MODULE 9

AIM

The aim of this module is to provide students with an introduction to DNA structure and its various conformations.

CONTENTS AND OBJECTIVES

- Introduction
- Structure of DNA
- Properties of DNA
- Structural conformations
  - ✓ A-DNA
  - ✓ B-DNA
  - ✓ Z-DNA

AN OVERVIEW OF DEOXYRIBONUCLEIC ACID (DNA)

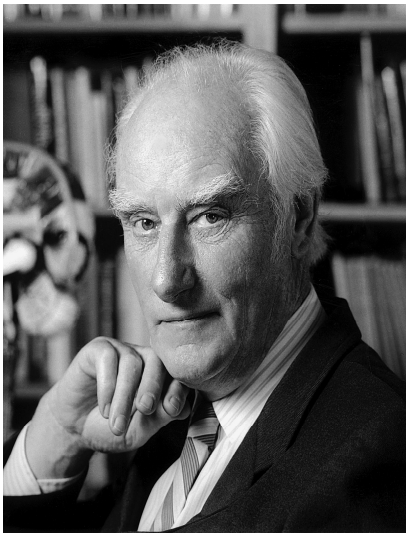
INTRODUCTION

- Deoxyribonucleic acid (DNA) is vital for the living organisms as it plays an important role in the storage and expression of genetic information.
- DNA is the basic hereditary material present in all the cells of an organism. It basically provides a blueprint for the cellôs functions, growth and reproduction.
- DNA contains genetic code which is read by the protein synthesis machinery for the synthesis of new proteins.
- The relationship between DNA and proteins is crucial for all living organisms as DNA is required for the synthesis of proteins and these proteins act as building blocks of the body, messengers, enzymes and hormones.

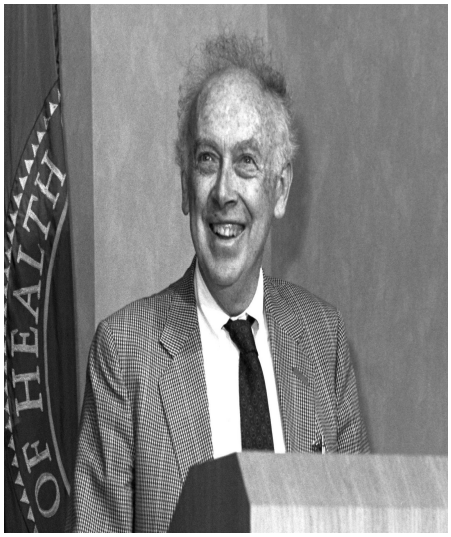
STRUCTURE OF DNA

- The discovery of DNA was remarkable and a hallmark of the modern molecular biology.
- Rosalind Franklin and Maurice Wilkins used X-ray diffraction to show that DNA produces characteristic X-ray diffraction pattern. From this, James Watson and Francis Crick deduced the double helical structure of DNA.
- The structure of DNA proposed by James Watson and Francis Crick showed two polynucleotide chains running in opposite directions, coiled around each other.
- The findings of Erwin Chargaff in 1949 solved the enigma of DNA base-pairing. He showed that even though the amount of DNA varies among organisms, the percentage of adenine always equals thymine and the percentage of guanine equals cytosine. This clearly means that adenine on one strand always pairs with thymine on the opposite strand and guanine pairs with cytosine.
- Adenine forms two bonds with thymine, whereas guanine forms three hydrogen bonds with cytosine.

- A Nobel Prize in physiology and medicine was awarded to Francis Crick, James Watson and Maurice Wilkins in 1962 for the discovery of DNA structure.



Francis Crick



James D. Watson

PROPERTIES OF DNA

- DNA is a double stranded structure. The two strands are twisted around each other in a helical manner.
- There is base-pairing between the bases of the two strands. The base-pairing is referred to as the primary structure. This sequence determines the actual structure of DNA.
- There are alternating deoxyribose and phosphate groups in the backbone of each polynucleotide chain with the DNA bases sticking out at the side.
- The phosphate groups have a negative charge giving the entire DNA an overall negative charge.
- The nitrogenous groups are classified into the following types:
    1. Fused 5 and 6 member rings known as purines. These include Adenine (A) and Guanine (G).
    2. 6-member ring structures known as pyrimidines. These include Thymine (T), Cytosine (C) and Uracil (U).

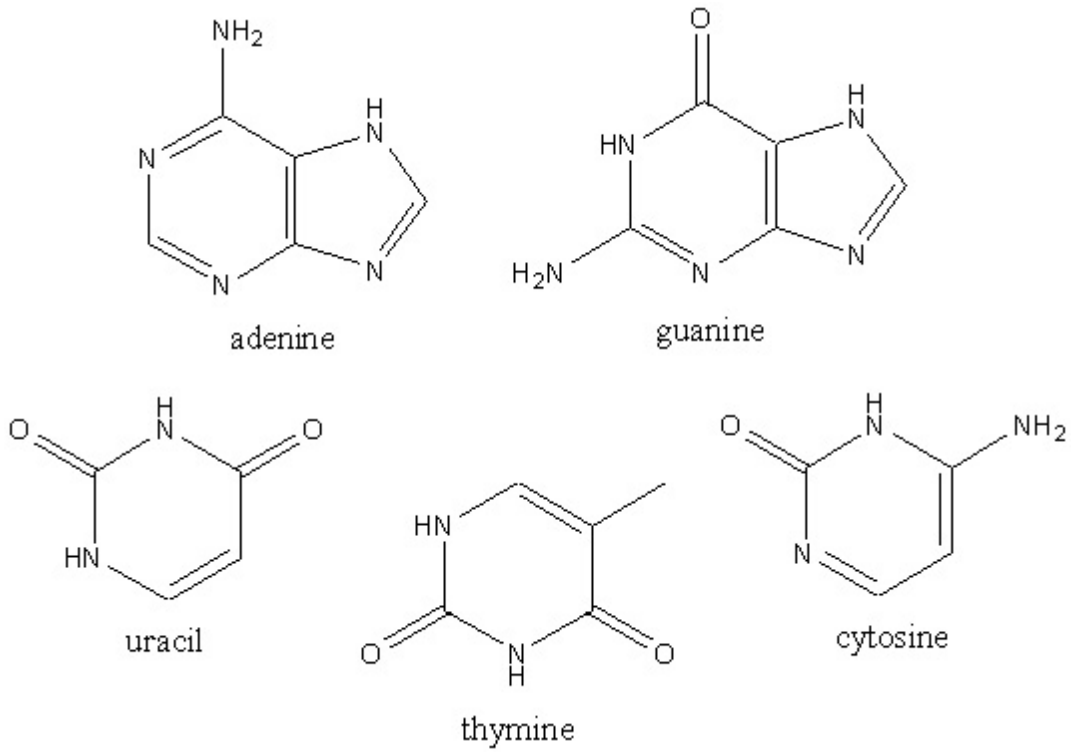
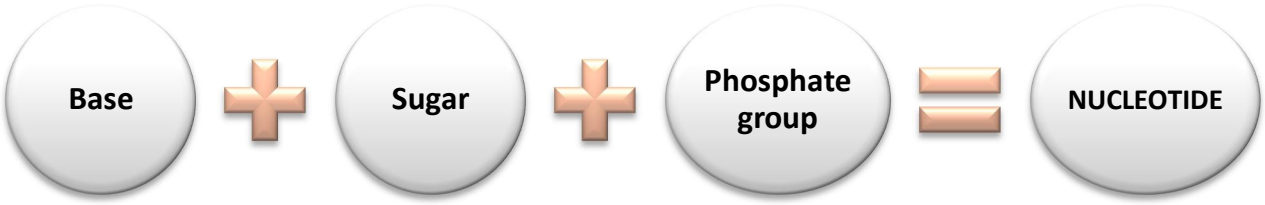


Fig. Structure of DNA bases

- The two DNA strands run in anti-parallel direction with respect to each other, i.e., one strand runs in 5â to 3âdirection and the other strand runs in 3â to 5âdirection.
- DNA is composed of a nucleotide component which consists of a nitrogenous base, a sugar and a phosphate residue. A sugar and a nitrogenous base without a phosphate group are known as nucleoside.
- Each base on one strand forms a non-covalent bond (hydrogen bond) with the one directly opposite to it on the other strand. This is termed as base-pairing.



STRUCTURAL CONFORMATIONS OF DNA

The three structural conformations of DNA are:

1. A-DNA
2. B-DNA
3. Z-DNA

The most common of these three types of conformations is the B-DNA, also known as Watson and Crick model of DNA double helix.

The type of conformation adopted by DNA depends on factors listed below:

- Salt concentration
- Hydration level
- DNA sequence
- Direction and amount of supercoiling of DNA
- Presence of chemically modified bases
- Presence of metal ions

A-DNA

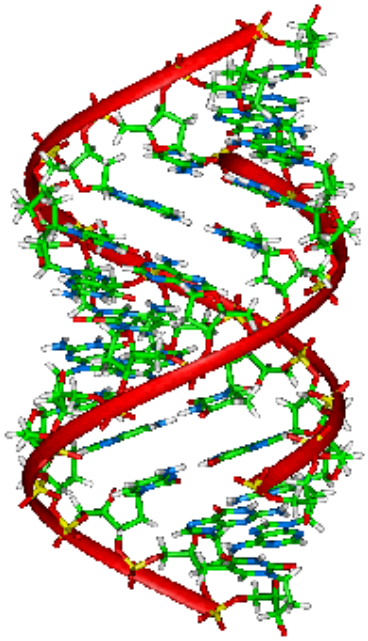
- This conformation was discovered by Rosalind Franklin.
- A DNA molecule with B-type conformation generally adopts this type of structural conformation under dehydrating conditions.
- A-DNA is favoured in triplex DNA.
- A-DNA is a right-handed helix and is much wider and flatter than B-DNA.

B-DNA

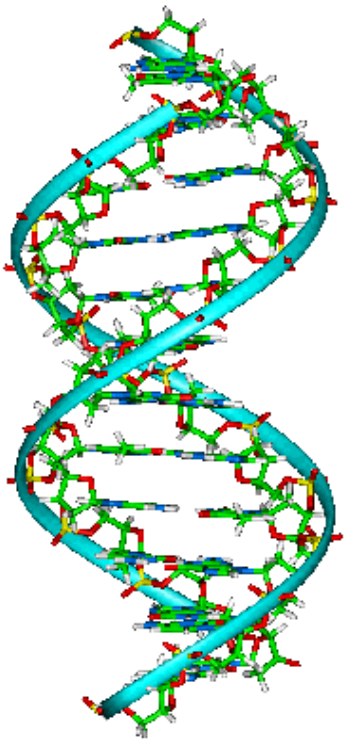
- This is the most predominant type of structural conformation of DNA. It was described by Watson and Crick.
- It is the most preferred conformation of DNA under the optimum physiological conditions such as pH, salt concentration, etc.
- B-DNA is a right-handed helix.
- B-DNA has a solid central core and only the edges are exposed to the solvent.

Z-DNA

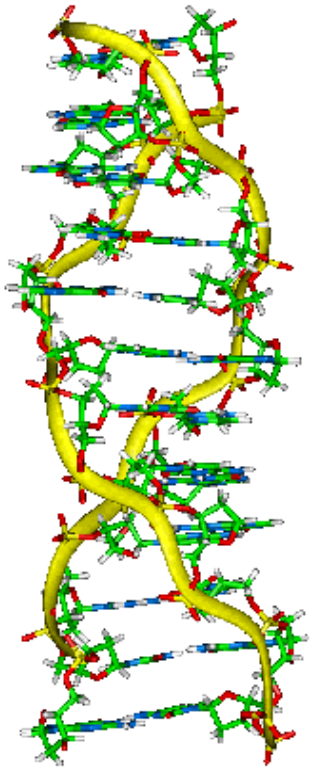
- Z-DNA is a left-handed helix in which the two strands wind to the left in a zig-zag pattern.
- This conformation is adopted when the DNA bears alternating stretches of purine-pyrimidine under high salt concentration.
- Z-DNA conformation was revealed by Andres Wang and Alexander Rich.



A-DNA



B-DNA



Z-DNA