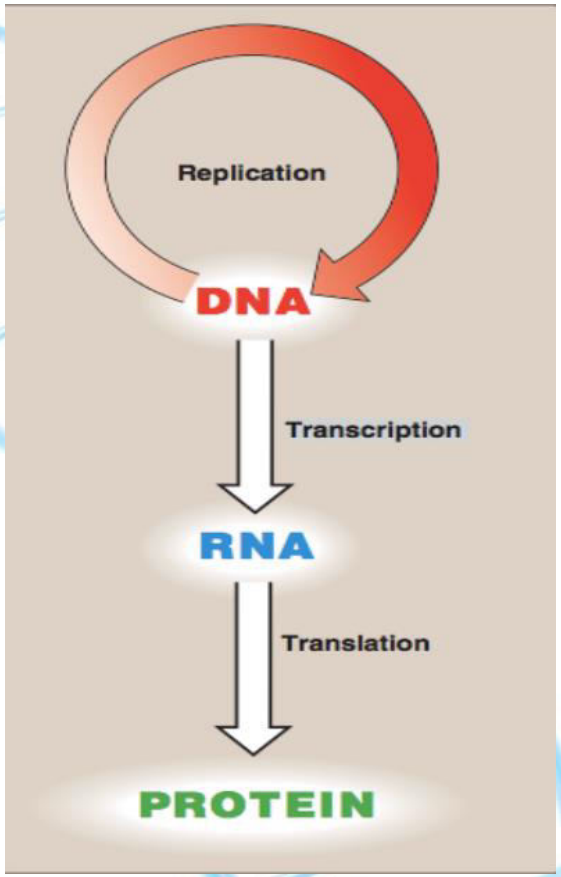
2018/9/24

Molecular Biology (2) (DNA&RNA)

- **Color Index:**
  - Important.
  - 436 Notes
  - **Original slides.**
  - **438 notes**
  - **Extra information**

Objectives:

- **understand DNA replication.**
- **know the transcription of genetic material into messenger RNA.**
- **get an idea about the translation of mRNA into a functional protein.**



Central dogma of Molecular Biology:

A portion of DNA, called a gene, is transcribed into RNA, then RNA is translated into proteins.

DNA is the genetic material

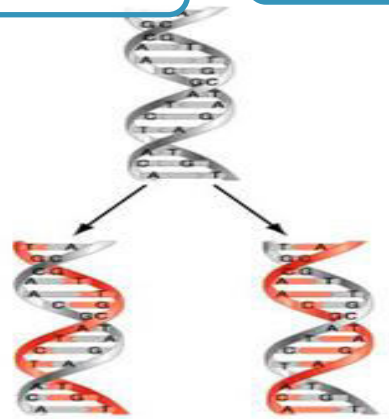
Therefor it must

- Replicate faithfully (in a correct way)
- Have the coding ability (**ability to transfer information**) to produce proteins for all cellular functions.

Features of Eukaryotic DNA Replication:

Semiconservative

- Parental strand
- **newly-replicated strand.**



Primed by short stretches of RNA

There must be a basic structure "a foundation". For The enzymes to work on

it can't start from scratch; therefore Primers (RNA nucleotides) are used (and they are later removed)

Bidirectional

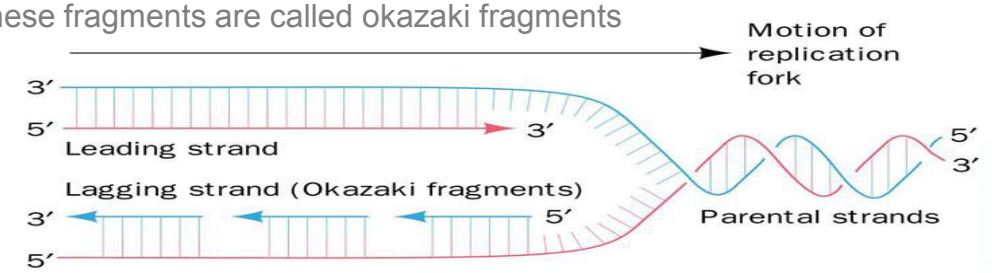
with multiple origins of replication.

Semi-discontinous.

- **The leading strand** synthesized <u>continuously</u>
- **the lagging strand** <u>discontinuous</u> (in fragments)

The directions will always be 5' -> 3' (either away or into the fork).

The two strands are antiparallel. However, DNA polymerase can ONLY work in a 5' 3' direction so we are left with gaps where the DNA polymerase can't continue working. These fragments are called okazaki fragments



Proteins involved in DNA replication

major thanks for 436 teamwork

*للتذكر: هل لك سبب تلوم بُه ؟ لا، توبه هو بريء

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	a (Alpha) , b (Beta) , g (Gamma) , d (Delta) , e (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.**

Untwists DNA strands, making a fork-like structure called **replication fork**

- **Single-stranded binding proteins.**

Prevents single strands from twisting again.

- **Primase**

Makes RNA primer.

- **DNA Polymerase**

1- Adds nucleotides to primer

2- proof reads (checks if bases added are correct),
if incorrect it replaces incorrect nucleotides.

NOTES:

Why do we need Single-stranded binding proteins?
The DNA has a lot of hydrogen bonds between its base pairs, and because hydrogen bonds are very strong they may form back on their own, so we need those proteins to keep the two strands apart to prevent hydrogen bonds from forming and reconnecting the strands while replication is still happening.

If there are multiple origins then there are multiple helicase.

some places in the DNA have specific sequence of codons (helicase origin)

DNA Replication video

Cont..

- **DNA polymerase.**

Removes the RNA primers by **exonuclease** activity.

- **DNA polymerase.**

Fills the gaps that we got after removing the RNA primers.

- **Ligase**

Connects the okazaki fragments by forming bonds between the sugar-phosphate backbone.

• Exonucleases are enzymes that remove nucleotides.

Transcription (mRNA synthesis)

- A portion of DNA (a gene) is transcribed into messenger RNA (mRNA).
- Only one of the DNA strands is transcribed (antisense strand).
- RNA polymerase II is responsible for this process.
- Direction of transcription is 5' to 3'.

In RNA:

there may be multiple RNA synthesis bubbles at the same time

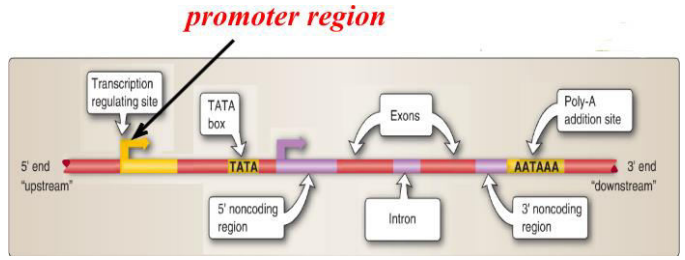
Transcription & Translation

Steps of mRNA Synthesis:

Chain initiation

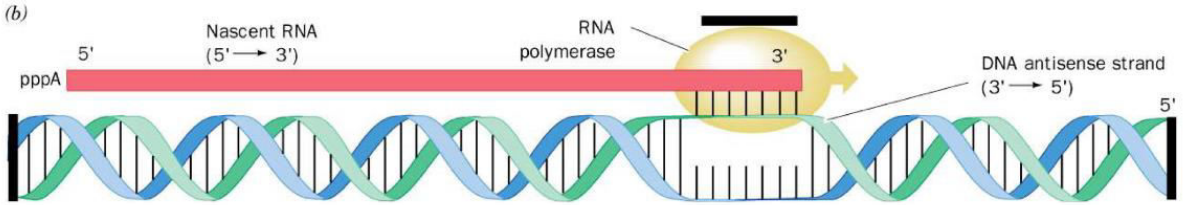
RNA polymerase II binds to promoter region of DNA to start transcription.

Note: Ta-Ta box is in the promotor region.



Chain elongation

A portion of DNA template unwinds (opens) at the point of RNA synthesis, which 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).

Post Transcriptional Modifications

The immature mRNA needs to be prepared to exit the nucleus.

This happens by:

1) Capping

The addition of a methylated guanine nucleotide at the **5' end** of the mRNA.

Functions

- Prevents mRNA degradation by exonucleases
- Helps the transcript bind to the ribosome during protein synthesis

2) Polyadenylation

The addition of a poly(A) tail (a highly conserved AAUAA sequence) at the **3' end** of mRNA.

Functions

- Protects mRNA from degradation
- For ribosomal recognition

3) Intron removal

(for releasing mature mRNA from nucleus.)

NOTES:

5' end → cap
3' end → tail

Introns:
intervening sequences that do not code for any proteins, therefore they must be removed.

Exons:
portions of the gene that code and express into a protein.

The RNA that has exons+ introns is considered to be immature RNA.

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 (THE CODON) is composed of three nucleotide bases

First position (5′ end)	Second position				Third position (3′ end)
	U	C	A	G	
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met[b]	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

Just memorize the **stop codons** and the **start codon**

64 possible codons

61 codons: specify for 20 amino acids

1 codon of the 61: Start codon (**AUG**)

the start codon AUG codes for the amino acid **methionine**,

SO, we find methionine always the first amino acid in the protien chain.

3 stop codons: (**UAA**), (**UAG**), and (**UGA**)

جملة لتسهيل حفظ كودونات التوقف
"يقال من يواعد يواجه"

UGAl mn **UAA**ed **UAG**eh

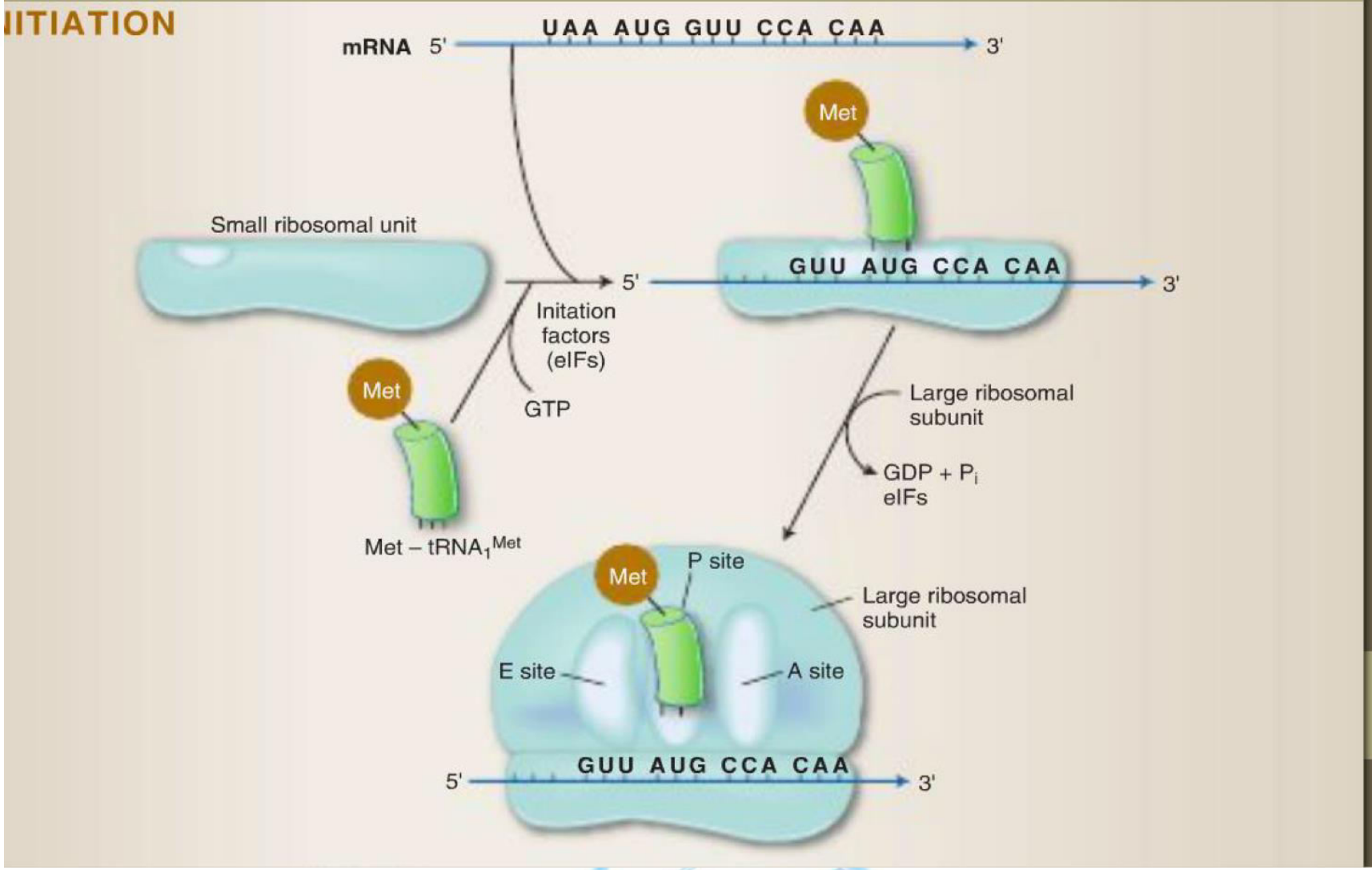
لتسهيل الحفظ:
Start codon starts with **A**
Stop codons start with **U**

- codons specify for amino acids
- A,U,G,C combine to give 64 different combinations.
- Since we have 20 amino acids, **more than one codon** can code for **the same amino acid**.
- stop codons **don't code** for any amino acids.

Components required for translation

- Amino acids
- Transfer RNA (tRNA)
- Aminoacyl-tRNA synthetases
  - an enzyme that binds the correct amino acid to the right tRNA
- mRNA
- Functionally competent ribosomes
- Protein factors
  - could be initiation or elongation factors
- ATP & GTP
  - Dr.note "you don"t have to memorize the stages that requires ATP+GTP"

Steps in Protein Translation



In these steps:

-Focus on the main thing that is happening.

-What the components are(in each step).

First step:

Initiation

Generally,this step means making complements.

It requires small and large ribosomal units,mRNA,amino acyl tRNA for methionine.

These all join to form the initiation complex and become ready to start.

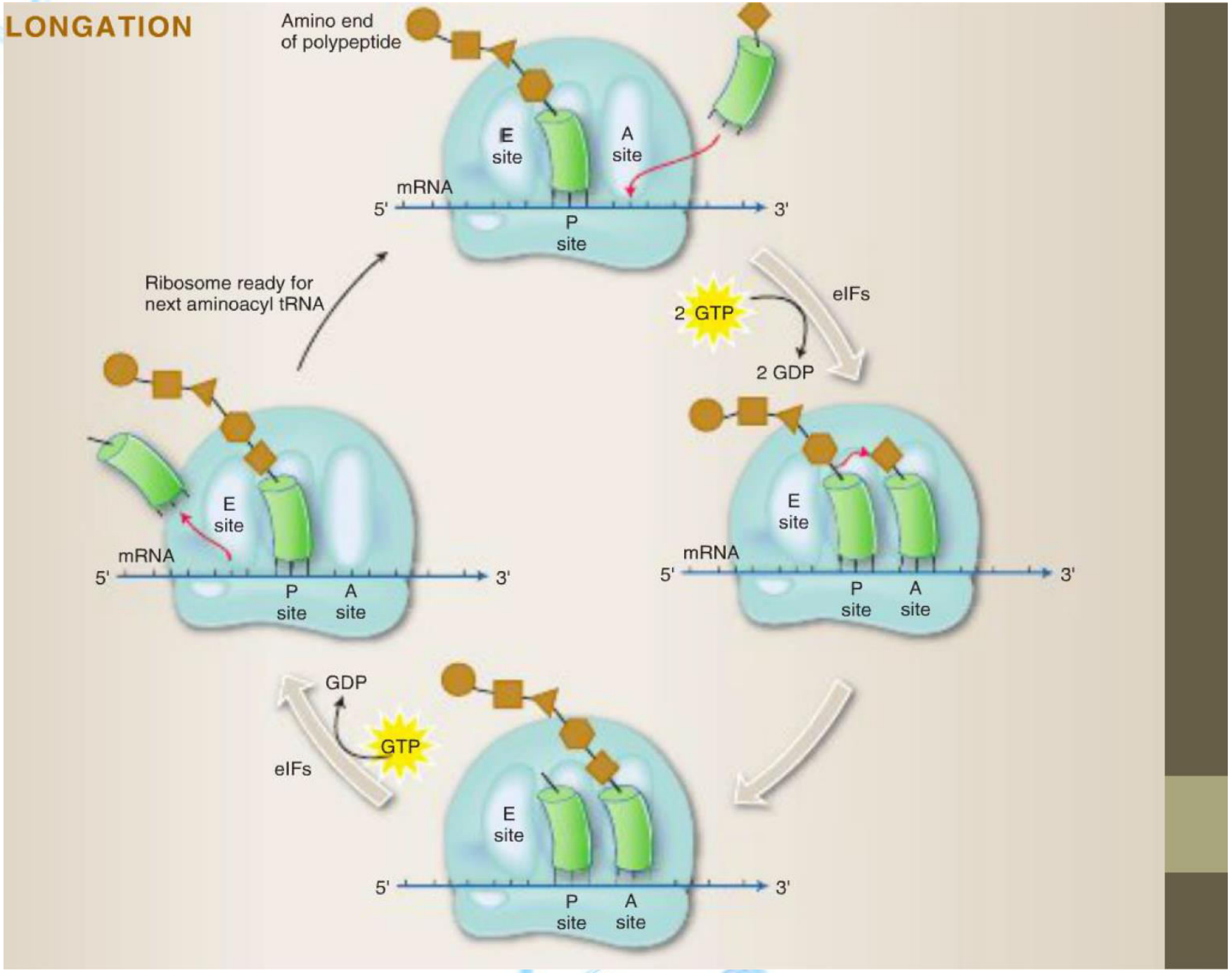
لتسهيل الحفظ سنربط حرف الموقع بالحدث:

A site: the first site (Accept)

P site: polymerization site

(protein formation site)

E site: exit site



Second step: Elongation

This step happens until termination (when it reaches a stop codon).

There is an IMPORTANT ENZYME involved here:

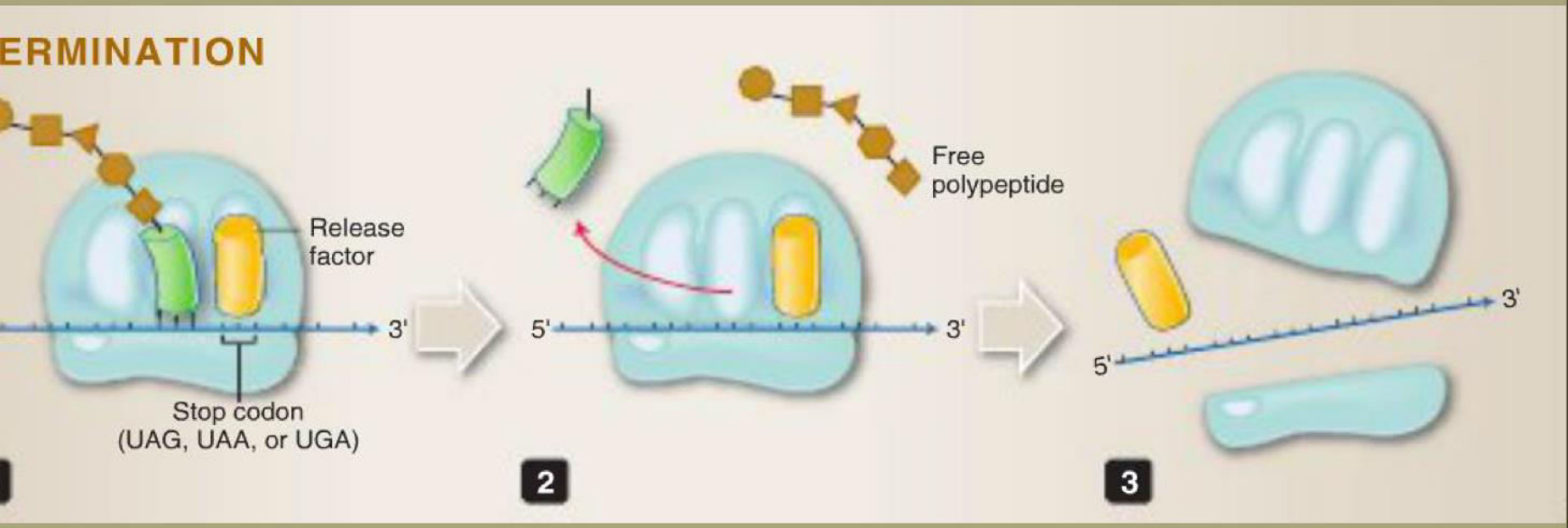
peptidyl transferase
(An RNA molecule with catalytic activity).

responsible of cutting the amino acid (elongation) + binding the polypeptide chain to the new amino acid .

Understand it like this:

it basically cuts the amino acids that are in the P site and add it to the one in the A site.

Thus, it catalyzes the formation of peptide bonds between amino acids.



Third and final step:Termination

(Memorize stop codons)

The initiation complex totally disjoints and the polypeptide is released.

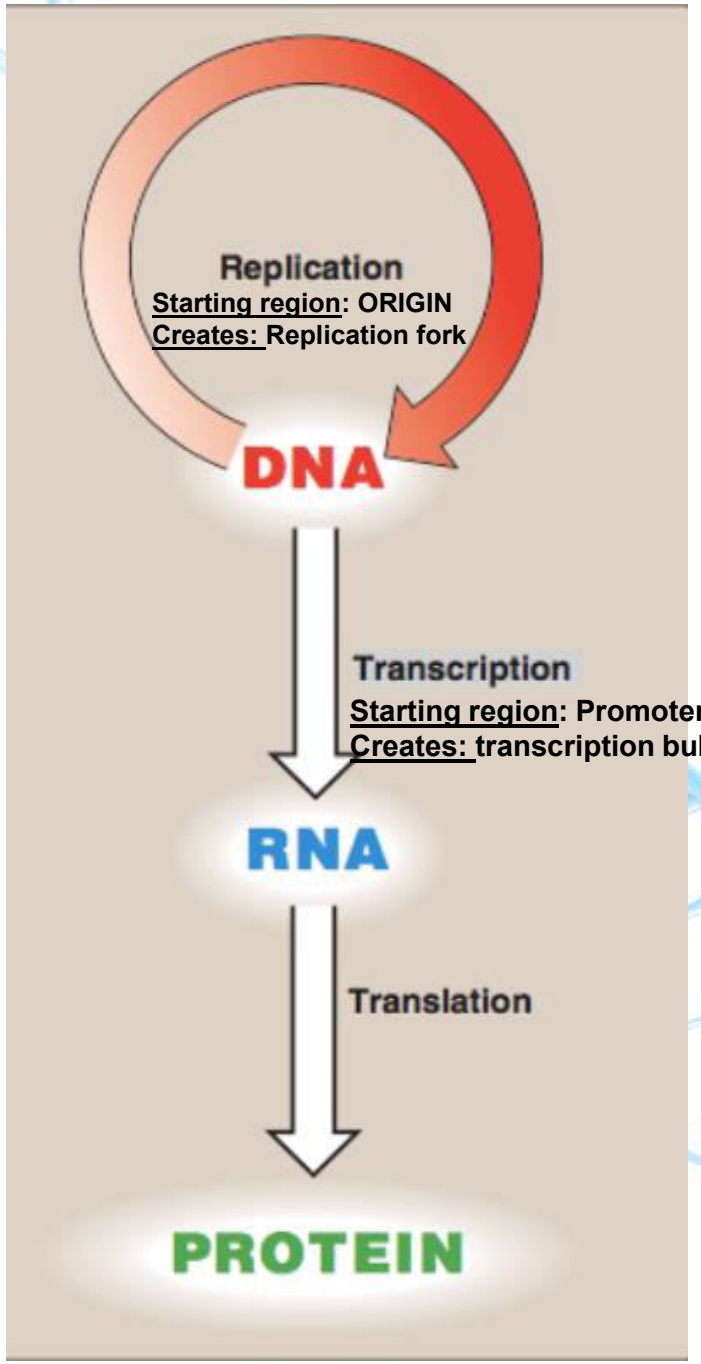
Take home messages

-DNA is the genetic material,so it must replicate faithfully and have the coding ability to produce proteins for all cellular functions.

-Only one strand of DNA(antisense strand) is transcribed into mRNA.

-The synthesized mRNA is protected from destruction and prepared for translation through post-transcriptional modification.

-mRNA transcription and protein synthesis processes are the same in both prokaryotic and eukaryotic cells with some differences.



Review

Flow of genetic information

DNA *is an* Informational molecule *composed of* Sequence of deoxribonucleotides *visualized as* DNA

provides

Information transfer

by

Transcription *visualized as* mRNA

resulting in the synthesis of

mRNA *is an* Informational molecule *composed of* Sequence of ribonucleotides *visualized as* mRNA

provides

Information transfer

by

Triplet codons *defined by* Genetic code *characterized as*

start:
AUG
stop:
UAG, UGA, UAA

which pair with

Specific anticodons

contained in

Aminoacyl-tRNAs *synthesized by* *Aminoacyl-tRNA synthetase* *visualized as*

recognizes A specific tRNA

recognizes A specific amino acid

Amino acid, Aminoacyl tRNA, Anticodon, UAC, AUG, Codon, mRNA

deliver amino acids to

Ribosomes *visualized as*

resulting in synthesis of

Protein *is a* Functional molecule *consisting of* Sequence of amino acids *visualized as*

MCQs

Q1:The primer is composed of:

A)Only RNA
B) Only DNA
C) DNA and RNA
D) Proteins
E) Both C and D

Q2: The 3 bases that are complementary to one of the mRNA codons are called,and are present on:

A)Semi codons,ribosomes
B) Antagonist codons,tRNA
C)anticodons,tRNA
D)reverse codons,rRNA

Q3: In mRNA synthesis , what is being transcribed into mRNA?

A)DNA
B)codons
C)gene
D)nitrogen bases
E)none of the above

Q4: In the final step of translation,what binds to the A site?

A)A stop codon
B)A release factor
C)Methionine D)Nothing

Answer key:

1) A
2) C
3) C
4) B

MCQs

Q5: Replication, Transcription, Translation respectively take place in:

A) All in nucleus of cell
B) Nucleus,cytoplasm,cytoplasm
C) Nucleus,nucleus,cytoplasm
D) All in cytoplasm

Q6:DNA replication results in 2 DNA molecules:

A) Each with 2 new strands
B) One with two new strands and one with 2 original strands
C) Each with 2 original strands
D) Each with one new strand and one original strand.

Answer key:

5) C
6) D

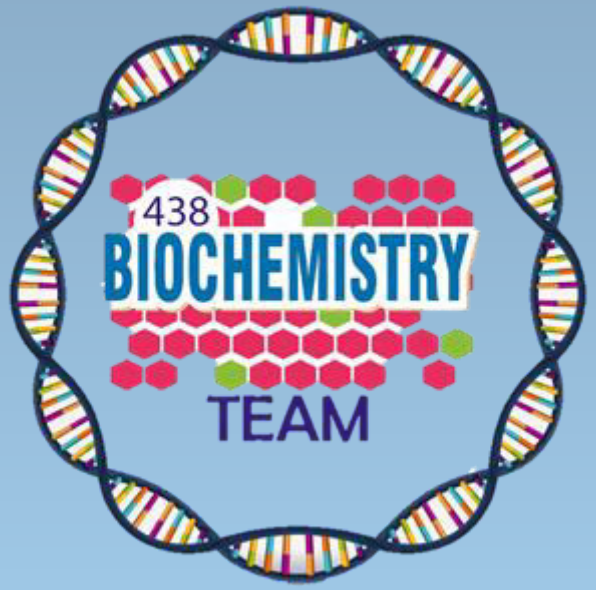
SAQs

- the sequence of three nucleotides that corresponds with a specific amino acid…
- the direction of the transcription is…..?
- in DNA replication the discontinuous synthesis produces 5'>3' DNA segments called…..?
- mention two of proteins involved in DNA replication…….?

Answer key:

1) Codons
2) 5'>’3
3) Okazaki fragments
4) they are 7 e.g DNA Halicase – primase - ligase

➢ Special thanks to:



Our logo designer:

Reem AlMazyad

swereem@hotmail.com

Biochemistry Team 435

@435biochemteam

435biochemistryteam@gmail.com

@biochemteam435

BIO TEAM

teambiochem437@gmail.com

Biochemistry team 436

@436biochemteam

biochemistrytem436@gmail.com

❖ Girls team:

- أجيد آل رشود
- الوتين البلوي
- إيلاف المسيحل
- جود الخليفة
- جود العتيبي
- سارة الهلال
- شهد السلامه
- طيف العتيبي
- عبير الخضير
- غيداء البريثن
- لينا العصيمي
- نورة التركي
- نورة المزروع
- نوف الحميضي
- هيفاء الوايلي

❖ Boys team:

- بدر الشهري
- حميد حميد
- سهيل باسهيل
- عمر الغامدي
- مهند القرني
- نايف السبر
- عبدالله الصبيحي

438 BIOCHEMISTRY TEAM

MED438
KING SAUD UNIVERSITY

❖ Team leaders:

ديما المزيد
رائد العجيري

❖ Contact us:

Biochemistryteam438@gmail.com