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THE FUNDAMENTAL UNIT OF LIFE

INTRODUCTION

The cell is the basic living unit of all organisms. The simplest organisms consist of a single cell whereas humans are composed of trillions of cells. If each of these cells was about the size of a standard brick we could build a colossal structure in the shape of a human over 5½ miles (10 km) height. Obviously, there are many differences between a cell and a brick. Cells are much smaller than bricks. An average sized cell is one fifth the size of the smallest dot you can make on a sheet of paper with a sharp pencil. In spite of their extremely small size cells are complex living structures.

Cells of the human body have many characteristics in common. However, most cells are also specialized to perform specific functions. The human body is made up of populations of these specialized cells. Communication and coordination between these populations are critical for a complex organism such as a human to survive.

Organisms are either single-called, such as most bacteria and protists, or multicelled, such as plants, animals, and most fungi. Your own body is a cooperative society of trillions of cells of many different specialized types. Just three examples are the muscle cells that move your arms and legs, the nerve cells that control your muscles, and the red blood cells that carry oxygen to your muscles and nerves. Everything we do-every action and every thought-reflects processes occurring at the cellular level.
Just as there are organs in the body so are organelles inside a cell.

Just as each organ has one or more special functions, similarly, each organelle has a specific function in a cell. We will learn about various organelles in detail in section structural organisation of cell.
The study of cells began in 1660, when English physicist Robert Hooke melted strands of spun glass to create lenses that he focused on bee stingers, fish scales, fly legs, feathers, and any type of insect he could hold still. When he looked at cork, which is bark from a type of oak tree, it appeared to be divided into little boxes, which were left by cells that were once alive. Hooke called these units “cells,” because they looked like the cubicles (cellae) where monks studied and prayed. Although Hooke did not realize the significance of his observation, he was the first person to see the outlines of cells.
In 1673, lenses were improved again, at the hands of Antonie van Leeuwenhoek of Holland. Leeuwenhoek used only a single lens, but it was more effective at magnifying and produced a clearer image than most two-lens microscopes then available. One of his first objects of study was tartar scraped from his own teeth.
Leeuwenhoek opened up a vast new world to the human eye and mind. He viewed bacteria and protozoa that people hadn’t known existed. However, he failed to see the single-celled “animalcules” reproduce, and therefore he perpetuated the popular idea at the time that life arises from the nonliving or from nothing. Nevertheless, Leeuwenhoek did describe with remarkable accuracy microorganisms and microscopic parts of larger organisms.

Interesting :

1. In four square centimetres of skin there are 3 metres of nerve fibers, 1300 nerve cells, 100 sweat glands, 3 million cells, and 3 metres of blood vessels. Except for your brain cells, 50,000,000 of the cells in your body will have died and been replaced with others, all while you have been reading this sentence.
   The central nervous system is connected to every part of the body by 43 pairs of nerves. Twelve pairs go to and from the brain, with 31 pairs going from the spinal cord. There are nearly 63 kilometres of nerves running through our bodies.

Messages travel along the nerves as electrical impulses. They travel at speeds up to 400kilometres per hour. It takes about 20 seconds for a red blood cell to circle the whole body.

2. There are about 210 known distinct human cell types.
3. The human body contains 20 times more microbes (microbe is an organism that is microscopic, microbes include bacteria, fungi, archaea or protists, but not viruses and prions, which are generally classified as non-living) than it does cells. In fact, a visitor from outer space might think the human race is just one big chain of microbe hotels.

Exploring Cells under the Microscope : To see something is to begin to know it. This simple statement is just as true of biology as it is of fine art. Our awareness of cells as the basic units of life is based largely on our ability to see them. The instrument that opened the eyes of the scientific world to the existence of cells was the light microscope, which was invented in the last quarter of the sixteenth century. The key components of early light microscopes were ground-glass lenses that bent incoming rays of light to produce magnified images of tiny specimens.

While the light microscope has a place in the early history of biology, similar instruments are just as important in ongoing research today. The basic principles that enable light microscopes to magnify the image of a specimen remain the same, but the quality of current lenses has improved significantly. Thus, the 200 to 300 fold magnification achieved in the seventeenth century has been improved to the well over a thousand fold magnification achieved by today's standard light microscopes. This degree of magnification allows us to distinguish structures as small as 1/2,000,000 of a meter, or 0.5 micrometer (μm). Light microscopes therefore reveal not just animal and plant cells (5–100 μm), but also organelles such as mitochondria anplasts (2–10 μm) and tiny organisms such as bacteria (1 μm). We will learn about mitochondria and chloroplasts in section structural organisation of cell.

Since the 1930s, an even more dramatic increase in magnification has been achieved by the replacement of visible light with streams of electrons that are focused by powerful magnets instead of glass lenses. Called electron microscopes, these instruments can magnify a specimen by more than 100,000-fold, revealing the internal structure of cells and even individual molecules such as proteins and nucleic acids. Both types of microscopy give us insights into how cells are organized and how different types of cell are physically adapted to specific functions in the body of a multicellular organism.

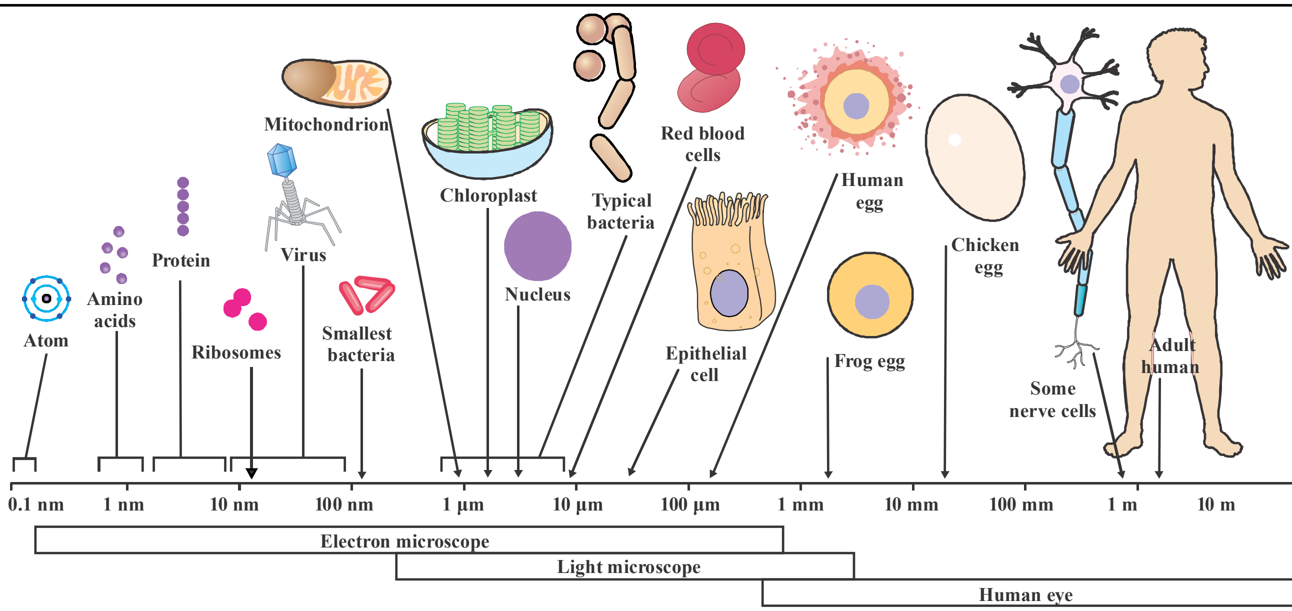


Figure : Biological size and cell diversity

The ability to distinguish the various parts of a specimen under a microscope depends on the existence of a way to create contrast. This has been a challenge for light microscopy because cells are generally transparent and their different structures do not contrast with one another, and as a result they tend to be indistinguishable.
The earliest solution to this problem was to stain the cells with dyes. Different parts of the cells take up different dyes, altering the light passing through them and producing different colors, thus distinguishing one structure from another. Today similar methods are still being used to visualize cellular structures and even the distribution of specific proteins within the cell.

ACTIVITY

Cut the onion bulb into four pieces (quarters) lengthwise.
From one of these quarters, remove one thick scale leaf. Take fleshy scale of onion in your hand and tear it from the inner (concave) side so as to get a thin transparent strip. Using a pair of forceps removes this strip (peel) and put it in a watch glass containing water. Cut a square piece of this peel (about 5 × 5 mm) and mount it on a slide in a drop of water. Cover the peel with a coverslip carefully so that the tissue does not get wrinkled. Examine the preparation under a microscope.
You may as well stain the material with iodine or eosin solution, which will make the nucleus more distinct. More details of the cell structure will be seen under a high power microscope, like compound microscope or electron microscope.
The cells of onion peel have a somewhat regular shape, linear or rectangular. Each cell has a prominent cell wall, a nucleus and the cytoplasm encircling one or two large vacuoles. The details are better seen in high power, specially the thick cell wall. Note that the cells are firmly bound together and the nucleus is placed towards one side, which is usually the case in plant cells.

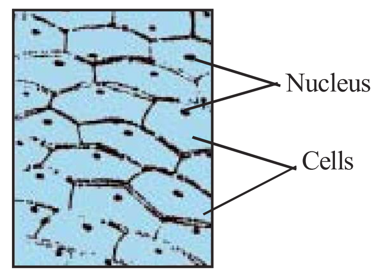


Figure : Cells of an onion peel

CELL THEORY

Despite the accumulation of microscopists' drawings of cells during the seventeenth and eighteenth centuries, the cell theory–the idea that the cell is the fundamental unit of all life-did not emerge until the nineteenth century. Historians attribute this delay in the development of the cell theory to poor technology, including crude microscopes and lack of procedures to preserve and study living cells without damaging them. Neither the evidence itself nor early interpretations of it suggested that all organisms were composed of cells. Hooke had not observed actual cells but rather their absence. Leeuwenhoek made important observations, but he did not systematically describe or categorize the structures that cells had in common.
In the nineteenth century more powerful microscopes, with better magnification and illumination revealed details of life at the subcellular level. In the early and mid-1830s, observers saw a darkened area, the nucleus, in plant cells and then in animal cells and the translucent, moving cytoplasm, which made up the rest of the cell.
In 1839, German biologists Matthias J. Schleiden and Theodor Schwann put together many observations made with microscopes to develop the cell theory.
The cell theory, in its modern form, includes the following three principles :

1. All organisms are composed of one or more cells, within which the life processes of metabolism and heredity occur.
2. Cells are the smallest living things, the basic units of organization of all organisms.
3. Cells arise only by division of a previously existing cell. Although life evolved spontaneously in the hydrogenrich environment of the early earth, biologists have concluded that additional cells are not originating spontaneously at present. Rather, life on earth represents a continuous line of descent from those early cells.

Two basic kinds of cells evolved on Earth: prokaryotic cells and eukaryotic cells. Bacteria and archaea consist of prokaryotic cells. All other organisms protists, plants, fungi, and animals–are composed of eukaryotic cells. A major difference between these two main classes of cells is indicated by their names. The word eukaryotic is from the Greek word eu, meaning "true," and karyon, meaning "Kernel." In this case, "kernel" refers to the nucleus, usually the largest organelle. Within eukaryotic cells. A prokaryotic cell lacks such a nucleus. The word prokaryotic (Greek pro, meaning before, and karyon, kernel) implies that prokaryotic cells appeared on Earth before eukaryotic cells. That evolutionary sequence is evident in the fossil record.

Eukaryotic Cells :

Plants, animals, fungi, and protista have eukaryotic cells. Organelles create specialized compartments where specific biochemical reactions can occur. In general, organelles keep related biochemicals and structures sufficiently close together to make them function more efficiently. The compartmentalization organelles provide also makes it unnecessary for the entire cell to maintain a high concentration of a particular biochemical.

A eukaryotic cell is organized like many small plastic bags within a large plastic bag. The most prominent organelle is the nucleus, which contains the genetic material Deoxyribo nucleic acid (DNA) organized with protein into rod-shaped chromosomes. The remainder of the cell consists of other organelles and the cytoplasm. About half of the volume of an animal cell consists of organelles; in contrast, a plant cell contains about 90% water. The cytoplasm and Organelles, including the nucleus, are considered the living parts of the cell. Nonliving cellular components include stored nutrients, minerals, and pigment molecules. Arrays of protein rods and tubules within plant and animal cells form the cytoskeleton, which helps to give the cell its shape.

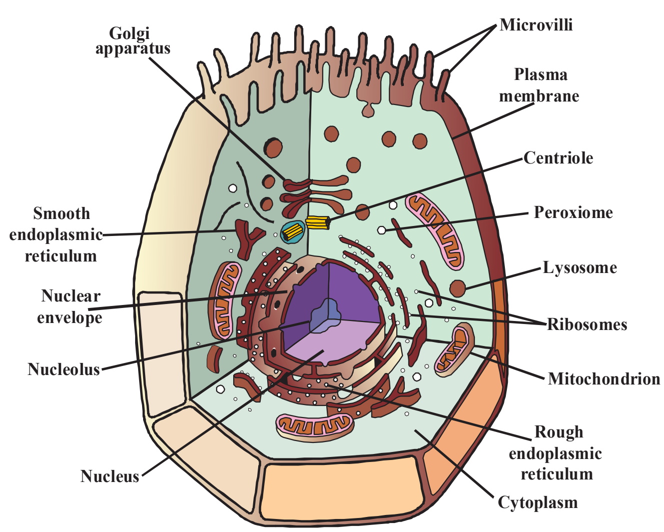


Figure : Animal cell

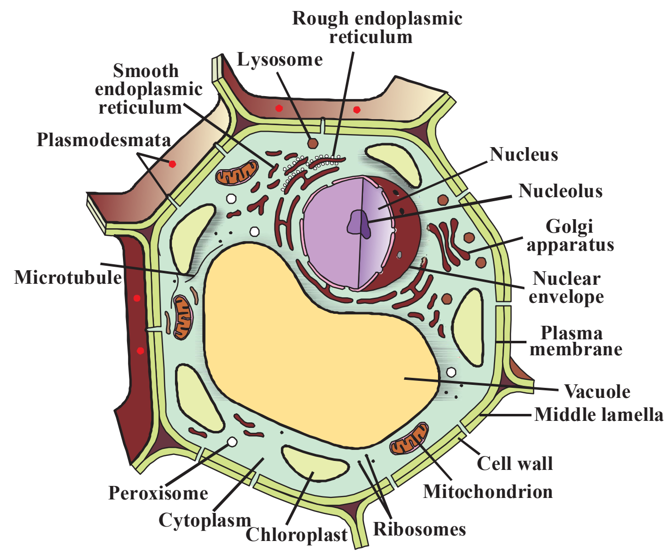


Figure : Plant cell

Prokaryotic Cells :

All prokaryotes lack true nuclei. These organisms include the familiar bacteria, as well as the **cyanobacteria**, organisms once known as blue-green algae because of their characteristic pigments and their similarity to the true (eukaryotic) algae. Bacteria cause many illnesses, but they are also very valuable in food and beverage processing and pharmaceutical production.

Most prokaryotic cells are surrounded by rigid **cell walls.**

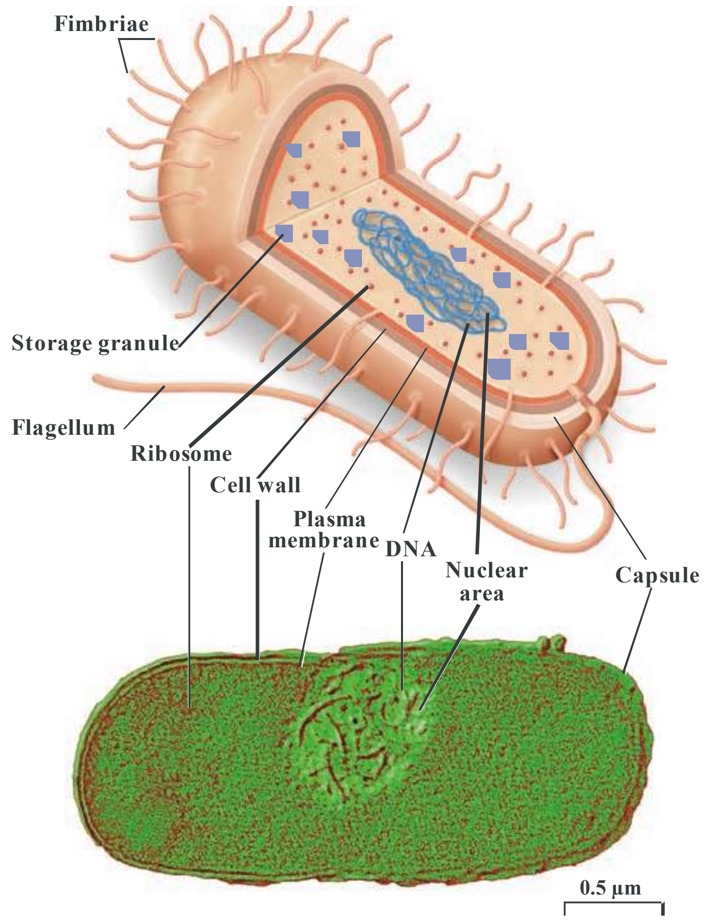


Figure : Structure of a prokaryotic cell

Comparison of Prokaryotic and Eukaryotic Cells

Characteristic	Prokaryotic Cells	Eukaryotic Cells
Organisms	Bacteria (including cyanobacteria)	Protista, fungi, plants, animals
Cell size	Usually 1–10 µm across	Usually 10–100 µm across
Oxygen required	By some	By many
Membrane-bound organelles	No	Yes
Membranes	Some	Many
Cytoskeleton	No	Yes
Cellular organization	Single cells or colonies	Some single-celled, most multiceullar with specialized cells
Nucleus	Absent	Present

Cell size :

The cells are generally very minute and microscopic. These are resolved only with the help of microscope. 10,000 cells can be arranged in a space of one millimeter length. Plant cells are comparatively larger than the animal cells. Their diameter varies between 15 µ to 100µ. The cells of cotton, sunhemp and coconut fibres are several centimeters in length. The egg of Ostrich is an example of largest animal cell. Its diameter is about 15 cm. The nerve cells are probably the longest cells measuring 1 – 1.5 meter.

1. Generally the size of a cell is less than one millimeter. Therefore the size of cells is expressed in micro units like micron (μ) and millimicron ($m\mu$). One millimeter has 1000μ and one micron (μ) has 1000 $m\mu$ and 10,000 Augstroms (Å).
2. The single largest cell in the world is of an ostrich.
3. The smallest cells are those of the Mycoplasma.
4. The largest human cell is the female ovum (0.01 mm in diameter).
5. The smallest human cell is the red blood cell (0.0075 mm or 7.5 μm).
6. An average human cell measures between 0.01 mm to 0.03 mm.
7. Nerve cells in animals are the longest cells.

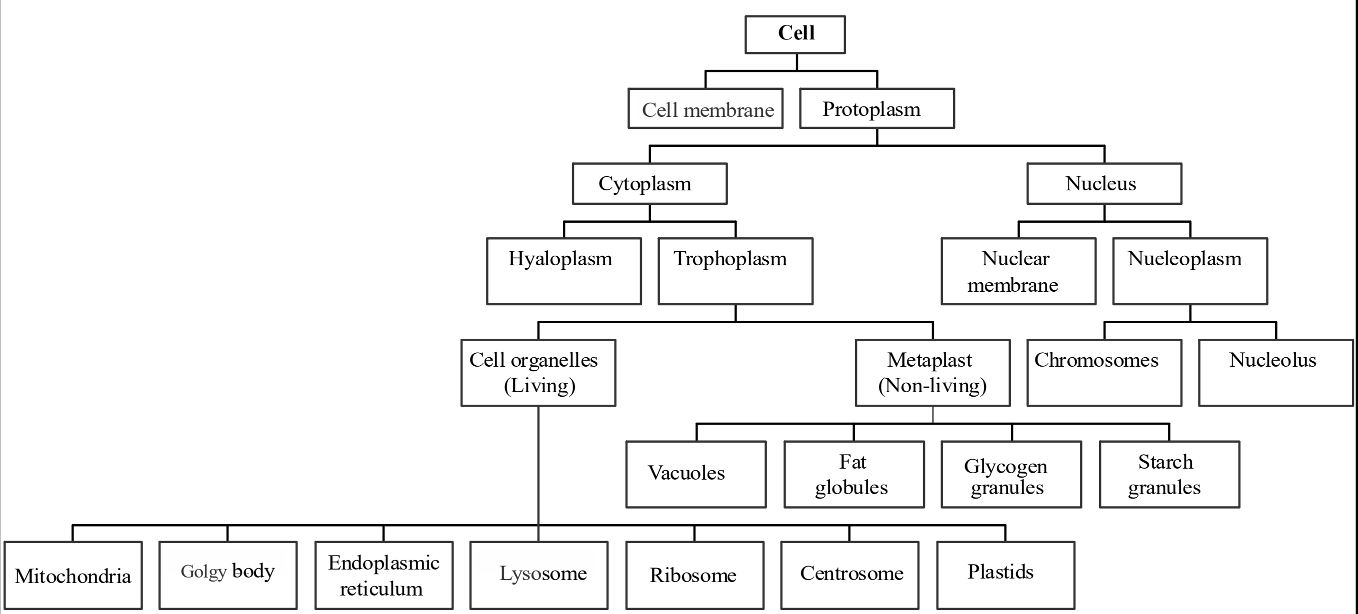
Functions of the Cell : The main functions of the cell include

1. **Basic unit of life :** The cell is the smallest part to which an organism can be reduced that still retains the characteristics of life.
2. **Protection and support :** Cells produce and secrete various molecules that provide protection and support of the body. For example, bone cells are surrounded by a mineralized material making bone a hard tissue that protects the brain and other organs and that supports the weight of the body.
3. **Movement :** All the movements of the body occur because of molecules located within specific cells such as muscle cells.
4. **Communication :** Cells produce and receive chemical and electrical signals that allow them to communicate with one another. For example, nerve cells Communicate with one another and with muscle cells causing them to contract.
5. **Cell metabolism and energy release :** The chemical reactions that occur within cells are referred to collectively as cell metabolism. Energy released during metabolism is used for cell activities such as the synthesis of new molecules muscle contraction, and heat production, which helps maintain body temperature.
6. **Inheritance :** Each cell contains a copy of the genetic information of the individual. Specialized cells are responsible for transmitting that genetic information to the next generation.

STRUCTURAL ORGANISATION OF CELL

A cell can be divided into two parts from the structural point of view-

(1) Cell membrane (2) Protoplasm.



CELL MEMBRANE

The cell membrane or plasma membrane is the outermost component of a cell. The cell membrane encloses the cytoplasm and forms the boundary between material inside the cell and material outside it. Substances outside the cell are called **extracellular substances** and substances inside the cell are called **intracellular substances** is a selective barrier that determines what moves into and out of the cell and plays a role in communication between cells.

The major molecules that make up the cell membrane are phospholipids and proteins. In addition. The membrane contains other molecules, such as cholesterol, carbohydrates, water, and ions. The phospholipids form a double layer of molecules. The polar phosplate-containing ends of the phospholipids are hydrophilic (water loving) and therefore face the water inside and outside the cell. The nonpolar fatty acid ends of the phospholipids are hydrophilic (water fearing) and therefore face away from the water on either side of the membrane toward the center of the double layer of phospholipids . The double layer of phospholipids forms a lipid barrier between the inside and outside of the cell.

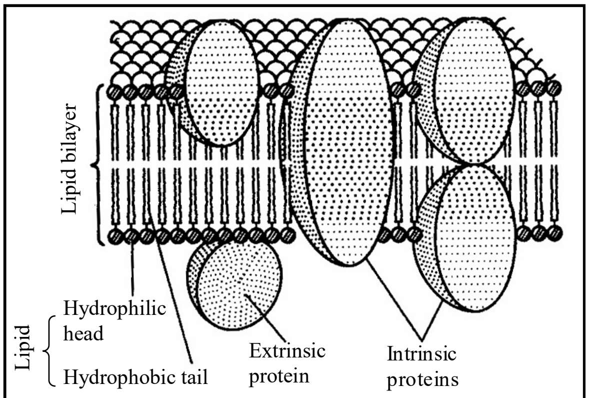


Figure : Fluid-Mosaic model

Studies of the arrangement of molecules in the cell membrane have given rise to a model of its structure called the **fluid mosaic model** (developed by S.J. Singer & G. L. Nicolron). The double layer of phospholipid molecules has a liquid quality. Cholesterol within the membrane gives it added strength and flexibility. Protein molecules "float" among the phospholipid molecules and, in some cases, may extend from the inner to the outer surface of the cell membrane. Carbohydrates may be bound to some protein molecules, modifying their functions. The proteins function as membrane channels carrier molecules, receptor molecules enzymes, or structural supports in the membrane. Membrane channels and carrier molecules are involved with the movement of substances through the cell membrane. Receptor molecules are part of an intercellular communication system that enables coordination of the activities of cells. For example, a nerve cell can release a chemical messenger that moves to a muscle cell and temporarily binds to its receptor. The binding acts as a signal that triggers a response such as contraction of the muscle cell.

CELL WALL

In plant cells a dead layer is also present outside the cell membrane. It is called as cell wall. It is secreted by the protoplasm of the cell and is made up of cellulose. It provides a definite shape, durability and additional protection to the plant cell. Cell wall is invariably lacking in animal cells.

Functions of the cell wall : The cell wall serves a variety of purposes including:

1. Maintaining/determining cell shape (analogous to an external skeleton for every cell). Since protoplasts are invariably round, this is good evidence that the wall determines the shape of plant cells.
2. Support and mechanical strength (allows plants to get tall, hold out thin leaves to obtain light).
3. Prevents the cell membrane from bursting in a hypotonic medium (i.e., resists water pressure).

4. Controls the rate and direction of cell growth and regulates cell volume
5. Ultimately responsible for the plant architectural design and controlling plant morphogenesis since the wall dictates that plants develop by cell addition
6. Has a metabolic role (i.e., some of the proteins in the wall are enzymes for transport, secretion)
7. Physical barrier to: (a) pathogens; and (b) water in suberized cells. However, remember that the wall is very porous and allows the free passage of small molecules, including proteins up to 60,000 MW. The pores are about 4 nm.
8. Carbohydrate storage - the components of the wall can be reused in other metabolic processes (especially in seeds). Thus, in one sense the wall serves as a storage for carbohydrates.
9. Signaling - fragments of wall, called oligosaccharins, act as hormones. Oligosaccharins, which can result from normal development or pathogen attack, serve a variety of functions including: (a) stimulate ethylene synthesis; (b) induce phytoalexin synthesis; (c) induce chitinase and other enzymes; (d) increase cytoplasmic calcium levels and (d) cause an "oxidative burst". This burst produces hydrogen peroxide, superoxide and other active oxygen species that attack the pathogen directly or cause increased cross-links in the wall making the wall harder to penetrate.
   Let's look at how this system works. Consider a pathogenic fungus like Phytophthora. In contact with the host plant the fungus releases enzymes such as pectinase that break down plant wall components into oligosaccharins. The oligosaccharins stimulate the oxidative burst and phytoalexin synthesis, both which will deter the advance of the fungus. In addition, the oligosaccharins stimulate chitinase and glucanase production in the plant. These are released and begin to digest the fungal wall. The fragments of fungal wall also act as oligosaccharins in the plant to further induce phytoalexin synthesis.
10. Recognition responses - for example: (a) the wall of roots of legumes is important in the nitrogen-fixing bacteria colonizing the root to form nodules; and (b) pollen-style interactions at mediated by wall chemistry.
11. Economic products - cell walls are important for products such as paper, wood, fiber.

How is the Structure of a Membrane Related to Its Function ?

As gatekeeper, the plasma membrane must perform three general functions :

1. Selectively isolated the cell's contents from the external environment.
2. Regulate the exchange of essential substances between the cells contents and the external environment.
3. Communicate with other cells.

How Do Substances Move Across Membranes ?

Molecules in Fluids Move in Response to Gradients

Because the plasma membrane separates the fluid in the cell's cytoplasm from its fluid extracellular environment. We must start with a few definitions :

1. A fluid is a liquid or a gas–that is, any substance that can move or change shape in response to external forces without breaking apart.
2. The concentration of molecules in a fluid is the number of molecules in a given unit of volume.
3. A gradient is a physical difference between two regions of space that causes molecules to move from one region to the other. Cells frequently generate or encounter gradients of concentration, pressure, and electrical charge. To understand how concentration gradients influence the movement of molecules or ions within a fluid, consider a sugar cube dissolving in coffee, or perfume molecules moving from an open bottle into the air. These substances are moving in response to a concentration gradient, a difference in concentration of those substances between one region and another. What causes this movement? The individual molecules in a fluid move continuously, bouncing off one another in random directions. Over time, these random movements will produce a net movement of molecules from regions of high concentration to regions of low concentration, process called **diffusion.**

By analogy with gravity, we will refer to such movements as going "down" the concentration gradient. If there are no factors opposing this movement, such as electrical charge or pressure differences of physical barriers, the movement of molecules from regions of high to low concentration will continue until the substance is evenly dispersed throughout the fluid or the air. In this evenly dispersed state, called a dynamic equilibrium, the concentration gradient no longer exists, Molecules continue their random movements and collisions (the dynamic aspect), but there is no longer any change in concentration occurring: the substance has reached an equilibrium with its surroundings.

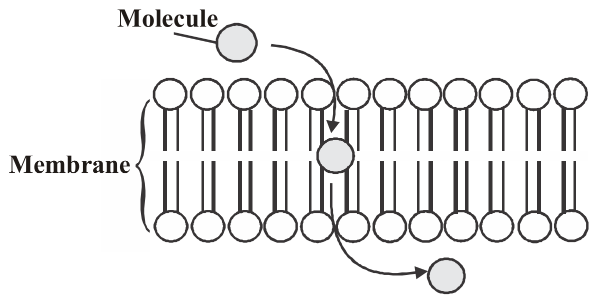


Figure : Diffusion

Movement Across Membranes Occurs by Both Passive and Active Transport

There are significant concentration gradients of ions and molecules across the plasma membrane of each cell because the cytoplasm of a cell is very different from the extracellular fluid. In its role as gatekeeper of the cell, the plasma membrane provides for two types of movement: (1) passive transport and (2) active transport.

During **passive transport**, substances move into or out of cells down concentration gradients. This movement by itself requires no expenditure of energy, since the concentration gradients provide the potential energy that drives the movement and controls the direction of movement, into or out of the cell. The lipids and protein pores of the plasma membrane regulate which molecules can cross, but they do not influence the direction of movement. It includes diffusion and osmosis.

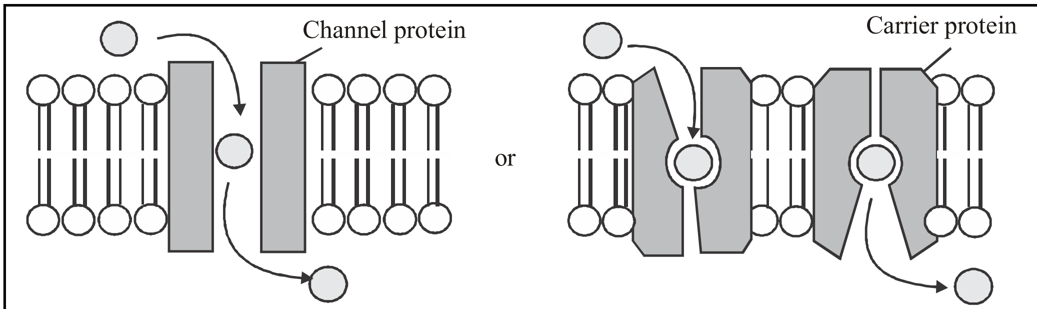


Figure : Passive Transport or Facilitated Diffusion

During **active transport**, the cell uses energy to move substances against a concentration gradient. In this case, transport proteins do control the direction of movement. A helpful analogy for understanding the difference between passive and active transports is to consider what happens when you ride a bike. If you don't pedal, you can go only downhill, as in passive transport. However, if you put enough energy into pedaling, you can go uphill as well, as in active transport.

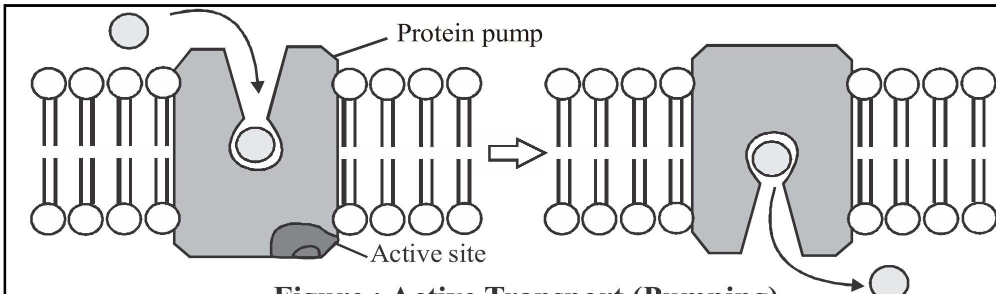
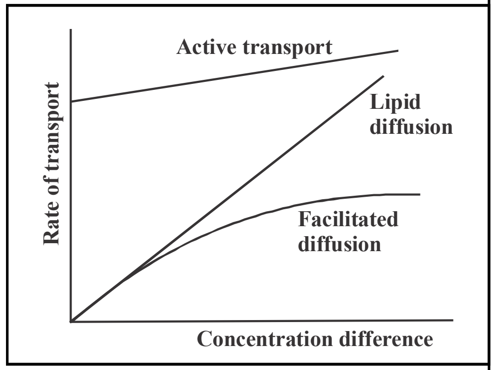


Figure : Active Transport (Pumping)

The rate of diffusion of a substance across a membrane increases as its concentration gradient increases, but whereas lipid diffusion shows a linear relationship, facilitated diffusion has a curved relationship with a maximum rate. This is due to the rate being limited by the number of transport proteins. The rate of active transport also increases with concentration gradient, but most importantly it has a high rate even when there is no concentration difference across the membrane. Active transport stops if cellular respiration stops, since there is no energy.



Osmosis :

Osmosis is a special kind of diffusion that involves the net movement of water (the principal solvent in biological systems) through a selectively permeable membrane from a region of higher concentration to a region of lower concentration. Water molecules pass freely in both directions, but as in all types of diffusion, net movement is from the region where the water molecules are more concentrated to the region where they are less concentrated. Most solute molecules (such as sugar and salt) cannot diffuse freely through the selectively permeable membranes of the cell. The principles involved in osmosis can be illustrated using an apparatus called a U-tube

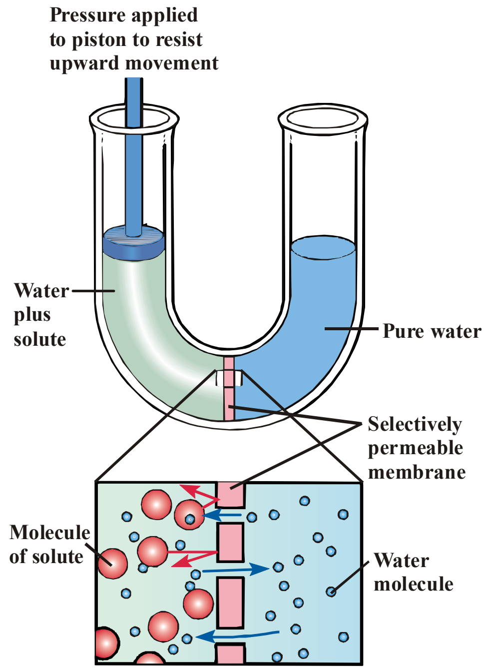
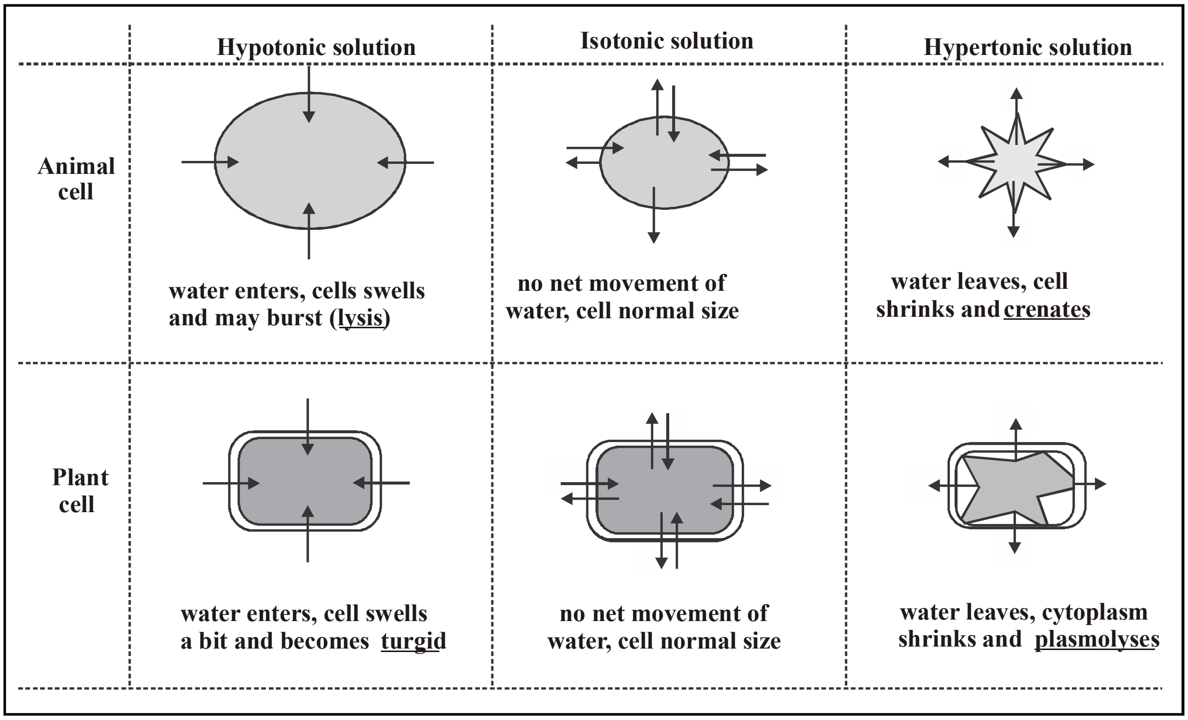


Figure : Osmosis

The fluids that continually bathe our cells consist of molecules dissolved in water. Because cells are constantly exposed to water, it is important to understand how a cell regulates water entry. If too much water enters a cell, it swells; if too much water leaves, it shrinks. Either response may affect a cell's functioning. Water moves across biological membranes by a form of simple diffusion called **osmosis**, which is influenced by the concentration of dissolved substances inside and outside the cell.

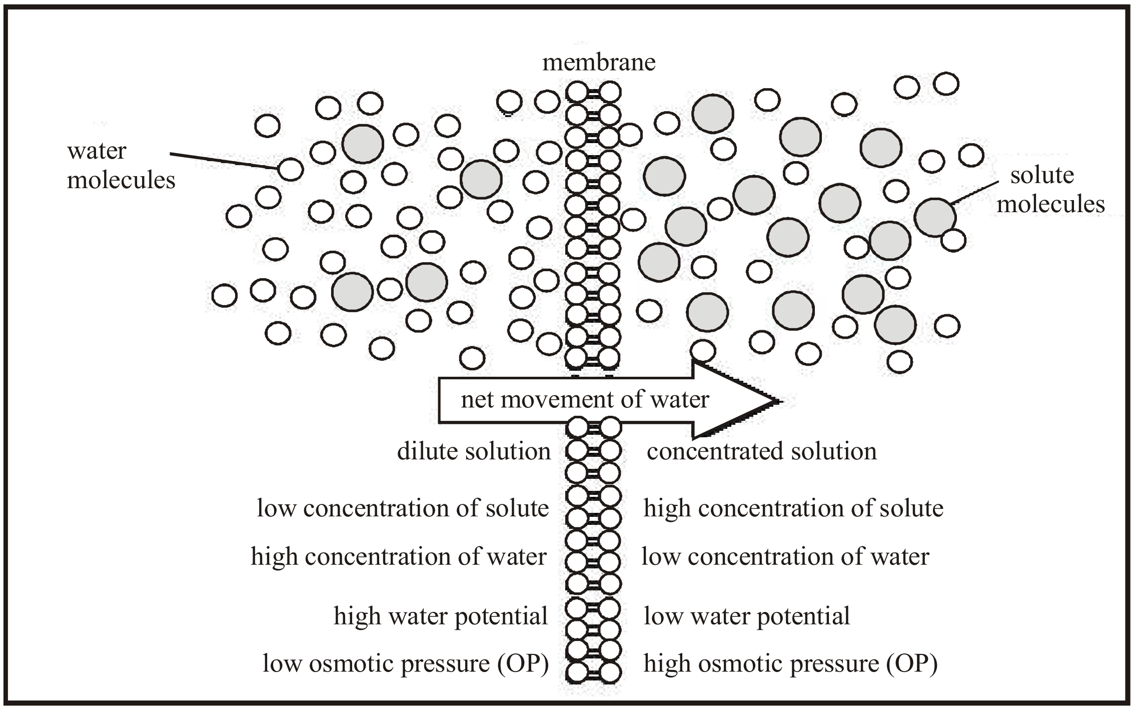


In osmosis, water is driven to move because the membrane is impermeable to the solute, and the solute concentrations differ on each side of the membrane. Water moves across the membrane in the direction that dilutes the solute on the side where it is more concentrated.

Variants of the word tonicity are used to describe osmosis in relative terms. Tonicity refers to the differences in solute concentration in two compartments separated by an impermeable membrane. Most cells are isotonic to the surrounding fluid, which means that solute concentrations are the same within and outside the cell. In this situation, there is no net flow of water, and a cell's shape does not change.

Disrupting a cell's isotonic state changes its shape as water rushes in or leaks out. If a cell is placed in a solution in which the concentration of solute is lower than it is inside the cell, water enters the cell to dilute the higher solute concentration there. In this situation, the solution outside the cell is hypotonic to the inside of the cell. The cell swells. In the opposite situation, if a cell is placed in a solution in which the solute concentration is higher than it is inside the cell, water leaves the cell to dilute the higher solute concentration outside. In this case, the outside is hypertonic to the inside. This cell shrinks.

Hypotonic and hypertonic are relative terms and can refer to the surrounding solution or to the solution inside the cell. It may help to remember that hyper means "over," hypo means "under," and iso means "the same." A solution in one region is hypotonic or hypertonic to a solution in another region.



Cell and Osmosis

If we put human red blood cells (RBCs) in a solution having the same water concentration as the inside of the cell (an isotonic solution), the cells look like this. They have smooth surfaces and are thinner in their centers than on their edges. These are normal red blood cells and is how they look when they are in our blood vessels. Water is moving into and out of these cells at the same rate. With no net change in water volume, the cells retain their normal shapes.

The cells in this picture have been left in a solution of lower water concentration (higher dissolved solids, hypertonic), and the net movement of water was out of the cells, from the area of higher water concentration (inside the cells) to the area of lower water concentration (outside the cells). This has caused the cells to deflate and their cell membranes to wrinkle.

The magnification here is a little lower and the lighting is a little different; however, the important difference to notice is the shape of the membranes. As the cells lost water by osmosis their membranes wrinkled, sort of the way a mylar balloon wrinkles as it loses air.

If we change the solution around the cells to one that has a lower water concentration (higher in dissolved solids), the net movement of water will be out of the cell, by osmosis. As it loses water, the cytoplasm will shrink and the cell membrane will follow it, being pulled away from the cell wall. With less water in the cytoplasm to support them, the cells lose their shape -- they shorten, thicken, and lose rigidity. This onion has become shriveled, soft, and pliable -- dehydrated.

Filtration :

Filtration is the movement of fluid through a partition containing small holes. The fluid movement results from the pressure or weight of the fluid pushing against the partition. The fluid and substances small enough to pass through the holes move through the partition, but substances larger than the holes do not pass through it.

For example, in a car, oil but nor dirt particles passes through an oil filter. In the body, filtration occurs in the kidneys as a step in urine production. Blood pressure moves fluid from the blood through a partition, or filtration membrane. Water, ions, and small molecules pass through the filtration membrane as a step in urine formation, whereas larger substances, such as proteins and blood cells, remain in the blood.

Getting Substances In and Out of Cells :

Endocystosis : Endocystosis is a general term for the process whereby very large particles of material are wrapped with plasma membrane and moved into the cell in the form of vesicles or vacuoles. None of the trapped material actually moves through the membrane, but remains on the other side of the original membrane, even while the vacuole is inside the cell.

Exocytosis : Exocytosis is the reverse of endocytosis. Quantities of material are expelled from the cell without ever passing through the membrane as individual molecules. By using the processes of endocytosis and exocytosis, some specialized types of cells move large amounts of bulk material into and out of themselves.

Phagocytosis : Solid particles are engulfed by phagocytosis ("cell eating"), a process that begins when solids make contact with the outer cell surface, triggering the movement of the membrane.
The desired particles are then enclosed within a small piece of the plasma membrane which forms a sac called a vacuole (or vesicle), with the food particle inside it. This vacuole is then moved to the interior of the cell. Strictly speaking, the food particles are not yet part of the cell as it is still surrounded by membrane.
Before food can be used, it must be broken down to smaller pieces and those pieces moved into the cytoplasm. Digestion occurs when the food vacuole is fused with a second vacuole, called a lysosome, that contains powerful digestive enzymes.
Food is degraded, its nutrients are absorbed by the cell and its waste products are left in the digestive vacuole, which may then leave the cell by exocytosis. Phagocytosis occurs in the scavenging white blood cells of our body. They prowl around looking for invading bacteria and viruses which they engulf and destroy.

Pinocytosis : Pinocytosis ("cell drinking") is almost the same process as phagocytosis, except it involves liquids instead of solids.
During exocytosis a vacuole containing material to be excreted from the cell moves to the plasma membrane and fuses with it. The vacuole membrane becomes part of the plasma membrane and the contents are released to the outside.
Cells use this method to eliminate the wastes left after digestion and metabolism and also to release a whole variety of materials that have been synthesized inside the cell but which are needed outside the cell. Release of hormones and digestive enzymes, found in multicellular animals, are two examples of this process.

Types and Characteristics of Movement Across Cell Membranes

Type	Transport	Examples
Diffusion	With the concentration gradient through the lipid portion of the cell membrane or through membrane channels	Oxygen, carbon dioxide, chloride ions, and urea
Osmosis	With the concentration gradient (for water) through the lipid portion of the cell membrane or through membrane channels	Water
Filtration	Movement of liquid and substances by pressure through a partition containing holes	In the kidneys, filtration of everything in blood except proteins and blood cells
Facilitated diffusion	With the concentration gradient by carrier molecules	Glucose in most cells
Active transport	Against the concentration gradient by carrier molecules	Sodium, potassium, calcium, and hydrogen ions; amino acids
Secondary active transport	Against the concentration gradient by carrier molecules; the energy for secondary active transport of one substance comes from the concentration gradient of another	Glucose, amino acids
Endocytosis	Movement into cells by vesicles	Ingestion of particles by phagocytosis and liquids by pinocytosis
Exocytosis	Movement out of cells by vesicles	Secretion of proteins

PROTOPLASM

The entire matter found inner to the cell membrane is called as protoplasm. It can be divided into two parts :
(1) Cytoplasm (2) Nucleus

CYTOPLASM

The substance present between cell membrane and nuclear membrane is called as cytoplasm. It is jeely-like material that is eight percent water and usually clear in colour. It has a clear, structureless fluid substance the hyaloplasm in which several structures are found floating. The living structures are called as cytoplasmic organs or cell organelles. The non-living things found in hyaloplasm are collectively termed as **metaplast** or cytoplasmic inclusions. Cell organelles and metaplast are collectively called as **trophoplast**.

The structureless liquid part of cytoplasm i.e. hyaloplasm is formed by the dissolution of several substances. The cytoplasmic inclusions include fat globules, glycogen and starch granules and other substances. It may also contain few vacuoles. In plant cells the vacuoles are more pronounced and are of larger size and number. Each vacuole is enclosed by a selectively permeable membrane called as **tonoplast**. The liquid part present within the vacuole is know as cell sap of **vacuolar sap**.

Major part of cell sap is water in which salts, excretory substances and other substances remain dissolved. Vacuoles maintain pressure balance in the cell. They also help in eliminating unnecessary substances and water from the cell.

The cytoplasm, as seen through an electron microscope, appears as a three-dimensional lattice of thin protein-rich strands. These lattices are known as microtrabecular lattice (MTL) and serves to interconnect and support the other "solid" structures in the cytoplasm. In other words, the cytoplasm is like a fence that is made up of lattes that are connected together. This fence's main purpose is to hold together the organelles within the cytoplasm. Cytoplasm is the home of the cytoskeleton, a network of cytoplasmic filaments that are responsible for the movement of the cell and give the cell its shape. The cytoplasm contains dissolved nutrients and helps dissolve waste products. The cytoplasm helps materials move around the cell by moving and churning through a process called cytoplasmic streaming. The nucleus often flows with the cytoplasm changing the shape as it moves. The cytoplasm contains many salts and is an excellent conductor of electricity, which therefore creates a medium for the vesicles, or mechanics of the cell. The function of the cytoplasm and the organelles which sit in it, are critical the cell's survival.

CYTOPLASMIC ORGANELLES

Large number of microscopic living structures are found in the cytoplasm which perform different functions in the cell. These structures are called as cytoplasmic organelles. In most of the cells generally mitochondria, Golgi body, endoplasmic reticulum, plastids, lysosomes, ribosomes and centrosomes are present as cell organelles.

THE ENDOPLASMIC RETICULUM (COMPARTMENTALIZATION OF THE CELL)

The term endoplasmic means “within the cytoplasm,” and the term reticulum comes from a Latin word that means “a little net”. Like the plasma membrane, the ER is composed of a lipid bilayer containing embedded proteins.

Endoplasmic reticulum is a network of tubules, vesicles and sacs that are interconnected. They may serve specialized functions in the cell including protein synthesis, sequestration of calcium, production of steroids, storage and production of glycogen, and insertion of membrane proteins. The first part of this presentation will focus on rough endoplasmic reticulum which gets its name from the presence of ribosomes on its surface. Eukaryotic cells have two forms of ER: rough and smooth.

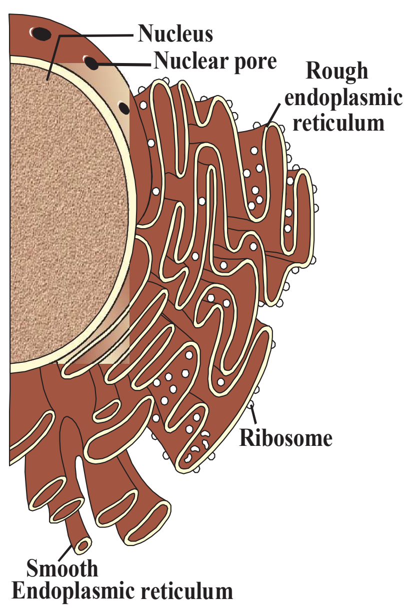


Figure : Endoplasmic reticulum

The different structures of smooth and rough ER reflect different functions. Enzymes embedded in the membranes of the smooth ER are the major site of lipid synthesis, including the phospholipids and cholesterol used in membrane formation.

Rough ER acts as a manufactures of proteins for export and smooth ER organizer of internal activities.

Rough endoplasmic reticulum bears the ribosomes during protein synthesis. The newly synthesized proteins are sequestered in sacs, called **cisternae**. The system then sends the proteins via small vesicles to the Golgi Complex, or, in the case of membrane proteins, it inserts them into the membrane.

Rough endoplasmic reticulum may either be vesicular or tubular. Or it may consist of stacks of flattened cisternae (like sheets) that may have bridging areas connecting the individual sheets. The Ribosomes sit on the outer surfaces of the sacs (or cisternae). They resemble small beads sitting in rosettes or in a linear pattern. Rough endoplasmic reticulum forms a branched reticulum that expands as the cell becomes more active in protein synthesis. Sometimes the reticulum branches out. Other times, the cisternae dilate and form large sacs that fill the cell.

THE NUCLEUS: (INFORMATION CENTER FOR THE CELL)

The largest and most easily seen of the organelles within a eukaryotic cell is the nucleus (Latin, meaning kernel or nut), which was first described by the English botanist Robert Brown in 1831. Nuclei are roughly spherical in shape and, in animal cells, they are typically located in the central region of the cell. In some cells, the nucleus seems to be cradled in this position by a network of fine cytoplasmic filaments.

The nucleus is the most prominent structure of the cell, taking up about 10% of the total volume of the cell. It is enclosed in a membrane, and it is only in eukaryotic cells. The nucleus contains two major things: one, the chromatin, and two the nucleolus. The nucleolus is the structure that manufactures ribosomes. Each cell nucleus usually contains at least one nucleolus. A double-layered membrane called the nuclear envelope contains the contents of the nucleus.

The nucleus is the repository of the genetic information that direct all of the activities of a living eukaryotic cell. Most eukaryotic cells possess a single nucleus, although the cells of fungi and some other groups have several to many nuclei. Mammalian erythrocytes (red blood cells) lose their nucleus when they mature.

With the loss of their nuclei, they lose all ability to grow, change, and divide, and become merely passive vessels for the transport of hemoglobin.

The nucleus is one of the most important structures in living organisms. It is what controls when the cell produces what proteins, when, and where, it controls growth, and it regulates metabolism. The function of the nucleus is quite simply the total control of the cell.

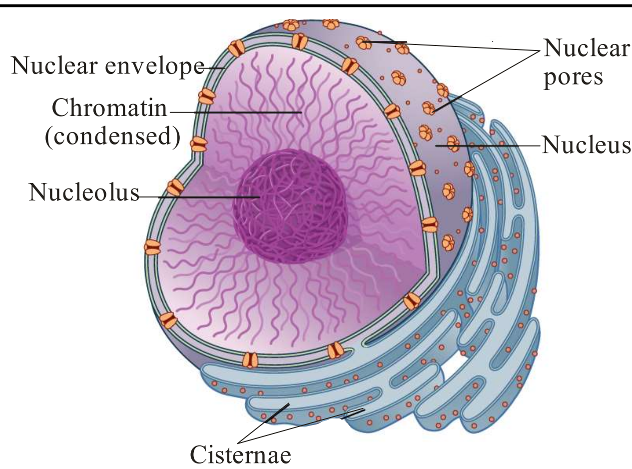


Figure : Structure of Nucleus

The cell stores information in the form of **DNA**, and most of the cell's DNA is located inside the nucleus.

When a cell divides, the information stored in DNA must be reproduced and passed intact to the two daughter cells. DNA has the unique ability to make an exact duplicate of itself through a process called **replication**. DNA molecules include sequences of nucleotides called **genes**, which contain the chemically coded instructions for producing the proteins needed by the cell. The nucleus controls protein synthesis by transcribing its information in **messenger RNA** (mRNA) molecules. Messenger RNA moves into the cytoplasm, where proteins are manufactured. DNA is associated with RNA and certain proteins, forming a complex known as **chromatin**. This complex appears as a network of granules and strands in cells that are not dividing. Although chromatin appears disorganized, it is not. Because DNA molecules are extremely long and thin, they must be packed inside the nucleus in a regular fashion as part of structures called **chromosomes**. In dividing cells, the chromosomes become visible as distinct threadlike structures. If the DNA in the 46 chromosomes of one human cell could be stretched end to end, it would extend for 2 meters.

The Nuclear Envelope : The surface of the nucleus is bounded by two phospholipid bilayer membranes, which together make up the **nuclear envelope**. The outer membrane of the nuclear envelope is continuous with the ER. Scattered over the surface of the nuclear envelope, like craters on the moon, are shallow depression called **nuclear pores**. These pores, 50 to 80 nanometers apart, form at locations where the two membrane layers of the nuclear envelope pinch together. Rather than being empty, nuclear pores are filled with proteins that act as molecular channels, permitting certain molecules to pass into and out of the nucleus. The inner membrane of the nuclear envelope lies next to a layer of thin filaments which surrounds the nucleus except at the nuclear pores. These may also serve as stabilizing filaments. This structure is called the "nuclear lamina".

EXPERIMENT

ASK CRITICAL QUESTIONS: Why is the nucleus so large? What is its importance?
DEVELOP HYPOTHESIS: Cells will be adversely aff ected if they lose their nuclei.
PERFORM EXPERIMENTS: Using a microloop, researchers removed the nucleus from each amoeba in the experimental group. Amoebas in the control group were subjected to the same surgical procedure, but their nuclei were not removed.

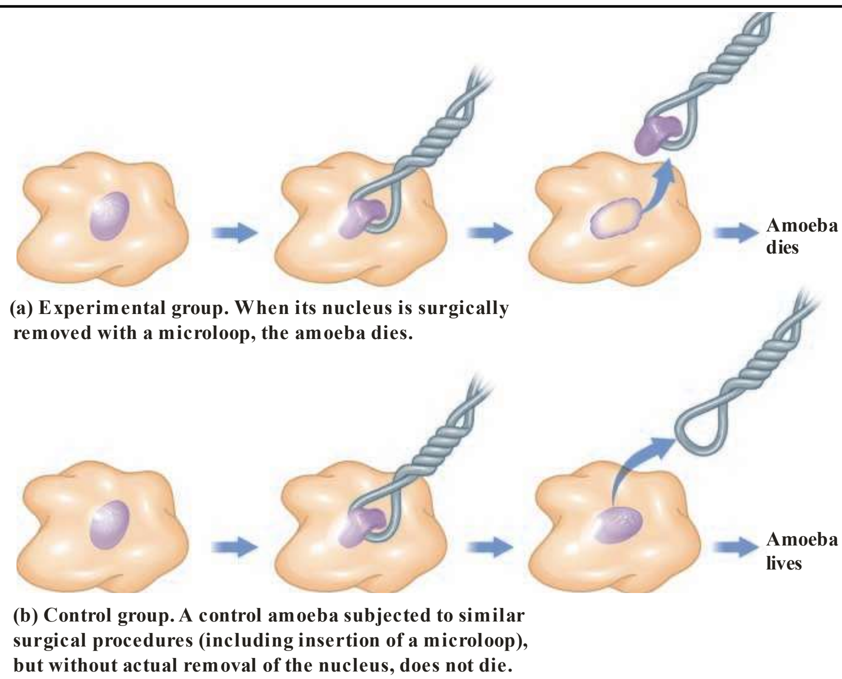


Figure : Testing a prediction regarding the importance of the nucleus

RESULTS: Amoebas without nuclei died. Amoebas in the control group lived.
CONCLUSION: Amoebas cannot live without their nuclei. The hypothesis is supported.

Although every part of a cell contributes to the life of the cell as a whole yet the key performer or the master of each cell is undoubtedly the nucleus. This can be easily understood by an experiment performed on Amoeba, a single cell animal.

RIBOSOME (FACTORY OF PROTEINS)

A tiny machine which is part of the mechanism of life.

Ribosomes occur both as free particles within cells and as particles attached to the membranes of the endoplasmic reticulum. A ribosome is made of about 40% protein and 60 % nucleic acid. It is composed of four nucleic acid molecules and about 70 different proteins.

A ribosome consists of two parts, a larger one and a smaller one, each of which has a characteristic shape. Ribosomes are very numerous in a cell and account for a large proportion of its total nucleic acid

They are found adhered in the form of granular structures on the surface of rough or granular endoplasmic reticulum and also present in free state in the cytoplasm. They are the only membraneless cell organelle i.e. they are not bounded by any membrane. Each ribosome is organised by two dissimilar units. Ribosomes contain sufficient amount of **RNA (Ribonucleic acid).** They function in protein synthesis. Ribosomes were discovered by **Claude** (1943) and named as ribosomes by **Palade** (1955). Ribosomes are popularly called as factory of proteins and engine of the cell.

In eukaryotes,

* Ribosomes that synthesize proteins for use within the cytosol (e.g., enzymes of glycolysis) are suspended in the cytosol.
* Ribosomes that synthesize proteins destined for:
  - secretion (by exocytosis)
  - the plasma membrane (e.g., cell surface receptors)
  - lysosomes

are attached to the cytosolic face of the membranes of the endoplasmic reticulum. As the polypeptide is synthesized, it is extruded into the interior (lumen) of the endoplasmic reticulum.

Then, before these proteins reach their final destinations, they undergo a series of processing steps in the Golgi apparatus

MITOCHONDRIA (POWER HOUSE OF THE CELL)

Mitochondria (singular –mitochondrion) is an important organelle in all the eukaryotic cells. Mitochondria are not found in prokaryotic cells. The number of mitochondria is highly variable in different kind of cells. Those cells in which high amount of energy is required contain large number of mitochondria. The necessary energy for a cell is actually generated by this organelle. Therefore mitochondrial are known as power house of the cell. The mitochondria were discovered in 1880 by Kolliker. The present name mitochondria was given by Benda (1890).

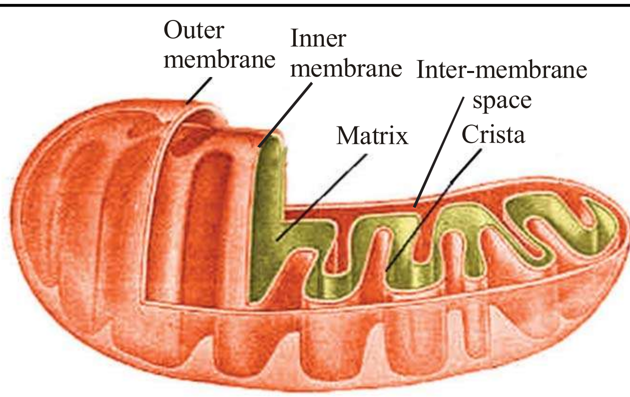


Figure : Structure of mitochondrion (Longitudinal section)

The shape of mitochondria is changeable. Sometimes these are thread like long and sometimes small like a grain. They are bounded by a double membrane.

The inner membrane is thrown in the finger like invaginations in its cavity called as cristae. The inner surface of cristae is provided with stalked particles. These are known as oxysomes of F_1 particles. The inner cavity of cristae is known as matrix. Mitochondria are rod-shaped organelles that can be considered the power generators of the cell, converting oxygen and nutrients into adenosine triphosphate (ATP). ATP is the chemical energy "currency" of the cell that powers the cell's metabolic activities. This process is called aerobic respiration and is the reason animals breathe oxygen. Without mitochondria (singular, mitochondrion), higher animals would likely not exist because their cells would only be able to obtain energy from anaerobic respiration (in the absence of oxygen), a process much less efficient than aerobic respiration. In fact, mitochondria enable cells to produce 15 times more ATP than they could otherwise, and complex animals, like humans, need large amounts of energy in order to survive.

Mitochondria contain about 60-70% proteins, 25-30% phospholipids and 0.5% RNA. Mitochondria also contain DNA deoxyribose nucleic acid as their own genetic material. Mitochondria are richly provided with the respiratory enzymes. Hence these are the sites of oxidation of food material thereby producing energy which is stored in the form of ATP.

GOLGI BODY

The golgi apparatus is found in most eukaryotic cells. The Golgi apparatus is usually composed of 5-8 membrane-bound sacs, called cisternae, but "as many as 60 have been observed". The cisternae stack has five functional regions: the cis-Golgi Network, the cis Golgi, the medial-Golgi, the trans-Golgi and the trans-Golgi network. The cis-Golgi Network fuses with vesicles from the endoplasmic reticulum which then travel through the stack until they reach the trans-Golgi network where they are packaged and sent to the required destination. Each region of the golgi apparatus contains enzymes which selectively modify the contents depending on where they are supposed to go. The Golgi apparatus directs proteins and lipids to their final destinations in the cell.

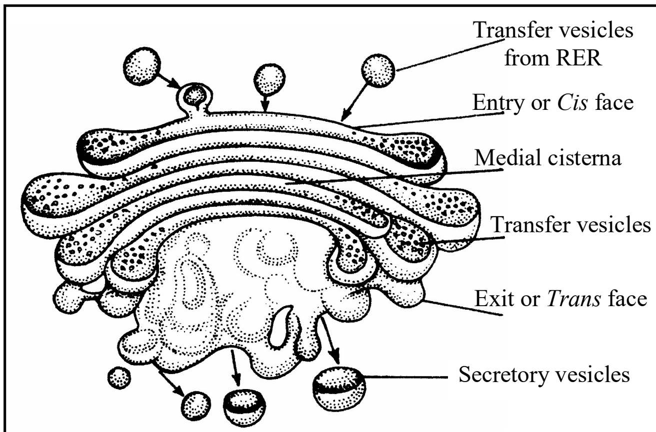


Figure : Structure of Golgi complex

Another membranous organelle, the Golgi apparatus, directs proteins and lipids produced by the ER to their final destinations, either inside the cell or out to the external environment. The Golgi therefore functions as a sorting station, much as the shipping department in a factory does. In a shipping department, goods destined for different locations must have address labels that indicate where they should be sent. Something similar happens in the Golgi, where the addition of specific chemical groups to proteins and lipids helps target them to other destinations in the cell. These cellular address labels include carbohydrates and phosphate groups.

Under the electron microscope, the Golgi looks like a series of flattened membrane sacs stacked together and surrounded by many small vesicles. These vesicles transport proteins from the ER to the Golgi and between the various sacs of the Golgi. Vesicles are therefore the primary means by which proteins and lipids move through the Golgi apparatus and to their final destinations.

LYSOSOMES : PRODUCERS OF DIGESTIVE ENZYMES FOR THE CELL

Lysosomes another class of membrane-bounded organelles, provide an impressive example of the metabolic compartmentalization achieved by the activity of the Golgi complex. They contain in a concentrated mix the digestive enzymes of the cell, which catalyze the rapid breakdown of proteins, nucleic acids, lipids, and carbohydrates. Throughout the lives of eukaryotic cells, lysosomal enzymes break down old organelles, recycling their component molecules and making room for newly formed organelles. As an example, mitochondria are replaced in some tissues every 10 days.

Even if there is no food to break down, lysosomes will attach to and digest the cell organelles for nutrients. Lysosomes are made of a membranous sac that contains enzymes and liquids. The membrane is selectively permeable in that in only lets small particles out. This ensures that everything that leaves has been digested and broken down thoroughly.

Interesting :

Some diseases result from nonfunctional lysosomal enzymes. For example, Pompe's disease results from the inability of lysosomal enzymes to break down the carbohydrate glycogen produced in certain cells. Glycogen accumulates in large amounts in the heart, liver, and skeletal muscles. Glycogen accumulation in the heart muscle cells often leads to heart failure. Lipid storage disorders are often hereditary and are characterized by the accumulation of large amounts of lipid in phagocytic cells. These cells take up the lipid by phagocytosis, but they lack the enzymes required to break down the lipid droplets. Symptoms include enlargement of the spleen and liver and replacement of bone marrow by lipid-filled phagocytes.

PLASTIDS

Plastids are found only in plant cells. On the basis of the type of pigment present, plastids are of three types. Those in which green pigment **chlorophyll** is found are called as **chloroplasts**. Plastids having other pigments but not chlorophyll are called as **chromoplasts**. Still others in which pigments are not found at all are termed as **leucoplasts**. The size and number of plastids is different in different plant cells. Plastids are bounded by an envelope of double membranes. Inside the plastids membraned lamellar structures are found. The pigments are located on these structures. Plastids have their own genetic material DNA. It is called as plastidome.
Chloroplasts are responsible for photosynthesis, contain chlorophyll which gives plants it green color. They use light energy to create chemical energy, while mitochondria use molecules and nutrients to create energy. The purpose of a chloroplast is to make sugars and starches using light energy. Chloroplasts, like mitochondria, contain their own DNA.

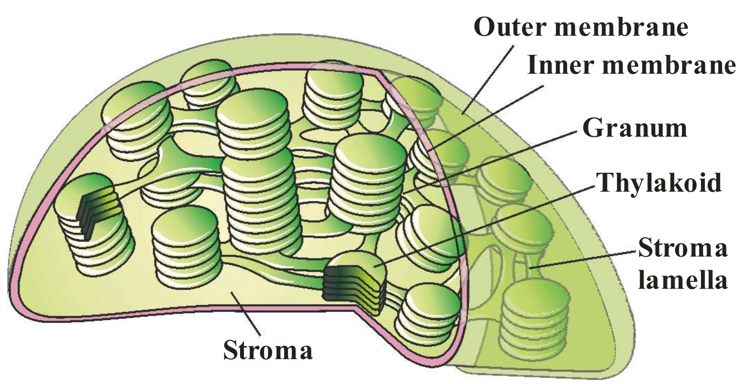


Figure : Sectional view of chloroplast

Plastids have following 2 Parts

(i) Grana (ii) Stroma

1. **Grana :** It constitute the lamellar system. These are found layered on top of each other, these stacks are called as grana. Each granum of the chloroplast is formed by superimposed closed compartments called thyllakoids.
Function : They are the site of light reaction of photosynthesis as they contain photosynthetic pigment chlorophyll. In each thyllakoid there is a presence of grana lamella on which Quantasomes are present which are called photosynthetic units. Each Quantasome posses 230 chlorophyll molecules.
2. **Stroma :** It is a granular transparent substance also called as matrix. Grana are embedded in it. Besides grana they also contain lipid droplets, starch grains ribosomes etc.
Function : They are the site of dark reaction of photosynthesis. Also helps in protein synthesis due to presence of ribosomes.

PLASMODESMATA

- Plasmodesmata are fine strands of cytoplasm connecting plant cells with their neighbors.
- This provides the cells with an easy passage for ions, small molecules, and macromolecules between cells.
- Plasmodesmata generally let only small molecules through the passages, but some proteins and viruses can bind to the plasmodsmata and let larger molecules pass through.
- Plasmodesmata also provides cells with a means to communicate with each other.
- Plasmodesmata is found in plant cells.

VACUOLES

Vacuoles are membrane-bound compartments whose functions include: removing unwanted structural debris, isolating materials that may be harmful to the cell, containing waste products of the cell, maintaining turgor pressure within the cell, maintaining an acidic internal pH, containing small molecules, kicking unwanted materials out of the cell, and enabling the cell to change shape.

The central vacuole in a plant cell is enclosed in a membrane called the tonoplast. Within the tonoplast is the cell sap which is, in effect, the chemical palate of the vacuole solution. In plant cells, (relating to turgor pressure) when a plant is well watered, water collects in cell vacuoles and causes the plant to be rigid. On the other hand, not enough water causes the plant to wilt because pressure in the vacuole is released.

CENTROSOME

Centrosome is generally found in animal cells. Only few types of plant cells show its presence. It is situated near the nucleus of the cell and shaped like a star. Each centrosome has two centrioles. The two centrioles are placed perpendicular to each other. Each centriole is made up of 9 fibres and each fibre is again made up of 3 microtubules. During the division of the animal cell the centrioles form spindle fibres. Similarly the centrioles also form the basal granule of cilia and flagella which serve as the organs of locomotion in microorganism, zoospores and motile gametes.

The tail of the sperm is formed by them. Centrioles were discovered by **Van Benden** (1875) and the present name was given by **Boveri** (1888).

CILIA AND FLAGELLA

Cilia and flagella are motile cellular appendages found in most microorganisms and animals, but not in higher plants. Cilia and flagella are both parts of the exterior of a cell, and are made up of microtubules. In multicellular organisms, cilia function to move a cell or group of cells or to help transport fluid or materials past them. Eukaryotic cilia and flagella are generally differentiated based on size and number: cilia are usually shorter and occur together in much greater numbers than flagella, which are often solitary.

Cilia are hair like particles on the outside of a cell that works with other structures and enable the cell to move or to move outside substances around the cell. Cilia move by many of them creating a "beating" motion, in one direction. On the return motion, the cilia are pulled back towards the cell's surface, which lets the cell move, and then the cilia straighten back out again and continue the motion. Each cilium is stimulated by the one in front of it, and they create "a rowing motion" and force movement on the cell or outside substances.
Flagella move in a somewhat different movement, they are more of a wavelike motion that starts at the base and moves up, with a continuous motion, not with distinct return strokes. Flagella can either be at the front of a cell, drawing the cell along, or behind the cell, pushing it forward.

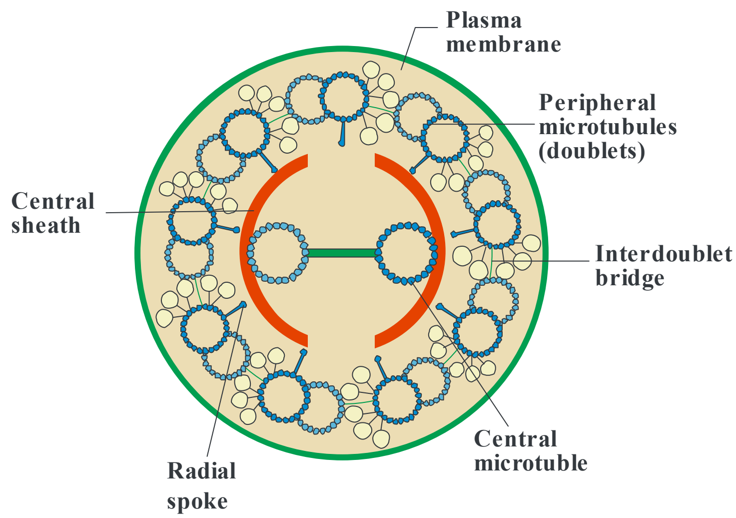


Figure : Section of cilia/flagella showing different parts

IMPORTANT POINTS

Organelles and Their Locations and Functions

Organelles Nucleus	Location and function(s)
Nucleus (DNA) and Nucleolus	Usually near center of the cell; contains genetic material of cell nucleoli; site of ribosome and messenger RNA synthesis. In the nucleus; site of ribosomal RNA and ribosomal protein synthesis.
Rough endoplasmic reticulum (rough ER)	In cytoplasm; many ribosomes attached to ER; site of protein synthesis.
Smooth endoplasmic reticulum (smooth ER)	In cytoplasm; site of lipid synthesis.
Golgi apparatus	In cytoplasm; modifies protein structure and packages proteins in secretory vesicles.
Secretory vesicle	In cytoplasm; contains materials produced in the cell; formed by the Golgi apparatus; secreted by exocytosis.
Lysosome	In cytoplasm; contains enzymes that digest material taken into the cell.
Mitochondrion	In cytoplasm; site of aerobic respiration and the major site of ATP synthesis.

Microtubule	In cytoplasm; supports cytoplasm; assists in cell division and forms components of cilia and flagella .
Cilia	On cell surface with many on each cell; cilia move substances over surface of certain cells.
Flagella	On sperm cell surface with one per cell; propels the sperm cells.
Microvilli	Extensions of cell surface with many on each cell; increase surface area of certain cells.

Comparison Between Plant and Animal Cells

S.No.	Animal cell	Plant cell
1.	Usually smaller, with less distinct boundaries	Usually larger with distinct out lines
2.	Cell membrane or plasma membrane forms the outer most envelope of the cell. There is no cell wall like structure outside it.	A non-living layer, the cell wall is found outside the cell membrane.
3.	In these cells vacuoles are absent. If present, they are small and evenly dispersed in cytoplasm.	In these cell, one or two large vacuoles are present. They occupy the maximum inner space of the cell. Vacuole and protoplasm are separated by a membrane called as tonoplast which encloses the vacuole.
4.	Plastids are absent in these cells.	Plastids are present.
5.	Nucleus is spherical and located in the centre of the cell.	Due to the presence of vacuole the nucleus is found shifted towards the periphery. There is also a possibility of change in the shape.
6.	Centrosomes re present and perform important role during cell division.	Generally absent.
7.	Golgi body is well developed and functional.	Generally less developed and scattered.
8.	In these cells the stored food is in the form of glycogen.	In plant cells the stored food is in the form of starch.

Cell Structures, their Function, and their Distribution in Living Cells

Structure	Function	Prokaryotes	Plants	Animals
Cell surface				
Cell wall	Protects, supports cell	Present	Present	Absent
Plasma membrane	Isolates cell contents from environment; regulates movement of materials into and out of cell; communicates with other cells	Present	Present	Present

CONCEPT MAP

THE FUNDAMENTAL UNIT OF LIFE

1. **Prokaryotic cells** are bounded by a plasma membrane but have little or no internal membrane organization. They have a nuclear area rather than a membrane-enclosed nucleus. Prokaryotes typically have a **cell wall** and **ribosomes** and may have propeller-like flagella.
2. **Eukaryotic cells** have a membrane-enclosed **nucleus** and **cytoplasm**, which contains a variety of organelles; the fluid component of the cytoplasm is the **cytosol**.
3. Plant cells differ from animal cells in that they have rigid cell walls, **plastids**, and large **vacuoles**; cells of most plants lack centrioles. Vacuoles are important in plant growth and development.
4. The nucleus, the control center of the cell, contains genetic information coded in DNA. The nucleus is bounded by a **nuclear envelope** consisting of a double membrane perforated with **nuclear pores** that communicate with the cytoplasm.
5. In plant cells, a cell wall composed mainly of cellulose is located outside the cell membrane.
6. The presence of the cell wall enables the cells of plants, fungi and bacteria to exist in hypotonic media without bursting.
7. The nucleus in eukaryotes is separated from the cytoplasm by double-layered membrane and it directs the life processes of the cell.
8. The ER functions both as a passageway for intracellular transport and as a manufacturing surface.
9. The Golgi apparatus consists of stacks of membrane-bound vesicles that function in the storage, modification and packaging of substances manufactured in the cell.
10. Most plant cells have large membranous organelles called plastids, which are of two types – chromoplasts and leucoplasts.
11. Chromoplasts that contain chlorophyll are called chloroplasts and they perform photosynthesis.
12. The primary function of leucoplasts is storage.
13. Most mature plant cells have a large central vacuole that helps to maintain the turgidity of the cell and stores important substances including wastes.
14. Prokaryotic cells have no membrane-bound organelles, their chromosomes are composed of only nucleic acid, and they have only very small ribosomes as organelles.
15. The **nucleolus** is a region in the nucleus that is the site of ribosomal RNA synthesis and ribosome assembly.
16. **The endoplasmic reticulum (ER)** is a network of folded internal membranes in the cytosol. **Smooth ER** is the site of lipid synthesis and detoxifying enzymes.
17. **Rough ER** is studded along its outer surface with ribosomes that manufacture proteins. Proteins synthesized on rough ER may be moved into the **ER lumen**, where they are modified by the addition of a carbohydrate or lipid.
18. The **Golgi complex** consists of stacks of flattened membranous sacs called **cisternae** that process, sort, and modify proteins synthesized on the ER. The Golgi complex also manufactures lysosomes.
19. Glycoproteins are transported from the ER to the cis face of the Golgi complex by **transport vesicles**, formed by membrane budding.
20. Chloroplasts is absent in animal cell.
21. Lysosomes are so called as they have digestive enzymes.
22. **Mitochondria**, the sites of aerobic respiration, are organelles enclosed by a double-membrane. The inner membrane is folded, forming **cristae** that increase its surface area. Mitochondria contain DNA that codes for some of its proteins.
23. **Chloroplasts** are plastids that carry out **photosynthesis**.
24. The inner membrane of the chloroplast encloses a fluid-filled space, the **stroma. Grana,** stacks of disclike membranous sacs called **thylakoids**, are suspended in the stroma.
25. According to the **fluid mosaic model**, membranes consist of a fluid phospholipid bilayer in which a variety of proteins are embedded.
26. Biological membranes are selectively permeable membranes; that is, they allow the passage of some substances but not others. **Diffusion** is the net movement of a substance down its **concentration gradient** from a region of greater concentration to one of lower concentration.
27. Osmosis is a kind of diffusion in which molecules of water pass through a selectively permeable membrane from a region where water has a higher effective concentration to a region where its effective concentration is lower.
28. Diffusion and osmosis are physical processes that do not require the cell to directly expend metabolic energy.
29. Schleiden and Schwann proposed cell theory in 1838-39.
30. Fluid mosaic model of cell membrane was put forward by Singer and Nicolson.