جامعة الملك سعود
King Saud University

MED437
KING SAUD UNIVERSITY

BIO TEAM

Molecular biology (1)

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Notes and explanations

Extra information

highlights

تمت المراجعة
غيداء آل مصمع
&
عبدالرحمن الحيسوني

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.

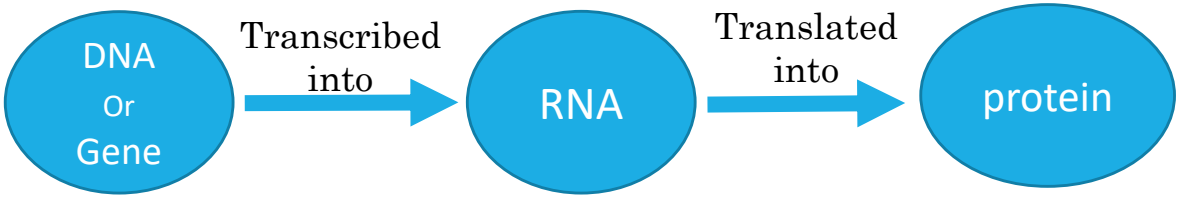
للتوضيح:
Dogma : a principle or set of principles laid down by an authority. (well established fact)

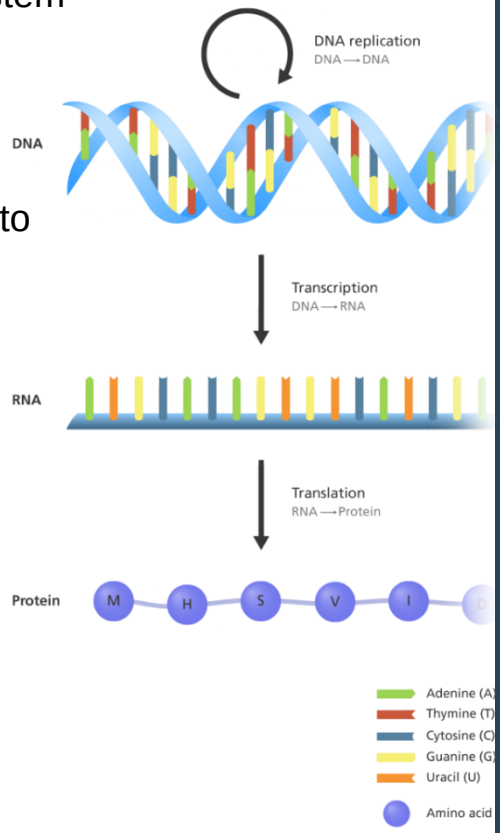
The central dogma of Molecular Biology

What is central of dogma?
is an explanation of the flow of genetic information within a biological system
“ DNA to RNA to protien”

It involves three components: DNA, RNA and protein.

a portion of DNA called a gene is transcribed into RNA then translated into protein.



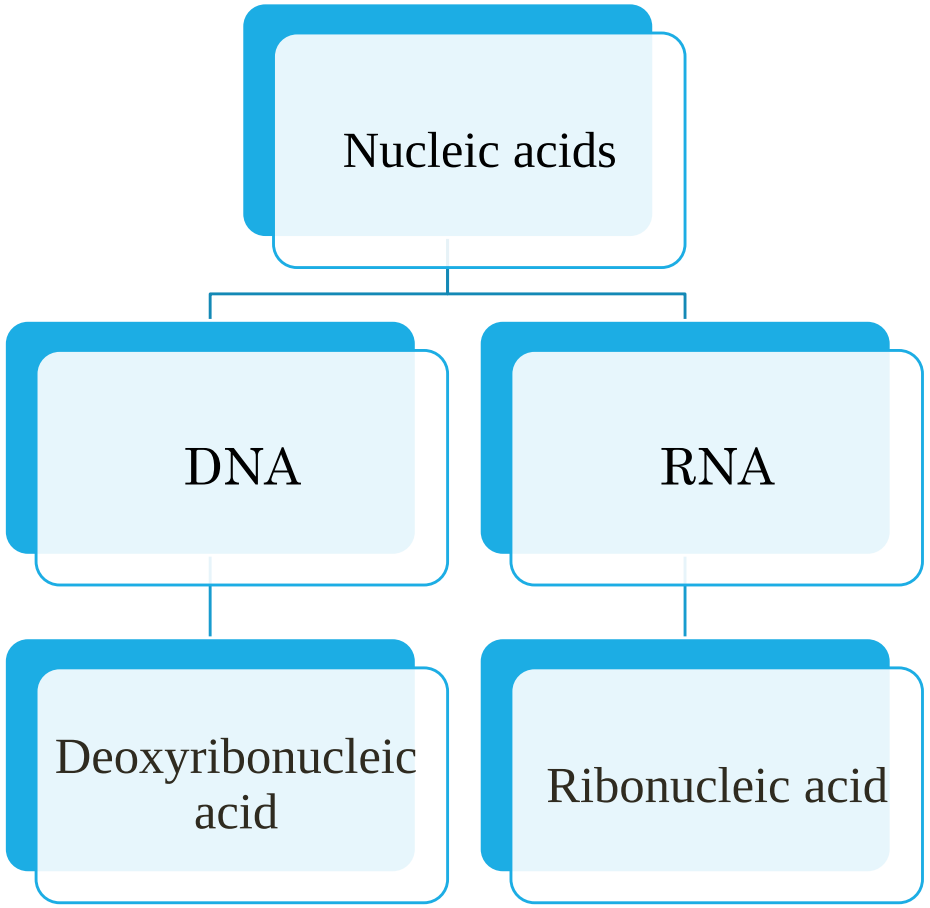


Human genome contains about 35,000 genes

Dr. Review:
1- a gene is inherited from parents to off spring
2-expression of gene defines a person
3-information is expressed as proteins; how?
DNA is transcribed to RNA in the nucleus then translated into protein in the cytoplasm.

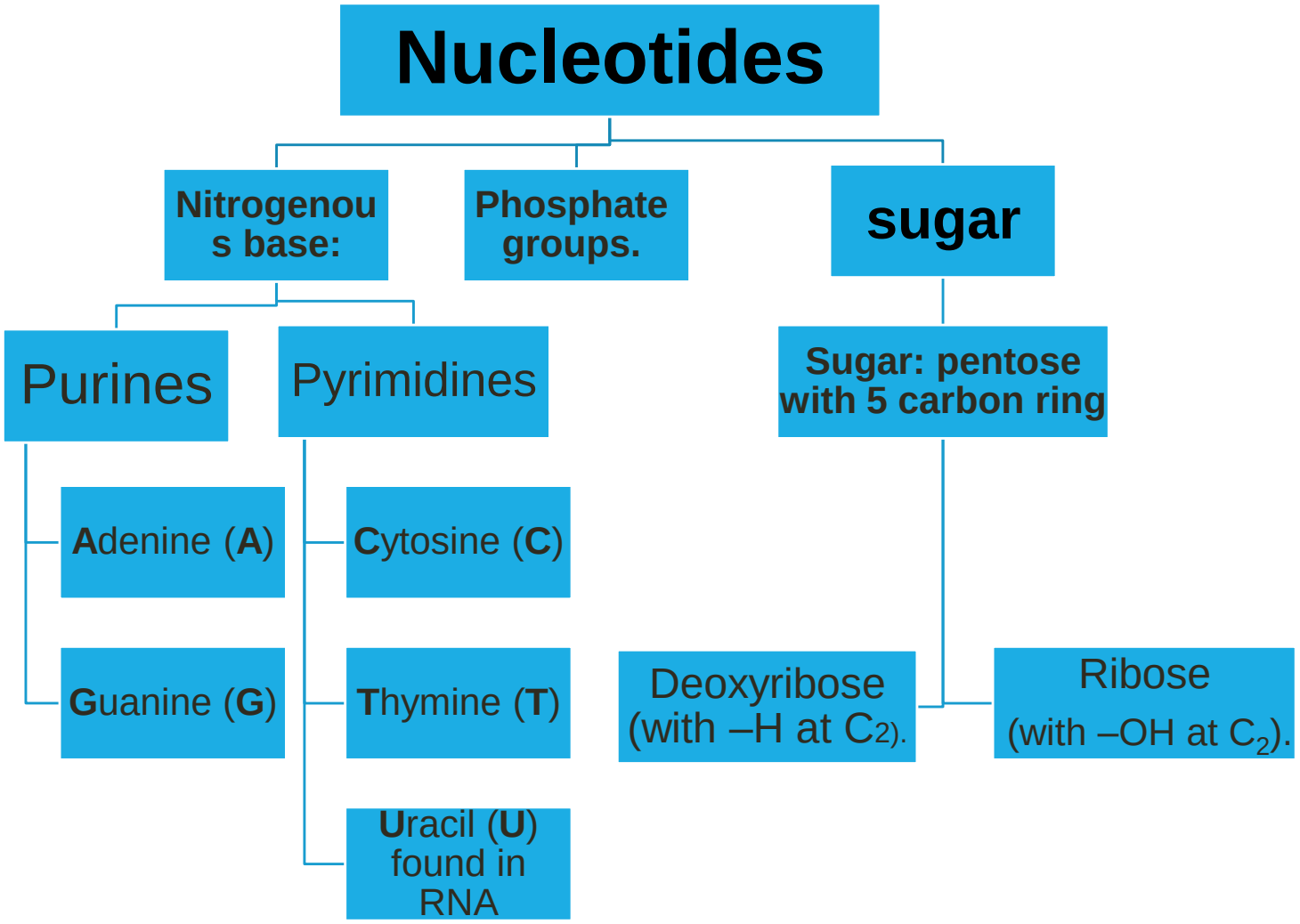
Nucleic acids.

- Is the unit Required for the storage and expression of genetic information.
- Building blocks of nucleic acids are nucleoside triphosphates (**nucleotides**).



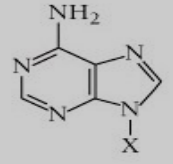
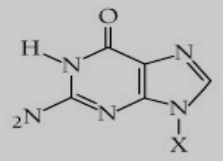
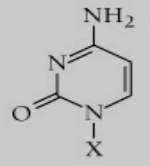
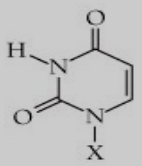
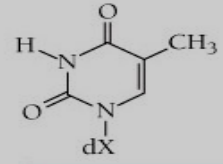
There are two chemically distinct types of nucleic acids: DNA and RNA, which perform several crucial functions.

- Nucleosides are composed of: nitrogen base + ribose sugar
- nucleotides are composed of: Nucleoside + phosphate group


Nucleotides
Nitrogenous base:
Phosphate groups.
sugar
Purines
Pyrimidines
Sugar: pentose with 5 carbon ring
Adenine (A)
Guanine (G)
Cytosine (C)
Thymine (T)
Uracil (U) found in RNA
Deoxyribose (with –H at C2).
Ribose (with –OH at C2).

Nitrogen bases

*No need to memorize structures but know the names.

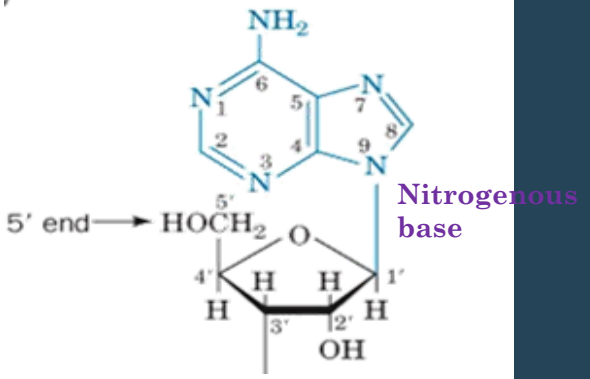
Base Formula	Base (X = H)	Nucleoside (X = ribose[a])	Nucleotide[b] (X = ribose phosphate[a])
	Adenine Ade A	Adenosine Ado A	Adenylic acid Adenosine monophosphate AMP
	Guanine Gua G	Guanosine Guo G	Guanylic acid Guanosine monophosphate GMP
	Cytosine Cyt C	Cytidine Cyd C	Cytidylic acid Cytidine monophosphate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

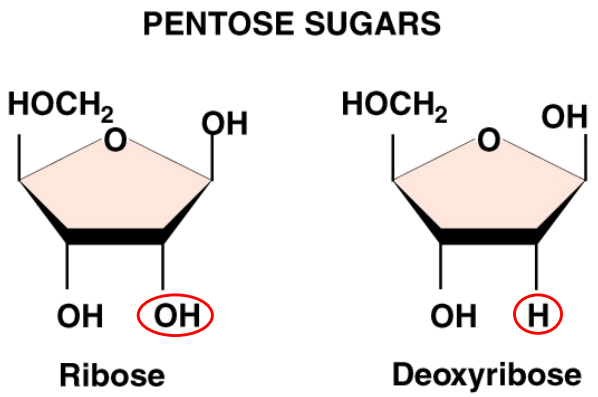
The pentose sugar

The sugar carbon numbers are primed (1′ 2′ 3′ etc.).

the nitrogenous base atoms are unprimed.

"So we can know if we are talking about the carbon atoms of the sugar or the nitrogenous base"



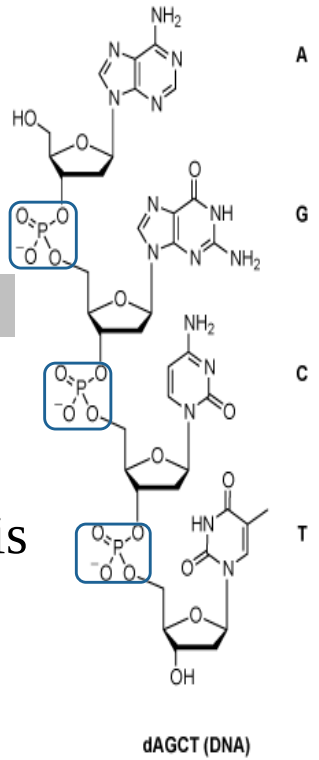


#The nitrogenous base is bonded to C_1' of sugar.

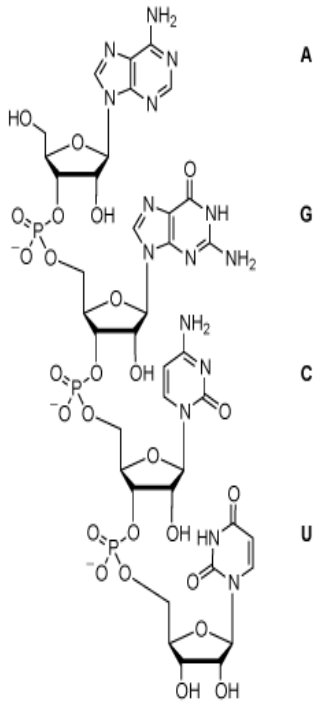
The PO_4 group is bonded to C_3' or C_5' of sugar.

Chemical structure of DNA & RNA

- The PO_4 bridges the 3’ and 5’ positions of ribose sugar.
- PO4 + Pentose sugar = The backbone of DNA structure
- The linkage between the nucleotides is called **phosphodiester bond**

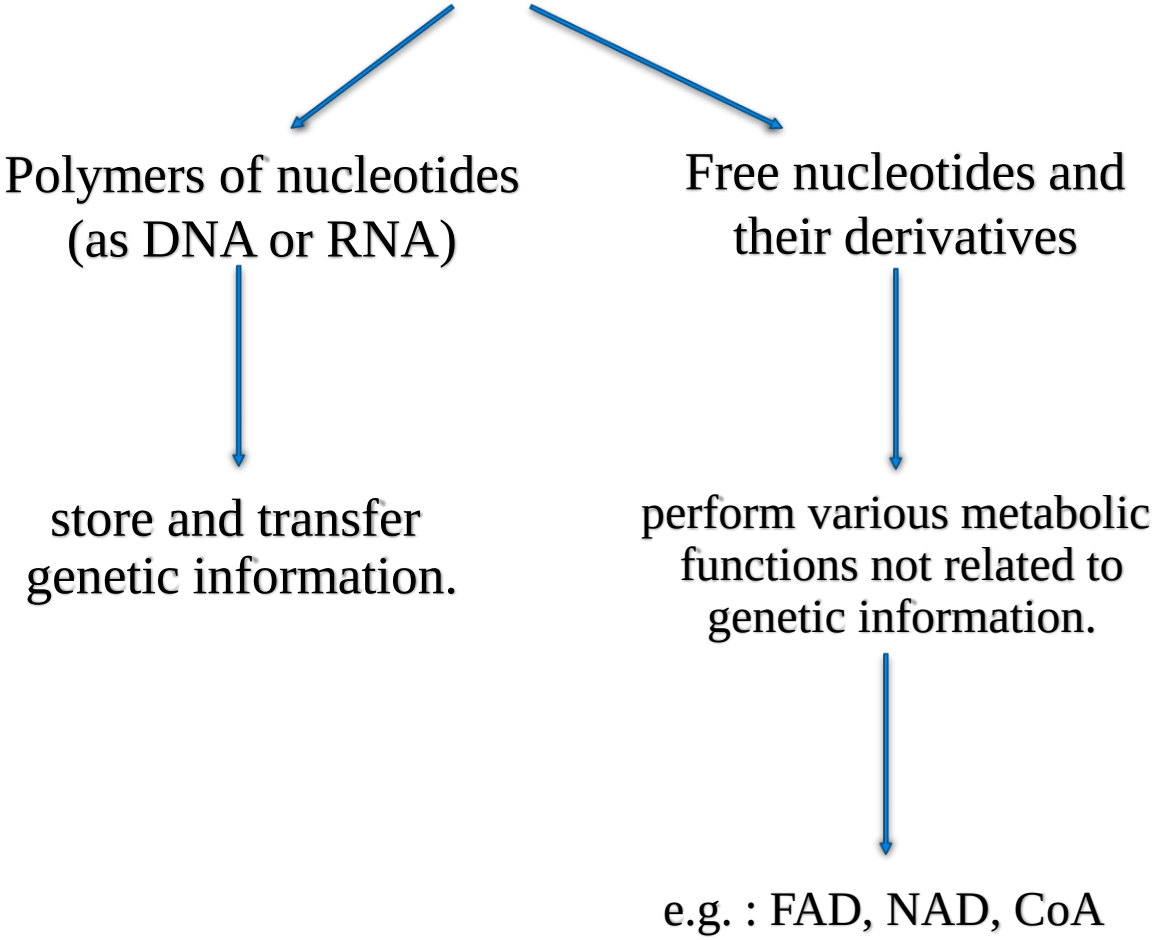


dAGCT (DNA)



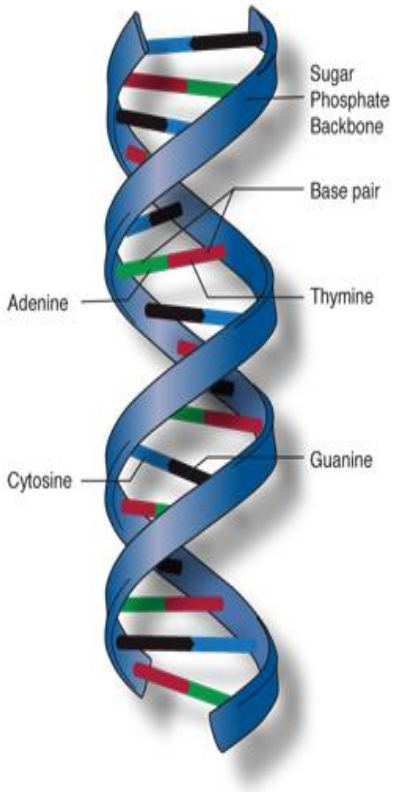
AGCU (RNA)

Function of nucleotides:



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.

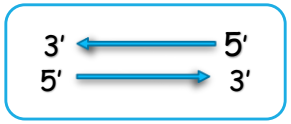


Features of Watson-Crick DNA structure

① Two polynucleotide chains wind or spiral around a common axis (helical axis) to form a double helix.

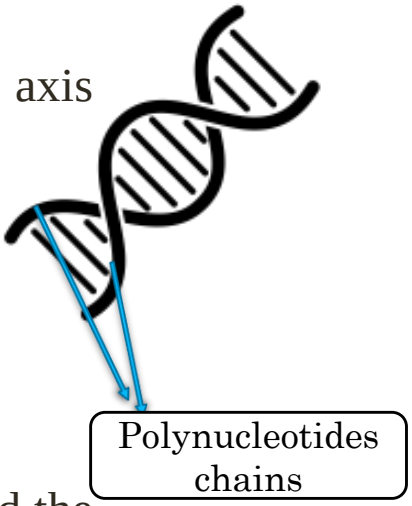
② The two strands are anti-parallel (run in opposite direction).

" One runs from 5 to 3 and the other from 3 to 5. "



① Each strand is a right-handed helix.

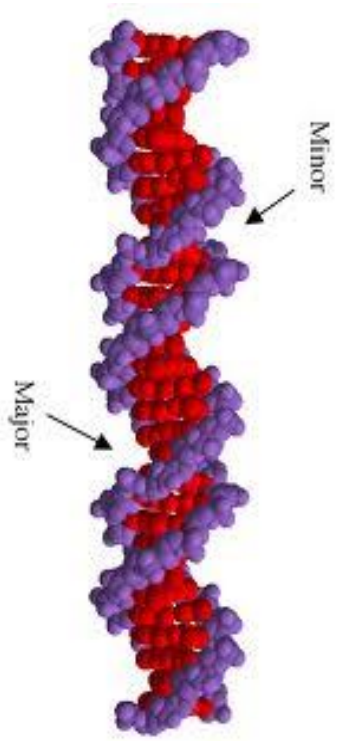
② The nitrogenous bases are in the center of the double helix and the sugar-phosphate chains are on the sides.



Opposite to what we have in peptide chain the hydrogen group inside and R chain hanging out.

⑤ The surface of the double helix contains 2 grooves: the major and minor grooves.

Grooves are the places where protein binds and interact with DNA



⑤ Each base is <u>hydrogen bonded</u> to a base in the opposite strand to form a base pair (A-T and G-C), known as <u>complementary base pairing.</u>

⑤ The helix has 10 base pairs (bp) per turn.

so, once the helix starts from place and comes

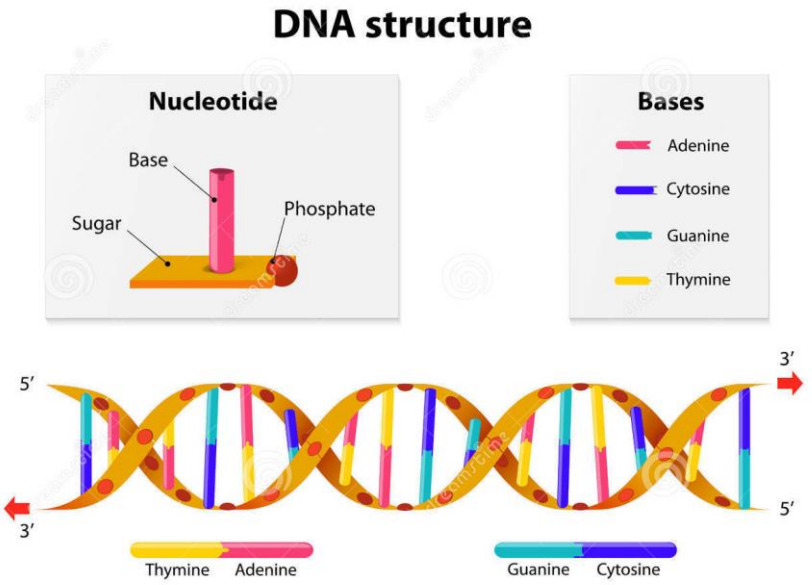
back to the same position that include 10 pairs.

Watson-Crick base pairs

Adenine bonds with thymine by double bonds, and Guanine bonds with Cytosine by triple bonds

purine { Adenine (A) = Thymine (T) ; Guanine (G) ≡ Cytosine (C) } pyrimidine

In RNA, Thymine is replaced by Uracil (U)



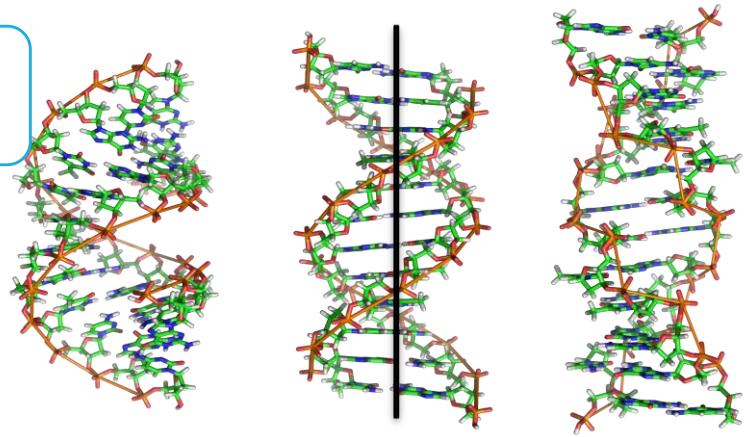
Types of DNA structure

	A-DNA	B-DNA(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	C_3	C_2	G (C_2) ; C (C_3)

The carbon where the oxygen is removed

major

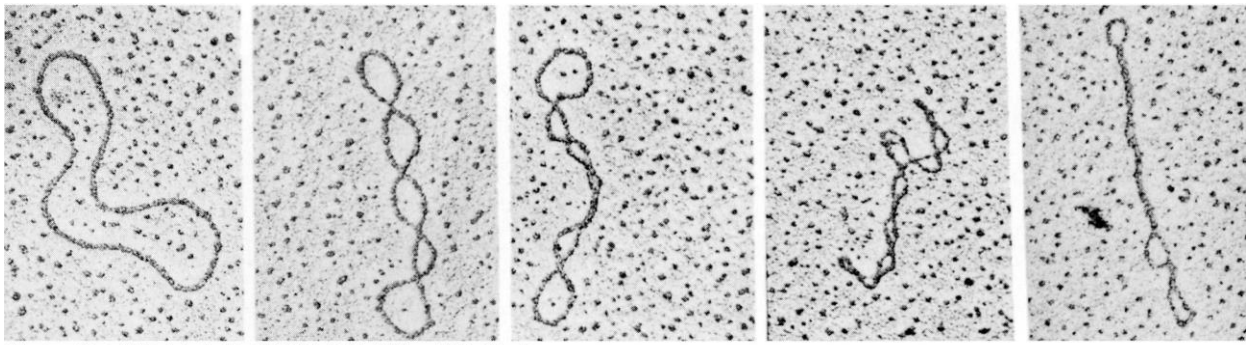
Minor



What is the importance of the grooves?
Grooves are the sites where the protein binds and Interact.

DNA supercoiling

- The chromosomes of many bacteria and viruses contain circular DNA which is supercoiled. «مما يقلل المساحة»

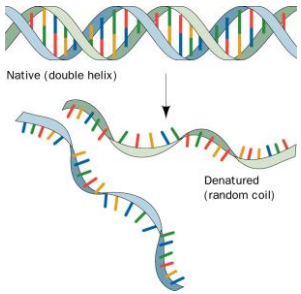


Electron micrographs by Laurien Polder. From Kornberg, A. and Baker, T.A., DNA Replication (2nd ed.), p. 36, W.H. Freeman (1992). Used with permission

تشبيه:
مثل السلسال اذا تعقد

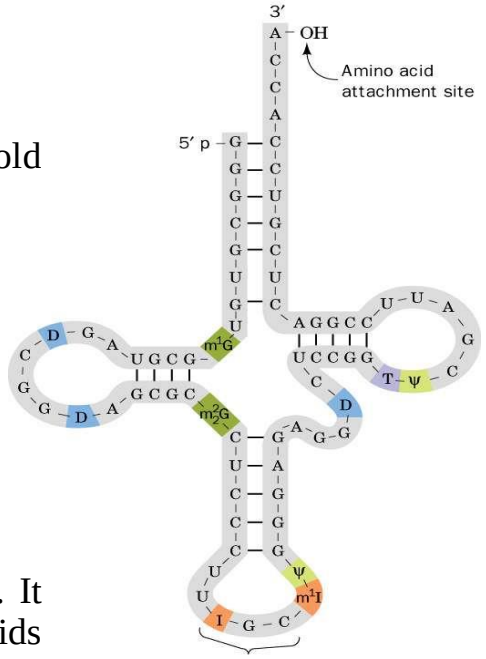
Melting temperature (MT)

- The temperature at which the double-stranded DNA is separated into two single strands . (Bonding between nitrogenous bases is lost "melted" and DNA is separated from a double strand to a single strand, if the heat was removed, it will come back to its original state)
- MT "melting temperature" of DNA depends on nitrogenous base content (A-T and G-C). A-T has 2 hydrogen bonds,G-C has 3 hydrogen bonds .
- G-C ➔ stronger than A-T. (the more G-C bonds there is the more heat you need to break it) (it works on stabilizing the shape of the molecule)
- Extra question example:
- Which one will have higher melting temperature?
- A) 40A-T bonds , 60G-C bonds B) 20A-T bonds , 80G–C bonds
- (B) because it has more bonds so it needs more energy and heat to "melt" the bonds



RNA (Types and function)

- **RNA is a single-stranded polymer of ribonucleotides.** (it can fold upon itself)
- **Types of RNA:**
  - mRNA (messenger RNA) ➔ Function: Transcription process (from DNA to mRNA).
  - tRNA (transfer RNA) ➔ Function: Recognition and transferring. It recognizes amino acids' codons and transfers the selected amino acids to the growing protein chain.
  - rRNA (ribosomal RNA) ➔ Function: Site of protein synthesis (factory).



Structure of a tRNA

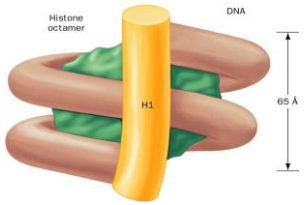
How DNA is organized in a chromosome?

- **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.**
- **How such large quantities of DNA are packed into a single cell? (with the help of proteins called histones)**
- **Each chromosome is a complex of a single linear DNA molecule and protein called chromatin. “Chromatin : DNA + Histones”**
- **50% of chromatin consists of proteins called histones.**
- **Difference between chromosome and chromatin ?**

DNA exists in Chromatin form in the nucleus. The chromatin condenses to form Chromosomes during cell division

To package the long sequence of the genomic DNA, it is highly organized into chromosomes.

Histones "chromatin stabilizers"



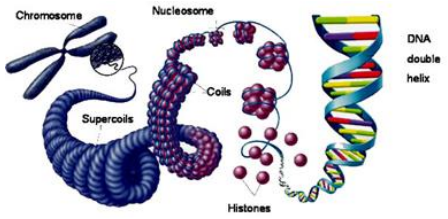
- Five major types of histones:

H1 H2A H2B H3 H4

Create a complex that the DNA can wrap around

Holds the wrapped DNA on the complex

- Histones have positively charged amino acids (arginine and lysine).
- These proteins bind to negatively charged PO_4 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; Sibhah in Arabic).

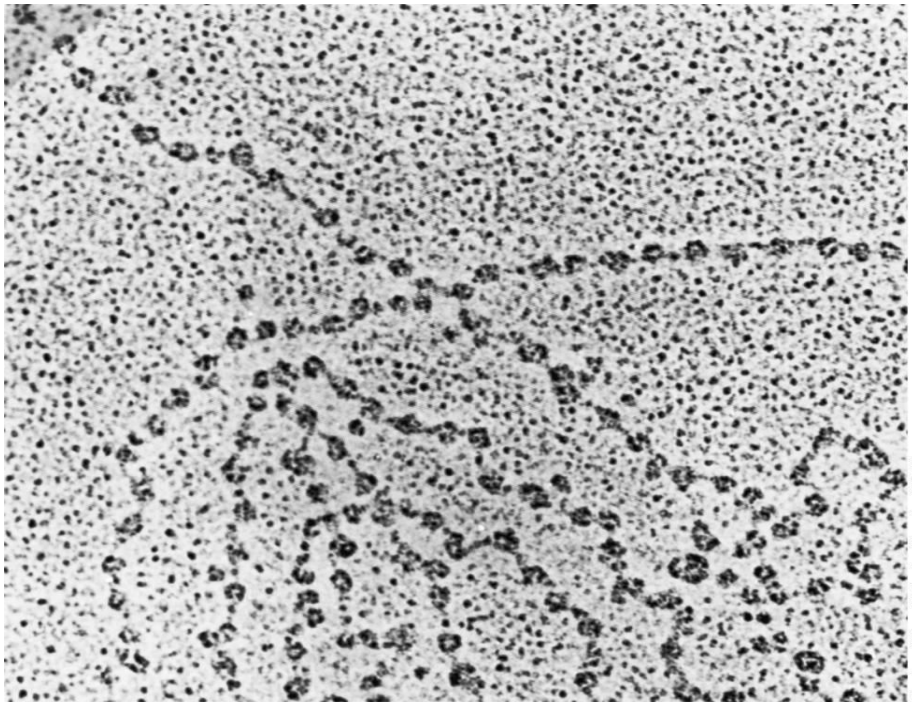
- Nucleosomes consist of the histone octamer (eight) and DNA

$$(H2A)_2(H2B)_2(H3)_2(H4)_2$$

- H1 binds to 2 complete helical turns of DNA.

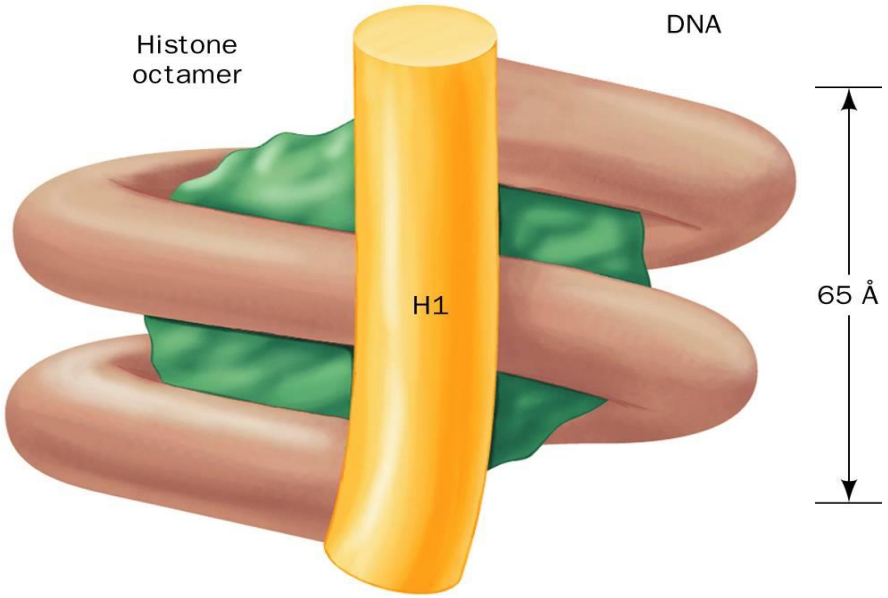
How DNA is packaged?

https://m.youtube.com/watch?v=gbSIBhFwQ4s

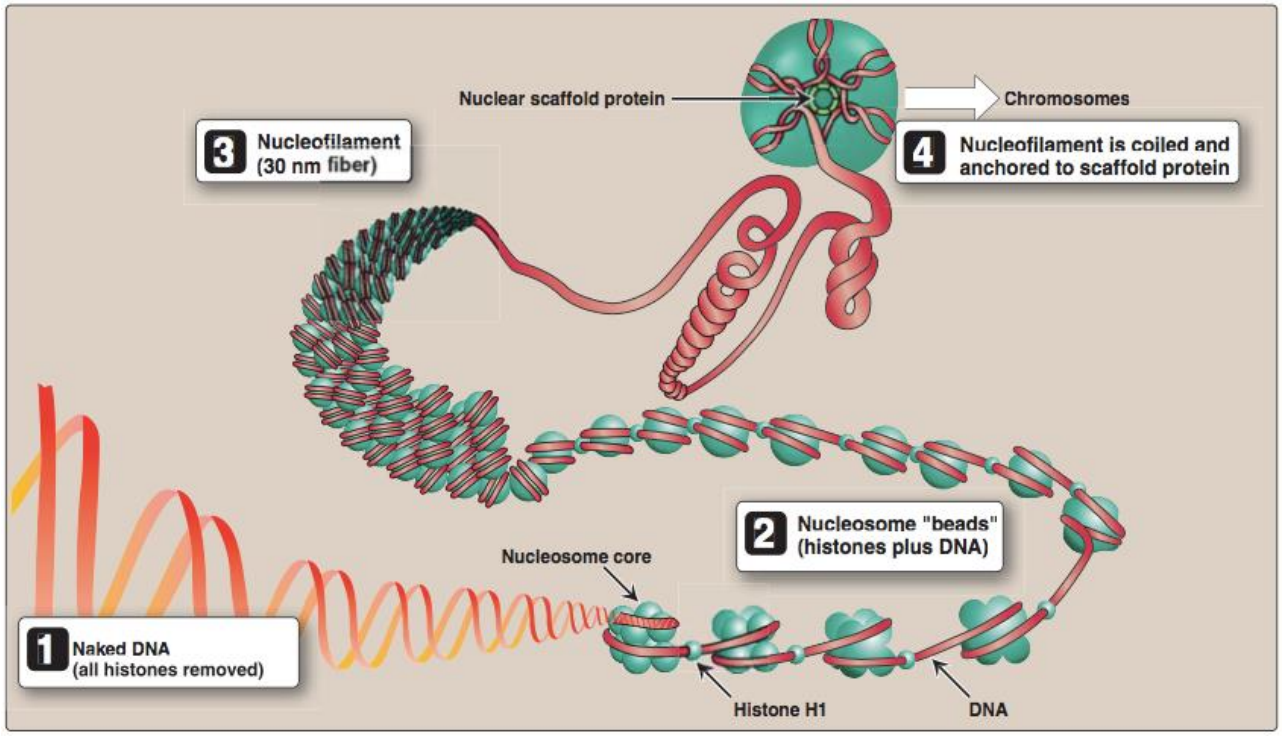


Courtesy of Oscar L. Miller, Jr., University of Virginia

Electron micrograph of chromatin showing nucleosomes



A nucleosome showing interaction of histones with the DNA



Chromatin filament with nucleosomes and naked DNA

MCQs

«اجتهاد شخصي للتدريب فقط وأرجو عدم الاعتماد عليها»

http://highered.mheducation.com/sites/0072552891/student_view0/chapter7/multiple_choice_quiz.html

GIRLS TEAM:

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- رهف الشنيبر
- شهد الجبرين
- لينا الرحمة
- سارة البليهد
- ليلى

BOYS TEAM:

1-Dawood Ismail.

2- turkey al-bnhar

3- saeed alsarar

4- abdulmalik alsharhan

5- mohammed al-quefly

6- nwaf abdulaziz

Team leaders:

1- Mohammed hassa hakeem

2- Reham alhalabi

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https://docs.google.com/presentation/d/16yNcm2Y08Cr0Am83lDRfH5NB4F1ng3tdHiB3O1AqMc8