Molecular biology 1

Editing File

Color Index:
- Main Text (black)
- Female Slides (Pink)
- Male Slides (Blue)
- Important (Red)
- Dr's Notes (Green)
- Extra Info (Grey)

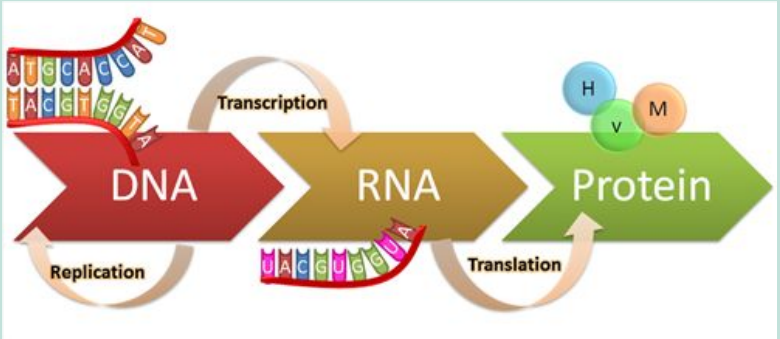
Objectives

- 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

A portion of DNA, called a gene is transcribed into RNA
RNA is translated into proteins
human genome contains about 35,000 genes

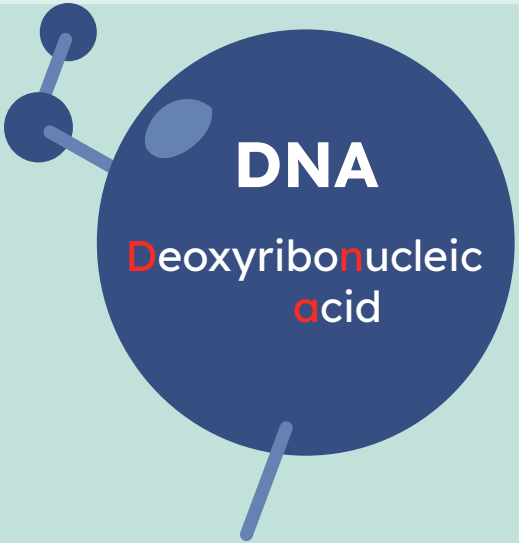
NOTE: The location of the replication and transcription is in the nucleus while translation in cytoplasm (med439)

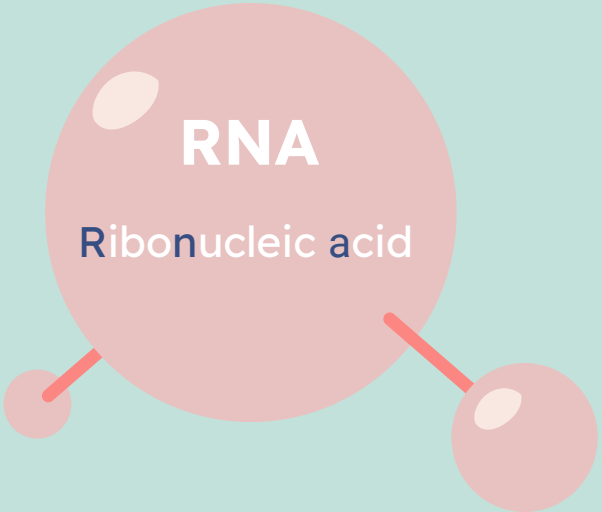


Nucleic acids

Required for the storage and expression of **genetic information**
Building blocks of nucleic acids are **nuclueoside triphosphates** (nucleotides)

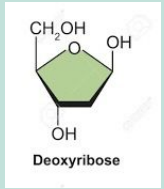
Two types of nucleic acids :

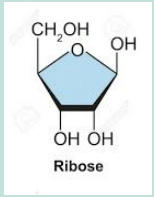


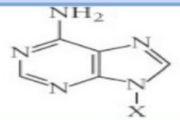
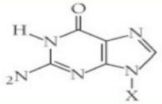
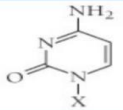
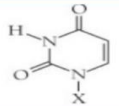
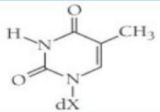


Nucleotides are composed of

- **Phosphate group**
- **Nitrogenous base**
  - Pyrimidines (1 ring)
    - Thymine (T)
    - Cytosine (C)
    - Uracil (U)
  - Purines (2 rings)
    - Adenine (A)
    - Guanine (G)
- **Sugar** (pentose with 5 carbon ring)
  - Ribose (RNA) (with –OH at C2)
  - Deoxyribose (DNA) (missing an oxygen at C2)





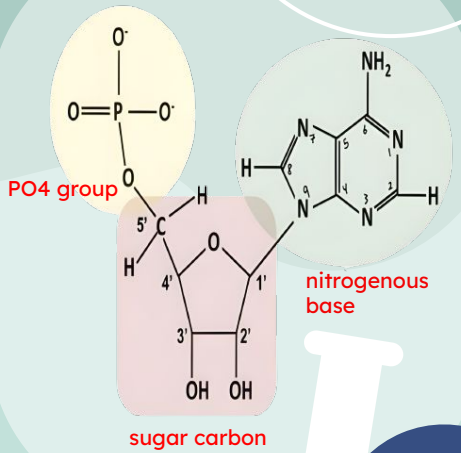
Base formula	**Base** (X=H)	**Nucleoside** (X=ribose) **(Base + Sugar)**	**Nucleotide** (X=ribose phosphate) **(Base + Sugar + phosphate)**
	Adenine Ade A	Adenosine Ado A	Adenylic acid Adenosine monophosphate AMP
	Guanine Gue G	Guanosine Guo G	Guanylic acid Guanosine monophosphate GMP
	Cytosine Cyt C	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.
- C5 is not part of the ring



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 direction of the phosphodiester bond is 3' → 5'**

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

Function of Nucleotides

- Polymers of nucleotides (as DNA or RNA) store and transfer genetic information

- Free nucleotides and their derivatives perform various metabolic functions not related to genetic information.
Other nucleotides: FAD, NAD, CoA (coenzymes)

THE DOUBLE HELIX OF DNA

The structure of DNA was first determined by James watson and Francis crick in 1953 (watson-crick structure)

Features of Watson-Crick DNA structure

2 polynucleotide chains wind around a common axis to form a **double helix**.

The nitrogenous bases are in the **center** of the double helix and sugar-phosphate chains are on the **sides**

The two strands are **anti-parallel** (run in opposite direction)

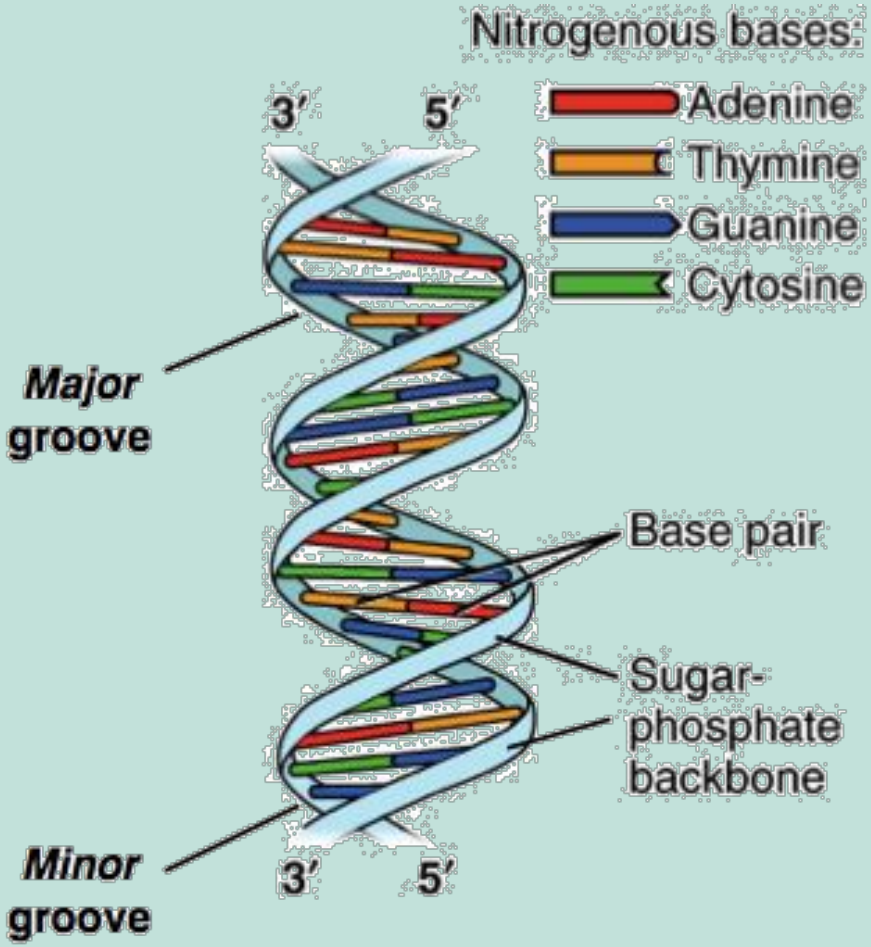
Surface of the double helix contains 2 grooves: major and minor grooves

Each strand is a right-handed helix.

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

Each base is **hydrogen bonded** to a base in the opposite strand to form abase pair (**A=T**) ,(**G 3 bonds C**) known as complementary base pairing

In RNA, Thymine is replaced by Uracil (U)


Nitrogenous bases:
Adenine
Thymine
Guanine
Cytosine
3′
5′
Major groove
Base pair
Sugar-phosphate backbone
Minor groove
3′
5′

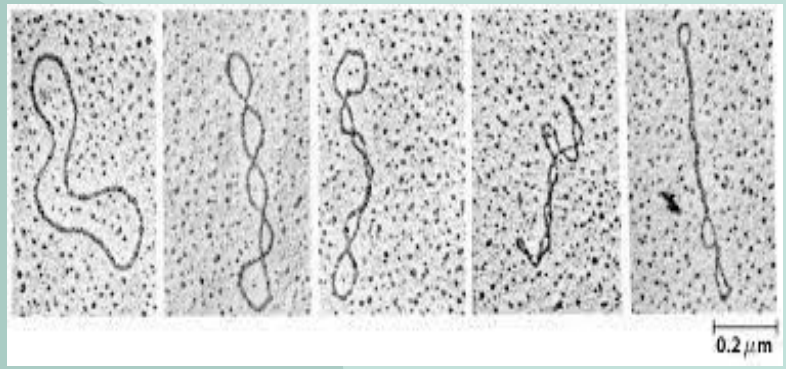
IMPORTANT SLIDE

Types of DNA	A-DNA	B-DNA (watson and 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.(ملتف بشدة)

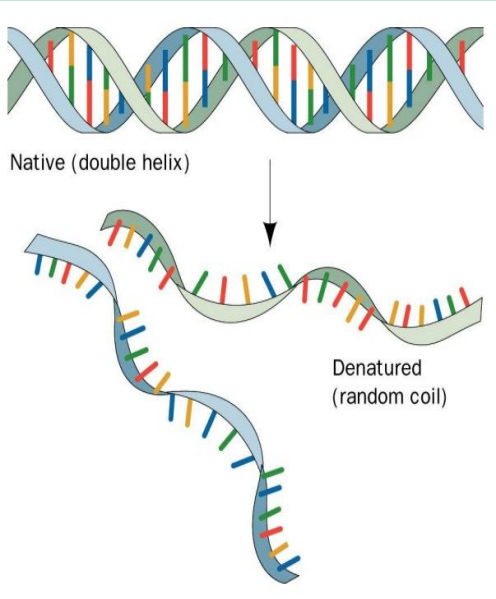
in order to take less space, and to give it more protection because they don't have nucleus.



Melting Temperature (MT)

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

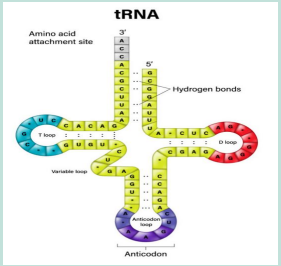
- Melting point of DNA **depends on nitrogenous base content** (A-T and G-C). **G-C** has **3 hydrogen bonds**, so it is **stronger** than A-T which only has 2.
  - If a protein have more G-C bonds it will require higher temperature to melt.
  - The phosphodiester link remains intake.

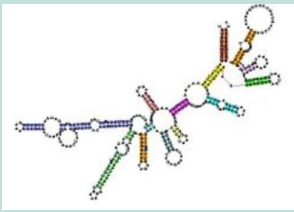


Types and Functions of RNA

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

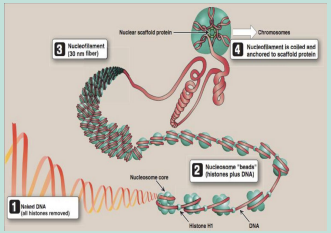
- histones have **five major types**:

  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

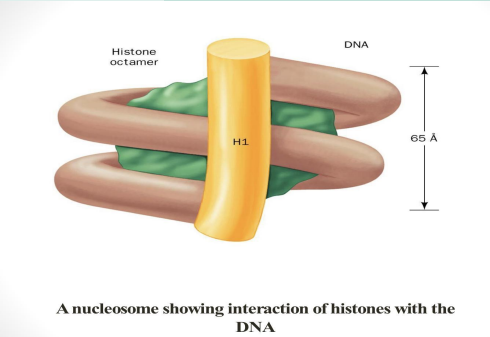
- Nucleosomes are particles consisting of **DNA** and **histones** connected by thin strands of naked DNA (like beads on a string; we call it سبحة in Arabic).



- 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.



A nucleosome showing interaction of histones with the 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.

Question 1

Nitrogenous base is bonded to ..... of sugar ?

A C1’

C C2’

B C3’

D C5’

Question 1

Nitrogenous base is bonded to ..... of sugar ?

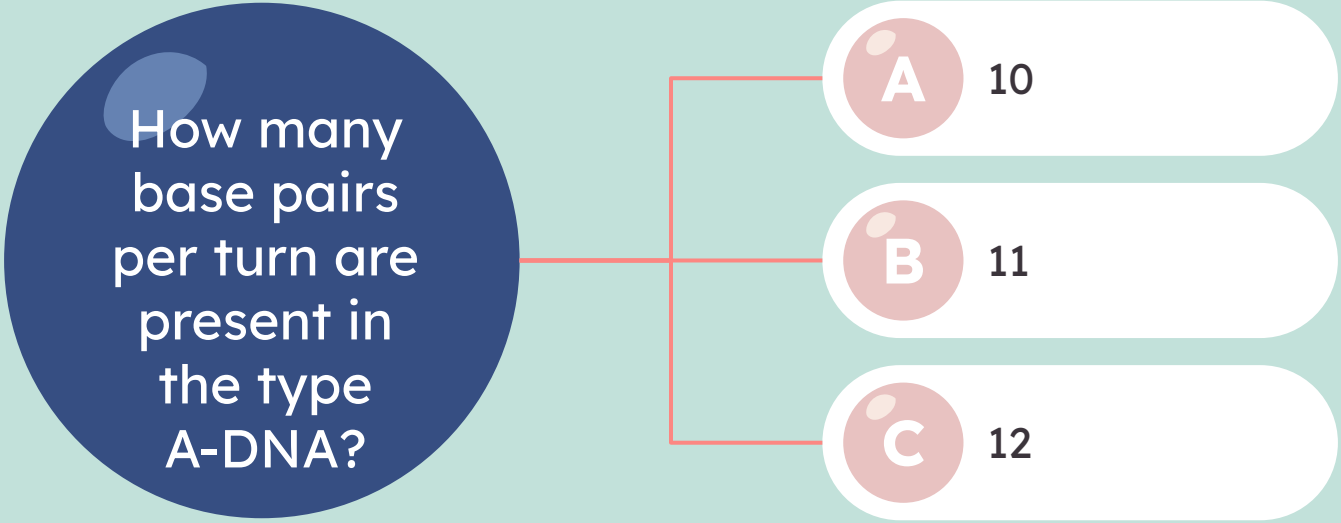
A C1’

C C2’

B C3’

D C5’

Question 2


How many base pairs per turn are present in the type A-DNA?
A
10
B
11
C
12

Question 2

How many base pairs per turn are present in the type A-DNA?

A 10

B 11

C 12

Question 3

The backbone of DNA structure
:
The PO_3-sugar?

True

False

Question 3

The backbone of DNA structure
:
The PO3-sugar?

True

False

Biochemistry Team

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