جامعة الملك سعود
King Saud University

Biochemistry team 436

# Molecular biology (1)

- Color Index:

Important. ▪

Extra Information. ▪

**Doctors slides.** ▪

436 Biochemistry team

**Revised by**

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# 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

## What is The Central dogma ?

The flow of information from DNA to RNA to Protein.

A portion of DNA, called a gene, is transcribed into RNA. ➢

RNA is translated into proteins. ➢

**Gene:** portion of DNA that transcribed into RNA.

Human genome contains about 35,000 genes ➢

Which counts for 5% of total DNA ➢

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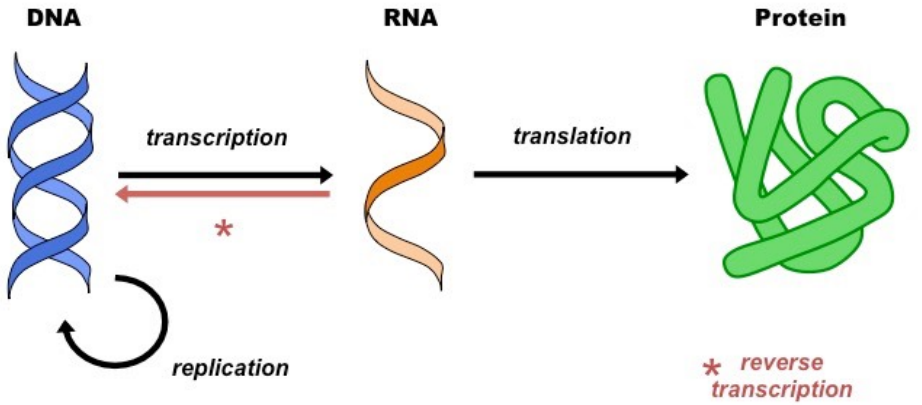
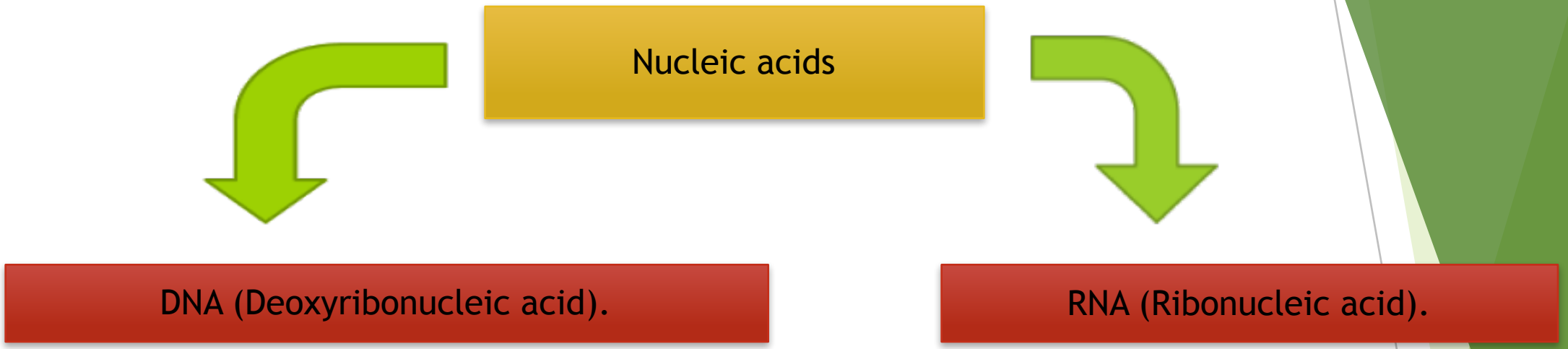





Nucleic acid (DNA and RNA) = Polymers of nucleotides (Adenylic acid, Guanlyc Acid, etc)

Nucleotides = Nucleoside (adenosine, Guanosine, etc) + phosphate

Nucleoside = nitrogenous base (Adenine, Guanine, etc) + ribose (sugar )

So.. many nucleoside with phosphate added to it gives us nucleic acid

the Building blocks of nucleic acids are nuclueoside triphosphates (**nucleotides**).

required for the storage and expression of genetic information .

Nucleotides
Are composed of:

Nitrogenous base:

Purines:

Adenine (A) and Guanine (G)

Pyrimidines:

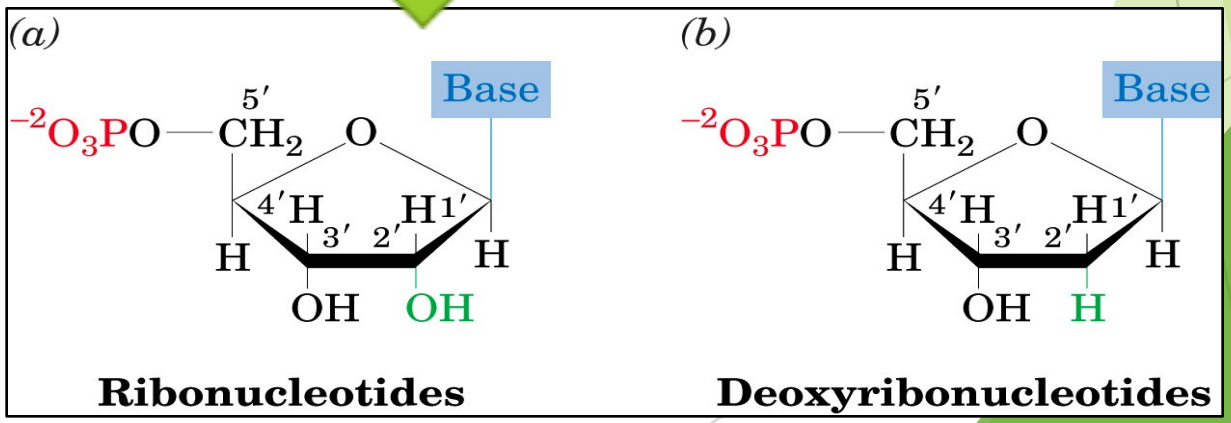
Cytosine (C), Thymine (T) and Uracil (U).

pentose: (Sugar with 5 carbon ring):

Ribose (with –OH at C2).

Deoxyribose (with only H at C2)

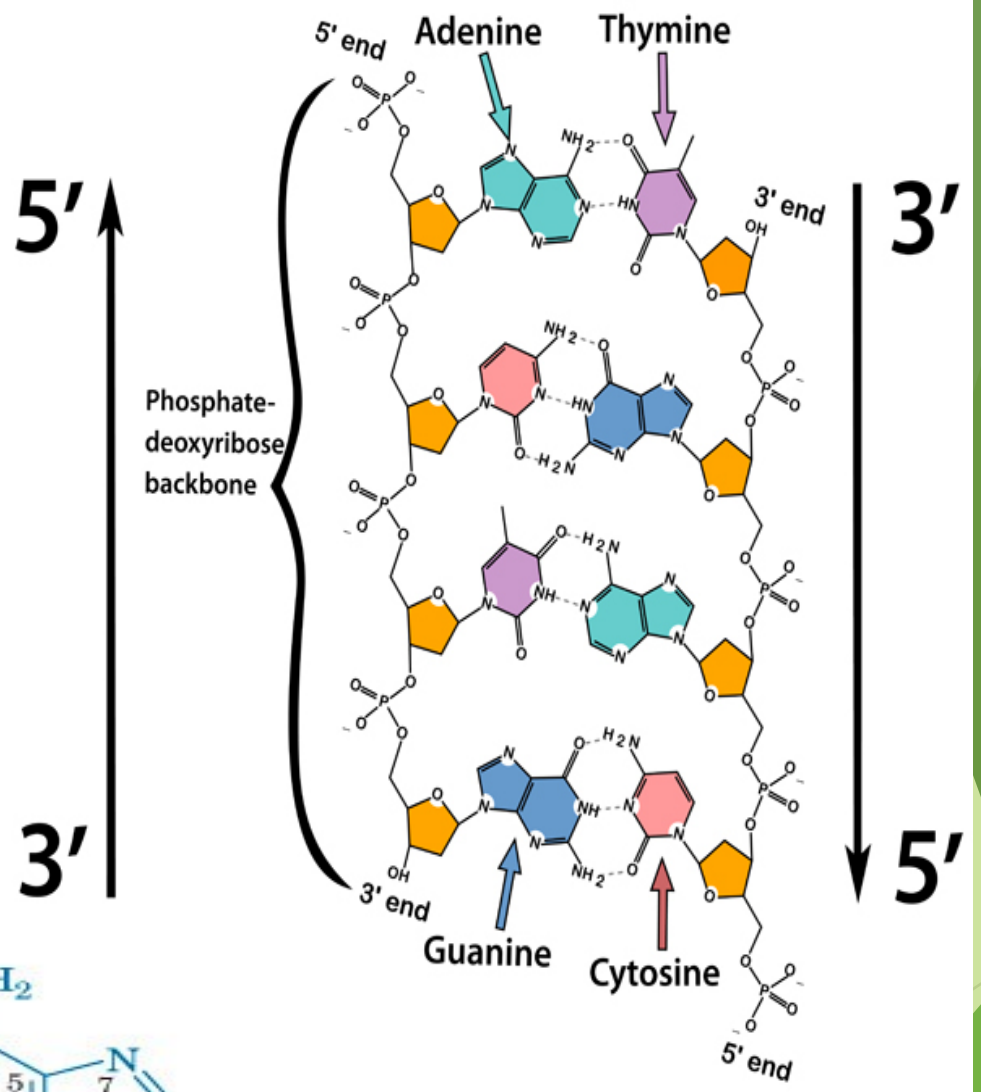
Phosphate groups

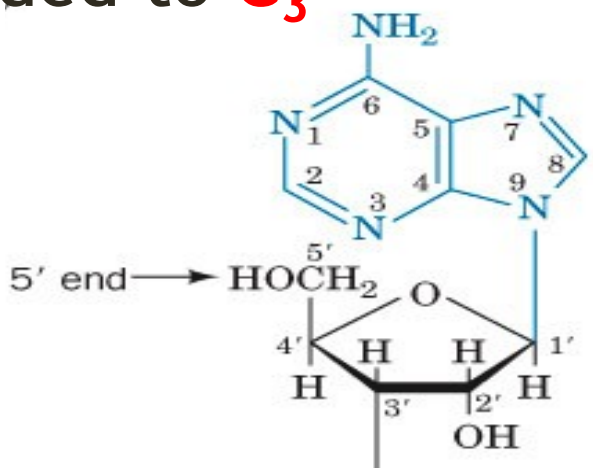


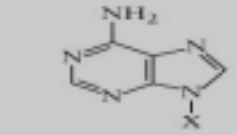
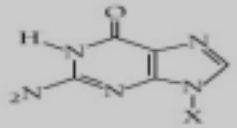
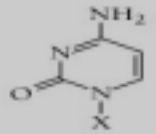
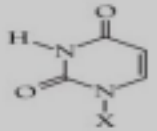
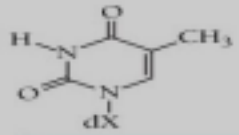
- The **sugar carbon** numbers are primed (1’ 2’ 3’ etc.), while **the nitrogenous base atoms** are unprimed.

- The nitrogenous base is bonded to $C_1$’ of sugar.

- The $PO_4$ group is bonded to $C_3$’ or $C_5$’ of sugar.



| Base Formula | Base (X = H) | Nucleoside (X = ribose[a]) | Nucleotide[b] (X = ribose phosphate[a]) |
|---|---|---|---|
|  | Adenine<br>Ade<br>A | Adenosine<br>Ado<br>A | Adenylic acid<br>Adenosine monophosphate<br>AMP |
|  | Guanine<br>Gua<br>G | Guanosine<br>Guo<br>G | Guanylic acid<br>Guanosine monophosphate<br>GMP |
|  | Cytosine<br>Cyt<br>C | Cytidine<br>Cyd<br>C | Cytidylic acid<br>Cytidine monophosphate<br>CMP |
|  | Uracil<br>Ura<br>U | Uridine<br>Urd<br>U | Uridylic acid<br>Uridine monophosphate<br>UMP |
|  | Thymine<br>Thy<br>T | Deoxythymidine<br>dThd<br>dT | Deoxythymidylic acid<br>Deoxythymidine monophosphate<br>dTMP |

NOTICE:

Purines: 2 rings and 4 nitrogen inside the rings

*You don't have to memorize the structures

Pyrimidines: 1 ring and 2 nitrogen inside the the ring

it would be a base and ending in "ine" if an H was in X place

if a ribose was in X place it would be a Nucleoside and ending in "osine"

if a ribose phosphate (ribose with a phosphate connected to it) was in place of X it would be a nucleotide and ending in "ylic acid"

AMP,GMP, is just an abbreviation

# Chemical structure of DNA and RNA

-The PO4 bridges the 3’ and 5’ positions of ribose sugar.

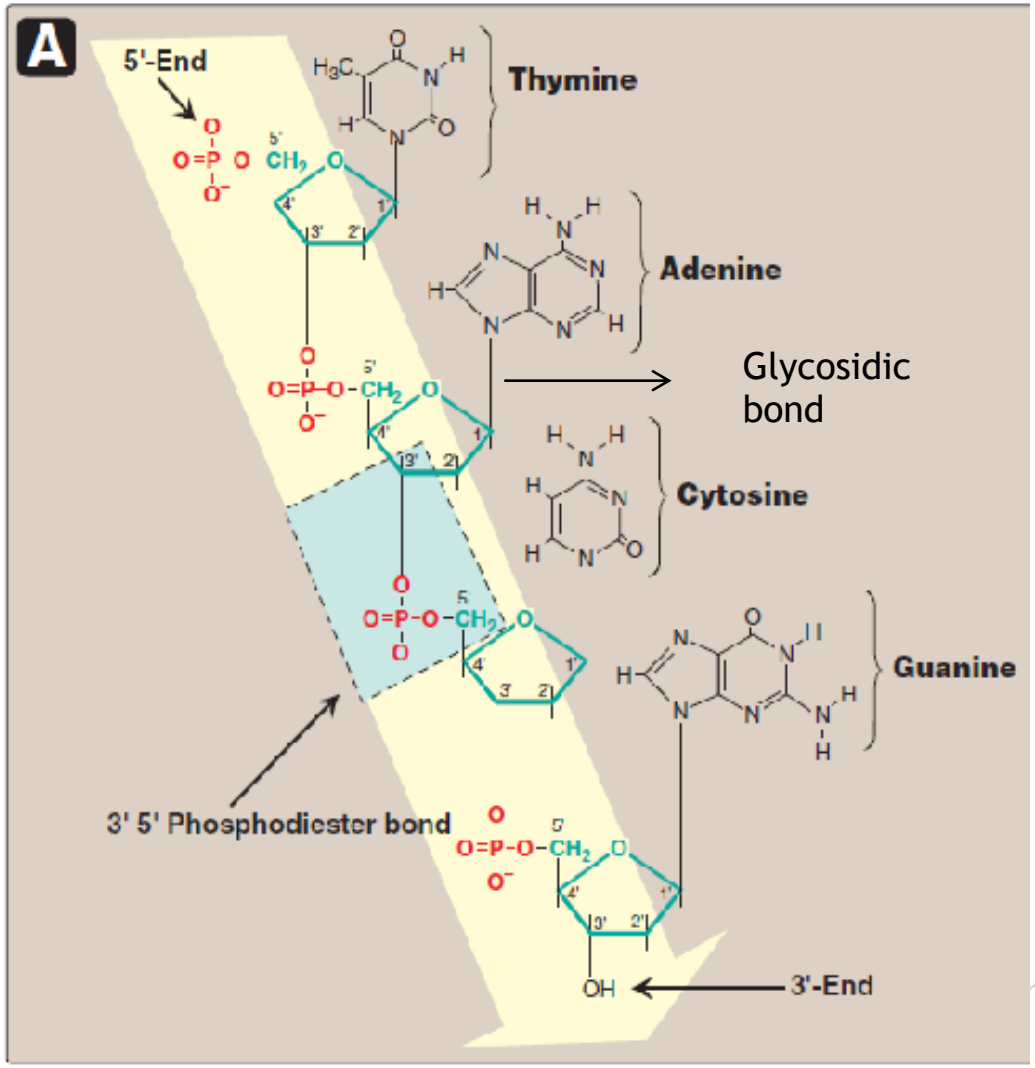
-The PO4 and sugar bonding is the backbone of DNA structure.

-The linkage between the nucleotides is called phosphodiester bond

The linkage between nitrogen bases and ribose sugar is glycosidic linkage.

*مهم جدا معرفة اسم الرابطة التي تربط بين النيوكليوتايدز (phosphodiester).

- مهم معرفة كل كربون ايش مرتبط فيها ..- مثلا النيتروجين بيس مرتبطه بكاربون رقم 1
- والفوسفات قروب يرتبط مع كربون 3 و/او 5.



# 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

# 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- Two polynucleotide chains wind around a common axis to form a double helix.

2- The two strands are anti-parallel (run in opposite direction). From 5 ----------3
3----------5

3- Each strand is a right-handed helix.

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

5-The surface of the double helix contains 2 grooves: the major and minor grooves. Places for bonding to regulate transcription or replication.

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

Adenine (A)≡ Thymine (T)

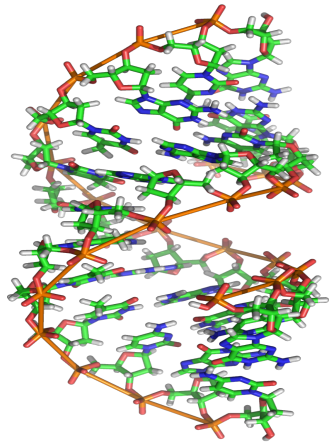
Guanine (G)≡ Cytosine (C)

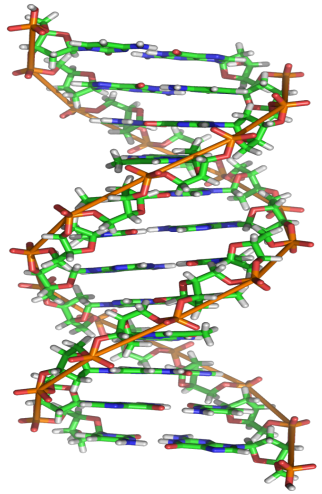
In RNA, Thymine is replaced by Uracil (U)

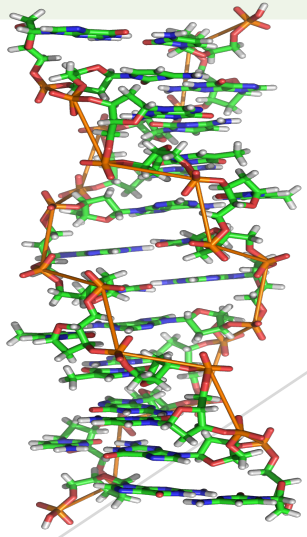
7-The helix has 10 base pairs (bp) per turn.

# Types of DNA structure

| | A-DNA | B-DNA<br>Watson-Crick model | Z-DNA |
|---|---|---|---|
| **Direction** | Right-handed | Right-handed | Left-handed |
| **Helix length** | Short | Elongated | More elongated |
| **Major groove** | Deep and narrow | Wide | Not real groove |
| **Minor groove** | Wide | Narrow | Narrow |
| **Placement of bp** | Displaced away from the helical axis | Centred over the helical axis | Zig-zag pattern (nearly perpendicular to the helical axis) |
| **bp per turn** | 11 | 10 | 12 |
| **Conformation of deoxyribose ـــالوين يمسك** | $C_3$ | $C_2$ | G ($C_2$) ; C ($C_3$)<br>مرة يمسك في رقم 3 ومرة في 2 |
| **Notes** | يوجد في حالتين :<br>1- DNA نسخ ال<br>2- Non coding RNA | غالبية الموجود في الجسم على هذا الشكل | - |

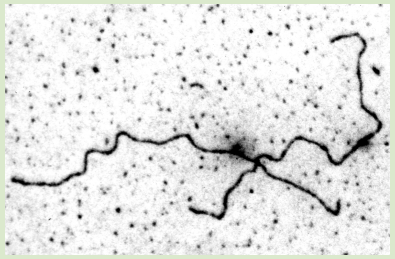
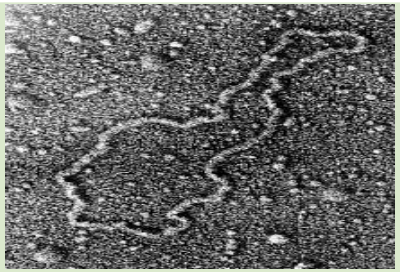






# DNA supercoiling

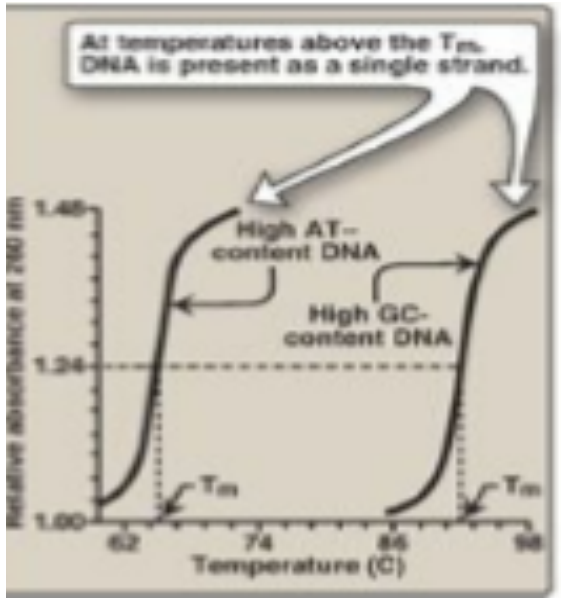
- The chromosomes of many bacteria and viruses contain circular DNA which is supercoiled.
- The end of DNA of human is not connected like bacteria، It is separated.

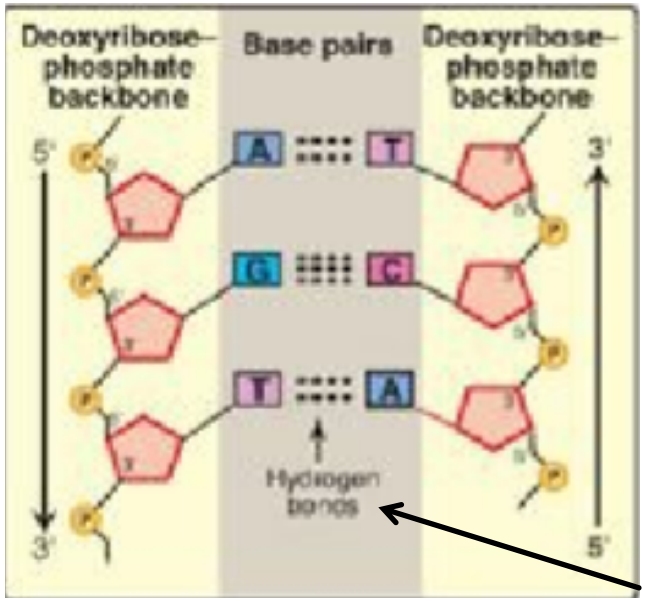
| DNA of human | DNA of bacteria |
| --- | --- |
|  |  |

# Melting temperature

- The temperature at which the double-stranded DNA is separated into two single strands.
- MT of DNA depends on nitrogenous base content (A-T and G-C).

| | A-T | G-C |
|---|---|---|
| Type of hydrogen bond | Double bond<br>- Less stable so needs lower MT- | Triple bond<br>-more stable so needs higher MT- |
| Separated at | 63-68 c° | 90-95 c° |



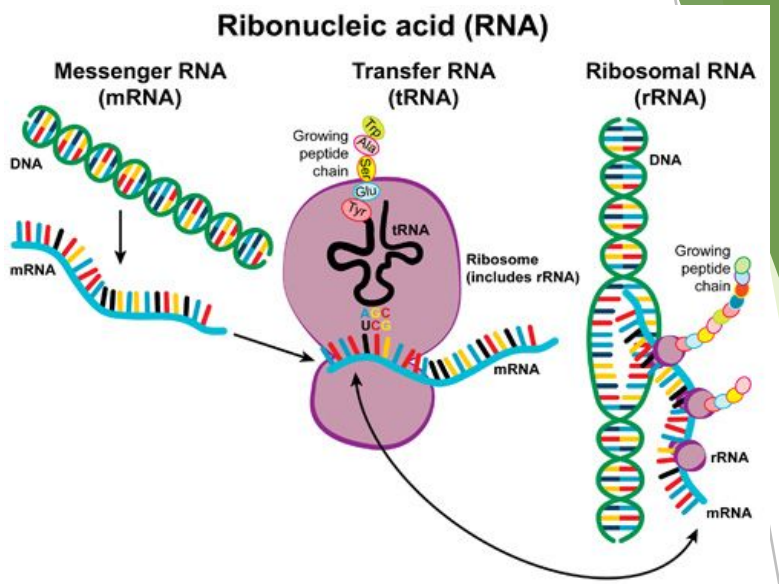



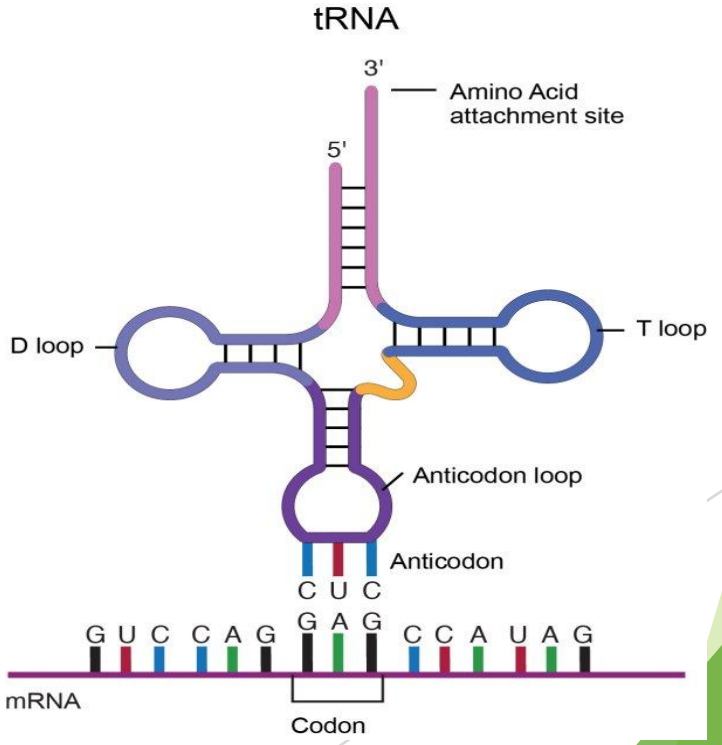

When reaches the MT only the hydrogen bonds between nitrogen bases are broken

# RNA (Types and function)

- **RNA is a single-stranded polymer of ribonucleotides.**
- Types of RNA :

| Type of RNA | Function |
|---|---|
| mRNA | Transcription process (from DNA to mRNA). |
| tRNA | Recognition and transferring. It recognizes amino acids' codons and transfers the selected amino acids to the growing protein chain. |
| rRNA | Site of protein synthesis (factory). |



# Nucleosomes

## What are they?

Nucleosomes are the individual units of chromatin

(particles consisting of DNA and histones connected by thin strands of naked DNA)

They consist of a segment of DNA wrapped around a core called histone octamer

( 8 particles of histone protein )

Two particles of each histone ( H2A, H2B, H3 and H4 ) assemble to form the core

While the fifth type of histone H1 forms the bond between the core and the DNA.

( H1 binds to 2 complete helical turns of DNA.)

# HOW DNA IS ORGANIZED IN A CHROMOSOME?

**How DNA is organized in a chromosome**

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

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

3- 50% of chromatin consists of protein called Histones

4- The human genome contains 3.5 billion base pairs and more than 95% is non-coding or "junk" DNA.

Major types of histones : H1 , H2A , H2B , H3 and H4.
- They consist of amino acids that are positively charged ( arginine and lysine ).
- Importance : These proteins (+) bind to PO4(-) groups of DNA, stabilizing the structure of chromatin.

* Note ; positively charged means ( polar basic ) - histidine is not included because it is a weak base -

# MSQ's

1- The linkage between the nucleotides is called :

a) Phosphate bond (b) phosphodiester bond (c) ester bond (d) phosphoester bond

2- how many bp per turn in Z-DNA ?

(a) 10 (b) 11 (c) 12 (d) 13

3- The most common DNA form in the body is :

a) A-DNA (b) B-DNA (c) Z-DNA (d) None

4- Conformation of deoxyribose in the Z-DNA form :

a) C3 (b) C4 (c) G (C2) ; C (C3) (d) None

1- B

2- C

3- B

4- c

## Boys team members:

1- عبدالعزيز الشديد.
2- فهد العتيبي.
3- محمد حبيب.
4- محمد العسيري.
5- محمد المهوس.
6- هشام القوسي.
7- حاتم النداح.
8- محمد حكمي

## -Team leaders:

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عبدالله المانع.

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