Category/ Organelle/Structure	Eukaryotes	Prokaryotes
Definition	Cells with membrane-bound organelles	Cells lacking membrane-bound organelles
Examples	Animals, plants, fungi	Bacteria, archaea
Nucleus	Exists, contains genetic material (DNA)	Doesn't have a true nucleus; DNA is free-floating in the cytoplasm or nucleoid region
Mitochondria	Exists, site of cellular respiration	Absent
Endoplasmic Reticulum	Exists, rough ER for protein synthesis	Absent or less structured
Golgi Apparatus	Exists, involved in packaging and sorting of proteins	Absent or less structured
Lysosomes	Exists, contains digestive enzymes	Rare or absent
Peroxisomes	Exists, involved in lipid metabolism and detoxification	Present but simpler in structure
Chloroplasts	Present in plant cells, site of photosynthesis	Absent
Ribosomes	Present (larger, 80S in cytoplasm and 70S in mitochondria and chloroplasts)	Present (smaller, 70S)
Vacuoles	Present, storage, and transport functions	Rare or absent
Centrioles	Present in animal cells, role in cell division	Absent
Cell Wall	Present in some (plants, fungi) for support	Present in some (bacteria) for protection
Flagella	Present (complex, composed of microtubules)	Present (simpler, composed of flagellin)
Cilia	Present (complex, shorter and numerous)	Absent
Plasma Membrane	Lipid bilayer with proteins and carbohydrates	Similar structure but lacks membrane-bound organelles

Category/ Organelle/Structure	Eukaryotes	Prokaryotes
Capsule	Absent	Present in some bacteria, protection and adherence
Nucleoid	Absent	Region where genetic material is concentrated
Plasmids	Present in some, small circular DNA	Present in some, small circular DNA
Magnetosomes	Absent	Present in some bacteria, help in magnetotaxis
Endospores	Absent	Present in some bacteria, survival structure
Pili	Absent or less common	Present in some, used for adherence and conjugation
Gas Vesicles	Absent	Present in some, aid in buoyancy

Feature	Muscle Cells	Nerve Cells
Shape	Long and cylindrical	Long and slender with many branches
Function	Contract and expand to help the organism move	Carry messages throughout the body
Example	Muscle fibers in the biceps	Neurons in the brain

discoveries of the scientists who unraveled the mysteries of cells:

- **Robert Hooke**: In 1665, Robert Hooke, an English scientist, is credited with discovering the cell. He used a simple microscope to examine cork tissue and observed tiny compartments that he called "cells."
- **Anton van Leeuwenhoek**: A Dutch scientist named Anton van Leeuwenhoek is recognized as the first person to observe living cells. Around 1674, he constructed a powerful microscope that enabled him to visualize microorganisms, including bacteria and blood cells.
- **Matthias Jakob Schleiden**: A German botanist named Matthias Jakob Schleiden is known for his work on plant cells. In 1838, he concluded that all plants are composed of cells, a significant contribution to the cell theory.
- **Theodor Schwann**: A German physiologist named Theodor Schwann is famous for his work on animal cells. In 1839, he proposed that all animal tissues are composed of cells, further solidifying the cell theory.
- **Rudolf Virchow**: A German pathologist named Rudolf Virchow made a groundbreaking discovery in 1855. He asserted that new cells can only arise from pre-existing cells, a concept known as "omnis cellula e cellula."

Plasma Membrane: The Barrier and Gatekeeper of Cells

Existence

The plasma membrane, also known as the cell membrane, surrounds the cytoplasm of plant and animal cells.

Function

The plasma membrane performs two crucial functions:

1. **Regulates the passage of materials into and out of the cell:** The plasma membrane acts as a selective barrier, allowing only certain substances to pass through while preventing others from entering or exiting the cell. This selective permeability is essential for maintaining the cell's internal environment and ensuring its survival.
2. **Prevents the spread of protoplasm outside the cell:** The plasma membrane acts as a protective barrier, enclosing the cell's contents and preventing them from leaking out. This containment is crucial for maintaining the cell's integrity and structure.

Structure

The plasma membrane is a complex structure composed of three main components:

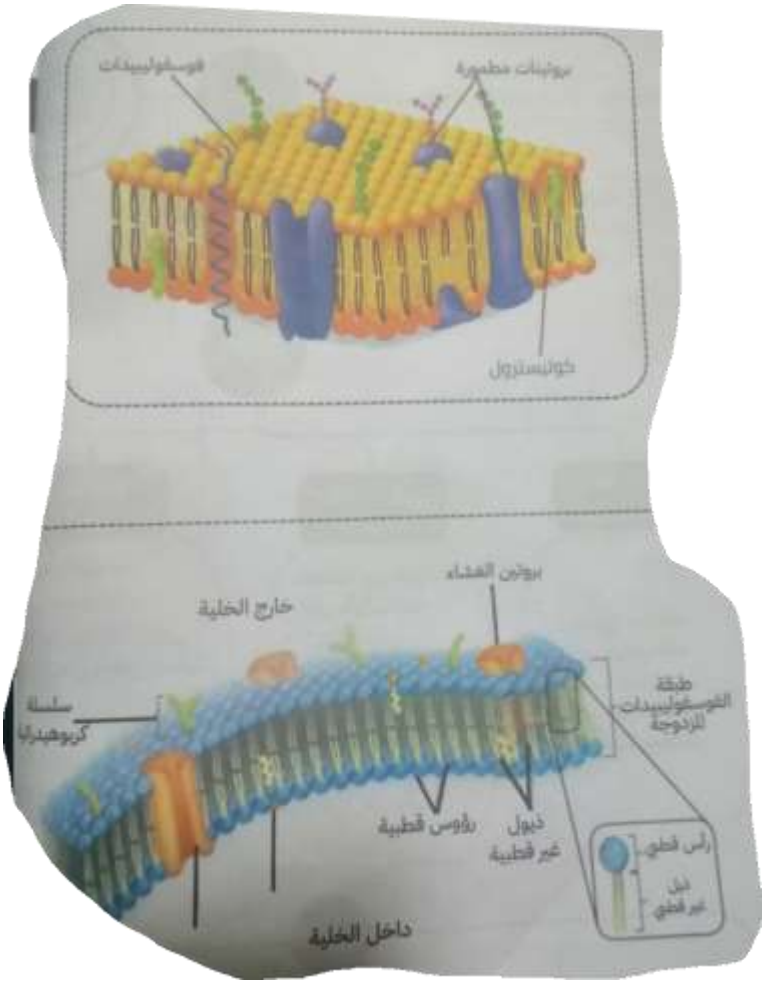
1. **Phospholipid bilayer:** The foundation of the plasma membrane is a double layer of phospholipid molecules. Phospholipids are amphipathic molecules, meaning they have both hydrophilic (water-loving) heads and hydrophobic (water-fearing) tails. In the bilayer, the hydrophilic heads face outwards, interacting with the aqueous environment inside and outside the cell, while the hydrophobic tails face inwards, forming a nonpolar barrier.
2. **Embedded proteins:** Interspersed within the phospholipid bilayer are various types of proteins. These proteins serve diverse functions, including:
    - **Transport proteins:** These proteins act as channels or pumps, facilitating the movement of specific molecules across the membrane.
    - **Receptor proteins:** These proteins bind to specific signaling molecules, allowing the cell to detect and respond to external stimuli.
    - **Enzymatic proteins:** These proteins catalyze biochemical reactions that occur on the membrane surface.
3. **Cholesterol:** Cholesterol molecules are embedded within the phospholipid bilayer, adding stability and fluidity to the membrane. Cholesterol helps maintain the membrane's structure and prevents it from becoming too rigid or too fluid.

Hydrophilic and Hydrophobic Regions

The phospholipid bilayer creates a distinct separation between the aqueous environment inside and outside the cell. The hydrophilic heads of the phospholipids interact with water molecules, while the hydrophobic tails form a nonpolar barrier that restricts the passage of water-soluble molecules. This separation is crucial for maintaining the cell's internal environment and regulating the movement of substances across the membrane.

Note

The plasma membrane is a dynamic structure that resembles a layer of oil on water due to the movement of phospholipid molecules within the bilayer. This fluidity allows for the movement of proteins and other membrane components, facilitating various cellular functions.



Protoplasm

Is the living part of a cell that is surrounded by a plasma membrane, it’s a mixure of small molecules, amino acids, proteins, etc.

The Endoplasmic Reticulum

Structure

The endoplasmic reticulum (ER) is a system of interconnected membranous sacs and tubules that is found in the cytoplasm of all eukaryotic cells. It is a major site for protein synthesis, lipid synthesis, and carbohydrate metabolism.

The ER is divided into two main types: rough endoplasmic reticulum (RER) and smooth endoplasmic reticulum (SER).

- **Rough endoplasmic reticulum (RER)** is covered with ribosomes, which are the organelles that synthesize proteins. The ribosomes bind to the ER membrane and synthesize proteins that are destined for secretion from the cell or for insertion into the cell membrane.
- **Smooth endoplasmic reticulum (SER)** does not have ribosomes attached to it. It is involved in lipid synthesis, carbohydrate metabolism, and detoxification.

Function

The ER performs a variety of functions, including:

- **Protein synthesis**: The RER is the site of protein synthesis for many proteins that are destined for secretion from the cell or for insertion into the cell membrane.
- **Lipid synthesis**: The SER is involved in the synthesis of lipids, including triglycerides, phospholipids, and cholesterol.
- **Carbohydrate metabolism**: The ER is involved in the metabolism of carbohydrates, including the breakdown of glucose for energy and the synthesis of glycogen for storage.
- **Detoxification**: The SER is involved in the detoxification of harmful substances, such as drugs and toxins.

Translation

The Arabic terms in the image are as follows:

- شبكة اندوبلازميه خشنه: Rough endoplasmic reticulum
- شبكة اندوبلازميه ملساء: Smooth endoplasmic reticulum
- غشاء نووي: Nuclear membrane
- كرماتين: Chromatin
- نويه: Nucleus

- ثقب نووي: Nuclear pore

Chromosomes

Chromosomes are a group of molecules that contain genetic information. They are responsible for the inheritance of traits, such as body shape, color, and sexuality. Chromosomes are also responsible for the formation of proteins and other molecules. Proteins are made up of amino acids, which are responsible for the synthesis of proteins and other molecules.

The structure of chromosomes:

Chromosomes are made up of two strands, called chromatids. The chromatids are joined together at a central region called the centromere. Each chromatid is made up of DNA (deoxyribonucleic acid), which is a molecule that contains the genetic code.

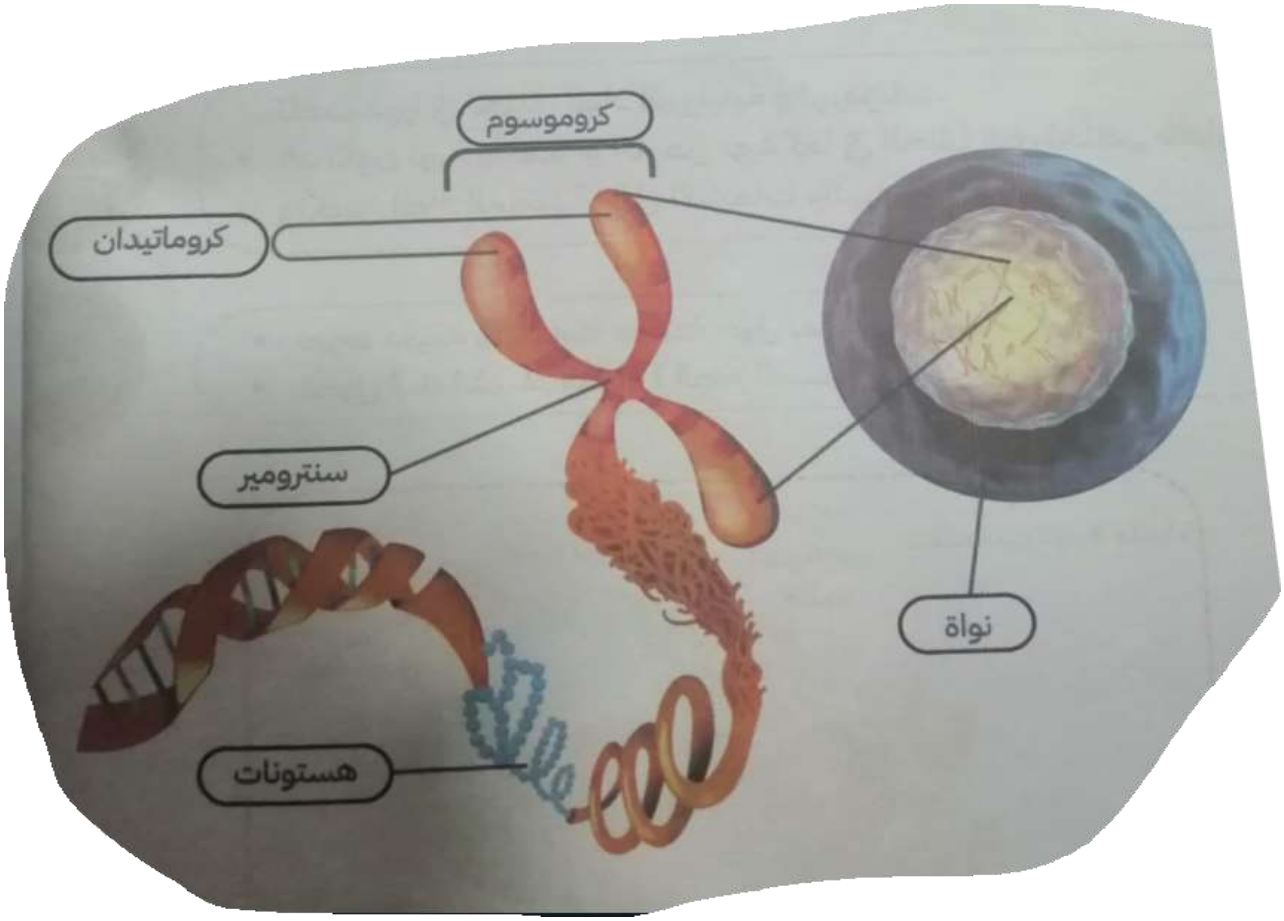
Function of chromosomes:

Chromosomes play a vital role in cell division. During cell division, the chromosomes replicate and then separate into two identical sets. One set of chromosomes goes to each daughter cell. This ensures that each daughter cell has a complete set of genetic information.

Translation of the text near the drawings:

- الكروموسومات chromosomes: Chromosomes

- النواة nucleus: Nucleus
- الهستونات histones: Histones
- الشبكه الخلويه endoplasmic reticulum: Endoplasmic reticulum
- الريبوسوم ribosome: Ribosome
- الكروماتيد chromatid: Chromatid
- السنتمير centromere: Centromere
- الغشاء النووي nuclear membrane: Nuclear membrane
- غلاف الخلية cell membrane: Cell membrane



Cell Wall

Surrounds plant cells, algae, fungi, and some bacteria. Does not surround animal cells.

Location:

Protects, supports, and gives the cell a specific shape. Allows water and dissolved substances to pass through it easily because it is perforated.

Composition:

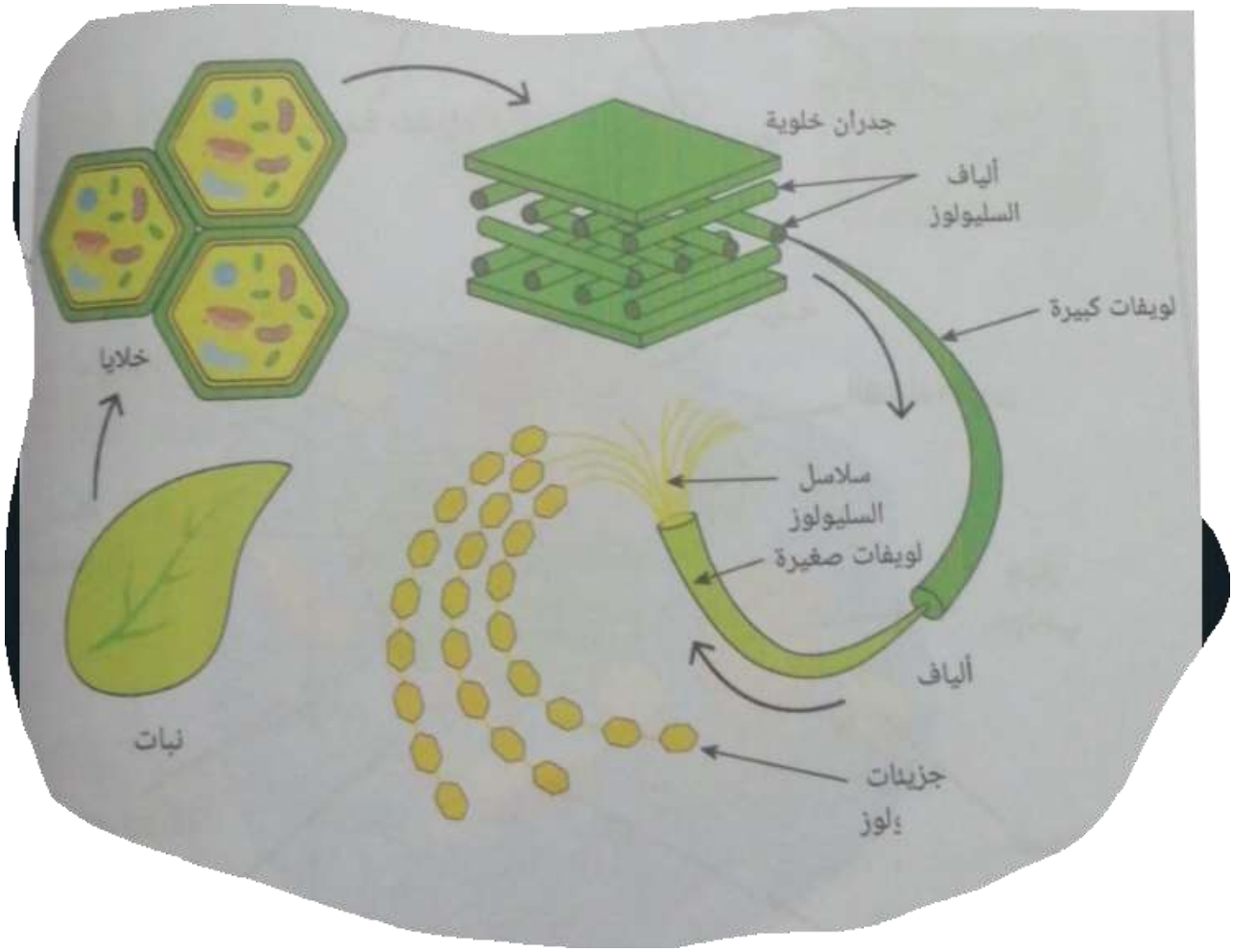
Composed mainly of cellulose fibers.

Types of cell walls:

- **Primary cell walls**: Thin, flexible walls that allow for cell growth.
- **Secondary cell walls**: Thick, rigid walls that are added after the cell has stopped growing.
- **Lignified cell walls**: Secondary cell walls that have been strengthened with lignin, a substance that makes them very hard and strong.

Drawing:

- Large vacuoles.
- Cell walls.
- Cellulose fibers.
- Middle lamella.
- Plasmodesmata.
- Cell membranes.



Cytoplasm

Location:

Fills the space between the cell membrane and the nucleus.

Composition:

A semi-liquid substance made up mostly of water and some organic and inorganic molecules.

Contents:

- **Cytoskeleton**: A network of fine threads and tubes that:
    - Provide the cell with support to help maintain its shape and consistency.
    - Act as tracks for the movement of various substances from one place to another inside the cell.

- **Cell organelles:**
    - **Membrane-bound organelles**: Enclosed by a membrane.
        - Endoplasmic reticulum
        - Golgi apparatus
        - Mitochondria
        - Plastids
        - Vacuoles
        - Lysosomes
    - **Non-membrane-bound organelles**: Not enclosed by a membrane.
        - Ribosomes
        - Centrioles

Organelles with no membrane

Ribosomes

Description:

Round, non-membranous organelles.

Function:

Synthesize proteins in the cell.

Location:

On the outer surface of the rough endoplasmic reticulum (bound ribosomes)

Freely suspended in the cytoplasm (free ribosomes)

Number:

Few bound ribosomes

More numerous than free ribosomes in the cytoplasm

Arrangement:

Exist as single units or in groups

Produce proteins that are transported by the endoplasmic reticulum to the outside of the cell after undergoing some modifications in the Golgi apparatus.

Produce proteins and release them directly into the cytoplasm to be used by the cell in vital processes such as growth, renewal, and others.

The central body / centrosome

Found in

Animal cells (except nerve cells and some fungal cells) near the nucleus.

Not found in plant cells, algae, and most fungi. In these cells, its function is performed by a region of the cytoplasm called the microtubule organizing center (MTOC).

Structure

Composed of two centrioles, which are tiny cylindrical organelles.

Each centriole is made up of nine groups of microtubules arranged in triplets.

Function:

1. Plays an important role during cell division, where spindle fibers extend between the centrioles located at each pole of the cell, pulling the chromosomes towards the poles of the cell, which helps in cell division.
2. Plays an important role in the formation of flagella and cilia, which are means of locomotion in some unicellular organisms.

Spindle Fibers

Centrioles:

Microtubule organizing centers that play a role in cell division.

Microtubules:

Long, hollow fibers made of tubulin proteins that play a role in cell structure, movement, and division.

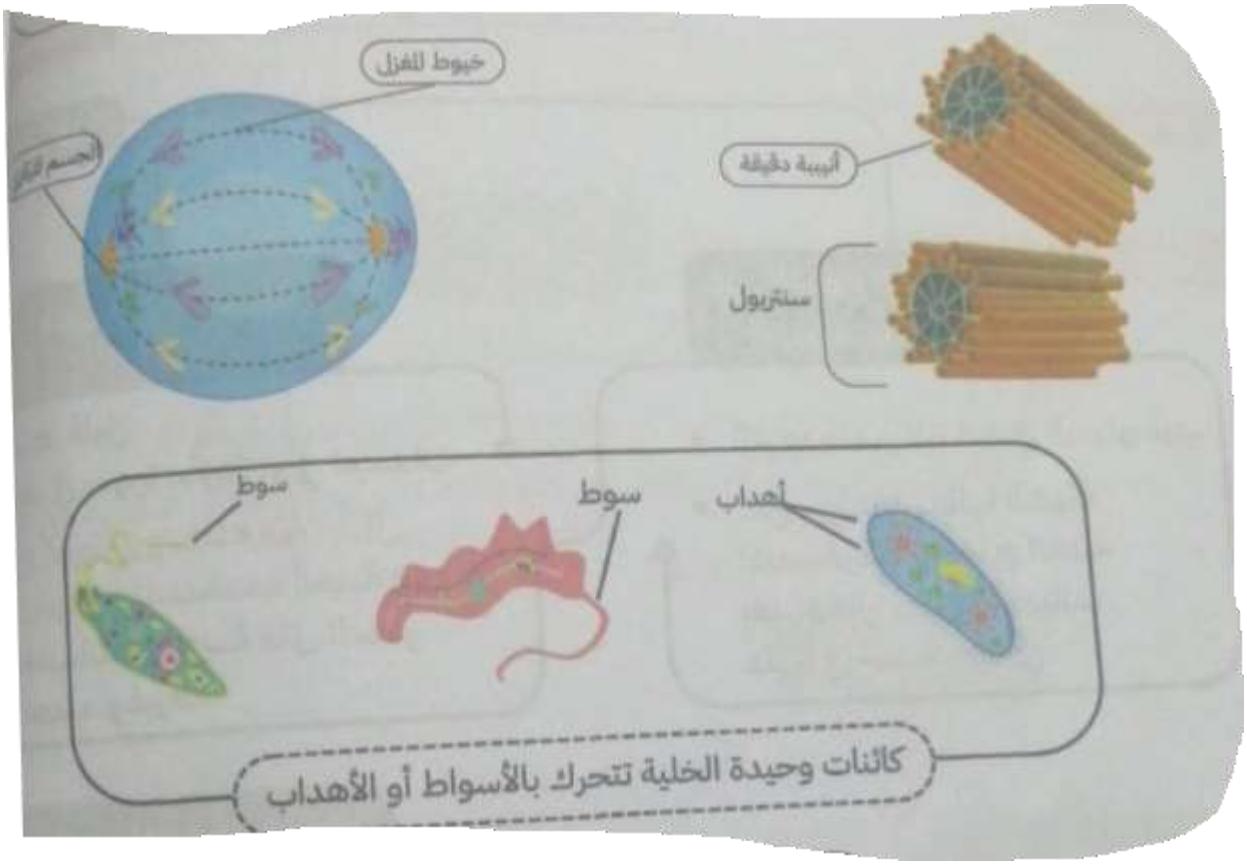
Cilia and Flagella:

Hair-like organelles that project from the cell surface and are used for locomotion in some unicellular organisms.

Unicellular organisms that move using flagella or cilia:

- Euglena
- Paramecium

- Sperm cells



Organelles with membrane

Endoplasmic reticulum

Definition

it's a web of membrane tubes

Location

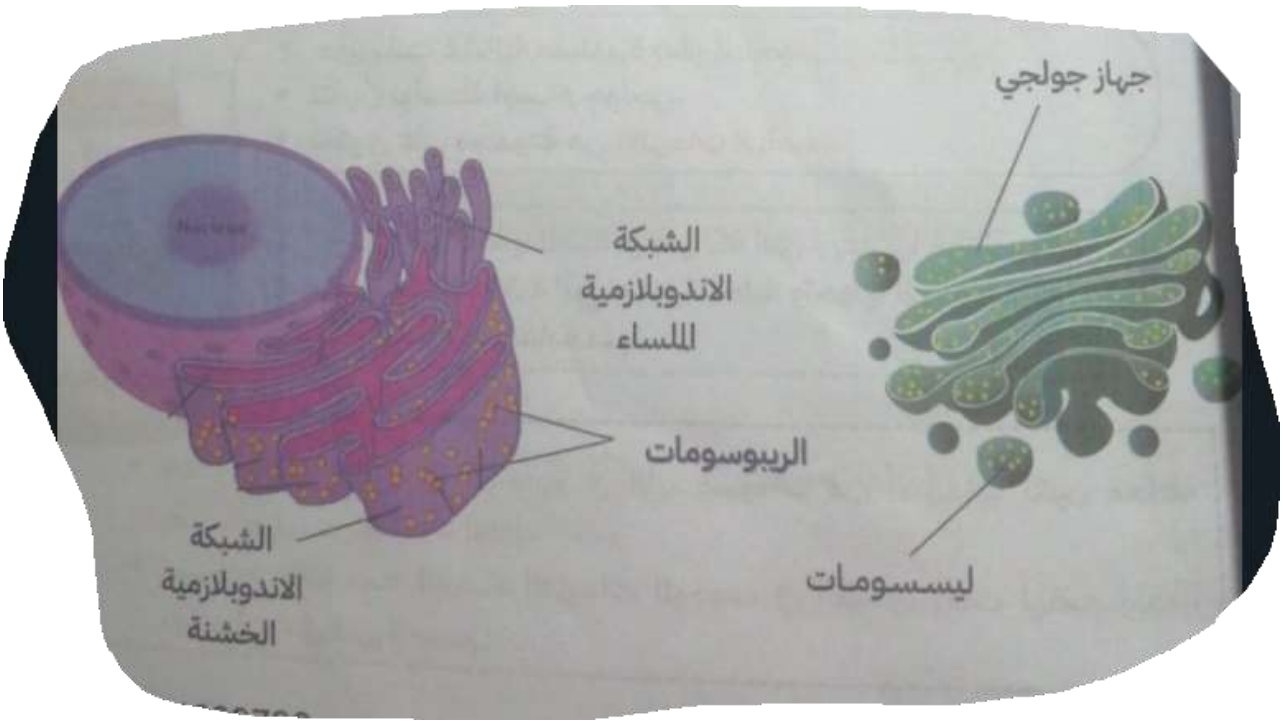
it exists everywhere in the cytoplasm, and it is connected to the nuclear membrane and cell membrane

Job

It's the cell's transport system

- It delivers stuff from a part to another
- It delivers stuff between the cytoplasm and the nucelus

Feature	Smooth ER	Rough ER
Ribosomes	No	Yes
Function	Synthesis of lipids, metabolism of carbohydrates and xenobiotics, secretion of steroids, detoxification of drugs	Synthesis and processing of proteins
Location	All cells	Mostly in cells that produce large amounts of proteins, such as liver cells, pancreas cells, and goblet cells in the intestine
Examples	Liver cells, muscle cells, adrenal cortex cells	Pancreas cells, goblet cells in the intestine, plasma cells



Golgi Apparatus

Description

A group of flattened, round-edged membrane sacs.

Name

It is named after the scientist Camillo Golgi who discovered it in 1898. In plants, it is called the dictyosome.

Number

Its number in the cell varies depending on the secretory activity of the cell, where it is more abundant in cells that secrete proteins (such as endocrine glands).

Function

It plays a role in the formation of cell secretions by:

1. Receiving molecules secreted by the endoplasmic reticulum through a group of transport vesicles.
2. Sorting these substances and making some modifications to them.
3. Distributing these substances in the cell to their sites of use or packaging them into secretory vesicles called lysosomes, which head towards the cell membrane.
4. Expelling them from the cell as secretory products.

Lysosome

Description

Small, round membrane vesicles formed by the Golgi apparatus.

Function

They contain a group of digestive enzymes.

1. They get rid of old or damaged cells that are no longer useful.
2. They digest the nutrients that the cell swallows and convert them into simpler substances that the cell can use.

Lysosomes are important for a variety of cellular processes, including:

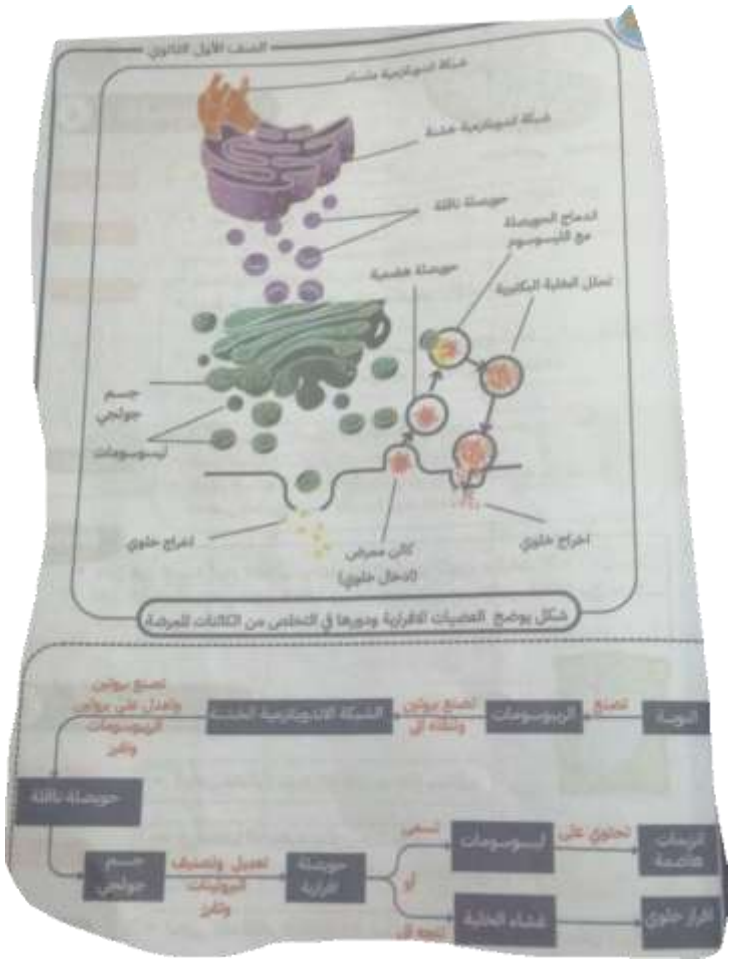
- Cell turnover: Lysosomes help to remove old or damaged cells, which is essential for cell renewal.
- Nutrient digestion: Lysosomes break down nutrients that the cell has engulfed into simpler substances that can be used by the cell.
- Defense against infection: Lysosomes also play a role in defending the cell against infection. When a pathogen enters the cell, it can be trapped in a lysosome and digested by the enzymes inside.

How digestion happen

Lysosomes

Lysosomes are small, round vesicles that contain digestive enzymes. They are formed by the Golgi apparatus. Lysosomes play a variety of roles in the cell, including:

- Breaking down old or **damaged cells**: Lysosomes help to remove old or damaged cells from the body. This is important for cell turnover, which is the process of replacing old cells with new cells.
- **Digesting nutrients**: Lysosomes can also digest nutrients that the cell has engulfed. This is important for the cell to obtain the nutrients it needs to survive.
- **Defense against infection**: Lysosomes can also play a role in defending the cell against infection. When a pathogen enters the cell, it can be trapped in a lysosome and digested by the enzymes inside.



Phagosomes

Phagosomes are vesicles that form around pathogens that are engulfed by the cell. They are formed by the plasma membrane. Phagosomes play a role in the elimination of pathogens by delivering them to lysosomes for digestion.

Granules

Granules are vesicles that contain antimicrobial proteins and peptides. These proteins and peptides can kill pathogens by disrupting their membranes, damaging their DNA, or interfering with their metabolism. Granules are released from the cell by exocytosis.

Mitochondria

Description:

- Found in all types of cells, and are more numerous in muscle cells due to the increased energy production required by muscles.

Structure:

- Surrounded by an inner and outer membrane.
- The inner membrane has folds called cristae that extend into the matrix.

Function:

- The cristae increase the surface area of the inner membrane, where the chemical reactions that produce energy take place.
- Mitochondria are the cell's powerhouses, responsible for energy production.
- They contain the enzymes necessary for cellular respiration, the process by which food is oxidized to produce energy.
- They also act as a reservoir for the materials needed to store the energy produced from cellular respiration.
- The oxidation of food, especially glucose, produces ATP (adenosine triphosphate) molecules, which store energy that the cell can use later.

Translation of the text near the drawings:

- Outer membrane
- Inner membrane
- Cristae

Vacoule

Description:

- Membrane-bound sacs filled with fluid.
- Found in both plant and animal cells.
- Can be small and numerous, or large and single.

Function:

- Store water and nutrients.
- Maintain cell turgor (pressure).
- Remove waste products.
- Help with plant growth and development.

Translation of the text near the drawings:

- Vacuole membrane
- Vacuolar fluid
- Tonoplast

Chloroplasts

Description:

- Organelles found in plant cells that contain chlorophyll, the green pigment that allows plants to photosynthesize.
- Have a double membrane, with an inner membrane that contains folds called grana.
- The stroma is the fluid-filled space inside the chloroplast.

Function:

- Convert sunlight into energy in the form of ATP and NADPH (nicotinamide adenine dinucleotide phosphate) through photosynthesis.
- Produce oxygen as a byproduct of photosynthesis.
- Also involved in other cellular processes, such as nitrogen fixation and starch storage.

Translation of the text near the drawings:

- Outer membrane
- Inner membrane

- Grana
- Stroma

Type of Chloroplast	Color	Chlorophyll	Carotenoid Pigments	Function	Location
Leukoplasts	White or colorless	Yes	No	Store starch	Green leaves and stems of plants
Chloroplasts	Green	Yes	No	Produce food through photosynthesis	Green leaves of plants
Chromoplasts	Yellow, orange, or red	No	Yes	Give fruits and vegetables their colors	Fruits, vegetables, and flowers

Feature	Light Microscope	Electron Microscope
Operating principle	Uses visible light to illuminate the specimen and magnify the image through a series of glass lenses.	Uses a beam of electrons to create an image of the specimen. Electrons are focused by electromagnetic fields instead of glass lenses.
Type of lenses	Glass lenses with varying focal lengths to achieve different magnifications.	Electromagnetic fields that act as lenses to focus the electron beam.
Maximum magnification	Up to 1500x It depends on • The quality of the lenses • You can zoom in with magnification = the product of lenses	Up to 1,000,000x or more It depends on • The electron laser wavelength being small compared to the light laser • It's printed on a flouride screen
Resolution	Limited by the wavelength of visible light, which is about 400-700 nanometers. This means that light microscopes can only resolve objects that are about 0.2 micrometers apart.	Limited by the wavelength of electrons, which is much shorter than the wavelength of visible light. This means that electron microscopes can resolve objects that are only a few nanometers apart.
Image quality	Images are often bright and colorful, but they may lack detail due to the limitations of light diffraction.	Images are black and white, but they are very high-resolution and can show fine details of the specimen.
Applications	Widely used in biology and medicine to study cells, tissues, and microorganisms.	Used to study the structure of materials at the atomic and molecular level.

Tuberculosis (TB)

- It’s an infectious disease caused by the bacterium Mycobacterium tuberculosis. It mainly affects the lungs and is spread through tiny droplets released into the air via coughs and sneezes.

- **What It does to cells**

TB bacteria enter the lungs and are ingested by white blood cells called macrophages. The bacteria can remain inactive inside the body (latent infection) or become active, causing symptoms.

- **Transmitting**

TB is extremely infectious and can be passed through a cough, sneeze, or even talking with an infected person.

- **How to detect**

A positive skin or blood test for TB along with a normal chest X-ray indicates a latent infection. Active infection leads to symptoms like appetite and weight loss, coughing, night sweats, fever, fatigue, and chills.

Prevention and Treatment

- There is a vaccine available to prevent TB, but its effectiveness is limited. Antibiotics like isoniazid and rifampin are used to treat TB. They are usually

prescribed in combinations of two to four different drugs.

Challenges

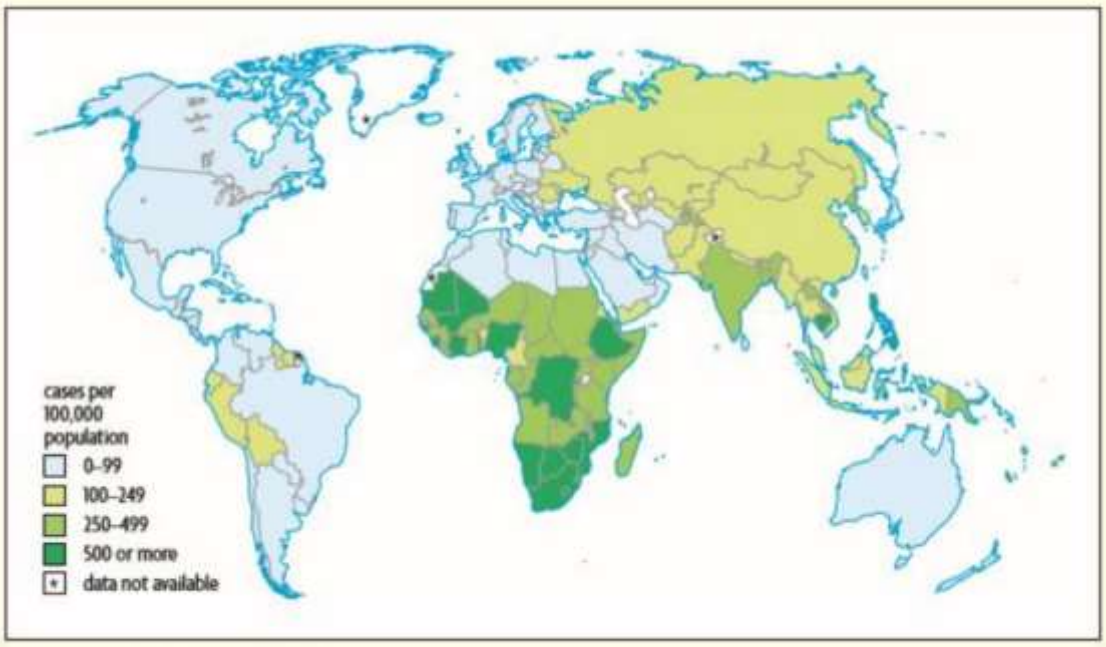
- Many strains of TB resist the drugs most used to treat the disease. Multidrug-resistant TB is particularly challenging to treat.
- Co-infection with HIV/AIDS significantly increases the risk of developing active TB due to a weakened immune system.
- Ensuring patients complete their full course of treatment is crucial to prevent antibiotic resistance.

Cure Research

- Scientists are working on developing new treatments for TB, especially in areas where Mycobacterium tuberculosis has become resistant to available drugs.

Statistics

- At least one-forth of the human population worldwide is estimated to be infected with TB bacteria.

- 

Global distribution of tuberculosis cases