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Topic: Cell…. The basic unit of life

B.Sc. Sem II

Dr. Pushpa Vishwakarma
Associate Professor
Dept. of Zoology

Definition

(Gr., *kytos*, cell+L., *cella*, hollow space)

"A cell is defined as the smallest, basic unit of life that is responsible for all of life's processes."

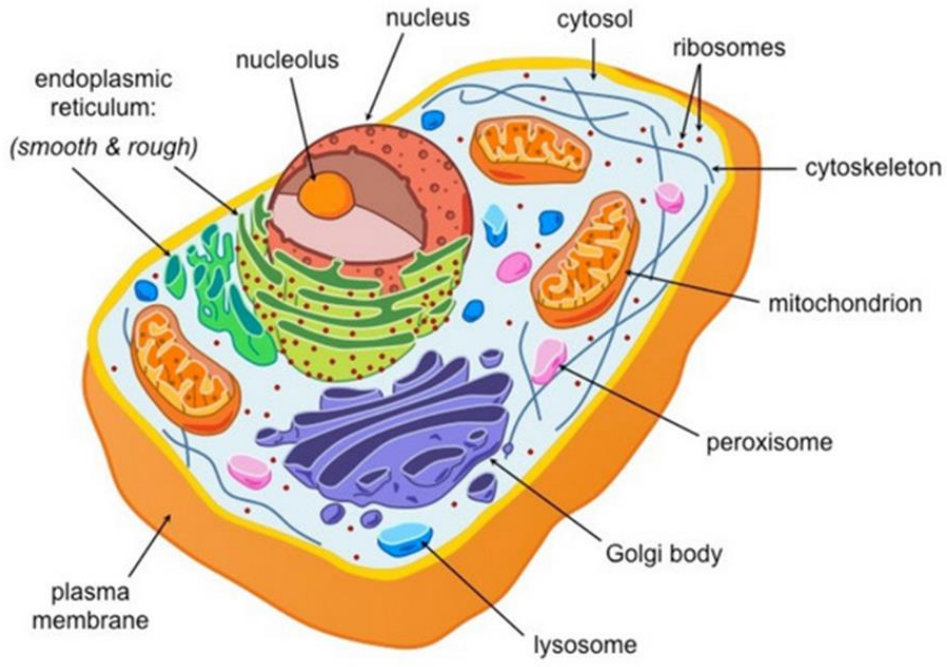


Fig. Diagrammatic representation of a cell

A cell is the structural, functional and biological unit of all organisms. It is a membrane-bound structure containing a cytoplasm and cytoplasmic structures. All living things are composed of cells.

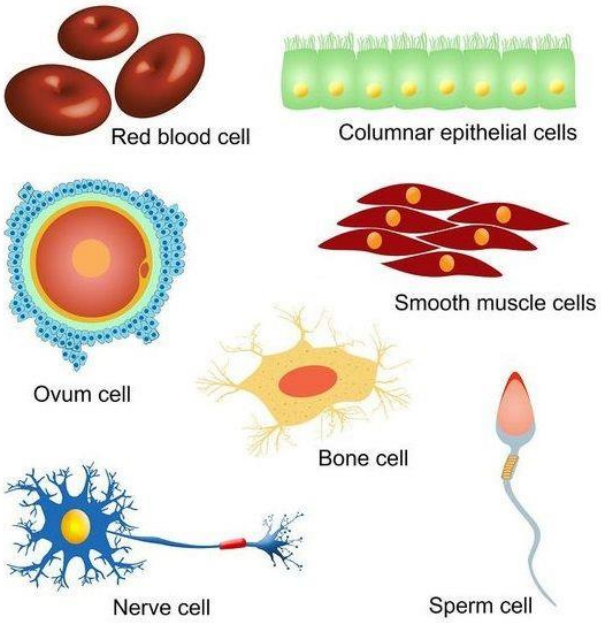
Robert Hooke was the first Biologist who discovered cells (Gr., *Cella*- a small chamber) in 1665.

Cells have many structures inside of them called organelles. These organelles are like the organs in a human and they help the cell stay alive. Each organelle has it's own specific function to help the cell survive.

A cell can replicate itself independently. Hence, they are known as the building blocks of life.

Each cell contains a fluid called the cytoplasm, which is enclosed by a membrane. Also present in the cytoplasm are several biomolecules like proteins, nucleic acids and lipids.

Shape and size of the cells:



The shape of the cells is variable. Their shapes may be rounded, cylindrical, irregular, triangular and tubular. They may be columnar, flat, spherical, stellate or long and thin. the shape of cells depends mainly on functional adaptations and partly on the surface tension and viscosity of the protoplasm, the mechanical action exerted by the adjoining cells and the rigidity of the cell membrane. The microtubules also have an important influence on the shape of the cell.

Size is extremely variable, measuring from 1µ to 1,75,000 µ or 175 mm. The ostrich egg cell is 176 mm in diameter, thus visible to naked eye. The great majority of cells are visible only with a microscope. The smallest animal cells have a diameter of 4µm. The nerve cell found in mammals may reach a length of 3 or 3.5 feet. Smaller cells are those of the pleuropneumonia-like organism (PPLO) such as *Mycoplasma gallisepticum* which produce respiratory disease in poultry. These organisms are filterable and measure 0.1µ in diameter.

Cell theory

The cell theory developed in 1839 by microbiologists Schleiden and Schwann describes the properties of cells. It is an explanation of the relationship between cells and living things. The theory states that:

- all living things are made of cells and their products.
- new cells are created by old cells dividing into two.
- cells are the basic building blocks of life.

The cell theory applies to all living things, however big or small. The modern understanding of cell theory extends the concepts of the original cell theory to include the following:

- The activity of an organism depends on the total activity of independent cells.
- Energy flow occurs in cells through the breakdown of carbohydrates by respiration.

- Cells contain the information necessary for the creation of new cells. This information is known as 'hereditary information' and is contained within DNA.
- The contents of cells from similar species are basically the same.
- DNA (the hereditary information of cells) is passed from 'parent' cells to 'daughter' cells during cell division.
- Cells are the smallest form of life; the functional and structural units of all living things. Our body contains several billion cells, organised into over 200 major types, with hundreds of cell-specific functions.
- Some functions performed by cells are so vital to the existence of life that all cells perform them (e.g. cellular respiration). Others are highly specialised (e.g. photosynthesis).

Characteristics of Cells

Cells provide structure and support to the body of an organism.

The nucleus(major organelle) holds genetic information necessary for reproduction and cell growth.

Every cell has one nucleus and membrane-bound organelles in the cytoplasm.

Mitochondria, a double membrane-bound organelle is mainly responsible for the energy transactions vital for the survival of the cell.

Lysosomes digest unwanted materials in the cell.

Endoplasmic reticulum plays a significant role in the internal organisation of the cell by synthesising selective molecules and processing, directing and sorting them to their appropriate locations.

Types of Cell

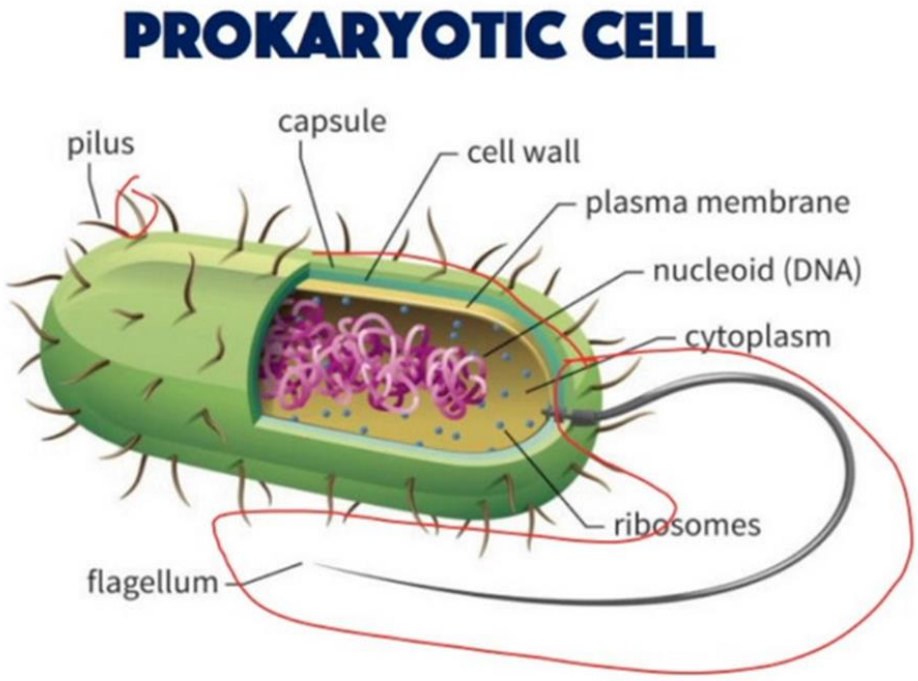


Fig. A bacterial cell

Prokaryotic Cells

Prokaryotic cells have no nucleus. some prokaryotes such as bacteria have the genetic material is freely suspended. This region is called the nucleoid.

They all are single-celled microorganisms. Examples include archaea, bacteria, and cyanobacteria.

The cell size ranges from 0.1 to 0.5 µm in diameter.

The hereditary material can either be DNA or RNA.

Prokaryotes reproduce by binary fission.

Prokaryotes can carry extrachromosomal DNA elements called plasmids **(A plasmid is an extra chromosomal, small DNA molecule within a cell that is physically separated from chromosomal DNA and can replicate independently)**, which are usually circular.

On the outside, flagella and pili project from the cell's surface. These are structures (not present in all prokaryotes) made of proteins that facilitate movement and communication between cells.

Similar to plants and algae, some prokaryotes also have photosynthetic pigments. These light-absorbing pigments enable photosynthetic bacteria to obtain nutrition from light.

Like plant cells, bacteria have a cell wall. Some bacteria also have a polysaccharide capsule layer surrounding the cell wall. This is the layer where bacteria produce biofilm, a slimy substance that helps bacterial colonies adhere to surfaces and to each other for protection against antibiotics, chemicals, and other hazardous substances.

Prokaryotic organisms have varying cell shapes. The most common bacteria shapes are spherical, rod-shaped, and spiral.

Prokaryotic cells lack organelles found in eukaryotic cells such as mitochondria, endoplasmic reticule, and Golgi complexes.

Using bacteria as our sample prokaryote, the following structures and organelles can be found in bacterial cells:

Capsule: Found in some bacterial cells, this additional outer covering protects the cell when it is engulfed by other organisms, assists in retaining moisture, and helps the cell adhere to surfaces and nutrients.

Cell Wall: The cell wall is an outer covering that protects the bacterial cell and gives it shape.

Cytoplasm: Cytoplasm is a gel-like substance composed mainly of water that also contains enzymes, salts, cell components, and various organic molecules.

Cell Membrane or Plasma Membrane: The cell membrane surrounds the cell's cytoplasm and regulates the flow of substances in and out of the cell.

Pili (Pilus singular): Hair-like structures on the surface of the cell that attach to other bacterial cells. Shorter pili called fimbriae help bacteria attach to surfaces.

Flagella: Flagella are long, whip-like protrusions that aid in cellular locomotion.

Ribosomes: Ribosomes are cell structures responsible for protein production.

Plasmids: Plasmids are gene-carrying, circular DNA structures that are not involved in reproduction.

Nucleoid Region: Area of the cytoplasm that contains the single bacterial DNA molecule.

Pleuropneumonia-like organisms (PPLO):

These are bacteria-like organisms having more simple structural organization and differ from bacteria in the absence of cell wall and mesosomes. PPLO have flexible plasma membrane which measures about 15k in thickness. Their cytoplasm is rich in enzymes required for protein synthesis and ATP metabolism.

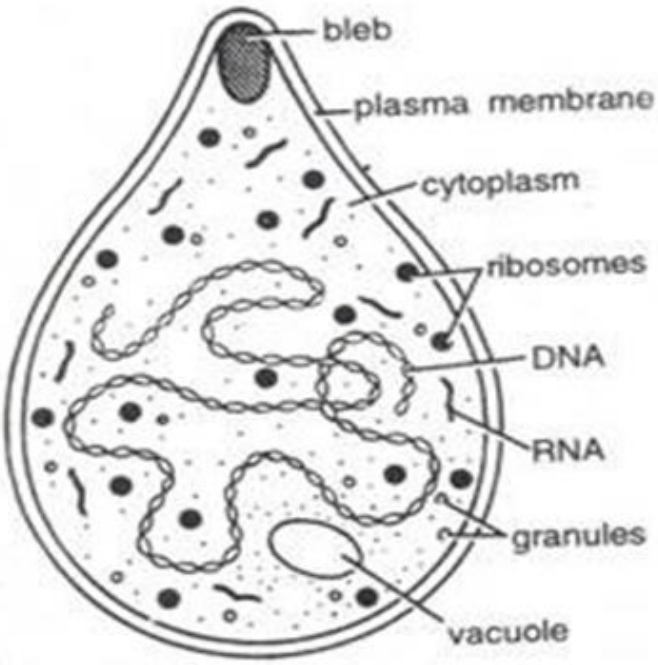


Fig. 5. A typical PPLO cell.

Nucleus is absent and instead there occurs double stranded DNA molecules of circular or fibrillar type. RNA combined with protein, forms granules resembling ribosomes. tRNA and mRNA are also present. The proteins are similar to those of larger cells; over 40 different kinds of enzymes have been identified. Lipids are also present.

W.V. Iterson (1969) placed PPLO with bacteria in the group Mycoplasmata cell but later Novikoff and Holtzman (1970) have excluded them from bacteria and considered them as simplest prokaryotic cells. Smallest PPLO belong to Mycoplasma measure about 0.1µ in diameter. It is saprophytic form found in sewage, compost and earth, etc.It has a definite life cycle. Another species *Mycoplasma gallisepticum* measures about 0.25µm in diameter and occurs as parasite in the cells and cell exudates of respiratory organs

of warm blooded animals. It causes various respiratory diseases in animals. It is useful in biochemical studies.

Blue-green algae:

It is another group of prokaryotes resembling bacteria in many aspects. Some of the blue-green algae forms are unicellular but most species are multicellular forming colonies of prokaryotic cells.

Viruses:

Viruses can not be classified as cells, because they have no nucleus, cytoplasm, or, except in myxoviruses, a limiting plasma membrane, and can not proliferate outside a living cell. But they are the simplest particles of living systems, i.e., their structure and function are determined by their genetic material, and they can produce copies of themselves by infecting suitable host cells and using the hosts raw materials and metabolic machinery for their own reproduction.

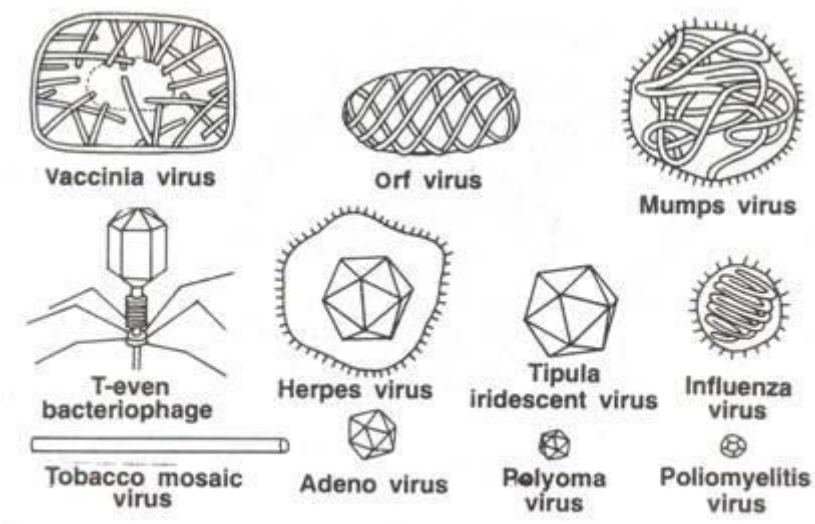


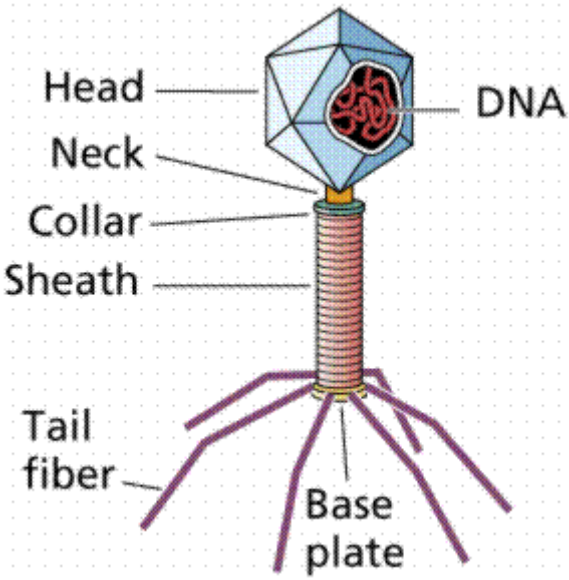
Fig. 7. Various types of viruses.

These are the simplest forms of life having macromolecular organization instead of cellular organization (i.e., nucleus, plasma membrane). Most viruses range in between 100 A to 3000 A in size and are usually smaller than bacteria. However, some viruses such as

measures about 0.75µ in diameter and is bigger than smallest bacterium PPLO.

Basically, all viruses consist of a central core of nucleic acid surrounded by a protein coat, In present terminology, an intact virus unit is called the virion, and its protein coat is known' as the capsid. The structure of plant and animal viruses is simpler than that of bacteriophages. Tail of bacteriophages is absent in plant and animal viruses.

Bacteriophages (Bacterial viruses)



Bacteriophages are viruses that attack bacteria. The name means "bacteria eaters" and is commonly shortened to just "phage". Phage particles comprises a "head" that contains DNA packaged within a protein coat, and a hollow "tail" by which they attach to the outside membrane of bacteria. The phage DNA is injected into the bacterium, where it uses the cell's replication machinery to reproduce itself. Production of new phage particles causes the host cell to rupture ("lyse") and release the phage, which go on to infect other bacteria. Early biochemical and genetic studies of phage are the foundations of modern molecular biology.

They are the most ubiquitous (numerous) biological species on Earth.

Phages are present in all aquatic and terrestrial environments (and so called natural phage).

They are viruses that only infect bacteria.

They are not able to infect eukaryotic cells (human, animal, fungus, plants and insects).

Eukaryotic cells

Plants, animals, fungi, slime moulds, protozoa, and algae are all eukaryotic.

About fifteen times wider than a typical prokaryote and thousand times greater in volume. The main distinguishing feature of eukaryotes as compared to prokaryotes is compartmentalization: the presence of membrane-bound organelles (compartments) in which specific activities take place. Most important among these is a cell nucleus,an organelle that houses the cell's DNA.

The plasma membrane resembles that of prokaryotes in function, with minor differences in the setup. Cell walls may or may not be present.

The eukaryotic DNA is organized in one or more linear molecules, called chromosomes, which are associated with histone proteins. All chromosomal DNA is stored in the cell nucleus, separated from the cytoplasm by a membrane .Some eukaryotic organelles such as mitochondria also contain some DNA.

The size of the cells ranges between 10–100 μm in diameter.

They reproduce sexually as well as asexually.

There are some contrasting features between plant and animal cells. For eg., the plant cell contains chloroplast, central vacuoles, and other plastids, whereas the animal cells do not.

Many eukaryotic cells are ciliated with primary cilia.

Primary cilia play important roles in chemosensation, mechanosensation, and thermosensation.

Motile eukaryotes can move using motile cilia or flagella. Motile cells are absent in conifers and flowering plants.

Eukaryotic flagella are more complex than those of prokaryotes.

They have a cytoskeleton composed of three filament types. They are the microtubules, microfilaments, and intermediate filaments.

They have cytosol, a gel-like substance that surrounds the organelles.

Differences between Prokaryotes and Eukaryotes

	Prokaryotes	**Eukaryotes**
Typical organisms	bacteria, archaea	protists, fungi, plants, animals
Typical size	~ 1–5 µm[18]	~ 10–100 µm[18]
Type of nucleus	nucleoid region; no true nucleus	true nucleus with double membrane
DNA	circular (usually)	linear molecules (chromosomes) with histone proteins
RNA/protein synthesis	coupled in the cytoplasm	RNA synthesis in the nucleus protein synthesis in the cytoplasm
Ribosomes	50S and 30S	60S and 40S
Cytoplasmic structure	very few structures	highly structured by endomembranes and a cytoskeleton

Cell movement	flagella made of flagellin	flagella and cilia containing microtubules; lamellipodia and filopodia containing actin
Mitochondria	none	one to several thousand
Chloroplasts	none	in algae and plants
Organization	usually single cells	single cells, colonies, higher multicellular organisms with specialized cells
Cell division	binary fission (simple division)	mitosis (fission or budding) meiosis

Similarities between prokaryotic and eukaryotic cells

- Although prokaryotic and eukaryotic cells differ in many ways, they too have similarities. Some of the similarities are discussed below:
- They both have DNA.
- They both have RNA.
- They are both covered by a cell membrane.
- They both have primary chemical structures such as carbohydrates, nucleic acid, proteins, fats, minerals, and vitamins.
- Both prokaryotic and eukaryotic cells have ribosomes.
- They both carried life processes such as reproduction and photosynthesis.
- They rely on energy supply in order to survive.
- They both regulate the flow of nutrients including the waste materials that go in and out of the cellules.

- Both eukaryotic and prokaryotic have chemical noses. These are helpful in monitoring the reactions that occur within the cells and their surrounding environment.
- They have a cytoskeleton within the cell.
- They both have cytoplasm, a fluid-like matrix in the cell.
- They both have structures that they can use for movement and adhesion to surfaces. In eukaryotes, the structures are flagella and cilia. In prokaryotes, the structures are pili, flagella, fimbriae, and endoflagella.

Components of a typical animal cell:

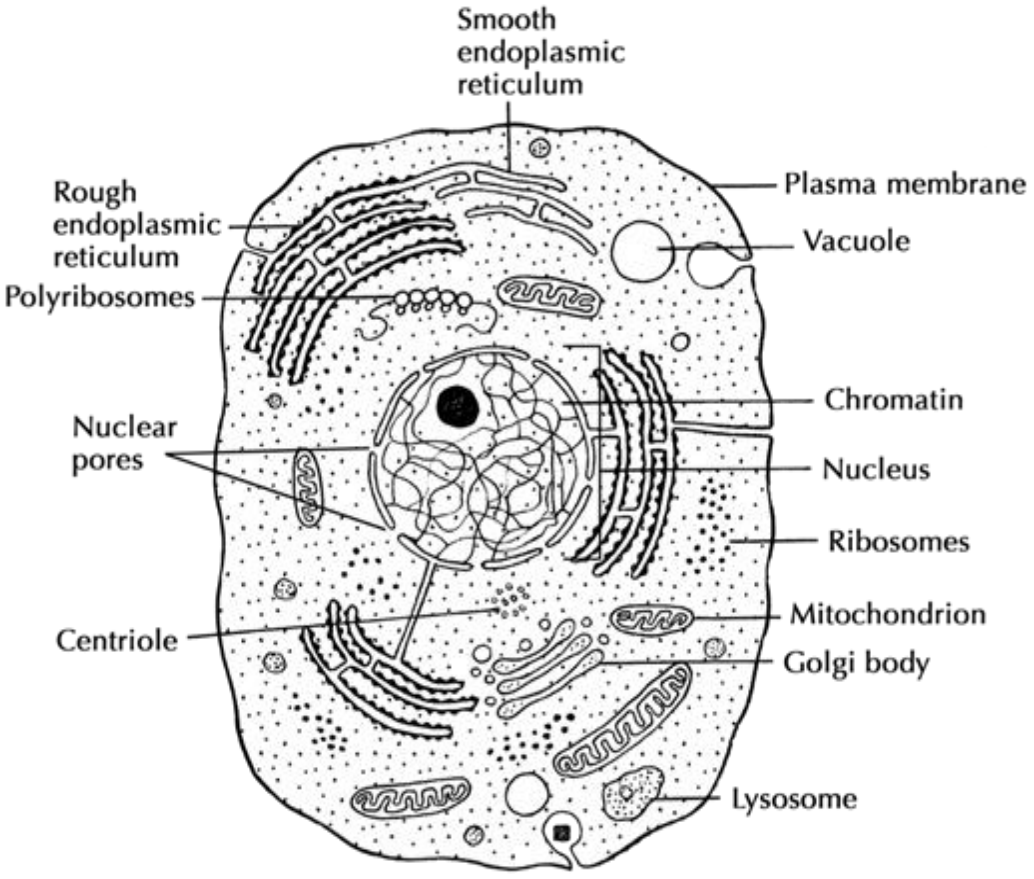


Fig. A Typical Animal cell

Nucleolus: the cellular site for the synthesis of ribosomal RNA

Nucleus: controls the functions of cells

Ribosome (little dots): essential in the process of synthesis of proteins

Vesicle: A small sphere of lipid bilayer in the cell that can transport molecules.

Rough endoplasmic reticulum: protein synthesis

Golgi apparatus (or "Golgi body") : transportation of materials within the cell

Cytoskeleton: cell skeleton, maintain the cell shape

Smooth endoplasmic reticulum: steroid or lipid synthesis

Mitochondrion: power house of cell

Vacuole: membrane-bound sacs to hold various solutions or materials

Cytosol: fluid that contains organelles, comprising the cytoplasm

Lysosome: digestive body, cell's suicide bags

Centrosome or cell centre : the area of cytoplasm around the centriole

Cell membrane: controls the entrance and exit of molecules and ions.