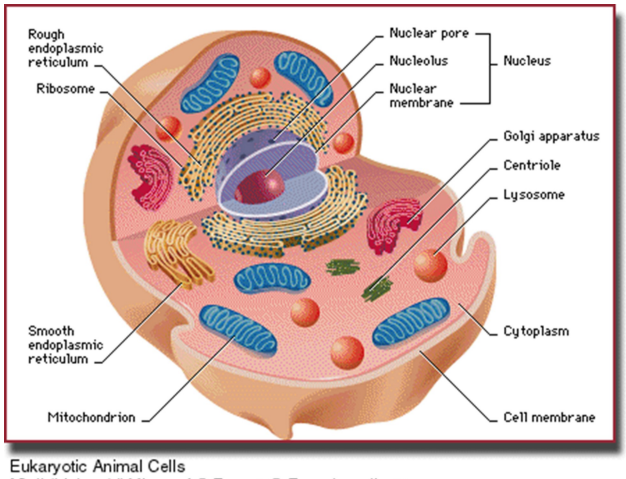
Cell Biology: An Introduction
28 October 2020 22:02

Definition and Introduction:



Eukaryotic Animal Cells
"Cell (biology)," Microsoft® Encarta® Encyclopedia 99.

- Cell biology is a branch of biology that studies cells - their physiological properties, their structure, the organelles they contain, interactions with their environment, their life cycle, division, death and cell function.
- This is done both on a microscopic and molecular level. Cell biology research encompasses both the great diversity of single celled organisms like bacteria and protozoa, as well as the many specialized cells in multicellular organisms such as humans, plants, and sponges.
- The cell can be defined as a basic functional unit of life.
- The term cell is derived from the Latin word and was first observed by a scientist named Robert Hook in the year 1665.
- All living organisms are composed of one or many cells to perform their individual functions.
- A cell is a smallest unit of a life, which is able to control and perform several functions in all living organisms.
- All unicellular organisms (single cell) including bacteria and archae, which are composed of a single cell, are examples of prokaryotic cells. All multicellular organisms (many or more than one cell) including humans, which are composed of complex or many cells, are examples of eukaryotic cells. Both prokaryotic cells and euk cells have cytoplasm, cell membrane and genetic material in common.
- The biological science which deals with the study of Structure, function, molecular organization, growth, reproduction and genetics of the cells, is called cytology.

History of Cell

Zacharias Janssen
Time: 1590
- Invented the first compound microscope

Robert Hooke
Time: 1665
- Used light microscope to look at thin slices of plant tissue (cork)
- Saw tiny chambers and coined the term 'cell'

Anton van Leeuwenhoek
Time: 1673
- First to see *living* microscopic organisms (in pond water)
- Termed these microorganisms 'animalcules'

Matthias Schleiden
Time: 1838
- Concluded that: "All living plants are made of cells"
- Credited for developing first two tenets of cell theory (with Schwann)

Theodore Schwann
Time: 1839
- Concluded that: "All living animals are made of cells"
- Credited for developing first two tenets of cell theory (with Schleiden)

Rudolph Virchow
Time: 1855
- Concluded that: "Where a cell exists, there must have been a pre-existing cell"
- Credited for developing the third tenet of the cell theory

Cell Theory
The cell theory is one of the foundational tenets of biology and explains the relationship between cells and living things.
Development of this theory occurred largely as a result of advancements in the field of microscopy

Principles of the Cell Theory

The cell theory states that:

1. All living things are composed of cells (or cell products)

2. The cell is the smallest unit of life

3. Cells only arise from pre-existing cells

Units of measurement of cell

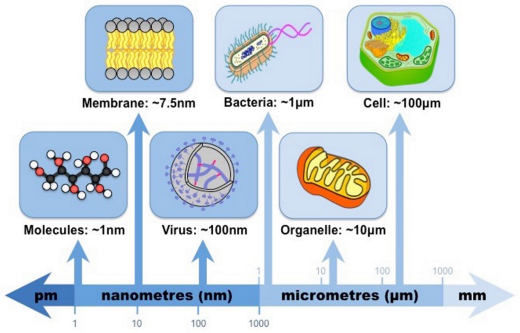
- Cells are very small invisible to the human eye. The biology student is unfamiliar with small units at which cells are visible.
- The micrometer formerly called micron (u) in equal to 0.000001 m (10-6 m). These units are generally used to describe the size of plant cells animal cells or microorganisms.
- The second unit is nanometer (nm) which is equal to 0.000000001 m (10-9). In older literature the term A is used which is equivalent to 0.1 nm or 10 m.
- Cells and their components are measured according to the metric system:

Multiplication Factor	Prefix	Symbol
1	–	m
$10^{-2} = 0.01$	centi-	cm
$10^{-3} = 0.001$	milli-	mm
$10^{-6} = 0.000001$	micro-	µm
$10^{-9} = 0.000000001$	nano-	nm
$10^{-12} = 0.000000000001$	pico-	pm

Relative Sizes of Biological Materials

- Eukaryotic cell (plant) = *~100 µm*
- Eukaryotic cell (animal) = *~10 – 50 µm*
- Organelle (e.g. mitochondrion) = *~1 – 10 µm*
- Prokaryotic cell (bacteria) = *~1 – 5 µm*
- Virus = *~100 nm*
- Plasma membrane = *~7.5 nm*
- Molecules (e.g. glucose) = *~1 nm*
- Atoms = *~100 pm*

Diagram of Relative Scale of Biological Materials



Prokaryotic and Eukaryotic Cell

❖ **Prokaryotic cells:**

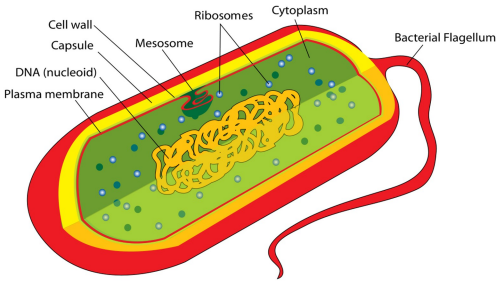
- Prokaryotic cells are single-celled entities that are primitive in structure and function.
- They lack a membrane-bound nucleus and other organelles.
- The term “prokaryote” is derived from two Greek words, ‘pro’ meaning ‘before’ and ‘karyon’ meaning ‘nucleus’.
- Prokaryotes are considered to be the first living organisms of the earth as they are the simplest form of life.

Characteristics of prokaryotic cells

The general characteristics of prokaryotic cells are listed below:

- In general, prokaryotic cells range in size from 0.1 to 5.0 µm and are considerably smaller than eukaryotic cells.
- The shape of prokaryotic cells ranges from cocci, bacilli, spirilla, and vibrio. However, prokaryotic cells with modifications of these shapes are also found in nature.
- The cellular organization of prokaryotic cells is primitive as they lack a membrane-bound nucleus and other membrane-bound cell organelles.
- The genetic material of prokaryotic cells in a single chromosome is made up of a single strand of DNA.
- A critical protein, histone protein, that is found bound in the chromosomes of eukaryotes is absent in prokaryotic cells.
- Prokaryotic cells also lack the nucleolus and the mitotic apparatus.
- The cell wall of prokaryotic cells is non-cellulosic and is made up of carbohydrates and lipids.
- Prokaryotic cells are asexual and thus, reproduce via asexual means without the formation of gametes.

- E.g. - Bacterial cells



❖ Eukaryotic Cells:

- Eukaryotic cells are the cells that are complex in structure and function as they have a membrane-bound well-defined nucleus and other membrane-bound organelles.
- The term "eukaryote" is derived from Greek words, "eu" meaning 'true' and "karyon' meaning 'nucleus.'
- Eukaryotic cells have a more advanced structural composition when compared to prokaryotes.
- By virtue of these advancements, eukaryotic cells are capable of performing more complex functions than prokaryotic cells.

Characteristics of Eukaryotic cells

The general characteristics of eukaryotic cells are listed below:

- The size of eukaryotic cells is significantly larger than prokaryotic cells as the size ranges from 10-100 µm in diameter.
- The shape of eukaryotic cells varies significantly with the type of cell. Some cells are pleiomorphic like Amoeba, whereas some have a defined shape like plant cells. The shape of the cells is highly influenced by environmental factors as well as other functional adaptations.
- Eukaryotic cells have a more advanced cellular organization with multiple membrane-bound organelles and well-defined nucleus.
- The genetic material of eukaryotic cells is DNA, and it is linear and has multiple origins of replication.
- The nucleus of eukaryotic cells is surrounded by a complex nuclear membrane. The chromosomes in the nucleus are complexed with histone protein to form linear chromosomes as opposed to circular chromosomes of prokaryotes.
- The cell wall that is present in some eukaryotic cells is made up of cellulose or other carbohydrates.
- Some eukaryotic cells like yeast cells reproduce asexually via mitosis or fission, whereas other cells reproduce sexually.
- E.g. - Animal cell, Plant cell

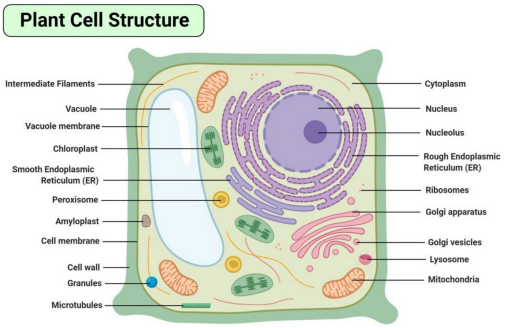


Figure: Plant Cell Structure, Image Copyright © Sagar Aryal, www.microbenotes.com

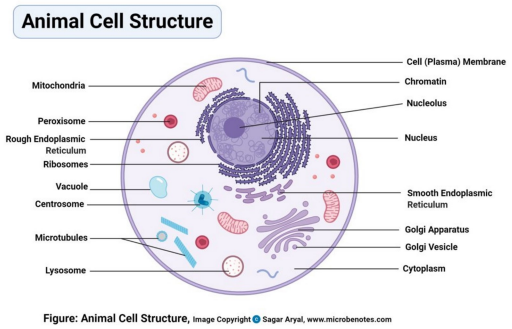


Figure: Animal Cell Structure, Image Copyright © Sagar Aryal, www.microbenotes.com

Differences between Prokaryotes and Eukaryotes

Character	Prokaryotes	Eukaryotes
Definition	Organisms made up of cell(s) that lack a cell nucleus or any membrane-encased organelles.	Organisms made up of cells that possess a membrane-bound nucleus as well as membrane-bound organelles.
Major groups	Bacteria, Archae, and Bluegreen algae	Algae, fungi, protozoa, plants, animals
Origin	Around 3.5 billion years ago.	Around 2 billion years ago.
Size (approximate)	0.5-3.0 µm	>5 µm
Cell Type	Usually unicellular	Unicellular as well as multicellular
Complexity	Simple	Complex organization.
Nucleur membrane	No nuclear membrane.	Classic membrane present.
Nucleolus	Absent	Present
Chromosome number	One	More than one
Chromosome shape	Circular	Linear
Genes	Expressed in groups called operons.	Expressed individually
Membrane-bound organelles	Absent	Present
Ribosomes (sedimentation coefficient)	70S (50S + 30S).Smaller.	80S (60S + 40S). Larger.
Ribosome's location	Free in cytoplasm or bound to cell membrane	Attached to rough endoplasmic reticulum
Mitochondria	Absent	Present
Golgi bodies	Absent	Present
Endoplasmic reticulum	Absent	Present
Mesosomes	Present. Performs the function of Golgi bodies and mitochondria and also help in the separation of chromosome during cell division.	Absent
Lysosomes	Absent	Present
Peroxisomes	Absent	Present
Chloroplasts	Absent; chlorophyll scattered in the cytoplasm	Present (in plants)
Microtubules	Absent or rare	Present
Centrosome	Absent	Present except in flowering plants.
Cytoskeleton	May be absent	Present
Glycocalyx	Present	Only in some
Cytoplasmic streaming	Absent	Present

Cytoplasmic membrane	Does not contain sterols (except *Mycoplasma*)	Contains sterols
Cell wall	Complex structure containing protein, lipids, and peptidoglycans	Present for plant cells and fungi; otherwise absent
Muramic acid	Present	Absent
Movement	Simple **flagellum**, if present	Complex **flagellum**, if present
Respiration	Via cytoplasmic membrane	Via mitochondria
Energy production site	Electron transport chain located in the cell membrane	Within membrane bound mitochondria
Metabolic rate	Higher due to larger surface area to volume ratio	Comparatively slow

Cell Biology and Other Biological Sciences

The cell biology has helped the biologists to understand various complicated life activities such as metabolism. growth, differentiation, heredity and evolution at the ular and molecular levels. Due to its wide application in various branches of biological science, many new hybrid biological sciences have sprung up. Some of them are as follows:

1) Cytotaxonomy (Cytology and Taxonomy):

Each plant and animal species has a definite number of chromosomes in its cells and the chromosomes of the individuals of a species resemble closely with one another in shape and size. These characteristics of the chromosomes help a taxonomist in determining the taxonomical position of a species. Further, cell biology furnishes strong support to the manner of origin of certain taxonomic units. Therefore, the cytotaxonomy can be defined as a cytological science which provides oytological support to the taxonomic position of any species.

2) Cytogenetics (Cytology and Genetics):

Cytogenetics is that branch of cell biology which is concerned with the cytological and molecular bases of heredity, variation, mutation, phylogeny, morphogenesis and evolution of organisms. The Weismann's germ plasm theory. Mendel's laws of inheritance and the concept of gene could be well understood only after the application of cytological concept to the genetics.

3) Cell Physiology (Cytology and Physiology):

The cell physiology is the study of life activities, size, nutrition, metabolism, excitability, growth, reproduction or cell division and differentiation of the cell. The cell physiology has helped in understanding various complicated physiological activities at cellular level.

4) Cytochemistry (Cytology and Biochemistry):

The cytochemistry is that branch of cytology which deals with the chemical and physico-chemical analysis of living matter. For example, the cytochemical analysis has revealed the presence of carbohydrates, lipids, proteins, nucleic acids and other organic and inorganic chemical compounds in the cells.

5) Ultrastructure and Molecular Biology:

These are the most modern branches of biology in which the merging of cytology with biochemistry, physico-chemistry and especially macromolecular and colloidal chemistry become increasingly complex. Knowledge of the sub microscopic organization or ultra-structure of the cell is of fundamental importance because practically all the functional and physicochemical transformations take place with the molecular architecture of the cell and at a molecular level. The recent discoveries in molecular biology such as the discovery of molecular model of DNA by Watson and Crick 1953, molecular interpretation of protein synthetic mechanism, genetic code, etc., have an extraordinary impact on modern cell biology and biology.

6) Cytopathology (Cytology and Pathology): The application of molecular biology to pathological science has

helped in understanding various human diseases at molecular level. Because most diseases are caused due to disorder of genetic codes in DNA molecule which alter the synthetic process of enzymes and ultimately disturbs metabolic activities of the cell.

7) Cyto-ecology (Cytology and Ecology):

The cytoecology is the science in which one studies the effects of ecological changes on the chromosome number of the cell. The cytological studies on plants and animals have revealed that the ecological habitat and geographical distribution have the correlation with chromosome numbers