Chapter 5: The Fundamental Unit of Life – Detailed Notes

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1. Introduction

All living things around us – whether tiny microorganisms or big animals and plants – are made up of very small units called cells. Just like a building is made of bricks, the body of every living organism is made of cells.

The discovery of the cell was first made by Robert Hooke in 1665 when he observed thin slices of cork under a microscope. Since then, scientists have found that cells are present in all living organisms and are the basic structural and functional units of life.

Cells are important because they carry out all the processes that keep an organism alive – such as growth, respiration, reproduction, and excretion. Each cell has its own shape and size depending on the work it does. For example, a nerve cell is long to carry messages, while a red blood cell is round and helps in carrying oxygen.

Scientists Schleiden and Schwann explained through the Cell Theory that all living beings are made up of cells, and later Rudolf Virchow added that* new cells come only from pre-existing cells*.

Thus, by studying cells, we understand how our body works, how life continues, and how even the smallest units combine to form complete living beings.

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2. Types of Organisms (based on cell number)

1. Unicellular Organisms:

- ***These are organisms made up of only one cell.***
- ***A single cell performs all the vital life functions like respiration, digestion, excretion, and reproduction.***
- ***Examples: Amoeba, Paramecium, Bacteria, Chlamydomonas.***

- *Interesting fact: In Amoeba, one cell can change its shape to move and capture food.*

2. Multicellular Organisms:

- *These organisms are made up of many cells.*
- *Different cells in their body perform different specialized functions (division of labour).*

- *For example:*
  - *Muscle cells help in movement.*
  - *Nerve cells carry messages.*
  - *Blood cells transport oxygen.*

- *Examples: Humans, Mango tree, Dog, Fish.*

- *Interesting fact: The human body has around 37 trillion cells!*

🔑 *Key Difference*

- *Unicellular organisms = One cell does everything.*
- *Multicellular organisms = Many cells share the work.*

1. Prokaryotic Cells

- *“Pro” means primitive, “karyon” means nucleus.*
- *These are the primitive type of cells where a true nucleus is absent.*
- *The genetic material (DNA) is present, but it is not enclosed within a nuclear membrane.*
- *They also lack membrane-bound cell organelles like mitochondria, plastids, Golgi apparatus, etc.*
- *Example organisms: Bacteria, Blue-green algae (Cyanobacteria), Mycoplasma.*

👉 *Key features:*

- *Small in size (1–10 µm).*
- *Simple structure.*
- *Nucleoid (DNA floating in cytoplasm).*
- *Only ribosomes are present as organelles.*

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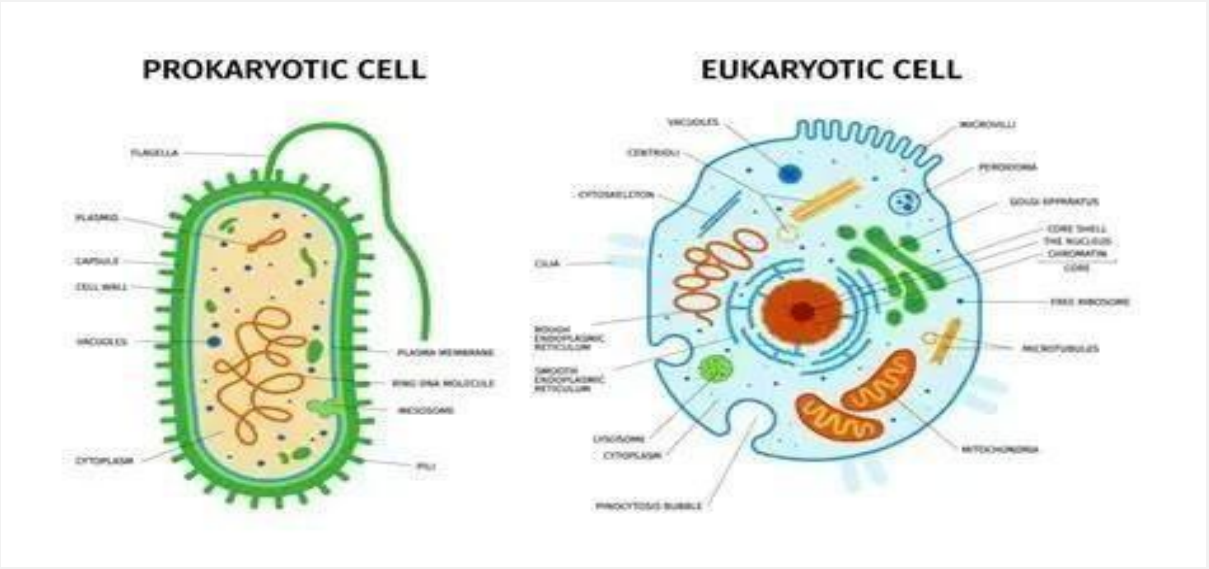
2. Eukaryotic Cells

- ***"Eu" means true, "karyon" means nucleus.***
- ***These are well-organized cells with a true nucleus.***
- ***The genetic material (DNA) is enclosed inside a nuclear membrane.***
- ***They contain membrane-bound cell organelles such as mitochondria, chloroplasts, Golgi bodies, lysosomes, etc.***
- ***Example organisms: Plants, Animals, Fungi, Protists.***

👉 ***Key features:***

- ***Larger in size (10–100 µm).***
- ***Complex structure.***
- ***True nucleus with nuclear membrane.***
- ***Many specialized organelles.***

3. Prokaryotic vs Eukaryotic Cells



Feature	Prokaryotic cells	Eukaryotic cells
Nucleus	No true nucleus (DNA in nucleoid)	True nucleus with nuclear membrane
Cell Size	Small (1–10 µm)	Larger (10–100 µm)
Structure	Simple	Complex

Organelles	**No membrane-bound organelles**	**Membrane-bound organelles present**
DNA	**Circular, without histone proteins**	**Linear, associated with histone proteins**
Feature	**Prokaryotic cells**	**Eukaryotic cells**
Ribosomes	**70S type (smaller)**	**80S type (larger)**

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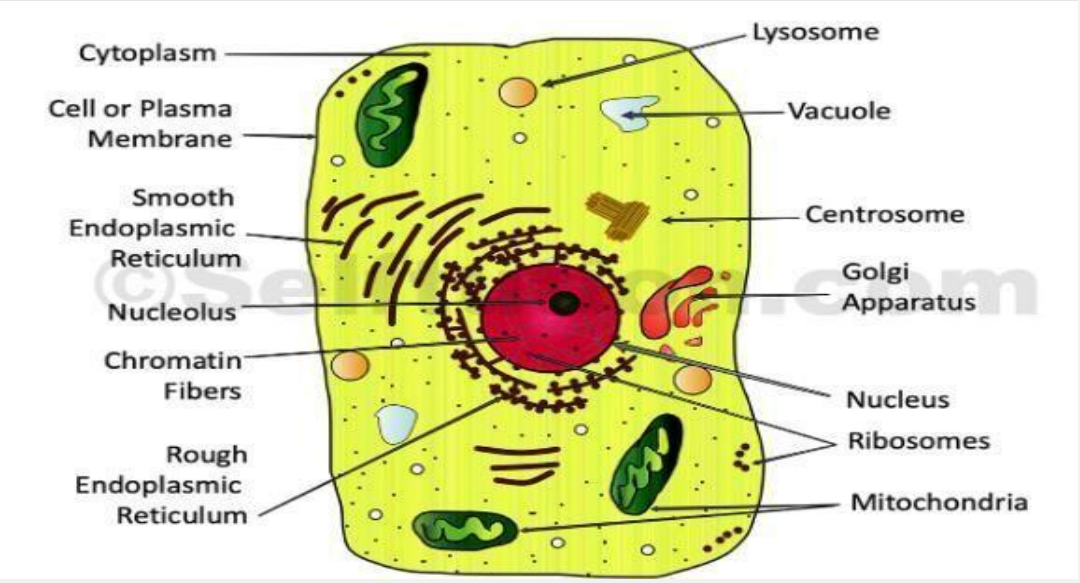
4. Structure of a General Cell

A general cell has three main parts – cell boundary, cytoplasm, and nucleus. These together make the cell a living and functional unit.



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1. Cell Boundary

(a) Cell Wall (only in plant cells)

- ***A thick, rigid outer covering made of cellulose.***
- ***It is absent in animal cells.***

- ***Functions:*** ○ ***Provides definite shape and strength to the cell.*** ○ ***Protects the cell against mechanical injury.*** ○ ***Allows free movement of water and gases (freely permeable).***
  ○ ***Maintains turgidity in plants (stiffness due to water inside the cell).***

(b) Plasma Membrane (Cell Membrane)

- *A thin, flexible layer present in both plant and animal cells, just inside the cell wall (in plants) or as the outermost covering (in animals).*
- *Made up of lipids and proteins.*

- *Functions:*
  - *Acts as a selectively permeable membrane – only certain substances can pass in and out (e.g., oxygen, carbon dioxide, water).*
  - *Maintains a balance of materials inside the cell.* ○ *Helps in communication and recognition with other cells.*

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2. Cytoplasm

- *A semi-fluid, jelly-like substance present inside the cell membrane.*
- *Made mainly of water, salts, sugars, proteins, and other organic molecules.*
- *It holds the cell's contents and provides a medium for all the biochemical reactions of life.*

- *Functions:*
  - *Acts as the site of chemical activities like respiration, synthesis of molecules, and breakdown of wastes.* ○ *Provides support to the internal parts of the cell.* ○ *Helps in movement of materials inside the cell.*

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3. Nucleus

- *Usually the largest part of the cell, often spherical.*
- *Surrounded by a double nuclear membrane with pores that allow exchange of materials.*
- *Contains chromatin – thread-like material made of DNA and proteins, which carries hereditary information.*
- *Inside the nucleus, a nucleolus is present, which makes ribosomes.*

- *Functions:*
  - *Controls all cell activities like growth, division, and metabolism.* ○ *Stores and passes on hereditary information (DNA).* ○ *Helps in protein synthesis by directing ribosomes.* ○ *Regulates cell division.*

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4. Plant Cell vs Animal Cell (Basic Structural Difference)

- ***Plant cells have both a cell wall and plasma membrane, while animal cells have only plasma membrane.***
- ***Plant cells usually contain a large central vacuole, while animal cells have small or no vacuoles.***
- ***Nucleus in both controls activities, but in plants it is often pushed to the side by the vacuole.***

***In short**: The structure of a general cell consists of the protective boundaries (cell wall and plasma membrane), the living fluid (cytoplasm), and the control centre (nucleus). These parts together make the cell capable of survival and functioning as the fundamental unit of life.*

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5. Cell Organelles and their Functions

Cells are like tiny factories, and each organelle is a specialized worker performing specific jobs. Understanding organelles helps us see how life works at the cellular level.

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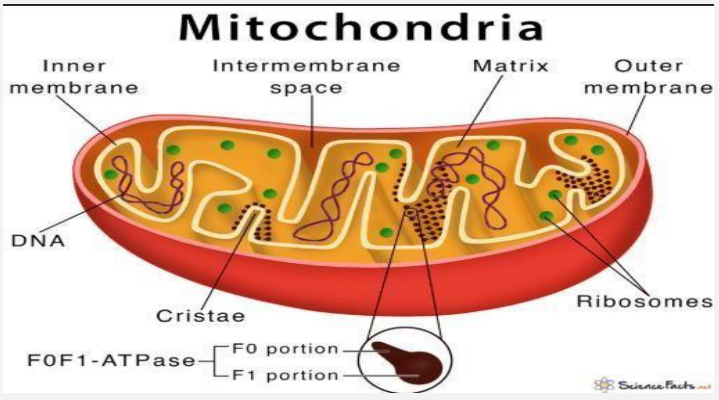
1. Mitochondria – The Powerhouse of the Cell

- ***Structure: Oval or rod-shaped, with double membrane. The inner membrane is folded into cristae.***
- ***Functions:***
    - ***Produces energy in the form of ATP through cellular respiration.***
    - ***Provides energy for growth, movement, and all life processes.***

Interesting Fact: Cells that need more energy (like muscle cells) have more mitochondria.



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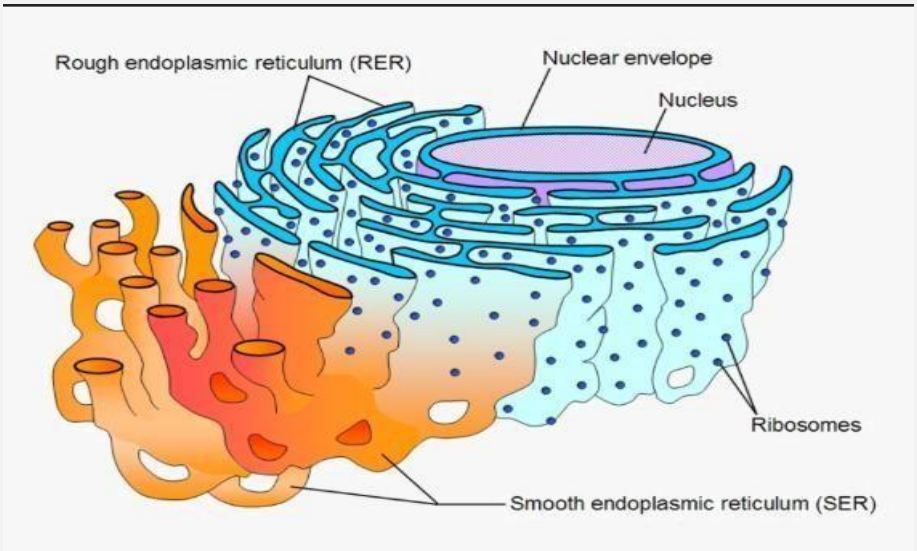
3. Endoplasmic Reticulum (ER) – The Transport Network

- ***Structure: Network of membranous tubules and sacs.***

- ***Types and Functions:***
  1. ***Rough ER (RER):***
     - ***Has ribosomes attached.***
     - ***Makes proteins and sends them to Golgi for packaging.***
  2. ***Smooth ER (SER):***
     - ***No ribosomes.***
     - ***Synthesizes fats, lipids, and steroids, and detoxifies harmful substances.***
- ***Analogy: ER is like a factory highway, moving products where needed.***



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4. Golgi Apparatus – The Packaging Center

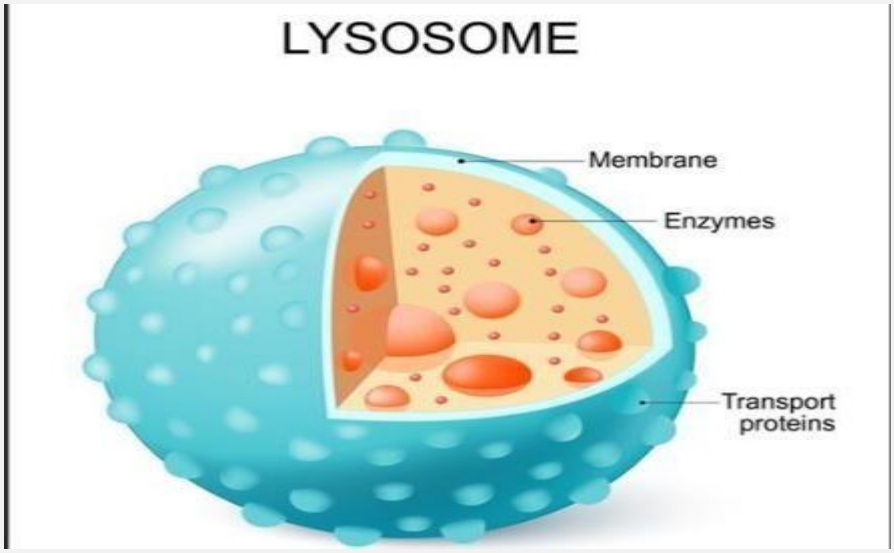
- ***Structure: Stack of flattened membrane sacs.***
- ***Functions:***
  - ***Modifies proteins and lipids received from ER. ○ Packages them into vesicles for transport inside or outside the cell.***
  - ***Forms lysosomes and secretory vesicles.***
- ***Analogy: Golgi is like a post office or packaging unit in a factory.***

5. Ribosomes – Protein Factories

- ***Structure: Tiny, round structures, free in cytoplasm or attached to RER.***
- ***Functions:***
  - ***Synthesizes proteins which are needed for cell structure, enzymes, and hormones.***
- ***Interesting Fact: Ribosomes are found in all cells (both prokaryotic and eukaryotic).***

6. Lysosomes – The Recycling Bags

- ***Structure: Small, spherical sacs containing digestive enzymes.***
- ***Functions:***
  - ***Breaks down food, waste, damaged organelles, and harmful microbes.*** ***Sometimes called the "suicidal bag" because they can digest the whole cell if needed.***
- ***Interesting Fact: Lysosomes keep the cell clean and healthy.***



7. Plastids – Energy and Color Centers (Only in Plants)

- ***Structure: Double-membrane organelles found in plant cells.***
- ***Types and Functions:***
  1. ***Chloroplasts: Contain chlorophyll, carry out photosynthesis (make food using sunlight).***
  2. ***Chromoplasts: Contain pigments like red, orange, yellow; give color to fruits and flowers.***
  3. ***Leucoplasts: Colorless; store starch, oils, or proteins.***

- *Interesting Fact: Chloroplasts can also move inside cells to capture sunlight efficiently.*

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8. Vacuoles – Storage Chambers

- *Structure: Membrane-bound sacs; large in plants, small in animals.*
- *Functions:*
  - *Stores water, food, pigments, or waste products.*
  - *In plants, maintain turgor pressure, which keeps the plant upright.*
- *Interesting Fact: Vacuoles can act as a storage tank and waste dump at the same time.*

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8. Cytoskeleton – The Cell's Skeleton and Highway

- *Structure: Network of protein filaments (microtubules, microfilaments).*
- *Functions:*
  - *Maintains cell shape and structure.*
  - *Helps in movement of organelles and cell division.*
- *Analogy: Cytoskeleton is like the scaffolding and conveyor belt of a factory.*

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9. Nucleus – The Control Center

- *Already covered in the previous topic, but remember:*
  - *Controls cell activities.* ○ *Contains DNA for heredity.*
  - *Directs synthesis of proteins.*

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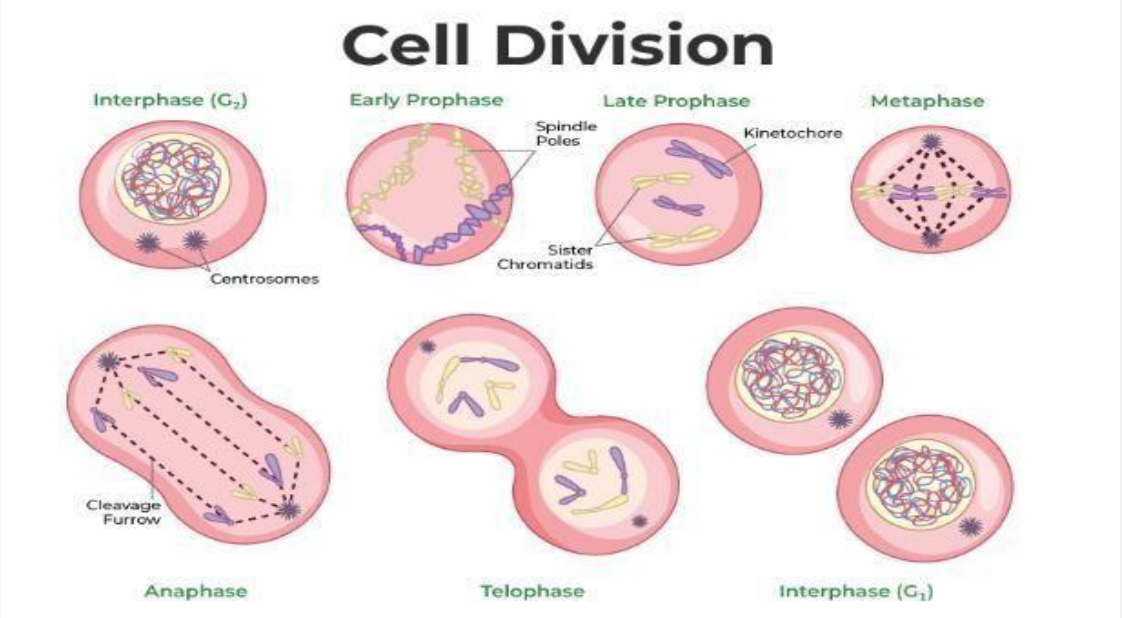
6. Cell Division

Cell division is the process by which a parent cell divides to form new cells. It is essential for growth, repair, and reproduction in all living organisms.



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1. Why Cells Divide

Cells divide for several reasons:

1. ***Growth: To increase the size of the organism (e.g., a child growing into an adult).***
2. ***Repair and Replacement: To replace damaged or dead cells (e.g., skin or blood cells).***
3. ***Reproduction:***
    - ***Asexual reproduction in unicellular organisms (e.g., Amoeba, Bacteria).***
    - ***Sexual reproduction in multicellular organisms (formation of gametes).***

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2. Types of Cell Division

(A) Mitosis – Division for Growth and Repair

- ***Definition: Mitosis is the type of cell division in which a single cell divides to form two identical daughter cells, each with the same number of chromosomes as the parent cell.***
- ***Where it occurs: In somatic (body) cells of plants and animals.***
- ***Purpose:***

- ***Growth of tissues and organs.***
- ***Repair of damaged cells.***
- ***Replacement of worn-out cells.***

- ***Stages of Mitosis:***

1. ***Prophase: Chromosomes condense and become visible. Nuclear membrane begins to disappear.***
2. ***Metaphase: Chromosomes line up at the cell's equator.***
3. ***Anaphase: Chromatids of each chromosome separate and move to opposite poles.***
4. ***Telophase: Nuclear membrane reforms around the chromosomes. Cytoplasm divides (cytokinesis), forming two identical cells.***

- ***Outcome: Two genetically identical daughter cells, same chromosome number as parent.***

(B) Meiosis – Division for Reproduction

- ***Definition: Meiosis is the type of cell division in which a single cell divides twice to produce four daughter cells, each with half the number of chromosomes of the parent cell.***
- ***Where it occurs: In sex cells (gametes) – sperm and egg in animals, pollen and ovule in plants.***
- ***Purpose:***
  - ***Reduces chromosome number by half so that after fertilization, the offspring has the correct chromosome number.***
  - ***Introduces genetic variation through recombination.***
- ***Stages:***
  - ***Two divisions: Meiosis I and Meiosis II, each with phases similar to mitosis.***
- ***Outcome: Four genetically different daughter cells, each with half the chromosomes of the parent.***

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3. Binary Fission (in Unicellular Organisms)

- ***Definition: A simple type of cell division in unicellular organisms like Amoeba or Bacteria.***
- ***Process:***
    1. ***The cell grows.***
    2. ***DNA replicates.***
    3. ***The cell splits into two identical daughter cells.***
- ***Purpose: A form of asexual reproduction.***

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4. Importance of Cell Division

- ***Growth: Increases the size of the organism.***
- ***Repair: Heals wounds and replaces damaged cells.***
- ***Reproduction: Helps unicellular organisms multiply; produces gametes in multicellular organisms.***
- ***Genetic Stability: Ensures daughter cells inherit the correct number of chromosomes.***

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7. Summary Table

Component	*Structure*	*Function*
Plasma membrane	*Lipid bilayer*	*Controls entry/exit*
Cell wall	*Cellulose*	*Protection & shape*
Nucleus	*Double membrane*	*Control center*

Mitochondria	*Double membrane, cristae*	*ATP production*
Chloroplast	*Double membrane, chlorophyll*	*Photosynthesis*
RER	*Ribosomes present*	*Protein synthesis*
SER	*No ribosomes*	*Lipid synthesis*
Golgi apparatus	*Flattened sacs*	*Packaging & transport*
Lysosome	*Enzyme sacs*	*Digestion*
Ribosomes	*RNA & protein*	*Protein synthesis*
Vacuole	*Membrane sac*	*Storage*
Centrosome	*Centrioles*	*Cell division*