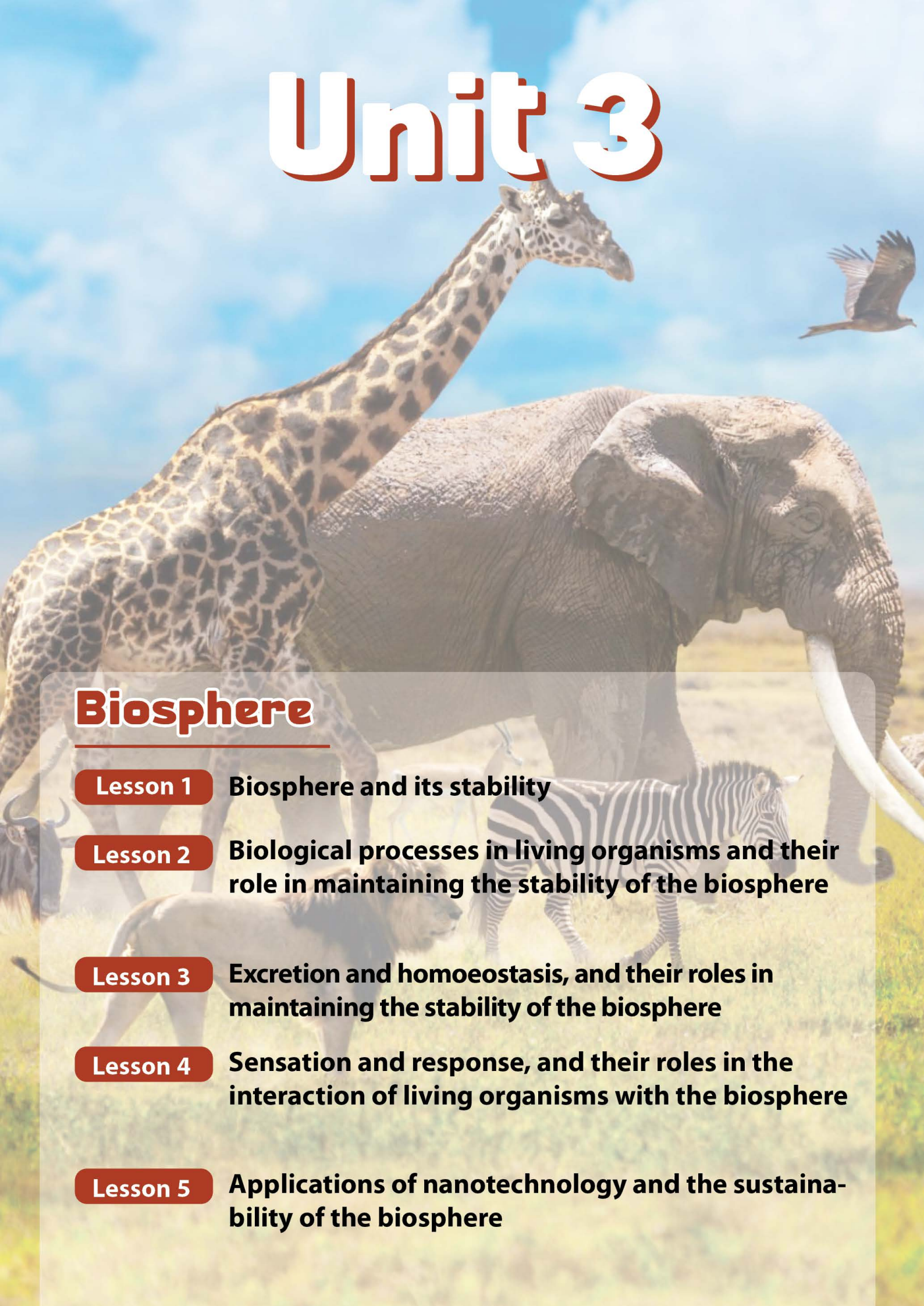
Unit 3



Biosphere

Part 1

LESSON 1

Biosphere and its stability

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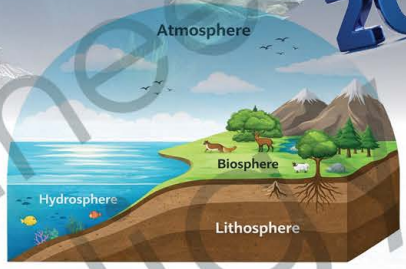
- You have learned in the previous semester, that the natural environment on Earth consists of four spheres, which are Hydrosphere, Atmosphere, Biosphere and Lithosphere.



- In this unit, we will study **Biosphere** in details

Biosphere

Part of planet Earth in which life exists, It extends from the depths of the oceans to the tops of mountains, passing through land and air.

- The biosphere is considered a **huge**, **integrated system** that **includes:**

All living organisms (plants, animals, microorganisms)	Environments (in which they live)

Living organisms interact with their surrounding environment **through** a constant exchange of matter and energy.

1 The relationship of Biosphere with the other Earth's spheres

- The biosphere is closely connected to the other spheres that make up planet Earth.
- Biosphere does not function independently; rather, it **depends on** other Earth's spheres **for** the continuity and balance of life.

Remember

The Earth's sphere are closely innterconnected to each other.

- **Living organisms that constitute the biosphere constantly interact with the other spheres GR ?**
  - To obtain essential substances necessary for all of their vital processes.

Interaction among Earth's Spheres

Hydrosphere

Supplies living organisms with the **water** necessary for all vital processes

Atmosphere

Provides **essential gases** such as oxygen required for respiration and carbon dioxide required for photosynthesis

Biosphere

Provides **mineral elements** through soil, upon which plants depend for their growth and stability

Lithosphere

EX

The life cycle of a plant represents a clear example of interaction among Earth's Spheres.

Photosynthsis

Plant absorbs water (Hydrosphere) and mineral salts (Lithosphere) from the soil and carbon dioxide from the air (Atmosphere).

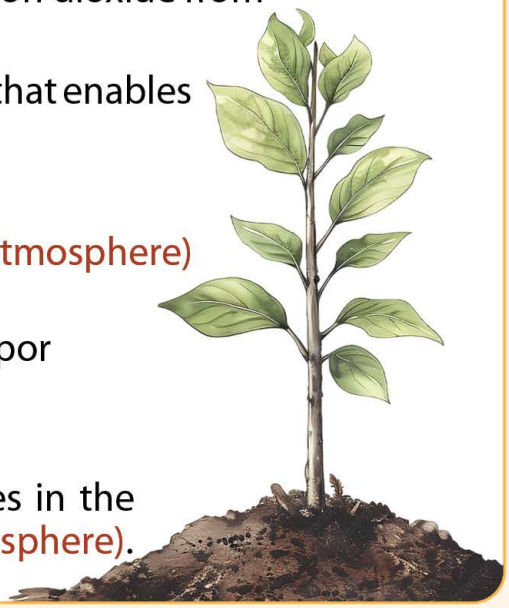
It uses solar energy to produce food that enables it to grow within the biosphere.

Gases exchanges

Plant releases oxygen into the air (Atmosphere) and returns part of the water to the atmosphere in the form of water vapor (Hydrosphere).

Decomposition

When the plant dies, it decomposes in the soil into simpler substances (Lithosphere).



Biotic and Abiotic factors

- The biosphere consists of living and non-living components that work together within a balanced system that makes life possible on the surface of Earth.

1 Biotic factors

- Include all living organisms that affect the environment and are affected by it, such as **plants**, **animals**, and **microorganisms**.
- Each organism plays a different role within ecosystems, where

Plants	Animals	Decomposers
Produce food through photosynthesis process and represent the **primary source of energy** for all other organisms.	Depend for their nutrition on plants or on other animals (prey). So, they are classified as **consumers**.	Break down remains of dead organisms and return essential elements to the environment, allowing ecosystem to reuse them, e.g: **Bacteria** and **Fungi**

2 Abiotic factors

- Include the non-living components of the environment as **light**, **water**, **temperature**, **soil**, **minerals**, and **air**.
- These factors are responsible for determining the types of living organisms that can survive in a particular area, GB?

  As each organism requires specific environmental conditions in order to grow and remain alive.

Through the interaction of biotic and abiotic factors, a balanced ecosystem is formed, which maintains the continuity of life within the biosphere.

EX **In a lake ecosystem**, fish, algae, and bacteria (Biotic factors) interact with the physical and chemical components (Abiotic factors) of lake's water in a continuous cycle of matter and energy exchange.

2 Levels of Organization in the Biosphere

- Life on Earth is organized into progressively complex levels, beginning with the individual organism and ending with the biosphere.

1 Individual

Is a single living organism that belongs to a specific type of living organisms, **such as**

1▶ **One fish in a lake**

2▶ **One tree in a forest**

2 Biotic population

A group of individuals of the same species share the same place and time and interact with each others for feeding, reproduction, and protection , **such as**

1▶ **Herd of antelopes in the African savanna**

2▶ **School of fish in the Red Sea**

3 Biological community

They are various populations of different species that live in the same area and interact within a complex network of feeding relationships, **such as**

▶ **Forest that includes trees, herbaceous plants, insects, birds, and mammals, all interacting with each other.**

4 Ecosystem

Geographic area where living organisms (biological community) and non-living things interact with each others.

When several ecosystems share similar climatic conditions and dominant living organisms, they form what is known as a biome.

Biomes

Large geographic areas (ecosystems) that share a specific climate conditions and have similar dominant organisms , such as

1▶ **Tropical rainforests** in the Amazon, Africa, and Asia share a warm, humid climate and a high level of biodiversity.

2▶ **Major deserts** share harsh climatic conditions and plants that are adapted to drought.

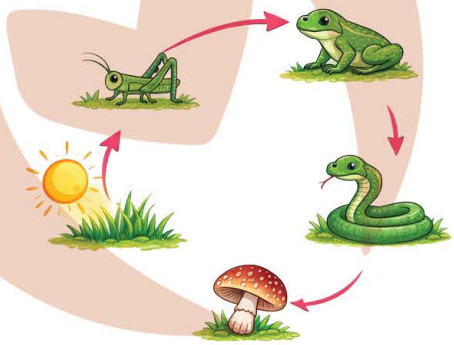
"The **highest** and **most comprehensive level** is the **biosphere**, which is the vast system that includes all biomes on Earth, encompassing land, water, and air, including all forms of life and their interactions with the other Earth's spheres."

- From previous we conclude that, organization of life follows an integrated hierarchical sequence, in which higher levels are composed of groups of lower levels.
- All levels are interconnected by complex and reciprocal interactions that ensure the survival of living organisms and the balance of ecosystems on our planet.
- One of the main mechanisms linking these levels is **food webs**.

Food chains and food webs

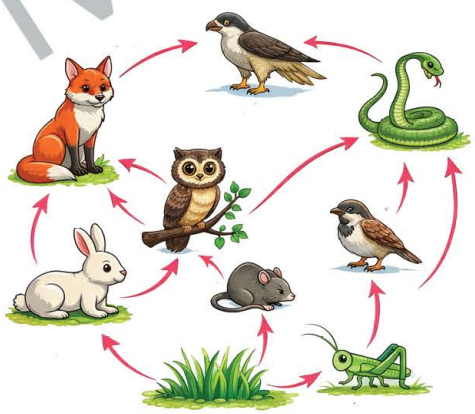
Food chain

It is a diagram that represents the transfer of nutrients and energy from a living organism to another in an ecosystem.



Food Web

It is a group of food chains that are interconnecting with each other in an ecosystem.



Note

Ecologists use food chains and food webs as models to illustrate energy transfer within an ecosystem, where

1) Each step in the food chain or food web is called trophic level
2) In any ecosystem, Autotrophic organisms makes up the first trophic level.
3) Heterotrophic organisms make up the subsequent trophic levels.

Importance of Food webs :

1 ▶▶ Illustrate how organisms obtain matter and energy.

2 ▶▶ Identify how each organism acquires its food

3 ▶▶ Clarifies role of each organisms within the community and its position in the food web,

4 ▶▶ Show how energy and nutrients are transferred across the different levels of biological organization.

Types of food webs:

1 Simple food webs

Food webs that depend largely on intermittent food resources, **such as** food webs in desert regions.

- **In desert ecosystems :**
  - Producers are limited (GR) **due to** water scarcity and extreme temperatures.
  - Animals adapt to use energy more efficiently.

2 Complex food webs

Food webs that are composed of multiple interconnected food chains, in which consumers do not rely on a single food source but on multiple sources.

Interconnected food chains have both positive and negative impacts :

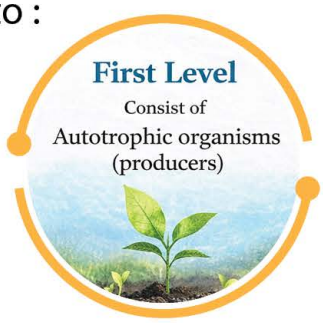
Positive Impact :
The interconnection makes the biological community more resilient to the loss of a single species.

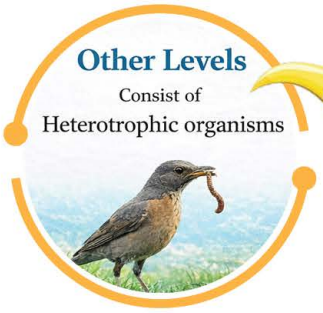
Negative impact :
Some changes may have a wide-ranging impact that **extends throughout the entire food web**, and this impact may be negative, **such as**

1) **The loss of plant cover**
2) **Water pollution.**

3 Nutritional Patterns in Biosphere

- Trophic level in any ecosystem is divided accrding to the nutritional patterns into :





- The production of food in an ecosystem begins with autotrophic organisms **(producers)**, followed by heterotrophic organisms (**consumers and decomposers)**.

FIRST : AUTOTROPHIC ORGANISMS

Autotrophic organisms (Producers)

Living organisms that produce their own food as they are capable of converting inorganic substances into energy-stored organic compounds, such as green plants and algae, as well as some specialized bacteria.

- Plants use light energy, carbon dioxide, and water to synthesize sugars and organic food through photosynthesis, as illustrated in the following equation:

$$\underset{\text{Carbon Dioxide}}{6CO_2} + \underset{\text{Water}}{12H_2O} \xrightarrow[\text{Chlorophyll}]{\text{light}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Water}}{12H_2O} + \underset{\text{Oxygen}}{6O_2}\uparrow$$

SECOND : HETEROTROPHIC ORGANISMS

Heterotrophic organisms

Living organisms that can't produce their own food and instead obtain energy by consuming producers or other consumers.

Heterotrophic organisms are divided into

- Consumers
- Decomposers

1 Consumers

▶ Consumers can be classified into trophic levels according to their food source:

Primary consumers (herbivores)	Secondary consumers (Carnivores)	Tertiary consumers (Carnivores)
Feed directly on plants	Feed on herbivores and may extend to higher-level predators.	Feed on secondary consumers

▶ Examples :

EX.1 **In river ecosystems:** microscopic algae (producers) feed small fish (primary consumers), which in turn feed larger predatory fish (secondary or tertiary consumers).

EX.2 **In terrestrial ecosystems:** trees and plants form the base of the food chain and are consumed by rabbits and gazelles, which are then preyed upon by wolves or eagles as higher-level consumers.

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2 Decomposers

- Decomposers as **Bacteria** and **Fungi** play a fundamental role in recycling matter within the ecosystem.
- They decompose the remains of dead plants and animals, converting them into **simple mineral elements** that return to soil and water.

Note

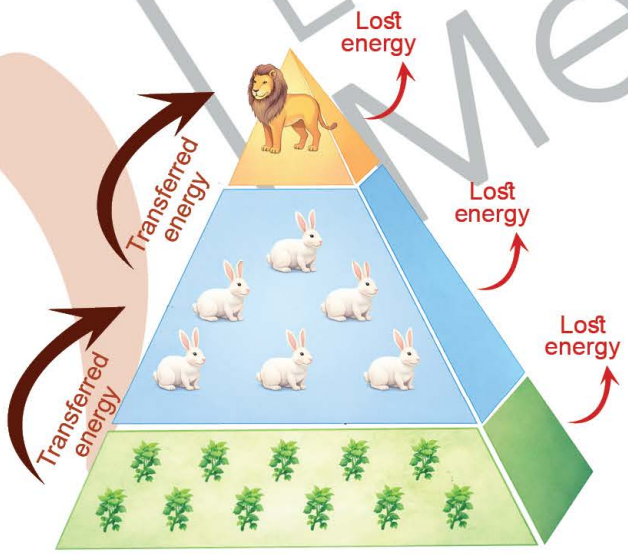
- **Decomposers** feed on organisms in all trophic levels
- **In the absence of decomposers**, organic matter and dead organisms would accumulate, and the cycling of nutrients would cease, negatively affecting all levels of ecological organization.
- Any food chain start with a producer ,then the consumers and ends with a decomposer

Illustrative example **In Nile Delta and Associated Lakes**

- **Algea and Phytoplankton**
  Producers
- **Zooplankton**
  Primary consumers
- **Small Fish**
  Secondary consumers
- **Predetory fish and Water Birds**
  Top-level consumers

Note : **During the energy transfer from a trophic level to another level, a large amount of energy is lost.**

Energy Flow in the Ecosystem



Direction of Energy transfer

3. When a carnivore feed on the herbivore, only 10 % of energy stored in the herbivore is transferred to it.
2. When a herbivore consumes a plant, 10% of energy stored in plant is transferred to it , a portion of this transferred energy is stored in the animal's cells and tissues and the rest is used in vital processes.
1. Plant receive light energy from Sun and convert it into chemical energy stored in food through photosynthesis process.

- **From the previous we notice that, about 90% of energy is not passed on to the next trophic level, as it is distributed through several pathways.**

The untransferred energy

1. **Energy used in vital processes:**
   Animals use part of the energy obtained from plants to carry out metabolic and life activities such as digestion, respiration, and movement which consume large amounts of energy.
2. **Energy lost as heat:**
   During metabolic activities, thermal energy is produced and released into the environment, and it is not transferred to organisms that feed on that animal.
3. **Energy stored in undigested materials:**
   Some plant components consumed by animals, such as tough fibers, are not fully digested. Consequently, part of the energy is excreted and remains stored in waste materials.

Therefore, the amount of energy transferred from one trophic level to the next **decreases progressively** as we move from producers to consumers.

Note

- The energy transferred from one level to another is equal to **10%** of the energy.
- **90%** of the energy is lost (untransffered) when moving from any level to the next level.

EX

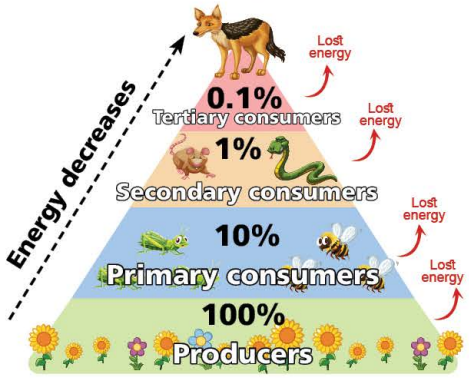
Suppose that the amount of energy stored in a given number of plants (producers) is 10,000 units ...

1. Only 1,000 units **(10%)** are transferred to the herbivores that feed on the plants **(primary consumers).**
2. Only 100 units **(10%)** are transferred to carnivores that feed on herbivores **(secondary consumers).**
3. Only 10 units **(10%)** are transferred to the predator that feeds on carnivores **(tertiary consumers).**

Ecological (trophic) Pyramids

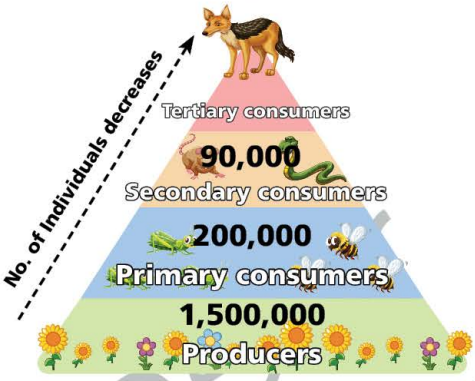
- Ecological pyramid are **graphical models** used to represent the amount of energy, the number of organisms, or the biomass at different trophic levels.

Pyramid of energy



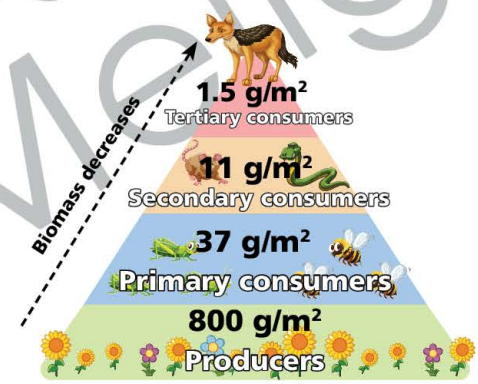
Represents flow of energy and its amount between trophic levels

Pyramid of numbers



Represents number of organisms in each trophic levels

Pyramid of biomass



Represents the total mass of organisms at each trophic level.

Note

- The base of ecological pyramids is occupied by producers
- The top of ecological pyramids is occupied by few numbers of large carnivores

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1 Producers form the base and the largest level energy pyramid?

As they are the most numerous and possess the greatest amount of energy and all the energy available to the higher trophic levels originates primarily from their conversion of light energy into usable chemical energy.

2 The quantity of energy, the number of organisms, or the biomass gradually decreases with each successive trophic level ?

As available energy decreases as we move toward the top of the pyramid.

3 Large predators are far fewer in number compared to plants and herbivores ?

As the number of organisms at the highest trophic level is relatively small because the available energy can support only a limited number of individuals.

Technological Application

Smart collars

Scientists have developed **smart collars** equipped with **precise sensors**, which are placed around the necks of wild animals in nature reserves in **Kenya**.

Idea of Working :

1) Sensors monitor movement rate, heart rate, and body temperature of the animal during its activities and while searching for food.
2) Sensors measure the amount of energy consumed by the animal.
3) Collected data are analyzed using artificial intelligence, to determine the amount of energy lost by the animals.

Importance :

It helped save herds of the endangered Iberian lynx, after discovering that a decline in prey populations had dangerously reduced the amount of available energy for them.

Part 2

LESSON 1

Biosphere and its stability

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3 Biochemical compounds in Biosphere

- All forms of nutrition in living organisms **aim to** supply them with basic chemical compounds upon which life is based.
- These compounds represent :

The sources in which energy is stored	The elements that regulate vital biological processes.

- These compounds are organic compounds belonging to **four main groups:**

1. Carbohydrates
2. Proteins
3. Lipids
4. Nucleic acids

FIRST : CARBOHYDRATES

Carbohydrates

Organic molecules composed of carbon, hydrogen, and oxygen in a ratio of 1:2:1, respectively, it represent the primary source of energy in most living organisms

↳ Most common organic compounds in living organisms

Classification of Carbohydrates

- Carbohydrates are classified into three main types:

Monosaccharides

- Simplest form

EX

Glucose (grape sugar)

Fructose (fruit sugar).

Disaccharides

- Formed of 2 molecules of monosaccharide.

EX

Sucrose (cane sugar)

Lactose (milk sugar).

Polysaccharides

- Composed of many monosaccharide units.

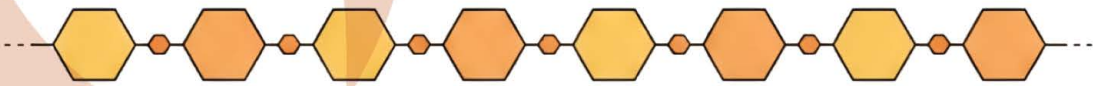
EX

Cellulose (component of plant cell walls)

Chitin (forms exoskeletons of arthropods)

Starch (stored in leaves and tubers of plants)

Glycogen (stored in the liver and muscles of animals)



Note

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Monosaccharides are used directly in cellular respiration to produce energy while **polysaccharides** are involved in cell structure, energy storage, or the formation of supportive structures.

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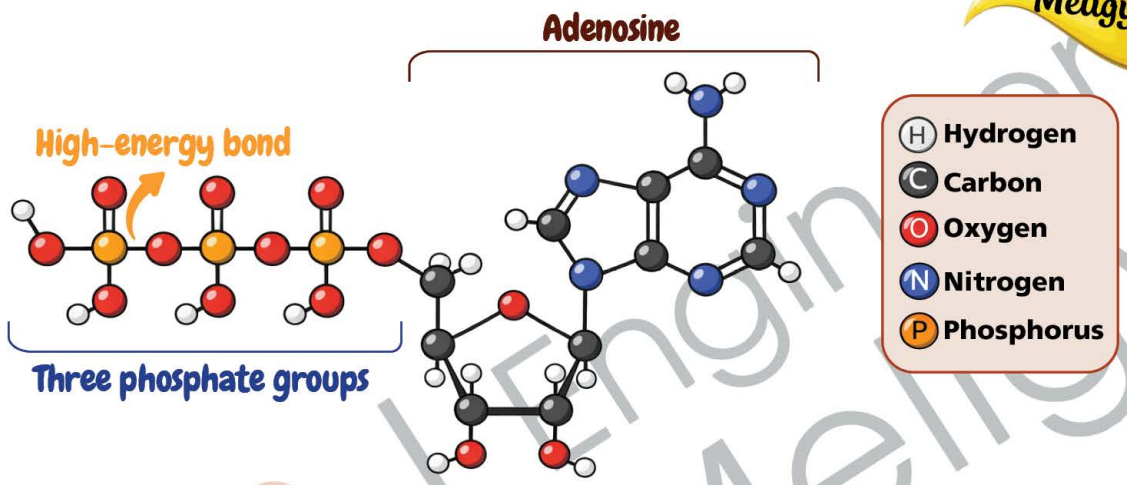
Energy in living cells

- Energy is stored inside living cells in molecules called **Adenosine triphosphate (ATP)**
- Adenosine triphosphate (ATP) is the direct source of energy inside living cells, as it represent the form of **chemical energy** that **can be used immediately in various biological processes**.

▶ Structure of ATP molecule:



- The bond between the second and third phosphate groups is a **high-energy bond** GR **due to because** it requires a large amount of energy to form.

Production and release of energy inside living cell

1 Glucose Oxidation

- **Glucose**, produced through the process of photosynthesis in autotrophic rganisms or obtained from food in heterotrophic organisms, **enters the cell**.
- **Glucose** is oxidized through a series of chemical reactions known as **cellular respiration**,
- During this process, its chemical bonds are gradually broken, leading to the release of energy.

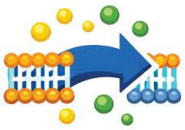
2 Storage of Energy in ATP Molecules

- The produced energy is **not used directly**; instead, it is stored in an organized manner within ATP molecules between the **second** and **third phosphate groups**.

3 Release of Energy from ATP Molecules

- When the cell requires energy, the high-energy bond is broken, converting ATP molecules into adenosine diphosphate (ADP) with the release of the energy needed for cellular activities, **such as :**

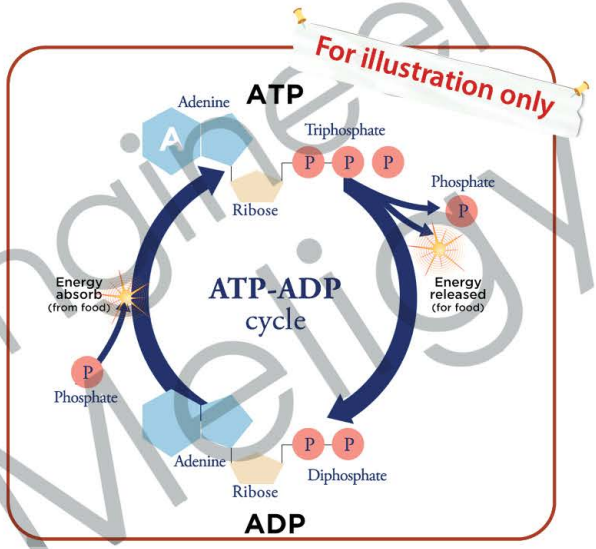
Muscle contraction



Transport of materials across membranes

Synthesis of biomolecules

- The cell can re-form **the active ATP molecule** from **ADP** by the adding of a new phosphate group to the ADP molecule , using part of the energy released from glucose oxidation.



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Medical Application

Continuous glucose monitoring (CGM)

Continuous glucose monitoring (CGM) devices measure blood sugar levels inside the body every few minutes with no need to for finger pricks, helping to track the availability of carbohydrates as a source of energy before they are converted into ATP molecules.

Importance of CGM devices :

Help patients and athletes understand the effect of carbohydrate-rich meals on energy production and accurately adjust diet patterns and physical activity levels to maintain stable energy and better health.

SECOND : PROTEIN

Proteins

Large, complex molecules made up of smaller units called **amino acids**, contain carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur.

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- **Proteins differ according to arrangement of amino acids within their chains which determines their shape and function,**

For example,

1▶ Structural proteins (such as keratin)

Give strength to hair and nails.

2▶ Enzymatic proteins (such as amylase)

Act as catalysts that accelerate the rate of biochemical reactions within the body without being consumed in the process.

▶ Importance of Proteins for living organisms:

1) They considered the main building unit in the bodies and in the structure of muscles, enzymes, some hormones, and antibodies.
2) When proteins are broken down during digestion, they are converted into amino acids that are reused to build new proteins according to the needs of the cells.

THIRD : LIPIDS

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Lipids

Organic compounds mainly composed of carbon, hydrogen, and oxygen and represents a concentrated source of energy for living organisms.

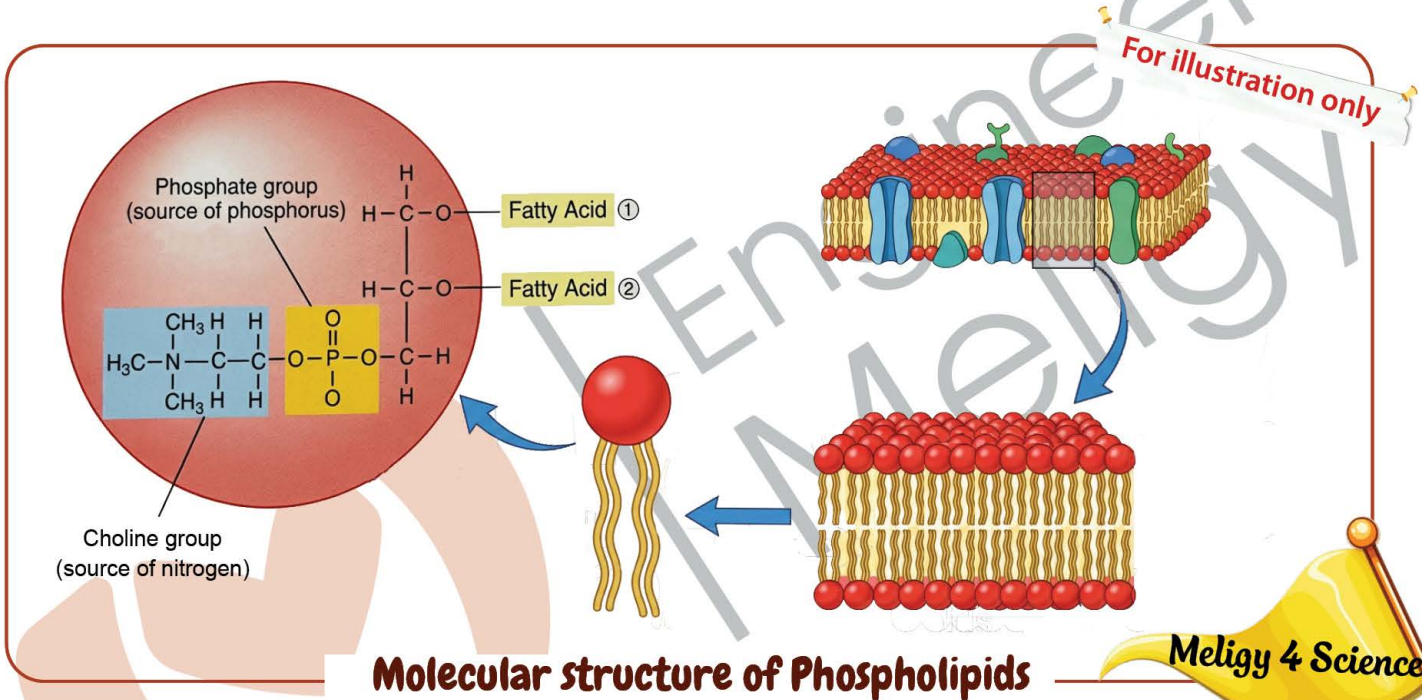
- Lipids are considered a **concentrated source of energy** in the body GB as their oxidation produces about **twice** the amount of energy produced by carbohydrates.

Note

- Lipids can be found in different forms, such as **vegetable oils** and **animal fats** which are stored in **adipose tissues** in the body and are used by cells as an energy source when needed.

▶ Importance of Lipids for living organisms:

1. Storing energy for use when needed .
2. Some lipids, such as cholesterol, are involved in formation of certain hormones and synthesis of some vitamins.
3. Thermal insulators, maintaining body temperature, such as the thick layer of fat in a polar bear.
4. Fundamental components of cell membranes, as **Phospholipids** form a bilayer that surrounds and protects the cell and regulates the movement of substances into and out of the cell.



Molecular structure of Phospholipids

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Calorific Content of Carbohydrates and Lipids

- **Calorific value of a food substance** is the amount of heat energy produced by burning 1 gram of food substance.
- The calorific value is measured in **kilojoules per gram (kJ/g)**.
- From a practical standpoint, the unit **kilocalorie per gram (kcal/g)** is commonly used.

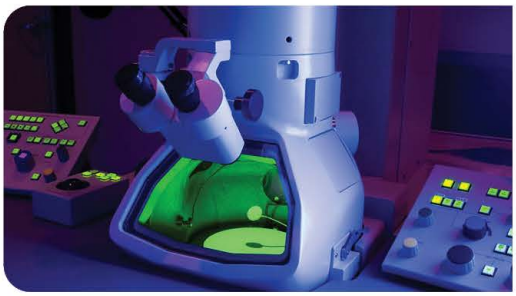
1 cal = 4.18 Joule

- On comparing the calorific content of carbohydrates and lipids of same amount, **we find that :**

calorific content of Carbohydrates < calorific content of Lipids

Medical Application

The electron microscope



- Modern technology has led to development of precise instruments that have enabled scientists to study the basic compounds of life at the molecular level as electron microscope, which relies on the use of a beam of electrons instead of light to form an image.
- The wavelength accompanying the electron can be controlled to be much shorter than the wavelength of light, allowing the visualization of very small structures such as membrane proteins and lipids that cannot be seen with conventional light microscopes.
- This advance has helped in understanding how molecules are arranged within cells Especially plasma membrane that are built from double layer of lipids, which has contributed to the design of modern drugs that target specific proteins inside the cell between foods.

FOURTH : NUCLEIC ACIDS

Nucleic acids

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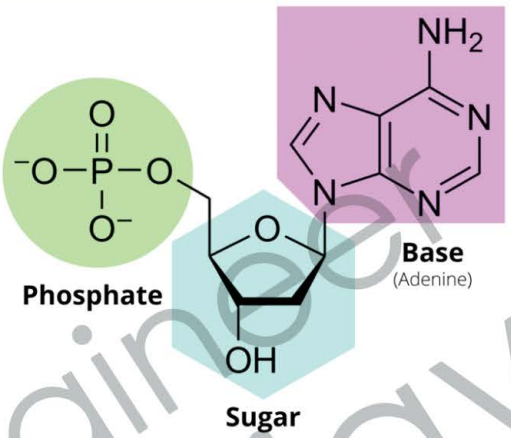
Organic compounds represent the basis of heredity, composed of small units called **nucleotides**.

▶ Structure of Nucleic acids :

- Each nucleotide consists of :
  1) **Pentose (five-carbon) sugar**
  2) **Phosphate group**
  3) **Nitrogenous base (5 types) :**

     Adenine (A), Thymine (T), cytosine (C), and Guanine (G), Uracil (U)



- The arrangement of these nitrogenous bases within the nucleic acid molecule leads to the formation of the **genetic code**, which determines all the characteristics of a living organism.

Types of Nucleic acids

- Nucleic acids are classified into two main types that differ in structure and function:

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Deoxyribonucleic Acid (DNA)		Ribonucleic Acid (RNA)	
Nitrogenous bases			
Adenine (A)	Cytosine (C)	Adenine (A)	Cytosine (C)
Guanine (G)	**Thymine (T)**	Guanine (G)	**Uracel (U)**
No. of strands			
Double helix (2 strands) of nucleotides		Single helix (one strand) of nucleotides	
Presence			
Found inside the nucleus of eukaryotic cells		Found in both inside and outside the nucleus	
Importance			
Carries the genetic information of the organism that is passed from one generation to the next		Involved in converting genetic information into proteins that that carry out various cellular activities.	

Modern Technological Applications

2026

CRISPR-Cas9

- **CRISPR-Cas9 technology** is one of the latest genetic engineering tools used In in modern laboratories to modify DNA.
- Scientists use this system as a **high-precise molecular scissors** to target a specific sequence of nitrogenous bases within the cell **genome**
- This allows scientists to make specific gene modification for specific purposes **such as** :
  - Correcting disease-causing genes, such as sickle cell anemia
  - Adding new genes or removing unwanted genes to produce crops with improved characteristics and disease resistance.

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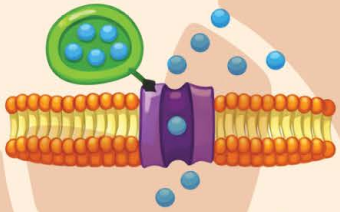
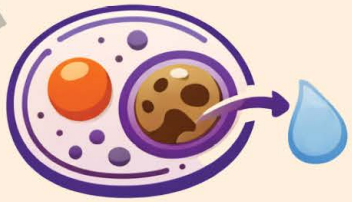
LESSON 2

Biological processes in living organisms and their role in maintaining the stability of the biosphere

- Living organisms need a **delicate system** that ensures the movement of essential materials within them, such as water, salts, oxygen, and nutrients.
- Most important vital processes in living organisms are :

Transportation	Respiration	Excretion
		
Meligy 4 Science Provides each cell with the materials it needs,	Converts stored energy in the materials into energy used to perform various vital activities	Gets rid of waste products resulting from vital processes.

Through the integration between these processes,

Living organisms contribute to the stability and balance of the biosphere GR,

as they recycle materials and energy to maintain the continuity of life on the planet Earth

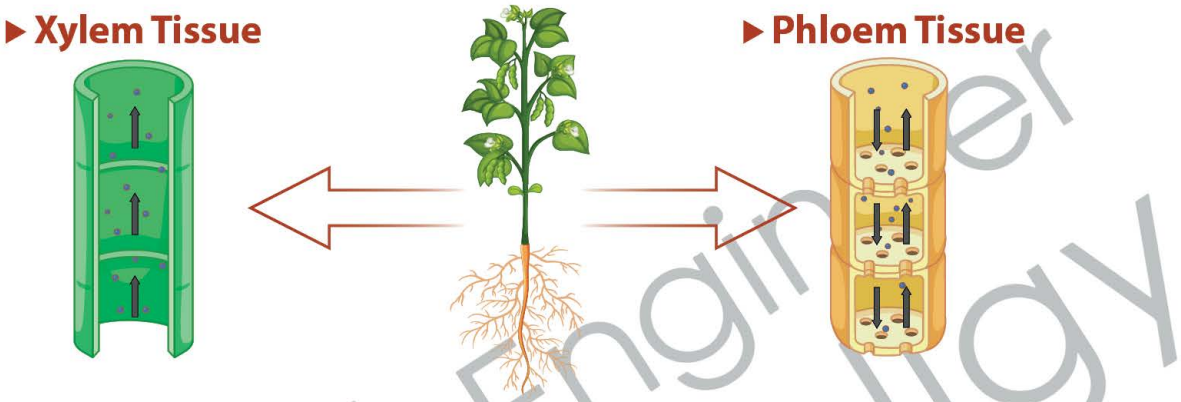
1 Transportation and its role in distribution of materials & Energy

FIRST : VASCULAR SYSTEM IN PLANTS

- **Higher plants have transport systems although they lack a specialized organs (as heart in humans) GR ?**

  To enable them to transfer water, salts, and nutrients within their vascular tissues which ensures their continued life and growth.

- **This system consists of 2 types of tissues which are :**



First Xylem tissue

▶ Role of xylem tissue:

Responsible for transporting raw materials as water and mineral salts absorbed from the soil to the leaves, to perform photosynthesis.

▶ Structure of xylem tissue:

- The xylem tissue in a mature plant consists of non-living structures that facilitate the passage of water .
- **Xylem tissue is composed of :**

  ① **Tracheids** Specialized cells

  ② **Vessels**

  Ⓐ Long hollow tubes extending from the roots to the leaves

  Ⓑ The walls are supported with a layer of a solid material called lignin. GR

  To
  - Gives the vessels strength and rigidity
  - Prevents their collapse
  - Resists comperssion which helps the vessels to maintain their shape even in the tallest plants

▶ Transportation of Water and minerals through xylem tissue:

Water and mineral salts move through the xylem vessels in one direction, as a continuous column against gravity from roots to leaves according to **Cohesion and Adhesion theory**

Cohesion and Adhesion Theory

- This theory is based on **3 types** of fundamental forces :

1 Cohesion Forces

- Forces that bind water molecules together due to precence hydrogen bonds.

Function - It keeps the water column in the **xylem vessels** connected during the movement .

2 Adhesion Forces

- Attractive forces between water molecules and the walls of the **xylem vessels**

Function - It helps to stabilize the **water column** as it rises upward.

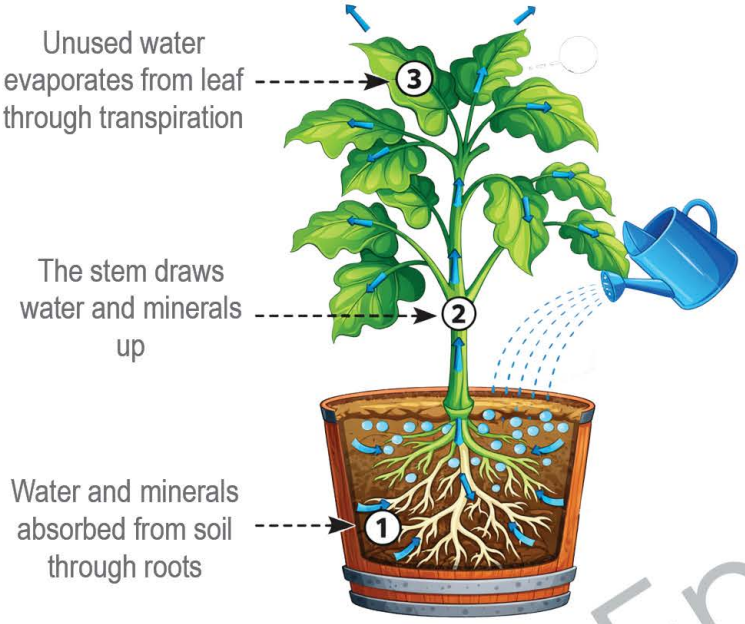
3 Transpiration Pull Forces

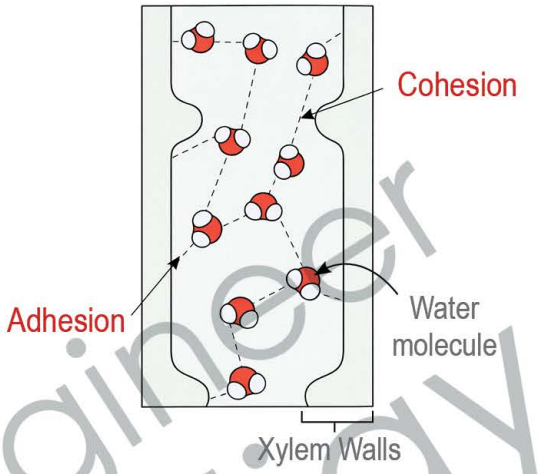
- The loss of water vapor from leaves through the stomata during transpiration **reduces** the **number** of water molecules in the leaf cells
- So, water pressure in leaf become lower than that in the stem or root, (negative).

Function - This creates a pulling force known as **"transpiration pull"** which pulls the connected water **column water** in the xylem vessels upwards.

NOTE

From previous we conclude that, Water and mineral salts move continuously from the root to the stem and leaves, Therefore, a tall plant like a pine tree can lift water tens of meters without a pump.





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▶ Role of the transpiration process

1 ▶▶ Getting rid of excess water in plant

2 ▶▶ Regulating the temperature of the plant.

3 ▶▶ Adding water vapor to the atmosphere.

4 ▶▶ Contributes to the formation of clouds and rainfall as part of the water cycle in nature. this results in a continuous force **pulling water** inside the plant from the root to the stem and leaves to great distances.

NOTE

Second Phloem tissue

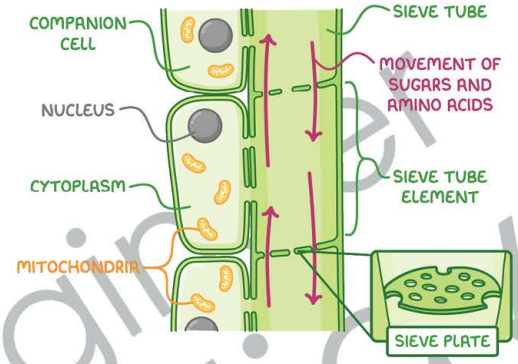
▶ Role of xylem tissue:

Responsible for transporting the **products of photosynthesis**, such as glucose and amino acids from the leaves to all parts of the plant, **including** roots, fruits, and seeds.

▶ Structure of phloem tissue:

Phloem tissue is mainly composed of living structures namely :

① Sieve tubes



- (A) Interconnected living cells , lined up side by side to form interconnected transport channels.
- (B) They are separated by sieve plates.
- (C) Do not contain a nucleus.

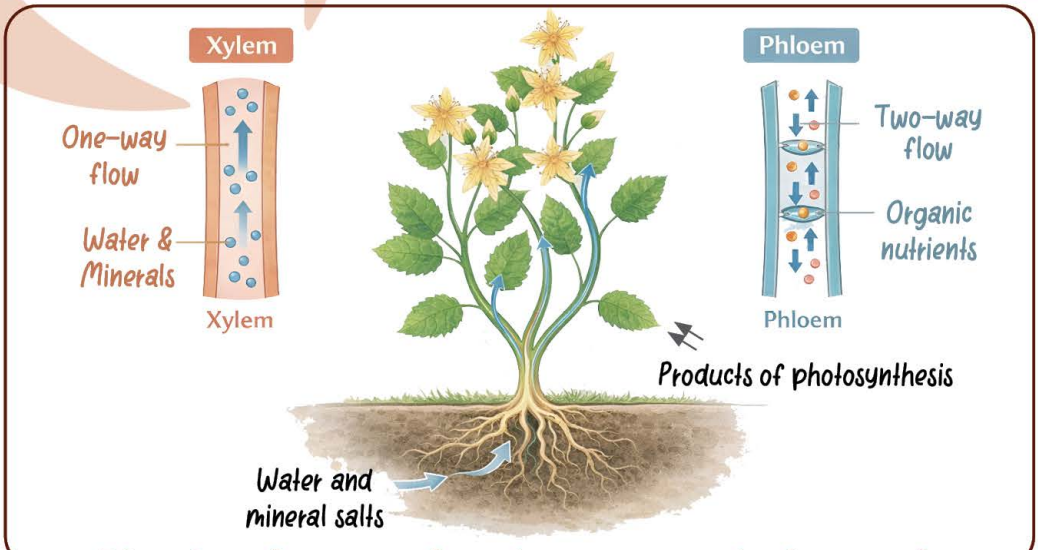
② Companion cells

- (A) Contain nucleus, so it provides Sieve tubes with energy (ATP molecules)
- (B) Regulate movement of nutrients through the phloem
- (C) Contain a nucleus.

▶ Transportation of nutrients through phloem tissue:

Transportortation occurs in **two directions**, upwards and downwards, according to the plant's needs at each stage of growth.

EX Sugars are stored in the roots during the winter and then transported back to the leaves in the spring to nourish new growth.



Direction of water and nutrient transport in the vascular tissues of the plant

Modern Technological Applications

Micro-CT scanning

- Micro-CT scanning, are used to study the complex mechanisms of water and nutrient transport within the plant with high accuracy
- This technology provides 3D images of vascular structures (xylem and phloem) tissues without destroying the plant specimen.
- Through theses images
  1) The **movement of water** through xylem vessels can be monitored
  2) Some phenomena whithin the vessels, such as the **formation of air bubbles** that prevent the continuity of water column against gravity can be checked.
- These experiments and applications help in
  1) Understanding the role of **cohesion** and **adhesion** properties in ascent of of water to the tops of trees,
  2) Providing information for developing **drought resistance strategies** and **improving water use efficiency** in agriculture.

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SECOND: CIRCULATORY SYSTEM IN HUMANS

- **Like plants, Human needs an internal transport system GB ?**
  To ensure that oxygen and nutrients reach all the body's cells.
- **The circulatory system performs this vital role through an integrated network, it consists of :**

▶ **Heart** ▶ **Blood vessels** ▶ **Blood**



1 Heart

Heart acts as a strong muscular pump, circulate blood through two main, complementary cycles.

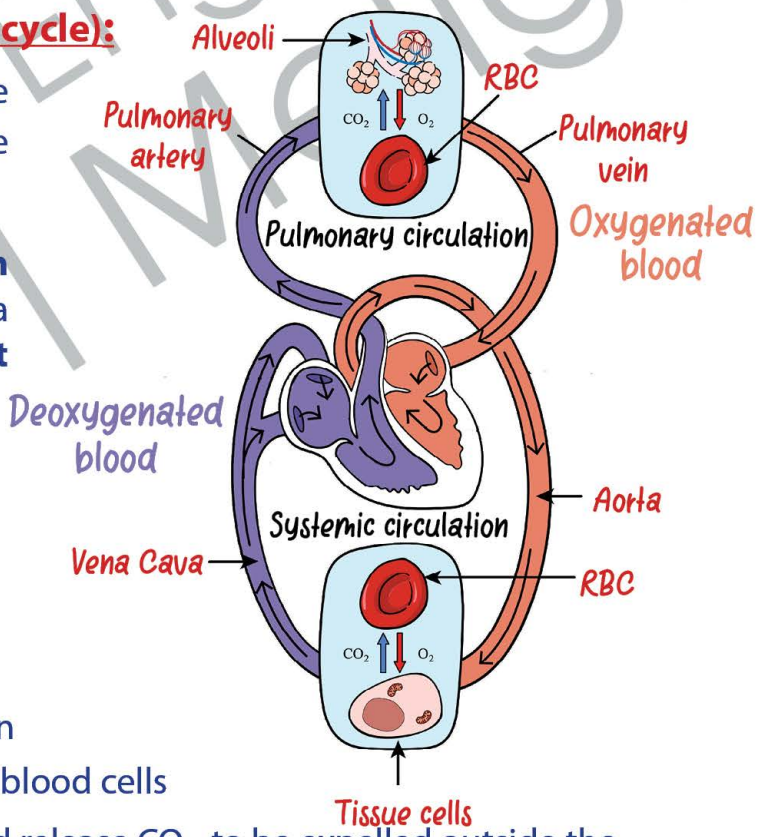
1 ▶ Systemic Circulation (The major cycle):

Ⓐ Oxygenated blood **(rich in O_2)** in the **left ventricle** is pumped into the **aorta** to all body tissues

Ⓑ While deoxygenated blood **(rich in CO_2)**, blood returns via the vena cava to the **right atrium**, then to the **right ventricle**.

2 ▶ Pulmonary circulation (The minor cycle):

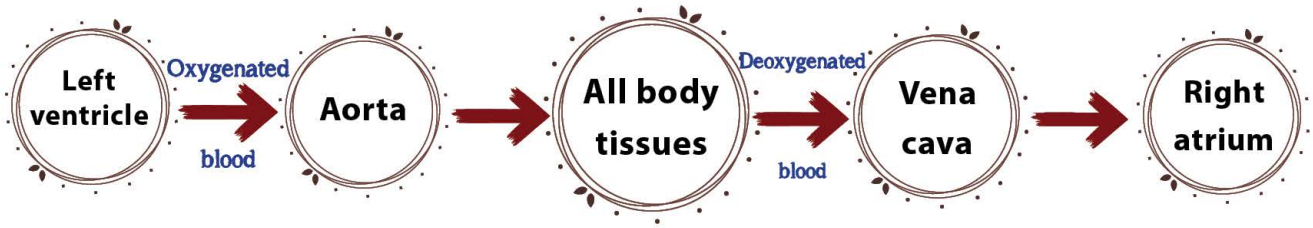
Ⓐ Deoxygenated blood is pumped from the **right ventricle** to the **lungs**.



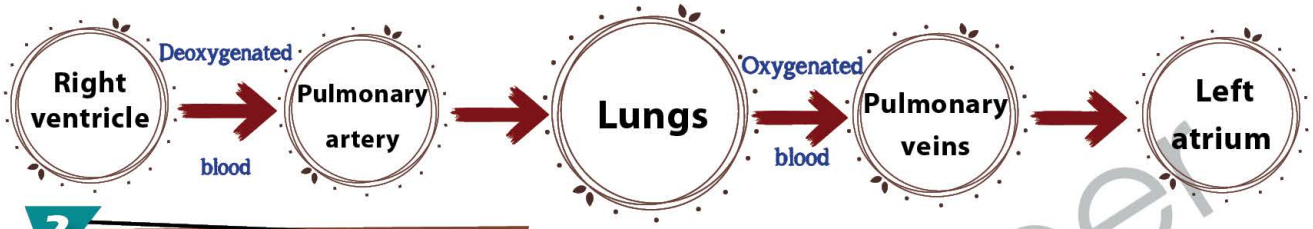
Ⓑ In lungs, gas exchange occurs between red blood cells and air sacs, **where** red blood cells obtain oxygen from the inhaled air, and release CO_2 to be expelled outside the body (through exhaled air)

Ⓒ Then, blood returns to the **left atrium** carrying oxygen (oxygenated blood), and then to the **left ventricle**.

SYSTEMIC CIRCULATION



PULMONARY CIRCULATION



2 Blood vessels

Blood vessels act as are networks for transporting energy and vital substances within a living organism.

Blood vessels are divided into

Veins

Return deoxygenated blood from the body to the heart at low pressure, with the help of valves that prevent backflow within the vein

Except for (pulmonary veins which carry oxygenated blood)

Blood capillaries

It's where exchange of substances, such as oxygen, carbon dioxide, glucose, and wastes, between the blood and the body's cells occurs

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Artries

Transport oxygenated blood under high pressure from the heart to different parts of the body

Except for (pulmonary artery which carry Deoxygenated blood)

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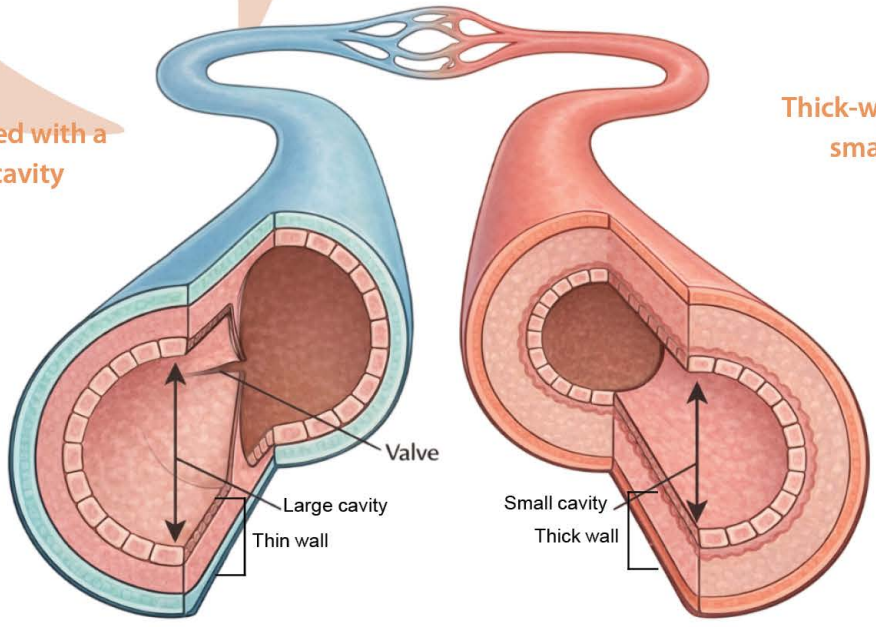
Thin-walled with a large cavity

Thick-walled with a small cavity



3 Blood

- **Blood is a viscous fluid consists of :**
  Red blood cells, White blood cells, Platelets and Dissolved proteins.
- **These components are the reason for its viscosity.**
- **It transports nutrients, gases, and metabolic waste.**

Note

- Circulatory system is integrated with the respiratory system, which supplies the blood with oxygen, and the excretory system, which get rid of wastes.
- **During physical exercise,**
  - The respiration and heart rates increase to provide the muscles with more oxygen and energy.
  - The sweating rate also increases

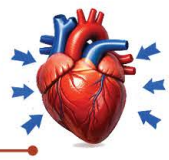
  This is a simple example of **homeostasis** in the body's functioning.

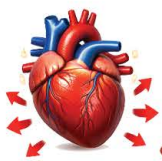
Blood pressure in human

Blood pressure

It's the the vital driving force of pumping of blood by the heart that ensures oxygen and nutrients reach all cells and tissues.

- **As blood circulates throughout the body, it exerts pressure on the walls of blood vessels (arteries and veins).**
- **This pressure is essential for continuous blood flow and is typically measured as one of two values:**





Systolic pressure

- It is the top value of blood pressure reading.
- Represents the maximum force exerted by the blood on the artery walls during the heart's contraction.
- Its normal value is 120 mmHg

Diastolic pressure

- It is the bottom value of blood pressure reading.
- Represents the minimum force exerted by the blood on the artery walls during the heart's relaxation.
- Its normal value is= 80 mmHg

Measuring blood pressure

Sphygmomanometer

Most common device for measuring blood pressure

Digital Blood Pressure Devices

Widely used nowadays as an alternative for mercury Sphygmomanometer

Factors affecting blood pressure

1 - Physical properties of blood

- **The physical properties of blood play a key role in maintaining blood pressure at its normal level. These properties include:**

1▶ Viscosity :

- Blood is a viscous fluid (more viscous than water) GR ?
  Because it contains red blood cells, white blood cells, platelets, and dissolved proteins.

If blood viscosity increases,
(as in cases of dehydration or an increased number of RBCs)
↓
Resistance to flow increases
↓
Blood pressure increases.

Blood viscosity controls its flow rate

If blood viscosity decreases,
↓
Blood flows more easily
↓
Blood pressure decreases

Note

- Some conditions that lead to increased blood viscosity :
  - Dehydration
  - Increase in the number of blood cells.

2 ▶ Blood density

- Density of blood changs with changing the proportions of its components (especially hemoglobin)
- This affects the effort required to pump blood.

Note

The elasticity of blood vessel walls during contraction and relaxation, and the pumping strength of the heart also affect the vital pressure.

2 - Other factors that affect blood pressure

- **Elasticity of blood vessel walls during contraction and relaxation**
- **Force of the heart's pumping**

Modern Physical Applications for treating high pressure

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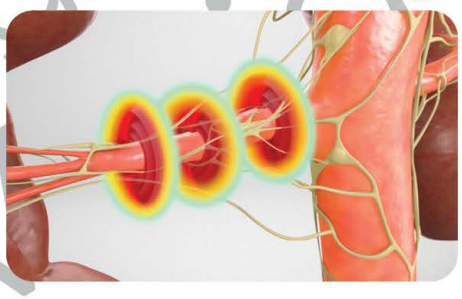
Renal Deneration

▶ Renal denervation is one of the latest techniques that helps stabilize blood pressure in patients who do not respond to medications.



▶ This technique is a simple, non-surgical medical intervention that depends on the use of high-frequency radio waves (Radio Frequency Energy)or ultrasound waves to inhibit or disable the active nerves around the kidney that send nerve signals leading to an excessive increase in blood pressure.

▶ Thus, advanced physical applications can contribute to protecting human health and supporting stability within the biosphere.

NOTE

LESSON 2

Biological processes in living organisms and their role in maintaining the stability of the biosphere

2 Respiration and obtaining energy

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FIRST : CELLULAR RESPIRATION

- Every cell in a living organism needs a energy to carry out its vital activities, such as :
  - Transporting materials across membranes
  - Division
  - Growth.
- Cells obtain this energy from the process of cellular respiration

Cellular respiration

A series of chemical reactions that release the chemical energy stored in glucose (latent energy) and store it as usable energy in the form of ATP

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Steps of cellular respiration

1st stage : Glycolysis

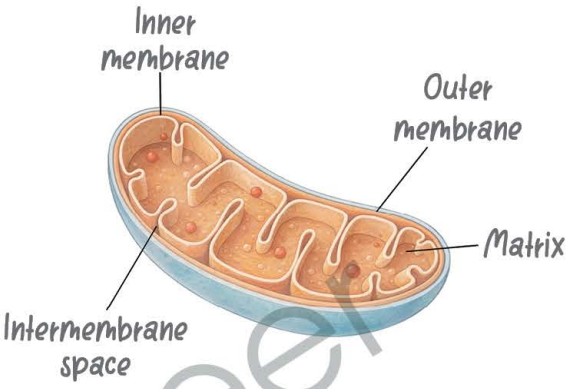
- 1st stage which takes place in in **the cytoplasm**
- Produce **small amounts of ATP** from breaking down of **one molecule of glucose .**

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow[\text{cytoplasm}]{\text{Glycolysis in the}} \text{Glycolysis products} + 2\ ATP$$

2nd stage: Divided into two types depending on availability of oxygen

1 Aerobic Respiration

- Occurs in conditions where oxygen is **available**.
- Glycolysis products move to the mitochondria (the energy-producing station in the cell) to **complete aerobic cellular respiration**



▶ This results in:

1) A large amount of energy: ATP molecules **(36 ATP molecules per glucose molecule).**
2) Carbon dioxide and water as by-products of energy production.

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{Enzyme}} 6CO_2 + 6H_2O + 36ATP$$

Glucose — Oxygen — Carbon Dioxide — Water — Energy

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Therefore, the process of aerobic respiration is considered highly efficient in producing energy.

2 Anaerobic respiration

- **In the absence or limited oxygen**, cells resort to anaerobic respiration to produce energy, resulting in a **limited amount of energy** (2 ATP molecules per glucose molecule).

-The breakdown of glucose occurs in the **cytoplasm**, and this breakdown produces either an **acidic** or **alcoholic product**, as follows:

Lactic acid fermentation

- Occurs in muscle cells.
- Produces lactic acid.

$$C_6H_{12}O_6 \longrightarrow 2C_3H_6O_3 + 2ATP$$

Glucose — Lactic acid — Energy

Alcoholic Fermentation

- Occurs in yeast cells.
- Produces ethanol (ethyl alcohol) and carbon dioxide.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 + 2ATP$$

Glucose — Ethanol — Carbon dioxide — Energy

EX **During intense exercise, oxygen supply to muscles decreases, so**

- Cells temporarily rely on anaerobic respiration to produce energy.
- This leads to the accumulation of lactic acid in muscle tissues, causing **muscle fatigue and soreness.**

SECOND : ENERGY AND CHEMICAL REACTIONS

- The law of conservation of energy is achieved in chemical reactions, where energy is transformed from one form to another without being destroyed or created.

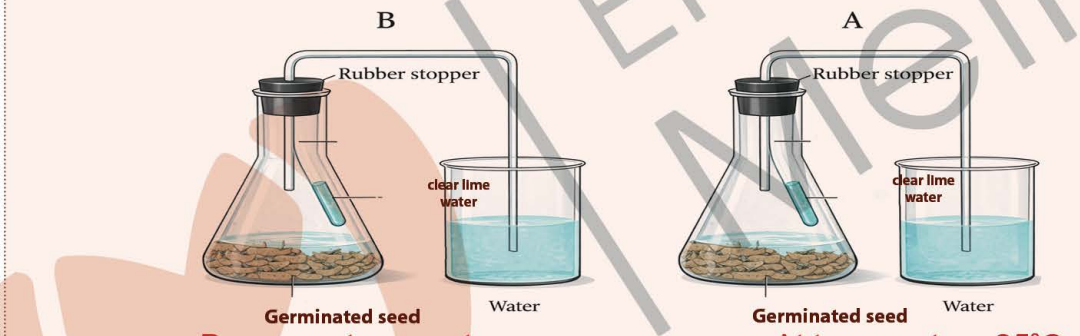
The complete chemical energy stored in glucose molecules (food) and oxygen

- **Stored chemical energy in ATP molecules** in addition to energy released - **With carbon dioxide and water produced**

- **It is clear that chemical reactions occur in cellular respiration processes that result in the release of energy. This type of chemical reaction is known as exothermic reactions.**

Effect of temperature on role of cellular respiration

Experiment



Decrease temperature — At temperature 25°C

Observation

1. Lime water turbid in bottle (A) more than bottle (B)
2. The rate of (CO_2) evolve in bottle (A) more than bottle (B)
3. Activity of seed in bottle(A) more than bottle (B)

Conclusion

1. The rate of respiration increase by increasing temperature
2. As the speed of reactions inside speed increase and vise versa

Note

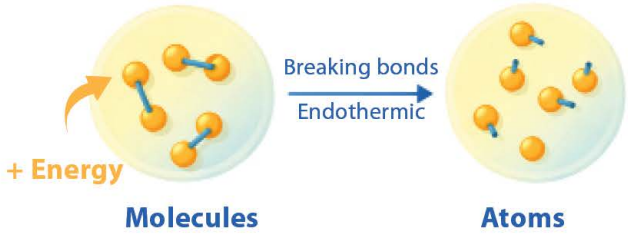
- Lime water used in detection of CO_2 as it converted from clear to turbid

Energy and Chemical reactions

- In a chemical reaction, bonds in the molecules of the reactants are broken and new bonds are formed in the molecules of the products, **accompanied by**:

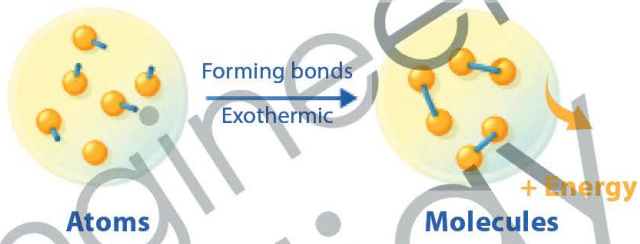
1

Consumption of a quantity of energy to break the chemical bonds between the reactant molecules.



2

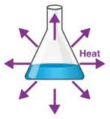
Production of a quantity of energy as a result of forming new bonds between the molecules of the substances produced from the reaction



NOTE

- **Chemical reactions are divided into two types based on the exchange of energy with the surrounding environment:**

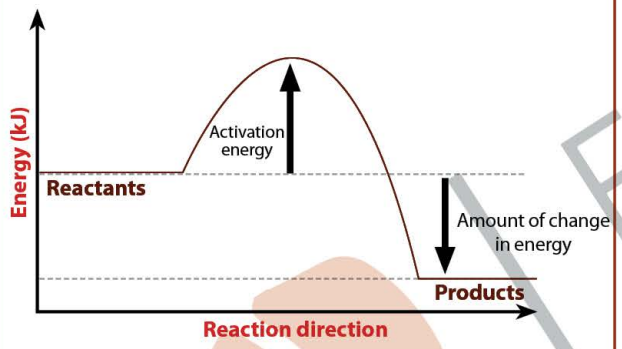
Exothermic reaction



The reactions that release heat to the surrounding causing an increase in its temperature

The sum of heat contents for the reactants is higher than the sum of the heat contents for the products.

$E_P < E_R$



EX

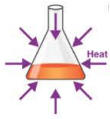
Aerobic cellular respiration in a living cell Glucose breaks down in the presence of oxygen into carbon dioxide and water, releasing energy which is stored in ATP molecules.

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{Enzymes}} 6CO_2 + 6H_2O + E$$

When hydrochloric acid solution is added to sodium hydroxide solution (alkali) in a glass flask (to produce sodium chloride and water) you feel warme or heat when touching the container (exothermic reaction), as heat energy is released

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow H_2O_{(l)} + NaCl_{(aq)} + Heat$$

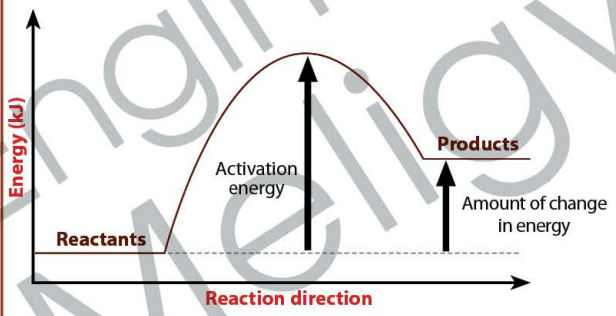
Endothermic reaction



The reactions that absorbs heat from the surrounding causing an decrease in its temperature

The sum of heat contents for the reactants is lower than the sum of the heat contents for the products.

$E_P > E_R$



EX

Photosynthesis in plants is an example of an endothermic reaction, where the plant absorbs light energy from the sun to convert carbon dioxide and water into glucose and oxygen.

$$6CO_2 + 12H_2O \xrightarrow{\text{Light Energy}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

The decomposition of solid potassium chlorate by heat into potassium chloride and oxygen gas.

$$2KClO_{3(s)} + Heat \longrightarrow 2KCl_{(s)} + 3O_{2(g)}$$

Calculating the amount of heat

- **To calculate the heat change (ΔH) (amount of heat released or absorbed during a reaction associated with a chemical reaction, follow these steps:**

1- Achieving the law of conservation of mass

- A chemical reaction can be expressed by a balanced symbolic chemical equation that shows the reactants and products to achieve the law of conservation of mass (matter)

Law of conservation of mass (matter)

The sum of the masses of the reactants equals the sum of the masses of the products.

- The quantities of reactants and products resulting from chemical reactions are measured in moles (mol)

Mole

A mole of a substance is the mass of a substance in grams equivalent to its molecular mass

EX

Water formation reaction

The mass of one mole of hydrogen (H) = 2g where its atomic mass is 1

The mass of one mole of oxygen (O_2) = 32g where its atomic mass is 16

The mass of one mole of water (H_2O) = 1×2+16 =18g

- In the previous equation, when the quantities of reactants and products are expressed in moles and grams respectively:

In moles :

2 moles of water are produced from the reaction of 1 mole of oxygen with 2 moles of hydrogen.

In grams :

4 g + 32g = 36g

Thus, we observe that the sum of the masses of the reactants equals the sum of the masses of the products, despite the release of energy in the form of heat. This example proves the law of low conservation of mass.

Law of Conservation of mass

Mass is neither created nor destroyed during a chemical reaction, but transformed from one form to another

Note

- The presence of heat as a product does not mean a loss of mass, GR ?

Because heat represents energy and not matter, and therefore is not included in the mass calculation.

2- Calculating the heat content (H) of products and reactants

Heat content of matter

The amount of chemical energy stored in one mole of a substance, and its unit of measurement is (kJ/mole).

- **Heat content differs from one substance to another,** due to difference in:

1 ▶▶ The type of atoms that make up the substance molecules.
2 ▶▶ The number of atoms that make up the substance molecules.
3 ▶▶ Type of bonds between substance molecules.

Change in Heat content (ΔH)

Difference between sum of heat contents of the products (H_P) and sum of heat contents of the reactants (H_R).

$$\Delta H = H_P - H_R$$

IF

$\Delta H_P < \Delta H_R$	$\Delta H_P > \Delta H_R$
ΔH = Negative sign	ΔH = Positive sign
Reaction is endothermic	Reaction is exothermic

Activity 1 Answer the following

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-The following equation illustrates the complete combustion of alcohol:

$$2CH_3OH + 3O_2 \rightarrow 2CO_2 + 2H_2O \qquad \Delta H = -726.5 \text{ kJ/mol.}$$

1) Is this reaction endothermic or exothermic? And why?

2) Calculate the amount of heat released (in kJ) from the combustion of 80 g of methanol. Given that (C=12, H=1 H , O=16)

Answer

1) Since ΔH is negative, this means that the enthalpy of the products is less than the enthalpy of the reactants.

The difference between them is released into the surroundings, meaning the reaction is **exothermic**.

2) Molar mass of methanol (CH_3OH):

$12+(3\times1)+16+1=$ **32 g**

Number of moles (n) equivalent to the given mass:

= mass ÷ molar mass = 80 ÷ 32 = **2.5 mol**

The amount of heat released from the combustion of 2.5 mol of CH_3OH

∵ Combustion of 1 mol of methanol gives -726.5

∴ Combustion of 2.5 mol of methanol gives :

$\Delta H = -726.5 \times 2.5 =$ **-1816.25 kJ**

Excretion and Homoeostasis, and their roles in maintaining the stability of the biosphere

Metabolic process (metabolism)

They are a **huge** number of precise, spontaneous biochemical reactions performed by the cells of the human body .

▶▶ Metabolic process help the body to:

1. 
Obtain energy from food

2. 
Build important biomolecules
(as proteins ,fats,carbohydrates)

3. 
Resist infections

4. 
Replace damaged cells

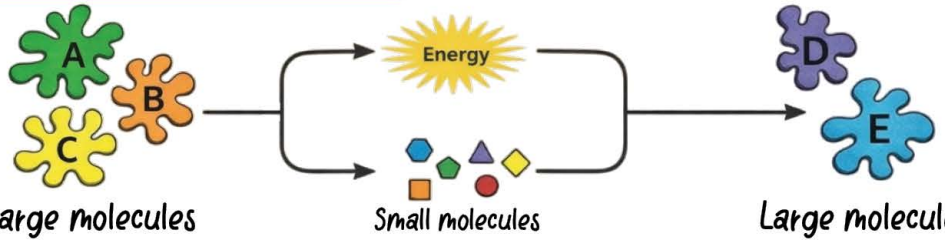
• Metabolism includes two opposing processes :

1 Anabolism

The process in which new substances the body needs are produced

2 Catabolism

The process in which complex molecules are broken down to obtain energy



Metabolic Waste

- Metabolic reactions are necessary, but not all products are useful GR? as some reactions leave behind harmful **by-products** that the body does not need

Metabolic wastes

Substances produced during metabolism that the body does not need and may be harmful if accumulated.

▶▶ Examples of metabolic waste:

Metabolic wastes

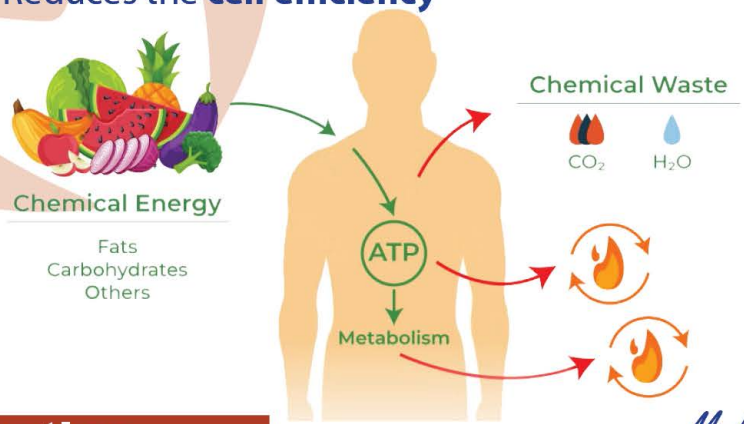
1. **Carbon dioxide (CO_2)** (resulting from cellular respiration)
2. **Ammonia (NH_3)** (resulting from the Breaking down of amino acids in the liver)
3. **Urea** Produced by converting toxic ammonia into a less harmful form
4. **Excess water and mineral salts** Substance that must be eliminated to maintain the balance of fluids and ions in the the body

Importance of Excretion

- Living organisms need a mechanism to get rid of Metabolic Wastes GR?

Because 1▶ The accumulation of these wastes disturps the chemical balance **of body fluids**

2▶ Reduces the **cell efficiency**



Excretion

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Biological process by which metabolic wastes are removed from the body and homeostasis (internal balance) is maintained

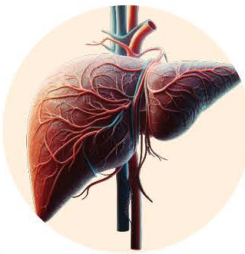
Aim

- Maintaining the balance of the body's internal environment **(Homeostasis)**

Excretory organs in human

1. The Kidneys

2. The Skin

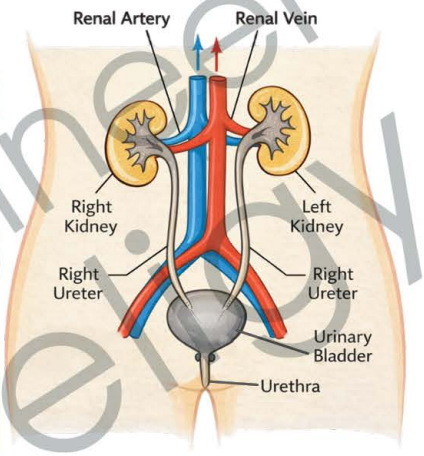
3. The Liver

4. The Lungs


First The Kidneys

Location
Located on **both** sides of the spine in the lower back

Size and Description
- Bean-shaped
-About the size of a fist

Function
1▶ Maintaining the balance between ions and water in the body
2▶ They filter blood from liquid wastes.



Structure of the Human Urinary System

1 Water and Salt Balance in the Body

Importance of ions

- **Ions like Sodium, Potassium, and Chloride:**
  1. Are essential for nerve and muscle function
  2. Regulate osmotic pressure inside and outside cells
  3. Maintaining blood pressure at its normal level.
- **When changes occur in the concentration of these ions during vital processes, the kidneys regulate this balance very precisely.**

Sodium concentration in the blood

Increases ↑
Kidneys increase water reabsorption to **dilute** the concentration of sodium in the blood.

Decreases ↓
Kidneys excrete a greater amount of water.

→ **To maintain the balance between ions and water in body fluids**

2 Purification of blood from liquid wastes

- The kidneys purify the blood from liquid wastes produced by metabolic reactions in the body through **two** main processes:

① Filtration process

- **Blood is filtered inside very fine structures called nephrons.**
- The filtrate contains water and wastes such as urea, excess salts, and ions including sodium, potassium, and chloride, in addition to glucose.
- **The nephrons do not allow large molecules, such as proteins and blood cells, to pass through.**

② Reabsorption process

- This occurs when these substances move from inside the nephron tubules to the blood circulating in the surrounding capillaries**. This process takes place in all parts of the nephron.**
- The most important beneficial substances reabsorbed into the blood are:

Reabsorption process

It is the process of reabsorbing beneficial substances from the fluid filtered in the nephron return into the blood

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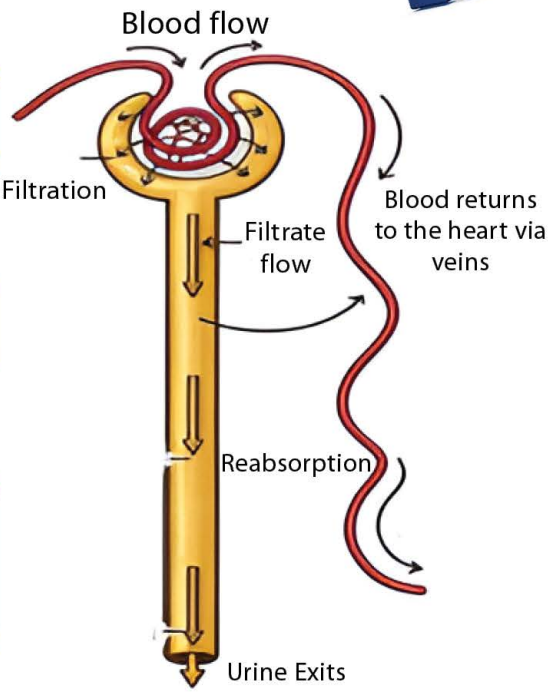
1. Most of the glucose
   To provide cells with energy
2. A large portion of water
   To maintain blood volume and balance
3. Important ions such as sodium , potassium, and chloride
   To regulate muscle and nerve functions and maintain blood pressure.



- Substances the body doesn't need travel through the ureters to the bladder, where they are **stored** until they are excreted from the body through the urinary tract as urine.

Urine

A **liquid** that is **excreted** outside the body. It consists of water, urea, excess salts and ions, large amounts of excess water, and some other **waste products**.

Importance of Reabsorption

- **Reabsorption** is a vital process for maintaining internal **balance** in the body, as it ensures that the body retains what it needs and eliminates what it does not.

Note

If the nephrons of the kidneys failed to carry out the reabsorption process properly, the body loses large amounts of water and beneficial elements, leading to:

① Disturbance in salt balance in the body
② Dehydration of the body
③ A decrease in blood pressure (in some cases)

NOTE

Second The Skin

- The skin represents the outer covering of the body.
- The skin consists of **three** main layers:

1. Epidermis

The outermost layer of the skin.

Function: Protects the body from microbes and water loss.

2. Dermis

Contains blood vessels, sweat glands, and hair follicles.

Function: Secretion of **sweat** which **help in** :

- Excretion of nitrogenous wastes
- Maintaining the balance of fluids inside the body.
- Regulation of body temperature as when it evaporates from the surface of the skin, excess heat is lost

Sweat

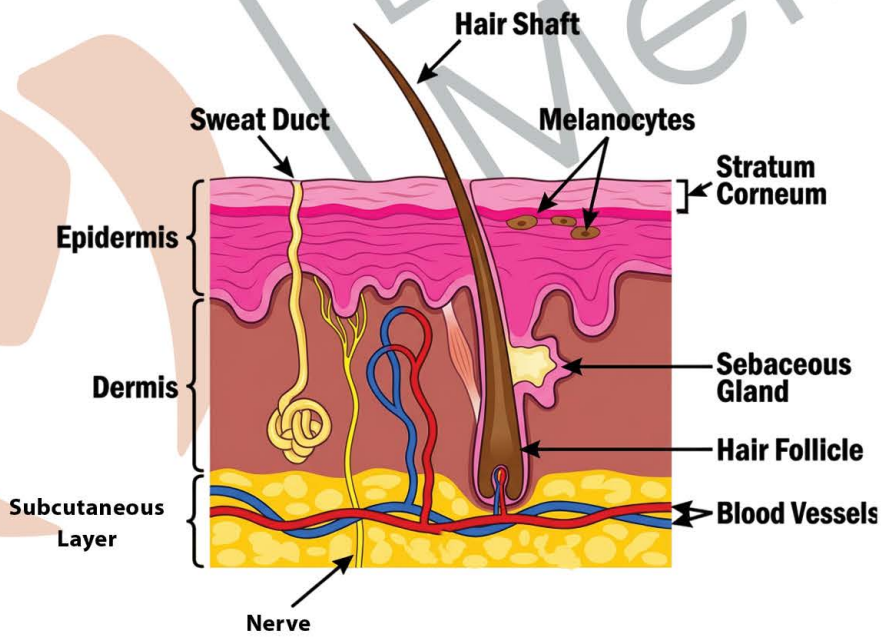
A liquid composed of water, dissolved salts (such as sodium chloride), and small amounts of urea.

3. Subcutaneous Layer

A layer rich in fats.

Function: Acts as a thermal insulator **as** :

- The presence of a fatty layer under the skin helps reduce heat loss.



Notes

① The skin helps regulate body temperature through **sweating** and **blood vessels**.

② The skin and kidneys work together to **remove excess water** and **mineral salts**, showing integration among excretory organs to maintain internal balance.

③ When body temperature **rises**, **sweating increases** and **urine output decreases**; the opposite happens when body temperature decreases.

Third The Liver

Function of the Liver

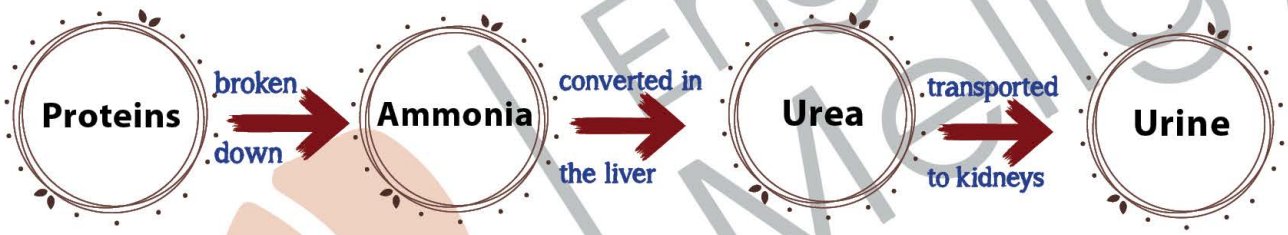
The liver is a purification center or main waste treatment station

1. **Removes** toxins from the blood and eliminates harmful substances resulting from metabolism.
2. **Converts** toxic substances into less harmful compounds that are easier to excrete from the body.

The Liver and Waste Elimination

1 ▶ Conversion of amino acids from protein digestion into urea

Amino acids resulting from protein digestion are converted in the liver into urea, which is then transported to the kidneys and excreted with **urine**.



2 ▶ Breakdown of hemoglobin

Hemoglobin, released from old red blood cells, is broken down in the liver. The pigment bilirubin is formed and excreted with bile into the intestine.

3 ▶ Detoxification of drugs and harmful substances

The liver removes many drugs, food additives, and toxic substances by converting them into compounds that can be eliminated from the body.

Note

① The liver contributes to maintaining the balance of the internal environment of the body.
② Urea and ammonia are nitrogenous wastes.

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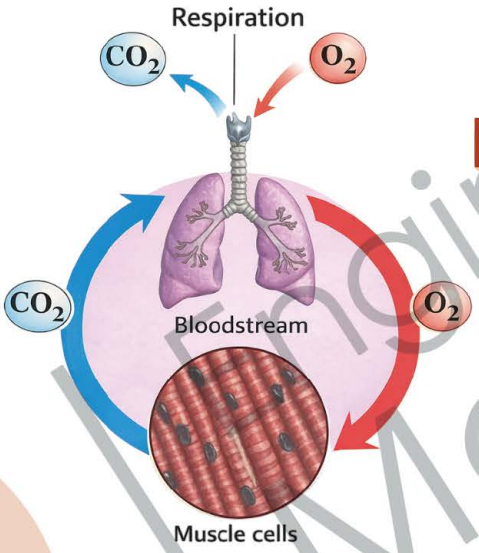
Fourth The Lungs

- **The lungs contribute to the process of excretion by eliminating gaseous wastes (carbon dioxide and water vapor) produced during cellular respiration**

① Body cells use **oxygen** gas and glucose to produce energy, resulting in carbon dioxide gas and water.



Role of the Lungs in Excretion

② **Carbon dioxide gas** is transported from the cells to the blood, which carries it to the lungs to be expelled from the body with exhaled air.

Note

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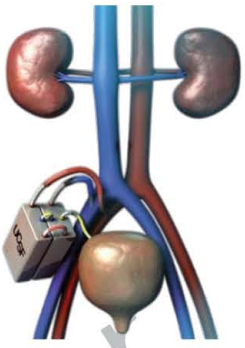
- Regular breathing is necessary to maintain the **balance** of gases in the blood and thus help preserve the body's internal balance, because the accumulation of carbon dioxide in the blood increases its acidity, which disrupts enzyme activity and threatens vital processes in the body.

NOTE

Technological Applications Related to Excretion

1 Artificial Kidney (Dialysis Machine)

▶▶ Importance



- **It is considered one of the most important modern medical technological applications. It is used in treating kidney failure and works as a substitute for the patient's kidneys, where the patient undergoes dialysis sessions to perform the functions of the natural kidney.**

▶▶ How it works

- **The artificial kidney operates based on physical and biological principles, as follows:**

Physical Principle

It mainly **depends on** the filtration process, where blood passes through a semi-permeable membrane :

- This membrane allows small molecules, such as water, salts, urea, and waste products, to pass through into a cleansing fluid.
- On the other side of the membrane, the passage of proteins and **large blood cells** is prevented.

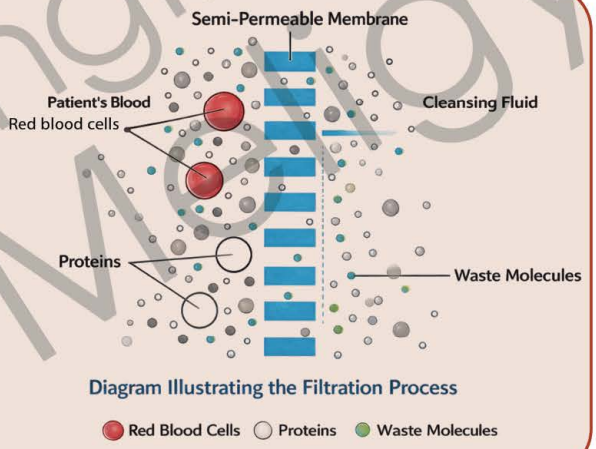


Diagram Illustrating the Filtration Process

Biological Principle

It is based on cell engineering, as the artificial kidney contains specialized living cells that are genetically engineered to perform some of the **functions** of **natural kidney cells,** such as:

- Secreting important compounds
- Regulating levels of specific salts

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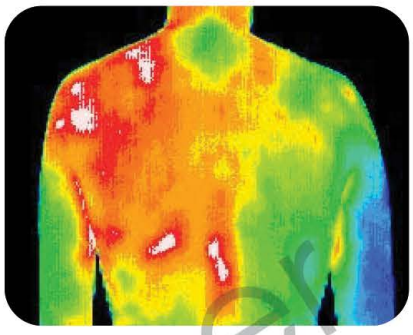
Conclusion

- The presence of specialized cells alongside filtration units ensures accurate regulation of blood balance.

2 Thermal Physics and the Function of Sweat Glands

▶▶ Application

- Thermal radiation measuring devices using infrared rays (Infrared Thermography)



▶▶ Importance

- These devices are used to monitor the body's internal thermal balance.
- The process depends on detecting the amount of heat emitted from the body as infrared radiation, which helps estimate the rate of heat loss through sweating.

This is considered a practical application of the concepts of thermal balance and evaporation.

3 Physics of Ultrasound from the Kidneys and Bladder

▶▶ Application

- Ultrasound devices (Ultrasound)

▶▶ Importance

- Used to image internal organs to form a clear picture of their condition, especially excretory organs such as the kidneys, ureters, and urinary bladder.
- This helps in diagnosing kidney stones or infections without the need for surgical intervention.which helps estimate the rate of heat loss through sweating.

▶▶ How it works

- **These devices depend on the properties of waves, such as:**

Reflection of Waves

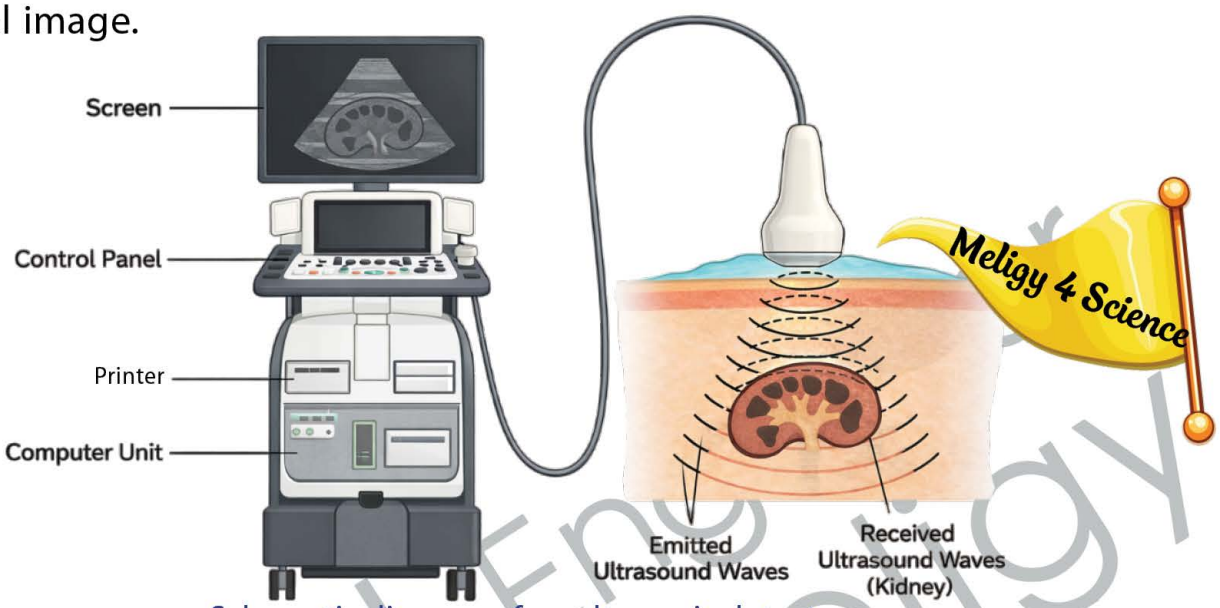
- Ultrasonic waves are reflected when they strike the boundaries separating different tissues, such as the wall of the urinary bladder or a solid object like kidney stones.
- The strength of the reflected waves depends on the acoustic resistance of the tissue.

Scattering of Waves

- Occurs when waves strike irregular surfaces or small particles inside tissues, which helps in revealing fine details of the organ.

Digital Processing

- The device measures the time taken for the waves to be sent and return (echo), and using the known speed of sound through tissue, it can accurately determine the position and depth of structures and convert them into a digital image.



Schematic diagram of an ultrasonic detector

NOTE

Cycles of Elements in the Biosphere

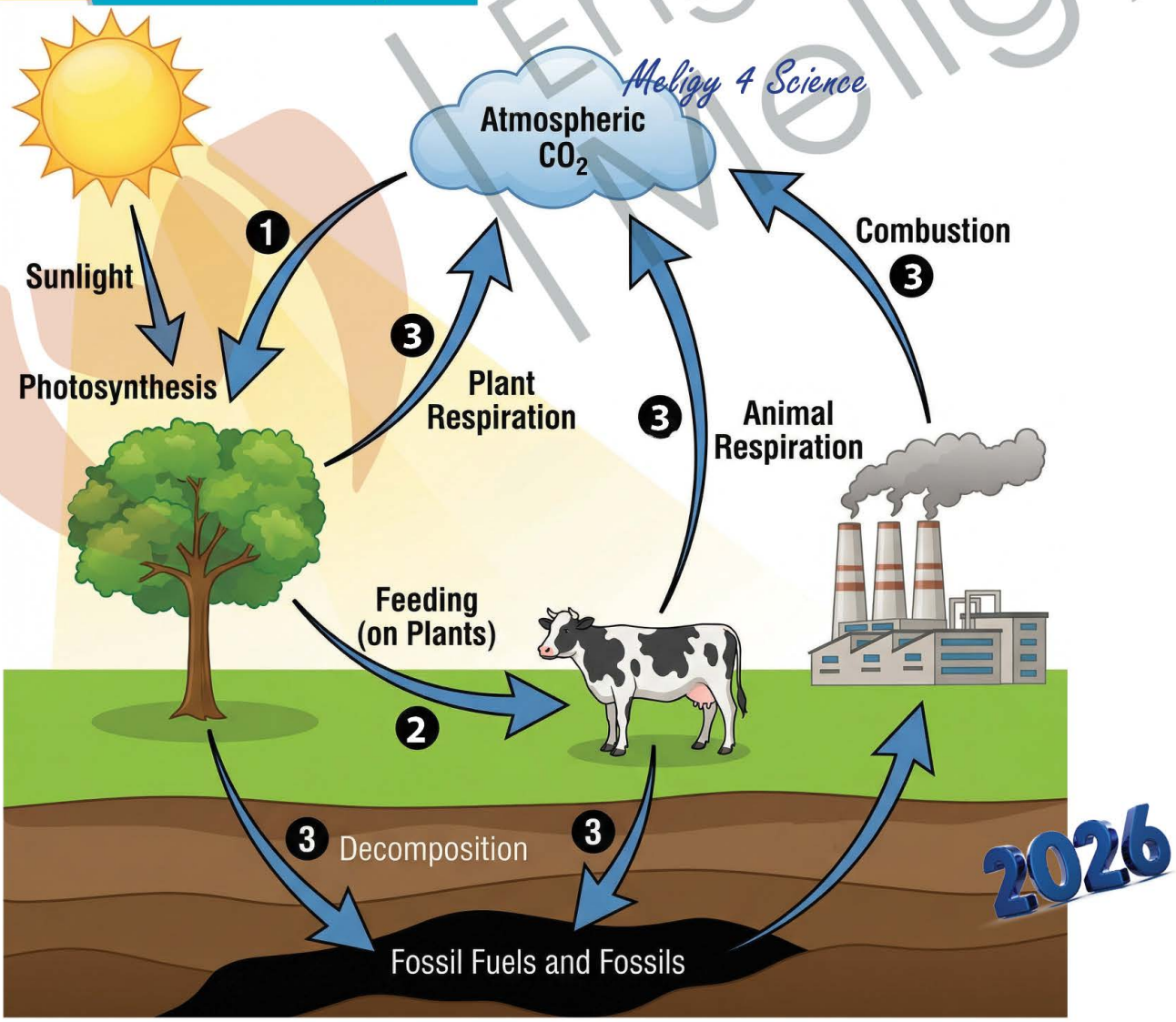
- The cycles of elements are essential for the continuation of life on Earth, **as** they include the recycling of elements between living organisms and the environment in a balanced way.
- Elements of the biosphere operate through continuous natural cycles that ensure the **survival of life on Earth.**

THE MOST IMPORTANT ELEMENTS

Carbon (C) | Nitrogen (N) | Phosphorus (P)

These elements enter successive cycles through which they move between air, water, soil, and living organisms.

First The Carbon cycle



1

Green plants absorb carbon dioxide from the atmosphere during the process of photosynthesis to produce food.

2

Organic compounds containing carbon are transferred to animals when they feed on plants.

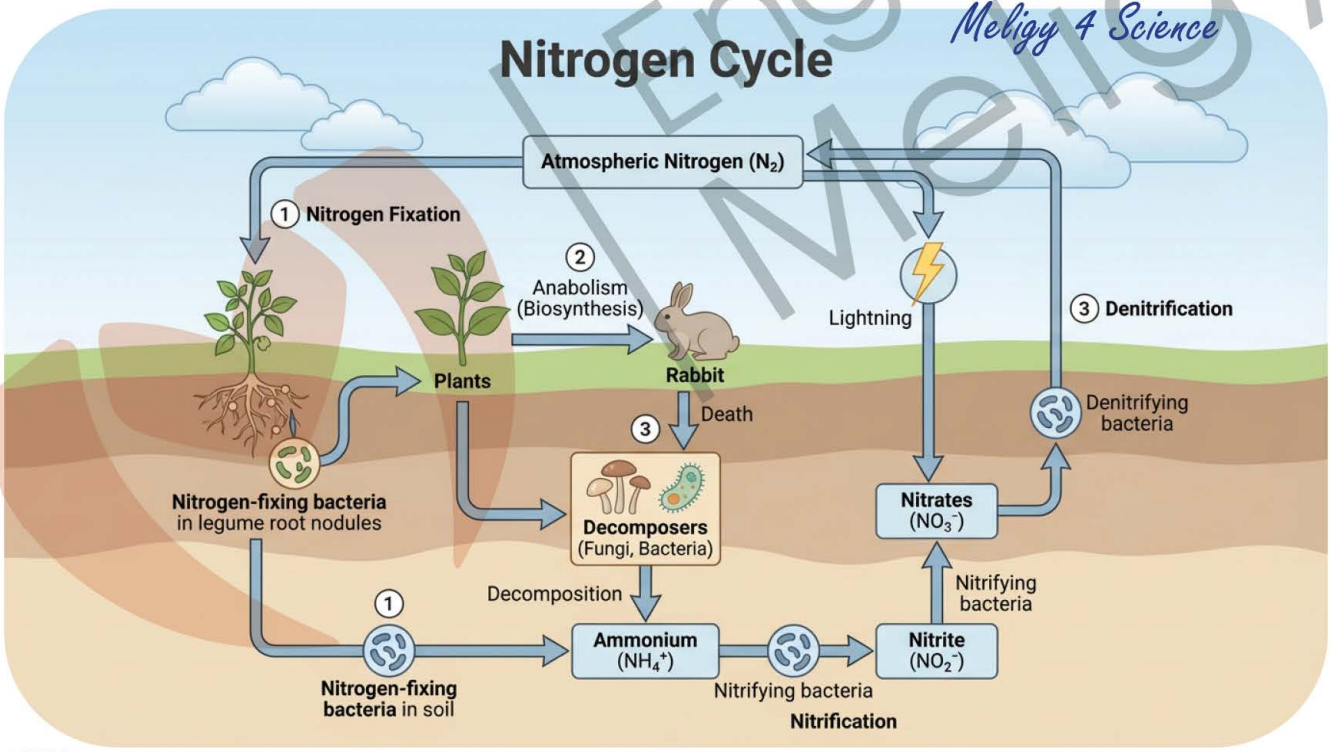
3

Carbon dioxide returns to the atmosphere in several ways, including:

1 - The release of CO_2 when living organisms respire or decompose.

2 - The emission of large amounts of carbon dioxide from factories and the burning of fossil fuels into the air.

Second The Nitrogen Cycle



1

The nitrogen cycle begins with the fixation of atmospheric nitrogen by soil bacteria, converting it into compounds that can be absorbed by plants.

2

Nitrogen compounds are transferred to animals through feeding.

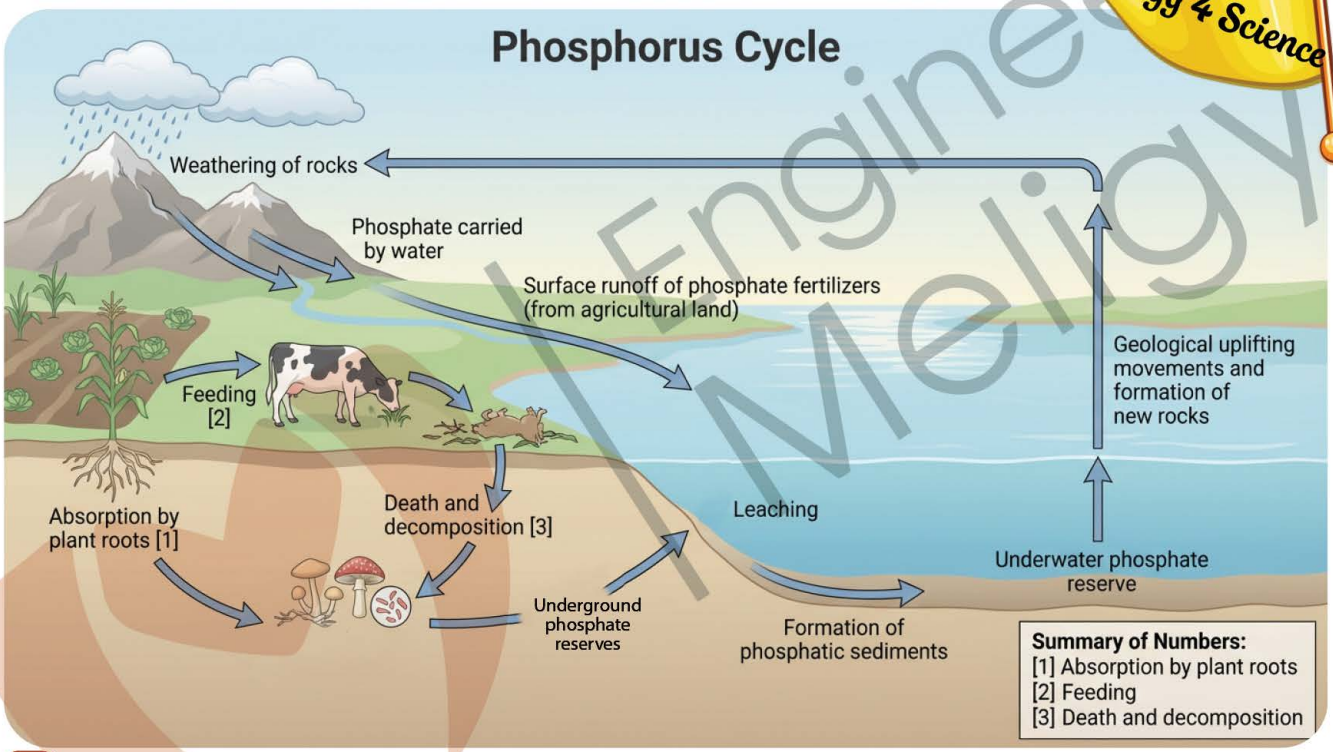
3

- Nitrogenous compounds return to the soil through waste products and the decomposition of dead organisms.
- Certain types of bacteria convert these compounds back into nitrogen gas, which is released into the atmosphere again.

Note

Nitrogen compounds are essential components of **proteins** inside living organisms.

Third The Phosphorus Cycle



1

Phosphorus compounds are found in phosphate rocks, and plants absorb them after they are released from rocks through weathering processes.

2

Phosphorus compounds are transferred to animals through the food chain, where they are used to form bones, teeth, nucleic acids (DNA and RNA), and energy molecules (ATP).

3

When living organisms die or through their waste, decomposers return phosphorus to the soil to be reused by plants.

Note

The phosphorus cycle **differs** from the carbon and nitrogen cycles in that it does not include the atmosphere; instead, it occurs between the **lithosphere**, **hydrosphere**, and **biosphere**.

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What We Conclude

- The excretion process is not limited to the removal of wastes from living organisms; it also represents an important link in the continuation of natural element cycles.
- **Excretory wastes, such as** carbon dioxide and urea, re-enter the carbon and nitrogen cycles in nature.
- For example, urea decomposes in soil by bacteria into ammonia **(NH_3)**, then into nitrate **(NO_3^-)**.
- Excretion processes and natural cycles together help maintain ecological balance and **sustainability** of the biosphere, allowing different forms of life to continue.

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NOTE

LESSON 4

Sensation and response, and their roles in the interaction of living organisms with the biosphere

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WHAT ARE SENSATION AND RESPONSE?

▶ **Sensation:**

The ability of living organisms to detect changes (stimuli) in the environment.

▶ **Response:**

The reaction of the organism to these stimuli.

- **These processes help organisms:**
  - (A) Survive
  - (B) Adapt to environmental changes
  - (C) Keep balance inside their bodies

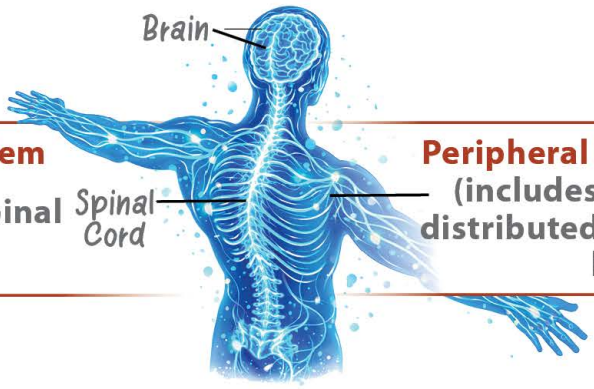
Together, they help maintain balance in the biosphere.

THE NERVOUS SYSTEM

- **The nervous system controls sensation and response** GR ?

As the nervous system is responsible for receiving information from the surrounding environment, processing it, and then issuing appropriate responses

- **Consists of ....**



Central Nervous System
(Includes brain and spinal cord)

Peripheral Nervous System
(includes all the nerves distributed throughout the body)

Function of Nervous system

1▶ **Receives signals from senses**
2▶ **Processes information**
3▶ **Sends commands to the body**
4▶ **Controls voluntary and involuntary actions**

Note *Meligy 4 Science*

Peripheral Nervous System connect the central nervous system to the other organs

1 Nerve Cells (Neurons)

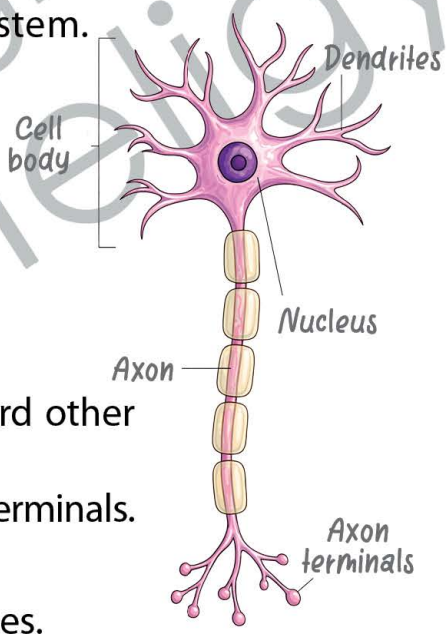
- Nerve cells are the **basic unit** of the nervous system.
- **Parts of a nerve cell:**

Cell body
- Contains nucleus and cytoplasm.

Dendrites
- Receive signals.

Axon
- Carries signals away from the cell body toward other cells or toward muscles and glands
- At the ends of it, there are branches called axon terminals.

Axon terminals
- Transmit signals to other cells through synapses.



- **Types of Nerve Cells:**

Nerve cells are classified according to their function into....

Type	Function
Sensory neurons	Carry signals from receptors to the Central Nervous System
Motor neurons	Carry commands from Central Nervous System to muscles and glands
Connecting neurons	Link sensory neurons with motor neurons

2 Transmission of Nerve Impulse and Membrane Potential

- **The distribution of ions inside the neuron differs from the outside across the cell membrane of the nerve cell according to the state the cell is going through**
- **The states that the nerve cell goes through are :**

1 Resting State (Polarization)

▶ **When the neuron is not stimulate (not excited) :**

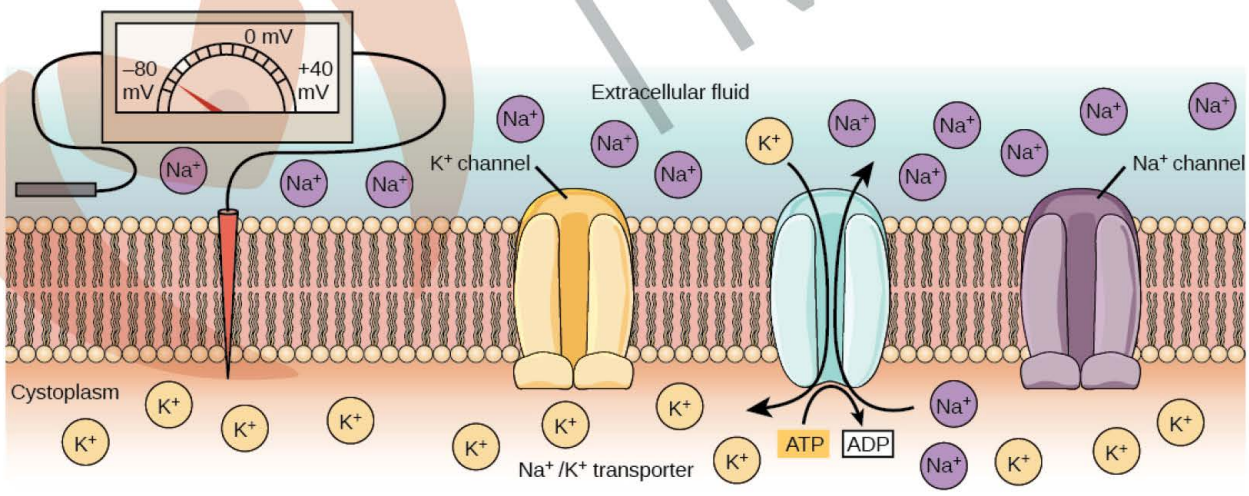
- There is a difference in ion concentration inside and outside the nerve cell.

Na^+ (sodium)	While	Potassium ions (K^+)
Higher outside the cell		Higher inside the cell

- This creates a potential difference ≈ **–70 mV** called **Membrane potential,** and the cell said to be in a **polarization state.**

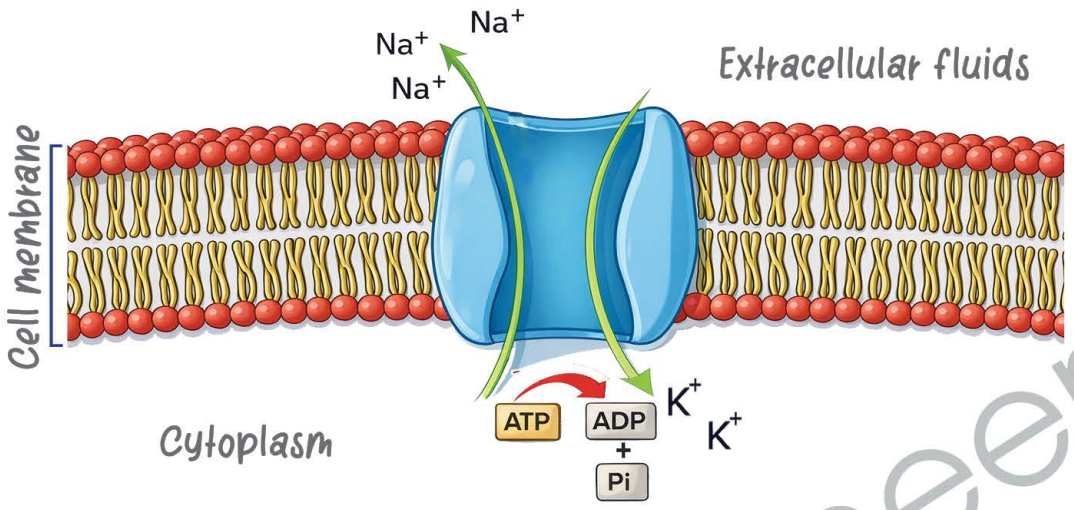
Polarization State

The state of the cell membrane of nerve cell **at rest**, where the outer surface of the membrane is **positive** and the inner surface is **negative**, due to the different distribution of ions inside and outside the cell.

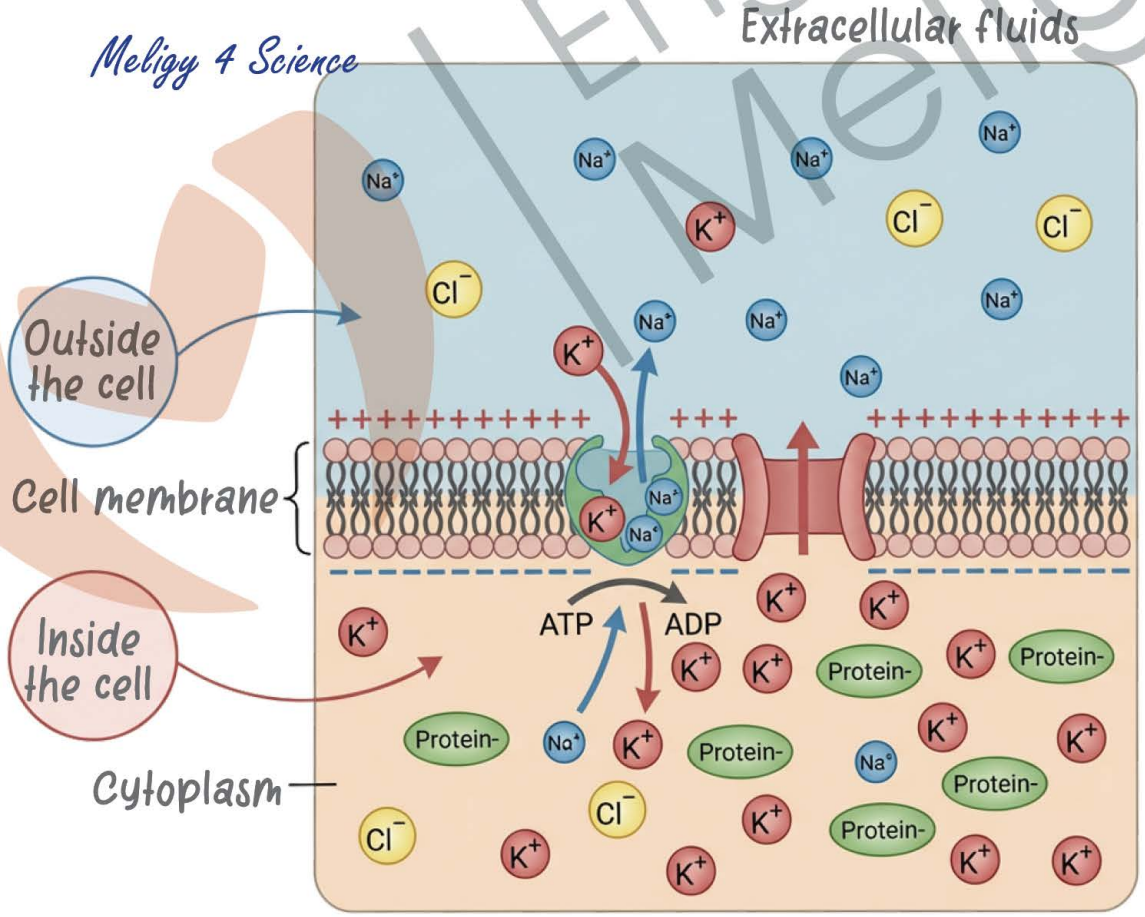


▶ **The potential difference results from three main mechanisms:**

Selective permeability of the membrane	Unequal distribution of ions	Sodium–potassium pump
Allows K^+ ions to exit at a higher rate than Na^+ ions to enter the cell	Concentration of -ve ions (as chloride ions) and proteins is higher **inside** the cell **than outside**	Uses ATP energy where each ATP molecule is used to pump **three Na^+ ions** out the cell for **two K+ ions** to enter the cell.



Sodium–potassium pump



Resting membrane potential

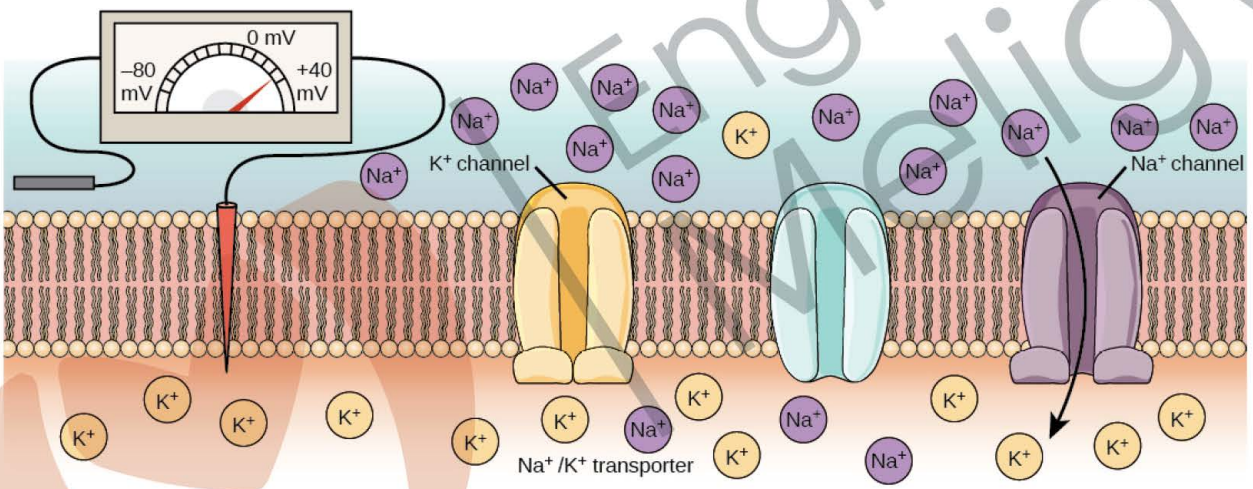
2 Excitation State (Depolarization)

▶ **When the nerve cell recieves a stimulus strong enough to stimulate it :**

- Special channels in the nerve cell membrane open **allowing** sodium ions (Na^+) to move at a rapid rate into the cell.
- **As a result**, The inside of the cell becomes **positive** and the potential difference reaches about **+40 mV**.
- The cell said to be in a depolarization state

Depolarization State

The state of the cell membrane of nerve cell in excitation state where the outer surface is **negative** and the inner surface is **positive** due to the rapid influx of sodium ions into the cell.



3 Repolarization

▶ **The first stimulated region of the cell membrane is repolarized when:**

- Sodium channels close to stop Na^+ from entering the cell.
- Potassium channels open to allow K^+ to exit the cell.

▶ **As a result :**

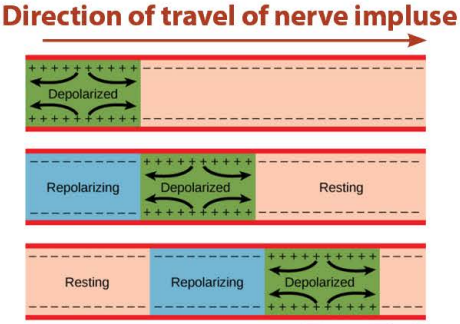
- Outer surface of the membrane is positive and the inner surface is negative.
- The potential deffirence returns to its previous value **(≈ −70 mV)**

▶ **Depolarization acts as a stimulus for the surrounding area,**

- Causing changes that are exactly similar to those that occur when the nerve cell is stimulated for the first time,
- Thus what is known as a **'nerve impulse'** is transmitted.

Nerve impulse

Signals (impulses) that propagate along the length of the neuron's axon through depolarization, followed by repolarization, and then resting.



REFRACTORY PERIOD

▶ **After repolarization:**

- The nerve cell does not respond to a new stimulus for short period of time **(about 0.001–0.003 seconds)**
- This period is called **Refractory period**

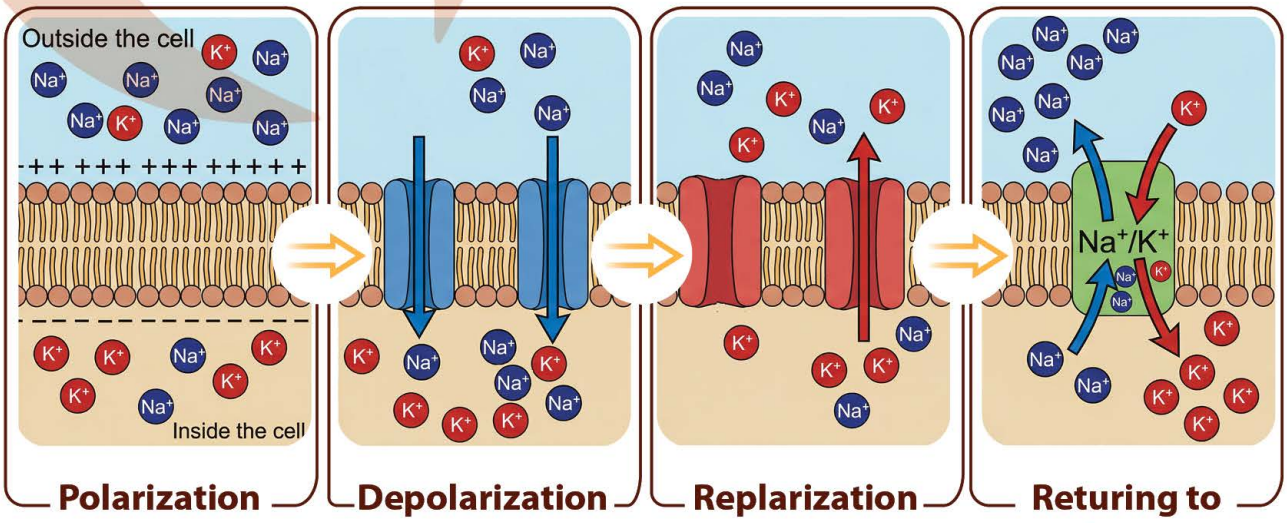
▶ **After this period:**

- The cell regains its ability to respond to another stimulus.

Refractory Period

A short period after each nerve impulse during which the cell does not respond to a new stimulus until it recovers the state it was in at rest.

CHANGES OCCUR TO THE NERVE CELL



3 The Synapse (The Chemistry of Neural Communication)

WHAT IS A SYNAPSE?

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- The nerve impulse does not pass directly from one neuron to another.
- **Instead,** it travels through a junction called **synapse**

Synapse

A junction through which the nerve impulse passes from the end of a nerve cell to the next one.

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- Each neuron forms many synapses with other neurons.

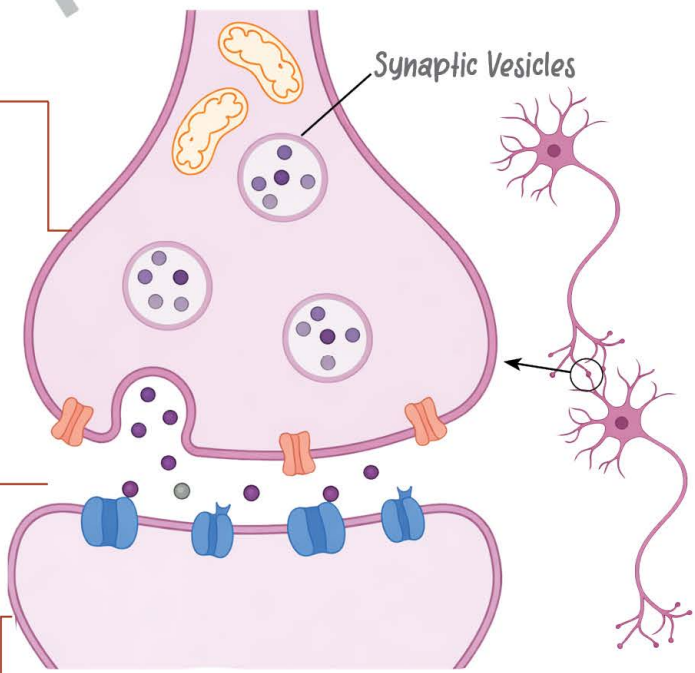
EX

A **Purkinje cell** in the brain can receive signals from about 200,000 synapses at the same time to produce one coordinated response

WHAT ARE THE COMPONENTS OF SYNAPSE?

1 Synaptic Knob (Presynaptic Membrane)

- A swelling at the end of the signaling cell's axon.
- Inside it are small sacs called "Synaptic Vesicles" containing chemical neurotransmitters such as: **Acetylcholine** and **Noradrenaline**.



2 Synaptic Cleft

A very minute space **(0.02 - 0.03 microns)** between the two adjacent cells.

3 Postsynaptic Membrane

It is the part of the cell membrane **receiving the signal**.

MECHANISM OF IMPULSE TRANSMISSION ACROSS A SYNAPSE

1 Step 1: Arrival of the Nerve Impulse

When the nerve impulse reaches the axon terminal:

- Calcium ion channels open.
- Ca^{+2} ions enter the synaptic knob

2 Step 2: Release of Neurotransmitters

- The entry of Ca^{+2} ions causes the release of Neurotransmitters into the synaptic cleft.

3 Step 3: Action of Neurotransmitter

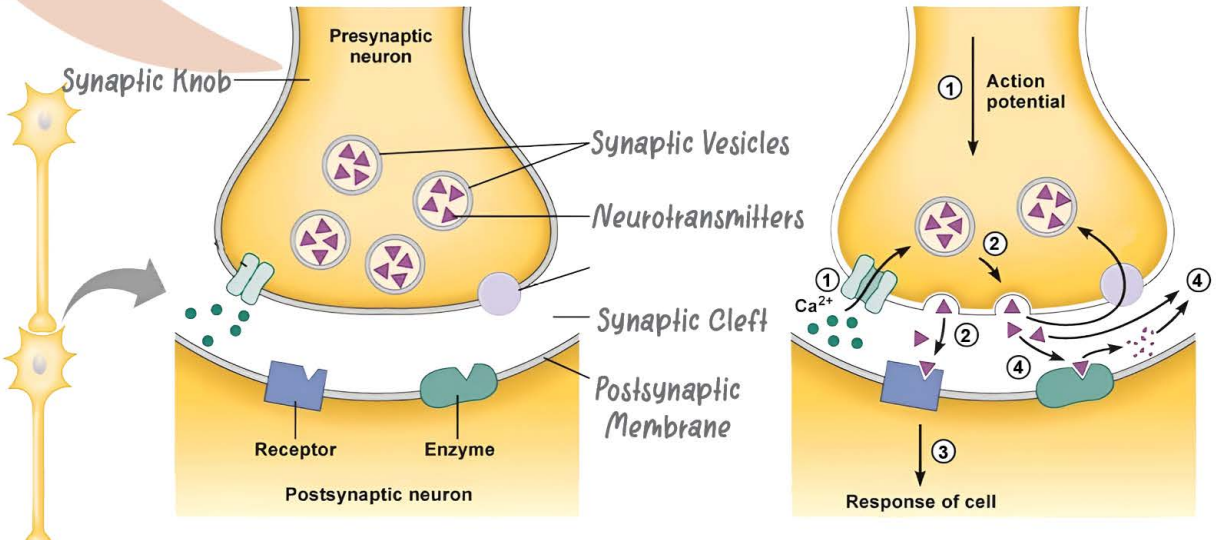
- Neurotransmitters diffuse across the synaptic cleft and bind to specific receptors on the next cell
- This binding opens sodium and potassium channels on the postsynaptic membrane and produces a new nerve impulse

4 Step 4: Termination of the Signal

After neurotransmitters (e.g. Acetylcholine) finish their role:

- They are broken down by specific enzymes.
- So, The postsynaptic membrane returns to its resting state.

Thus, nerve impulses travel through the nervous system with high precision and speed, enabling the body to respond to stimuli.



Technological Applications

Nerve Conduction Velocity (NCV) Test

- **A diagnostic test used to examine Nerve function and integrity**
- **It helps to:**
  - Detect nerve damage
  - Identify nerve and spinal cord disorders
  - Determine the location and severity of nerve injuries
- **How is the NCV Test Performed?**

1- Surface electrodes are placed on **the skin** over **specific nerves**.

2- **Small electrical impulses** are applied to stimulate the nerves.

3- The nerve responses **recorded**, **measured** and **analysed**

This technique needs no surgery or injections, so it's Generally safe

4 Effect of nervous system on biosphere

The nervous system plays a vital role in maintaining homoeostasis in living organisms and stability of biosphere, as:

- Its signals **regulate various vital activities** to ensure the body's rapid and accurate response to environmental changes which contribute to maintaining the internal balance of living organisms
- It **maintains the stability of the biosphere**, where the balanced interaction between organisms and their environments remains the basis for the continuation of life on Earth

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LESSON 5

Applications of nanotechnology and the sustainability of the biosphere

- Advances in science allow humans to observe what is smaller than cells, and control matter at the molecular and atomic levels.
- This led to the development of nanotechnology, which changed how humans interact with the biosphere.

▶ **Nanotechnology helps solve major problems in:**
Medicine, **Energy**, and **Environment**.

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EX

- **One of the biggest medical challenges was treating cancer cells without harming healthy cells.**

Traditional treatments		Nanotechnology Solution
Chemotherapy and radiation kill cancer cells but also damage healthy tissues and cause severe side effects	Which developed into	Cancer drugs are enclosed in targeted nanoparticles. that move directly to cancer cells and release the drug only at the tumor site

- **Results:**
  - ▶ Higher treatment efficiency
  - ▶ Fewer side effects
  - ▶ Less damage to healthy tissues

1 Concept of Nanotechnology

The word nanotechnology consists of 2 parts

Nano

Derived from the Greek word (Nanos) which means dwarf

Technology

Means The practical usage of knowledge in a certain field.

Nanotechnology

The technology of dealing with materials in infinitesimally small dimensions measured at nanoscale to produce materials with new and unique properties.

- **Nanomaterials are materials in which:**
  - At least one dimension is between 1 and 100 nm
  - **At this scale:** Materials show properties different from their normal size

Note

Nanometer is the measuring unit of the extremely small dimensions (materials at the nanoscale) , where it's is part of 1000 million (billion) parts of meter.

$1\ nm = 10^{-9}\ m$

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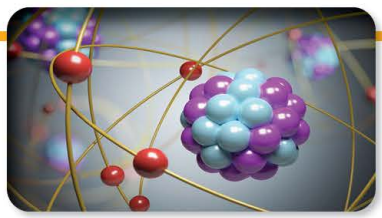
▶ **Some examples that illustrate the scale of the nanometer:**

The diameter of a sand grain = 10^6 nm (1,000,000 nm)

The diameter of water molecule = 0.3 nm.



The diameter of an atom ranges from 0.1 to 0.3 nm.

Properties of Nanomaterials

- **When a material shrinks to this small size, its chemical and physical properties change, such as :**

Color | Hardness | Solubility | Electrical conductivity | Melting point

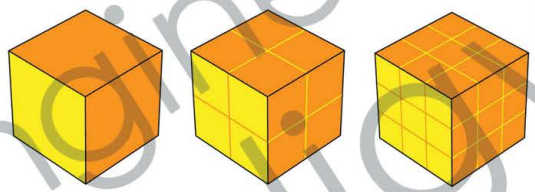
- The material properties change due to **two** main factors:

1. Increased surface area to volume ratio
2. Quantum effects

1 Increased surface area to volume ratio

- When particles become very small Their surface area increases greatly compared to their volume and their ability to react increases

EX Granulated sugar dissolves faster than a sugar cube (because its larger surface area increases the chances of contact and collisions between the water and sugar molecules)



Larger surface area = higher reactivity

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2 Quantum effects at the nanoscale

- Quantum effects appears when the dimensions of a particle converge with the wavelengths associated with the movement of electrons, causing the material to behave in entirely new way

▶ Examples on Nanoparticles

Nano-Gold

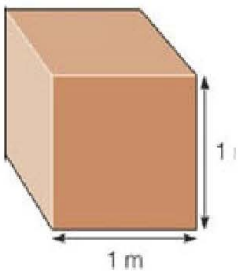
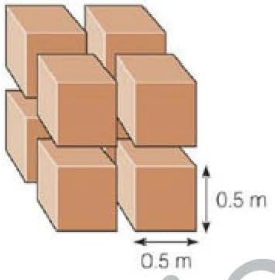
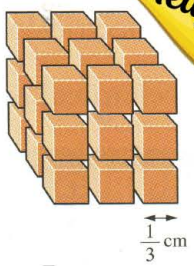
- Normal gold is bright yellow.
- At the nanoscale, Its color changes to red, orange, or blue, depending on particle size.

Nano-Copper

When copper is reduced to the nanoscale, Its hardness and strength increase compared normal copper

Illustrative example

- Assume that you have three cubes made of a given material, each with an edge length of 1 cm.
- Two of these cubes are divided into different numbers of smaller parts, resulting in a change in the ratio of surface area to volume, as shown in the following table.

Figures			
Length of the cube side (L)	1 cm	$\frac{1}{2}$ cm	$\frac{1}{3}$ cm
Number of cubes	1	8	27
total surface area = (L^2) × no. of cubes	$(1\ cm)^2 \times 6 \times 1 = 6\ cm^2$	$(\frac{1}{2}\ cm)^2 \times 6 \times 8 = 12\ cm^2$	$(\frac{1}{3}\ cm)^2 \times 6 \times 27 = 18\ cm^2$
Total volume = (L^3) × no. of cubes	$(1\ cm)^3 \times 1 = 1\ cm^3$	$(\frac{1}{2}\ cm)^3 \times 8 = 1\ cm^3$	$(\frac{1}{3}\ cm)^3 \times 27 = 1\ cm^3$
the ratio between the surface and the volume = Surface area / Volume	$\frac{6}{1} = 6\ cm^{-1}$	$\frac{12}{1} = 12\ cm^{-1}$	$\frac{18}{1} = 18\ cm^{-1}$

2 Nanochemistry

Nanochemistry

Branch of science that studies synthesis, characterization, and applications of nanomaterials, and focuses on understanding why materials behave differently at the nanoscale.

Note

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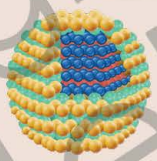
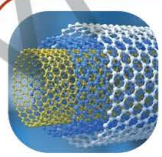
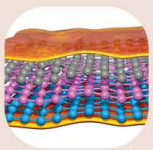
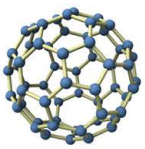
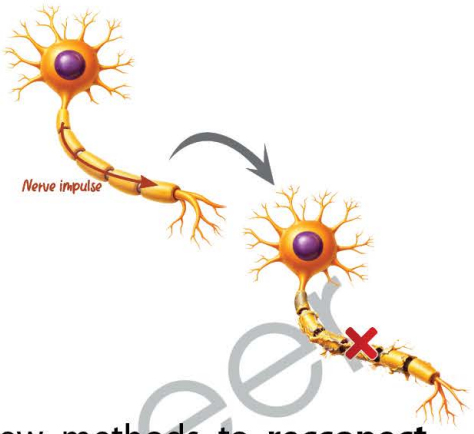
Any part of the material, no matter how small it is, has 3 dimensions (Length - Width - Height)

- **Nanomaterials are classifed according to its dimensions into :**

Type	Description	Examples
Zero-Dimensional (0D) Materials	- All dimensions are within the nanoscale. - They appear as very tiny particles or dots.	 Quantum dots  Nanoparticles (as Gold and Silver nanoparticles)
One-Dimensional (1D) Materials	- Only one dimension (**e.g. length**) is beyond the nanoscale while the other two dimensions (**width and height**) are within the nanoscale	 Carbon nanotubes  Nanowires  Nanofibers
Two-Dimensional (2D) Materials	- Two dimensions are beyond the nanoscale (large surface area) while only its thickness dimension is within the nanoscale - They appear as **thin sheets** or **layers**.	 Graphene  Thin films  Nanolayers
Three-Dimensional (3D) Materials	- All dimensions are beyond the nanoscale, but they are composed of nanoscale building blocks or have nanoscale pores or grains.	 Porous nanomaterials  Polycrystalline nanomaterials (nanocomposites)

3 Examples of nanotechnology applications in biosphere

FIRST : NERVE CONDUCTION USING NANOMATERIALS



- Nerve impulses travel through nerve cells as **electrical signals** that pass from one neuron to another across **the synapse,** allowing the body to respond rapidly to different stimuli.
- **If a part of this pathway is damaged,** the nerve signal cannot pass through the damaged area, causing loss of sensation or movement in the injured part.
- Nanoscience has enabled scientists to develop new methods to **recconect damaged nerves** to help nerve impulses to pass again through injured areas, almost as if the nerve were not damaged.

Electrically conductive nanomaterials

- **Electrically conductive nanomaterials are used to transmit nerve signals, such as:**
  - ▸▸ **Carbon nanotubes**
  - ▸▸ **Nanowires**

▸ **Working mechanism :**

- Nanomaterials conduct electrical impulses in a way similar to healthy nerve fibers.
- When carbon nanotubes or nanowires are placed between the two ends of a cut or damaged nerve ,they form a nanobridge that allows electrical nerve impulses to pass from one end to the other.

▸ **Results :**

- Helps gradually restore movement or sensation.

Neural Nanotech Interfaces

- **Neural Nanotech Interfaces are used to** record nerve impulses and transmit the signals to external devices such as:
  - ▸▸ **Smart prosthetic limbs**

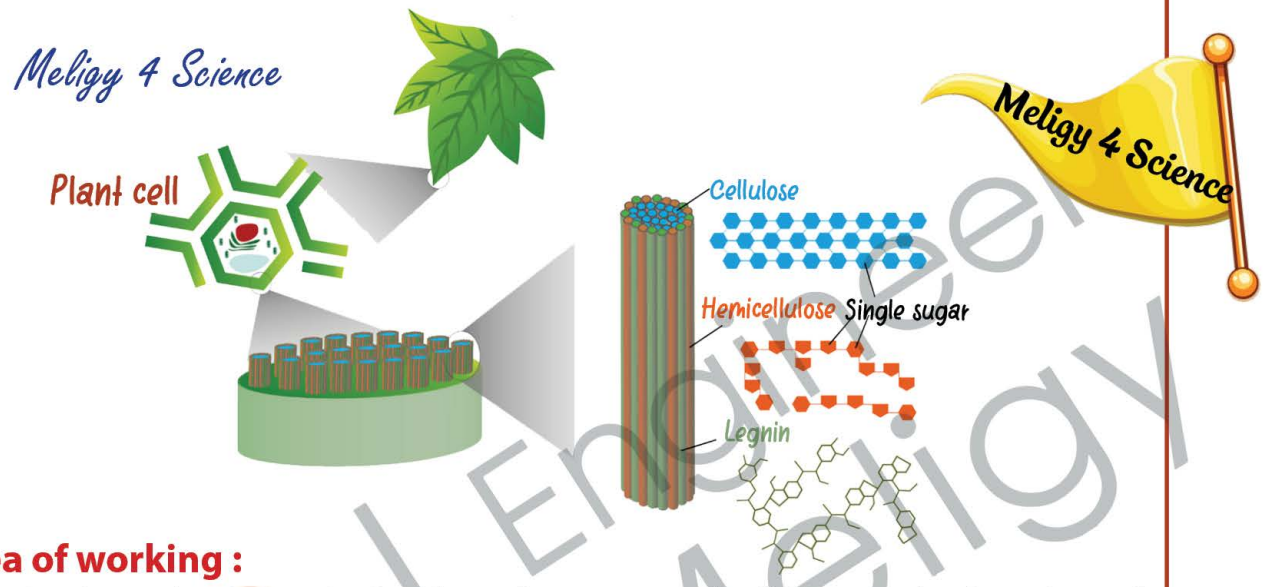
▸ **Applied Example :**

- Scientists have implanted **nanochips** in the brains of paralyzed patients that capture nerve impulses then send them to a computer or prosthetic limb
- **As a result:**
  Patients can move artificial limbs Or communicate with devices just by thinking

SECOND : BIOFUEL CELLS AND NANOTECHNOLOGY

Biofuel cells

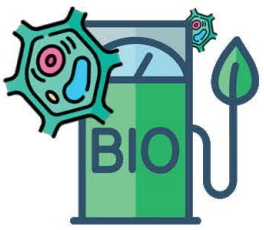
- **Biofuel cells are a prime example of mimicking biological processes in technology.**
- **They are devices that produce energy in a way similar to cellular respiration.**



▶ Idea of working :

- Scientists have drawn inspiration from the process of **cellular respiration**, through which living cells **produce energy from food**.
- **In this process**, glucose is oxidized inside the mitochondria in the presence of oxygen to produce energy molecules (ATP) that cells use to carry out their various activities.
- This concept has been applied to design **clean** and **safe energy-generating devices**, which can be used to operate medical devices implanted in the human body by utilizing glucose present in the blood as a source of energy.

▶ Similarities and differences between living cells and biofuel cells:

Similarities		Differences
Glucose is oxidized (loses electrons). Energy is released.		Living cells produce ATP, while biofuel cells convert chemical energy directly into electrical energy that can be used to power devices.

▶ Working mechanism of biofuel cell:

Biofuel cells act like sustainable batteries, <u>where</u> :

- **At the anode**, enzymes are used to oxidize glucose to release electrons and protons .
- **Electrons flow toward cathode**, creating an electric current similar to how electricity flows in wires to light a lamp.

Role of Nanotechnology in increasing biofuel cell efficiency

▶▶ **Nanotechnology greatly improves biofuel cell efficiency, where**

- **Carbon nanotubes** and **gold nanoparticles** are used to **coat electrodes.**
- These nanomaterials:

1 ▶ **Speed up chemical reactions**

2 ▶ **Improve electron transport**

3 ▶ **Act as electrical catalysts**

Note *Meligy 4 Science*

Their role is similar to enzymes in mitochondria, which speed up respiration reactions.

Unit 4

Lithosphere

LESSON 1

The Lithosphere and the Stability of Planet Earth

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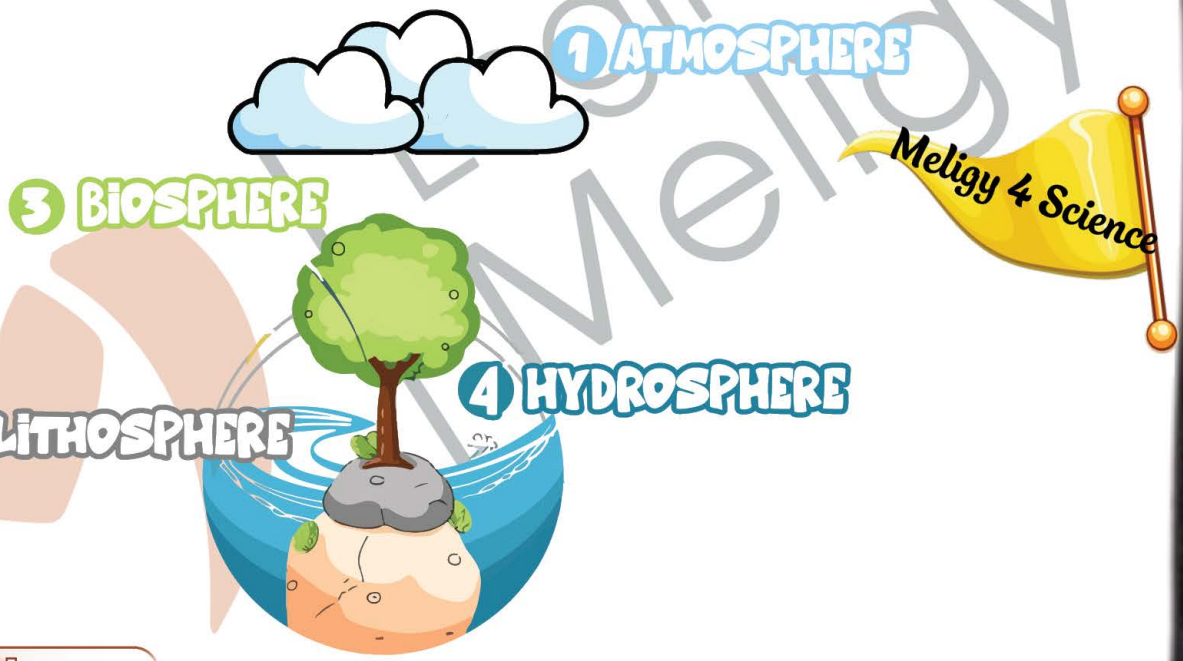
- The **lithosphere** represents one of the main spheres of the Earth, and it works in integration with the other spheres:



lithosphere

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It appears as fixed or static, but in reality, it is a **dynamic sphere** that changes **continuously** with time

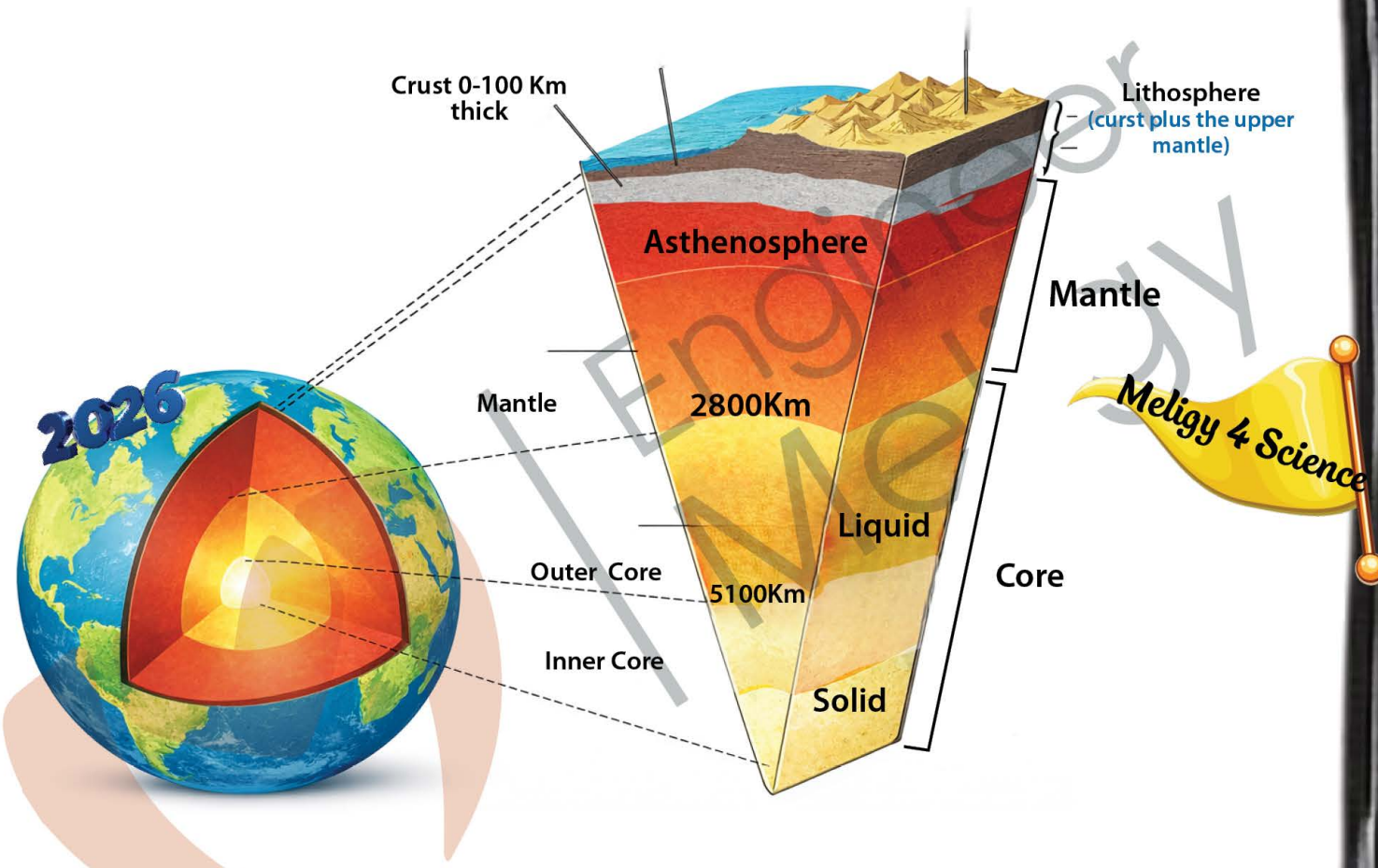
Factors that affect on lithosphere

1. Internal forces of the Earth.
2. External processes on its surface.

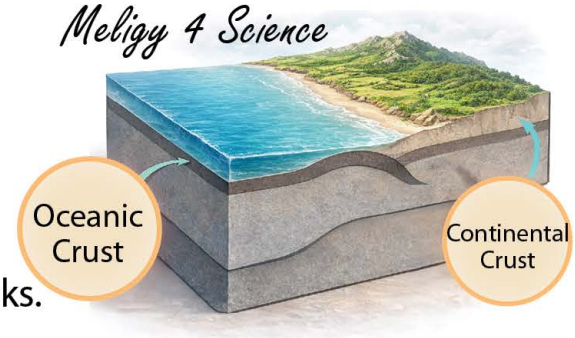
Zones (Layers) of Planet Earth

- Consists of three main zones that differ from each other which are :

1. The Earth's Crust
2. The mantle
3. The Core (Nucleus)



1- The Earth's Crust



Location

- It is the thin outer zone of the Earth

Composition

- Igneous, sedimentary and metamorphic rocks.

Volume

- (about 1% only) of the planet's volume.

- **The Earth's crust is divided into two main types that differ in density, thickness, and location:**

	A- Continental Crust	B- Oceanic Crust
Description	Rocks that represent land on the Earth's surface where atmosphere lies above it.	Rocks that is found beneath the oceans water and open seas
Thickness	It is thicker than the oceanic crust, ranging from 30 : 100 km	It is much thinner than the continental crust, as its thickness ranges between 3 : 5 km.
Formation	Rocks rich in silica and aluminum, known as **Sial rocks.**	Rocks rich in silica and magnesium, in addition to iron, known as **Sima rocks**.
Density	It is less dense than the oceanic crust due to the nature of its rocks and their chemical composition, as it is rich in aluminum.	It is denser than the continental crust as it is rich in magnesium and iron.

Continents rise and protrude above sea level due to the lower density of continental crust compared to oceanic crust.

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2- The mantle

Location

- Lies right **beneath** the Earth's crust

Composition

- Rocks rich in iron and magnesium silicates , in addition to iron, known as **Sima rocks.**

Mass

- It is the **largest** of Earth's zones in mass, as it represents about 67% (2/3) of earth's mass

- **It's dividies into : upper mentle and lower mantle that differ in density and other physical properties due to that change in pressure and temperture .**

1 ▶▶ Upper mentle

Upper part

- Lies **beneath** the Earth's crust
- Consists of solid rocks
- Shares with the Earth's crust in forming what is Known as the "Lithosphere"

lower part (Asthenosphere)

- Lies **beneath** the lithosphere
- Consists of semi-Molten rocks called (magma) and behaves like high viscosity fluids.
- It's the region where convection currents occur which are considered as the main driving force of tectonic plates **movement** above it

2 ▶▶ Lower mentle (Mesosphere)

Location

- Lies right **beneath** the Earth's crust

Physical state

- Its rocks are characterized by extreme solidity due to exposure to immense pressure that increases with **depth**.

NOTES

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- Although the temperature in the Mesosphere is extremely high , the high pressure in this zone keeps rocks in their solid state and prevent their melting ,which gives it unique physical properties different from that's of the asthenosphere

3- The Core

Location

- **Innermost** part of the Earth

Composition

- Iron and nickel.

Mass

- About **33 %** (1/3)% of the Earth's mass.

- **It's divides into**

A- Outer Core	B- Inner Core (center of earth)
State	
Molten liquid	Solid (due to immense pressure exerted on it by the surrounding spheres.).
Temperature	
Up to 5000°C	Very high. Density: High (highest density spheres).

Earth's Magnetic Field

Cause : Movement of molten iron and nickel in the outer core around the inner core.

Importance

1. **Protects Earth from harmful cosmic rays**
2. **Shields Earth from solar particles**

NOTES

Lithosphere

lithosphere

It is a **geological** unit that represents the rigid outer part of the Earth. It consists of the Earth's crust and the rigid **upper** part of the upper mantle.

NOTES

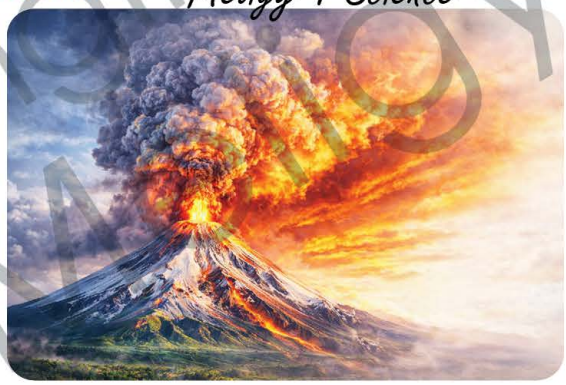
It is considered the geological surface on which most geological **phenomena** occur, such as the formation of landforms and the occurrence of volcanoes and earthquakes.

Location

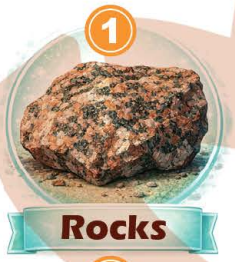
- Bounded by the atmosphere or the hydrosphere from above and the asthenosphere from below.

Thickness

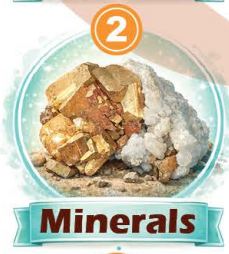
- Its average thickness is about 100 km.



Components of the Lithosphere



- The main structural material of the **lithosphere,**
- Forming the solid crust of the Earth.
- **Classified** into igneous, sedimentary, and metamorphic rocks.



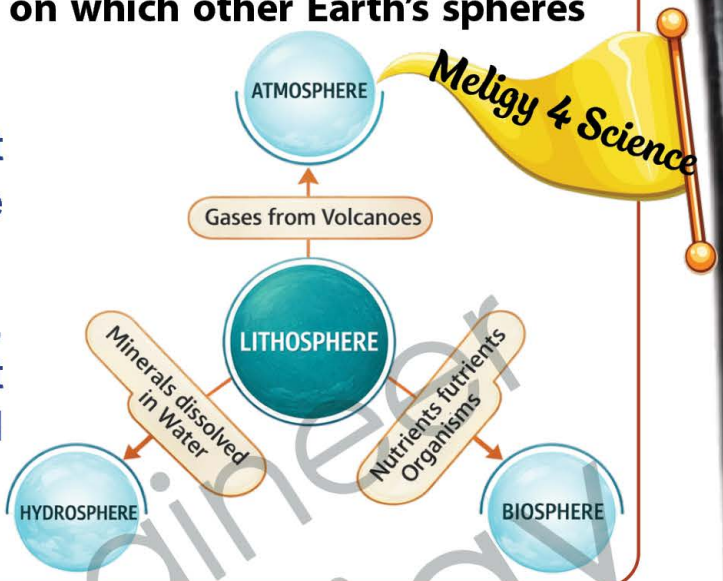
- Basic **building units** of rocks ,used in industry and construction.
- **Inorganic solid substances Naturally occurring** that have a definite chemical composition and a specific crystalline structure.

- A fundamental component of the **lithosphere**, used in agriculture and the natural ecosystem, as it nourishes plants and retains nutrients.

Importance of the Lithosphere to Other Earth's Spheres

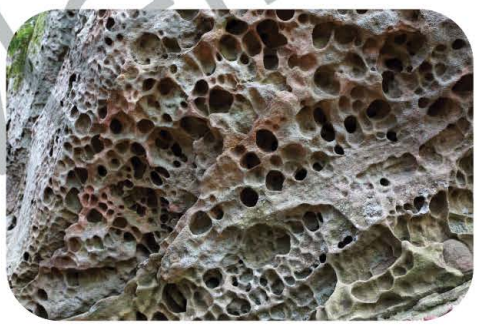
The lithosphere is the foundation on which other Earth's spheres depend, as it:

1. Forms the solid base that supports everything above the Earth's crust.
2. Provides physical, biological, and chemical processes that help maintain the stability and balance of the planet.



First Effect of the Lithosphere on the Atmosphere

- **The lithosphere affects the atmosphere through chemical reactions called (Chemical weathering). that occur to rocks.**



EX Regulating the concentration of carbon dioxide (CO_2) in the atmosphere through.

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- When silicate rocks, such as basalt and gabbro that are rich in calcium pyroxene ($CaSiO_3$).

Are exposed to ⇨ **Water (H_2O)** **Carbon dioxide (CO_2)**

- **Chemical reactions occur that break down the rocks.**

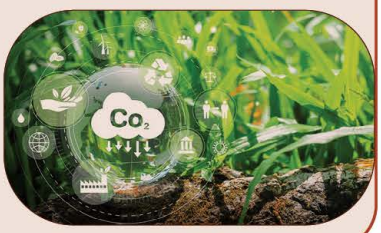
What Happens During Chemical Weathering?

Step	Process	Explanation
1	Release of calcium ions	Calcium ions (Ca^{2+}) are released from the rocks
2	Formation of bicarbonate	Calcium ions react with bicarbonate ions (HCO_3^-) formed during the reaction
3	Formation of calcium bicarbonate	Calcium bicarbonate [$Ca(HCO_3)_2$] is formed and dissolves in running water
4	Transport by rivers	Dissolved calcium bicarbonate is carried by rivers to the seas
5	Precipitation in seas	In the seas, it can later precipitate as calcium carbonate ($CaCO_3$) and become part of solid sediments

$$CaSiO_3 + \underbrace{2\,CO_2 + 3\,H_2O}_{H_2CO_3\ (\text{Carbonic Acid})} \rightarrow Ca(HCO_3)_2 + H_4SiO_4$$

Final Conclusion From these processes

- **We conclude that the lithosphere**
  - Helps **regulate** the composition of the atmosphere
  - **Reduces** atmospheric CO_2 levels
  - **Contributes** to reducing the **greenhouse** effect over long periods of time



NOTES

Second The Impact of the Lithosphere on the Hydrosphere

How Rocks Affect water

- When water passes through different rock layers, **some minerals** dissolve in the water
- This changes the salt concentration and dissolved elements in water, such **as:**

Iron (Fe) | Calcium (Ca) | Magnesium (Mg)

- **Although the lithosphere plays a role in supplying the hydrosphere with salts and elements necessary for life, but the increase in salt concentration can cause many problems including: Water hardness**

Water hardness

Is a property of water resulting from its **high concentrations** of positively charged ions, **especially** dissolved calcium (Ca^{+2}) and magnesium (Mg^{+2}) ions.

Causes

- Water passing through rocks rich in **calcium** and **magnesium** salts

Consequences

- **Soap** becomes less effective.
- **Limescale deposits** form in Boilers and Water pipes

What the Laws of Solubility Explain

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- **They explain**
  - Why water properties **differ** from one region to another.
  - Hard water is formed as a result of water passing over **rocks** rich in calcium and magnesium salts.
  - Supplying the **hydrosphere** with salts and elements necessary for **living organisms** and required for industry

Factors Affecting Minerals solubility in water

1. Nature of Chemical Bonds in Minerals
2. Water Temperature
3. Pressure on Water
4. Presence of Acids in Nature

1- Nature of Chemical Bonds in Minerals

- **The solubility of a mineral is affected by the type of chemical bonds present between its molecules. For example**

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	Ionic bonds	Covalent bonds
Solubility in Water	Dissociates and dissolves easily	Dissociates and dissolves very slowly
Example	Calcium carbonate ($CaCO_3$) in the calcite mineral, which forms the limestone rock. It dissociates in water, especially acidic water containing carbon dioxide.	Silica (SiO_2) in the quartz mineral, which forms the sandstone rock. Therefore, silicate rocks are more resistant to weathering

2- Water Temperature

Increasing water temperature → Leads to → Increased solubility of most salt and minerals.

EX
- **Hot spring** water dissolves more minerals
- When it cools, **minerals** are **deposited**.

Hot spring

3- Pressure on Water

Increased pressure → Leads to → Increased solubility of carbon dioxide (CO_2) in water → Leads to → Increased solubility of many minerals

EX

- **Increased pressure on deep groundwater leads to the dissolution of a high percentage of CO_2 gas in it, which**
  - Enhances the water's ability to dissolve many rocks.
  - High concentration of bicarbonate salts in water

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4- Presence of Acids in Nature

- **Rainwater dissolves atmospheric CO_2, forming carbonic acid (H_2CO_3)→(acidic rains).**

Increased acidity → Leads to → Increased mineral solubility.

Cave in limestone

EX

- **Acid rain increases the rate of ionic bond breaking such as calcite, which leads to the formation of caves and cavities in limestone .**

Conclusion

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- Solubility factors affect the quality of **drinking**, **agricultural**, and **industrial** water.
- Understanding these factors helps improve **water treatment** and **purification** systems.

Modern Applications: Zeolite

What is Zeolite?

- A **porous volcanic** rock used in water treatment.

How It Works

- **Acts as a natural filter.**
-Traps impurities and heavy metals inside tiny pores.

Porous volcanic rock (zeolite)

Importance

- **Improves** drinking water **quality**.
- Reduces the use of chemicals.
- Widely used in Europe and Asia.
- Helps **protect** the hydrosphere and supports sustainability

Third The Impact of the Lithosphere on the Biosphere

How the Lithosphere Affects Living Organisms

- When rocks are exposed to weathering agents, they gradually **break down.**
- These **agents** include

Rainwater OR Temperature changes OR **Weak acids** such as carbonic acid (formed when carbon dioxide dissolves in water)

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AS

1. **Rocks weather, their minerals decompose into ions**
2. **These ions are retained in the soil which acts as a natural production line that supplies plants with essential nutrients.**

NOTES

▶▶ Examples of Rocks Supplying Nutrients

Phosphate Rock

- Contains minerals rich in phosphorus.
- Chemical weathering releases phosphate ions (PO_4^{3-}) into the soil
- These ions are absorbed by plant roots and are essential for Growth and Energy transfer in plants

Granite Rock

- Contains the mineral feldspar.
- Feldspar decomposes and releases potassium ions (K^+).
- Uses of Potassium in Plants
  - Regulates the opening and closing of stomata.
  - Helps in energy production inside plant cells.

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Conclusion

- The **lithosphere** is a natural reservoir.
- It continuously feeds the biosphere through simple chemical reactions
- These reactions convert mineral elements into forms that plants can easily absorb with soil water.

NOTES

Tectonic plates

2026

Tectonic plates

These are **large** groups of massive rock pieces that resemble floating slabs and make up the **lithosphere**.

Causes of tectonic plates movement

- **The heat rising from the Earth's interior leads to**

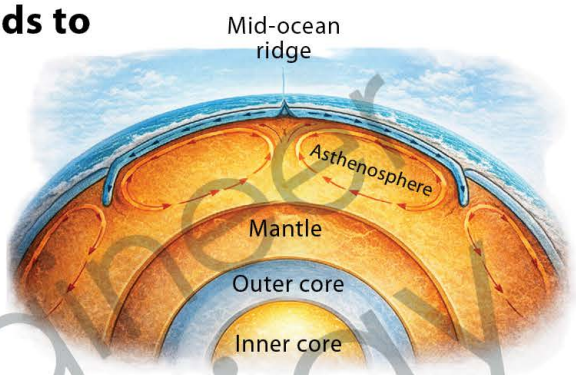
The formation of convection currents within the molten material (magma) in the asthenosphere.

These cause

The softer rock beneath the lithosphere to move.

As a result

The tectonic plates move slowly above them at a rate of a few centimeters per year.



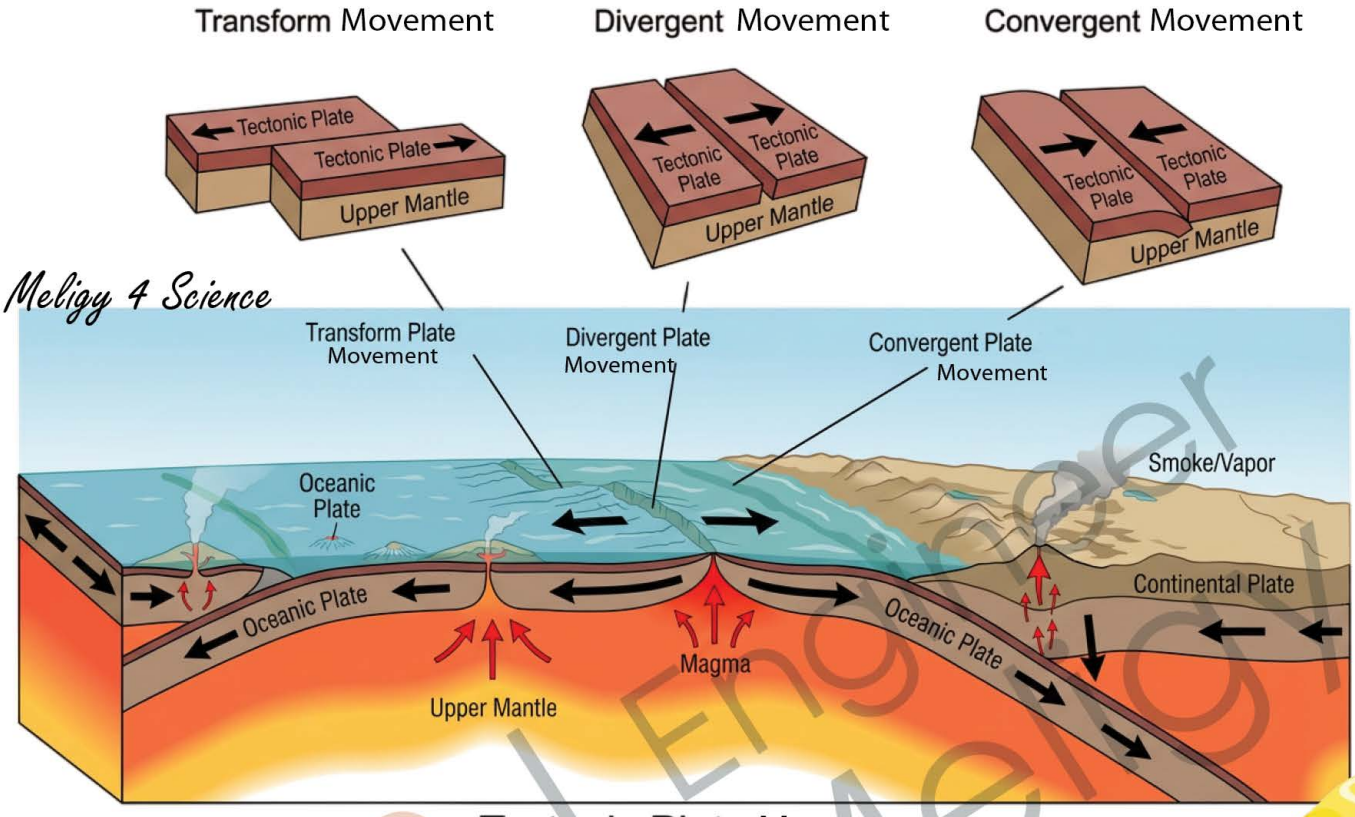
Convection currents in the mantle

Importance of Tectonic Plate Movement

1. **Continuously reshapes the Earth's surface, as its effects are clear and significant, even though it is slow**
2. **Helps maintain the Earth's geological balance**

NOTES

Types of Tectonic Plate Movement



Tectonic Plate Movement

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First Convergent Movement

- **Occurs when two tectonic plates move toward each other and collide.**

Result

- Rocks are compressed and pushed upward
- This leads to the formation of high mountain ranges

EX

- **Himalayas mountains**

Himalayas mountains

Second Divergent Movement

- **Occurs when two tectonic plates move away from each other.**

Result

- Cracks and fissures form in the Earth's crust.
- Magma rises from the Earth's interior

The African Rift

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EX

- **Volcanic mountains or volcanic islands**
- **New ocean floor.**
- **Rift valleys, such as the African Rift**
- **Widening of coastal valleys.**

Third Transformational Movement

- **Occurs when two tectonic plates slide past each other.**

Result

- The movement of one of the plates may be hindered
- Causing energy to accumulate and be released suddenly released as earthquakes
- Faults are formed.

EX

- **San Andreas Fault in the United States.**

San Andreas Fault

NOTES

NOTES

LESSON 2

The materials that make up the lithosphere and their role in the stability and continuity of the Earth

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What is the Lithosphere

- The **lithosphere** is the outer solid layer of the Earth
- It is made up of **rocks**.
- Rocks are made up of **minerals**.
- Minerals are made up of **elements**.

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Order

Lithosphere → Rocks → Minerals → Elements

A Minerals

Minerals

A naturally occurring, inorganic solid with a **fixed** or **semi-fixed** chemical composition and a regular crystalline structure that gives it distinctive physical properties.

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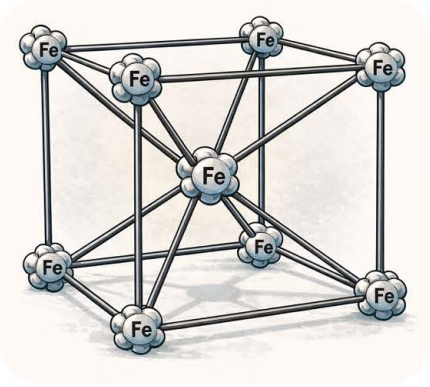
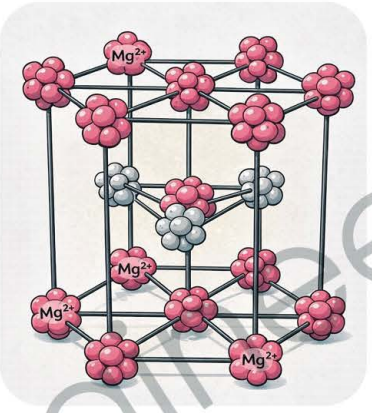
Importance of Minerals

1. Minerals are the basic building blocks of rocks.
2. Rocks make up the lithosphere.



Iron crystal lattice



Magnesium crystal lattice

Intetraction of Minerals with the Environment

- Minerals in rocks interact with water, air, and living organisms, leading to

- **By studying the materials that make up the lithosphere, we can understand how the lithosphere remains balanced and continues to perform its vital and engineering role on Earth**

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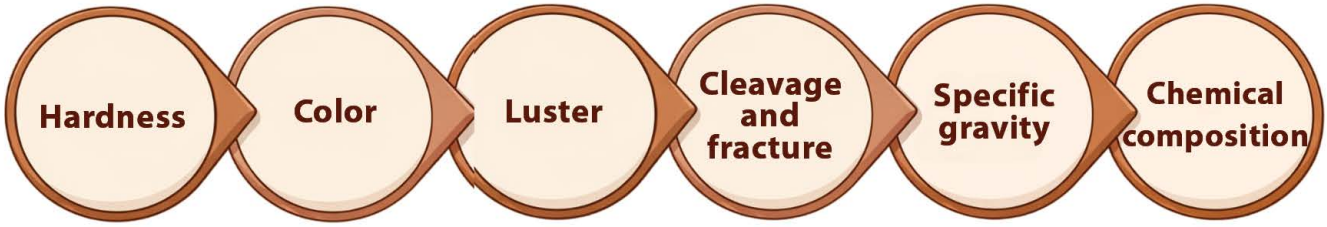
Properties of Minerals and Rocks

- Rocks differ from each other according to the minerals they contain.



1- Hardness

Hardness

A physical property shows how **resistant** a mineral or rock is to scratching

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Measuring Hardness

- **Hardness is measured using the Mohs scale.**
- **The scale ranges from**
  - **1 → Softest**
  - **10 → Hardest**

Examples of Mineral Hardness

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1- Gypsum

- Low hardness (about 2)
- Soft mineral
- Easy to crush
- Scratches easily
- Not suitable for load-bearing or manufacturing tools requiring scratch resistance.

2- Quartz

- High hardness (about 7)
- Hard mineral
- Scratch-resistant
- Used in
  - **Glass industry**
  - **Erosion resistant parts**

Hardness and Construction

1. Hardness affects the mechanical strength of rocks.
2. Rocks with hard minerals
   - **More resistant to weathering (erosion)**
   - **Examples: granite, sandstone**
3. Rocks with soft minerals
   - **Less resistant to weathering**
   - **Example: limestone (rich in calcite)**

Hardness and Construction

- High-hardness rocks like granite are used in

1. Hospitals
2. Department stores
3. Train stations

- **Reason: They resist erosion and weathering in high-traffic areas.**

▶▶ **Hardness of Rocks Used in Ancient Egyptian Statues**

	Statue	Rock Type	Hardness
Khafre		Diorite	7
Ramses II		Red granite	6 - 7
The Sphinx		Limestone	3-4
Amenhotep III		Alabaster	2.5-3

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NOTES

- The hardness of minerals can be tested using simple daily tools
- Example : fingernail, copper coin, steel nail

Practical Activity

Testing the Hardness of Rocks

1 Different Rock Samples:

Gypsum
(Hardness ≈ 2)

Limestone
(Hardness ≈ 3)

Granite (Hardness 7)
(Hardness 7)

2 Tools for Scratch Testing:

Steel Nail
(Hardness 4.5)

Coin
(Hardness 3)

Human Fingernail
(Hardness 2.5)

Aim

- Compare the **hardness** of different rocks using simple tools

Method

- Scratch each rock with each tool and record results

Results

- **Gypsum** scratched easily, limestone scratched by coin and nail, granite scratched only by nail

Conclusion

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- **Gypsum is least hard, limestone is medium, granite is hardest**

Order of Hardness

Gypsum → Limestone → Granite

2- Color

Importance of Color

- **Color helps identify some minerals with distinctive colors.**

Example

- **Malachite has a clear green color.**

Malachite

Why Color Is Not Enough

- **Different** minerals may have the same color.
- One mineral may **appear** in different colors
- Example: **Calcite** appears in many colors.

3- luster

luster

How light reflects from the surface of a mineral.

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Types of Luster in Minerals

Type of Luster	Description	Examples
Metallic Luster	The mineral looks shiny like metal	 Gold  Pyrite
Glassy Luster	The mineral looks like glass	 Quartz  Calcite
Matte Surface	The mineral surface is not shiny	 Basalt

NOTES

- Pyrite is called "fool's gold" because it looks like gold but is different in composition and density
- Calcite may be transparent or opaque and appears vitreous in many colors.

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Important Note

1. Color and luster alone cannot identify minerals
2. Other properties must be used, such as
   - Hardness
   - Cleavage and fracture
   - Reaction with dilute acids

4- Specific gravity

- Specific Gravity is a measure of how heavy a substance is compared to water.

Specific gravity

The ratio between the mass of a given volume of a substance and the mass of the same volume of water at °4C.

$$\text{Specific gravity} = \frac{\text{Mass of a given volume of a substance}}{\text{Mass of the same volume of water at °4C}}$$

▶▶ It has no unit because it is a ratio

What Does Specific Gravity Tell Us

- It indicates whether a mineral is heavy or light.
- Minerals rich in heavy elements have high specific gravity.

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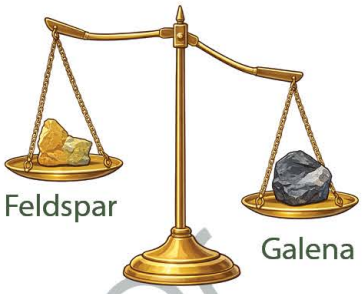
NOTES

Types of Minerals According to Specific Gravity

Type of Mineral	Description	Examples
Heavy minerals	High specific gravity because they contain heavy elements (like lead, silver)	Galena (lead sulphide PbS)
Light minerals	Low specific gravity because they contain light elements	Feldspar



Importance of Specific Gravity of Rocks

- (1) **Igneous** rocks rich in iron and **heavy** elements → high specific gravity
- (2) **Sedimentary** rocks like sandstone → low specific gravity

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In engineering and geology

1. It helps determine the composition of underground layers
2. Useful in construction sites, drilling, and geophysical surveys
3. Helps engineers know what lies beneath the Earth's surface without drilling

NOTES

5- Cleavage and Fracture

- **When a mineral breaks, it shows one of two properties:**

ITEM	Cleavage	Fracture 2026
Definition	The ability of a mineral to split along specific crystalline extensions, reflecting the structure of the bonds within the crystal.	The fracture pattern resulting when the fracture does not follow specific crystalline extensions.
Surfaces Resulting from Fracture	Smooth and Symmetrical Surfaces	Smooth and Symmetrical Surfaces
Example	▶ Mica : Excellent cleavage in one direction → splits into thin sheets ▶ Feldspar : Cleavage in two or three directions at specific angles  Mica  Feldspar	▶ Quartz : has conchoidal fracture  Quartz

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Importance of Knowing Cleavage or Fracture

- ▶ Minerals with clear cleavage may break easily under stress.
- ▶ Using such rocks in:
  - Quarry walls
  - Building foundations
- ▶ Can cause cracks, fragmentation, landslides, or collapse

6- Chemical Composition of Minerals

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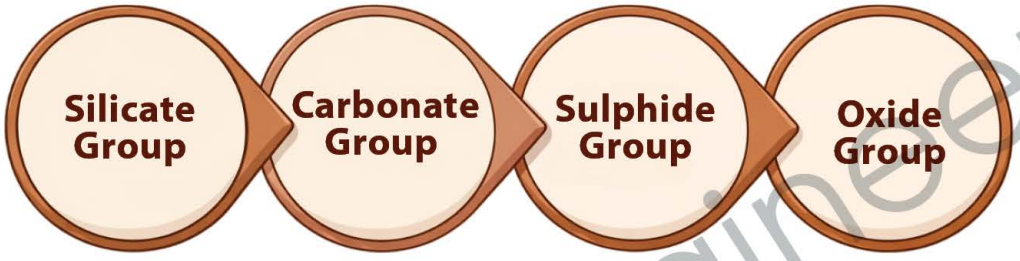
The chemical composition of a mineral refers to

- The types of elements it contains
- Their proportions

- **Minerals can be classified according to their chemical composition into major groups, including**



Characteristics of Important Groups

Silicate Group

- Forms **most** of the Earth's crust
- Examples: Quartz, Feldspar, Pyroxene
- Usually hard
- Resistant to dissolution in weak acids
- Remain in soils and rock sedimentsfor long periods **without** decomposing

Carbonate Group

- Example: Calcite ($CaCO_3$) found in limestone
- Partially **soluble** in weak acids
- Reacts with dilute acids(such as dilute carbonic acid) producing carbon dioxide gas (effervescence)
- Calcium ions and bicarbonate ions are transferred to the aqueous solution, as shown in the following two equations

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$$\underset{\text{Carbon Dioxide}}{CO_{2(g)}} + \underset{\text{Water}}{H_2O_{(l)}} \rightleftharpoons \underset{\text{Carbonic Acid}}{H_2CO_{3(aq)}}$$

$$\underset{\text{Calcium Carbonate}}{CaCO_{3(s)}} + \underset{\text{Carbonic Acid}}{H_2CO_{3(aq)}} \longrightarrow \underset{\text{Calcium Ions}}{Ca^{2+}_{(aq)}} + \underset{\text{Bicarbonate Ions}}{2HCO^-_{3(aq)}}$$

How to Distinguish Between Silicates and Carbonates

Test	Result
Add dilute acid	Carbonates → bubbles
	Silicates → no reaction

Mineral Resources in the Lithosphere

Formation of Minerals in the Earth's Crust

- **Minerals are formed in the lithosphere through different geological processes, such as**

Process	Explanation
Crystallization of magma	- **Minerals** form when magma cools and solidifies
Evaporation of water	-**Mineral** salts precipitate when water evaporates
High pressure and heat	- Atoms rearrange when rocks are subjected to **high pressure and temperature**

- **Although more than 4,000 minerals are known, only a small number make up most rocks in the lithosphere.**

1- Role of Minerals in Earth's Stability and Sustainability

- **Minerals play an essential role in maintaining Earth's structure and natural balance**

1. **Give rocks hardness and cohesion**
2. **Help in the formation of continents and mountains**
3. **Contribute in determine soil properties**

4. **The different distribution of elements within the Earth's crust, resulting from the chemical and physical diversity of minerals, supports natural processes**
Such as: - The rock cycle, Movement of tectonic plates

2- Role of Minerals in Modern Industries

- **Minerals strongly affect daily human life and modern technology.**

First Quartz

- **Is widely used in modern technology**

Use	Explanation
Precision watches	- Quartz crystals vibrate at a constant rate when exposed to an electric potential difference
Mobile phones & Globel Positioning System (GPS)	- Adjust electronic signals and provide precise timing for data transmission, ensuring that calls, messages, and map locations arrive accurately.

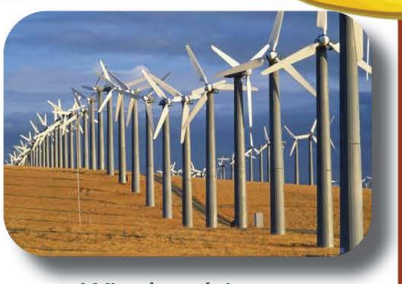
GPS

Second Iron

- **Is extracted from ores such as hematite and magnetite**

Uses of iron

- **Metal structures and heavy machinery**
- **Electric cars and high-speed trains which contribute to reducing carbon emissions and achieving a more sustainable future**
- **Wind turbine structures for clean energy**



Wind turbines

NOTES

- **Egypt has launched a high-speed electric train project (2000 km) connecting cities on the Red Sea and the Mediterranean to**
  - **Facilitate** the transport of people and goods between production areas and export ports.
  - **Support** economic and urban development throughout the country.

Third Silicon

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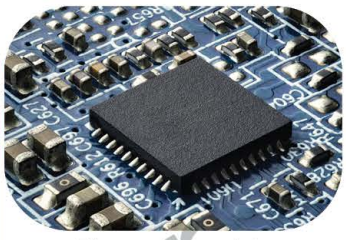
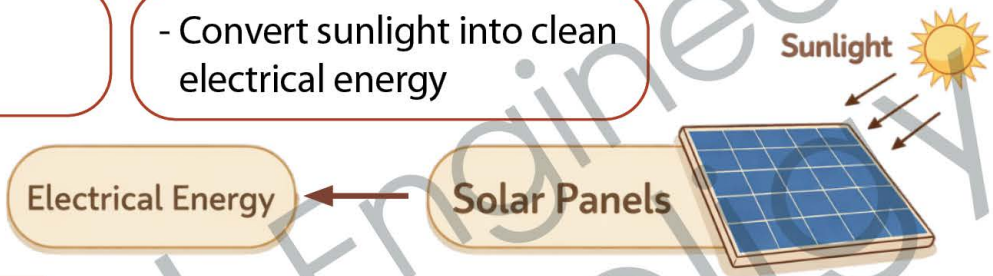
- Is extracted from sand (quartz)

Application	Use
Electronic chips inside computers and smartphones	- Control the flow of electric current in electronic circuits making it the basis for the operation of processors and electronic circuits.



Electronic chips

Solar panels	- Convert sunlight into clean electrical energy



Fourth Lithium

- Is the lightest metallic element found in the Earth's crust.

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Properties

1. It is characterized by its high capacity for storing energy for extended periods and releasing it with high efficiency

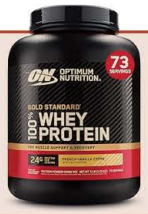
Because of this, it is called "The oil of the 21st century"

Uses of Lithium Batteries

- Smartphones
- Electric cars
- Digital watches
- Laptops
- Drones
- Satellites

Drone

3- Role of Minerals in Medicine

Mineral / Alloy	Main Medical Use
Calcium and iron compounds	- They are key components of nutritional supplements used to treat mineral deficiencies in the human body 
Titanium	- Medical Applications in Bone implants and Joint replacements Bec: (strong, light, it does not react with body tissues, it is not rejected by the immune system) 
Neodymium–Iron–Boron (Nd–Fe–B)	- One of the strongest permanent magnets in the world - Used in MRI machines - Produces strong magnetic fields to image internal organs without surgery 
Cobalt	- Used in the production of : Lithium-ion batteries for smart medical pumps and Wearable health-monitoring devices 
Lithium	- Lithium is used in batteries for portable medical devices, such as - Pacemakers - Blood glucose measuring devices 
Gold & Silver Nanoparticles	- Targeted drug delivery to cancer cells to Increase treatment accuracy and reducing damage to healthy tissue 2026 

NOTES

- **The lithosphere is considered a natural reservoir rich in mineral resources that form the Earth's surface and is an essential part of industrial, medical and technological development**

B The Rock Cycle

- Although rocks may seem solid and unchanging, they are part of a continuous and dynamic system called the rock cycle

Rocks change over time due to

External factors
- Wind ,water
- Temperature changes

Internal factors
- Pressure, heat
- Earth's internal forces

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- These changes happen very slowly and may take thousands or millions of years.

Stages of the Rock Cycle

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1 Step 1: Formation of Igneous Rocks

- The rock cycle begins when magma inside the Earth or lava on the surface cools and solidifies.
- Cooling of magma → Igneous rocks

2 Step 2 : Weathering (Breakdown of Rocks)

- Rocks are broken into small pieces (sediments)
- Caused by wind, rain, temperature changes, and water

3 Step 3 : Transport and Deposition

- Wind and water carry sediments
- Sediments settle in rivers, seas, and oceans

4 Step 4 : Formation of Sedimentary Rocks (Lithification)

- Sediments accumulate
- They become compacted and cemented
- Sedimentary rocks are formed

5 Step 5 : Formation of Metamorphic Rocks (Metamorphism)

- Sedimentary rocks may be pushed deep underground
- High heat and pressure change their minerals
- Rocks change without melting
- New metamorphic rocks are formed

6 Step 6 : Melting (Formation of Magma)

- At very great depths, rocks completely melt
- They return to magma
- The rock cycle starts again

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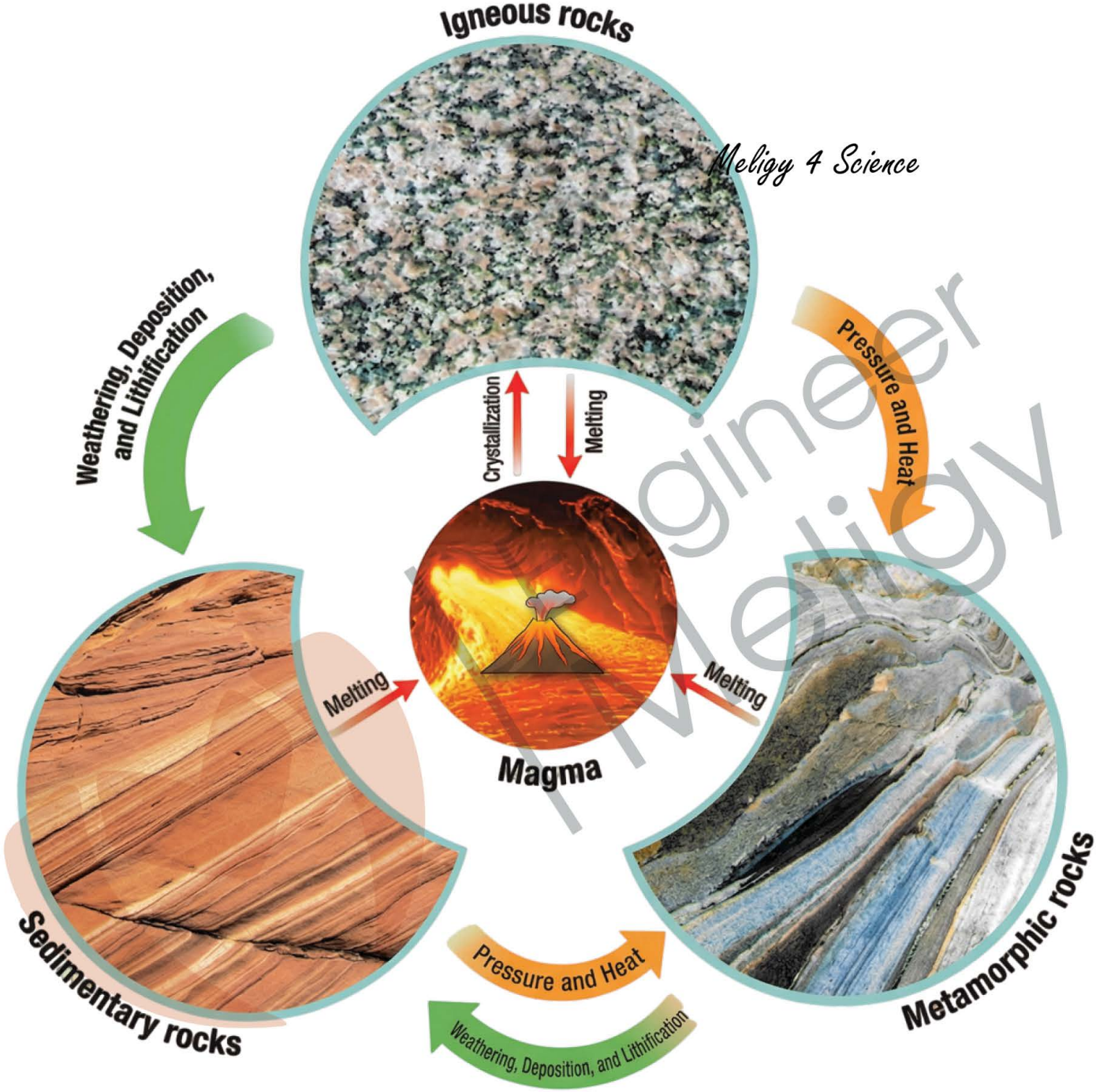

The Rock Cycle

Examples of the Rock Cycle in Nature

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Svccessiue rock layers in

Mountains and mountain roads, which represent deposits that have accumulated **over millions of years**, forming sedimentary rocks

Marble vsed in bvildings

It is a **metamorphic rock** resulting from the exposure of limestone to intense heat and pressure

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Sand composed of minerals

Silica resulting from the disintegration and crushing of rocks, which is used in the manufacture of glass

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NOTES

LESSON 3

The Lithosphere and the Sustainability of Energy Resources

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- The lithosphere is considered as a source for a **wide range** of **renewable** **and non-renewable** **energy resources** , which cover a large portion of global global energy demand.

▶▶ **The lithosphere is the primary source for :**

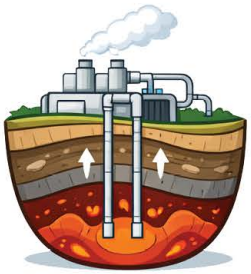
1 **Fossil fuel**

As coal, petroleum, and natural gas

2 **Nuclear Energy**

Derived from radioactive elements as Uranium

3 **Geothermal energy**

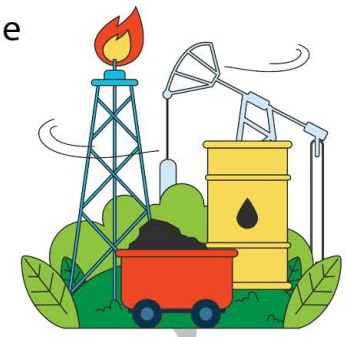


Originates from the Earth's heat.

- **Studying the lithosphere allows us to <u>determine</u> :**
  1. **The locations of energy resources**
  2. **How to extract them.**
  3. **How to use them efficiently and sustainably.**

The Lithosphere and Fossil Fuels

- Fossil fuel is the most abundant energy source available in the lithosphere.



Occurrence
- Lithosphere contains huge deposits of fossil fuels

Importance
- Considered the primary source for energy in the world.

Organic Origin Theory

- The **Organic Origin Theory** explains the formation of petroleum and natural gas as follows:

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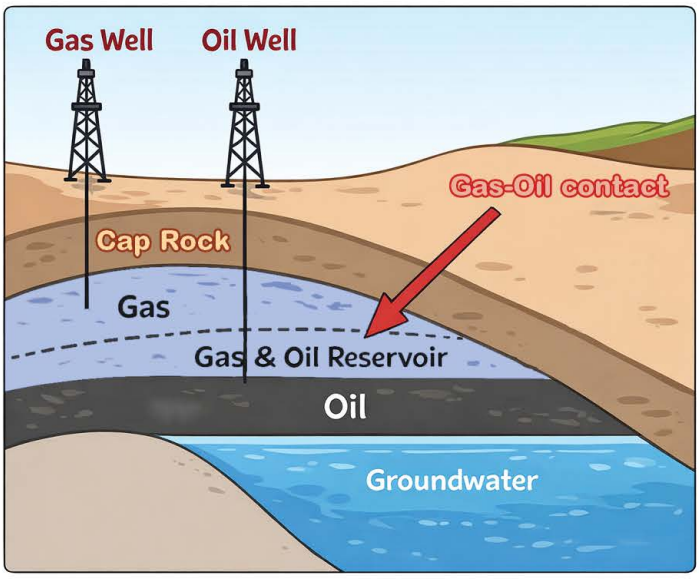
1. Petroleum and natural gas are fromed from the remains of living organisms, **especially marine microorganisms** that were buried in sedimentary rocks at the bottoms of seas and oceans millions of years ago and the thickness of rock layers increased over time.

2. **Due to** the enormous pressure and rising temperature **caused by** the heat of the Earth's interior, the organic remains rich in carbon and hydrogen were transformed within the sedimentary rock layers **(source rocks)** into hydrocarbon compounds from which petroleum and natural gas were formed.

Source rocks

Rocks in which **organic remains** rich in carbon and hydrogen are transformed into hydrocarbon compounds that form petroleum and natural gas.



NOTE Petroleum and natural gas usually accumulate underground in **Oil Traps** under high pressure, where petroleum oil floats above water, and natural gas accumulates above the oil.

Oil Traps

Sedimentary rock basins formed underground within impermeable (non-porous) rock layers in the shape of a dome, and they represent accumulation zones for petroleum and natural gas.

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1 Petroleum Extraction

- Petroleum is extracted according to the following processes:

Location identification

- Companies rely on **3-D seismic (surveying)** to determine location of petroleum in reservoir rocks which **enables geologists to:**
  - Draw accurate maps of rock structures.
  - Pinpoint the locations of oil accumulation with greater precision.
  - Increase success of the extraction process
  - Reduce environmental impacts

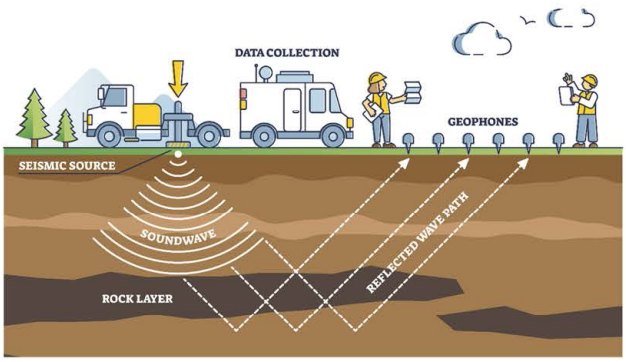
Deep drilling

- Drilling process is done by using **specialized drilling rigs** that can reach great depths, either **underground** or beneath **the sea floor**.
- Companies insert strong steel casings (pipes) into the well GB ?

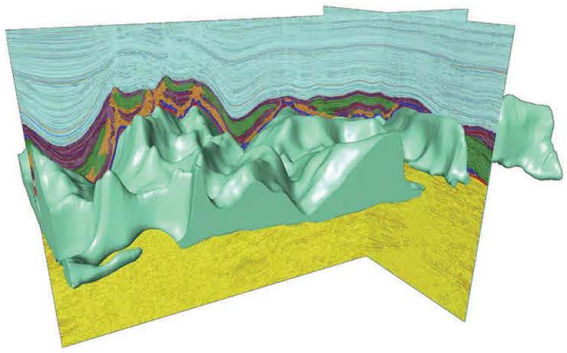
  to ensure its stability and prevent unwanted leakages.

Lifting

- When the drills reach the rock layer containing the oil, the natural pressure within the reservoir is often allowed to push the oil upwards, where the oil continues to flow until the pressure diminishes.
- Modern techniques such as **water** or **gas injection** could be used to lift the petroleum to the surface when the pressure is low.



Seismic Sensing (Surveying)



3D Seismic Sensing data analysis

NOTES

- The amount of petroulm that can be extracted by natural pressure is approximately 20% of the oil in the field
- The quantity of petroleum that can be extracted depends on the viscosity of the crude oil where viscosity affects the fluid's resistance to flow as follows

The higher the viscosity of the liquid → **The more thick (desnse) it becomes.** → **Flow slowly due to increased attraction (cohesive) forces.** → **The rate of crude oil extraction decreases**

Technological Applications

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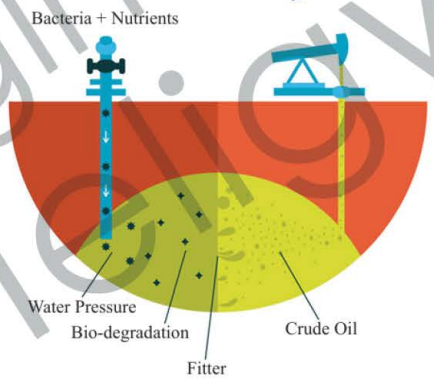
Enhanced Bio-Oil Recovery



▶ Modern technology used by some companies involves the use of microorganisms, such as certain types of bacteria,

▶ **Importance :**
It helps increase the amount of petroleum extracted from rocks.

▶ **Mechanism of action :**
- Microorganisms are injected into old or low producing oil wells,
They begin to multiply within the rock pores.
The bacteria secrete natural chemical substances, which work to change the properties of the petroleum and the surrounding rock layer such as :

Organic gases → **Increase the pressure inside the reservoir, facilitating oil movement.**

Bio-acids → **Help dissolve certain minerals that impede oil movement.**

Biopolymers → **Reduce the viscosity of the oil, allowing the oil to move and flow more easily into the well.**

▶ **Adventages :**
- This process increases the efficiency of extraction without the need for strong pumping operations or high energy consumption.
- This makes it a modern and environmentally friendly technique that is used today in several fields worldwide to support production and reduce the loss of stored petroleum.

2 Components of Crude Oil

- Crude oil consists of a complex mixture of hydrocarbon compounds with varying properties., **including:**

1 Hydrocarbons compounds

- Organic compounds containing only Carbon (C) and Hydrogen (H).
- They form the main components of crude oil.

2 Non-hydrocarbons compounds

- Include elements like Sulfur, Nitrogen, Oxygen, and some metals.
- They form small portion of crude oil.

3 Fractional Distillation of Crude Oil

Fractional Distillation

Process performed to separate the different hydrocarbon components of crude oil and convert them into useful products.

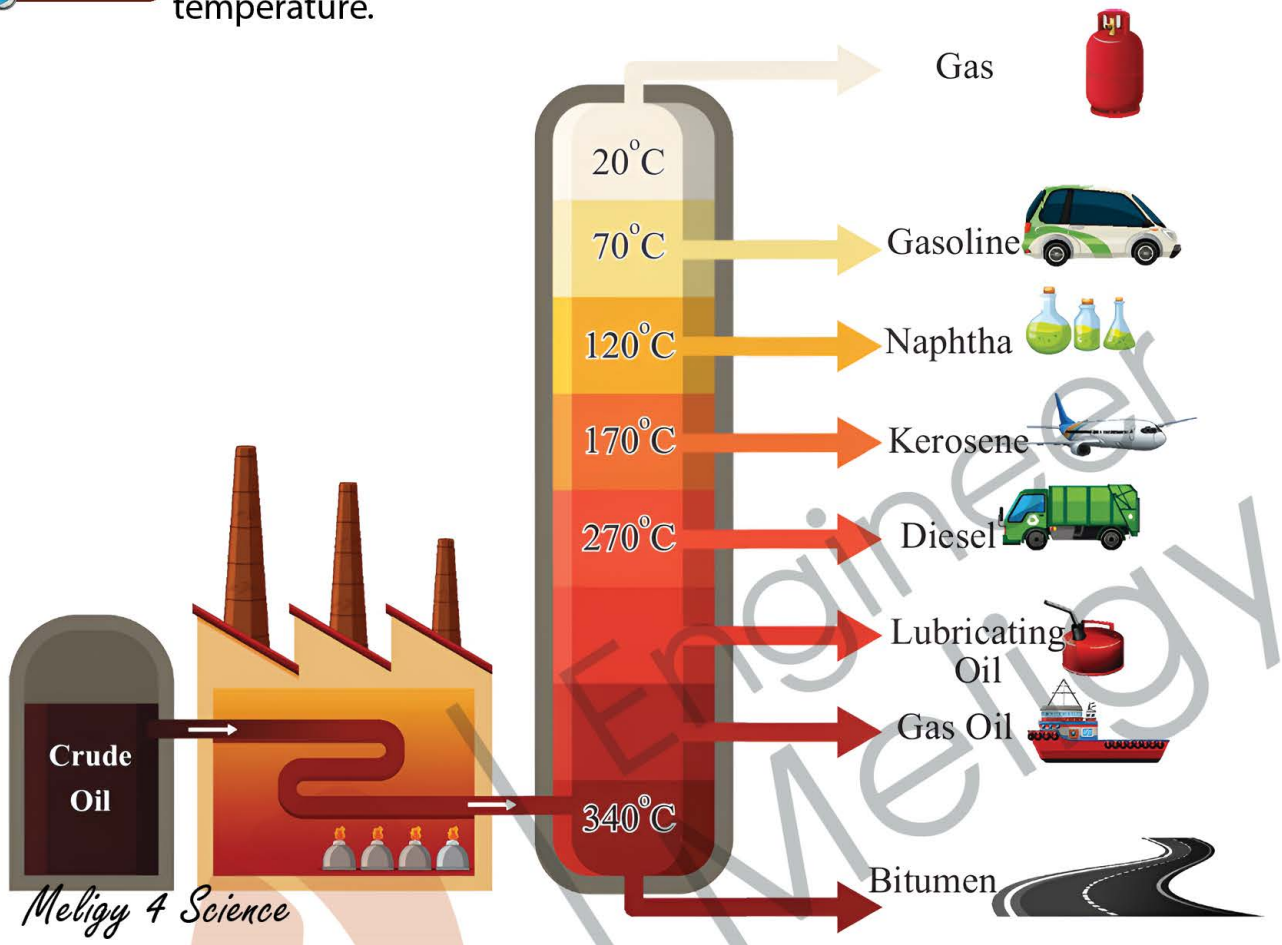
- Fractional disstilation process depends on differences in boiling points and densities.
- **Petroleum products** are what give oil its practical and economic importance, as each petroleum product has numerous uses and different applications, **such as :**

Gasoline **Diesel** **Fuel oil**

▸▸ How is Fractional Distillation Performed??

Process	Explanation *Meligy 4 Science*
1 **Heating Crude Oil**	Crude oil is heated to high temperatures, reaching up to 400°C , in specialized furnaces until it turns into a mixture of vapors.
2 **Vapors enter Distillation Tower**	Hot vapor mixture is pumped into a tall tower called the fractional distillation column , which is characterized by having high temperatures at its base and gradually decrease towards the top.
3 **Separating of Components Based on Boiling Point**	Hydrocarbons differ in their boiling points, and thus they condense at different levels: **Diesel and Kerosene** → condense at **middle levels**. **Gasoline (Benzine)** → condenses at **higher levels** where the temperature is lower. **Light gases** → Exit from the **top of the tower** (as Butane and Propane).

NOTE Each fraction is collected separately according to its condensation temperature.



Modern Examples of Industrial Applications

1. In modern refineries across the Arabian Gulf and Egypt, digital control systems are used to precisely adjust temperatures and cooling rates. This makes the distillation process more efficient and reduces energy consumption.
2. Some refineries also rely on thermal and hydro-cracking units to convert heavy hydrocarbons into high-quality, lighter gasoline (benzine). This high-quality gasolineis then used in modern vehicles with low emissions.
3. In advanced industries, the light gases produced from the top of the tower are utilized in the production of petrochemicals, such as plastics, resins, and synthetic fibers. These materials are essential components in electronic devices, electric vehicles, and lightweight building materials.

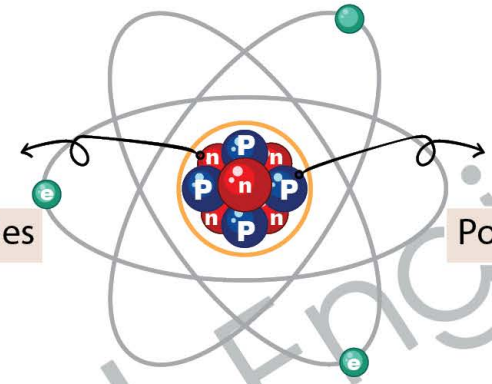
The Lithosphere as a Source of Nuclear Energy

- The lithosphere is a source of radioactive elements used in the production of nuclear energy, foremost among them being **Uranium**.

Structure of the Atom and Isotopes

- The nucleus of any element consists of:

Neutrons (±ve)
Electrically neutral particles



Protons (+ve)
Positively charged particles

- To express an atom of any element, we use two terms, which are:

A — Mass number
no. of neutrons (n) + no. of protons (p)

Z — Atomic number
no. of protons (p)

$^{A}_{Z}X$ — Element symbol

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Atomic number (Z)

number of protons (positive charges) present in the nucleus of an atom and it is written at the lower left of the element symbol.

Mass Number (A)

The sum of no. of protons and no. of neutrons in the nucleus of an atom and it is written at the upper left of the element symbol.

Radioactive Uranium Element

- **Uranium is one of the special elements found in lithosphre .**

Occurrence

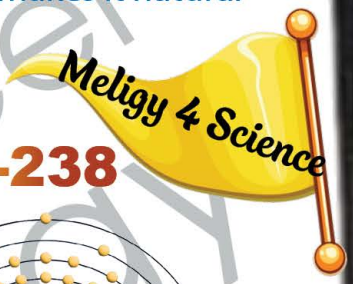
- Naturally occurs within certain igneous and sedimentary rocks.
- It is extracted in the form of minerals such as

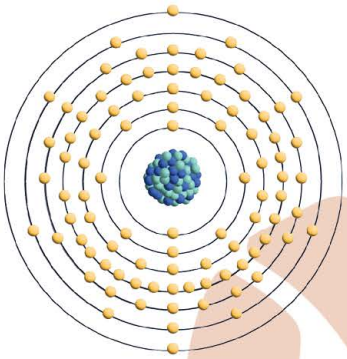
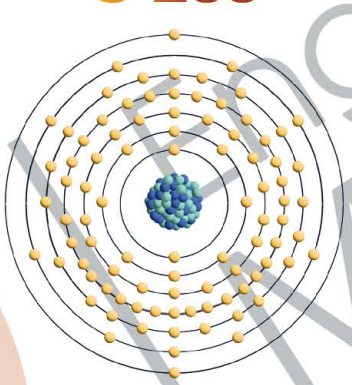
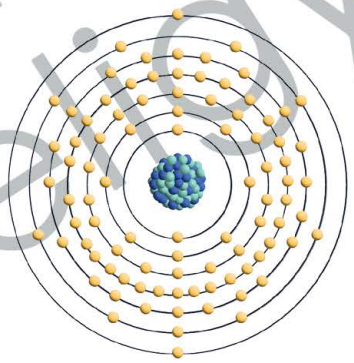
Uraninite & **Carnotite**

Characteristics

- Has large, unstable atomic nuclei with large mass number which makes it naturally radioactive elements.

Isotopes



U-234	U-235	U-238
		
Uranium 234	Uranium 235	Uranium 238
92 Protons 142 Nuetrons	92 Protons 143 Nuetrons	92 Protons 146 Nuetrons

The most abundant, representing about 99% of naturally occurring uranium on Earth.

NOTES

Isotopes are atoms of the same element with different forms as they have the same number of protons (Z) in their nuclei but differ in the mass number (A), and consequently in the number of neutrons (N).

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Importance

- Basis for nuclear energy production as it releases enormous amounts of energy when its atomic nucleus splits in a process called **nuclear fission.**

How Energy Is Produced from Uranium

1. **Uranium ore** is extracted from rocks, then refined and prepared in the form of nuclear fuel rods inside nuclear reactors.

2. When a **neutron** strike the nucleus of a **uranium atom**, the nucleus splits into smaller parts (**nuclear fission**), releasing a massive amount of thermal energy.

3. The released thermal energyis used to heat water and convert it into **steam**, which drives turbines that, in turn, operate electrical generators to **generate electricity**

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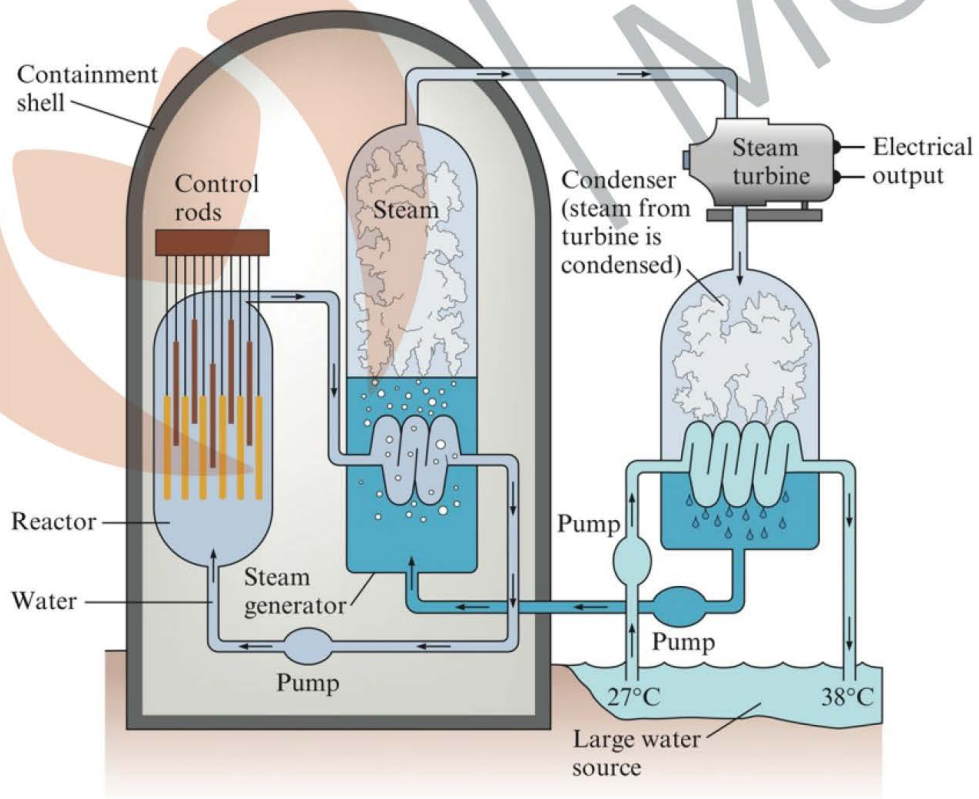
For illustration only

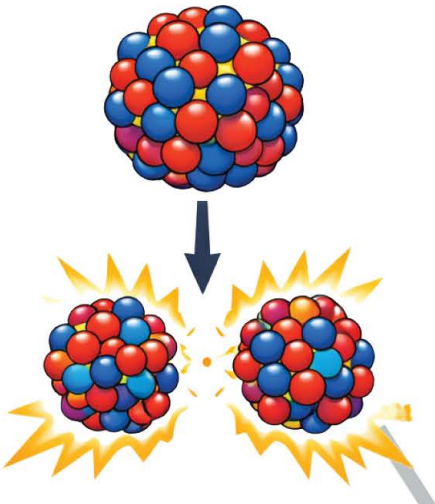


Production of energy in nuclear reactors

Nuclear reactions

- **Processes that occur within the nucleus of an atom, causing a change in its structure.**
- **The most important types of nuclear reactions are:**

1 Nuclear Fission

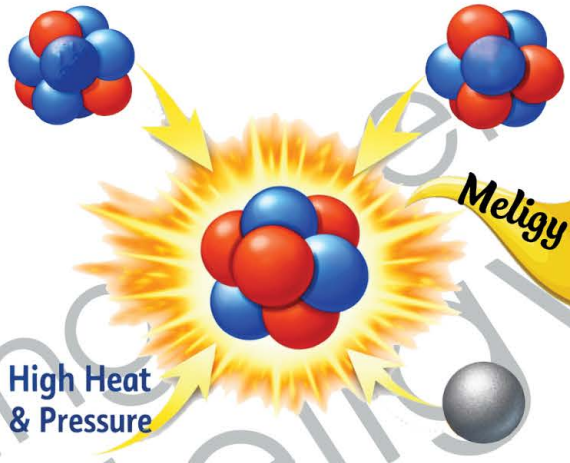


The nucleus of an atom splits into several parts

Reactions occur in nuclear reactors.

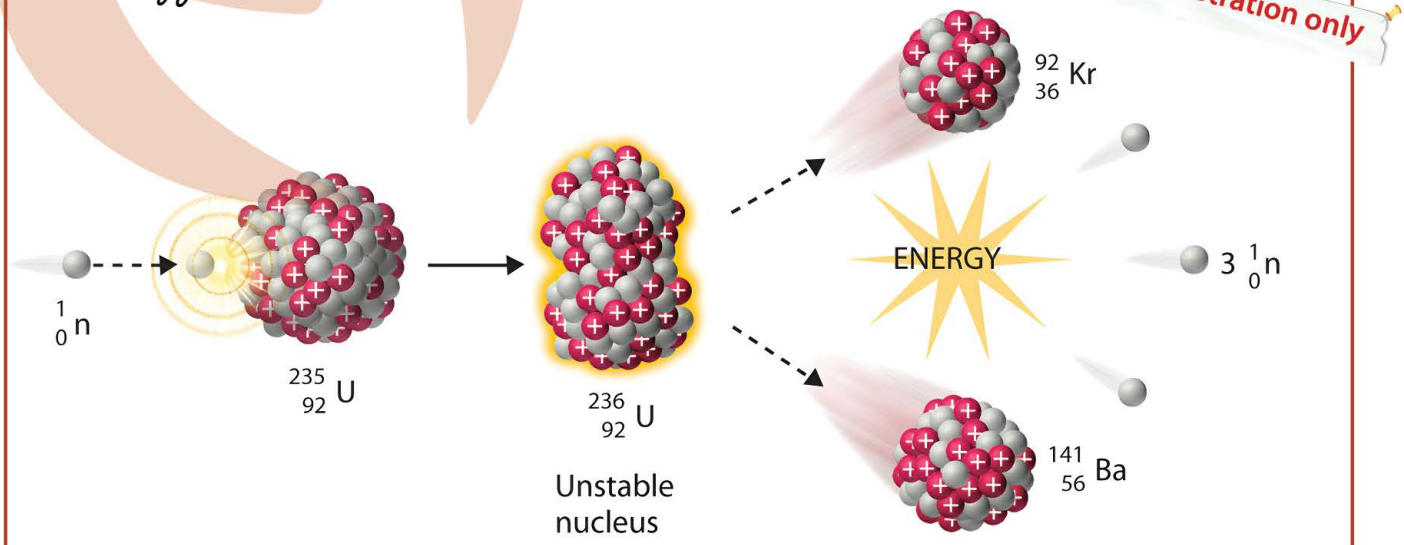
Example

2 Nuclear Fusion



Small nuclei combine to form a larger, heavier nucleus.

Reactions occurs naturally in the Sun and other stars



Nuclear fission of Uranim atom

Modern Technological Applications of Nuclear Energy

- **Today, nuclear energy is an essential part of the global energy system** GR **?**

  Because it produces large, consistent quantities of electrical energy with almost zero Carbon emissions.

Examples

1. Many countries rely on nuclear energy **to** secure a significant portion of their electricity needs, **such as** France, Japan, South Korea, and the United Arab Emirates.

2. **Modern research** is trending toward the development of

   Generation IV reactors & **Small Modular Reactors (SMRs)**

   which use smaller amounts of nuclear fuel and are easier to install, making nuclear energy a promising option to support the global transition toward sustainable and environmentally friendly energy sources.

3. **El-Dabaa Nuclear Power Plant in Egypt** .

El-Dabaa Nuclear Power Plant

It's a modern example of exploiting lithospheric resources for nuclear energy production.

Location :

Matrouh Governorate on Mediterranean coast.

Structure :

Comprises four advanced reactors that use radioactive elements extracted from rocks, such as Uranium, to generate substantial electrical power.

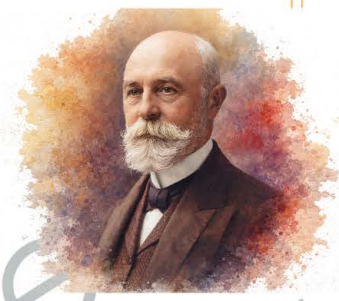
Importance :

El-Dabaa project is a significant step in Egypt's transition toward safe and clean energy sources, as

1. It contributes to providing a stable electricity supply that reduces reliance on fossil fuels and supports development plans.
2. Enhances Egypt's scientific and engineering capabilities and paves the way for developing modern technologies based on the responsible use of lithospheric resources.

The Discovery of Radioactivity

Henri Becquerel — Discoverer of radioactivity



In 1896, **Henri Becquerel** was studying the properties of X-rays.

Experiment 1

He exposed Uranium salt to sunlight and placed it on photographic plates wrapped in black paper, , believing that Uranium absorbed solar energy and then released it as X-rays.

Observation

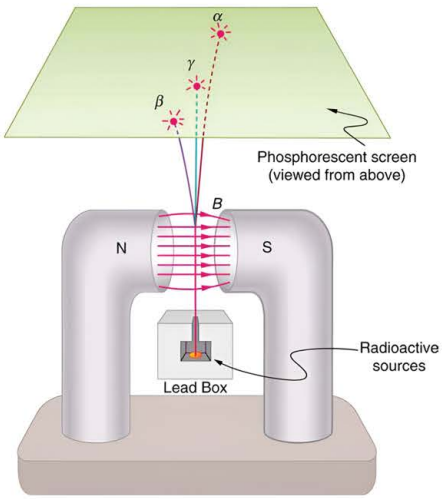
When he conducted his experiment during cloudy weather, the images remained strong and clear

Conclusion

Uranium emits radiation without the need for an external energy source like the sun.

Experiment 2

Becquerel used a device, as shown in the figure, **to** demonstrate that the radiation he discovered could not be X-rays which are **electrically neutral**.



Observation

The magnetic field affected the emitted radiation, revealing three paths that indicated the presence of three types of radiation:

- **Negative (Alpha Particles α)**
- **Positive (Gama Particle γ)**
- **Electrically neutral (Beta Particles β)**

Conclusion

The emitted radiation cannot be X-rays as they are **electrically neutral and their path is not altered by a magnetic**

Marie Curie

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- **Marie Curie** and her husband, **Pierre**, began studying various **Henri Becquerel** radioactive materials
- She coined the term "**radioactivity**" for the phenomenon Becquerel had recently discovered.
- Curies extracted uranium from its ore and they found that the **remaining ore exhibited greater radioactivity than pure uranium**.

Conclusion

They concluded that the ore contained other radioactive elements, which led to the discovery of the elements Polonium and Radium.

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Precautions for Nuclear Radiation Protection

1. **Keeping radioactive sources protected** (preferably by placing them in a lead-lined container).

2. **Transporting them only** when necessary and while following strict regulations.

3. **Wearing protective clothing** to shield the body from radiation emitted by radioisotopes.

4. **Wearing face masks** to avoid inhaling the vapors of radioactive materials.

5. **Continuously monitoring** the radiation levels in the **environment** surrounding the radioactive materials using a Geiger counter or similar device.

Lithosphere and Renewable Energy Sources

- Some properties of rocks and minerals **help us** produce clean energy.
- Humans have various ways of obtaining energy from the lithosphere, **including**

1.  Geothermal Energy
2.  Energy from Piezoelectricity
3.  Energy from compressed air storage in Rocks
4.  Natural Hydrogen Energy (White Hydrogen)

1 Geothermal Energy

Geothermal energy

Energy originates from the heat stored deep within the Earth.

Occurrence

- Results from several natural processes such as :
  1. Decay of radioactive elements inside rocks
  2. Movement of hot magma beneath the Earth's crust.

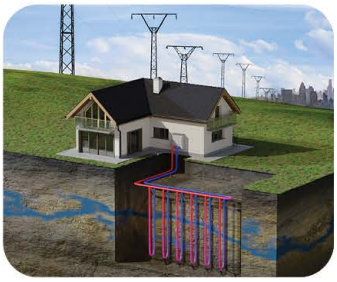
Temperature increases as we move inward, This is called the **Earth's thermal gradient**.

When fissures or openings are present in the lithosphere,

Groundwater can pentrate to deep layers → It is intensely heated → Then rises to the surface → It forms hot springs or pressured steam.

What Is It Used For?

- Countries use this natural heat by establishing geothermal power plants where the rising steam is used directly in ....
  1. Driving turbines → Generating electricity
  2. Heating buildings
  3. Various industrial applications



Importance of Geothermal energy

- **Geothermal energy is an important solution for achieving sustainable development and reducing dependence on fossil fuels, GR ?**

- Because its

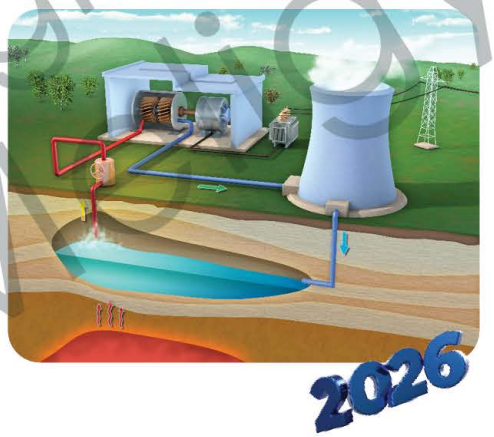
1 ▶▶ Renewable

2 ▶▶ Clean Does not produce pollution

3 ▶▶ Originates from a continuously available source in areas with suitable geological conditions

Technological Applications

Enhanced Geothermal Systems (EGS)



▶ An advanced technology developed by scientists in recent years **to** generate electricity from the heat of deep rocks.

▶ **Mechanism of action :**

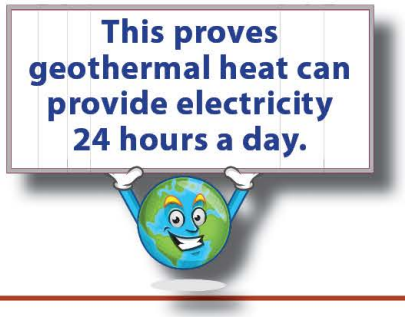
1. Engineers drill deep wells into extremely hot rocks at depths that may reach 4–6 kilometers.
2. Then they pump quantities of water into fine fractures within the rocks to absorb high heat.
3. Water returns to the surface to drive turbines and generate electricity.

▶ **Adventages :**

- This technology is a **major scientific achievement** as it allows the utilization of the lithosphere's heat and looks forward to a future of sustainable energy resources based on **deep geothermal heat** as a **global source of electricity**.

▶ **Example :**

The United States has successfully tested EGS power plants.



Practical Activity

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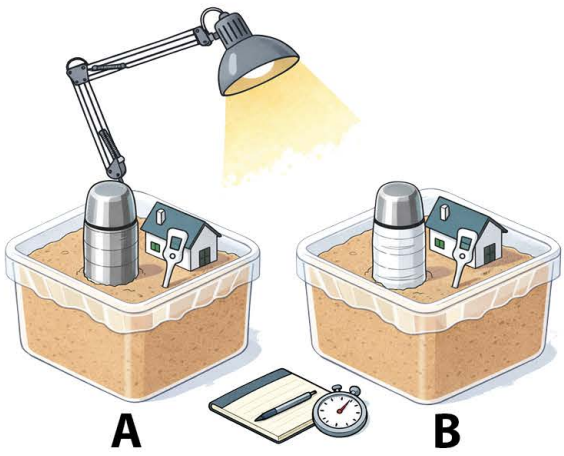
Section	Description
Aim	To show how heat stored underground (like geothermal energy) keeps soil warm for a long time.
Materials Needed	- **2** transparent plastic boxes (A & B) - **2** insulated bottles (with hot water) - Soil or sand - **2** digital thermometers - Cardboard (roof) - Transparent cover - Stopwatch - Lamp - Paper - Pen
Step 1: Prepare the Boxes	Place the soil or sand in the two boxes at the same height - Box A = acts as the heat reservoir - Box B = act as reference (normal soil).
Step 2: Add Heat Source	- **In Box A,** bury the hot water bottle in the center. - **In Box B,** leave soil only OR use an insulated bottle ,so that the heat does not escape
Step 3: Measure Temperature	- Place a thermometer near the soil surface in each box. - Record the initial temperature.
Step 4: Simulate Sunlight	- Cover both boxes with transparent plastic. - Turn on lamp for 1–2 hours.
Step 5: Record Data	- Measure temperature every 15–30 minutes. - Compare temperature changes in A and B.

Observation

Box (A) retains a higher temperature compared to Box (B)



Explanation

- The hot water bottle buried in Box (A) acts as a heat reservoir
- So, Heat transfers by conduction from water to soil.
- Water has high heat capacity, so it stores and releases heat slowly.

Improving the Heat reservoir Design

- The desgin of heat reservoir can be improved **to** retain heat for a longer time **by**:

1. **Thermal insulation**
   Covering the box with insulating materials like cork or wool to reduce heat loss to the surrounding air.
2. **Increasing water volume**
   Using more water stores more thermal energy, so the soil stays warm longer.
3. **Using materials with higher heat capacity**
   Replacing normal soil with materials that retain heat better.
3. **Airtight sealing**
   Preventing air exchange to reduce heat escape.

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Applications of Geothermal Storage Systems

▶ 1 **In Agriculture**
- Used in greenhouses.
- Water barrels absorb heat during the day.
- At night, they slowly release heat

▶ 2 **In Civil Engineering**
- Used in underfloor heating systems.
- Hot water circulates under floors.
- The floor radiates heat to warm the building.

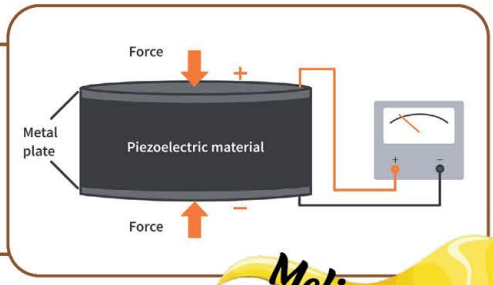
▶ Advantages of using Geothermal Energy

Environmentally	Economically
• Reduces harmful emissions like CO_2.	• Saves money over time.
• Helps reduce global warming.	• Renewable and sustainable.
• Provides clean energy.	• Reduces dependence on fossil fuels.
• Does not pollute air or soil.	

2 Energy from Piezoelectricity

Piezoelectricity

Modern innovation that relies on the properties of certain minerals found in the lithosphere, such as **quartz**.



Scientific Basis

- **When quartz is:**

Pressed or **Bent** or **Vibrated**

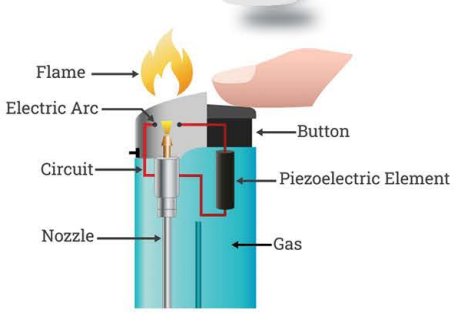
- It generates an **electric charge** without the need for any external energy source.

- **The concept of piezoelectricity is based on the fact that:**

Mechanical pressure acting on the material distorts its crystalline structure. **Which** Causes an imbalance in the distribution of electric charges in its crystals. **Thus** Generating a difference in electric potential between its surfaces.

Importance

The piezoelectric effect is used in the type of **gas lighters** that generate an electric spark to ignite gas by pressing a button, which in turn applies pressure to crystal.



Modern Applications

1. Generating electricity from pedestrian footsteps in stations and shopping centers, where **smart flooring** converts the pressure of feet into energy used to power lighting or charge small devices.
2. Generating electricity from vibrations and vehicles motion
3. Car sensors, security systems, and vibration tracking devices in bridges and buildings.
4. Charging sensors implanted inside the human body without a battery, which is a **breakthrough in medical applications.**

3 Compressed Air Energy Storage (CAES) in Rocks

Compressed Air Energy Storage (CAES)

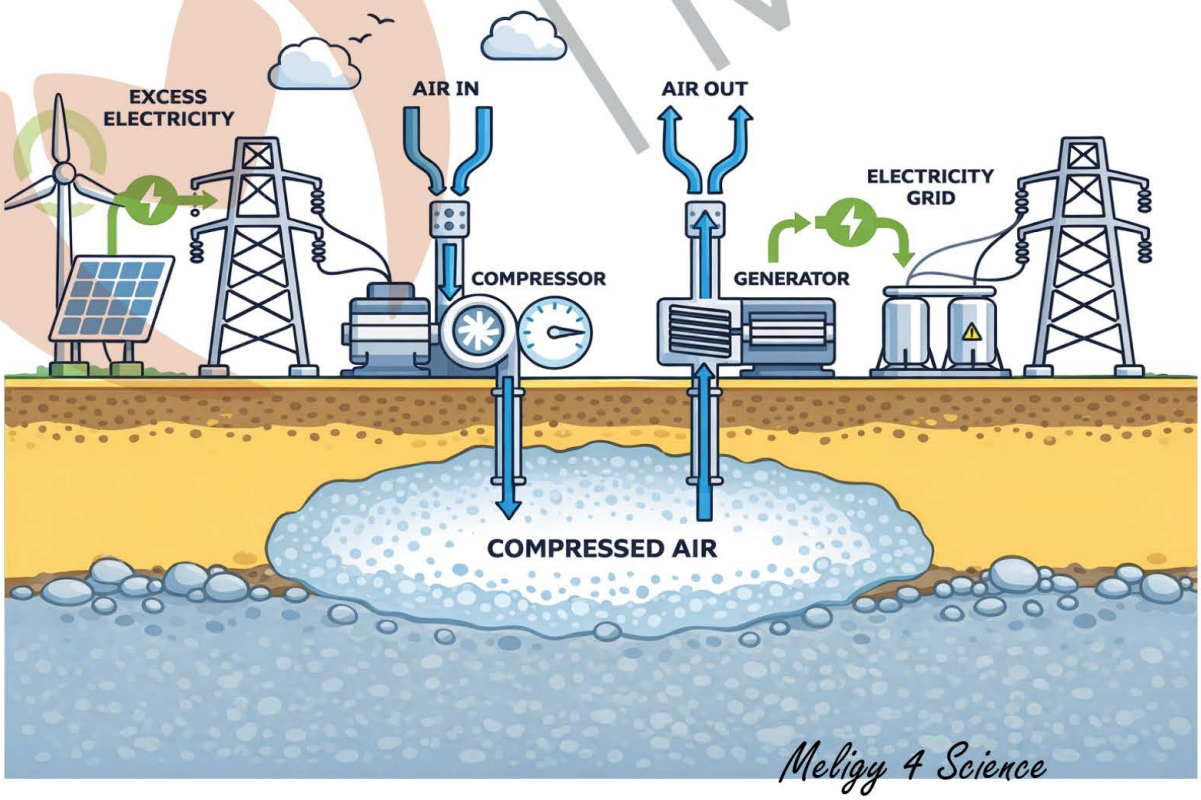
A modern renewable energy technology that uses underground rock cavities to store compressed air and produce electricity later.

Scientific Basis

The concept is based on using electricity generated from renewable sources, **such as** solar or wind power, to compress air and force it into deep rock cavities.

How It Works

1. Electricity from renewable sources (solar or wind) is used to compress air.
2. The compressed air is stored in deep underground rock cavities.
3. The air remains trapped under high pressure.
4. When electricity is needed, the air is released from the rock cavities to a power station.
5. The escaping air turns turbines → generators produce electricity.



The efficiency of CAES technology

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- **The efficiency of CAES technology depends on 2 factors :**

1 – Gas Laws

- When a power plant forces a large quantity of air into a small space (volume) inside rocks, the pressure inside this space rise significantly and temperature rises due to the closer of the air molecules and their faster movement.

2 – Properties of the lithosphere

2026

- **Where,**

Rock strength (Hardness) & **Ability to withstand pressure**

Are what makes storing compressed air inside them possible and safe

- **We find that solid rocks :**
  - ▶▶ Withstand high air pressure without collapsing, which allows large quantities of air to be trapped inside their cavities.
  - ▶▶ This high pressure is what gives the air, when released later, the ability to operate generators and generate electricity.

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NOTE

Some power plants store the thermal energy produced from compressed air , then reuse it when air is released to the turbines, **which** reduces energy loss and increases the efficiency of the plant.

NOTES

4 Natural Hydrogen Energy (White Hydrogen)

Compressed Air Energy Storage (CAES)

A modern renewable energy technology that uses underground rock cavities to store compressed air and produce electricity later.

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What Is White Hydrogen?

- White hydrogen is natural hydrogen gas formed inside the lithosphere, without human production.
- It is one of the newest discovered renewable energy sources.

How Is It Formed?

1. Water enters cracks in rocks.
2. It meets iron-rich minerals like **Olivine** **(iron and magnesium silicates)**
3. A chemical reaction occurs in which water molecules (H_2O) bind to iron atoms (Fe) within the mineral
4. Olivine changes into new mineral called **Serpentine** **(hydrated magnesium silicate)**
5. Hydrogen gas (H_2) is released.
6. Hydrogen accumulates in rock cavities and accumulates in places where it can be extracted.

Why Is It Important?

White hydrogen:

1 ▶▶ Is cheaper than industrial hydrogen.

2 ▶▶ Forms naturally underground.

3 ▶▶ Produces no carbon emissions when used as fuel.

NOTES