جامعة المستقبل
AL MUSTAQBAL UNIVERSITY

# كلية العلوم
# قسم الادلة الجنائية

# Lecture (8)

## عنوان المحاضرة

## Structure and Function of DNA

**المادة : بايلوجي**

**المرحلة : الاولى**

**اسم الاستاذ: م.م هويدا نزال حسين**

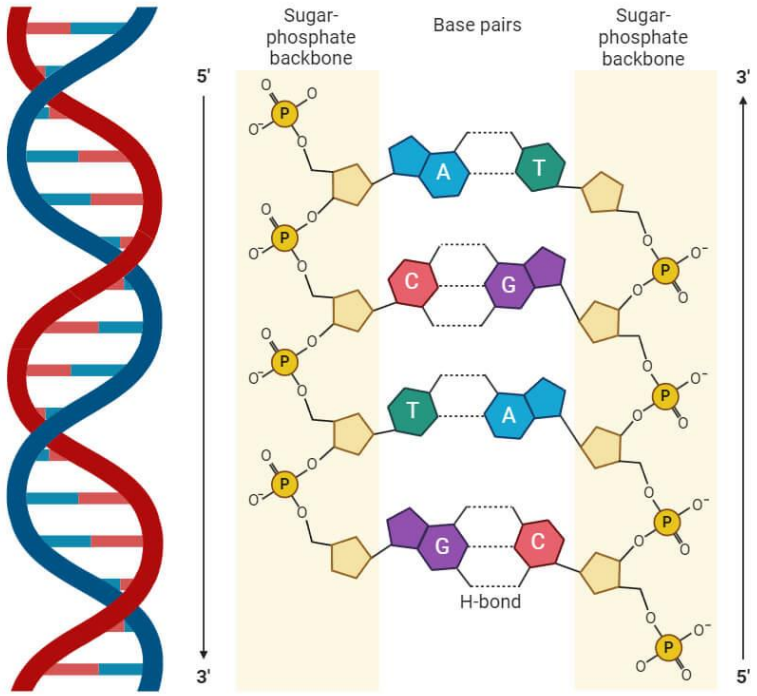
Al-Mustaqbal University
College of Science
Forensic Evidence Department

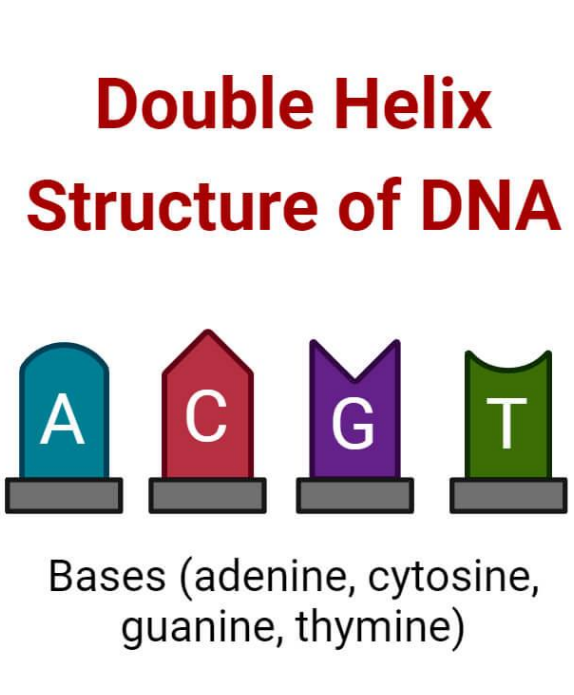
# Structure and Function of DNA

## 1. Introduction

Deoxyribonucleic Acid (DNA) is the primary hereditary material in almost all living organisms. It carries the genetic instructions that define cellular structure, regulate biological activities, and ensure the transmission of traits from one generation to the next. A clear understanding of DNA structure and function is fundamental for students of biology, medicine, biotechnology, and forensic sciences.

Despite its remarkable chemical stability, DNA possesses sufficient flexibility to allow genetic variation and evolutionary change. Its unique molecular organization permits accurate replication, precise regulation of gene expression, and long-term storage of genetic information.



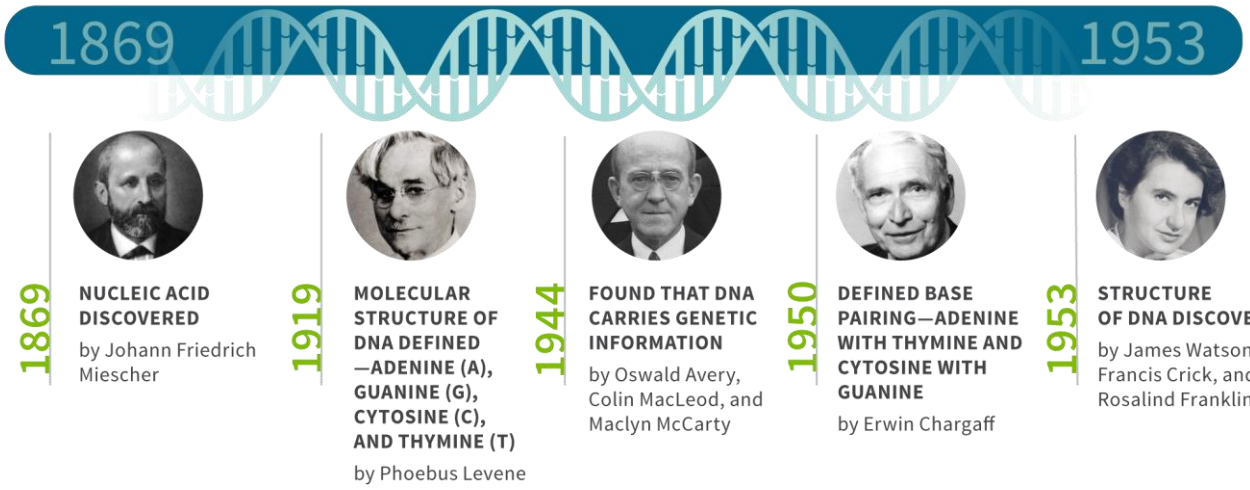



## 2. Historical Background

The identification of DNA as the genetic material was achieved through a series of landmark discoveries:

- **1869**: Friedrich Miescher isolated a phosphorus-rich substance from cell nuclei, which he named *nuclein*.
- **1944**: Avery, MacLeod, and McCarty provided experimental evidence that DNA is the molecule responsible for heredity.
- **1953**: James Watson and Francis Crick proposed the double helix model of DNA, based on X-ray diffraction data generated by Rosalind Franklin and Maurice Wilkins.

These discoveries established the foundation of modern molecular biology.



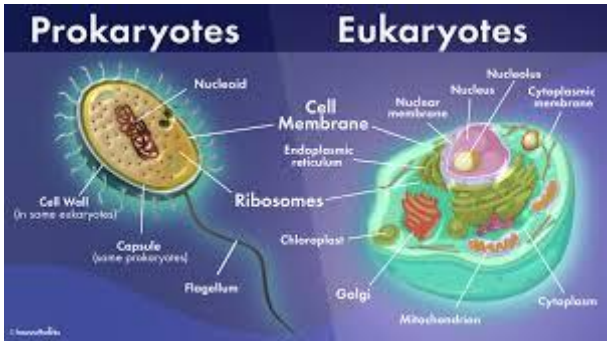

## 3. Definition of DNA

DNA is a long, double-stranded polymer composed of repeating subunits known as nucleotides. Genetic information is encoded in the linear sequence of nitrogenous bases along the DNA strand. This sequence functions as a molecular code that directs protein synthesis and regulates cellular activities.

## 4. Cellular Location of DNA

The intracellular location of DNA varies according to cell type:

- **Eukaryotic cells**: DNA is primarily located in the nucleus, organized into chromosomes.
- **Mitochondria**: Possess their own mitochondrial DNA (mtDNA), involved in energy metabolism.
- **Chloroplasts**: Plant cells contain chloroplast DNA essential for photosynthesis.
- **Prokaryotic cells**: DNA is located in the nucleoid region and is not enclosed by a nuclear membrane.



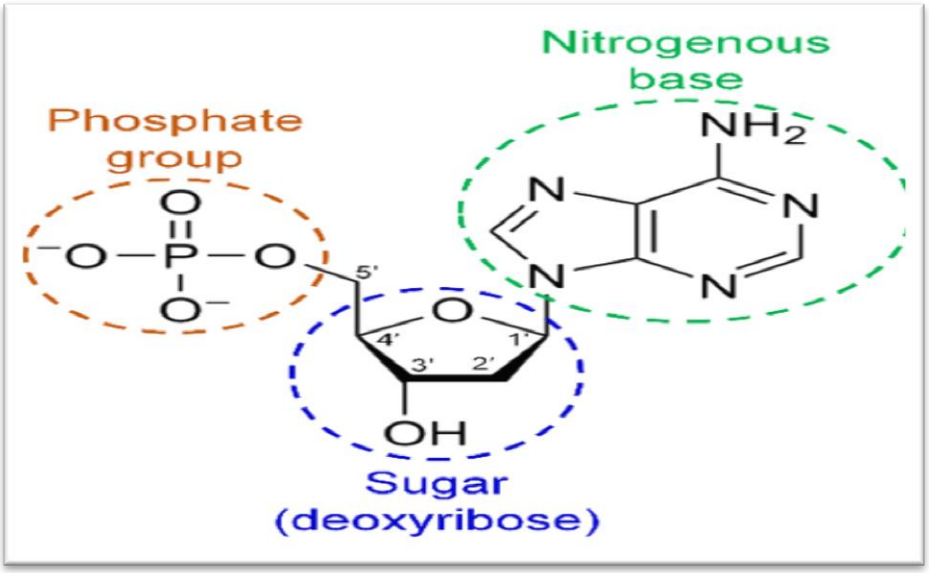

## 5. Chemical Composition of DNA

### 5.1 Nucleotides

DNA is constructed from nucleotides, each consisting of:

1. A nitrogenous base
2. A five-carbon sugar (deoxyribose)
3. A phosphate group

These nucleotides are linked together to form long polynucleotide chains.




## 5.2 Nitrogenous Bases

DNA contains four nitrogenous bases:

- Adenine (A)
- Guanine (G)
- Cytosine (C)
- Thymine (T)

They are classified into two groups:

- **Purines**: Adenine and Guanine (double-ring structures)
- **Pyrimidines**: Cytosine and Thymine (single-ring structures)

## 6. Sugar-Phosphate Backbone

The structural framework of DNA is formed by alternating sugar and phosphate groups, known as the sugar-phosphate backbone. Adjacent nucleotides are connected by strong **phosphodiester bonds** between the 3′ carbon of one sugar and the 5′ carbon of the next.

This arrangement gives each DNA strand a distinct polarity, designated as the **5′ end** and **3′ end**, which is critical for replication and transcription.

## 7. Double Helix Structure of DNA

DNA molecules consist of two polynucleotide strands twisted around each other to form a double helix.

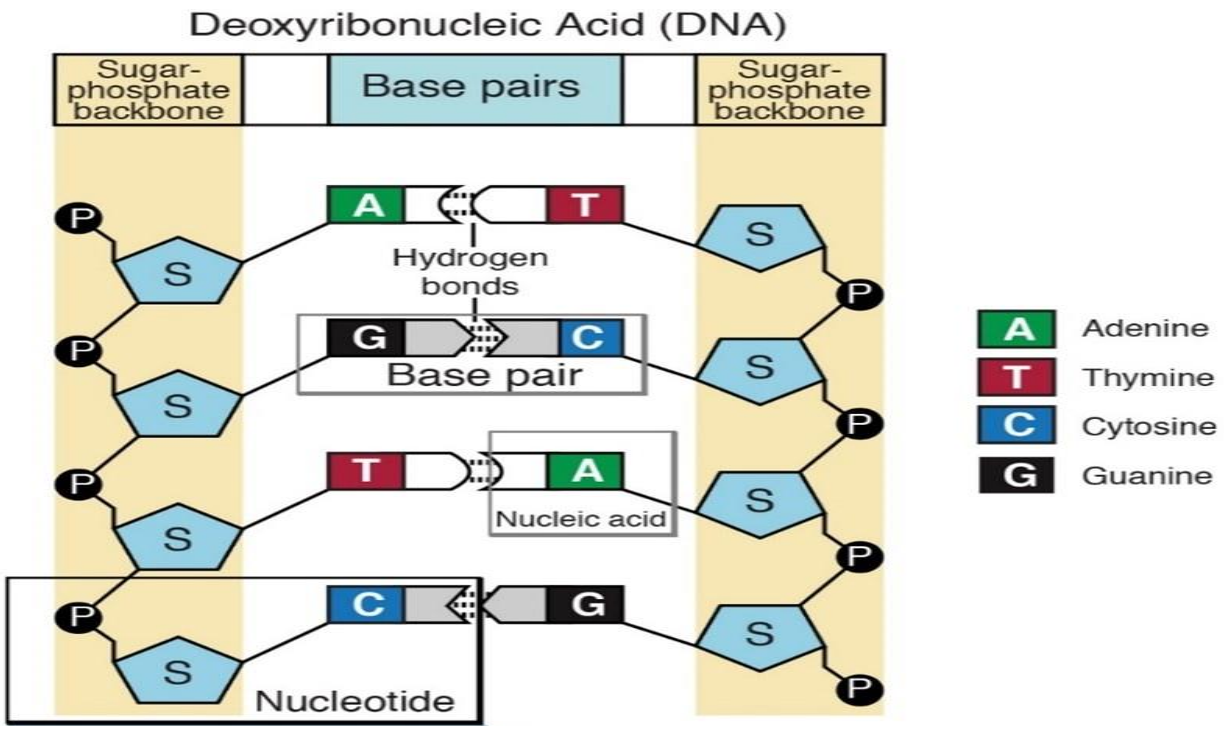
### 7.1 Key Structural Features

- Two antiparallel strands running in opposite directions
- Complementary base pairing between strands
- Stabilization by hydrogen bonds between paired bases

### 7.2 Base Pairing Rules

- Adenine pairs with Thymine through two hydrogen bonds
- Guanine pairs with Cytosine through three hydrogen bonds

This complementary pairing ensures both structural stability and faithful replication of genetic information.



# 8. Types of DNA Helices

## 8.1 B-DNA

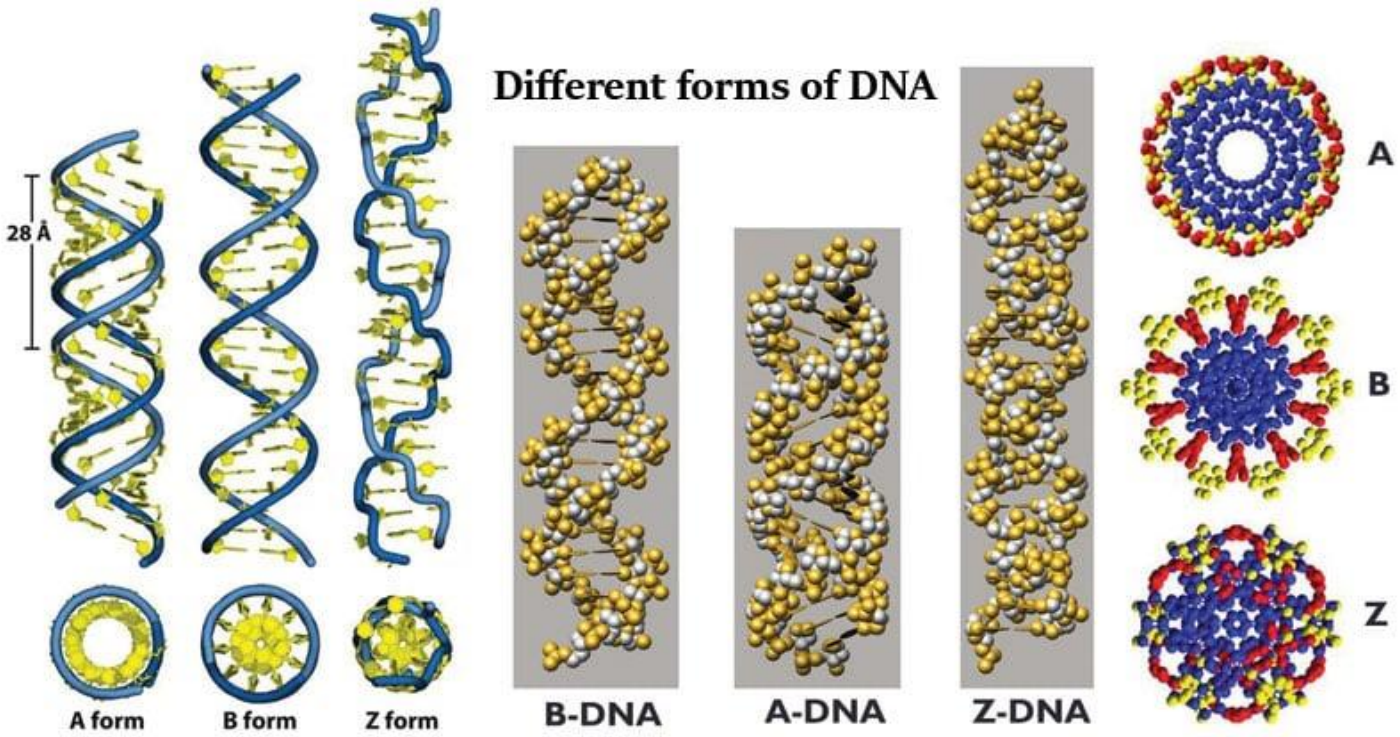
- The most common form found in living cells
- Right-handed helix
- Exists under normal physiological conditions

## 8.2 A-DNA

- Shorter and wider than B-DNA
- Observed in dehydrated DNA and DNA-RNA hybrid molecules

## 8.3 Z-DNA

- Left-handed helical structure
- Rich in GC base pairs
- Suggested to have a role in gene regulation



## 9. DNA Packaging and Chromatin Structure

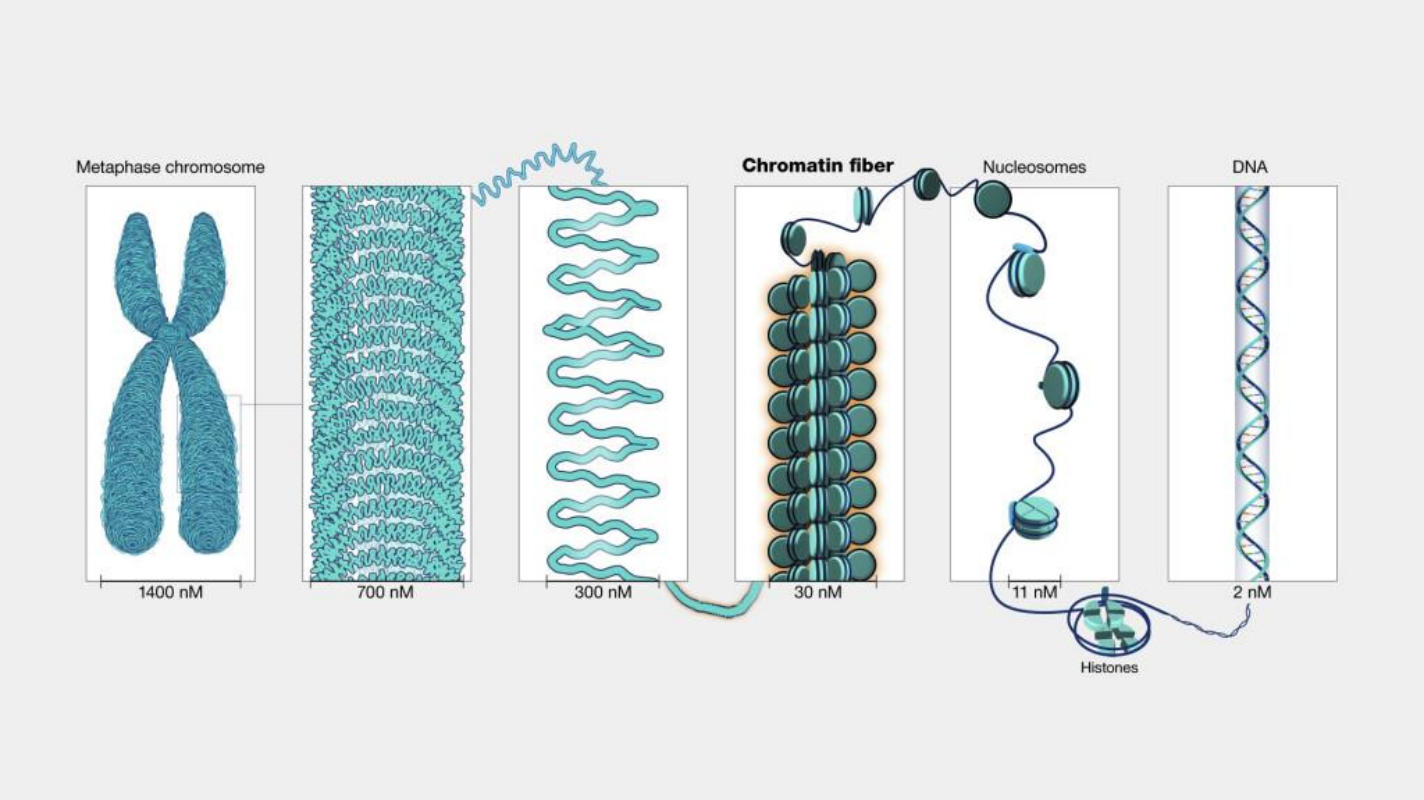
In eukaryotic cells, DNA is highly condensed to fit within the nucleus while remaining functionally accessible.

### 9.1 Histones and Nucleosomes

DNA wraps around histone proteins to form nucleosomes, the basic units of chromatin organization.

### 9.2 Chromatin Types

- **Euchromatin**: Lightly packed and transcriptionally active
- **Heterochromatin**: Densely packed and transcriptionally inactive




## 10. DNA Replication

DNA replication is the biological process by which a DNA molecule produces an identical copy of itself.

### 10.1 Characteristics of Replication

- Semi-conservative mechanism
- Occurs during the S phase of the cell cycle

### 10.2 Enzymes Involved

- DNA helicase
- DNA polymerase
- RNA primase
- DNA ligase

Replication ensures the accurate transmission of genetic information to daughter cells.

## 11. Transcription

Transcription is the process by which genetic information encoded in DNA is copied into RNA.

### 11.1 Stages of Transcription

- Initiation
- Elongation
- Termination

The resulting messenger RNA (mRNA) carries genetic instructions from the nucleus to ribosomes.

## 12. Translation and Protein Synthesis

Translation occurs in the cytoplasm, where ribosomes decode the mRNA sequence to synthesize specific proteins.

Proteins perform essential cellular roles, including enzymatic catalysis, structural support, transport, and regulation.

## 13. Regulation of Gene Expression

Gene expression is tightly controlled to ensure that genes are activated only when needed.

Key regulatory mechanisms include:

- Promoters and enhancers
- Transcription factors
- Epigenetic modifications

Such regulation is vital for normal development and cellular differentiation.

---

## 14. Mutations in DNA

Mutations are permanent alterations in the DNA sequence.

**Types of Mutations**

- Point mutations
- Insertions
- Deletions

Mutations may have harmful, beneficial, or neutral effects on the organism.

---

## 15. Importance of DNA in Science and Medicine

DNA plays a central role in numerous scientific and medical applications, including:

- Diagnosis of genetic diseases
- Forensic identification
- Biotechnology and genetic engineering
- Evolutionary and population studies