Gene expression

By:
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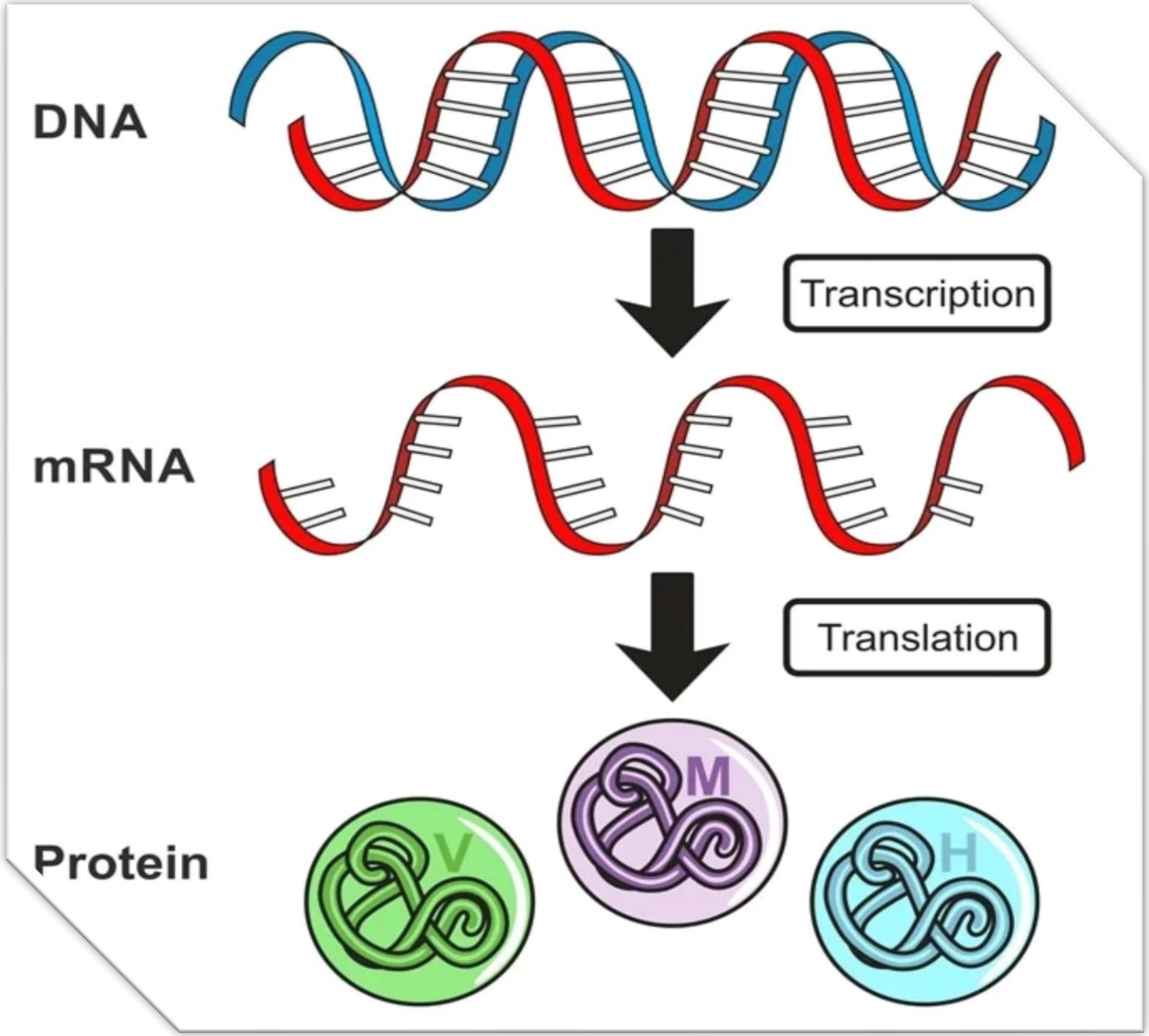


Learning outcomes

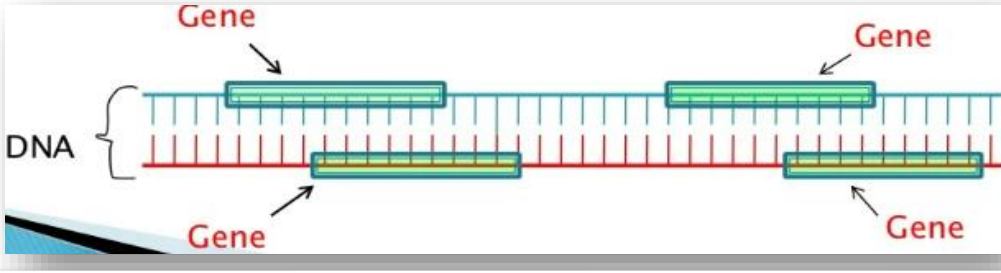
By the end of lecture, students should be able to:

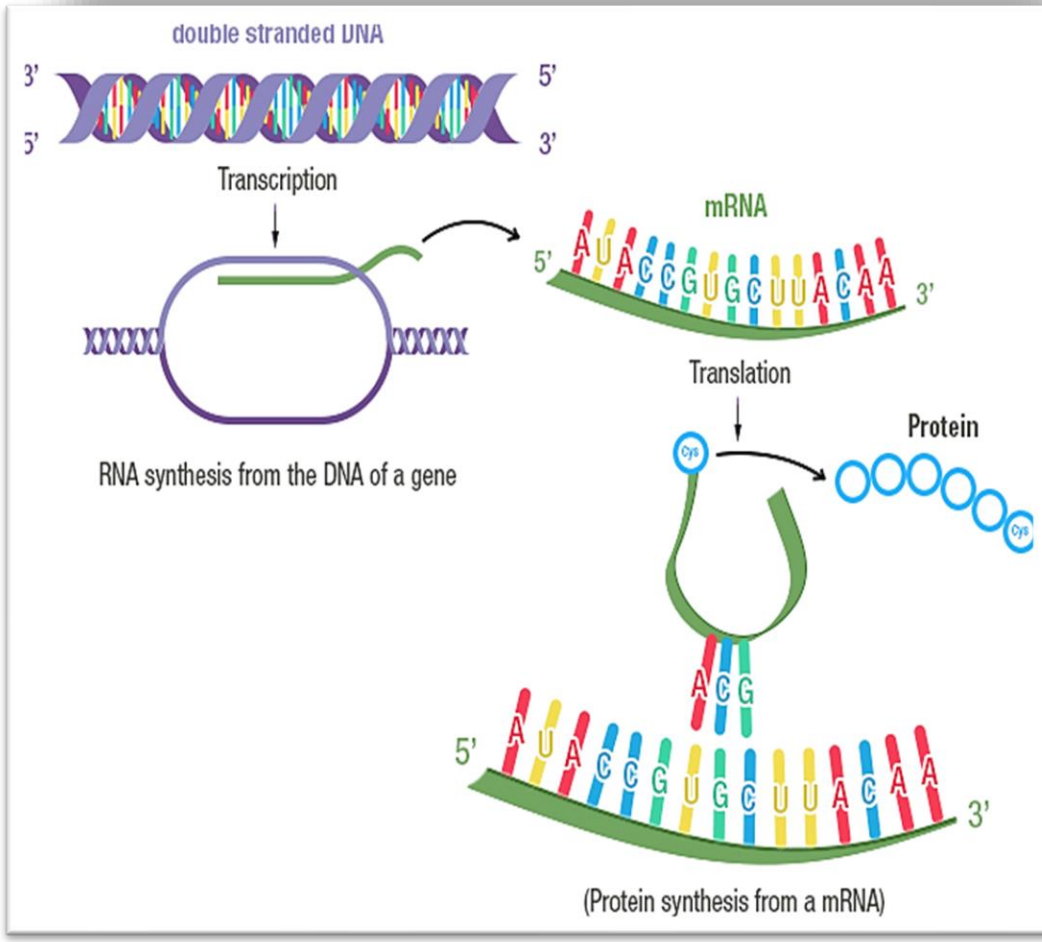
- *Identify the process of gene expression?.*
- *Describe the role RNA plays in gene expression?.*
- *Explain what happens during transcription?.*
- *Explain how do codons determine the sequence of amino acids that results after translation?*
- *Describe the major steps of translation?*
- *Identify the concept of regulation of gene expression*

What is Gene & Gene expression

- **Gene:** is a segment of DNA that codes RNA and protein = is a stretch of DNA that encodes information

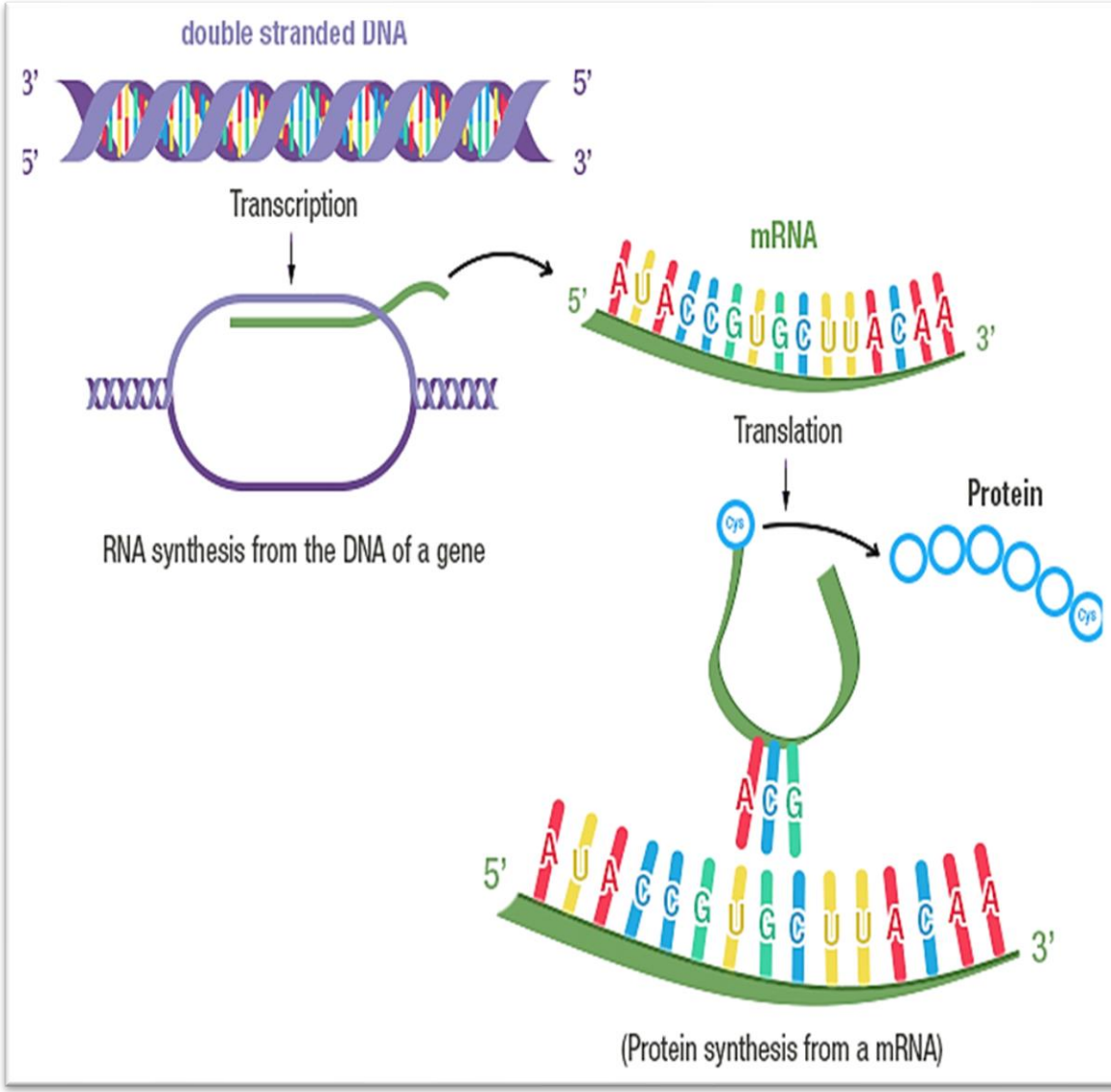
- **Gene expression:** is the process by which information from a gene is used in the synthesis of a functional gene product (proteins) which manifested into specific traits.





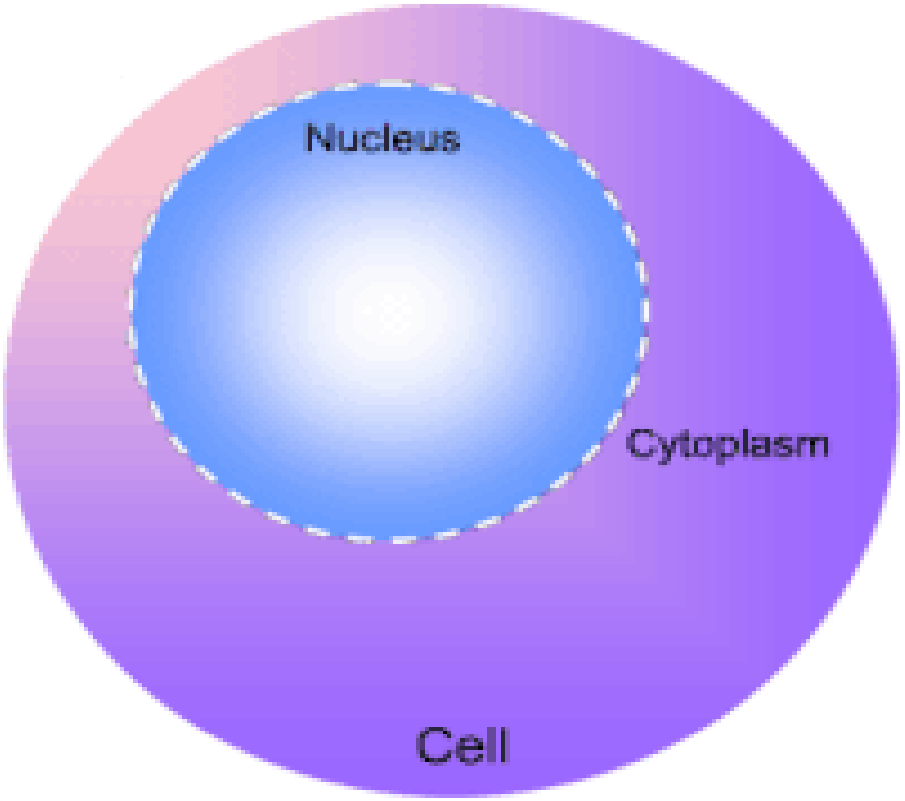
Gene expression

- **DNA** provides the original information from which proteins are made in a cell, but DNA does not directly make proteins
- **RNA** is a Major Player in gene expression which takes the information from DNA and makes proteins. All the steps in gene expression involve RNA.



Central Dogma of Molecular Biology

- So, the biological information flows from DNA to RNA, and from them to proteins.
- This is central Dogma of life.



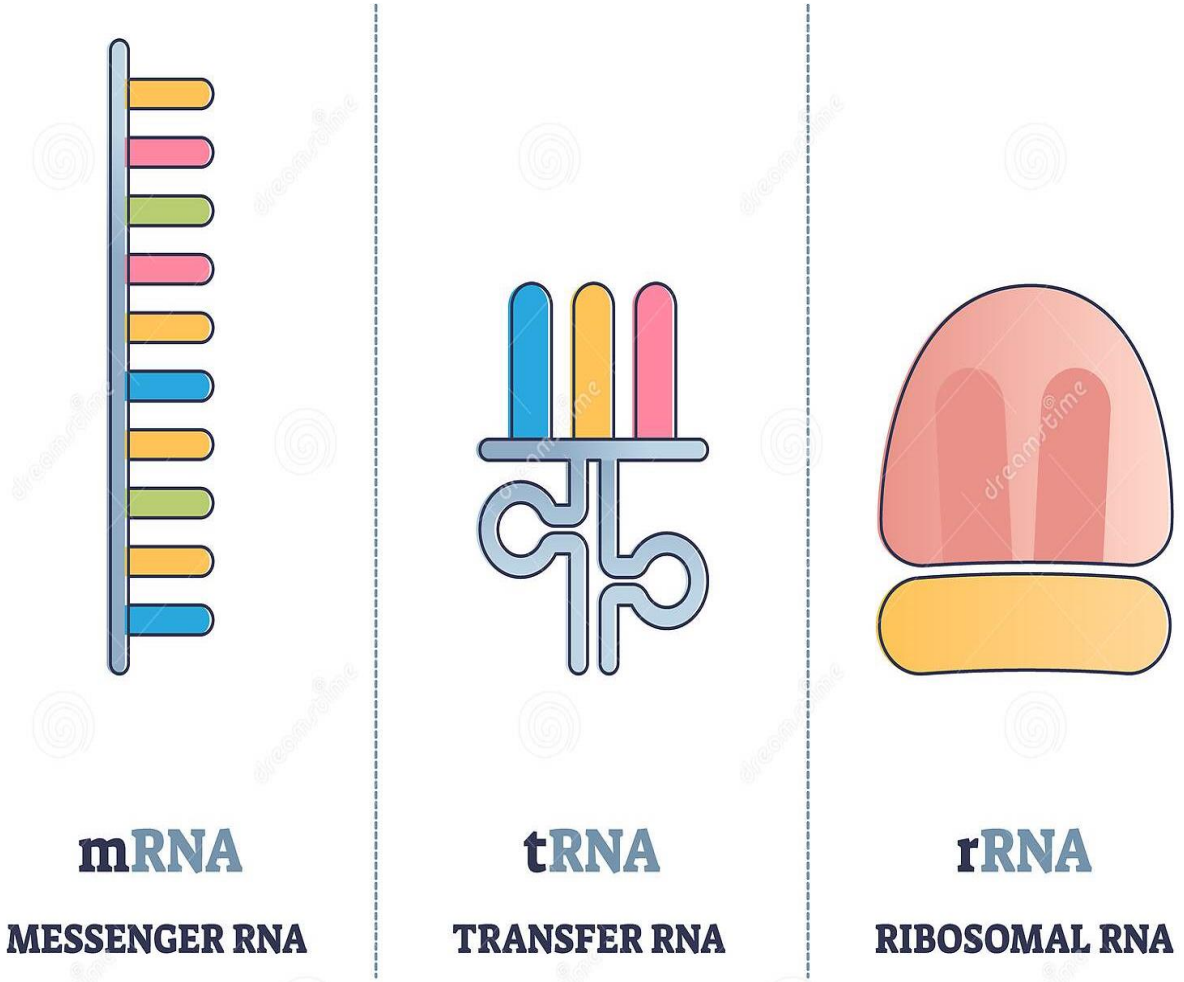
Types of RNA

- In cells, the three main types of RNA which play a role in gene expression are:

1- Messenger RNA (m.RNA)

2- Transfer RNA (t.RNA)

3- Ribosomal RNA (r.RNA)

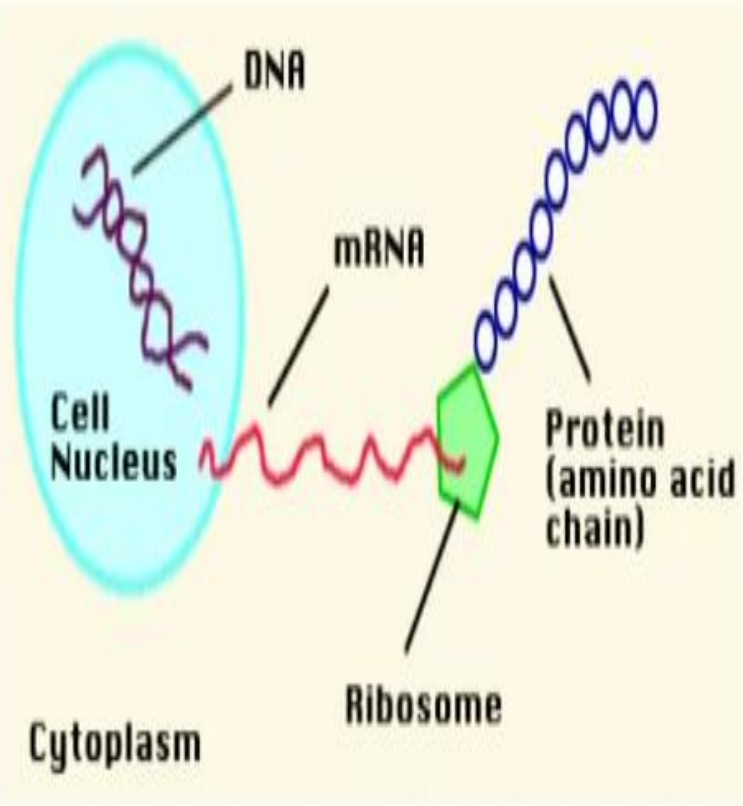


1. Messenger RNA (mRNA)

- **5%** of cellular RNA

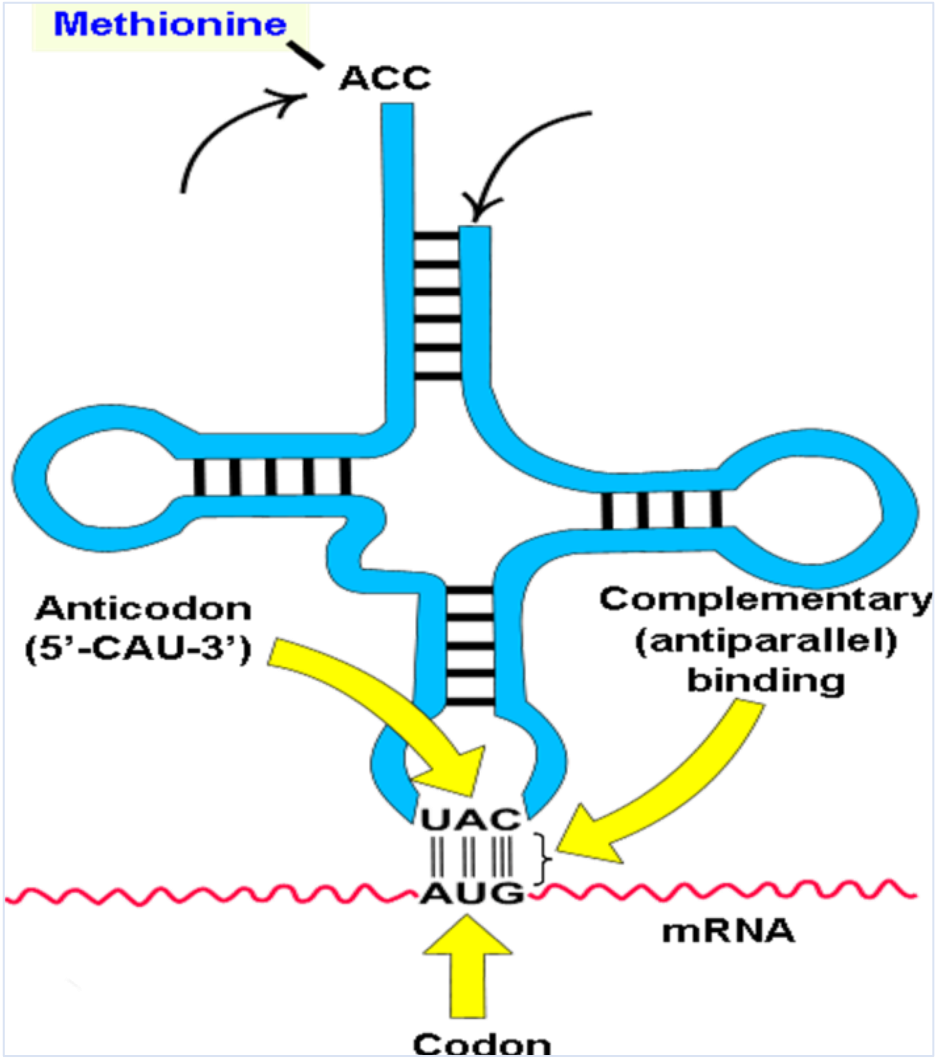
-Function: mRNA carries instructions for making a protein from a gene and delivers the instructions to the site of translation (from DNA in the nucleus to ribosomes in cytoplasm).

-Each protein has specific m.RNA



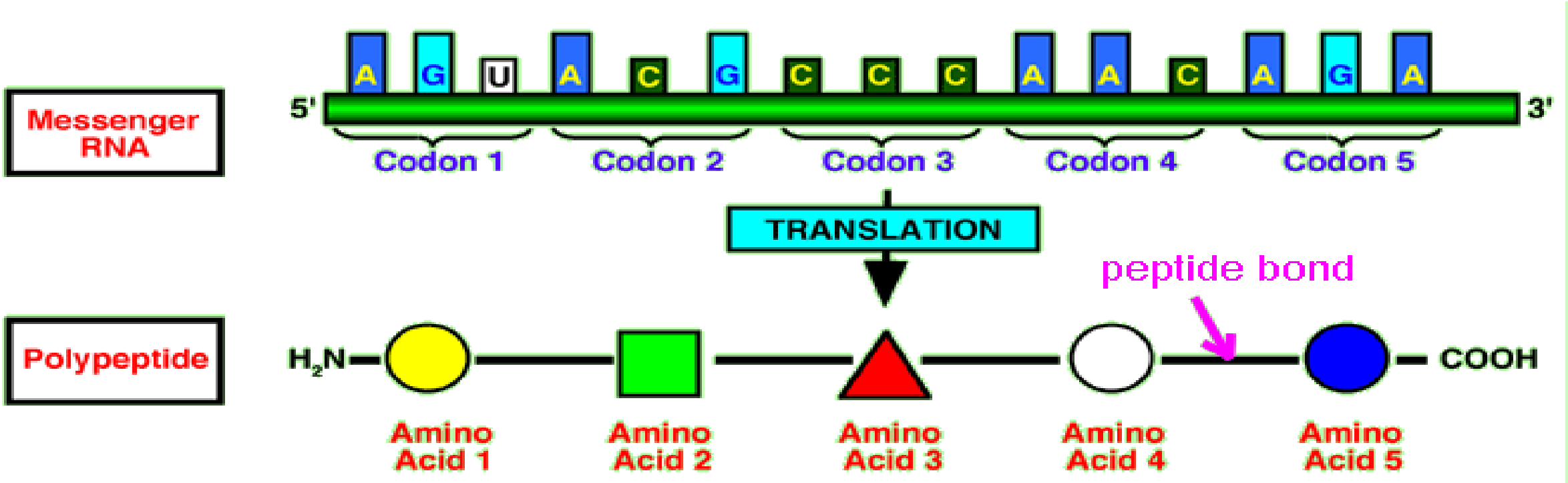
2. Transfer RNA (tRNA)

- It forms **15 %** of total RNA
- clover-leaf appearance
- **Function:** At the site of translation, it "**reads**" the instructions carried by the mRNA, then **translates the mRNA** sequence **into** protein subunits called **aminoacids**
- During translation, each tRNA (**anti-codon loop**) recognizes a certain three nucleotide mRNA sequence termed a **"codon"** and brings in the correct amino acid.



What is the Genetic codon??

- It is the sequence of three adjacent nucleotides on mRNA. i.e. triplet codon.
- There are 64 mRNA codons. Each codon specifies only one amino acid

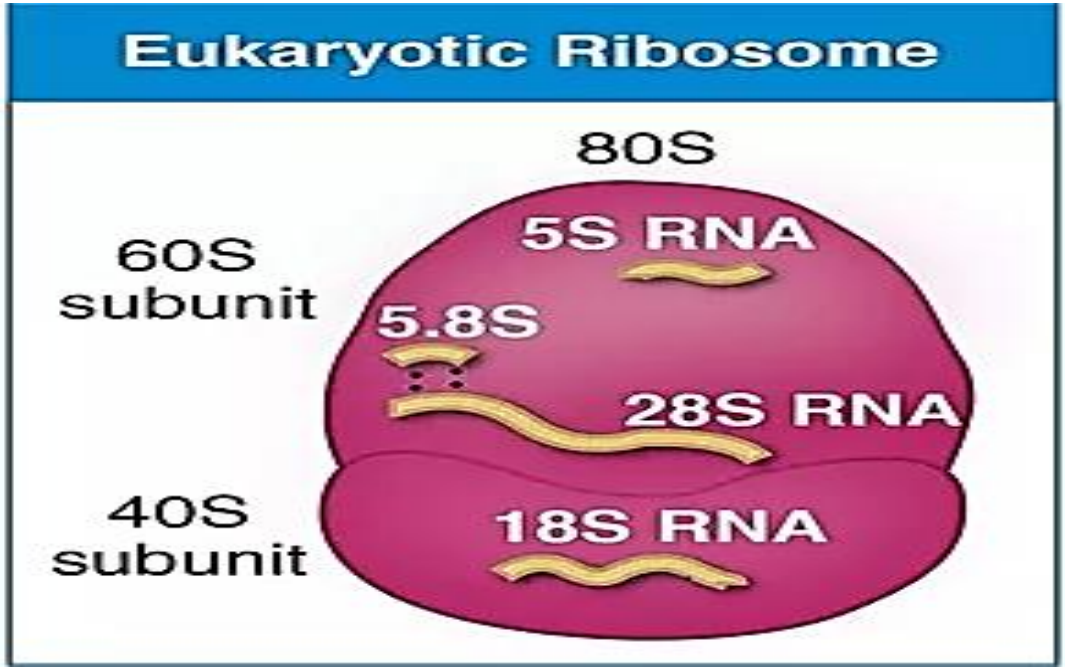


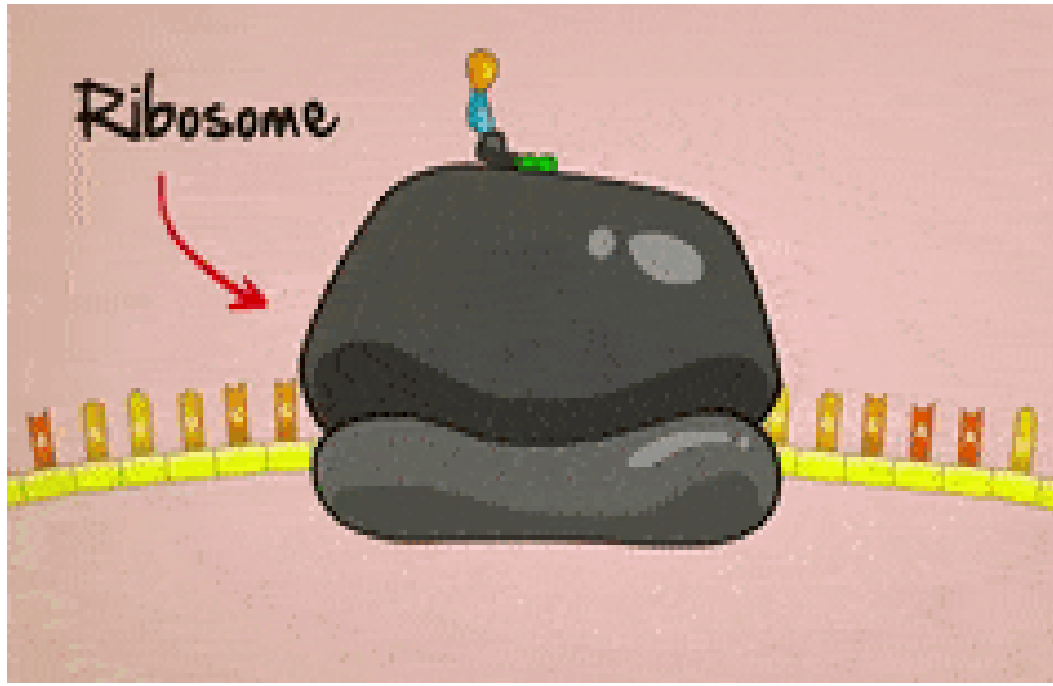
3. Ribosomal RNA (rRNA)

1-Forms about **80 %** of total RNA

2- **rRNA** together with more than 50 proteins, serve as the framework of the ribosomes, which are the sites at which **amino acids** assemble into a polypeptide.

Ribosomes are machinery of protein synthesis





Stages involved in the gene expression

- There are two stages involved in the expression of a gene:

❑First stage: Transcription:

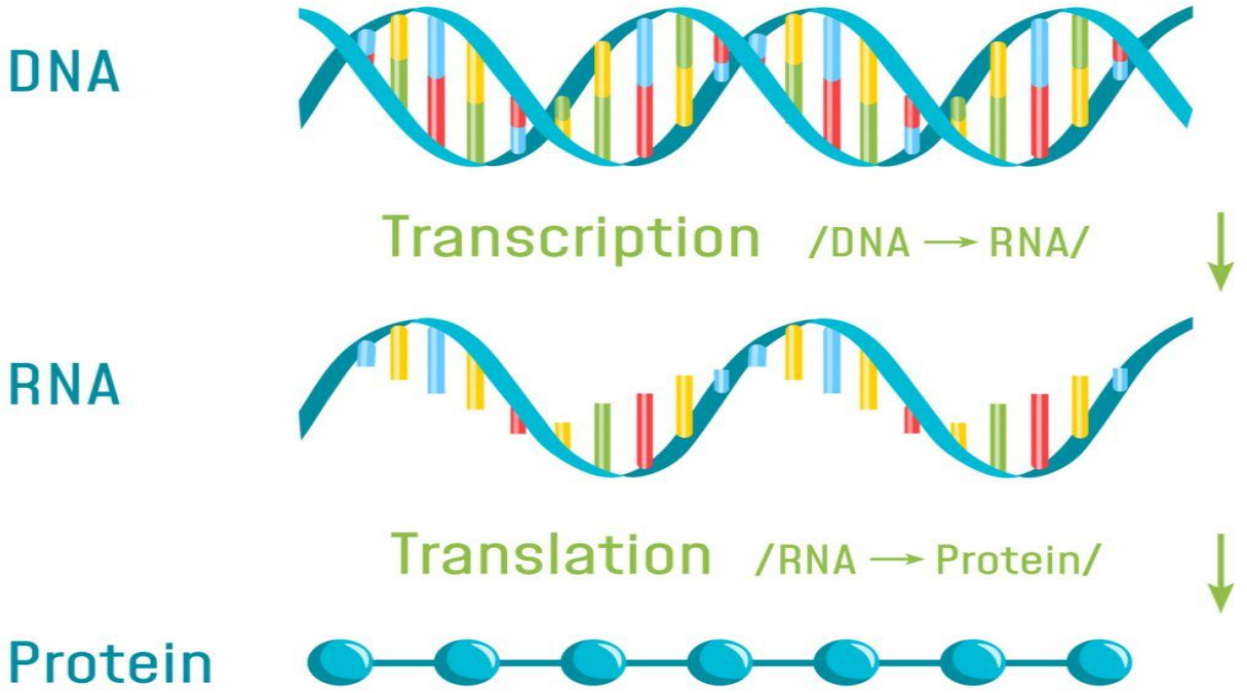
the process of making RNA from the information in DNA, similar to copying (transcribing) notes from the board (DNA) to a notebook (RNA).

❑Second stage: Translation:

Uses the information in RNA to make a specific protein, similar to translating a sentence in one language (RNA, the nucleic acid "language") to another language (protein, the amino acid "language").

1st stage: Transcription

Definition: It is the synthesis of mRNA molecule from DNA template



Transcription

Requirements for transcription

1. DNA Template (Promotor, transcribed region, termination region)
2. RNA polymerase enzymes.
3. Four ribonucleoside triphosphate (ATP, GTP, UTP and CTP).
4. Transcription factors & Transcription elements.

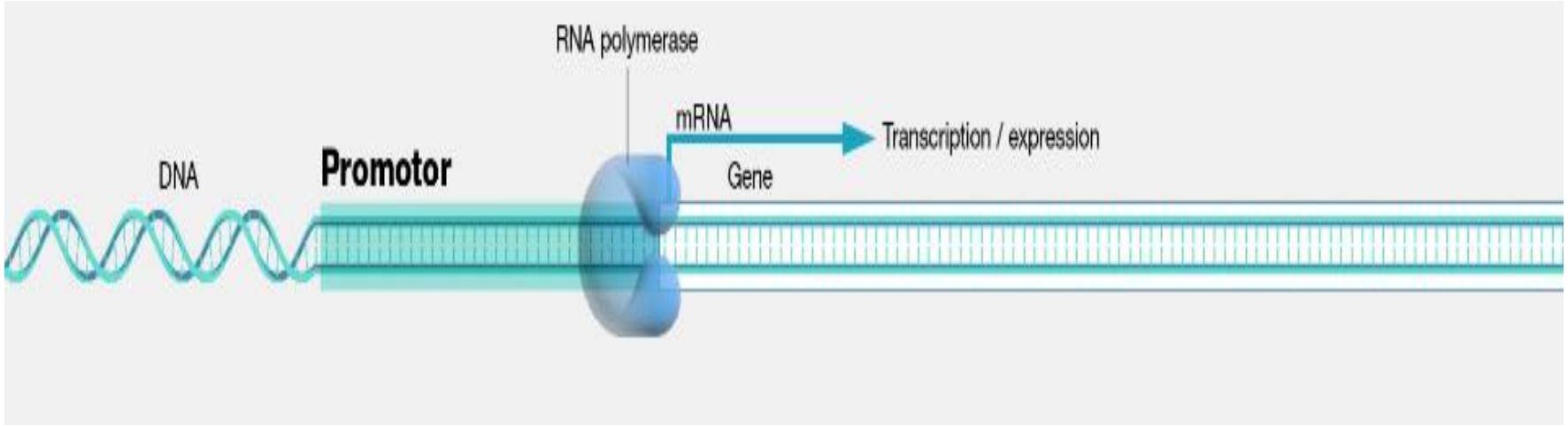
Requirements for transcription

1- Promotor:

- It is a specific DNA sequence located upstream of a gene.
- It is the site of binding of RNA polymerase (RNAP) and transcription factors.

2- RNA polymerase (RNAP):

RNA polymerase (RNAP) binds to promotor to initiate transcription

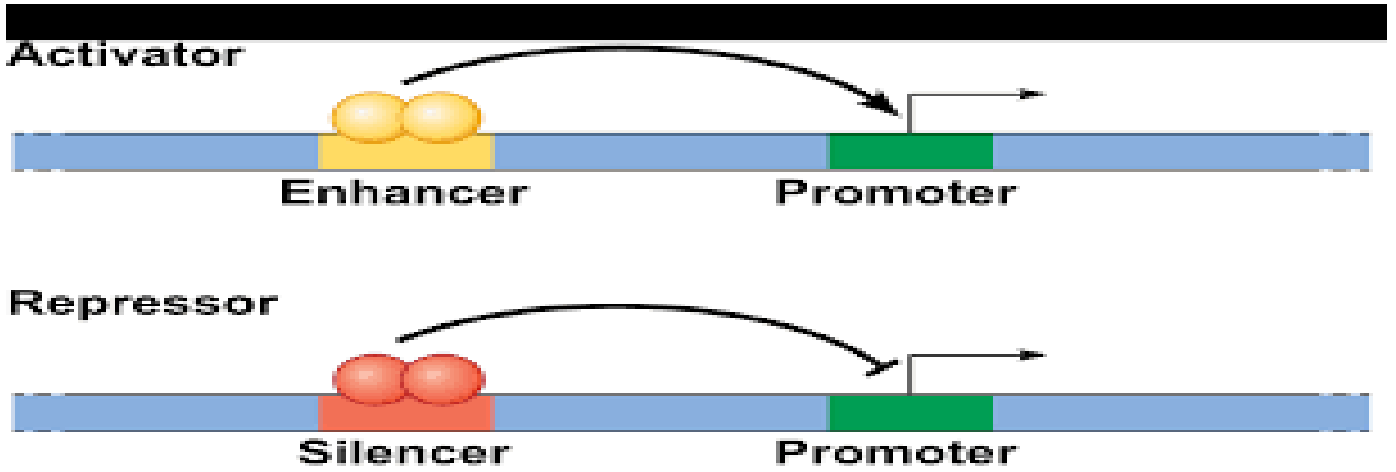


3- Transcription elements:

- They are located either upstream or downstream or within the gene
- They control the frequency of transcription
- They include:

❑Enhancer: it increases the rate of transcription

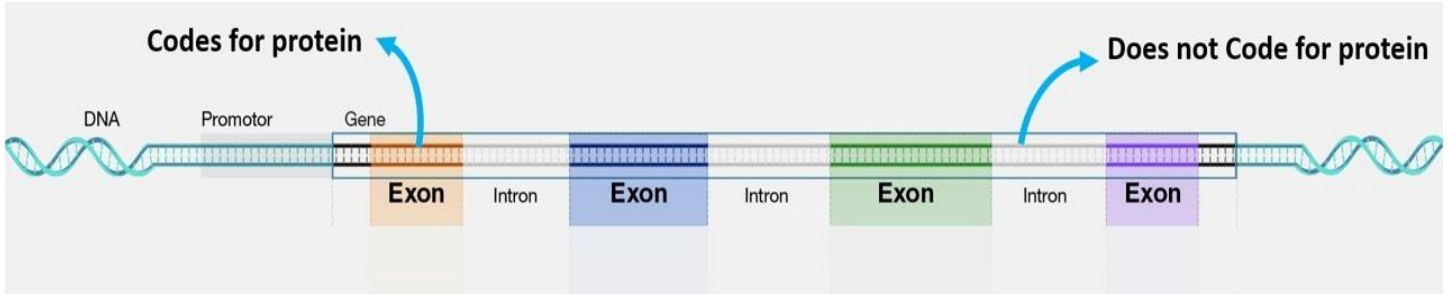
❑Silencer: it decreases the rate of transcription



Requirements for transcription

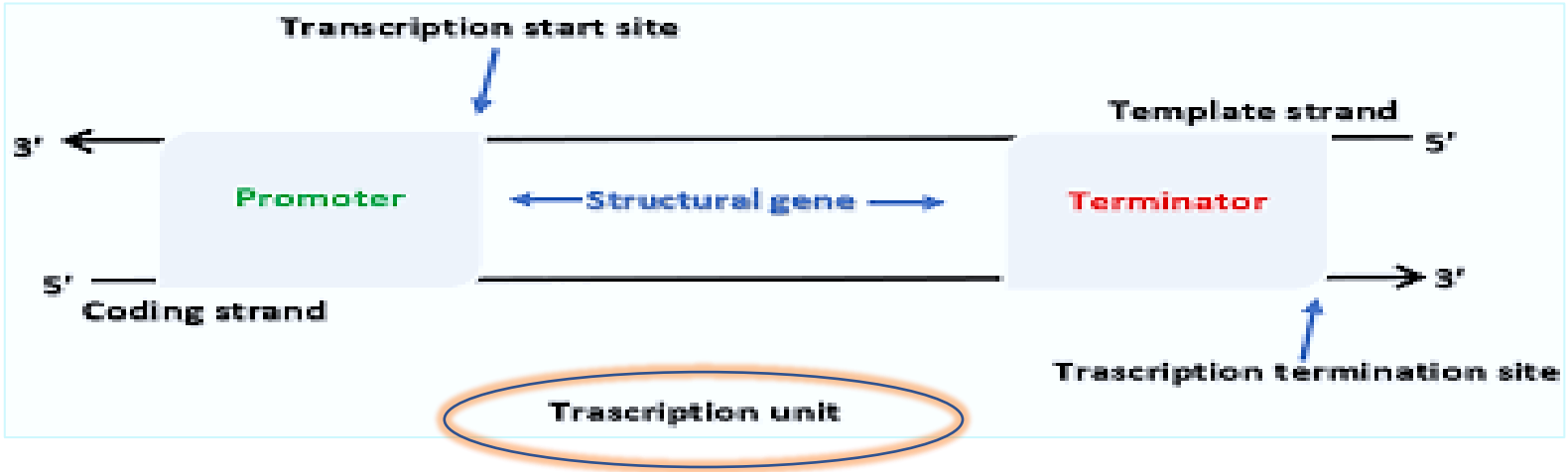
4- Transcribed region:

DNA sequence to be transcribed to RNA. It is composed of exons interrupted by introns.



5- Termination region:

DNA sequence at the end of transcription region.



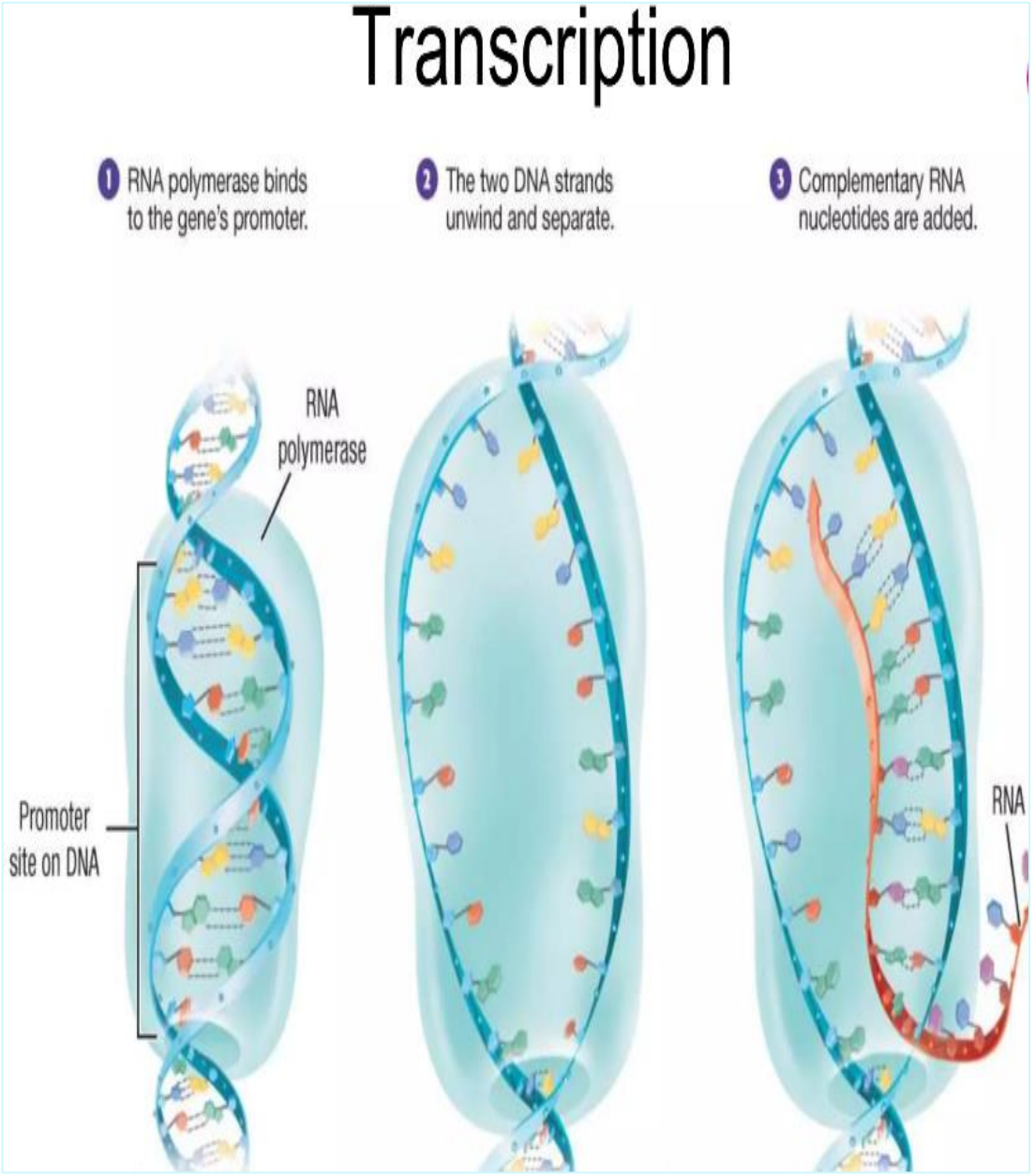
Steps

- **Initiation**

  - Transcription begins when RNA polymerase binds to the promoter. RNA polymerase then unwinds and separates the two strands of the double helix to expose the DNA bases to be transcribed.

- **Elongation**

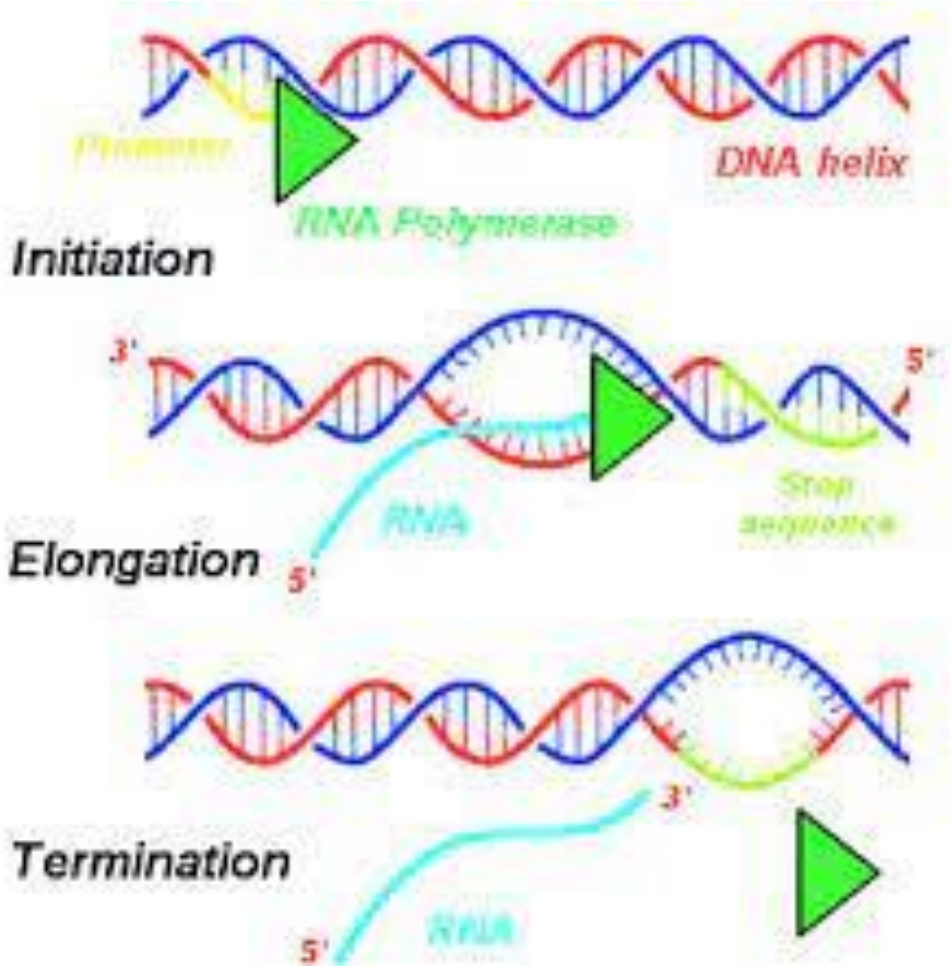
  - RNAP starts synthesis of RNA strand complementary to DNA template strand till termination region is reached.



Steps

- **Termination**

- Occurs at a specific base sequence, called the terminator, on the DNA template strand.
- The RNAP detaches from DNA and releases the RNA transcription product represents a complementary base sequence to the base sequence in the DNA template strand.



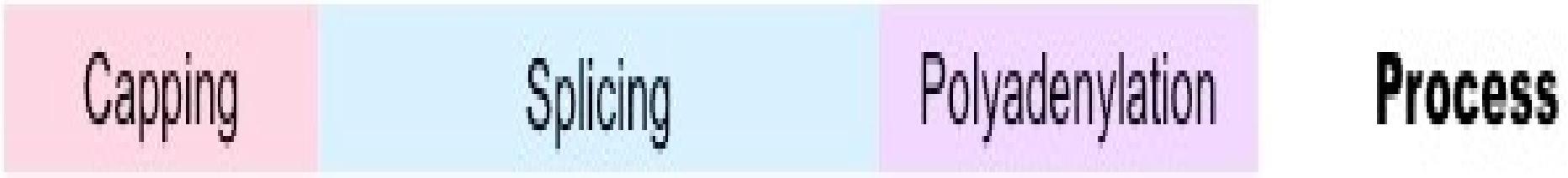
Steps of Transcription

Post-transcriptional modification

Nascent RNA (Primary transcript) needs to be modified to become mature (functional).

This includes:

1) Capping :It involves the addition of a **Methylguanosine triphosphate** group to the **5'-end** of the transcribed RNA
2) Polyadenylation : the **addition of a long chain of adenine** nucleotides (a poly-A tail) to the **3'-end** of the transcript
3) Splicing

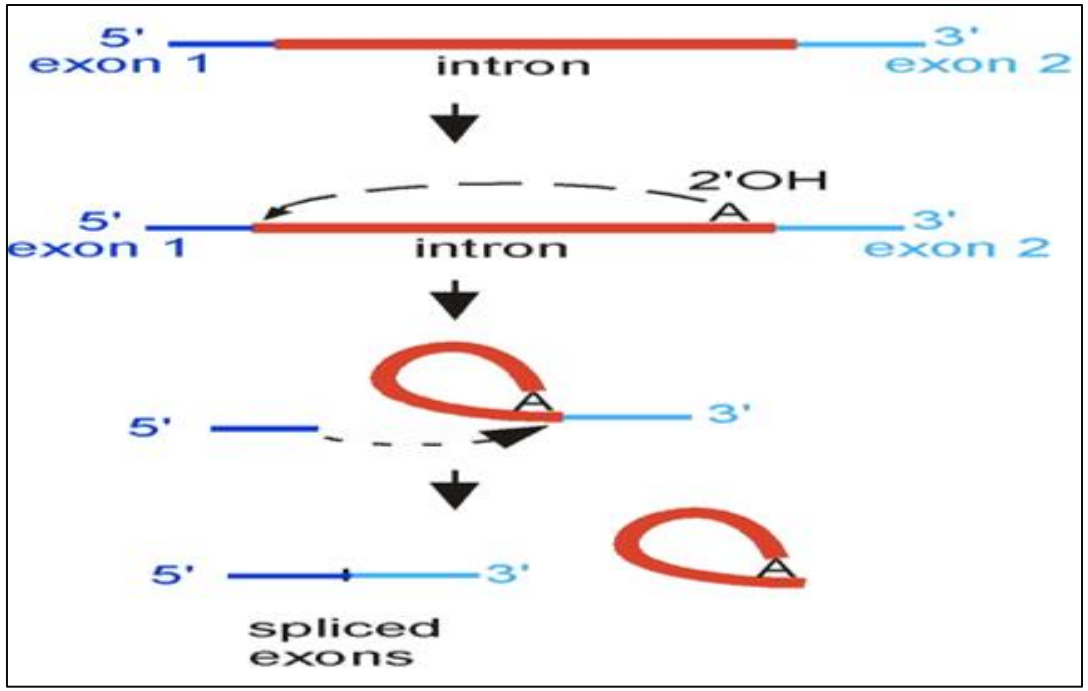


3- Splicing:

Heterogeneous nuclear (pre-mRNA) contains:

- **Coding sections** called **exons** (expressed sequences)
- **Noncoding sections** called **introns** (intervening sequences)

Splicing: Removal of introns from the hnRNA/pre-mRNA, and linking the exons to form the **mature mRNA**



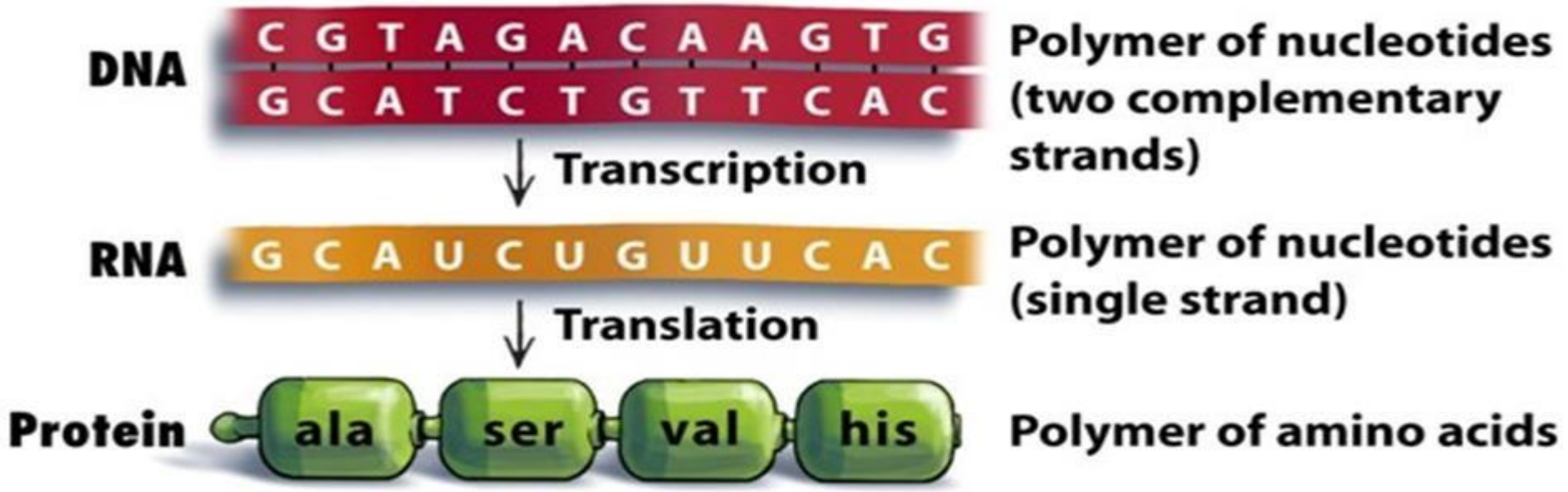

Made with KINEMASTER
instructions to make proteins are contained in our DNA. DNA contains genes. A gene is a continuous string of

2nd stage: Translation

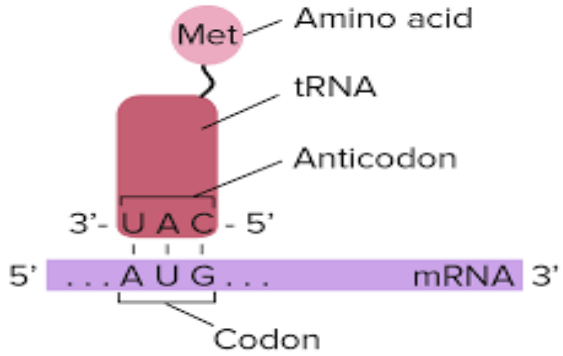
Definition:

-It is the synthesis of protein using mRNA as the template

-Translation takes place in the cytoplasm, where tRNA, rRNA, and mRNA interact to assemble proteins.



Requirements for protein synthesis

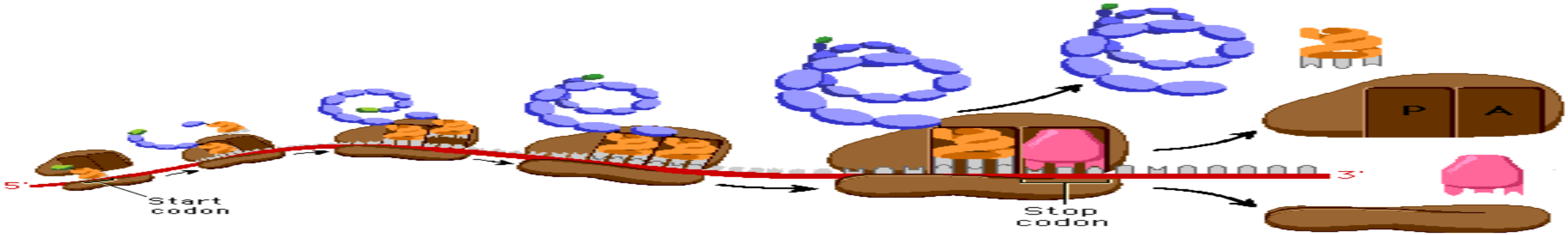


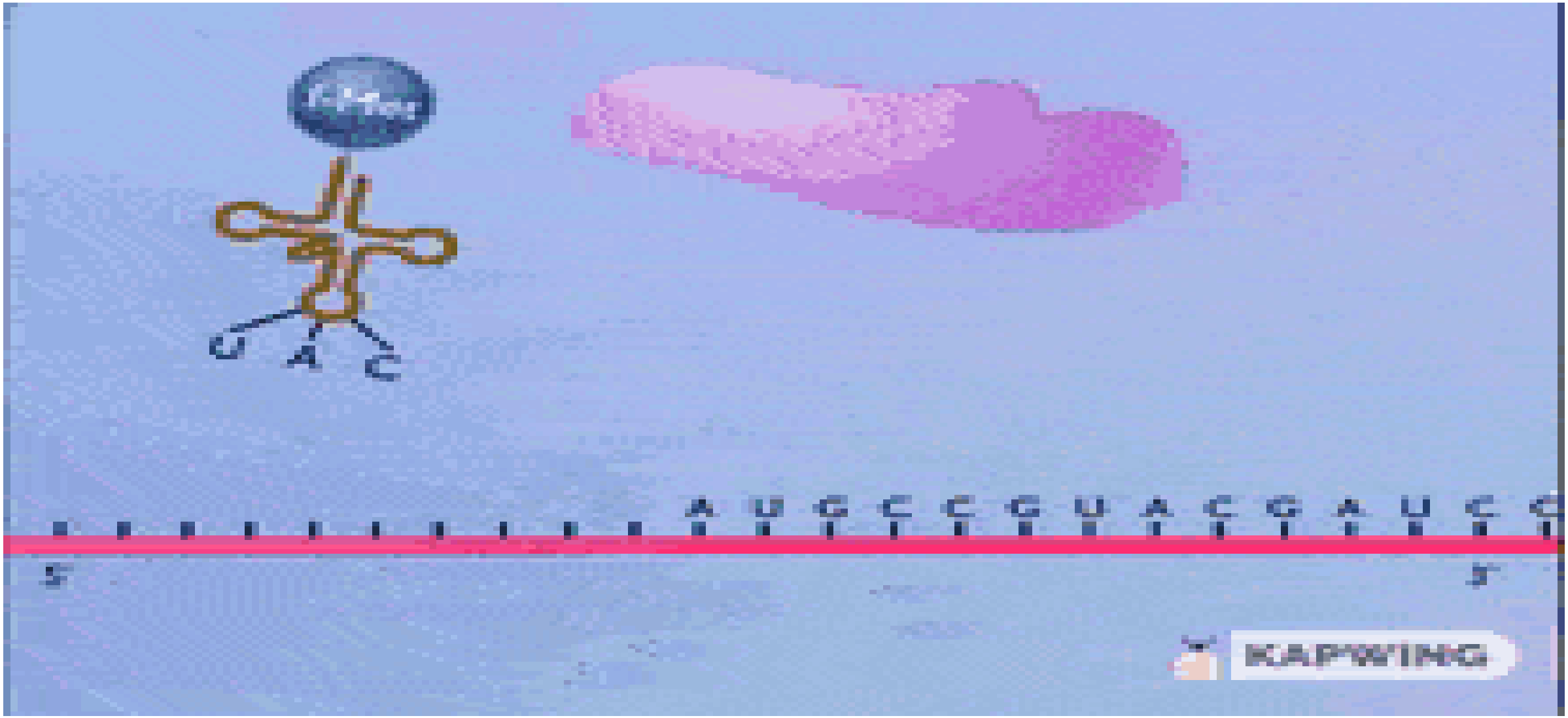
1. **A ribosome:** protein synthesizing machinery.
2. **mRNA:** the template that carries information needed for arranging the amino acids in the proper order of the specific protein.
3. **tRNA:** carries the amino acids to the proper place in the polypeptide chain.
4. **Amino acids:** the building units 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. **A source of energy:** in the form of ATP and GTP .

4 Steps for Translation

1. **Activation of aa:** 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.**





https://www.youtube.com/watch?v=qIwrhUrvX-k
https://youtu.be/Ikq9AcBcohA

Regulation of gene expression

- It includes various mechanisms used to increase or decrease the production of specific gene products (protein or RNA) .
- The relationship between genes and their effects is complex. Despite the principle of the genetic code, every gene cannot be simply linked to a single outcome· Some genes are expressed only at certain times or under specific conditions.

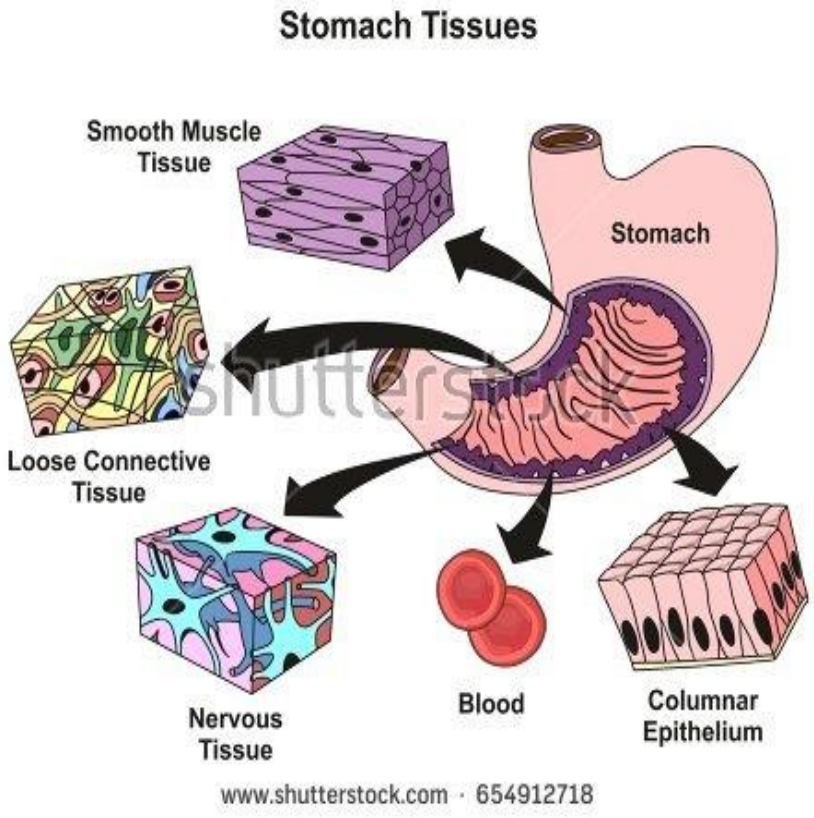
Importance of Regulation of gene expression

- The final outcome of gene expression is affected by the tissue type, the environment of the cells and the timing of gene expression.

1- Tissue – specific expression : The genetic information in each somatic cell is the same

But

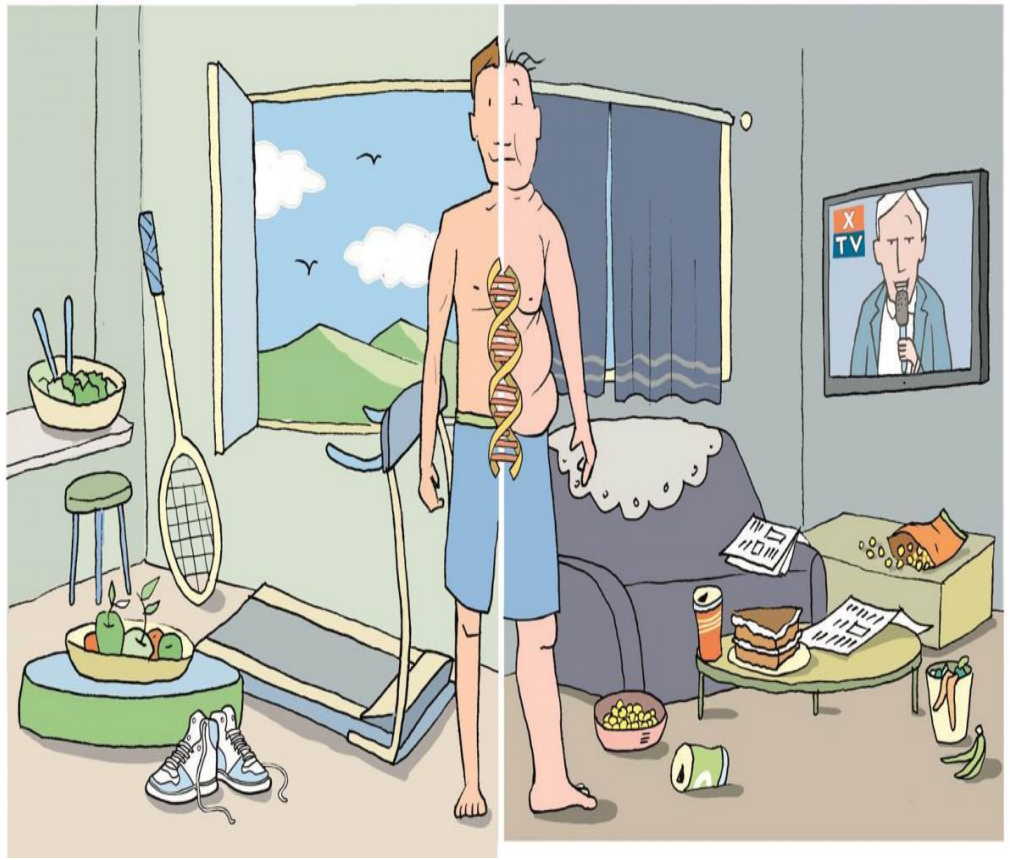
The difference between different tissues depend on the pattern of genes expression in these tissues .



Regulation of gene expression

2-The human cells **adapt to environmental changes** By altering gene expression

3- Dysregulation of gene regulation can lead to **disease**



Regulation of gene expression

It occurs at several levels:

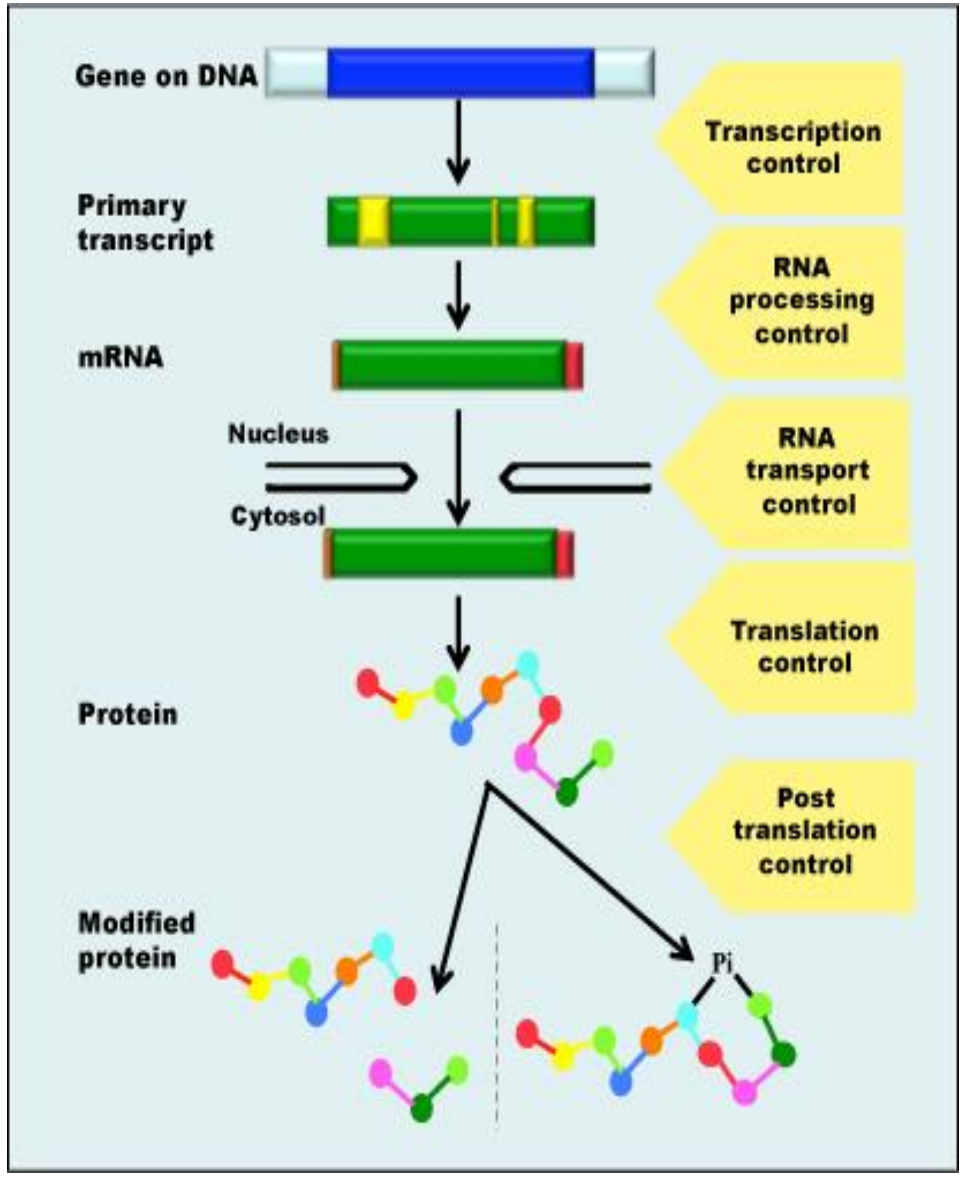
A.Control at DNA level .

B.Control at transcription level

C.Control at post-transcriptional level

D.Control at translational level

E.Control at post-translational level



At the level of transcription

1-Chromatin remodeling :

A- Chromatin condensation .

B- Chromatin acetylation .

C- DNA methylation

2-DNA regulatory regions :

A- Enhancer .

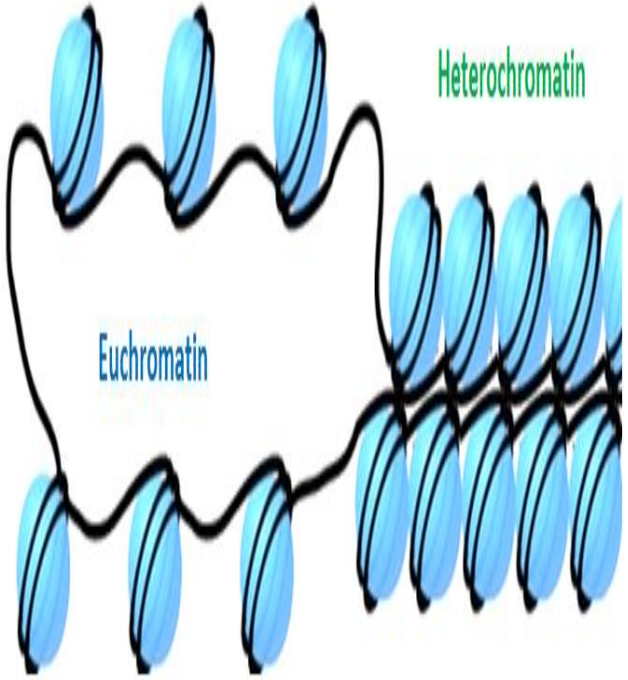
B- Silencer .

At the level of transcription

1-Chromatin remodeling

A- Chromatin condensation:

Affects the ability of RNA polymerase to reaches specific genes to activate transcription.



2 forms:

1-Heterochromatin : transcriptionally **inactive**

2-Euchromatin : transcriptionally **active**

At the level of transcription

1-Chromatin Remodeling

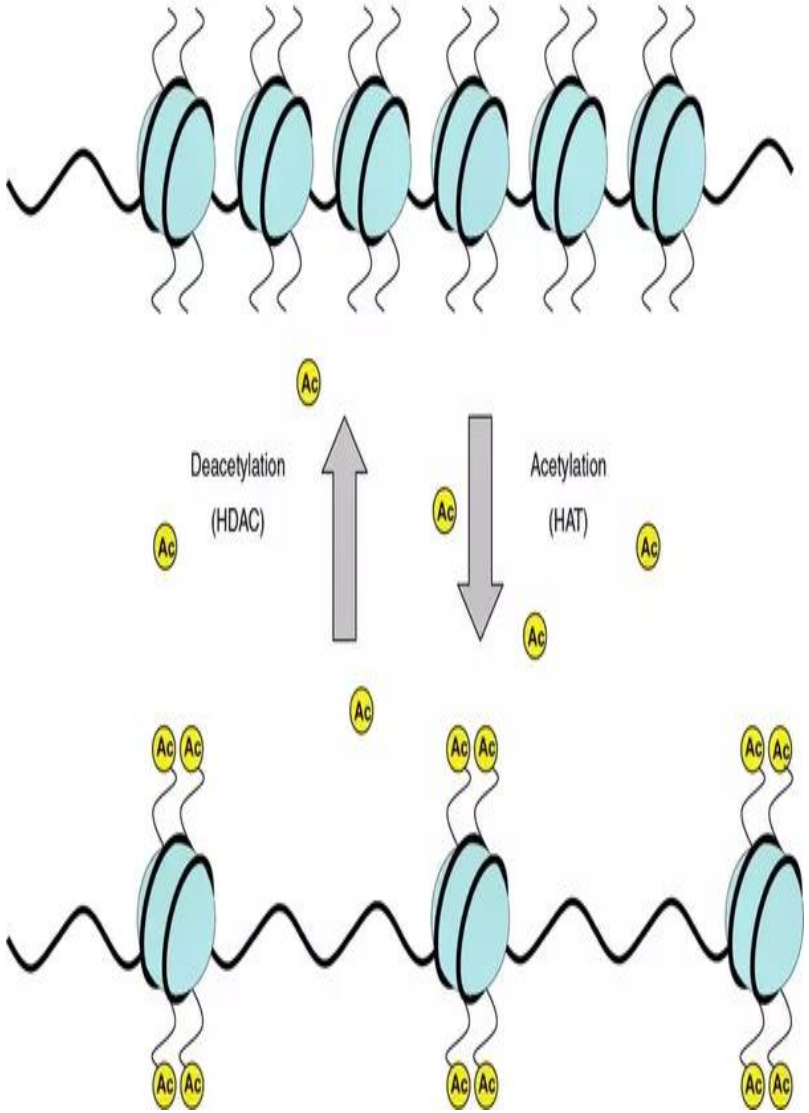
B- Chromatin acetylation (Dynamic and Reversible)

1- Acetylation of lysine residues of histone protein removes the + ve charge of histone , reducing affinity between histones and DNA leads to repulsion of histones .

2-This makes RNA polymerase reaches the genes

and **enhance transcription**

3-It is catalyzed by **histone acetyl-transferase** (HATs) , histone deacetylation by **histone deacetylase**



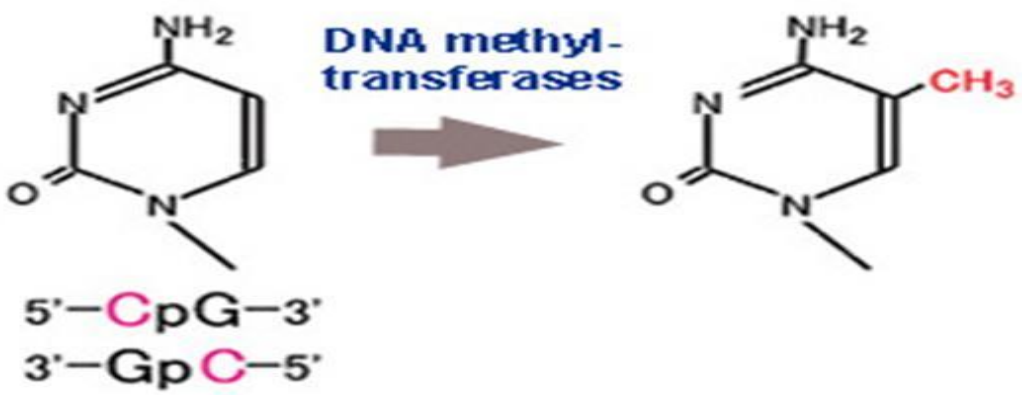
At the level of transcription

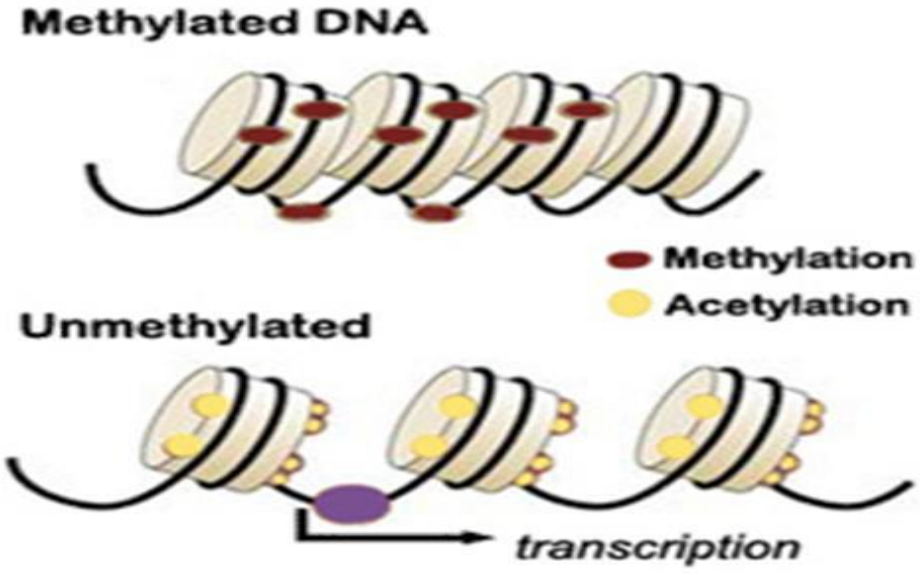
1-Chromatin Remodeling

C-DNA methylation

-DNA methylation is catalyzed by DNA methyltransferases (DNMTs)

-Methylation of cytosine bases in DNA **inhibit transcription** , maintains genes turn off .

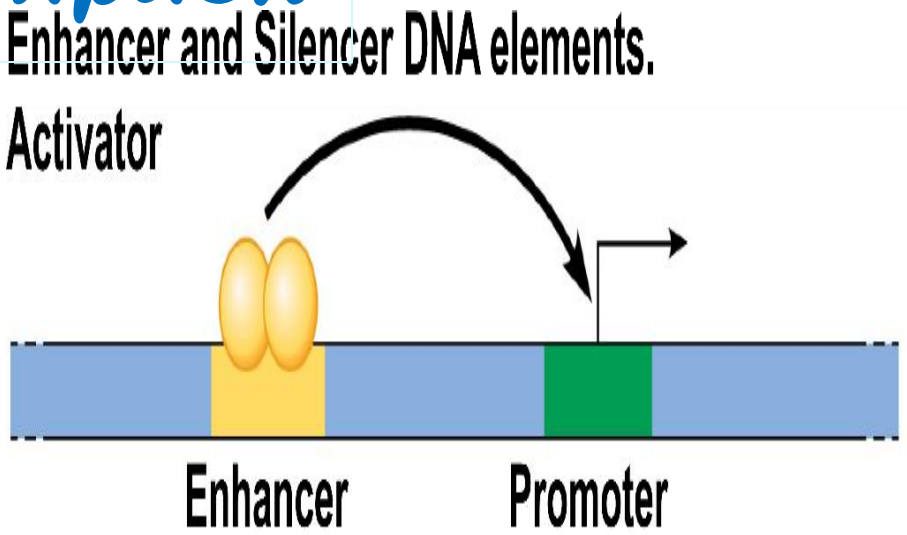


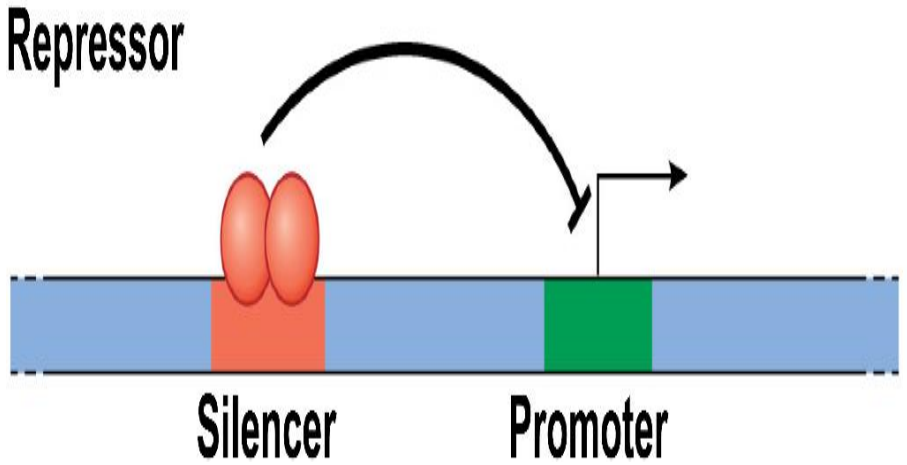


At the level of transcription

2-DNA regulatory regions

1 Enhancer	2 Silencer
DNA sequence which activates transcription	DNA sequence which inhibit transcription
They are recognized by specific enhancer binding proteins (TF-activator)	They are recognized by proteins (repressors)
-It facilitates binding of RNA polymerase to promoter	repressors prevent RNA polymerase from binding to promoter .





Summary

- Gene expression produces proteins by transcription and translation.
- This process takes place in two stages, both of which involve RNA.
- In cells, three types of RNA complement DNA and translate the genetic code into proteins.
- During transcription, the information in a specific region of DNA (a gene) is transcribed, or copied, into mRNA.
- The genetic code is based on codons that each represent a specific amino acid.
- Translation occurs in a sequence of steps, involves three kinds of RNA, and results in a complete polypeptide.
- The relationship between genes and their effects is complex. Despite the simplicity of the genetic code, every gene cannot be simply linked to a single outcome.

Review Questions.

- What is the main participant in the process of Transcription and Translation?
- What is the structural unit of DNA & RNA & what are three parts that make up a single subunit?
- Mention 3 differences between RNA and DNA?
- What are the 3 types of RNA and their function?.
- In the process of Transcription, what is the name of the site where the process begins?-
- What is the main protein that is involved in the process?


Thank You