Nucleic Acids Structure and Function

The learning objectives

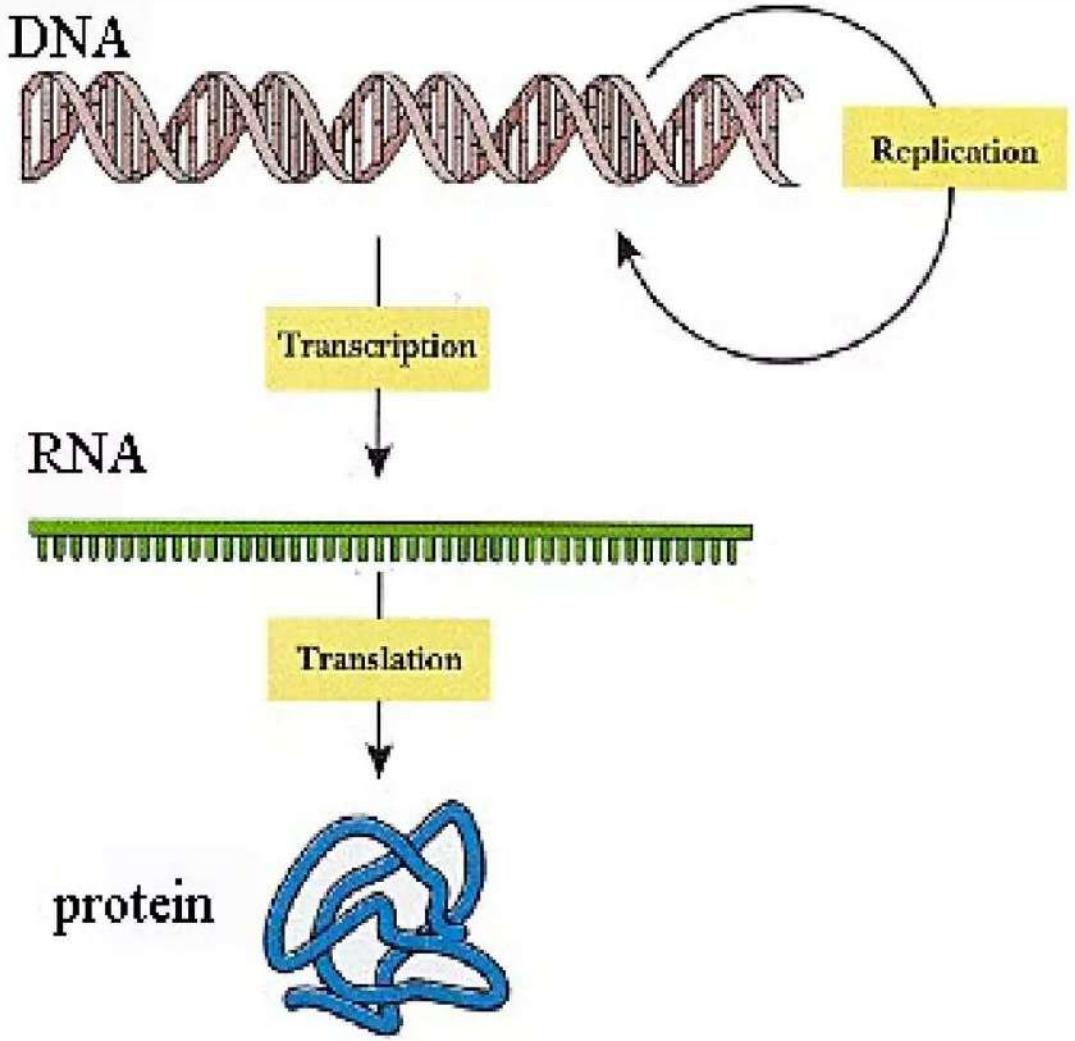
By the end of this session the student should be able to:

1. Outline the molecular structure of DNA and RNA.
2. Explain the significance of specific base pairing.
3. Define the main properties of DNA.
4. Define the central dogma of molecular biology.
5. Distinguish between single- stranded and double-stranded nucleic acids.
6. Explain the meaning of denaturation and re-annealing of DNA.

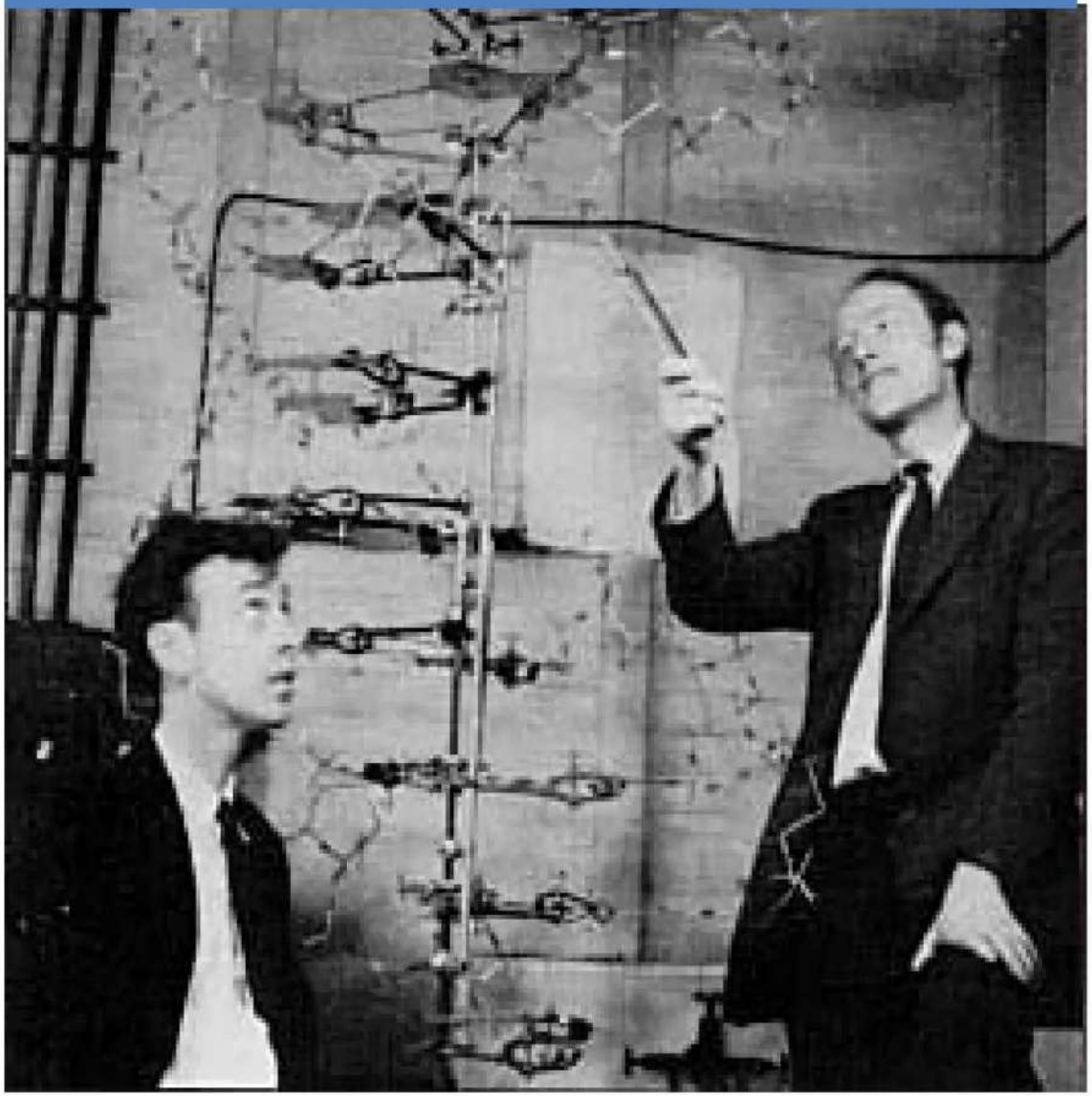
The deoxyribonucleic acid (DNA)

- DNA: is the **store** of the genetic information.
- It is the principal **regulator** of the cell physiology.
- DNA contains the instructions for creation and functioning of the organism, it acts as;
  - ✓ Template for replication.
  - ✓ Codes for proteins.

The central dogma of molecular biology



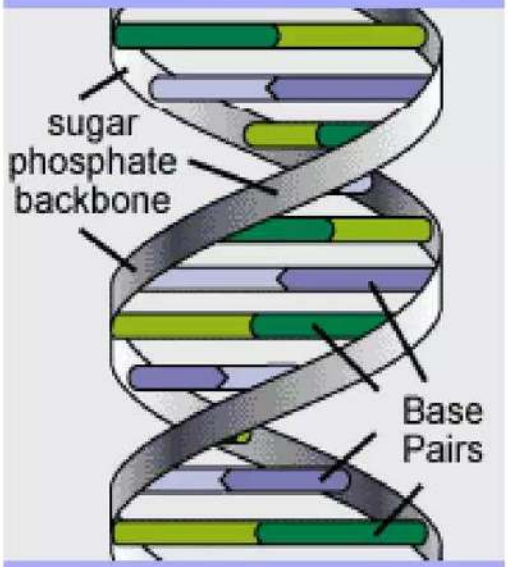
The Watson-Crick structure of DNA



The Watson-Crick structure of DNA

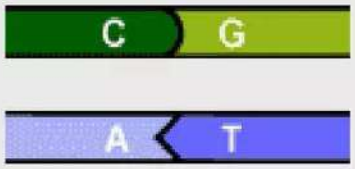
1. It is a **double-stranded** right-handed helix.
2. Each strand is is a polymer of 2-deoxyribonucleotides linked by 3'-5'phosphodiester links.
3. The nitrogenous bases in the nucleotides of DNA are A,G,C,T.
4. The bases in the two complementary strands are **specifically paired** and held together by hydrogen bonds.

The DNA molecule consists of two ribbon-like strands that wrap around each other resembling a twisted ladder.



The rungs of the ladder are Nucleotide Base Pairs that always combine in this way:

C with G and **A with T**



The Watson-Crick structure of DNA

5. The two strands are **polar** and **anti-parallel** .

6. The bases are **planner** and **perpendicular** to the axis of the DNA molecules.

7. The width of the DNA molecules is 2 nm (20 A°), and the height of the helical turn is 3.4 nm (34 A°).

8. The genetic information resides in the sequence of bases in the DNA strands.

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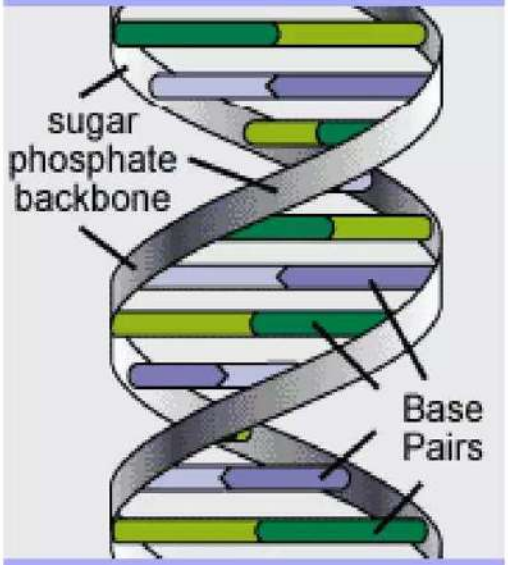

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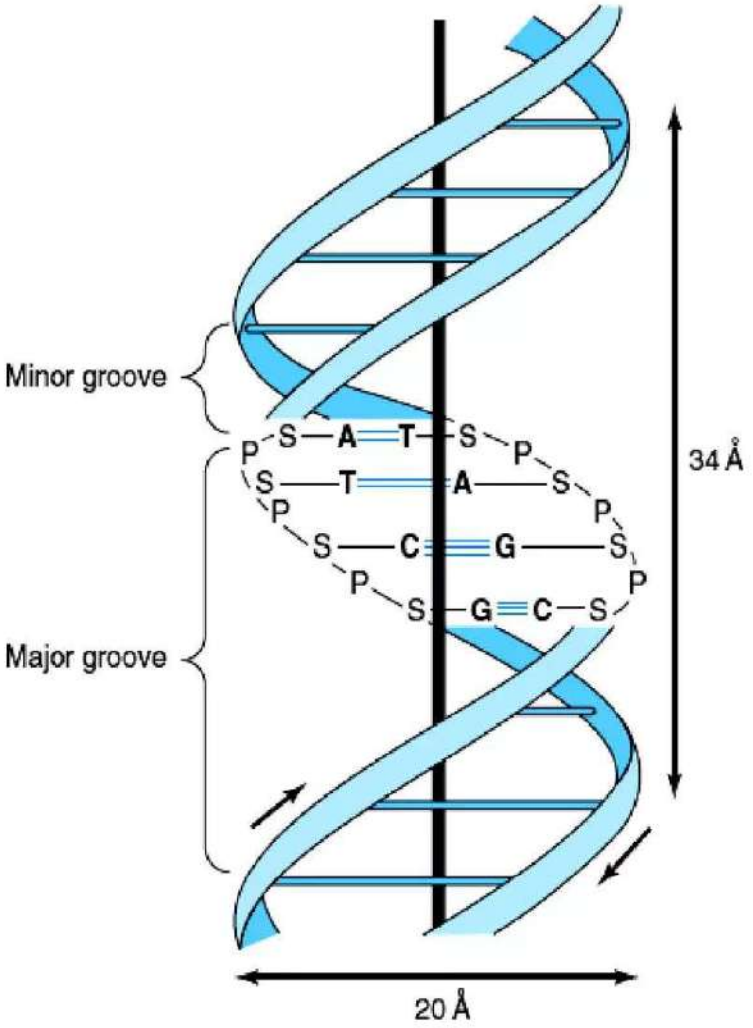
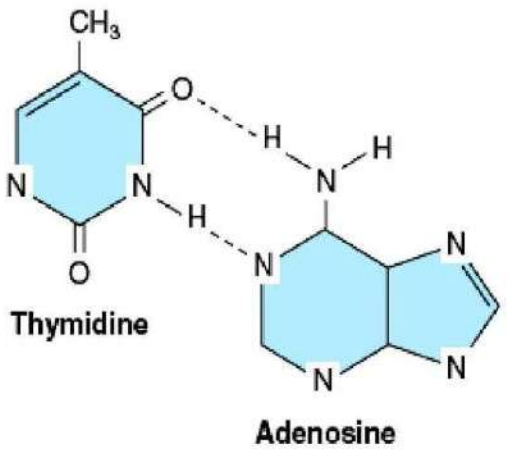
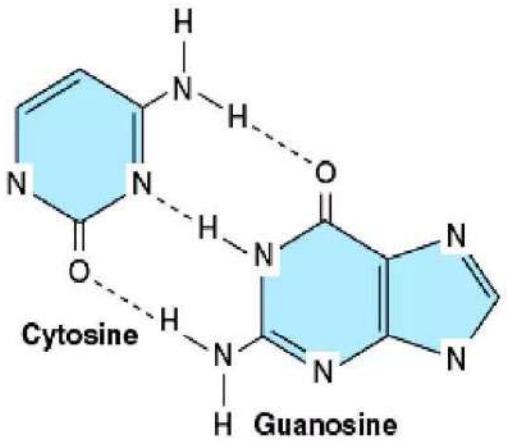
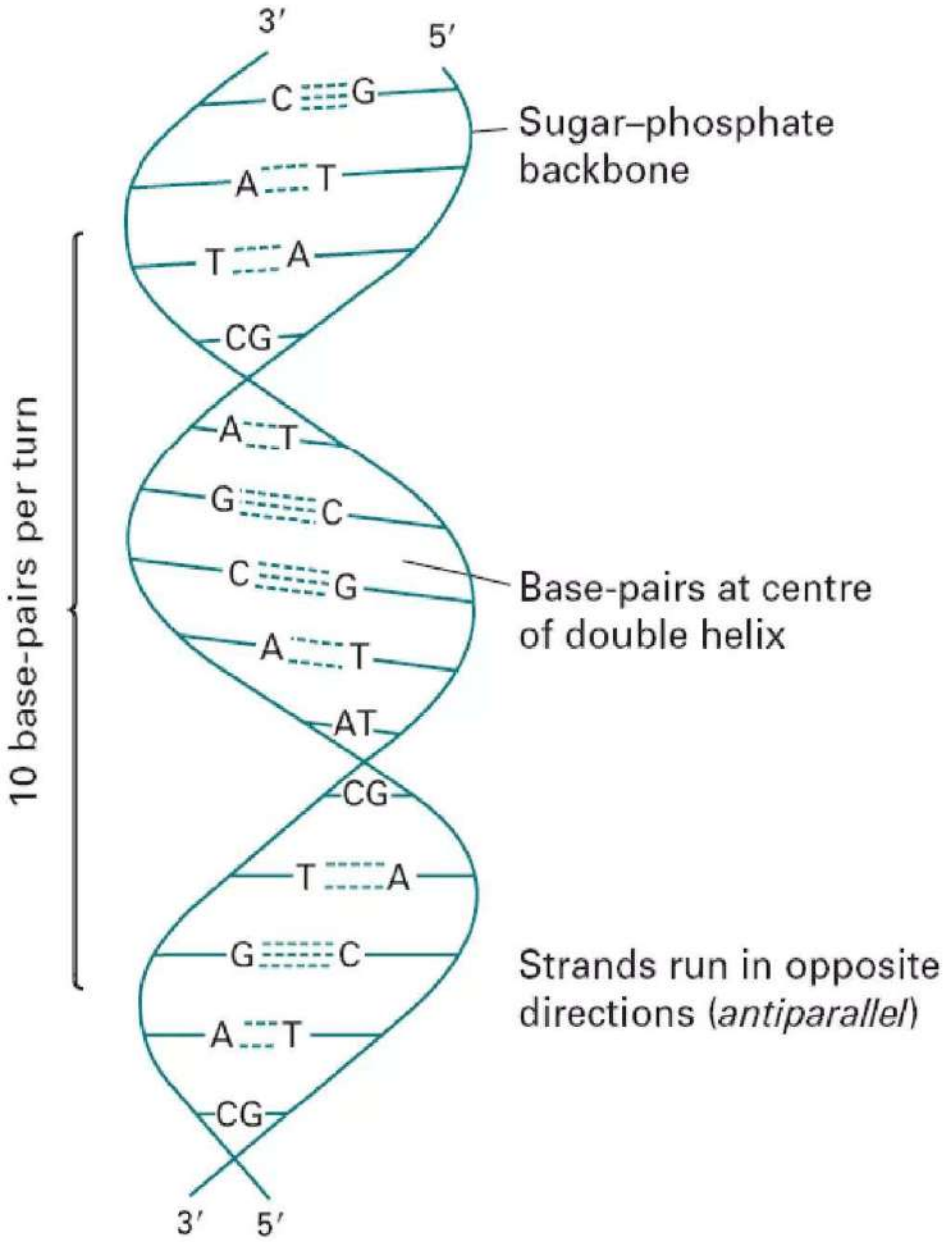
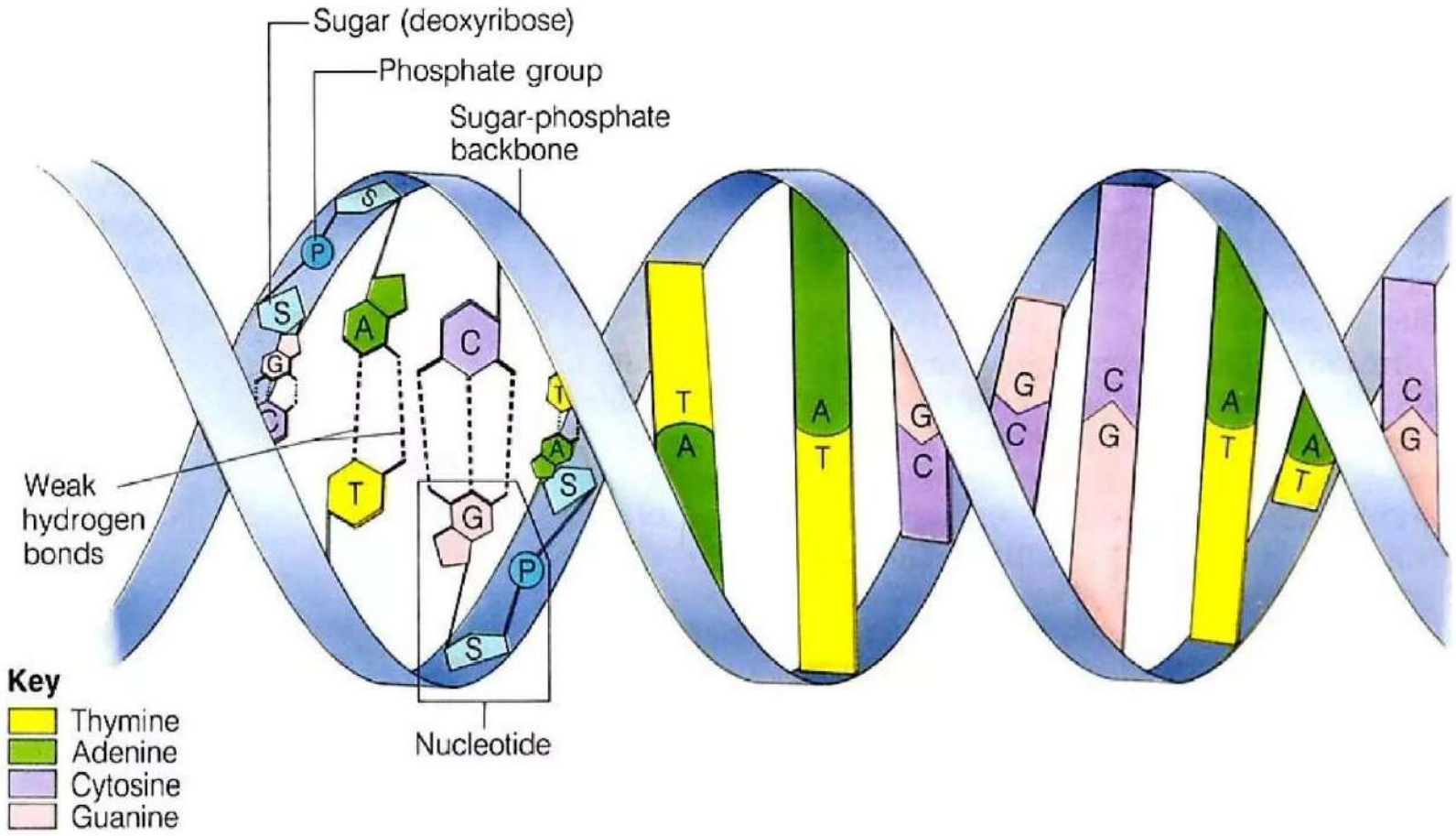




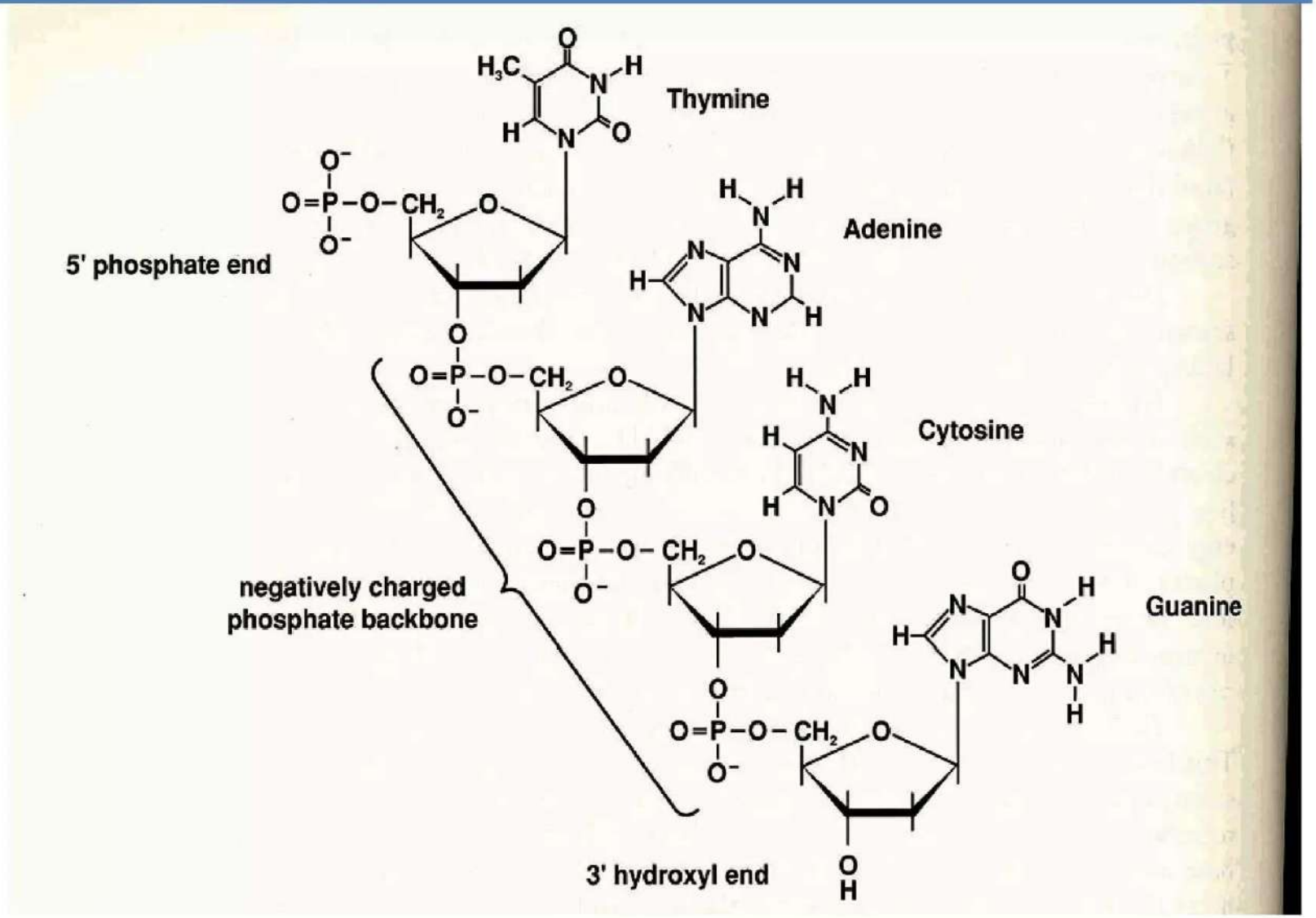



3′
5′
C
G
A
T
T
A
CG
A
T
G
C
C
G
A
T
AT
CG
T
A
G
C
A
T
CG
3′
5′
Sugar–phosphate backbone
Base-pairs at centre of double helix
Strands run in opposite directions (*antiparallel*)
10 base-pairs per turn

The Watson-Crick structure of DNA

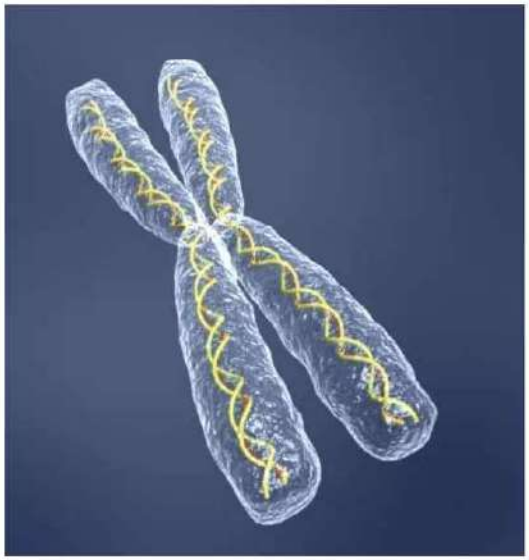


The Watson-Crick structure of DNA



The structure of DNA

- DNA exists as circular molecule in some organisms such as bacteria, bacteriophages, and many DNA-containing animal viruses.

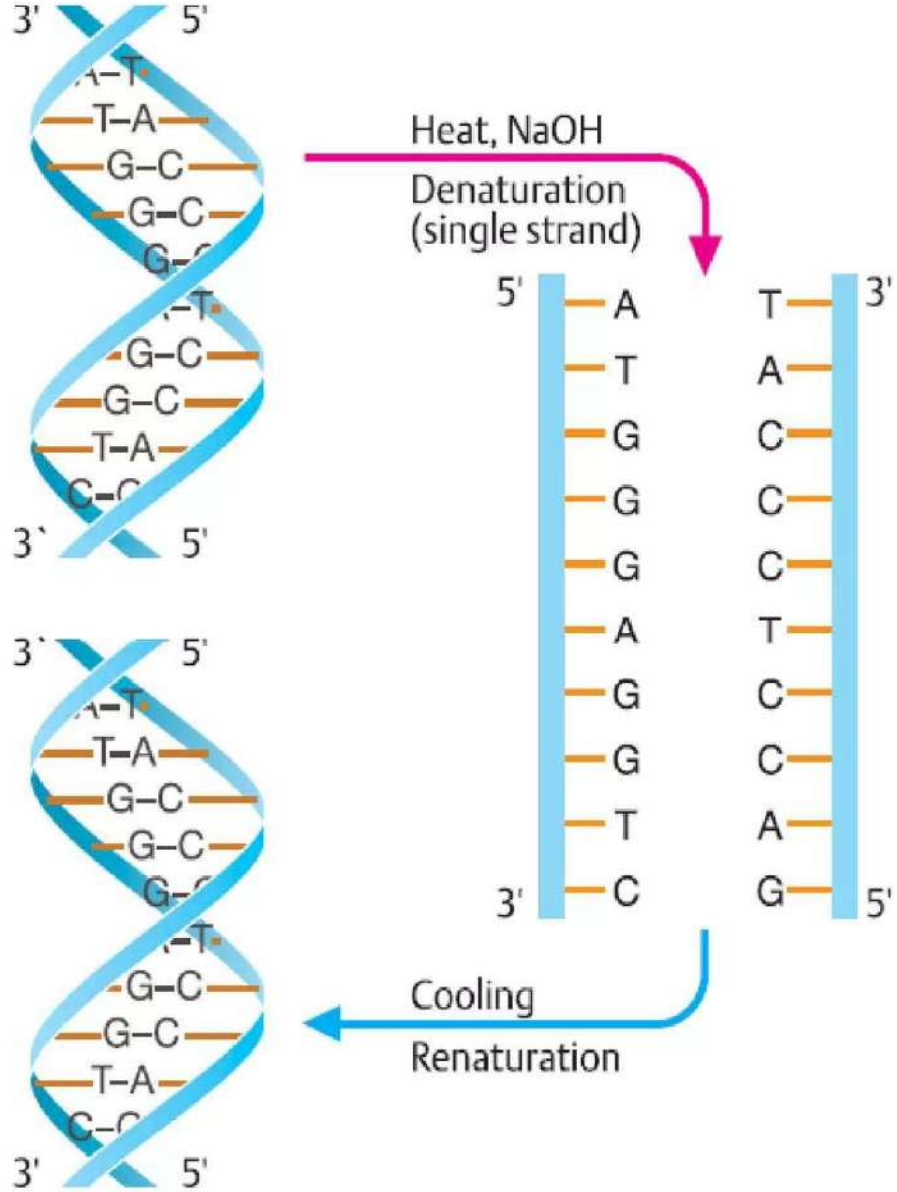


Chromosome (DNA) of eukaryotic

Circular DNA molecule of bacteria

DNA denaturation of

Denaturation is the melting of double stranded DNA to generate two single strands.



C. Denaturation and renaturation

The denaturation of DNA

- **Denaturation** may result from:
  - Heating above its T*m*.
  - High pH
  - Organic solvents (dimethyl sulfoxide).
  - Lowering the salt conc. of the DNA solution

- **Viscosity** of DNA solutions decreases on denaturation.

- **Hyperchromicity** (increased absorbance of UV on denaturation)

The Reannealing of DNA

- **Reannealing** is the reformation of the double stranded DNA.
- **Viscosity** of DNA solutions increases on reannealing.
- **Hyporchromicity** (decreased absorbance of UV on reannealing)

The RNA structure differs from that of DNA

- The RNAs are polymers of ribonucleotides linked together by 3'-5' phosphodiester bonds.

- RNAs share many structural features with DNA but have some specific characteristics, these are:
  - it is usually single rather than double stranded
  - it contains ribose rather than deoxyribose
  - it contains the base uracil rather than thymine

The types of RNA

1. Messenger RNAs (mRNAs).
2. Transfer RNAs (tRNAs).
3. Ribosomal RNAs (rRNAs).

Prokaryotes and eukaryotes

4. small nuclear RNA (snRNA).
5. microRNA (miRNA).
6. small interfering RNA (siRNA)

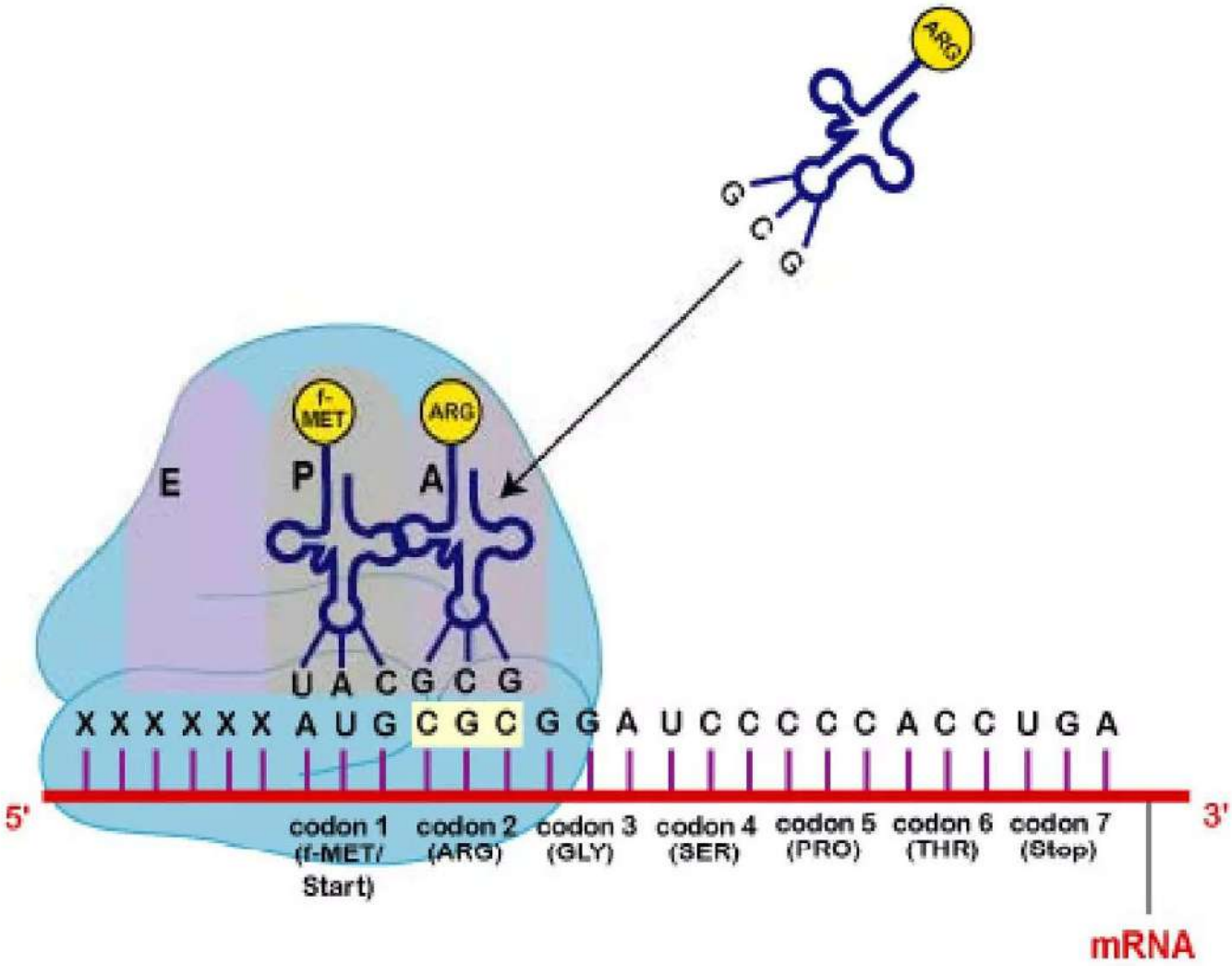
Only in eukaryotes

The Roles of Different Kinds of RNA		
RNA Type	**Size**	**Function**
Transfer RNA	Small	Transports amino acids to site of protein synthesis
Ribosomal RNA	Several kinds—variable in size	Combines with proteins to form ribosomes, the site of protein synthesis
Messenger RNA	Variable	Directs amino acid sequence of proteins
Small nuclear RNA	Small	Processes initial mRNA to its mature form in eukaryotes
Small interfering RNA	Small	Affects gene expression; used by scientists to knock out a gene being studied
Micro RNA	Small	Affects gene expression; important in growth and development

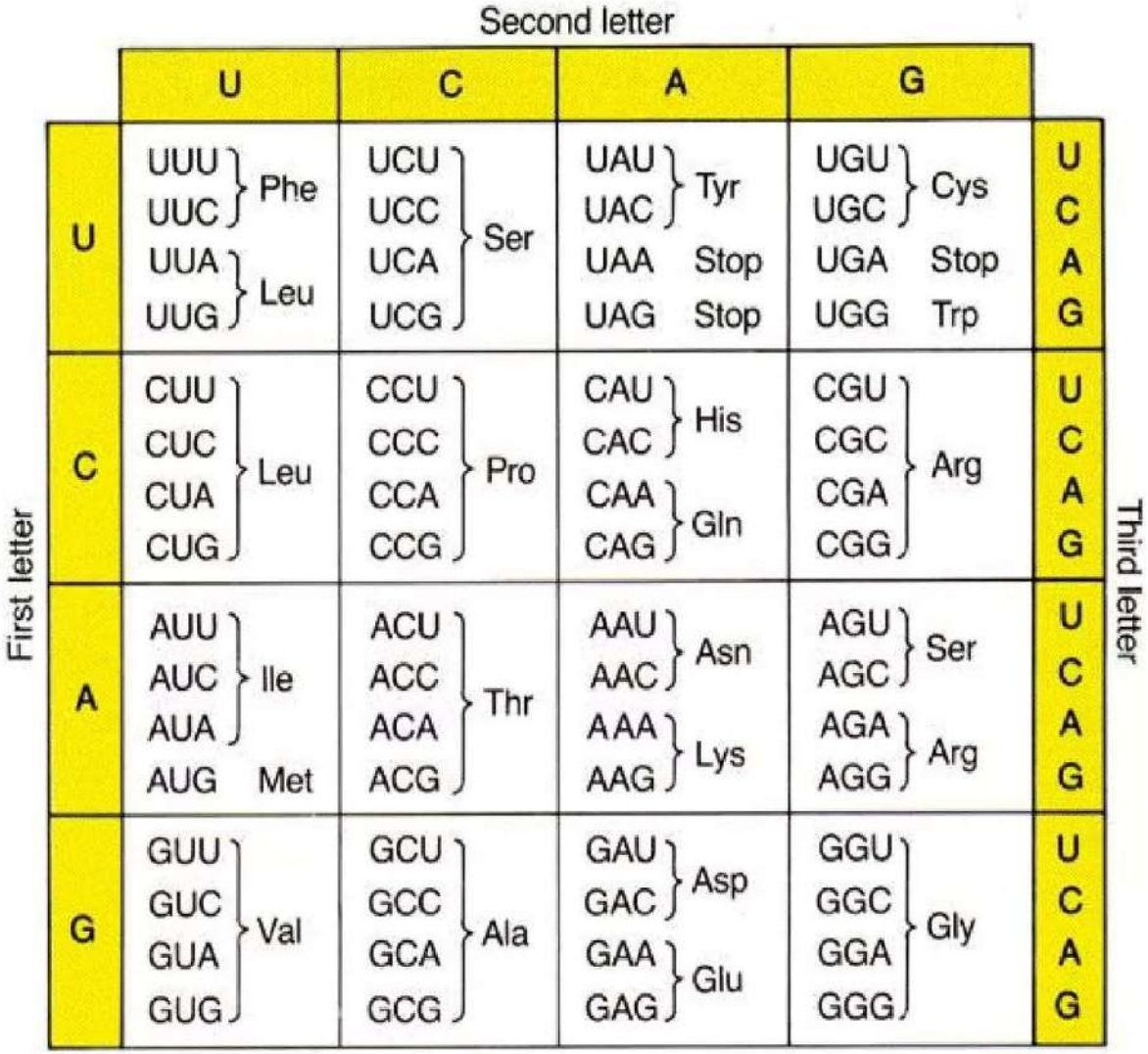
The messenger RNA (mRNA)

- Heterogeneous in size and stability.
- Carries the **codons** specifying amino acid sequences in proteins
- Act as **templates** for protein synthesis.

The messenger RNA (mRNA)



The table of genetic code

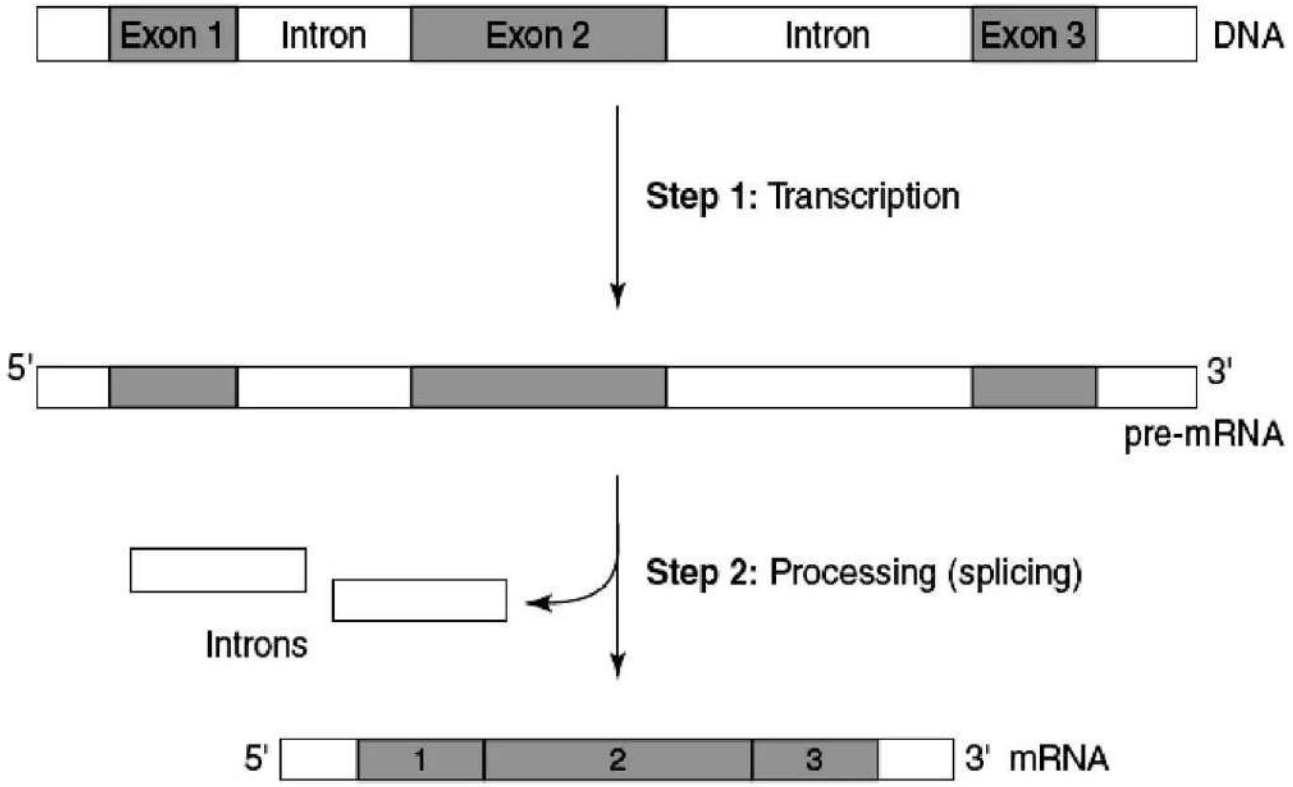


Eukaryotic mRNAs have several unique properties

1. The 5'-terminal is capped by 7-methylguanosine triphosphate.

2. Has poly(A) “tail” in the 3'-terminals.

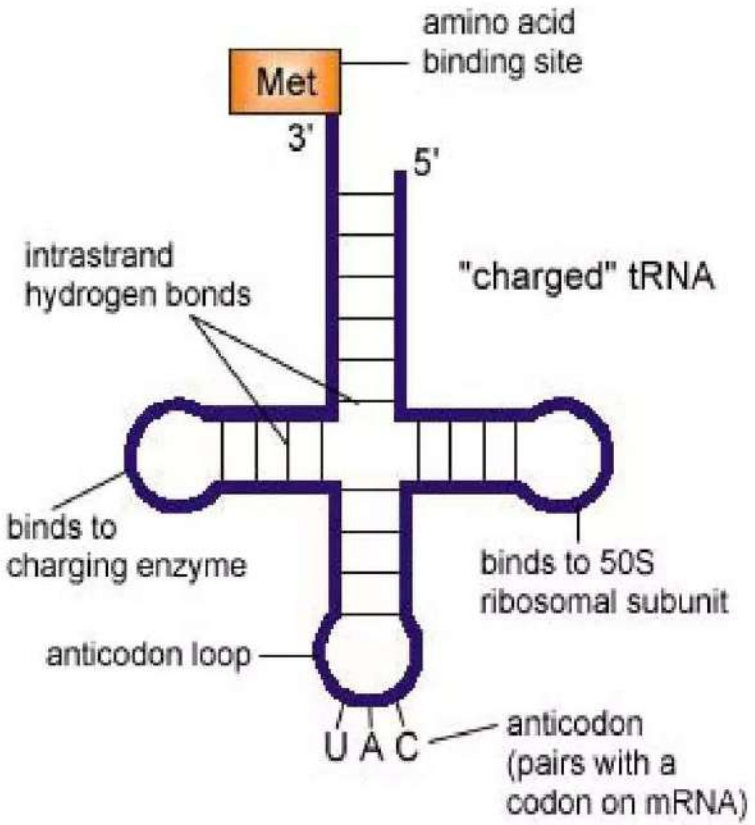
Eukaryotic mRNAs have several unique properties



Eukaryotics is synthesized as pre-mRNA (heteronuclear RNA) which contain intervening regions (Introns).

Transfer RNA (tRNA)

- They are the smallest RNAs.
- Fold into tertiary structure by formation of intra-molecular base pairs .
- Have clover leaf shape (hair-pin).
- Transfer amino acids into the ribosomes.
- Act as an **adaptor** molecule.



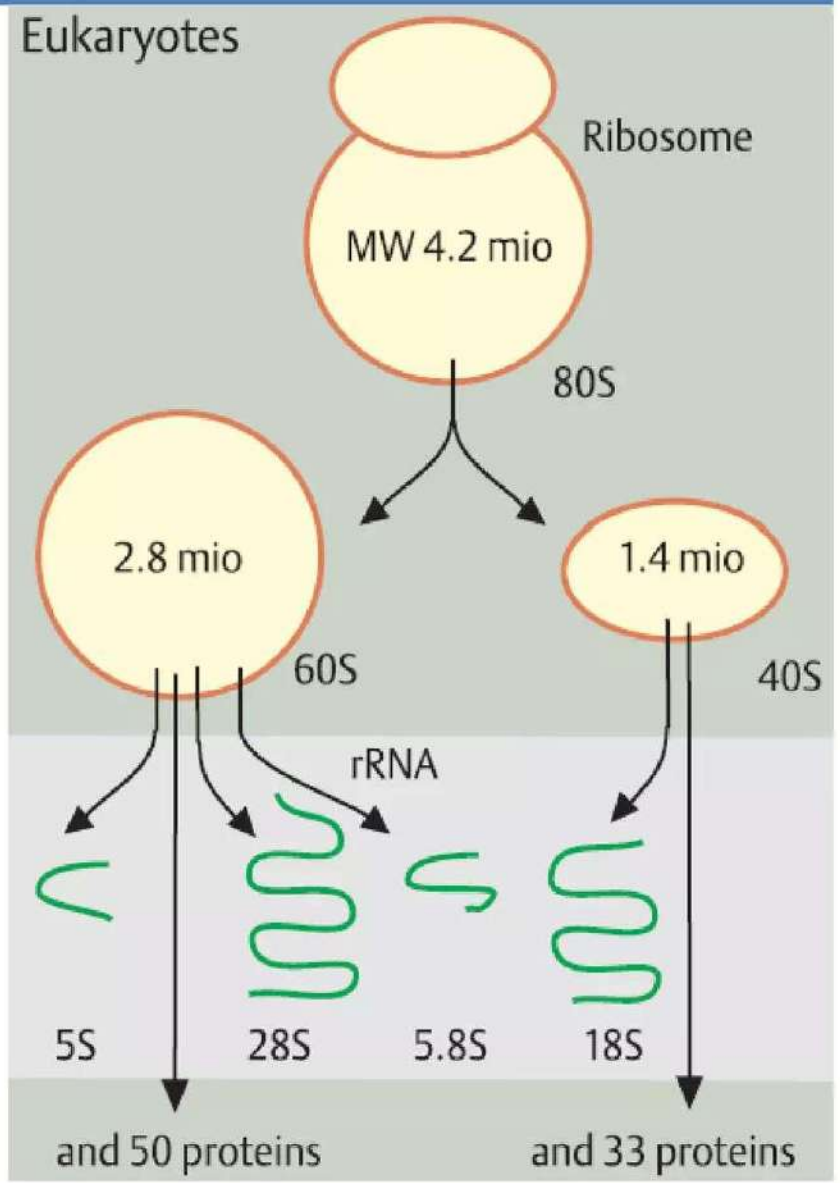
Ribosomal RNA (rRNA)

- Have structural and catalytic functions.

- They have a **ribozyme** function, the 28S rRNA catalyze the synthesis of peptide bonds (*peptidyl transferase*).

Ribosomal RNA (rRNA)

- It is a nucleoprotein particle.
- The mammalian ribosome, has a sedimentation velocity of 80S (Svedberg units).
- Consists of large 60S and small 40S subunits.



Small nuclear RNA (snRNA)

- A large number of highly conserved small stable molecules of RNA found in eukaryotic cells.
- The majority of them exists as **nucleoproteins** distributed in both the nucleus and the cytosol.
- They are involved in mRNA processing and gene regulation.

microRNA (miRNA)

- Are short RNA molecules found in eukaryotic cells.
- Have very few nucleotides (an average of 22) compared with other RNAs.
- Have multiple roles in regulation of gene expression.

Small interfering RNA (siRNA)

Also known as short interfering RNA or silencing RNA

Are double-stranded RNA molecules

Have 20-25 nucleotides in length

They interfere with the expression of a specific gene.