

WELCOME



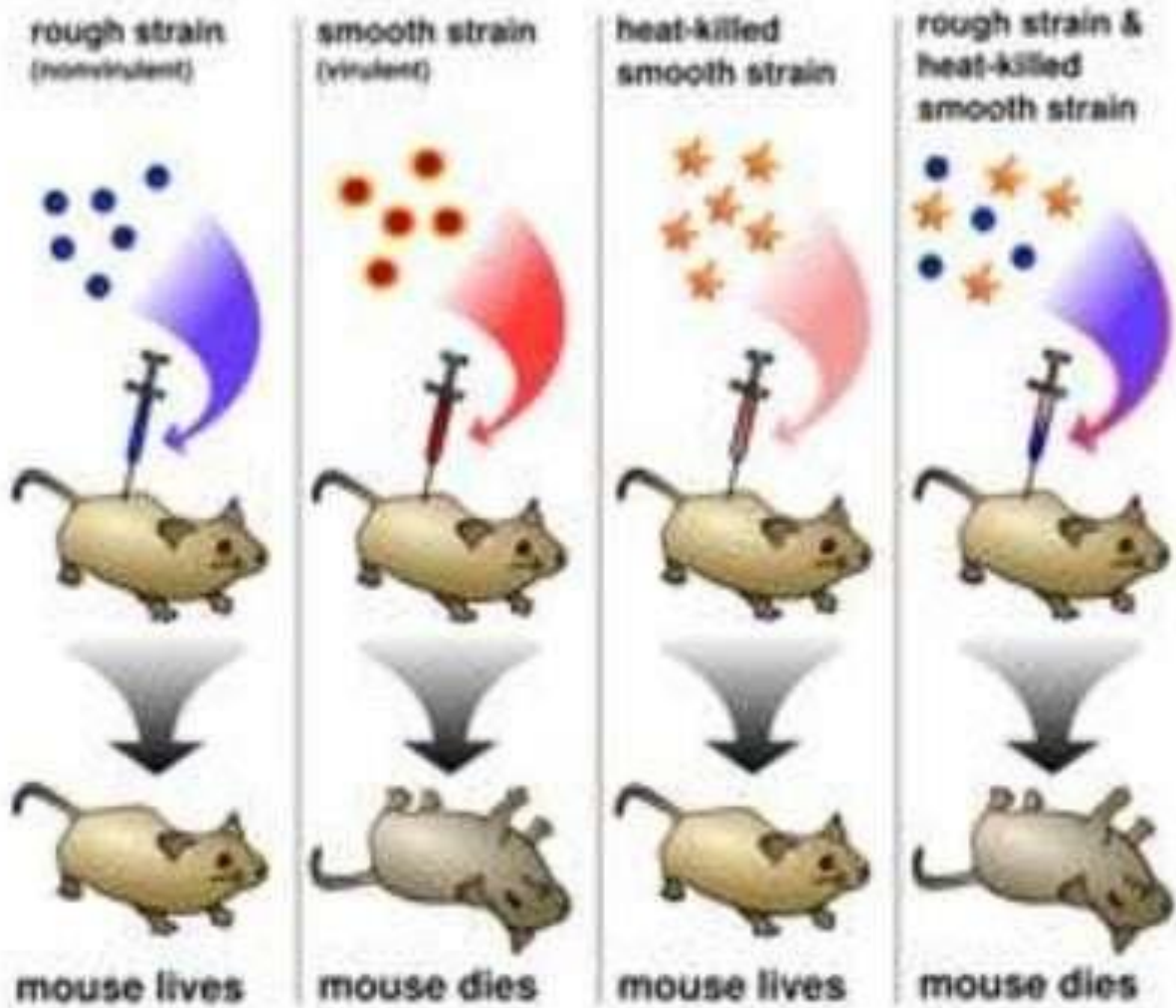
Assignment Presentation
On

DNA STRUCTURE AND FUNCTION

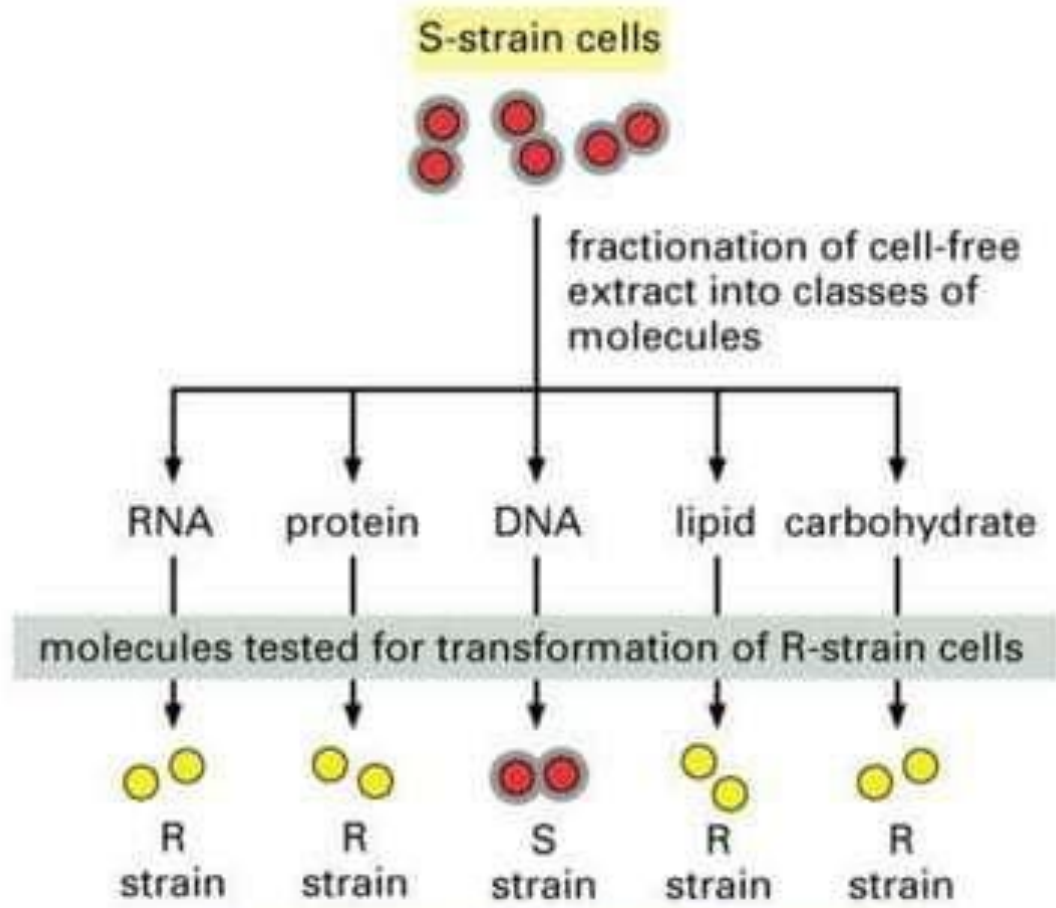
PRINCIPLES OF BIOTECHNOLOGY (MBB 501)

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Transformation: Robert Griffith (1928)



CONCLUSION: The molecule that carries the heritable information is DNA.

Figure 5-4 Essential Cell Biology, 2/e. (© 2004 Garland Science)

HISTORY

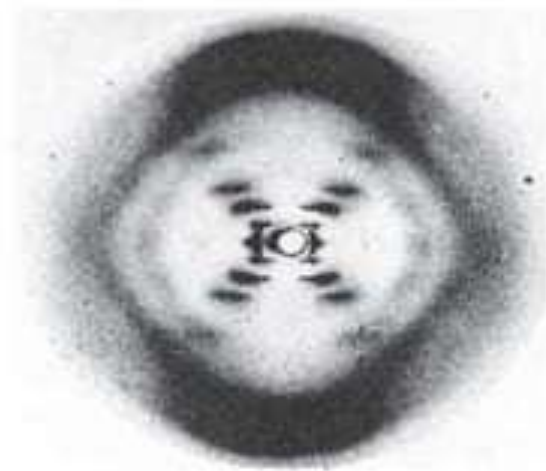
- In 1869, **Miescher discovered "nuclein" (DNA) in the** cells from pus & later he separated it into a protein and an acid molecule. It came to known as nucleic acid after 1874.
- 1926 , **Levene proposed "Tetra nucleotide theory"** which states that Nucleic acid consists of only 4 nitridesas it gives 4 different nucleotides on hydrolysis.





Rosalind Franklin used X-ray crystallography to help visualize the structure of DNA

Fig. 10-66



(b) Franklin's X-ray diffraction photograph of DNA



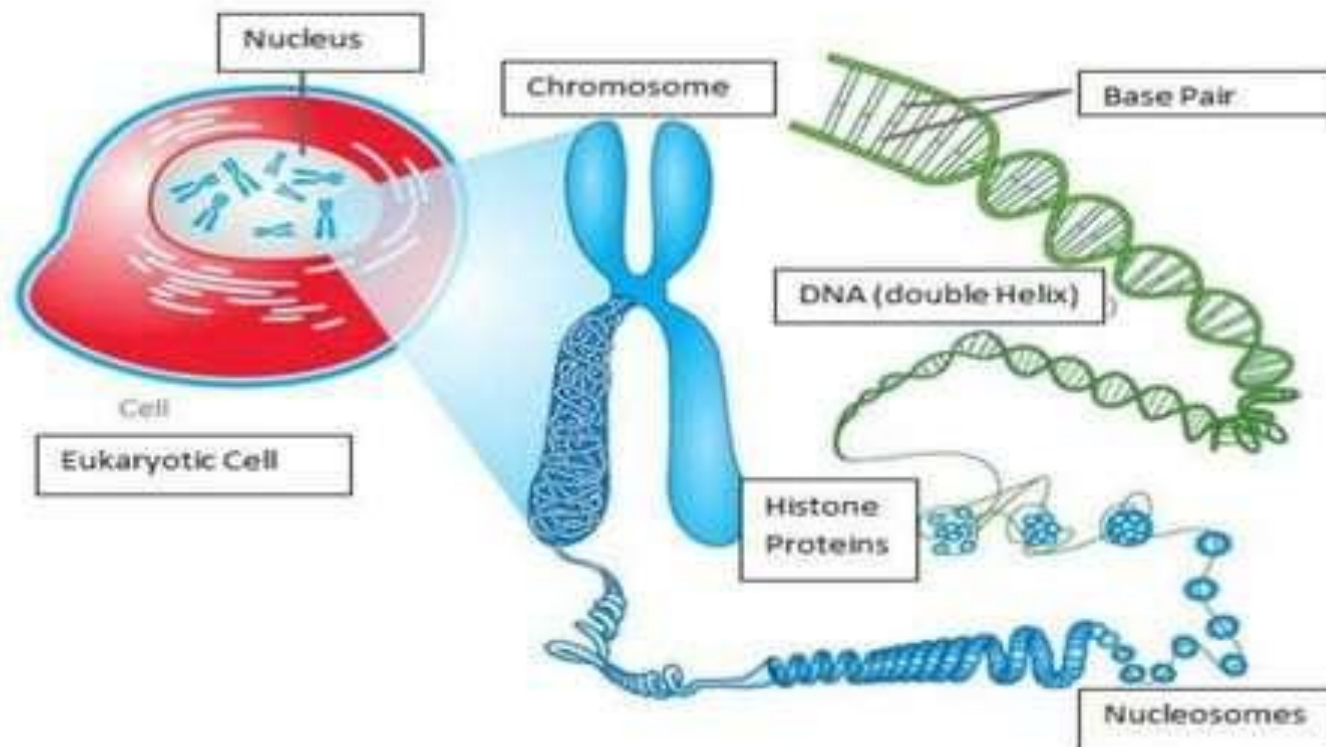


- James D. Watson and Francis Crick, co-originators of the doublehelix model.



BRIEFING ON DNA...

- DNA is found in the cells of all living things.
- DNA contains all of the genetic information that makes you who you are and every
- individual organism has unique DNA like a finger print.



- It contained phosphorus in the form of phosphate
- Deoxyribo nucleic acid
- It is a molecule that encodes the genetic instructions.
- Most DNA molecules are double-stranded helices.
- Each molecule consists of two long biopolymers made of simpler units called nucleotides—each nucleotide is composed of a nucleobase recorded using the letters G, A, T, and C.
- DNA is well-suited for biological information storage.



- DNA Stands for “DeoxyriboNcleic Acid”.
- Term DNA was given by Zaccharis
- DNA is biopolymer consist of nucleotide as monomeric unit.
- DNA is double helical structure in eukaryote and prokaryote, but in virus it may be double stranded or single stranded and presented as monopartite or multipartite.
- In eukaryotes, DNA is presented in nucleus surrounded by nuclear membrane
- In prokaryotes, DNA is presented in nucleoid region of Cytoplasm without nuclear membrane
- In virus, DNA is presented in the core of virus surrounded by Protein layer (called as capsid).



WHAT IS DNA?

- DNA, or deoxyribonucleic acid, is the hereditary material in humans and almost all other organisms. Nearly every cell in a person's body has the same DNA.
- **Where is it located?**
- Most DNA is located in the cell nucleus (where it is called nuclear DNA), but a small amount of DNA can also be found in the mitochondria (where it is called mitochondrial DNA or mtDNA).



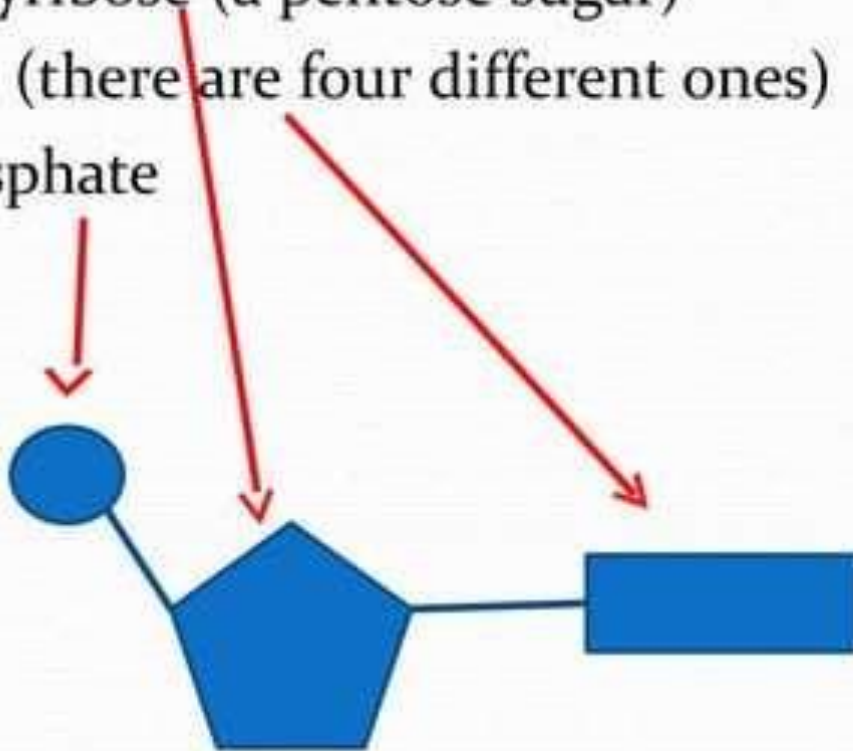


DNA STRUCTURE

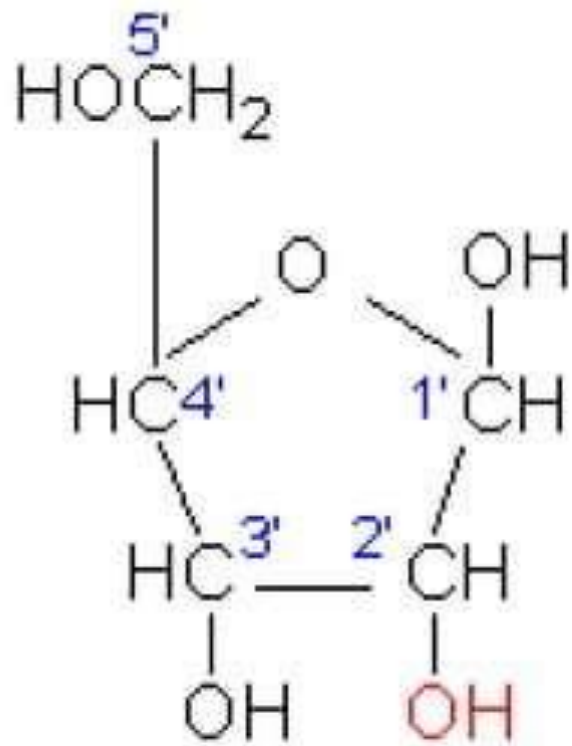
- The structure of DNA is illustrated by a right handed double helix, with about 10 nucleotide pairs per helical turn
- Each spiral strand, composed of a sugar phosphate backbone and attached bases, is connected to a complementary strand by hydrogen bonding (noncovalent) between paired bases, adenine (A) with thymine (T) and guanine (G) with cytosine (C).

DNA Structure

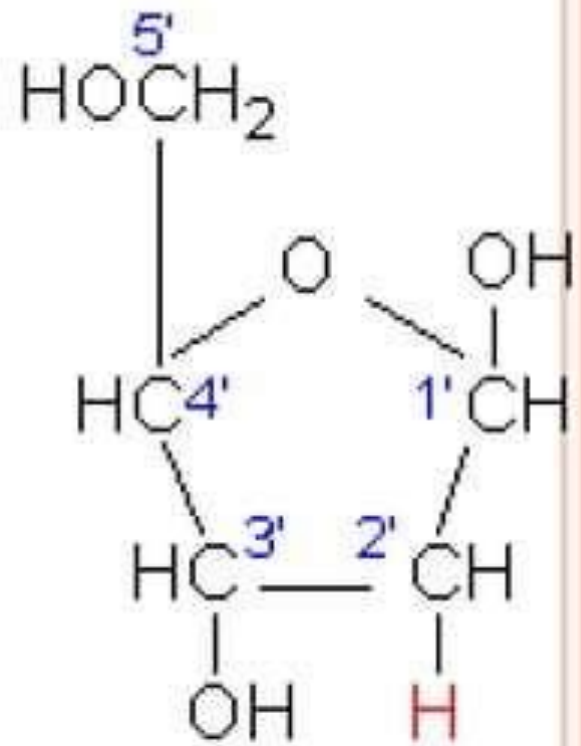
- DNA has three main components
 - 1. deoxyribose (a pentose sugar)
 - 2. base (there are four different ones)
 - 3. phosphate



THE SUGARS



Ribose
(in RNA)



2'-Deoxyribose
(in DNA)

The Bases

- They are divided into two groups
 - Pyrimidines and purines
- Pyrimidines (made of one 6 member ring)
 - Thymine
 - Cytosine
- Purines (made of a 6 member ring, fused to a 5 member ring)
 - Adenine
 - Guanine
- The rings are not only made of carbon (specific formulas and structures are not required for IB)

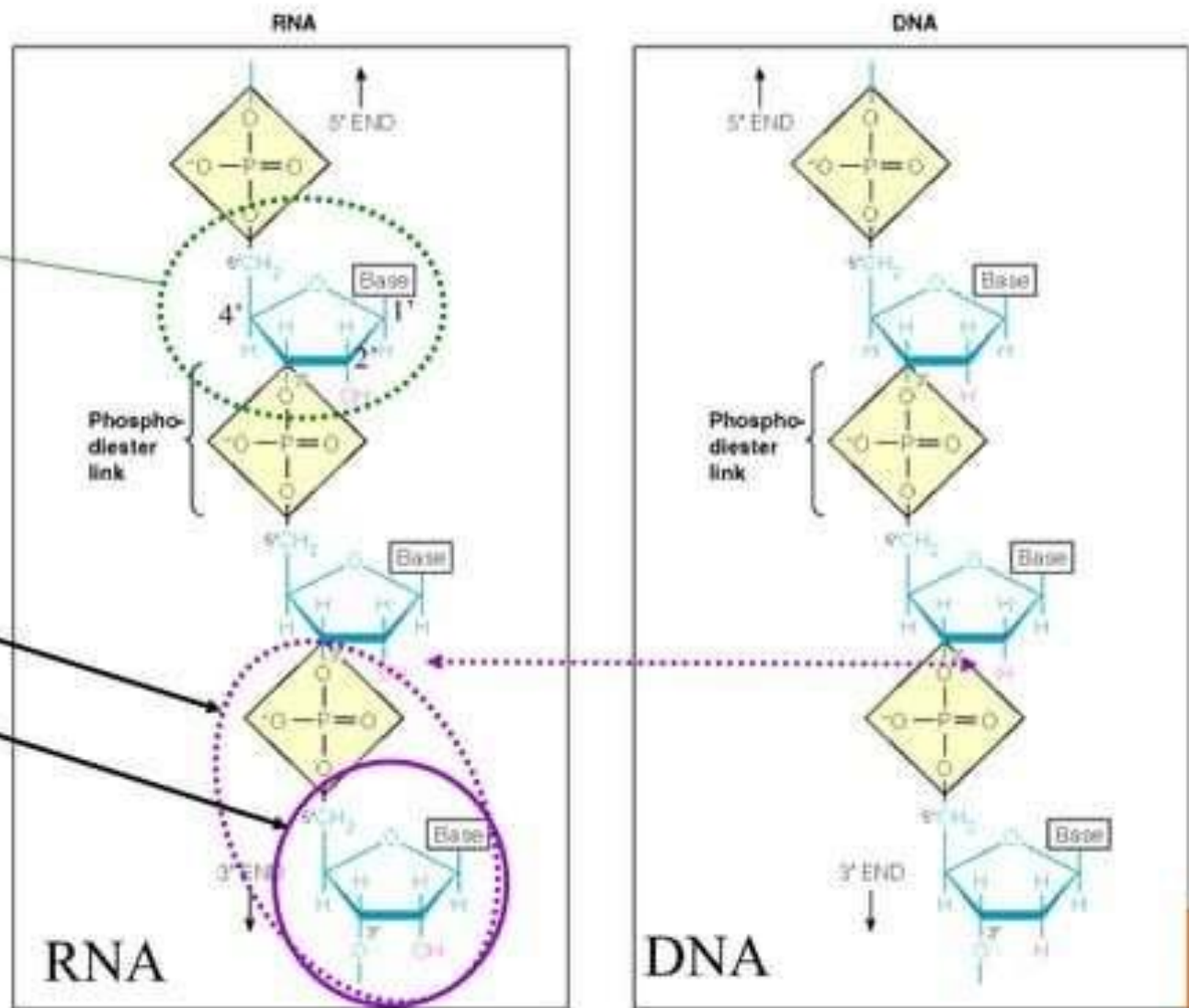


CHEMICAL STRUCTURE OF DNA AND RNA

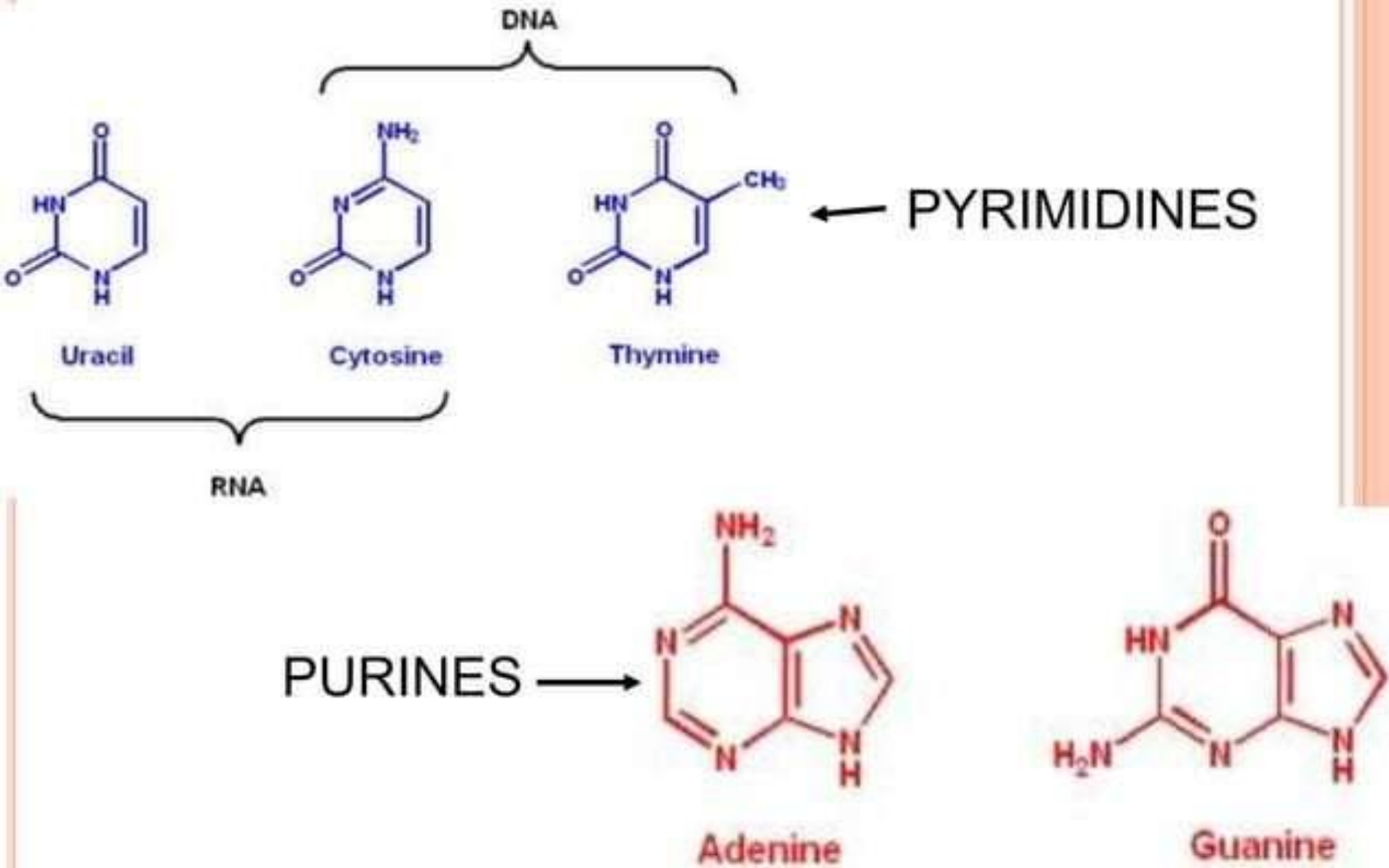
The C is named 1'-5'

Nucleotide

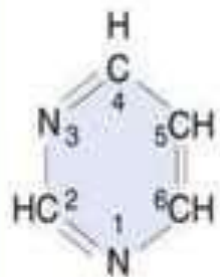
Nucleoside



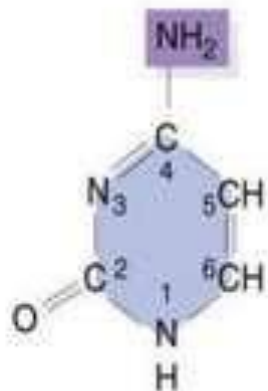
THE BASES



NITROGENOUS BASES



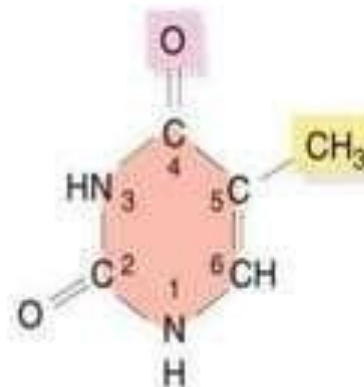
Pyrimidine



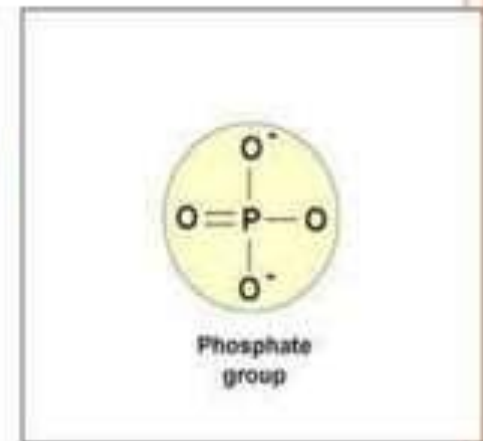
Cytosine (C)



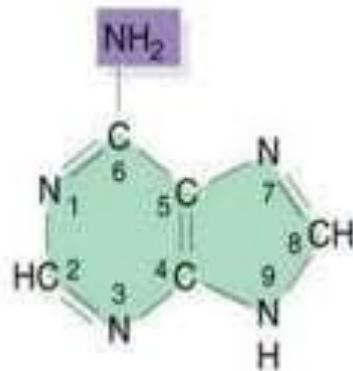
Uracil (U)
(found in RNA)



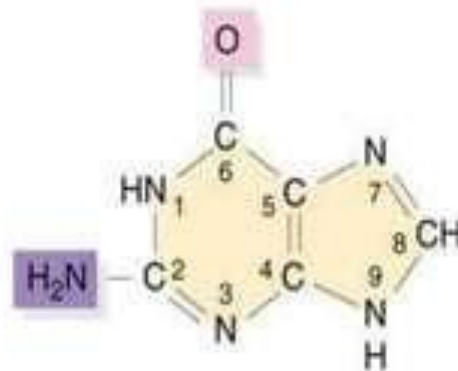
Thymine (T)
(found in DNA)



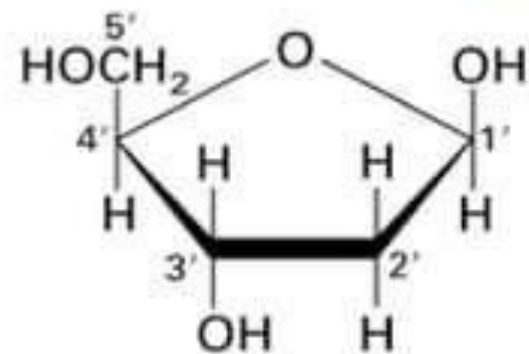
Purine



Adenine (A)



Guanine (G)



2-Deoxyribose

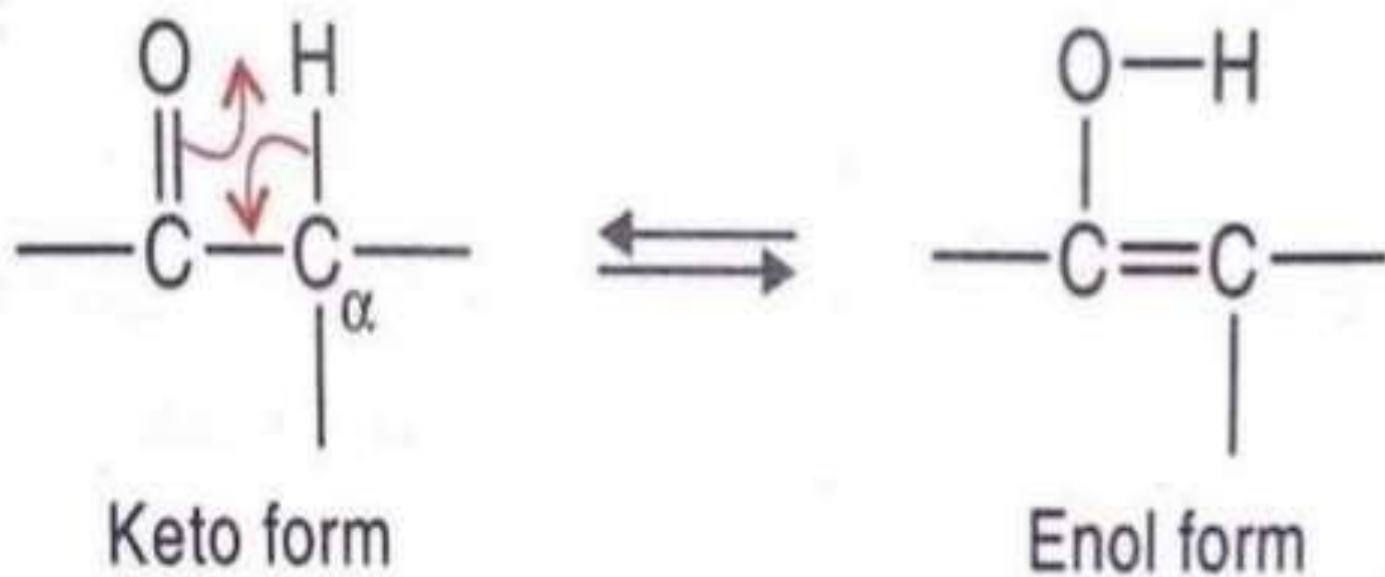
TAUTOMERISM

- **Tautomers** are isomers of a compound which differ only in the position of the protons and electrons. ... A reaction which involves simple proton transfer in an intramolecular fashion is called a **tautomerism**. Keto-enol **tautomerism** is a very common process, and is acid or base catalysed.

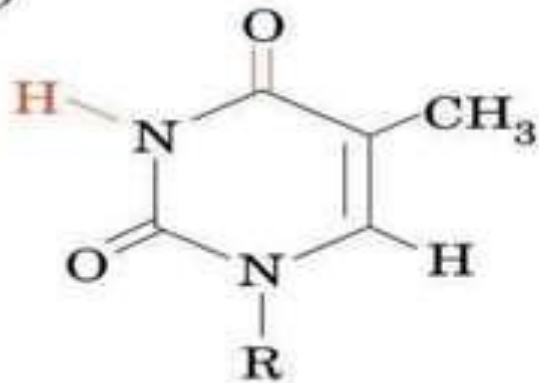


KETO-ENOL TAUTOMERISM

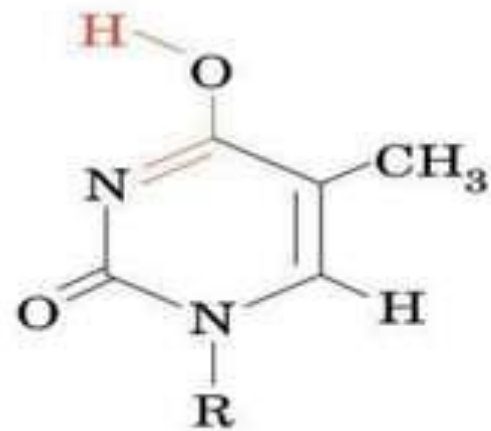
Aldehydes, ketones and some other compounds undergo this special type of tautomerism. It involves the migration of a proton from α -carbon to the carbonyl oxygen.



(a)

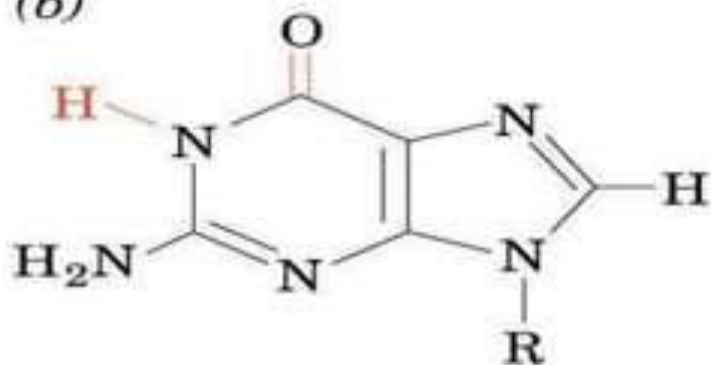


Thymine
(keto *or* lactam form)

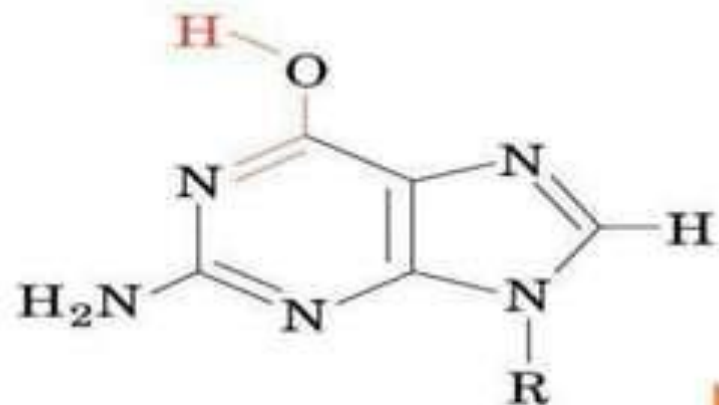


Thymine
(enol *or* lactim form)

(b)



Guanine
(keto *or* lactam form)



Guanine
(enol *or* lactim form)

TABLE 43.1: Base + sugar are nucleosides

<i>Ribonucleosides</i>		
Adenine + Ribose	→	Adenosine
Guanine + Ribose	→	Guanosine
Uracil + Ribose	→	Uridine
Cytosine + Ribose	→	Cytidine
Hypoxanthine + Ribose	→	Inosine
Xanthine + Ribose	→	Xanthosine
<i>Deoxyribonucleosides</i>		
Adenine + Deoxy ribose	→	Deoxy adenosine (d-adenosine)
Guanine + Deoxy ribose	→	d-guanosine
Cytosine + Deoxy ribose	→	d-cytidine
Thymine + Deoxy ribose	→	d-thymidine

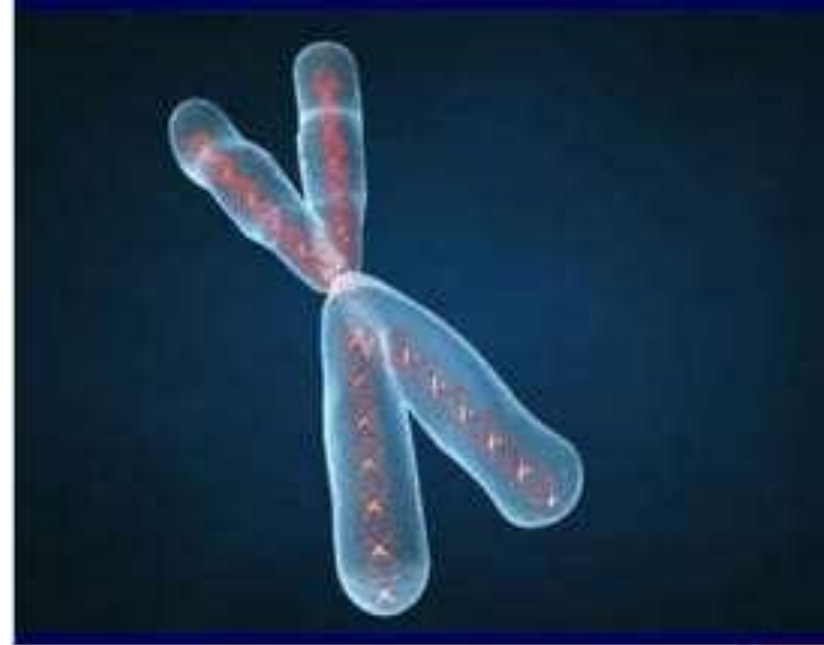


TABLE 43.2: Base + sugar + phosphate = nucleotide

<i>Ribonucleotides</i>		
Adenosine	+ Pi	→Adenosine monophosphate (AMP) (Adenylic acid)
Guanosine	+ Pi	→Guanosine monophosphate (GMP) (Guanylic acid)
Cytidine	+ Pi	→Cytidine monophosphate (CMP) (Cytidylic acid)
Uridine	+ Pi	→Uridine monophosphate (UMP) (Uridylic acid)
Inosine	+ Pi	→Inosine monophosphate (IMP) (Inosinic acid)
<i>Deoxyribonucleotides</i>		
d-adenosine	+ Pi	→d-AMP (d-adenylic acid)
d-guanosine	+ Pi	→d-GMP (d-guanylic acid)
d-cytidine	+ Pi	→d-CMP (d-cytidylic acid)
d-thymidine	+ Pi	→d-TMP (d-thymidylic acid)

FUNCTIONS

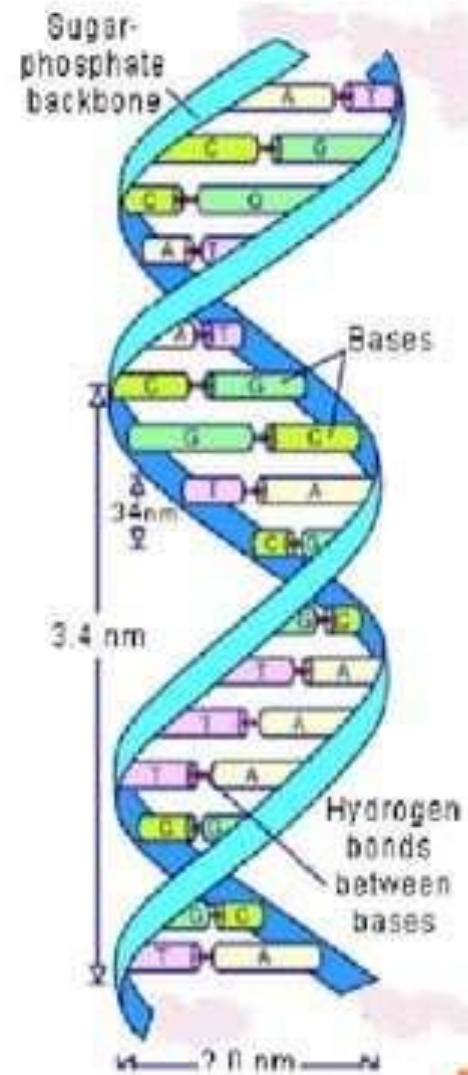
- Nucleotides are precursors of the nucleic acids, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).
- The nucleic acids are concerned with the storage and transfer of genetic information.
- The universal currency of energy, namely ATP, is a nucleotide derivative. Nucleotides are also components of important co-enzymes like - NAD⁺ and FAD, and - metabolic regulators such as cAMP and cGMP.
- Dna must be stable
- There are coding and noncoding regions found on DNA
- Coding region code for genes(proteins).
- Non-coding regions can be either DNA junk or help regulate protein synthesis.



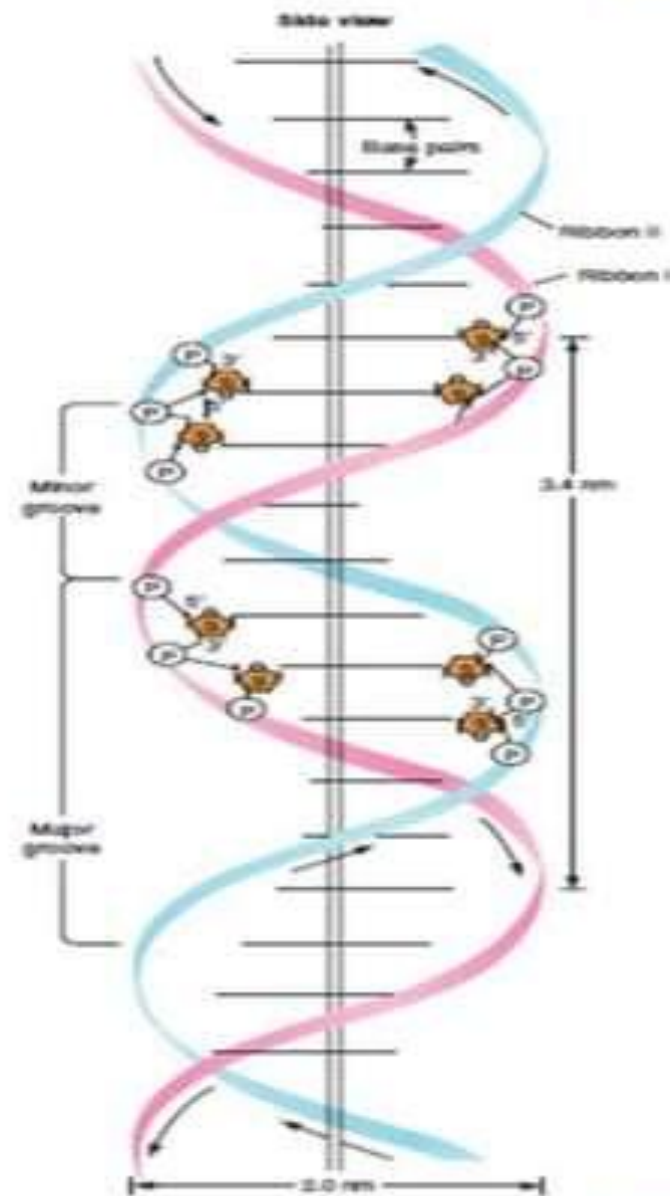
DNA STRUCTURE

In 1953, Watson and Crick postulated a three dimensional model of DNA structure that accounted for both the X-ray data and the characteristic base pairing in DNA.

- It consists of two helical polynucleotide chains.
- Two polynucleotide chains coil around the same axis to form a right-handed double helix.
- In the helix, the two chains or strands are anti-parallel i.e. have an opposite polarity.
- Backbone of each chain which consists of alternate sugar-phosphate residues, (hydrophilic) are on the outside of the double helix, facing the surrounding.



- The purine and pyrimidine bases of each strand face inward towards each other.
- The bases are stacked perpendicular to the long axis of the double helix.
- The base pair are 0.34 nm apart in DNA helix. A complete turn of helix takes 3.4 nm, therefore in each helical turn, 10 bases are present. The external diameter of helix is 2 nm.
- The helix has two external grooves, the narrow groove is called as **minor groove** while the wide groove is called as **major groove** . The major groove is the site for DNA binding proteins. The minor grooves often are the site for binding small molecules.



- The pairs of bases are always between a purine and pyrimidine, specifically the pairs A-T and G-C, which are the base pairs found by Chargaff.
- There is hydrogen bonding between the bases. 2H-bonds between A & T and 3H-bonds between G & C
- Two chains do not have the same base composition (not identical), but two chains are **complementary** to each other. Such chains are called as **complementary** chains.

1st chain ---- ATACGCAC---3A, 1T, 3C, 1G

2nd chain ---- TATGCGTG---1A, 3T, 1C, 3G

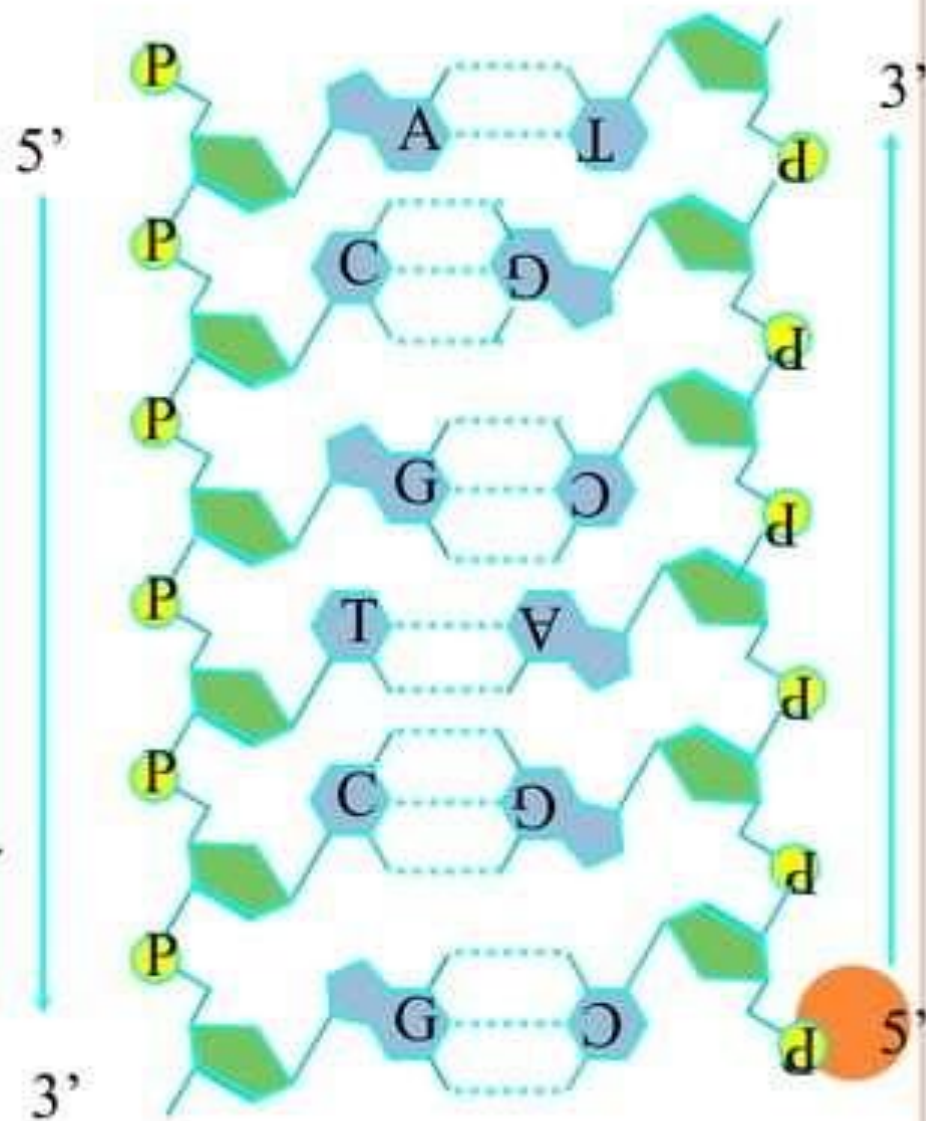


DNA IS A DOUBLE HELIX

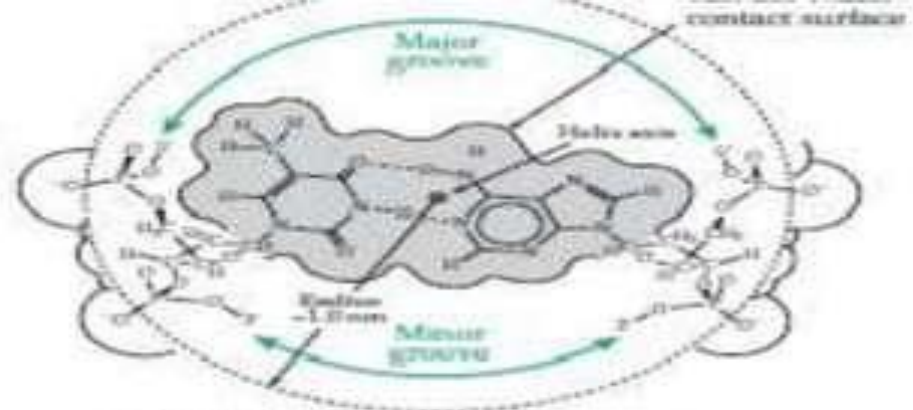
A sugar and phosphate “backbone” connects nucleotides in a chain.

Hydrogen bonds between paired bases hold the two DNA strands together.

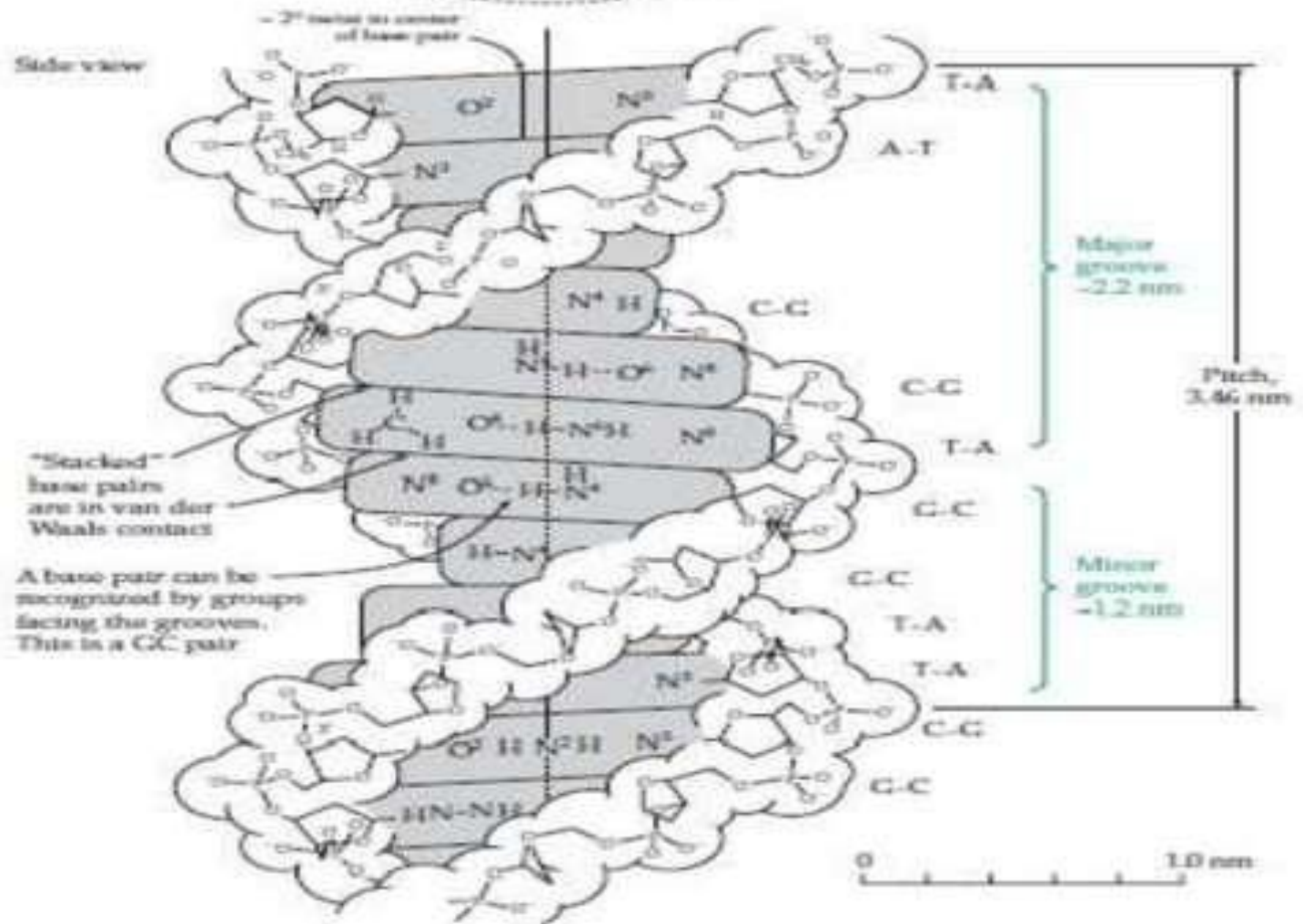
DNA strands are antiparallel.



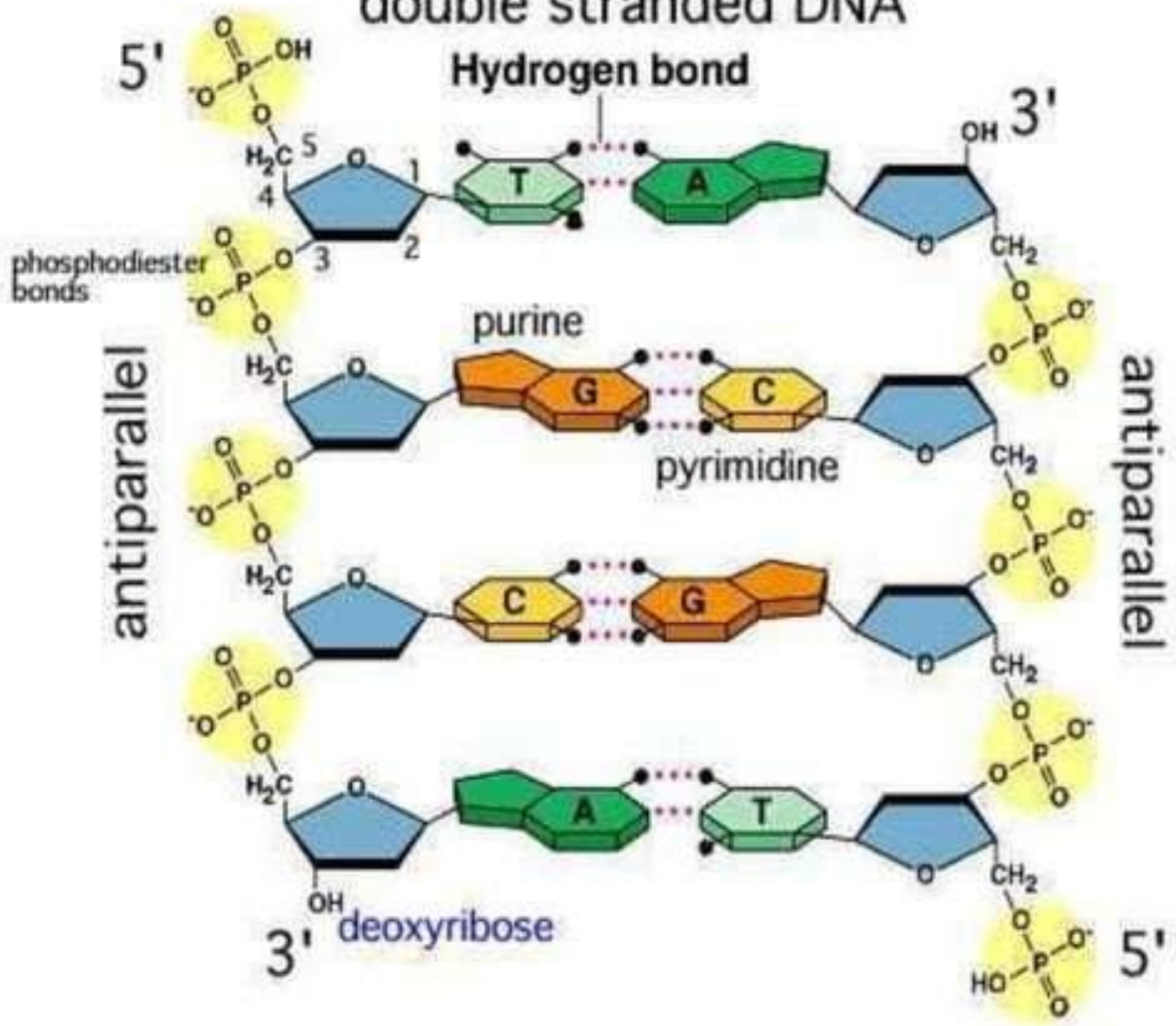
Top view

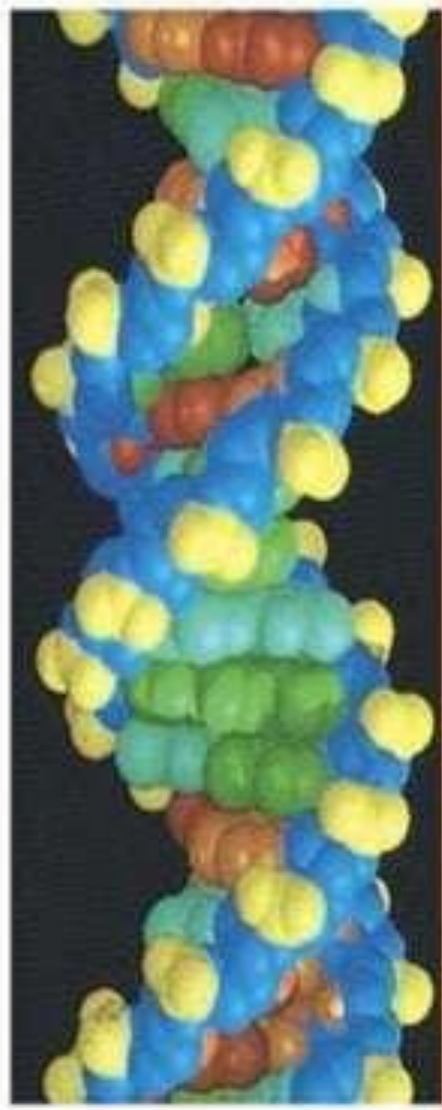
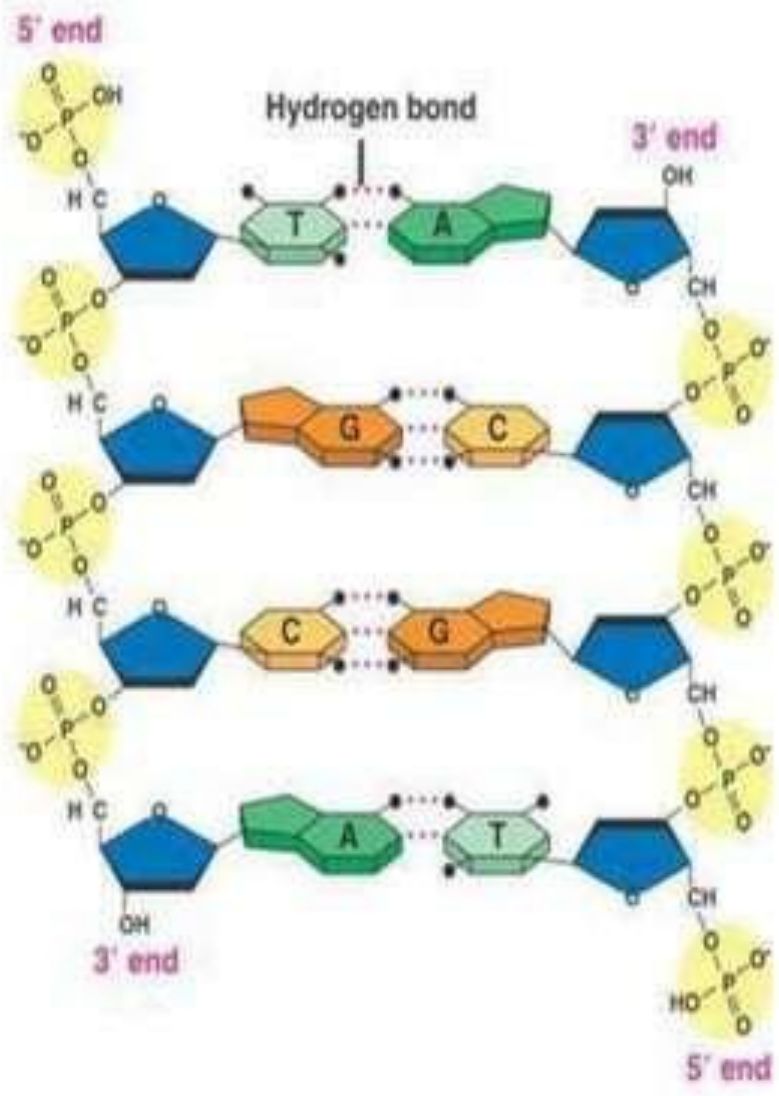
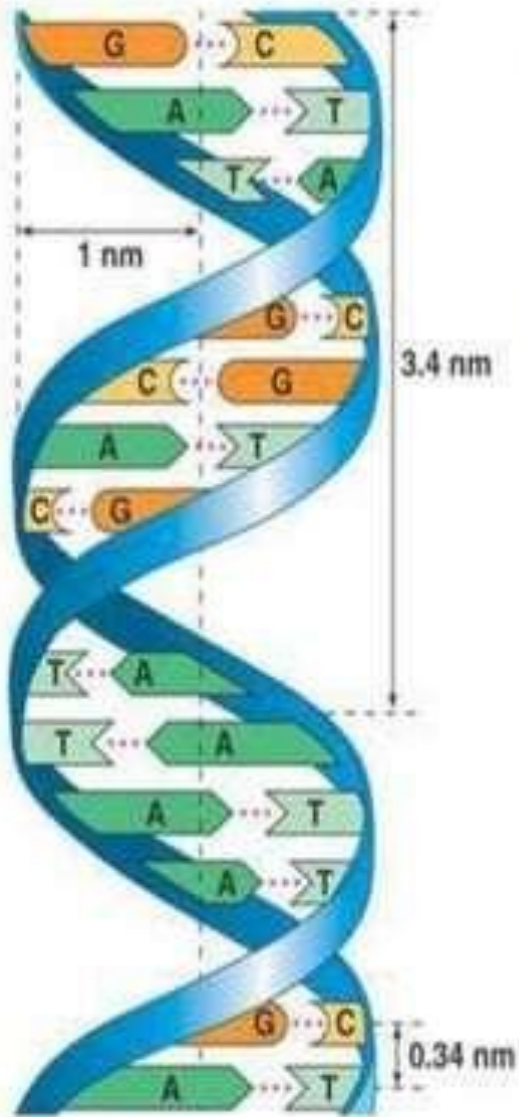


Side view



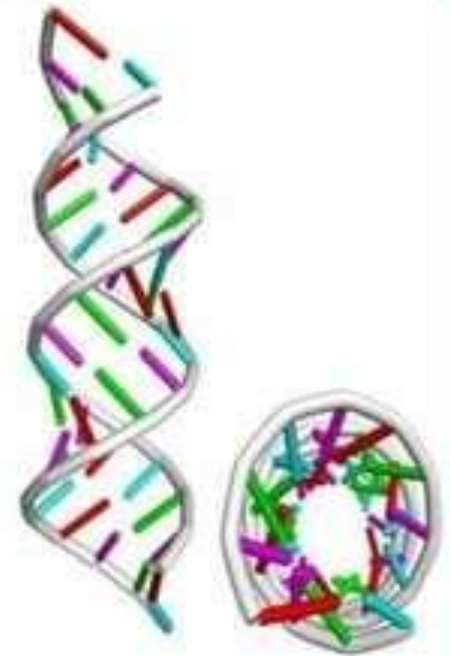
double stranded DNA





A-DNA

- **A-DNA is one of the many possible double helical structures of DNA.**
- It is most active along with other forms.
- Helix has left-handed sense, shorter more compact helical structure.
- It occurs only in dehydrated samples of DNA, such as those used in crystallograph experiments.



A-DNA



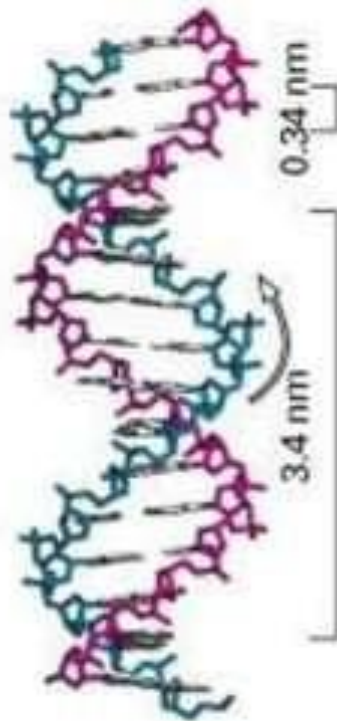
○ **Structure**

- A-DNA is fairly similar to B-DNA.
- Slight increase in the number of bp/ rotation (resulting in a tighter rotation angle), and smaller rise/turn.
- deep major groove and a shallow minor groove.
- Favoured conformation at low water concentrations.
- In a solution with higher salt concentrations or with alcohol

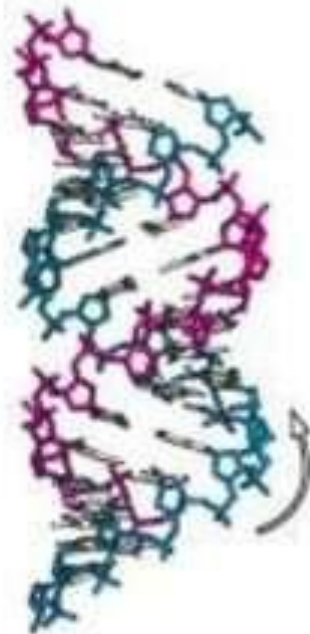
added, the DNA structure may change to an **A form**, **which is** still right-handed, but every 2.3 nm makes a turn and there are 11 base pairs per turn.



(a) B DNA



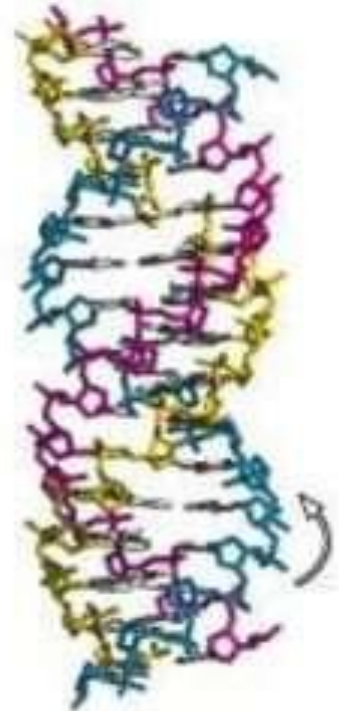
(b) A DNA



(c) Z DNA

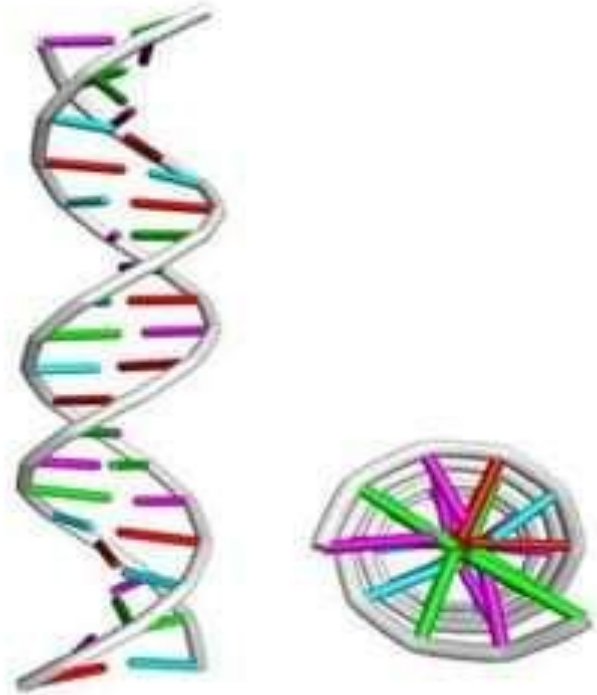


(d) Triple-Helical DNA



B-DNA

- Most common DNA conformation in vivo.
- Favoured conformation at high water concentrations.
- Also known as Watson & Crick model of DNA.
- First identified in fibre at 92% relative humidity.



B-DNA

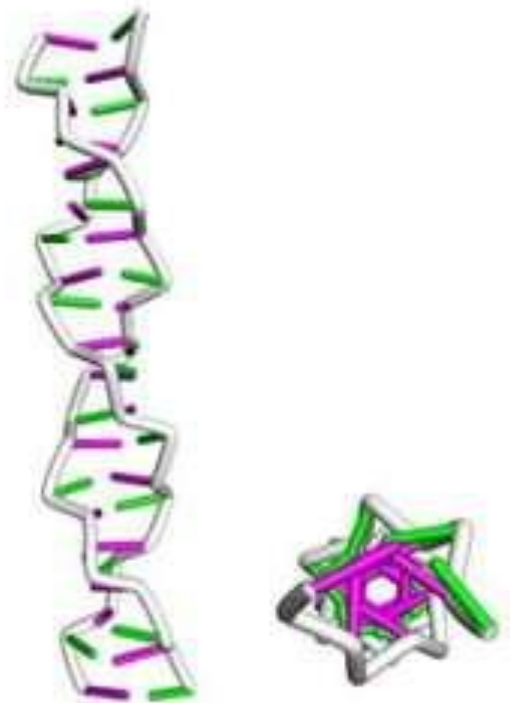


- Structure
- Narrower, more elongated helix than A.
- Wide major groove easily accessible to proteins & Narrow minor groove.
- Base pairs nearly perpendicular to helix axis
One spiral is 3.4nm or 34Å.
- Distance between two H-bonds is 0.34nm or 3.4Å.



Z-DNA

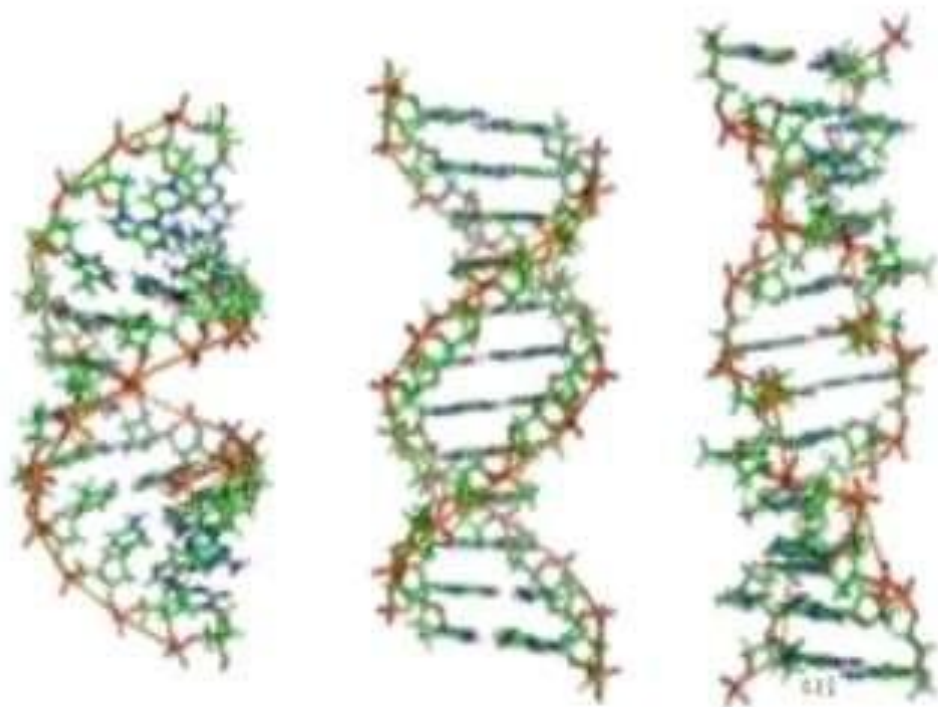
- **Z-DNA is one of the many possible** double helical structures of DNA.
- Helix has left-handed sense.
- It is most active double helical structure.
- Can be formed in vivo, given proper sequence and super helical tension, but function remains obscure.



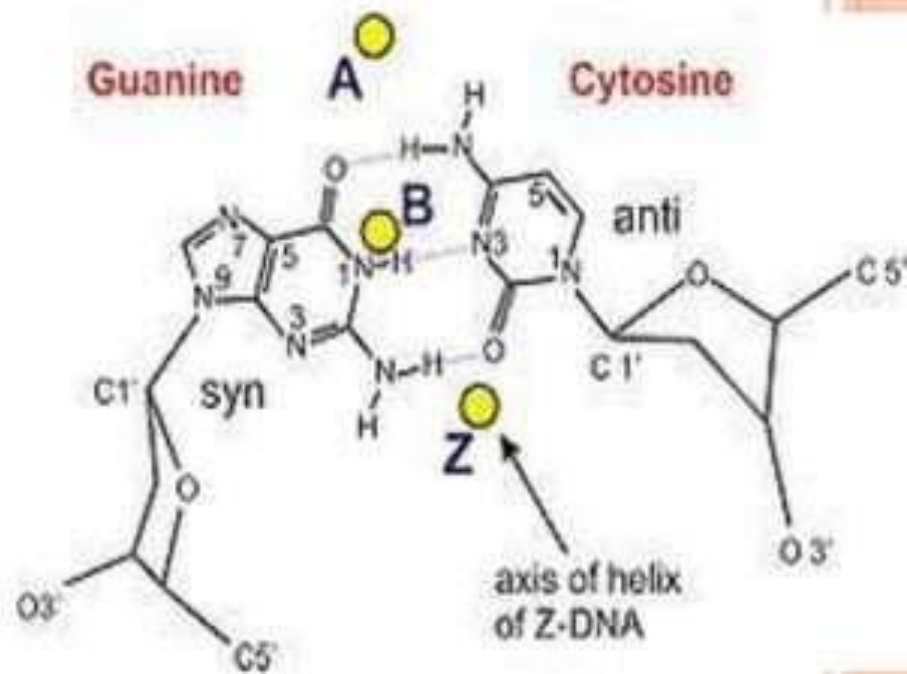
Z-DNA



	A form	B form	Z form
Helical sense	Right handed	Right handed	Left handed
Diameter	~26 Å	~20 Å	~18 Å
Base pairs per helical turn	11	10.5	12
Helix rise per base pair	2.6 Å	3.4 Å	3.7 Å
Base tilt normal to the helix axis	20°	6°	7°
Sugar pucker conformation	C-3' endo	C-2' endo	C-2' endo for pyrimidines; C-3' endo for purines
Glycosyl bond conformation	Anti	Anti	Anti for pyrimidines;



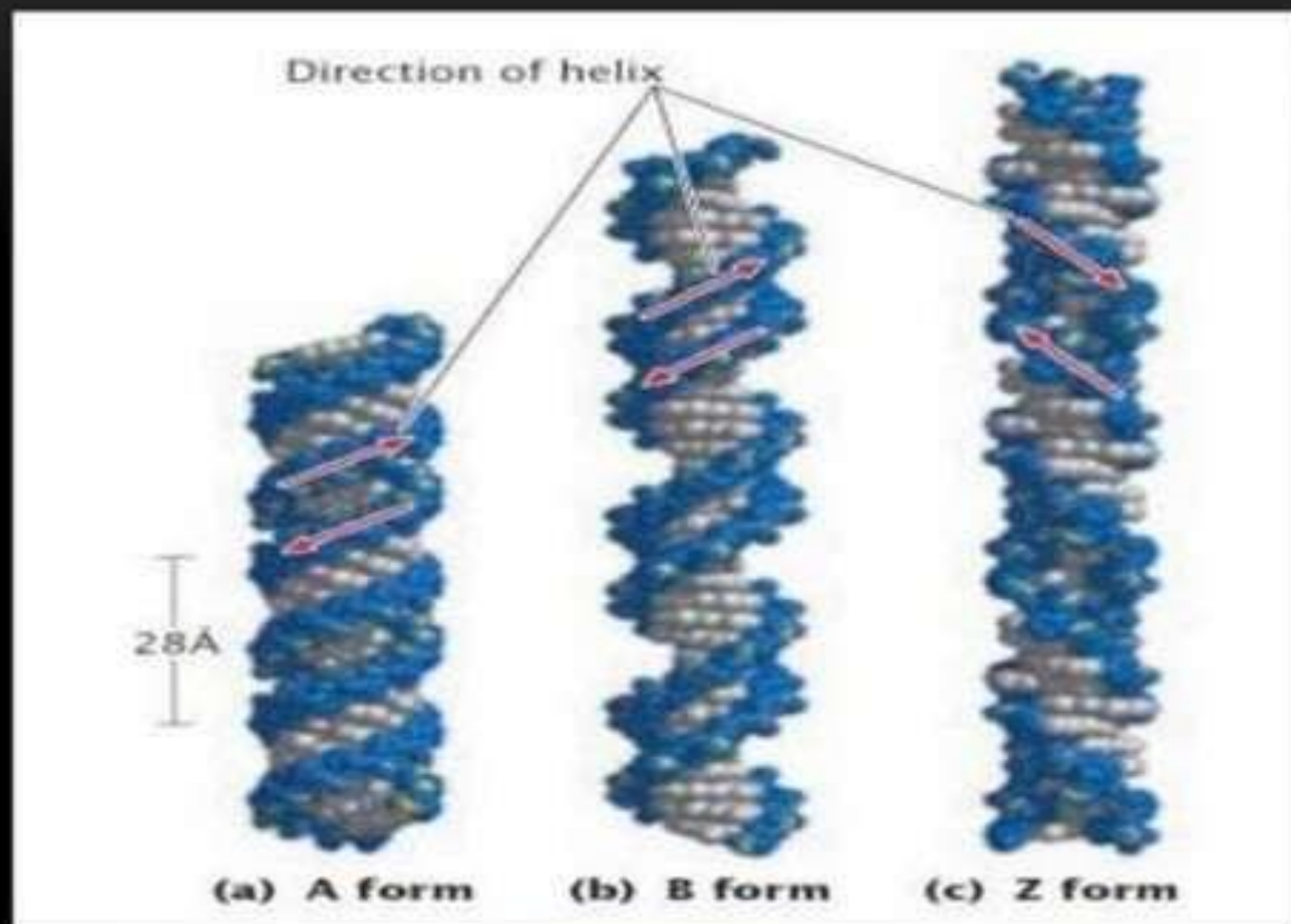
Side view of A-, B-, and Z-DNA.



The helix axis of A-, B-, and Z-DNA.

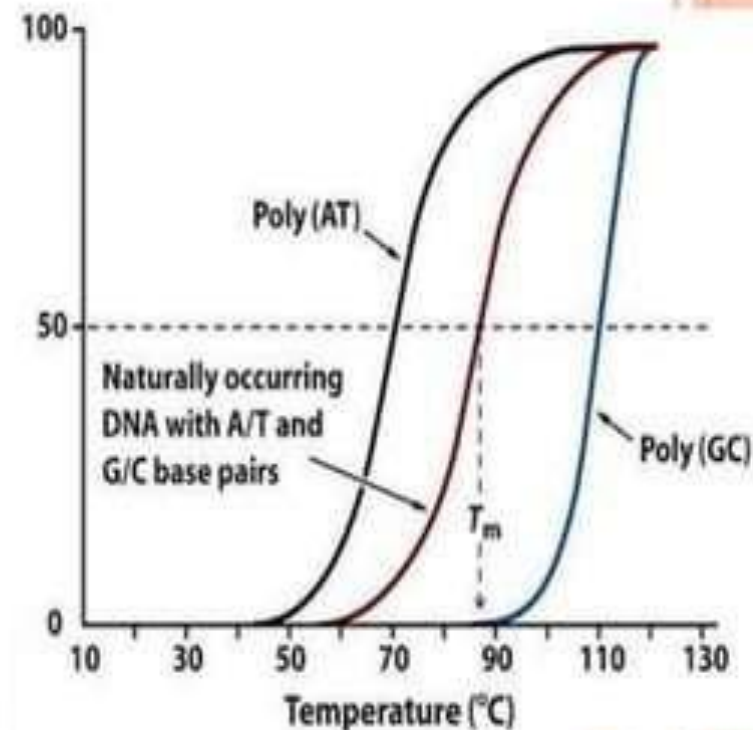
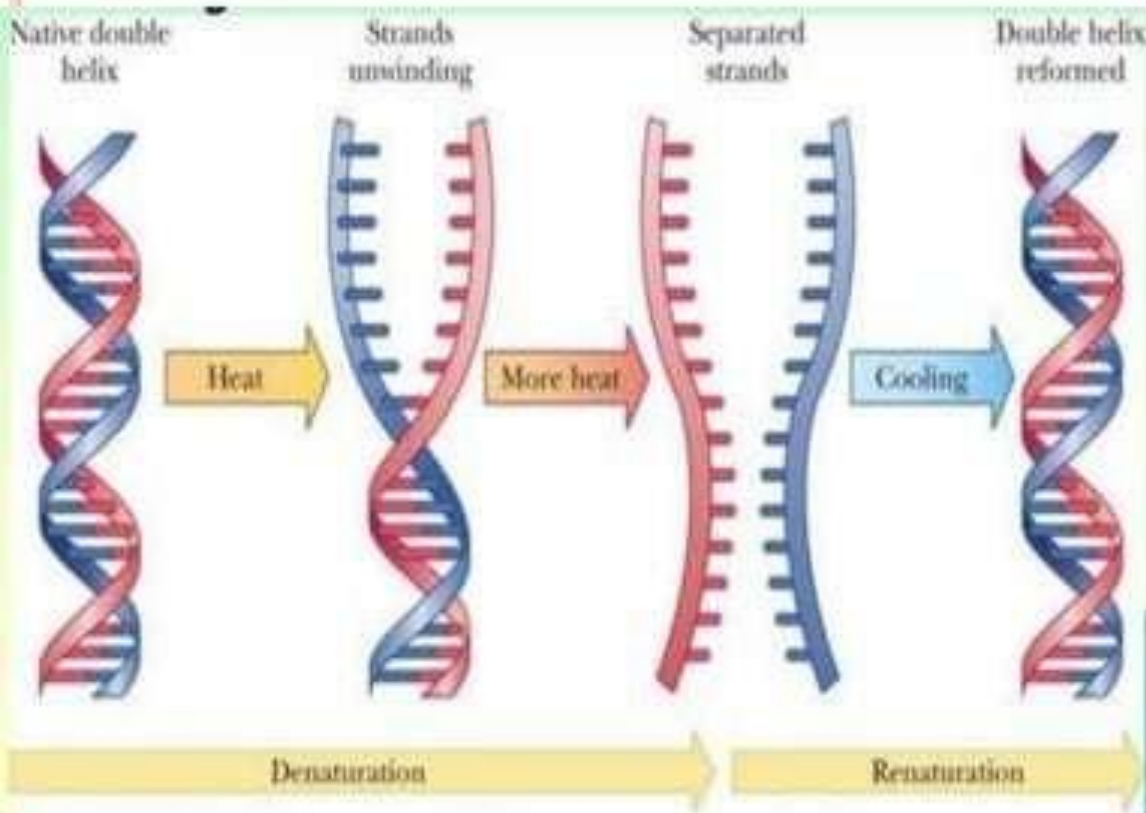


Direction of Helix



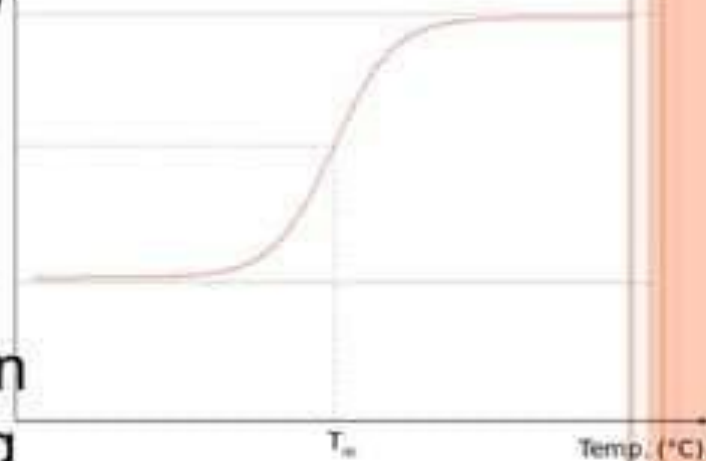
“DNA DENATURATION”

- DNA Denaturation is the separation of a double strand into two single strands, which occurs when the **hydrogen bonds** between the strands are broken.



HYPERCHROMIC EFFECT

- is the increase of absorbance (*optical density*) of a material. The most famous example is the hyperchromicity of DNA that occurs when the DNA duplex is denatured. The UV absorption is increased when the two single DNA strands are being separated, either by heat or by addition of denaturant or by increasing the pH level. The opposite, a decrease of absorbance is called **hypochromicity**.



CONCLUSION

- The secondary structure of DNA is important in many events in cellular life. Replication, transcription and regulation of expression of many genes depends on local differences or changes in DNA structure. Recombination which leads to rearrangement of genes takes advantage of the ability to form an unusual structure called a Holliday's structure. Also different kinds of mutations occur as a result of specific DNA structure.



THANK YOU

