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# DAILY CLASS NOTES

## Science & Technology

**Unit 1**

**Cellular Biology**

*Topics Covered:*

- Syllabus
- Cell



Space for Notes

## UNIT-1 : CELLULAR BIOLOGY

### Syllabus

#### Prelims Paper I

- General Science

#### Mains

- Science and Technology - Developments and their applications and effects in everyday life.
- Achievements of Indians in Science and Technology
- Indigenization of technology
- Developing new technology
- Awareness in the fields of
  - IT (Information Technology), Space, Computers, Robotics, Nano-technology, Biotechnology
- Issues related to IPR (Intellectual Property Rights)

### Sources:

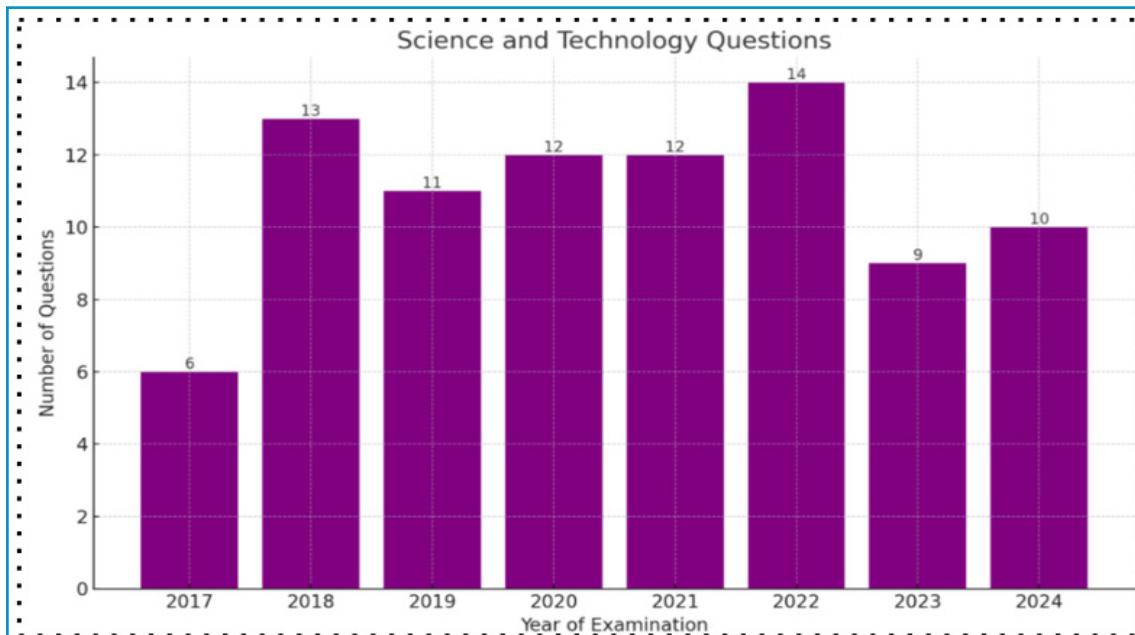
#### Study Material

- Class notes
- UPSC Wallah books

#### NCERT Chapters

- Class 8 NCERT: Chapter 2 → Microorganisms: Friend and Foe
- Class 9 NCERT: Chapter 5 → The Fundamental Unit of Life
- Class 10 NCERT: Chapter 4 → Carbon and Its Compounds
- Class 11 NCERT
  - Biology: Chapter 8 → Cell – The Unit of Life
  - Physics (Part-1): Chapter 7 → Gravitation
    - ◆ Kepler's Laws, Universal Law Of Gravitation, Acceleration Due To Gravity Of The Earth, Escape Speed, Earth Satellites, Energy of an Orbiting Satellite
  - Physics (Part-2): Chapter 14 → Waves
    - ◆ Transverse And Longitudinal Waves, The Principle Of Superposition Of Waves, Reflection Of Waves
- Class 12 NCERT
  - Physics: Chapter 13 → Nuclei
    - ◆ Nuclear Energy
  - Chemistry:
    - ◆ Chapter 2 → Electrochemistry
      - ◆ Fuel Cells
    - ◆ Chapter 10 → Biomolecules
- Class 12 NCERT
  - Biology:
    - ◆ Chapter 7 → Biology of Human Welfare
    - ◆ Chapter 8 → Biotechnology

### UPSC Prelims PYQs Trend Analysis Year Wise:



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### UPSC Mains PYQs Trend Analysis Year Wise:

- Questions from biotechnology and Space technology are a regular trend.

Topics	2024	2023	2022	2021	2020	2019	2018	2017	2016	2015	2014
Biotech + Health	Life Material + IPR	Micro-org - Fuel	Vaccines	App. Biotech	Covid 19	Farmers	Biopharma	Stem Cell Therapy			
Space Tech	Asteroids ↗	Chandrayan3	JWST			BAS		Chandrayan + MOM	Achievement	IRNSS	
	Toll Collection										
	DPPA Act 2023										
ICT	Social Med + Encrypt	AI (Health vs Privacy)									
IPR	Life Material + IPR				Traditional Knowledge (Medicine)				TKDL (Open Source)	Copyright, P. TM	
Defence Tech			S400								
Nano Tech				Health							
Nobel Prize			Blue LED						Govt. missions		
Scientists				M.S. Swaminathan	S.N. Bose						
General S&T	Safe Drinking Water			Agni Appl						Research (S&T)	
Nuclear Energy					Nuc. E. Prog	FBR					
Robotics									Robots		

## CELL

The cell is the **structural and functional unit of life**, which means that the structure of our body is made up of cells, and all the functions we perform are done by the cell.

- Cells, as the **fundamental units of life**, possess a complex structure that allows them to carry out various functions necessary for the existence and functioning of living organisms.
- Cells are capable of independent existence.
- Living beings can be:
  - Unicellular organisms** – Made up of a single cell. **Example:** Amoeba, bacteria, fungi, paramecium, etc
  - Multicellular organisms** – Composed of multiple cells. **Example:** Humans, animals, plants



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- Cells come in various shapes and sizes, such as muscle cells, neuron cells, sperm cells, and egg cells. Their combination forms an organism.

### Characteristics of the Cell:

- Reproduction:** Cells play a role in both sexual and asexual modes of reproduction.
- Cell structure:** It includes topics such as the division of labour.
- Metabolism:** Metabolism covers digestion, excretion, respiration, and blood circulation.
- Adaptation:** There are two types of adaptation: short-term adaptation and long-term adaptation.

### Discovery of the Cell:

- Robert Hooke (1665):** The discovery of the cell is credited to Robert Hooke, an English scientist, who first **observed cells in 1665**.
  - Hooke was examining a thin slice of cork under a microscope.
  - The cork appeared to be made up of tiny, **box-like structures**, which he called "cells" because they resembled the small rooms (cells) that monks lived in.
- Anton van Leeuwenhoek (1674):** Anton van Leeuwenhoek, a Dutch scientist, made significant improvements to the microscope.
  - He was the first to observe live cells, including bacteria, red blood cells, and sperm cells. He discovered free-living cells in pond water.
- Robert Brown (1831):** In 1831, while examining orchid cells under a microscope, Robert Brown observed a small, round structure inside the cell. He identified **this structure as the nucleus**.
  - He was the first to describe the **nucleus and recognize its importance within the cell**.
- Jan Evangelista Purkinje:** In the context of Purkinje cells in the cerebellum, Purkinje's work also extended to the study of the protoplasm in neurons.
  - While Purkinje specifically coined the term **protoplasm**, which includes cytoplasm and nucleus.
  - His research on cells contributed to the general understanding of protoplasmic structures in both muscle and nerve tissue.
- The Cell Theory (1830s):**
  - Matthias Schleiden (1838):** German botanist Matthias Schleiden proposed that **all plants are made up of cells**.
    - His work laid the foundation for the idea that **cells are the fundamental units of life in plants**.
  - Theodor Schwann (1839):** German zoologist Theodor Schwann extended this idea to animals, proposing that **all living organisms, both plants and animals, are made of cells**.
    - The single cell is known as a **zygote**, and the human body contains trillions of cells.
    - This led to the formulation of the first part of the **Cell Theory**, which states that **all living things are composed of cells**.

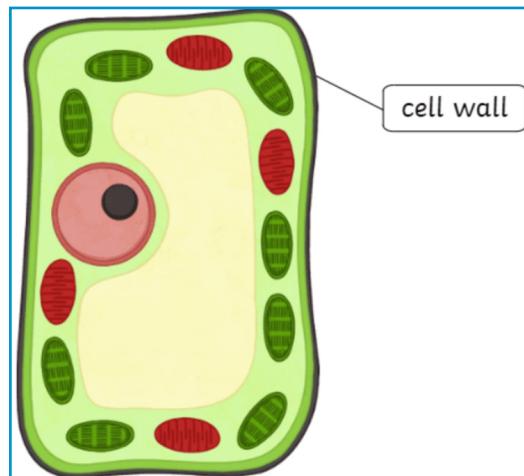
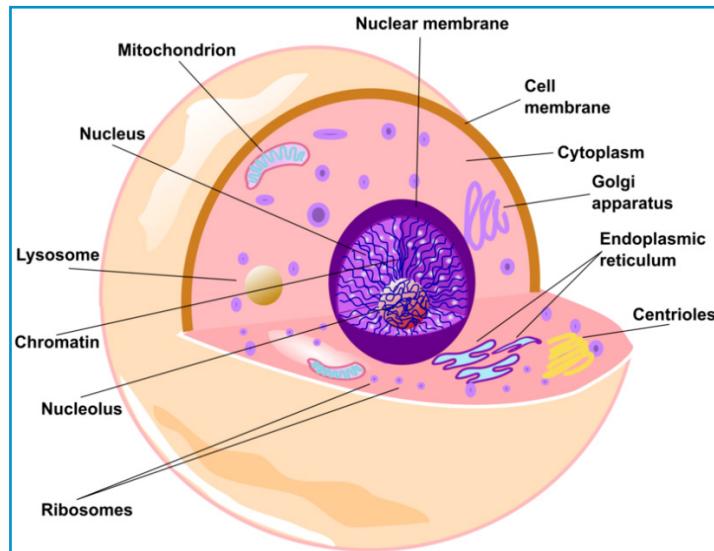
- **Rudolf Virchow (1855):** German physician Rudolf Virchow added the final piece to the Cell Theory by stating that **all cells are derived from pre-existing cells.**
  - ◆ This completed the modern understanding that cells are the basic structural and functional units of life.
- The electronic microscope was developed in 1940

### Various Components of the Cell:

- **Cell Membrane (Plasma Membrane):** It is a selectively permeable lipid bilayer made up of phospholipids, proteins, and carbohydrates.
- **Cytoplasm:** It is a gel-like substance filling the cell's interior.
- **Nucleus:** It is a Membrane-bound organelle containing genetic material (DNA).
- **Cell wall:** The cell wall is a rigid, protective outer layer found **only in plant cells.** It provides structural support and protection and helps maintain the shape of the cell.

### Cell structure (Organelles):

- **Outer cover:**
  - Cell wall (**Only in plant cells**)
  - Cell membrane or plasma membrane
- **Cytoplasm:**
  - Mitochondria
  - Endoplasmic Reticulum
  - Ribosomes
  - Golgi Bodies
  - Lysosomes
  - Plastids (**Only in plant cells**)
  - Centrosome (**Only in animal cells**)
  - Vacuole
- **Nucleus:**
  - Genetic material



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### Cell Wall

- The **cell wall** is a rigid, non-living structure that provides support and protection to the cell. It is found in plants, bacteria, algae, and fungi.
- The cell wall is a **characteristic feature of plant cells.** It is freely permeable, meaning it allows substances to pass through without restriction.
- **Chemical Composition of the Cell Wall:**



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- Plants – Made of **cellulose** (the most abundant organic substance; found in paper and wood)
- Algae – Primarily made of **cellulose**
- Fungi – Made of **chitin**
- Bacteria – Composed of **peptidoglycan**
- Functions:
  - It provides structural support and rigidity to the plants.
  - It **defends the plants against pathogens** (any organism or agent, like viruses, bacteria, or parasites, that can cause disease or illness in a host)
  - It helps in maintaining the **shape and strength** of the plant.
  - **Plasma Membrane:**
- It is made up of **Phospholipid and Protein**. Its characteristic feature of all the cells- it is present in all types of cells.
- It is a **selectively permeable membrane**, which means it depends on conditions required for the growth and development of cells, on what comes in and what goes out at that moment.

### Extra Edge

#### Permeability Types:

- **Freely Permeable:** Allows all substances to pass through without restriction.
- **Semi-Permeable:** Allows only certain substances to pass through.
- **Selectively Permeable:** Regulates and controls which substances can enter and exit.
- **Non-Permeable:** Does not allow any substances to pass through.

### Cytoplasm

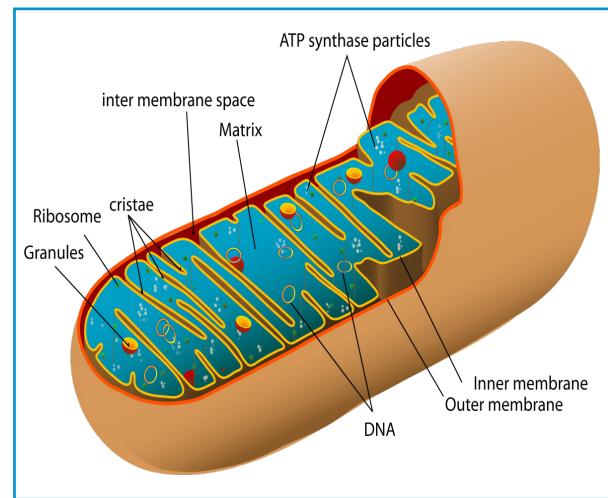
- It is a **semi-fluid substance** inside the cell membrane.
- It acts as a **storage site** for various organelles.
- It is present between the **nucleus and the plasma membrane**.

### Mitochondria (Powerhouse of the Cell)

- **Function:** It is called the “**powerhouse of the cell**” as it produces energy by breaking down food through the oxidation of glucose in the presence of oxygen (i.e. respiration of the cell).



- **Process:** During cellular respiration, a glucose molecule with oxygen is gradually broken down into **carbon dioxide and water**. It releases energy as well, which is in the form of **ATP**.
  - **ATP (Adenosine Triphosphate)** is the energy currency.





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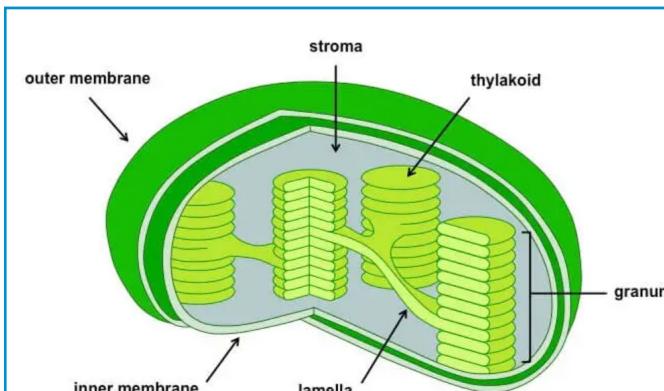
- **Structure:** It is a double-layered organelle.
- The mitochondrial matrix is the viscous fluid that contains mitochondrial DNA. It has a dual membrane structure and has its own DNA. Hence, mitochondria are semi-autonomous organelles.
- **Cristae:** Cristae are intricate structures within mitochondria that play a role in cellular respiration.
- **Mitochondrial DNA (mtDNA)** gives it partial independence.
  - ◆ **Matrilineal Inheritance:** Children get mitochondrial DNA from their mother (but not their father). In other words, a child inherits mitochondrial disorders entirely from the mother's side and not from the father.
- A semi-autonomous organelle is one that can divide independently during cell division and perform essential functions, such as energy production, due to the presence of mitochondrial DNA (mtDNA).

### Plastids

- It is available in plants. Plastid has a double membrane structure and has its own plastid DNA and therefore it is a semi-autonomous organelle.
- Plastids also possess DNA and ribosomes, which are responsible for protein synthesis.
- It is of the following types:
  - **Chloroplast:** They are colorful (Pigments). It will give a green colour when Chlorophyll is present.
  - **Chromoplast:** It will give an orange colour when Carotene is present. It will give a yellow colour when Xanthophylls is present. All these also help in Photosynthesis
  - **Leucoplast:** It is colourless/ transparent because no pigment is present. Its function is to store food for plants. E.g. starch.

#### Structure:

- It is also a double-membrane structure. Its internal structure includes grana and thylakoids. The fluid present within it is known as stroma.
- It also contains its own DNA. Since it carries its own DNA, this organelle is considered semi-autonomous.



**Note:** Manipulating plastid function can improve crop yield, nutritional content, and environmental resilience. Hence, it is crucial for agrobiotechnology.

### Endoplasmic Reticulum and Ribosomes

- **Ribosomes:** Ribosomes help in synthesising proteins. Ribosomes are made of proteins and rRNA.
- **Endoplasmic Reticulum (ER):** Endoplasmic Reticulum is a single-layered organelle

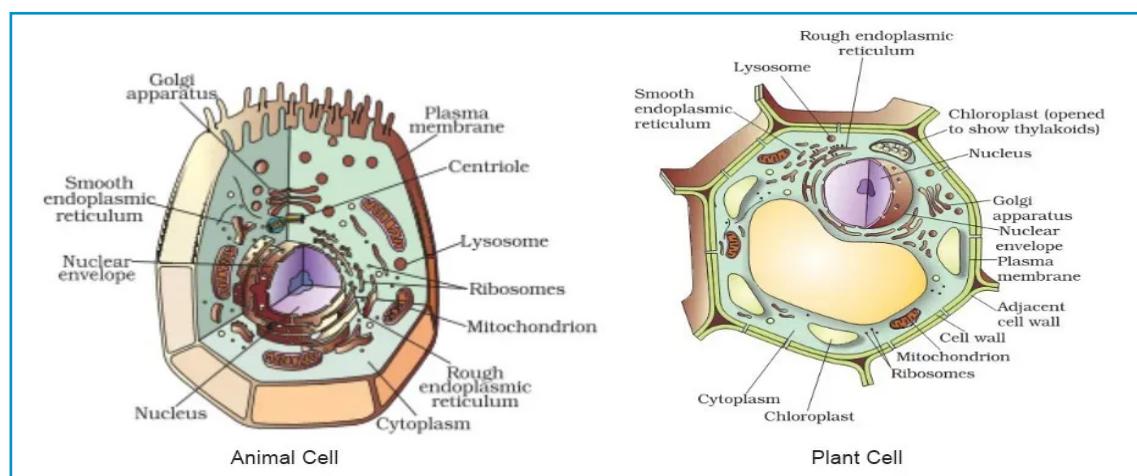


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- It is like a maze (or tube or sac-like structure) surrounding the nucleus that connects with the nuclear membrane and runs throughout the cytoplasm.
- The **rough endoplasmic reticulum** (rough ER) gets its name from the bumpy ribosomes attached to its surface.
- Smooth Endoplasmic Reticulum (Smooth ER)** plays a key role in the synthesis of lipids (fatty compounds), phospholipids, and steroids (Eg; testosterone, estrogen, progesterone). It helps in the detoxification of drugs and poisons in liver cells.

### Golgi Bodies:

- Golgi bodies originate from the **Endoplasmic Reticulum (ER)**.
- Its functions include the packing and transportation of protein. It can modify proteins into different enzymes (e.g. lysosomes).



### Lysosomes:

- Lysosomes originate from the **Golgi bodies**.
- They contain **powerful digestive enzymes** capable of breaking down cellular components, which is why they are often referred to as the “**suicidal bags**” of the cell.
- Lysosomes do **not** destroy healthy cells; instead, they target old, infected, or dying cells.
- The highest concentration of lysosomes is found in white blood cells.

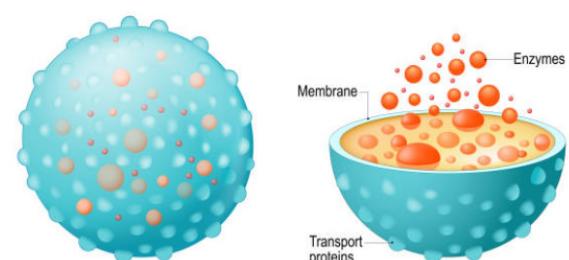
### Centrosomes:

- It is responsible for **cell division**.
- It divides chromosomes or genetic material inside the cell.
- Centrioles are **cylindrical** in shape, and they play a vital role in cell division.

### Vacuole:

- They are empty structures found in the **cytoplasm**.
- They serve as **storage sacs** for solid and liquid contents, such as proteins, sugars, and waste products.
- In plant cells, vacuoles occupy up to **90%** of the cell's volume.

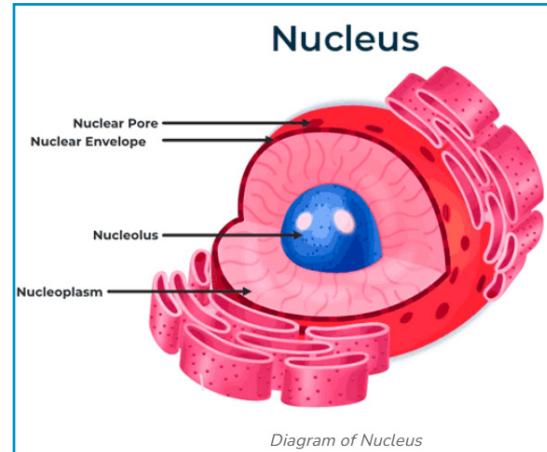
### LYSOSOME



- In animal cells, vacuoles are present but are much smaller in size.

#### Nucleus:

- The nucleus is known as the control center or the brain of the cell.
- It is enclosed by a double membrane called the nuclear membrane.
- Inside the nucleus is a fluid called nucleoplasm.
- The nucleolus is also located within the nucleus.
- The nucleolus was first described in the early 1830s as a "nucleus within the nucleus," with the name "nucleolus" coined by the German physiologist Gabriel Gustav Valentin.
- In humans, chromosomes become visible during cell division. Humans have 23 pairs (46 total) of chromosomes.
- Nucleolus helps in the production of ribosomes.
- Cells can not be seen with open eyes.
- The largest cell is of the Ostrich's egg.



**Nucleus**

Diagram of Nucleus



Space for Notes

- Functions of a Nucleus:** It contains genetic material.

- Chromosomes:** The nucleus contains thread-like structures called chromosomes. Chromosomes are attached to the histones that provide structural support for a chromosome. It is only visible during cell division.
- A complex genetic material found inside the nucleus is called chromatin, also referred to as the chromatin network or chromatin complex.
- Histone Protein:** It is a non-genetic material and is common among humans. They provide structural support or stability of DNA. Histone proteins help in packaging DNA.

#### Deoxyribonucleic Acid (DNA):

- DNA is in a double helical structure and is the genetic material of the cell.
- This is the genetic material, and all the genetic information is written on it. Every human has 99.9 percent of the same DNA structure. The rest 0.01 percent differ. This difference makes every human different from one another.

#### Gene:

- Gene is the functional segment/unit of DNA. This tells us that not all parts of DNA are functional.
- Polygenic Inheritance:** Normally, one gene determines one trait/character/phenotype. However, sometimes a single character can be determined by multiple sets of genes. This is known as the polygenic effect. Example: Colour of our skin.
- There are approximately 30,000 genes in one cell.
- It carries instructions for making proteins or RNA.
- Genes are located on chromosomes in the cell nucleus.



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- Genes are inherited from parents and passed to offspring.

### Genome:

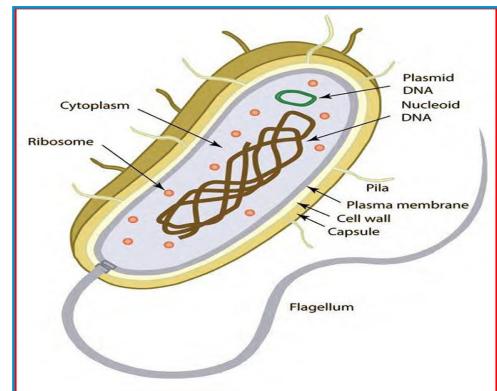
- It is the **complete set** of an organism's genetic material.
- It includes all the **genes** and **non-coding DNA**.
- The genome is found in the cell's **nucleus**.
- It is made up of **DNA** in humans and **RNA** in some viruses.
- The genome carries all the information needed for growth and development.
- It is **inherited** from both parents and passed to offspring.
- The genome is organized into **chromosomes**.
- Variations in the genome contribute to individual differences.

### Types of Cells:

- Prokaryotic Cells:** Prokaryotic Cells are the simplest type of cells. They do not have a nucleus or other organelles. They are found in bacteria and archaea.
- Eukaryotic Cells:** Eukaryotic Cells are more complex than prokaryotic cells. They have a nucleus and other organelles, such as mitochondria and chloroplasts. Eukaryotic cells are found in plants, animals, fungi, and protists.

### Prokaryotic Cells have the Following Features:

- They do not have a nucleus.
- Their DNA is not enclosed in a membrane.
- They have a **single circular chromosome**.
- They have ribosomes, but they are **not bound** to the endoplasmic reticulum.
- They do not have mitochondria or chloroplasts.
- Examples:** Bacterial cells (Amoeba, Paramecium)



### Extra Edge:

#### The Structure of a Bacterial Cell:

- Cell membrane:** The cell membrane is a thin, flexible layer that surrounds the cell. It controls what enters and leaves the cell.
- Cytoplasm:** The cytoplasm is the jelly-like substance inside the cell. It contains all of the cell's organelles, as well as the cell's DNA.
- Nucleoid:** The nucleoid is the region of the cytoplasm where the cell's DNA is located. It is not enclosed by a membrane, like the nucleus of a eukaryotic cell.
- Ribosomes:** Ribosomes are tiny organelles that make proteins. They are found in the cytoplasm and in the endoplasmic reticulum.
- Plasmid:** A plasmid is a small, circular piece of DNA that is not part of the cell's main chromosome. Plasmids can carry genes that code for different traits, such as antibiotic resistance.
- Flagellum:** A flagellum is a long, whip-like structure that helps the cell to move.
- Pili:** Pili are short, hair-like structures that help the cell to attach to other cells or surfaces.

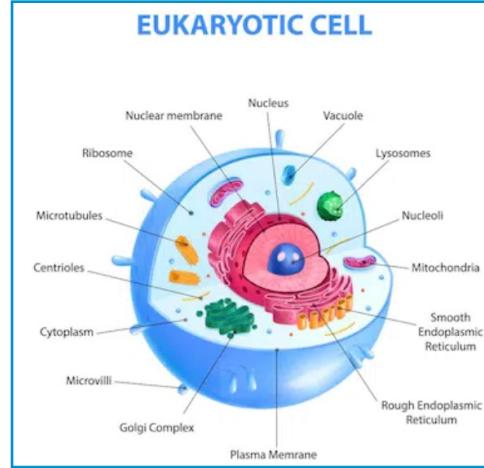
### Eukaryotic Cells have the Following Features:

- They have a nucleus.
- Their DNA is enclosed in a membrane.
- They have multiple linear chromosomes.
- Their ribosomes are bound to the endoplasmic reticulum.
- They have mitochondria and chloroplasts.
- Examples: Cells of multicellular organisms. (Animal cells, plant cells, fungus, protozoan)

### Plant and Animal Cells:

Both plant and animal cells have:

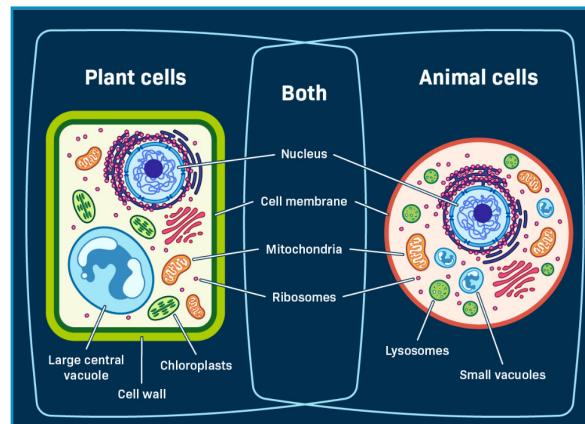
- **Cell Membrane (Plasma Membrane):** Controls the movement of substances in and out of the cell.
- **Nucleus:** Contains genetic material and controls cell activities.
- **Cytoplasm:** A jelly-like substance where cellular processes occur.
- **Cell Wall (Plant Cells):** It is only found in plant cells. It is a rigid layer that protects the plant from difficult weather conditions.



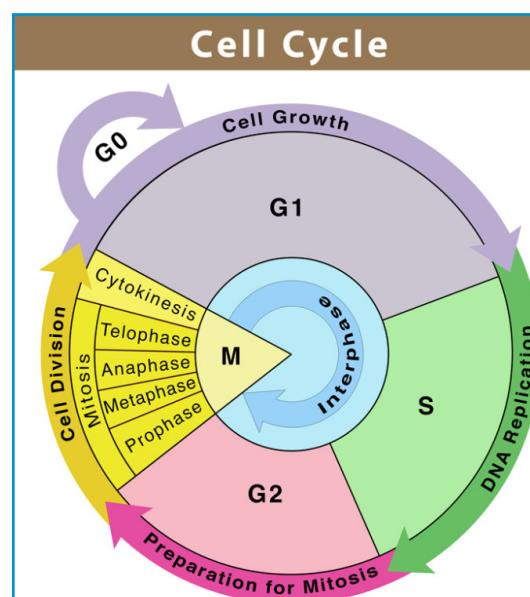
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### The Cell Cycle:

The cell cycle is a cyclical process that cells go through to grow and divide. The cell cycle has four main phases: G1, S, G2, and M.



- **G1:** This is the first gap phase, where the cell grows and prepares for DNA replication. During this phase, the cell increases in size and synthesizes proteins and RNA.
- **S:** This is the synthesis phase, where the DNA is replicated. During this phase, the cell duplicates its DNA so that each daughter cell will have a complete set of chromosomes.
- **G2:** This is the second gap phase, where the cell prepares for mitosis. During this phase, the cell synthesizes more proteins and RNA and makes sure that the DNA has been replicated correctly.
- **M:** This is the mitotic phase, where the cell divides into two daughter cells. During this phase, the chromosomes condense, the nuclear membrane breaks down, and the





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**mitotic spindle forms.** The mitotic spindle is a structure that helps to separate the chromosomes during mitosis. The chromosomes then separate and move to opposite poles of the cell, and the cell divides into two daughter cells.

### Cell Division:

- **Mitosis:**

- It is a type of cell division that results in two identical daughter cells.
- The number of chromosomes remains the same in the daughter cells as in the parent cell.
- It is used for the growth and repair of the body.

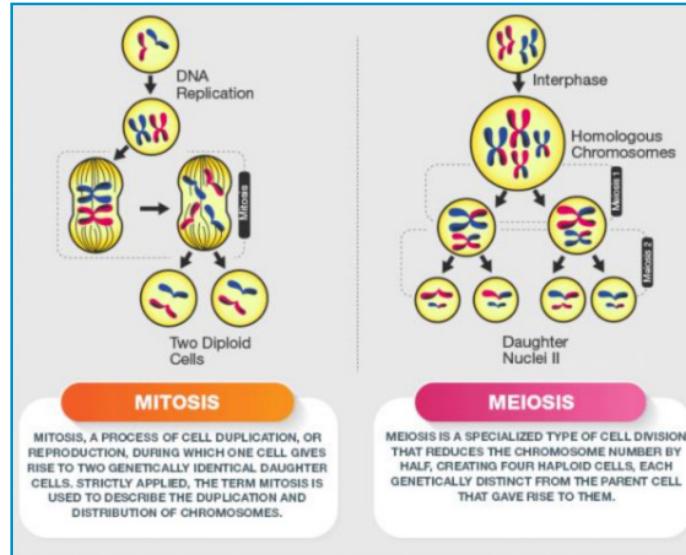
- **Meiosis:**

- It is a type of cell division that results in four daughter cells.
- The number of chromosomes is reduced by half in the daughter cells compared to the parent cell.
- It is used for the production of gametes (sex cells).

#### Mitosis Division:

- Nuclear division is the process by which the nucleus of the cell divides into two daughter nuclei. This happens in the **m phase of mitosis**, which is the stage where the chromosomes are duplicated and the cell prepares to divide.
- The **chromosomes are duplicated** in the first stage of mitosis, called **prophase**. In this stage, the chromosomes condense and become visible. The nuclear membrane breaks down and the nucleolus disappears.
- In the second stage, called the **metaphase**, the chromosomes line up in the middle of the cell. In this stage, the chromosomes line up in the middle of the cell.
- In the third stage, called the **anaphase**, the chromosomes separate and move to opposite poles of the cell. In this stage, the chromosomes are separated and move to opposite poles of the cell.
- In the fourth and final stage, called the **telophase**, the nuclear envelope reforms around each set of chromosomes, and the cell divides into two new cells. In this stage, the nuclear membrane reforms and the nucleolus reappears. The cell then divides into two daughter cells.

#### Mitosis vs Meiosis



Mitosis	Meiosis
Provides a 'repair and maintenance' service to old and damaged body cells.	It plays a crucial role in germ cell production.



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Mitosis occurs in <b>somatic cells</b> ; this means that it takes place in <b>all types of cells</b> that are not involved in the production of gametes.	Meiosis contains two <b>separate cell divisions</b> , meaning that one parent cell can produce <b>four gametes</b> (eggs in females, sperm in males). In each round of division, cells go through four stages: prophase, metaphase, anaphase, and telophase.
Mitosis is called <b>equational division</b> because the number of chromosomes in daughter cells remains equal to parent cells.	Meiosis is called <b>reductional division</b> because the number of chromosomes in daughter cells is <b>reduced to half that of the parent cells</b> .
Mitosis produces <b>diploid cells</b>	Meiosis produces a <b>haploid cell</b>
Mitosis is the type of cell division by which a <b>single cell divides</b> .	<b>Two divisions</b> , meiosis I and meiosis II, are required to produce gametes

### The Process of Cell Division in a Human Cell:

- Human cells have **46 chromosomes**, which are made up of **DNA**. Meiosis is a type of cell division that **produces gametes**, or sex cells. In meiosis, the number of chromosomes is **reduced by half**, so each gamete has **23 chromosomes**. This is because a human cell has **23 pairs of chromosomes**, for a total of **46 chromosomes**. In meiosis, each chromosome pair separates, so each gamete **only gets one chromosome from each pair**.
- Male cells produce **sperm cells**, which are the male gametes. Female cells produce **egg cells**, which are the female gametes. When a sperm cell fertilizes an egg cell, the two gametes fuse together to form a zygote. **The zygote has 46 chromosomes, the same number of chromosomes as a human cell**. This is because the sperm cell and egg cell each contributed 23 chromosomes to the zygote.
- Cell division is used to repair cells that have been damaged or injured. **For example**, if a person gets a cut, the cells in the cut area will divide to repair the damage. This process is called a **Rep cell**.

### Somatic Cells and Gamete Cells: Two Main Types of Human Cells

#### Somatic Cells

- Somatic cells make up all the **tissues and organs** in the human body.
- Each somatic cell contains **46 chromosomes**, arranged in **23 pairs**.
- These chromosomes are made of **DNA**, the genetic material that determines a person's traits.
- The process of division in somatic cells is called **mitosis**, which results in **two identical daughter cells**.
- Functions:
  - Growth and repair of the body
  - Involvement in metabolism, immunity, and other vital processes

#### Gamete Cells

- Gamete cells are the **reproductive cells**: **sperm** in males and **egg** in females.



### Space for Notes

- Each gamete contains **23 chromosomes** (haploid number).
- During **fertilization**, the sperm and egg fuse to form a **zygote** with 46 chromosomes—restoring the diploid number.
- The formation of gametes occurs through **meiosis**, a specialized type of cell division.
  - Meiosis produces **four daughter cells**, each with **23 chromosomes**.
  - This ensures **genetic diversity** in offspring.



## UPSC PRELIMS PYQ:

1. Which of the following statements are correct regarding the general difference between plant and animal cells? (2020)

1. Plant cells have cellulose cell walls whilst animal cells do not.
2. Plant cells do not have plasma membranes, unlike animal cells which do.
3. A mature plant cell has one large vacuole whilst an animal cell has many small vacuoles.

Select the correct answer using the code given below:

- |                  |                  |
|------------------|------------------|
| (a) 1 and 2 only | (b) 2 and 3 only |
| (c) 1 and 3 only | (d) 1, 2 and 3   |

Ans: (c)

2. Which of the following cell organelles plays the most significant role in protein synthesis?

(2001)

- (a) Lysosome and Centrosome

- (b) Endoplasmic Reticulum and Ribosome
- (c) Golgi apparatus and Mitochondria
- (d) Lysosome and Mitochondria

Ans: B

3. Match List I (Physiological processes) with List II (Cell organelles) and select the correct answer by using the codes given below the lists. (1996)

List I	List II
1. Photosynthesis	A. Plasma membrane
2. Mineral uptake	B. Chloroplast
3. Respiration	C. Mitochondria
4. Protein Synthesis	D. Ribosomes
(a) I-A, II-B, III-C, IV-D	
(b) I-A, II-B, III-D, IV-C	
(c) I-B, II-A, III-C, IV-D	
(d) I-B, II-A, III-D, IV-C	

Ans: (c)

