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CHEMICAL STRUCTURE OF DNA

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Abstract

DNA (Deoxyribo nucleic acid) is a genetic biomolecule that contains the genetic informations for all living organisms. It's a double helix, a twisted Ladder like structure, located in the nucleus of a cell and mitochondria . In DNA genetic informations are stored in coded language it passes from one generation to next, responsible for the development , function and reproduction of an organism. DNA is a polymer made up of nucleotides , each containing deoxyribose sugar , a phosphate group and base pairs , forming a double helix structure .DNA contains two strands which is made up of nucleotide that is called polynucleotide strands held together by covalent bond and form the building block of DNA . Both strands run in antiparallel direction so it provides specific directionality and polarity to the molecule .In nucleotide the base pairs are held together by hydrogen bond Adenine (A) always pair with Thymine (T) and Guanine (G) always pair with cytosine (C).According to Chargaff's rule A=T and G=C .DNA contain one major and one minor groove, major groove deep and wide, other side minor groove is narrow and shallow. The major process is the interaction of DNA with protein that is through the minor and major groove, this process plays a crucial role in DNA replication and transcription. Further thousand of shorter segments of DNA combined together and form chromosomes, that are shorter fragments called genes . Each gene stores information in coded language for the formation of protein.

Keywords: Genetic Biomolecule; Double helix; Twisted ladder; Deoxyribose sugar; Nucleotides; Chromosome; Polymer

1. Introduction:

DNA was first identified by biologist Johannes Friedrich Miescher in 1869 in white blood corpuscles. The double helix ladder-like structure of a DNA molecule was later discovered by James Watson and Francis Crick. This structure is also called twisted ladder because it looks like a spiral ladder. Structure composed of two polynucleotide strands that run in opposite directions (antiparallel manner), so that the DNA helix has Directionality in nature. The Backbone of the ladder is made up of sugar-phosphate groups held together by Phosphodiester Bond. The another unit of helix is nucleotide which is composed of nitrogenous base pair, pentose sugar and phosphate group. Base pairing always done in complementary manner means that Adenine always pairs with Thymine (A-T) and Cytosine always pairs with Guanine (C-G) through hydrogen bonding. So structure always follow Chargaff's rule, it says that the amount of purines always equal to the amount of pyrimidines. Adenine forms two hydrogen bonds with thymine while Guanine forms three hydrogen bonds with Cytosine. Double helix structure contains major and minor grooves in alternate manner on its surface. The major groove is large and deep while the minor groove is narrow and shallow. They both provide surface for protein binding. It provides flexibility to DNA helix and play important roles in DNA replication, transcription and protein synthesis. There are two types of DNA that are prokaryotic and eukaryotic DNA. Prokaryotic DNA is found in the cytoplasm of the nucleoid region. It is double stranded, circular and lacks introns. Eukaryotic DNA is linear and double stranded found in the nucleus. It contains non coding region introns and also bound with histone protein.

2. Chemistry of DNA:

2 (i). Sugar- Phosphate backbone:

The sugar-phosphate backbone forms the double helix structural framework of nucleic acids (DNA and RNA). This backbone is composed of alternating sugar (deoxyribose) and phosphate groups, linked together by covalent bond called

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phosphodiaster bond forming a chain and defines directionality of the molecule. This backbone provide structural support, stability and maintain shape of DNA.

2 (i) (a). Phosphodiester Bonds

The phosphate group of one nucleotide and sugar group of the next nucleotide link together and form this specific covalent bond.

2 (i) (b). Hydrophilic Nature

The phosphate group is a negative charge molecule so provides the backbone negatively charged and hydrophilic (water loving) in nature.

2 (i) (c). Directionality

The backbone of DNA is directionality in nature that is 5' to 3' direction. It is a specific polarity with one end of strand having free phosphate group linked to the 5' carbon of sugar and other end having free hydroxyl group linked to the 3' carbon of sugar that is called 5' to 3' orientation. Both the strand runs in antiparallel direction.

2 (ii). Nucleotide:

A nucleotide contains three basic units as shown in **Fig. 1.** a nitrogenous base, a pentose sugar (either ribose or deoxyribose), and one or more phosphate groups. These units are covalently bonded to each other and form the building blocks of DNA and RNA.

2 (ii) (a). Nitrogenous Base

Nucleotide comprises either Pyrimidine or Purine base .DNA double helix models contain Adenine (A), Guanine (G), Cytosine (C), and Thymine (T) base pairs. Adenine (A) always pairs with thymine (T) and have two hydrogen bonds and guanine (G) always pairs with cytosine (C) and have three hydrogen bonds.

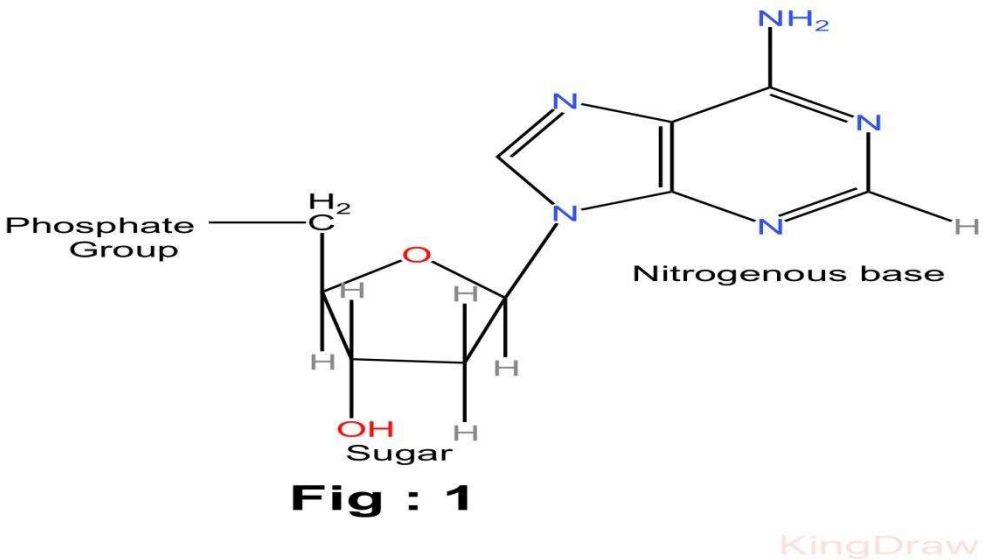

Figure 1: Structure of nucleotide.

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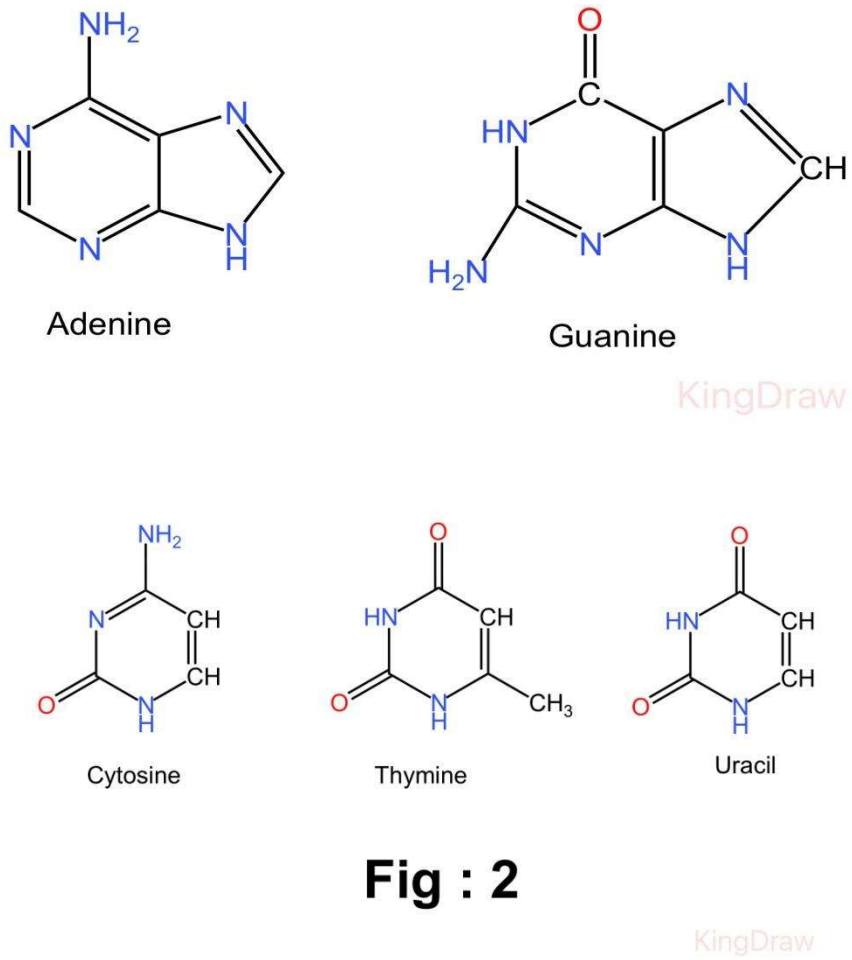

Figure 2: Structure of nitrogenous base pairs

2 (ii) (b). Sugar

A nucleotide carries a pentose sugar in DNA and RNA. DNA (Deoxyribonucleic acid) comprises deoxyribose sugar and RNA (Ribonucleic acid) comprises ribose sugar.

A nitrogenous base chemically bonded with sugar is called deoxyribose sugar.

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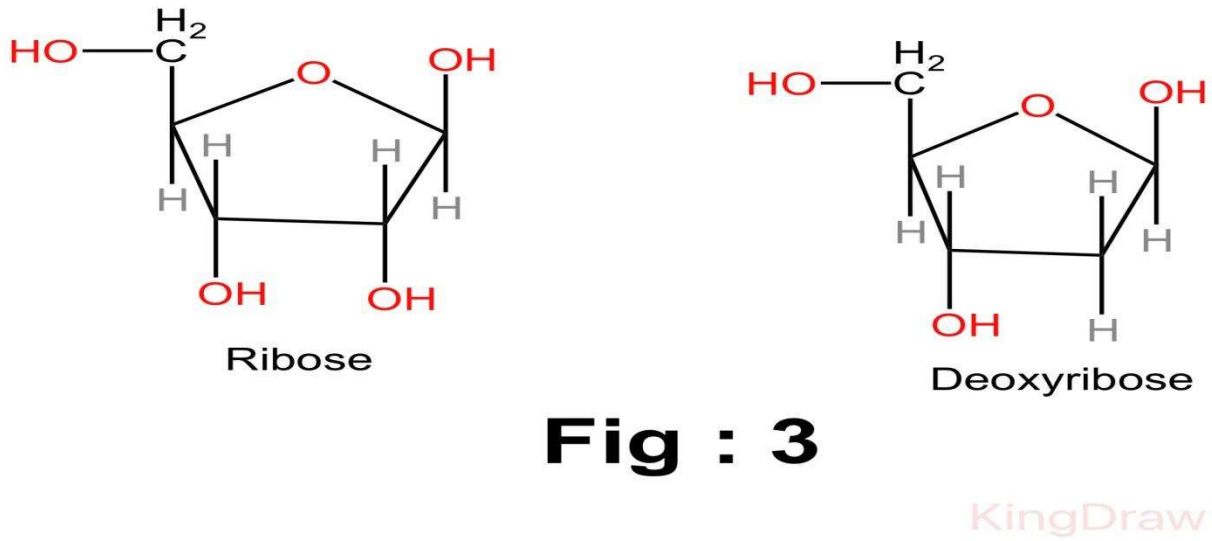

Figure 3: Structure of deoxyribose and ribose sugar molecule

2 (ii) (c). Phosphate-

A phosphate group is a phosphorus atom bonded to four oxygen atoms, but it play important role in the structure of nucleic acid. In DNA and RNA along with pentose sugar and base pairs, phosphate also forms the basic core. As part of energy carriers, like ATP, it provides energy for the movement of muscles.

2 (iii). Major and Minor Grooves:

It is the structural property of DNA double helix model, during twisting of both the strands , irregular base pairing occurs and formation of specific grooves takes place called major and minor grooves .It's provide structural flexible to the helix. Both the grooves play a very crucial role in DNA replication and transcription.

2 (iii) (a). Difference between Major and Minor groove

- The major groove is large, deep and wide the other side minor groove is small, narrow and shallow.
- Major groove contain 10-12 base pairs per turn while minor groove have 5-6 base pairs per turn of a helix.
- Major groove provides a great exposure for protein interaction on the surface of DNA because it contains more number of base pairs than Minor groove.

- The width of the major groove is 22-26 Å and 12-15 Å in the minor groove.

2 (iv). Chargaff's rule:

It is proposed by Erwin Chargaff, state that in DNA the amount of Adenine is equal to the amount of Thymine and the amount of Cytosine is equal to the amount of Guanine. This means that the total number of purines bases is equal to the total number of pyrimidines bases. It is based on the complementary base pairing in DNA double helix structure that is Adenine always pairs up with Thymine and Guanine always pair with Cytosine.

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A+G = T+C

Purines = Pyrimidines

3. Prokaryotic DNA:

It is found in the nucleoid region of the cytoplasm. It is double stranded, circular genetic material, lacking introns that are non-coding regions and also not associated with histone protein.

4. Eukaryotic DNA:

It is a multiple, linear, double stranded DNA molecule present in the membrane bound organelle that is the nucleus. It is larger, more complex and contains more genes and contains introns. Eukaryotic DNA is bound with histone protein to form chromatin which is condensed into chromosomes during cell division.

Conclusion:

DNA double helix model explain the whole chemistry of DNA, according to this DNA is a polymer genetic material made up of nucleotides. It is double stranded, contain two nucleotide chain held together by covalent bond. Nucleotides contain base pairs, pentose sugar and phosphate group. In base pairing Adenine always pairs with thymine and Guanine always pairs with Cytosine. Adenine forms two hydrogen bonds with Thymine and Cytosine forms three hydrogen bonds with Guanine. According to Chargaff' this base pairing occurs and follows a specific rule that is the amount of Purines always equal to the amount of Pyrimidines. The backbone of nucleic acid made up of sugar- phosphate and held together by phosphodiester bonds. It provides structural stability to the molecule. Both strands run in antiparallel direction , one of the two runs in 5' to 3' direction and the other one in 3' to 5' direction .DNA contains one major and one minor groove, major groove deep and wide , other side minor groove is narrow and shallow. These grooves provide surface for protein binding and play a very crucial role in DNA replication, transcription.

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