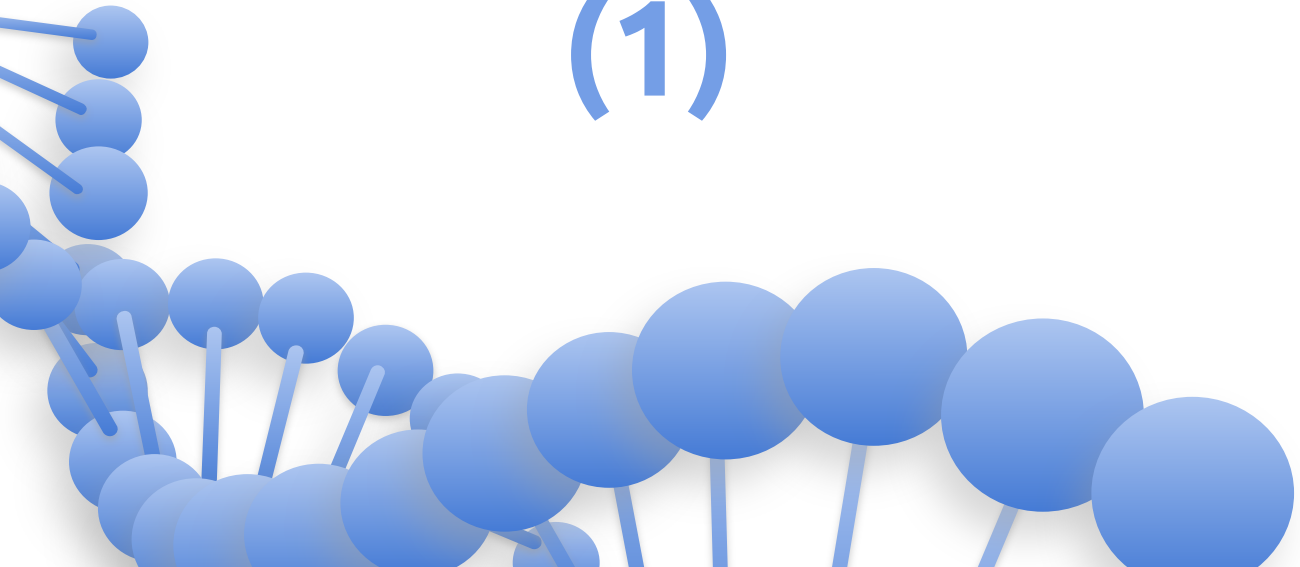
Lecture 3

Molecular Biology (1)



Color Index

- Girls' slides
- Boys' slides
- Doctors' notes
- Important
- Extra info

Editing File

Biochemistry 442

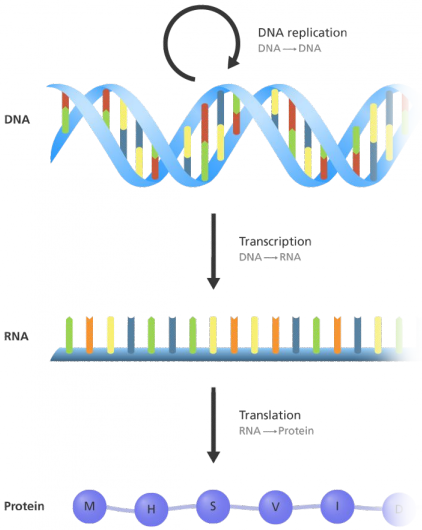
MED 442

Objectives

- Know the central dogma of molecular biology.
- Understand the composition, types and structure of DNA and RNA.
- Describe the organization of DNA in the chromosome and the role of histone proteins.

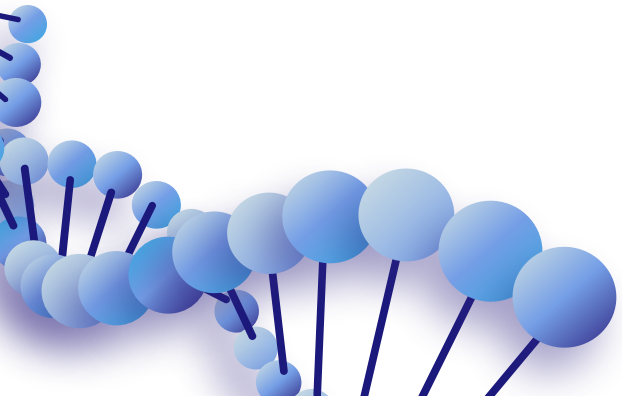
The Central Dogma of Molecular Biology

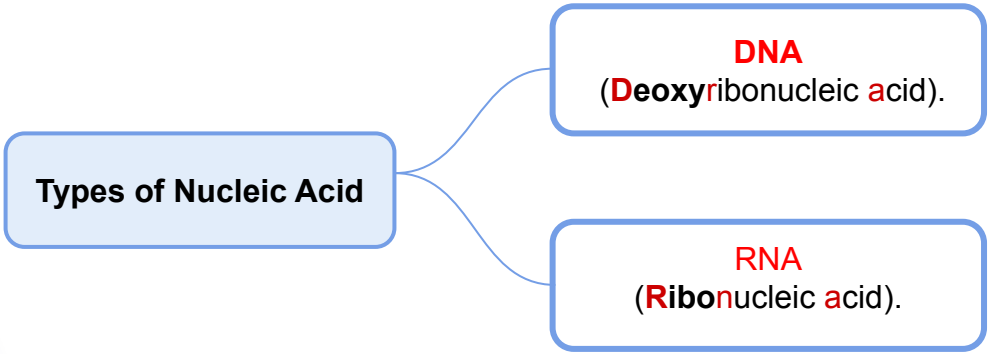
- The ‘Central Dogma’ is the process by which the instructions in DNA are converted into a functional product.
- A portion of DNA, called a gene , is transcribed into RNA.
- RNA is translated into proteins.
- Human genome contains about 35,000 genes.
- The location of the **replication and transcription** is in the **nucleus** while **translation** in **cytoplasm (med439)**.



Nucleic Acid

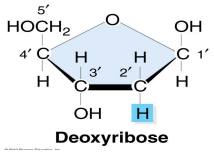
- Nucleic acids are required for the storage and expression of **genetic information.**
- The building blocks of nucleic acids are **nucleoside triphosphates** (**nucleotides**)

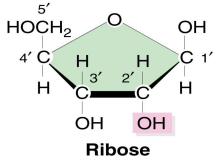




Nucleotides

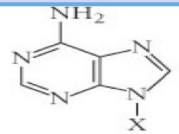
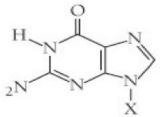
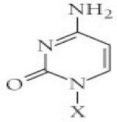
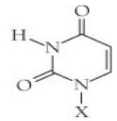
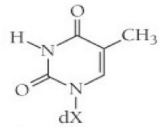
Nucleotides are composed of:

- **Sugar**
  Pentose with 5 carbon ring
  - Deoxyribose **(DNA)**
    (Missing an oxygen at C2)
    

    Deoxyribose
  - Ribose **(RNA)**
    (With -OH at C2)
    

    Ribose
- Phosphate group
- Nitrogenous base
  - Pyrimidines (1 ring)
    - **Cytosine (C)**
    - **Thymine (T)**
    - **Uracil (U)**
  - Purines (2 rings)
    - **Adenine (A)**
    - **Guanine (G)**

Nucleotides

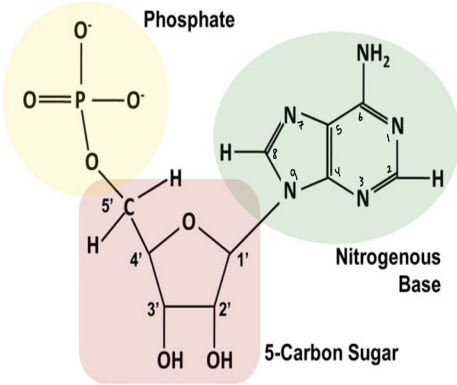
Base formula	**Base** (X=H)	**Nucleoside** (X=ribose) **(Base + Sugar)**	**Nucleotide** (X=ribose phosphate) **(Base + Sugar + phosphate)**
	Adenine Ade A	Adenosine Ado A	Adenylic acid Adenosine monophosphate AMP
	Guanine Gue G	Guanosine Guo G	Guanylic acid Guanosine monophosphate GMP
	Cytosine Cyt C	Cytidine Cud C	Cytidylic acid Cytidine monophosphate CMP
	Uracil Ura U	Uridine Urd U	Uridylic Uridine monophosphate UMP
	Thymine Thy T	Deoxythymidine dThd dT	Deoxythymidylic acid Deoxythymidine monophosphate dTMP

Purines

Pyrimidines

Nucleotides Structure

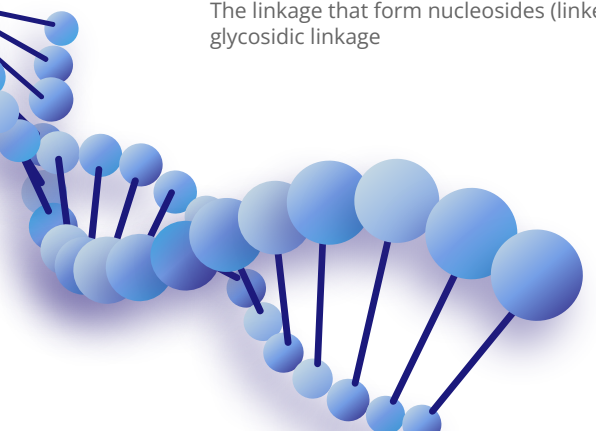
- The **sugar carbon numbers** are **primed** (1’ 2’ 3’ etc.), while the **nitrogenous base atoms** are **unprimed**.
- The **nitrogenous base** is bonded to **C1’** of sugar
- The **PO4** group is bonded to **C3’ or C5’** of sugar.

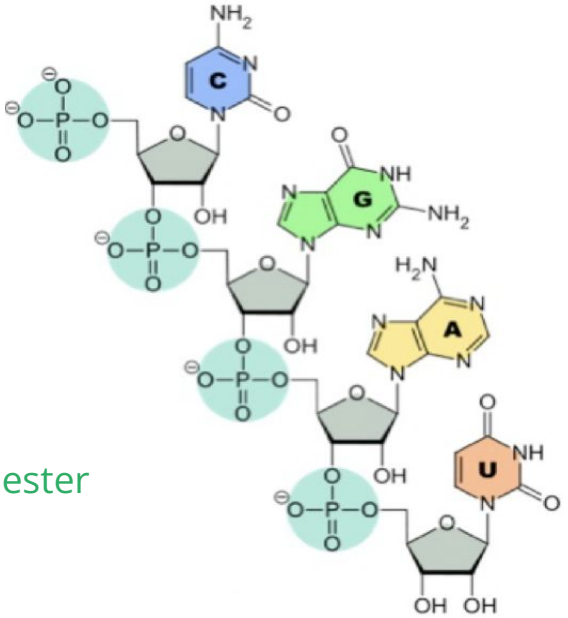


Chemical Structure of DNA and RNA

- The **PO4** bridges the **3’ and 5’ positions** of ribose sugar.
- The **PO4** and **sugar bonding** is the **backbone of DNA structure**
- The **linkage between the nucleotides** is called **phosphodiester bond**

  The linkage that form nucleosides (linkeage between nitrogen base and ribose is called glycosidic linkage





The direction of the phosphodiester bond is 3’ → 5’

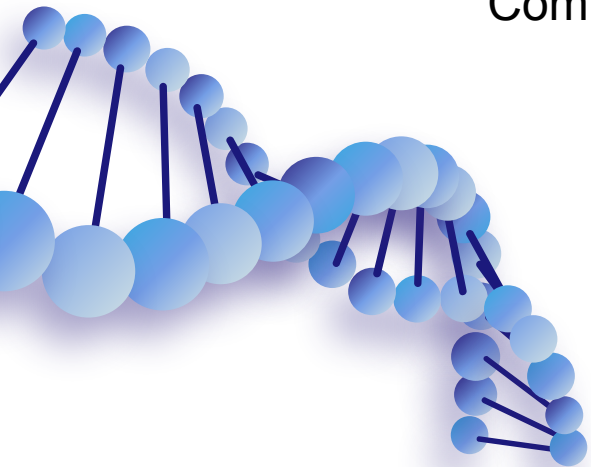
Function of Nucleotides

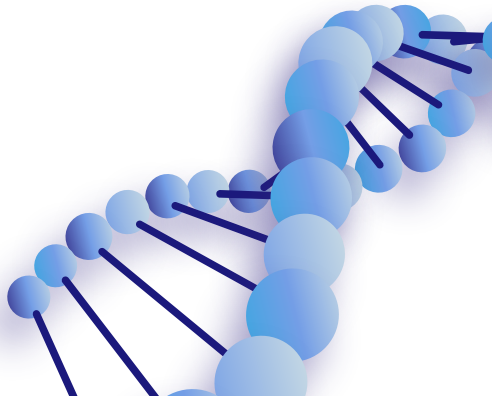
1. **Polymers of nucleotides** (as DNA or RNA) **store** and **transfer** genetic information
2. Free nucleotides and their derivatives perform **various metabolic functions** not related to genetic information.
3. Other nucleotides: **FAD, NAD, CoA**

The Double Helix DNA

The structure of DNA was first determined by James Watson and Francis Crick in 1953.

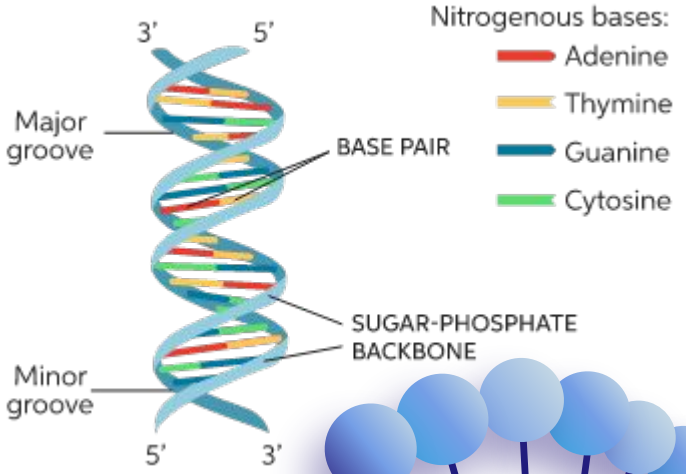
Commonly known as Watson-Crick structure





Features of Watson-Crick DNA Structure

1. **2 polynucleotide chains** wind around a common axis to form a **double helix**
2. **The 2 strands are antiparallel** (run in opposite direction).
3. Each strand is a **right-handed helix**
4. **nitrogenous bases** are in the **center** of the double helix, **sugar-phosphate chains** are on the **sides**

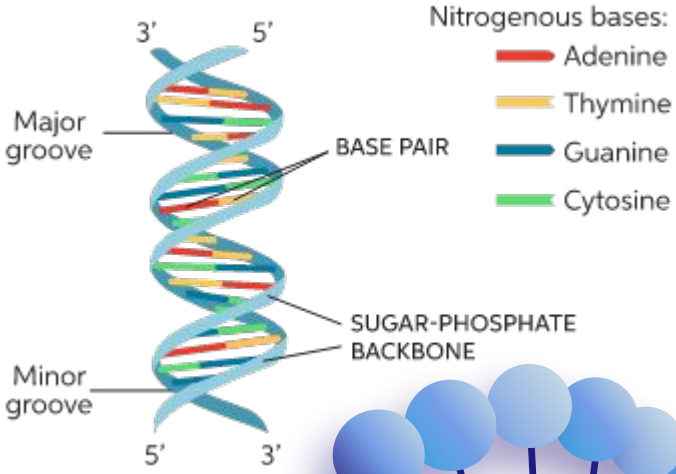


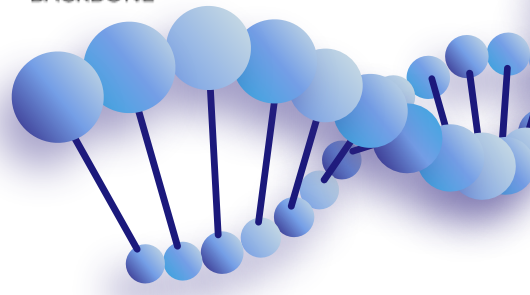
Features of Watson-Crick DNA Structure

5 Surface of the double helix contains **2 grooves: major and minor grooves**

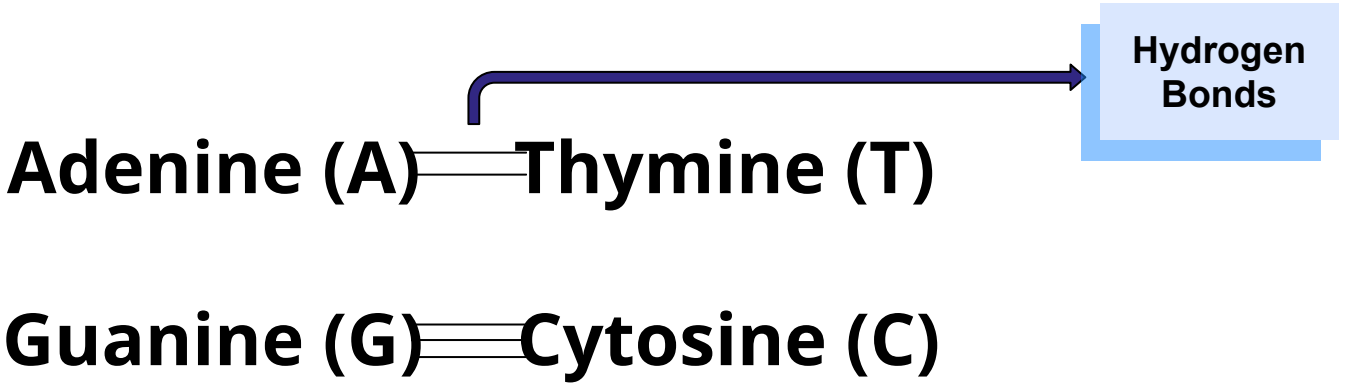
6 Each base is **hydrogen bonded** to a base in the opposite strand to form a base pair (A-T and G-C), known as **complementary base pairing.**

7 The helix has **10 base pairs (bp) per turn**





Watson-Crick Base Pairs



In **RNA**, **Thymine** is replaced by **Uracil (U)**

IMPORTANT SLIDE

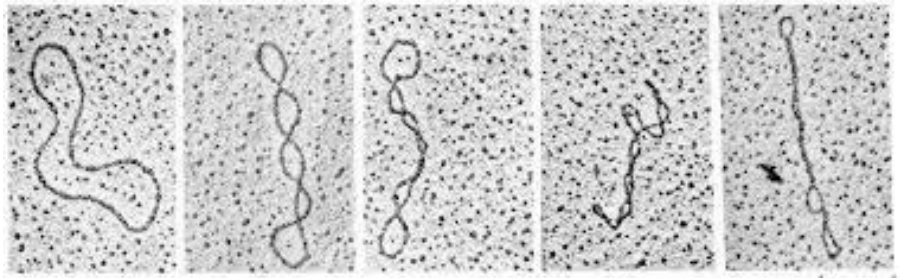
Types of DNA Structure

Types of DNA	A-DNA	B-DNA **(Watson & Crick)**	Z-DNA
Direction*	Right-handed (Clockwise)	Right-handed (Clockwise)	Left-handed (Anti-clockwise)
Helix Length*	Short	Elongated	More Elongated
Major Groove	Deep and Narrow	Wide	Not a real groove
Minor Groove	Wide	Narrow	Narrow
Placement of bp	Displaced away from the helical axis	Centered over the the helical axis	Zig-zag pattern (nearly perpendicular to the helical axis)
bp per turn*	11	10	12
Conformation of Deoxyribose	C3	C2	G (C2) ; C (C3)

DNA Supercoiling

The chromosomes of many bacteria and viruses contain circular DNA which is **supercoiled (مُلْتَف بشدة)**

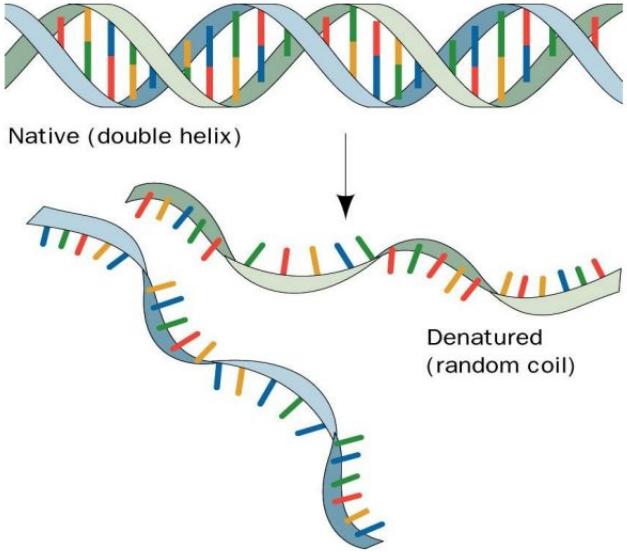
in order to take less space, and to give it more protection because they don't have nucleus



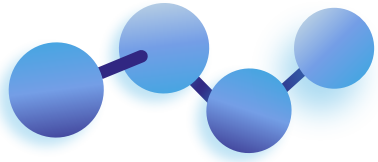
Melting Temperature (MT)

- The temperature at which the double-stranded **DNA is separated into two single strands.**

- Melting point of DNA **depends on nitrogenous base content** (A-T and G-C). **G-C** has **3 hydrogen bonds**, so it is **stronger** than A-T which only has 2.

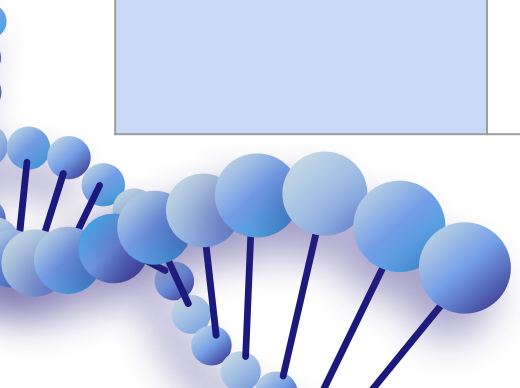


Types and Functions of RNA



RNA is a **single- stranded polymer** of ribonucleotides

Types of RNA	Messenger RNA	Transfer RNA	Ribosomal RNA
Functions	transcription Process **(DNA → mRNA)**	- **Recognition**: It recognizes amino acids codons - **Transferring**: transfers the selected amino acids to the growing protein chain.	-Site of **protein synthesis** (factory) - It is the **RNA component** of a ribosome



Organization of DNA

- The human genome contains 3.5 billion base pairs and **more than 95% is non-coding** or “junk” DNA

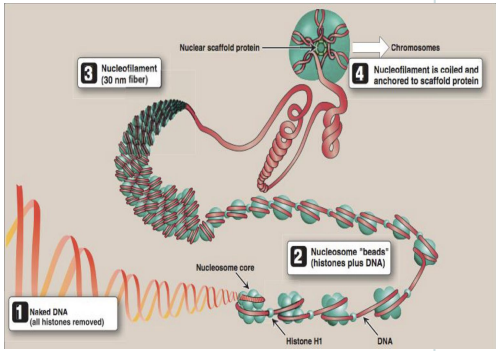
- The DNA from single 23 human chromosomes have a length of **1 meter.**

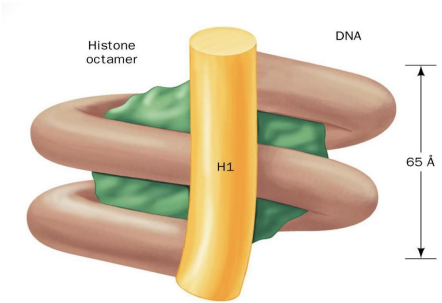
- Each chromosome is a complex of a single linear DNA molecule and protein
- called **chromatin**.

- 50% of chromatin consists of proteins called **histones.**
  - histones have **five major types**:
    - H1 H2A H2B H3 H4
  - Histones have **positively charged** amino acids (arginine and lysine).
  - These proteins bind to **negatively charged PO4 groups** of DNA to **stabilize** the chromatin structure.

Nucleosomes

- Nucleosomes are particles consisting of **DNA** and **histones** connected by thin strands of naked DNA (like beads on a string; we call it سبحة in Arabic).
- Nucleosomes consist of the **histone octamer** (eight) and DNA **$(H2A)_2$, $(H2B)_2$,$(H3)_2$, $(H4)_2$**
- **H1** binds to **2 complete helical** turns of DNA.





Take Home Messages

- The central dogma of molecular biology involves three components: DNA, RNA and protein.
- There are two chemically distinct types of nucleic acids: DNA and RNA, which perform several crucial functions.
- To package the long sequence of the genomic DNA, it is highly organized into chromosomes.

Quiz

1- Which of the following is a purine?			
a) adenine	b) cytosine	c) thymine	d) uracil
2- How many base pairs per turn are there in the DNA helix?			
a) 12	b) 16	c) 10	d) 20
3- Which of the following is NOT a type of DNA structure?			
a) A-DNA	b) B-DNA	c) C-DNA	d) Z-DNA
4- What percentage of chromatin consists of histones?			
a) 70%	b) 80%	c) 100%	d) 50%
5- Which histone binds to 2 complete helical turns of DNA?			
a) H3	b) H2A	c) H1	c) H2B

1. A
2. C
3. C
4. D
5. C

Our Team

Meshari Alshathri
Talal Alharbi
Azzam Alotaibi
Basel Al-Zahrani
Saleh Aldeligan
Mohammed AlGhamdi
Abdulaziz Lafy
Rayan Alahmari
Mohammed Alrobeia

Ajwan Aljohani
Mashael Alasmri
Razan Almanjomi
Razan Almohanna
Mashael Alsuliman
Reema Alhussien
Moudi Alsubaie
Renad Alayidh
Roaa Alharbi
Lara Alageel

Leaders

Sara Alsheikh & Mohammed Alshehri

Biochemistry
442

M4
E4
D2