The module: Molecules, Genes & Diseases (MGD)

Session 4
Lecture 7
Duration: 1 h.

Nucleotides and nucleic acids

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Session lectures 7 & 8 are in blackboard and you can find the material in: Albert Essential Cell Biology 3ed ed. 2010 Chapter 5.
Lippincott's Illustrated Reviews: Cell and Molecular Biology (2010) Chapters 6 & 7.

For more detailed instruction, any question, cases need help please post to the group of session.

Intended learning outcomes of Lecture 7:

At the end of this lecture you should be able to:

♦ Recognize the structural components of DNA and RNA molecules. **(LO.1)**

♦ Recognize and apply the conventions used to represent these components and the conventions used to represent DNA or RNA base sequences. **(LO.2)**

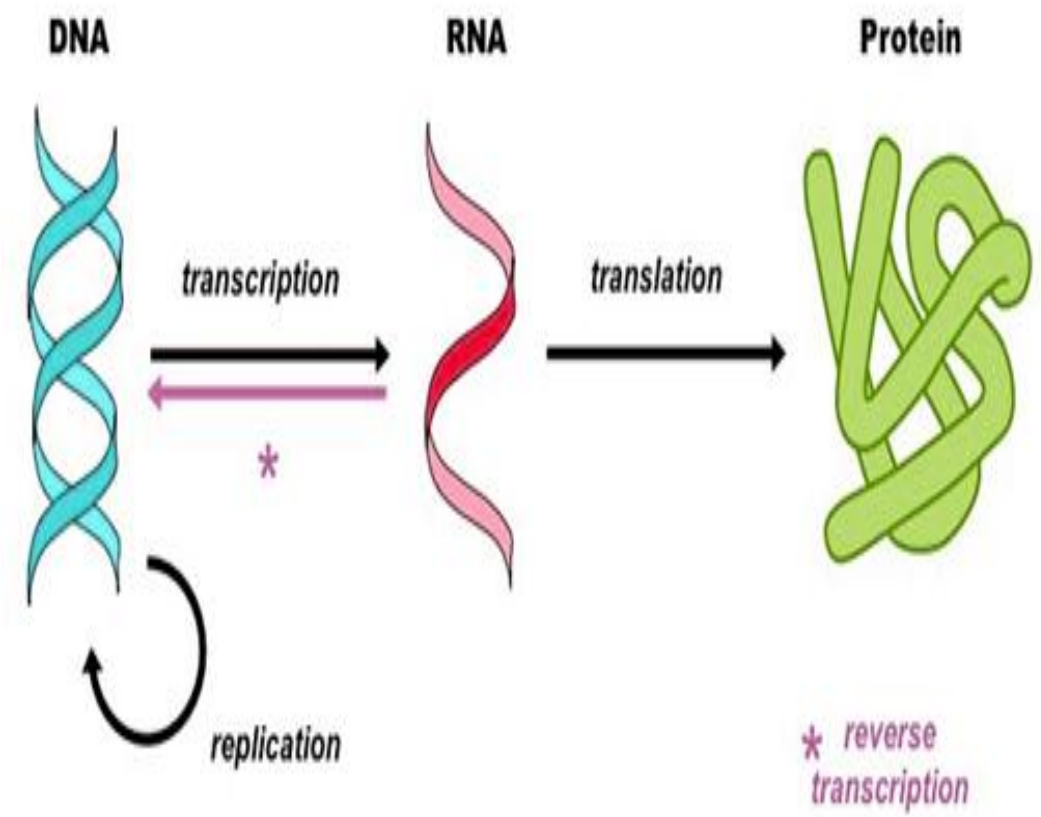
♦ Explain polarity of a DNA or RNA chain. **(LO.3)**

♦ Explain the importance of hydrogen-bonding and base-pairing in defining nucleic acid secondary structure. **(LO.4)**

♦ Describe the key features of the DNA double helix. **(LO.5)**

The Central Dogma of Molecular biology (LO.1)

In most organism DNA is the storage of genetic information with exception of RNA viruses.



The Central Dogma: is the flow of information from DNA to RNA to Protein

Genotype → Phenotype
Genes → Proteins

Retrovirus: ex : human immunodeficiency virus (HIV): The information flow:

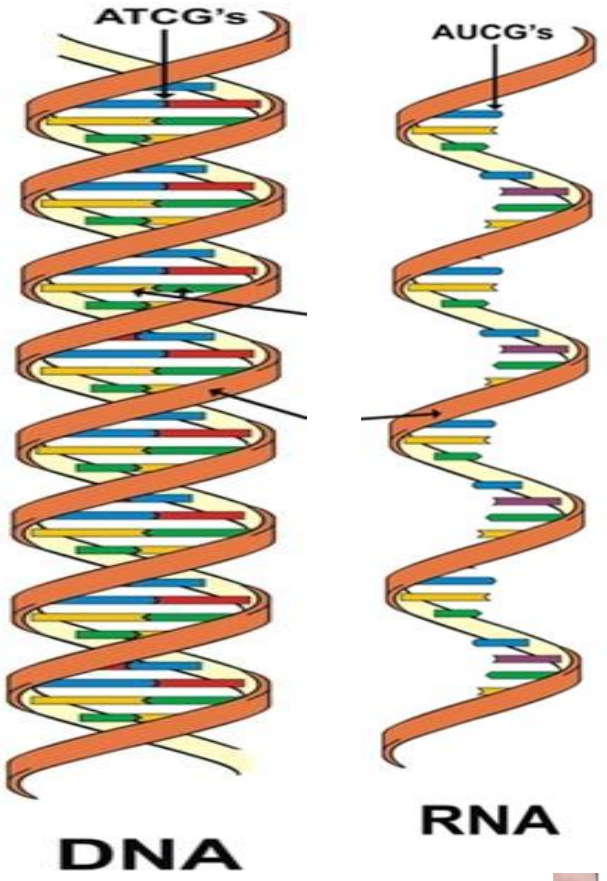
RNA —Reverse Transcription→ DNA → RNA → Protein
Genetic material

(LO.1)

The structural components of DNA & RNA molecule

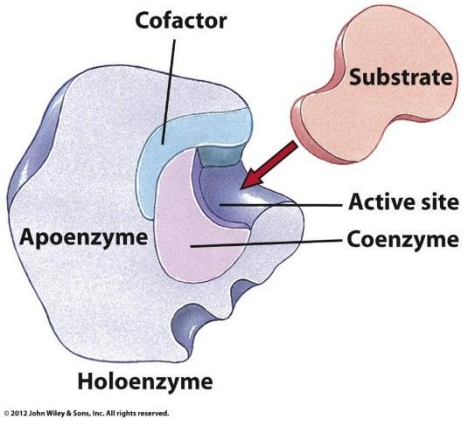
Nucleotides – the monomer or building blocks of nucleic acids (DNA & RNA).

☺ Also nucleotide serves diverse physiologic functions as protein synthesis, regulation & signal transduction.



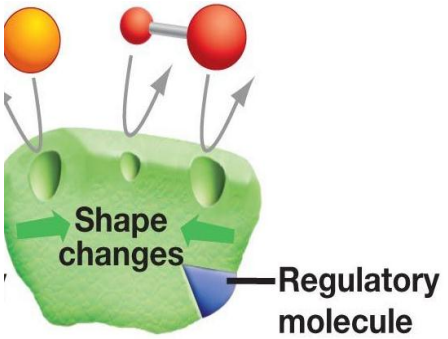
Biomedical importance of nucleotides: (LO.1)

- Form part of many coenzymes.

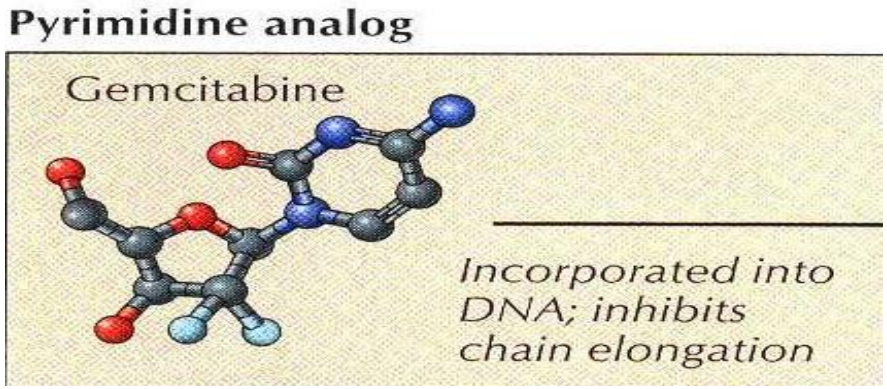


- Serve as donors of phosphoryl groups, sugars, or lipids.

- Regulation of enzyme activity.

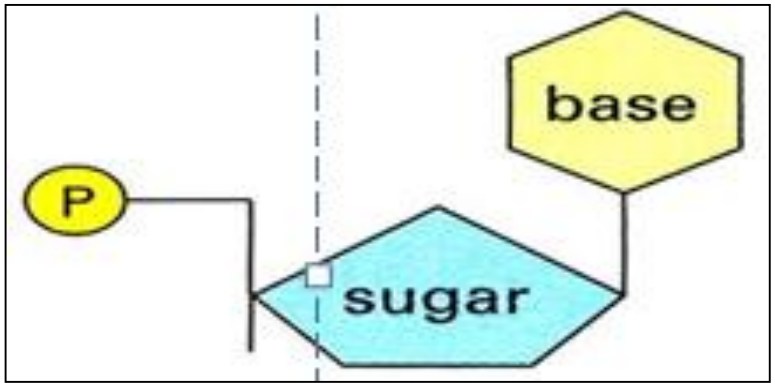


- Synthetic purine & pyrimidine analogs are employed for chemotherapy of cancer & AIDS (e.g., **azidothymidine)**. Also as suppressors of the immune response during organ transplantation.

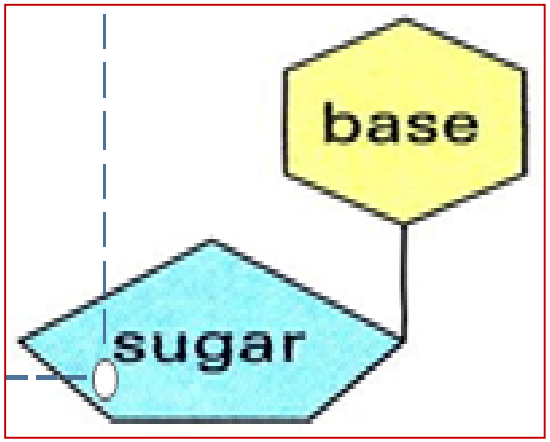


Nucleotide Vs. Nucleoside

(LO.1)



Nitrogenous base + Sugar + Phosphate= Nucleotide



Nitrogenous base + Sugar = Nucleoside

☺

Homework:

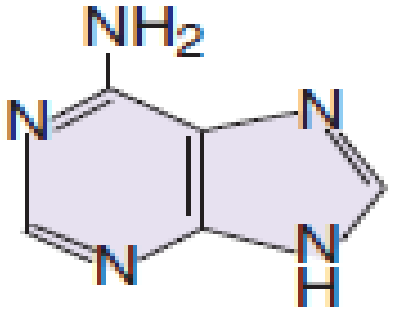
Nomenclature

Types of nitrogen bases in nucleic acids

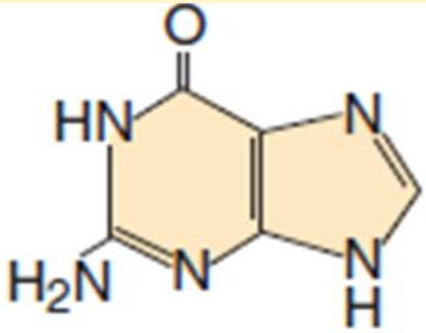
(LO.1)

☺ Folate derivatives participate in the biosynthesis of both purines and pyrimidines.
(Metabolism module)

Purines

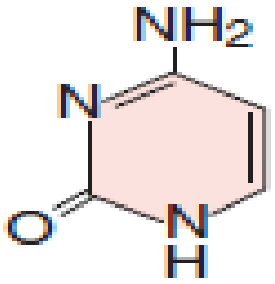


Adenine

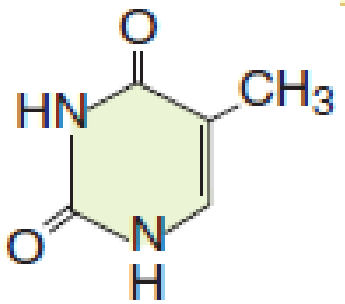


Guanine

Pyrimidines

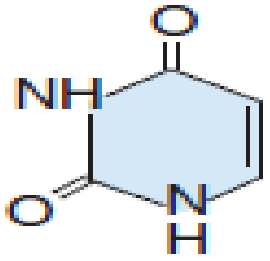


Cytosine



Thymine

DNA



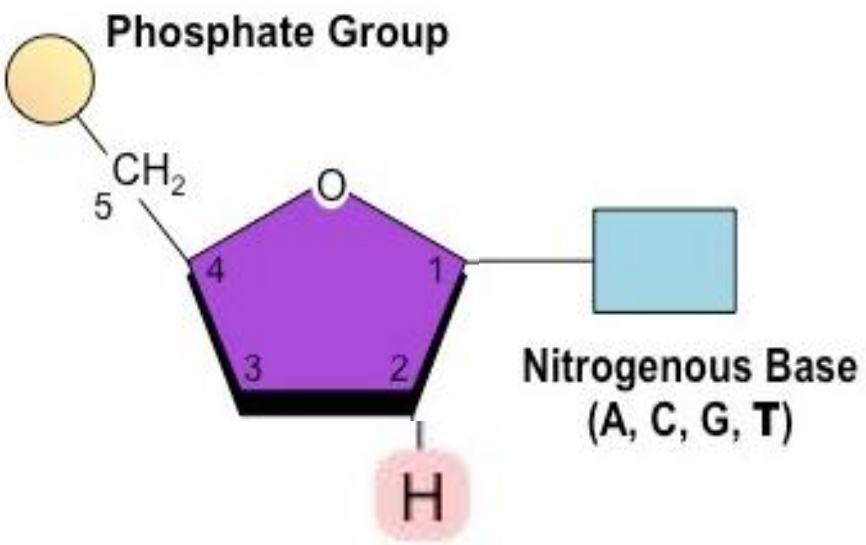
Uracil

RNA

instead of Thymine

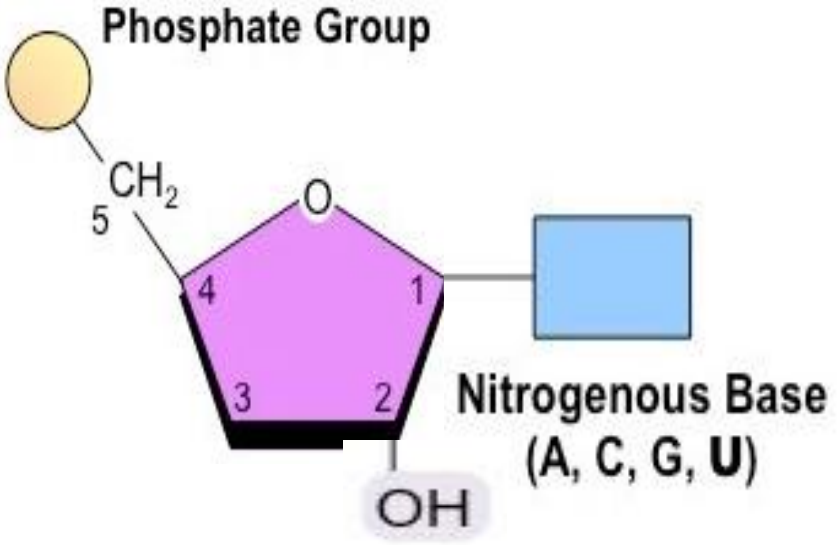
(LO. 1)

Type of sugar and nitrogen bases in DNA & RNA



Pentose Sugar
(Deoxyribose)

DNA Nucleotide

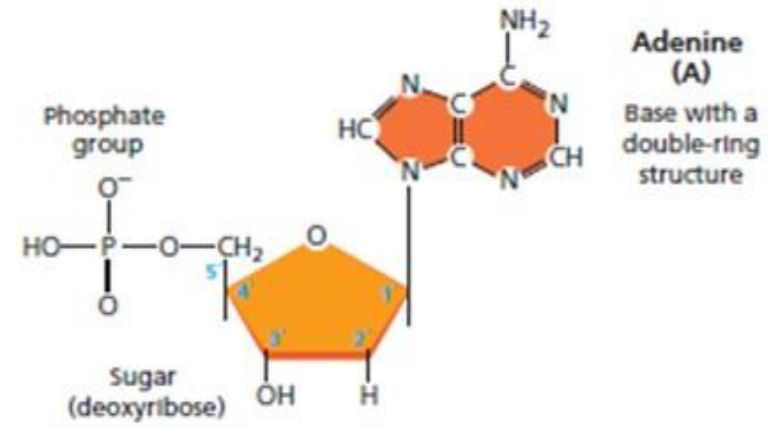


Pentose Sugar
(Ribose)

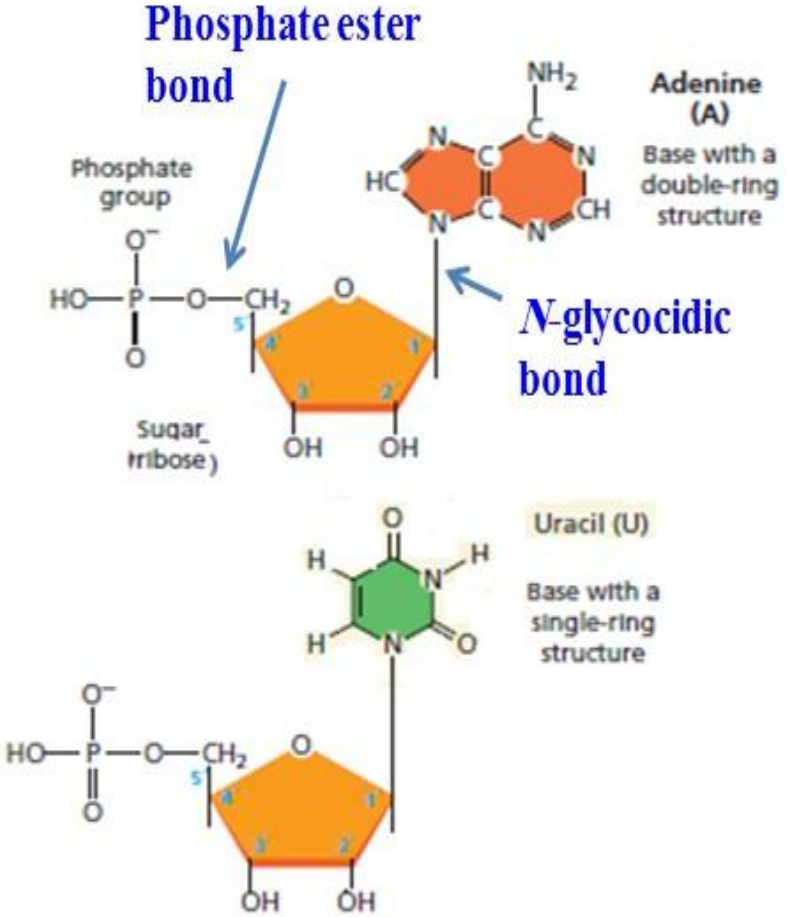
RNA Nucleotide

Nucleotides

(LO.1)



Deoxyribonucleotide in DNA

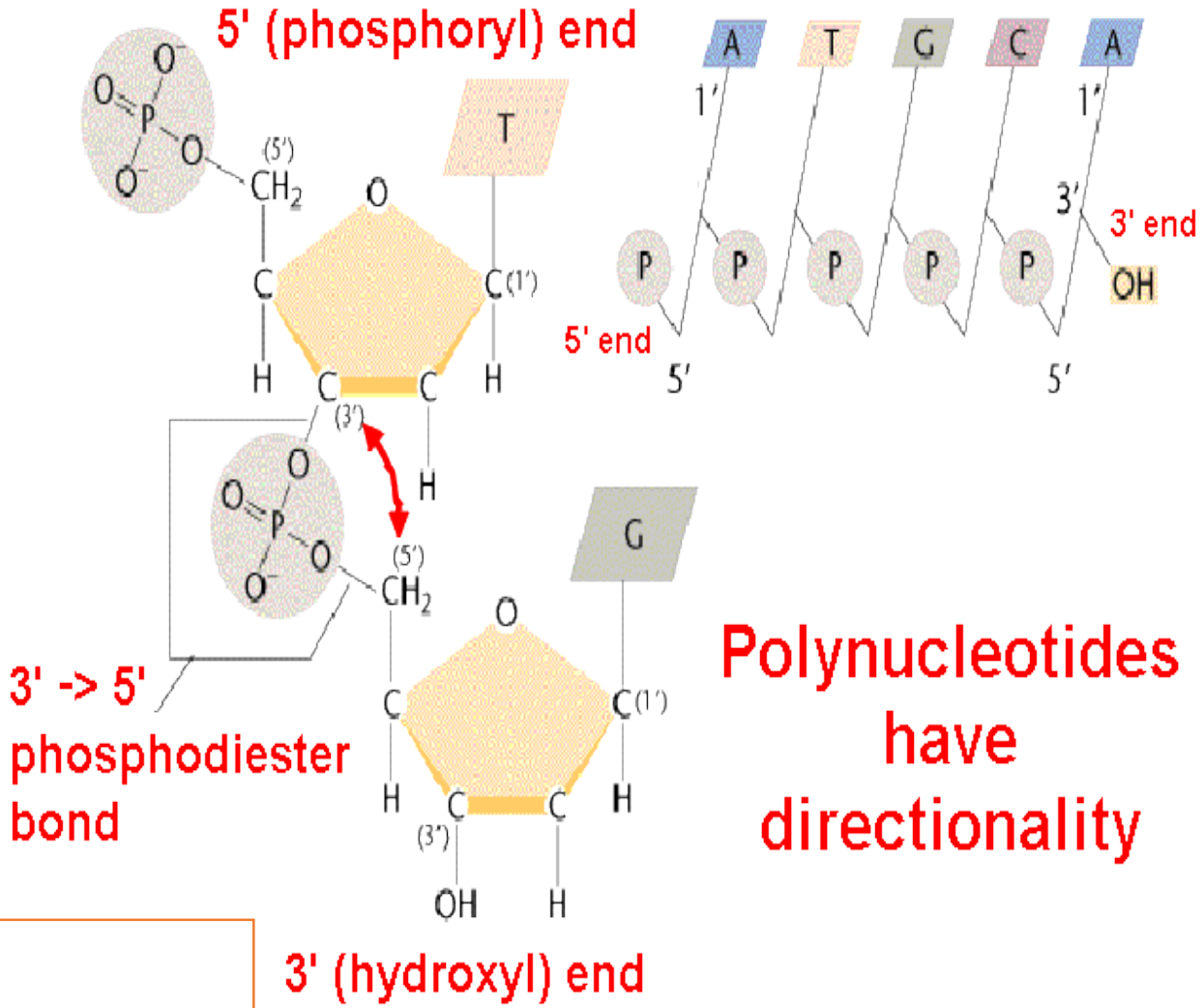


Ribonucleotide in RNA

Polynucleotides:

(LO.1)

Nucleotides are covalently linked together via **phosphodiester bonds.**



(after Klug & Cummings 1997)

☺DNA has two polynucleotides chains. RNA has only one.

(LO.2)

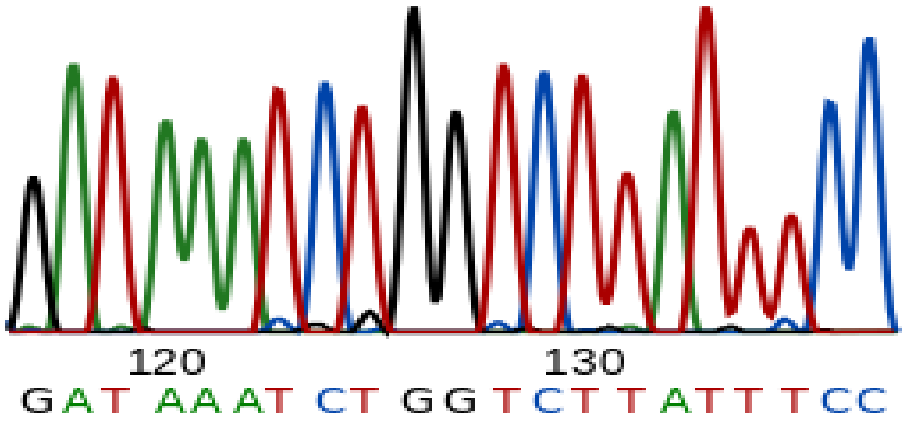
Nucleic acid sequence

is a succession of letters that indicate the order of nucleotides within a DNA or RNA molecule.

- Sequences are usually presented from 5’ end to 3’ end.
- Specifying the sequence is equivalent to defining the covalent structure of the entire molecule.

5’ AGTACG 3’

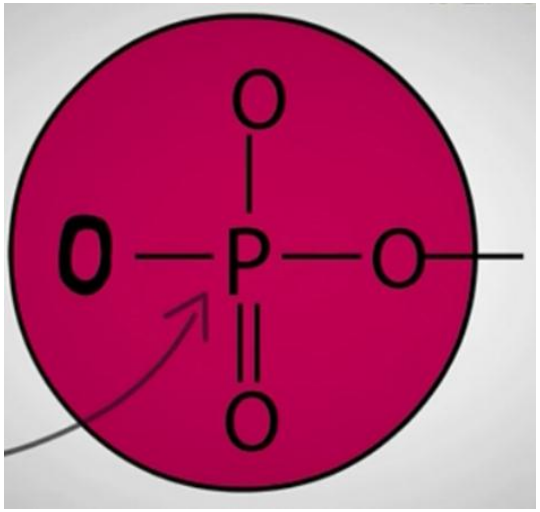
3’ TCATGC 5’

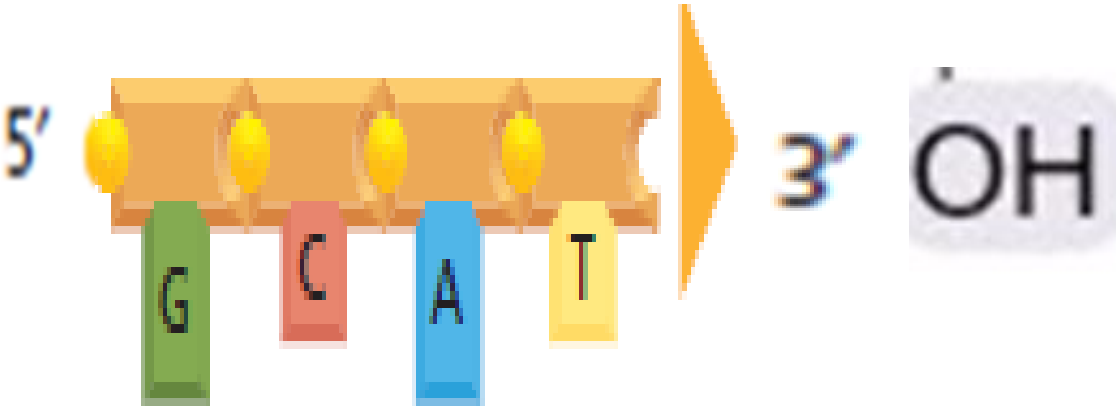


Polarity

(LO. 3)

Each single-stranded nucleic acid chain has a **polarity**, two distinct ends: a 5’ end with a free phosphate and a 3’end with a free OH-group.

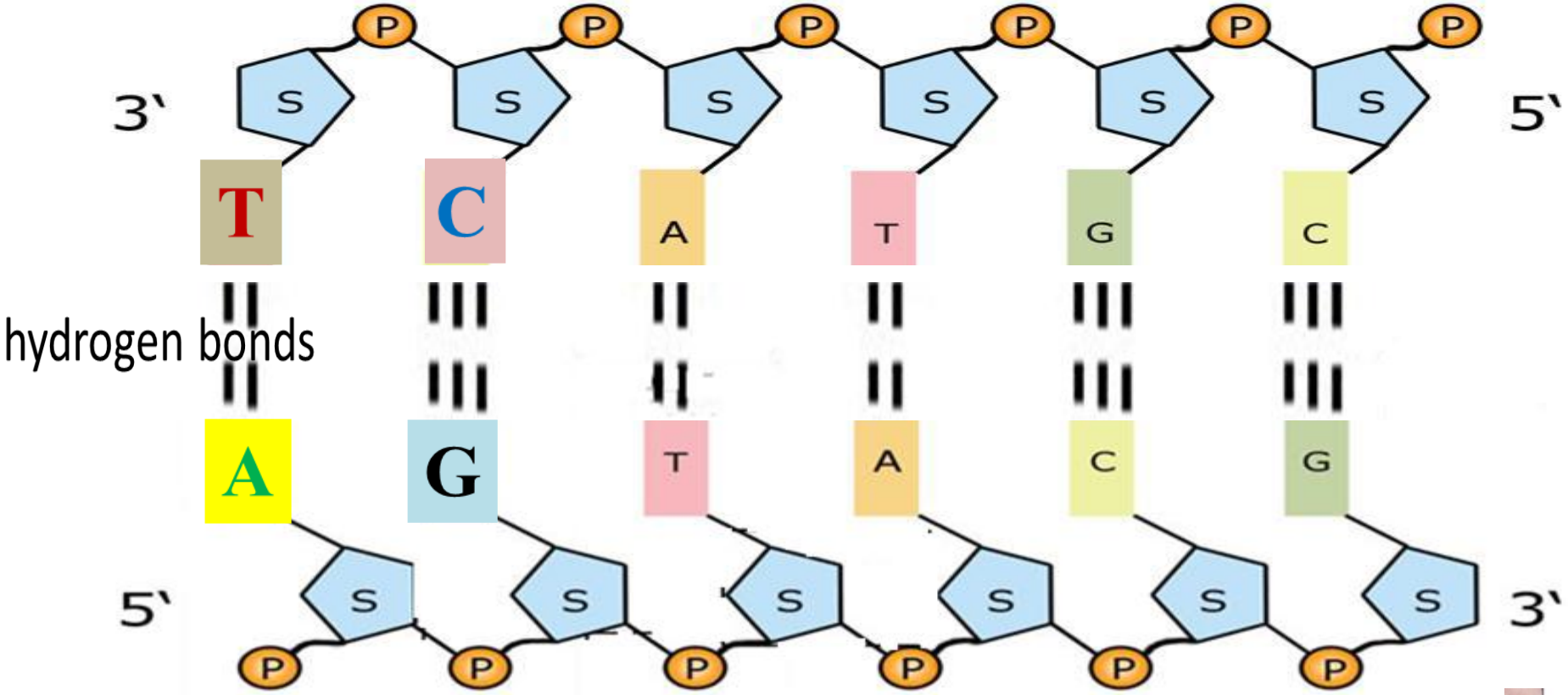




Hydrogen bonds:

(LO .4)

In double stranded nucleic acids the bases of each base pair is held together by hydrogen bonds, 3 hydrogen bonds in the GC-base pair and **2 hydrogen bonds for the AT and AU base pairs.!!!**



LO.4

Hydrogen bonds importance:

interact to stabilize and form the double helix structure.

Hydrogen bonds between bases can be made and broken easily, allowing DNA to undergo accurate replication and repair.

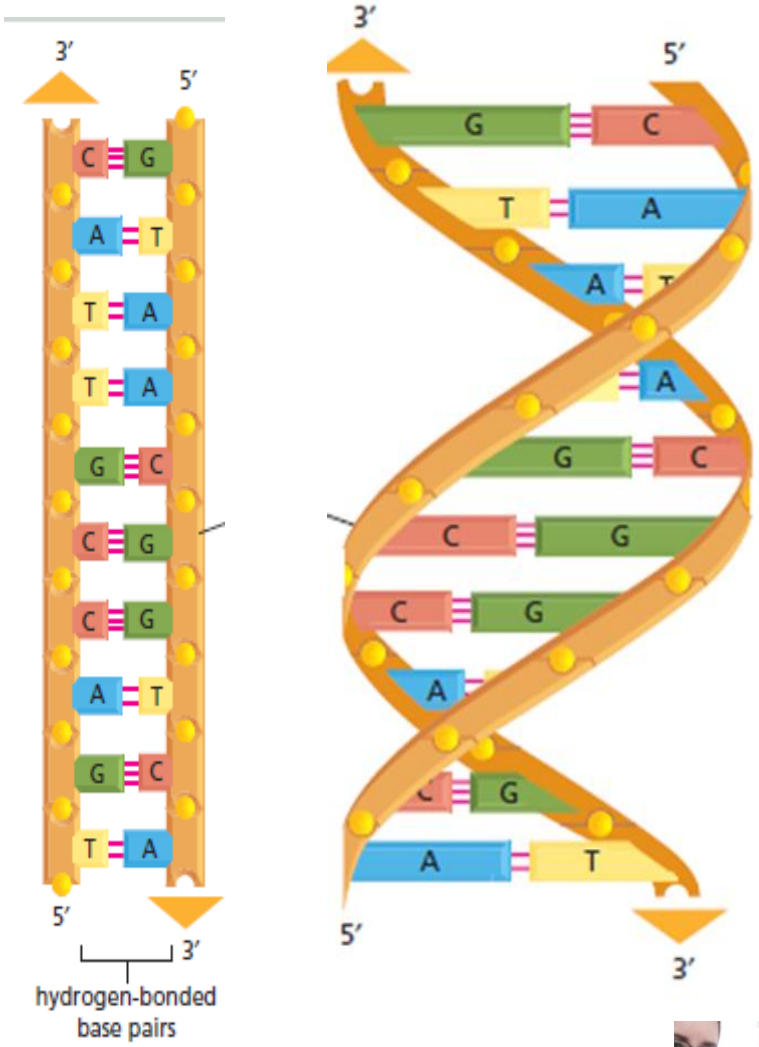
(disruption the hydrogen bonds between the paired bases using acidic or alkaline pH or heating).

Features of DNA double helix

LO.5

According to Watson and Crick model, DNA characterizes by:

- **DNA usually exit as double-stranded helix molecule.**
- **Antiparallel: DNA is composed of two polynucleotide chains running in opposite directions. (Why)?**
- **The chain run in 5'→3' direction,**



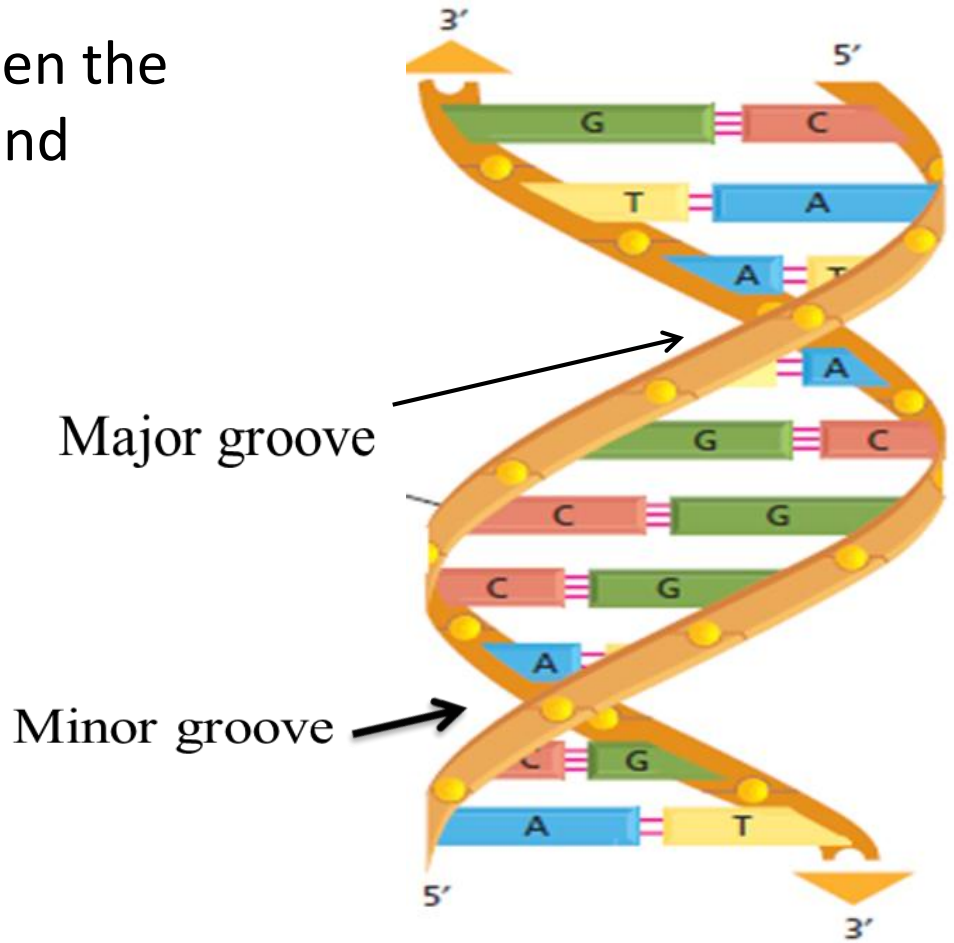
DNA double helix

LO.5

- The spatial relationship between the two strands creates—the major and minor grooves in DNA.

- **The hydrophobic** Base pairs are packed in the interior of the double helix.

- Each base pair is of similar width, thus holding **(the hydrophilic)** sugar–phosphate back- bones an equal distance apart along the DNA molecule.



LO.5

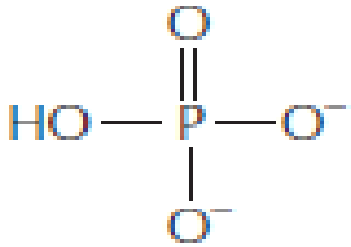
DNA double helix

► The members of each base pair can fit together within the double helix because the two strands of the helix run antiparallel to each other—that is, they are oriented with opposite polarities.

► The antiparallel sugar–phosphate strands then twist around each other to form a double helix containing 10 base pairs per helical turn.

➢ Negative charge of DNA helix:

The third -OH group on the phosphate is free and dissociates a hydrogen ion at physiologic pH.



Therefore, DNA helix has negative charges coating its surface that facilitate the binding of specific proteins(histones and non-histones).

DNA double helix (Homework)

LO.5

Describe the three forms of DNA

How many base pair present in each form?

Which form is considered the chief form in the cell?