Cell Biology

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6th Term (II)
Unit 5. The Cell

Introduction

- Observe the two pictures given above. Do you observe any similarity between them?
- Close your eyes and imagine a brick wall. What is the basic building block of the wall? A single brick, of course.
- Like a brick wall, your body is composed of basic building blocks, and are named as "Cells".
- The cell is the basic structural and functional unit of every living organism.
- The cell is self-sufficient to carry out all the fundamental and essential functions of an organism.

The Cell

- All living things are made of one or more cells. There are variety of cell types however, they all have some common characteristic features.

Discovery of the cell

- The Englishman Robert hooke was a scientist, mathematician, and inventor. He improved microscope which was usedin those days, and built a compound microscope. He placed water-lens beside the microscope to focus the light from an oil-lamp on specimens to illuminate them brightly. So that he able to see the minute parts of the objects clearly.

- One day Hooke made thin sections of the cork and observed them through his microscope. He observed many small identical chambers which were hexagonal in shape. He was surprised.

- After that he saw many objects like Butterfly's wings, Bee's compound eyes etc.,

- Based on this observations Hooke published a book named Micrographia in the year 1665, where he first used the term Cell . He describe the structure of tissue using the term cell.

- In Latin the word 'cellua' means a small chamber.

- The branch of science that deals with the study of cells is called 'Cell Biology'.

The Structural Organization Of The Cell

A typical cell consists of three major parts:

1. An outer cell membrane.
2. A liquid cytoplasm.
3. A nucleus.

- Analogous to the body's internal organ, like eyes, heart, lungs organelles are specialized structures and perform valuable functions necessary for normal cellular operation. Many of miniscule but distinct structures called Organelles lie within the cell.

Size of the cell

- The size of cells may vary from a micrometer (a million of a metre) to a few centimeters. Most cells are microscopic and cannot be seen with the nacked eye. They can be observed only through the Microscope.

- Smallest size of the cell is present in Bacteria. The size of the bacterial cell ranges from 0.01 micrometer to 0.5 micro meter.

- On the other hand the largest cell is the egg of an ostrich with 170 millimeter width. We can see this with the nacked eye. In Human body the nerve cells are believed to be the longest cells.

Cell size has no relation to the size of an organism. It is not necessary that the cells of, say an elephant be much larger than those of a mouse.

Shapes

- Cells are of different shapes. For example some shapes are given in the below pictures.

Number

- The number of cells present in different organisms may vary. Organisms may be either unicellular (single cell) or multicellular. Organisms such as Bacteria, Amoeba, Chlamydomonas, and Yeast are unicellular. On the other hand, organisms such as Spirogyra, Mango, and Human beings are multicellular. (i.e) made up of a few hundreds to million cells.

Approximate number of cells in the human body is 3.7 X1013 or 37,000,000,000,000

TYPES OF CELL

- Generally cells are classified into two types. First one is Prokaryotic cell .It has No true nucleus consisting of no nuclear membrane. Another one is Eukaryotic cell. It has True nucleus consisting of nuclear membrane.

Prokaryotic cell

- The unicelluar organisms like Bacteria has Prokaryotic cells. It has No true nucleus. This type of nucleus is called as nucleiod. No nuclear membrane is around this nucleiod. These cells were the first form of life on earth. It is ranging from 0.003 to 2.0 micro meter in diameter.

Eukaryotic cell

- Cells which has true nucleus is called as eukaryotic cell. It is bigger than prokaryotic cells. It's organelles bounded by membrane.

- Ex. Plants,animals, most of the fungi and algae.

Differences between Prokaryotic cell Eukaryotic cell

Prokaryotic cell	Eukaryotic cell
It's diameter ranges from 1 to 2 micron	It's diameter ranges from 10 t0 100 micron
Absence of membrane bound organelles	Presence of membrane bound organelles
Nucleus consisting of no nuclear membrane	True nucleus consisting of nuclear membrane
Absence of nucleoli	Presence of nucleoli

Plant cell and Animal cell

- Both plant and animals are made up of cells. Both cells are eukaryotic in nature, having a well defined membrane – bound nucleus.

Plant cell

- ❖ It is usually larger in size. It is hard in nature.
- ❖ Plant cell have a cell wall in addition to their cell membrane.
- ❖ Plant cell have chloroplast which contain chlorophyll
- ❖ Plant cells have large vacuoles. Centrioles are absent.

Animal cell

- ❖ Animal cells are generally smaller than plant cells. It is not so hard as plant cell.
- ❖ A cell wall is absent.
- ❖ Chloroplast is usually absent.
- ❖ An animal cell may have many small vacuoles.
- ❖ Centrioles are found in animal cells

Dimension - cell structure

1. How does a cell look like?
2. What is its shape and size?

- The above cell has a three dimensional view. We can see the three sides of the cell structure. You can also view the size, shape and location on the organelles of the cell also.
- 3-D view is appealing because it is more like reality
- In 3-D, We can see the entire view of the cell. It exposes the accurate size and shape and shows the correct location of the cell organelles.

Cell components and their functions

S. No	Cell Components	Main Functions	Special Name

1.	Cell wall	• Surrounds and protects the cell • Make the cell stiff and strong	Supporter and protector
2.	Cellmembrane	• Holds and protects the cell • Controls the movement of materials in and out of the cell	Gate of the cell
3.	Cytoplasm	• A watery, gel-like materia • which cellparts move	Area of movement
4.	Mitochondria	• Produce and supply most Theenergyfor the cell	Power house of the cell
5.	Chloroplasts	• Contain green pigment chlorophyll • Capture the energy of sunlight and use it to produce food for the cell photosynthesis.	Food producers for the cell (Plant cell)
6.	Vacuoles	• Store food, water, and chemicals	Storage tanks
7.	Nucleus	• Acts as 'brain' of the cell • Regulates and controls all cell activities	Control centre
8.	Nucleusmembrane	• Surrounds and protects th nucleus control the mover materials in and out of th nucleus	Gate of the nucleus

7th Std term(II)
Unit – 4 Cell Biology

Introduction

- Sona had a dinner, some hour later; sheexperienced a stomach pain and wentto aclinic. After examination, the Doctor told Sonathat she had eaten foodcontaminated with atype of bacteria which might have caused foodpoisoning.Bacteria are micro-organisms thatcan be seen only under microscope and notseenthrough nacked eyes. Salmonella species isa bacterium that can cause food-borneinfection.

- Our earth is a beautiful place where indifferent types of organisms happilycoexist.From minute mosses to huge conifers, invisiblebacteria to huge blue whale,all have a basic unitcalled Cell. Let us study about the cell.

Cell as a fundamental unit of life:

- The building wall is made up of numerousbricks. In the similar manner, a beehive iscomposed of numerous hexagonal units. Someof the organisms arerepresented by a single cell.Therefore, they show a simple organization. Thebasicfunctional unit of an organism is called, a cell.Structures of a cell represent thearrangementof parts or organells in a cell. Function is theactivity of each part ororganell in a cell. Cellsare the basic building blocks of an organism.You learnt thatatoms are the basic buildingblocks of matter in chapter three. Likewise,humanbody is made up of animal cell and plantis made up of plant cell.

Unicellular organisms

- Some simple organisms are made upof only one cell. They are calledunicellularorganisms, which can be seen with the help ofa microscope. There aremany single ‐ celledmicroscopic organisms.

- Have a look at the image. Chlamydomonasand an Amoeba, a single cellorganism which carryout entire functions the bodyof all organisms are made upof tiny buildingblocks called, cells. Bacteria are also one celledunicellularorganisms.

Multicellular Organism

- The cells are organized into tissues, organsand organ systems in amulticellular organism.Macroscopic organisms are visible and consist of manyells. The body of macroscopicorganisms involves various functions. Youcan see cells of onion and human through amicroscope. Onion and man are examples formulticellular organism.

Cell to organism

- Many cells function together to formtissues, different tissues combinedtogether toform an organ and different organs to form anorgan system, whichleads to form an organism.

Organisms

- Many types of organ systems functiontogether in a body, e.g. respiratorysystem,digestive system, excretory system circulatorysystem etc.

Organ System

- Many organs together form an organsystem, which is concerned with aspecificfunction. For example, Respiratory system,which has organs like nostrils,nasal chamber,wind pipe and lungs that helps in the process ofrespiration. In aplant, the root system consistsof primary root, secondary root and tertiaryroot,which does the function of conduction ofwater, mineral and also fixation.

Organ

- A collection of different tissues workedtogether to perform a specific functionorfunctions is called an organ. Human body hasdifferent organs like stomach, eye,heart, lungsetc., are made up of different type of tissues.Plants have organs such asleaves, stems, androots.

Tissue

- Tissue is a group of cells, organized for aspecific function. Tissues havefollowing featureslike same shaped cells or different shapedcells to perform acommon function. Humanand other animals are made up of nervous,epithelial,connective and muscle tissues. Plantshave transport, protective and ground tissues.

Cell

- The cell is a basic structural and functionalunit of life. Cell is the building unitof livingorganisms. You can see in a hand, how manytypes of cells are there towork together toperform its functions. So, cell is known as thebasic unit of life.

Plant and Animal cell comparison

- Why do plant cellsdiffer from animal cells?They differ from eachother becausethey have toperform different functions.Now you know that thereare many main similarities between plant andanimal cells. Let us see how they differfrom oneanother as given in the picture.

Human cells related to functions Different types of cells

- Our body is made up of many differentkinds of cells. Each type of cell isspecialized toperform a specific function. Depending on thefunction, cell hasspecific shape, size and mayhave some components which other type ofcells do nothave. Have a look at the differencesbetween nerve cells and red blood cells in theimages. Even though there are many differenttypes of cells, there are somecomponentscommon to all type of cells. Let us take a look atthis in the next section.

What's inside a cell?

- Inside a cell, there are many tiny structurescalled cell organelles. Theseorganelles areresponsible for providing needs of the cell.They work to bring infood supplies, get ridof waste, protection and repair of the cell, andhelp it to growand reproduce. Each one has aspecific function to do for the cell. And, if anyoneorganelle stops its function, then the cell isprogrammed to die.

Cell Structure

- As we have mentionedbefore, all cells have somecommon structure.

These are

1. Cell membrane
2. Cytoplasm, and
3. Nucleus (In most eukaryotic cells).

- The structure of a typical plant and animal cellshows following peculiarities:

Cell membrane

- The boundary of an animal cell is theplasma membrane, which is also calledas cellmembrane

Cell wall - "Supporter and Protector"

- All animal and plant cells are enclosed orsurrounded by a cell membrane asyou learnedbefore. However, as you might have noticedpreviously that, animalcells often have anirregular shape, whereas plant cells have a muchmore regular and rigid shape.

- Plant cells have an additional layer on theouter side of the cell membrane.This is calledas the cell wall that provides a frame work forsupport and stability.The cell wall is formed from variouscompounds, the main one being cellulose.Cellulose helps to maintain the shape of theplant cell. This allows the plant toremain rigidand upright even if it grows to great heights.Each cell is interconnectedwith its neighbouringcells through openings called Plasmodesmata.

Stem Cells

Stem cells are quite amazingas they can divide andmultiply while at the sametime with their ability to develop into anyother type of cell. Embryonic stem cellsarevery special as they can become absolutelyany type of cell in the body, forexample,blood cell, nerve cell, muscle cell or glandcell. So they are utilized by theScientistand Medicos, to cure and prevent somediseases like

Spinal cord injury.

Cytoplasm - I am the "Area of Movement".

- When you look at the temporary mountsof an onion peel, you can see a largeregion ofeach cell an enclosed by the cell membrane. Thisregion takes up very littlestain. It is called thecytoplasm.

- The cytoplasm includes all living parts ofthe cell with in the cell membrane,excluding thenucleus. The cytoplasm is made up of the cytosoland cell organelles.The cytosol is a watery, jellylikemedium made up of 70% - 90% water andusuallycolourless.

- Cell organelles and structures presentin a cell are endoplasmic reticulum,vacuole,ribosome, Golgi body, lysosome, mitochondria,centriole, chloroplast,surrounded by plasmamembrane and cell wall.

Protoplasm vs. Cytoplasm

- In particular, the material inside and outsidethe nuclear membrane is knownas ProtoplasmThe fluid inside the nucleus is known as thenuclear fluid or nucleoplasm and outside thenucleus is called as cytoplasm.

Inside the cytoplasm Mitochondria - "Power house of the Cell"

- Do you remember learning about the foodas the energy source for the body?Just as woodis burnt to release the stored potential energyto make a fire to heatsome water The food thatyou ate to be broken down in order to releasethe energywhich can be used by your body tofunction. Mitochondria are responsible to dothisfunction.

- Very active cells have more mitochondriathan cells that are less active. Whichtype of cell,do you think, will have more mitochondria, amuscle cells or a bonecell?

- Mitochondrian is an oval or rod shapeddouble membrane bounded organelle.Aerobicrespiratory reactions take place within themitochondrion to release energy.So it is knownas "the Power

House” of the cell. The energyproduced within themitochondrion is used forall the metabolic activities of the cell

Chloroplast- “Food Producers”

- Do you notice the green organellespresent in plant cells and absent in animalcells.Chloroplasts are the only cell organelles thatcan produce food from thesunenergy. Only plants withchloroplast are able to dophotosynthesis because theycontain the very importantgreen pigment, chlorophyll.Chlorophyll can absorbradiant energy fromthe Sun and convert it to the chemical energywhich can beused by the plants and animals.Animal cells lack chloroplasts and are unable todophotosynthesis.

Golgi complex- I need a break

- Membrane bounded sacs are stacked on topof the other with associatedsecretory vesicles arecollectively known as Golgi complex. Functionsof Golgicomplex are the production of secretorysubstances, packaging and secretion. This is thesecret behind the change in the colour and tasteof fruits

Lysosome- “Suicidal Bag”
Everything I touch, I destroy

- You will find organelles called aslysosomes, which are very small to viewusinga light microscope. They are the main digestivecompartments of the cell. Theylyse a cell, hencethey are called “suicidal bag”.

Centrioles

- They are generally found close to thenucleus and are made up of tube-likestructures.Centrioles or centrosomes are present only inanimal cells and absent inplant cells. It helpsin the separation of chromosomes during celldivision.

Endoplasmic reticulum - You guys, be quiet, I have so much work to do

- It is an inter membranous network madeup of flat or tubular sacs within thecytoplasm.Endoplasmic reticulum is of two types. Theyare rough endoplasmicreticulum and smoothendoplasmic reticulum.

- **Rough endoplasmic reticulum**: are rough dueto the ribosomes attached to themembrane.which helps in the synthesis of protein.

- **Smooth endoplasmic reticulum**. It is a networkof tubular sacs withoutribosomes on themembrane. They play a role in the synthesis oflipids, steroids andalso transport them withinthe cell.

Nucleus - Everyone do what I say. Acting like the "Brain" of the cell

- Plant and animal cells have a nucleus insidethe cytoplasm. It is surrounded by anuclearenvelope. One or two nucleolus and thechromatin body are present insidethenucleus. During cell division, the chromatinbody is organised into achromosome.Storage of genetic material and transfersheredity characters fromgeneration togeneration are the functions of chromosome.

Functions of Nucleus

- In controls all the processes and chemicalreactions that take place inside the cell
- Inheritance of character from one generation to another

Red blood cells

Red bloodcells do notcontain anucleus. Without a nucleus,these cells diequickly; about two millionred blood cells die every second! Luckily,the bodyproduces new red blood cellsevery day.

10thstd

Unit 16 - PLANT AND ANIMAL HORMONES

Introduction

- The word hormone is derived from the Greek word “hormon” meaning “ to excite”. The function of control and coordination in plants is performed by chemical substances produced by the plants called plant hormones. In plants several cells are capable of producing hormones. These phytohormones are transported to different parts of the plants to perform various physiological functions.

- Endocrine glands in vertebrate animals possess a diversified communication system to co-ordinate physiological and metabolicfunctions by chemical integration. The endocrine system acts through chemical messengers known as hormones which are produced by specialized glands. Physiological processes such as digestion, metabolism, growth, development and reproduction are controlled by hormones.

Plant Hormones

- Plant hormones are organic molecules that are produced at extremely low concentration in plants. These molecules control morphological, physiological and biochemical responses.

Types of Plant Hormones

- There are five major classes of plant hormones. They are:

1. Auxins
2. Cytokinins
3. Gibberellins
4. Abscisic Acid (ABA)
5. Ethylene

- Among all these plant hormones auxins, cytokinins and gibberellins promote plant growth while abscisic acid and ethylene inhibit plant growth.

Auxins

- Auxins (Gk. auxein = to grow) were the first plant hormones discovered. The term auxin was introduced by Kogl and Haagen- Smith (1931). Auxins are produced at the tip of stems and roots from where they migrate to the zone of elongation. Charles Darwin (1880), observed unilateral growth and curvature of canary grass (Phalariscanariensis) coleoptiles. He came to the conclusion that some ‘influence’ was transmitted from the tip of the coleoptile to the basal region. This ‘influence’ was later identified as Auxin by Went.

Went’s Experiment

- Frits Warmolt Went (1903– 1990), a Dutch biologist demonstrated the existenceand effect of auxin in plants. He did a series of experiments in Avena coleoptiles.

- In his first experiment he removed the tips of Avena coleoptiles. The cut tips did not grow indicating that the tips produced something essential for growth.In his second experiment he placed the agar blocks on the decapitated coleoptile tips. The coleoptile tips did not show any response. In his next experiment he placed the detached coleoptile tips on agar blocks. After an hour, he discarded the tips and placed this agar block on the decapitated coleoptile. It grew straight up indicating that some chemical had diffused from the cut coleoptile tips into the agar block which stimulated the growth.

- From his experiments Went concluded that a chemical diffusing from the tip of coleoptiles was responsible for growth, and he named it as “Auxin” meaning ‘to grow”.

- Types of Auxins: Auxins are classified into two types, namely natural auxins and synthetic auxins.

- **Natural Auxins:** Auxins produced by the plants are called natural auxins. Example: IAA (Indole – 3 - Acetic Acid)

- **Synthetic Auxins:** Artificially synthesized auxins that have properties like auxins are called as synthetic auxins. Example: 2, 4 D (2,4Dichlorophenoxy Acetic Acid).

- Physiological effects of auxins: Auxins bring about a variety of physiological effects in different parts of the plant body.

1. Auxins promote the elongation of stems and coleoptiles which makes them to grow.

2. Auxins**induce root formation** at low concentration and inhibit it at higher concentration.

3. The auxins produced by the apical buds suppress growth of lateral buds. This is called **apical dominance**.

4. Seedless fruits without fertilization are induced by the external application of auxins. (**Parthenocarpy**). Examples: Watermelon, Grapes, Lime etc.

5. Auxins**prevent** the formation of **abscission layer**.

Phenyl Acetic Acid (PAA) and Indole 3 Acetonitrile (IAN) are natural auxins. Indole 3 Butyric Acid (IBA), Indole-3- Propionic Acid, α-Naphthalene Acetic Acid
(NAA), 2, 4, 5-T (2,4,5Trichlorophenoxy Acetic Acid) are some of the synthetic auxins.

Cytokinins

- Cytokinins (Cytos - cell; kinesis - division) are the plant hormones that promote cell division or cytokinesis in plant cells. It was first isolated from Herring fish sperm. Zeatin was the cytokinin isolated from Zea mays. Cytokinin is found abundantly in liquid endosperm of coconut.

Physiological effects of cytokinins

1. Cytokinin induces cell division (cytokinesis) in the presence of auxins.
2. Cytokinin also causes cell enlargement.
3. Both auxins and cytokinins are essential for the formation of new organs from the callus in tissue culture (Morphogenesis).
4. Cytokinins promote the growth of lateral buds even in the presence of apical bud.
5. Application of cytokinin delays the process of ageing in plants. This is called Richmond Lang effect.

Gibberellins

- Gibberellins are the most abundantly found plant hormones. Kurosawa (1926) observed Bakanae disease or foolish seedling disease in rice crops. This internodal elongation in rice was caused by fungus Gibberellafujikuroi. The active substance was identified as Gibberellic acid.

Physiological effects of gibberellins

1. Application of gibberellins on plants stimulate extraordinary elongation of internode. e.g. Corn and Pea.

2. Treatment of rosette plants with gibberellin induces sudden shoot elongation followed by flowering. This is called bolting

3. Gibberellins promote the production of male flowers in monoecious plants (Cucurbits).

4. Gibberellins break dormancy of potato tubers.

5. Gibberellins are efficient than auxins in inducing the formation of seedless fruit - Parthenocarpic fruits (Development of fruits without fertilization) e.g. Tomato.

Abscisic Acid

- Abscisic acid (ABA) is a growth inhibitor which regulates abscission and dormancy. It increases tolerance of plants to various kinds of stress. So, it is also called as stress hormone. It is found in the chloroplast of plants.

Physiological effects of abscisic acid

1. ABA promotes the process of abscission (separation of leaves, flowers and fruits from the branch).
2. During water stress and drought conditions ABA causes stomatal closure.
3. ABA **promotes senescence** in leaves by causing loss of chlorophyll.
4. ABA **induces bud dormancy** towards the approach of winter in trees like birch.
5. ABA is a powerful **inhibitor of lateral bud growth** in tomato.

Ethylene

- Ethylene is a gaseous plant hormone. It is a growth inhibitor. It is mainly concerned with maturation and ripening of fruits. Maximum synthesis of ethylene occurs during ripening of fruits like apples, bananas and melons

Physiological effects of ethylene

- Ethylene promotes the ripening of fruits. e.g. Tomato, Apple, Mango, Banana, etc
- Ethylene inhibits the elongation of stem and root in dicots.
- Ethylene hastens the senescence of leaves and flowers.
- Ethylene stimulates formation of abscission zone in leaves, flowers and fruits. This leads to premature shedding.
- thylene breaks the dormancy of buds, seeds and storage organs

Human Endocrine Glands

- Endocrine glands in animals possess a versatile communication system to coordinate biological functions. Exocrine glands and endocrine glands are two kinds of glands found in animals. Endocrine glands are found in different regions of the body of animals as well as human beings. These glands are called ductless

- glands. Their secretions are called hormones which are produced in minute quantities. Th e secretions diff use into the blood stream and are carried to the distant parts of the body. They act on specifi c organs which are referred as target organs.

The branch of biology which deals with the study of the endocrine glands and its physiology is known as 'Endocrinology'. Thomas Addison is known as Father of Endocrinology. English physiologists W. M. Bayliss and E. H. Starling introduced the term hormone in 1909. They fi rst discovered the hormone secretin.

- Exocrine glands have specifi c ducts to carry their secretions e.g. salivary glands, mammary glands, sweat glands.

- Endocrine glands present in human and other vertebrates are

❖ Pituitary gland
❖ Thyroid gland
❖ Parathyroid gland
❖ Pancreas (Islets of Langerhans)
❖ Adrenal gland (Adrenal cortex andAdrenal medulla)
❖ Gonads(Testes and Ovary)
❖ Thymus gland

- Pituitary Gland The pituitary gland or hypophysis is a pea shaped compact mass of cells located at the base of the midbrain attached to the hypothalamus by a pituitary stalk. The pituitarygland is anatomically composed of two lobes and perform different functions. They are the anterior lobe (adenohypophysis) and the posterior lobe (neurohypophysis). The intermediate lobe is non-existent in humans.

- The pituitary gland forms the major endocrine gland in most vertebrates. It regulates and controls other endocrine glands and so is called as the "Master gland".
- Hormones secreted by the anterior lobe (Adenohypophysis) of pituitary

- The anterior pituitary is composed of different types of cells and secrete hormones which stimulates the production of hormones by other endocrine glands. The hormones secreted by anterior pituitary are

- Growth Hormone
- Thyroid stimulating Hormone
- Adrenocorticotropic Hormone
- Gonadotropic Hormone which comprises the Follicle Stimulating Hormone and Luteinizing Hormone
- Prolactin

- Growth hormone (GH) GH promotes the development and enlargement of all tissues of the body. It stimulates the growth of muscles, cartilage and long bones. It controls the cell metabolism. Th e improper secretion of this hormone leads to the following conditions.

Dwarfism:

- It is caused by decreased secretion of growth hormone in children. The characteristic features are stunted growth, delayed skeletal formation and mental disability.

Gigantism:

- Over secretion of growth hormone leads to gigantism in children. It is characterised by overgrowth of all body tissues and organs. Individuals attain abnormal increase in height.

Acromegaly:

- Excess secretion of growth hormone in adults may lead to abnormal enlargement of head, face, hands and feet.

Thyroid stimulating hormone (TSH)

- TSH controls the growth of thyroid gland, coordinates its activities and hormone secretion.

Adrenocorticotropic hormone (ACTH)

- ACTH stimulates adrenal cortex of the adrenal gland for the production of its hormones. It also influences protein synthesis in the adrenal cortex.

Gonadotropic hormones (GTH)

- The gonadotropic hormones are follicle stimulating hormone and luteinizing hormone which are essential for the normal development of gonads.

Follicle stimulating hormone (FSH)

- In male, it stimulates the germinal epithelium of testes for formation of sperms. In female it initiates the growth of ovarian follicles and its development in ovary.

Luteinizing hormone (LH)

- In male, it promotes the Leydig cells of the testes to secrete male sex hormone testosterone. In female, it causes ovulation (rupture of mature graafian follicle), responsible for the development of corpus luteum and production of female sex hormones estrogen and progesterone.

Prolactin (PRL)

- PRL is also called **lactogenic hormone**. This hormone initiates development of mammary glands during pregnancy and stimulates the production of milk after child birth.

Hormones secreted by the posterior lobe (Neurohypophysis) of pituitary

- The hormones secreted by the posterior pituitary are

1. Vasopressin or Antidiuretic hormone

2. Oxytocin

Vasopressin or Antidiuretic hormone (ADH)

- In kidney tubules it increases reabsorption of water. It reduces loss of water through urine and hence the name antidiuretic hormone.

- Deficiency of ADH reduces reabsorption of water and causes an increase in urine output (polyuria). This deficiency disorder is called Diabetes insipidus.

Oxytocin

- It helps in the contraction of the smooth muscles of uterus at the time of child birth and milk ejection from the mammary gland after child birth.

Thyroid Gland

- The thyroid gland is composed of two distinct lobes lying one on either side of the trachea. The two lobes are connected by means of a narrow band of tissue known as the isthmus. This gland is composed of glandular follicles andlined by cuboidal epithelium.The follicles are filled with colloid material called thyroglobulin.

- An amino acid tyrosine and iodine are involved in the formation of thyroid hormone. The hormones secreted by the thyroid gland are

1. Triiodothyronine (T_3)
2. Tetraiodothyronine or Thyroxine (T_4)

Functions of thyroid hormones

- The functions of thyroid hormones are

❖ Production of energy by maintaining the Basal Metabolic Rate (BMR) of the body.
❖ Helps to maintain normal body temperature.
❖ Influences the activity of central nervous system.
❖ Controls growth of the body and bone formation.

- ❖ Essential for normal physical, mental and personality development .
- ❖ It is also known as personality hormone.
- ❖ Regulates cell metabolism.

Thyroid Dysfunction

- When the thyroid gland fails to secrete the normal level of hormones, the condition is called thyroid dysfunction. It leads to the following conditions

Hypothyroidism

- It is caused due to the decreased secretion of the thyroid hormones. The abnormal conditions are simple goitre, cretinism and myxoedema.

Goitre

- It is caused due to the inadequate supply of iodine in our diet. This is commonly prevalent in Himalayan regions due to low level of iodine content in the soil. It leads to the enlargement of thyroid gland which protrudes as a marked swelling in the neck and is called as goitre.

Cretinism

- It is caused due to decreased secretion of the thyroid hormones in children. The conditions are stunted growth, mental defect, lack of skeletal development and deformed bones. They are called as cretins.

Myxoedema

- It is caused by deficiency of thyroid hormones in adults. They are mentally sluggish, increase in body weight, puffiness of the face and hand, oedematous appearance.

Hyperthyroidism

- It is caused due to the excess secretion of the thyroid hormones which leads to Grave's disease. The symptoms are protrusion of the eyeballs (Exopthalmia), increased metabolic rate, high body temperature, profuse sweating, loss of body weight and nervousness.

Parathyroid Gland

- The parathyroid glands are four small oval bodies that are situated on the posterior surface of the thyroid lobes. The chief cells of the gland are mainly concerned with secretion of parathormone.

Functions of Parathormone

- The parathormone regulates calcium and phosphorus metabolism in the body.They act on bone, kidney and intestine to maintain blood calcium levels.

Parthyroid Dysfunction

- The secretion of parathyroid hormone can be altered due to the following conditions.

- Removal of parathyroid glands during thyroidectomy (removal of thyroid) causes decreased secretion of parathormone. The conditions are

1. Muscle spasm known as **Tetany**(sustained contraction of muscles in face, larynx, hands and feet).
2. Painful cramps of the limb muscles

Pancreas (Islets of Langerhans)

- Pancreas is an elongated, yellowish gland situated in the loop of stomach and duodenum. It is exocrine and endocrine in nature. The exocrine pancreas secretes pancreatic juice which plays a role in digestion while, the endocrine portion is made up of Islets of Langerhans.

- The Islets of Langerhans consists of two types of cells namely alpha cells and beta cells. The alpha cells secrete glucagon and beta cells secrete insulin.

Human insulin was first discovered by Fredrick Banting, Charles Best and MacLeod in 1921. Insulin was first used in treatment of diabetes on 11th January 1922.

Functions of Pancreatic hormones

- A balance between insulin and glucagon production is necessary to maintain blood glucose concentration.

Insulin

- ❖ Insulin helps in the conversion of glucose into glycogen which is stored in liver and skeletal muscles.
- ❖ It promotes the transport of glucose into the cells.
- ❖ It decreases the concentration of glucose in blood.

Glucagon

- ❖ Glucagon helps in the breakdown of glycogen to glucose in the liver.

- ❖ It increases blood glucose levels.

Diabetes mellitus

- The deficiency of insulin causes Diabetes mellitus. It is characterised by

- ❖ Increase in blood sugar level (Hyperglycemia).
- ❖ Excretion of excess glucose in the urine (Glycosuria).
- ❖ Frequent urination (Polyuria).
- ❖ Increased thirst (Polydipsia).
- ❖ Increase in appetite (Polyphagia).

Adrenal Gland

- The adrenal glands are located above each kidney. They are also called supra renal glands.

- The outer part is the adrenal cortex and the inner part is the adrenal medulla. The two distinct parts are structurally and functionally different.

Adrenal Cortex

- The adrenal cortex consists of three layers of cells. They are zonaglomerulosa, zonafasciculata and zonareticularis

Hormones of Adrenal Cortex

- The hormones secreted by the adrenal cortex are corticosteroids. They are classified into

1. Glucocorticoids
2. Mineralocorticoids

Functions of adrenocortical hormones
Glucocorticoids

- The glucocorticoids secreted by the zonafasciculata are cortisol and corticosterone

- They regulate cell metabolism.
- It stimulates the formation of glucose from glycogen in the liver.
- It is an anti-inflammatory and anti-allergic agent.

Mineralocorticoids

- The mineralocorticoids secreted by zonaglomerulosa is aldosterone

1. It helps to reabsorb sodium ions from the renal tubules.
2. It causes increased excretion of potassium ions.

- It regulates electrolyte balance, body fluid volume, osmotic pressure and blood pressure.

Adrenal Medulla

- The adrenal medulla is composed of chromaffin cells.They are richly supplied with sympathetic and parasympathetic nerves.

Hormones of Adrenal Medulla

- It secretes two hormones namely

1. Epinephrine (Adrenaline)
2. Norepinephrine (Noradrenaline)

- They are together called as “Emergency hormones”. It is produced during conditions of stress and emotion. Hence it is also referred as “flight, fright and fight hormone”.

Functions of adrenal medullary hormones
Epinephrine (Adrenaline)

- It promotes the conversion of glycogen to glucose in liver and muscles.
- It increases heart beat and blood pressure.
- It increases the rate of respiration by dilation of bronchi and trachea.
- It causes dilation of the pupil in eye.
- It decreases blood flow through the skin.

Norepinephrine (Noradrenalin)

- Most of its actions are similar to those of epinephrine.

Reproductive Glands (Gonads)

- The sex glands are of two types the **testes** and the **ovaries**. The testes are present in male, while the ovaries are present in female.

Testes

- Testes are the reproductive glands of the males. They are composed of seminiferous tubules, Leydig cells and Sertoli cells. Leydig cells form the endocrine part of the testes. They secrete the male sex hormone called testosterone.

Functions of testosterone

- ❖ It influences the process of spermatogenesis.
- ❖ It stimulates protein synthesis and controls muscular growth.
- ❖ It is responsible for the development of secondary sexual characters (distribution of hair on body and face, deep voice pattern, etc).

Ovary

- The ovaries are the female gonads located in the pelvic cavity of the abdomen. They secrete the female sex hormones

1. Estrogen
2. Progesterone

- Estrogen is produced by the Graafian follicles of the ovary and progesterone from the corpus luteum that is formed in the ovary from the ruptured follicle during ovulation.

Functions of estrogens

- It brings about the changes that occur during puberty.
- It initiates the process of oogenesis.
- It stimulates the maturation of ovarian follicles in the ovary.
- It promotes the development of secondary sexual characters (breast development, high pitched voice etc).

Functions of progesterone

- It is responsible for the premenstrual changes of the uterus.
- It prepares the uterus for the implantation of the embryo.
- It maintains pregnancy.
- It is essential for the formation of placenta.

Thymus Gland

- Thymus is partly an endocrine gland and partly a lymphoid gland. It is located in the upper part of the chest covering the lower end of trachea. Thymusin is the hormone secreted by thymus.

Functions of Thymosin

- It has a stimulatory effect on the immune function.
- It stimulates the production and differentiation of lymphocytes.

APPOLO STUDY CENTRE CHENNAI

11^{th} STD (Term I)
Unit – 6 Cell: The Unit of Life

- The word 'cell' comes from the Latin word 'Celle" which means 'a small compartment'. The world cell was first used by Robert Hooke (1662) therefore the term 'cell'is as old as 300 years.

Discovery

- **Aristotle** (384-322BC), was the one who first recognised that animals and plants consists of organised structural units but unable to explain what it was. In 1660's Robert Hooke observed something which looks like 'honeycomb with a great little boxes' which was later called as 'cell' from the cork tissue in 1665. He compiled his work as Micrographia. Later, Antonie von Leeuwenhoek observed unicellular particles which he named as 'animacules'. Robert Brown (1831-39) described the spherical body in the plant cells as nucleus. **H. J. Dutrochet**(1824), a French scientist, was the first to give idea on cell theory. Later, **Matthias Schleiden**(German Botanist) and **Theodor Schwann** (German Zoologist) (1833) outlined the basic features of the cell theory. **Rudolf Virchow** (1858) explained the cell theory by adding a feature stating that all living cells arise from pre-existing living cells by 'cell division'.

Microscopy

- Microscope is an inevitable instrument in studying the cell and subcellular structures. It offers scope in studying microscopic organisms therefore it is named as microscope (mikros – small; skipein – to see) in Greek terminology. Compound microscope was invented by Z. Jansen.

- Microscope works on the lens system which basically relies on properties of light and lens such as reflection, magnification and numerical aperture. The common light microscope which has many lenses are called as compound microscope. The microscope transmits visible light from sources to eye or camera through sample, where interaction takes place.

Bright field Microscope

- Bright field microscope is routinely used microscope in studying various aspects of cells. It allows light to pass directly through specimen and shows a well distinguished image from different portions of the specimen depending upon the contrast from absorption of visible light. The contrast can be increased by staining the specimen with reagent that reacts with cells and tissue components of the object.

- The light rays are focused by condenser on to the specimen on a microslide placed upon the adjustable platform called as stage. The light comes from the Compact Flourescent Lamp (CFL) or Light Emitting Diode (LED) light system. Then it passes through two lens systems namely objective lens (closer to the object) and the eye piece (closer to eye). There are four objective lenses (5X, 10X, 45X and 100X) which can be rotated and fixed at certain point to get required magnification. It works on the principle of numerical aperture value and its ownresolving power.

- The first magnification of the microscope is done by the objective lens which is called primary magnification and it is real, inverted image. The second magnification of the microscope is obtained through eye piece lens called as secondary magnification and it is virtual and inverted image (Figure 6.2 a, b and c).

Dark Field Microscope

- The dark field microscope was discovered by Z. Sigmondy (1905). Here the field will be dark but object will be glistening so the appearance will be bright. A special effect in an ordinary microscope is brought about by means of a special component called 'Patch Stop Carrier'. It is fixed in metal ring of the condenser component. Patch stop is a small glass device which has a dark patch at centre of the disc leaving a small area along the margin through which the light passes. The light passing through the margin will travel oblique like a hollow cone and strikes the object in the periphery, therefore the specimen appears glistening in a dark background. (Figure 6.2 d and e).

Phase contrast microscope

- This was invented by Zernike (1935). It is a modification of light microscope with all its basic principle. The objects observed by increasing the contrast by bringing about change in amplitude of the light waves. The contrast can be increased by introducing the 'PhasePlate' in the condenser lens. Phase plate is a circular component with circular annular etching.

- Light passes with different velocity after coming out of the thinnest and thickest areas of the phase plate thereby increasing the contrast of the specimen. A hollow cone of light passes through the condenser. Direct light pass through thin area of phase plate, whereas light passing from the specimen reaches thick area of phase plate. The light passing through thicker area travel at low speed, on the other hand the light passing through thin area reach fast therefore contrast is increased in the specimen. Phase contrast microscope is used to observe living cells, tissues and the cells cultured invitro during mitosis (Figure 6.2 f and g).

Electron Microscope

- Electron Microscope was first introduced by Ernest Ruska (1931) and developed by G Binning and H Roher (1981). It is used to analyse the fine details of the cell and organelles called ultrastructure. It uses beam of accelerated electrons as source of illumination and therefore the resolving power is 1,00,000 times than that of light microscope.

- The specimen to be viewed under electron microscope is dehydrated and impregnated with electron opaque chemicals like gold or palladium. This is essential for withstanding electrons andalso for contrast of the image.

There are two kinds of electron microscopes namely

1. Transmission Electron Microscope (TEM)
2. Scanning Electron Microscope (SEM)

Transmission electron microscope:

- This is the most commonly usedelectron microscope which provides two dimensional image. The components of the microscope are as follows:

a. Electron Generating System
b. Electron Condensor
c. Specimen Objective
d. Tube Lens
e. Projector

- A beam of electron passes through the specimen to form an image on fluorescent screen. The magnification is 1–3 lakhs times and resolving power is 2–10 Å. Itis used for studying detailed structrue of viruses, mycoplasma, cellular organelles, etc

Scanning Electron Microscope:

- This is used to obtain three dimensional image and has a lower resolving power than TEM. In this, electrons are focused by means of lenses into a very fine point. The interaction of electrons with the specimen results in the release of different forms of radiation (such as auger electrons, secondary electrons, back scattered electrons) from the surface of the specimen. These radiations are then captured by an appropriate detector, amplified and then imaged on fluorescent screen. The magnification is 2,00,000 times and resolution is 5–20 nm (Figure 6.5 a and b).

Cell Theory

- In 1833, German botanist Matthias Schleiden and German zoologist Theodor Schwann proposed that all plants and animals are composed of cells and that cells were the basic building blocks of life.

These observations led to the formulation of modern cell theory.

- All organisms are made up of cells.
- New cells are formed by the division of pre-existing cells.
- Cells contains genetic material, which is passed on from parents to daughter cells.
- All metabolic reactions take place inside the cells.

Exception to Cell Theory

- Viruses are puzzle in biology. Viruses, viroids and prions are the exception to cell theory. They lack protoplasm, the essential part of the cell and exists as obligate parasites which are sub-cellular in nature.

Cell Doctrine (Cell Principle)

The features of cell doctrine are as follows:

- All organisms are made up of cells.
- New cells are produced from the pre-existing cells.
- Cell is a structural and functional unit of all living organisms.
- A cell contains hereditary information which is passed on from cell to cell during cell division.
- All the cells are basically the same in chemical composition and metabolic activities.
- The structure and function of cell is controlled by DNA.
- Sometimes the dead cells may remain functional as tracheids and vessels in plants and horny cells in animals.

Protoplasm Theory

- Corti first observed protoplasm. Felix Dujardin (1835) observed a living juice in animal cell and called it "Sarcode" . Purkinje (1839) coined the term protoplasm for sap inside a plant cell. Hugo Va n Mo h l (1846) indicated importance of protoplasm.

- Max Schultze (1861) established similarity between Protoplasm and Sarcode and proposed a theory which later on called "Protoplasm Theory" by O. Hertwig (1892). Huxley (1868) proposed Protoplasm as a "physical basis of life".

Protoplasm as a Colloidal System

- Protoplasm is a complex colloidal system which was suggested by Fisher in 1894 and Hardy in 1899. It is primarily made of water contents and various other solutes of biological importance such as glucose, fatty acids, amino acids, minerals, vitamins, hormones and enzymes.

- These solutes may be homogeneous (soluble in water) or heterogeneous mass (insoluble in water) which forms the basis for its colloidal nature.

Physical Properties of Protoplasm

- The protoplasm exist either in semisolid (jelly-like) state called 'gel' due to suspended particles and various chemical bonds or may be liquid state called 'sol'. The colloidal protoplasm which is in gel form can change into sol form by solation and the sol can change into gel by gelation. These gel-sol conditions of colloidal system are prime basis for mechanical behaviour of cytoplasm.

1. Protoplasm is translucent, odourless and polyphasic fluid.
2. It is a crystal colloid solution which is a mixture of chemical substances forming crystalloid i.e. true solution (sugars, salts, acids, bases) and others forming colloidal solution (Proteins and lipids)
3. It is the most important property of the protoplasm by which it exhibits three main phenomena namely Brownian movement, amoeboid movement and cytoplasmic streaming or cyclosis. Viscosity of protoplasm is 2–20 centipoises. The Refractive index of the protoplasm is 1.4.
4. The pH of the protoplasm is around 6.8, contain 90% water (10% in dormant seeds)
5. Approximately 34 elements are present in protoplasm but only 13 elements are main or universal elements i.e. C, H, O, N, Cl, Ca, P, Na, K, S, Mg, I and Fe. Carbon, Hydrogen, Oxygen and Nitrogen form the 96% of protoplasm.
6. Protoplasm is neither a good nor a bad conductor of electricity. It forms a delimiting membrane on coming in contact with water and solidifies when heated.
7. Cohesiveness: Particles or molecules of protoplasm are adhered with each other by forces, such as Van der Waal's bonds, that hold long chains of molecules together. This property varies with the strength of these forces.
8. Contractility: The contractility of protoplasm is important for the absorption and removal of water especially stomatal operations.
9. Surface tension: The proteins and lipids of the protoplasm have less surface tension, hence they are found at the surface forming the membrane. On the other hand the chemical substances (NaCl) have high surface tension, so they occur in deeper parts of the cell protoplasm.

Cell sizes and shapes

- Cell greatly vary in size, shape and also in function. Group of cells with similar structures are called tissue they integrate together to perform similar function, group of tissue join together to perform similar function called organ, group of organs with related function called organ system, organ system coordinating together to form an organism.

Shape

- The shape of cell vary greatly from organism to organism and within the organism itself. In bacteria cell shape vary from round (cocci) to rectangular (rod). In Vorus. shapepf the envelope varies from round to hexagonal or'T' shaped. In fungi, globular to elongatedcylindric cells and the spores of fungi vary greatly in shape. In plants and animals cells vary in shape according to cell types such as parenchyma, mesophyll, palisadem tracheid, fiber, epithelium and others

Types of cells

- On the basis of the cellular organization and the nuclear characteristics, the cell can be divided into

- Prokaryotes
- Mesokaryotes and
- Eukaryotes

Prokaryotes

- Those organisms with primitive nucleus are called as prokaryotes (pro – primitive; karyon – nucleus). The DNA lies in the 'nucleoid' which is not bound by the nuclear membrane and therefore it is not a true nucleus and is also a primitive type of nuclear material. The DNA is without histone proteins. Example: Bacteria, blue green algae, Mycoplasma, Rickettsiae and Spirochaetae.

Mesokaryotes

- In the year 1966, scientist Dodge and his coworkers proposed another kind of organisms called mesokaryotes. These organisms which shares some of the characters of both prokaryotes and eukaryotes. In other words these are organisms intermediate between pro and eukaryotes. These contains well organized nucleus with nuclear membrane and the DNA is organized into chromosomes but without histone protein components divides through amitosis similar withprokaryotes.CertainProtozoa like Noctiluca, some phytoplanktons like Gymnodinium,Peridinium and Dinoflagellates are representatives of mesokaryotes.

Eukaryotes

- Those organisms which have true nucleus are called Eukaryotes (Eu – True; karyon – nucleus). The DNA is associated with protein bound histones forming the chromosomes. Membrane bound organelles are present. Few organelles may be arisen by endosymbiosis which is a cell living inside another cell. The organelles like mitochondria and chloroplast well support this theory.

- The first cell might have evolved approximately 3.8 billion years ago. The primitive cell would have been similar to present day protists (Figure 6.7).

Plant and Animal cell
Ultra Structure of Eukaryotic Cell

- The eukaryotic cell is highly distinct in its organisation. It shows several variations in different organisms. For instance, the eukaryotic cellsin plants and animals vary greatly (Figure 6.8).

Animal Cell

- Animal cells are surrounded by cell membrane or plasma membrane. Inside this membrane the gelatinous matrix called protoplasm is seen to contain nucleus and other organelles which include the endoplasmic reticulum, mitochondria, golgi bodies, centrioles, lysosomes, ribosomes and cytoskeleton.

Plant cell

- A typical plant cell has prominent cell wall, a large central vacuole and plastids in addition to other organelles present in animal cell (Figure 6.9 and 6.10).

Protoplasm

- Protoplasm is the living content of the cell that is surrounded by plasma membrane. It is a colourless material that exists throughout the cell together with the cytoplasm, nucleus and other organelles. Protoplasm is composed of a mixture of small particles, such as ions, amino acids, monosaccharides, water, macromolecules like nucleic acids, proteins, lipids andpolysaccharides. It appears colourless, jelly like gelatinous, viscous elastic and granular. It appears foamy due to the presence of large number of vacuoles. It responds to the stimuli like heat, electric shock, chemicals and so on.

Cell Wall

- Cell wall is the outermost protective cover of the cell. It is present in bacteria, fungi and plants whereas it is absent in animal cell. It was first observed by Robert Hooke. It is an actively growing portion. It is made up of different complex material in various organism. In bacteria it is composed of peptidoglycan, in fungi chitin and fungal cellulose, in algae cellulose, galactans and mannans. In plants it is made up of cellulose, hemicellulose, pectin, lignin, cutin, suberin and silica.

- In plant, cell wall shows three distinct regions (a) Primary wall (b) Secondary wall (c) Middle lamellae (Figure 6.11).

Primary wall

- It is the first layer inner to middle lamellae, primarily consisting of loose network of cellulose microfibrils in a gel matrix. It is thin, elastic and extensible. In most plants the microfibrils are made up of cellulose oriented differently based on shape and thickness of the wall. The matrix of the primary wall is composed of hemicellulose, pectin, glycoprotein and water. Hemicellulose binds the microfibrils with matrix and glycoproteins control the orientation of microfibrils while pectin serves as filling material of the matrix. Cells such as parenchyma and meristems have only primary wall.

Secondary wall

- Secondary wall is laid during maturation. It plays a key role in determining the shape of a cell. It is thick, inelastic and is made up of cellulose and lignin. The secondary wall is divided into three sublayerstermed as S1, S2 and S3 where the cellulose microfibrils are compactly arranged with different orientation forming a laminated structure and the cell wall strength is increased.

Middle lamellae

- It is the outermost layer made up of calcium and magnesium pectate, deposited at the time of cytokinesis. It is a thin amorphous layer which cements two adjacent cells. It is optically inactive (isotropic).

Plasmodesmata and Pits

- Plasmodesmata act as a channel between the protoplasm of adjacent cells through which many substances pass through. Moreover, at few regions the secondary wall layer is laid unevenly whereas the primary wall and middle lamellae are laid continuously such regions are called pits. The pits of adjacent cells are opposite to each other. Each pit has a pit chamber and a pit membrane. The pit membrane has many minute pores and thus they are permeable. The pits are of two types namely simple and bordered pit.

Functions of cell wall

- The cell wall plays a vital role in holding several important functions given below

    1. Offers definite shape and rigidity to the cell.
    2. Serves as barrier for several molecules to enter the cells.
    3. Provides protection to the internal protoplasm against mechanical injury.
    4. Prevents the bursting of cells by maintaining the osmotic pressure.

5. Plays a major role by acting as a mechanism of defense for the cells.

Cell Membrane

- The cell membrane is also called cell surface (or) plasma membrane. It is a thin structure which holds the cytoplasmic content called 'cytosol'. It is extremely thin (less than 10nm).

Fluid Mosaic Model

- Jonathan Singer and Garth Nicolson (1972) proposed fluid mosaic model.It is made up of lipids and proteins together with a little amount of carbohydrate. The lipid membrane is made up of phospholipid. The phospholipid molecule has a hydrophobic tail and hydrophilic head. The hydrophobic tailrepels water and hydrophilic head attracts water. The proteins of the membrane are globular proteins which are found intermingled between the lipid bilayer most of which are projecting beyond the lipid bilayer. These proteins are called as integral proteins. Few are superficially attached on either surface of the lipid bilayer which are called as peripheral proteins. The proteins are involved in transport of molecules across the membranes and also act as enzymes, receptors (or) antigens.

- The Carbohydrate moleculesof cell membrane are short chain polysaccharides. These are either bound with 'glycoproteins' or 'glycolipids' and form a 'glyocalyx'

- The movement of membrane lipids from one side of the membrane to the other side by vertical movement is called flip flopping or flip flop movement. This movement takes place more slowly than lateral diffusion of lipid molecule. The phospholipids can have flip flop movement because the phospholipids have smaller polar regions, whereas the proteins cannot flip flop because the polar region is extensive.

Function of Cell Membrane

- The functions of the cell membrane is enormous which includes cell signalling, transporting nutrients and water, preventing unwanted substances entering into the cell, and so on.

Cell Transport

- Cell membrane act as a channel of transport for molecules. The membrane is selectively permeable to molecules. It transports molecules through energy dependant process and energy independent process. The membrane proteins (channel andcarrier) are involved in movement of ions and molecules across the membrane (Figure 6.13).

Endocytosis and Exocytosis

- Cell surface membrane are able to transport individual molecules and ions. There are processes in which a cell can transport a large quantity of solids and liquids into cell (endocytosis) or out of cell (exocytosis) (Figure 6.14).

- **Endocytosis:** During endocytosis the cell wraps the cell surface membrane around the material and brings it into cytoplasm inside a vesicle. There are two types of endocytosis:

1. Phagocytosis – Particle is engulfed by membrane, which folds around it and forms a vesicle. The enzymes digest the material and products are absorbed by cytoplasm.
2. Pinocytosis – Fluid droplets are engulfed by membrane, which forms vesicles around them.

- **Exocytosis:** Vesicles fuse with plasma membrane and eject contents. This passage of material out of the cell is known as exocytosis. This material may be a secretion in the case of digestive enzymes, hormones or mucus.

Signal Transduction

- The process by which the cell receive information from outside and respond is called signal transduction. Plants, fungi and animal cell use nitric oxide as one of the many signalling molecules. The cell membrane is the site of chemical interactions of signal transduction. Receptors receives the information from first messenger and transmit the message through series of membrane proteins. It activates second messenger which stimulates the cell to carry out specific function.

Cytoplasm

- Cytoplasm is the main arena of various activities of a cell. It is the semifluid gelatinous substance that fills the cell. It is made up of eighty percent water and is usually clear and colourless. The cytoplasm is sometimes described as non nuclear content of protoplasm. The cytoplasm serves as a molecular soup where all thecellular organelles are suspended and bound together by a lipid bilayer plasma membrane. It constitutes dissolved nutrients, numerous salts and acids to dissolve waste products. It is a very good conductor of electricity. It gives support and protection to the cell organelles. It helps movement of the cellular materials around the cell through a process called cytoplasmic streaming. Further, most cellular activities such as many metabolic pathways including glycolysis and cell division occur in cytoplasm.

Cell Organelles
Endomembrane System

- The system of membranes in a eukaryotic cell, comprising the plasma membrane, nuclear membrane, endoplasmic reticulum, golgi apparatus, lysosomes and vacuolar membranes (tonoplast). Endomembranes are made up of phospholipids with embedded proteins that are similar to cell membrane which occur within the cytoplasm. The endomembrane system is evolved from the inward growth of cell membrane in the ancestors of the first eukaryotes.

Endoplasmic Reticulum

- The largest of the internal membranes is called the endoplasmic reticulum (ER). The name endoplasmic reticulum was given by K.R. Porter (1948). It consists of double membrane. Morphologically the structure of endoplasmic reticulum consists of:

1. Cisternae are long, broad, flat, sac like structures arranged in parallel bundles or stacks to form lamella. The space between membranes of cisternae is filled with fluid.

2. Vesicles are oval membrane bound vacuolar structure.
3. Tubules are irregular shape, branched, smooth walled, enclosing a space

- Endoplasmic reticulum is associated with nuclear membrane and cell surface membrane. It forms a network in cytoplasm and gives mechanical support to the cell. Its chemical environment enables protein folding and undergo modification necessary for their function. Misfolded proteins are pulled out and are degraded in endoplasmic reticulum. When ribosomes are present in the outer surface of the membrane it is called as rough endoplasmic reticulum(RER), when the ribosomes are absent in the endoplasmic reticulum it is called as smooth Endoplasmic reticulum(SER). Rough endoplasmic reticulum is involved in protein synthesis and smooth endoplasmic reticulum are the sites of lipid synthesis. The smooth endoplasmic reticulum contains enzymes that detoxify lipid soluble drugs, certain chemicals and other harmful compounds.

Golgi Body (Dictyosomes)

- In 1898, Camillo Golgi visualized a netlike reticulum of fibrils near the nucleus, were named as Golgi bodies. In plant cells theyare found as smaller vesicles termed as dictyosomes. Golgi apparatus is a stack of flat membrane enclosed sacs. It consist of cisternae, tubules, vesicles and golgi vacuoles. In plants the cisternae are 10-20 in number placed in piles separated from each other by a thin layer of inter cisternal cytoplasm often flat or curved. Peripheral edge of cisternae forms a network of tubules and vesicles. Tubules interconnect cisternae and are 30-50nm in dimension. Vesicles are large round or concave sac. They are pinched off from the tubules.They are smooth/secretary or coated type. Golgi vacuoles are large spherical filled with granular or amorphous substance, some function like lysosomes. The Golgi apparatus compartmentalises a series of steps leading to the production of functional protein.Small pieces of rough endoplasmic reticulum are pinched off at the ends to form small vesicles. A number of these vesicles then join up and fuse together to make a Golgi body. Golgi complex plays a major role in post translational modification of proteins and glycosidation of lipids (Figure 6.16 and 6.17).

Functions:

- Glycoproteins and glycolipids are produced
- Transporting and storing lipids.
- Formation of lysosomes.
- Production of digestive enzymes.
- Cell plate and cell wall formation
- Secretion of Carbohydrates for the formation of plant cell walls and insect cuticles.
- Zymogen granules (proenzyme/pre-cursor of all enzyme) are synthesised.

Mitochondria

- It was first observed by A. Kolliker (1880). Altmann (1894) named it as Bioplasts. Later Benda (1897, 1898), named as mitochondria. They are ovoid, rounded, rod shape and pleomorphic structures. Mitochondrion consists of double membrane, the outer and inner membrane. The outer membrane is smooth, highly permeable to small molecules and it contains proteins called Porins, which form channels that allows free diffusion of molecules smaller than about 1000 daltons and the inner membrane divides the mitochondrion into two compartments, outer chamber between two membranes and the inner chamber filled with matrix.

- The inner membrane is convoluted (infoldings), called crista (plural: cristae). Cristae contain most of the enzymes for electron transport system. Inner chamber ofthe mitochondrion is filled with proteinaceous material called mitochondrial matrix. The inner membrane consists of stalked particles called elementary particles or Fernandez Moran particles, F1 particles or Oxysomes. Each particle consists of a base, stem and a round head. In the head ATP synthase is present for oxidative phosphorylation. Inner membrane is impermeable to most ions, small molecules and maintains the proton gradient that drives oxidative phosphorylation

- Mitochondria contain 73% of proteins, 25-30% of lipids, 5-7 % of RNA, DNA (in traces) and enzymes (about 60 types). Mitochondria are called Power house of a cell, as they produce energy rich ATP.

- All the enzymes of Kreb's cycle are found in the matrix except succinate dehydrogenase. Mitochondria consist of circular DNA and 70S ribosome. They multiply by fission and replicates by strand displacement model. Because of the presence of DNA it is semi-autonomous organelle. Unique characteristic of mitochondria is that they are inherited from female parent only. Mitochondrial DNA comparisons are used to trace human origins. Mitochondrial DNA is used to track and date recent evolutionary time because it mutates 5 to 10 time faster than DNA in the nucleus.

Plastids

- The term plastid is derived from the Greek word Platikas (formed/moulded) and used by A.F.U. Schimper in 1885. He classified plastids into following types according to their structure, pigments and function. Plastids multiply by fission.

- According to Schimper, different kind of plastids can transform into one another.

Chloroplast

- Chloroplasts are vital organelle found in green plants. Chloroplast has a double membrane the outer membrane and the inner membrane separated by a space called periplastidial space. The space enclosed by the inner membrane of chloroplast is filled with gelatinous matrix, lipo-proteinaceous fluid called stroma. Inside the stroma there is flat interconnected sacs called thylakoid. The membrane of thylakoid enclose a space called thylakoid lumen.

- Grana (singular: Granum) are formed when many of these thylakoids are stacked together like pile of coins. Light is absorbed and converted into chemical energy in the granum, which is used in stroma to prepare carbohydrates. Thylakoid contain chlorophyll pigments. The chloroplast contains osmophilic granules, 70s ribosomes, DNA (circular and non histone) and RNA. These chloroplast genome encodes approximately 30 proteins involved in photosynthesis including the components of photosystem I & II, cytochrome bf complex and ATP synthase. One of the subunits of Rubisco is encoded by chloroplast DNA. It is the major protein component of chloroplast stroma, single most abundant protein on earth. The thylakoid contain small, rounded photosynthetic units called quantosomes. It is a semi-autonomous organelle and divides by fission

Functions:

- Photosynthesis
- Light reactions takes place in granum,
- Dark reactions take place in stroma,
- Chloroplast is involved in photo-respiration.

Ribosome

- Ribosomes were first observed by George Palade (1953) as dense particles or granules in the electron microscope. Electron microscopic observation reveals that ribosomes are composed of two rounded sub units, united together to form a complete unit. Mg2+ is required for structural cohesion of ribosomes. Biogenesis of ribosome are denova formation, auto replication and nucleolar origin. Each ribosome is made up of one small and one large sub-unit Ribosomes are the sites of protein synthesis in the cell. Ribosome is not a membrane bound organelle.

- Ribosome consists of RNA and protein: RNA 60 % and Protein 40%. During protein synthesis many ribosomes are attached to the single mRNA is called polysomes or polyribosomes. The function of polysomes is the formation of several copies of a particular polypeptide during protein synthesis. They are free in non-protein synthesising cells. In protein synthesising cells they are linked together with the help of Mg2+ ions.

Lysosomes (Suicidal Bags of Cell)

- Lysosomes were discovered by Christian de Duve (1953), these are known as suicidal bags. They are spherical bodies enclosed by a single unit membrane. They are found in eukaryotic cell. Lysosomes are small vacuoles formed when small pieces of golgi body are pinched off from its tubules.

- They contain a variety of hydrolytic enzymes, that can digest material within the cell. The membrane around lysosome prevent these enzymes from digesting the cell itself.

Functions:

- Intracellular digestion: They digest carbohydrates, proteins and lipids present in cytoplasm.
- Autophagy: During adverse condition they digest their own cell organelleslike mitochondria and endoplasmic reticulum
- Autolysis: Lysosome causes self destruction of cell on insight of disease they destroy the cells.
- Ageing: Lysosomes have autolytic enzymes that disrupts intracellular molecules.
- Phagocytosis: Large cells or contents are engulfed and digested by macrophages, thus forming a phagosome in cytoplasm. These phagosome fuse with lysosome for further digestion.
- Exocytosis: Lysosomes release their enzymes outside the cell to digest other cells.

Peroxisomes

- Peroxisomes were identified as organelles by Christian de Duve (1967). Peroxisomes are small spherical bodies and single membrane bound organelle. It takes part in photorespiration and associated with glycolate metabolism. In plants, leaf cells have many peroxisomes. It is also commonly found in liver and kidney of mammals. These are also found in cells of protozoa and yeast (Figure 6.23).

Glyoxysomes

- Glyoxysome was discovered by Harry Beevers (1961). Glyoxysome is a single membrane bound organelle. It is a sub cellular organelle and contains enzymes of glyoxylate pathway. β-oxidation of fatty acid occurs in glyoxysomes of germinating seeds Example: Castor seeds.

Microbodies

- Eukaryotic cells contain many enzyme bearing membrane enclosed vesicles called microbodies. They are single unit membrane bound cell organelles: Example: peroxisomes and glyoxysomes.

Sphaerosomes

- It is spherical in shape and enclosed by single unit membrane. Example: Storage of fat in the endosperm cells of oil seeds.

Centrioles

- Centriole consist of nine triplet peripheral fibrils made up of tubulin. The central part of the centriole is called hub, is connected to the tubules of the peripheral triplets by radial spokes (9+0 pattern). The centriole form the basal body of cilia or flagella and spindle fibers which forms the spindle apparatus in animal cells. The membrane is absentin centriole (non-membranous organelle)

Vacuoles

- In plant cells vacuoles are large, bounded by a single unit membrane called Tonoplast. The vacuoles contain cell sap, which is a solution of sugars, amino acids, mineral salts, waste chemical and anthocyanin pigments. Beetroot cells contains anthocyanin pigments in their vacuoles. Vacuoles accumulate products like tannins. The osmotic expansion of a cell kept in water is chiefly regulated by vacuole and the water enters the vacuoles by osmosis.

- The major function of plant vacuole is to maintain water pressure known as turgor pressure, which maintains the plant structure. Vacuoles organises itself into a storage/sequestration compartment. Example: Vacuoles store, most of the sucrose of the cell.

1. Sugar in Sugar beet and Sugar cane.
2. Malic acid in Apple.
3. Acids in Citrus fruits.
4. Flavonoid pigment Cyanidin 3 rutinoside in the petals of Antirrhinum.
5. Tannins in Mimosa pudica.
6. Raphide crystals in Dieffenbachia.

7. Heavy metals in Mustard (Brassica).
8. Latex in Rubber tree and Dandelion stem.

Cell Inclusions

- The cell inclusions are the non-living materials present in the cytoplasm. They are organic and inorganic compounds

Inclusions in prokaryotes

- In prokaryotes, reserve materials such as phosphate granules, cyanophycean granules, glycogen granules, poly β-hydroxy butyrate granules, sulphur granules, carboxysomes and gas vacuoles are present. Inorganic inclusions in bacteria are polyphosphate granules (volutin granules) and sulphur granules. These granules are also known asmetachromatic granules.

Inclusions in Eukaryotes

- Reserve food materials: Starch grains, glycogen granules, aleurone grains, fat droplets
- Secretions in plant cells are essential oil, resins, gums, latex and tannins
- Inorganic crystals – plant cell have calcium carbonate, calcium oxalate and silica
- Cystolith – hypodermal leaf cells of Ficusbengalensis, calcium carbonate
- Sphaeraphides – star shaped calcium oxalate, Colocasia
- Raphides – calcium oxalate, Eichhornia
- Prismatic crystals – calcium oxalate, dry scales of Allium cepa

Nucleus

- Nucleus is an important unit of cell which control all activities of the cell. Nucleus holds the hereditary information. It is the largest among all cell organelles. It may be spherical, cuboidal, ellipsoidal or discoidal.

- It is surroundedby a double membrane structure called nuclearenvelope, which has the inner and outer membrane. The inner membrane is smooth without ribosomes and the outer membrane is rough by the presence of ribosomes and is continues with irregular and infrequent intervals with the endoplasmic reticulum. The membrane is perforated by pores known as nuclear pores which allows materials such as mRNA, ribosomal units, proteins and other macromolecules to pass in and out of the nucleus. The pores enclosed by circular structures called annuli. The pore and annuli forms the pore complex. The space between two membranes is called perinuclear space.

- Nuclear space is filled with nucleoplasm, a gelatinous matrix has uncondensedchromatin network and a conspicuous nucleoli. The chromatin network is the uncoiled, indistinct and remain thread like during the interphase. It has little amount of RNA and DNA bound to histone proteins in eukaryotic cells.

- During cell division chromatin is condensed into an organized form called chromosome. The portion of Eukaryotic chromosome which is transcribed into mRNA contains active genes that are not tightly condensed during interphase is called Euchromatin. The portion of a Eukaryotic chromosome that is not transcribed into mRNA which remains condensed during interphase and stains intensely is called Heterochromatin. I Nucleolus is a small, dense, spherical structure either present singly or in multiples inside nucleus and it's not membrane bound. Nucleoli possesses genes for rRNA and tRNA.

Functions of the nucleus

- Controlling all the cellular activities
- Storing the genetic or hereditary information.
- Coding the information in the DNA for the production of enzymes and proteins.
- DNA duplication and transcription takes place in the nucleus.
- In nucleolus ribosomal biogenesis takes place.

Chromosomes

- Strasburger (1875) first reported its present in eukaryotic cell and the term 'chromosome' was introduced by Waldeyer in 1888. Bridges (1916) first proved that chromosomes are the physical carriers of genes. It is made up of DNA and associated proteins.

Structure of chromosome

- The chromosomes are composed of thread like strands called chromatin which is made up of DNA, protein and RNA. Each chromosome consists of two symmetrical structures called chromatids. During cell division the chromatids forms well organized chromosomes with definite size and shape. They are identical and are called sister chromatids. A typical chromosome has narrow zones called constrictions. There are two types of constrictions namely primary constriction and secondary constriction. The primary constriction is made up of centromere and kinetochore. Both the chromatids are united at centromere, whose number varies. The monocentric chromosome has one centromere and the polycentric chromosome has many centromeres. The centromere contains a complex system of protein fibres called kinetochore. Kinetochore is the region of chromosome which is attached to the spindle fibre during mitosis.

- Besides primary there are secondary constrictions, represented with few occurrence. Nucleoli develop fromthesesecondary constrictions are called nucleolar organizers. Secondary constrictions contains the genes for ribosomal RNA which induce the formation of nucleoli and are called nucleolar organizer regions

- A satellite or SAT Chromosome are short chromosomal segment or rounded body separated from main chromosome by a relatively elongated secondary constriction. It is a morphological entity in certain chromosomes.

- Based on the position of centromere, chromosomes are called telocentric (terminal centromere), Acrocentric (terminal centromere capped by telomere), Sub metacentric (centromere subterminal) and Metacentric (centromere median). The eukaryotic chromosomes may be rodshaped (telocentric and acrocentric), L-shaped (sub-metacentric) and V-shaped (metacentric).

- Telomere is the terminal part of chromosome. It offers stability to the chromosome. DNA of the telomere has specific sequence of nucleotides. Telomere in all eukaryotes are composed of many repeats of short DNA sequences (5'TTAGGG3' sequence in Neurosporacrassa and human beings). Maintenance of telomeres appears to be an important factor in determining the life span and reproductive capacity of cells so studies of telomeres and telomerase have the promise of providing newinsights into conditions such as ageing and cancer. Telomeres prevents the fusion of chromosomal ends with one another.

- Holocentric chromosomes have centromere activity distributed along the whole surface of the chromosome during mitosis. Holocentric condition can be seen in Caenorhabditiselegans (nematode) and many insects. There are three types of centromere in eukaryotes. They are as follows:

- **Point centromere:** the type of centromere in which the kinetochore is assembled as a result of protein recognition of specific DNA sequences. Kinetochores assembled on point centromere bind a single microtubule. It is also called as localized centromere. It occurs in budding yeasts

- **Regional centromere:** In regional centromere where the kinetochore is assembled on a variable array of repeated DNA sequences. Kinetochore assembled on regional centromeres bind multiple microtubules. It occurs in fission yeast cell, humans and so on.

- **Holocentromere-** The microtubules bind all along the mitotic chromosome. Example: Caenorhabditiselegans (nematode) and many insects.

- Based on the functions of chromosome it can be divided into autosomes and sex chromosomes.

- Autosomes are present in all cells controlling somatic characteristics of an organism. In human diploid cell, 44 chromosomes are autosomes whereas two are sex chromosomes. Sex chromosomes are involved in the determination of sex.

- Special types of chromosomes are found only in certain special tissues. These chromosomes are larger in size and are called giant chromosomes in certainplants and they are found in the suspensors of the embryo. The polytene chromosome and lamp brush chromosome occur in animals and are also called as giant chromosomes.

- Polytene chromosomes observed in the salivary glands of Drosophila (fruit fly) by C.G. Balbiani in 1881. In larvae of many flies, midges (Dipthera) and some insects the interphase chromosomes duplicates and reduplicates without nuclear division. A single chromosome which is present in multiple copies form a structure called polytene chromosome which can be seen in light microscope. They are genetically active. There is a distinct alternating dark bands and light inter-bands. About 95% of DNA are present in bands and 5% in inter-bands. The polytene chromosome has extremely large puff called Balbiani rings which is seen in Chironomous larvae. It is also known as chromosomal puff. Puffing of bands are the sites of intense RNA synthesis. As this chromosome occurs in the salivary gland it is known as salivary gland chromosomes. Polyteny is achieved by repeated replication of chromosomal DNA several times without nuclear division and the daughter chromatids aligned side by side and do not separate (called endomitosis). Gene expression, transcription of genes and RNA synthesis occurs in the bands along the polytene chromosomes. Maternal and paternal homologues remain associated side by side is called somatic pairing.

- Lampbrush chromosomes occur at the diplotene stage of first meiotic prophase in oocytes of an animal Salamandar and in giant nucleus of the unicellular alga Acetabularia. It was first observed by Flemming in 1882. The highly condensedchromosome forms the chromosomal axis, from which lateral loops of DNA extend as a result of intense RNA synthesis.

Flagella
Prokaryotic Flagellum

- Bacterial flagella are helical appendages helps in motility. They are much thinner than flagella or cilia of eukaryotes. The filament contains a protein called flagellin. The structure consists of a basal body associated with cytoplasmic membrane and cell wall with short hook and helical filament. Bacteria rotates their helical flagella and propels rings present in the basal body which are involved in the rotary motor that spins the flagellum.

Structure of flagella in Bacteria

- The gram positive bacteria contain only two basal rings. S-ring is attached to the inside of peptidoglycan and M-ring is attached to the cell membrane. In Gram negative bacteria two pairs of rings proximal and distal ring are connected by a central rod. They are L-Lipopolysaccharide ring P-Peptidoglycan ring, S-Super membrane ring and M-membrane ring. The outer pair L and P rings is attached to cell wall and the inner pair S and M rings attached to cell membrane (Figure 6.28).

Mechanism of flagellar movement – proton motive force

- In flagellar rotation only proton movements are involved and not ATP. Protons flowing back into the cell through the basal body rings of each flagellum drives it to rotate. These rings constitute the rotary motor. The proton motive force (The force derived from the electrical potential and the hydrogen ion gradient across the cytoplasmic membrane) drives the flagellar motor. For the rotation of flagellum the energy is derived from proton gradient across the plasma membrane generated by oxidative phosphorylation. In bacteria flagellar motor is located in the plasma membrane where the oxidative phosphorylation takes place. Therefore, plasma membrane is a site of generation of proton motive force.

Eukaryotic Flagellum– Cell Motility
Structure

- Eukaryotic Flagella are enclosed by unit membrane and it arises from a basal body.Flagella is composed of outer nine pairs of microtubules with two microtubules in its centre (9+2 arrangement). Flagella are microtubule projection of the plasma membrane. Flagellum is longer than cilium (as long as 200µm). The structure of flagellum has an axoneme made up microtubules and protein tubulin (Figure 6.29).

Movement

- Outer microtubule doublet is associated with axonemal dynein which generates force for movement. The movement is ATP driven. The interaction between tubulin and dynein is the mechanism for the contraction of cilia and flagella. Dynein molecules uses energy from ATP to shift the adjacent microtubules. This movement bends the cilium or flagellum.

Cilia

- Cilia (plural) are short cellular, numerous microtubule bound projections of plasma membrane. Cilium (singular) ismembrane bound structure made up of basal body, rootlets, basal plate and shaft. The shaft or axoneme consists of nine pairs of microtubule doublets, arranged in a circle along the periphery with a two central tubules, (9+2) arrangement of microtubules is present. Microtubules are made up of tubulin. The motor protein dynein connects the outer microtubule pair and links them to the central pair. Nexin links the peripheral doublets of microtubules

Cytological Techniques
Prearation of Slides

- There are different types of mounting based on the portion of a specimen to be observed

  a. **Whole mount:** The whole organism or smaller structure ismounted over a slide and observed.
  b. **Squash:** Is a preparation where the material to be observed is crushed/ squashed on to a slide so as to reveal their contents. Example: Pollen grains, mitosis and meiosis in root tips and flower buds to observe chromosomes.
  c. Smears: Here the specimen is in the fluid (blood, microbial cultures etc.,) are scraped, brushed or aspirated from surface of organ. Example: Epithelial cells.
  d. Sections: Free hand sections from a specimen and thin sections are selected, stained and mounted on a slide. Example: Leaf and stem of plants.

Recording the Observations

- The observations made through a microscope can be recorded by hand diagrams or through microphotographs.
- **Hand diagrams:** Hand diagrams are drawn using ordinary pencil by observing the slide and drawing manually.

- **Microphotograph:** Images of structures observed through microscopes can be further magnified, projected and saved by attaching a camera to the microscope by a microscope coupler or eyepiece adaptor. Picture taken using a inbuilt camera in a microscope is called microphotography or microphotograph.

Staining Techniques

- Staining is very important to observe different components of the cell. Each component of the cell has different affinity towards different stains. The technique of staining the cells and tissue is called 'histochemical staining' or 'histochemistry'.

Unit -7 Cell Cycle

- One of the most important features of the living cells is their power to grow and divide. New cells are formed by the division of pre-existing cells. Cells increase in number by cell division. The parent cell divides and passes on genetic material to the daughter cells.

The Role of the Nucleus

- As studied earlier, the nucleus is the organising centre of the cell. The information in the nucleus is contained within structures called chromosomes. These uniquely:
- Control activities of the cell.
- Genetic information copied from cell to cell while the cell divides.
- Hereditary characters are passed on to new individuals when gametic cells fuse together in sexual reproduction.

Chromosomes

- At the time when a nucleus divides, the chromosomes become compact and multicoiled structure. Only in this condensed state do the chromosomes become clearly visible in cells. All othertimes, the chromosomes are very long, thin, uncoiled threads. In this condition they give the stained nucleus the granular appearance. The granules are called chromatin.

The four important features of the chromosome are:

- The shape of the chromosome is specific: The long, thin, lengthy structured chromosome contains a short, constricted region called centromere. A centromere may occur anywhere along the chromosome, but it is always in the same position on any given chromosome.
- The number of chromosomes per species is fixed: for example the mouse has 40 chromosomes, the onion has 16 and humans have 46.
- Chromosomes occur in pairs: The chromosomes of a cell occur in pairs, called homologous pairs. One of each pair come originally from each

parent. Example, human has 46 chromosomes, 23 coming originally from each parent in the process of sexual reproduction.

- Chromosomes are copied: Between nuclear divisions, whilst the chromosomes are uncoiled and cannot be seen, each chromosome is copied. The two identical structures formed are called chromatids.

Nuclear Divisions

- There are two types of nuclear division, as mitosis and meiosis. In mitosis, the daughter cells formed will have the same number of chromosomes as the parent cell, typically diploid (2n) state. Mitosis is the nuclear division that occurs when cells grow or when cells need to be replaced and when organism reproduces asexually.

- In meiosis, the daughter cells contain half the number of chromosomes of the parent cell and is known as haploid state (n).

- Whichever division takes place, it is normally followed by division of the cytoplasm to form separate cells, called as cytokinesis.

Cell Cycle

- Definition: A series of events leading to the formation of new cell is known as cell cycle. The phenomenonal changes leading to formation of new population take place in the cell cycle. It was discovered by Prevost and Dumans (1824). The series of events include several phases.

Duration of Cell Cycle

- Different kinds of cells have varied duration for cell cycle phases. Eukaryotic cell divides every 24 hours. The cell cycle is divided into mitosis and interphase. In cell cycle 95% is spent for interphase whereas the mitosis and cytokinesis last only for an hour.The different phases of cell cycle are as follows.

Interphase

- Longest part of the cell cycle, but it is of extremely variable length. At first glance the nucleus appears to be resting but this is not the case at all.

The chromosomes previously visible as thread like structure, have dispersed. Now they are actively involved in protein synthesis, at least for most of the interphase.

G_1 Phase

- The first gap phase – 2C amount of DNA in cells of G_1. The cells become metabolically active and grows by producing proteins, lipids, carbohydrates and cell organelles including mitochondria and endoplasmic reticulum. Many checkpoints controlthe cell cycle. The checkpoint called the restriction point at the end of G_1, determines a cells fate whether it will continue in the cell cycle and divide or enter a stage called G_0 as a quiescent stage and probably as specified cell or die. Cells are arrested in G_1 due to
- Nutrient deprivation
- Lack of growth factors or density dependant inhibition
- Undergo metabolic changes and enter into G_0 state.

- Biochemicals inside cells activates the cell division. The proteins called kinases and cyclins activate genes and their proteins to perform cell division. Cyclins act as major checkpoint which operates in G_1 to determine whether or not a cell divides.

G_0Phase

- Some cells exit G_1 and enters a quiescent stage called G_0, where the cells remain metabolically active without proliferation. Cells can exist for long periods in G_0 phase. In G_0 cells cease growth with reduced rate of RNA and protein synthesis. The G_0 phase isnot permanent. Mature neuron and skeletal muscle cell remain permanently in G_0. Many cells in animals remains in G_0 unless called on to proliferate by appropriate growth factors or other extracellular signals. G_0 cells are not dormant.

S phase – Synthesis phase – cells with intermediate amounts of DNA.

- Growth of the cell continues as replication of DNA occur, protein molecules called histones are synthesised and attach to the DNA. The centrioles duplicate in the cytoplasm. DNA content increases from 2C to 4C.

G2 – Te second Gap phase – 4C amount of DNA in cells of G2 and mitosis

- Cell growth continues by protein and cell organelle synthesis, mitochondria and chloroplasts divide. DNA content remains as 4C. Tubulin is synthesised and microtubules are formed. Microtubles organise to form spindle fbre. Te spindle begins to form and nuclear division follows.

- One of the proteins synthesized only in the G2 period is known as Maturation Promoting Factor (MPF). It brings about condensation of interphase chromosomes into the mitotic form.

- DNA damage checkpoints operates in G1 S and G2 phases of the cell cycle.

Cell Division
Amitosis (Direct Cell Division)

- Amitosis is also calleddirect or incipient cell division. Here there is no spindle formation and chromatin material does not condense. It consist of two steps: (Figure 7.2).

Karyokinesis:

- Involves division of nucleus.
- Nucleus develops a constriction at the center and becomes dumbell shaped.
- Constriction deepens and divides the nucleus into two.

Cytokinesis:

- Involves division of cytoplasm.
- Plasma membrane develops a constriction along nuclear constriction.
- It deepens centripetally and finally divides the cell into two cells.

- Example: Cells of mammalian cartilage, macronucleus of Paramecium and old degenerating cells of higher plants.

Drawbacks of Amitosis

- Causes unequal distribution of chromosomes.
- Can lead to abnormalities in metabolism and reproduction.

Mitosis

- The most important part of cell division concerns events inside the nucleus. Mitosis occurs in shoot and root tips and other meristematic tissues of plants associated with growth. The number of chromosomes in the parent and the daughter (Progeny) cells remain the same so it is also called as equational division.

Closed and Open Mitosis

- In closed mitosis, the nuclear envelope remains intact and chromosomes migrate to opposite poles of a spindle within the nucleus (Figure 7.3).Example: Many single celled eukaryotes including yeast and slime molds.

- open mitosis, the nuclear envelope breaks down and then reforms around the 2 sets of separated chromosome.
- Example: Most plants and animalsMitosis is divided into four stages prophase, metaphase, anaphase and telophase (Figure 7.6).

Prophase

- Prophase is the longest phase in mitosis. Chromosomes become visible as long thin thread like structure, condenses to form compact mitotic chromosomes. In plant cells initiation of spindle fibres takes place, nucleolus disappears. Nuclear envelope breaks down. Golgi apparatus and endoplasmic reticulum are not seen.

- In animal cell the centrioles extend a radial array of microtubules towards the plasma membrane when they reach the poles of the cell. T is arrangement of microtubules is called an aster. Plant cells do not form asters.

Metaphase

- Chromosomes (two sister chromatids) are attached to the spindle fibres by kinetochore of the centromere. The spindle fibres is made up of tubulin. The alignment of chromosome into compact group at the equator of the cell is known as metaphase plate. This is the stagewhere the chromosome morphology can be easily studied.

- Kinetochore is a DNA–Protein complex present in the centromere DNA where the microtubules are attached. It is a trilaminar disc like plate.The spindle assembly checkpoint which decides the cell to enter anaphase.

Anaphase

- Each chromosome split simultaneously and two daughter chromatids begins to migrate towards two opposite poles of a cell. Each centromere splits longitudinally into two, freeing the two sister chromatids from each other. Shortening of spindle f bre and longitudinal splitting of centromere creates a pull which divides chromosome into two halves. Each half receive two chromatids (that is sister chromatids are separated). When the sister chromatids separate the actual partitioning of the replicated genome is complete.

- Aubiquitine ligase is activated called as the anaphase-promoting complex cyclosome (APC/C) leads to degradation ofthe key regulatory proteins at the transition of metaphase to anaphase. APC is a cluster of proteins that induces the breaking down of cohesion proteins which leads to the separation of chromatids during mitosis (Figure 7.5).

Telophase

- Two sets of daughter chromosomes reach opposite poles of the cell, mitotic spindle disappears. Division of genetic material is completed afer this karyokinesis, cytokinesis (division of cytoplasm) is completed, nucleolus and nuclear membranes reforms. Nuclear membranes form around each set of sister chromatids now called chromosomes, each has its own centromere. Now the chromosomes decondense. In plants, phragmoplast are formed between the daughter cells. Cell plate is formed between the two daughter cells, reconstruction of cell wall takes place. Finally the cells are separated by the distribution of organelles, macromolecules into two newly formed daughter cells.

Cytokinesis

Cytokinesis in Animal Cells

- It is a contractile process. The contractile mechanism contained in contractile ring located inside the plasma membrane. The ring consists of a bundle of microfilaments assembled from actin and myosin. This fibril helps for the generation of a contractile force. This force draws the contractile ring inward forming a cleavage furrow in the cell surface dividing the cell into two.

Cytokinesis in Plant Cell

- Division of the cytoplasm ofen starts during telophase. In plants, cytokinesis cell plate grows from centre towards lateral walls - centrifugal manner of cell plate formation.

- Phragmoplast contains microtubules, actin filaments and vesicles from golgi apparatus and ER. The golgi vesicles contains carbohydrates such as pectin, hemicellulose which move along the microtubule of the pharagmoplast to the equator fuse, forming a new plasma membrane and the materials which are placed their becomes new cell wall. The first stage of cell wall construction is a line dividing the newly forming cells called a cell plate. The cell plate eventually stretches right across the cell forming the middle lamella. Cellulose builds up on each side of the middle lamella to form the cell walls of two new plant cells.

Significance of Mitosis

- Exact copy of the parent cell is produced by mitosis (genetically identical).

1. Genetic stability – daughter cells are genetically identical to parent cells.
2. Growth – as multicellular organisms grow, the number of cells making up their tissue increases. The new cells must be identical to the existing ones.
3. Repair of tissues - damaged cells must be replaced by identical new cells by mitosis.

4. Asexual reproduction – asexual reproduction results in offspring that are identical to the parent. Example Yeast and Amoeba.
5. In flowering plants, structure such as bulbs, corms, tubers, rhizomes and runners are produced by mitotic division. When they separate from the parent, they form a new individual.The production of large numbers of ofsprings in a short period of time, is possible only by mitosis. In genetic engineering and biotechnology, tissues are grown by mitosis (i.e. in tissue culture).
6. Regeneration – Arms of star fish

Meiosis

- In Greek meioum means to reduce. Meiosis is unique because of synapsis, homologous recombination and reduction division. Meiosis takes place in the reproductiveorgans. It results in the formation of gametes with half the normal chromosome number.Haploid sperms are made in testes; haploid eggs are made in ovaries of animals.

1. In flowering plants meiosis occurs during microsporogenesis in anthers and megasporogenesis in ovule. In contrast to mitosis, meiosis produces cells that are not genetically identical. So meiosis has a key role in producing new genetic types which results in genetic variation.

Stages in Meiosis

- Meiosis can be studied under two divisions i.e., meiosis I and meiosis II. As with mitosis, the cell is said to be in interphase when it is not dividing.

Meiosis I-Reduction Division

- **Prophase I** – Prophase I is of longer duration and it is div ided into 5 substages – Leptotene, Zygotene, Pachytene, Diplotene and Diakinesis**Leptotene** – Chromosomes are visible under light microscope. Condensation of chromosomes takes place. Paired sister chromatids begin to condense.

- Zygotene – Pairing of homologous chromosomes takes place and it is known as synapsis. Chromosome synapsis is made by the formation of synaptonemal complex. The complex formed by the homologous chromosomes are called as bivalent (tetrads).

- **Pachytene**– At this stage bivalent chromosomes are clearly visible as tetrads. Bivalent of meiosis I consists of 4chromatids and 2 centromeres. Synapsis is completed and recombination nodules appear at a site where crossing over takes place between non-sister chromatids of homologous chromosome. Recombination of homologous chromosomes is completed by the end of the stage but the chromosomes are linked at the sites of crossing over. This is mediated by the enzyme recombinase.

- **Diplotene**– Synaptonemal complex disassembled and dissolves. The homologous chromosomes remain attached at one or more points where crossing over has taken place. These points of attachment where 'X' shaped structures occur at the sites of crossing over is called Chiasmata. Chiasmata are chromatin structures at sites where recombination has been taken place. They are specialised chromosomal structures that hold the homologous chromosomes together. Sister chromatids remain closely associated whereas the homologous chromosomes tend to separate from each other but are held together by chiasmata. This substage may last for days or years depending on the sex and organism. The chromosomes are very actively transcribed in females as the egg stores up materials for use during embryonic development. In animals, the chromosomes have prominent loops called lampbrush chromosome.

- **Diakinesis** – Terminalisation of chiasmata. Spindle fbres assemble. Nuclear envelope breaks down. Homologous chromosomes become short and condensed. Nucleolus disappears.

Metaphase I

- Spindle fibres are attached to the centromeres of the two homologouschromosomes. Bivalent (pairs of homologous chromosomes) aligned at theequator of the cell known as metaphase plate. Each bivalent consists of two centromeres and four chromatids.
- The random distribution of homologous chromosomes in a cell in Metaphase I is called independent assortment.

Anaphase I

- Homologous chromosomes are separated from each other. Shortening of spindle fibers takes place. Each homologous chromosomes with its two chromatids and undivided centromere move towards the opposite poles of the cells. The actual reduction in the number of chromosomes takes place at this stage. Homologous chromosomes which move to the opposite poles are either paternal or maternal in origin. Sister chromatids remain attached with their centromeres.

Telophase I

- Haploid set of chromosomes are present at each pole. The formation of two daughter cells, each with haploid number of chromosomes. Nuclei are reassembled. Nuclear envelope forms around the chromosome and the chromosomes becomes uncoiled. Nucleolus reappears.

- In plants, after karyokinesis cytokinesis takes place by which two daughter cells are formed by the cell plate between 2 groupsof chromosomes known as dyad of cells (haploid).The stage between the two meiotic divisions is called interkinesis which is short-lived.

Meiosis II – Equational division.

- This division is otherwise called mitotic meiosis. Since it includes all the stages of mitotic divisions.

Prophase II

- chromosome with 2 chromatids becomes short, condensed, thick and becomes visible. New spindle develops at right angles to the cell axis. Nuclear membrane and nucleolus disappear.

Metaphase II

- Chromosome arranged at the equatorial plane of the spindle. Microtubules of spindle gets attached to the centromere of sister chromatids.

Anaphase II

- Sister chromatids separate. The daughter chromosomes move to the opposite poles due to shortening of microtubules. Centromere of each chromosome split, allowing to move towards opposite poles of the cells holding the sister chromatids.

Telophase II

- Four groups of chromosomes are orgamnised into dour haploid nuclei. The spindle disappears. Nuclear envelope, nucleolus reappears.

- After karyokinesis, cytokinesis follows and four haploid daughter cells are formed, called tetrads.

Significance of Meiosis

- This maintains a definite constant mumber of chromosomes is organisms.
- Crossing over takes place and exchange of genetic material leads to variations amog species. These variations are the raw materials to evolution. Meiosis leads to genetic variability by partitioning different combinations of genes into gametes through independent assortment.
- Adaptation of organisms to various environmental stress.

Mitogens

- The factors which promote cell cycle proliferation is called mitogens. Plant mitogens include gibberellin, ethylene, Indole acetic acid, kinetin. These increase mitotic rate.

Mitotic Poisons (Mitotic Inhibitors)

- Certain chemical components act as inhibitors of the mitotic cell division and they are called mitotic poisons.

Endomitosis

- The replication of chromosomes in the absence of nuclear division and cytoplasmic division resulting in numerous copies within each cell is called endomitosis. Chromonema do not separate to form chromosomes, but remain closely associated with each other. Nuclear membrane does not rupture. So no spindle formation. It occurs notably in the salivary glands of Drosophila and other flies. Cells in these tissues contain giant chromosomes (polyteny), each consisting of over thousands of intimately associated, or synapsed, chromatids. Example: Polytene chromosome.

Anastral

- This is present only in plant cells. No asters or centrioles are formed only spindle fibres are formed during cell division.

Amphiastral

- Aster and centrioles are formed at each pole of the spindle during cell division. This is found in animal cells.

Unit -8 Biomolecules

Water

- Water is the most abundant component in living organisms. Life on earth is inevitablu linked to water. Water makes up 70 % of human cell and upto 95% of mass of aplanet cell

- Water is a tiny polar molecule and can reasily pass through membranes. Two electronegative atoms of oxygen share a hydrogen bonds of two water molecule. Thus, they can stick together by cohesion and results in lattice formation (Figure 8.4).

Properties of Water

- Adhesion and cohesion property
- High latent heat of vaporisation
- High melting and boiling point
- Universal solvent
- Specific heat capacity

Primary and Secondary Metabolites

- Most plants, fungi and other microbes synthesizes a number of organic compounds. These components are called as metabolites which are intermediates and products of metabolism. The term metabolite is usually restricted to small molecules. It can be catergorized into two types namely primary and secondary metabolites based on their role in metabolic process (Figure 8.5).

- **Primary metabolites** are those that are required for the basic metabolic processes like photosynthesis, respiration, protein and lipid metabolism of living organisms.

- **Secondary metabolites** does not show any direct function in growth and development of organisms.

Organic Molecules

- Organic molecules may be small and simple. These simple molecules assemble and form large and complex molecules called macromolecules. These include four main classes – carbohydrates, lipids, proteins and nucleic acids. All macromolecules except lipids are formed by the process of polymerisation, a process in which repeating subunits termed monomers are bound into chains of different lengths. These chains of monomers are called polymers.

Carbohydrates

- Carbohydrates are organic compounds made of carbon and water. Thus one molecule of water combines with a carbon atom to form CH2O and is repeated several (n) times to form (CH2O)n where n is an integer ranging from 3–7. These are also called as saccharides. The common term sugar refers to a simple carbohydrate such as a monosaccharide or disaccharide that tastes sweet are soluble in water (Figure 8.7).

Monosaccharides – The Simple Sugars

- Monosaccharides are relatively small molecules constituting single sugar unit. Glucose has a chemical formula of C6H12O6. It is a six carbon molecule and hence is called as hexose
- All monosaccharides contain one of two functional groups. Some are aldehydes, like glucose and are referred as aldoses; other are ketones, like fructose and are referred as ketoses.

Disaccharides

- Disaccharides are formed when two monosaccharides join together. An example is sucrose. Sucrose is formed from a molecule of α-glucose and a molecule of fructose.

- In the reverse process, a disaccharide is digested to the component monosaccharide in a hydrolysis reaction. This reaction involves addition of a water (hydro) molecule and splitting (lysis) of the glycosidic bond.

Polysaccharides

- These are made of hundreds of monosaccharide units. Polysaccharides also called "Glycans". Long chain of branched or unbranchedmonosaccharides are held together by glycosidic bonds. Polysaccharide is an example of giant molecule, a macromolecule and consists of only one type of monomer.

- This is a condensation reaction releasing water. The bond formed between the glucose and fructose molecule by removal of water is called glycosidic bond. This is another example of strong, covalent bond.aresweetless. Cellulose is an example built from repeated units of glucose monomer.Depending on the function, polysaccharides are of two types -storage polysaccharide and structural polysaccharide (Figure 8.8).

Starch

- Starch is a storage polysaccharides made up of repeated units of amylose and amylopectin. Starch grains are made up of successive layers of amylose and amylopectin, which can be seen as growth rings. Amylose is a linear, unbranched polymer which makes up 80% of starch. Amylopectin is a polymer with some 1, 6 linkages that gives it a branched structure.

Test for Strach

- We test the presence of starch by adding a solution of iosin in potassium iodide. Iodine molecules fit nearly into the starch helix, creating a blue-black colocu

- Test on potato; b. test on starch –iodine reaction c. starch – iodine reaction

Chitin

- Chitin is a homo polysaccharide with amino acids added to form mucopolysaccharide. The basic unit is anitrogen containing glucosederivative known as N-acetyl glucoseamine.It forms the exoskeleton of insects and other arthropods. It is also present in the cell walls of fungi.

Test for Reducing Sugars

- Aldoses and ketoses are reducing sugars. This means that, when heated with an alkaline solution of copper (II) sulphate (a blue solution called benedict's solution), the aldehyde or ketone group reduces Cu^{2+} ions to Cu^{+} ions forming brick red precipitate of copper(I) oxide. In the process, the aldehyde or ketone group is oxidised to a carboxyl group (–COOH). This reaction isused as test for reducing sugar and is known as Benedict's test. The results of benedict's test depends on concentration of the sugar. If there is no reducing sugar it remains blue.

- Sucrose is not a reducing sugar

- The greater the concentration of reducing sugar, the more is the precipitate formed and greater is the colour change.

Lipids

- The term lipid is derived from greek word lipos, meaning fat. These substances are not soluble in polar solvent such as water but dissolve in non-polar solvents such as benzene, ether, chloroform. This is because they contain long hydrocarbon chains that are non-polar and thus hydrophobic. The main groups of compounds classifiedas lipids are triglycerides, phospholipids, steroids and waxes.

Triglycerides

- Triglycerides are composed of single molecule of glycerol bound to 3 fatty acids. These include fats and oils. Fatty acids are long chain hydrocarbons with a carboxyl group at one end which binds to one of the hydroxyl groups of glycerol, thus forming an ester bond. Fatty acids are structural unit of lipids and are carboxylic acid of long chain hydrocarbons. The hydrocarbon can vary in length from 4 – 24 carbons and the fat may be saturated or unsaturated. In saturated fatty acids the hydrocarbon chain is single bonded (Eg. palmitic acid, stearic acid) and in unsaturated fatty acids (Eg. Oleic acid,linoleic acid) the hydrocarbon chain is double bonded (one/two/three). In general solid fats are saturated and oils are unsaturated, in which most are globules.

Membrane Lipids

- A class of lipids that serves as major structural component of cell membrane is phospholipids. These contain only 2 fatty acids attached to the glycerol, while the third glycerol binding site holds a phosphate group. This phosphate group is in turn bonded to an alcohol. These lipids have both hydrophobicand hydrophilic regions. The structure of lipid bilayer helps the membrane in function such as selective permeability and fluid nature (Figure 8.15).

Steroids

- These are complex compounds commonly found in cell membrane and animal hormones. Eg. Cholesterol which reinforces the structure of the cell membrane in animal cells and in an unusual group of cell wall deficient bacteria – Mycoplasma.

Waxes

- These are esters formed between a long chain alcohol and saturated fatty acids.Lecithin is a food additive and dietery supplement

- Fur, feathers, fruits, leaves, skin and insect exoskeleton are naturally waterproofed with a coating of wax.

Proteins

- Proteins are the most diverse of all macromolecule. Proteins make up 2/3 of total dry mass of a cell. The term protein was coined by Gerardus Johannes Mulder and is derived form a greek word proteos which means of the first rank.

- Amino acids are building blocks of proteins. There are about 20 different amino acids exist naturally. All amino acids have a basic skeleton consisting of a carbon (a-carbon) linked to a basic amino group.(NH2), an acidic carboxylic group (COOH) and a hydrogen atom (H) and side chain or variable R group. The amino acid is both an acid and a base and is called amphoteric.

- A zwitterion also called as dipolar ion, is a molecule with two or more functional groups, of which at least one has a positive and other has a negative electrical charge and the net charge of the entire molecule is zero. The pH at which this happens is known as the isoelectric point (Figure 8.19).

Classification of Amino acids

- Based on the R group amino acids are classified as acidic, basic, polar, non-polar.The amino group of one amino acid reacts with carboxyl group of other amino acid, forming a peptide bond. Tw o amino acids can react together with the loss of water to form a dipeptide. Long strings of amino acids linked by peptide bonds are called polypeptides. In 1953 Fred Sanger first sequenced the Insulin protein (Figure 8.18 and 8.20 a and b).

Structure of Protein

- Protein is synthesised on the ribosome as a linear sequence of amino acids which are held together by peptide bonds. After synthesis,the protein attains conformational change into a specific 3D form for proper functioning. According to the mode of folding, four levels of protein organisation have been recognised namely primary, secondary, tertiary and quaternary.
- The primary structure is linear arrangement of amino acids in a polypeptide chain.
- Secondary structure arises when various functional groups are exposed on outer surface of the molecular interaction by forming hydrogen bonds. This causes the aminoacid chain to twist into coiled configuration called α-helix or to fold into a flat β-pleated sheets.
- Tertiary protein structure arises when the secondary level proteins fold into globular structure called domains.
- Quaternary protein structure may be assumed by some complex proteins in which more than one polypeptide forms a large multiunit protein. The individual polypeptide chains of the protein are called subunits and the active protein itself is called amultimer.

- For example: Enzymes serve as catalyst for chemical reactions in cell and are non-specific. Antibodies are complex glycoproteins with specific regions of attachment for various organisms.

Protein Denaturation

- Denaturation is the loss of 3D structure of protein. Exposure to heat causes atoms to vibrate violently, and this disrupts the hydrogen and ionic bonds. Under these conditions, protein molecules become elongated, disorganised strands. Agents such as soap, detergents, acid, alcohol and some disinfectants disrupt the interchain bond and cause the molecule to be nonfunctional (Figure 8.25).

Protein Bonding

- There are three types of chemical bonding

Hydrogen Bond

- It is formed between some hydrogen atoms of oxygen and nitrogen in polypeptide chain. The hydrogen atoms have a smallpositive charge and oxygen and nitrogen have small negative charge. Opposite charges attract to form hydrogen bonds.

- Though these bonds are weak, large number of them maintains the molecule in 3D shape

Ionic Bond

- It is formed between any charged groups that are not joined together by peptide bond. It is stronger than hydrogen bond and can be broken by changes in pH and temperature.

Disulfide Bond

- Some amino acids like cysteine and methionine have sulphur. These form disulphide bridge between sulphur atoms and amino acids.

Hydrophobic Bond

- This bond helps some protein to maintain structure. When globular proteins are in solution, their hydrophobic groups point inwards away from water.

Test for Proteins

- The biuret test is used as an indicator of the presence of protein because it gives a purple colour in the presence of peptide bonds (–C– N–). To a protein solution an equal quantity of sodium hydroxide solution is added and mixed. Then a few drops of 0.5% copper (II) sulphate is added with gentle mixing. A distinct purple colour develops without heating.

Enzymes

- Enzymes are globular proteins that catalyse the many thousands of metabolic reactions taking place within cells and organism. The molecules involved in such reactions are metabolites. Metabolism consists of chains and cycles of enzyme-catalysed reactions, such as respiration, photosynthesis, protein synthesis and other pathways. These reactions are classified as

    - **anabolic** (building up of organic molecules). Synthesis of proteins from amino acids and synthesis of polysaccharides from simple sugars are examples of anabolic reactions.
    - **catabolic** (breaking down of larger molecules). Digestion of complexfoods and the breaking down of sugar in respiration are examples of catabolic reactions.

    - Enzymes can be extracellular enzyme as secreted and work externally exported from cells. Eg. digestive enzymes; or intracellular enzymes that remain within cells and work there. These are found inside organelles or within cells. Eg. insulin

Properties of Enzyme

- All are globular proteins.
- They act as catalysts and effective even in small quantity.
- They remain unchanged at the end of the reaction.
- They are highly specific.
- They have an active site where the reaction takes place.
- Enzymes lower activation energy of the reaction they catalyse.

- As molecules react they become unstable, high energy intermediates, but they are in this transition state only momentarily. Energy is required to raise molecules to this transitionstate and this minimum energy needed is called the activation energy. This could be explained schematically by 'boulder on hillside' model of activation energy.

Lock and Key Mechanism of Enzyme

- In a enzyme catalysed reaction, the starting substance is the substrate. It is converted to the product. The substrate binds to the specially formed pocket in the enzyme – the active site, this is called lockand key mechanism of enzyme action. As the enzyme and substrate form a ES complex, the substrate is raised in energy to a transition state and then breaks down into products plus unchanged enzyme.

Factors Affecting the Rate of Enzyme Reactions

- Enzymes are sensitive to environmental condition. It could be affected by temperature, pH, substrate concentration and enzyme concentration.

- The rate of enzyme reaction is measured by the amount of substrate changed or amount of product formed, during a period of time.

Temperature

- Heating increases molecular motion. Thus the molecules of the substrate and enzyme move more quickly resulting in a greater probability of occurence of the reaction. The temperature that promotes maximum activity is referred to as optimum temperature.

- The optimum pH is that at which the maximum rate of reaction occurs. Thus the pH change leads to an alteration of enzyme shape, including the active site. If extremes of pH are encountered by an enzyme, then it will be denatured.

Substrate Concentration

- For a given enzyme concentration, the rate of an enzyme reaction increases with increasing substrate concentration (Figure 8.32).

Enzyme Concentration

- The rate of reaction is directly proportional to the enzyme concentration.

Introducing the Michaelis-Menton Constant (Km) and ItsSignificance

- When the initial rate of reaction of an enzyme is measured over a range of substrate concentrations (with a fixed amount of enzyme) and the results plotted on a graph. With increasing substrate concentration, the velocity increases – rapidly at lower substrate concentration.

- However the rate increases progressively, above a certain concentration of the substrate the curve flattened out. No further increase in rate occurs.

- This shows that the enzyme is working at maximum velocity at this point. On the graph, this point of maximum velocity is shown as Vmax.

Inhibitors of Enzyme

- Certain substances present in the cells may react with the enzyme and lower the rate of reaction. These substances are called inhibitors. It is of two types competitive and non-competitive

Competitive Inhibitor

- Molecules that resemble the shape of the substrate and may compete to occupy the active site of enzyme are known as competitive inhibitors. For Example: the enzyme that catalyses the reaction between carbon di oxide and the CO2 acceptor molecule in photosynthesis, known as ribulosebiphosphate carboxylase oxygenase (RUBISCO) is competitively inhibited by oxygen/carbon-di-oxide in the chloroplast. The competitive inhibitor is malonate for succinic dehydrogenase.

Non-competitive Inhibitors

- There are certain inhibitors which may be unlike the substrate molecule but still combines with the enzyme. This either blocks the attachment of the substrate to active site or change the shape so that it is unable to accept the substrate. For example the effect of the amino acids alanine on the enzyme pyruvate kinase in the final step of glycolysis.

- Certain non-reversible/irreversible inhibitors bind tightly and permanently to an enzyme and destroy its catalytic properties entirely. These could also be termed as poisons. Example – cyanide ions which blocks cytochrome oxidase in terminal oxidation in cell aerobic respiration, the nerve gas sarin blocks a neurotransmitter in synapse transmission.

Allosteric Enzymes

- They modify enzyme activity by causing a reversible change in the structure of the enzyme active site. This in turn affects the ability of the substrate to bind to the enzyme. Such compounds are calledallosteric inhibitors. Eg. The enzyme hexokinase which catalysis glucose to glucose-6 phosphate in glycolysis is inhibited by glucose 6 phosphate. This is an example for feedback allosteric inhibitor.

End Product Inhibition (Negative Feedback Inhibition)

- When the end product of a metabolicpathway begins to accumulate, it may act as an allosteric inhibitor of the enzyme controlling the first step of the pathway. Thus the product starts to switch off its own production as it builds up. The process is self – regulatory. As the product is used up, its production is switched on once again. This is called end-product inhibition (Figure 8.35).

Enzyme Cofactors

- Many enzymes require non-protein components called cofactors for their efficient activity. Cofactors may vary from simple inorganic ions to complex organic molecules. They are of three types: inorganic ions, prosthetic groups and coenzymes.

- Holoenzyme – active enzyme with its non protein component.

- Apoenzyme – the inactive enzyme without its non protein component.
- Inorganic ions help to increase the rate of reaction catalysed by enzymes. Example: Salivary amylase activity is increased in the presence of chloride ions.

- Prosthetic groups are organic molecules that assist in catalytic function of an enzyme. Flavin adenine dinucleotide (FAD) contains riboflavin (vitB2), the function of which is to accept hydrogen. 'Haem' is an iron-containing prosthetic group with an iron atom at its centre.

- Coenzymes are organic compounds which act as cofactors but do not remain attached to the enzyme. The essential chemical components of many coenzymes are vitamins. Eg. NAD, NADP, Coenzyme A, ATP

Nomenclature of Enzymes

- Most of the enzymes have a name based on their substrate with the ending –ase. For example lactase hydrolyses lactose and amylase hydrolyses amylose. Other enzymes like renin, trypsin do not depict any relation with their function.

Nucleic Acids

- As we know DNA and RNA are the two kinds of nucleic acids. These were originally isolated from cell nucleus. They are present in all known cells and viruses with special coded genetic programme with detailed and specific instructions for each organism heredity.DNA and RNA are polymers of monomers called nucleotides, each of which is composed of a nitrogen base, a pentose sugar and a phosphate. A purine or a pyrimidine and a ribose or deoxyribose sugar is called nucleoside. A nitrogenous base is linked to pentose sugar through n-glycosidic linkage and forms a nucleoside. When a phosphate group is attached to a nucleoside it is called a nucleotide. The nitrogen base is aheterocyclic compound that can be either a purine (two rings) or a pyrimidine (one ring). There are 2 types of purines –adenine (A) and guanine (G) and 3 types of pyrimidines – cytosine (C), thymine (T) and uracil (U) (Figure 8.38).

- A characteristic feature that differentiates DNA from RNA is that DNA contains nitrogen bases such as Adenine, guanine, thymine (5-methyl uracil) and cytosine and the RNA contains nitrogen bases such as adenine, guanine, cytosine and uracil instead of thymine. The nitrogen base is covalently bonded to the sugar ribose in RNA and to deoxyribose (ribose with one oxygen removed from C2) in DNA. Phosphate group is a derivative of (PO43-) phosphoric acid, and forms phosphodiester linkages with sugar molecule (Figure 8.39).

Formation of Dinucleotide and Polynucleotide

- Two nucleotides join to form dinucleotide that are linked through 3′-5′ phosphodiester linkage by condensation between phosphate groups of one with sugar of other. This is repeated many times to make polynucleotide.

Structure of DNA

- Watson and Crick shared the Nobel Prize in 1962 for their discovery, along with Maurice Wilkins, who had produced the crystallographic data supporting the model. Rosalind Franklin (1920–1958) had earlier produced the first clear crystallographic evidence for a helical structure. James Watson and Francis Crick (Figure 8.40) of Cavendish laboratory in Cambridge built a scale model of double helical structure of DNA which is the most prevalent form of DNA, the B-DNA. This is the secondary structure of DNA.

- As proposed by James Watson and Francis Crick, DNA consists of right handed double helix with 2 helical polynucleotide chains that are coiled around a common axis to form righthanded B form of DNA. The coils are held together by hydrogen bonds which occur between complementary pairs of nitrogenous bases. The sugar is called 2′-deoxyribose because there is no hydroxyl at position 2′. Adenine and thiamine base pairs has two hydrogen bonds while guanine and cytosine base pairs have three hydrogen bonds.

- As published by Erwin Chargaff in 1949, a purine pairs with pyrimidine and vice versa. Adenine (A) always pairs with Thymine (T) by double bond and Guanine (G) always pairs with Cytosine (C) by triple bond.

Features of DNA

- If one strand runs in the 5'-3' direction, the other runs in 3'-5' direction and thus are antiparallel (they run in opposite direction). The 5' end has the phosphate group and 3end has the OH group.

- The angle at which the two sugars protrude from the base pairs is about 120°, for the narrow angle and 240° for the wide angle. The narrow angle between the sugars generates a minor groove and the large angle on the other edge generates major groove.
- Each base is 0.34 nm apart and a complete turn of the helix comprises 3.4 nm or 10 base pairs per turn in the predominant B form of DNA.

- DNA helical structure has a diameter of 20 A° and a pitch of about 34 A°. X-ray crystal study of DNA takes a stack of about 10 bp to go completely around the helix (360°).

- Thermodynamic stability of the helix and specificity of base pairing includes (i) the hydrogen bonds between the complementary bases of the double helix (ii) stacking interaction between bases tend to stack about each other perpendicular to the direction of helical axis. Electron cloud interactions (Ft - n) between the bases in the helical stacks contribute to the stability of the double helix.

- The phosphodiesterlinkages gives an inherent polarity to the DNA helix. They form strong covalent bonds, gives the strength and stability to the polynucleotide chain.

- Plectonemic coiling - the two strands of the DNA are wrapped around each other in a helix, making it impossible to simply move them apart withoutbreaking the entire structure. Whereas in paranemic coiling the two strands simply lie alongside one another, making them easier to pull apart.

- Based on the helix and the distance between each turns, the DNA is of three forms – A DNA, B DNA and Z DNA.

Ribonucleic Acid (RNA)

- Ribonucleic acid (RNA) is a polymeric molecule essential in various biological roles in coding, decoding, regulation and expression of genes. RNA is single stranded and is unstable when compared to DNA.

Types of RNA

- mRNA (messenger RNA): Single stranded, carries a copy of instructions for assembling amino acids into proteins. It is very unstable and comprises 5% of total RNA polymer. Prokaryotic mRNA (Polycistronic) carry coding sequences for many polypeptides. Eukaryotic mRNA (Monocistronic) contains information for only one polypeptide.

- tRNA (transfer RNA): Translates the code from mRNA and transfers aminoacids to the ribosome to build proteins. It is highly folded into an elaborate 3D structure and comprises about 15% of total RNA. It is also called as soluble RNA.

- rRNA (ribosomal RNA): Single stranded, metabolically stable, make up the two subunits of ribosomes. It constitutes 80% of the total RNA. It is a polymer with varied length from 120–3000 nucleotides and gives ribosomes their shape. Genes for rRNA are highly conserved and employed for phylogenetic studies.