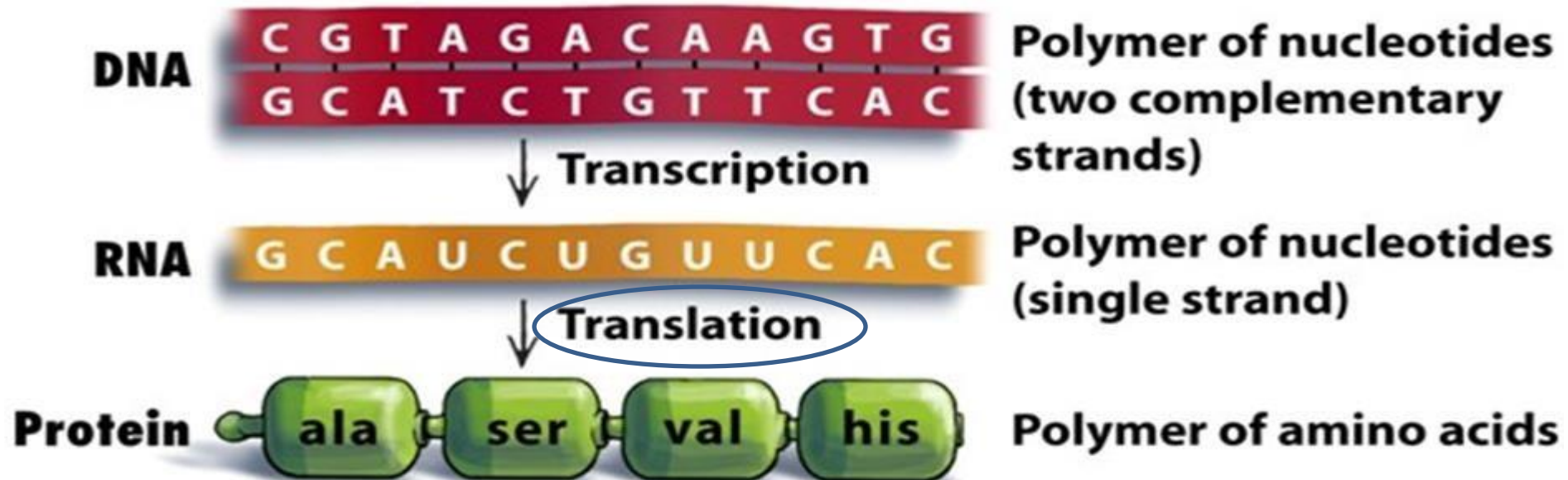




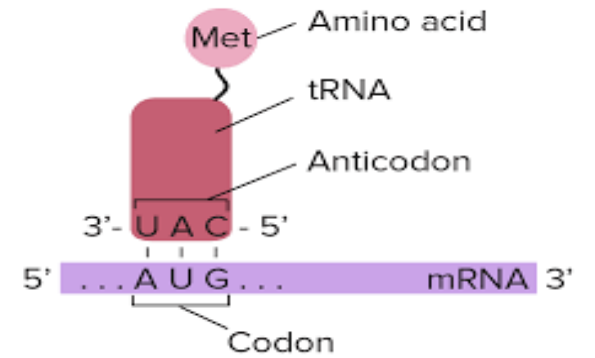
# Translation

## Definition:

- ❑ The **synthesis of protein** using **mRNA** as the template.
- ❑ The mRNA carries the instructions (**genetic code**) to make protein in the process of translation
- ❑ Site: **cytoplasm**



# Requirements for protein synthesis

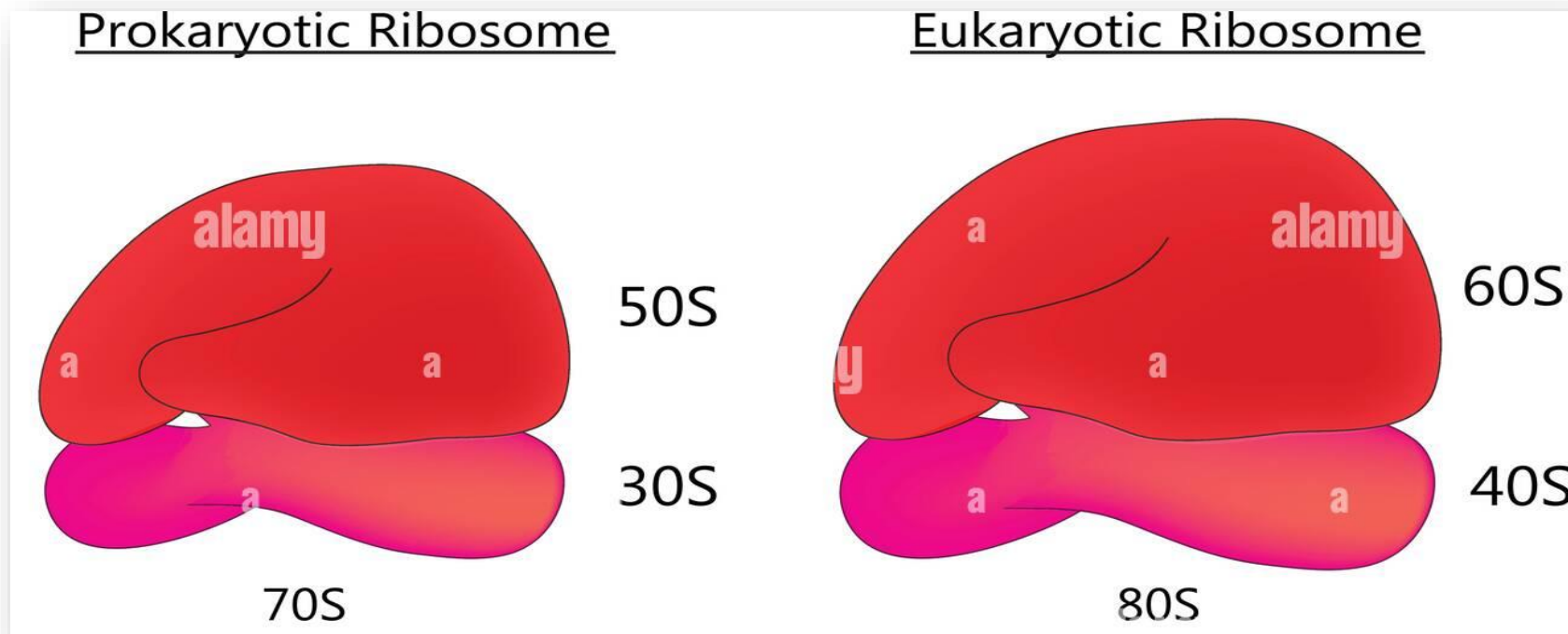


1. **A ribosome:** protein synthesizing machinery.
2. **mRNA:** the template that carries information needed for arranging the amino acids in the proper order of the specific protein.
3. **tRNA:** carries the amino acids to the proper place in the polypeptide chain.
4. **Amino acids:** the building units of the protein.
5. **Aminoacyl-tRNA synthetase enzyme:** connects the amino acids to the specific carrier tRNA.
6. **Protein factors:** as initiation factors (IF), elongation factors (EF) and releasing factors (RF).
7. **Source of energy:** in the form of ATP and GTP .

# Ribosome

## ➤ Types:

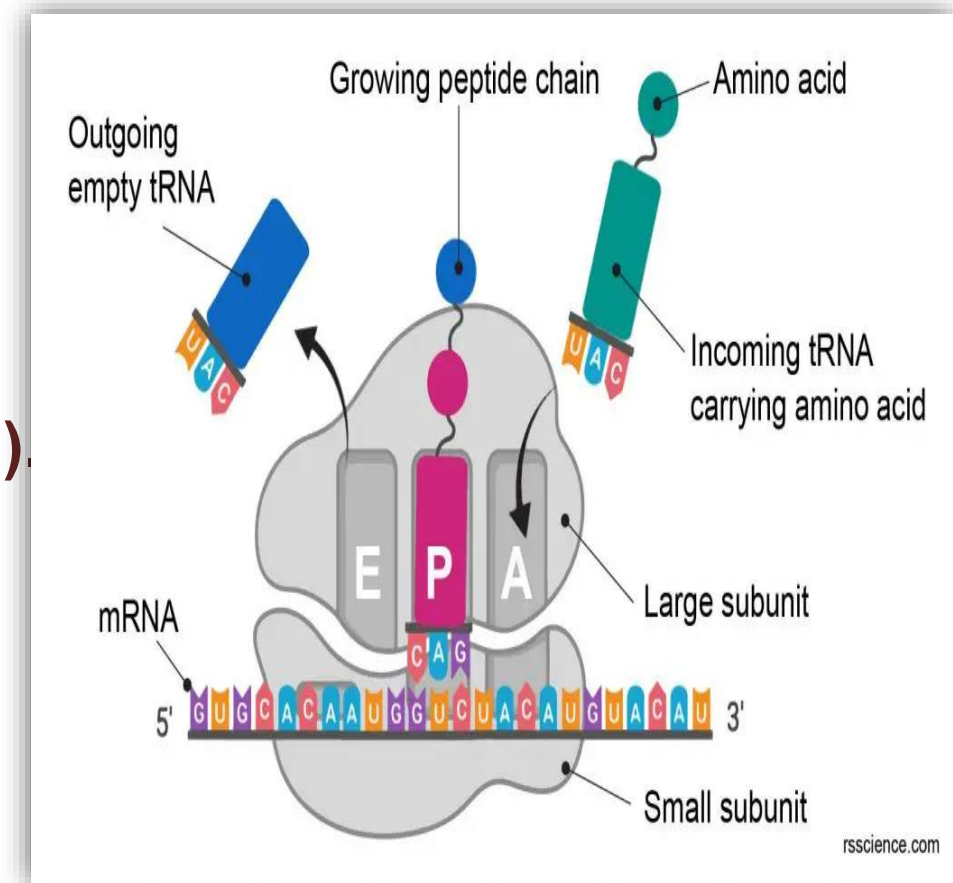
- The **eukaryotic 80S** ribosome is formed of **60S** and **40S** ribosomal subunits.
- The **prokaryotic 70S** ribosome is formed of **50S** and **30S** ribosomal subunits.



# Ribosome

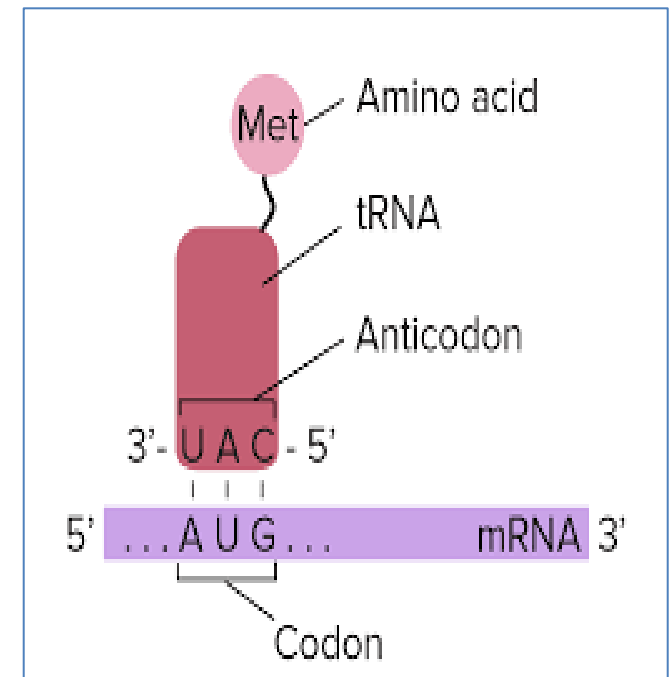
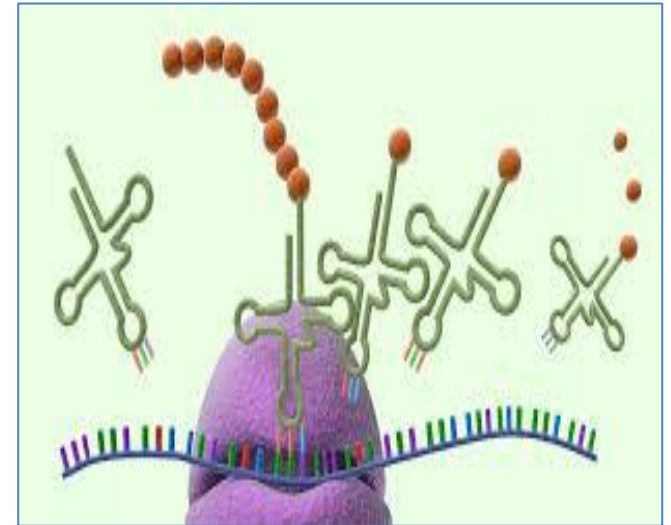
## ➤ Sites on the ribosome:

- During translation, the ribosome has binding sites for tRNA molecules :
  - ❑ The **A site** binds an **incoming Aminoacyl-tRNA**.
  - ❑ The **P site** is occupied by **Peptidyl-tRNA**.  
(This tRNA carries the polypeptide chain of amino acids that has already been synthesized).
  - ❑ The **E site**: For release ( **Exit** ) of **uncharged tRNA**.



# Transfer RNA (tRNA)

- ❑ The tRNA carries amino acids during translation.
- ❑ There is **at least one specific tRNA** for each **amino acid**. Some amino acids (those having **> one codon**) may be carried by **> one tRNA** type.
- ❑ When a **tRNA** carries an amino acid it is said to be **charged**, and when an **amino acid** is carried by a tRNA it is said to be **activated**.



# Steps for Translation

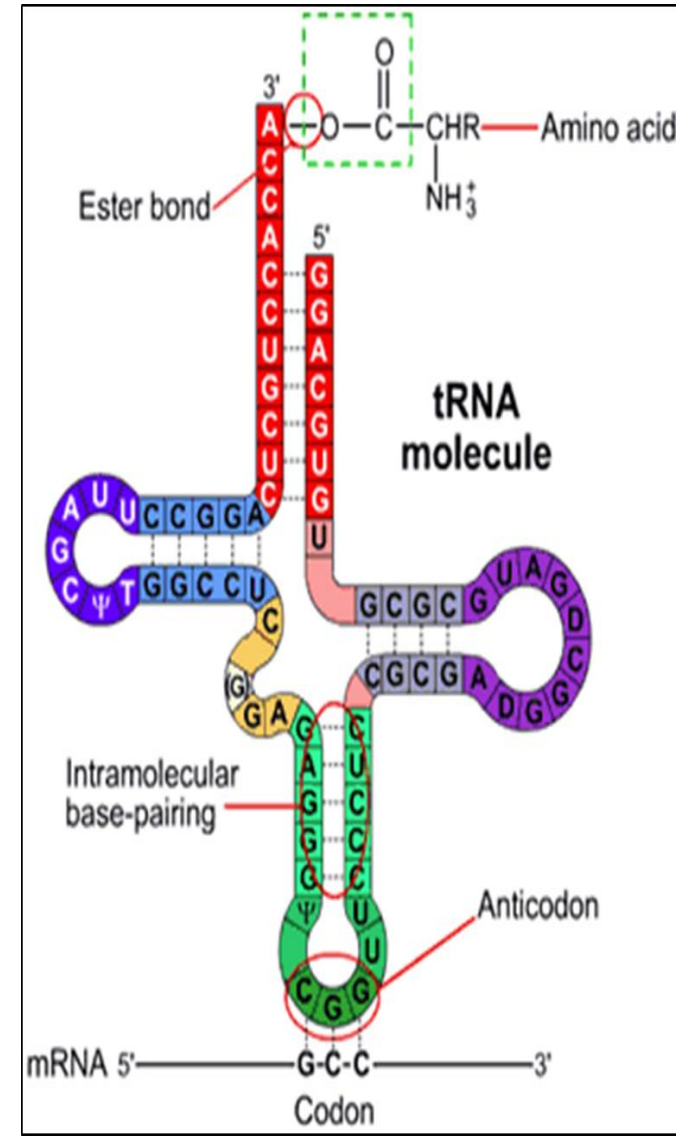
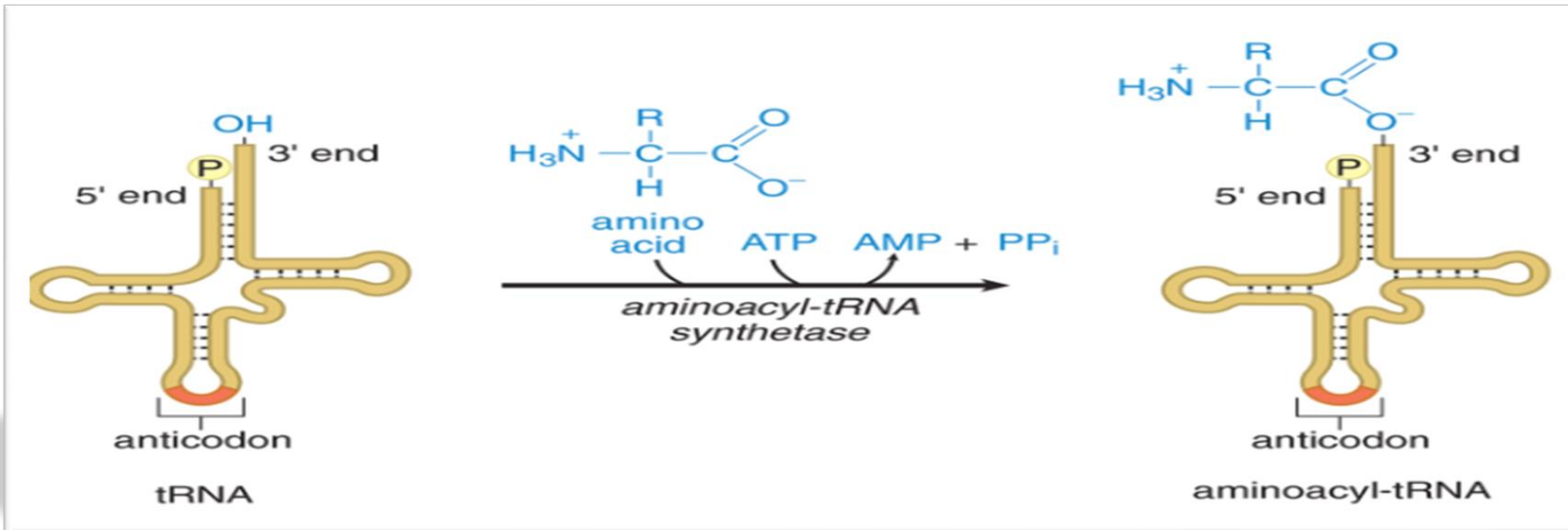
1. **Activation of amino acid:** synthesis of aminoacyl-tRNA
  2. **Initiation:** formation of the initiation complex
  3. **Elongation:** polypeptide chain synthesis
  4. **Termination:** release of the polypeptide chain
- The polypeptide chain produced may be modified by **post-translational modification**.



# Steps of translation

## 1- Activation of amino acids (Synthesis of aminoacyl-tRNA):

- ❑ Charging of **tRNA** by its specific amino acid on the 3'-OH terminus end of the acceptor arm by ester bond.
- ❑ The enzyme responsible for **charging of tRNA** by its specific A.A is known as **aminoacyl tRNA synthetase**.
- ❑ **2 high energy bonds (from 1 ATP) are needed**



# 2- Initiation

## □ Assembly of the translation machinery:

Ribosome assembles with the other 2 types of RNAs forming **the initiation complex**:

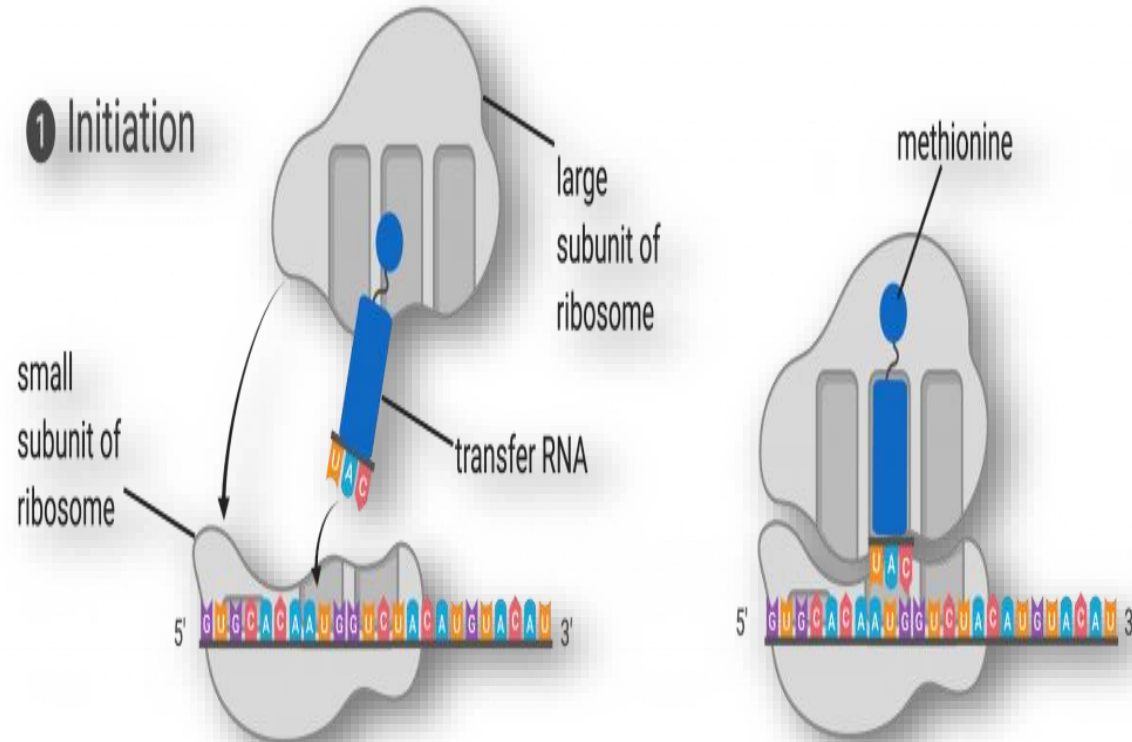
### 1- Ribosome:

-Two pieces, large and small subunits

2- **An mRNA** with instructions for the protein synthesis

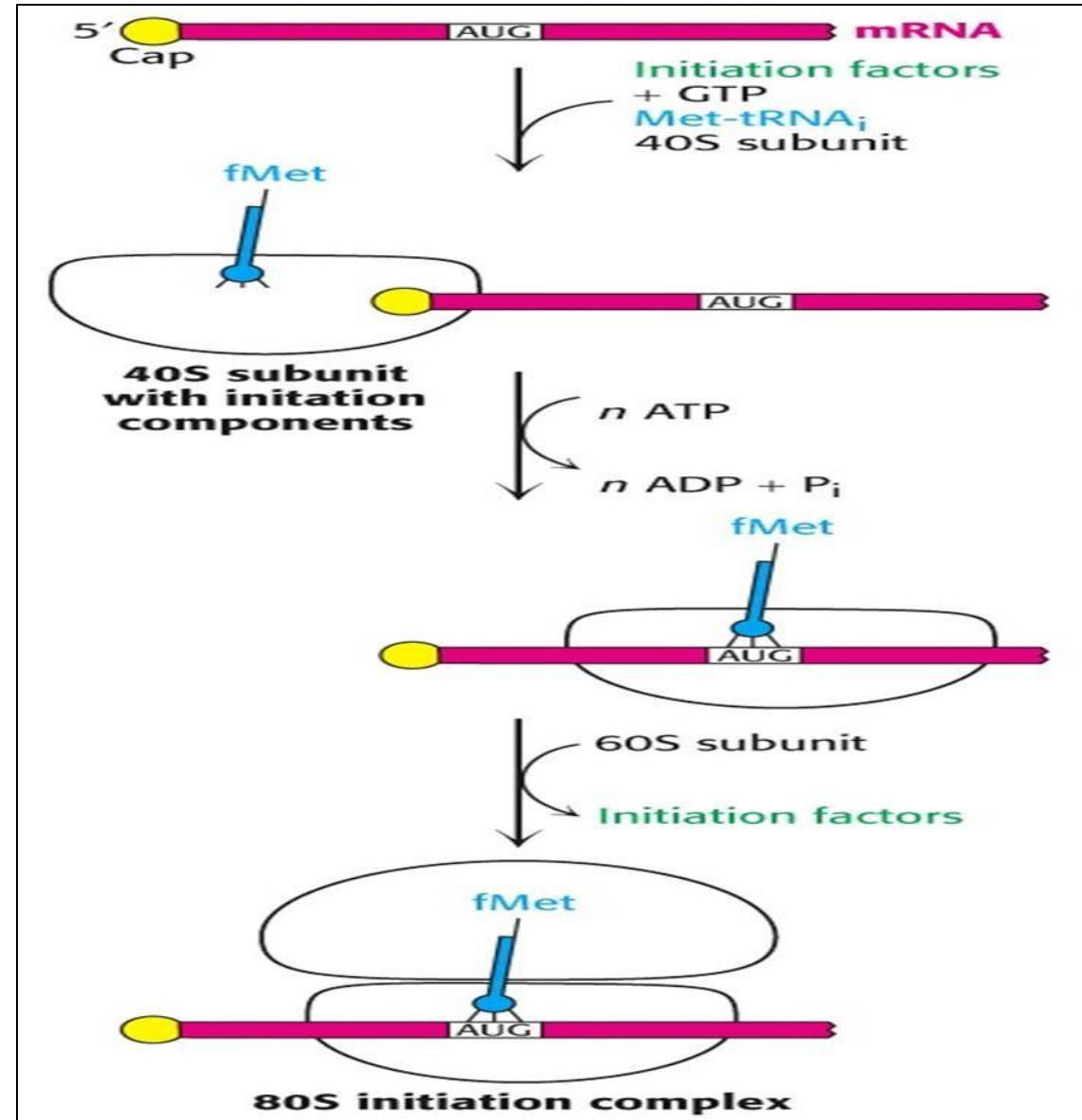
3. **An "initiator" tRNA** carrying the first amino acid in the protein, which is almost always methionine (Met) interacts with the start codon AUG.

### 4. Initiation factors



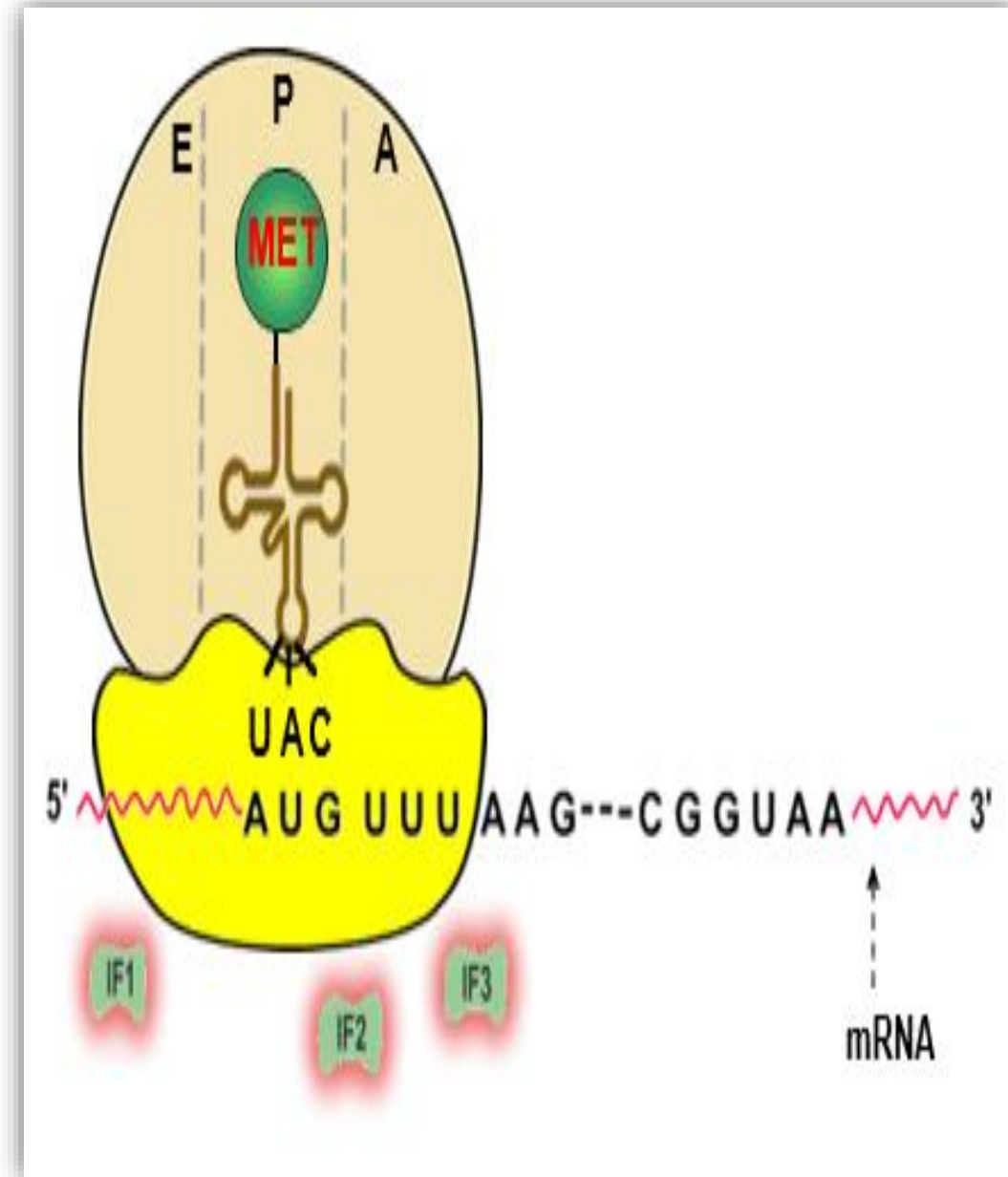
# 2- Initiation

- ❑ An "initiator tRNA" binds to **small** ribosomal subunit.
- ❑ This complex then attach to the **cap structure** at the 5' end of mRNA and scan for the **start codon AUG** mediated by several **initiation factors**.
- ❑ At the start codon, **large** ribosomal subunit joins the complex & **initiation factors** are released



# 2- Initiation

- The complete ribosome (80s) contain two sites for tRNA molecules. These are P (peptide) site which occupied by met-tRNA and A (aminoacyl) site which is free and ready to receive the subsequent aminoacyl tRNA.



# 3- Elongation

- Elongation is a **cyclic** process involving 3 steps and is catalyzed by **elongation factors**.

- ❑ **Step (1) Binding of the new amino acyl-tRNA to A site:**

- ❑ tRNA brings the correct new amino acid to A-Site. **1 GTP** is needed

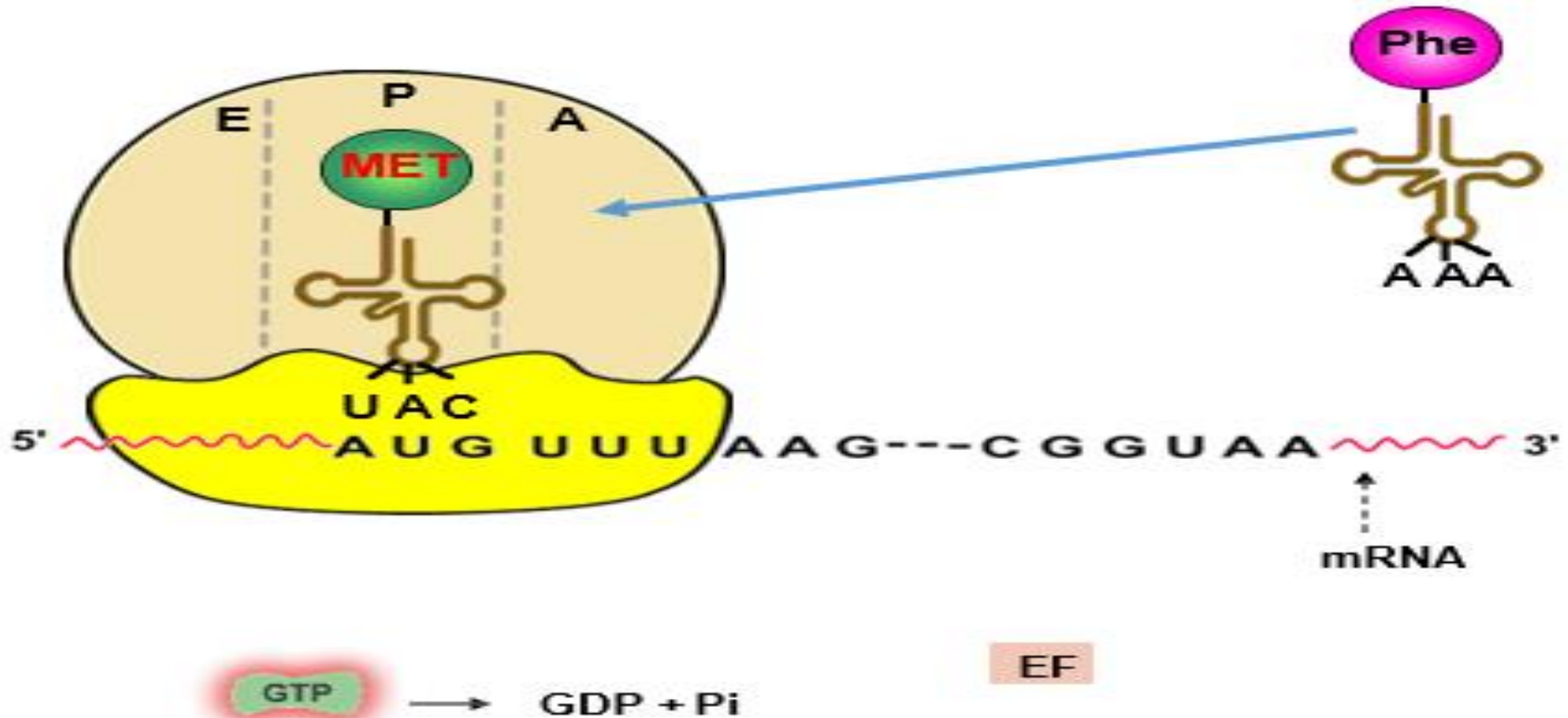
- ❑ **Step (2) peptide bond formation**

- ❑ Formation of peptide bond between the old and the newly added amino acid catalyzed by **peptidyl transferase** enzyme present inside the 60s subunit.

- ❑ **Step (3) translocation**

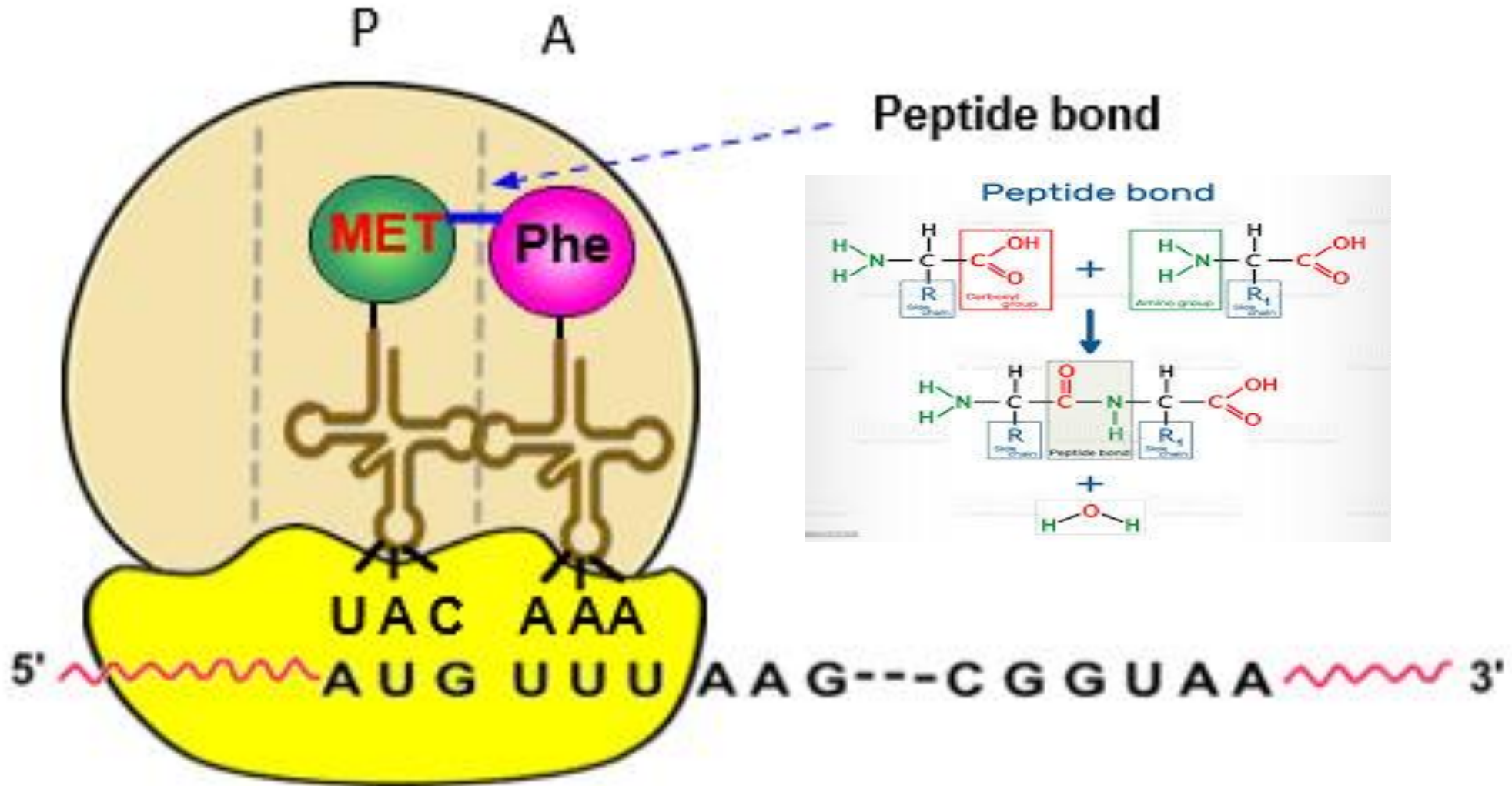
- ❑ the ribosome moves 3 nucleotides towards the 3' end of mRNA. This requires **EF2** and **GTP**.

# 1. Binding of new amino acyl-tRNA to the A site

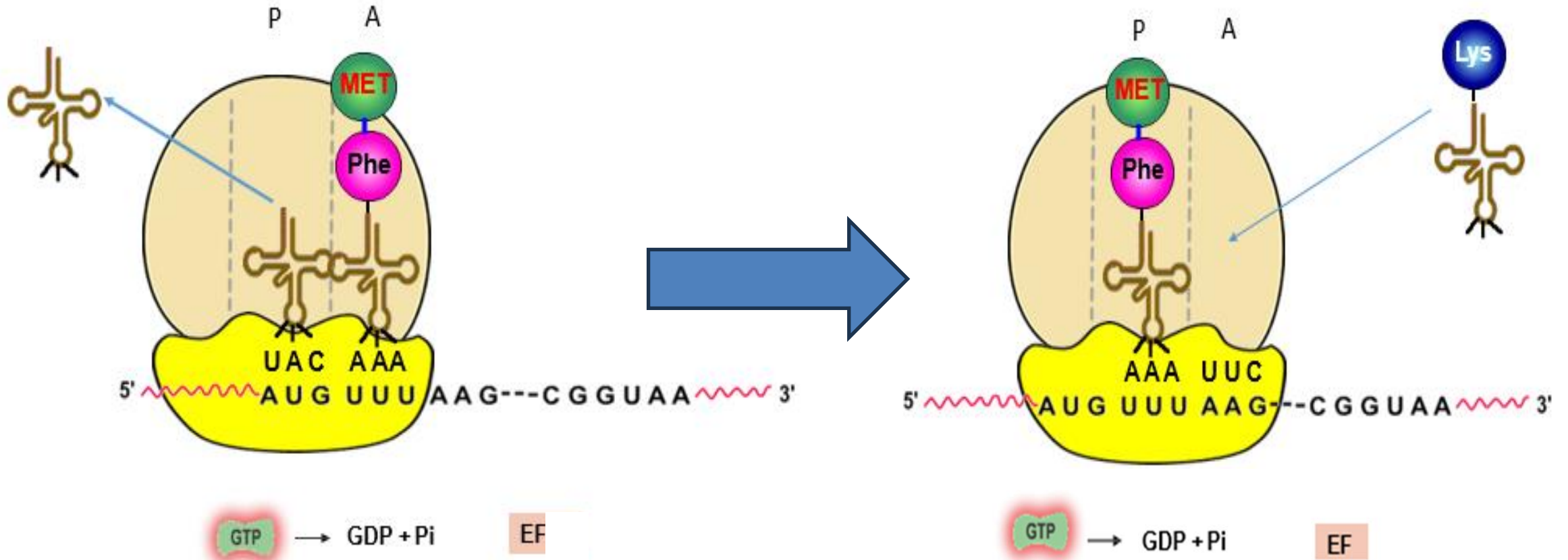


**1 GTP** is needed for binding of amino acyl tRNA to A site

## 2. Peptide bond formation



# 3. Translocation

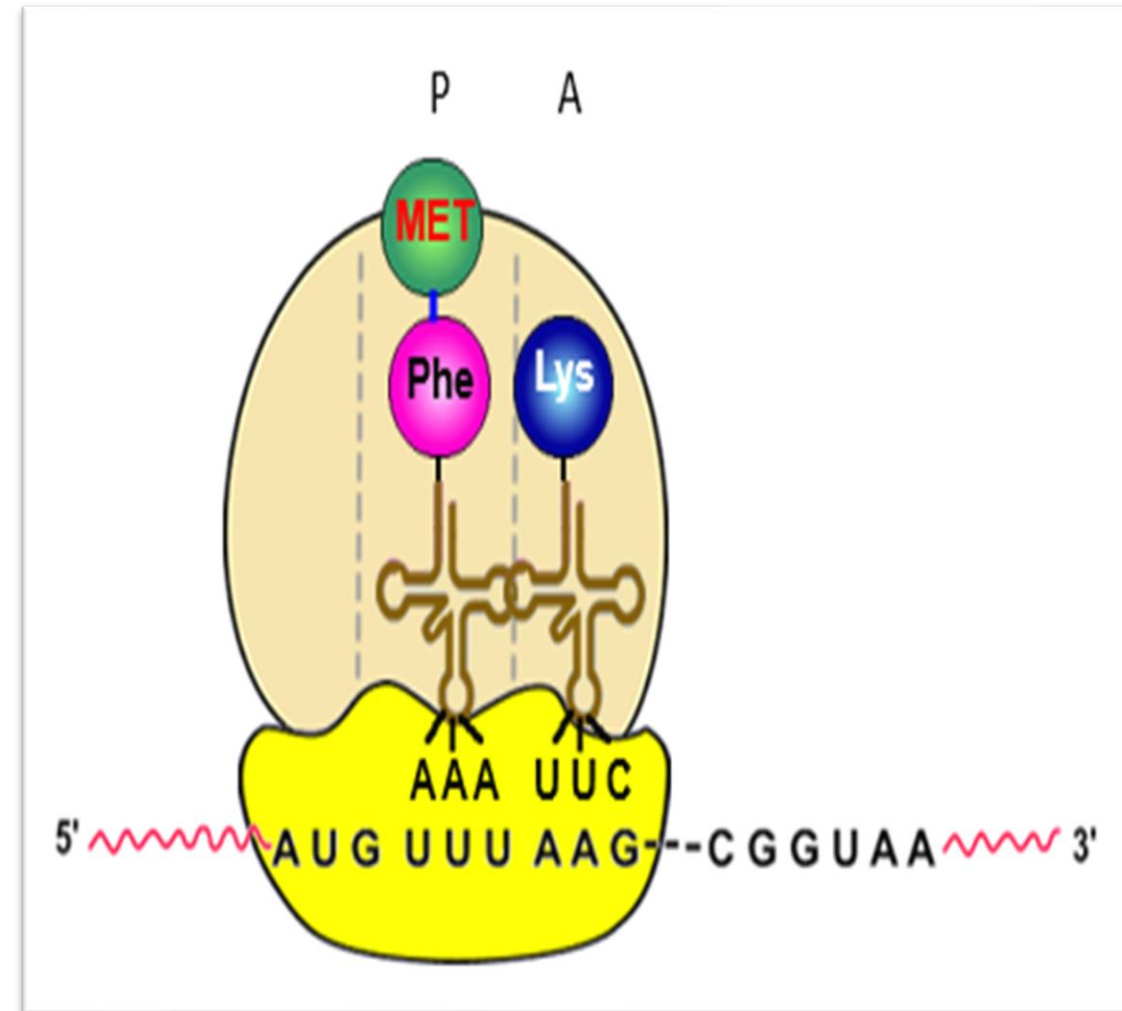


-tRNA in P-site release the amino acids onto the tRNA in A- site and becomes empty  
-the ribosome moves 3 nucleotides towards the 3' end of mRNA

**1 GTP** is needed for translocation

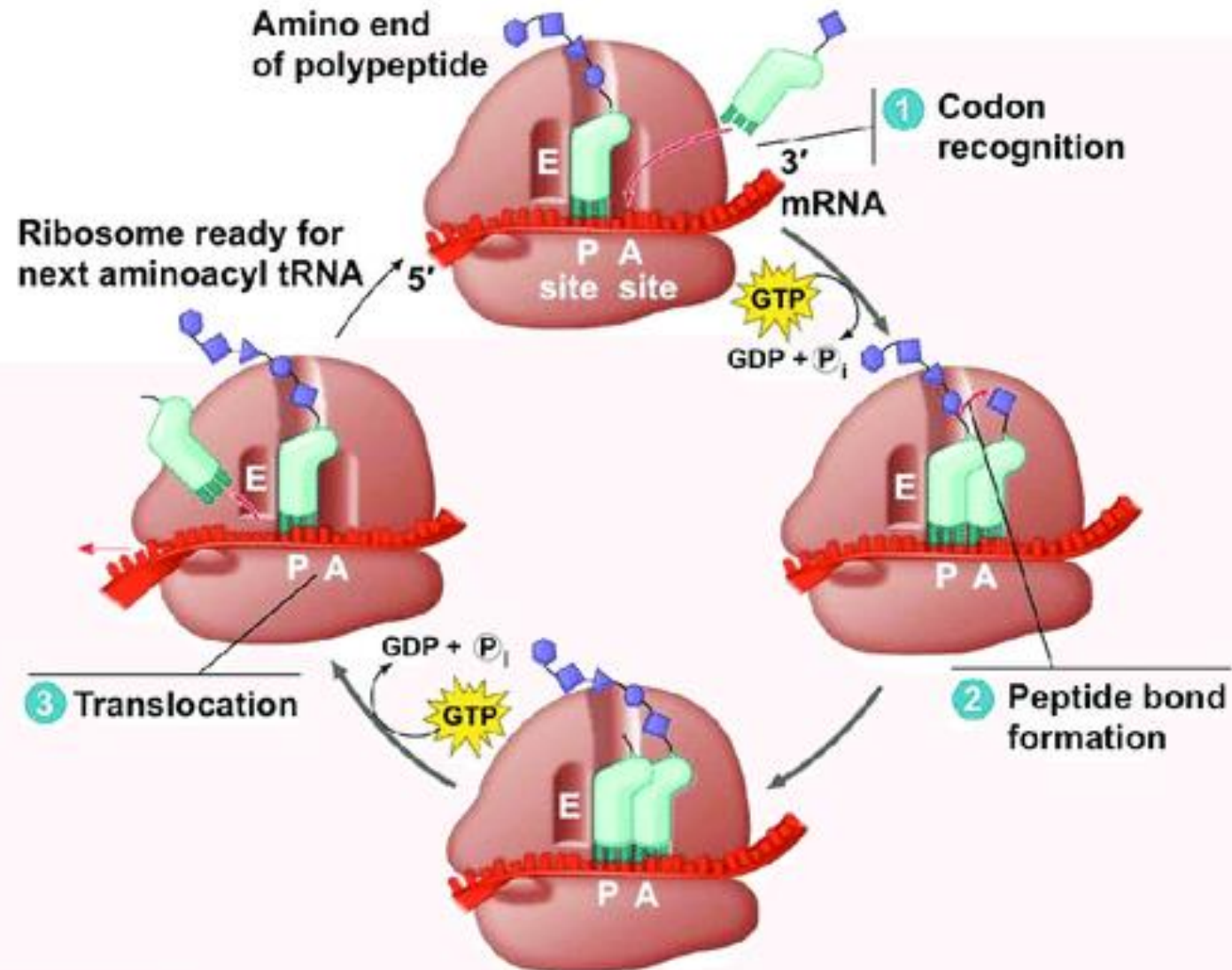
The following events occur as a result of translocation:

- Release of **uncharged tRNA** from **E** site.
- Transfer of the newly formed **peptidyl-tRNA** from **A** site to **P** site.
- The **A site** becomes **free** (can be occupied by another new amino acyl tRNA according to the codon anticodon recognition).



.....Start new cycle of elongation

# Elongation is a cyclic process



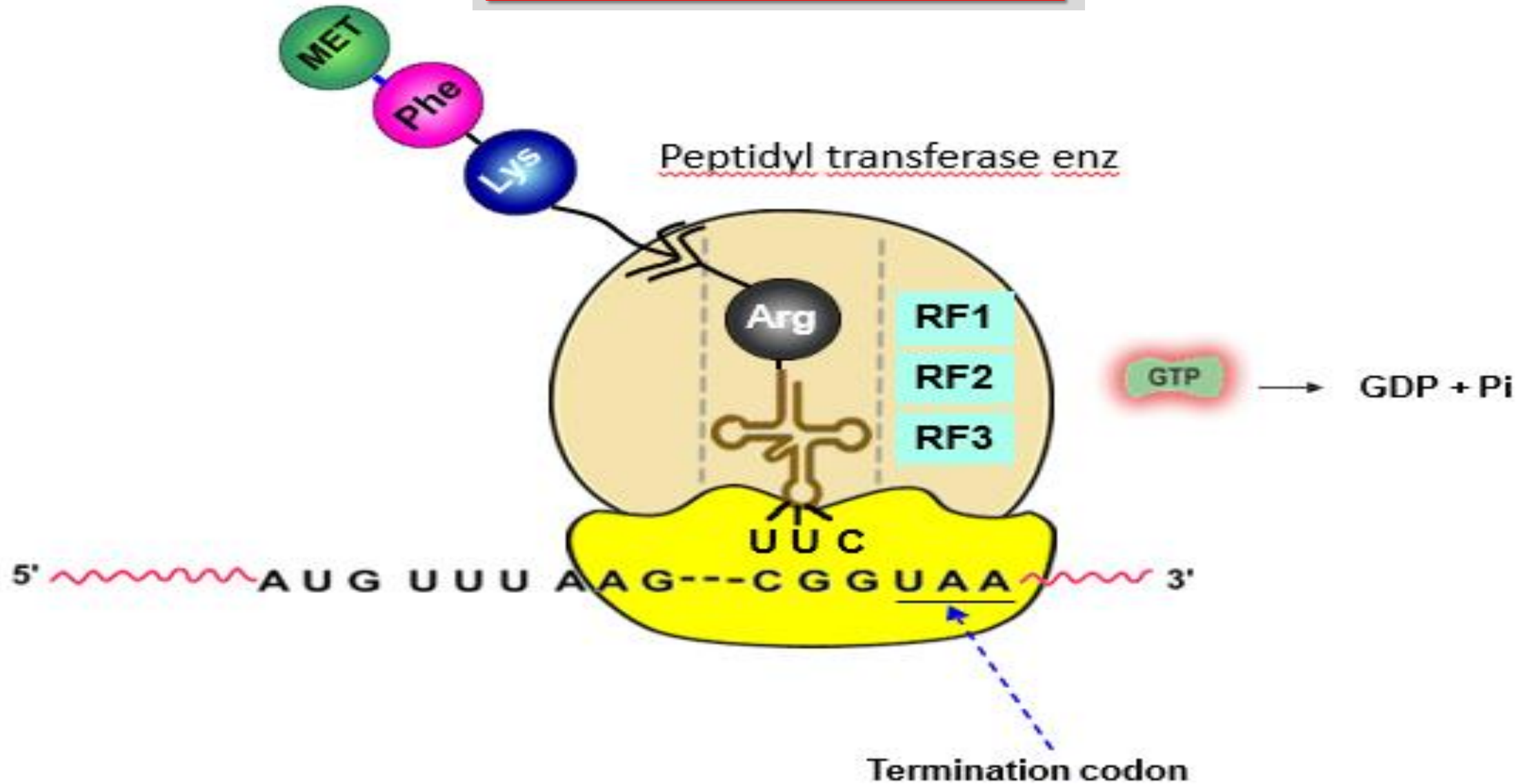
**Energy required for formation of one peptide bond**  
**(for adding new amino acid to the polypeptide chain)**

- For each new peptide bond formed, **4** high energy phosphate bonds are cleaved
- **2 high energy bonds** (from **1 ATP**) for activation
- **1 GTP** for binding of new aminoacyl tRNA to A site
- **1 GTP** for translocation

# 4-Termination

- ❑ Elongation of polypeptide chain continues until one of the 3 **stop codons (UAA, UAG, UGA)** is reached by ribosomes aligned with the **A** site.
- ❑ **Releasing factors (RF)** appear in **A** site and can recognize all three termination codons.
- ❑ **RFs + GTP + peptidyl transferase** promotes the hydrolysis of bond between polypeptide chain and tRNA occupying the **P** site.
- ❑ **This hydrolysis leads to:**
  - **Release** of both **polypeptide** and **tRNA**.
  - **Dissociation** of 80s ribosomes into **40s** and **60s** subunit.

# 4-Termination





<https://www.youtube.com/watch?v=qlwrhUrvX-k>  
<https://youtu.be/lkq9AcBcohA>

# Questions

**What is the correct sequence of protein synthesis?**

- A: rRNA--- DNA---protein**
- B: mRNA---DNA---Protein**
- C: DNA---mRNA---Protein**
- D: DNA---rRNA---protein**
- E: DNA---protein---mRNA**



**Which one of the following is the first amino acyl tRNA which initiates translation?**

**A: Methionyl tRNA**

**B: Formylmethionyl tRNA**

**C: Tyrosinyl tRNA**

**D: Alanyl tRNA**

**E: Glycinyl tRNA**



**The formation of a peptide bond during the elongation step of protein synthesis results in the splitting of how many high energy bonds?**

**A: 1**

**B: 2**

**C: 3**

**D: 4**

**E: 5**





Thank You

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