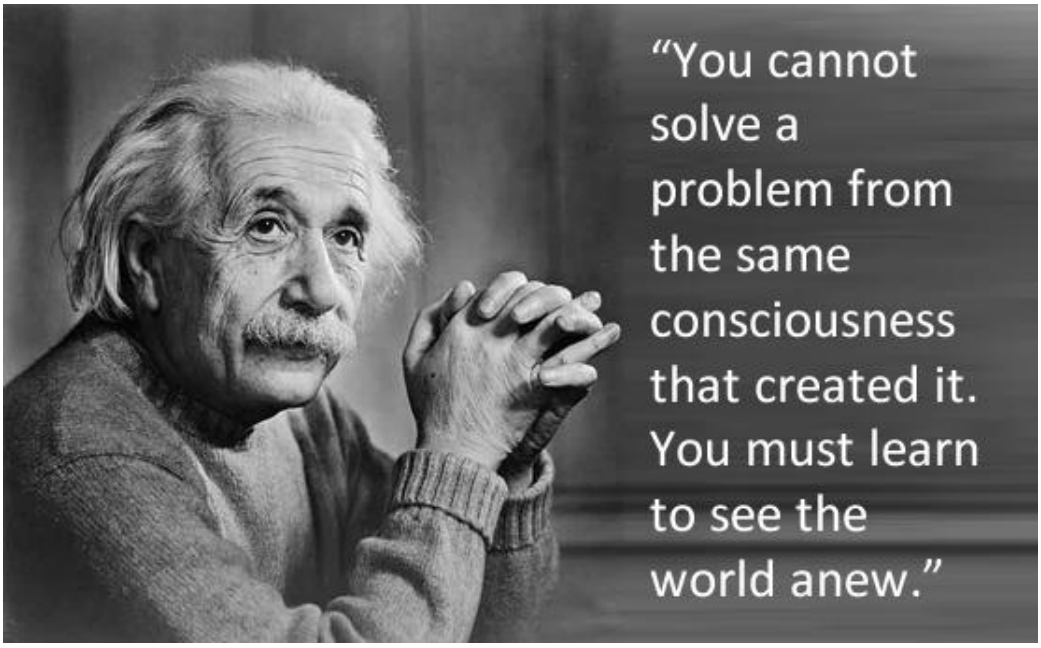
Molecular biology - 2

Foundation block

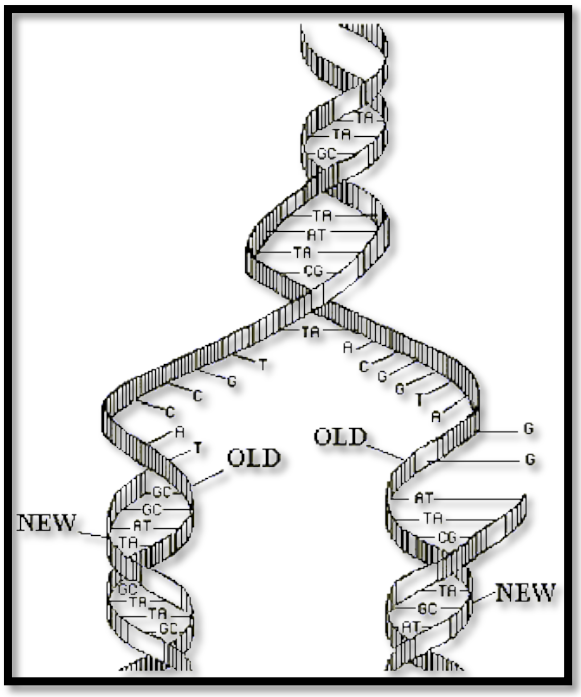


Color Index:

- **Pink = Girls**
- **Blue = Boys**
- **Red = Important**

- DNA replication model:

Semiconservative model (one parental strand “origin” and newly replicated strand).



- The direction of DNA replication:
  - ❖ Unidirectional replication (in one direction)
  - ❖ Bidirectional replication (in two directions)

- DNA replication is Semi-discontinuous :

The leading strand is continuous (in the direction of the replication fork) the lagging strand is discontinuous (the opposite direction of the replica fork).

- Enzymes involved in DNA replication:

Enzyme name	Function
Helicase	Unwinds parental double helix
Single-strand Binding protein	stabilizes separate strands
Primase	adds ashort primer to template strand
DNA polymerase	forms new strands
DNA polymerase I (exonuclease)	removes RNA primer and inserts the correct bases
Ligase	joins Okazaki fragments (in the lagging strand) and seals gaps in sugar-phosphate backbone

Explanation :

Leading strand in the correct direction 5’ to 3’ (the fork direction)

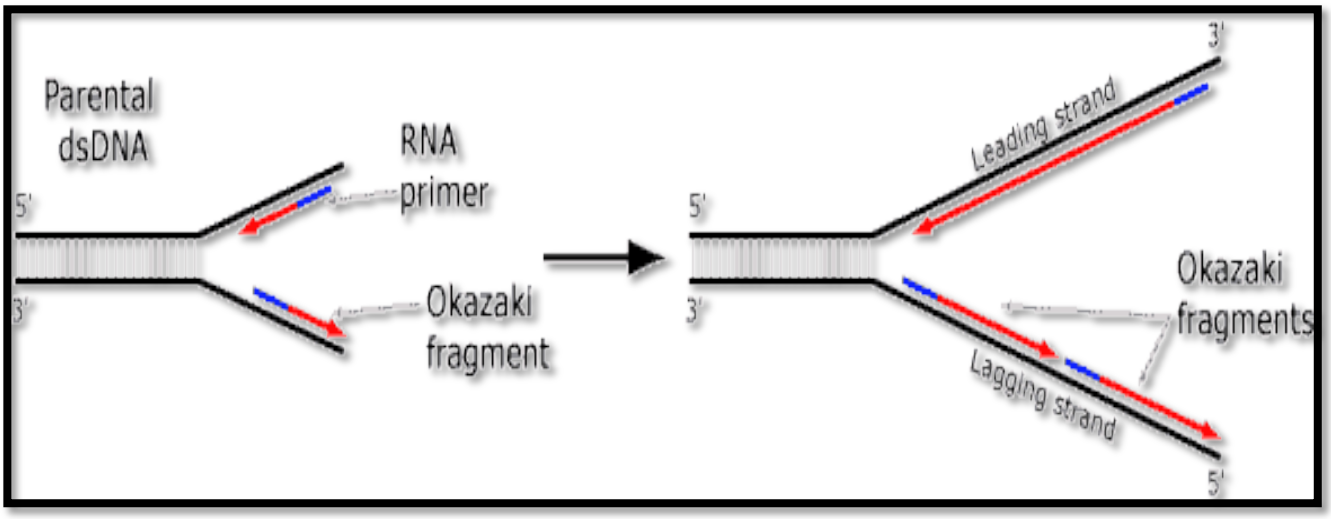
Lagging strand is in the wrong direction , so the ligase come and joint okazaki fragments together from 3’ to 5’ in the lagging strand the direction of the ligase now is in the correct direction (direction of the replication fork) .

5 types of DNA polymerases are found in E. coli

DNA polymerase I & II : functions in repair and replication

DNA polymerase III: main DNA replication enzyme

DNA polymerase IV & V : functions in DNA repair



Replication :

1. Helicase protein binds to DNA sequences called origins and unwinds DNA strands .
2. SS(Single-strand Binding protein) binding proteins prevent single strands from rewinding
3. protein makes a short segment of RNA primer complementary to the DNA

Eukaryotic DNA Replication Enzymes:

5 types of DNA polymerases in Eukaryotes :

1. DNA polymerase α
2. DNA polymerase β
3. DNA polymerase γ (Mitochondrial DNA replication enzyme)
4. DNA polymerase δ
5. DNA polymerase ε

4. DNA polymerase enzyme adds DNA nucleotides to the RNA primer and proofreads bases added and replaces incorrect nucleotides
5. Leading strand synthesis continues in a 5’ to 3’ direction
6. Discontinuous synthesis produces 5’to3’DNA segments called Okazaki fragments
7. Exonuclease activity of DNA polymerase I removes RNA primers
8. Polymerase activity of DNA polymerase I fills the gaps Ligase forms bond between sugar-phosphate backbone.

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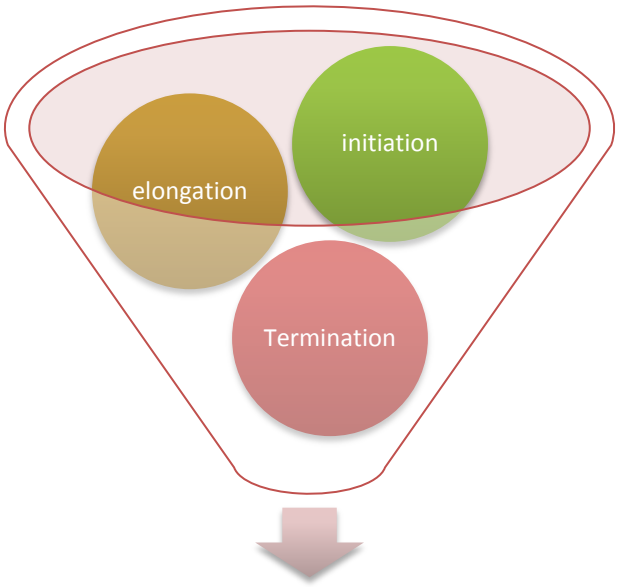
End of DNA replication.

Start of DNA transcription by RNA

Transcription :

- A process of mRNA (messenger RNA) synthesis from DNA (gene)
- The enzyme responsible for this process is RNA polymerase
- Only one of the DNA strands is transcribed
- A complementary strand of messenger RNA (mRNA), is produced from the DNA template
    - **The direction of transcription is 5’ → 3’**



TRANSCRIPTION

(1) Chain Initiation(starting):

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

(2) Chain Elongation:

a) A portion of DNA template unwinds (opens) at the point of RNA synthesis by DNA gyrase.
b) This forms a short length of RNA-DNA hybrid.
c) The unpaired "bubble" of DNA in the open initiation complex travels along the direction of RNA polymerase.

(3) Chain termination(ending):

- DNA contains specific sites which stop transcription.
- Transcription is terminated at a sequence of 4-10 AT base pairs.
- Before mRNA moves out of the nucleus it should be modified with 2 steps:

a) **Capping:** an addition of methylated guanine nucleotide at 5’ end of mRNA. Its function is to prevent mRNA degradation by exonuclease enzyme.

b) **Polyadenylation:** an addition of poly A tail (poly adenylate…AAAAAAA…) at 3’ end of mRNA. It has 2 functions:

1. protect mRNA from degradation.

2. Ribosomal RNA will recognize the mRNA.

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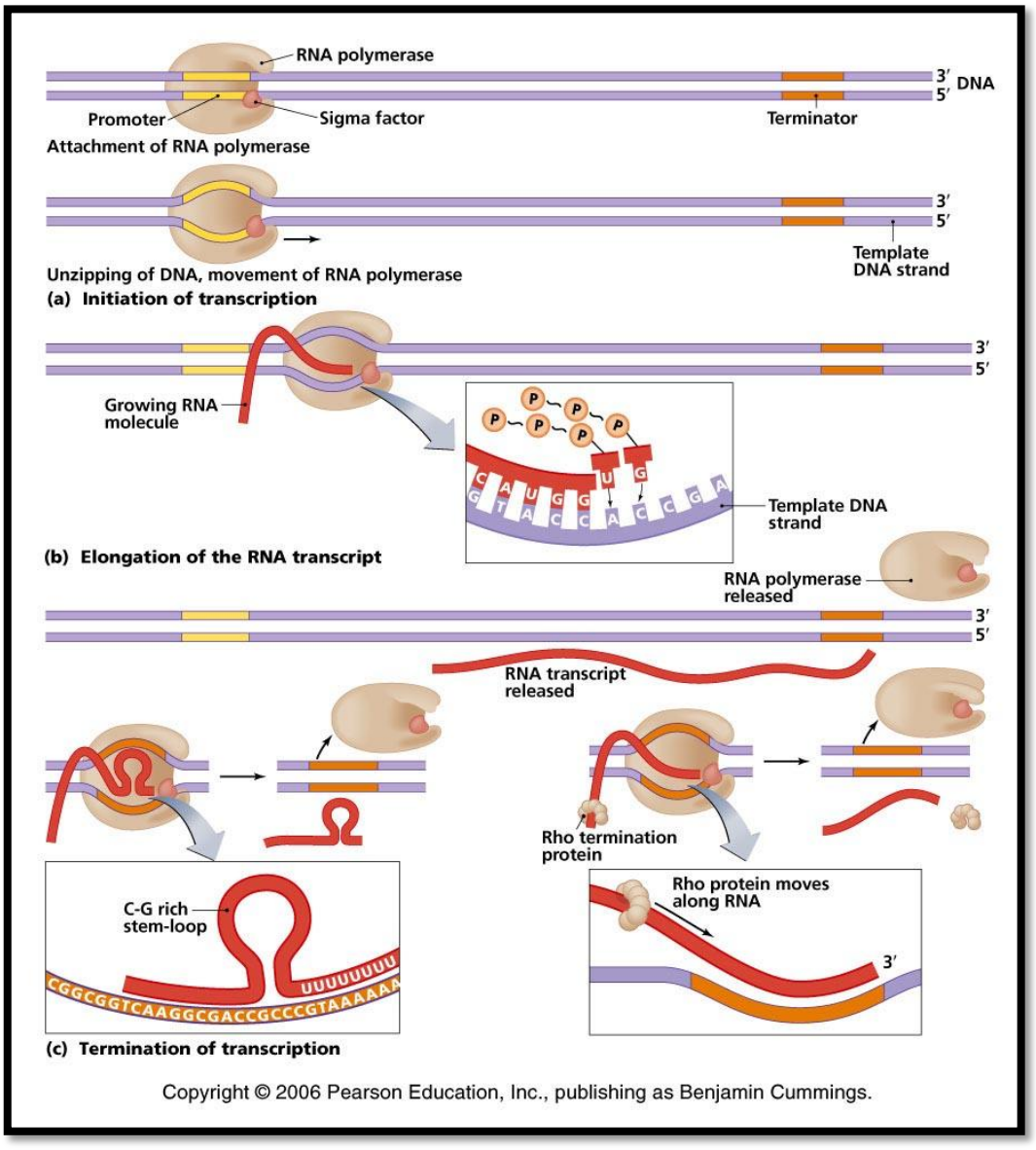


End of DNA transcription.

Start of RNA translation

Translation (protein synthesis):

Synthesizing protein by Ribosomal RNA from mRNA. mRNA has codes present protein.

(1) Chain Initiation:

- Translation is initiated by initiation factors (IF-1,IF-2,IF-3)
- They combine ribosome ,mRNA and tRNA together
- The first tRNA binds to AUG(start codon)

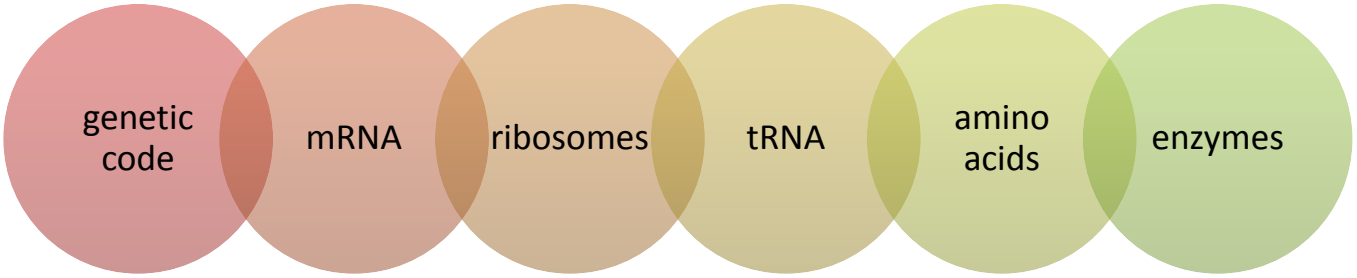
(2) Chain Elongation:

- The second tRNA bind to A-site of ribosome
- Peptide bond formation takes place between two amino acids (transpeptidation)
- P-site tRNA is empty and leaves the ribosome
- A-site tRNA carries the growing protein chain and moves to P-site (translocation)

(3) Chain termination:

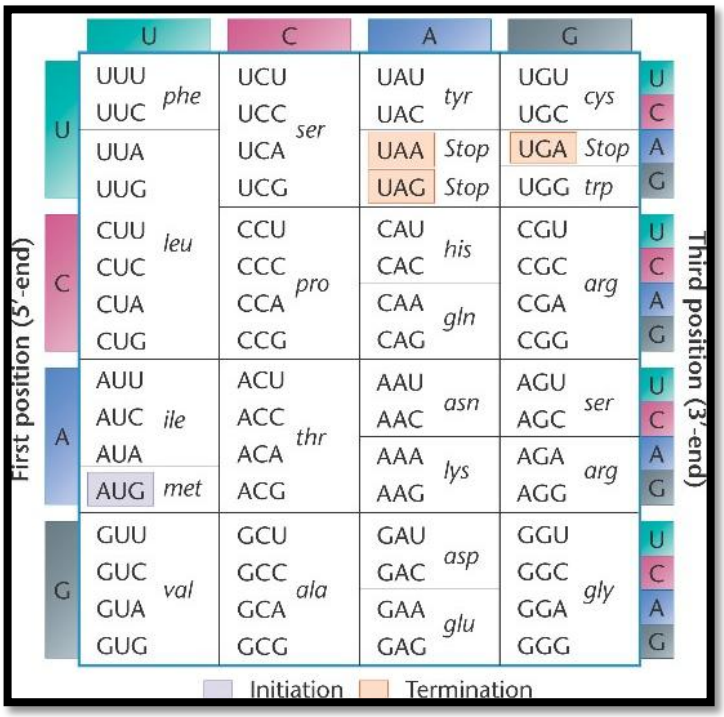
- mRNA contains **stop codons (UAA,UAG,UGA)**
- When ribosomes reads any stops codon the translation is terminated
- This releases the new protein chain
- Post-translation modification

Components of protein synthesis



The Genetic code:

- A genetic code contains 3 nucleotides (Triplet), non-overlapping, comma-free (has no comma).
- 64 possible codons:
  - 61 codons specify 20 amino acids
  - 1 start codon (also specifies an aa)
  - 3 stop codons
- One codon can specify only one amino acid BUT One amino acid can be coded for by more than one codon.
- Mitochondrial DNA has different codons.



- Transcription of DNA give us RNA and the translation of RNA give us Protein :

5’-AATCGCCATACGCACGCA-3’

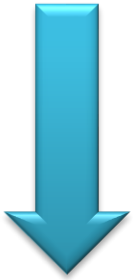
3’-TTAGCGGTATGCGTGCGT-5

DNA

Start with the (promoter) and end with the (terminator)

A with T

C with G



Transcription

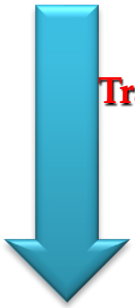
5’-AAUCGCCAUACGCACGCA-3’

RNA

Start with the (start codon) and end with the (stop codon)

A with U

C with G



Translation in ribosomes

N-Asn-Arg-His-Thr-His-Ala-C

PROTEIN (polypeptide)

Start with N (N terminal) and end with C (C terminal)

Extra links:

- Transcription and translation:
  http://youtu.be/h3b9ArupXZg
- Animation (replication, transcription and translation)
  Download it from here