Unit 3 - Introduction to Biological Sciences

▷ Darwinian Evolution

↳ Charles Darwin → 'Father of evolution'
because of his contribution in the establishment ~~because~~ of Theory of Evolution on the basis of natural selection.

↳ He, on his voyage on the ship HMS Beagle, visited many islands in the Pacific Ocean, Atlantic Ocean and Galapagoes island and collected living and fossil specimens of flora, fauna and geology factors.

↳ He proposed ~~the~~ his theory in a book named 'Theory of Evolution based on natural selection'.

* 5 Principles of Darwinian Evolution

→ Darwinian theory is based on 5 principles.

1) Overproduction

↳ More individuals are born in each generation that will survive and reproduce.

2) Variation & Hereditary

↳ There are some natural variations among individuals of same species. Many of the favorable adaptations (characteristics) are hereditary to the next generation.

3) Survival of existence

[[Every organism has to struggle for its existence.]]

↳ Human population increases with geometric progression and food production increases with arithmetic progression. So, after some time, the population of one species increases and this has to be checked by different means.

↳ The struggle may be intraspecific (b/w one or similar species) or interspecific (b/w different species).

↳ It may also be due to natural calamities. eg. storm, earthquake, epidemic.

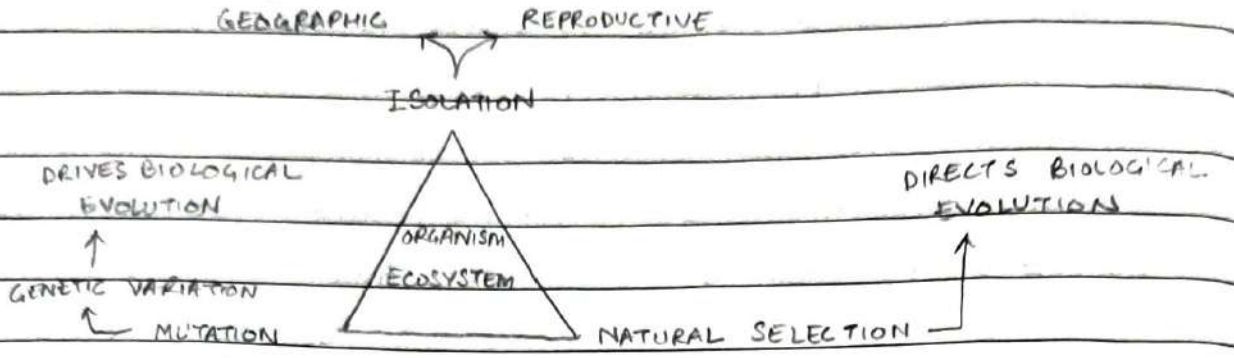
4) Survival of the fittest
↳ The species with better adaptations with the change in environment survives as compared to the species with less or no adaptations.
5) Modification of the Species.
↳ Gradual modifications of species could have occurred over the long periods of geological time.

* Natural Selection
[[Nature selects its organisms -]]
↳ Surviving individuals will give rise to ~~next~~ next generation. The successful variations are transmitted to the next generation.
↳ In this way, this generation tends to become better adapted to their environment.
↳ The organisms always struggle to maintain their existence as nature decides the survival of the fittest.
↳ For eg. industrial melanism in moths.
The changes occurred in the moth population in different areas of England because of natural selection. Before industrialisation, the tree trunks were lighter and light-coloured moths were predominant. Dark-coloured moths were also present but they were limited in number. As a result of industrialisation, pollution resulted in the darkening of tree trunks so that light-coloured moths became more visible to birds / predators and were, therefore, eaten by them. As a result of this, at the end of 19th century, the common light-coloured moths were almost replaced by the black (dark) variety.

* Molecular Perspective of Darwinian Theory (Neodarwinian)
It is modified, calliberated version of Darwinian Theory and considers the concept from Mendelian Genetics and population

Genetics and Biological species concept (aka three pillars)

→ It consists of three pillars :

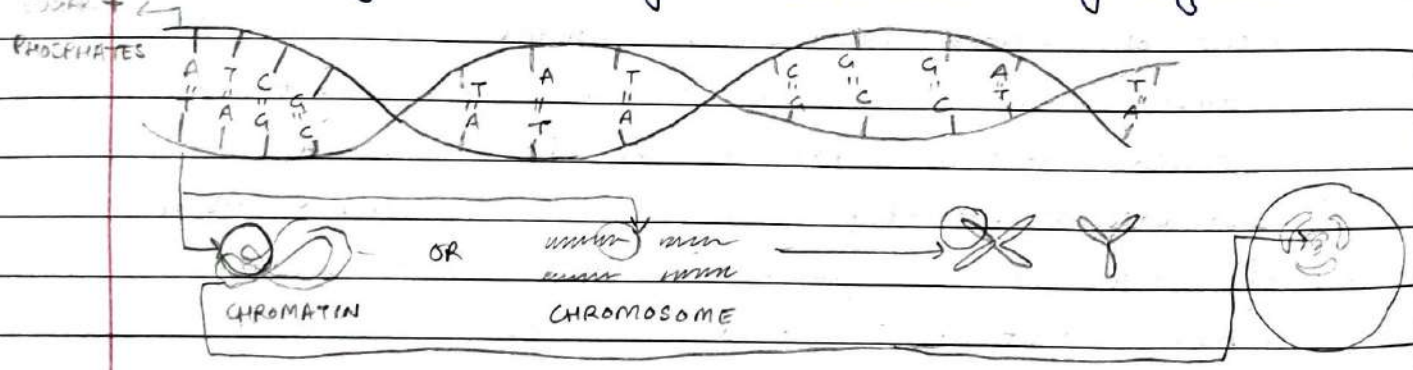


Note :- In DNA, there are :

- Sugars
- Phosphates
- Nitrogenous bases → Adenine (A)
  → Cytosine (C)
  → Thiamine (T)
  → Guanine (G)

Hydrogen bonds.
A=T (Complementary)
C=G

These nitrogenous bases give characteristics of organism.



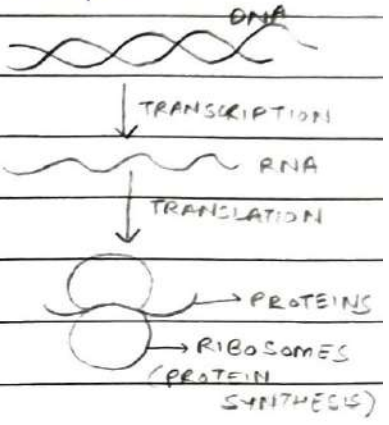
* **Geographic Isolation** - Separation of species by a physical barrier like water forms, oceans, mountains etc.
→ Organisms are ultimately separated from exchanging genetic material with other organisms of same species

* **Reproductive Isolation** - Members of different species cannot

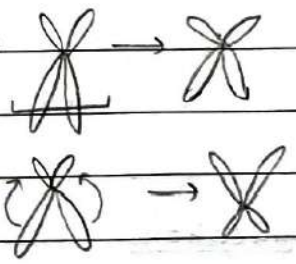
interbreed & produce offsprings

Strategies (of Mutation)	Mechanism
1) Local changes in DNA sequence	- Replication errors by mutagens. - Mutagens
2) DNA rearrangement	- Mutagens - Recombinational reshuffling of DNA segments
3) DNA acquisition	- Horizontal gene transfer

Note 1) - Replication errors i.e. errors while transcripting.
- Mutagens bring about change in DNA.



2) - Mutagens cause change like cutting off of chromosome.
- Reshuffling of DNA like a bottom part can come at the top.



* Introduction to Phylogeny

→ Evolution is defined as the change in characteristics of a population of organisms over generations.

→ Phylogeny - A phylogeny describes the relationships among group of organisms such as which groups are most closely related, which diverged most recently from a common ancestor

→ A group of organisms being compared in the phylogeny might be population, species or groups of species such as genus, kingdoms etc.

→ When comparing group, we often use the generic term 'Taxa' which could refer to any of these levels of groups.

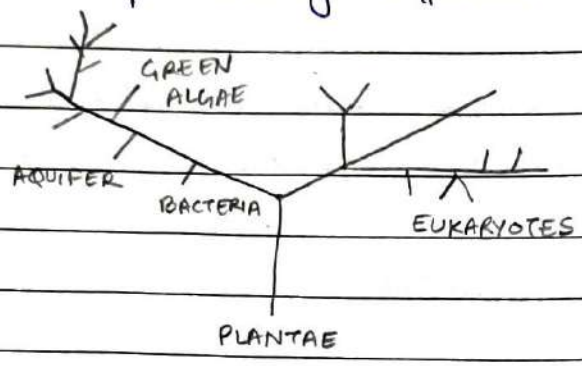
→ Phylogenetic relationships provide information on shared ancestry among taxa.

* Phylogenetic Tree

↳ Scientists use a diagram called phylogenetic tree to show the evolutionary pathways and connections among taxa.

→ A phylogenetic tree is a hypothesis of the evolutionary past, since one cannot go back to confirm the proposed relationships.

→ In other words, a 'tree of life' can be constructed to illustrate when different organisms evolve and to show the relationships among different organisms.



* Levels of Organization

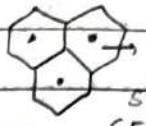
→ Taxonomy means arrangement. It is the science of classifying organisms to construct internationally shared classification systems with each organism placed into more and more intrusive groups.

→ Taxonomic classification system aka 'Linnaean system' after its inventor named 'Carl Linnaeus, a Swedish botanist, zoologist and physician. This system uses a heirarchial model. Moving from the point of origin, the groups become more specific until one branch ends as a single species.

		eg:	Canis lupus familiaris (dog)
	Sub species		
	↑		
	species		Canis lupus (dog, cat, fox etc.)
	↑		↑
	Genus		Canis
	↑		↑
General to Specific ↑	Family		Canidae
	↑		↑
	Order		Carnivore
	↑		↑
	Class		Mammalian
	↑		↑
	Phylum		Chordata (animals w/ vertebral column)
	↑		↑
	kingdom		Monera, Protista, Fungi, Plantae, Animalia
	↑		↑
	Domain		Eukaryote, Prokaryote

* Cellular Assemblies from Unicellular to Multicellular.

↳ Robert Hooke → discovered cell in cork.
(cork is a non-living tissue).
He observed honeycomb-like structures and called them cell.



↳ Leeuvanhock → observed first living cell in pond water.

* Cell Theory

↳ Proposed by Schleiden and Schwaan.

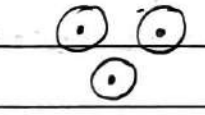
↳ According to this theory, all living organisms, whether plants or animals are composed of cells and cell is the basic unit of life.

↳ Another Scientist, Virchow, extended this theory by suggesting that all cells arise from pre-existing cells.

* Shape of Cell

↳ Shape of cell depends upon its functions.

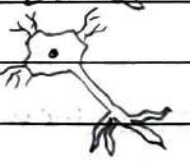
eg1. RBCs are spherical in shape because they have to flow in the body.



eg2. Muscle cells are fibrous because they form and give bulge of muscles.

eg3. Bone cells stack on each other to give a hard structure.

eg4. Neurons have a branched structure as they have to connect w/ each other to form a network.



* Unicellular Organism

↳ Single-celled organisms are called unicellular organisms.
eg. amoeba, paramecium.

↳ A single cell performs several functions.
eg. amoeba has pseudopodia for ingestion, vacuole for

waste & water regulation.

* Multicellular Organism

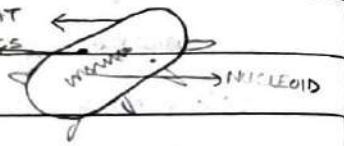
↳ Organisms made up of many cells are multicellular organisms. eg. all plants and animals.

↳ Different cells perform different functions they are specifically made for. eg. muscle cells, bone cells, RBCs, neurons etc. in animals all perform their own functions.

* Prokaryotes & Eukaryotes

Prokaryotic Cell	Eukaryotic Cell
↳ True nucleus is absent	↳ True nucleus is present.
↳ Membrane-bound organelles are absent.	↳ Membrane-bound organelles are present.
eg. Bacteria, blue green algae	eg. All plants and animals.

→ In prokaryotic cell, an underdeveloped nucleus called nucleoid is present.



* Natural Structure of Cell

→ Basic components of cell → Plasma membrane
→ Nucleus
→ Cytoplasm → Organelles → Mitochondria
→ Endoplasmic reticulum
→ Ribosomes
→ Golgi apparatus
→ Lysosomes

* Plasma Membrane

→ It is present in all cells, whether eukaryotes or prokaryotes

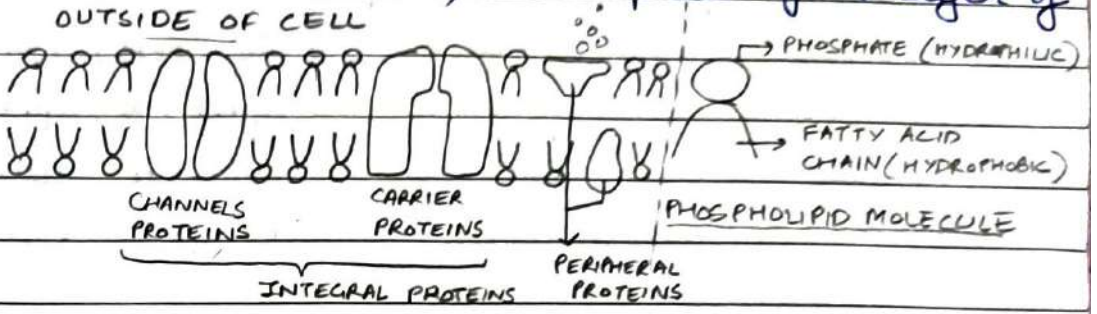
↳ The content of the cell is enclosed within the plasma membrane

↳ It is selectively permeable i.e. it allows only essential nutrients to pass through it ~~and removes~~

↳ It removes waste material from the cell.

Imp → Structure of Plasma Membrane

↳ According to Fluid Mosaic Model, it comprises of bilayer of phospholipids



↳ Desired proteins are embedded in phospholipid layer :

Proteins in Phospholipid layer

Integral Proteins

Channel Proteins
→ Transport substances by diffusion or osmosis
→ Passive transport

Carrier Proteins
→ Require energy (ATP) for transport of substances from low conc. to high conc.
→ Active transport.

Peripheral Proteins
→ Provide strength to plasma membrane
→ Carbohydrates + Proteins ↓ Glycoproteins

↳ The transport of substances where no energy is required is called passive transport, eg. diffusion, osmosis.

↳ Transport of substances where energy is required is called active transport. eg.

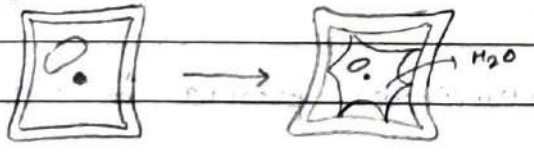
* Cell Wall

→ Another outer covering present in plant cell and bacteria but absent in bacteria.

→ It provides strength to the cell.

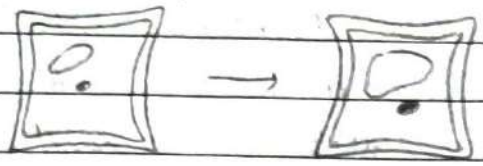
→ It also helps the cell to withstand the changes in the environment.

↳ When the plant cell in the hypertonic solution, the content of the cell shrinks away from the cell wall. This happens due to osmosis. If cell shrinks too much, it dies.



↳ When the plant cell in the hypotonic solution, the cell

swells up and exerts pressure on the cell wall. In turn, the cell wall also exerts an equal & opposite pressure towards inside of cell and prevents it from bursting.



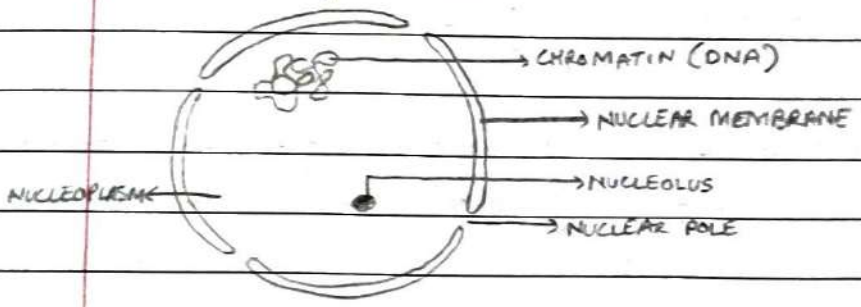
* Nucleus

→ It is a double-membrane organelle, with a double-layered membrane structure.

→ It contains hereditary material (DNA) of cell.

→ It plays an important role in many cellular activities eg. cell division.

→ Structure of Nucleus



[↳ Chromatin is the thread-like structure containing DNA.
↳ Nucleolus occupies 25% of space of nucleus.]

↳ The double-layered membrane is called as nuclear membrane.

↳ It has some pores called nuclear pore, dense thread-like structure called chromatin which contains DNA (which is also present in the nucleus of the cell), a dark-coloured body which occupies 25% of the space of nucleus called the nucleolus.

↳ In prokaryotes, true nucleus is not present but nucleoid is present which contains chromosome or DNA.

* Endoplasmic Reticulum

→ Flat ~~thread-like~~ plate-like structures present near the nucleus

→ It is of 2 types:

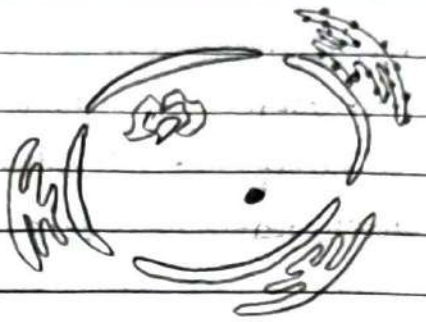
↳ Rough ER (RER)

↳ Smooth ER (SER)

→ RER

↳ Appears rough because of presence of ribosomes.

↳ Ribosomes are responsible for synthesis of proteins.



→ SER

↳ Smooth because of absence of ribosomes.

↳ Transports proteins to different parts of cell, wherever needed.

↳ It is involved in synthesis of lipids.

→ One of the functions of ER is the repair of the plasma membrane from the proteins and fats synthesized by ER.

* Tissues

→ Group of cells with same structure and perform a specific function

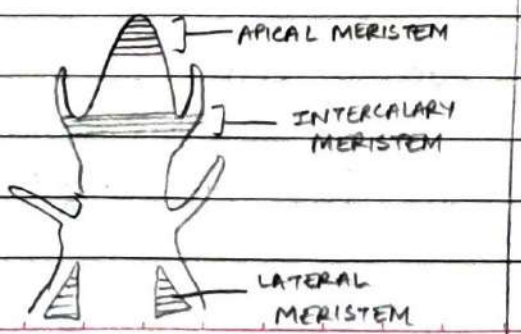
→ Types ⟶ Plant tissues

↳ Animal tissues

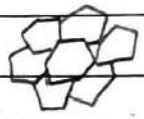
* Plant Tissues

→ On the basis of dividing capacity, plant tissues can be classified as:

- Meristematic Tissue
  - Apical Meristem
  - Intercalary Meristem
  - Lateral Meristem
- Permanent Tissue
  - Simple Permanent Tissue
    - Parenchyma
    - Sclerenchyma
    - Collenchyma
  - Complex Permanent Tissue
    - Xylem
    - Phloem



→ Apical Meristem
↳ Present on growing tips of roots and shoot
↳ Increases the length of root and shoot.
→ Intercalary Meristem
↳ Present at the base of leaves or internodes
↳ Helps in longitudinal growth
→ Lateral Meristem
↳ Present on lateral sides of shoot and root.
↳ Increases the thickness of plant.
→ When meristimatic tissue stops dividing, it forms parmanent tissue.
→ Simple Permanent Tissue
↳ Contains only one type of cell.
↳ Parenchyma
↳ Thin cell wall
↳ Function - storage

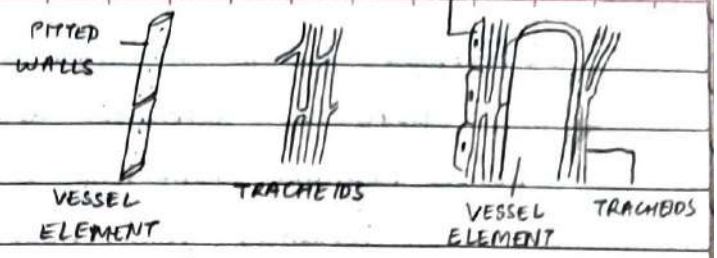


↳ Collenchyma
↳ Uneven thickening of cell wall with pectin.
↳ Function - Provides mechanical strength to plant.

↳ Sclerenchyma
↳ Even thickening of cell wall with lignin.
↳ Present in seeds, nuts, husk of coconut.

→ Complex Permanent Tissue
↳ Consists of more than one type of cell
↳ Xylem
↳ Conducts water & minerals from root to other parts of plant.
↳ Cell type :

- Vessel element
- Tracheids
- Xylem parenchyma.

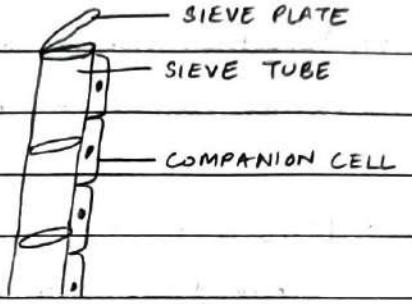


↳ Phloem

↳ Conducts food material from leaves to other parts of plant.

↳ Cell type:

- Sieve plate
- Sieve tissue
- Companion cells.

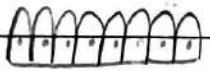


* Animal Tissues

→ Types

1) Epithelial tissue
2) Connective tissue
3) Muscular tissue
4) Nervous tissue

→ Epithelial Tissue

Simple Cuboidal	Simple Squamous	Simple Columnar
		
→ Cuboidal cells → Location - lining of kidney tubules and ducts of salivary glands	→ Flat cells → Location - lining of mouth, oesophagus, lungs.	→ Elongated cells. → Location - inner lining of intestine and gut.

→ Connective tissue connects various body parts.
It may be:

↳ Areolar tissue - found in skin and muscles around the blood vessels and nerves.

↳ Adipose tissue - acts as a storage site for fats ; found between internal organs and below the skin.

↳ Dense Regular Connective tissue - eg. tendons, ligaments.
[tendons join bone to muscles & ligaments join bone to bone]

↳ Skeletal tissue - they form bones & cartilage of our body.

↳ Fluid tissue - eg. blood, lymph

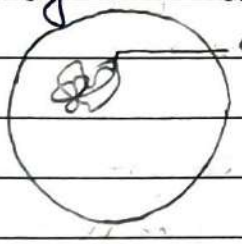
→ Muscular tissue
↳ Function - to provide movement to the body.
↳ Types :
1) Straited muscular or voluntary muscles.
2) Unstraited muscular or involuntary muscles.
3) Cardiac

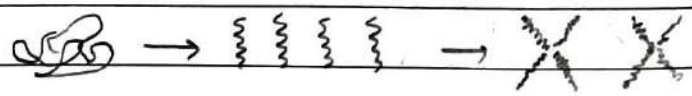
- See more from pdf.

→ Nervous tissue
↳ Present in brain & spinal cord.
→ Neurons form the nervous system.

* Chromosomes

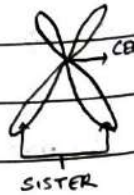
↳ They are made up of DNA and carry genetic information.





↳ In nucleus, chromatins is present. It is a thin, fibrous form of DNA. It shortens and thickens to form chromosome before cell division.

→ To prepare for cell division, chromosomes replicate. Each replicated chromosome has 2 sister chromatids that are identical & are joined by a centromere.

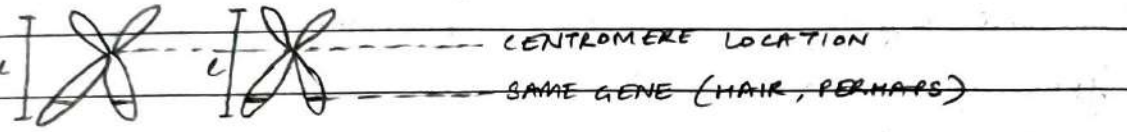


Chromosomes always come in pairs.

→ Human has 46 chromosomes or 23 pairs. (One from mother & one from father).

* Homologous chromosomes

↳ Have same length, gene sequence & centromere location

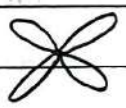


* Classification of Chromosome

↳ Depending on position of centromere

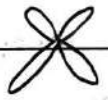
1) Metacentric

↳ centromere is present in the middle of chromosome, forming 2 equal arms



2) Sub-metacentric

↳ centromere is present slightly above the middle of chromosome, resulting in one shorter & one longer arm.

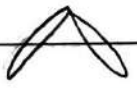


3) Acrocentric

↳ centromere is situated close to the end of the chromosome, forming extremely short and long arms.

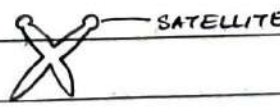
4) Telocentric

↳ centromere is present at the terminal of chromosome



5) Satellite chromosome

↳ Sometimes, a few chromosomes have non-staining secondary constrictions at a constant location. This gives the a small fragment called Satell



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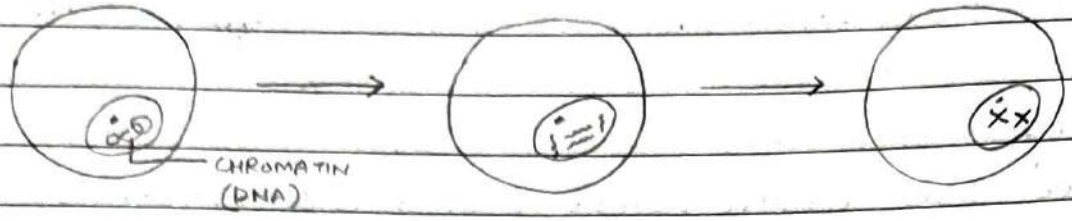
* Cell Division

→ Before cell division, chromatin shortens & thickens.



For cell division, chromatin replicates or duplicates.

→ Types of cell division :
- ↳ Mitosis (2n)
- ↳ Meiosis (n)

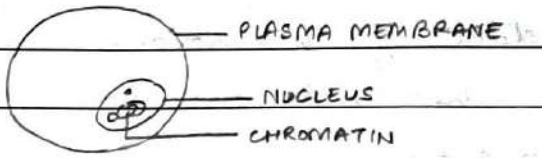
* Mitosis

→ Cell division in which chromosome no. remains same.

→ Stages → Interphase
Prophase
Metaphase
Anaphase
Telophase
Cytokinesis

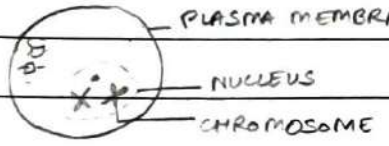
→ IPMAT

1) Interphase



→ Preparatory stage
↳ Resting stage

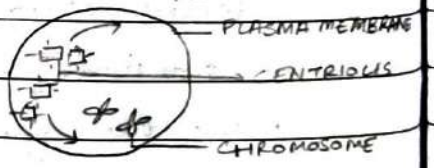
2) Prophase



→ Early Prophase
- ↳ Nuclear membrane starts disappearing.
- ↳ Nucleolus starts disappearing.

↳ Chromatin becomes short, thick & replicates itself to form chromosomes.

→ Late Prophase
- ↳ Nuclear membrane completely disappears
- ↳ Nucleolus completely disappears.
- ↳ Centriole also replicates and starts moving towards opposite poles.

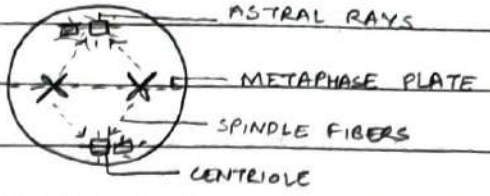


Bind the 2 centrioles together.

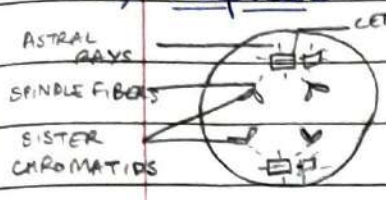
3) Metaphase

→ Chromosome moves towards equator of cell, forming a metaphase plate.

→ Spindle fibers arise



4) Anaphase



→ Shortening of spindle fibers occurs.

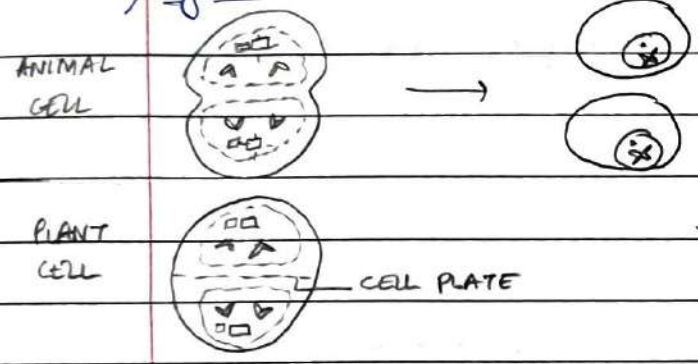
→ Sister chromatids separate and move towards opposite poles.

5) Telophase

→ Nuclear membrane starts reappearing

→ Nucleolus starts reappearing.

6) Cytokinesis



→ Plasma membrane pinches off from both sides and divides its cell into two daughter cells.

In plant cell,

→ Cell plate arises in the middle & divides the cell into 2 parts.

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* Meiosis

→ Cell division which reduces the chromosome no. to half.

→ A cell divides twice → Meiosis I & Meiosis II

→ 4 daughter cells are produced.

→ Stages → Interphase

Meiosis I	Meiosis II
Prophase I	Prophase II
Metaphase I	Metaphase II
Anaphase I	Anaphase II
Telophase I	Telophase II
Cytokinesis I	Cytokinesis II

[P.T.O] →

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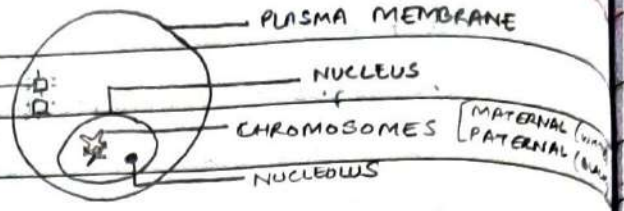
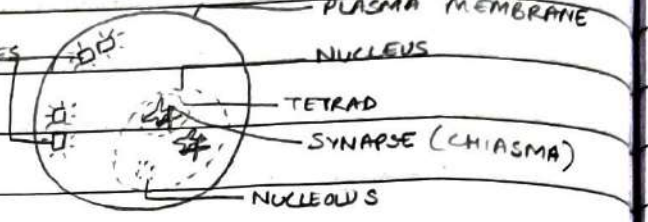
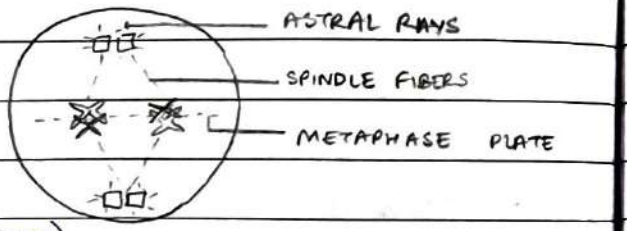
1) Interphase
[similar to mitosis]
↳ Resting stage
↳ Cell prepares for cell division.
↳ Centrioles activate before cell division.



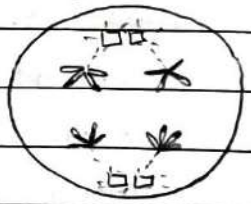
2) Meiosis I
i) Prophase I
↳ ~~Bivalent~~ Tetrad - paired maternal and paternal homologous chromosomes
↳ Synapsis occurs i.e. homologous chromosomes pair up to form tetrad.
↳ Crossing over occurs at chiasma / synapse (exchange of genetic material).
↳ Nuclear membrane disappears
↳ Nucleolus disappears



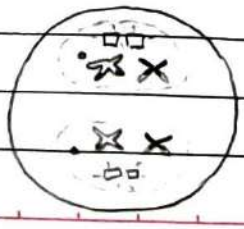
ii) Metaphase I
↳ Chromosomes move towards equator of cell, forming metaphase plate (Each side has one maternal & one paternal chromosome)
↳ Spindle fibers arise, connecting chromosomes to centrioles.
↳ Astral rays bind the centrioles together.



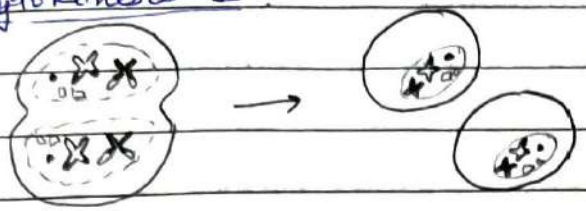
iii) Anaphase I
↳ Shortening of spindle fibers occurs.
↳ Homologous Chromosomes separate & move towards opposite poles. There is exchange of genetic material between homologous maternal & paternal chromosomes



iv) Telophase I
↳ Nuclear membrane & nucleolus start reappearing.



v) Cytokinesis I



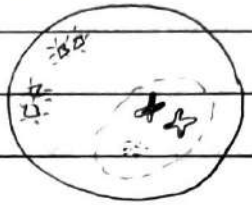
↳ Plasma membrane pinches from both sides and divides cell into 2 daughter cells.

3) Meiosis II [occurs in each daughter cell]

i) Prophase II

→ Nuclear membrane & nucleolus disappears

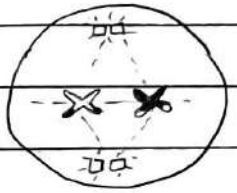
→ Centriole remains activated.



ii) Metaphase II

→ Chromosomes move towards equator of cell, forming metaphase plate

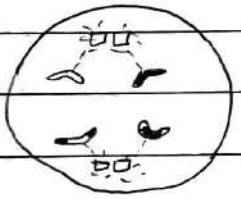
→ Spindle fibers arise.



iii) Anaphase II

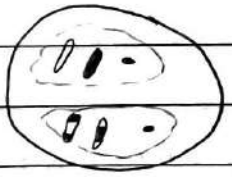
→ Spindle fibers shorten

→ Sister chromatids move towards opposite poles.



iv) Telophase II

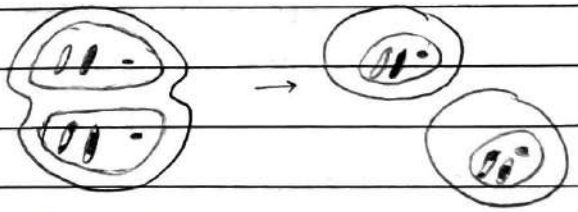
→ Nuclear membrane & nucleolus reappears.



v) Cytokinesis II

→ Plasma membrane pinches from both sides and divides cell into 2 haploid cells i.e. gametes

→ Cell plate arises in plant cell for this.



* Bioindicators

↳ A bioindicator is a living organism that gives us an idea about the health of an ecosystem.

↳ If pollutants are present in an ecosystem, these organisms may change their morphology, physiology or behaviour, or they could even die.

↳ Bioindicators can be plants, animals or microorganisms

1) Plants Bioindicators eg. lichens (symbiotic relationship between algae & fungi)
   ↳ lichens are present on rocks, tree trunks in hilly areas
   ↳ Symbiotic relationship → when one organism supports the survival of other organism.
   ↳ In healthy ecosystem, lichens are present more compared to unhealthy ecosystem.
   eg.(cont.) mosses, tree barks, leaves

2) Animal Bioindicators eg. frog
   ↳ frog requires suitable habitat in both terrestrial & aquatic environments and have permeable skin that can easily absorb toxic chemicals. This character makes frog especially prone to environmental disturbance.

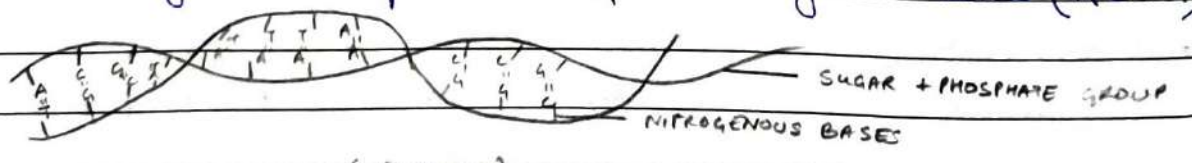
3) Microorganism Bio Indicators
   ↳ They are easy to sample and are present in all ecosystems
   ↳ Microorganisms can be used as bioindicators of aquatic & terrestrial ecosystem health. They are found in large quantities and easier to sample than other organisms.

4) Aquatic macroinvertebrates
   eg. copepods (small crustaceans (→ prawn, crab, shrimp, lobster etc.) found in every fresh water and salt water)

* Mutation

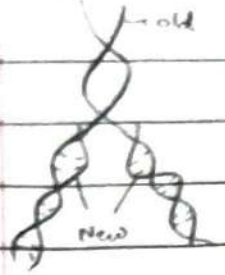
[↳ Change in DNA is called mutation.]

↳ DNA = Sugar + Phosphate Group + Nitrogenous bases (ACTG)



(nitrogenous)

↳ Change in DNA base pair sequence due to various environmental factors like UV light or mistakes during replication.



↳ A = T , C = G

↳ DNA replicates to form new thread (after unwinding of old DNA)

* Types of Mutation

1) Point Mutation

↳ Alteration in single nucleotide in a gene

eg. Sickle cell anemia

↳ Types - deletion, duplication, inversion, insertion

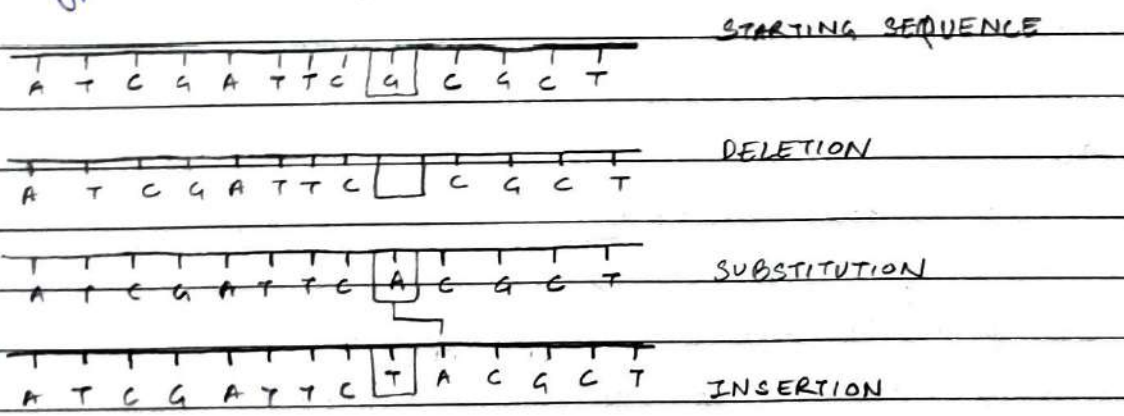
2) Frame shift Mutation

↳ Alter the framework of gene

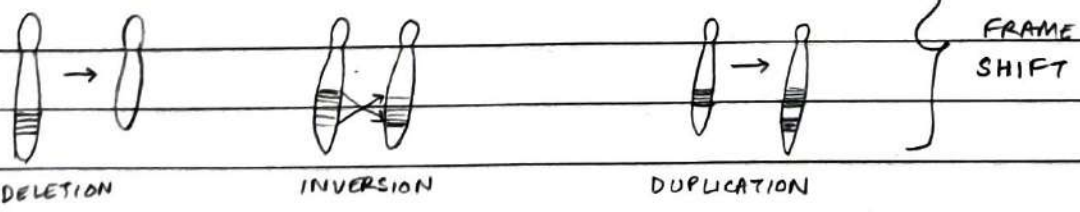
eg. Tay-Sachs disease

↳ Types - transcription, translocation.

1)



2)



BFF ♡