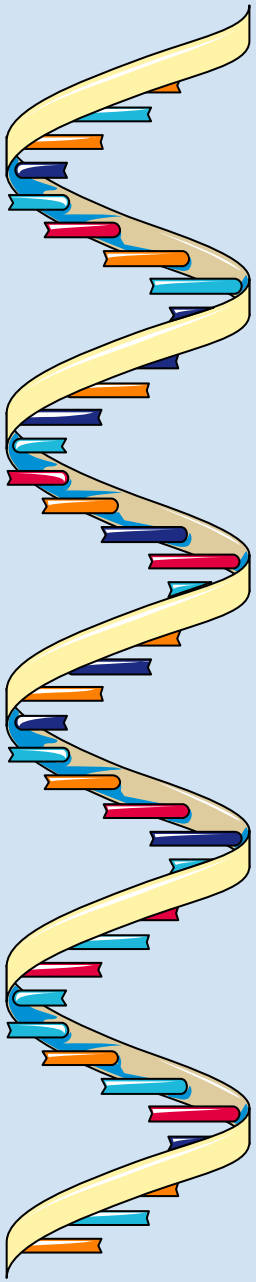
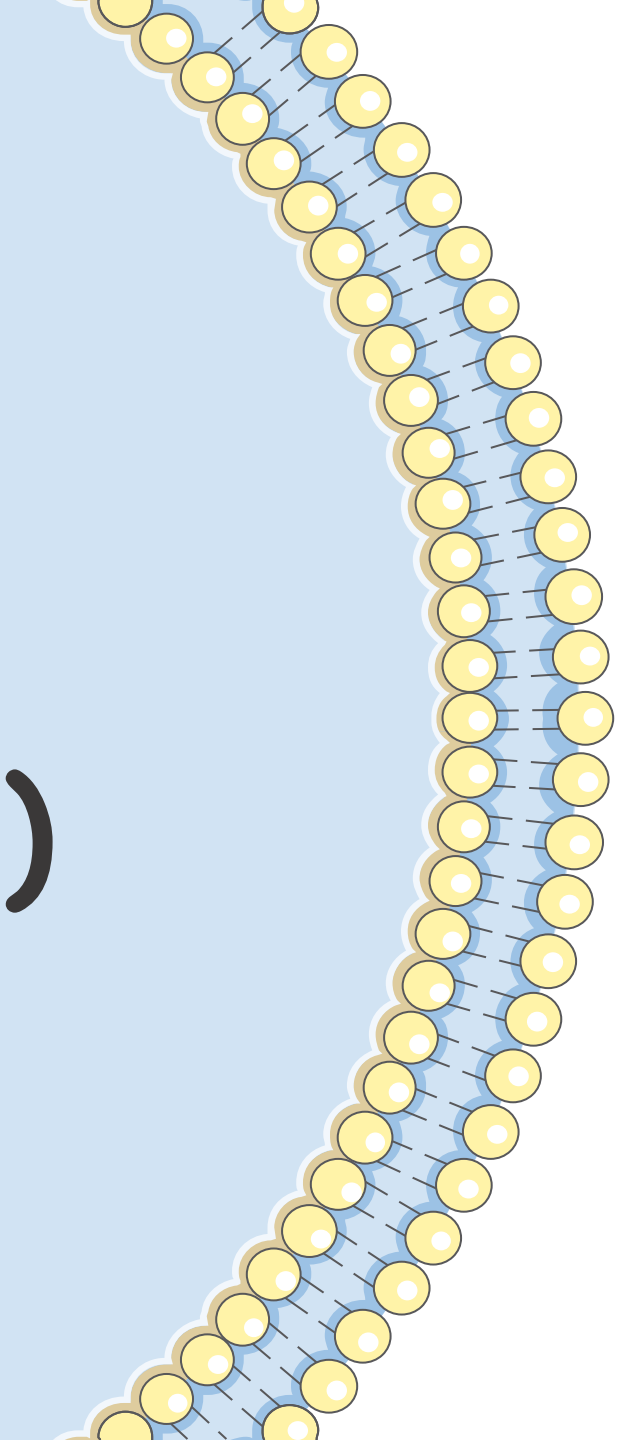


Molecular Biology (1)



MED441
KING SAUD UNIVERSITY

Revised & Reviewed by: Abdulaziz & Bahammam Faye Wael Sendi

3
V1

Foundation Block - KSU

Color Index:

- Main text
- Important
- Notes
- Boys slides'
- Girls slides'
- Extra

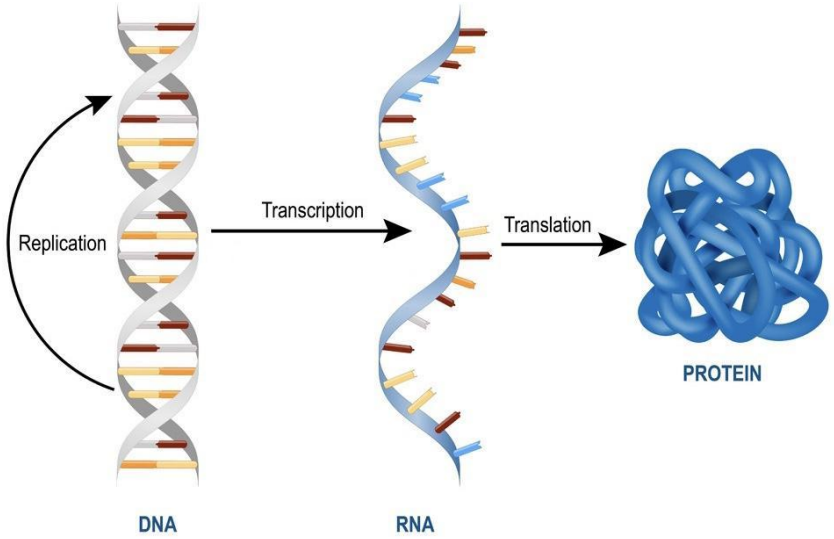
Editing File

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

- Molecular biology is the biology of all macromolecules structure and function.
- The central dogma of molecular biology describes the two-step process, transcription and translation, by which the information in genes flows into proteins:
  DNA ⟶ RNA ⟶ protein. in other meanings, understand the concept of molecular biology.(med439)
- A portion of **DNA**, called a **gene**, is transcribed into **RNA**.
- RNA is translated into **proteins**.
- Human genome contains about 35,000 genes.
- DNA replication and transcription both occurs in the nucleus, but translation occur in the cytoplasm (in the ribosomes).



Dogma= a well established fact.

Nucleic Acids

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

Nucleic Acids

DNA
(Deoxyribonucleic Acid)

RNA
(Ribonucleic Acid)

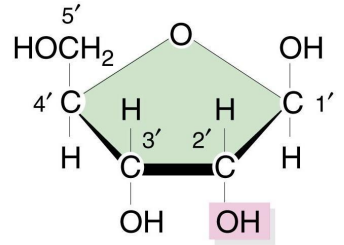
Nucleotides

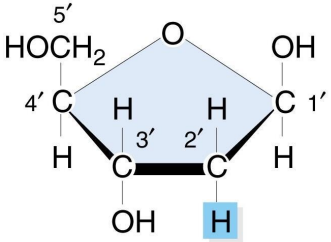
Note:

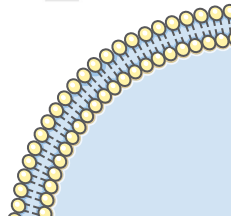
- Nitrogenous base + sugar + phosphate group→ **Nucleotide (nucleoside triphosphate)**
- Nitrogenous base + sugar →**nucleoside**

Nucleotides
are composed of:

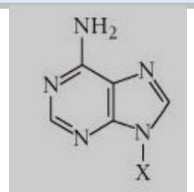
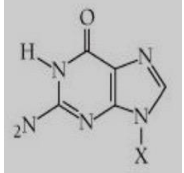
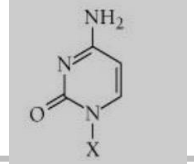
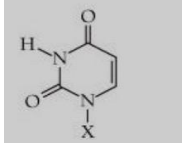
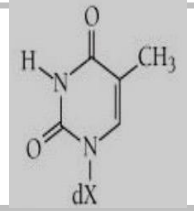
- Nitrogenous Base
  - Purines (2 rings)
    - **A**denine (**A**)
    - **G**uanine (**G**)
  - Pyrimidines (1 ring)
    - **C**ytosine (**C**)
    - **T**hymine (**T**)
    - **U**racil (**U**)
- Phosphate group
- Sugar (Pentose with 5 carbon ring)
  - Ribose (with -OH at C2)
  - Deoxyribose (missing an oxygen at C2)







Nucleotides

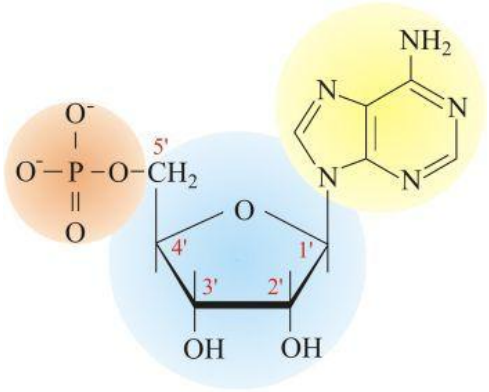
Base Formula	Base (X=H) If an H was in X place it would be a base that ends with "ine"	Nucleoside (X=ribose[a]) if a ribose was in X place it would be a nucleoside that ends with "osine" for purines, and "idine" for pyrimidenes	Nucleotide[b] (X= ribose phosphate[a]) If a ribose phosphate (ribose with a phosphate connected to it) was in place of X it would be a nucleotide that ends with "ylic acid"
	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

Purines have **2 rings** with **4 nitrogen** inside the rings. (med436)

Pyrimidines have **1 ring** with **2 nitrogen** inside the ring (med436)

Nucleotide 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.

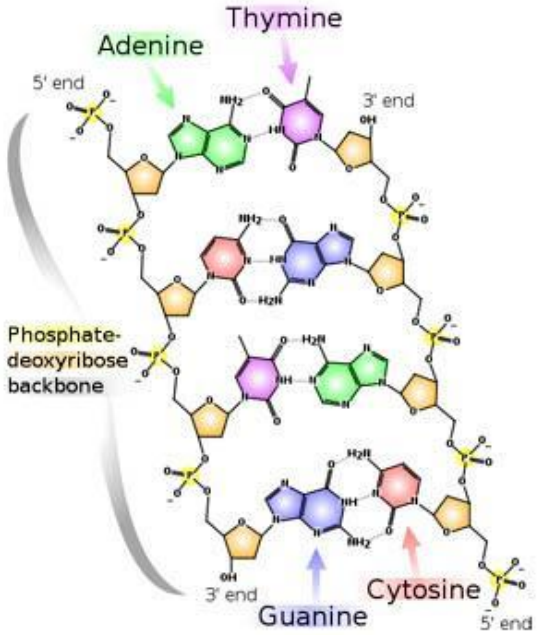


The **phosphate group** is bound to the 5' carbon. During **DNA** synthesis, the **phosphate group** of a new deoxyribonucleotide is covalently **attached** by the enzyme **DNA** polymerase to the 3' carbon of a nucleotide already in the chain.

- Helpful video

Chemical structure of DNA & RNA

- The PO_4 bridges the 3′ and 5′ positions of ribose sugar.
- The PO_4 and sugar bonding is the backbone of DNA structure.
- The linkage between the nucleotides is called phosphodiester bond.
- the linkages that forms nucleosides (linkage between nitrogenous bases and ribose) is called glycosidic linkage. (med439)



Function of nucleotides

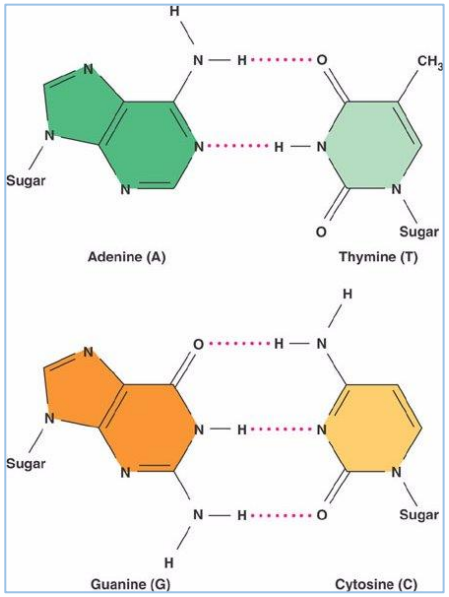
- Polymers of nucleotides (as DNA or RNA) store and transfer genetic information.
- Free nucleotides and their derivatives perform various metabolic functions not related to genetic information. (e.g.:ATP)
  - If you add 2 more phosphates to Adenosine monophosphate (AMP) you'll get Adenosine triphosphate (ATP) which is the energy currency of the cell.
- 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.

Watson-Crick base pairs:

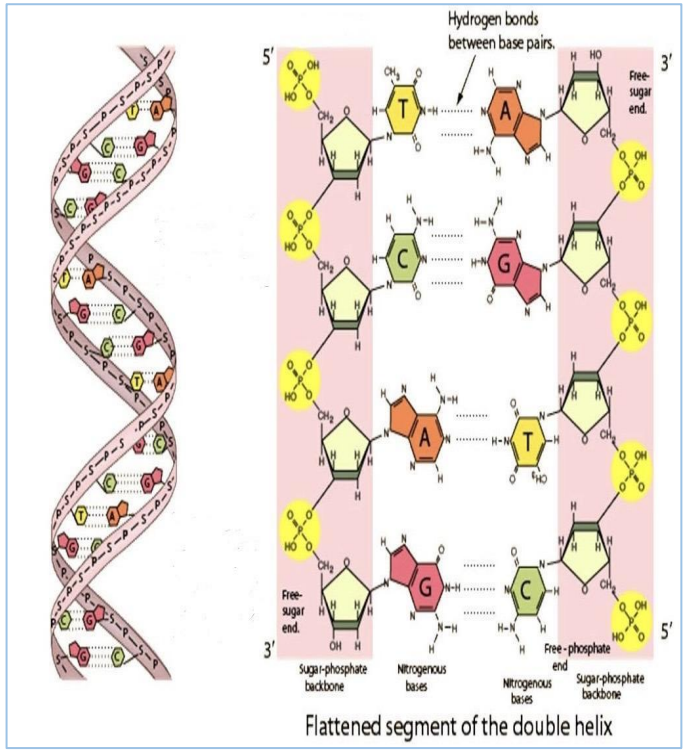
- Adenine (A) = Thymine (T)
- Guanine (G) ≡ Cytosine (C)
- In **RNA**, Thymine is replaced by Uracil (U).



The bond between (G) & (C) is much stronger, because they have 3 hydrogen bonds whereas the (A) &(T) have 2 hydrogen bonds

Features of Watson-Crick DNA structure

1. Two polynucleotide chains wind around a common axis to form a double helix.
   (The two strands are held together by hydrogen bonds between the bases)
2. The two strands are anti-parallel (run in opposite direction), 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, major and minor.
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. (and 3.6 amino acid per turn)

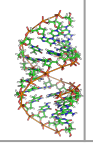
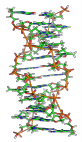


Flattened segment of the double helix

- Helpful video

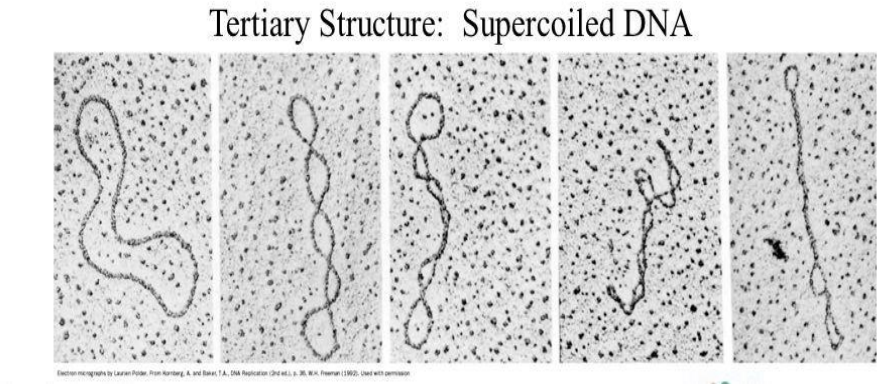
Types of DNA structure

Note: Directions , Helix length , Major and Minor grooves and The number of base pairs per turn for each type are very IMPORTANT.
Also, you might be asked in the exam to differentiate between two types.

Types of DNA	A-DNA	B-DNA (Watson-Crick)	Z-DNA
Direction	Right-Handed	Right-Handed	Left-Handed
Helix length	Short	Elongated	More Elongated
Major groove	Deep and narrow	Wide	Not a real groove
Minor groove	Wide	Narrow	Narrow
Placement of base pairs	Displaced away from the helical axis	Centered over the helical axis	Zig-zag pattern (nearly perpendicular to the helical axis)
Base pairs per turn	11	10	12
Conformation of deoxyribose (The carbon where oxygen is removed)	C3	C2	G (C2) or C (C3)
Seen in	-DNA replication -Non-coding RNA 	Most common in human body 	Seen in the sites Where DNA is copied 

DNA Supercoiling

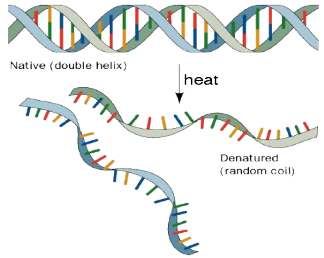
- The chromosomes of many bacteria and viruses contain circular DNA which is supercoiled in order to take a smaller place, and to give it more protection.



Melting temperature (MT)

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

- Melting point (MT) 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 two.



Schematic representation of strand separation in duplex DNA resulting from heat denaturation

The types and functions of RNA

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

1

mRNA (Messenger RNA)

Transcription process (DNA → mRNA)

2

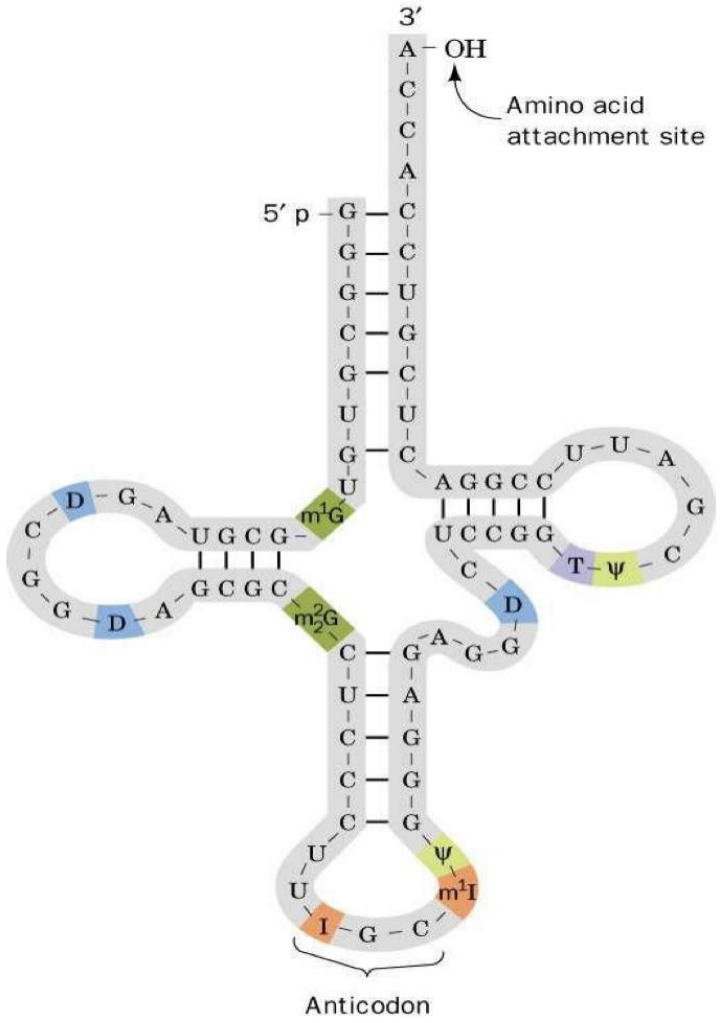
tRNA (transfer RNA)

Recognition and transferring, it recognizes amino acids' codons and transfers the selected amino acids to the growing protein chain.

3

rRNA (ribosomal RNA)

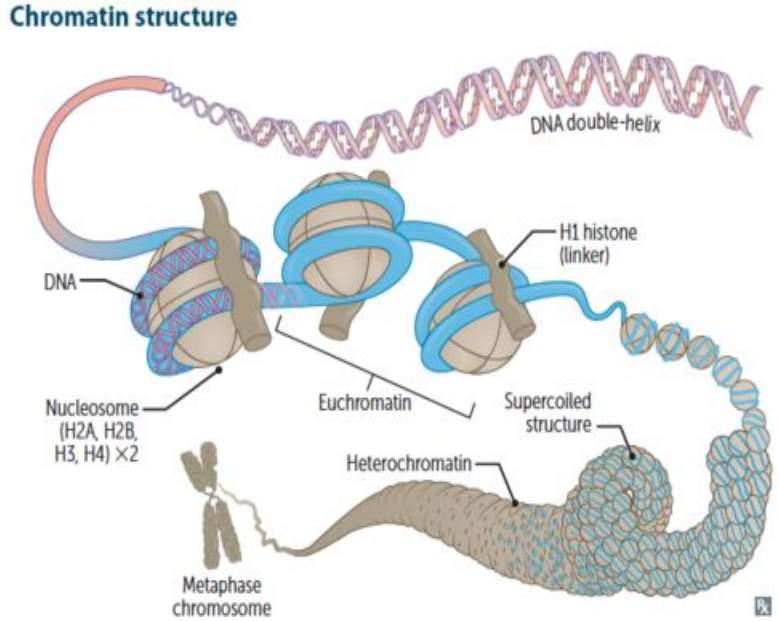
Site of protein synthesis (factory)

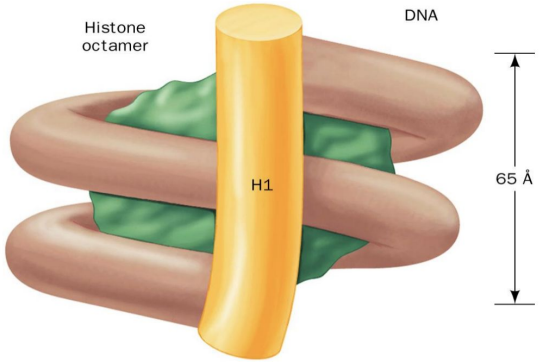


Structure of a tRNA

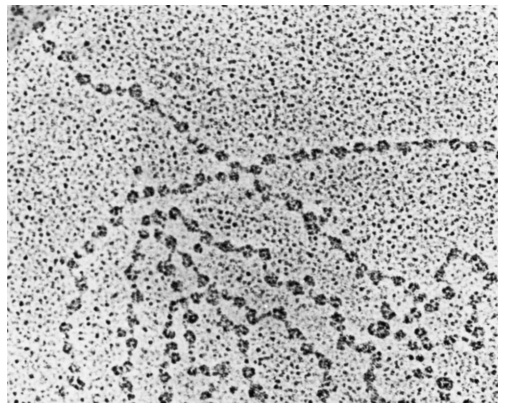
Organization of DNA

- The human genome consists of 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 of H1, H2A, H2B, H3, H4.
  -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 are particles consisting of DNA and Histones connected by thin strands of naked DNA (like beads on a string:سبحه in arabic).
- Nucleosomes consist of the histone octamer (8 histones) and DNA.
- Octamer consists of (8 histones) $(H2A)_2$ $(H2B)_2$ $(H3)_2$ $(H4)_2$ except H1.
- H1 binds to 2 complete helical turns of DNA.
  H1 binds to the octamer with naked DNA (could be the dr note as well)
- H1 clips the DNA to keep it in place, (it's not part of the octamer)





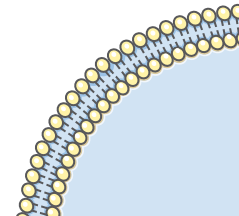
A nucleosome showing interaction of histone with the DNA



Electron micrograph of chromatin showing nucleosomes

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

Q1: …… of chromatin consists of …….. called ……?							
A	all,proteins, histones	B	half,proteins, amino acids	C	half,proteins, histones	D	all,DNA, histones
Q2:how many base pairs per turn are present in the type Z-DNA?							
A	11	B	12	C	10	D	13
Q3:The linkage between nucleotides is called ……..?							
A	hydrogen bond	B	nitrogen bond	C	glycosidic linkage	D	phosphodiester bond
Q4: the backbone of DNA structure. ……..?							
A	the PO3-sugar bond	B	the PO4-sugar bond	C	the nitrogen bases	D	the sugar-nitrogen bond
Q5:More than ….. of the human genome is non-coding DNA							
A	5%	B	90%	C	85%	D	95%

Answer Key: 1) C 2) B 3) D 4) B 5) D

Q6:what is the function of tRNA?

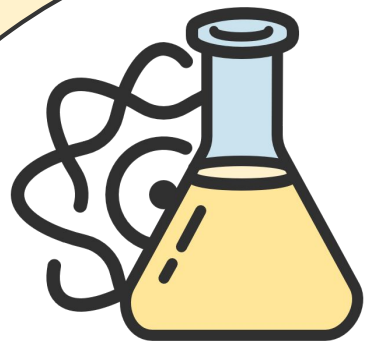
Answer: it recognizes amino acids' codons and transfers the selected amino acids to the growing protein chain.

Q7:Enumerate the five major types of histones?

Answer:H1, H2A, H2B, H3, H4.

Q8:define the melting temperature for DNA?

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



Biochemistry 441

Girls

Boys

Ghadah Alarify - Leader

Yara Almufleh
Reema Alrashedi
Wareef Almousa
Joud Alangari
Fay Alluhaidan
Sarah Alhamlan
Arwa Almobeirek
Jumana AL-qahtani
Latifa Alkhdiri
Alanoud Alhaider
Futoon Almotairi
Manal Aldhirgham
Raaoum Jabor
Norah alawlah
Shahad Helmi
Rand Aldajani

Khalid Alhamdi - Leader

Ahmed Alayban
Sultan Alosaimi
Abdullah Alomran
Bassam Alghizzi
Ibrahim Aljurayyan
Mohammed Almutairi
Turki Alkhalifa
Malik Alshaya
Faisal Alhmoud
Abdulrahman Alnoshan
Ahmed Alqahtani
Hamad Alshaalan
Anas Alharbi
Mohammed Alwahibi
Saad Alghadir
Firas Alqahtani

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