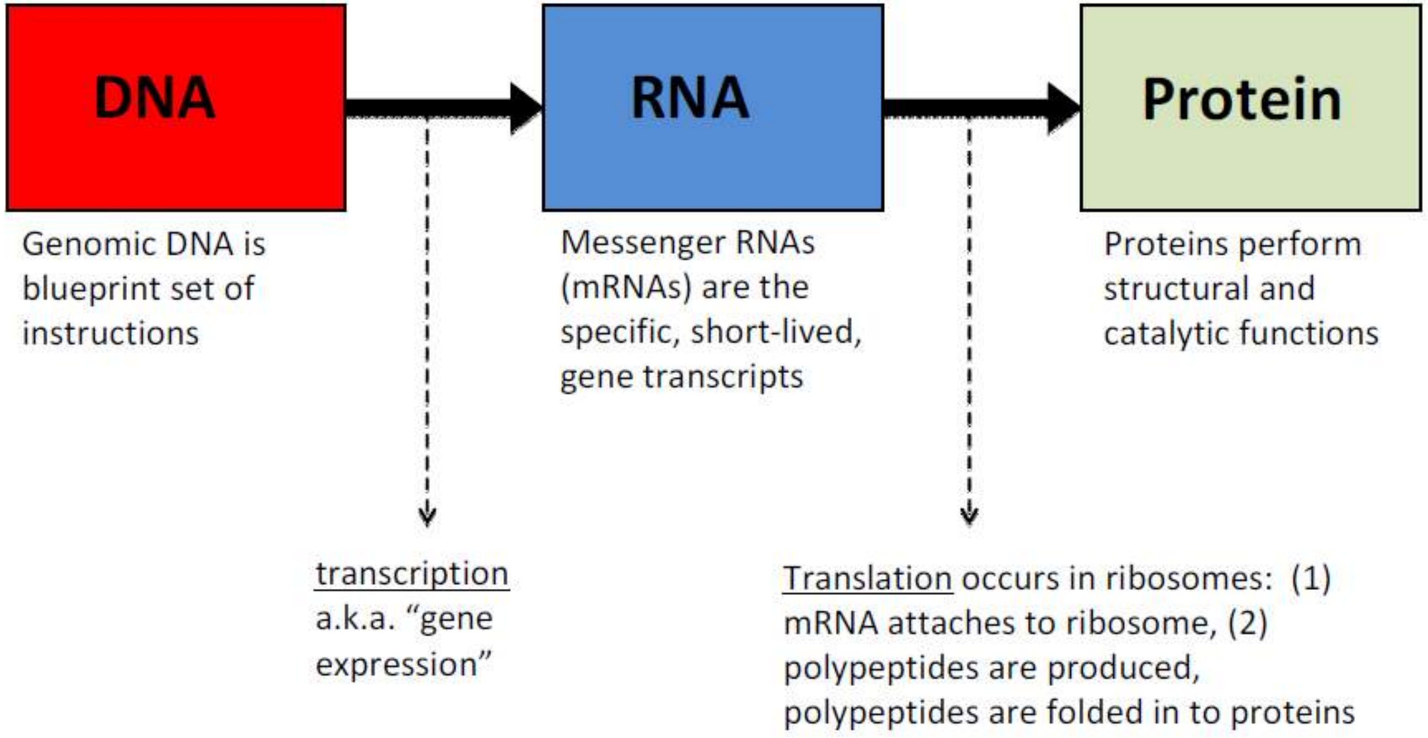
Unit 2

THE MOLECULAR AND BIOCHEMICAL BASIS OF AN ORGANISM

- Protein synthesis

CENTRAL DOGMA

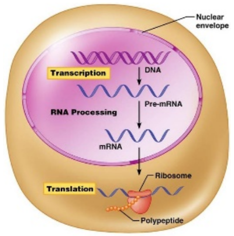
The central dogma is a framework for understanding the flow of genetic information. It states that DNA makes RNA, and RNA makes protein. Again, the process is way more complicated than this. But, when we talk about the steps that occur during any part of this sequence, we say that it's included in the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



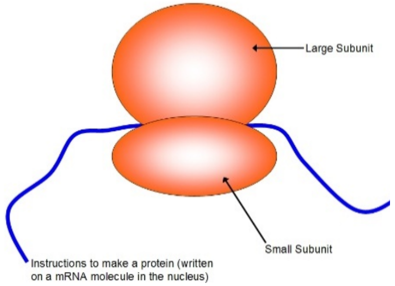
CELL MACHINARY REQUIRED FOR PROTEIN SYNTHESIS

THREE ORGANELLES ARE NEEDED TO CREATE A FUNCTIONING PROTEIN

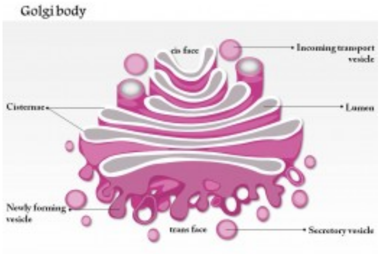
- NUCLEUS



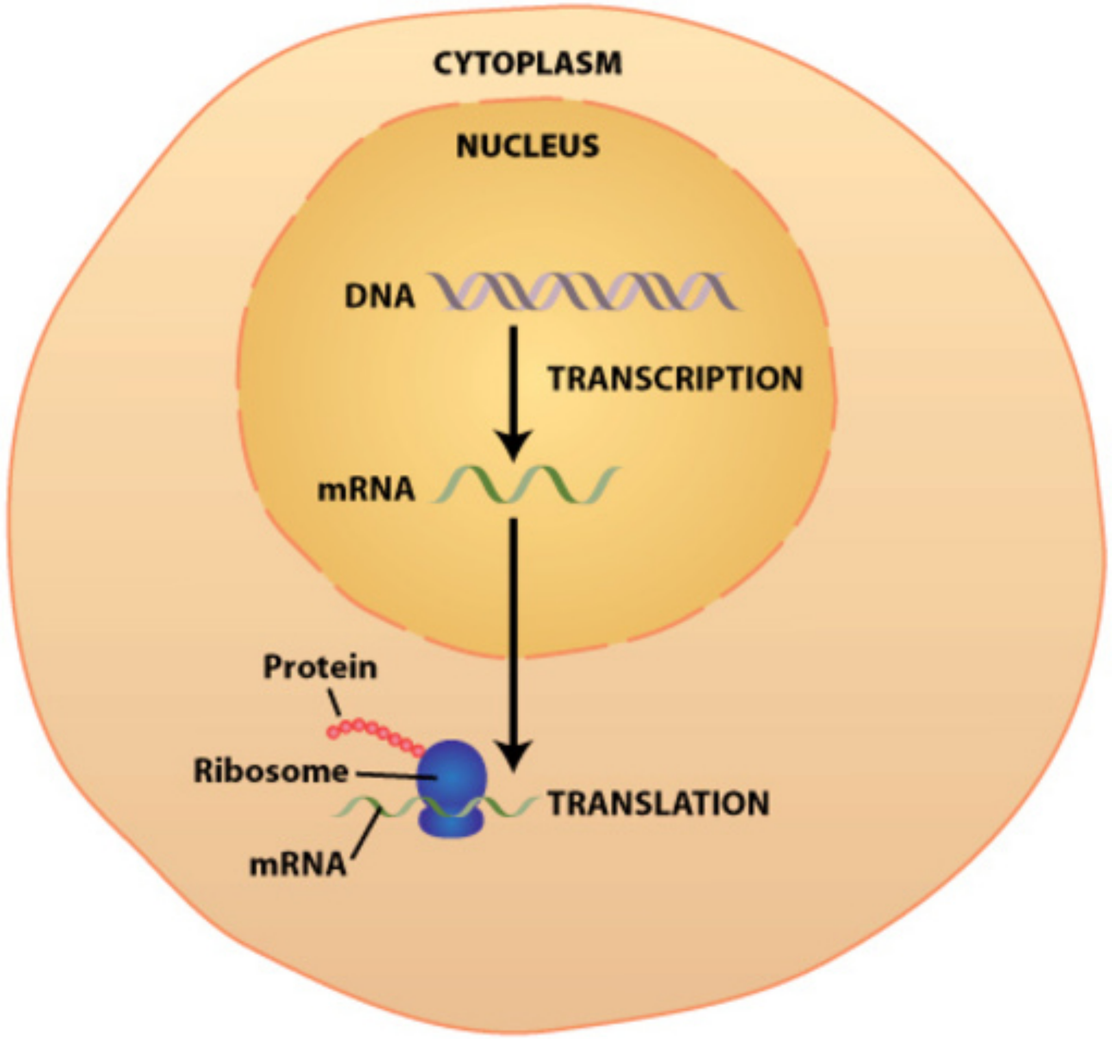
- RIBOSOMES



- GOLGI APPARATUS

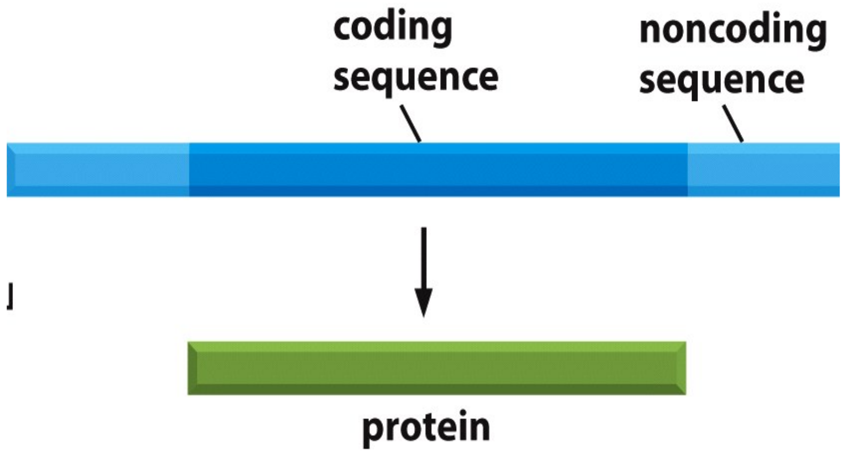


NUCLEUS


CYTOPLASM
NUCLEUS
DNA
TRANSCRIPTION
mRNA
Protein
Ribosome
TRANSLATION
mRNA

MESSENGER RNA (mRNA)

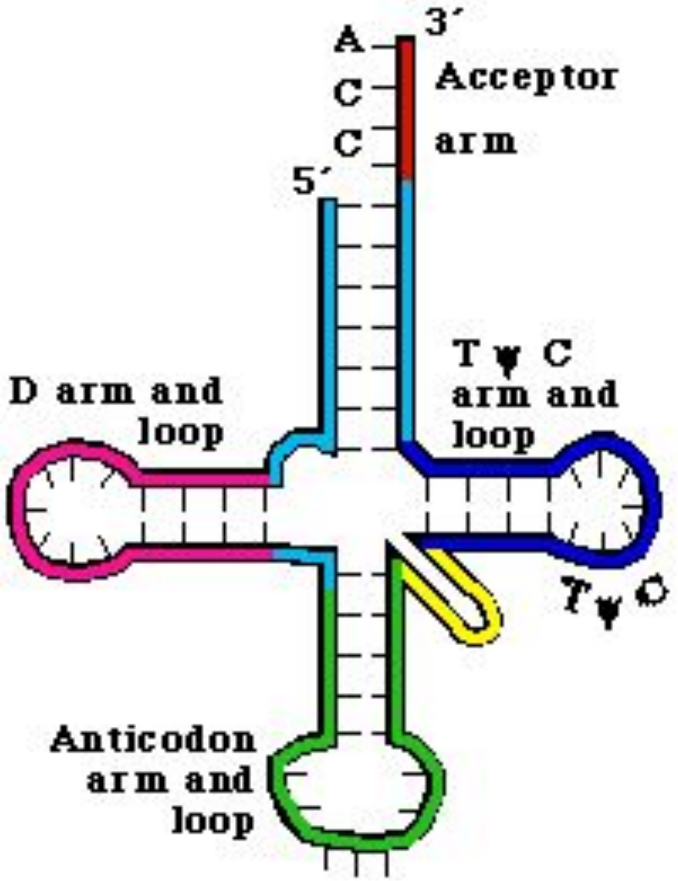
Remember: Small enough to leave the nucleus. **DNA is too big!**



- ❑Comprises only 5% of the RNA in the cell
- ❑Most heterogeneous in size and base sequence
- ❑All members of the class function as messengers carrying the information in a gene to the protein synthesizing machinery

TRANSFER RNA (tRNA)

- ❖ tRNA molecules vary in length from 74 to 95 nucleotides, have clover leaf like structure.
- ❖ The tRNA molecule serve as adapters for the translation of the information in the sequence of nucleotides of the mRNA into specific amino acids.
- ❖ There are at least 20 species of tRNA molecules in every cell, at least one corresponding to each of the 20 amino acids required for protein synthesis.
- ❖ All tRNA molecules have four main arms. The acceptor arm terminates in the nucleotides CCA.



○ **Presence of un usual base pairs**

- In addition to usual N-bases (A,U,G,C) tRNA contains number of unusual bases.
- These unusual bases are important as they **protect t-RNA molecules from dehydration by Rnase**, when tRNAs are floating freely in cytoplasm.

Acceptor arm	-Amino acid binding site - CCA at 3'end
Anticodon arm	Binds with mRNA

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

The Genetic Code

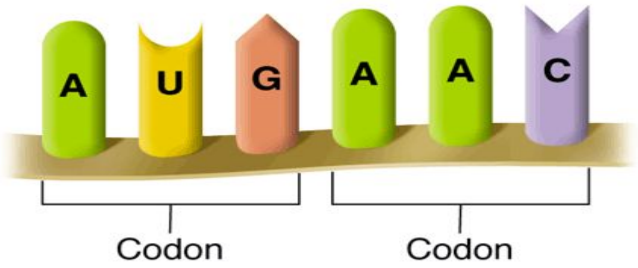
- Properties of the genetic code:
  - Universal
    - With few exceptions, all organisms use the code the same way
    - Encode the same 20 amino acids with the same 64 triplets
  - Degenerate (redundant)
    - There are 64 codons available for 20 amino acids
    - Most amino acids encoded by two or more codons
  - Unambiguous (codons are exclusive)
    - None of the codons code for two or more amino acids
    - Each codon specifies only one of the 20 amino acids
  - Contains start and stop signals
    - Punctuation codons
    - Like the capital letter we use to signify the beginning of a sentence, and the period to signify the end

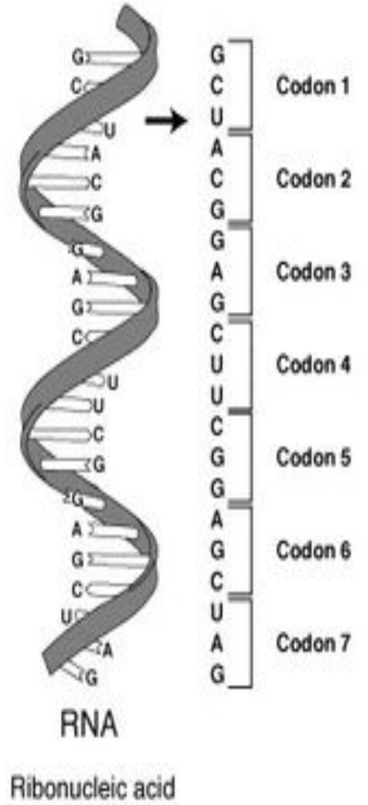
Second letter

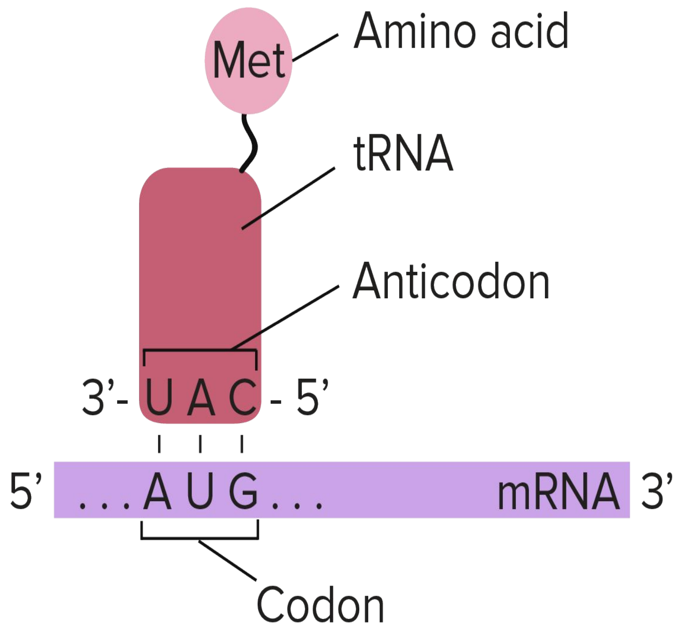
First letter	U	C	A	G	Third letter
U	UUU, UUC Phe UUA, UUG Leu	UCU, UCC, UCA, UCG Ser	UAU, UAC Tyr **UAA Stop** **UAG Stop**	UGU, UGC Cys **UGA Stop** UGG Trp	U C A G
C	CUU, CUC, CUA, CUG Leu	CCU, CCC, CCA, CCG Pro	CAU, CAC His CAA, CAG Gln	CGU, CGC, CGA, CGG Arg	U C A G
A	AUU, AUC, AUA Ile **AUG Met**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

How the code is read

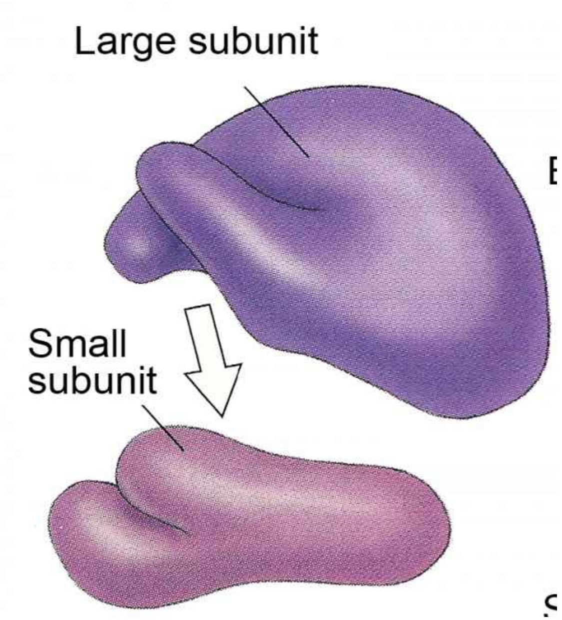
1. How the code is read:
    a. Every 3 bases on mRNA represents a code for an amino acid = <u>codon.</u>
    b. Amino acids are abbreviated most times by using the first 3 letters of the amino acid's name.
        - Met = methonine
        - Leu = leucine

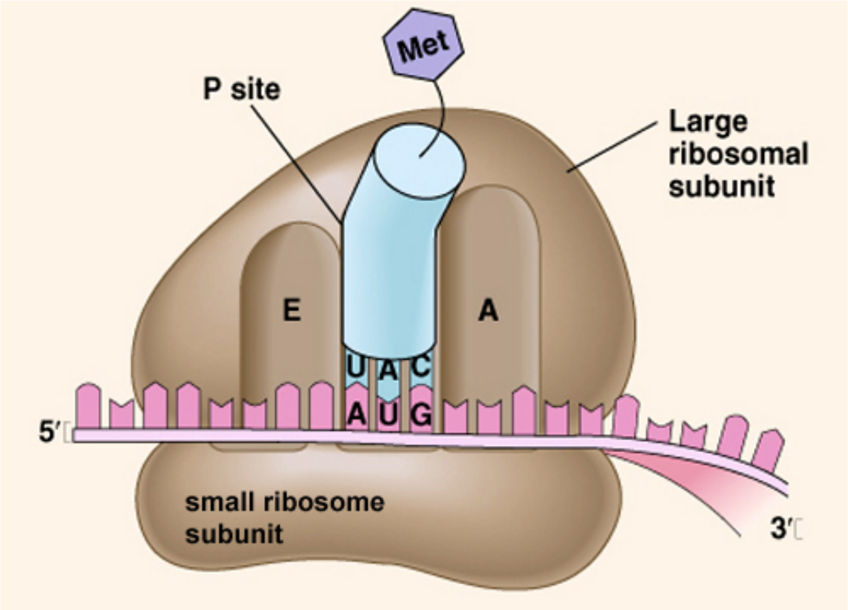






RIBOSOMES

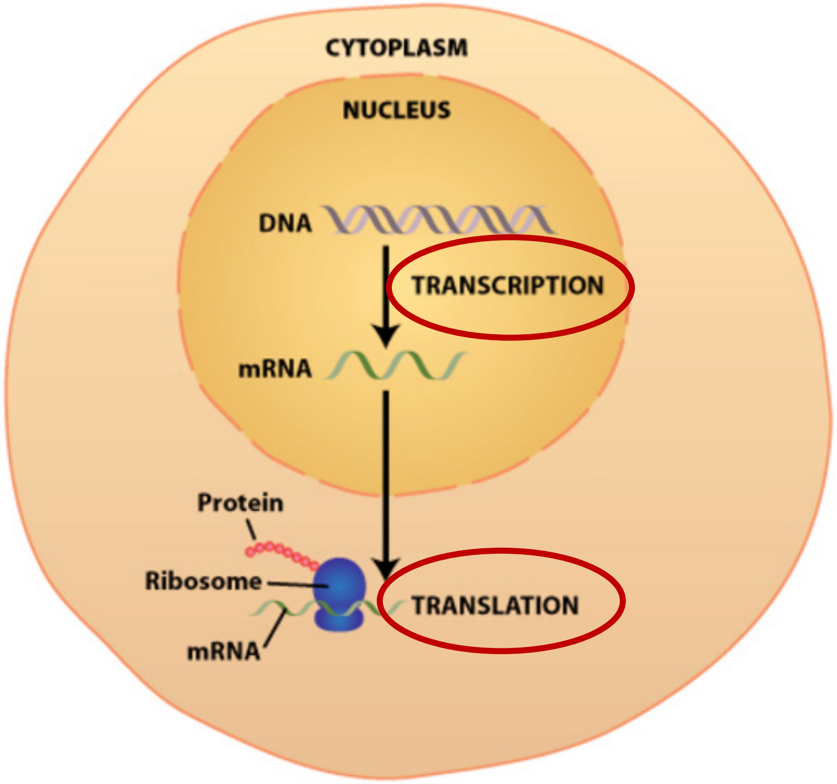




- The T site where the tRNA first lands
- The A site where the tRNA <u>anticodon binds to the mRNA codon</u>
- The P site where the tRNA adds its amino acid to the polypeptide chain
- The E site where the tRNA goes before leaving the ribosome

Steps/Mechanism of Protein synthesis

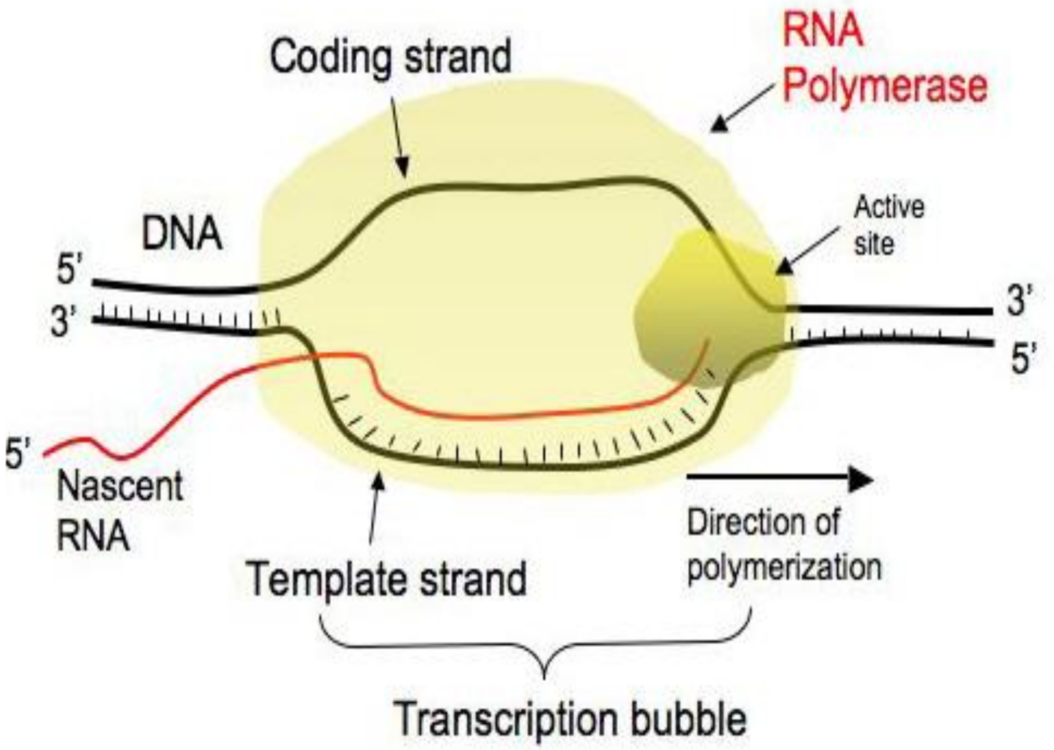
When cells synthesize, or *make* proteins there are two major processes going on. These processes are called **transcription** and **translation**.



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.

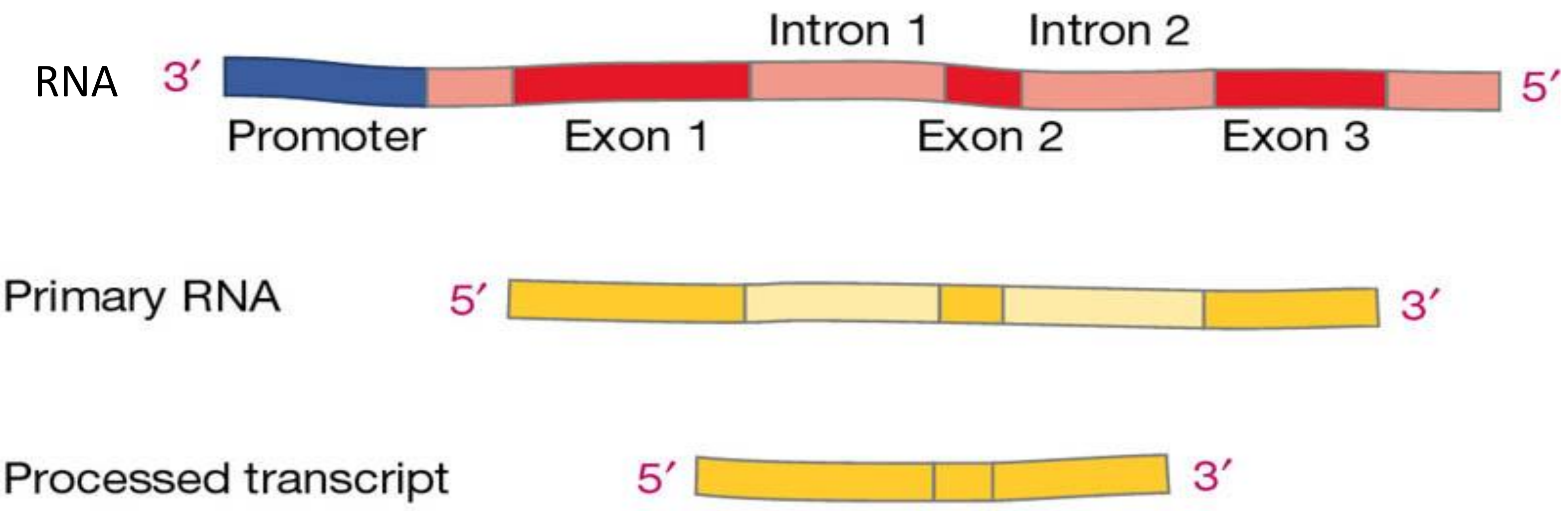


mRNA EDITING- SPLICING

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

Protein synthesis decodes the information in messenger RNA

Protein synthesis occurs in three phases:

1. Initiation – the translation machinery locates the start codon in mRNA

2. Elongation – codons are read 5′ → 3′ as the protein is synthesized from the amino end to the carboxyl end

3. Termination – special proteins hydrolyze the polypeptide from the last tRNA when a termination codon is reached

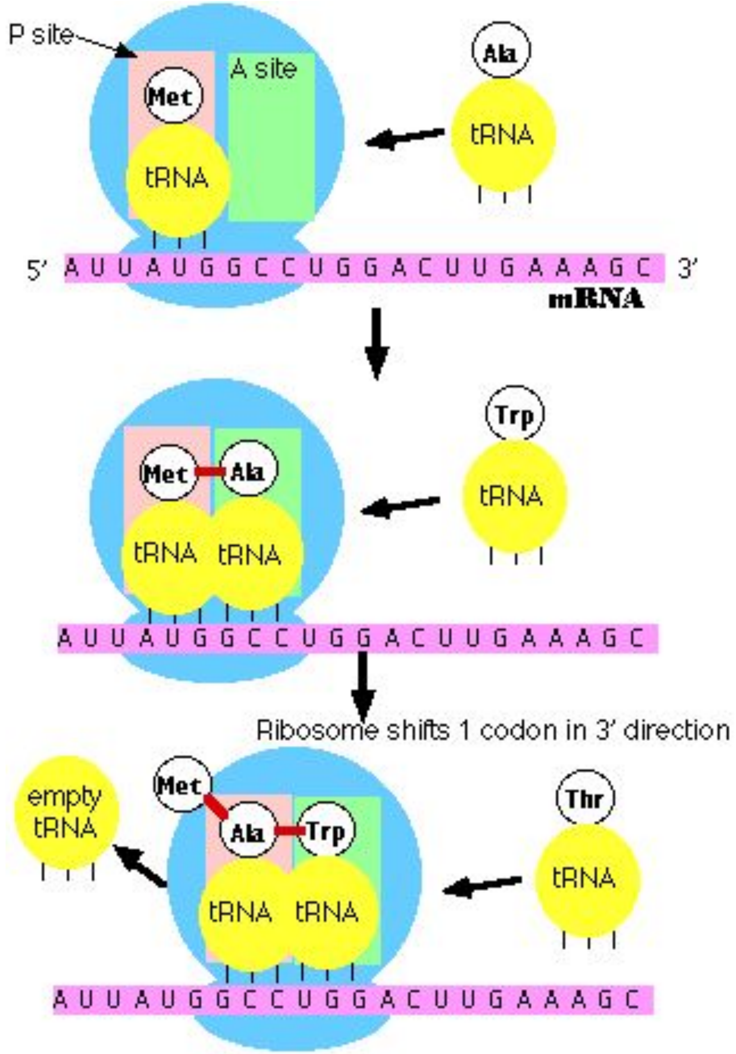
Steps in Translation

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

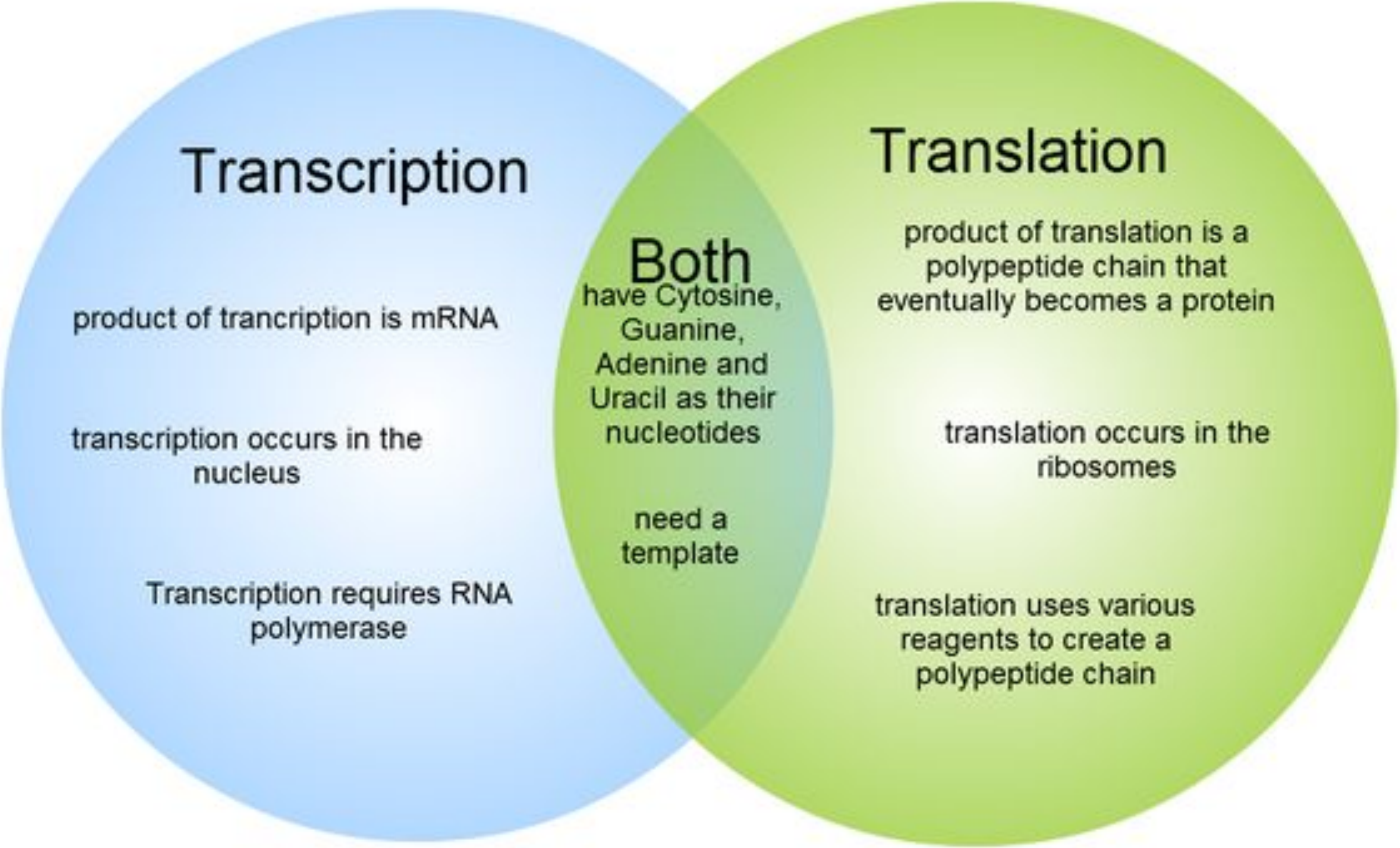
2) tRNA brings in an amino acid that matches the mRNA codon

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

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



DIFFERENCE BETWEEN TRANSCRIPTION AND TRANSLATION



SUMMARY

- Central dogma
- Cell machinery for protein synthesis
- Transcription and translation
- Differences between the two

Questions

1. Define central dogma?
2. Draw the structure of mRNA and tRNA?
3. What is genetic code? What are its properties?
4. How is genetic code helpful in protein synthesis?
5. Explain the process of transcription?
6. Define mRNA splicing?
7. Explain the process of protein synthesis?
8. Differentiate between transcription and translation?
9. Differentiate between the transcription process occurring in prokaryotes and eukaryotes?