Chapter-5

FUNDAMENTAL UNIT OF LIFE

STUDY NOTES

CELL

The body of all organisms is made up of tiny microscopic units called cell.

The cell is a fundamental, structural and functional unit of living organisms and basic unit of life.

All living organisms are made up of cells. Cells make tissues, tissues together make organ, organs make organ system and organ systems make body of organisms. So cell is called structural unit of life.

All the basic functions of the body like respiration, excretion etc. are carried out by cell through its cell organelles, so cell is called functional unit of life.

Cell biology is the study of cells in all aspects of structure and functions.

DISCOVERY OF CELL

Cell was first discovered by Robert Hook in 1665. He observed the cell in a cork slice with the help of a primitive microscope.

Anton Von Leeuwenhoek (1674) was the first to observe free cells, like bacteria, protozoa, red blood cells and sperms in his home made microscope.

Mycoplasma or PPLO (Pleuro pneumonia like organism) is the smallest free living prokaryotic living cell with a diameter of approximately 0.2µm.

INTERESTING FACT

MICROSCOPE

A microscope is an instrument that makes an enlarged image of a small object, thus revealing details of an object which cannot be seen by our naked eyes.

COMPOUND MICROSCOPE AND IT' S PARTS

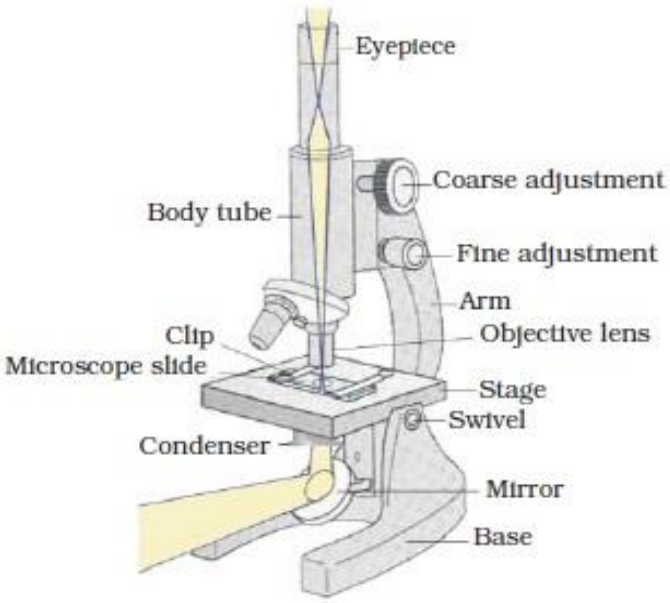


Fig. 5.1: Compound microscope

CELL THEORY:

The cell theory, that all the plants and animals are composed of cells and that the cell is basic unit of life, was presented by

Two biologists, M. Schleiden (1838) and T. Schwann (1839).

The cell theory was further expanded by a German physiologist, Rudolf Virchow (1855). He gave the phrase Omnis cellula-e-cellula, i.e., all cells arises from pre-existing cells.

Modified cell theory is termed as cell principle or modern cell theory which postulates that:

- All living organisms are composed of cells or cell products.
- All living cells arise from pre-existing cells.
- All cells are basically alike in chemical composition and metabolic processes

SHAPE, SIZE AND NUMBER OF CELLS

Cell shape:

The shape of cells is related to the specific function they perform.

Some cells like Amoeba and WBCs have changing shapes.

In some cases the cell shape could be more or less fixed and peculiar for a particular type of cell; for example, nerve cells have a typical shape.

Cell size:

The size of the cell also varies considerably in different animals and plants.

The average cell size varies from 0.5 to 20µ (µ = micrometer).

In human body, the smallest cell is RBC and the longest one is the nerve cells.

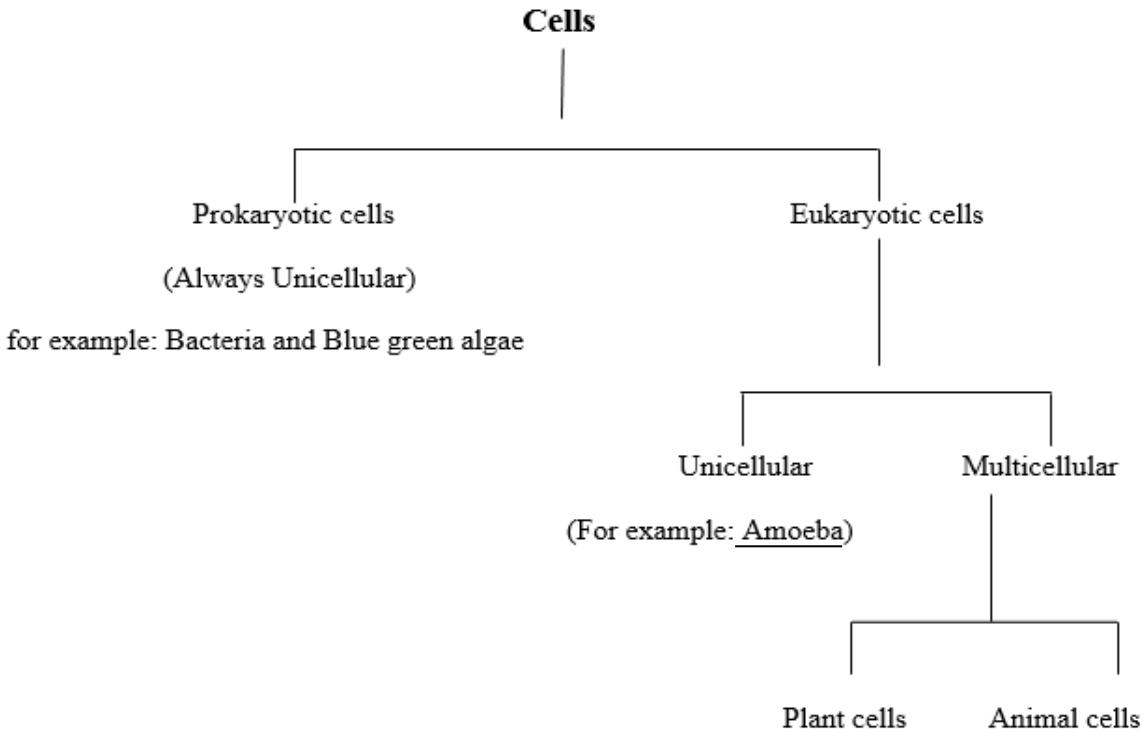
Number of cells

Living organisms can be Unicellular (E.g. Bacteria, Amoeba etc.) Or Multicellular (E.g. Plants, Animals etc.)

Each day, approximately 50 to 70 billion cells die in human body as a part of normal process that serves a healthy and protective role. Those that die in largest number are skin cells, blood cells and some cells that line structures like organs and glands.

INTERESTING FACT

Types of Cells:



NOTE- Protozoa are defined as a diverse group of eukaryotic organisms. They are unicellular or single-celled organisms and act like animals in which they move around and feed on prey. Protozoa is a Greek word that means 'first animals'. This name is given because of their animal behaviour and the belief that they are descendants from the earliest or first forms of life.

S. No.	**Prokaryotic cell**	**Eukaryotic cell**
1	'Pro' means primitive and 'karyon' means nucleus. Cells having primitive nucleus	'Eu' means true and 'karyon' means nucleus. Cells having true nucleus.
2	Prokaryotes are always unicellular organisms.	Unicellular and multicellular
3	Nucleus is not well defined and known as nucleoid	Well defined nucleus is present
4	Membrane bound organelles such as Mitochondria, Golgi complex etc. are absent.	Membrane bound organelles, such as Mitochondria, Golgi complex etc. are also present.
5	Ribosomes are smaller and scattered randomly in the cytoplasm.	Ribosomes are bigger. They are either attached to endoplasmic reticulum or are found free.
6	The prokaryotes include archaebacteria, bacteria and cyanobacteria (blue green algae).	Eukaryotes include all living organisms, except bacteria and blue-green algae

NOTE- Always lay stress in writing compatible differences and in tabular form.

COMMONLY MADE ERROR - Students often fail to write proper differences. Many of them forget to write the term nucleoid, while explaining nuclear region of prokaryotic

Structural organization of cell:

Structurally the cell is formed of three major parts:

1. Plasma membrane or cell membrane

2. Cytoplasm and its contents

3. Nucleus

Plasma membrane (cell membrane):

Plasma membrane is the outermost covering of the cell that separates the contents of the cell from its external environment.

Plasma membrane is living, thin, delicate, elastic, selectively permeable membrane.

The plasma membrane is flexible and made up of organic molecules called lipids and proteins.

INTERESTING FACT

Viruses do not have any membrane and therefore do not show characteristics of life until and unless they enter a living organism and utilizes their cell machinery to increase their number. So cell theory is not true for virus.

Functions:

Plasma membrane permits the entry and exit of some materials in the cells. It also prevents movement of some other material. Therefore, the plasma membrane is called a selectively permeable membrane.

Substances can pass across a membrane by two processes- diffusion and osmosis.

Diffusion: Some substances like carbon dioxide or oxygen can move across the cell membrane by a process called diffusion.

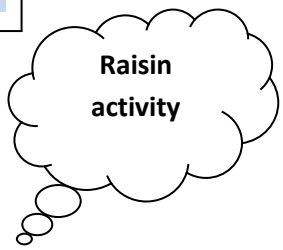
Diffusion is the spontaneous movement of molecules from a region of its higher concentration to a region of its lower concentration.

Example: movement of carbon dioxide and oxygen during respiration organisms.

Osmosis:

The movement of water molecules through a selectively permeable membrane from a region of higher water concentration to a region of lower water concentration is called osmosis.

COMMONLY MADE ERROR- Students often confuse between osmosis and diffusion



What will happen if you put an animal cell or plant cells into solution of sugar or salt prepared in water?

If the medium surrounding the cell has a higher water concentration than the cell, i.e., if solution is a much diluted solution, the cell will gain water by osmosis. Such a dilute solution is called **hypotonic solution.**

Water molecule will pass across the plasma membrane in both directions, but more water molecules will enter the cell than will leave. The cell will therefore, swell up and increase in volume. This process is called **endosmosis.**

If the medium surrounding the cell is exactly the same water concentration as the cell, there will be no net movement of water across the plasma membrane resulting in no change in the size of the cell. Such a solution is called **isotonic solution**.

If the medium has a lower concentration of water than the cell, i.e., if it is very concentrated solution, the cel will lose water by osmosis. Such a concentrated solution is called **hypertonic solution**.

In this case too, water crosses the plasma membrane in both the directions, but this time more water leaves the cell than enter it. The cell will therefore, shrink and reduce in volume. This process is known as **exosmosis.**

TIPS TO REMEMBER –

Hyper-Exo (out) and Hypo- Endo (in). So it becomes easy to answer questions like, What happens to an animal cell when kept in hypotonic and hypertonic solution.

Cell wall:

In plant cells, there occurs a rigid cell wall which lies outside the plasma membrane.

Cell wall is thick, non-living and permeable covering made up of cellulose. Cellulose is a kind of carbohydrate (polysaccharide) and it provides structural strength to the plant.

Functions:

Cell wall protects cell membrane and the internal structures of the cell.

It provides rigidity and determines the shape of the plant cell.

It prevents drying of the cell and helps it to bear unfavorable conditions.

It provides mechanical strength to the plant cells.

Protoplasm:

All cells contain living substance called protoplasm. It is jelly-like, viscous, colourless semi-fluid substance in which various cell organelles and inclusion remains in colloidal form.

Protoplasm can be distinguished in two forms:

Cytoplasm: it is that part of protoplasm which surrounds the nucleus.

Nucleoplasm: it is that part of protoplasm which is located inside the nucleus.

Protoplasm = Cytoplasm + Nucleoplasm

Cytoplasm:

The part of the cell which occurs between the plasma membrane and nucleus envelop is called the cytoplasm

Cytoplasm consists of an aqueous ground substance, the cytosol, containing a variety of cell organelles and other inclusions such as insoluble waste and storage product (starch, lipid, etc.).

Chemically cytoplasm contains about 90% water, 7% proteins, 2% carbohydrates and lipids and 1% inorganic minerals, minerals vitamins, etc.

Nucleus:

The nucleus is a major, centrally located spherical cellular component. It is the centre from where all cellular activities are controlled. It is the carrier of hereditary material in the cell.

It is bounded by two membranes, both forming a nuclear envelope. The nuclear envelope contains many pores known as nuclear pores and encloses the liquid ground substance, the nucleoplasm.

The nuclear pores allow transfer of materials between the nucleoplasm and the cytoplasm. Within nucleoplasm are embedded two types of nuclear structures- nucleolus and chromatin material.

Nucleolus:

The nucleolus may be one or more in number ad is not bounded by any membrane.

Nucleolus consists of DNA, RNA and protein.

It is the site of ribosome formation. Nucleolus is known as factory of ribosomes.

Chromatin material:

The chromatin is a thin, thread-like intermingled mass of chromosome material and composed of the genetic substance DNA (deoxyribonucleic acid) and proteins (i.e., histones).

DNA stores all the information necessary for the cell to function (metabolism), to grow and to reproduce further cells of the next generation.

The chromatin is condensed into two or more thick ribbon-like chromosomes during the division of cell.

Functional segments of DNA are called genes.

Genes carry information for protein synthesis, which in turn control the development of characters. Since genes are present on chromosomes and chromosomes pass from one generation to the next through, genes are called hereditary units.

Functions of nucleus:

The nucleus controls all metabolic activities of the cell. If the nucleus is removed from the cell, the protoplasm ultimately dries up and dies.

It regulates the cell cycle.

It is the storehouse of genes which are concerned with the development and manifestation of all the body characters.

Nucleus helps in the formation of ribosomes and RNA.

It helps in the transmission of characters from one generation to the next.

Note- The ribosomes, which are present in all active cells(RER), are the sites of protein manufacture. The manufactured proteins are then sent to various places in the cell depending on need, using the ER. The SER helps in the manufacture of fat molecules, or lipids, important for cell function. Some of these proteins and lipids help in building the cell membrane. This process is known as **membrane biogenesis.**

Cell organelles:

A cell has to perform different functions with the help of its various membrane- bound cell organelles.

Cell organelles are "small organs" of the cell and are found embedded in the cytosol. They form living part of the cell and each of them has a definite shape, structure and function.

NAME OF THE ORGANELLE	STRUCTURE	FUNCTONS
ENDOPLASMIC RETICULUM	It is absent in prokaryotic cells and matured RBCs of mammals. ER occurs in three forms: Cisternae (i.e., closed, fluid-filled sacs), vesicles and tubules. ER is of two types: 1.Rough endoplasmic reticulum (RER) with ribosome attached on its surface. 2. Smooth endoplasmic reticulum (SER) which is without ribosome.	It forms intracellular transporting system. SER takes part in the synthesis of lipids. RER is concerned with the transport of proteins which are synthesized by ribosome on their surface.
GOLGI COMPLEX (GOLGI APPARATUS OR GOLGI BODY)	Golgi complex was discovered by Camillo Golgi (1898). It occurs in almost all eukaryotic cells. It is not found in prokaryotic cells. Golgi apparatus consists of a set of membrane-bounded, fluid-filled vesicles, vacuoles and flattened cisternae.	1. It is known as packaging and dispatching unit of the cell. 2. It is involved in the synthesis of cell wall, plasma membrane and lysosomes. 3. It is involved in the formation of cell plate during cell division.

RIBOSOMES	They are present both in prokaryotic and eukaryotic cells. Ribosomes are dense, spherical and granular particles which occur freely in cytoplasm or remain attached to the endoplasmic reticulum (RER). Chemically ribosomes are made up of ribonucleic acid (RNA) and proteins. Ribosomes are of two types: 70S and 80S	Ribosome is the site of protein synthesis so it is known as protein factory of the cell.
MITOCHONDRIA	They are present in eukaryotic cell but absent in prokaryotic cells. Mitochondria exist in variable shapes. It is a double membranous organelle. Outer membrane is smooth and inner membrane forms folds like structure called cristae. The cristae consist of Oxysomes (F0-F1) particles on its surface. The matrix inside it contains ribosome, respiratory enzymes and a circular DNA.	Mitochondria generate energy in the form of ATP (Adenosine Tri Phosphate),that is why it is called powerhouse of the cell. 2. Mitochondria have their own ribosome and DNA, they can synthesize their own proteins, and they are self-duplicating units. So, they are regarded as semiautonomous organelles.
LYSOSOMES	Lysosomes are dark, spherical, single membrane bound sacs containing several digestive enzymes. These enzymes are capable of digesting or breaking down all organic materials. Lysosomes are formed by Golgi complex. They are found in the cytoplasm of eukaryotic cell, mostly in animal cells.	Lysosomes are involved in intracellular digestion. During starvation or aging, the cell digests its own organelles through lysosomal enzymes, a process called autophagy. Lysosomes help to keep the cell clean by digesting any foreign material as well as worn out cell organelles. When a cell is destined to die, the lysosomal enzymes digest the whole cell, a process

		called autolysis. Therefore lysosomes are also known as 'suicide bags' of the cell.
PLASTIDS (The term 'plastid' was given by Haeckel in 1866. **Plastids occur in most plant cells and are absent in animal cells.** **CHLOROPLAST**	They are spherical or discoidal in shape and are enclosed in double membrane. Inside a plastid, two definite regions are clearly visible- Grana and Stroma. Grana are stacks of membrane-bounded, flattened discoid sacs containing the molecules of chlorophyll. Stroma is the homogeneous matrix in which grana are embedded. Plastids contain their own DNA and ribosomes i.e., they have their own protein synthesizing machinery. They are also self-replicating organelles. On the basis of colour, plastids are of following three types: **Chloroplast**: Green-colored plastids containing chlorophyll. **Leucoplast**: Colorless plastids. It helps in storage of food materials e.g. store carbohydrates (amyloplasts), Stores lipids (elaioplasts) and stores proteins (aleuroplasts). **Chromoplast**: Colored plastids (except green color).	Chloroplasts are photosynthetic organelles. The chlorophyll present in them, trap solar energy for the purpose of synthesizing food for the plant. So chloroplasts are the 'Kitchen of the cells'. Leucoplasts help in storing food products like starch, protein and lipids. Chromoplast provide color to flower which in turn attracts insects for pollination.

CENTROSOMES	Centrosome is found only in animal cells. It is not bounded by any membrane but consists of two granule-like centrioles. Centrioles are hollow cylindrical structures which are made up of microtubules.	1. Centrosome helps in cell division in animal cells. During cell division centrioles migrate to the poles of animal cells and are involved in the formation of the spindle. 2. They produce basal bodies from which cilia and flagella arise.
VACUOLES	➢ Vacuoles are fluid-filled or solid-filled and membrane bound spaces in the cytoplasm. ➢ Vacuoles are small sized in animal cells while plant cells have very large vacuoles. ➢ The vacuole is bounded by a membrane, called tonoplast. The vacuole is filled with cell sap which is watery solution rich in sugar, amino acids, proteins, minerals and metabolic wastes.	➢ Vacuoles are meant for the storage of food, water and other substances. ➢ Vacuoles help to maintain the osmotic pressure in a cell (osmoregulation). ➢ Vacuoles provide turgidity and rigidity to the plant cells.

DIFFERENCE BETWEEN PLANT CELL AND AN ANIMAL CELL

BASIS FOR COMPARISON	PLANT CELL	ANIMAL CELL
Meaning	The fundamental and functional unit of Kingdom Plantae of the Eukaryotic cells, having true nucleus along with the many organelles, specially	Animal cells are also the basic unit of life of Kingdom Animalia of the Eukaryotic cells, having all the necessary organelles

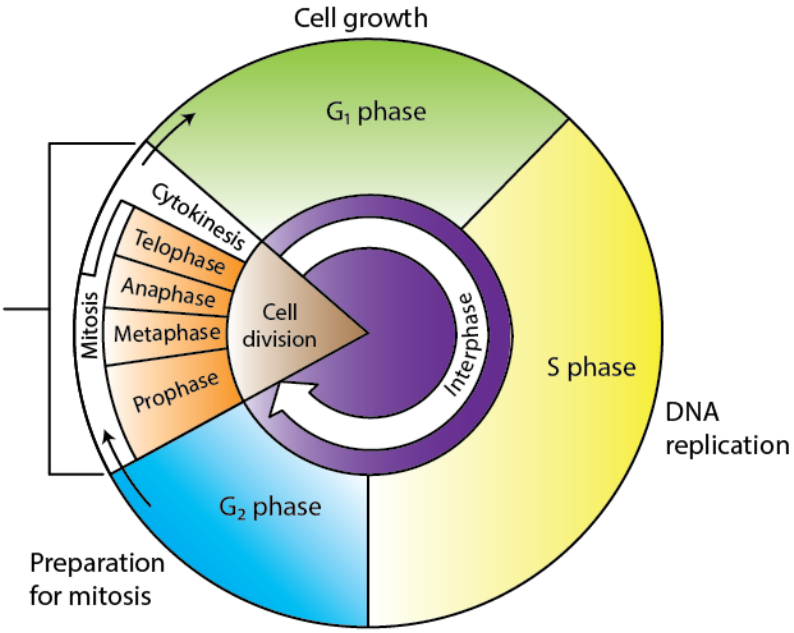
	the cell wall, chloroplast and the vacuoles.	with specified functions.
Cell Size	Usually larger, which is fixed.	Smaller in size and irregular.
Cell Shape	Rectangular.	Round.
Enclosed by	A plant cell is enclosed by rigid cell wall along with the plasma membrane.	The animal cell is enclosed by a flexible, thin plasma membrane only.
Nucleus	Present and lies on one side of the cell.	Present and lies in the centre of the cell wall.
Centrosomes/Centrioles	Absent	Present
Plastids	Present with chloroplast in them.	Plastids are absent.
Cilia	Absent.	Usually present.
Glyoxysomes	May be present.	Absent.
Plasmodesmata	Present.	Absent.
Desmosomes/Tight junction	Absent.	Present.
Mitochondria	Present in fewer number.	Present in large number.
Vacuoles	Only one huge vacuole.	Animal cells contain many in numbers.
Lysosomes	Rarely noticed in plant cells.	Present.

Chloroplast	Plant cell contains chloroplast, which they use in storing energy.	Animal cells lack chloroplast and use mitochondria for energy storing purpose.
Reserve food	Present as starch.	Present as glycogen.
Synthesis of nutrients	They can synthesize all amino acids, vitamins and coenzymes.	They are not able to synthesize any amino acids, vitamins and coenzymes required by them.
Cytokinesis	Occurs by cell plate only.	Occurs by furrowing or constrictions.
Hypotonic/Hypertonic Solutions	Plant cell does not burst if placed in hypotonic solution.	Animal cells burst in hypertonic solution as they do not have the cell wall.

CELL CYCLE- MITOSIS AND MEIOSIS

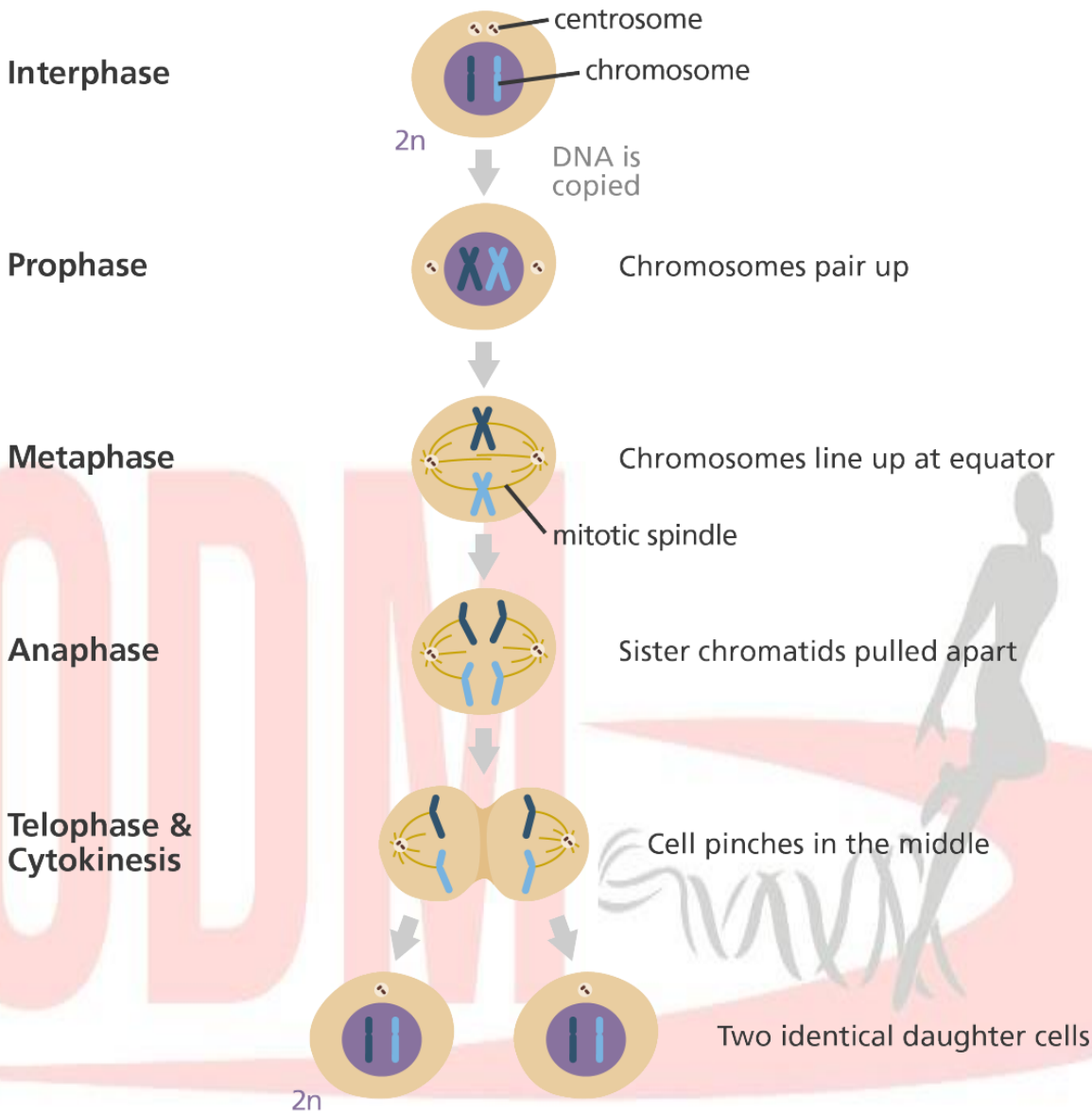
The cell cycle is a four-stage process in which the cell increases in size (gap 1, or G1, stage), copies its DNA (synthesis, or S, stage), prepares to divide (gap 2, or G2, stage), and divides (mitosis, or M, stage). The stages

G1, S, and G2 make up interphase, which accounts for the span between cell divisions.



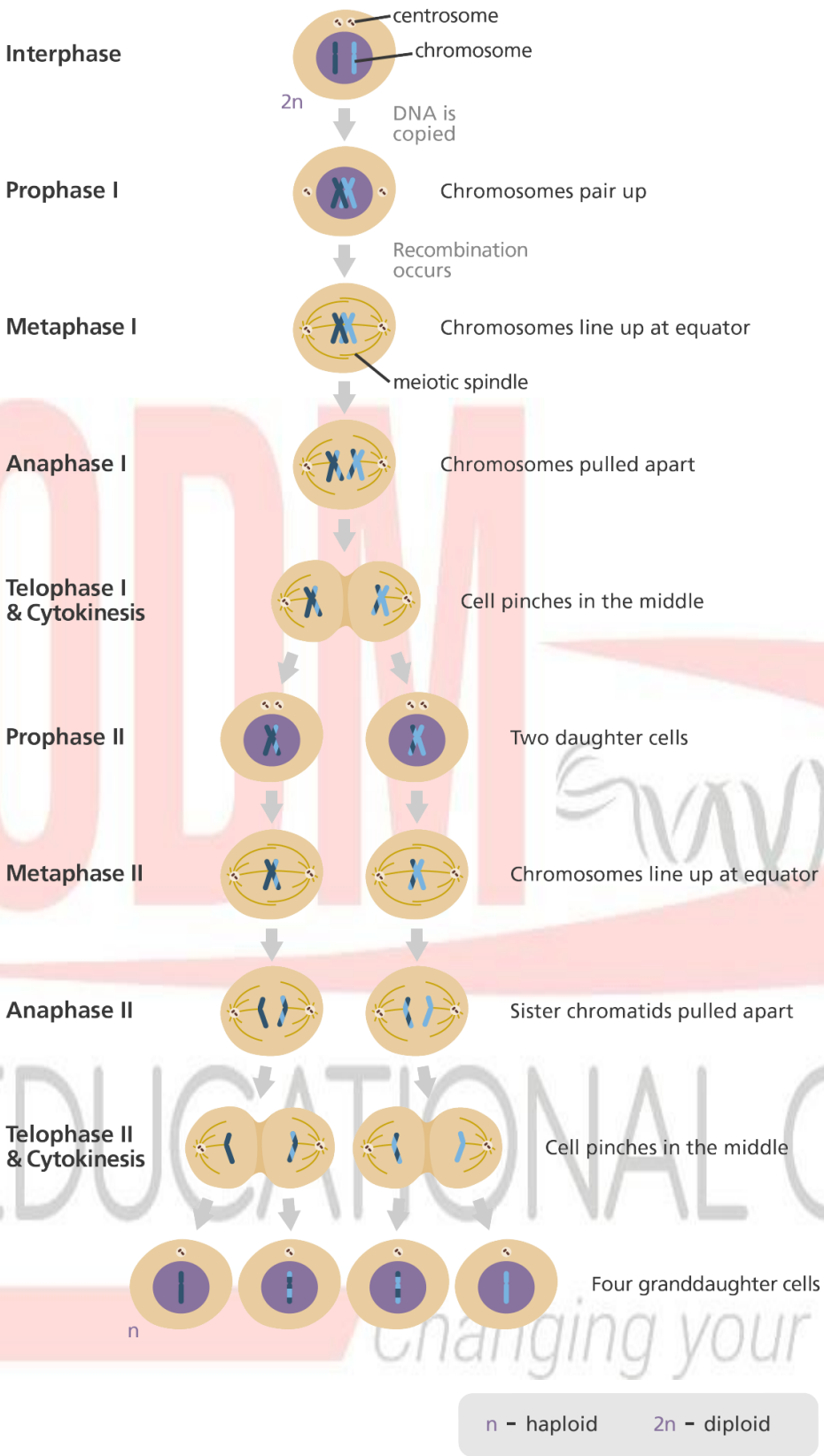
MITOSIS

Mitosis is a process where a single cell divides into two identical daughter cells (cell division). During mitosis one cell divides once to form two identical cells. The major purpose of mitosis is for growth and to replace worn out cells.



MEIOSIS

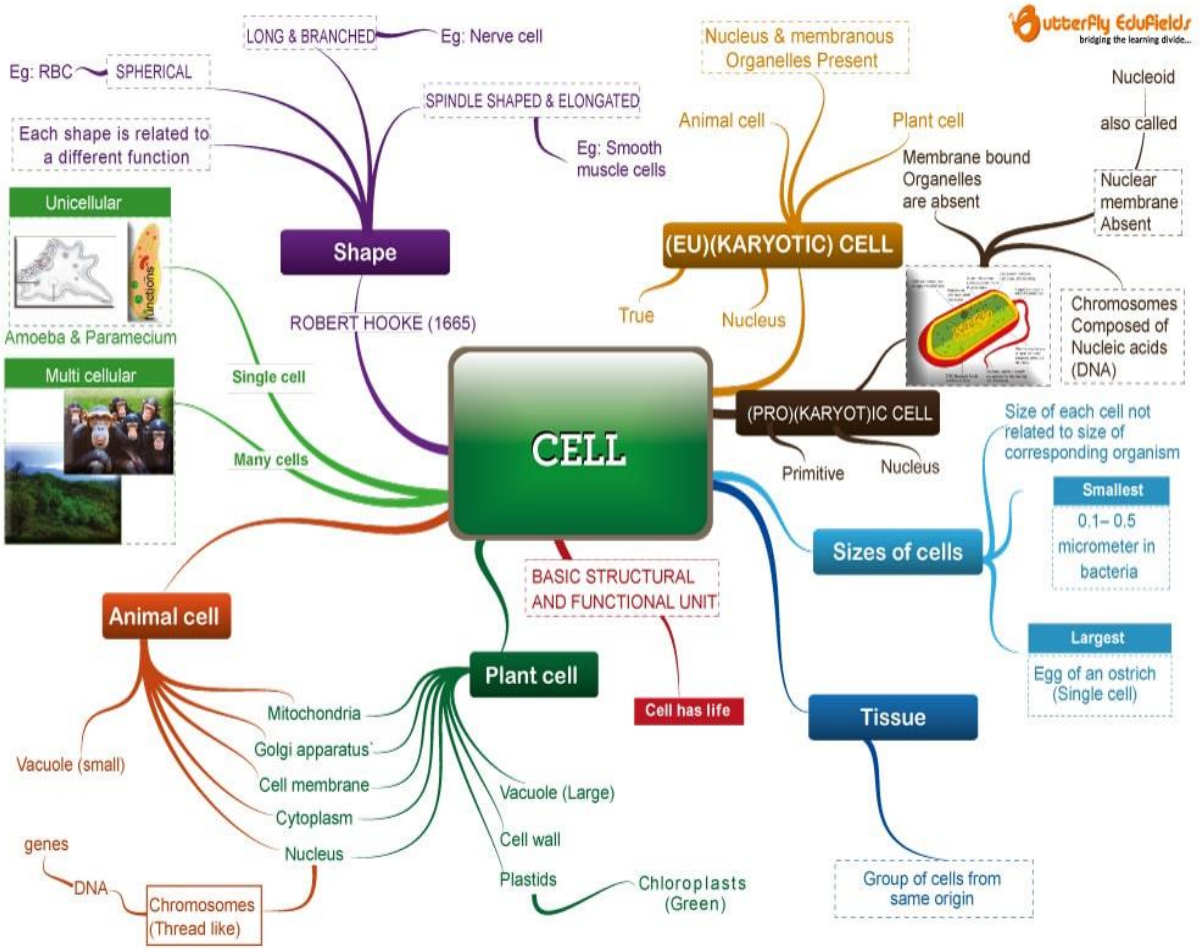
Meiosis is a process where a single cell divides twice to produce four cells containing half the original amount of genetic information. These cells are our sex cells – sperm in males, eggs in females. During meiosis one cel divides twice to form four daughter cells.



DIFFERENCE BETWEEN MITOSIS AND MEIOSIS

Mitosis	Meiosis
Mitosis occurs in somatic cells	Meiosis occurs in germ cells
Different stages are – Prophase, metaphase, anaphase and telophase	Different stages are – Prophase I, metaphase I, anaphase I and telophase I Prophase II, metaphase II, anaphase II and telophase II
Only one nuclear division occurs	Two nuclear divisions occur
Chromosome number remains unaffected	Chromosome number is reduced to half
Mother cell can either be haploid or diploid	Mother cell is always diploid
It is necessary for growth and repair	It is necessary for sexual reproduction
Crossing over do not take place	Crossing over takes place

CONCEPT MAP-


CELL
BASIC STRUCTURAL AND FUNCTIONAL UNIT
Shape
LONG & BRANCHED
Eg: Nerve cell
Eg: RBC
SPHERICAL
SPINDLE SHAPED & ELONGATED
Eg: Smooth muscle cells
Each shape is related to a different function
ROBERT HOOKE (1665)
Unicellular
Amoeba & Paramecium
Multi cellular
Single cell
Many cells
(EU)(KARYOTIC) CELL
Nucleus & membranous Organelles Present
Animal cell
Plant cell
Membrane bound Organelles are absent
Nucleoid
also called
Nuclear membrane Absent
True
Nucleus
Chromosomes Composed of Nucleic acids (DNA)
(PRO)(KARYOT)IC CELL
Primitive
Nucleus
Sizes of cells
Size of each cell not related to size of corresponding organism
Smallest
0.1– 0.5 micrometer in bacteria
Largest
Egg of an ostrich (Single cell)
Tissue
Group of cells from same origin
Animal cell
Mitochondria
Golgi apparatus
Cell membrane
Cytoplasm
Nucleus
Vacuole (small)
genes
DNA
Chromosomes (Thread like)
Plant cell
Vacuole (Large)
Cell wall
Plastids
Chloroplasts (Green)
Cell has life