15. BIOMOLECULES

iv) NUCLEIC ACIDS

- Nucleic acids are long chain biopolymer's of nucleotides with a polyphosphate ester chain.
- Proteins have polyamide chain combine with nucleic acids to gives nucleoproteins.
- Nucleoproteins present in living cells are
  (i) Ribonucleic acid (RNA)
- (ii) Deoxyribonucleic Acid (DNA)
- DNA on hydrolysis gives deoxyribose, phosphoric acid, pyrimidine and pureine bases.
- RNA on hydrolysis gives oxyribose, phosphoric acid, pyrimidine and pureine bases.
- These are phosphorus rich biomolecules made of *nucleotides.*
- **Altmann** gave the term *Nucleic acids*.
- These are of two types known as **DNA** and **RNA.**

Deoxyribonucleic Acid (DNA)

- It is mainly present in *chromosomes* and a little amount in *Chloroplast* and *Mitochondria.*
- It is *genetic material* in all organisms except in plant viruses.
- It is referred as ***chemical basis of heredity***.

Structure:

- **Watson** and **Crick** gave the structure of DNA in 1953 by considering the above facts. For this they were given *Nobel Prize* in 1962.
- Each strand shows **5′→ 3′** polarity and consists of many nucleotides. They run *antiparallel* to each other.
- It is tightly coiled in the chromosomes.
- Each nucleotide is a *deoxyribonucleotide* and consists of a pentose sugar **Deoxyribose** ($C_5H_{10}O_4$), a **phosphate** and a **nitrogen base**.
- Nucleotide without phosphate is known as *Nucleoside*.
- Alternate arrangement of phosphate and deoxyribose sugar forms the *backbone* of each DNA strand. *Phospho diester bonds* exist between the sugar and phosphate.
- A nitrogen base is attached to the sugar by glycosidic bond towards the interior of strand.
- Nitrogen bases are of two types known as *Purines* and *Pyrimidines*.
- Purines are *heterocyclic* compounds and have two **C-N** rings. They are **Adenine** and **Guanine**.
- Pyrimidines are *homocyclic* compounds and have only one C-N ring. They are **Cytosine** and **Thymine.**
- **A**denine of one-strand pairs with **T**hymine of another strand and **two** hydrogen bonds are formed between these two.
- Similarly **G**uanine pairs with **C**ytosine and **three** hydrogen bonds are formed between these two.
- AT/GC ratio varies from species to species.

- AT/GC ratio is 1.52 in human 0.93 in E.coli.
- AT and GC are called as *complementary* nitrogen base pairs.
- Complementary nitrogen base pairs with hydrogen bonds between them form the **steps** or **rings** of the molecule.
- The length of DNA molecule is variable. Its diameter is **20A°**.
- Length of *each spiral* of DNA is **34A°**. Each spiral has **20** nucleotides with **10** in each strand.
- The distance between adjacent nucleotides is **3.4A°** and the angle between them is **36°**.

Functions of DNA

- It has two functions known as Autocatalysis and Heterocatalysis.

1. Autocatalysis:

- Duplication of a DNA molecule into two-daughter DNA molecule is called as *Autocatalysis* or *Replication.*
- In this process the two strands of DNA unwind by the action of **Endonucleases**, which break the hydrogen bonds between the two strands.
- The unwinding starts at one end and advances towards the other end.
- Each strands acts as *template* on which a new strand is synthesised by the action of **DNA polymerase**. In this way two daughter DNA molecules are formed which resemble each other.
- Since one of the parental DNA strand is retained in each daughter DNA molecule, it is called as *semi conservative* mode of replication.
- One stand of DNA is synthesized discontinuously in small pieces which are finally joined by enzyme called **DNA ligase** to the other continuously chain.
- The genetic information of human cell is contained in 23 pars of chromosomes.
- Chromosomes is composed by several thousand genes or segments of DNA.
- Human gene contains 2.9 billion base pairs.
- DNA promotes the synthesis of proteins and regulates various biochemical reactions of the cell.
- In this process the DNA template transfers the genetic information in the form of code words to messenger RNA. This process is called as **Transcription** that helps in the synthesis of proteins.
- Replication takes places at a region of the molecule where the stands separates is called a replication fork.

$$\text{DNA} \xrightarrow[\text{duplication}]{\text{replication (or)}} \text{DNA} \underset{\text{reverse transcription}}{\overset{\text{transcription}}{\rightleftharpoons}} \text{RNA} \xrightarrow{\text{translation}} \text{Proteins}$$

Ribonucleic Acid (RNA) :

- It is mainly present in *ribosomes* and small amounts in *mitochondria* and *chloroplasts.*
- It is synthesised in the nucleous and later released into the cytoplasm.
- It is of two types known as *genetic* and *non-genetic* RNA.
- Genetic RNA is present in many plant viruses such as *Tobacco Mosaic Viru*s (**TMV**).
- Non-genetic RNA is involved in protein synthesis.

Structure of RNA :

- It is usually *single* stranded. It is double stranded in some viruses such as ***Reo virus*** and ***Wound Tumour virus***.
- Strand is made of many Ribonucleotides. Each nucleotide has a phosphate group, a **Ribose** sugar ($C_5H_{10}O_5$) and a Nitrogen base.
- The nitrogen bases are **Adenine, Guanine** (Purines) and **Cytosine** and **Uracil** (Pyrimidines).
- Uracil differs with Thymine in lacking *methyl* (**CH_3**) group.
- Purines and Pyrimidines *do not* exist in 1: 1 ratio.
- Hydrogen bonding is uncommon.
- It has 80 to few thousand nucleotides.

Types of RNA :

- There are three types of RNA known as *messenger* RNA, *ribosomal* RNA and *transfer* RNA.

1. Messenger RNA:

- It has an unfolded **linear** strand consisting of *few hundred* nucleotides.
- It is synthesised on DNA strand (template). This process is called as *Transcription*.
- It accounts for **5 – 10%** of total cellular RNA.
- Its molecular weight is **5,00,000** Daltons.
- It is *most unstable* RNA with a life span of **2** minutes in prokaryotes and up to **4** hours in Eukaryotes.
- It carries protein synthesis information in the form of *codons* from DNA to ribosomes.
- Codons are triplets. A set of three adjacent nucleotides or nitrogen bases on the m-RNA is called as *Codon.*
- There are **64** codons formed by the four nitrogen bases. Out of these **61** are sense codons and the remaining **3** are nonsense codons (**UAA, UAG** and **UGA**).
- The *first* codon of messenger RNA is **AUG** or **GUG**.
- UCA on mRNA codes for the amino acid serine and CAG codes for glutamine.
- More than one codon can code for the same amino acid.
- CUU and CUC can both code both for Leucine.
- Codons synonymous and genetic code is degenerate.
- Mutations can cause the change in the sequence of amino acids.
- Three complimentary nucleotides for recognition of the triplets in m-RNA (anticodon).
- The features of genetic code are (i) it is universal (ii) it is commaless (iii) its degenerate (iv) third base in the codon is not specific.

2. Ribosomal RNA:

- It is *most stable* RNA.
- It is single stranded and usually *folded* to form *pseudo* helices.

- At the helices, it shows hydrogen bonding between the complementary nitrogen bases of the same strand.
- It is the *largest* RNA.
- It helps in maintaining the structure of Ribosomes and perhaps involves in protein synthesis.

Transfer RNA:

- It is also known as **Soluble RNA** or **Adaptor RNA**.
- Transfer RNA helps in bringing the *amino acids* from cytosol to ribosomal surface at the time of protein synthesis.

Nucleosides and Nucleostides :

Nucleosides :

- The molecules in which one of the nitrogen bases (purine or pyrimidine)is bonded with a sugar molecule is called **nucleoside.**

Base + Sugar = Nucleoside

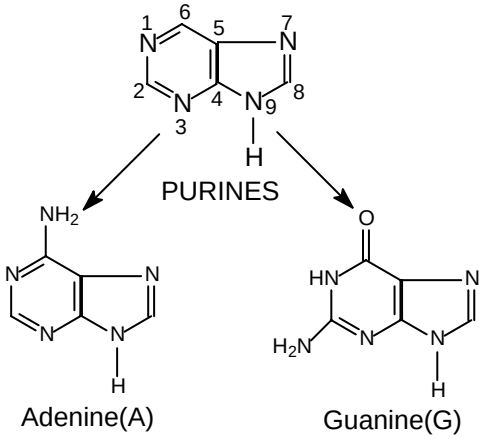
Nucleotides :

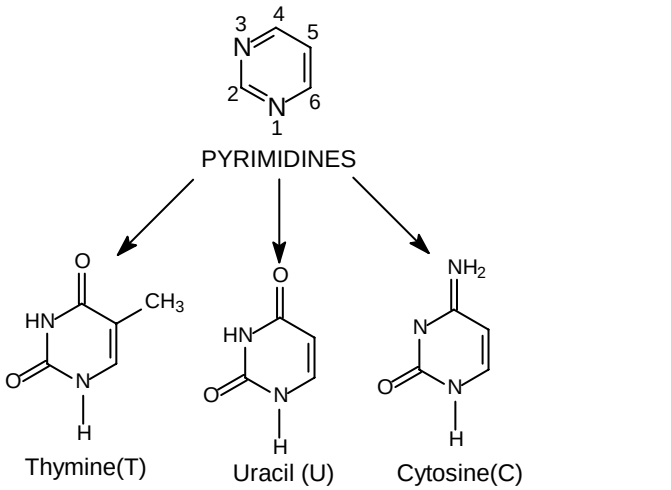
- When the phosphate group is attached to the nucleoside, the compound formed is called **nucleotide.**

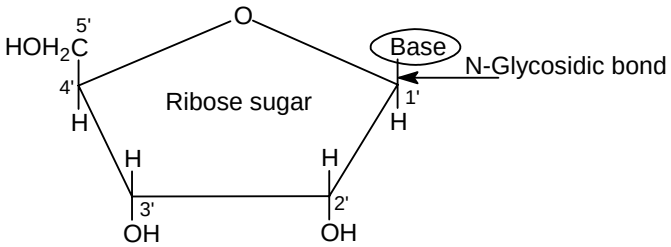
Base + Sugar + Phosphate = Nucleotide

- the sugar in RNA nucleoside is **ribose** while the sugar in DNA nucleoside is **deoxyribose.**

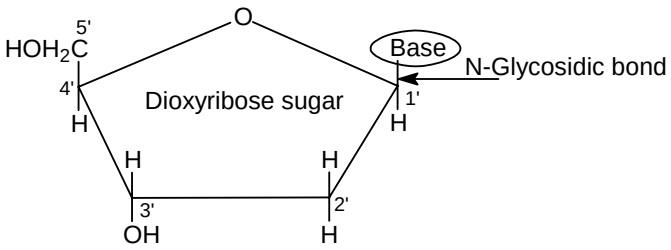
Bases :



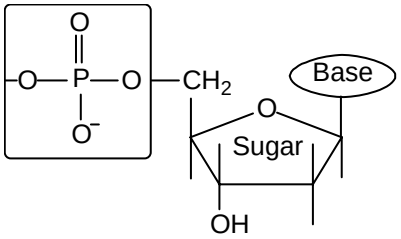


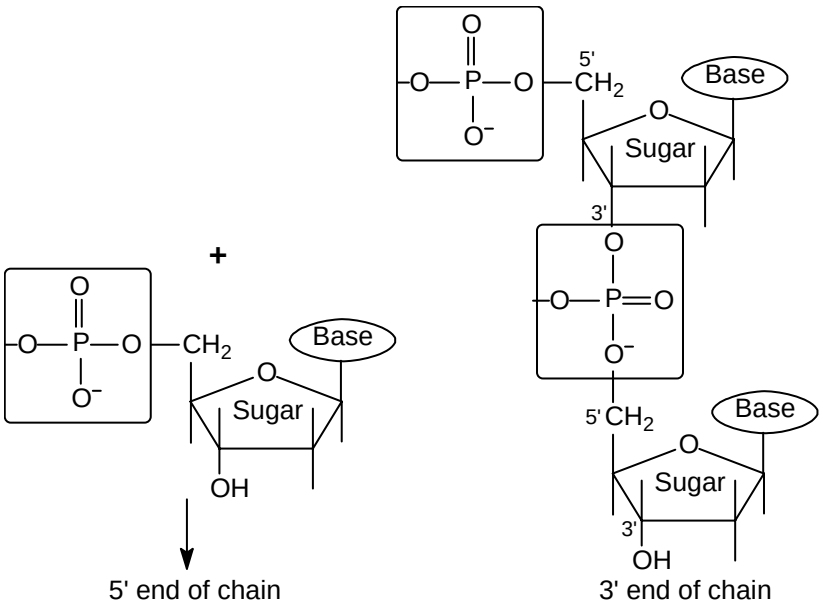


Nucleoside from RNA



Nucleoside from RNA




O
O—P—O
O⁻
CH2
Base
O
Sugar
OH
+
5' end of chain
5'
3'
O—P═O
3' end of chain