Unit :1

The Cellular Organization of a Living Organism

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

Two important terms...

Phenotype: The outlook of an organism

Genotype: The genetic information written in DNA

Phenotypes

Genotype

GCCAAGAATGGCTCCCACCT
GGCTCTCAGACATTCCCCTGGTCCAA
CCCCCAGGCCATCAAGATGTCTCAGA
GAGGCGGCTAGACACCCAGAGACCT
CAAGTGACCATGTGGGAACGGGATGT
TTCCAGTGACAGGCA

Genotype

ATGTTTCCACCTTCAGGTTCC
ACTGGGCTGATTCCCCCCTCC
CACTTTCAAGCTCGGCCCCTT
TCAACTCAGAGAGGCGGCTA
GACACCCAGAGACCTCAAGT
GACCATGTGGGAACGGGATG
TTTCCAGTGACAGGCAG

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

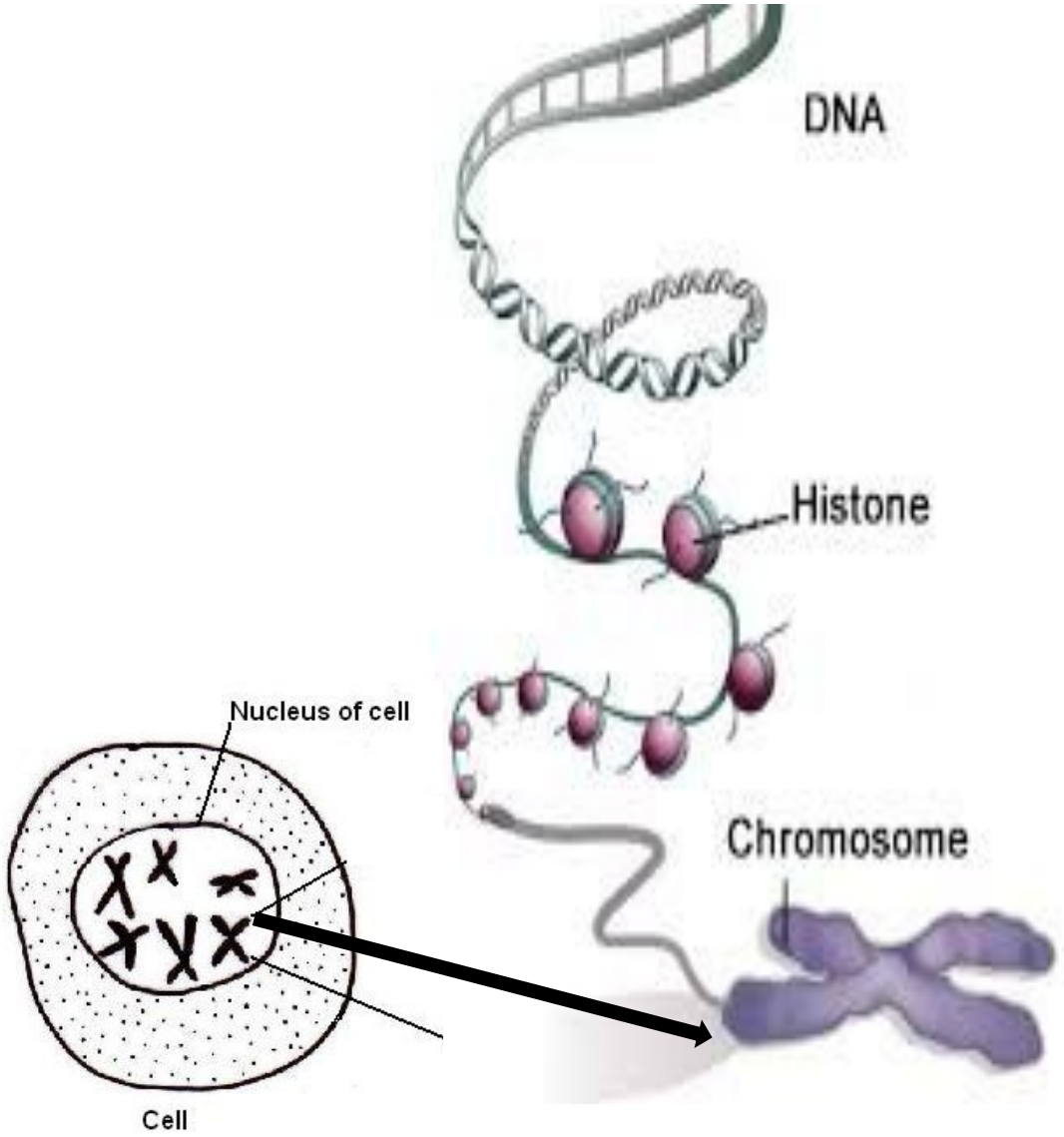
Chromosomes are string-like structures located inside the nucleus of animal and plant cells. The word **chromosome** is derived from the Greek words "*chromo*" meaning color and "*soma*" meaning body.

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** *in1882*
- *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.*

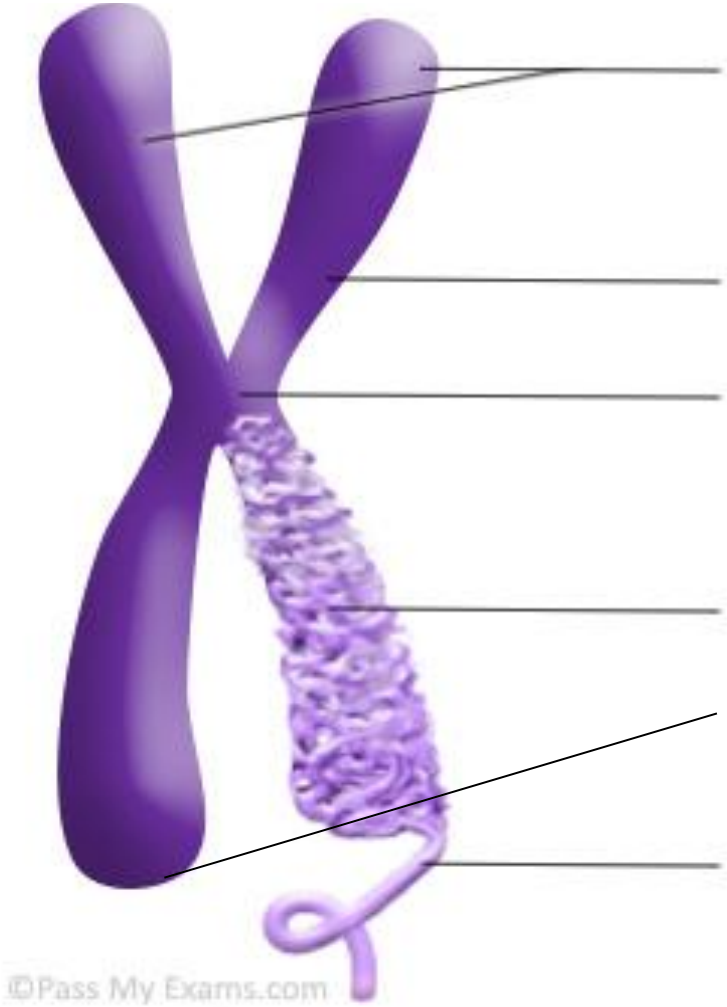
What is inside the chromosomes……



- Chromosome is made up of a chemical called ***Deoxyribonucleic acid*** **(DNA)**.
- Each chromosome contains one DNA molecule. The DNA is coiled tightly around proteins called **histones**.
- These proteins provide structural support to a chromosome and allow the very long DNA molecule to form a **compact** shape and **fit inside the nucleus** of a cell.

Packing required → To avoid unwanted tangle of long chain DNA
For equal distribution of it during cell division.

Structure of a chromosome



Two Identical Chromatids
One is an exact copy of the other and each contains one DNA molecule.

p arm – short arm structure

Centromere – constricted point of the chromosome

q arm – long arm structure

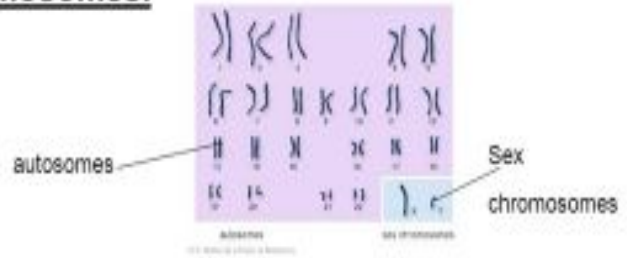
Telomeres: Tips of chromosome

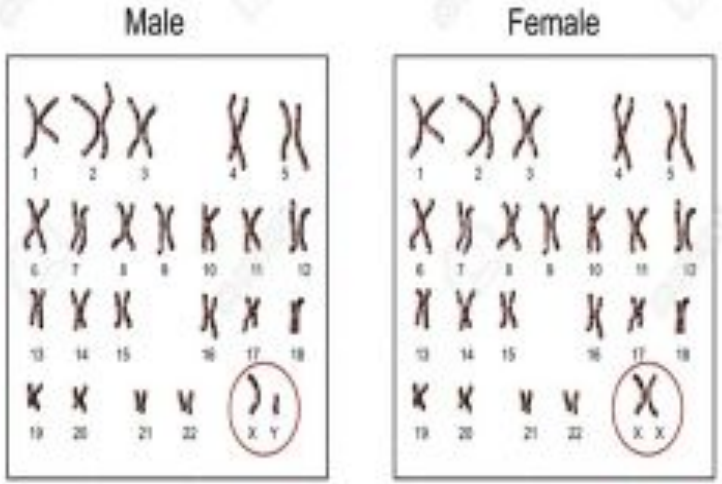
DNA molecule – long string like DNA molecule formed into a compact structure by proteins called histones.

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

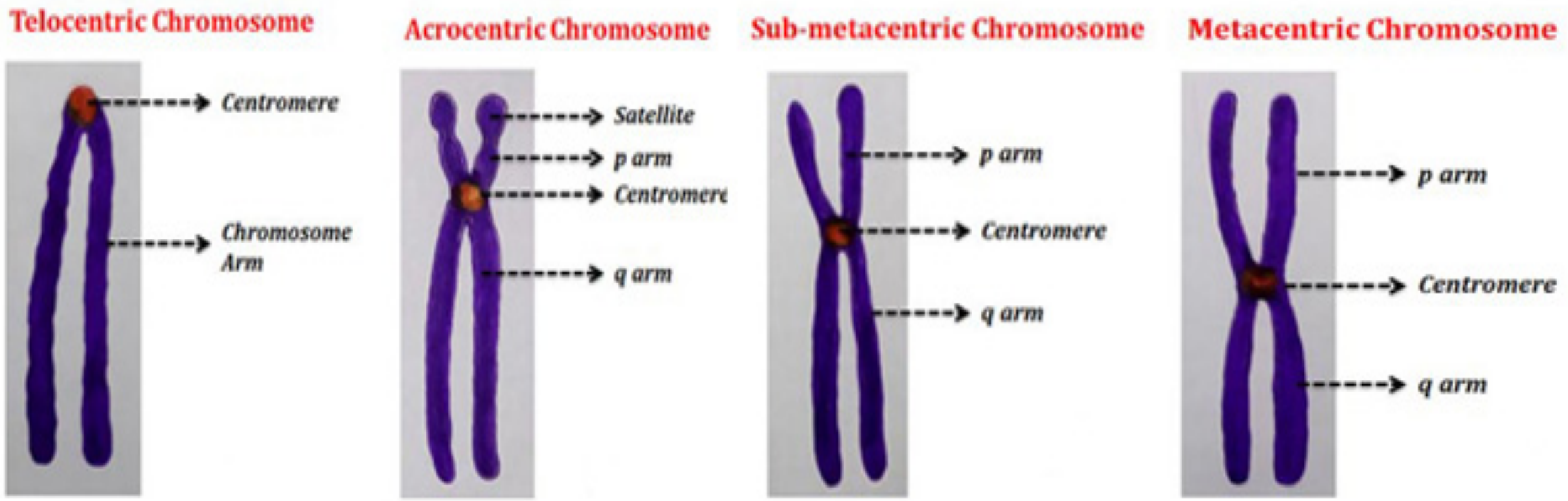
- Body chromosomes.
- Codes for traits that do not depend on your gender.
- EX. Hair, eye color, ear shape.

SEX CHROMOSOMES

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

Types of chromosomes

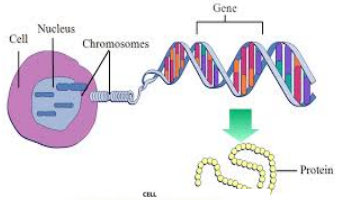
BASED ON THE POSITION OF CENTROMERE



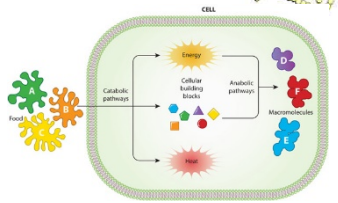
Functions of chromosomes

- Chromosomes contain genes and all the hereditary information is located in the genes.

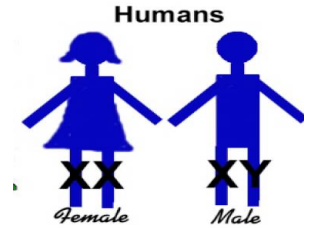
- Chromosomes control the synthesis of structural proteins and thus help in cell division and growth



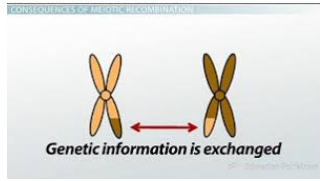
- They control cellular differentiation



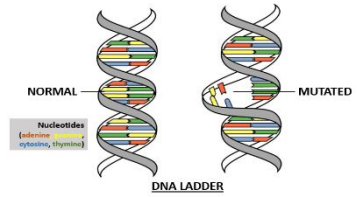
- By directing the synthesis of particular enzymes, chromosomes control cell metabolism
- Chromosomes form link between off springs and parents.



- Some chromosomes called as sex chromosomes determine the sex of the individuals
- Through the process of crossing-over, chromosomes introduce variations

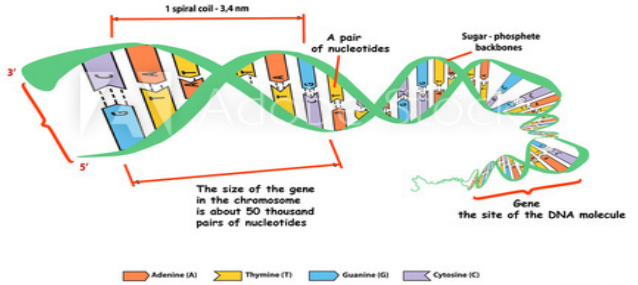


- Mutations are produced due to changes in gene chemistry.

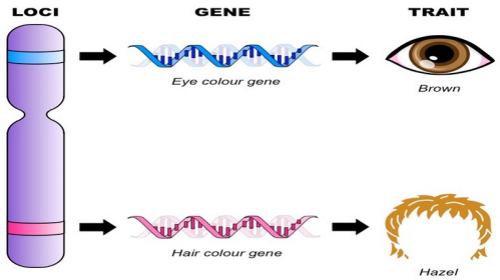


Genes

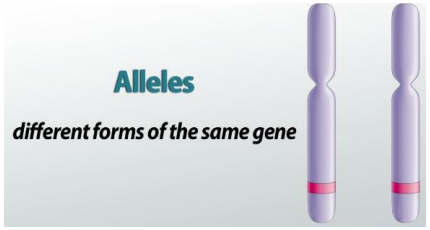
- A gene is a small section of DNA that contains the instructions for a specific molecule, usually a protein.
- The purpose of genes is to store information.



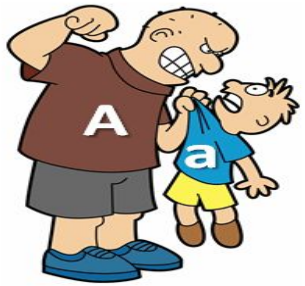
- Each gene contains the information required to build specific proteins needed in an organism.



- 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

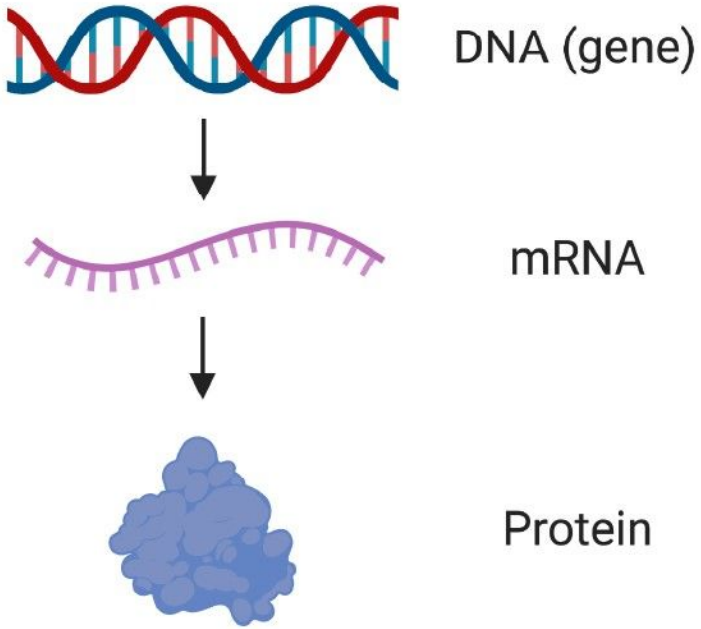


PHENOTYPE

- 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 .
- Proteins are the building blocks for everything in your body.
- Bones and teeth, hair and earlobes, muscles and blood, are all made up of proteins.



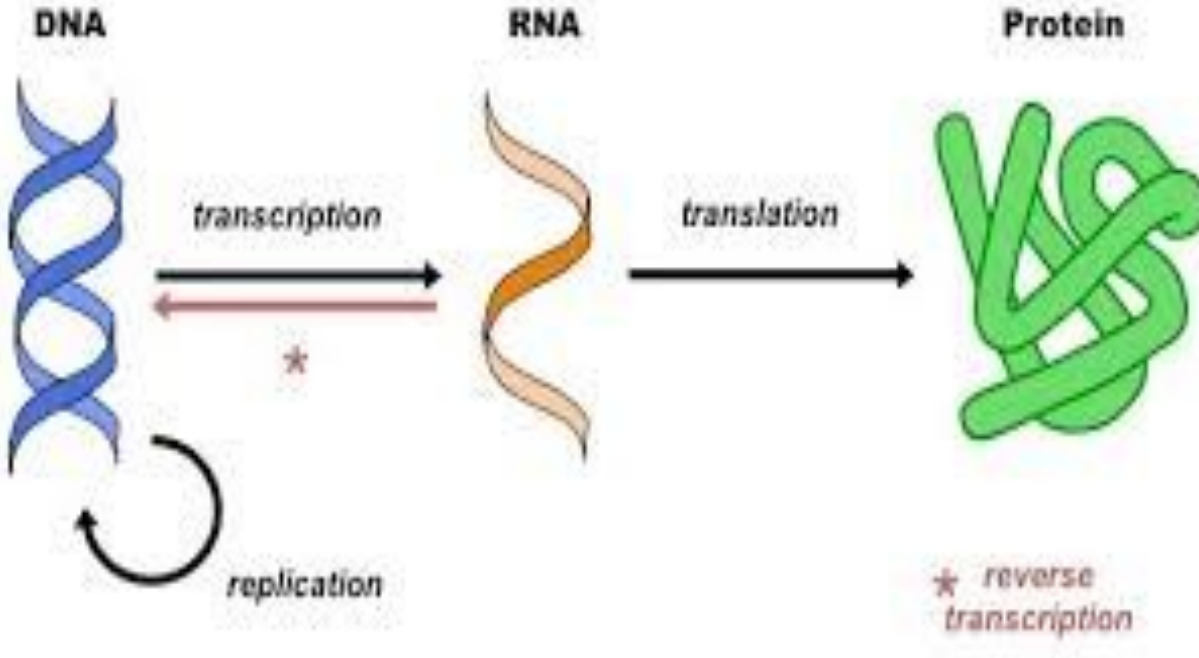
Questions

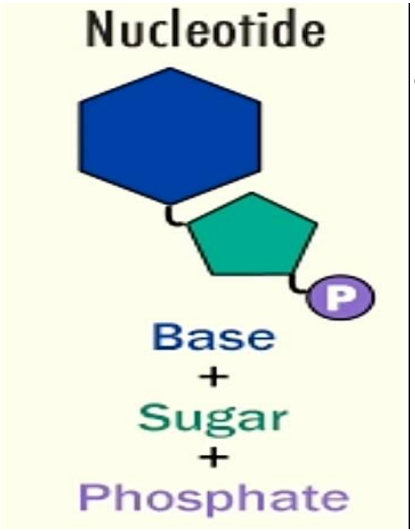
1. Define chromosomes and genes? What is the structure of chromosome?
2. What are the different types of chromosomes based on the position of centromere?
3. Explain sex chromosomes (allosomes) and autosomes?
4. What are the functions of chromosomes?
5. Define : Alleles, phenotype, geneotype, dominant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

Nucleic acid

- Nucleic acid are are biological molecules essential for life.
- Ex. For heredity and protein synthesis

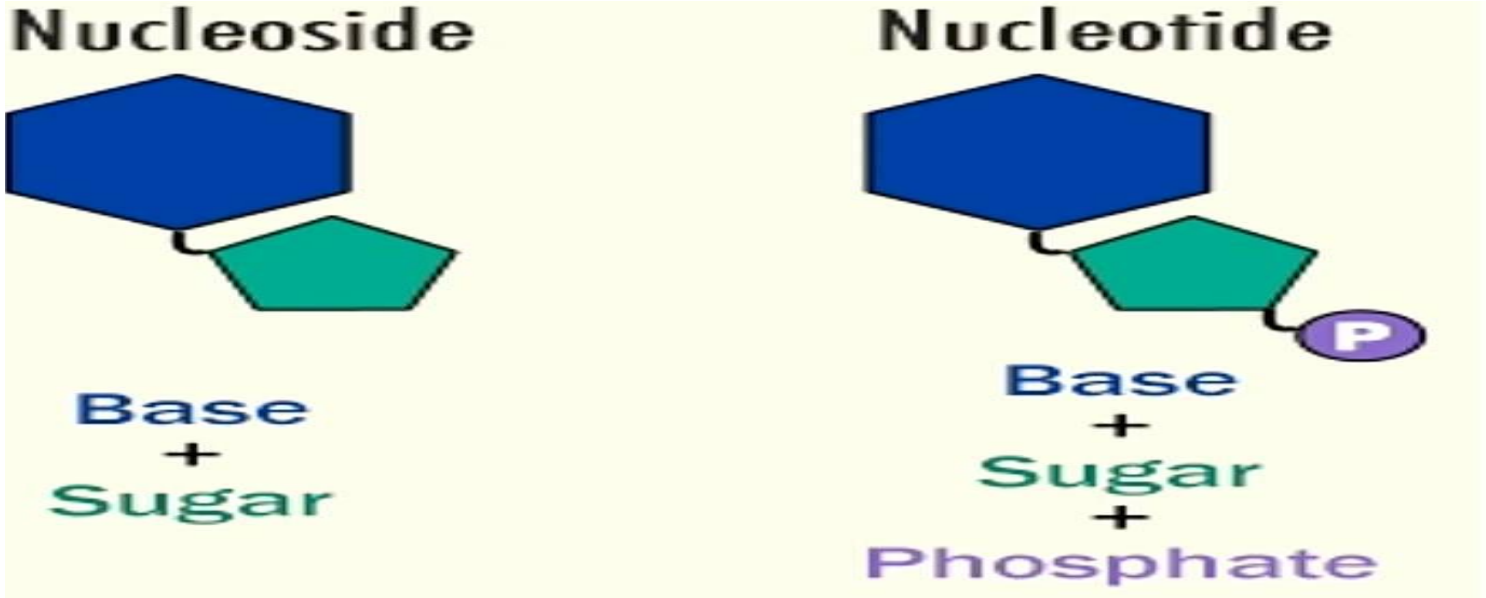
- There are two types of nucleic acid that are Deoxyribonucleic acid (**DNA**) and Ribonucleic acid (**RNA**)





- These are polymers consisting of long chains of **monomers** called **nucleotides**

NUCLEOSIDE / NUCLEOTIDE



- **Nitrogenous Base** (ATCG/ AUCG).
- **Pentose Sugar**. (In DNA, the sugar is 2'-deoxyribose. ... In RNA Ribose sugar)
- **Phosphate Group**.

Nitrogenous bases

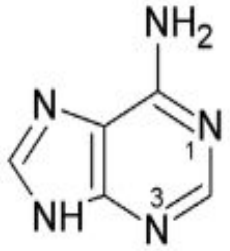
There are are the two categories of nitrogenous bases

- Purines : adenine & guanine
- Pyrimidines: cytosine & thymine

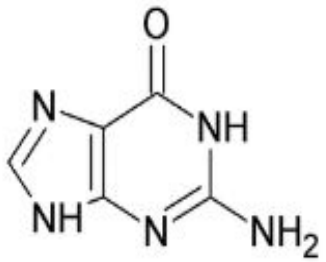
Nitrogenous bases in DNA and RNA

- 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

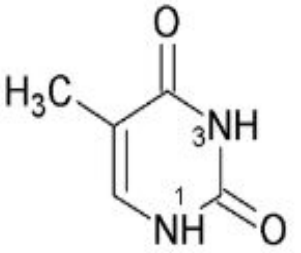


Adenine

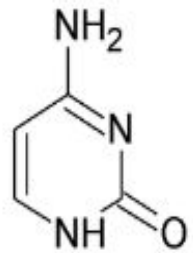


Guanine

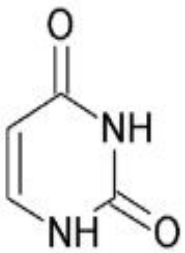
Pyrimidines



Thymine



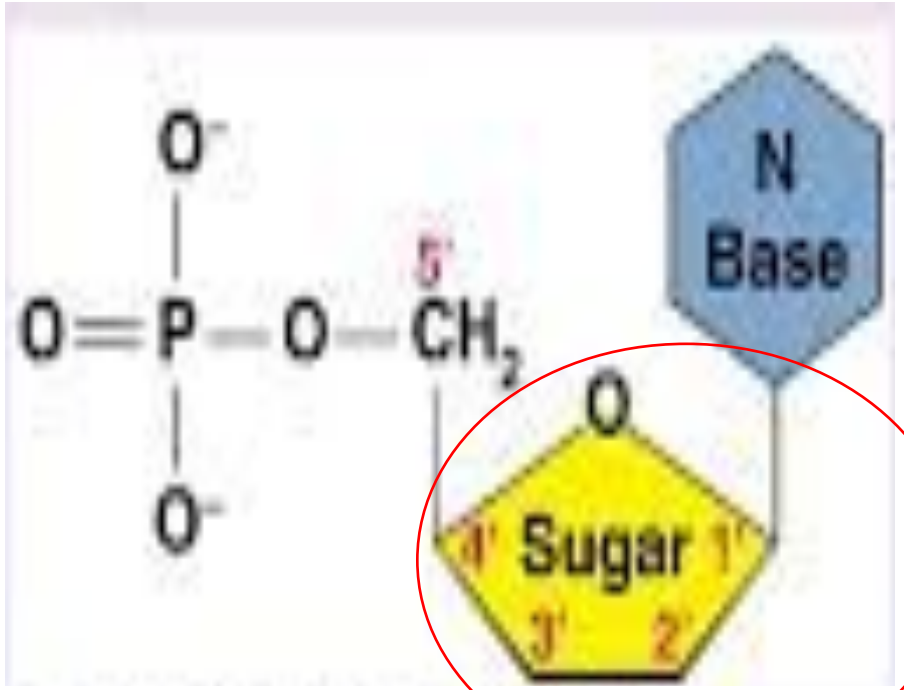
Cytosine

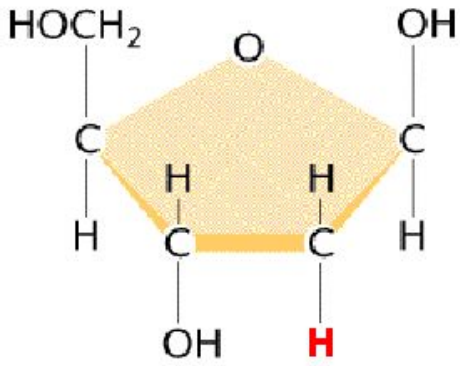


Uracil

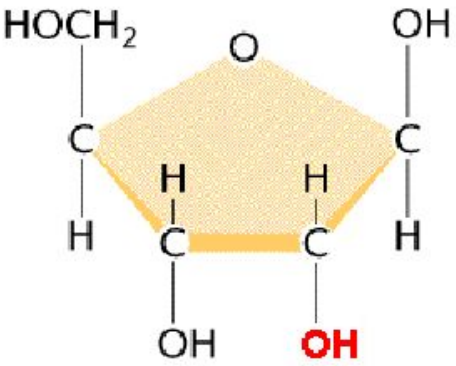
Sugar

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





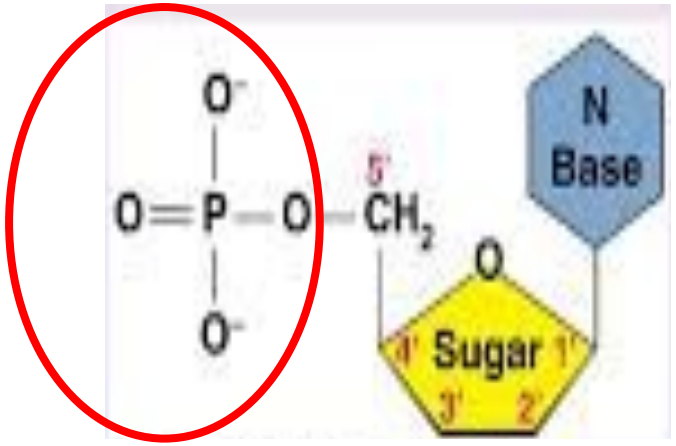
2-Deoxyribose



Ribose

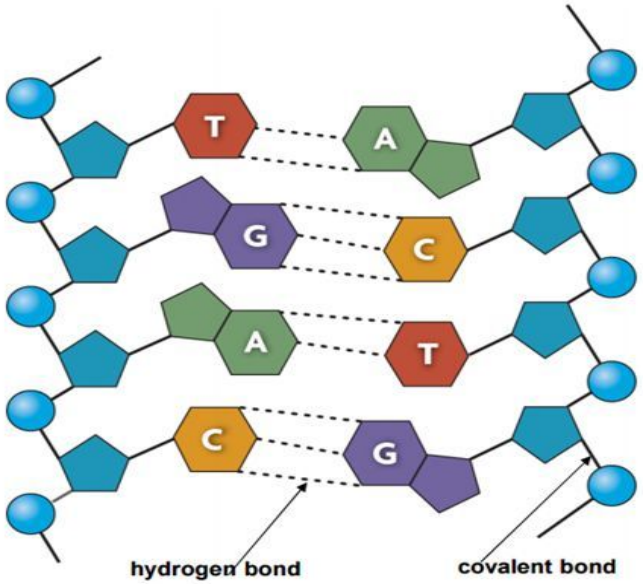
Phosphate Group

In DNA and RNA the backbone is composed of alternating sugar and **phosphate** groups



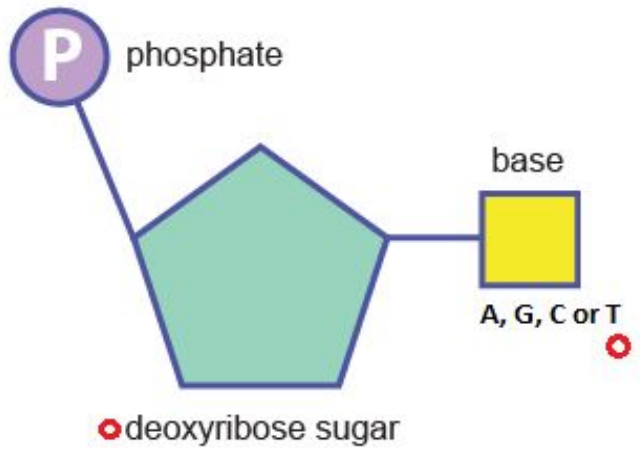
Bonds in DNA

- The backbone is connected by covalent bonds
- The bases are connected by hydrogen bonds

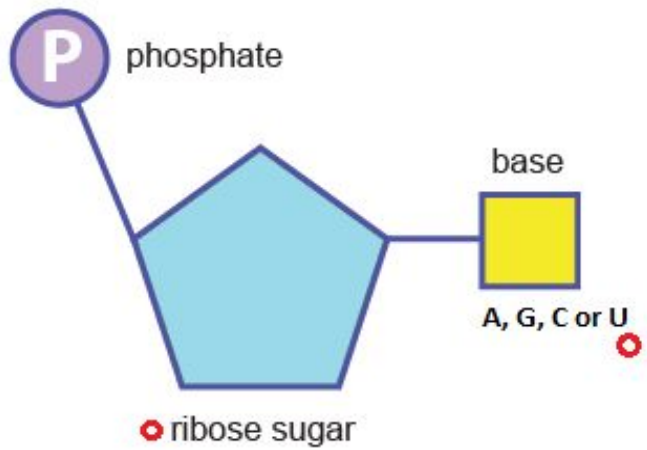


Difference between DNA and RNA are:

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

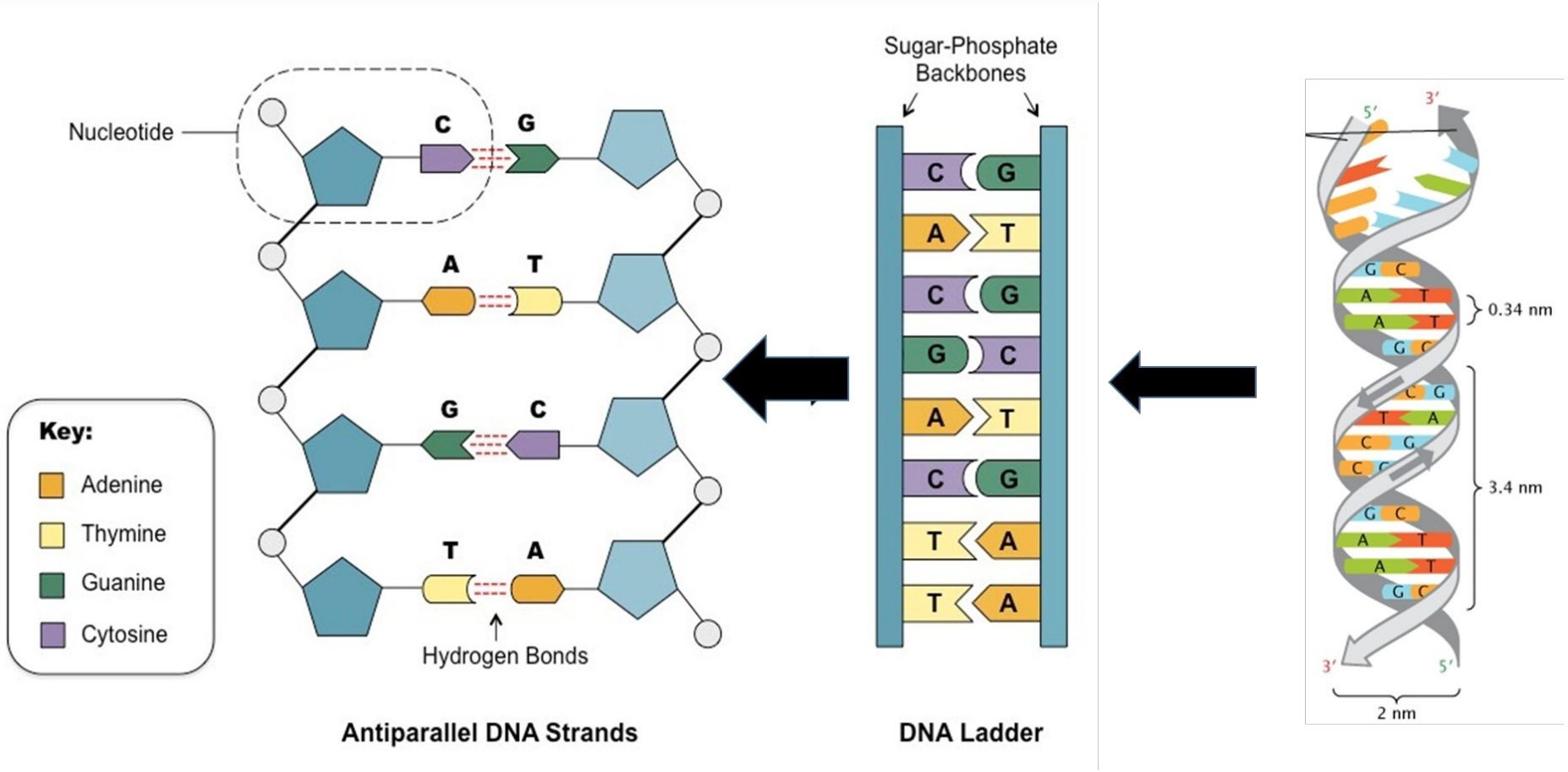
DEOXYRIBONUCLEIC ACID (DNA)

Frederick Griffith: In 1928 confirmed DNA is the genetic materials

Rosalind Franklin: In 1952 took various x ray photos of DNA

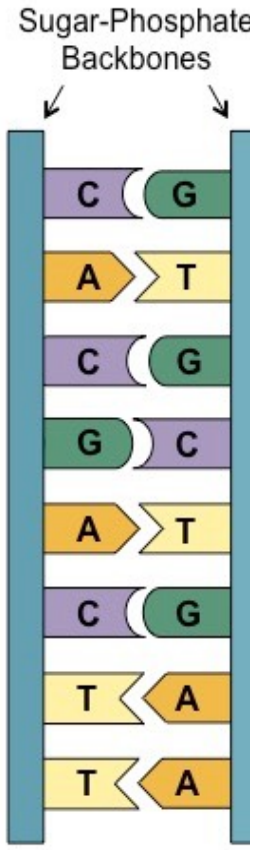
Watson and crick : In 1953 build the first model of DNA from Franklins X rays.

DOUBLE HEICAL STRUCTURE OF DNA



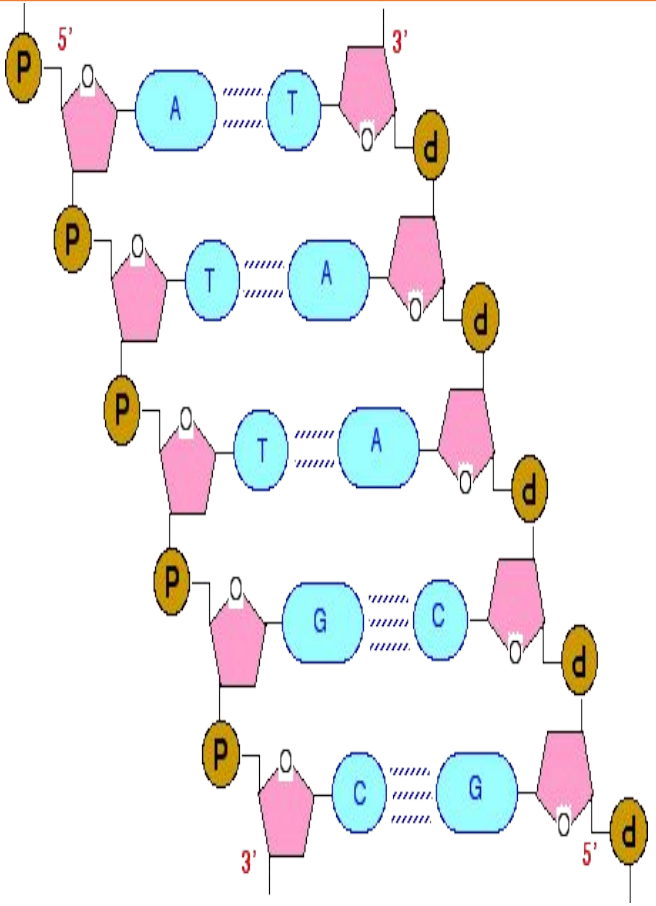
- The width(or diameter) of a double helix is 20 A °(2nm).
- Each turn (pitch)of the helix is 34A°(3.4nm) with 10 pairs of nucleotides, each pair placed at a distance of about 3.4 A °(0.34nm).

Salent features of double helical structure of DNA



DNA Ladder

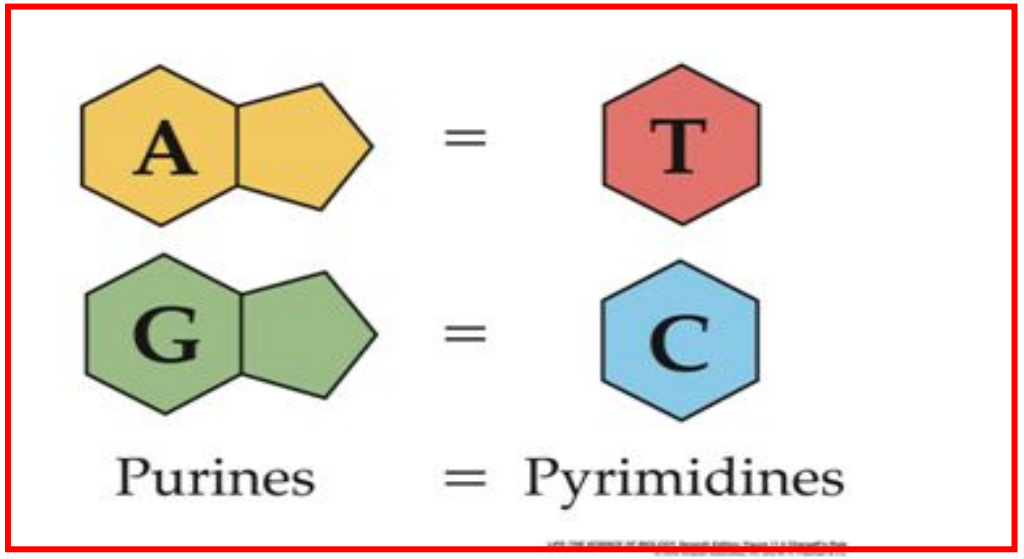
- The two strands are antiparallel i.e., one strand runs in the 5’ to 3’direction while the other in 3’ to 5’ direction.
- The two polynucleotide chains are not identical but complementary to each other due to base pairing.
- Each strand of DNA has a hydrophillic deoxyribose phosphate backbone on the 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.

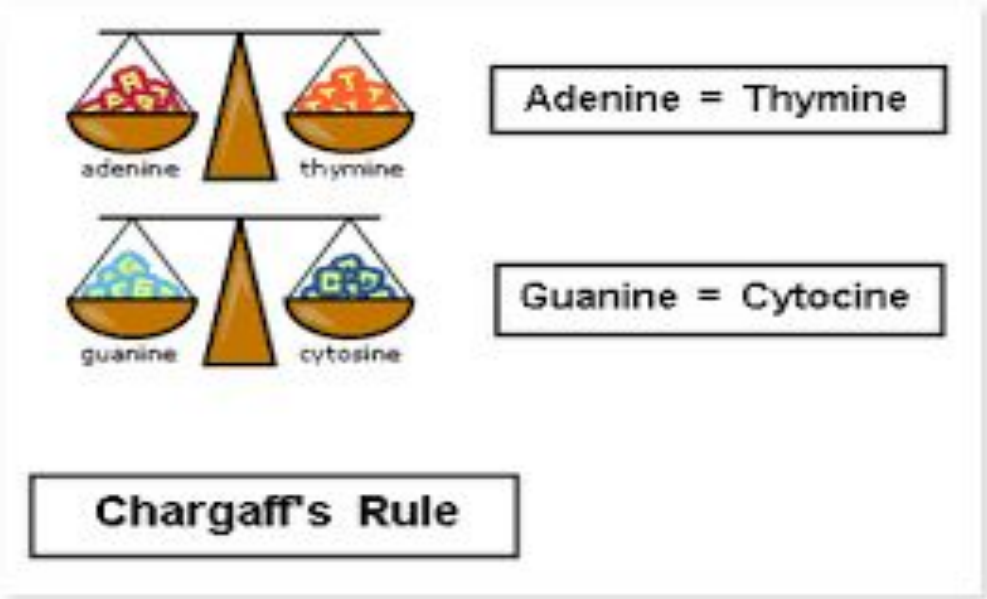


CHARGAFF'S RULE

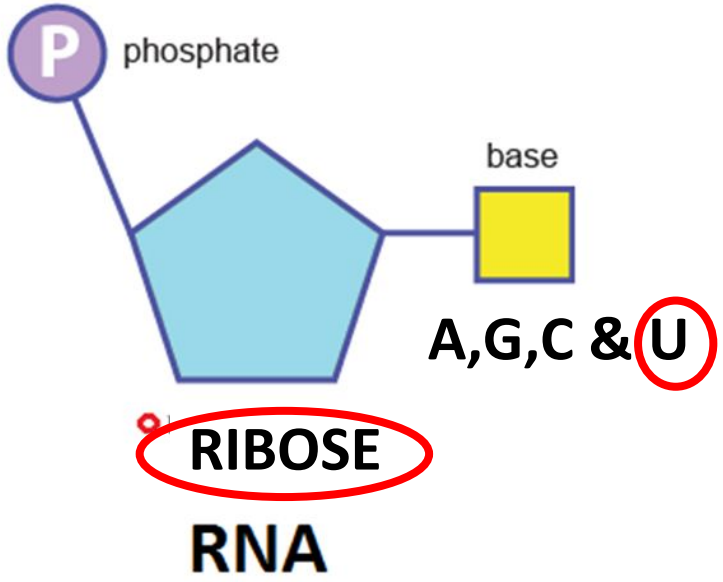
- Chargaff studied percentages of nitrogenous bases (1950)
- Percentage of guanine and cytosine are almost equal
- Percentages of adenine and thymine are almost equal
- Chargaff's Rule supports idea that Adenine (A) bonds to Thymine (T) and Cytosine (C) bonds to Guanine (G)

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



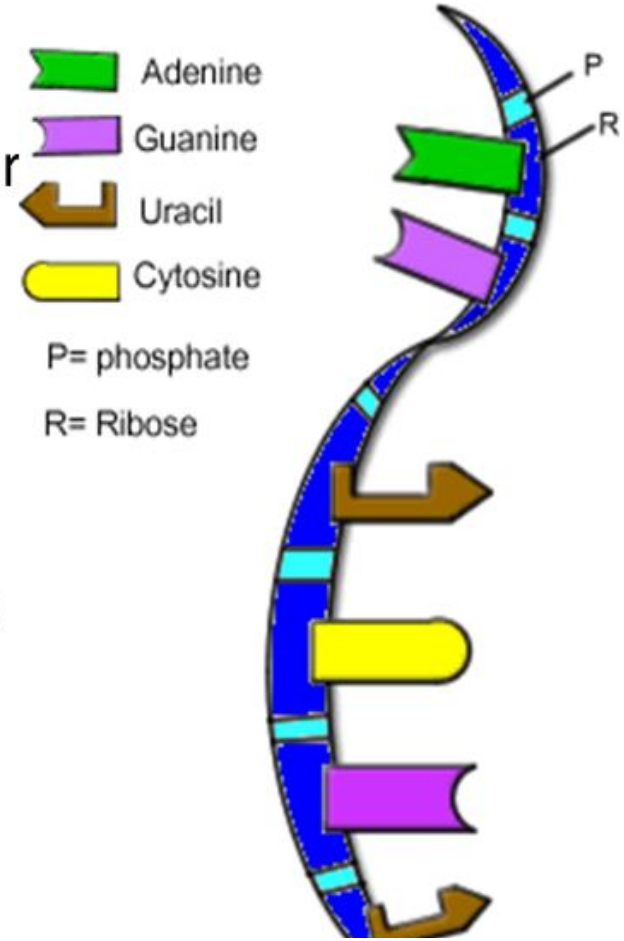


RIBONUCLEIC ACID (RNA)



(Similar to DNA with several key differences)

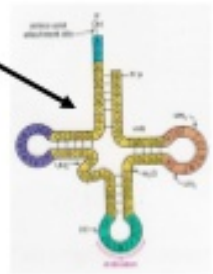
- Made up of a repeating strand of nucleotides, contains all 3 parts similar to DNA (sugar, phosphate, nitrogen base)
- The sugar in RNA is called Ribose
- Contains the nitrogen base Uracil instead of Thymine. Uracil will bind to Adenine (like thymine did)
- RNA is single strand



Types of RNA

mRNA	tRNA	rRNA
"messenger"	"transfer"	"ribosomal"
made using DNA	<u>transfers</u> an amino acid to the growing protein	makes up the bulk of ribosomes
carries genetic info from the nucleus to the ribosome	cloverleaf shape	
every 3 bases (codon) specifies an amino acid	3 complimentary bases (anticodon) binds to the mRNA codon	

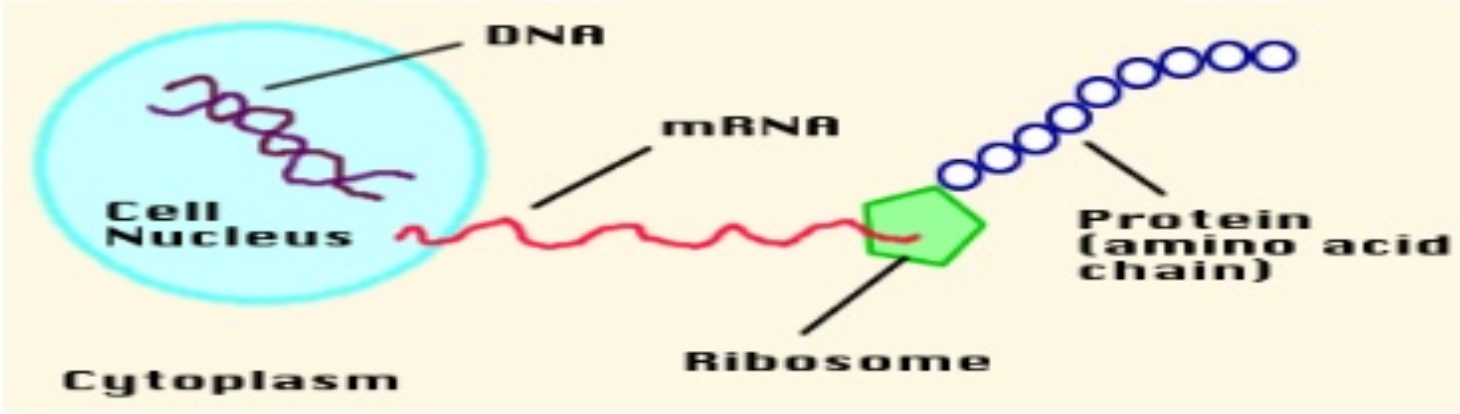
Messenger RNA
Carries instructions for polypeptide synthesis from nucleus to ribosomes in the cytoplasm.



Ribosome

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

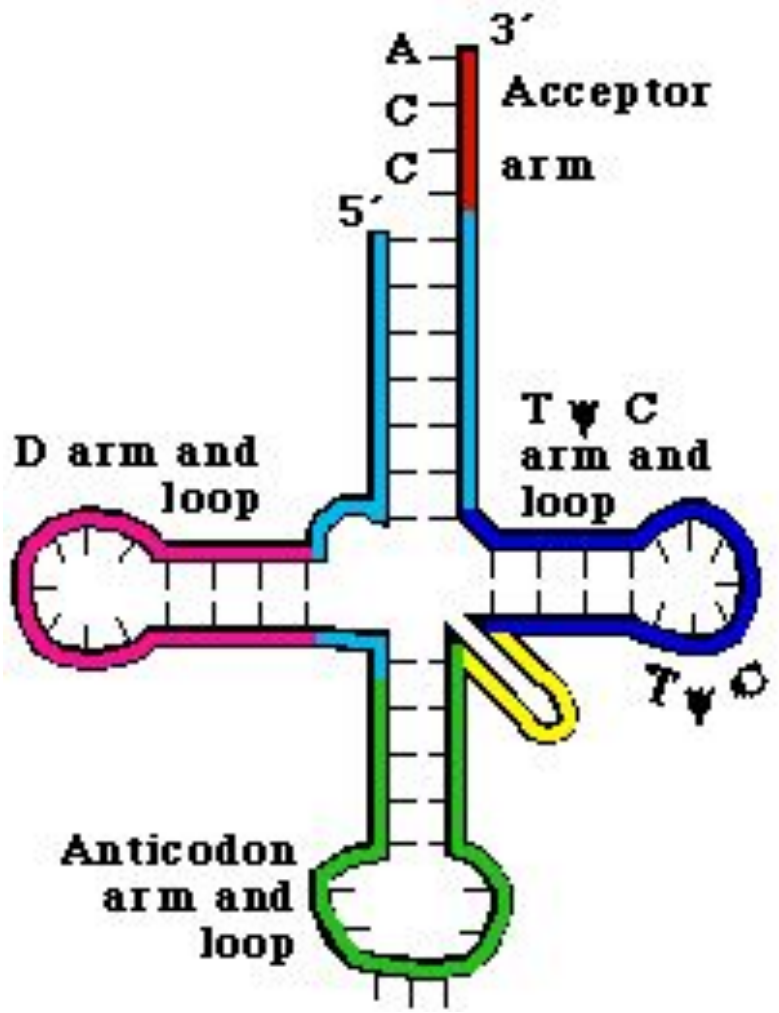
MESSENGER RNA (mRNA)



- Comprises only 5% of the RNA in the cell
- Most heterogeneous in size and base sequence
- All members of the class function as messengers carrying the information in a gene to the protein synthesizing machinery

Remember: Small enough to leave the nucleus. DNA is too big!

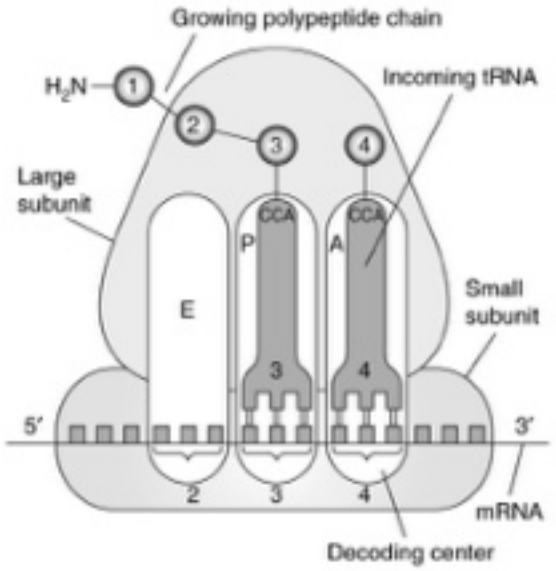
TRANSFER RNA (tRNA)

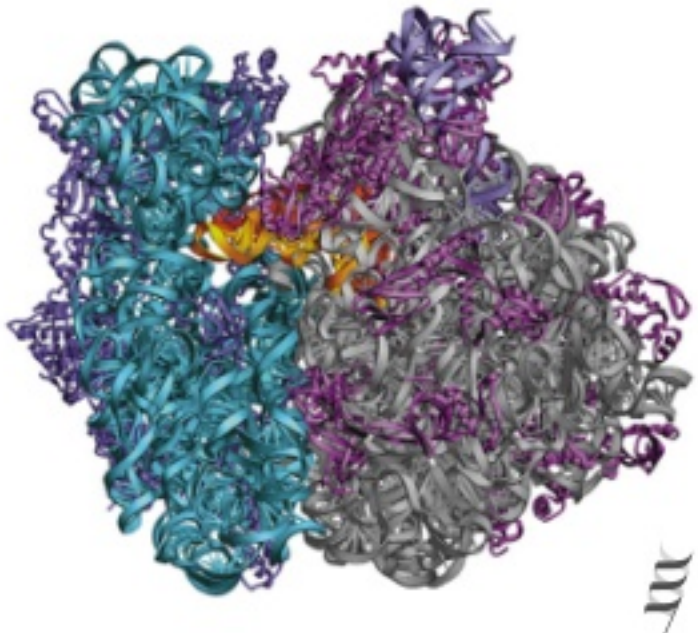


RIBOSOMAL RNA (rRNA)

rRNA

Ribosome= 60 % rRNA and 40 % proteins





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 and example?
6. What are the functions of different types of RNA?