Unit-1

CELL - BASIC UNIT OF LIFE

↳ All living beings are made up of the basic unit of life - cells. It is the smallest unit of living matter and each cell is able to carry out the processes of life.

↳ The cells were first described by Robert HOOKe in 1665. (examined thin slices of pork and found holes).
Later in 1674, Atony van Leeuwenhoek found moving org. by observing them under lenses and microscopes.
All these observations led to development of cell Theory.

* Cell Theory

- All living things and organisms are made up of cells and their products.
  - ↳ Multicellular - composed of many cells Eg: humans
  - ↳ Unicellular - only one cell. Eg: Bacteria
- cells are basic building units of life.
  Smallest structures capable of surviving on their own.
- New cells arise from pre-existing cells by division. (Cell division)
  Zygote - arises from fusion of egg cell and a sperm cell.

Evidence for the cell Theory - Scientists thought that cells must arise from non-living material but it was eventually proven, that this was not the case, and instead proved to be arised from pre-existing cells.

Simple expriment to prove this -

- Take two containes → put food
- Sterilise both → so that living organisms are killed.
- Leave one of them open and seal the other closed.

In the open → growth of mould
whereas no such growth in the sealed container.
Because in the open container cells are able to enter from the external environment and start to divide and grow.

CELL

PROKARYOTES	EUKARYOTES
↳ Unicellular organism does not contain mem. bound nucleus or organalles.	↳ Any cell that contains clearly defined nucleus and membrane bound organalles.
↳ Bactaria & Archaea	↳ Animal, Plant, Fungi & Protist
↳ Nucleus is absent (nucleoid region)	↳ Nucleus is present (Membrane bound)
↳ Cell size - 1-5 mm (micrometer)	↳ 10-100 mm
↳ DNA replicates entire genome at once.	↳ DNA is highly regulated with selective origins and sequences.

↳ One long single loop of DNA & plasmids.

↳ Small Ribosomes

↳ Faster growth rate

↳ organelles are absent

↳ More than one chromosomes.

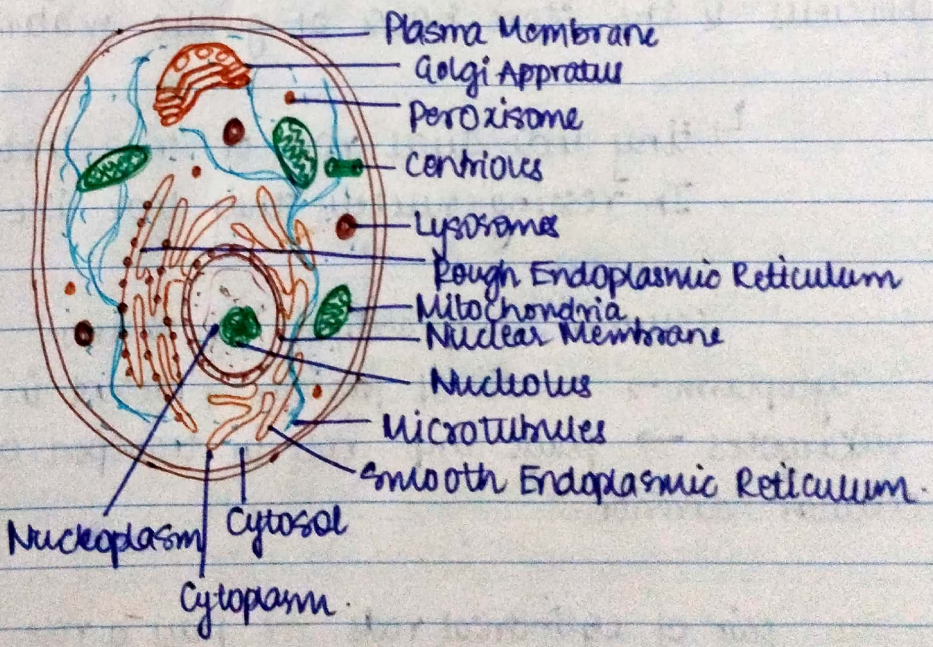
↳ Large Ribosomes

↳ slower growth rate.

↳ organelles are present

→ Eukaryotic cells are 15 times wider and 1000 times greater in volume than a typical prokaryotic cell.

* cell structure & function



STRUCTURE OF CELL

Cell / Plasma Membrane: Outermost layer of the living cell which gives structure & shape.
Chief function is to regulate the passage of materials into and out of the cell.
Singer & Nicholai - MOSAIC MODEL - explains the dynamic nature of protiens in the cell membrane.

Nucleus & Nucleolus: Nucleus is a round or oval body lying in the center of the cell enclosed by a double membrane known as nuclear membrane or envelop.
Within the nucleus, one more nucleoli may be seen → dense bodies containing the subunits for the ribosomes.
→ Nucleolous is involved in assembly and synthesis of ribosomes.
→ Nucleus is the store house of genetic material known as Chromosomes
↳ tiny individual rod or string throughout the life of cell. In resting nucleus they look like single network of cell.

Cytoskeleton: cellular "scaffolding" or "skeleton" contained within cytoplasm → made of protein, present in both prokaryote & eukaryotes → plays imp role in transport of materials & cellular division.

Centrioles: pair of cylindrical rods → play a role in the formation of spindle apparatus, essential feature for both mitosis and meiosis.

Mitochondria: Powerhouse of the cell.

Round long rod shaped organelles prominent in cells with high metabolic activity.

→ Double wall: outer smooth membrane
inner extensively folded. / cristae
↳ have variety of enzymes embedded in them

→ These enzymes are responsible for breakdown of sugar molecules to release ATP (adenosine triphosphate) used to transport energy within the cell for metabolism.

→ Mitochondria contain their own DNA and ribosomes.

Endoplasmic Reticulum: series of membranous channels, continous network extending from cell membrane to nuclear membrane.

→ General functions - Facilitation of protein & transport of synthesised protein.

RER & SER
↓
contains ribosomes.

RER → involved in the transport of protein
SER → involved in transport of lipids or detoxification of variety of poisons.

Ribosomes: components of cell that make proteins from amino acids. (Workhorses of protein biosynthesis).

Golgi Apparatus: Stacks of flattened sacs.

Major function is the storage, modification & packing of materials for release outside the cell membrane.

Lysosome: Similar in shape to mitochondria, smaller, single mem.
Contain powerful enzymes that would digest cellular contents if they were not contained within the impermeable lysosomal membrane.
Play a role in intercellular digestion & may also be imp. in the destruction of certain structures during the process of development.

Vacuoles: discrete, clear regions within the cell that contain water & dissolved materials. Reservoir for fluids & salts
Membrane: Tonoplast

Organelles in Plant cell -

Chloroplast: Conduct photosynthesis, material within → stroma.
Cell wall: Structure made out of polysaccharide, peptidoglycan or glycoprotein → structural support & protection.
Control the turgidity of the cell.

Genetic Information & Protein synthesis

→ Genetic information → chromosomes → nucleus
↳ coded along the length of polymeric molecule DNA
→ Genes control the synthesis of RNA.
→ Nucleic acid → polynucleotide
(consisting of nucleotides as repeating subunits)

DNA organised into genes.
↳ Fundamental unit of genetic information.

→ Each nucleotide is made up of
① Pentosugar
② Nitrogenous Base
③ Phosphate.

→ Nucleotides are joined together through phosphodiester linkages between 3' of one nucleotide and 5' of the adj. one.

Pentosugar: Type of cyclic 5 carbon sugar, connects two phosphate groups one at 3rd & second at 5th carbon and also nitrogenous bases linked to 1st carbon. DNA → deoxyribose
RNA → ribose.

Nitrogenous Base: Contains 5 major heterocyclic bases.

Adenine (A)
Guanine (G)
Cytosine (C)
Thymine (T)
Uracil (U).

→ Common in DNA

In case of RNA thymine is replaced with Uracil

Adenine & Guanine → Purine

Cytosine, Thymine & Uracil → Pyrimidine.

Phosphate: attached to 5' carbon of the sugar → phosphodiester linkage.
↳ solely responsible for stg -ve charge of the nucleic acids.

Protein Structure

→ Most abundant organic molecules of the living system.
→ 50% of cellular dry weight.
→ Form fundamental basis of structure & function of life.

Forces influencing protein structure -

↳ Hydrogen Bonds
↳ Hydrophobic Interactions
↳ Electrostatic Bonds
↳ Vander Walls Forces.

- Primary Structure (20 amino acids chain)
- Secondary Structure
- Tertiary Structure
- Quaternary Structure

Functions of Protein :

Structural Functions

↳ Responsible for structure & strength of the body. Include collagen & elastin found in bone matrix, vascular system & other organs & α-keratin present in epidermal tissues.

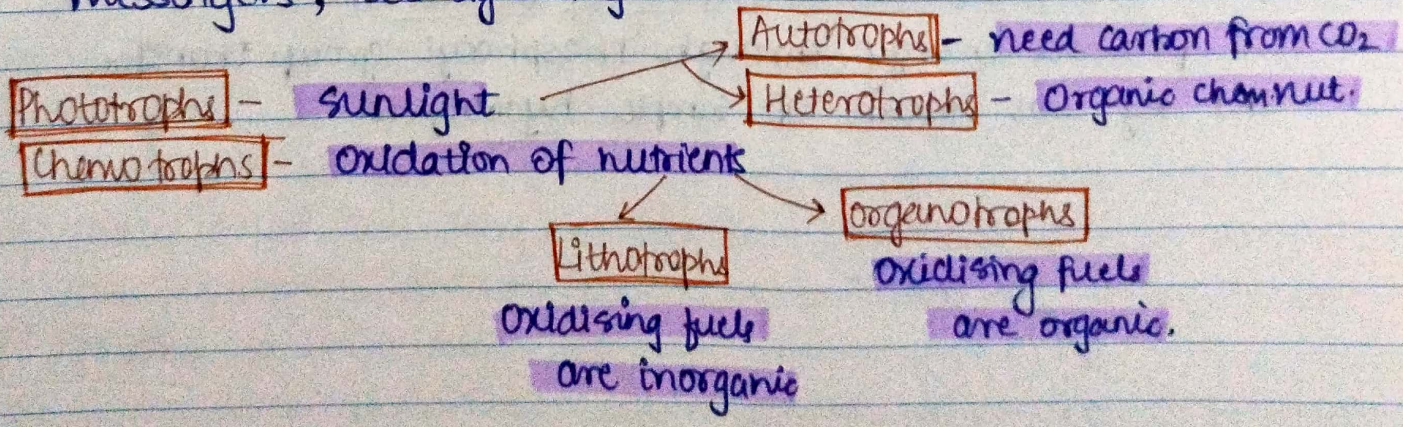
Dynamic Functions

↳ These include proteins acting as enzymes, hormones, blood clotting factors, immunoglobulins, membrane receptors, storage proteins, besides their function in genital

control, muscle contraction, respiration etc.
Proteins performing dynamic functions are regarded as "the working horse" of cell.

Cell Metabolism

→ Living cells & organisms must perform work to stay alive that requires the input of energy and is given to cell by cell metabolism.
↳ highly coordinated cellular activity in which many multienzyme systems cooperate to -
↳ obtain chemical energy by capturing solar energy (autotrophs) or degrading energy-rich nutrients from the environment (heterotrophs)
↳ convert nutrient molecules into cells own characteristic molecules
↳ polymerize monomeric precursors into macromolecules: protein, nucleic acids & polysaccharides.
↳ synthesize & degrade biomolecules req for specialised cellular functions, such as membrane lipids, intercellular messengers, cell signalling.



Cell metabolism → thousands of enzyme-catalysed chemical rxns in cell.

↓

into many sequences

↓

PATHWAYS.

→ Some pathways degrade complex organic nutrients → simple end products.

(in order to extract chemical energy) & convert it into form useful to the cell.

Together these degradative, free energy yielding rxns are designated CATABOLISM.

→ Other pathways start with small precursor molecules & convert them to larger & more complex molecules, including proteins & nucleic acids.

↳ ANABOLISM.

* ATP is major connecting link b/w catabolic & anabolic components.
* ATP plays an important role in cellular metabolism:
  ATP is the "energy currency of the cell".
* ATP provides energy through phosphoryl group transfer and by not mean of simple hydrolysis.

Amino acid metabolism:

↳ amphipathic molecules with amino & carboxyl grp at each of its terminal. They play several physiological roles in our body:

a) These are building blocks of protein, imp. constituent of biological or plasma membrane.

b) Many proteins are modified by the covalent attachment of fatty acids (lipoprotein) or carbohydrates moieties (glycoprotein) which targests them, to membrane locations (such as membrane bound receptors).

c) Amino acid → serve as fuel molecules when carbohydrates are either unavailable or not properly utilised.

d) Amino acids → serves as cofactors for various enzymes, hormones & intracellular messengers of cellular activities likes cell signaling, cell adhesion etc.

Fatty Acid metabolism:

↳ long hydrocarbon chain with terminal carboxylate group.

a) Building blocks of phospolipids & glycolipids, which are componets of biological membranes or plasma membrane.

b) Many proteins are modified by the covalent attachment of fatty acids (lipoprotein), which targets them, to membrane locations (such as membrane bound receptor).

c) Fatty acids are fuel molecules → stored in our body as triacylglycerols → oxidized to meet → energy needs of cell or organism

d) Fatty acids derivatives → serve as sex hormones & intracellular messengers of cellular activities.

Carbohydrate Metabolism

↳ play several physiological roles in our body:

a) It is an imp. constituent of biological or plasma membrane.
b) Many carbohydrates are modified by the covalent attachment of fatty acids (glycolipids) or protein ~~synthesis~~ moieties (glycoprotein) which targets them, to membrane locations (such as mem. bound receptor).
c) carbohydrates serve as fuel molecules.
d) Provide energy for various enzymes, hormones & intracellular messengers of cellular activities like cell signaling, cell adhesion etc.

Carbohydrate Metabolism ⟶ invaives metabolic pathways ⟵ generation of energy for cellular processes.

- ↳ Glycolysis.
- ↳ Citric Acid Cycle (tricarboxylic acid cycle or KERB'S CYCLE
- ↳ Electron Transport chain & oxidative phosphorylation.

* Kerb's cycle occurs in mitochondria. common pathway to completely oxidise fuel molecules.

HOMEOSTASIS

↳ coined by American physiologist 'Walter Canon'.

homoios (same) stasis (to stand)

→ The processes by which body regulates its internal environment are referred to as homeostasis.

Eg- After cut processes -

- Primary Homeostasis: formation of platelet plug.
- Secondary Homeostasis: formation of fibrin through coagulation cascade.
- Tertiary Homeostasis: formation of plasma for breakdown of the clot.

Homeostatic Regulation:

Adjusting of physicological systems → to maintain stable internal environment → req. const. monitoring & adjustment 'H.R.' ← as condns change

3 steps -

Receptor - receives inf. that something changes in the enviroment.
control center - receives & processes inf.
Effectors - responds to commands of control center by either opposing or enhancing stimulus.

For regulating body temp → temp. receptors in skin

→ Factors which are homeostatically regulated:

1) Conc. of nutrients.
2) Conc of O_2 & CO_2
3) Conc of waste prod.
4) Conc of water, salt & other electrolytes.
5) Vol and pressure.

* Pathways that alter homeostasis.
↳ maintained through series of

Control mechanism or the body suffers various illness or disease.

→ When the cells in the body begin to malfunction
→ deficiency (cells not getting all they need)
→ toxicity (cells poisoned by things they do not need)

Extrinsic homeostatic system -

regulated by nervous system & endocrine system

↳ Nervous system depends on sensors on skin / sensory organs to recieve stimuli → transmit msg. to brain. → processed and transfered to → effector system. → response.

↳ Endocrine system involves chemical component to reflex.
Sensors send msg → endocrine effector (parathyroid)
makes Parathyroid Hormone (PTH)
PTH is released in blood when blood calcium levels are low.

Intrinsic homeostatic system –

involves only one organ and tissue

When muscles use more O_2 and also produce more CO_2, intrinsic controls cause dilation of blood vessels, allowing more blood into those areas of the muscles.

NERVOUS SYSTEM

↳ receives cont. supply from the blood, interruption to flow can cause brain damage or death.

↳ Nervous system maintains homeostasis by controlling & regulating other parts of the body.

↳ Eg: abnormal lowering of body temp., the effector acts to ↑sl body temp. adaptive response returns the body to state of normalcy.

↳ Two major portions:

Central Nervous system

Peripheral Nervous system → consist of spinal nerves

↳ Autonomic Nervous system → operates subconscious level (motor neurons that control internal organs)

- Sympathetic (Emergency situations)
- Parasympathetic (Necessary for everyday existence effects).

Central Nervous system

↳ Regulating centres – Brain & spinal cord.

hypothalamus ⟶ influences actions of
→ Medulla oblongata
→ automatic N.S
→ Pituitary gland

(conc. with homeostasis)

ENDOCRINE SYSTEM

→ consist of glands which secrete special comp. called hormones into the bloodstream.

→ regulates metabolism & dev of most body cells.

eg- sex hormones
- ↳ activate sebaceous glands
- ↳ dev of mammary glands
- ↳ alter dermal flow
- ↳ release lipids from adipocytes etc.

besides governing reproduction.

Cicitonin Hormone → Calcium → Bone growth

→ Muscular system (hormones adj. muscle metabolism, energy prod. & growth)

→ Nervous system (neural metabolism, regulate fluid/electrolyte balance)

→ Cardiovascular system (regulate heart rate & blood pressure)

* Hormones have anti inflammatory effects → control the lymphatic system.

CELL GROWTH & REPRODUCTION

→ Growth and reproduction are major charachteristics of life without which life would come to an end.
Reproduction continues life & provides the basis of evolution.

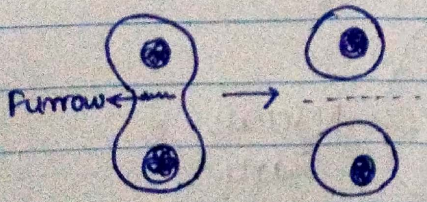
Cell division

Prokaryotic cell division
↓
FISSION

cell grows, replicates its genital material & divide into 2 single-celled entities.

Cytokinesis: division of cytoplasm

↳ In animal cells, constriction develops and finally divides the cell into two daughter cells.



*Cell furrow method.

Eukaryotic cell division
↓
More complicated -
- Cell divi. do not depend on environmental cues
- cells have many chromosomes, so process of replication & segregation are not that simple.
- clear nucleus whose div. is essential prior to cell div.
- In case of plants, cell wall.

MITOSIS
- Identical daug. cells
- Asexual / Somatic cells
- Growth & Repair

MEIOSIS
- daugh. cells with half the genetic content
- Gametes
- *Sexual Repro.
- Variation.

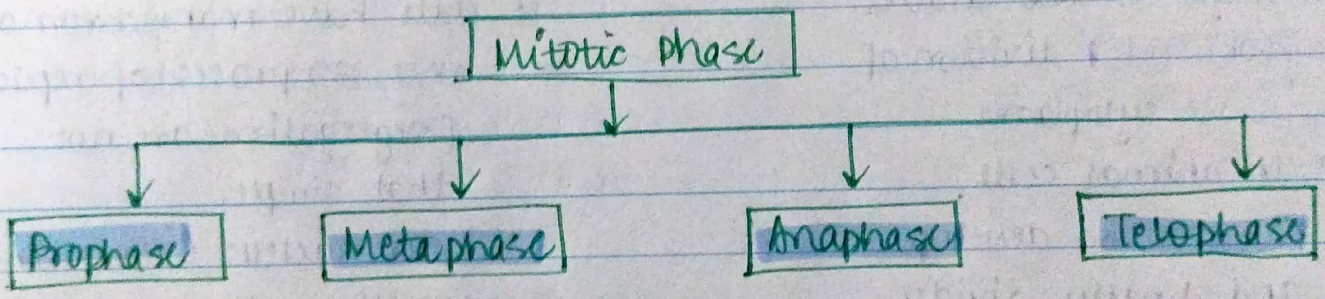
*Mitosis

→ Mitosis is the process of duplication that generates two identical daughter cells from a single parent cell.

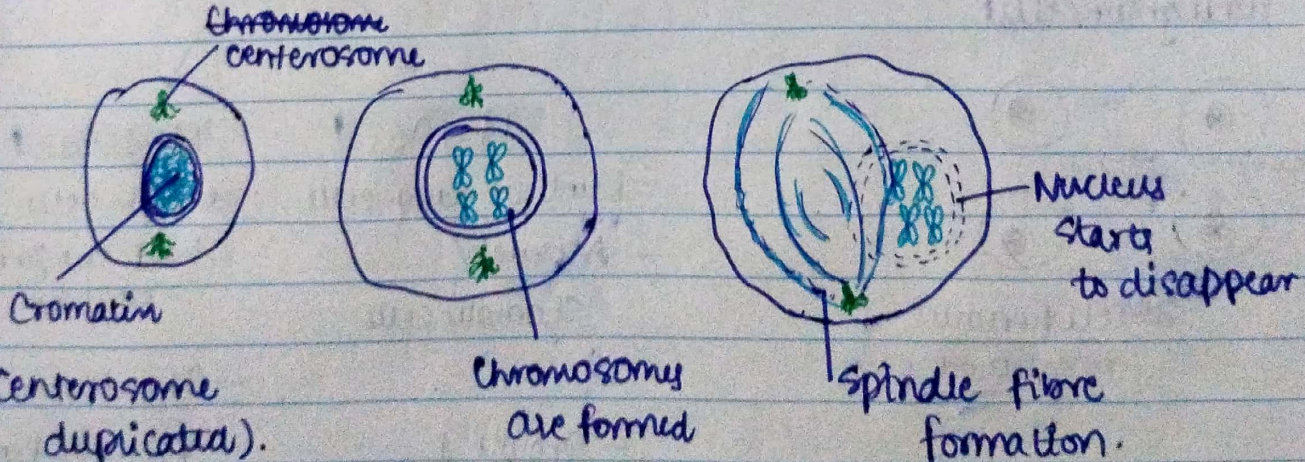
→ Between cell divisions, a eukaryotic cell is in a phase called interphase. So the cell cycle consist of an interphase & an M(mitotic phase).

G_1 S G_2

G_1 → cells synthesize RNAs and proteins
S → DNA synthesis & chromosome replication.
G_2 → Begin the mitosis also called M(mitotic) phase where nuclear & cytoplasmic divisions occur.



*Prophase:

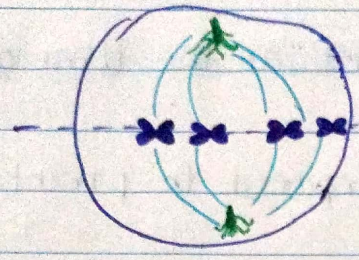


(Centerosome duplicated).

Chromosomes are formed

Spindle fibre formation.
Nuclear envelop disappear

* Metaphase:



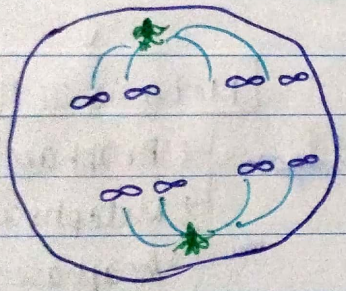
* pro metaphase

↳ chromosomes start attaching themselves with spindle fibres (Kinetochores)

↳ protiens that act as molecular motors.

→ chromosomes start arranging at the equitorial plane of the cell.

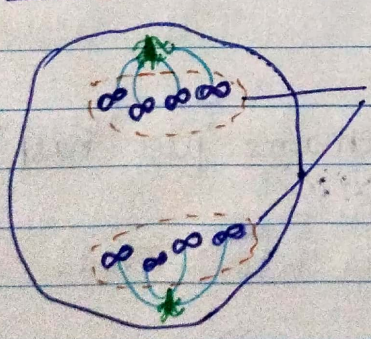
* Anaphase:



→ Seperation of chromatids

sister chromatids move to opposide ends of the spindle

* Telophase



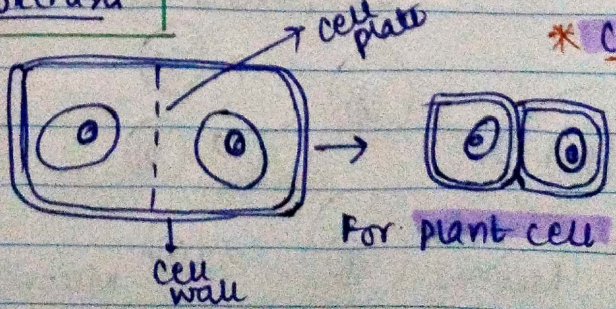
nuclear envelop reforms

Nucleolous reappears,

Cell organelles reforms

It is the end and each of the daughter nuclei enters another interphase.

Cytokenisis



* Cell Plate method

* Meiosis

→ Meiosis is the cell division which occurs at the time of gamete formation.

→ No. of chromosomes remain half as compared to parent cell.

(46) chro. $\xrightarrow[\text{div}]{\text{meiosis}}$ (23) chr.

2n (diploid) n (haploid)

→ Nucleus divides twice but DNA is replicated once.

Meiosis division

Meiosis I

- Prophase I
  - Leptotene
  - Zygotene
  - Pachytene
  - Diplotene
  - Diakinesis.
- Metaphase I
- Anaphase I
- Telophase I

Meiosis II

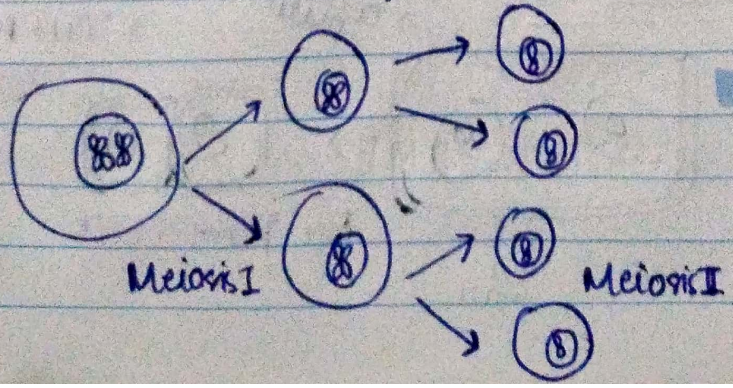
- Prophase II
- Metaphase II
- Anaphase II
- Telophase II.

Meiosis I → **reductional division**

Because chromosome no. remains just half to its parent cell.

Meiosis II → **equational division**

Because no. of chromosomes remain equal to its parent cell.



1 cell → 4 daughter cells

Meiosis I

- Karyokinesis (div. of nucleus) → Prophase I, Metaphase I
- Cytokinesis (div. of cytoplasm) → Anaphase I, Telophase I

Prophase I

→ **Leptotene**  → chromosomes become visible, shorten thicken and homologous come close

→ **Zygotene**  → Pairing of homologous occurs called synopsis forming bivalent or tetrad.

→ **Pachytene**  → Overlapping of chromosomes occurs by forming chiasmata, exchange of segments take place called crossing over.

→ **Diplotene**  → Crossing over & overlapping finish.

→ **Diakinesis**  → Chromosomes ready for Metaphase I.

Meta/Ana/Telo → same as mitosis

Cell Differentiation

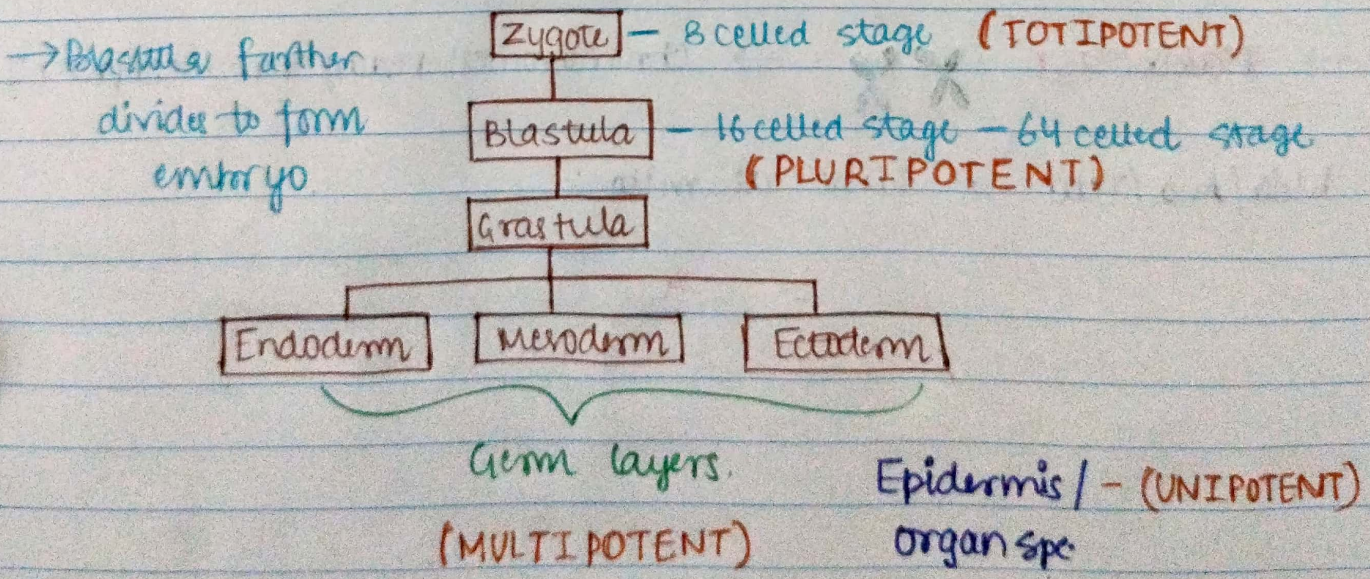
→ It is a biological process whereby an unspecialized cell becomes more specialized.

→ Regulation starts from the embryo level, diff. occurs numerous times during dev. of multicellular org., as org. changes from simple zygote → complex system of tissues or cell type.

→ Embryo contains various cells and each cell has capability to develop into many different ways.

→ cells are genetically identical after differentiation but have diff structure & functions.

* Totipotent - fertilized egg or early zygote has the ability to give rise to every type of cell in the adult body.



→ 3 different layers

* Mesoderm (Middle layer)
* Ectoderm (External layer)
* Endoderm (Internal layer)

Meso	Ecto	Endo.
→ Cardiac Muscles	→ Epidermis	→ Lung cells
→ Skeleton "	→ Neuron of brain	→ Thyroid cells
→ RBC	→ Pigment cells	→ Pancreatic cells.
→ Smooth "		
→ Kidney cells		