Text 1

THE EARLY EARTH AND THE BUILDING BLOCKS OF LIFE

The Earth was formed about 4.5 billion years ago from the swirling dust and gas remnants of an old star's supernova explosion. As the molten mass settled and cooled, a solid crust soon formed, probably within as little as about 150 million years, along with a rudimentary atmosphere composed largely ofcarbon dioxide, water vapour and nitrogen.

After a near-catastrophic collision with another planet soon after the Earth's formation (which created the Moon in the process), it is thought that warm oceans gradually formed, from steam escaping from the crust and from volcanic activity and icy meteorites, relatively soon after the Earth's formation, perhaps within 750 million years of Earth's formation (about 3.8 billion years ago).

Although the environment at that time (including the constant bombardment by asteroids and prodigious volcanic activity) would have been highly hazardous to life, the necessary ingredients were all present in some form or another: liquid water, chemical building blocks (usually taken to be the six elements: oxygen, hydrogen, carbon, nitrogen, sulphur and phosphorus) and some kind of energy source.

Liquid water is considered essential to the initial development of life because many chemicals dissolve easily in water allowing them to mix together and react, because liquid water is the right temperature for chemical reactions to happen, and also because many chemicals have parts which are attracted to water and parts which are repelled by it (which also helps reactions happen). Carbon is important because of its ability to form long chain-like molecules (carbon chains form the backbone of organic molecules). Hydrogen and oxygen (the two elements that make up water molecules) as well as nitrogen can all bond with carbon in many different ways, and large molecules made from carbon, hydrogen, oxygen and nitrogen also tend to be very stable. All chemical reactions need an energy source to drive them, whether it be ultraviolet light from the Sun or electrical energy from lightning or chemical energy from deep-sea vents, all of which would have been available on the early Earth.

Cyanobacteria (also known as blue-green algae), one of the earliest types of prokaryotic bacteria, formed into colonies or mats called stromatolites, and fossilized remains of these have been found in Australia dating back to between 3.4 and 2.8 billion years ago. Ancient as their origins are, these bacteria (which are still around today) were already biologically complex, with cell walls protecting their protein-producing DNA, so scientists think it is likely that life actually began much earlier, perhaps as early as 3.8 billion years ago.

These early cyanobacteria were the first oxygen-producing, evolving, phototropic organisms, and they were responsible for the initial oxygenation of the Earth's atmosphere, as they produced oxygen while sequestering carbon dioxide in organic molecules during the period from 2.7 to 2.2 billion years ago. Photosynthesizing plants evolved later and continued this process, leading to the build up of increasing levels of oxygen in the atmosphere, as well as the release of nitrogen into the atmosphere as the oxygen reacted with ammonia. Eventually, a layer of ozone (an allotrope of oxygen) formed in the atmosphere, which better protected early lifeforms from ultraviolet radiation. While oxygen was apparently not needed for the origination of life on Earth (indeed it is thought by many scientists that the absence of oxygen was a necessary condition), the rapid explosion of life began only after oxygen became abundant.

The first eukaryotic cells (organisms with one or more complex cells, each of which contains a nucleus and is surrounded by a membrane that holds the cell's genetic material) evolved sometime between 2.5 and 1.7 billion years ago, perhaps coincident with the rise in atmospheric oxygen to a level able to support this more complex life. The nucleus in these cells was able to hold and protect complex molecules such as RNA and DNA.

As recently as the 1970s, a whole new group of single-celled organisms known as archaea was discovered, which is now recognized as a third domain of life, completely separate from both prokaryotes and eukaryotes. Many scientists believe archaea to be the common ancestor of both prokaryotes and eukaryotes, and as such may represent the oldest form of life on earth.

Throughout the Proterozoic era, from about 2.3 billion years ago until around 600 million years ago, life on Earth was mostly single-celled and small, consisting of bacteria, archaea and eukaryotic algae. The first multi-cellular life probably arose around 1.2 billion years ago, in geological terms almost overnight, while the landmass of the Earth was still a single continent called Rodinia. It presumably started out as a sort of symbiosis, a loose cooperation between single cells that gradually became more and more complex. Recent research on single-celled organisms called choanoflagellates has yielded the rather surprising fact that single-celled organisms began communicating with each other (and effectively working together as a single unit) due to a random mutation in a single gene, a fascinating illustration of how a tiny genetic change can have huge repercussions. Evolution appeared to speed up again about 550 million years ago with the sudden appearance of the first hard-bodied animals in the fossil record.

I. Answer the questions:

1. What are the necessary "ingredients" for life?
2. Why is liquid water considered essential to the initial development of life?
3. Why were cyanobacteria responsible for the initial oxygenation of the Earth's atmosphere?
4. When did the first eukaryotic cells evolve?
5. What do scientists believe to be the common ancestor of both prokaryotes and eukaryotes?
6. When did the first multi-cellular life arise? How did it start?

II. Prove that cyanobacteria were already biologically complex between 3.4 and 2.8 billion years ago.

III. Summarize the main ideas of the text.

Text 2
CELL MEMBRANE STRUCTURE

Cell membrane is the outer covering of a cell that protects the internal organelles. Otherwise known as plasma membrane, it carries out various vital functions.

It is a common fact that cells are the fundamental building blocks of life. A cell forms the basic structural and functional unit of any living thing. While some organisms, like bacteria are single-celled, most of the other living things are multicellular. In case of multicellular organisms, there are various types of cells, which are assigned with different tasks. As the functions of different types of cells vary, the individual parts of a cell too have their own tasks.

There are two types of cells – eukaryotic and prokaryotic.

Plants, animals, fungi, protozoans, etc. possess eukaryotic cells, prokaryotic cells are found in bacteria only. Eukaryotic cells are concerned, the basic structure includes parts like DNA, ribosomes, vesicles, endoplasmic reticulum (both rough and smooth), Golgi apparatus, cytoskeleton, mitochondria, vacuole, centrioles, lysosome, cytoplasm, plasma membrane and cell wall.

Plant cells have a large vacuole and a definite cell wall, animal cells lack cell wall but some may have very small vacuoles. So in case of animal cells, cell membrane is the outermost covering.

Otherwise known as plasma membrane or plasmalemma, the cell membrane is one of the vital parts of a cell that encloses the internal organelles. This membrane separates the interior of a cell from the outside environment.

A cell membrane physically separates the contents of the cell from the outside environment, but in plants, fungi and some bacteria, there is a cell wall that surrounds this membrane. However, the cell wall acts as a solid mechanical support only. The actual function of cell membrane is the same in both cases and it is not much altered by the mere presence of a cell wall.

Phospholipids

The cell membrane is made of two layers of phospholipids and each phospholipid molecule has a head and a pair of tails. The head region is hydrophilic (attraction towards water molecules) and the tail ends are hydrophobic (stays away from water molecules). Both layers of phospholipids are arranged in such a manner that the head regions form the outer and inner surface of this membrane and the tail ends come close to the center of the cell membrane.

The cell membrane houses different types of protein molecules, which are embedded in the phospholipid layer. Most of these protein molecules as well as the phospholipids are capable of lateral movement.

Membrane Proteins

Membrane proteins can be classified into three main subdivisions – integral, peripheral and lipid-anchored proteins. The integral ones span the entire width of the cell membrane, whereas peripheral ones are found on its inner or outer surfaces. Those in the third category are found anchored to the membrane with the help of lipid molecules.

While some of these protein molecules provide structural support to the membrane, some others are attached to the cytoskeleton that is suspended in the cytoplasm. There are certain proteins that are responsible for transportation of ions and molecules across the cell membrane. Some of these proteins have other functions, like cell to cell communication, identification, enzymatic activities and signaling.

The main components of the cell membrane are phospholipids and proteins. However, it has cholesterol molecules that make the membrane rigid and flexible. They also make it difficult for water soluble substances to pass through the membrane. On the outer surface of the cell membrane, glycolipids and glycoproteins are found. They are nothing other than lipids and protein molecules attached to short chain carbohydrates. All these components work jointly to carry out the cell membrane functions.

I. Answer the questions:

1. What is the main function of the cell membrane?
2. What are two types of cells? Where are eukaryotic cells found?
3. What is the difference between plant and animal cells?
4. What is the structure of phospholipid molecule? In what manner are the layers of phospholipids arranged?
5. How can membrane proteins be classified? What are their main distinctions?
6. What other components does the cell membrane have?

II. Write an annotation of the text.

Text 3
WHAT DOES A CELL MEMBRANE DO?

Anchors the Cytoskeleton

A cell membrane works as an enclosure for the internal organelles and protects them. This function is very vital in animal cells, which lack cell wall. This membrane anchors the cytoskeleton (a cellular “skeleton” made of protein and contained in the cytoplasm) and gives shape to the cell.

The microfilaments of the cytoskeleton are attached to certain proteins in the cell membrane, especially the integral ones. It has also been suggested that these microfilaments hold the proteins in place, as the latter have the tendency to move.

Cellular Transport

The cell membrane is responsible for the transportation of molecules and ions in and out of the cell. The membrane being semipermeable, allows certain molecules to move freely across it. Most of the small hydrophobic (no affinity for water) molecules pass through this membrane freely. Some of the tiny hydrophilic molecules may also succeed. But others have to be carried across the membrane.

Movements of molecules across the membrane may or may not require use of cellular energy. Such movements across the plasma membrane can be divided into three types – passive, active and bulk transport.

Passive Transport does not require the cells to spend any energy. It can happen in the form of simple diffusion, facilitated diffusion or osmosis. Simple diffusion refers to the movement of molecules through a membrane, from an area of higher concentration to another with lower concentration. Such movement continues till both the sides have a uniform concentration.

There are certain factors that affect the rate of passive or simple diffusion. A faster movement can be noticed, in case of a vast difference in concentration (between the inner and outer sides) or if the temperature is high.

The smaller the molecules, the faster they can cross the membrane. In case of osmosis too, water (solvent) moves through a semipermeable membrane, in case one side of the membrane has a higher solute concentration (solute is substance dissolved in a liquid solvent) than the other. In this case, the movement of solvent molecules is from the less concentrated solution to a more concentrated part. Osmosis is also a form of passive diffusion.

A type of passive transport is facilitated diffusion. In facilitated diffusion, the molecules pass through the channels in certain transport proteins. Even this type of diffusion does not require any energy. However, if the molecules to be carried are too large or the intended movement is against the gradient (from low concentration to high), then energy has to be spent. In such cases, the molecules/ions are identified by certain proteins, before they are transported across the plasma membrane, by another set of proteins which derive energy from ATP and this is called active transport. In this type of transport, the proteins are really selective and specific. These transport proteins have openings on one end, through which the molecules or ions enter and get attached to the functional groups inside the protein. The transport proteins derive energy from ATP and change their shape to release the molecule on the other side of the cell membrane.

Bulk transport is often done with the help of vesicles. The transportation of materials out of the cells is called exocytosis. If the transportation is from outside to inside, the process is called endocytosis, which can be of three types – phagocytosis, pinocytosis and receptor-mediated.

In endocytosis, the plasma membrane creates a small depression (pseudopodium), into which the materials to be transported are gathered, to form a vesicle. The vesicle is moved to the inner surface of the cell membrane and is later merged with the Golgi apparatus.

The phagocytosis is transport of solids, pinocytosis refers to movement of liquids that are carried inside vesicles. Receptor-mediated endocytosis is a complex form, wherein receptor proteins in the membrane bind to the materials to be transported. Only specific molecules/ions can be transported through this method.

In case of exocytosis, the vesicles move to the inner surface of the plasma membrane, pass through it and open outside, so that the contents are released outside the cell. The ruptured vesicles merge with the plasma membrane. Apart from transporting materials outside the cell, exocytosis is also helpful in restoring the plasma membrane. The vesicles for exocytosis are either formed from the endoplasmic reticulum or the Golgi complex. These vesicles filled with materials to be expelled, are transported from the inner regions to the periphery, with the help of cytoskeleton.

Cellular transport is one of the vital plasma membrane functions. Apart from providing support to the cytoskeleton and transporting molecules and ions, cell membranes have various other functions too.

Interaction with other cells: The membrane is also responsible for attaching the cell to the extracellular matrix (non-living material that is found outside the cells), so that the cells can group together to form tissues.

Communication with other cells: The protein molecules in the cell membrane receive signals from other cells or the outside environment and convert the signals to messages that are passed to the organelles inside the cell.

Undertakes Metabolic Activities: In some cells, certain protein molecules group together to form enzymes, which carry out metabolic reactions near the inner surface of the cell membrane.

This is only a brief overview about cell membrane functions and structure. In short, cells are microscopic, but are highly evolved to perform these complex tasks. In case of humans, an average adult has about 100 trillion cells in the body. It is the smooth functioning of these cells that keeps the person healthy.

I. Answer the questions:

1. What is the cytoskeleton?
2. What are the factors that affect the rate of passive or simple diffusion?
3. What is facilitated diffusion?

II. Name and define the three types of cellular transport.

III. Explain the difference between exocytosis and endocytosis.

IV. Name other functions cell membranes have apart from providing support to the cytoskeleton and transporting molecules and ions.

V. Summarize the main ideas of the text.

Text 4
SIMILARITIES BETWEEN PLANT AND ANIMAL CELLS

Both animal and plant cells are eukaryotic cells and have several similarities. The similarities include common organelles like cell membrane, cell nucleus, mitochondria, endoplasmic reticulum, ribosomes and golgi apparatus.

Cell Membrane

Also known as plasma membrane, this membrane is the outermost limiting membrane of the cell that encompasses all the cell contents. This membrane is formed from proteins and lipids and acts as an interface between the cell organelles dunked in the cytoplasm inside the cell and the extracellular fluid on the cell's exterior, which bathes all the cells. It is a semi-permeable membrane and permits the passage of selective substances from the exterior to the interior of the cell and vice versa. Besides this main membrane, the cell also features elaborate network of internal membranes which envelop the different cell organelles, forming several membrane-enclosed compartments within the cell.

Cell Nucleus

The hallmark of a eukaryotic cell is the presence of a membrane-bound nucleus. The very term "eukaryotic" means possessing a "true nucleus". Plants and animal cells have a nucleus, which is a spherical body containing several organelles, nucleolus and chromosomes consisting of DNA. The nucleus is enveloped by a nuclear membrane, which keeps the contents of the nucleus from dissipating into the cytoplasm of the cell. The nucleus controls various functions of the cell by controlling protein synthesis.

Mitochondria

These are cell organelles enclosed by membranes and are scattered in the cytoplasm of the cell. Mitochondria features an outer membrane that encloses the entire structure and an inner membrane that encloses a fluid-filled matrix. The inner membrane features shelf-like cristae projecting into the matrix. It also possesses some 5–10 circular molecules of DNA. Mitochondria are cells responsible for production of energy in the form of ATP. Thus, they are also known as the powerhouse of the cell. Their numbers vary from a few hundreds to a few thousands in a cell, depending on how active the cell is. Mitochondrial cells can increase their number by a process of fission and can reduce their numbers by fusing together.

Endoplasmic Reticulum (ER)

It is an extensive membranous labyrinth, which accounts for half the total membrane in eukaryotic cells. The term "endoplasmic" means within the cytoplasm and "reticulum" refers to network. ER consists of a network of membranous sacs and tubules called cisternae. There are two types of ER – rough ER and smooth ER. Rough ER is the endoplasmic reticulum that has a bumpy appearance due to the presence of ribosomes attached to them. The smooth ER does not have ribosomes adhering to them. Rough ER is responsible for protein synthesis, while the smooth ER synthesizes lipids and is responsible for carbohydrate metabolism and detoxification of drugs and other poisons.

Ribosomes

These are small, spherical, non-membranous organelles composed of ribonucleic acid (RNA). Ribosomes comprise 65 % ribosomal RNA and 35 % ribosomal proteins. They are responsible for protein synthesis and are sites where the cell assembles proteins in accordance with the genetic instructions obtained. Cells which have high protein synthesis rate feature the presence of a large number of ribosomes. Ribosomes are found scattered in the cytoplasm as well as adhering to the outer portion of the endoplasmic reticulum.

Golgi Apparatus

These are stacks of cisternae (flattened sacs of unit membrane) that are mainly devoted to processing the proteins formed in the ER. Their job is to transform proteins into more complex molecules. The Golgi complex also contains a large number of vesicles, which are used to send molecules to the cellular membrane, where excretion is carried out. The Golgi apparatus is mostly responsible for molecular traffic direction in the cell.

Vacuole

Found in all plant cells and most animal cells, vacuoles are fluid-filled sacs present in the cytoplasm of cells that have no definite shape or size. Their main function is storage; storing gases, fluid, nutrients, poison, waste material, etc. Vacuoles function differently in plant and animal cells. They carry out a large number of different functions right from excretion of wastes, to inter-cellular digestion, maintaining turgor pressure, cell pH, etc. In plant cells, the vacuoles are large and in fully-grown plants, only a single large vacuole is seen. However, in animal cells, several small vacuoles are present. Therefore, even though both animal and plant cells have vacuoles, they have a lot of differences.

Besides these similarities, plant and animal cells have a few differences. For example, plant cells include a cell wall that surrounds the cell membrane, thereby making the cells in plants sturdier. They also contain chloroplasts which capture sunlight for photosynthesis and a large central vacuole for water storage. Animal cells contain organelles called centrioles, responsible for animal cell division, which are not found in plant cells. Moreover, animal cells also possess lysosomes that perform the same role as the vacuole in the plant cell.

I. Answer the questions:

1. What similarities do animal and plant cells include?
2. How does cell membrane act?
3. What is the function of cell nucleus?
4. What do mitochondria feature? What are mitochondria responsible for?
5. What does the term “endoplasmic” mean?
6. Where are ribosomes found?
7. What does the Golgi complex contain?
8. What is the difference between vacuoles functioning in plant and animal cells?

II. Define the two types of endoplasmic reticulum. What are rough ER and smooth ER responsible for?

III. Write an annotation of the text.

Text 5
CELL NUCLEUS

In cell biology, the cell nucleus, or simply nucleus, is the center of the activities in a cell. Let us discuss the main function of this important organelle.

Any body, be it a plant or animal, is made up of millions of tiny structures known as cells. Cells are the tiniest part of a body, invisible to the naked eye and can be seen only with the help of a microscope. In a human body, there are approximately about 100 trillion or 10^{14} cells. As we know there are two types of cells – eukaryotic cells and prokaryotic cells. The difference between these cells is that prokaryotic cells lack a cell nucleus, whereas, eukaryotic cells have a well-defined nucleus.

The nucleus was said to be discovered by a renowned Scottish botanist Robert Brown, who described this part observed in plant cells, through a microscope, as an opaque spot. This theory was later researched and developed by Antonie Philips van Leeuwenhoek, who is known as the father of microbiology. The word nucleus is taken from the Latin word nucleus, which means "centre" or "kernel". If we observe the structure and functions of the nucleus we can see that it contains genetic material and is the largest organelle in the cell. The nucleus is covered by a nuclear membrane, which separates it from other organelles in the cell. This part is the most important component of a cell.

All the cells in an eukaryotic organism have a single nucleus. But there are a few exceptions like the paramecium, a microscopic organism which has two nuclei (plural for nucleus) and some molds which have many nuclei. Interestingly, the human red blood cells do not have a nucleus.

The nucleus is spherical in shape and is located in the cytoplasm of the cell. It is separated from the rest of the cell organelles with a nuclear envelope or nuclear membrane. This membrane protects the DNA and other genetic material present inside the nucleus.

The nucleus size is measured in microns or micrometers and is approximately 1.7 µm.

The main function of this cell organelle is storing the chromatins, which are strands of the DNA and which carry the genes. There are a total of 46 chromosomes in a cell. This cell organelle is also the site for protein synthesis, where the messenger RNA (mRNA) undergo transcription. This process is known as gene expression.

Nucleus plays a vital role in the production of ribosomes, which synthesize proteins from amino acids. The ribosomes also convert genetic information obtained from RNA to proteins. These ribosomes are secreted by the nucleolus.

The nucleus also acts as a storehouse for genetic information to be transferred, by the process of meiosis (where the number of chromosomes is divided into half), to the coming generations.

The metabolism of nutrients and the release of energy in the cells takes place in the nucleus. The cell cycle is controlled by the nucleus and it also takes care of the wear and tear of the genetic material.

There is a nuclear pore complex present in the nucleus which helps in transportation of the molecules of protein through the nuclear membrane.

Sometimes playing a role as "the brain of the cell', the nucleus also assists in controlling actions like eating, movement, and reproduction.

I. Answer the questions:

1. What is the difference between eukaryotic cells and prokaryotic cells?
2. What does the word "nucleus" mean?

3. What is the most important component of a cell?

4. What is the main function of nuclear membrane?

II. Give the definition of gene expression.

III. Define the main functions of nucleus.

IV. Summarize the main ideas of the text.

Text 6
FUNCTIONS OF LYSOSOMES

Lysosomes are specialized membrane-bound vesicles that contain enzymes for molecular digestion. Owing to these enzymes, they play a major role in recycling of molecules, disposal of cellular debris, cell membrane repair, phagocytosis as well as programmed cell death.

Lysosomes are spherical, membrane-bound organelles present in the cytoplasm of animal cells. Plant cells rarely contain lysosomes. The word *lysosome* is derived from the two Greek words – *lysis* (destruction) and *soma* (body). These spherical organelles are bound by a phospholipid bilayer and are about 0.2 to 2 μm in diameter. This membrane-bound interior has a pH of 4.8 and contains a set of lytic enzymes called hydrolases, which can collectively digest almost any type of macromolecule. Proteins, lipids, polysaccharides, DNA, RNA, etc., can be hydrolyzed by these enzymes inside the acidic interior of the lysosomes.

Lysosomes are polymorphic and exist as primary, secondary, autophagic and secretory lysosomes. The breakdown of unwanted macromolecules is the main function of these organelles. In addition, they are also involved in cell membrane repair and play a major role in the immune response against foreign bodies like bacteria, viruses and other antigens.

Autophagy

Autophagy is the intracellular process by which the cell degrades its own components using the lysosomal machinery and recycles the molecules. Damaged macromolecules, malformed proteins, non-functional, long-lived proteins, and damaged and old organelles are all broken down by the lysosomal enzymes. A phospholipid membrane is formed around the target component, resulting in the formation of a vesicle called autophagic vacuole. This vacuole then fuses with the primary lysosome where the hydrolases digest the macromolecules to sugars, amino acids and nucleotides, which are the primary building blocks of every cell. These useful digestion products are released into the cytosol and can be utilized in the synthesis of new macromolecules and organelles, whereas the unwanted products are released outside the cell. Also during starvation, or nutrient-limiting conditions, autophagy of normal organelles occurs, thus helping to maintain the level of nutrients required for the normal cellular processes.

Role in Endocytosis and Phagocytosis

Endocytosis is the process for cellular uptake of foreign material. Phagocytosis is a specialized form of endocytosis wherein large bodies such as dead cells, cell debris, bacteria, viruses, etc., are engulfed. The uptake occurs through specialized vesicles which fuse with the lysosomes followed by the degradation of the foreign entity by hydrolases. Directly or indirectly, both these processes play a crucial role in pathogen destruction.

Role in Apoptosis

Apoptosis or programmed cell death is a very intricately controlled mechanism of cellular suicide. Such a mechanism is essential during embryonic development and for destruction of old cells, infected cells and cells with DNA damage. Apoptosis is initiated through various pathways in a cell, one of them being lysosome-mediated apoptotic pathway. Certain proteases present in lysosomes have been identified as one of the initiators for such cell death. These proteases lead to a series of signals and events characterized by breakdown of the cellular components. These components are packed into vesicles termed apoptotic bodies which are engulfed by neighboring cells. The lysosomes of the neighboring cells bring about the residual digestion of these components.

Role in Fertilization

Lysosomes are also capable of releasing their digestive enzymes outside the cell to bring about extracellular digestion. During fertilization, the lysosomal contents of sperms are released outside the cell in order to bring about the digestion of the limiting membrane around the egg. This facilitates fusion of the sperm and egg. In addition to this, once the two cells fuse, the paternal mitochondria are destroyed through the lysosomal machinery of the egg. Sperm-derived mitochondria tend to accumulate genetic mutations due to the high metabolic activity of sperms. Hence, they need to be eliminated from the fused cell to avoid the transfer of mutations to the resulting embryo.

Cell Membrane Repair

Conditions of mechanical stress and pathogenic actions can lead to disruption of certain patches or formation of pores in the cell membrane. The secretory lysosomes fuse with the cell membrane at a location close to the damaged patch. This results in the release of hydrolases outside the cell. Of these hydrolases, a specialized hydrolase called acid sphingomyelinase (ASM) causes the internalization of damaged patch by the cell. Moreover, the fusion of the lysosome with the membrane provides extra lipids and prevents constriction of the cellular boundary.

Lysosomal malfunction leads to about 50 different types of rare inheritable metabolic disorders. New ones continue to be identified.

Defective or missing digestive enzymes lead to the accumulation of substrates within the cell, thus impairing metabolism. Such deficiency or dysfunction of lysosomal enzymes results in several inheritable metabolic disorders that are collectively termed as lysosomal storage diseases.

Lysosomal storage diseases are characterized by the presence of abnormally enlarged lysosomes containing accumulated undigested cellular components. The components or macromolecules that accumulate depends on the specific enzyme that is dysfunctional. Pompe disease, Tay-Sachs disease, mucopolysaccharidosis (MPS), and Gaucher’s disease are some examples. In some cases, symptoms like short stature, bone deformities, cardiac and respiratory difficulties, enlarged head, liver and spleen, etc., are observed at birth. However, in some cases, the onset of the disease occurs at a later age and various organs are affected depending on the type of disease. The life expectancy is highly variable and those with severe forms may survive up to 5–10 years of age. These diseases are currently incurable and the treatments available mostly lessen the symptoms.

I. Answer the questions:

1. What are the main functions of lysosomes?
2. What does lysosomal malfunction lead to?

II. Give the definition of lysosomes. What language is the word *lysosome* derived from?

III. Choose any function of lysosomes and try to explain it in detail.

IV. Give examples of lysosomal storage diseases and name their symptoms.

V. Summarize the main ideas of the text.

Text 7
STRUCTURE AND FUNCTIONS OF CYTOPLASM

The cytoplasm is the fluid that occupies and fills the space inside a cell. The gel-like cytoplasm contains and holds the various organelles of the cell in place. It is a thick, gelatinous, semitransparent fluid present in both eukaryotic and prokaryotic cells. It is enclosed in the plasma membrane. The cytoplasm has three major components – the cytosol, organelles, and cytoplasmic inclusions.

Cytosol

The cytosol is the part of cytoplasm that is not occupied by any organelle. It is a gelatinous fluid, where other components of the cytoplasm remain suspended. It mainly consists of cytoskeleton filaments, organic molecules, salt, and water. Cytoskeleton filaments are the protein filaments. The cytoskeleton consists of structures called “microfilaments” and “microtubules” that form a skeletal network, thereby giving shape to the cell and holding the various organelles in place.

Microfilaments are thin fibers made up of actin polymers. They facilitate the movement of substances inside a cell. Microtubules are hollow cylindrical structures made up of tubulin polymers. They assist the movement of different organelles, and play a crucial role in cell division by aiding the movement of chromosomes in the nucleus during mitosis. The cytosol also contains enzymes, fatty acids, sugar, and amino acids. The cytosol accounts for almost 70 % of the total cell volume.

Organelles

Organelles are a group of small structures that remain suspended in the cytoplasm and perform a variety of functions. The structure of some of the major organelles found in the cytoplasm is:

Endoplasmic Reticulum (ER)

Mitochondrion

It is termed as the “power house” of a cell. It is a double membrane-bound structure that can be found in most eukaryotic cells. The function of this organelle is to produce and store energy in the form of adenosine triphosphate (ATP) molecules, which are generated by using the chemical energy derived from food.

Ribosomes

Ribosomes are usually found either floating in the cytosol, or attached to the membrane of the rough endoplasmic reticulum. There are two major components of a ribosome – the small ribosomal subunit and the large subunit. The small subunit is responsible for reading the mRNA, while the large subunit attaches the amino acid molecules to form polypeptide chains. Ribosomes are the site of protein synthesis.

Chloroplast

The chloroplast is a specialized organelle found in plant and algal cells. It is mainly concerned with conducting photosynthesis. The pigment chlorophyll present in chloroplasts captures energy from sunlight and convert it to organic molecules. Apart from carrying out photosynthesis, this specialized organelle is concerned with the production of amino acids and fatty acids.

Cytoplasmic Inclusions

They consist of different types of insoluble particles or molecules that remain suspended in the cytosol. Cytoplasmic inclusions are not surrounded by any membrane. They are basically granules of starch and glycogen, and they can store energy. Crystals of some minerals and lipid droplets can also be found in the cytoplasm. Lipid droplets are composed of lipids and proteins, and they help store fatty acids and steroids in the cell.

Cytoplasmic inclusions can contain substances that need to be excreted from the cell by the process of “exocytosis”. The stored nutrient molecules present in these inclusions are taken up and used by the cell whenever needed. The inclusions may include minerals like silver and lead as well. In humans, they contain the pigment “melanin” that protects the skin from the ultraviolet rays of the sun.

Functions of the Cytoplasm

The cytoplasm acts as the medium where various organelles can remain suspended at their proper places with the help of cytoskeletal fibers.

Besides giving shape to the cell, the cytoskeleton facilitates the movement of the cell and the different substances found within the cell.

The enzymes present in the cytoplasm help breakdown the macromolecules so that they can be used by various organelles. For example, mitochondria cannot use glucose present in the cell, unless it is broken down by the enzymes into pyruvate. The enzymes act as catalysts in glycolysis, as well as in the synthesis of fatty acid, sugar, and amino acid.

Several crucial biochemical reactions and cellular activities take place in the cytoplasm. The cytoplasm is the site of vital functions like cell reproduction, protein synthesis, anaerobic glycolysis, and cytokinesis.

The various organelles contained in the cytoplasm perform their specific functions, which are crucial for the proper working and survival of the cell.

The processes related to the growth, expansion, as well as the division of the cell take place in the cytoplasm.

The nutrients are absorbed and stored in the cytoplasm so that these can be used by various organelles when needed. The cytoplasm also helps dissolve the waste products.

In some organisms, the microtubules function as cilia and flagella help in the locomotion of the organism.

The organelles present in the cytoplasm perform functions that are crucial for the survival of the cell. However, the smooth operation of all these functions depends on the existence of cytoplasm, as it provides the medium for carrying out these vital processes.

I. Answer the questions:

1. What are the three major components of the cytoplasm?
2. What is the structure of some of the major organelles found in the cytoplasm?
3. What do cytoplasmic inclusions consist of?

II. Characterize cytosol as the part of cytoplasm.

III. Name the main functions of cytoplasm and explain one of them in detail.

IV. Write an annotation of the text.

Text 8
PHAGOCYTOSIS PROCESS

Cells need their daily share of food just like humans do. They do it through the phagocytosis process. Phagocytosis is a process used by certain cells to absorb and ingest solid particles. The particles that are absorbed and ingested can be nutrient particles or bacteria. The cells capable of ingesting by the phagocytosis process are known as phagocytes.

Phagocytes can be free-living unicellular organisms, such as amoeba, or they can be a part of the body cells of a multicellular organism. Phagocytes belong to the family of processes that are collectively referred to as “endocytosis”, consisting of all the processes that involve ingestion of material by cell.

The phagocytosis process is a specific type of endocytosis that involves vesicular internalization of solid particles, such as bacteria, unlike other endocytic processes that involve vesicular internalization of liquids. Certain unicellular organisms, such as the protists, use this particular process as a means of feeding. It provides them a part or all of their nourishment. This mode of nutrition is known as phagotrophic nutrition. In amoeba, this process takes place by engulfing the nutrient with the help of pseudopodia that are present all over the cell, whereas in ciliates, a specialized groove or chamber known as the cytostome is present where the process takes place.

Other examples of phagocytosis include some immune system cells that engulf and kill certain harmful, infectious microorganisms, and other unwanted foreign materials. Mammalian immune system contains certain phagocytes that help them destroy and get rid of pathogenic bacteria and other infectious organisms. In these cells, the engulfment of foreign material is facilitated by actin-myosin contractile system. It allows the cell membrane to expand in order to soak in the particle and then contract immediately, ingesting it.

Steps Involved

It is quite fascinating to watch this process under a microscope. One can actually see the phagocyte absorbing the foreign particles. There are several distinct steps involved in the process of phagocytosis. Let us have a look at each of them.

In case of unicellular organisms, the process of phagocytosis takes place when the organism comes in contact with nutrient particles. The phagocytes in the immune system are activated in the presence of certain bacterial cells, inflammatory cells, or other foreign bodies. Let us talk about the general steps involved in the process.

Step 1: The phagocyte gets actuated by the presence of certain particles around it. As soon as it detects a foreign particle, the phagocyte produces surface glycoprotein receptors that increase its ability to adhere to the surface of the particle.

Step 2: The phagocyte slowly attaches to the surface of the foreign particle. The cell membrane of the phagocyte begins to expand and forms a cone around the foreign particle.

Step 3: The cell membrane surrounds the foreign particle from all sides to create a vacuole, known as phagosome or food vacuole. The phagosome is then passed into the cell for absorption.

Step 4: Now occurs the role of the lysosomes, which are cell structures specialized in digesting the particles that enter the cell through the cell membrane. The lysosomes break the food vacuole or phagosome into its component materials. The essential nutrients, if any, are absorbed in the cell, and the rest is expelled as waste matter. In case of the immune system, the cell creates a peroxisome, a special structure that helps the body to get rid of the toxins.

In unicellular organisms like amoeba, the process of phagocytosis is necessary for survival, as they are totally dependent on it for nutrients. Some of these organisms have adapted special traits which enable them to locate and keep a track of food particles.

I. Give the definition of phagocytosis.
II. Give any example of the phagocytosis process.
III. Try to describe the steps involved in the process of phagocytosis.
IV. Summarize the main ideas of the text.

GLOSSARY

A

Abscisic acid: A plant hormone with the formula $C_{15}H_{2}0O_{4}$.

Abscission: Shedding of flowers and leaves and fruit following formation of scar tissue in a plant.

Absolute zero: The lowest theoretically attainable temperature (at which the kinetic energy of atoms and molecules is minimal); 0 Kelvin or –273.15 Celsius of –459.67 Fahrenheit.

Absorption: A process in which one substance permeates another; a fluid permeates or is dissolved by a liquid or solid. Skin absorption is a route by which substances can enter the body through the skin.

Absorption spectrum: The spectrum of electromagnetic radiation that has passed through a medium that absorbed radiation of certain wavelengths.

Abyssal zone: The deep sea (2,000 meters or more) where there is no light.

Acclimatization: Adaptation to a new climate (a new temperature or altitude or environment).

Acoelomate: Animals, like flatworms and jellyfish, that have no body cavity (coelom). Semi-solid mesodermal tissues between the gut and body wall hold their organs in place.

Actin: One of the proteins into which actomyosin can be split; can exist in either a globular or a fibrous form.

Action potential: The local voltage change across the cell wall as a nerve impulse is transmitted.

Activation energy: The energy that an atomic system must acquire before a process (such as an emission or reaction) can occur.

Active site: The part of an enzyme or antibody where the chemical reaction occurs.

Adenylate cyclase: An enzyme that catalyzes the formation of cyclic AMP from ATP.

Aerobic: Depending on free oxygen or air.

Amino acid: A class of organic compounds containing an amino group and a carboxylic acid group.

Amniote: Organisms that produce an egg composed of shell and membranes that creates a protected environment in which the embryo can develop out of water.

Asexual reproduction: Process of reproduction involving a single parent that results in offspring that are genetically identical to the parent.

B

B cell: Type of lymphocyte in the humoral immunity of the adaptive immune system.

Bacteria: Single-cell microscopic organisms which lack a true nucleus. They represent one of the three domains.

Bacteriophage: Virus that infects and multiplies within bacteria.

Binary fission: One cell dividing into two identical daughter cells.

Biocatalysis: Catalysis in living (biological) systems. In biocatalytic processes, natural catalysts, such as protein enzymes, perform chemical transformations on organic compounds.

Biochemistry: The branch of science that explores the chemical processes within and related to living organisms. It is a laboratory based science that brings together biology and chemistry. By using chemical knowledge and techniques, biochemists can understand and solve biological problems.

Biomass: Organic matter derived from living, or recently living organisms. Biomass can be used as a source of energy and it most often refers to plants or plant-based materials which are not used for food or feed, and are specifically called lignocellulosic biomass.

Biome: Very large ecological areas on the earth's surface, with fauna and flora (animals and plants) adapting to their environment.

Blastocyst: A mammalian blastula in which some differentiation of cells has occurred.

Blood: The red liquid that circulates in the arteries and veins of humans and other vertebrate animals, carrying oxygen to and carbon dioxide from the tissues of the body.

Blood-brain barrier: A semipermeable membrane separating the blood from the cerebrospinal fluid, and constituting a barrier to the passage of cells, particles, and large molecules.

C

Cell: The structural and functional unit of all organisms; an autonomous self-replicating unit that may exist as a functional independent unit of life (as in the case of unicellular organism), or as a sub-unit in a multicellular organism that is specialized into carrying out particular functions towards the cause of the organism as a whole.

Carbonate: Any member of two classes of chemical compounds derived from carbonic acid or carbon dioxide.

Cell biology: Cell biology explains the structure, organization of the organelles they contain, their physiological properties, metabolic processes, signalling pathways, life cycle, and interactions with their environment.

Cell membrane: The semipermeable membrane surrounding the cytoplasm of a cell.

Cell theory: The theory that all living things are made up of cells.

Centroid: The centroid of a triangle is the intersection of the three medians of the triangle (each median connecting a vertex with the midpoint of the opposite side). It lies on the triangle's Euler line, which also goes through various other key points including the orthocenter and the circumcentre.

Centrosome: In cell biology, the centrosome is an organelle that is the main place where cell microtubules get organized. They occur only in plant and animal cells.

Chemical bond: A chemical bond is a lasting attraction between atoms that enables the formation of chemical compounds. The bond may result from the electrostatic force of attraction between atoms with opposite charges, or through the sharing of electrons as in the covalent bonds.

Chloroplast: Animal cells do not have chloroplasts. Chloroplasts work to convert light energy of the Sun into sugars that can be used by cells. The entire process is called photosynthesis and it all depends on the little green chlorophyll molecules in each chloroplast.

Chromosome: A threadlike strand of DNA in the cell nucleus that carries the genes in a linear order.

D

Darwinian fitness: The genetic contribution of an individual to the next generation's gene pool relative to the average for the population, usually measured by the number of offspring or close kin that survive to reproductive age.

Dendrite: A short branched extension of a nerve cell, along which impulses received from other cells at synapses are transmitted to the cell body.

Denitrification-Nitrogen cycle: Denitrification is a microbially facilitated process of nitrate reduction (performed by a large group of heterotrophic facultative anaerobic bacteria) that may ultimately produce molecular nitrogen (N_2) through a series of intermediate gaseous nitrogen oxide products.

Deoxyribonucleic acid: The four bases found in DNA are adenine (abbreviated A), cytosine (C), guanine (G) and thymine (T). These four bases are attached to the sugar/phosphate to form the complete nucleotide, as shown for adenosine monophosphate.

DNA replication: The double helix is unwound and each strand acts as a template for the next strand. Bases are matched to synthesize the new partner strands. DNA replication is the process of producing two identical replicas from one original DNA molecule.

Dynein: A motor protein (also called molecular motor or motor molecule) in cells which converts the chemical energy contained in ATP into the mechanical energy of movement.

E

Ecdysone: A steroidal prohormone of the major insect molting hormone 20-hydroxyecdysone, which is secreted from the prothoracic glands. Insect molting hormones are generally called ecdysteroids.

Ecosystem: An interaction of living things and non living things in a physical environment.

Ecotype: In evolutionary ecology, an ecotype, sometimes called ecospecies, describes a genetically distinct geographic variety, population or race within a species, which is adapted to specific environmental conditions.

Ectoderm: The outermost layer of cells or tissue of an embryo in early development, or the parts derived from this, which include the epidermis, nerve tissue, and nephridia.

Ectotherm: An ectotherm, from the Greek εκτός (ektós) "outside" and θερμός (thermós) "hot", is an organism in which internal physiological sources of heat are of relatively small or quite negligible importance in controlling body temperature. Some refer to these organisms as "cold blooded".

Effector cell: Plasma cells, also called plasma B cells, plasmocytes, plasmacytes, or effector B cells, are white blood cells that secrete large volumes of antibodies. They are transported by the blood plasma and the lymphatic system.

Electrochemical gradient: An electrochemical gradient is a gradient of electrochemical potential, usually for an ion that can move across a membrane. The gradient consists of two parts, the electrical potential and a difference in the chemical concentration across a membrane.

Embryo: A development stage of a multicellular organism.

Endemism: The ecological state of a species being unique to a defined geographic location, such as an island, nation, country or other defined zone, or habitat type; organisms that are indigenous to a place are not endemic to it if they are also found elsewhere.

Endocytosis: A form of active transport in which a cell transports molecules (such as proteins) into the cell (endo- + cytosis) by engulfing them in an energy-using process.

Enzyme: Enzymes are biological molecules (proteins) that act as catalysts and help complex reactions occur everywhere in life. Let's say you ate a piece of meat. Proteases would go to work and help break down the peptide bonds between the amino acids.

Evolution: The change in genetic composition of a population over successive generations, which may be caused by natural selection, inbreeding, hybridization, or mutation.

Evolutionary biology: The subfield of biology that studies the evolutionary processes that produced the diversity of life on Earth starting from a single origin of life. These processes include the descent of species, and the origin of new species.

F

Facultative anaerobe: Organism which is capable of producing energy through aerobic respiration and then switching to anaerobic respiration depending on the amounts of oxygen and fermentable material in the environment.

Fetus: A human embryo after eight weeks of development.

G

Gene: A locus (or region) of DNA that encodes a functional RNA or protein product, and is the molecular unit of heredity. The transmission of genes to an organism's offspring is the basis of the inheritance of phenotypic traits.

Genetic variation: Variations of genomes between members of species, or between groups of species thriving in different parts of the world as a result of genetic mutation. Genetic diversity in a population or species is a result of new gene combinations (e.g. crossing over of chromosomes), genetic mutations, genetic drift, etc.

H

Habitat: A place for animals, people and plants and non-living things.

Histology: The study of the microscopic anatomy of cells and tissues of plants and animals.

I

Immune response: how your body recognizes and defends itself against bacteria, viruses, and substances that appear foreign and harmful.

Immunogloblin: Also known as antibodies, are glycoprotein molecules produced by plasma cells (white blood cells). They act as a critical part of the immune response by specifically recognizing and binding to particular antigens, such as bacteria or viruses and aiding in their destruction.

J

Jejunum: The midsection of the small intestine of many higher vertebrates like mammals, birds, reptiles is called jejunum. It is located between the duodenum and the ileum.

K

Krebs cycle: The citric acid cycle – also known as the tricarboxylic acid (TCA) cycle or the Krebs cycle – is a series of chemical reactions used by all aerobic organisms to generate energy through the oxidation of acetyl-CoA derived from carbohydrates, fats and proteins into carbon dioxide and chemical energy in the form of guanosine triphosphate (GTP).

L

Leukocyte: A colourless cell which circulates in the blood and body fluids and is involved in counteracting foreign substances and disease; a white (blood) cell. There are several types, all amoeboid cells with a nucleus, including lymphocytes, granulocytes, and monocytes.

Linked genes: When two genes are close together on the same chromosome, they do not assort independently and are said to be linked.

Lipid: A substance that is insoluble in water and soluble in alcohol, ether, and chloroform. Lipids are an important component of living cells. Together with carbohydrates and proteins, lipids are the main constituents of plant and animal cells. Cholesterol and triglycerides are lipids.

Lipoprotein: A biochemical assembly that contains both proteins and lipids, bound to the proteins, which allow fats to move through the water inside and outside cells. The proteins serve to emulsify the lipid molecules.

M

M phase: Mitosis and cytokinesis together define the mitotic (M) phase of an animal cell cycle – the division of the mother cell into two daughter cells, genetically identical to each other and to their parent cell.

Macroevolution: Evolution on a scale of separated gene pools. Macroevolutionary studies focus on change that occurs at or above the level of species, in contrast with microevolution, which refers to smaller evolutionary changes (typically described as changes in allele frequencies) within a species or population.

Macromolecule: A very large molecule, such as protein, commonly created by polymerization of smaller subunits (monomers). They are typically composed of thousands or more atoms.

Macronutrient: A nutrient that provides calories or energy. Nutrients are substances needed for growth, metabolism, and for other body functions. Since 'macro' means large, macronutrients are nutrients needed in large amounts.

Medulla: The continuation of the spinal cord within the skull, forming the lowest part of the brainstem and containing control centres for the heart and lungs.

Meiosis: A type of cell division that reduces the number of chromosomes in the parent cell by half and produces four gamete cells. This process is required to produce egg and sperm cells for sexual reproduction.

Metaphase: The third phase of mitosis, the process that separates duplicated genetic material carried in the nucleus of a parent cell into two identical daughter cells.

Mitosis: The process in which a eukaryotic cell nucleus splits in two, followed by division of the parent cell into two daughter cells. The word *mitosis* means "threads", and it refers to the threadlike appearance of chromosomes as the cell prepares to divide.

Molecular biology: A branch of science concerning biological activity at the molecular level. The field of molecular biology overlaps with biology and chemistry and in particular, genetics and biochemistry.

N

Natural selection: A process in nature in which organisms possessing certain genotypic characteristics that make them better adjusted to an environment tend to survive, reproduce, increase in number or frequency, and therefore, are able to transmit and perpetuate their essential genotypic qualities to succeeding generations.

Neurobiology: The study of cells of the nervous system and the organization of these cells into functional circuits that process information and mediate behaviour. It is a subdiscipline of both biology and neuroscience.

O

Organ: A collection of tissues joined in a structural unit to serve a common function.

Organism: Any contiguous living system, such as an animal, plant, fungus, or bacterium.

P

Paleontology: The study of the history of life on Earth as reflected in the fossil record. Fossils are the remains or traces of organisms (plants, animals, fungi, bacteria and other single-celled living things) that lived in the geological past and are preserved in the crust of the Earth.

Pathobiology: The study or practice of pathology with greater emphasis on the biological than on the medical aspects.

Pathology: A medical specialty that is concerned with the diagnosis of disease based on the laboratory analysis of bodily fluids such as blood and urine, as well as tissues, using the tools of chemistry, clinical microbiology, hematology and molecular pathology.

Physiology: The branch of biology dealing with the functions and activities of living organisms and their parts, including all physical and chemical processes.

Psychobiology: Behavioral neuroscience, also known as biological psychology, biopsychology, or psychobiology is the application of the principles of biology to the study of physiological, genetic, and developmental mechanisms of behavior in humans and other animals.

Q

Quark: An elementary particle and a fundamental constituent of matter. Quarks combine to form composite particles called hadrons, the most stable of which are protons and neutrons, the components of atomic nuclei.

R

Reproduction: Giving birth to one of its kind, sexually or asexually.

RNA: A polymeric molecule implicated in various biological roles in coding, decoding, regulation, and expression of genes.

S

Sexual reproduction: Type of reproduction in which cells from two parents unite to form the first cell of a new organism.

Sociobiology: A field of scientific study that is based on the hypothesis that social behavior has resulted from evolution and attempts to explain and examine social behavior within that context.

Structural biology: A branch of molecular biology, biochemistry, and biophysics concerned with the molecular structure of biological macromolecules, especially proteins and nucleic acids, how they acquire the structures they have, and how alterations in their structures affect their function.

Synthetic biology: An interdisciplinary branch of biology and engineering. The subject combines various disciplines from within these domains, such as biotechnology, evolutionary biology, molecular biology, systems biology, biophysics, computer engineering, and genetic engineering.

T

Transcription: The first step of gene expression, in which a particular segment of DNA is copied into RNA (mRNA) by the enzyme RNA polymerase.

U

Unicellular organism: An organism that consists of only one cell, unlike a multicellular organism that consists of more than one cell.

V

Vacuole: A vacuole is a membrane-bound organelle which is present in all plant and fungal cells and some protist, animal and bacterial cells.

Virology: The study of viruses – submicroscopic, parasitic particles of genetic material contained in a protein coat – and virus-like agents.

W

White Blood: Cell component of the blood that functions in the immune system. Also known as a leukocyte.

X

Xanthophyll: The yellow colored photosynthetic pigments.

Y

Yeast artificial chromosome: Genetically engineered chromosomes derived from the DNA of the yeast, Saccharomyces cerevisiae, which is then ligated into a bacterial plasmid.

Z

Zygote: Eukaryotic cell formed by a fertilization event between two gametes.