तत् त्वं पूषन् अपावृणु
केन्द्रीय विद्यालय संगठन

केन्द्रीय विद्यालय संगठन

Kendriya Vidyalaya Sangathan

जैव प्रौद्योगिकी

BIOTECHNOLOGY

कक्षा/Class: XI

2024-25

विद्यार्थी सहायक सामग्री

Student Support Material

संदेश

विद्यालयी शिक्षा में शैक्षिक उत्कृष्टता प्राप्त करना केन्द्रीय विद्यालय संगठन की सर्वोच्च वरीयता है। हमारे विद्यार्थी, शिक्षक एवं शैक्षिक नेतृत्व कर्ता निरंतर उन्नति हेतु प्रयासरत रहते हैं। राष्ट्रीय शिक्षा नीति 2020 के संदर्भ में योग्यता आधारित अधिगम एवं मूल्यांकन संबन्धित उद्देश्यों को प्राप्त करना तथा सीबीएसई के दिशा निर्देशों का पालन, वर्तमान में इस प्रयास को और भी चुनौतीपूर्ण बनाता है।

केन्द्रीय विद्यालय संगठन के पांचों **आंचलिक शिक्षा एवं प्रशिक्षण संस्थान** द्वारा संकलित यह 'विद्यार्थी सहायक सामाग्री' इसी दिशा में एक आवश्यक कदम है । यह सहायक सामग्री कक्षा 9 से 12 के विद्यार्थियों के लिए सभी महत्वपूर्ण विषयों पर तैयार की गयी है । केन्द्रीय विद्यालय संगठन की 'विद्यार्थी सहायक सामग्री' अपनी गुणवत्ता एवं परीक्षा संबंधी सामाग्री-संकलन की विशेषज्ञता के लिए जानी जाती है और अन्य शिक्षण संस्थान भी इसका उपयोग परीक्षा संबंधी पठन सामग्री की तरह करते रहे हैं । शुभ-आशा एवं विश्वास है कि यह सहायक सामग्री विद्यार्थियों की सहयोगी बनकर सतत मार्गदर्शन करते हुए उन्हें सफलता के लक्ष्य तक पहुंचाएगी ।

शुभाकांक्षा सहित ।

निधि पांडे
आयुक्त, केन्द्रीय विद्यालय संगठन

STUDENT SUPPORT MATERIAL

ADVISOR

Mrs. Nidhi Pandey, IIS, Commissioner,
KVS (HQ), New Delhi

CO-ORDINATION TEAM AT KVS (HQ)

1. **Ms. Chandana Mandal, Joint Commissioner (Training)**
2. **Dr. P. Devakumar, Joint Commissioner (Academics)**
3. **Dr. Ritu Pallavi, Assistant Commissioner (Training)**

CONTRIBUTORS

1. **Mrs. Shahida Parveen, Director, ZIET MUMBAI**
2. **Mr. Lakshmi Narayanan, Principal, PM SHRI K.V Virudhunagar, CHENNAI Region**
3. **Mrs. Remya P. Iyer, PGT (Biotech.) K.V IIT, Guwahati , GUWAHATI Region**
4. **Ms. Nabaneeta Das , PGT (Biotech.) K.V IIT, Kharagpur, KOLKATA Region**
5. **Mr. Abhinav Goyal, PGT (Biotech.) PM SHRI K.V Khanapara, GUWAHATI Region**
6. **Mrs. Arpita Basu, PGT (Biotech.) PM SHRI K.V No.1 Saltlake, Kolkata KOLKATA Region**
7. **Ms. Ajanta Panda PGT (Biotech.) PM SHRI K.V No.1 Sambalpur, BHUBANESWAR Region**
8. **Mr. Anand K PGT (Biotech.) PM SHRI K.V Ganeshkhind, Pune, MUMBAI Region**

Special Acknowledgement

1. **Mrs. Sneha Nandekar,PGT(Biotech.) PM SHRI K.V No.2 Colaba, MUMBAI, Region**
2. **Mrs. Neha Gera Chawla , PGT (Biotech.) K.V INS Hamla, MUMBAI Region**
3. **Mrs. Babita Thukral, PGT (Biotech.) K.V IIT Powai, MUMBAI Region**

REVIEW TEAM

1. **Mr. T. Narayana Dhas TA Biology ZIET MUMBAI**
2. **Mr. S. N Ojha PGT (Biology) PM SHRI K.V No. 1 REWA,**

JABALPUR Region

CLASS XI
BIOTECHNOLOGY

INDEX

EXAMINATION TIPS

- Know the chapters to be covered and the weightage for each chapter.
- Know the Question paper pattern along with weightage for various types of questions (VSA, SA, Case-based, LA –Type)
- Learn the definition of various terms.
- Practice important diagrams by drawing & labelling
- Make your own notes in simple language in a way you can understand & remember.
- You can discuss / teach what you have learnt with/to the peer group. The more you share the more you remember.
- Have a time table for self-study at home More time is to be allotted for the subjects which require deep & concentrated study. Combination of tough and easy subjects in a day will keep you away from getting bored and tired.
- Write important formulae/ name of scientists & their contribution & display them in your study room in prominent places and make a habit to put a glance at them whenever possible.
- Try to study in early hour of the day as it leads to more retention of concepts.
- Fast and legible handwriting is essential for Exam. This can be mastered only when practiced throughout the year.
- Write as many dummy tests / exams as possible at home apart from the ones administered in the school
- Till the syllabus is completed, you can write and practice chapter-wise tests with a schedule of one subject in a day.
- Sample Question papers from CBSE site along with Student Support Material provided in the school will be of great help for self-administered tests/exams.
- You can practice 3-hr exam by randomly selecting previous years question papers from CBSE.
- You should know and restrict to the word-limit of VSA/SA/LA-Type questions.
- Try to write the known answer as fast as possible and save time for other answers to think, recall and write.
- Wherever required, show the steps especially while answering the questions as step-wise marking pattern is also followed by CBSE.

All the Best

- Try to write the known answer as fast as possible ane savew time for other answers to think, recall and write .

CLASS- XI (2024-25)
COURSE
STRUCTURE

One Paper **Time: 3 hrs.**
Max. Marks 70+30

Units		Marks
Unit- I	Biotechnology: An overview	5
Unit-II	Molecules of Life	20
Unit-III	Genetics and Molecular Biology	20
Unit-IV	Cells and Organisms	25
	Practical	30
	Total	**100**

CLASS XI

(Theory)

One Paper Time: 3 hrs. **Total Marks: 70**

Unit-I Biotechnology: An overview **5 Marks**

Chapter 1: Biotechnology: An Overview

Historical Perspectives, Technology and Applications of Biotechnology, Global market and Biotech Products.

Unit-II Molecules of Life **20 Marks**

Chapter 1: Biomolecules: Building Blocks

Building Blocks of Carbohydrates - Sugars and their Derivatives, Building Blocks of Proteins
- Amino Acids, Building Blocks of Lipids - Simple Fatty Acids, Glycerol and Cholesterol,Building Blocks of Nucleic Acids – Nucleotides.

Chapter 2: Macromolecules: Structure & Function

Carbohydrates - The Energy Givers, Proteins - The Performers, Enzymes - The Catalysts,Lipids and Biomembranes - The Barriers, Nucleic Acids - The Managers

Unit-III Genetics and Molecular Biology **20 Marks**

Chapter 1: Concepts of Genetics

Historical Perspective, Multiple Alleles, Linkage and Crossing Over, Genetic Mapping.

Chapter 2: Genes and Genomes: Structure and Function

Discovery of DNA as Genetic Material, DNA Replication, Fine Structure of the Genes, From Gene to Protein, Transcription – The Basic Process, Genetic Code, Translation, Mutations, Human Genetic Disorders.

Unit IV Cells and Organisms **25 Marks**

Chapter 1: The Basic Unit of Life

Cell Structure and Components, Organization of Life

Chapter 2: Cell Growth and Development

Cell Division, Cell Cycle, Cell Communication, Nutrition, Reproduction, Immune Response inAnimals.

PRACTICALS

Note: Every student is required to do the following experiments during the academicsession.

1. Preparation of buffers and pH determination
2. Sterilization techniques
3. Preparation of bacterial growth medium
4. Cell counting
5. Sugar Estimation using Di Nitro Salicylic Acid test (DNS test)
6. Assay for amylase enzyme
7. Protein estimation by biuret method

Scheme of Evaluation

Time: 3 Hours **Max. Marks 30**

The scheme of evaluation at the end of session will be as under:

Two experiments	:	20
Marks Viva on experiments	:	5
Marks Practical record	:	5 Mark

Prescribed Books:

1. **A Text Book of Biotechnology -** Class XI : Published by CBSE, New Delhi
2. **As reference- Biotechnology -** Class XI : Published by NCERT, New Delhi
3. **A Laboratory Manual of Biotechnology -** Class XI : Published by CBSE, New Delhi

BIOTECHNOLOGY

CLASS XI

UNIT-I BIOTECHNOLOGY: AN OVERVIEW

Marks- 5

Chapter 1: Biotechnology: An Overview

Contents of the chapter

A. **Historical Perspectives**

B. **Technology and Applications of Biotechnology**

C. **Global market and Biotech Products**

CHAPTER 1- BIOTECHNOLOGY: AN OVERVIEW [5 Marks]

Biotechnology can be defined as-
"Any technological application that uses biological systems, living organisms or derivatives thereof to make or modify products or processes for specific uses" (Food and Agriculture Organization).

Biotechnology has been used for centuries for preparing fermented food and beverages

Modern biotechnology is based on the fundamentals of biology and its applications to improve the quality of human life

It is also multidisciplinary in nature-

- ✓ Biophysics
- ✓ Bioinformatics
- ✓ Biochemistry
- ✓ Cell biology
- ✓ Genetics
- ✓ Molecular Biology
- ✓ Immunology
- ✓ Microbiology
- ✓ Nanobiotechnology
- ✓ Biomedical Engineering
- ✓ Tissue Engineering
- ✓ Chemical Engineering

A. Historical Perspectives

- ➢ Prehistoric - Fermentation Products like curd, bread, wine and beer
- ➢ Around 2000 BC- Egyptians crushed dates storage and production of Vinegar
- ➢ 1500 BC- Mesopotamia, Palestine and Egypt -Use of germinated cereals (Malt) to prepare beer with yeast, formation of wine from crushed grapes
- ➢ Prehistoric Europe - Preservation of food (meat) drying, smoking, curing, pickling in brine (salt water) and treatment with salt

- Mummification process in Egypt- dehydration with mixture of salts
- 18th Century- Fermentation could be classified by final products-
  - Evolution of gas
  - Formation of alcohol
  - Formation of acid
- Lavoisier provided chemical basis for the nature of alcoholic fermentation by estimation of carbon

Microorganisms as causative agents of fermentation

- Early 19th Century- Nicolas Appert- Preservation of food by putting them in air tight containers and heated in boiling water- Canning Industry
- Gay Lussac examined Appert's closed heated vessels and found that they lacked oxygen. This led to the belief that oxygen was necessary for fermentation.
- 1837- Construction of achromatic compound microscope and demonstration that fermentation is caused by microorganisms
- 1838- Charles Cagniard–Latour described the involvement of brewer's yeast in alcoholic fermentation due to –
  - it was always found in fermentation
  - fermentation stopped when yeast was killed
  - yeast grew in the process of fermentation
- 1857- Louis Pasteur published his first report on formation of lactic acid from sugar in fermentation.
- 1860- Louis Pasteur presented detailed report on alcohol fermentation
- Our ancestors have developed a variety of dishes with the help of fermenting bacteria, like *Lactobacillus, Leuconostoc, Lactococcus, Enterococcus, Pediococcus* etc.
- 20th century- discovery of antibiotics and its ever increasing demands led to technologies for large scale production in industrial sectors

Preparation of curd

Requirements:

- Milk

- Yogurt (as starter culture)

Procedure:

- Boil milk (85-90°C)- this kills all the other microbes in the milk
- Cool the milk to 40-45°C and add 2-3 tablespoons of curd (which contains the bacteria for fermentation) to the warm milk and mix.
- Cover the container with a lid or a cloth to maintain warmth.
- Place the container in a warm place (around 40-45°C) for fermentation for 4 to 8 hours. This helps the bacteria to grow.
- After the incubation period check the curd
- Refrigerate the curd to stop the fermentation process.
- You may use a portion of this curd as a starter culture for future batches.

B. Technology and applications of Biotechnology

- Living organism can be used to produce many products-
  - Some of these are naturally produced in microbes
  - Others are produced by introducing foreign genes
- Introduction of foreign genes and genetic modification of an organism could be done after-
  - Genetic mapping to determine the location of gene
  - Sequencing the genes and methods to introduce a foreign gene in an organism
- Different technologies used in Biotechnology

Technology	Characters	Products
Bioprocess Technology	• Use of living cells (commonly yeast and bacteria) for production of desired products • Use of enzymes for a biochemical reaction	• Traditional-fermented food products and beverages • Bioprocess with recombinant DNA technology-human insulin, hepatitis B vaccine,

		cheese making, biodegradable plastics, laundry detergent enzymes
Cell Culture	• Growing cells in laboratory or industry • Cell culture may be Plant cell culture or animal cell culture	• Plant cell culture products- source of flavour, aroma, colour and metabolites of therapeutic value • Animal cell culture may be used for genetically engineered cattle, therapeutics, and diagnostic products
Recombinant DNA Technology	• Joining DNA fragments from two different sources to make precise manipulations	• Creation of genetically modified organisms- GM crops and animals
Cloning	• Creation of genetically identical molecules, cells, plants or animals	• Gene cloning- drug discovery, development of transgenic crops • Animal cloning- improve livestock
Protein Engineering	• Improvement of proteins to make them more stable in structure and improve function	• Drug development, food processing, and industrial manufacturing
Biosensors	• Biology with microelectronics	• Used to measure very small

	• Biological component- enzyme/cell/antibody linked to a transducer	concentrations of a substance- nutritional value, freshness and safety of food, location and measurement of pollutants
Nanobiotechnology	• Study and manufacture of ultra small structures	• Fast diagnosis of diseases • Improving specific and timing of drug delivery system

➢ Applications of biotechnology

Health Industry	• Protein pharmaceuticals • Vaccines • Therapeutics • Diagnostics
Agriculture Industry	• Biopesticides/ Biofertilizers • Crops tolerant to Biotic and Abiotic stress • Pharmaceutical production
Chemical Industry	• Fermentation for organic chemicals • Production of high purity chemicals • Use of energy efficient processes
Cleaning Industry	• Use of enzymes like proteases in detergents
Textile Industry	• Use of enzymes for finishing of fabrics • Use of genetically modified cotton
Pulp and Paper Industry	• Improvement of physical properties of fibre • Bio bleaching of pulp

C. Global market and Biotech Products

Market for biotechnology products and services has increased substantially.

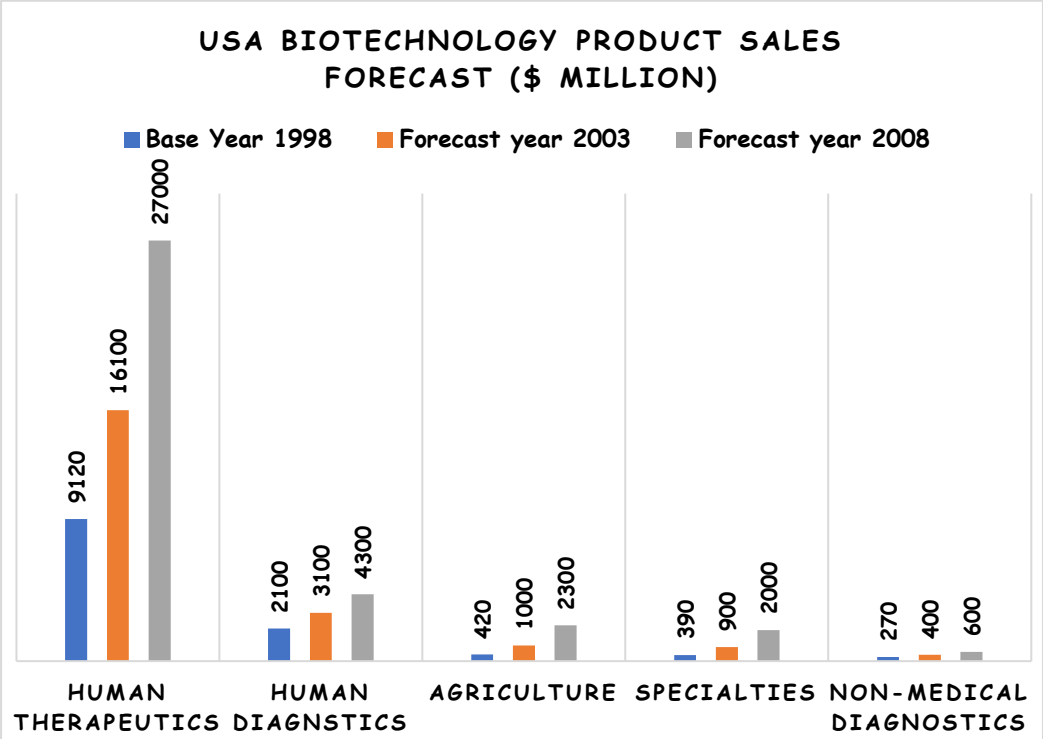


Table- Cell cultures and their products

Cell type	Cells	Products
Mammalian cells	Hybridoma, Myeloma	Monoclonal Antibodies, Recombinant Antibodies
	Chinese Hamster Ovary, Baby Hamster Kidney cell lines	Interferon, tissue plasminogen Activator (tPA) , erythropoientin (EPO)
	Human Kidney 293 cell lines	Adenovirus for gene therapy
	Human lung fibroblast MRC-5	Attenuated hepatitis C virus
	Monkey Kidney epithelial cell Vero	Inactivated polio virus
Bacteria	*Escherichia coli*	Insulin, human growth Hormone, somatostatin, interferon, Bovine growth hormone

Yeast	*Saccharomyces cerevisiae*	Hepatitis B virus surface antigen (vaccine against Hepatitis B)

Agronomic Traits introduced in crop plants-

- Herbicide tolerance
- Insect resistance
- Disease resistance
- Abiotic stress resistance (water, temperature, salts, metal)
- Value added traits (oil, vitamins and minerals)
- Nutritional quality
- Properties like shelf life, flavours, etc.
- Allergen reduction
- Nitrogen fixation
- Yield
- Pharmaceutical production

****

Multiple Choice Questions

1. What are the different products of fermentation?
   a. Acid
   b. Alcohol
   c. Gases
   d. All of the above
2. Which of the following bacteria is not used for fermentation?
   a. Lactobacillus
   b. Leuconostoc
   c. Escherichia
   d. Enterococcus
3. Which of the following is the correct sequence of steps for setting curd?
   a. Cold milk + curd → incubation → curd formation
   b. Warm milk + curd → incubation → curd formation
   c. Warm milk + curd → refrigeration → curd formation
   d. Cold milk+ curd → refrigeration → curd formation
4. Why warm milk is used for curd preparation?
   a. Warm milk helps the growth of bacteria
   b. Hot milk may kill bacteria
   c. Very cold milk may render bacteria inactive

d. All the reasons given above are true

5. Microbial fermentation is an example of
   - **a. Bioprocess technology**
   - b. Cell culture
   - c. Recombinant DNA technology
   - d. All of the above

6. Bioprocess technology is the use of-
   - a. Unicellular microorganisms
   - b. Enzymes
   - c. Yeast
   - **d. All of the above**

7. Which of the following are products of bioprocess technology?
   - a. Bread, pickle
   - b. Wine, beer
   - c. Human insulin, hepatitis B vaccine
   - **d. All of the above**

8. What is cell culture technology?
   - **a. Growing cells outside living organisms**
   - b. Growing unicellular microbes in a medium
   - c. Creating genetically modified microbes
   - d. Creating genetically identical sheep

9. What is cloning?
   - a. Generating identical molecules
   - b. Generating identical cells
   - c. Generating identical plants and animals.
   - **d. All of the above**

10. SNCT involves
    - a. Transfer of somatic nucleus to an enucleated zygote
    - b. Transfer of sperm nucleus to an enucleated zygote
    - **c. Transfer of somatic nucleus to an enucleated ovum**
    - d. Transfer of sperm nucleus to an enucleated ovum

a. h

12. RDT involves
    - a. Manipulation of DNA
    - b. Recombining DNA from different sources
    - c. Modification of plants and animals
    - **d. All of the above**

13. What is protein engineering?
    - a. Improvement of proteins
    - b. Changing proteins
    - **c. Modification of proteins using RDT**
    - d. None of the above

14. Which of the following mammalian cells are used to produce inactivated polio virus?
    a. Chinese hamster ovary cells
    b. Baby hamster kidney cells
    c. Human lung fibroblasts
    d. Monkey kidney epithelial cell
15. What can be done to improve crop yields?
    a. Disease resistance
    b. Pest resistance
    c. Abiotic stress resistance
    d. All of the above

Assertion and Reason type questions

Answer these questions selecting the appropriate option given below:

a. Both Assertion and Reason are true and the reason is the correct explanation of the assertion

b. Both Assertion and Reason are true but the reason is not the correct explanation of the assertion

c. Assertion is true but Reason is false

d. Both Assertion and Reason are false

1. technos are used to clean our environment

1. Assertion: Bioremediation technologies are used to clean our environment

   Reason: Bioremediation removes toxic substances from contaminated soils and groundwater.

   Answer: A

2. Assertion: Cloning technology generates a population of genetically identical molecules, cells and organisms.

   Reason: Cloning is used for drug discovery, transgenic crops and livestock improvement.

   Answer: A

3. Assertion: Recombinant DNA technology is used to make precise manipulations at gene level.

   Reason: Recombination of genes is a process for making clones of animals.

Answer: C

4. Assertion: Biotechnology has wide applications in crop improvement.

   Reason: Genetically modified crops may have properties of stress tolerance, improved nutritional value and other beneficial properties.

   Answer: A

2 Mark Questions

1. Define biotechnology. Why is modern biotechnology considered multidisciplinary in nature?
   Biotechnology can be defined as-
   "Any technological application that uses biological systems, living organisms or derivatives thereof to make or modify products or processes for specific uses" (Food and Agriculture Organization).

   Modern biotechnology considered multidisciplinary in nature as it is dependent on various disciplines of sciences for the achievement of the goal of making specific products for betterment of human life.

2. Mention any two applications of biotechnology in crop improvement.
   Gene cloning- drug discovery, development of transgenic crops
   Animal cloning- improve livestock
3. Outline the steps involved in SCNT.
   - Enucleation of Ovum (Removing nucleus) and transfer the nucleus of a somatic cell to the enucleated ovum
   - The resulting cell behaves like a zygote and develops as the clone of the donor of the somatic cell
4. How are engineered proteins different from existing proteins? Mention the applications of engineered proteins.
   Engineered proteins do not exist in nature and are improvement of the existing proteins.
   Applications- drug development, food processing, industrial manufacturing
5. Name any four traditional fermented foods of India.
   Dahi, Srikhand, Jalebi, Bhatura, etc

3 Mark Questions

1. What is cloning? How is molecular cloning different from animal cloning? Mention any two applications of molecular cloning.
   Cloning technology allows us to generate a population of genetically identical molecules, cells, plants or animals. Molecular or gene cloning is the process of creating genetically identical DNA molecules. Animal cloning is done to create copies of animals.
   Two applications of molecular cloning-
   a. Drug discovery
   b. Development and production of transgenic crops

2. What is cell culture technology? Mention one application of plant and animal cell culture each.
   Cell culture technology is the growing of cells outside of living organisms.
   Plant cell culture is an important source of compounds used as flavours, colours, and aromas by the food-processing industry.
   Animal cell culture - Livestock breeding

3. Name any two unicellular organisms that are most commonly used in bioprocess technology. Name any two products produced in each of these organisms.

   Yeast (*Saccharomyces cerevisiae)* and bacteria (*Escherichia coli).*

   Products produced in *Escherichia coli*- Insulin, human growth Hormone, somatostatin, interferon, Bovine growth hormone.

   Products produced in *Saccharomyces cerevisiae* - Hepatitis B virus surface antigen (vaccine against Hepatitis B)
4. What are biosensors? How do biosensors function? Mention any two applications of biosensors.
   Biosensor technology couples the knowledge of biology with microelectronics. A biosensor is composed of a biological component, such as a cell, enzyme or antibody, linked to a tiny transducer—a device powered by one system that then supplies power (usually in another form) to a second system.

Biosensors are detecting devices that rely on the specificity of cells and molecules to identify and measure substances at extremely low concentrations. When the substance of interest binds with the biological component, the transducer produces an electrical or optical signal proportional to the concentration of the substance.

Biosensors can be used for:
measurement of nutritional value,
freshness and safety of food
location and measurement of environmental pollutants

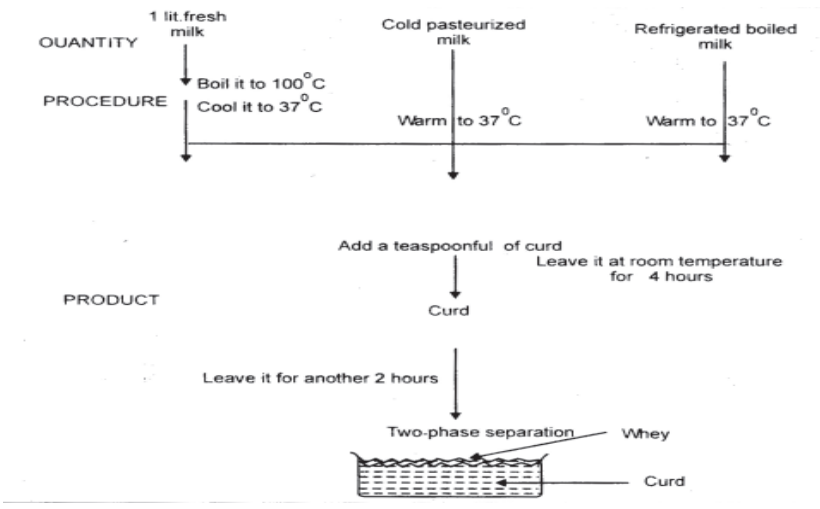
5. What is nanobiotechnology? Mention any two applications of this technology.

Nanotechnology is the study, which involves manipulation and manufacture of ultra-small structures and machines made of as few as one molecule. Nanobiotechnology uses the knowledge of nanotechnology and biomolecules of cell to produce desired technology.

Some applications of nanobiotechnology includes; fast diagnosis of disease, bio-nanostructures creation for getting functional molecules into cells, improvement of specificity and timing of drug delivery.

5 Mark Questions

Study the flow diagram of curd production in industry. Study the diagram and answer the following questions:



a) Why is the milk boiled or pasteurized before using it for curd preparation?
Boiling the milk or pasteurization of milk kill all the microbes in the milk

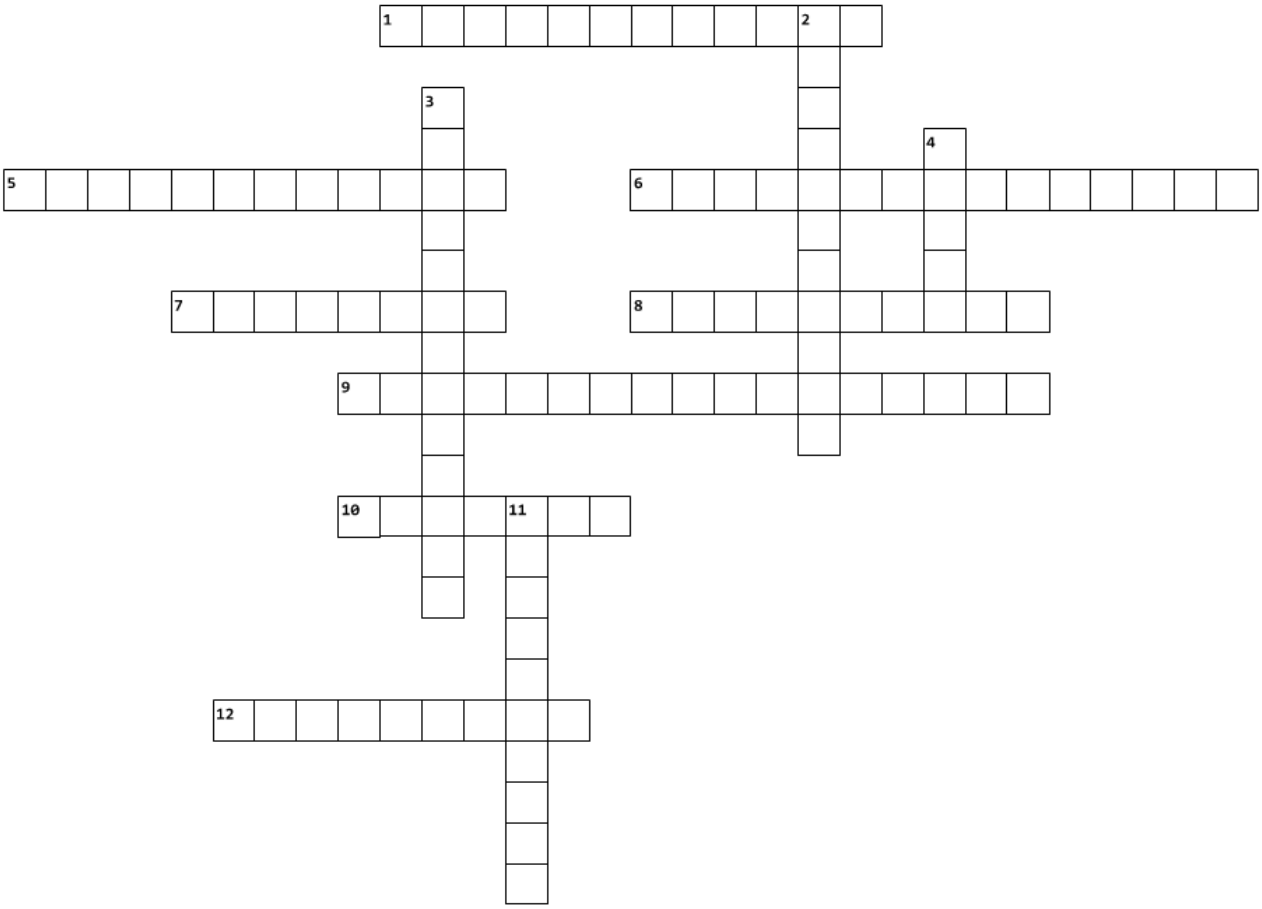
b) Why is curd added to milk for preparing curd?
Curd contains the bacteria (*Lactobacillus*) which turns milk into curd

c) Why is it important to warm the milk before adding curd
Curd bacteria need warm temperatures to grow.

d) Why is the milk left at room temperature after the curd is mixed in it?
Curd bacteria can grow at room temperature

e) If after mixing curd in the milk we keep the mixture in the refrigerator what will be the result after 4 hours?
Curd will not be formed as the growth of the bacteria is very slow at low temperatures.

CROSSWORD



Across

1. Study of chemical processes in living systems

5. Process that produces alcohol, acid and gas

6. Drug or medicine used in medical treatment

7. Science of heredity and variations in organisms

8. Characteristics or indicative of a disease

9. Coupling of nanotechnology and biomolecules

10. Process of creating copies of molecules or organisms

12. Microelectronics coupled with biology

Down

2. Joining of DNA fragments from two different sources is _____ DNA technology

3. Use of living systems to make or modify products and processes

4. Unicellular eukaryotic cells that is commonly used in bioprocess

11. Study of defense mechanism of human body

UNIT-II MOLECULES OF LIFE

Marks- 20

Chapter 1: Biomolecules: Building Blocks

Contents of the chapter

- Building Blocks of Carbohydrates - Sugars and Their Derivatives
- Building Blocks of Proteins - Amino Acids
- Building Blocks of Lipids - Simple Fatty Acids, Sphingosine, Glycerol and Cholesterol
- Building Blocks of Nucleic Acids - Nucleotides

Chapter 2: Macromolecules: Structure and Function

Contents of the chapter

- Carbohydrates - The Energy Givers
- Proteins - The Performers
- Enzymes - The Catalysts
- Lipids and Biomembranes - The Barriers
- Nucleic Acids - The Managers

UNIT-2: MOLECULES OF LIFE

CHAPTER 1: BIOMOLECULES: BUILDING BLOCKS

GIST OF THE CHAPTER:

Building Blocks of Carbohydrates:

Hydrates of carbon are carbohydrates which can be represented as $(CH_2O)_n$.

Monosaccharides:

These are monomers of complex carbohydrates and are aldehyde or ketone derivatives of straight chain polyhydroxy alcohols containing 3-7 carbon atoms. All naturally occurring monosaccharides are dextrorotatory and hence are represented by 'D' prefix.

To be classified as monosaccharide, it must contain the following:

i) A ketone or an aldehyde functional group
ii) Polyhydroxy alcohols
iii) 3 to 7 Carbon atoms.

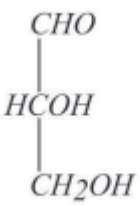
Monosaccharides are named on the basis of the carbonyl carbon atom and the total number of carbon atoms present in them.

Example:

i) Aldehyde containing are aldoses and ketone containing are ketoses.
ii) Aldohexose: aldehyde containing 6 carbon atoms
iii) Ketopentose: Ketone containing 5 carbon atoms

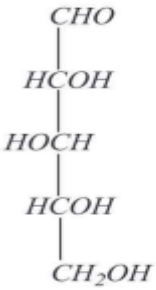
Fischer Projections of Aldoses (Straight Chain Structures) :

i) Aldotriose (D-Glyceraldehyde)



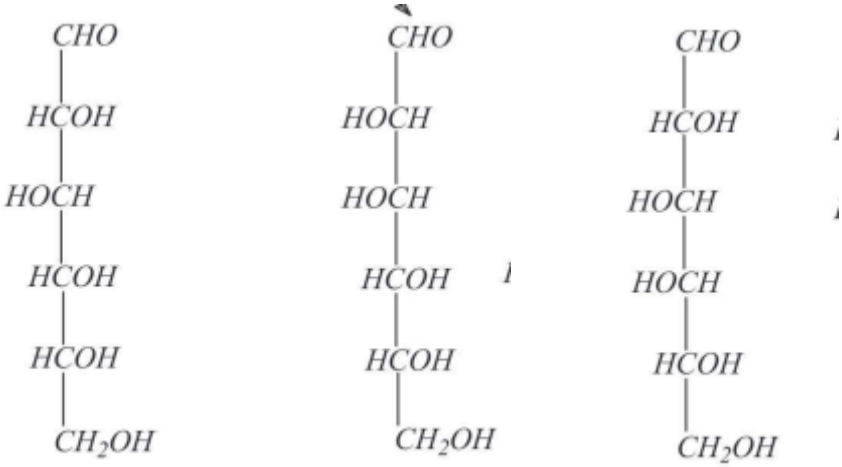
D-Glyceraldehyde

ii) Aldopentose (D Ribose)



D-Ribose (Rib)

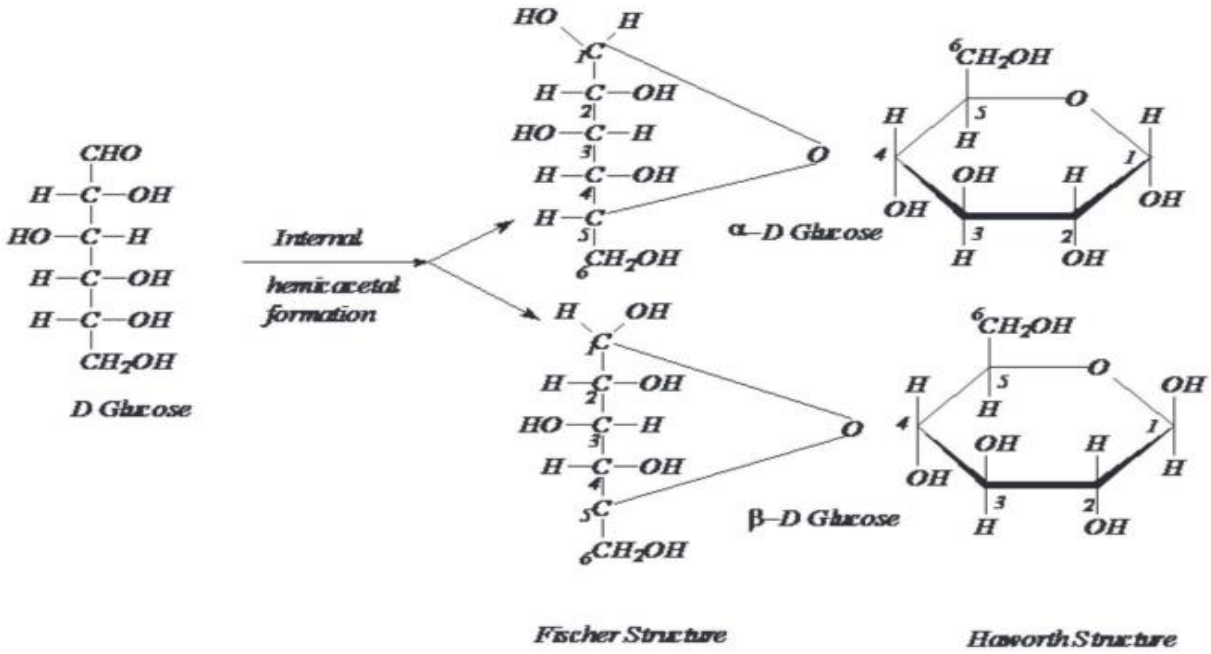
iii) Aldohexoses (D Glucose, D Mannose, D Galactose)



D-Glucose D-Mannose D-Galactose

Fischer to Haworth Projection:

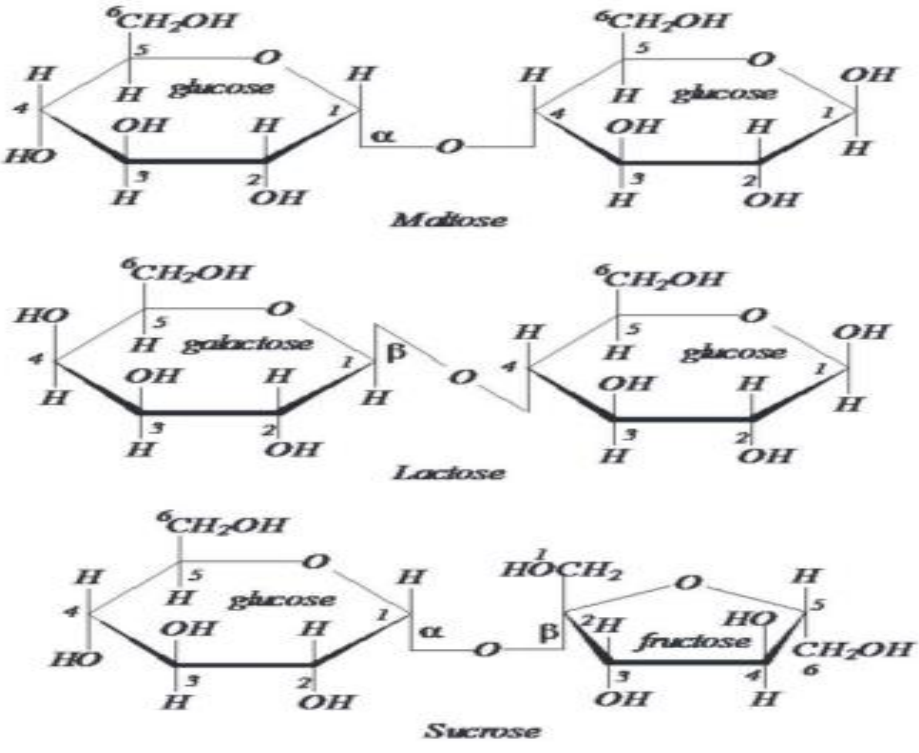
- The simple sugars have two major functional groups – hydroxyl and carbonyl groups. One internal OH group can react with the carbonyl group which can react to form hemiacetals or hemiketals leading to form a ring structure.
- 5 membered ring structures are called 'furanoses' and six membered ring structures are called pyranoses.
- The carbonyl carbon atom (C 1 in aldoses and C 2 in ketoses) is called the anomeric Carbon atom because on formation of a ring structure, the carbon atom becomes asymmetric leading to the formation of two configurations or anomeric forms called alpha anomers and beta anomers.



Glycosidic Bond: The bond that links two monosaccharides and is formed between OH group of the anomeric carbon atom of one monosaccharide and OH group of C4 / C6 of another monosaccharide.

- Disaccharide: Two monosaccharides
- Oligosaccharides: 3-20 residues
- Polysaccharides: more than 50 residues

Examples of disaccharides:



Properties of Sugars:

Reducing Sugars: Sugars bearing atleast one free anomeric carbon atom that has not formed any glycosidic bond and can reduce mild oxidizing agents. Example: Maltose and Sucrose.

Test for Reducing Sugars:

Benedict's Test: CuSO4 in Benedict's solution reacts with free anomeric carbon atom of reducing sugar to form a yellow to red precipitate of Cuprous Oxide.

$CuSO_4$ -> Cu^{2+} + $SO4^{2-}$

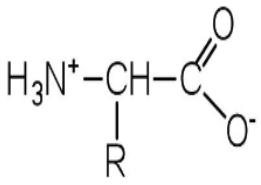
Cu^{2+} (ox) + Reducing Sugar -> Cu^{+} (Red)

4 Cu^{+} + O_2 -> 2Cu_2O (Red ppt)

These tests are routinely conducted in pathological laboratories to ascertain the presence of sugar in blood / urine).

Amino Acids: Building blocks of proteins.

- There are 20 naturally occurring amino acids which are levorotatory in nature. (except in bacterial cell walls)
- All the amino acids have a common structure containing a Chiral Carbon atom (Cα), α amino group, α carboxylate group and a unique side chain that determines whether the amino acid hydrophobic, polar uncharged or polar charged.
- Only Glycine doesn't have a chiral carbon atom and proline doesn't have α amino group instead it has an α imino group.
- At pH 7.4, at aqueous solutions, amino acids are present in the zwitter ionic form.



Peptide Bond: The peptide bond that forms between carboxylic group of previous amino acid and amino group of next amino group by condensation reaction involving removal of one water molecule.

- Dipeptide: two amino acids

- Tripeptide: three amino acids

Test for amino acids:

- Amino acids have many reactive groups like the α amino group, the carboxylic groups, phenolic groups, sulphydryl groups, alcoholic groups etc which can be used for different reactions.
- **Ninhydrin Test (Triketohydrindantin hydrate)**: Ninhydrin is a very powerful oxidising agent & in its presence amino acids undergo oxidative deamination liberating ammonia, carbon dioxide, a corresponding aldehyde and reduced form of ninhydrin. The ammonia formed from alpha amino group reacts with ninhydrin and its reduced product (hydrindantin) to give a blue complex called Ruhemann's purple (diketohydrin).
- **Proline is an exception as it forms yellow complex.**

Derivatives of Amino Acids:

Amino Acid	**Derivative**	**Function**
Glutamic Acid	GABA (Gamma amino Butyric Acid)	Neurotransmitter
Tryptophan	Serotonin	Neurotransmitter
Tyrosine	Thyroxine & Adrenaline	Hormones
Tryptophan	Auxin (Indole acetic acid)	Plant Hormone
Histidine	Histamine	Allergic reactions

Vitamins & Coenzymes:

Some enzymes require small organic molecules known as coenzymes for facilitating their activity. These molecules are derived from vitamin precursors, particularly belonging to B Complex.

Vitamin	Co-enzyme form	Enzyme catalysed reaction
1. Thiamine	Thiamine pyrophosphate	Decarboxylase reactions
2. Niacin	Nicotinamide adenine dinucleotide (NAD+) Nicotinamide adenine dinucleotide phosphate (NADP+)	Dehydrogenase reactions
3. Riboflavin	Flavin adenine dinucleotide (FAD)	Oxidase reactions
4. Pantothenic acid	Co-enzyme A	Acyl transfer reactions
5. Pyridoxamine (B6)	Pyridoxal phosphate	Transaminase reactions
6. Cobalamin (B12)	5'-Deoxyadenosylcobalamine	Molecular rearrangement reactions
7. Biotin	Biotin-lysine complexes (biocytin)	Carboxylase reactions
8. Lipoic acid	Lipoyl-lysine complexes (lipoamide)	Acyl transfer reactions
9. Folic acid	Tetrahydrofolate reactions	One carbon transfer

Lipids:

- Lipids are important constituents of biological membranes which are generally sparingly soluble in water but are readily soluble in organic solvents such as chloroform therefore can be easily separated from the water-soluble biomolecules.
- Lipids are classified as fatty acids, phospholipids, steroids etc.
- Steroids are special group of lipids derived from cholesterol, the most abundant steroid in animals.
- Unsaturated Fatty acids can be tested through bromine water test.
- Acrolein test is used to detect triglycerides and phospholipids.
- Phospholipids are important constituent of membrane which act as a barrier as well as contain receptors of cell-to-cell communication.

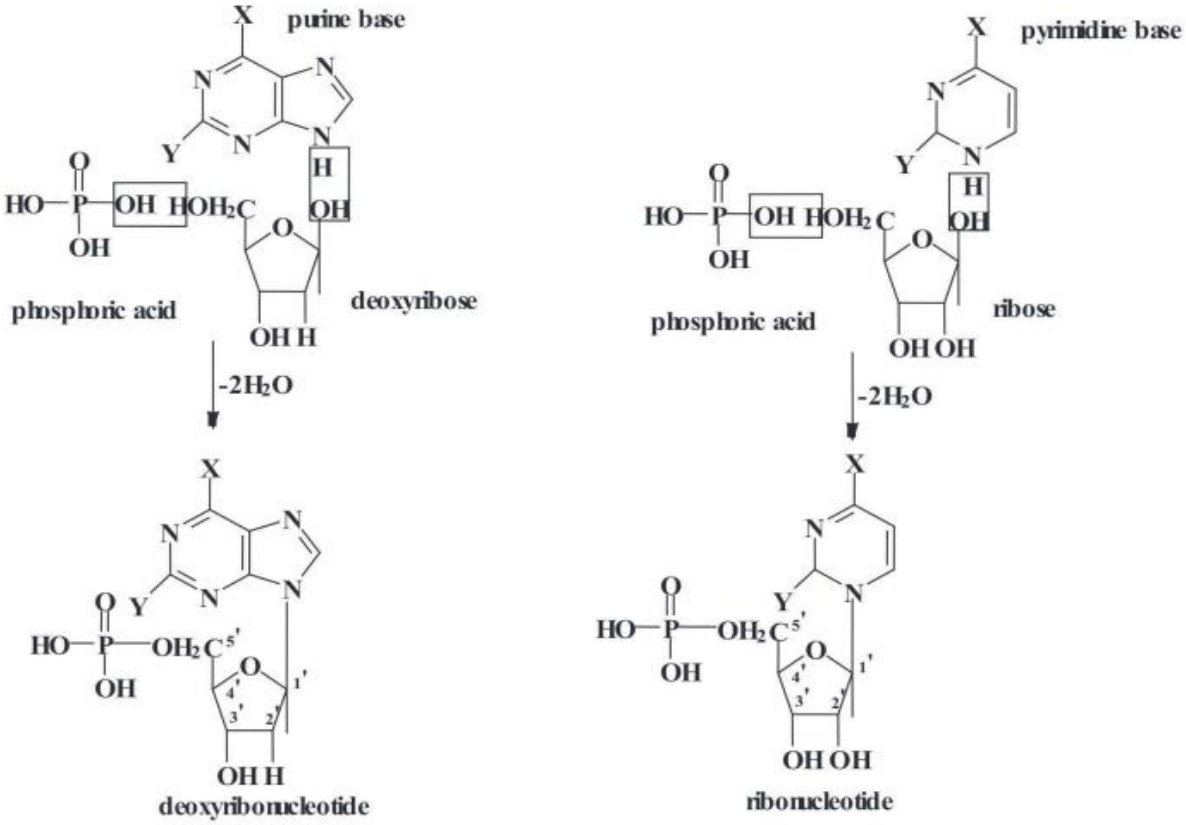
Nucleotides: Building blocks of Nucleic acids

A nucleotide has three components:

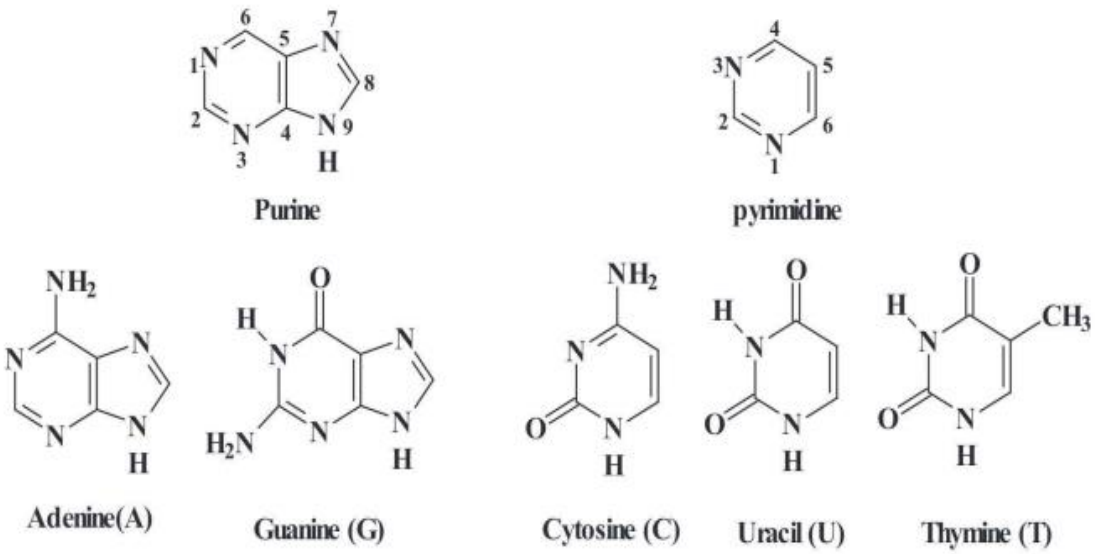
i) A pentose sugar which is deoxyribose in DNA and ribose in RNA.

ii) An inorganic phosphate residue

iii) A nitrogenous base (purine / pyrimidine): These have heterocyclic ring structure made up of carbon and nitrogen atoms.



Types of Nitrogenous Bases:

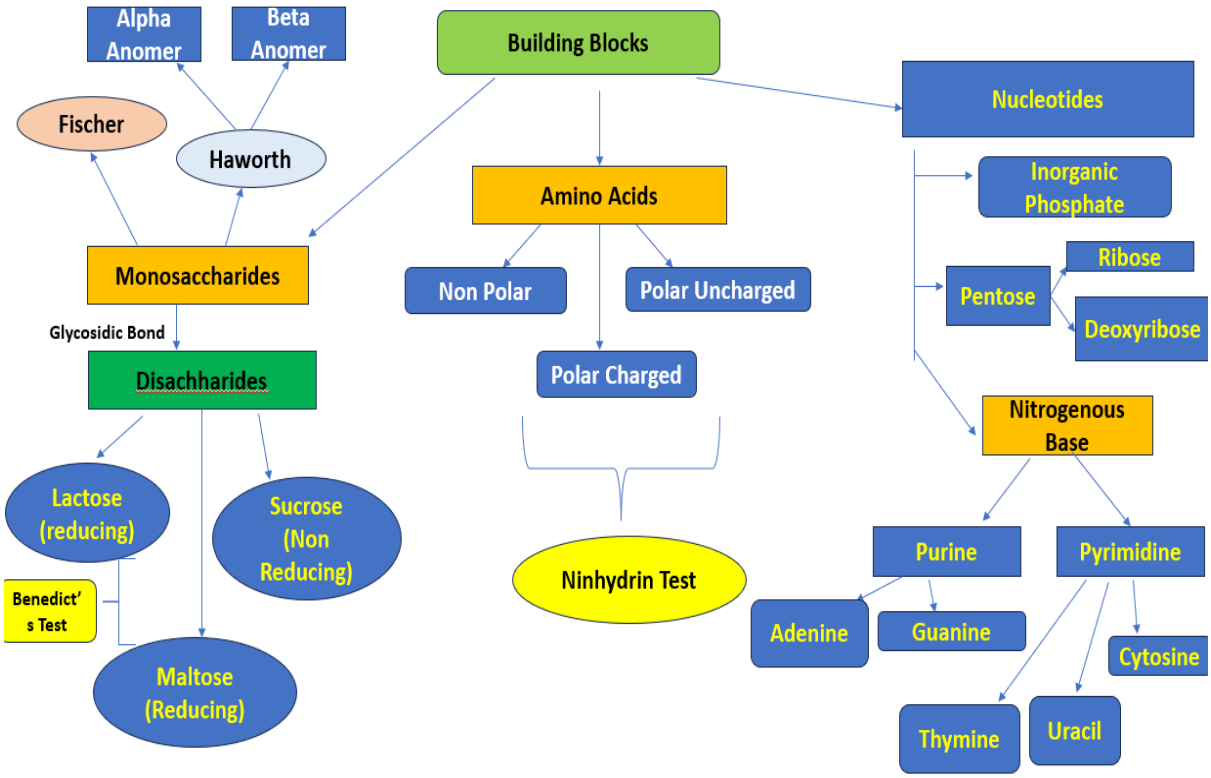


Test for nucleotides:

Orcinol Test: It can be performed for both deoxyribose and ribose sugars. A pentose reacts in the presence of a strong acid to yield furfural. Orcinol in the presence of catalyst ferric chloride reacts with furfural to produce green coloured compound.

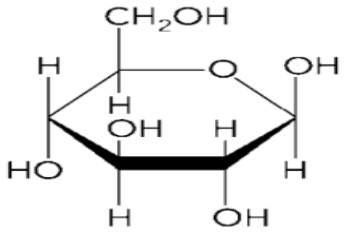
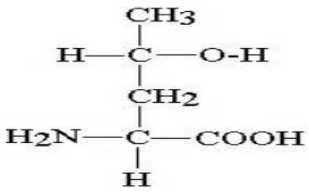
Diphenylamine Test: Performed for deoxyribonucleotides.

CONCEPT MAP



MULTIPLE CHOICE QUESTIONS:

1	_____ is an example of ketohexose? a) D-Glucose b) D-Glyceraldehyde c) D-Fructose d) D-Mannose
2	Which of these is not an absolute characteristic of any monosaccharide? a) Presence of aldehyde or ketone functional group

	b) Polyhydoxy groups c) Presence of 3 to 7 carbon atoms d) Formation of Haworth Projection (ring structure)
3	The anomeric carbon atom of D Galactose is: a) C 1 b) C 2 c) C 3 d) C 4
4	Identify the monosaccharide depicted here:  a) Alpha D Galactose b) Beta D Galactose c) Alpha D Glucose d) Beta D Glucose
5	Which of the following generally forms a furan ring? a) D-Glucose b) D-Glyceraldehyde c) D-Fructose d) D-Mannose
6	Identify the amino acid and its category:  a) Serine, Polar Uncharged b) Threonine, Polar Uncharged c) Methionine, Hydrophobic d) Leucine, Hydrophobic
7	The amino acid that gives yellow colour in Ninhydrin Test is: a) Lysine

<table>
<tr><td></td><td>b) Tryptophan
c) Proline
d) Asparagine</td></tr>
<tr><td>8</td><td>Identify A & B in the given table:
<table>
<tr><th>Amino Acid</th><th>Derivative</th><th>Function</th></tr>
<tr><td>Tryptophan</td><td>A</td><td>B</td></tr>
</table>
a) A: Serotonin; B: Neurotransmitter
b) A: GABA; B: Neurotransmitter
c) A: Thyroxine; B: Hormone
d) A: Histamine; B: Allergic Reactions</td></tr>
<tr><td>9</td><td>Which of these enzyme catalysed reactions are carried out by vitamin Pantothenic acid?
a) Transaminase Reactions
b) Acyl transfer reactions
c) Molecular rearrangement reactions
d) Decarboxylase reactions</td></tr>
<tr><td>10</td><td>Which of these chemicals is used in Acrolein test?
a) Ninhydrin
b) Bromine
c) Potassium Hydrogen Sulphate
d) Ferric chloride</td></tr>
<tr><td>11</td><td>The bond present between the pyrimidine nitrogenous base and ribose sugar of a nucleotide is:
a) Peptide bond
b) Phosphodiester bond
c) N1-C1’ glycosidic bond
d) N9-C1’ glycosidic bond</td></tr>
<tr><td>12</td><td>The disaccharide Lactose id made up of which of these:
a) α D Glucose + β D Glucose
b) β D Galactose + β D Glucose
c) α D Glucose + β D Fructose
d) α D Galactose + β D Glucose</td></tr>
<tr><td>13</td><td>In the pathological laboratories, which of these tests is conducted to detect the blood/urine sugar levels?
a) Orcinol Test
b) Acrolein Test</td></tr>
</table>

	c) Benedict's Test d) Bromine water Test
14	In the formation of hemiacetal ring structure of D Glucose, functional groups of which of the following carbons would react? a) C1 and C4 b) C2 and C5 c) C1 and C5 d) C2 and C4
15	Which of these reactive groups of amino acids is involved in the Ninhydrin test? a) Carboxylic group b) Phenolic group c) Sulfhydryl group d) Alpha amino group
16	Which of these is an un saturated fatty acid? a) Oleic acid b) Palmitic acid c) Stearic acid d) All of the above
17	Acrolein test can be performed to detect which of these? a) Fatty acids b) Triglycerides c) Phospholipids d) Both b & c
18	Identify the nitrogenous base which has amino function group at C6: a) Adenine b) Guanine c) Thymine d) Uracil
19	Which if these nitrogenous bases is not present in DNA? a) Adenine b) Guanine c) Thymine d) Uracil
20	If you are using diphenyl amine, you are detecting the

	presence of which of these? a) Saturated Fatty Acid b) Reducing Sugar c) Deoxyribonucleotides d) Ribonucleotides
21	Upon demethylation, the structure of Thymine would resemble: a) Adenine b) Guanine c) Cytosine d) Uracil
22	Which of these elements is not present in a nucleotide? a) C b) H c) P d) S
23	The structure of Glucose and Galactose differ at which carbon atom? a) C1 b) C3 c) C4 d) C5
24	Which of these is not an aromatic amino acid? a) Tyrosine b) Serine c) Phenylamine d) Tryptophan
25	Which of these is a non-reducing sugar? a) Lactose b) Maltose c) Sucrose d) Both a and b
26	Amino acids naturally occur in _____ configuration about their Cα position a) D b) L c) Both D and L

	d) Either D or L
27	_____ is an amino alcohol a) Sphingosine b) Stearic Acid c) Palmitic Acid d) Cholesterol
28	Which functional groups of monosaccharides are involved in formation of ring structures? a) Acid b) Hydroxy c) Carbonyl d) Both b & c
29	The non polar amino acid containing a 'S' atom is a) Cysteine b) Methionine c) Proline d) Serine
30	Which of these is a component of a nucleotide? a) Ribose Sugar b) Inorganic Phosphate c) Nitrogenous Base d) All of these

Answers:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C	D	a	d	C	b	c	A	b	c	D	b	c	c	d
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
A	D	a	D	C	d	d	C	b	c	B	a	d	b	d

Assertion-Reason Based Questions

The following questions are A-R based questions consist of two statements– Assertion (A) and Reason (R). Answer these questions selecting the appropriate option given below:

A. Both Assertion and Reason are true and the reason is the correct explanation of the assertion

B. Both Assertion and Reason are true but the reason is not the correct explanation of the assertion

C. Assertion is true but Reason is false

D. Both Assertion and Reason are false

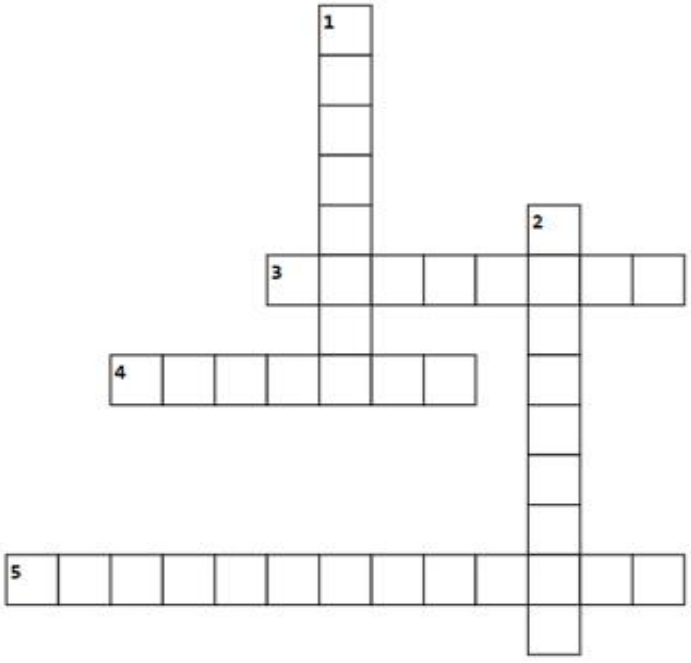
1. Assertion: The bond between two monosaccharides is formed due to dehydration. Reason: The bond is formed between OH group of anomeric 'C' of one monosaccharide and OH of another monosaccharide.
2. Assertion: Sugars with free anomeric carbon are called reducing sugars. Reason: These can reduce alkaline solutions of copper salts.
3. Assertion: Proline gives a purple product in Ninhydrin test. Reason: Proline has alpha amino group that reacts with Ninhydrin.
4. Assertion: Nitrogenous bases are heterocyclic. Reason: All Nitrogenous bases are made up of two rings.
5. Assertion: The carbon atom carrying carbonyl group is called anomeric carbon in ring structure. Reason: The carbon atom becomes asymmetric upon forming ring structure.
6. Assertion: Glucose is classified as an aldose. Reason: Glucose has an aldehydic functional group and is a hexose.
7. Assertion: Cholesterol is the most abundant steroid in animals. Reason: Steroids are a special group of lipids derived from cholesterol.
8. Assertion: DNA is the hereditary material of a cell. Reason: DNA is made up of deoxyribonucleotides.

9. Assertion: Sucrose is a non-reducing sugar Reason: Sucrose is made up of glucose and fructose
10. Assertion: There are many forms of biomolecules in a cell Reason: These biomolecules work in isolation.

Answers:

1	2	3	4	5	6	7	8	9	10
A	a	D	c	a	a	B	A	b	d

CROSS WORDS



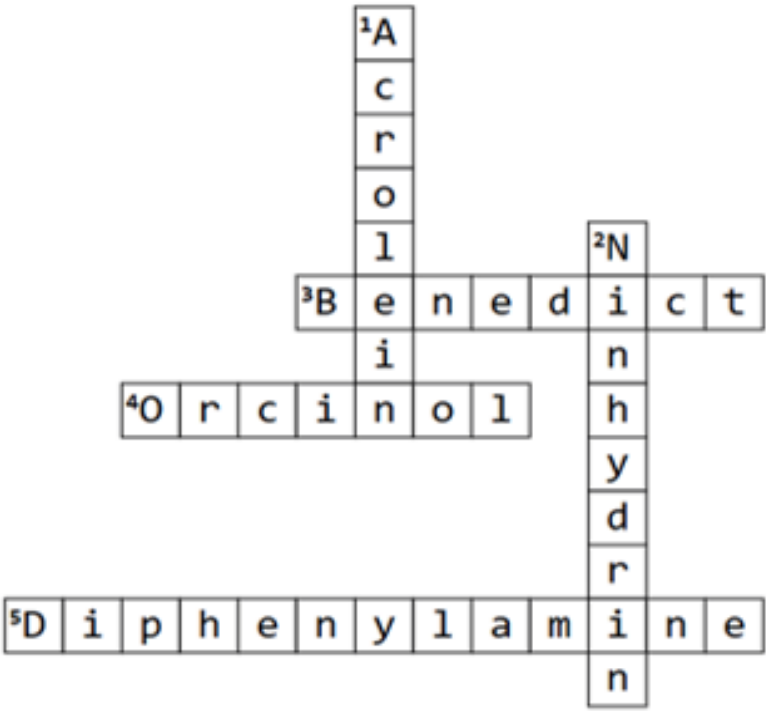
Across

3. Reducing Sugar
4. Pentose Sugar
5. Deoxyribose

Down

1. Triglycerides + Phospholipids
2. Amino Acids

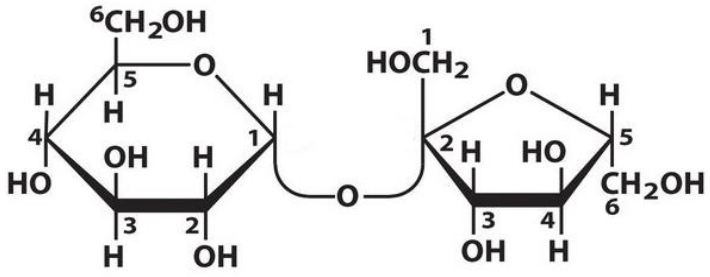
ANSWER:



VERY SHORT ANSWER TYPE QUESTIONS (2 MARKS)	
1.	**Identify the following:** **a) The bond between ribose sugar and nitrogenous base.** **b) The coenzyme derivative of the vitamin thiamine**. Answer: a) N Glycosidic Bond b) Thiamine Pyrophosphate
2.	**What is a glycosidic bond?** Answer: Glycosidic bonds are formed due to condensation reaction between hydroxyl residue on C-1 of one monosaccharide and the C-4 on another monosaccharide.
3.	**What are reducing sugars? How would you test for the presence of reducing sugars in a sample?** Answer: A reducing sugar can act as a reducing agent as it has a free aldehyde or ketone group. Benedict's test can detect reducing sugars.
4.	**What is the difference between α & β anomers?** In Haworth projection (cyclic), if the OH group on far right it is up α anomer (same plane with last C) while if it is opposite it is β anomer.
5.	**Name the two monosaccharides that are present and Sucrose and also name the glycosidic bond.**

	α D Glucose and β D Fructose. A 1->2 Glycosidic bond.
6.	**What are nitrogenous bases? Name the purines & pyrimidines.** A *nitrogenous base* is simply a *nitrogen* containing heterocyclic molecule that has the same chemical properties as a *base*. They are particularly important since they make up the building blocks of DNA and RNA.
7.	**Name the sulphur containing amino acids. Which of these is polar by nature?** Methionine and Cysteine are sulphur containing amino acids. Cysteine is polar.
8.	**Name any two hydroxyl containing amino acids. Which of these is aromatic by nature?** Tyrosine and Serine. Tyrosine is aromatic amino acid.
9.	**How can the understanding of a biomolecule be essential for a Biotechnologist?** A Biotechnologist can devise methods to manipulate cells and their constituents and help make big leap in the understanding of health and diseases and thus can contribute for human welfare.
10.	**Naturally occurring amino acids have which configuration about their alpha carbon atom? Give one example of exception.** Naturally occurring amino acids have "L configuration about their alpha carbon atom except rarely in some bacterial cell walls.
11.	**What are coenzymes? Coenzymes are derived mostly from which group of vitamins?** Co-enzymes are small organic molecules derived from vitamin precursors that facilitate the activity of many enzymes. They are particularly derived from vitamins belonging to the B-complex group
12.	**Identify these nucleotides?** **a) 6 amino purine** **b) 2 keto 6 amino pyrimidine** **c) 2 amino 6 keto purine**

	d) 2,4 diketo 5 methyl pyrimidine a) Adenine b) Cytosine c) Guanine d) Thymine.
13.	**What does the term 'residue' denote in a nucleotide?** The term 'residue' denotes that during the formation of the nucleotide, a part of the molecule is bonded to another, usually by the elimination of water and, hence, what is left is termed as a residue.
14.	**What is the difference between a ribose and deoxyribose sugar? Name the bond present between the pentose sugar and the inorganic phosphate of a nucleotide?** A ribose sugar has 2' OH group while a deoxyribose sugar lacks the 2' OH group. The bond present between the pentose sugar and the inorganic phosphate of a nucleotide is phosphoester bond.
15.	**How many hydrocarbon rings are present in cholesterol? What are special group of lipids derived from cholesterol?** Four hydrocarbon rings are present in cholesterol. Steroids are the special group of lipids derived from cholesterol.

SHORT ANSWER TYPE QUESTIONS (3 MARKS)	
1.	**Identify the disaccharide and write the names of the monosaccharides in it in their correct order with their anomeric forms:**  Sucrose formed of α D Glucose and β D Fructose.
2.	**Write any two tests for detecting lipids.** **Answer:** a) Acrolein test: Acrolein test is used to detect the presence of triglycerols or phospholipids. The glycerol

component when heated with potassium hydrogen sulphate ($KHSO_4$) gets dehydrated to form unsaturated aldehyde called acrolein which has a pungent smell.

b) Bromine Water test: **Bromine water is used to test for unsaturated fats because it changes colour in their presence by adding bromine across their double bonds and hence a coloured solution of bromine decolourized.**

3. **Fill in the blanks:**

Amino Acid	**Derivative**	**Function**
Glutamic Acid	**A**	**Neurotransmitter**
B	**Auxin (Indole acetic acid)**	**Plant Hormone**
Histidine	**Histamine**	**C**

A: GABA (Gamma amino Butyric Acid)

B: Tryptophan

C: Allergic reactions

4. **a) What are the different components of a nucleotide?**
b) What is the difference between a nucleotide and a nucleoside?
b) Why does the heterocyclic nature of ring of nitrogen base mean?

a) A pentose sugar residue, an inorganic phosphate residue and a nitrogenous base.

b) A nucleoside is made up of a pentose sugar residue and a nitrogenous base while nucleotide is a nucleoside bonded with an inorganic phosphate residue.

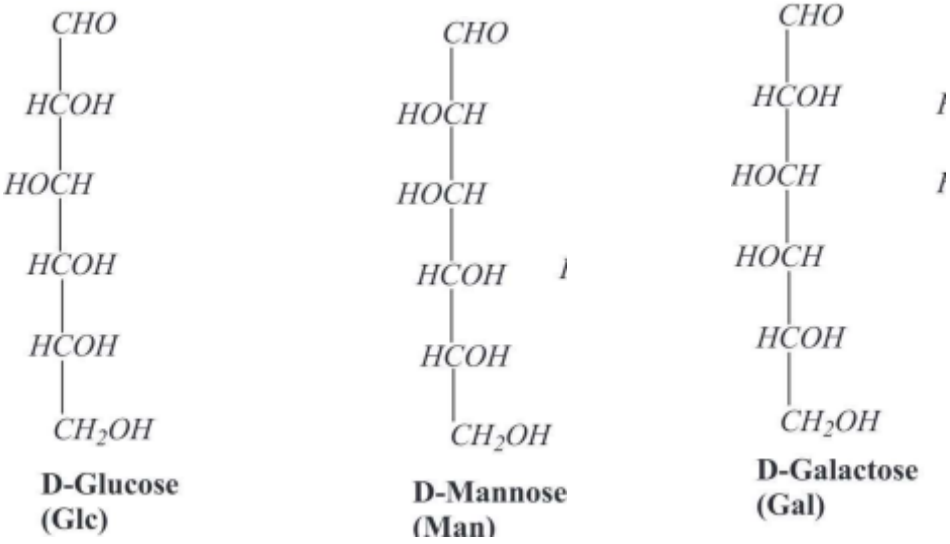
c) The ring of nitrogen bases are made up of 'C' and 'N' atoms.

5. **Describe the test conducted to detect the presence of deoxyribonucleotides.**
Deoxyribonucleotides react with diphenylamine under acidic conditions to give a blue coloured complex. The reaction involves the dehydration of a-deoxyribose of the

	nucleotide or DNA in the presence of acid to m-hydroxylevulinic aldehydes which react with diphenylamine to form the coloured complex.
6.	**a) Name any four reactive groups present in amino acids which can be used for different reactions.** **b) Which of these reacts with the reagent Ninhydrin?** **c) Amino acids undergo which kind of reaction with Ninhydrin?** a) Amino acids have many reactive groups like the α amino group, the carboxylic groups, phenolic groups, sulfhydryl groups, alcoholic groups etc b) Alpha amino group reacts with Ninhydrin c) Oxidative deamination
7.	**i) Identify the common names of these chemicals or products involved in Ninhydrin test.** **a) Triketohydrindene hydrate** **b) Diketohydrin** **ii) What are liberated upon reaction of Ninhydrin with alpha amino group of amino acid?** i) a) Ninhydrin b) Ruhemann's Purple ii) Ammonia, carbon dioxide, an aldehyde, hydrindantin
8.	**Draw the structure of any** **a) polar amino acid** **b) positively charged amino acid** c) **aromatic amino acid** Any correct drawing.
9.	**a) Explain the test that is used to detect the presence of reducing sugars in blood/urine of patients.** **b) Name another test used to detect reducing sugars.** **a)** Benedict's Test: CuSO4 in Benedict's solution reacts with free anomeric carbon atom of reducing sugar to form a yellow to red precipitate of Cuprous Oxide. $CuSO_4$ -> Cu^{2+} + $SO4^{2-}$ Cu^{2+} (ox) + Reducing Sugar -> Cu^{+} (Red) Cu^{+} + O_2 -> $2Cu_2O$ (Red ppt)

	b) Fehling's test.
10.	**i. Name the chemical used in the following:** **a. Benedict's test** **b. Acrolein test** **c. Test for unsaturated fatty acids** **d. Catalyst in Orcinol method** **ii. Name any two steroid hormones.** i. a. $CuSO_4$ b. KHSO4 c. Br Water d) $FeCl_3$ ii. Estrogen & Progesterone
11.	**Draw the structure of one saturated and one unsaturated fatty acid.** Structure of saturated fatty acid : Stearic Acid and one unsaturated fatty acid: Oleic acid
12.	**Draw the structure of dAMP** Correct structure
13.	**a) Why is the carbonyl carbon atom of monosaccharides called as anomeric carbon in ring structure?** **b) Name any two functional groups present in monosaccharides** **c) Name one aldotetrose.** a) The carbonyl carbon atom of monosaccharides is called as anomeric carbon in ring structure because it becomes chiral in ring structure with two anomeric forms b) Hydroxyl and carbonyl groups c) D-Erythrose
14.	**a) Draw the structure of lactose** **b) Name the two monosaccharides in lactose** **c) Name the bond between the two monosaccharides in lactose** a) Correct structure of lactose b) B D Galactose & β D Glucose c) B 1-> 4

15.	**Draw the Fischer projections of D Glucose, D Mannose and D Galactose. Name the carbon atoms which differ in the configuration of D Glucose and D Mannose.**



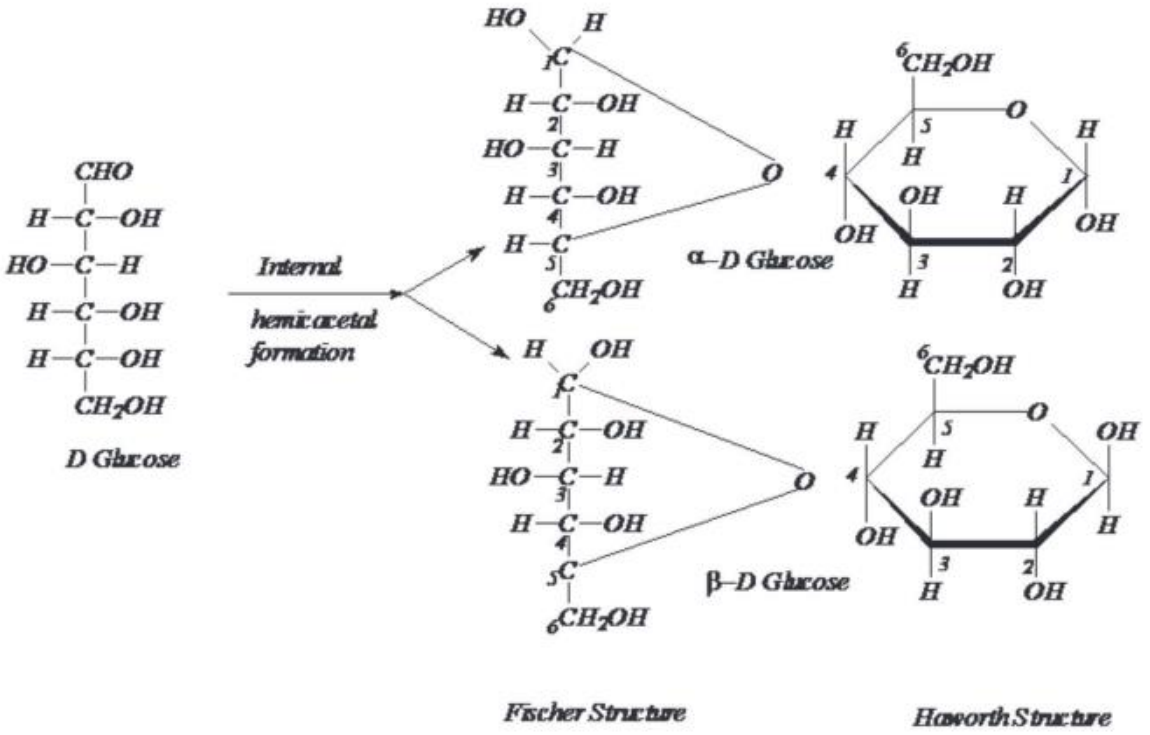
D Glucose and D Mannose at carbon atom 3 in the configuration

LONG ANSWER TYPE QUESTIONS (5 MARKS)	
1	**a) Name and describe the test for amino acids.** **b) Which amino acid gives a differently coloured complex for the above test and why?** **c) What are reducing sugars?**

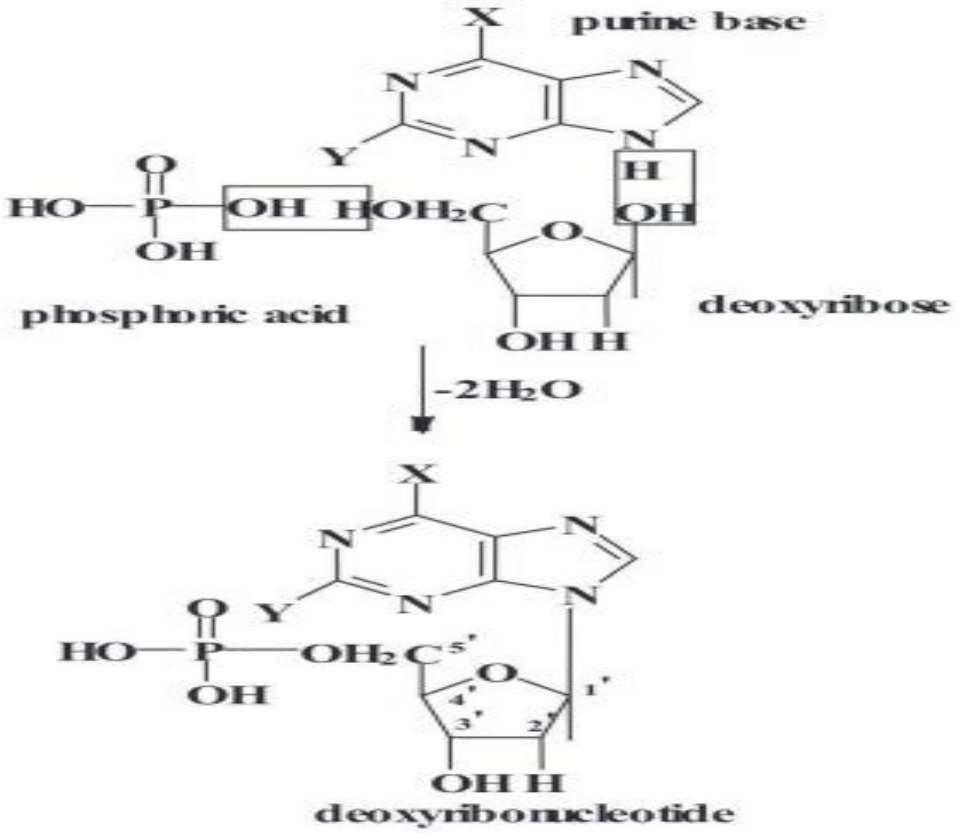
a) Ninhydrin Test (Triketohydrindantin hydrate):

Ninhydrin is a very powerful oxidising agent & in its presence amino acids undergo oxidative deamination liberating ammonia, carbon dioxide, a corresponding aldehyde and reduced form of ninhydrin. The ammonia formed from alpha amino group reacts with ninhydrin and its reduced product (hydrindantin) to give a blue complex called Ruhemann's purple (diketohydrin).

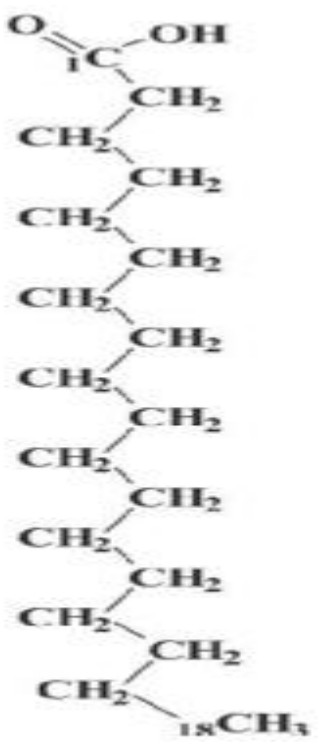
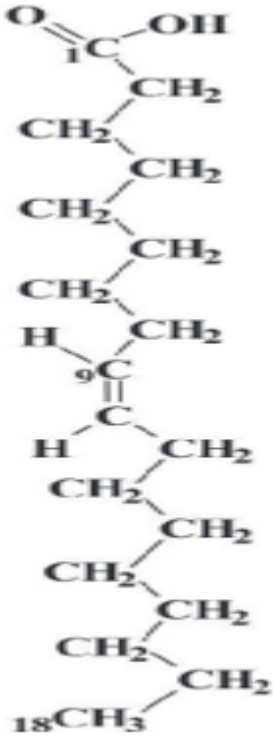
	b) Proline is an exception as it forms yellow complex. **c) Reducing Sugars:** Sugars bearing at least one free anomeric carbon atom that has not formed any glycosidic bond and can reduce mild oxidizing agents. Example: Maltose and Sucrose.
2.	**How is Haworth Projection of a monosaccharide formed from its Fischer projection?** **Fischer to Haworth Projection:** • The simple sugars have two major functional groups – hydroxyl and carbonyl groups. One internal OH group can react with the carbonyl group which can react to form hemiacetals or hemiketals leading to form a ring structure. • 5 membered ring structures are called 'furanoses' and six membered ring structures are called 'pyranoses'. • The carbonyl carbon atom (C 1 in aldoses and C 2 in ketoses) is called the anomeric Carbon atom because on formation of a ring structure, the carbon atom becomes asymmetric leading to the formation of two configurations or anomeric forms called alpha anomers and beta anomers.



3. **a) Show the formation nucleotide by representing all the components and the reactions between them.**

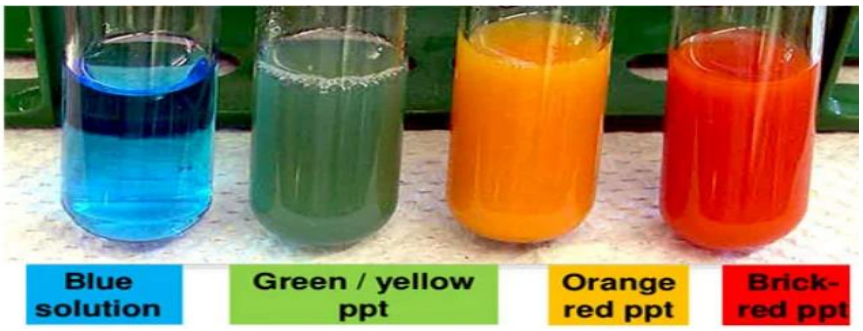


c) Why are carbon atoms in ribose sugar of a nucleotide prefixed with (‘) symbol?

	To differentiate from the carbon atoms of nitrogenous base.
4.	a**) Compare the structure of saturated and unsaturated fatty acid with the help of a diagram.** **b) Name and explain the test that differentiates between saturated and unsaturated fatty acids.**  Stearic acid  Oleic acid a) b) Unsaturated fatty acids add halogens across their double bonds and a coloured solution of bromine water, for example, is decolorized.
5.	**a) What is the molecular formula of carbohydrates?** **b) What are the properties of monosaccharides?** **c) Give an example of ketohexose.** a) Molecular formula of carbohydrates are multiples of $(CH_2O)n$. b) Properties of monosaccharides are: i) A ketone or an aldehyde functional group ii) Polyhydroxy alcohols iii) 3 to 7 Carbon atoms. c) Fructose is a ketohexose.

CASE BASED QUESTIONS (5 MARKS)

1. Benedict's Test: Benedict's Test is used to test for simple carbohydrates. The Benedict's test identifies reducing sugars which have free ketone or aldehyde functional groups. Benedict's solution can be used to test for the presence of glucose in urine / blood.
Some sugars such as glucose are called reducing sugars because they are capable of transferring hydrogens (electrons) to other compounds, a process called reduction. When reducing sugars are mixed with Benedict's reagent and heated, a reduction reaction causes the Benedict's reagent to change colour. The colour varies from green to dark red (brick) or rusty-brown, depending on the amount of and type of sugar.



Source: Benedict's Test- Principle, Preparation, Procedure and Result Interpretation (microbiologyinfo.com)

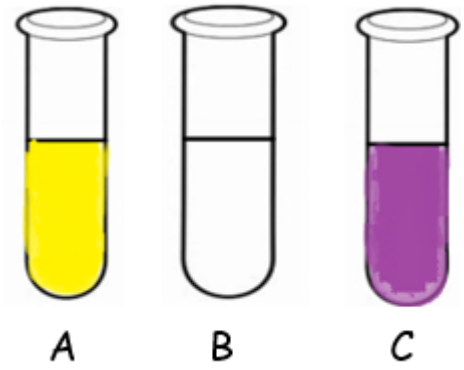
a) What are reducing sugars?

b) From the above figure, conclude the presence of reducing sugar in different samples.

c) Write the reaction of Benedict's test.

a) Sugars bearing at least one free anomeric carbon atom that has not formed any glycosidic bond and can reduce mild oxidizing agents.

b) Blue -> none, Green -> traces of reducing sugar, Orange -> moderate reducing sugar, Red -> excess amounts of reducing sugar.

	c) CuSO4 in Benedict's solution reacts with free anomeric carbon atom of reducing sugar to form a yellow to red precipitate of Cuprous Oxide. $CuSO_4$ -> Cu^{2+} + $SO4^{2-}$ Cu^{2+} (ox) + Reducing Sugar -> Cu^{+} (Red) 4 Cu^{+} + O_2 -> 2Cu_2O (Red ppt)
2.	 **In the above figure, there are three test tubes, each labelled as A, B and C. This reaction has been performed to test for ninhydrin.** **a) Conclude reaction in the different test tubes.** **b) Explain the principal of the ninhydrin test.** a) The test tube A tests positive for proline, test tube B tests negative for amino acids, test tube C tests positive for other amino acids except proline. b) Ninhydrin is a very powerful oxidising agent & in its presence amino acids undergo oxidative deamination liberating ammonia, carbon dioxide, a corresponding aldehyde and reduced form of ninhydrin. The ammonia formed from alpha amino group reacts with ninhydrin and its reduced product (hydrindantin) to give a blue complex called Ruhemann's purple (diketohydrin).
3.	**Lipids are important constituents of biological membranes and are generally sparingly soluble in water, but are readily soluble in organic solvents. Some of the important building blocks of larger lipids**

	are the long-chain hydrocarbons containing fatty acids (stearic and oleic acid), the C,8 amino alcohols (sphingosine), glycerol and cholesterol (present in animal cell membranes). Steroids are a special group of lipids derived from cholesterol, the most abundant steroid in animals. **a) Name one organic solvent in which lipids can dissolve.** **b) What are the simplest lipids?** **c) Name two glycerol derived lipids.** **d) Which lipid is the main constituent of plasma membranes.** e) **Which is the most abundant steroid in animals?** a) Chloroform b) Fatty acids c) Triglycerols & Phospholipids d) Phospholipids e) Cholesterol
4.	**A 22-year-old biochemistry student is studying the structural differences between deoxyribonucleotides and ribonucleotides in her course. She learns that both types of nucleotides contain purines and pyrimidines, but there are specific distinctions in their compositions. Adenine and guanine, which are purines, are found in both deoxyribonucleotides and ribonucleotides. In contrast, cytosine is a common pyrimidine in both types, whereas thymine is exclusive to deoxyribonucleotides, and uracil is exclusive to ribonucleotides. Furthermore, she notes that the purines and pyrimidines are bonded to the sugar phosphate residue by a glycosidic bond involving the C-1' of the sugar and the N-9 of a purine or the N-1 of a pyrimidine.** **i) Which of the following statements accurately**

	describes a structural characteristic of nucleotides? **A. Thymine is present in ribonucleotides but not in deoxyribonucleotides.** **B. Cytosine is only found in deoxyribonucleotides.** **C. Uracil is present in deoxyribonucleotides but not in ribonucleotides.** **D. Adenine and guanine are found in both deoxyribonucleotides and ribonucleotides.** Ans: D. **ii) Which nitrogenous base is found in RNA but not in DNA?** Ans: Uracil iii) **What is the bond between a pyrimidine and a ribose sugar?** Ans: N1 -> C1' iv) **Which nitrogenous base is methyl containing?** Ans: Thymine **v) What is the net charge of nucleic acids and why?** Ans: Negative because of the presence of phosphate groups.
5.	**A 20-year-old biochemistry student is revising for her upcoming exam on carbohydrates. She learns that sugars like glucose, fructose, and sucrose are carbohydrates with molecular formulas that are multiples of $(CH_2O)n$, classifying them as carbon hydrates. She studies that monosaccharides, which can have up to six carbon atoms, are fundamental building blocks of larger carbohydrates and other biomolecules. Depending on the number of carbon atoms, these monosaccharides are categorized into trioses, tetroses, pentoses, and hexoses. Additionally, they possess either an aldehydic or ketonic functional group, leading to classifications such as aldoses and ketoses. For instance, glucose, an aldohexose, has six carbon atoms**

and an aldehydic group, while fructose, a ketohexose, also has six carbon atoms but contains a ketonic group. She also notes that all naturally occurring sugars have a D-configuration based on the asymmetric carbon of D-glyceraldehyde.

i) Which of the following correctly describes a characteristic of monosaccharides?

A. Glucose is a ketohexose with a D-configuration.
B. Fructose is an aldopentose with a D-configuration.
C. Monosaccharides with an aldehydic functional group are called ketoses.
D. A sugar with five carbon atoms and an aldehydic group is called an aldopentose.

Ans: D

ii) Depending on what are the monosaccharides considered trioses, pentoses, hexoses etc?

Ans: Number of carbon atoms

iii) **Name any two functional groups of monosaccharides?**

Ans: Aldehyde, Ketone, Hydroxy

iv) **What is the natural configuration of monosaccharides?**

Ans: Dextrorotatory.

v) **Which carbon atom is carbonyl carbon atom in ketoses?**

Ans: C2

B

UNIT-2: MOLECULES OF LIFE

CHAPTER 2: MACROMOLECULES: STRUCTURE AND FUNCTION

GIST OF THE CHAPTER:

A) Carbohydrates: The energy givers

- These are polymers of many monosaccharide units joined by glycosidic bonds and are known as polysaccharides or glycans.
- A polysaccharide chain can be linear or highly branched (in linear chains the glycosidic bond is between C1 to C4 and in branched chains the branching is between C1 to C6.

Types of Polysaccharides:

1. **<u>Homopolysaccharide</u>**: If the polysaccharide chain consists of only one type of monosaccharide.

   Ex: **Starch & Cellulose** in plants and **Glycogen** in animals is made up of only repeating units of Glucose.

   Starch & Glycogen: α(1→4)

   Cellulose: β(1→4)

2. **<u>Heteropolysaccharide</u>**: When the polysaccharide chain consists of more than one type of monosaccharide units.

   Ex: **Peptidoglycan** (in cell walls of bacteria).

Functions:

- **Provides energy** (glucose gives instant energy in cells)
- **Structural** (polysaccharides can serve as structural components of cells to provide shape, strength and rigidity). Ex:

  i) Cellulose is the most abundant biomolecules in biosphere and is present in cell wall of plants.

  ii) Peptidoglycan forms cell wall of bacteria & gives them shape like spherical (coccus), rod like (bacillus) etc and prevents from osmotic lysis.

- **Storage**: Monomers like glucose can be stored in cells to form polysaccharides like starch in plants and glycogen in animal muscles and liver.

B) Proteins: The Performers

- Proteins are the most diverse biomolecules structurally and functionally.
- Small peptides less than 50 amino acids serve as peptide hormones like insulin and growth hormones.
- Larger polypeptides (more than 50 amino acids) perform various activities like muscular contraction, enzymes, oxygen carrying, vision and sense, immune protection, cell control, signaling etc.
- Since polypeptide chains are made up of a combination of 20 different amino acids in different ratios and compositions, a protein's function is the most diverse due to diversity in it's structure.
- Moreover in 3D form, each protein has a uniquely folded form that provides it with its function.
- Examples:
  1. GFP (Green fluorescent protein) – It is a protein in marine jellyfish which fluoresces green colour in the dark to evade invaders.
  2. Haemoglobin: It is present I the RBC of animals and carries oxygen to different tissues.
  3. Myoglobin: A protein that stores oxygen.
  4. Antibodies: These are immune proteins that provides defense.
  5. Enzymes: Act as bio-catalysts and carry all the biochemical reactions in cells.

LEVELS OF PROTEIN STRUCTURES:

1. **Primary Structure:**
   - The linear sequence of amino acids in a polypeptide chain, the direction of which is from amino terminal to carboxyl terminal.

- For determining the primary structure of a protein (sequencing) it is essential to know the protein's purity and molecular weight and composition.
- Multimeric protein must be dissociated into their individual chains.
- Edman Degradation which uses **sequential sequencing** and is used even in today's **sequenators**. Using this only around 50 amino acids can be detected at a time.

2. Secondary Structure:

The regular arrangement of amino acids within localized regions of the polypeptide chain.

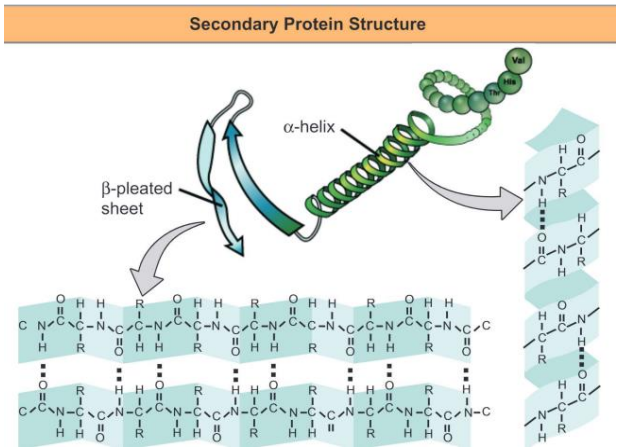
Types: α Helix & β Sheets

α Helix:

- It was first demonstrated by Linus Pauling, a noble laurate.
- It is a spiral structure which is mostly right handed and is formed due to hydrogen bonding between C=O group a peptide bond of n^{th} amino acid with peptide bond of $(n+4)^{th}$ amino.
- It is present more in hair and nail proteins called keratin which are stretchable. Ex: Horn or Hooves of animals.

β Sheets/pleats

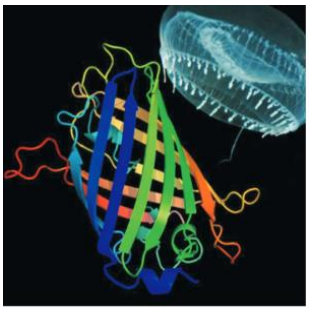
- It is formed when two parts of a polypeptide chain join side by side and are bonded by hydrogen bonds.
- Two or more polypeptide chains can also be bonded by this way to form parallel or anti-parallel chain.
- Proteins rich in beta pleats like silk fibroin or from spider webs are extremely strong and non stretchable and are used to make fabrics or bullet proof jackets.



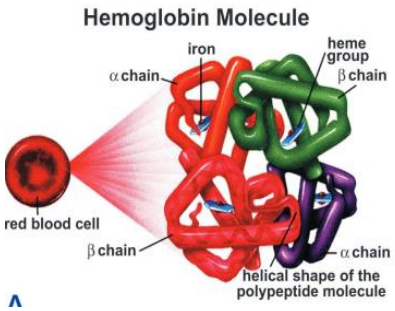
3. **Tertiary Structure:**
   - Proteins made up of single polypeptides such as the oxygen storage protein in muscle called myoglobin fold into a globular structure which is described as it's tertiary structure.

   - Protein tertiary structure is the three-dimensional shape of a protein. the tertiary structure will have a single polypeptide chain "backbone" with one or more protein secondary structures, the protein domains. Amino acid side chains may interact and bond in a number of ways.

   - A popular method of drawing protein structures as indicated in the illustration of GFP (green fluorescent protein) is a ribbon diagram where the polypeptide is drawn as helical ribbon to depict helical segments and straight drawn back and forth sheets to depict pleats.



4. **Quaternary Structure:**
   - Some proteins may be made up of more than one polypeptide where each chain is a subunit.
   - Hemoglobin has 2 **α** and 2 β chains.
   - **Sickle Cell Anemia:** The amino acid at 8th position of chain changes from Glutamic acid to Valine which results in abnormal change in the shape of RBC like a sickle with enormous reduction in oxygen carrying capacity.



Sickle cell **RBC**

Enzymes - The Catalysts

- A major group of proteins are enzymes which are biocatalysts. A catalyst is a reagent which accelerates a reaction.

SL. NO.	Enzymes	Inorganic Catalysts
1.	Enzymes are highly specific. Ex: an enzyme which catalyses the oxidation of D-alanine (D-alanine oxidase) cannot oxidise L-alanine.	Inorganic catalysts, on the other hand, are relatively non-specific. Ex: Finely divided platinum is an inorganic catalyst which is used in the industrial process to make sulphuric acid (Contact process) as well as the industrial process to make ammonia (Haber process).
2.	Enzymes are able to enhance reaction rates at ordinary room temperature and normal atmospheric pressure	Inorganic catalysts usually require several atmospheres of pressure and temperatures exceeding 500°C
3.	Enzymes can be regulated to control the formation of a product. Ex: Feed Back inhibition	Inorganic catalysts can not be regulated

Catalytic power of enzymes

- The region where the substrate binds to the enzyme is known as the substrate binding site or the 'active site' because it is at this site that activity leading to product formation takes place.
- Once the substrate diffuses into the active site in the enzyme the substrate molecules are correctly oriented

so that groups are easily transferred leading to product formation.

- Substrates are also distorted by binding to the enzyme active site and this causes certain bonds to break easily and new bonds to form which leads to product formation

International units: The activity of enzymes is measured in units called IU (international units). An IU is the activity of the enzyme which can catalyze the conversion of 1 µmole of substrate to product in one minute at room temperature (usually taken to be 25°C).

Use of Enzymes in Biotechnology

- The antibiotic penicillin is a potent inhibitor of the transpeptidase rendering the bacterial cell wall weak and susceptible to host destruction mechanisms. Pharmaceutical companies are constantly on the lookout for natural and designed inhibitors which can specifically target key enzymes of pathogenic (disease causing) bacteria.
- Many enzymes are essential as tools in genetic engineering. Some of these are the restriction endonucleases which cut DNA precisely at certain sequences, preparing them for use in recombinant DNA technology.
- Other uses of enzymes include their use in the food industry (use of the proteolytic enzyme papain as a meat tenderizer), as reagents in diagnostic tests (ELISA tests) and their role as therapeutic reagents in medicine (streptokinase administered after a stroke.

Lipids and Biomembranes - The Barriers

- Important lipids show amphipathic character, which makes them ideal candidates for the formation of biomembranes.
- All biological structures such as cells, bacteria and

organelles are enveloped by membranes which are strong impermeable barriers that protect the cytoplasmic contents from osmotic changes. The phospholipids are the dominant group of lipids which constitute all membranes.

Functions of Biomembranes

- Membranes present ideal impermeable barriers for preventing cellular contents from spilling out or extracellular constituents from entering in.
- Water-soluble molecules such as sugars, amino acids and salts (NaCl, KCI) cannot freely penetrate the lipid membranes. Hence, special transporter molecules such as proteins are positioned within the membranes to facilitate transport.
- Membranes are the locales where important cellular processes such as cell-cell recognition, cell signaling and energy generation (oxidative phosphorylation) take place.

Nucleic Acids -The Managers

- Two different kinds of nucleic acids are present in almost every cell - ribonucleic acids (RNA) and deoxyribonucleic acids (DNA).
- The bonds formed between two nucleotide residues is specifically called a phosphodiester bond.
- The phosphodiester bond is formed between a 5' phosphate group of one nucleotide and 3' hydroxyl group of another nucleotide and is, therefore, referred to as 5' -3' phosphodiester bond.

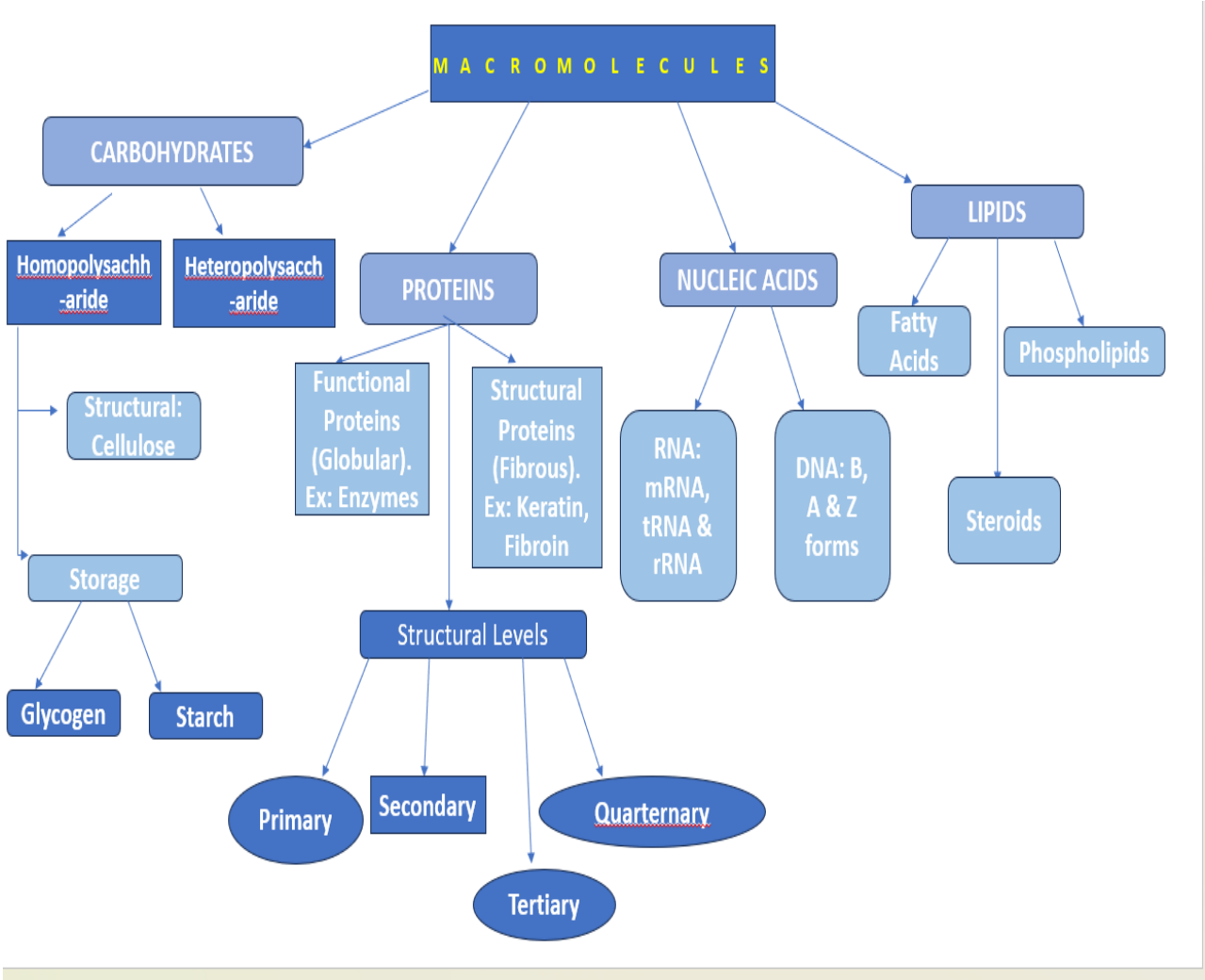
Forms of RNA:

Properties	**mRNA**	**tRNA**	**rRNA**
Stability	Highly unstable	Moderately stable	Moderately stable
%	5	15	80
Length	75-3000	90	120 - 3000
Function	Code for amino acids	translation	Forms ribosomes

DNA: Double helical structure of DNA proposed by Watson & Crick

- DNA is a double stranded structure.
- The two strands associate in an anti- parallel manner, one strand runs 5' to 3' while the other runs in a 3' to 5' direction.
- The base sequence on one strand is complementary to the base sequence on the other strand because of the base pairing rule
- The two stranded structure which can be represented like a step ladder with the base pairs forming the rungs, folds around an imaginary axis forming a double helical conformation.

CONCEPT MAP



MULTIPLE CHOICE QUESTIONS

1	Which of these is involved in making secondary structure of proteins? a) Amino terminal b) Carboxyl terminal c) Hydrogen bonds d) Side chains

2	Which of the following is NOT a function of biomembranes? a) Acting as impermeable barriers b) Water-soluble molecules such as sugars, amino acids and salts (NaCl, KCI) cannot freely penetrate the lipid membranes c) Helps cell-cell recognition processes d) Synthesizing proteins
3	Which characteristics accurately describe the structure of DNA? a) Each strand runs 5' to 3' direction b) It has one strand c) Both strands run in the same direction d) The strands run parallel to each other
4	What structural element in proteins is characterized by a spiral shape? a) Fibroin b) α-helix c) Keratin d) β-pleat
5	What role do restriction endonucleases play in genetic engineering? a) They cut DNA at specific sequences b) They replicate DNA strands c) They join DNA fragments d) They modify gene expression
6	Which characteristic distinguishes smaller polypeptides from larger ones? a) Presence of peptide bonds b) Chemical composition c) Structural diversity d) Number of amino acid residues
7	What chemical process occurs in the formation of peptide bonds in proteins? a) Addition of water molecule b) Addition of amino group

	c) Removal of water molecule d) Removal of carboxyl group
8	How does carbonic anhydrase affect the dissolution of CO2 in water? a) It requires high pressure to work b) It enhances the rate by 10^8 times c) It has no effect on the rate d) It decreases the rate by 10^8 time
9	What causes sickle cell anemia, and how does it affect oxygen transport? a) Lack of hemoglobin causes RBCs to collapse, impairing oxygen delivery b) Excess hemoglobin production leads to oversized RBCs, hindering flow c) Normal hemoglobin alters RBC shape, reducing oxygen capacity d) Mutant hemoglobin changes RBC shape, decreasing oxygen binding
10	Which of these is administered to a stroke patient? a) Papain b) Streptokinase c) Restriction Endonuclease d) Transpeptidase
11	Which types of RNA are present in higher quantities in cells? a) Messenger RNA and Ribosomal RNA b) Messenger RNA and Transfer RNA c) Transfer RNA and Small nuclear RNA d) Ribosomal RNA and Transfer RNA
12	Glycogen is an important storage form of which kind of monosaccharide in animal muscles and liver? a) Alpha D Glucose b) Beta D Glucose c) Alpha D Mannose d) Beta D Mannose

13	If the molecular weight of a protein is 33000 Da, how many approximate numbers of amino acids are present in it? a) 100 b) 200 c) 300 d) 330
14	Which of the two names are associated with sequencing of proteins: a) Fred Sange & Pehr Edman b) G.N Ramachandran & Linus Pauling c) Hershey & Chase d) Watson & Crick
15	Which kind of non-covalent interactions are most prominent in secondary structures of proteins? a) Hydrophobic interactions b) Vander Waal's interactions c) Electrostatic interactions d) Hydrogen Bonds
16	Which of these is **NOT** a globular protein? a) Keratin b) Myoglobin c) Haemoglobin d) GFP
17	Which of these factors can lead to denaturation of enzymes? a) Heat b) pH Change c) Chane in salt concentration d) All of these
18	Peptidoglycan is a heteropolysaccharide present in the cell wall of bacteria which is formed in the presence of enzyme transpeptidase. Which antibiotic is a potent inhibitor of the enzyme transpeptidase? a) Ampicillin b) Penicillin

	c) Tetracycline d) Erythromycin
19	Which of these enzymes is used in food industry for meat tenderization? a) Carbonic anhydrase b) Restriction Enzyme c) Papain d) Streptokinase
20	Which of these is statements correct a) mRNA is highly stable b) 5% of total RNA is constituted of rRNA c) tRNA molecules are 75-3000 nucleotides long d) Ribosomal RNA associate with ribosomal proteins to from ribosomes.
21	Which form of DNA is found in synthetic oligodeoxynucleotides? a) A b) B c) Z d) All the above
22	If a 10 base pair double stranded DNA has 20 % 'A' residues, how many 'G' residues would be present in it? a) 2 b) 4 c) 6 d) 8
23	Which of the following is a heteropolysaccharide? a) Glycogen b) Starch c) Peptidoglycan d) Cellulose
24	How many amino acids are present in a hexapeptide? a) 3 b) 4 c) 5 d) 6

25	Noble laureate Linus Pauling elucidated which of the following regarding protein structure? a) Beta Sheet of secondary structure. b) Alpha helix of secondary structure. c) Amino Acid sequencing technique. d) Quaternary structure of proteins.
26	Which characteristics are true for messenger RNA (mRNA)? a) It is highly stable and long-lasting b) It has a variable length of nucleotides c) It is folded into a complex 3-D structure d) It makes up about 50% of total RNA
27	Which protein structure is primarily responsible for the strength and non-extensibility of silk fibers? a) α-helices b) Keratins c) β-pleats d) Fibroins
28	Which statements accurately describe the phosphodiester bond in nucleic acids? a) It is referred to as a 3' -5' phosphodiester bond b) It only occurs in DNA, not in RNA c) It forms between a 5' phosphate group and a 3' hydroxyl group d) It connects two amino acid residues
29	Which conformation of DNA is the most prominent? a) A b) B c) Z d) All the above
30	Which of these is the most unstable? a) mRNA b) rRNA c) DNA d) tRNA

Answers:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
c	d	a	c	a	d	c	b	d	b	d	b	c	a	d
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
a	d	b	c	d	c	d	c	c	b	b	c	c	b	a

Assertion-Reason Based Questions

The following questions are A-R based questions consist of two statements– Assertion (A) and Reason (R). Answer these questions selecting the appropriate option given below:

A. Both Assertion and Reason are true and the reason is the correct explanation of the assertion

B. Both Assertion and Reason are true but the reason is not the correct explanation of the assertion

C. Assertion is true but Reason is false

D. Both Assertion and Reason are false

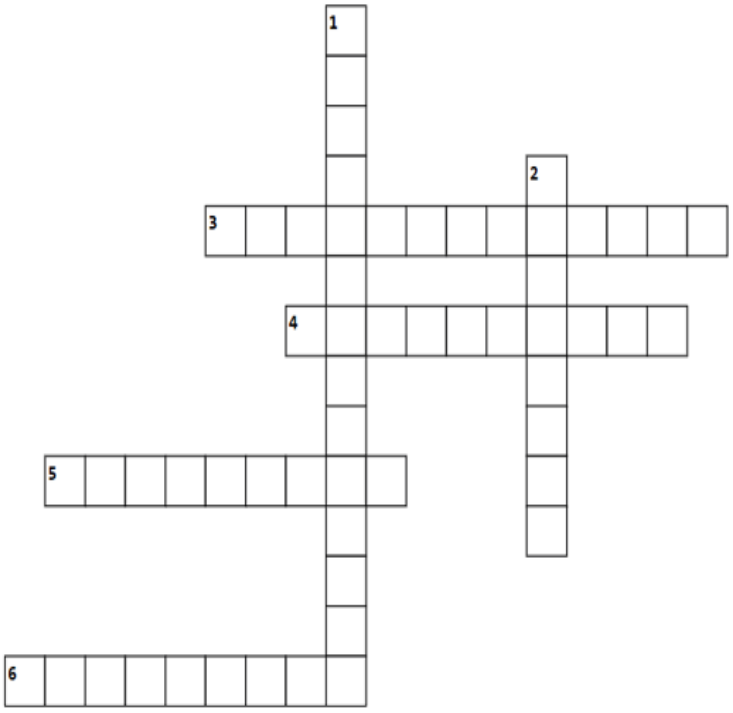
1. Assertion: Enzymes exhibit substrate specificity. Reason: D-alanine oxidase cannot oxidize L-alanine.
2. Assertion: Haemoglobin's quaternary structure aids in oxygen transport. Reason: Haemoglobin has four subunits, unlike myoglobin.
3. Assertion: α-helices in proteins have a right-handed orientation. Reason: Right-handed α-helices are stabilized by hydrogen bonds.
4. Assertion: All biological membranes are generally impermeable barriers. Reason: Biological membranes are made up of phospholipid bilayers.

5. Assertion: Proteins are the structurally and functionally most diverse biomolecules. Reason: Proteins are made up of four different kinds of nucleotides.
6. Assertion: Larger proteins are sequenced after cleaving into smaller fragments using trypsin and chymotrypsin. Reason: Sequenators can sequence up to only 50 amino acids in one go.
7. Assertion: Enzyme that can hydrolyse proteins cannot hydrolyse nucleic acids. Reason: Enzymes can work under optimum conditions of temperature and pressure only.
8. Assertion: The bond formed between two nucleotides is called a 5' – 3' phosphodiester bond. Reason: The bond is formed between 5' Phosphate of previous nucleotide and 3' OH of next nucleotide.
9. Assertion: Sickle cell anaemia is caused due to a mutant haemoglobin. Reason: The oxygen carrying capacity of haemoglobin is reduced.
10. Assertion: Bilayer of Phospholipids make up the biological membranes. Reason: Phospholipids are amphipathic in nature.

Answers:

1	2	3	4	5	6	7	8	9	10
b	A	b	a	c	a	b	c	b	A

CROSSWORDS



Across

3. Plasmamembrane

4. Quaternary Structu

5. Histone

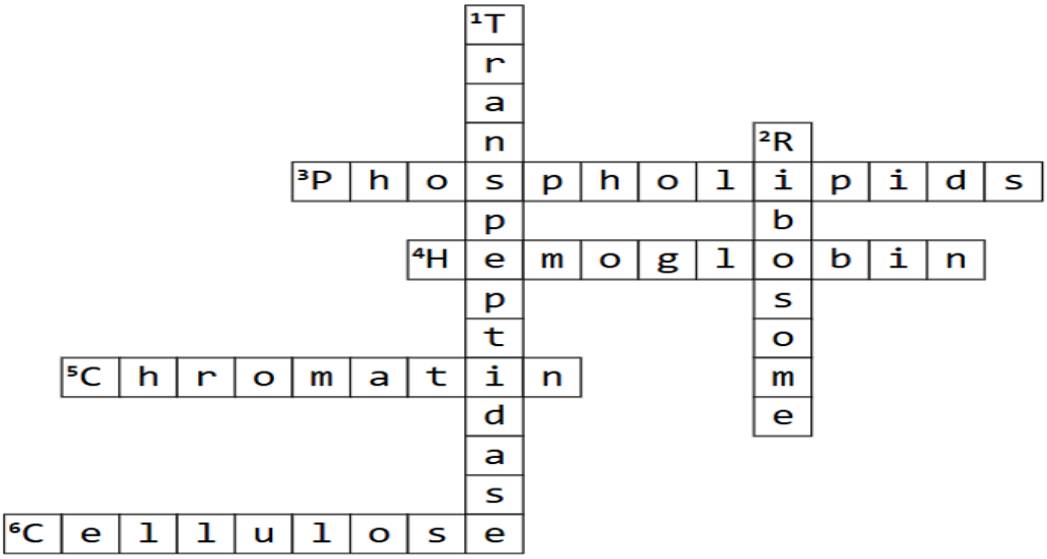
6. Plant Cell wall

Down

1. Breaks Peptidoglycan

2. rRNA

ANSWER:



	VERY SHORT ANSWER TYPE QUESTIONS (2 MARKS)
1.	**Identify the following:** **a) The heteropolysaccharide that forms the cell walls of bacteria.** Peptidoglycan **b) The structural homopolysaccharide in plant cells** Cellulose
2.	**Define 'IU' of enzyme activity.** An IU is the activity of the enzyme which can catalyse the conversion of 1 µmole of substrate to product in one minute at room temperature (usually taken to be 25°C).
3.	**Give one structural and functional aspect of carbohydrates with example.** Structural: Cell wall (cellulose) & Functional: Storage (Glycogen), Energy (Glucose).
4.	**What is Ramachandran Plot?** Ramachandran Plot is based on geometry ad stearic orientation around peptide bonds using which can predict orientation of amino acid sequences towards alpha helix or beta sheets.
5.	**If the molecular weight of a polypeptide chain is 22000D, how many amino acids might be present in it**? Approximate weight of one amino acid = 110 D Hence 200 amino acids are present.
6.	**Why proteins are the most structurally and functionally diverse molecules?** Proteins are made up of 20 different amino acids which can confer maximum combinations.
7.	**Name the sequencing method used in modern day protein sequenators.** Edman Degradation developed by Pehr Edman which can sequence up to 50 amino acids in one go.

8.	**What are prosthetic groups in proteins?** Prosthetic groups in proteins are small organic molecules which can be 'haem' in haemoglobin or vitamin B complex derivatives known as 'co-enzymes' in many enzymes.
9.	**What is the contribution of Fred Sanger in determination of protein structure?** The first protein to be sequenced was the hormone 'insulin' was sequenced by Fred Sanger showed. He invented a method of protein sequencing using a stepwise release and identification of acids starting from the N-terminal amino acid.
10.	**How is haemoglobin different from myoglobin?** The multi subunit interaction in haemoglobin confers unique oxygen transporter functions, unlike in the single subunit containing myoglobin which is an oxygen storage protein.
11.	**What is an active site of enzyme?** The 'active is that site that leads to product formation. The active site occupies a very small region in the enzyme molecule. The substrate has to diffuse and find the active site. Once it diffuses into the active site in the enzyme the substrate molecules are correctly oriented so that groups are easily transferred leading to product formation.
12.	**What is a phosphodiester bond?** The phosphodiester bond is formed between the 3' -OH of one nucleotide and 5' phosphate residue of an adjacent nucleotide in a nucleic acid chain.
13.	**Which property of lipids make them ideal candidates for making biomembranes?** Important lipids show amphipathic character, that is, they have dual properties of hydrophilicity (water liking) and hydrophobicity (water hating). This interesting amphipathic character makes them ideal candidates for the formation of biomembranes.

14.	**What is Sickle cell anaemia?** In patients suffering from sickle cell anaemia the haemoglobin due to an altered amino acid in its -chain forms string like structures reducing the oxygen carrying ability of the deformed RBC.
15.	**Fill in the blanks:** a) If important enzymes are targeted by substrate-like molecules known as inhibitors, the organism may perish. One example is the antibiotic penicillin, which inhibits the activity of the enzyme _____. Answer: transpeptidase b) Understanding the 3-D structure of an enzyme can aid in designing inhibitors that fit into the _____ binding sites. Answer: substrate

SHORT ANSWER TYPE QUESTIONS (3 MARKS)	
1.	**Mention any three uses of biological membranes.** a) Due to their dual character of having an internal hydrophobic region and an external hydrophilic portion, membranes present ideal impermeable barriers for preventing cellular contents from spilling out or extracellular constituents from entering in. b) Water-soluble molecules such as sugars, amino acids and salts (NaCl, KCI) cannot freely penetrate the lipid membranes. Hence, special transporter molecules such as proteins are positioned within the membranes to facilitate transport. **c)** Membranes are the locales where important cellular processes such as cell-cell recognition, cell signaling and energy generation (oxidative phosphorylation) take place.

2.	**Draw the structure of:** **a) Beta D Galactose** **b) Tryptophan**
3.	**Compare the three forms of RNA in brief in terms of total concentration, length and stability.** a) Messenger RNA (mRNA) has the information to make a protein. It is very unstable and comprises -5% of total RNA polymer. Its length is highly variable, of the range 75-3000 nucleotides. b) Transfer RNA (tRNA) is a small molecule, about 90 nucleotides long. It is highly folded into an elaborate 3-D structure and comprises about 15% of total RNA. c) Ribosomal RNA (rRNA) which is 80% of the total RNA, is associated with subcellular structures
4.	***Why are enzymes better over inorganic catalysts?*** a) Enzymes are specific towards their substrates. b) Enzymes catalyze reactions under normal conditions of temperature and pressure. c) Enzymes lower the activation energy of reaction and thus have very high catalytic powers.
5.	***Give a brief account to explain that proteins are the most diverse biomolecules.*** Proteins have diverse functions for example haemoglobin is present in the RBC of animals and carries oxygen to different tissues; Myoglobin stores oxygen; Antibodies are immune proteins that provides defense and enzymes act as bio-catalysts and carry all the biochemical reactions in cells.
6.	***What are the functions of biological membranes?*** a) Enables separate environment inside cells and organelles. b) Allows controlled exchange of materials between a cell and its environment. c) Many membranes are sites for biochemical reactions. d) Defence is provided by membrane bound antibodies.
7.	**Mention briefly about the packaging of DNA in cells.** A typical human cell is 20 µm in diameter. The nucleus

	has a diameter of 5 µm. The 46 chromosomes present have a total of $6x10^9$ bp corresponding to a length of 2 m if the DNA is completely stretched. Such packaging usually involves a process known as supercoiling. Enzymes known as 'topoisomerases' keep the DNA in a highly supercoiled state along with packaging proteins such as 'histones'.
8.	**Mention the features of B DNA as demonstrated in Watson and Crick model of double helical DNA.** a) DNA is a double stranded structure. b) The two strands associate in an anti-parallel manner, one strand runs 5' to 3' while the other runs in a 3' to 5' direction. **c)** The base sequence on one strand is complementary to the base sequence on the other strand
9.	**Mention some functions of carbohydrates** a) **Provides energy** (glucose gives instant energy in cells) b) **Structural** (polysaccharides can serve as structural components of cells to provide shape, strength and rigidity). Ex: iii) Cellulose is the most abundant biomolecules in biosphere and is present in cell wall of plants. iv) Peptidoglycan forms cell wall of bacteria & gives them shape like spherical (coccus), rod like (bacillus) etc and prevents from osmotic lysis.
10.	**'Enzymes are highly specific while inorganic catalysts are not.' With the help of an example explain the statement.** An enzyme which catalyses the hydrolysis of proteins cannot catalyse the hydrolysis of nucleic acids although in both reactions water is added across a covalent bond. An even more exquisite example of specificity is that an enzyme which catalyses the oxidation of D-alanine (D-alanine oxidase) cannot oxidise L-alanine. While, finely divided platinum is an inorganic catalyst which is used in the industrial process to make sulphuric acid (Contact process) as well as the industrial process to make ammonia (Haber process).

11.	**a) Why are proteins the most diverse biomolecules?** **b) What is the difference between smaller and larger polypeptides?** a) Proteins are structurally and chemically the most diverse group of macromolecules found in organisms. Because they are linear polymers of 20 amino acids. b) Smaller polypeptides (less than 50 amino acid residues) serve as peptide hormones such as insulin and growth hormone; larger polypeptides (50 and more amino acid residues) perform a diverse array of activities including enzyme activity, muscular contraction, vision and immune protection.
12.	**How is protein sequencing done? What is the sequencing strategy for larger polypeptides?** Sequenators are machines which chemically label the N-terminal amino acid of a polypeptide, release specifically the labelled amino acid residue leaving the rest of the protein shortened by one residue. The labelled amino acid is identified by a chromatographic technique. This procedure is repeated as many times as the number of residues the protein contains. Hence the identity of each released amino acid from the N-terminal of the protein will lead to the sequence of the protein read from N-terminal to C-terminus. In practice the sequenator can accurately read about 50 amino acid residues in one go. Therefore, if the protein is large it is cleaved by specific proteolytic enzymes such as trypsin and chymotrypsin into fragments around 50 amino acid residues long and then subject to sequencing
13.	**Compare between alpha helices and beta sheets with the help examples.** An a-helix is a spiral structure and depending on the contour of the polypeptide backbone can have a right-handed orientation or a left-handed one. Most naturally occurring proteins have right-handed helices. The other secondary structural element, known as a -pleat, is a sheet like structure wherein two or more sections of the polypeptide strand come together. Both a-helices and b-

	pleats are stabilized by hydrogen bonds. Some naturally occurring insoluble fibrous proteins like keratins which make up the major proteins of the extra dermal tissues such as hair, hooves and horns predominantly have only helices. Silk which consists predominantly of the protein silk fibroin is made up of mainly -pleats. Hair proteins having springlike structure, are extensible (can be stretched around curlers) whereas the pleat like structures present in silk makes the silk fibres strong and non-extensible. Fibroin from certain spider webs is used to make bullet proof vests.
14.	**a) Draw a labelled structure of the double helix of DNA citing all properties.** **b) What will be the complementary sequence for** **5' ATGACGGATCAGAG3'** a) Correct labelled diagram b) 3' TACTGCCTAHTCTC 5'
15.	**At what levels of protein structures, the following are involved in making bonds?** **a) H bond formed between C=O and N-H of two different peptide bonds.** **b) Alpha Carboxyl group of previous amino acid and alpha amino group of next amino acid.** c) **Side chains of amino acids.** a) Secondary structure (alpha helix or beta sheets) b) Peptide bonding in primary structure c) Tertiary structure.

Long Answer Type questions (5 Marks)	
1.	**a) Describe the different levels of protein structure.** The different levels of protein structure **Primary Structure:** The linear sequence of amino acids in a polypeptide chain, the direction of which is from amino terminal to carboxyl terminal. **Secondary Structure:** The regular arrangement of amino acids within localized regions of the polypeptide chain.

	Types: α Helix & β Sheets **α Helix:** It is a spiral structure which is mostly right handed and is formed due to hydrogen bonding between C=O group a peptide bond of n^{th} amino acid with peptide bond of $(n+4)^{th}$ amino. **β Sheets/pleats:** It is formed when two parts of a polypeptide chain join side by side and are bonded by hydrogen bonds. **Tertiary Structure:** Proteins made up of single polypeptides such as the oxygen storage protein in muscle called myoglobin fold into a globular structure which is described as it's tertiary structure. **Quaternary Structure:** Some proteins may be made up of more than one polypeptide where each chain is a subunit. **b) Name the sequencing method used in modern day protein sequenators.** Edman Degradation which uses **sequential sequencing** and is used even in today's **sequenators**
2.	**a) What are the three forms of DNA?** The three forms of DNA are A, B and Z. **b) What factors influence the formation of different DNA conformations under specific conditions?** The DNA helix can have a right handed orientation (B and A conformations) or a left handed, zig-zag (Z) orientation. The B conformation of DNA is thought to be the dominant form in vivo. Under certain conditions such as lower humidity, a conformationally different form known as A-DNA is formed This form of DNA is right- handed helical but with a slightly larger diameter and lower pitch. A third form of DNA discovered in synthetic oligodeoxynucleotides referred to as Z-DNA consists of a left-handed helix whose sugar-phosphate backbone has a zig-zag appearance (hence Z DNA) **c) Which form is the most prominent?** The B form of DNA is the most prominent.

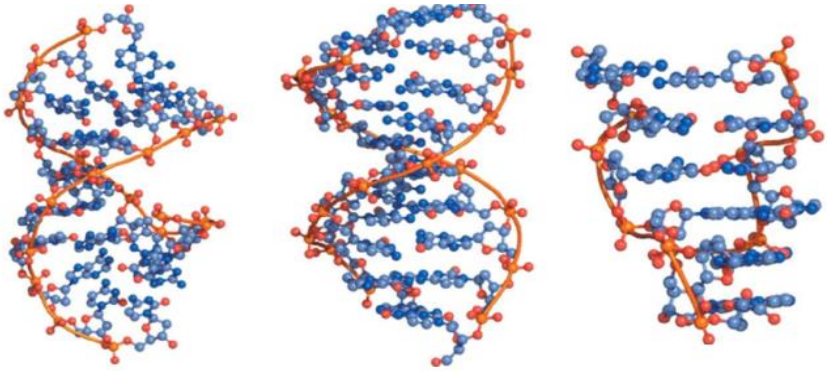
	d) How can you compare the structure of DNA with a ladder and its rungs? The two stranded structure which are like a step ladder with the complementary base pairs forming the rungs, folds around an imaginary axis forming a double helical conformation.
3.	**a) How do different organisms, such as bacteria and humans, differ in terms of the structure and packaging of their chromosomes?** A bacterial cell (prokaryote) E. coli has one chromosome. Human beings have 23 pairs of chromosomes in their somatic cells (diploid). The E. coli chromosome has a circular DNA molecule. However, in higher organisms, DNA is linear. **b) What role do topoisomerases and histones play in the packaging of DNA within chromosomes, and how does this process vary between prokaryotic and eukaryotic cells?** In eukaryotic cells, chromosomes are confined to the nucleus. Such packaging usually involves a process known as supercoiling. Enzymes known as 'topoisomerases' keep the DNA in a highly supercoiled state along with packaging proteins such as 'histones' while the double stranded circular DNA of prokaryotes are smaller and are without histones. **c) If 2 m DNA has to be packaged into the confines of a 5 μm diameter nucleus, the chromosomes have to be condensed by how much?** By a factor of 10^5
4.	**a) How does the quaternary structure of multimeric proteins, such as hemoglobin, contribute to their unique functions compared to single subunit proteins like myoglobin?** Multimeric proteins which have more than one polypeptide chain (referred to as subunits) interact within their subuits to form compact 3-D structures a description of which is its quaternary structure.

	Haemoglobin, an oxygen transporter protein found in erythrocytes has 4 subunits which interact with each other. The importance of these interactions is realized when haemoglobin is compared in function to myoglobin a single subunit containing protein. Both proteins have an organic haem molecule attached to each polypeptide chain which is responsible for oxygen binding; however, the multi subunit interaction in haemoglobin confers unique oxygen transporter functions, unlike in the single subunit containing myoglobin which is an oxygen storage protein. **b) In what ways do alterations in protein structure, such as the formation of string-like structures in sickle cell anaemia, impact the function of proteins like haemoglobin in oxygen transport?** The deformation created in the structure of an RBC when the haemoglobin molecule undergoes mutation to sickle cell haemoglobin. In patients suffering from sickle cell anaemia the haemoglobin due to an altered amino acid in its -chain forms string like structure reducing the oxygen carrying ability of the deformed RBC. **c) Can you discuss the significance of protein structure in relation to its function in both health and disease?** Explain using examples from haemoglobin and myoglobin.
5.	**a) How do homopolysaccharides differ from heteropolysaccharides in terms of their composition?** If the polysaccharide is built around only one kind of sugar then it is called a homopolysaccharide but if two or more different sugars or sugar derivative residues are polymerized then these polymers are called heteropolysaccharides

	b) What roles do polysaccharides play in living organisms, and how do they contribute to the overall function and structure of tissues? Cellulose, a structural homopolysaccharide widely distributed in plants, is the most abundant biomolecule in the biosphere. Polysaccharides serve as structural components which increase the strength of any tissue they are located in or serve as storage forms of energy which living systems can draw upon when needed. Glycogen is an important storage form of glucose present in animal liver and muscle which the animal can draw upon for its energy needs; likewise, starch is the storage form of glucose in plants. Peptidoglycans are heteropoly saccharides present in the cell walls of bacteria. These impart the characteristic shape to bacteria. c) **Can you explain the significance of glycogen, starch, and peptidoglycans in terms of energy storage and structural support in different organism.** Glycogen is an important storage form of glucose present in animal liver and muscle which the animal can draw upon for its energy needs; starch is the storage form of glucose in plants and Peptidoglycans are heteropoly saccharides present in the cell walls of bacteria. These impart the characteristic shape to bacteria.

Case Based Questions (5 Marks)	
1.	**A 16-year-old African American male presents to the clinic with complaints of fatigue and episodes of severe pain in his joints and abdomen. He has a history of anaemia and was diagnosed with sickle cell disease. Physical examination reveals pallor and mild jaundice. Laboratory tests show haemoglobin electrophoresis consistent with sickle cell disease.** **I. Which of the following best explains the reduced oxygen-carrying capacity in this patient?** a) Myoglobin structure alteration b) Decreased red blood cell lifespan c) Altered haemoglobin subunit structure d) Deficiency in vitamin B complex

	Answer: c) Altered haemoglobin subunit structure **II. How many polypeptides are present in a haemoglobin protein?** Answer: There are four polypeptides present in a haemoglobin protein. **III. What kind of conformational change happens in sickle cell haemoglobin?** Answer: The polymerized sickle haemoglobin forms a string like structure. **IV. How does it affect the function of haemoglobin?** Answer: The oxygen carrying capacity is reduced enormously. **V. What symptoms can be seen in case of Sickle cell Anaemia?** Answer: complaints of fatigue and episodes of severe pain in his joints and abdomen.
2.	**A 28-year-old male presents to the clinic with fever, chills, and a productive cough. He is diagnosed with bacterial pneumonia. The physician prescribes penicillin. The patient inquires about how the antibiotic works. The physician explains that penicillin inhibits an essential bacterial enzyme, transpeptidase, involved in cell wall synthesis, leading to cell lysis.** **I. Which of the following best describes the mechanism by which penicillin exerts its antibacterial effect?** a) It binds to bacterial DNA, preventing replication. b) It disrupts the bacterial cell membrane, causing leakage. c) It inhibits transpeptidase, preventing cell wall synthesis. d) It interferes with protein synthesis at the ribosomal level. Answer: c) It inhibits transpeptidase, preventing cell wall synthesis. **II. Who discovered the antibiotic penicillin?** Answer: Alexander Fleming **III. What is In-Silica Based study?** Answer: Computer based study. **IV. How can determination of 3D structure of**

	enzyme help in designing inhibitors? Answer: The enzyme structures can be displayed in computers and scientists involved in drug discovery research can design antibiotics in-silica which can fit into the substrate binding sites.
3.	**The three forms of DNA are depicted below. Looking at the figure given below, answer the following:**  i) ii) iii) **a) Identify the three forms of DNA from i) to iii).** **b) Which of these forms are right-handed?** **c) Which form is formed in lower humidity?** **d) Which of these forms is left-handed?** **e) Which form is present in synthetic oligonucleotides?** a) i) A form ii) B form iii) Z form b) A form and B form c) A form d) Z form e) Z form
4.	**Proteins are the most diverse biomolecules. The word protein is derived from the Greek word, 'proteios' meaning 'primary' or of 'prime importance'. The monomeric units of proteins are the α-amino acids. Amino acids contain an amino (-NH_2) and carboxylic (-COOH) functional groups. The amino acids of proteins form peptide bonds with each other.** **a) In which direction the sequence of a protein is read?** **b) Mention few diverse functions of proteins.** **c) Name the bond formed between two amino acids.**

	d) Which technique can determine the entire amino acid sequence of a protein. **e) Which protein was first sequenced and by whom?** a) Amino terminal to carboxyl terminal. b) Proteins work as enzymes, hormones, antibodies, receptors etc. c) Peptide bond d) Edman Degradation e) Human Insulin by Fredrick Sanger.
5.	**A monosaccharide consists of a single aldose or ketose unit. D-Glucose is for example the most common monosaccharide in nature. It is both an important nutrient (under normal condition the brain uses exclusively glucose for energy), but also the building block of the polysaccharides starch and cellulose. Oligosaccharides contain up to 20 monosaccharide units. Polysaccharides are made from long chains or networks of monosaccharides units. Carbohydrates have several important functions in nature. One is the short (glucose) to midterm (starch glycogen) storage of energy, another the provision of building materials for cell walls (structure) such as cellulose.** Source: coledavid.com **a) Name one non-reducing disaccharide?** **b) Which anomer of D Glucose is present in starch?** **c) Name one heteropolysachharide?** **d) Name one structure polysaccharide.** **e) Give two examples of polysachharides which have storage function.** a) Sucrose b) Alpha D Glucose c) Peptidoglycan d) Cellulose e) Starch & Glycogen.

B

UNIT-III GENETICS AND MOLECULAR BIOLOGY

Marks- 20

Chapter 1: Concepts of Genetics

Contents of the chapter

- Historical Perspective
- Multiple Alleles
- Linkage and Crossing Over
- Genetic Mapping

Chapter 2: Genes and Genomes: Structure and Function

Contents of the chapter

- Discovery of DNA as Genetic Material
- DNA Replication
- Fine Structure of Genes
- From Gene to Protein
- Transcription-The Basic Process
- Genetic Code
- Translation
- Regulation of Gene Expression
- Mutations
- DNA Repair
- Human Genetic Disorders

B

UNIT – III :- GENETICS AND MOLECULAR BIOLOGY

CHAPTER – 1:- CONCEPTS OF GENETICS

CONTENTS OF THE CHAPTER:-

- Historical perspective
- Mendelian Genetics
- Chromosomal Theory of Inheritance
- Multiple Alleles
- Linkage & Crossing over
- Genetic Recombination
- Genetic Mapping
- Gene Interaction
- Extranuclear Inheritance
- Quantitative Inheritance

Gist of the Chapter:-

- **INTRODUCTION**

1. Children inherit their biological parents' genes that express specific traits, such as some physical characteristics, natural talents, and genetic disorders.
2. The process by which characters are transmitted from one generation to next generation is called Inheritance / Heredity.
3. The differences in traits of individuals of a progeny from each other and from their parents are called Variation.
4. The study of scientific facts of heredity and variation is referred to as Genetics .
5. The basic understanding of inheritance of traits through generations comes from the studies made by Gregor Johann Mendel, an Austrian monk – "Father of Genetics ".

- **HISTORICAL PERSPECTIVES**

1. Famous Greek philosopher Plato and Aristotle also recognised the role of heredity in human beings.
2. Invention of the first compound microscope by Jenson in 1590 increases researchers to look Deep and unravel the basis of inheritance.

3. In 1717, Thomas Fairchild produces the first hybrid between *Dianthus barbetus* and *Dianthus caryophyllis* In an inter spacific cross.
4. In 1763, Joseph kolreuter studied hybridization in plants and recognise the role of both parents in heredity and also performed back crosses.
5. In 1809, Lamarck proposed the theory of inheritance of acquired characteristics.
6. In 1831, Robert brown discovered the nucleus in tradescantia cells.
7. In 1866, Mendel published his landmark paper on "Experiments in plant hybridization" which letter becomes a foundation of laws of heredity.
8. His work was ignored for a long time until in 1900 3 scientist namely de Vries, Tschermark and Correns independently discovered the Mendel's law of heredity.
9. In 1902, Sutton and Boveri drew attention to the parallelism between the mendelian factors and that of chromosomes during meiosis and established the chromosomal basis of inheritance.
10. In 1906, Bateson coined the term 'genetics' to cover all methods considering heredity and variation.
11. W.Johannsen introduced the word 'gene' in 1910.

❖ **MENDELIAN GENETICS**

1.Gregor Mendel experimented on garden pea (*Pisum sativum*) to study the inheritance pattern of seven contrasting characters such as plant height, flower colour, flower position, pod colour, pod shape, seed colour & seed shape.

2.When a cross is made between parents with one pair of contrasting characters it is called as Monohybrid Cross.

3.Each gene exists in two alternate forms called Alleles .

4.When two similar alleles for a trait are present in an individual it is referred as Homozygous alleles .

5. When two different alleles for a trait are present in an individual it is referred as Heterozygous alleles .

6.The progeny descendent by self-pollination from a single homozygous plant is called Pure line .

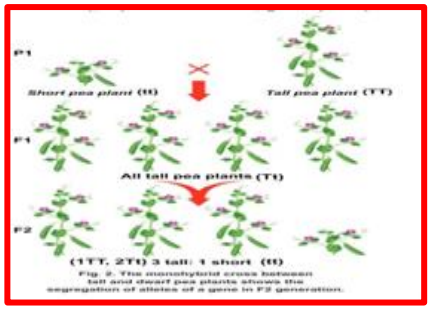
7.The phenotypic ratio of a monohybrid cross is 3:1 & genotypic ratio is 1:2:1 .

8.A Test cross involves F1 individuals with the recessive parents . It helps to determine whether a dominant phenotype is homozygous or heterozygous for a specific allele .

9. **MENDEL'S LAW OF INHERITANCE**

i) Law of Dominance – It states that out of the two contrasting characters , one is dominant & other is recessive . In heterozygous condition dominant character is always expressed where as the recessive character is supressed .

ii).Law of segregation - During the formation of gamete, each gene separates from each other so that each gamete carries only one allele for each gene



iii).Law of independence assortment- The alleles of two (or more) different genes get sorted into gametes independently of one another

.

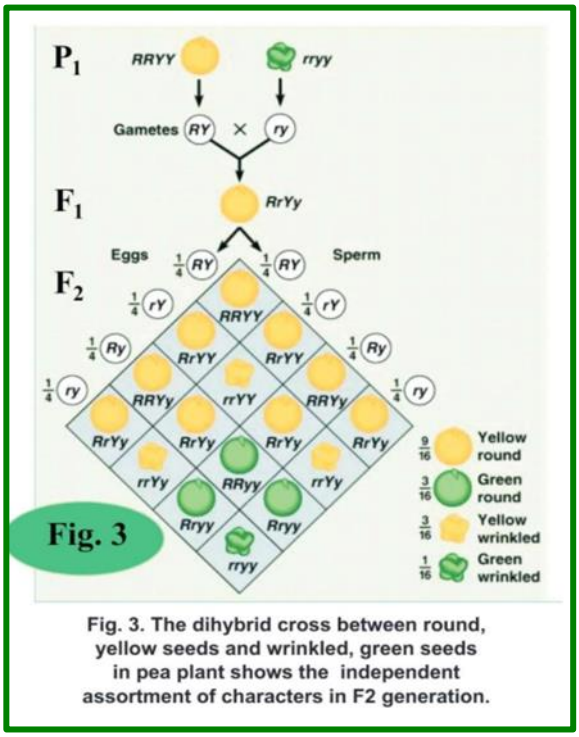
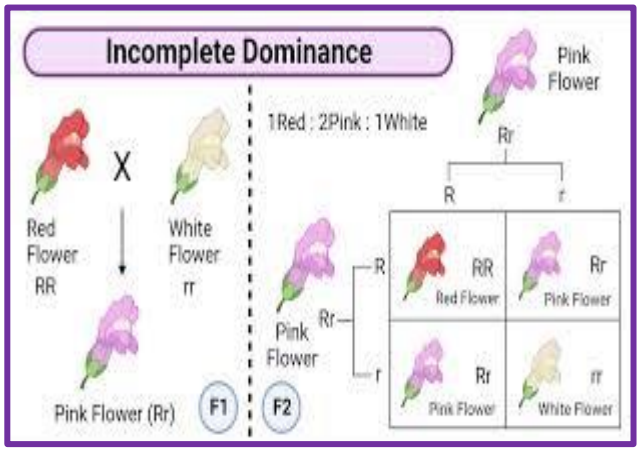


Fig. 3. The dihybrid cross between round, yellow seeds and wrinkled, green seeds in pea plant shows the independent assortment of characters in F2 generation.

12. Incomplete Dominance:- In case of Incomplete Dominance, the two alleles of a trait are not related as dominant & recessive, but the dominant gene in heterozygous condition reduce expression, so that each of the allele expresses itself partially



13. Codominance- When both the alleles of parental generation get equally expressed in F1 heterozygote , it is known as codominance . Eg. ABO Blood groups in Human.

❖ CHROMOSOMAL THEORY OF INHERITANCE-

Proposed by W. Sutton & T. Boveri (1902)

1.The hereditary factors are carried in nucleus & nucleus contains chromosomes .

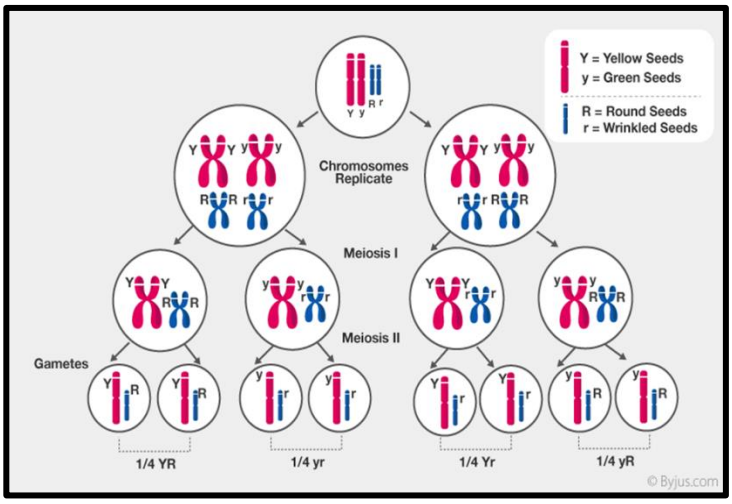
2.Chromosomes are present in pairs .

3.The sperm & egg having haploid set of chromosomes fuse to re-establish the diploid state .

4.The two alleles of a gene pair are located on homologous sites on homologous chromosomes in a linear order . As there are two chromosomes of each kind in somatic cell there must be two genes of each kind , one in each of the two homologous chromosomes .

5.Homologous chromosomes synapse during meiosis and get separated to pass into different cells. This forms the basis for segregation and independent assortment.

A gamete receives only one chromosome of each type and thus has only one gene for a trait The paired condition is restored by fusion of gametes .



❖ MULTIPLE ALLELES

Alleles or allelomorphs are the alternative forms of a gene present at the same locus on the homologous chromosomes. Some genes have more than two allelic forms, which is referred to as multiple alleles. A diploid cell contains any of the two alleles, one each on the homologous chromosomes and a haploid cell contains only one allele.

❖ DNA sequencing studies have revealed that single nucleotide polymorphism (due to allelic differences) is very common in many organisms including us. One can expect that out of every 1000 base pairs of DNA one base pair is likely to be different between any two individuals. Many of these changes would not have phenotypic consequences but they would certainly be useful in DNA fingerprinting and genetic studies.

Table 1.Some example of Multiple Allele in animals and plants

Trait and Organism	Gene symbol	Phenotype
Eye colour in Drosophila	w/w	White
	W^a/w^a	Apricot
	W^{ch}/w^{ch}	Cherry
	$W^{bl}/^{bl}$	Blood
	W^w/W^w	Wine
	W^{ts}/w^{ts}	Stellenbusch wild type
Blood group in human beings	I^A/I^A	A
	I^A/I^O	A
	I^B/I^B	B
	I^B/I^O	B
	I^A/I^B	AB
	I^O/I^O	O

❖ LINKAGE AND CROSSING OVER

1. Only those genes that are located on different chromosomes normally show the independent assortment. Mendel was lucky in many ways that the seven pairs of contrasting characters he studied in the pea plant, were present on seven different chromosomes of pea. That is why he was able to get the expected 9:3:3:1 ratio in the dihybrid F, progeny.
2. Linkage is the phenomenon of inheritance of genes together and to retain their parental combination even in the offspring .
3. Genes (alleles) present on the same chromosome normally do not show independent segregation because they are physically linked together (called as linked genes)
4. The characters controlled by linked genes are known as linked characters
5. Crossing over is a process of interchange of chromosomal segments between non-sister chromatids (closely present) of a homologous pair of chromosomes .
6. The analysis of the frequency of recombination between two genes allows the estimation of relative distance between them on a chromosome. The recombination frequency is measured by analysing the number of different phenotypes (original parental types versus the novel recombinant types) in the segregating populations originating from a single heterozygous individual.

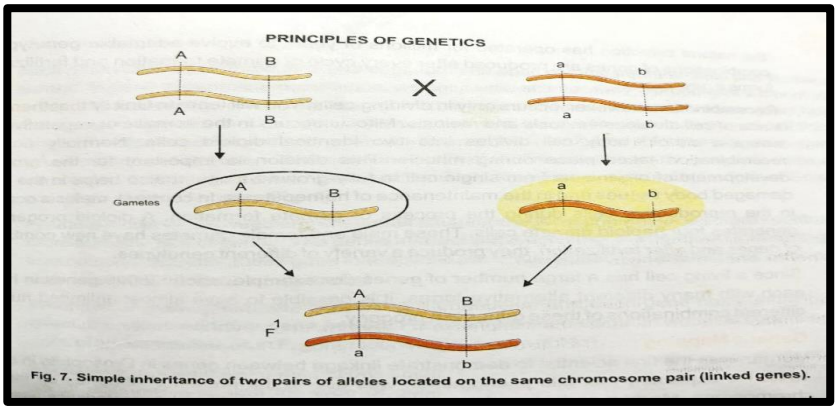


Fig. 7. Simple inheritance of two pairs of alleles located on the same chromosome pair (linked genes).

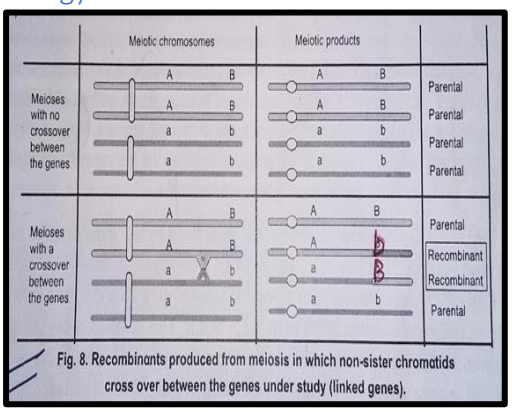
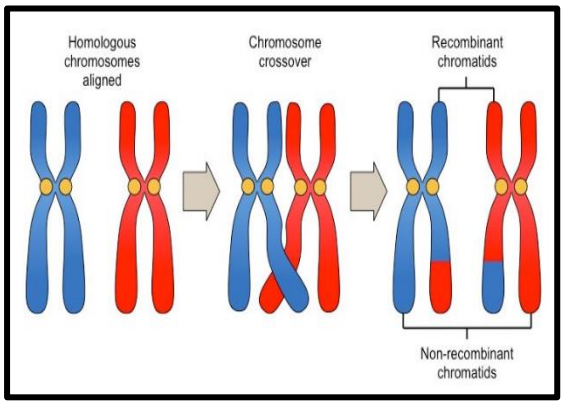


Fig. 8. Recombinants produced from meiosis in which non-sister chromatids cross over between the genes under study (linked genes).



GENETIC RECOMBINATION

1.Genetic Recombination may be defined as the exchange of genetic material between homologous chromosomes. The segments of DNA of a chromosome are exchanged with the other chromosome of pair and thus, it generates new combinations of genes.

2.Genetic recombination gives rise to different combinations of the existing allelic forms (multiple alleles) of the thousands of separate genes in a species.

3.Recombination is the basis of tremendous genetic in sexually reproducing organisms.

4.The process of sexual reproduction is designed to generate practically limitless combination of genes on which the natural selection has operated for millions of years to evolve adaptable genotypes.

5.New combination of genes is produced every cycle of gamete formation and fertilization that forms a new zygote.

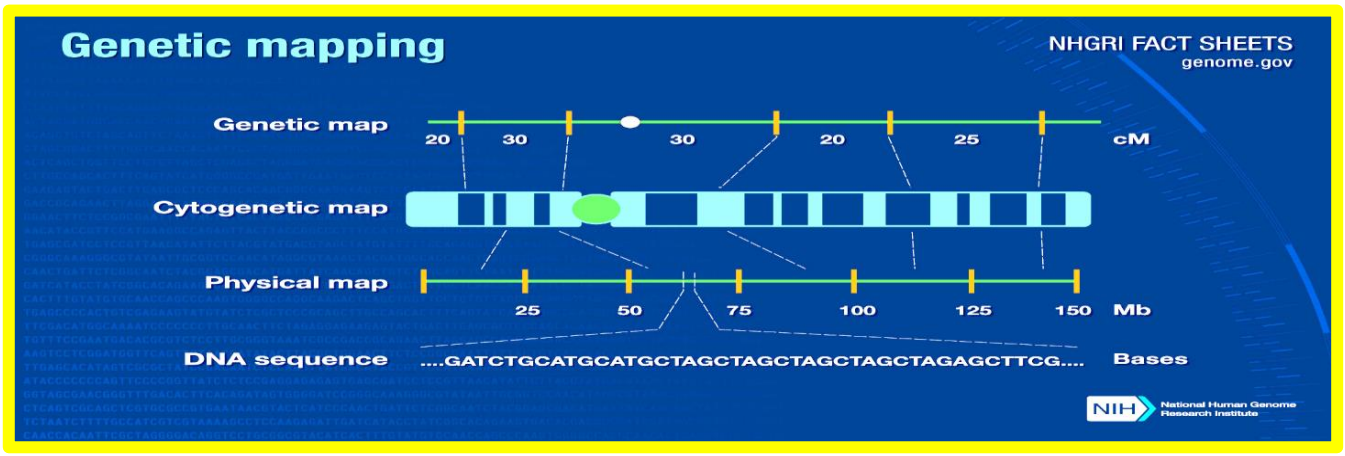
❖ GENETIC MAPPING

1.T.H Morgan was the first scientist to demonstrate linkage between genes in Drosophila in the year 1911. He explained that this phenomenon was due to the presence of genes on the same chromosome. Morgan and co-workers found numerous hereditary characteristics associated together in groups, the so-called linkage groups.

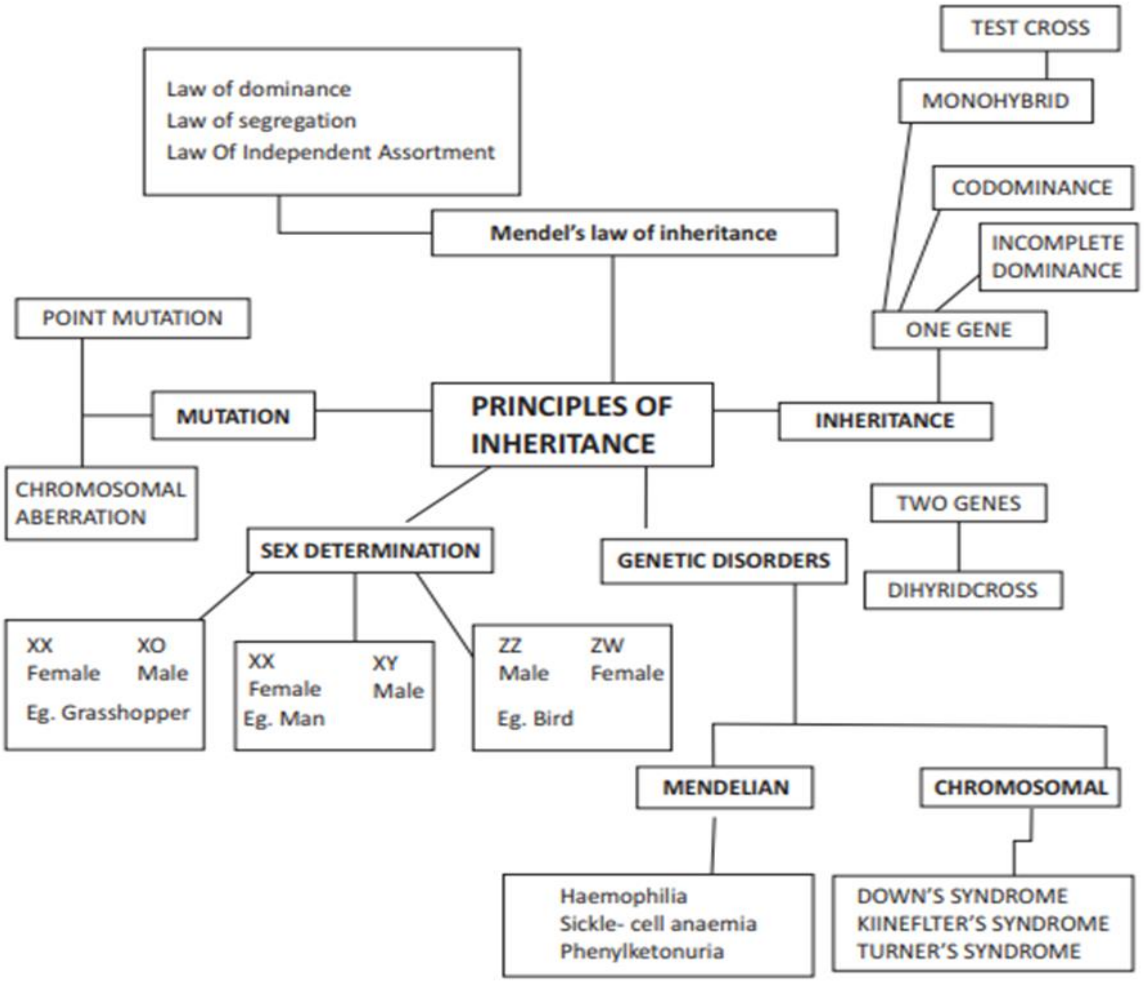
2.For example, white eyes, miniature wings, yellow body colour, etc. constituted a group of traits that were linked with the sex of Drosophila. They were four linkage groups in Drosophila.
3.Morgan also expressed the opinion that probably there was a relationship between the combination frequencies and of linked genes and their linear distance along the chromosome.
4.The basis of gene mapping can be best understood by taking the simplest example of three genes A, B and C located in a linear order on a chromosome.
5.We know the degree of separation between genes A and B and that between genes B and C, then it should be possible to estimate the distance between genes A and C.

Distance is calculated based on the recombination frequencies in the segregating progeny and is known as the genetic distance, which is often expressed in the unit centiMorgan (cM).
6.One cM corresponds to roughly one percent recombination frequency between the two genes.
7.In order to develop genetic maps of chromosomes, one not only needs to know the distance between genes but also their order along the chromosome. The order of genes can also be determined based on the recombination frequencies, in this case the frequency of double cross over.

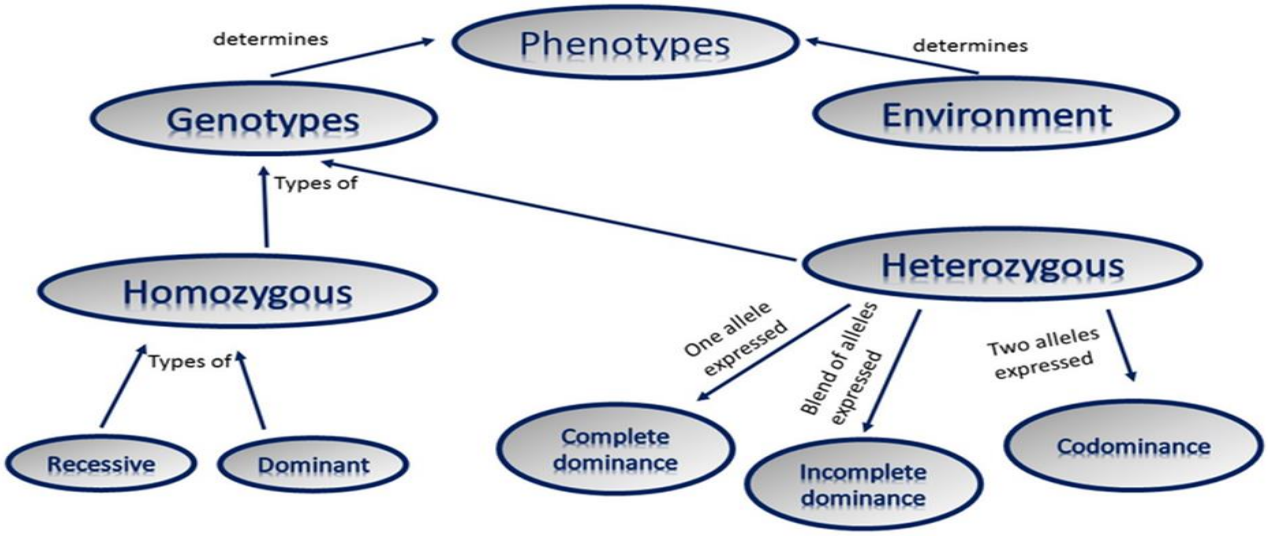
8.A common method used in mapping genes has been to measure recombination frequencies between three gene pairs segregating in a single cross, or a three-point cross. This is well illustrated by the work of Bridges and Olbrycht (1926) on three sex-linked characters in Drosophila


Genetic mapping
NHGRI FACT SHEETS
genome.gov
Genetic map
20
30
30
20
25
cM
Cytogenetic map
Physical map
25
50
75
100
125
150
Mb
DNA sequence
....GATCTGCATGCATGCTAGCTAGCTAGCTAGCTAGAGCTTCG....
Bases
NIH
National Human Genome Research Institute

CONCEPT MAP


TEST CROSS
MONOHYBRID
Law of dominance
Law of segregation
Law Of Independent Assortment
CODOMINANCE
Mendel's law of inheritance
INCOMPLETE DOMINANCE
POINT MUTATION
ONE GENE
MUTATION
PRINCIPLES OF INHERITANCE
INHERITANCE
CHROMOSOMAL ABERRATION
TWO GENES
SEX DETERMINATION
GENETIC DISORDERS
DIHYRIDCROSS
XX Female XO Male
Eg. Grasshopper
XX Female XY Male
Eg. Man
ZZ Male ZW Female
Eg. Bird
MENDELIAN
CHROMOSOMAL
Haemophilia
Sickle- cell anaemia
Phenylketonuria
DOWN'S SYNDROME
KIINEFLTER'S SYNDROME
TURNER'S SYNDROME

EXPRESSION OF TRAITS



QUESTION BANK

MULTIPLE CHOICE QUESTIONS (1 mark)

Q.1 Mendel's Law of Independent Assortment holds good for genes located on—

a) Non-homologous chromosome **b)Homologous chromosome**

c)Extra nuclear genetic material d)same chromosome

Q.2 What would be the genotype of the parents if the offspring have the phenotype in

1:1 proportion ?

a)Aa x Aa b)AA X AA c)Aa x AA **d)Aa x aa**

Q,3 The recombination frequency between the four linked genes is as follows :

I.Between X & Y is 40% II. Between Y & Z is 30%

III. Between Z & W is 10% IV. Between W & X is 20%

Select the option that shows the correct order of the position of W,X,Y & Z genes

on the chromosome .

a)Y-X-Z-W **b)Y-W-Z-X** c)X-Y-Z-W d)Z-X-Y-W

Q.4.In Antirrhinum RR is phenotypically red flowers, rr is white and Rr is pink.

Select the correct phenotypic ratio in F1 generation when a cross is performed between RR X Rr

a) 1red:2pink:1white b)2pink:1white

c)2red:2pink d)All pink

b)

Q.5 In a dihybrid cross, if you get 9:3:3:1 ratio it denotes that ---

a) the alleles of two genes are interacting with each other

b) it is a multigenic inheritance

c) it is a case ogf multiple allelism

d)the alleles of two genes are segregating independently

Q.6 Person having genotype IAIB would show the blood group as AB . This is because of

a)Pleiotropy **b)co-dominance**

c)segregation d)incomplete dominance

Q.7 Distance between genes & percentage of recombination shows----

a) a direct relationship b) an inverse relationship

c) a parallel relationship d) no relationship

Q.8 If a plant with genotype AaBb is self-fertilized, the probability of getting

AABB genotype will be (A and B are not linked)

a) 1/2 b) 1/4 c) 1/8 **d) 1/16**

Q.9 9:7 ratio in the F2 generation represents

a) Incomplete dominance b) Co-dominance

c)Epistasis d) Complementary interaction

Q.10 An exception to Mendel's law is

a) Independent assortment **b) Linkage**

c)Dominance d) Purity of gametes

Q.11 Homozygosity and heterozygosity of an individual can be determined by

a) Test cross b) Back cross
c) Self-fertilization d)All of the above

Q.12 If a colourblind woman marries an average-visioned man, their sons will be

a) **Three-fourths colourblind and one-fourth normal**
b) One-half colourblind and one-half normal
c)All normal visioned
d)All colourblind

Q.13 Farmers planted 200 kernels of corn and produced 140 tall & 40 short plants.

The genotypes of these offspring are likely similar:

a) TT, tt **b) TT, Tt, tt** c) TT, Tt d) Tt, tt

Q.14 What if the 25th codon (UAU) of the gene encoding a 50 amino acid polypeptide is mutated to UAA?

a) A 24 amino acid polypeptide is formed

b)A 25 amino acid polypeptide is formed

c)**A 49 amino acid polypeptide is formed**

d)Two polypeptides of 24 and 25 amino acids
are formed

Q.15 In most species, mitochondrial DNA is passed down from

a) DNA b) Mother and Father

c) Father **d) Mother**

SHORT ANSWER TYPE QUESTIONS SA-I (2 marks)

Q.1 Define genes, alleles, homozygous, heterozygous, monohybrid cross, dihybrid cross.

Ans. Genes: The basic hereditary unit of life.
Alleles: The different forms of a gene.
Homozygous: When all the alleles of a gene are identical.
Heterozygous: When the alleles of a gene are different.
Monohybrid cross: A *monohybrid cross* is a breeding experiment between parental generation organisms that differ in a single given trait.

Dihybrid cross: A *dihybrid cross* is a breeding experiment between parental generation organisms that differ in a two given traits.

Q.2 What are oligogenes and polygenes?

Ans. Oligogenes: A gene that produces or significantly affects the expression of a qualitative heritable characteristic, acting either alone or with a few other genes.

Polygenes: A gene whose individual effect on a phenotype is too small to be observed, but which can act together with others to produce observable variation.

Q.3 What are the Mendelian Laws of genetics?

Ans. Law of Dominance: Mendel's Law of Dominance states that recessive alleles will always be masked by dominant alleles.

Law of Segregation of genes: The Law of Segregation states that every individual organism contains two alleles for each trait, and that these alleles segregate (separate) during meiosis such that each gamete contains only one of the alleles.

Law of Independent Assortment: The Law of Independent Assortment states that alleles for separate traits are passed independently of one another from parents to offspring.

Q.4 What were the reasons behind Mendel's success?

Ans.

a) Selection of bisexual plant.
b) Record keeping and mathematical derivations.
c) Study of one character at a time.

Lucky in selecting traits that were present in different chromosomes.

Q.5 What is the difference between autosomes and sex chromosomes?

Ans. An autosome is a chromosome that is not an allosome (a sex chromosome). Autosomes appear in pairs whose members have the same form but differ from other pairs in a diploid cell, whereas members of an allosome pair may differ from one another and thereby determine sex.

Q.6 What is the difference between qualitative and quantitative inheritance?

Ans. The trait with quantitative genetic inheritance is caused by segregation of many gene pairs, each with small effect. At the same time the trait is influenced by a lot of minor environmental effects while qualitative inheritance follow Mendelian laws and are generally controlled by one or two genes.

Give some examples of traits controlled by qualitative & quantitative inheritance?

Qualitative inheritance: Blood type, enzyme defects.

Quantitative: Skin & eye colour.

Q.7 Define gene mapping by taking an example of your choice. Define Centimorgan (CM).

Ans: The basis of gene mapping can be best understood by taking the simplest example of three genes A, B and C located in a linear order on a chromosome.

We know the degree of separation between genes A and B and that between genes B and C, then it should be possible to estimate the distance between genes A and C. Distance is calculated based on the recombination frequencies in the segregating progeny and is known as the genetic distance, which is often expressed in the unit centiMorgan (cM).

One cM corresponds to roughly one percent recombination frequency between the two genes

Q.8 Explain the relation between gene expression and environmental control in quantitative gene expression.

Ans. P= G+ E, where P is total phenotype, G is the gene effect while E is the environmental effect

Q.9 Define linkage and crossing over.

Ans. Genes (alleles) present on the same chromosome normally do not show independent segregation because they are physically linked together (called as linkage) (Fig. 7). Still there is some degree of assortment during meiosis due to the process of crossing over involving breaking and rejoining (exchange) of DNA segments between homologous chromosomes

Crossing over is a process that breaks the original linkage between the genes present in chromosomes, The amount of such crossing over depends primarily upon the distance between the genes

Q.10 Diagrammatically show crossing over process and linkage.

Ans. Linkage

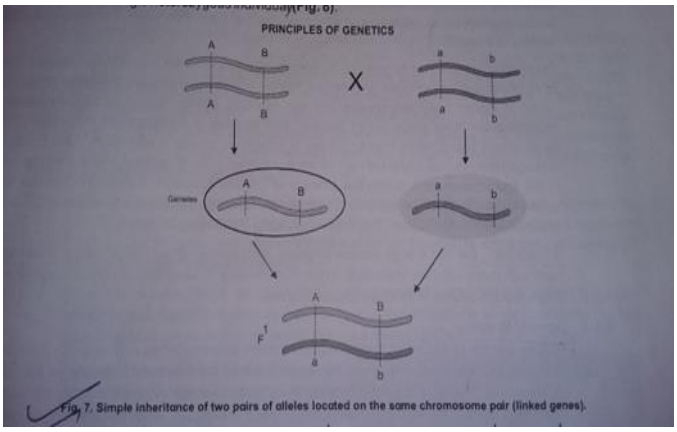


Fig. 7. Simple inheritance of two pairs of alleles located on the same chromosome pair (linked genes).

Crossing over

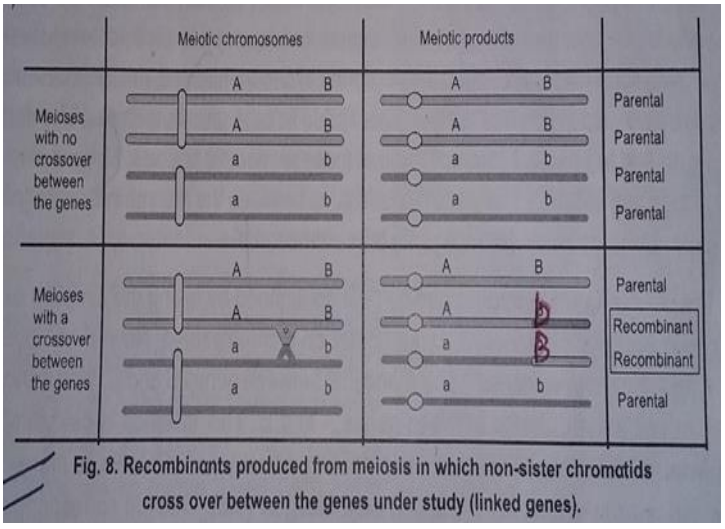


Fig. 8. Recombinants produced from meiosis in which non-sister chromatids cross over between the genes under study (linked genes).

SHORT ANSWER TYPE QUESTIONS SA-II (3 marks)

Q.1 *Explain sex linked inheritance with some examples.*

Ans. Genes that are carried by either sex chromosome are said to be sex linked. Men normally have an X and a Y combination of sex chromosomes, while women have two X's. Since only men inherit Y chromosomes, they are the only ones to inherit Y-linked traits. Men and women can get the X-linked ones since both inherit X chromosomes.

Eg: colour-blindness & Haemophilia in humans, eye colour in drosophila.

Q.2 *What is Linkage? How does it challenge Mendel's law of independent assortment?*

Ans. Genetic linkage is the tendency of genes that are close together on a chromosome to be inherited together during the meiosis phase of sexual reproduction.

It challenges law of independent assortment as the law states that all genes assort independently and new combinations are found in F2 while due to linkage parental combinations appear more in F2.

Q.3 What is crossing over? How does recombination frequency depend upon crossing over?

Ans. Chromosomal crossover (or crossing over) is the exchange of genetic material between homologous chromosomes that results in recombinant chromosomes during sexual reproduction during pachytene stage of meiosis.

Recombination frequency is a measure of genetic linkage and is used in the creation of a genetic linkage map. Recombination frequency is the frequency with which a single chromosomal crossover will take place between two genes during meiosis.

Q.4 What are multiple alleles? Give one example.

Ans. Multiple alleles is a type of non-Mendelian inheritance pattern that involves more than just the typical two alleles that usually code for a certain characteristic in a species. With multiple alleles, that means there is more than two phenotypes available depending on the dominant or recessive alleles that are available in

the trait and the dominance pattern the individual alleles follow when combined together.

The human ABO blood type is a good example of multiple alleles.

Q.5 Explain the chromosomal theory of inheritance in brief.

Ans.The chromosomal theory of inheritance was proposed independently by Sutton and Boveri.:

a) Like homologous chromosomes alleles are also in pairs.
b) Like homologous pair of chromosomes alleles also segregate during gamete formation.

Like homologous pair of chromosomes alleles also assort independently

Q.6 Differentiate between codominance and incomplete dominance.

Ans. Incomplete dominance: In the snapdragon, *Antirrhinum majus*, a cross between a homozygous white-flowered plant and a homozygous red-flowered plant will produce offspring with pink flowers This type of relationship between alleles, with a heterozygote phenotype intermediate between the two homozygote phenotypes, is called **incomplete dominance**.

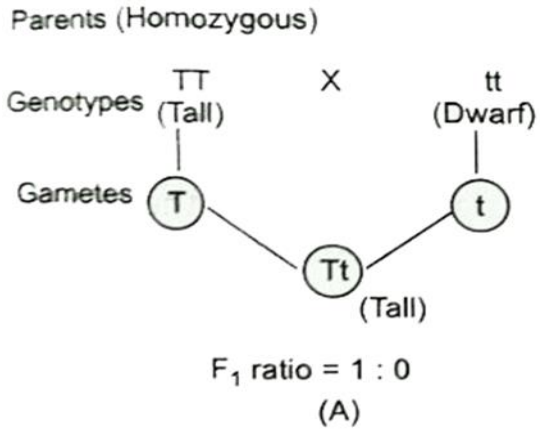
Codominance: In which both alleles are simultaneously expressed in the heterozygote. Eg. ABO blood group in humans.

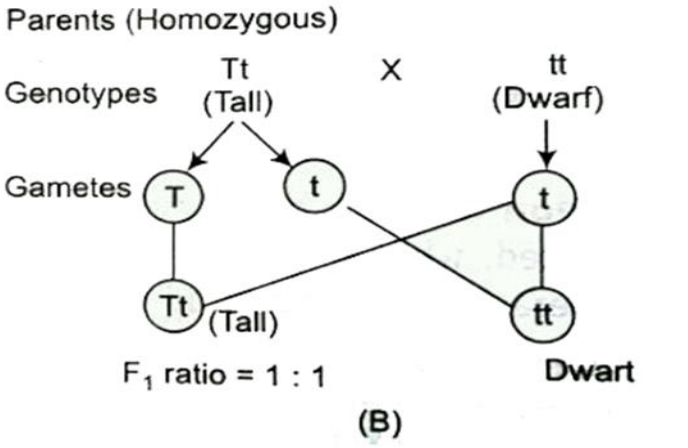
Q.7 Explain the Hardy-Weinberg's Law in brief.

Ans. The Hardy–Weinberg states that allele and genotype frequencies in a population will remain constant from generation to generation in the absence of other evolutionary influences, mutations and if there is random mating.

Q.8 Define test cross. Derive the value .

Ans A Test cross involves F1 individuals with the recessive parents . It helps to
determine whether a dominant phenotype is homozygous or heterozygous for a
specific allele .





Q.9 Taking an example of your choice prove the law of an independent assortment.

Ans Dihybrid cross- The alleles of two (or more) different genes
get sorted into gametes independently of one another

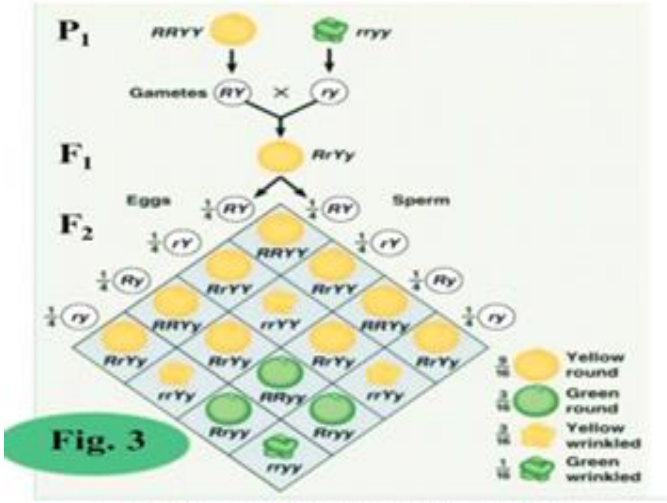


Fig. 3. The dihybrid cross between round, yellow seeds and wrinkled, green seeds in pea plant shows the independent assortment of characters in F2 generation.

Q.10 What do you mean by extranuclear inheritance ? What are the features of it ?

Ans. The inheritance due to the genes present in the cytoplasm and not on chromosome (mitochondria & chloroplast) is called Extranuclear or Cytoplasmic Inheritance .

The characters controlled by cytoplasmic genes show the features :-

i) Lack of Mendelian segregation and typical Mendelian ratio

ii)Governed by mitochondrial or chloroplast DNA

iii)They show maternal inheritance as these characters are usually transmitted only by ovules(uniparental maternal inheritance), with some exceptions where male parent (like pollen) can also contribute to cytoplasm.(biparental)

Eg:- Inheritance of leaf variegation of Mirabilis jalapa plant, inheritance pattern of petite mutants of Saccharomyces cerevisiae ,

LONG ANSWER TYPE QUESTIONS (5 marks)

Q.1 What are additive and non-additive gene interactions?

Ans. Additive genetic effects [Ratio 15:1]: A mechanism of quantitative inheritance such that the combined effects of genetic alleles at two or more gene loci are equal to the sum of their individual effects.

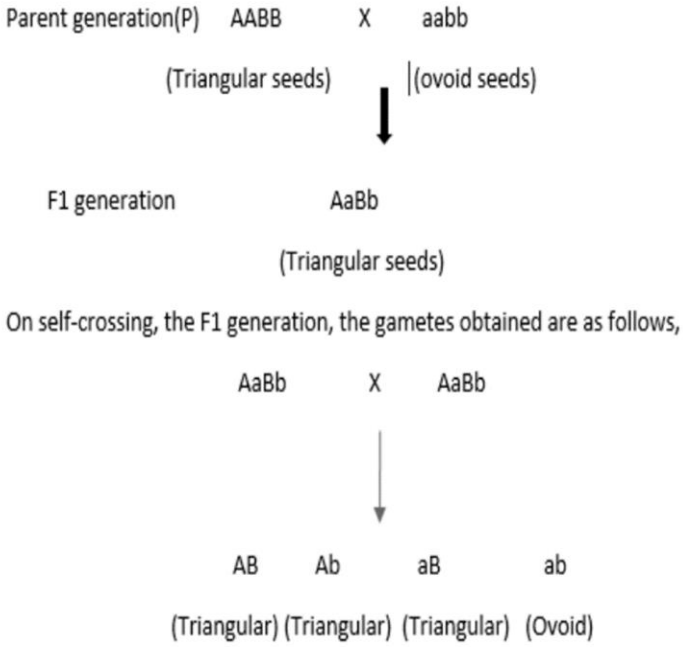
Non additive Interaction:

Epistasis: Epistasis is the interaction of different loci to produce a particular trait in a nonadditive way. Scientists have discovered that a great many traits depend on epistatic relationships among a number of different genes.

Complementary gene interaction [Ratio: 9:7]: Involves two pairs of non-allelic genes. When dominant forms of both the genes involved in complementary gene interaction are alone have same phenotypic expression. But, if they are present in combination, yield different phenotypic effect.

Supplementary Gene interaction [Ratio: 9:3:4]: Involves two pairs of non-allelic genes. One of the dominant gene has visible effect itself. Second dominant gene expresses itself when supplemented by the other dominant gene of a pair. Coat color (black, albino and agouti) of mice follows supplementary gene interaction.

Dominant Epistasis [12: 3: 1 Ratio]: When a dominant allele at one locus can mask the expression of both alleles (dominant and recessive) at another locus, it is known as dominant epistasis. In other words, the expression of one dominant or recessive allele is masked by another dominant gene.



Male / Female	AB	Ab	aB	ab
AB	AABB (T)	AABb (T)	AaBB (T)	AaBb (T)
Ab	AABb (T)	AAbb (T)	AaBb (T)	Aabb (T)
aB	AaBB (T)	AaBb (T)	aaBB (T)	aaBb (T)
ab	AaBb (T)	Aabb (T)	aaBb (T)	aabb (O)

RATIO – 15:1

Q.2 *Explain in brief the extra nuclear inheritance with the help of examples.*

Ans.; Extranuclear inheritance or cytoplasmic inheritance is the transmission of genes that occur outside the nucleus. It is found in most eukaryotes and is commonly known to occur in cytoplasmic organelles such as mitochondria and chloroplasts or from cellular parasites like viruses or bacteria.

Shell coiling in Limnae: In the snails (gastropods), the shell is spirally coiled. In most cases the direction of coiling of the shell is clockwise, if viewed from apex of the shell. This type of coiling is called dextral. However, in some snails the coiling of shell may be

counter clockwise or sinistral. Both types of coilings are produced by two different types of genetically controlled cleavages, one being dextral cleavage, another being sinistral cleavage.

Chloroplast inheritance in variegated four 'o' clock plant: Mirabilis contains three types of leaves and parts: (1) Full green leaves or branches having chloroplast, (2) White (pale) leaves and branches having no chloroplast, (3) Variegated branches having leukoplast in white (pale) areas and chloroplast in green patches. The nature of maternal leaf type decides the progeny leaf type.

Petite in yeast: The petite mutants in yeast fail to grow on carbon source such as glucose and produce smaller colonies (the "littles") when grown on sugars such as glucose.Since this difference can be observed only when such yeast cultures are kept in a oxygen-containing environment; so it is concluded that petite mutants have a defective aerobic respiratory mechanism. These petites differ from wild type, called grande and are characterized by (i) their insensitivity to inhibitors of aerobic pathways (such as cyanide), (ii) absence of cytochromes a, a_3, b and a number of other changes in mitochondrial respiratory enzymes; (iii) incomplete development of mitochondria; and (iv) lack of stainability of petite mitochondria. The petite mutants can be segregational, i.e., they follow Mendelian segregation and, therefore, presumably controlled by chromosomal genes. They may also be vegetative, i.e., non- segregational or extra-chromosomal. The genetic basis of petite character is a cytoplasmic factor which may be absent or defective in petites. Thus, a vegetative petite can be neutral or it may be suppressive. The neutral petites are not transmitted while suppressive petites are transmitted to a fraction of vegetative diploid progeny.

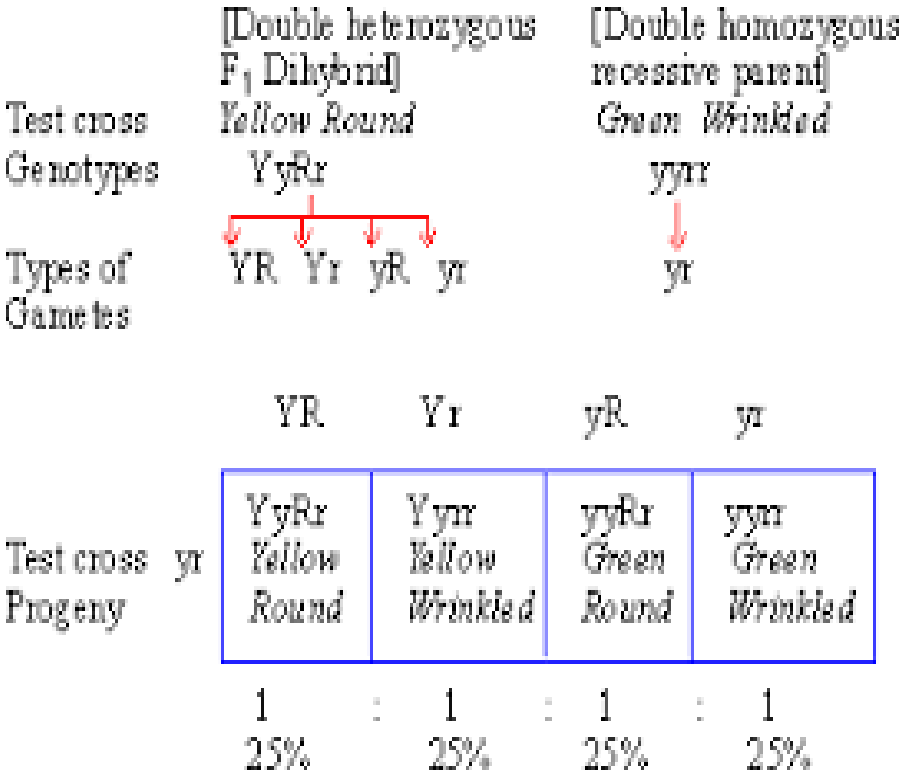
Q.3 A dihybrid heterozygous tall and yellow pea plant was crossed with the double recessive plant. (i) What type of cross is this?

(ii) Work out the genotype & phenotype of progeny

(iii)What principle of Mendel is illustrated through the result of this cross?

Ans: When a dihybrid heterozygous tall and yellow pea plant was crossed with the double recessive plant then (i) What type of cross is this?

Ans: This type of cross is known as a test cross. (ii) Work out the genotype & phenotype of progeny



(iii) What principle of Mendel is illustrated through the result of this cross? Ans: Through the result of testcross Mendel's Principle of Independent Assortment is illustrated. According to the principal, in the inheritance of contrasting characters, the factors of each pair of characters segregate independently of the factors of the other pair of characters.

Q.4 A double recessive plant was crossed with a dihybrid heterozygous round, yellow seeded garden pea (Pisum sativum).

a. What type of cross is this?
b. Find out the phenotype and genotype of the progeny
c. Which of Mendel's principles is illustrated through the result of this cross?

Ans. (a) When a double recessive plant was crossed with a dihybrid heterozygous round, yellow seeded garden pea (Pisum sativum) then, this type of cross is called a dihybrid test cross.

(b) Below given is the Work-out the phenotype and genotype of the progeny-

Gametes	(RY), (Ry), (rY), (ry)	X	(ry)	
Gametes	RY	Ry	rY	ry
F_1 progeny ry	RrYy Round, Yellow	Rryy Round and Green	rrYy Wrinkled Yellow	rryy Wrinkled Green
Phenotypic ratio	: 1	: 1	: 1	: 1
Genytopic ratio	: 1	: 1	: 1	: 1

(c) Through the result of the dihybrid test cross Mendel's principle of independent assortment is illustrated.

COMPETENCY – BASED QUESTIONS

Q.1 The human male never passes on the gene for haemophilia to his son. Why is it so?

Ans: The human male never passes on the gene for haemophilia to his son because the gene for haemophilia is present on the X chromosome. A male has only one X chromosome which he receives from his mother and the Y chromosome from his father. The human male passes the X chromosome to his daughters or female progeny and not to the sons or male progeny.

Q.2 A woman with an O blood group marries a man with an AB blood group (i) Work out all the possible phenotypes and genotypes of the progeny. (ii) Discuss the kind of dominance in the parents and the progeny in this case.

Ans: When a woman with an O blood group marries a man with an AB blood group then

(i) Work out all the possible phenotypes and genotypes of the progeny.

Ans: All the possible phenotypes of the progeny include blood groups A and B and genotypes of the progeny will be A Ii and B Ii because blood group AB has alleles A B I I and blood group O has ii which on the cross gives both types of blood groups A and B while the genotype of progeny will be A Ii and B Ii . Father's genes: A B I I Mother's genes: ii Therefore, the cross will be

Mother's genes→ Father's genes↓	i	i
I^A	I^Ai	I^Ai
I^B	I^Bi	I^Bi

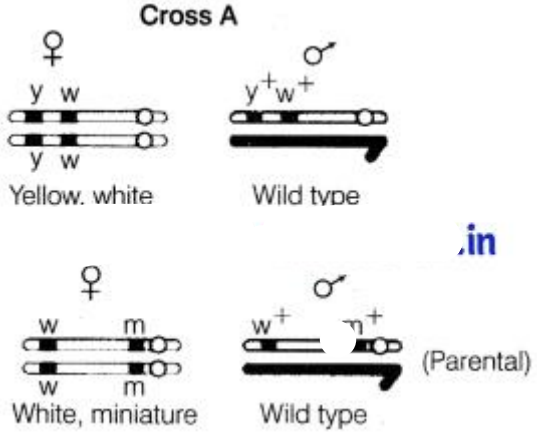
(ii) Discuss the kind of dominance in the parents and the progeny in this case.

Ans: In the above-mentioned case, the kind of dominance in the parents and the

Q.3A man with AB blood group marries a woman with O group blood.
(i) Work out all the possible phenotypes and genotypes of the progeny.
(ii) Discuss the kind of domination in parents and progeny in this case?

Ans: When a man with AB blood group marries a woman with O group blood then (i) Half the progeny will have blood group A with genotype A O I I & half the progeny will have blood group B with genotype B O I I .
(ii) In this case both the genes A I and B I are dominant over the O I gene therefore the progeny shows either blood group A or B. Since in parents both the dominant genes are present together this phenomenon is called codominance.

Q.4 Study the figures given below and answer the question



Identify in which of the crosses, the strength of linkage between the genes is higher. Give reasons in support of your answer. (Foreign 2014)
Ans:
The strength of linkage is higher in the cross A than in cross B

because linkage is higher when two genes are present closely on the same chromosome than those genes which are far apart. In cross B, the chances of crossing over or recombination are higher because the genes are loosely linked.

Q.5 In a dihybrid cross, white-eyed, yellow-bodied female Drosophila crossed with red-eyed, brown-bodied male Drosophila produced in F_2-generation 1.3% recombinants and 98.7% progeny with parental type combinations. This observation of Morgan deviated from Mendelian F_2-phenotypic dihybrid ratio. Explain, giving reasons Morgan's observation.
Ans:
The results obtained were due to the linkage. It is the phenomenon in which two or more linked genes are inherited together and their frequency of recombination in a test cross progeny is less than the expected 50%. In Morgan's experiment on Drosophila, the genes for eye colour and body colour show linkage and do not allow crossing over during gamete formation. Hence, parental type progeny is in greater ratio than that of recombinants.

ASSERTION – REASONING QUESTIONS

Q.1 Assertion: A gamete contains a single allele for each trait.
Reason: During gametogenesis, the two alleles of each trait segregate, on passing into each gamete at random.

Ans. A- Both A & R are correct and R is the correct explanation of A

Q.2 Assertion: In four -O' clock or snapdragon plant, a cross between a homozygous white-flowered individual and a homozygous red-flowered one produces pink-flowered plants.
Reason: In these plants, the flower colour is determined by three alleles.

Ans: C – A is true but R is false.

Q.3 Assertion: In a person with AB blood group, the erythrocytes carry both A and B antigen on their surface.
Reason: The alleles I^A & I^B that produce AB blood group, are codominant and both are expressed.

Ans A- Both A & R are correct and R is the correct explanation of A

Q.4 Assertion: Frequency of crossing overs is higher than the observed frequency of recombination of traits in the offsprings.

Reason: More than one cross over many occur simultaneously between the same chromatids.

Ans. A-If both A and R are true and R is the correct explanation of A.

Q.5 Assertion: A woman is capable of suing a man of refusing to own a child, who has blood group O. The man has blood group B and woman has A.

Reason: She is right as genetically; he can be the father of the child.

Ans:- A both A and R are true and R is the correct explanation of A.

Q.6 Assertion: There is expression of only one gene of the parental character in Mendelian monohybrid cross in F1 generation.

Reason: In a dissimilar pair of factors one member of the pair dominates the other.

Ans:- B Assertion & Reason both are correct but reason is not correct explanation of assertion

Q.7 Assertion: When the two genes in a dihybrid cross are situated on the same chromosome, the proportion of parental gene combinations is much higher than non-parental type.

Reason: Higher parental gene combinations can be attributed to crossing over between two genes.

Ans. C Assertion is correct statement but reason is wrong statement

Q.8 Assertion: Haemophilia never occurs in female.

Reason: Genes for Haemophilia located on X-Chromosome

Ans. D- Assertion is wrong statement but reason is correct statement.

Q.9 Assertion: - Mendel used true-breeding pea lines for artificial pollination experiments for his genetic studies.

Reason: For several generations, a true-breeding line shows the stable trait inheritance and expression.

Ans.- A -Both A and R are true and R is the correct explanation of A

Q.10 Assertion: In human the genotype with all the dominant alleles (AABBCC) will express darkest skin colour.

Reason: In a polygenic trait, phenotype reflects the contribution of each allele.

Ans- A -Both A and R are true and R is the correct explanation of A

CASE-STUDY – I

Read the following passage and answer the given questions:

Hybridisation experiment carried out by Mendel where he crossed tall and dwarf pea plants to study the inheritance of one gene. He collected the seeds produced as a result of this cross and grew them to generate plants of the first hybrid generation. This generation is also called the Filial1 progeny or the F1. Mendel observed that all the F1 progeny plants were tall, like one of its parents; none were dwarf (Figure 5.3). He made similar observations for the other pairs of traits – he found that the F1 always resembled either one of the parents, and that the trait of the other parent was not seen in them.

I. If a plant heterozygous for tallness is crossed with homozygous dwarf plants, what will be the proportion of plants produced in F2 generation? What type of cross is it? (2)

Ans. Tall (Tt) – 50% Dwarf (tt) – 50 % Phenotypic ratio - 1:1 Genotypic Ratio-1:1

Test Cross

II. At what stage the separation of alleles occurs during hybridisation as per Mendel's principle of segregation? (1)

Ans. Gamete formation

III. In a monohybrid cross the F2 progeny shows ¾ proportion tall plants and ¼

proportion dwarf plants, what is the proportion of homozygous plants in F2 generation? (1)

Ans- 50%

CASE-STUDY – II

Mendelian disorders are mainly determined by alteration or mutation in the single gene. These disorders are transmitted to the offspring on the same lines as we have studied in the principle of inheritance. The pattern of inheritance of such Mendelian disorders can be traced in a family by the pedigree analysis. Most common and prevalent Mendelian disorders are Haemophilia, Cystic fibrosis, Sickle cell anaemia, Colour blindness, Phenylketonuria, Thalassemia, etc.

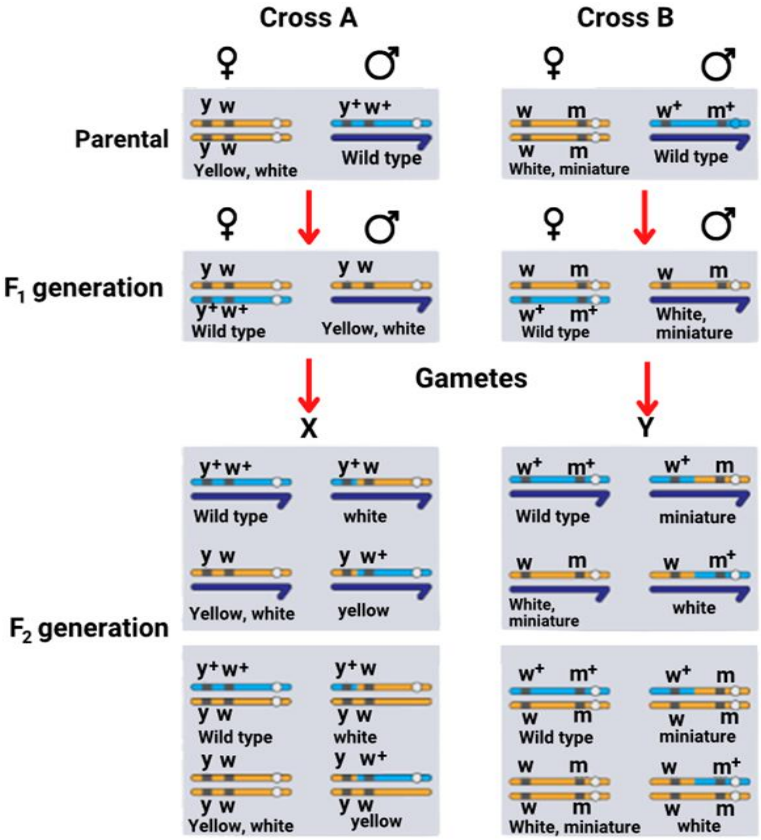
I. Which disease related to blood disorder is called Royal disease? (1)

Ans.- Haemophilia

II. Cystic fibrosis is an autosomal recessive genetic disorder. What are the chances that the child would have the disease if any one of the parents (either mother or father) is a carrier of the faulty cystic fibrosis gene (Cc)? (1)

Ans. 0 percent

III. If the father in a family has a disease while the mother is normal, the daughters only are inherited by this disease and not the sons. Name this type of disease? Give an example of X-linked recessive chromosomal disorder. (2)



Ans. Sex-linked dominant, Color blindness, Haemophilia

CASE-STUDY – III

During a study of inheritance of two genes, teacher asked students to perform an experiment. The students crossed white eyed, yellow bodied female Drosophila with a red eyed, brown bodied male Drosophila (i.e., wild). They observed that progenies in F_2 generation had 1.3 percent recombinants and 98.7 percent parental type combinations. The experimental cross with results is shown in the given figure. [**Note**: Dominant wild type alleles are represented with (+) sign in superscript.]

(i) In the given experiment, identify the linked genes ? What are linked genes

Ans. Genes for eye colour and body colour are linked (1)

Linked gene remain together , are inherited together & retain their parental combination in the progeny

(ii) Genes white eyed and yellow bodied located very close to one another on the same chromosome tend to be transmitted together, what do we call them? (1)

Ans- Linked genes

(iii) State any two conclusions that can be drawn from the above Experiment? (2)

Ans.(a) The physical distance between two genes determines strength of linkage

(b) The physical distance between two genes determines frequency of crossing over

CHAPTER – 2:- GENES AND GENOMES: STRUCTURE AND FUNCTION

❖ DISCOVERY OF DNA AS GENETIC MATERIAL

1.In 1928, Frederick Griffith studied the bacterium Streptococcus pneumoniae (also called Diplococcus pnemoniae) that causes human pneumonia.

2.There are two strains:

a) one of the strains has polysaccharide capsule on cell wall. This strain gives rise to smooth edged colonies when grown on appropriate media and are thus called ' Type S ' . Such strains are virulent.

b) mutate strain, give rise to the nonvirulent form that lacks the polysaccharide capsule. They produce rough-edged colonies on appropriate media and are thus, designated as 'Type R'.

A. GRIFFITH'S EXPERIMENT

1.When the R strain was injected into the mice. The mice survived as R cell were avirulent strains.

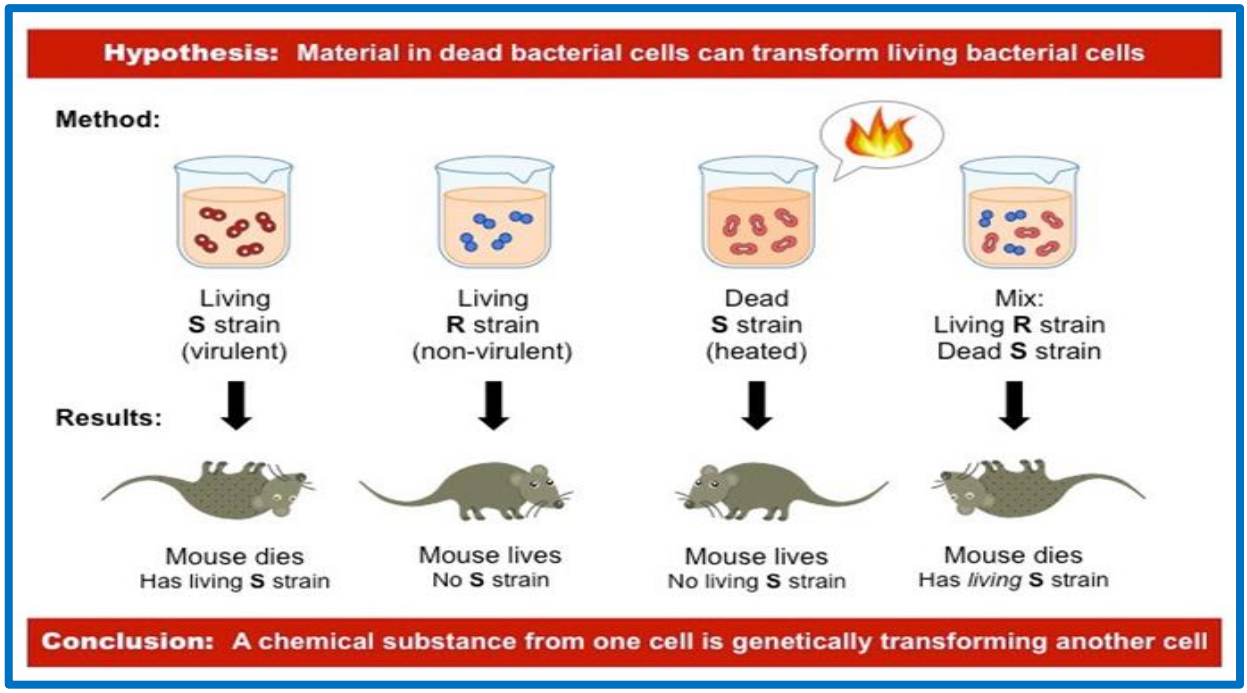
2.When the S strain was injected into the mice. The mice died as the S cell were virulent strains.

3. when he killed some virulent S cells by boiling them and injected these heat-killed S cells into mice. The mice survived,

4.when mice were injected with a mixture of heat-killed S cells and live R cells, the mice died as a result of pneumococcal infection. ➢Furthermore, the bacteria isolated from a mouse that had died from such a mixed infection were only of the S type.

➢These results showed that the live R cells had somehow been replaced by or transformed to S bacteria.

➢Conclusion: 'Transforming principle' present in the cell debris of S cells which is responsible for the observed transformation of R cells to S cells.



B. IDENTIFICATION OF DNA AS THE TRANSFORMING PRINCIPLE

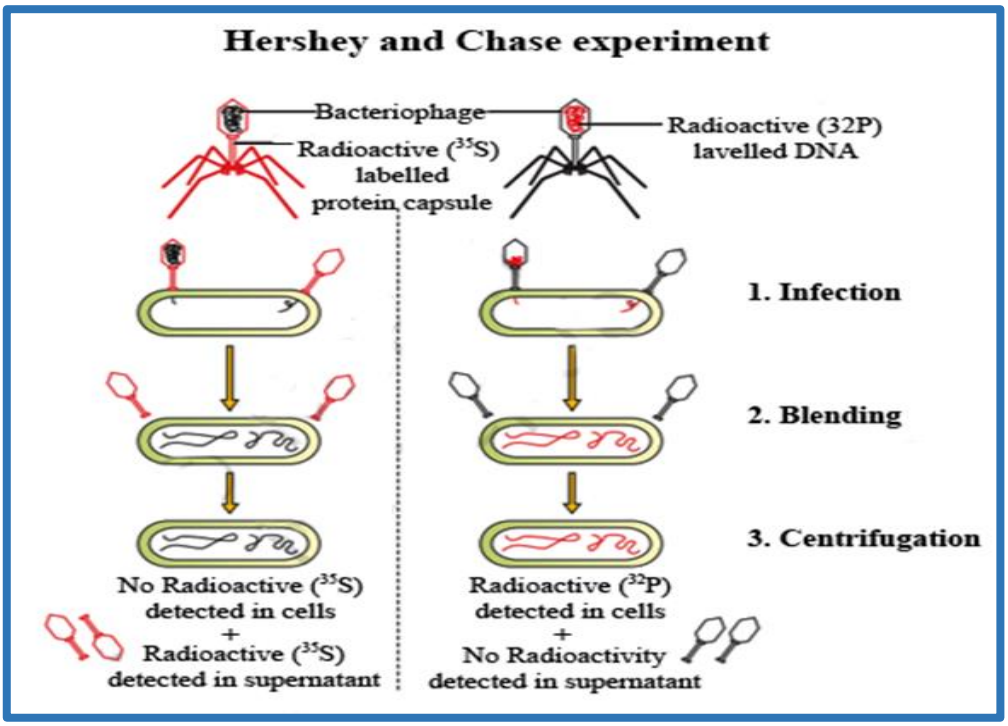
•The nature of transforming factor was confirmed by Oswald Avery, Colin MacLeod, and Maclyn McCarty in 1944.
•They prepared a filtrate of heat-killed S cells and treated it with hydrolytic enzymes that degrade: DNA, RNA and proteins.
•Cell-filtrate treated with DNA degrading enzyme lost its transforming ability. But those treated with either RNA or protein degrading enzymes retained the ability to transform the R cells into the S cells. So the transforming principle was identified as DNA.

C. 1. A Hershey and M. Chase performed an experiment using bacteriophage T2 in 1952, which finally proved that DNA is the genetic material.

2. Bacteriophage T2 is a virus, which infects the bacteria Escherichia coli.
3. This virus is made up of DNA and proteins. When bacteriophage infects bacteria, complete virus does not enter in the bacterium but only some part of virus.
4. After some time the bacterial cells lyse and large number of phase particle are released.

D. THE HERSHEY -CHASE EXPERIMENT:

1. In experiment one, they specifically labelled the DNA by growing them in presence by radioactive isotope of phosphorus. As the protein does not contain phosphorus only DNA was radiolabelled.
2. In another experiment the virus protein was specifically labelled by radioactive sulphur containing amino acid cystein.
•These radio-labelled viruses were used to infect the E. coli.
•After certain period of time coat of virus was removed from the bacterial surface by physical shearing.
•The bacterial cells were pelleted by centrifugation leaving viral coat in supernatant. The supernatant showed 35S radioactivity.
• whereas the bacterial pellet showed 32P radioactivity.
•Therefore it was confirmed that only DNA of virus entered in the bacterial cells not protein and DNA of virus was responsible for the formation of large number of viral progeny.



❖ DNA REPLICATION

1.James Watson and Francis Crick suggested a model for DNA duplication based on the specific (complementary) base pairing that occurs between the nitrogenous bases of the two strands of a DNA molecule.

2. The two strands of the double helix separate and each of the separated parental strands then act as a template for the synthesis of a new complementary daughter strand.

3. This mode of DNA replication is called semi-conservative replication.

4. The evidence for this model, however, came from the experiment performed by M.S. Meselson and F. W. Stahl in 1958.

1. MESELSON AND STAHL EXPERIMENT

➢This experiment was performed to prove the semi conservative nature of DNA replication. Matthew Meselson & Franklin Stahl experimented with bacteria E.coli in 1958.

Step 1. E.Coli was grown in a medium with N-15 for several generations

•Step 2. E.coli with only N-15 in their DNA were transferred to a medium with N-14

•Cells of E.coli were allowed to divide. Sample was taken and DNA was extracted periodically as cell division continued to check what type of DNA is being formed now. One replication in E.coli takes around 20 minutes. So, generation I is formed in 20 minutes.

•Therefore samples are taken after 20 minutes, then again after 40 minutes. Densities of DNA from the sample were measured to reach to results & conclusion.

2. Results

•Generation I: DNA was found to have intermediate density after 1 replication

•Generation II: Equal amounts of DNA with two different densities were found.

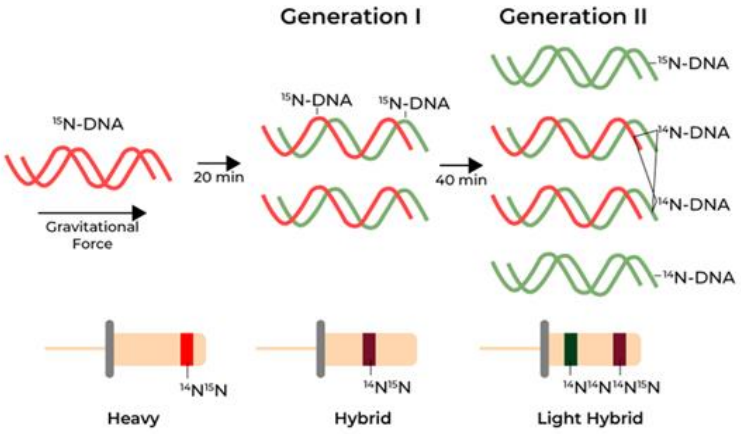
3. Conclusion

a)Presence of a hybrid/ intermediate density excluded Conservative hypothesis. Had it been Conservative hypothesis, Generation 1 would have been either Blue(N-15) or Green(N-14); and not an Intermediate one.

b) Presence of N-14 DNA in Generation II excluded Dispersive hypothesis. If it was Dispersive, each DNA should have had the same density. But, in Generation II, we could see 50% of the DNA have intermediate density, whereas remaining 50% have N-14 density.

c)Semi-conservative hypothesis could explain the entire experimental result. Separation of strands concept could explain the outcomes of Generation I & II.

d)Thus, it was proved that DNA replication is Semi-conservative in nature.



4. Replication usually starts at a specific site on a DNA sequence known as the origin of replication. •The bacterial chromosome consists of a single origin of replication, whereas the eukaryotic chromosomes contain multiple origins of replication.

   •The point at which replication occurs is termed as the replication fork. It is sometimes also called the growing point.

5. ENZYMES IN DNA REPLICATION

(i) Topoisomerases: This enzyme is required for the initiation of the unwinding of DNA. Nicking and relegating DNA by topoisomerases relieve the tension holding the helix in its coiled and supercoiled structures.

(ii) Helicases: These enzymes unwind the original double helix, once supercoiling has been removed by topoisomerases. Helicases disrupt the hydrogen bonds holding the two strands of DNA together. This activity requires energy that is generated by the hydrolysis of ATP.

(iii) Single-strand binding proteins (SSBs): These proteins selectively bind to the single-stranded DNA region produced by the action of helicases. SSBs prevent the single stranded region of DNA from reforming the duplex state during replication.

(iv) DNA polymerases: ▪This enzymes are responsible for the synthesis of new DNA.

•DNA polymerases can synthesize DNA only in the 5' to 3' direction.

•They extend the DNA chain by catalysing the formation of a phosphodiester bond between the 3'-hydroxyl end of the growing DNA chain and the 5' phosphate of the incoming deoxy-ribonucleoside triphosphate (dNTP).

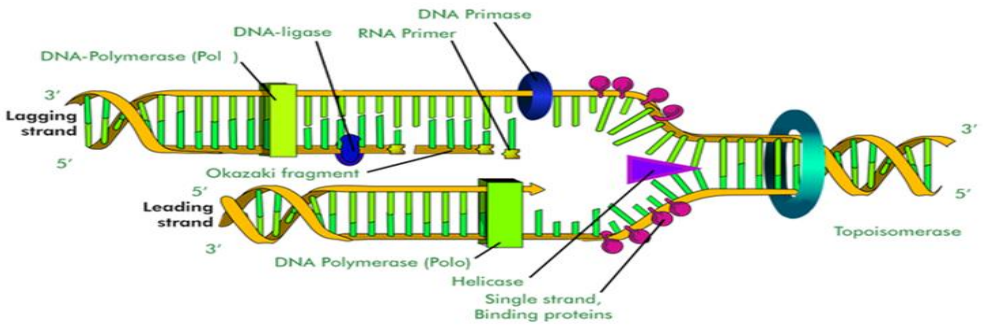
•The dNTP is governed by complementary base pairing with the template strand.

•This activity catalyses the removal of nucleotides one by one from the 3' end of the polynucleotide chain to correct the occasional base pairing error that may occur during strand synthesis. This is called proofreading

E. coli DNA polymerase I has 5' to 3' exonuclease activity as well. This activity is required for the removal of RNA primers during the synthesis of the lagging strand.

(v) Primase: The requirement for the free 3'-hydroxyl group is fulfilled by a short fragment of RNA that is synthesized at the initiation sites by the enzyme Primase in E. coli and DNA polymerase in eukaryotes. RNA primers is almost certainly the most common mechanism for initiating DNA synthesis,

(Vi) DNA ligase: This enzyme seals any nicks in the DNA by forming a phosphodiester bond between 3'-hydroxyl and 5'phosphate groups.



6. **SEMI-DISCONTINUOUS REPLICATION**:

a) During DNA replication one of the newly synthesized strands is polymerized in the 5' to 3' direction, while the other strand is polymerized in the 3' to 5' direction.

•b) Synthesis of the 3' to 5' strand (called the lagging strand), is synthesized discontinuously as a series of short DNA fragments. Each of these fragments is synthesized with the usual 5' to 3' polarity and is referred to as Okazaki fragment, after R. Okazaki, who first identified them.

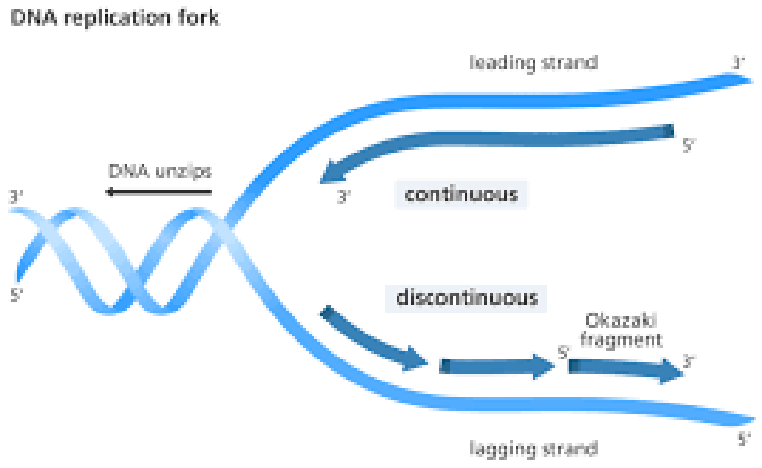
c)In case of bacteria, these fragments are 1000-2000 nucleotides in length, but in eukaryotes, these fragments are probably less than 200 nucleotides long.

d)Finally these separate Okazaki fragments are joined together to produce the daughter strand. •The other strand which grows overall in the 5' to 3' direction (called the leading strand) is synthesized continuously.

e) During DNA replication, one strand is synthesized continuously and the other strand is synthesized discontinuously, replication is said to be semi-discontinuous.

f) For the synthesis of the lagging strand, priming is a repeated process that must occur every time a new Okazaki fragment is initiated. This would leave the lagging strand not as a single piece of DNA, but as a series of disconnected short pieces of DNA attached to RNA primers.

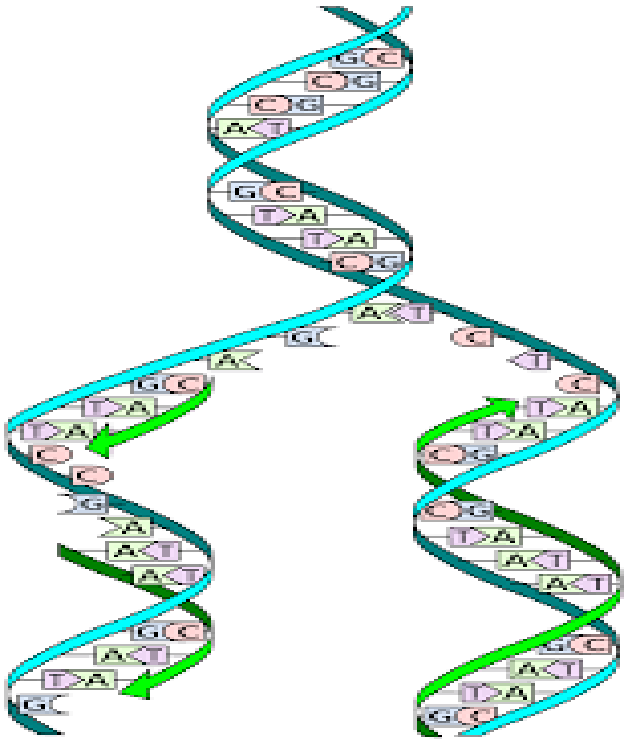
g) In E. coli, the RNA primers are excised by the 5' to 3'exonuclease activity of DNA polymerase I and the new DNA is synthesized by the 5' to 3’ polymerase activity of the same enzyme. The adjacent Okazaki fragments are then joined together by ligase, to form an intact lagging strand.



❖ FINE STRUCTURE OF GENES

1. A gene can be defined as a segment of DNA, which carries biological information for the formation of some RNA molecule (non-coding genes) or polypeptides (coding genes).
Some of the examples of non-coding genes are: rRNA, tRNA and microRNA genes.

2.Each gene (coding region) carries:
a) Promoter (controlling elements present at the upstream region and drives the expression of gene).
b)Terminator (that is present at the downstream region of the gene and is involved in the termination of transcription).

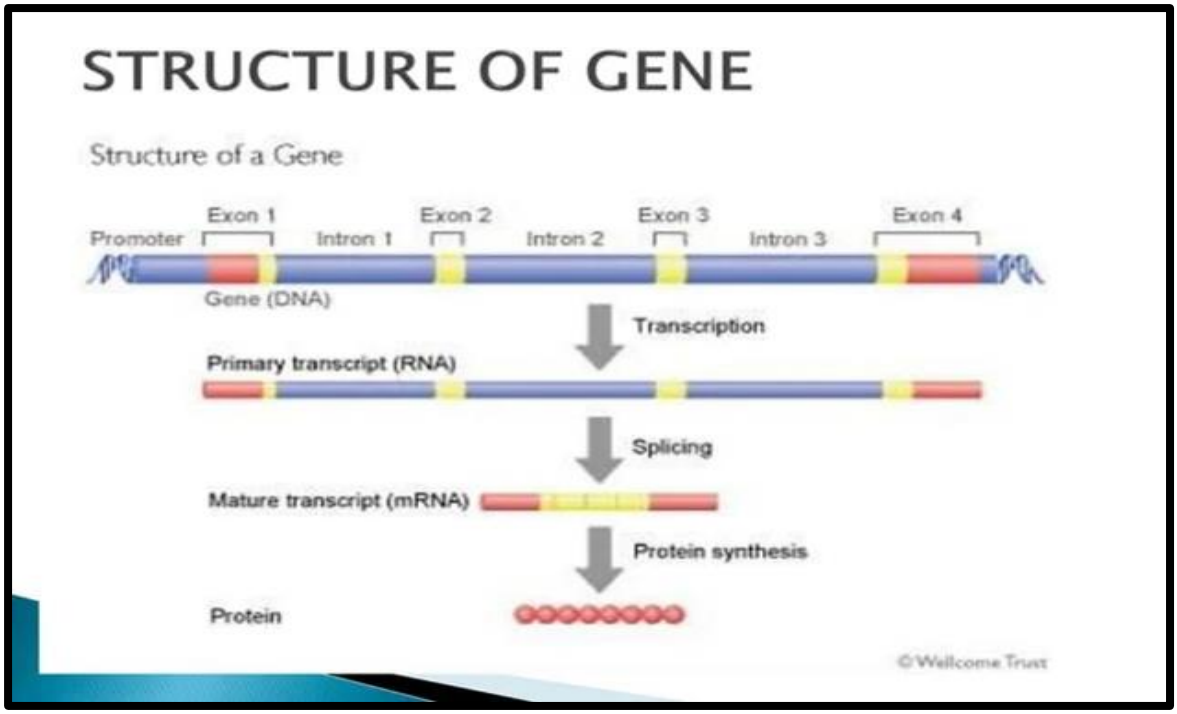


3.The biological information carried by a gene is present in its nucleotide sequence, which is essentially a set of instructions for the synthesis of an RNA molecule that may eventually produce a polypeptide chain. This process is known as gene expression.

4.Genes may consist of stretches of intervening DNA sequences, which do not carry any message (introns) along with the regions that contain biological information (exons). Such genes are known as 'split genes' (also called discontinuous genes or mosaic genes), and are common in higher organisms, including humans.
The number of introns in a gene may vary from none to more than a hundred.

5.Organisms have a mechanism to remove introns after transcription of a gene. This process is called RNA splicing.

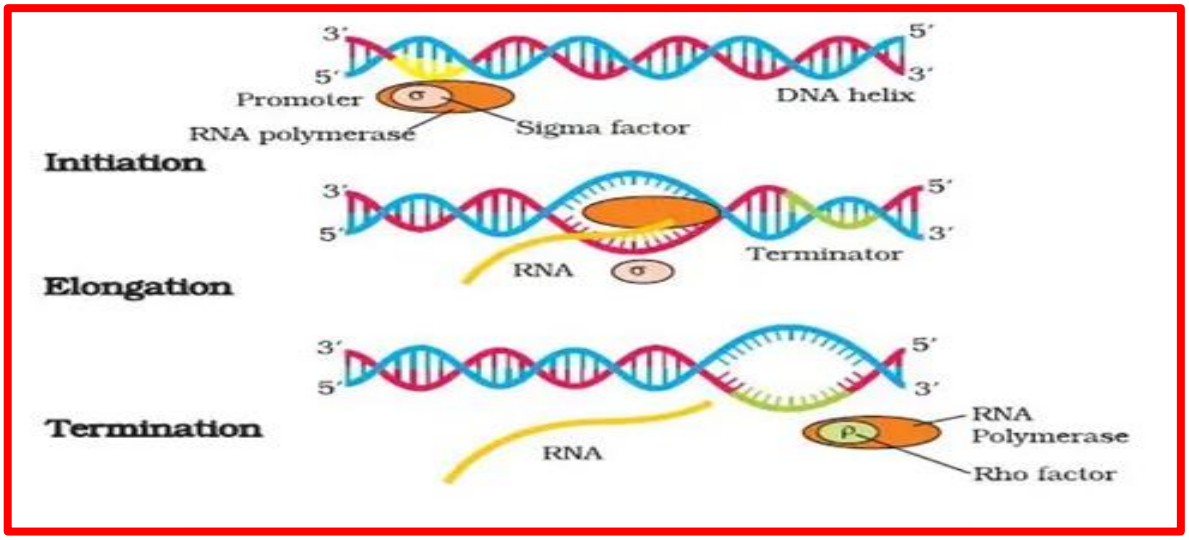
Some genes may lose the biological information they had once coded for as a result of mutations, so that they are no longer functional. Such genes are known as PSEUDOGENES



❖ FROM GENE TO PROTEIN

1. The RNA, which acts as a 'carrier' of the genetic information from nucleus to the cytoplasm, is called the messenger RNA or mRNA.
2. The process of synthesis of mRNA from a DNA template is known as transcription.
3. The gene information can be amplified by having many copies of the mRNA made from a single copy of DNA.
4. Once the mRNA is synthesized as a complimentary copy of one of the strands of DNA that make up a gene, it moves into the cytoplasm. In the cytoplasm, it serves as a template for the synthesis of proteins by a process known as translation.
5. Therefore, the flow of information in cells is: DNA RNA Proteins.
6. This is also referred to as 'central dogma' in molecular biology.

7. In case of retroviruses, where the genetic material is RNA, the RNA is converted by a process of reverse transcription into a single- stranded DNA, which is then converted into double-stranded DNA



❖ TRANSCRIPTION – THE BASIC PROCESS

It is the process of transfer of sequence information from DNA to RNA.

1.The DNA strand whose nucleotide sequence is complementary to that of the mRNA is called the template or anti- sense strand.

2. The other strand whose base sequence is identical to that of the mRNA (except for T in DNA to U in RNA) is called the sense or coding strand.

3.The enzyme responsible for transcription in both prokaryotes and eukaryotes is called DNA- dependent RNA polymerase or more commonly as RNA polymerase.

4.This enzyme moves along the template DNA synthesizing RNA in the 5' to 3' direction.

5.RNA polymerases do not require a primer. The DNA site to which an RNA polymerase molecule binds to accomplish initiation is called promoter.

The first nucleotide corresponding to the position at which transcription begins is labelled as +1 and is called the transcription start site.

6.A single RNA polymerase is responsible for the synthesis of all mRNA, rRNA and tRNA in the eubacterium E. Coli.

7.This enzyme can be separated into two components –

a)The core enzyme: The core enzyme is comprising two copies of the á subunit and one copy each of the â and â' subunits. It has a general affinity for DNA and is responsible for elongating the RNA chain.

b)A sigma factor : When the core enzyme is joined by the sigma factor, the resultant holoenzyme loses much of its affinity for random DNA and binds tightly to the promoter sequence.

TRANSCRIPTION MECHANISM:

1. RNA synthesis now begins within a transcription bubble, in which the two strands of DNA are separated to make the template strand available for base pairing with the incoming rNTP.

2. The holoenzyme synthesizes the first phosphodiester bond in the RNA chain and initiation is thus achieved.

3.At this point, the sigma factor dissociates and the remaining core enzyme now released from the promoter moves down the gene extending the RNA chain.

4.The elongation of the RNA chain continues till the RNA polymerase reaches the terminator sequence in DNA.

Here the enzyme stops adding nucleotides to the growing RNA chain, releases the RNA transcript and dissociates from the DNA template.

1. In case of eukaryotic cells, the situation is slightly more complex.

✓There are three different RNA polymerases transcribing the different classes of RNA molecules:

a)RNA polymerase I transcribes rRNA

b)RNA polymerase II transcribes mRNA

c)RNA polymerase III transcribes tRNA and other small RNAs.

✓Each of these polymerases contains 8- 14 subunits.

✓Difference between the E. Coli and eukaryotic RNA polymerases is that none of the eukaryotic RNA polymerases can directly recognize the promoter.

✓Another difference between mRNA production in prokaryotes and eukaryotes is that in case of eukaryotes, all three major types of RNAs, i.e., mRNA, rRNA and tRNA, are derived from a precursor RNA molecule termed the primary transcript or pre-RNA.

2. **PROCESSING REACTIONS RNA TRANSCRIPT INCLUDE:**

(i)modification at the 5' end of the primary RNA transcript called capping. During capping, an extra guanosine residue is first added to the terminal . This guanosine residue is then further modified by addition of methyl groups.

(ii)addition of a string of adenosine residues, forming a poly (A) tail at the 3' end of the mRNA (called as polyadenylation).

(iii) removal of those parts of the introns from the primary transcript. This process of removal of introns and joining together of the exons is known as splicing.

❖ GENETIC CODE

1.Since there are twenty different amino acids and only four different bases. However, a combination of three nucleotides could specify 64 amino acids.

2.Each amino acid is indeed coded by a sequence of three nucleotides (triplet) called a codon. The triplet code for each amino acid would thus provide 64 different codons in the genetic code.

3.General properties of the genetic code were known by 1961. The experiments of M. Nirenberg, H. Matthaei, S. Ochoa and H. G. Khorana over the next four years helped in deducing which codons specify which amino acid.

4.Out of the 64 codons, 61 codons are used to specify amino acids.

5.The remaining three codons, UGA, UAA and UAG, do not represent any amino acid and are used to signal the termination of protein synthesis. These are referred to as termination codons or stop codons or nonsense codons.

FEATURES OF GENETIC CODE:

(i)The genetic code is unambiguous. Each codon corresponds to only one amino acid.

(ii)The genetic code is degenerate – there are more than one codon specifying each amino acid.

(iii)The genetic code is non–overlapping. Each base along the mRNA is a part of only one codon.

(iv) The genetic code is comma less. There are no intermediary nucleotides between different codons.

(v)Codons specifying the same or related amino acids tend to be similar in

sequence. Often the base in the third position of a codon is not significant.

(vi) The genetic code is largely universal.

First letter	Second letter: U	Second letter: C	Second letter: A	Second letter: G	Third letter
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

❖ TRANSLATION :

TRANSLATION: The synthesis of proteins, directed by mRNA, is known as 'translation.

tRNA (The Adaptor):

▪The tRNAs are small RNAs (73 to 93 bases long) that have a very specific secondary and tertiary structure.

▪Secondary structure of tRNAs can be represented in the form of a clover leaf.

▪The tRNA molecule has four arms, named for their structure or function.

a. The first is the acceptor arm, so called because the amino acid becomes attached to this arm.
b. The TØC arm is named for the presence of this triplet sequence (Ø stands for pseudouridine).

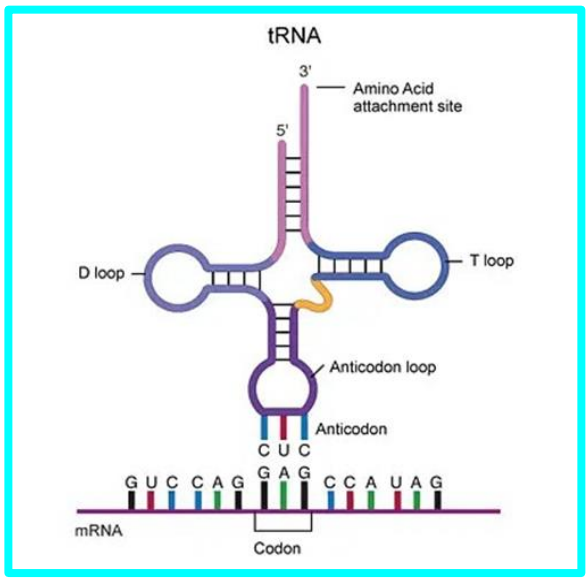
c. The anticodon arm always contains the anticodon triplet in the centre of the loop.

d. The D arm is named for its content of dihydrouridine.

1.One tRNA molecule recognize more than one codon, by 'wobble pairing', which means that the pairing between the anticodon of the tRNA and the codon of the mRNA always follows the watson- crick base pairing rules (that is, A pairs only with U and G pairs only with C) at the first two codon positions, but the hydrogen bonding is more flexible at the third codon position.

2.The acceptor arm of the tRNA molecule contains a terminal 3' trinucleotide sequence of 5' CCA 3', the terminal A base having a free hydroxyl group on the ribose sugar.

➢ The amino acid is attached to the hydroxyl group, by the action of enzymes called aminoacyl-tRNA synthetases.



3.**RIBOSOME:** Ribosomes are composed of two subunits:

a.Eukaryotes- a large subunit – 60S and a small subunit – 40S

b. Prokaryotes- a large subunit – 50S and a small subunit – 30S

➢There are two sites on a ribosome for binding tRNA molecules –

i.the A site (acceptor site) and

ii.the P site (donor site).

a)The A site is the entry site for an aminoacyl – tRNA molecule. Prior to the entry of an aminoacyl – trna, the A site

exposes the codon representing the next amino acid due to be added to the chain.

b)The P site is the binding site for a peptidyl- tRNA carrying the nascent polypeptide chain. The codon representing the most recent amino acid to have been added to the nascent polypeptide chain lies in the P site.

c)When both the A and P sites are occupied, peptide bond formation takes place by a reaction in which the polypeptide chain carried by the peptidyl-tRNA is transferred to the amino acid carried by the aminoacyl – tRNA. This creates a new peptidyltrna(longer by one amino acid) in the A site and leaves a deacylated tRNA(devoid of any amino acid) in the P site.

D)The deacylated tRNA is expelled and the new peptidyl- tRNA is shifted into the P site, as the ribosome moves one codon along the mRNA. •The next codon to be translated now lies in the A site which is ready for a new aminoacyl- tRNA to enter, when this entire cycle of events will be repeated.

MECHANISM OF TRANSLATION:

A. INITIATION

▪Protein synthesis begins at the AUG codon on the mRNA and involves the formation of an initiation complex.

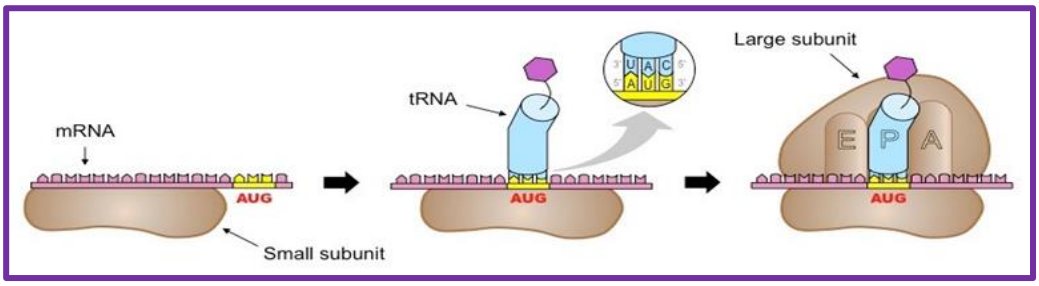
▪This complex consists of:

i.smaller ribosomal subunit,

ii.mRNA and

iii.the initiator tRNA (tRNA carrying methionine in eukaryotes and formyl-methionine in prokaryotes) .

▪The formation of this initiation complex also requires the activity of certain protein



factors known as initiation factors and GTP. ▪The initiation complex subsequently combines with the larger ribosomal subunit and the initiator – tRNA becomes bound to the P site.

▪One molecule of GTP is hydrolyzed.

▪Hence in the initiation complex, we have the initiator trna in the P site, while the A site is empty, awaiting delivery of the second amino acid on its tRNA. Initiation is thus completed.

B. <u>ELONGATION:</u>

➢The alignment of the AUG codon with the anticodon of the initiator-tRNA in the P site,

➢The successive codon in the A site, thus establishing the specificity for the next, incoming amino-acyl tRNA binding at the A site.

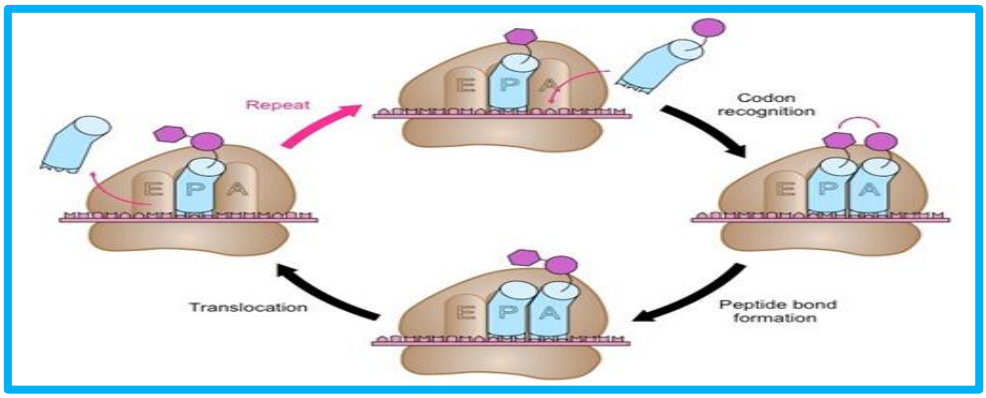
➢The binding of this second aminoacyl-tRNA (and all the subsequent aminoacyl-tRNA binding) requires the hydrolysis of one molecule of GTP and protein elongation factors.

➢Peptide bond formation then occurs between the carboxyl group of the methionine bound to the initiator-tRNA in the P site and the free amino group of the amino acid attached to the aminoacyl-tRNA in the A site.

➢This reaction is catalyzed by an enzyme called peptidyl transferase and produces a dipeptide attached to the second tRNA present in the A site.

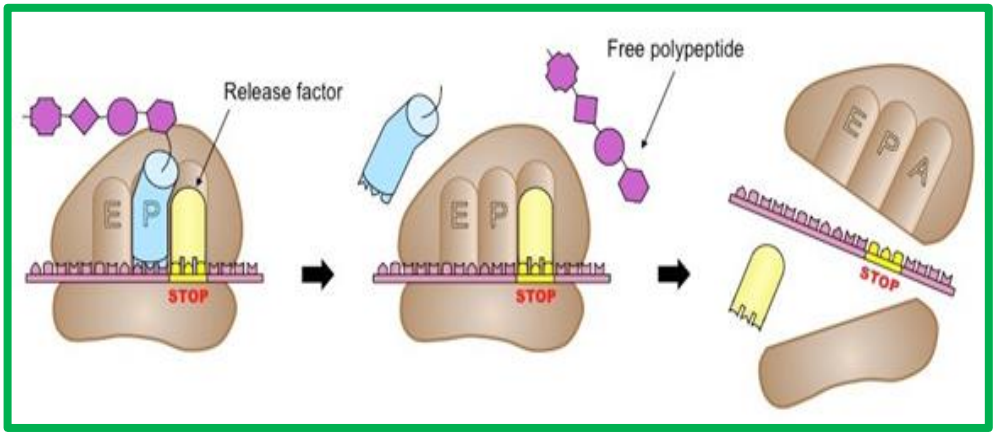
➢After peptide bond formation, the A site is filled with a peptidyl-tRNA and the P site contains an uncharged tRNA. In the next step, called translocation, the ribosome is re-positioned one codon further along the mRNA.

➢As a result, the tRNA carrying the newly synthesized dipeptide is transferred from the A site to the P site and the uncharged tRNA is expelled to be reused. Translocation also requires the activity of another elongation factor and the hydrolysis of one molecule of GTP.



C. TERMINATION

▪The elongation cycle repeats itself until the ribosome reaches any one of the three termination codons.
▪The A site is now entered not by a tRNA, but by a protein called release factor, leading to the release of the nascent polypeptide chain,
▪ mRNA and also the dissociation of the ribosomal subunits.
▪The termination process is energy - independent in bacteria and requires the hydrolysis of one molecule of GTP in eukaryotes.
▪The mRNA molecules are translated simultaneously by many ribosomes increasing the rate of protein synthesis.
▪The complex of mRNA and ribosomes is called polyribosomes or polysomes.



❖ **MUTATIONS:** changes that occur in the nucleotide of DNA sequence. Such hereditary changes called as "mutations".

- Mutation theory was first proposed by Hugo de Vries in 1901, based on his observations on evening primrose.
- These genetic variations are the basis for different phenotypes in a given organism.
- , mutations can be induced by physical mutagens like UV-light, X-rays and gamma
  rays or chemical mutagens like alkylating agents (e.g. ethyl methane sulphonate).

Mutations can occur in the coding region (genes) as well as non-coding (inter-genic) regions of the DNA molecule.

- Mutations in the genes can lead to changes in the allele and formation of new phenotypes (mutants).

- But, mutations in the non-coding regions are probably silent and have no effect on the cell or phenotype.
- Mutations can occur either in somatic cells

and these are non-heritable or germ cells and these •are heritable.

Genome mutations: Euploid types that contain more than two sets of chromosomes are called polyploids, and they can be triploids (3n), tetraploids (4n), pentaploid (5n) and hexaploids (6n). Polyploids are common in

- plants and very rare in animals. The odd number of polyploids (e.g. triploids) are sterile.
- On the other hand, even number of polyploids (tetraploids and hexaploids) are usually fertile
- . These polyploids as well as haploids have important applications in plant breeding.

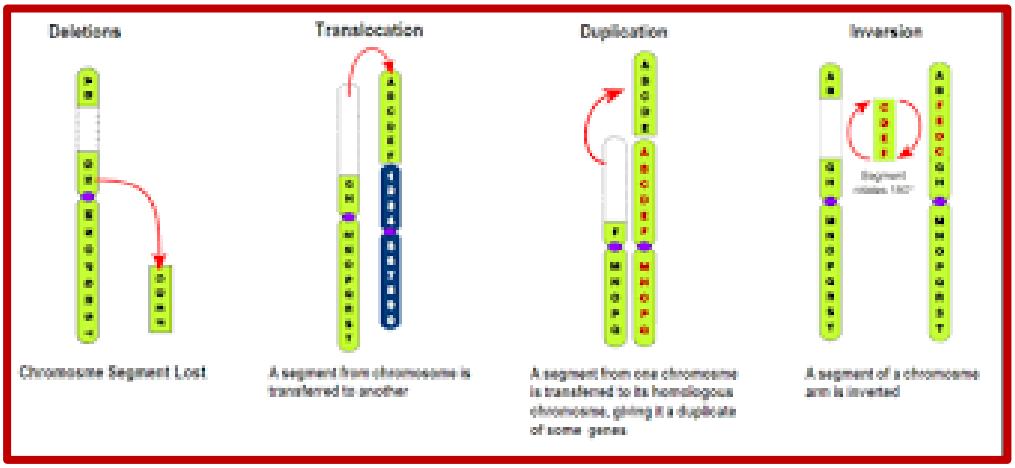
In case of aneuploids, chromosome number is abnormal and differs from the wild-type by only

addition or deletion of one or a small number of chromosomes.

- For example, an organism with one chromosome less than the normal diploid number (2n-1) is known as monosomic.
- aneuploids 2n+1 and 2n-2 are called trisomic and nullisomic, respectively.
- The non-disjunction (unequal separation of chromosomes in mitosis or meiosis) or chromosome duplications are the cause of aneuploidy.

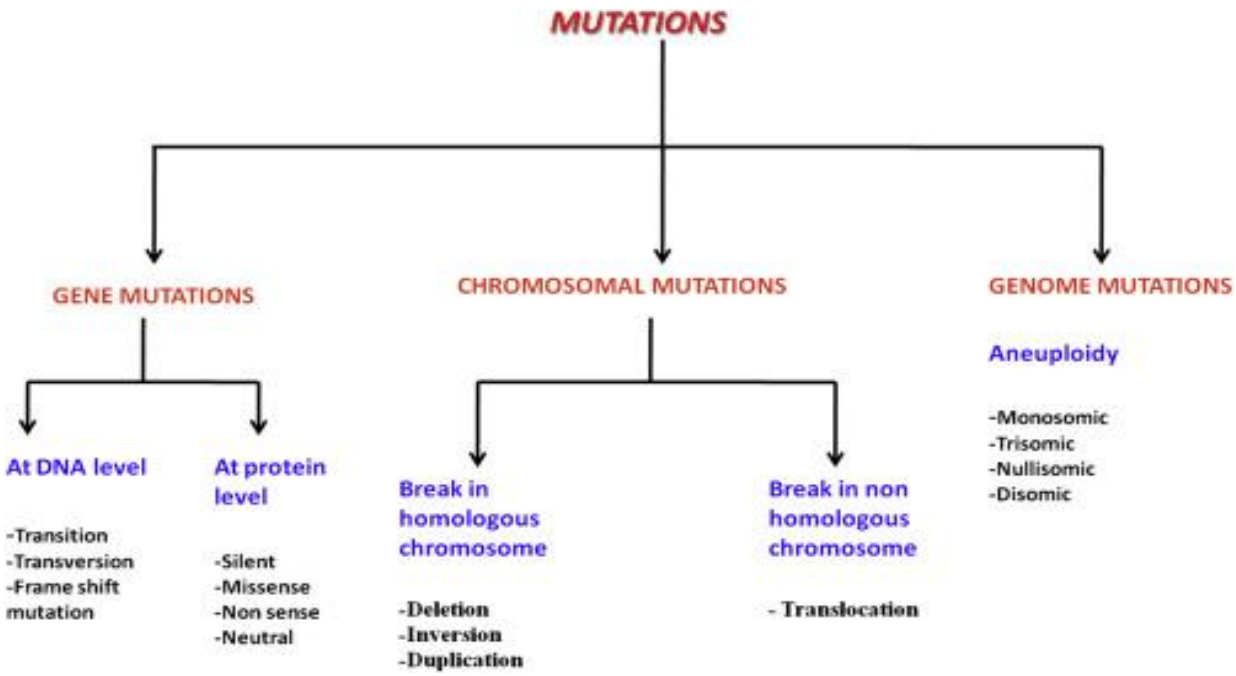
Chromosome mutations - the loss (deletions), additions or duplications (insertions) or rearrangements (inversions and translocations) of chromosomes.

- In inversion, a chromosome segment is removed, rotated through 180°, and reinserted in the same location causing change in gene order.
- If centromere is outside the inversion, then the inversion is called as paracentric,
- whereas inversions containing the centromere are pericentric.
- Translocations involve the reciprocal exchange of chromosome parts between non-homologous chromosomes, 'resulting in rearrangements (reciprocal translocation).



Gene mutations - small alterations in a gene and also called as 'point mutations'.

- These changes involve a change in a single nucleotide (substitutions or deletions) of a gene, which results in the modification of gene product (i.e. protein) and eventually the phenotype.
- A replacement of purine molecule (say adenine) by another purine (e.g. guanidine) is known as transition (say, GC to AT or AT to GC).
- If a purine molecule (say, guanidine) is replaced by a pyrimidine molecule (say, cytocine), then it is called as transversions (e.g. GC to CG or AT to TA)
- The addition or deletion of a single base in a gene is known as frameshift mutation.



❖ **HUMAN GENETIC DISORDERS:** DNA mutations play an important role in the development of diseases and cancers. Eg: haemophilia, sickle cell anaemia and cystic fibrosis are caused by mutations.

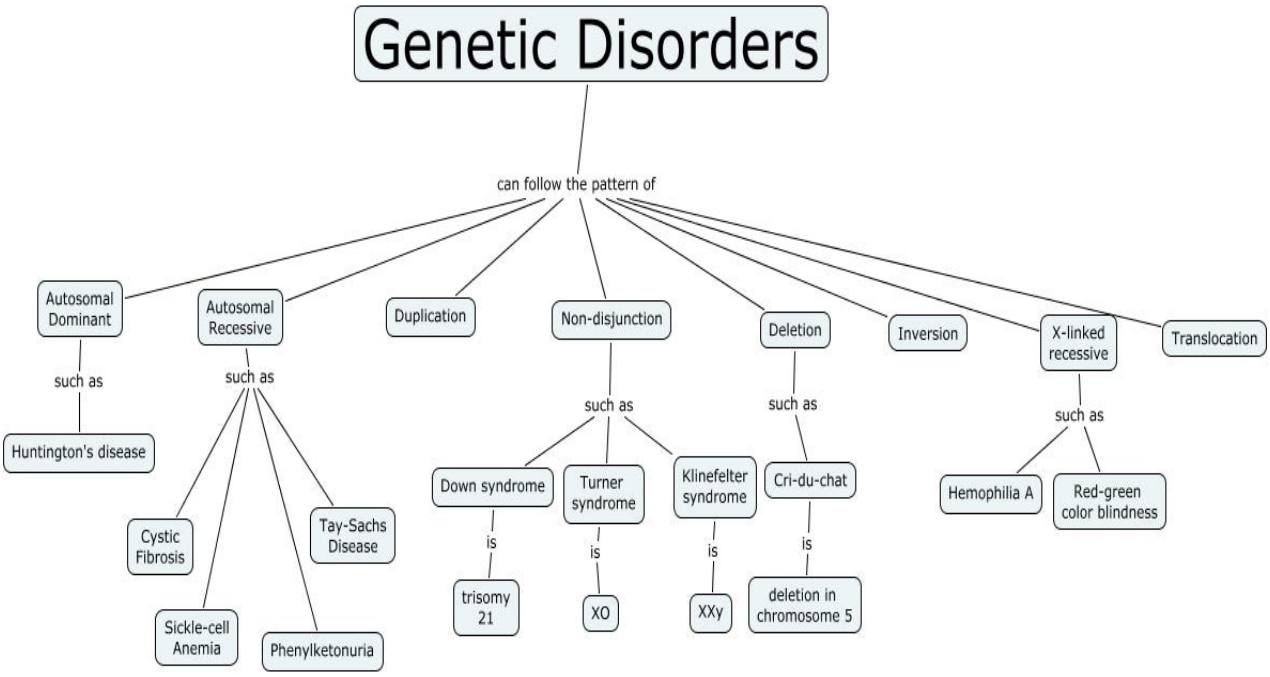
- There are over 500 genetic disorders and some of these genetic disorders are due to aneuploidy. For examples:

a) Klinefelter syndrome (males with XXY trisomic. They show feminine characters),

b) Turner's syndrome (females with XO monosomic. They show male features.

c)Down syndrome (males or females with trisomy of 21st chromosome. Theyshow mental retardation, short stature and with other characteristics).

d)Xeroderma pigmentosum is a skin cancer (melanomas) caused due to deficiency in DNA repair enzymes.



QUESTION BANK

MULTIPLE CHOICE QUESTIONS (1 mark)

1. Frederick Griffith discovered-
   a) DNA is the genetic material
   b) RNA is the genetic material
   c) Sterptococcus has two strains
   d) Bacterial transformation

2. Who proposed semiconservative mode of replication for DNA?
   a) Watson and Crick
   b) Meselson and Stahl
   c) Hershey and Chase
   d) Beadle and Tatum
3. The discontinuously synthesized DNA fragments are later joined by:
   a) DNA helicase
   b) Topoisomerase
   c) DNA ligase
   d) DNA polymerase
4. Some amino acids are coded by more than one codon. Hence genetic code is :
   a) Unambiguous
   b) Non-specific
   c) Degenerate
   d) Universal
5. Which of the following anticodons will hybridize with the mRNA codon 5'---AUG---3'.
   a) 5'----UAC—3'
   b) 5'---TAC---3'
   c) 3'--UAC---5'
   d) 3'---TAC—5'

6. In a transcription unit, the promoter is located towards

   a)**5'end of the structural gene**
   b)3'end of the structural gene
   c)5'end of the template strand
   d)3'end of the coding strand

7. The primer in DNA replication is

   a) **Small ribonucleotide polymer**
   b) Helix destabilizing protein
   c)Small deoxyribonucleotide polymer
   d)Enzyme joining nucleotides of new strands

8. Genetic information is transferred from nucleus to cytoplasm through

1. RNA
2. Anticodon

3. DNA
4. Lysosomes

9. The enzyme involved in transcription

1. DNA Polymerase I
2. DNA Polymerase III
3. **RNA Polymerase**
4. DNA Polymerase II

10. Non-sense codons participate in

1. Releasing t-RNA from polynucleotide chain
2. Formation of unspecified amino acids
3. Terminating message of gene-controlled protein synthesis
4. Conversion of sense DNA into non-sense DNA

11. The proofreading enzyme in DNA replication is

1. Primase
2. **DNA Polymerase I**
3. Ligase
4. DNA Polymerase II

12. Select a ribozyme

1. Peptidyl transferase
2. Helicase
3. Ribonuclease-P
4. **Both (a) and (c)**

13. Which step does not occur in translation?

1. **Replication**
2. Termination
3. Elongation
4. Initiation

14. The energy source for the elongation process is

1. Creatine-PO_4
2. **GTP**

3. ATP
4. All of the above

15. The anticodon of initiation codon for protein synthesis is

1. UUU
2. AUG
3. **UAC**
4. CAU

16. Which enzyme is not produced during lactose catabolism by E.coli?

1. ***β*-galactosidase**
2. Lactose Permease
3. Thiogalactoside transacetylase
4. Lactose dehydrogenase

17. The eukaryotic replication of DNA is

1. **Bidirectional with many origins**
2. Unidirectional with many origins
3. Bidirectional with a single origin
4. Unidirectional with a single origin

18. The amino acid coded by 3 codons is

1. Proline
2. **Isoleucine**
3. Tryptophan
4. Serine

19. Spliceosomes are absent in the cells of

1. Plants
2. Animals
3. **Bacteria**
4. Fungi

20. A molecule that acts as a genetic material must fulfil the following traits, except

1. It should be structurally and chemically unstable
2. **It should have the ability to generate its replica**

3. It should facilitate slow changes necessary for evolution.
4. It should be able to express itself in the form of Mendelian characters.

21. What will the amount of guanine in a DNA if the total amount of adenine and thiamine in the DNA is 45%?

1. 45%
2. 65%
3. **27.5%**
4. 22.3%

22. Which was the last human chromosome to be completely sequenced ?
(a) **Chromosome 1**
(b) Chromosome 11
(c) Chromosome 21
(d) Chromosome X

23. n some viruses, DNA is synthesised by using RNA as template. Such a DNA is called
(a) A – DNA
(b) B – DNA
(c) **cDNA**
(d) rDNA.

24 If the sequence of nitrogen bases of the coding strand of DNA in a transcription unit is: 5' – ATGAATG – 3', the sequence of bases in its RNA transcript would be
(a) 5' – AUG A AUG – 3'
(b) 5' – UACUU AC – 3'
(c) 5' – CAUUCAU – 3'
(d) **5' – GUAAGUA – 3'.**

25. he amino acid attaches to the tRNA at its
(a) 5'- end
(b**) 3' – end**
(c) anticodon site
(d) DHUloop.

26. The structure in chromatin seen as 'beads-on string' when viewed under electron microscope are called
(a) nucleotides
(b) nucleosides

(c) histone octamer
(d**) nucleosomes.**

27. They year 2003 was celebrated as the 50th anniversary of discovery of
(a) transposons by Barbare Me Clintock
(b) **structure of DNA by Watson and Crick**
(c) Mendel's laws of inheritance
(d) biotechnology by Kary Mullis.

28. The three codons which result in the termination of polypeptide chain synthesis are
(a) UAA, UAG, GUA
(b) **UAA, UAG, UGA**
(c) UAA, UGA, UUA
(d) UGU,UAG,UGA

29. Amino acids which are specified by single codons are
(a) phenylalanine and arginine
(b**) tryptophan and methionine**
(c) valine and proline
(d) methionine and arginine.

30. The mutations that involve addition, deletion or substitution of a single pair in a gene are referred to as
(a) **point mutations**
(b) lethal mutations
(c) silent mutations
(d) retrogressive mutations.

SHORT ANSWER TYPE QUESTIONS SA-I (2 marks)

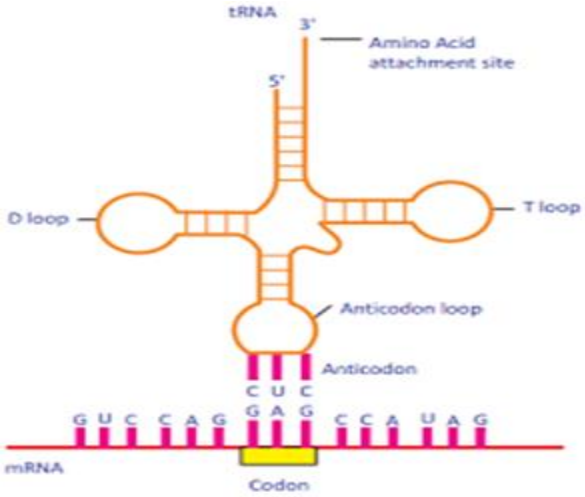
Q.1. Define Aneuploidy. How is it advantages?
Answer- Any change in the number of chromosomes .
One of the primary applications of aneuploidy in **crop improvement** is the development of new plant varieties.

Q.2. What is the difference between Pericentric and Paracentric chromosome inversion?
Answer- Pericentric inversions include the centromere, while paracentric inversions occur outside of the centromere.

Q.3. What are the properties of Genetic Code?
Answer- Triplet code

- Non-ambiguous and Universal
- Degenerate code
- Nonoverlapping code
- Commaless
- Start and Stop Codons
- Polarity- 5' to 3'

Q.4. Draw neat labelled diagram of tRNA.
Answer:-



Q.5. Describe the role of Helicases, DNA polymerase and DNA ligase.
Answer- DNA Polymerase: It helps in the replication of double-stranded DNA into two identical DNA molecules Helicase: It helps in the separation of double-stranded DNA into single strands allowing each strand to be copied.
Ligase: It acts as glue by joining 2 DNA fragments to form a new DNA strand

Q.6. Define the following: Overlapping genes, Repetitive DNA, split genes , gene clusters, endosymbiosis.
Answer:- Overlapping genes: An overlapping gene is a gene whose expressible nucleotide sequence partially overlaps with the expressible nucleotide sequence of another gene. In this way, a nucleotide sequence may make a contribution to the function of one or more gene products.

Repetitive DNA: Repeated sequences (also known as repetitive elements, or repeats) are patterns of nucleic acids that occur in multiple copies throughout the genome.

Split genes: An interrupted gene (also called a split gene) is a gene that contains sections of DNA called exons, which are expressed as RNA and protein, interrupted by sections of DNA called introns, which are not expressed.

Gene clusters: A gene cluster is a group of two or more genes found within an organism's DNA that encode for similar polypeptides, or proteins, which collectively share a generalized function & are correlated

Endosymbiosis: endosymbiotic theory, is an evolutionary theory of the origin of eukaryotic cells from prokaryotic organisms

Q.7. What are promoters, exons, introns?
Answer:-Promoter: A promoter is a region of DNA that initiates transcription of a particular gene by binding to RNA polymerase. Promoters are located near the transcription start sites of genes, on the same strand and upstream on the DNA.

Exons: An exon is any part of a gene that will encode a part of the final mature RNA.

Introns: An intron is any part of a gene that will not encode a part of the final mature RNA and will be removed by splicing.
Q.8. What is the central dogma of life?
Answer:- The central dogma of molecular biology describes the flow of genetic information in cells from DNA to messenger RNA (mRNA) to protein.

Q.9. What is charging of tRNA?
Answer:-It is the binding of the tRNA with the specific amino acid by the following steps:
a) Amino Acid + ATP -> Amino acyl AMP + ADP
b) Amino acyl AMP + tRNA -> Amino acyl tRNA + AMP.
Both the steps are catalysed by amino acyl tRNA synthetase enzyme.

Q.10.
Name the different types of eukaryotic RNA polymerases and their roles.

Answer:- RNA polymerase I: transcribes rRNA.
RNA polymerase II: transcribes mRNA.
RNA polymerase III: transcribes tRNA

Q.11. What is the difference between sense and antisense strand of DNA?
Answer:- Sense Strand: The strand of DNA which is not transcribed and is similar to the mRNA.
Antisense Strand: The strand of DNA which is transcribed and is complementary to the mRNA

Q.12. What is Wobble hypothesis?
Answer- Wobble hypothesis states that the genetic codes are degenerate. It explains that the third base pairing varies with respect to the base at the third position like G may pair with T or U.

Q.13. Differentiate between transition and transversion mutation.
Answer- Transition- It is the substitution of a purine from another purine base or pyrimidine from another pyrimidine (C↔TC↔T or A↔GA↔G)
Transversion- is the substitution of a purine from a pyrimidine or pyrimidine from a purine.

Q.14. What are the 3 processes of central dogma?
Answer- From existing DNA to make new DNA (DNA replication) From DNA to make new RNA (transcription) From RNA to make new proteins (translation).
Q.15. What is the difference between exons and coding exons?
Answer- An exon is a region of the genome that ends up within an mRNA molecule. Exons are coding, in that they contain information for making a protein, whereas introns are non-coding.

SHORT ANSWER TYPE QUESTIONS SA-II (3 marks)

Q.1What are nucleosomes? Draw the structure of a nucleosome.
Answer:-A nucleosome is a basic unit of DNA packaging in eukaryotes, consisting of a segment of DNA wound in sequence around eight histone protein cores.
The Histones of all higher organisms have five major proteins namely, H_1, H_{2A}. H_{2B}, H_3, H_4.
DNA is wrapped twice around the beaded octamer & the exit sites of DNA are sealed by H_1 protein

The strand of DNA interconnecting two nucleosome beads is called linker DNA.

Q.2What are the post transcriptional modifications in eukaryotes?
Answer:- a) Capping: The addition of 7 methyl guanosine to the 5' end of an mRNA. (prevents degradation of mRNA from nucleases and helps in localization)
b) Splicing: The removal of introns and joining of exons of the heterogenous mRNA.
c) Polyadenylation: The addition of a polyA tail at the 3' end of a mRNA.

Q.3.What is Griffith's experiment of transformation?
Answer:-Griffith's experiment, reported in 1928 by Frederick Griffith, was the first experiment suggesting that bacteria are capable of transferring genetic information through a process known as transformation.
Griffith used two strains of Pneumococcus. These bacteria infect mice. He used a type III-S (smooth) and type II-R (rough) strain. He injected mice with the strains and observed the following:
Mouse + R strain -> live mouse.
Mouse + S strain -> Mouse dead
Mouse + R strain + heat killed S strain-> Mouse killed (live S strain were obtained from dead mouse)

Q.4.Who confirmed Griffith's experiment and how?
Answer:- The Avery–MacLeod–McCarty experiment was an experimental demonstration, reported in 1944 by Oswald Avery, Colin MacLeod, and Maclyn McCarty, that DNA is the substance that causes bacterial transformation.

R strain + extract of heat killed S strain + RNase -> S strain

R strain + extract of heat killed S strain + DNase -> R strain

R strain + extract of heat killed S strain + protease -> S strain

Q.5.What is Hershey and Chase's experiment?
Answer:- Hershey and Chase used T2 phage, a bacteriophage, for their experiments. The phage infects a bacterium by attaching to it and injecting its genetic material into it. They put labels on phage DNA with radioactive Phosphorus-32. They then followed the phages while they infected E. coli. They found that the radioactive element was only in the bacteria, and not in the phage.

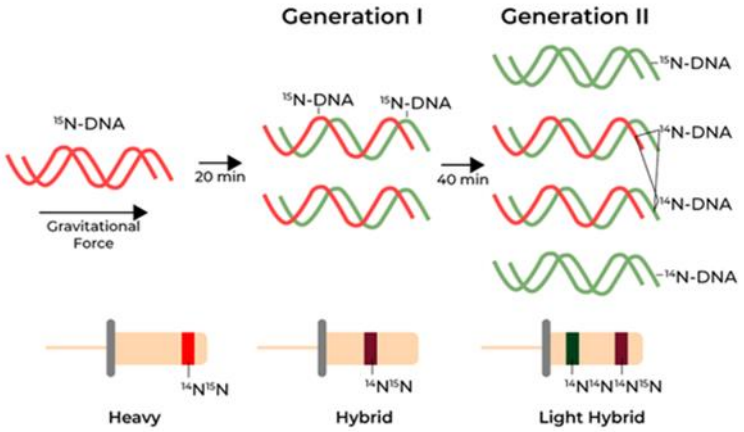
In a second experiment, they put labels on the phage protein with radioactive Sulfur-35. After the phage was attached to the bacterium, the radioactive element was found in the phage, but not in the bacteria. This showed them that genetic material which infects the bacteria is DNA
Diagram:- Refer pg. No. 67 (Text book)

Q.6. Give a brief account of the different human genetic disorders along with their ploidy and characteristics.
Answer:- Klinefelter syndrome (KS) also known as 47,XXY or XXY, is the set of symptoms that result from two or more X chromosomes in males. The primary feature is sterility.

Down syndrome is usually caused by an error in cell division called "nondisjunction." Nondisjunction results in an embryo with three copies of chromosome 21 instead of the usual two leading to mental retardation.
Turner syndrome (TS), also known as 45,X or 45,X0, is a condition in which a female is partly or completely missing an X chromosome leading to sterility.

Q.7.Describe the numerical and structural changes in chromosomes.
Answer:-Numerical changes:
Structural changes:
1.Deletion 2. Duplication 3.Inversion 4.Translocation
Diagrams:- Refer pg No. 83 (Text book)
Differentiate the DNA repair mechanisms in prokaryotes and eukaryotes.
Prokaryotes: Photoreactivation is a type of DNA repair mechanism. It is the recovery of ultraviolet irradiated damages of DNA by visible light. As the name suggests, it is a light dependent process. In this DNA repair method cells recovers its DNA after UV exposure induced damages by photolyases which activates only in presence of light.
Eukaryotes: Nucleotide excision repair (NER) is a particularly important excision mechanism that removes DNA damage induced by ultraviolet light (UV). UV DNA damage results in mostly thymine dimmers that are repaired by DNA glycosylases and DNA polymerases.

Q.8. 1Differentiate between transition and transversion mutation.
Answer- Transition- It is the substitution of a purine from another purine base or pyrimidine from another pyrimidine (C↔TC↔T or A↔GA↔G)
Transversion- is the substitution of a purine from a pyrimidine or pyrimidine from a purine.
Q.9.Describe briefly the experiment performed byMeselson & Stahl to show that DNA Replication is semi-conservative .
Answer:- 1. MESELSON AND STAHL EXPERIMENT
➢This experiment was performed to prove the semi conservative nature of DNA replication. Matthew Meselson & Franklin Stahl experimented with bacteria E.coli in 1958.
Step 1. E.Coli was grown in a medium with N-15 for several generations
•Step 2. E.coli with only N-15 in their DNA were transferred to a medium with N-14
•Cells of E.coli were allowed to divide. Sample was taken and DNA was extracted periodically as cell division continued to check what type of DNA is being formed now. One replication in E.coli takes around 20 minutes. So, generation I is formed in 20 minutes.
•Therefore samples are taken after 20 minutes, then again after 40 minutes. Densities of DNA from the sample were measured to reach to results & conclusion.
2. Results
•Generation I: DNA was found to have intermediate density after 1 replication
•Generation II: Equal amounts of DNA with two different densities were found.
3. Conclusion
a)Presence of a hybrid/ intermediate density excluded Conservative hypothesis. Had it been Conservative hypothesis, Generation 1 would have been either Blue(N-15) or Green(N-14); and not an Intermediate one.
b) Presence of N-14 DNA in Generation II excluded Dispersive hypothesis. If it was Dispersive, each DNA should have had the same density. But, in Generation II, we could see 50% of the DNA have intermediate density, whereas remaining 50% have N-14 density.
c)Semi-conservative hypothesis could explain the entire experimental result. Separation of strands concept could explain the outcomes of Generation I & II.
d)Thus, it was proved that DNA replication is Semi-conservative in nature.



Q.10. Describe briefly the experiment performed by Griffith to show that DNA is the genetic material of the organisms .

Answer:- . A. GRIFFITH'S EXPERIMENT

1.When the R strain was injected into the mice. The mice survived as R cell were avirulent strains.

2.When the S strain was injected into the mice. The mice died as the S cell were virulent strains.

3. when he killed some virulent S cells by boiling them and injected these heat-killed S cells into mice. The mice survived,

4.when mice were injected with a mixture of heat-killed S cells and live R cells, the mice died as a result of pneumococcal infection.

➢Furthermore, the bacteria isolated from a mouse that had died from such a mixed infection were only of the S type.

➢These results showed that the live R cells had somehow been replaced by or transformed to S bacteria.

➢Conclusion: 'Transforming principle' present in the cell debris of S cells which is responsible for the observed transformation of R cells to S cells.

Diagram:- refer to the content

LONG ANSWER TYPE QUESTIONS (5 marks)

Q.1. What are the different enzymes and proteins involved in DNA replication and what are their roles?

Answer:- 1.Topoisomerases are enzymes that participate in the overwinding or underwinding of DNA by causing nick in one strand and religating it after one rotation.

2.Helicases: Unwind double strands of DNA by breaking hydrogen bonds.

3.Single strand binding (SSB) proteins: Binds to single strands of DNA to prevent rebinding of the strands.

4.Primase: It is an enzyme involved in the replication of DNA and is a type of RNA polymerase. It catalyzes the synthesis of a short RNA (or DNA in some organisms) segment called a primer complementary to a ssDNA template.
5.DNA polymerases : These are enzymes that synthesize DNA molecules from deoxyribonucleotides. DNA polymerase I (Kornberg enzyme) has 5' -3' exonuclease activity and helps in removal of primers and joining okazaki fragments. The main enzyme is DNA polymerase III which has high processivity and performs replication.
6.DNA ligase: seals the nicks or gaps in DNA strands by constructing phosphodiester bond between 3'-OH & 5'-PO_4 of fragments of DNA.

Q.2. Give a brief account of the mechanism of DNA replication.
Answer:- SEMI-DISCONTINUOUS REPLICATION -Replication starts at the ori site and results in formation of a replication bubble which forms a replication fork in both directions.
Initiation: The helicases unwind theDNA strands while SSBs bind to the single strands. The primaes forms the primers on both the strands.
Elongation: DNA polymerase III polymerises in 5'-3' direction but there are two strands in opposite directions so the two new strands that are formed are of two types i.e.
Leading strand: the strand is formed continuously in 5'-3' direction.
Lagging strand: it is formed in small fragments called okazaki fragments which are later joined together.
:
a)During DNA replication one of the newly synthesized strands is polymerized in the 5' to 3' direction, while the other strand is polymerized in the 3' to 5' direction.
•b)Synthesis of the 3' to 5' strand (called the lagging strand), is synthesized discontinuously as a series of short DNA fragments. Each of these fragments is synthesized with the usual 5' to 3' polarity and is referred to as Okazaki fragment, after R. Okazaki, who first identified them.
c)In case of bacteria, these fragments are 1000-2000 nucleotides in length, but in eukaryotes, these fragments are probably less than 200 nucleotides long.
d)Finally these separate Okazaki fragments are joined together to produce the daughter strand. •The other strand which grows overall in the 5' to 3' direction (called the leading strand) is synthesized continuously.

e)During DNA replication, one strand is synthesized continuously and the other strand is synthesized discontinuously, replication is said to be semi-discontinuous.
f)For the synthesis of the lagging strand, priming is a repeated process that must occur every time a new Okazaki fragment is initiated. This would leave the lagging strand not as a single piece of DNA, but as a series of disconnected short pieces of DNA attached to RNA primers.
g)In E. coli, the RNA primers are excised by the 5' to 3'exonuclease activity of DNA polymerase I and the new DNA is synthesized by the 5' to 3’ polymerase activity of the same enzyme. The adjacent Okazaki fragments are then joined together by ligase, to form an intact lagging strand.

Q.3. Explain the different steps of transcription.
Answer:- Transcription is the first step in gene expression, in which information from a gene is used to construct a functional product such as a protein. The goal of transcription is to make a RNA copy of a gene's DNA sequence. For a protein-coding gene, the RNA copy, or transcript, carries the information needed to build a polypeptide (protein or protein subunit).
Stages of transcription
Initiation. RNA polymerase binds to a sequence of DNA called the promoter, found near the beginning of a gene. Each gene (or group of co-transcribed genes, in bacteria) has its own promoter. Once bound, RNA polymerase separates the DNA strands, providing the single-stranded template needed for transcription.
Elongation. One strand of DNA, the template strand, acts as a template for RNA polymerase. As it "reads" this template one base at a time, the polymerase builds an RNA molecule out of complementary nucleotides, making a chain that grows from 5' to 3'. The RNA transcript carries the same information as the non-template (coding) strand of DNA, but it contains the base uracil (U) instead of thymine (T).
Termination. Sequences called terminators signal that the RNA transcript is complete. Once they are transcribed, they cause the transcript to be released from the RNA polymerase.

Q.4. Give a brief account of the mechanism of translation.
Answer:-
Initiation: Translation begins with the binding of the small ribosomal subunit to a specific sequence on the mRNA chain. The small subunit binds via complementary base pairing between one of

its internal subunits. and the ribosome binding site, a sequence of about ten nucleotides on the mRNA located anywhere from 5 and 11 nucleotides from the initiating codon, AUG. Once the small subunit has bound, a special tRNA molecule, called N-formyl methionine, or fMet, recognizes and binds to the initiator codon. Next, the large subunit binds, forming what is known as the initiation complex. With the formation of the initiation complex, the fMet-tRNA occupies the P site of the ribosome and the A site is left empty and this entire initiation process is facilitated initiation factors that help with the binding of ribosomal subunits and tRNA to the mRNA chain.

Elongation: With the formation of the complex containing fMet-tRNA in the peptidyl site, an aminoacyl tRNA with the complementary anticodon sequence can bind to the mRNA passing through the acceptor site. This binding is aided by elongation factors that are dependent upon the energy from the hydrolysis of GTP. Elongation factors go through a cycle to regenerate GTP after its hydrolysis. Now, with tRNA bearing a chain of amino acids in the p site and tRNA containing a single amino acid in the A site, the addition of a link to the chain can be made. This addition occurs through the formation of a peptide bond, the nitrogen-carbon bond that forms between amino acid subunits to form a polypeptide chain. This bond is catalyzed by the enzyme peptidyl transferase. The peptide bond occurs between the carboxyl group on the lowest link in the peptide chain located at the p site and the amine group on the amino acid in the A group. As a result, the peptide chain shifts over to the A site, with the original amino acid on the A site as the lowest link in the chain. The tRNA in the A site becomes peptidyl RNA, and shifts over to the P site. Meanwhile, the ribosome engages in a process called translocation: spurred by elongation factors, the ribosome moves three nucleotides in the 3' prime direction along the mRNA. In other words, the ribosome moves so that a new mRNA codon is accessible in the A site.

Termination: At termination, the polypeptide is freed from the ribosome at the termination codon, and tRNAs stop bringing the amino acids in the polypeptide chain.

Q.5 What is mutation? Expolain various types of Chromosomal mutation with diagrams

Answer:- The changes that occur in the nucleotide of DNA sequence. Such hereditary changes called as "mutations".

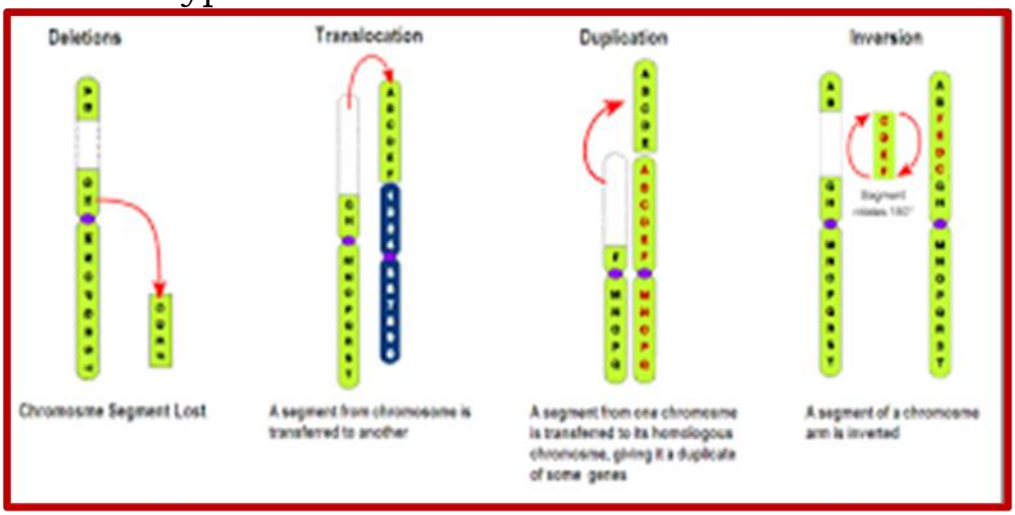
Types of Chromosomal mutsation :-

1.Duplication: When the sister chromatids are not the replica of each other and are not able to split in the middle due to some redundancy in the genes of that sequence, duplication occurs. These sister chromatids are separated into different cells where they overexpress the traits and produce more proteins.

2.Deletion: Deletion of a part of a chromosome during meiosis resulting in the break-off in the chromosome and losing the part is deletion. Deletion is a fatal mutation as it can cause the death of the zygote if the sequence lost is vital for survival.

3.Translocation: When the broken piece of the chromosome is not completely lost but it gets attached to a different, non-homologous chromosome that has also lost a part. This is referred to as translocation. It can cause serious problems due to the genes encoded in the wrong location.

4.Inversion: a part of a chromosome breaks off and is inverted. It then attaches itself to the same chromosome. This is referred to as inversion. This type of mutation is referred to as a silent mutation.



ASSERTION – REASONING QUESTIONS

Q.1 Assertion : If each strand from a parental DNA acts as template for synthesis of a new strand, the two double stranded daughter DNA thus produced would be indentical to the parental DNA molecule.

Reason : The length of DNA double helix in a typical mammalian cell is calculate simply by multiplying the total number of bp with distance two consecutive bp.

Answer -A (If both assertion and reason are true and the reason is the correct explanation of the assertion.)

Q.2. Assertion : In transforming principle, when streptococus pneumoniae (Pneumococcus) bacteria are grown on a culture plate,

some produce smooth shiny colonies (S) while other produce rough colonies (R).
Reason : S strain bacteria have a mucous (polysaccharide) coat, while R strain does not.
Answer- A (If both assertion and reason are true and the reason is the correct explanation of the assertion.)

Q.3 Assertion : Split genes are found in eukaryotes.
Reason : Introns or intervening sequences are found in prokaryotes.
Answer- C (If assertion is true but reason is false.)

Q.4 Assertion: The primary transcript produced in eukaryotic is translated without undergoing any modification or processing.
Reason: The hn-RNA in humans has exons and introns.
Answer- D (If both assertion and reason are false.)

Q.5 Assertion :Transcription is the mode in which DNA passes its genetic information to RNA.
Reason : Transcription takes place in the cytoplasm of eukaryotic cells.
Answer- (c) If the Assertion is true but the Reason is false.

Q.6. Assertion-DNA replication is semi-conservative in nature
Reason-In each cycle of replication the complementary strands of parental double
helix is conserved .
Answer - A (If both assertion and reason are true and the reason is the correct explanation of the assertion.)

Q.7 Assertion- The human genome comprise of a large amount of repetitive sequences
Reason- The repetitive sequences in the genome don't have direct coding functions.
Answer- B (If both assertion and reason are true but the reason is the not the
correct explanation of the assertion)

Q.8 Assertion- P site & A site of a ribosome are different
Reason- P site is present in smaller unit & A site is present in larger unit
Answer - - (c) If the Assertion is true but the Reason is false

Q.9.Assertion- A non-overlapping code means that a base in mRNA is not used for different codon.

Reason- In translating mRNA molecule the codons do not overlap, but read sequentially .

Answer- A (If both assertion and reason are true and the reason is the correct explanation of the assertion.)

Q.10.Assertion- Histones are basic proteins of major importance in packaging of eukaryotic DNA.

Reason- Histones are five major types H1, H2A. H2B, H3, H4.

Answer- B (If both assertion and reason are true but the reason is the not the correct explanation of the assertion)

PASSAGE-BASED / CASE-BASED / SOURCE-BASED QUESTIONS

CASE-STUDY-I

The process of translation requires transfer of genetic information from a polymer of nucleotides to synthesise a polymer of amino acids. The relationship between the sequence of amino acids in a polypeptide and nucleotide sequence of DNA or mRNA is called genetic code. George Gamow suggested that in order to code for all the 20 amino acids, code should be made up of three nucleotides.

Q.1. What is a codon?.(1)

Ans. A part of the messenger RNA molecule that has a sequence of 3 bases coding for an amino acid.

Q.2. Three consecutive bases in the DNA molecule provide the code for each amino acid in a protein molecule. What is the maximum number of different triplets that could occurs ? What are non-sense codons ? (2)

Ans- 64

They never code for any amino acid -UAA, UAG, UGA

Q.3 Which DNA sequence would be needed to produce the following polypeptide sequence? Alanine- Arginine- Lysine- Phenylalanine (1)

Ans-CGT GCT TTC TTT

CASE-STUDY- II

Nondisjunction is the failure of homologous chromosomes to disjoin correctly during meiosis. It leads to the formation of a new cell with an abnormal amount of genetic material. A number of clinical conditions are the result of this type of chromosomal mutation. This results in the production of gametes containing a greater or

lesser chromosomal amount than normal ones. Consequently, the individual may develop a trisomy or monosomal syndrome. Nondisjunction can occur in both Meiosis I and Meiosis II of the cellular division. It is also the main cause of many genetic disorders; however, its origin and process remain vague. Although it results in the majority of cases from errors in maternal meiosis II, both paternal and maternal meiosis I do influence it. Maternal age is considered a risk factor for trisomy, as well as recombination alterations and many others that can affect chromosomal segregation.

Q1. Which of the following conclusions can be true regarding aneuploidy? (1)

Ans.i)It is the presence of an extra chromosome in a diploid cell.

ii)It can be less number of chromosomes in a diploid cell.

Q.2. Wahat are the causes of Aneuploidy ? (2)

Ans.- i).Most of the aneuploidy results from errors in cell division involved in egg formation.

ii).Nondisjunction in meiosis I can lead to more abnormal cells than disjunction in meiosis II.

Q.3. Assertion: All types of genetic disorders are caused by chromosomal nondisjunction.

Reason: Chromosomal nondisjunction always affects female individuals.

Ans- Both assertion and reason are incorrect

CASE-STUDY - III

The process of copying genetic information from template strand of DNA and RNA is called transcription. It is mediated by RNA polymerase. Transcription takes place in the nucleus of eukaryotic cells. In transcription only a segment of DNA and only one of the strands is copied into RNA.

Q.1.What is the binding site of RNA polymerase ? (1)

Ans. Promoter

Q.2.What are monocistronic structural genes ? Where do you find them ? (2)

Ans.- If a stretch of replicating DNA contains a single cistron, it is called monocistronic

Eukaryotes

Q.3.Assertion: A single RNA polymerase in prokaryotes synthesis all types of RNAs

Reason: Prokaryotic RNA polymerase has sigma factor. (1)

a) Both assertion and reason are true and reason is the correct explanation of assertion

UNIT IV- CELLS AND ORGANISMS

Marks: 25

Chapter 1: The Basic Unit of Life

Contents of the chapter

- Cell Structure and Components

Chapter 2: Genes and Genomes: Structure and Function

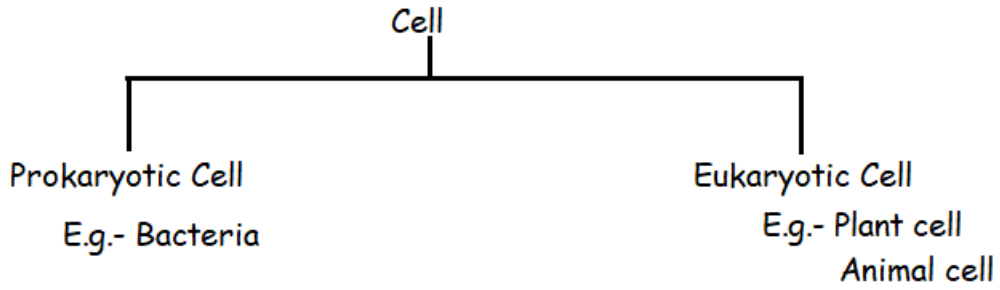
Contents of the chapter

- Cell Division
- Cell Cycle
- Cell Communication
- Nutrition
- Reproduction
- In Vitro Fertilization
- Immune Response in Animals

CHAPTER 1: BASIC UNIT OF LIFE

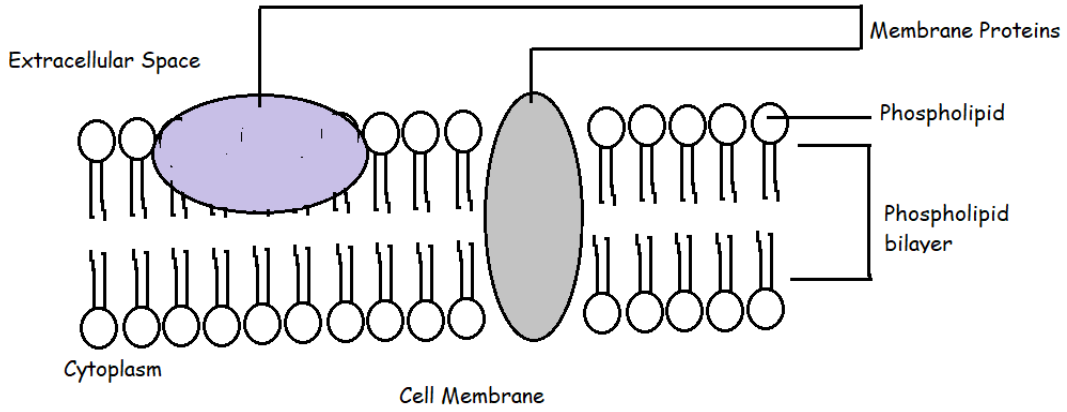
Cell Structure and Components

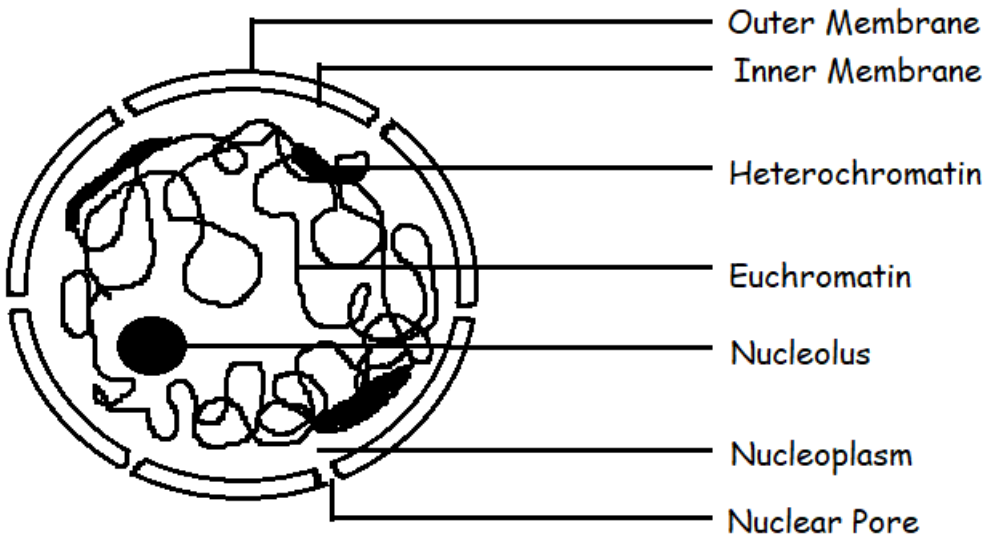
- ✓ **Cell**- the basic unit of structure and function of life
- ✓ **Cell biology-** study of cell and cellular processes
- ✓ Common features of all cells-
  - Presence of cell membrane
  - Presence of cytoplasm
  - Presence of genetic material (DNA)
  - Presence of ribosomes
- ✓ Presence of cell wall in bacteria and plant cell make both cells tougher as compared to animal cells.

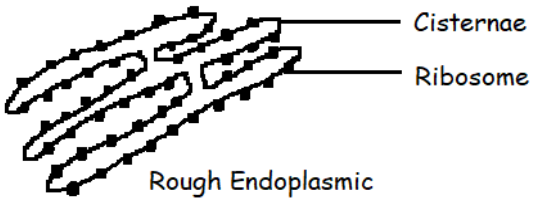


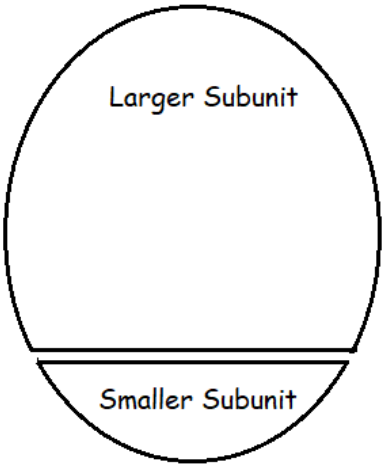
- ✓ Prokaryotic cell- Cells in which DNA is not bounded by a membrane (nucleus is absent) and absence of membrane bound organelles. In bacteria it is called nucleoid.
- ✓ Eukaryotic cell- Cells which have membrane bound nucleus and cell organelles. E.g.- Plant cells and animal cells.
- ✓ Cell organelles of eukaryotic cell- Endoplasmic Reticulum, Ribosomes, Mitochondria, Golgi Apparatus, Lysosome, Peroxisomes, Plastids, Cytoskeleton.

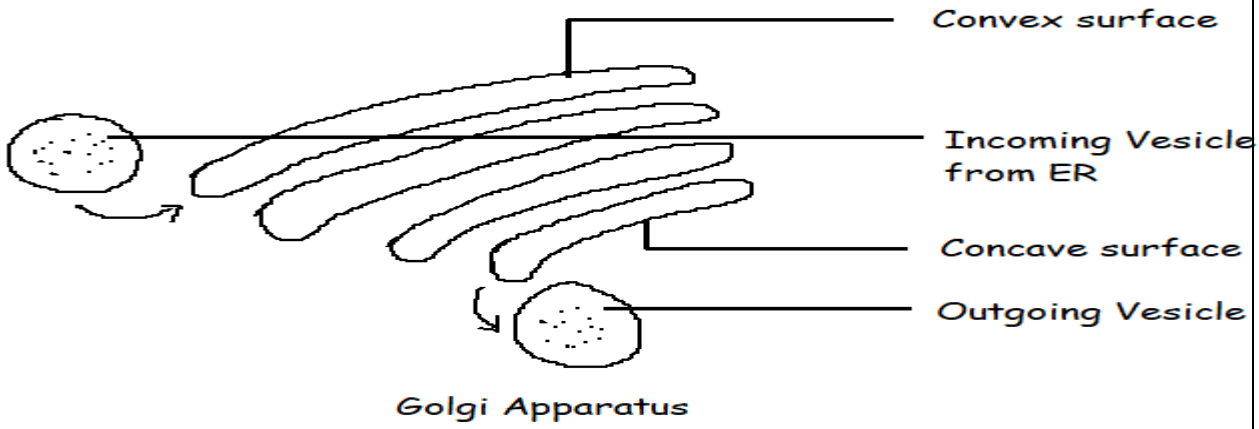
Components of cell	Features	Functions
Cell Membrane	• Made up of phospholipids and proteins • Cell membrane is semipermeable (allow passage of some solutes) • Phospholipids form a lipid bilayer and	• Separates the interior of cell from external environment • Exchange of gases • Bounds organelles • Site for metabolic activities like photosynthesis, oxidative phosphorylation

	protein molecules are scattered in this bilayer • Some proteins penetrate partly while others penetrate all the way	• Carries receptors which bind to extracellular signal molecules • Some proteins form channels, enzymes, cell-cell adhesion, immune response
		
Nucleus	• Largest cell organelles • Spherical or ovoid and about 10 µm in diameter • Two membrane- outer and inner membrane • Outer membrane continues with ER • Contains - chromatin, nucleolus and nucleoplasm • Chromatin can be divided into heterochromatin and euchromatin • Nucleolus is a round structure contains large amount of DNA	• Chromatin contains DNA which contains genes that determine the traits of an organism • Site of synthesis of RNA for protein synthesis • Synthesis of rRNA, tRNA • Assembly of ribosomes takes place in the less dense region at the center is where rRNA is folded and assembled with proteins. • Nuclear pores are connection between the cytoplasm and nucleoplasm for exchange of materials

	and rRNA • Nuclear membrane has pores	
 Nucleus		
Cytoplasm	• Ground, aqueous substance in the cell • It contains cell organelles and inclusions (insoluble cellular waste or storage products) • Protoplasm = nucleus + cytoplasm • Cytosol – soluble part of cytoplasm • Cytosol contains microfilaments, 90% water and dissolved ions, salts, sugars, amino acids, nucleotides, dissolved gases	• Store house of various biochemicals • Site of many reactions of metabolic pathways like glycolysis, synthesis of fatty acids, nucleotides and some amino acids • Cytoplasmic streaming is observed in live cells
Endoplasmic	• Complex network	• RER- site for

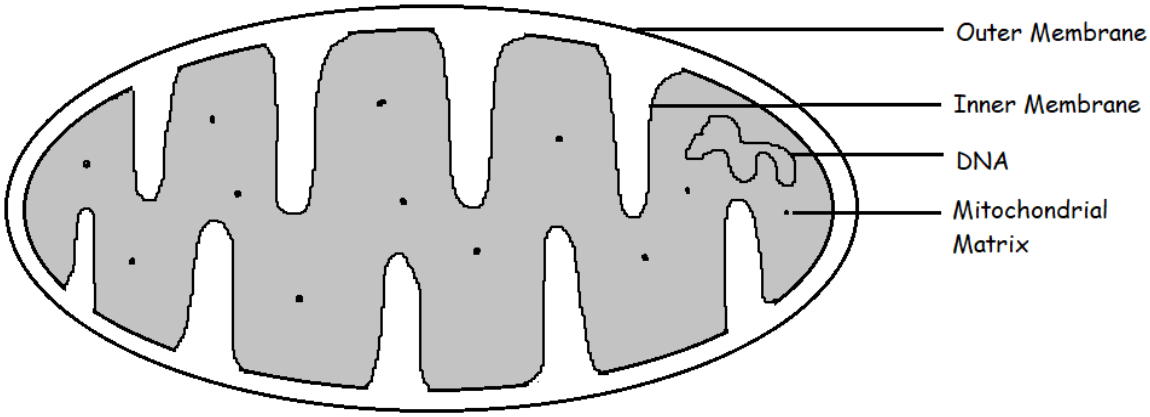
Reticulum (ER)	or reticulum of membranes throughout the cytoplasm • Contains flattened membrane bound sacs- cisternae • Two types – rough endoplasmic reticulum (RER) and smooth endoplasmic reticulum (SER) • RER membranes are associated with ribosomes • SER membranes do not have any ribosomes	synthesis of proteins • SER- lipid synthesis • Transports proteins to Golgi apparatus
 Rough Endoplasmic Reticulum  Smooth Endoplasmic Reticulum		
Ribosomes	• Small- 20 nm diameter • Made up of almost equal amounts of rRNA and protein- ribonucleoproteins • prokaryotic ribosome- 70 S and eukaryotic ribosome – 80 S • 70 S ribosome is also found in	• Ribosomes bind to the mRNA and provide site for protein synthesis with charged tRNA

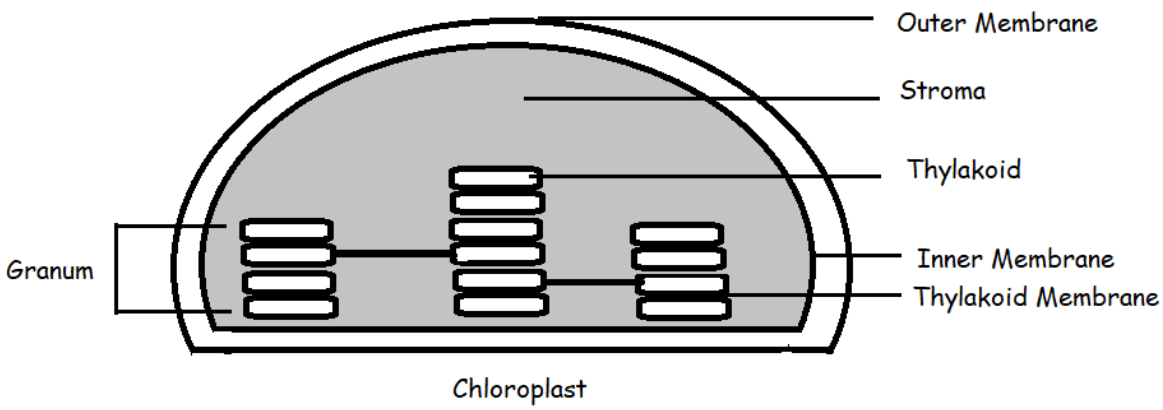
	mitochondria and chloroplast • Ribosomes are made up of 2 subunits- larger subunit and smaller subunit	
Prokaryotic Ribosome (70 S) * Larger Subunit- 50 S * Smaller Subunit- 30 S	 Ribosome	Eukaryotic Ribosome (80 S) * Larger Subunit- 60 S * Smaller Subunit- 40 S
Golgi Apparatus	• Consists of membrane bound sacs – cisternae • Cisternae are formed by fusion of vesicles from ER • Fusion of vesicles takes place on outer convex surface • Vesicles bud off from the inner concave surface	• Addition of carbohydrate moiety to proteins- Glycosylation • Glycoproteins serve as receptors on cell surface • Synthesis of lysosomes



Golgi Apparatus

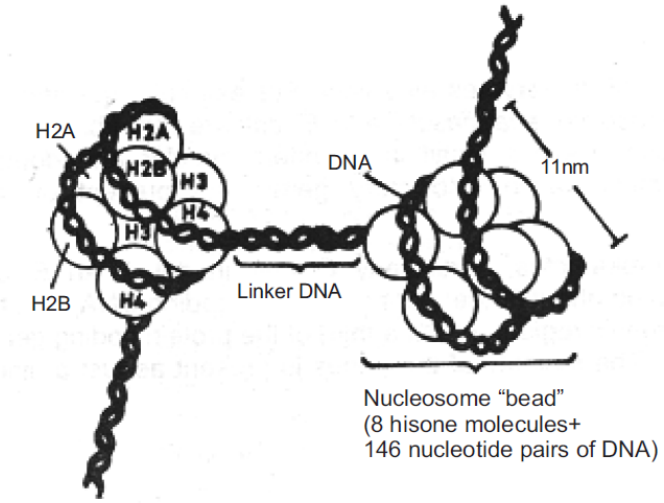
Lysosome	• Small, single membrane bound organelles • Contain hydrolytic enzymes (synthesized on ER and transported to Golgi apparatus) • Hydrolytic enzymes – nuclease, protease and lipases	• Primary lysosomes fuse with phagocytic vesicles to form phagolysosome • Digest the materials which have been phagocytosed by cells
Peroxisome	• Small, single membrane bound organelles • Contain enzyme-catalase	• Participate in metabolic process involved in oxidation
Mitochondria	• Elongated, double membrane bound organelles • Inner membrane is folded inwards-cristae • Mitochondrial matrix contains ribosomes, circular DNA,	• Power house of the cell • Site for Kreb's cycle and oxidative phosphorylation and electron transport

	phosphate granules • Contain hydrolytic enzymes (synthesized o	
 Mitochondrion		
Plastids- (only in plant cells) Three types	• Organelles with two membranes	
1. Chloroplast	• Contain chlorophyll and carotenoids • They are about 3-10 µm in diameter • Stroma- ground substance • Thylakoids- membrane system in stroma that are flattened and fluid filled • Grana- Stack of thylakoids • Lamellae- the membrane between grana • Thylakoid membranes contain chlorophyll and other pigments	• Pigments absorbs sunlight for photosynthesis • Perform photophosphorylation

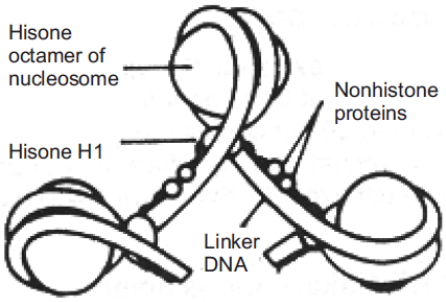
	with enzymes and electron carriers	
 Chloroplast		
2. Chromoplast	• Contain pigments- red, orange and yellow • Non-photosynthetic	• Present in fruits and flowers to impart colour
3. Leucoplast	• Colourless plastids	• Storage of food • Amyloplast- Starch storage • Lipidoplast- Lipids storage • Proteoplast- Protein storage
Cytoskeleton	• Network of fibrous proteins • Two types- Microtubles and microfilaments	• Helps cells maintain their shape • Movement of cell, organelles
1. Microtubules	• Unbranched, hollow, cylindrical • Consists of protein- Tubulin • In spindles, flagella, cilia	• Movement of cells • Movement of chromosomes during cell division • Movement of cell organelles like Golgi vesicles
2. Microfilaments	• Fine protein filaments • Actin protein • Occur in sheets and bundles just	• Involved in endocytosis and exocytosis • Involved in movement of cells

	below the cell membrane	

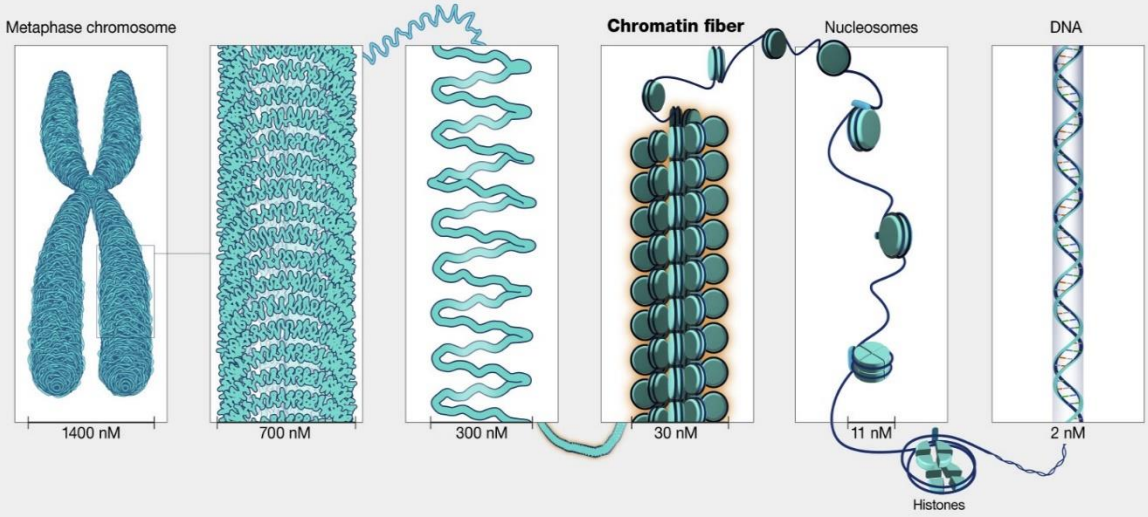
DNA → Chromatin → Chromosome



Nucleosomes showing core histones



Nucleosomes showing linker histones and DNA



Organization of Life

Biological hierarchy- organizing components of living organisms and living organisms

Molecules (DNA, Proteins, Carbohydrates, Lipids)

⬇

Cell (Molecules are organized to form a cell. E.g.- bacteria- single cells and cells of multicellular organisms)

⬇

Tissue (Group of cells with similar origin and function. E.g. Muscle tissue, Nervous tissue, etc.)

⬇

Organ (Different tissues are organized into organs like heart, brain, etc.)

⬇

Organ System (Groups of organs function together to form system like Digestive system- stomach, liver, pancreas)

⬇

Organism (Group of organ systems work together to form an organism)

⬇

Population (Group of individuals of the same species in an area and time)

⬇

Community (Group of different species that live and interact in an area)

⬇

Ecosystem (Communities along with physical environment in the area)

⬇

Biomes (Larger areas that are representative of environmental conditions like forests, deserts, etc.)

⬇

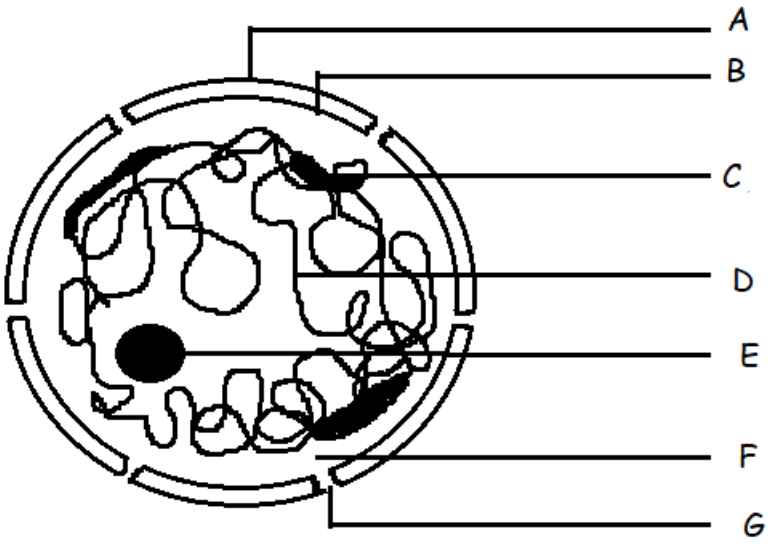
Biosphere (All biomes together which includes all living organisms of earth)

Multiple Choice Questions

1. Cell is basic _____
    a. Structural and functional unit of plants
    b. Structural and functional unit of animals
    c. Structural and functional unit of life
    d. Structural and functional unit of bacteria
2. All cells do not have-
    a. Cytoplasm
    b. Cell membrane
    c. Ribosome
    d. Mitochondria
3. Which of the following is true about bacteria?
    a. It is a prokaryotic cell
    b. It has a nucleus
    c. It has 80 S ribosomes
    d. It has no cell wall
4. Why plant cells and bacterial cells are tougher than animal cells?
    a. They are both prokaryote
    b. They both have cell wall
    c. They both have nucleus
    d. They have cytoplasm
5. Which of the following will be found in both bacteria and mitochondria?
    a. Cell wall
    b. Ribosomes
    c. Cristae
    d. Chlorophyll
6. Which of the following is not a function of cell membrane?
    a. It has surface receptors that receives signals
    b. It allows all the solutes in and out of the cell
    c. It separates the outside of cell from cytoplasm
    d. It the site of many metabolic reactions
7. Which of the following is not a function of membrane protein?
    a. Synthesis of proteins
    b. Cell-cell adhesion
    c. Channel for some solutes
    d. Metabolic reactions

8. Which of the following is not a feature of fluid mosaic model?
   a. Phospholipids are present in bilayer form
   b. Proteins are present in the bilayer
   c. Some proteins penetrate the lipid bilayer
   d. Central layer of lipid covered by protein on both side
9. What is the route of secretion of proteins from a cell?
   a. ER → Vesicles of ER → Cisternae of Golgi apparatus → Vesicles → Membrane of cell
   b. ER → Vesicles of ER → Cristae of Golgi apparatus → Vesicles → Membrane of cell
   c. Vesicles of ER → ER → Cisternae of Golgi apparatus → Vesicles → Membrane of cell
   d. ER → Vesicles of ER→ Vesicles → Cisternae of Golgi apparatus → Membrane of cell
10. Why is rough ER called so?
   a. It has rough surface due to vesicles
   b. It has rough surface due to ribosomes
   c. It has rough surface due protein synthesis
   d. It has rough surface due to cristae
11. Which of the following is not the function of Golgi body?
   a. Secretion of proteins from cell
   b. Synthesis of lysosomes
   c. Glycosylation of protein
   d. Synthesis of proteins
12. Microsomes are-
   I. Never found in intact cells
   II. Small sacs that are covered in ribosomes
   III. Formed due to homogenization of Endoplasmic Reticulum
   IV. Formed for transport of proteins within the cell
   a. I, II, IV
   b. I, III, IV
   c. I, II, III
   d. II, III, IV
13. Catalase are found in _____
   a. Peroxisome
   b. Lysosome
   c. Phagosome
   d. phagolysosome

14. Vesicles are formed from the ____ side of Golgi apparatus and fuse at the ____ side of the Golgi apparatus.
    a. Inner Concave, Outer Convex
    b. Outer Convex, Inner Concave
    c. Outer Concave, Inner Convex
    d. Inner Convex, Outer Concave
15. Which of the following is the correct pair of plastids and their functions?
    a. Chloroplast- storage of food
    b. Chromoplast- photosynthesis
    c. Amyloplast- storage of starch
    d. Proteoplast- storage of polysaccharides
16. Where is ribosome assembly done?
    a. Centre of nucleolus
    b. Centre of nucleus
    c. Periphery of nucleus
    d. Periphery of nucleolus
17. Ribosome is party assembled in _____ and the assembly is completed in _____
    a. Nucleus and cytoplasm
    b. Nuclear membrane and cytoplasm
    c. Nucleolus and nuclear membrane
    d. Nucleoplasm and nuclear membrane
18. In the following diagram parts of a nucleus are labelled A to G. Which of the following is the incorrect label?



    a. A- Outer Membrane
    b. F- Nucleoplasm

c. D- Heterochromatin
d. E- Nucleolus

19. Which organelle is called the powerhouse of cells?
a. Plastids
b. Nucleus
c. Vacuole
d. Mitochondria

20. Which of the following metabolic activity does not take place in the cytoplasm?
a. Glycolysis- breakdown of sugar
b. Synthesis of fatty acids
c. Synthesis of nucleotides
d. Synthesis of sugars

21. Under the microscope, how will a live cell look different from a dead cell?
a. The live cell will show metabolism
b. The live cell will show movement of chromatin
c. The live cell will show movement of cytoplasm and organelles
d. The live cell will the microfilaments and microtubules

22. Which cells are more likely to have a greater number of lysosomes?
a. Muscles
b. Macrophages
c. Neurons
d. Epithelial cells

23. Which of the following is not the content of cytosol?
a. Inclusion bodies
b. Amino acids
c. Sugars and salts
d. Nucleotides

24. The major role of cytoskeleton is –
a. Maintaining the shape of cells
b. Movement of cell
c. Movement of organelles of cell
d. All of these

25. Which of the following is not true about the inner membrane of mitochondria?
a. It is highly folded inwards to form cristae
b. It contains enzymes and electron transporters

c. It is highly folded to form cisternae

d. It is the site of ATP synthesis

Assertion and Reason Questions-

Assertion (A) and Reason (R). Answer these questions selecting the appropriate option given below:

a. Both Assertion and Reason are true and the reason is the correct explanation of the assertion

b. Both Assertion and Reason are true but the reason is not the correct explanation of the assertion

c. Assertion is true but Reason is false

d. Both Assertion and Reason are false

26. Assertion: Chromoplasts are non- photosynthetic.
Reason: They are present in fruits and flowers of plants and give them bright colours.
Answer- B

27. Assertion: Mitochondria are called the power house of the cells.
Reason: Mitochondria produce ATP with the help of proteins in its inner membrane
Answer- A

28. Assertion: Macrophages have large number of primary lysosomes.
Reason: Macrophages are involved in phagocytosis
Answer- A

29. Assertion: Lysosomes contain hydrolytic enzymes.
Reason: Lysosomes are synthesized by peroxisomes.
Answer- C

30. Assertion: Cytoplasm of the living cell does not show cytoplasmic streaming.
Reason: Cytosol is the insoluble part of cytoplasm.
Answer- D

31. Assertion: Cell membrane has many proteins that carry out a variety of functions.
Reason: Nuclear membrane does not have any proteins associated with it.
Answer- C

32. Assertion: Nucleolus of the nucleus stains lightly.
Reason: Nucleolus is made up of proteins.
Answer- D

33. Assertion: Cell membrane is semipermeable.
Reason: The phospholipid bilayer does not allow water soluble substances like glucose to pass through it.
Answer- A

34. Assertion: Plant cell is a prokaryotic cell.
Reason: Plant cell does not have a cell membrane but only a cell wall.
Answer- D

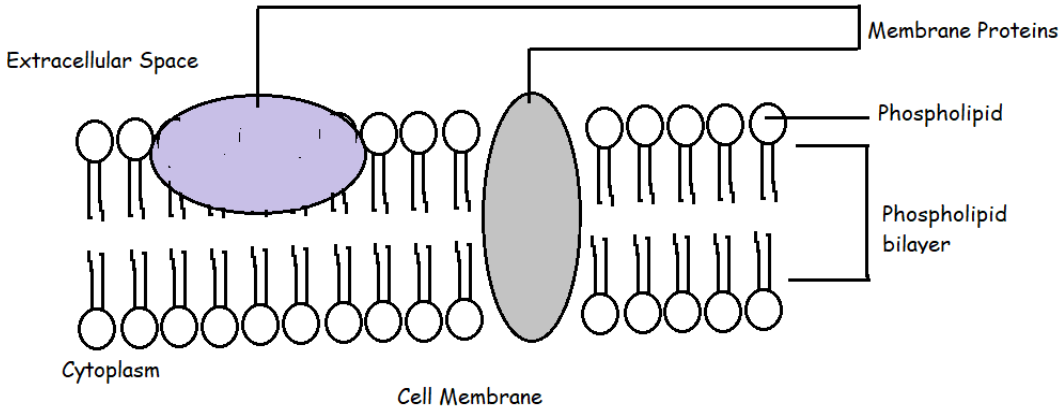
35. Assertion: Cytoplasm of the living cell does not show cytoplasmic streaming.
Reason: Cytosol is the insoluble part of cytoplasm.
Answer- D

Short Answer Type Questions

1. Distinguish between eukaryotic and prokaryotic cell

Eukaryotic cell	Prokaryotic cell
Membrane bound nucleus	No membrane bound nucleus
Membrane bound cell organelles	No membrane bound cell organelles
80 S ribosomes in cytoplasm	70 S ribosomes in cytoplasm

2. Draw the structure of cell membrane and label any two parts



3. Mention the characteristics of nucleus.
   - Spherical or ovoid and about 10 µm in diameter
   - Two membrane- outer and inner membrane
   - Outer membrane continues with ER
   - Contains -chromatin, nucleolus and nucleoplasm
   - Chromatin can be divided into heterochromatin and euchromatin

- Nucleolus is a round structure contains large amount of DNA and rRNA
- Nuclear membrane has pores

4. Distinguish between euchromatin and heterochromatin

Euchromatin	Heterochromatin
Loosely coiled chromatin	Highly coiled chromatin
Transcriptionally active part of genome	Transcriptionally inactive part of genome
Stains lightly	Stains darker

5. What are inclusion bodies?
   Insoluble cellular wastes or storage products in the cytoplasm are called inclusion bodies.
6. How are chloroplast similar to mitochondria? Similarities-
   - Both organelles have their own circular DNA
   - Both organelles have double membrane
   - Both organelles have 70 S ribosomes
7. How are mitochondria and chloroplast different?
   - Mitochondria generates ATP by oxidative phosphorylation while chloroplast uses light to generate ATP.
   - Chloroplast has green pigment- chlorophyll while mitochondria lack it.
8. Distinguish between microtubules and microfilaments

Microtubules	Microfilaments
Protein- tubulin	Protein- actin
Found in- cilia, flagella, and spindle fibre	Found in- cytoplasm below the membrane
Responsible for the movement of cell organelles, chromosomes, and cell (cilia and flagella)	Responsible for endocytosis, exocytosis, and movement of cells

9. What is the importance of plastids in plant cells?
   a. Plastid containing chlorophyll is important for photosynthesis
   b. Plastid containing other colours are important for brightly coloured flowers and fruits

c. Plastids that do not contain any colour are important for food storage

10. What is phagolysosome?

Phagolysosomes are formed in a cell when a phagosome (formed due to endocytosis) is fused with lysosome (contains hydrolytic enzymes) to digest the content of the phagosome.

11. Why are ribosomes called ribonucleoproteins?

Ribosomes contain equal amounts of rRNA and proteins. Hence, they are called ribonucleoproteins.

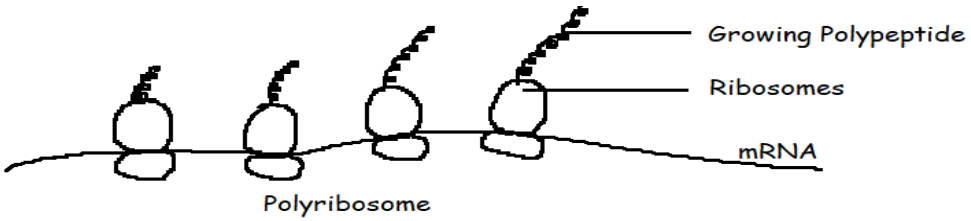
12. What is a nucleosome? What happens to the chromatin during cell division?

The DNA and the histones are organized into beadlike structure called nucleosomes. The core is made up of histone proteins (octamer) and the DNA is wrapped around it.

The chromatin that is thread and bead structure in an interphase nucleus condenses to form a dense structure called the chromosome during cell division.

13. What is polyribosome?

Many ribosomes are attached to a single mRNA. This is used to synthesize proteins efficiently.



14. What is glycosylation? What is the importance of glycoproteins?

Addition of carbohydrate moiety to the proteins in cisternae of Golgi apparatus is called **glycosylation.**

Glycoproteins serve as important receptors on cell surfaces.

15. What is the role of nucleolus in a cell?

It contains large amounts of DNA that codes for rRNA. rRNA is an important component of ribosomes. Hence, nucleolus has an important role in the synthesis of ribosomes.

Long Answer Type Questions

1. Observe the image given below and answer the following questions-[5]

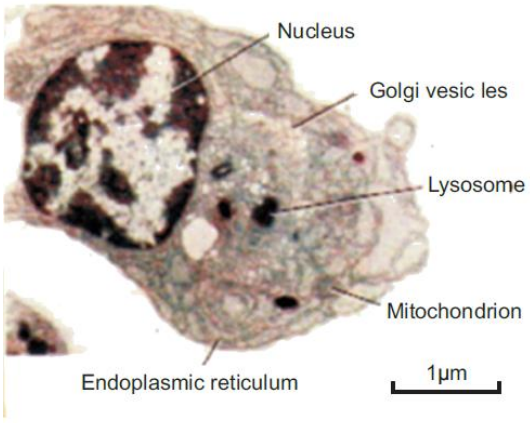


Image A

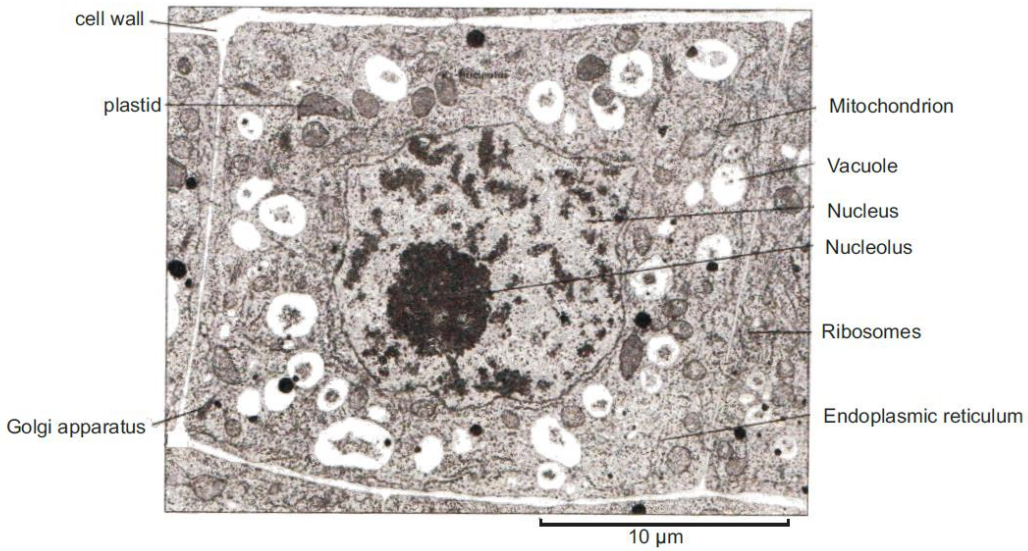


Image B

a. Identify images A and B.

A- Animal Cell

B- Plant cell

b. How are they different from each other?

Animal cell	Plant cell
Cell wall absent	Cell wall present
Plastids absent	Plastids present
Centrioles present	Centrioles absent

c. How are they similar to each other?
They both have cell membrane and membrane bound organelles
They both have cytoplasm which is the sire of many metabolic activities

2. Mention any five functions of cell membrane.
   a. It separates the interior of the cell from the external environment.
   b. It controls exchange of gases, solutes etc., between the interior of the cell and its external environment.
   c. It bounds the organelles in the cell such as nucleus, mitochondria, chloroplasts and Golgi apparatus where specialized metabolic pathways take place.
   d. Sometimes it functions as the site for photosynthesis or oxidative phosphorylation.
   e. It carries the receptors to which various ligands such as hormones, antibodies and other chemicals can attach and initiate a variety of reactions.
3. Mention any five functions of membrane proteins.
   a. Channel proteins that allow the movement of some molecules
   b. Membrane protein may function as enzymes
   c. Some glycoproteins help in cell-cell adhesion and play important role in immune system
   d. Some proteins act as receptors to external signals and relay the information to the nucleus
   e. Some membrane proteins act as electron carriers and help in the phosphorylation

Case Based Question

1. Read the following excerpt and answer the following questions

Each ribosome consists of two subunits, one small and one large. Based on their
sedimentation rate in a centrifuge machine, ribosomes are classified into two types, 70S and 80S. The 70S ribosomes are found in bacterial cells while 80S ribosomes are found in plant and animal cells. It is important to note that 70S ribosomes are also found in the mitochondria and chloroplasts of eukaryotes.

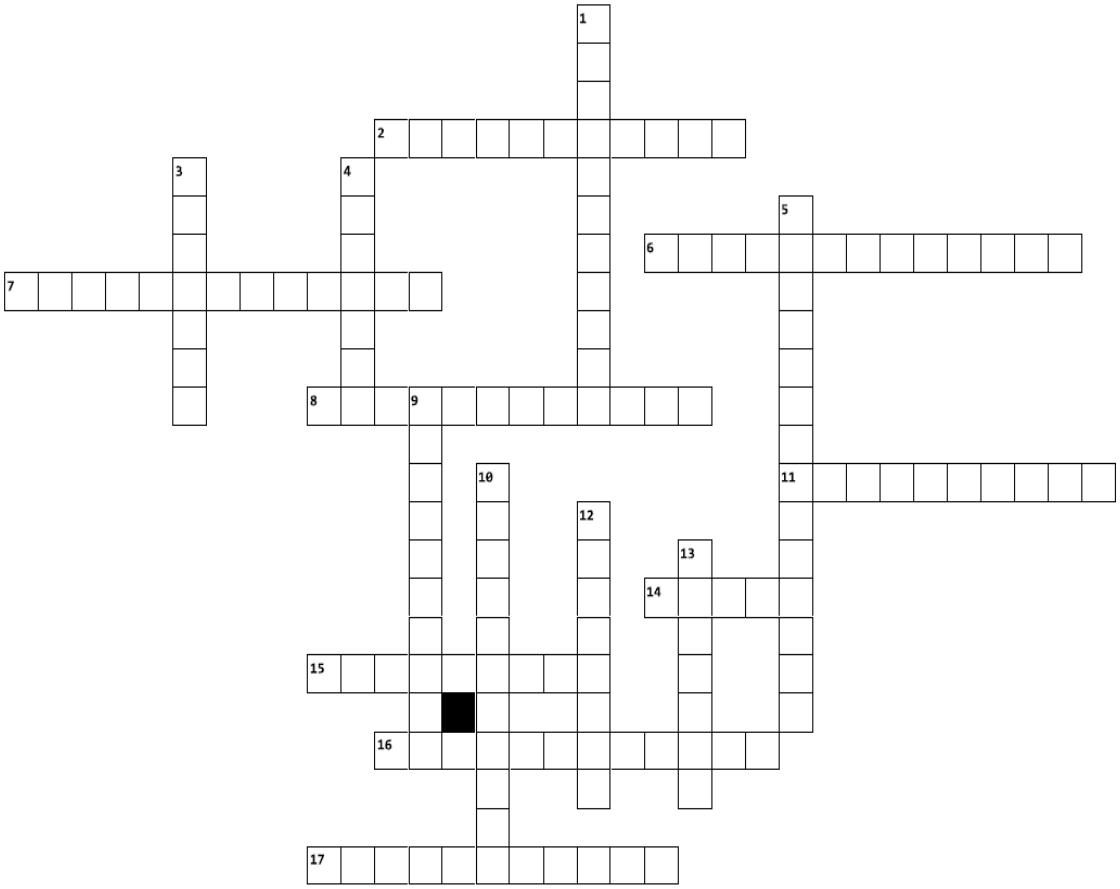
a. What is the location of ribosomes in eukaryotic and prokaryotic cell?

Cytoplasm of cell and in eukaryotes on the Rough Endoplasmic Reticulum

b. Why is ribosome considered a dimer?
Ribosomes are made of 2 subunit- one small and one large

c. Which organelles of eukaryotic cell contains 70S ribosomes? What can be inferred about the origin of organelles?
Mitochondria and chloroplasts
They may be related to prokaryotic cells

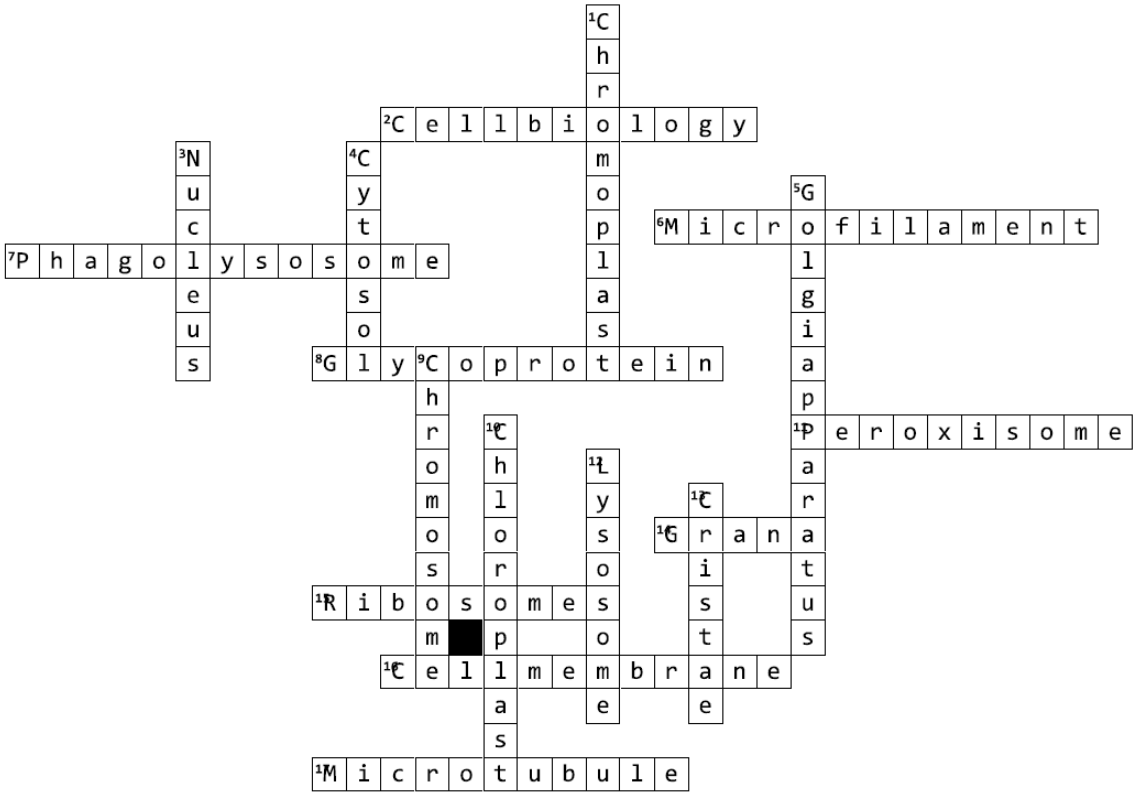
CROSSWORD PUZZLE



Across	Down
2. Study of cell and cellular processes **6.** Cytoskeleton that is made up of actin **7.** Phagocytic vesicle fused with lysosome **8.** Proteins that help with cell-cell adhesion **11.** Organelle that contain the	**1.** Coloured but non-photosynthetic plastid **3.** Membrane bound organelles that contain DNA **4.** Soluble part of the cytoplasm **5.** Cell organelle named after Camillo Golgi **9.** Chromatin is condensed

enzyme peroxisome **14.** Stack of thylakoid **15.** RER is rough due to the presence of these **16.** Structure that surrounds all cells **17.** Cytoskeleton that is made up of tubulin protein	during cell division to form ___ **10.** Plastid that contains photosynthetic pigments **12.** Single membrane bound organelle that contains digestive enzymes **13.** The inner membrane of mitochondria is folded to form ___

Answer



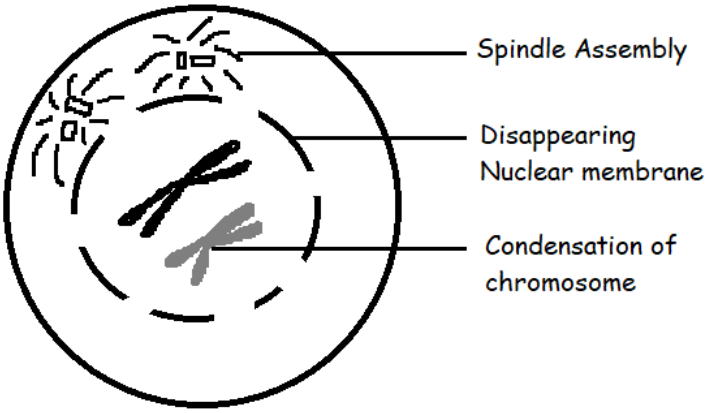
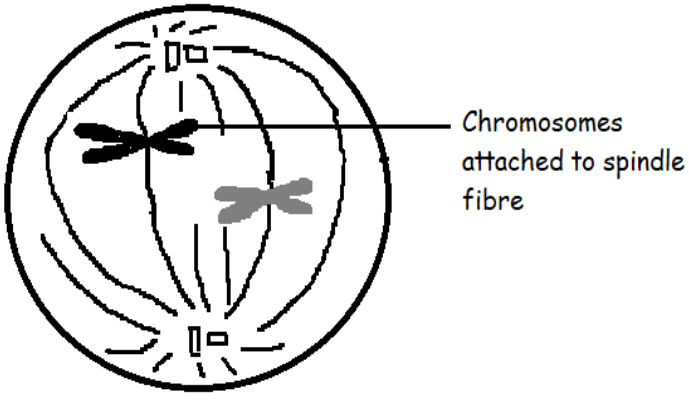
B

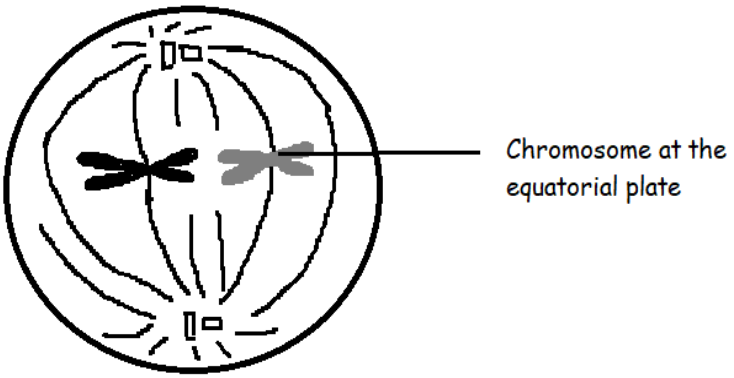
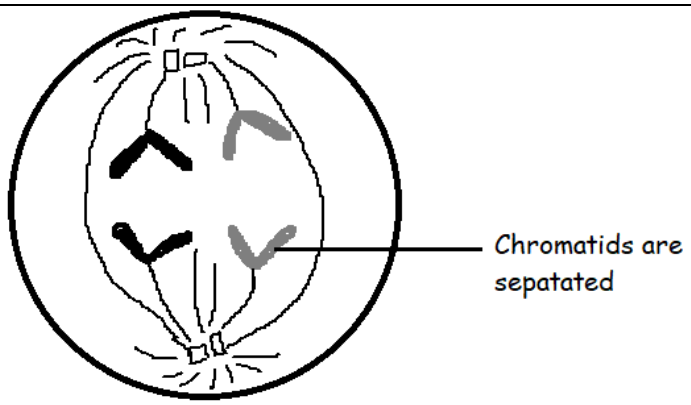
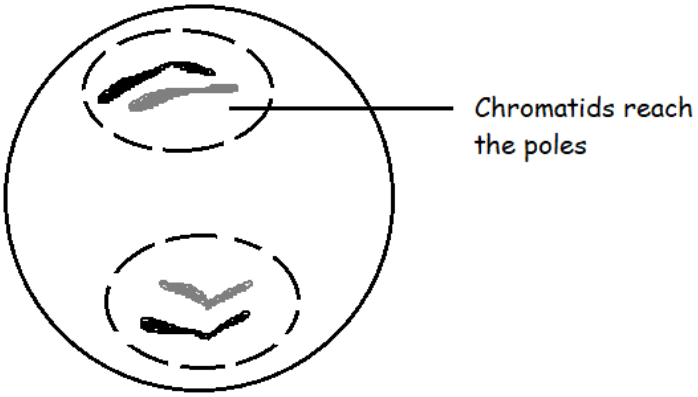
CHAPTER 2- CELL GROWTH AND DEVELOPMENT

A. Cell division

Mitosis

- ✓ Division of nucleus.
- ✓ Results in two nuclei that have same number of chromosomes as the parent nucleus.
- ✓ Divided into five different phases- Prophase, Prometaphase, Metaphase, Anaphase and Telophase.

Phases	Characteristics	Diagram
Prophase	▪ Condensation of chromatin to form chromosomes ▪ Cytoskeleton disassembles ▪ Spindle fiber begins to form from the centriolar organizing centres ▪ Disassembly of nuclear envelope	
Prometaphase	▪ Spindle fibers attach to the kinetochore of chromosomes ▪ Chromosomes begin aligning at the equatorial plate	

Metaphase	• Alignment of chromosomes at the equator • Each chromatid is connected to a spindle fiber from the opposite from opposite pole	
Anaphase	• Separation of sister chromatid from each other • Chromatids move towards opposite poles	
Telophase	• Chromatids reach opposite poles • Appearance of nuclear envelope • Uncoiling of chromatids to chromatin • Cell organelles start appearing	

Cytokinesis-

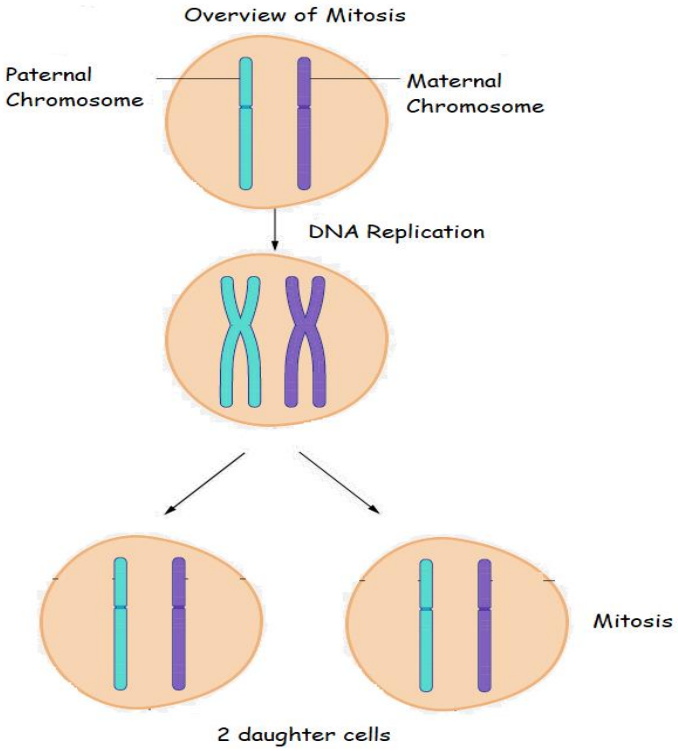
- ✓ Followed by karyokinesis (nuclear division)
- ✓ Animal cell- A cleavage furrow divides the cytoplasm between the two cells
- ✓ Plant cell- Cytoplasm is divided by construction of cell plate inside the cell

Result of mitosis-

- ✓ 2 genetically identical daughter cells are produced.

Importance of Mitosis

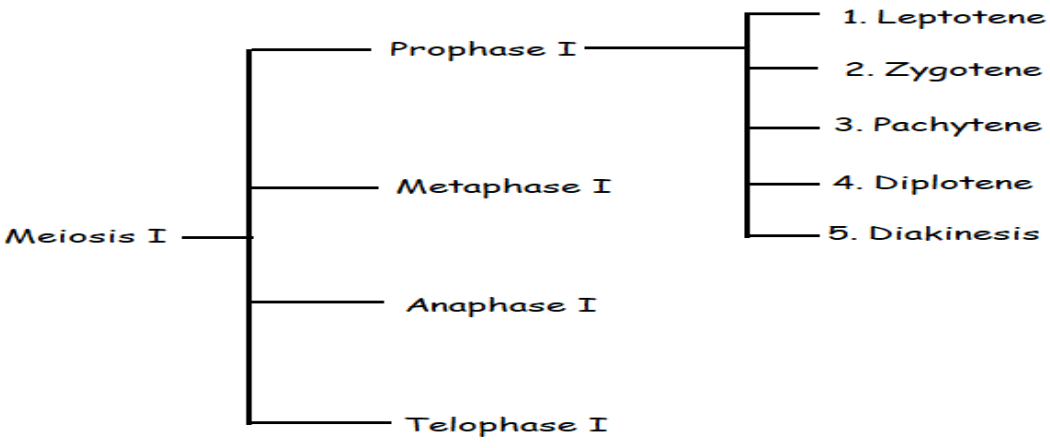
- ✓ Growth and development of organisms
- ✓ Healing and repair of organisms

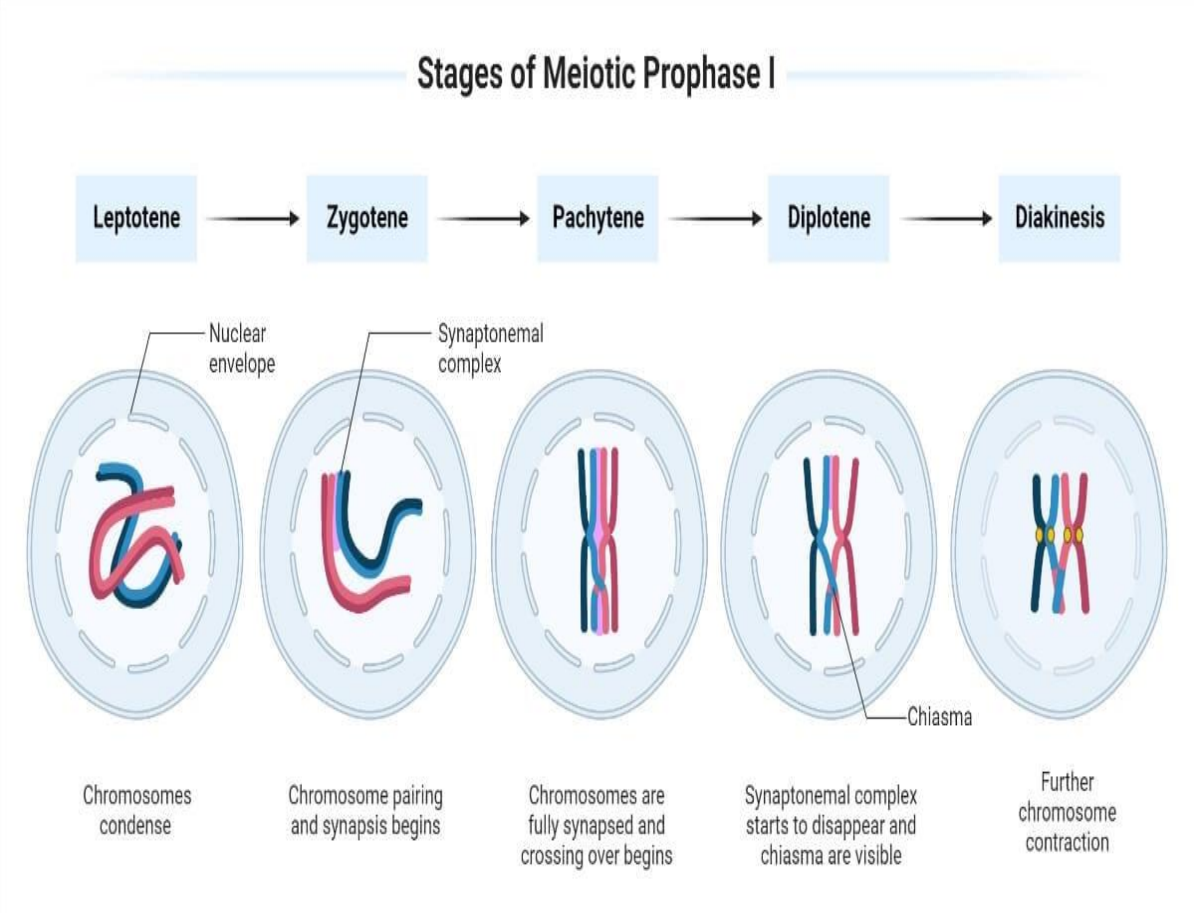


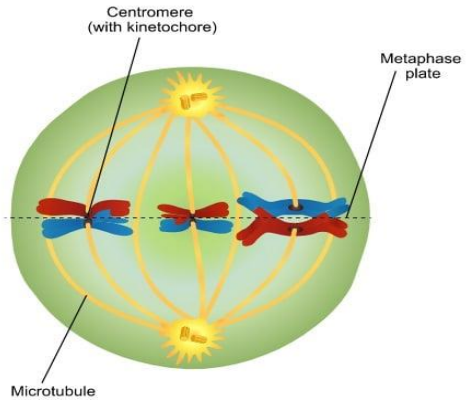
Meiosis

- ✓ Two successive nuclear divisions: Meiosis I and Meiosis II
- ✓ Meiosis I is reductional division (separation of homologous chromosomes)
- ✓ Meiosis II is equational division (separation of chromatids)

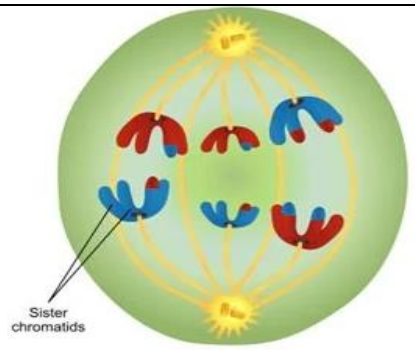
Meiosis I



Phases	Characteristics
Leptotene	Condensation of chromatin to form chromosomes
Zygotene	Synapsis – Process of pairing of homologous chromosomes Paired chromosomes are also bivalent or tetrad
Pachytene	Crossing over – process of exchange of parts of non-sister chromatids of homologous chromosomes
Diplotene	Homologous chromosomes move away from each other and remain attached at some points forming 'X' shaped structures - Chiasmata
Diakinesis	Meiotic spindle assembled Disappearance of nucleolus Breakdown of nuclear envelope Movement of tetrads towards metaphase plate
	
Metaphase I	Homologous chromosomes are paired at the metaphase plate Each chromosome is attached to the spindle fiber of opposite poles



Anaphase I	Chromosomes start moving towards opposite poles



Homologous chromosomes move to the opposite poles of the cell.

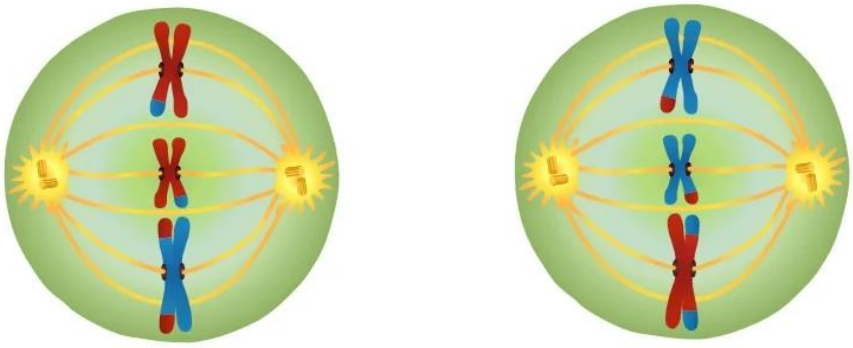
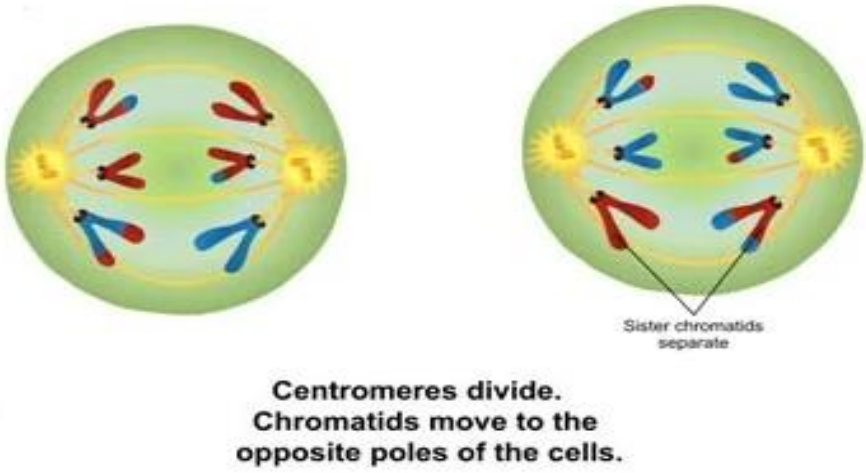
Telophase I	Movement of homologous chromosomes to the opposite poles is completed Nuclear membrane is formed
Cytosinesis	Cell is split into two daughter cells containing half number of chromosomes

Meiosis II

Follows Meiosis I and is like Mitosis

The interphase between two divisions is very short or non-existent (depending on species)

Phases	Characteristics
Prophase II	▪ Condensation of chromatin to chromosomes ▪ Cytoskeleton disassembles ▪ Spindle fiber begins to form from ▪ Disassembly of nuclear envelope
Metaphase II	▪ Chromosomes are arranged on the metaphase plate

	▪ Spindle fibers are attached to kinetochore of centromere
	
Anaphase II	▪ Separation of sister chromatids as they are pulled by the spindle fibres towards the opposite poles
	
Telophase II	▪ Chromatids reach the opposite poles and four haploid nuclei are formed
Cytokinesis	▪ Cytoplasm is divided between the daughter cells

Result of meiosis-

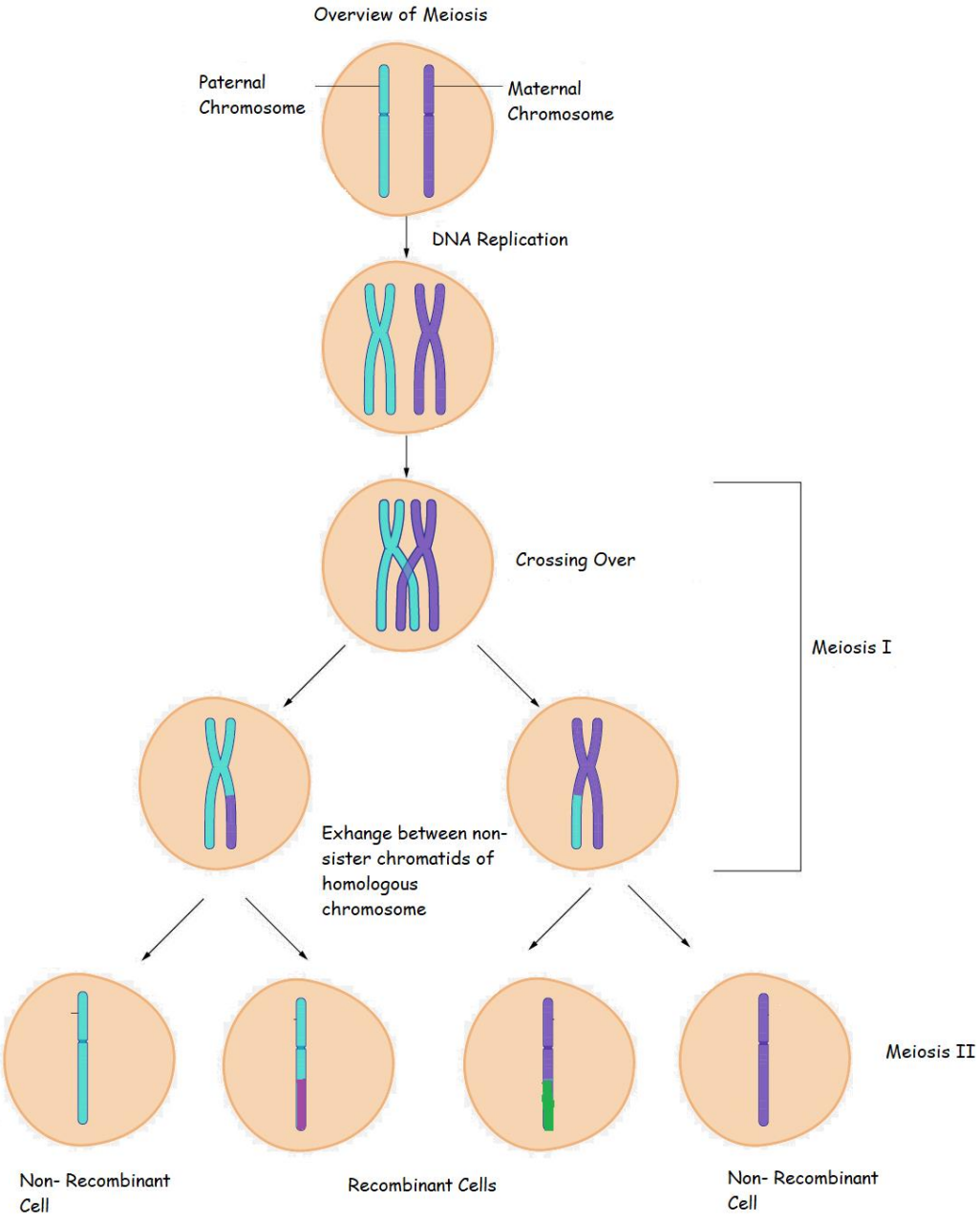
- ✓ 4 haploid (n) daughter cells are produced

[In case of humans 2n= 46, n=23]

Importance of Meiosis

- ✓ Gamete formation in sexually reproducing organisms
- ✓ Creating genetic variations

- ✓ Generation of haploid number of chromosomes in each gamete so the number of chromosomes is maintained in each generation



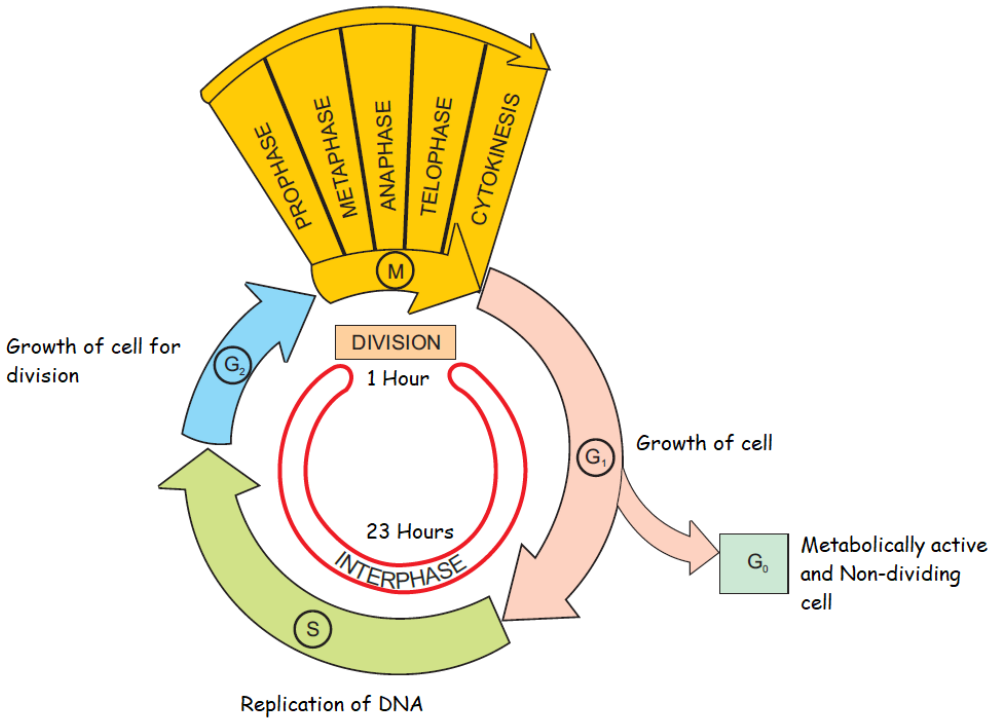
B. Cell cycle

- ✓ The events or change in cells from one cell division to start of another cell division.
- ✓ Cell cycle can be divided into two phases- Interphase and M phase (Mitosis).

- ✓ Eukaryotic cell may take 18-24 hours to complete cell cycle and mitosis completes in about an hour.
- ✓ For a cell cycle of 24 hours- 23 hours is Interphase and 1 hour is mitosis

Interphase

- ➢ Preparation of the cell for the next division
- ➢ Absence of chromosomes (they uncoiled to chromatin state)
- ➢ Interphase can be divided into 3 phases-
  - G_1 Phase (Gap 1) - Cell growth and metabolically active
  - S Phase – Synthesis or replication of DNA
  - G_2 Phase- Cell growth continues for mitosis
- ➢ G_1 Phase is an important stage as the cell may commit to either of the two paths-
  - Commit to division, then the S phase follows
  - Withdraw from division, then the cell enters G_0 phase (metabolically active but non-dividing cell)
- ➢ Cells may remain in G_0 phase for long time but may be stimulated to enter G_1 phase and continue the cell cycle



Cell cycle

Regulation of Cell Cycle

- ✓ This is important to produce normal healthy cells after each round of division

- ✓ Cell Cycle is regulated by checkpoints
- ✓ There are three checkpoints
  1. G_1/S checkpoint- Size of the cell is monitored and DNA is not damaged.
  2. G_2/M checkpoint- DNA replication completed; DNA damage repaired
  3. M Phase checkpoint- Spindle fiber formation and attached to the kinetochore of chromosomes
- ✓ If these criteria are fulfilled then the cell cycle is stopped at the phase till the task is completed
- ✓ Failure of any of the checkpoints can lead to cells with genetic damage

Molecules that regulate the cell cycle-

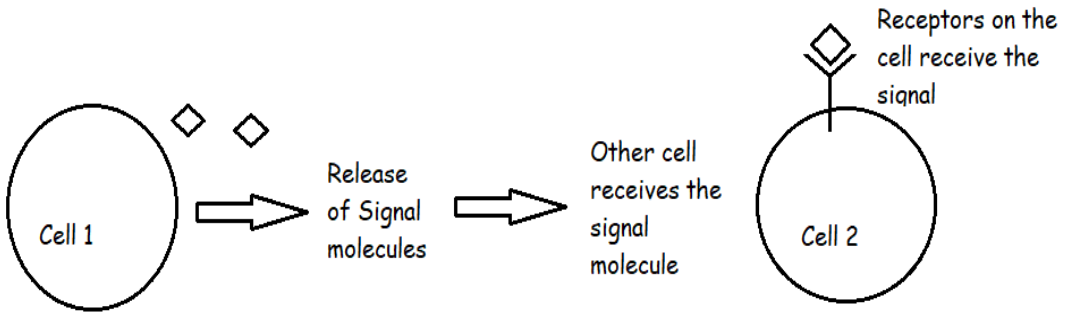
- ✓ Heterodimeric protein kinase (Hetero- means different, dimer- 2 subunits)
- ✓ One subunit is Cyclin (regulatory subunit). These are Cyclin A, B, D and E
- ✓ Second regulatory subunit is Cdk (Cyclin dependent kinase). These are Cdk1, Cdk2, Cdk4 and Cdk6
- ✓ In cyclins and Cdk complex, cyclin determines which proteins are phosphorylated by the cyclin-Cdk complex. Hence, they control the passage of cell through various checkpoints.

Cyclin	Cdk	Progression of cell cycle
D and E	Cdk2, Cdk4 and Cdk6	G_1 → S
A	Cdk1	S → G_2
B	Cdk1	G_2 → M

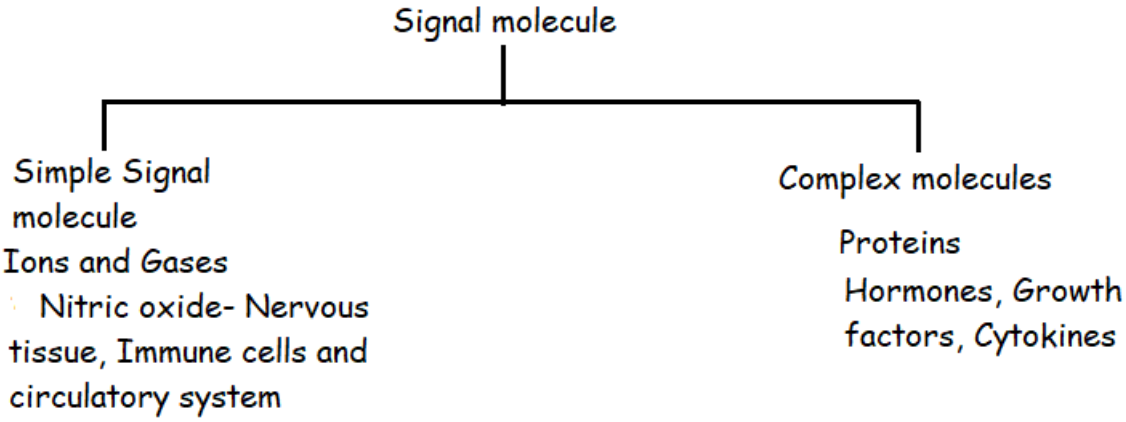
- ✓ DNA damage checkpoints also operate during G1, S and G2 phases. In case of DNA damage, they stop the cell cycle. DNA is repaired and cell cycle is resumed. These are regulated by CHK1 and CHK2

C. Cell communication

- ✓ All cells communicate with each other and their environment.
- ✓ Bacteria senses presence of glucose and amino acids in their environment and move towards them.
- ✓ Eukaryotic cells sense presence of molecules secreted by other cells (Signal molecules) and respond to them, allowing cell-cell communication.



- ✓ Signalling molecules- Molecules that may cause change in the target cell by binding to receptors of the target cells



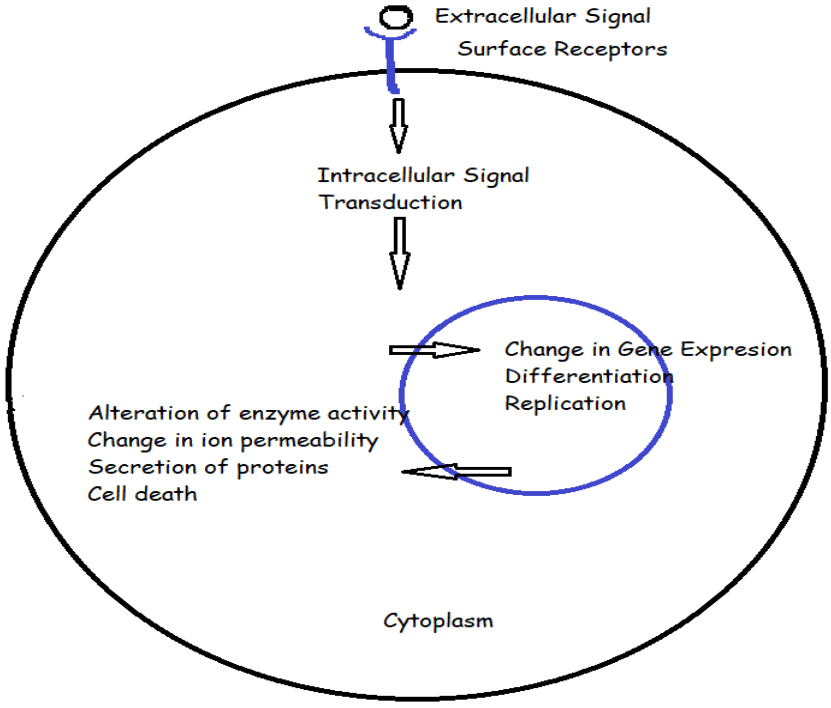
- ✓ Eicosanoids (class of lipids) includes signalling molecules like prostaglandins and leukotrienes.
- ✓ The distance at which these signalling molecules act also varies from local action to over long distances.
- ✓ Most signalling molecules bind to -
  a. Receptors on the surface of target cells
  b. Intracellular receptors inside the cells
- ✓ Cell surface Receptors

a. GPCRs- A large family of cell surface receptors act via guanine nucleotide binding proteins **(G proteins)** called **G protein-coupled receptors.**
b. Tyrosine kinase receptors- A group of receptors that act by phosphorylating their substrate proteins at tyrosine residues.

✓ Intracellular reactions of cell to signal molecule-
a. Intracellular signal transduction is initiated by the receptor
b. Signal is transmitted to the nucleus directly or by a network of molecules

✓ Signal transduction pathways- Network of molecules in the cytoplasm that transmit the signal from cell membrane to nucleus. These pathways include molecules like
a. cyclic AMP (cAMP)
b. Ca^{+2} and calcium-binding protein calmodulin
c. MAP (mitogen activated protein) kinases
d. NF-κB transcription factor

✓ Result of signal transduction-
a. Change in gene expression
b. Differentiation
c. Replication
d. Alteration of enzyme activity
e. Changes in ion permeability
f. death of the cell and many others



D. Nutrition

- ✓ All living organisms need nutrients to survive
- ✓ Nutrients provide energy and components for growth and reproduction
- ✓ Elements of Nutrients-
  - Three elements-Carbon, Hydrogen and Oxygen form the base of biomolecules like carbohydrates, proteins, fats and nucleic acid
  - Additional elements like Nitrogen, Phosphorus and Sulphur bond with Carbon in biomolecules
  - Elements that do not bond to Carbon and exist as ions or bound to some proteins- Sodium, Calcium, Magnesium, Chloride ions
  - Elements require in very small quantities- Microelements or trace elements- Manganese, Copper, Zinc, Cobalt, Selenium, and Iodine. These are part of vitamins and are important
- ✓ Plant Nutrition-
  - Plants produce their own food by the process of photosynthesis
  - Fix Carbon dioxide and water with sunlight in presence of chlorophyll to form sugar molecules and oxygen- Photosynthesis
  - This process generally takes place in palisade parenchyma of leaves
  - Spongy parenchyma absorbs CO_2 from air
  - Water and minerals are absorbed by the root hair (thin walled extensions of the epidermal cells in roots)
  - Some plants form associations with nitrogen fixing bacteria (convert atmospheric nitrogen into water soluble compounds)
- ✓ Animal Nutrition-
  - Animals consume the food synthesized by plants depend on other organisms
  - They have a digestive system where the complex nutrients are broken down into simpler absorbable molecules
  - Some gut bacteria also help in nutrition – bacteria in human gut synthesizes Vitamin K and B12 or bacteria found in the rumen of cattle digests cellulose

- Vitamins are needed by animals in small amounts. Vitamins are generally procured form diet.
- Vitamins of two types-
  - ❖ Water soluble (Vitamin B complex and Vitamin C)
  - ❖ Fat soluble (Vitamin A, D and E)
- Deficiency of Nutrients may lead to various diseases-
  - ❖ Protein deficiency- Stunted growth of children
  - ❖ Iron or Folic acid deficiency- Anemia
  - ❖ Vitamin C deficiency- Scurvy (Bleeding gums)
  - ❖ Vitamin A deficiency- Weak eyesight
  - ❖ Vitamin B_6 and B_{12} deficiency- nervous tissue problems

✓ Microbe Nutrition-
- Most bacteria and fungi are saprophytes (grow on dead plants and animals)
- They produce enzymes to digest the complex nutrients of dead plant or animal and absorb the simple molecules

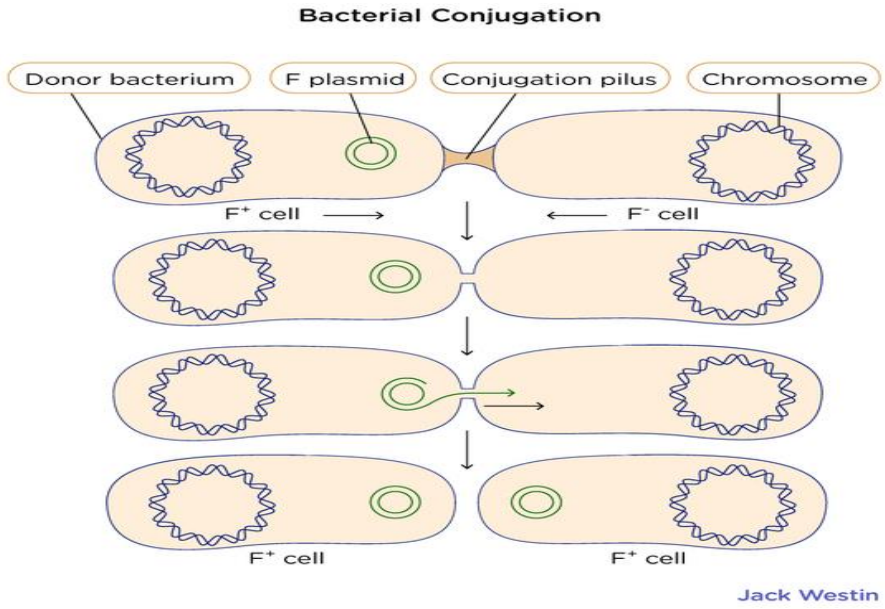
E. Reproduction

✓ Process of producing new individuals (offspring) by parents
✓ This involves transmission of genetic material to the next generation
✓ It ensures survival of species and increase the population of species
✓ It also allows for genetic diversity

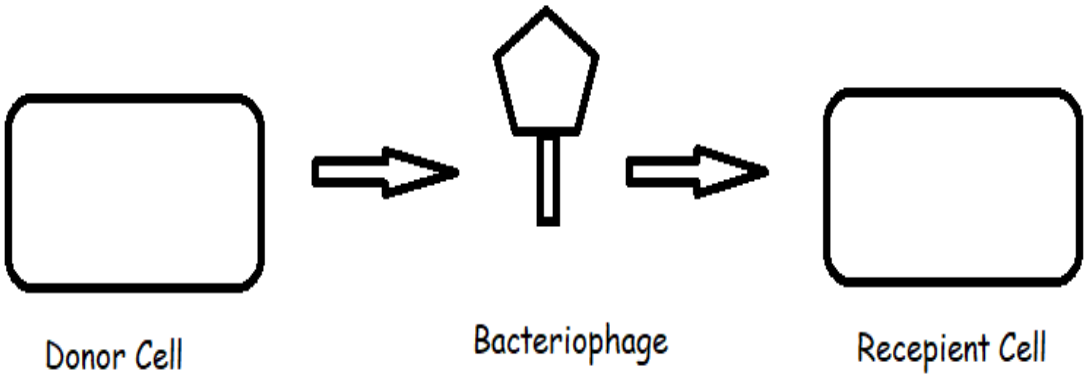
Reproduction in Microbes

- Generally asexual- no genetic exchange between cells
- A single cell divides to produce 2 cells and on successive divisions 4 cells, 8 cells and so on
- The number of microbes (bacteria) will increase exponentially
- Variations may arise due to mutation during DNA replication and genetic recombination
- Genetic recombination Variations may occur under the following processes-
  - ❖ Transformation
    Cells do not come in contact with each other
    Donor cell → releases DNA → actively taken by recipient cell
  - ❖ Conjugation

Donor bacterium has F plasmid (circular double stranded DNA which can confer some traits to the host cell)- F^+ Cell
Recipient bacterium does not have F plasmid- F^- Cell
Donor attaches to the recipient by a pilus and a copy of the plasmid is transferred to the recipient cell

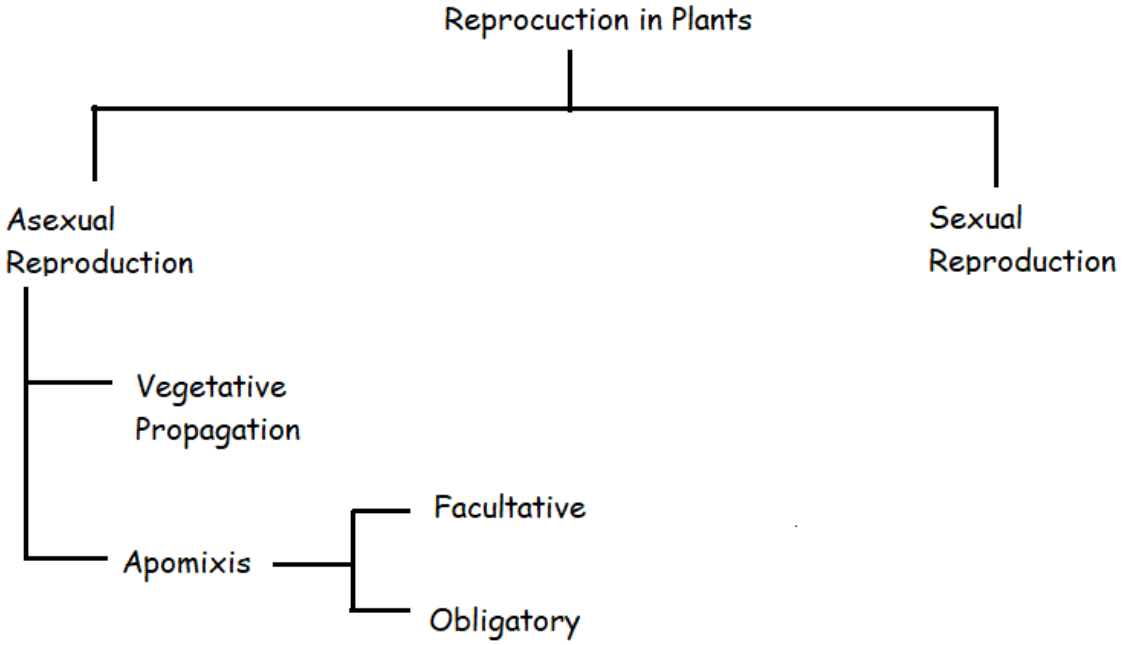


❖ Transduction
Bacteriophage- virus that infects bacteria
DNA is transferred from donor cell to recipient cell by bacteriophage



✓ **Reproduction in Plants**

- Reproduction in plants occur by both asexual and sexual reproduction



- **Asexual reproduction-**
  - ❖ Offspring are produced from somatic cells or unfertilized gametes
  - ❖ Two types- Vegetative reproduction and Apomixis

  Vegetative reproduction-

  - ❖ New plants are produced from somatic cells (vegetative propagules or vegetative parts- stem, tubers, bulbils, leaves, roots)
  - ❖ No seeds are produced
  - ❖ New plants are clones of the parent plant, therefore this method of reproduction is also called clonal propagation
  - ❖ Propagation may occur naturally or artificially (stem cutting, grafting, micropropagation)

  Apomixis

  - ❖ Embryos and seeds are developed without fertilization
  - ❖ Facultative apomixis- Plants in which both apomixis and sexual reproduction takes place
  - ❖ Obligate apomixis- Plants in which reproduction occurs only by apomixis
- **Sexual reproduction**
  - ❖ Offspring are produced by the fusion of male and female gametes
  - ❖ Flower is the reproductive part of plants
  - ❖ Complete flower has four parts-

a. Sepals
b. Petals
c. Stamen (Male part) = Anther + Filament
d. Pistil (Female part) = Stigma + Style + Ovary

Anther-

- 4 pollen sac called microsporangia (diploid-2n).
- The cells of microsporangia undergo meiosis to produce microspores (haploid- n).
- Microspores divide mitotically to produce pollen grains.
- Mature pollen grains have two cells- Tube cell and generative cells (divides to produce two sperm cells)

Ovary

- Ovary has one or more ovules attached to wall of ovary.
- Ovule has one or two outer layers of cells called integuments enclose the megasporangium (2n)
- Opening in the integuments is called micropyle.
- Ovum production-

a. The megasporangium (2n) cells undergo meiosis and unequal cytokinesis (cytoplasm is unequally distributed) to produce four megaspores (1n).
b. Three of megaspores degenerate and largest of these megaspores develops into embryo sac.
c. The nucleus of megaspore undergoes 3 mitotic division to produce 8 nuclei.
d. Two nuclei (centrally located) are polar nuclei. Three nuclei at the micropylar end and chalaza end are surrounded by cell wall
e. The central cell at the micropylar end is ovum.

Pollination and germination of Pollen grain

- Transfer of pollen grains form anther to stigma.
- Pollen grain takes up water and pollen tube emerge
- Pollen tube grows through the style towards the embryo sac
- Two male gametes (generative cell divides and produces 2 male gametes) also move along the pollen tube

Fertilization

- ❖ Pollen tube reaches the micropyle end and two nuclei are released in the embryo sac.
- ❖ One nucleus fuse with the nucleus of ovum and forms zygote
- ❖ Second nucleus fuse with the two polar nuclei- triple fusion (three haploid nuclei = 3n)- endosperm is formed
- ❖ Two fertilization events are called double fertilization
- ❖ Ovule develops into seed after fertilization- zygote develops into embryo and endosperm provides nutrition to the developing embryo.

✓ **Reproduction in Animals**

- **Asexual reproduction**

❖ This mode of reproduction is limited to unicellular organisms
❖ Occurs by Binary fission and multiple fission
❖ Binary fission- parent cell divides into 2 daughter cells. E.g. *Paramecium* and *Amoeba*
❖ Multiple fission- repeated division of the parent nucleus followed by division into many daughter cells. E.g.- *Plasmodium*

- **Sexual reproduction**

❖ Sexual reproduction involves production of offspring by the mixing of genetic material of two parents.
❖ Genetic material of parents is carried in the nuclei of specialized cells called gametes.
❖ Gametes are haploid and carry a single set of chromosomes derived by meiosis. Gametes are of two types, male and female.
❖ The fusion of haploid gametic nuclei is called **fertilization** or **syngamy,** and results in the formation of a diploid zygote.
❖ The zygote grows and develops into mature organism of the next generation.
❖ Species that have separate male and female individuals are called **unisexual.** Examples are human beings *(Homo sapiens)* and higher animals.
❖ Species capable of producing both male and female gametes within the same organism are described as **bisexual** or **hermaphrodite**.
❖ Lower animals such as tapeworms, earthworms, snails and some fishes are bisexual.

Human Reproduction

❖ Male reproductive system-

- Composed of a pair of testes, genital ducts, accessory glands and the penis.
- The testes are situated in the scrotal sac outside the abdominal cavity.
- Testis is an ovoid shaped gland consisting of coiled tubules called seminiferous tubules.
- Seminiferous tubules produce male gametes, spermatozoa (sperms) by a complex process of division and differentiation called **spermatogenesis.**
- Sperms are carried to the epididymis, and then via the vas deference to the penis.
- Male gametes are produced throughout life.

❖ Female reproductive system
- Consists of ovaries and fallopian tubes, the uterus, vagina and external genitalia.
- Ovaries are attached to the wall of the body cavity. Ova (singular, ovum) is produced in this organ by **oogenesis.**
- The fallopian tube is a muscular tube that transports female gametes from the ovary to the uterus.
- Females release ovum once every 28 days - Ovulation

❖ Fertilization
- Following copulation, sperms enter the uterus and swim towards the ovum in fallopian tube
- The sperm and ovum come in contact and the sperm nucleus enters the ovum, entry of other sperms is prevented.
- Fusion of sperm and ovum nuclei- Zygote
- Two haploid nuclei fuse to restore the diploid number of chromosomes.

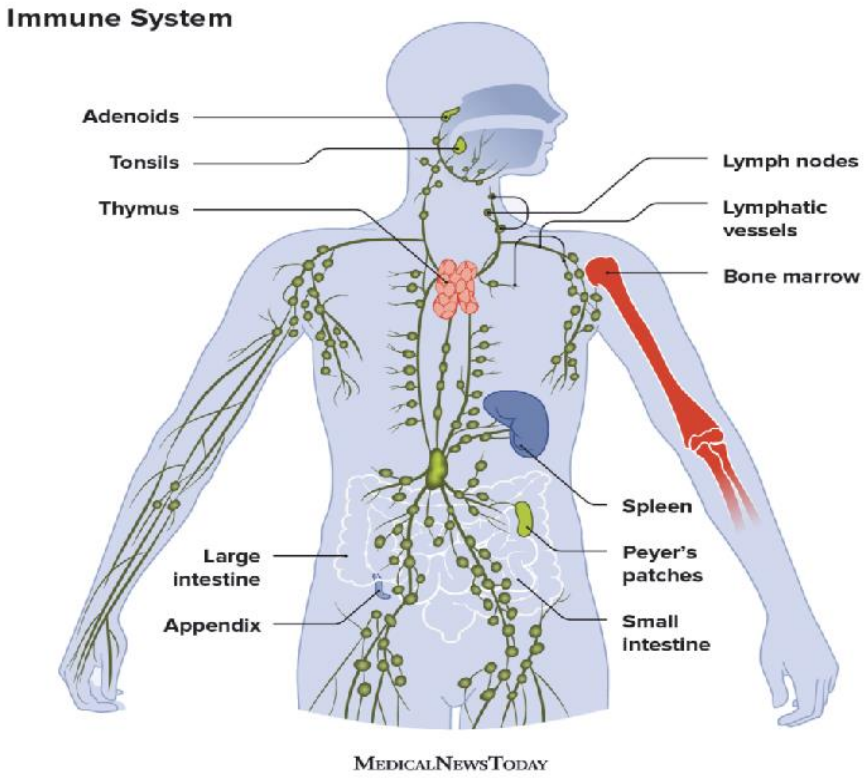
In Vitro Fertilization (IVF)

❖ IVF is part of larger technology called ART- Assisted Reproductive Technologies
❖ Fertilization is carried out in a petri dish or test tube- babies are called test tube babies
❖ First test tube was Louise Brown born in 1978
❖ Created to help infertile couple conceive

- ❖ Process in which ovum is fertilized by the sperm outside the female body
- ❖ The fertilized ovum is allowed to divide and then the embryo is implanted in female body
- ❖ Three basic microtechniques:
  (i) the isolation and selection of male and female gametes
  (ii) the fusion of pairs of gametes, and
  (iii) single zygote culture
- ❖ Process-
  a. Stimulation of ovulation by females by using hormones
  b. Ova are collected from female by aspiration needles
  c. Eggs are separated from surrounding tissue
  d. Eggs are incubated with sperms for 18 hours (ratio is 1: 75000)
  e. Fertilized eggs are kept in special medium for 48 hours
  f. Embryo should be 8-10 cells by 72 hours
  g. Best embryos are transferred to the uterus of a female and it develops into a baby
- ❖ IVF can be carried out with cryopreserved (stored in liquid nitrogen) eggs and sperm.

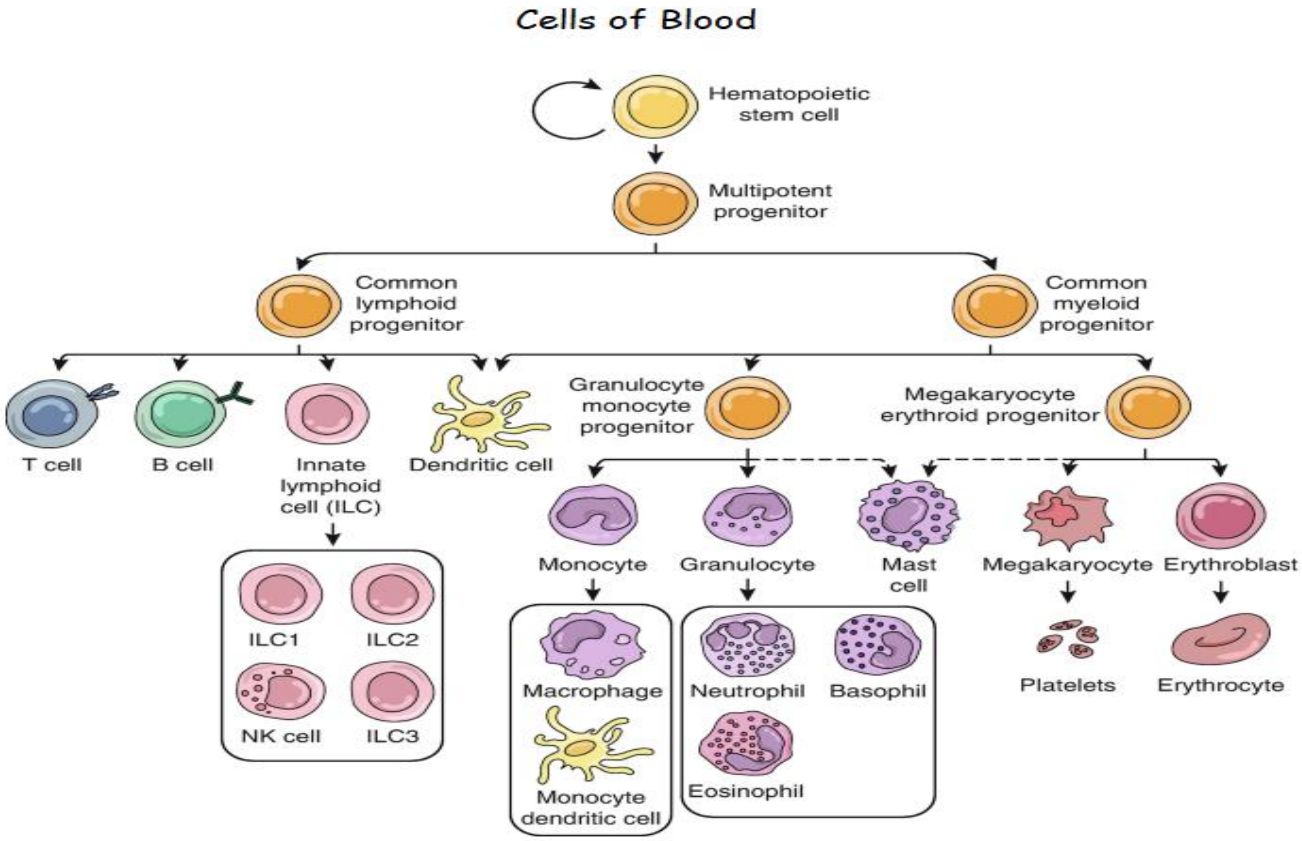
F. Immune response in Animals

- ✓ System that protects body against pathogens
- ✓ The response of the body against the pathogens is called immune response
- ✓ Invertebrates like starfish, earthworm, insects and hydra do not possess an immune system.
- ✓ Immune system consists of- lymphoid organs and cells
- ✓ Lymphoid organs- Primary and secondary lymphoid organs
- ✓ Primary lymphoid organs- organs in which the cells of immune system originate and mature. E.g. bone marrow and thymus
- ✓ Secondary lymphoid organs- the organs where the cells of immune system settle and function after maturation. E.g. lymph nodes, spleen and GALT (Gut Associated Lymphoid Tissue)



- ✓ Cells of Immune system- Lymphocytes, macrophages, natural killer cells, dendritic cells, etc.
- ✓ Lymphocytes are small cells. They are of two types based on the types of molecules present on their surface and functions- B and T lymphocytes
- ✓ Dendritic cells (DC) are present in skin
- ✓ Antigen Presenting Cells- B-lymphocytes and dendritic cells capture antigens and present these to T-lymphocytes
- ✓ Neutrophils (phagocytic cells) are present in blood they have multi-lobes nucleus and granules in cytoplasm- granulocytes
- ✓ Other granulocytes are the eosinophils and basophils.
- ✓ Monocytes are present in blood migrate to tissue and become tissue macrophages- histiocytes.
- ✓ Macrophages are large phagocytic cells. Depending on their location they are-
  - Liver – Kupffer cells

- Lungs – Alveolar cells
- Paritoneal cavity- Paritoneal macrophages



https://link.springer.com/chapter/10.1007/978-3-030-25553-4_2

The immune response

- ✓ Pathogens may gain entrance into our body through skin or respiratory tract, etc.
- ✓ Pathogens are carried to lymph nodes by lymph
- ✓ Lymph nodes have macrophages, B and T-lymphocytes
- ✓ Pathogen is engulfed by macrophages and presents the components of pathogens to T-lymphocytes.
- ✓ several cellular mechanisms lead to release of interleukins by the macrophages, B-lymphocytes and T-lymphocytes.
- ✓ Interleukins activate the B and T-lymphocytes
- ✓ Activated B-lymphocytes differentiate into plasma cells and secrete antibodies or immunoglobulins (Ig)

✓ Igs are glycoprotein made up of 4 polypeptides joined by disulphide bridges. Each chain has variable and constant regions. Five different Igs are IgG, IgM, IgA, IgD and IgE. Immune response mediated by Igs is humoral response.

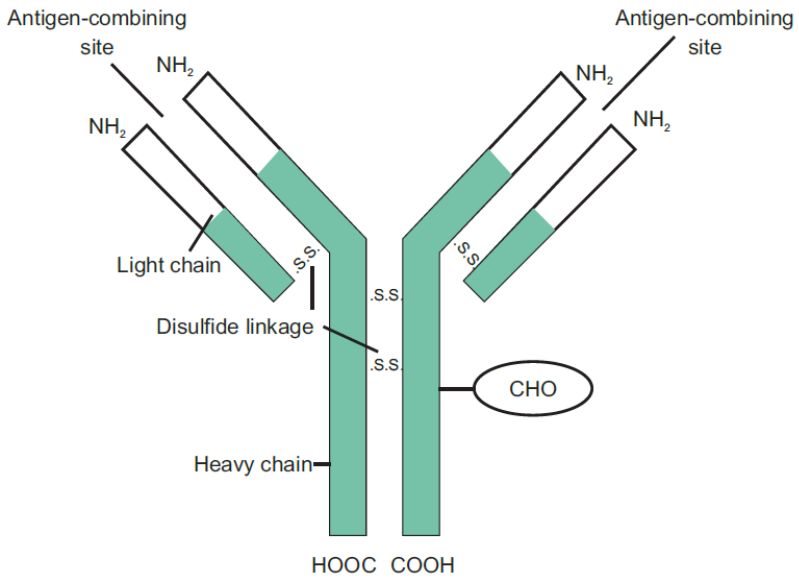


Figure: Structure of Immunoglobulin

✓ Activated T-lymphocytes, macrophages and NK cells attack host cells with pathogen and kills them. This is called cell mediated immune (CMI) response.

Multiple Choice Questions

1. Cell division is important for organisms for which of the following reasons?
   a. Growth and repair
   b. Reproduction
   c. Distribution of genetic material among daughter cells
   d. All the above
2. Which of the following is the correct sequence of phases of mitosis?
   a. Prophase → anaphase → metaphase → telophase
   b. Prophase → metaphase → anaphase → telophase
   c. Prophase → telophase → anaphase → metaphase
   d. Anaphase → prophase → metaphase → telophase

3. The cell division in which all the daughter eukaryotic cells receive equal genetic material is ____
   a. Mitosis
   b. Meiosis
   c. Cytokinesis
   d. Both a and b
4. Which of the following is not observed in Prophase of mitosis?
   a. Condensation of chromatin
   b. Disassembly of cytoskeleton and assembly of mitotic spindle
   c. Assembly of nuclear envelope
   d. Attachment of spindle microtubules to the kinetochore of chromosome
5. Metaphase of mitosis is characterized by-
   a. Alignment of chromosomes at the equator of spindle
   b. Alignment of chromosomes at the poles of the spindle
   c. Alignment of chromosomes in the nucleus of the cell
   d. Alignment of chromosomes on the spindle fibre
6. Telophase of mitosis is not characterized by-
   a. Chromatids reach the opposite poles of spindle
   b. Appearance of nuclear envelope and other organelles
   c. Chromatids are uncoiled in the nucleus
   d. Chromosomes reach the opposite poles of spindle
7. Cytokinesis is _____
   a. Division of cytoplasm between daughter cells
   b. Division of nucleus between daughter cells
   c. Division of cytoplasm and nucleus
   d. Division of chromosomes between daughter cells
8. Karyokinesis is _____
   a. Division of cytoplasm between daughter cells
   b. Division of nucleus between daughter cells
   c. Division of cytoplasm and nucleus
   d. Division of cell organelles between daughter cells
9. How cytokinesis is carried out in plant cells?
   a. Cleavage furrow cuts the cytoplasm between two cells
   b. Cell plate formation between two cells
   c. Division of cytoplasm between daughter cells
   d. All of these
10. How cytokinesis is carried out in animal cells?
   a. Cleavage furrow cuts the cytoplasm between two cells
   b. Cell plate formation between two cells

c. Division of cytoplasm between daughter cells
d. All of these

11. Cell division that results in gamete formation in diploid organisms is ____
a. Meiosis
b. Mitosis
c. Binary fission
d. All of these

12. The correct sequence of stages in Prophase I of Meiosis I is
a. Leptotene → zygotene → Diplotene → Pachytene →Diakinesis
b. Leptotene → zygotene → Pachytene → Diplotene →Diakinesis
c. Diakinesis → Diplotene → Pachytene → Zygotene → Leptotene
d. Diplotene → Pachytene → Zygotene → Leptotene → Diakinesis

13. What is synapsis?
a. Pairing of non- homologous chromosomes
b. Paring of maternal and paternal homologues
c. Exchange of chromatids in a chromosome
d. Exchange of parts of chromatids

14. Which of the following is true about Meiosis I and Meiosis II?
a. Meiosis I and II are both reductional division
b. Meiosis I is equational and Meiosis II is reductional division
c. Meiosis II is equational and Meiosis I is reductional division
d. Meiosis I and II are both equational division

15. How is Anaphase I different from Anaphase II?
a. Homologous chromosomes separate in anaphase I and chromatids separate in anaphase II
b. Homologous chromosomes separate in anaphase II and chromatids separate in anaphase I
c. Homologous chromosomes separate in both anaphase II and anaphase I
d. Chromatids of a chromosome separate in both anaphase I and anaphase II

16. The cell cycle is divided into two basic phases - _____ and _____.
a. Prophase and Interphase
b. Interphase and Meiosis
c. Interphase and Mitosis
d. Interphase and Metaphase

17. Which of the following is not a correct pair?

a. G_o- Cells do not undergo division
b. G_1- Growth of cells
c. S- Synthesis of organelles
d. G_2- Growth of cell for cell division

18. Which of the following check point of cell cycle checks the growth of cell?
a. G_1/S checkpoint
b. G_2/M checkpoint
c. M phase checkpoint
d. All of these

19. Which of the following check point of cell cycle checks the attachment of spindle fibres to chromosomes?
a. G_1/S checkpoint
b. G_2/M checkpoint
c. M phase checkpoint
d. All of these

20. DNA damage checkpoints which are operative during G_1, S, G_2 are regulated by
a. Cdk2, Cdk4
b. Cdk1 and B-cyclin
c. Cyclins only

21. **CHK1 and CHK2**Intracellular signal transduction involves the molecules like-
a. Cyclic AMP
b. G-protein coupled receptors
c. Ca^{2+} and calcium binding proteins
d. MAP kinase

22. Which of the following is a group of micronutrients?
a. Carbon, hydrogen, oxygen, nitrogen
b. Phosphorus, manganese, sulphur, calcium
c. Manganese, copper, zinc, cobalt
d. Iodine, Carbon, phosphorus, sodium

23. Which of the following nutrients is synthesized in human gut by bacteria?
a. Vitamin K and vitamin B12
b. Vitamin B1 and Vitamin K
c. Vitamin E and Vitamin B6
d. Vitamin C and Vitamin D

24. Which of the following is not a correct pair of nutrient and deficiency disease?

a. Iron or folic acid- anemia
b. Vitamin D- bone deformities
c. Vitamin B6 and B12- nervous tissue problems
d. Vitamin C- weak eyesight

25. Reproduction ensures-
a. Continuity of species
b. Transmission of genetic material from parents to offspring
c. Diversity is generated in species
d. All of these

26. Why is the entire progeny of bacteria identical to its parent cell?
a. One single cell gives rise to the progeny
b. Two cells fuse to give rise to progeny
c. Variation in progeny arises due to random mutation
d. Bacterial cell division is exponential in nature

27. Genetic recombination occurs in
a. Asexual reproduction
b. Vegetative propagation
c. Sexual reproduction
d. All of these

28. Genetic recombination occurs in bacteria by-
a. Transformation
b. Conjugation
c. Transduction

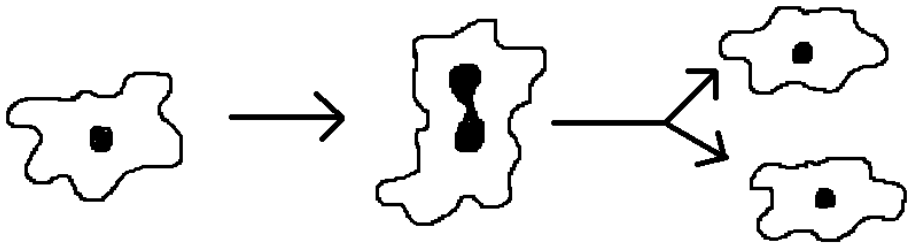
29. **All of these**The mechanism by which genetic material from one bacterium is transferred to another by a phage (virus) is called:
a. Transduction
b. Transformation
c. Transfection
d. Transportation

30. Which of the following is not true about reproduction in plants?
a. Plants undergo both sexual and asexual reproduction
b. In apomixis, embryo and seeds are produced with fertilization
c. In sexual reproduction there is double fertilization
d. Sexually reproducing plants produce haploid gametes

31. Which of the following is not the correct pair?
a. Zygote - embryo

b. Triple fusion – primary endosperm nucleus
c. Endosperm- gives rise to new plant
d. Embryo sac- contains ovum

32. Identify the mode of reproduction in the image given below



a. Asexual reproduction, multiple fission
b. Asexual reproduction, binary fission
c. Sexual reproduction, binary fission
d. Sexual reproduction, multiple fission

33. Which of the following statements is not true about zygote?
a. Fusion of male and female gametes results in formation of zygote
b. Zygote carries a set of chromosomes from each parent
c. Zygote grows and develops into mature organisms
d. Zygote is a multicellular structure that develops into organism

34. Ovulation means
a. Process of movement of an ovum in the fallopian tube in females
b. Process of release of an ovum from one of the ovaries in females
c. Process of fusion of ovum with sperm in fallopian tube in females
d. Process of cell division that results in the formation of ovum in ovary

35. IVF includes the combination of three basic micro techniques in correct sequence is-
I. Isolation and selection of male and female gametes
II. Single zygote culture
III. Fusion of pair of gametes
a. III → II → I
b. I → III → II
c. II → I → III
d. II → III → I

36. Which of the following is not a lymphoid organ?

a. Liver
b. Thymus
c. Bone marrow

37. SpleenWhich of the following is the correct pair of tissue and macrophages?
a. Liver – Kupffer cells
b. Lungs – Alveolar cells
c. Paritoneal cavity- Paritoneal macrophages
d. Basophils - Blood

38. Which of the following organisms possess immune system?
a. Starfish
b. Earthworms
c. Rat
d. Hydra

39. Which of the following is not a characteristic of macrophages?
a. Macrophages are phagocytic cells
b. Macrophages are large cells with many vacuoles
c. Macrophages migrate from tissues to blood
d. Macrophages can present antigens to T-lymphocytes

40. Which of the following is not an antibody?
a. Ig G
b. Ig M
c. Ig A

Ig Assertion and Reasoning Questions

Assertion (A) and Reason (R). Answer these questions selecting the appropriate option given below:
a. Both Assertion and Reason are true and the reason is the correct explanation of the assertion
b. Both Assertion and Reason are true but the reason is not the correct explanation of the assertion
c. Assertion is true but Reason is false
d. Both Assertion and Reason are false

41. Assertion: Interphase is the longest phase in cell cycle.
Reason: Cells undergo growth and metabolic activities, DNA replication and many other processes during interphase.
Answer- A

42. Assertion: Metaphase II and metaphase of mitosis are similar.
Reason: Chromatids separate from the chromosome in both metaphase of mitosis and metaphase II.
Answer- A

43. Assertion: Each chromosome consists of two sister chromatids.
Reason: Chromatids are attached at the centromere which has a plate-like structure called kinetochore
Answer- B
44. Assertion: Cells that enter the G_0 phase remain viable and metabolically active.
Reason: Cells that have complete G_1, S and G_2 undergo mitosis.
Answer- B
45. Assertion: Cell cycle is regulated by molecules- cyclins and Cdks.
Reason: Proteins are phosphorylated by cyclin- Cdk complex.
Answer- A
46. Assertion: Plants can synthesize their own food while animals cannot.
Reason: Animals needs raw materials like water and carbon dioxide for preparation of food.
Answer- C
47. Assertion: Most microbes like bacteria and fungi are saprotrophs.
Reason: Bacteria and fungi obtain nutrients from digesting dead and decaying matter.
Answer- A
48. Assertion: Pollination is the transfer of ovum from stigma to anther.
Reason: Pollination can occur with the help of insects only.
Answer- D
49. Assertion: Germination of seed causes embryo gives rise to a new plant.
Reason: The endosperm of the seed provides food for the new plant.
Answer- C
50. Assertion: IVF is the method of fertilization in a petri dish.
Reason: IVF is part of a larger discipline called Assisted Reproductive Technologies
Answer- B

Short Answer Type Questions

1. Mention the characteristics of Interphase.
Characteristics of Interphase-

i. Absence of visible chromosomes
ii. Chromatin are uncoiled and nucleus looks homogenous
iii. Highly active DNA replication, protein synthesis

2. What will happen if DNA damaged in a cell cycle?

If DNA is damaged then the checkpoints will arrest the cell cycle progression and allow for DNA repair before cell cycle is resumed.
Failure of the checkpoint control will result in increased DNA damage in the cell.

3. What is a signaling molecule? Mention the different types of signaling molecule with examples.

Signalling molecules are molecules which causes plant and animal cells respond.

These may be-
i. Simple molecules like ions and gases
ii. Complex proteins like hormones, growth factors and cytokines
iii. A class of lipids called eicosanoids includes signalling molecules like prostaglandins and leukotrienes.

The distance at which these signalling molecules act also varies.
a. Some act locally
b. Others carry signals over long distances.

4. What are receptors? Mention any two types of receptors.

Molecules (proteins) that bind to signal molecules are called receptors.
Two types of cell receptors-
a. Extracellular receptors
b. Intracellular receptors

5. What changes can be observed after a signaling molecule binds to a receptor?

Cellular response that may include-
a. changes in gene expression,
b. differentiation,
c. replication,
d. alteration of enzyme activity,
e. changes in ion permeability or

f. death of the cell.

6. What is a signal transduction pathway?

Once a signalling molecule binds receptor on a cell, it initiates a series of intracellular reactions towards interior of the cell and signal is transmitted from cell membrane to nucleus. This process is called **intracellular signal transduction.** The signal may be transmitted directly or via a cascade pathway involving many proteins. These pathways between the cell membrane and the cell nucleus are called **signal transduction pathways.**

7. What are macronutrients and how are they different from micronutrients? Why are the trace elements so important for living organisms?

Elements like manganese, copper, zinc, cobalt, selenium, and iodine are required in very small amounts and are called micronutrients or trace elements.
Micronutrients are required in very little amounts while macronutrients are required in larger quantities.
Some of these trace elements are part of vitamins and play important function in animal nutrition.

8. How do bacteria help in animal nutrition? Give examples to illustrate.

Bacteria which live in the gut of the animals, also help in animal nutrition. Bacteria in the human gut synthesize vitamin K and vitamin B_{12} that are absorbed by the human body and utilized for various functions. Bacteria found in the rumen of cattle break down the cellulose of the fodder into smaller sugar molecules, which are absorbed by the cattle.

9. Mention the effects of deficiency of the following nutrients in human body-
   a. Protein
   b. Iron and folic acid
   c. Vitamin C
   d. Vitamin D
   e. Vitamin A
   f. Vitamin B6 and B12

Nutrient	Effects of deficiency
Protein	Stunted growth in children
Iron and folic acid	Anemia
Vitamin C	Scurvy
Vitamin D	Bone deformities
Vitamin A	Weak eyesight
Vitamin B6 and B12	Nervous tissue problem

10. What is reproduction? Why is it important?

Reproduction refers to the ability of living organisms to produce individuals of the same species.
Importance-
Transmission of genetic material from parental generation to the next generation. Reproduction ensures continuity of the species. It also allows increase in the total number of individuals in the species.
Diversity is generated in a species.

11. What is apomixis? Briefly describe its types.
Embryos and seeds developed with of fertilization.
Two types of apomixis
    - Facultative apomixis- Plants in which both apomixis and sexual reproduction takes place
    - Obligate apomixis- Plants in which reproduction occurs only by apomixis

12. What is vegetative propagation? Why is it called clonal propagation? Why is it asexual reproduction?
Vegetative reproduction takes place when new individuals are produced from somatic cells (i.e., vegetative propagules like stem cuttings, tubers, bulbils, leaves, roots, etc.) This does not involve seed formation.

The clone or all the individuals derived from vegetative parts will be exactly similar to the parent cell and each other in terms of genotype and phenotype, and therefore such propagation is also called clonal propagation.

New plants arise from a single parent without any fusion of gametes. That's why it is asexual reproduction.

13. Fill in the blanks with the options given about the formation of pollen grains in plants-

The anther consists of _____ [4] pollen sacs, also called as microsporangia with ___ [2n] number of chromosomes. The cells of microsporangia undergo meiosis to produce microspores that is _____ [haploid]. The microspores divide _____ [meiotically] to produce pollen grains. A mature pollen grain consists of _____ [two] cells; one within the other i.e. the tube cell contains a generative cell within it. The generative cell divides to produce _____ [two] sperm cells.

14. Fill in the blanks with the options given about the formation of female gametes in plants-

Within the ovary are one or more ovules attached to the ovary wall. The ovule has one or two outer layers of cells called _____ [integuments] and an opening called _____ [micropyle]. The integuments enclose the megasporangium that is _____ [diploid]. The megasporangium cells undergo meiosis and _____ [unequal] cytokinesis to produce ____ [four] megaspores (1n). The largest of these megaspores undergo _____ [mitotic, meiotic] divisions to produce a _____-celled [8] embryo sac. One of these cells is the egg. There is also a central cell containing ____ [two] polar nuclei and ____ [three] antipodals.

15. What is syngamy? What is the importance of this process?

Fusion of gametic nuclei (male and female) is called syngamy or fertilization. This results in the formation of zygote. The zygote carries a set of chromosomes derived from each parent and restores diploid set of chromosomes. The zygote grows and develops into mature organism of the next generation.

16. Distinguish unisexual and bisexual organisms. Give examples of each.

Unisexual organisms	Bisexual organisms
Organisms that have both sexes in separate individuals – male and females	Organisms that have both sexes in same individuals- hermaphrodite
e.g. human beings, lions, deer	e.g. tapeworms, earthworms

17. What is IVF? How is it carried out (list the steps)?

Fertilization is carried out in a petri dish or test tube- babies are called test tube babies**.** Process in which ovum is fertilized by the sperm outside the female body. The fertilized ovum is allowed to divide and then the embryo is implanted in female body.

Process-

a. Stimulation of ovulation by females by using hormones
b. Ova are collected from female by aspiration needles
c. Eggs are separated from surrounding tissue
d. Eggs are incubated with sperms for 18 hours (ratio is 1: 75000)
e. Fertilized eggs are kept in special medium for 48 hours
f. Embryo should be 8-10 cells by 72 hours
g. Best embryos are transferred to the uterus of a female and it develops into a baby

18. Distinguish between primary lymphoid and secondary lymphoid organs.

Primary lymphoid organs	Secondary lymphoid organs
Organs in which the cells of immune system originate and mature.	Organs where the cells of immune system settle and function after maturation.
E.g. bone marrow and thymus	E.g. lymph nodes, spleen and GALT (Gut Associated Lymphoid Tissue)

19. Distinguish between T-lymphocytes and B-lymphocytes.

B-lymphocytes	T-lymphocytes
Lymphocytes that mature in Bone marrow	Lymphocytes that mature in Thymus
Mediates humoral immunity	Mediates cell mediated immunity
Produces immunoglobulins	Does not produce immunoglobulin

20. What are interleukins? What is the function of interleukin?

The macrophages break down the pathogens, then presents components of the pathogen to T-lymphocytes. After this, several cellular mechanisms occur in which several soluble substances called interleukins are produced by the macrophages, B-lymphocytes and T-lymphocytes.

Function of interleukin- B-lymphocytes and the T-lymphocytes get activated.

Long answer Type Questions

1. What is the significance of Prophase I of Meiosis I. Name the phases of Prophase I of Meiosis I where we can observe the following-

a. Pairing of homologues
b. Start of condensation of chromosomes
c. Crossing over
d. Chiasmata formation

Recombination of non-sister chromatids of homologous chromosomes occurs in prophase I of meiosis I. This leads to the genetic variation in gamete formation.

a. Pairing of homologues- zygotene

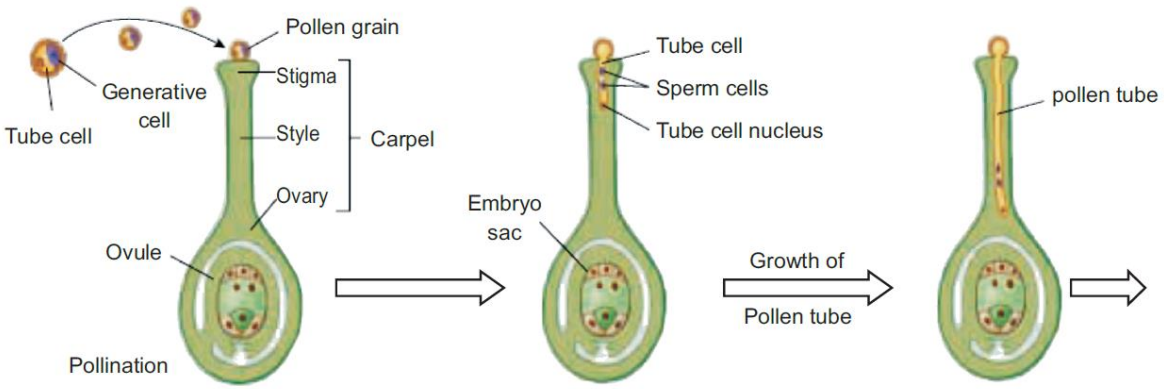
b. Start of condensation of chromosomes - leptotene

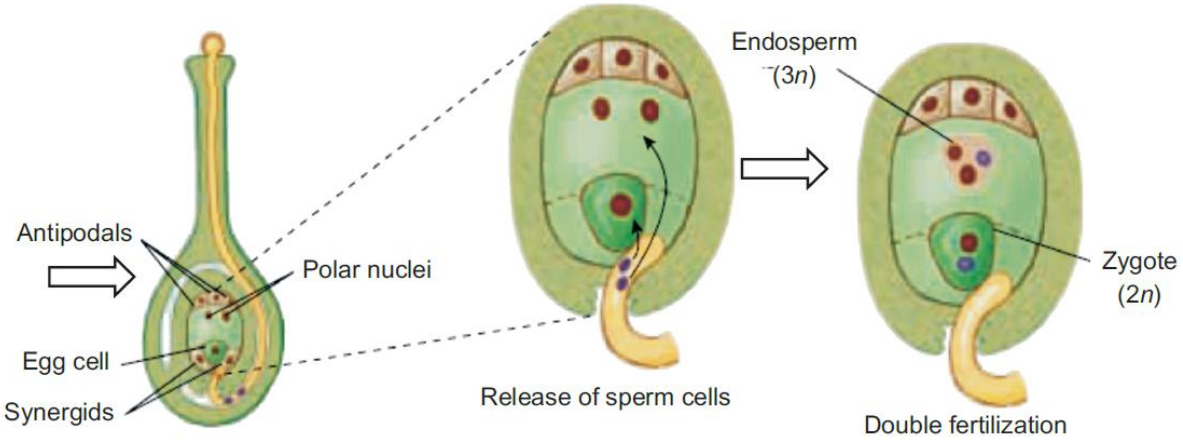
c. Crossing over- pachytene

d. Chiasmata formation- diplotene

2. What is double fertilization? Explain with diagrams.

- Pollen tube reaches the micropyle end and two nuclei are released in the embryo sac.
- One nucleus fuse with the nucleus of ovum and forms zygote.
- Second nucleus fuse with the two polar nuclei- triple fusion (three haploid nuclei = 3n)- endosperm is formed.
- Two fertilization events are called double fertilization.

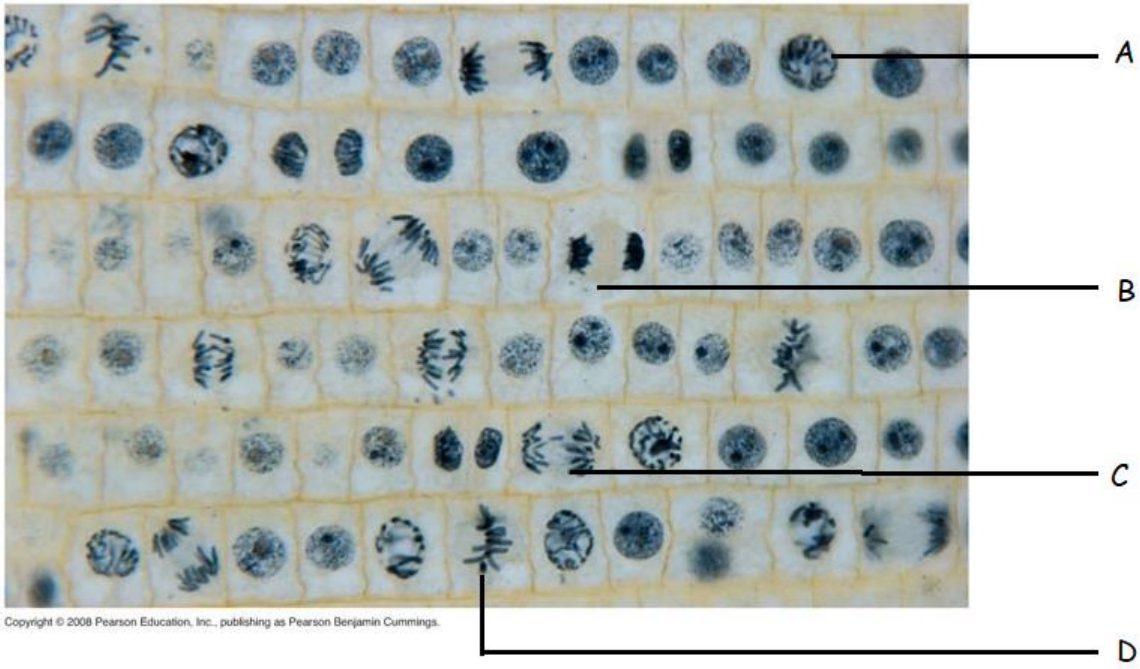




3. Distinguish between mitosis and meiosis.

Mitosis	Meiosis
One division of nucleus	Two divisions of nucleus
Two diploid daughter cells are produced	Four haploid daughter cells are produced
Occurs in somatic cells	Occurs in germ cells
No crossing over takes place	Crossing over takes place in Prophase I of Meiosis I
Involved in healing and growth	Involved in production of male and female gametes

4. Identify the stages labelled A, B, C and D in mitosis and mention the features of the stages. What is the importance of mitosis?



A- Prophase – The chromatin start condensation
B- Telophase- The chromatids reach the poles of spindle fibre
C- Anaphase- The chromatids are pulled towards the poles
D- Prometaphase/ metaphase- Arrangement of chromosomes on the metaphase plate.

Importance of mitosis

Growth and maintenance of the organisms

5. Bacteria reproduces asexually. How do variations arise in bacteria?
   Variations may arise by fusion of gametes or exchange of genetic materials between cells. In bacteria fusion of gamete does not occur but variations may occur due to the following reasons-

a. Transformation
   Cells do not come in contact with each other
   Donor cell → releases DNA → actively taken by recipient cell

b. Conjugation
   Donor bacterium has F plasmid (circular double stranded DNA which can confer some traits to the host cell)- F^+ Cell
   Recipient bacterium does not have F plasmid- F^- Cell
   Donor attaches to the recipient by a pilus and a copy of the plasmid is transferred to the recipient cell

c. Transduction
   Bacteriophage- virus that infects bacteria
   DNA is transferred from donor cell to recipient cell by bacteriophage

d. Random mutations that occur during DNA replication

6. List the cells of immune system and mention their functions.

Cells of Immune System	Functions
B lymphocytes	Mediate humoral immunity, Antigen presenting cells
T lymphocytes	Mediate cell mediated immunity
Dendritic cells	Skin immune function, Antigen presenting cells
Monocytes	Migrate to tissue become macrophages
Nuetrophils	Phagocytic cells
Macrophages	Phagocytic cells of tissues, Antigen presenting cells

Case Based Questions

1. Asexual Reproduction in Microbes

Microorganisms such as bacteria reproduce mainly by asexual means in which a single organism divides to produce identical offspring. For example, a single bacterium at successive divisions will produce 2, 4, 8, 16, 32, …bacteria. Thus, during reproduction, the number of bacteria increases exponentially. This is called exponential or logarithmic growth. In this type of reproduction, there is no mixing of genetic material between two cells. Thus, the entire progeny is identical to the parental cell. Variation among the progeny, if any, is due to random mutations that occur in DNA during replication.

a. If there were 5 bacterial cells in the medium, under ideal conditions how many bacteria will be produced after 4 rounds of cell division.

   $5 \text{ X } 2^4 = 80$ cells

b. Why are the microbe progeny similar to the parent cell?

   The microbe progeny is similar to the parent cell as the parent cell under goes repeated division without any exchange in the genetic material.

c. Variations can also arise in bacteria due to transformation, transduction and conjugation. Discuss the role of virus in giving rise to variations in bacteria.

   Virus infects a bacterium and its genetic material is integrated into the host cell. When a mature virus is formed some of the host DNA may become part of the viral DNA. When this virus infects another bacterium, it transmits the parts of the old bacterial DNA into the new host. This is how variations may be generated due to virus.

2. **Cell Cycle**

Study the cell cycle flow diagram below and answer the following questions-

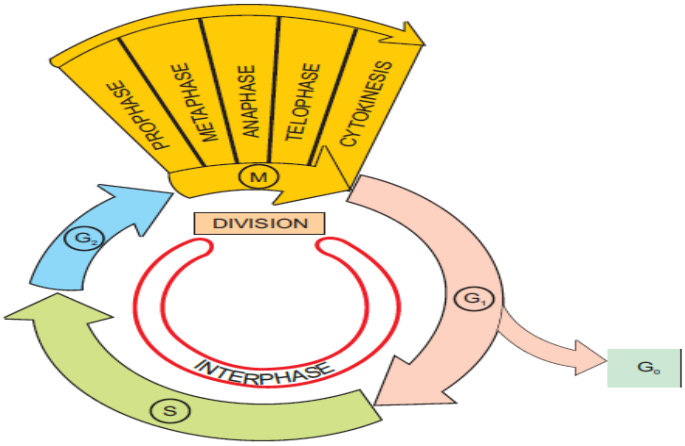


Figure- Cell Cycle

a. What does the G_o in the cell cycle signify?

The G_o in the cell cycle signifies those cells those are non-dividing. They may stay in this phase for a long time and my re-enter the cell cycle

b. If a cell completes cell cycle in 24 hours, how long does the interphase and division phase last for.

If a cell completes cell cycle in 24 hours, the interphase lasts for 23 hours and division phase lasts for one hour.

c. How is the cell cycle regulated? Mention the names of the molecules involved in the regulation of cell cycle.

Cell cycle is regulated by the check points. There are three check points-

G1/S- checks the growth of the cells, G2/M checks the DNA replication completion and the M checkpoint checks that all the spindle fibres are attached to the kinetochore of the chromosomes.

The molecules involved in the regulation of cell cycle are Cyclins and Cyclin Dependent Kinases

3. **Immune Response:**

The immune system has evolved to protect the host from a universe of pathogenic microbes that are themselves constantly

evolving. The immune system also helps the host eliminate toxic or allergenic substances that enter through mucosal surfaces. Central to the immune system's ability to mobilize a response to an invading pathogen, toxin or allergen is its ability to distinguish self from non-self. The host uses both innate and adaptive mechanisms to detect and eliminate pathogenic microbes.

a. Why does the immune system have to constantly evolve?

Pathogens are constantly evolving. So, the immune system must also evolve to protect the organism.

b. How do pathogens gain entry into our body?
Pathogens may gain entry into our body an injury in the skin or through the mucosal surface.

c. What must an immune system do before it responds to a chemical or pathogen? What would happen if this ability is lost?
Immune system must be able to recognise and distinguish self from non-self.
If it loses this property then it may attack its own cells and pathogens may escape the immune system

4. **Cytoskeletal structures of the cell**

Cytoskeleton is a system of filaments or fibres that is present in the cytoplasm of eukaryotic cells. These fibres are mainly of two types – microtubules and microfilaments. The filaments that comprise the cytoskeleton are so small that their existence was only discovered because of the greater resolving power of the electron microscope. The cytoskeleton organizes other constituents of the cell and has various other important functions.

a. Why is the cytoskeleton called so?
Maintain the structure of cell and movement of cell just as the skeletal system of our body.

b. What would happen if the cytoskeleton is not present in a cell?
The cell may lose its structure and the movement of the organelles may not occur

c. The chemical colchicine prevents the formation of spindle fibres during mitosis due to which cell division stops at metaphase.

Which of the cytoskeletal structures do you think is affected by it? Why do you think that it is harmful for the cell?
It will inhibit the microtubules.
It will be harmful for the cell as there will be no cell division.

5. **The cell membrane**

The cell membranes are semipermeable, i.e., they allow the passage of some solutes through them but not the others. The membranes are composed of proteins and lipids. The lipids in the membranes are phospholipids. Earlier studies using electron microscope showed that the cell membranes were ca. 7.5 nm wide and consisted of 3 layers. The central layer is the lipid bilayer, on both sides of which, is present a protein layer. This was called **unit membrane hypothesis**. However, using several additional techniques, it has now been shown that phospholipids form a fluid lipid bilayer and that the protein molecules float in it. This is called **fluid mosaic model.**

a. Cell membranes do not allow water soluble molecules like glucose to pass through it freely. Why?
Cell membranes are composed of phospholipids which have a non-polar tail that are aligned in a bilayer. So, they are impermeable to water soluble molecules.

b. Why is the fluid mosaic model preferred over the unit membrane model?

Membrane is fluid in nature due to the presence of lipids. Proteins are embedded in the lipid bilayer and this can be proved by the fact that transmembrane proteins that transport other molecules

c. Name any four functions of proteins in the membrane?

Functions of membrane proteins (any four)

i. Receptors for ligands
ii. Electron carrier

iii. Channel and pore

iv. Cell to cell adhesion

v. Membrane protein in immune response

6. **Immunoglobulins**

Observe the diagram and answer the following questions-

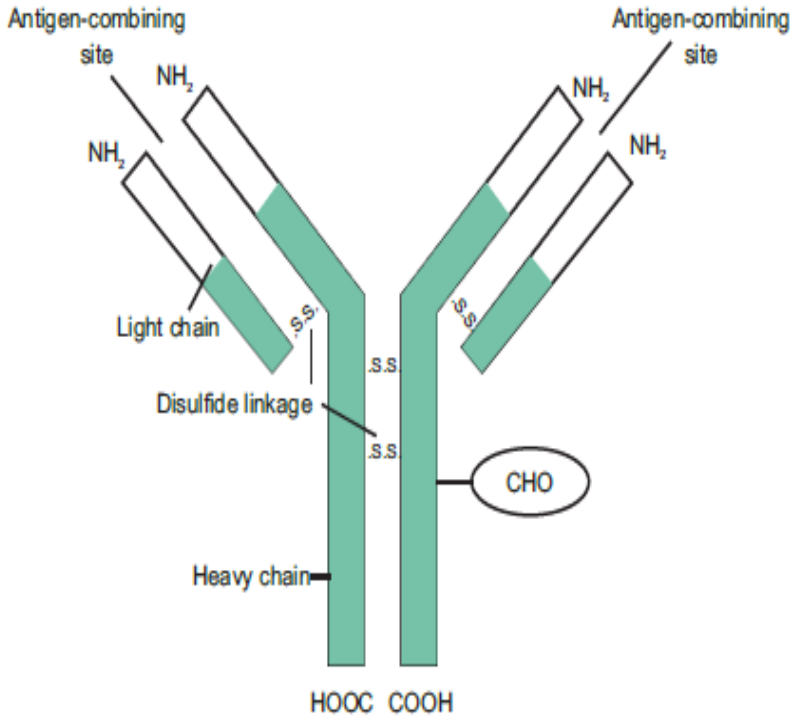


Fig. 13. Diagrammatic structure of an immunpglobulin (Ig) molecule

a. Which cells produce these molecules?

B lymphocytes- plasma cells

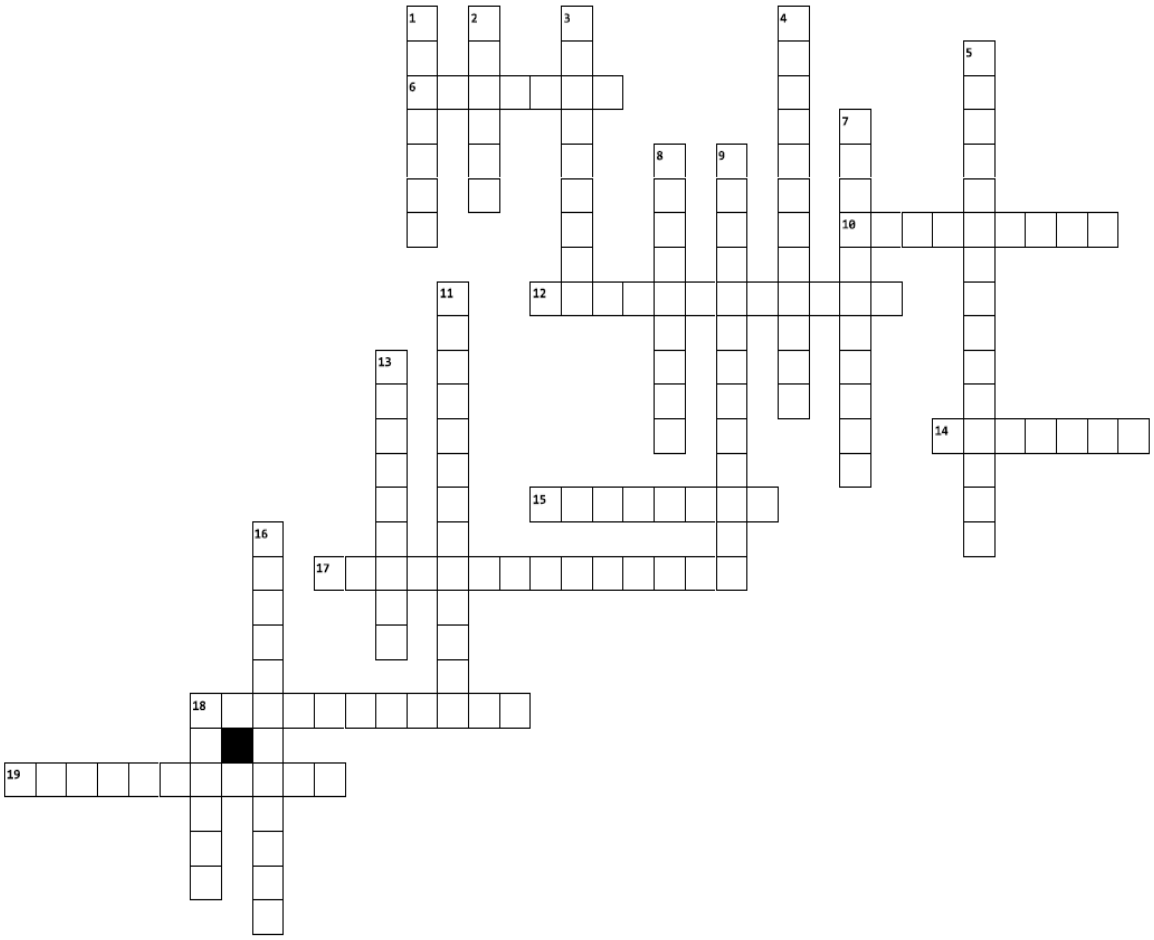
b. How many polypeptide chains constitute a single Ig molecule?

4- polypeptide chains, 2- heavy chain and 2 light chain

c. Which bond holds the polypeptide chain together in the molecule? Which type of immunity is mediated by Immunoglobulins?

Disulphide bridges or S-S bonds. Humoral Immunity

Cross Word Puzzle



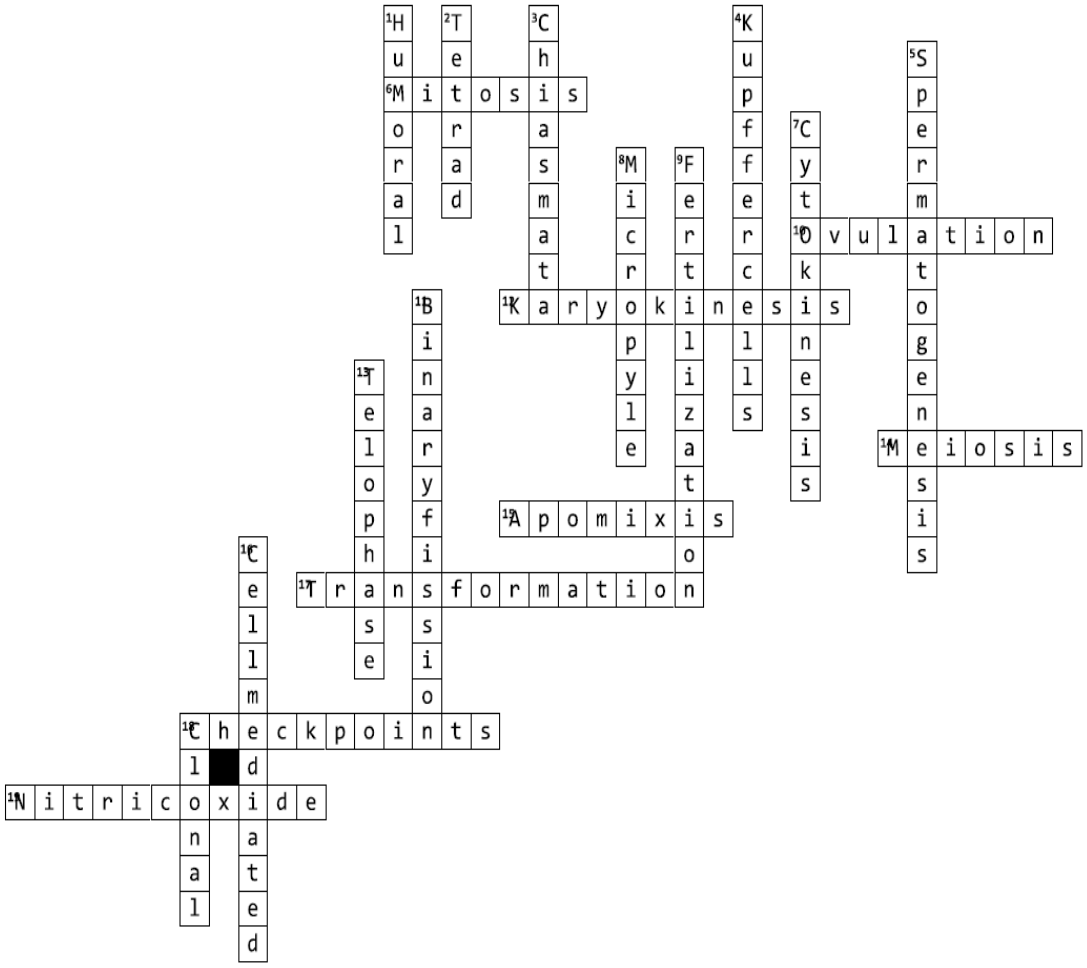
Across

6. Cell division where 2 daughter cells receive equal genetic material
10. Release of mature ovum
12. Division of nucleus
14. Cell division where 4 haploid cells are produced
15. Seeds and embryo are developed without fertilization
17. Method of genetic recombination in bacteria where donor and recipient cells do not come into contact
18. Cell cycle is dependent on a series of ____ for progression from one stage to another
19. major signaling molecule in nervous, immune and circulatory systems

Down

1. Immunity that is mediated by antibodies
2. A pair of synapsed homologous chromosome
3. The X-shaped structures formed by separating chromosomes in Prophase I
4. Macrophages in liver
5. The process of division and differentiation to produce spermatozoa
7. Division of cytoplasm
8. Opening of the integuments
9. Fusion of male and female gamete
11. Asexual reproduction of Amoeba
13. The phase of nuclear division where chromosomes reach the poles of spindle
16. Immunity that is mediated by T-cells, macrophages and NK cells
18. Vegetative propagation is also known as_____ propagation

Answer



Question Papers

SOLVED SAMPLE QUESTION PAPER

SUB: BIOTECHNOLOGY CLASS: XI TIME: 3 HOURS
MM: 70

General Instructions:

i) All questions are compulsory.
ii) Question no. 1 to 12 are MCQ based questions of one mark each.
iii) Question no. 13 to 16 are Assertion Reasoning based questions of one mark each.
iv) Question no. 17 to 21 are very short answer-based questions of two marks each.
v) Question no. 22 to 28 are short answer-based questions of three mark each.
vi) Question no. 29 to 30 are case-based questions of four mark each.
vii) Question no. 31 to 33 are long answer-based questions of five mark each.

SECTION A

1 _____ technology couples the knowledge of biology with microelectronics: 1

a) Protein Engineering c) Nanotechnology
b) Biosensor d) Cloning

2 At which stage of meiosis the crossing over occurs? 1

a) Zygotene c) Diplotene
b) Pachytene d) Diakinesis

3 If a ds DNA sequence consists of 20% A residues, what will be the percentage of G residues? 1

a) 10 % c) 30 %
b) 20 % d) 40 %

4 Which of the following is not an example of aldose? 1
a) D-Ribose c) D-Galactose
b) D-Arabinose d) D-Fructose

5 Which enzyme is administered to a stroke patient? 1
a) Streptokinase c) Carbonic anhydrase
b) Restriction Endonuclease d) Alanine oxidase

6 The secondary structure of the silk protein fibroin mainly constitutes of: 1
a) Beta Sheet c) Both beta sheet and alpha helix
b) Alpha helix d) None of these

7 Which type of epithelial tissue lines the respiratory tract? 1
a) Stratified c) Ciliated Columnar
b) Squamous d) Pseudostratified

8 Which interdisciplinary nature of Modern Biotechnology deals with conversion of raw materials or chemicals into more useful or valuable forms with the application of physical and life sciences? 1
a) Molecular Biology c) Chemical Engineering
b) Biomedical Engineering d) Tissue Engineering

9 The theory of spontaneous generation was put to complete rest by whom? 1
a) Gregor J Mendel c) Hugo De Vries
b) Sutton & Boveri d) Pasteur & Tyndall

10 The other name of the neurotransmitter hydroxy tryptamine which is derived from tryptophan is 1
a) GABA c) Auxin
b) Serotonin d) Adrenaline
c)

11 Which of the following is not a 'STOP codon'? 1
a) AUG c) UGA
b) UAG d) UAA

12 The main inorganic component of bone tissue is: 1

a) Hydroxyapatite c) Phosphate

b) Hyaline d) Sulphate

Question no. 13 to 16 are Assertion Reasoning based questions of one mark each.

Choose the correct option:

a) Both assertion and reason are correct and reason is the correct explanation of the assertion.

b) Both assertion and reason are correct but reason is not the correct explanation of the assertion.

c) Assertion is correct but reason is false.

d) Both assertion and reason are false

13 **Assertion:** Xylem is a complex permanent tissue. 1

Reason: Xylem is made up of tracheid, vessel elements, parenchyma and fibers

14 **Assertion:** Law of independent assortment is always true. 1

Reason: Linked genes show high recombination frequency.

15 **Assertion:** PCD is also called cellular suicide. 1

Reason: PCD is a highly ordered process.

16 **Assertion:** Special transporter protein molecules are present in membranes to facilitate transport. 1

Reason: Water soluble molecules such as sugars, amino acids, salts etc cannot freely transport.

SECTION B (VERY SHORT ANSWER QUESTIONS)

17 Name the type of bonds found between: 2

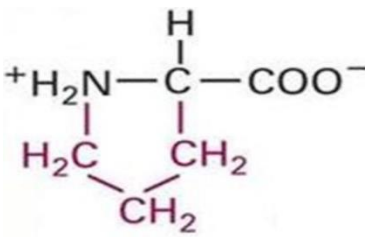
a) Amino acids

b) Nucleotides

c) Monosaccharides

d) Ribose sugar and nitrogenous base

18 Identify the amino acid and mention its nature: 2



19 With the help of a neat diagram show crossing over. 2

20 Differentiate between incomplete and codominance with suitable examples. 2

21 What is active site of an enzyme? What is 'Feed-back inhibition' of enzyme? 2

OR

Mention the mechanism of working of the antibiotic penicillin in brief.

SECTION C (SHORT ANSWER BASED QUESTIONS)

22 a) What are stem cells? 1+2=3

b) What are the differences between embryonic and adult stem cells?

23 Mention any three uses of biological membranes. 3

24 With the help of a labelled diagram show the different stages of cell cycles (mention one key feature of each stage) and show the check points. 3

OR

Draw a labelled diagram of the L.S of an ovule. What is triple fusion?

25 Draw the structure of: 3

a) Lactose
b) Adenine

OR

Write the test for:

a) Amino acids
b) Glycerol derived lipids

26 a) Draw a labelled structure of B-DNA. 2+1=3

b) Write a sequence of ds DNA of ten base pairs representing the basic features.

27 Three unique features found across different kinds of organism's genomes are mentioned below. Identify the kind of organism that has the feature and define the term: 3

a) Operons
b) Overlapping genes
c) Split genes.

28 Define Nanotechnology. Mention any two uses of nanobiotechnology. 1+2=3
OR
OR 3
Mention any four agronomic traits that can be achieved through Biotechnology.

SECTION D (CASE BASED QUESTOINS)

29 **Read the following and answer any four questions from (i) to (v) given below:** 4

In 1955, Ochoa isolated RNA polymerase, the enzyme that copies molecules of RNA from DNA. He made the first synthetic RNA molecules. Later, Nirenberg and Khorana took the lead in deciphering the genetic code. To an extract from *E. coli*, they added synthetic RNA and radioactively labeled amino acids and observed what kind of polypeptides were made. For example, poly-U RNA - an RNA string made completely of uracil - directed the formation of a phenylalanine chain, so the triplet UUU clearly encodes phenylalanine. This was the first codon deciphered. (Because of the redundancy of the genetic code, more than one codon can encode most amino acids; for example, the codon UUC also specifies phenylalanine.) In time, all the codons were deciphered.

(Source: National Human Genome Research Institute)

(i) What is a codon?
(ii) Three consecutive bases in the DNA molecule provide the code for each amino acid in a protein molecule. What is the maximum number of different triplets that could occur?
a) 4 b) 16 c) 32 d) 64
(iii) Listed below are some amino acids and their corresponding mRNA triplets.

Amino acid	**mRNA triplet**
Asparagine	AAU
Tyrosine	UAU
Proline	CCU
Valine	GUU

Which DNA sequence would be needed to produce the following polypeptide sequence? Valine-Tyrosine- Proline- Asparagine?

a) UAU CCU GUU AAU
b) AAU GUU CCU UAU
c) GUU UAU CCU AAU
d) CCU AAU GUU AUA

(iv) Which amino acid is coded by the start codon 'AUG'?

(v) Name any two scientists who deduced the genetic codon.

30 Adaptive immunity contains specialized immune cells and antibodies that target and eliminate foreign invaders while also remembering what those substances look like and creating a new immune response to prevent sickness in the future. Adaptive immunity can last a few weeks or months, or it might endure a long period, even for the rest of a person's life. 1+2+2=4

Humoral immunity and cell-mediated immunity are two forms of adaptive immune responses that allow the human body to protect itself against dangerous agents including bacteria, viruses, and poisons, in a targeted manner. While there is some overlap between these immune response arms -

both rely on lymphoid cell functions - there are also some significant differences.

i) Which of the following provides humoral immunity?
   a) B cells
   b) T cells
   c) Both B and T cells
   d) Macrophages

ii) Name any four classes of immunoglobulins.

iii) Mention any two differences between cell mediated and humoral immune system.

OR

What are primary and secondary lymphoid organs? Give examples of both.

SECTION E (LONG ANSWER QUESTIONS)

31 Proteins are the most abundant biomolecules of the living system. The chief sources of proteins are milk, cheese, pulses, fish, meat, peanuts, etc. They are found in every part of the body and form a fundamental basis of the structure and functions of life. These are also required for the growth and maintenance of the body. The word protein is derived from the Greek word, 'proteios' meaning 'primary' or of 'prime importance'. Chemically, proteins are the polymers in which the monomeric units are the α-amino acids. Amino acids contain an amino (-NH_2) and carboxylic (-COOH) functional groups. 1+1+3= 5

a) Calculate the approximate number of amino acids that may be present in a pure protein having molecular weight of 44000 D.
b) What was the first protein sequenced and by whom?
c) Describe about the secondary and tertiary

structures of proteins.

32	a) What is the difference between semiconservative and semi-discontinuous replication? b) What are Okazaki fragments? c) Mention any two properties of DNA polymerases. OR a) Why did Hershey and Chase use phosphorous and sulfur for their experiments? b) With the help of a labelled diagram show the experiment of Hershey and Chase.	2+1+2=5 2+3=5
33	a) Which is the longest phase of meiosis? b) What is synapsis and at which stage it occurs? c) Mention any three differences between mitosis and meiosis?	1+1+3=5

SECTION A

1	b) Biosensor	1
2	b) Pachytene	1
3	c) 30 %	1
4	d) D-Fructose	1
5	a) Streptokinase	1
6	a) Beta Sheet	1
7	c) Ciliated Columnar	1
8	c) Chemical Engineering	1
9	d) Pasteur & Tyndall	1
10	b) Serotonin	1
11	a) AUG	1
12	a) Hydroxyapatite	1
13	a) Both assertion and reason are correct and reason is the correct explanation of the assertion.	1
14	d) Both assertion and reason are false	1

15 b) Both assertion and reason are correct but reason is not the correct explanation of the assertion. 1

16 a) Both assertion and reason are correct and reason is the correct explanation of the assertion. 1

SECTION B (VERY SHORT ANSWER QUESTIONS)

17 a) Peptide bond 2
b) Phosphodiester bond
c) Glycosidic bond
d) N Glycosidic bond

18 Proline, it is hydrophobic in nature. 2

19 Correct diagram 2

20 Incomplete Dominance is shown in the flower colour of *Mirabilis Jalappa*. When parents with homozygous dominant gene for red coloured flower and homozygous recessive gene for white coloured flower are crossed, the progeny has pink flowers. It is because the dominant allele cannot suppress the expression of the recessive allele completely. 2

Codominance is seen in case of blood group of human where both the dominant alleles I^A and I^B are expressed equally.

21 Active Site: The region where the substrate binds to the enzyme is known as the substrate binding site or the 'active site' because it is at this site that activity leading to product formation takes place. 2

Feed Back Inhibition: Enzymes can be regulated. If excess of a product is made which is against the cell economy, the enzyme is made to slow down by the interaction of the product with the enzyme, a phenomenon called feedback inhibition. Enzymes which are controlled by feedback inhibition are known as regulatory enzymes.

OR

Bacteria have a cell wall made up of a large heteropolymer known as peptidoglycan which in its biosynthesis requires the activity of an enzyme known as transpeptidase. The antibiotic pencillin (discovered by Alexander Fleming) is a potent inhibitor of the transpeptidase rendering the bacterial cell wall weak and susceptible to host destruction mechanisms.

SECTION C (SHORT ANSWER BASED QUESTIONS)

22 a) Stem cells are unspecialized pluripotent cells which can show self-renewal and can be differentiated into many cell types. 1+2=3

b) Embryonic stem cells are pluripotent while adult stem cells are multipotent. Adult stem cells are present in regenerative organs like bone marrow, skin, intestinal epithelial cells etc.

23 a) Due to their dual character of having an internal hydrophobic region and an external hydrophilic portion, membranes present ideal impermeable barriers for preventing cellular contents from spilling out or extracellular constituents from entering in. 3

b) Water-soluble molecules such as sugars, amino acids and salts (NaCl, KCI) cannot freely penetrate the lipid membranes. Hence, special transporter molecules such as proteins are positioned within the membranes to facilitate transport.

c) Membranes are the locales where important cellular processes such as cell-cell recognition, cell signaling and energy generation (oxidative phosphorylation) take place.

24 With the help of a labelled diagram show the different stages of cell cycles (mention one key 3

feature of each stage) and show the check points.
OR
Draw a labelled diagram of the L.S of an ovule.
What is triple fusion?

25 Draw Correct structure. 3

OR

a) **Ninhydrin Test (Triketohydrindantin hydrate)**: Ninhydrin is a very powerful oxidising agent & in its presence amino acids undergo oxidative deamination liberating ammonia, carbon dioxide, a corresponding aldehyde and reduced form of ninhydrin. The ammonia formed from alpha amino group reacts with ninhydrin and its reduced product (hydrindantin) to give a blue complex called Ruhemann's purple (diketohydrin).

b) Acrolein test: Glycerol, one of the components of triglycerides and phospholipids when heated with potassium hydrogen sulphate gets dehydrated to an unsaturated aldehyde called acrolein. Acrolein can be identified by its characteristic pungent smell.

26 a) Correct diagram 2+1=3
b) 5' ATCACTCGAT 3'
3' TAGTGAGCTA 5'

27 a) Operons: Operons are gene clusters found in prokaryotes where each gene is coregulated. 3
b) Overlapping genes: These are gene within genes present in viruses.
c) Split genes: Split genes are split into coding regions called exons and non-coding regions called introns and are found in eukaryotes.

28 Nanotechnology is the study which involves manipulation and manufacture of ultra small structures. Uses of nanobiotechnology are fast diagnosis of diseases, drug delivery. 1+2=3
OR
3

Agronomic traits that can be achieved through Biotechnology:
Herbicide Resistance, Insect resistane, Disease resistance, Abiotic stress resistance.

SECTION D (CASE BASED QUESTOINS)

29 (i) Codon is a triplet code of mRNA containing three bases which code for a specific amino acid. 4
(ii) d) 64
(iii) c) GUU UAU CCU AAU

(iv) Methionine

(v) Nirenberg and Hargobind Khurana

30 i) B cells 1+2+2=4
ii) Ig A, Ig G, Ig M, IG D
iii)

- Cell mediated is characterized by increased number of T lymphocytes while humoral immune system is characterized by increased number of B cells.
- Humoral immune system produces antibodies on B cells.

OR

Primary lymphoid organs like bone marrow and thymus produce mature lymphocytes which differentiate in the secondary lymphoid organs like lymph nodes, GALT, MALT etc.

SECTION E (LONG ANSWER QUESTIONS)

31 a) 440 1+1+3=5
b) The first protein to be sequenced was sequenced insulin by Fredrick Sanger.
c) Secondary structures regular and local arrangements formed due to hydrogen bonding between C=O of one peptide bond and N-H of

another peptide bond. There are either alpha helices or beta sheets. Alpha helices are extensible and are present in proteins like keratin while beta sheets are non-extensible and very strong present in silk fibroin.

Tertiary structure is formed due to interactions between the side chains and either form globular structure or fibrous structure. Proteins made up of a single polypeptide such as the oxygen storage protein in muscle called myoglobin fold into a globular structure which is described as its tertiary structure. This protein has eight helices interconnected with unstructured peptide chains. The helices are packed against each other giving a compact globular or spheroidal structure. Most soluble proteins are globular in nature

32 a) Semiconservative DNA replication refers to the principle of replication in which when a new DNA molecule is formed, one strand is the old parental strand while another strand is the newly formed strand. Semi-discontinuous replication means when replication occurs, both the anti-parallel template strands are used simultaneously for forming the new complementary strands in 5' to 3' direction by the DNA Polymerase, hence one strand is formed continuously and is called the Leading strand while the other is formed as Okazaki fragments and hence forms discontinuously and is lagged lagging strand. 2+1+2=5

b) Okazaki fragments are small stretch of fragments which are formed in the lagging strand and are joined later. 2+3=5

c) DNA polymerases cannot initiate the process of DNA replication, hence always need a free 3' OH

group provided by primers and DNA polymerase can add complementary bases in 5' to 3' direction only.

OR

a) Hershey and Chase use phosphorous and sulfur because only DNA contains phosphorous while only protein contains Sulphur. The study was performed to confirm whether DNA or protein is the genetic material.

b) Correctly labelled diagram with correct steps.

33 a) Prophase I the longest phase of meiosis. 1+1+3=5

b) Synapsis is the pairing of all the chromatids of the homologous chromosomes during zygotene stage of Meiosis I forming the bivalent tetrad.

c)

- Mitosis results in formation of two daughter cells only while meiosis results in formation of four cells called as gametes.
- Daughter cells in Mitosis are identical to each other as well as parents while in Meiosis all the four gametes are unique.
- In mitosis the chromosome numbers are maintained while in meiosis the chromosome number is halved.

UNSOLVED SAMPLE PAPER I

SUB: BIOTECHNOLOGY CLASS: XI

TIME: 3 HOURS MM: 70

General Instructions:

i) All questions are compulsory.
ii) Question no. 1 to 12 are MCQ based questions of one mark each.
iii) Question no. 13 to 16 are Assertion Reasoning based questions of one mark each.
iv) Question no. 17 to 21 are very short answer-based questions of two marks each.
v) Question no. 22 to 28 are short answer-based questions of three mark each.
vi) Question no. 29 to 30 are case-based questions of four mark each.
vii) Question no. 31 to 33 are long answer-based questions of five mark each.

1. If you are researching on improving the delivery of a drug, which of the following techniques you are working on: 1
   a) Cloning
   b) Nanobiotechnology
   c) Biosensors
   d) Bioprocessing
2. The antibiotic penicillin is a potent inhibitor of which enzyme? 1
   a) Cellulase
   b) DNA ligase
   c) Transpeptidase
   d) Aminoacyl tRNA synthetase
3. The RNA primers formed during DNA replication are removed by: 1
   a) DNA Polymerase I
   b) DNA Polymerase II
   c) DNA Polymerase III
   d) DNase I

4. The important event of Glycosylation occurs in: 1
   a) Lysosomes
   b) Golgi Complex
   c) Mitochondria
   d) Endoplasmic reticulum
5. The hormones like adrenaline and thyroxine are derivatives of the amino acid: 1
   a) Serine
   b) Tyrosine
   c) Histidine
   d) Tryptophan
6. Which of the following epithelial tissues have absorptive function? 1
   a) Squamous
   b) Ciliated
   c) Columnar
   d) Stratified
7. Chemical mutagenesis was first reported by: 1
   a) Muller
   b) Stadler
   c) Morgan
   d) Auerback
8. Who coined the term 'Genetics'? 1
   a) Johannsen
   b) Bateson
   c) Mendel
   d) Tschemark
9. Study of cells and their interaction with environment is called: 1
   a) Cell Biology
   b) Tissue Engineering
   c) Bioinformatics
   d) Microbiology
10. Nobel laureate Linus Pauling contributed to the elucidation of: 1
   a) Beta Pleats
   b) Peptide Fingerprinting
   c) Alpha helix

d) DNA double helix

11. By nature, antibodies are: 1
   a) Lipoproteins
   b) Phosphoproteins
   c) Metalloproteins
   d) Glycoproteins

12. Bromine water test is done for: 1
   a) Amino acids
   b) Saturated Fatty acids
   c) Unsaturated Fatty acids
   d) Deoxyribose sugar

Question no. 13 to 16 are Assertion Reasoning based questions of one mark each.

Choose the correct option:

a) Both assertion and reason are correct and reason is the correct explanation of the assertion.
b) Both assertion and reason are correct but reason is not the correct explanation of the assertion.
c) Assertion is correct but reason is false.
d) Both assertion and reason are false.

13. Assertion: Euchromatin regions stain lightly. 1
   Reason: Euchromatin regions are less condensed and loosely coiled.

14. Assertion: In Retroviruses, the genetic material is DNA. 1
   Reason: It can directly insert its genome in host.

15. Assertion: After late G1, some cells withdraw from the cell cycle and enter G0 phase. 1
   Reason: These cells are metabolically inactive.

16. Assertion: Genes are linked by virtue of their being located on the same chromosome. 1
   Reason: Mendel's law of independent assortment of genes is based on the independent orientation of the different homologous chromosomes pairs during meiosis.

17. Draw the structure of any one Sulphur containing amino 2

. acid.

18. a) What will be the ratio of phenotypes expressed when a plant that is heterozygous for two traits is crossed with a plant that is homozygous recessive for both traits? 2
b) What does the law of Independent assortment state?

19. Name and mention the roles of any two enzymes that are used in biotechnology industry. 2

20. With the help of a cross, explain incomplete dominance. 2

21. Name and mention in brief the strategy for sequencing of amino acids. 2

22. Draw the following 3
a) dUMP
b) Lactose

OR

Write in brief about the following tests:
a) Acrolein test.
b) Ninhydrin test.

23. What is crossing over? Mention its role in sexual reproduction. 3

24. Explain in brief the following techniques: 3
a) Bioprocessing
b) Protein Engineering

25. Explain any two types of genetic recombination in bacteria. 3

26. a) Draw a labelled diagram of an antibody. 2+1=3
b) What are macrophages?

OR

a) Draw a labelled diagram of an ovule (L.S).
b) What is double fertilization.

27. What properties of enzymes enable them to achieve enormously high catalytic powers? 3

28. a) Name on protein and indicate its location for each of 1X3=3

. the following:
i) Structural protein
ii) Defense protein

b) Name one enzyme and its coenzyme form.

c) Name one form of DNA which has a left-handed helix conformation.

Question no. 29 to 30 are case-based questions of four mark each. Read the passages given below and answer accordingly.

29 . In 1952, Alfred Hershey and Martha Chase took an effort to find the genetic material in organisms. Their experiments led to an unequivocal proof to DNA as genetic material. Bacteriophages (viruses that affect bacteria) were the key element for Hershey and Chase experiment. 1X4=4

i) On which medium were the viruses cultivated by Alfred Hershey and Martha Chase?
a) A medium containing radioactive potassium (K)
b) A medium containing radioactive Uranium (U)
c) A medium containing radioactive phosphorous (P)
d) A medium containing potassium (K)

ii) Which of the following is not a stage in the "Hershey-Chase experiment"?
a) Blending
b) Centrifugation
c) Infection
d) Conjugation

iii) What will happen when the radioactive protein capsule of the virus is attached onto the bacteria?
a) Radioactivity is detected in the supernatant
b) Radioactivity is absent in the supernatant
c) Radioactive DNA is injected into the bacterium
d) Attachment of the virus to the bacterium doesn't occur

iv) Who proved that DNA was indeed the genetic material through experiments?
a) Alfred Hershey and Maclyn McCarty
b) Oswald Avery and Maclyn McCarty
c) Oswald Avery and Martha Chase
d) Alfred Hershey and Martha Chase

30. Meiosis is a mechanism in which a single cell divides twice to produce four cells that contain half of the original amount of genetic data. Those cells are our sex cells-male sperm, female eggs. One cell divides up twice during meiosis to create four daughter cells. These four daughter cells are only half as numerous as chromosomes of the parent cell-haploid. Meiosis is divisible into nine stages. These are divided between the first division of the cell (meiosis I) and the second division thereof (meiosis II). 1X4=4

i) **The RNA and protein synthesis occurs in_____**
a) M phase
b)S phase
c) G1 Phase
d) G2 phase
ii) **When does synapsis occur at Meiosis?**
a) Zygotene
b) Leptotene
c) Diplotene
d) Pachytene
iii) Cell Plate is laid during _____
a) Cytokinesis
b) Karyokinesis
c) Interphase
d) Metaphase
iv) **There are chromosomes arranged along the equator _____**
a) Prophase
b) Metaphase

c) Anaphase
d) Telophase

31. Explain in brief all the levels of structure of proteins. 5

32. a) What did Meselson and Stahl observed when: 2+3=5
i) They cultured *E.coli* in a medium containg NH4Cl for a few generations and centrifuged the content.
ii) They transferred one such bacterium to the normal medium of NH4Cl and cultured for two generation.
b) What did Meselson and Stahl conclude from this experiment. Explain with the help of diagram.

OR 1X5=5

Draw a schematic representation of the structure of the transcription unit and show the following in it.
a) Direction in which transcription occur
b) Polarity of two strand involved
c) Template strand
d) Terminator codons
e) Initiation codon

33. Identify the following organelles and write one function of each: 1X5=5
a) form microsomes when the cell is homogenized.
b) Have catalases
c) Are formed from Golgi complex and contain hydrolytic enzymes
d) The inner membrane is folded into cristae
e) Consist of equal amounts of RNA and proteins.

UNSOLVED SAMPLE PAPER II

SUB: BIOTECHNOLOGY CLASS: XI

TIME: 3 HOURS **MM: 70**

General Instructions:

i) All questions are compulsory.

ii) Question no. 1 to 12 are MCQ based questions of one mark each.

iii) Question no. 13 to 16 are Assertion Reasoning based questions of one mark each.

iv) Question no. 17 to 21 are very short answer-based questions of two marks each.

v) Question no. 22 to 28 are short answer-based questions of three mark each.

vi) Question no. 29 to 30 are case-based questions of four mark each.

vii) Question no. 31 to 33 are long answer-based questions of five mark each.

SECTION A

1. **Which amino acid does gives yellow colour in ninhydrin test?** 1

a) Alanine
b) Lysine
c) Proline
d) None of the Above

2. **Which of these is not a product of fermentation?** 1

a) Lactic acid
b) Oxygen
c) Carbon dioxide
d) Ethanol

3. **Which one is the resting phase of cell cycle-** 1

a) Interphase
b) Anaphase
c) Metaphase
d) None of the above

4. **Who proposed double helix model?** 1

a) Griffith
b) Watson and Crick
c) Chase
d) None of the above

5. **Every time in his research Mr. Ashok finds a cell organelle that has a green color pigment. Name the organelle.** 1

a) Chloroplast
b) Mitochondria
c) Golgibody
d) Lysososme

6. **Which of the following immunity is called the first line of defense?** 1

a) Innate Immunity
b) Active immunity
c) Passive immunity
d) Acquired immunity

7. **Identify the repeating units of glycogen** 1

a) Alpha Glucose
b) Beta Glucose
c) c Both a and b
d) None of these

8. **Which is the most abundant biomolecule on earth?** 1

a) Mineral salts
b) Proteins
c) Lipids
d) Carbohydrates

9. **The genotypic ratio of a Dihybrid cross is-** 1

a) 1:2:1
b) 3:1
c) 2:1:1
d) 9:3:3:1

10. **Which of the following disorder is an example of point mutation?** 1

a) Sickle cell anaemia
b) Down's syndrome
c) Night blindness
d) Thalassemia

11. **Which of the following is start codon?** 1

a) AUG
b) GUG
c) UAA
d) UCU

12. **Who proposed the semi conservative mode of DNA replication?** 1

a) Watson and Crick
b) Meselson and Stahl
c) Hershey and Chase
d) Beadle and Tatum

Question No. 13 to 16 consist of two statements – **Assertion (A) and Reason (R).**

Answer these questions selecting the appropriate option given below:

A. Both Assertion and Reason are true and the reason is the correct explanation of the assertion

B. Both Assertion and Reason are true but the reason is not the correct explanation of the assertion

C. Assertion is true but Reason is false

D. Both Assertion and Reason are false

13 **Assertion**- Transcription is the mode in which DNA passes its genetic information to RNA. 1

Reason-Transcription takes place in the cytoplasm of eukaryotic cell.

14 **Assertion**-: In Griffith's experiment, a mixture of heat-killed virulent bacteria R and live non-virulent bacteria S, lead to the death of mice 1

Reason- Transforming principle' got transferred from heat killed R strain to S strain and made it virulent.

15 **Assertion**- Unsaturated fats are more reactive compared with the saturated fats**.** 1

Reason -Unsaturated fats have only single bonds in their structure.

16 **Assertion-** Mitosis is important in the life of an organism, especially in the growth of a multicellular organism. 1

Reason-Mitosis restores the nucleocytoplasmic ratio.

SECTION B

17 Differentiate mitosis and meiosis (2 points) 2

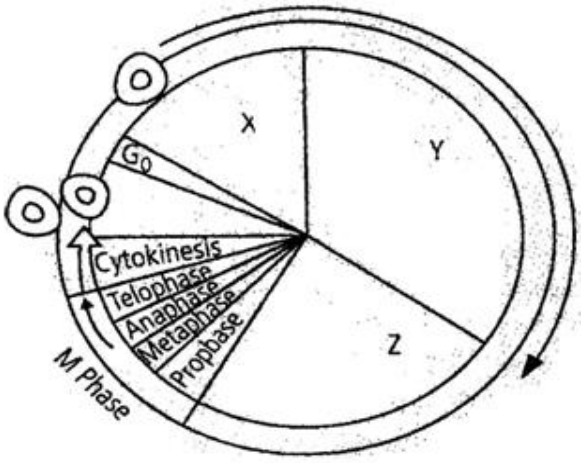
18 Why mitochondria are called as semi-autonomous organelles. Draw its well labeled diagram 2

OR

Give the biochemical composition(components) of plasma membrane. How are protein molecules arranged in membrane.

19 Amino acids exist as zwitterions. Give its structure. Why amino acids are essential? 2

20 The following diagram refers to a typical Cell cycle. Identify the parts marked as X, Y and Z. Also give one significance of Y phase. 2



21 Draw the Fischer projection (open chain structure) of glucose sugar. 2

SECTION C

22 Enlist the six features of genetic code 3

23 Difference between 3

a) Transition and transversion

b) Prokaryotic and eukaryotic nucleus

c) Paracrine and endocrine cell signaling

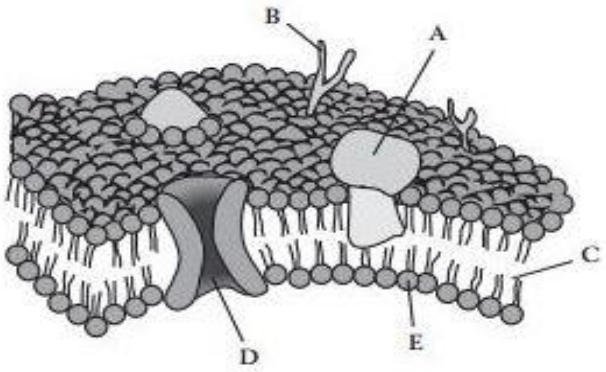
24 Explain RNA processing in eukaryotic organisms. 3

25. The given diagram shows the structure of cell membrane. 3

A) Which labelled part represents hydrophilic and hydrophobic structure?

B) Which labelled part represents transmembrane integral protein? Also mention its function.

C) What is the name of this model?



26 Why DNA is called Blue print of life. Describe double helix model of DNA 3

27 Explain the central dogma of molecular biology 3

28 Give the structure of tRNA. Also explain its role in protein synthesis. 3

SECTION D

29 Harish was very much interested in physical exercise and used in participate in the body building competition. One day one of the friends suggested him to consume muscle building diet available in the market and also give the sample of such diet. Harish showed this sample to the biology teacher who after examination found it to be diet rich in protein. 4

Read the above passage and answer the following question.

a) What is the building block of protein
b) What is importance of amino acid in organism?
c) Difference between essential and non-essential amino acids.
d) Draw the structure of any one essential amino acid.

30 Griffith experiment was a stepping stone for the discovery of genetic material. Frederick Griffith experiments were conducted with *Streptococcus pneumoniae*. During the experiment, Griffith cultured *Streptococcus pneumoniae* bacteria which showed two patterns of growth. One culture plate consisted of smooth shiny colonies (S) while other consisted of rough colonies (R). The difference was due to the presence of mucous coat in S strain bacteria, whereas the R strain bacteria lacked them. Griffith injected both S and R strains to mice. The one which was infected with the S strain developed pneumonia and died while that infected with the R strain stayed alive. 4

In the second stage, Griffith heat-killed the S strain bacteria and injected into mice, but the mice stayed alive. Then, he mixed the heat-killed S and live R strains.

This mixture was injected into mice and they died. In addition, he found living S strain bacteria in dead mice

a) According to Griffith experiment what is transforming principle.

b) What is the conclusion of Griffith experiment?

c) Which bacteria killed the mice in Griffith's

d) transformation experiment?

e) Name the scientist who identifying the DNA as Transforming principle

SECTION E

31 A) Name the stages of cell cycle at which one of the following events occur: 5

i) Chromosome is moved to spindle equator.

ii) Centromere splits and chromatids separate.

iii) Crossing over between homologous chromosomes takes place.

B Define mutation and name common mutagens found

OR

Explain with diagram steps involved in transcription.

32 Name any five enzymes involved in DNA replication. Name the key functions for each of them. 5

OR

Give the classification of amino acids under following heads:
a) Essential and non-essential b) polar and non-polar c) aliphatic and aromatics.

33 What is Law of independent assortment. Explain with the 5

help of a suitable example.

OR

a. Draw the structure of peptide bond 1 +

b. Explain the formation of peptide bond 2 +

c. Write the test for lipid detection and carobohydrate detection 1 +

d. Differentiate RNA and DNA (ONE VALID POINT) 1

UNSOLVED SAMPLE PAPER III
SUB: BIOTECHNOLOGY CLASS: XI

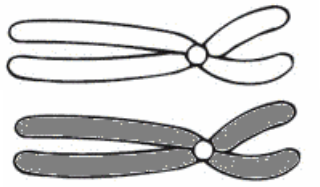
TIME: 3 HOURS **MM: 70**

General Instructions:

i) All questions are compulsory.
ii) Question no. 1 to 12 are MCQ based questions of one mark each.
iii) Question no. 13 to 16 are Assertion Reasoning based questions of one mark each.
iv) Question no. 17 to 21 are very short answer-based questions of two marks each.
v) Question no. 22 to 28 are short answer-based questions of three mark each.
vi) Question no. 29 to 30 are case-based questions of four mark each.
vii) Question no. 31 to 33 are long answer-based questions of five mark each.

Section A

1. Which characteristic arrangement of two homologous chromosomes is observed in the diagram given below? 1



(a) Bivalent or Tetrad formation
(b) Crossing over for genetic recombination
(c) Metaphase arrangement
(d) Centromere of the chromosomes are observed

2. Match the columns A with B- 1

Column A	Column B
a) Genes	i) any character of an organism that can be measured or described
b) Phenotype	ii) different alleles for specific traits on homolog chromosomes
c) Chromosomes	iii) contain hereditary units or genes
d) Heterozygote	iv) once called the inheritance “factors” by Men

(a) a- iv; b-ii; c-iii; d-i
(b) a- iv; b-i; c-iii; d-ii

(c) a- iii; b-i; c-iv; d-ii
(d) a- iv; b-i; c-ii; d-iii

3. Why warm temperature for curd formation? 1
(a) Warm temperature keeps the curd solid
(b) Warm temperature helps in growth of curd bacteria
(c) Warm temperature helps in killing the curd bacteria
(d) Warm temperature helps in keeping curd warm

4. Which of the following agronomic trait in crops cannot be improved by using biotechnology? 1
(a) High yield (b) Insect resistance (c) Disease resistance (d) Long life

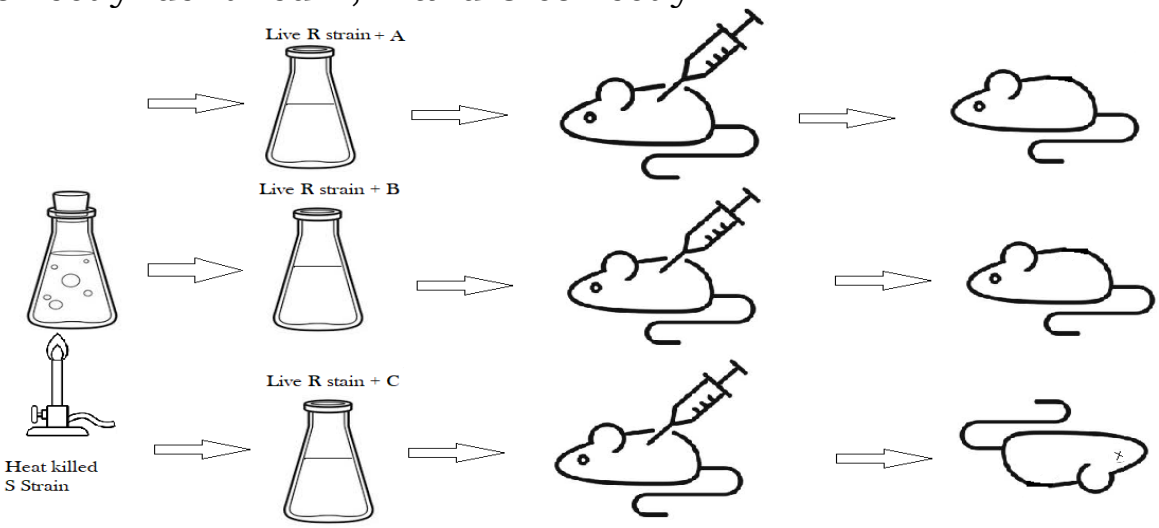
5. What of the following organelles has a single membrane? 1
(a) Lysosome (b) Nucleus (c) Mitochondria (d) Plastid

6. Which of the following is not a function of the cell membrane? 1
(a) It separates the cell and its contents from the surrounding
(b) It receives signals from its surroundings and transmits it to the cytoplasm
(c) It carries out DNA replication and synthesis of proteins
(d) It is the site for some of the metabolic reactions

7. Match the following is not the correct chromosomal mutation identification- 1

Sl. No.	Original chromosome	Mutation	Identification
(a)	A B C D E F G	A B E F G	Deletion
(b)	A B C D E F G	A B C D E F G F G	Duplication
(c)	A B C D E F G	A B E D C E F G	Inversion
(d)	A B C D E F G	A B E D C E F G	Translocation

8. In the diagram of Avery, MacLoed and McCarty, which student has correctly identified A, B and C correctly- 1



(a) A-Protein of R strain, B- DNA of R strain, C- Sugars of R strain
(b) A-Protein of S strain, B- DNA of S strain, C- Sugars of S strain
(c) A-Protein of R strain, B- Sugar of R strain, C- DNA of R strain
(d) A-Protein of S strain, B- Sugar of S strain, C- DNA of S strain

9. DNA repair checkpoints are regulated by- 1
(a) Cyclin A and CDK-2
(b) CHK1 and CHK2
(c) Cyclin B and CDK-1
(d) Cyclin A and CDK-1

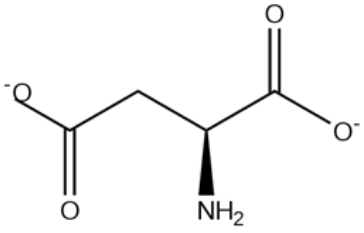
10. Which of the following is not a correct pair of amino acids and their 1

derivatives?

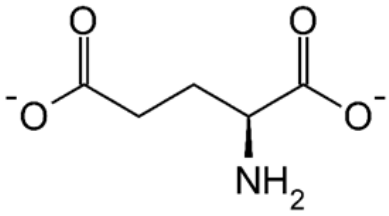
(a) Glutamic acid- GABA
(b) Tryptophan- serotonin
(c) Tyrosine- adrenaline
(d) Methionine- histamine

11. Which of the following sequences is DNA? 1
(a) AAUGGCGUAGCUAG (b) LMNAARSTQWMMG
(c) UUGCAACGAUCGA (d) ATCCGTAGCTAGCTA

12. Classify the amino acids that has the following structures- 1



Aspartate



Glutamate

(a) Both are Acidic (b) Both are Basic
(c) Both are Polar uncharged (d) Both are Non-polar Aromatic

Question No. 13 to 16 consist of two statements – Assertion (A) and Reason (R). Answer these questions selecting the appropriate option given below:
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true and R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

13. **Assertion:** Apoptosis is a programmed method of cell death in our body. 1
Reason: Cells undergo necrosis when there is injury.

14. **Assertion:** DNA replication is bidirectional. 1
Reason: DNA replication once initiated from ori, two replication forks are formed that move away from the point of origin in opposite direction.

15. **Assertion:** All naturally occurring sugars are of D configuration. 1
Reason: All naturally occurring amino acids are of L configuration about their α-C

16. **Assertion:** Amino acids are classified at the pH of 7.4. 1

Reason: pH of 7.4 is physiological pH that is it the pH of human blood.

Section B

17. Draw the structure of glucose to show the formation of internal hemiacetal. 2

18. A, B, C and D are four solutions without label. Study the table regarding different biochemical tests and identify them. 2

Solution	Benedict's test	Ninhydrin test	Bromine water test	Diphenylamine test
A	No	Yes (blue)	No	No
B	Yes	No	Yes	No
C	No	No	No	Yes
D	Yes	Yes (yellow)	No	No

19. The mother is of blood group O and the father is of blood group AB. What would be the expected blood group of the children? Will any of the children have mother's blood group? Give reason for your answer. 2

20. Give reason why: 2
    a. Nuclear membrane has nuclear pores.
    b. Some parts of chromatin stain darkly while other parts stain lightly.

21. Distinguish between vegetative propagation and apomixis. 2

OR

Distinguish between microtubules and microfilaments.

Section C

22. Explain how the lac operon functions in presence and absence of lactose. 3

OR

Briefly explain the central dogma of molecular biology.

23. You have a polypeptide which has molecular weight of 33,000 Da. You want to sequence it and the following information is needed. 3
    a. Calculate the number of amino acids in the polypeptide.
    b. What may be the maximum size of a peptide fragment for it be sequenced accurately by the sequenator? How many fragments need to be generated for the given polypeptide to sequence it in a sequenator?
    c. After the sequencing one of the peptides, the first 5 amino acids are as follows-

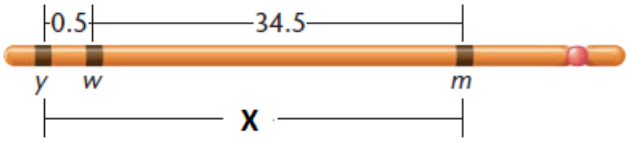
Arginine- lysine- isoleucine- methionine- valine
Which end is the N terminal and which is the C terminal?

24. a. Distinguish between enzymes and chemical catalysts. (any two contrasting points) 3
b. Mention how enzymes function in an antibiotic like penicillin.

25. (a) Expand RDT. 3
(b) How is recombinant DNA molecule generated in RDT?
(c) Mention any two applications of RDT.

26. What are the different types of plastids. Mention their function in plants. 3

27. The figure given below shows a map of three genes on the X chromosome of Drosophila melanogaster namely *yellow* (y), *white* (w) and *miniature* (m) genes. The number represents the recombination frequencies between the two genes. Answer the following questions- 3

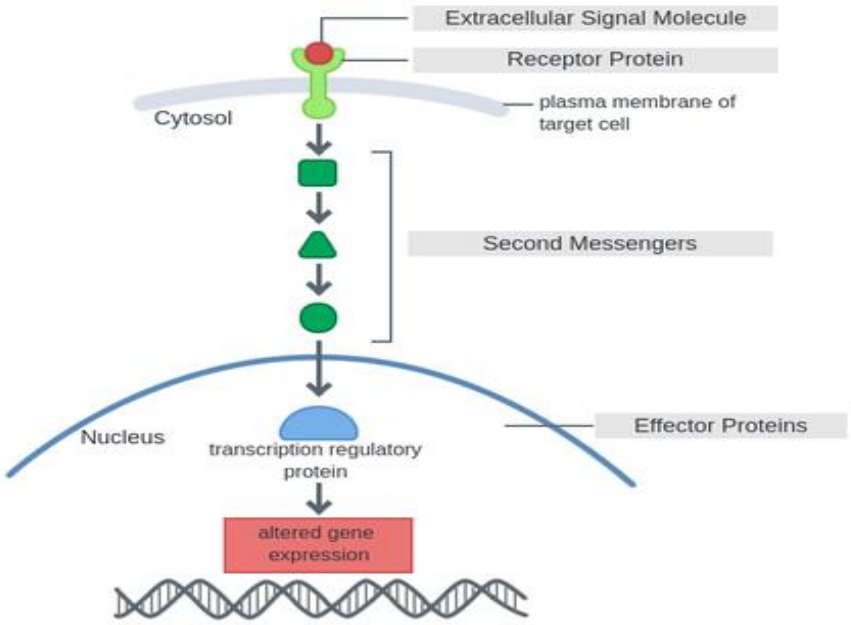


a. What is the genetic distance between genes y and w?
b. What is the genetic distance between genes y and m?
c. A plant has 12 linkage groups. What will be the number of chromosomes in the zygote, ovum and endosperm of the plant?

28. What is genetic recombination? 3
Identify the following methods of genetic recombination in bacteria.
(a) Donor releases DNA in the medium and recipient takes it from the medium.
(b) Donor carries a small piece of DNA called F factor and comes in contact with bacteria without F factor and F factor is transferred to the recipient.
(c) Phage virus gets bacterial DNA from one host and transfers it to another bacteria.
(d) Variation is due to the random changes in the nucleotide sequence during DNA replication.

Section D

29. Once a signaling molecule binds receptor on a cell, it initiates a series of intracellular reactions towards interior of the cell and signal is transmitted from cell membrane to nucleus. This process is called **intracellular signal transduction.** The signal may be transmitted directly or via a cascade pathway involving many proteins. These pathways between the cell membrane and the cell nucleus are called **signal transduction pathways.** There is an amazing degree of networking among these pathways. A large variety of molecules are involved in these pathways and include molecules like cyclic AMP (cAMP), Ca+2 and calcium-binding protein calmodulin, MAP (mitogen activated protein) kinases, NF-κB (nuclear factor- kappa B) transcription factor etc. All this results in cellular response that may include changes in gene expression, differentiation, replication, alteration of enzyme activity, changes in ion permeability or even death of the cell. 4



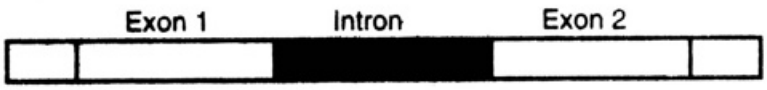
(a) Mention any two changes that can occur due to signal transduction.
(b) Which molecules may act as a signal molecule inside the cell?
(c) Which molecules bind to the extracellular signal molecules? Give any two examples of such molecules.

OR

Cells may produce their own signals so that they may divide, differentiate or any other function. When a cell becomes cancerous which signals will it produce for itself? Why do you

think these signals are produced by the cell?

30. Genes may consist of stretches of intervening DNA sequences, which do not carry any message (introns) along with the regions that contain biological information (exons). Such genes are known as 'split genes' (also called discontinuous genes or mosaic genes), and are common in higher organisms, including humans. The number of introns in a gene may vary from none to more than a hundred. 4



(a) Which types of organisms have split genes or mosaic genes?
(b) Introns are removed and exons are joined to each other in which molecule? Name the process of removing introns.
(c) Why are the genes of the higher organisms larger in size when compared to bacterial genes? Draw a diagram to show the genes of bacteria and higher organisms.

OR

Discuss why genes are coded to RNA before the synthesis of proteins?

Section E

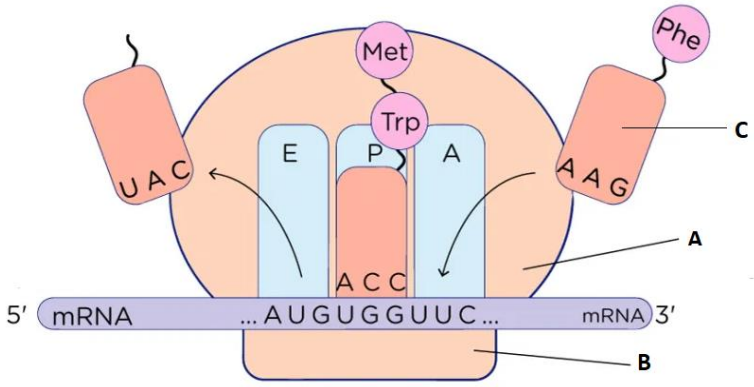
31. i. Mention the three components of a nucleotide. 5
ii. Distinguish between purines and pyrimidines. (any two points with examples)
iii. Distinguish between DNA and RNA. (any two points)

OR

Write down any three features of Watson and Crick model of DNA with appropriately labelled diagram.

32. Answer the following questions on translation- 5
a. Name the start codon. Which amino acid does this code for?

b. Name the stop codons. Which amino acids do they code for?
c. Identify A, B and C in the following diagram



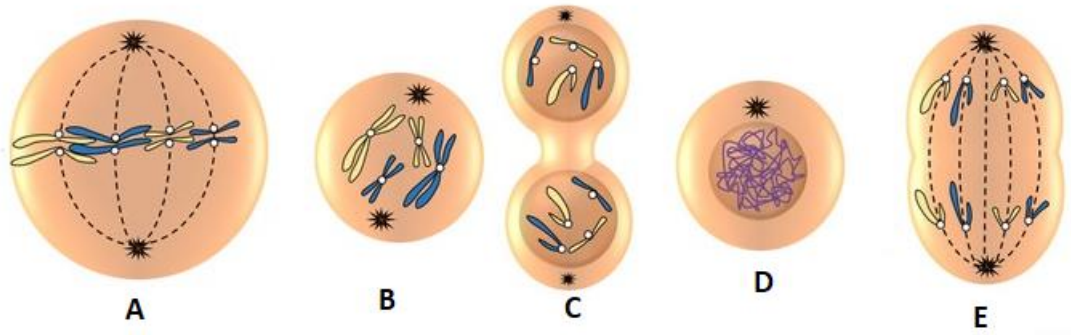
d. Identify the step of translation depicted in the diagram above.
e. What happens when the A site reaches a stop codon?

OR

Identify the enzymes, proteins involved in different steps of DNA replication-

a. Synthesis of primers in *E. coli* and eukaryotes
b. Sealing any nicks by formation of phosphodiester bond
c. Disruption of hydrogen bond
d. Unwinding and removing supercoiling
e. Prevent single stranded DNA from reforming

33. Study the following diagram and answer the following questions: 5



(a) Identify the type of cell division and label A, B, C, D and E.
(b) Why is this cell division called equational division?
(c) Mention any two changes that takes place in interphase before cell division.

OR

i. Complete the following table- [1 ½ +1+2 ½]

Cells of Immune System	Function of the Cells
Macrophages	a. _____
B Lymphocytes	b. _____

T Lymphocytes	c. _____

ii. Which cells of the immune system are called antigen presenting cells? (Any two)
iii. Draw a labelled diagram of Immunoglobulin.

****


तत् त्वं पूषन् अपावृणु
केन्द्रीय विद्यालय संगठन
Kendriya Vidyalaya Sangathan
18, Institutional Area
Shaheed Jeet Singh Marg
New Delhi – 110016 (India)
Phone : +91-11-26858570