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Molecular Biology

Doctor 2019 | Medicine | JU

Sheet Slides

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Important things to keep in mind: SHEETS AND SLIDES, and that BOTH are enough for the final.

Nucleic acids

2 types:
1-Deoxyribonucleic acid (DNA).
2-Ribonucleic acid (RNA).

-If you look at human body or human cells ,there are 4 types of macromolecules (large molecules):
1-Nucleic acids.
2-Proteins.
3-Carbohydrates.
4-Lipids.

-**Nucleic acids, carbohydrates and proteins** are polymers , which means that they are composed of repeated units known as monomers.

For example: a nucleic acid is a polymer of nucleotides (a nucleotide attached to another nucleotide ,etc) , so it's a chain of nucleotides attached to each other.

-**Lipids** are macromolecules but not polymers.

What is molecular biology?

-It's a fancy word or term for biochemistry , it's biochemistry except it deals with DNA and RNA.
-it describes the molecular processes that take place in cells.

Genetics vs. molecular biology:

-Genetics deals with:

- inheritance of phenotypes.
-genetic diseases that occur at the level of chromosomes, **for instance**: Chromosomal defects.
-there is an overlap between genetics and molecular biology ,but molecular Biology is like zooming into the molecules ,so it's amplified (zoomed) genetics.

The central dogma (philosophy,عقيدة) of molecular biology:

-it describes the processes of DNA ,transcription replication and translation.

- **DNA replication:** making another copy of DNA from are of DNA using an enzyme known as DNA polymerase.(DNA—>DNA)
- **Transcription:**using DNA to make a copy of RNA using RNA polymerase. (DNA—>RNA)
- **Translation:**synthesis proteins from RNA using ribosomes as will as other molecular components.

By understanding more processes that take place inside cells this dogma has been expended ,in addition to the previous processes we have:

✔ **Reverse transcription:**making DNA out of RNA ,so we use RNA as a template to make DNA by using reverse transcriptase.

✔ **RNA replication:**using RNA as a template that can be copied to make another copy of RNA by using RNA polymerase enzyme , and it's a reversible process.

DNA replication,transcription, and translation take place in our cells.

Reverse transcription and RNA replication (the additional processes <making DNA from RNA or making RNA from RNA>) take place mainly in viruses like:corona virus and HIV virus(they are RNA viruses) , these viruses their genome is RNA not DNA ,they are called **Retroviruses**.

☆ **Nucleic acids** are linear polymers of nucleotides (monomers).

☆ **DNA** is a double stranded molecule ,can be folded or packed into a coiled DNA.

☆ **DNA** is coiled to form chromosomes.

☆ **Nucleotides:**

- adenine.
- Cytosine.
- Guanine.
- thymine(DNA), uracil (RNA)

Deoxy means that it doesn't have oxygen. (منزوع الاكسجين)

☆ **Nucleotides are composed of 3 components:**

1-sugar:

- **pentose:**five carbon sugar.
- Known as **ribose(existed in RNA)** or **deoxyribose(existed in DNA).**
- Ribose will have a hydroxyl group(OH) on carbon NO.2' while Deoxyribose will have a(H),with no oxygen as in ribose.
- ‼Numbers of carbons are very important specifically 5&3.

2-phosphate:attached to the sugar at carbon NO.5 of pentose and it's negatively charged.

^_^ DNA & RNA are **negatively charged** because of these high negative charged groups.

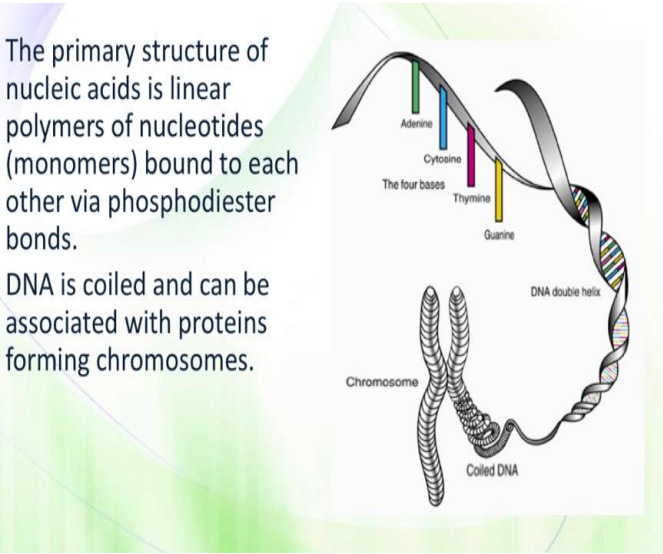
3-nitrogenous base:attached to carbon No.1 of pentose sugar by forming a glycosidic bond ,and there are two types of nitrogenous bases:pyrimidines and purines.

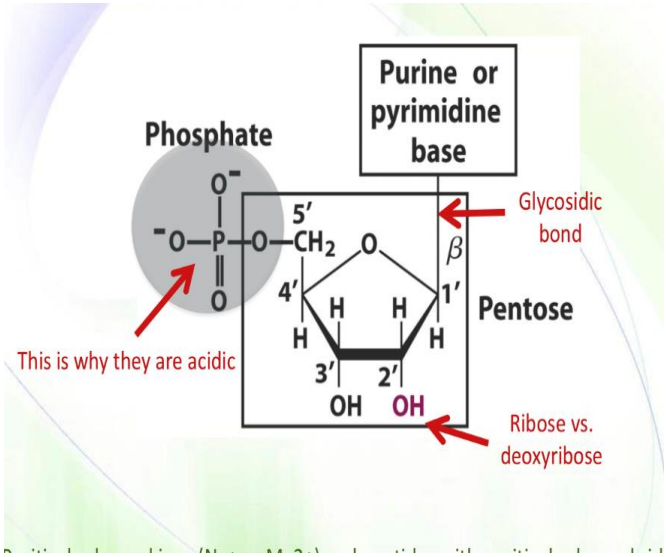
😆As we said in DNA &RNA molecules there are al lot of (-ve) charges that would create a sort of repulsion and it makes the molecule a bit unstable.

😆If we add (+ve) charged ions like Mg+ or Na+, these will bind to the (-ve) charges of the phosphate ,masking the negative charges and stabilizing the molecule themselves.

😆In our cells (eukaryotic cells) DNA is complexed with histones ,which are positively charged molecules , in the cell ,histones also neutralize and stabilize DNA.

💡How to remember and differentiate between purine and pyrimidine by letters:





✔ **Purine ,**that is the little word ,is related toto the large structure (Double ring structure).

✔ **pyrimidine,** that is the large word ,refers to the small structure (single ring structure).

💡How to differentiate between no. of atoms in sugar & nitrogenous bases:

✔ in sugar the numbers have a sign above them (1'→this sign means prime ,ex. 1 prime , 2 prime….).

🏵 **purines:** adenine and guanine.

✔ The difference between them is that the carbon no.6 in adenine has amino group ,but in guanine it is a ketone group.

✔ Both of them exist in RNA & DNA.

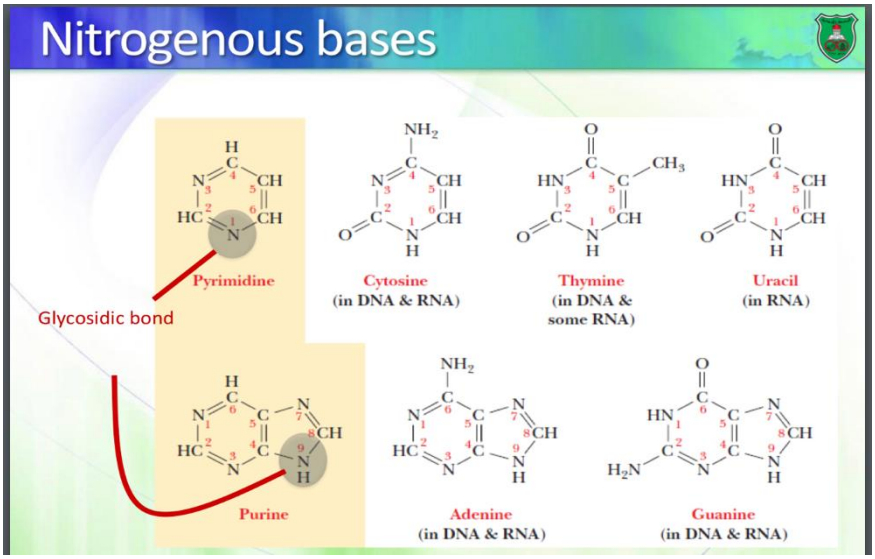
مش مطلوب نميز بينهم كتركيب

❁ **pyrimidine:**cytosine ,thymine and uracil.

✔ **Cytosine** has an amino group (-NH2) on 4 ,and it exists in both RNA & DNA.

✔ **Uracil** has a ketone group (=O)on 4 ,and it exists in RNA only.

✔ **Thymine** looks like uracil except that it has an additional methyl group(-CH3) on 5 ,and it exists in DNA and some RNA (these are exception, the rule is that thymine exists in DNA).



❁ **differences between DNA and RNA: (in prokaryotes and eukaryotes (not viruses)).**

DNA	RNA
In general double stranded (made of two strands)	In general single stranded
Has a deoxyribose as the sugar (without oxygen on 2')	Has a ribose as the sugar (OH on 2')
Thymine, guanine, cytosine and adenine	Uracil , guanine, cytosine and adenine

Nucleotides vs. Nucleosides:

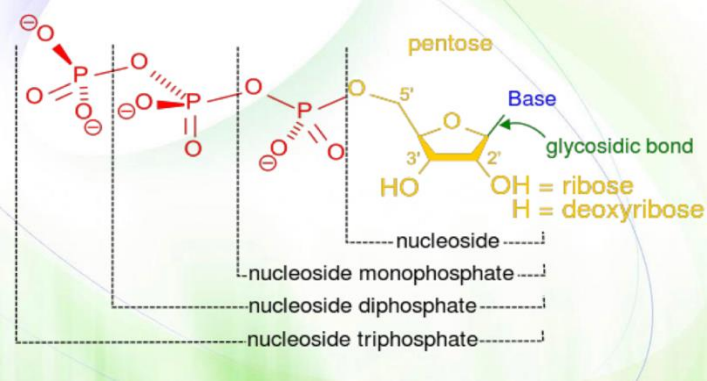
👉**Nucleoside:**a molecule that is made of sugar (ribose or deoxyribose) and a base.

👉**Nucleotide:**a molecule that is made of sugar, base and one, two, or three phosphate groups.

Nucleoside monophosphate:nucleoside (sugar+ base)+one phosphate group.

Nucleoside diphosphate:nucleoside+two phosphate groups.

Nucleoside triphosphate:nucleoside+three phosphate groups.(Like the ATP * adenosine triphosphate*)



Special naming for mono-phosphates:

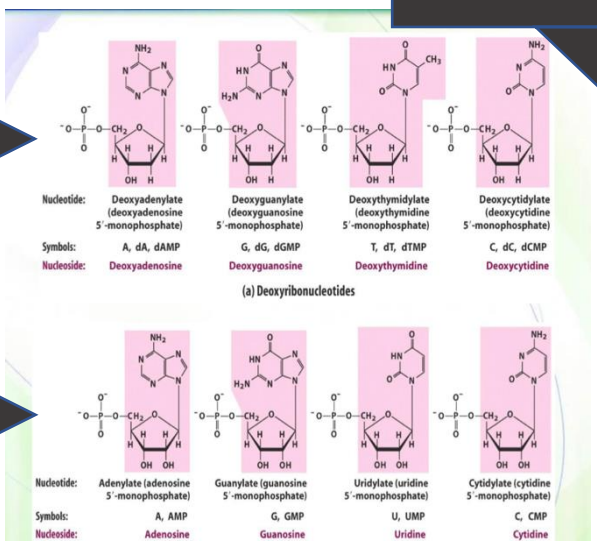
👉For simpler naming , Using (- ylate) that the nucleotide has ONE phosphate group.

So , the part (-ine) indicates that this molecule is a Nucleoside.

Note the abbreviations like: dA ,A ,dAMP, CMP, etc

The sugar is deoxyribose—>DNA

The sugar is ribose—>RNA



In RNA:

- Adenosine monophosphate= Adenylate ,A or AMP.
- Guanosine monophosphate=Guanylate ,G ,or GMP.
- Uridine monophosphate= Uridylate ,U or UMP.
- cytidine monophosphate= Cytidylate., C or CMP.

In DNA:

- Deoxyadenosine monophosphate= DeoxyAdenylate ,A ,or dAMP.
- Deoxyguanosine monophosphate=DeoxyGuanylate ,G ,or dGMP.
- Deoxythymidine monophosphate= Deoxythymidylate ,T or dTMP.
- Deoxycytidine monophosphate= DeoxyCytidylate., C or dCMP.

Nucleic acid polymers:

✔ nucleotides attached to each other by phosphodiester bonds between carbon 3' of sugar of the nucleotide and the carbon 5' of the next nucleotide mediated by a phosphate group.

✔ It has ends (3' end and 5' end) , notice that the top of the polymer (the first nucleotide has a 5' prime carbon with a phosphate only ,the parallel has the 3' carbon.

✔ when we want to add more nucleotides we add them to the 3' end forming a phosphodiester bond.

✔ The phosphate group on the 5'carbon of the first nucleotide in the sequence of nucleotides remains untouched.

How do you distinguish whether the polymer is DNA or RNA?

1) We look at the sugar (ribose → RNA / deoxyribose → DNA).
2) The nitrogenous bases (T → DNA / U → RNA)

If you were provided a nucleotide how would you distinguish which type it is?

1) we look at the sugar(ribose/deoxyribose).
2) We look at the phosphate group:
   - No phosphate group → nucleoside.
   - If there is one phosphate group → monophosphate nucleotide.
     Two → diphosphate nucleotide.
     Three → triphosphate nucleotide.
3) we look at the base
   - purine(G / A).

🦋pyrimidine(U/T/C).

‼The doctor isn't going to ask us to differentiate between different purines and different pyrimidines.

🥹what is the sequence of the molecule in the left(what is the order of the nucleotides in this polymer)?

✨A,C,G,U.

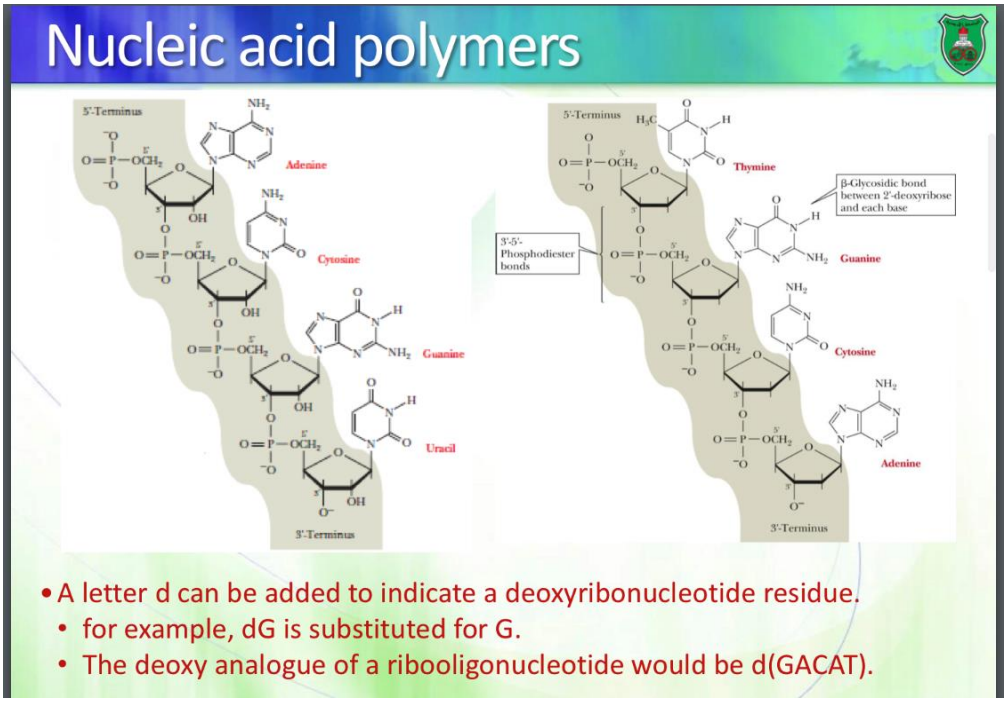
‼**it should be 5'→3'.**

🥹what is the sequence of the (DNA)?(the molecule in the right)

✨T,G,C,A.

👉Here we don't have to say deoxyadenosine , deoxyguanosine,etc…
Because the question is "what is the sequence of the **DNA** molecule,once it Is specified that it is a DNA we don't have to say deoxy ,it's just given that the sugar must be deoxyribose.

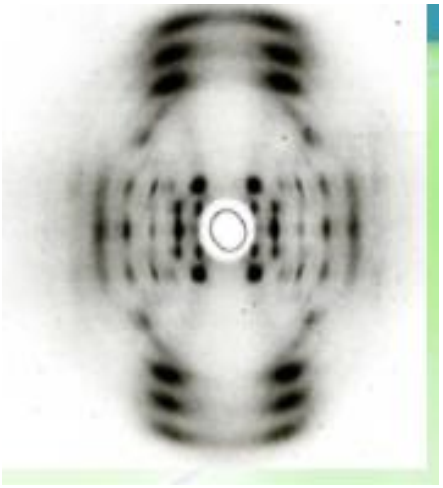
↓↓RNA↓↓. ↓↓DNA↓↓



DNA structure:

✔ DNA structure has been identified by two scientists known as Watson and crick.

✔ In their scientific paper, they only published this figure. From this figure, they were able to draw the structure of DNA, and that's why they got the nobel prize.



Watson and crick model of DNA:

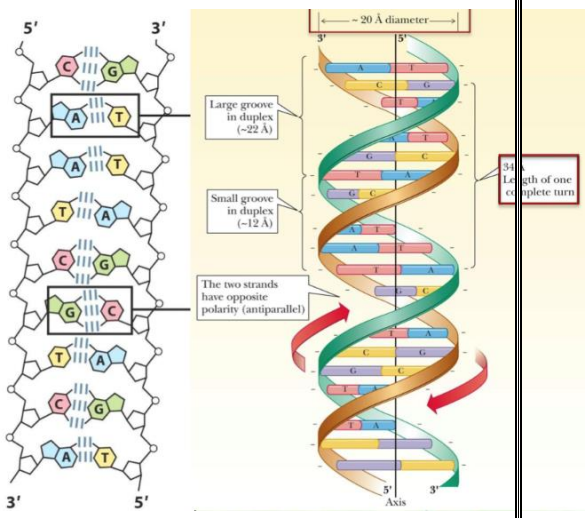
1)**Double helix(like a spring):** ✔ It is a double stranded molecule (made of two strands) and these two strands intertwine around each other.

✔ This winding is not perfect, there is an angle to the rotation of DNA molecule.

2) **specific base pairing:**

✔ we have a stretch (phosphate, sugar, phosphate, sugar...) and the bases are almost perpendicular on the chain, you have these bases on both sides of the chain and there is hydrogen bonding between these bases.

✔ This hydrogen bonding is very specific.



Example :

C pairs with G all time
Forming 3 hydrogen bonds.

A pairs with T all time
Forming 2 hydrogen bonds.

2)**complementary:**

✔whenever you have pyrimidine on one side, you have purine on the other side, because the base paring is **complementary** (they complete each other, whenever there is a A there is a T opposite to it and so on), So the two strands are complementary to each other.

3)**back bone and Side chain:**

✔Back bone is basically phosphate, sugar ,phosphate, sugar….

✔Side chains which are the bases ,extends inward

✔in fact if you look at how bases are oriented (positioned)→

They oriented inward ,so The bases lie inside the double helix, they are hidden inside the molecule

4)**Antiparallel**: The two strands are antiparallel (the two ends are opposite to each other)👇👇

👉you have **one strand** from top to bottom→the top:5' ,the bottom 3'.

the complementary strand→ the top:3'and the bottom: 5'.

Chargaff's rules: chargaff is a scientist who noticed that:

🦋The number of A =the number of T.

🦋The number of C= the number of G.

🦋The number of purines=the number of pyrimidines BUT the number of(A+T) is not necessarily equal to the number of (C+G).

🦋You can have DNA molecule that is mainly composed Adenines and Thymine and very little Guanines and Cytosines.

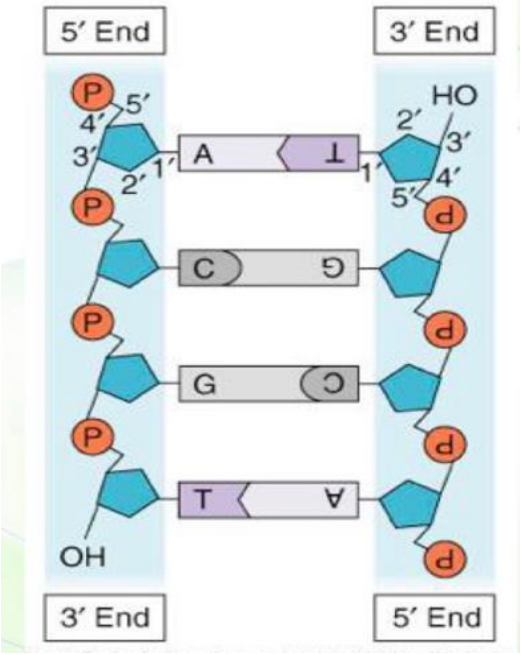
What is the sequence of this DNA molecule?

👉**Hint:**:You should start from the 5' end

Left: A,C,G,T

Right : A,C,G,T

‼you can say: the sequence is 3' TGCA 5',Doctor says "you won't find it in. textbook, but you will find it in my exam, So pay attention on it."



‼ The professor says he won't necessarily give you the sequence of both strands. He will only give you one and ask for the other. You must keep in mind that knowing the sequence of one strand, you can figure out the sequence of the second COMPLEMENTARY strand.

هاد الجزء ما كتبناه لأنه ما حتفهموه زي لما تشوفوه بالفيديو(بالفيديو جدًا واضح)، فارجعوا للفيديو اذا سمحتم من ١٨:٣٤-١٠:٣٦ 💜

5) **DNA is flexible, yet**

✔ It's like an electrical wire, so you can bend it BUT it can't be easily broken.

DNA grooves:

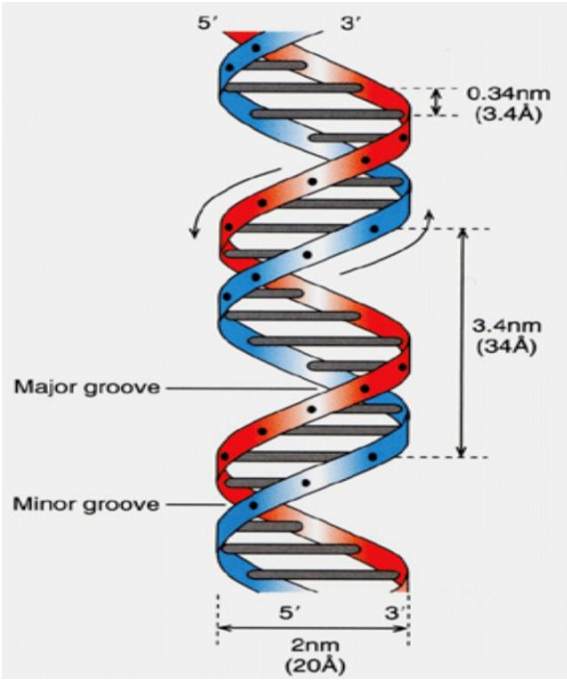
✔ DNA isn't a perfect helix ,it has an angle to it.

✔ Due to that imperfection, DNA has two distinct structures:

🦋 Major and Minor grooves ,this is due to the imperfect winding of the helix

- major groove : larger than minor groove with bigger space.
- minor groove : smaller than major groove with smaller space.

🦋 the difference between them is the size.



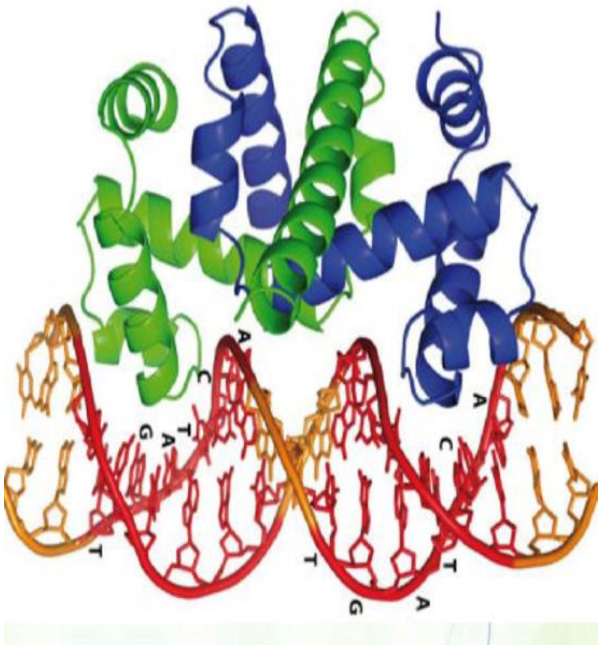
What is the significance of these grooves?

🦋 Proteins interact with DNA and these interactions are very important, they prefer to interact with DNA at the major grooves, so the protein inserts itself inside the major groove because there is enough space for it to insert itself inside DNA.

✔ interactions can take place in minor groove but primarily interactions take place at the major groove..

✔ The interaction takes place between amino acids of proteins with the bases of the DNA molecule.

✔ This interaction occurs via non-covalent interactions
(Hydrogen bond, electrostatic interactions, Van Dear waals interactions and hydrophobic interactions).



❀ Prokaryotes vs. Eukaryotes (in DNA structure):

🦋 prokaryotic cells:

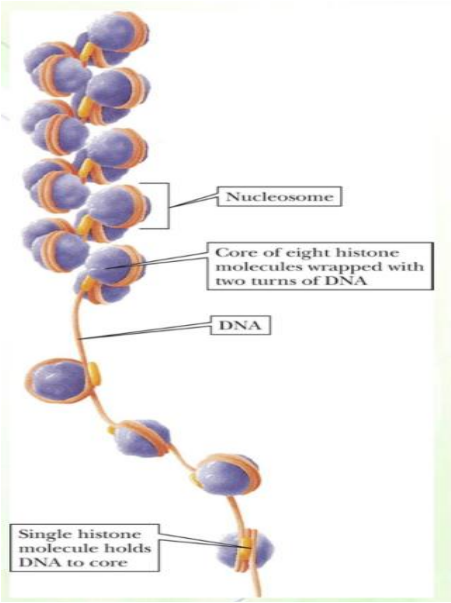
✔ The DNA is a circular single loop that is not placed in a nucleus(this is why their name is prokaryotes).

🦋 Eukaryotic cells:

✔ DNA is composed of different strands of different lengths that are placed in a nucleus (surrounded by nuclear membrane ,so this is why their name is eukaryotes (Eu means real)).

✔ In a single eukaryotic cell, the length of DNA is 2 meters ,it must be packed inside a nucleus by wrapping DNA around histones(positively charged proteins) they interact with the phosphate group of the nucleotides and it make charge nutralization.(DNA is coiled to package the large DNA)

✔ Chromatin = DNA molecule + proteins.



❁we have DNA (in red) wrapped around histones (in yellow)(it looks like beads-on-a-string) and free DNA (free from proteins) known as linker DNA.

❁**Nucleosome:**the structure that is composed of histone +DNA (double stranded molecule)that is wrapped around it+ linker DNA.

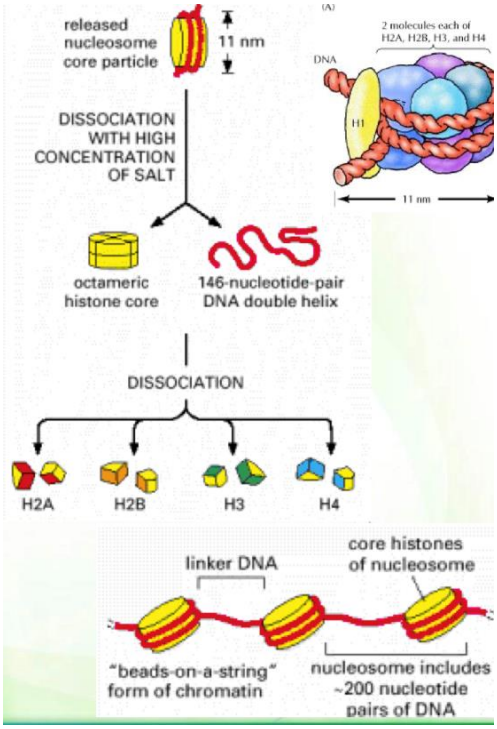
❁**The histone protein core**:an octamer (made of 8 histone molecules ,two molecules of histone H2A, H2B H3 and H4).

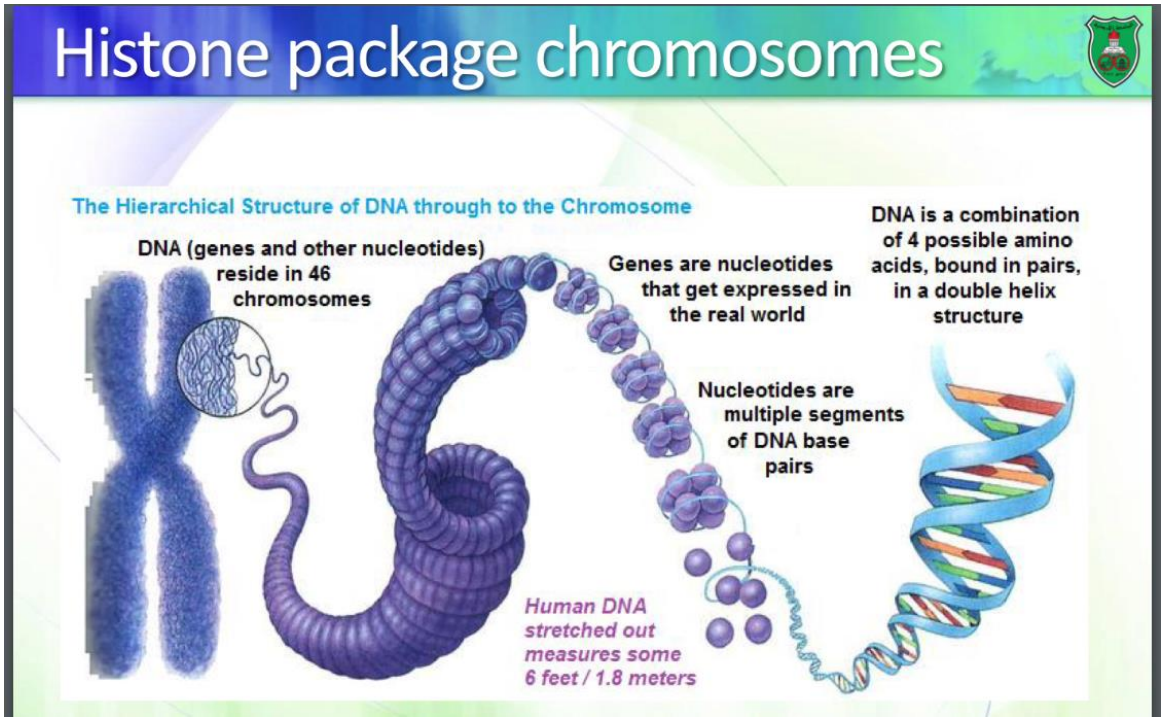
❁**Chromatosome:**the structure that is composed of histone,DNA wrapped around it and H1.(when DNA is packaged very very tightly, you have histone 1 associated with DNA)

❁**The difference between chromatosome and nucleosome** that the chromatosome doesn't involve the linker DNA.

❁**H1:**seals the octamer and DNA wrapped around it.

❁**Chromosome:**single large molecule of DNA+histone and it is a single unit.





Terms to keep in mind:

Chromatin:combination between DNA and proteins(histones), and it's a part of chromosome.

DNA:composed of nucleotides.

C**hromosome:**DNA wrapped around histones into a large unit.

Gene: sequence of nucleotides and a region in DNA where by you can have synthesis of proteins through the processes of transcription and translation, so there is a starting point and an end point producing a single protein molecule, and we can have multiple genes on a stretch of DNA molecule.

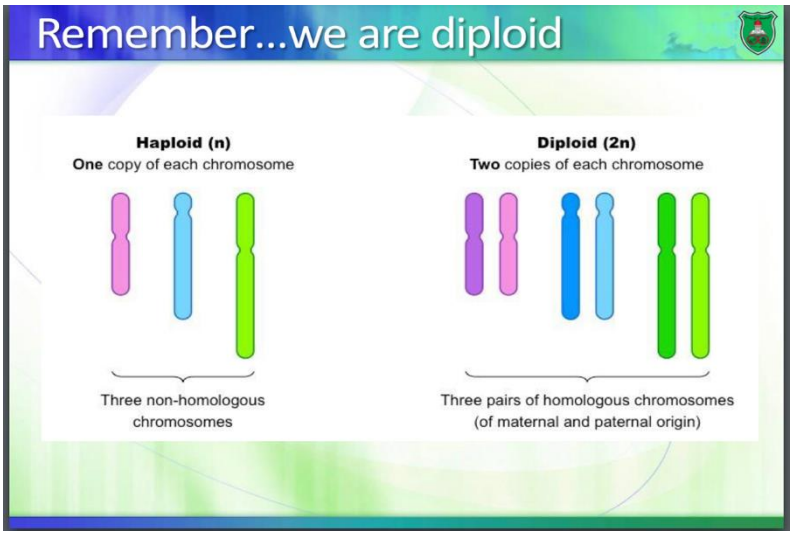
We all have the same genes on every single chromosome in the same order, ex : in chromosome 1, we have gene A, gene B and gene C...etc at certain position and you have in chromosome 1 the same gene in the same order in the same location.

Humans are Diploid (2n): every cell contains Two copies of every chromosome (homologous chromosomes).

Homologous chromosome:two copies of chromosomes (one comes from father and one comes from mother, the sequence as almost similar and the order of genes is exactly the same.

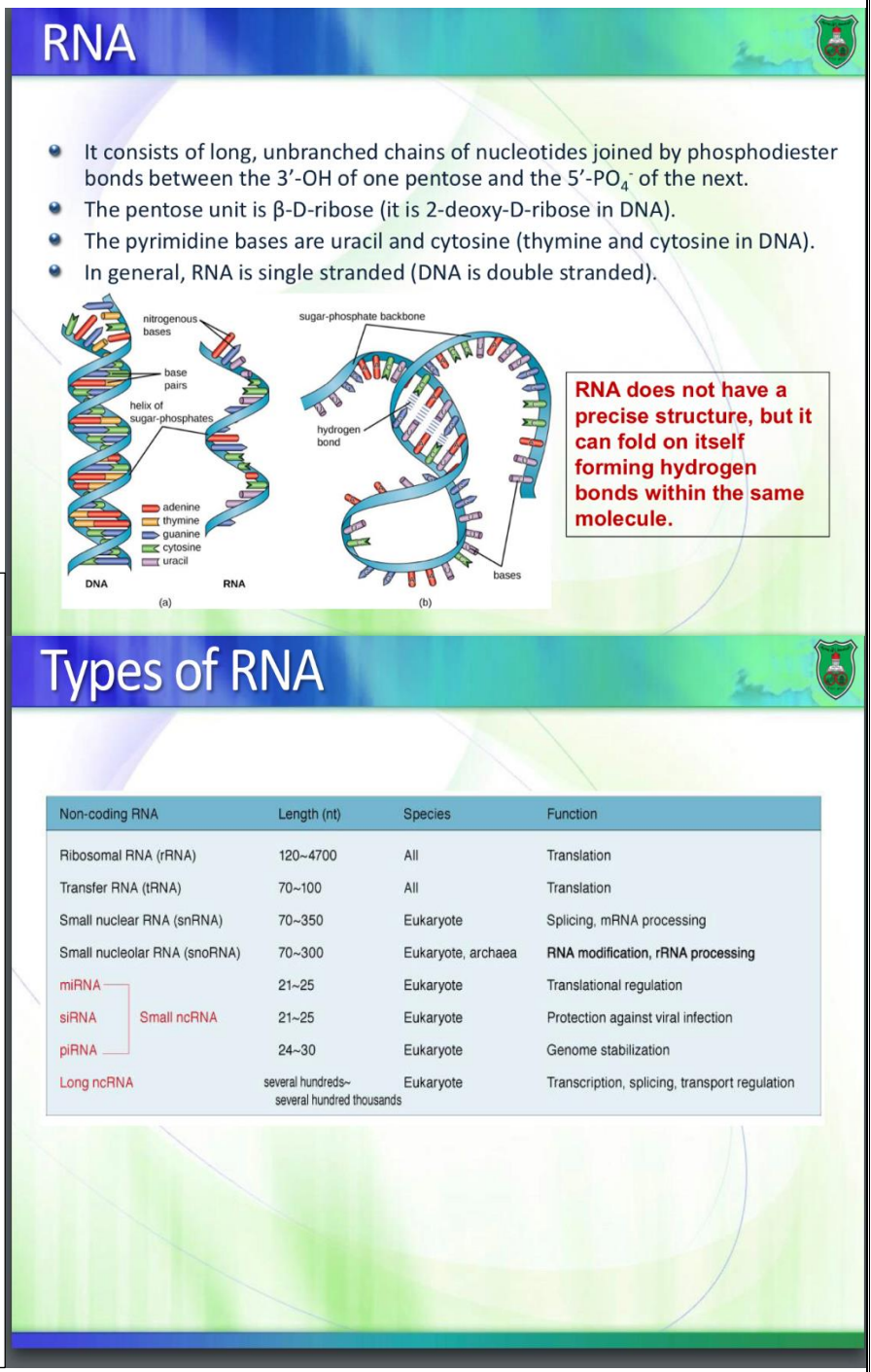
Haploid (1n):contains one copy of chromosome, only In germs (sperm and egg).

Note: the basis of inheritance patterns when a gene is dominant or recessive Example : phenotype like eye color or hair color is different among individuals,even though they can have two different copies of genes, one from the mother and the other from the father.



❁ **RNA:** Single stranded molecule, it doesn't have a particular structure like DNA(DNA is double helical molecule but RNA may have different formes)

🧬 RNA molecules have hydrogen bonding between bases if they are **complementary** to each other.



❁ In the past few years, there has been an explosion in the different types of RNA molecules that we have identified.

❁ We learned that there are three different types of RNA molecules (rRNA,mRNA,tRNA), but scientists have discovered different types of RNA with different functions and different names, We will not talk about all of these RNA molecules but they are known as non-coding RNA (ncRNA) which means that They don't code for proteins

👉 mRNA is coding RNA because it codes for proteins.

❁ 🙂 ما ضفت كل السلايدات مشان راح يكون كتير ف ادرسوا سلايد+شيت. 🤍

"Happiness can be found, even in the darkest of times, if one only remembers to turn on the light." 🤩

Good luck ❁