PUC Ist yr SEMESTER-2

Unit II. Chemical constituents of living cells

Module No 11. Nucleic Acids

WHAT ARE NUCLEIC ACIDS

The nucleic acids are of fundamental importance to living organisms as they control all the cellular activities directly or indirectly through the synthesis of all cellular proteins, and hence of all cellular constituents. There are two types of nucleic acids namely deoxyribonucleic acids (DNA) and ribonucleic acid
(RNA). Both types of Nucleic acids are normally present in the nucleus of a cell. RNA is chiefly located in the cytoplasm outside the nucleus. They derive their name because of their primary occurrence in the nucleus and acidic nature.

A Swiss biochemist Friedric Miescher (1871) was the first to discover them associated with the proteins of the cell nucleus and gave the name nuclein. Altmann (1899) gave the term nucleic acid to replace the nuclein.

DNA is localised mainly in the nucleus as a part of chromosomes, it is also found in mitochondria, chloroplast and in other self reproducing cell organelles. RNA's bulk is found in the cytoplasm though some is also found in nucleus particularly in nucleolus with smaller amounts on the chromosomes and the nuclear sap. DNA is the hereditary material. RNA was in some way involved in protein synthesis and that DNA was involved in RNA synthesis.

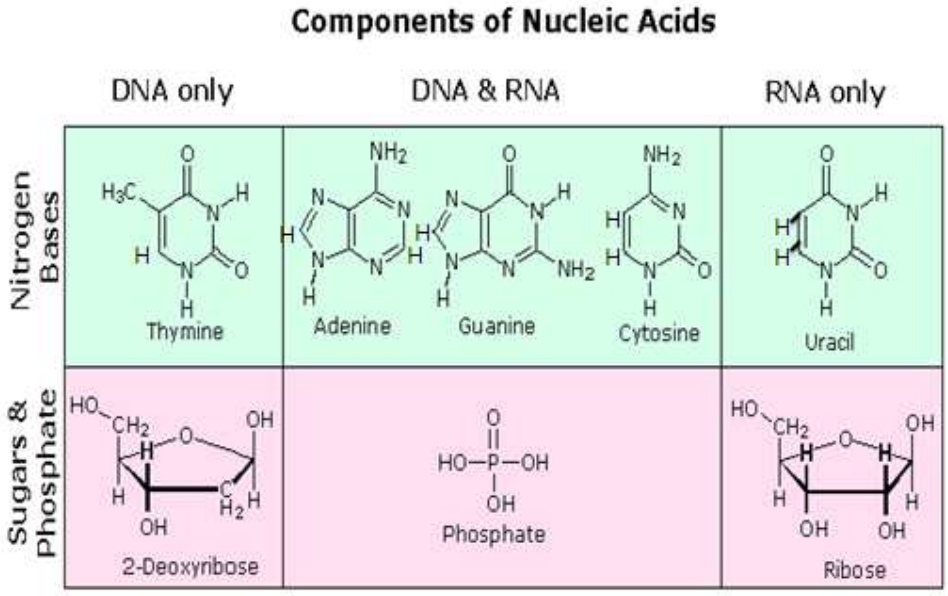
COMPONENTS OF NUCLEIC ACIDS

NUCLEOTIDE STRUCTURE

- Nucleic and molecule is a long chain polymer (polynucleotide) composed of monomeric units, called nucleotides. These nucleotides are the building blocks of nucleic acids. A nucleotide is the structural unit of nucleic acid and consists of a nitrogenbase, sugar and phosphoric acid.
- Each nucleotide includes three components:
    1. a ring-shaped molecule belonging to the class of purine or pyrimidine bases

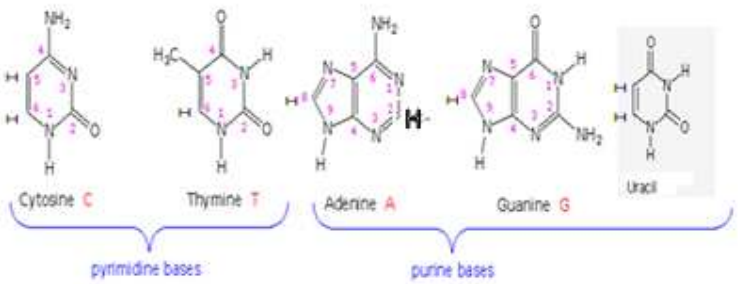
2. a 5-carbon, or pentose, sugar
3. one or more phosphate groups

Five nitrogen bases are involved in DNA/RNA. These bases belong to the class of purines and pyrimidines. The sugar is pentose called ribose. If one oxygen atom is less in this sugar it is deoxyribose sugar.



PURINES AND PYRIMIDINES

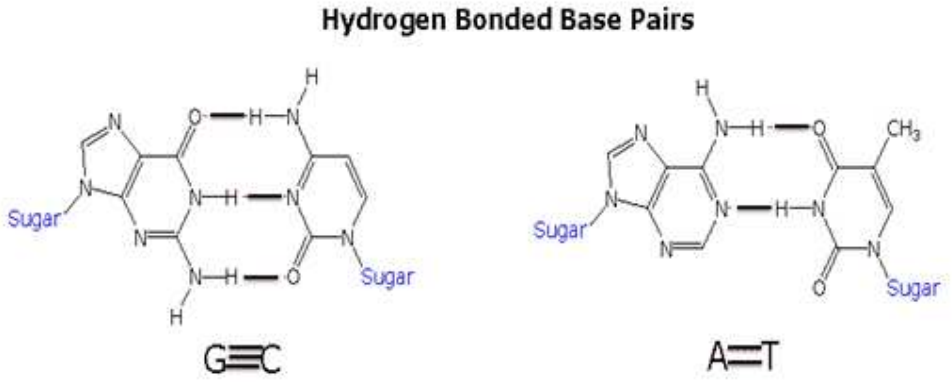
- Every nucleotide contains a nitrogenous base. These bases are classified as **purines** (These are two - ringed nitrogen compounds) and **pyrimidines** (a single ringed nitrogen compounds).
- In DNA, there are four different bases: **Adenine** (A) and **Guanine** (G) the purines. **Cytosine** (C) and **Thymine** (T) are the pyrimidines. These are frequently symbolized by their single letter abbreviations.
- RNA also contains four different bases. Three of these are the same as in DNA: Adenine, Guanine, and Cytosine. RNA contains **Uracil** (U) instead of Thymine (T).

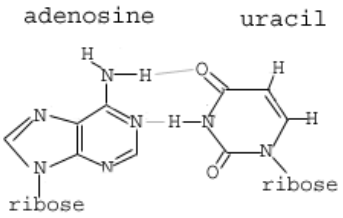


BASE PAIRING

In DNA, Adenine always pairs with Thymine, and Guanine always pairs with Cytosine. The pairing is the same in RNA except Uracil replaces Thymine. As a consequence of this pairing in DNA, there are always the same number of A and G residues and T and C residues. This is known as Chargaff's rule.

The result of this pairing is that two different nucleic acid molecules with complementary sequences wrap around each other to form a double helix. This is shown schematically in the picture.





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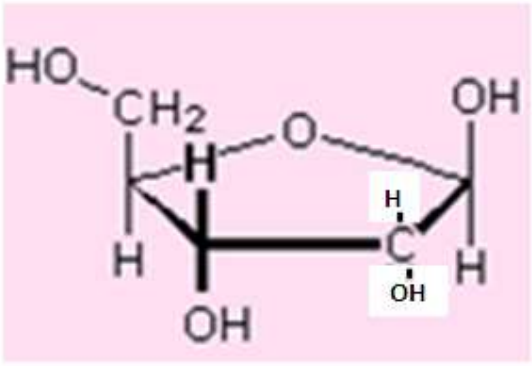
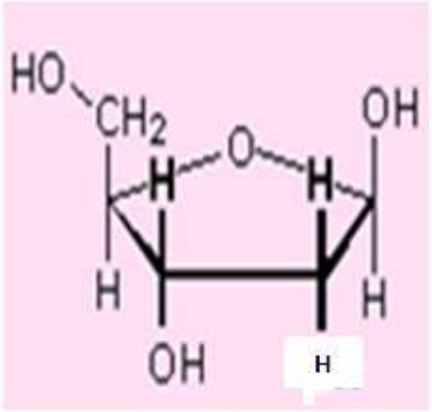
SUGARS: RIBOSE AND DEOXYRIBOSE

- The sugars found in nucleic acids are pentose sugars, with five Carbon atoms.
- Ribose, found in Ribonucleic acid (RNA), is a "normal" sugar, with one oxygen atom attached to each carbon atom.



α–D Ribose sugar

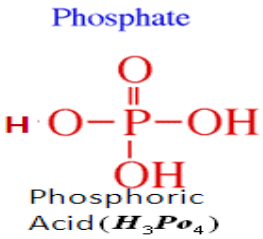
- Deoxyribose, found in Deoxyribonucleic acid (DNA) contains one oxygen atom lesser (at 2nd Position) than the ribose sugar present in RNA.



α -2-Deoxyribose sugar

PHOSPHATE

- Phosphate is a salt of phosphoric acid.

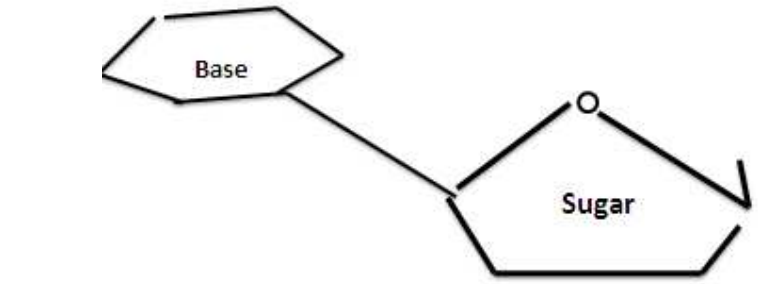


- Phosphate groups are joined together to form phosphoester bonds.
- A combination of a nitrogenous base and a molecule of sugar is called a **nucleoside**. When one or more phosphates are added to this nucleoside, it is known as **nucleotide**.

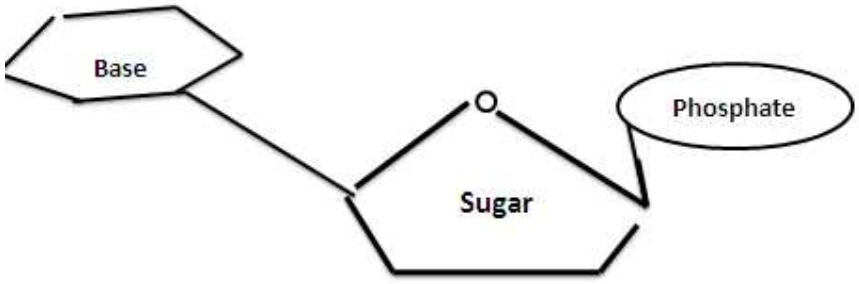
  Nucleotides formed with ribose are termed ribonucleotides, while those formed with deoxyribose are termed deoxyribonucleotides. There are four kinds of nucleotides in DNA.

  A. Deoxy adenylic acid
  B. Deoxy gyanylic acid
  C. Deoxy cytidylic acid
  D. Deoxy thymidylic acid

- The nucleotides bond to each other to form polynucleotide in DNA and RNA. Nucleic acids are linear polymers in which the nucleotides are linked together by means of phosphate diester bridges with the pentose sugar. These bonds link the 3 carbon in one nucleotide to the 5′ carbon in the pentose of the adjacent nucleotide. The back bone of nucleic acid consists of alternating phosphates and pentoses. The nitrogen bases are attached to the sugars of this backbone. The phosphoric acid uses two of its three acid groups in the 3`-5` diester links.

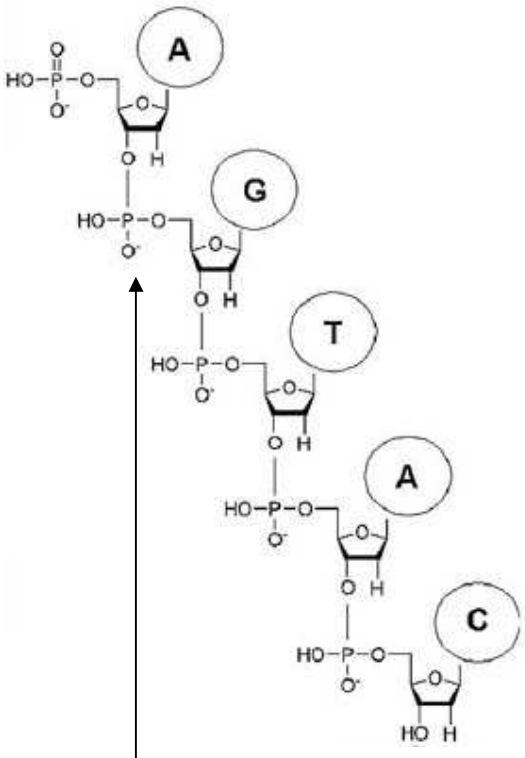


Nucleoside



Nucleotide

Nucleotide



Phospho diester bond

- Nucleotides typically have one, two, or three phosphate groups, and are named **monophosphate (α)**, **diphosphate (β)**, or **triphosphate (γ)** accordingly.

CHECK POINTS

1. The nucleic acids are very large molecules.
2. Deoxyribonucleic acid and ribonucleic acid are two types of nucleic acids found in living organisms.
3. Each nucleic acid is composed of three main parts. Sugar, nitrogenous bases and Phosphate.
4. The ribose or deoxyribose is the sugar component, purines and pyramidines are Nitrogenous bases, and phosphate is a salt of Phosphoric acid.
5. One purine form hydrogen bond with one pyramidine.
6. Adenine and guanine are purines and have two ringed structures.
7. Cytosine, thiamine and uracil are pyramidines and are made up of one ring structures.
8. Adenine always forms bond with thiamine or uracil and guanine with cytosine.
9. The sugar molecule bonds with base to form nucleoside.
10. The nucleoside bonds to phosphate with phosphate ester bonds and forms a nucleotide.

Short answer Questions:

1) Give an account of the components of nucleic acid.
2) What are the different nitrogen bases of a nucleotide?
3) How the structure of sugar is different in both nucleic acids.
4) Which bases are purines and Pyrimidines?
5) Write briefly about the different sugars which account for the structure of nucleic acids.
6) What is the role of phosphates in the structure of nucleic acids?
7) What is a nucleic acid and give types of nucleic acids.

Long answer Questions:

1) What are the bases present in nucleic acids and explain them.
2) Give details on the components of Deoxyribonucleic acid.

3) Explain about the structural importance of sugar, phosphate, purine and pyrimidines of ribonucleic acids.

Multiple choice questions:

1. DNA is made up of the bases A, T, ___, and cytosine.
   A. Guanine
   B. Lysine
   C. Glycine
   D. Glutamic acid

2. Components of DNA are
   A. Phosphate, ribose, pyrimidines, and purines
   B. Sulfate, ribose, pyrimidines, and purines
   C. Phosphate and nucleotides
   D. Phosphate, deoxyribose, pyrimidines, and purines

3. With which of the following does thymine form hydrogen bonds in DNA?
   A. Adenine
   B. Guanine
   C. Cytosine
   D. Uracil

4. With which of the following does Ademine form hydrogen bonds in RNA?
   A. Adenine
   B. Guanine
   C. **Uracil**
   D. Cytosine

5. The sugar that is found in DNA but not in RNA is _____.
   A. Ribose
   B. Deoxyribose
   C. Hexose
   D. None of the above

6. The combination of base and sugar is called _____.
   A. Nucleotide
   B. Nucleoside
   C. Nitrogen base
   D. None of the above

7. Purine bases are
   A. G & C
   B. A & T
   C. A & G
   D. T & C
8. RNA doesn't have
   A. Thymine
   B. Uracil
   C. Guanine
   D. Cytosine
9. Which of the following found only in RNA
   A. Adenine
   B. Uracil
   C. Cytosine
   D. Guanine
10. RNA differs from DNA is having
   A. Thymine in place of uracil
   B. Uracil in place of adenine
   C. Uracil in place of thymine
   D. Both thymine and uracil