Cell → Tissue → organ → system → body

Living organisms can be divided according to their structure into 2 main groups :-

1- Unicellular organisms (their bodies consist of only one cell) e.g. Amoeba.

2- Multicellular organisms :-

A) Their body consists of systems (Digestive, Respiratory, etc.)
B) Their systems consists of organs (Stomach, Lung, etc)
C) Their organs consists of tissues (Connective, muscular, nervous)
D) Their tissues consist of cells.

So ***We must study the cell first, to understand what is happening inside our bodies.***

Discovery of the cell

In 1665, The English scientist ***Robert Hook*** *made a microscope and observed that Cork tissue (a plant tissue) which covers the trunks of some old trees consists of tiny* ***cavities*** *similar to honey combs and are arranged in successive layers, and he called them cells which comes from the Latin word* ***Cellula*** *which means a small cavity.*

The Dutch scientist ***Van Leauwenhook*** *made a microscope and he examined different animals parts.*

The German botanist ***Matthias*** *discovered that all plant tissues are built from cells too,*

Schleiden *is considered as the* ***founder of the cell theory****, which states that the cell is the building unit of living organisms.* -

The German zoologist ***Theodor Schwann*** *concluded that all animal tissues consist of cells.*

The German scientist ***Rudolf Virchow*** *concluded that:* ***the cell is also the functional unit of living organisms*** *and the new cells are produced from pre - existing cells.*

The English botanist ***Robert Brown*** *discovered the nucleus of the cell.*

The discoveries of these scientists helped in formulating what is known as the ***cell theory****, which* ***declares or states that:***

1- The Cell is the basic structural and functional unit of the living organism.

2- All cells are produced from pre-existing (old) cells, and produce new cells, i.e., cells divide to produce new cells.

The cellular theory is very important in biology because:

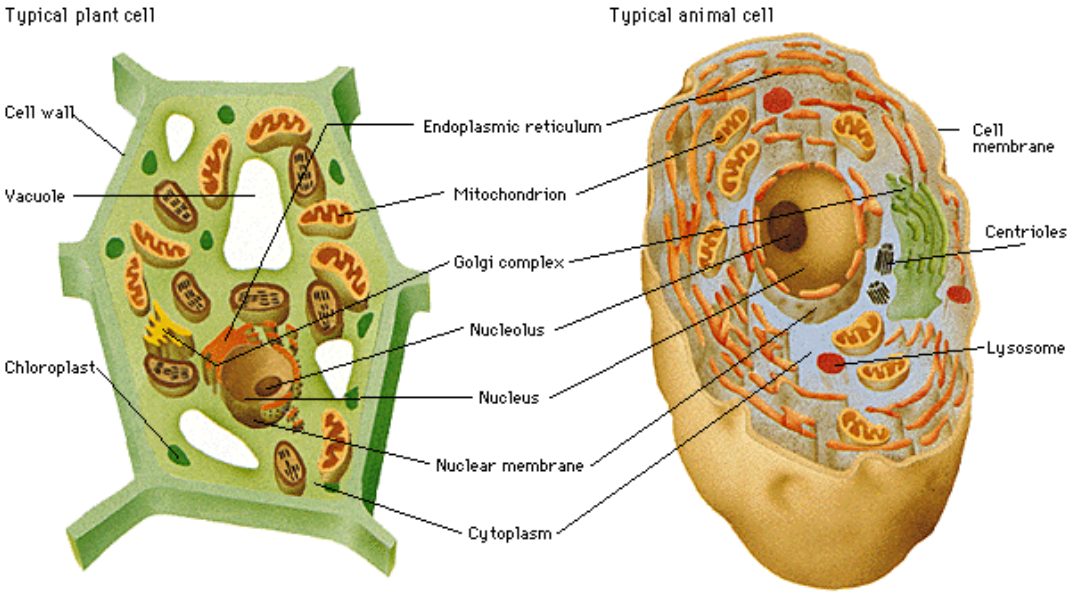
- *It confirms that all body systems in all living organisms have the same identity (way of building)*
- *Also it makes us study various kinds of living organisms on the same basis.*

Fine structure of the cell

(The structure of the cell under electron microscope)

- ***The cell is built up of the protoplasm, which is differentiated into the nucleus and the cytoplasm.***
- ***The cell is surrounded by the plasma membrane in addition to the cell wall in case of plant cell only***

Animal and plant cells



The Cell wall & the Cell membrane

Cell wall

- *In plant cells only*
- *Young plants cells have primary cell wall made of cellulose.*

But old cells have secondary cell wall made of cellulose in addition to lignin or cutin or suberin.

- *Primary cell wall is flexible to allow the cell to elongate, but secondary wall is more rigid and less flexible*
- *Primary cell wall is fully permeable, i.e., it allows all substances to pass through)*

Function

- *Encloses, supports and protects the contents of the cell (extra protection) and give it its final shape*

Cell membrane

- *In both plant and animal cells*

it appears under electron microscopes a light line sandwiched between 2 dark lines.

- *It is built from a double layer of phospholipids in which portions are embedded.*
- *Selectively permeable which allows some substances to pass into the cell and prevents others.*

Function

- *Encloses and protects the cell contents*
- *Controls what enters and leaves the cell according to the needs of the plant.*

The protoplasm

- *Protoplasm is a Greek word, which means the primary form.*

- ***In 1839, Purkinje noticed that protoplasm is the main substance in all life forms.***
- ***It appears under the light microscope as a clear colloidal, semi - fluid (semi – solid), gelatinous, or jelly - like.***
- ***It contains tiny granules (organelles), moving in a circular fashion (cytoplasmic organelles)***

Composition of the protoplasm

Most of protoplasm is water in addition to:
1- organic components
Carbohydrates, lipids (fats), proteins, and nucleic acids
2- inorganic components
- Mineral salts dissolved in water. e.g., iron, sodium, calcium, phosphorus, sulphur ..... Etc.
Water forms about 4/5 of the protoplasm weight.
The water content differs in plants in various habitats:
In case of desert plants, water forms about 65% of the cell weight, because of the shortage of water and the rise in temperature in the desert.
In case of water plants, and some marine animals, water reaches about 95% of the cell

Importance of water:
- ***Water is essential for the chemical reactions that take place inside the cell***
- ***It acts as a solvent for many substances***
- ***It protects the living cell from a sudden rise in temperature, because it is not affected easily by a rise in temperature of the surrounding medium.***

The protoplasm is differentiated into a nucleus in the center of the cell surrounded by the cytoplasm

The cytoplasm

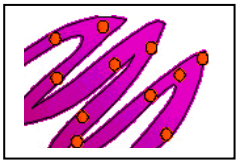
- ***Is a viscous, jelly like fluid like the white of an egg.***
- ***It solidifies if its temperature exceeds 55^{o}C,***
- ***It contains different structures called cytoplasmic organelles, which have different shapes, sizes, chemical composition and functions***

- ***Organelle: is a tiny structure, which perform a particular function within the cytoplasm.***

These organelles are:
Endoplasmic reticulam and ribosomes, Mitochondria (Mitochondrion), Golgi apparatus (body), Centrioles (centrosome), Plastids, Lysosomes,

Cytoplasmic organelles

1- Endoplasmic Reticulum (E. R.) and ribosomes
Presence *It is present in all cells*
Structure
- *It consists of a group of minute cavities (vesicles or sacs) enclosed (Bounded) by*



thin membranes.

- *These cavities are tubular or irregular in shape flattened and parallel to each other*
- *These cavities may appear as separate cavities, spherical, or oval in shape.*
- *These cavities are connected together or intermingle to from internal network inside the cell (cytoplasm) .*
- *The endoplasmic reticulum may be connected with both the nuclear membrane and the plasma membrane.*
- *It may also connect between neighboring cells*

There are two types of endoplasmic reticula

1- Rough endoplasmic reticulum

- *Which carries numerous granules called **ribosomes** on its outer surface*

2- smooth endoplasmic reticulum

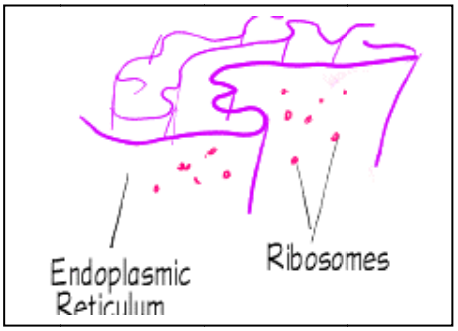
In which ribosomes are absent.

- *Ribosomes are sites of protein synthesis in the cell.*

Function

- *Ribosomes on the surface of rough endoplasmic reticulum are responsible for protein synthesis*
  - *The function of rough ER is to store proteins made by ribosomes and transport them to where they act.*

  N.B. *the proteins made by ribosomes may be enzymes or hormones, so it takes part in the formations of secretions in the cell.*
- ***ER** is the internal transport system of the cell which connects between different parts of the cell.*
- *It also connects between the nuclear membrane and the cell membrane.*
- *It also connects between the cell and other neighboring cells.*
- *The function of smooth ER is the synthesis of **fats and glycogen (animal starch)***



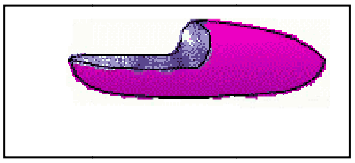
2- The ribosomes:

- *Are very fine granules.*
- *Are found in large numbers on the outer* **surface of rough endoplasmic reticulum or among its branches or free in the cytoplasm.**
- *Ribosomes are the centers for protein* **synthesis in the cell.**

3- Mitochondria

Presence:

- *They appear in the cytoplasm* ***of nearly*** **all animal and plant cells.**



Structure:

- *Are sausage like structures (from 0. 5 to 2 microns in length).*

Each mitochondrion has two membranes

1- outer smooth membrane

2- inner folded membrane

- *They exist in large numbers in liver and muscle cells.*

Function:

- *Mitochondria are the centers for energy production (respiration) and storage in the cell because they contain respiratory enzymes in addition to other materials needed to release energy from food and store it.*

$$Glucose + O_2 \longrightarrow CO_2 + H_2O + E$$

The breaking down of glucose in respiration occurs in different stages each stage is catalyzed (activated) by a respiratory enzyme.

- *The number of mitochondria increases in case of active cells such as **liver** and **muscle** cells in animals*

Enzyme is a substance which acts as a catalyst which speeds up a chemical reaction

4- Golgi apparatus (body)

Presence:

- *They are present in the cytoplasm of*

all plant and animal cells.

- *It exists close to the nucleus or around it.*
- *Golgi body is more abundant (exist*

*in large amounts or numbers) in **glandular cells (i.e.,** secretory organs such as glands.)*

Structure

- *It is similar to the structure of endoplasmic reticulum*
- *It consists of flattened and parallel, vesicles or sacs, which contain numerous tiny particles, and are bounded or enclosed by thin **smooth** membranes*
- *There are spherical (rounded) vesicles at its edges*

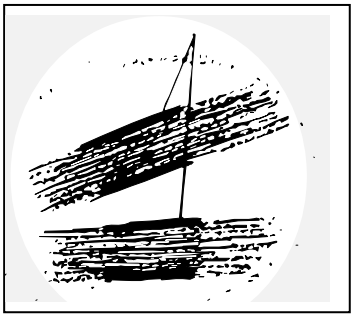
Function

- *It stores proteins made by ribosomes to be transported or secreted later.*
- *Some of the secretions (hormones or enzyme) produced by the cell are **glyco-proteins** (composed of carbohydrate part + protein part*
- *The protein part is made by ribosomes but the carbohydrate part is added to the protein part in Golgi body.*
- *So, Golgi body stores and secretes secretory substances (enzymes or hormones)*

5- Centrioles (centrosome)

Presence

*They exist **close to the nucleus** in most animal cell and in very few kinds of primitive plant cells*



Structure

*Are two **rod - like** structures at right angle to each other*

Function

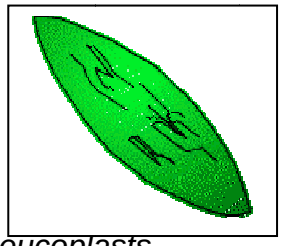
- *They have an important role in cell division*
- *During cell division, each rod or centriole migrates to one of the cell poles, and each of them becomes the centre of radiating protein fibrils called **the spindle** which extend towards the middle or the equator of the cell which help to divide the cell into two cells.*

6- Plastids

Presence

- *Are present in the cytoplasm of **some types** of plant cells, and in very few kinds of unicellular animals such as: Chlamydomonas and Euglena !!*

There are different shapes of plastids, such as:



1- Spherical, oval, disc - shaped, plate - shaped or irregular in shape.
*2- Spiral - shaped in **spirogyra** alga*
*3- Star - shaped plastid in **Zygnemia** alga*
*4- Cup - shaped plastid in **chlamydomonas** alga*

Types of plastids

There are three types of plastids: chloroplasts, chromoplasts and Leucoplasts

Type	***1- chloroplasts*** *(green plastids)*	***2- chromoplasts*** *(coloured plastids)*	***3- Leucoplasts*** *(colourless plastids)*
Colour	*green*	*red, yellow, orange, and brown according to the type and amount of pigments they contain.*	*colourless*
Pigments *(coloured substances)*	*Chlorophyll*	*contain different types of pigments*	*contain no pigments*
Position	*they exist in green leaves and green stems of some plants* *- they never exist in roots (except aerial roots)*	*- they exist in petals of flowers, in fruits, in vegetables. and in the leaves of few kinds of plants* *- They also exist in some roots such as **beet** and **turnip.*** *- in some coloured algae*	*- they store food.* *- they exist in parts of the plant away from the light such as: Inner cabbage leaves, onion leaves and roots.*
Function	*photosynthesis*	*they are responsible for colouring*	*storage of food such as **starch (amyloplastids) and fats (elaioplastids)*** *- they could change to **chloroplasts** or **chromoplasts**.*

7- Lysosomes

Lyso = lysis = breaking down
some = body

Presence

Are more abundant in animal cells (e.g., liver, kidney and small intestine cells) than in plant cells

- *Are known as lysosomal compartments in plant cells.*

Structure

Are tiny bodies which contain a group of digestive enzymes which activate (catalyze) the digestion of proteins, fats and carbohydrates.

Function

The function of lysosomes differs from one cell to another

For example:

- *Lysosomes of white blood cells can break down bacteria .*
- *They can digest worn out organelles and worn out cells so, they are called suicide bags.*
- *They can digest proteins, fats and carbohydrates.*

Special Thanks to Prof. Dr Carl Davis for his clear and accurate images of plant cell .

The nucleus

Size: - the largest organelle in the cell

Shape: Spherical, ellipsoidal, filamentous, or even irregular.

Membrane: Surrounded by a very thin membrane, which are actually 2 membranes (fusing together at intervals leaving tiny pores, which are connected, to the endoplasmic reticulum.

Filled with: (Nuclear sap) which is more or less like jelly, very clear fluid.

Other stuff may be inside the nucleus: Nucleoli, Chromatin reticulum (tiny threads coiled around each other).

Role: During cell division the chromatin reticulum forms chromosomes.

Chromosomes:

Each one consists of 2 chromatids attached together in the centromere.

The number of chromosomes in the same species are the same (maize has 20 chromosomes for example).

They carry the genes, which determine the inherited characters.

They appear clearly during cell division only.

They vary in length (0.2 to 50 microns) and in diameter (0.2 to 2 microns).

At a certain stage of the cell division they look like a cylinder with several constructions.

Believe it or not!

Some cells have more than one nucleus (coenocyte) such as muscle fiber in valentary muscles while others have no nucleus (R.B.C) so they have a short life time (4 months) and they can't reproduce (that is why they got to be produced from another organ – bone marrow-)

Those biology scientists!

They used microsurgery to remove the nucleus of an amoeba just to understand the function of it (the poor amoeba stopped dividing and died few days later. So they considered the nucleus as the center of the vital activities of the cell.

Other components of the cell:

Fat globules, glycogen, colouring pigments, hormones, enzymes, vitamins, are found in the **Cell vacuoles** and various crystals cytoplasm of the cell.

Vacuoles are found in plant cell in the form of small vacuoles at first and then in the form of large vacuoles which contains juice.
Animal cells are usually avoided of these vacuoles but sometimes it contains very small ones.
A thin membrane (tonoplast) surrounds it *to regulate the diffusion of the dissolved substances in or out the cell.*

Cell activities

1- Vegetative activities:- to keep the individual's life and growth, Such as respiration, excretion, Digestion … etc.
2- Reproduction activities: - includes the production of either new cells or new individuals.

Size of the cell

Normally (5 to 15 microns) in diameter, but sometimes there are a smaller cells such as bacteria (< 3 microns), and there are soma plant and animal cells their diameter > 1 cm. Like cotton fibers.

Comparison between animal and plant cells

P.O.C	Plant cell.	Animal cell.
Cell wall	Made of cellulose.	Missing.
Plastids	Found.	Missing.
Centrioles	Missing except some primitives	Present.
Cilia and flagella	Missing in higher plants.	Present in some of them.
Lysosomes	Have similar structures called lysosomal compartment.	Present.
Vacuoles	Large one in the mature cell.	Small or missing.