Biochemistry Module For Medical Students
Lecture 6 : Proteins Synthesis

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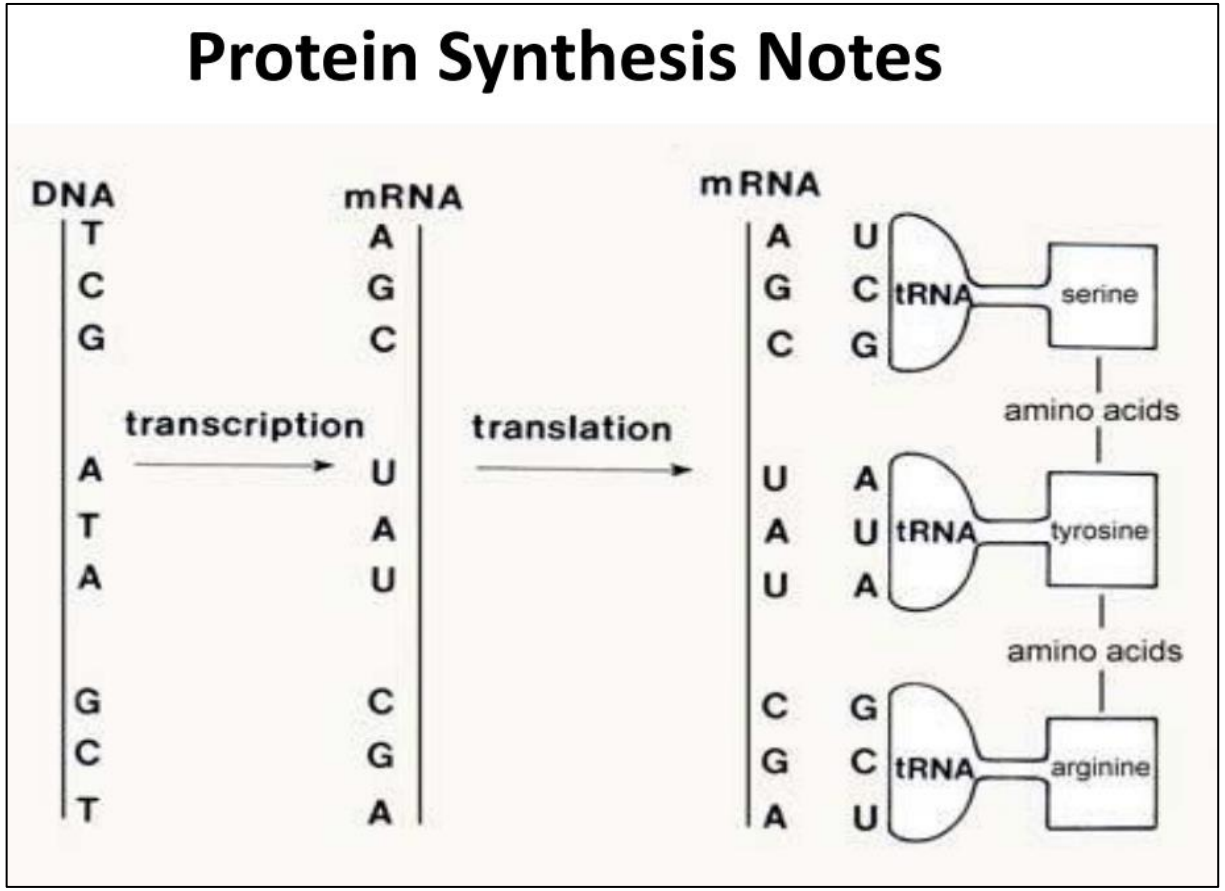


Learning Objective:

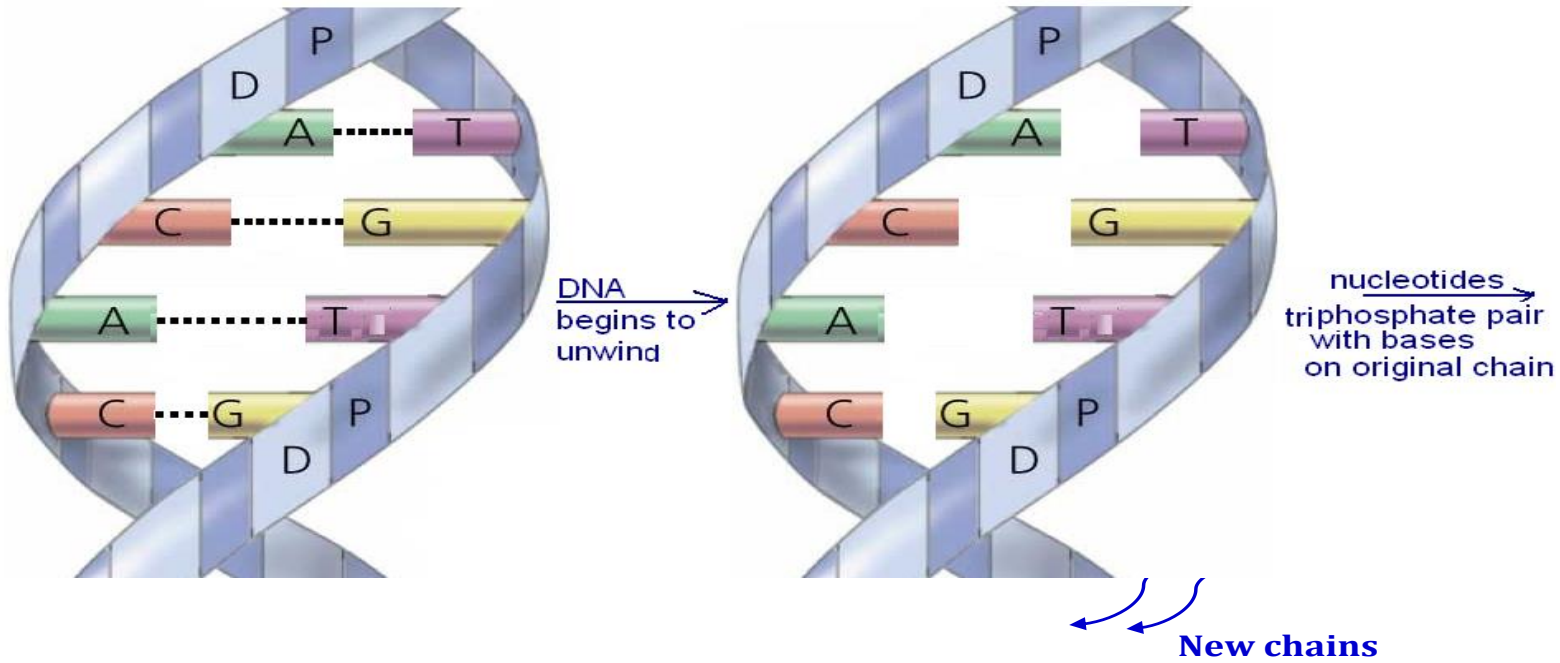
- **Identify the roles of mRNA, ribosomes, tRNA and amino acids in the process of translation.**
- **Understand what start codons and stop codons.**
- **Understand how a polypeptide is built, one amino acid at a time, in the different docking sites of the ribosome.**

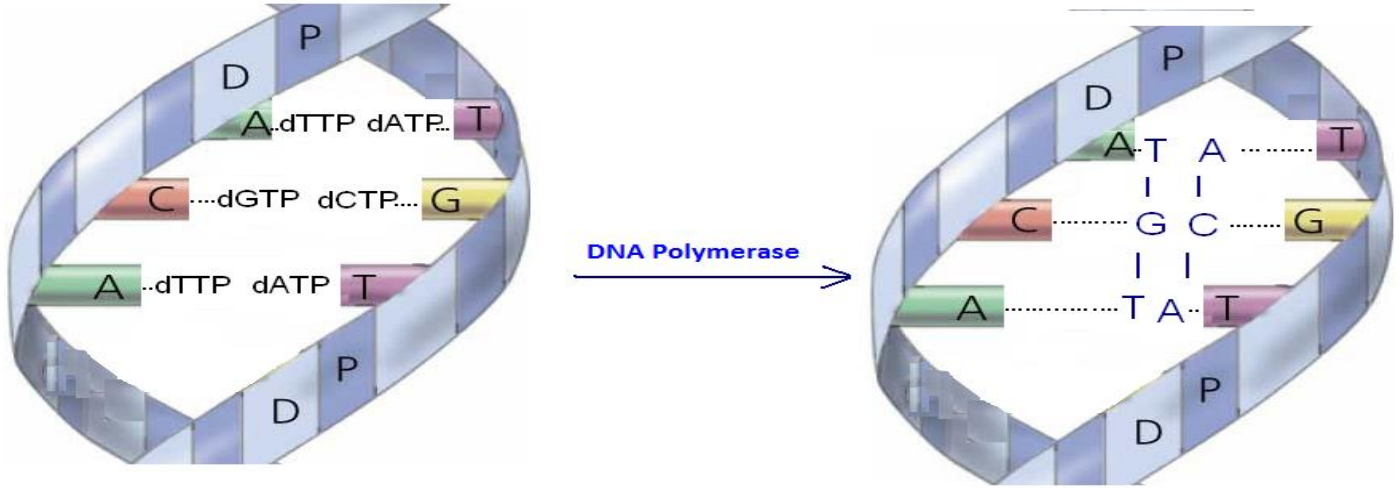
Heredity and DNA Replication:

Heredity is the process by which the physical and mental characteristics of parents are passed on to their children.

- **DNA contain the information needed to transmit the characteristics of a species from one generation to the next as well as the information needed for the species to grow and live.**
- **DNA molecules are contained in chromosomes located in the nuclei of cells.**
- **All DNA molecules have the same double-helix structure and the same deoxy ribose-phosphate backbone, and all contain the same four bases.**
- **The sequence of bases in the structure of DNA that contains the genetic information of a particular species.**
- **Genetic information must be reproduced exactly each time a cell divides. This is done by making an exact copy of DNA molecule. (The process by which DNA molecules reproduce themselves in the molecules of cell is called DNA replication)**
- **The process of replication begins when the two chains of a DNA molecule slowly unwind to expose each chain, which serves as a template for the synthesis of two new molecules of DNA.**
- **The cellular fluid surrounding DNA molecules in the nucleus is rich in the nucleotide tri phosphates dATP, dCTP, dGTP & dTTP needed to synthesize new DNA molecules.**

These nucleotides tri phosphates move into position along the unwind part of the DNA chains. They pair with the proper complementary base (A to T or T to A, and C to G or G to C). Once the nucleotide tri phosphate is in place, the enzyme DNA polymerase catalyzes the reaction that joins the nucleotide into the new chain.





Replication of DNA

RNA:

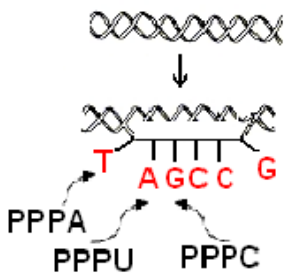
RNA molecules, like DNA molecules, are polymers of nucleotides joined together by 5' , 3' phospho diester linkage. RNA differs from DNA in three ways:

- **The genetic information carried by DNA is incorporated into the structure of RNA. The RNA molecules use this information to specify and synthesize the amino acid sequence in proteins.**
- **The information or message in a DNA molecule about the order of assembly of amino acid is given to an RNA molecule in a process called (Transcription)**

- **The process of transcription include:**

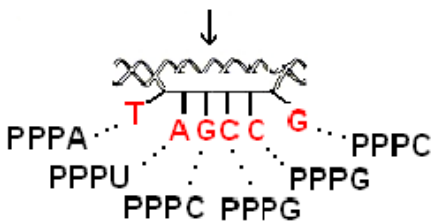
1) **A section of the double helix of DNA unwinds to expose a short segment that has the code for an RNA molecule. Only one of the complementary DNA chains is involved in directing the base sequence of RNA.**
2) **Ribonucleotide tri phosphates, from the cellular fluids, move into position along the unwind part of the DNA double helix.**
3) **Transcription occurs in complementary fashion. (U in RNA instead of T in DNA)**
4) **The enzyme RNA polymerase catalyzes the reaction that joins the nucleotides together into the RNA chain with elimination of pyrophosphate.**
5) **The newly formed RNA chain drops off and the DNA re-forms the double helix.**

portion of DNA molecule



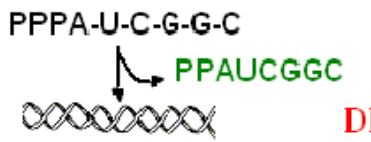
portion of DNA molecule

section of DNA molecule unwinds
Ribonucleotides move into position

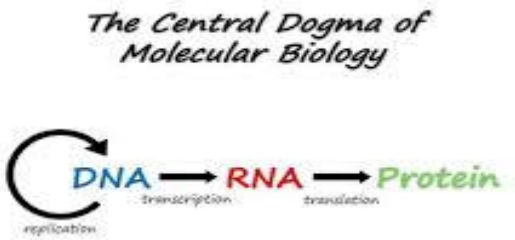


the enzyme RNA polymerase catalyzes the reaction that joins nucleotides into RNA

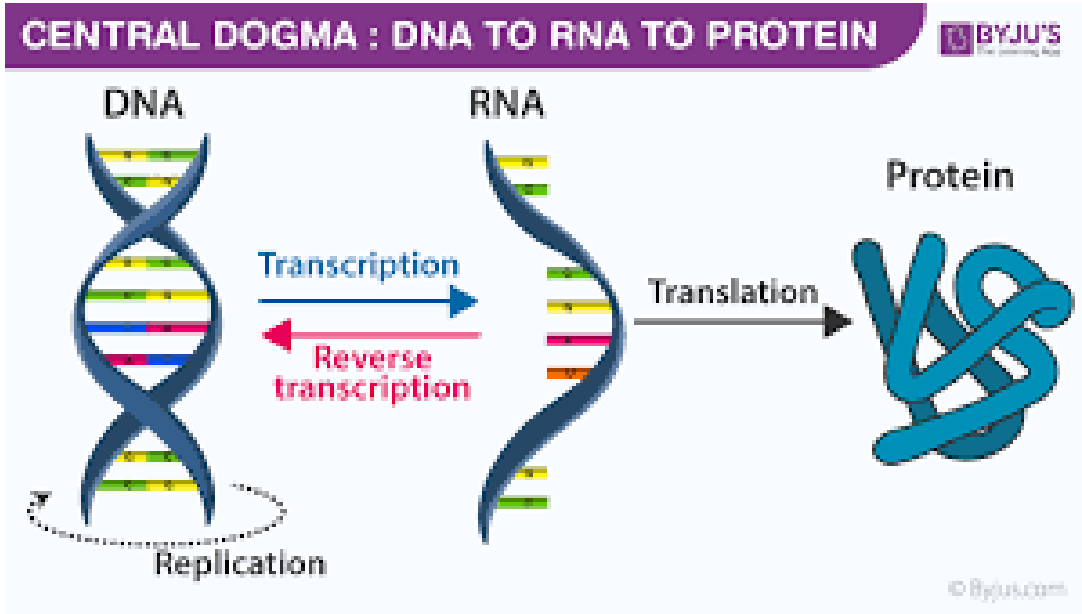
RNA chain drops off



DNA double helix reforms

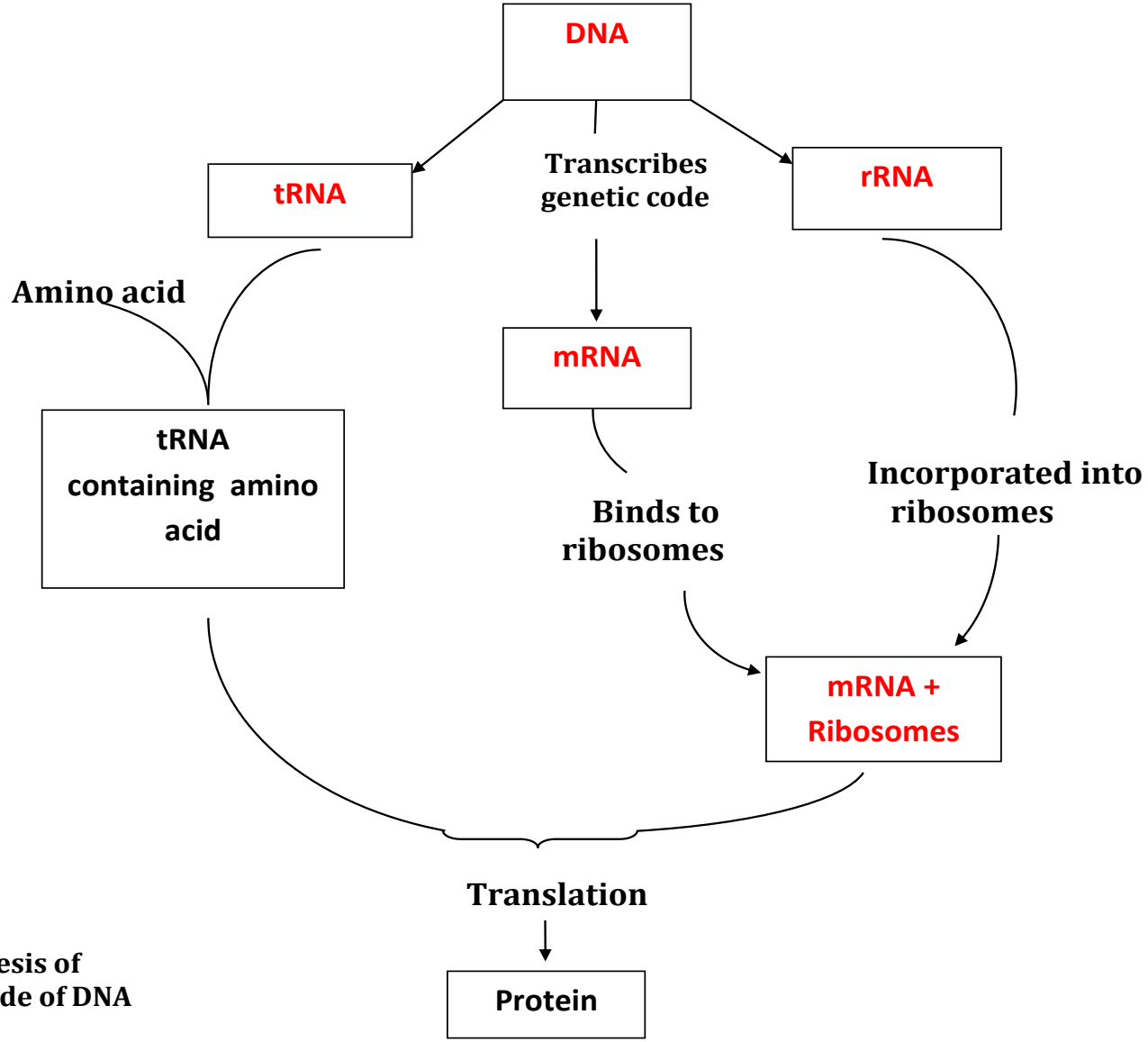


The **central dogma** of molecular biology describes the two-step process, transcription and translation, by which the information in genes flows into proteins:
DNA → RNA → protein.
Transcription is the synthesis of an RNA copy of a segment of DNA.



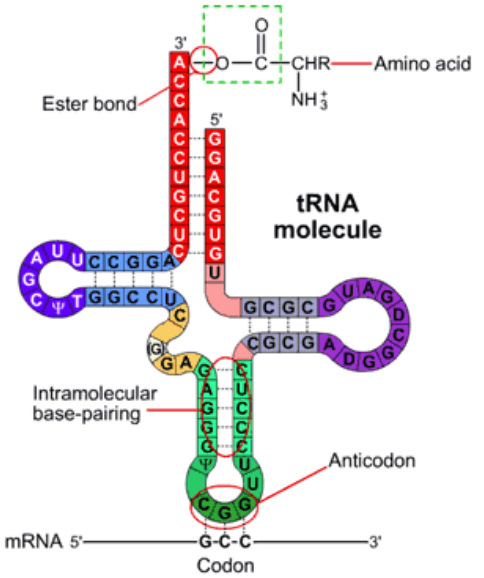
The DNA is used as atemplate to make three kinds of RNA:

messenger RNA (mRNA), transfer RNA (tRNA), and ribosomal RNA (rRNA)



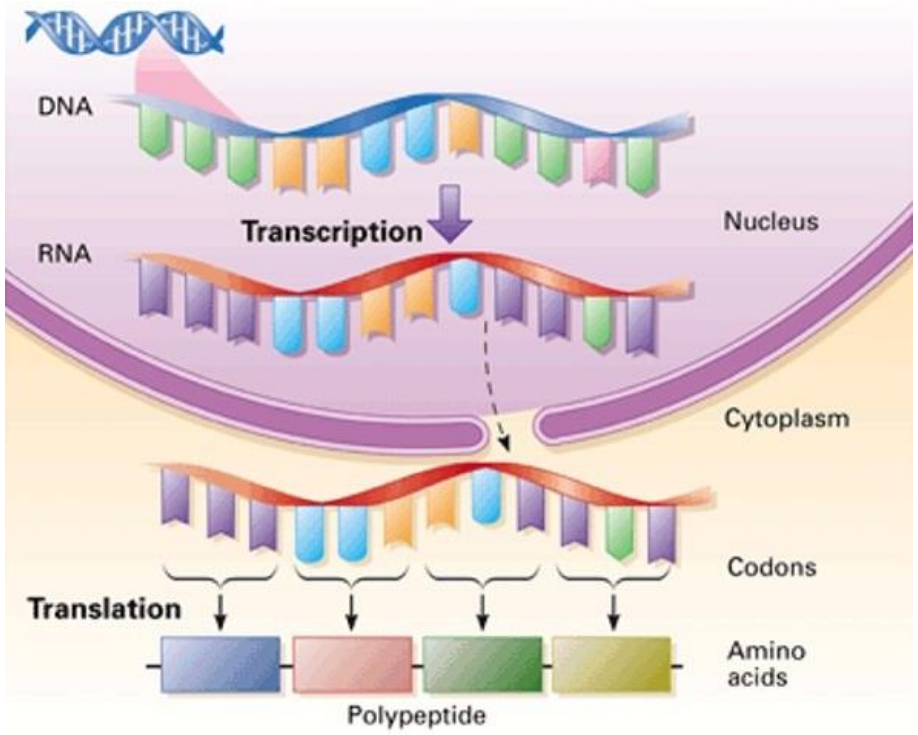
Role of RNA in the synthesis of Proteins from the genetic code of DNA

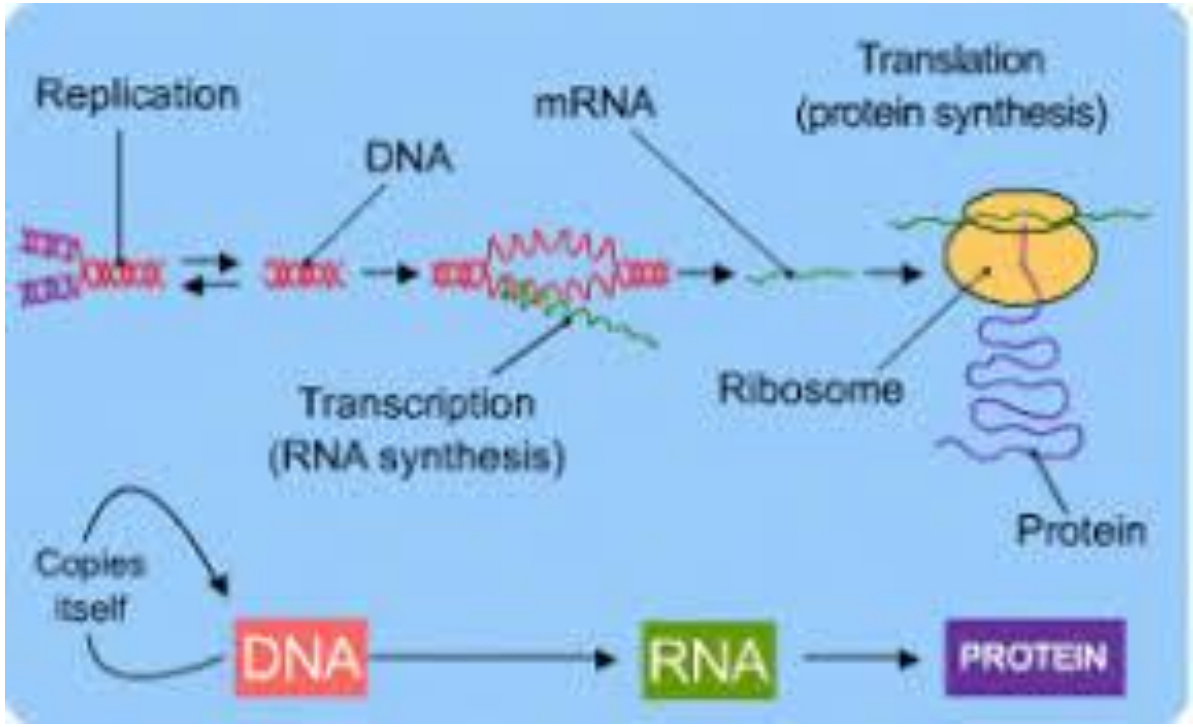
- **The primary function of tRNA is to bring to the ribosomes the amino acids to be incorporated into the protein.**
- **Each of the 20 amino acids is transported by a different tRNA.**
- **All tRNA have a similar shape.**
- **Two parts of tRNA molecule have important biological functions.**
- **The (First) is the site where the specific amino acid is joined (3´ end).**
- **The (Second) part is the loop at the bottom of the molecules.**
- **This loop contains a specific three-base sequence that represents a specific code for the amino acid carried by the tRNA. This three-base region is called (anticodon).**



Translation and the Genetic Code:

The genetic information needed for protein synthesis is transcribed from DNA to mRNA. Translation is the process by which the three-base code in mRNA is turned into a 20-unit code needed to specify the amino acid sequence in proteins. Translation occurs by using a specific sequence of three nucleotide bases on mRNA called (a base triplet or codon).



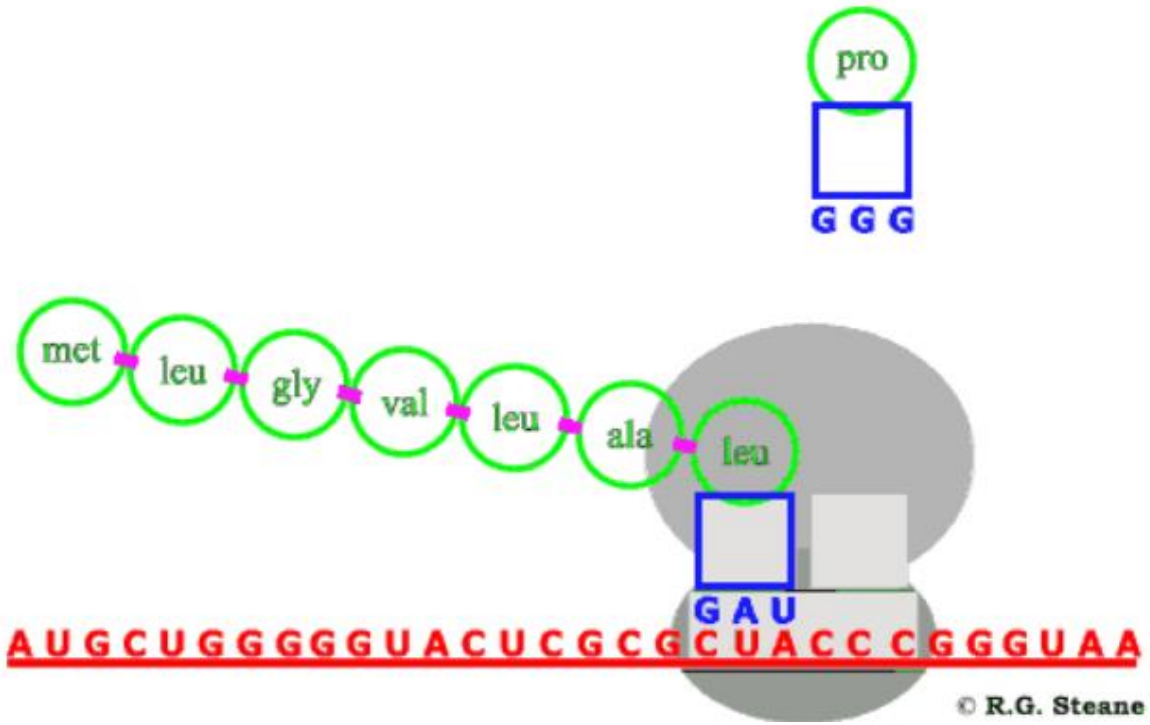


Translation :

1. Edited mRNA attaches to a ribosome

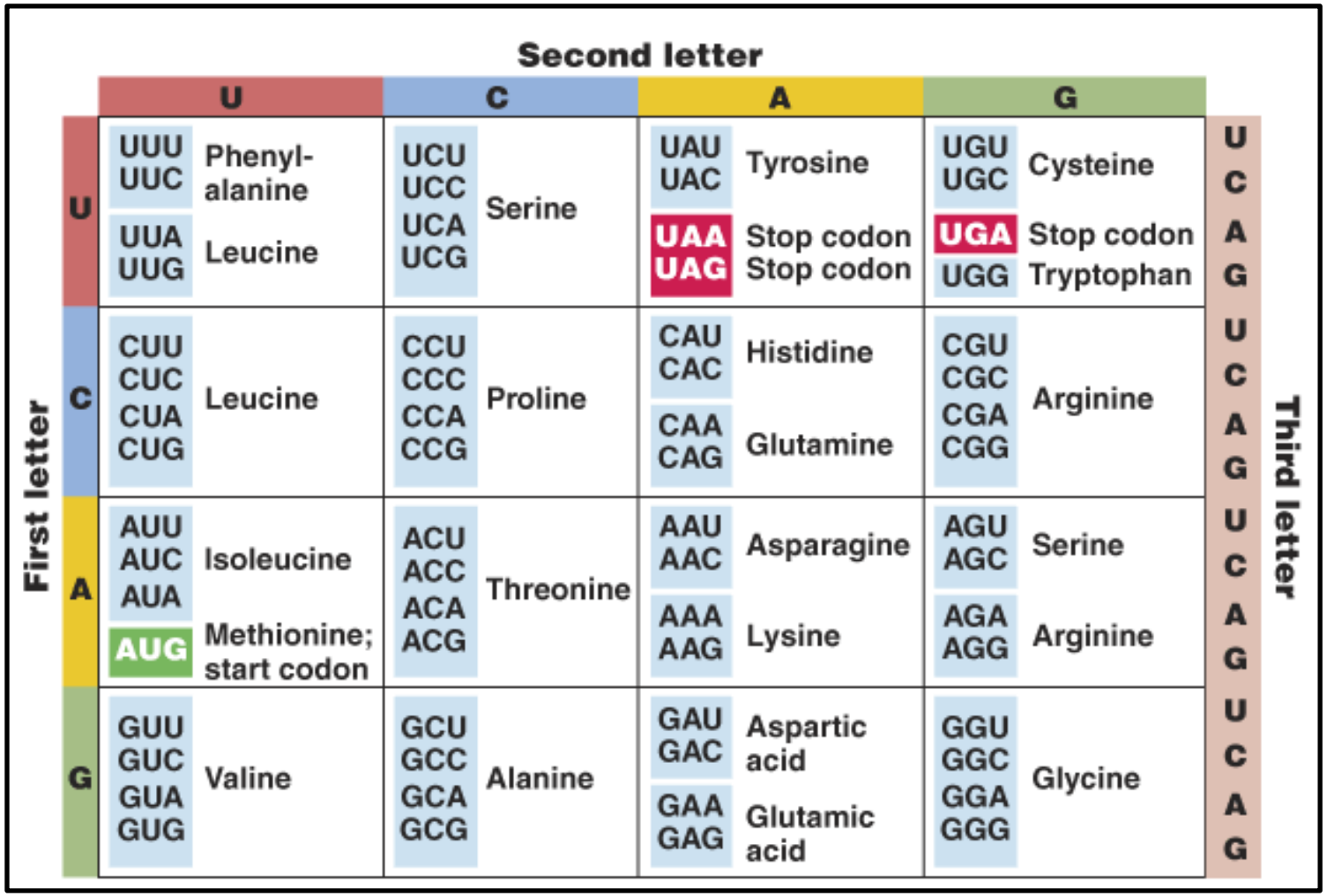
2. As each codon of the mRNA molecule moves through the ribosome, the tRNA brings the proper amino acid to the ribosome. – Notice the anticodon on tRNA – it is complementary to the mRNA codon –

The amino acids are joined together by chemical bonds called peptide bonds to build an amino acid chain called a "polypeptide"

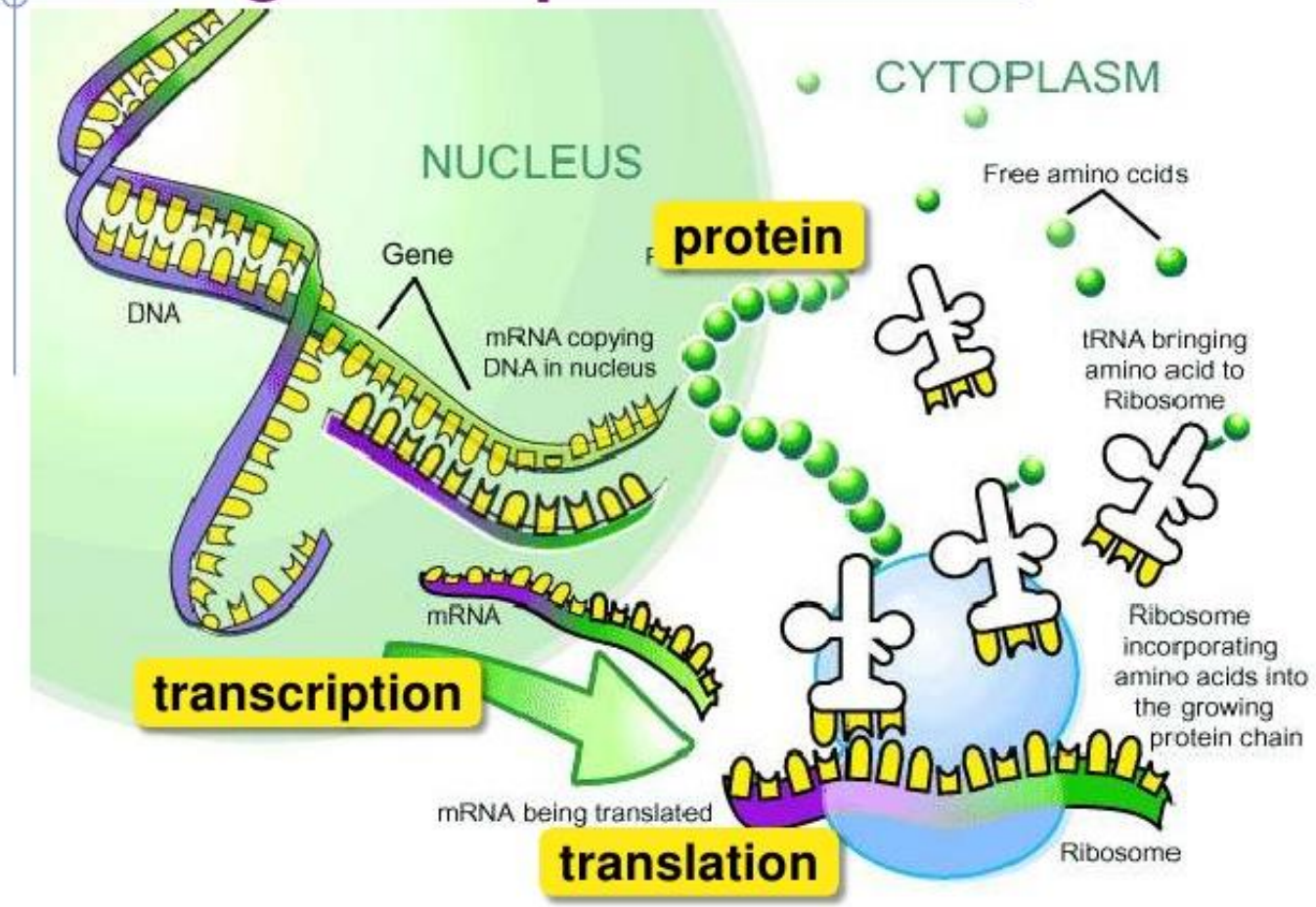


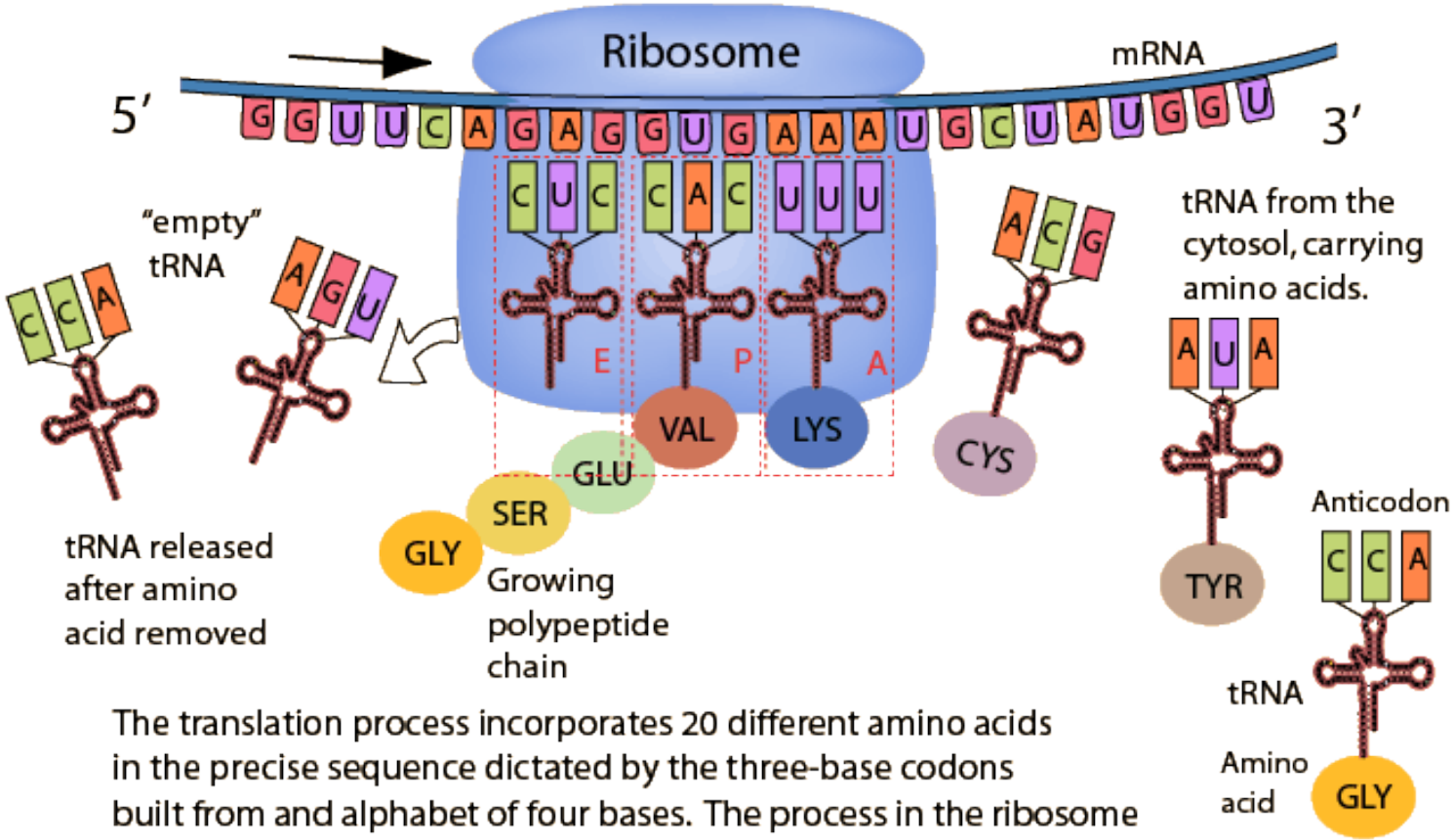
Protein synthesis:

Protein synthesis begins when the codons on an mRNA molecule combine with the complementary bases of the anticodons of tRNA. Molecules of mRNA carry the genetic information from DNA to the ribosomes. When attached to the ribosomes, they direct protein syntheses .The size of an mRNA molecule depends on the size of the protein it is directed to make.



From gene to protein





The translation process incorporates 20 different amino acids in the precise sequence dictated by the three-base codons built from and alphabet of four bases. The process in the ribosome builds the polypeptide chains tha will become proteins.

This sequence of steps continues until one of the three codons UAA, UAG or UGA is reached. These are the stop signals that terminate protein synthesis on the mRNA chain.

Mutations:

A mutation is any chemical or physical change that alters the sequence of bases in a DNA molecule.

* **When the change involves single base in DNA it is called a (point mutation).**
* **Some point mutation may occur spontaneously; others result from ultraviolet light, ionizing radiation, or a variety of chemical compounds. Anything that causes mutation is called a (mutagen).**
* **Point mutation cause the synthesis of proteins with defects in their amino acid sequence.**

Types of point mutation:

1) **Insertion: involves the addition of one or more extra nucleotides besides those already present in a DNA chain.**
2) **Deletion: one or more nucleotides is missing from the normal sequence in DNA. The change in amino acid sequence caused by insertion or deletion occurs during the translation of mRNA.**
3) **Substitution of one base for another.**

Review Questions:

- What is meant by DNA replication?
- What basically occurs in DNA replication?
- What do we call a change in the nucleotide sequence?
- What is RNA primarily responsible for?
- What are two differences chemically between RNA and DNA?
- What are the three types of RNA and their functions?
- What is transcription?
- What brings translation to an end?
- What is translation and when does it begin?