Third UG – Botany

Fifth Semester

Paper V

Cell Biology, Genetics and Plant Breeding

Unit 1
Cell Biology

Lesson 2
Cell wall

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Completed Lesson

Unit 1 - Lesson 1 (The cell)

1. Introduction
2. Prokaryotic and eukaryotic cells
3. Structure of plant cell
4. Nucleus

objectives

1. To learn the structure of plant cell wall.

2. To understand the chemical nature of cell wall.

3. To know the fine structure of cell wall.

4. To learn the function of the cell wall.

Structure of the Lesson

1. Introduction
2. Structure of cell wall
3. Thickness of cell wall
4. Pits
5. Chemical nature of cell wall
6. Fine structure of the cell wall
7. Functions of the cell wall

Introduction

1. One of the characteristic features of the plant cell is the presence of cell wall.

2. It provides rigidity to the plant body.

3. It protects the protoplasm from external injury and prevents the movement of water into the cell.

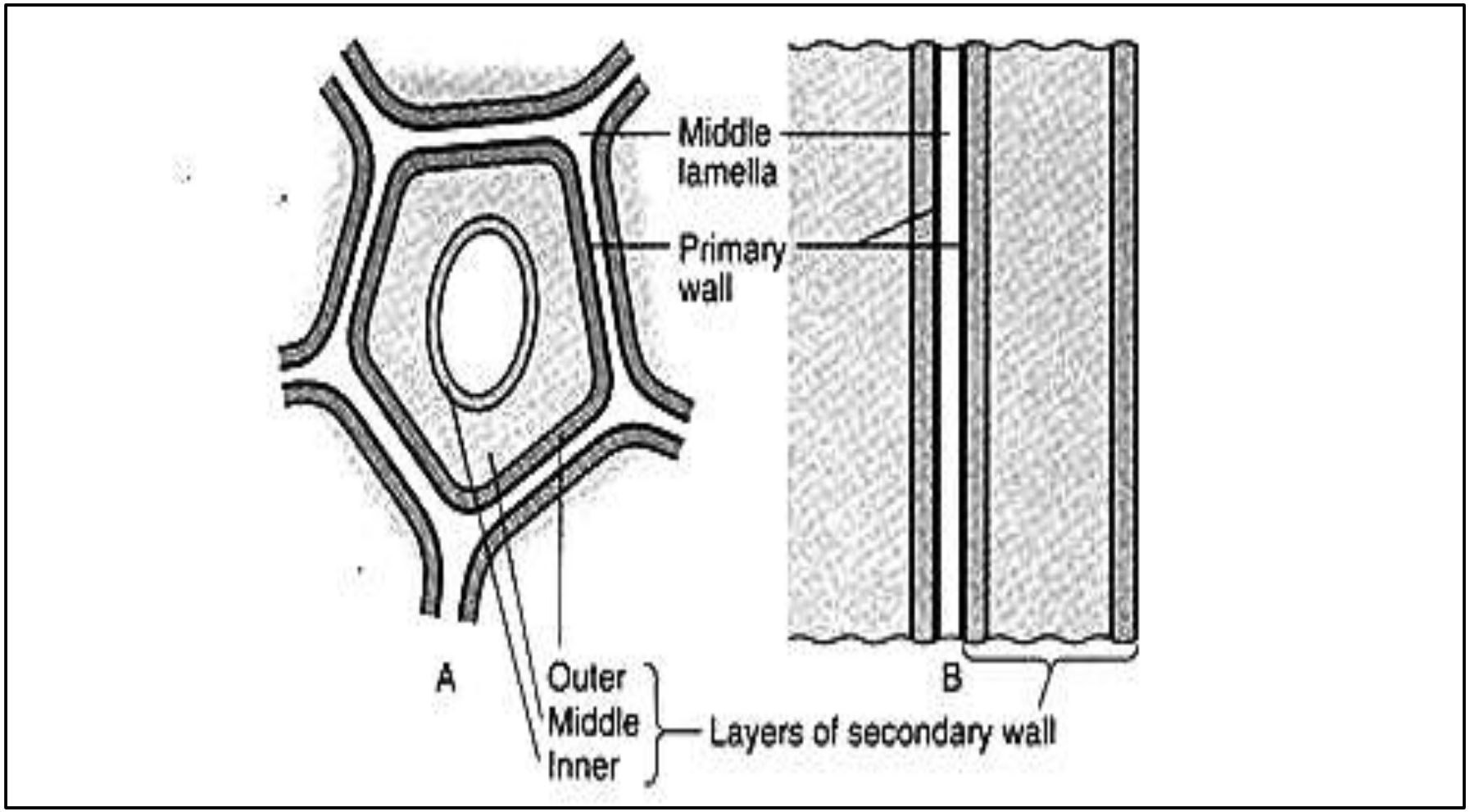
Cell wall structure
cell wall layers

Cell wall layers

In all higher plants the cell wall shows differentiation into the following **four layers -**

1. Middle lamella
2. Primary cell wall
3. Secondary cell wall
4. Tertiary cell wall (occasionally)

Structure



A) Arrangement of various layers of cell wall in a mature plant cell.

B) A portion of enlarged cell wall.

Layer 1: Middle lamella

1. The middle lamella is formed between adjacent cell walls during cell division.
2. It consists of a comparatively thin layer of intercellular material.
3. It is a jelly – like structure and acts as a cementing material between the primary cell walls of adjacent cells.
4. The middle lamella is made up of **pectin, cellulose and calcium.**
5. **Pectin is a hydrophilic** colloidal substance.

Layer 2: Primary Cell Wall

1. The primary cell wall is formed during the early stages of growth and development.

2. It is composed of **cellulose, hemicelluloses, polysaccharides and many other pectic substances.**

3. The primary cell wall is elastic and undergoes extension with the growth of the cell.

4. In many roots, fleshy stems, fruits and leaves, the cells contain only the primary cell wall and the middle lamella .

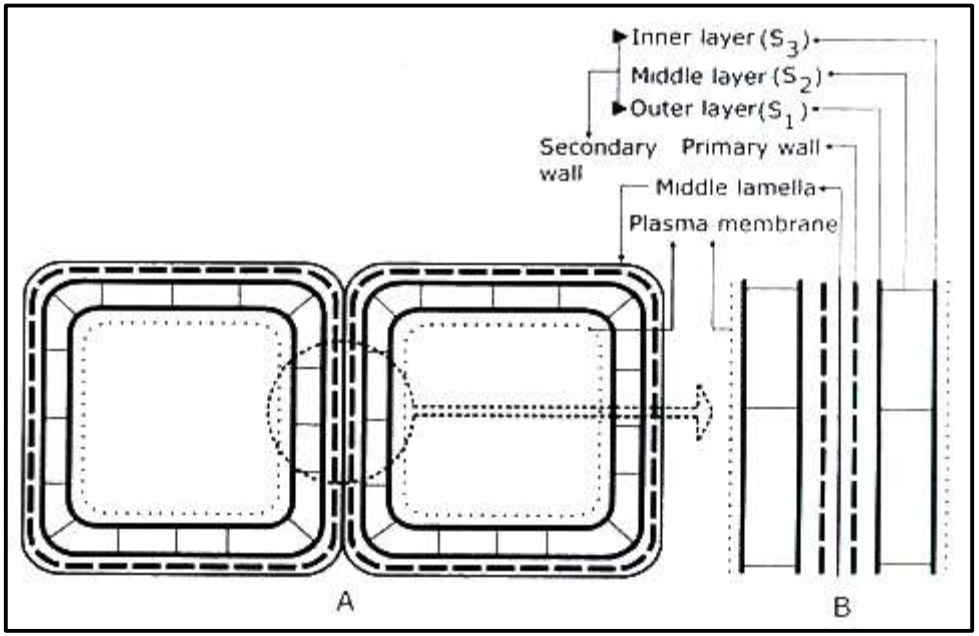
Layer 3: Secondary cell wall

1. It is found only in certain mature and highly specialized cells.
2. Some cells deposit additional layers on the inner surface of the primary wall and this layer is the secondary cell wall.
3. After the formation of secondary cell wall the protoplasm disappears in many cells.
4. The secondary cell wall is usually made up of **cellulose, hemicellulose and polysaccharide.**
5. During maturity, substances like lignin, suberin, waxes, tannins and calcium carbonate are also deposited on the secondary wall.
6. It gives high mechanical strength to the plants.

Sub layers in Secondary cell wall

7. The secondary cell wall commonly has three layers.
    - Outer layer (S1)
    - Middle layer (S2)
    - Inner layer (S3)
8. Among these, the middle layer is usually the thickest.

A) **Diagram illustrating the primary and secondary cell walls between adjacent cells**
B) A portion of the enlarged cell wall.



Layer 4: Tertiary Cell Wall

1. In some tissues a tertiary cell wall is formed on the inner surface of the secondary cell wall.
2. This layer is very thin and is found in the **xylem, tracheids of Gymnosperms.**
3. It is composed mainly of **xylan, instead of cellulose.**

Thickenings of the Cell Wall

Thickenings of the Cell Wall

1. Generally the wall materials are deposited uniformly throughout the cell.

2. But in some cases (**trachery elements**) they are localized to certain areas on the cell wall and show special patterns.

3. These thickenings provide mechanical support to the cell and usually develop when the cell has attained its full size.

Wall thickening - Types

1. **Annular:** The lignin is deposited in the form of rings on the interior of the primary cell wall.
2. **Spiral:** The thickenings occur in a spiral or spring - like manner.
3. **Scalariform:** The lignin is deposited in a ladder - like manner.
4. **Reticulate:** The lignin is deposited in such a manner that an irregular network is formed.
5. **Pitted:** The wall material is deposited throughout the wall except at some small areas, known as **pits.**

a) Annular, b) Spiral, c) Scalariform, d) Reticulate, e) Pitted (i. Simple, ii. Bordered).

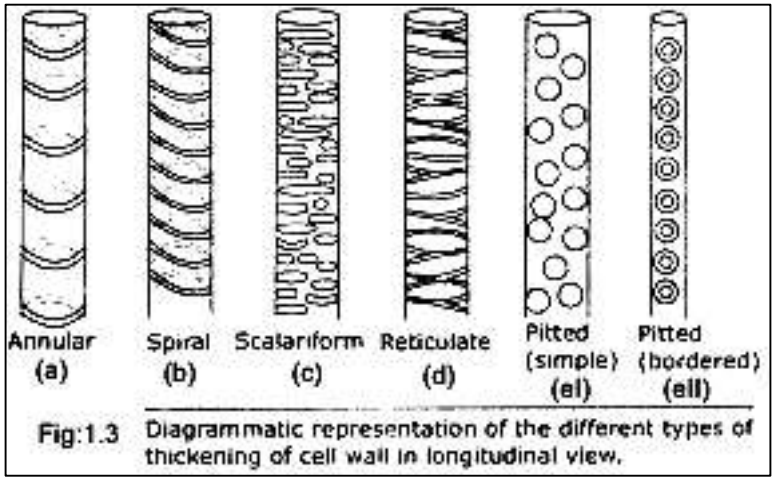


Fig:1.3 Diagrammatic representation of the different types of thickening of cell wall in longitudinal view.

Pits
Primary pit fields
primary pits
Pit types

Primary pit fields and primary pits

Primary pit fields:

1. Primary pit fields are found in cells which contain only the primary cell wall.
2. In certain areas the primary cell wall is thin and contains a group of pores. These areas are called as the primary pit fields.

Primary pits:

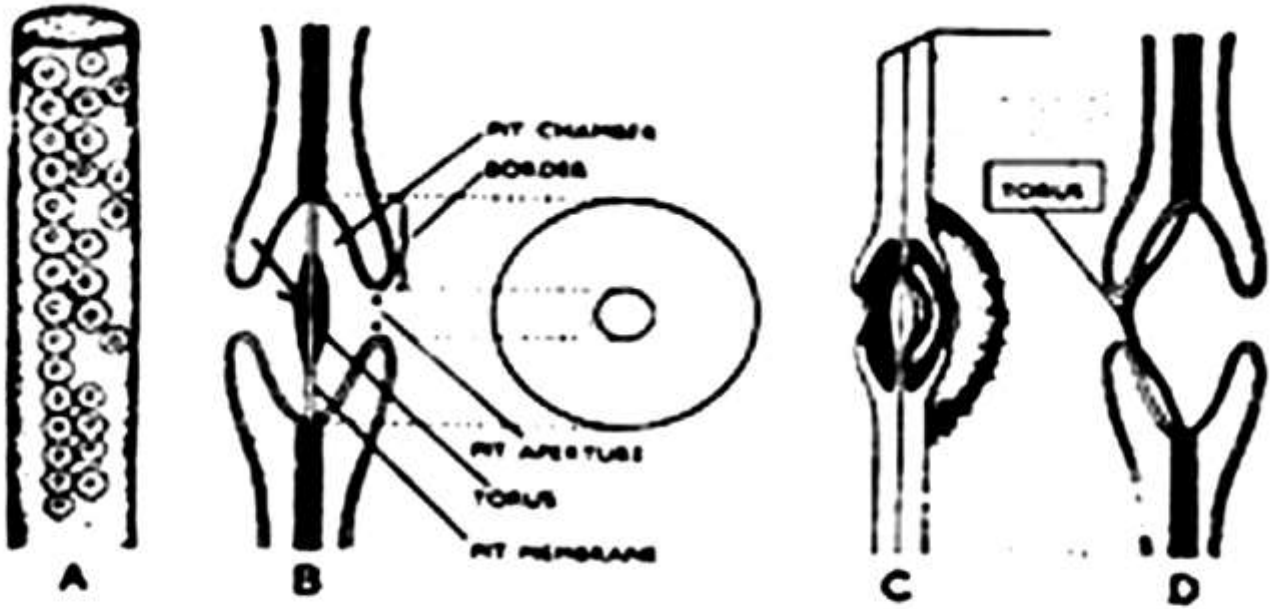
1. Some plants the secondary cell wall has depressions or cavities called pits. Pits are usually found in non-living cells like tracheids and fibres, whose function is conduction and support.
2. Pits are of two types - Simple pits and Bordered pits

Pits types

Pits are of two types - Simple pits and Bordered pits

1. B**ordered pit:** In this type the secondary cell wall projects over the cavity of the pit, enclosing a pit chamber, which opens outside through a pit aperture.
2. **Simple pit** there is no projecting margin.
3. Adjacent pits are separated by the middle lamella and the primary cell wall, which together form the **pit membrane**.
3. The pit membrane may have a thickening called the **torus**, which is formed by circular deposition of microfibrils.
4. The part of the membrane surrounding the torus is called the **margo.**
5. Margo has small openings through which aqueous substances flow from one cell to another.

Diagrammatic representation of a pit with torus



A. A vessel with bordered pit in front view. B. Same in sectional view C. Perspective diagram of the same D. Sectional view of bordered pit with changed position of torus

The pit membrane usually has a thickening called torus.

Origin and growth of the cell wall

Origin and growth of the cell wall

Stages

Stage 1:

New cell wall formation takes place during cell division at the time ofcytokinesis.

Stage 2:

A barrel – shaped body called the **phragmoplast** appears in the region of equatorial plate of the dividing mother cell.

Stage 3:

The microtubules of mitotic spindle pass through the phragmoplast.

Stage 4:

The small vesicles coming from the ER migrate to the equatorial plate and fuse with one another to form a discontinuous membrane called **cell plate**, inside the phragmoplast.

Stage 5:

The cell plate enlarges and soon reaches the side walls of the dividing mother cell. At this stage, the viscosity of the cell plate becomes higher and **on both sides thin lamella** are laid down by the daughter protoplasts.

Growth of cell wall - stages

Stage 6:

These lamella are the precursors of **primary walls** of daughter cells.

Stage 7:

The cell plate gradually undergoes changes to form the **middle lamella.**

Stage 8:

The secondary wall develops later on by the deposition of cellulose, hemicelluloses and pectin beneath the primary cell wall.

Stage 9:

The cell wall increases both in length and thickness.

The growth in length takes place by '**intussusception'** method.

The increase in thickness takes place by the method of '**apposition'.**

Intussusception& apposition growth

1. **Intussusception** is **growth** by deposition of new materials between existing components of cell walls. Cell elongation also occurs through **intussusception**.
2. In **apposition**, new wall layers are laid and **growth** of wall in new cells occurs.

Chemical composition
(or)
Molecular organization of the cell wall

Chemical composition of the cell wall

The plant cell wall is composed of a variety of polysaccharides, proteins, lignins, hemicelluloses and other compounds including mineral deposits.

1. **Cellulose:**

   a) The main chemical component of the cell wall is cellulose which is one of the substances present in abundance on the earth.

   b) Each cellulose molecule consists of at least 500 glucose molecules.

   c) Cellulose is a polymer of D-glucose Units interlinked by -1, 4 Glycosidic bonds.

   d). It is the simplest polysaccharide which makes up about 50 percent of the total plant material by weight.

2. **Hemicellulose:**

   a) It comprises of a group of n-cellulose polysaccharides.

   b) They include monosaccharide units such as arabinose, xylose, mannose and galactose.

Chemical composition of the cell wall

3. Pectins:

a) Pectins are located in the middle lamella and the outermost layer of the secondary wall.

b) They are the derivatives of polygalacturonic acids.

4. Lignins:

a) Lignins make up about 25 percent of the dry weight of a tree.

b) Lignin is a polysaccharide derivative having a complex structure.

c) It is characterized by having aromatic alcohols of high molecular weight such as hydrophenyl propane.

d)Lignin gives strength to the cell wall. It also resists fungal/pathogen attack.

e).Lignification of cell wall usually begins in the middle lamella and then proceeds to primary and secondary cell walls.

Chemical composition of the cell wall

5. Cutin, wax and suberin:

A variety of lipids are associated with the cell wall for strengthening and to check the evaporation of water from the plant body.

Usually cutin forms a continuous layer, the cuticle.

Cutin and waxes are synthesized and secreted on to the surface by the epidermis.

Suberin occurs in association with cellulose, mostly in the cork cells of the periderm and casparian strips in the walls of the root cells.

Fine structure of the cell wall

Fine structure of the cell wall

- Electron microscopic studies have revealed that cellulose in the cell wall **occurs in the form of fine strands or macrofibrils**, which are arranged in a more or less regular fashion.
- The macrofibrils are about 0.5 in thickness and about 1 long.
- Each macrofibril is composed of approximately **250 microfibrils of 25 nm or 250 A^0 thick.**
- Each microfibril in turn consists of small aggregates which are known as **micelles or elementary fibrils.**
- Each micelle is made up of 100 parallely arranged **cellulose chains**.
- **Each cellulose chain is a polymer of D-Glucose units linked by -1, 4 Glycosidic bonds.**

Fine structure of the cell wall

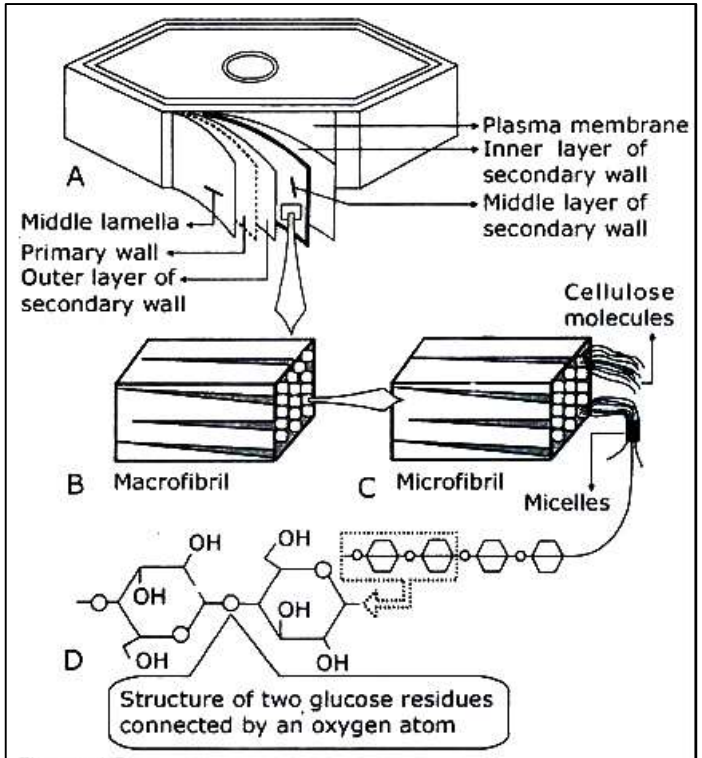


Figure 1.5

Diagram illustrating the structure of cell wall of a fibre. A. Diagrammatic representation of cross section of fibre in three dimensional view showing middle lamella, the primary wall and three layers of secondary wall. B. Macrofibril from a portion of the middle layer of secondary wall. C. Microfibril from a portion of macrofibril.

Functions of the cell wall

- The plant cell wall provides definite shape, strength and rigidity.
- It also provides protection against mechanical stress and physical shocks.
- It helps to control cell expansion due to the intake of water.
- Also helps in preventing water loss from the cell.
- It is responsible for transporting substances between and across the cell.
- It acts as a barrier between the interior cellular components and the external environments.
- It acts as a structural skeleton for the plant.

Stay home – Stay safe


THANK YOU

Third UG – Botany

Fifth Semester

Paper V

Cell Biology, Genetics and Plant Breeding

Unit II
Genetic material

Lesson 1
DNA as genetic material

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Structure of today's Lesson

1. Introduction
2. DNA as genetic material
3. Transformation

    a) Griffith experiment

    b) Oswald Avery, Colin Macleod and Maclyn McCarty experiment

4. Bacteriophage Infection

    a) Hershy and Chase experiment

Objectives

1. To understand DNA as genetic material.
2. To understand experiments in support of DNA as the genetic material.

Role of DNA in heredity

- It is commonly known that DNA is the genetic material.
- In fact, for many decades, scientists thought that proteins found in chromosomes were the molecules that carry genetic information and did not know that DNA was the heredity material.
- Scientists have carried some experiments to identify the DNA as the carrier of genetic information.

DNA as genetic material

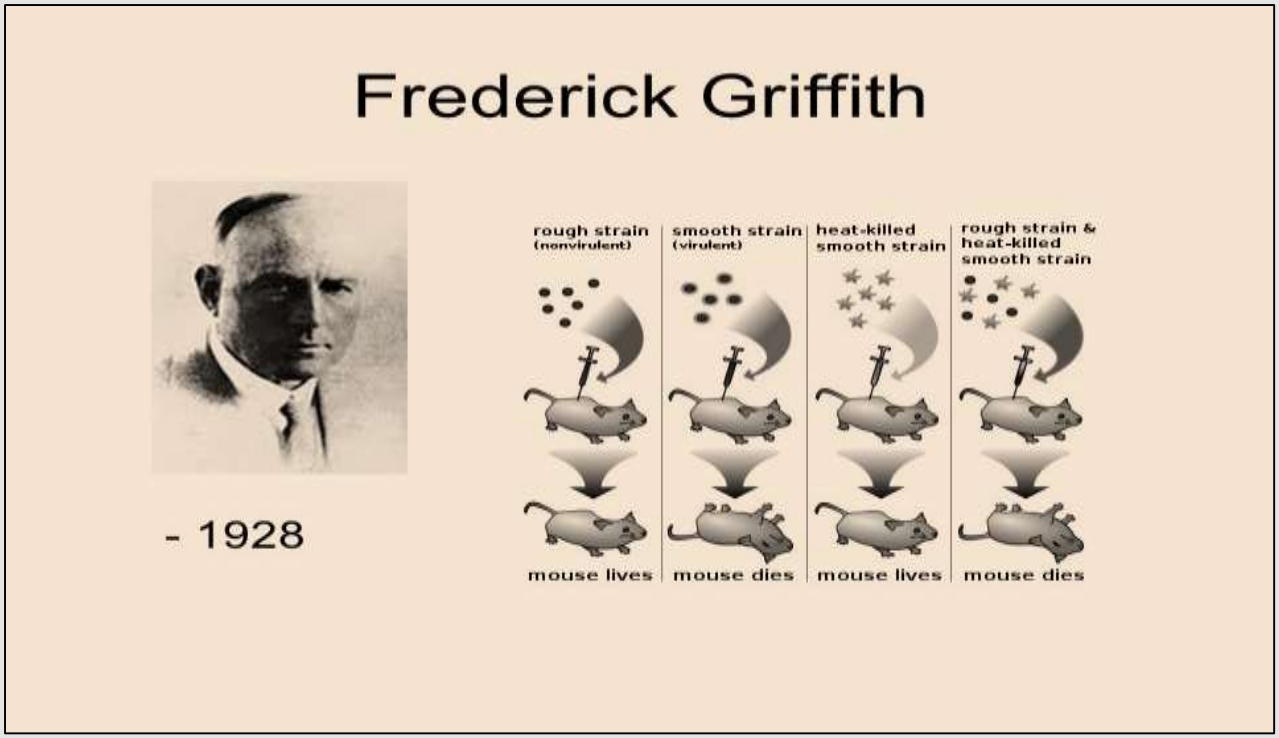
There are some experiment evidences which prove that in most of the organisms DNA is the genetic material and only in some viruses RNA is the genetic material. These experiments include:

- Transformation of bacteria (Griffith)
- Bacteriophage infection (Hershy and Chase convince evidence that DNA is genetic material)
- Transduction
- Biochemical evidences

Transformation

The genetic recombination in which naked DNA from one cell can enter and integrate in another cell is known as genetic transformation.

Griffith expts. of transformation



Griffith systematic experiments with ***Diplococcus pneumonia*** gave a clue that a chemical substance was responsible for genetic transformation.

Frederick Griffith Experiment: Bacterial transformation

- In 1928, British bacteriologist Frederick Griffith conducted a series of experiments using ***Streptococcus pneumoniae*** bacteria and **mice**.
- In his experiments, Griffith used two related strains of bacteria, known as R (rough- without capsule) and S (with a capsule).

Experiment 1: R strain

- **R strain:** When grown in a petri dish, the R bacteria formed colonies, or clumps of related bacteria, that had well-defined edges and a rough appearance (hence the abbreviation "R").
- He selected R_2 strain for his experiments.
- The R bacteria were non – virulent (non – pathogenic), meaning that they **did not cause sickness w**hen injected into a mouse.

Experiment 2: S strain

- S bacteria formed colonies that were rounded and smooth (hence the abbreviation "S").
- The smooth appearance was due to a polysaccharide, or Sugar based, coat produced by the bacteria.
- This coat protected the S bacteria from the mouse immune system, making them virulent (capable of causing disease).
- He selected S3 strain for his experiments.
- Mice injected with live S bacteria **developed pneumonia and died.**

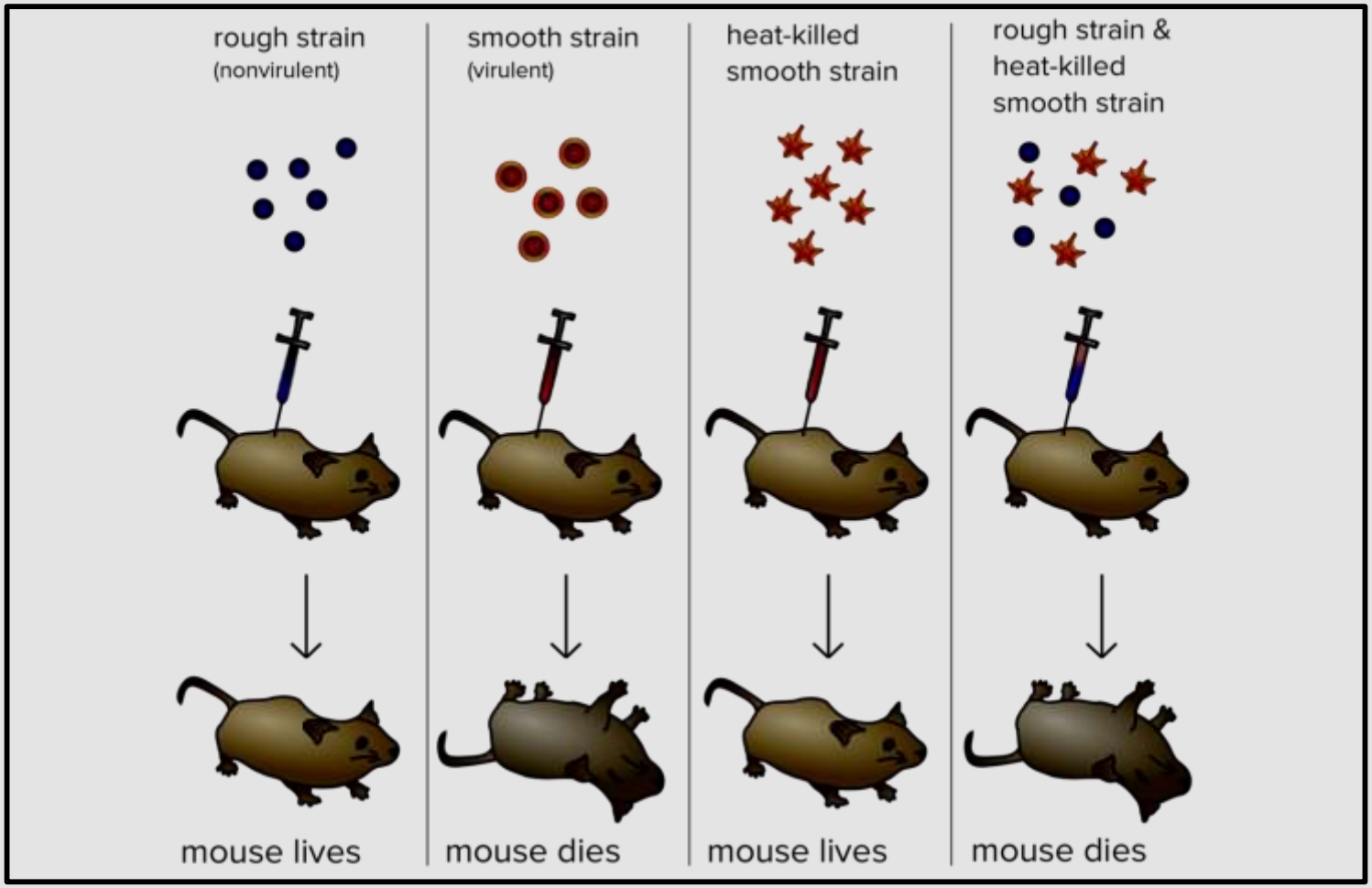
Experiment 3: Heat killed S strain

- As part of his experiments, Griffith tried injecting mice with heat-killed S bacteria (that is, S bacteria that had been heated to high temperatures, causing the cells to die).
- Unsurprisingly, the heat-killed S bacteria did not cause disease in mice.
- The experiments took an unexpected turn .

Experiment 4: Heat killed S strain

- In his 4th expt. harmless R bacteria were combined with harmless heat-killed S bacteria and injected into a mouse.
- He observed that the mouse develop pnenumonia and die.
- When Griffith took a blood sample from the dead mouse, **he found that it contained living S bacteria!**

Griffith experiment



Conclusion of Griffith experiments

- Griffith concluded that the R-strain bacteria must have taken up what he called a "**transforming principle"** from the heat-killed S bacteria, which allowed them to "transform" into smooth-coated bacteria and become virulent.

Draw back of Griffith experiment

- Griffith experiment was a turning point towards the discovery of hereditary material.
- However, it failed to explain the biochemistry of genetic material.
- Hence, a group of scientists, Oswald Avery, Colin MacLeod and Maclyn McCarty continued the Griffith experiment in search of biochemical nature of the hereditary material.

Experiment for Identifying the transforming principle

Avery, McCarty, and MacLeod (1944)

Oswald Avery, Maclyn McCarty & Colin MacLeod Experiment

- In 1944, three Canadian and American researchers, Oswald Avery, Maclyn McCarty, and Colin MacLeod, set out to identify Griffith's "transforming principle."
- They began with large cultures of heat-killed S cells and, through a long series of biochemical steps (determined by careful experimentation), progressively purified the transforming principle by washing away, separating out, or enzymatically destroying the other cellular components.
- By this method, they were able to obtain small amounts of highly purified transforming principle, which they could then analyze through other tests to determine its identity.
- Several lines of evidence suggested to Avery and his colleagues that the transforming principle might be DNA.

Evidence suggested to Avery the transforming principle might be DNA

- **The purified substance gave a negative result in chemical tests known to detect proteins, but a strongly positive result in a chemical test known to detect DNA**.
- The elemental composition of the purified transforming principle closely resembled DNA in its ratio of nitrogen and phosphorous.
- Protein- and RNA-degrading enzymes (protease and RNAase) had little effect on the transforming principle, but enzymes (DNAase) able to degrade DNA eliminated the transforming activity.
- These results all pointed to DNA as the likely transforming principle.

Interpretation of results

- However, Avery was cautious in interpreting his results. He realized that it was still possible that some contaminating substance present in small amounts, not DNA, was the actual transforming principle.
- Because of this possibility, debate over DNA's role continued until 1952, when Alfred Hershey and Martha Chase used a different approach to conclusively identify DNA as the genetic material.

The Hershey-Chase experiments

The Hershey-Chase experiments

- In 1952 Alfred Hershey and Martha Chase provide convincing evidence that DNA is genetic material.
- They studied **bacteriophage** , or viruses that attack bacteria.
- The phages **T2** they used were simple particles composed of protein and DNA, with the outer structures made of protein and the inner core consisting of DNA.
- The bacteria is ***E. coli***
- .

The Hershey-Chase experiments

- Hershey and Chase knew that the phages attached to the surface of a host bacterial cell and injected some substance (either DNA or protein) into the host.
- This substance gave "instructions" that caused the host bacterium to start making lots and lots of phages—in other words, it was the **phage's genetic material.**
- They developed two phages with ***E.coli*** in two types of media

- To establish whether the phage injected DNA or protein into host bacteria, Hershey and Chase prepared two different batches of phage.
- In each batch, the phage were produced in the presence of a specific radioactive element, which was incorporated into the macromolecules (DNA and protein) that made up the phage.
- In one medium with radioactive sulphur S35 and radioactive phosphorous P32.

- One sample was produced in the presence of a radioactive isotope of sulfur S35. Sulfur is found in many proteins and is absent from DNA, so only phage proteins were radioactively labeled by this treatment.
- The other sample was produced in the presence of a radioactive isotope of phosphorous P32. Phosphorous is found in DNA and not in proteins, so only phage DNA (and not phage proteins) was radioactively labeled by this treatment.

- Each batch of phage was used to infect a different culture of bacteria.
- After infection had taken place, each culture was whirled in a blender, removing any remaining phage and phage parts from the outside of the bacterial cells.
- Finally, the cultures were centrifuged, or spun at high speeds, to separate the bacteria from the phage debris.

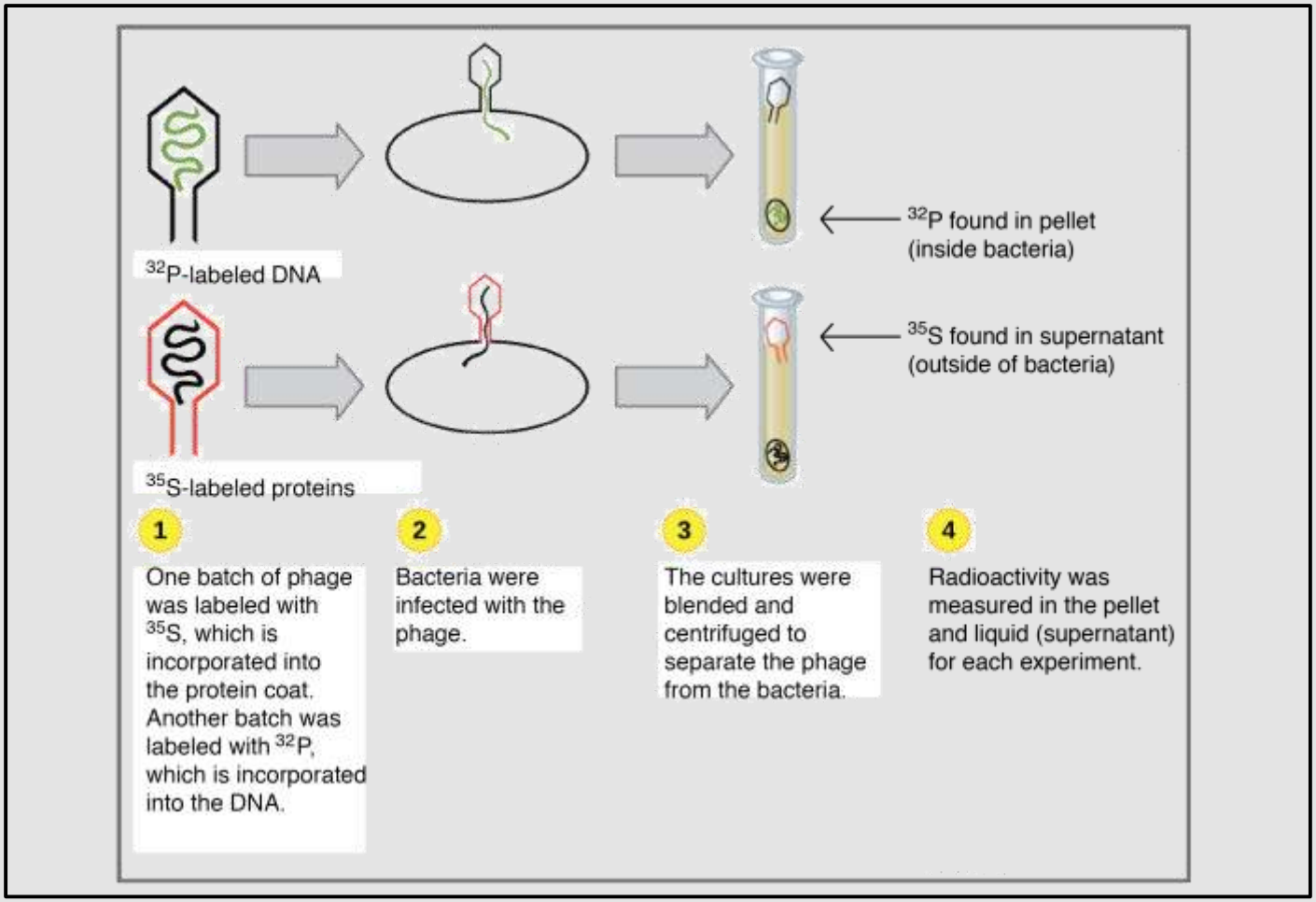
- Centrifugation causes heavier material, such as bacteria, to move to the bottom of the tube and form a lump called a **pellet**.
- Lighter material, such as the medium (broth) used to grow the cultures, along with phage and phage parts, remains near the top of the tube and forms a liquid layer called the **supernatant**.

Conclusion

- When Hershey and Chase measured radioactivity in the pellet and supernatant from both of their experiments, they found that a large amount of P appeared in the pellet, whereas almost all S appeared in the supernatant.
- **Based on this and similar of experiments, Hershey and Chase concluded that DNA, not protein, was injected into host cells and made up the genetic material of the phage.**

Hershey and Chase Experiment

Radioactiove label used32P for DNA & 35S for protein



Transduction

- The genetic recombination in bacteria in which DNA is transferred from one bacteria cell to another via the bacteriophage is known as transduction.
- Bacteriophages attack the bacteria, lyse them and multiply inside the bacteria.
- In this process , some times a small DNA segment of bacteria is contained by the bacteriophage.
- When this attacks another bacteria , the DNA of the previous bacteria from bacteriophage is integrated with the DNA of new bacteria and change some of the features of new bacteria.
- This also suggest that DNA is the genetic material.
- Transduction may be general or specialized.
- Transduction has been reported in several bacteria like *E.coli, Pseudomonas, Salmonella* etc.

Biochemical Evidences

There are several biochemical evidences which also support that Dna is the genetic material.

Next class

Nucleic acids

Stay home – Stay safe


THANK YOU

Third UG – Botany

Fifth Semester

Paper V

Cell Biology, Genetics and Plant Breeding

Unit II
Genetic material

Lesson 2
Enzymes involved in DNA Replication

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Structure of today's Lesson

1. Introduction
2. Enzymes involved in DNA replication in prokaryotes.
3. DNA polymerase
4. DNA primase
5. DNA helicases
6. DNA gyrases

Objectives

1. To understand enzymes involved in DNA replication
2. To learn different types enzymes in DNA replication.
3. To know about DNA polymerase, Helicases and Gyrases.
4. To learn DNA replication in eukayotes.

What are enzymes?

1. Enzymes are proteins that speed up the rate of a chemical reaction in a living organism.
2. It acts as catalyst for specific chemical reaction, converting a specific set of substrates into specific products.
3. Without enzymes life would not exists.

Enzymes involved in DNA replication

- DNA replication requires the following enzymes:

1. DNA polymerase
2. DNA primase
3. DNA helicase
4. DNA ligase
5. DNA gyrases(Topoisomerase)

Of these DNA polymerase is the main enzyme followed by helicase and gyrases.

DNA polymerase

1. This is the chief enzyme of DNA replication
2. Its activity was discovered by Kornberg in 1956.
3. There are at least three types of DNA polymerases reported in E.coli
4. They are:

   - DNA polymerase-I (Pol.-I)
   - DNA polymerase-II (Pol.-II)
   - DNA polymerase-III (Pol.-III)

5. All the DNA polymerases require the following components to do replication.

   1. A template DNA strand
   2. A short primer (either RNA and DNA)
   3. A free $3'$-OH in the primer

6. They add one nucleotide at a time to the free 3'OH of the primer and extend the primer chain in 5' to 3' direction.

DNA polymerase I

1. This was first purified by Kornberg in 1956.
2. This enzyme has three activities, which appear to be located in different parts of the molecules.
3. Polymerase activity -which catalyses the chain growth in the 5’ - 3’ direction.
   - 3’ to 5’ exonuclease activity-which removes mismatched bases(DNA proof reading)
   - 5’ to 3’ exonuclear activity-which degrades double strand DNA (excision repair). An exonuclease digests nucleic acids from one end (it does not cut DNA internally)

3. DNA polymerase I is encoded by gene *pol* A and has a single polypeptide chain. This can initiate DNA replication in vitro at a nick in a DNA duplex

DNA polymerase II

1. This enzyme repairs the damaged DNA.
2. It has 5′-3′ polymerase and 3′-5′ exonuclease activities.

DNA polymerase III

1. This enzyme is responsible for DNA replication *invivo*.
2. It has 5^{l}-3^{l} polymerase and 3^{l}-5^{l} exonuclease activities.
3. It is composed of several subunits
4. Both leading and lagging strands are elongated by DNA polymerase III holoenzyme.
5. This multi subunit complex is a dimer, one half synthesizing the leading strand and the other the lagging strand.
6. Once the lagging and leading strands have been elongated by DNA polymerase III, they are removed and the gaps are filled by DNA polymerase I

Components of DNA polymerase III

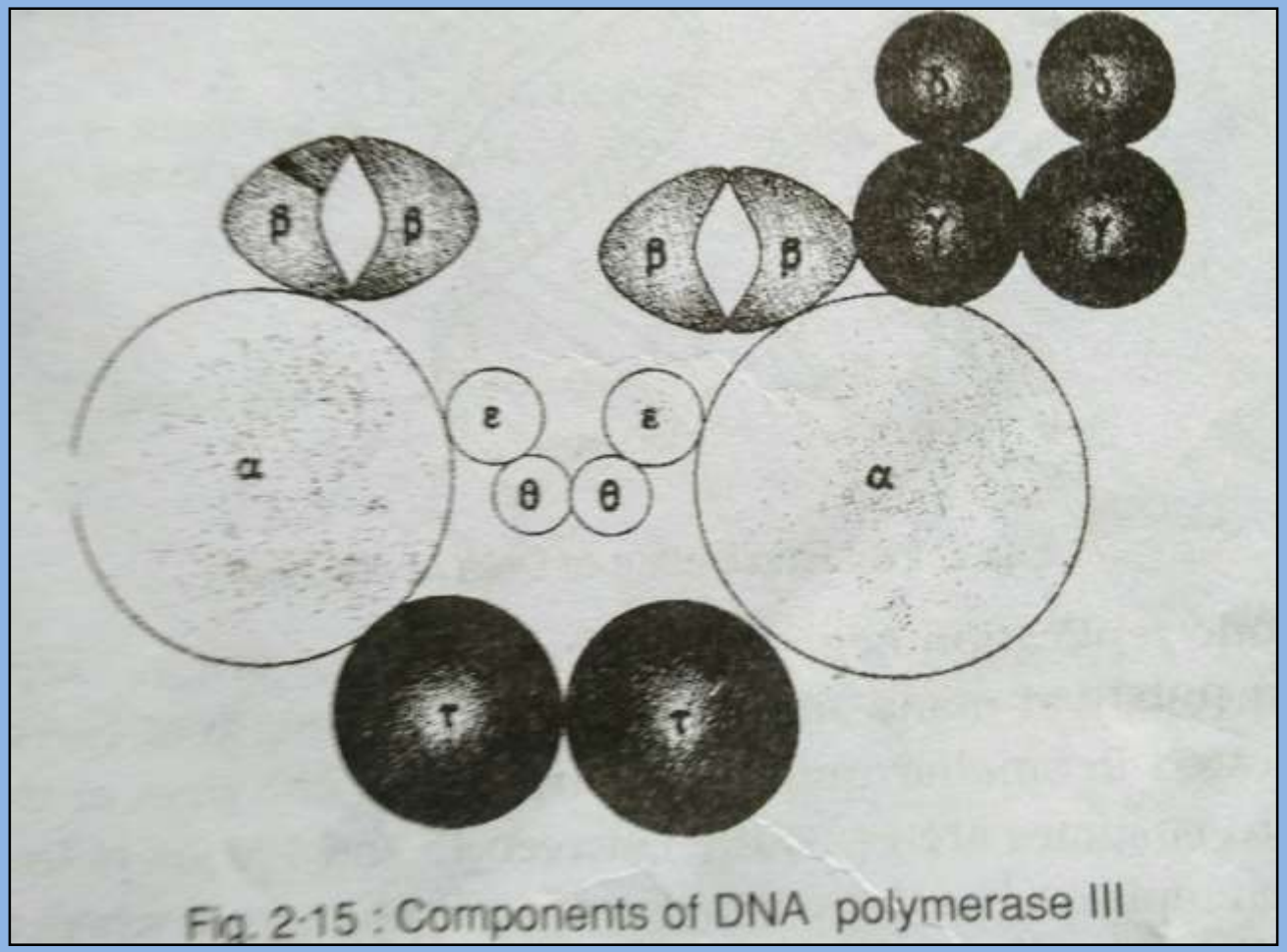


Fig. 2-15 : Components of DNA polymerase III

DNA primases

1. DNA polymerase can only add nucleotides to the 3’ end of the existing DNA strand.
2. How then, does DNA polymerase add the first nucleotide at a new replicaton fork?
3. This problem is solved with the help of an enzymes called **primase.**
4. Primase makes RNA primer that provides a 3’ end for DNA polymerase to work on.
5. A typical primer is about 5 to 10 nucleotides long.
6. The primer primes DNA synthesis. (get it started).
7. Once the RNA primer is in place DNA polymerase extends it, adding nucleotides one by one to make a new DNA strand that is complementary to the template strand.

DNA helicases

- These are ATP dependent unwinding enzymes which promote separation of the two parental strands and establish replication fork

DNA gyrases (Topoisomerases)

1. The action of a helicase introduces a positive super coil into the duplex DNA a head of the replication fork.
2. DNA gyrases relax super coil by attaching to the transiently super coil duplex, nicking (cutting)one of the two strands and rotating it through the unbroken strand.
3. DNA gyrase also called bacterial topoisomerase II necessary for super coiling of chromosomal DNA in bacteria and topoisomerase IV is required for segregation of bacterial genomes into 2 daughter cells during cell division.

DNA ligases

1. It is an enzyme which can connect two strands of DNA together by forming a bond between the phosphate group of one strand and the deoxyribose group of another .
2. It is used in cell to join together okazaki fragments which are formed on the lagging strand during DNA replication.

Enzymes and their function in DNA replication

Enzyme	Function
DNA polymerase III	The 'replicase' enzyme
DNA polymerase I	A repair enzyme involved in removing errors and filling in gaps in the sequence
DNA ligase	Seals 'nicks' in the sugar-phosphate backbone
RNA polymerase or RNA primase	Make RNA primers to get the DNA polymerase III started
RNase H	Removes the RNA primers once they have completed their function
DNA helicase and DNA gyrase	Unwind the DNA duplex
Helix-destabilizing protein	Prevents the unwound DNA from immediately rewinding

DNA replication in Eukaryotes

DNA replication in Eukaryotes

1. The chromosomes in eukaryotes have much complex structure than that of prokaryotic chromosomes.
2. The duplication of the chromosomes of eukaryotes involves not only the replication of their giant DNA molecules, but also the synthesis of the associated histone and non histone proteins.
3. However at the molecular level the replication of DNA in eukaryote is quite similar to that of prokaryotes regardless of its complexity.
4. It appears to involve the same mechanism as in prokaryotes.
5. Replication takes place due to the participation of a series of proteins like unwinding proteins, ss DNA binding proteins, topoisomerase, primase, DNA polymerase and ligase.
6. Eukaryotic replication is semiconservative and semi- discontinuous.

DNA replication in Eukaryotes

1. Eukaryotic DNA replication begins at different sites of origin.
2. Replication takes place simultaneously at many sites along the entire length of chromosome.
3. The DNA is replicated in smaller units called replicons.
4. The sizes of the replicons in eukaryotic chromosomes are generally between 15 and 100µm in length (50-300 kb).
5. Each replicon has its own origin of replication from where the replicating forks move bidirectional.
6. The replication forks travel away from each other until they meet a neighboring fork.
7. The chromosome of a yeast cell contains approximately 400 origins of replication scattered throughout their DNA

8. In higher organisms, each chromosome set has nearly 30,000 replication origin points and these are initiated during S phase which lasts for several hours.
9. Like prokaryotic DNA polymerases there are 5 different types of DNA polymerases which have been isolated from eukaryotic cells. They are designated as

    -Alpha (α)

    -Beta (β)

    -Gamma (ɾ)

    -Delta (δ)

    -Epselon (ϵ)

10. **Polymerase 'α'** is tightly associated with the primase, which initiates the synthesis of primers at 5^{l} end of each okazaki fragment as the polymerase primase complex moves along the lagging strand template.
11. **Polymerase 'β'** plays a role in DNA repair mechanism.
12. **Polymerase 'ɾ'** replicates mitochondrial DNA.
13. Most of the fragments on the lagging strand are assembled by **polymerase –'δ'.** It also shows proof reading property in animal cells.
13. **Polymerase 'ϵ'** appears to play some role in replication of nuclear DNA.

- All the eukaryotic DNA polymerases elongate DNA strands in the 5^{l}-3^{l} direction by the addition of nucleotides to a 3 OH group.
- None of them is capable of initiation of a daughter DNA strand without a RNA primer.

Replication of DNA in eukaryotes

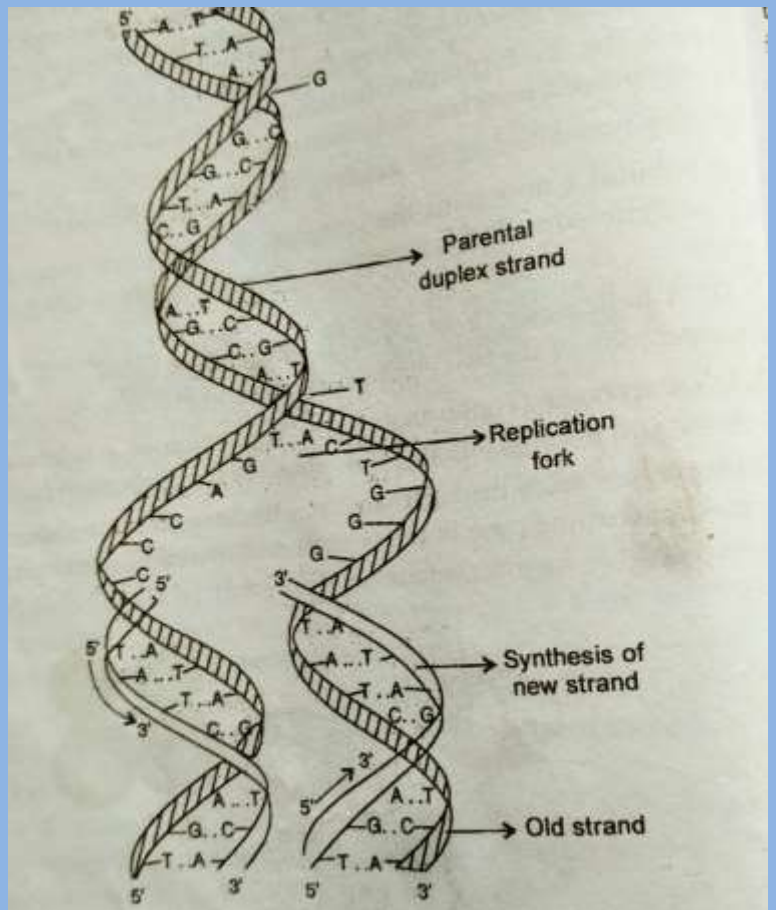


Fig. 2·16 : Replication of DNA in eukarytes

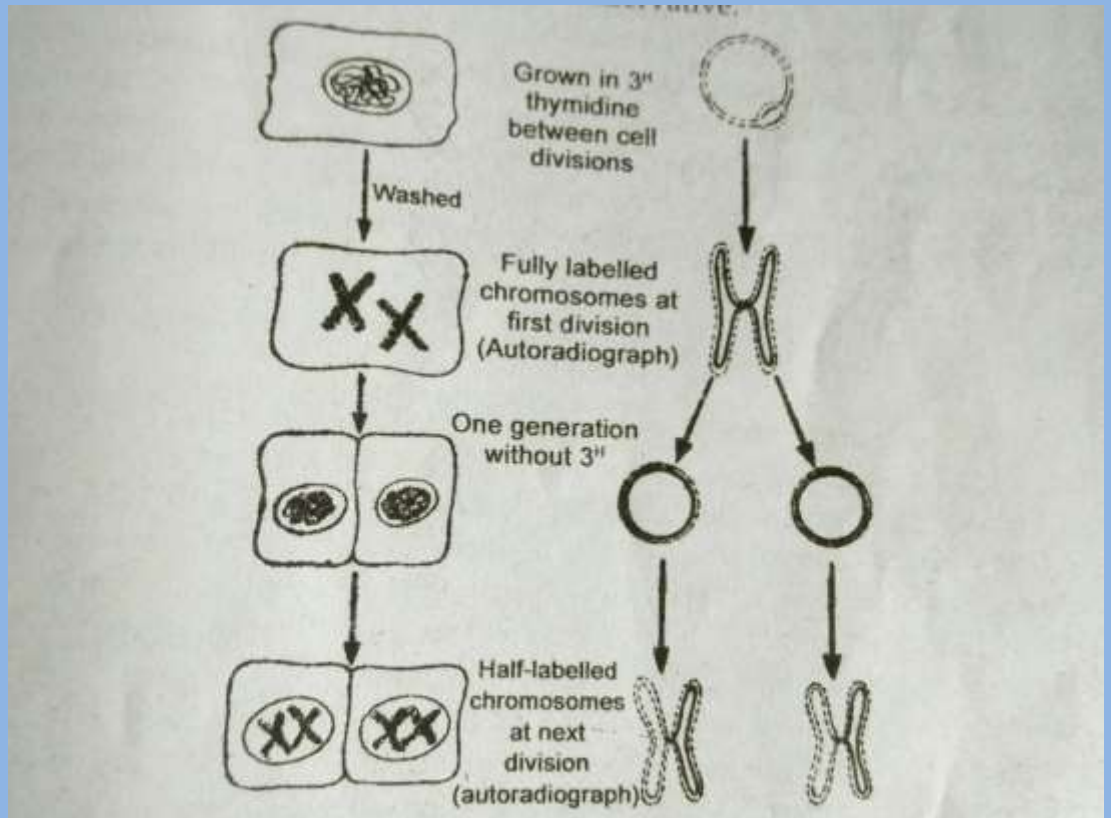
Difference between pro and eukaryotic DNA replication

PROKARYOTIC DNA REPLICATION	EUKARYOTIC DNA REPLICATION
Prokaryotic DNA replication is the process by which a prokaryotic organism duplicates its entire genome in order to pass the second copy to a daughter cell	Eukaryotic DNA replication is the process by which the eukaryotic genome duplicates prior to cell division
A continuous process	Occurs during the S phase of the cell cycle
Takes place in the cytoplasm	Takes place in the nucleus
DNA is circular and double-stranded	DNA is linear and double-stranded with ends
There is a small amount of Prokaryotic DNA	The amount of eukaryotic DNA is 50 times more than that of prokaryotic DNA
DNA forms loop-like structures by wrapping around histone-like protein molecules	DNA forms nucleosomes and shows higher order packaging
Consists of a single origin of replication	Consists of multiple origins of replication (over 1000)
Carried out by DNA polymerase I and III	Carried out by DNA polymerase α, δ, and ε
Okazaki fragments are comparatively large, 1000-2000 nucleotides in length	Okazaki fragments are small, around 100-200 nucleotides in length
DNA gyrase is required	DNA gyrase is not required
A rapid process - around 2000 nucleotides are added per second	A slow process - around 100 nucleotides are added per second
Final product is two circular chromosomes	Final product is two two sister chromatids

Experimental evidences

1. In 1957, J.H. Taylor and P. Wood provided experimental evidences in support of semi conservative replication in eukaryotes by using auto radiography technique and light microscopy in dividing root tips of the bean, *Vicia faba.*
2. They labelled *V.faba* chromosome by growing root tips for 8hrs. In medium containing radioactive H thymidine(tritiated).
3. The root tips were then removed from the medium, washed and transferred to non – radioactive medium containing colchicine that arrests separation of metaphase chromosomes.
4. The distribution of radio active DNA at the first and second generation of duplication, both chromatids of the chromosomes are labelled.
5. However, at the metaphase, only one of the chromatids of each pair was radioactive.
6. These results indicate that the replication of DNA in eukaryotes is semi conservative.

Taylor and Wood experiment



2·17 : Taylor's auto radio graphic evidence showing semi-conservative replication
DNA of eukaryotic chromosomes

Next class

Types of RNA

Stay home – Stay safe


THANK YOU

Third UG – Botany

Fifth Semester

Paper V

Cell Biology, Genetics and Plant Breeding

Unit II
Genetic material

Lesson 2
Nucleic acids

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Structure of today's Lesson

1. Introduction
2. Constituents of Nucleic acids
3. Nucleosides
4. Nucleotides
5. Primary structure of DNA

Objectives

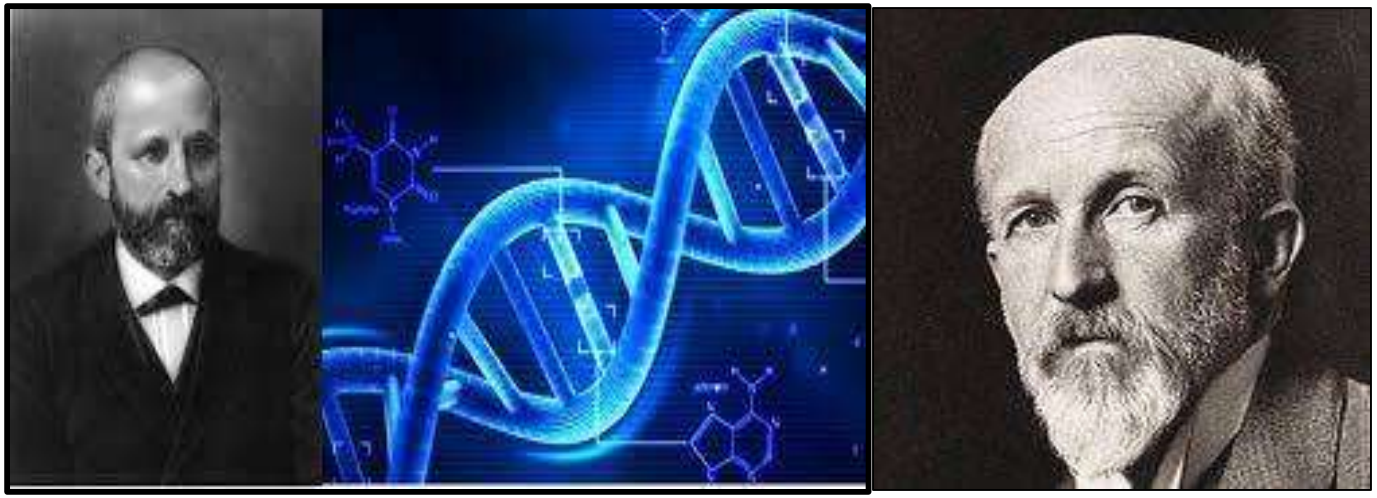
1. To understand the constituents of nucleic acids.
2. To learn the primary structure of DNA.

Introduction

1. Nucleic acids are complex informational macromolecules.
2. They are found in all living cells and viruses.
3. The most common nucleic acids are (deoxy ribose nucleic acid) and RNA (ribose nucleic acid).
4. DNA is mainly found in the chromosomes but some DNA is also found in mitochondria and chloroplasts.
5. RNA is present mainly in the cytoplasm and in ribosomes but RNA also occurs in mitochondria and chloroplasts. All plant viruses contain RNA.

History and discovery

1. Nucleic acids were first isolated in 1868 by a swiss scientist – **Joseph Frederick Meischer** from the nuclei of the pus cells on hospital bandages.
2. He thought it to be a phosphorous rich nuclear protein and named it as nuclein.
3. Later in 1889 a German pathologist **Richard Altman** coined the term nucleic acid.



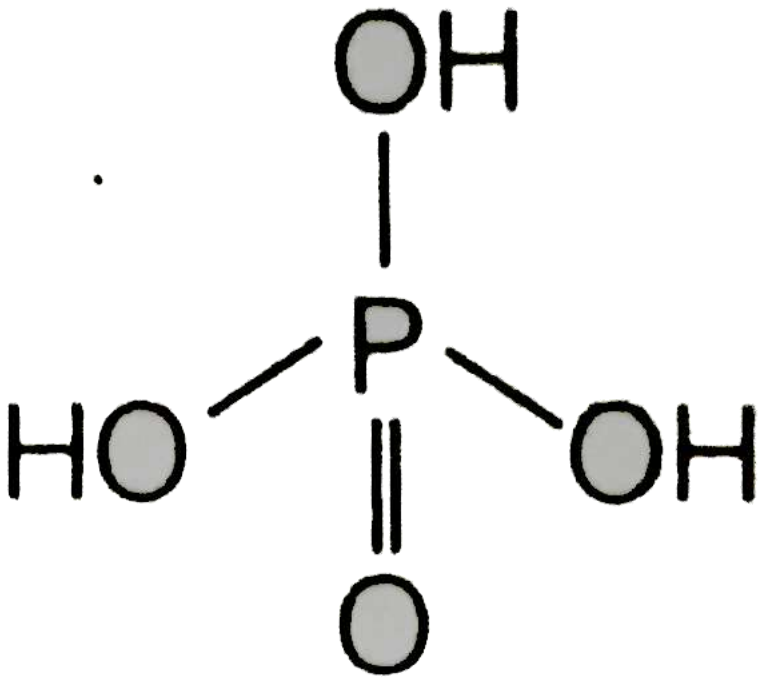
Constituents and Structure of Nucleic Acids

Chemical analysis have shown that nucleic acids DNA & RNA composed of the following three types of molecules.

a) Phosphoric acid
b) Pentose sugar
c) Organic bases

1. Phosphoric acid

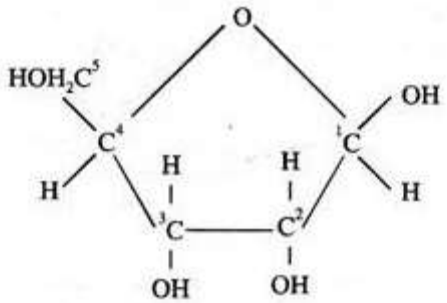
1. Orthophosphoric acidhas 3 reactive hydroxyl groups (-OH) of which two are involved in forming the sugar-phophate backbone of DNA.
2. A phosphate moiety binds to the 5'C of one & 3'C of the other neighbouring pentose molecule of DNA to produce the phosphodiesterb (5'C – O – P – C 3')linkage



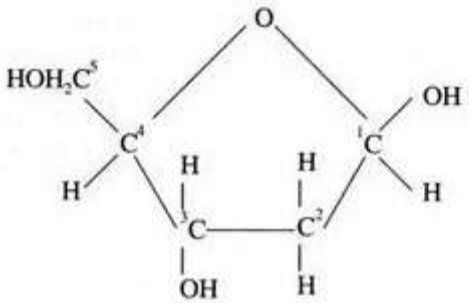
2. Pentose sugar

1. The pentose present in RNA is called D – ribose from which this nucleic acid gets its name.
2. But DNA contains 2’=deoxy-D-ribose (or simply, deoxyribose), which reason for the name deoxyribose nucleic acid.
3. The oxygen atom present at the second carbon of ribose is missing in deoxyribose, giving its namr 2’-deoxyribose.
4. The position of carbon atoms of the two pentose sugar are denoted as 1’,2’,3’,4’ and 5’ in order to differentiate them from the corresponding positions in nitrogen bases.

Structure
Pentose sugars found in nucleic acids



β - D- Ribose



β - D - 2 - deoxyribose

3. Organic bases

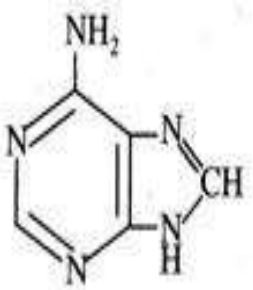
1. The organic bases present in nucleic acids are heterocyclic compounds containing nitrogen in their rings. Hence, they are also called nitrogenous bases.
2. Nitrogenous bases are of two types.
3. Purines and pyrimidines.

Purines

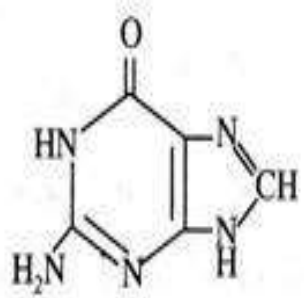
1. These are derived from their purine, which contains a six membered pyrimidine ring, and a five – membered imidazole ring.
2. It is related to uric acid.
3. The pyrimidine ring contains nitrogen (N)in the 7^{th} and 9^{th} positions.
4. The N present at the 9^{th} position of purines participate in a covalent linkage with the 1'C of the pentose.
5. Adenines (A) and Guanine (G) are purines.

Purines
Adenine and Guanine

1. These are normally found in both RNA and DNA.
2. In adenine an amino group (-NH2) group is present at 6th position.
3. But in Guanine, a keto(=O) group is found at position 6 and an additional –NH2 group attaced at the position 2.



ADENINE



GUANINE

Pyrimidines

1. Pyrimidine bases consists of a six- membered pyrimidine ring, with nitrogen (N) atoms in the place of carbon at positions 1 and 3.
2. The three pyrimidine bases (T, C, U) contain a keto oxygen (=O) at position 2.
3. In cytosine, an amino (-NH2) group is also present at position 4.
4. In the case of uracil (U), a keto (=O) group is present at the fourth carbon, while thymine (T) iis essentially 5-methyl uracil i.e. a keto (=O) oxygen at position 4 and a –CH3 group at carbon 5.
5. All the pyrimidines , therfore, contain an - H atom at position 3, which is involved in their linkage with the 1C’ of pentose sugar

Structure of Pyrimidines- Thymine, Cytosine & Uracil

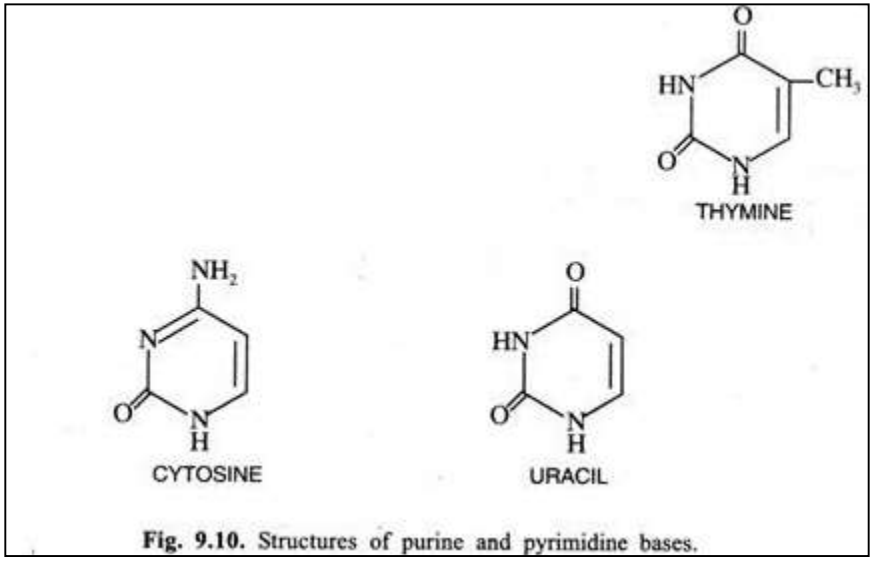


Fig. 9.10. Structures of purine and pyrimidine bases.

Difference between RNA and DNA

Table 9.1. Differences between RNA & DNA

RNA	DNA
1. Single stranded structure.	1. Usually double stranded structure.
2. Bases are : Adenine, Guanine, Uracil and Cytosine.	2. Bases are : Adenine, Guanine, Thymine, and Cytosine.
3. Pentose Sugar is β-D Ribose	3. Pentose sugar is β-D-2-deoxyribose (*i.e.*, O atom at 2nd carbon is absent).

Nucleosides

1. In nucleic acids, organic bases are linked with the pentose sugar molecules, by a beta glycosidic bond to form nucleoside.
2. Combination of a base and pentose sugar is called as a nucleoside.
3. Nucleosides containing ribose sugar are called **ribonucleoside** while those possessing deoxyribose sugar as **deoxy ribonucleoside.**
4. The 4 common ribiosides are called **adenosine, guanosine, uridine and cytidine.**
5. Similarly the 4 common **deoxyribosides are deoxy – adenosine, deoxy gunosine,deoxycytidine and thymidine**.
6. The names of 4 pyrimidine nucleoside end with the suffix –**dine** whereas those of purine molecules end with suffix -**sine**

Structure of nucleosides

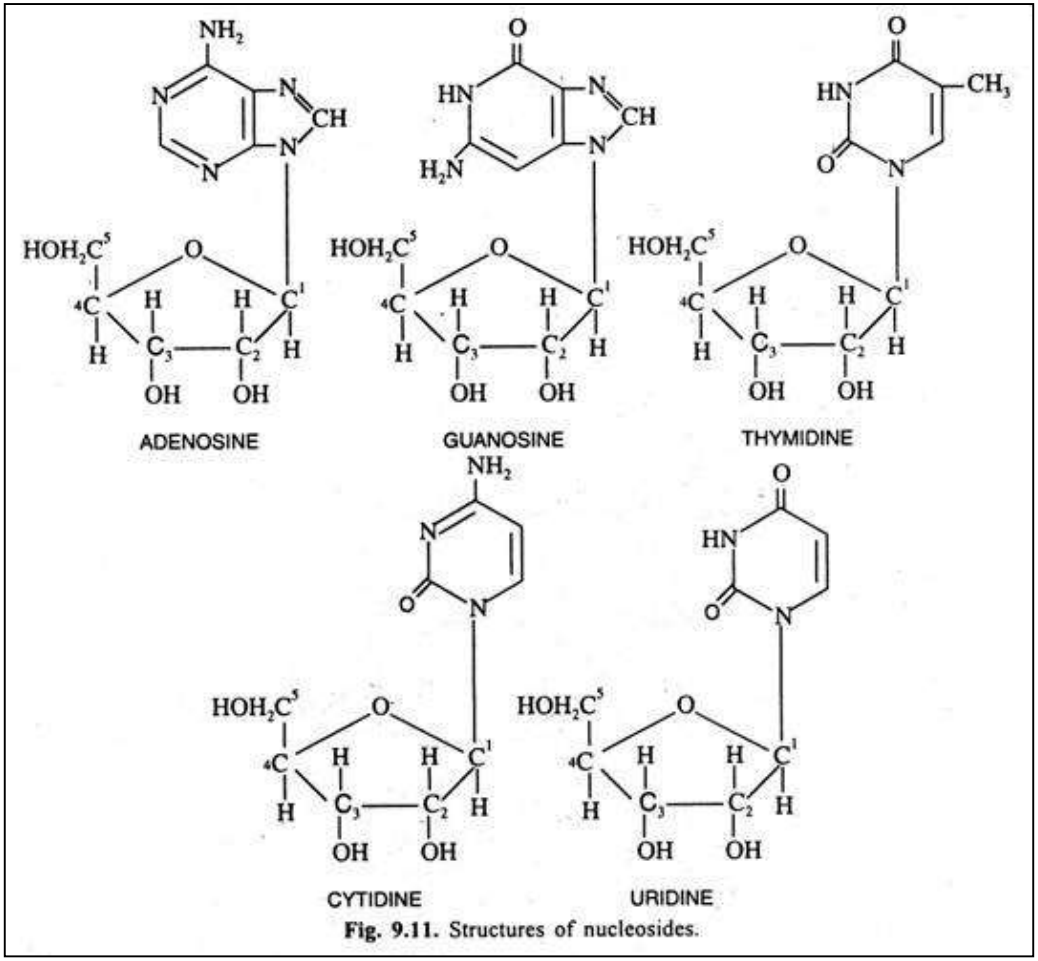


Fig. 9.11. Structures of nucleosides.

Nucleoside

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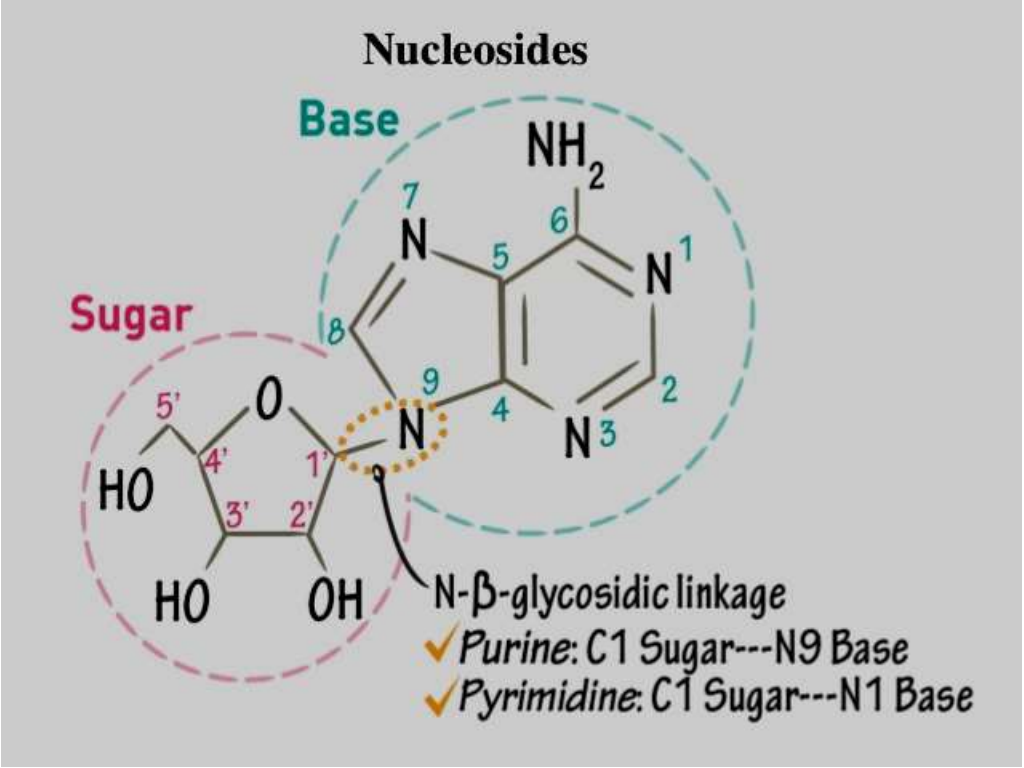
Nucleosides
Base
Sugar
NH2
N
N
N
N
O
HO
HO
OH
N-β-glycosidic linkage
Purine: C1 Sugar---N9 Base
Pyrimidine: C1 Sugar---N1 Base

Nucleosides of RNA and DNA

Base	Sugar	Nucleoside	Trivial name*	Abbreviation
Ribonucleosides				
Adenine	Ribose	Adenine ribonucleoside	Adenosine	AR
Guanine	Ribose	Guanine ribonucleoside	Guanosine	GR
Cytosine	Ribose	Cytosine ribonucleoside	Cytidine	CR
Thymine	Ribose	Thymine ribonucleoside	Thymidine	TR
Uracil	Ribose	Uracil ribonucleoside	Uridine	UR
Deoxyribonucle-osides				
Adenine	Deoxyribose	Adenine deoxyribonucleoside	Deoxyadenosine	AdR
Guanine	Deoxyribose	Guanine deoxyribonuceloside	Deoxyguanosine	GdR
Cytosine	Deoxyribose	Cytosine deoxyribonucleoside	Deoxycytidine	CdR
Thymine	Deoxyribose	Thymine deoxyribonucleoside	Deoxythymidine**	TdR
Uracil	Deoxyribose	Uracil deoxyribonucleoside	Deoxyuridine	UdR

Nucleotides

1. A nucleotide is formed when a phosphate group is attached to the 5'C of the pentose sugar of a nucleoside.
2. Combination of a nucleoside and phosphoric acid is called as a nucleotide
3. The nucleotide produced by the different ribosides are:

- 5'-adenylic acid,
- 5'-guanylic acid,
- 5' – cytidylic acid
- 5' – uridylic acid

These are simply known as ribinucleotides or ribotides.

4. Similarly, the nucleotides formed by 4 deoxyribisides are

- deoxyadenylic acid
- deoxyguanylic acid,
- deoxycytidylic acid
- thymidylic acid.

Together they are called deoxyrinonucleotides or simply deoxytibotides.

Nucleotides

5. The deoxyribinucleotides are covalently linked to one another to form a linear polymer or strand.
6. The back bone is composed of alternating sugar and phosphatte groups joined by 3’ – 5’ phophate bonds.
7. The nitrogen bases were thought to project from the back bone like a column of stacked shelves.
8. Since each of the stacked nucleotide in a strand has polarity, the same direction is attributed to the entire strand.
9. One end is 3’ end and the other is the 5’ end

Various types of nucleotides of DNA &RNA

Base	Deoxyribotide	Ribotide
Adenine	Deoxyadenylic acid	5’ Adenylic acid
Guanine	Deoxyguanylic acid	5’ Guanylic acid
Cytosine	Deoxycytidylic acid	5’ Cytydylic acid
Thymine	Thymidylic acid	-
Uracil	-	5’ uridylic acid

Structure of nucleotides

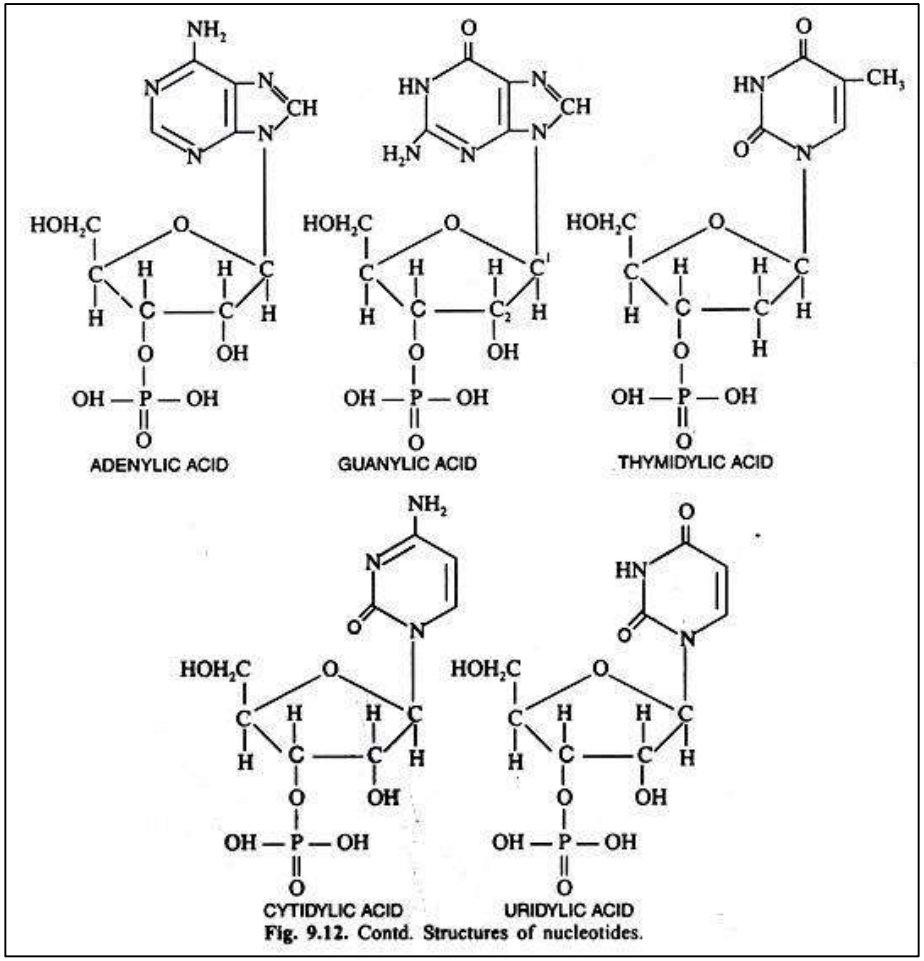

Fig. 9.12. Contd. Structures of nucleotides.

Nucleotides

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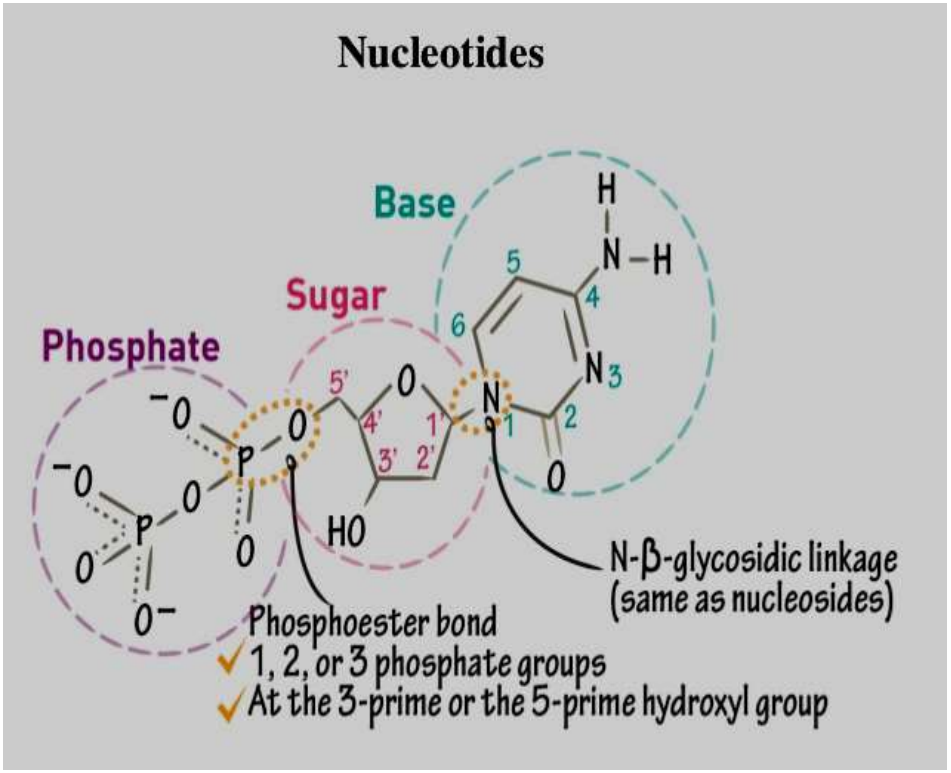


Nucleoside and Nucleotides

Base	Nucleoside	Nucleotide
Adenine	Adenosine	Adenylic acid
Guanine	Guanosine	Guanylic acid
Thymine	Thymidine	Thymidylic acid
Cytosine	Cytidine	Cytidylic acid
Uracil	Uridine	Uridylic acid

Diagrammatic representation of the constituents of nucleic acids

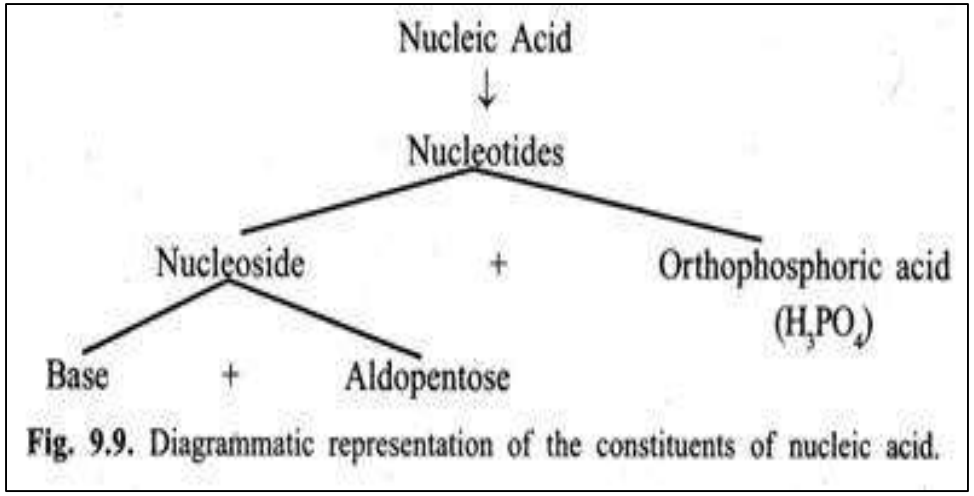
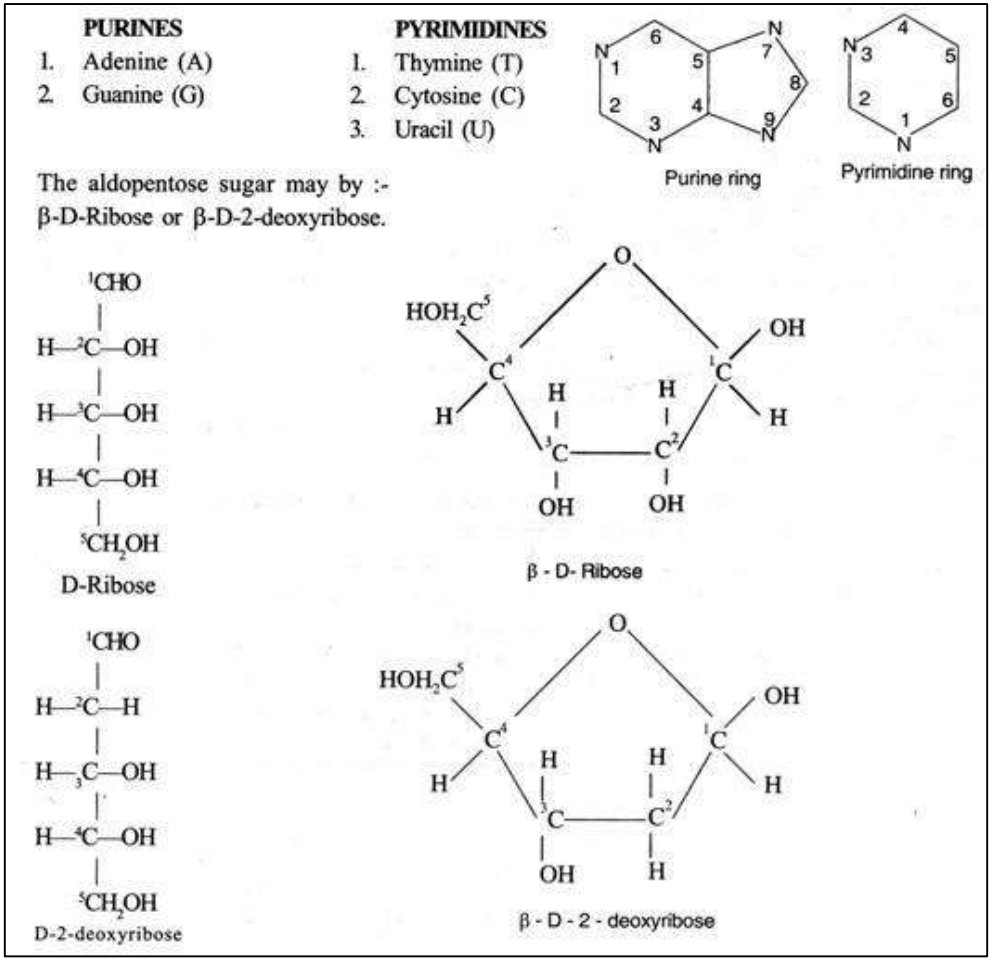


Fig. 9.9. Diagrammatic representation of the constituents of nucleic acid.

Structure of constituents of nucleic acids



Primary structure of DNA

1. A native DNA molecule is double stranded.
2. Each of the 2 strand of a DNA molecule is a polymer of deoxyribonucleotides and is known as polynucleotide.
3. The sugar moieties of two adjacent nucleotides are joined together by a bond mediated by the phosphate group.
4. This bond is known as phophodiester bond.
5. The 3’ –OH group (sugar moiety) of the first nucleotide bond with 5’PO4 group of the second nucleotide.
6. This generates a 5’C –O-P-S-C3’ linkage.
7. This is repeated ‘n’ –number of times to produce a polynucleotide chain.
8. At the end of the chain, the 5’ C of pentose has a free –OH , while the 3’C of the pentose of the opposite end has a free –OH.
9. These two ends are known as 5’ and 3’ ends.
10. Thus a linear arrangement of nucleotides proceeds on the 5’-3’ direction.

Polynucleotide strand

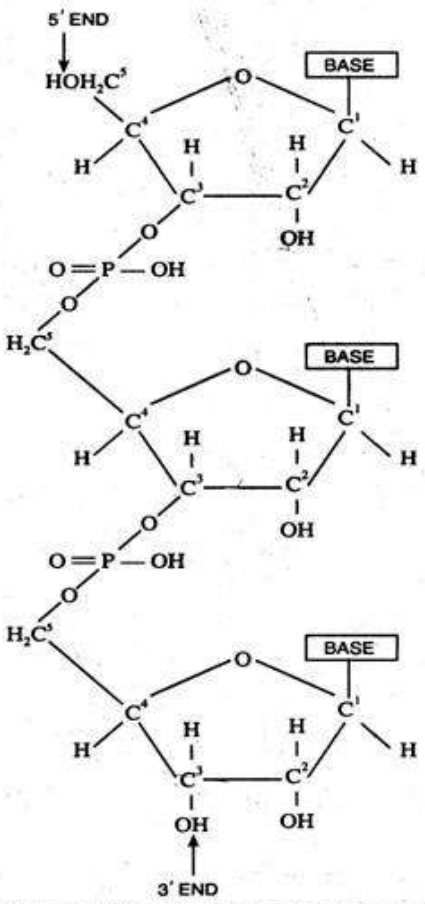


Fig. 9.13. Polynucleotide chain showing phosphorous ester links.

Next class

DNA double helix

Stay home – Stay safe


THANK YOU

Third UG – Botany

Fifth Semester

Paper V

Cell Biology, Genetics and Plant Breeding

Dr. A. Sujatha, Department of Botany, MVR Degree College, Gajuwaka, VSP

Unit II
Genetic material

Lesson 2
Nucleic acids

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Structure of today's Lesson

1. Introduction
2. DNA double helix (Watson and Crick model)

    2.1. The Chargaff's rule

    2.2. Organization of DNA

    2.3 Salient features of Watson and Crick model of DNA

3. Types of DNA
4. Functions of DNA

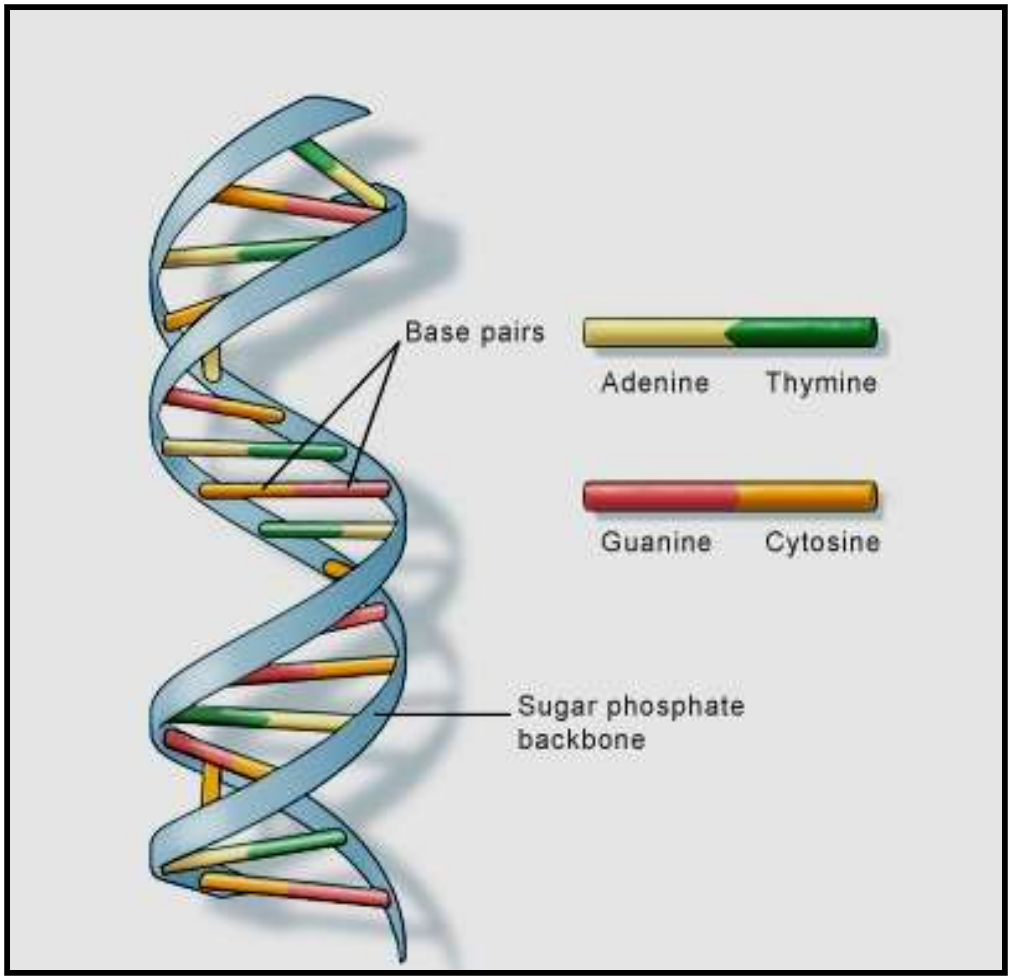
Objectives

1. To understand the Watson and Crick model.
2. To learn the types of DNA.
3. To know about the functions of DNA

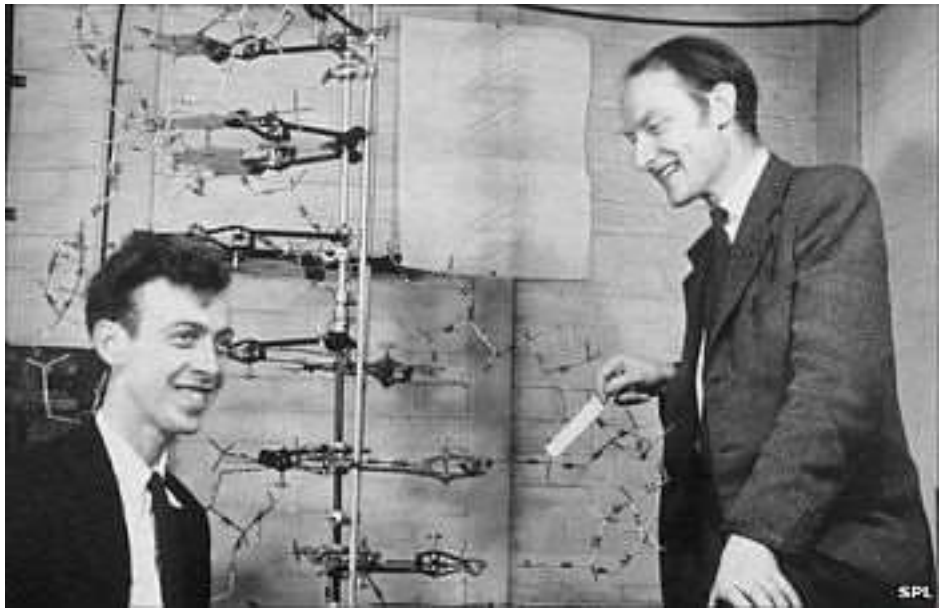
Introduction

1. Many people believe that American biologist James Watson and English Physicist Francis Crick discovered DNA in 1950. But in reality this is not true.
2. **First piece of work**: In 1860 Swiss chemist Frederich Meischer first isolated nucleic acids from pus cells. Named it as nuclein.
3. **Laying the ground work**: Levene 1931 - investigation on structure of DNA, Reported polynucleotide nature of DNA and DNA is a polynucleotide chain.
4. **Strengthing the foundation**: Erwin Chargaff formulates rules in 1940 based on the chemical analysis.
5. **Organization of DNA**: Wilkins et al 1950 – reported organization of DNA from X – ray crystallography studies with purified DNA.
6. Putting all these evidences together Watson and Crick proposed the double helical structure of DNA in 1953.
7. So Watson and crick are the first scientists to formulate an accurate description of DNA , double helical structure.
8. Without the foundations provided by these pioneers, Watson and Crick may never have reached their ground breaking conclusion of 1953 the DNA molecule exsits in the form of three dimensional double helix.

DNA is a double helix formed by base pairs attached to a sugar-phosphate backbone.



The DNA double Helix (Watson and Crick model)



Leven is the first person reported the chemical nature of DNA

Scientists of DNA -2

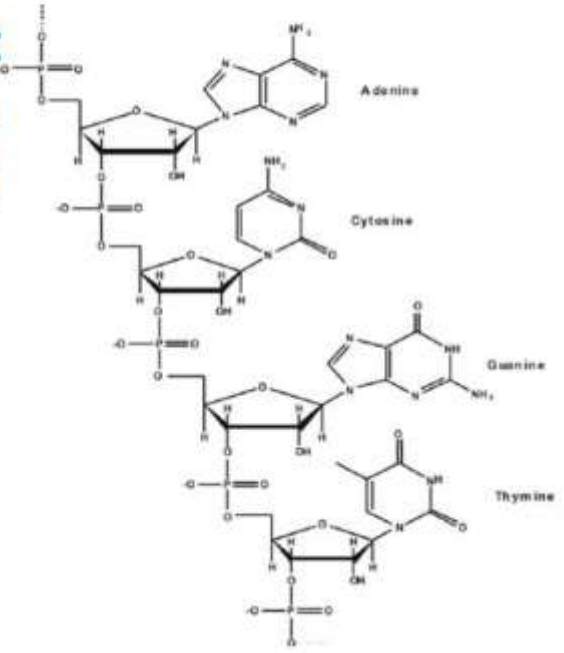
Biotech Review

Phoebus Levene

The first Biochemist who identified the Chemical Nature of DNA

&

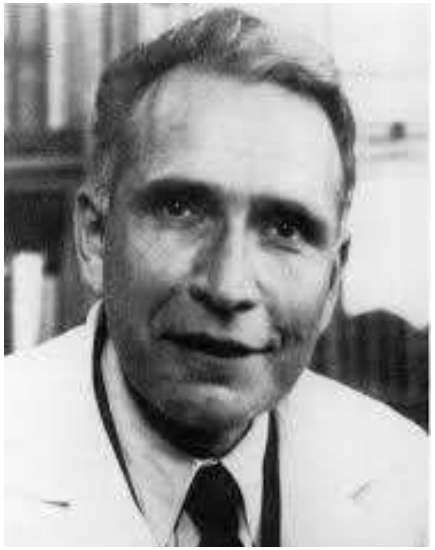
Tetranucleotide Hypothesis

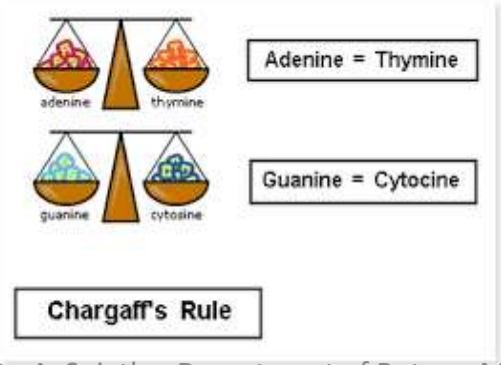


Levene postulate

1. The deoxyridonucleotides and their ability to form polynuncleotide chains were discovered by Levene in 1931.
2. He postulated that the four nucleotides occur in a regularly repeated tetranucleotide sequence eg. AGCT AGCT AGCT ……..etc.

The Chargaff's Rule





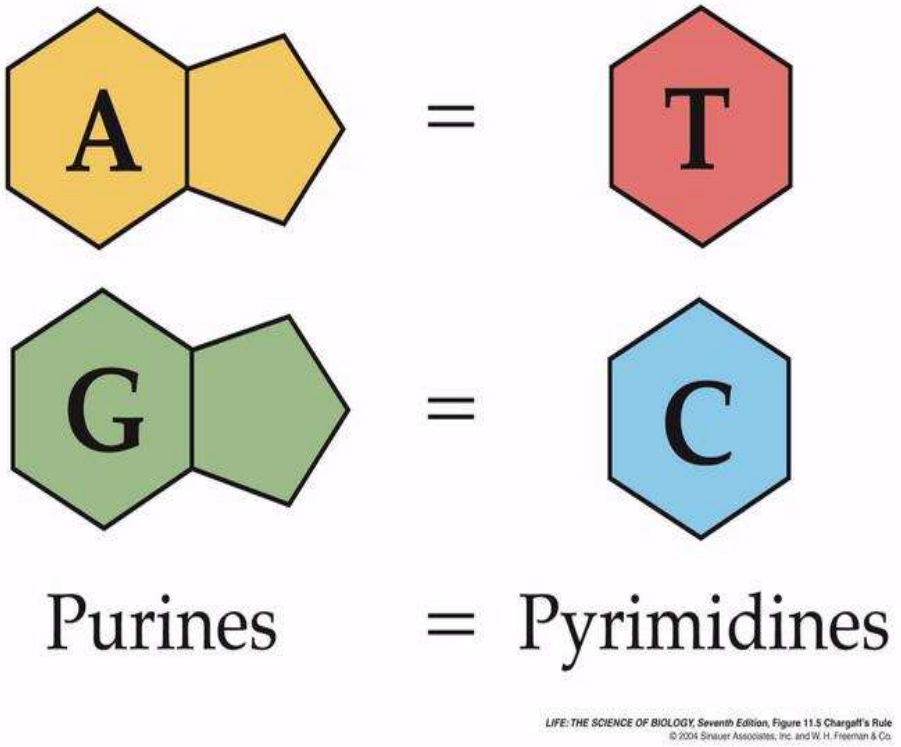
Chemical analysis of DNA by Ervin Chargaff

Chemical analysis of DNA by Ervin Chargaff and others during 1940 revealed the following facts:

1. As a rule, the number of pyrimidine bases (C + T) is equal to the number of purine bases (A + G).
2. There is an equivalence between the bases carrying amino groups at the 6 or 4 position (A + C) and those carrying keto groups at these positions (T + G).
3. The quantity of A was equal to that of T, while the quantity of G was comparable to those of C at least in eukaryotes.
4. This is popularly known as Chargaff's rule of molar equivalence.
   Chargaff's rule suggests that A is always paired with T and G always paired with C. (A = T, G =C).

The Chargaff's Rule

1. As a rule, the number of pyrimidine bases (C + T) is equal to the number of purine bases (A + G).
2. There is an equivalence between the bases carrying amino groups at the 6 or 4 position (A + C) and those carrying keto groups at these positions (T + G).



LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 11.5 Chargaff's Rule
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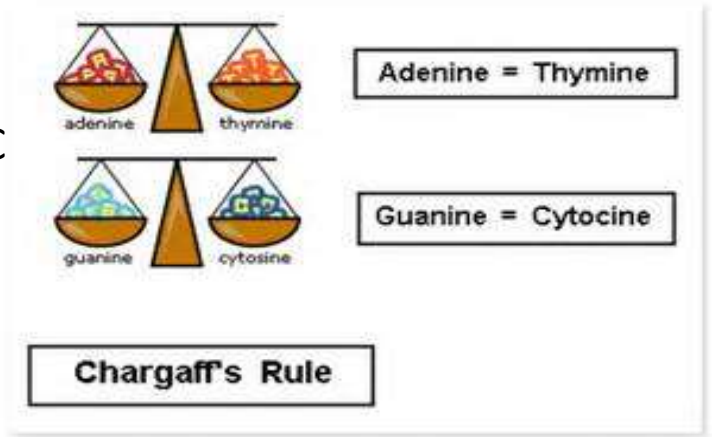
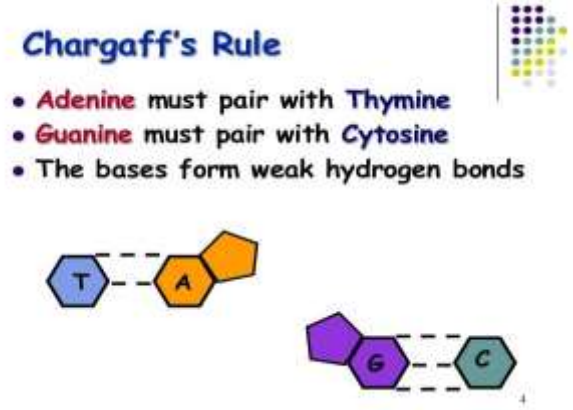
The Chargaff's Rule

3. The quantity of A was equal to that of T, while the quantity of G was comparable to those of C at least in eukaryotes.



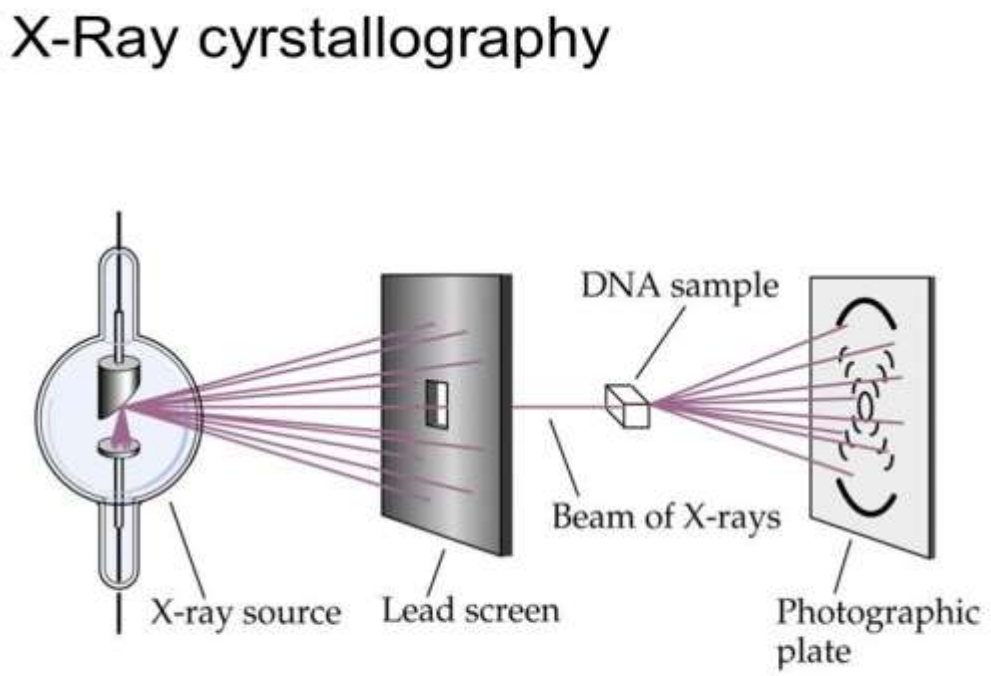
4. This is popularly known as Chargaff's rule of molar equivalence.

   Chargaff's rule suggests that A is always paired with T and G always paired with C. (A = T, G =C).



Organization of DNA

Rosalind Franklin's X-ray diffraction patterns of **DNA** molecules rendered the important clue that **DNA** has the **structure** of a double **helix**



Wilkins, Franklin et al X- ray studies

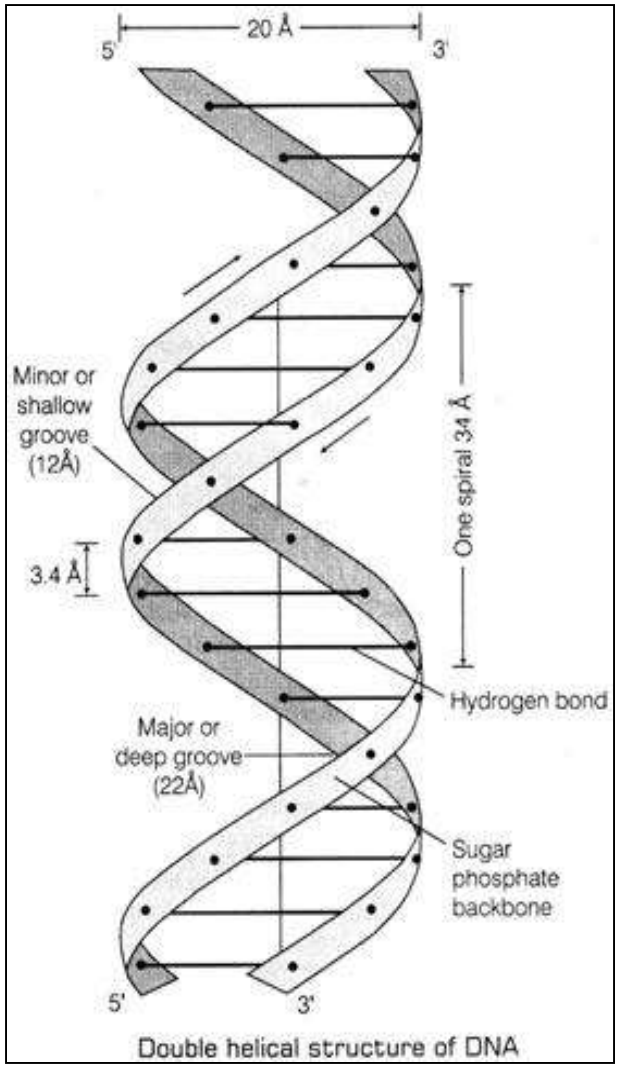
1. The data of Wilkins, Franklin and others on X- ray crystallography of purified DNA revealed that the molecules is a multi stranded fibre with a diameter of about 22A^{o}
2. It was found to have gaps at 34 A^{o} along the fibre and the occurrence of a repeating unit every 3.4 A^{o}.
3. These finding were available by early 1950s.
4. Using this data, Watson and Crick proposed the double helix model of DNA in 1953.
5. This model soon became widely accepted.

The main features of Watson – Crick model of DNA

Watson and Crick proposed the double helix model of DNA in 1953

Watson – Crick model of DNA

1. A DNA molecule is made up of two polynucleotide strands or chains.
2. Each polynucleotide is composed of many nucleotides joined by phosphodiester linkage between their sugar and phosphate residues.
3. The two strands of a DNA molecule are oriented anti parallel to each other i.e. one strand runs in 5’ → 3’ direction, while the other runs in 3’→ 5’ direction.
4. The ant parallel orientation of the two strands is essential for the formation of hydrogen bonds between pairs of DNA bases.



Double helical structure of DNA

Features of Watson – Crick model of DNA

Complementary base pairing

4. The adenine (A) present in one strand of DNA molecule is linked by two hydrogen bonds with thymine (T) located opposite to it in the other strand and vice – versa (A = T). Similarly , G located in one strand forms three hydrogen bonds with the C present opposite to it in the strand and vice versa (G =C).

   The formation of hydrogen bonds between A & T and between G & C is known as ***Complementary base pairing*.**

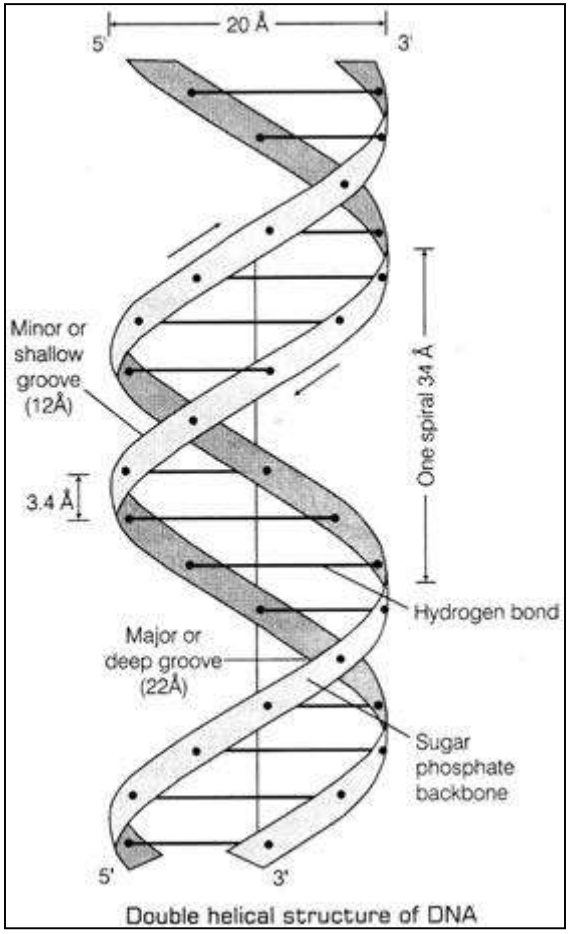
Features of Watson – Crick model of DNA *denaturation*

5. The hydrogen bond is relatively weak bond. But since a DNA molecule has several hydrogen bonds they effectively keep the two strands of a DNS molecule together. These bonds can be readily disrupted when DNA is either heated or treated with an alkali. This produce single stranded and this process is called ***denaturation.***
6. The two strands of DNA are coiled together in a right – handed helix forming the DNA double helix. The diameter of this helix is 20 A^o, while the pitch (the length of helix required to complete one turn) is 34 A^o.
7. Each turn contains 10 equally spaced base pairs. The distance between successive base pairs (bp) is 34 A^o and the angle between them is 36 A^o

Features of Watson and Crick model of DNA

6. Each turn of a DNA molecule include one major (wider) groove and one minor (narrow) groove along the phophodiester backbone. Proteins interact with DNA at these grooves or sites.
7. The genetic information resides on one of the two strands which is called *template strand.*
8. During replication, the two strands of DNA molecule uncoil and each strand produce a daughter complementary strand. It results in the formation of two daughter DNA molecules. Each daughter molecule contains a parental strand and a new strand. This provides for an almost error – free, high fidelity replication of the genetic material (semi – conservation)

Watson – Crock double helical of DNA



Double helical structure of DNA

Molecular structure of DNA

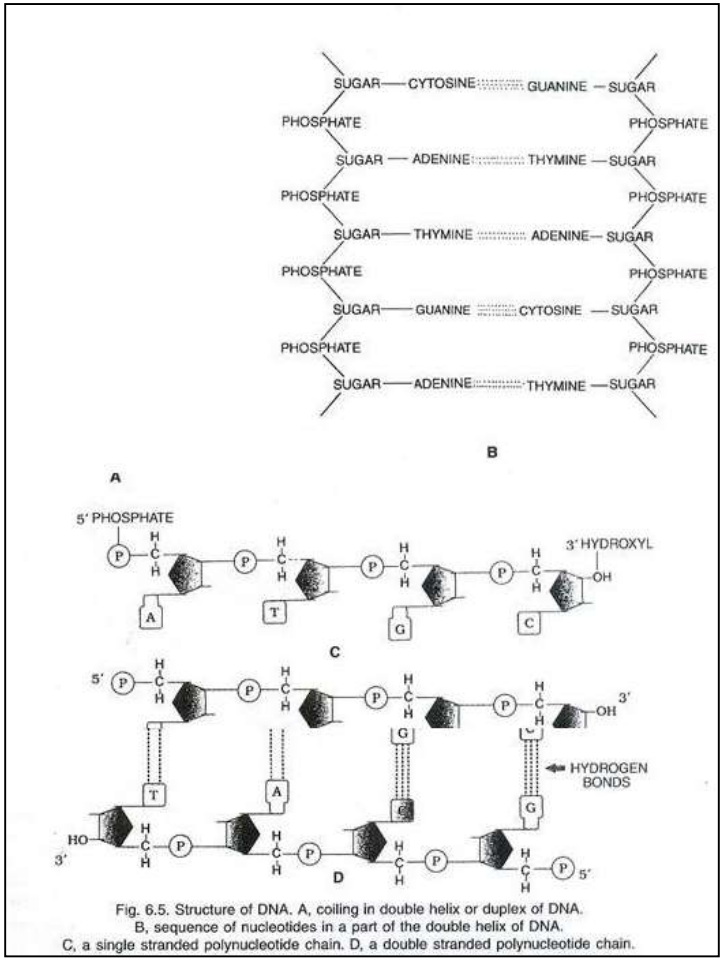


Fig. 6.5. Structure of DNA. A, coiling in double helix or duplex of DNA. B, sequence of nucleotides in a part of the double helix of DNA. C, a single stranded polynucleotide chain. D, a double stranded polynucleotide chain.

Types of DNA

Four types of DNA

Depending upon the nucleotide base per turn of the helix, pitch of the helix, tilt of the base pair and humidity of the sample, the DNA can be observed in four different forms, namely A, B, C and Z.

B – DNA & A - DNA

1. B – DNA: The commonly found DNA is known as the B – DNA. It shows clockwise (right – handed) helix structure with 10 base pairs per turn and has a pitch of 34 $A^{o.}$
2. A – DNA : Dehydrated DNA occurs in A form. It is a right handed helix but it has 11 base pairs per turn with a pitch of 28 $A^{o.}$ It is unlikely that native DNA occurs in A form. But DNA – RNA heteroduplex and RNA double helixes occur in this form in vivo.

A and B- DNA

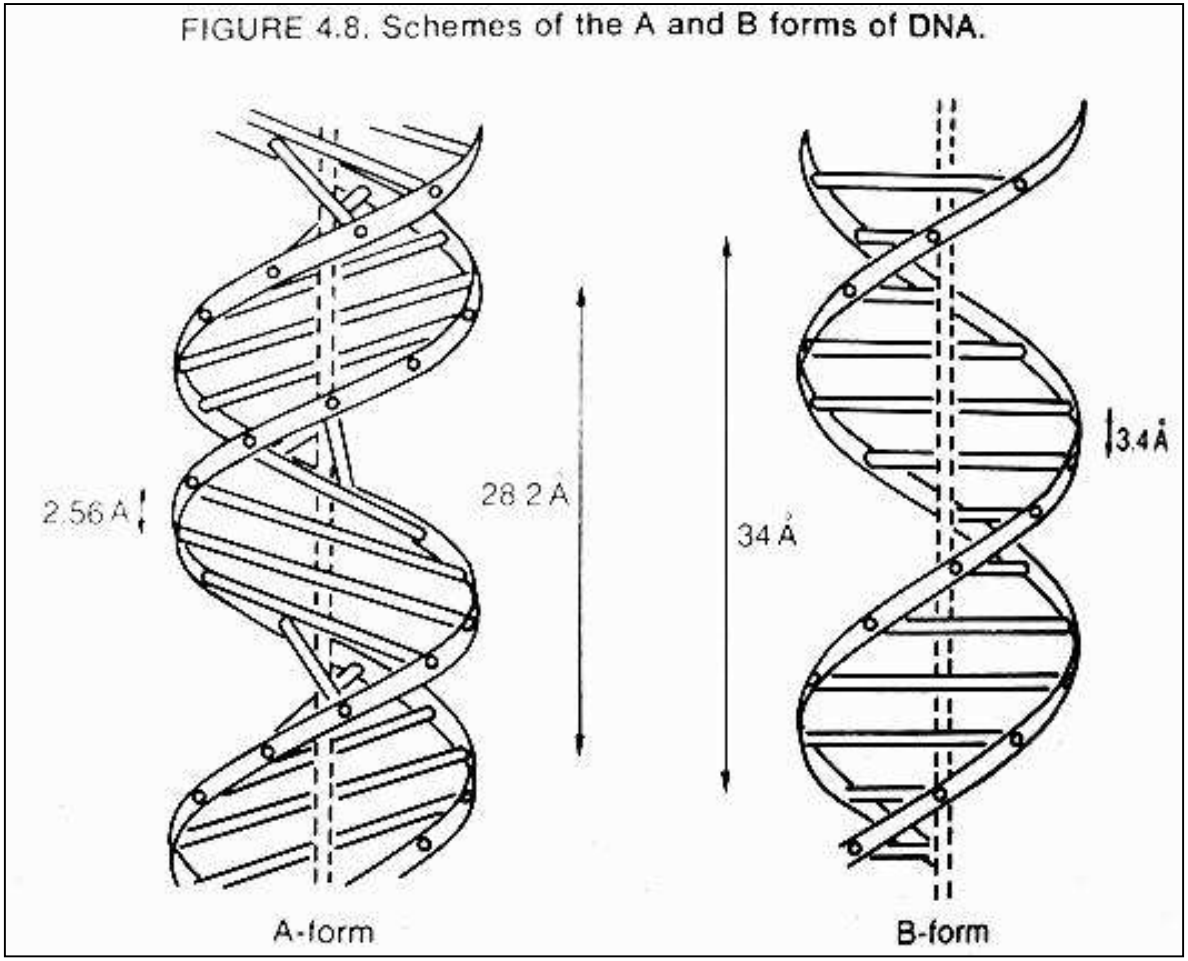


FIGURE 4.8. Schemes of the A and B forms of DNA.
2.56 Å
28.2 Å
34 Å
3.4 Å
A-form
B-form

Z and C - DNA

3. Z – DNA : It is a left handed (anticlock wise) double helix having 12 base pairs per turn. It has a pitch of 45 A^o. In Z – DNA the sugar – phosphate backbone follows a zig – zagged path giving its name Z – DNA. It has a single groove with a greater density of negative charges than B – DNA . Z – DNA was discovered in vitro condition and not known in vitro.
4. C – DNA: it is right handed (clockwise) helix having 9.33 bp per turn, 19 A^o diameter and 31 A^o pitch. It is more tightly wound than B- DNA

Characteristic features of B-DNA and Z DNA

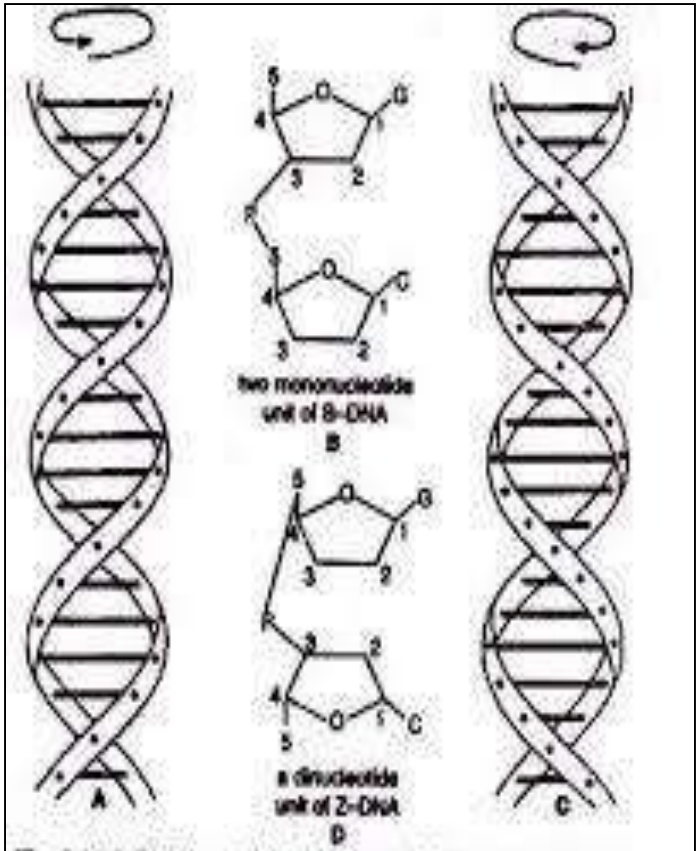
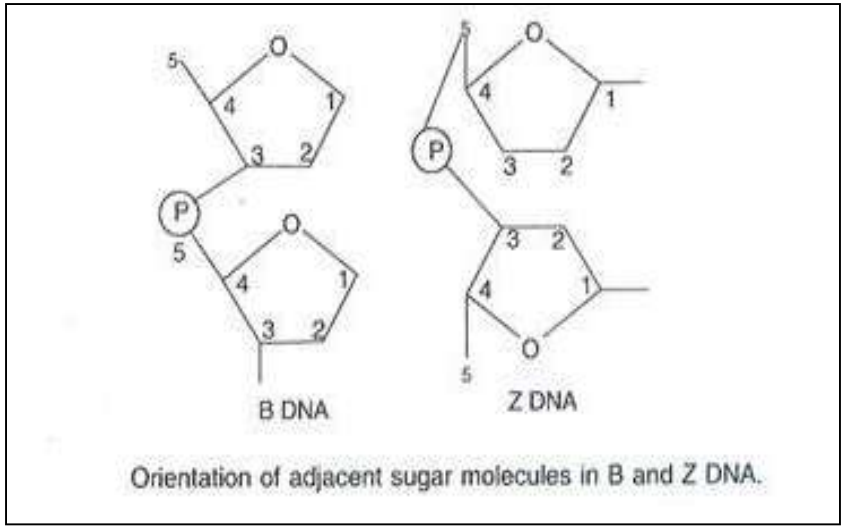


Fig. 8.11 A-D. Characteristic features of B-DNA and Z-DNA A. Double helical structure of B-DNA showing right handed helix. B. Arrangement of two nucleotides of B-DNA. C. Double helical structure of Z-DNA showing left handed helix. D. Arrangement of two nucleotides in opposite directions in Z-DNA.

Orientation of adjacent molecules in B and Z - DNA



Orientation of adjacent sugar molecules in B and Z DNA.

Similarities between Z – DNA and B – DNA

1. Both are double helical
2. In both DNAs two polynucletide strands of helix are antiparallel.
3. Both forms exhibit G – C pairing.

Differences between Z – DNA and B - DNA

1. Z- DNA has left handed helical sense, while B – DNA has right handed helical sense.
2. The phosphate backbone of Z – DNA follows a zig – zag course, while in B – DNA this backbone is regular.
3. In Z – DNA, the adjacent sugar residues have opposite orientation, while in B DNA they have same orientation. Due ti this , repeating unit is a dinucleotide in Z – DNA as against a mononucleoside unit in B – DNA.
4. In z- DNA one complete helix has 12 bps of six repeating dinucletide units, while in B – DNA one complete helix has only 10bps or 10 repeating units.
5. The angle of twist (rotation) oer repeating unit (dinucleotide) in z – DNA is 60 A^o than the 36 A^o of mononucleotide in B – DNA.

Comparison between different types of DNA

Parameter	A-DNA	B-DNA	Z-DNA
Orientation	Right-handed	Right-handed	Left-handed
Helix diameter (Å)	26	20	18
Rise (Å)	2.56	3.38	3.70
Pitch (Å)	28.2	33.8	44.5
Base pairs/turn	11	10	12
Helix twist (°)	32.7	36.0	–30.0
Major groove width[a] (Å)	2.7	11.7	2.0
Minor groove width[a] (Å)	11.0	5.7	8.8

[a] Groove width is the perpendicular separation of helix strands drawn through phosphate groups, added by 5.8 Å to account for van der Waals radii of phosphate groups.

Functions of DNA

Two important functions of DNA

1. Autocatalysis

2. Heterocatalysis.

1. Autocatalysis

1. The process of duplication of a single DNA molecule into 2 daughter DNA molecules is called **autocatalysis or replication.**
2. DNA replicates by semi – conservative mechanism, i.e. the daughter DNA molecule show one old strand (parent) and one newly synthesized strand.

2. Heterocatalysis

1. DNA promotes the synthesis of proteins and regulates various biochemical reactions of cell.
2. In this process , the DNA templates transfer genetic message to mRNA by a process called **transcription**.
3. mRNA helps in the synthesis of proteins,

DNA $\xrightarrow{\text{transcription}}$ mRNA $\xrightarrow{\text{translation}}$ Protein

Next class

Replication of DNA

Stay home – Stay safe


THANK YOU

Third UG – Botany

Fifth Semester

Paper V

Cell Biology, Genetics and Plant Breeding

Unit 1
Cell Biology

Lesson 2
Plasma membrane

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Completed Lessons

Unit 1: Cell biology

Lesson 1- The cell

1.1 Introduction
1.2. Prokaryotic and eukaryotic cells
1.3. Structure of plant cell
1.4. Nucleus

Lesson 2 - Cell wall

2.1 Introduction
2.2 Structure
2.3 Thickening of cell wall
2.4 Pits
2.5.Origin and growth of cell wall
2.6 Chemical Nature of cell wall
2.7 Fine structure of cell wall
2.8 Functions of cell wall

Plasma membrane

2.9 Introduction

2.10 Chemical composition

2.11 Structure of the Plasma membrane

Structure of today's Lesson

Plasma membrane

2.12 Functions of Biological membranes.

2.13 Movement of substances across cell membrane.

Objectives

1. To describe the function of the biological membrane.

2. To Know the difference between active and passive transport system.

Introduction

1. The cytoplasm in both and animal cells is surrounded by the **plasma membrane** and it is also known as **plasma lemma**.
2. Similar type of limiting membranes are also present in other organelles :

   Mitochondria, Golgi complex, ER, chromoplast etc., This separate their contents from the cytosol and are called **unit membranes or cell membranes**.

3. The cell membrane and plasma membrane are collectively known as **biological membranes.**
4. All of these membranes have a common structure and composition.

Functions of the Biological membranes

Main functions

1. It is a selectively permeable membrane.
2. Transporting machinery for metabolic essentials.
3. Responding to stimuli.
4. Compartmentalization.
5. Site of biochemical activities

The efficient function of the membrane is required for an effective coordination of biological reactions.

1. **It is a selectively permeable membrane**

1. It regulates the entry of **appropriate substances** into all the cells and ensures that **inappropriate substances** are kept out.
2. In this way it acts as a selectively permeable barrier.

2. Transporting machinery for metabolic essentials

1. Plasma membrane contains the necessary machinery for physically transporting substances.
2. Carrier proteins in the membrane are involved in the transport of certain materials like gases, solutes etc., from one side of the membrane to the other.
3. There are many processes like passive diffusion, facilitated diffusion, pinocytosis, active transport etc are involved in transport of metabolic essentials across the membrane.

3. **Responding to stimuli**

1. All biological membranes have on their outer surface specific protein molecules acting as receptors.

2. These unite with complementary substances providing external stimuli to the cell.

4. Compartmentalization

1. Membranes are the living boundaries of the cytoplasm and cellular organelles.
2. They form continuous and unbroken sheets that divide the living matter into self-sustaining units to perform specialized functions.

5. **Site of biochemical activities**

1. Cells have to perform different biochemical activities in the presence of enzymes.

2. Membranes provide the structural frame work for the location of various enzymes.

Eg. The presence of orderly enzymatic system in the mitochondrial membrane to acieve electron transport.

Movement of substances across the cell membrane

Types of movement

Substances can move into and out of cells through the cell membrane.

The main types of movement are –

1. Passive transport
2. Facilitated diffusion
3. Active transport
4. Bulk transport

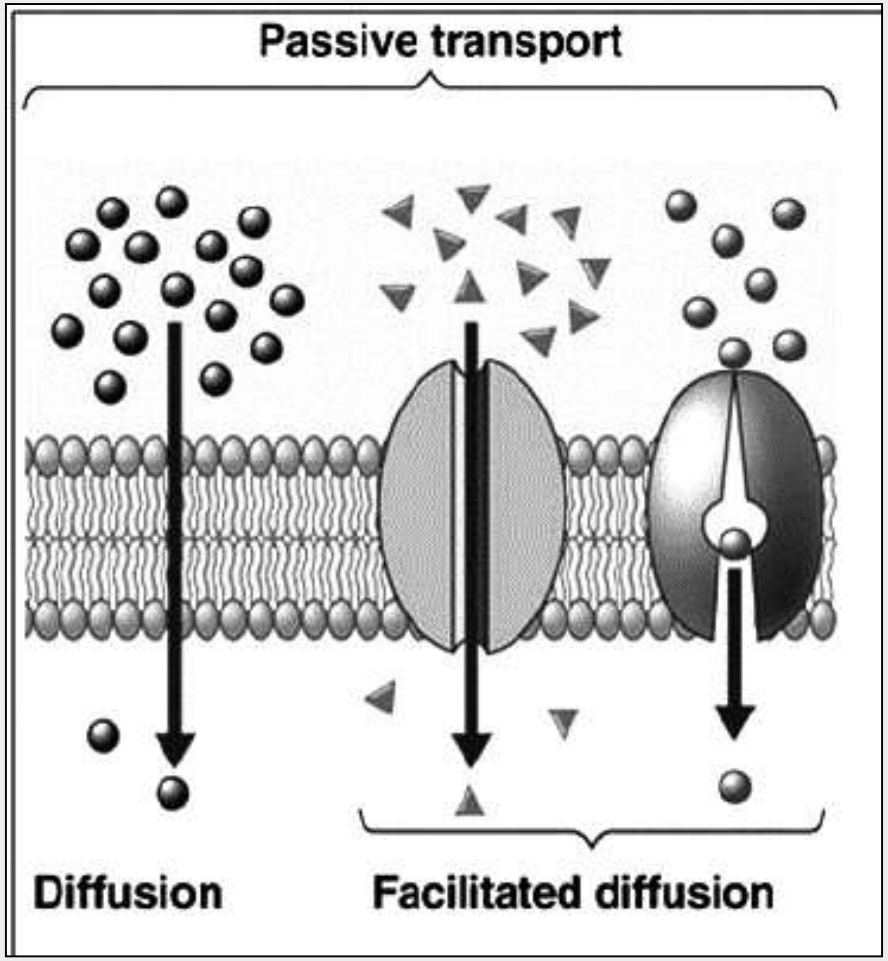
1.Passive transport

1. It is a spontaneous process.
2. Passive transport is a movement of ions and other atomic or molecular substances (oxygen or carbondioxide, water) across the cell membranes from a region of high concentration to a region of low concentration,without the need of energy input.
3. The rate of passive transport depends on the permeability of the cell membrane, which in turn depends on the organization and characteristics of the membrane lipids and proteins.
4. Eg. Osmosis: The water molecules move through the semipermeable membrane from a region of lower solute concentration to region of higher solute concentration. The process of water molecules entering the cell is called endosmosis and the reverse is exosmosis.

2. Facilitated diffusion

1. Essential substances like glucose and aminoacids move across the membrane through specific membrane associated carrier molecules.
2. These molecules form a complex with glucose and facilitate the diffusion of glucose into the cell through the membrane.
3. It is also called as carrier mediated osmosis.
4. Since glucose is the body's primary source of direct energy, most cells contain a membrane protein (glucose transporter) that facilitates the diffusion of glucose from the blood stream into the cell.

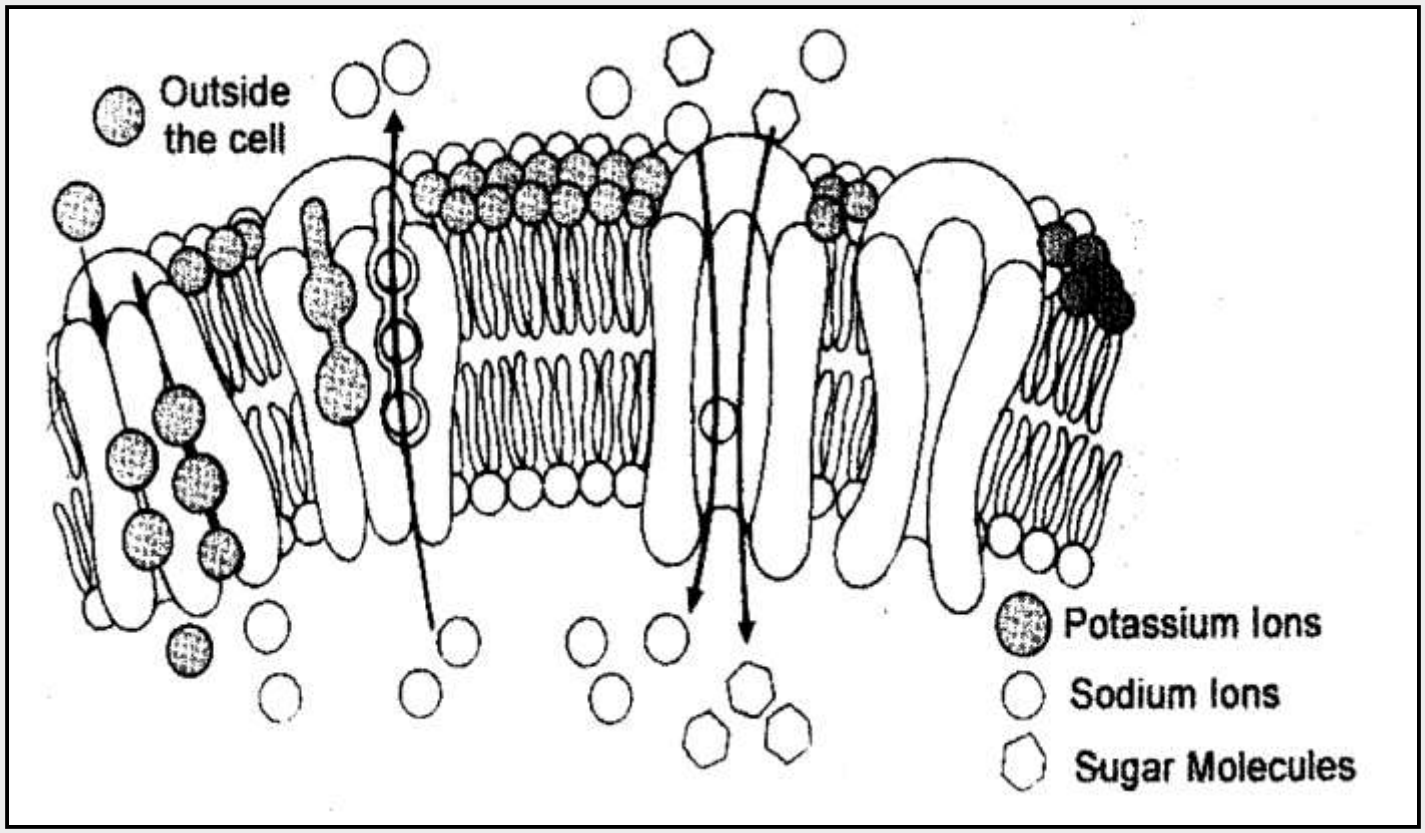
A. Passive transport
B. Facilitated diffusion



3. Active transport

1. Sometimes a substance is required to be transported through the membrane against concentration gradient. Hence it requires cellular energy in the form of ATP to achieve this movement.
2. Like facilitated diffusion , active transport depends on integral membrane proteins that are capable of selectively binding a particular substance and moving that substance acros the membrane, driven by changes in protein's conformation.
3. Unlike facilitated diffusion, active transport requires the expenditure of energy.

Active transport across membrane



4. Bulk transport

1. The movement of macromolecules such as proteins or polysaccharides into or out of the cell is called **bulk transport**.
2. There are two types of bulk transport,
   Exocytosis
   Endocytosis
3. These require the expenditure of energy (ATP).

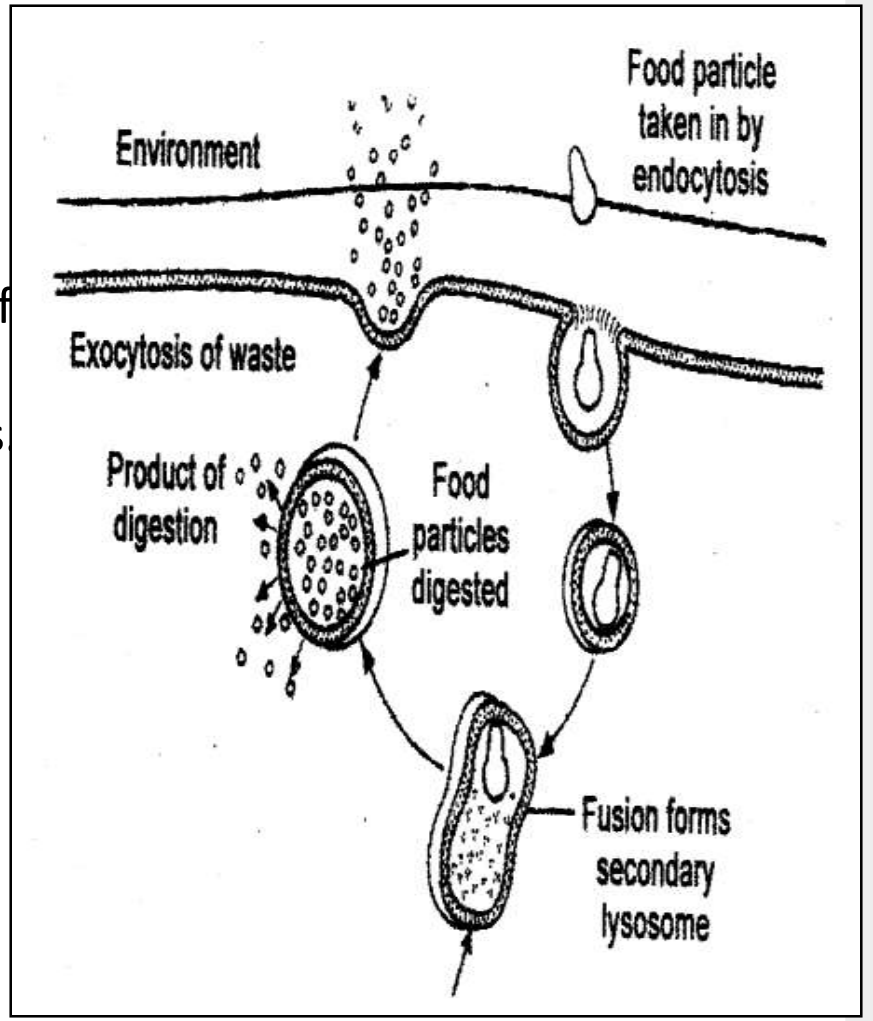
Endocytosis (Pinocytosis)

1. In endocytosis the cell membrane invaginates and fuses around an extracellular macromolecule (ligand) forming a vesicle called endosome.

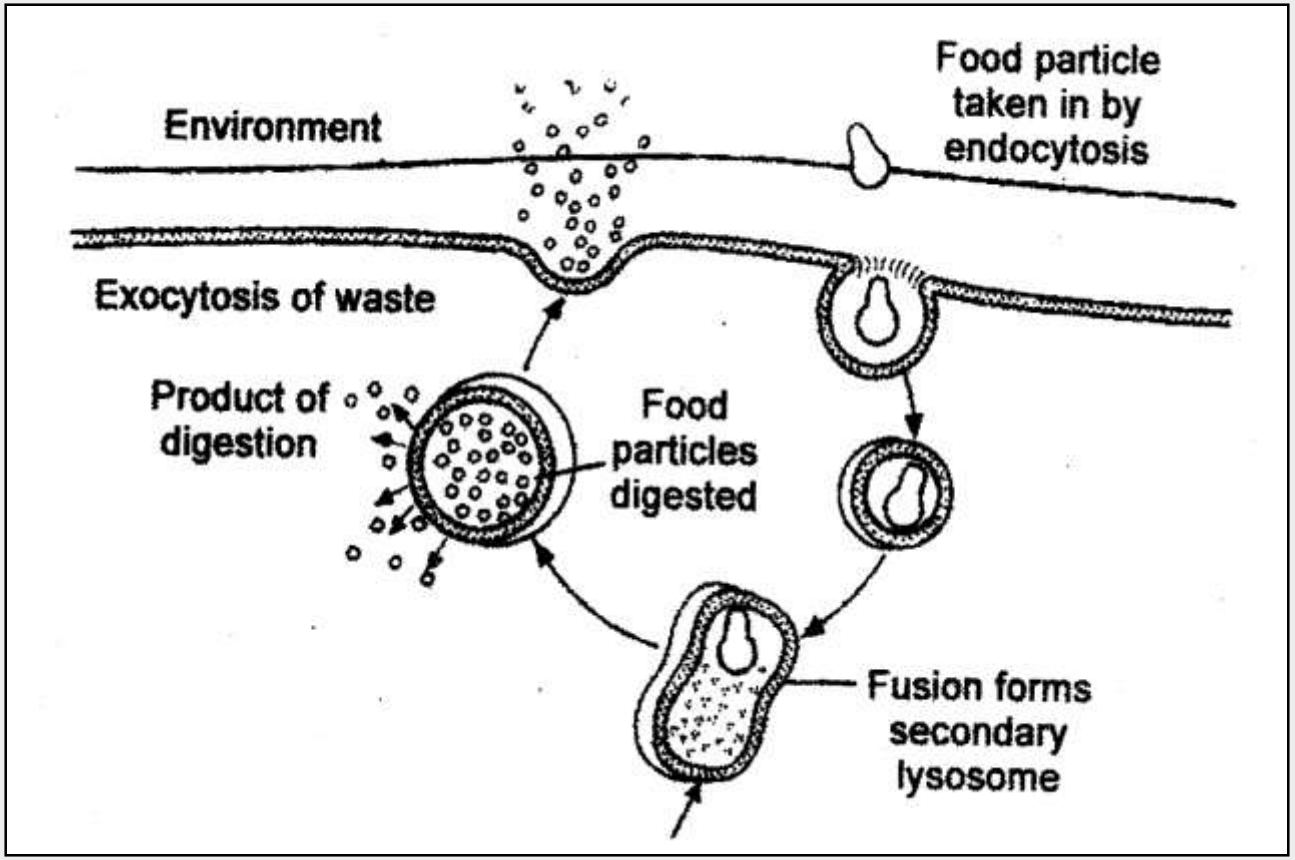
2. The endosome migrates to the interior of the cell and fuse with the pre-existing lysosomes to form the digestive vacuoles.

3. The food is digested by the hydrolytic enzymes of the lysosome.

4. The digested food is ultimately diffused from the digestive vacuoles into the surrounding cytoplasm.

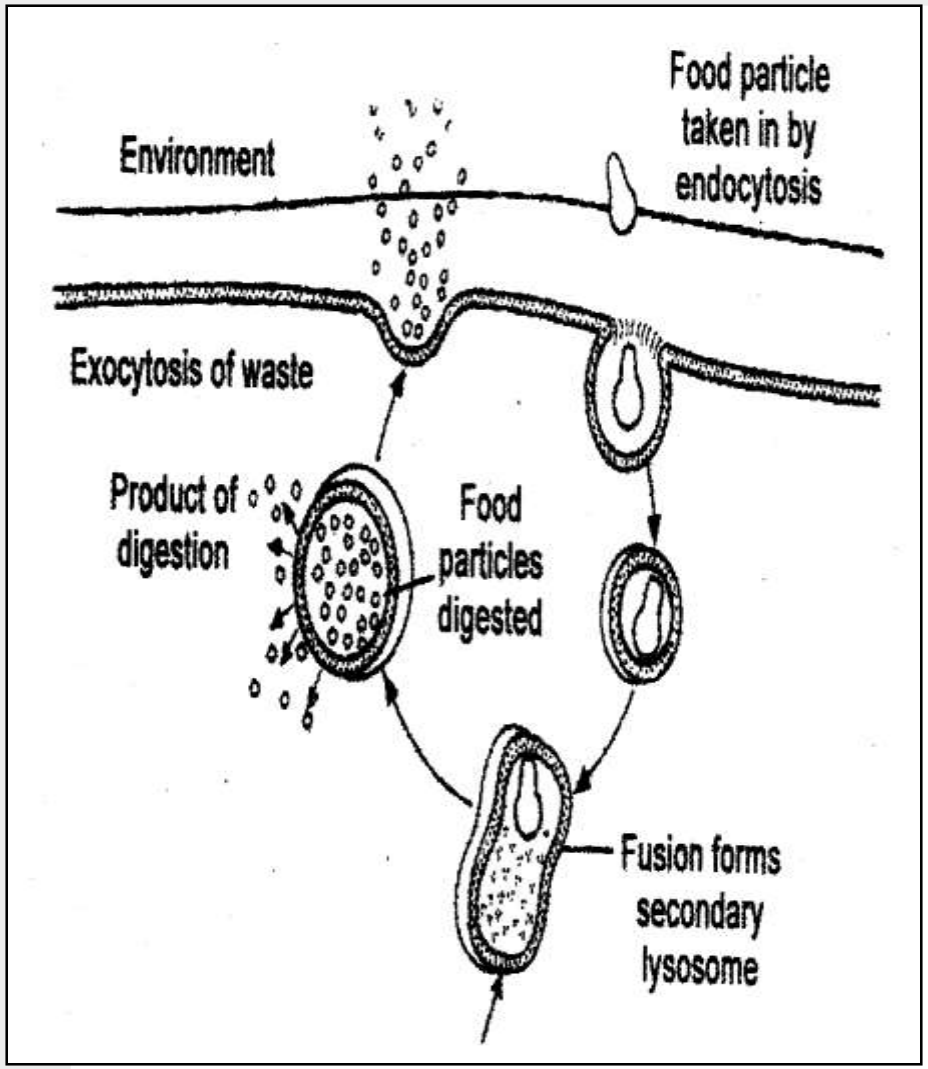


Endocytosis (pinocytosis)



Bulk transport of fluid substances through the process of endocytosis (pinocytosis).

Exocytosis (cell vomiting)



1. In exocytosis (cell vomiting) an intracellular vesicle containing substance targeted for extracellular release, fuses with the cell membrane and releases its contents to the outer medium.
2. In excytosis materials are exported out of the cell via secretory vesicles

Eg:- Release of neurotransmitter molecules by exocytosis in the presence of Ca^{2+} ions.

Next lesson

Unit 1

Lesson 3: Chromosomes

1. Introduction
2. History
3. Chromosome number
4. Size
5. Autosomes and sex chromosomes
6. Structure of chromosomes
7. Karyotype

Stay home – Stay safe


THANK YOU

Third UG – Botany

Fifth Semester

Paper V

Cell Biology, Genetics and Plant Breeding

Unit 1
Cell Biology

Lesson 2
Plasma membrane

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Structure of today's Lesson

Plasma membrane

2.9 Introduction

2.10 Chemical composition

2.11 Structure of the Plasma membrane

2.12 Functions of Biological membranes

2.13 Movement of substances across cell membrane

Objectives

1. To understand the chemical composition of plasma membrane.
2. To learn ultra structure of the plasma membrane.

3. To describe the function of the biological membrane.

4. To Know the difference between active and passive transport system.

Introduction

1. The cytoplasm in both and animal cells is surrounded by the **plasma membrane .**
2. It is also called **as plasma lemma**.
3. This type of limiting membranes are also present in other organelles :

   Mitochondria
   Golgi complex
   ER
   Chromoplast etc.,

This separate their contents from the cytosol and are called **unit membranes or cell membranes**.

5. The cell membrane and plasma membrane are collectively known as **biological membranes.**

3. All of these membranes have a common structure and composition.

Chemical composition

1. It consist of lipoproteins.
2. The ratio of protein to lipid varies from 1:0.8 to 1:4.
3. In addition to lipoproteins polysaccharides, DNA and RNA have also been found in certain cases.

1. Lipids

1. The most common fats found in the membrane are phospholipids, glycolipids and sterols.

2. All of them are amphipathic i.e., they have both hydrophilic and hydrophobic portions.

3. The three most important phospholipids are :

Lecithin
Choline
Cephalin

} made up of glycerol, fatty acids, phosphoric acid and a complex of sphingosine

2. Proteins

Three different types of proteins are present in the membrane.

1. **Structural proteins**:

   These form the backbone of the membrane and are strongly lipophilic in nature.

2. **Functional proteins**:

   These are like enzymes that catalyse several physiological reactions (e.g., glucose, 6-phosphatase found in membranes of ER and the cytochrome oxidase present in Mitochondria).

3. **Carrier proteins**:

   These bring about the diffusion of substances across the membrane.

2. Proteins

4. The proteins present in the plasma membrane are further differentiated into
   - integral proteins
   - peripheral proteins
5. The integral proteins have hydrophobic interaction.
6. The peripheral proteins have hydrophilic interaction.

Peripheral and integral proteins

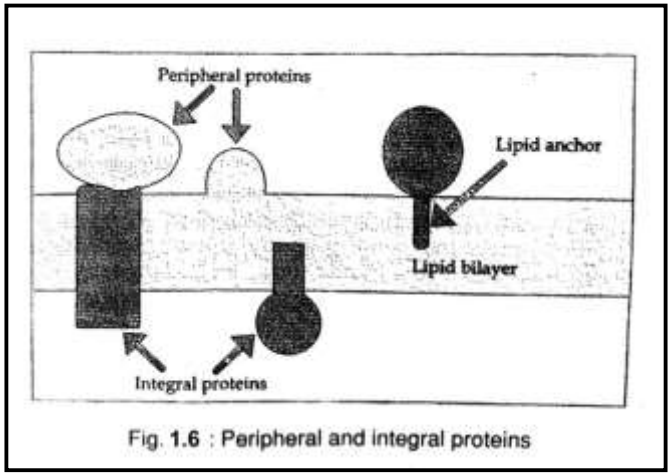


Fig. 1.6 : Peripheral and integral proteins

3. Other constituents

Small amounts of the following constituents are distributed in certain biological membranes.

- polysaccharides,
- Sialic acid
- DNA, RNA
- Traces of co-enzymes
- Porphyrins
- metal ions etc.,
- Carbhohydrates of the membrane are usually located at the extracellular surface forming **gilcocalyx**.

Structure of the plasma membrane

Molecular Models of plasma membrane

1. Several cell biologists attempted to understand the molecular structure of the plasma membrane in various ways and proposed models for the same.

2. These models can be classified into two basic categories:

a) Bilayer models: In this model, the proteins and lipids are arranged in the form of layers.

b) **Micellar models**: In this model, there is a presence of number of small and similar independent subunits in the plasma membrane.

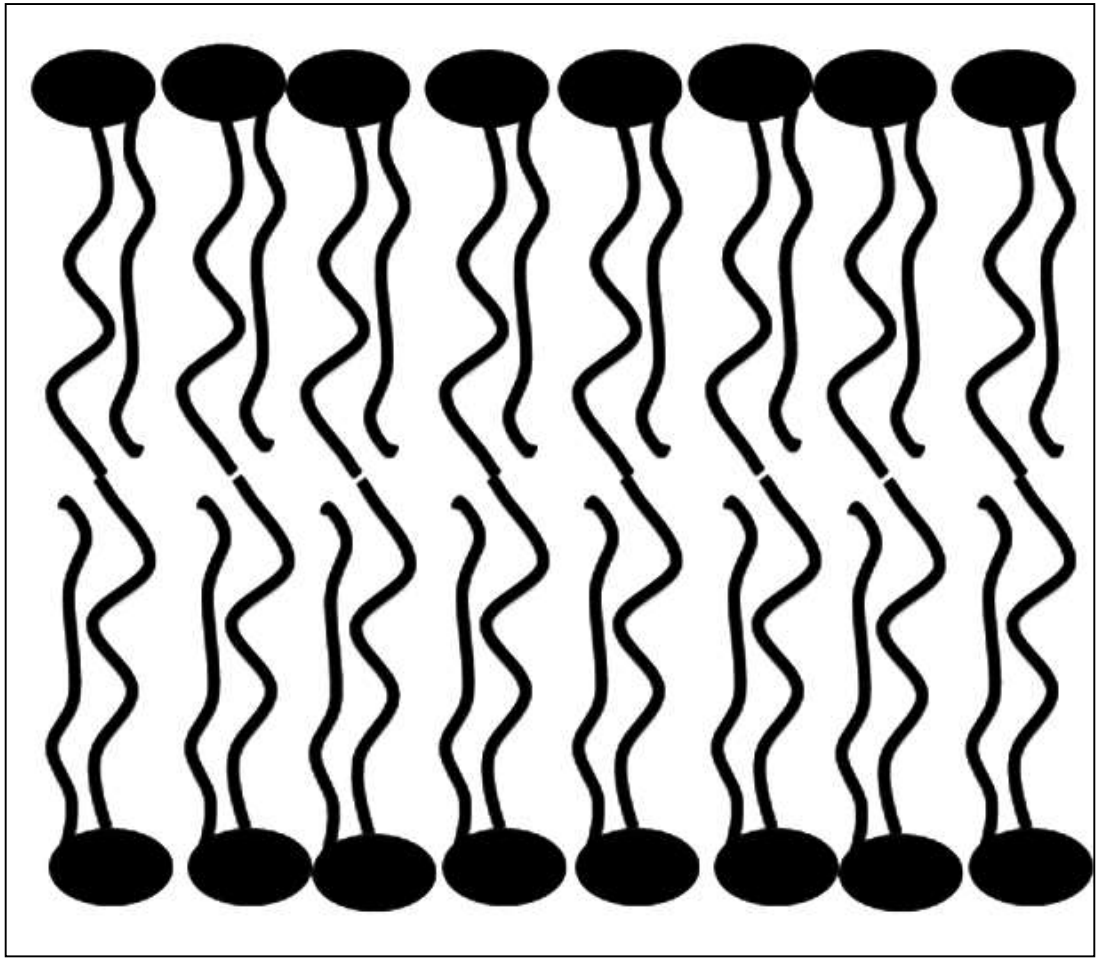
Molecular Models

1. **Lipid bilayer model**: E. Gorter and F. Grendal (1925).
2. **Danielli – Davson model**: James Danielli and Hugh Davson(1935).
3. **Unit membrane model**: Robertson (1957).
4. **Fluid Mosiac model**: S.I Singer and G. Nicolson (1972).
5. **The Micellar model**: Hilleir and Hoffman (1953).

1. Lipid Bilayer Model

1. In 1925, Gorter and Grendel have suggested that plasma membrane is composed of double layer of lipid molecules.
2. Based on their observations made in the lipids, extracted from human erythrocyte membrane.
3. They measured the surface area that lipid would cover over the surface of water.
4. They concluded that the plasma membrane contained a bimolecular layer of lipids or simply lipid bilayer.
5. They also suggested that the polar groups of each molecular layer were directed towards the out side of the layer.
6. Their ideas have laid foundation for the future models of the structure.

Lipid bilayer model of plasma membrane



Interior Surface

Lipid bilayer

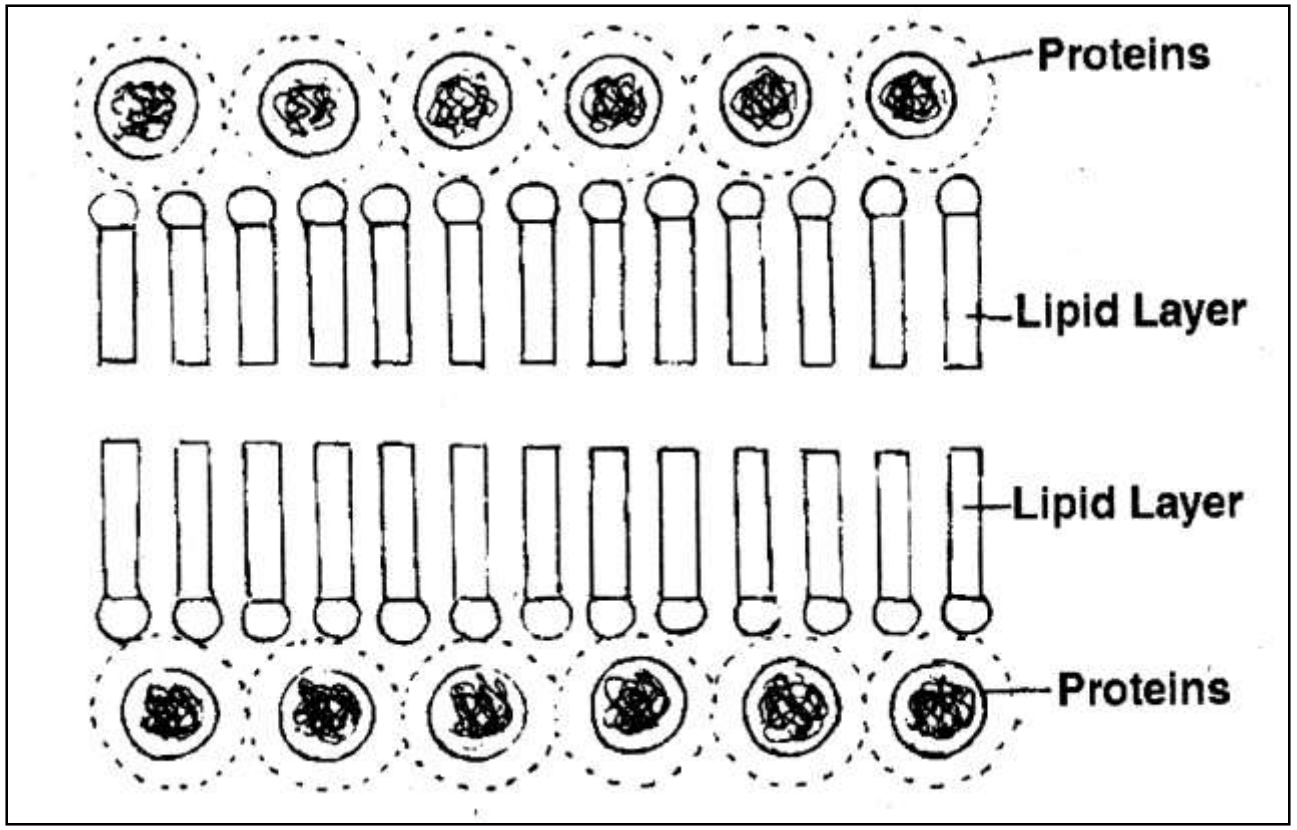
Exterior Surface

2. Danielli – Davson Model
(Trilaminar Sandwich model)

1. This model was proposed by Danielli and Davson in 1935.
2. They proposed that the membrane consists of two layers of lipid molecules.
3. Initially they supposed that proteins existed as covalently bonded globular structures bound to the polar ends of lipids.
4. **Subsequently they developed the model in which the protein appears to be smeared over the hydrophilic ends of the lipid bilayer.**
5. This model makes its popularity for a long time.
6. Electron Microscopic picture of plasma membrane revealed a three layer structure of two 2.5 nm thick lines separated by a clear 4 nm space.
7. Later on various modifications have been proposed for this model.

Sandwich model of Danielli and Davson

Exterior

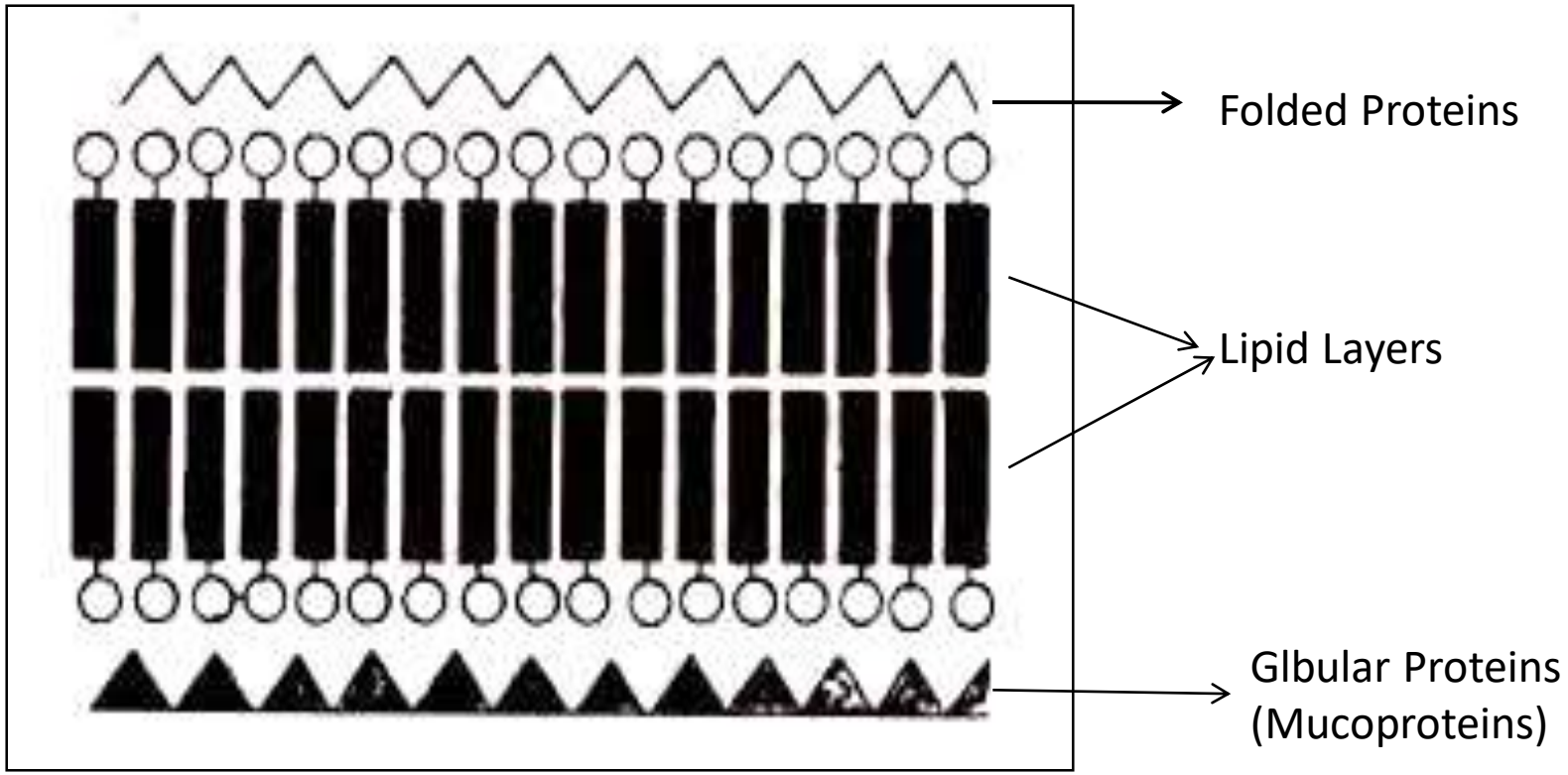


Interior

3. Unit Membrane Model

1. It was proposed by Robertson (1959) after studying the membrane with the help of electron microscope.
2. The unit membrane model is similar to Danielli – Davson model except that the protein layers at the exterior and interior are different.
3. The outer surface has mucoproteins while the inner surface has non – mucoproteins.
4. The membranes of cell organelles, plasma membrane and endoplasmic reticulum are thought to have unit membrane structure.
5. But later on it has been shown that the arrangement of proteins and lipids is variable in different membranes.
6. Robertson's unit membrane concept was based on the study of the myelin sheath of a nerve fibre, which is a non – typical membrane.
7. Hence, this model cannot be considered as a representative structure.

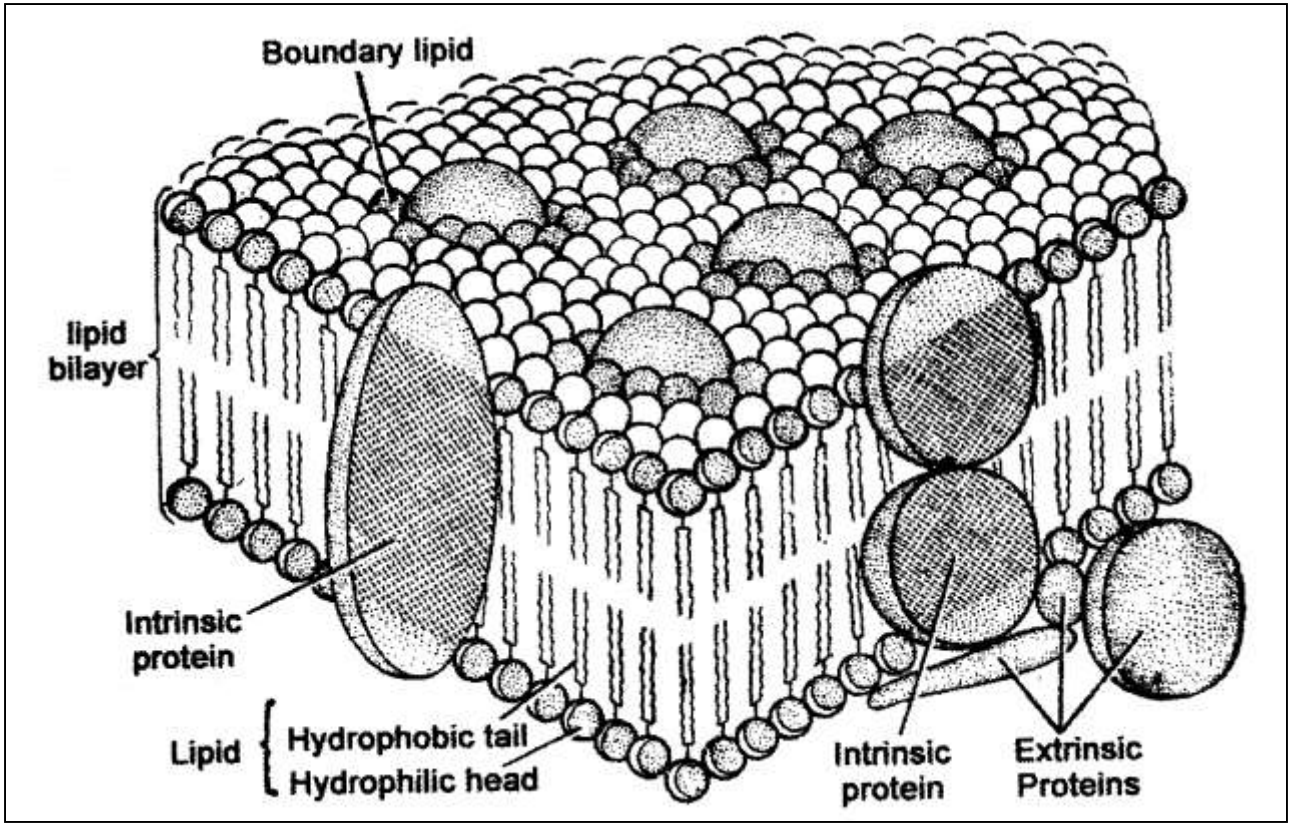
Robertson’s unit membrane model



4. Fluid Mosaic Model

1. This model was proposed by S.J. Singer and Garth L. Nicolson in 1972 .
2. This model describes the structure of plasma membrane as a mosaic of components.
3. **Here the lipid molecules are present in a fluid state capable of rotating and moving laterally within the membrane.**
4. **The proteins occur as a ‘mosaic’ of discontinuous particles that penetrate deeply into the lipid sheet.**
5. In a way, these protein particles resemble floating icebergs in the sea of lipids.

Fluid mosaic model of plasma membrane.



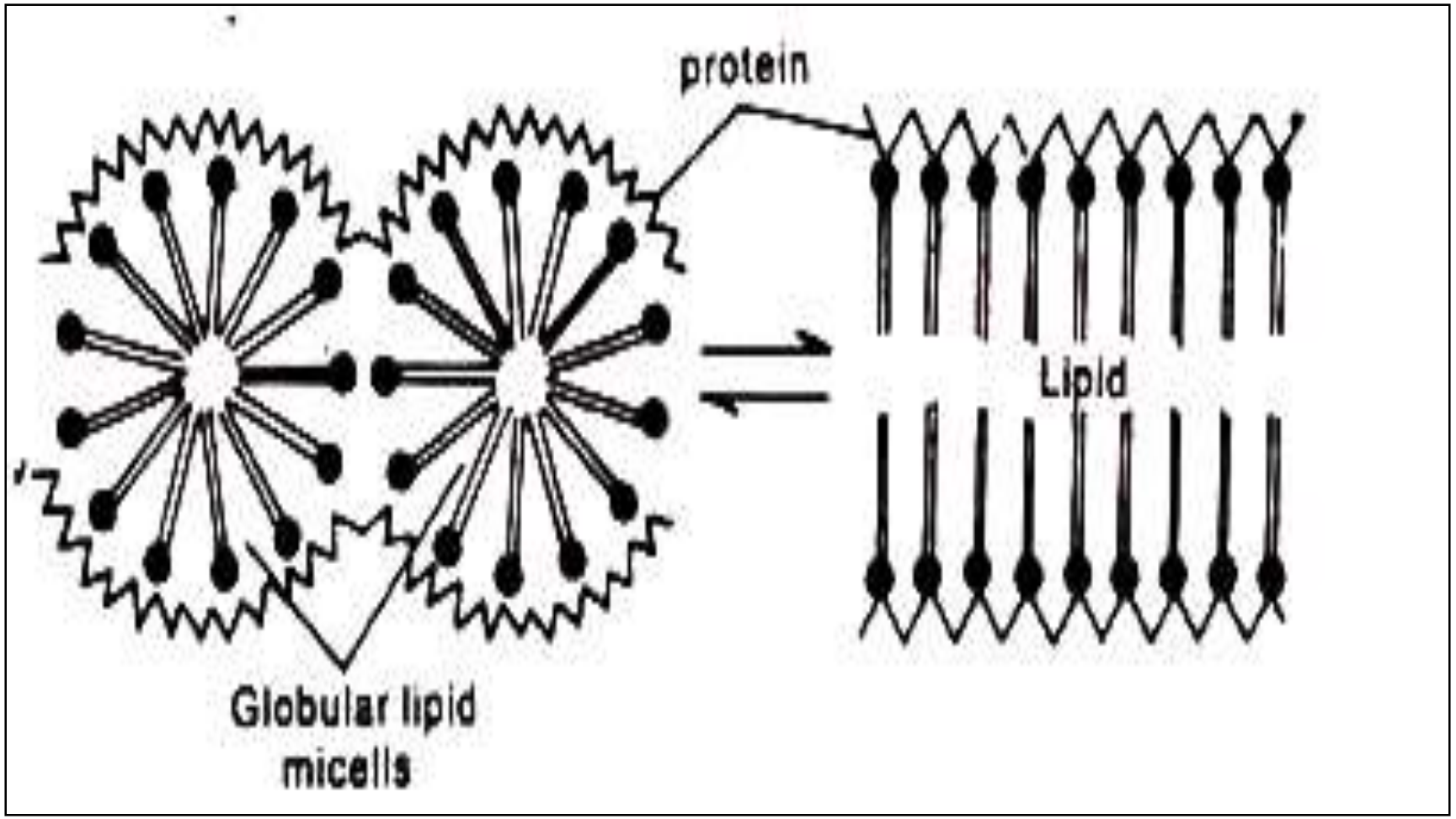
Fluid Mosaic model

1. Thus, Fluid mosaic model describes the structure of the plasma membrane as:
2. A double layer of phospholipids with their polar ends away from one another
3. And the globular molecules of proteins and sterols scattered in between.
4. Integrated proteins penetrate lipid bilayer partially or wholly and project out from both the extracellular and cytoplasmic sides of the membrane.
5. The globular peripheral proteins are loosely attached to the membrane lipids

5. Micellar Model

1. In 1953, Hilleir and Hoffman have suggested tat biological membrane may have **non-lamellar pattern consisting instead of mosaic of globular subunits known as micelles,** which have a lipid core and hydrophilic shell of polar groups.
2. Each micelle is about 40 – 70A^{o} in diameter.
3. **The lipid micelles are possible buildings blocks of membranes** since tend towards spontaneous association and disassociation.

Transformation between micellar and lamellar states of plasma membrane.



Micellar Model

- The protein components of the membrane form a monolayer on either side of the plane of lipid micelles.
- The spaces between micelles represent water filled pores ($4A^{o}$).
- These pores are lined partly by the polar groups of micelles and partly by the polar groups of associated proteins.

Functions of the Biological membranes

Functions

- **It is a selectively permeable membrane**: It regulates the entry of appropriate substances into all the cells and ensures that inappropriate substances are kept out. In this way it acts as a selectively permeable barrier.
- **Transporting machinery for metabolic essentials**: Carrier proteins in the membrane are involved in the transport of certain materials like gases, solutes etc., across the plasma membrane.
- **Responding to stimuli**: All biological membranes have on their outer surface specific protein molecules acting as receptors, which unite with complementary substances or ligands providing external stimuli to the cell.
- **Compartmentalization**: Membranes are the living boundaries of the cytoplasm and cellular organelles. They form continuous and unbroken sheets that divide the living matter into self-sustaining units to perform specialized functions.
- 5) **Site of biochemical activities**: Cells have to perform different biochemical activities in the presence of enzymes. Membranes provide the structural frame work for the location of various enzymes.
- As a result, there is an effective coordination of biological reactions.

Movement of substances across the cell membrane

- Substances can move into and out of cells through the cell membrane. The main types of movement are –
- Passive transport
- Facilitated diffusion
- Active transport
- Bulk transport

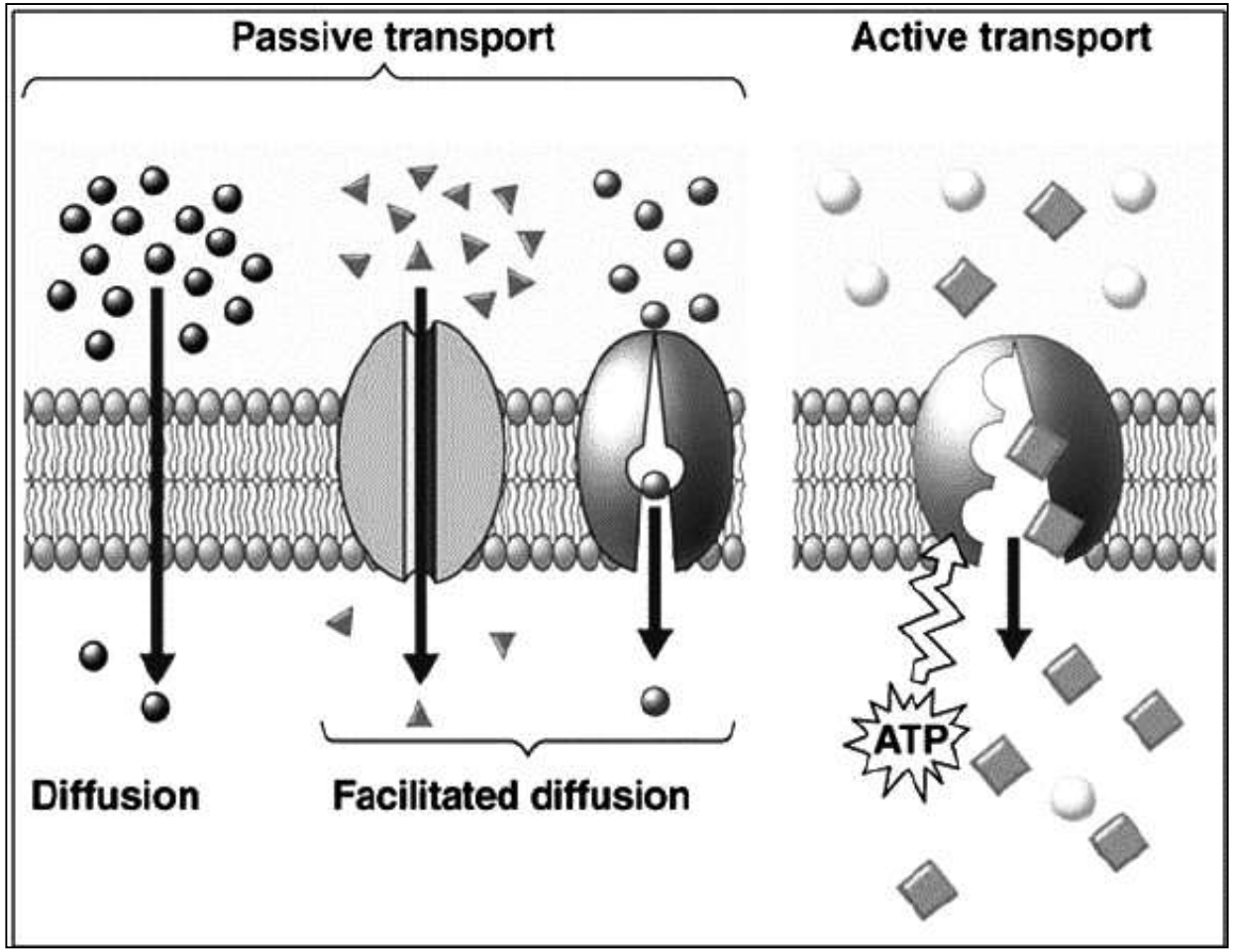
Passive transport

- Passive transport is a movement of ions and other atomic or molecular substances across the cell membranes without the need of energy input (Fig. 1.12a). The rate of passive transport depends on the permeability of the cell membrane, which in turn depends on the organization and characteristics of the membrane lipids and proteins

Facilitated diffusion

- In facilitated diffusion (also called as carrier mediated osmosis) molecules form a complex with glucose and facilitate the diffusion of glucose into the cell through the membrane (Fig. 1.12b). Since glucose is the body's primary source of direct energy, most cells contain a membrane protein (glucose transporter) that facilitates the diffusion of glucose from the blood stream into the cell.

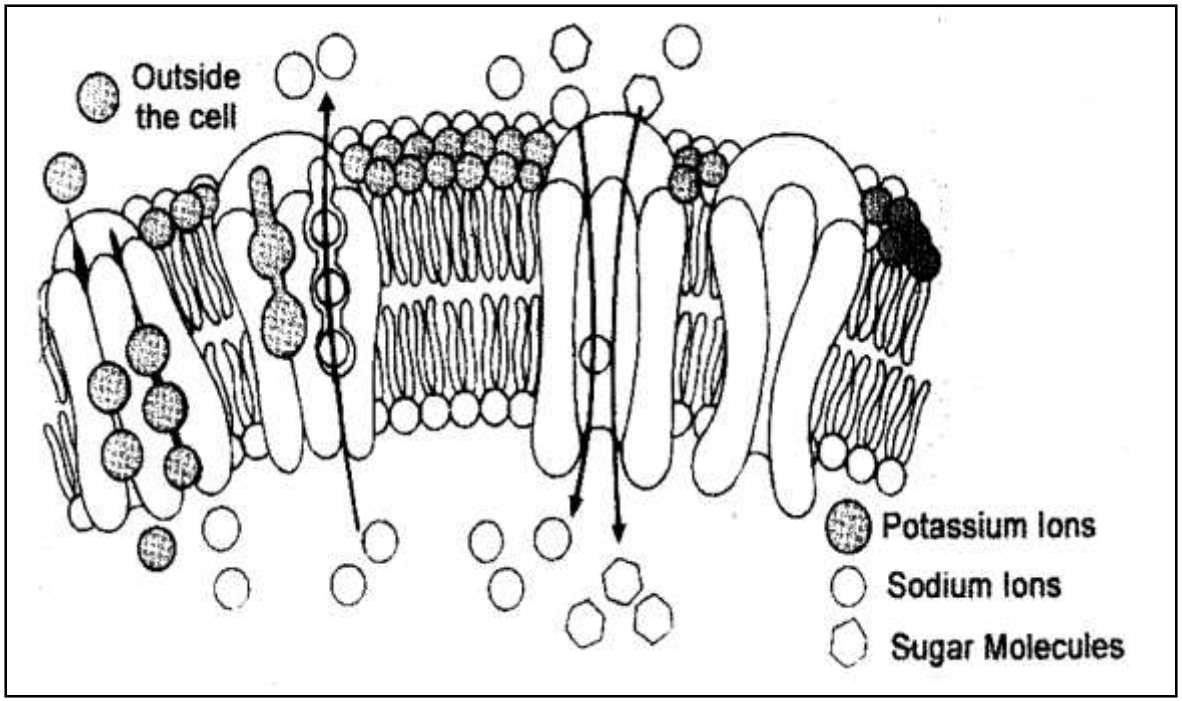
A. Passive transport.
B. Facilitated diffusion



Active transport

- Active transport is the movement of molecules across a membrane from a region of their lower concentration to a region of their higher concentration against the concentration gradient. Active transport requires cellular energy to achieve this movement.

Active transport across membrane



Bulk transport

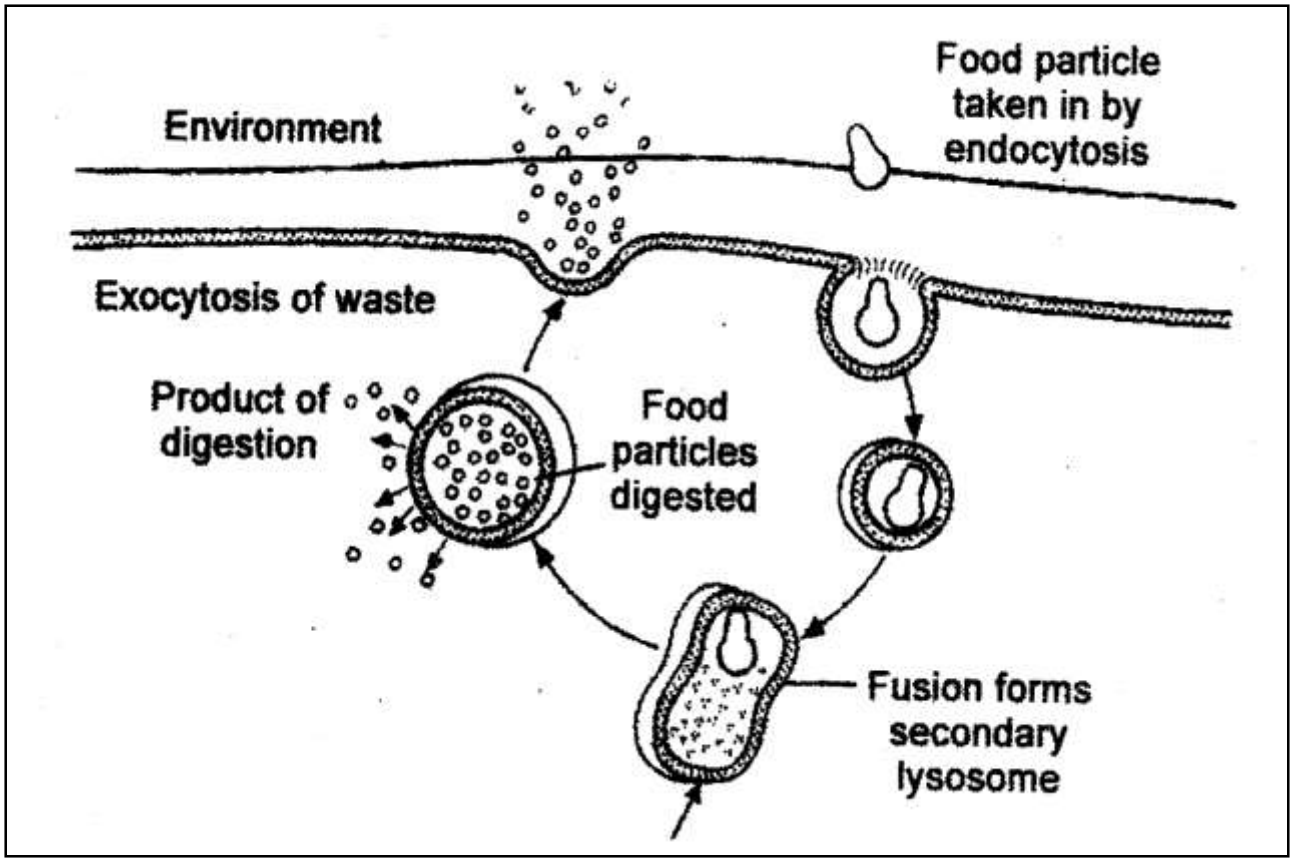
- The movement of macromolecules such as proteins or polysaccharides into or out of the cell is called bulk transport. There are two types of bulk transport, exocytosis and endocytosis and these require the expenditure of energy (ATP). In excytosis materials are exported out of the cell via secretory vesicles.

Endocytosis

In endocytosis the cell membrane invaginates and fuses around as extracellular macromolecule (ligand) forming a vesicle called endosome. The endosome migrates to the interior of the cell and fuse with the pre-existing lysosomes to form the digestive vacuoles.

The food is digested by the hydrolytic enzymes of the lysosome.

Endocytosis (pinocytosis)



Bulk transport of fluid substances through the process of endocytosis (pinocytosis).

Exocytosis (cell vomiting)

- In exocytosis (cell vomiting) an intracellular vesicle containing substance targeted for extracellular release, fuses with the cell membrane and releases its contents to the outer medium.
- This process of membrane fusion and content discharge is called exocytosis.
- Eg:- Release of neurotransmitter molecules by exocytosis in the presence of ca^{2+} ions.

Stay home – Stay safe


THANK YOU

Third UG – Botany

Fifth Semester

Paper V

Cell Biology, Genetics and Plant Breeding

Dr. A. Sujatha, Department of Botany, MVR Degree College, Gajuwaka, VSP

Unit II
Genetic material

Lesson 2
DNA replication

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DNA- Replication

Structure of today's Lesson

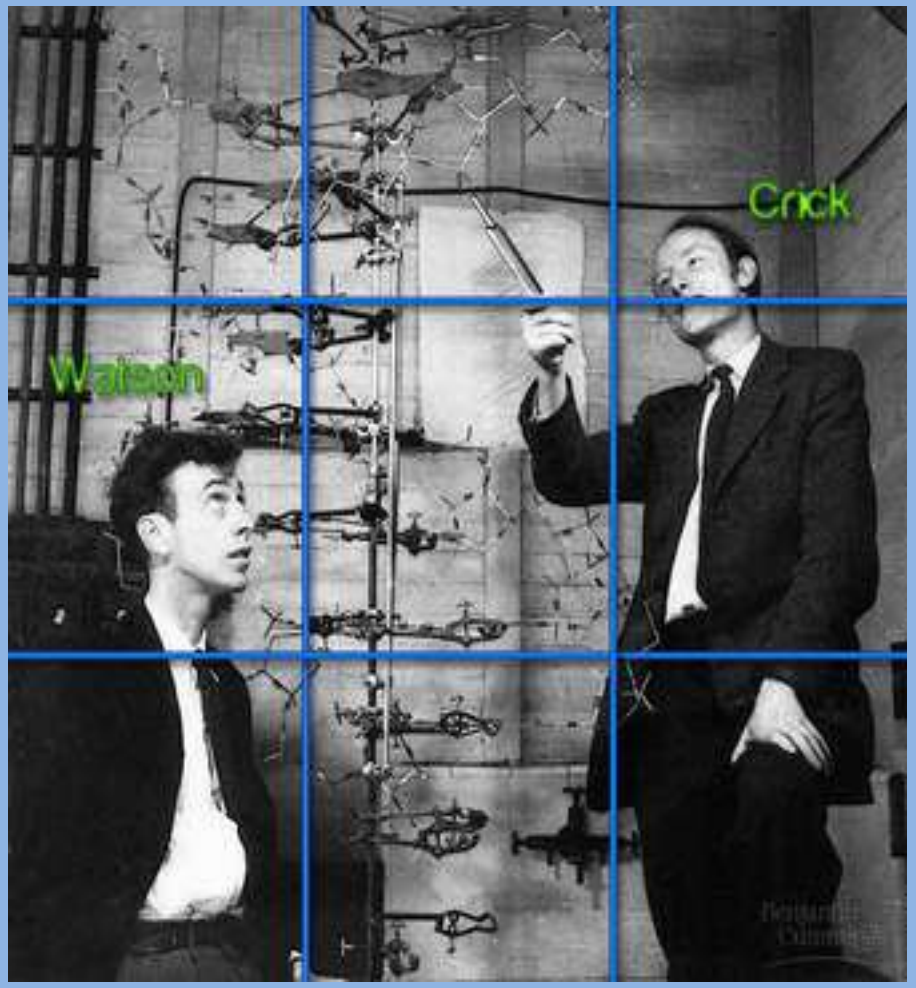
1. Introduction
2. Types of DNA replication
3. Salient features of DNA replication

Objectives

1. To understand the DNA replication.
2. To learn the types of DNA replication.
3. To know about the salient features of DNA replication.

Introduction

- The process by which a DNA molecule produces its identical copies is described as DNA replication.
- It is a type of self reproduction of DNA, where two daughter molecules are formed from a single DNA molecule.



DNA replication

There were three models for how organisms might replicate their DNA. They are:

1. Dispersive replication
2. Conservative replication
3. Semi conservative replication

The semi-conservative model, in which each strand of DNA serves as a template to make a new, complementary strand, seemed most likely based on **DNA's** structure.

Dispersive replication

1. The two strands of parent DNA break randomly and produce several pieces.
2. These pieces replicate and reunite to form a new daughter DNA molecule.
3. These new molecules contain a mixture of old and new nucleotides scattered along, the chains.
4. The daughter molecules are described as hybrids.
5. This mechanism is neither accepted nor proved experimentally.

Conservative replication

1. After replication, one daughter DNA contains the original two strands of the parent molecule.
2. While the other daughter molecule contains two newly synthesized strands.
3. This method not accepted.

Semi-conservative replication

1. This method was proposed by Watson and Crick.
2. Because of the specificity of base pairing , the sequence of bases along one chain automatically determines the base sequence along the other.
3. Thus each chain of the double helix can serve as a template for the synthesis of the complementary strand.
4. More precisely semi – conservative means half of the DNA conserved i.e ; only one strand is synthesized and the other half of the original DNA is retained.

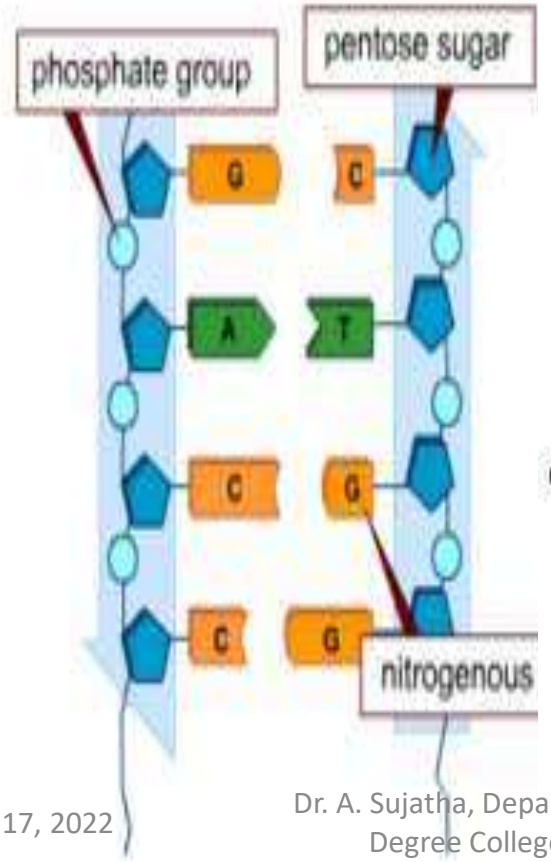
Evidences for semi – conservative replication

1. Meselson – Stahl's experiment
2. Cairn's Auto radiography experiment

Basic features of DNA replication

1. DNA molecule consists a sequence of bases on two strands.
2. The two strands have complementary base pairing. Therefore the main role of replication is to duplicate the base sequence of parent DNA molecule.
3. Adenine of one strand pairs with thymine of the opposite strand and guanine pairs with cytosine.
4. This specific complementary base pairing provides the mechanism for the replication.

5. So the two strands uncoil and separate from each other.
6. Each strand functions as a template for the new complementary daughter strand.
7. The base sequence of parent or old strand directs the base sequence of new or daughter strand.
8. If there is adenine in the parent complementary thymine will be added to the new strand.
9. Similarly, if there is cytosine in the parent strand, complementary guanine will be copied into the new daughter strand.
10. Maintenance of integrity of genetic information is the main feature of replication.


phosphate group
pentose sugar
G
C
A
T
C
G
C
G
nitrogenous

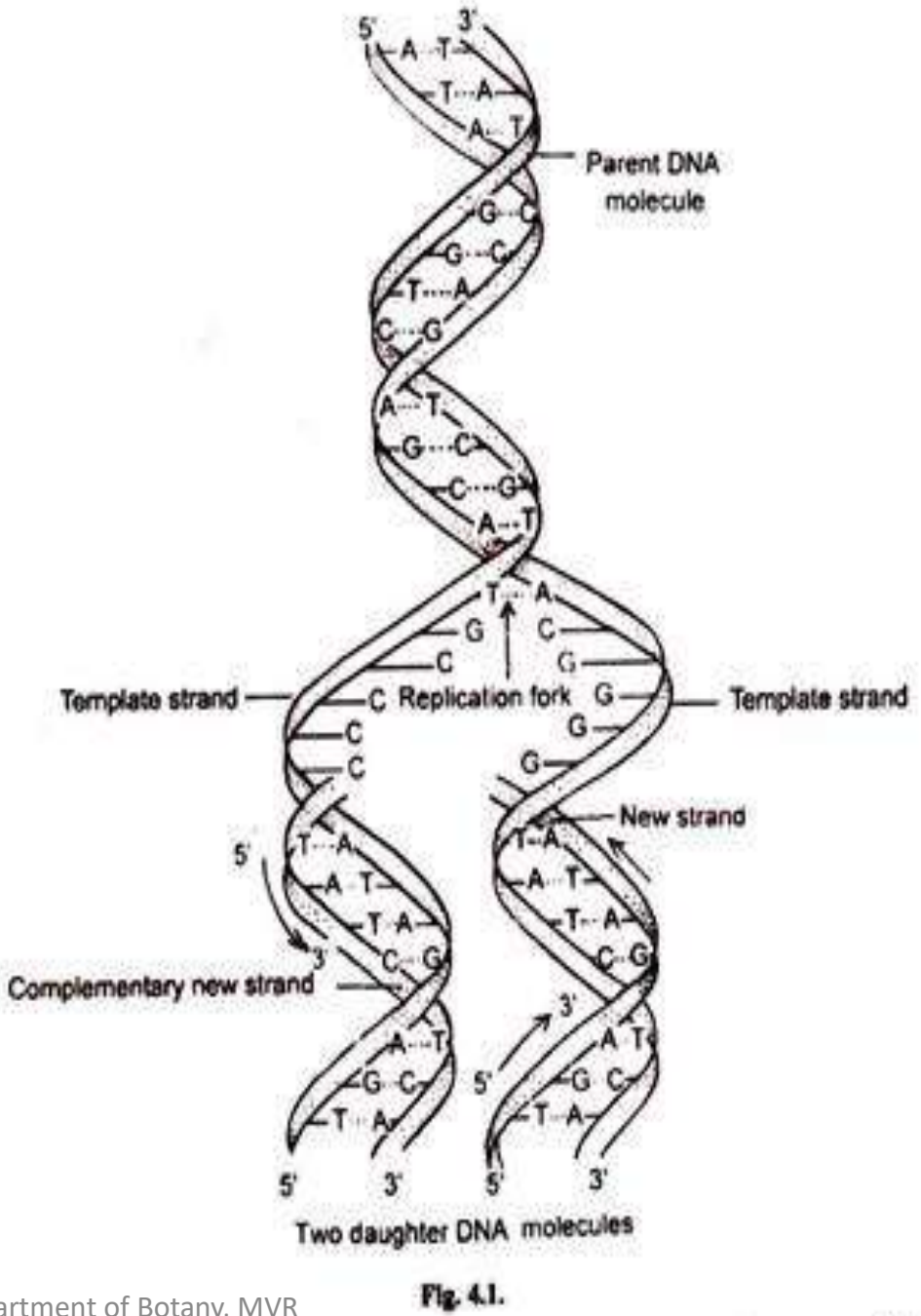

5'
3'
Parent DNA molecule
Template strand
Replication fork
Template strand
New strand
Complementary new strand
5'
3'
5'
3'
5'
3'
Two daughter DNA molecules

Fig. 4.1.

Mechanism of DNA Replication:

- DNA replication is a complex event and includes the following 3 major phases.
  1. Initiation
  2. Elongation
  3. Termination
  - Replication occurs inside the chromosomes during interphase.
  - The parent DNA strand serve as templates for the synthesis of new DNA strands.
  - DNA replication occurs by semi-conservative method.
  - It is catalyzed by the DNA Polymerase.

1. Initiation:

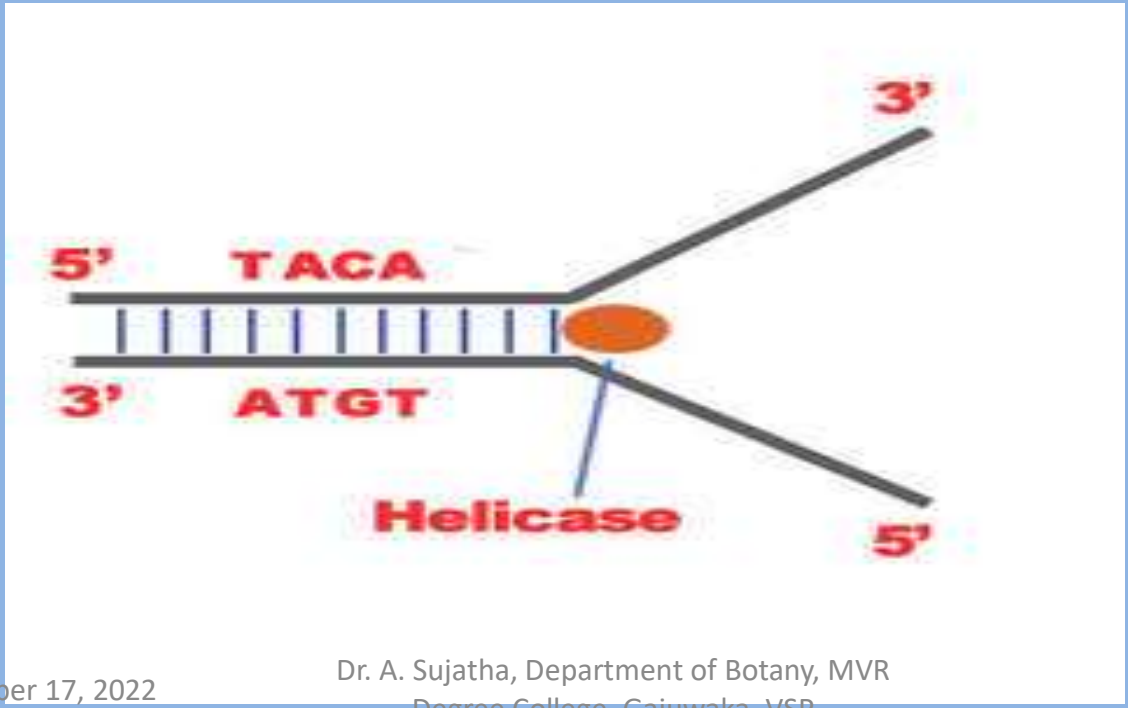
- DNA replication begins at certain unique and fixed points called origin or ‘ori’.

- Two enzymes ‘DNA gyrase’ and ‘DNA helicase’ bind to the origin points induce the unwidening and separation of complementary strands of DNA double helix.

- This separation is known as ‘melting’.

- Melting of DNA produces Y-shaped replication forks at origin region.

- As the two strands separate the bases are exposed to enzymes.
- An enzyme called ‘RNA polymerase’ or ‘primase’ initiates transcription of the strand (3^{l}-5^{l}) and generates a 10-60 nucleotide long primer (RNA) (transcribed in 5^{l}-3^{l} direction).

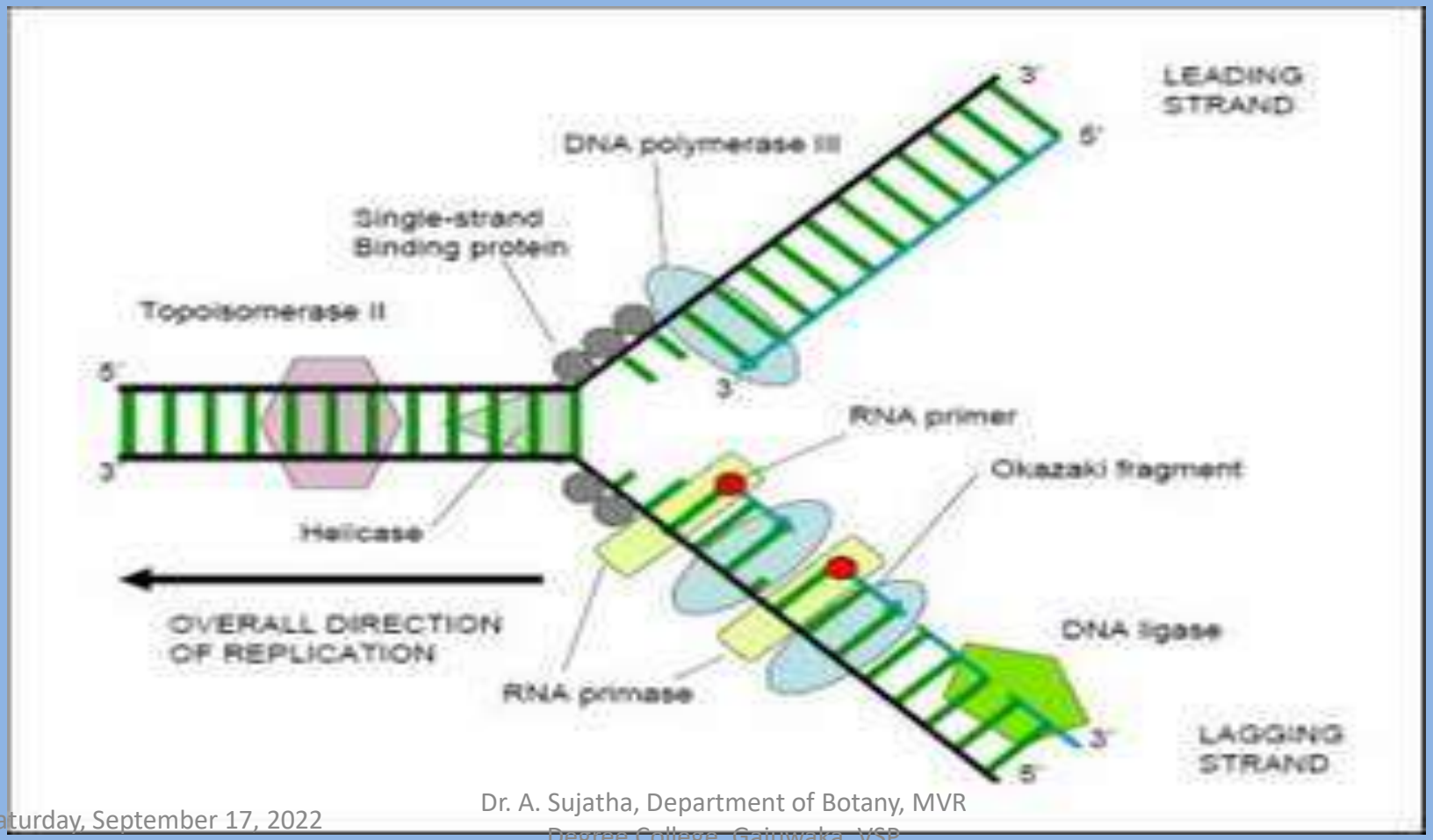


2.Elongation:

- The free 3^{I} OH of this primer RNA provides the initiation point for the synthesis of new DNA strand.
- Deoxyribonucleotides are added to the 3^{I} OH group of the last ribonucleotide of the RNA primer.
- This leads to elongation of the primer nucleotides in the 5^{I}-3^{I} direction.
- This is mediated by DNA polymerase –III.
- This enzyme require the free 3^{I} OH of a pre-existing polynucleotide for the elongation of DNA replication.
- The DNA polymerase progressively adds deoxyribonucleotides to the free 3^{I} OH of this growing polynucleotide chain.

- Consequently, the replication of 3^{l}-5^{l} strand of a DNA molecule proceeds continuously.
- The replication of second strand (5^{l}-3^{l} strand) of the DNA molecule is discontinuous.
- It begins some what later than that of the 3^{l}-5^{l} strand.
- Therefore the 3^{l}-5^{l} strand of DNA molecule is known as the leading strand while the 5^{l}-3^{l} strand is termed as the lagging strand.
- The helicase enzyme progressively unwinds the duplex and the replication fork moves along like a bubble.

- The replication of the lagging strand generates small polynucleotide fragments called okazaki fragments.
- The replication of lagging strand proceeds from the replication fork towards the origin.



3. Termination:

- When the formation of daughter strand synthesis completed the RNA primers are removed by DNA polymerase-I by its 5^{I}-3^{I} exonuclease activity.

- The remaining gap is sealed by lygase.

- DNA lygase catalyses the winding of 2 strands.

- Prokaryotic DNA lygase needs NAD^{+} as cofactor while eukaryotic DNA lygase requires ATP.

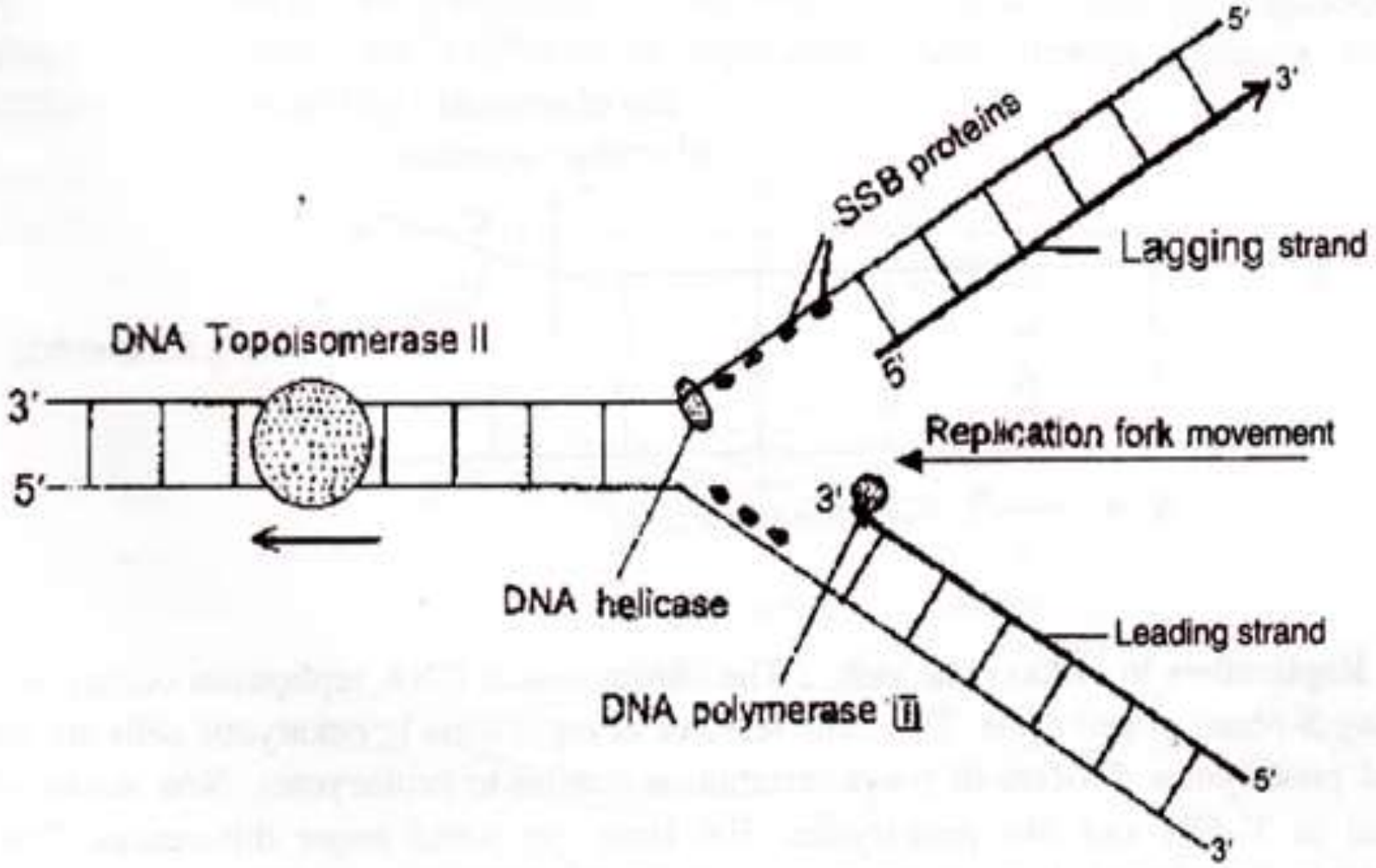


Fig. 4.7. Unwinding of double helix.

Next class

- Enzymes involved in DNA replication

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Third UG – Botany

Fifth Semester

Paper V

Cell Biology, Genetics and Plant Breeding

Unit II
Genetic material

Lesson 3
Types of RNA

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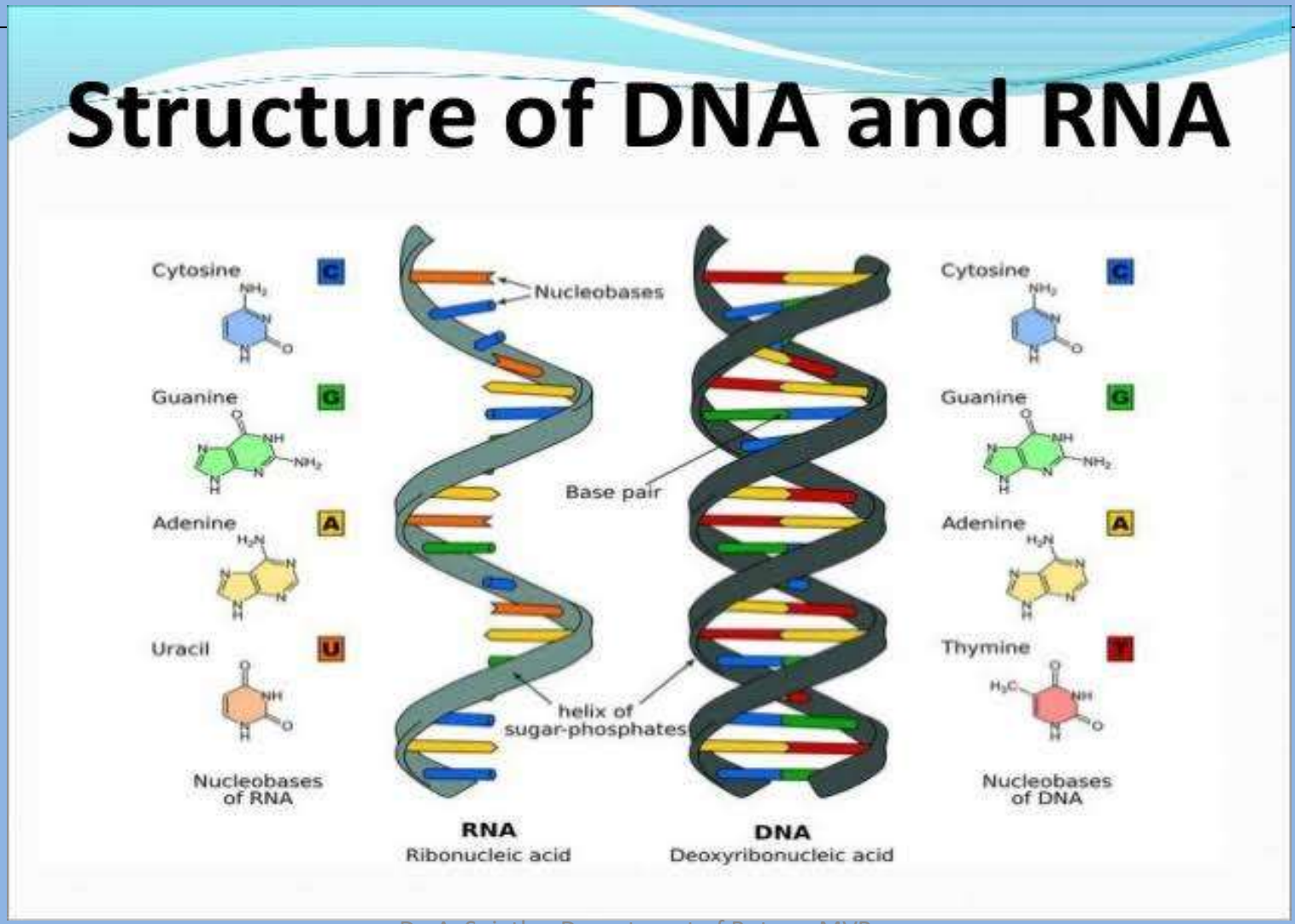
Structure of today's Lesson

1. Introduction
2. RNA structure
3. Types of RNA
4. mRNA
5. rRNA
6. tRNA

Introduction

1. **Ribonucleic acid** (**RNA**) is a polymeric molecule essential in various biological roles coding, decoding, regulation and expression of genes.
2. RNA & DNA are nucleic acids.
3. Along with lipids, proteins, and carbohydrates, nucleic acids constitute one of the four major macromolecules essential for all known forms of life.
4. Like DNA, RNA is assembled as a chain of nucleotides.
5. But unlike DNA, RNA is found in nature as a single strand folded onto itself, rather than a paired double strand.

RNA and DNA structure



RNA

1. Most prokaryotic and eukaryotic cells contain RNA in addition to DNA.
2. Some viruses however contain no DNA but only RNA.
3. In them, RNA is the sole genetic material and carries the responsibilities of DNA. Such RNA is called **genetic RNA**.
4. Eg TMV, Yellow Mosiac Virus (YMV), wound tumour viruses, influenza, polio viruses etc
5. Further in those cell where DNA is the genetic material, there occur another RNA called **Non-genetic RNAs**. Those RNA depend on DNA for their synthesis and are ultimately translated into the linear sequence of amino acids in a polypeptide chain (protein synthesis).

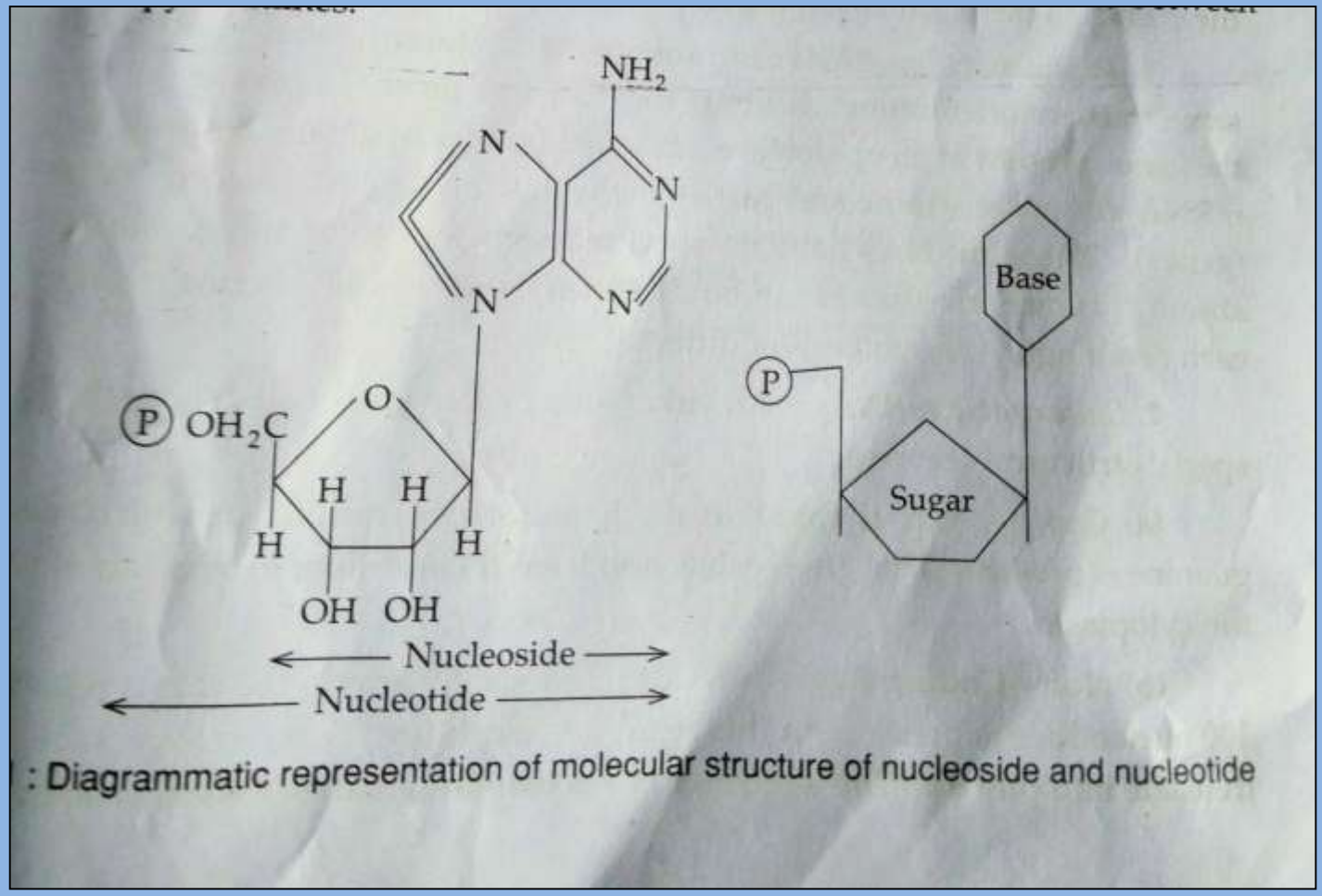
Occurrence of RNA

1. **Non- genetic RNA** generally found in the cytoplasm and the nucleolus.
2. In the cytoplasm, it is found freely but also found associated with ribosomes.
3. RNA is also found in mitochondria and chloroplast.

Structure of RNA

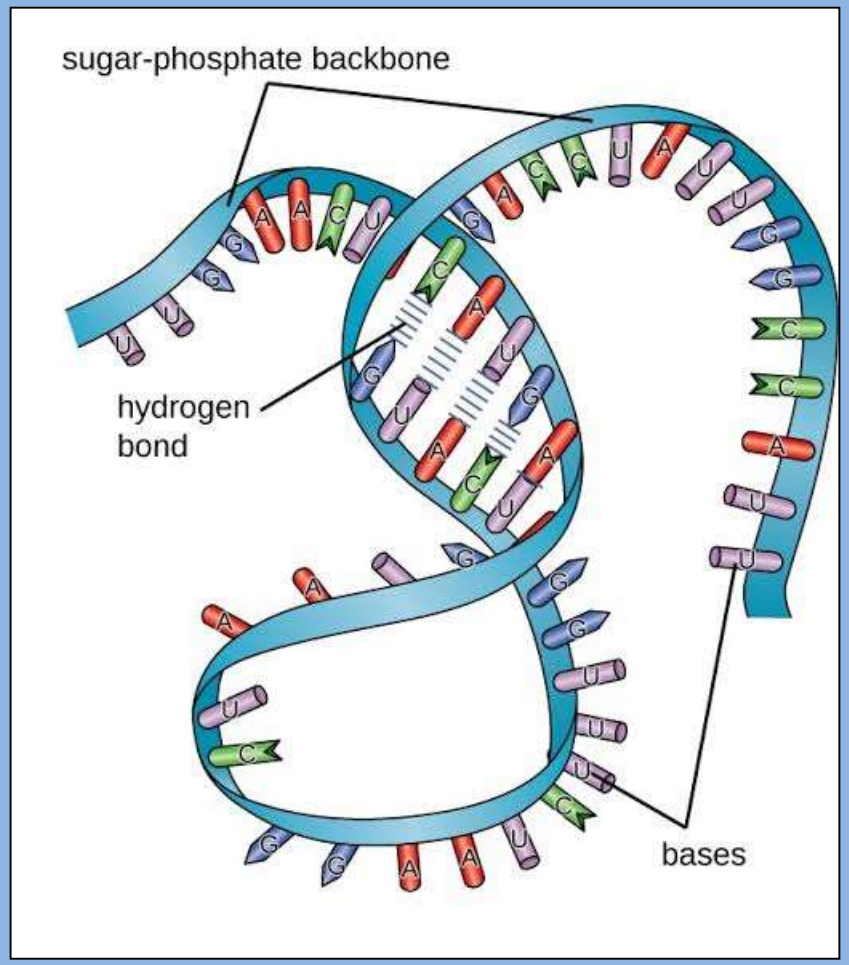
1. It is an unbranched polynucleotide chain.
2. It is formed by phosphodiester bonds between ribonucleotides in 3’ – 5’ direction.
3. The number of ribonucleotides in RNA range from as few as 75 to many thousands.
4. RNA nucleotides have ribose sugar in place of deoxyribose in DNA, which participates in the formation of sugar – phosphate back bone of RNA.
5. The nitrogen bases are adenine (A), guanine(G), Cytosine (C), and uracil (U).
6. Uracil differs from thymine of DNA in lacking a methly group at 5’ position.
7. These nitrogen bases do not show complementary, hence there is no 1 ;1 ratio between purines and pyrimidines.

Molecular structure of nucleoside and nucleotide



: Diagrammatic representation of molecular structure of nucleoside and nucleotide

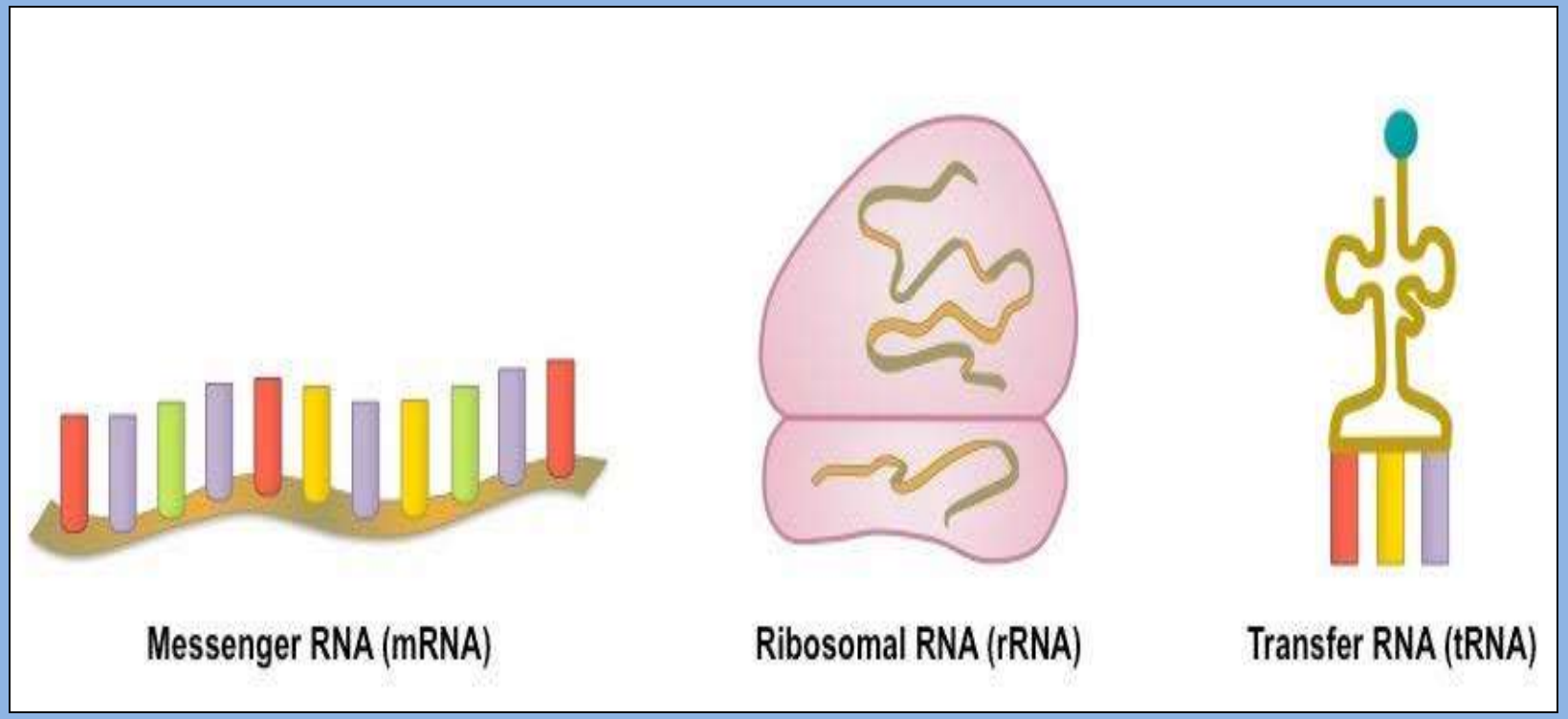
Structure of RNA



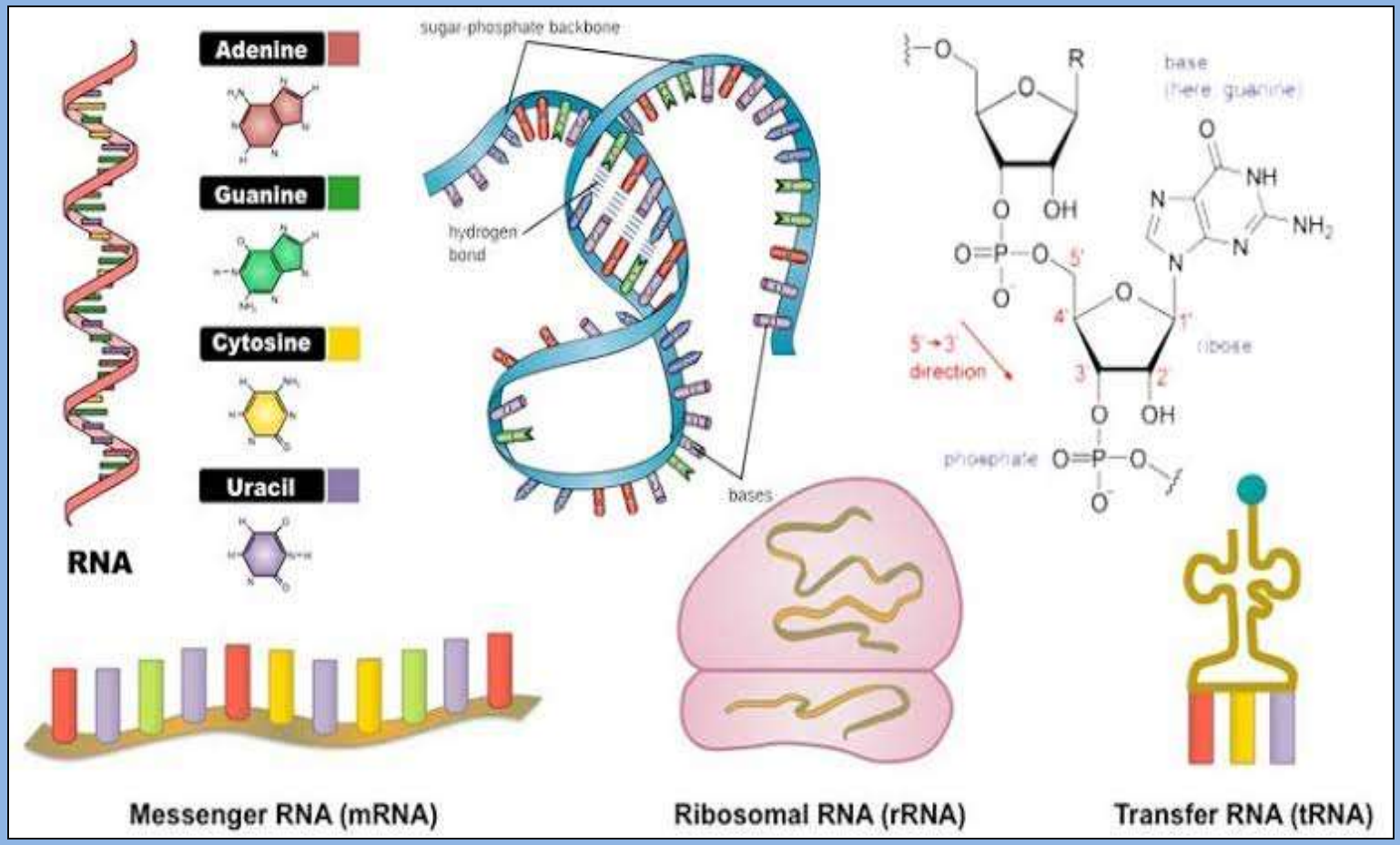
Types of RNA

1. Three types of non- genetic RNA molecules are found in all prokaryotic and eukaryotic cells.
2. Their synthesis is dependent on DNA template.
3. They are mRNA, rRNA and tRNA.

Types of rRNA



RNA and Types of RNA



mRNA

1. mRNA carries genetic information from chromosomal DNA to ribosome for protein synthesis, so it functions as messenger.
2. Therefore, Jacob and Monod in 1961 named this RNA as mRNA .
3. It is 5% to 10% of the total quantity of RNA present in the cytoplasm.
4. The molecular weight of an average sized mRNA is $5X10^6$ daltons.

mRNA

5. mRNA is formed as a complementary strand from one of the two strands of DNA (transcription). So the sequence of bases of each mRNA is complementary to antisense strand of DNA.
6. The only difference is that in place of thymine , uracil is present.
7. It immediately diffuses into the cytoplasm, where protein synthesis takes place.

mRNA

8. In prokaryotes mRNA is metabolically unstable with a half- life time from a few seconds to about 2 minutes.
9. Transcription and translation proceed simultaneously.
10. But in eukaryotes , it is relatively stable with a half life time ranging from a few hrs. to one day.

Eukaryotic and prokaryotic mRNA

Eukaryotic and prokaryotic mRNA

1. Generally, a single prokaryotic molecule codes for more than one polypeptide.
2. Such an mRNA is known as Poly cistronic m-RNA .
3. On the other hand all eukaryotic m-RNA are monocistronic i.e code for a protein specified by a single cistron.
4. Both eukarytic and prokaryotic mRNA have the following features:
   - 1). A 5. leader sequence, that is not translated
   - 2). A coding region, which begins with about 1500nucleotides and this region translates protein.
   - 3). Non- coding region at the 3'end.
5. Both types of mRNA molecules are synthesized with triphosphate group at 5'end , so there is no basic difference between the two.

Prokaryotic mRNAs

1. In prokaryotes different genes concerned with the same trait are often clustered together in group known as an operon.
2. All genes are present in an operon are transcribed into a single mRNA molecule.
3. These mRNA are polycistronic and carries the codes for several adjacent DNA cistrons (genes).
4. These mRNAs have no specified significance at the five end (cap absent).
5. Hence ribosomes can bind at many sites in the interior of an mRNA each resulting in the synthesis of different protein.

Eukaryotic mRNAs

All eukaryotic mRNA molecules show the following special structural features:

A) Cap

B). Non-coding region (NCR)

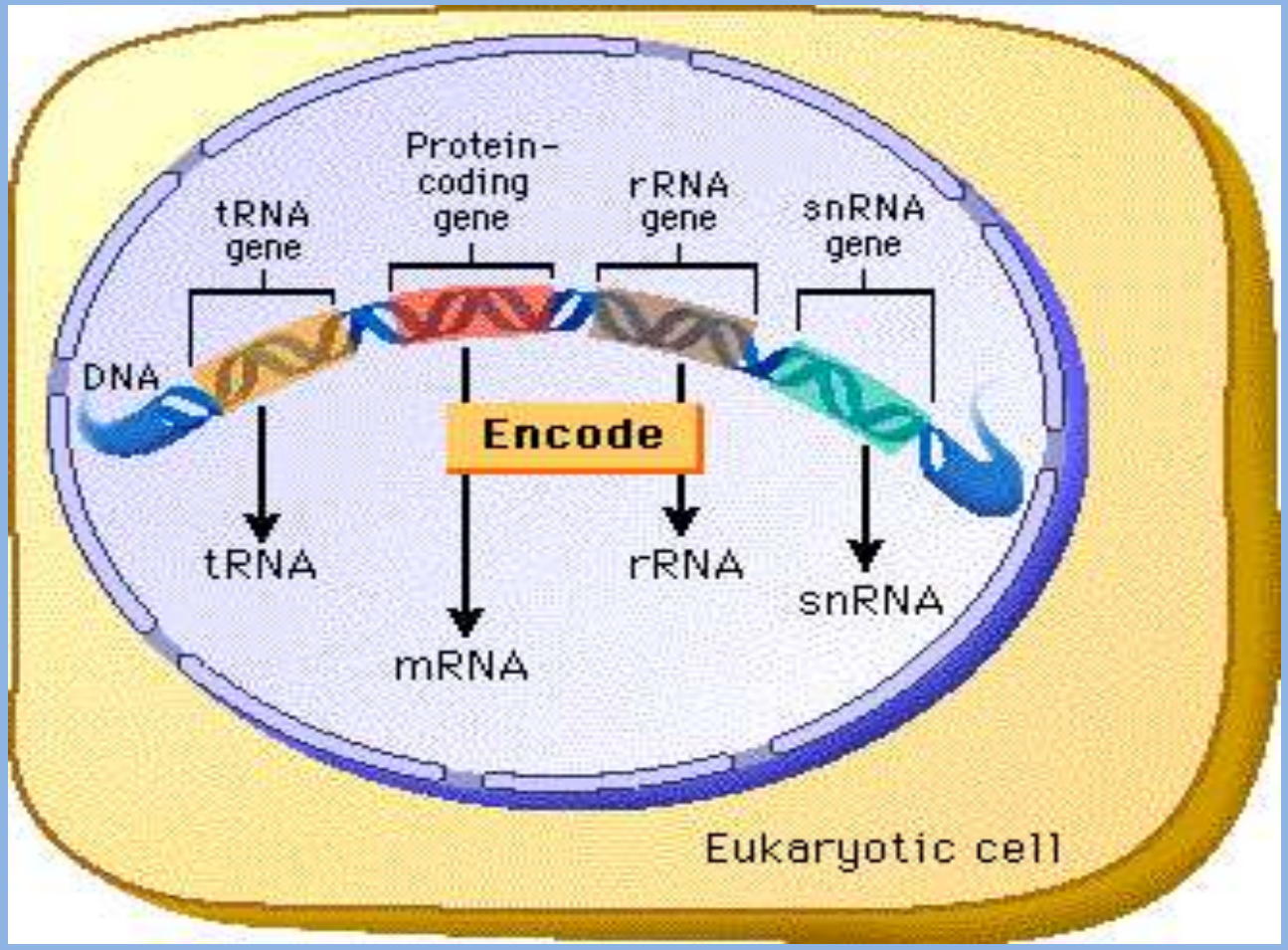
C). Initiation codon

D). Coding region(CR)

E). Termination codon

F). Poly- A sequence

Eukaryotic cell RNA



Cap

1. A ‘cap’ is found at the 5’ end of the mRNA in which methylated guanine is present.

2. This gives protection from the action of exonucleases present in the cytoplasm.

Non- coding region (NCR)

1. Immediately after the cap , a regionof 10 to 100 nucleotides is present.
2. In this region A and U are found in excess and dose not translate into proteins.
3. This sequence of nucleotides is called leade sequence.

Initiation codon

- In both pro and eukaryotes, primary codon AUG is found.

Coding Region (CR)

- This region consists of about 1500 nucleotides and this region translates protein.

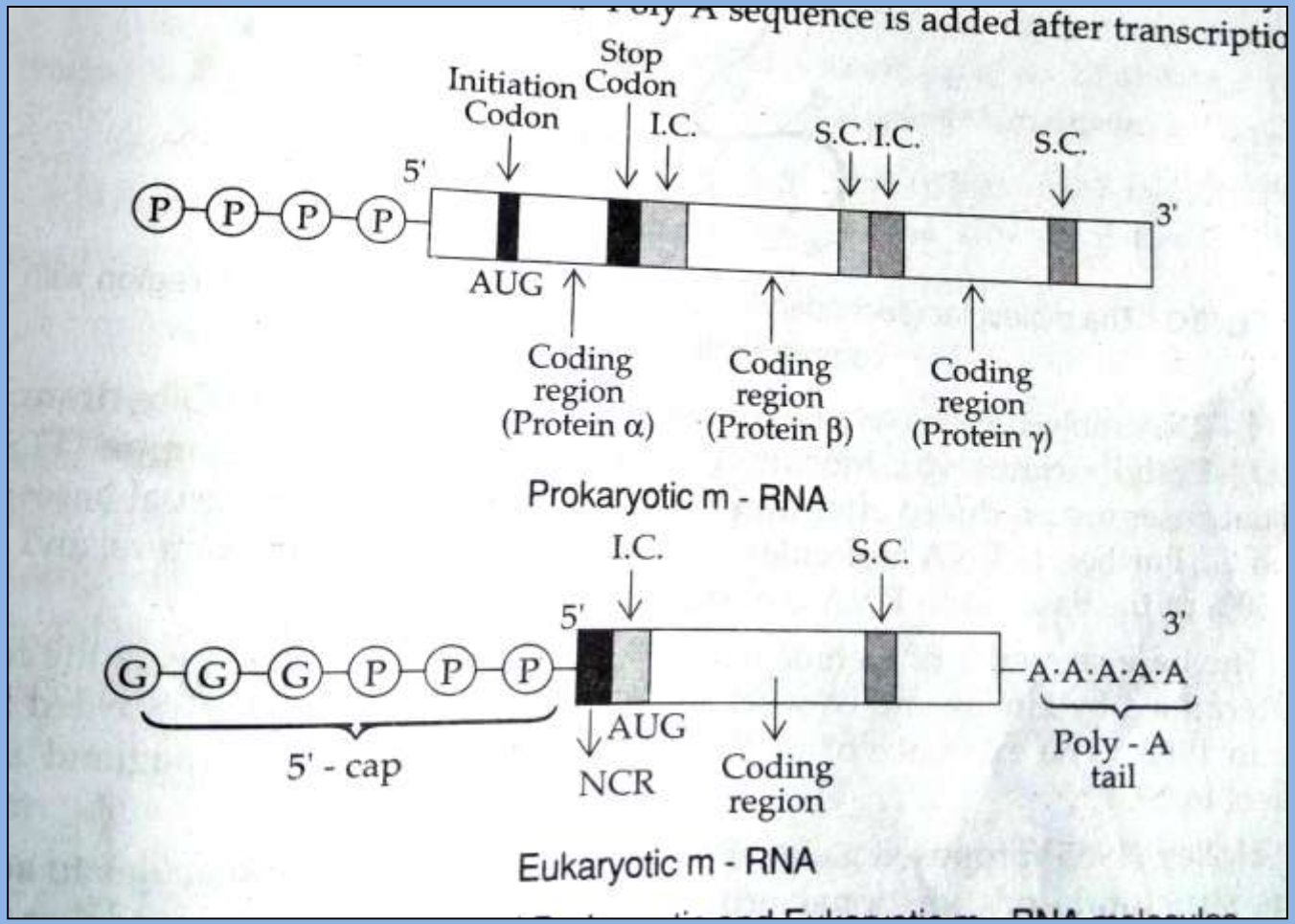
Terminal codon

1. The coding region ends with a termination codon.
2. The termination codons on eukaryotic cell are UAA, UAG, and UGA.

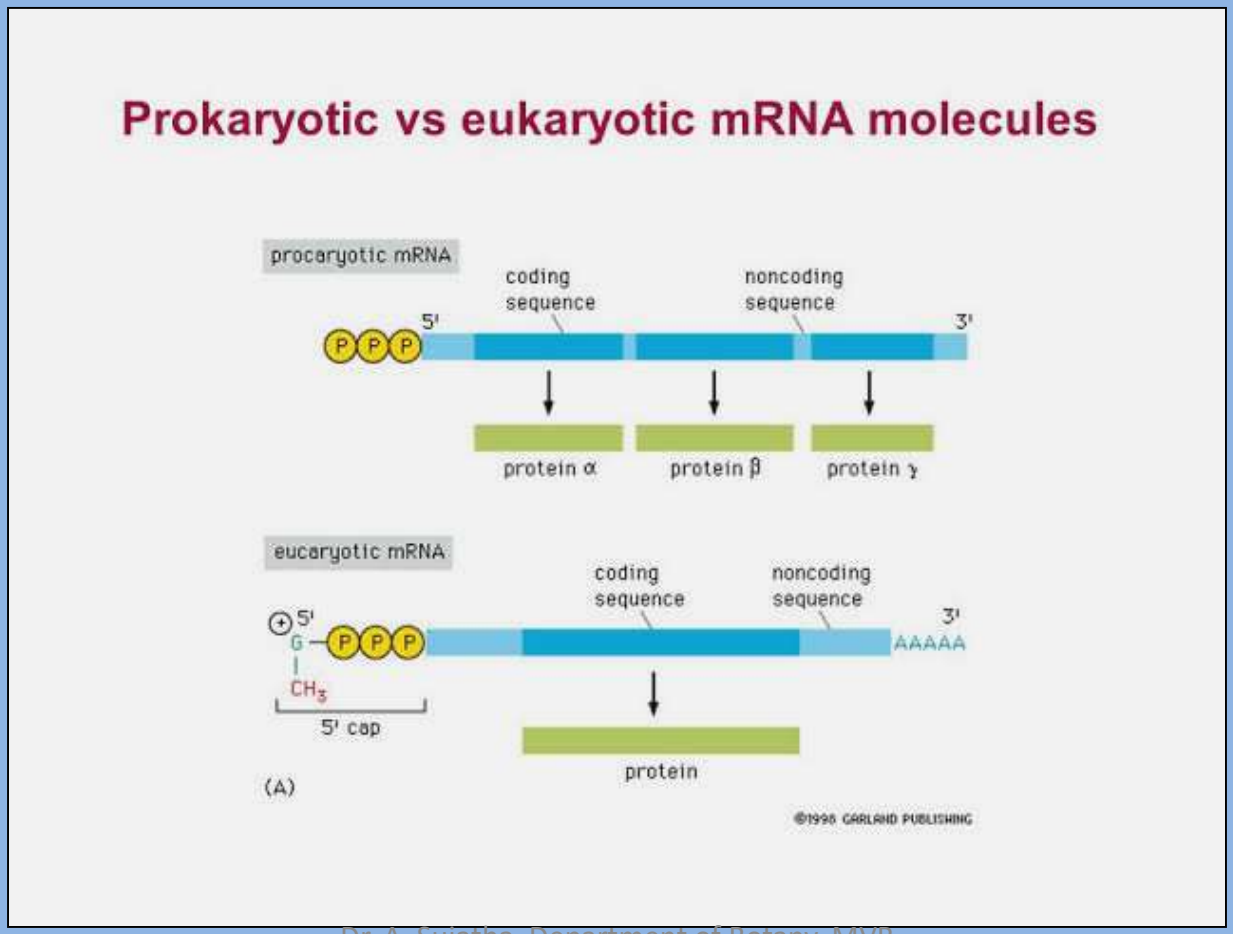
Poly – A sequence

- At the 3’end of mRNA, poly adenylate or poly – A (AAAA…….A) sequence is found.
- Poly A sequence is added after transcription.

Pro and eukaryotic mRNA



Pro and eukaryotic mRNA molecules



rRNA

1. rRNA or insoluble RNA (i-RNA) constitutes the largest part (upto 80%) of the total cellular RNA .
2. It is primarily found in ribosomes.
3. It consists of a single strand of nucleotides, which is folded at several places to form pseudohelices, where the bases show complementary base pairing.
4. The r-RNA contains G – C content more than 50%.
5. r-RNA molecule remain stable at least up to two generations.

rRNA - prokaryotes

1. Ribosomes of prokaryotic cells are 70s type and are composed of 60% rRNA and 40% proteins.
2. They dissociate into a smaller 30S subunit and a larger 50S subunit.
3. The 30S subunit has a single 16S rRNA molecule, which is associated with 21 different types of ‘S’ proteins.
4. The largest subunit has a 23 S rRNA and 5S rRNA molecule complexed with 31 different ‘L’ proteins.

rRNA - Eukaryotes

1. The cytoplasmic ribosomes of eukaryotes are 80S size and contain 40% rRNA and 60% protein.
2. They consists of a 40S and 60S subunits.
3. The 40S subunit has one molecule each of 28S, 58S and 5S rRNA and 49 different proteins.

Next class

- tRNA
- Difference between DNA and RNA

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