Nucleic Acids

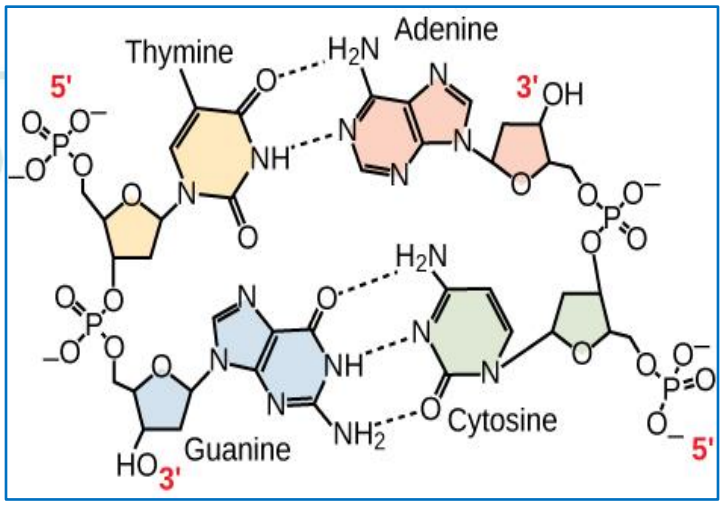
A nucleic acid is a complex, high-molecular-weight biochemical macromolecule composed of nucleotide chains that convey genetic information. The most common nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Nucleic acids are found in all living cells and viruses.

Deoxyribonucleic acid (DNA)

Deoxyribonucleic acid (DNA) is a nucleic acid which carries genetic instructions for the biological development of all cellular forms of life and many viruses. DNA is sometimes referred to as the molecule of heredity as it is inherited and used to propagate traits.

Structure of DNA

DNA is a double-stranded helix. That is each DNA molecule is comprised of two biopolymer strands coiling around each other to form a double helix structure. These two DNA strands are called polynucleotides, as they are made of simpler monomer units called nucleotides.



• Each strand has a 5′end (with a phosphate group) and a 3′end (with a hydroxyl group).

• The strands are antiparallel, meaning that one strand runs in a 5′to 3′direction, while the other strand runs in a 3′ to 5′ direction.

• The two strands are held together by hydrogen bonds and are complimentary to each other.

• Basically, the DNA is composed of deoxyribonucleotides.

• The deoxyribonucleotides are linked together by 3′ – 5′phosphodiester bonds.

• The nitrogenous bases that compose the deoxyribonucleotides include adenine, cytosine, thymine, and guanine.

• The complimentary of the strands are due to the nature of the nitrogenous bases. The base adenine always interacts with a thymine (A-T) on the opposite strand via two hydrogen bonds and cytosine always interacts with guanine (C-G) via three hydrogen bonds on the opposite strand.

• The shape of the helix is stabilized by hydrogen bonding and hydrophobic interactions between bases.

• The diameter of double helix is 2nm and the double helical structure repeats at an interval of 3.4nm which corresponds to ten base pairs

Primary structure of DNA

Although sometimes called "the molecule of Heredity", pieces of DNA are not single molecules. Rather, they are pairs of molecules, double helix .

Each molecule is a strand of DNA: a chemically linked chain of nucleotides, each of which consists of a sugar, a phosphate and one of four kinds of Aromatic hydrocarbon "bases".Because DNA strands are composed of these nucleotide subunits, they are polymers.

Secondary structure of DNA

The DNA helix can assume one of three slightly different geometries, of which the "B"form described by James D. Watson and Francis Crick is believed to predominate in cells. It is 2nm wide and extends 3.4 nm per 10 bp of sequence.

The B form of the DNA helix twists 360° per 10.6 bp in the absence of strain. The two other known double-helical forms of DNA, called A and Z, differ modestly in their geometry and dimensions. The A form appears likely to occur only in dehydrated samples of DNA, such those used in crystallography experiments, and possibly in hybrid pairings of DNA and RNA strands.

Segments of DNA that cells have methylated for regulatory purposes may adopt the Z geometry, in which the strands turn about the helical axis like a mirror image of the B form.

Tertiary structure of DNA

The DNA of a single human cell, if stretched to its full length is 1.74 meters.

To get DNA into a cell's nucleus it must be packaged into a more tightly compacted form. The structural flexibility of DNA allows it to adopt more compacted structures than simple linear B-form DNA.

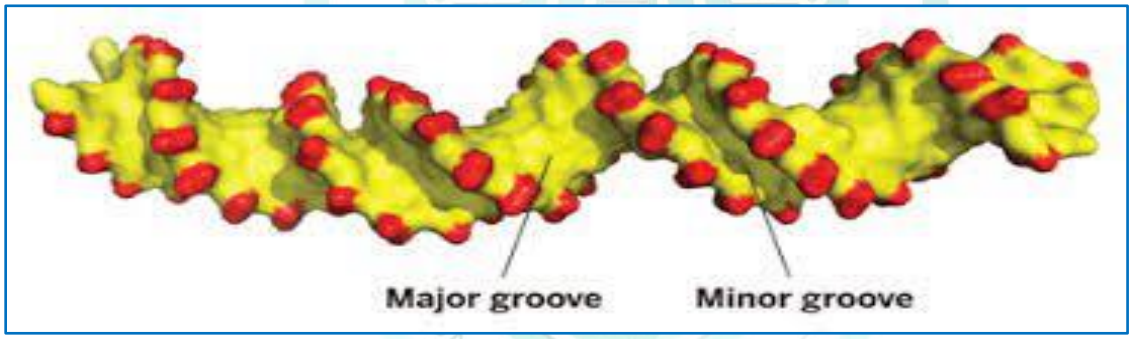
Major and Minor Grooves of the DNA

• As a result of the double helical nature of DNA, the molecule has two asymmetric grooves. One groove is smaller than the other.

• This asymmetry is a result of the geometrical configuration of the bonds between the phosphate, sugar, and base groups that forces the base groups to attach at 120-degree angles instead of 180 degree.

• The larger groove is called the major groove, occurs when the backbones are far apart; while the smaller one is called the minor groove, occurs when they are close together.

• Since the major and minor grooves expose the edges of the bases, the grooves can be used to tell the base sequence of a specific DNA molecule.



Functions of DNA

DNA has a crucial role as genetic material in most living organisms. It carries genetic information from cell to cell and from generation to generation.

Thus its major functions include:

• Storing genetic information

• Directing protein synthesis

• Determining genetic coding

• Directly responsible for metabolic activities, evolution, heredity, and differentiation.

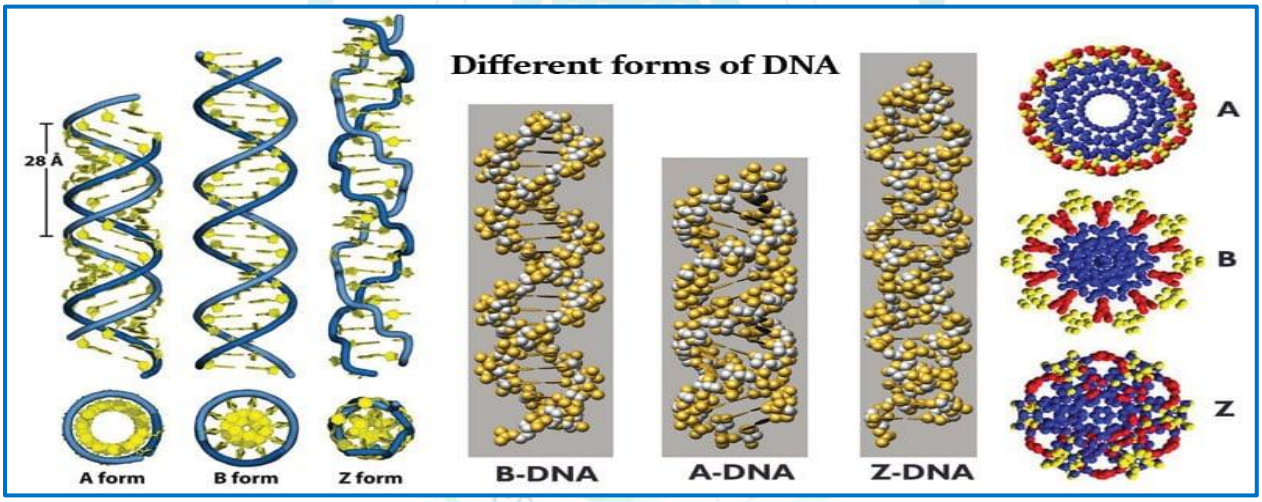
It is a stable molecule and holds more complex information for longer periods of time.

Forms of DNA

Most of the DNA is in the classic Watson-Crick model simply called as B-DNA or B- form DNA

• In certain condition, different forms of DNAs are found to be appeared like A-DNA, Z-DNA, B- DNA.

• This deviation in forms is based on their structural diversity.



Feature	B-DNA	A-DNA	Z-DNA
Type of helix	Right-handed	Right-handed	Left-handed
Helical diameter (nm)	2.37	2.55	1.84
Rise per base pair (nm)	0.34	0.29	0.37
Distance per complete turn (pitch) (nm)	3.4	3.2	4.5
Number of base pairs per complete turn	10	11	12
Topology of major groove	Wide, deep	Narrow, deep	Flat
Topology of minor groove	Narrow, shallow	Broad, shallow	Narrow, deep