

Molecular biology (2)



Color index :




Main text

IMPORTANT

Extra Info

Drs Notes

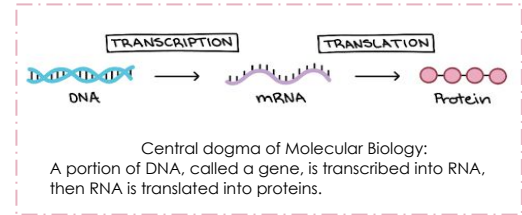
Objectives:

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

DNA is the genetic material

- Therefore it must be :

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



Features of Eukaryotic DNA Replication

1 Semiconservative with respect to parental strand:

- Daughter DNA molecules contain one parental strand and one newly-replicated strand.

2 Bidirectional with multiple origins of replication.

3 Primed by short stretches of RNA.

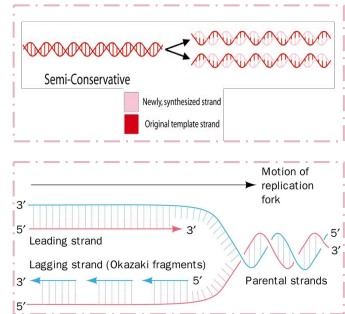
There must be a basic structure "a foundation". For The enzymes to work on. It can't start from the scratch; therefore primers (RNA nucleotides) are used (and they are later removed)

4 Semi-discontinuous

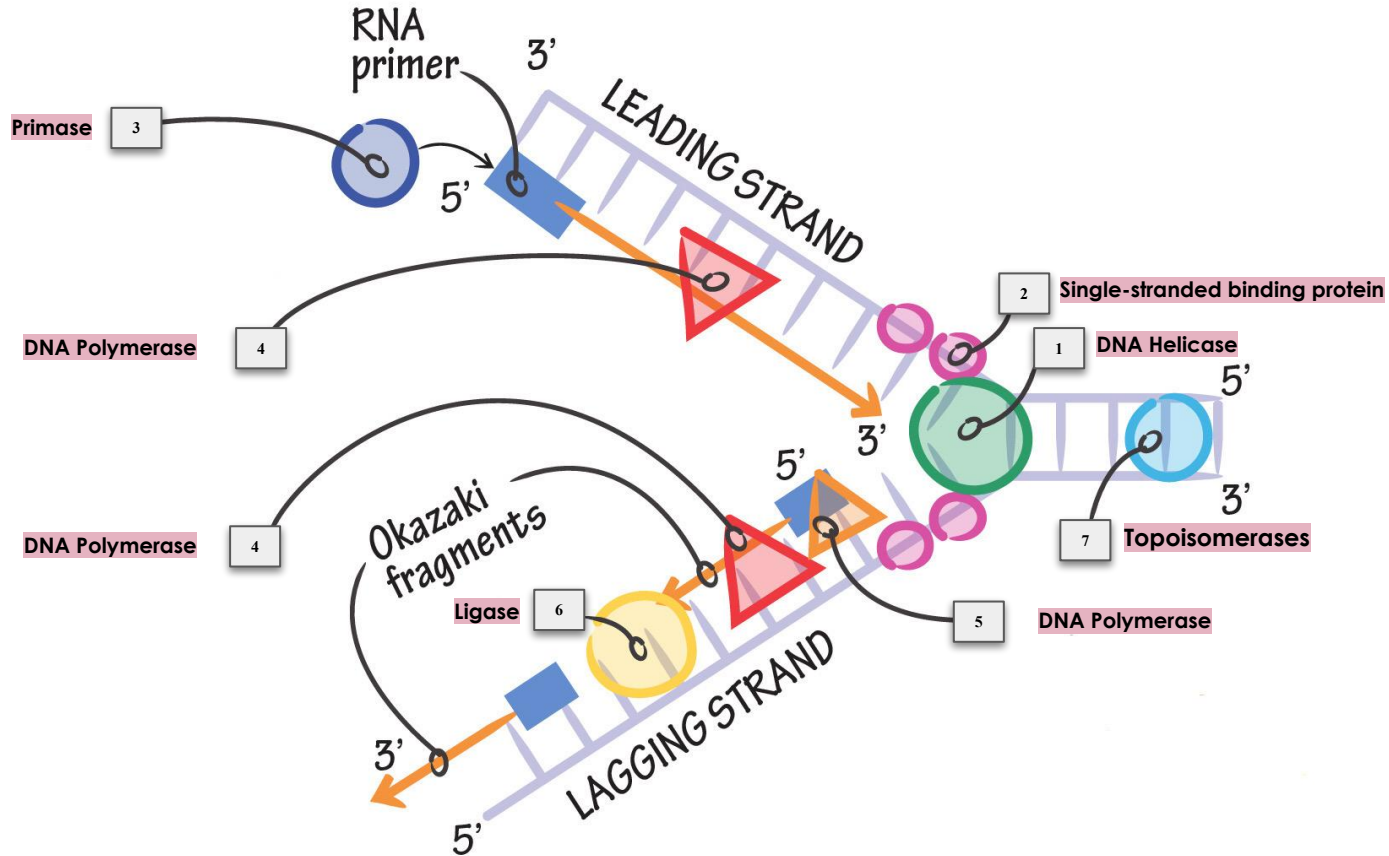
- The **leading** strand synthesized **continuously**
- The **lagging** strand **discontinuous** (in fragments)

In DNA replication, both daughter strands (**leading** strand red, **lagging** strand blue) are synthesized in their **5' → 3' directions**.

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.



Steps in DNA replication



Steps in DNA replication

 [A helpful video Part 1](#)

 [A helpful video Part 2](#)

1 **DNA Helicase** untwists DNA strands by binding to DNA sequence (helicase origin) making a fork-like structure called replication fork . some places in the DNA have specific sequence of codons (helicase origin) so if there are multiple origins then there are multiple helicase.

2 **Single-stranded binding protein** prevents single strands from twisting again
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.

3 **Primase** makes RNA primer.

4 **DNA Polymerase**

- Adds nucleotides to primer adds to 3' end only this means that DNA replication only progress from 5' to 3' end
- proofreads (check if bases added are correct), if incorrect it replaces incorrect nucleotides.

Leading strand : oriented 3' to 5' **towards the fork** تكون مستقيمة while lagging strand : oriented 5' to 3' towards fork → Okazaki fragments (discontinuous replication) تكون قطع

5 **DNA Polymerase** here remove the RNA primers by exonuclease activity and fills the gaps the we got after removing the RNA primers.

What's exonuclease ? They're enzymes that remove nucleotides.

6 **Ligase** connects the okazaki fragments on the lagging strands by forming bonds between the sugar-phosphate backbone.

7 Topoisomerases cut and relieves supercoiled DNA downstream of replication fork

if you wanna understand more [watch this video](#) التفيد والتعقيد وتفكك ونفكك الوضع ونفكك التفيد والتعقيد
overwinding التي صار يعني نقدر نقول لما يجي الـ helicase فصل الـ strands الباقيين اللي ورا بيلفون على بعضهم فلازم ننقذ الوضع ونفكك التفيد والتعقيد

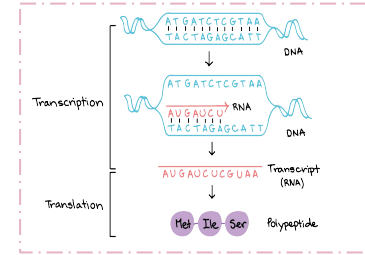
Proteins involved in DNA replication

للتذكير*: هل لك سبب تلوم يُه ؟ لا، تويه هو بريء
thanks to 436 teamwork

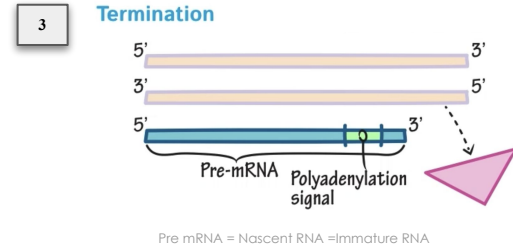
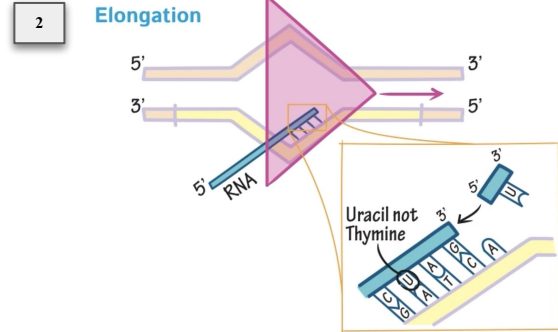
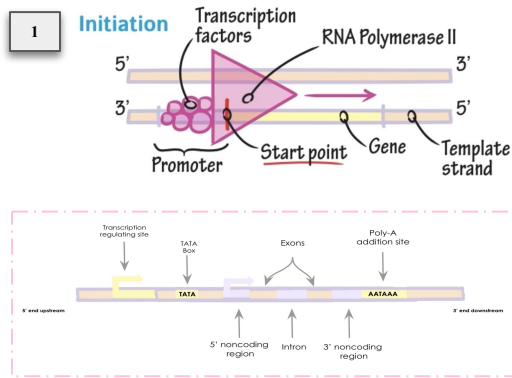
Name	Types	Functions
DNA Helicase	—	An enzyme (protein) that binds to DNA sequences called origins and unwinds DNA strands.
Single-stranded DNA binding proteins	—	Prevents single strands from winding.
DNA Primase	—	An enzyme that makes a short segment of RNA primer which is complementary to the DNA
DNA polymerases	α (Alpha), β (Beta), γ (Gamma) , δ (Delta), ϵ (Epsilon).	<ul style="list-style-type: none"> - Adds DNA nucleotides to the RNA primer. - Proofreads bases added and replaces incorrect nucleotide
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)

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**).
- The **RNA polymerase II** is responsible for this process.
- The **direction of transcription is 5' → 3'**.
Antisense strand: DNA strand which runs from 3' to 5'.
- the importance of mRNA is to carry information from DNA to the ribosomes for protein synthesis



Steps in mRNA synthesis



Steps in mRNA synthesis

 [A helpful video](#)

Or  [A helpful video](#)

- some concepts you need to understand them before reading the steps :
 - Multiple mRNA copies allow for more proteins to be produced
 - Transcription factors : proteins which bind the promoter and recruit the RNA polymerase
 - Template strand : strand of DNA which the gene to be transcribed is located

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

There's a region on the strand called promoter region then the transcription factors will come and bind to the promoter region this step is important because the RNA polymerase II enzyme will be recruited by transcription factors

نقدر نقول ان RNA polymerase II جتھا القوة والطاقة انها تعمل بسبب وجود الـ transcription factors
then the transcription begins and continues 3' to 5' along template strand

2 Chain elongation: A portion of DNA template unwinds (opens) at the point of RNA synthesis. This forms a short length of RNA-DNA hybrid.

Complementary RNA nucleotides added to the growing RNA strand (uracil instead of thymine in the RNA strand).

3 Chain termination: DNA contains specific sites which stop transcription (at a sequence of 4-10 AT base pairs).

Polyadenylation signal in the transcribed RNA signals proteins to cut it from the polymerase

بمعنى اخر Polyadenylation signal موجوده بالـ RNA الجديد بترسل اشارات لبروتينات تجي توخر الـ RNA polymerase enzyme عند ترتيب محدد من القواعد المذكوره فوق

Newly formed RNA is called Pre-mRNA or immature RNA because it still needs to be processed

Post transcriptional modification

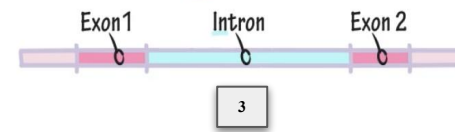
5' CAPPING



POLY-A TAIL



INTRON SPLICING "In between"



- the newly formed mRNA "immature" has to go in some modification to become "a mature RNA" and to protect the mRNA from degradation
- we have **3 types of modification** "NOT steps":

1 Capping: Addition of a **methylated guanine nucleotide** at **5' end** of mRNA. This cap is added during transcription.
Function:

- prevents mRNA degradation by exonucleases.
- helps the transcript bind to the ribosome during protein synthesis.

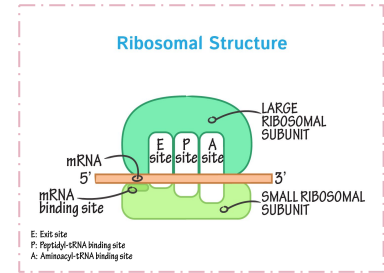
2 Polyadenylation: Addition of a **poly(A)** tail a highly conserved AAUAA sequence at **3' end** of mRNA.
Multiple adenines added at the end of the polyadenylation signal
Functions:

- To protect the mRNA from degradation
- For ribosomal RNA recognition.

3 Intron removal: Introns are non-coding sequence of DNA/RNA or Sections of the RNA sequence that are found in between exons so in this modification Introns will be removed from the RNA by the spliceosome.
Spliceosome ? Group of small nuclear RNAs and proteins which join together to recognize and remove **introns** from transcribed RNA for releasing **mature mRNA** from nucleus.

Translation (protein synthesis)

- **Translation** : 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**).
- You should know that **ribosomal structure** consists of 2 subunits each made of protein and RNA:
 - Small ribosomal subunit - has **mRNA binding site**.
 - Large ribosomal subunit
- in the ribosome you have 3 tRNA binding sites : **E** site (**E**xit), **P** site (**P**eptidyl-tRNA), **E** site (**E**xit)



بمعنى ان بال ribosome فيه ثلاث مناطق لارتباط ال tRNA اما المكان اللي اول مايوصل له ال tRNA اللي هو **A** او المكان المسؤول عن بناء رابطة ببتيدية للاحماض الامينية **P** او اخر شي المكان اللي اذا وصل له tRNA يعني راح يطلع من ال ribosome خلاص اللي هو **E**

The possible codons

- 61 codons specify 20 amino acids
 - عندنا ٦٤ كود ٣ منها للتوقف وال ٦١ الباقية موجوده عشان يكون كل كود مسؤول انه يتعرف على حمض اميني واحد فقط
 - codons specify for amino acids A,U,G,C combine to give 64 different combinations 61 of them encode amino acids and 3 specify termination of translation. .Since we have 20 amino acids, more than one codon can code for **the same amino acid**.
- One start codon (**AUG**) (the start codon could be use also as codon for **methionine**) SO, we always find methionine the first amino acid in the protein chain.
- 3 stop codons : **UAA, UAG and UGA**

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

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



جمله لتسهيل حفظ stop codons

“ يقال من يواعد يواجه ”

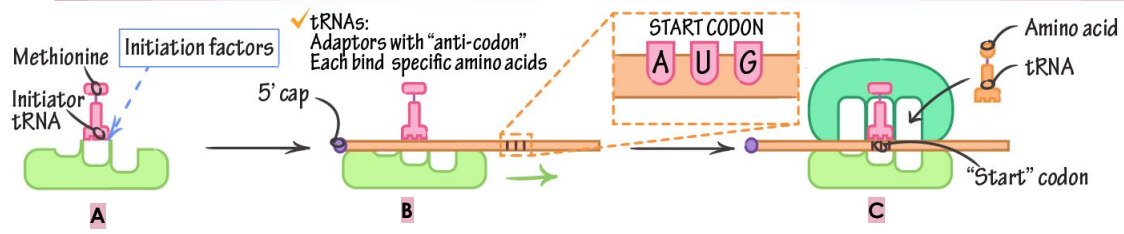
UGA! mn UAAed UAGeh

Components required for translation

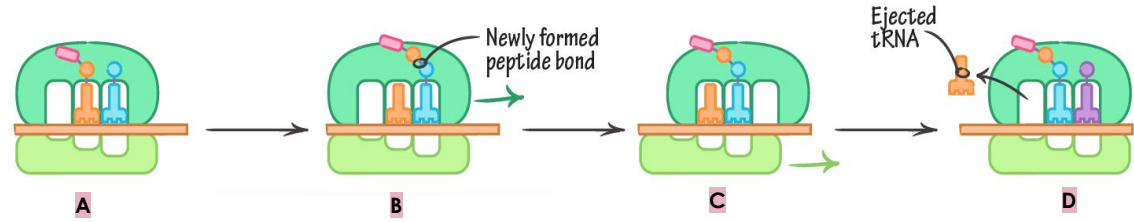
- 01 Amino acids.
- 02 Transfer RNA (tRNA).
- 03 Aminoacyl-tRNA synthetases. (Its job is to connect the appropriate amino acids onto its tRNA)
- 04 mRNA.
- 05 Functionally competent ribosomes.
- 06 Protein factors.
- 07 ATP and GTP.

Steps in protein translation

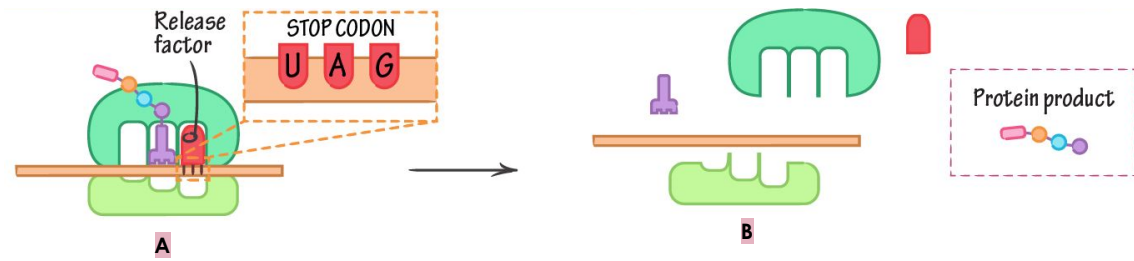
1 Initiation



2 Elongation



3 Termination



Steps in protein translation

1 Initiation :

- **A** Initiator tRNA (methionine) binds to small ribosomal subunit (with help from initiation factors)

You'll see that tRNAs are adaptors with a three nucleotide "anti-codon" section that binds to mRNA codons and also bind amino acids.

زي معايرنا في منطقة في الـ ribosome اسمها RNA binding site راح يجي الـ Initiator tRNA اللي معاه الحمض الاميني methionine اللي هو حق البدايه زي ما عرفنا يرتبط به بالمنطقة هالار تباط اللي يحفزها يستمر هو وجود initiation factors بينهم

- **B** then the small ribosomal subunit/initiator tRNA complex binds mRNA (using **5' cap to bind the 5' end**) this complex scans towards the 3' end until it locates the **start codon (AUG)** which sets the appropriate reading frame).

زي معايرنا ان الـ capping هي احد الـ modification للمRNA طيب الحين يجي الـ small ribosomal subunit اللي معاه initiator tRNA (اسمهم الكامل هو **small ribosomal subunit/initiator tRNA complex**) يرتبط mRNA والكاتب تعلقك ان هذي نهايه mRNA بمعنى اخر تعلقنا ان هذي five end فالـ small ribosomal subunit راح تبتعد عن نهايه mRNA وثناء ايتعادها ورحلتها للـ three end راح توصل عند الـ start codon

- **C** tRNA is now bound to the **AUG** codon then the large ribosomal subunit arrives to form **initiation complex** .

The initiation complex break down when stop codon binds to the release factor (tRNA).

الحين بسبب ارتباط الـ start codon جا الـ large ribosomal subunit وارتبط في التشكيلة ههيه بحيث خلاص بيدون يستقبلون كل tRNA مترتبط بحمض اميني وكل حمض اميني له كود خاص للتعرف عليه على mRNA

2 Elongation :

- **A** our new tRNA molecule shifts from the A-site to the P-site and now has growing chain of amino acids bound to it and a new tRNA with amino acid will arrive to the A site .

- **B** the peptide chain is shifted to the amino acid in the A-site and indicate the **newly formed peptide bond** this happened by **peptidyl transferase enzyme** that forms peptide bonds between adjacent amino acids using tRNAs during the translation process of protein biosynthesis then large ribosomal subunit shifts 3' one codon.

في **A** قلنا ان الـ tRNA اللي كانت بـ A site راحت للـ P site ومعها رابطته بيتبديية growing peptide chain وحت tRNA جديده معها بحمض اميني ارتبطت بـ A site بعدها في **B** الرابطة البيبتيدية اللي في P site راح تزوح للـ tRNA الجديده عن طريق انزياح اسمه **peptidyl transferase enzyme** وبعد ماراحت الرابطة للـ tRNA الموجوده بـ A site وبعدها الـ large ribosomal subunit راح تتحرك بمعنى اخر تبني تتخلص من الـ tRNA الفاضيه وتخليها بـ E site وتخلي اللي معها الرابطة بـ P site

- **C** Small ribosomal subunit follows - tRNA that was in P-site now in E-site and tRNA that was in A-site now in P-site.

- **D** E-site tRNA ejected and new A-site tRNA added.

C بكل بساطة يقول لك ان الـ large ribosomal subunit تحركت واجد لليمين فلزام يجي الـ small ribosomal subunit يلحقهم لليمين ولما لحقهم **D** شاف ان الـ tRNA الفاضيه موجوده بالـ E site فالـ ribosome طلعها خلاص منه واستقبل tRNA جديده معها حمض اميني جديد في A site وهالشي راح ينعاد لين يوصلون مرحله التوقف

3 Termination :

- **A** When codon in A-site is stop codon (**UAG, UAA, or UGA**) a release factor is added to the A-site.

- **B** Release factor binding releases the peptide chain and causes ribosome to dissociate.

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.

Quiz

Q1 : Which of the following is true about DNA

- | | | | |
|-------------------------------|-------------------------------------|--|--------------------------|
| A) Must replicate faithfully | B) Must have the ability of coding | C) Produce protein for all cellular functions | D) All of them are true |
|-------------------------------|-------------------------------------|--|--------------------------|

Q2 : An enzyme that binds to DNA sequences called Origins and unwinds DNA strands?

- | | | | |
|--------------------|----------------|------------------|-----------------|
| A) DNA Polymerase | B) DNA Ligase | C) DNA Helicase | D) Telomerases |
|--------------------|----------------|------------------|-----------------|

Q3 : mRNA has genetic codes for amino acids present in ?

- | | | | |
|--------------|--------------|-------------|---------|
| A) Polymers | B) Proteins | C) Enzymes | D) DNA |
|--------------|--------------|-------------|---------|

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

- | | | | |
|------------------|----------------------|----------------|-------------------|
| A) A stop codon | B) A release factor | C) Methionine | D) A start codon |
|------------------|----------------------|----------------|-------------------|

Q5 : 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. |
|-----------------------------|--|----------------------------------|---|

Q6 : Addition of a poly (A) tail (a highly conserved AAUAA sequence) at 3' end of mRNA

- | | | | |
|-------------|---------------------|--------------------|--------------------|
| A) Capping | B) Polyadenylation | C) Intron removal | D) Intron removal |
|-------------|---------------------|--------------------|--------------------|

SAQs :

Q1: enumerate start codon and the 3 stop codons ?

Q2: in DNA replication the discontinuous synthesis produces 5'→ 3' DNA segments called.....?

Q3: the direction of the transcription is.....?

★ MCQs Answer key:

1) D 2) C 3) B 4) B 5) D 6) B

★ SAQs Answer key:

- 1) Start codon: a AUG, Stop codons: UAA, UGA, UAG.
- 2) Okazaki fragments
- 3) 5'→ 3'



Girls team:

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Nada Babilli

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Reem alamri

Reema Alomar
Reem Alqahtani

Renad Alhumaidi
Shaden Alobaid

Noura Alsalem
Lama Alahmadi

Sadem Alhazmi
Somow Abdulrahman

Budoor Almubarak
Samar Almohammedi

Nuha Alkudsi
Norah Alsheikh
Muneerah Alssdhan
Mayasem Alhazmi
Noura alshathri
Duaa Alhumoudi



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Mohammed alsayari

📍 Abdullaziz alomar
Abdulaziz alrabiah
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📍 Abdullah almazro
Hamad almousa
Ahmad alkhayat

"There is no elevator to success, you have to take the stairs"

📍 Shatha Aldhohair

Mishal Althunayan

Made by 📍



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