CELL : THE UNIT OF LIFE

POINTS TO REMEMBER

Gram positive bacteria : Bacteria that take up gram stain.

Gram negative bacteria : Bacteria that do not take up gram stain.

Prokaryotic cells : Cells which lack a well defined nucleus and membrane bound cell organelles. *e.g.*, bacteria, cyanobacteria, mycoplasma.

Eukaryotic cells : Cells which have a well defined nucleus and membrane bound cell organelles. *e.g.*, all protists, plants, animals and fungi cells.

Passive transport : Transport of molecules across a membrane along the concentration gradient, *i.e.*, from higher to lower concentration without the consumption of energy.

Active transport : Transport of molecules against concentrataion gradient, *i.e.*, from lower to higher concentration with the consumption of energy (ATP).

Polyribosome/polysome : A chain like structure formed when several ribosome are attached to a single mRNA.

PPLO : Pleuro Pneumonia Like Organisms.

Cell : Cell is the structural and functional unit of life. Cell Theory was formulated by Scheleiden and Schwann and was modified by Rudolf virchow states :

(a) All living organisms are composed of cells and products of cells.

(b) All cells arise from pre-existing cells.

Prokaryotic cells

Genetic material is not enveloped by nuclear envelope. Many bacteria contain extra chromosomal DNA – plasmids.

Cell Envelope

Prokaryotic cells have a chemically complex cell envelope which consists of a tightly bound 3 layered structure *i.e.*, outermost **glycocalyx** followed by **cell wall** and then **plasma membrane.**

A specialised structure – **mesosome** is formed by the extension of plasma

membrane into the cell. Mesosomes help in cell wall formation, DNA replication and distribution to daughter cells, respiration, secretion process, to increase surface area of plasma-membrane and enzymatic content.

Bacterial cells may be motile or non-motile. Motile bacterias have **flagella** composed of three parts – filament, hook and basal body. Pili and fimbriae are surface structures which do not play any role in motality. These structures help the bacteria to attach with rocks and the host tissues.

70S ribosomes are associated with plasma membrane and is made of two subunits – 50S and 30S. Ribosomes are site of protein synthesis.

Eukaryotic cells

Possess an organized nucleus with nuclear envelope and have a variety of complex locomotory and cytoskeletal structures.

Cell Membrane

Singer and Nicolson (1972) gave 'Fluid mosaic model'. According to this the quasi-fluid nature of lipid enables lateral movement of proteins within the overall bilayer.

Functions : Selectively permeable.

Cell Wall is a non-living rigid structure which gives shape to the cell and protects cell from mechanical damage and infection, helps in cell-to-cell interaction and provides barrier to undesirable macromolecules.

Cell wall of algae is made of cellulose, galactans, mannans and minerals like calcium carbonate. Plant cell wall consists of cellulose, hemicellulose, pectins and proteins.

Middle lamella is made of calcium pectate which holds neighbouring cells together.

Plasmodesmata connect the cytoplasm of neighbouring cells.

Endoplasmic Recticulum (ER)

Consists of network of tiny tubular structures. ER divides the intracellular space into two distinct compartments – luminal (inside ER) and extra luminal (cytoplasm).

(i) **Rough Endoplasmic Reticulum (RER) :**

- Ribosomes attached to outer surface.
- Involved in protein synthesis and secretion.

(ii) Smooth Endoplasmic Reticulum (SER) :

- Lack ribosomes.
- Site for synthesis of lipid.

Golgi apparatus :

Consists of cisternae stacked parallel to each other. Two faces of the organelle are convex **cis** or forming face and concave **trans** or maturing face.

Functions : Performs packaging of materials, to be delivered either to the intra-cellar targets or secreted outside the cell. Important site of formation of glycoproteins and glycolipids.

Lysosomes :

Membrane bound vesicular structures formed by the process of packaging in the golgi apparatus. Contain hydrolysing enzymes (lipases, proteases, carbohyrases) which are active in acidic pH. Also called 'Suicidal Bag'.

Function : Intracellular digestion.

Vacuoles :

Membrane bound space found in the cytoplasm. Contain water, sap, excretory product, etc.

Function : In plants **tonoplast** (single membrane of vacuole) faciliates transport of ions and other substances.

Contractile vacuole for excretion in ***Amoeba*** and food vacuoles formed in protistis for digestion of food.

Mitochondria :

Double membrane structure. Outer membrane smooth and inner membrane forms a number of infoldings called cristae.

Function : Sites of aerobic respiration. Called 'power houses' of cell as produce cellular energy in the form of ATP. Matrix possesses single circular DNA molecule, a few RNA molecules, ribosomes (70S). It divides by fission.

Plastids :

Found in plant cells and in euglenoides. Chloroplasts, chromoplasts and leucoplasts are 3 types of plastids depending on pigments contained.

Chloroplasts are double membraned structure. Space limited by inner membrane is called **stroma.** Flattened membranous sacs called **thylakoids** in stroma. Chlorophyll pigments are present in thylakoids.

Function : Site of photosynthesis.

Ribosomes

Compased of RNA and proteins; without membrane. Eucaryotic ribosomes are 80S.

Function : Site of protein synthesis.

Cilia and Flagella

Cilia are small structures which work like oar, which help in movement.

Flagella are longer and responsible for cell movement. They are covered with plasma membrane. Core is called **axoneme** which has 9 + 2 arrangement.

Centrosome and Centrioles

Centrosome contains two cylindrical structures called centrioles. Surrounded by amorphous pericentriolar material. Has 9 + 0 arrangement. Centrioles form the basal body of cilia or flagella and spindle fibres for cell division in animal cells.

Nucleus : With double membrane; nuclear pores; has chromatin, nuclear matrix and nucleoli (site for rRNA synthesis).

Chromatin : DNA + non histone proteins.

Chromosomes (on basis of position of centromere) :

Metacentric : Middle centromere.

Sub-metacentric : Centromere nearer to one end of chromosome.

Acrocentric : Centromere situated close to its end.

Telocentric : Has terminal centromere.

Satellite : Some chromosomes have non-staining secondary constrictions at a constant location, which gives the appearance of small fragment called satellite.

Differences between prokaryotic and eukaryotic cell

Prokaryotic cell	Eukaryotic cell
It is a single membrane system.	It is a double membrane system.
Cell wall surrounds the plasma membrane.	Cell wall surrounds the plasma membrane in some protists, most fungi and all plant cell. Animal cell lacks it.
Cell wall is composed of peptidoglycans. Strengthening material is murein.	It is composed of polysaccharide. Strengthening material is chitin in fungi and cellulose in other plants.
Cell membrane bears respiratory enzymes.	It lacks respiratory enzymes.
Cytoplasm lacks cell organelles *e.g.*, Mitochondria, ER, Golgi body etc.	Cytoplasm contains various cell organelles.
Ribosomes are only 70 S type.	Ribosomes are both 80 S and 70 S type.
There are no streaming movements of cytoplasm.	Cytoplasm show streaming movements.
Nuclear material is not enclosed by nuclear envelope and lies directly in cytoplasm. It is called nucleoid.	It is enveloped by nuclear envelope. Nucleus is distinct from cytoplasm.
DNA is circular and not associated with histone proteins.	Nuclear DNA is linear and associated with histone proteins extranuclear DNA is circular and histone protein free.
Sexual reproduction absent but parasexuality present.	Sexual reproduction is present.
Cell division mostly amitotic.	Cell division is typically mitotic.

Protoplasm (Proto = first, plasm = fluid)

Protoplasm is a complex, granular, elastic, viscous and colourless substance. It is selectively or differentially permeable. It is considered as "Polyphasic colloidal system".

Discoveries

(1) J. Huxley defined it as "physical basis of life".

(2) *Dujardin* (1835) discovered it and called them "sarcode".

(3) Purkinje (1837) renamed it as "Protoplasm".

(4) *Hugo Von Mohl* (1844) gave the significance of it.

(5) *Max Schultz* (1861) gave the protoplasmic theory for plants.

(6) *Fischer* (1894) and *Hardy* (1899) showed its colloidal nature.

(7) *Altman* (1893) suggested protoplasm as granular.

Table : 3.1-4 Chemically composition

Water	75 – 85%	Carbon	20%
Proteins	10 – 25%	Oxygen	62%
Lipids	2 – 3%	Hydrogen	10%
Inorganic materials	1%	Nitrogen	3%
Trace elements 5% (*Ca, P, Cl, S, K, Na, Mg, I, Fe* etc.)			

Maximum water content in protoplasm is found in hydrophytes, *i.e.*, 95% where as minimum in seeds, spores (dormant organs) *i.e.*, 10 – 15%. In animals water is less (about 65%) and proteins are more (about 15%).

Enzymes of Mitochondria

(1) **Outer membrane :** Monoamine oxidase, glycerophosphatase, acyltransferase, phospholipase A.

(2) **Inner membrane :** Cytochrome b,c_1,c,a, (cyt.b, cyt.c_1, cyt.c, cyt.a, cyt.a_3) NADH, dehydrogenase, succinate dehydrogenase, ubiquinone, flavoprotein, ATPase.

(3) **Perimitochondrial space :** Adenylate kinase, nucleoside diphosphokinase.

(4) **Inner matrix :** Pyruvate dehydrogenase, citrate synthase, aconitase, isocitrate dehydrogenase, fumarase, α – Ketoglutarate dehydrogenase, malate dehydrogenase.

Origin : Mitochondria are self-duplicating organelles due to presence of DNA molecules so new mitochondria are always formed by growth and division of pre-existing mitochondria by binary fission.

Functions

(1) Mitochondria are called power house or storage batteries or ATP mills formation of ATP is called oxidative phosphorylation.

(2) Intermediate products of cell respiration are used in the formation of steroids, cytochromes, chlorophyll, etc.

(3) These are also seat of some amino acid biosynthesis.

(4) Mitochondria also regulate the calcium ion concentration inside the cell.

Shape : Plastids

Shape	Example
Cup shaped	*Chlamydomonas sp.*
Stellate shaped	*Zygnema.*
Collar or girdle shaped	*Ulothrix*
Spiral or ribbon shaped	*Spirogyra*
Reticulate/net like	*Oedogonium*
Discoid	*Voucheria*
Spherical	*Chlorella*
Biconvex/ovoid	Angiosperm

Table : 3.1-5 Difference between cilia and flagella

Cilia	Flagella
More in number (may be upto 14,000 per cell).	Less in number (1-8).
Small sized (5-10 μm).	Large sized (upto 100-200 μm).
Generally distributed on whole body.	Generally located at anterior end of body.
Beat in either metachronous or synchronous coordination.	Beat independently.
Sweeping or rowing motion.	Undulatory motion.
Locomotion, feeding, circulation, etc.	Only locomotion.

Cytoskeleton

In eukaryotic cell, a framework of fibrous protein elements became necessary to support the extensive system of membranes. These elements collectively form cytoskeleton of the cell. There are of three types.

(1) **Microtubules :** These were first discovered by De Robertis and Franchi (1953) in the axons of medullated nerve fibres and were named neurotubules. The term was coined by Slautterback (1963).

Position : The microtubules are electron-microscopic structures found only in the eukaryotic cellular structures like cilia, flagella, centriole, basal-body, astral fibres, spindle fibres.

Structure : A microtubule is a hollow cylindrical structure of about 250 Å in diameter with about 150 Å luman. Its wall is about 50Å thick. Its walls is formed of 13 parallel, proto-tubules.

Chemical composition : These are mainly formed of tubulin protein. A tubulin protein is formed of 2 sub-units : α – tubulin molecule and β – tubulin molecule which are alternatively in a helical manner.

Functions

(1) These form a part of cytoskeleton and help in cell-shape and mechanical support.

(2) The microtubules of cilia and flagella help in locomotion and feeding.

(3) The microtubules of asters and spindle fibres of the mitotic apparatus help in the movement of chromosomes towards the opposite poles in cell-division.

(2) **Microfilament**

Discovery : These were discovered by Paleviz et. al. (1974).

Position : These are electron-microscopic, long, narrow, cylindrical, non-contractile and proteins structures found only in the eukaryotic cytoplasm. These are present in the microvilli, muscle fibres (called myofilaments) etc. But these are absent in prokaryotes.

Structure : Each microfilament is a solid filament of 50-60 Å diameter and is formed of a helical series of globular protein molecules. These are generally grouped to form bundles.

Chemical composition : These are mainly formed of actin-protein (contractile).

Functions

(1) The microfilaments forms a part of cytoskeleton and change the cell shape during development, motility and division.

(2) The microfilaments bring about directed movements of particles and organelles along them in the cell.

(3) The microfilaments also produce streaming movements of cytoplasm.

(4) The microfilaments are responsible for the movement of cell membrane during endocytosis and exocytosis.

(3) **Intermediate filaments**

Location : They are supportive elements in the cytoplasm of the eukaryotic cells. They are missing in mammalian RBCs.

Structure : The IFs are somewhat larger than the microfilaments and are about 10 *nm* thick. They are solid, unbranched and composed of nonmotile structural proteins, such as keratin, desmine, vimentin.

Functions

(1) They form a part of cytoskeleton that supports the fluid cytosol and maintains the shape of the cell.

(2) They provided strength to the axons.

(3) They keep nucleus and other organelles in place.

A R Assertion & Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) *If both the assertion and the reason are true and the reason is a correct explanation of the assertion*

(b) *If both the assertion and reason are true but the reason is not a correct explanation of the assertion*

(c) *If the assertion is true but the reason is false*

(d) *If both the assertion and reason are false*

(e) *If the assertion is false but reason is true*

1. Assertion : The number of mitochondria in a cell do not correspond to the function of the cell.

Reason : Mitochondria are common to both plant and animal cells. **[KCET 2006]**

2. Assertion : Mitochondria and chloroplasts are semiautonomous organelles.

Reason : They are formed by division of pre-existing organelles as well as contain DNA but lack protein synthesizing machinery **[AIIM 2005]**

3. Assertion : A cell membrane shows fluid behaviour.

Reason : A membrane is a mosaic or composite of diverse lipids and proteins. **[AIIMS 2003]**

4. Assertion : Lysosomes help in photorespiration.

Reason : Lysosome have basic enzyme. **[AIIMS 1999]**

5. Assertion : Na^+- K^+ ATPase is an important membrane associated enzyme.

Reason : It helps in ion transfer across the membrane.

6. Assertion : The number of cells in a multicellular organism is inversely proportional to the size of body.

Reason : All the cells in the biological world are of same size. **[AIIMS 2002]**

7. Assertion : It is important that the organisms should have cell.

Reason : A cell keeps its chemical composition steady within its boundary. **[AIIMS 2002]**

8. Assertion : Leucoplasts give rise to other types of plastids.

Reason : Chromoplasts do not get changed to other types of plastids.

9. Assertion : Cell wall is not found in animal cell.

Reason : Animal cells are covered by cell membrane. **[AIIMS 2001, 13]**

10. Assertion : ER acts as a circulatory system.

Reason : ER functions as cytoskeleton.

11. Assertion : Eukaryotic cells have more DNA than prokaryotic cells.

Reason : Eukaryotes are genetically more complex than prokaryotes. **[MP PMT 1993]**

12. Assertion : Schleiden and Schwann were the first to observe the cells and to put forward cell theory.

Reason : The cells are always living unit. **[AIIMS 1994]**

13. Assertion : Cell membrane is semipermeable.

Reason : The constituent molecules can freely move in the membrane. **[AIIMS 1994]**

14. Assertion : Mitochondria is known as power house of cell.

Reason : ATP production takes place here. **[AIIMS 2000]**

Assertion and Reason

1	e	2	c	3	a	4	d	5	a
6	d	7	a	8	b	9	a	10	b
11	a	12	d	13	b	14	a		