

Biology: The study of life (living things).

Living things are composed of units called cells.

Unicellular organism: A one-celled organism.
Ex: paramecium, bacteria, amoeba

Multicellular organism: Organisms with more than one cell.
Ex: cat, dog, worm, human

Cell Theory

(First stated in 1858)

Contains four Statements:

1. All living organisms are composed of one or more cells.
2. Cells are the basic unit of structure and function in all organisms.
3. All cells are derived from pre-existing cells.
4. In a multicellular organism, the activity of the entire organism depends on the total activity of its independent cells.

HISTORICAL DEVELOPMENT OF CELL THEORY

Spontaneous generation → Idea that living things come from non living sources

Ex: maggots appear on meat if left out too long
After it rains — frogs
Insects and plants seem to come out of mud in ponds.

Aristotle (334 BC) → Put forward the idea of spontaneous generation.
He classified all organisms as plants or animals.

Thomas Henry Huxley (1870) → Used the term **abiogenesis** to describe the concept of spontaneous generation.

Francesco Redi (1668) → Challenged the idea of spontaneous generation.
Helped proposed the idea known as **biogenesis** – Life comes from Life.

- Did the First controlled experiment.
- He hypothesized that if maggots come from fly eggs, then maggots will appear only in open jars where flies can deposit eggs on meat. When testing, he placed some meat samples in covered jars and some in uncovered jars. He found that maggots appeared only in uncovered containers. He tested many times and obtained the same results even with different meats.

Leeuwenhoek (1675) → discovers and invents the simple microscope.

- Using his microscope, he sees microorganisms.

John Needham (1748) → performed an experiment similar to Redi's.

- He boiled a meat broth (to kill microbes); sealed one container (not airtight --- sterile) and left another open.
- The result was microbes were present. This supported spontaneous generation.

Spallanzani (1776) → repeated Needham's experiment.

- He boiled the containers for one hour; then, sealed the flasks tightly.
- No microbes were present.
- The microbes appeared hours after the seals were broken.
- He believed that microorganisms were carried in air and multiplies when they had a food supply.

Pasteur (1861) → repeated Spallanzani's work.

- He used S - shaped necked flasks (heat flask and bend into an S-shaped curve) which allowed air and microbes in.
- When he boiled the solution in the base of the flask this created steam which condensed and formed water droplets which trapped microbes in the neck of the flask. The broth remained clear. He broke the necks of the flasks. The broth turned cloudy. Flasks were tipped and the microbes mixed with the broth. The broth turned cloudy. Some of his flasks (on display) are still sterile today.

THE CELL - The basic unit of life

Robert Hooke (1665) → studied slices of cork and saw hollow sacs he called "Cells".

Schleiden (1838) → Cells were present in plant tissue.

Schwann (1839) → Cells were present in animal tissue.

This suggested that all organisms were composed of one or more cells.

Robert Brown (→ Discovered the center of the cell. He called it the ***nucleus***.

Virchow (1858) → Observed dividing cells and concluded that ***cells can arise only from other cells.***

Microscope Development

Leeuwenhoek (1600's)

- Father of Microscopy
- Made the first Simple Microscope (Single Lens)

Charles Spencer (1900's)

- Improves optics in compound microscope.

Knott and Ruska (1930's)

- Invented the Electron Microscope

Types of Microscopes

1. **Light Microscope** → Uses light as a source of illumination for objects.
 - a. Simple Light Microscope -- Microscope composed of only 1 lens.
 - b. Compound Light Microscope – Microscope composed of 2 or more lenses.

2. **Electron Microscope** → Uses Electrons as a source of illumination for objects.
 - a. *TEM* – Transmission Electron Microscope
 - Shoots a beam of electrons through specimen.
 - Produces a 2D micrograph (picture) of a specimen.
 - b. *SEM* – Scanning Electron Microscope
 - Shoots a beam of electrons at the *surface* of a specimen.
 - Produces a 3D micrograph.

Comparison of the light microscope with an electron microscope

Type of Microscope	Source of Illumination	Magnification	Resolution	Specimen Preparation
Light	visible light	up to 2000 x	about 0.2_ m	usually killed, fixed and stained
Electron	electrons	TEM : typically 10 000 x to 500 000 x SEM : typically 1 000 x to 10 000 x	TEM : about 0.2 nm SEM : about 1 to 10 nm	usually killed, dried and fixed fixed, cleaned, and coated with metal

Cells

Cell: Basic Structural Unit of Life.

Types of Cells

Prokaryotic: Cells that **DO NOT** contain a true membrane – bound nucleus;

- DNA is concentrated in an area called the nucleoid.

Ex: all bacterial cells

Eukaryotic: Cells that contain a true membrane – bound nucleus.

- The nucleus is an enclosed region that separates the DNA from the rest of the cell contents.
- Eukaryotes contain a number of specialized structures called organelles.

There are TWO types of Eukaryotic Cells

- a. Animal Cells
- b. Plant Cells

Organelles: Specialized structures within a Eukaryotic cell that carries out a specific function.

Organelles work together to keep cell functioning.

Structures (organelles) found in eukaryotic cells

Organelle name	Description of structure	Description of function	Plant or animal?
nucleus	round; occupies center of cell	control center of the cell	both
mitochondrion	“peanut-shaped” Has 2 membranes	cellular respiration “powerhouse of cell”	both
ribosome	little balls found on ER	protein synthesis	both
Centrioles/ centrosomes	Right angles to each other	Cell division	animal
vacuole	round vesicle (large in plants, small in animals)	storage of food, wastes, water etc.	both
chloroplast	“cucumber-shaped” Contains discs called Thylakoids. Thylakoids are in stacks	photosynthesis	plant

	called Grana		
lysosome	round sac – contains digestive enzymes	digestion	both (limited in plants)
Golgi apparatus	stacked discs – like pancakes	vesicle formation, packages products for shipment to other cells	both
ER - two types Smooth – No ribosomes Rough – has ribosomes	long, thin membranes; thick structure surrounding	transport of materials	both
cell wall	Made of chitin and cellulose	structural support	plant
cytoskeleton	thin, long structures 2 types: Microtubules → Hollow Microfilaments → Solid	skeletal support	
cell membrane	thin lipid bilayer	controls entry/ exit of materials	both
Cytoplasm	Fluid of cell	Site of many reactions.	both

Other Cell Structures/Parts

Chromatin

- Fibers of DNA which coil-up during the early stages of cell division to form the visible chromosomes.
- Found in the Nucleus

Nuclear Envelope

- The double membrane which surrounds the nucleus.
- Contains protein channels called nuclear pores.

Nucleolus

- Small dense structure found inside a nucleus.
- Contains chromatin that creates *ribosomes*.

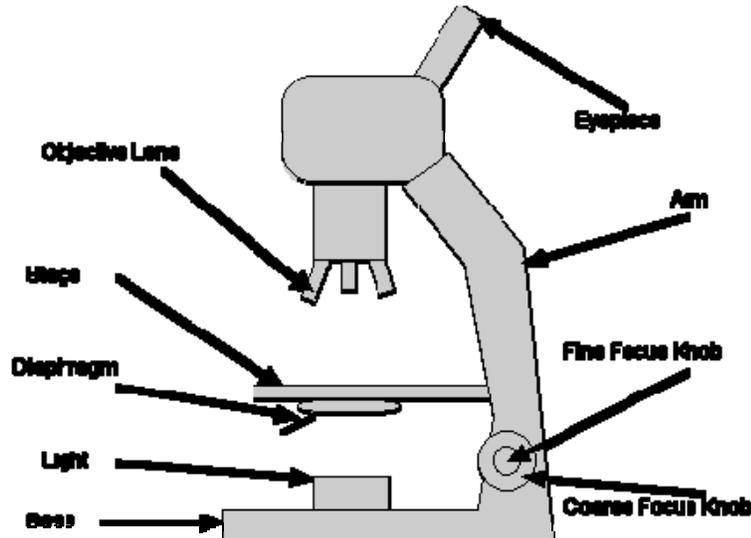
Cilia

- Short hair-like projections from the cell membrane
- Function in producing wave-like motion. Can move the cell or particles around it.

Flagella

- Long hair-like projections from the cell membrane.
 - Function in whip-like motion. Moves the cell.
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Compound Light Microscope Parts and Functions



1. **Eyepiece** The lens you look through. Usually 10x
2. **Arm** Used for carrying the microscope.
3. **Objective Lens** Lens that magnifies the object. Usually three on a typical microscope.
 - i. Low Power – 4x in magnification
 - ii. Medium Power – 10x in magnification
 - iii. High Power – 100x in magnification
4. **Stage** Flat area where slide is placed. Contains a hole in the middle through which light penetrates.
5. **Diaphragm** Flat disc with holes in it just below the stage. Controls the amount of light hitting the object.
6. **Light source** Mirror or electrical light that illuminate the object being viewed.
7. **Base** Bottom of microscope. Provides support for other parts.
8. **Coarse Focus Knob** Knob which brings objects into focus *quickly*. Usually only used on **low** power.
9. **Fine Focus Knob** Knob used for fine focusing of objects. Used on **Medium** and **high** power.

Using a Microscope – Things to Know

a. **Magnification:** The ratio of image size to actual specimen size.

Calculating Magnification – Use the formula below.

$$\text{Magnification} = \text{objective lens} \times \text{eyepiece}$$

Ex: Magnification = 40x (high power) X 10x (eyepiece) = 400x total magnification.

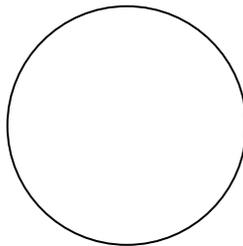
Note: maximum magnification of a light microscope is usually 2000X

b. **Resolving Power:** The ability of a microscope to distinguish between two objects that are close together.

Note: Maximum resolving power of Light microscope = 0.2 μm or 200nm
Maximum resolving power of Electron Microscope = 0.2 nm

Remember: Any light microscope with a resolving power LESS than 0.2 μm you will not see the objects as distinct and separate. They will appear as one object.

c. **Field of View:** The area you see as you look through the eyepiece. The area is round.



Determining the Size of the Field of View

a. **Low Power** → Measure using a mm ruler.

b. **Medium and High Power** → use the formula below

$$F.O.V._{med\ or\ high} = FOV_{low} \times \frac{Mag_{low}}{Mag_{med\ or\ high}}$$

Ex: $FOV_{med} = 5mm \times \frac{40x}{100x}$

$$FOV_{med} = 5mm \times 0.4$$

$$FOV_{med} = 2mm$$

d. **Specimen Size:** The actual size of a specimen. Found by doing a calculation.

$$\text{Specimen size} = \frac{FOV}{\# \text{ specimens fitting across}}$$

e. **Preparing a Wetmount Slide**

- A. Obtain clean slide and coverslip.
 - B. Place specimen in drop of water.
 - C. Place drop of water on slide using a dropper.
 - D. Place coverslip on 45degree angle on one side of drop of water. (*do not touch the water*)
 - E. Move coverslip until it just touches the drop of water.
 - F. Drop coverslip.
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The Cell Membrane

Function: The cell membrane controls what enters and leaves the cell. This is done to maintain *homeostasis*.

- transports raw materials into the cell
- transports created materials and waste out of the cell
- Prevents unwanted material from entering the cell.
- Prevents escape of materials from cell needed for cell functions.

Homeostasis: The process of maintaining a stable internal environment.

Cell Membrane Structure: Described by the *Fluid Mosaic Model*.

Fluid Mosaic Model: A model that describes the cell membrane as being a double layer (*bilayer*) composed of a *phospholipid backbone* with proteins embedded throughout. The layer is flexible and is able to move.

Phospholipid Bilayer: Composed of a Head and Tail section.

Head: Hydrophilic or “water loving” (points to the outside of the cell)

Tail: Hydrophobic or “water hating” (points to the inside of the cell).

Cellular Transport Mechanisms

The cell carries out transport in one of two ways – Passive or Active Transport.

1. **Passive Transport:** Transport of materials without the use of energy.
2. **Active Transport:** Transport of materials with the use of Energy (ATP)

ATP -- Adenosine TriPhosphate. It is the energy molecule of the cell.

3. **Bulk Transport:** Transport of large materials through the cell membrane.

1. Passive Transport

There are **three** types of Passive Transport.

- a) Simple Diffusion
- b) Facilitated Diffusion
- c) Osmosis – *a type of special diffusion*

A. Simple Diffusion

The movement of particles from an area of **high** concentration to an area of **low** concentration along a **concentration gradient**. Movement occurs until particles are scattered evenly.

High Concentration: An area having a large amount of particles.

Low Concentration: An area having a small amount of particles.

Concentration Gradient: The difference between an area with many particles and one with few particles.

Q. What drives Diffusion?

A. Molecules and particles are in constant random motion known as *Brownian Motion*. This motion is what creates a concentration gradient and as such causes particles to move.

Note: Particles such as **Oxygen(O₂)**, **Carbon Dioxide(CO₂)** and **Alcohols** cross the cell membrane by simple diffusion. These particles are small enough to pass right through the membrane.

Factors Affecting the Rate of Diffusion

1. *Temperature* --- the higher the temperature the greater the rate of diffusion.
2. *Size of Molecule* --- the smaller the molecule the faster diffusion occurs.
3. *Size of Concentration Gradient* – the greater the difference between areas with high concentration and areas with low concentration, the faster diffusion occurs.

B. Facilitated Diffusion

Similar to diffusion except, the particles trying to cross the cell membrane are too large, so they are assisted/facilitated by **special proteins** in the cell membrane.

Two types of Proteins in the cell membrane

1. Carrier Protein Facilitated Diffusion –

Diffusion of **NONCHARGED** molecules across the cell membrane.

Ex: Glucose

2. Channel Protein Facilitated Diffusion -

Diffusion of **CHARGED** particles such as **ions** across the cell membrane.

Ex: sodium, Na⁺ ions, K⁺ ions

C. Osmosis

This is the diffusion of **water** across a semipermeable membrane. Water flows from an area of HIGH concentration to an area of LOW concentration.

Types of Membranes

- i) *Permeable* -- a membrane that allows all particles to cross.
- ii) *Semipermeable* – a membrane that allows some particles to cross, but not others.
- iii) *Impermeable* -- a membrane that **does not** allow any particles to cross.

Osmosis and Effects on Cells

Tonicity: The relative concentration of solutes on either side of a membrane. Tonicity of solutions is measured in one of three ways.

- a) *Hypertonic solution:* A solution having a **greater** concentration of *solutes* than solvent.
- b) *Isotonic solution:* A solution having an **equal** concentration of solutes and solvent.
- c) *Hypotonic solution:* A solution having a **lower** concentration of solutes than solvent.

NOTE: Water ALWAYS flows from a HYPOTONIC solution to a HYPERTONIC solution.

Effect of Osmosis on Plant Cells

Plasmolysis: The **shrinking** of a **plant cell's** cytoplasm because of a **loss of water**.

Turgor Pressure: The **swelling** of a **plant cell** because of an **increase in water**.

Effect of Osmosis on Animal Cells

Crenation: The **shrinking** of an **animal cell** because of a **loss of water**.

Cytolysis: The **swelling and bursting** of an **animal cell** because of an **increase in water**.

2. Active Transport

Active Transport: The movement of materials *AGAINST* the concentration gradient. Active transport requires the cell to use *energy* (ATP).

3. Bulk Transport

Bulk Transport: The movement of large particles through the cell membrane. These particles are too large to cross the cell membrane by normal means. The cell has to use energy to accomplish this. The membrane folds in on itself to create **vesicles (vacuoles)** that contain the materials.

Two types of Bulk Transport

- a. Exocytosis: This is the movement of large particles out of the cell.
- b. Endocytosis: This is the movement of large particles into the cell.

There are *two* types of Endocytosis.

- i) Phagocytosis: Referred to as “**Cell eating**”. The cell ingests a piece of solid material such as a Red Blood Cell or a bacterium.
- ii) Pinocytosis: Referred to as “**Cell Drinking**”. The cell ingests a small amount of “extra cellular fluid” from the outside of the cell.

Extracellular Fluid: Fluid located immediately outside a cell that surrounds and bathes the cell.

Receptor Assisted Endocytosis: A special type of Endocytosis where transport of materials occurs with the help of special proteins that act as receptors.

Cell size --- Surface Area to Volume Ratios

Cells are microscopic. The reason cells are microscopic has to do with **two** critical factors.

- a) Surface area of the cell membrane
- b) Volume of cytoplasm within a cell.

The cell membrane is responsible for controlling what enters and leaves the cell.

The volume of a cell is a measure of the cytoplasm of the cell. The cytoplasm contains all the organelles in a cell and is the site of many reactions.

As a cell's volume grows, the cell membrane has to increase in size in order to bring in enough nutrients and to get rid of wastes to supply the needs of the cell.

IF the cell membrane is not able to increase enough to account for the increasing volume, the cell will not be able to survive.

A useful ratio called the **surface Area to Volume Ratio** is a good measure of the efficiency of the interaction between the cell membrane and the volume of the cytoplasm.

A ratio of 1:1 indicates a balance between the volume of the cytoplasm and the cell membrane's surface area.

The **larger** the ratio the more *efficient* the cell is at exchanging materials between the cell membrane and the cytoplasmic volume. In other words, the cell membrane is large enough in surface area to bring in enough materials to supply the volume of the cell while at the same time getting rid of enough wastes.

Cell Energy – *Photosynthesis and Respiration*

All cells need energy.

Energy is used to:

- create molecules
- build membranes and organelles
- move molecules into and out of cell
- movement

Energy in cells comes in the form of ATP.

ATP = Adenosine TriPhosphate.

A nucleotide made up of:

- Adenine
- Ribose (a sugar)
- 3 Phosphate groups

Q. How Does ATP provide Energy?

A. When the bond between the 2nd and 3rd phosphate group is broken, energy is released for the cell to use.

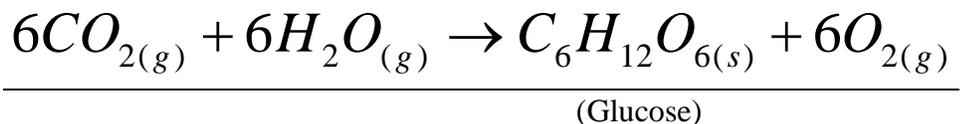
Cells make energy in one of two ways:

- 1) Photosynthesis
- 2) Respiration

Photosynthesis

Plants create energy by combining water with Carbon Dioxide in the presence of light to create Glucose (*source of energy*) and oxygen.

Reaction of Photosynthesis



Photosynthesis occurs in the Chloroplasts of plant cells.

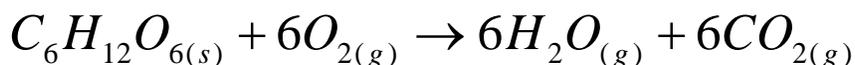
The two stages of Photosynthesis

- a) Light Reaction --- occurs within the *grana* of a chloroplast.
- b) Calvin Cycle or Dark reaction --- occurs in the *stroma* (fluid) of the chloroplast.

Cellular Respiration

Cells create ATP (energy) by combining glucose with oxygen to produce water and Carbon dioxide.

Reaction of Respiration



Respiration occurs within the **Mitochondrion** of a cell.

The two types of Respiration

1. Aerobic Respiration: This is respiration that occurs in the presence of oxygen. This type of respiration releases water, oxygen and **36 ATP** molecules.
2. Anaerobic Respiration: This is respiration that occurs *without* oxygen. There are two types of anaerobic respiration.
 - a) **Fermentation** – The breakdown of vegetables and fruits by bacteria . Releases **alcohol, carbon dioxide** and **2 ATP molecules**.
 - b) **Lactic Acid Fermentation** – Occurs in muscle cells. Results in a build of Lactic acid that makes muscles sore. Releases **lactic acid, carbon dioxide** and **2 ATP molecules**.

Respiration and Photosynthesis are OPPOSITE, but COMPLEMENTARY processes.

This means that what is created in one is used as a reactant in another.

Photosynthesis uses Water and Carbon dioxide to create Glucose and Oxygen while Respiration uses Glucose and Oxygen to create water and carbon dioxide.

One process depends upon the other to run.