

PUC Ist year-Semester -2

UNIT II: Chemical constituents of living cells

MODULE 12: DNA – Structure and Function

DNA STRUCTURE

The structure of DNA molecule (B-type) was proposed by **J.D. Watson** and **F.H.C. Crick** in 1953. **Watson** and **Crick's** model is known as **double helix**. It is composed of two strands which are spirally coiled around one another. The strands are antiparallel to one another and are held closely by hydrogen bonds. It is coiled around its own axis.

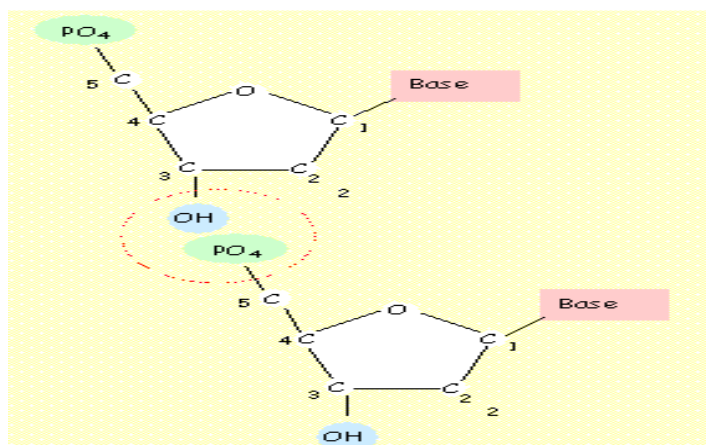
DNA is a macro molecule formed by the linking of several thousand nucleotides. These are called monomers or building blocks of DNA. Hence, it is called **polynucleotide strand**. The two strands are complimentary to one another and are linked by nitrogen base pairs which appear as steps (rungs). The nucleotides are chemically composed of three parts – **phosphate group, deoxyribose sugar ($C_5H_{10}O_4$)** and **nitrogen bases**. Nitrogen bases are of 4 types namely **Adenine, Guanine, Cytosine** and **Thymine**. Adenine and Guanine are called **Purines** while Cytosine and Thymine are called **Pyrimidines**. In DNA molecule, the association of a sugar molecule and a base is known as a '**nucleoside**' and the association of phosphate group, sugar and a base is called a '**nucleotide**'.

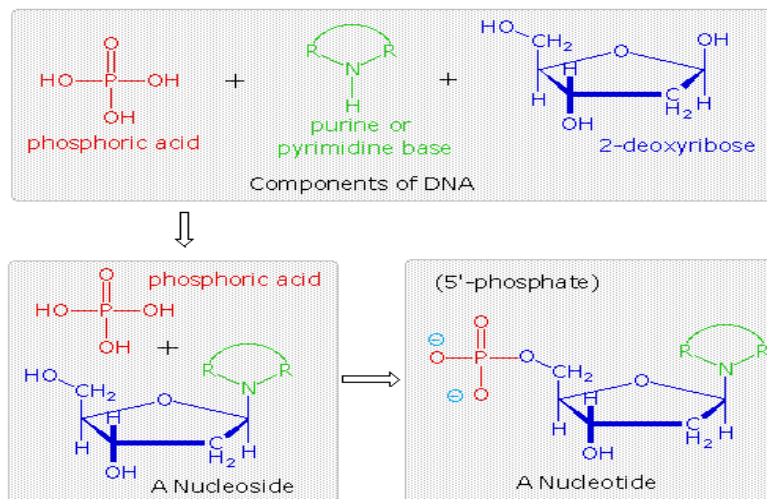
The nitrogen bases A, T and G, C are complimentary to each other. **Erwin Chargaff** discovered purines (A, G) and pyrimidines (C, T) exist in 1:1 ratio. Adenine (A) is complimentary to Thymine (T) and vice versa. They attract each other by two weak hydrogen bonds ($A=T$). Guanine (G) and Cytosine (C) are complimentary to each other and attract by forming three hydrogen bonds ($G\equiv C$). Due to this type of base pairing the two

strands are complementary to each other. The base pair interaction leads to the formation of double helix with stacked base pairs. This is called annealing.

The back bone of DNA polynucleotide strand is formed by alternately arranged phosphate and sugar groups. They are linked with each other by **phosphate – diester bonds**. With these bonds the DNA molecules is formed by helical coiling of two antiparallel strands running one from 5'.....3' and other from 3' 5'. Or in opposite direction so that the 3' end of one chain lies besides the 5'end of the other. One end of the poly nucleotide chain has a sugar residue with c-3 carbonatom which is not linked to another nucleotide and the other end sugar residue c-5 is also not linked. These are known as 3' and 5' end respectively.

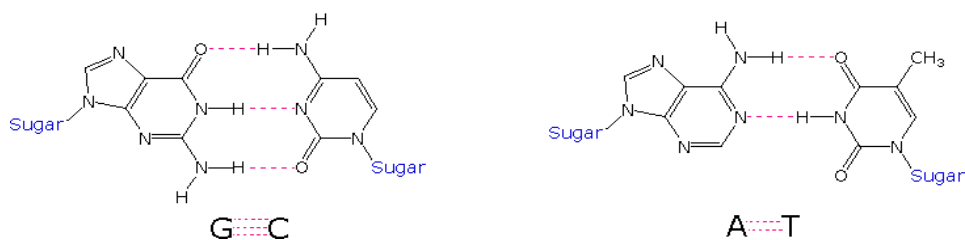
The DNA double helix can be compared to a twisted ladder. The steps are formed by the nitrogen bases and the side walls by the sugar and phosphate molecules. In fact the nitrogen bases occupy the centre of the double helix, the sugar molecules are present in the middle while phosphate molecules are outside of the sugar molecules.





Two bases are bonded together by phospho-diester bonds

Hydrogen Bonded Base Pairs



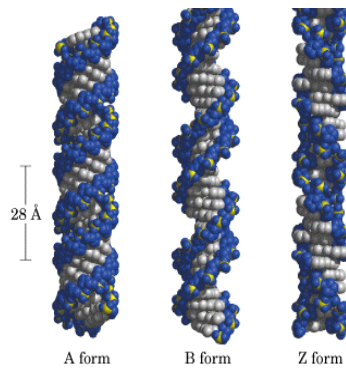
DNA consists of two complementary chains twisted around each other. One turn of helix measures about 34\AA . It contains 10 paired nucleotides placed at regular interval of 3.4\AA . The diameter of the helix is roughly 20\AA . A narrow helical groove and a wide helical groove run along the length of DNA helix. The narrow groove (minor groove) is the distance between the paired molecules while the wide groove (major groove) is the space between successive turns when the pair is wound into helix.

The Double Helix Structure for DNA

1. It has a very high molecular weight (30,000 to several millions)
2. It shows high absorption spectrum at ultraviolet light (260 nm).
3. It is denatured when heated up to 70°C .
4. High pH and low salt conditions also cause denaturation of DNA.
5. It is the chief genetic material in all organisms except in most of the plant viruses.

Four types of DNA have been identified. They are: A- DNA, B – DNA, Z – DNA and C-DNA.

- B – DNA is more common and has clockwise helix structure. Watson and Crick model described was the B- form.
- Z – DNA is uncommon and has an alternating clockwise and anticlockwise helix structure. The strands in it are zig zag.
- The ‘A’ form is a wider right-handed spiral.
- The ‘C’ form is narrow angled right-handed spiral.



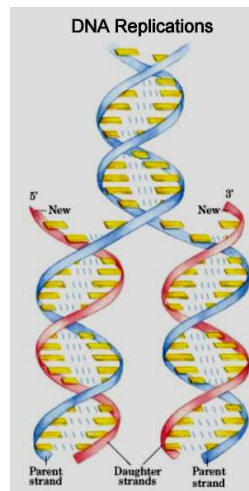
FUNCTIONS

Genes present in DNA are responsible for the transmission and expression of genetic information.

DNA has two functions:

- 1) Autocatalysis and
- 2) Heterocatalysis

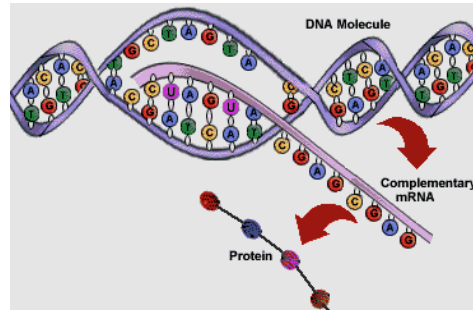
Autocatalysis: The process of duplication of a single DNA molecule into two daughter DNA molecules is called ‘autocatalysis’ or ‘replication’. In other words the duplication process of DNA is called DNA replication.



Heterocatalysis: The DNA transfers the genetic message to messenger RNA (Complementary RNA) by a process called **transcription** which helps in the synthesis of proteins.

DNA → **Messenger RNA** → **Protein**

TRANSCRIPTION



<http://www.scientificpsychic.com/fitness/transcription.gif>

CHECK POINTS

1. Nucleotides can serve as monomers for the assembly of polymeric nucleic acids.
2. The nucleotides contain deoxyribonucleotides; the polymer is deoxyribonucleic acid, or DNA. DNA is normally double-stranded (although some viruses contain single-stranded DNA).
3. The DNA is a double helix with two strands running opposite to one another.
4. Each strand of DNA consists of a "backbone" of alternating units of phosphate and deoxyribose.
5. Purine or pyrimidine bases are attached to the 5-C deoxyribose sugar, and form base pairs with purine or pyrimidine bases from the opposite strand.
6. The only effective pairs are Adenine with Thymine (A-T pairs) and Guanine with Cytosine (G-C pairs).
7. DNA condenses to form chromatin. It consists of histone proteins wrapped by DNA called nucleosomes.

8. DNA function: medium of long-term storage and transmission of genetic information.
9. B DNA, A DNA, C DNA & Z DNA are different types of DNA.

QUESTIONS

Short answer questions:

1. How many strands make up a DNA double helix?
2. What is a "strand" of DNA?
3. What holds one strand against the other in the double helix?
4. What are the four pairs of DNA bases that form in the double helix?
5. Which DNA double helix do you think would be harder to separate into two strands: DNA composed predominantly of AT base pairs, or of GC base pairs? Why?
6. What is autocatalysis?
7. Define heterocatalysis.
8. What are the properties of DNA?
9. How many types of DNA are recognized and what is the difference between them?

Long answer questions:

1. What was basis for discovery of DNA structure by Watson and crick? Describe the model given by them.
2. Write in detail about the functions and types of DNA.

Multiple choice questions

1. DNA strands are antiparallel because of
 - A. H bonds**
 - B. Phospho-diester bonds
 - C. disulphide bonds
 - D. Phospho-ester bonds
2. The number of base pairs in one complete turn of B- DNA helix is
 - A. 12
 - B. 10**
 - C. 11
 - D. 8
3. What is a "double helix"?
 - A. Two Y-shaped strand
 - B. Two loops, like a figure eight
 - C. Two spirals, like a twisty ladder**
 - D. Two X-shaped strands
4. DNA is constructed by repeating units. What are these units called?
 - A. Amino acids
 - B. Nucleotides**
 - C. Monosaccharides
 - D. Fatty acids
5. To whom is the discovery of the structure of DNA credited?
 - A. Gregor Mendel
 - B. Charles Darwin
 - C. James Watson**
 - D. Hargobind Khorana

6. What part of DNA is found at the centre of the molecule?
- A. Amino acids
 - B. Nitrogen Bases**
 - C. Phosphates
 - D. Sugars
7. What process is used to copy DNA to produce another identical strand?
- A. Replication**
 - B. Translation
 - C. Transcription
 - D. Annealing
8. The most important molecule involved in long-term storage of genetic information is
- A. protein
 - B. lipid
 - C. deoxyribonucleic acid or DNA**
 - D. ribonucleic acid or RNA
9. The primary chemical structure of DNA includes
- A. a phosphorylated sugar backbone**
 - B. Individual components called amino acids
 - C. Individual components called triglycerides
 - D. Complete structural symmetry
10. Double-stranded DNA, when it occurs, is
- A. Antiparallel
 - B. parallel
 - C. complementary

D. Both A and C

11. The base pairing arrangements that occur in double-stranded DNA as determined by hydrogen bonding include
- A. A with C and G with T
 - B. A with U and G with C
 - C. A with T and G with C**
 - D. C with T and A with G
12. The complementary strand of DNA strand having nucleotide sequence as GAT CAA is
- A. TTGATG
 - B. AGAAUU
 - C. CUAGUU
 - D. CTAGTT**
13. The diameter of DNA molecule is
- A. 20 Å**
 - B. 50 Å
 - C. 100 Å
 - D. 200 Å