DNA Structure

Grade: First year – Ashur Medical college 2023/2024

Module: HDTD lecture 7&8

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Dr. Tareef Fadhil Date: 24 Jan. 2024

OBJECTIVES:

DESCRIBE THE STRUCTURE OF NUCLEOTIDE

DESCRIBE THE MAIN STRUCTURE OF DNA AND RNA.

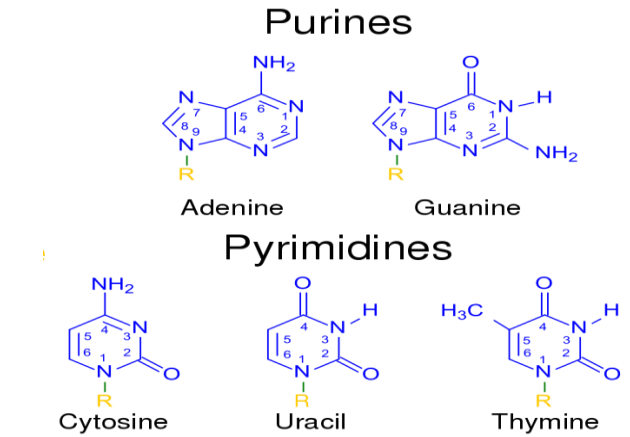
DESCRIBE THE FUNCTIONS OF DNA.

LIST AND DEFINE THE TYPES OF RNA.

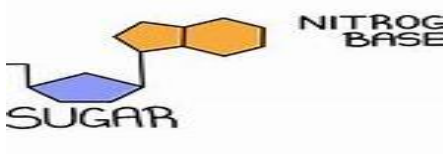
DEFINE AND DESCRIBE THE CENTRAL DOGMA.

- DEFINE THE REPLICATION OF DNA.
- LISTS THE STEPS OF REPLICATION.
- LIST THE ENZYMES ESSENTIAL FOR THE DNA REPLICATION

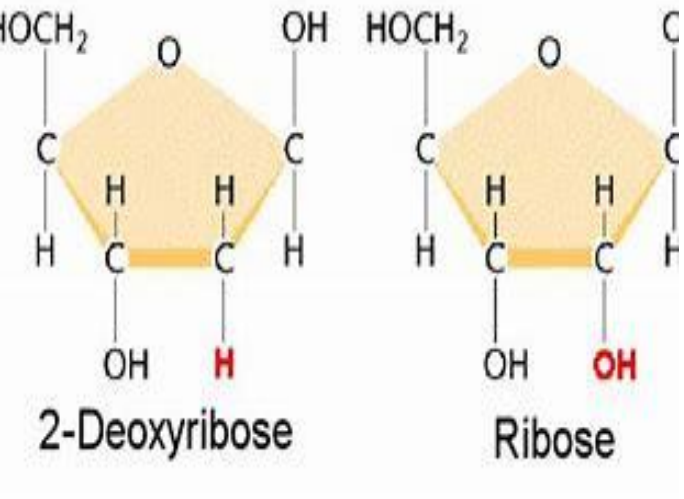
A nucleotide is the building block (monomeric unit) of nucleic acids DNA and RNA polymers that present in nucleus (DNA and RNA) , mitochondria (DNA) or cytoplasm and ribosome (RNA)

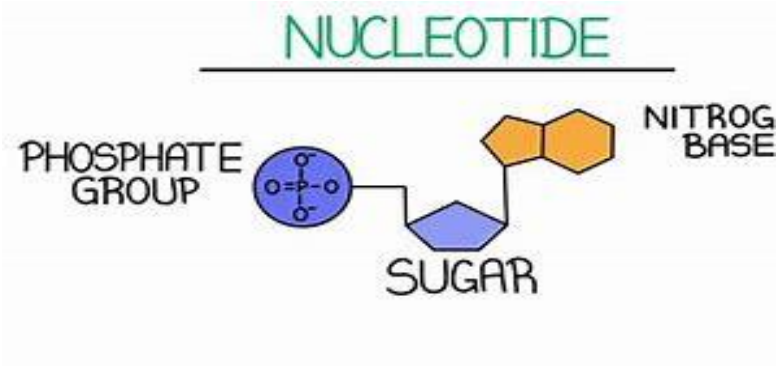


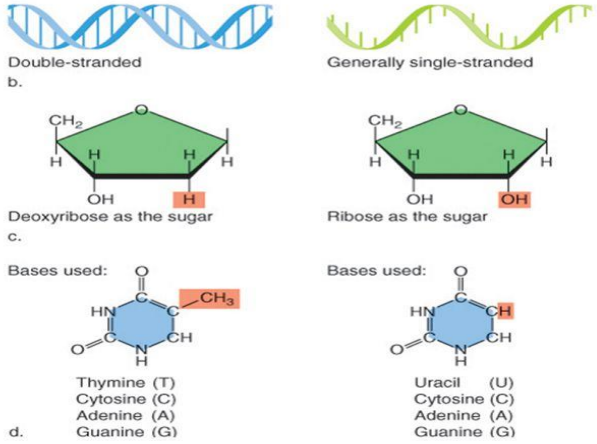
A- Nitrogenous base (nucleobase) :
Purines pyrimidines
B- Pentose
(Nitrogenous base (nucleobase) +Pentose) = Nucleoside



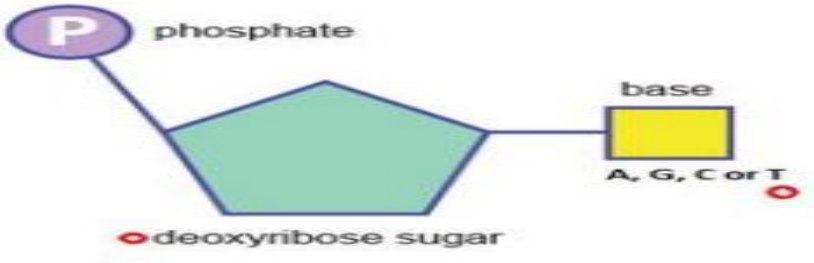
C-Phosphate A **nucleotide** typically contains **one phosphate group**. This phosphate group is crucial for linking nucleotides together to form the backbone of **DNA** and **RNA**.



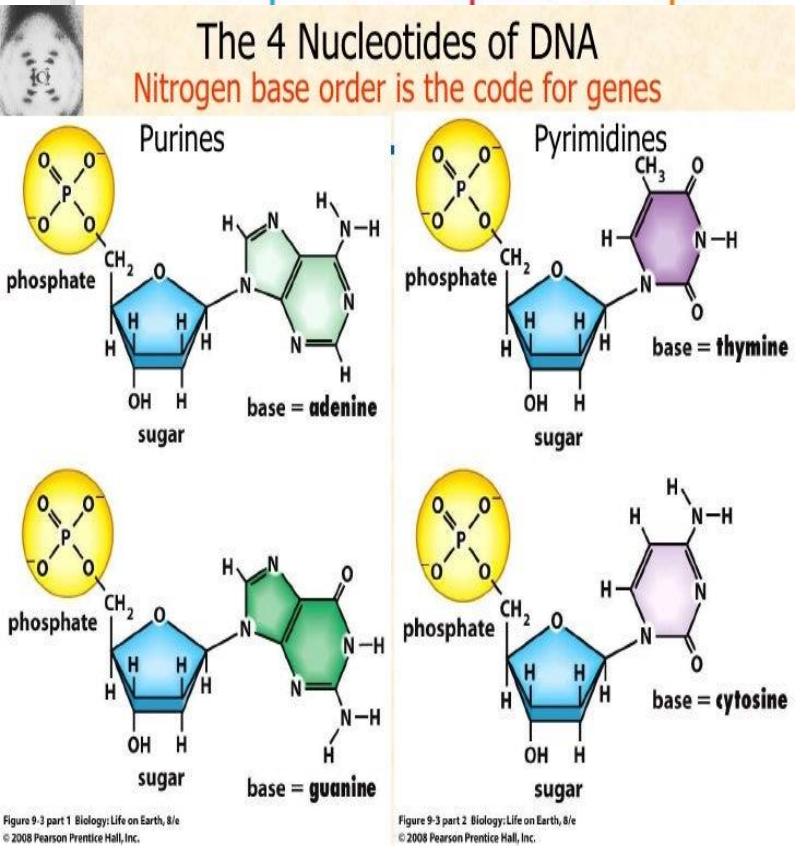




DNA Nucleotide Structure







- They are the monomeric units of the informational biopolymer, deoxyribonucleic acid (DNA):
- **A. Nitrogenous base (Nucleobase):**
- **A.1. purines**
- **A.1.1.Adenine**
- **A.1.2.Guanine**
- **A.2.pyrimidines**
- **A.2.1.Thymine**
- **A.2.2.cytosine**
- **B. Five-carbon sugar molecule which is deoxyribose**
- **C- one phosphate group.**

B. DNA Sugar and DNA nucleoside

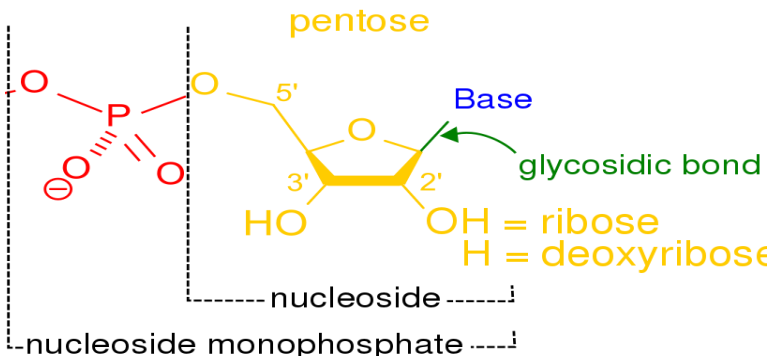
- Is a five-carbon sugar molecule (deoxyribose).
- The C-1 of deoxyribose is bounded to N-1 of pyrimidine or N-9 of purine .
- DNA Nucleoside = deoxyribose + nuclobase.

DNA nucleosides (deoxyribonucleosides) nomenclature:

Base	Type	Nucleoside
Adenine (A)	Purine	Deoxyadenosine
Guanine (G)	Purine	Deoxyguanosine
Cytosine (C)	Pyrimidine	Deoxycytidine
Thymine (T)	Pyrimidine	Deoxythymidine

C. DNA phosphate group

- A DNA nucleotide is sometimes termed as "nucleoside *mono*phosphate " which indicates that a nucleotide is bounded to one phosphate group.



Nucleotides nomenclature

Base	Nucleoside	Nucleotide
Adenine (A)	Deoxyadenosine	Deoxyadenosine monophosphate (dAMP), Deoxyadenosine 5'-monophosphate , Deoxyadenylic acid , Deoxadenylate
Guanine (G)	Deoxyguanosine	Deoxyguanosine monophosphate (dGMP) ,Deoxyguanosine 5'monophosphate , Deoxyguanylic acid , Deoxyguanylate
Cytosine (C)	Deoxycytidine	Deoxcytidine monophosphate, Deoxycytidine 5' monophosphate , Deoxycytidylic acid , Deoxycytidylate
Thymine (T)	Deoxythymidine	Deoxthymidine monophosphate (dTMP), Deoxythymidine 5'monophosphate , Deoxythymidylic acid , Deoxycytidylate

Despite the presence of basic nucleobases the acidic nature of the phosphate groups dominates. The acidity of DNA primarily arises from these phosphate groups.

- Individual **phosphate** molecules repetitively connect the **sugar** ring molecules in two adjacent nucleotide monomers

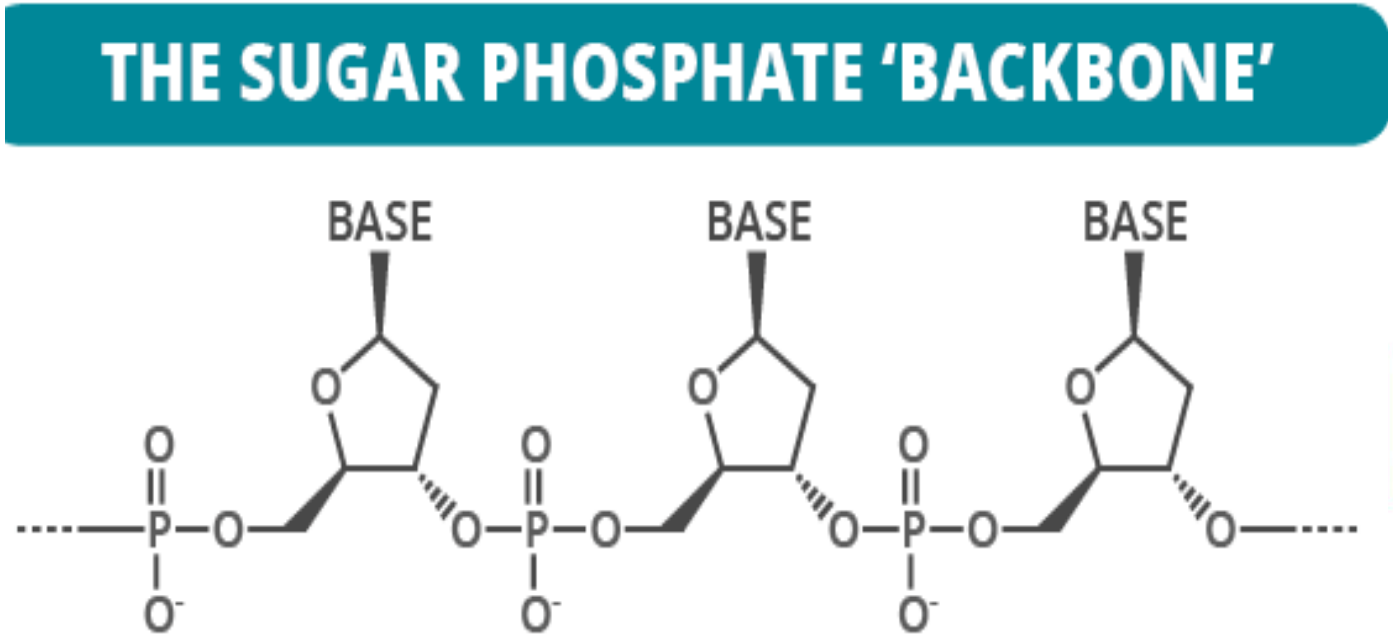
The nucleotides are joined together using **phosphodiester** bonds

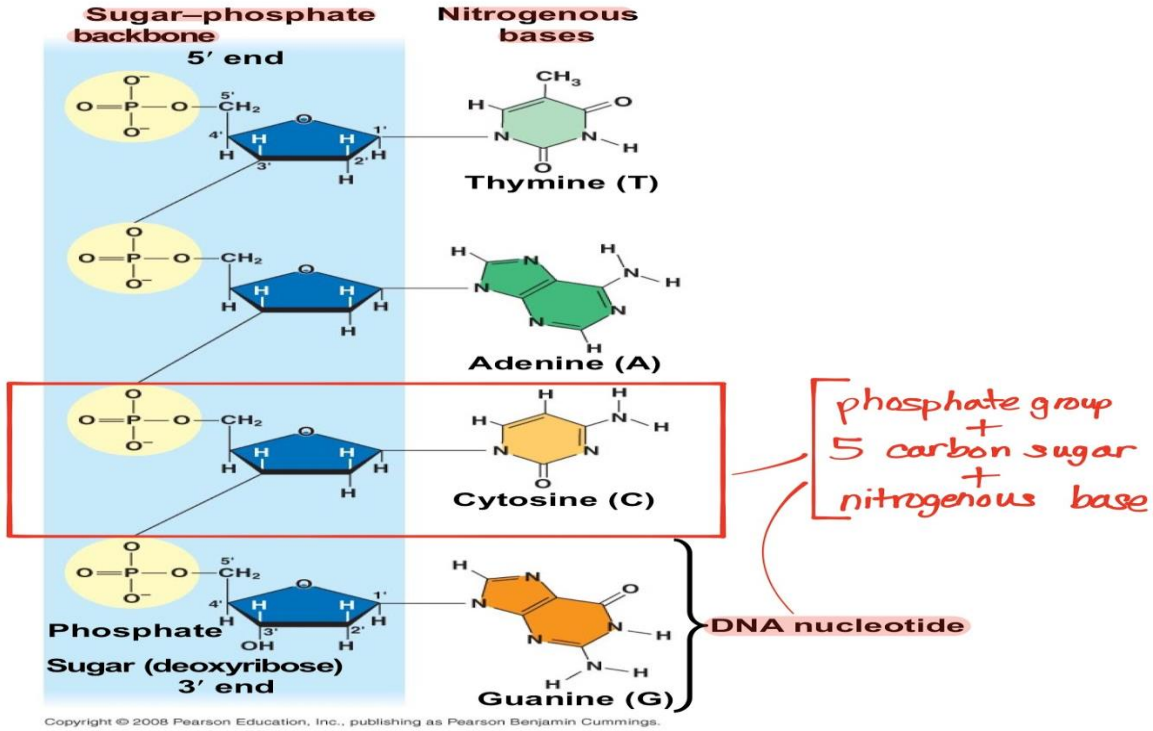


Specifically, the 3'-OH (3'-hydroxyl) (3 prime hydroxyl) of sugar of one deoxyribonucleotide is joined to the 5'-OH of adjacent sugar by a phosphatediester bridge. Thus the phosphate-sugar backbone is said to consist of 5'—3'

Nucleotide polymer:

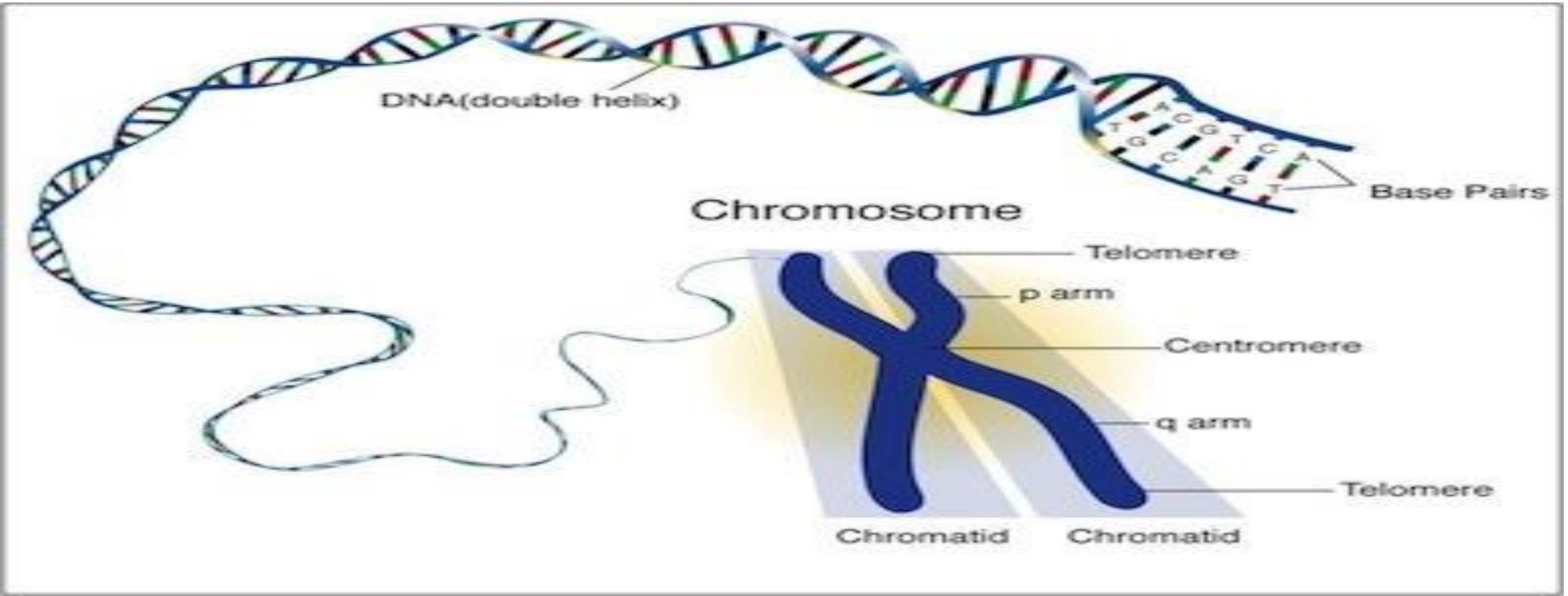
Chain-joins of sugar and phosphate molecules create a 'backbone' strand for each strand of double helix. , connecting the nucleotide monomers of a nucleic acid end-to-end into a long chain.





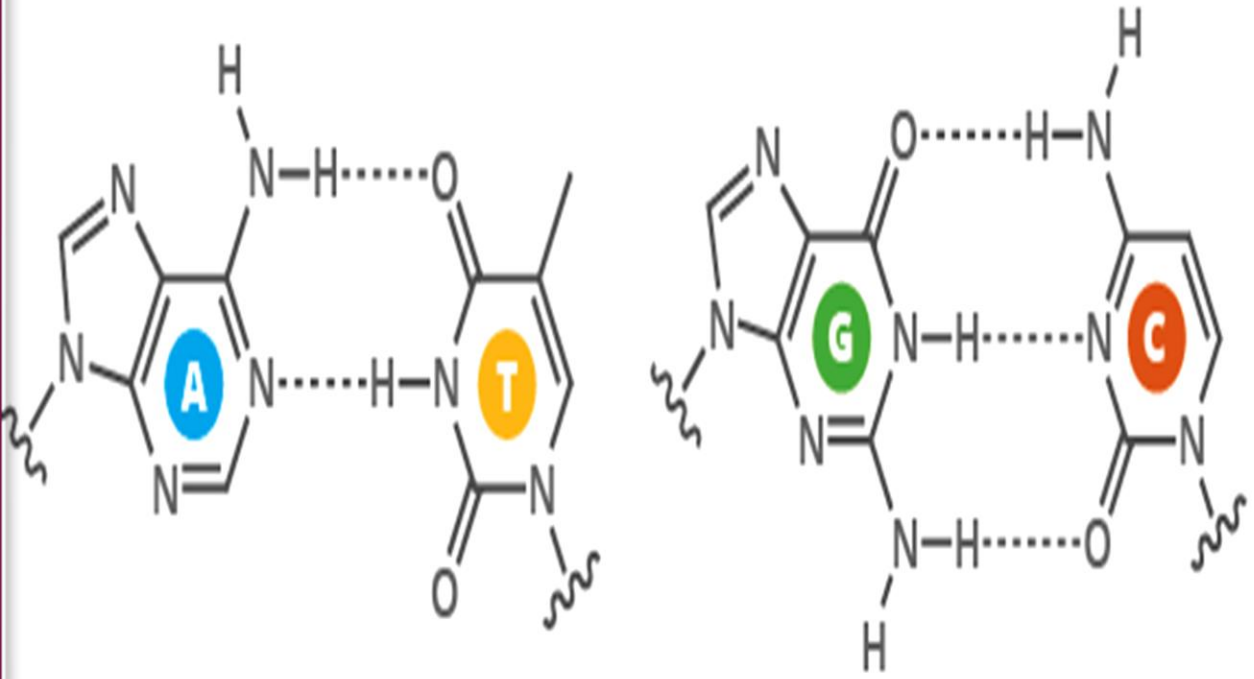
Codon is a sequence of three nucleotides which together form a unit of genetic code for certain amino acid for example . While gene is the functional unit of heredity such as polypeptide (protein).

A DNA molecule making up a single chromosome is usually composed of around 2000 million nucleotide pairs.



Phosphodiester bonds VS hydrogen bonds

DNA strands are held together by hydrogen bonds between bases on adjacent strands. Adenine (A) always pairs with thymine (T), while guanine (G) always pairs with cytosine (C). Adenine pairs with uracil (U) in RNA.



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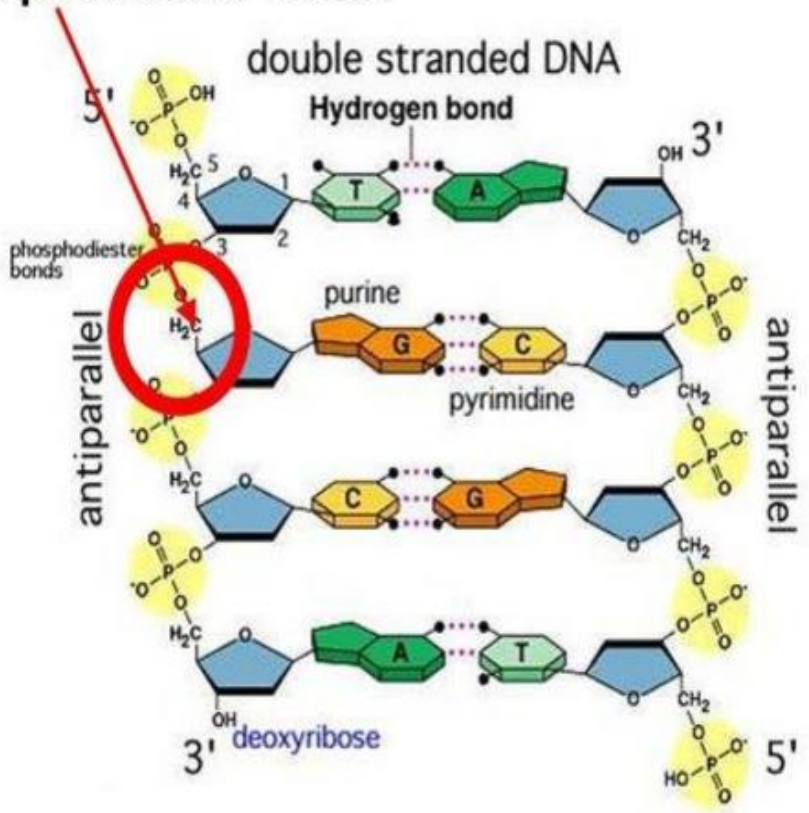
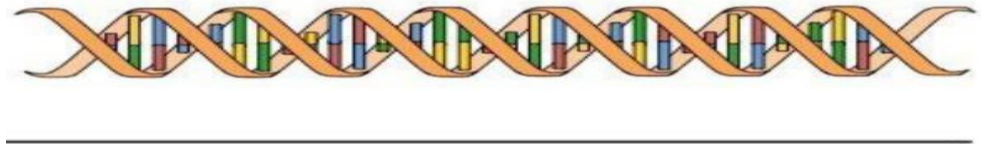
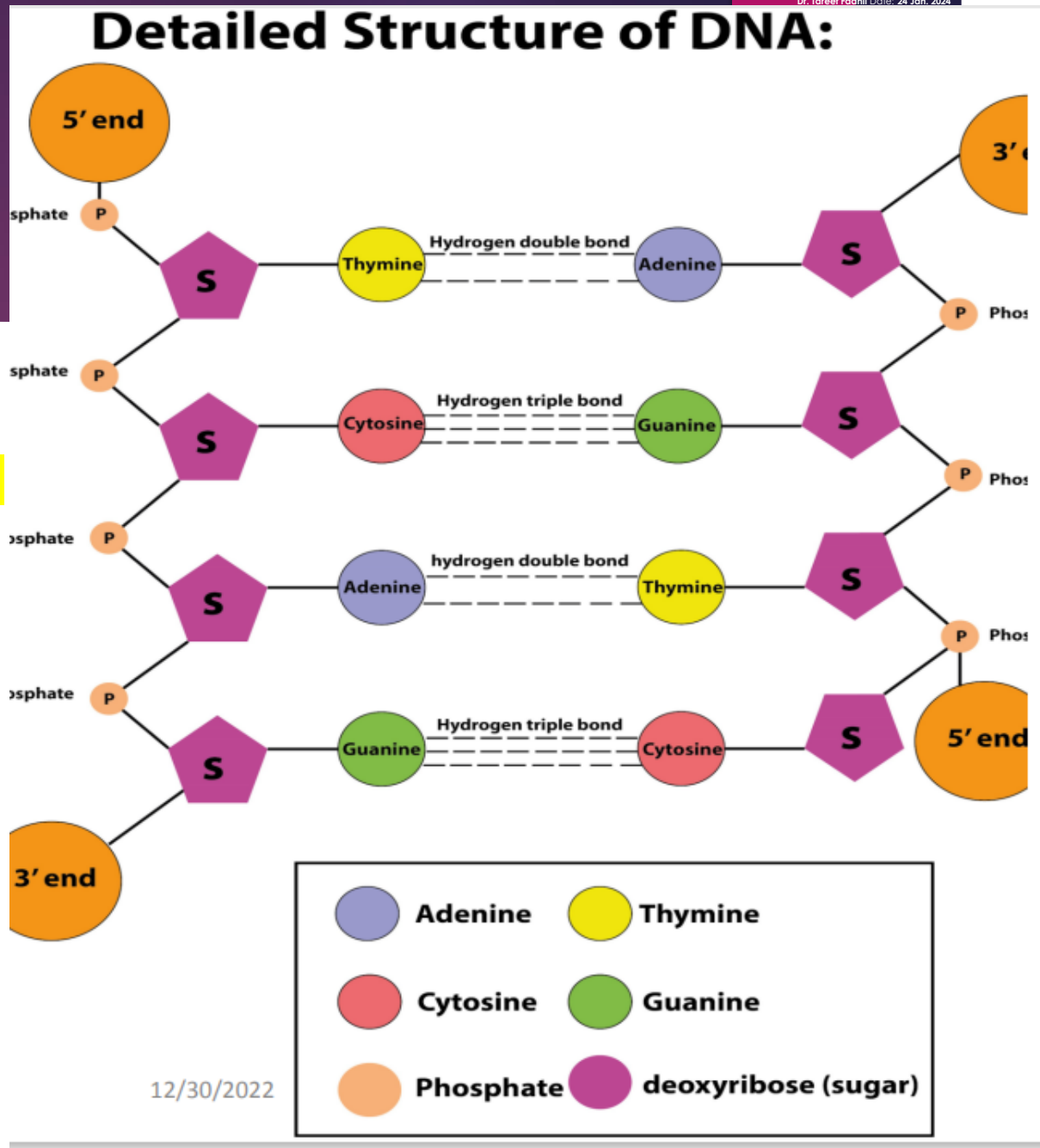


The DNA is a double helix structure composed of antiparallel chains held together by inter-nucleobases hydrogen bonds.



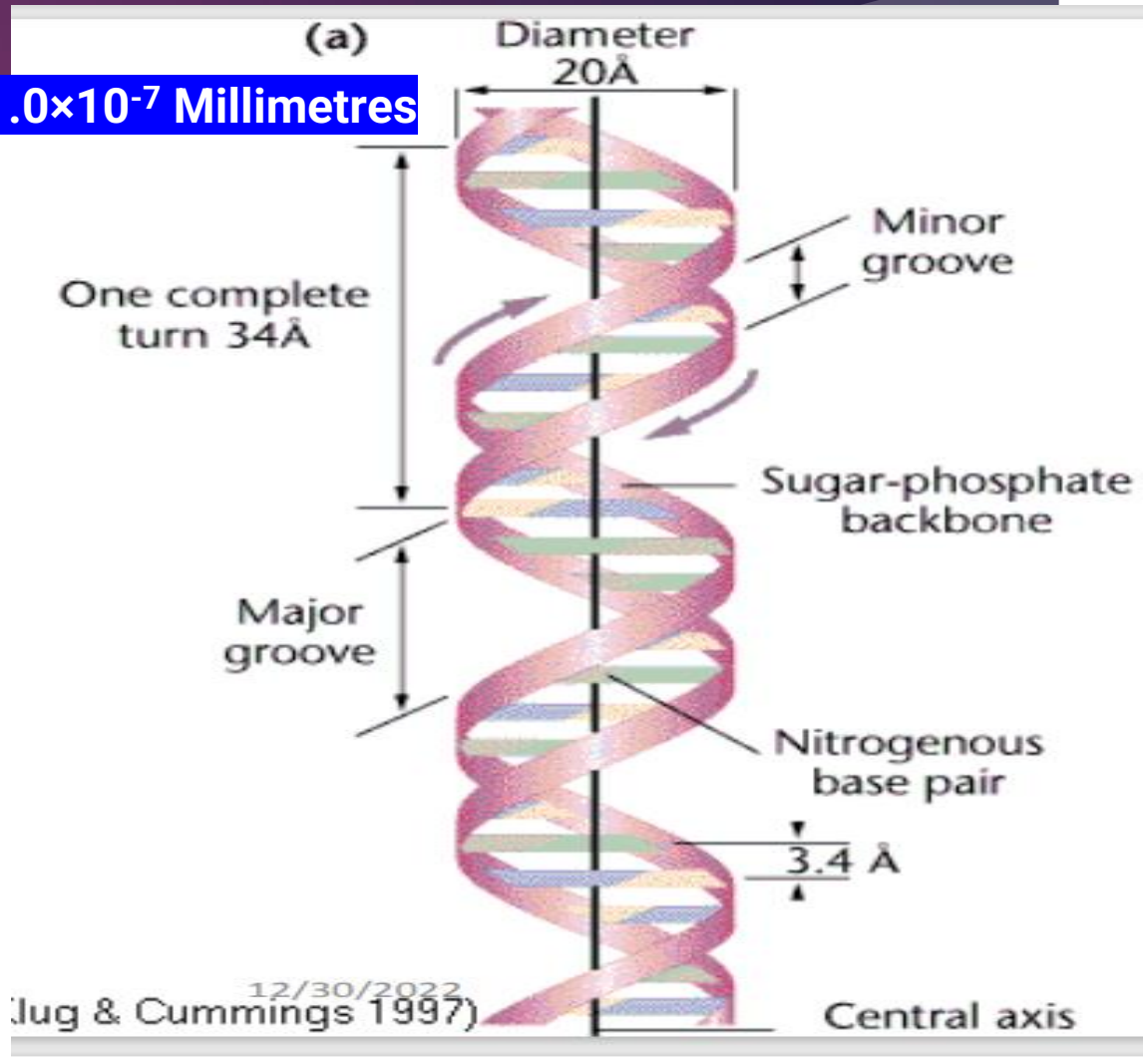


James Watson and Francis Crick two-strand or double-helix DNA model 1953.

1 Angstroms = 1.0×10^{-7} Millimetres

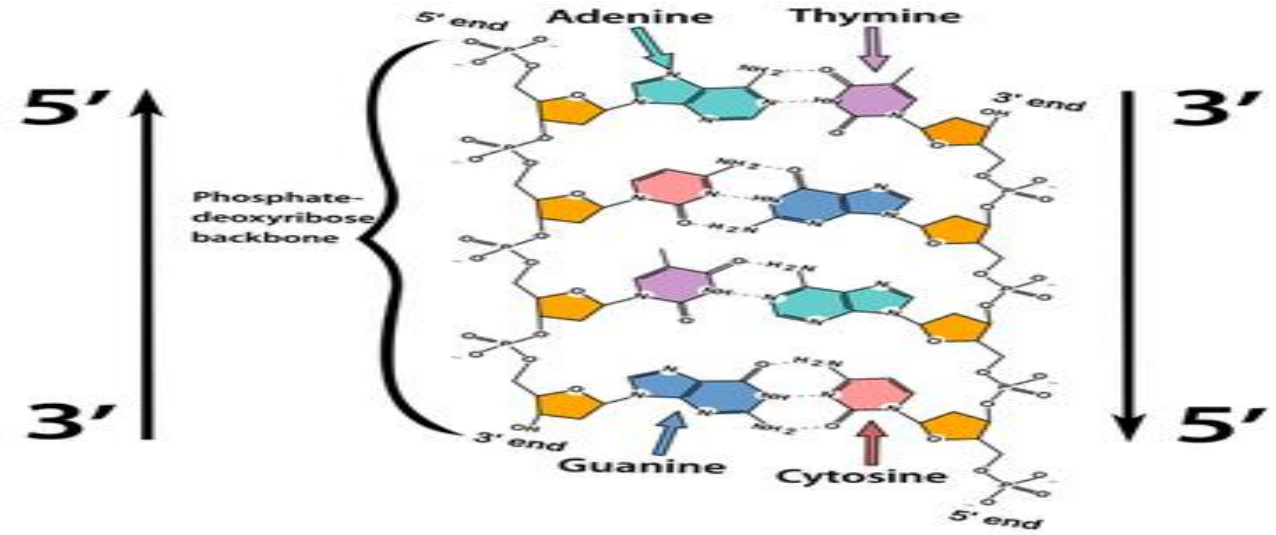
X-ray diffraction data showed the DNA molecule consist of:

- 1. Two right-handed helical polynucleotide chains.
- 2. These two chains are of opposite polarity (antiparallel) .
- 3. The two chains are coiled around the same axis to form a double helix.
- 4. The diameter of double helix is approximately 20-22A˚.
- 5. Each turn of the double helix covers a distance of 34A˚ (3.4 nm).
- 6. The distance between adjacent nucleotides is 3.4A˚
- 7-There must be (10) nucleotide per turn.
- 8. The twisting of the two strands around one another forms a double helix with narrow groove (12A˚across) called Minor groove & a wide groove (22A˚across) called Major groove.



Each complete turn = 10 base pairs

The percentage of A always equals the percentage of T and the percentage of G equals the percentage of C. The percentage of each type of nucleotide content differs from species to species.



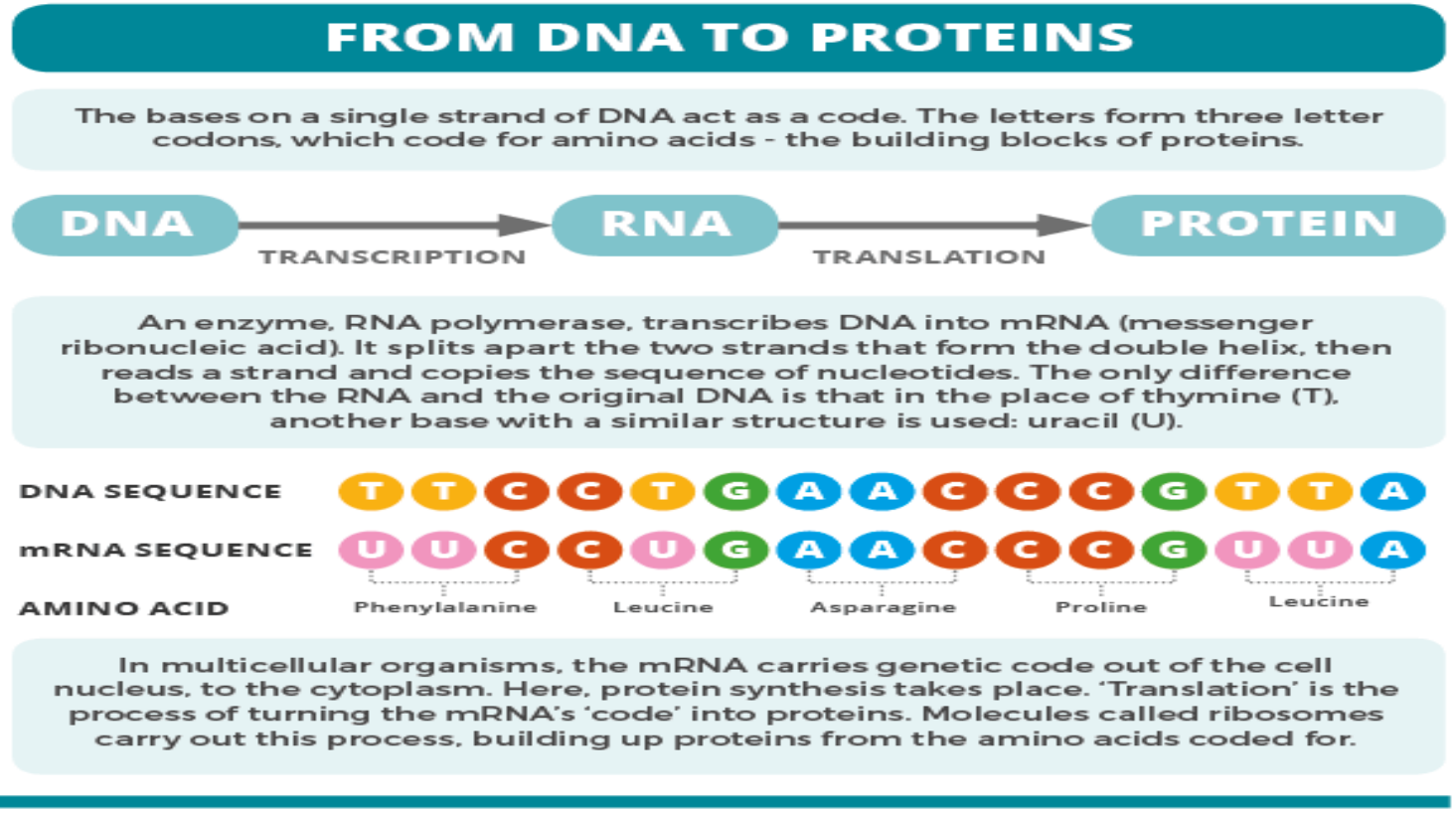
antiparallel

DNA Functions :

1- Carry messages for protein synthesis.

2- Copying information when cells divide.

3-Transmitting information to offsprings.



The order of **deoxynucleotide** in a gene is crucial for determining the genetic instructions encoded within **DNA.**

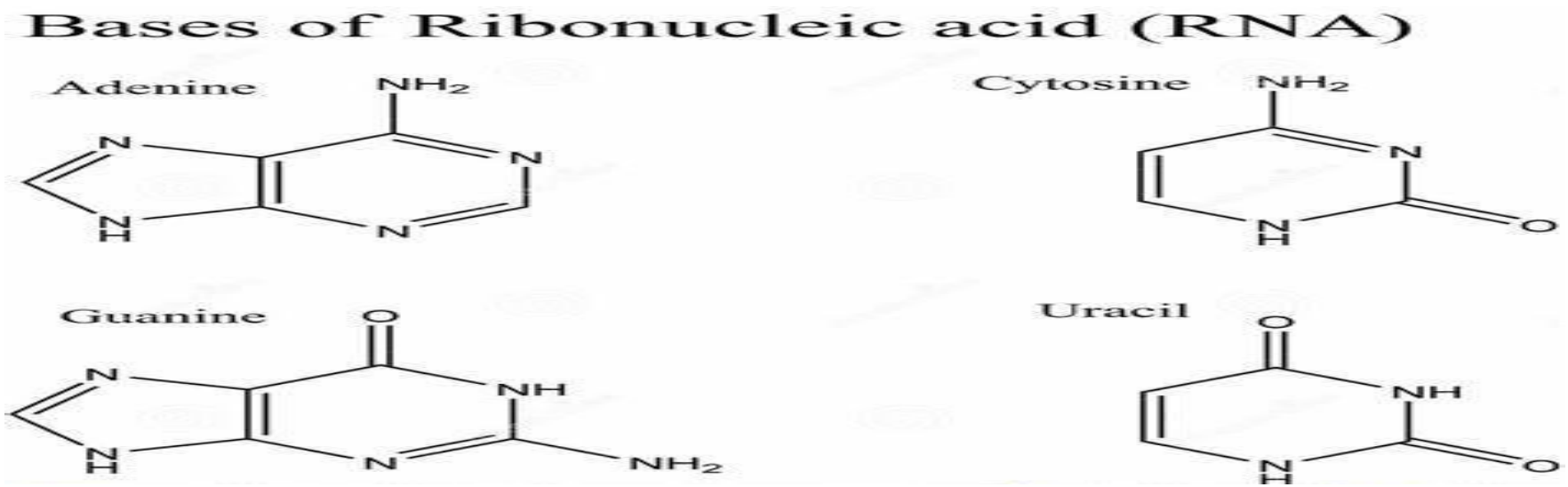
Why the DNA is a double Helix?

The double helix allows the 3 billion base pairs in each cell to fit into a space just 6 microns across.

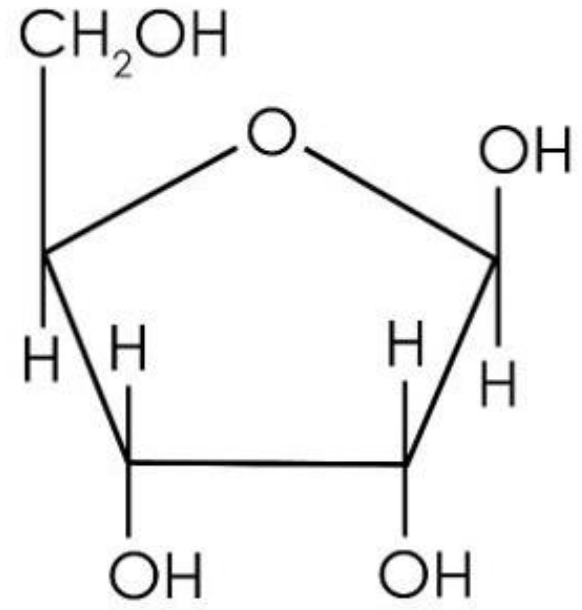
- If you stretched the DNA in one cell all the way out, it would be about 2m long and all the DNA in all your cells put together would be approximately 2.0×10^{13} meters which accounts ~3.3 of the diameter of the solar System.

1- RNA nucleobases

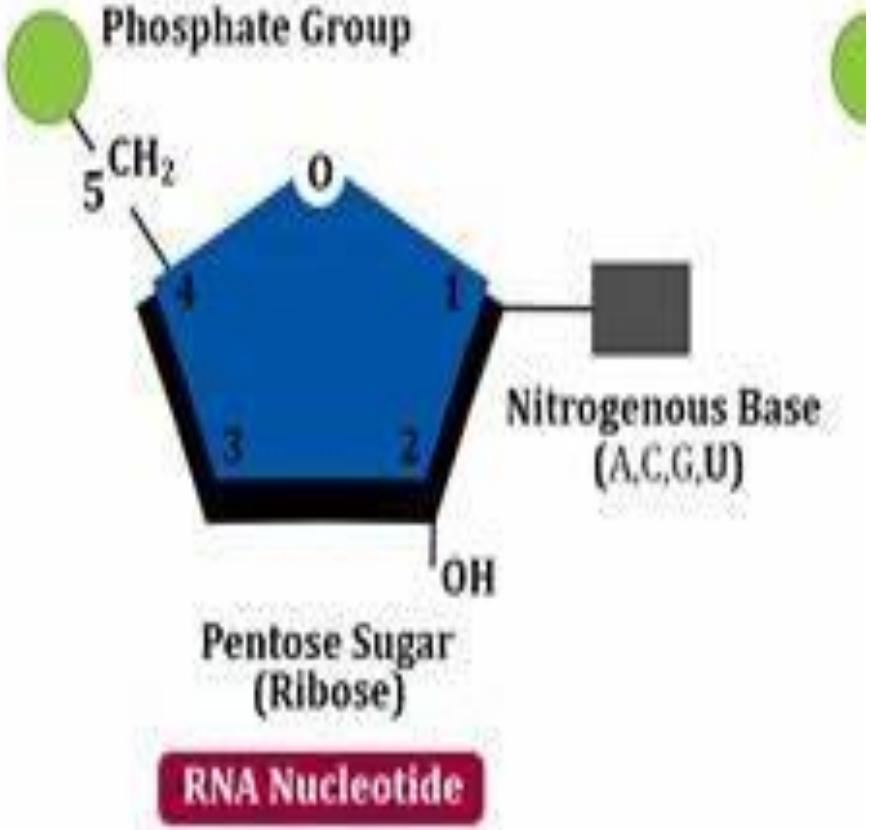
- **: The four nucleobases in RNA are Adenine**
- **, Guanine cytosine, and uracil.**



2-RNA pentose & 3- phosphate



Ribose (RNA)



RNA nucleotide :nomenclature

Ribonucleotides are basic monomeric building blocks for RNA.
There are 4 different ribonucleotides according to its nucleobases :

Base	RNA Nucleoside	RNA Nucleotide	DNA Nucleoside	DNA Nucleotide
Adenine (A)	adenosine	adenosine monophosphate (dAMP), adenosine 5′-monophosphate , adenylic acid , adenylate	Deoxyadenosine	Deoxyadenosine monophosphate (dAMP), Deoxyadenosine 5′-monophosphate , Deoxyadenylic acid , Deoxadenylate
Guanine (G)	guanosine	guanosine monophosphate (dGMP) ,guanylic acid guanosine 5′-monophosphate ، , guanylate	Deoxyguanosine	Deoxyguanosine monophosphate (dGMP) ,Deoxyguanosine 5′monophosphate ، Deoxyguanylic acid , Deoxyguanylate
Cytosine (C)	cytidine	cytidine monophosphate,cytidine 5′-monophosphate , ycytidylic acid , ycytidylate	Deoxycytidine	Deoxcytidine monophosphate, Deoxycytidine 5′ monophosphate , Deoxycytidylic acid , Deoxycytidylate
Uracil (T)	Uridine	Uridine monophosphate (dTMP), Uridine 5′-monophosphate , 5′-uridylic acid, Uridylate	Deoxythymidine	Deoxthymidine monophosphate (dTMP), Deoxythymidine 5′monophosphate , Deoxythymidylic acid , Deoxycytidylate

- Azacitidine is a chemical analogue of the nucleoside **cytidine**. **Azacitidine** is used for the treatment of certain leukemias. Acyclovir is a **guanosine** analogue.






THANK
YOU