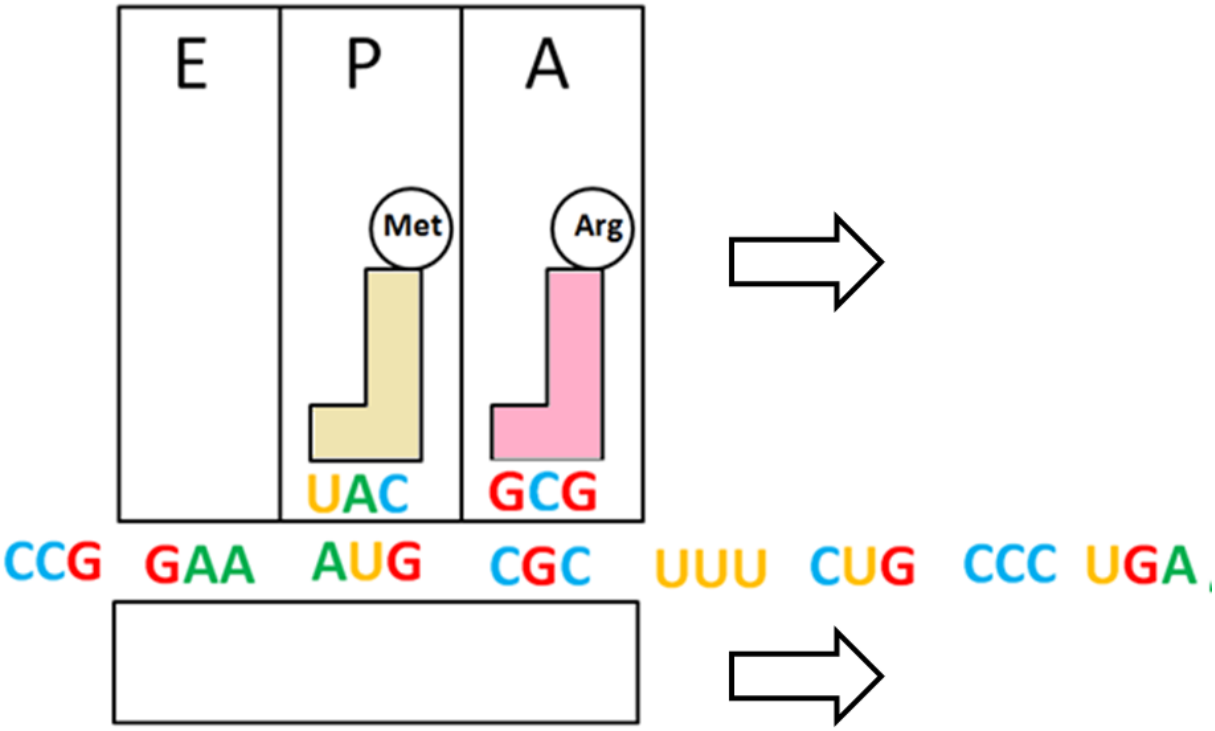
- A second tRNA molecule will enter the A site of the ribosome.

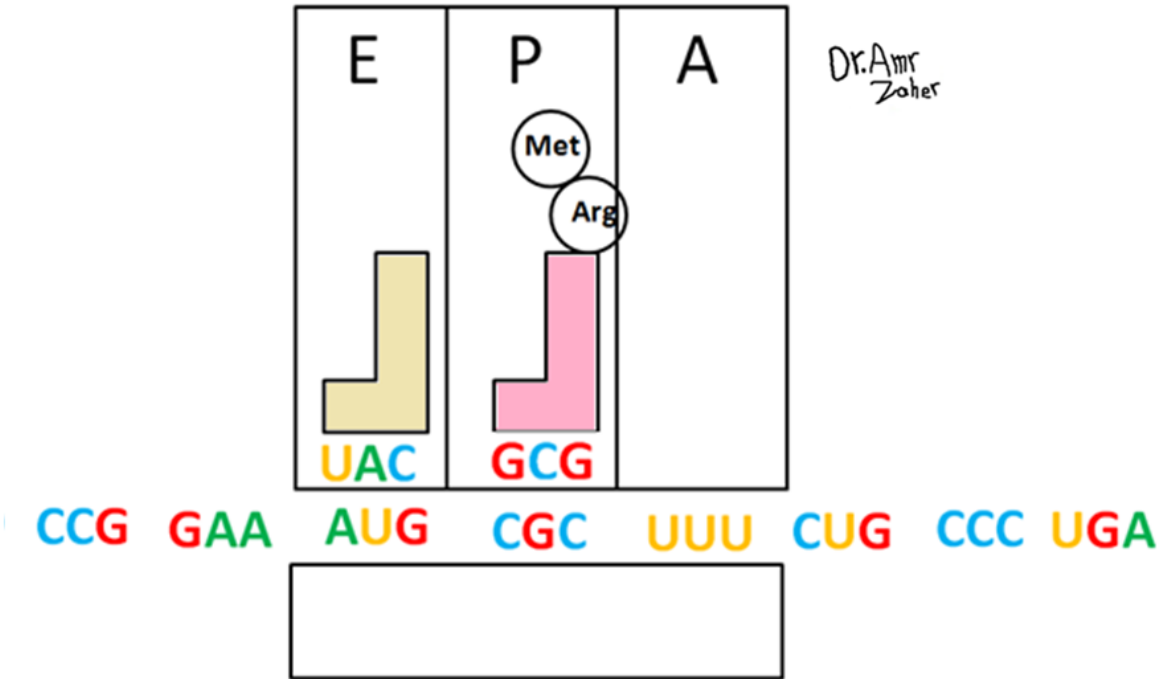


- Where its anticodon will interact with the codon aligned with this site.

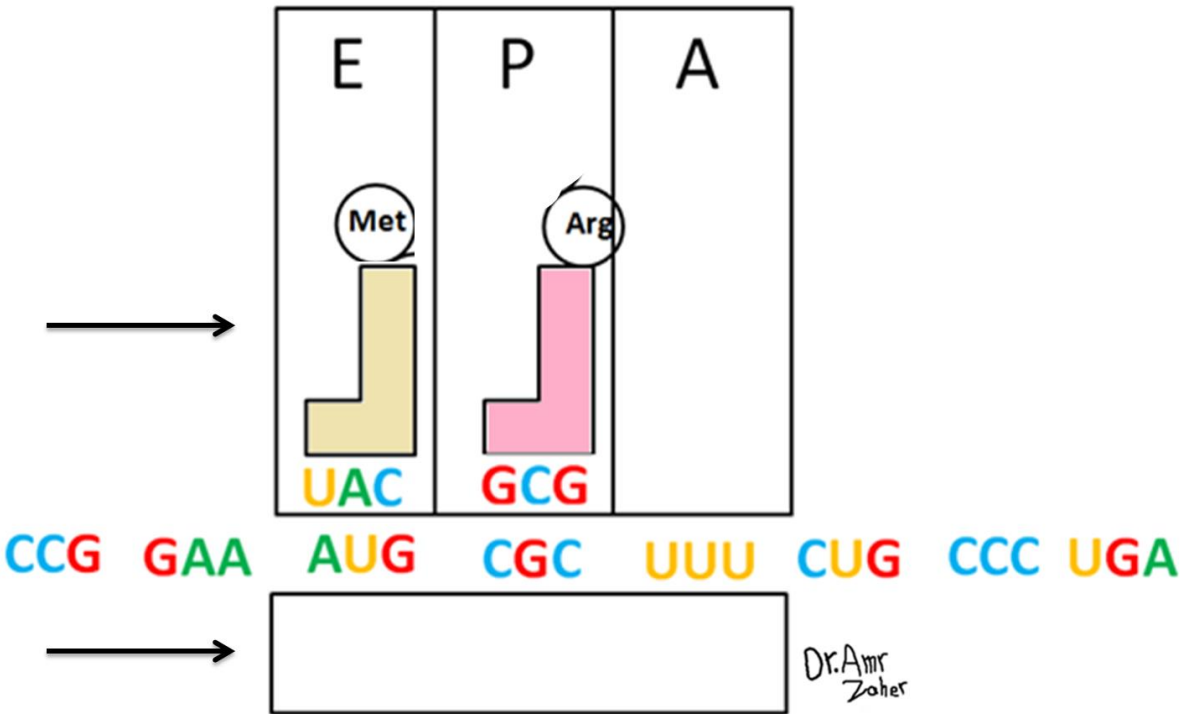


Ribosome moves left to right along mRNA.

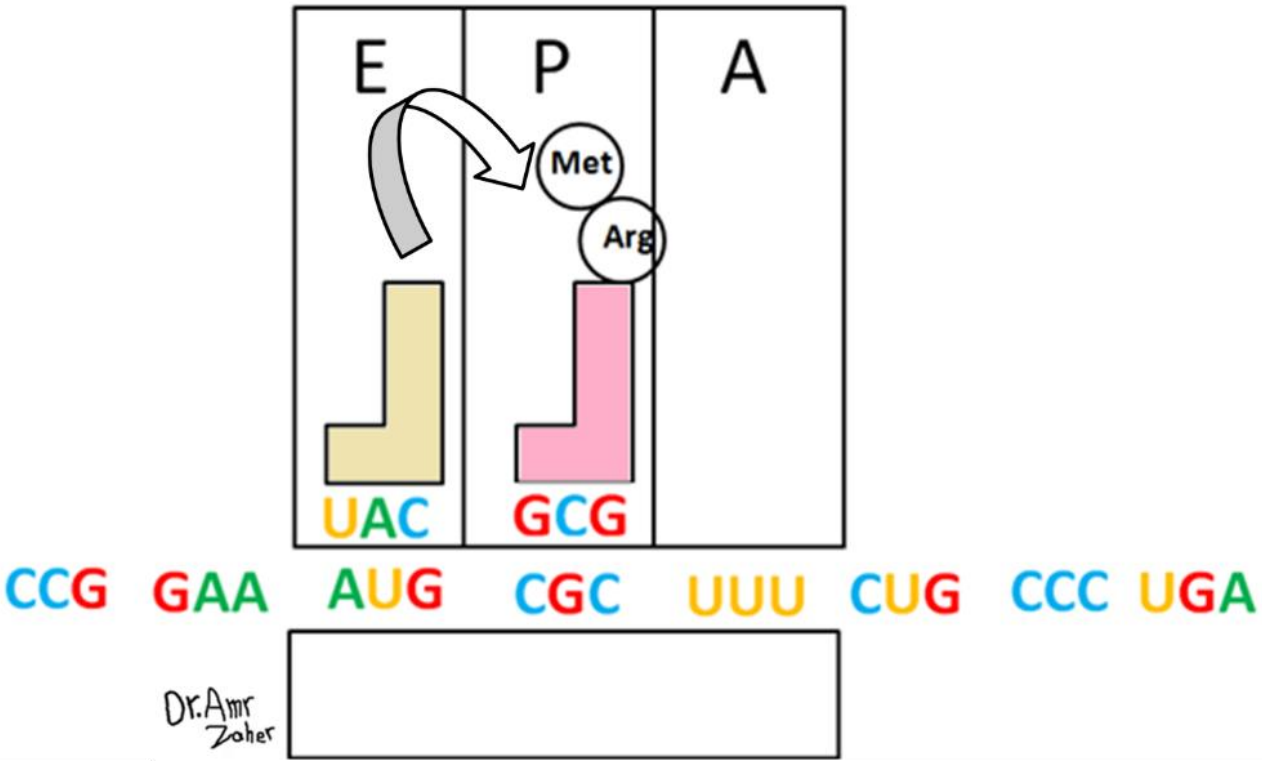




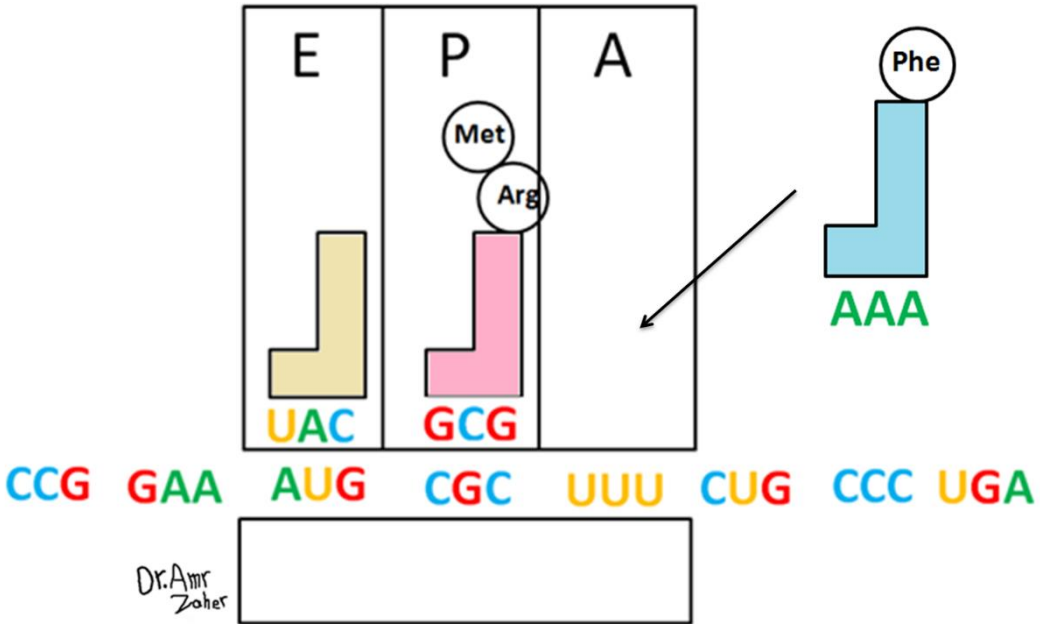
- Moving the first tRNA molecule into its E site, and the second tRNA molecule into its P site, leaving A site open for another tRNA molecule.

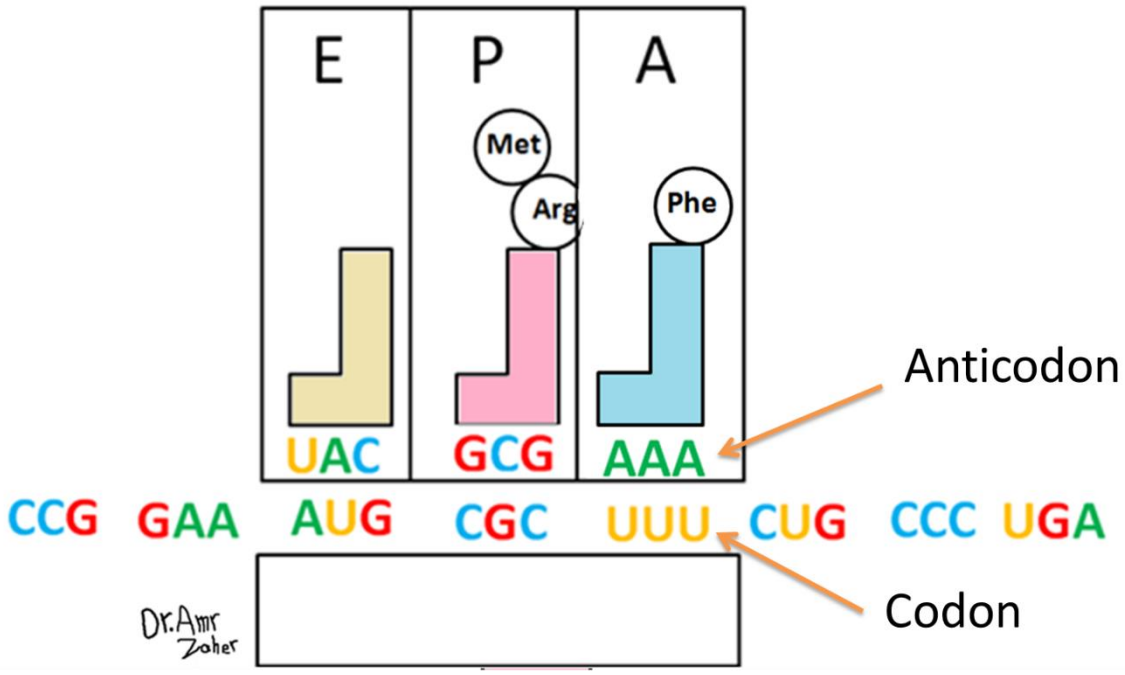


- During this transition, the amino acid from the first tRNA is transferred to the amino acid that still attached to the second tRNA molecule
- A covalent bond (peptide bond) will form between the 2 amino acids.

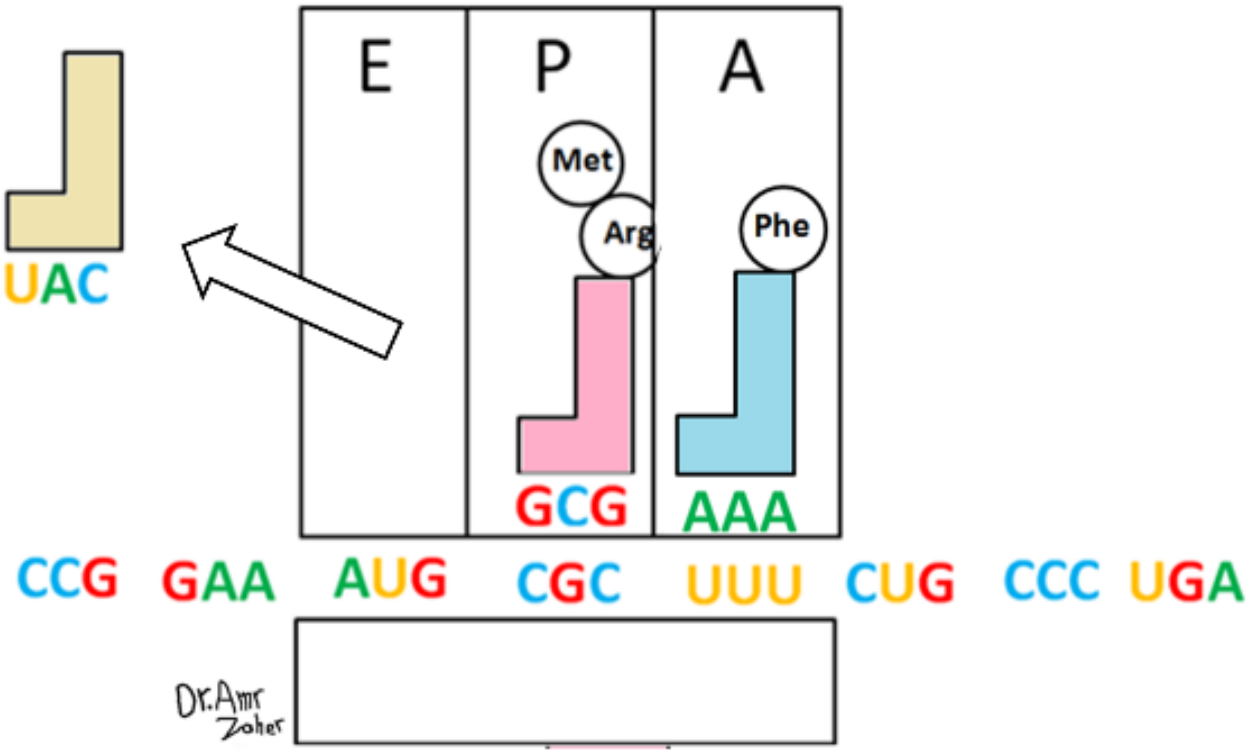


- A third mRNA will join the A site, where its anticodon will interact with the codon.

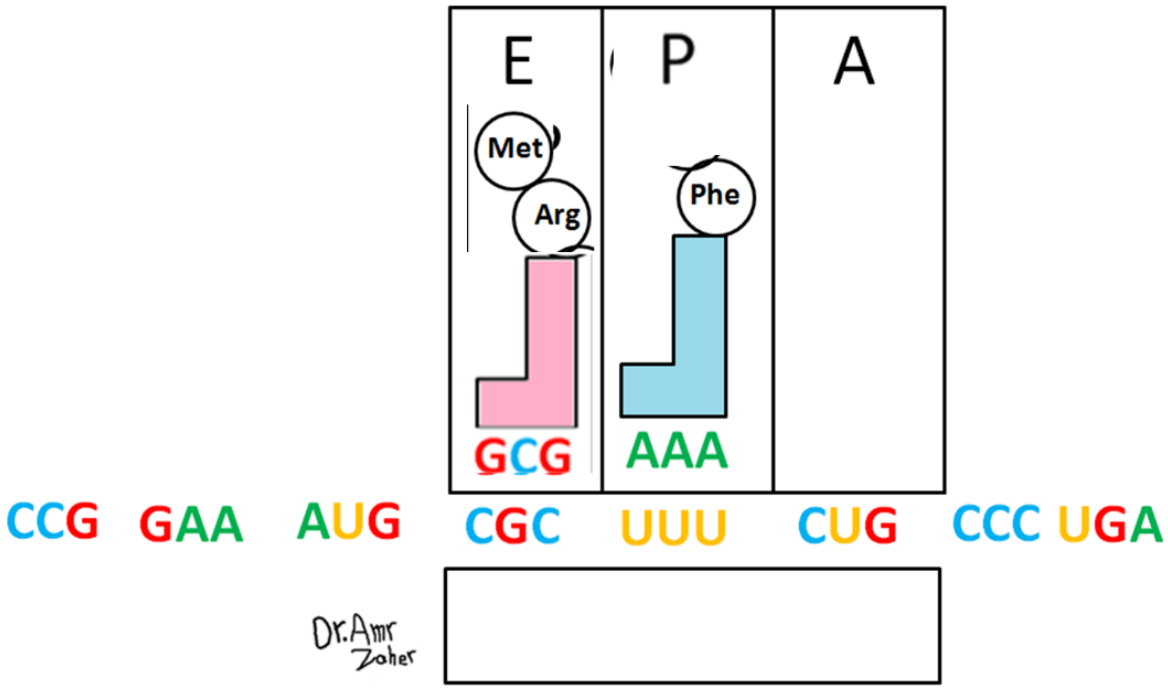




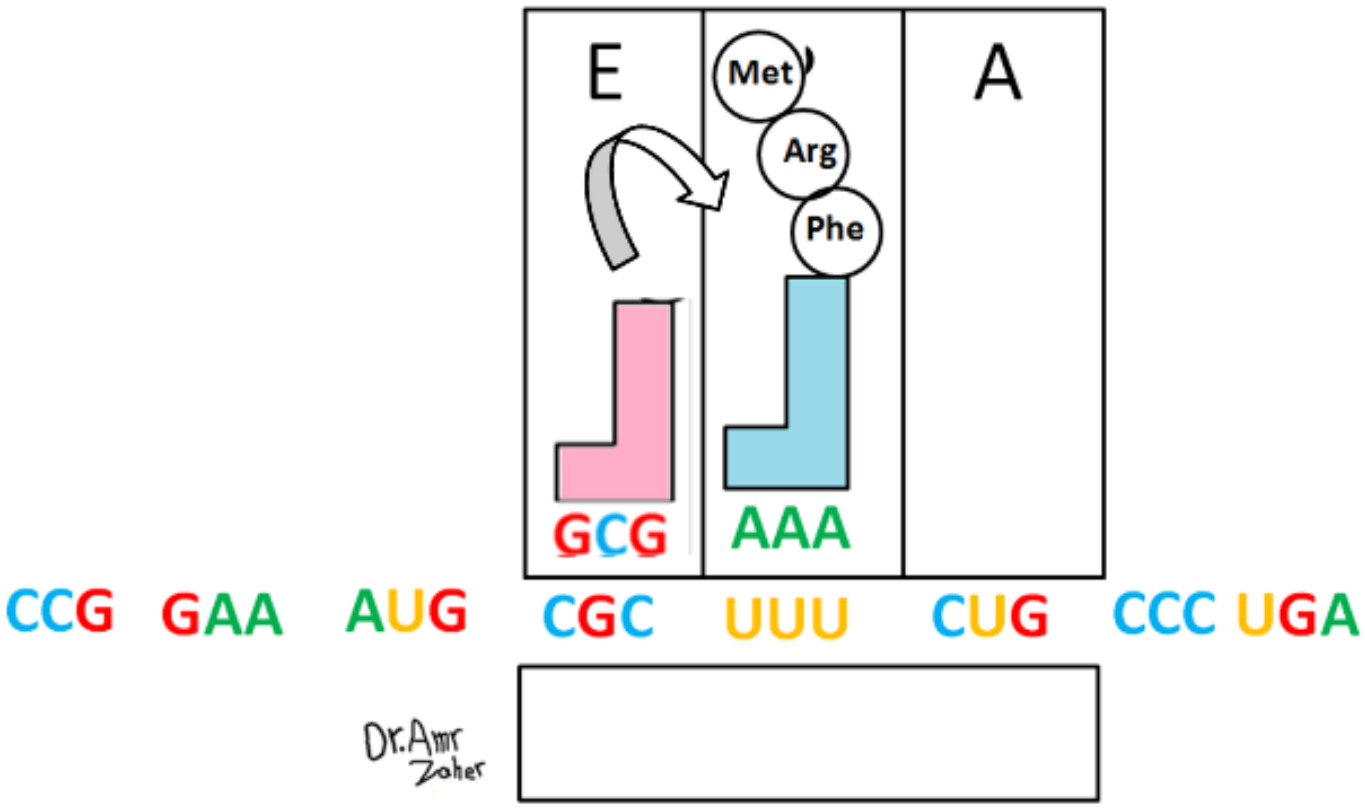
- The tRNA molecule that now doesn't have an attached amino acid is then ejected from the ribosome, detaching from the mRNA
- Moving back into the cytoplasm, where will eventually attached to a new amino acid and be available for translation one again.



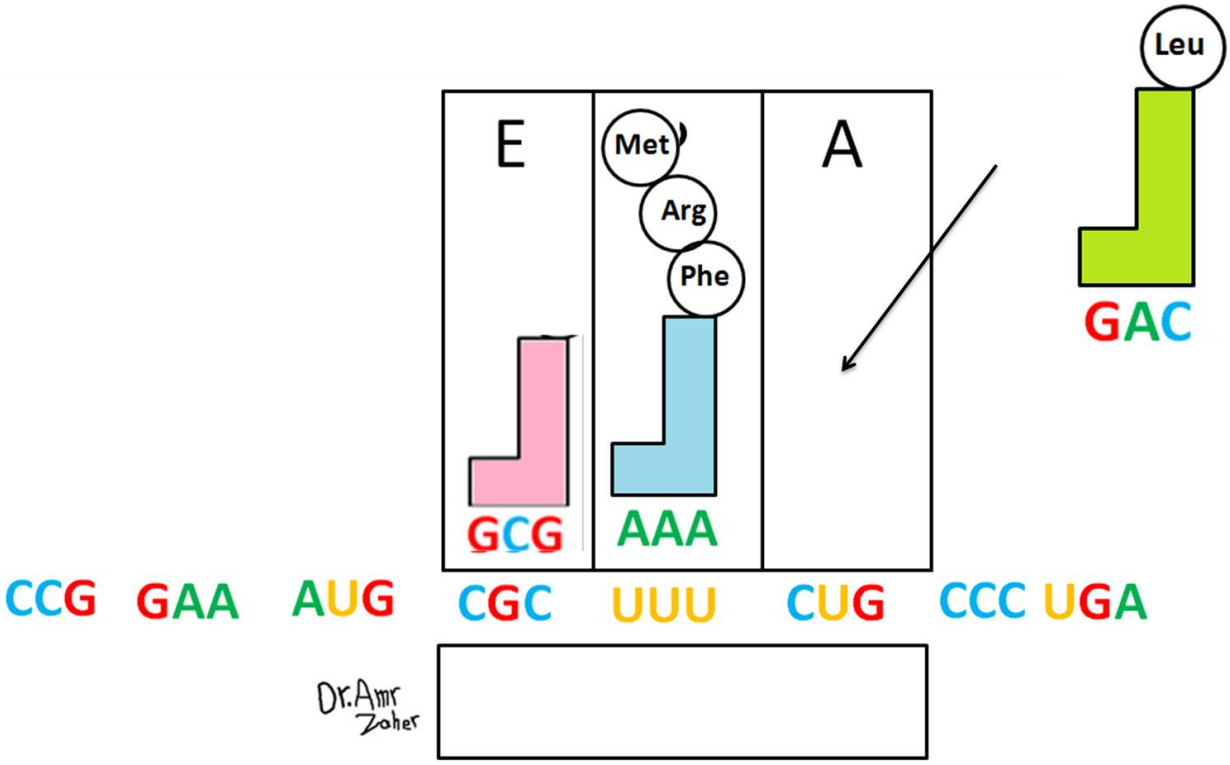
- Moving the second tRNA molecule into its E site, and the third tRNA molecule into its P site, leaving A site open for another tRNA molecule.

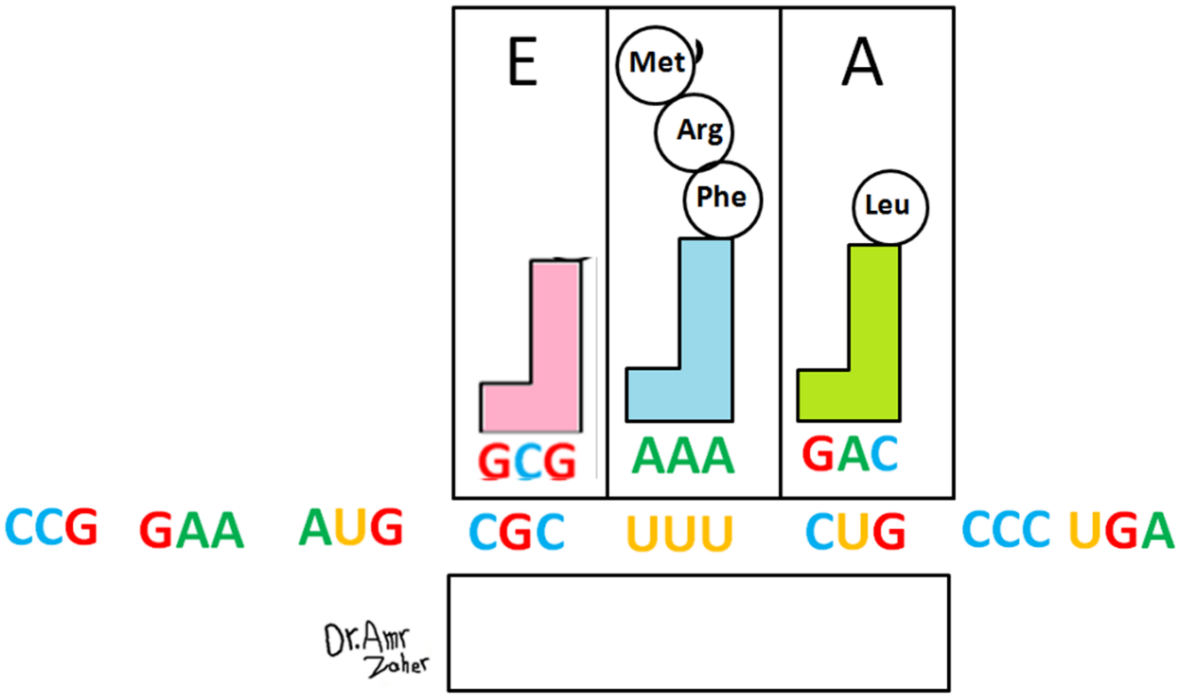


- The amino acid from the second tRNA is transferred to the amino acids that still attached to the third tRNA molecule



- The process continued, a fourth tRNA molecule will come into the A site




E
Met
Arg
Phe
A
Leu
GCG
AAA
GAC
CCG GAA AUG CGC UUU CUG CCC UGA
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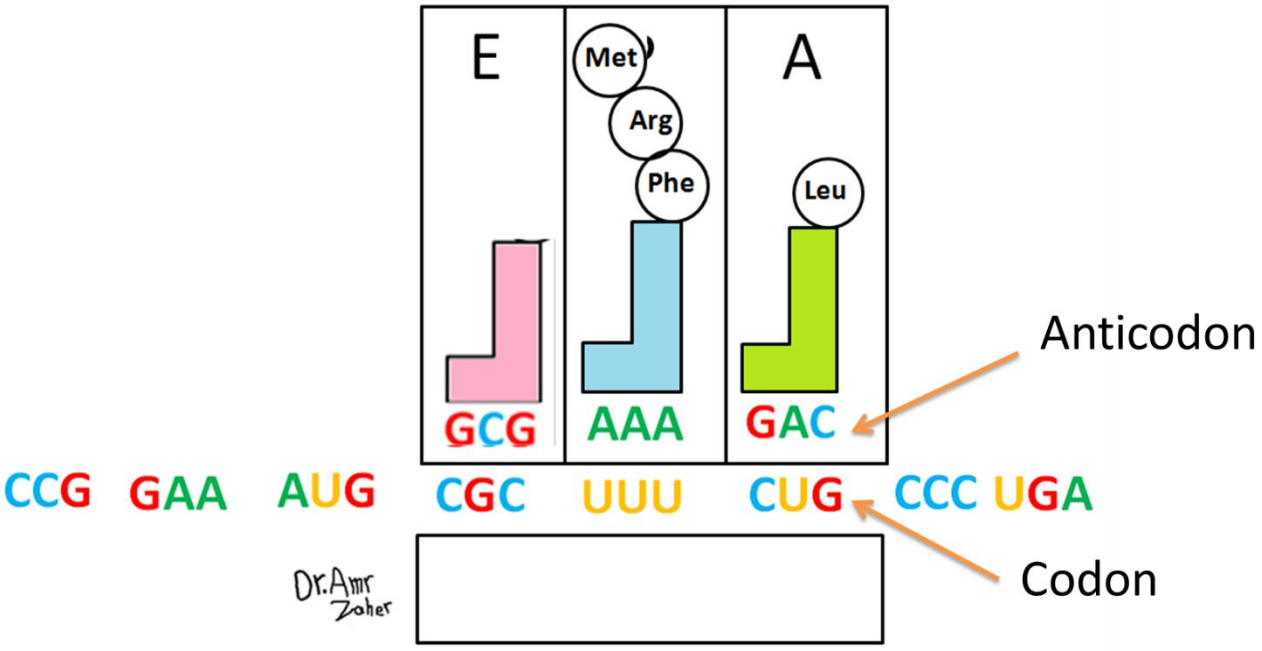
E
Met
Arg
Phe
A
Leu
GCG
AAA
GAC
Anticodon
CCG GAA AUG CGC UUU CUG CCC UGA
Codon
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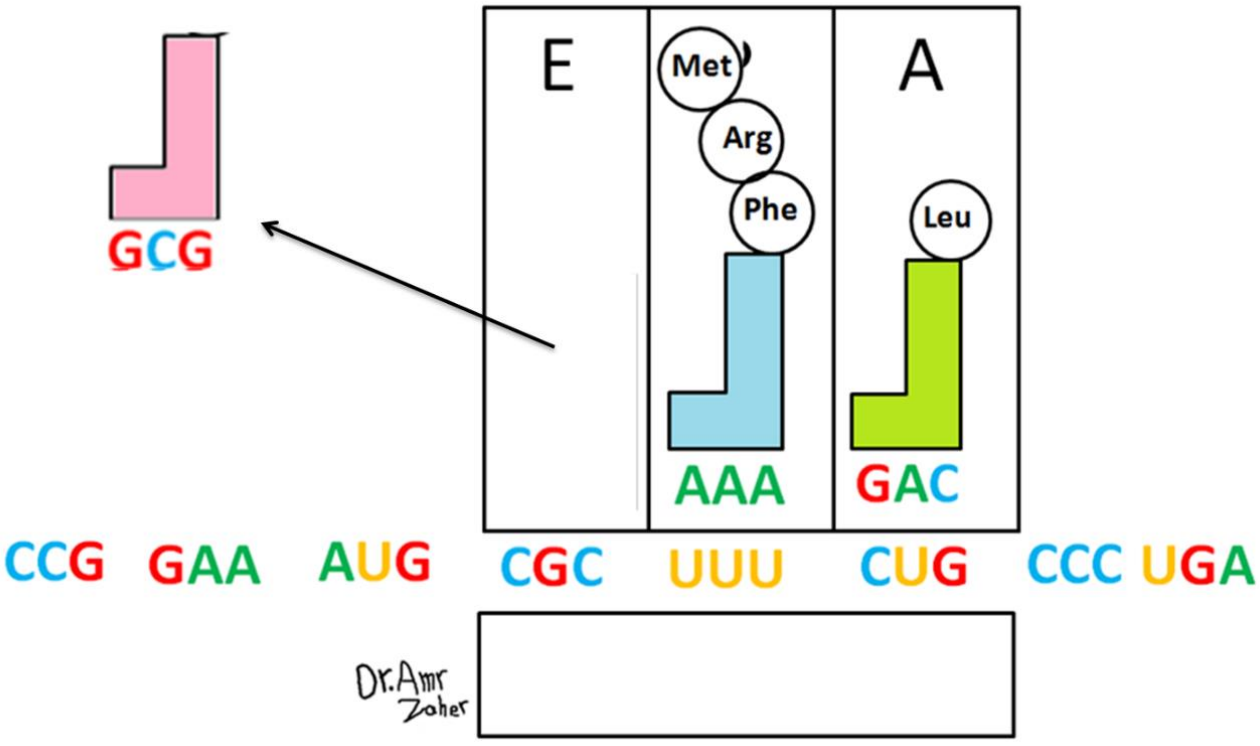
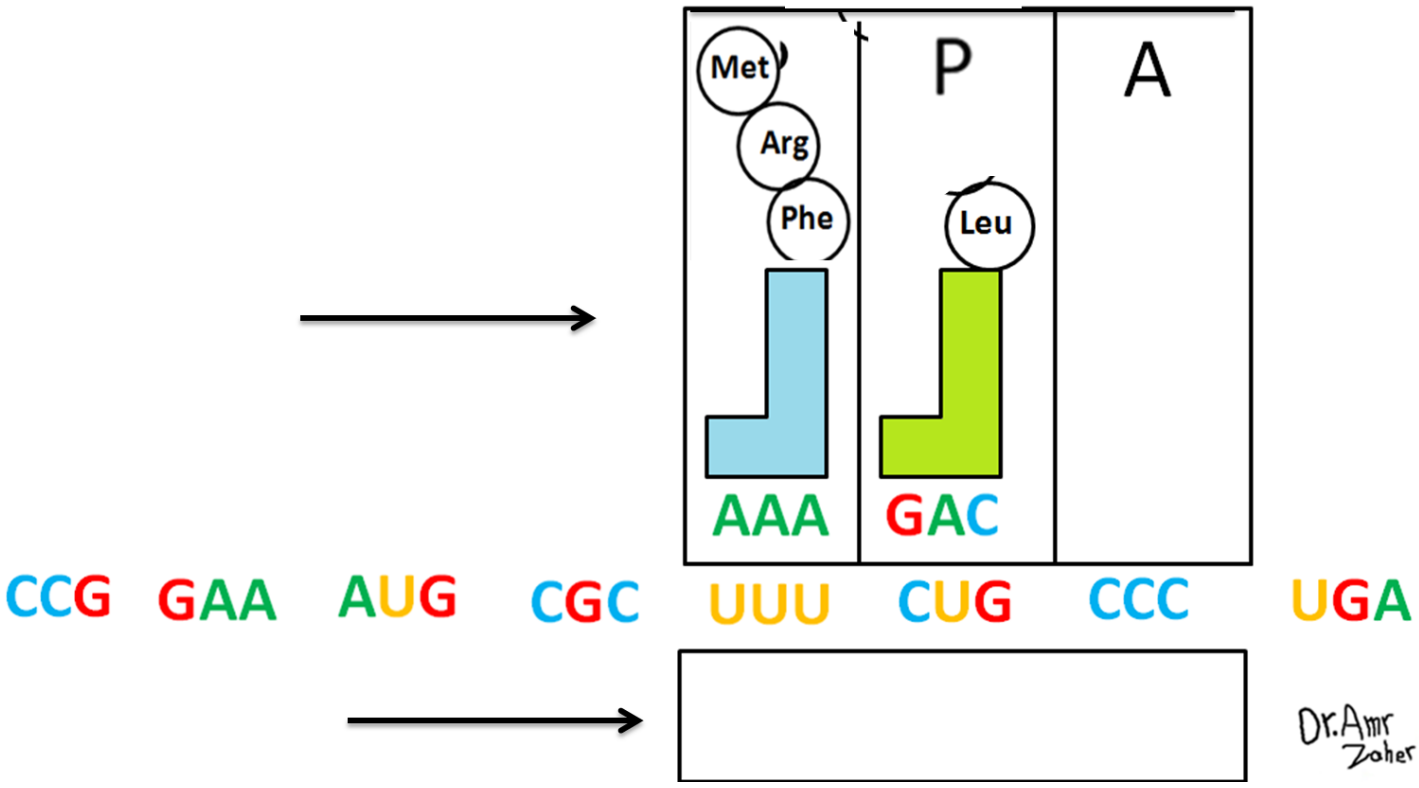
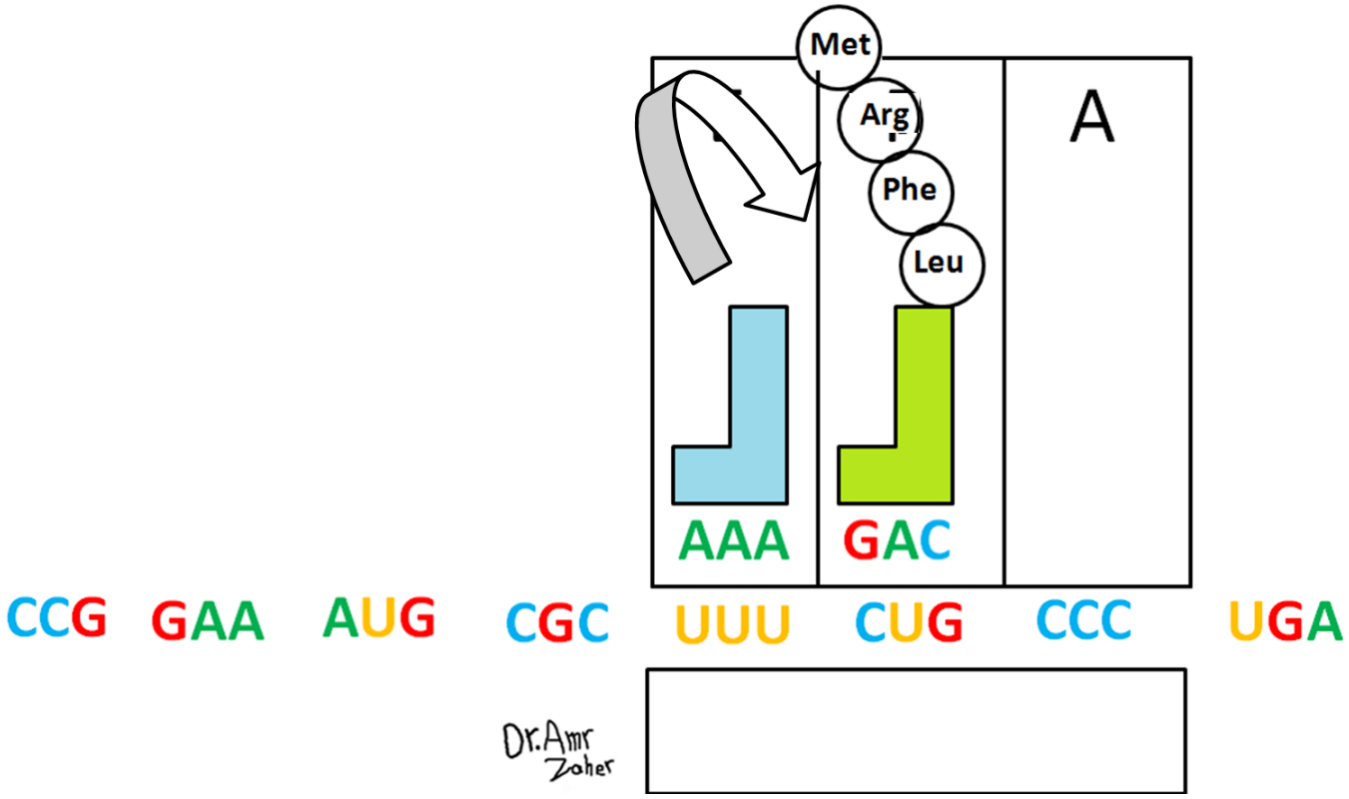
- The tRNA molecule that now doesn't have an attached amino acid is then ejected from the ribosome, and can be reused again.



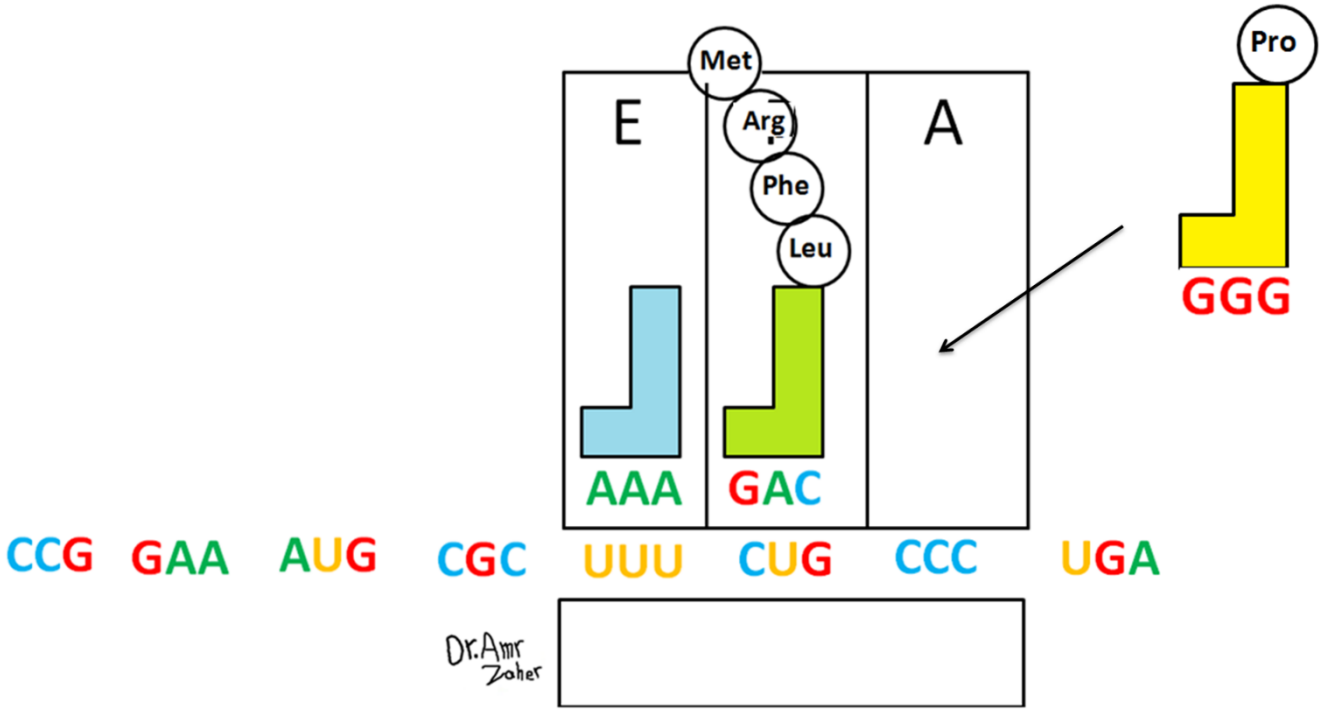
- The ribosome simply moves down to the next codon.
- Moving the third tRNA molecule into its E site, and the fourth tRNA molecule into its P site, leaving A site open for another tRNA molecule.

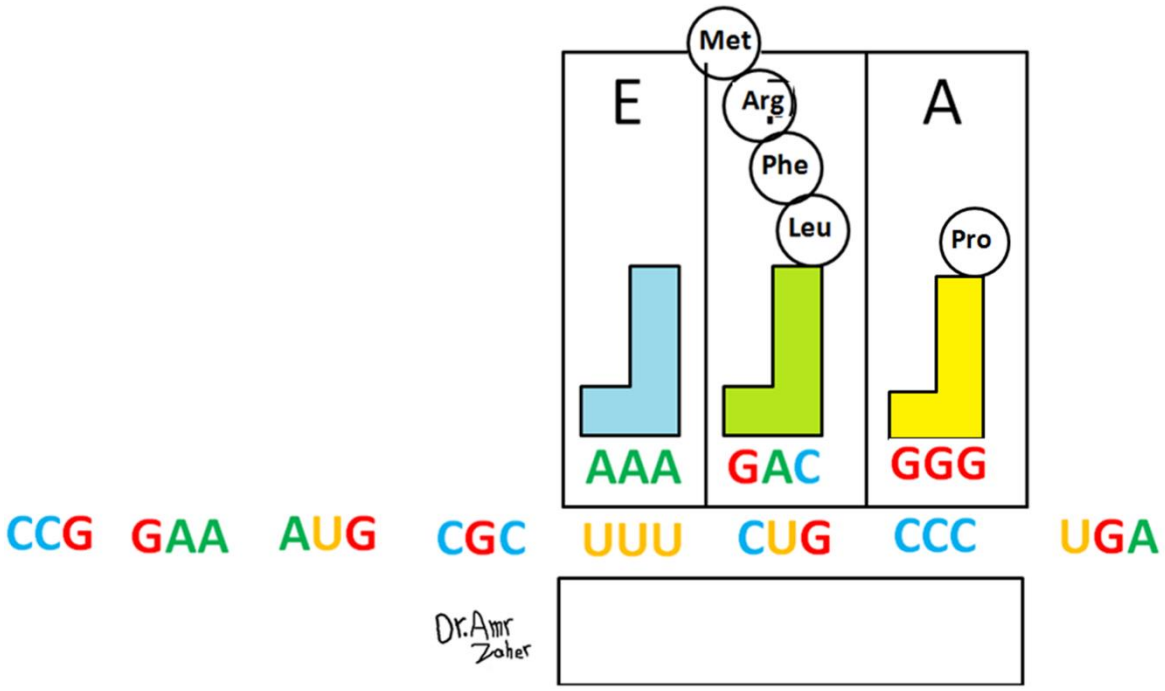


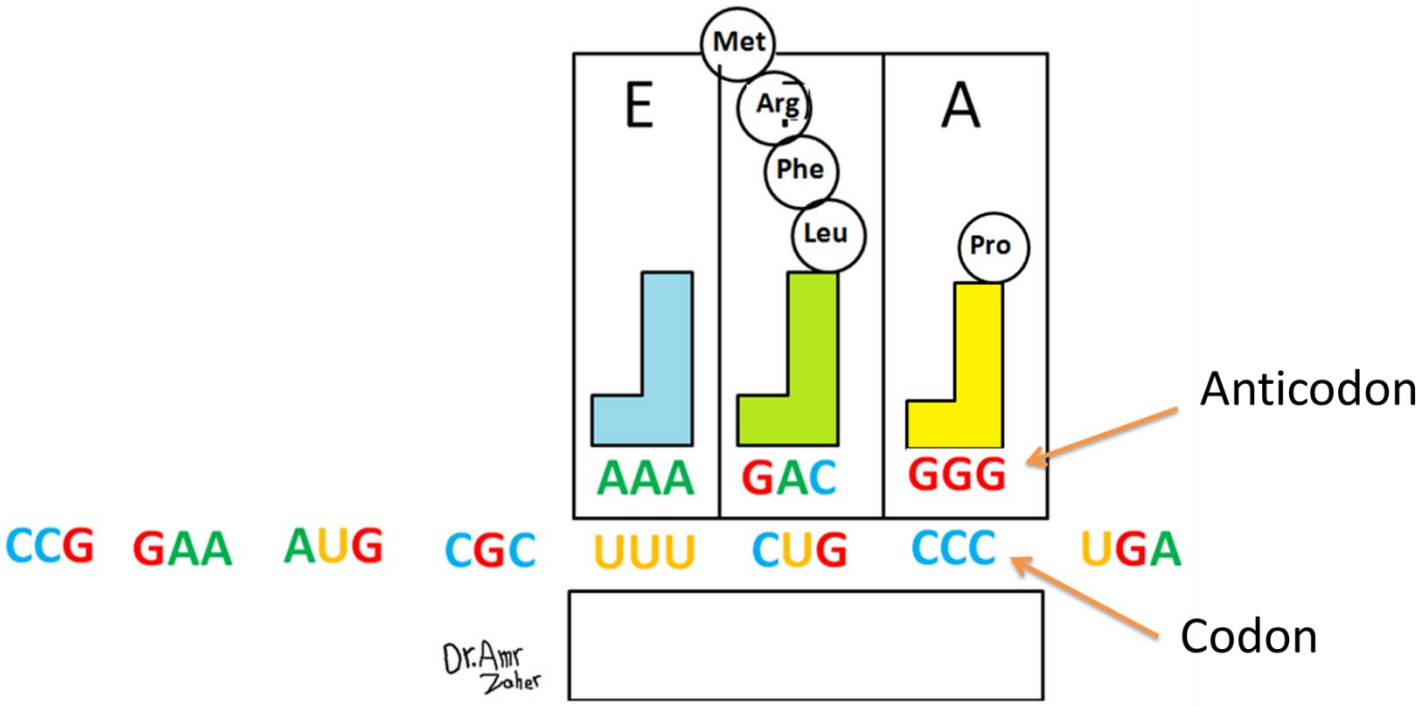
- The amino acids from the third tRNA is transferred to the amino acid that still attached to the fourth tRNA molecule.
- A growing chain of amino acids that will extend out of the ribosome.



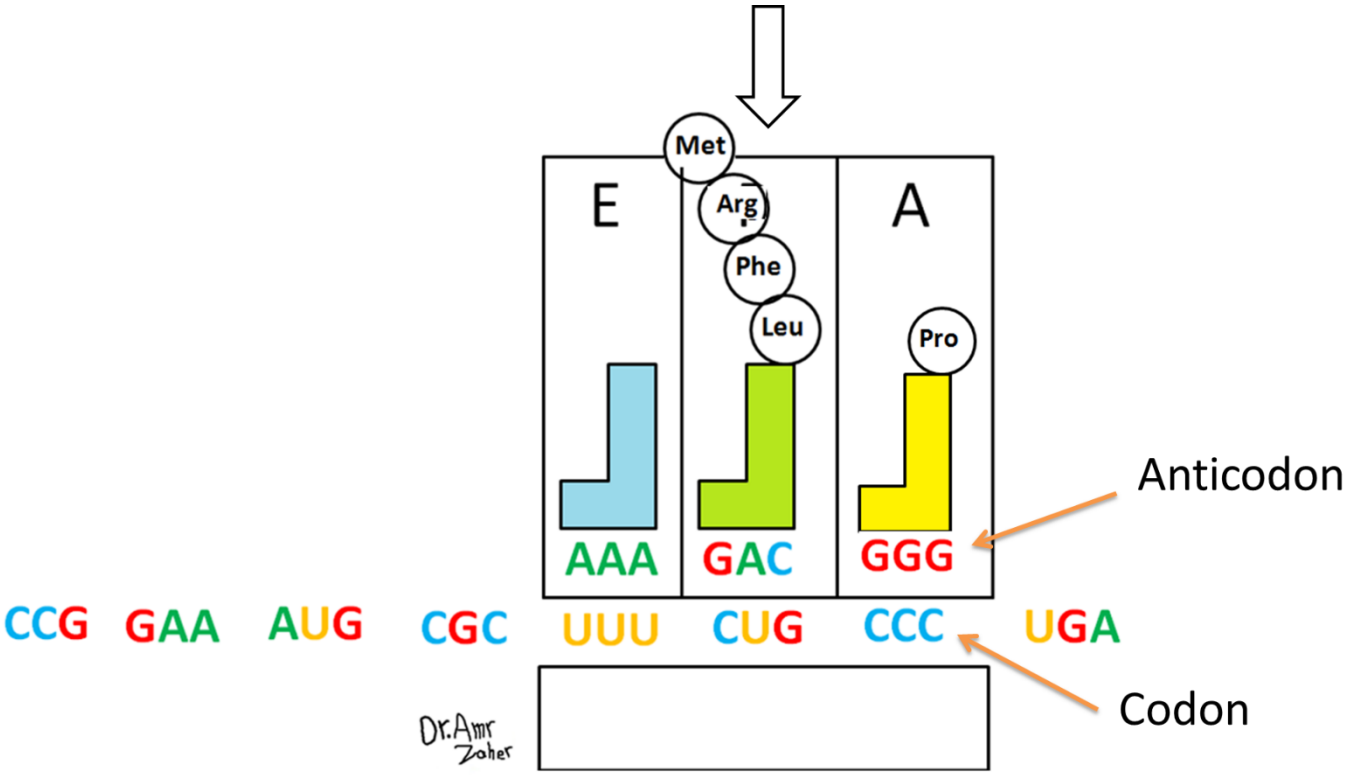
- A fifth tRNA molecule will join the A site.



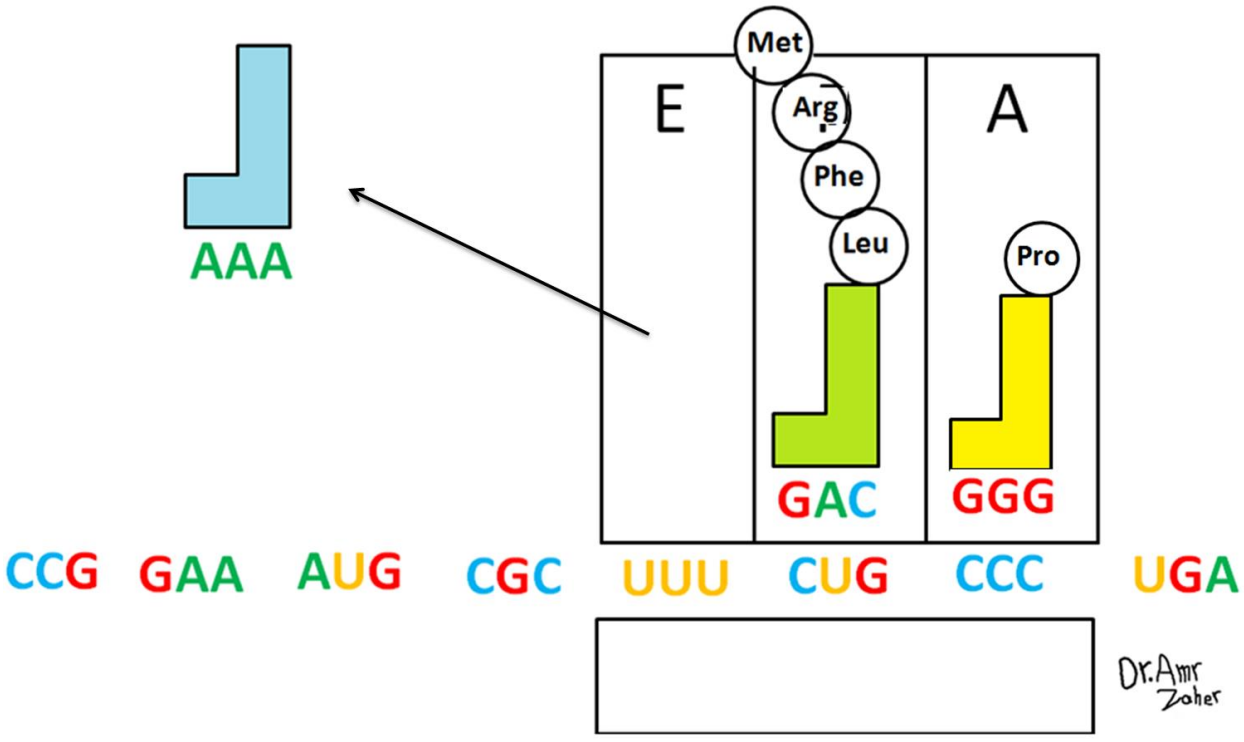

Met
Arg
Phe
Leu
Pro
E
A
AAA
GAC
GGG
CCG GAA AUG CGC UUU CUG CCC UGA
Dr.Amr Zaher


Met
Arg
Phe
Leu
Pro
E
A
AAA
GAC
GGG
Anticodon
CCG GAA AUG CGC UUU CUG CCC UGA
Codon
Dr.Amr Zaher

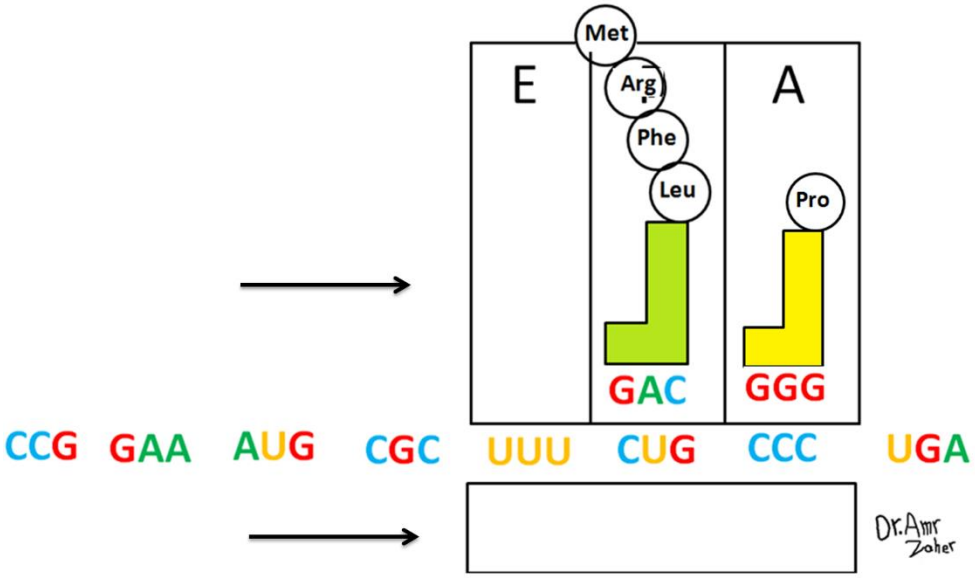
- The P site continually hold the growing polypeptide chain as the ribosome moves along the mRNA molecule.

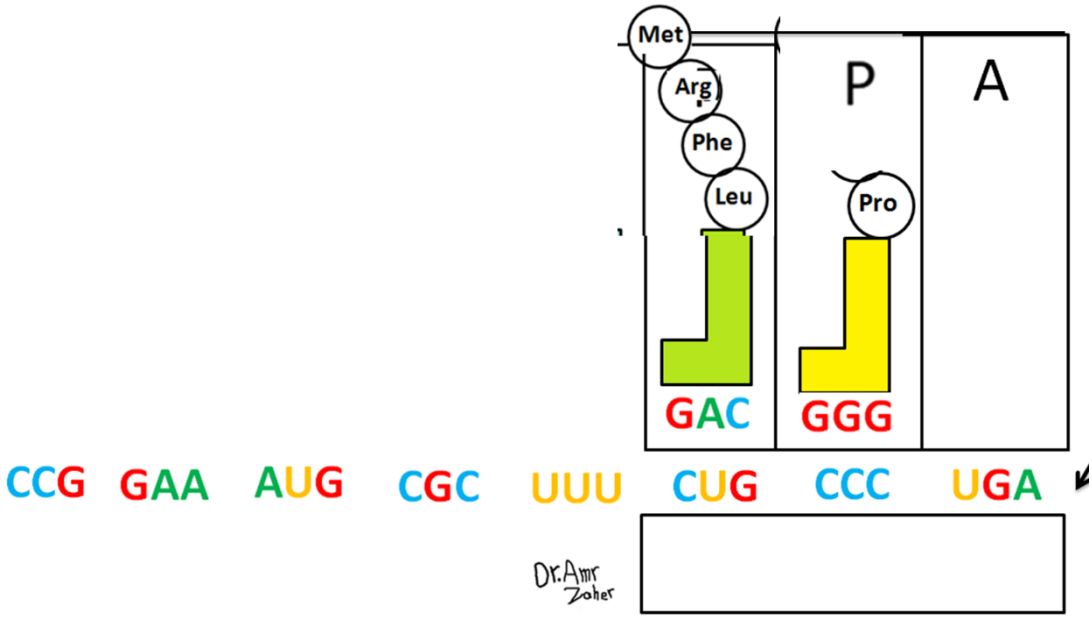


- The tRNA molecule that now doesn't have an attached amino acid is then ejected from the ribosome, detaching from the mRNA.

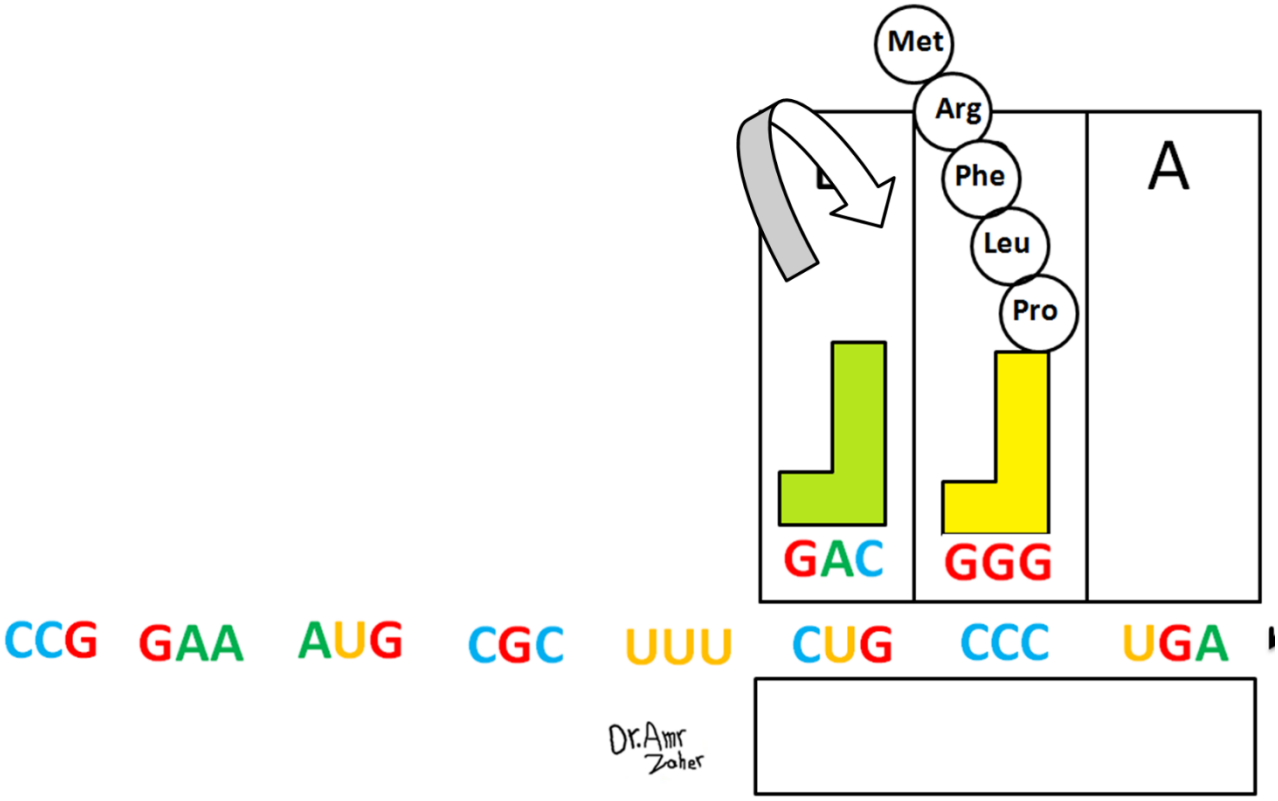


➢ Ribosome moves again.

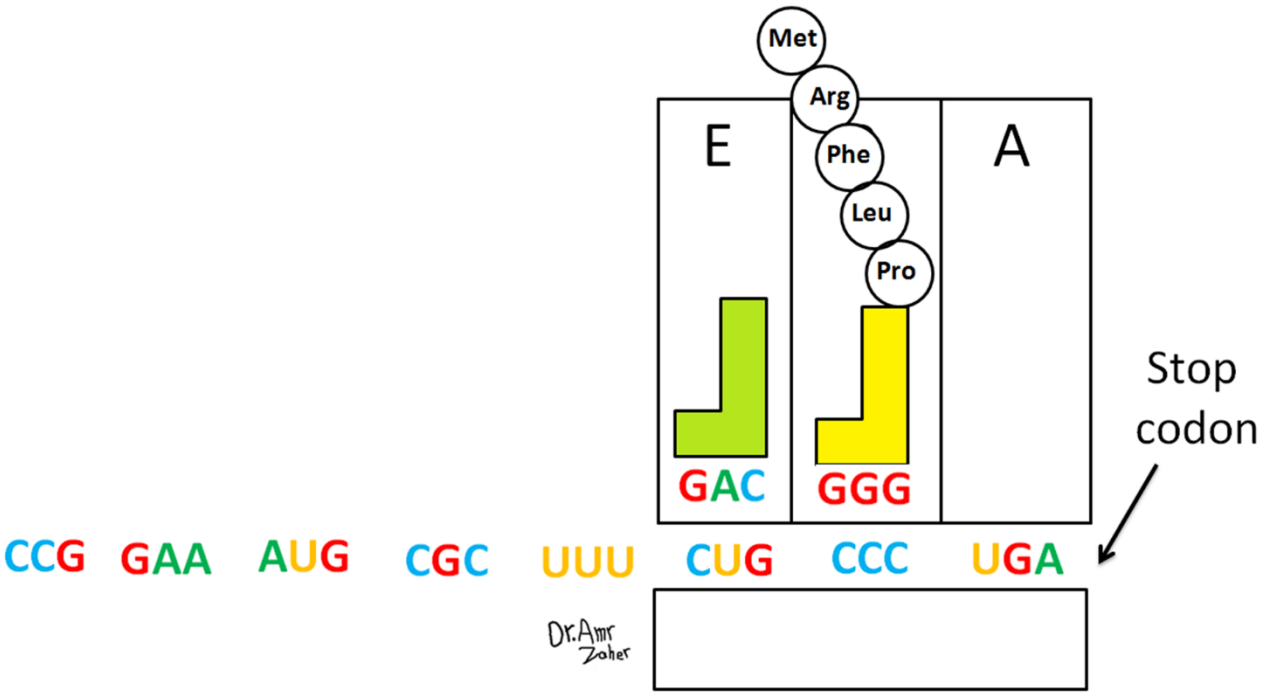




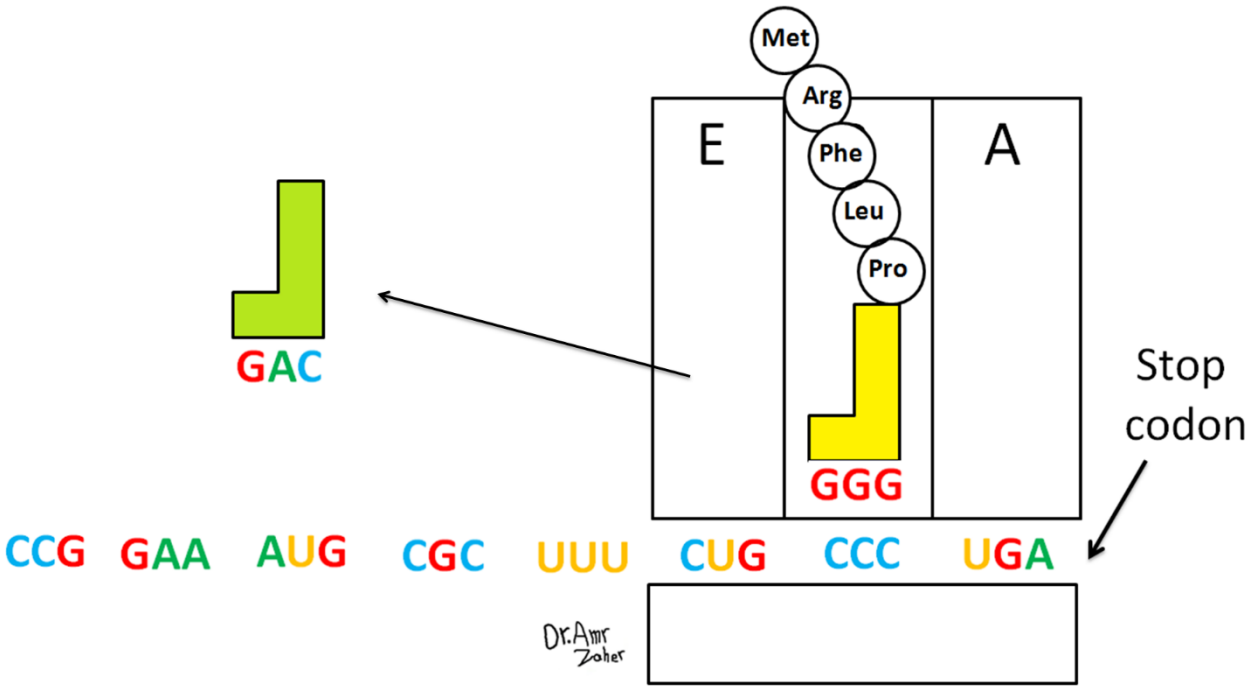
- The amino acids from the fourth tRNA is transferred to the amino acid that still attached to the fifth tRNA molecule.



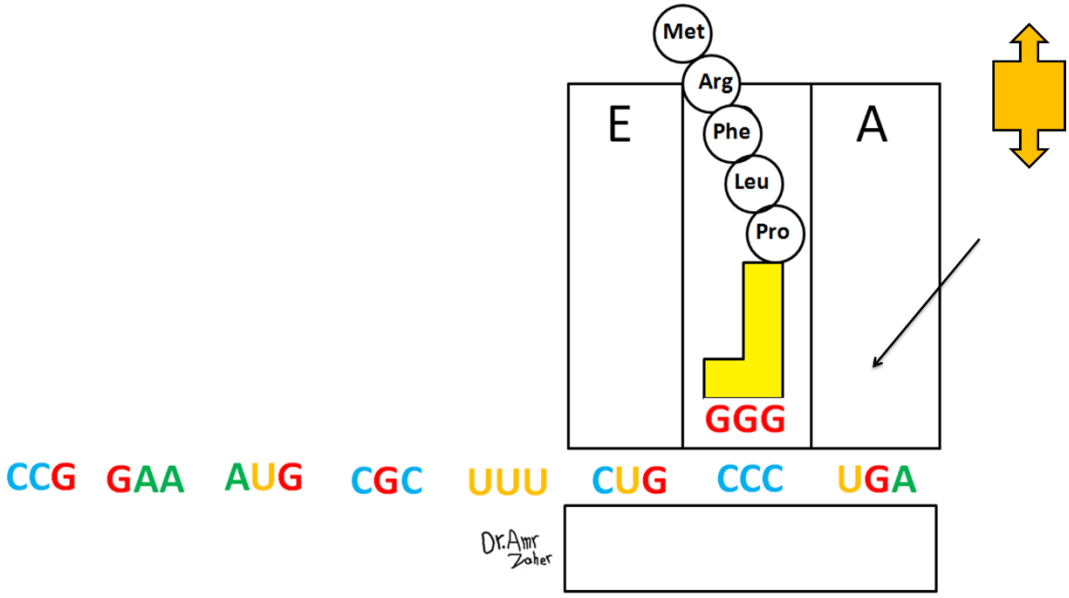
- Eventually the ribosome reach the stop codon UGA.
- The stop codon aligns with the A site of the ribosome

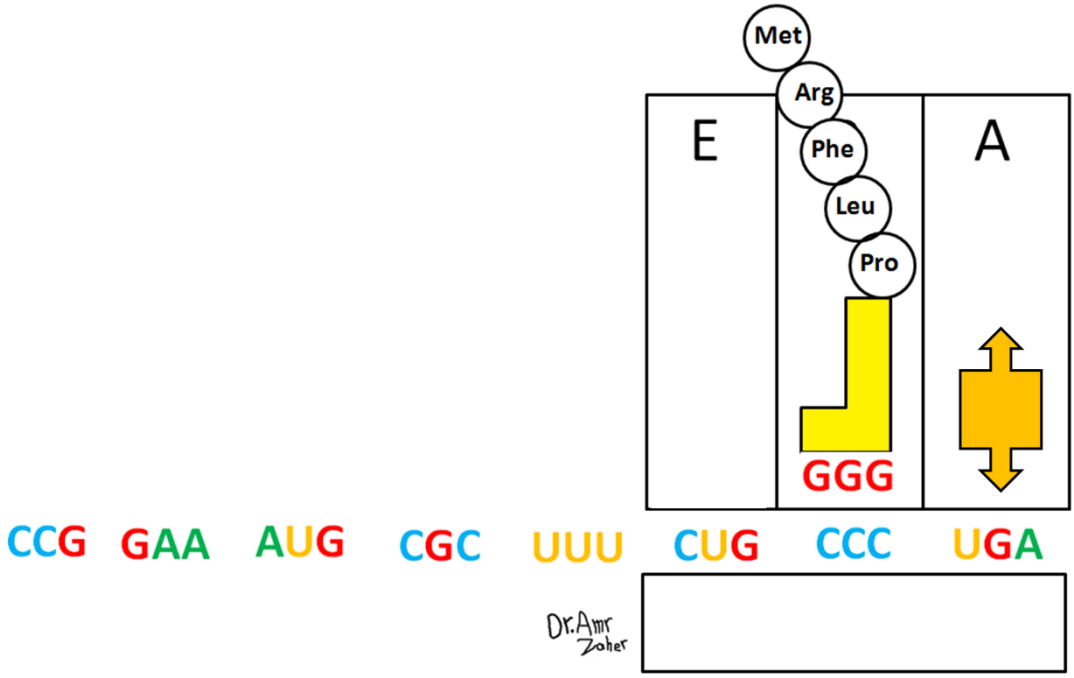


- The tRNA molecule that now doesn't have an attached amino acid is then ejected from the ribosome, detaching from the mRNA.
- **It is a stop codon, basically tells the ribosome the job is finished.**

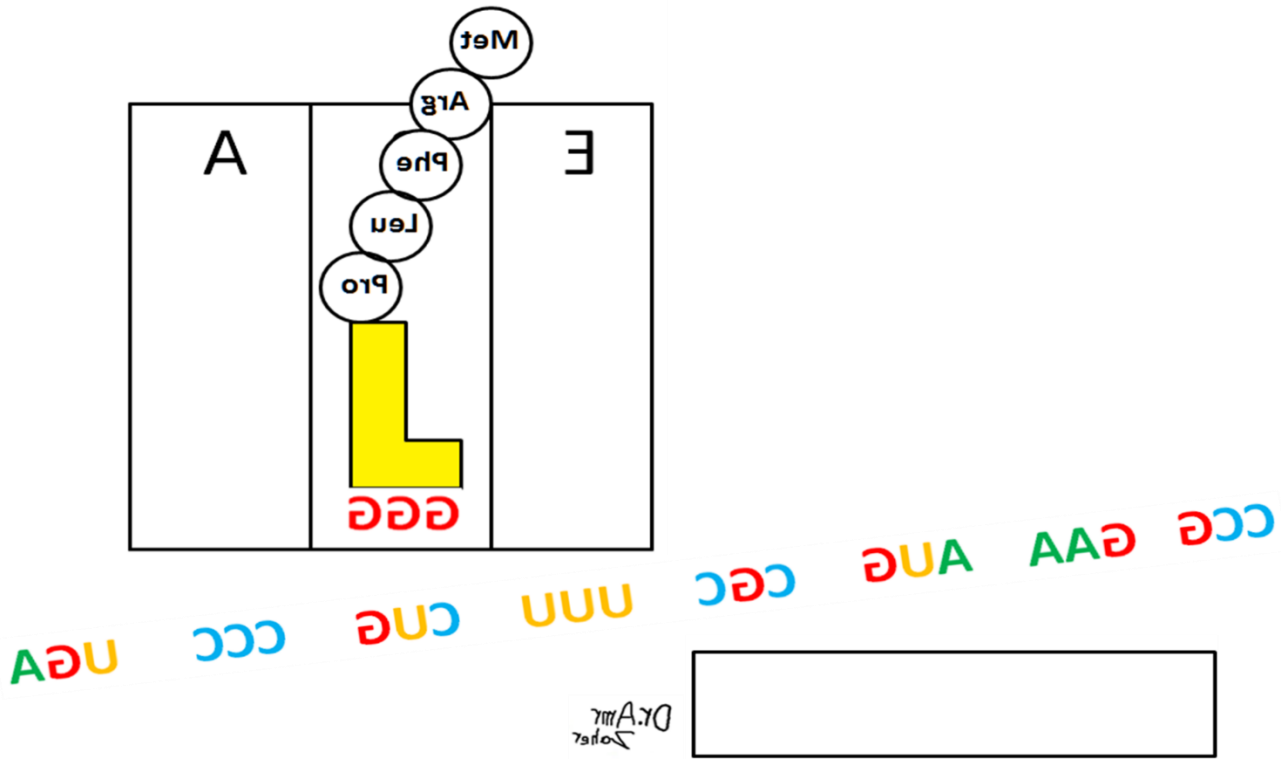


- The P site contains the tRNA molecule attached to the entire polypeptide chain made in the process of translation.
- A protein called a release factor enters the A site and interact with the stop codon

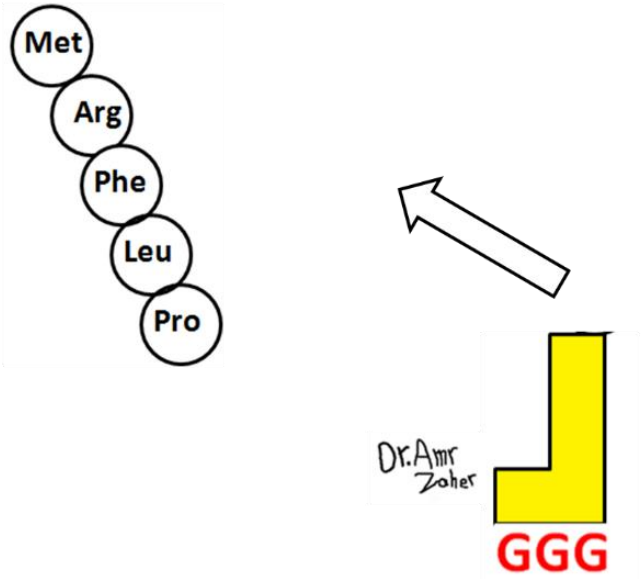




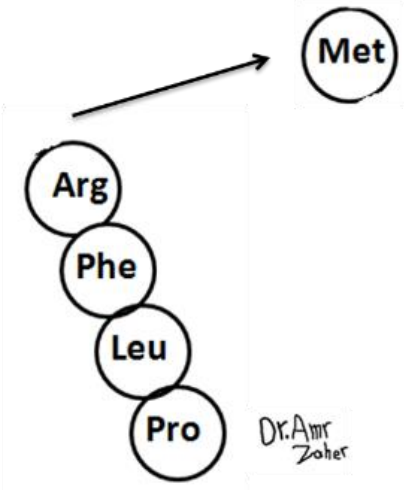
- This interaction causes the 2 ribosomal subunits to detach from each other and from the mRNA.



- The tRNA will also detached from the polypeptide chain

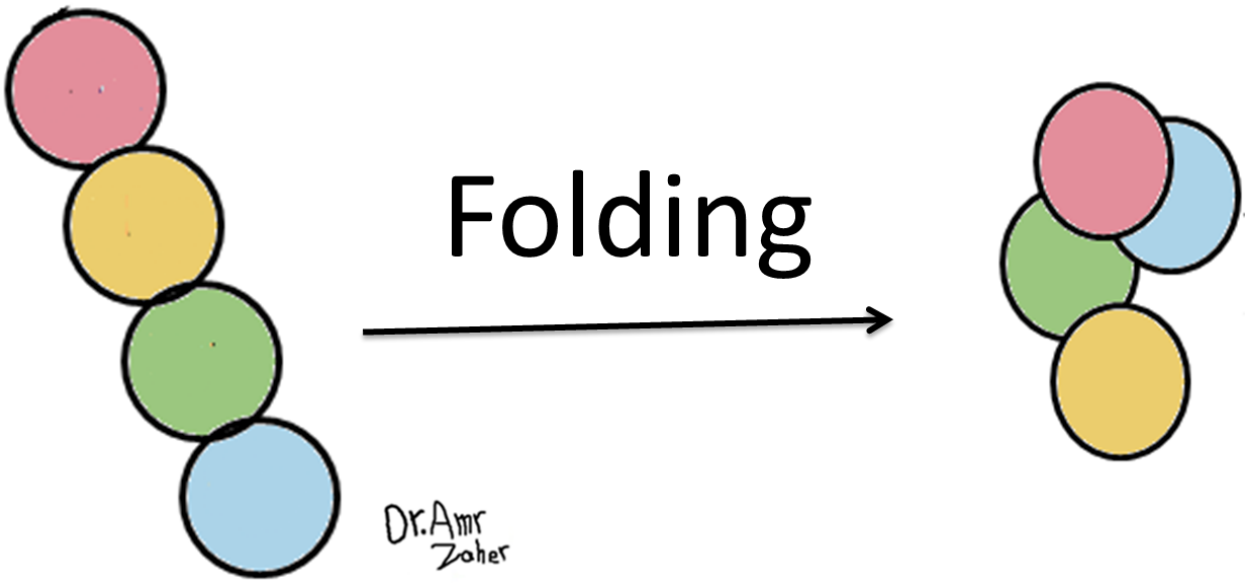


- The polypeptide chain could get rid of the methionine before folding.



Folding

Protein folds to become a biologically active 3D structure.


Folding
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If you can't explain it
simply, you don't understand
it well enough.

Albert Einstein