Nucleic Acids

-Ms. Rupal Mishra

Nucleic Acid

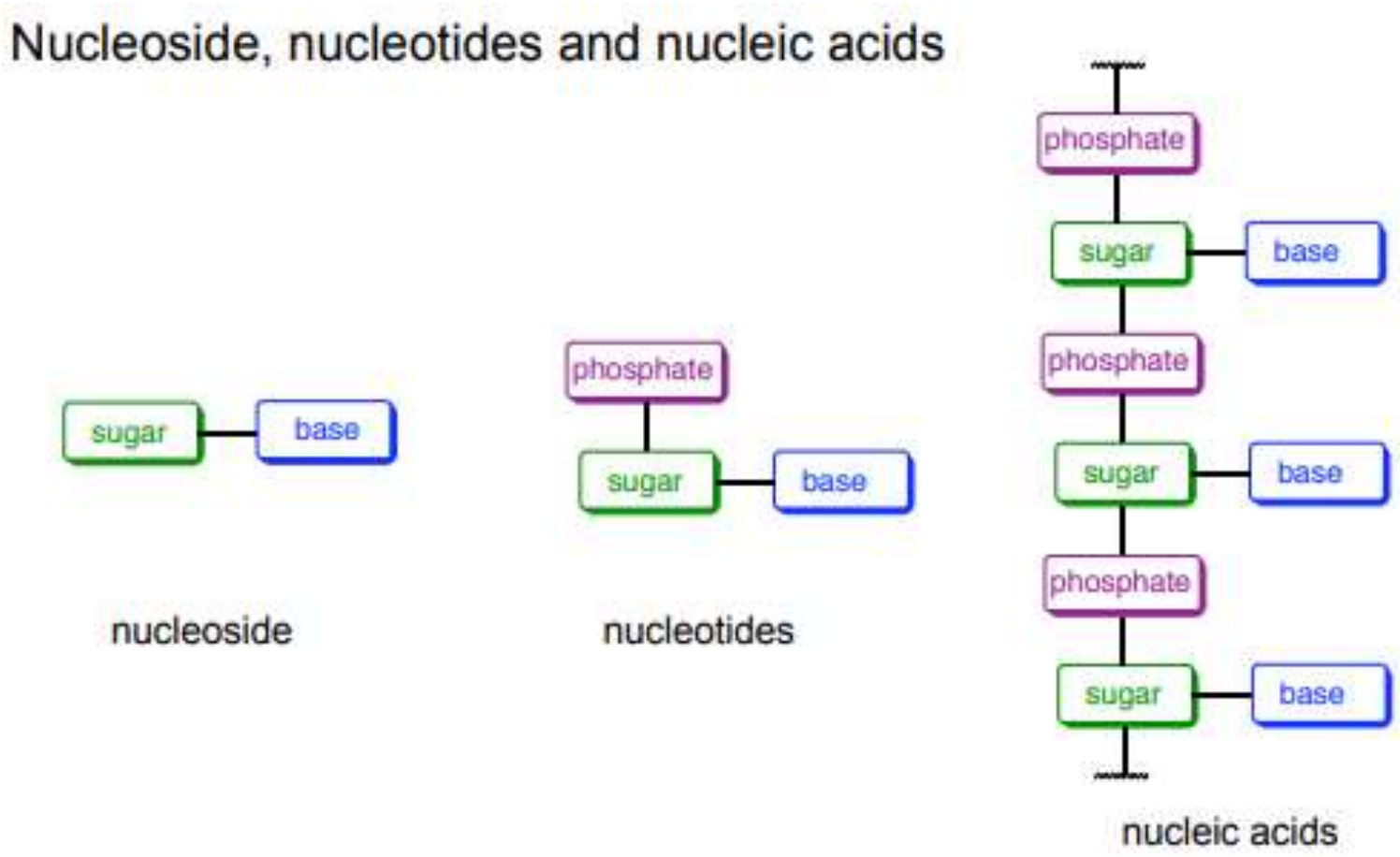
- Nucleic acids (**DNA and RNA**) perform a variety of crucial functions in organisms.
- **DNA** stores and transfers genetic information, it serves as the template for the synthesis of new DNA and RNAs.
- **RNA**s carry out protein synthesis.
- **Nucleic acids** contain only a few different components, but they have great structural diversity.
- This diversity results from the many possible combinations of those few components due to the large sizes of DNA and RNA.

Nucleic Acid

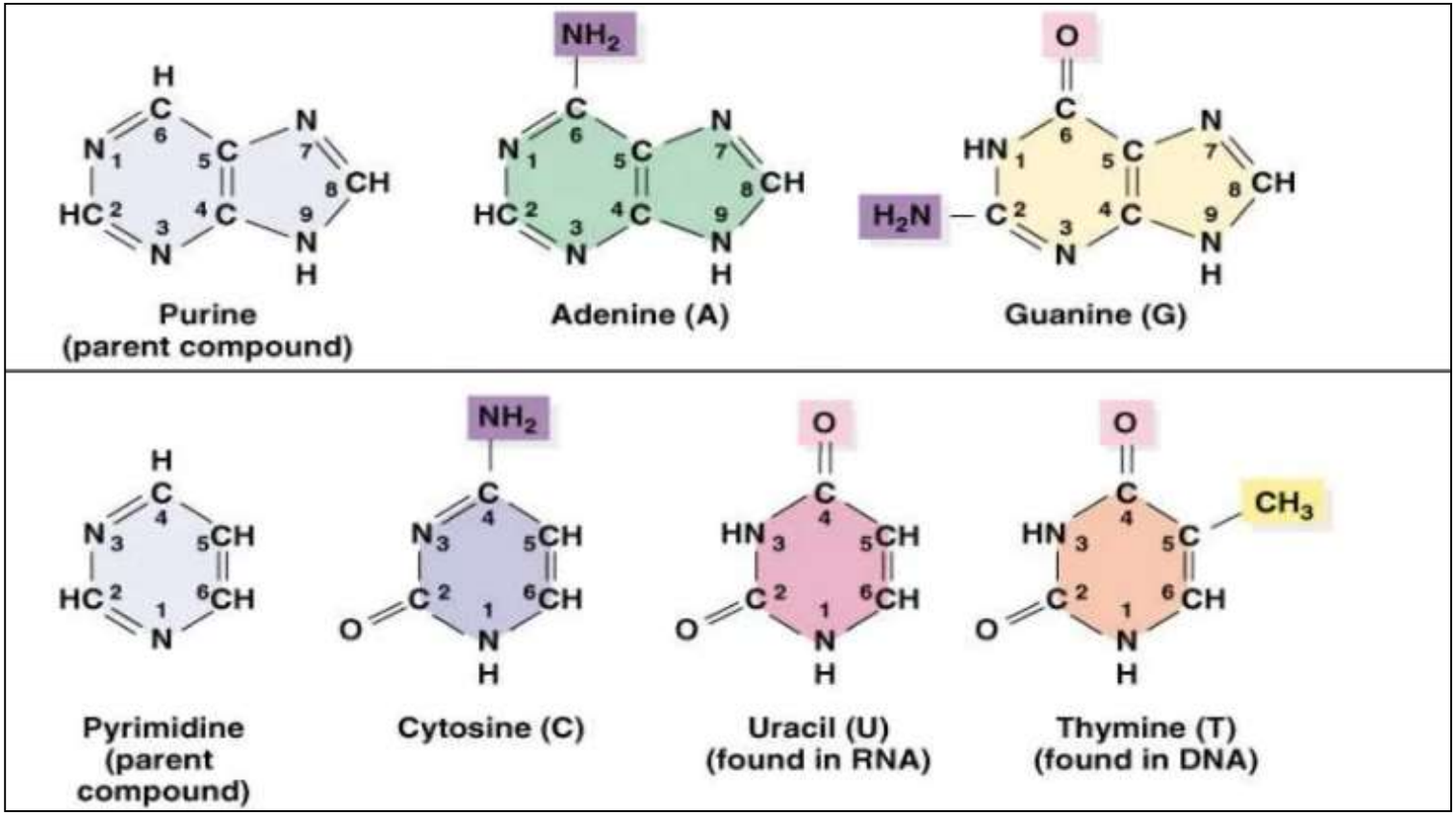
- The **two classes** of nucleic acids are DNA (deoxyribonucleic acid) and RNA (ribonucleic acid).
- While they have significantly **different structures**, we can describe both DNA and RNA as **polynucleotides** (polymers of nucleotides).
- The **monomeric units** for nucleic acids are called nucleotides.
- Nucleotides are made up of **three structural subunits**

    1. Sugar: ribose in RNA, 2-deoxyribose in DNA
    2. Heterocyclic base
    3. Phosphate

Nucleotide


Nucleoside, nucleotides and nucleic acids
sugar
base
nucleoside
phosphate
sugar
base
nucleotides
phosphate
sugar
base
phosphate
sugar
base
phosphate
sugar
base
nucleic acids

Types of Cyclic Base



Deoxyribonucleic Acid (DNA)

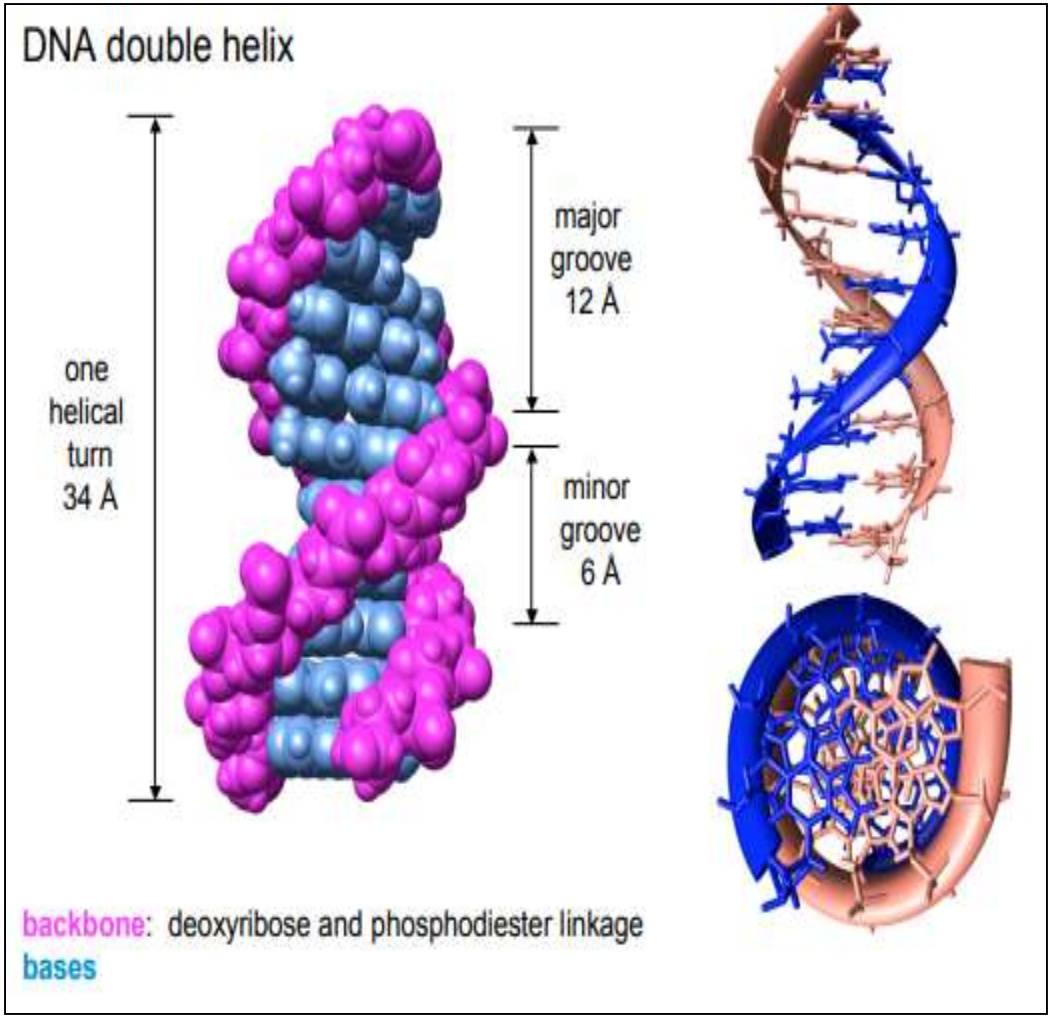
- DNA - a **polymer** of deoxyribonucleotides.
- Usually double stranded.
- Has double-helix structure.
- Found in chromosomes, mitochondria and chloroplasts.
- It acts as the genetic material in most of the organisms.
- Carries the genetic information.

Deoxyribonucleic Acid (DNA)

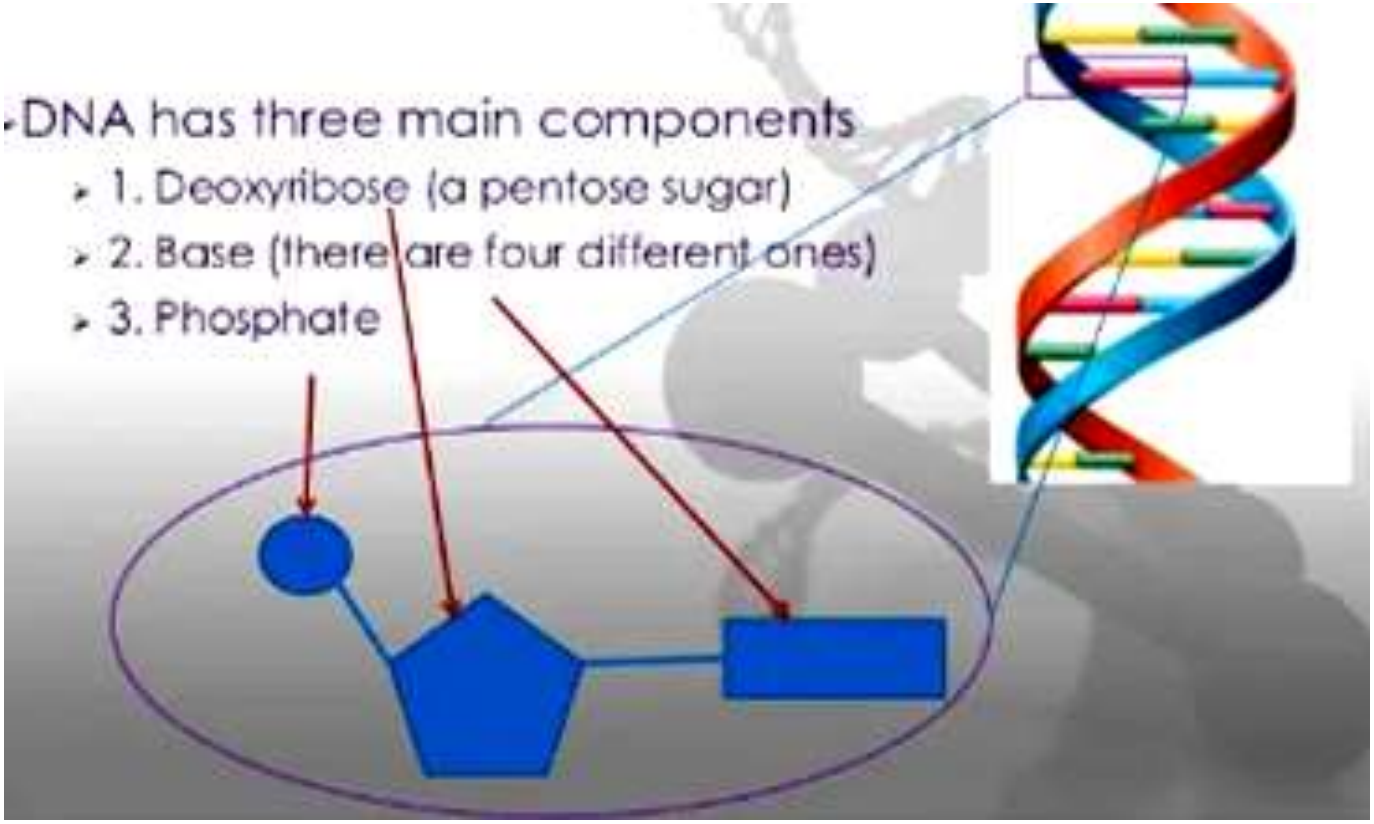
- **1868**: DNA as an acidic substance present in nucleus was first identified by Friedrich Meischer in 1868. He named it as ‘Nuclein’.
- **1944**: Avery, MacLeod & McCarty - Strong evidence that DNA is genetic material
- **1950**: Chargaff - careful analysis of DNA from a wide variety of organisms. Content of A,T, C & G varied widely according to the organism, however: A=T and C=G (Chargaff’ Rule)
- **1953**: Watson & Crick - structure of DNA (1962 Nobel Prize with M. Wilkens, 1962)

Deoxyribonucleic Acid (DNA)

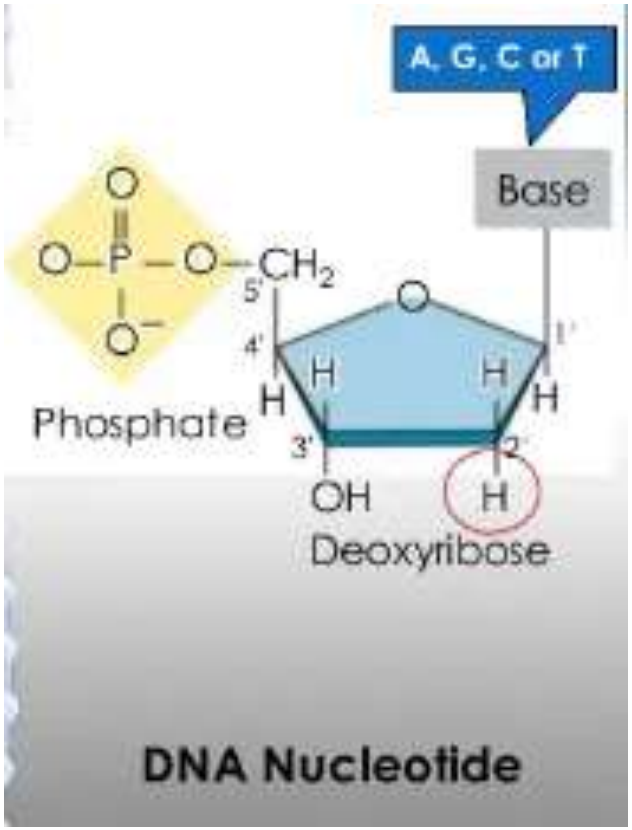
- **Two polynucleotide strands**, running in opposite directions (anti-parallel) and coiled around each other in a double helix.
- The strands are held together by complementary hydrogen bonding between specific pairs of bases.

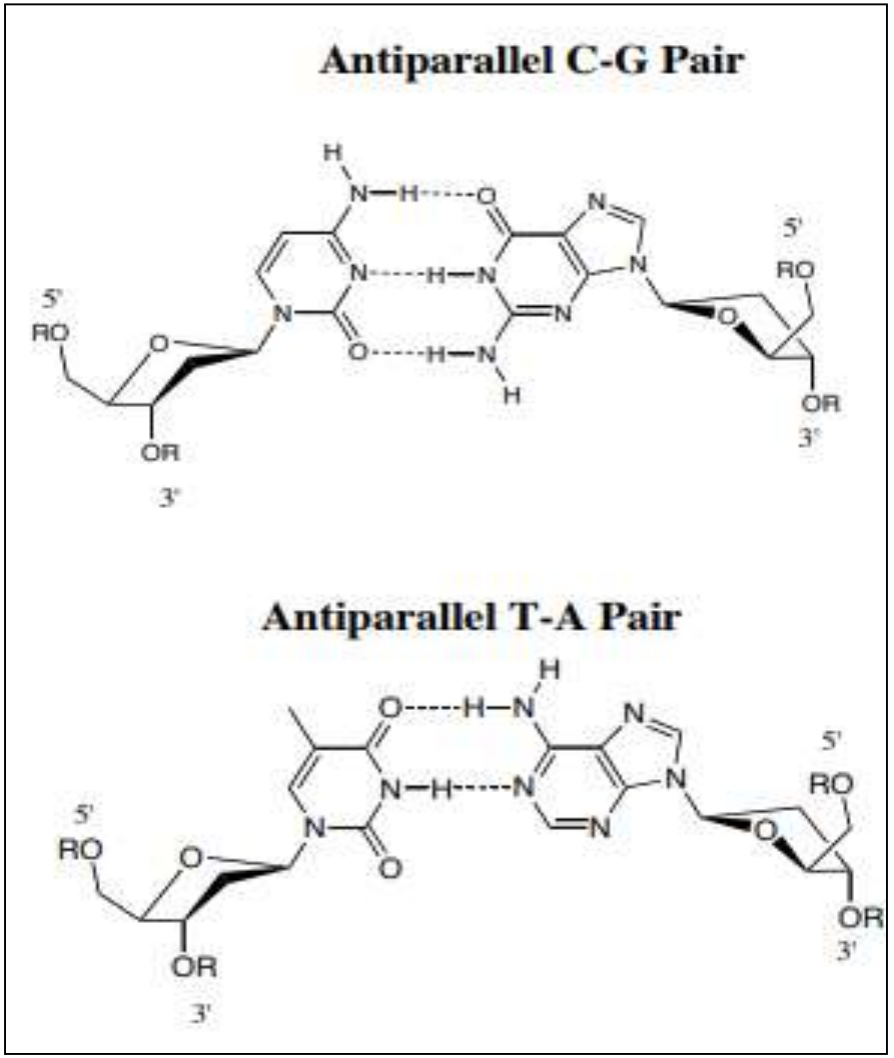


Deoxyribonucleic Acid (DNA)

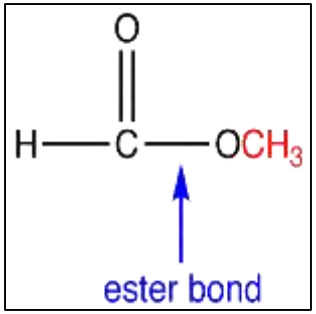


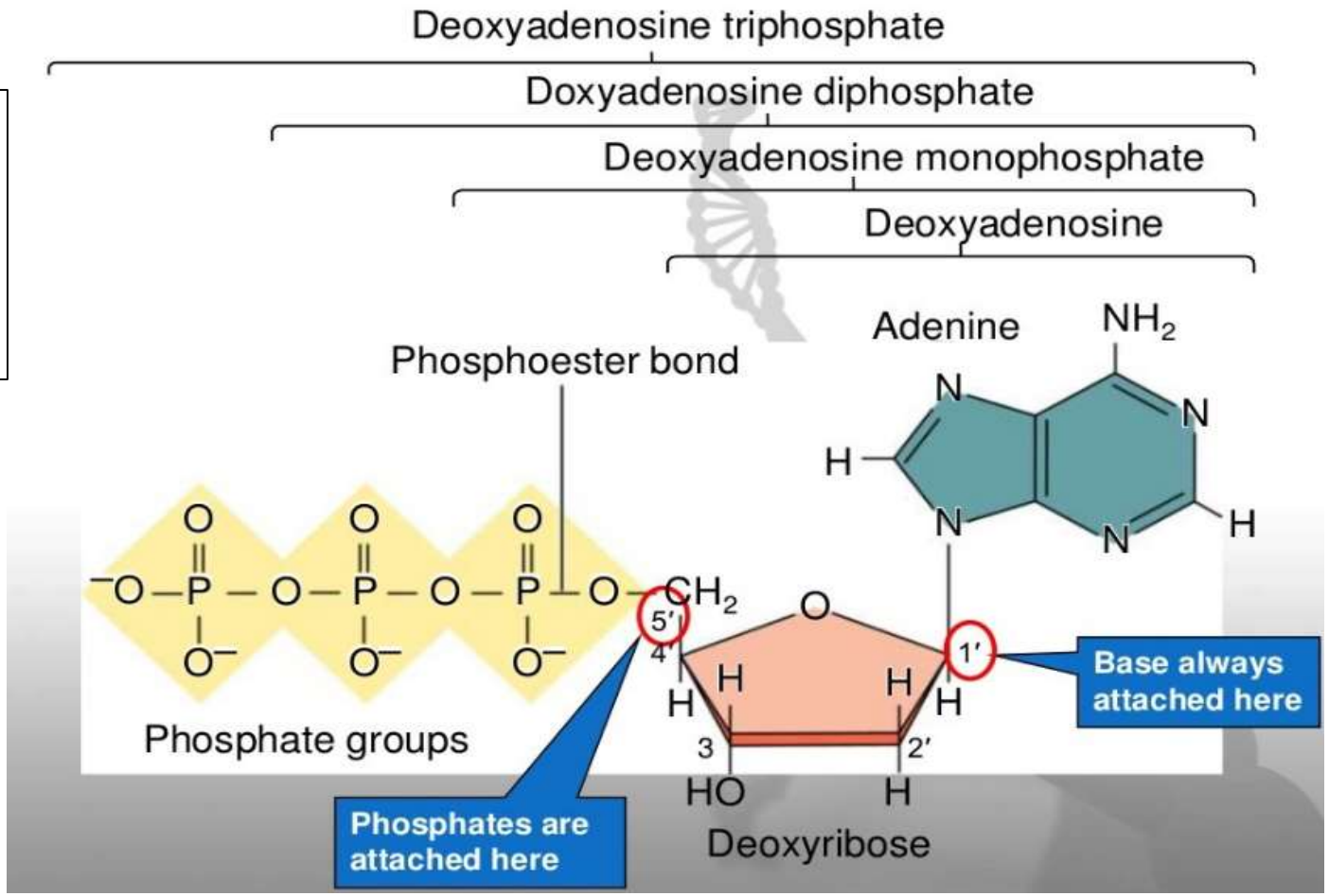
Deoxyribonucleic Acid (DNA)





Deoxyribonucleic Acid (DNA)





Deoxyribonucleic Acid (DNA)

Different Structural Forms of DNA

1) B-DNA
2) A-DNA
3) Z-DNA

B-DNA

- **B-DNA** is biologically the most common
- It is alpha-helix meaning that it has a Right handed, or clockwise, spiral.
- Complementary base pairing (A-T / G-C)
- Ideal B-DNA has 10 base pair per turn
- So each base is twisted 36 degree relative to adjacent bases.
- Base pair are 0.34 nm apart.
- So complete rotation of molecule is 3.4 nm.
- Axis passes through middle of each basepairs.
- B-DNA structure is **most stable configuration** for a random sequence of nucleotides under physiological condition.

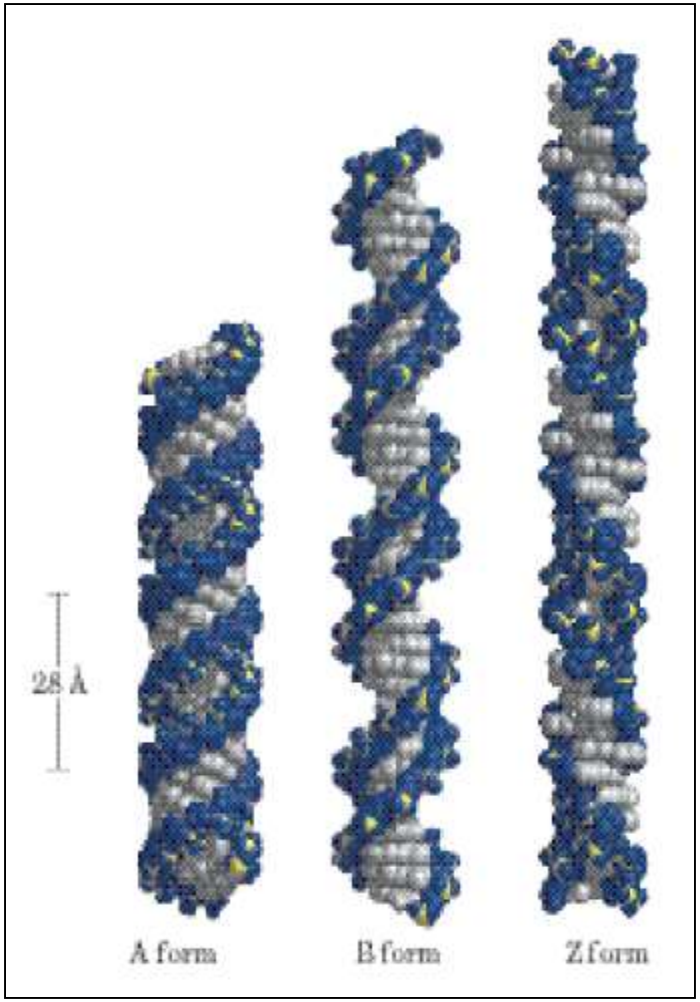
A-DNA

- A-DNA is a Right-handed helix .
- Wider and flatter than B-DNA 11 bp per turn.
- Its bases are tilted away from main axis of molecule.
- Narrow Deep major Groove and Broad, Shallow minor Groove.
- Observed when less water is present. i.e., Dehydrating condition.
- A-DNA has been **observed in** two context:
  - Active site of DNA polymerase (~3bp)
  - Gram (+) bacteria undergoing sporulation

Z-DNA

- Z-DNA is a left-handed helix
- Seen in **Condition** of High salt concentration.
- In this form **sugar-phosphate backbones** zigzag back and forth, giving rise to the name Z-DNA(for zigzag).
- 12 base pairs per turn.
- A deep Minor Groove, No Discernible (detectable) Major Groove.
- **Part of some active genes** form Z-DNA, suggesting that Z-DNA may play a role in regulating gene transcription.

Deoxyribonucleic Acid (DNA)



Property	B-DNA	A-DNA	Z-DNA
Strand	Antiparallel	Antiparallel	Antiparallel
Type of Helix	Right-handed	Right-handed	Left-handed
Overall shape	Long and narrow	Short and wide	Elongated and narrow
Base pair per turn	10	11	12
Distance between adjacent bases	0.34 nm	0.23 nm	0.38 nm
Pitch/turn of helix	3.40 nm	2.82 nm	4.56 nm
Helical Diameter	2.0 nm	2.3 nm	1.8 nm
Tilt/inclination of bp to axis	1^0	20^0	9^0
Major Groove	Wide & Deep	Narrow & Deep	No discrenible
Minor Groove	Narrow, shallow	Broad, Shallow	Narrow, Deep

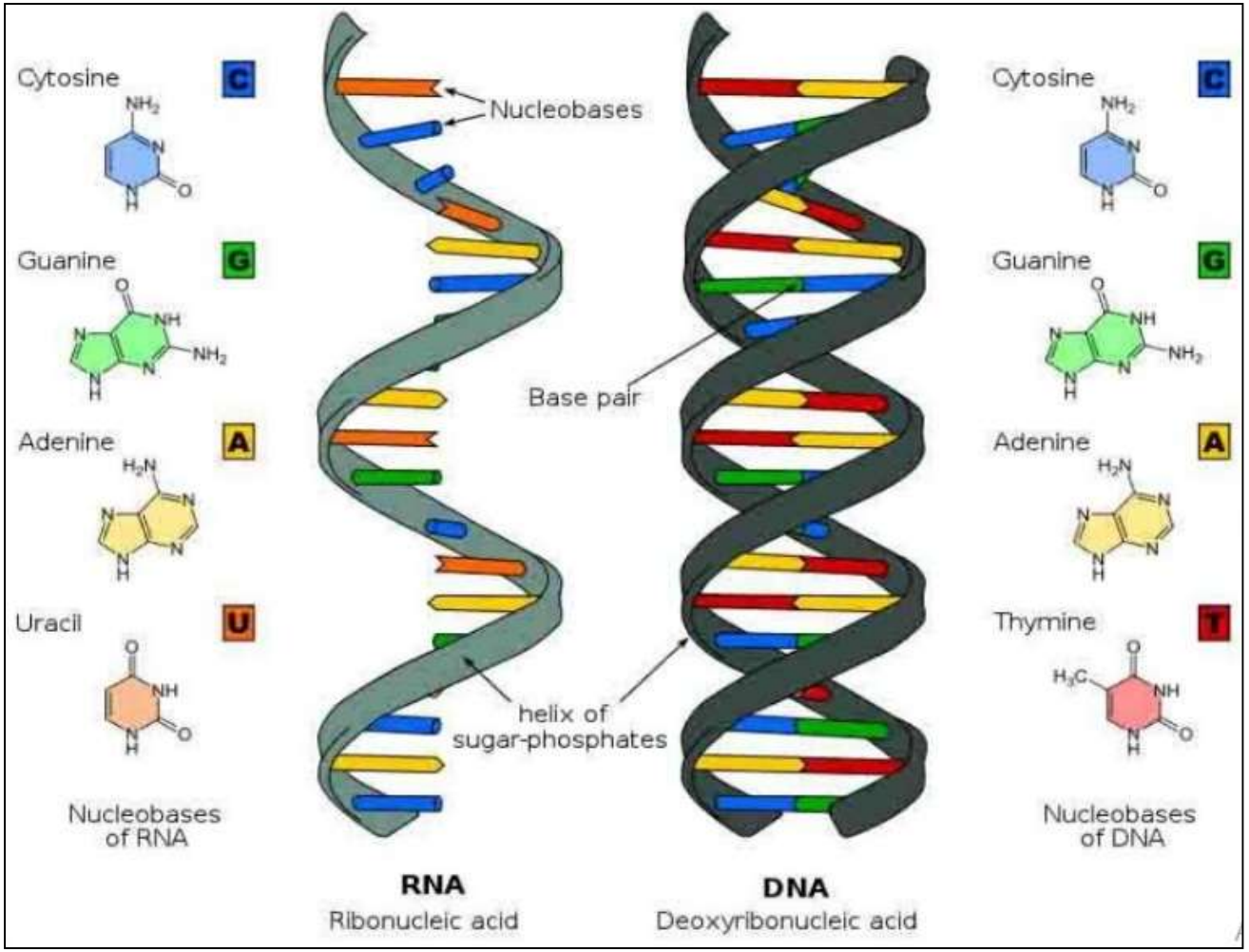
Ribonucleic Acid (RNA)

- RNA is a polymer of ribonucleotides linked together by phosphodiester linkage.
- In **1967** Carl Woese found the catalytic properties of RNA and speculated that the earliest forms of life relied on RNA both to carry genetic information and to catalyse biochemical reactions.
- These theories were not validated until the work of Nobel Prize laureate Thomas R. Cech.
- Usually single stranded and helical in structure.
- But double stranded also present in some viruses (acts as the genetic material in some viruses).

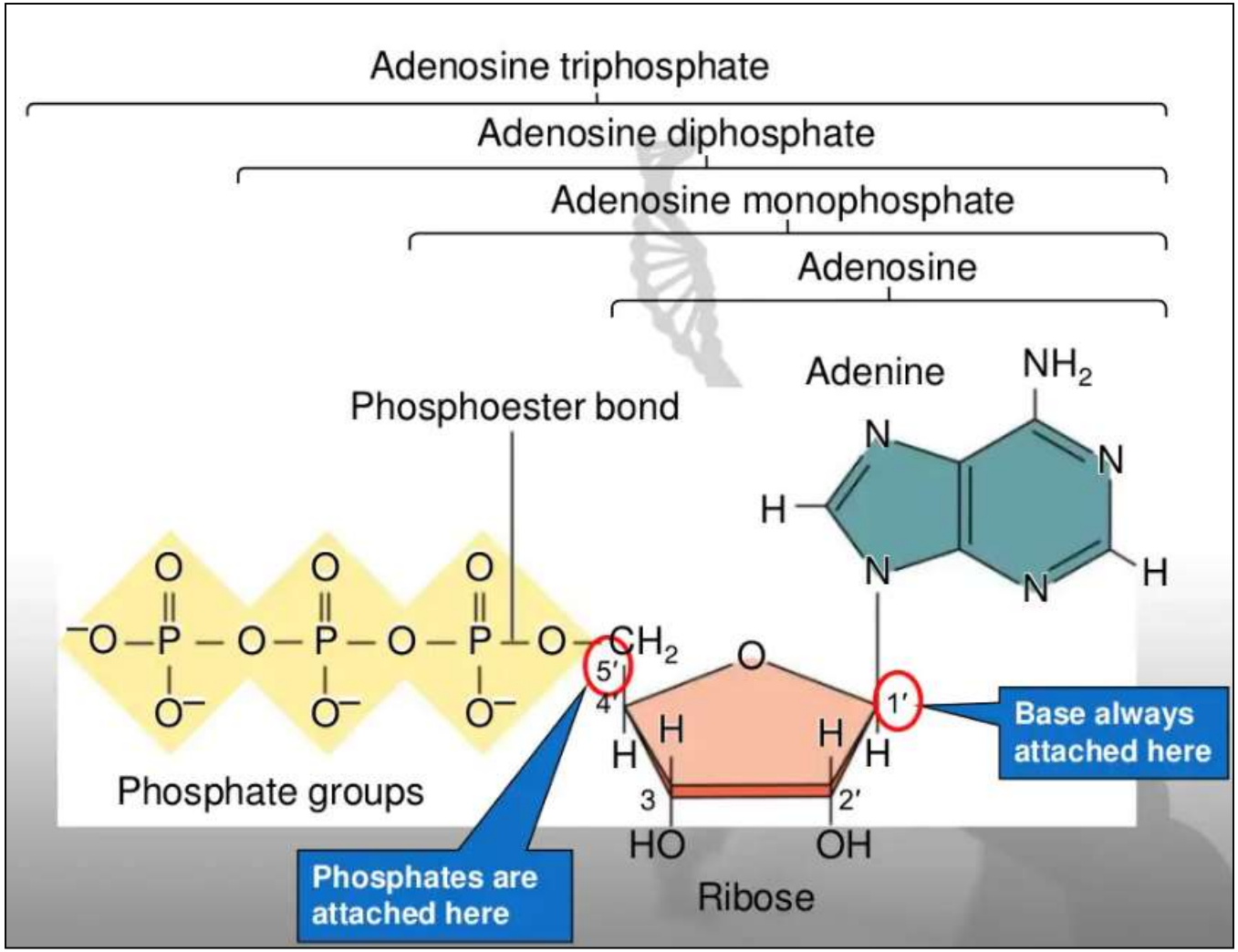
Ribonucleic Acid (RNA)

- RNA exists in several different single-stranded structures, most of which are directly or indirectly involved in protein synthesis or its regulation.
- RNA strands are typically several hundred to several thousand nucleotides in length.
- RNA contains ribose rather than 2-deoxyribose and uracil rather than thymine.
- DNA is found in the cell nucleus and mitochondria; RNA is more disperse in the cell.

Ribonucleic Acid (RNA)



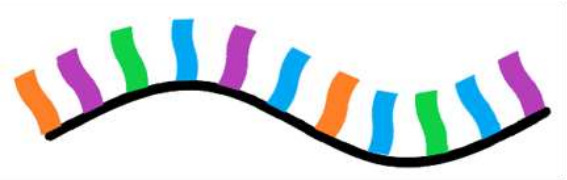
Ribonucleic Acid (RNA)



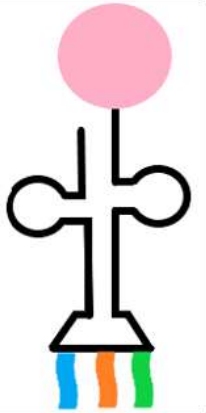
Ribonucleic Acid (RNA)

- There are three **different types of RNA** :
  1) messenger RNA (mRNA)
  2) ribosomal RNA (rRNA)
  3) transfer RNA (tRNA)
- They function as messenger (mRNA), adapter (tRNA), structural (rRNA).

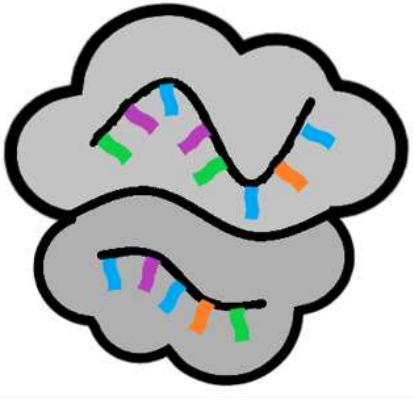
Ribonucleic Acid (RNA)



Messenger RNA



Transfer RNA



Ribosomal RNA

	mRNA	tRNA	rRNA
molecular weight (grams/mole)	25,000 to 1,000,000	23,000 to 30,000	up to 1,000,000

mRNA vs tRNA vs rRNA

mRNA	tRNA	rRNA
mRNA is a subtype of RNA molecule which carries a portion of the DNA code to other parts of the cell for processing	tRNA molecule is a small RNA molecule, which is clover-leaf shaped and transfers a specific amino acid in the cytoplasm to the ribosome	rRNA molecule is a component of the ribosome and serves as the organelle of translation
Linear in shape	Clover-leaf shaped molecule	Sphere shaped molecule
Carries the message of transcript DNA codes of polypeptides from the nucleus to the ribosomes	Carries specific amino acids to the ribosome, aiding the translation	Associated with specific proteins to form ribosomes
Consists of codons	Consists of anticodons	Lacks codon or anticodon sequences
Size of the molecule is typically 400 to 12,000 nt in mammals	Size of the molecule is 76 to 90 nt	Size can be either 30S, 40S, 50S, and 60S

THANK YOU