Molecular Biology 2

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Notes and explanations

Extra information

highlights

Objectives:

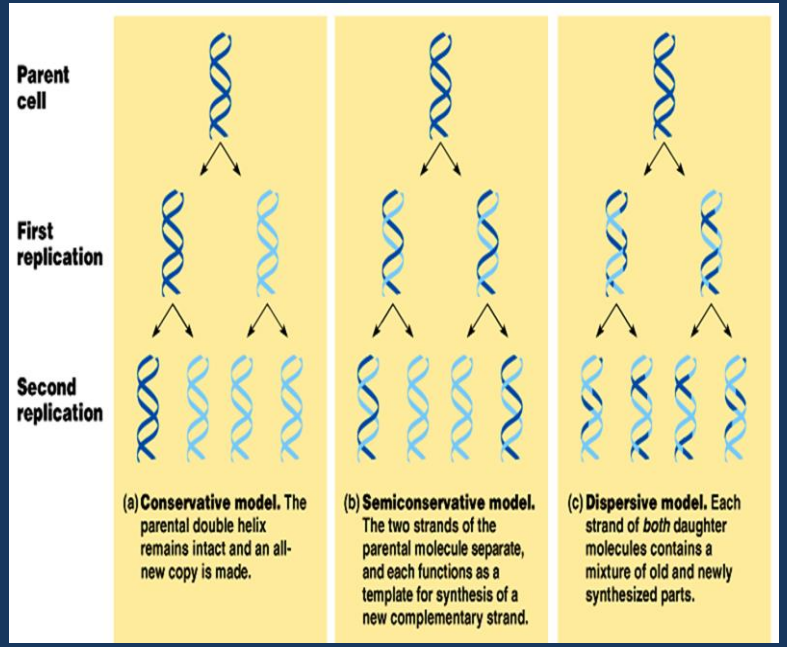
1. To understand DNA replication
2. To know the transcription of genetic material into messenger RNA
3. To get an idea about the translation of mRNA into a functional protein.

DNA is the genetic material

1- it replicates faithfully. (without mutations or mistakes)

2-has the coding ability (ability to transfer information) to produce proteins for all cellular functions.

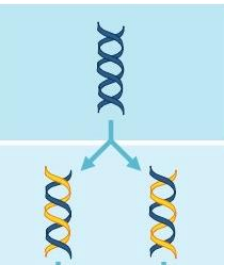
Because it carries all the important genetic information; we should be able to inherent it without mistakes, and we should have a correction system if there were mistakes.



Features of Eukaryotic DNA:

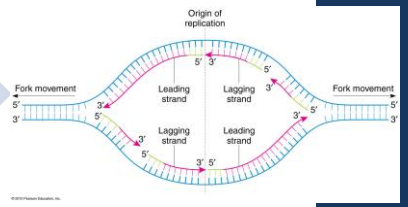
Semiconservative

- Daughter DNA molecule contains one parental strand and one newly-replicated strand



Bidirectional goes in both directions with **multiple** origins of replication

- Origin of replication: is a particular sequence in a genome at which replication is initiated. The opening point of DNA



Primed by short stretches of RNA.

- a short segment of RNA, 10 nucleotides long**) is required to start a new chain; removed later on during replication**

Semi-discontinuous

- The leading strand is synthesized continuously and the lagging strand is discontinuous (in fragments)
- The directions will always be 5' -> 3' (either away or into the fork)

DNA:
Reading : 3' > 5'
Synthesis :5' > 3'

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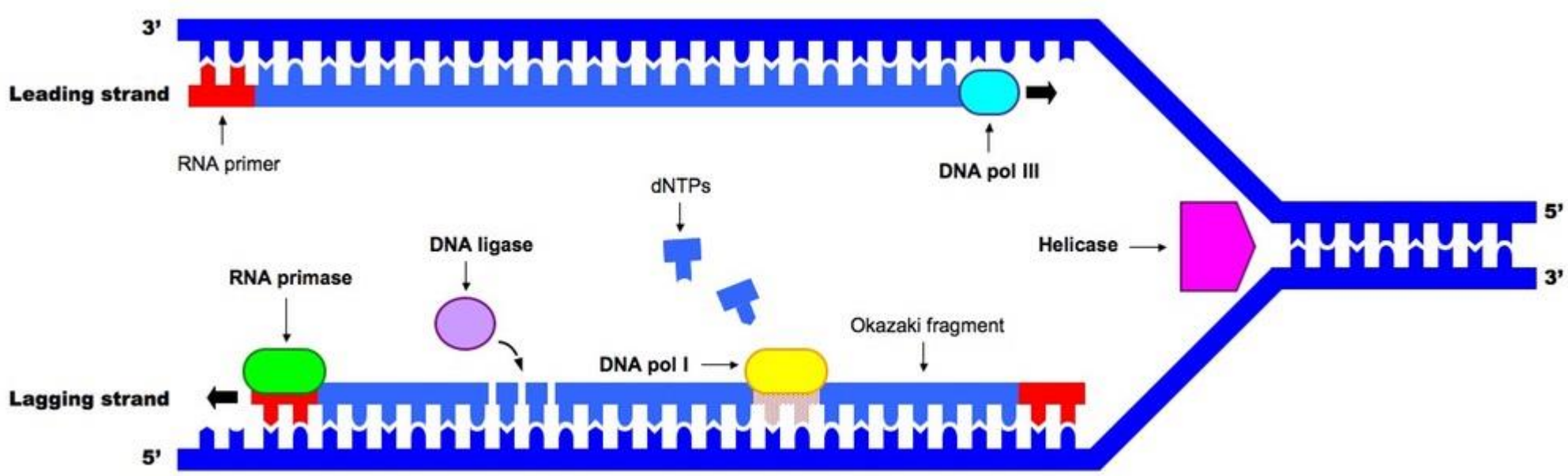
Proteins involved in DNA replication

Name	Types	Functions
DNA Helicase	_____	-An enzyme that binds to DNA sequences called Origins and unwinds DNA strands.
Single-stranded DNA binding proteins	_____	Prevents single strands from winding.
DNA Primase	_____	An enzyme that makes a short segment of RNA primer which is complementary to the DNA
DNA polymerases	α (Alpha) , β (Beta) , γ (Gamma) , δ (Delta) , ε (Epsilon).	An enzyme that adds DNA nucleotides to the RNA primer. -Proofreads bases added and replaces incorrect nucleotides.
DNA ligase	_____	An enzyme that forms bonds between the sugar-phosphate backbone.
Topoisomerases	Topoisomerases I	(cut one of the DNA strands)
	Topoisomerases II	(cut both of the DNA strands)
Telomerases	_____	An enzyme that adds nucleotides to telomeres (a reign at the end of a chromosome)

Steps in DNA replication

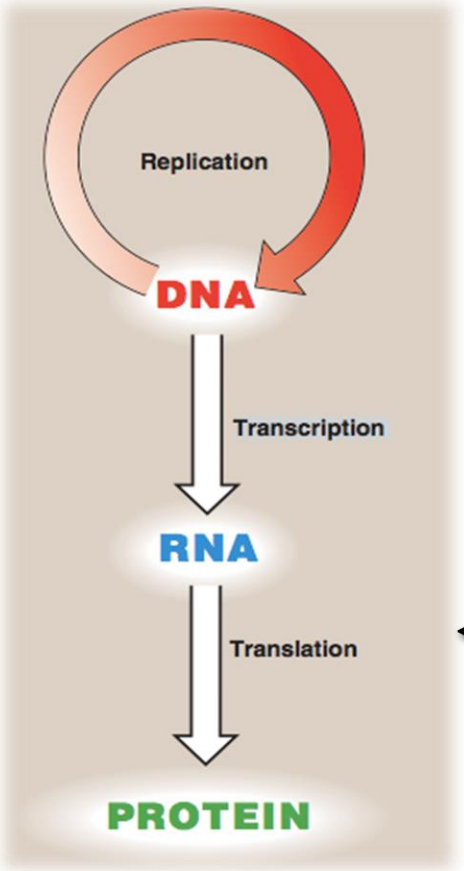
Helicase	Binds at the origin point , Untwists DNA strands, making a fork-like structure → called replication fork
Single-stranded binding proteins.	Prevents single strands from twisting again. (keeps DNA strands opened)
Primase	Makes RNA primer. (a short segment of RNA complementary to the DNA)
DNA polymerase.	1-Adds nucleotides to the primer (from 5' to 3') and checks if the bases added are correct or not, if not → removes incorrect nucleotides.(proofreads and corrects) 2- Removes the RNA primers by exonuclease activity (which creates gaps) 3-Fills the gaps that we got after removing the RNA primers (adding form 3' to 5')
Ligase	Connects the okazaki fragments by forming bonds between the sugar-phosphate backbone.(from 5' to 3')

DNA replication



Leading strand : continuous synthesis from 5' to 3' direction.
Lagging strand : discontinuous synthesis produce 5' to 3' DNA segments (okazaki fragments)

The central dogma of Molecular Biology



*A portion of **DNA**, called a **gene**, is transcribed into **RNA**.*

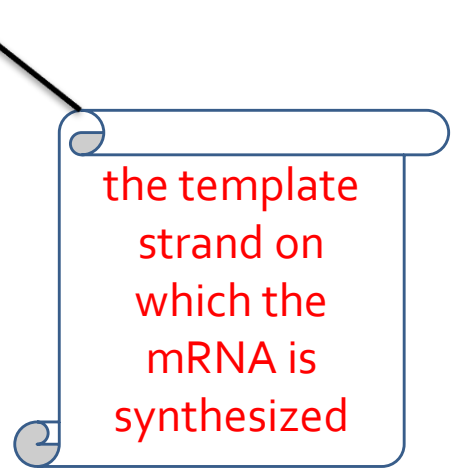
*RNA is translated into **proteins**.*

Transcription (mRNA synthesis)

- A portion of **DNA** (a **gene**) is transcribed into messenger RNA (**mRNA**).

ملاحظة:
Pay attention to the number of the protein (RNA polymerase II)

- Only one of the DNA strands is transcribed (**antisense strand**).

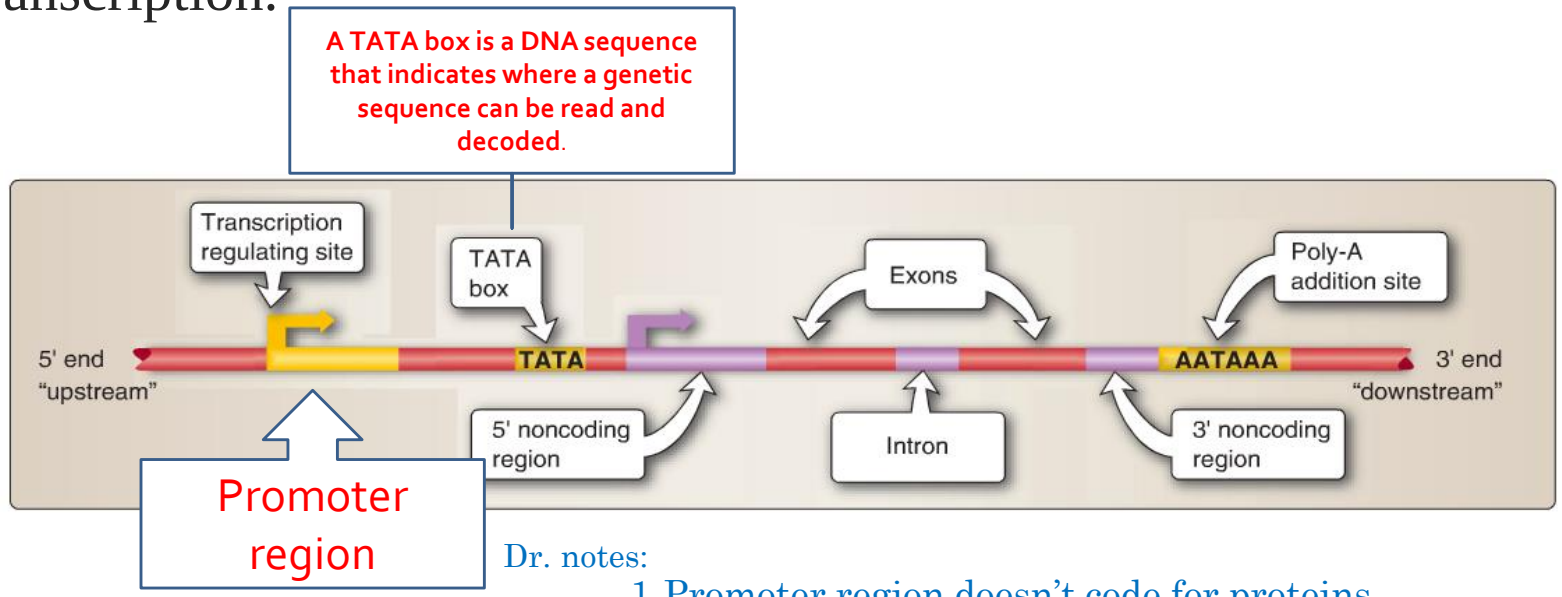


- The **RNA polymerase II** is responsible for this process.
- The direction of transcription is **5' → 3'**.

Dr.note: The mRNA chain is complementary to the mother DNA chain, whereas the amino acid chain has the same sequence of the mother DNA and a complementary sequence to the mRNA

Steps of mRNA synthesis

- **1-Chain initiation:**
  - RNA polymerase II binds to ***promoter region*** of DNA to start transcription.



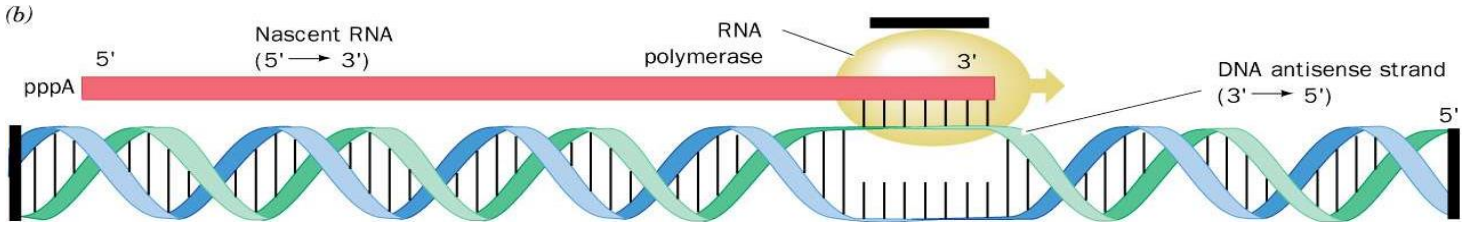
Dr. notes:

1-Promoter region doesn't code for proteins
2- before the promoter region is called (upstream) and after it is called (downstream)
3- exons will be expressed as protein while introns will be removed.
4-unlike DNA replication, RNA transcription happens only in one direction

Steps of mRNA synthesis

- **Chain elongation:**
  - A portion of DNA template unwinds (opens) at the point of RNA synthesis. (called a bubble)
  - This forms a short length of RNA-DNA hybrid.
- **Chain termination:**
- DNA contains specific sites which stop transcription (at a sequence of 4-10 AT base pairs).

After the termination we get an immature RNA, because this RNA has to travel to the cytoplasm, it needs some modifications to protect it and help the ribosomes recognize it. (post transcriptional modification)



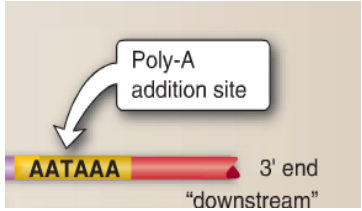
Post-transcriptional modification

- **Capping:** Addition of a methylated guanine nucleotide at 5’ end of mRNA

  Function:
  - To prevent mRNA degradation by exonucleases.
  - It helps the transcript bind to the ribosome during protein synthesis.

- **Polyadenylation:** Addition of a poly(A) tail (a highly conserved AAUAA sequence) at 3’ end of mRNA.

  Functions:
  - To protect the mRNA from degradation
  - For ribosomal RNA recognition

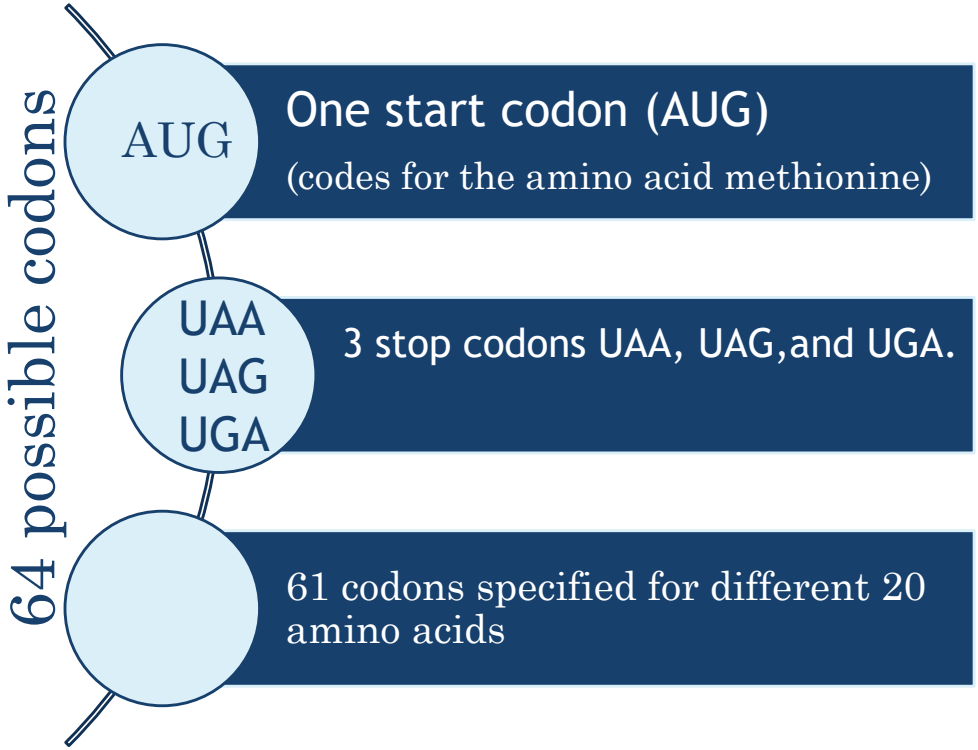


- **Intron removal for releasing mature mRNA from nucleus.**

Translation (Protein synthesis)

It is a process of protein synthesis from mRNA

- mRNA has genetic codes for amino acids present in proteins.
- **The genetic code** is a dictionary that identifies the correspondence between a sequence of nucleotide bases and a sequence of amino acids.
- **Each individual word in the code is composed of three nucleotide bases (codons).**



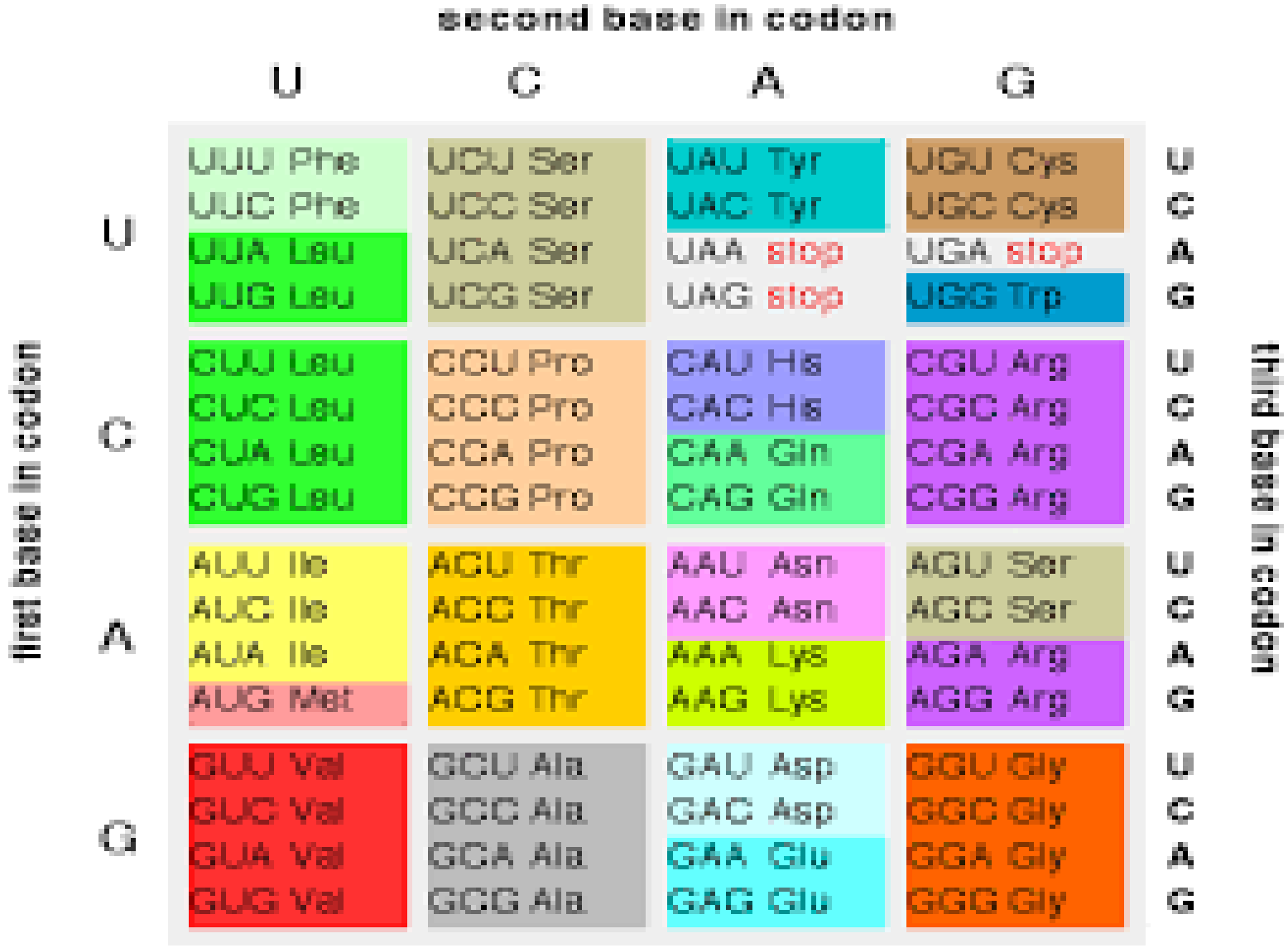
الكودون هو ثلاثة "
نيوكليتايد تكون شفرة لحمض أميني معين"

61 coding codons (including the start codon)
3 non coding stop codons

جملة لتسهيل حفظ كودونات التوقف:

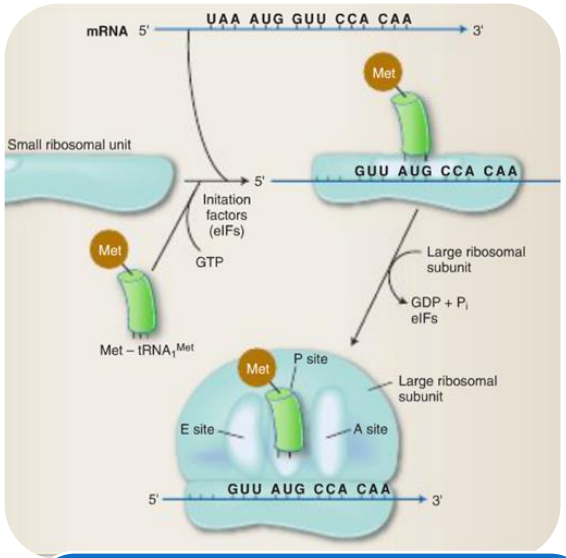
" يُقال من يواعد يُواجه"
UGAl mn UAAed UAGeh

You only need to memorize the stop codons and the start codon (written in the previous slide)



Components required for Translation

- Amino acids
- Transfer RNA (tRNA)
- Aminoacyl tRNA synthetase
- mRNA
- Functionally competent ribosomes
- Protien factors
- ATP and GTP



1. Initiation: in general it means {making complements}

Puts (ribosoms +tRNA+ mRNA} together and make it ready to start

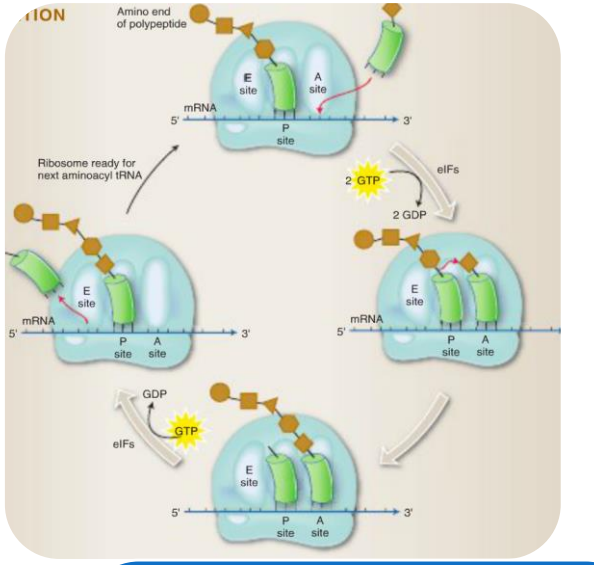
Produces an initiation complex made of :

1- small ribosomal subunit

2- large ribosomal subunit

3-mRNA

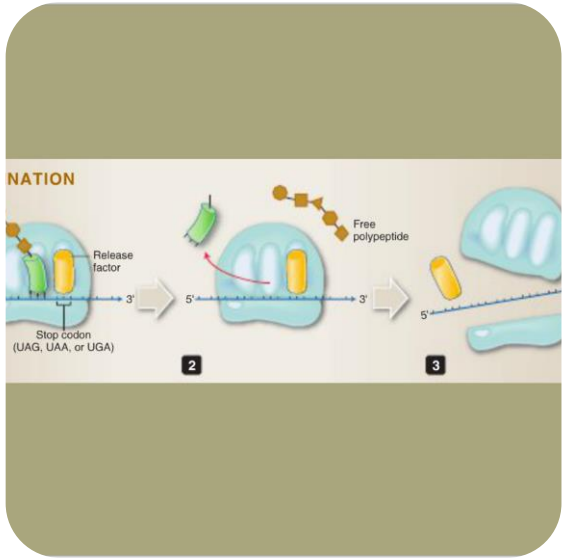
4- methionine tRNA



Elongation: it happens until the termination (stop codon)

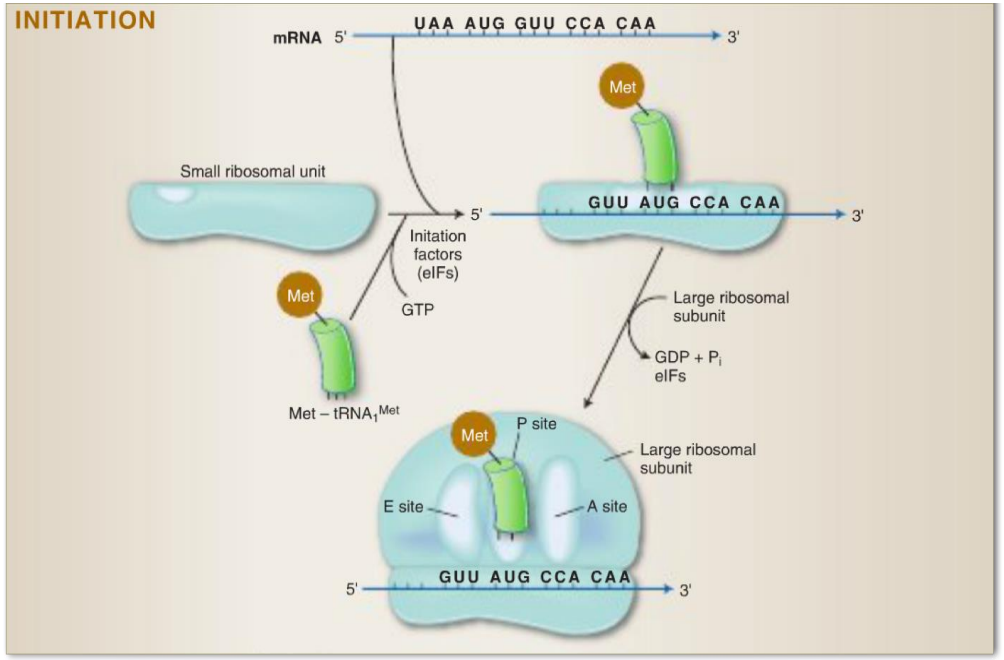
* P =peptide side, A=incoming amino acids, E= Exit site

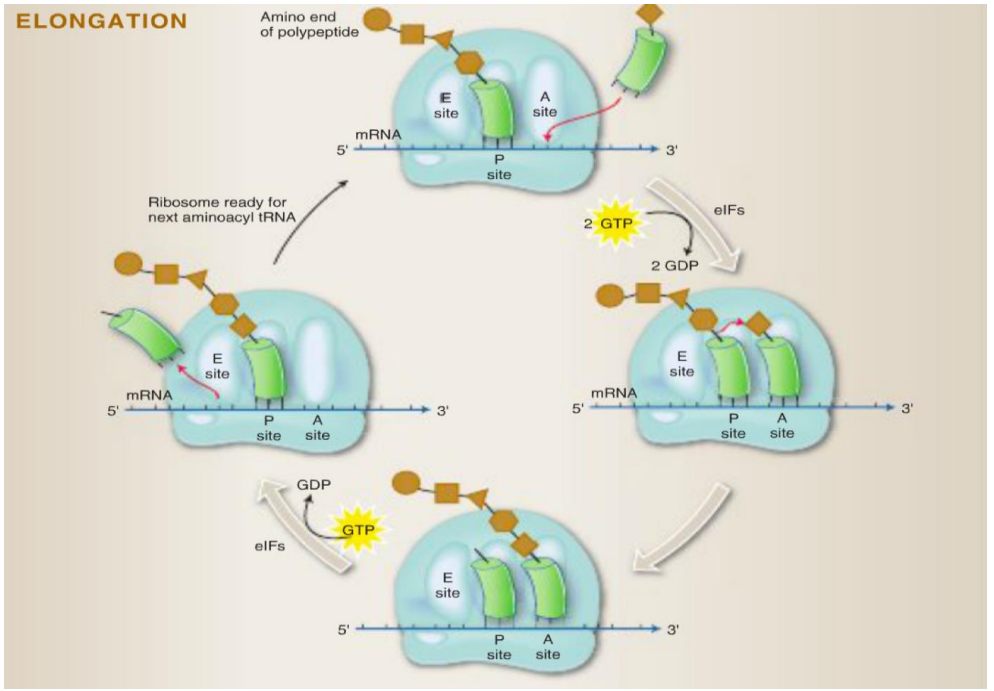
Important enzyme in elongation : peptidyl transferase

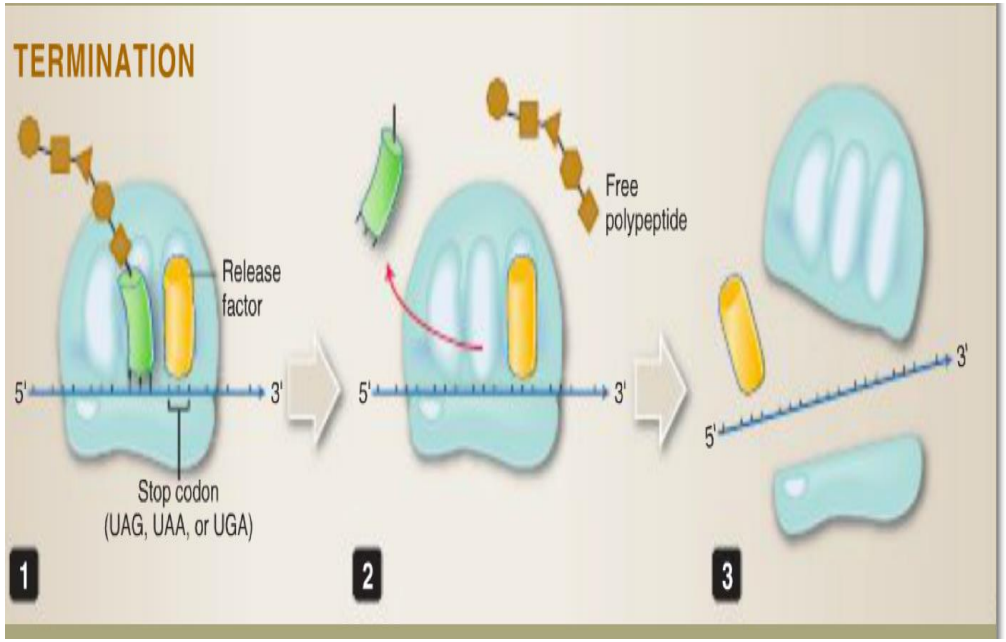


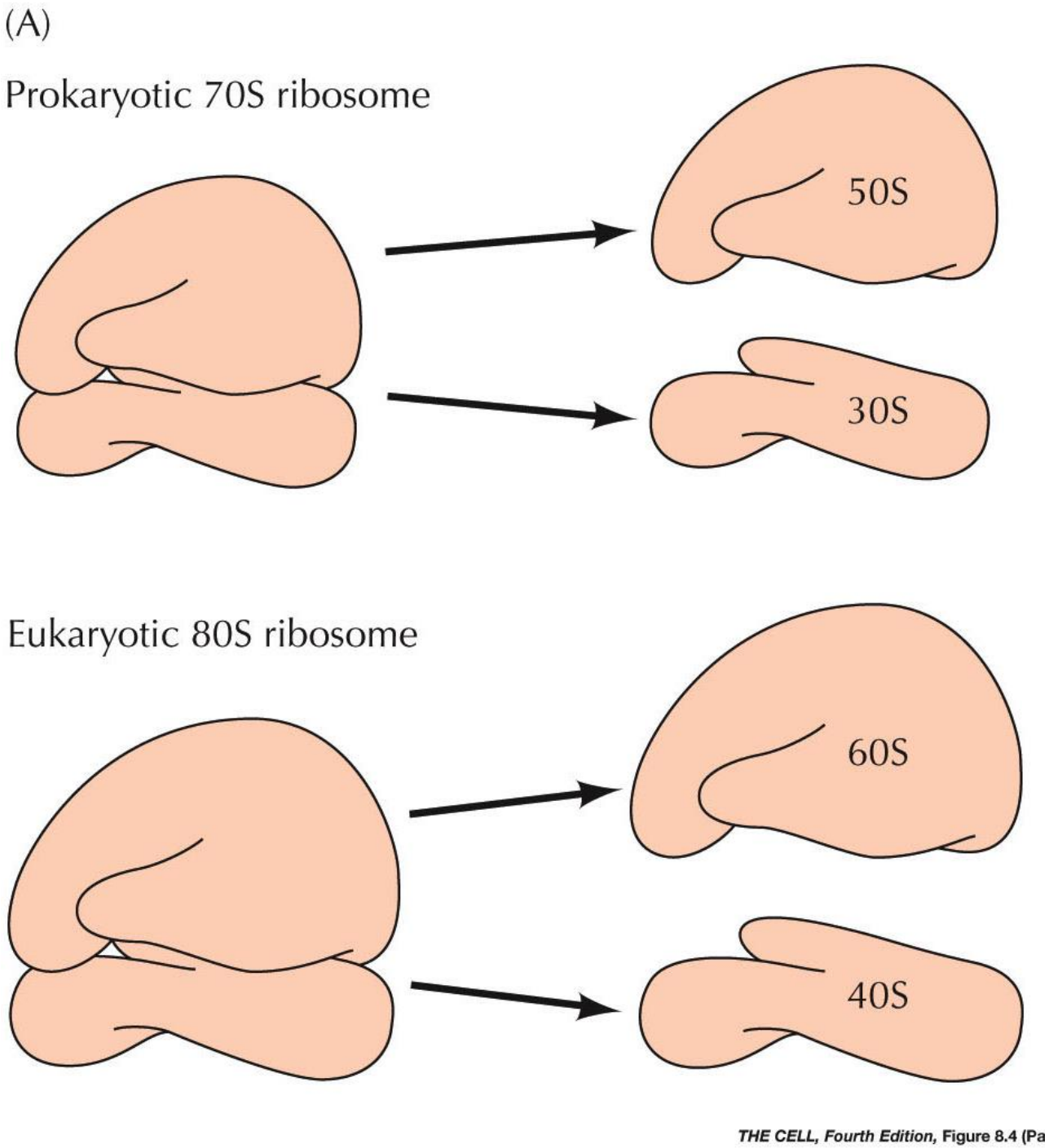
Termination : the release factor binds to the A site > everything disassembles

(يتفكك الريبوسوم بمجرد ارتباط عامل فك الارتباط في الموقع أ)


INITIATION
mRNA 5'
UAA AUG GUU CCA CAA
3'
Met
Small ribosomal unit
5'
GUU AUG CCA CAA
3'
Initation factors (eIFs)
GTP
Met
Met – tRNA$_1^{Met}$
Large ribosomal subunit
GDP + P$_i$
eIFs
Met
P site
Large ribosomal subunit
E site
A site
5'
GUU AUG CCA CAA
3'


ELONGATION
Amino end of polypeptide
E site
A site
mRNA
5'
3'
P site
Ribosome ready for next aminoacyl tRNA
2 GTP
eIFs
2 GDP
GDP
GTP
eIFs


TERMINATION
Release factor
5'
3'
Stop codon (UAG, UAA, or UGA)
Free polypeptide
1
2
3



THE CELL, Fourth Edition, Figure 8.4 (Pa

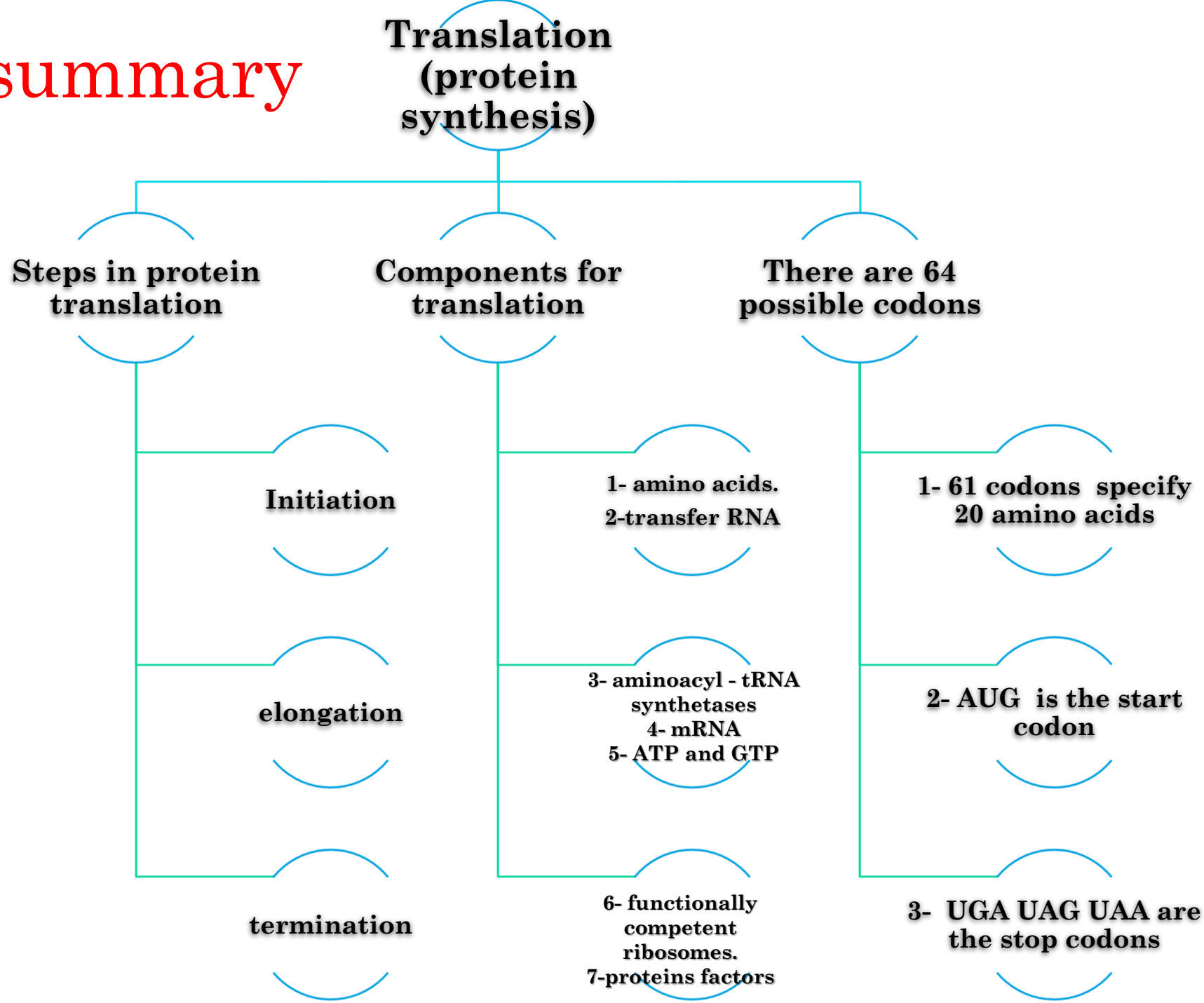
Mentioned in males lecture:

- All prokaryotes have 70S ribosomes. 70S ribosome is made up of a large subunit (50S) and small subunit (30S)
- Eukaryotes have larger ribosomes (80S) made up of 60S and 40S subunits.

- S= Svedberg units to measure the size of the subunits

- In humans the start codon is **Methionine.**
- In bacteria the start codon might code with different codons.

In summary


Translation (protein synthesis)
Steps in protein translation
Components for translation
There are 64 possible codons
Initiation
elongation
termination
1- amino acids.
2-transfer RNA
3- aminoacyl - tRNA synthetases
4- mRNA
5- ATP and GTP
6- functionally competent ribosomes.
7-proteins factors
1- 61 codons specify 20 amino acids
2- AUG is the start codon
3- UGA UAG UAA are the stop codons

Quiz

- Only ……..of the DNA strands is transcribed (**antisense strand**)

One Two Three Four

- Protein makes a short segment of RNA

Single stranded Primase DNA Helicase Ligase

- Addition of a methylated guanine nucleotide **at 5' end of mRNA**

Polyadenylationcc intron axone capping

- Polyadenylation and capping function as

helps the transcript bind to the ribosome during protein synthesis

ribosomal RNA recognition

a protect the mRNA from degradation

None

1-A
2-B
3-D
4-C

GIRLS TEAM:

- الهنوف الجلعود
- رهف الشنيير
- شهد الجبرين
- لينا الرحمة
- سارة البليهد
- ليلى الصباغ

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1-Dawood Ismail.

2- turkey al-bnhar

3- saeed alsarar

4- abdulmalik alsharhan

5- mohammed al-quefly

6- nwaf abdulaziz

Team leaders:
1- Mohammed hassa hakeem
2- Reham alhalabi

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For editing file:

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