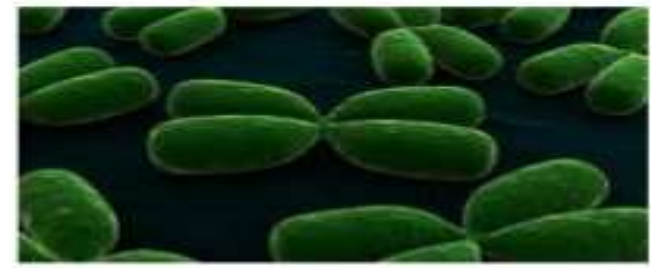


Unit :1

The Cellular Organization of a Living Organism

- **BASIC STRUCTURE AND FUNCTION OF CHROMOSOMES**
- **CONCEPT OF GENE**

INTRODUCTION



Chromosomes are the structures that contain the genetic material

- They are complexes of DNA and proteins

The **genome** comprises all the genetic material that an organism possesses

- In bacteria, it is typically a single circular chromosome
- In eukaryotes, it refers to one complete set of *nuclear* chromosomes

Chromosomes are string-like structures located inside the nucleus of animal and plant cells. The word **chromosome** is derived from the Greek words “*chromo*” meaning color and “*soma*” meaning body.

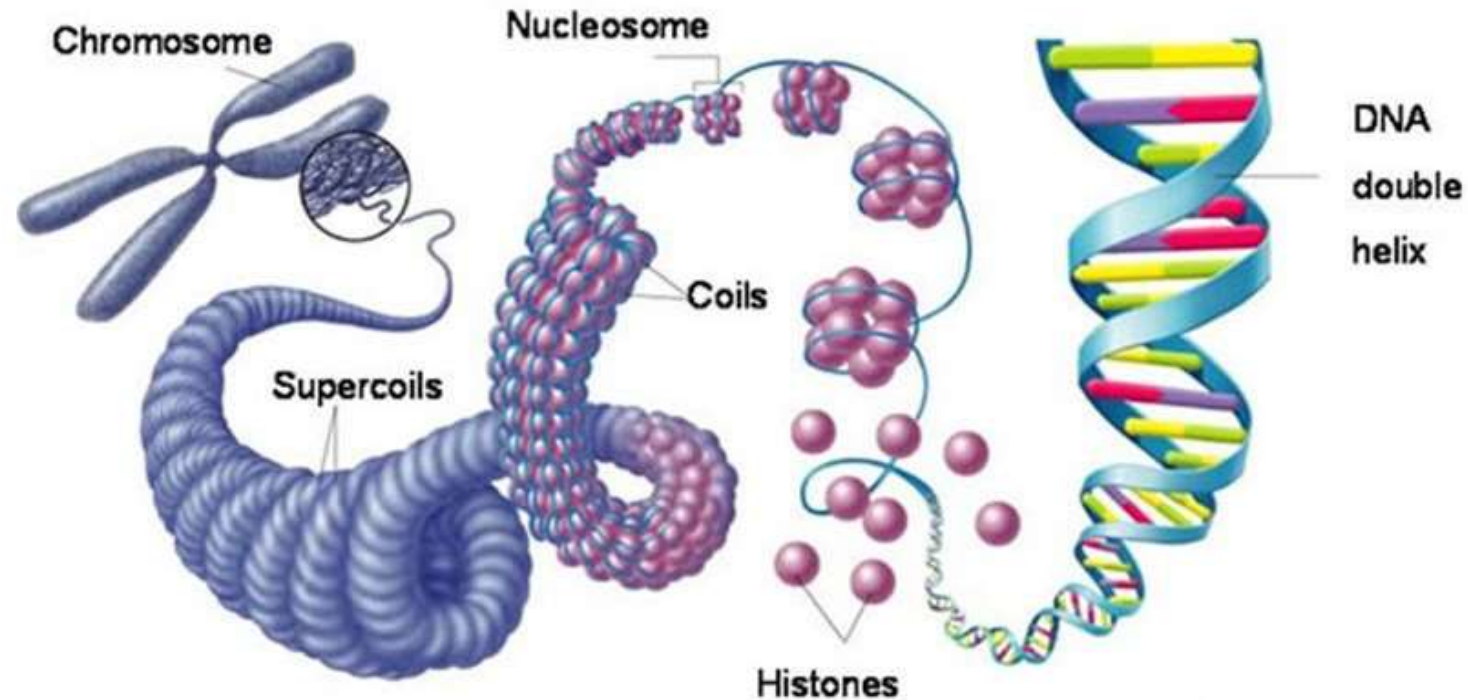
Scientists gave this name to chromosomes because the structures become strongly stained when colorful dyes are applied to them

Discovery of chromosomes

- *Chromosomes were first observed by the German embryologist Walther Fleming in 1882*
- *when he was examining the rapidly dividing cells of salamander larvae.*
- *Chromosomes are thread like structures that appear inside the nucleus at the time of cell division.*



What is inside the chromosomes.....



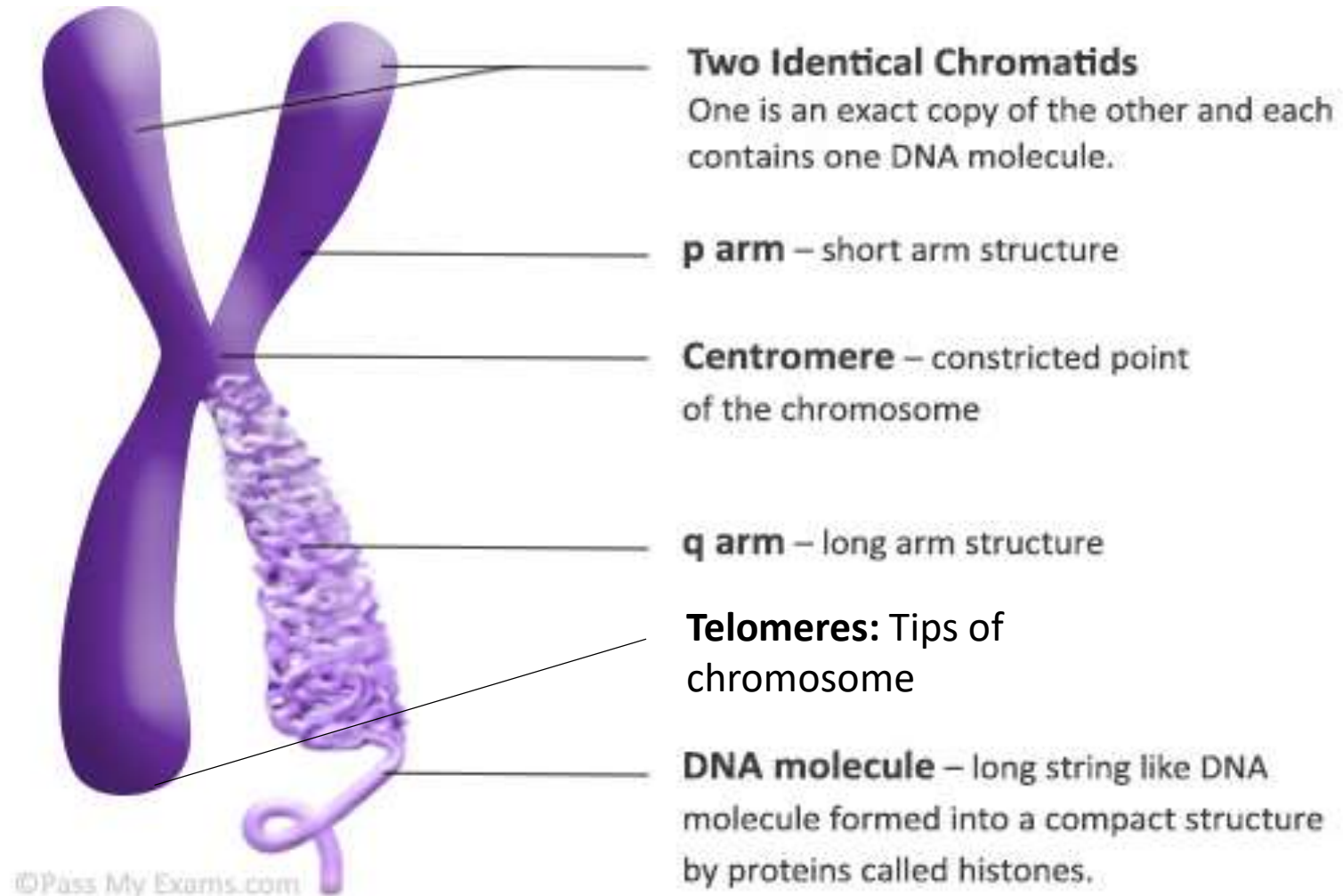
Strands of DNA wrap around a protein (**histone**) forming **nucleosomes**.

Nucleosomes coil together forming **chromatin**.

Chromatin loops and coils together forming **supercoils**.

Supercoils bunch together forming **chromosomes**.

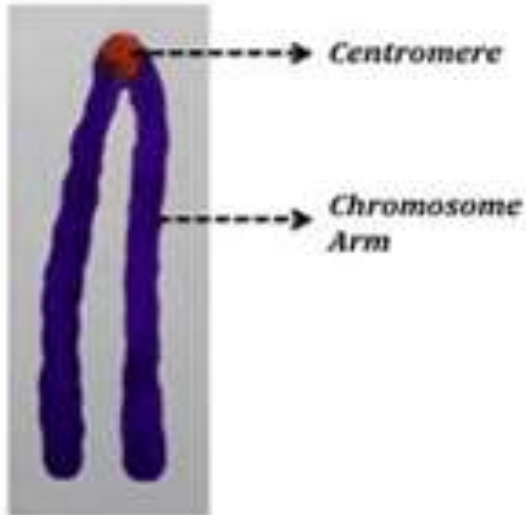
Structure of a chromosome



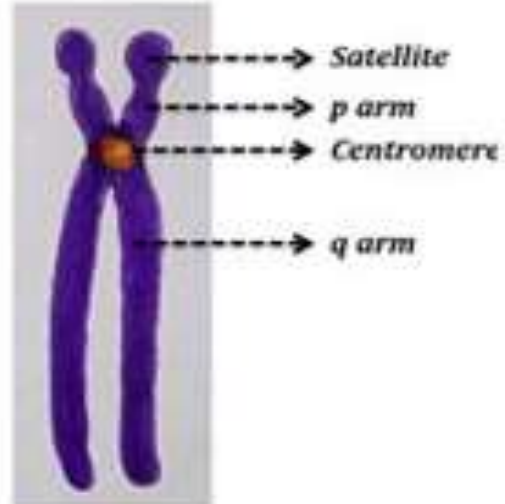
Types of chromosomes

BASED ON THE POSITION OF CENTROMERE

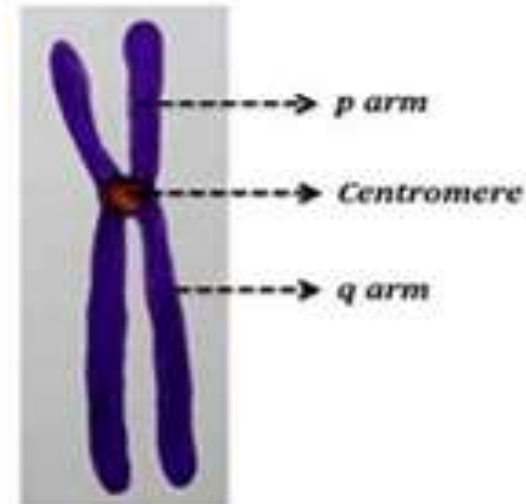
Telocentric Chromosome



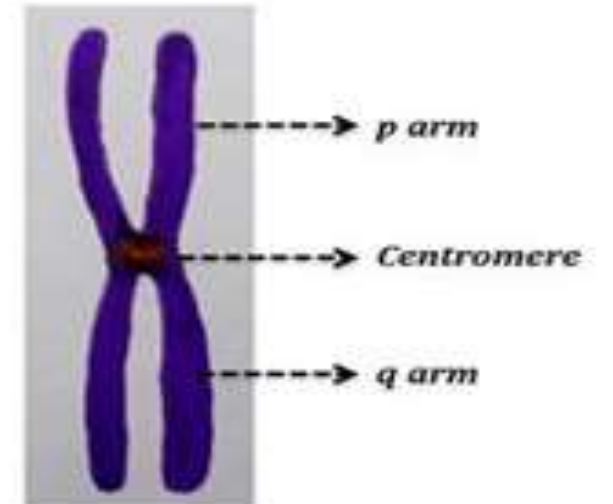
Acrocentric Chromosome



Sub-metacentric Chromosome



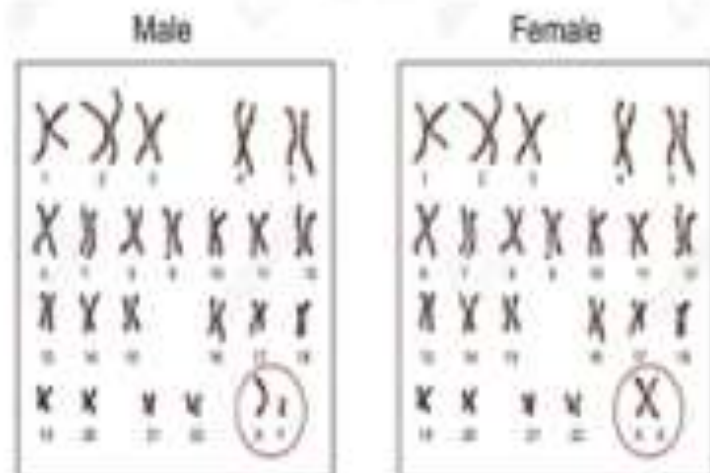
Metacentric Chromosome



Types of chromosomes

Autosomes and Sex Chromosomes

- In the human chromosome complement there are 22 pairs of homologous chromosomes called **autosomes** and play no part in sex determination.
- The last pair- pair number 23- determine the sex of the individual and are known as the **Sex Chromosomes**.



Typical human male

44 autosomes,
1 X sex chromosome
1 Y sex chromosome

Typical human female

44 autosomes,
2 X sex chromosomes

AUTOSOMAL CHROMOSOMES

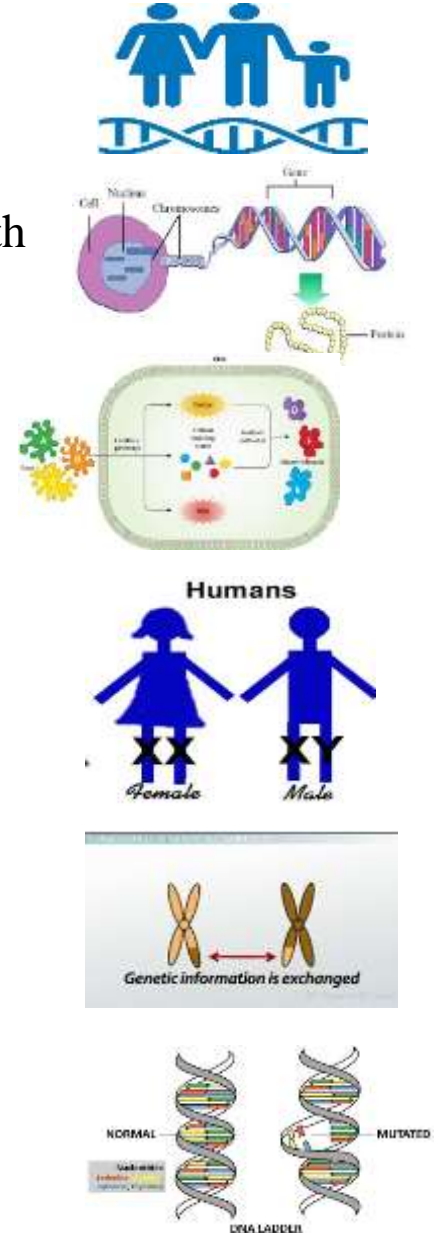
- Body chromosomes.
- Codes for traits that do not depend on your gender.
- EX. Hair, eye color, ear shape.

SEX CHROMOSOMES

- Make a person male or female.
- Codes for gender specific traits.
- EX. Baldness, hemophilia, colorblindness.

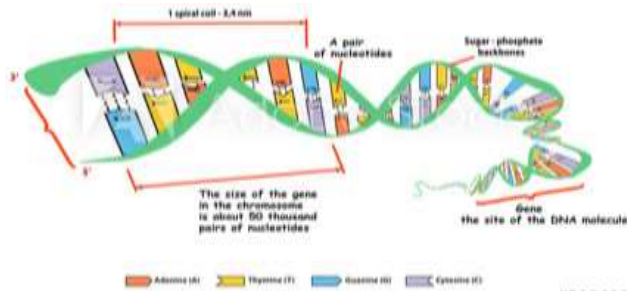
Functions of chromosomes

- Chromosomes contain genes and all the hereditary information is located in the genes.
- Chromosomes control the synthesis of structural proteins and thus help in cell division and growth
- They control cellular differentiation
- By directing the synthesis of particular enzymes, chromosomes control cell metabolism
- Chromosomes form link between off springs and parents.
- Some chromosomes called as sex chromosomes determine the sex of the individuals
- Through the process of crossing-over, chromosomes introduce variations
- Mutations are produced due to changes in gene chemistry.

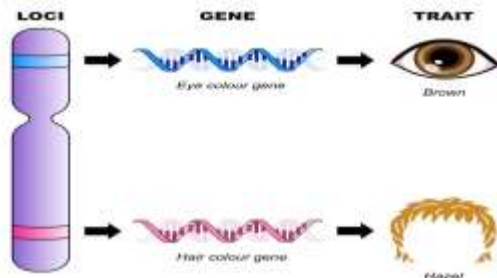


Genes

- A gene is a small section of **DNA**? that contains the instructions for a specific molecule, usually a **protein**?
- The purpose of **genes**? is to store information.



- Each gene contains the information required to build specific proteins needed in an organism.



- Genes come in different forms, called **alleles**?
- An individual's **phenotype**? is determined by the combination of alleles they have.
- The characteristic associated with a certain allele can sometimes be **dominant**? or **recessive**



A = dominant
a = recessive

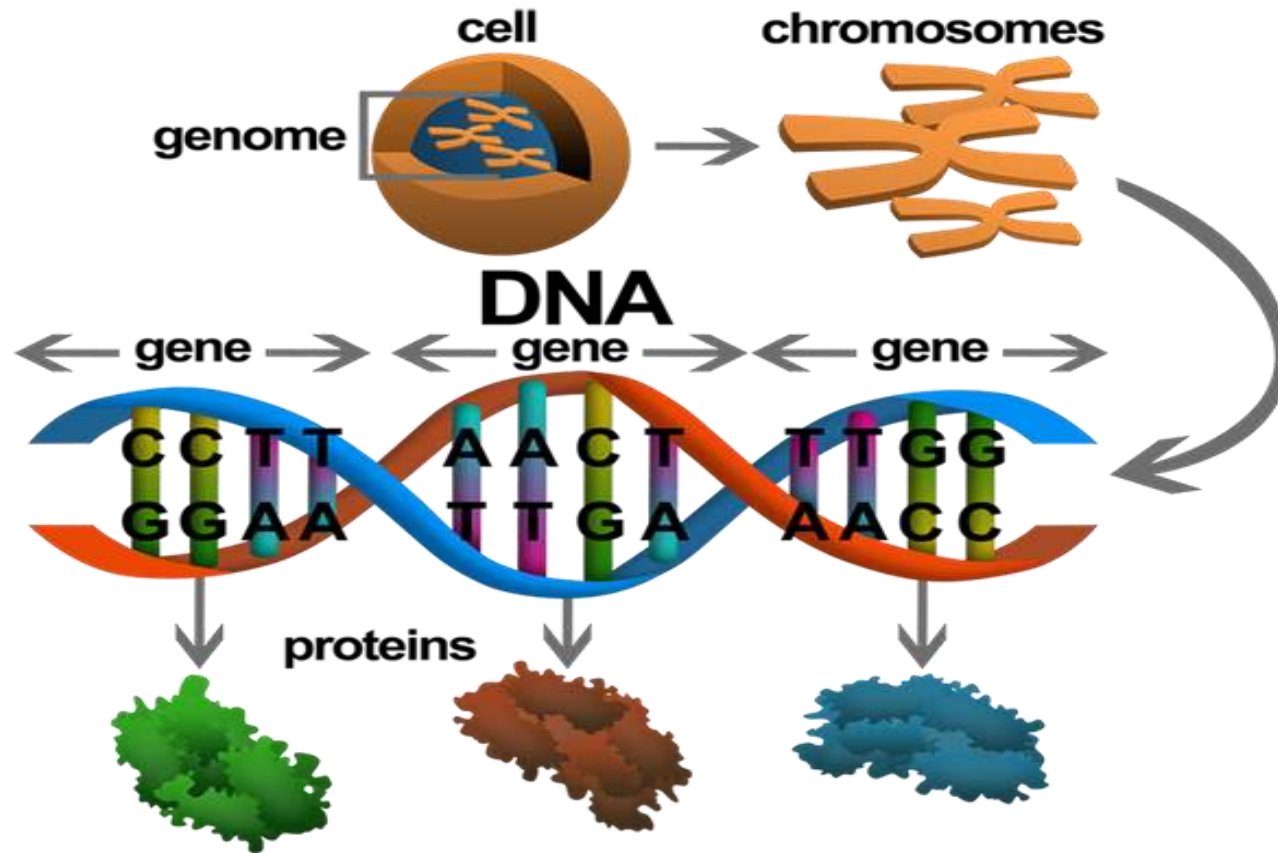


PHENOTYPE

- Physical appearance of an individual.
- Observable or measurable traits.
- **Genetics + environment**

How do genes work

Each gene has a special job to do. The DNA in a gene spells out specific instructions—much like in a cookbook recipe — for making proteins

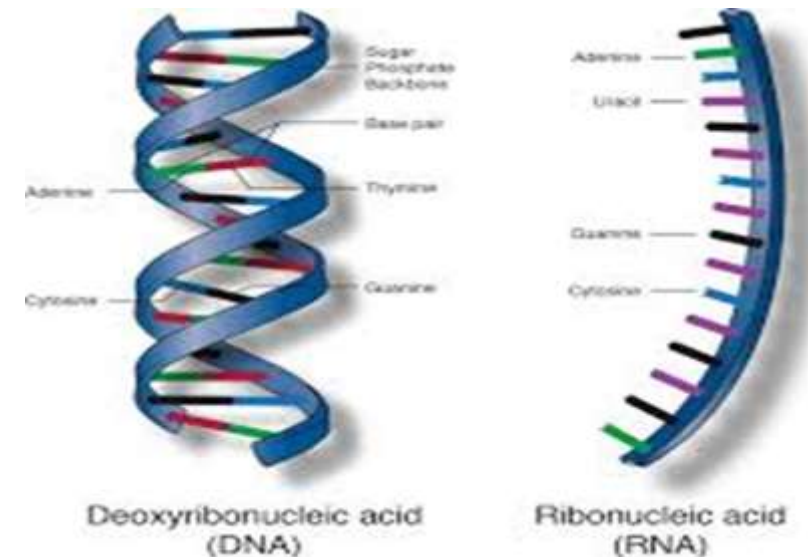


Questions

1. Define chromosomes and genes? What is the structure of chromosome?
2. What are the different types of chromosomes based on the position of centromere?
3. Explain sex chromosomes (allosomes) and autosomes?
4. What are the functions of chromosomes?
5. Define : Alleles, phenotype, geneotype, dominant and recessive genes

Nucleic acid

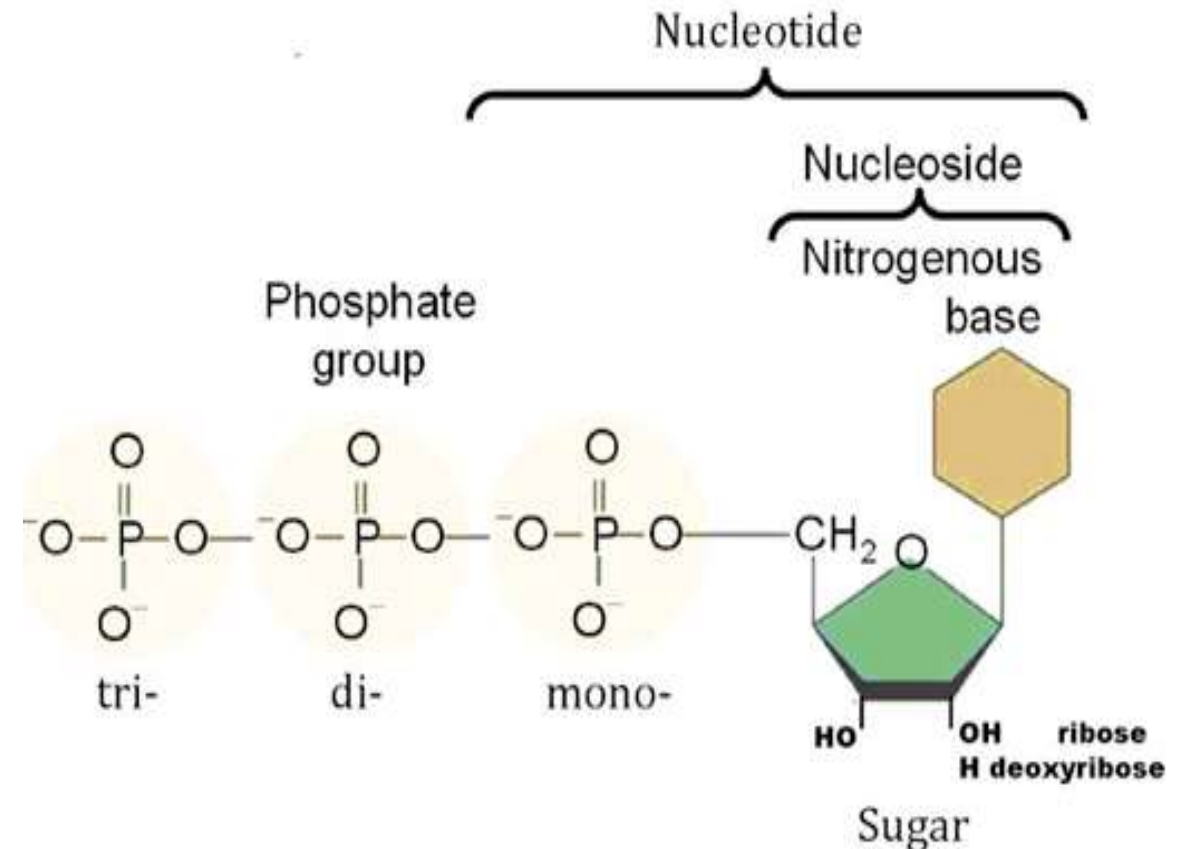
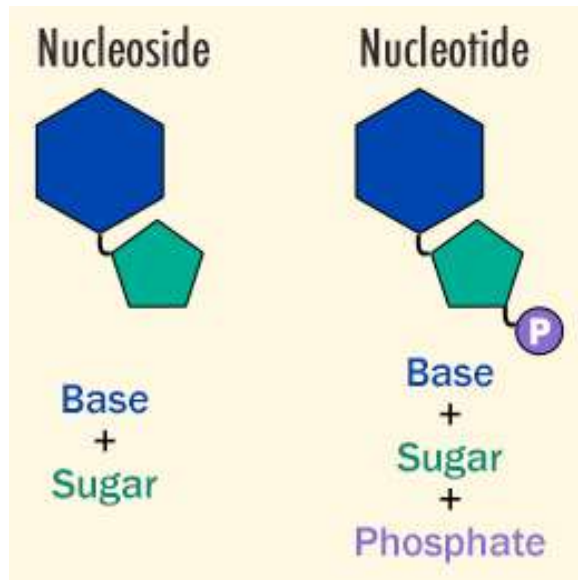
- Nucleic acid are biological molecules essential for life.
- There are two types of nucleic acid that are Deoxyribonucleic acid (**DNA**) and Ribonucleic acid (**RNA**)
- These long thread like polymers are made up of a linear array of monomers called nucleotides.



NUCLEOTIDE/NUCLEOSIDE

A nucleotide consists of

- ❑ Nitrogenous Base.
- ❑ Pentose Sugar. In DNA, the sugar is 2'-deoxyribose. ...
- ❑ Phosphate Group. A single phosphate group is PO_4^{3-} .



Nitrogenous bases

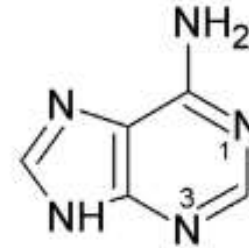
There are the two categories of nitrogenous bases

- ❑ Purines : adenine & guanine
- ❑ Pyrimidines: cytosine & thymine ,uracil

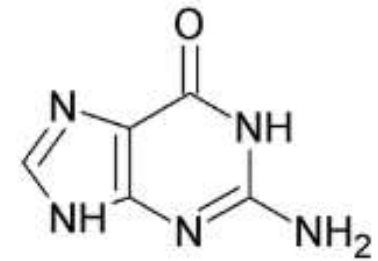
Nitrogenous bases in DNA and RNA

- ❑ In DNA are adenine (A), guanine (G), cytosine (C) and thymine (T).
- ❑ In RNA, are adenine (A), guanine (G), cytosine (C) and uracil (U) the only differing nitrogenous base

Purines

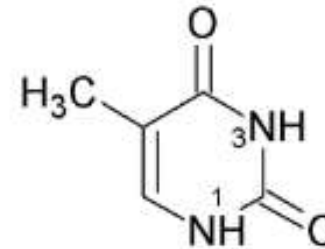


Adenine

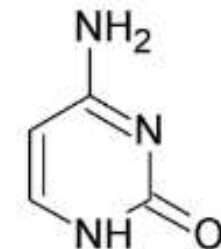


Guanine

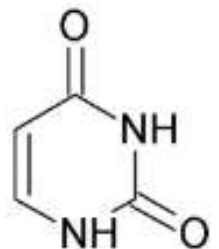
Pyrimidines



Thymine



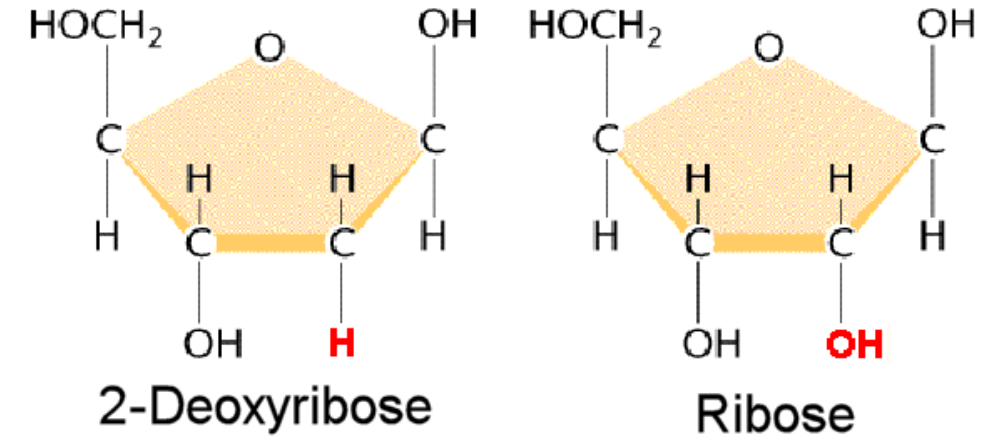
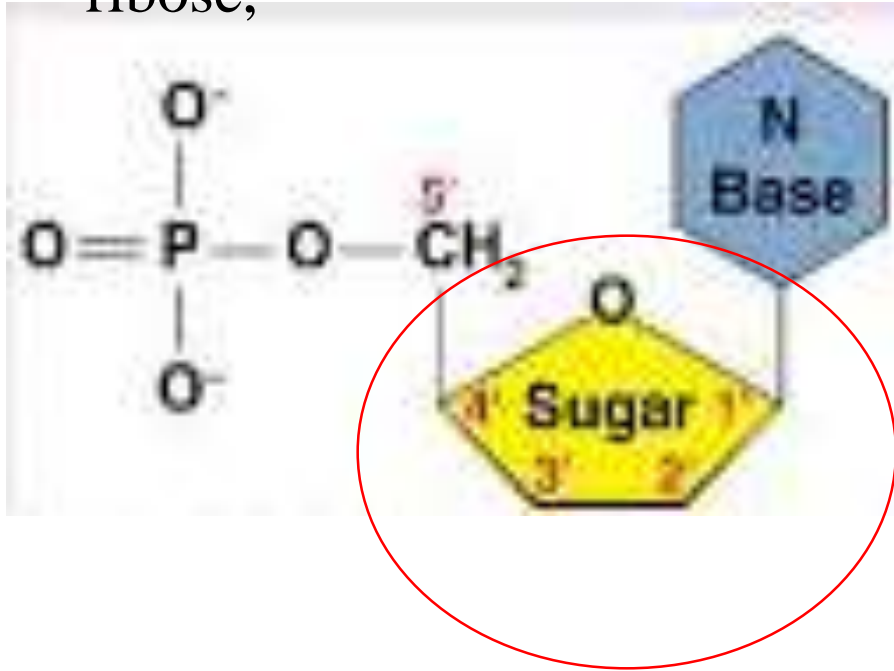
Cytosine



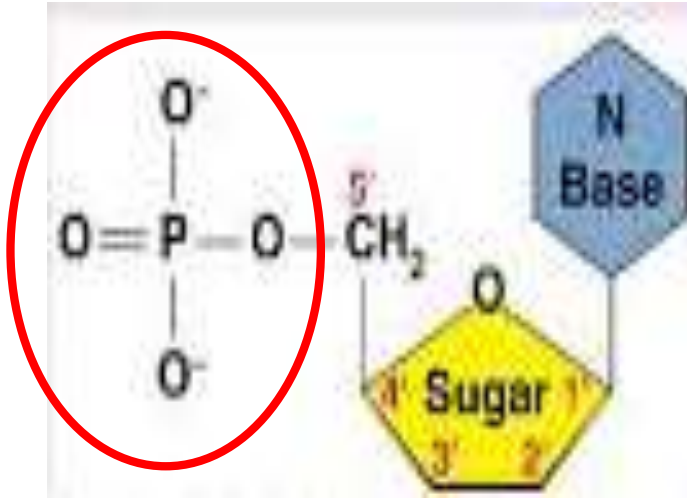
Uracil

Sugar

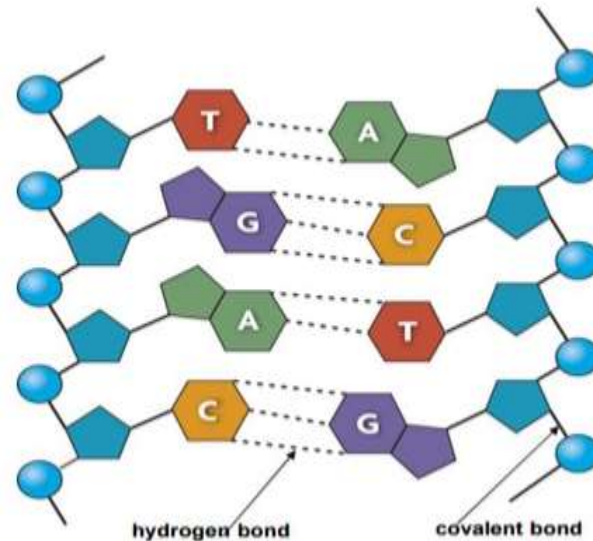
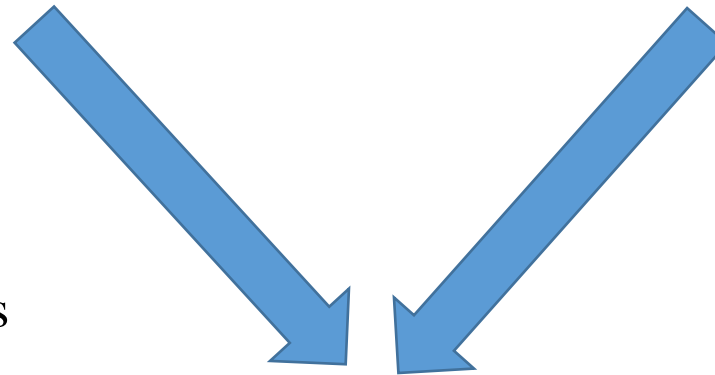
- ❑ The sugar present in a molecule of DNA is deoxyribose
- ❑ The sugar present in a RNA molecule is ribose,



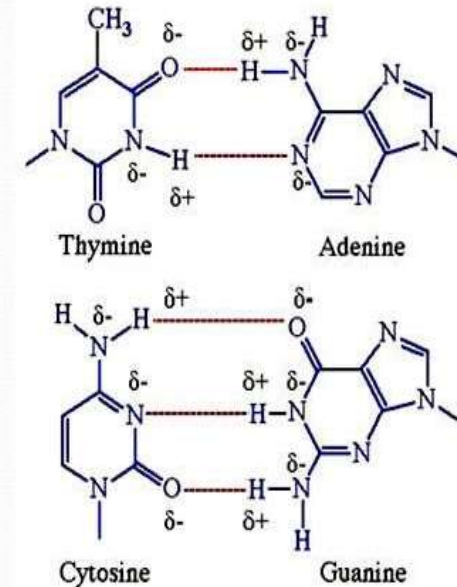
Bonds in DNA



- In DNA and RNA the backbone is composed of alternating sugar and **phosphate** groups which form covalent bond.



Hydrogen Bonds in DNA



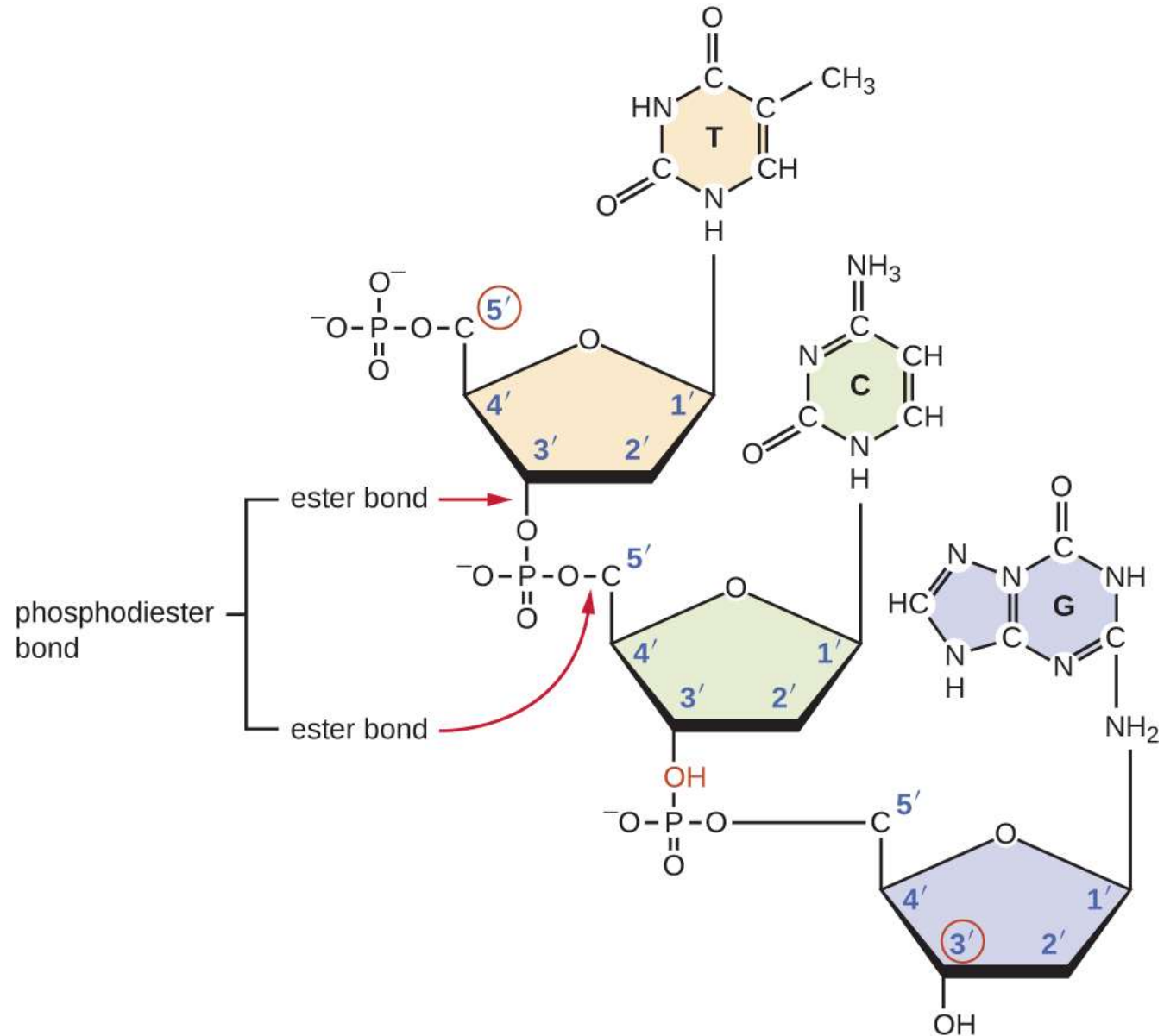
•Here are the two diagrams outlining where the hydrogen bonds are within DNA (red lines).

•Base A and T are held together by two hydrogen bonds (an O-H and N-H bonds)and bases G and C are bonded together by three hydrogen bonds (2 O-H bonds and 1 N-H bond).

•The different number of Hydrogen bonds ensure that the bases link together correctly

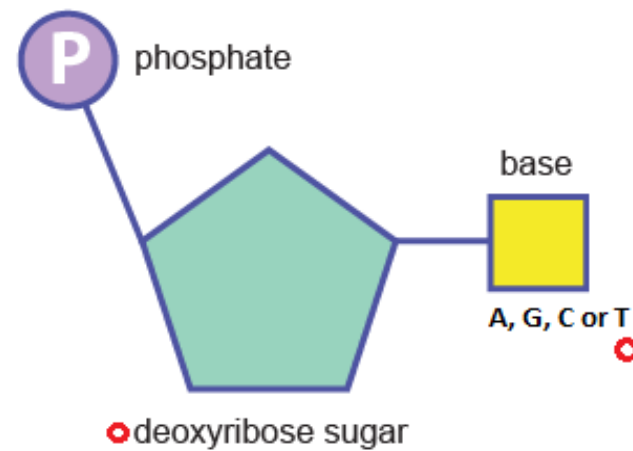
Role of Phosphodiester linkage

- Phosphodiester Bonds Link Successive Nucleotides in Nucleic Acids
- The successive nucleotides of both DNA and RNA are covalently linked through phosphate-group “bridges,” in which the 5'-phosphate group of one nucleotide unit is joined to the 3-hydroxyl group of the next nucleotide, creating a phosphodiester linkage.

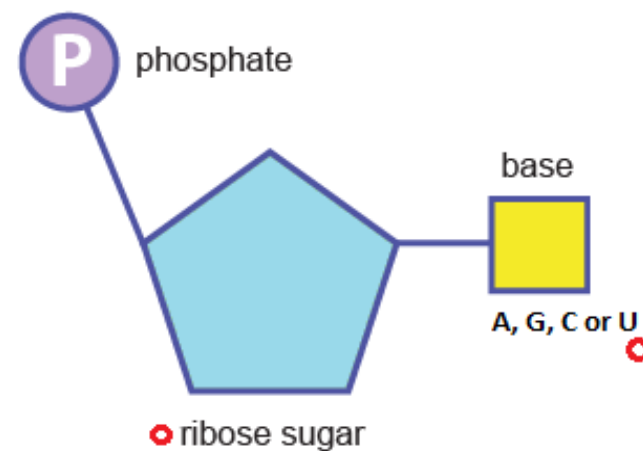


Difference between DNA and RNA are:

DNA	RNA
It is double stranded nucleic acid.	It is single stranded nucleic acid.
It contains deoxyribise sugar.	It contains ribose sugar.
It contains Thymine (T) as a nitrogenous base.	It contains Uracil (U) instead of Thymine.
It is the genetic and hereditary material of the cells.	It is involved in synthesis of proteins.
It is present in the nucleus of the cells.	It is present in both nucleus and cytoplasm.



DNA



RNA

Deoxyribonucleic acid



✂ Discovery of the DNA double helix

- **Frederick Griffith** - (1928) Discovers that a factor in diseased bacteria can transform harmless bacteria into deadly bacteria.

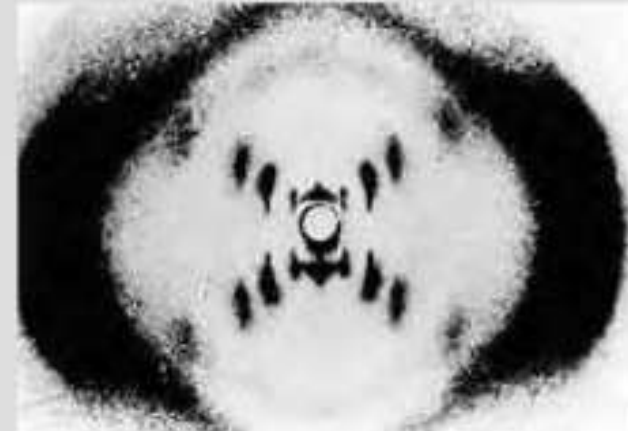
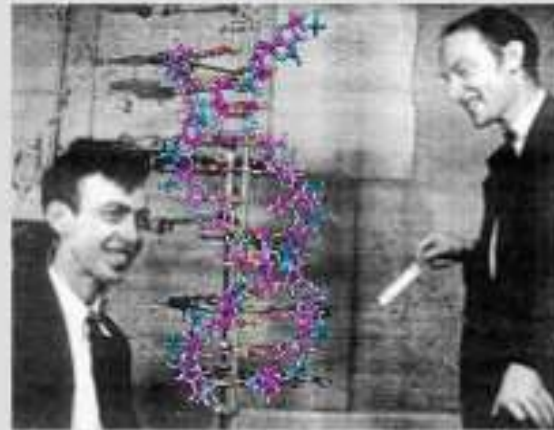


- **Maurice Wilkins** - worked on the structure of DNA.

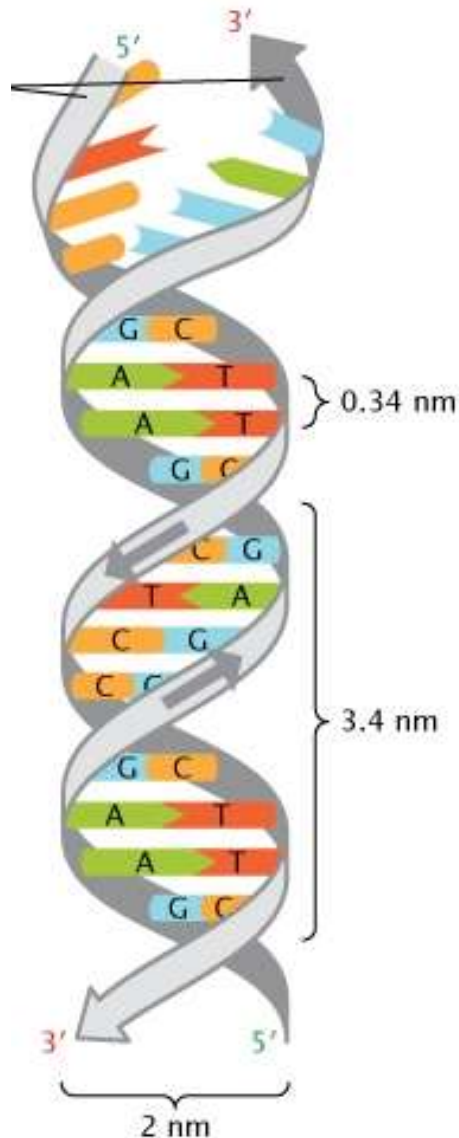


- **Rosalind Franklin** - (1952) - Worked out helical structure of DNA by X-ray photo of DNA.

- **Watson and Crick** - (1953) described the DNA molecule from Franklin's X-ray.

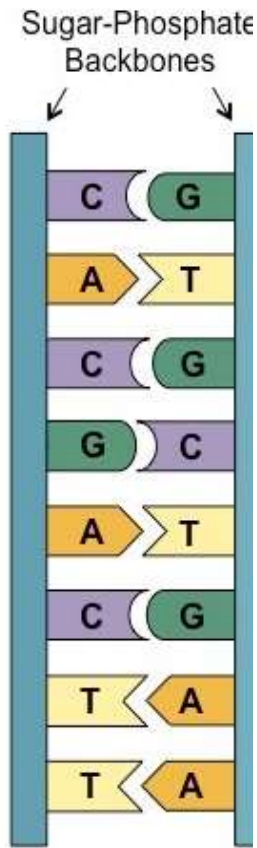


Double helical structure of DNA



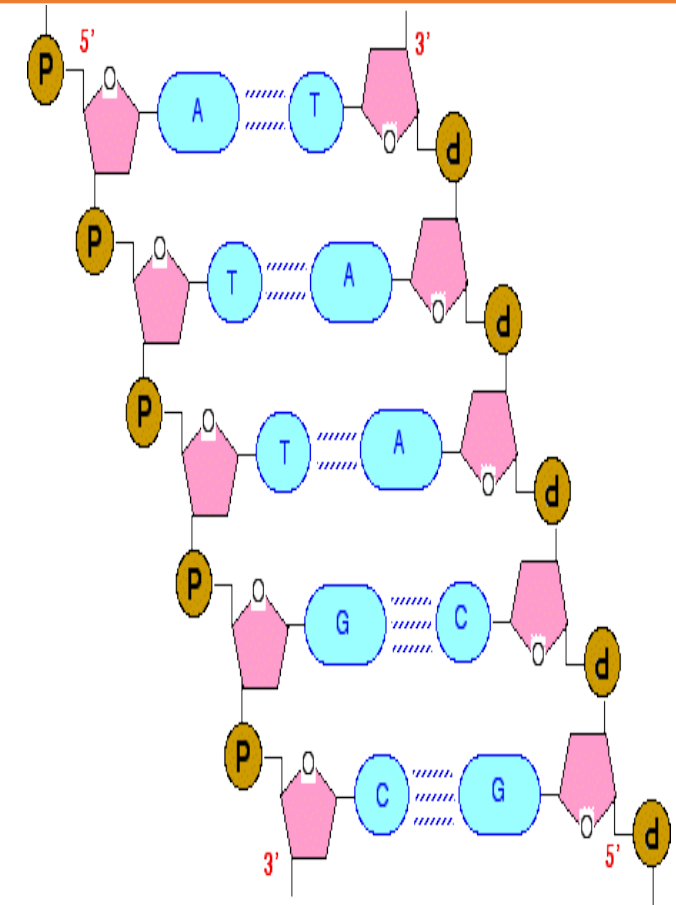
- The width(or diameter) of a double helix is 20 \AA (2nm).
- Each turn (pitch)of the helix is 34 \AA (3.4nm) with 10 pairs of nucleotides, each pair placed at a distance of about 3.4 \AA (0.34nm).

Salient features of double helical structure of DNA



DNA Ladder

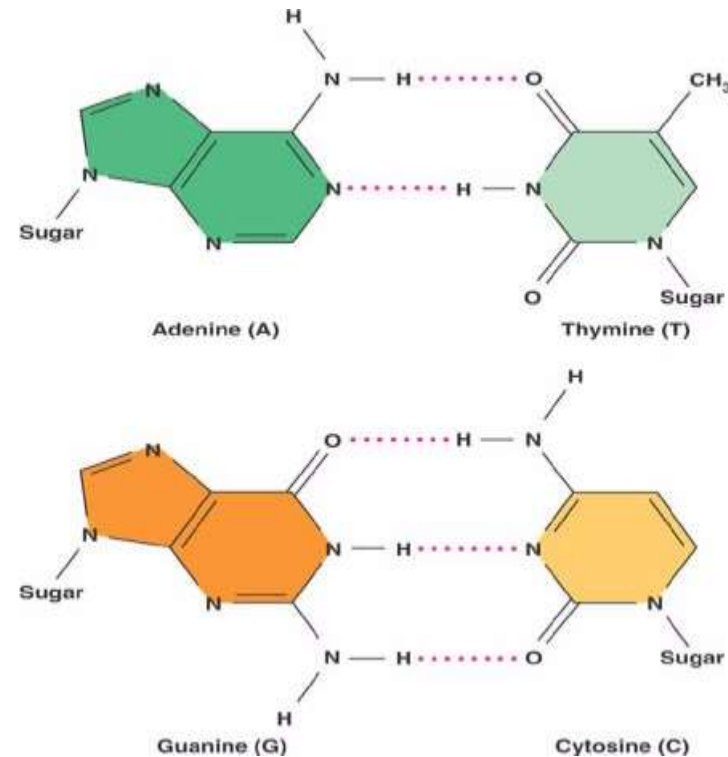
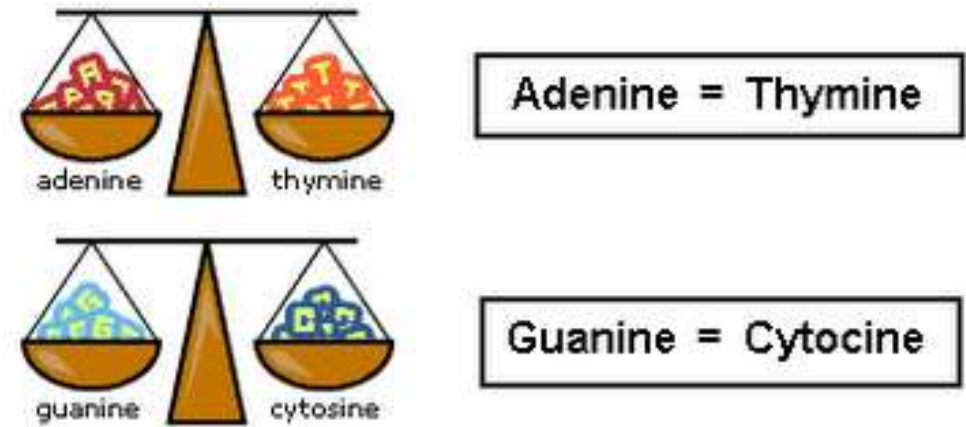
- The two strands are antiparallel i.e., one strand runs in the 5' to 3' direction while the other in 3' to 5' direction.
- The two polynucleotide chains are not identical but complementary to each other due to base pairing.
- Each strand of DNA has a hydrophilic deoxyribose phosphate backbone on the outside (periphery). The two strands are held together by hydrogen bonds formed by complementary base pairs. The A-T pair has 2 hydrogen bonds while the C-G pair has 3 hydrogen bonds. The G-C is stronger by about 50% than A-T.
- The hydrogen bonds are formed between a purine and pyrimidine only. The only base arrangement possible in DNA structure is A-T, T-A, G-C, C-G.
- The genetic information resides on one of the two strands known as template strand or sense strand. The opposite strand is antisense strand.



CHARGAFF'S RULE

- Chargaff studied percentages of nitrogenous bases (1950)
- Percentage of guanine and cytosine are almost equal
- Percentages of adenine and thymine are almost equal
- Chargaff's Rule supports idea that Adenine (A) bonds to Thymine (T) and Cytosine (C) bonds to Guanine (G)

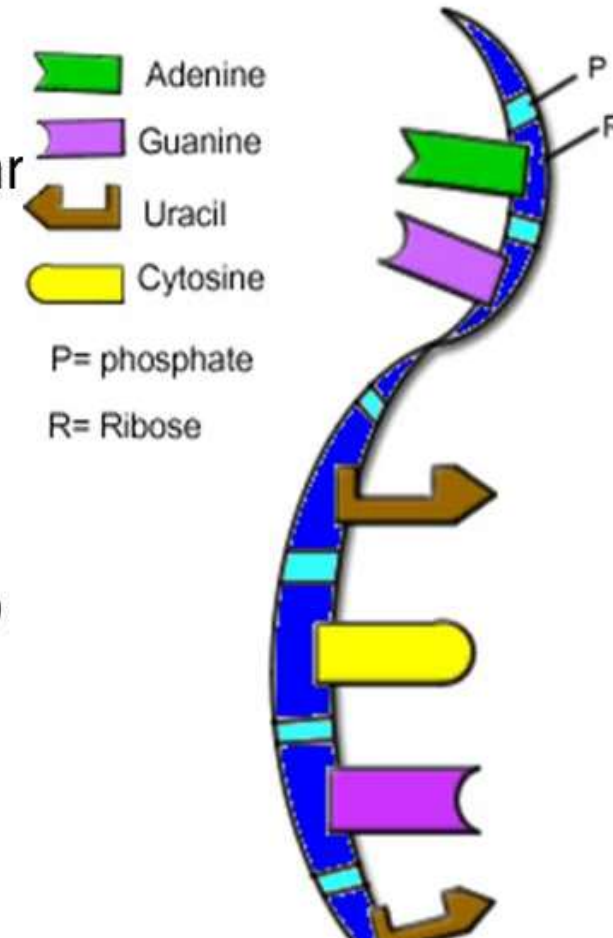
$$(\%A + \%T) + (\%G + \%C) = 100\%$$



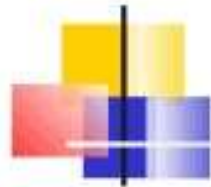
RIBONUCLEIC ACID (RNA)

(Similar to DNA with several key differences)

- Made up of a repeating strand of nucleotides, contains all 3 parts similar to DNA (sugar, phosphate, nitrogen base)
- The sugar in RNA is called Ribose
- Contains the nitrogen base Uracil instead of Thymine. Uracil will bind to Adenine (like thymine did)
- RNA is single strand



Types of RNA



mRNA

“messenger”

made using DNA

carries genetic info
from the nucleus to
the ribosome

every 3 bases
(codon) specifies
an amino acid



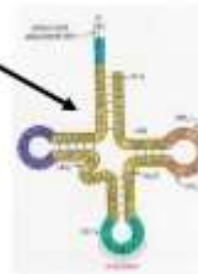
tRNA

“transfer”

transfers an amino
acid to the growing
protein

cloverleaf shape

3 complimentary
bases (anticodon)
binds to the mRNA
codon



rRNA

“ribosomal”

makes up the
bulk of ribosomes



Ribosome

Ribosomal RNA
Forms an important part of
both subunits of the
ribosome.

Questions

1. Define nucleotides and nucleosides? What are the composition of different nucleic acids?
2. What are the different bonds present in DNA and how are they formed?
3. What are the differences between DNA and RNA?
4. What are the salient features of the double helical structure of DNA proposed by Watson and Crick?
5. Explain Chargaff's rule with an example?
6. What are the functions of different types of RNA?