

## **1.4: Nucleic Acids – DNA Structure: Watson and Crick Model, Forms of DNA (A, B and Z)**

### **DNA: Watson and Crick Model**

- ❖ By using X-ray diffraction and chemical observation Watson and Crick [1953] proposed a model for a DNA molecule which has widely accepted.
- ❖ According to this model a DNA molecule composed of two long polypeptide chains.
- ❖ The two chains runs in opposite direction that's why they are antiparallel to each other one polypeptide chain runs in 5'-3' direction and another is in 3'-5' direction.
- ❖ In such a structures sugar - phosphate backbone lies on the outside of the molecule while the nitrogenous bases of the two chains are projected towards the centre.
- ❖ Watson and Crick shared the Nobel Prize in 1962 for their discovery, along with Maurice Wilkins who had continued research to provide a large body of crystallographic data supporting the model.
- ❖ Working in the same lab, Rosalind Franklin (1920 - 1958) had earlier produced the first clear crystallographic evidence for a helical structure.
- ❖ Crick went on to do fundamental work in molecular biology and neurobiology.
- ❖ Watson become Director of the Cold Spring Harbor Laboratory, and headed up the Human Genome Project in the 1990s.

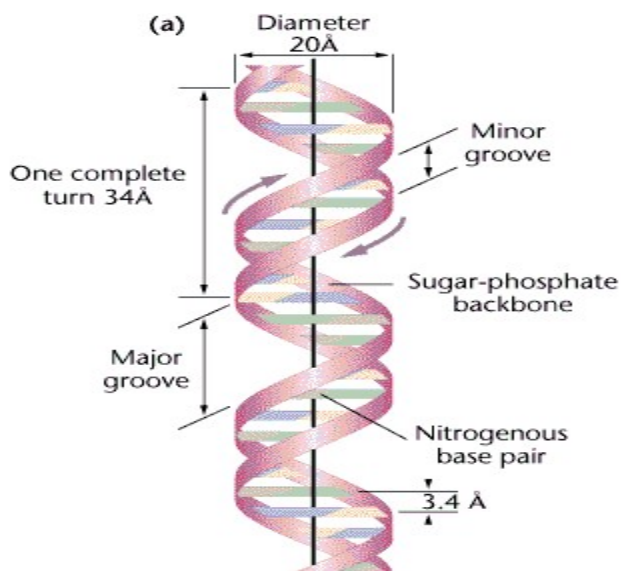
### **Base Pairing**

- ❖ It is observed that the nitrogen bases present on one strand pairs with the nitrogen bases of opposite strands.
- ❖ Purine base A always pairs with pyrimidine base T with double hydrogen bond [A=T]. And the purine base G always pairs with the pyrimidine base C with triple hydrogen bond [G≡C].
- ❖ The nitrogen bases along with the hydrogen bonds make up the rungs the ladder. These are also referred as transverse bars.
- ❖ In the DNA molecule total number of purine base is always equal to the total number of pyrimidine base. This is called Chargaff's Rule; it gives 1:1 ratio.

### **Polarity of strands**

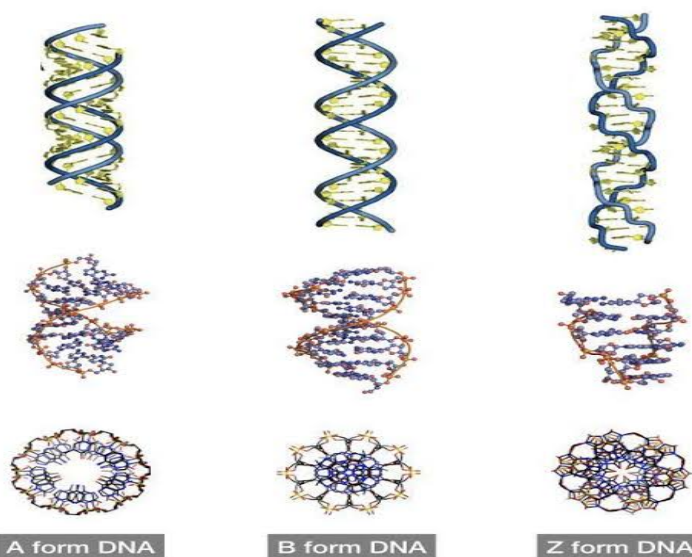
- ❖ Each strand of DNA has polarity.
- ❖ One end is considered as 5' or C-5 and were as other is 3' or C-3 end.
- ❖ At 5' end there is free phosphate group while at the 3' end there is free -OH group, one strand of DNA is oriented in 3'-5' and complementary strand is in 5'-3'.
- ❖ Each nucleotide present on the DNA strand is joined with next nucleotide by means of phospho-diester linkage.
- ❖ The two strands of DNA are considered as antiparallel and the strand runs parallel to each other.
- ❖ The base sequence present on one strand of DNA decides the base sequence of the other strand; the strands are regarded as complementary strand.

## Major and Minor grooves



- ❖ DNA strands undergo coiling around a central axis of the double helix results in the formation of major and minor grooves by the twisting of the two strands.
- ❖ The diameter the DNA molecule is  $20\text{Å}$ .
- ❖ One loop for spiral turns of the molecule measures  $34\text{Å}$  and is called pitch of DNA molecule.
- ❖ Each loop contains ten pairs of nucleotides. Therefore the distance between two successive nucleotide pairs is  $3.4\text{Å}$ .

## Forms of DNA



- ❖ The most common form of DNA which has right handed helix proposed by Watson and Crick is called B-form of DNA or B-DNA.

- ❖ In addition DNA can exist in different forms such as A, B, C, D, H, Z forms. The difference in these forms is associated with
  - The number of base pairs per turn of DNA helix.
  - The angle between each base pair.
  - The helical width or diameter of the DNA molecule.
  - The Handedness [left or right] of double helix.

### **The A-Form of DNA (A-DNA)**

- ❖ Structure of A-DNA has been proposed by Rosalind Franklin.
- ❖ The A-form of DNA is found at 75% relative humidity in the presence of  $\text{Na}^+$ ,  $\text{K}^+$  or  $\text{Ca}^+$  ions.
- ❖ It contains eleven base pairs as compared to ten base pairs of B-DNA which tilt from the axis of helix by  $20^\circ$ .
- ❖ Due to this displacement the depth of major groove increases and that of minor groove decreases.
- ❖ The distance of per turn is  $28\text{\AA}$ .
- ❖ A single turn consists of 11 nucleotide base pairs so the distance between two base pairs is  $2.6\text{\AA}$ .
- ❖ The diameter of whole DNA is  $26\text{\AA}$ .
- ❖ The A-form is metastable and quickly turns to the D-form.

### **The B-Form of DNA (B-DNA)**

- ❖ Structure of B-form of DNA has been proposed by Watson and Crick.
- ❖ It is present in every cell at a very high relative humidity (92%) and low concentration of ions. It has antiparallel double helix, rotating clockwise (right hand) and is made up of sugar-phosphate backbone combined with base pairs or purine-pyrimidine.
- ❖ The base pairs are perpendicular to longitudinal axis of the helix. The base pairs tilt to helix by  $6^\circ$ .
- ❖ The distance of per turn is  $34\text{\AA}$  called pitch of DNA.
- ❖ A single turn consists of 10 nucleotide base pairs so the distance between two base pairs is  $3.4\text{\AA}$ .
- ❖ The diameter of whole DNA is  $20\text{\AA}$ .
- ❖ The B-form of DNA is metabolically stable and undergoes changes to A, C or D forms depending on sequence of nucleotides and concentration of excess salts.

### **The Z-Form of DNA (Z-DNA) or Left Handed DNA**

- ❖ Robert Wells has proposed a left handed DNA structure.
- ❖ On the other hand in 1979, Rich and coworkers at MIT (U.S.A.) obtained Z-DNA by artificially synthesizing in the form of crystals.
- ❖ They proposed a left handed double helix model with zig-zag sugar-phosphate backbone running in antiparallel direction.

- ❖ Therefore, this DNA has been termed as Z-DNA.
- ❖ The Z-DNA has been found in a large number of living organisms including mammals, protozoans and several plant species formed by high concentration of salt.
- ❖ It is a long DNA having  $7^{\circ}$  angle of tilt.
- ❖ The distance of per turn is  $44\text{\AA}$ .
- ❖ A single turn consist 12 nucleotide base pairs so the distance between two base pair is  $3.7\text{\AA}$ .
- ❖ The diameter of whole DNA is  $18\text{\AA}$ .