IMPORTANT QUESTIONS CLASS – 11 BIOLOGY CHAPTER -8 CELL: THE UNIT OF LIFE

1. Define Cell. Explain its Structure.

Meaning and Types of Cell- Basic Unit of Life:

Robert Hooke (1665) observed the so called cells for the first time in a thin slice of cork under a very primitive microscope invented by him. He coined the term "cell". Living cells were seen for the first time by Anton Van Leeuwenhoek (1632-1723), with his improved microscope. Much later (1838-39) cell-theory was proposed by two German biologists separately – viz., M.J. Schleiden for plants and Theodor Schwann for animals. According to them, "Cells are the structural and functional units of living organisms." Later, Rudolph Virchow (1855) extended the cell theory and suggested that all living cells arise from pre-existing cells (Omnis cellula e cellula).

Viruses are the most notable exception to the cell theory because they lack internal organisation and protoplasm. Other exceptions include protozoans, fungi and algae because their entire organisation is represented by just one cell.

Size of the Cell:

Usually the cells are microscopic and their size varies between 10 µm and 100 µm. The smallest cells are those of PPLO (Pleuropneumonia like organisms) whose size may vary between 0.1 to 0.4 µm. The largest cell is the egg of ostrich measuring about 15 cm in its outer diameter. The longest animal cell is the nerve cell which may be approximately one metre long, while the longest plant cell is the sclerenchymatous fibre of Boehmeria nevia (about 55 cm long).

The factors governing the size of the cell are:

(i) The ratio between the volume of the nucleus and that of the cytoplasm.

(ii) The ratio of the cell surface to the cell volume.

(iii) The rate of metabolism.

(iv) The size and the number of chromosomes.

Shape of the Cell:

There is a great variation in the shape of cell. Some cells, e.g., Amoeba, slime moulds and WBCs have a constantly changing shape while others (e.g., neurons, muscle cells, RBCs, etc.) have a characteristic shape. The shape is governed by the plasma membrane and the cell wall, if present.

Numbers of the Cells:

The body of protozoans, bacteria, certain fungi and algae is represented by one cell only. They are called as unicellular or acellular forms. Most of the animals and plants are made up of several cells. They are called multicellular.

On the basis of the nuclear organisation, cells are of two types:

1. Prokaryotic:

Cells in which mitochondria, chloroplast and nuclear membrane are absent are called prokaryotic cells. For example bacteria, blue green algae (cyanobacteria), and mycoplasma.

2. Eukaryotic:

Cells in which nucleus and membrane bound organelles are present are called eukaryotic cells. They are found in all plants and animals.

2. What is a Cell Wall? What are the Functions of it?

The presence of a cell wall is a characteristic feature of plant cells. It is always formed by the activity of the protoplasm.

The adjacent cell walls are cemented together by middle lamella composed of calcium or magnesium pectate cell wall is differentiated into three layers, viz.:

1. Primary Cell Wall:

It is the outermost layer of the cell wall present on both the sides of middle lamella. It is usually thin (1-3 μm), and elastic. The chief constituents of the primary cell wall are cellulose and hemicellulose, some amount of pectin and a structural protein extension (rich in proline and hydroxyproline) may also be present. In thin walled cells (like meristematic cells, parenchyma, collenchyma and mesophyll cell) primary cell wall remains as the only layer.

2. Secondary Cell Wall:

It is much thicker (5-10 μm), rigid and inelastic It is formed only when the growth in the surface area of the primary cell wall ceases. Its position is in between the primary wall and the protoplast. The secondary cell wall may be thickened on account of the deposition of substances like cutin, suberin, lignin and pectin.

3. Tertiary Cell Wall:

It is of rare occurrence (in tracheids of gymnosperms). It is deposited on the inner side of the secondary cell wall. It is relatively richer in xylem (a polymer of pentose sugar D-xylose) than cellulose.

Functions of Cell Wall:

Functions of cell wall are largely mechanical. It acts like a skeleton of the plant by providing rigidity strength and flexibility. It maintains the shape and structure of the cells and the tissues, and protects the protoplasm against mechanical injuries. By impregnation of cutin and suberin it also reduces loss of water by transpiration. It, being freely permeable, helps in the absorption and transportation of water and solutes in the different parts of the plant.

3. What is Protoplasm? Explain the Nature and Properties of it.

Felix Dujardin (1835) described protoplasm in protozoa. He called it "Sarcode". The term protoplasm was coined by Johannes E. Purkinje (1839) and Hugo Von Mohl (1846) independently. Huxley called protoplasm as the physical basis of life, for life cannot exist apart from it.

Protoplasm refers to the living substance of the cell and includes all parts of the cell. It is the set of all metabolic functions. The protoplasm can be divided into cytoplasm and nucleus.

Cytoplasm:

It is the part of cell occurring between plasma membrane and nucleus. This term was introduced by Strassburger (1882).

It is composed of two distinct types of structures, viz.:

(i) A continuous fluid like substance called cytosol.

(ii) A number of organelles which are having definite function.

Physical Nature of Protoplasm:

(i) It is a thick, greyish, viscous jelly-like translucent fluid of colloidal nature.

(ii) The colloid particles exhibit Brownian movement.

(iii) It shows Tyndall's effect, i.e., when a beam of strong light is passed through it in a dark room, the path of light appears like a cone.

(iv) It is a reversible colloidal system. It can be watery (Sol) at one time and jelly like at another (Gel). The sol and gel states are reversible.

Chemical Nature of Protoplasm:

Generally the elements of protoplasm are grouped in the following three categories according to their abundance in the protoplasmic matrix:

(i) Major Constituents:

These include Oxygen (62%), Carbon (20%), Hydrogen (10%) and Nitrogen (3%).

(ii) Trace Elements:

These occur in very low quantities or in traces.

The trace elements are- calcium, potassium, phosphorus, sodium, chlorine, magnesium, sulphur, iodine and iron.

(iii) Ultrastructure Elements:

These are required by the cell as co-factors for various metabolic reactions, e.g., copper, cobalt, manganese, zinc, molybdenum, boron, silicon, etc.

Biological Properties of Protoplasm:

(i) Irritability:

Protoplasm shows the ability to respond to stimuli.

(ii) Conductivity:

Protoplasm of neurons is specially adapted to conduct the impulses.

(iii) Metabolism:

Protoplasmic matrix is the seat of various metabolic processes of the cell.

(iv) Growth:

A successful metabolism always results into synthesis of new protoplasm thereby causing growth of the cell.

(v) Reproduction:

Protoplasm is a self-perpetuating substance.

4. Define Plasma Membrane. What are the Functions of it? Explain its Structure.

Cytoplasm of all the living cells is enclosed by a living membrane called as cell membrane, plasma membrane or plasmalemma. The term cell membrane was given by C. Nageli and C. Cramer (1855) while the term plasmalemma was coined by J.Q. Plower (1931).

To explain the structure of plasma membrane several models have been proposed. The most accepted model is fluid mosaic model.

The Fluid Mosaic Model:

Proposed by Singer and Nicholson (1972), this model is now widely accepted. According to this model, there is a continuous bilayer of phospholipid molecules and globular proteins are embedded in it. The membrane is, thus, considered to be a semifluid structure in which lipids as well as intrinsic proteins are able to make movements within the bilayer. The concept of fluidity implies that lipids and proteins are held in their position by non-covalent bonds.

The proteins in the membrane are of two types:

(i) Extrinsic (Peripheral) Proteins:

These are superficially attached to outer and inner surfaces of lipid bilayer. They are soluble and can readily dissociate from the membrane, e.g., spectrin of RBC membrane.

(ii) Intrinsic (Integral) Proteins:

They penetrate partially or even completely through the lipid bilayer, e.g., ATPase, cytochrome oxidase, rhodopsin, etc. These are amphipathic like the phospholipids. Their hydrophilic head protrudes from the surface of the membrane while hydrophobic end is embedded in the membrane. These are capable of lateral diffusion in the lipid bilayer.

Besides lipids and proteins, carbohydrates also occur at the outer surface of the membrane. These are covalently linked to polar heads of phospholipids or proteins forming glycolipids, or glycoproteins. The glycoproteins form the glycocalyx of the animal-cell surface, which is helpful in cell adhesion and cell recognition.

Functions of Plasma Membrane:

1. It forms a limiting boundary of the cell.

2. Being selectively permeable it allows only useful substances to enter the cell and thus maintains the homeostasis of the cell.

3. Through its receptors it helps in binding hormones, drugs, neurotransmitters, growth factors, etc.

4. The glycocalyx of the membrane helps in cell recognition, adhesion and in exchange of materials or information.

5. It helps in bulk transport by phagocytosis, pinocytosis and exocytosis.

5. What is Mitochondria? Explain its Structure and Functions.

Historical Background:

Mitochondria were first observed in flight muscles of insects by Kolliker (1850). W. Fleming (1882) called them as fila. R. Altman (1892) called them bioplast. The term mitochondria were given by Benda. In plant cells, mitochondria of a cell are collectively called as "chondriome", whereas those of muscle cells are called as sarcosomes.

Shape:

Mitochondria vary in shape but are generally rod shaped, filamentous or granular.

Size:

The average length of mitochondria is between 3-4 µm and the average diameter 0.5-2.0 µm. In the oocytes of Rana pipiens 40 µm long mitochondria have been reported.

Number:

On an average 200-300 mitochondria are present in a cell. But variations are also reported. For example in the algae Micromonas and Microsterias, only one mitochondria is seen in a cell. Their maximum number has been reported in a protozoan Chaos where it is estimated to be approximately 5,00,000.

Ultrastructure:

A mitchondrion is a double membrane bound structure, each membrane being about 60 Å thick. The two membranes are separated by a perimitochondrial space of about 60-80 Å.

The outer membrane is smooth, tightly stretched and elastic. The inner membrane is rough and selectively permeable. It encloses an inner chamber filled with a matrix which contains most of the enzymes of Krebs' cycle, 70 S ribosomes, two to six circular DNA molecules, divalent cations, e.g., Ca^{++}, Mg^{++}, etc.

The inner membrane is rich in enzymes like succinate dehydrogenase, cytochrome oxidase, ATPase, etc. The side of the inner membrane facing the matrix is called the M-face while the side facing the outer chamber or cytoplasm is called the C-face. The inner membrane is thrown into several fingers like folds projecting into the matrix. These folds are called as crests or cristae. The cavity of the cristae is called the intracristae space and is continuous with the perimitochondrial space.

Attached to M-face of inner membrane are several elementary particles, or oxysomes. Each particle is made up of three parts-viz.; a polyhedral head, a stalk, and a cuboidal base.

These particles are placed at regular intervals of 100 Å. In a mitochondrion their number may vary from $10^4 – 10^5$.

Functions of Mitochondria:

(i) Pyruvic acid produced during glycolysis enters mitochondria where it is subjected to Krebs cycle and electron transport system to produce ATP by oxidative phosphorylation. Almost total usable energy of a cell is produced by mitochondria. Hence, it is called as the "Powerhouse" of the cell.

(ii) It accumulates certain ions (e.g., Ca^{++} and Fe^{+++}), ferritin, phospholipids, and bile pigments.

(iii) It stores neutral fats and lipids, vitamin C, vitamin A, carotenoids and carcinogenic hydrocarbons.

(iv) It is involved in the elongation of fatty acids and in the synthesis of lipids.

(v) It has an important role in the synthesis of structural proteins, yolk and glycogen. Mitochondrion is a semiautonomous organelle. It is so, because it contains DNA as well as ribosomes, and is therefore able to synthesize some of the proteins required by it.

Mitochondrion is a symbiotic prokaryote. Altman believed mitochondria (and chloroplast also) to be a prokaryotic organism which had entered the cytoplasm of a eukaryotic cell during early days of evolutionary history. The reasons in favour of this hypothesis are the resemblances between their ribosomes, DNA and structure of membranes.

6. What are Plastids? What are the Types of Plastids? Explain the Structure and Function of Chloroplast.

The term plastid was coined by A.F.W. Schimper (1885). Schimper and Meyer (1883-85) is covered these organelles. These are the second largest organelle of the cell and are scattered in the cytoplasm of all green plants. They are not found in blue-green algae, fungi and bacteria.

The plastids are of three types, viz.:

1. Leucoplasts

2. Chromoplasts

3. Chloroplasts

One form of plastid can change into the other.

1. Leucoplasts:

These are the plastids without any pigment and are chiefly concerned with food storage. These are found in embryonic cells, gametes, meristematic regions, seeds and in underground parts.

They are of the following three types:

(i) Amyloplasts:

These store starch. They are found in tubers, cotyledons and endosperm.

(ii) Elaioplasts:

These store fats and oils; for example, in seeds.

(iii) Proteinoplasts or Aleuronolasts:

They store proteins. These are abundant in cotyledons of pulses.

2. Chromoplasts:

These contain pigments of various colours, e.g., carotenoids and xanthophylls.

3. Chloroplasts:

These are the most important plastids found in almost all plants except parasitic plants.

Shape:

Their shape is usually ovoid, discoid or ellipsoid in higher plants. In lower plants the chloroplasts have very unusual shape and size. In Spirogyra chloroplast is ribbon shaped, in Oedogonium it forms a net-work, in Desmids and Zygnema the chloroplasts are like radiating platelets, in Chlamydomonas it is cup shaped, in Ulothrix girdle shaped and in Anthoceros spindle shaped.

Size:

The size of chloroplast is variable but on an average its diameter ranges between 4-6 µm and the length between 90-100 µm. These are relatively larger in polyploid plants and sciophytes.

Number:

Normally, there are 20-50 chloroplasts in a plant cell but in algae just one chloroplast may be present in a cell.

Ultrastructure:

Chloroplast is a double membrane bound organelle. Each membrane is 60 Å thick. The space between outer and inner membranes is called as periplastidial space (100-300 Å). The inner space is filled with a granular and transparent fluid known as stroma or matrix. The stroma contains fat globules, starch grains, osmiophilic granules, pyrenoids, and enzymes of dark reaction. The matrix also contains RNA, DNA and 70S ribosomes.

In the stroma, a characteristic system of lamellae is present. These are made up of unit membrane bound structures called thylakoids (100-300 Å wide) which are stacked over one another. One such stack is called as a granum. A granum may comprise 50-100 thylakoids. In a chloroplast usually 40-60 grana are found. The grana are interconnected by intergrana lamellae (also called as stroma lamellae or the frets).

On the inner surface of thylakoid membranes particles of 185 Å lengths, 150 Å widths and 100 Å thicknesses are present. These are called "quantasomes". These were discovered by Park and Biggins (1963). These are the smallest photosynthetic units capable of carrying out photochemical reaction.

Chloroplast is a semiautonomous organelle, due to presence of DNA, RNA and ribosomes. Chloroplast is capable of synthesising some of its proteins required for integrity of thylakoid membranes. The DNA of chloroplast is responsible for cytoplasmic inheritance and dividing ability of chloroplasts. Due to all these facts, chloroplast, like mitochondria, is said to be semiautonomous organelle.

Functions of Chloroplast:

In the presence of light, carbon dioxide and water chloroplasts manufacture organic food for the plants by the process of photosynthesis. The food prepared by plants is then made available to heterotrophs. The entire process of photosynthesis is completed in two steps- viz.; light reaction and dark reaction. The light reaction takes place in grana which trap the solar energy and store it as chemical energy. During dark reaction, which occurs in stroma, this energy is utilised to combine CO_2 and water to build carbohydrates.

Another important function of chloroplasts is to manufacture ATP by the process of photophosphorylation.

7. What is Endoplasmic Reticulum? What are the types and functions of it?

Meaning of Endoplasmic Reticulum:

The endoplasmic reticulum is an extensive network of vesicles and tubules in the cytoplasm. It is more concentrated in the inner region of the cytoplasm than in its peripheral region hence the name endoplasmic reticulum. It was discovered by Porter (1945). It is found in most of plant and animal cells, except mature RBCs, prokaryotes and blue green algae.

The endoplasmic reticulum has the typical unit membrane structure having a thickness of 50 – 60 Å. It exists in three main forms in different cells, depending upon their metabolic state.

These forms are as follows:

1. Cisternae (Lamellae):

These are elongated and unbranched tubules arranged in parallel bundles. They may be interconnected with each other. This form of endoplasmic reticulum is characteristic of cells which are actively involved in protein synthesis.

2. Tubules:

These are small, smooth walled and branched structures of different sizes and shapes. These are characteristic of non-secretory cells, e.g., developing spermatids, muscle cells, etc., and are mainly concerned with storage and transport of steroid hormones, cholesterol, glycerides, etc.

3. Vesicles:

They are large, rounded or irregular structures of smooth membrane. They are abundant in synthetically active cells, e.g., Liver cells, pancreatic cells, developing spermatocytes, etc.

Types of Endoplasmic Reticulum:

There are two distinct morphological types of endoplasmic reticulum, viz.:

1. Rough Endoplasmic Reticulum (RER):

It is called as rough or granular because the membranes are covered with ribosomes giving them a rough appearance. Ribosomes are attached to the membranes through their larger subunit (60S) by a specific glycoprotein called as 'ribophorin'. The RER is more stable and is predominantly found in those cells which are actively engaged in protein synthesis, e.g., the enzyme secreting cells.

2. Smooth Endoplasmic Reticulum (SER):

In this type, the membranes do not bear ribosomes hence appear smooth. They are usually tubular; cisternae are rare. This form of endoplasmic reticulum is less stable. It is characteristic of cells in which synthesis of non-protein substances, phospholipids, glycolipids and steroid hormones takes place, for example in adipose tissue, adrenal cortex, interstitial cells of testis, etc.

When a cell type has abundant SER, it usually has little RER and vice-versa.

Functions of Endoplasmic Reticulum:

1. The endoplasmic reticulum provides mechanical support for the colloidal structure of the cytoplasm.

2. It helps in exchange of materials between nucleus and cytoplasm.

3. It separates the cytoplasm into compartments and maintains the ionic gradients and electrical potential across these compartments.

4. The endoplasmic reticulum may help intracellular circulation of various substances.

5. The RER provides a site for protein synthesis by attaching ribosomes on it.

6. Jones and Fawcett (1966) have shown the presence of drug metabolising and detoxifying enzyme-systems in the endoplasmic reticulum.

7. The SER helps in synthesis and storage of lipids, cholesterol and glycogen.

8. In testis, ovary and adrenal cortex it synthesises steroid hormones.

8. What are Lysosomes? Explain the Ultrastructure and Functions of it.

These are smallest membrane bound organelles. They originate directly from the endoplasmic reticulum or from the Golgi complex. These were discovered by Christian de Duve (1955).

It is universally present in animal cells. It is not found in plant cells and prokaryotes.

Ultrastructure:

These are single unit-membrane bound globular structures filled with enzymes. Their diameter varies between 0.2 to 0.8 μm. The lysosomal membrane is impermeable to substrates of enzymes contained in the lysosome.

The enzymes are kept in an inert condition through electrostatic binding of acid groups in the lipoprotein matrix of membrane.

If the enzymes are released, they can digest the cell itself, hence, the lysosomes are also called as “suicide bags” of the cell. Since most of the lysosomal enzymes function better under acidic conditions, they are collectively termed as “acid hydrolases”.

Functions of Lysosome:

1. Extracellular Digestion:

Lysosomal enzymes are released outside the cell where they digest the substrate.

2. Intracellular Digestion:

It may involve autophagy or heterophagy. During autophagy the lysosomes digest the organelles of their own cell while during heterophagy exogenous materials are broken down. Sometimes both autophagy and heterophagy may occur simultaneously in the same lysosomal vesicle. Such vesicles are called as “ambilysosomes.”

3. Hormone Secretion:

Lysosomes modify the secretory products synthesised by the cell before they are released. For example thyroid hormones are released by hydrolysis of thyroglobulin in the secondary lysosomes. Secretion of prolactin from anterior pituitary is controlled by lysosomes.

4. Fertilisation:

The acrosome of sperm is looked upon as a giant lysosome. It helps in dissolving the egg membrane to facilitate the entry of sperm.

5. Developmental Processes:

Resorption of the tadpole tail and regression of insect larval tissues involves lysosomal acid hydrolases. In mammalian females the involution of uterus and mammary glands immediately after the child-birth involves lysosomes.

6. Malfunctioning of Lysosome:

Malfunctioning of lysosome results in tissue damage and may cause several diseases including some cancers.

9. What is Golgi Complex? Explain the Ultrastructure and Functions of it.

It was discovered by Camillo Golgi (1898) in the nerve cells of barn owl.

In plant cells these are also called dictyosomes.

Ultrastructure:

Electron microscope reveals the presence of three membranous components in it, viz.:

1. Cisternae or Lamellae:

They are flattened; parallel sacs piled one upon the other to form stacks.

The cisternae may be flat but are more usually slightly curved. This gives the whole stack convex and concave faces. There are named them as forming or proximal face and maturing or distal face respectively as new lamellae are formed on the forming face and mature lamellae are lost on the maturing face.

2. The Small Vesicles:

They arise from the cisternae by budding.

3. Tubules:

These are like cisternae, but are highly branched.

Functions of Golgi Complex:

1. General Secretion:

These are involved in extra and intra-cellular secretions.

2. Synthesis of Polysaccharides:

The Golgi complex in the goblet cells of the colon produces mucigen. This secretory material contains a large portion of carbohydrate.

3. Glycosylation:

Addition of carbohydrates to the proteins occurs in the Golgi complex as well as in the rough endoplasmic reticulum as both of them contain the enzyme glycosyl transferase. After completion of glycosylation the glycoprotein is released into the lumen of Golgi cisternae.

4. Sulphation:

Golgi complex takes part in sulphate metabolism. Compounds containing active sulphur are formed in two steps. Sulphate is first activated by ATP then the activated sulphur is transferred to acceptor molecule by sulphotransferases.

5. Plasma Membrane Formation:

Secretory granules originating from the Golgi complex fuse with the plasma membrane. The membrane of the granules becomes incorporated in to the plasma membrane and thus contributes to the renewal of the membrane.

6. Cell-Plate Formation:

Substances like pectin and hemicelluloses, which form the matrix of the cell plate, are contributed by the Golgi complex.

7. Lipid Packaging and Secretion:

Golgi complex provides a membrane for envelopment of lipid, so that it can be released from the cell.

8. Acrosome Formation:

Electron microscopic studies have revealed the derivation of acrosomal membrane from the membranes of Golgi derived vesicles.

9. Lysosome Formation:

Primary lysosomes are formed by the Golgi complex.

10. Neurosecretion:

In many cells, neurosecretory material is synthesised by ribosomes or endoplasmic reticulum, and are packed in Golgi complex.

10. What are Chromosomes? Explain its Structure and Functions.

Meaning of Chromosomes:

All the living organisms have specific characteristics which they transmit to their offspring through successive generations. The characteristics are identified as hereditary traits. These traits are controlled by special units, called as genes, which are borne by the chromosomes. The chromosomes are, thus defined as self-duplicating nuclear filaments having specific organisation and individuality.

Historical Aspects:

W. Fleming (1897) saw deeply stainable thread like material in the nucleus and called it as chromatin. These threads were named chromosomes by Waldeyer (1888). Sutton and Boveri suggested and later proved experimentally that chromosomes were the physical carriers of hereditary characters. Based on this fact they proposed the chromosomal theory of inheritance.

Chromosome Number:

Benden and Boveri (1887) reported that the number of chromosomes is constant for a particular species. The number of chromosomes present in gamete is said to represent one complete set and is called haploid number which is represented by ‘n’. The total number of genes present in a haploid set of chromosomes is known as genome. The somatic cells contain two sets of chromosomes which together represent the diploid number (2n).

Similarly if an individual possesses more than two sets of chromosomes it is said to be polyploid condition (3n, 4n …… and so on). In polyploid individuals the ancestral primitive number is called as base number and is represented as X. For example in the common Triticum aestivum the diploid number (2n) is 42 and haploid number (n) is 21, but its base number (x) is 7 which means that Triticum is a hexaploid (i.e., 2n = 6x).

The minimum number of chromosomes recorded in plants is n = 2 in Haplopappus gracilis (Compositae). The maximum number has been reported from the fern Ophioglossum reticulatum (2n = 1260).

Morphology of Chromosomes:

Size:

The size of chromosomes varies from species to species but is generally specific for a particular species. The chromosome size is generally measured at the mitotic prophase. The chromosomes may be 0.2 to 50 mm in length, for e.g., 3 mm in Drosophila, 5 mm in human beings, 8-12 mm in Zea Mays, 0.25 mm in fungi and 30 mm in Tillium.

Plant chromosomes are usually larger than animal chromosomes and likewise the chromosomes of the monocots are larger than those of the dicots.

Shape:

The shape of the chromosome changes from phase to phase during the continuous process of cell division. During interphase the chromosomes appear as extended fine thread like stainable structures called chromatin threads. However, the shape and structure of the chromosomes can be studied best at the metaphase and anaphase stages of cell division because at these phases the chromosomes contract to the maximum. They
may be rod shaped, J-shaped, L-shaped or V-shaped, depending on position of the primary constriction (centromere) along the length of a chromosome.

Structure:

During interphase, the stained chromosome appears as a thin and coiled filament, composed of chromatin. This filament was named as chromonema by Vejdovsky (1912). Sometimes chromonema and chromatid are used synonymously, but actually these are different. A chromatid refers to one half of the chromosome which is connected at the centromere, while the chromonema represents thread like structures constituting respective chromatids.

Earlier it was thought that chromonema remain embedded in a Paranemic coils amorphous matrix which in turn is covered by a very thin chromosomal sheath or pellicle. However, the electron microscopic studies have not confirmed the presence of matrix and pellicle. The chromonema may be composed of two or more fibres depending on the species.

These fibres remain coiled with each other forming either paranemic or plectonemic coils. In paranemic coiling the coils of the chromonemal fibres are easily separable but in the plectonemic coiling the chromonemal filaments remain so intimately coiled that they cannot be separated easily.

The following parts are distinguished in a condensed chromosome:

1. Primary Constriction:

Each chromosome has a non-stainable region at a specific point along its length. This region is called primary constriction.

2. Centromere:

Within the primary constriction, there is a clear central zone called centromere. This is the point of attachment of the sister chromatids and also the site of attachment of the mitotic spindle fibre. The portion of the chromosome on either side of the centromere is called arm of the chromosome. Functionally the centromere is related to the movement of the chromosomes at anaphase. During this movement, depending upon the relative ratio of the two arms, the chromosomes acquire the shape of I, J, L or V.

The centromere is made up of four very small granules arranged in a square. These granules are called centromeric chromomeres which remain connected to the chromatid fibres. The chromosomes of many organisms contain only one centromere. Such chromosomes are called monocentric, those with two or more centromeres are respectively called dicentric and polycentric.

3. Kinetochore:

The kinetochore is a proteinaceous disc attached to the centromeric chromomeres. Two kinetochores, one in each chromatid, are observed. These are centres of assembly for the microtubules at the metaphase.

4. Secondary Constriction I:

It is also called as nucleolar organiser. The part of the chromosome beyond the secondary constriction is called as satellite or trabant. The chromosomes having a satellite are called as SAT chromosome. SAT stands for "sine acid thymonucleinico", means absence of thymonucleic acid in this part. It contains genes for synthesis of ribosomal RNAs.

5. Secondary Constriction II:

One or more additional constrictions called secondary constriction II may also be present on the chromosome. Their position is fixed hence these are useful in identifying a chromosome in a set.

6. Telomere:

Tips of the chromosomes containing heterochromatic material or repetitive DNA sequences are called telomeres. Each telomere has definite polarity. It does not allow other chromosomes to stick with it or its union with the broken ends.

According to position of centromere, following types of chromosomes are identified:

(i) Telocentric:

Their centromere is situated at one end. At anaphase, it looks like 'I'.

(ii) Acrocentric:

Their centromere lies almost near the tip of chromosome so that one arm is exceptionally short and the other is long. At anaphase, these chromosomes look like 'J'.

(iii) Submetacentric:

In this type of chromosome the centromere lays a little away from the centre, dividing the chromosome into two unequal arms. Such chromosome looks like 'L' at the anaphase.

(iv) Metacentric:

In this type of chromosome, the centromere lies in the middle of the chromosome, dividing it into two equal arms. The metacentric chromosome becomes V-shaped during anaphase.

Chemical Composition and Models of Chromosomes:

The major constituents of the chromosomes include DNA, RNA, histone and non-histone proteins and metal ions. It carries the genetic information from one generation to other. The RNA is transcribed by DNA and most of it is transported to the cytoplasm. The histone proteins present in the chromosomes are basic proteins that are composed of basic amino acid such as lysine and arginine.

These remain associated with the DNA and act as repressors of gene activity. The non--histone proteins are mostly acidic and act as enzymes, important among them are DNA polymerase, RNA polymerase and nucleoside triphosphatase. Besides these metallic ions such as Mg^{++}, Ca^{++}, etc. keep them intact and also act as regulators of various enzymes.

Models of Chromosome Structure:

Various models showing the mode of attachment between DNA and proteins in a chromosome have been proposed, among which the nucleosome model is most accepted one.

Nucleosome Model:

A.L. Olins and D. E. Olins (1974) reported the presence of a series of bead like structures in electron micrographs of interphase chromatin fibres. These particles were called as nu (h) bodies. Later Outdet (1975) called them as nucleosome. R.D. Kornberg and Thomas discovered that each spherical unit representing the core is composed of 140 base pairs of DNA and a histone octamer having two molecules of each of four different histones- viz., H_2A, H_2B, H_3 and H_4.

The histone H_1 is loosely associated with the chromatin. Around the core particle of nucleosome, DNA molecule is wrapped 1.75 times. The complete nucleosome is a flattened particle of 55 Å in height and 110 Å in diameter. The core particle made up of histone octamer is 40 Å high and 80 Å wide. The beaded nucleosomes are interconnected by DNA filaments called linker DNA. Their length may vary from 8 to 114 nucleotide base pairs.

The nucleosomal beads are further coiled to form a super-coiled structure called as solenoid.

Functions of Chromosomes:

The chromosomes are most vital component of the cell. These control almost all cellular activities at physiological, molecular and morphological levels.

Besides these, they perform the following main functions:

1. The chromosomes maintain the identity of species.

2. These determine the sex of species of animals and plants.

3. These act as a vehicle of hereditary characters from one generation to other.

4. With the help of their chemical constituents, the DNA and RNA, they synthesize proteins and enzymes.

5. The lampbrush chromosomes synthesize yolk in oocytes of many vertebrates.