Cell: The Unit of Life - Part 1

Objectives

After going through this lesson, the learners will be able to:

- Define a cell
- Discuss the cell theory and link it with the origin of cell
- Enumerate and describe various types of cells
- Differentiate between a prokaryotic and eukaryotic cell

Content Outline

- Introduction
- Cell - a General Overview
- Cell Theories
- Prokaryotic Cell
- Eukaryotic Cell
- Summary

Introduction

The environment in which we live is composed of different living organisms and non-living things. What distinguishes living from non-living? Or animate from inanimate? It is the presence of the basic unit of life which we call 'the cell'. All living organisms are composed of cells which form the structural and functional unit. Antonie Von Leeuwenhoek for the first time saw and described a live cell.

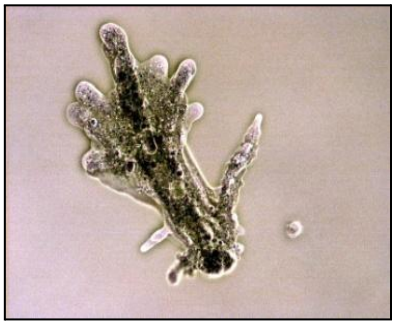
Portrait of Antonie van Leeuwenhoek (1632–1723) by Jan Verkolje

Source:

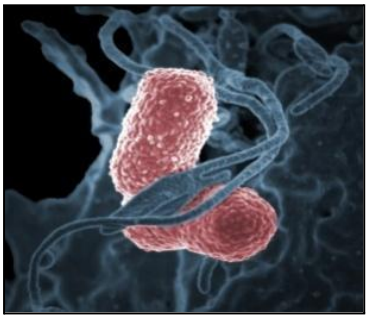
https://en.wikipedia.org/wiki/Antonie_van_Leeuwenhoek#/media/File:Anthonie_van_Leeuwenhoek_(1632-1723)._Natuurkundige_te_Delft_Rijksmuseum_SK-A-957.jpeg

Organisms can be unicellular (one celled organism) or multicellular (many celled organisms) based on the number of cells.

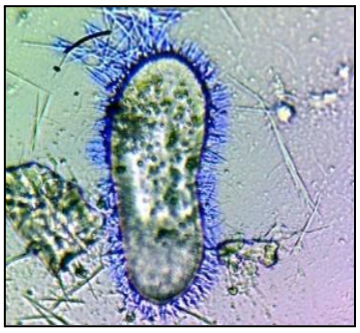
Some examples of Unicellular organisms are amoeba, bacteria, paramecium, algae, etc.



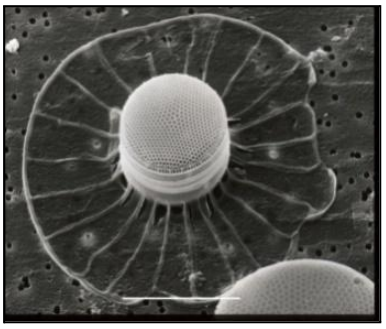
Amoeba



Bacteria



Paramecium



Unicellular Algae (Diatom)

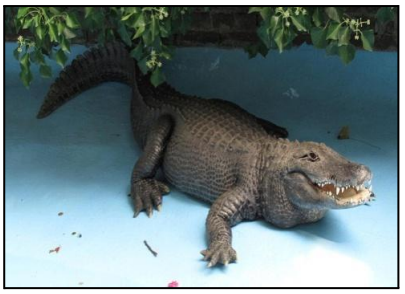
Hypolimnas misippus(Butterfly)

A Beetle (Ladybird)

Albino paradise fish

Some examples of multicellular organisms include insects, fish, amphibians, reptiles, mammals, etc.

A Frog



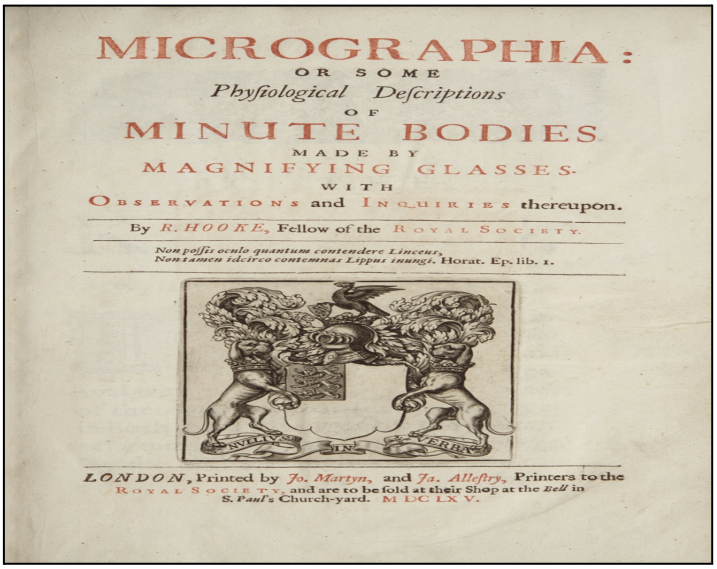
Crocodile

Zebra

Cell: A general Overview

Cell is a basic life unit and structural and functional component of any living organism. The discovery of 'the cell' can be attributed to the 17th century scientist Robert Hooke who recorded and published his observations of cellular life in a book titled, *'Micrographia'* in the year 1665.

Robert Hooke (1635 – 1703)


MICROGRAPHIA:
OR SOME
Physiological Descriptions
OF
MINUTE BODIES
MADE BY
MAGNIFYING GLASSES.
WITH
OBSERVATIONS and INQUIRIES thereupon.
By R. HOOKE, Fellow of the ROYAL SOCIETY.
Non possis oculo quantum contendere Lincei,
Non tamen idcirco contemnas Lippus inungi. Horat. Ep. lib. 1.
LONDON, Printed by Jo. Martyn, and Ja. Allestry, Printers to the ROYAL SOCIETY, and are to be sold at their Shop at the Bell in S. Paul's Church-yard. M DC LX V.

Title page of *Micrographia*

Source: https://en.wikipedia.org/wiki/Micrographia#/media/File:Micrographia_title_page.gif

The invention of the microscope and its further improvement led to more precise descriptions of the cell. Later, Robert Brown discovered the nucleus in the cell.

Know more

Experimental Preparation of Temporary Mounts of an Onion Peel

Objective:

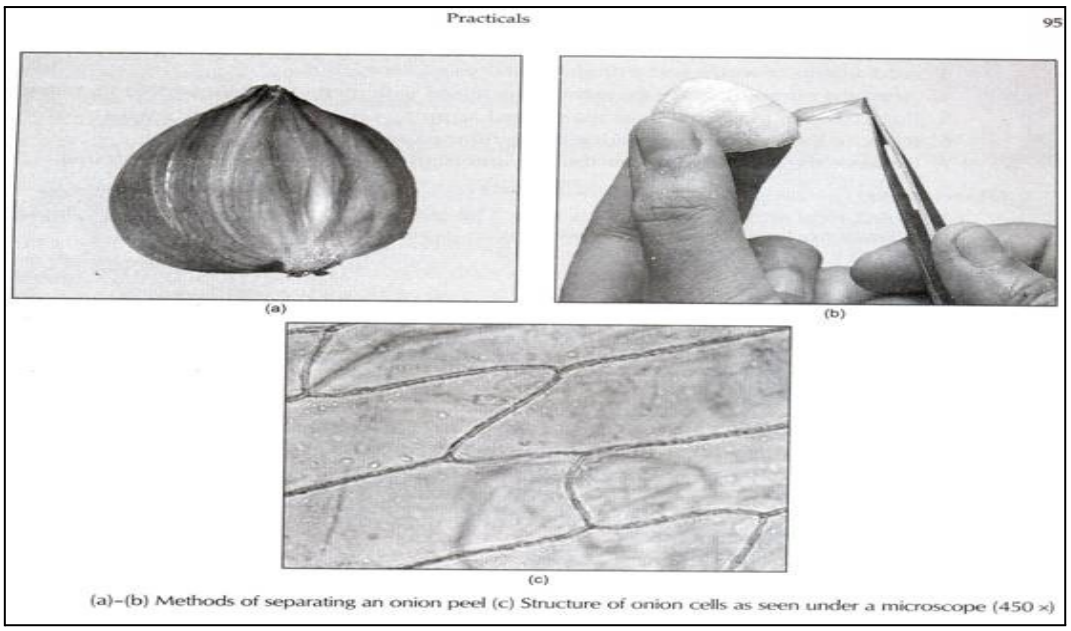
To observe plant cells by preparing a stained temporary mount of an onion peel and to record observations and draw labeled diagrams.

Apparatus and materials required:

An onion, glass slide, watch glass, coverslip, forceps, needles, brush, blade, filter paper, safranin, glycerine, dropper, water, and a compound microscope.

Procedure:

1. Take an onion and remove its outermost peel with the help of a needle.
2. Cut a small part from an inner scale leaf with the help of a blade.
3. Separate a thin, transparent peel from the convex surface of the scale leaf with the help of forceps.
4. Keep this peel in a watch glass containing water
5. Add two drops of safranin stain in the watch glass and evenly stain the peel.
6. Take a clean slide and put a drop of glycerine in the centre of the slide.
7. With the help of a brush and a needle transfer the peel on the slide. Glycerine prevents the peel from drying up.
8. Carefully cover it with a coverslip and avoid any air bubble from entering onto the coverslip.
9. Remove any excessive glycerine with a filter paper.
10. Observe the prepared mount of the peel under the low and high magnification of a compound microscope.



(a)–(b) Methods of separating an onion peel (c) Structure of onion cells as seen under a microscope (450 ×)

Observations:

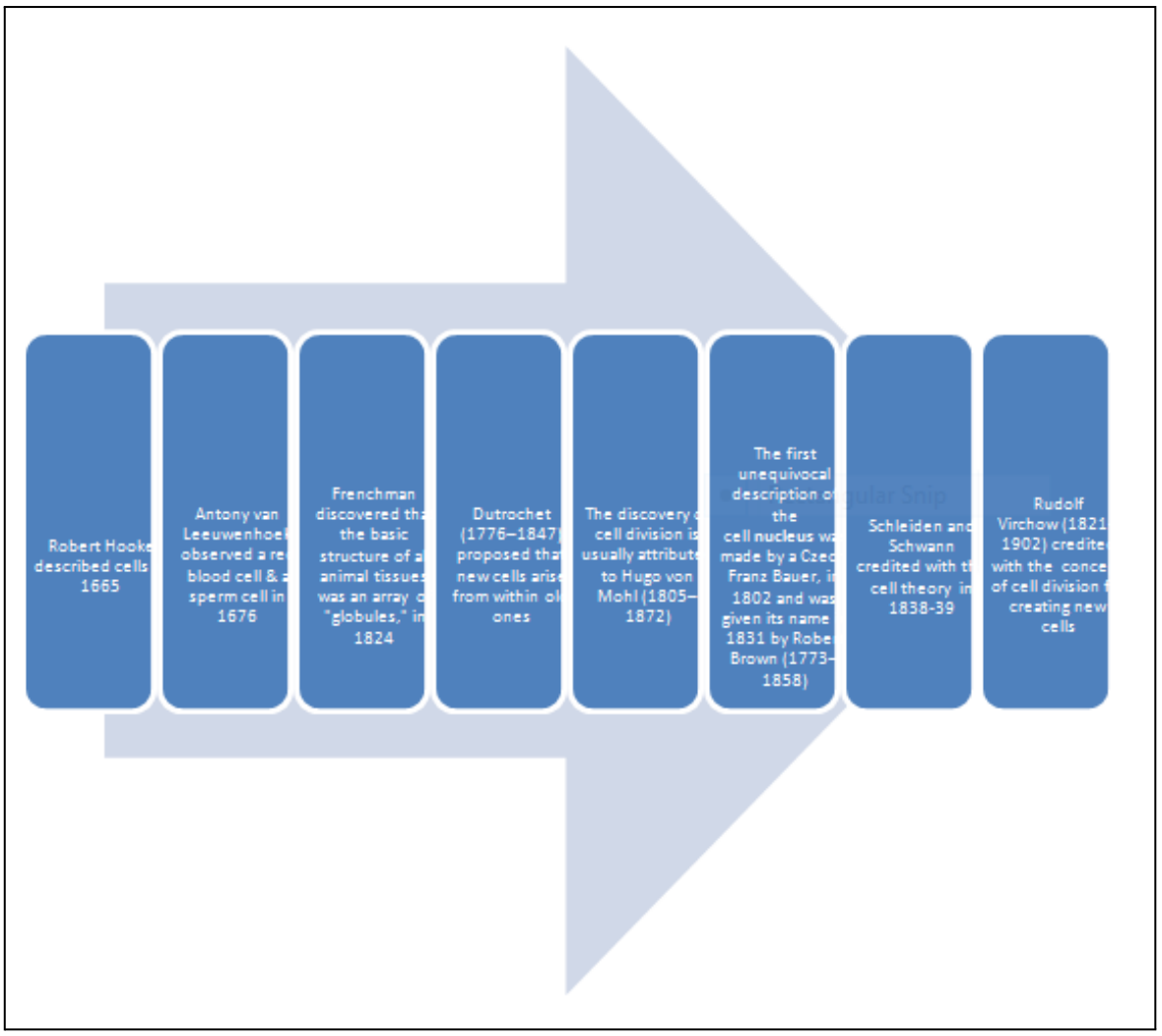
A large number of rectangular cells are visible. These cells lie close to each other with intercellular spaces between them. These cells are surrounded by distinct cell walls. These cells have a dark stained nucleus and a large vacuole in the centre.

Precautions:

1. Both Over-staining and under-staining should be avoided.
2. Folding of the peel should be avoided.
3. Clean and dry glass slide and cover-slip should be used.
4. Cover-slip should be put carefully avoiding any air bubbles.

Cell Theories

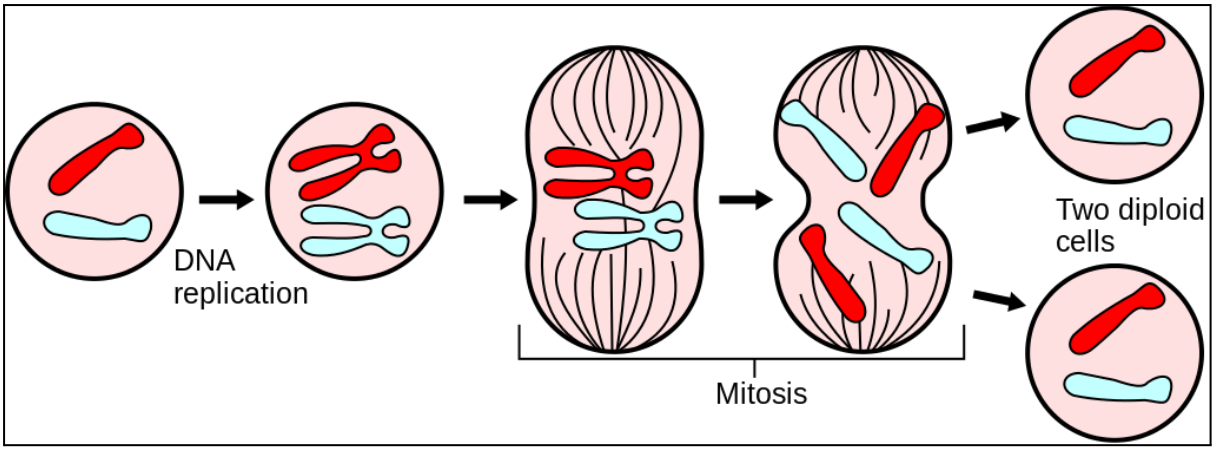
Theories in Science are formulated after many refutations and paradigmatic shifts as rightly put forth by Kuhn (1972) in his 'Structure of Scientific Revolutions'. Cell theories also had to go through many structural and functional modifications to give rise to the present theory which is being largely accepted in the scientific community.



The present cell theory was jointly put forward by Schleiden and Schwann (1839) in their paper titled, "Microscope Investigations on the similarity of structure and growth in animals and plants". Both Schleiden and Schwann made some crude observations individually for plant and animal tissues respectively such as the following:

- Cells constitute the ultimate units of all plant tissues
- Animal cells lack a cell wall
- Cells of both plants and animals are similar

However, both Schleiden and Schwann could not provide explanations for the birth of new cells. It was Rudolf Virchow (1855) who for the first time discovered and observed that new cells arise from the division of pre-existing cells. Soon after this Haeckel (1866) established that it is in the nucleus that all the hereditary material gets stored and is transmitted to the future generations.



After all these findings, the cell theory has been further modified and the following are its fundamental features:

1. Organisms are composed of different types of cells and their products.
2. Each cell is made up of a small mass of protoplasm having a nucleus and bounded by a cell membrane with or without a cell wall.
3. New cells arise from pre-existing cells.
4. All cells are basically alike in their chemistry and physiology.
5. Function of an organism is governed by the sum total of activities and interactions of its constituent cells.

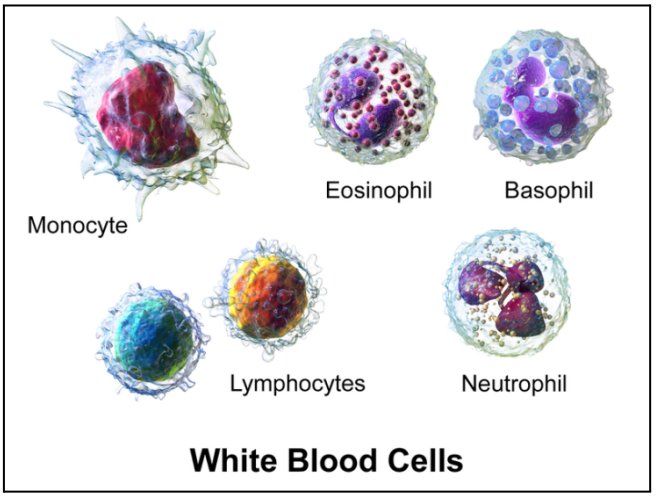
Types of Cells

Cells can be of different shapes and sizes depending upon the function they perform.

Red Blood Cells - Points to Ponder

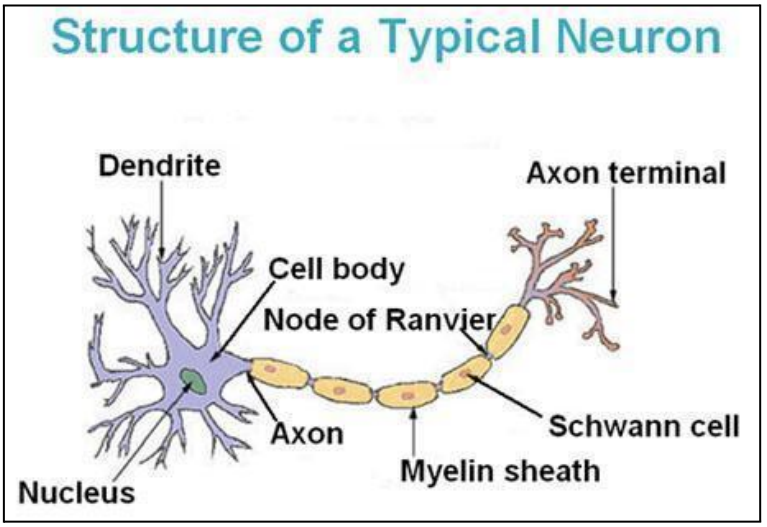
- Also referred to as Erythrocytes, are the most common type of blood cells.
- RBCs are the principal means for delivering Oxygen to the body tissues.
- The cytoplasm of RBCs is rich in haemoglobin, an Iron-containing Biomolecule.
- Mature red blood cells are flexible and oval Biconcave disks.

- They lack a cell nucleus and most organelles.



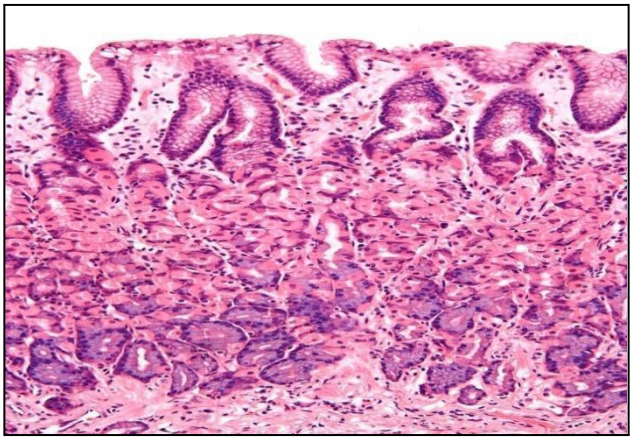
Points to Ponder:

- White Blood Cells (WBCs) also referred to as Leukocytes are the cells of the immune system.
- They help in protecting our body from infections or any foreign invaders.
- All WBCs possess nuclei which distinguishes them from the other blood cells.
- Based on the structure, WBCs can be divided into two types- Granulocytes & Agranulocytes.



Points to Ponder:

- A Neuron is an electrically excitable cell that processes & transmits information through electrical or chemical signals.
- Signaling to the other neurons occurs through specialized connections called, 'Synapses'.
- Neurons are the core components of the brain and spinal cord of the Central Nervous System (CNS) and ganglia of the Peripheral Nervous System (PNS).
- There are several types of specialized neurons, such as Sensory Neuron, Motor Neuron, and Interneuron.

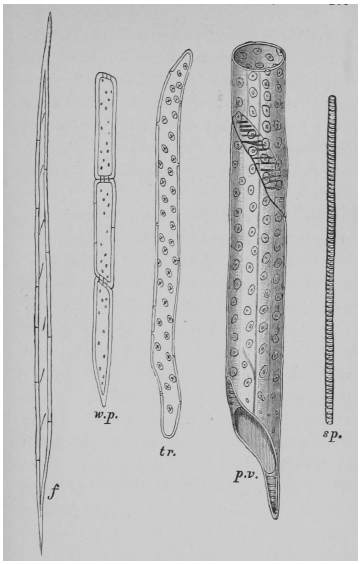


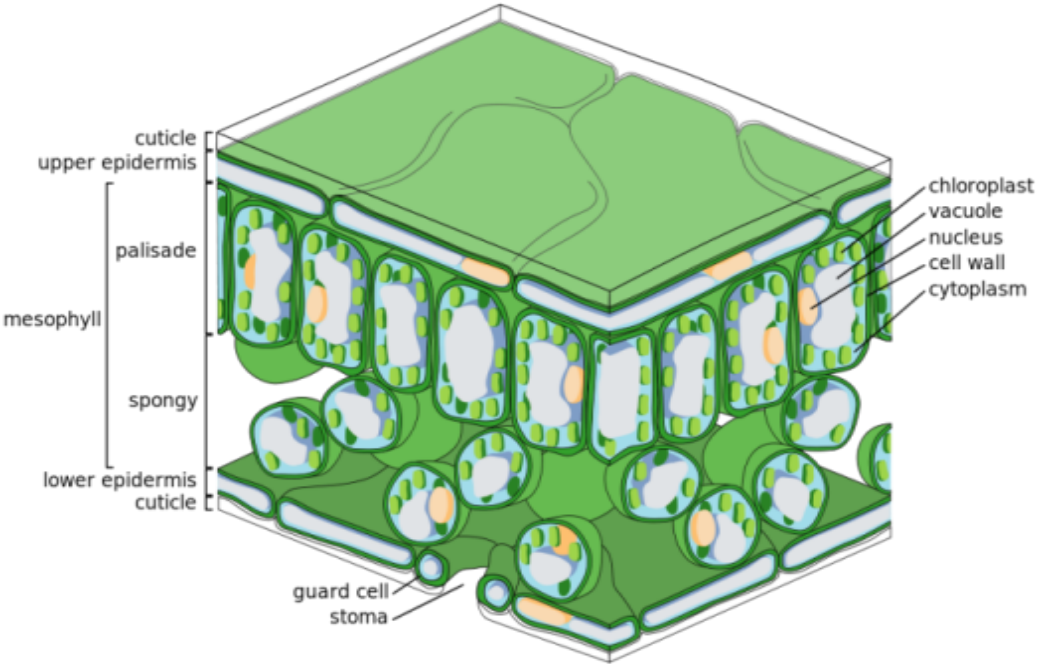
Columnar Epithelial Cells

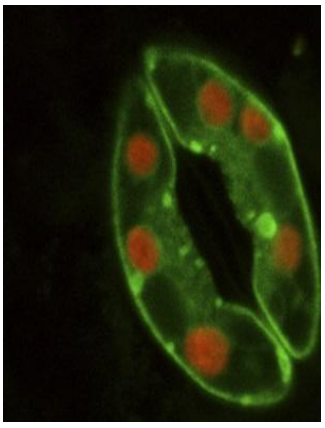
- Simple Columnar Epithelium is uni-layered
- In Humans, most of the digestive tract is lined with Columnar epithelium
- It can be ciliated or nonciliated

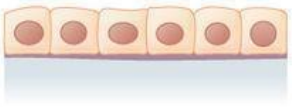
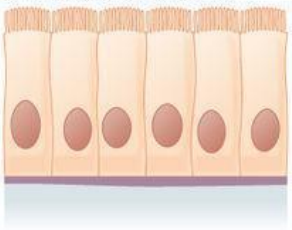
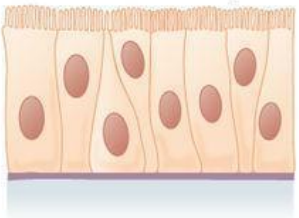
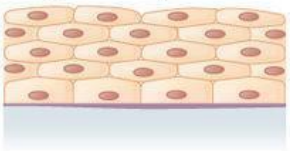
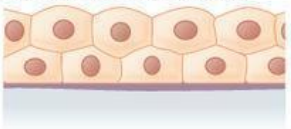
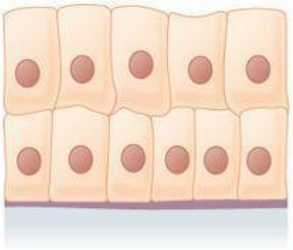
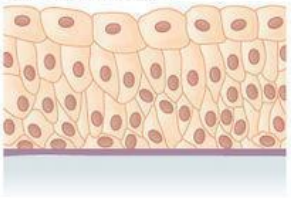
Tracheid Cell

- Tracheids are the elongated cells in the Xylem of Vascular plants
- They serve in the transport of water and mineral salts
- Tracheids are of two types- tracheary elements and vessel elements
- Tracheids do not have perforation plates



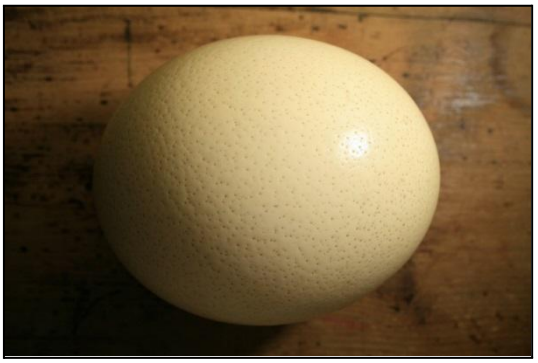

cuticle
upper epidermis
palisade
mesophyll
spongy
lower epidermis
cuticle
guard cell
stoma
chloroplast
vacuole
nucleus
cell wall
cytoplasm



Cells	Location	Function
Simple squamous epithelium 	Air sacs of lungs and the lining of the heart, blood vessels, and lymphatic vessels	Allows materials to pass through by diffusion and filtration, and secretes lubricating substance
Simple cuboidal epithelium 	In ducts and secretory portions of small glands and in kidney tubules	Secretes and absorbs
Simple columnar epithelium 	Ciliated tissues are in bronchi, uterine tubes, and uterus; smooth (nonciliated tissues) are in the digestive tract, bladder	Absorbs; it also secretes mucous and enzymes
Pseudostratified columnar epithelium 	Ciliated tissue lines the trachea and much of the upper respiratory tract	Secretes mucus; ciliated tissue moves mucus
Stratified squamous epithelium 	Lines the esophagus, mouth, and vagina	Protects against abrasion
Stratified cuboidal epithelium 	Sweat glands, salivary glands, and the mammary glands	Protective tissue
Stratified columnar epithelium 	The male urethra and the ducts of some glands	Secretes and protects
Transitional epithelium 	Lines the bladder, uretha, and the ureters	Allows the urinary organs to expand and stretch

A Stomatal Cell

- Stomata are tiny pores used for gaseous exchange in plants.
- They are found on the under-surface of plant leaves.
- It is also used for the removal of surplus Oxygen and water vapours (Transpiration).



Ostrich Egg

- An Ostrich egg is the largest of all the eggs
- An Ostrich egg is around 15 cm (5.9 in) long, 13 cm (5.1 in) wide, and weighs 1.4 kilograms

  (3.1 lb), over 20 times the weight of a chicken's egg

Caulerpa Taxifolia

- It is an aquatic alga.
- It is the world's largest single-celled living organism.
- It is composed of a single cell that can grow up to a length of six to twelve inches.

Activity:

Q1. Categorize the above mentioned cells into Plant Cells and Animal Cells and write down on what basis this distinction was made.

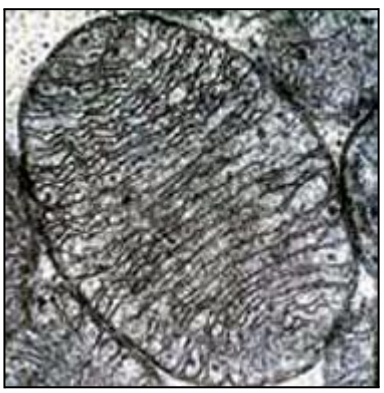
Q2. Categorize the above mentioned cells into Eukaryotic and Prokaryotic cells.

Animal cells and plant cells, although appear to be similar in shape or structure but are basically quite different and these differences are attributed to their distinct structure and function that they have to perform. The major differences between plant cells and animal cells can be listed as follows:

S. No.	Plant Cell	Animal Cell
1.	Plant cells are bigger in size	Animal cells are usually smaller in size
2.	The plasma membrane of plant cells is surrounded by a rigid cell wall made of cellulose	Cell wall is absent
3.	Plastids are present	Except the protozoan, *Euglena* no animal cells possesses Plastids
4.	Plant cells have a large central sap vacuole	Vacuoles are many but smaller in size
5.	Reserve food is in the form of Starch	Reserve food is in the form of Glycogen
6.	Plant cells can make their own food by the process of Photosynthesis	Animal cells cannot make their own food

Prokaryotic & Eukaryotic Cells

Another category for differentiating between different kinds of cells is Eukaryotic and Prokaryotic cells. These two cells differ anatomically and functionally. Prokaryotic cells lack a well defined nucleus and are found in bacteria whereas Eukaryotic cells are found in higher organisms like plants and animals. The Present-day eukaryotic cells have evolved from a common prokaryotic ancestor along three lines of descent, mainly giving rise to archaebacteria, eubacteria, and eukaryotes. Also, the Mitochondria and chloroplasts originated from the



endosymbiotic association of aerobic bacteria and cyanobacteria, respectively, with the ancestors of eukaryotes.

The origin of eukaryotic cells from prokaryotic cells has been explained by the Endosymbiotic Theory (Lynn Margulis, 1967). The theory proposed that the organelles distinguishing eukaryotic cells evolved through symbiosis of individual single-celled prokaryotes (bacteria & archaea).

Figure: An internal symbiont, Mitochondria has a matrix & membranes just like any free-living proteobacterial cell

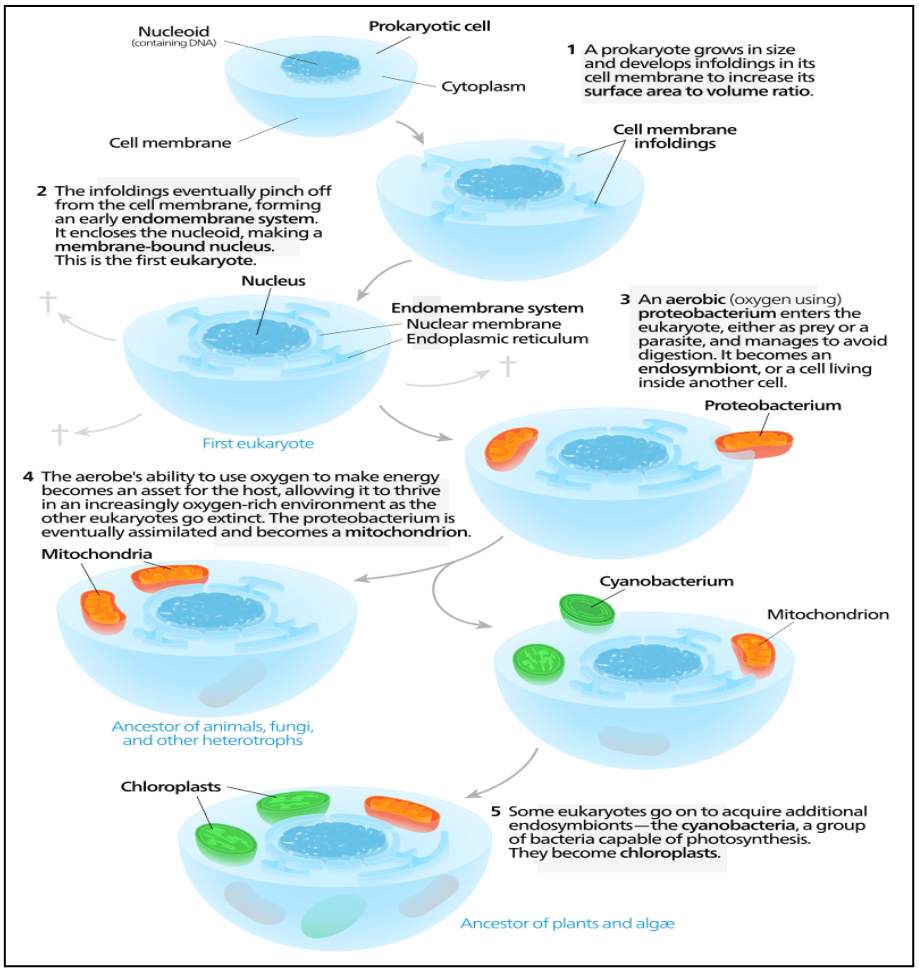


Figure: Model depicting the origin of Mitochondria & Plastids in Eukaryotic Cells

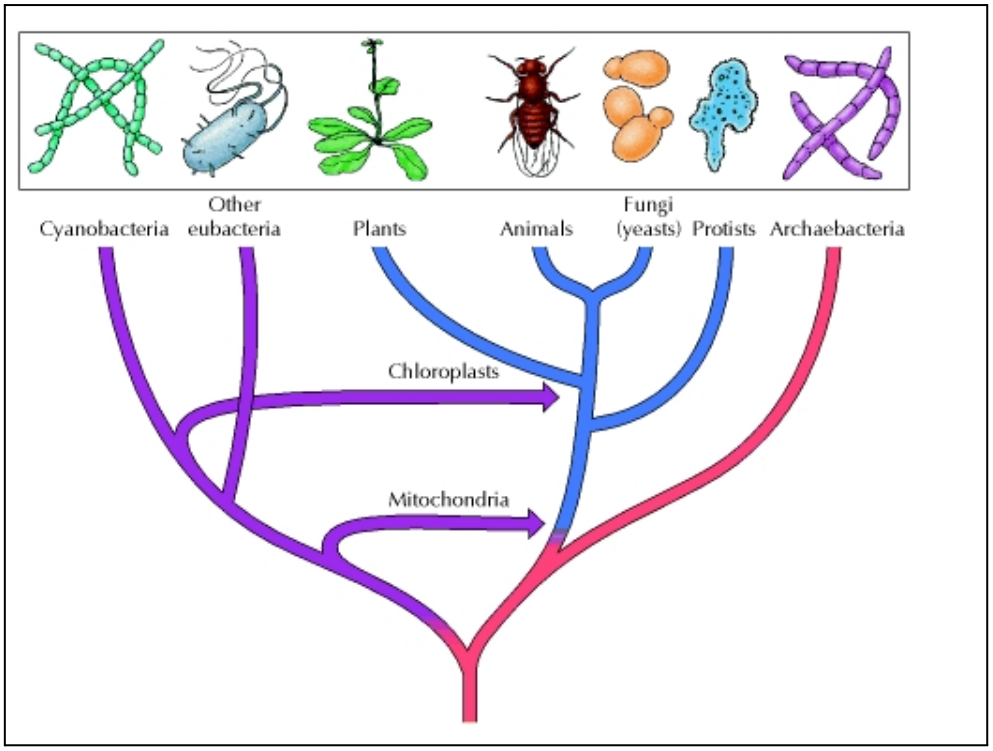


Figure: Evolution of Cells

(Source: https://www.ncbi.nlm.nih.gov/books/NBK9841/figure/A103/?report=objectonly)

Activity:

Q3. In the given two pictures, one of a Eukaryotic and a Prokaryotic cell, observe them carefully and note down the similarities and differences.

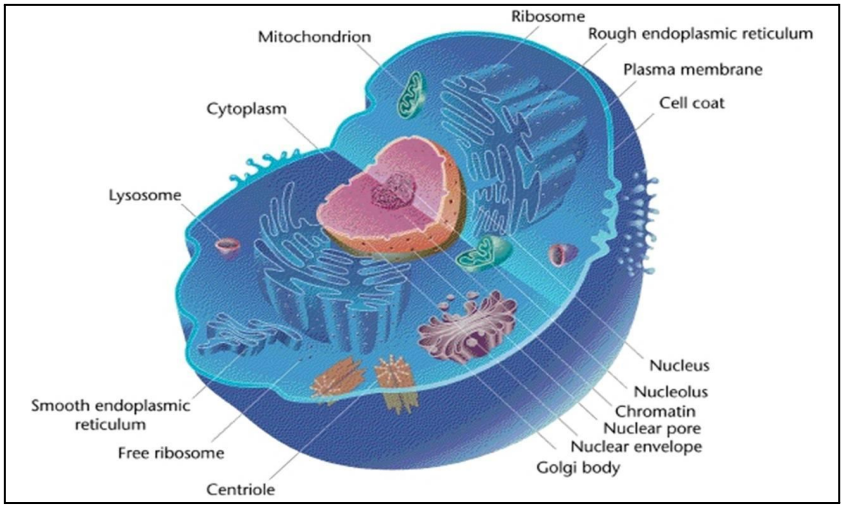


Figure: A Eukaryotic Animal Cell

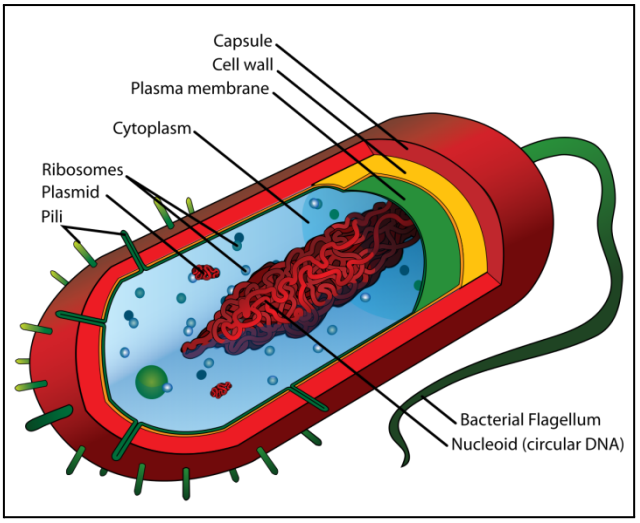


Figure: A Bacterial Cell

Prokaryotic Cells

The prokaryotic cells are represented by bacteria, blue-green algae, mycoplasma and PPLO (Pleuro Pneumonia Like Organisms). They are generally smaller and multiply more rapidly than the eukaryotic cells (Figure 8.2). They may vary greatly in shape and size. The four basic shapes of bacteria are bacillus (rod like), coccus (spherical), vibrio (comma shaped) and spirillum (spiral). The organisation of the prokaryotic cell is fundamentally similar even though prokaryotes exhibit a wide variety of shapes and functions. All prokaryotes have a cell wall surrounding the cell membrane except in mycoplasma. The fluid matrix filling the cell is the cytoplasm. There is no well-defined nucleus. The genetic material is basically naked, not enveloped by a nuclear membrane. In addition to the genomic DNA (the single chromosome/circular DNA), many bacteria have small circular DNA outside the genomic DNA. These smaller DNA are called plasmids. The plasmid DNA confers certain unique phenotypic characters to such bacteria. One such character is resistance to antibiotics.

Nuclear membrane is found in eukaryotes. No organelles, like the ones in eukaryotes, are found in prokaryotic cells except for ribosomes. Prokaryotes have something unique in the form of inclusions. A specialised differentiated form of cell membrane called mesosome is the characteristic of prokaryotes. They are essentially infoldings of cell membrane.

Eukaryotic Cells

The eukaryotes include all the protists, plants, animals and fungi. In eukaryotic cells there is an extensive compartmentalisation of cytoplasm through the presence of membrane bound organelles. Eukaryotic cells possess an organised nucleus with a nuclear envelope. In addition, eukaryotic cells have a variety of complex locomotory and cytoskeletal structures. Their genetic material is organised into chromosomes. All eukaryotic cells are not identical. Plant and animal cells are different as the former possess cell walls, plastids and a large central vacuole which are absent in animal cells. On the other hand, animal cells have centrioles which are absent in almost all plant cells.

Some of the important differences between a Prokaryotic & Eukaryotic cell can be listed in the following table:

S. No.	Prokaryotic Cell	Eukaryotic Cell
1.	The cell size is usually small (0.1-5.0µm)	The cell size is larger (5-100µm)
2.	One envelope organization	Two envelope organization
3.	Nucleus is absent, only nucleoid is found	An organized nucleus is found with a nuclear envelope, chromatin, nucleoli & nucleoplasm
4.	DNA is naked	DNA is associated with Histone proteins
5.	DNA is circular	Nuclear DNA is linear
6.	Mitochondria & Golgi apparatus are absent	Mitochondria & Golgi apparatus are present
7.	Lysosomes and other microbodies are absent	Microbodies including Lysosomes are present

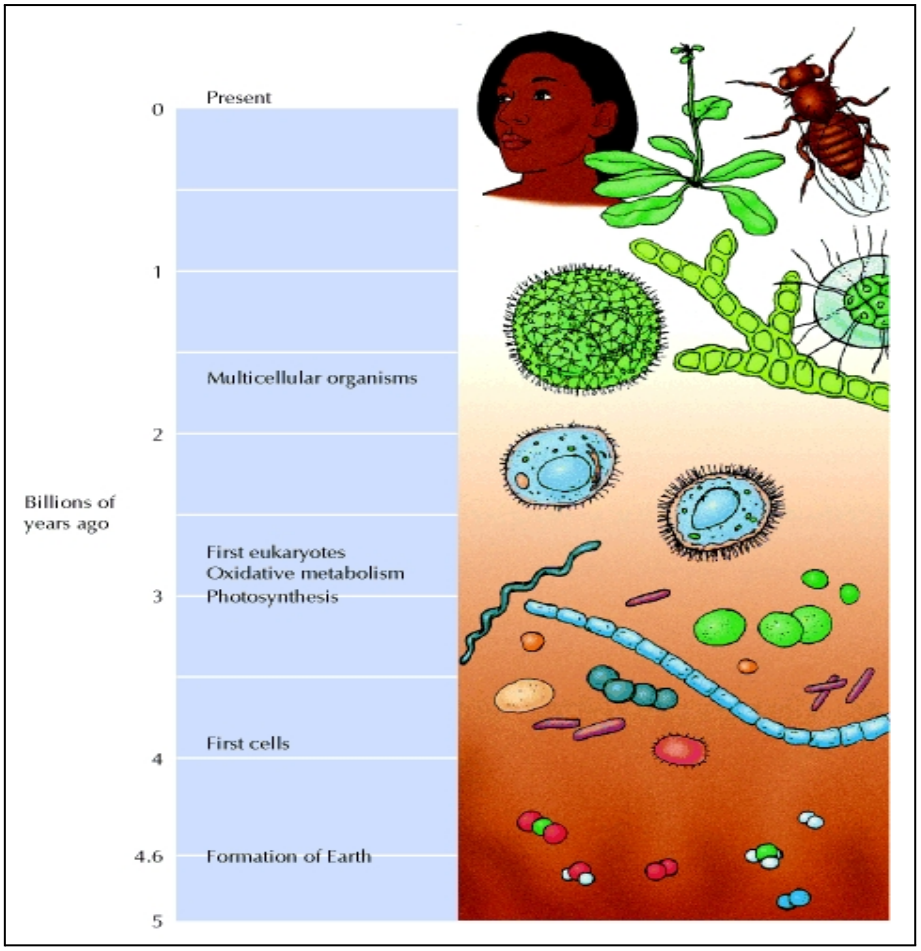
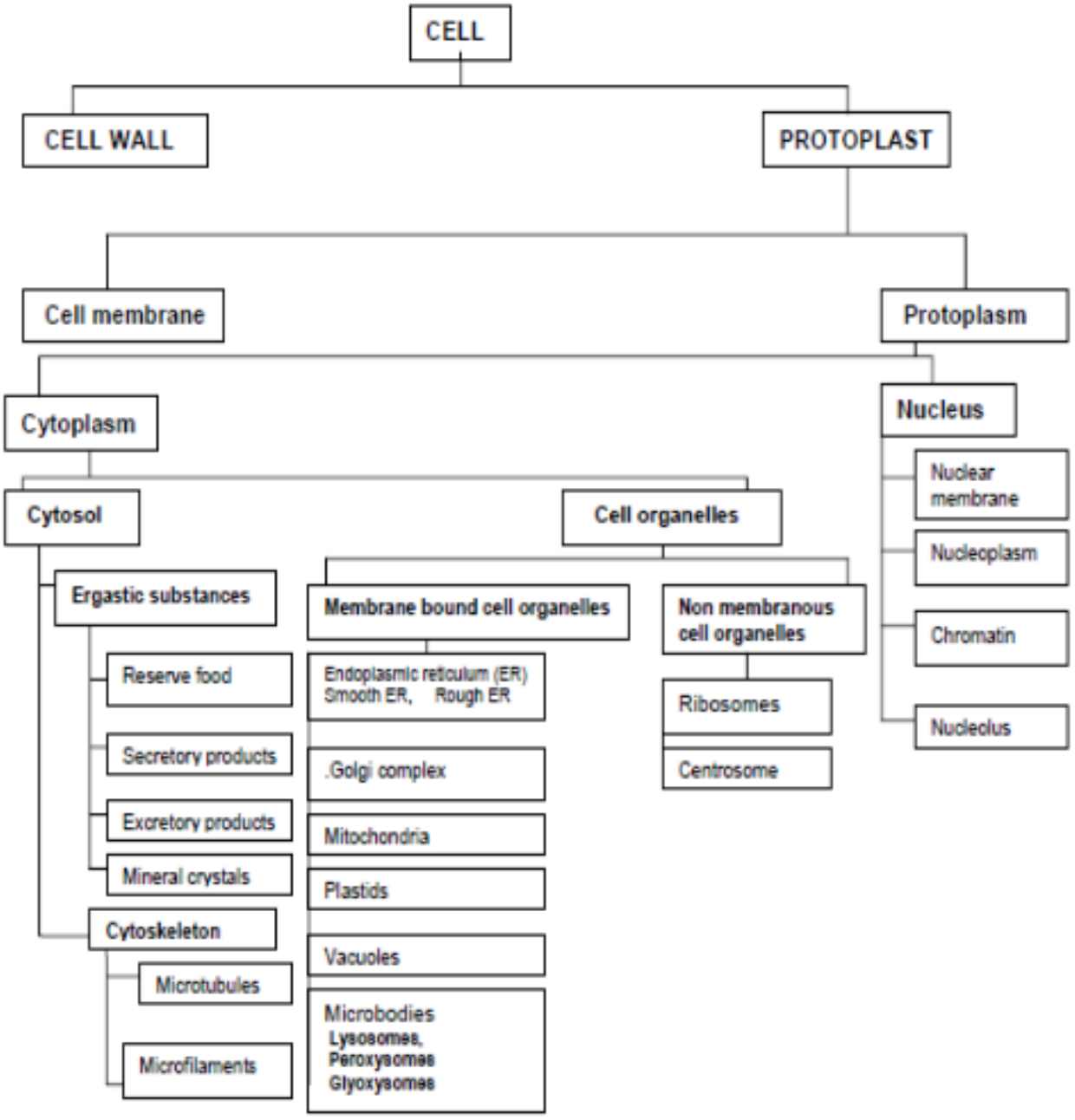


Figure: Evolution of Eukaryotic Cells

(Source: https://www.ncbi.nlm.nih.gov/books/NBK9841/)

Summary

The present module discussed the evolution of the cell as a structural unit of life, and drew comparisons among different types of cells, including prokaryotic cell, eukaryotic cell, plant cell, and animal cells. Evolutionary history of different cells from the primordial cell types has been explained along with evidence. The following concept map of the 'cell' has emerged from this discussion.


CELL
CELL WALL
PROTOPLAST
Cell membrane
Protoplasm
Cytoplasm
Nucleus
Nuclear membrane
Nucleoplasm
Chromatin
Nucleolus
Cytosol
Cell organelles
Ergastic substances
Membrane bound cell organelles
Non membranous cell organelles
Reserve food
Secretory products
Excretory products
Mineral crystals
Cytoskeleton
Microtubules
Microfilaments
Endoplasmic reticulum (ER)
Smooth ER, Rough ER
.Golgi complex
Mitochondria
Plastids
Vacuoles
Microbodies
Lysosomes,
Peroxysomes
Glyoxysomes
Ribosomes
Centrosome