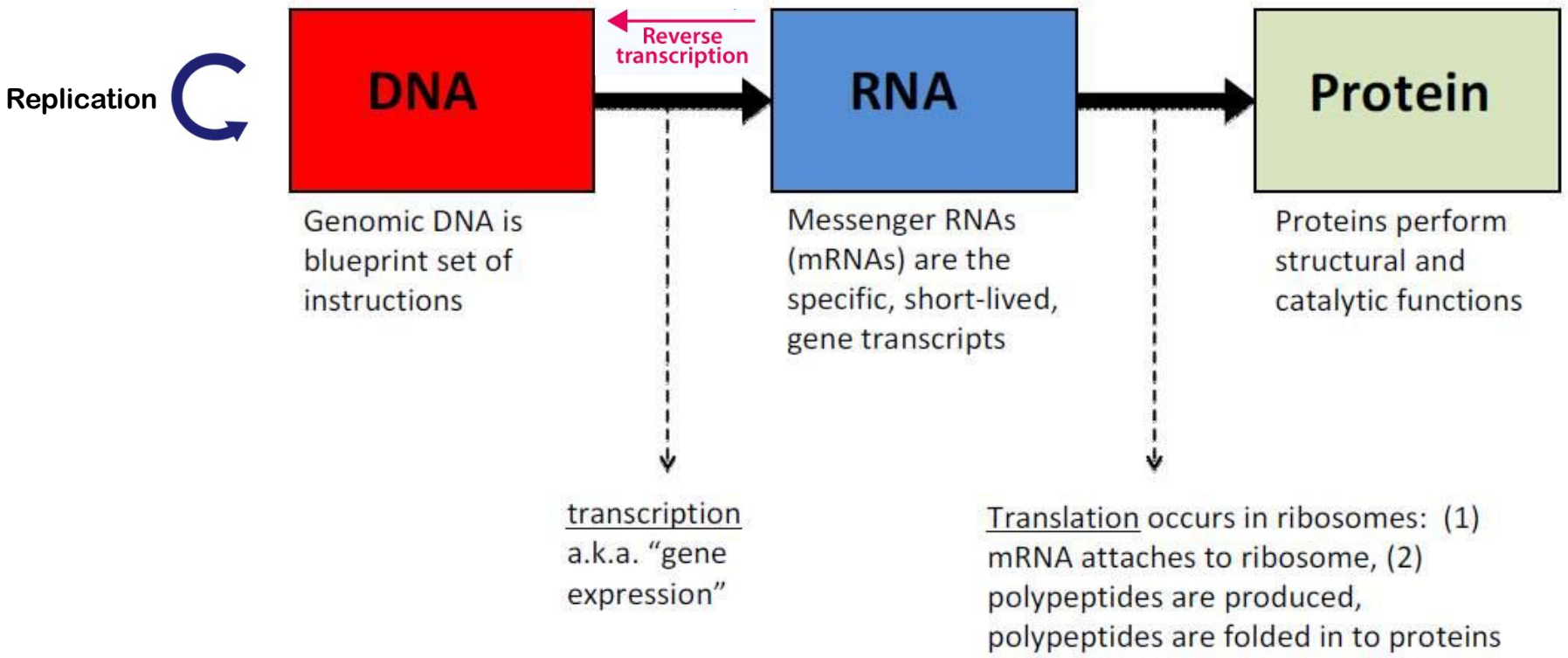
PROTEIN SYNTHESIS

CENTRAL DOGMA

The central dogma is a framework for understanding the flow of genetic information. It states that DNA makes RNA, and RNA makes protein. Again, the process is way more complicated than this. But, when we talk about the steps that occur during any part of this sequence, we say that it's included in the central dogma.



GENETIC CODE

- body can make millions of different proteins, all from the same **20 amino acids,** and encoded by genes made of just **4 nucleotides** (A,T,C,G)
- **Genetic code –** a system that enables these 4 nucleotides to code for the amino acid sequence of all proteins
- minimum code to symbolize 20 amino acids is 3 nucleotides per amino acid
- **Base triplet** – a sequence of 3 DNA nucleotides that stands for one amino acid
  - **codon** - the 3 base sequence in mRNA
  - **64 possible codons** available to represent the 20 amino acids
    - 61 code for amino acids
    - **Stop Codons** – **UAG, UGA**, and **UAA** – signal the 'end of the message', like a period at the end of a sentence
    - **Start Codon** – **AUG** codes for methionine , and begins the amino acid sequence of the protein

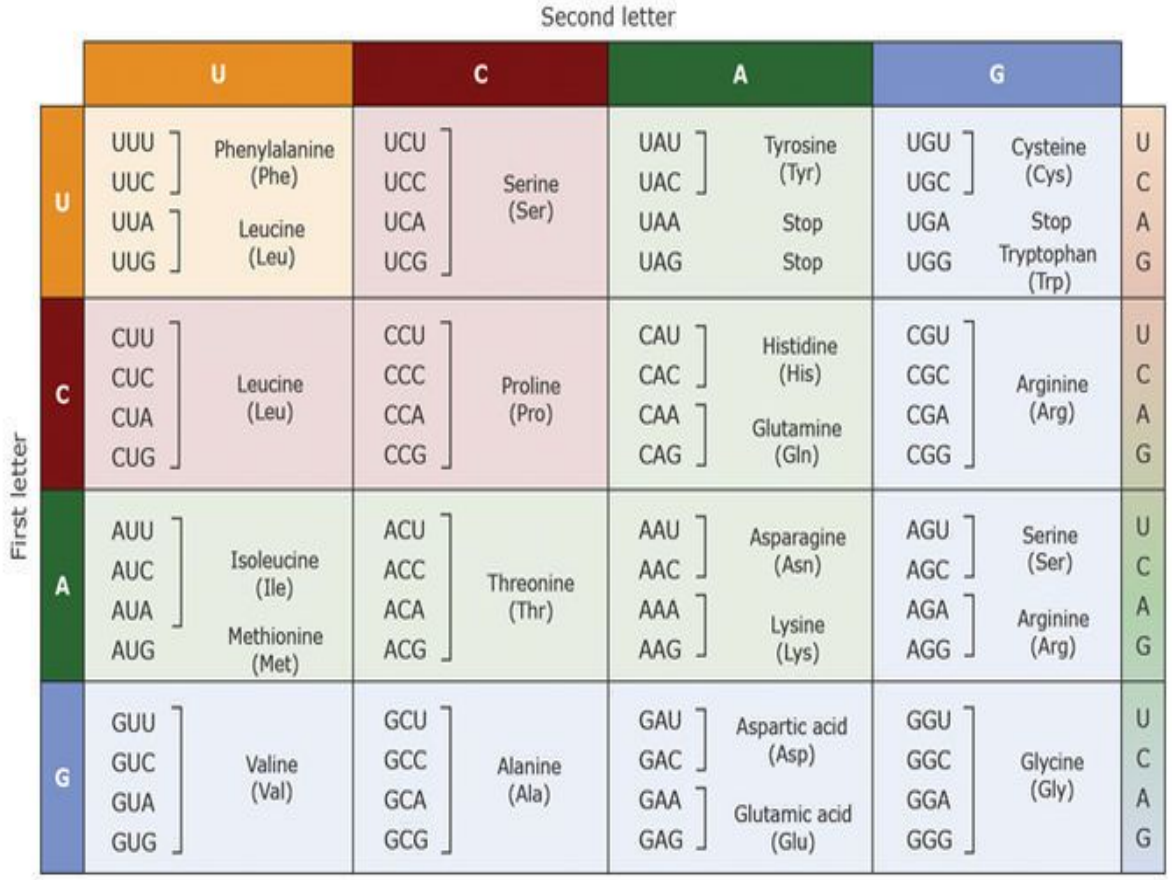
PROPERTIES OF GENETIC CODE

1) Triplet - Each amino acid is encoded by a sequence of three consecutive nucleotides, called a **codon**.

2) Universal - The genetic code is the same in almost all organisms. With few exceptions, all organisms use the code the same way, i.e., encode the same 20 amino acids with the same 64 triplets (more appropriately by 61 triplets).

3) Degenerate / Redundant - The degeneracy of the genetic code means that some amino acids may be specified by more than one codon.

4) Unambiguous / Exclusive - Each codon specifies only one of the 20 amino acids. None of the codons code for two or more amino acids

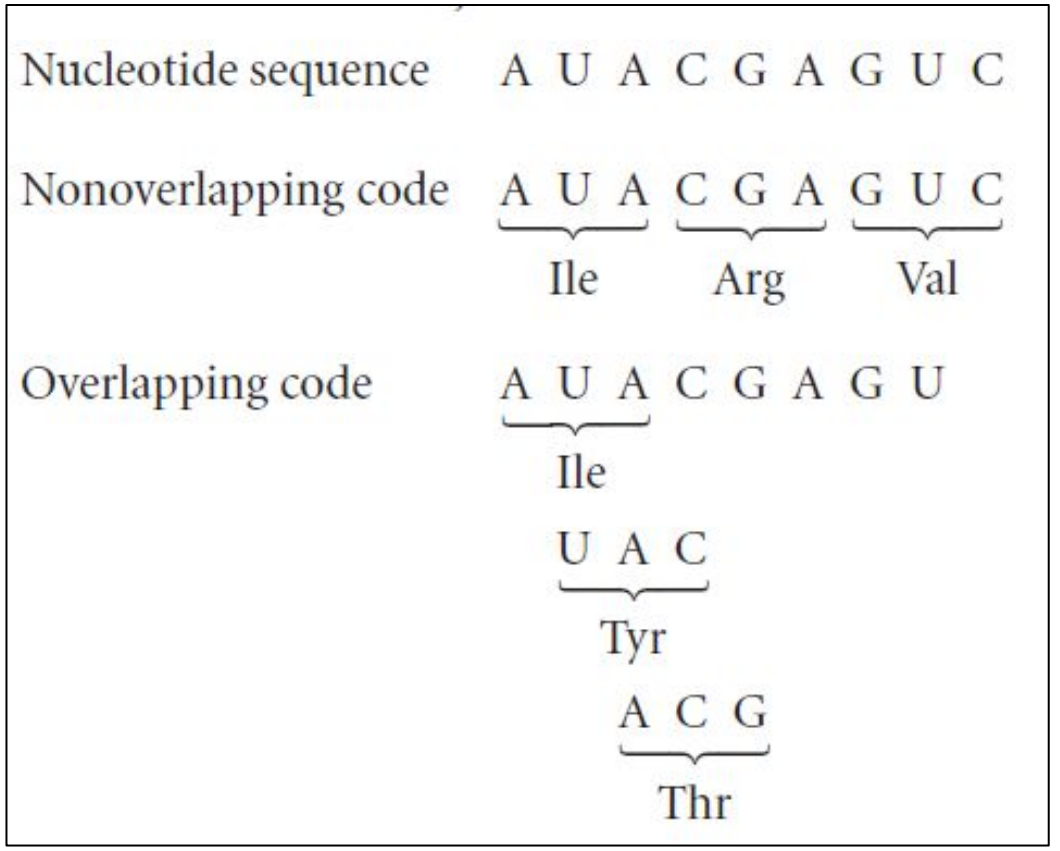


PROPERTIES OF GENETIC CODE

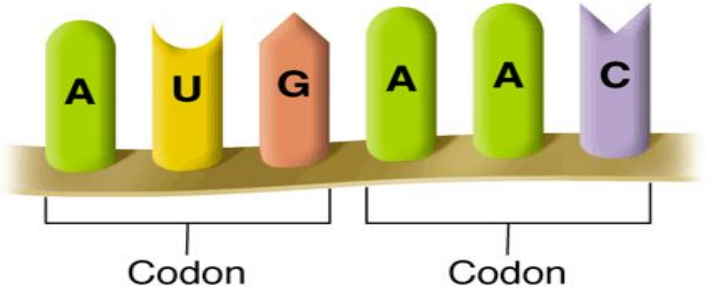
5) Nonoverlapping - Each nucleotide in an mRNA sequence belongs to a single reading frame. The **reading frame is set by an initiation codon**, which is usually AUG. When a reading frame has been set, codons are read as successive groups of three nucleotides.

6) Contains start and stop signals (Punctuation codons) - The initiation codon is usually **AUG** and it codes for **met in eukaryotes and f-met in prokaryotes**. Any one of three termination codons **(UAA, UAG, and UGA)** can signal the end of a protein; no amino acids are encoded by the termination codons.

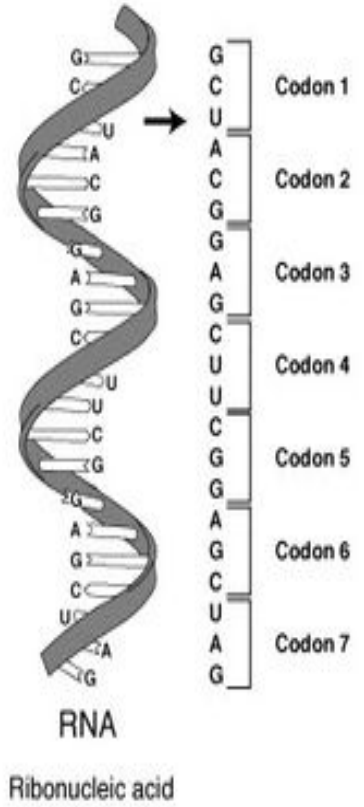
7) Commaless - Between the codons, there are no intervening nucleotides (or commas or gaps).

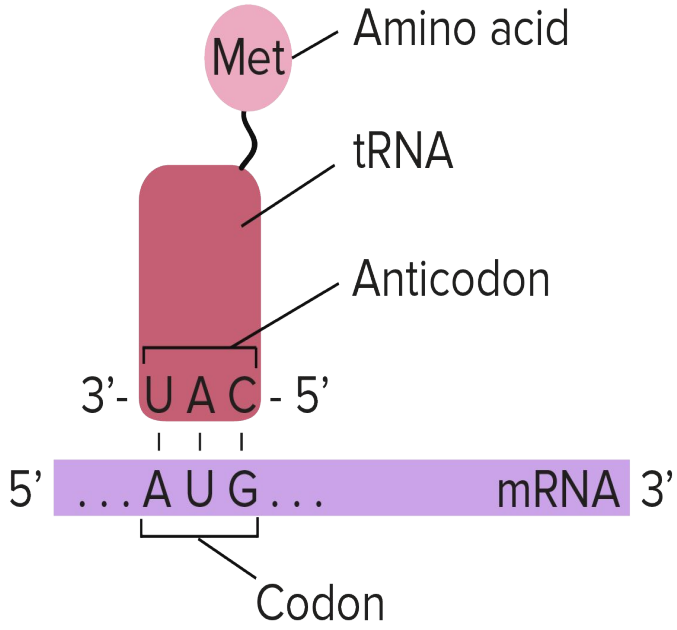


How the code is read?



1. How the code is read:
   a. Every 3 bases on mRNA represents a code for an amino acid = <u>codon.</u>
   b. Amino acids are abbreviated most times by using the first 3 letters of the amino acid's name.
      - Met = methonine
      - Leu = leucine

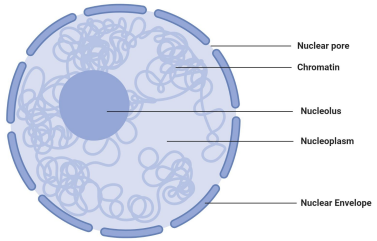




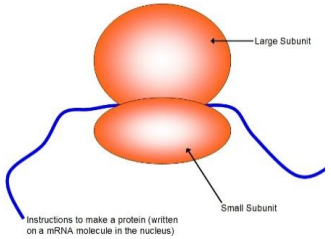
CELL MACHINERY REQUIRED FOR PROTEIN SYNTHESIS

THREE ORGANELLES ARE NEEDED TO CREATE A FUNCTIONAL PROTEIN

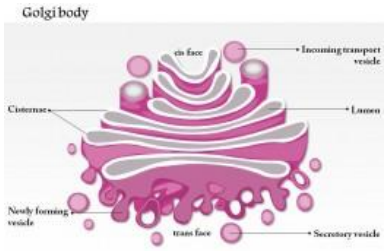
- **NUCLEUS**

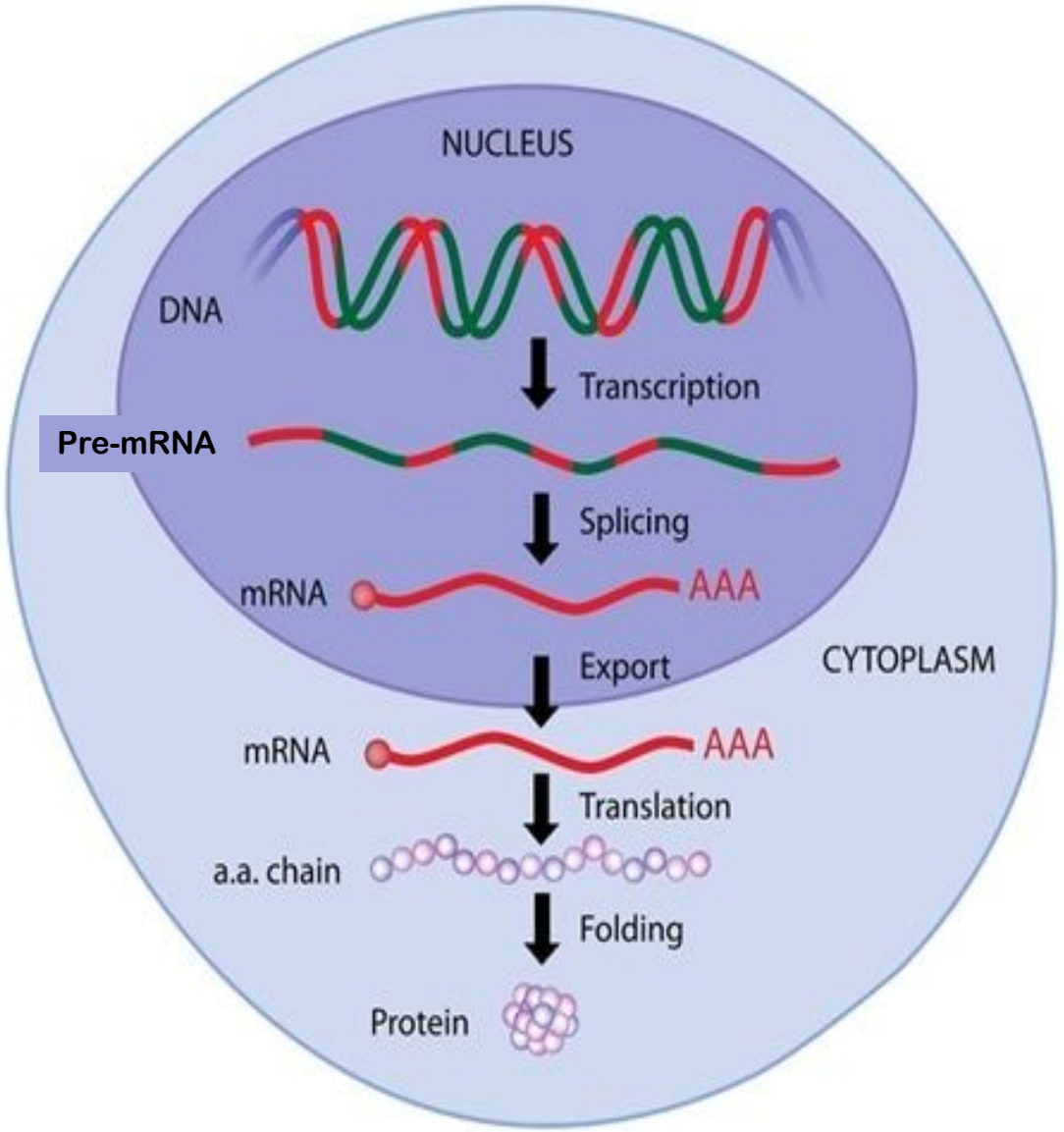


- **RIBOSOMES**



- **GOLGI APPARATUS**





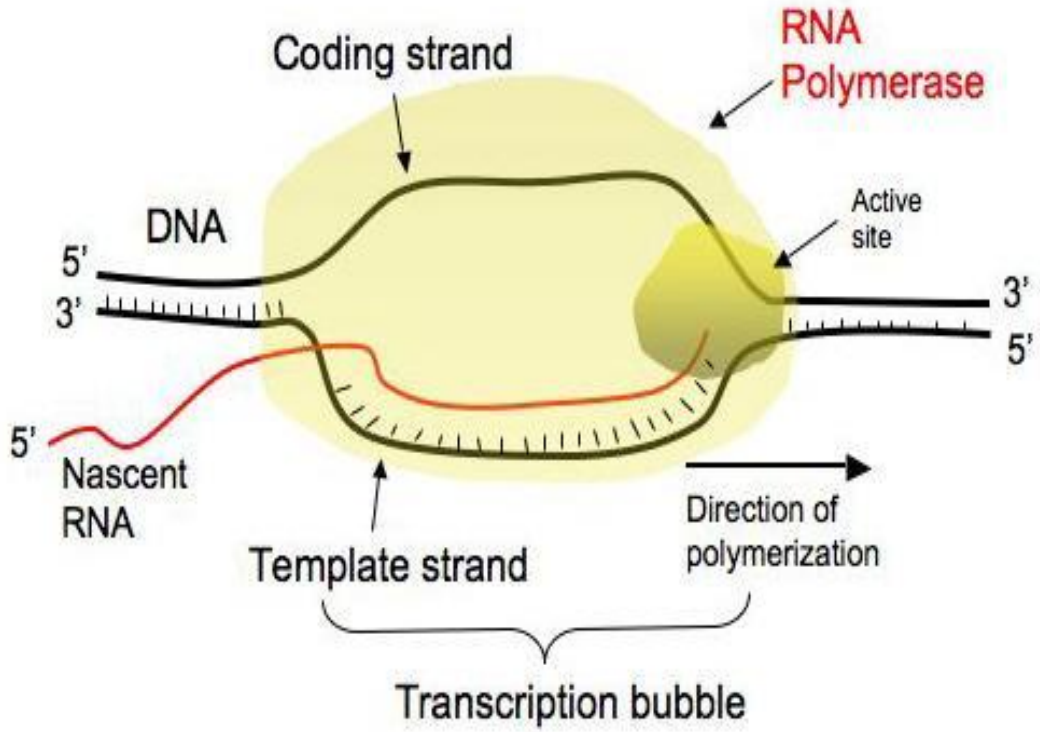
Requirements for Transcription

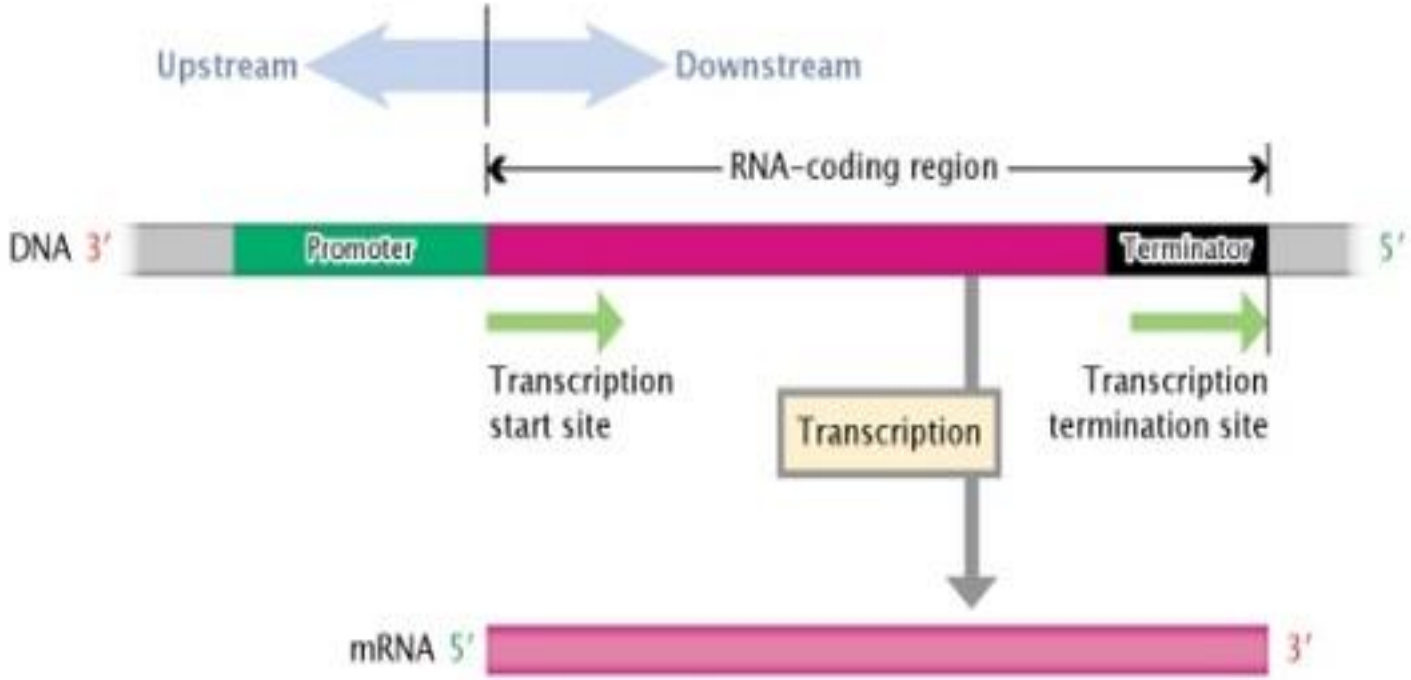
- a gene segment on the DNA
- many free floating RNA nucleotides
- the enzyme RNA polymerase

TRANSCRIPTION

Three stages

- Initiation phase: RNA-polymerase recognizes the **promoter** and starts the transcription.
- Elongation phase: the RNA strand is continuously growing.**The direction of synthesis is always 5' to 3'**
- Termination phase: the RNA-polymerase stops synthesis and the nascent RNA is separated from the DNA template.

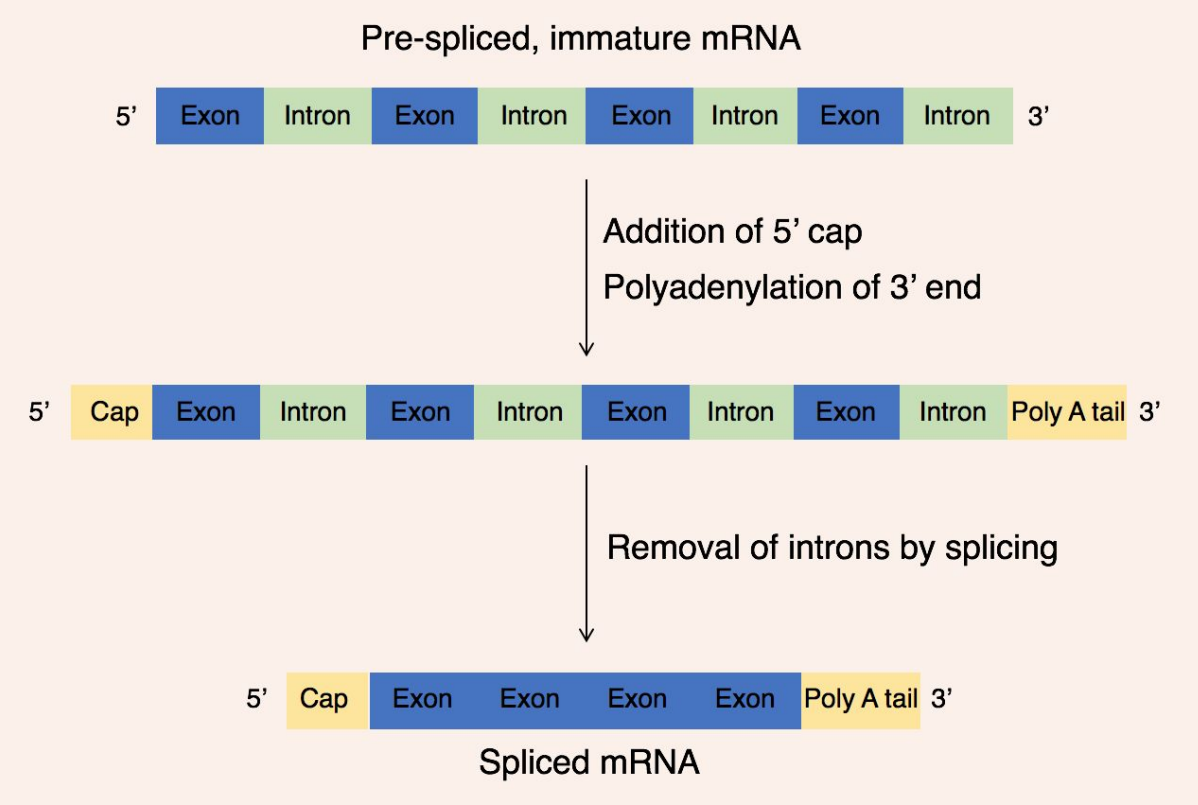




A DNA transcription unit is composed, from its 3' to 5' end, of an RNA-coding region (pink rectangle) flanked by a promoter region (green rectangle) and a terminator region (black rectangle). Regions to the left, or moving towards the 3' end, of the transcription start site are considered \"upstream;\" regions to the right, or moving towards the 5' end, of the transcription start site are considered \"downstream.\"

mRNA EDITING - SPLICING

- There are some parts of the DNA sequence that aren't involved in coding for proteins. These parts are called **introns**, and the introns must be removed from mRNA.
- The parts that are involved in coding are called **exons.**
- Pre-mRNA has to be edited in order to remove the introns and make a complete coding set. This is achieved by a process called **splicing.**



TRANSLATION

- What is it?

  The making of a protein

- Where does it take place?

  Prokaryotes = cytoplasm

  Eukaryotes = cytoplasm

- What is needed?

  mRNA, 2 ribosomal subunits, tRNA and amino acids

Steps in Translation

INITIATION

1) A ribosome attaches to mRNA molecule, and begins reading the mRNA at the "start" codon

2) tRNA brings in an amino acid that matches the mRNA codon

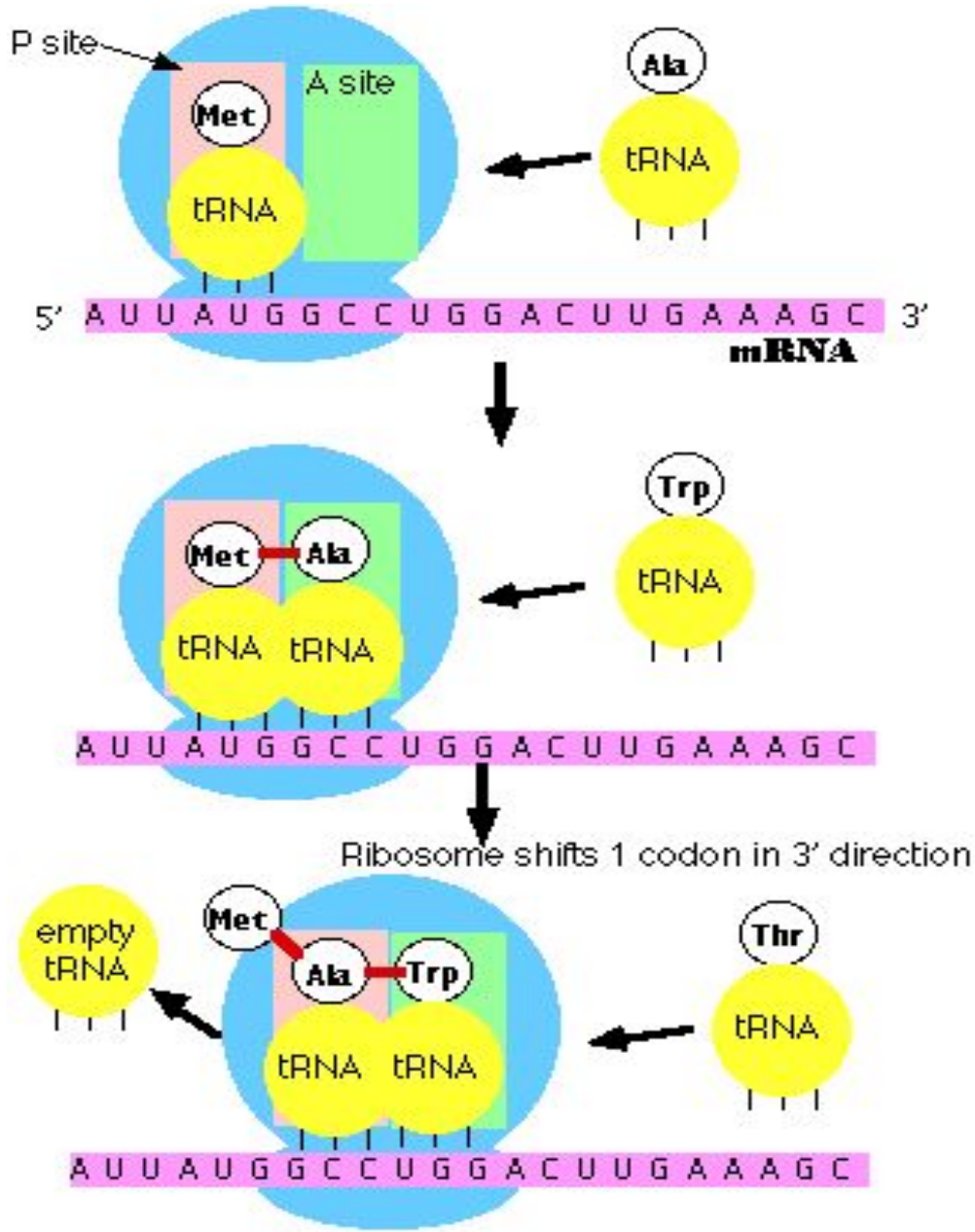
ELONGATION

Codons are read 5' → 3' as the protein is synthesized from amino end to carboxyl end

3) The ribosome helps amino acids bond to each other, and moves the growing polypeptide over to make room for the next amino acid

TERMINATION

4) When the ribosome reaches a "stop" codon, it releases the mRNA and the protein



DIFFERENCE BETWEEN TRANSCRIPTION AND TRANSLATION

	TRANSCRIPTION	TRANSLATION
DEFINITION	It is the first step of gene expression that converts DNA into all types of RNA	It is the second step of gene expression that converts mRNA into protein
LOCATION	It occurs in the nucleus of eukaryotes and cytoplasm of prokaryotes	It occurs in the cytoplasm of both prokaryotes and eukaryotes
TEMPLATE	The template is antisense strand of DNA	The template is mRNA
REQUIREMENTS	Segment of DNA template strand, four types of ribonucleotides and RNA polymerase	mRNA, Ribosomes, tRNA and 20 types of amino acids
PRODUCT	All types of RNA	Protein

DIFFERENCE BETWEEN PROKARYOTIC AND EUKARYOTIC TRANSLATION

Prokaryotic Translation	Eukaryotic Translation
70S type ribosomes are involved	80S type ribosomes are involved
Can be coupled to transcription	Cannot be coupled to transcription
mRNA carrying the codons is already present in the cytoplasm	mRNA carrying the codons is exported from the nucleus into cytoplasm
mRNA is less stable	mRNA is more stable
Occurs on the ribosomes present in cytosol	Occurs on the ribosomes present in cytosol and rough endoplasmic reticulum
mRNA formed after transcription can immediately undergo translation	mRNA formed after transcription is first processed and than it can undergo translation
mRNA is polycistronic, can produce more than one peptides	mRNA is monocistronic, can produce only one peptide
Initiator tRNA carries formylated methionine	Initiator tRNA carries methionine

PRACTICE QUESTIONS

Short questions

1) Define splicing.
2) Why is genetic code considered to be degenerate/universal/exclusive?
3) What are start and stop codons?
4) Define exons and introns.

Long questions

1) What is “Central dogma of life”?
2) What is the difference between transcription and translation?
3) Describe the steps involved in transcription with well labelled diagram.
4) Describe the steps involved in translation with well labelled diagram.

IMPORTANT DIAGRAMS - Central Dogma of life (Slide 2), Protein formation summary (Slide 7), Transcription (Slide 9), Splicing (Slide 11), Translation (Slide 13)

Gene expression

Central dogma
DNA→RNA→Protein

uses

Genetic code

consists of

64 codons

code for

Amino acids

Stop

Start

Prokaryotes

Coupled

Transcription

Translation

RNA processing

Eukaryotes

steps

requires

Initiation

RNA polymerase

Elongation

Termination

requires

steps

Initiation

Ribosome

Elongation

Termination