

Molecular Basis of Inheritance

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- In the previous chapter, you studied the patterns of inheritance and their genetic basis.
- However, during Mendel's time, the nature of the 'factors' (which we now know as genes) responsible for inheritance was unknown.
- Over the next century, intensive research was conducted to determine the nature of genetic material, ultimately leading to the discovery that DNA (**Deoxyribonucleic Acid**) is the genetic material in most organisms.

Types of Nucleic Acids

- Nucleic acids are **polymers of nucleotides**.
- There are two main types of nucleic acids found in living systems:

1. DNA (Deoxyribonucleic Acid):

- Acts as the genetic material in most organisms.

2. RNA (Ribonucleic Acid):

- Functions as the genetic material in some viruses.
- Primarily acts as a messenger (**mRNA**).
- Also plays additional roles:
 - As an adapter (**tRNA**).
 - As a structural component (**rRNA**).
 - In some cases, as a catalytic molecule (**ribozymes**).

You have already learned about the structure of nucleotides and how they link to form nucleic acid polymers in Class XI.

Topics Covered in this Chapter

- In this **chapter**, we will discuss:
 1. Structure of DNA
 2. DNA Replication
 3. Transcription – the process of making RNA from DNA
 4. Genetic Code – the sequence that determines amino acids in proteins
 5. Translation – the process of protein synthesis
 6. Regulation of gene expression
 7. Human Genome Project – basics of genome sequencing and its consequences

Introduction to DNA

- We will begin by understanding the **structure of DNA**, the most fascinating molecule in living organisms.
- In later sections, we will explore:
 - Why DNA is the most abundant genetic material
 - Its relationship with RNA
 - And how it forms the foundation of modern genetics and genomics

The DNA

- DNA (Deoxyribonucleic Acid) is a long, double-stranded polymer made up of repeating units called deoxyribonucleotides.
- The length of DNA is usually measured in:
 - Nucleotides (nt) – for single-stranded DNA
 - Base pairs (bp) – for double-stranded DNA
- The DNA length varies widely among different organisms and is considered a unique and defining feature of each species.

Examples of DNA length in various organisms

1. ϕ ×174 (Phi X 174 Bacteriophage):

- Contains **5,386 nucleotides** (single-stranded circular DNA virus)
- It was the first DNA-based genome to be sequenced.

2. Lambda phage (λ phage):

- Possesses **48,502 base pairs** of double-stranded DNA
- Often used in molecular biology as a cloning vector.

3. Escherichia coli (E. coli):

- Contains approximately **4.6×10^6 base pairs**
- This bacterial genome is well studied and serves as a model organism.

4. Human haploid genome:

- Contains approximately **3.3×10^9 base pairs**

Structure of Polynucleotide Chain

Nucleotide Composition

Each nucleotide consists of three components:

1. Nitrogenous Base:

- **Purines:** Adenine (A), Guanine (G)
- **Pyrimidines:** Cytosine (C), Thymine (T – in DNA), Uracil (U – in RNA)

2. Pentose Sugar:

- Ribose in RNA
- Deoxyribose in DNA

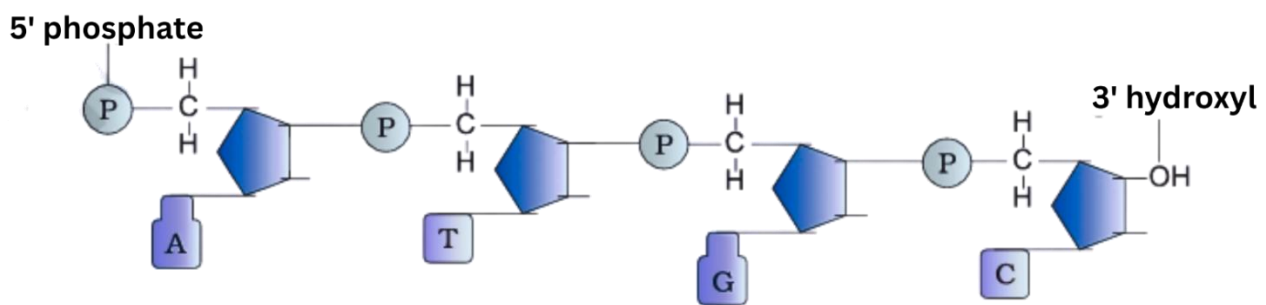
3. Phosphate Group

Nucleoside and Nucleotide Formation

- A nitrogenous base is linked to the **1' carbon** of sugar via N-glycosidic bond forming a nucleoside:
 - Examples: Adenosine, Guanosine, Cytidine, Uridine (RNA); Deoxyadenosine, Deoxyguanosine, etc. (DNA)
- A phosphate group links to the **5' OH** of the sugar via a phosphoester bond, forming a nucleotide.

Polynucleotide Chain

- Nucleotides are linked by **3' → 5'** phosphodiester bonds forming a long chain.
- The chain has directionality:
 - **5' end:** Free phosphate group
 - **3' end:** Free OH group of the sugar
- The sugar-phosphate backbone forms the structural frame, while nitrogenous bases project from it.



A Polynucleotide chain

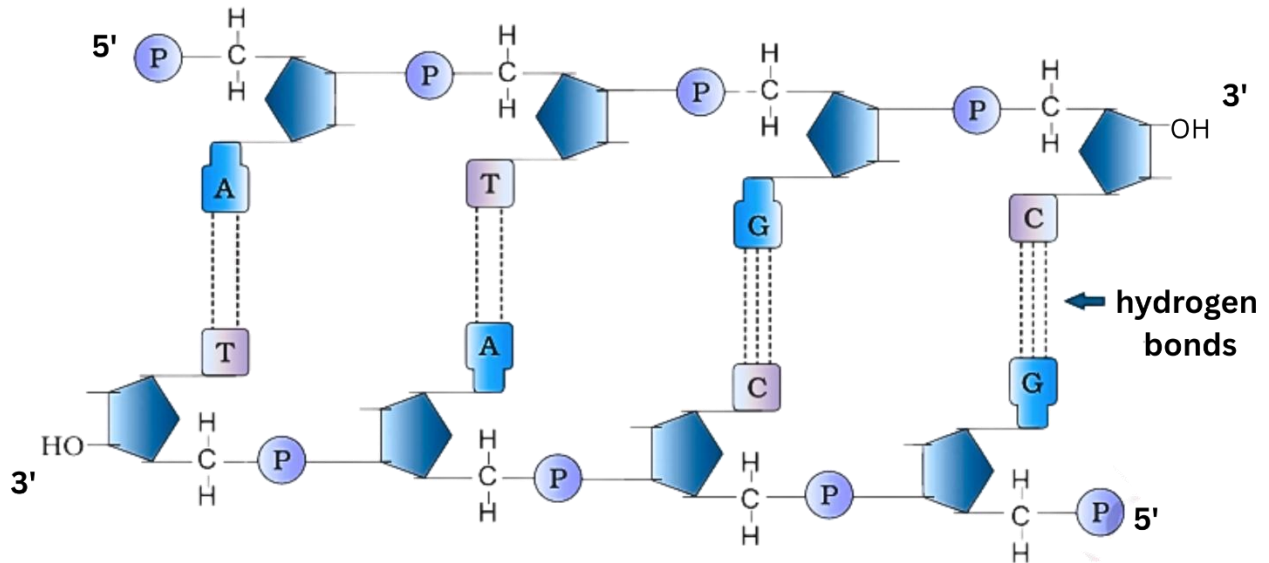
Structural Insights

- **RNA** has an extra –OH at the 2' carbon and contains uracil instead of thymine.
- **DNA** was first identified by Friedrich Miescher (1869) and named 'Nuclein'.
- The double helix structure was proposed by **Watson and Crick (1953)**, based on:
 - X-ray diffraction data by Wilkins and Franklin
 - **Chargaff's Rule:** A = T, G = C (1:1 ratio in double-stranded DNA)

Salient Features of DNA Double Helix

1. **Double-stranded** polynucleotide chains with sugar-phosphate backbone and bases on the inside
2. Anti-parallel orientation: One strand is 5' → 3'; the other is 3' → 5'
3. Complementary base pairing:
 - A pairs with T (2 H-bonds)

- G pairs with C (3 H-bonds)
- Ensures uniform spacing (purine always with pyrimidine)

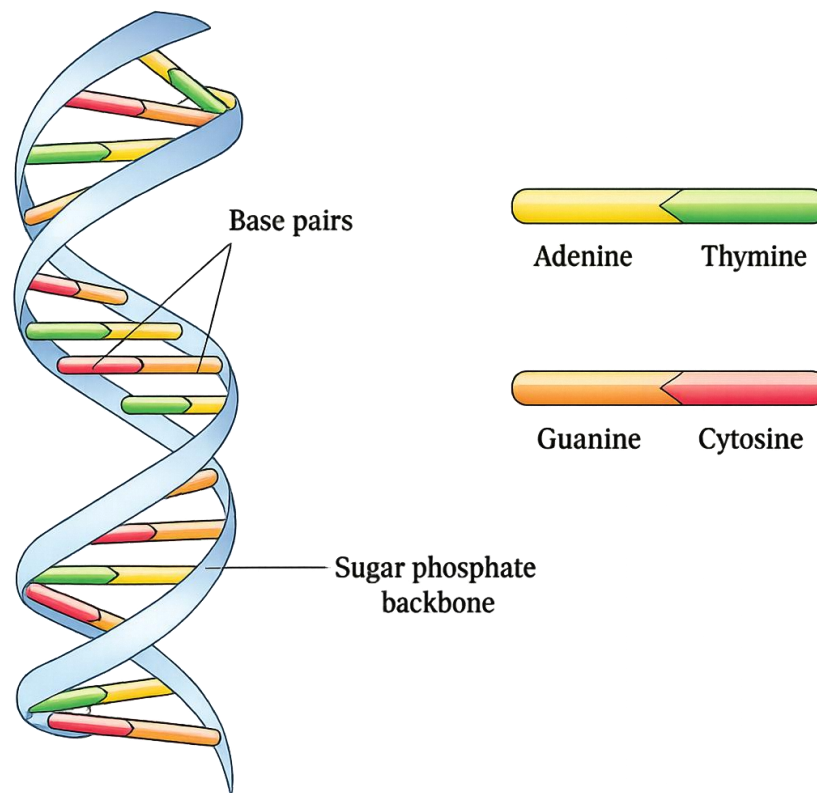


Double stranded polynucleotide chain

4. Right-handed helix:

- Pitch: 3.4 nm (one turn of helix)
- 10 base pairs per turn
- Distance between base pairs: 0.34 nm

5. Base stacking and hydrogen bonds stabilize the helical structure



DNA double helix

Genetic Implications of Double Helix



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