INFORMOSOME

Volume-II

A Compendium cum Proceedings

of Departmental seminar given

by the students of UG, Botany Honours.

An initiative of the Department of Botany (UG and PG)

Hooghly Mohsin college


CHARACTERISTICS
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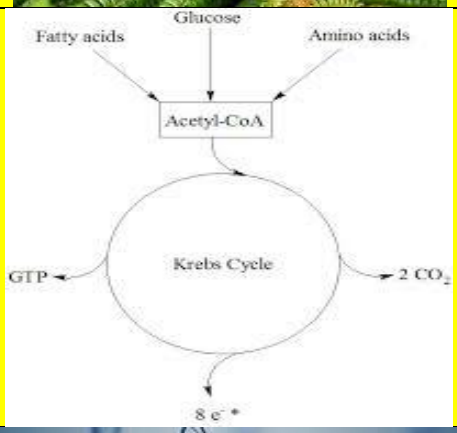
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2 CO_2
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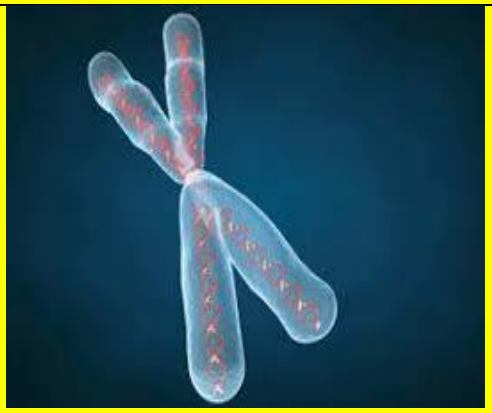

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Date: 26/08/2021

From:

The Head (HOD)

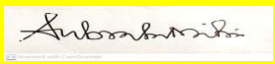
The PG Department of Botany,

Hooghly Mohsin College, Chuchura, Hooghly.

It is really an event of exhilaration that Botany Department of Hooghly Mohsin College is going to release students seminar volume 'INFORMOSOME'.

Students' seminars provide an opportunity to give expression of their ideas and vision and display their creativity and imagination and develop them to their full potential. Young students are thus equipped enough to meet the challenges of life in a mature and effective way. I am sure that under the guidance of teachers and overall supervision; provide students a platform for maturing their literary talents.

I extend my best wishes to the students' community and hope that this seminar volume will be a shining record of the achievements of the students and teachers and inspire all to a greater heights.



Dr.SUBRATA MITRA, ASSOCIATE PROF. AND HEAD, UNDER GRADUATE AND POST GRADUATE DEPT. OF BOTANY,HOOGHLY MOHSIN COLLEGE. CHUCHURA, HOOGHLY

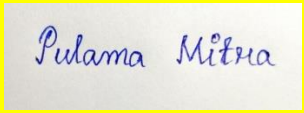
Note from Assistant Editors desk: -

The topics covered in this eBook include various aspects in the field of Botany. The students have carried out the work on topics which include classical as well as applied portions of Botany. The classical portions of this field include topics such as the types of venation in leaf, structure of gynoecium in flowers, various fungi (such as *Ascobolus, Agaricus)* and many others. On the other hand topics covering the applied portions include structure of DNA, experiments proving DNA to be the genetic material, structure of nucleosome and chromatin, gene mutations etc. Topics on practical aspects of life such as the impact of Covid-19, defense system of the Sunderbans against natural calamities have also been covered in this eBook.

While going through their papers we realized that they have researched a lot on the particular topics and thus they have provided a lot of information. Many of the students have gone through the core portions of their respective topics in order to complete this research work. Several links and references of the respective texts as well as the pictures have been provided. These links provide a broad field of gaining knowledge in various aspects as they lead to a vast source of information. These links as well as the sub-links present in each site have also enriched our knowledge. Topics which are of main concern in today's life have been discussed in this eBook. Pictorial representations, diagrams, graphs have also been added for the better understanding of their particular topic. The methods of representation of all the individual students are quite elucidative. While reviewing their papers we also enhanced our knowledge and came across several new facts and discoveries that we were not aware of.

The students have done a great job on their part. From the very inception of their student hood in the department they have been working hard and they are emotionally quite attached with this project. I wish them every success in all their future endeavors.

(ARKA DEY, 3rd year, Assistant Editor)



(PULAMA MITRA, 3rd year, Assistant Editor)

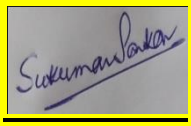
A note from Associate Editors' Desk

It gives us an immense pleasure to announce that the department of Botany, Hooghly Mohsin College, boasts of a bunch of budding botanists who are really enthusiastic in showcasing their prowess and mettle in delivering and writing some very interesting research papers on the very onset of their inception in this department. The students are our pride and their honest endeavours has culminated in shaping this E-seminar Proceeding-cum-scientific dossier that highlights some varied and updated knowledge about the myriad aspects of Plant Science. All the departmental professors have given their valuable inputs into shaping up the inquisitive minds of our students, without whose help and active support the whole episode would have been a mess.

The students have tried to showcase their enthusiasm in selecting their topic, and reading and writing the manuscripts and delivering their seminar talks that entailed their genuine hard work. We have encouraged the First Year (2^{nd} semester) UG students to concentrate on the core and fundamental topics of Botany and give their utmost sincerity to prove their foundation and knowledge. The 2^{nd} year (4^{th} Semester) students have chosen a wide array of topics which included cell biology; Orchid biology and fundamental molecular biology, which they have conceptualized from their syllabus. But they have taken a wonderful venture to explore the insights of the topics chosen, and they were ultimately able to come up with wonderful papers. The final semester students (Semester VI) were extremely prudent in choosing the topics for paper writing. They exploration ranges from the world of plant genetics and breeding to Plant biotechnology to environmental Biotechnology. Their outreaches have really been well documented, thoroughly researched and scientifically represented.

We could see that our encouragement and support induced the scientific temperament of literature searching, data collection, documentation vis- a- vis content writing with scientific explanations and comments in our students against the backdrop of the toughest days of Covid pandemic. I feel our efforts that we are able to take the appropriate steps in this regard, which has been extremely successful.

We wish them all-round success in their future academic life.



Dr. Manashi Aditya, (Assistant Professor, Associate Editor, Informosome)

Dr. Sukumar Sarkar (Associate Professor, Associate Editor, Informosome)

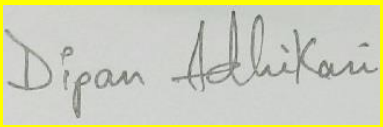
From Editor-in-Chief's Desk:

Knowledge is power and information is the foundation of knowledge. In the toughest hours of Covid pandemic, when the normal life came to a standstill, the Department of Botany, Hooghly Mohsin College had been engaged in an episode of constant academic care and encouragement for all the students of this department to cater to them in the utmost way possible. In this event of online activities, the department had organized students' seminars and encouraged them to utilize the challenge of writing scientific paper. The department is indebted to Dr. Debobrata Mukhopadhyay (Ex-HOD) of the department in this context, who constantly encouraged and created an atmosphere of motivation among all the departmental staffs and the students to excel in a better way. This constant encouragement and interactions had yielded this result in the shape of this ebook cum seminar proceedings for the first time in the history of this department. All the departmental staff members were cordial and energetic to reap this fruit.

While editing the scientific writing of the students, what I could envisage that the students are highly motivated and technologically savvy in preparing their research articles. They have done sound research and literature reviewing to choose the topics, data collection and content development. What is also a point of great delight that all of them followed the finer nuances of scientific paper writing at this very tender age as undergraduate students. The choice of topic and content developments were delightful and engrossing to read. I have enjoyed a lot reading these write-ups.

We, the teachers of this department, are the stakeholders of the emotional content development of our students apart from helping them in their regular academic pursuits. I strongly feel all the departmental teachers are whole-heartedly devoted to quenching their thirst for knowledge and developing their scientific acumen. This has been nicely reflected in their deliverance of seminar lecture and paper writing.

I wish them all-round development of their scientific career in the coming years.



(Dr. Dipan Adhikari, Assistant Professor and Editor-in-Chief, Informosome, the e-book)

Table of contents

Paper- I

STRUCTURE OF DNA

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ABSTRACT

DNA is a complex, long chain molecule that contains the genetic blue print for building and maintaining all living organisms. In 1953, James D.Watson and Francis Crick unveiled two aspects of DNA's structure namely thepairing of the nucleotide bases in a complementary fashion (adenine with thymine and cytosine with guanine) and its double helical nature. The monomer that make up of a DNA is called nucleotide. Each nucleoside consists of a pentose sugar and nitrogen bases. The orientation is 5'- 3', this 5'-3'linkage is known as phosphodiester bond. DNA double helix has a major groove and minor groove.

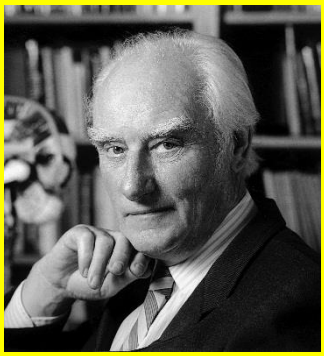
Discovery of Double Helical Structure of DNA by James D.Watson and Francis Crick(1953) is based on the following important contributions:

- Study of X-ray diffraction pattern by Wilkins and Franklin
- Chargaff's chemical analysis of DNA showing equimolarity in adenine and thymine and in cytosine and guanine.
- Gulland's conclusion that bases of DNA interact through hydrogen bonds.

Keywords :-

DNA, Double helix model, Bond, Nitrogen Base, Deoxyribose, Phosphoric Acid, Nucleoside, Nucleotide, Phosphodiester Bond.

James Watson



Francis Crick

INTRODUCTION

Deoxyribonucleic acid more commonly known as DNA, is a complex molecule that contains all of the information necessary to build and maintain an organism. All living things have DNA within their cells. The DNA segments that carry the genetic information are called genes, but there are DNA sequences that have structural purposes, or are involved in regulating the expression of genetic information by acting as deoxyribozymes.

DNA is a long chain polymer was understood in late 1930s. The widely accepted model of the DNA is the double helix structure proposed by American scientist James D. Watson and Bristish scientist Francis Crick (1953).

Figure – DNA

Watson studied X-ray diffraction photographs of DNA prepared in the laboratory of Maurice Wilkins at King's College, London. Those were produced by Wilkins's colleague, Rosalind Franklin. On this basis Watson and Crick concluded that DNA has a helical structure and the helix had a uniform width of 2 nm with its purine and pyrimidine bases stacked at a distance of 0.34nm.

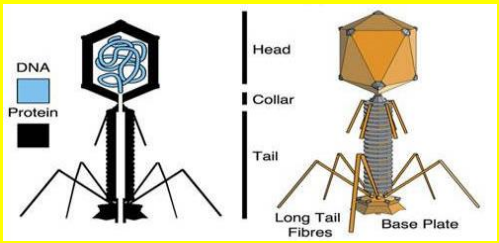
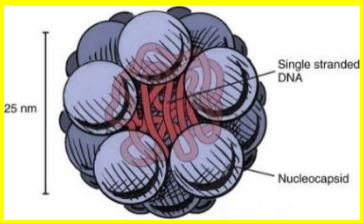
Watson and Crick tried to make models of a double helix in confirmation with the X-ray measurements, putting sugar-phosphate chains on the inside of the molecule and nitrogenous bases outside. Later, Watson tried to put the sugar-phosphate chain on the outside and nitrogenous bases inside the DNA molecule. At first, Watson presumed that only identical bases form pairs i.e., adenine pairswith adenine, cytosine with cytosine or guanine with guanine. But such pairs could not fit with the X-ray data. Therefore, it was concluded that in a molecule of 2nm width, a purine on one strand can pair only with a pyrimidine on the opposite strand.

Types of DNA:-

DNA is of two types -

1. Double stranded DNA

2. Single stranded DNA

Type	Example	
Double stranded DNA (ds DNA)	Higher animal and plants Bacteria Polyoma virus and small pox virus The T-even bacteriophages (T2,T3,T4).	 Figure- Bacteriophage (Source – Google)
Single stranded DNA(ss DNA)	The bacteriophages ΦX174 and several bacterial viruses.	 Figure-

(Source-Cell Biology, C.B.Powar)

CHEMICAL COMPOSITION:-

The chemical analysis indicated that DNA is composed of three different types of compounds. They are:

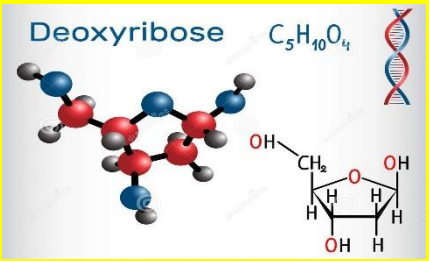
1. Sugar molecules : Sugar is represented by a pentose sugar,the deoxyribose or 2'deoxyribose.

2. Phosphoric Acid

3. Nitrogenous bases

• Deoxyribose

Deoxyribose is a pentose sugar with five carbon atoms. The name 2'-deoxyribose (a pentose sugar) indicates that it is derivative of ribose sugar by the replacement of hydroxyl group(-OH) at carbon atom 2' with a hydrogen group (-H).The number of carbon atoms in deoxyribose are prime (the dash on each number is called prime).The prime is used to distinguish the carbon atoms in the sugar from carbon and nitrogen atoms in the rings of nitrogenous bases.



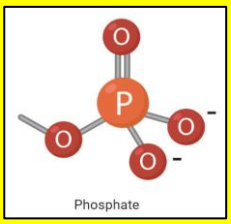


Figure- Deoxyribose, Phosphoric Acid DNA is phosphate based on the inorganic compound Phosphoric acid i.e. H_3PO_4

- Nitrogenous bases :

The nitrogen bases are derivative of two parent compounds, i,e., purine and pyrimidine.

- Pyrimidine is a six membered ring, which is similar to the benzene ring(having nitrogen at 1 and 3 position).The pyrimidine compounds in DNA are-Thymineand Cytosine.
- Purine consists of a pyrimidine ring and a nine membered imidazole ring (having nitrogen at 7 and 9 position). The purine compounds in DNA are-Adenine and Guanine.

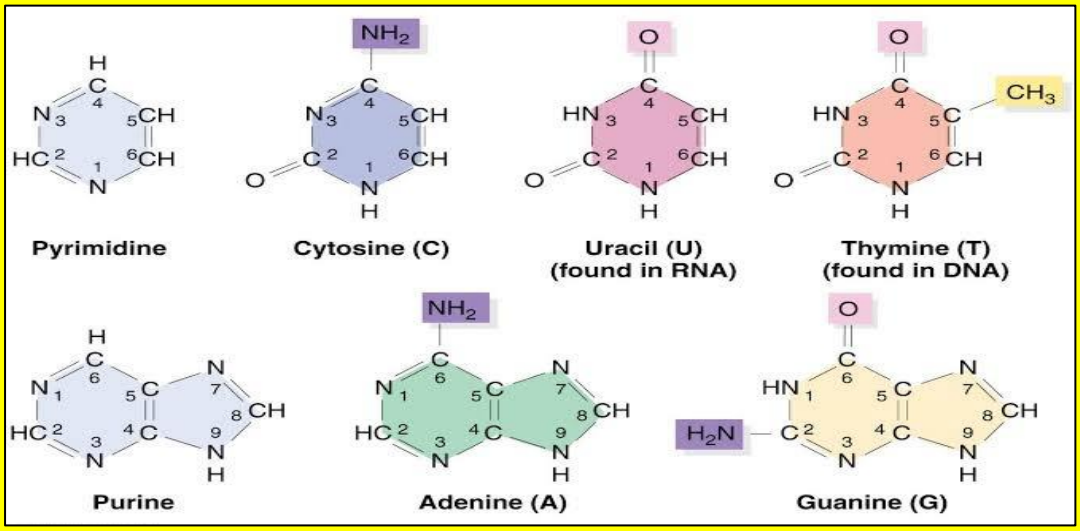


Figure – Nitrogenous bases (Thymine (2, 4-Dioxy, 5-methylpyrimidine) is represented by – T, Cytosine (2-oxy, 4-aminopyrimidine)is represented by – C, Adenine (6-amino purine)is represented by – A, Guanine (2-amino, 6-oxypurine) is represented by – G)

(Source-Principles of MolecularBiology, Veer Bala Rastogi)

Nucleoside:

The N_2 bases are covalently attached to 1'C of the pentose sugar (Deoxyribose sugar)by B-N glycosidic bond. This combination of a sugar and base is called nucleoside.

- Nucleotide:

  Addition of a phosphate group (PO_4) to a nucleoside yields a nucleotide. This phosphate group attached to the nucleoside at 5'C by an ester bond.

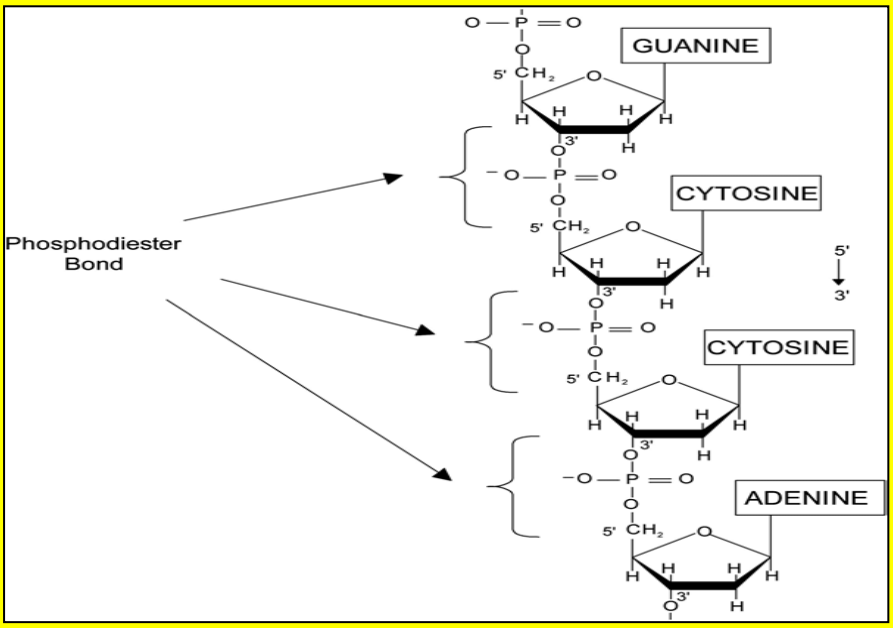


Figure- Nucleoside and Nucleotide (Source- Google)

- Phosphodiester Bond :

To form a polynucleotides of DNA, nucleotides are linked together by a covalent bond between the phosphate of one nucleotide of 3'C(OH) of the sugar of another nucleotide.This 5'-3' linkage is known as phosphodiester bond(relatively strong).

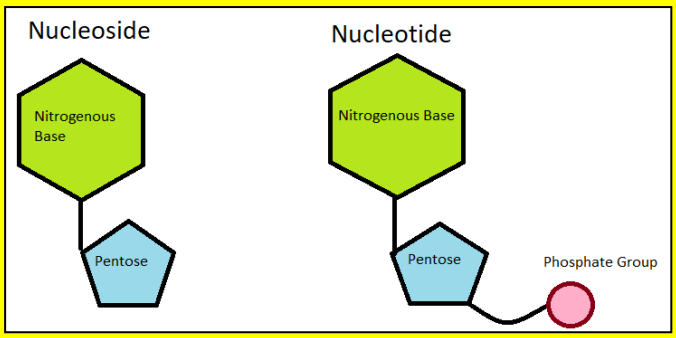
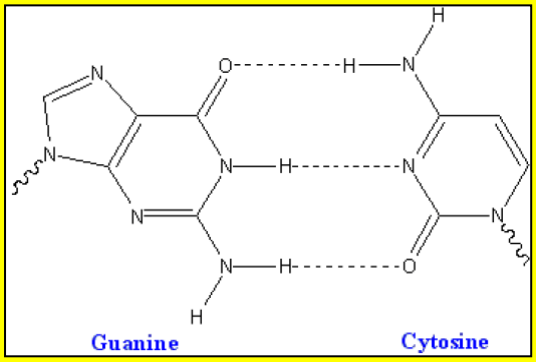


Figure – Phosphodiester bond (Source - Google)

DESCRIPTION OF THE DNA DOUBLE HELIX STRUCTURE



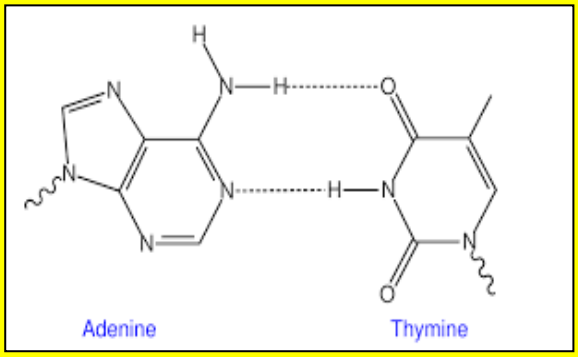


Figure - Covalent bond between Guanine and Cytosine ; Figure- Covalent bond between Adenine and Thymine (Source- Google)(Source- Google)

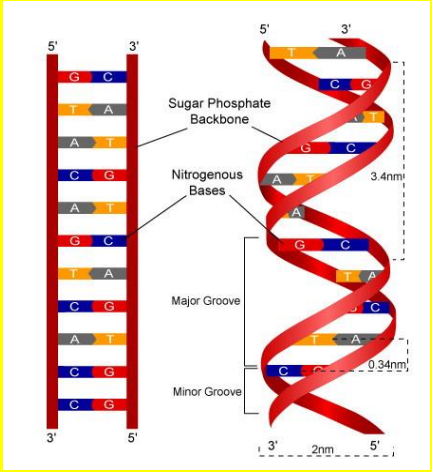


Figure – Description of DNA double helix structure (Source- Google)

The DNA molecule consists of 2 polynucleotide chains, around each other in a right handed double helix i.e. in a clockwise fashion(except Z DNA). The two chains are anti parallel, i.e. the two strands are oriented in opposite direction, with one strand oriented in the 5'-3' way and the other oriented 3'-5'.The two strandswrap around each other in a way that they can not be separated without unwinding the helix. The bases occupy the core of the helix, and the sugar-phosphate chains coils about its periphery. The bases of both chains are flat structure and in each of the two polynucleotide chains (2 strands) are bonded together by hydrogen bonds.

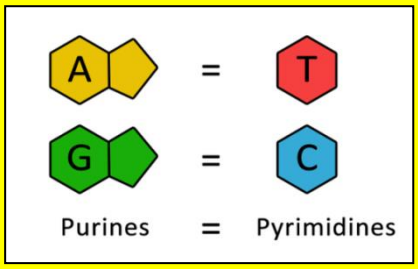


Figure- Chargaff's rule (Source- Google)

As per Chargaff's rule Adenine (A) always pairs with Thymine (T)by two non covalent bonds and Cytosine (C) always pairs with Guanine(G) by three non covalent bonds.So, the total amount of A of cell is equivalent to the total number of T, and the total number of C that of G. Thus, A+T =1and G +C =1or A +G=C+T.

The helix has a shallow groove called minor groove and a wider groove called major groove across. Due to presence of a pyrimidine and purine bases, DNA shows strong ultraviolet absorption at 260nm.

• The diameter of the DNA double helix is 20 Å or 2nm.

• The double helix makes a complete turn of 360 Å.

• The pitch i.e.the length of the helix needed to complete one turn is 34 Å.

• In the physiologic solution,there are 10.4 bp in each pitch rather than 10 found in DNA fibre. Thus, the length between the two bases (perpendicularly) is 3.4 Å.

• Each base pair is rotated 36 Å relative to its neighbour.

• The axial rise of the helix per base pair is 3.37 Å.

• The tilt of a base is 6.3 Å.

(Source-Principles of Molecular Biology, Veer Bala Rastogi, Page-13)

SUMMARY

Characteristics	
Abbreviation	B DNA
Base Pair per turn of helix	10
Axial rise	3.37 Å
Tilt of base pairs	6.3^0
Pitch of the helix	34 Å
Helical diameter	23.7 Å
Rotation per base pair	$+36.0^0$

SIGNIFICANCE

The biological significance of Watson and Crick's double helical model of DNA is as follows:

1) Information storage
2) Information transfer
3) Self replication
4) Variation
5) DNA repair

CONCLUSION

As per the above explanation we have understood that, every cell has it's own DNA and RNA. But before the discovery of DNA, we didn't have any idea about this. After Watson and Crick's discovery of the DNAdouble helical model, we learn how DNA is important for a cell and we get a idea about this.It is a great discovery in biological science and also in medical science. However, there are others several DNA's structure which are different from the above mentioned DNA double helical model, described by Watson and Crick and they are A-DNA, Z-DNA, H-DNA.

ACKNOWLEDGEMENT

Every paper begins with an idea and materializes with concrete efforts. At first, I would like to thank almighty God who gave me the strength to work on this seminar topic.

I am extremely grateful to Dr. Purushottam Pramanik, Pincipal, HOOGHLY MOHSIN COLLEGE for the arrangement of Student Seminar Lecture Program.

It is indeed gratifying to have the privilege to express my deep sense of gratitude and appreciation to each and every teacher of PG department of Botany, Hooghly Mohsin Collegefor allowing me to work on this topic.

I would also like to thank my parents and my teachers who helped me to complete my topic.

BIBLIOGRAPHY

- https://images.app.goo.gl/mtA988iUdnVbxfGGA
- https://images.app.goo.gl/uM8QmPb45Qs5uMcNA
- https://images.app.goo.gl/avky5pTSJDX8vfxU6
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- https://images.app.goo.gl/2nKxvR8W6FoFDTp2A
- https://images.app.goo.gl/PWp3A4F43KvkfAZT6
-
- C.B.Powar [Cell Biology, Himalaya Publishing House, ISO 9001: 2015 CERTIFIED; Page-146]

- .Veer Bala Rastogi [Principles of Molecular Biology, MEDTECH A Division of Scientific International pvt. Ltd. ; Page- 125]

Paper- II

EXPERIMENTS THAT PROVE DNA AS THE GENETIC MATERIAL

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ABSTRACT

Our modern understanding of DNA's role in heredity has led to a variety of practical application, including forensic analysis, paternity testing and genetic screening. Thanks to thesewide-range of uses, today many people have at least a basic awareness of DNA. It may be surprisingto realize this less than a century ago. Even the best educated members of scientific community were not able to show that DNA was genetic material. In this paperwe'll look at some of classical experiments that led to the identification of DNA as the carrier of genetic information.

It has been described about how British bacteriologist Frederick Griffith conducted a series of experiments using *Streptococcus pneumoniae*on mice to show how DNA causes transformation of non-virulent strain of *Streptococcus pneumoniae* into virulent strain.

Description of about how Oswald Avery,McCarty and Colin Macleod performed experimentsshowing that DNA act asgenetic material have also been included.

Lastly, it has also been discussed about Hershey and Chase experiments where Alfred Hershey and Martha chase proved DNA to be thegenetic material using bacteriophage by lysing it into bacteria, where the bacteriophages were marked with radioactive Phosphorus and Sulphur.

Keywords: DNA,genetic material, experiments, *Streptococcus pneumoniae*.

INTRODUCTION

DNA is a double helical polynucleotide strand which act as the genetic material of all the organism. Example -in virus. The concept that the DNA is the genetic material for most of the organism has been developed and supported by several direct and indirect evidence. The direct evidence was based on experiments, whereas the indirect evidences was based on Feulgen technique and quantitative measurement of the amount of DNA in haploid and diploid cells.

Following are the experimental evidences:

1. GRIFFITH EXPERIMENT:

In 1928 F. Griffith performed a classic experiment using virulent bacterial strain that causes pneumonia in mice.
In this experiment two bacterial strain of *Streptococcus pneumonia* were chosen:

a. virulent S III type which show smooth colony and contains a capsule made of specific polysaccharide
b. non-virulent R II type which show rough colony and capsule is absent.

Griffith took 4 mice and injected them with different solutions. The first one was injected with the S III strain organisms; the second one was injected with the R II strain organisms; the third mouse was injected with heat-killed S III strain organisms; and the last one was injected with a mixture of heat-killed S III strain and live R II strain organisms. The result was thatthe first and fourth mice died due to the infection, while the second and third mice survived. When he extracted the infectious agent from the dead mice, in both cases, he found S III strain organisms.

(Source- Griffith, Frederick (January 1928). "The Significance of Pneumococcal Types". The Journal of Hygiene. **27** (2): 113-159)

- Mice + S III type strain → Dead mice
- Mice + R II type strain → Mice alive
- Mice + S III type strain (heat killed) → Mice alive
- Mice + S III type strain (heat killed) + R II type strain → Dead mice

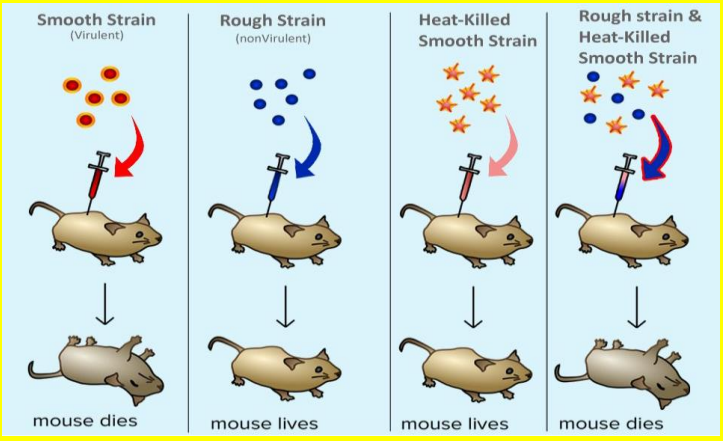

Figure 1- Griffith experiment (Source –Google)

2. AVERY–MACLEOD–MCCARTY'S EXPERIMENT

Avery, Macleod and McCarty 1974 repeated Griffith's experiment in invitro system.

They also used two bacterial strain of *Streptococcus pneumonia* were:
a.virulent S III type which show smooth colony and contains a capsule made of specific polysaccharide
b. non-virulent R II type which show rough colony and capsule is absent.

They worked with a batch of heat-killed S III strain bacteria. They divided it into 5 batches. In the first batch, they destroyed the polysaccharide coat of the bacteria; in the second batch they destroyed its lipid content; they destroyed the RNA of the bacteria in the third batch; with the fourth batch, they destroyed the proteins; and in the last batch, they destroyed the DNA. Each of these batches was individually mixed with live R II strain bacteria and injected into individual mice.

From all 5 mice, all of them died except the last mouse. From all the dead mice, live S III strain bacteria was retrieved. This experiment clearly proved that when the DNA of the S III strain bacteria were destroyed, they lost the ability to transform the R II strain bacteria into live S III strain ones. When other components, such as the polysaccharide coat, lipid, RNA or protein were destroyed, transformation still took place. Although the polysaccharide coat was a virulent factor, it wasn't responsible for the transfer of the genetic matter.

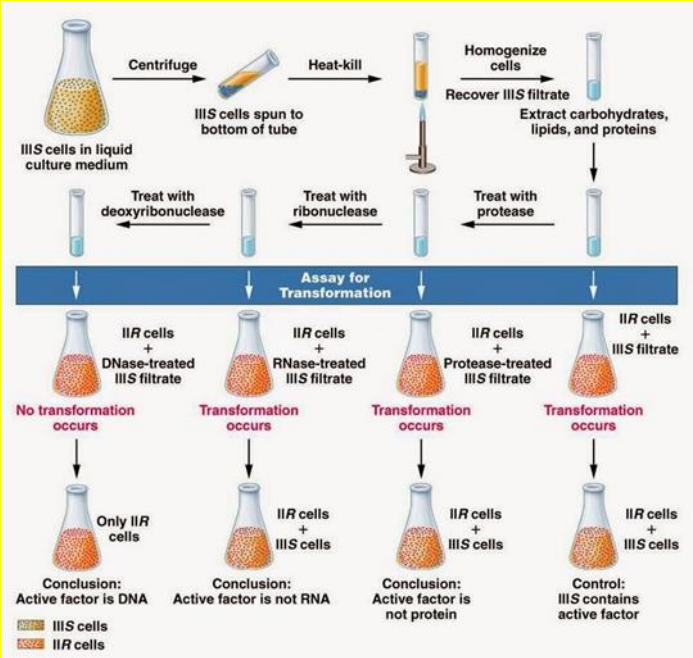

Figure 2 -Avery Macleod experiment (Source– Google)

3. HERSHEY CHASE EXPERIMENT

By using radioactive traces Alfred Hershey and Martha Chase in 1982 proved DNA to be the genetic material.The experiment began with the culturing of viruses in two types of medium. One set of viruses (A) was cultured in a medium of radioactive phosphorus (P^{32}) whereas another set (B) was cultured in a medium of radioactive sulfur (S^{35}). They observed that the first set of viruses (A) consisted of radioactive DNA but not radioactive proteins. This is because DNA is aphosphorus-

based compound while protein is not. The latter set of viruses (B) consisted of radioactive protein but not radioactive DNA.The host for infection was E. coli bacteria. The viruses were allowed to infect bacteria by removing the viral coats through a number of blending and centrifugation.

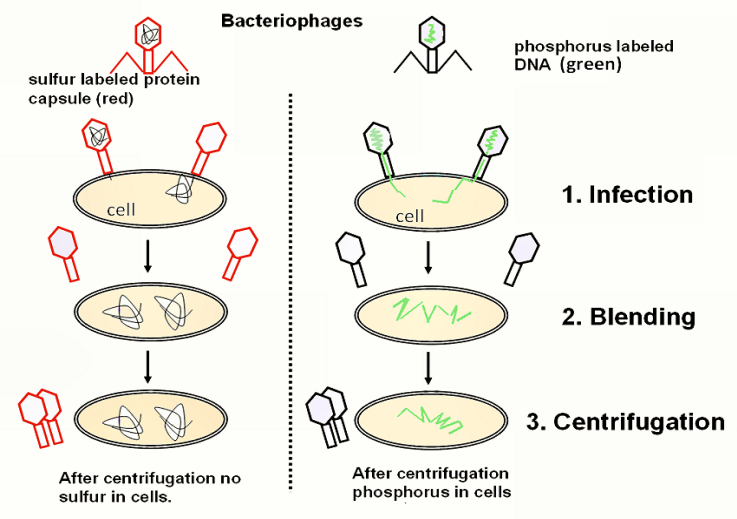

Figure 3– Hershey Chase experiment **(**Source-Google)

It was observed that E. coli bacteria which were infected by radioactive DNA viruses (A) were radioactive but the ones that were infected by radioactive protein viruses (B) were non-radioactive.

This proves that genetic information is carried by DNA.

CONCLUSION

Ankita Adhikary (2021) - Until the final experiment performed by Hershey and Chase, DNA was thought to be a rather simple and boring molecule. It wasn't considered structured enough to perform such a complicated and extremely important function. However, after these experiments, scientists started paying much more attention to DNA, leading us to where we are in research today!

ACKNOWLEDGMENT

At first, I would like to place my deep sense of gratitude to Dr.DebabrataMukhopadhyay for allowing me to choose this topic and also giving me this opportunity. I would also like to thank each and every teacher of PG department of Botany, Hooghly Mohsin College.

BIBLIOGRAPHY

- *Avery, MacLeod, and McCarty (1944).* "Studies on the Chemical Nature of the Substance Inducing Transformation of Pneumococcal Types: Induction of Transformation by a Desoxyribonucleic Acid Fraction Isolated from Pneumococcus Type III". *Journal of Experimental Medicine.* ***79*** *(1): 137–158.* doi:10.1084/jem.79.2.137. PMC 2135445. PMID 19871359.

- *Griffith, Frederick (January 1928).* "The Significance of Pneumococcal Types". *The Journal of Hygiene. **27** (2): 113–159.* doi:10.1017/S0022172400031879. JSTOR 4626734. PMC 2167760. PMID 20474956.

- *Hershey A, Chase M (1952).* "Independent functions of viral protein and nucleic acid in growth of bacteriophage". *J Gen Physiol. **36** (1): 39–56.* doi:10.1085/jgp.36.1.39. PMC 2147348. PMID 12981234.

- https://en.m.wikipedia.org/wiki/Griffith%27s_experiment)
- - https://www.scienceabc.com/pure-sciences/avery-macleod-and-mccarty-hershey-chase-dna-experiments.html)
- averymacleod experiment - Bing images
- https://ib.bioninja.com.au/higher-level/topic-7-nucleic-acids/71-dna-structure-and-replic/hershey-and-chase.html)
- https://en.wikipedia.org/wiki/Hershey%E2%80%93Chase_experiment

Paper- III

DIVERSITY AND DISTRIBUTION OF ORCHIDS

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ABSTRACT

Although cryptogams and phanerogamous plants are abundantly grow in here and there but orchids are very rare. They are distributed throughout the world in the temperate and tropical regions, where the majority of genera are epiphytes. The genera found in the temperate and arctic regions are mostly terrestrial. The largest genera are *Spiranthes, Habenaria, Cypripedium, Dendrobium, Vanda , Bulbophyllum* etc. In our country, 1600 species are found in the Himalayas and other hills. There are many saprophytic orchids like *Corallorhiza,Neottia nidus-avis* (Bird's nest orchid) etc. Long thin stems which climb to the tree tops, where they fix themselves by aerial roots arising from nodes. These roots are characterized by a special development of the epidermis to form the velamen, a tissue consisting of several layers of short trachieds. The sponge like tissue absorbs water from the atmosphere, and passes it on to the internal tissues. The roots of epiphytes serve as anchorage organs and for intake of mineral nutrients. Mycorrhizalassociation is also found in the root of orchids.

INTRODUCTION

Orchids are a very unique family of flowers; they are the largest family of flowering plants. The orchid has evolved so successfully and consider the most advanced family among Monocotyledons. The evolution of the orchids mean that they have learnt to adapt to eachindividual environment. During this process of adaptation the orchid has drawn on insects, birds and butterflies to ensure its successful pollination. The orchid is recognized as an exotic plant and has become the obsession of many an avid gardener. Orchid hybrids are naturally occurring as well and breed by enthusiasts. The ability of the orchid to evolve means that it is continually changing, it is possible that there are orchid hybridsformed and lost faster than man can record them.

What are Orchids?

Orchids are perennial herbs; epiphyte, saprophyte or terrestrial monocots withbisexual, epigynous, and zygomorphic flowers. Perianth 6 in two whorls, of which the posterior median member of the inner whorl is larger in size forminglabellum.Stamens 1or 2, pollen grains are present in pollinia.Filament is united with the style and forms a column, the Gynandrium**.**Carpel 3, syncarpous, ovary inferior.

SYSTEMATIC POSITION :

(Source- Plant Systematics : Gurcharan Singh)

Bentham & Hooker (1862)

Phanerogams

Monocotyledones

Microspermae

Orchidaceae

Hutchinson (1959)

Angiospermae

Monocotyledones

Corolliferae

Orchidales

Orchidaceae

Characteristics of OrchidaceaeFamily :-

(Source -Dr. Robert L. Dressler, 1989 ,Google)

- Most orchids have only one stamen.
- Stamens and pistil are partly or completely united which is called gynostemium or column.
- The median petal opposite to the fertile stamen is often greatly modified and called the labellum or lip.
- A modified stigma called a rostellumplaysa role in transfer ofpollens.
- Pollen grains are in masse, called pollinia.

CLASSIFICATION

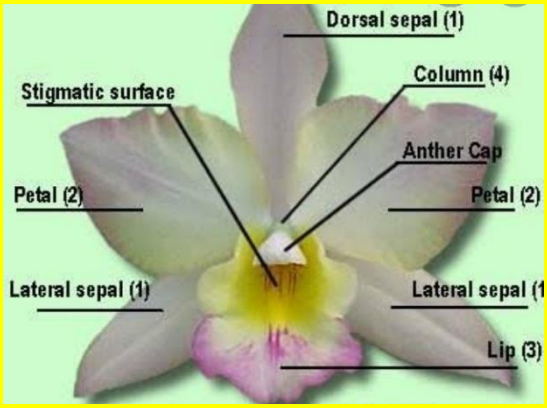

Figure - Morphology of Orchid Flower (Source -Google)

Orchid can be divided into two basic growth types

- Monopodial(one footed) have a main stem which countries to grow year after. (Eg. Phalenopsis, Renothera, Vanda)
- Sympodial (many footed)
  The plant produces a series of adjacent shoots which grow to a certain size , bloom , then stop growing to be replaced by the next growth.
  (Eg. Cattleya, Cymbidium)

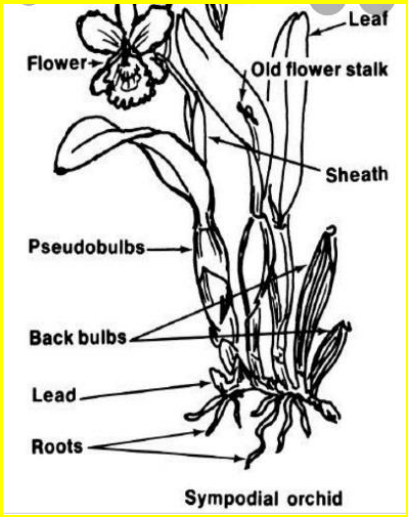

Figure –Sympodial orchid (Source : Google)

Orchids can be divided into four types according to growing condition

- **Epiphytes**- Air plants, which grow on trees.

- **Lithophytes-** The rock growers, cling to the surfaces of rocks**.**
- **Saprophytes-** Those that grow in mulch, often on the forest floor.
- **Terrestrials-** Which anchor themselves in soil or sand. As most orchids are epiphytes, they can be grown on tree bark, crumbled charcoal, pebbles or on wooden or cork plaques.

DESCRIPTION OF COMMON ORCHIDS

1.Cattleyas –Cattleyas were discovered in 1824 when William Cattley received a sickly plant of *Cattleyalabiata* used as packing material in a shipment of orchids and nursed it back to health. When it bloomed, it created quite a stir! Cattleyas are still among the most popular types of orchids today.

Figure –*Cattleya labiata* (Source-Google)

2. *Cymbidium*–*Cymbidium*** orchids are among the snowiest types of orchids, with sprays with numerous large ,colourfulflowers, usually in winter. These plants are quite popular, and some have been cultivated for thousands of years. They need cool temperature to initiate blooming.

Figure –*Cymbidium* sp. (Source - Google**)**

3. *Dendrobium*-

Figure –*Dendrobium* sp. (Source -Google**)**

Dendrobium is a large genus, with about 1200 species. They tend to like bright light, but most other care requirements have exceptions. They are one of most popular types of orchids, and many are quite beautiful.

4. Lady Slipper Orchids- Lady Slipper Orchids is a catch- all term for a few orchids, typically referring to any pant in tribe Cypripedioideaewhich includes the genera *Cypripedium*, *Paphiopedium*,,*Phragmipedium*, ,*Mexipediumand Selenipedium*. These types of orchids all have

Figure–*Paphiopedium* sp. (Source **:**Google)

a " slipper ", a pouch-shaped labellumin which their pollinating insects get stuck.

5. *Phalenopsis*- *Phalenopsisis* the Moth orchid, is one of the most commonly available and easiest to grow orchid genera.It is an especially good choice for beginners to orchid growing. They have large, showy flowers that came in awidevariety of colours. Mostspecies haveseveral flowers per stem, but some have one or two.There are a great many hybrid varieties on the market.

Figure–*Phalenopsis* sp. (Source - Google)

6. *Vandas*– *Vandas* are beautiful orchids that like lots of light and warm temperatures. They tend to have large, round flowers. Most other types of orchids in vandallinaceae are similar.

Figure-*Vanda roxburghii* (Source – Google)

USES OF ORCHIDS:-

Medicinal value:

- ***Dendrobium***is used as a source of tonic, analgesic and anti inflammatory substances.
- In India, in the preparation of **‘ Chyavanprash'**, four orchids are used.
- Round the world, it is used to cure rheumatism, malaria, tuberculosis, cuts, wounds and burn injuries, asthma and several other ailments.

Commercial value:

- The use of vanilla (vanillin) extracted from the pods of **Vanillaplanifolia** is used as a flavouring agent in chocolates and ice creams.
- The popular beverage called **'Faham'** or **'Madagascar tea'** on the islands of Madagascar is prepared from the orchid **Jumelleafragrans.**
- Some orchid sp. are used as colouring agent.
- In N.America, bulbs and tubers of orchid sp. were consumed.

(Source-Hait, Bhattacharya, Ghosh, Vol-2;A Textbook of Botany- B.P.Pandey)

BIOTECHNOLOGICAL APPROACH & BREEDING OF NEW VARITIES:-

The progress of Biotechnology, scientists are able to produce new intergenic hybrids of orchids through Plant tissue culture process.
(Source -Google)

Some of the important intergenic hybrids are:-

- *Ascocentrum× Vanda = Ascocenda*
- *Arachnis × Vanda = Aranda*
- *Aerides × Vanda = Aeridovanda*
- *Brassovola× Cattleya= Brassocattleya*
- *Phalenopsis× Vanda = Vandanopsis*
- *Cattleya× Laelia = Laeliocattleya*
- *Cattleya× Sophronities = Sophrocattleya*

CONCLUSION

Flowers have captured a remarkable place in modern culture. So, there is a latest demand for flowers especially with regards to orchids as they keep very well and a plethora of choices in flower form odour and colour. Conservation, sustainable utilization and management of orchids is the key feature to ensure the natural growth and proliferation of these beautiful members of the plant kingdom as they are diminishing alarmingly at low levels.

ACKNOWLEDGEMENT

First of all, I am indebted to the ALMIGHTY GOD for giving me an opportunity to excel in my efforts to compete this seminar on time.

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BIBILOGRAPHY:-

- **https://WWW.slideshare.net/Utpaldas2015/orchids-48741974**
- **https://scholar.google.com/citations?user=EH4FzuEAAAAJ&hl=en**
- **https://lookingafterorchids.com/different-types-of-orchids-and-classification-of-orchids/**
- **https://images.app.goo.gl/H1tTB61ei7xxvy83A**
- **https://images.app.goo.gl/mHgVUAQFCBTweKVT7**
- **https://images.app.goo.gl/6WJgZafyraEmNV8J9**
- **https://images.app.goo.gl/XjtmMAk38h5RDWd76**
- **https://images.app.goo.gl/koVdUqaQauo6WooB8**
- **https://images.app.goo.gl/tgVUkRv4mS7Ka9337**
- **A TEXTBOOK OF BOTANY, ANGIOSPERMS**
  Dr. B. P. PANDEY; S. CHAND Publishers
  (Page – 373,Distribution) , SI. No- 36
- **A TEXTBOOK OF BOTANY**
  Bhattacharya, Hait, Ghosh; NCBA Publishers.
  (Page- 515) ,Vol- 2,MONOCOTYLEDONS
- **Plant Systematics Third Edition**
  Theory and Practice, Page- 431
  Gurcharan Singh_ CBS Publishers & Distributors PVt Ltd.

Paper- IV

STRUCTURE OF TRANSFER RNA (tRNA)

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ABSTRACT

Mature tRNA molecules have clover leaf structure with a 5' phosphate group and CCA nucleotide sequence with a -OH group at the 3' end. In eukaryotes, the tRNA genes are transcribed by RNA polymerase3. Initially the primary transcripts or pre- tRNA molecules are produced from tRNA genes and require post transcriptional processing. The pre-tRNAs have an additional 5' sequence, which is cleaved by ribonuclease P. Some pre-tRNA molecules have introns located in the anticodon loop which are removed by splicing with the help of an endonuclease. There is no transesterification reaction involved and ligation is accomplished by RNA ligase. Though, all tRNAs have a CCA terminal at the 3' end with a free-OH group, some pre-tRNA molecules are devoid of it and in such cases CCA sequence is added post transcriptionally. About 10% of the bases in tRNAs are modified by methylation of uridines and are converted to pseudouridines. The site of processing of tRNA is the nucleus.

KEY WORDS- tRNA, Structure

INTRODUCTION

The tRNA or transfer RNA is a type of RNA, which helps in the synthesis of protein from mRNA. tRNA functions as an adapter molecule during the translation process. It was earlier known as soluble RNA or sRNA. There are generally 20 types oftRNA and 15% of RNA of a cell are tRNA showing primary secondary and tertiary structure.

PRIMARY STRUCTURE

It is a linear structure consisting of 60-90 unpaired nucleotide bases.

Figure- Primary structure of tRNa (Source- Google)

SECONDARY STRUCTURE

In 1965, R.W.Holly suggested the 'Clover leaf' model of **tRNA**. The 'Clover leaf' model of**tRNA** structure accounts for its secondary structure and functional properties.

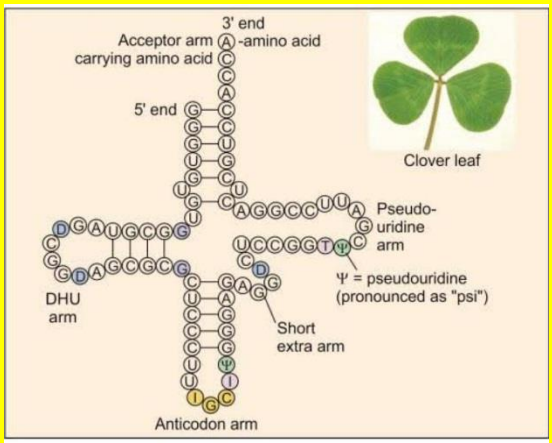


Figure- Clover leaf model (Source- Google)

According to the model the **tRNA** consists of the following loops -

1. DHU loop
2. Anticodon loop
3. Thymine loop
4. Extra/variable loop
5. Amino acid acceptor region

1. DHU LOOP-

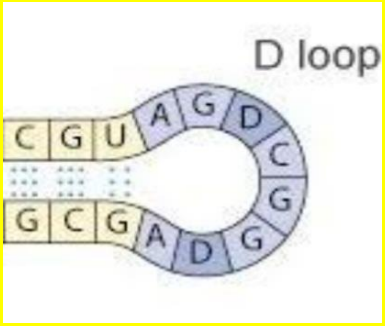


Figure- DHU Loop (Source-Google)

The DHU loop or di-hydro-uridine loop or simply 'D' loop is the first one from the 5' end. It is made up for the recognition by the specific aminoacyl **tRNA**synthetase and is made up of 8-12 unpaired bases as well as contains dihydrouridine.

2. ANTICODON LOOP-

- The anticodon loop is the second loop from the 5' end and has 7 unpaired bases.
- It is located opposite to the amino acid acceptor region and has 3 nucleotide to recognise and form hydrogen bonds with mRNA,thus reading the genetic message. It is complimentary to the corresponding triplet codon of mRNA i.e. function as an anticodon.
- Anticodon nucleotides vary from one **tRNA** to another.
- But the distance between the anticodon site and it's oppositely situated amino acid acceptor region is uniform and it is 66 Degree angstrom.

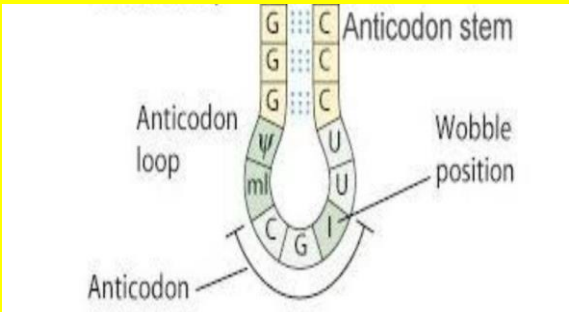


Figure- Anticodon loop (Source-Google)

3. THYMINE LOOP-

- This loop has 7 unpaired bases and is thought to be interact with a complementary region of 5s rRNA during Protein synthesis.It is involved in the binding of **tRNA** molecules to the ribosomes.
- This loop contains the triplet codon TψC, in all known **tRNA**s, therefore it is also known as TψC loop.
- TψC contains an unusual base known as pseudouridine(ψ) .

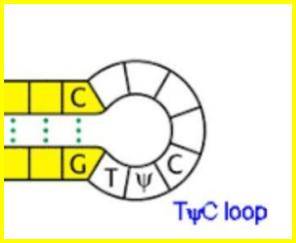


Figure-Thymine loop (Source- Google)

4. EXTRA / VARIABLE LOOP-

The extra loop of the **tRNA** is the most variable. On the basis of variable loop, **tRNA**s are classified as-

- Class-1 **tRNA**
- Class-2 **tRNA**
- Class-1 **tRNA**: They have only 3-5 bases in their extra loop. They represent 75% of all the **tRNA**s.
- Class-2 **tRNA**:They have 13-21 unpaired bases in this extra loop with upto 5 base pairs in a stem.

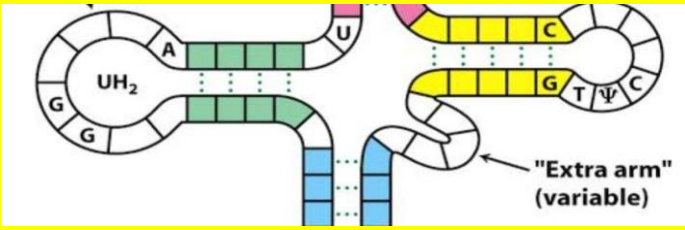


Figure- Variable loop (Source- Google)

5. AMINO ACID ACCEPTOR REGION-

- The **tRNA** molecules contains the same terminal sequence of 5’ CCA 3’ bases at the 3’ end of the polynucleotide chain.This is called Amino acid acceptor region.
- The last residue, adenylicacid(A) is the amino acid attachment site and the amino acid binds on(2’or3') of the OH group of the terminal adenine residue.

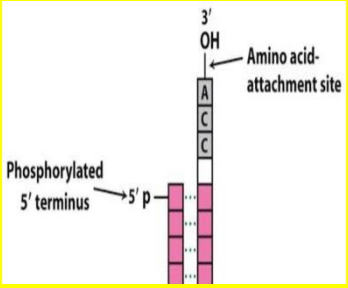


Figure- Amino acid acceptor region

TERTIARY STRUCTURE

- Tertiary structure of **tRNA** resemble with L-shaped structure, which may be critical for their function.
- In this configuration, the 'D' and 'Anticodon' arms are straighten to form one arm of the 'L'.
- The ‘Thymine' loop and the ‘Acceptor’ arm are also straighten and twist to form the other arm of the ‘L' in such a way that ‘Thymine loop lies close to the ‘D' loop,where the arms of ‘L' meets.
- In this configuration, the anticodon is located at the tip of one arm of the ‘L’ while the amino acid acceptor region is present at the tip of the other arms.

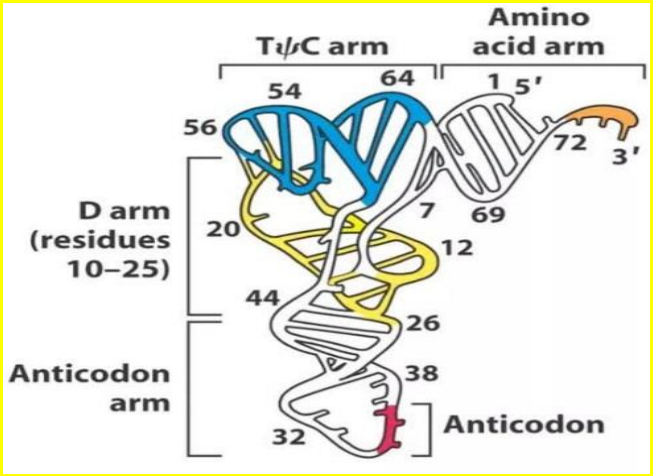
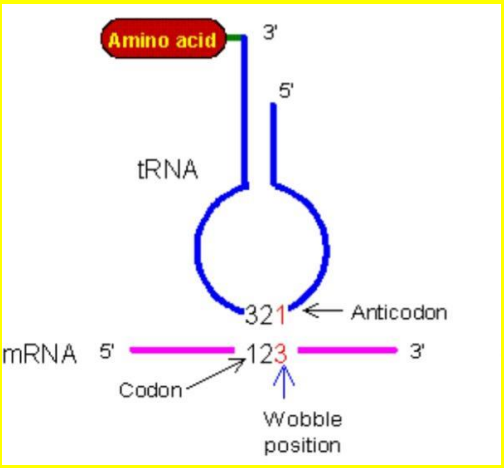


Figure- Tertiary structure of tRNA (Source- Google)

WOBBLE HYPOTHESIS-

The wobble hypothesis proposes that normal base pairing can occur between nitrogen bases in position 1 and 2 of the codon and the corresponding bases (3 or 2) in the anticodon. Actually,the base 1 in anticodon can form non-Watson-Crick base pairing with the third position of the codon.



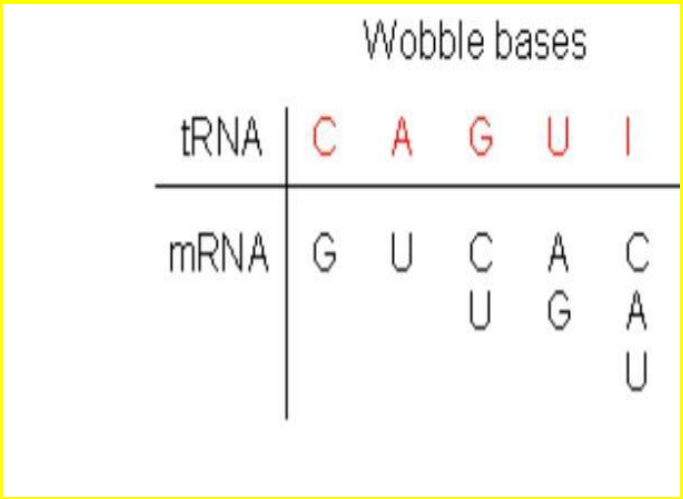


Figure - Wobble Hypothesis Figure – Wobble bases (Source- Google)

CONCLUSION

The tRNA is a special type of RNA compared to other RNAs, because it forms double stranded structure. It plays a major and important role during translation process. Transfer RNA is an interesting topic in the field of research.

ACKNOWLEDGEMENT

I would like to express my sincere respect and gratitude to Dr.DebabrataMukhopadhyaysir(HOD of Botany Department) for providing me an opportunity to do this work.
I would also like to extend my gratitude to each and every teacher of PG department of Botany, Hooghly Mohsin College for their able guidance and support in completing my work.
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BIBLIOGRAPHY

- Daewoo Pak et al .tRNA structure and evolution and standardization to the three nucleotide genetic code .Transcription. 2017; 8(4): 205–219. Published online 2017 Jun 20. Doi: 10.1080/21541264.2017.1318811 PMCID: PMC5574529 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5574529/#__ffn_sectit
- Instant Notes Biochemistry, B. D. Hames& N. M. Hooper, second edition, section G-10-RNA synthesis and processing-page-210

- Zhang J, Ferre-D'Amare AR. The tRNA elbow in structure, recognition and evolution. Life (Basel) 2016; 6; PMID:26771646 [PMC free article] [PubMed] - https://www.mdpi.com/2075-1729/6/1/3
- https://images.app.goo.gl/mgef4UWfkRERSJdEA
- **https://images.app.goo.gl/Miav89hi114F1eJP7**
- **https://images.app.goo.gl/WW1ipeEVf4bs1LeGA**
- **https://images.app.goo.gl/ADiCoNRzbDeKPn1x8**
- **https://images.app.goo.gl/ADiCoNRzbDeKPn1x8**
- **https://images.app.goo.gl/sRYx5UtvRofYj2WY7**
- **https://images.app.goo.gl/jtYFLz8L3HbE16Hv8**
- **https://images.app.goo.gl/dN8LRMFzhGAcA31X7**

Paper- V

IMPACT OF COVID-19 ON MENTAL HEALTH OF STUDENTS

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ABSTRACT

COVID-19 pandemic and lockdown has brought about a sense of fear and anxiety around the globe. This phenomenon has led to short term as well as long term psychosocial and mental health implications for children, adolescents specially students.

This paper is aimed at throwing a light on the current scenario around the globe and how students are getting impacted by COVID-19 pandemic and enforcement of nationwide or regional lockdowns to prevent further spread of infection.

Some articles and advisories on mental health aspects of students during the COVID-19 pandemic were collected and thematically organized . In this paper ,some comparison charts based on the pre and post pandemic situations from the reviews that were conducted by some renowned journals.

Keywords: COVID-19, Lockdown, Mental health, students.

INTRODUCTION

The novel coronavirus disease (COVID-19), which originated in China, was declared a public health emergency by the World Health Organization (WHO) on January 30th, 2020. After a steep global increase in the number of infected persons, different countries took various stringent measures to curb its spread. Lockdowns in India were imposed from March 24, 2020; schools remain closed and online classes have replaced classroom teaching. This situation provided students with the perfect conditions for solitude and increased internet use. The lack of outdoor activities, estrangement from social life, parental anxiety, over use of social media and fear of missing out anything, altogether had significant impact on mental health of several students across the globe.

The major mental health issues reported were stress, anxiety, depression, insomnia, denial, anger and fear. COVID 19 related suicides have also been increased through the passing time.

WHAT ARE THE IMPACTS?

- The Happiness Index of the World Happiness Report (WHR) indicates that India's rank has deteriorated over the years. Starting with rank 111 in 2013, it has consistently been going down and was 139 in the 2021 report – a dip of 25%.

Figure 1-India Ranked 139 out of 149 in UN World Happiness Report 2021 (Source -Google)

- According to a survey carried out by the Indian Psychiatry Society, there was a 20% rise in the number of cases of mental illness at the end of March 2020. Since then, things have become much worse. There are a few mental health problems in students that are specifically increasing due to Covid-19 and the lockdown:

1. Anxiety related to exam preparations and exam results this becomes worse due to therepeated postponement of exams.
2. Depressive thoughts and recurrent suicidal thoughts because of social isolation.
3. Behavioral and emotional disorders due to spending long screen hours.
4. Feeling of distrust due to not being able to physically meet with friends and other peers.

- During the pandemic, a larger than average share of young adults (ages 18-24) reported symptoms of anxiety or depressive disorder. Compared to all adults, young adults are more likely to report substance use (25% vs. 13%) and suicidal thoughts (26% vs. 11%)

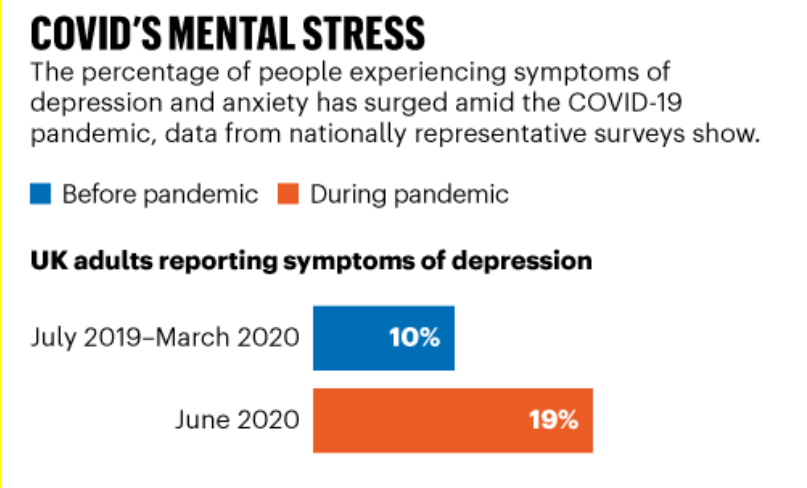

Figure 2 - Report: Anxiety and Depression Symptoms Surged During Pandemic (Source- Google)

- An increased number of suicidal cases were reported among the students during the lockdown

1 A final year MBBS student from Vadodara died last year.
2 Around 66 students committed suicide in Kerala during lockdown.
3 Many NEET and JEE aspirants committed suicide during the pandemic and there are several other cases also reported.

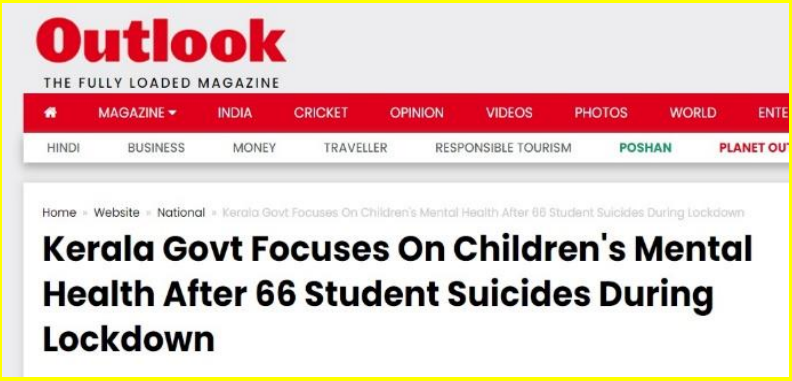

Figure 3- Kerala Govt Focuses On Children's Mental Health After 66 Student Suicides During Lockdown (Source- Google)

Figure 4- 5 Students Die by Suicides in TN Over Fears of NEET (Source–Google)

- According to a report it was seen that during lockdown in India37% of the suicides were due to financial distress or food shortage or starvation, 19% due to loneliness,18% due to fear of infection or death. 11% due to withdrawal syndrome, 2.7% due to harassment and 12% due to other causes.

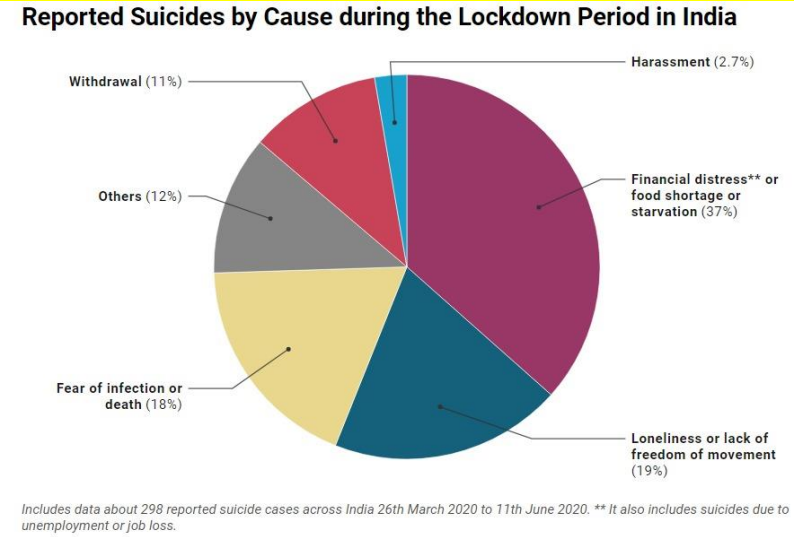

Figure 5- Suicide cases during lockdown *(Source-Google)*

HOW TO COPE UP?

- Stay informed - but don't obsessively check the news – Follow worthy sources like CDC, WHO and other trusted site.

Figure 6- WHO (Source- Google)

Figure 7 – CDC (Source- Google)

- Stay connected - even when physically isolated- stay in touch with friends and family virtually.

Figure 8 –Socialising (Source – Google)

Take a good care of health and spirit - engage yourself in different hobbies, meditate and have a good sleep cycle.

- Ask for help from elders and from counselor if needed.
  Manodarpan (mhrd.gov.in)is a website for psychological support for students implemented during lockdown.

Figure 9 -Coronavirus (COVID-19) , Health and wellbeing (Source- Google)

CONCLUSION

Some 71% Indian population still addresses mental illness with prejudice. The need of the hour is to sensitize and educate individuals about the signs and symptoms of mental illness while normalizing the idea of seeking support for themselves and their beloved ones.

ACKNOWLEDGEMENT

Every paper begins with an idea and materializes with concrete efforts. At first, I would like to thank almighty God who gave me the strength to work on this seminar topic.

It is indeed gratifying to have the privilege to express my deep sense of gratitude and appreciation to each and every teacher of PG department of Botany, Hooghly Mohsin College for allowing me to

work on this topic. I would also like to thank my parents, my classmates and all other peoples who helped me in completing my topic.

BIBLIOGRAPHY

- Kumar K, et al, The experiential impact of isolation and quarantine on patients during the initial phase of the COVID-19 pandemic in India.
  Ind Psychiatry J. 2020 Jul-Dec;29(2):310-316. doi: 10.4103/ipj.ipj_178_20. Epub 2021 Mar 15. PMID: 34158718
- NikunjMakwana, Disaster and its impact on mental health: A narrative review,J Family Med Prim Care. 2019 Oct; 8(10): 3090–3095. Published online 2019Oct31.
  Doi: 10.4103/jfmpc.jfmpc_893_19,
  PMCID: PMC6857396https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6857396/

- WHO. (2020a). Healthy parenting. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public/healthy-parenting.
- World Health Organization. Coronavirus Disease 2019 (COVID-19) Situation Report-64. World Health Organization; 2020. [Last accessed on 2020 Apr 11]. Available from: https://wwwwhoint/docs/default-source/coronaviruse/situation-reports/20200324-sitrep-64-covid-19pdfsfvrsn=703b2c40_2
  The experiential impact of isolation and quarantine on patients during the initial phase of the COVID-19 pandemic in India - PubMed (nih.gov)
- Zhai Y., Du X. Mental health care for international Chinese students affected by the COVID-19 outbreak. *Lancet Psychiatry*. 2020;7(4):e22. doi: 10.1016/S2215-0366(20)30089-4. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
  - India Ranked 139 out of 149 in UN World Happiness Report 2021, Finland Tops (affairscloud.com)
  - Report: Anxiety and Depression Symptoms Surged During Pandemic, 42% of Americans Affected | CNSNews
  - Kerala Govt Focuses On Children's Mental Health After 66 Student Suicides During Lockdown (outlookindia.com)
  - -https://www.thecitizen.in/index.php/en/NewsDetail/index/15/18987/Analysis-of-Suicides-Reported-Since-the-Lockdown
  - Taxes Without Borders (freebeacon.com)
  - CDC offers perspective on handling autos, vehicle HVAC amid COVID-19 threat - Repairer Driven NewsRepairer Driven News
  - https://www.facebook.com/morkholao/photos/a.181022569113239/646710545877770/?type=3&is_lookaside=1
  - Coronavirus (COVID-19) | Health and wellbeing | cryptoknowhow- cryptoknowhow.info

Paper- VI

MICROSPOROGENESIS & MEGASPOROGENESIS

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ABSTRACT

The formation of microspores by meiotic division of microsporocyte is a process that is carried out within the anther locule. It is covered by primary wall made up of cellulose and shortly before meiosis this wall

disintegrates and is replaced by a massive deposit of cellulose outside the plasma membrane(Heslop-Harrison, 1966; Risueno, Gimenez-Martin, and Garcia, 1973). Meiosis halves the chromosome number of microsporocytes creating four microspores from each microsporocyte. That meiosis is triggered by the synthesis of some factors in tissues other than the sporogenous cell (Walter, 1985).

Like microsporogenesis and formation of the male gametes, megasporogenesis and development of the egg are also so closely linked that they must be considered together. The essence of megasporogenesis is the formation of megaspores by meiosis of the megasporocyte (the megaspore mother cell). The transformation of the mega spore into the female gametophyte (the embryo sac housing the egg) is the centrepiece of the subsequent events of female sexual differentiation in flowering plants. In addition to satisfying the relatively simple requirement of housing the egg, the embryo sac must also anticipate the nutritional demands of the egg and the developing zygote. This problem is solved by the presence of ultrastructural features in the cells of the embryo sac for transfer of nutrients.

KEY WORDS: Anther locule, Plasmodesmata, Sporogenous cell, Outer Integument Wall, Ingrowth Archesporial Cell, Functional Megaspore

INTRODUCTION

Microsporogenesis or male meiosis is the earliest step in pollen ontogeny. It consists of nuclear divisions associated with cytoplasmic divisions or cytokinesis. This process starts with microsporocytes or pollen mother cells enclosed in a callose envelope within which meiosis takes place. Cytokinesis takes place through the formation of intersporal walls composed of callose. Once meiosis is completed, the four microspores form a tetrad embedded within the callose wall of the pollen mother cell, until the callose is digested by an enzyme called callase. In most species, apertures are already visible at the late tetrad stage, suggesting that aperture pattern (shape, number and distribution of apertures on the pollen grain surface within the tetrad) is determined during microsporogenesis.

Megasporogenesis is the formation of megaspores inside the ovules of seed plants. A diploid cell in the ovule, called a megasporocyte or a megaspore mother cell, undergoes meiosis and gives rise to four haploid megaspores. In most plants, only one of the megaspores then goes on to develop into a megagametophyte within the ovule, while the other three disintegrate. In the ovules of angiosperms, megasporogenesis takes place within a structure called a nucellus, and it is the megaspore farthest from the micropyle of the ovary that survives.

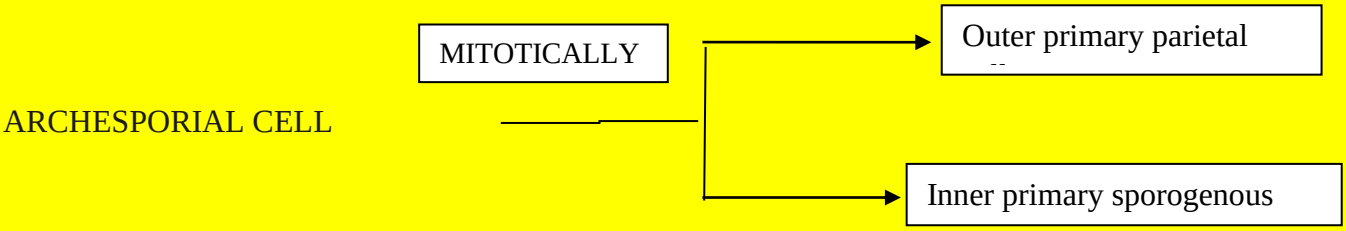
MICROSPOROGENESIS

❖ WHAT IS MICROSPOROGENESIS?

Microsporogenesis is the formation of microspore inside the microsporangia (or pollen sacs) of seed plant. A diploid cell in the microsporangium; called a microsporocyte or a pollen mother cell, undergoes meiosis and gives rise to four haploid (n) microspores.

DEVELOPMENT OF MICROSPORE MOTHER CELL AND MICROSPOROGENESIS (DEVELOPMEMT OF MICROSPORES i.e., POLLEN GRAIN) :

- Microspores (Pollen grains) develop inside Microsporangia which develops inside the corners of 4-lobed Anther.
- Outer layer of anther is called Epidermis. Below the epidermis at each corner, some cells become differentiated from others at each corner by their dense protoplasm- Archesporium or Archesporial cells.
- Each Archesporial cell then divides mitotically and forms an outer primary cell and inner primary sporogenous cell.



- Primary Parietal Layer divide both periclinally and anticlinally and form multilayered antheridial wall.
- The primary sporogenous cells either directly function as spore mother cell or divide mitotically into a number of cells which functions as spore mother cells.

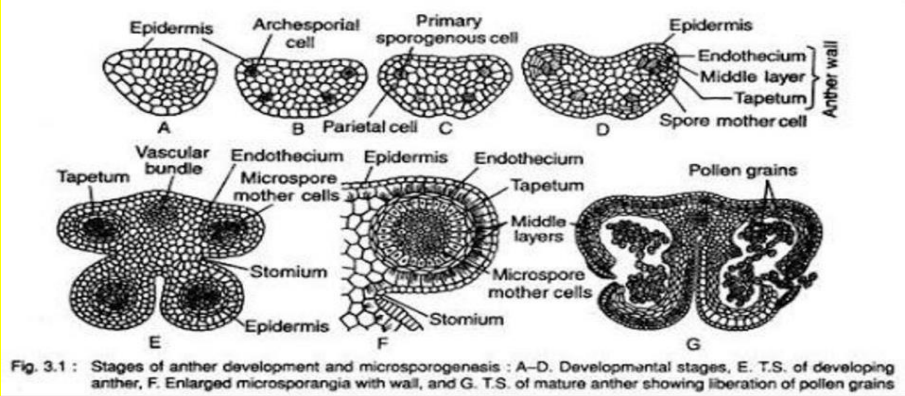


Fig. 3.1 : Stages of anther development and microsporogenesis : A–D. Developmental stages, E. T.S. of developing anther, F. Enlarged microsporangia with wall, and G. T.S. of mature anther showing liberation of pollen grains

Figure 1 – Stages of anther development and microsporogenesis (Source- Google)

- The spore mother cell undergoes meiotic division and gives rise to four microspores arranged tetrahedrally.
- Microspores are of various shapes - Polyhedral (milk thistle, *Sonchus palustris* of Asteraceae, cubical (*Basella alba* of Basellaceae) trigonal (common in Onagraceae) cylindrical (*Rheo discolor* of Commelinaceae) etc. The size of the pollen grains generally virous from 10-80µm, but the size may be even 100µm in diameter.
- The pollen grains have two walls- outer exine (the exine is further differentiated into two region, outer sexine and inner nexine) and inner intine. The exine is cutinized and tough with different ornamentation. It may be warty, spiny etc.

(Source- Bhattacharya. Hait. Ghosh)

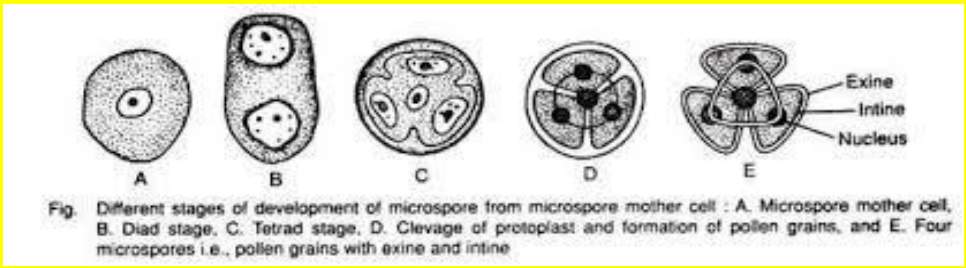


Fig. Different stages of development of microspore from microspore mother cell : A. Microspore mother cell, B. Diad stage, C. Tetrad stage, D. Clevage of protoplast and formation of pollen grains, and E. Four microspores i.e., pollen grains with exine and intine

Figure 2 – Different stages of development of microspore from microspore mother cell

(Source- Bhattacharya. Hait. Ghosh,)

MICROGAMETOGENESIS (DEVELOPMENT OF MALE GAMETOPHYTE) :

- Microspore i.e., the pollen grain is the first cell of the male gametophyte, which contains only one haploid nucleus.
- The cell undergoes unequal division and forms a small generative cell and a large vegetative or tube cell.
- Initially the generative cell remains lying at once corner of the spore wall. Within short time, it gets detached and becomes ellipsoidal or fusiform in shape and remains suspended in the cytoplasm of the vegetative cell (2-celled stage i.e., vegetative cell and generative cells).
- Later on, the generative cell divides and gives rise to two ellipsoidal or lenticular or spherical cell-MALE GAMETES (3-celled stage i.e., vegetative cell and two male gametes).
- The second division i.e., the division of generative cell, may take place either in the pollen grain or in the pollen tube which develops through germ pore after pollination.

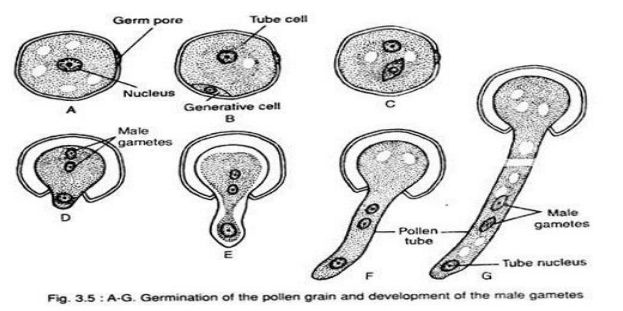


Fig. 3.5 : A-G. Germination of the pollen grain and development of the male gametes

Figure 3- Germination of pollen grain and development of male gametes (Source- Bhattacharya. Hait. Ghosh,)

SIGNIFICANCE OF TUBE NUCLEUS:

Earlier workers thought that the tube nucleus had great significance in the direction of the growth of the pollen tube, as it is usually present just behind the growing point within the pollen tube. However, recent workers differ with the above opinion and consider it is a non-functional vestigial structure, based on the following facts:

- In branched pollen tube, the tube nucleus remains in one tube, but all the tube grows normally.
- It does not always occupy the position behind the pollen tube, but it many cases it lies behind the male gametes.
- In some cases, the growing pollen tube does not have any tube nucleus as it generates prior to the development of pollen tube.**(Source- Bhattacharya. Hait. Ghosh,)**

MEGASPOROGENESIS

❖ WHAT IS MEGASPOROGENESIS?

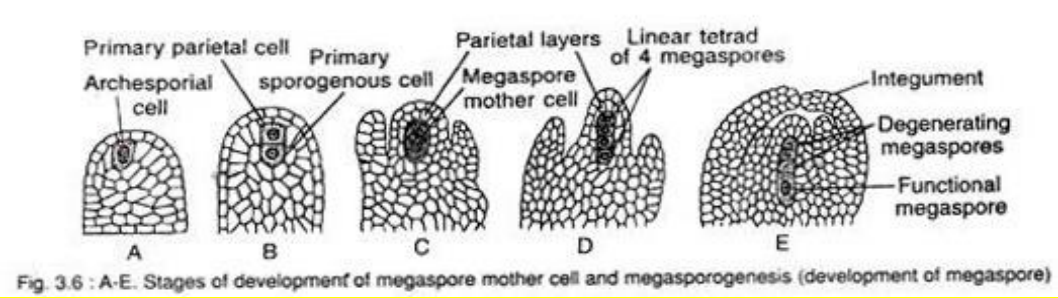


Fig. 3.6 : A-E. Stages of development of megaspore mother cell and megasporogenesis (development of megaspore)

Megasporogenesis refers to the development of megaspores from the megasporocyte, the cell that undergoes meiosis. Meiosis of the megasporocyte nucleus result in the formation of four haploid megaspore nuclei. In most Taxa meiosis is followed by cytokinesis, resulting in four megaspore cells.

DEVELOPMENT OF MEGASPORE MOTHER CELL:

- One hypodermal cell of the nucleus becomes differentiated from the outer by its bigger size, dense cytoplasm and conspicuous nucleus, called archesporial cell.
- The archesporial cell divides transversely and an outer primary parietal cell.
- The primary sporogenous cell function as megaspore mother cell and the primary parietal cell undergoes repeated vertical division and forms layer of parietal cell. Sometimes, the archesporial cell does not divide and directly function as megaspore mother cell.

The megaspore mother cell is diploid (2n) which undergoes meiosis (they divide transversely) and forms four haploid (n) megaspore. The megaspores are then arranged in an axial row, called linear tetrad. Figure 4- Stages of development of megaspore mother cell and megasporogenesis.

- Out of four megaspores, only one which remains towards the chalazal end behave as function megaspore and the other three which remain towards the micropylar end, gradually degenerate. The function megaspore forms the female gametophyte i.e., the embryo sac.

(Source - Bhattacharya. Hait. Ghosh,)

MEGAGAMETOGENESIS (FORMATION OF FEMALE GAMETOPHYTE i.e., EMRYO SAC)

- Megaspore is the first female gametophyte. The functional megaspore becomes enlarged at the expense of tapetum and the nucellus and thus forming the female gametophyte i.e., embryo sac.
- Initially the embryo sac is uni-nucleate and with further growth its nucleus divides by three successive division and forms eight nuclei. Out of eight nuclei, initially four remain towards the micropyle end and the other four towards the chalazal ends.
- One nucleus from each pole then moves towards the centre and forms a pair of polar nuclei. These nuclei fuse together and form 2n nucleus, the definite nucleus. It is also known as fusion nucleus or secondary nucleus.
- The three nuclei of the micropylar end form the egg apparatus and the rest three at te chalazal end are called antipodal cells. In the egg appratus, each nucleus is surrounded by viscous mass of cytoplasm without any wall, of which the middle one is the largest and it is called egg, ovum or oosphere and the rest two (one on each side of the egg) are the synergids or helping cell.

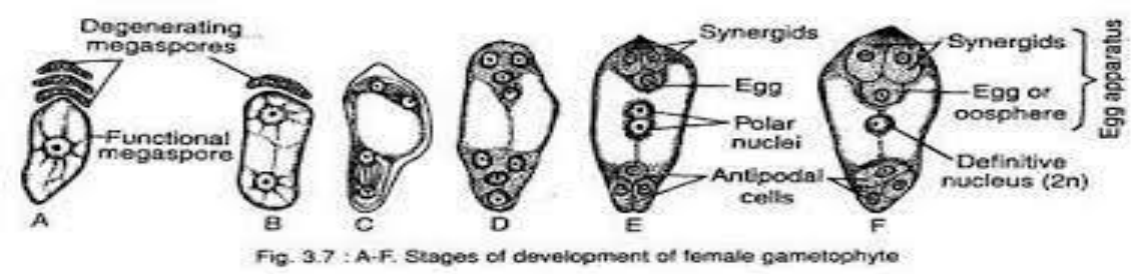


Figure 5- Stages of development of female gametophye (Source - Google)

This type of embryo sac development is very common in angiosperm and is also known as monosporic type because out of four megaspores, only one remains functional and forms the embryo sac. (Source- Bhattacharya. Hait. Ghosh)

OTHER TYPES OF EMBRYO SAC DEVELOPMENT

Female Gametophyte Type	Megasporogenesis			Megagametogenesis			
	Mega-sporocyte	Meiosis I	Meiosis II	Mitosis I	Mitosis II	Mitosis III	Mature female gametophyte
Monosporic 8-nucleate *Polygonum* type							
Monosporic 4-nucleate *Oenothera* type							
Bisporic 8-nucleate *Allium* type							
Tetrasporic 16-nucleate *Peperomia* type							
Tetrasporic 16-nucleate *Penaea* type							
Tetrasporic 16-nucleate *Drusa* type							
Tetrasporic 8-nucleate *Fritillaria* type							
Tetrasporic 8-nucleate *Plumbagella* type							
Tetrasporic 8-nucleate *Plumbago* type							
Tetrasporic 8-nucleate *Adoxa* type							

Figure 6 - Embryo sac development (Source – Google)

CONCLUSION

Successive microsporogenesis results in two cells after meiosis I and four cells after meiosis II. These microspores are developed inside the corner of 4-lobed Anther. It gets dispersed and land on the stigma. The microspores develop a protective layer to prevent itself from unfavorable condition. Upon landing on stigma, it reaches the ovary through style.Each ovule has a megaspore mother cell that undergoes meiosis to form four haploid megaspores. Three of them degenerates and one divide to form the embryo sac. Each embryo sac has three celled egg apparatus-1egg cell and two synergids, three antipodal cells and two polar nuclei. The polar nuclei eventually fuse to produce a diploid secondary nucleus.One of the two microspore after entering the ovule fuses with the egg cell(syngamy) to form a zygote. The other microspore fuses with the diploid secondary nucleus to produce the triploid primary endosperm nucleus (PEN). Syngamy and triple fusion is together called double fertilization. The ovules thus develop into seeds and ovaries develop into fruit.

ACKNOWLEDGEMENT

We all know that every living organism try to continue their species over time. That is why they 'Reproduce'. Even plants too reproduce. But how? This question inspired me to study what is deep inside the **Reproduction of plants**, what are the structures involved, how they divide, how they get fertilized even having a gap in their reproductive parts. Thus, it was my inspiration. But studying alone doesn't bear a fruit without a proper guidance. Therefore, I took the help of our respected professors whom I want to present a thanks.

I hereby thank the arranger of the Seminar, respected **Principal of Hooghly Mohsin College Dr. Purushottam Pramanik**. Secondly, our respected **Head of the Department, Dr. Debabrata Mukhopadhyay**, and other respected professors of the PG Department of Botany. Last but not the least, I would also like to thank my whole family for guiding for all kind of tiny detailing which helped my study over the topic more informative and look attractive. Thank You.

BIBILIOGRAPHY

1. https://academic.oup.com/
2. https://www.dictionary.com/
3. https://www.dictionary.com/browse/microsporogenesis#:~:text=%5B%20m%C4%AB%E2%80%B2kr%C9%99%2Dsp%C3%B4r%E2%80%B2,rise%20to%20four%20haploid%20
4. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/megasporogenesis#:~:text=Megasporogenesis%20refers%20to%20the%20development,resulting%20in%20four%20megaspore%20
   Figure.1-https://player.slideplayer.com/109/17996330/slides/slide_2.jpg
   Figure.2- The textbook of botany Vol-2, Bhattacharya. Hait. Ghosh, Chapter 4, page-263
   Figure. 3-https://qforquestions.com/wp-content/uploads/2018/07/pollen-germination.jpg
   Figure.4 -https://qphs.fs.quoracdn.net/main-qimg-3f1917bf3d2d939b02ed4d1af345f6e0
   Figure. 5-https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQSuK_x74wgLz_EEljCa6oFfwBt9u4fW3JYSBjBnGhSOruDMw9I5sN_wFhWRFCZxHIVVIY&usqp=CAU
   Figure. 6-https://ars.els-cdn.com/content/image/3-s2.0-B9780128126288500110-f11-09-9780128126288.jpg
5. A Textbook of Botany Vol II by Bhattacharya, Hait, Ghosh. (New Central Book Agency (P) Ltd.- Page No. 262-268
6. Ncert Biology XI- Page Number 40-41

Paper-VII

STRUCTUREAND FUNCTION OF ATP

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ABSTRACT:

Adenosine triphosphate (ATP) is a universal mediator of metabolism and signalling across unicellular and multicellular species. There is a fundamental interdependence between the dynamics of ATP and physiology that occur inside and outside the cell.

Characterizing and understanding ATP dynamics provide valuable mechanistic insight into processes that ranges from neurotransmission to the chemotaxis of immune cells. Therefore, we require the methodology to interrogate both temporal and spatial components of ATP dynamics from the subcellular to the organismal levels in live specimen. Several probes have been combined with imaging approaches, particularly optical microscopy, to enable qualitative and quantitative detection of this critical molecule. In the review, we survey current examples of technologies available for visualizing ATP in living cell, and identify areas where new toolsand approaches are needed to expand our capabilities.

INTRODUCTION:

ATP or adenosine triphosphate is made up of the molecule adenine (which itself is made up of adenine and ribose sugar) and three phosphate group. Its chemical formula is $C_{10}H_{16}N_5O_{13}P_3$ and molar mass is 507.18g/mole. It is soluble in water and posses a high energy content due to having two phospho-anhydride bond connecting the three phosphate groups.

STRUCTURE:

It was discovered in 1929 by Lohman and Jendrassik. The structural feature of ATP reveals the following-----

- ✓ It is a nucleotide triphosphate consisting of three component -5C ribose sugar, a nitrogenous base(adenine) and three phosphates.
- ✓ The adenine is attached by 9 nitrogen atoms to the 1'C of the ribose sugar (by glycosidic bond).
- ✓ The 5'C of the ribose sugar is attached to a triphosphate group through ester linkage.
- ✓ The three phosphoryl groups are called as α, β and terminal one as γ.
- ✓ Its density is 1.04 /cubic cm and melting point is 187°C.
- ✓ ATP is stable in a solution with a pH ranging from 6.5 to7. 4.
- ✓ Within the cell ATP exists mostly in form of ATP – Mg^{++} where Mg^{++} is bonded to oxygen.
- ✓ (Barclay CJ, Energetic of Contraction. Compr Physiol. 2015 Apr ;5(2) :961-95[PubMed].

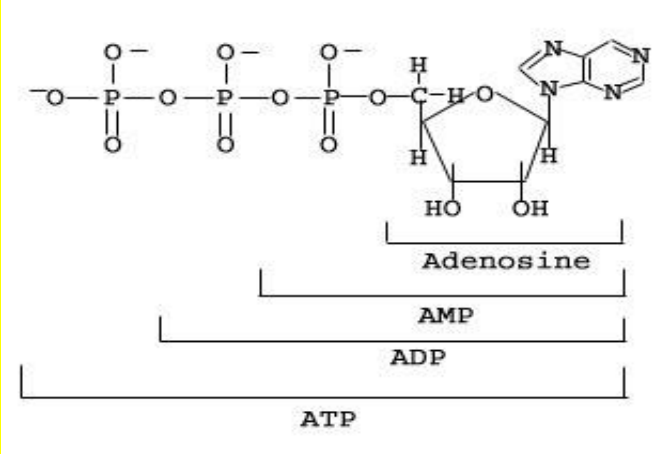

Figure- ATP structure (Source-Google)

FUNCTION

ATP is one of the most important cellular components which not only act as energy currency molecule, but also function is very important life sustaining reaction such as---

- ✓ Intracellular signalling including general signal transduction pathway.
- ✓ Helps in amino acid activation during protein synthetis.
- ✓ Helps in synthesis of one of the four monomersof RNA and DNA(deoxyATP).
- ✓ Helps in active transport of molecule through plasma membrane.
- ✓ Helps in extracellular signalling and neurotransmitter.(Source- Wang X, et al, 2017)

- ✓ However, the main role of ATP to sustain life is due to its high energy content, dueto the presence of high energy P-O-P bond, so it acts as a direct energy supplier to all form of metabolic events and hence it is called energy currency molecule. (Source -Agteresch et al, 1999)

The functional role of ATP as an energy currency molecule is represented in the following-

- ➢ ATP is stable in the aqueous solution between PH 6.5 to 7.4, in absence of any catalysts.
- ➢ At more extreme pH it rapidly hydrolyses into ADP and phosphate.

The hydrolysis of ATP into ADP and inorganic phosphate releases 30.5 kj/mole of enthalpy (with a change in free energy of 3.4 kJ/mole).

$$ATP + H_2O \longrightarrow ADP + Pi$$

(Source -Beis and Newsholme 1975)].)

- The living cells maintain in the ratio of ATP and ADP approximately 5:1 in equilibrium.
- Sometimes ATP is hydrolysed into AMP and phosphate releasing 45.6 kJ/mole of enthalpy.

  $$ATP + H2O \longrightarrow AMP + PPi$$
- In content of biochemical reaction, the P-O-P bond are frequently referred to as high energy bond which on hydrolysis release the above amount of energy.
- The substitute of ATP used in living cell is GTP, the magnitude and efficiency of which is comparatively lower.

(Source–Instant notes biochemistry, B.D. Hames and N.M. Hooper)

CONCLUSION:

ATP is the fuel of life. It's an energy currency molecule-the most important source of chemical and mechanical energy in living system. Therefore, ATP plays a vital role in the biological world. All living cells use adenosine triphosphate molecule as a fuel of energy to survive. Even viruses rely on ATP.

ACKNOWLEDGEMENT:

In the accomplishment of this seminar topic successfully, many people have bestowed upon me their blessings andheart pledged support. It is indeed gratifying to have the privilege to express my deep sense of gratitude and every professor of PG Department of Botany, Hooghly Mohsin College for allowing me to work on this topic. I would also like to thank my parents, my classmates and all other people who helped me in completing my topic.

BIBLIOGRAPHY:

- ✓ Agteresch HJ, Dagnelie PC, Van den Berg JW, Wilson JH, Adenosine triphosphate: established and potential clinical applications. Drugs, 1999 Aug; 58(2) 211-32.
- ✓ Barclay CJ, Energetic of Contraction. Compr Physiol. 2015 Apr ;5(2) :961-95[PubMed].
- ✓ Beis I, Newsholme EA. The content of adenine nucleotides, phosphagens and some glycolytic intermediate in resting muscles for vertebrates and invertebrates. Biochem J. 1975 oct;152(1) :23_32[PMC free article] [PubMed].
- ✓ Instant notes biochemistry, B.D. Hames and N.M. Hooper,2nd edition, Section C, page 78)
- ✓ Wang X, Zhang X, Wu D, Huang Z, Hou T, Jian C, YUP, LUF, Zhang R, Sun To, LiJ, QiW, Wang Y, GaoF, Cheng H. Mitochondrial flashes regulate ATP homeostatis in the heart. Elife. 2017 jul 10;6 [PMC free article].
- ✓ https://www.sparknotes.com/biology/cellrespiration/intro/section1/

Paper-VIII

NUCLEOSOME AND CHROMATIN STRUCTURE

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ABSTRACT

In eukaryotic cells the large sized DNA fits into a nucleus which is comparatively with a very small diameter. Several investigations and different opinions ultimately led to the foundation of nucleosome model proposed by Roger Kornberg. It states that 200 bp of DNA wind around a histone H2A, H2B, H3 and H4 and is closely associated with one molecule of histone H1 to form a nucleosome. The nucleosome with a diameter of 10nm is the structural unit of chromatinfiber and the DNA present in between the nucleosome are called as linker DNA, which are associated with several types of non-histone proteins. Since the thickness of chromatinfiber is 30nm, the nucleosomes have shown further level of packaging which is best described by solenoid model. Solenoid model states that to attain the 30nm chromatinfiber 6 nucleosomes are closely packed together with their linker DNA inserted inwards to form a turn that ultimately gave rise to the 30nm chromatin fiber.

Keywords: DNA, nucleosome, chromatin, histone, non-histone, solenoid

INTRODUCTION

Human genome contains about 6µm of DNA. This large DNA must be subdivided into 2-3 parts of chromosome in order to fit within the nucleus of diameter 0.5µ. So, there must be huge level of compactions and packaging of DNA to form the chromatin and subsequently the chromosome.

MODELS OF PACKAGING OF DNA FOR CHROMATIN ORGANISATION

1. Single Stranded Model of Taylor (1962)- It states that DNA is present in single strand within the chromosome.
2. Multiple Stranded Model of Ris (1963)- It states that DNA is present in multiple strands forming chromatin.
3. Folded Fiber Model of Dupraw (1969)- It states that DNA is irregularly coiled within the chromosome.
4. Nucleosome Model of Roger Kornberg (1974)- Nucleosome are the basic structural unit of chromatin consisting of 200 bp of DNA which surrounds a histone core(made of two molecules of each of histone H2A, H2B, H3 and H4) for 1.65 times and is closely associated with one molecule of histone H1.

NAME	DNA (%)	HISTONE(%)
Pea(Embryonic axis)	39	40
Pea (Cotyledon)	43	34
Rat (Liver)	37	37

(Source- Dupraw, E.J. 1991; Cell and Molecular Biology, Academic Press, New York.)

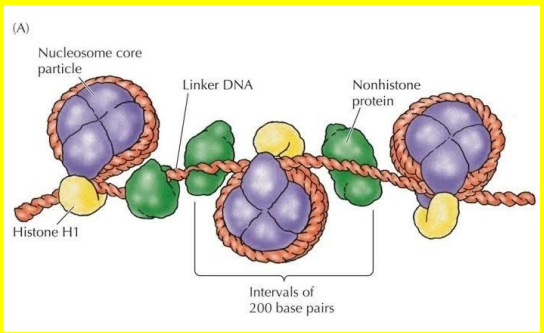

Figure 1 – Packaging of nucleosome (Source- Google)

WHAT IS HISTONE?

Histones are the basic proteins which are rich in basic amino acid lysine and arginine. They are associated with DNA by non-covalent bond and also acts as gene repressor.
(**Source-** The cell a molecular approach, G. Cooper and R. E. Haushman, chapter 4, page no.- 150)

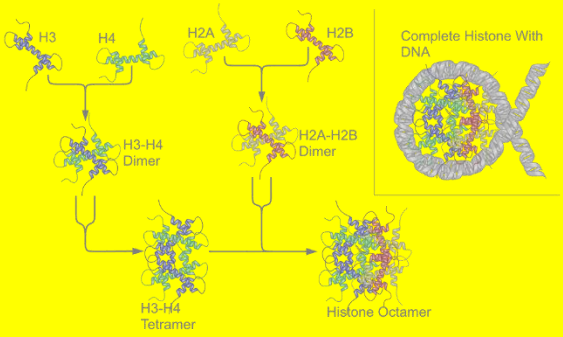

Figure 2- Types of histone protein (Source- Google)

STRUCTURAL ORGANISATION OF NUCLEOSOME

- A histone core is formed by two molecules of each of histone proteins such as H2A, H2B, H3 and H4. This histone core is also called octamer.
- Physical study shows that 146 bp of DNA wrap around this histone core for 1.65 times to form a chromatosome which is stabilized by one molecule of histone H1 to form nucleosome.
- The DNA present in between two nucleosomes is called linker DNA which is variable in length. Several non-histone proteins are randomly associated with this linker DNA.
  (Source- Instant notes biochemistry,B.D. Halmes and N.M. Hooper,2nd edition, Section F, Page no.- 153**)**

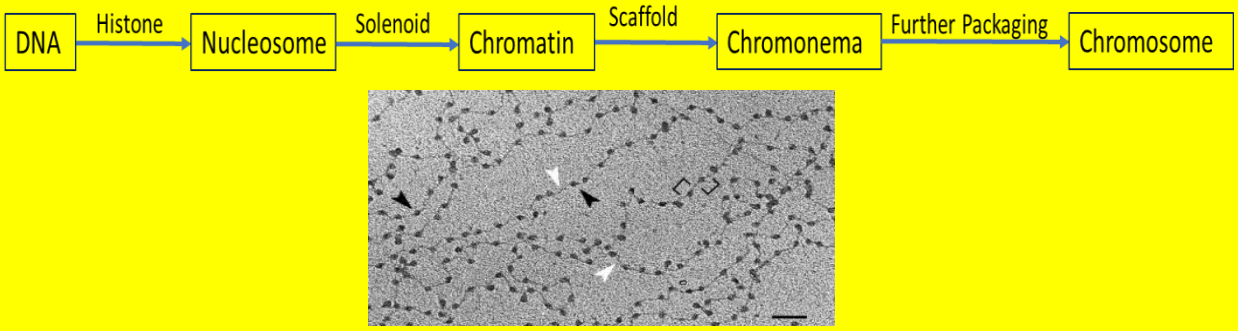

Figure3– Bead on a string like structure (Source– Google)

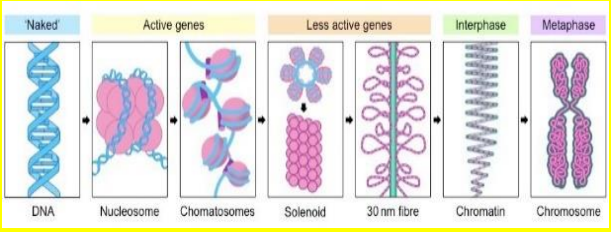

Figure 4- Further packaging of nucleosome (Source- Google)

FURTHER PACKAGING OF NUCLEOSOME

The thickness of nucleosome is 10nm whereas the thickness of chromatin thread during interphase is 30nm.

Further packaging of nucleosome can be described by two models:

- ❖ Zigzag Model- This model states that the nucleosomes are not arranged definitely but a zigzag arrangement is present giving rise to a spring like appearance. The linker DNA is placed interior to the spring.
- ❖ Solenoid Model

SOLENOID MODEL

- ✓ It was seen that 10nm fiber of nucleosome gets coiled upon itself to form 30nm wide helix with 5 or 6 nucleosomes per turn in the helix. This 30nm structure was called as solenoid.
- ✓ In this helix successive turns come close together, so that their center-to-center distance was about 10nm.
- ✓ It was also proved that H1 protein helped in folding of 10nm fiber into 30nm solenoid because when H1 was removed, this ordered folding was found to be absent and only irregular clumping of nucleosome could be observed.
- ✓ It is also speculated that solenoid has to fold or coil again during condensation of chromatin.
- ✓ Approximate packaging ratio of histone and DNA in a solenoid is 1:50.
  (Source- Instant notes biochemistry, B.D. Halmes and N.M. Hooper,2nd edition, Section F, Page no.-154**)**

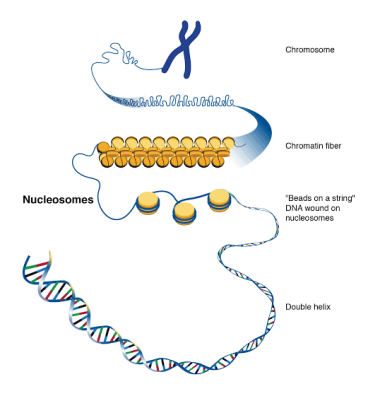

Figure 5-Solenoid model (Source- Google)

CHROMATIN STRUCTURE

The material of which chromosomes are composed is called chromatin. Chromatin was classified into two groups by Emil Heitz in 1928 on the basis of its stain ability with basic dyes particularly the Feulgen reagent. These two groups are Euchromatin and Heterochromatin.
(**Source-** Kornberg, R.D. 1974. Chromatin structure: A repeating unit of histones and DNA. Science 184: 868-871.)

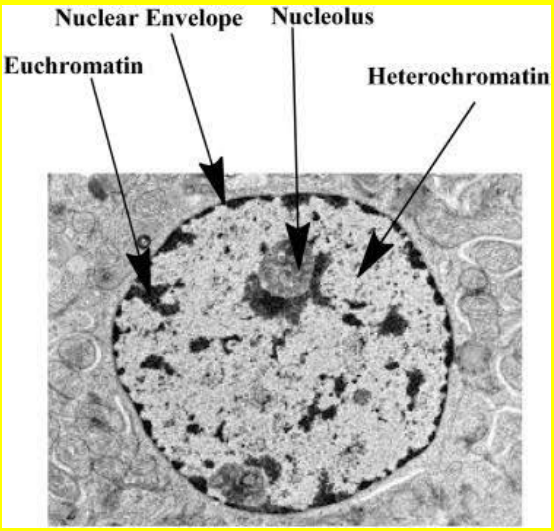

Figure 6-Euchromatin and Heterochromatin (Source- Google)

EUCHROMATIN

- ✓ Euchromatin is that part of the chromatin that remains loosely coiled and lightly stained during interphase.
- ✓ It generally replicates normally in the S phase of the cell cycle.
- ✓ During divisional phase it remains tightly coiled and deeply stained.
- ✓ Generally, 90% of a chromatin are euchromatin.

HETEROCHROMATIN

- ✓ Heterochromatin is that part of the chromatin that remains tightly coiled and deeply stained during interphase
- ✓ During divisional phase it remains loosely coiled and lightly stained.
- ✓ It replicates at late S phase of the cell cycle.
- ✓ Generally, 10% of a chromatin are heterochromatin.

TYPES OF HETEROCHROMATINS

Heterochromatin is divided into two groups:

- ❖ Constitutive Heterochromatin- This type of heterochromatin remains permanently heterochromatic in all types of cells during all stages of development. E.g., Centromere and telomere are constitutive heterochromatin.
- ❖ Facultative Heterochromatin- This type of heterochromatin remains specifically heterochromatic at certain stages of development.
  E.g., Barr body

CONCLUSION

The packaging of DNA into nucleosome and its further packaging into chromatin through solenoid structure not only accommodate a very long size DNA in a comparatively small nucleus with a very small diameter, but also it protects the DNA from injury due to radiations and any other external

agencies. It is evident that the 30nm chromatin fiber is differentiated into euchromatin and heterochromatin. There is no doubt that heterochromatin is generally inert, i.e., it does not contain any genes while most of the genes are present in euchromatin.

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I would also like to thank my parents and my friends who helped me a lot in finishing this project within the limited time frame.

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BIBLIOGRAPHY

- https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcTkYFVSO_IO7uu5exc-qWuJLBNWqg8YI2Zppw&usqp=CAU
- https://upload.wikimedia.org/wikipedia/commons/8/8a/Nucleosome_structure.png
- https://weekly.biotechprimer.com/wpcontent/uploads/2016/02/Nucleosome-e1455052786697.jpg
- https://ib.bioninja.com.au/_Media/organisation-of-dna_med.jpeg
- https://www.genome.gov/sites/default/files/tg/en/illustration/nucleosome.jpg
- https://ars.els-cdn.com/content/image/1-s2.0-S0141813017304786-gr7.jpg
- Heitz, Emil (1928). “Das Heterochromatin der Moose”. JahrbücherfürWissenschaftlicheBotanik. 69:762-818.
- Kornberg, R.D. 1974. Chromatin structure: A repeating unit of histones and DNA. Science 184: 868-871.
- Ris, H., and Chandler, B.L., in Synthesis and Structure of Macromolecules, Cold Spring Harbor Symp. Quant. Biol., 28, 1 (1963).
- Taylor, J.H., Intern. Rev. Cytol., 13,39 (1962).

Paper- IX

TYPES OF DNA

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ABSTRACT

Nucleic acids are any group of long, linear macromolecule that carries geneticinformation directing all cellular functions; composed of linked nucleotides. Nucleic acids are of two types: DNA and RNA.

- DNA (Deoxyribonucleic acid): An extremely long, double-stranded nucleic acid molecule arranged as double helix that is the main constituent of the chromosomes and that carries the genes as segments along its strands.
- Variations in DNA:Most of the DNA is in the classic Watson-Crick model simply called as **B-DNA or B-form DNA**.
- In certain condition, different forms of DNAs are found to be appeared like**A-DNA, Z-DNA, C-DNA, D-DNA, E-DNA.**These deviations in forms are based ontheir structural diversity.
- Only B and Z conformations occur as cellular DNA, other forms are found rigidly in controlled and experimental conditions.
- Whether a DNA sequence will be in the A-, B-, C-, D-, E- or Z-conformation, depends, on two different conditions. They are**ionic and hydration environment**, which canfacilitate conversion between different helical forms.They have different features in their own way.

Key Words:DNA, Nucleic acid ,Conformation , B-DNA , Z- DNA .

INTRODUCTION

- DNA molecules exist in different forms in different conditions. The various conformations that DNA can adopt depends on following factors:

1. Hydration level (it means that what is the amount of water presents in the surroundings)
2. Salt and metal ions concentration

- Various forms that DNA double helix can exist in are:

1. B DNA
2. A DNA
3. Z DNA
4. E DNA
5. C DNA
6. D DNA

Only B and Z conformations occur as cellular DNA, other forms are found rigidly in controlled and experimental conditions.

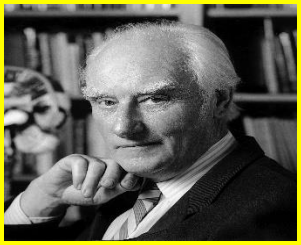
(Source-Principles of Molecular Biology, Veer Bala Rastogi)

Description of features of different types of DNA in different conditions:-

- **B-DNA:**

- Most common and predominant form in which DNA exist in cells.
- The Watson and Crick model is a B-DNA.
- DNA prefers to exist in B form under the normal physiological condition of pH and salt concentration (relative high humidity 92% and low concentration of Ions) found in the cell.

Pic 1: James D. Watson



Pic 2: Francis Crick

- Watson and Crick model of DNA whose key features are as follows:

1. B DNA is a right handed helix.
2. In this form bases occupy the core whereas sugar phosphate backbone occursat the peripheral portion of the helix.
3. The helical diameter is 20 Å.
4. Each turn on helix in B DNA has a helical height of 34 Å.
5. Each turn in the B DNA consists of 10 base pairs.
6. Distance between adjacent base pair in 3.4 Å.
7. The base pair tilt of helix is by 6.3 degrees.
8. It has wide and deep major groove and narrow and deep minor groove.

(Source- Principles of Molecular Biology, Veer Bala Rastogi)

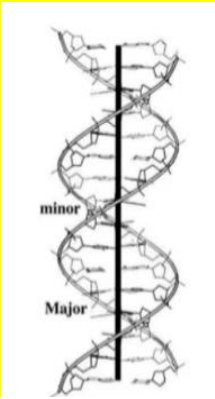


Figure3: B-DNA

(Source- Google)

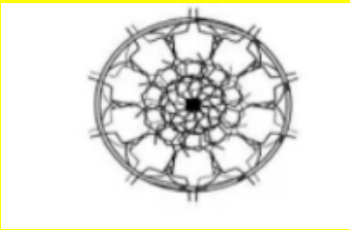


Fig 4: Top view of B-DNA

(Source- Google)

➢ A-DNA:

- It is presumed that A DNA is derived from B DNA as a result of hydrophobic molecules under dry condition.
- The A form of DNA is found at 75% relative humidity in presence of Na^+, K^+or CS^+ions.

1. It has right handed helix.
2. It contains 11 base pairs as compared to the 10 base pairs of B-DNAwhich tiltsfromthe axis of helix by 20.2°.
3. The A form is metastable and quickly turns to the D form.

(Source-Principles of Molecular Biology, Veer Bala Rastogi)

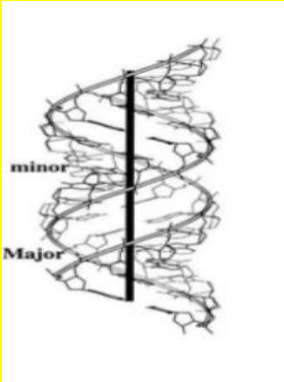


Fig 5: A-DNA

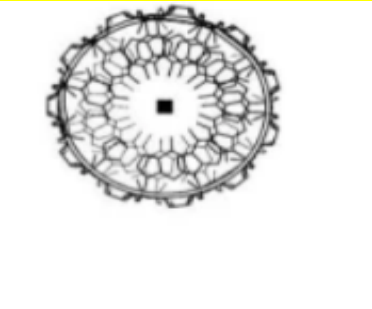


Fig 6: Top view of A-DNA

➢ Z-DNA:

- ❑ It is not very common form and present in high NaCl concentration and high GC (Guanine≡Cytosine)concentration region of the cell.
- ❑ The existence of Z DNA in *Drosophila* has been demonstrated using antibodies that recognize and bind specifically to Z DNA.

Figure 7*: Drosophila*

(Source- Google)

1. The existence of Z-DNA was discovered by Alexander Rich and Andrew Wang (1979).

Fig 8: Alexander Rich

Fig 9: Andrew Wang

2. Left handed double helical structure.
3. It bears zigzag sugar phosphate backbone in the two antiparallel strands.
4. Z-DNA is one of the biologically active forms found in *vivo* in cells.
5. Each helical turn contains 12 nucleotides.
6. Major groove is flat while minor groove is narrow and deep.

(Source- Principles of Molecular Biology, Veer Bala Rastogi)

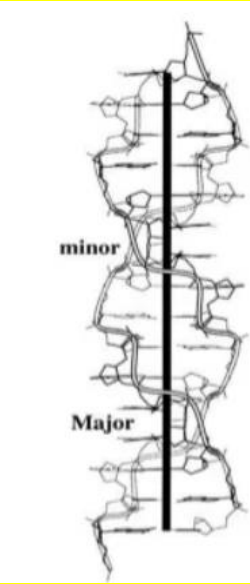


Fig 10: Z-DNA

(Source- Google)

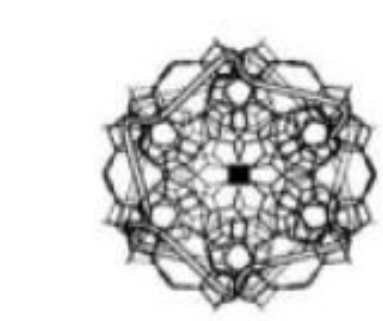


Fig 11: Top view of Z-DNA

(Source- Google)

- **Comparison between A, B & Z-DNA:**

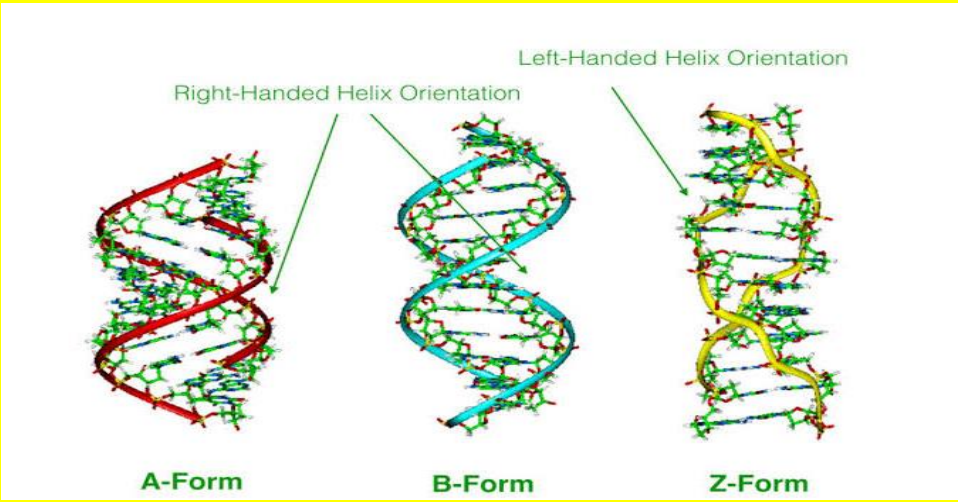


Figure- A-DNA, B- DNA, C-DNA (Source – Google)

As we can clearly see, the A& B-DNA is right handed helix orientation and Z is left handed helix orientation.In A & B-DNA we can see regular orientation of nucleotides and in Z DNAzig zag orientation of nucleotides. In A & B-DNA sugars are not alternately present, so repeated units are mononucleotides. But in Z-DNA sugars are alternately present, so repeated units are dinucleotides.

(Source-Youtube)

- **E-DNA:**

1. E-DNA has a long helical axis rise and base perpendicular to the helical axis.
2. Deep major groove and shallow minor groove.
3. E-DNA is allowed to crystallizefor a longer period , the methylated sequence forms standard A-DNA.
4. The E-DNA surface is highly accessible to solvent, with waters in the major groove sitting on exposed faces of the stacked nucleotides.

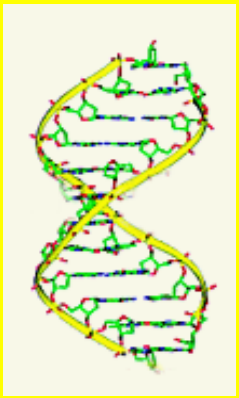


Fig 13: E-DNA

(Source – Google)

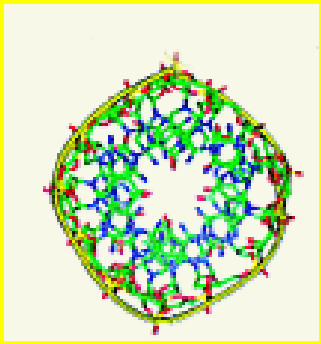


Fig 14: Top view of E-DNA

(Source-Google)

- **C-DNA:**

- Formed at 66% humidity and in presence of lithium ions.

1. Right handed helix with 9.33 bp per turn.
2. Helical diameter is 19 Å.
3. C DNA is narrow and less compact than A DNA and B DNA.

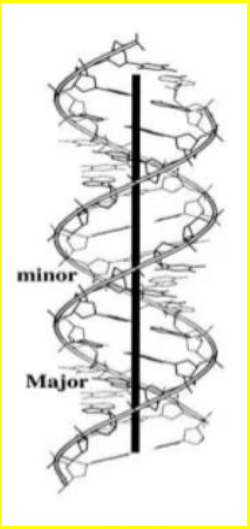


Fig 15: C-DNA

(Source- Google)

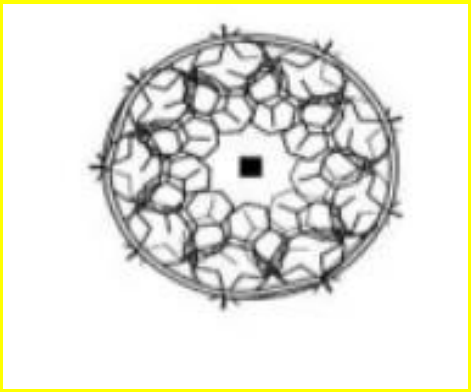


Fig 16: Top view of C-DNA

(Source- Google)

➢ **D-DNA:**

❑ D DNA has been detected in nature only in T2 Bacteriophage.

Fig 17: T_2 Bacteriophage

(Source- Google)

1. Extremely rare variant with only 8 bp per helical turn.
2. This form of DNA is found in DNA molecules which are devoid of guanine.

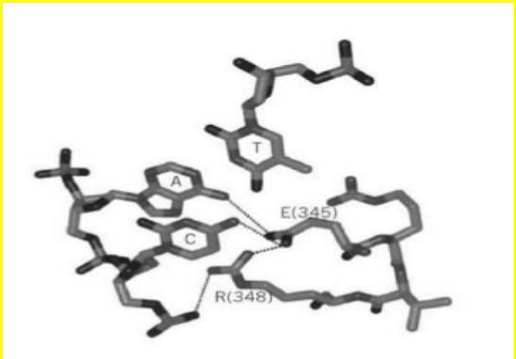


Figure: Structure devoid of Guanine (Source- Google)

3. Base pairs are negatively tilted.

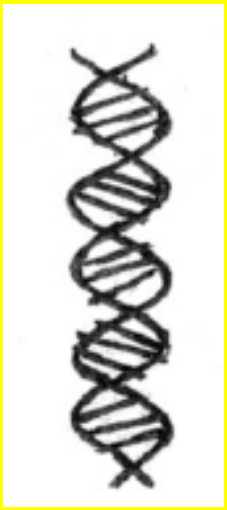


Fig: D-DNA

(Source- Google)

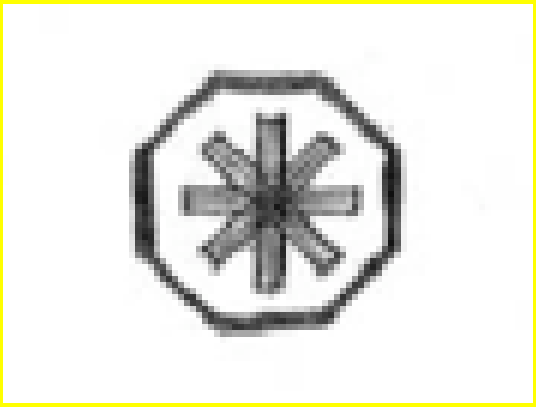


Fig: Top view of D-DNA

(Source- Google)

➢ **Summary:**

Features	A-DNA	B-DNA	C-DNA	D-DNA	E-DNA	Z-DNA
Base pair per turn of helix	11	10	9.33	8	7.5	12
Tilt of base pairs	20.2°	6.3°	-7.8°	-16.7°	-	7°
Axial Rise	2.56 Å	3.37Å	3.32 Å	3.03 Å	3.25 Å	3.7Å
Pitch of the helix	28.15 Å	34 Å	31 Å	-	24.4 Å	45Å
Helical Diameter	23 Å	20 Å	19 Å	-	-	18 Å
Rotation per base pair	32.7°	36°	38.6°	-	48°	30.0°
Handedness of the double helix	Right	Right	Right	Right	Right	Left

CONCLUSION

Local structural transitions from the common B-DNA conformation into other DNA forms can be functionally important. This chapter describes the structures of DNA forms called alternative DNA conformations that are different from the canonical B-DNA helix. Also discussed are the requirements for the formation of alternative DNA structures, as well as their possible biological roles. The formation of non-B-DNA within certain sequence elements of DNA can be induced by changes in environmental conditions, protein binding and super helical tension. Several lines of evidence indicate that alternative DNA structures exist in prokaryotic and eukaryotic cells.It is a great discovery in molecular biology science.

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I would also like to thank my parents and my teacherswho helped me a lot in finalizing this topic with all kind of tiny detailing within the limited time frame which helped my study over the topic more informative and look attractive. Thank You.

BIBILIOGRAPHY

1. **Principles of Molecular Biology by Veer Bala Rastogi, 2nd Edition,Page- 137 to 140**
2. **iGenetics by Peter d. Russell, 3rd Edition, Page- 44**
3. **https://youtu.be/D6seXe3NTFs**
4. https://pubmed.ncbi.nlm.nih.gov/10966645/#:~:text=Like%20B%2DDNA%2C%20E%2D,minor%20groove%20of%20A%2DDNA
5. **Fig 1**: https://images.app.goo.gl/tbqHdNf67gamK2Ko7
6. **Fig 2**: https://images.app.goo.gl/NoVZTZWfE2ppAGobA
7. **Fig 3,4,5,6,10,11,15,16:**https://microbenotes.com/wp-content/uploads/2018/08/Forms-of-DNA.jpg
8. **Fig 7**: https://images.app.goo.gl/RsriMpR6a1N9dDgAA
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10. **Fig 9:**https://twas.org/directory/wang-andrew-h-j
11. **Fig 12:**https://www.okultura.cz/WordPress/wp-content/uploads/ABZ-formy-DNA-696x466.jpeg
12. **Fig 13,14:**https://www.researchgate.net/figure/Comparing-E-DNA-with-B-DNA-and-A-DNAa-Views-into-top-and-down-bottom-the-helix-axes_fig1_12354748?hcb=1
13. **Fig 17:** https://images.app.goo.gl/j7j4dVxYW3dgh11i8
14. **Fig 18**: https://images.app.goo.gl/zFyDicg4D4qC43vk8

15. **Fig 19,20:** https://www.google.com/imgres?imgurl=https%3A%2F%2Fwww.researchgate.net%2Fprofile%2FClaude-Gagna%2Fpublication%2F8230878%2Ffigure%2Ffig1%2FAS%3A601753988898826%401520480739795%2Fllustrations-of-different-conformations-of-ds-DNA-The-first-four-nucleic-acid-molecules.png&imgrefurl=https%3A%2F%2Fwww.researchgate.net%2Ffigure%2Fllustrations-of-different-conformations-of-ds-DNA-The-first-four-nucleic-acid-molecules_fig1_8230878&tbnid=p6dGxOWOMk03oM&vet=1&docid=YUJ6XiVQTHNzPM&w=850&h=317&itg=1&hl=en-GB&source=sh%2Fx%2Fim

Paper- X

Structure of Protein

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ABSTRACT

Proteins are linear heteropolymers of a fixed length. A linear chain of amino acids folds into a particular three-dimensional conformation determined by the sequence of the amino acids in the chain . This constitutes the primary or most basic level of protein structure. Proteins are generally self-folding due to forces such as hydrogenbonds, disulfide bridges, and salt bridges (ionic interactions between charged residues), as well as hydrophobic and hydrophilic interactions that cause it to bend, coil, or fold into a secondary structure such as the alpha helix and beta-pleated sheet. The same forces that cause the protein to fold into a secondary structure cause even further compactness in some structures, such as in globular proteins, giving rise to a tertiary protein structure. When a protein contains more than one polypeptide chain, the overall configuration of the unit gives rise to a quaternary structure. As proteins are extraordinarily complex molecules and have most diverse functions, a basic understanding of its structure is necessary to comprehend its role in organism.

INTRODUCTION

Protein structure is the three-dimensional arrangement of atoms in an amino acidchain molecule. Proteins are polymers specifically polypeptides – formed from sequences of amino acids, the monomers of the polymer. A single amino acid monomer may also be called a *residue* indicating a repeating unit of a polymer. Proteins formed by amino acids undergoing condensation reactions, in which the amino acids lose one water molecule per reaction in order to attach to one another with a peptide bond. By convention, a chain under 30 amino acids is often identified as a peptide, rather than a protein. To be able to perform their biological function, proteins fold into one or more specific spatial conformations driven by a number of non-covalent interactions such as hydrogen bonding, ionic interactions, Van der Waals forces and hydrophobic packing. To understand the functions of proteins at a molecular level, it is often necessary to determine their three-dimensional structure. This is the topic of the scientific field of structural biology, which employs techniques such as X-ray crystallography, NMR spectroscopy, cryoelectron microscopy (cryo-EM) and dual polarisation interferometry to determine the structure of proteins.

Protein structures range in size from tens to several thousand amino acids. By physical size, proteins are classified as nanoparticles, between 1–100 nm. Very large protein complexes can be formed from protein subunits. For example, many thousands of actin molecules assemble into a microfilament.A protein usually undergoes reversiblestructural changes in performing its biological function. The alternative structures of the same protein arereferred to as different conformations, and transitions between them are called conformational changes.

PROTEINS.

- Proteins are the most abundant organic molecules of the living system.
- They constitute about 50% of the cellular dry weight.
- They constitute the fundamental basis of structure and function of life.
- In 1839, Dutch chemist G.J Mulder was first to describe about proteins.
- The term protein is derived from a Greek word proteios meaning first place.
- The proteins are nitrogenous macromolecules that are composed of many amino acids.(https://www.britannica.com/science/protein)

AMINO ACIDS.

- Amino acids are a group of organic compounds containing two functional groups – amino and carboxyl ; an organic R group that is unique to each amino acid.
- The amino group [NH_2] is basic while the carboxyl group [COOH] is acidic in nature.
- There are about 300 amino acids that occur in nature . Only 20 of them occur as proteins.

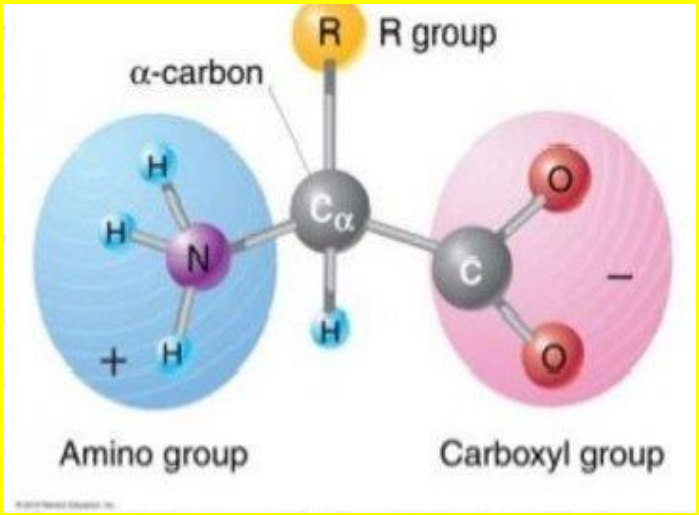

Figure- Amino acid (Source-Google)

CHEMICAL STRUCTURE OF AMINO ACIDS.

Each amino acid molecule contains a central carbon atom, called the alpha carbon to which both an amino and a carboxyl group are attached. The remaining two bonds of the alpha carbon atom are generally satisfied by a hydrogen (H) atom and the R group . The formula of a general amino acid is given below :-

(Source- Google)

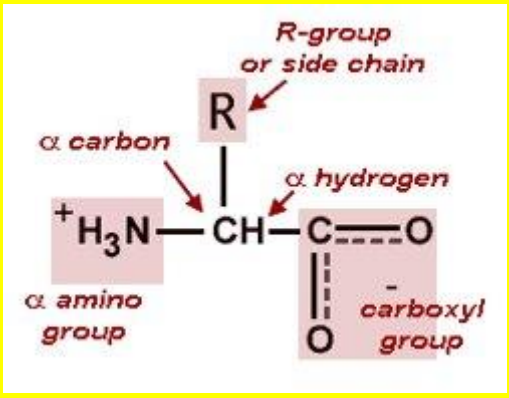

Figure- Structure of amino acid

(Source-Google)

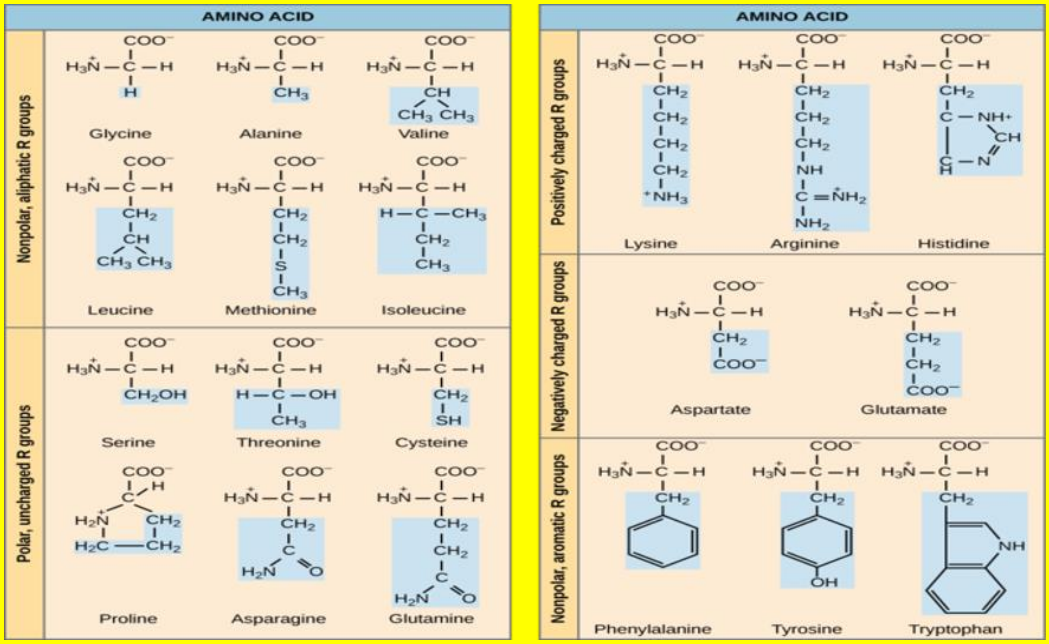

Figure- Group of amino acids (Source- Google)

PEPTIDE BOND FORMATION.

- Alpha carboxyl group of one amino acid forms a covalent bond with alpha amino group of another amino acid by the removal of a molecule of water.
- The newly formed amino acids are also called a dipeptide
- The dipeptide can then form a second peptide bond with a third amino acid to give tripeptide .
- Repetition of this process generates a polypeptide or protein of specific amino acid sequence.

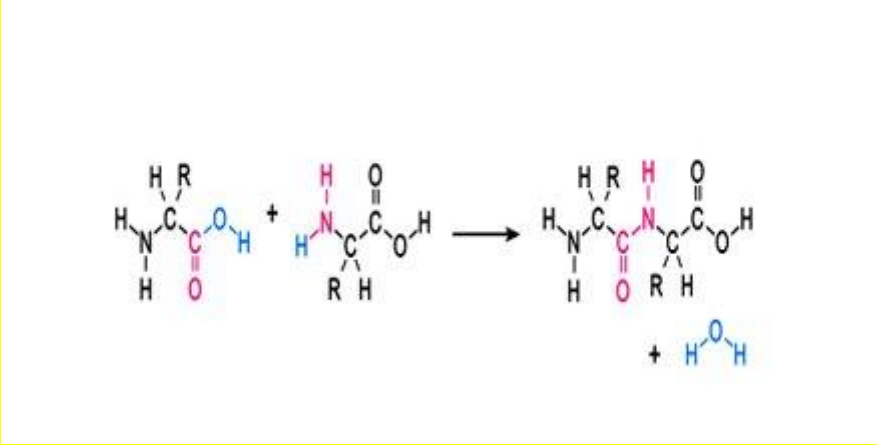

Figure-Peptide bond formation (Source-google)

THREE DIMENSIONAL STRUCTURE OF PROTEINS.

Proteins have different levels of organization.

1.Primary structure

2.Secondary structure

3.Tertiary structure

4.Quaternary structure.

PRIMARY STRUCTURE

The primary structure of proteins refers to the sequence of amino acids present in the polypeptide chain.

Amino acids are covalently linked by peptide bonds

Each component amino acid in a polypeptide is called a "residue" or "moiety".

By convention, the primary structure of a protein starts from the amino terminal(N) end and ends in the carboxyl terminal end.

The primary structure helps to predict the secondary and tertiary structures and also helps to understand the molecular mechanism of action of proteins.

(Source- Deutzmann R. 2004)

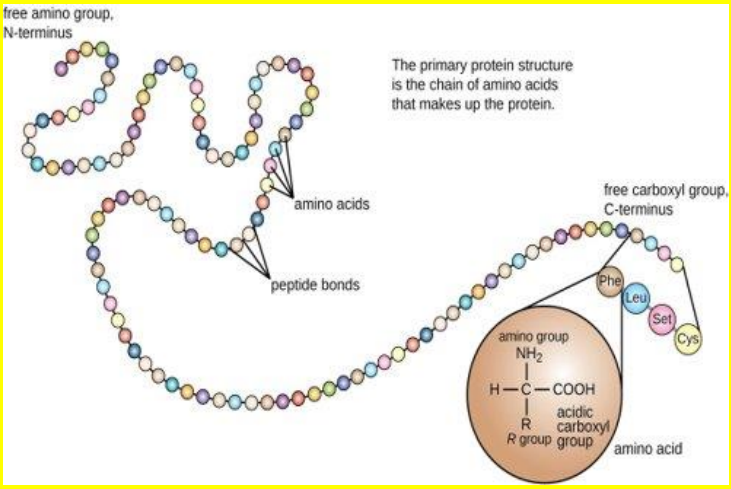

Figure- Primary structure of protein (Source- Google)

SECONDARY STRUCTURE

The Secondary structure of proteins refer to the local spatial arrangement of polypeptide chain mainly formed through hydrogen bonds between backbone atoms.

(Source-Banach et al, 2019)

It consists of :-

1. Alpha helix

2. Beta pleated sheet

3.Beta bends

4.Non repetitive structures

5.Super secondary structures.

POLYPEPTIDE CHAIN CONFORMATION

- The backbone or main chain of a protein refers to the atoms that participate in peptide bonds , ignoring the side chains of the amino acid residues.
- The only reseasonable free movements are rotations around the C_{α}–N bond (measured as phi) and the C_{α}–C bond (measured as psi).
- These angles are both defined as 180° when the polypeptide chain is in full conformation.
- The conformation of the backbone can therefore be described by the torsion angles (also called dihedral angles or rotational angles).

(Source- Sneha et al, 2016)

ALPHA HELIX.

- Spiral structure
- Tightly packed , coiled polypeptide backbone core
- Side chain extend outward
- Stabilized by hydrogen bonding between carbonyl oxygen and amide hydrogen
- Amino acids per turn – 3.6 and pitch – 5.4 Å
- Alpha helical segments are found in many globular proteins.

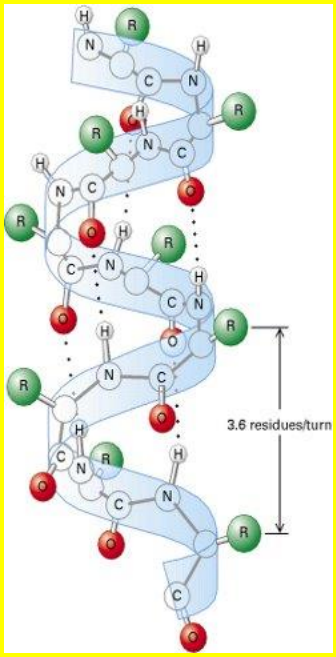

Figure- Alpha helix (Source- Google)

BETA PLEATED SHEET

- Formed when two or more polypeptides line up side by side.
- Individual polypeptide - β strand.
- Each β strand is fully extended.
- They are stabilized by hydrogen bond between N-H & carbonyl groups of adjacent chains.
- There are 2 types of β sheets
  - Parallel β sheets – polypeptide chains run in same direction.
  - Antiparallel β sheets- polypeptide chains run in opposite direction.

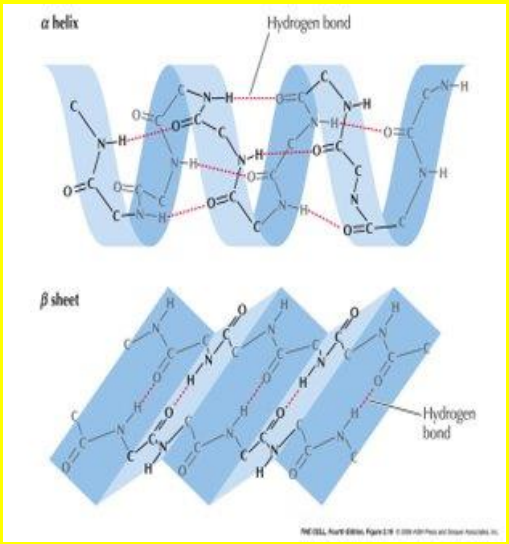

Figure- Beta pleated sheet (Source- Google)

BETA BENDS

- Permits the change of direction of the peptide chain to get a folded structure.
- It gives a protein globularity rather than linearity.
- H bond stabilizes the β bend structure.
- Proline and glycine are frequently found in the turns.
- Beta turns often promote the formation of antiparallel β sheets.
- Involve four successive amino acid residues.

(Source-Pauling et al., 1951).)

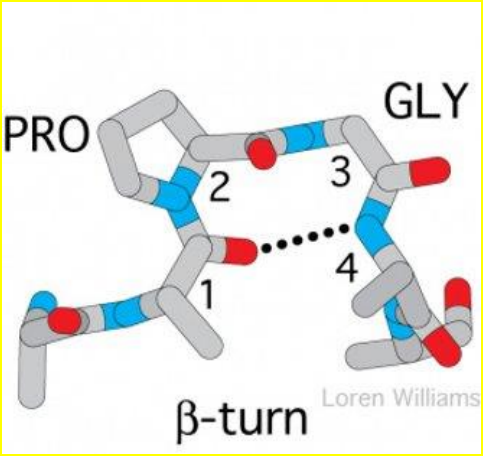

Figure- Beta turn (Source-Google)

NON – REPETITIVE STRUCTURES

In addition to α helices and β strands , a folded polypeptide chain contains two other types of secondary structures called loops and turns.

Loops and turns connect α helices and β strands.

The most common types cause a change in direction of polypeptide chain allowing it to fold back on itself to create a more compact structure.

Loops that have only 4 or 5 amino acid residues are called turns.

Reverse turns are a form of tight turn where the polypeptide chain makes a 180° change in direction.

Reverse turns are also called β turns because they usually connect adjacent β strands in a β sheet.

(Source-Richardson J S. 1981)

TERTIARY STRUCTURE

- The tertiary structure defines the specific overall 3-D shape of the protein.
- Tertiary structure is based on various types of interactions between the side chains of the peptide chain.

TYPES OF INTERACTIONS

1. Hydrogen bonds
2. Ionic bonds
3. Hydrophobic interactions
4. Covalent bonds.
5. Disulfide bridge : formed between the sulfhydryl groups of cysteine amino acids

(Source- Klose, D. P., Wallace, B. A. &Janes, R. W. 2Struc: the secondary structure server. Bioinformatics 26, 2624–2625, 10.1093/bioinformatics/btq480 (2010).

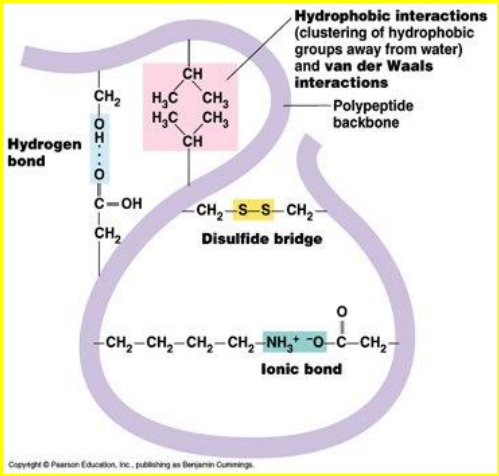

Figure- Tertiary structure (Source-Google)

DOMAINS

A domain is a basic structural unit of a protein structure distinct from those that make up the conformations. Part of protein that can fold into a stable structure independently. Different domains can impart different functions to proteins. Proteins can have one to many domains depending on protein size.

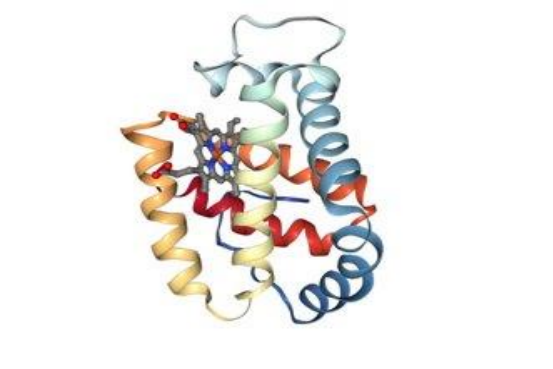

Figure- Domains (Source- Google)

QUATERNARY STRUCTURE

The quaternary structure of proteins involves the clustering of several individual peptide or protein chains into a final specific shape.

A variety of bonding interactions including hydrogen bonding,salt bridges and disulfide bonds hold the various chains into a particular geometry.

Two kinds of quaternary structure , both are multi-subunit proteins

* Homodimer : association between identical polypeptide chains.

* Heterodimer : interactions between subunits of different structures.

(Source-Skipper, 2005)

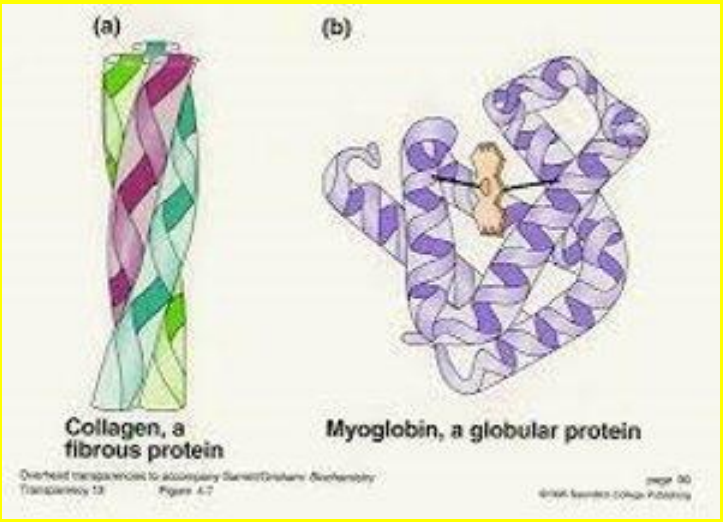

Figure- a) Collagen , b) Myoglobin (Source- Google)

GLOBULAR PROTEINS.

- Globular proteins fold up into compact, spherical shapes.
- Water soluble
- They include transport proteins such as – haemoglobin,myoglobin and those embedded in membranes.

(Source- Chang-Hui Shen, 2019)

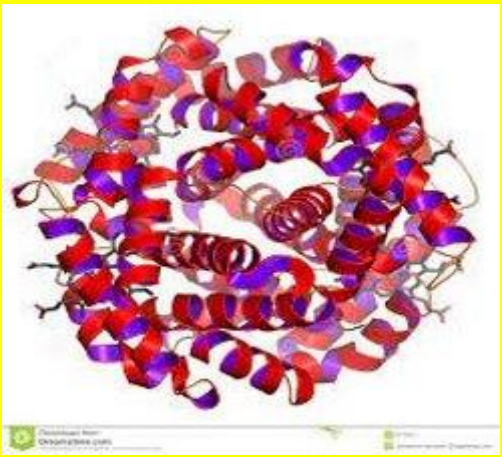

Figure- Globular proteins (Source- Google)

FIBROUS PROTEINS

- Typically water insoluble
- Rope like proteins that provide strength and framework to tissues.

- Example – Collagen.
- 3 polypeptides supercoiled like a rope
- Provides structural strength for role in connective tissue.

(Source- Viney, 2001)

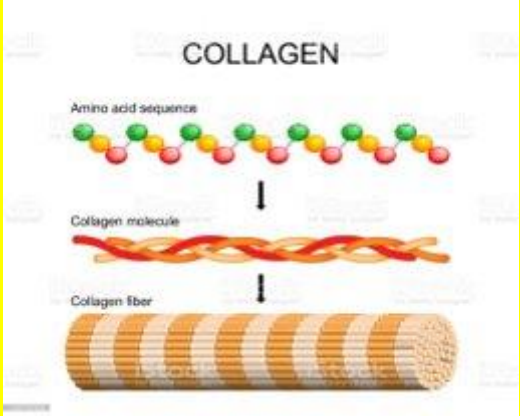

Figure: Fibrous protein (Source- Google)

CONCLUSION -

Proteins are extraordinarily complex molecules. Of all the molecules encountered in living organisms, proteins have the most diverse functions . So a basic understanding of the structure of proteins is necessary to comprehend its role in organisms . Further researches will provide more insight into the structure of several other proteins in the coming year.

ACKNOWLEDGEMENT

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BIBLIOGRAPHY

- https://byjus.com/jee/peptide-bond/
- https://biochem-vivek.tripod.com/id20.html
- https://slidetodoc.com/protein-outline-protein-definition-protein-structure-protein-function/
- https://socratic.org/questions/differences-between-alpha-helix-and-beta-pleated-sheet-structures-of-proteins
- https://www.mun.ca/biology/scarr/MGA2_03-18b.html
- https://www.umass.edu/molvis/workshop/osaka09m.htm
- https://courses.lumenlearning.com/introchem/chapter/amino-acids/
- http://www.bio.miami.edu/tom/courses/bil255/bil255goods/03_proteins.html
- https://alevelnotes.com/notes/biology/biological-molecules/biological-