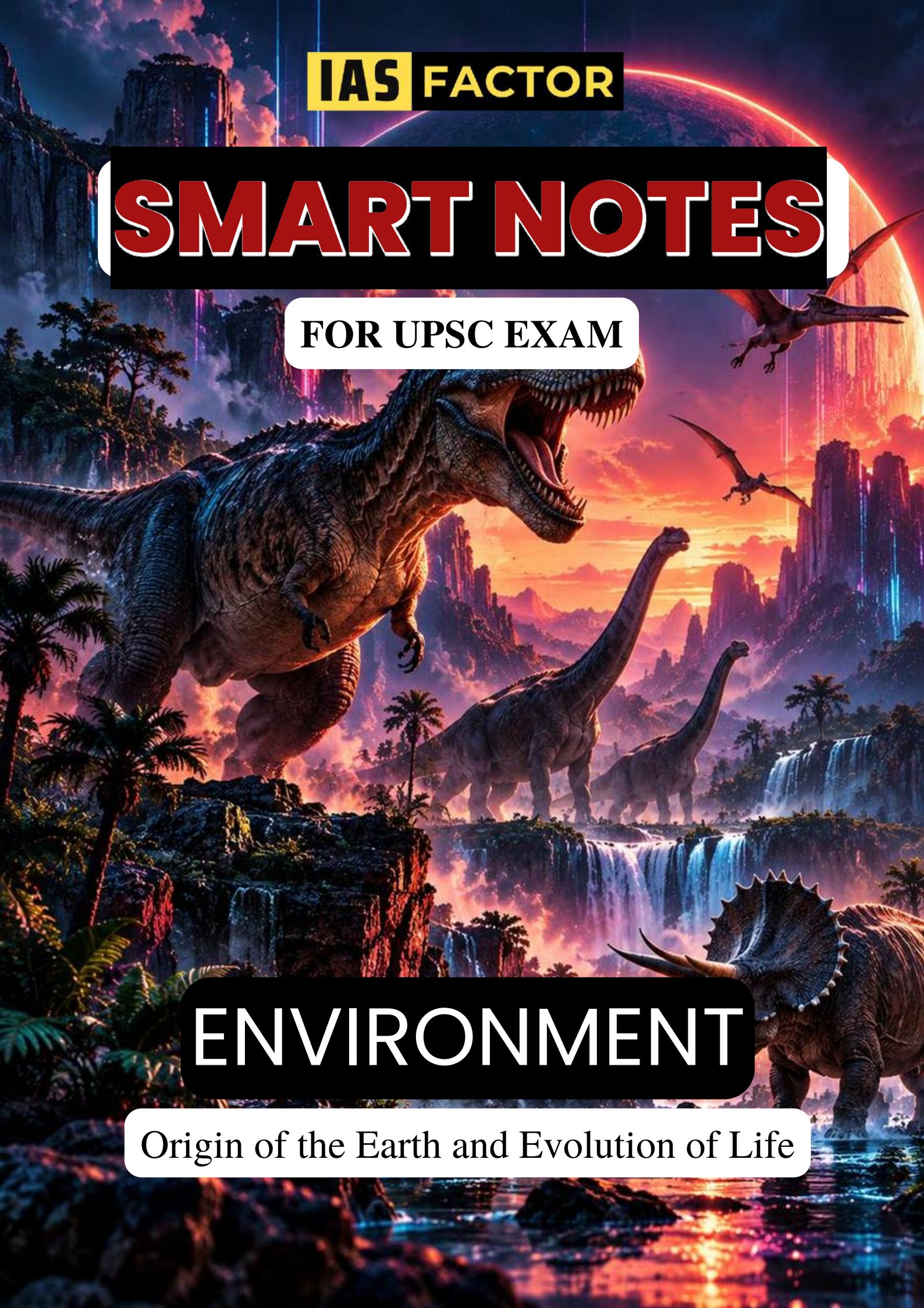
IAS FACTOR

SMART NOTES

FOR UPSC EXAM

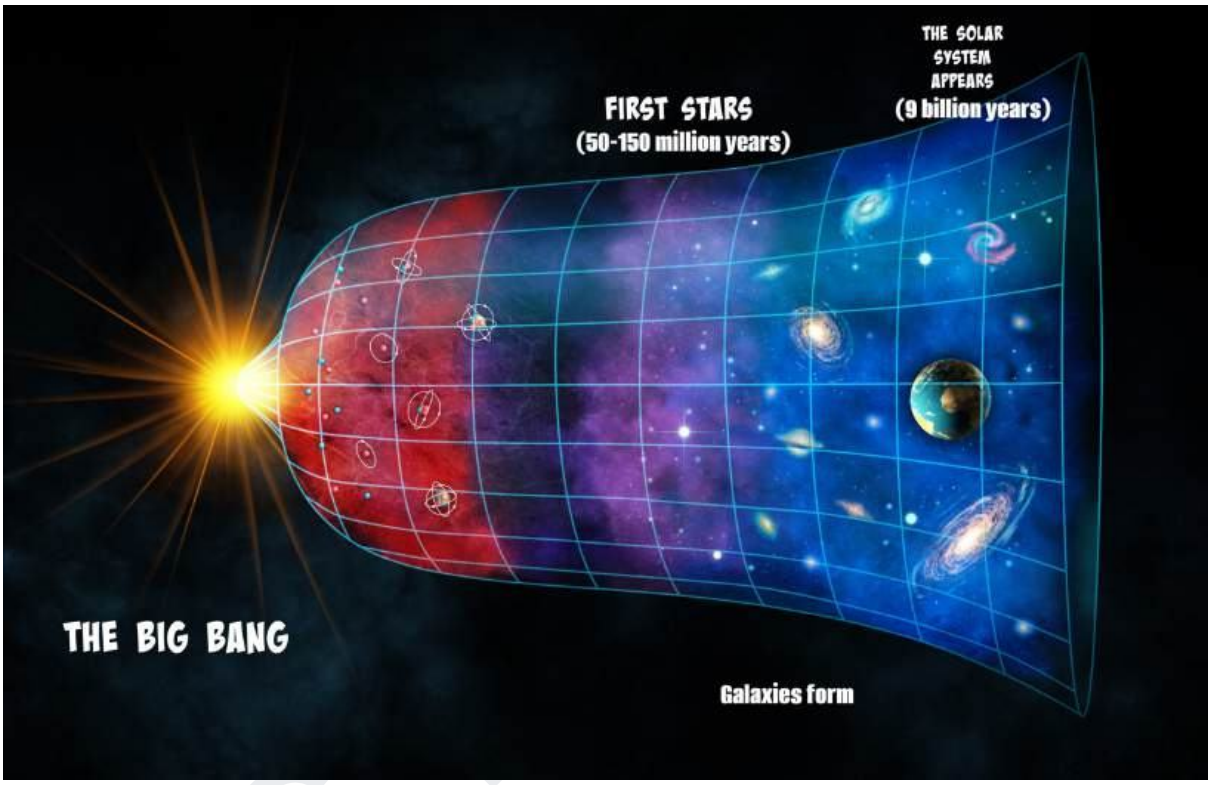


ENVIRONMENT

Origin of the Earth and Evolution of Life

Origin of the Universe, Earth and Evolution of Life

Q. Explain the Big Bang Theory and its significance in understanding the origin and evolution of the Universe.



- The **Big Bang Theory** is the most widely accepted scientific explanation for the origin and early development of the universe.
- According to this theory, the universe began from an extremely **hot and dense state** and started expanding.
- As the universe expanded, it gradually **cooled**.
- Matter eventually formed stars, galaxies and other celestial bodies.
- The universe is estimated to be about **13.8 billion years old**.

Q. Explain the process of formation of the Solar System and the major celestial bodies associated with it.

The solar system developed much later than the universe.
It formed from a huge cloud of **gas and dust**.
Gravity caused this material to come together.
Most of the material accumulated at the centre and eventually formed the **Sun**.
The remaining material around the young Sun gradually came together to form:

- planets
- moons
- asteroids
- comets
- other smaller bodies

The Earth and the rest of the solar system formed about **4.5–4.6 billion years ago**.

Q. Explain the major stages involved in the formation and early development of the Earth.

- The early Earth was extremely **hot**.
- Much of its material was molten.
- Over a very long period, the Earth gradually cooled.
- Cooling caused the outer surface to solidify.
- This hardened outer layer developed into the **Earth's crust**.
- Water vapour in the atmosphere also cooled and condensed.
- Long periods of rainfall helped water collect in depressions.
- These water bodies eventually developed into the early **oceans and seas**.



Q. Explain why the early Earth was extremely hot and molten, and describe the factors responsible for its internal heat.

- The Earth formed about **4.5–4.6 billion years ago** from materials such as dust, rock and gases present around the young Sun.
- In its earliest stage, the Earth was **extremely hot**.
- Much of the young Earth was in a **molten or semi-molten state**.
- Several factors contributed to this intense heat:

★ Frequent collisions with asteroids and other rocky bodies released enormous amounts of energy.
★ The compression of material by gravity produced heat.
★ Radioactive elements inside the Earth released heat through their decay.

Because the Earth was largely molten, materials could move and separate according to their density.

Q. What is Differentiation? Explain how this process led to the formation of the major internal layers of the Earth.

- As the young Earth remained hot and partly molten, its materials gradually became arranged into different layers.
- **Heavier materials**, especially iron and nickel, moved towards the centre.
- **Lighter materials** moved towards the outer portions.
- This gradual separation helped produce the major internal layers of the Earth:
    - **Core** – the innermost and densest region.
    - **Mantle** – the thick layer surrounding the core.
    - **Crust** – the thin outermost solid layer.

Important Fact: The separation of Earth's materials according to their density is called differentiation.

Q. Explain the process of cooling of the Earth and the formation of its crust.

- Over millions of years, the Earth gradually began to **lose heat**.
- The outer portion cooled faster because it was directly exposed to space.
- As the temperature decreased, molten material near the surface began to **solidify**.
- This created a thin, hard outer layer.
- With further cooling, this solid outer layer developed into the **Earth's crust**.
- However, the interior of the Earth remained extremely hot.
- Volcanic activity continued to bring molten material and gases from the interior to the surface.

Important Fact: The crust is the Earth's outermost solid layer, while the Earth's interior still contains enormous amounts of heat.

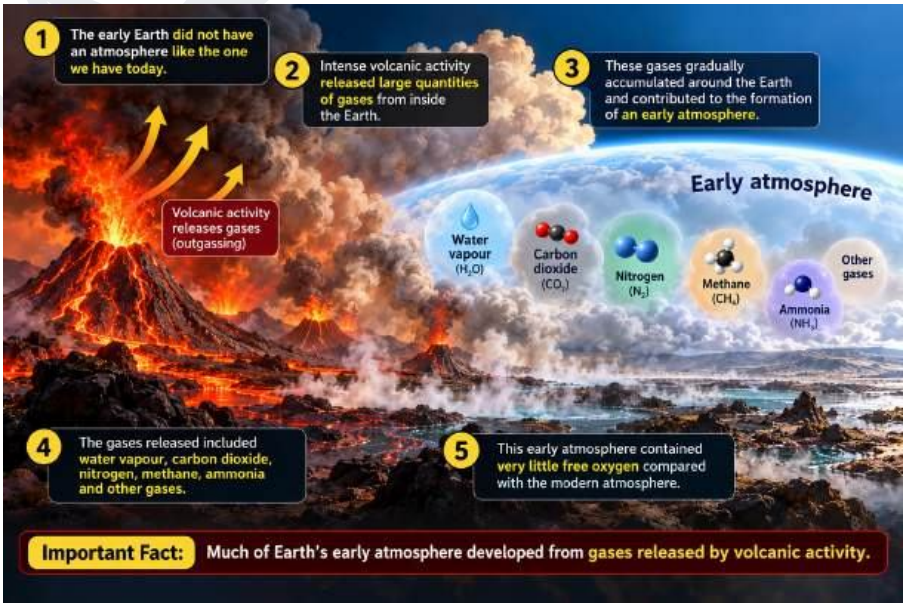
Q. Explain how the cooling of the early Earth led to the formation of clouds and rainfall.

- A large amount of **water vapour** was present in the early atmosphere.
- As the Earth continued to cool, the temperature of the atmosphere also decreased.
- Water vapour began to **condense into tiny droplets of liquid water**.
- These droplets formed dense clouds.
- Eventually, water began falling to the surface as **rain**.
- The process of cooling, condensation and rainfall continued for a very long period.
- At first, some water reaching the extremely hot surface would have evaporated again.
- As the surface cooled further, increasing amounts of liquid water could remain on the Earth.

Important Fact: Cooling of the Earth allowed atmospheric water vapour to condense into liquid water.

Q. Explain the process of formation of oceans and seas and discuss their significance in the evolution of life on Earth.

- Rainwater gradually accumulated in the **lower areas and depressions** of the Earth's surface.
- Rivers and surface runoff also carried water towards these low-lying regions.
- Over a very long period, enormous quantities of water collected in these depressions.
- These large water bodies developed into the Earth's early **oceans and seas**.
- The formation of permanent oceans was an important stage in Earth's history.
- Oceans later provided suitable environments for important chemical processes and eventually for the **development of early life**.



Q. Describe the major layers of the Earth's interior and explain their important characteristics.

The Earth is broadly divided into three major layers:

Crust

- The **crust** is the outermost solid layer of the Earth.
- It is the layer on which we live.
- Compared with the entire Earth, the crust is extremely thin.
- The material of the crust is solid and relatively cool compared with deeper parts of the Earth.

Mantle

- The **mantle** lies below the crust.
- It extends deep into the Earth's interior.
- It consists mainly of hot, dense rocky material.
- Temperature and pressure increase as we move deeper into the Earth.

Core

- The **core** is the innermost part of the Earth.
- It begins at a depth of roughly **2,900 km** below the surface.
- Temperatures in the core can reach around **5,000°C or more**.
- The core is mainly composed of **iron and nickel**.
- The outer core is liquid, while the inner core is solid because of the enormous pressure.

Important Facts

- Earth has three major internal divisions: **crust, mantle and core**.
- Temperature generally **increases with depth**.
- The core begins roughly **2,900 km below the surface**.
- The outer core is liquid, while the inner core is solid.

Q. Explain the Rotation of the Earth and describe their major characteristics.

Rotation of the Earth

- The Earth spins continuously around an imaginary line called its **axis**.
- This spinning movement is known as **rotation**.

- The Earth's axis is an imaginary line passing through the **North Pole and South Pole**.
- Earth rotates from **west to east**.
- Because of this west-to-east rotation, the Sun, Moon and stars appear to move across the sky from **east to west**.
- Earth completes one rotation in approximately **24 hours**.
- More precisely, a solar day is about **24 hours**, while Earth's rotation relative to distant stars takes about **23 hours 56 minutes**.

Formation of Day and Night

- At any given time, approximately half of the Earth faces the Sun.
- The part facing the Sun experiences **day**.
- The part facing away from the Sun experiences **night**.
- As the Earth rotates, different places gradually move into and out of sunlight.
- This produces the regular alternation of **day and night**.
- The boundary separating the illuminated half of Earth from the dark half is called the **circle of illumination** or **terminator**.

Speed of Rotation

- Earth does not have the same rotational speed at every latitude when measured as distance travelled along the surface.
- The surface moves fastest near the **Equator**, at roughly **1,670 km per hour**.
- The surface speed decreases towards the poles.
- At the geographical poles, this surface speed becomes effectively zero because the poles lie on the rotational axis.

Effects of Earth's Rotation

Rotation is responsible for several important phenomena:

- **Day and night**.
- The apparent daily movement of the Sun from east to west.
- Differences in **local time** between places at different longitudes.
- It contributes to the **Coriolis effect**, which influences the movement of winds and ocean currents.
- Earth's rotation also contributes to its slightly flattened shape at the poles and bulging shape around the Equator.

Important Facts

- **Rotation:** Spinning of Earth on its axis.
- **Direction:** West → East.
- **Time:** Approximately 24 hours.
- **Major effect:** Day and night.
- **Axis:** Imaginary line joining the North and South Poles.

- **Equatorial rotational speed:** About 1,670 km/hour.

Q. Explain the Revolution of the Earth and examine the role of Earth's axial tilt in the occurrence of seasons.



- While rotating on its axis, the Earth also travels around the **Sun**.
- This movement of Earth around the Sun is called **revolution**.
- Earth follows a definite path around the Sun.
- This path is called an **orbit**.
- Earth's orbit is not a perfect circle. It is **slightly elliptical**.
- The average distance between the Earth and the Sun is approximately **150 million kilometres**.
- This average distance is also known as **one Astronomical Unit (AU)**.

Time Taken for Revolution

- Earth takes approximately **365 days and 6 hours**, or about **365¼ days**, to complete one revolution around the Sun.
- Our ordinary calendar year contains **365 days**.
- The additional fraction of a day accumulates over successive years.
- This is the basic reason for adding an extra day periodically through the **leap-year system**.
- A leap year normally contains **366 days**, with **29 February** as the additional day.

- The calendar rules are slightly more precise than simply adding one day every four years: century years must normally be divisible by **400** to be leap years.

Earth's Tilt

- Earth's axis is **tilted** rather than standing perpendicular to the plane of its orbit.
- The axis is tilted about **23.5° from the perpendicular** to Earth's orbital plane.
- The same tilt can also be described as about **66.5° relative to the orbital plane**.
- As Earth revolves around the Sun, its axis continues to point approximately in the same direction in space.

Revolution and Seasons

- The **seasons are mainly caused by Earth's axial tilt combined with its revolution around the Sun**.
- They are not caused simply by changes in Earth's distance from the Sun.
- When the Northern Hemisphere is tilted towards the Sun, it receives more direct sunlight and experiences longer days. This produces **summer** there.
- At the same time, the Southern Hemisphere is tilted away from the Sun and experiences **winter**.
- About six months later, the situation is reversed.
- Thus, the Northern and Southern Hemispheres generally experience **opposite seasons**.

Important Facts

- **Revolution:** Movement of Earth around the Sun.
- **Orbit:** Path followed by Earth around the Sun.
- **Time:** About 365¼ days.
- **Average Earth–Sun distance:** About 150 million km.
- **Axial tilt:** About 23.5° from the perpendicular to the orbital plane.
- **Major result of revolution + axial tilt:** Seasonal changes.

Q. Explain the rotation and revolution of the Moon and discuss how these movements influence its appearance as seen from the Earth.

- The **Moon is Earth's natural satellite**.
- It moves around the Earth while the Earth itself moves around the Sun.
- The Moon also rotates on its own axis.

Revolution of the Moon

- The Moon revolves around the Earth in an approximately elliptical orbit.
- Relative to the distant stars, it takes about **27.3 days** to complete one revolution.
- This period is called the **sidereal month**.

- However, the time from one new moon to the next is about **29.5 days**.
- This longer period is called the **synodic month**.
- The difference occurs because the Earth is also moving around the Sun while the Moon is orbiting Earth.

Rotation of the Moon

- The Moon also rotates on its own axis.
- Interestingly, the Moon takes approximately **27.3 days to rotate once** and about the same amount of time to revolve once around Earth.
- Because its rotation and revolution periods are nearly equal, approximately the **same side of the Moon always faces Earth**.
- This condition is called **synchronous rotation** or **tidal locking**.
- The side normally facing Earth is called the **near side**.
- The opposite side is called the **far side**.
- The far side is sometimes incorrectly called the "dark side." It is not permanently dark; it also receives sunlight.

Phases of the Moon

- The Moon does not produce its own visible light.
- It appears bright because it **reflects sunlight**.
- As the Moon revolves around Earth, we see different portions of its sunlit half.
- These changing appearances are called the **phases of the Moon**.
- Major phases include:
    - **New Moon**
    - **First Quarter**
    - **Full Moon**
    - **Last/Third Quarter**
- Between these major phases are crescent and gibbous phases.
- One complete cycle of lunar phases takes approximately **29.5 days**.

Surface and Atmosphere of the Moon

- ➢ The Moon has an extremely thin **exosphere**, rather than a substantial atmosphere like Earth's.
- ➢ Therefore, there is almost no atmospheric protection from solar radiation or incoming space particles.
- ➢ The lunar surface contains:
    - mountains
    - valleys
    - craters
    - plains
- ➢ Many craters were produced by impacts from asteroids and meteoroids.
- ➢ The dark plains visible from Earth are called **maria** (*mare* in the singular).
- ➢ They are ancient plains formed largely from solidified volcanic lava.

Water on the Moon

- The Moon does not have oceans, rivers or lakes of stable liquid water on its surface.
- However, scientists have detected **water molecules and water ice** on the Moon.
- Water ice is particularly important in permanently shadowed regions near the **lunar poles**, where temperatures remain extremely low.

Life on the Moon

➢ No confirmed evidence of **past or present life** has been discovered on the Moon.
➢ Conditions on its surface are extremely harsh because of:
  - almost no atmosphere
  - extreme temperature variations
  - strong radiation exposure
  - lack of stable surface liquid water

Q. Describe the major components of the Earth's atmosphere and explain their importance in sustaining life.

- The Earth is surrounded by a layer of gases called the **atmosphere**.
- The atmosphere makes life possible and also helps regulate temperature.

Major Components of the Atmosphere

➔ **Nitrogen – about 78%**
➔ **Oxygen – about 21%**
➔ Other gases occur in much smaller quantities, including:
  - **argon**
  - **carbon dioxide**
  - **neon**
  - **water vapour**
  - **ozone**

Importance of Oxygen

- Most animals, plants and many microorganisms require oxygen for **cellular respiration**.
- Respiration releases energy from food.

Importance of Carbon Dioxide

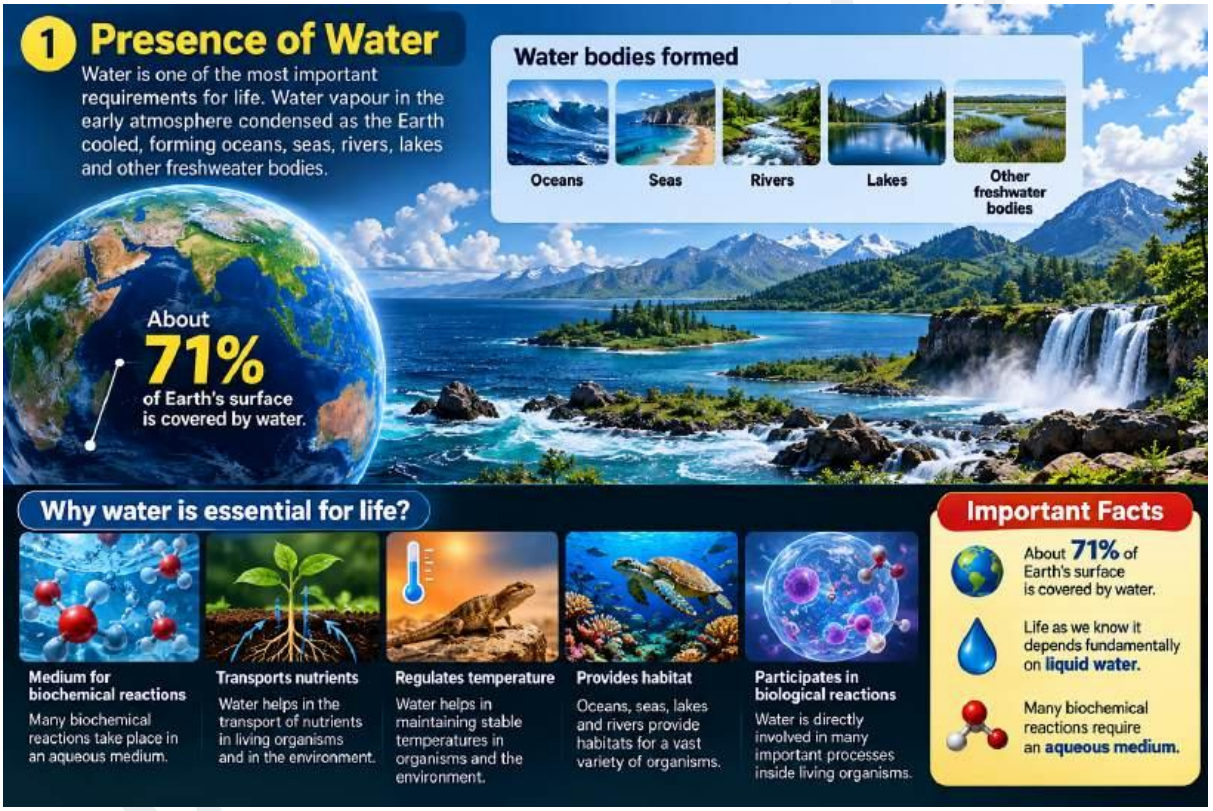
- Green plants use **carbon dioxide** during photosynthesis.
- Photosynthesis produces organic food and releases oxygen.

Importance of Ozone

- Ozone in the upper atmosphere absorbs much of the Sun's harmful **ultraviolet radiation**.
- This helps protect living organisms on Earth.

Important Facts

- **Nitrogen ≈ 78%**
- **Oxygen ≈ 21%**
- **Oxygen is essential for aerobic respiration.**
- **Carbon dioxide is required for photosynthesis.**
- **Ozone helps protect life from harmful ultraviolet radiation.**



Q. Explain how suitable temperature conditions have contributed to the development and survival of life on Earth.

Suitable Temperature

- Temperature is one of the major factors controlling the survival and distribution of organisms.
- Earth's distance from the Sun allows temperatures at which **liquid water can exist over large areas**.

- The atmosphere and oceans also help regulate temperature.
- Different organisms can tolerate different ranges of temperature.
- Extreme heat or cold can disturb biological processes and limit survival.

Important Fact

- A relatively stable temperature range and the presence of **liquid water** are crucial for sustaining Earth's diverse life.

Q. What is buffering capacity? Explain its role in maintaining stable pH conditions and supporting life on Earth.

- Living systems function best within particular chemical conditions.
- One important factor is **pH**, which indicates how acidic or alkaline a substance is.
- A pH of **7 is neutral**.
- Soil and water have natural chemical processes that can resist sudden changes in pH.
- This is known as **buffering capacity**.
- Stable chemical conditions are important for the survival and growth of organisms.

Important Facts

- **pH 7 = neutral.**
- Buffering reduces sudden changes in pH.
- Stable pH conditions support biological processes

Q. Explain the process of chemical evolution and its role in the emergence of the earliest forms of life on Earth.

The development of life can be understood as a long sequence:

Simple chemicals → complex organic molecules → earliest life → photosynthetic organisms → oxygen-rich atmosphere → complex organisms

Chemical Evolution

- On the primitive Earth, simple inorganic substances were present in the atmosphere and oceans.
- Under suitable conditions, chemical reactions produced increasingly complex molecules.
- Organic molecules important for life gradually developed.
- This long process is described as **chemical evolution**.

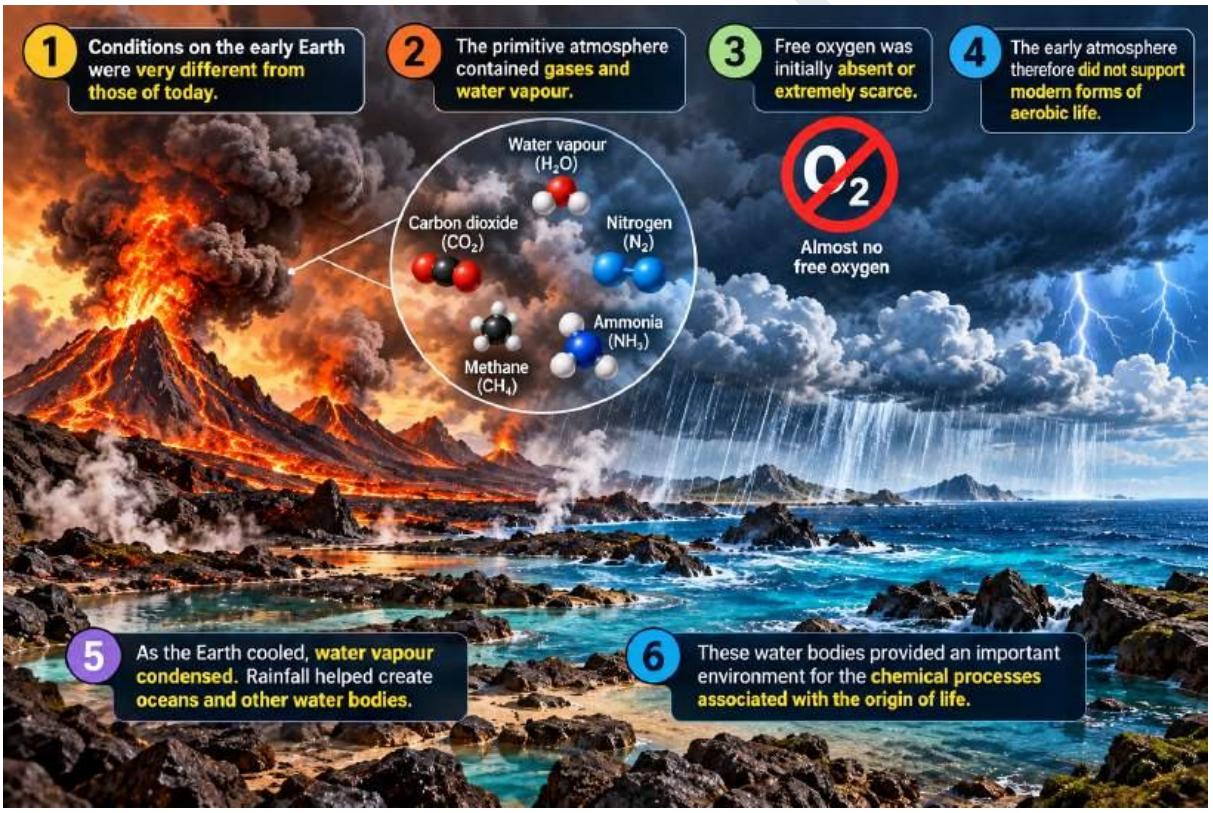
Appearance of the Earliest Organisms

- The earliest organisms were extremely simple and **unicellular**.
- Evidence of very ancient microbial life goes back more than **3 billion years**.
- Early life was dominated by microorganisms for an enormous part of Earth's history.
- These organisms existed long before plants, animals and humans appeared.

Important Facts

- The earliest organisms were **simple and unicellular**.
- Microbial life existed billions of years before complex plants and animals.
- Life originated very early in Earth's geological history.

Conditions on the Primitive Earth



Q. Explain how the evolution of photosynthesis transformed the Earth's atmosphere and created conditions for the development of complex life.

The appearance of photosynthesis was a major turning point in the history of the Earth. It gradually transformed an atmosphere that contained very little free oxygen into one in which oxygen became an important component.

The Beginning of Photosynthesis

Some of the earliest microorganisms developed the ability to use **sunlight as a source of energy**. Among the most important were organisms similar to modern **cyanobacteria**.

They used sunlight, water and carbon dioxide to produce the organic matter needed for growth. In the process, **oxygen was released**.

In the beginning, this oxygen did not immediately accumulate in the atmosphere. Much of it reacted with substances already present in the oceans and rocks, particularly **iron**.

Oxygen Begins to Accumulate

As photosynthesis continued for millions of years, more oxygen was produced. Eventually, the amount being produced became large enough for oxygen to begin accumulating in the atmosphere.

A major rise in atmospheric oxygen occurred about **2.4 billion years ago**. This period is known as the **Great Oxidation Event**.

The increase in oxygen changed both the atmosphere and the oceans. For many organisms adapted to an oxygen-poor environment, oxygen was harmful. Other organisms gradually evolved ways of using it.

Aerobic Respiration Develops

The availability of oxygen made **aerobic respiration** possible.

Aerobic respiration allows organisms to release much more usable energy from food than many forms of respiration that do not use oxygen. This greater availability of energy later became important for the evolution of **larger and more complex organisms**.

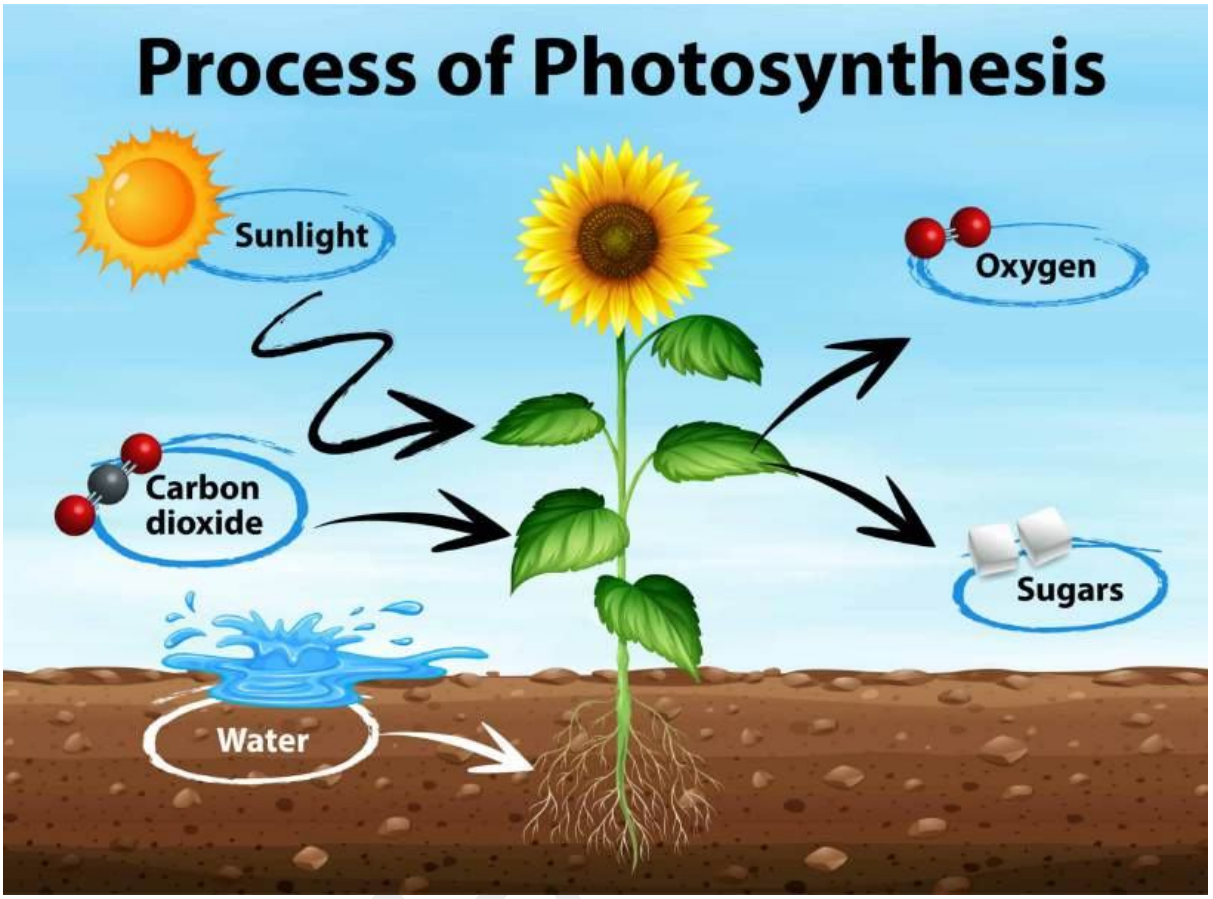
Formation of the Ozone Layer

As oxygen increased in the atmosphere, some oxygen molecules in the upper atmosphere were converted into **ozone**.

Ozone gradually formed a protective layer in the atmosphere. The **ozone layer absorbs much of the Sun's harmful ultraviolet radiation**.

This protection was important because excessive ultraviolet radiation can damage living cells. The development of the ozone layer eventually made environments closer to Earth's surface, including land, more suitable for life.

A Planet Transformed by Life



Photosynthesis shows that life did not simply adapt to conditions on Earth. Living organisms also **changed the planet itself**.

Early photosynthetic microorganisms altered the composition of the atmosphere, increased the availability of oxygen, contributed to the formation of the ozone layer and helped create conditions in which more complex forms of life could eventually evolve.

Important Facts

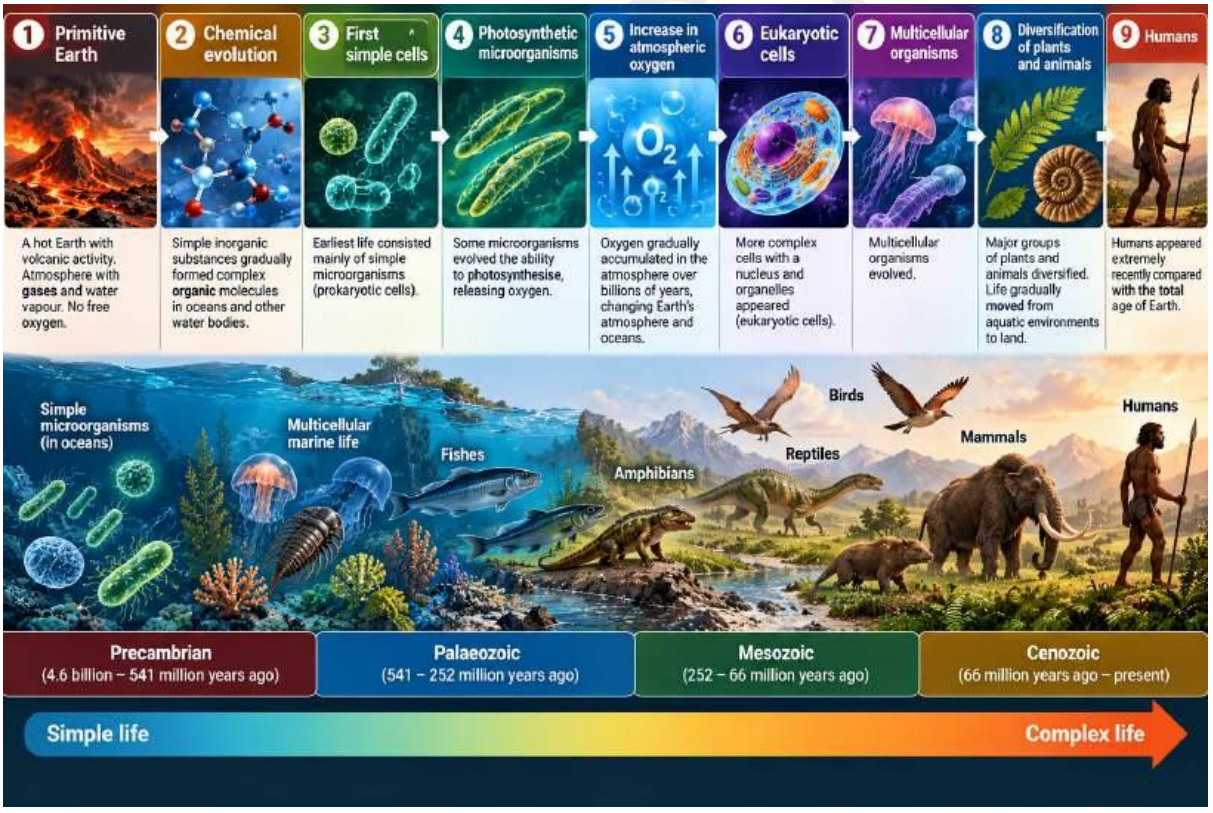
- Early Earth contained **very little free oxygen**.
- Early photosynthetic microorganisms, especially **cyanobacteria**, were major producers of oxygen.
- Atmospheric oxygen increased significantly during the **Great Oxidation Event**, beginning about **2.4 billion years ago**.
- Oxygen made efficient **aerobic respiration** possible.
- Atmospheric oxygen also enabled the formation of the protective **ozone layer**.
- Photosynthesis therefore changed not only living organisms but also the **atmosphere, oceans and future course of life on Earth**.

Geological History – Easy Sequence to Remember

Earth forms → earliest life → photosynthesis → oxygen increases → multicellular life → marine animals diversify → fishes → amphibians → reptiles → dinosaurs → birds and mammals → flowering plants → mammal diversification → humans

Key Timeline

- **4.6 billion years ago** – Earth forms
- **More than 3 billion years ago** – earliest microbial life
- **~2.4 billion years ago** – major atmospheric oxygenation
- **~541 million years ago** – Cambrian diversification
- **~252 million years ago** – beginning of Mesozoic
- **~230 million years ago** – earliest dinosaurs
- **~200 million years ago** – early mammals
- **~66 million years ago** – end-Cretaceous mass extinction
- **~300,000 years ago** – *Homo sapiens*



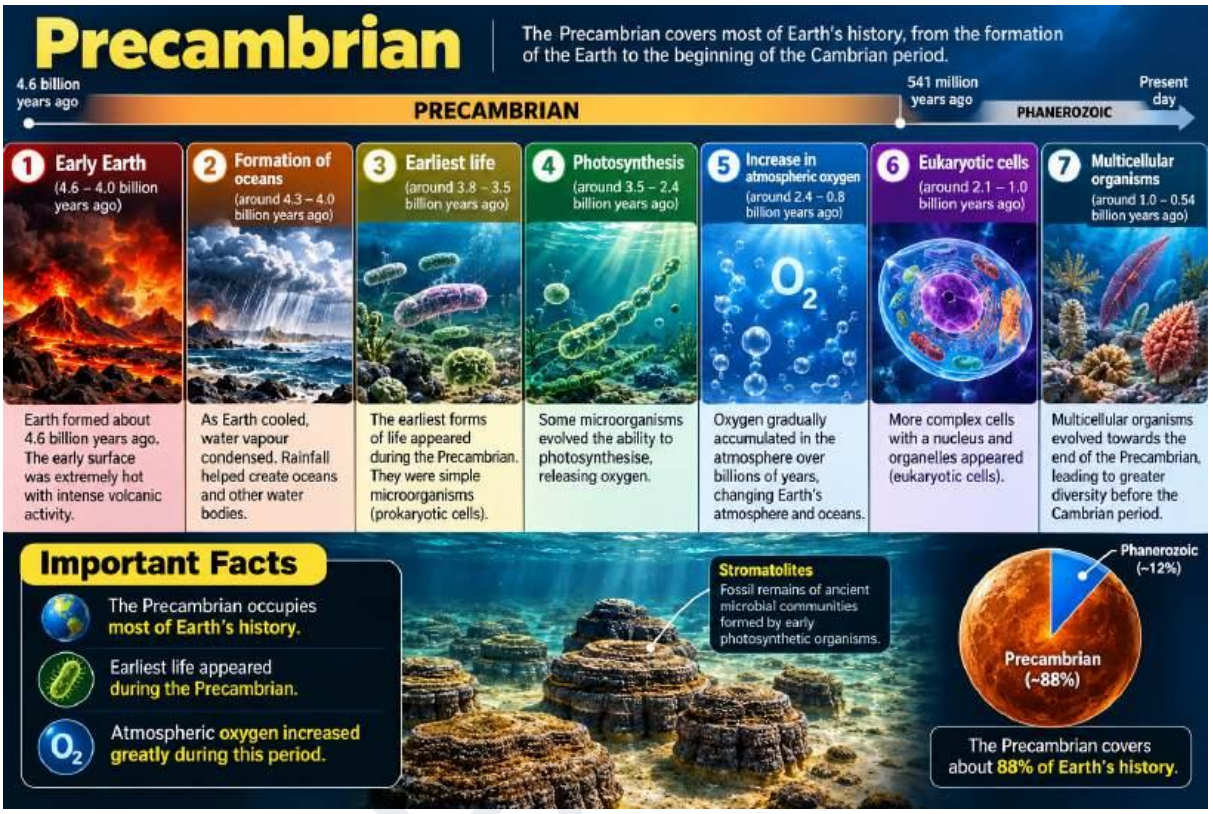
Geological Time Scale

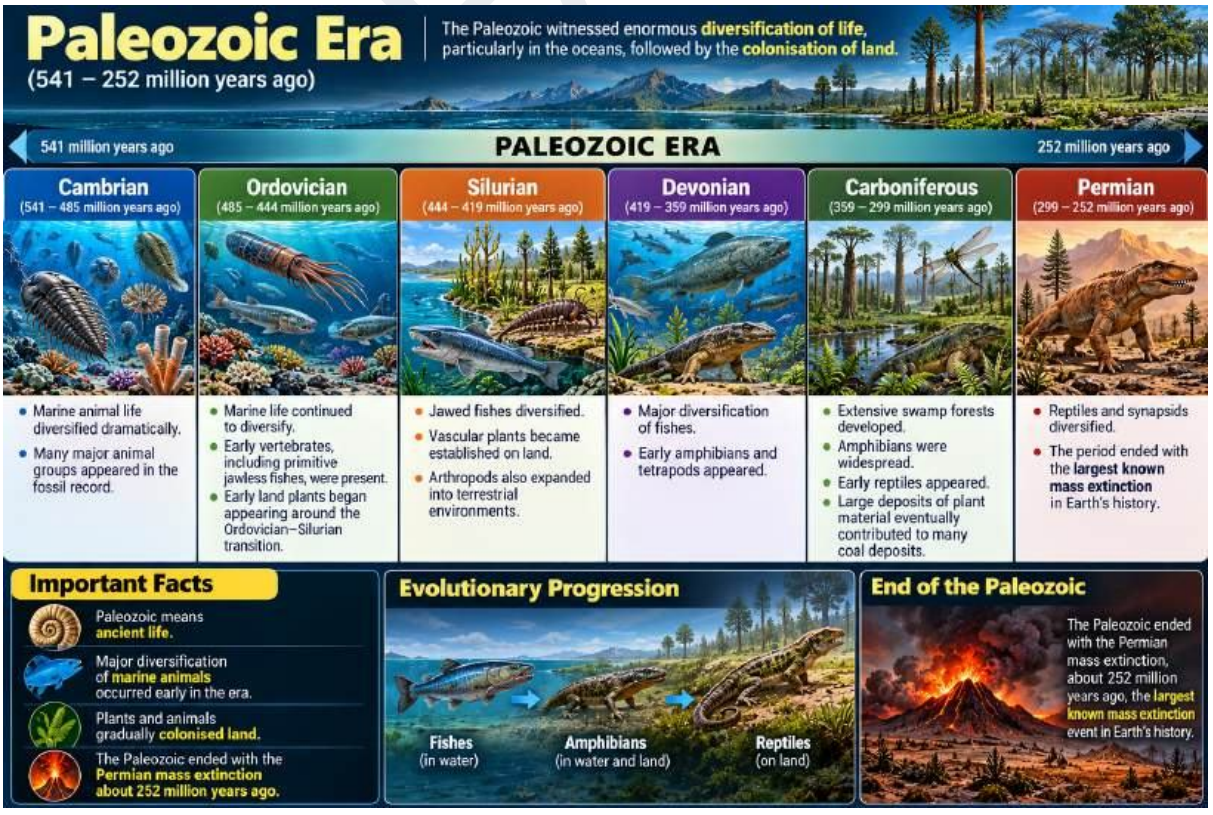
The **geological time scale** divides Earth's long history into major units based on important geological and biological events.

Earth's history is commonly divided into:

- **Precambrian**

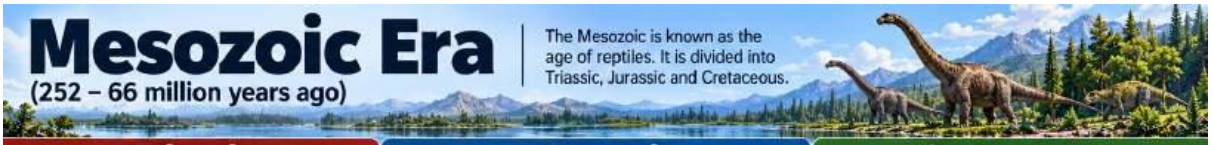
- **Paleozoic Era**
- **Mesozoic Era**
- **Cenozoic Era**





Mesozoic Era
(252 – 66 million years ago)

The Mesozoic is known as the age of reptiles. It is divided into Triassic, Jurassic and Cretaceous.

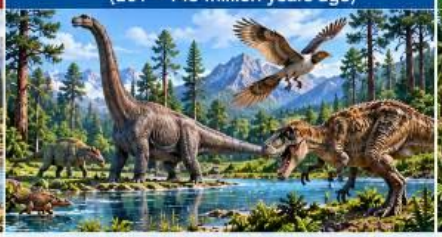


Triassic
(252 – 201 million years ago)



- The first dinosaurs appeared.
- The earliest mammals also appeared.

Jurassic
(201 – 145 million years ago)



- Dinosaurs became highly diverse and widespread.
- Early birds evolved.
- Gymnosperms remained important components of vegetation.

Cretaceous
(145 – 66 million years ago)



- Flowering plants or angiosperms appeared and diversified.
- Dinosaurs continued to dominate many terrestrial ecosystems.
- The period ended with a major mass extinction about 66 million years ago.
- All non-avian dinosaurs became extinct.

Important Facts

- Mesozoic means **middle life.**
- Dinosaurs appeared during the **Triassic.**
- Early birds appeared during the **Jurassic.**
- Flowering plants diversified during the **Cretaceous.**
- Non-avian dinosaurs became extinct about **66 million years ago.**

Key Developments through the Mesozoic

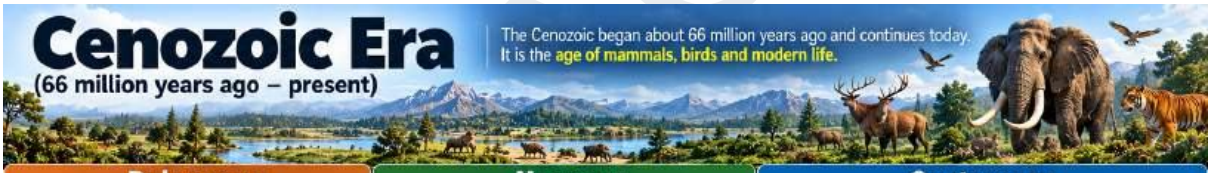


Dinosaurs appear (Triassic) | Early birds evolve (Jurassic) | Flowering plants diversify (Cretaceous) | Mass extinction (66 million years ago) end of Cretaceous

252 million years ago — Triassic (252 – 201 mya) | Jurassic (201 – 145 mya) | Cretaceous (145 – 66 mya) — 66 million years ago

Cenozoic Era
(66 million years ago – present)

The Cenozoic began about 66 million years ago and continues today. It is the **age of mammals, birds and modern life.**

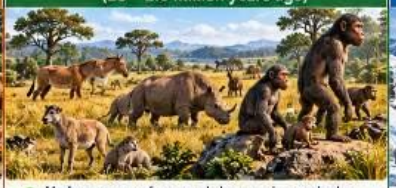


Paleogene
(66 – 23 million years ago)



- Mammals and birds diversified after the end-Cretaceous extinction.
- Many new groups of mammals appeared.
- Flowering plants became dominant in many terrestrial ecosystems.

Neogene
(23 – 2.6 million years ago)



- Modern groups of mammals became increasingly diverse and widespread.
- Grasslands expanded.
- Primates diversified.
- Hominin lineage began to evolve towards the end of this period.

Quaternary
(2.6 million years ago – present)



Pleistocene (2.6 million – 11,700 years ago) | **Holocene** (11,700 years ago – present)

- Pleistocene experienced repeated glacial and interglacial periods.
- The genus *Homo* diversified during the Quaternary.
- *Homo sapiens* appeared roughly 300,000 years ago.
- Holocene began about 11,700 years ago and continues today.

Important Facts

- Cenozoic means **recent life.**
- It began about **66 million years ago.**
- Mammals diversified **greatly during** the Cenozoic.
- Modern humans appeared **only very recently** in Earth's history.

The Quaternary Period in Detail

The Quaternary is the most recent geological period. It includes the Pleistocene and Holocene epochs.



Pleistocene
(2.6 million – 11,700 years ago)

- Repeated glacial and interglacial periods.
- Large mammals such as mammoths, woolly rhinoceroses and giant deer were present.
- The genus *Homo* diversified.

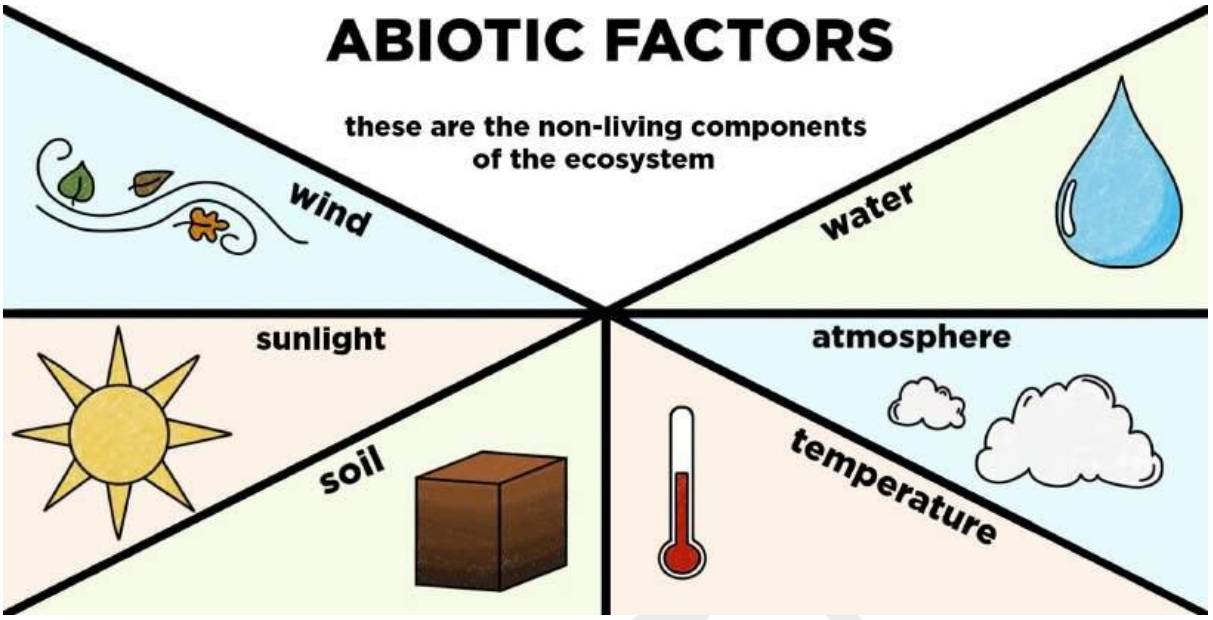


Holocene
(11,700 years ago – present)

- Began about 11,700 years ago.
- Climate became relatively stable and warm.
- Development of agriculture, settlements and complex societies.
- Continues today.

66 million years ago — Paleogene (66 – 23 mya) | Neogene (23 – 2.6 mya) | Pleistocene (2.6 million – 11,700 years ago) | Holocene (11,700 years ago – present) — Present day

Abiotic Components of the Environment



Every organism lives under a particular set of environmental conditions. Some of these conditions are created by living organisms, while others come from the non-living surroundings. The non-living part of the environment is described as its **abiotic component**.

Light, water, temperature, air, soil, rocks and minerals are among the major abiotic components. They influence the kind of organisms that can live in a place and the way they survive there.

Light

For most ecosystems, energy ultimately comes from the **Sun**.

Green plants capture sunlight and use it for **photosynthesis**. During this process, light energy is converted into chemical energy and stored in food.

Animals cannot produce food in this way. Herbivores obtain energy by eating plants, while carnivores obtain it by eating other animals. Thus, solar energy passes through an ecosystem from one organism to another.

Sunlight → Green plants → Herbivores → Carnivores

Light also affects many other aspects of life. The duration and intensity of daylight can influence flowering in plants, breeding in animals, migration and daily activity.

Important Facts

- The **Sun** is the main source of energy for most ecosystems.
- Plants capture solar energy through **photosynthesis**.

- Energy stored by plants passes to other organisms through feeding relationships.

Rainfall and Water

- Water is essential for life. A large proportion of the bodies of living organisms consists of water, and most of the chemical reactions necessary for life take place in a watery medium.
- Plants need water for photosynthesis, transport of minerals and maintenance of their tissues. Animals need it for digestion, circulation, excretion and regulation of body temperature.
- The availability of water also determines the character of an ecosystem. Areas receiving abundant rainfall may support forests, while regions with very little rainfall may develop deserts or dry grasslands.
- Water itself forms a habitat. Rivers, ponds, lakes, wetlands, seas and oceans support a great variety of organisms.
- Rainfall is therefore important not simply as a source of water. Its **amount, timing and seasonal distribution** can influence the vegetation and animal life of an entire region.

Important Facts

- Water is necessary for the basic chemical processes of life.
- Rainfall has a major influence on the vegetation of a region.
- The availability of water also affects the distribution of animals.
- Freshwater and marine environments provide habitats for enormous numbers of organisms.

Temperature

Life can survive only within certain temperature limits, although these limits differ greatly between species.

Temperature affects the rate at which many biological and chemical processes take place. Very high or very low temperatures can interfere with normal cellular activity.

Different organisms have evolved different ways of dealing with temperature. Polar organisms can survive extreme cold, while desert organisms are adapted to high daytime temperatures and large differences between day and night.

Temperature also works together with other environmental factors. A high temperature, for example, can increase evaporation and make water less available.

Changes in temperature with **latitude, altitude, season and time of day** help explain why different places support different communities of plants and animals.

Important Facts

- Different organisms have different ranges of **temperature tolerance**.
- Temperature affects metabolism, growth, reproduction and distribution.
- Temperature conditions change with latitude, altitude and season.
- Temperature and water availability are closely connected.

Atmosphere

The Earth is surrounded by a layer of gases known as the **atmosphere**. These gases are essential for life and also influence weather and climate.

Dry air near the Earth's surface consists mainly of:

- **Nitrogen – about 78%**
- **Oxygen – about 21%**
- **Argon – about 0.93%**
- **Carbon dioxide – about 0.04%**

Water vapour is also present, but its amount varies considerably from place to place and over time.

Oxygen is required for **aerobic respiration** by most organisms. Plants use carbon dioxide during **photosynthesis**. Nitrogen is essential for the formation of proteins and other biological molecules, although most organisms cannot use atmospheric nitrogen directly.

The atmosphere also plays an important role in maintaining Earth's temperature and protecting life from harmful radiation.

Important Facts

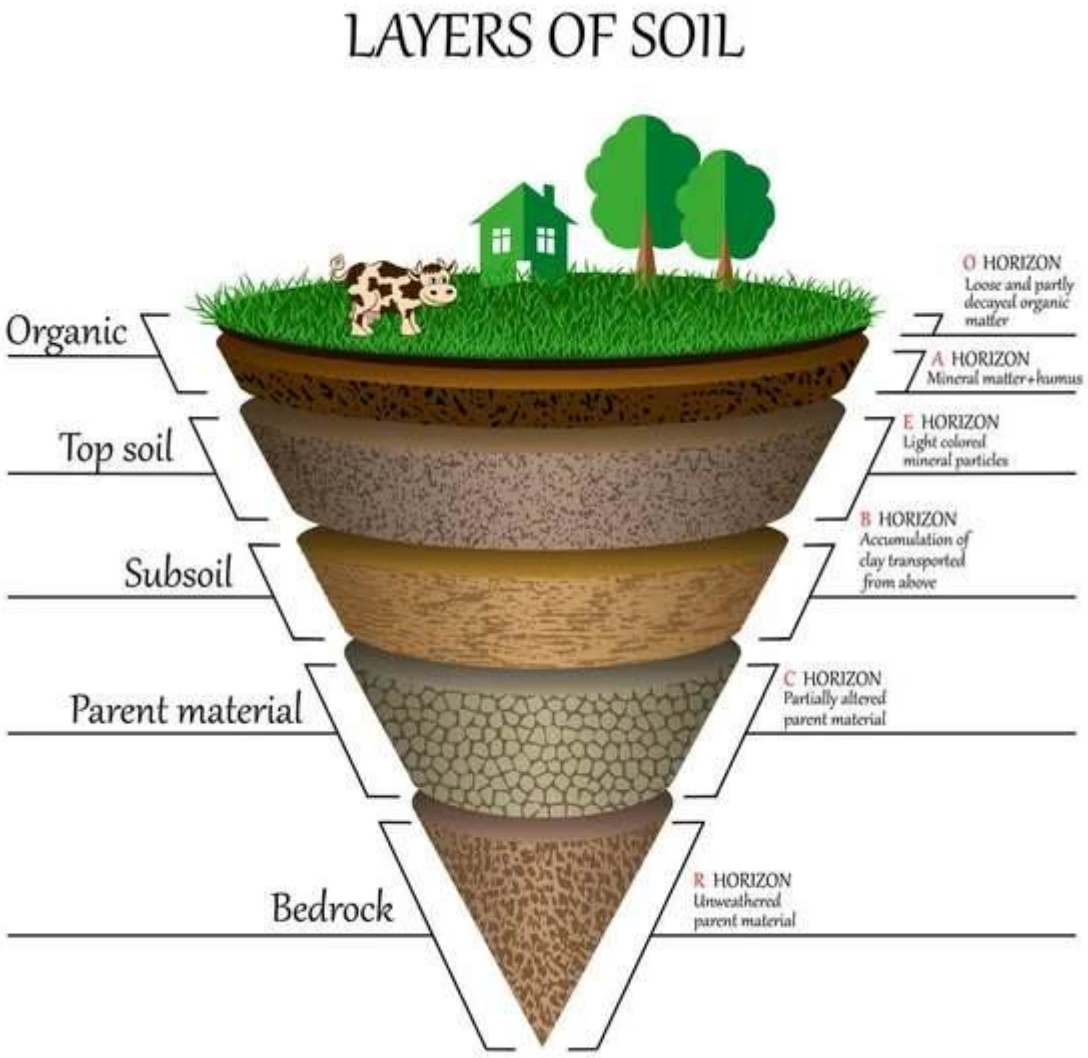
- **Nitrogen** is the most abundant gas in the atmosphere.
- **Oxygen** is essential for aerobic respiration.
- **Carbon dioxide** is used by plants in photosynthesis.
- Atmospheric gases are involved in the carbon, oxygen and nitrogen cycles.

Substratum

Every organism needs a physical place in which or on which it can live. This supporting surface or material is called the **substratum**.

On land, the most important substratum is usually **soil**. Soil is not simply broken rock. It is a complex mixture containing mineral particles, water, air, organic matter and numerous microorganisms.

Plants anchor their roots in soil and obtain water and mineral nutrients from it. Many animals also live directly in the soil. Earthworms, insects and numerous microscopic organisms spend much or all of their lives below the surface.



The nature of the soil influences the vegetation that can grow in an area. Its depth, texture, mineral content, water-holding capacity and acidity can all affect plant growth.

Substrata are equally important in aquatic environments. Organisms may attach themselves to rocks, live in sand or mud, or occupy sediments at the bottom of lakes and oceans.

Even the deep ocean provides specialised substrata. Communities of organisms are found around **hydrothermal vents**, where hot, mineral-rich water emerges from the ocean floor.

Important Facts

- **Substratum** is the surface or material on or within which an organism lives.
- Soil is the major substratum in most terrestrial environments.
- Soil contains **minerals, organic matter, water, air and living organisms**.
- Rocks, sand, mud and seabed sediments can act as substrata in aquatic environments.
- The nature of the substratum can determine which organisms are able to establish themselves in a particular habitat.

Biotic Components of the Environment

Q. What are the biotic components of an environment? Explain the roles of producers, consumers and decomposers in maintaining an ecosystem.

Biotic components are the **living parts of an environment**.

They include:

- plants
- animals
- fungi
- bacteria
- protozoa
- other microorganisms
- human beings

Living organisms interact continuously with one another.

Green Plants

- Green plants manufacture their own food through **photosynthesis**.
- They are therefore known as **producers**.
- Plants form the basic energy source for most food chains.
- They also release oxygen during photosynthesis.

Sunlight + CO_2 + Water → Photosynthesis → Food + Oxygen

Animals

- Animals cannot manufacture their own food in the same way as green plants.
- They depend directly or indirectly on other organisms.
- Animals are therefore **consumers**.
- Some eat plants.
- Some eat other animals.
- Others consume both.

Microorganisms and Decomposition

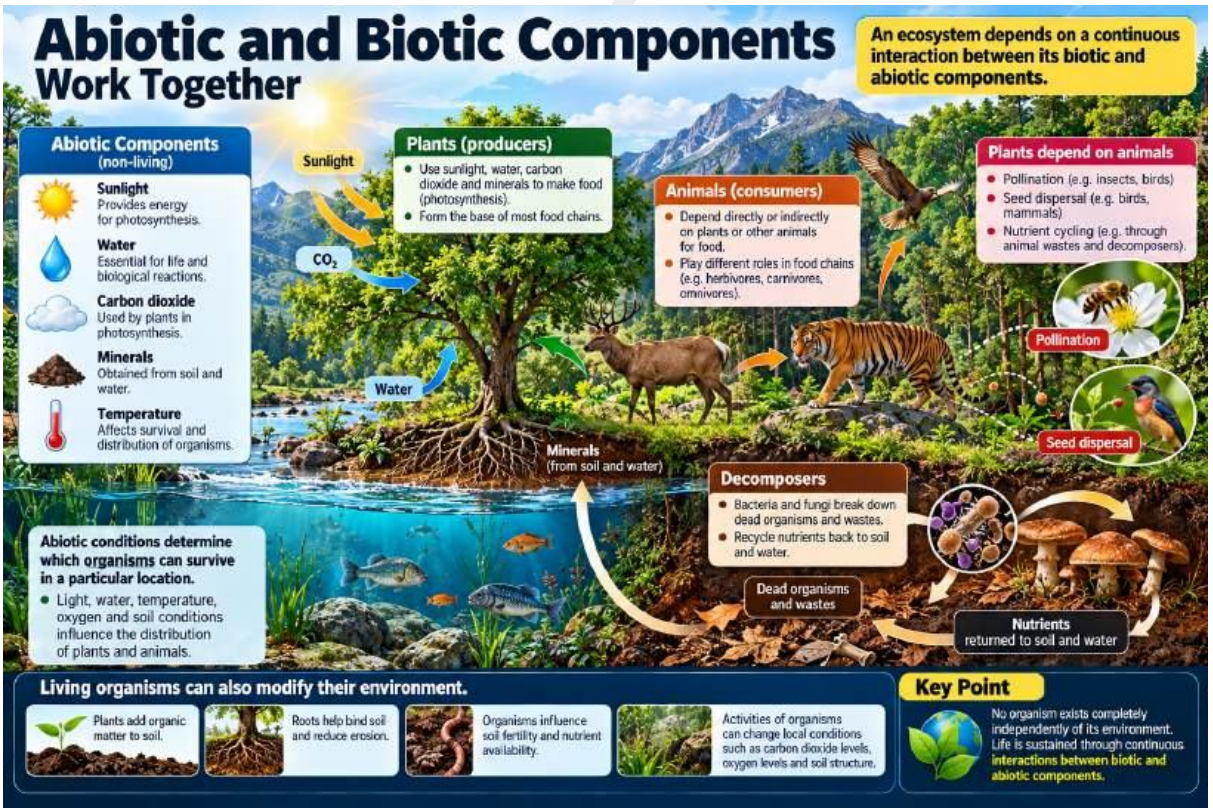
- Bacteria and fungi play a major role in breaking down dead organisms and wastes.
- Such organisms are called **decomposers**.
- Decomposition releases nutrients locked inside dead organic matter.
- These nutrients return to soil and water.
- Plants can absorb and reuse them.

This creates an important cycle:

Plants → Animals → Death and waste → Decomposers → Nutrients → Plants

Important Facts

- **Producers:** mainly green plants and other photosynthetic organisms.
- **Consumers:** organisms that obtain food from other organisms.
- **Decomposers:** mainly bacteria and fungi that break down dead organic matter.
- Decomposition helps **recycle nutrients** within ecosystems.



Mains Practice Questions

1. Explain the major conditions that make the Earth suitable for the origin and sustenance of life. **(10 Marks, 150 Words)**
2. Discuss the role of photosynthetic organisms in transforming the early atmosphere and facilitating the evolution of complex life on Earth. **(10 Marks, 150 Words)**
3. Explain how abiotic and biotic components interact with each other to maintain the functioning of an ecosystem. **(10 Marks, 150 Words)**
4. Trace the major stages in the evolution of life on Earth from the earliest organisms to the emergence of human beings, with reference to the geological time scale. **(15 Marks, 250 Words)**
5. Examine the significance of water, atmosphere, solar radiation and temperature in determining the distribution and survival of life on Earth. **(15 Marks, 250 Words)**

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