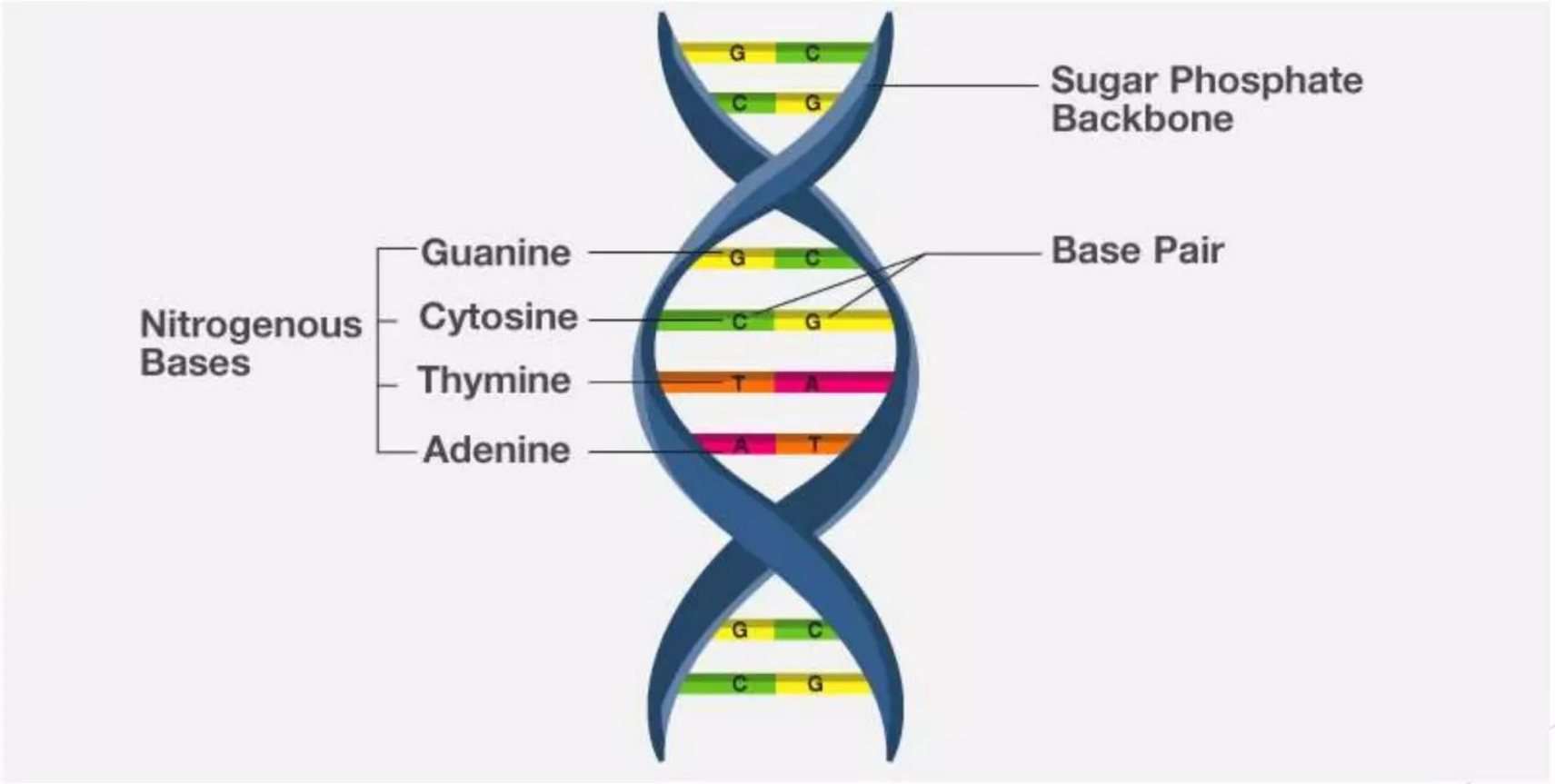
DNA (Deoxyribonucleic Acid)



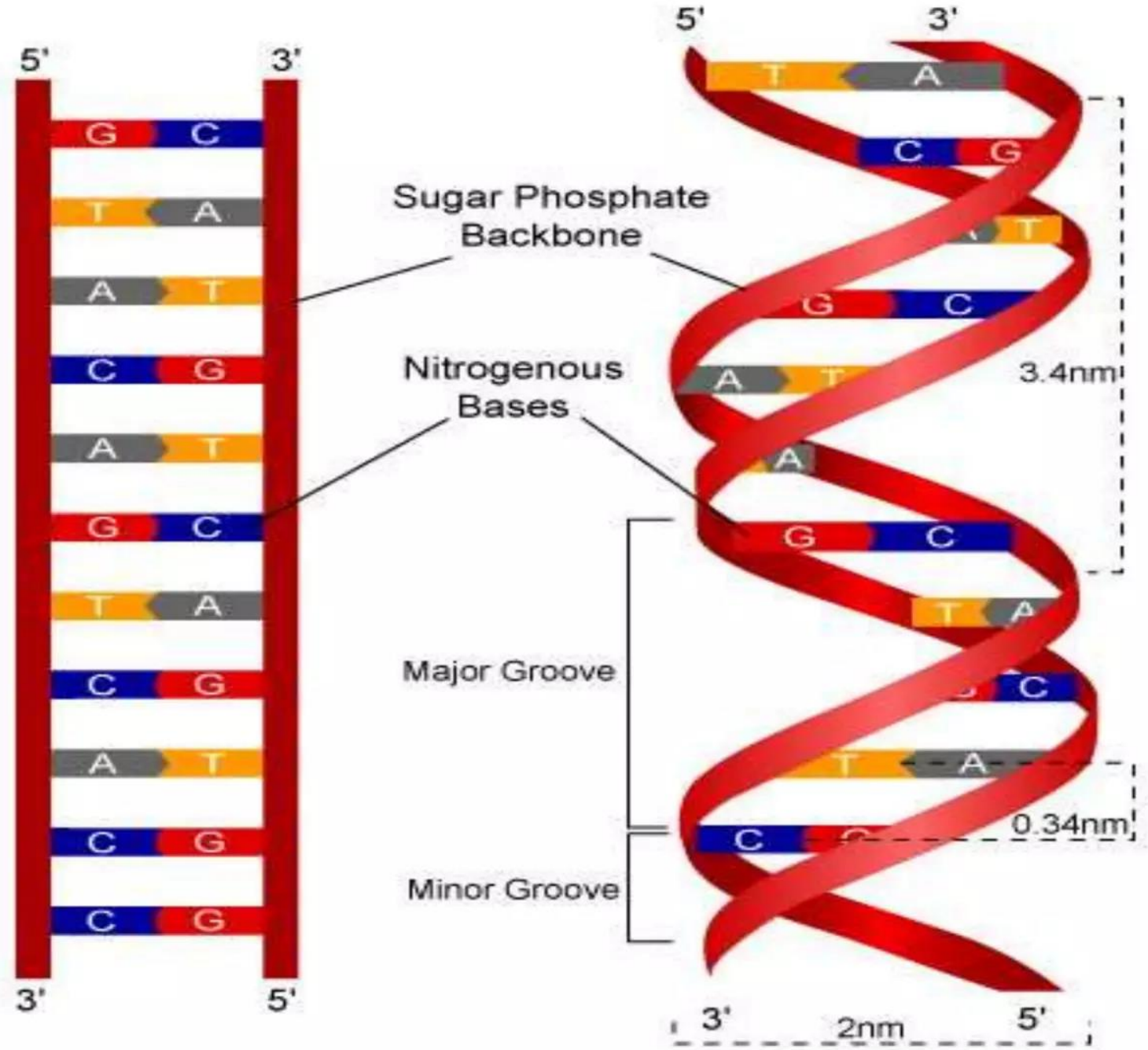
DNA (Deoxyribonucleic Acid)

- James Watson and Francis Crick first proposed the structural model of DNA in 1953.
- They got the Nobel Prize for their work in 1962.
- Proposed Double Helix model for structure of DNA- remarkable proposition was base pairing between two strand of polynucleotide. Comparable to twisted ladder.

NUCLEOTIDES

- Each DNA (and also RNA) strands consists of chain of nucleotides.

- Each nucleotide chain is made up of three main components –
  1. Nitrogenous base – These bases are classified into two types –
     1. Purines – The purines bases are Adenine (A) and Guanine (G).
     2. Pyrimidines – The pyrimidine bases are Thymine (T), Cytosine (C) and Uracil (U) (Uracil takes place of Thymine in RNA).
  2. Deoxyribose Sugar – It is a pentose sugar with 5 carbon atoms
  3. Phosphate molecules


5'
3'
G C
T A
A T
C G
A T
G C
T A
C G
A T
C G
C G
3'
5'
Sugar Phosphate Backbone
Nitrogenous Bases
Major Groove
Minor Groove
3.4nm
0.34nm
2nm
3'
5'

BONDS BETWEEN NUCLEOTIDES

- The two nucleotides chain of DNA are held together by two types of molecular forces.

Hydrogen Bonds

- These are formed between the nitrogenous bases on opposite nucleotide strands.
- They are always between a purines and pyrimidine nitrogenous base only.
- Adenine base on one strand always pairs with thymine on the other strand (A-T or T-A)
- Guanine base on one strand pairs with cytosine on the other hand. (G-C or C-G)

PHOSPHATE DIESTER BONDS

- These bonds are between sugar molecules

CLASSIFICATION OF DNA

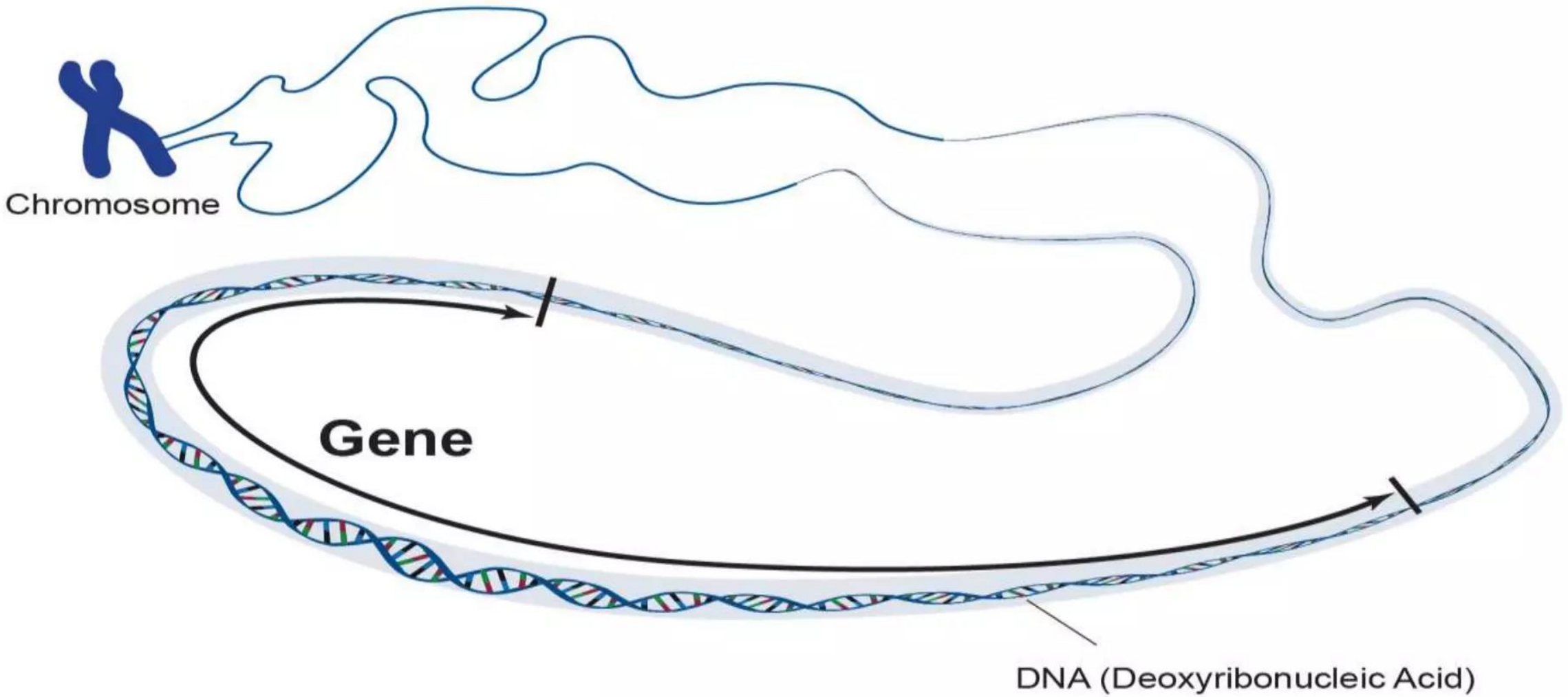
- Depending on the types of DNA Sequence

1. Single copy DNA Sequence – In this type nucleotide sequences are present only once without any repetition of nucleotide. They account for 50-60 % of human DNA.
2. Moderately repetitive DNA Sequence – In these the nucleotide sequences are repeated many times and constitute about 25-40 % of human DNA. Most of them have no function.
3. High repetitive DNA Sequences – It is characterized by repetition of nucleotides several times (Hundreds to millions). These are non coding sequences and constitute about 10-15% of Human DNA.

FUNCTION OF DNA

- It is the genetic material, therefore responsible for carrying all the hereditary information.
- It has property of replication essential for passing genetic information from one cell to its daughters or from one generation to next.
- Crossing over produces recombination
- Changes in sequence and no. of nucleotides causes Mutation which is responsible for all variations and formation of new species.
- It controls all the metabolic reaction of cells through RNAs and RNA directed synthesis of proteins.

GENE



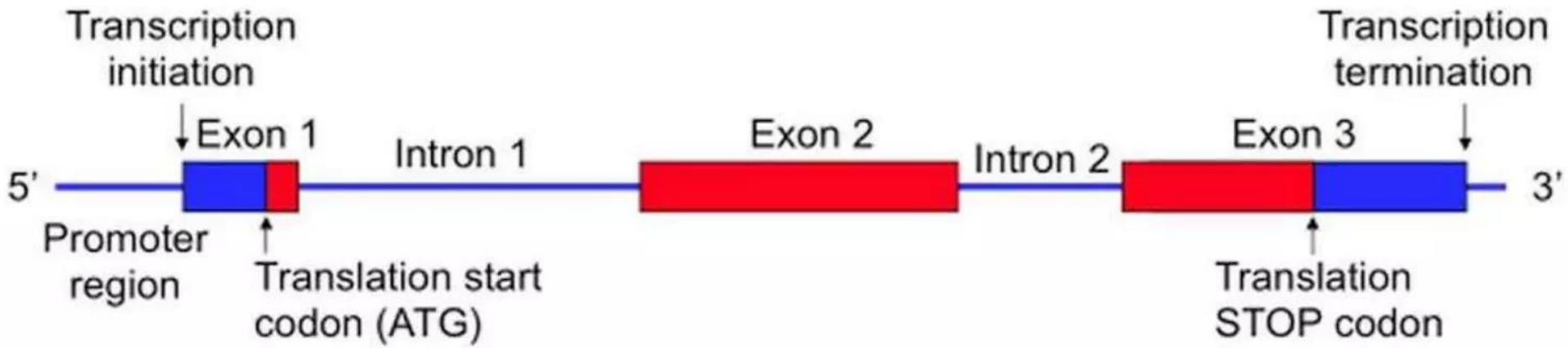
GENE

- The gene is the Functional unit of Heredity.
- Each gene is a segment of DNA that give rise to a protein product or RNA.
- A gene may exist in alternative forms called alleles.
- Chromosome in fact carry genes.
- Each chromosome consists of a linear array of genes.

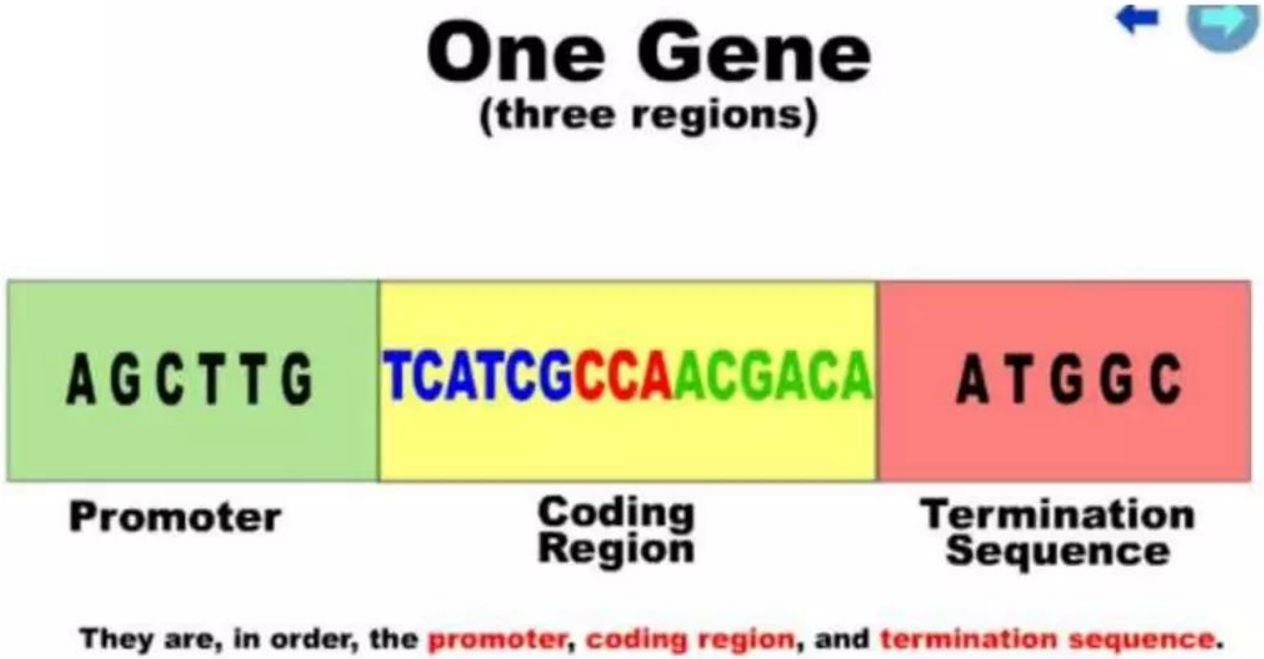
GENE STRUCTURE

- Each gene consist of a specific sequence of nucleotides.
- Gene may be silent or active.
- When active the genes direct the process of protein synthesis.
- Genes do not code for proteins directly but my means of genetic code.
- The genetic code consists of a sequence codeword called codons.
- A codon for an amino acid consists of a sequence of three nucleotides base pairs called triplet codon

Gene Structure



REGION OF GENE



INITIATOR AND STOP CODONS

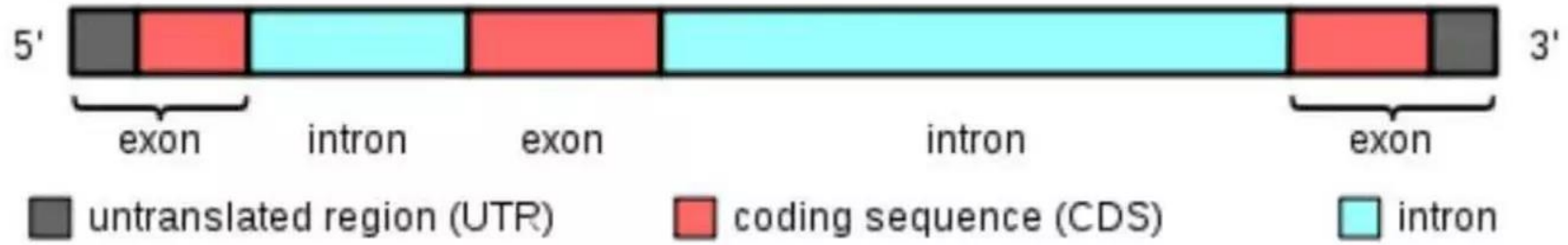
- The boundaries of a gene is known are known as start and stop codons.
- The start codons tells when to begin protein production and stop (termination) codons tells when to end the protein production.

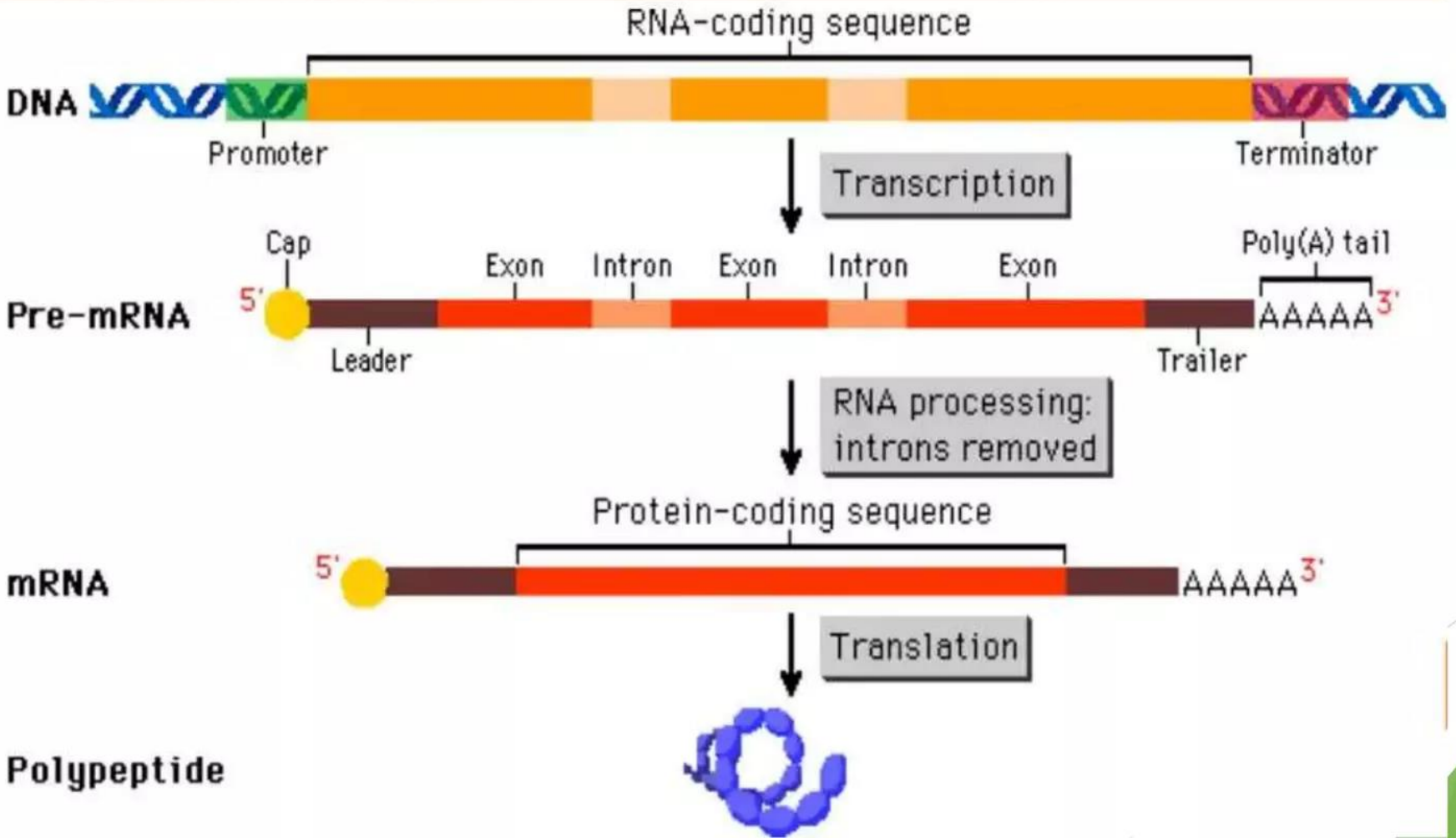
CODING REGION

- The nucleotide sequence between the start and stop codons is the core region known as coding region.
- This region is divided in to two main segment namely exons and introns.

- Exon – This region codes for producing a protein
- Introns – These are the regions between exons and do not code for a protein. (Non coding region)

Eukaryotic gene.

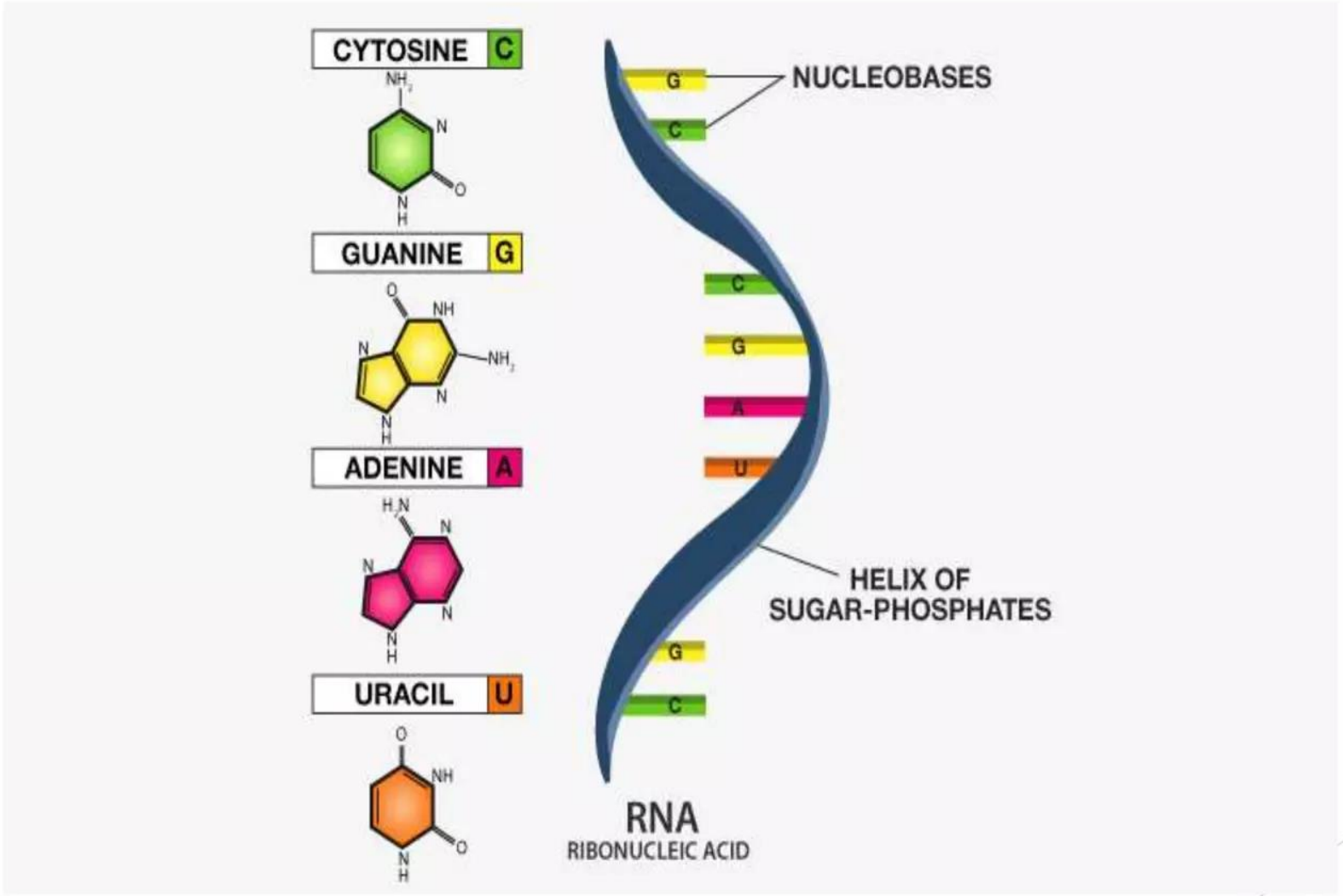




REGULATORY REGION

- These are also non coding regions which control gene expression.
- Promoters – These are the regions which bind to transcription factors either strongly or weakly.
- Enhancers – These are the regions which can enhance the effect of weak promoter.
- Silencers – These are the regulatory regions that can inhibit transcription.

RNA


CYTOSINE C
GUANINE G
ADENINE A
URACIL U
NUCLEOBASES
HELIX OF SUGAR-PHOSPHATES
RNA
RIBONUCLEIC ACID

RNA

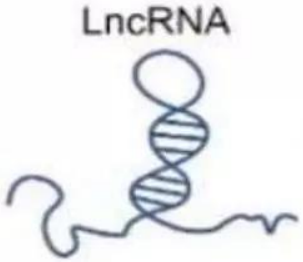
- The RNA is chiefly presents within the ribosomes and nucleolus.
- RNA differs from DNA in three main ways:
  - RNA is single stranded
  - The sugar residue within the nucleotide is ribose rather than Deoxyribose.
  - Specific pyrimidine base Uracil is used in place of Thymine.

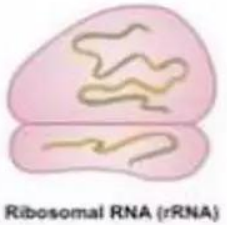
Types of RNA

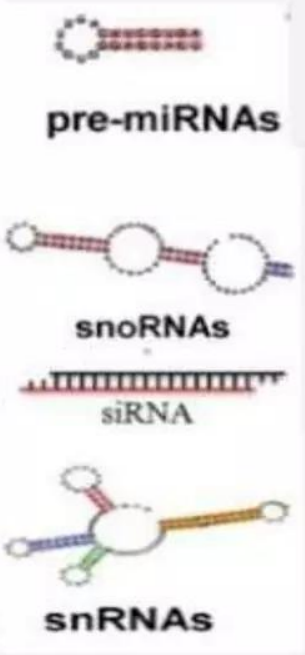
- The two major types of RNA are :
- Coding RNA (m-RNA)
- Non Coding RNA (nc-RNA)

TYPES OF RNA

- RNA
  - mRNA (messenger RNA)
    - housekeeping ncRNA
      - tRNA (transfer RNA)
      - rRNA (ribosomal RNA)
  - ncRNA (non-coding RNA)
    - regulatory ncRNA
      - ≥ 200 nucleotides
        - lncRNA (long non-coding RNA)
      - < 200 nucleotides
        - small ncRNA
          - microRNA (19 to 22 nucleotides)
          - snoRNA (small nucleolar RNA)
          - siRNA (small interfering RNA)
          - snRNA (small nuclear RNA)
          - piRNA (PIWI-interacting RNA)







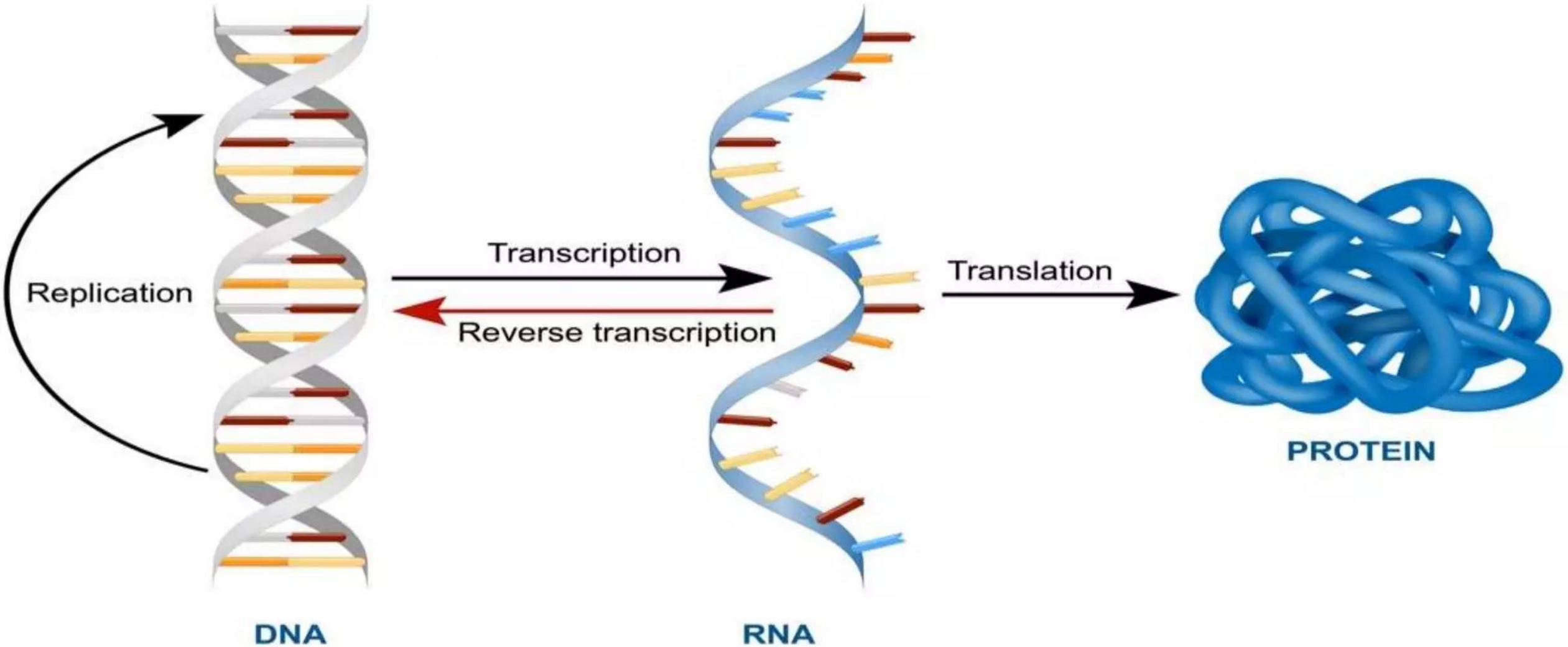
m- RNA

- m-RNA contains a coding RNA Sequence. It carries the message from the DNA to the ribosomes in the cytoplasm required for protein synthesis.
- It contains both exons and introns similar to DNA.
- During protein synthesis the introns (non coding sequences) are cut and removed resulting in smaller m-RNA.

NON Coding RNA

- These do not code for proteins.
- Transfer RNA – It conveys the message carried by the m-RNA to the ribosomes.
- Ribosomal RNA (r-RNA) – They play a significant role in the binding of m-RNA to ribosomes and protein synthesis.
- Micro-RNA (mi-RNA) – The miRNA play a role in normal development.

PROTEIN SYNTHESIS



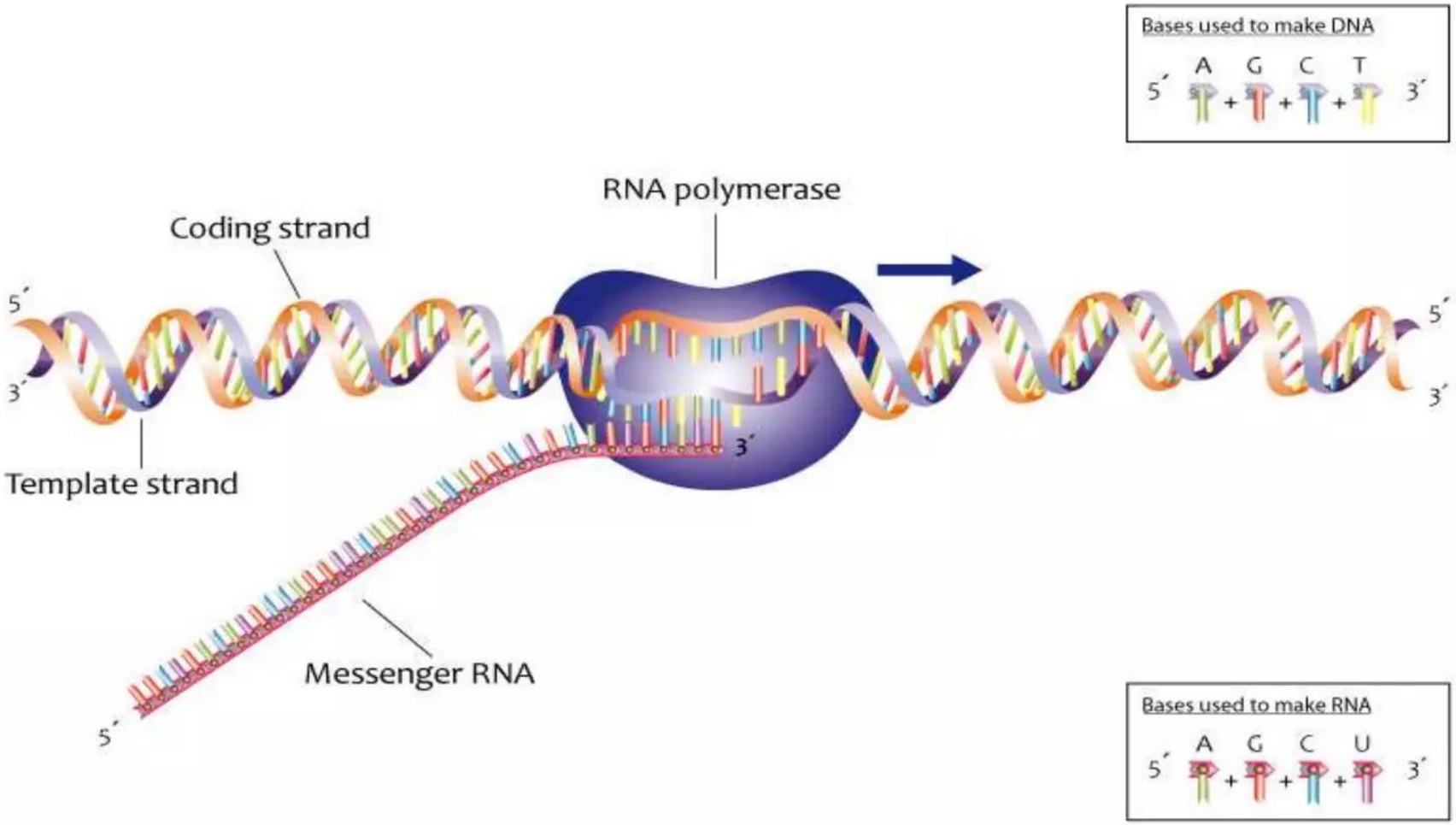
STEPS IN PROTEIN SYNTHESIS

- Several steps are involved in the synthesis of protein.
- The genetic information in cells flows in one way:

- DNA Specifies the synthesis of RNA
- RNA Specifies the synthesis of Amino Acids.
- The two main steps in protein synthesis are transcription and translation.

TRANSCRIPTION

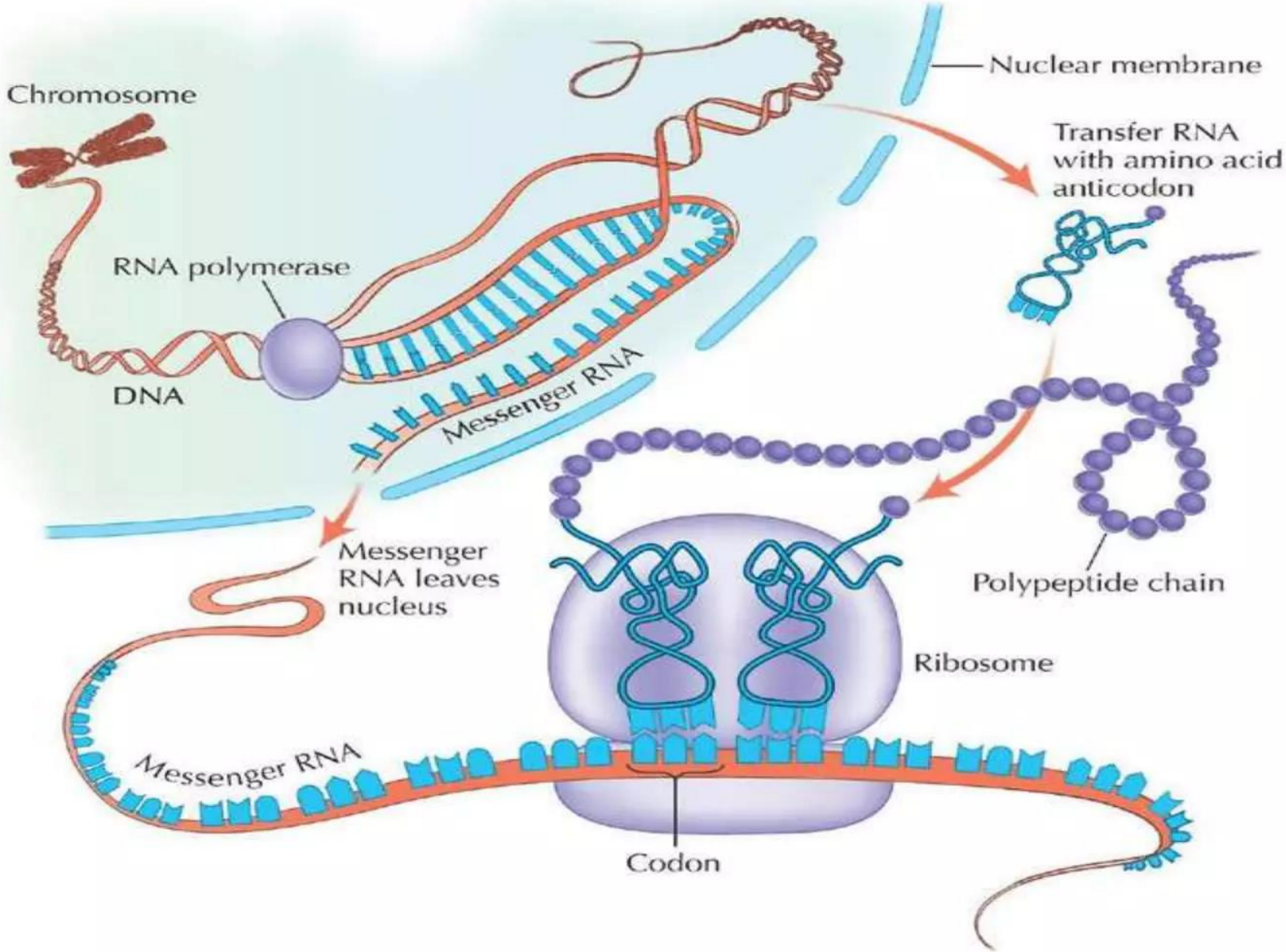
- Transcription is a process in which genetic information is transmitted from DNA to RNA .
- It is the first step in protein synthesis and occurs in the nucleus.
- When the genes are active, proteins called transcription factors are produced.
- These transcription factors binds to promoter or enhancer region of genes
- Transfer of the genetic information from DNA –dependent RNA polymerase **(Transcriptase)**
- It produces a new complimentary copy of the whole gene and is known as primary RNA molecule.
- The primary RNA molecule undergoes splicing in which introns are removed from exons, to produce single-stranded messenger ribonucleic acid (mRNA) molecule.
- The mRNA migrates from the nucleus to the cytoplasm and is used as a template for protein synthesis.


Bases used to make DNA
5´ A G C T 3´
RNA polymerase
Coding strand
5´
3´
3´
5´
3´
Template strand
Messenger RNA
5´
Bases used to make RNA
5´ A G C U 3´

TRANSLATION

- Translation is the transmission of the genetic information from mRNA to form protein.
- In the cytoplasm, mRNA to form protein.
- In the cytoplasm, mRNA attaches to ribosomes, which is the site of protein production.
- During translation, smaller RNA molecules known as transfer RNA (tRNA) bind to the ribosome.
- The tRNA deliver amino acid to the ribosomes and synthesizes a linear chain of amino acids called a polypeptide (primary protein) and later forms proteins.

Translation and Proteins



DNA

↓

RNA

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PROTEIN