molecular biology

رؤوف إبراهيم الصالحي

Molecular Biology

structure of nucleic acids

* what is molecular biology? is biochemistry (It's talks about the different reactions, biochemical structures and information about these molecules But it's specifically related to DNA and RNA (It's branch of molecular Biology) It's not genetics, there's an overlap between genetics and molecular biology

↓

Deals with biochemical reactions that take place in DNA and RNA

↓

Deals with patterns of Inheritance of phenotypes and genotypes (Genetic material and the physical appearance)

— with chromosomal structures rather than small molecules like DNA and RNA

* There's something known as the central dogma of molecular biology

* The central dogma of molecular biology is basically the following:-

* you have a DNA molecule and these DNA molecule is the genetic material of cells or organisms and this DNA molecule is used to make RNA molecule, this is done via a process known as transcription and it's catalyzed by an enzyme known as RNA polymerase.

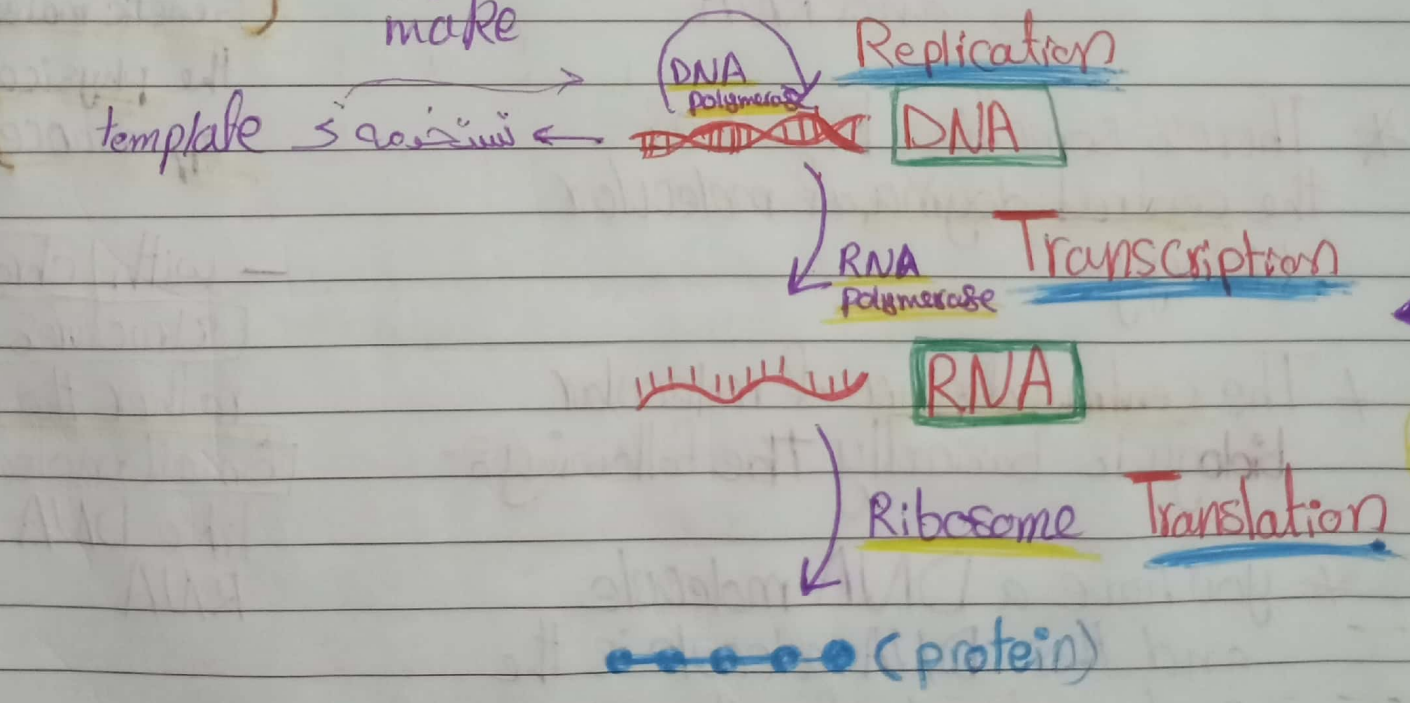
Five Apple

RNA is then used to synthesize proteins in a process known as Translation and this involves ribosomes

DNA can make a copy of it self via a process known as Replication and catalyzed by DNA polymerase

* So this is really the central dogma of molecular biology, which is basically

DNA —used to make→ RNA —used to make→ proteins



Also, there's things more complex for example, you can make DNA out of RNA, you can make RNA out of RNA...

Five Apple

Nucleic acid

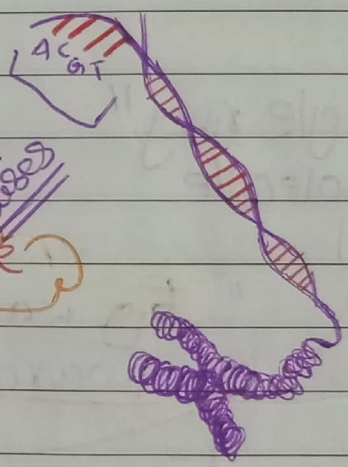
There are 2 types

DNA — Deoxyribonucleic acid (DNA)

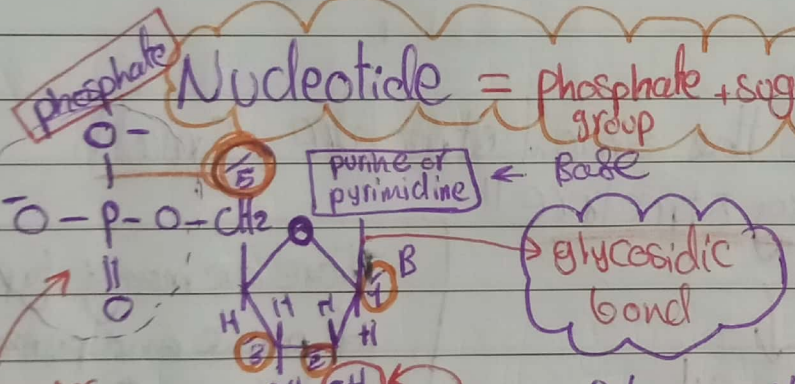
RNA — Ribonucleic acid

* The primary structure of nucleic acid is linear polymers of **nucleotides** (monomers) bound to each other via phosphodiester bonds

* DNA is coiled and can be associated with proteins forming



Nucleotide = phosphate group + sugar + base

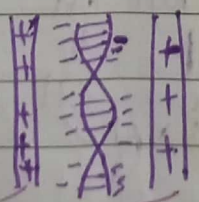


this is why they are acidic

Ribose VS deoxyribose

- Ribose → RNA
- deoxyribose → DNA

H instead of OH



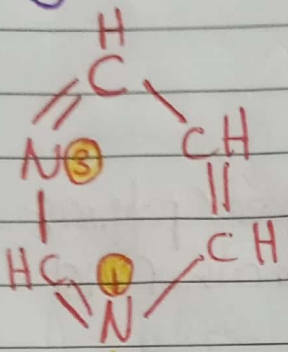
very important to the stability (less repulsion)

* positively charged ions Na^+ or Mg^{+2} associate with the phosphate groups

* Example : histones ← positive proteins

Nitrogen bases

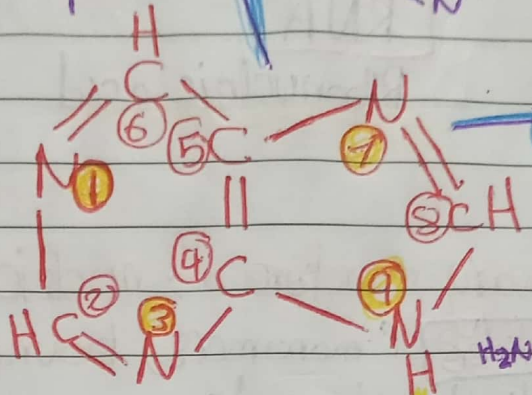
pyrimidine



→ Glycosidic bond

Sugar

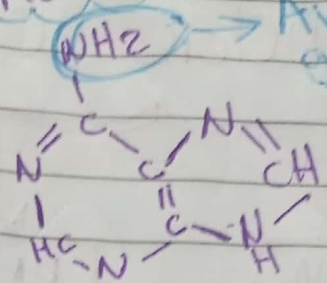
purine



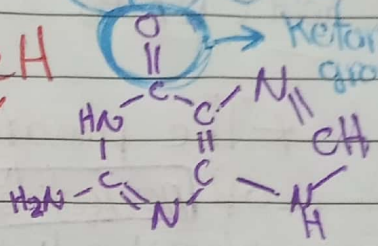
→ Glycosidic bond

Sugar

Adenine



Guanine



" single ring" molecule

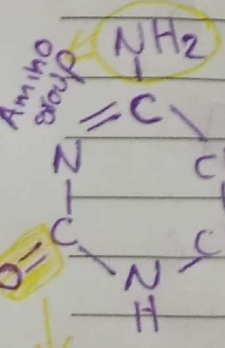
" double ring molecule"

" big ward for the small structure, small ward for big structure"

There are many types of purine and pyrimidine but those 5 make up Nucleic acid

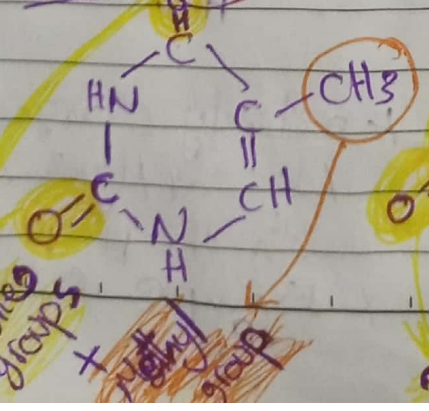
:)

cytosine (in DNA & RNA)

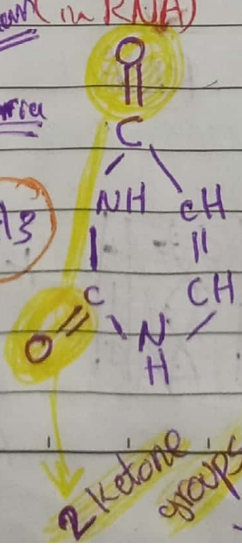


Thymine (in DNA & some of RNA)

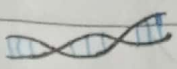
not in human (in RNA) in bacteria



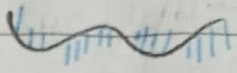
Uracil (in RNA)



DNA Vs RNA



Double stranded



Generally single stranded

sugar — deoxyribose — ribose

Bases: T, C, A, G — U, C, A, G

there is always exceptions. Especially in lower organisms like viruses and Bacteria

Nucleotides

Nucleotide = phosphate group + sugar + Base

* Nucleoside monophosphate

Nucleoside = sugar + Base

→ can have 1 or 2 or 3 phosphate groups

- 1 → nucleoside monophosphate
- 2 → nucleoside diphosphate
- 3 → nucleoside triphosphate

Nucleotides

1) يعرف أنه Nucleotide من
[phosphate + sugar + base]

2. How many phosphate?!
3. Sugar

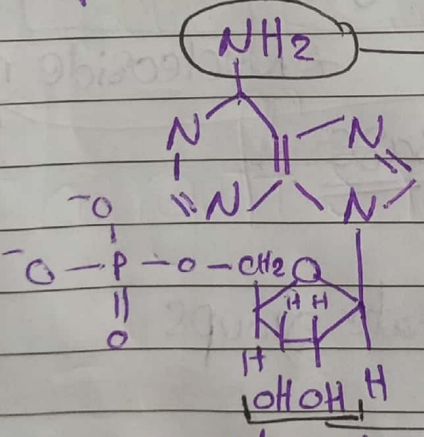
H OH
↓ ↓ ribose
Deoxyribose

4. Base

purine / pyrimdine

5. * نحدد نوع الـ Base من
الكيمياء لكونه له فرق

Examples:-



Amino group → Adinne

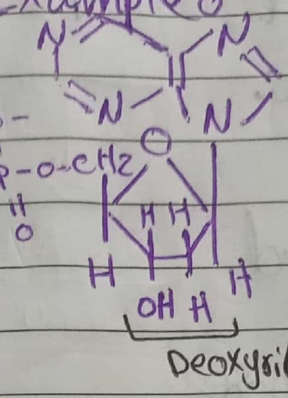
(Adenosine 5'monophosphate)
(Adenylate)

ribose

Nucleoside 8- Adenosine

symbol A , AMP

Examples:



NH2 → Amino → Adenine

* (Deoxyadenylate)
Dexoyadenosine 5'-monophosphate

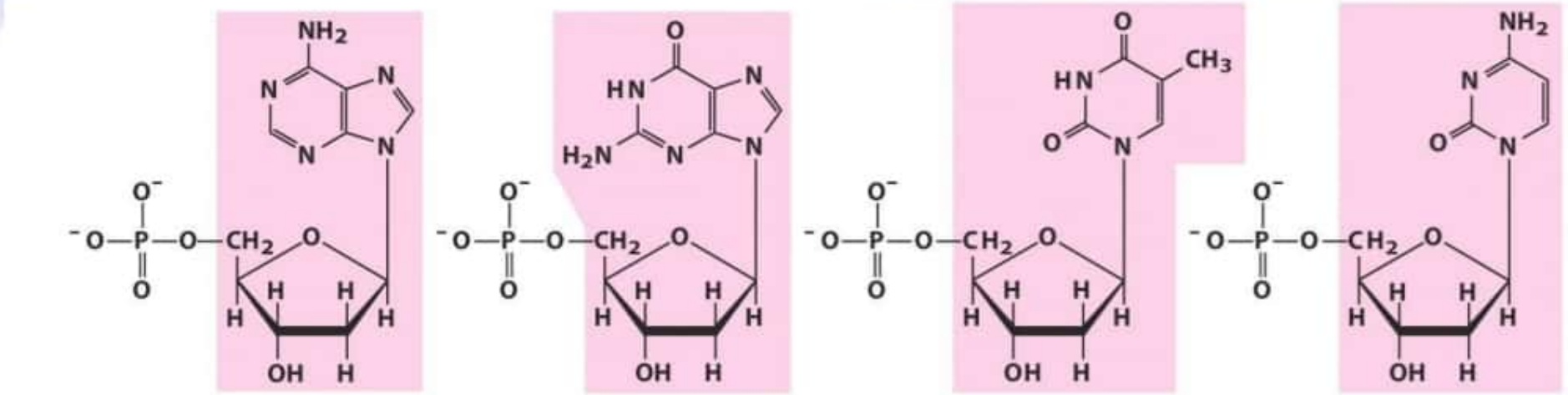
Symbols; A , dA , dAMP

* If we have two phosphate it's become

dAdP → di

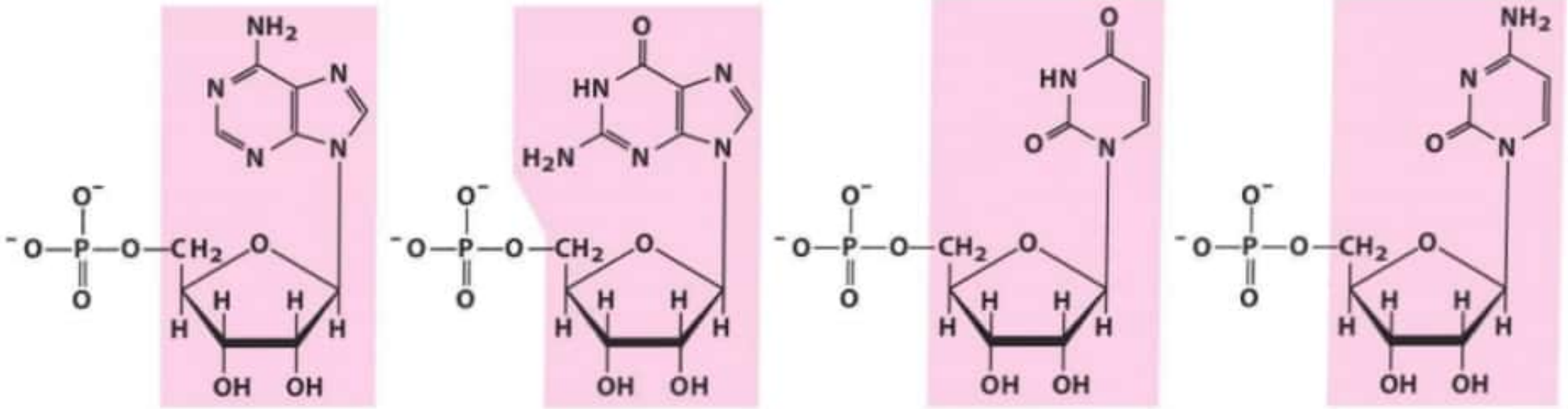
If we have Three phosphate

dATP → tri



Nucleotide:	Deoxyadenylate (deoxyadenosine 5′-monophosphate)	Deoxyguanylate (deoxyguanosine 5′-monophosphate)	Deoxythymidylate (deoxythymidine 5′-monophosphate)	Deoxycytidylate (deoxycytidine 5′-monophosphate)
Symbols:	A, dA, dAMP	G, dG, dGMP	T, dT, dTMP	C, dC, dCMP
Nucleoside:	Deoxyadenosine	Deoxyguanosine	Deoxythymidine	Deoxycytidine

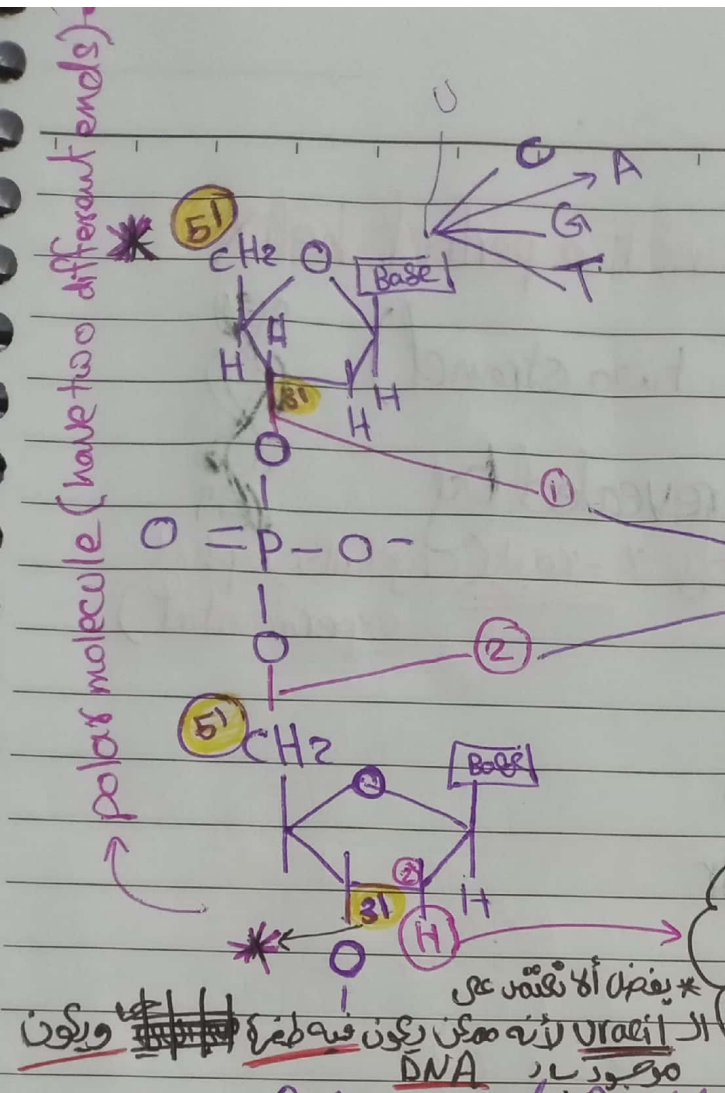
(a) Deoxyribonucleotides



Nucleotide:	Adenylate (adenosine 5′-monophosphate)	Guanylate (guanosine 5′-monophosphate)	Uridylate (uridine 5′-monophosphate)	Cytidylate (cytidine 5′-monophosphate)
Symbols:	A, AMP	G, GMP	U, UMP	C, CMP
Nucleoside:	Adenosine	Guanosine	Uridine	Cytidine

(b) Ribonucleotides

polar molecule (have two different ends)



two nucleotide bind to each other by

2 ester linkage

(phosphodiester bond)

① ②

from here we know if it DNA or RNA molecule

H ⇝ DNA OH ⇝ RNA

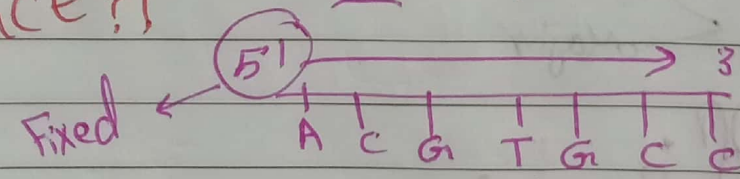
* يفرق انه نتكلم عن الـ RNA لانه ممكن يكون فيه طفرة ويكون موجود بـ DNA

* RNA and DNA are polymers made up of monomers (nucleotides).

start reading from 5'

* what is the sequence?!

5' نبدأ السلسلة بـ 5'



Because we add nucleotids to 3' end.

DNA structure

not a perfect helix

* Double helix (two stranded)

* DNA structure was revealed by Watson and Crick by X-ray (crystallography experimental)

1953

* Specific base-pairing

A=T , G=C , pur=pyr

* Complementary

* Backbone vs side chains

* Stability and Flexibility

* Grooving < minor / major

Chargaff's rules

number of (A)s = (T)s

number of (G)s = (C)s

number of purines = pyrimidines

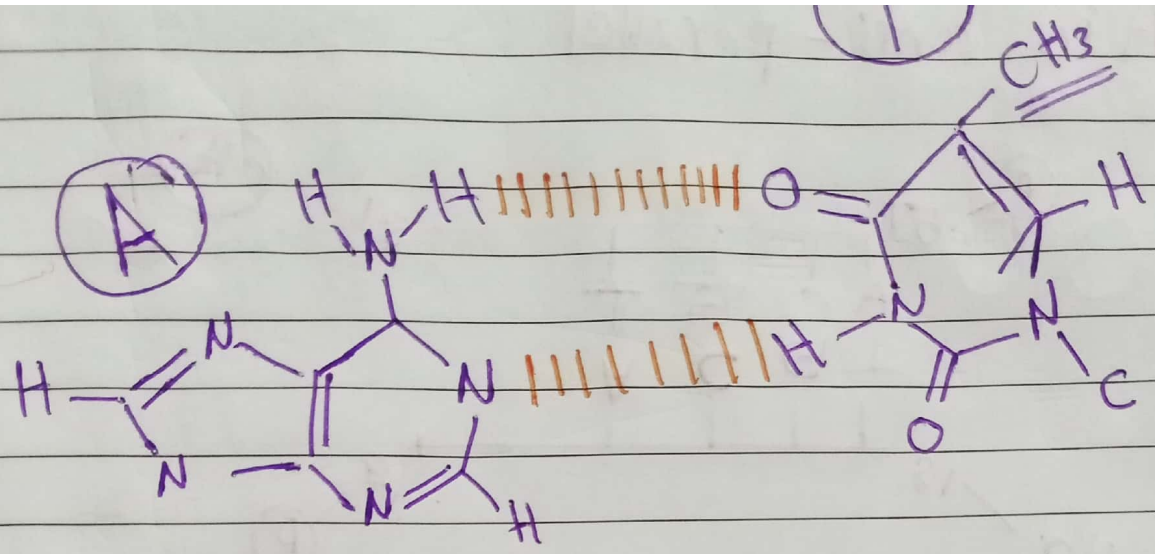
A+G = T+C

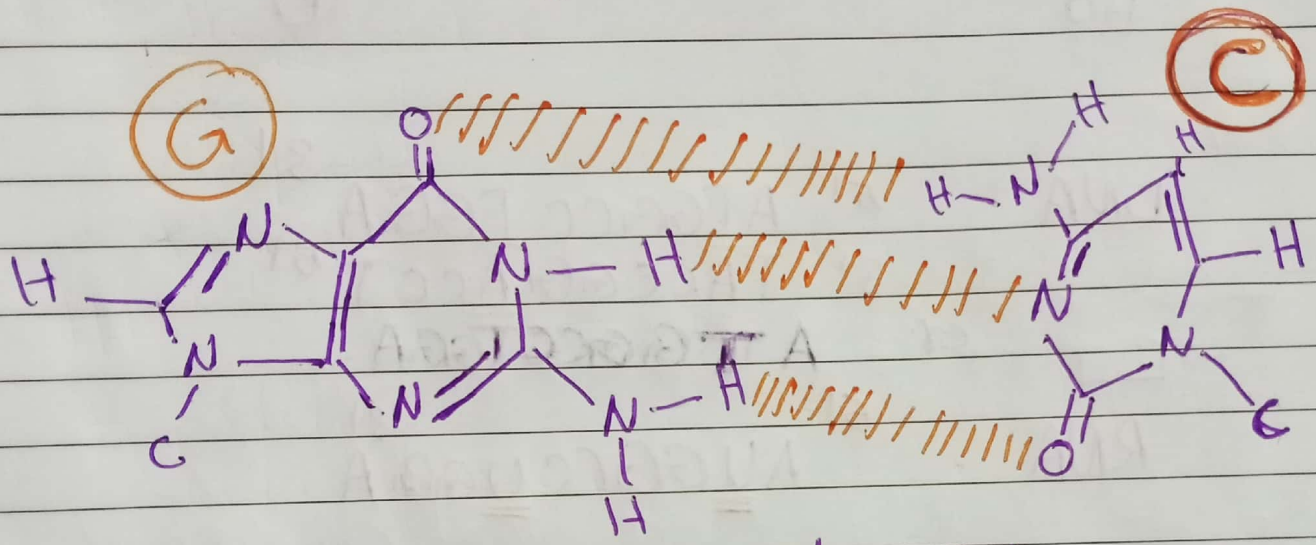
A=T C≡G

2 hydrogen bonds

3 hydrogen bonds

Five Apple



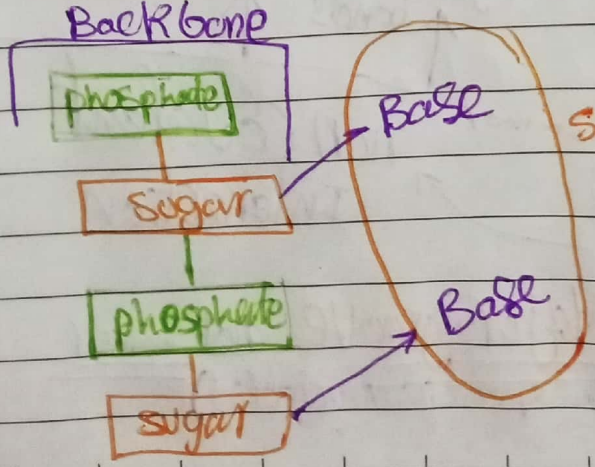


* DNA is complementary (the bases complement each other) The two strand are complete each other

C ≡ G

A = T

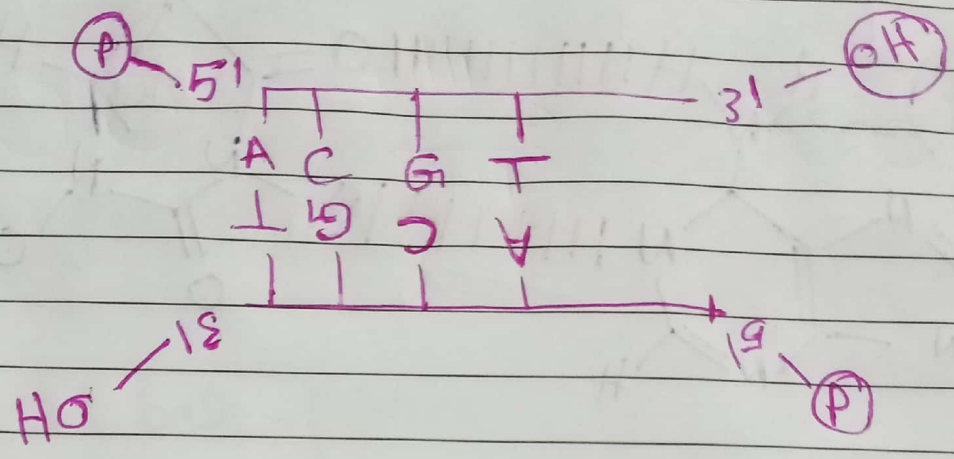
* Backbone , Side chains



Backbone = phosphate + sugar

Side chain = Base

DNA is anti-parallel



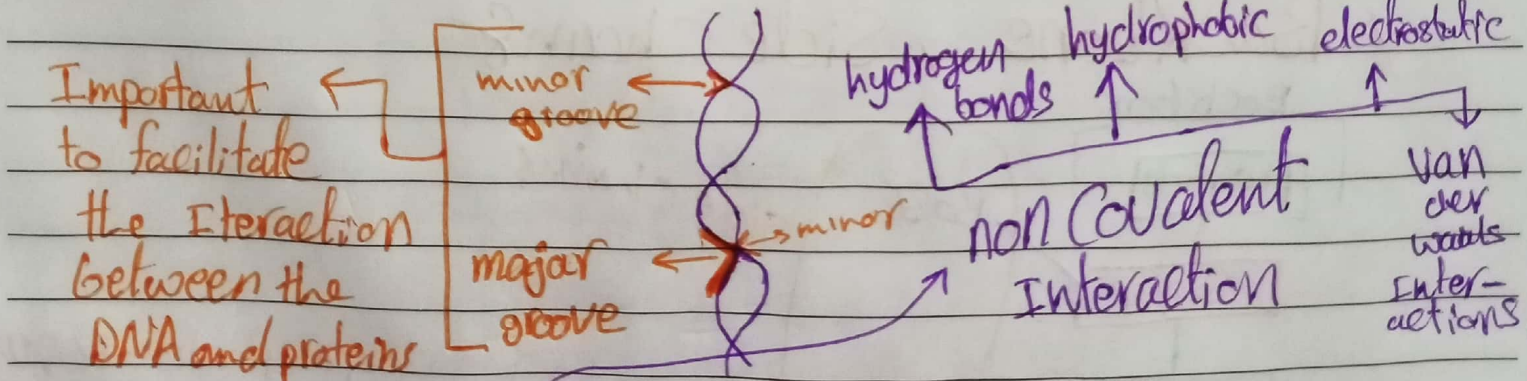
DNA 5' ATGGCCTGGA 3'
3' TACCGGACCT 5'

or ATTGGCCTGGA

5' 3'
RNA AUGGCCUGGA

DNA groove

not perfect (ي)
helical molecule



proteins can insertect in the Major groove not minor
(Spacific amino acid with specific Nucleotid)

prokaryotes and Eukaryotes

- prokaryotes
  - lack nucleous (No nucleus)
  - single loop of DNA (round / circular)
- Eukaryotes
  - true nucleus with DNA (linear)
  - non-looped chromosomes

* IF we look at DNA in a single cell we found it 2 m long (it's really large) and we have to packed it in small rounded structure known as nucleus

لو اخذنا من كل خلية الـ DNA اللي موجود في جسم الإنسان
(يوجد 10^{14} خلية في جسم الانسان) وربطناهم مع بعض طولهم =
المسافة بين الأرض والشمس 500 رايح جاي !

* كيف بنعمله packing عن طريق ارتباطه بالـ Histones

DNA molecules is rapped around Histone

* Chromatin = DNA molecule + proteins
* The basic structural unit of chromatin is known as nucleosome

* A nucleosome consists of DNA wrapped around a nucleosome core particle, linker DNA, and Histone H1

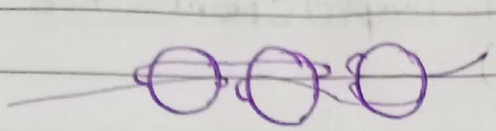
Histone core particle is an octameter (two of each (Histone: H2A, H2B, H3, H4))

Nucleosome = octamere + 146 nucleotide pair DNA double helix + linker DNA + H

linker DNA
chromatosome

DNA octamere

Euchromatin

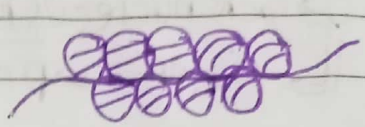


loose

+ H1

− H1

Heterochromatin



packed

Terms

Chromosome = colored body

↳ color ↳ object (body)

* we usually have one arm of chromosome (chromatid) when cell want to undrge meiosis they doublecate the arm into another arm (sister chromatid)

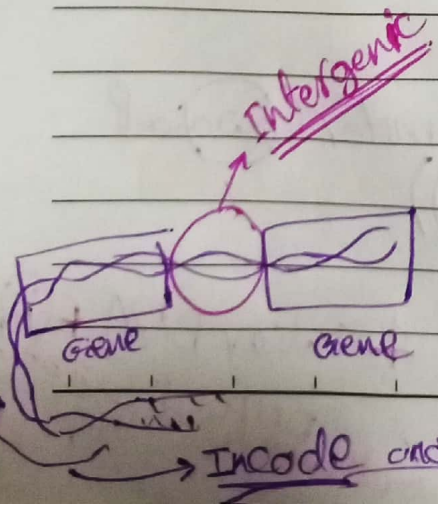
* weather it's one chromatid or having a sister chromatid associated with it's known as chromosome

Chromatin = DNA + protein

↓ ↓

Hetero- Eu-

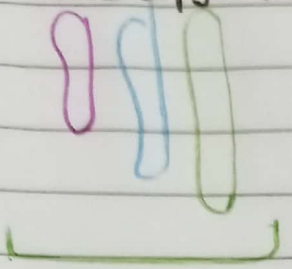
packed loose



Nucleosome = DNA + protein (Histone) + linker DNA

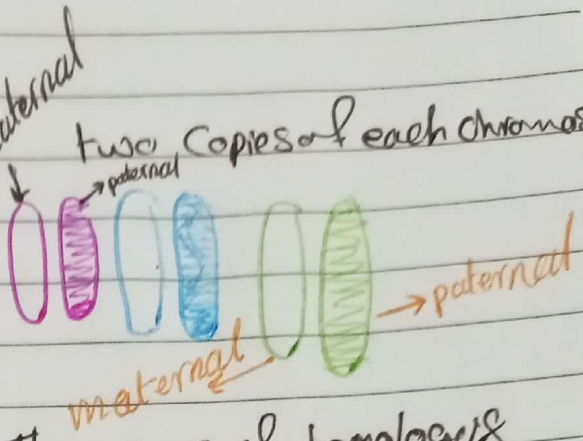
our cells are diploid

one copy of each chromosome



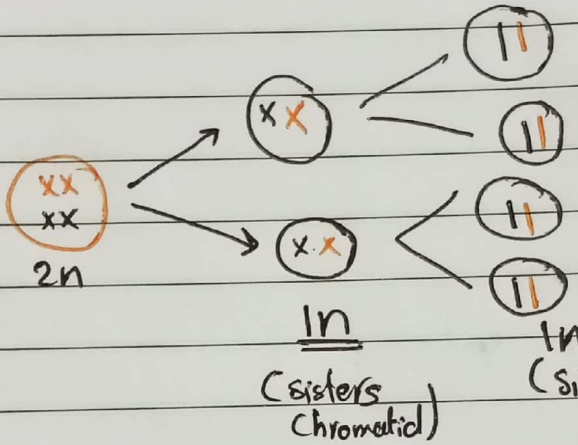
Three non-homologus chromosome (Haploid) 1n

two copies of each chromosome



Three pairs of homologous chromosomes (of maternal and paternal origin)

Diploid 2n



RNA (long, unbranched chain of nucleotides joind by phosphodiester bond between the 3'-oH of one pentose and 5'-poq of the next)

↓

ribose (it's 2-deoxyribose in DNA) in RNA

* The pyrimidine bases include uracil and cytosine (thymine and cyctosin in DNA)

* usually RNA is single stranded

* it can fold on itself forming hydrogen bonds within the same molecule.