
بسم الله الرحمن الرحيم

DEOXYRIBONUCLEIC ACID

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By the end of lecture we will able to know : (basic chemistry of genetic)

- Chemical structure of DNA
- CHARGAFF’S RULE
- FORMs OF DNA
- Biomedical importance

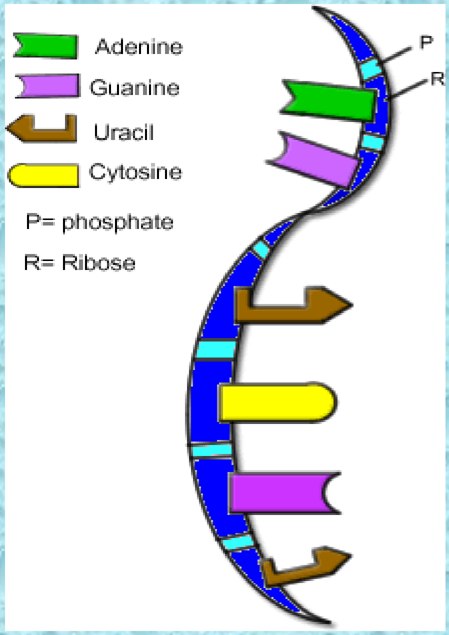
NUCLEIC ACID

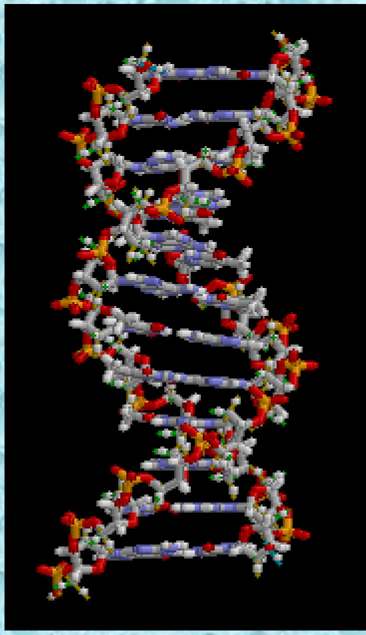
- Nitrogenous non protein substances made up of polymeric macromolecules called NUCLEOTIDES.

TYPES OF NUCLEIC ACID

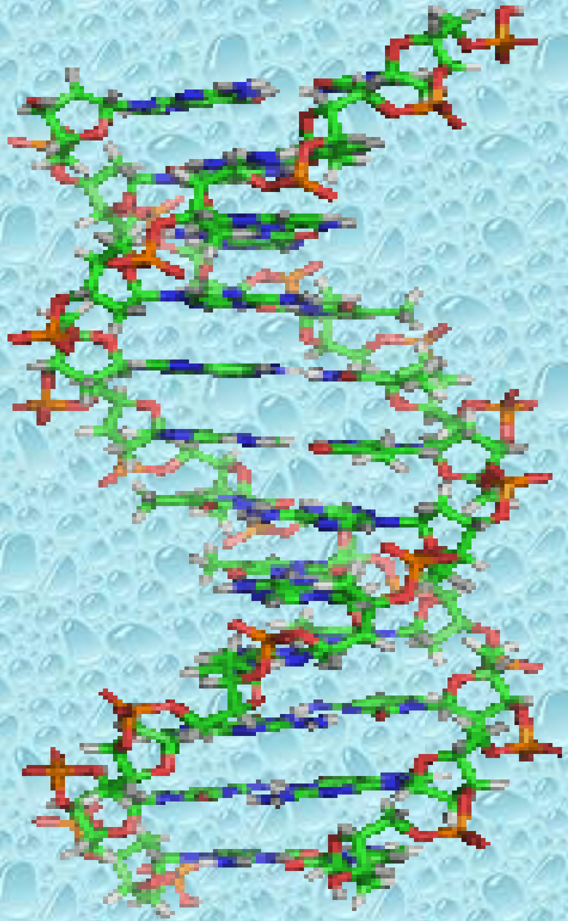
Two types of nucleic acid present in living organisms

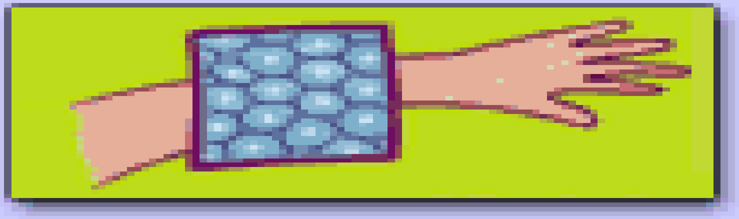
1. DNA-Deoxyribonucleic acid
2. RNA-Ribonucleic acid





DEOXYRIBONUCLEIC ACID

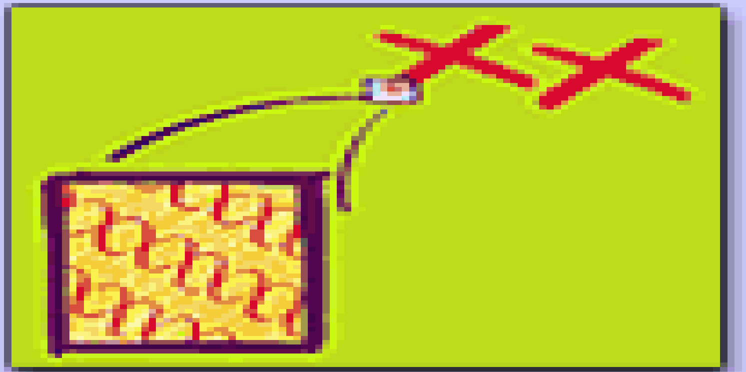




Every living thing is made of cells.

Most plant and animal cells have a nucleus. The nucleus tells the cell what to do.

Inside the nucleus are chromosomes.



Chromosomes are made of long strands of tightly coiled DNA. (If you stretched out the DNA from a human cell, it would be about six feet long!)

AMAZING DNA FACTS

- **DNA from a single human cell extends in a single thread for almost 2 meters long!!!**

- **It contains information equal to some 600,000 printed pages of 500 words each!!!**

  (a library of about 1,000 books)

DNA stands for:
D: Deoxyribose
N: Nucleic
A: Acid

DNA is <u>too small</u> to see, but under a microscope it looks like a twisted up ladder!

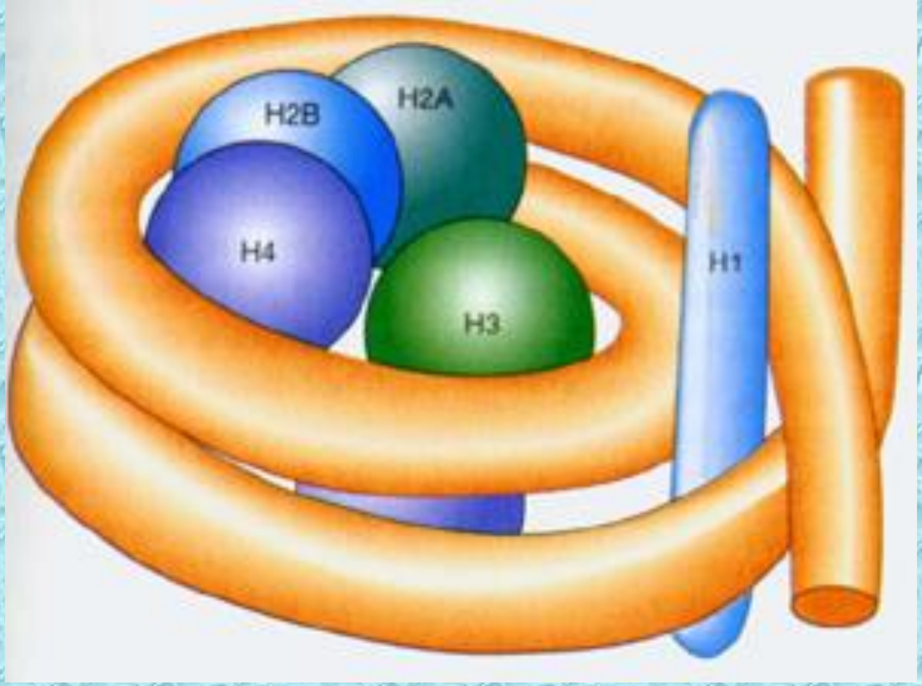
<u>**Every**</u> living thing has <u>**DNA**</u>. That means that you have something in common with a zebra, a tree, a mushroom and a beetle!!!!

DEOXYRIBONUCLEIC ACID

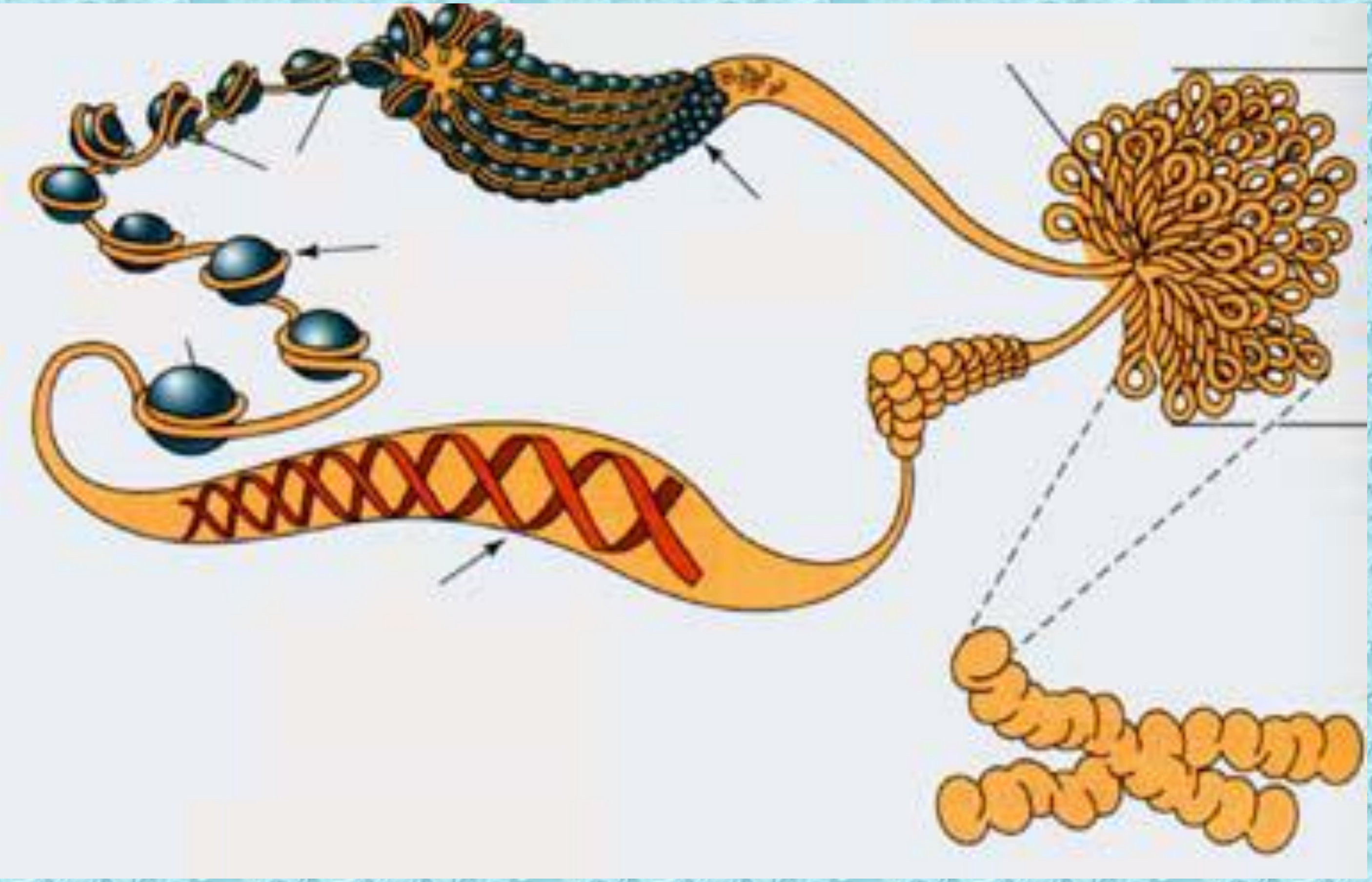
- DNA is the molecular basis of inheritance
- DNA is a polymer of deoxyribonucleotides.
- It is found in chromosomes, mitochondria and chloroplast.
- The nuclear DNA is bounded to basic proteins called histone.
- DNA is present in every nucleated cell and carries genetic information.

DNA is Coiled Around Histone Proteins

- DNA is wrapped around nuclear proteins called Histones
- This forms a complex called a Nucleosome
- Histones are H1, H2A, H2B, H3, H4



DNA is Further Packaged



CHEMICAL STRUCTURE

DNA consist of three components

- **1.Nitrogenous base**

  a. purine

  b. pyrimadine

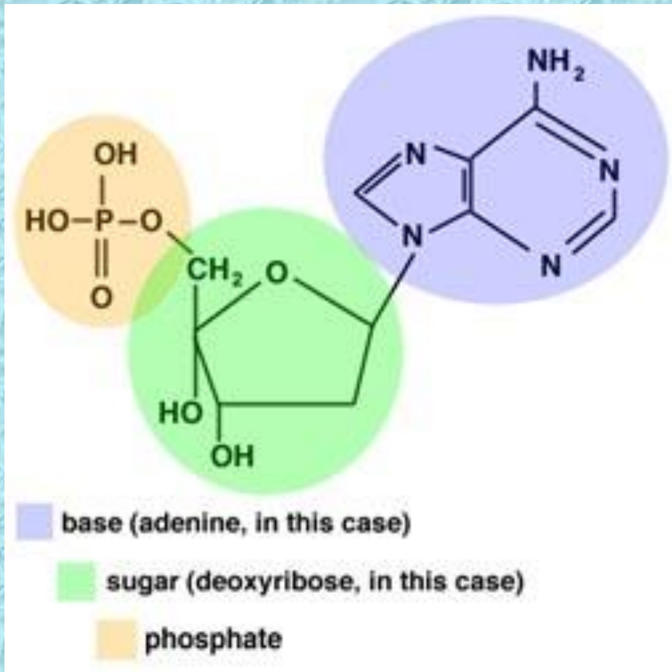
  DNA = adenine , cytosine , guanine , thymine.

- **2.Pentose sugar**

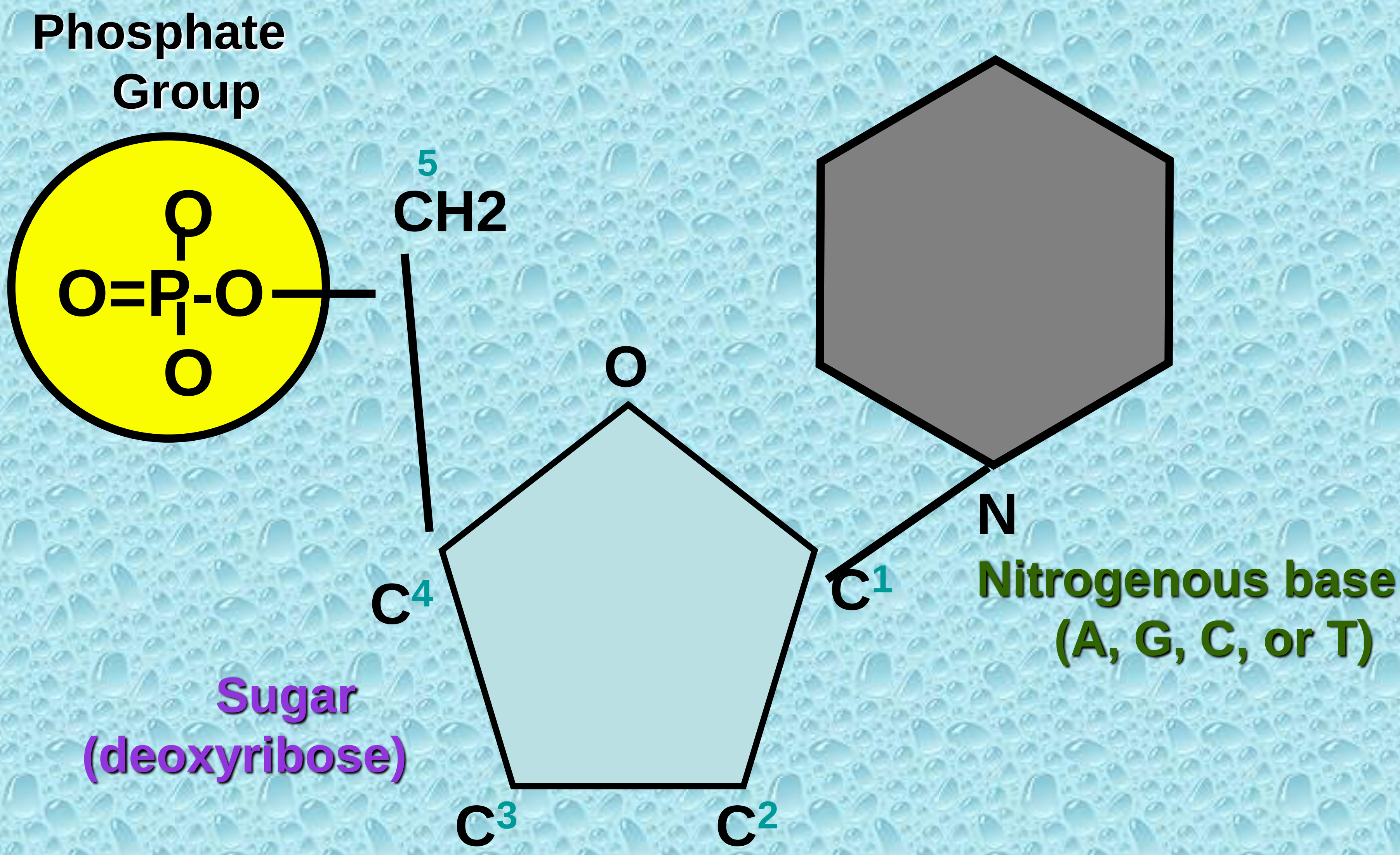
  .D-2-deoxyribose

- **3. Phosphate group**

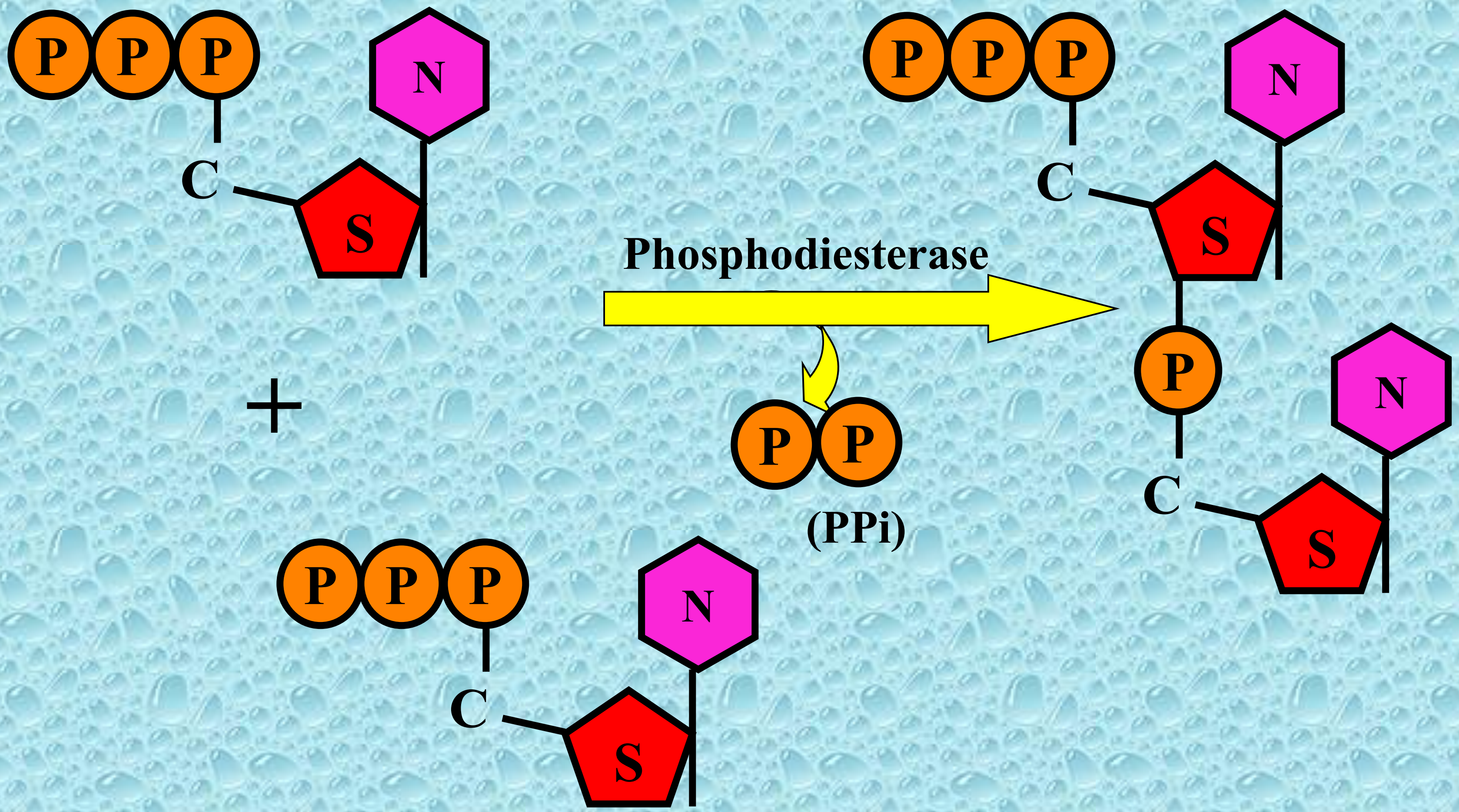
- **DNA is made up of repeating molecules called <u>NUCLEOTIDES</u>**



DNA Nucleotide

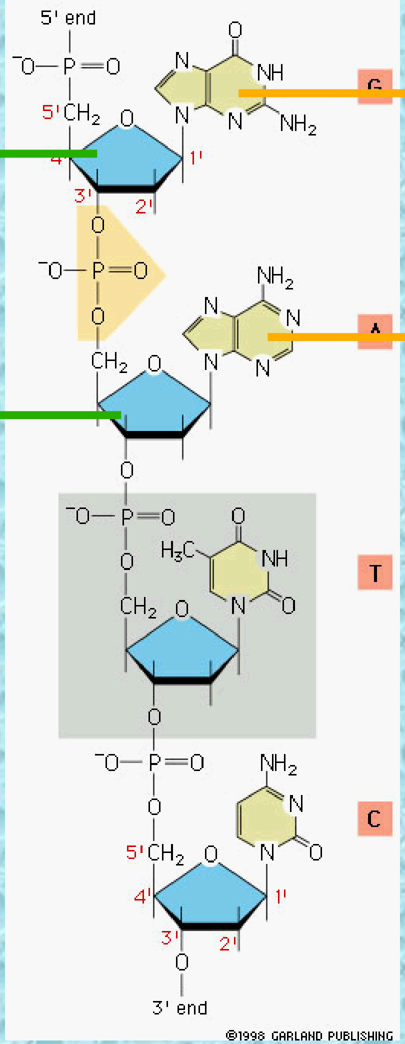


Nucleic Acid Structure
Polymerization



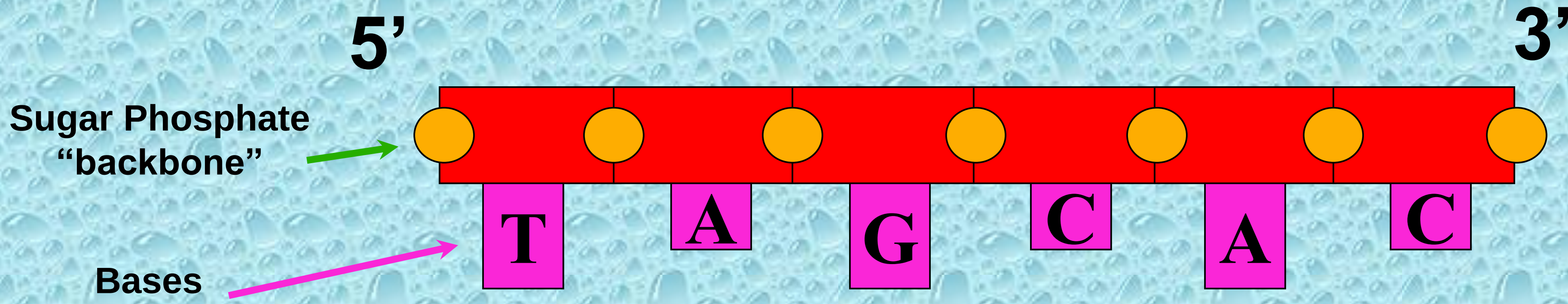
Nucleic Acid Structure
Polymerization

Sugar Phosphate
“backbone”



Nucleotide

Nucleic Acid Structure
Polymerization



5' 3'

TAG-CAC

Watson & Crick proposed…

- **DNA had specific pairing between the nitrogen bases:**

ADENINE – THYMINE

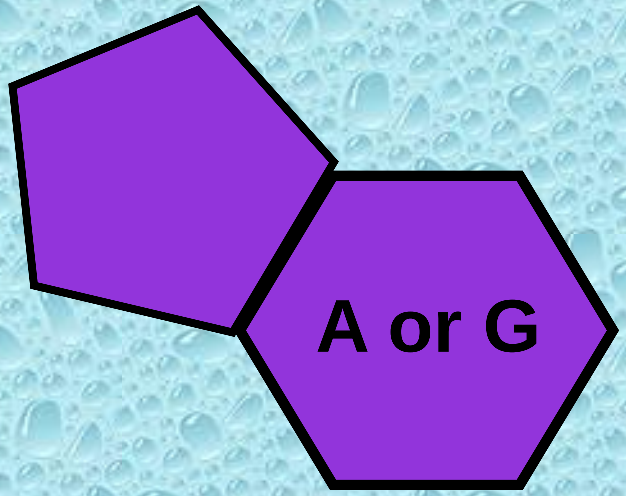
CYTOSINE - GUANINE

- **DNA was made of 2 long stands of nucleotides arranged in a specific way called the "Complementary Rule"**

Nitrogenous Bases

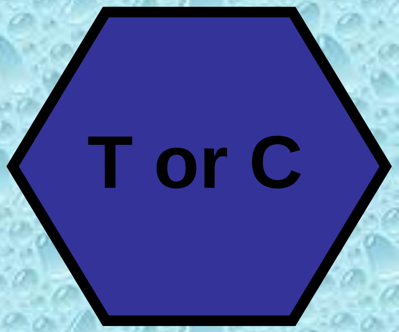
- **PURINES**

1. **Adenine (A)**
2. **Guanine (G)**



- **PYRIMIDINES**

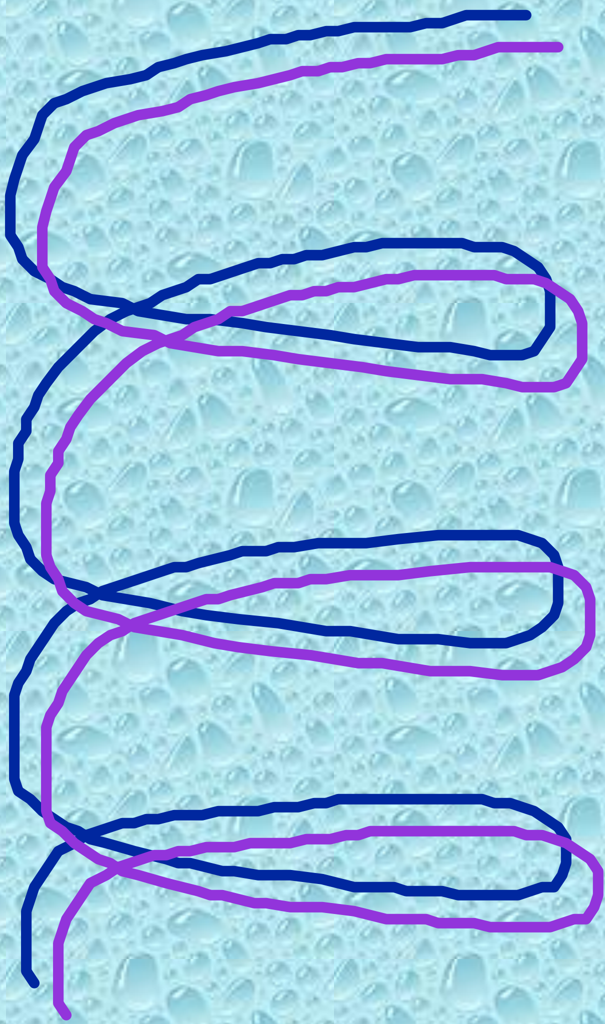
3. **Thymine (T)**
4. **Cytosine (C)**

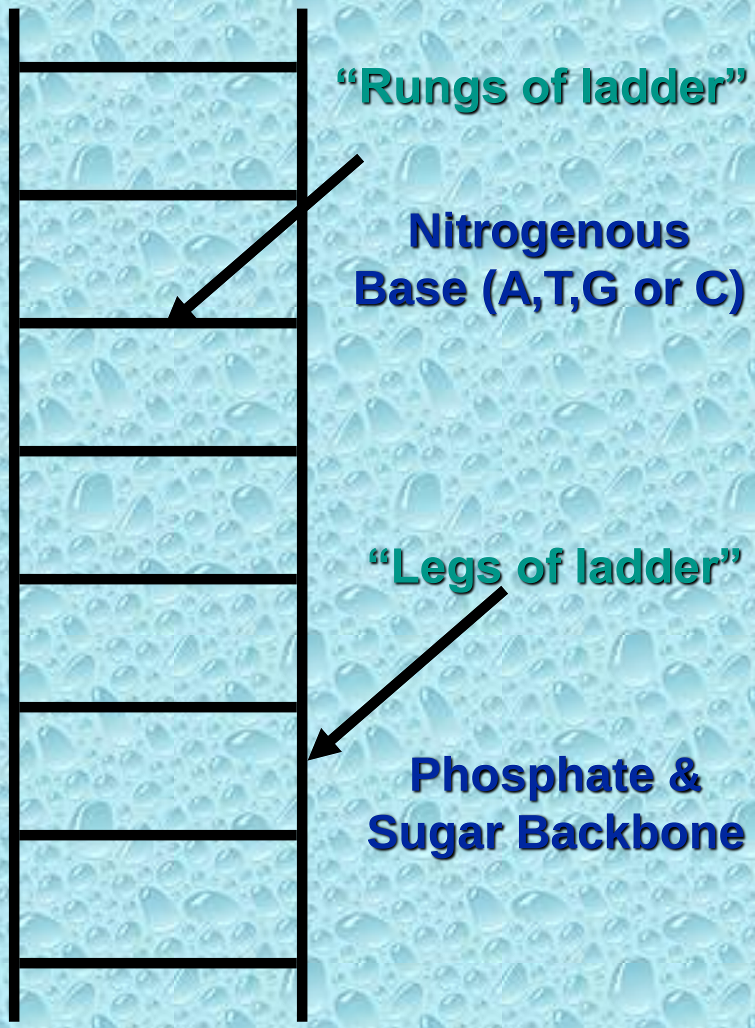


In fact, the DNA usually consists of a double strand of nucleotides

The sugar-phosphate chains are on the outside and the strands are held together by chemical Bonds(Hydrogen bonds) between the bases

DNA Double Helix

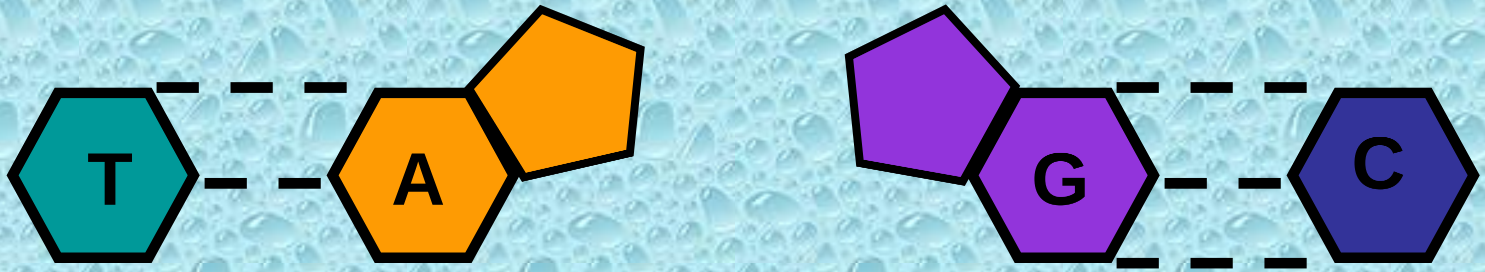




Chargaff's Rule(1940)

The molar equivalence b/w the purines and pyrimidines bases of DNA

- **Adenine** must pair with **Thymine**
- **Guanine** must pair with **Cytosine**
- Their amounts in a given DNA molecule will be **the same**.

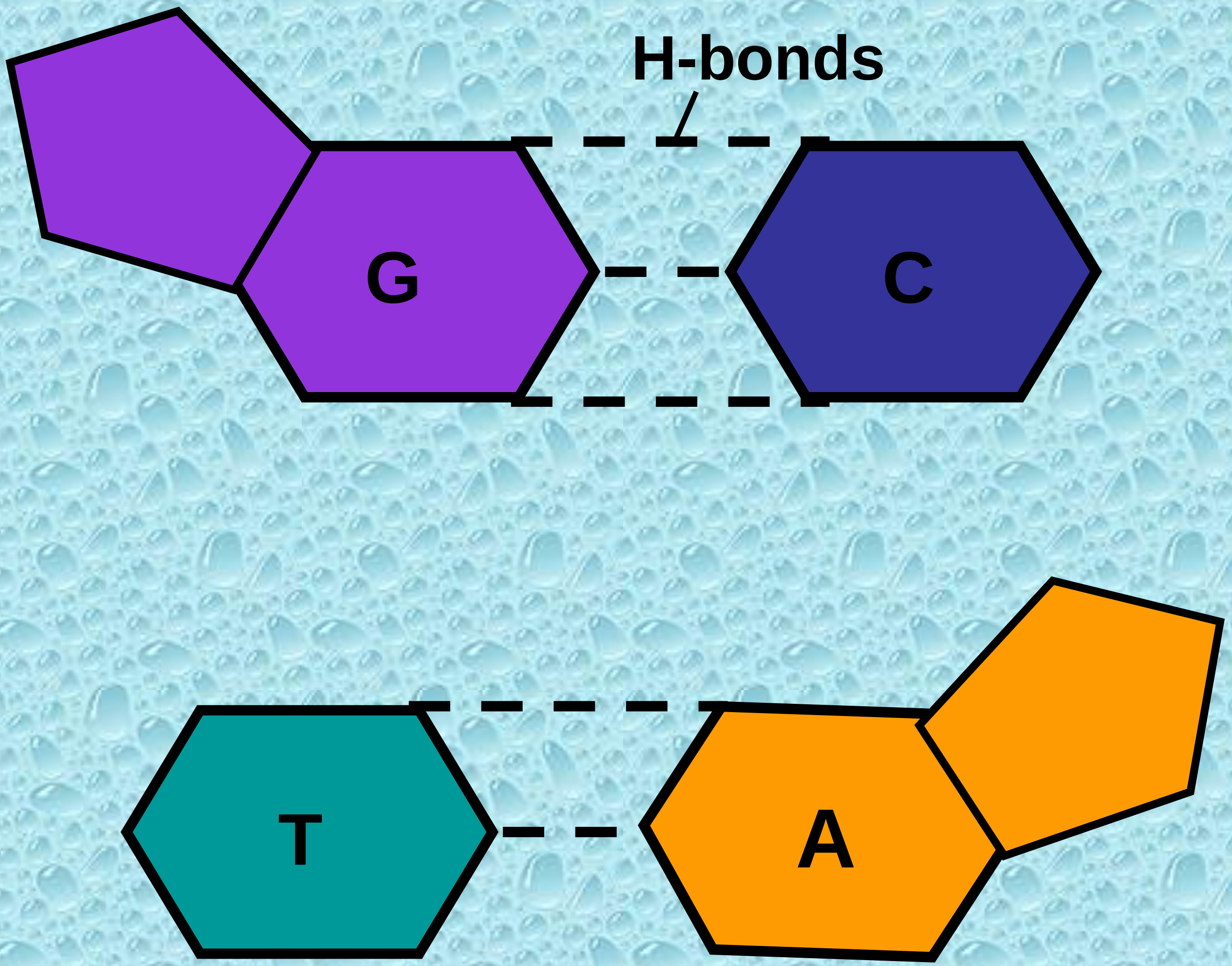


CHARGAFF'S RULE

- The purines to pyrimidines ratio in DNA =1

  i.e. A+G = T+C or A+G /T+C=1
- In DNA molecule, the glycosidic bonds between sugar and bases are not directly opposite each other hence two grooves of unequal width are formed around the double helix. The edge of the helix >180 degree ,it is called the major groove and when it is <180 degree ,it is called minor groove.

BASE-PAIRINGS



DNA double Helix

1. Rt handed in B-DNA and A-DNA and Lt handed in Z –DNA.
2. Consists of two polydeoxynucleotide strands twisted around each other on a common axis.
3. Two axis are antiparallel i.e one runs in 3, to 5 , and other 5 , to 3, direction.
4. diameter of helix is 20 A^o .
5. Each turn (pitch) is 34 A^o

6. hydrophilic backbone of deoxyribose phosphate towards periphery of molecule and hydrophobic bases are inside.

7. Two strands are not identical but complementary to each other due to base pairing.

8. Two strands held togather by H-bonds.

$A = T$ and $C \equiv G$.

9. The complementary base pairing proves Chargaff's rule.

10. The double helix has wide major and narrow minor grove.

11. The genetic information on template or sense strand and the other as antisense.

Genetic code

The sequence of bases in DNA forms the **Genetic Code**

A group of three bases (**a triplet**) controls the production of a particular amino acid in the cytoplasm of the cell

The different amino acids and the order in which they are joined up determines the sort of protein being produced

The proteins build the cell structures.

They also make enzymes.

The DNA controls which enzymes are made and the enzymes determine what reactions take place.

The structures and reactions in the cell determine what sort of a cell it is and what its function is

So DNA exerts its control through the enzymes

STRUCTURE OF DNA

PRIMARY STRUCTURE

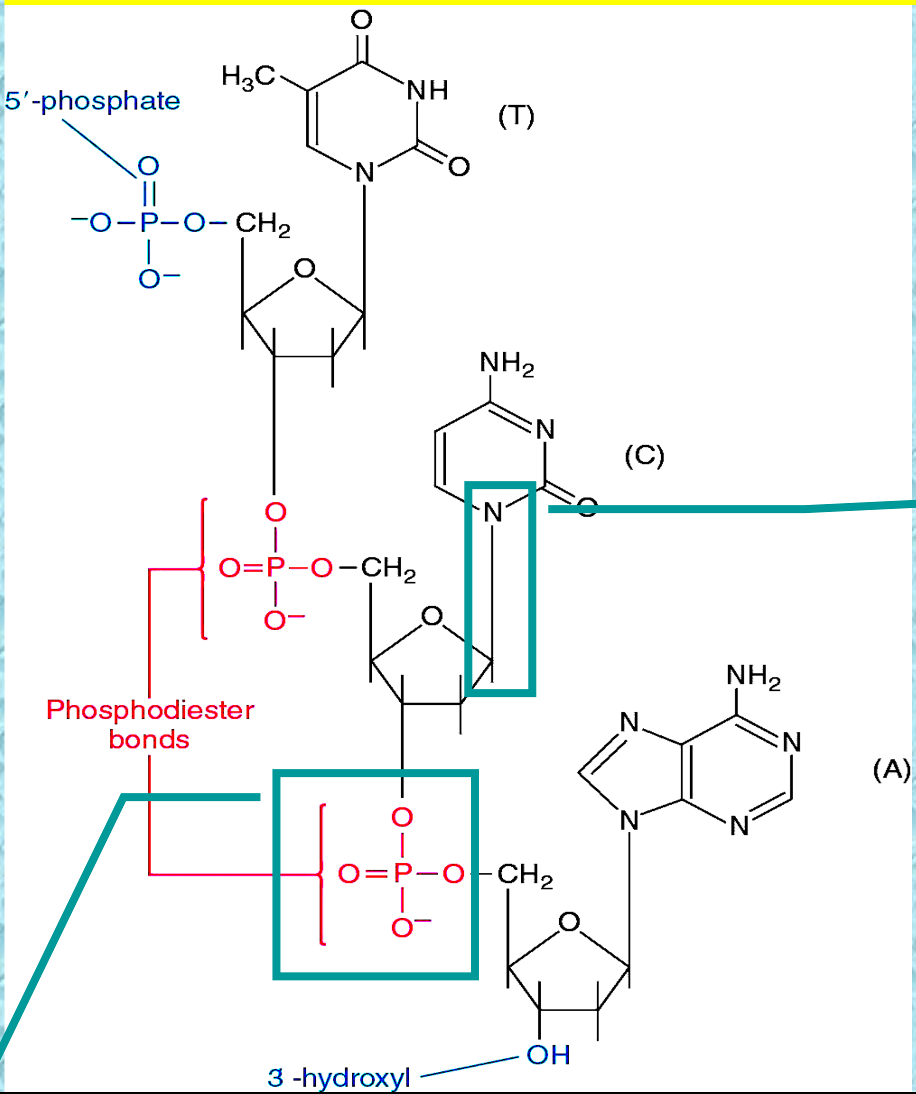
- Chromosomal DNA consists of a very long DNA molecules (M wt 1.6x 10^{6} to 2 x10^{10})
- Each DNA molecule is a polymer of about 10^{1o} deoxyribonucleotides.
- DNA has following 4different forms of deoxyribonucleotides.

MONOMERIC UNITS OF DNA

a. Adenine deoxyribonucleotides[dA]
b. Thymine deoxyribonucleotides[dT]
c. Guanine deoxyribonucleotides[dG]
d. Cytocine deoxyribonucleotides[dC]

- Each nucleotide is linked to the neighbouring nucleotide through 3`,5`-phosphodiester bond.
- The DNA stand that bears a free 5`-phosphate group without phosphodiester linkage is called 5`-end ,the opposite end bears a free 3` -OH or 3`- phosphate group is called the 3` -end.
- The primary structure of DNA is the number and sequence of different deoxyribo-nucleotides in its strands joined together by phosphodiester linkage.

5' – 3' polynucleotide *linkages*



2) N-glycosidic bonds

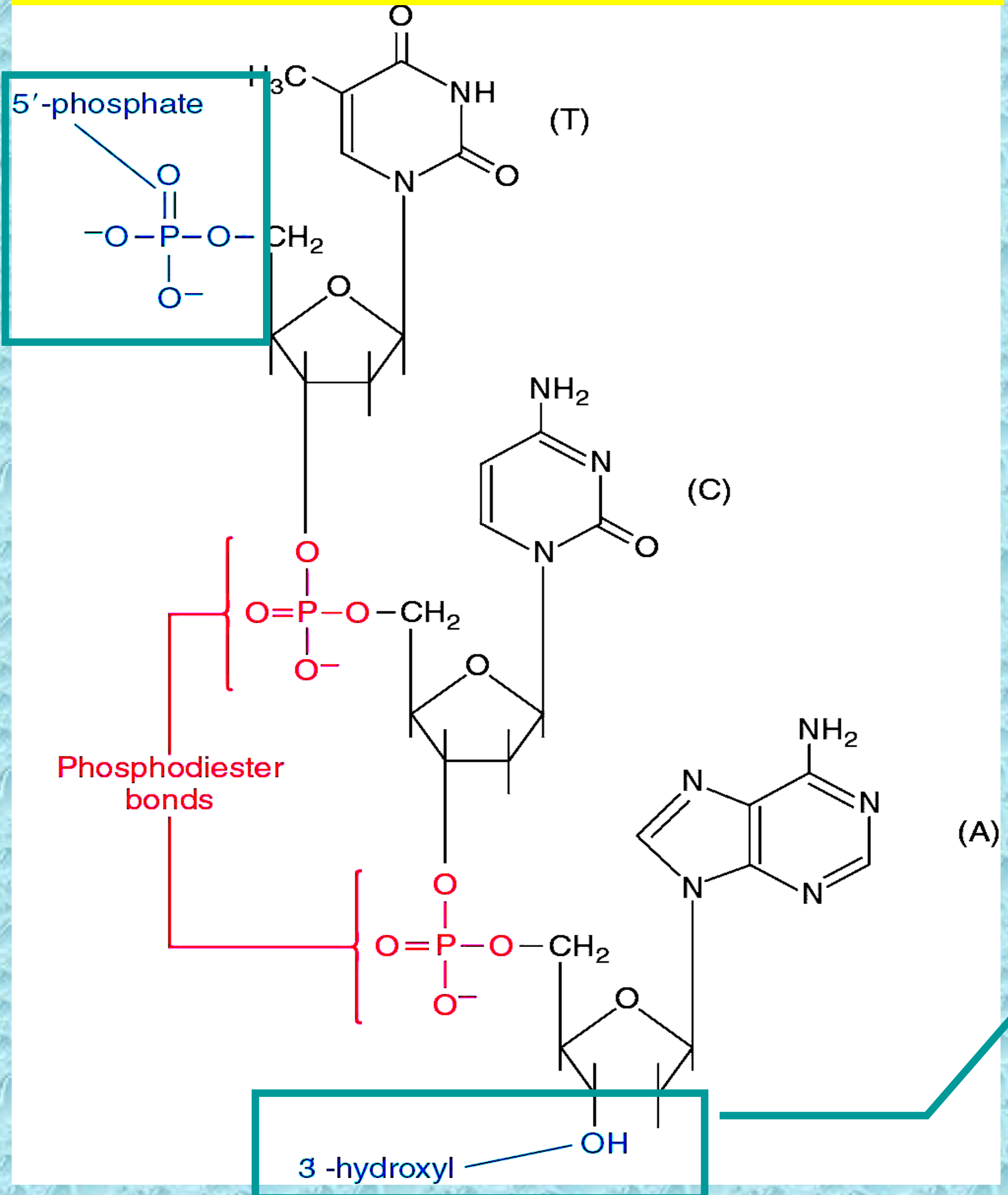
Links nitrogenous base to C1' pentose in beta configuration

1) Phospho<u>di</u>ester bonds

5' and 3' links to pentose sugar

5' – 3' polarity

5' end

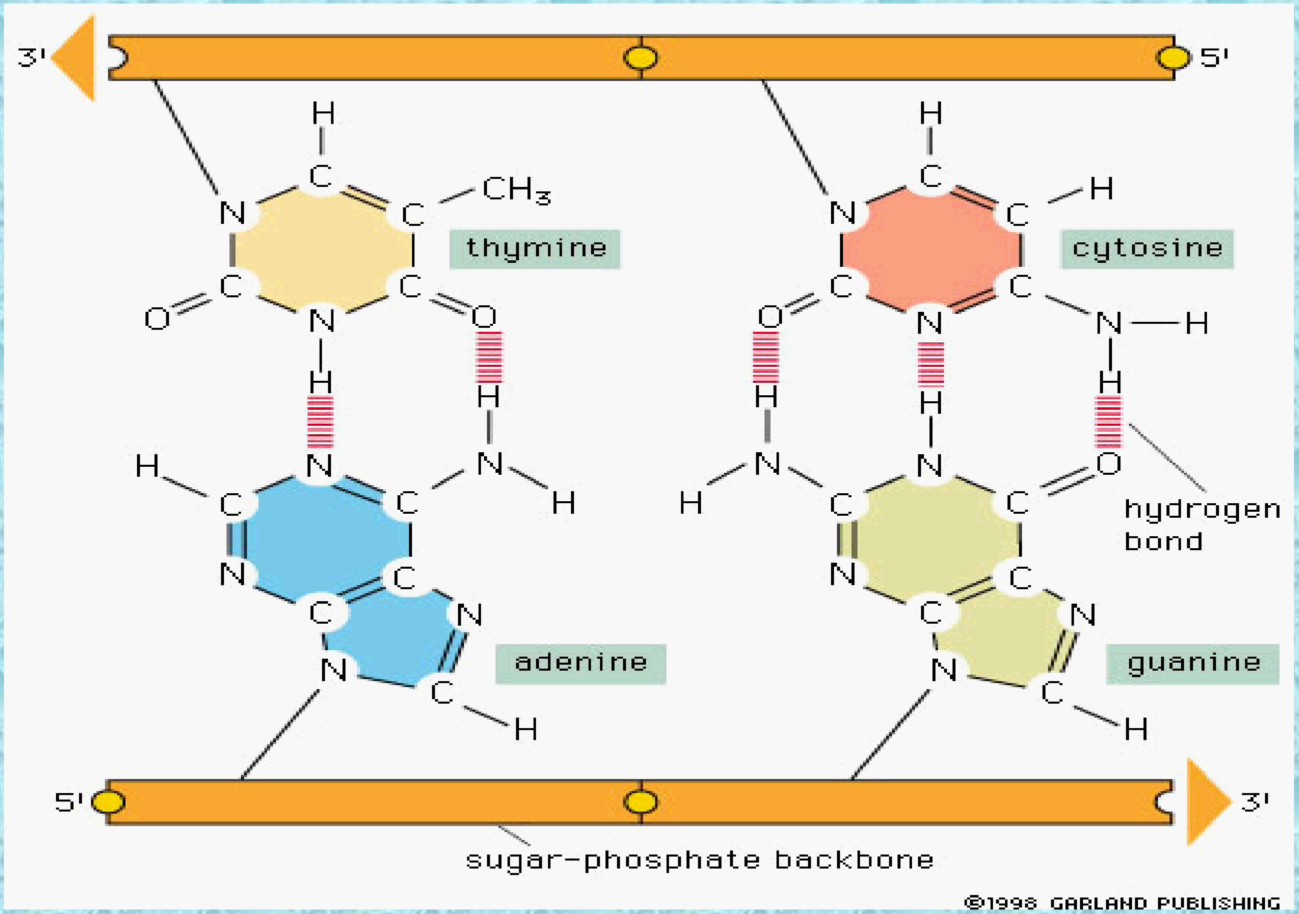


3' end

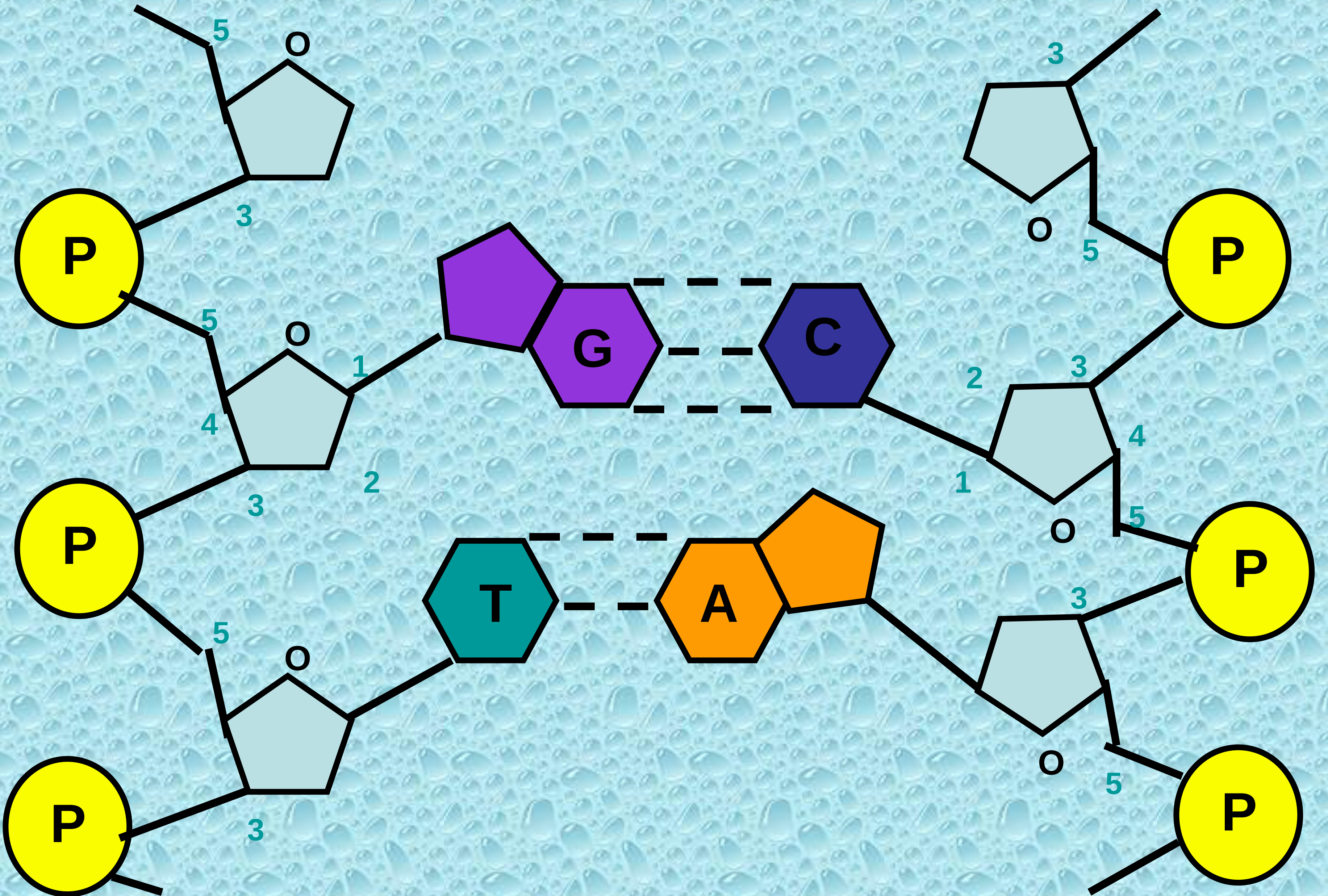
SECONDRY STRUCTURE

- It is double stranded helix formed by the two polydeoxyribonucleotides strands coiled around a central axis.
- The helix is right/left handed.
- The strands are antiparallel to each others.
- Sugar + phosphate = back bone of helix. (hydrophilic).
- The aromatic hydrophobic rings of bases, located in the interior of the helix are perpendicular to the long axis of the helix.
- Adenine of one DNA strand bound to Thymine of other DNA strand by double H=H bound.
- Guanine of one DNA strand bound to Cytosine of other DNA strand by triple H $\equiv$ H bound.

Nucleic Acid Structure
“Base Pairing”

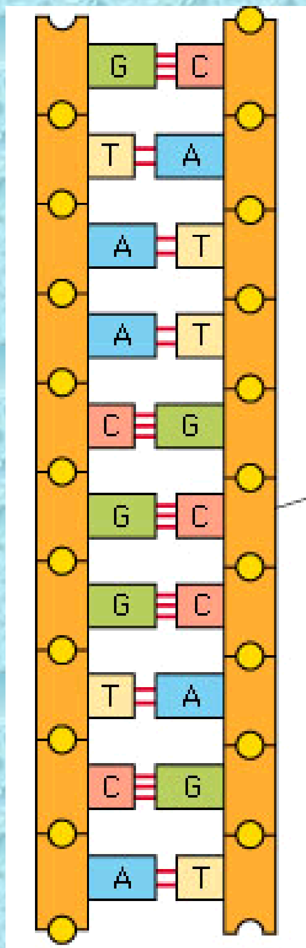


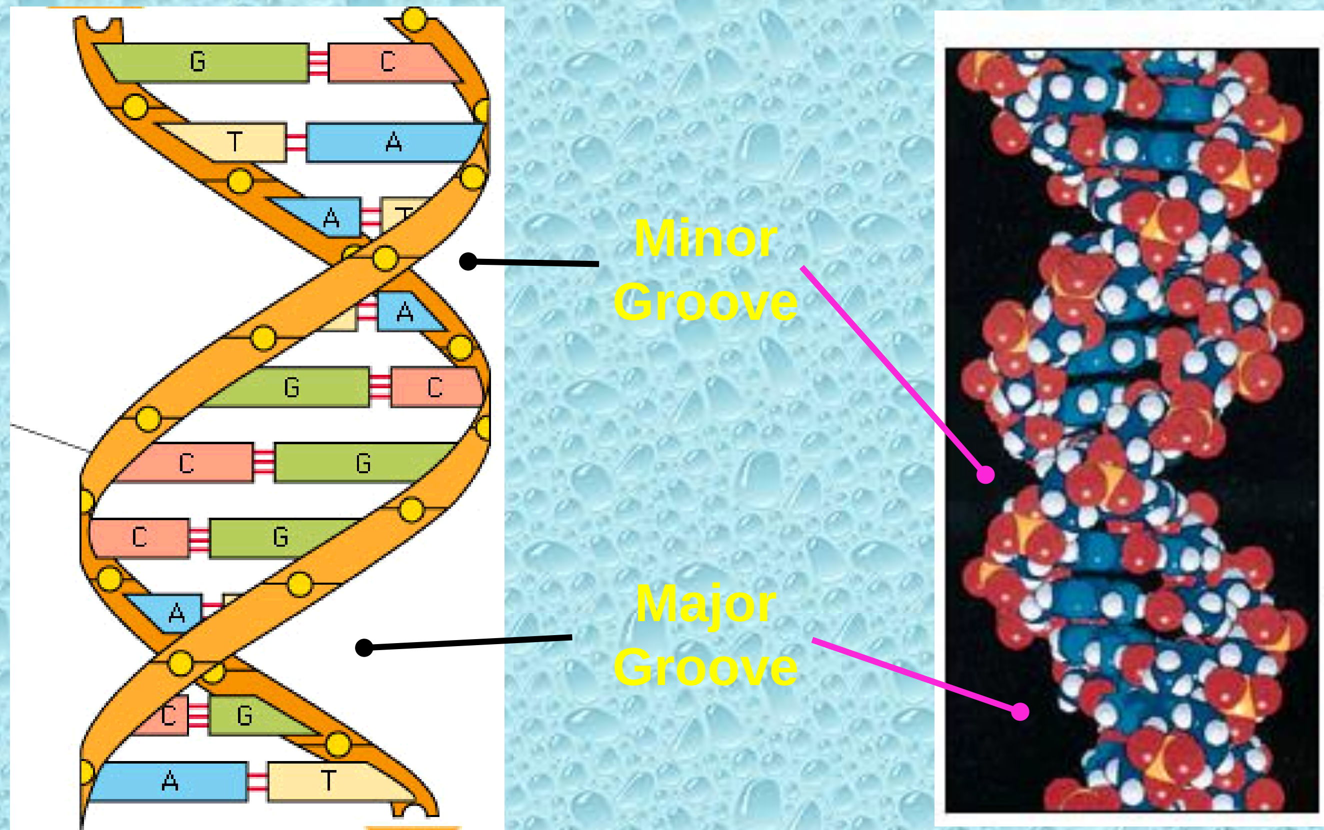
DNA Double Helix

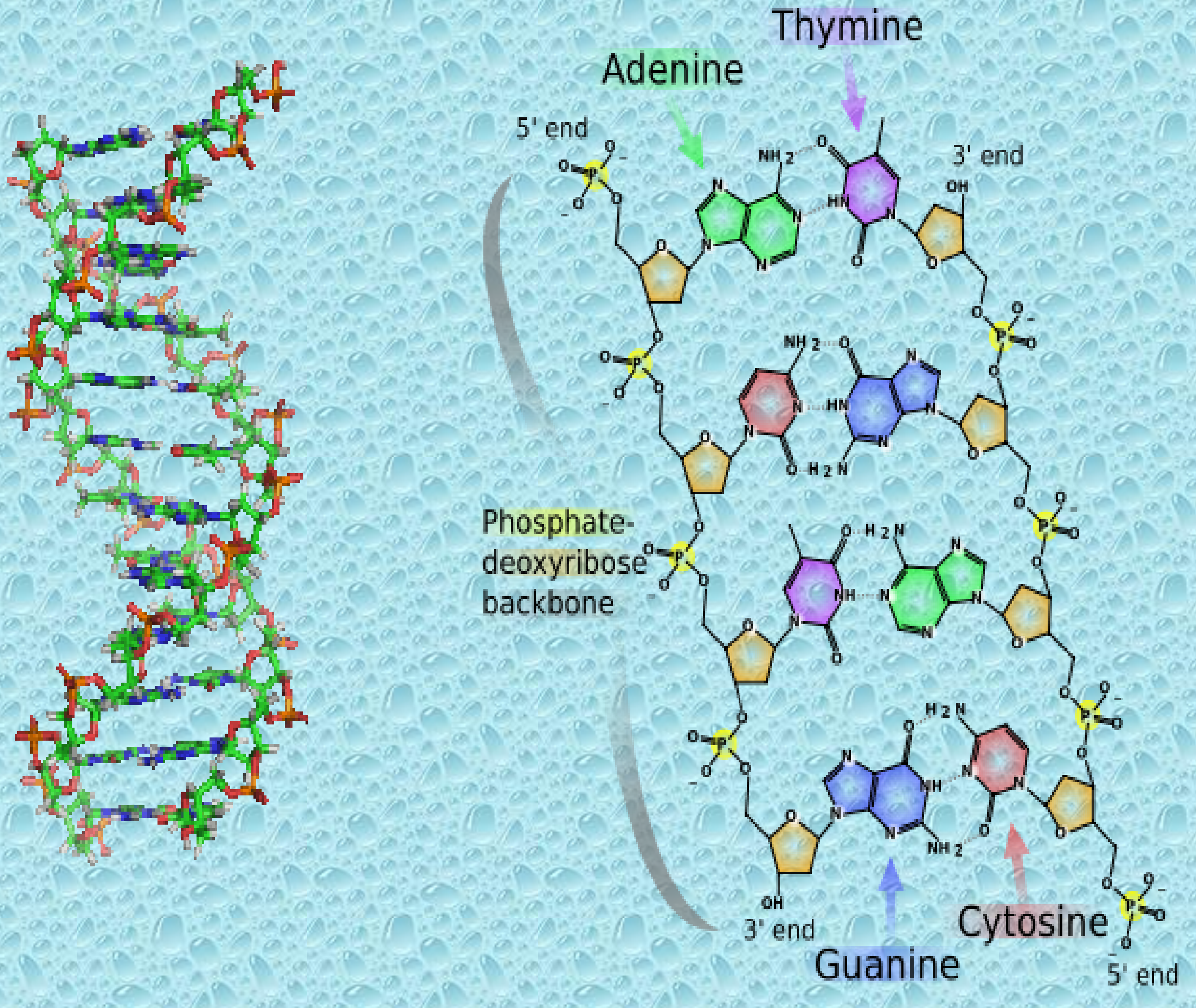


Nucleic Acid Structure

The double helix

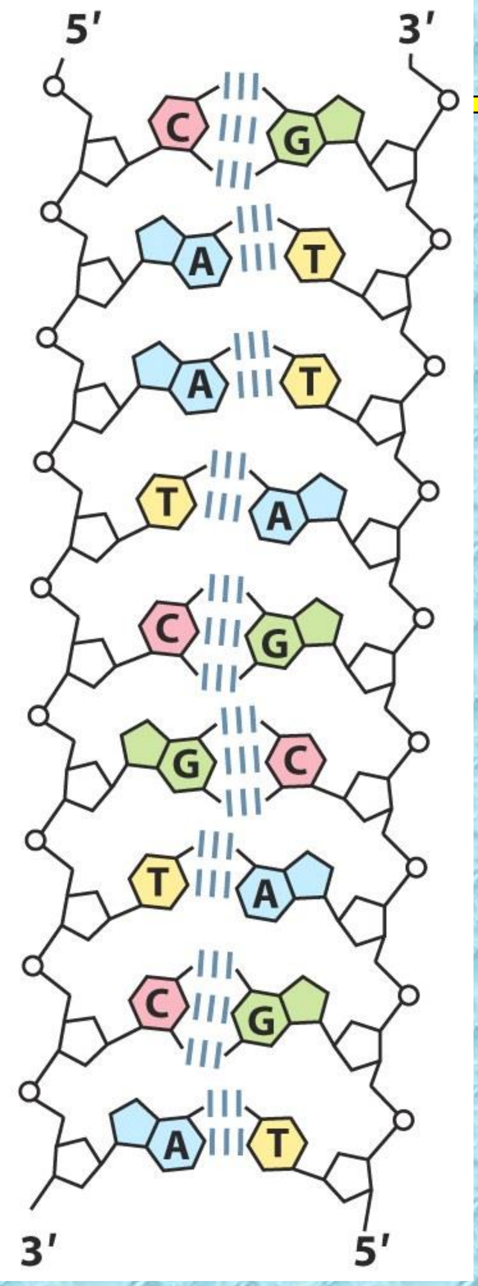


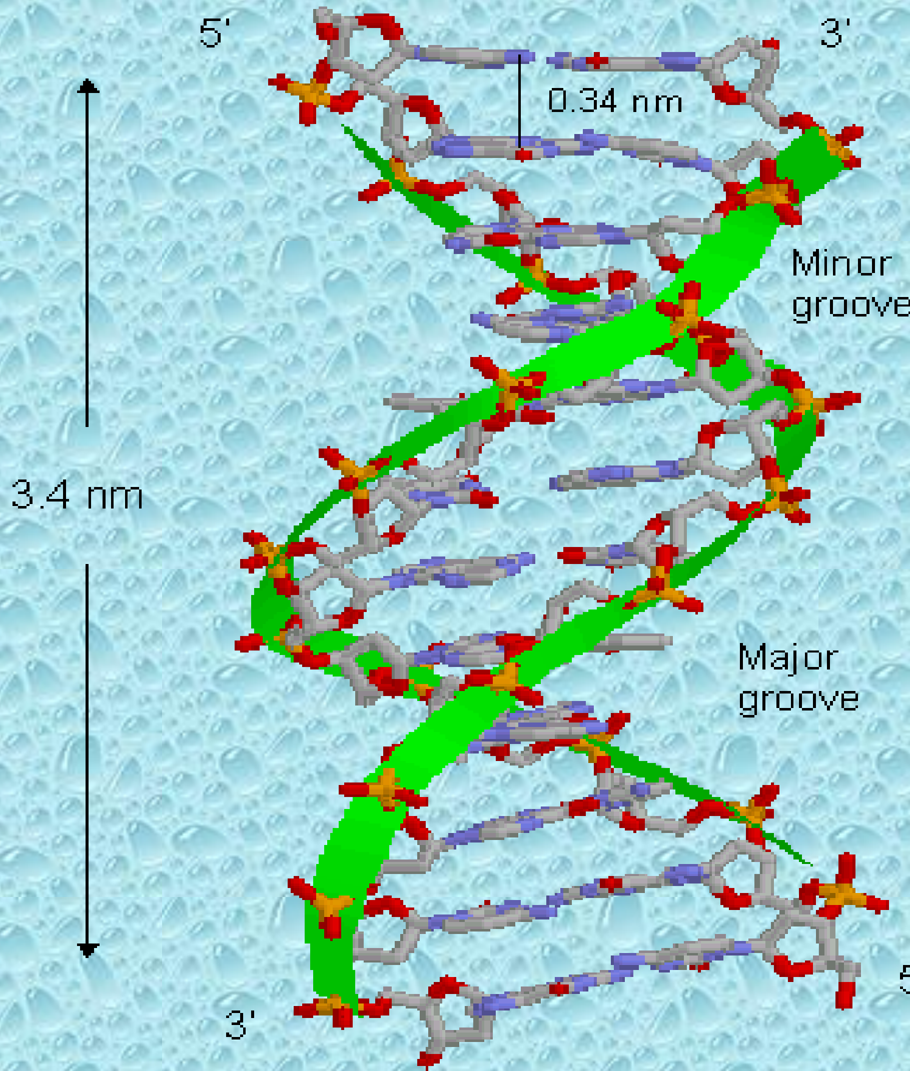



Thymine
Adenine
5' end
3' end
Phosphate-
deoxyribose
backbone
3' end
Guanine
Cytosine
5' end

DNA strands

- The antiparallel strands of DNA are not identical, but are complementary.
- This means that they are positioned to align complementary base pairs: C with G, and A with T.
- So you can predict the sequence of one strand given the sequence of its complement.
- Useful for information storage *and* transfer!



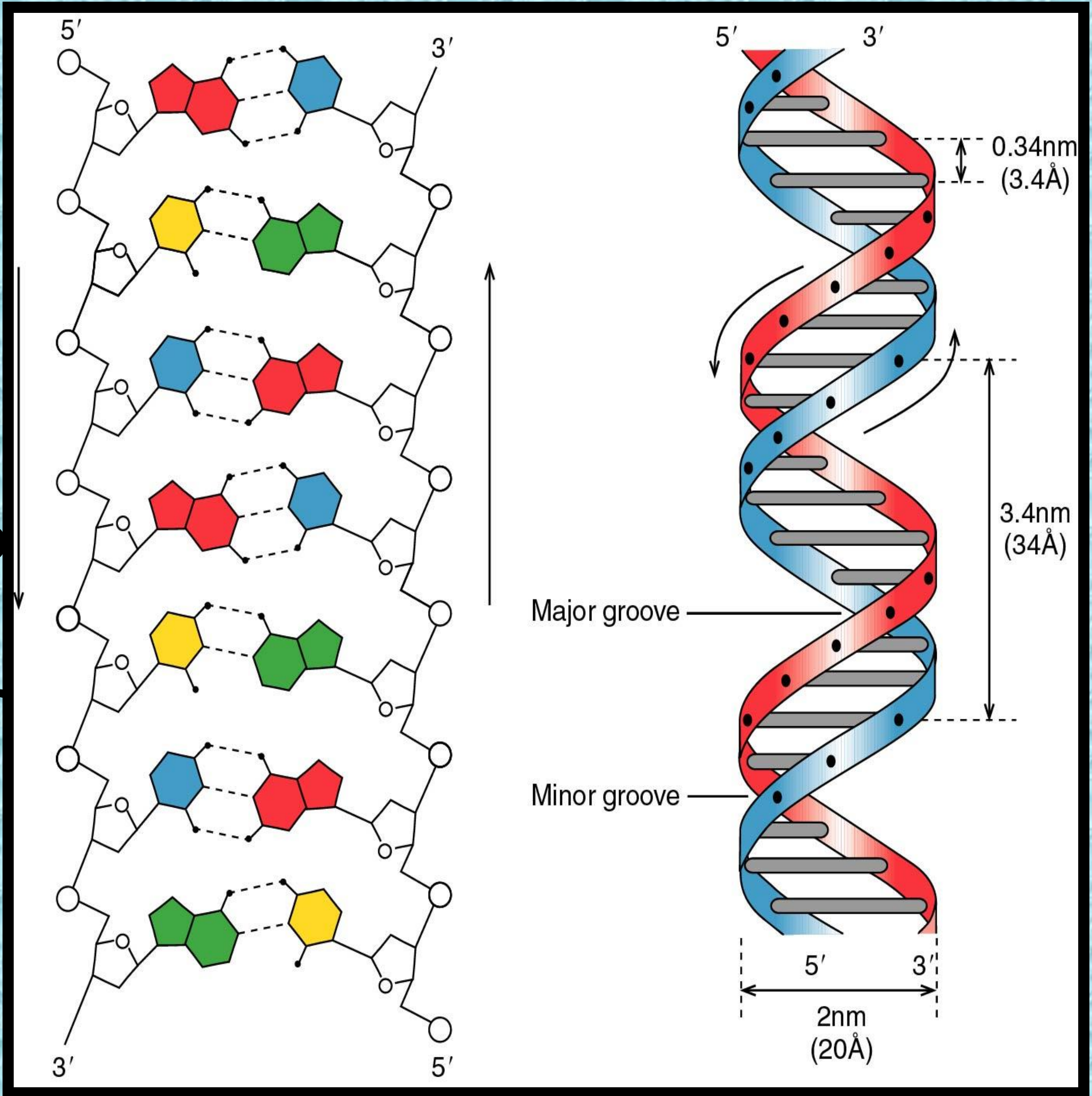

5'
3'
0.34 nm
3.4 nm
Minor
groove
Major
groove
3'
5'

FORMs OF DNA

- DNA exist in several conformations depending upon the bases , composition , chemical and physiological conditions and structure. The double helical structure of DNA exists in at least 6 different forms A-E and Z, among those following are important
- 1. B- DNA.
- 2. A- DNA.
- 3. Z- DNA

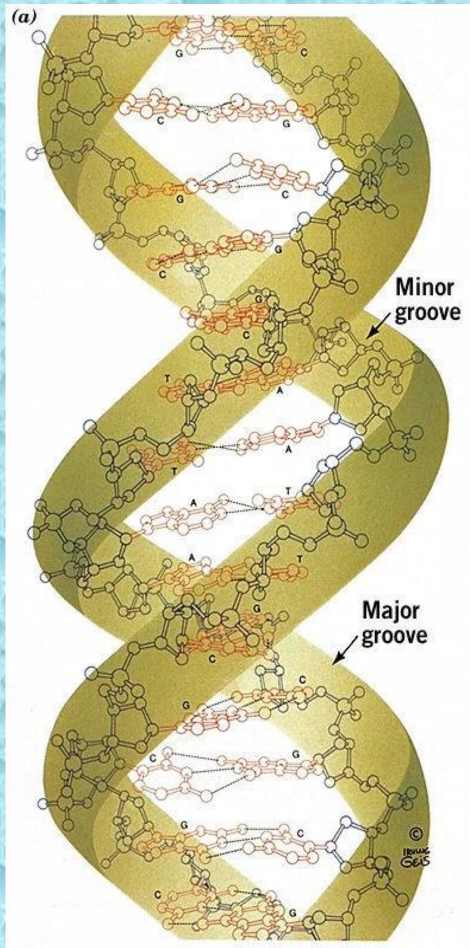
Essential features of B-DNA

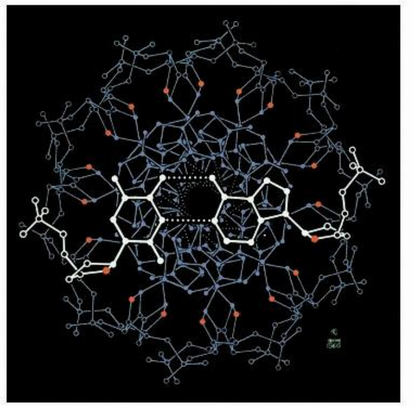
- Right twisting
- Double stranded helix
- Anti-parallel
- Bases on the inside (Perpendicular to axis)
- Uniform diameter (~20A)
- Major and minor groove
- Complementary base pairing



B-DNA

- Right-handed helix
- intermediate
- planes of the base pairs nearly perpendicular to the helix axis
- tiny central axis
- wide + deep major groove
- narrow + deep minor groove





GEOMETRY OF B-DNA

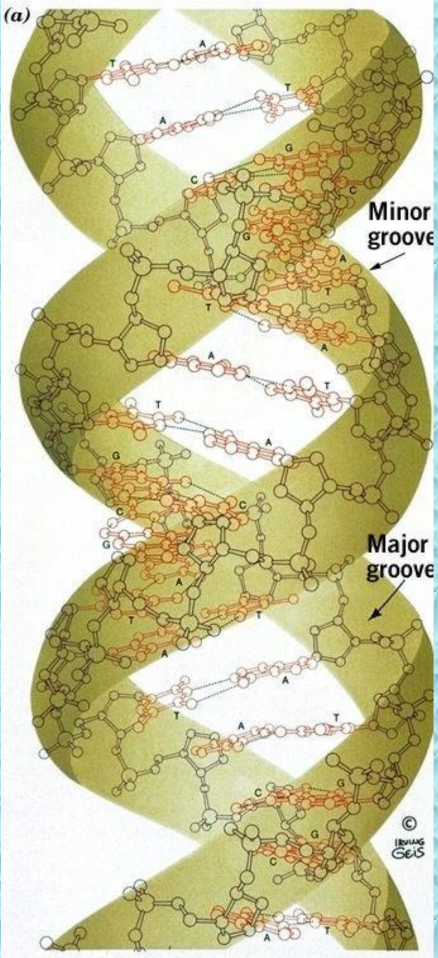
- B-DNA IS BIOLOGICALLY THE MOST COMMON
- BASE THICKNESS
  - AROMATIC RINGS WITH 3.4 A THICKNESS
  - IDEAL B-DNA HAS 10 BASE PAIRS PER TURN

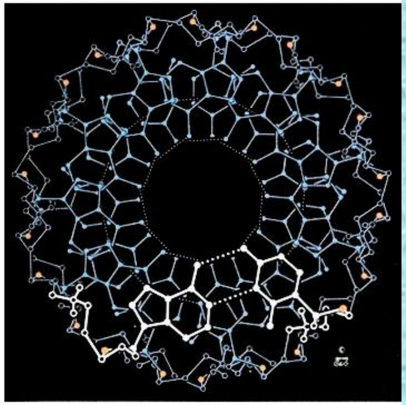
- MINOR GROOVE IS NARROW
- MAJOR GROOVE IS WIDE

DNA conformations

A- DNA

- Right-handed helix
- Widest
- planes of the base pairs inclined to the helix axis
- 6A hole along helix axis
- narrow + deep major groove
- Wide + shallow minor groove
- 11.6 BP PER TURN

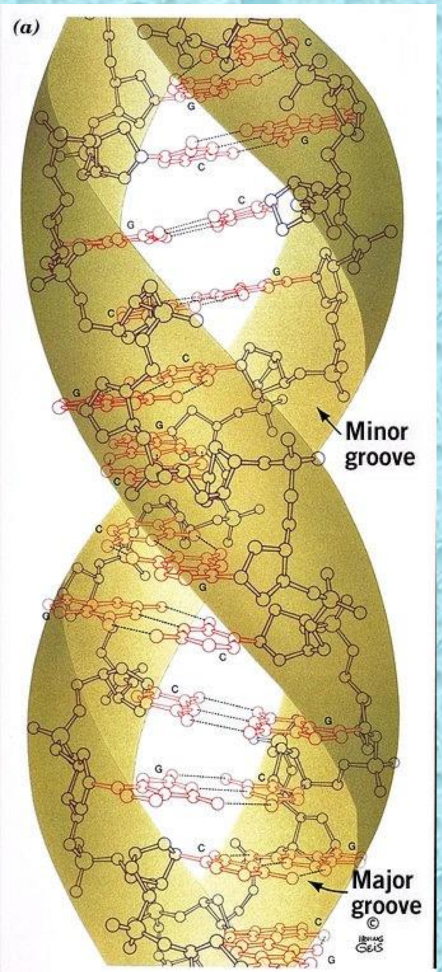


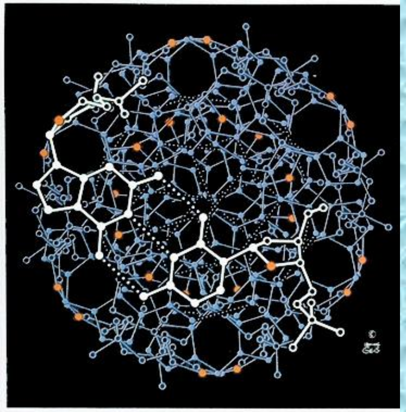


DNA conformations

Z-DNA

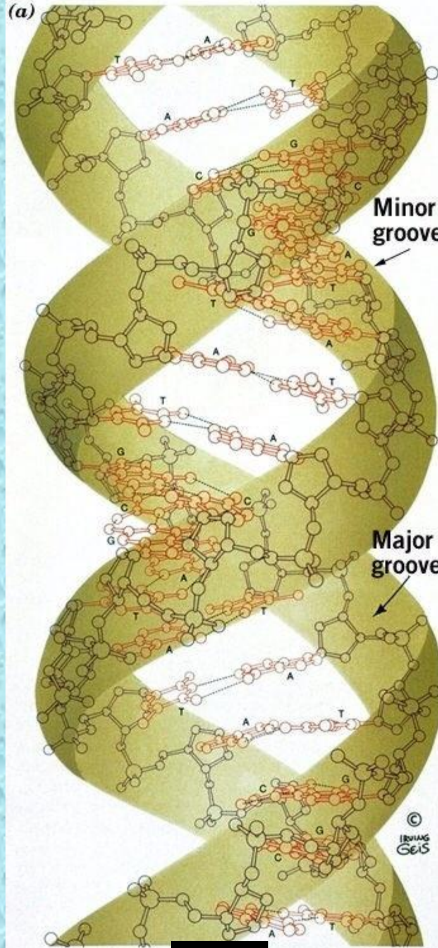
- Left-handed helix
- Narrowest
- planes of the base pairs nearly perpendicular to the helix axis
- no internal spaces
- no major groove
- narrow + deep minor groove



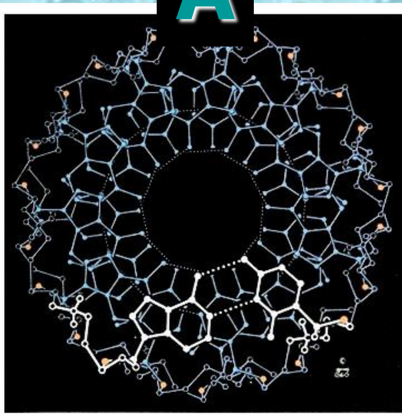


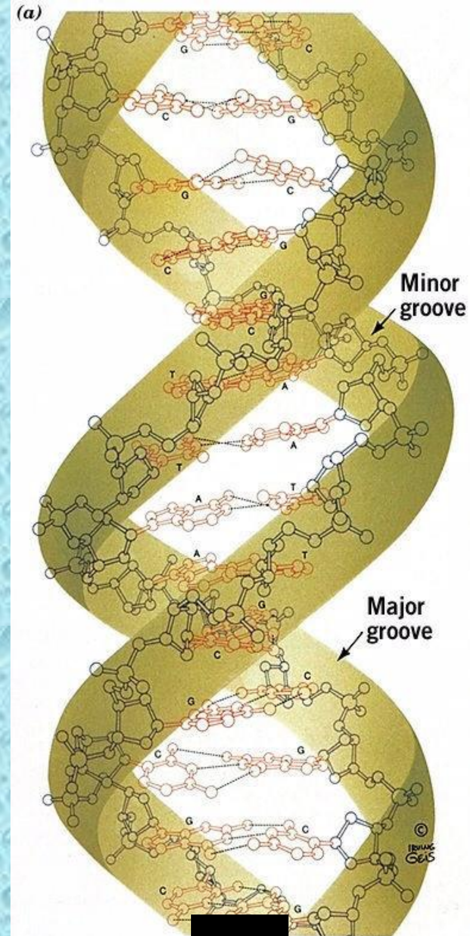
DNA conformations

	A- DNA	B-DNA	Z-DNA
Helix	Right-handed	Right-handed	Left-handed
Width	Widest	Intermediate	Narrowest
Planes of bases	planes of the base pairs inclined to the helix axis	planes of the base pairs nearly perpendicular to the helix axis	planes of the base pairs nearly perpendicular to the helix axis
Central axis	6A hole along helix axis	tiny central axis	no internal spaces
Major groove	Narrow and deep	Wide and deep	No major groove
Minor groove	Wide and shallow	Narrow and deep	Narrow and deep

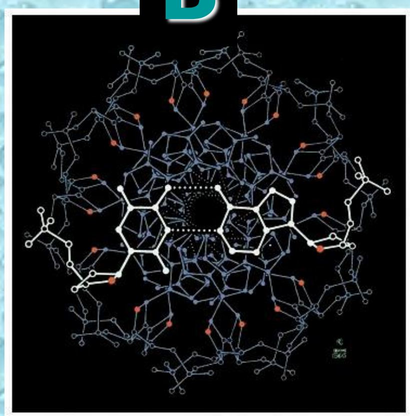

(a)
Minor groove
Major groove
©

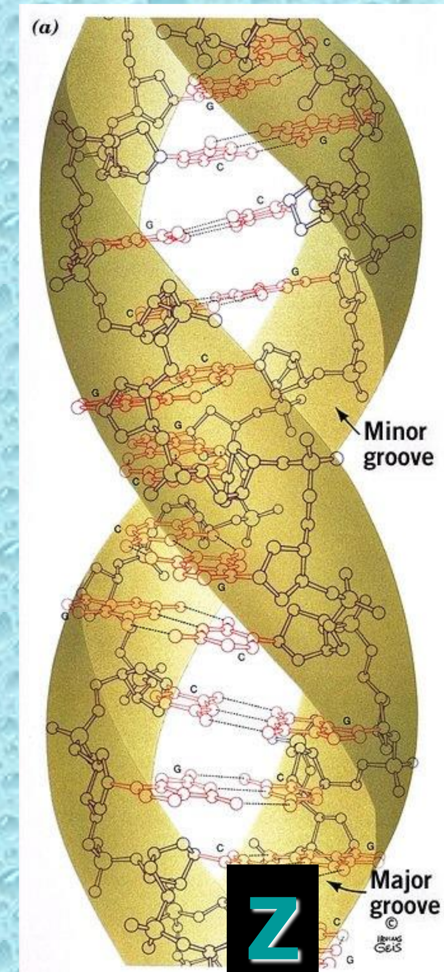
A



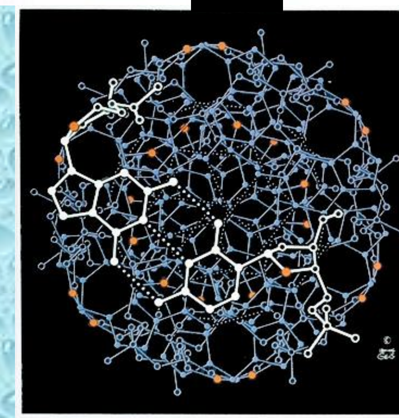

(a)
Minor groove
Major groove
©

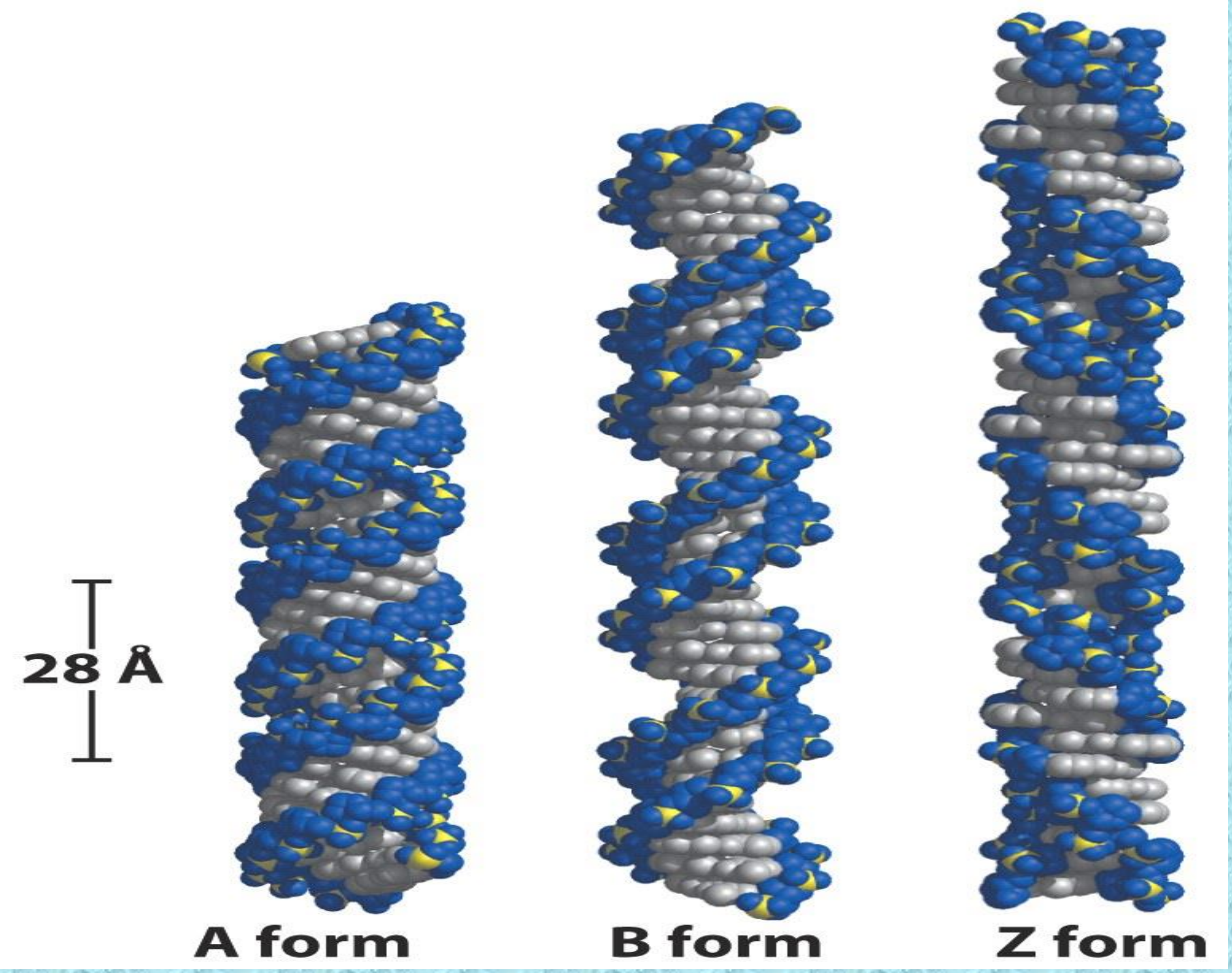
B




(a)
Minor groove
Major groove
©

Z





28 Å
A form
B form
Z form

You can tell people apart by their fingerprints…

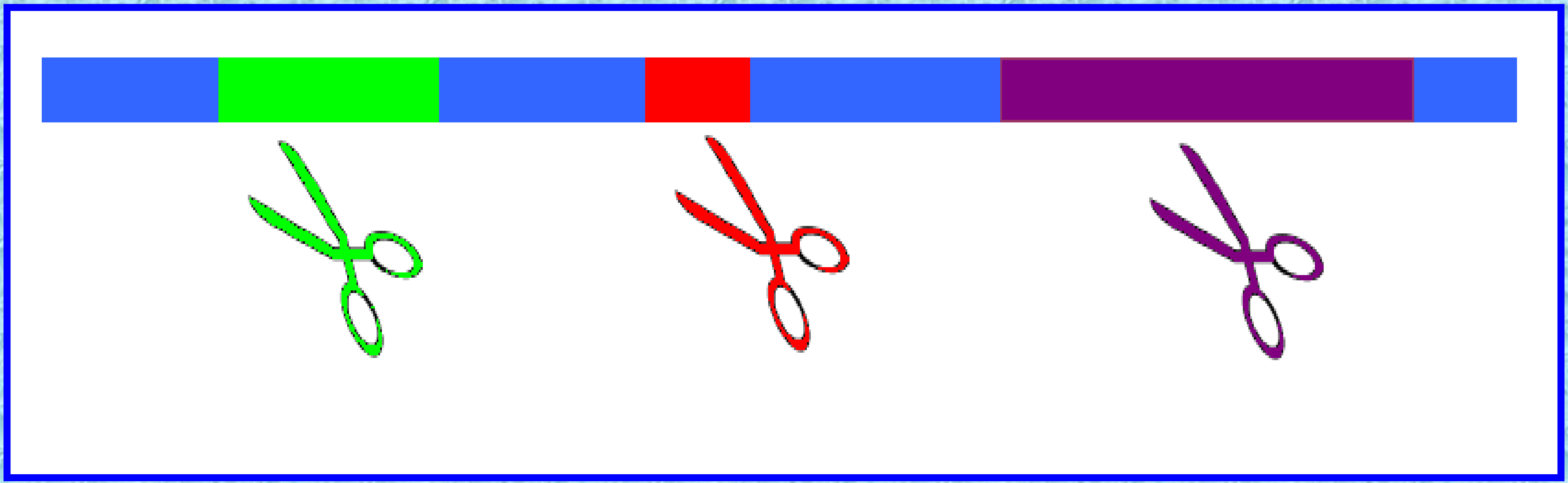
Because everyone's fingerprints are different!

DNA is like a fingerprint because everyone's is a little different!

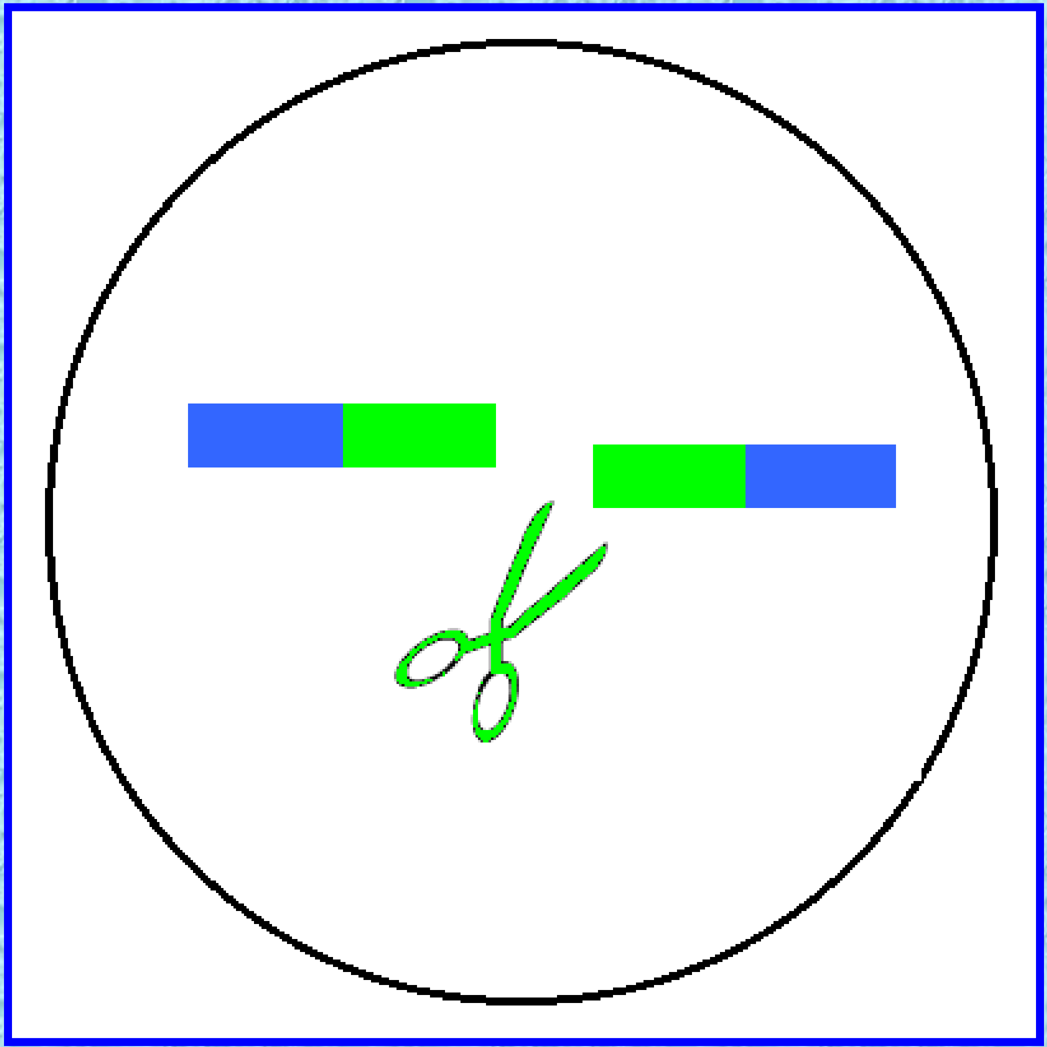
How does the police look at DNA to figure out who committed a crime?

STEP #1

The DNA gets cut up by special scissors!!!

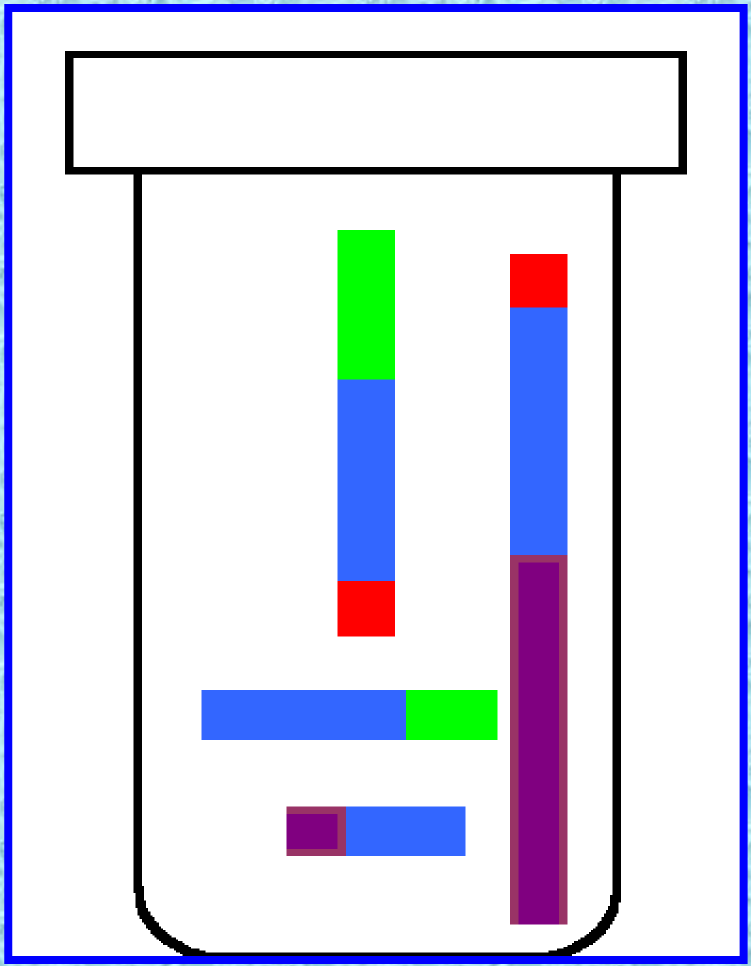


The scissors can only cut the same colour!



STEP # 2

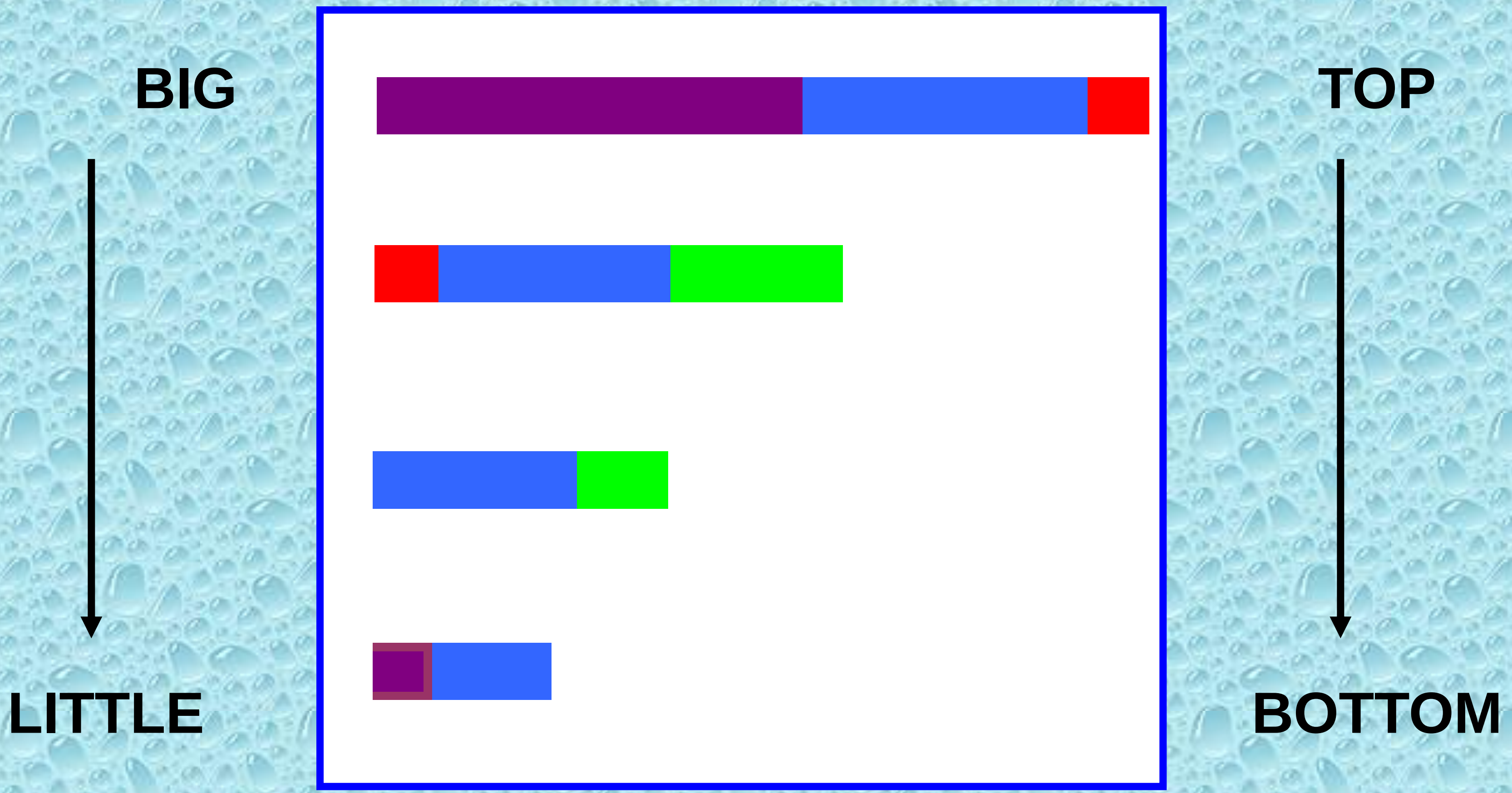
All of the cut up pieces of DNA are different sizes.



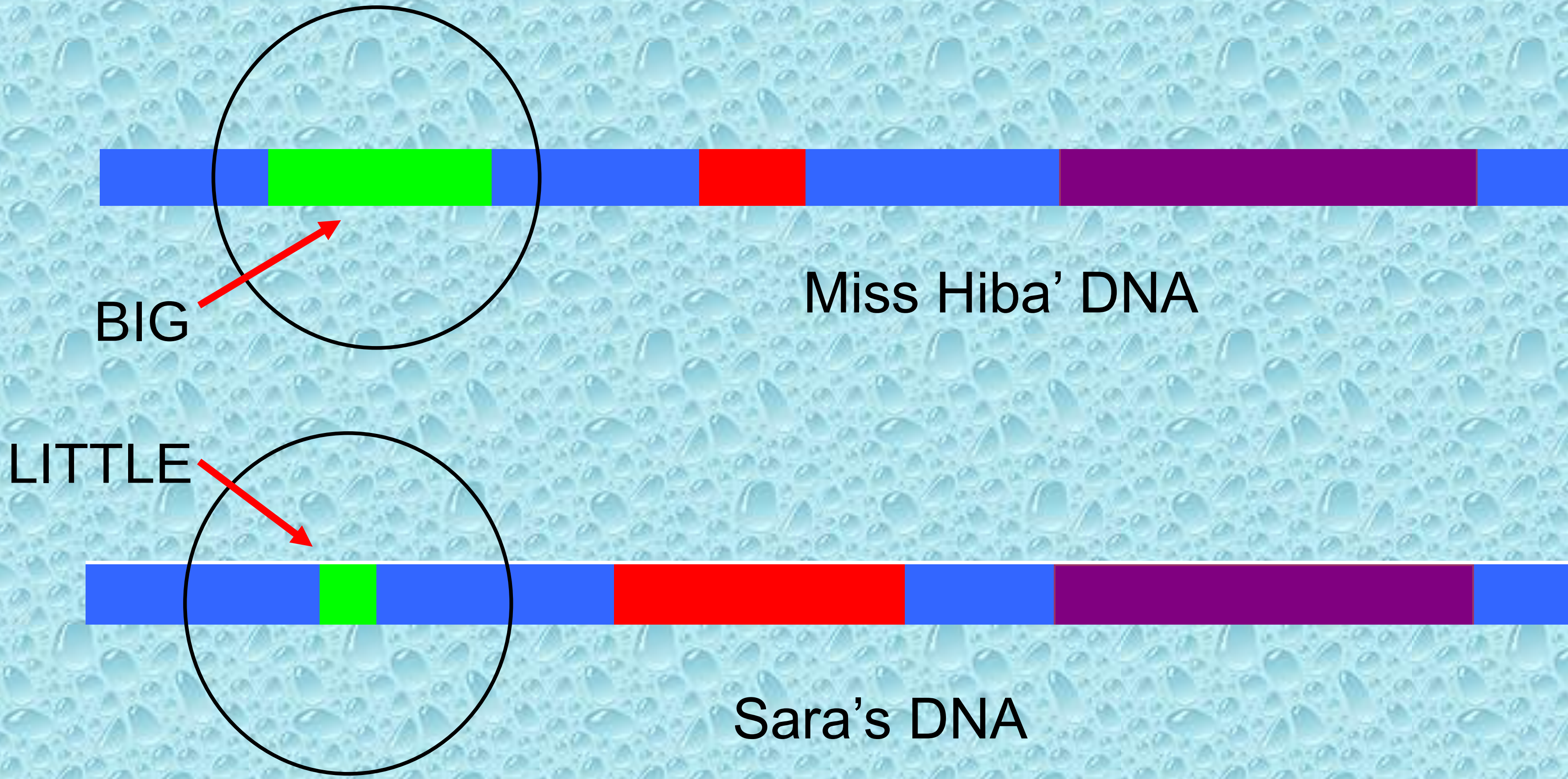
STEP # 3

A special machine sorts the DNA by size.

(Little pieces are fast, so they move faster to the bottom.)

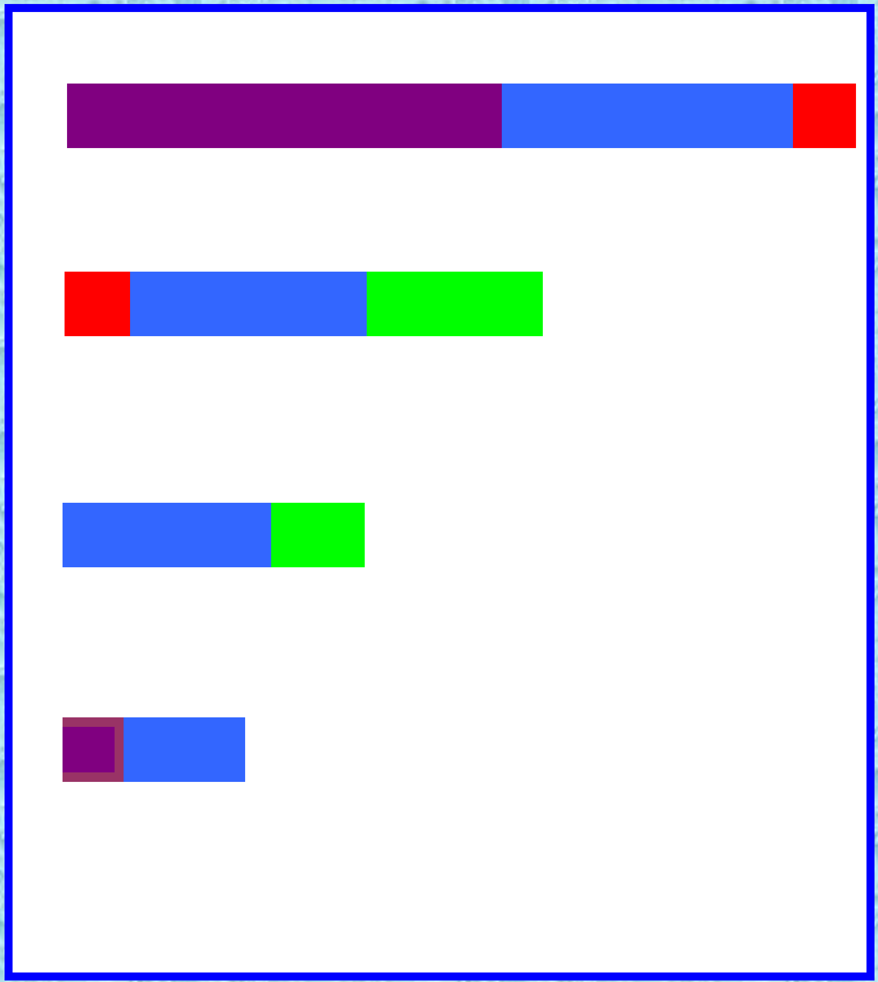


We are <u>ALL</u> a little bit different!

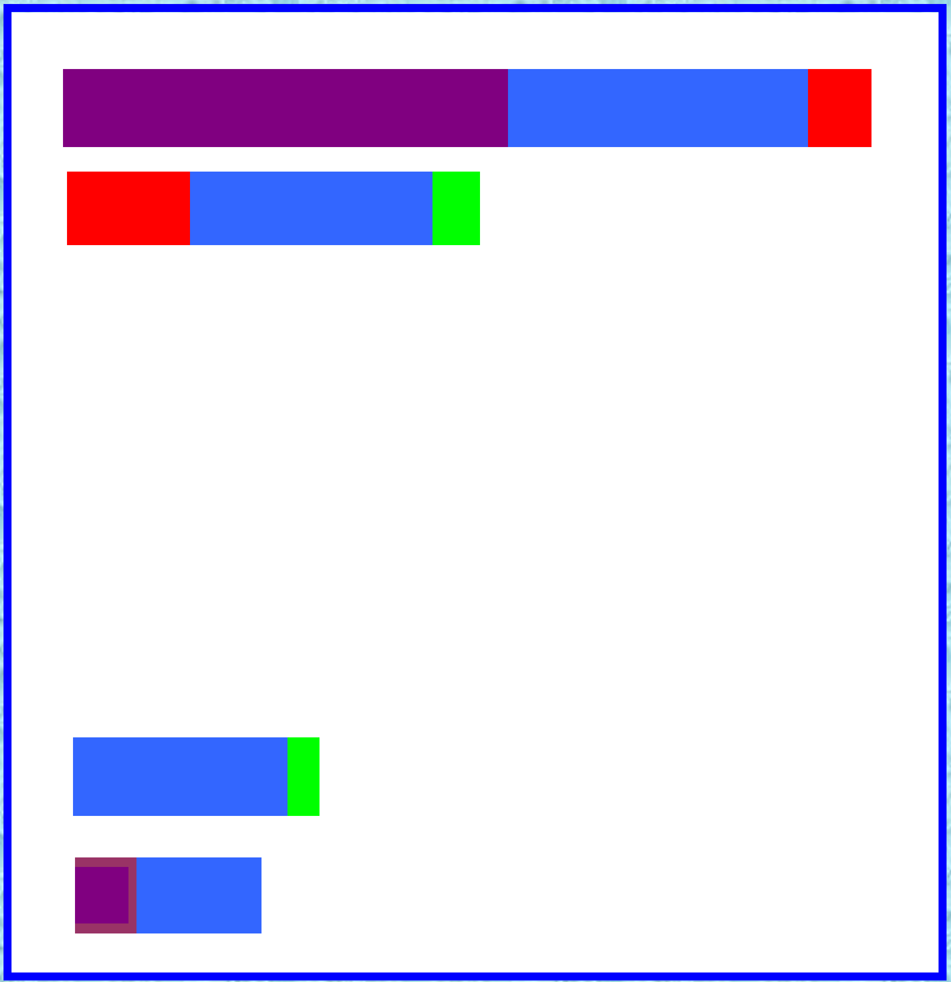


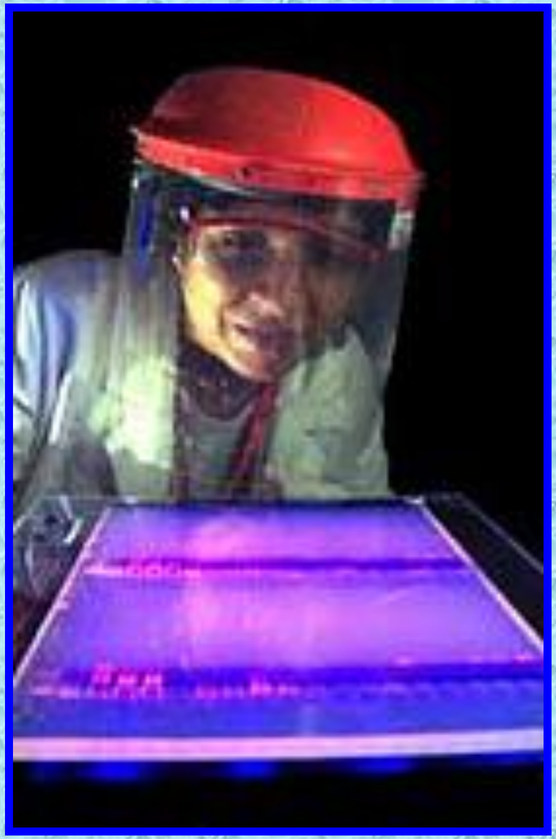
Our DNA has different sizes of pieces so it makes a different pattern when it's all cut up.

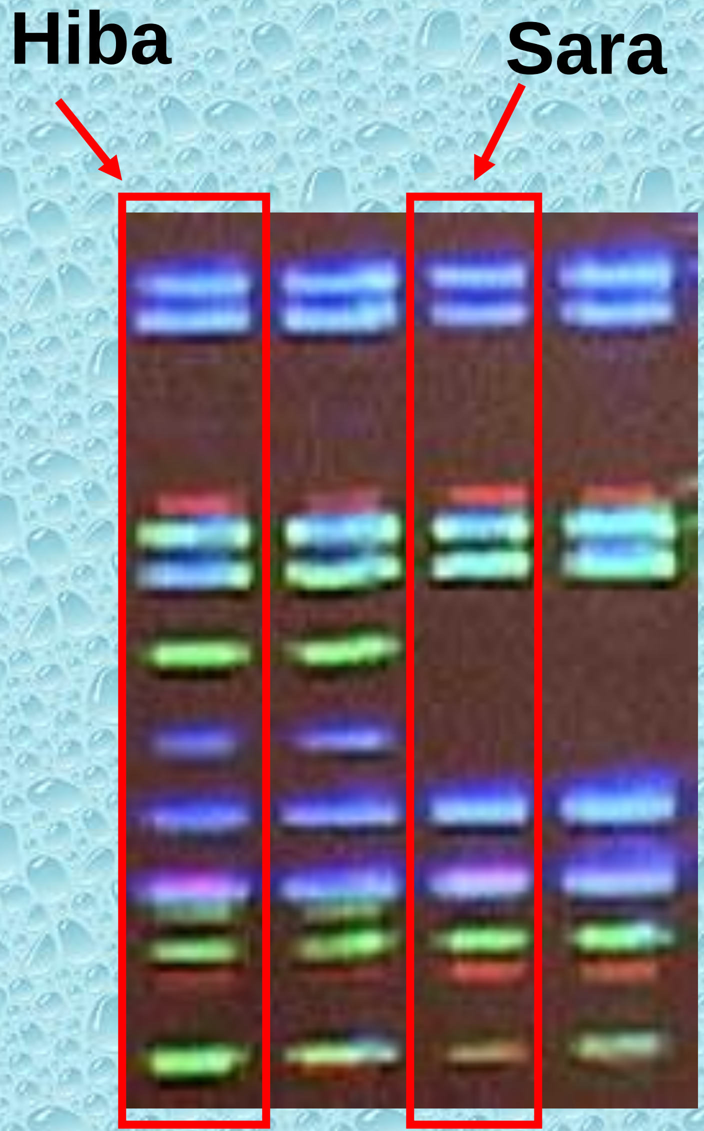
Miss Hiba' DNA



Sara's DNA







This is what it really looks like!!!

ANY QUESTION

- CHATTERJEA BIOCHEMISTRY
- LIPPINCOTT BIOCHEMISTRY
- HARPERS BIOCHEMISTRY
- SATYANARAYANA BIOCHEMISTRY
- INTERNET

Thank you