DEPTH OF BIOLOGY

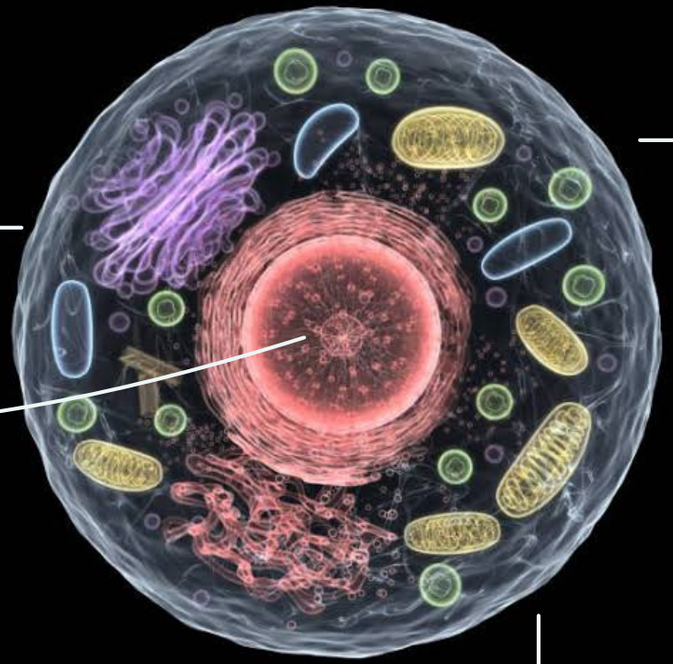
Characteristics of Cell.

→ Provide Structure & Support to Organism.

Available in different Shape & Sizes.

Structural, Functional & Biological Unit of Life.

1665.
Discovered by Robert Hooke.



Cell Can replicate Itself

Nucleus Contain genetic Information for Growth & Reproduction.

Study of Cell Called Cell Biology.

Smallest Cell.
↓
Mycoplasma.

Unicellular → ●

Or

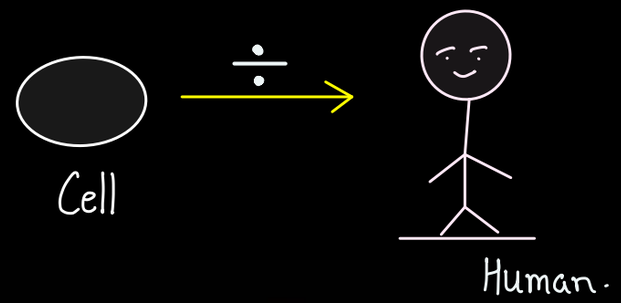
Multicellular → 

DEPTH OF BIOLOGY

Cellular level of organization

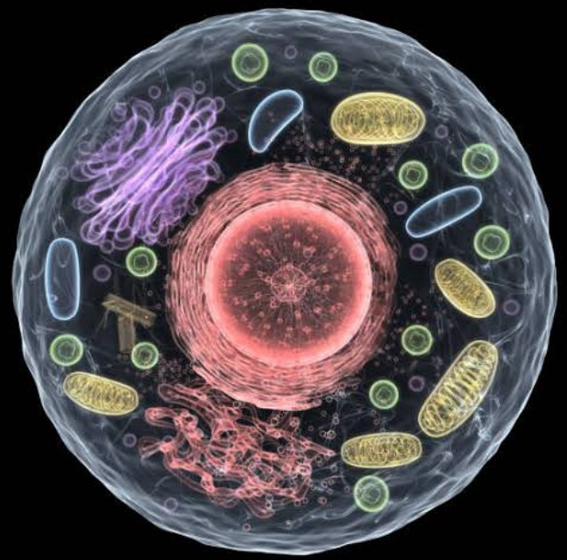
The cellular level of organization refers to the basic structural and functional unit of life, where cells, the smallest units capable of reproducing themselves, are the fundamental building blocks of all living organisms

Structure & Function of cell → Discovered by Robert Hooke.



Cells are the structural, functional, and biological units of all living beings.

A cell can replicate itself independently. Hence, they are known as the building blocks of life. A cell is the structural and fundamental unit of life.



The study of cells from its basic structure to the functions of every cell organelle is called Cell Biology.

Robert Hooke was the first Biologist who discovered cells.

DEPTH OF BIOLOGY

All organisms are made up of cells. They may be made up of a single cell (unicellular), or many cells (multicellular). Mycoplasmas are the smallest known cells.

Each cell contains a fluid called the cytoplasm, which is enclosed by a membrane. Also present in the cytoplasm are several biomolecules like proteins, nucleic acids and lipids. Moreover, cellular structures called cell organelles are suspended in the cytoplasm.

They provide structure to the body and convert the nutrients taken from the food into energy. They are of different shapes and sizes

In 1665, Robert Hooke, while examining a thin slice of cork under a microscope, observed tiny, box-like structures and coined the term "cell" to describe them, marking the beginning of cell discovery

DEPTH OF BIOLOGY

Characteristics of Cells

Following are the various essential characteristics of cells:

Cells provide structure and support to the body of an organism.

The cell interior is organised into different individual organelles surrounded by a separate membrane.

The nucleus (major organelle) holds genetic information necessary for reproduction and cell growth.

Every cell has one nucleus and membrane-bound organelles in the cytoplasm.

Mitochondria, a double membrane-bound organelle is mainly responsible for the energy transactions vital for the survival of the cell.

Lysosomes digest unwanted materials in the cell.

Endoplasmic reticulum plays a significant role in the internal organisation of the cell by synthesising selective molecules and processing, directing and sorting them to their appropriate locations.

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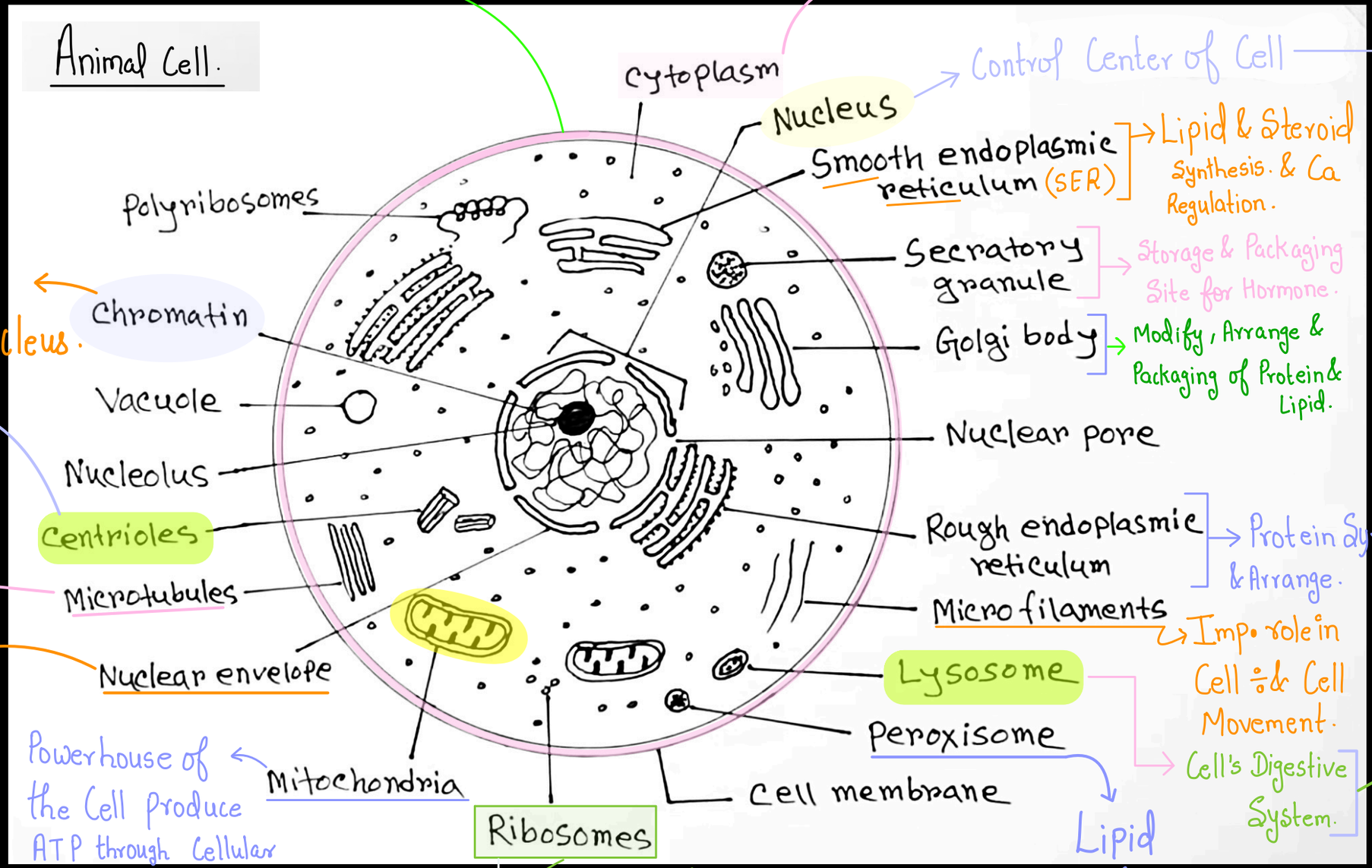

Semipermeable Membrane ↔ Protect the Cell & Control In/out of Molecule.

Jelly like Substance, Contain all Cell Organele

Control Center of Cell → Contain DNA. → Surrounded by Nuclear Membrane. Which Has pore for In/Out Molecule

Pore Diameter = 100 to 150 nm.

Lipid & Steroid Synthesis. & Ca Regulation.

Storage & Packaging Site for Hormone.

Modify, Arrange & Packaging of Protein & Lipid.

• Pack DNA for fit in Nucleus.

Cilia & Flagella formation. & Cell ÷

Imp. role in Cell ÷ & Motility.

Separate the Cytoplasm & Nucleoplasm.

Protein Synthesis, Modification & Arrange.

& ensure that protein are Correctly folded before release into Cell.

Imp. role in Cell ÷ & Cell Movement.

Cell's Digestive System. → Break down Waste & Cellular debris & Virus Bacteria.

Powerhouse of the Cell produce ATP through Cellular Respiration.

Protein factory of Cell.

→ May be free floating or attached with ER.

Metabolism.

Functions of Cell

Cells perform a variety of essential functions to sustain life. These functions are coordinated to maintain the cell's integrity, energy production, growth, and communication with other cells. Here's a breakdown of the key functions of a cell:

1.Metabolism:

The cell carries out chemical reactions necessary for life. These include processes like breaking down nutrients to release energy (catabolism) and building complex molecules (anabolism), which are vital for growth, maintenance, and energy storage.

2. Energy Production:

Cells produce energy primarily in the form of ATP (adenosine triphosphate) through processes like cellular respiration (in mitochondria) and photosynthesis (in plant cells via chloroplasts).

DEPTH OF BIOLOGY

3. Protein Synthesis:

Cells synthesize proteins based on genetic instructions stored in DNA. Ribosomes, along with the rough endoplasmic reticulum (ER), help in translating the genetic code into functional proteins that are essential for structure and function.

4. Growth and Development:

Cells divide and grow to form new cells, which allows organisms to develop and repair tissues. This includes the cell cycle, which leads to mitosis (for growth or repair) or meiosis (for sexual reproduction).

5. Reproduction:

Cells reproduce either sexually (through meiosis) or asexually (through mitosis), ensuring the continuation of genetic material and the survival of the organism.

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6. Homeostasis:

Cells maintain a stable internal environment (homeostasis) by regulating factors like temperature, pH, and ion concentrations. The cell membrane plays a crucial role in this by controlling the movement of substances into and out of the cell.

7. Transport:

Cells transport substances across the membrane and within the cell. This includes active transport (requiring energy) and passive transport (like diffusion or osmosis) to maintain proper concentrations of molecules.

8. Communication:

Cells communicate with each other through signaling molecules (such as hormones or neurotransmitters) and receptor proteins on the cell surface. This communication is crucial for coordinating cellular functions, growth, and immune responses.

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9. Defense and Protection:

Cells, especially those in the immune system, play a role in defending the body against harmful microorganisms, foreign substances, and damaged cells. This can involve processes like phagocytosis (cellular eating) or apoptosis (programmed cell death).

10. Waste Disposal:

Cells remove metabolic waste products (such as carbon dioxide, urea, or ammonia) through processes like exocytosis or via the lysosomes, which break down waste materials and cellular debris.

11. Structural Support:

The cytoskeleton gives the cell its shape, supports its internal structure, and aids in cellular movement and transport. It also helps with cell division.

12. Storage:

Cells store nutrients, ions, and other substances in organelles like vacuoles or lysosomes (in animal cells) for future use, or to keep harmful substances isolated until they can be dealt with.

Unit-1

Genome Organization-

Genome organization- refers to how all the genetic material (DNA) in a cell is arranged and structured. This DNA contains the instructions for how a living thing grows, functions, and passes traits to the next generation.

In prokaryotes (like bacteria), the DNA is usually a single circular molecule found in an area called the nucleoid. They may also have small extra pieces of DNA called plasmids.

In eukaryotes (like plants, animals, and humans), the DNA is stored in the nucleus and is arranged into linear chromosomes. The DNA wraps around proteins called histones to form a compact structure known as chromatin.

Gene Expression-

Gene expression is the process by which the information in a gene is used to make a protein or RNA molecule. It's how the genetic instructions are turned into something useful for the cell.

Steps of Gene Expression:

Transcription: The DNA code of a gene is copied into a molecule called mRNA.

Translation: The mRNA is used as a guide to build a protein with the help of ribosomes.

Regulation of Gene Expression:-

Gene expression is tightly controlled so that the right proteins are made at the right time, in the right amount, and in the right cells.

Stimulates the expression of certain genes and inhibits that of others is called regulation of gene expression.

[DNA $\xrightarrow{X}$ RNA]

Transcription level (formation of primary transcript).

Processing level (regulation of splicing).

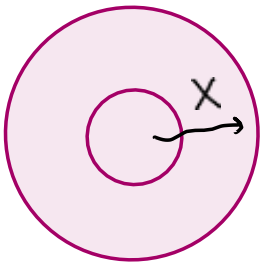
Intron (Remove) → Non-Coding Part.

& Exon Add.

Transport of mRNA from nucleus to the cytoplasm.

Translational level.

X (RNA → Protein)



Importance of siRNA & Micro RNA-

siRNA stands for small interfering RNA. It is a tiny piece of RNA that can turn off a gene.

siRNA is like a pair of scissors that cuts messages in the cell, so bad or unneeded proteins are not made.

Why is siRNA important?

Stops bad genes – siRNA can stop a gene from making a harmful protein.

Fights viruses – it helps the cell destroy virus RNA.

Used in medicine – scientists use siRNA to treat diseases by stopping the genes that cause them.

Used in research – siRNA helps scientists study what happens when a gene is turned off.

How does it work?

siRNA finds the matching mRNA (message from DNA).

It cuts the mRNA so the cell can't make the protein.

This turns off the gene.

Micro - RNA

microRNA is a very small RNA molecule microRNA's job is to stop certain genes from making proteins when they are not needed.

How does it work?

The cell uses DNA to make a message called mRNA.
mRNA tells the cell how to build a protein.
If the protein is not needed, microRNA sticks to the mRNA.

This blocks the message or destroys it.
The protein is not made.

Why is microRNA important?

Controls gene activity – turns genes "off" when not needed.

Helps in development – controls how cells grow and become different.

Prevents disease – stops harmful proteins that can cause cancer or other problems.

Used in medicine – scientists study miRNA to find new treatments.

Gene Mapping & Gene Sequencing-

Gene mapping is the process of finding the location of genes on a chromosome —like marking places on a map.

Why is it important?

Finds where genes are in our DNA.

Helps understand diseases caused by genes.

Used in research to study how traits are passed down.

Helps in medicine to find and fix genetic problems.

How is it done?

Scientists look at DNA and traits in families.
They find which genes are linked to which traits or diseases.
Then, they mark the gene's location on the chromosome.

Gene sequencing-

Means finding out the order of the letters (A, T, C, G) in a gene.

These letters are the building blocks of DNA.

Why is it important?

Tells us the exact DNA code of a gene.
Helps find mutations (changes) that can cause diseases.

Used to study genes, understand traits, and develop treatments.

Simple Example:-

DNA is like a sentence made of four letters: A, T, C, and G.
Gene sequencing reads the sentence to understand what it says.

How is it done?

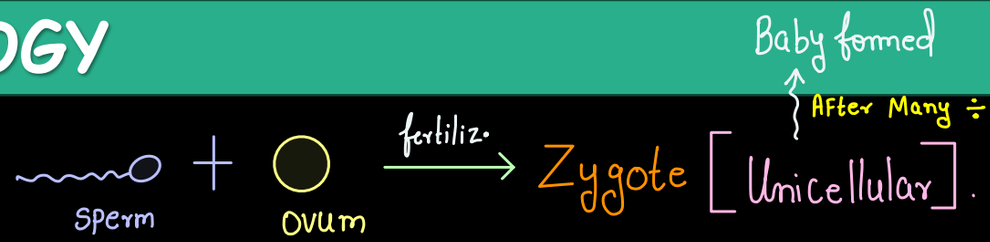
Scientists take a sample of DNA.

Machines read the order of A, T, C, and G.

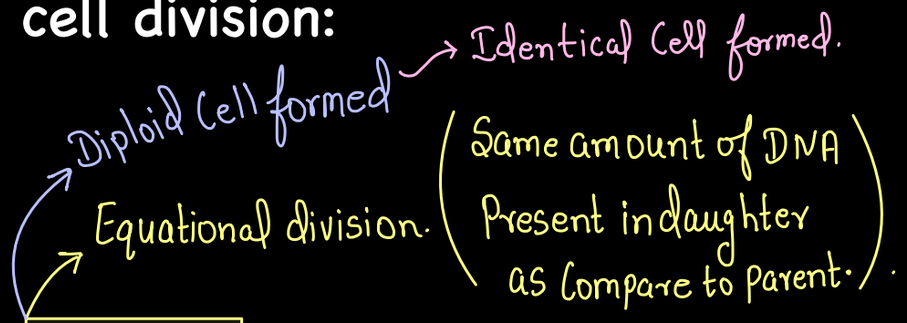
The result shows the exact sequence of the gene.

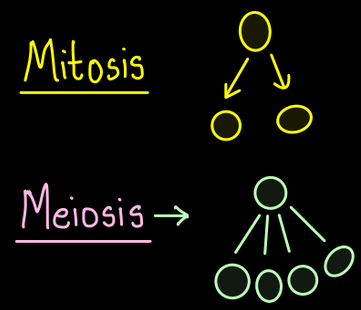
DEPTH OF BIOLOGY

Cell division



Cell division is the process by which a single cell splits into two or more new cells. This is how organisms grow, repair damaged tissues, and reproduce. There are two main types of cell division:





Mitosis: The division of a single cell into two identical daughter cells, each with the same number of chromosomes as the original cell. This type of division helps with growth and tissue repair.

Reductional Division. / Haploid Cell formed.

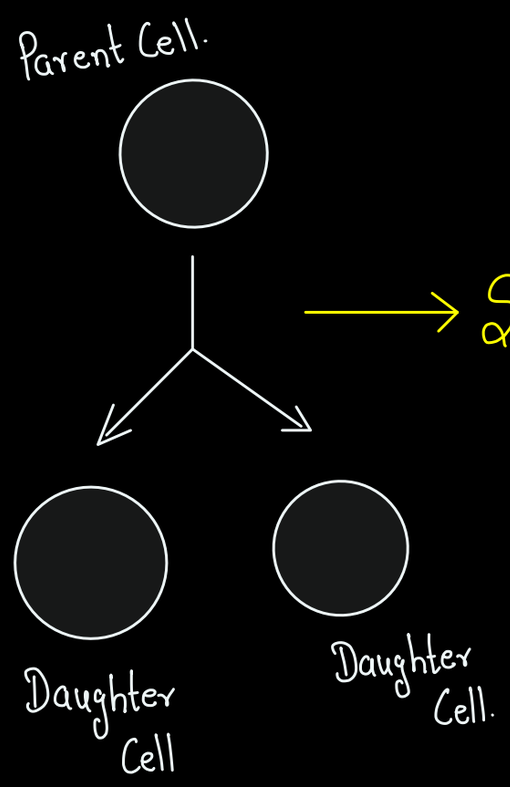
Meiosis: A special type of division that reduces the number of chromosomes by half, creating four cells (like sperm or egg cells in animals) that are genetically different from the parent cell. This is essential for sexual reproduction.

DEPTH OF BIOLOGY

Cell Cycle

Include Organelle duplication, DNA replication.

Cell Growth.



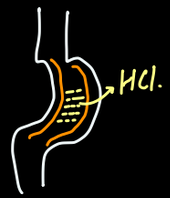
→ Series of Events takes Place in a Cell.

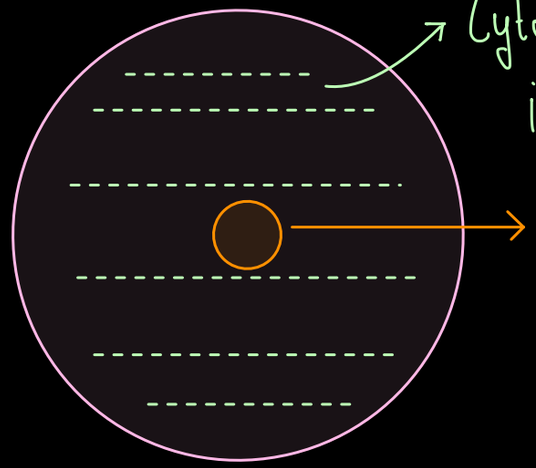
That Cause it to divide into two Daughter Cell.

These processes are Highly Cordinated & Genetically Controlled by Cyclins & CDK 5.

-पोडीवार

eg → Lining of Stomach divides in 3-4 days.





Cytoplasmic Growth is a Continous Process.

Nucleus. (Brain of the Cell).

Lead to Distrubance in Nucleo-Cytoplasmic ratio.

Which Leads to Cell division.

DEPTH OF BIOLOGY

Cell Cycle

Divided into 2 PHases.

I^st

Interphase

→ Preparation PHase. (Preparation for Cell division).

→ Resting PHase.

More then 95% of Cell Cycle. (>95%)

→ Here Cell Growth takes place

Organelle duplicate & DNA replicate.

Interphase divided into 3 PHase.

G_1 | S | G_2 PHase.

→ DNA replicate here.

II^nd.

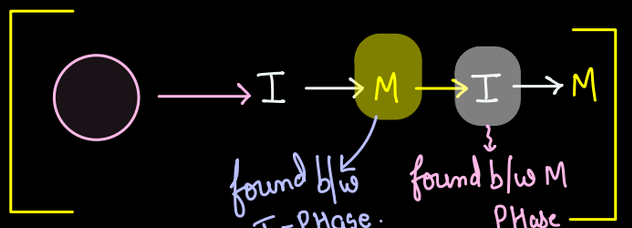
M-Phase / Mitosis

→ < 5% time

→ Most dramatic PHase.

→ Here I^st karyokinesis (Nucleus ÷)

then Cytokinesis takes place. (Cytoplasm ÷)



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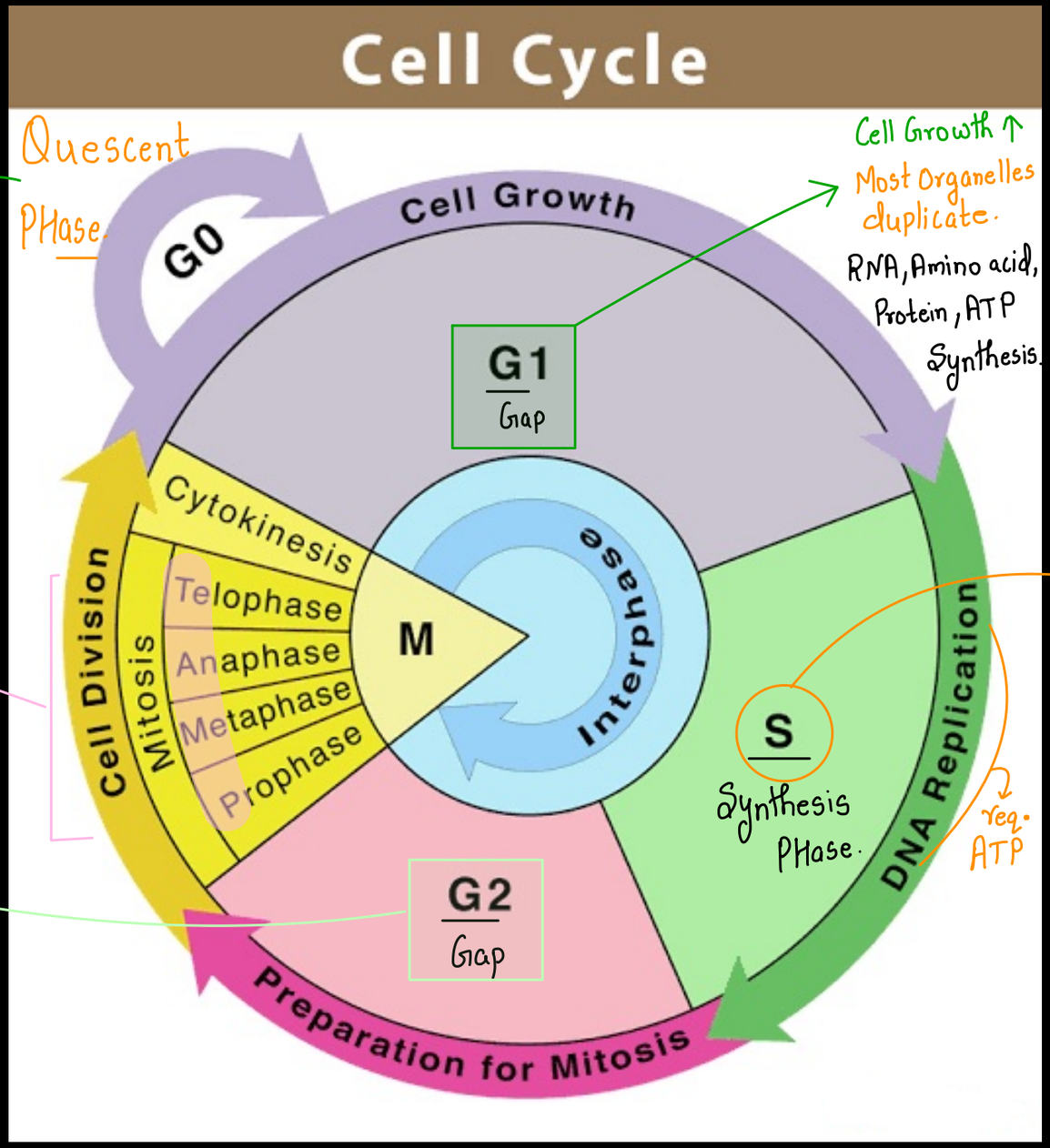


(Heart Cell
Brain Cell.) Exit from Go Phase.

Quescent Phase.

Cell Growth ↑
Most Organelles duplicate.
RNA, Amino acid, Protein, ATP Synthesis.

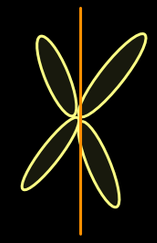
Karyokinesis

Organelle like Mitocho. & Chloroplast duplicate.

RNA, Amino Acid, Protein (Tubulin) formed.

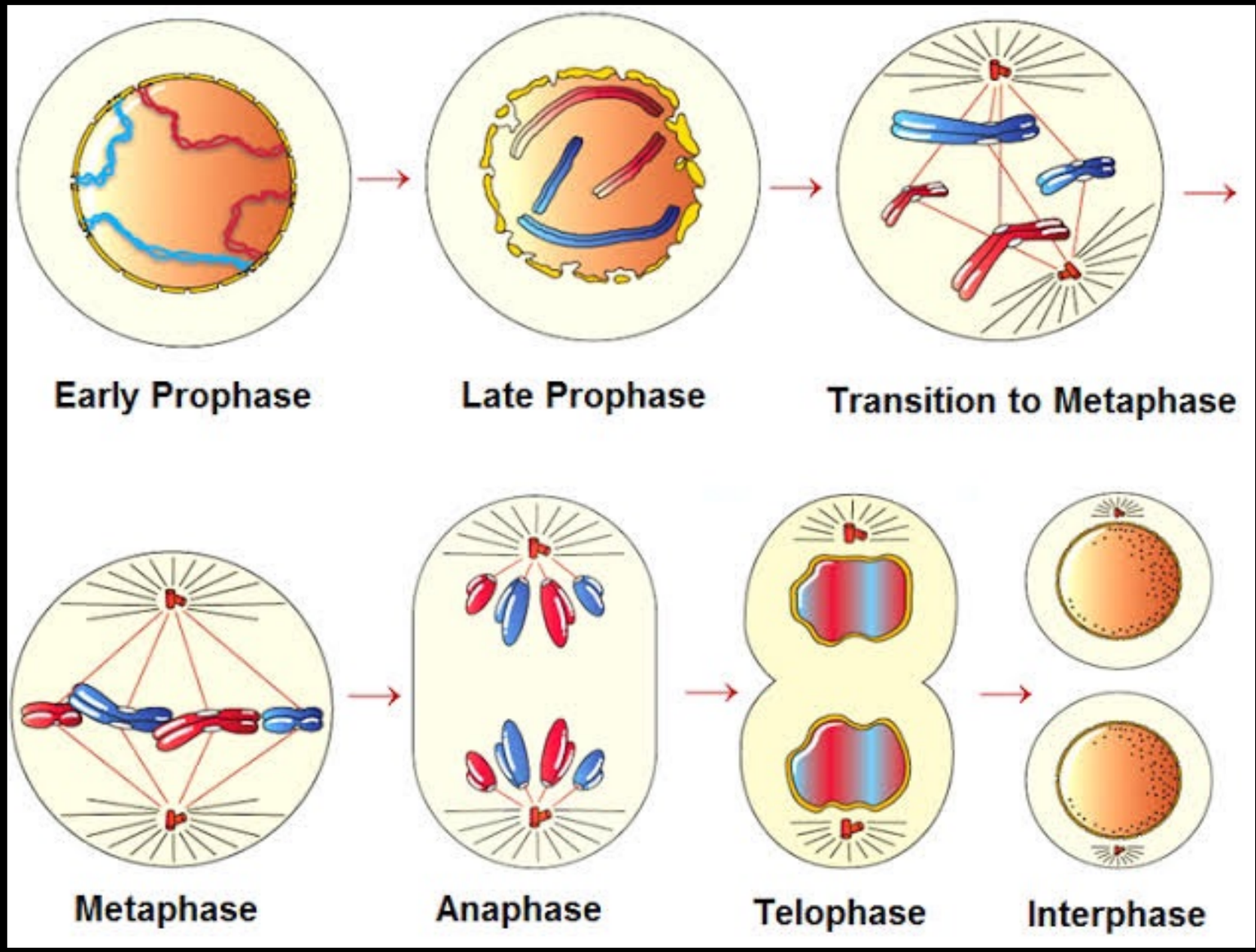
DNA replication.
- Centriole duplication.
- Histone protein formation.
- DNA Content double but number of Chromosome remains Same.

req. ATP



DEPTH OF BIOLOGY

Mitosis



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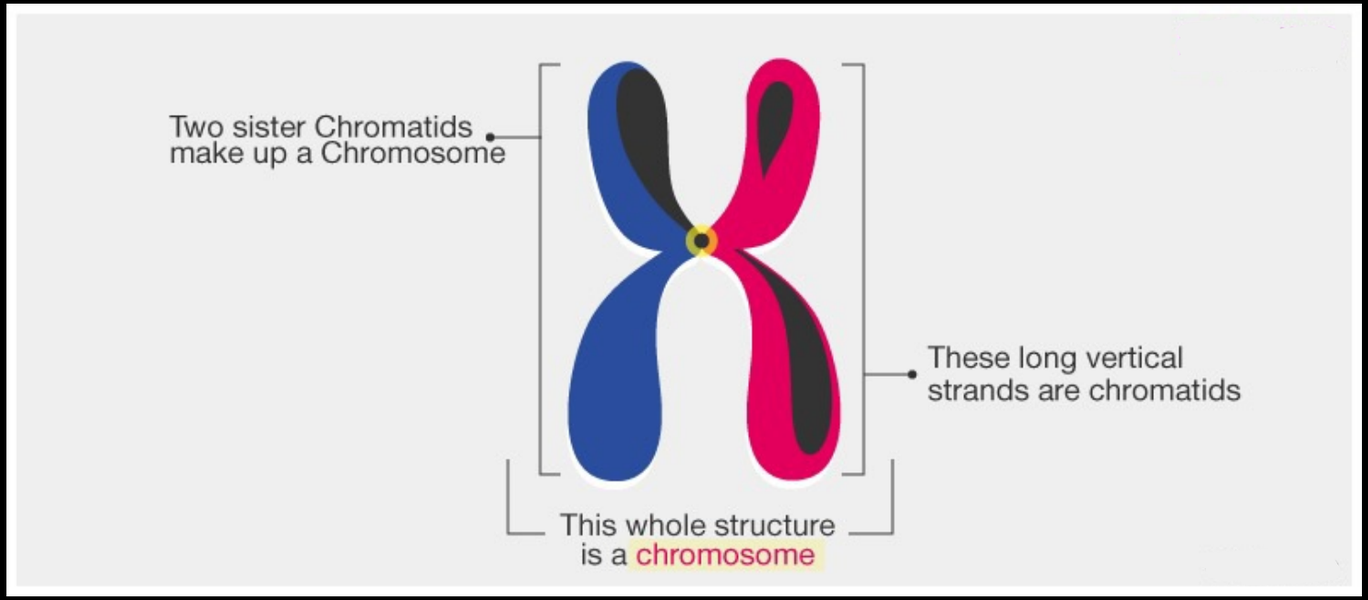
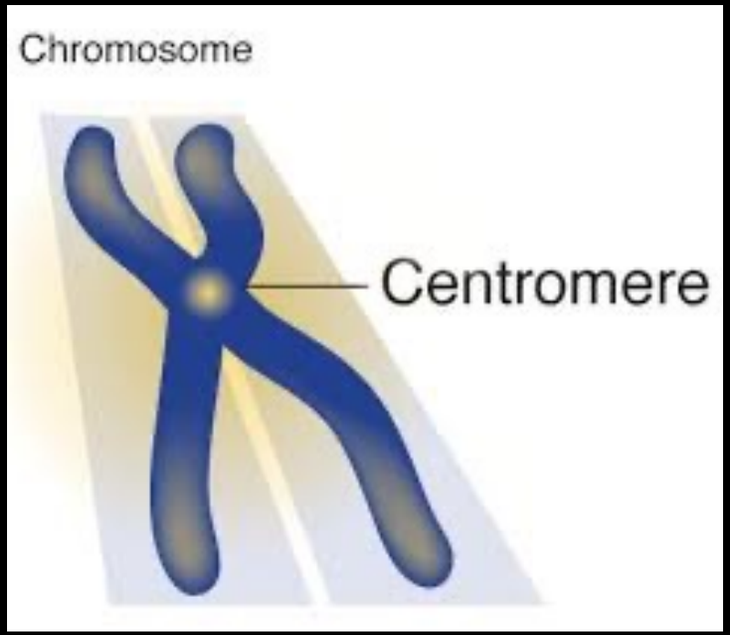


The centromere is a constricted region on a chromosome that connects two sister chromatids



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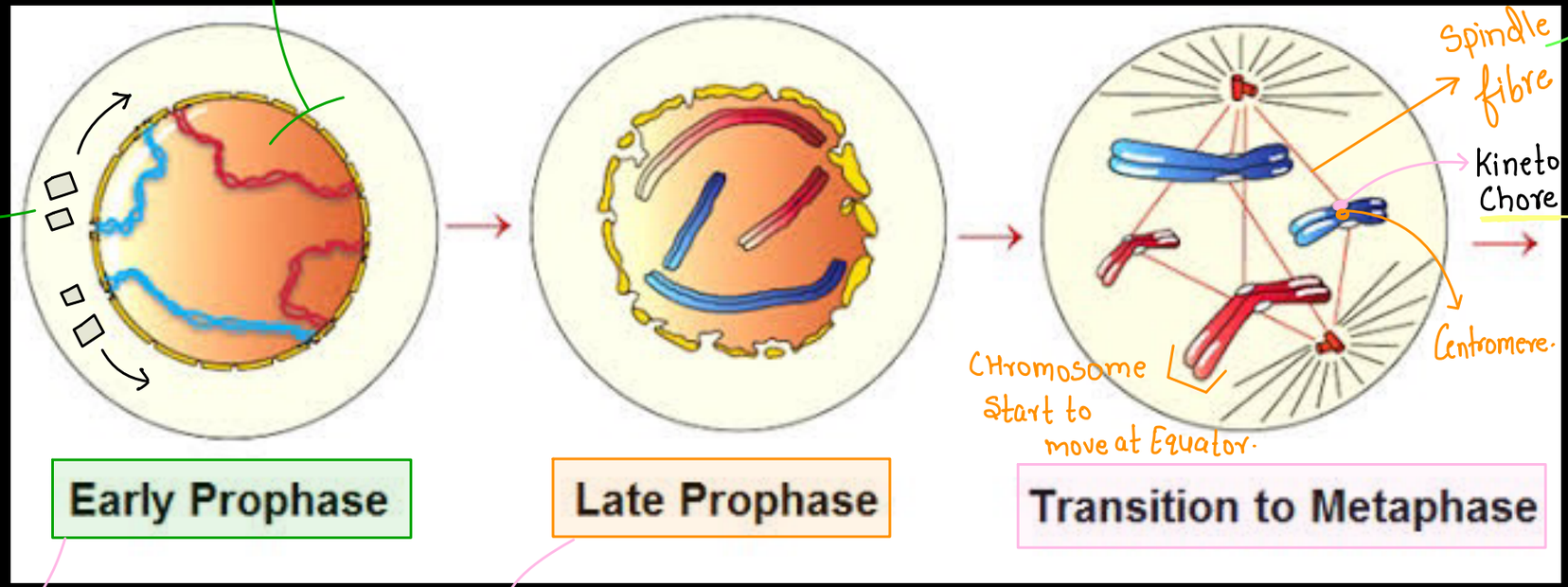
Nuclear Membrane damage & Cytoplasm & Nucleoplasm Mixing Start.

- Centriole Start to Move towards Oppossite poles.



Composed of Microtubule.
↓
Made up of Protein (Tubulin)

It is a protein Structure that attach Chromosome to Spindle Microtubule

Initiation of Chromatin Condensation.

Golgi Complex
ER
Nucleolus
Nuclear Membrane
→ Disappear.

DEPTH OF BIOLOGY

In this Stage We Can perform Karyotyping as well.

↓

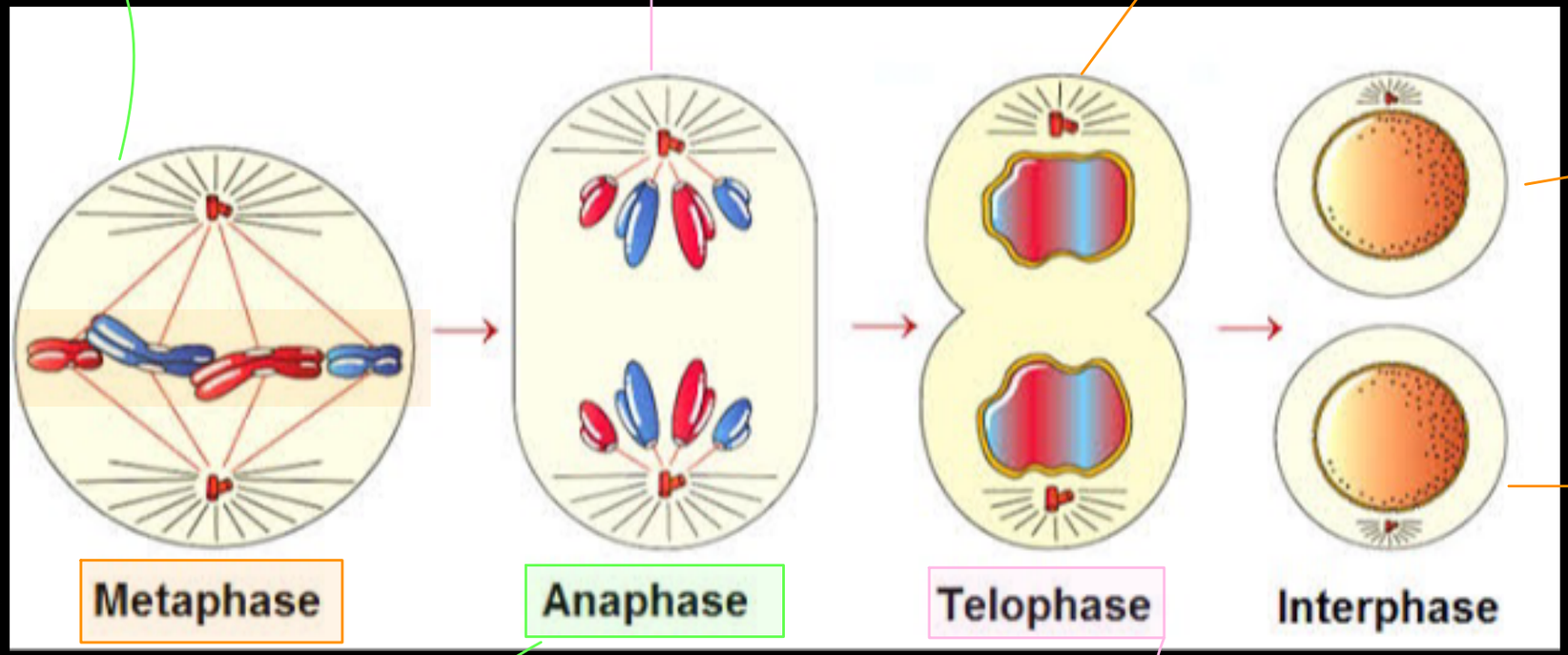
Procedure for Check Genetic Disorder.

Chromosome aligned at the Middle of the Cell.

☆ In this Stage Chromosome Can be most easily Visible So, we Can easily do Cytogenetics [study of Chromosome].

→ Centromere Split

Final Stage of Mitosis



Again repeat

→ Sister Chromatid Separation takes place.

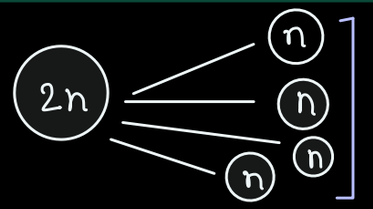
→ Chromosome Moves towards Opp. Pole.

→ Reverse Prophase.

- Chromosome reach their respective poll.
- ER, Golgi body reappear.

DEPTH OF BIOLOGY

Meiosis (Reductional Division).



All are different from Each other (Evolution).

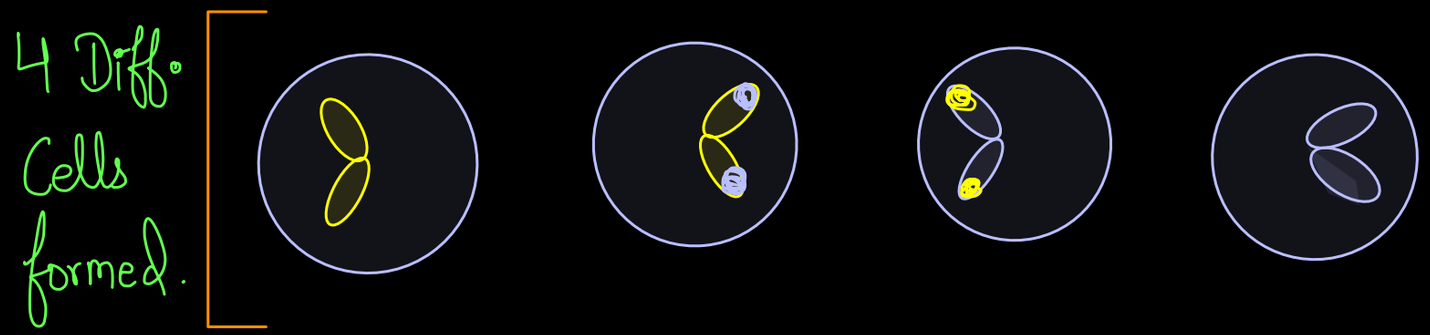
(Variation).

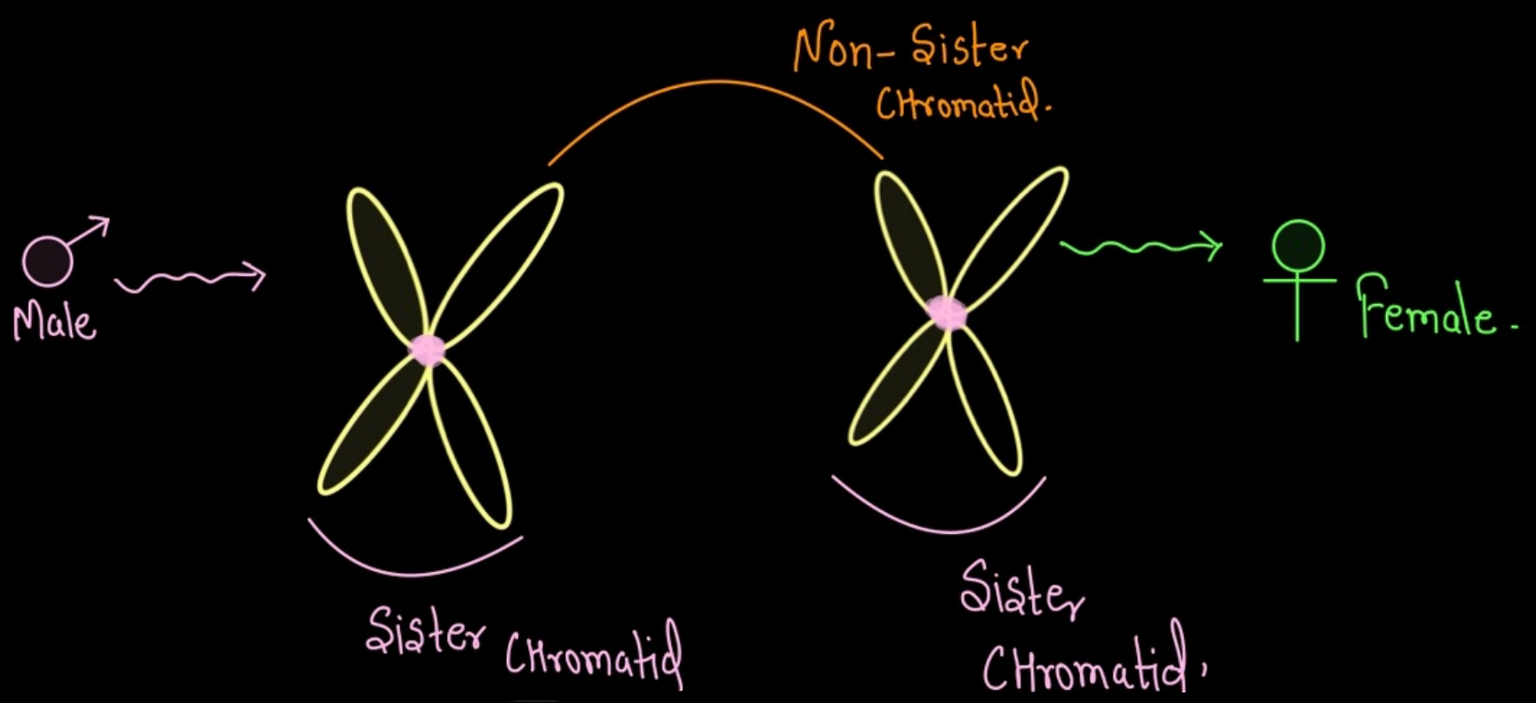
Meiosis is a type of cell division that reduces the chromosome number by half and produces four non-identical daughter cells, each with half the number of chromosomes of the original cell. This process is essential for sexual reproduction because it produces gametes (sperm and eggs in animals, and pollen and ovules in plants) that can combine during fertilization to form a new organism with the proper number of chromosomes.

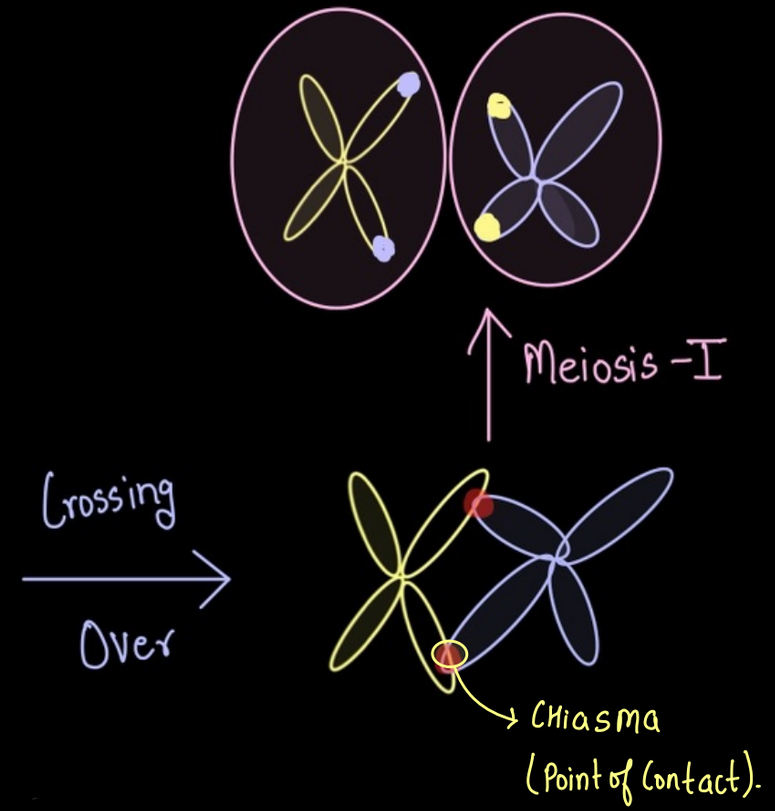
G_1, S, G_2

* Meiosis done in 2 Steps
  - Meiosis I = Reductional division → Crossing Over takes place.
  - Meiosis II = Just like Mitosis.

DEPTH OF BIOLOGY







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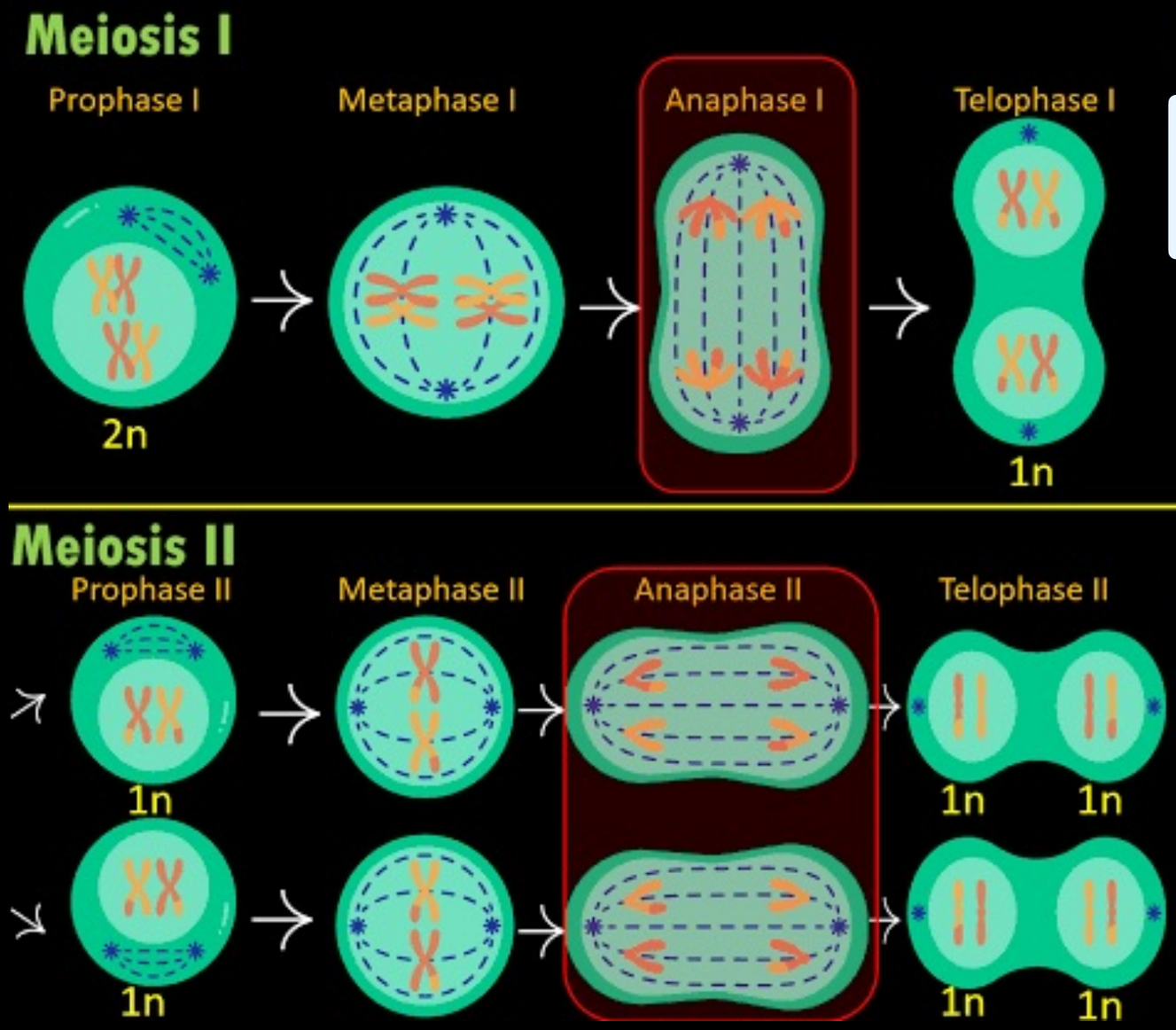


Meiosis I

1. From a diploid parent cell 2 haploid cells are formed with half number of chromosome (reduction division).

Reduction Division

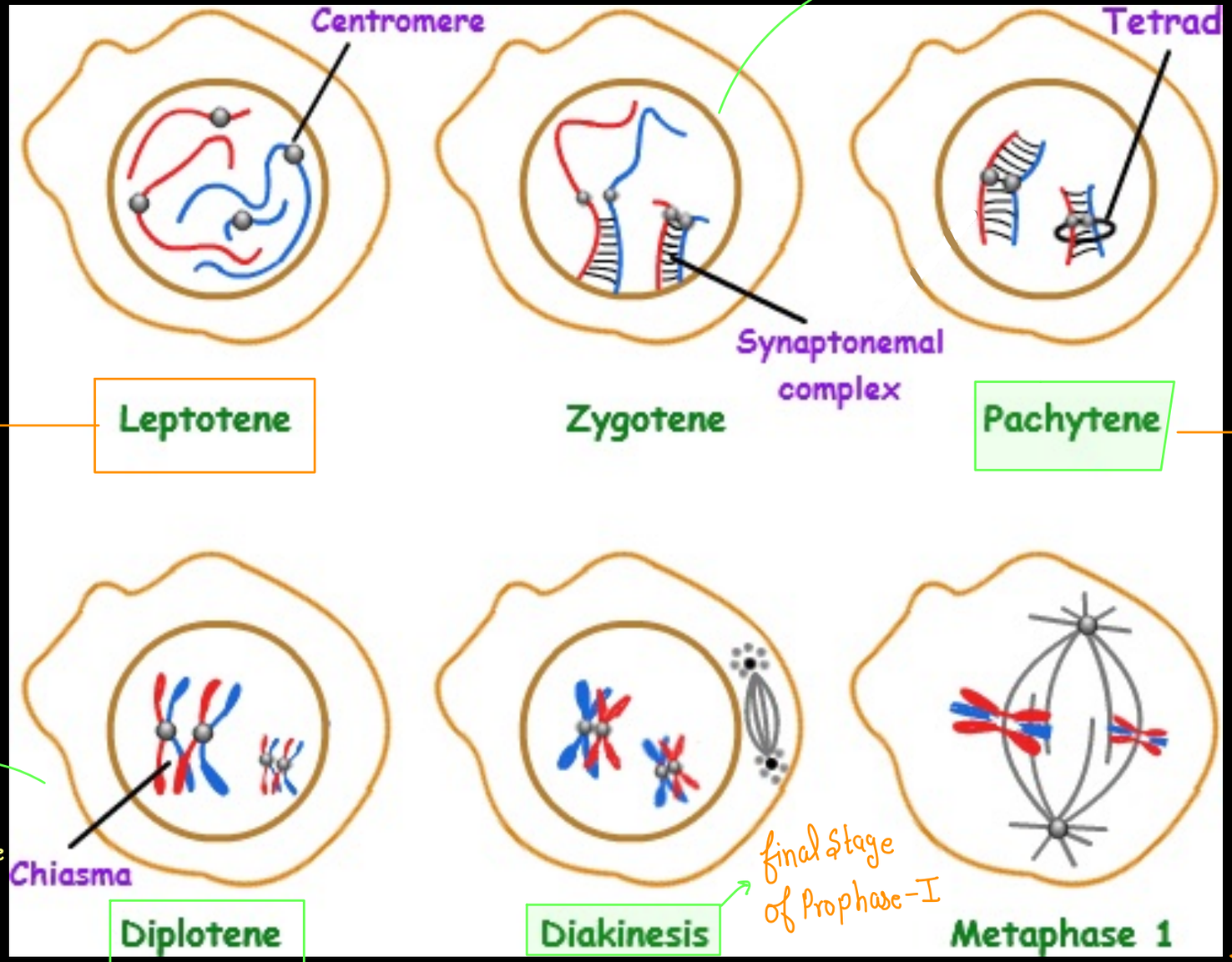
Meiosis II

From 2 haploid cells, 4 haploid cells formed with same number of chromosome (equational division).

Equational Division

DEPTH OF BIOLOGY

Prophase-1



First Sub stage of Prophase – I

Chromosome Condense

Bouquet Like Structure.

Pairing of Homologus Chromosome. (Pairing Called Synapsis).

- Paired Chromosome Called Bivalent.
- Formation of Synaptonemal Complex.

→ Bivalent or Tetrad Clearly Visible.

- Apperance of Recombination Nodule
- Crossing Over b/w Homologus & Non-Sister Chromatid.

☆ Recombinase enzyme Involved in Crossing Over.

Dissolution of Synaptonemal Complex. & Homologus Chromosome Separate each other.

X-shape Chiasma formed

final stage of Prophase-I

Cell Death

Cell death is a natural process where cells die when they are old, damaged, or not needed.

It helps keep the body healthy by removing unwanted or dangerous cells.

Types of Cell Death:-

1. Apoptosis (programmed cell death)

Planned and safe cell death

Cell shrinks, breaks into small parts, and is removed without harming nearby cells

Important in growth, development, and disease prevention

2. Necrosis
3. Autophagy

Cell death- Regulators-

Main Regulators (Simple):-

1. Bcl-2 Family

Some stop cell death (like Bcl-2, Bcl-xL)

Some start cell death (like Bax, Bak)

They control the mitochondria, which helps decide life or death.

2. Caspases

They are like scissors inside the cell.

When turned on, they cut up the cell to cause safe death (apoptosis).

Example: Caspase-3, Caspase-8, Caspase-9.

3. Death Receptors

These are on the outside of the cell.

They receive signals from other cells that tell the cell to die.

Example: Fas and TNF receptors.

4. p53

A watchdog protein that checks if the cell's DNA is damaged.

-Intrinsic (Mitochondrial) Pathway – Step by Step:

Cell is stressed or damaged
(e.g., DNA damage, lack of oxygen, toxins)

Mitochondria are affected
The cell signals the mitochondria to start the death process.

Bax and Bak proteins make holes in the mitochondria

Cytochrome c is released from mitochondria into the cytoplasm

Cytochrome c joins with a protein called APAF-1
Together they form a complex called the apoptosome.

Apoptosome activates Caspase-9
This is an "initiator caspase" that starts the cell death process.

Caspase-9 activates Caspase-3

Caspase-3 is the "executioner" that breaks down cell parts.

The cell breaks down and dies in a clean and controlled way.

Stress → Mitochondria → Cytochrome c →

Caspase-9 → Caspase-3 → Cell death (apoptosis)

Extrinsic (Death Receptor) Pathway – Step by Step:-

Death signal comes from outside the cell
(e.g., a protein like FasL or TNF)

Signal binds to a death receptor on the cell surface
Examples of receptors: Fas receptor (CD95), TNF receptor

Receptors activate and form a complex inside the cell
Called the DISC (Death-Inducing Signaling Complex)

DISC activates Caspase-8

Caspase-8 is the "initiator" enzyme
Caspase-8 activates Caspase-3
Caspase-3 is the "executioner" enzyme
Caspase-3 breaks down the cell parts
The cell dies in a clean and controlled way (apoptosis)

Necrosis-

Necrosis –

Due to infection, trauma, lack of blood, toxins, or chemicals.

Cell loses control
The cell membrane is damaged and cannot protect the cell.

Cell swells
Water and ions enter the cell uncontrollably.

Organelles swell and stop working
Mitochondria and nucleus get damaged.

Cell bursts (ruptures)
The cell membrane breaks open.

Cell contents leak out
This causes inflammation in nearby tissues.

Nearby cells may also be damaged
Necrosis often spreads and causes pain and swelling.

What is Autophagy?

Autophagy means "self-eating."
It is a natural process where the cell cleans itself by breaking down its old, damaged parts.

Step-by-Step Process of Autophagy (Simple):

Cell senses stress or low energy
(like starvation or damage inside the cell)

Damaged parts or waste are marked
(like broken mitochondria, proteins, etc.)

A double membrane forms around the waste
This forms a bubble called an autophagosome.

Autophagosome joins with a lysosome
Lysosomes are cell parts that contain digestive enzymes.

Lysosome breaks down the waste
The contents are digested into small useful pieces.

Cell reuses the building blocks
These parts help the cell survive and make new materials.

Stress → Autophagosome forms → Joins lysosome

* Waste digested → Cell reuses parts