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# ORIGIN OF EARTH AND EVOLUTION OF THE ENVIRONMENT

We live on a beautiful planet called earth, along with a wide variety of plants, animals and other organisms. Our earth, however, is part of a vast universe. The universe is about 15 to 20 billion years old. The age of the earth is approximately 4 to 5 billion years, while human beings evolved only around 2 million years ago. In this lesson, you shall learn how the earth originated, how it got its own environment and in what ways human beings have been using the environmental resources for their welfare and development.



## OBJECTIVES

After completing this lesson, you will be able to:

- *trace the origin of the earth;*
- *list the conditions, which make the earth a unique planet for supporting life;*
- *describe the sequence of steps in the origin and evolution of life prior to the appearance of humans;*
- *explain the term environment;*
- *enumerate the various biotic and abiotic constituents of the environment.*

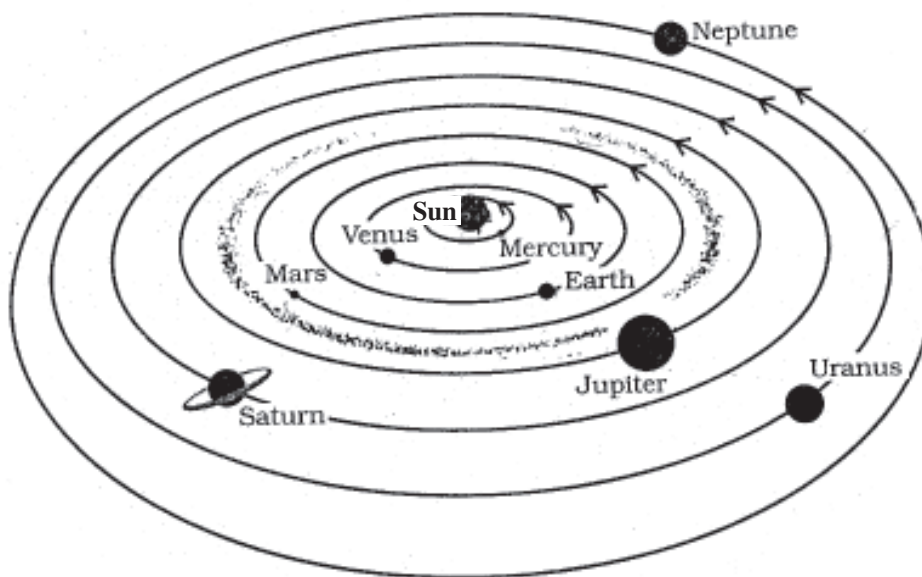
## 1.1 EARTH AS PART OF THE UNIVERSE AND THE SOLAR SYSTEM

Our earth, with all its diversity alongwith other planets and their satellites, the sun, the moon, the many galaxies (huge groups of millions of stars) form the universe. There are also countless asteroids and comets in orbit around the sun. All these are also part of the universe. It extends much farther than can be seen by the most powerful telescope. No one knows where the universe ends.



**Notes**

When you look up at the sky on a clear night, you see many points of light – most of which are stars. Stars are huge balls of bright, hot glowing gases. The ‘Sun’ is also a star. It is the star nearest to earth – about 150 mk (million kilometers) away. **A solar system** consists of a star in the middle with a number of planets orbiting around it. The earth is a part of its solar system. It is one of the eight planets of the solar system that has the sun (a star) in the middle and the eight planets moving around it. Until recently solar system was believed to have nine planets. However, on the basis of the latest scientific assessment, Pluto, is no longer regarded as a planet of earth’s solar system. (Fig. 1.1)



*Fig. 1.1: Planets orbiting the sun*

## **1.2 ORIGIN OF THE UNIVERSE AND ORIGIN OF THE EARTH**

The widely accepted theory of the origin of universe is the “BIG BANG” theory. According to this theory, universe started with a huge explosion and matter (dust and gases) filled the entire space. The temperature of the universe then, was about hundred billion degrees Celsius. Scientists believe that the big bang occurred about 15 to 20 billion years ago. The huge collection of dust and gases then began to spin. As it spun faster and faster, the centre became very hot. It became the Sun. From the edges of this ball of dust and gas, big blobs or chunks of dust broke off and formed eight ball shaped planets. This founded our solar system (Fig. 1.2). The earth broke off about 4.5 billion years ago with an explosion. It was a burning hot white mass of gas and dust. Over a long period of time, dust and gas gradually condensed to form solid rock. Such condensation and shrinking made the earth heat up so much that the rock melted into a gluey liquid. After millions of years, the outer surface of the earth or the earth’s crust cooled and formed hard rock again, just as melted chocolate or wax solidifies upon cooling. The interior of the earth is still very hot.

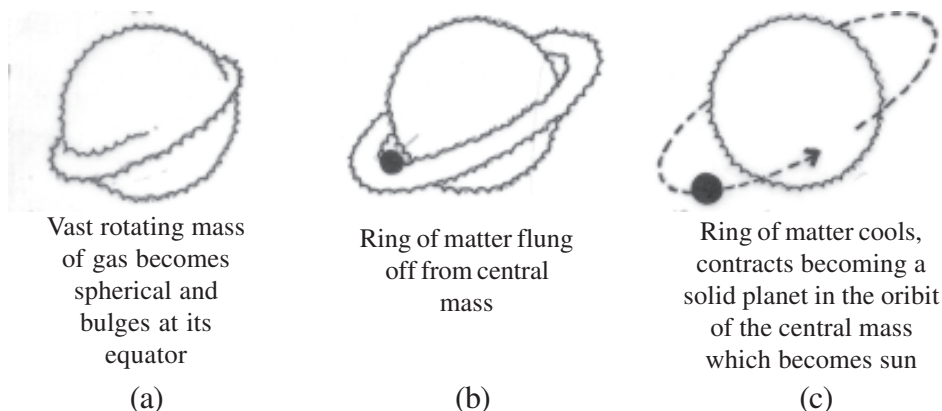


Fig. 1.2: Formation of planets

The **crust** of the earth was formed from cooling and hardening of the molten matter and hot gases. With cooling of the earth the crust hardened and formed the land. Cooling of the earth also condensed water vapour into liquid water filling the depressions to form seas.

### 1.2.1 The earth

The earth with its blue skies, vast oceans and lush green forests is the home to wide variety of organisms. It has its own unique atmosphere. The atmosphere also helps to regulate the ambient (surrounding) temperature which is suitable for supporting life.

If you could dig a deep hole into earth the deeper you go, the hotter it becomes. At the depth of about eight km it is hot enough to roast a human body. About 32 km deep you would reach the part of earth which is called **mantle**. This is made of hard rock. The centre or **core** of the earth is approximately 6,400 km from the surface having a temperature close to 5000°C. Much of the earth's core is hot liquid (Fig. 1.3a)

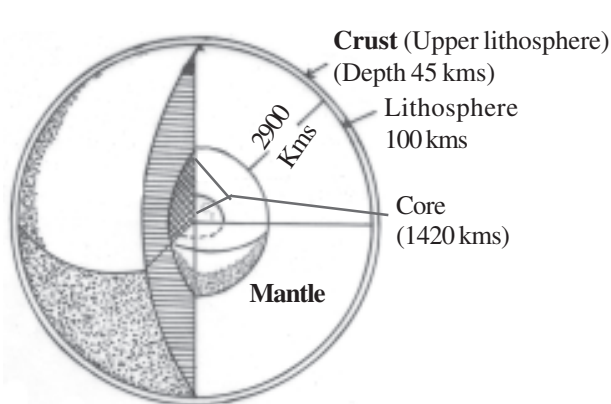


Fig. 1.3a: Interior of the earth



Fig. 1.3b: Rotation of the earth

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As you already know, once every 24 hours, the earth rotates on its axis like a spinning top. So the day and night cycle is of 24 hours. A planet's axis is an imaginary line passing through the centre of the planet. (Fig. 1.3b). The earth not only rotates around its axis but also revolves around the sun. The earth completes one full circle around the sun or completes one orbit of the sun in  $365\frac{1}{4}$  days. An orbit is the path along which a planet moves around the sun.

While earth revolves around the sun, moon orbits the earth. The moon completes one orbit in 27.33 days. The moon, as we know today, is without water and air and life. From the space, the earth looks like a beautiful bright bluish planet because of its blue oceans.



### INTEXT QUESTIONS 1.1

1. Approximately how old is the earth?  
\_\_\_\_\_
2. Name the star around which the earth revolves along with other planets of the solar system.  
\_\_\_\_\_
3. What do you mean by "solar system"?  
\_\_\_\_\_
4. Why does the day and night cycle consist of only 24 hours?  
\_\_\_\_\_
5. If you were to view earth from space, which colour would earth reflect?  
\_\_\_\_\_

### 1.3 EARTH—THE UNIQUE PLANET WHICH SUSTAINS LIFE

In our solar system, earth is the only planet which is known to sustain life. Only earth has air and water to support life.

Let us briefly review the conditions on the other seven planets of the solar system.

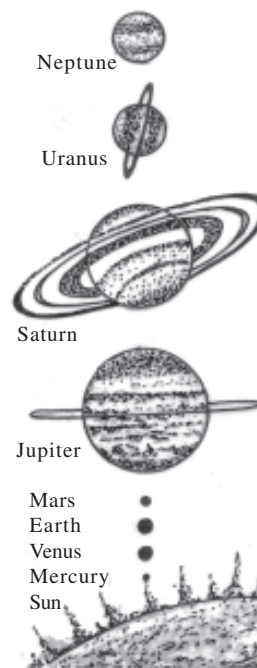
- **Mercury** (Buddha) is closest to the sun. It has a temperature range of  $427^{\circ}\text{C}$  on its side facing the Sun and  $-270^{\circ}\text{C}$ , on its dark side. It has no atmosphere.
- **Venus** (Shukra) is the closest neighbour of the earth. It is about 40 mk away. It is an extremely hot planet with a temperature of  $480^{\circ}\text{C}$ . Its atmosphere has 96% carbon dioxide and poisonous gases like sulphur dioxide and carbon monoxide.
- **Mars** (Mangal) is also close to earth. It is called the red planet. It has 95% carbon monoxide and reddish dust. It is relatively a very cold planet and as of now presence



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of life on it has not been conclusively established.

- **Jupiter** (Brahhaspati) is the largest planet of the solar system. It is mainly a rapidly spinning ball of gas specially clouds of ammonia, and has no solid surface.
- **Saturn** (Shani) consists mainly of hydrogen and helium. Its atmosphere has 90% nitrogen and a temperature of (-184°C). It is also made up of hydrogen cyanide which is a highly poisonous gas. It is characterized by a ring that surrounds it.
- **Uranus** (Arun) is also a very cold planet. Uranus is a distant planet of solar system and 7<sup>th</sup> in order from the sun. Uranus and Neptune are the outermost planets of the solar system. Uranus has a highly tilted rotational axis.
- **Neptune** (Varun) is much smaller than earth, cold and dark with its surface coated with frozen methane.
- **Earth** is the only planet known to sustain life.



**Fig. 1.4:** Our solar system

Scientists do not know of any other planet in the universe besides the earth, where there is life. There are hundreds of stars in the universe and they have planets orbiting round them. But whether the necessary conditions to support life exist there is not known.

As compared to other planets mentioned above, earth has the following unique conditions which have enabled it to sustain life.

### 1.3.1 Conditions necessary for sustaining life

#### a. Presence of water

As already mentioned, during the evolution of the earth, water vapour in the primitive atmosphere condensed into liquid water. This gave rise to the formation of oceans, rivers and other fresh water bodies. Three-fourth of earth's surface is covered with water.

Water is a universal solvent and life originated in water. Two thirds of a living organism consists of water and 90 percent of cell content is also water. Biochemical reactions in living organisms require an aqueous medium. Therefore, water is important for the survival of living organisms.

#### b. Atmosphere

The earth is enveloped by a gaseous atmosphere that supports life. The earth's atmosphere consists of nitrogen (78%) and oxygen (21%), small amounts of carbon dioxide, water vapour, ozone and rare gases like argon, neon etc.

Oxygen from the atmosphere is used by the living organisms during respiration. Oxygen is necessary to oxidize food for liberating energy required for various activities in the living organisms. Green plants utilize carbon dioxide from the atmosphere during photosynthesis.



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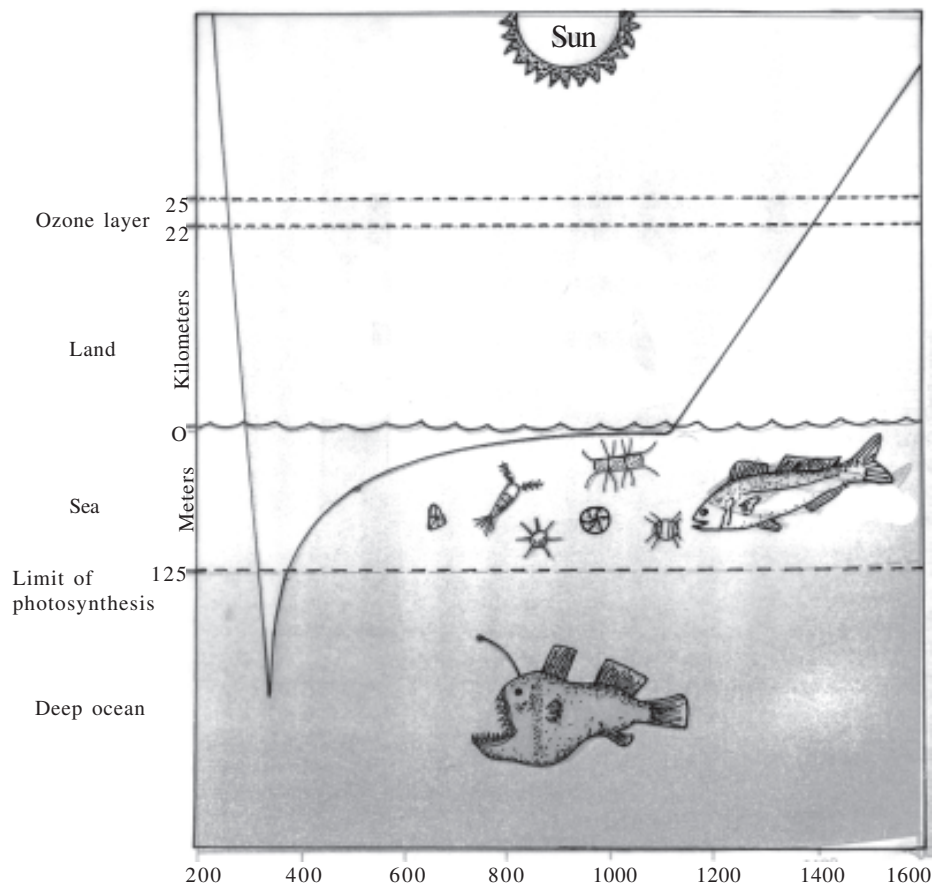
**c. Temperature**

The average temperature of the earth is 16°C. This is the most comfortable temperature for the living organisms to survive.

**d. Buffering capacity of earth**

The most unique feature of the earth is its buffering action due to which a neutral pH (pH-7) is maintained in the soil and water bodies. The neutral pH is congenial for the survival and sustenance of living organisms.

Earth gets light from the sun, the star nearest to earth, approximately 150 km away. It is the ultimate source of energy.



*Fig. 1.5: Solar radiations and life on the earth*



**INTEXT QUESTIONS 1.2**

1. List the conditions that make earth a unique planet.

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2. From where earth gets energy?

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3. Why oxygen is essential for life?

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**1.4 ORIGIN AND EVOLUTION OF LIFE PRIOR TO THE APPEARANCE OF HUMAN BEINGS**

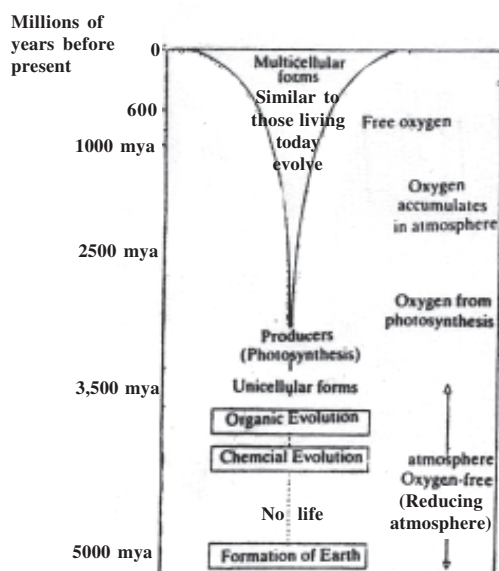
To begin with, conditions on earth were inhospitable for life. Gases of the primitive atmosphere were primarily methane, ammonia, carbon dioxide and hydrogen. Water vapour filled the atmosphere but there was no free oxygen. It was thus a reducing atmosphere on primitive earth and no life existed.

**Biological evolution- from the simple organisms to complex organisms**

As earth cooled, water vapour condensed to form liquid water. Rains poured to form water bodies on earth. The molecules of life were formed in the water.

From the molecules of the life evolved bacteria, the earliest and simplest organisms. The oldest fossils of bacteria which were the first living organisms on earth have been found in rocks that are 3-5 billion years old.

For almost two billion years, different kinds of bacteria lived on earth. One of these evolved a green pigment called chlorophyll. These chlorophyll-containing bacteria used carbon dioxide and water and released oxygen through photosynthesis and started accumulating in the atmosphere.



*Fig. 1.6: Diagrammatic representation of major events of life on earth (mya = millions of years ago)*



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Continued photosynthesis by such bacteria progressively accumulated oxygen in the atmosphere. Thus the atmosphere gradually transformed from reducing to oxidizing. At one point of time oxygen content in the atmosphere become 21%.

Such changes served as a big trigger for biological evolution to begin and progress and this led to the invasion of land by living organism.

As time passed, protists evolved from bacteria. Both bacteria and protists are unicellular. Then came multicellular organisms, the fungi followed by plants and animals. Today the diversity of living organisms is comprised of five kingdoms of life. Monera, Prototictista, Fungi, Plantae and Animalia.

THE GEOLOGICAL TIME SCALE					RELATIVE TIME SPAN OF ERAS	
Era	Period	Eph	Age (million year)	Some important events in the history of life		
Cenozoic	Quaternary	Recent	0.01	Historic time	Genozoic Mesozoic  Paleozoic         Precambrian	
		Pleistocene	1.8	Ice ages; humans appear		
	Tertiary	Pliocene	5	Ape like ancestors of humans appear		
		Miocene	23	Continued radiation of mammals and angiosperms		
		Oligocene	34	Origins of most modern mammalian orders, including apes		
		Eocene	57	Angiosperm dominance increases; further increase in mammalian diversity		
		Paleocene	65	Major radiation of mammals, birds, and pollinating insects		
		Cretaceous	144	Flowering plants (angiosperms) appear; dinosaurs and many groups of organisms become extinct		
	Mesozoic	Jurassic		208		Gymnosperms continue as dominant plants; dinosaurs dominant first birds
		Triassic		245		Gymnosperms dominate landscape; first dinosaurs and mammals
Paleozoic	Permian		285	Radiation of reptiles, origin of mammal-like reptiles and most modern orders of insects; extinction of many marine invertebrates		
		Carboniferous	360	Extensive forests of vascular plants; first seed plants; origin of reptiles; amphibians dominant		
	Devonian		408	Diversification of bony fishes; first amphibians dominant		
		Siturian	438	Diversity of jawless vertebrates; colonization of land by plants and arthropods; origin of vascular plants		
	Ordovician		505	First vertebrates (jawless fishes); marine algae abundant		
		Cambrian	544	Origin of most invertebrate phyla; diverse algae		
Precambrian			700	Origin of first animals		
			1500	Oldest eukaryotic fossils		
			2500	Oxygen begins accumulating in atmosphere		
			3500	Oldest definite fossils known (prokaryotes)		
			4600	Approximate origin of Earth		

*Fig. 1.7: Geological time scale*





### INTEXT QUESTIONS 1.3

1. Name the gases that were found in the primitive atmosphere.

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2. Which were the earliest organisms that evolved on earth?

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3. How did oxygen come into atmosphere?

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4. Name the five kingdoms of life

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## 1.5 WHAT IS ENVIRONMENT

Every living organism is constantly interacting with its environment comprised of air, light, water, land or substratum and the various kinds of living organisms.

The environment may be defined as the **surroundings or conditions in which an organism lives or operates**. The environment broadly includes living and non living components which are listed in the table given below.

*Table 1.1: Components of the environment*

Abiotic	Biotic
Light, climate (humidity and temperature) atmospheric gases, water, substrata (soil, river/sea bed).	Living organisms including plants, animals, microorganisms (bacteria, fungi, protozoa), and human beings.

### A. Abiotic components

- i. **Light** – Sunlight provides energy. Green plants utilize sun light for photosynthesis for synthesizing food for themselves as well as all other living organisms.
- ii. **Rainfall** – Water is essential for all living beings. Majority of biochemical reactions take place in an aqueous medium. Water helps to regulate body temperature. Further, water bodies form the habitat for many aquatic plants and animals.
- iii. **Temperature** – Temperature is a critical factor of the environment which greatly influences survival of organisms. Organisms can tolerate only a certain range of temperature and humidity.

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- iv. **Atmosphere** - The earth's atmosphere is made of 21% oxygen, 78% nitrogen and 0.038% carbon dioxide. Rest are inert gases (0.93% Argon, Neon etc).
- v. **Substratum**- Organisms may be terrestrial or aquatic. Land is covered by soil and a wide variety of microbes, protozoa, fungi and small animals (invertebrates) thrive in it. Roots of plants pierce through the soil to tap water and nutrients. Terrestrial animals live on land. Aquatic plants, animals and microbes live in fresh water as well as in the sea. Some microbes live even in hot water vents under the sea.

### B. Biotic components

- i. **Green Plants** – Prepare food through photosynthesis for all living organisms.
- ii. **Animals** – Individuals of the same species occur in a particular type of habitat. They also live with other species. One species forms food for another. Micro-organisms and fungi decompose dead plants and animals releasing nutrients locked in bodies of dead organisms for reuse by the growing plants.

Living organisms, therefore, need both abiotic and biotic components of the environment for survival. A delicately balanced relationship between living organisms and their environment is critically important for their survival.



### INTEXT QUESTIONS 1.4

1. Define environment.  
\_\_\_\_\_
2. Name its biotic components.  
\_\_\_\_\_
3. List its abiotic components.  
\_\_\_\_\_
4. In a sentence, mention why environmental degradation should be prevented.  
\_\_\_\_\_



### WHAT YOU HAVE LEARNT

- The universe consists of galaxies of stars.
- Stars are huge balls of hot glowing gases. Sun is also a star.
- Our solar system is composed of the sun and eight planets moving around it.
- Earth is one of the planets of our solar system.



- The universe originated when there was a huge explosion that filled all the space with dust and gases.
- The ball of dust and gases spun fast which gave out great heat and the very hot centre broke off as the sun.
- It is believed that planets broke off from the periphery of this hot ball of dust and gases.
- The earth has three parts namely the core, the mantle and the outermost crust.
- The earth rotates in its orbit around the sun; and also rotates upon on its own axis. This rotation causes day and night cycle.
- The earth is the only planet in the solar system which can sustain life as it has water, atmosphere, suitable temperature and gets sufficient light from the sun.
- The age of the earth is 4 to 5 billion years and life first originated on earth 3.5 billion years ago as evidenced by the oldest fossils found till now.
- The atmosphere of primitive earth was very different – hot and full of gases carbon-dioxide, water vapour, methane, ammonia and hydrogen but no oxygen. When earth cooled, water vapour condensed into liquid water and fell as rains.
- How the first cell came into existence is still unknown, but perhaps the single celled bacteria were among the earliest organisms. Through biological evolution millions of different kinds of organisms have evolved subsequently.
- All organisms depend on their environment for survival.
- All organisms live in close association with their environment.
- Environment is defined as the surroundings of an organism.
- The environment comprises of non living (abiotic) components like temperature, light, water, humidity etc. and living or biotic components such as other organisms sharing those surroundings.



### TERMINAL EXERCISE

1. Trace the origin of the earth.
2. Describe briefly the solar system to which the earth belongs.
3. State the big bang theory of origin of universe.
4. Why is earth able to sustain life while no other planet is known to have life?
5. Name the five kingdoms of living organisms.
6. Define environment. List the various components of the environment.

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### ANSWER TO INTEXT QUESTIONS

#### 1.1

1. 4.5 billion years
2. Star
3. Planets orbiting central star
4. Because earth completes one full rotation s on its axis in 24 hours
5. Blue

#### 1.2

1. (i) Presence of water (ii) Presence of Air (iii) Comfortable range of temperature  
(iv) Buffering capacity
2. Sun
3. Oxygen is used in respiration to oxidize food for liberating energy.

#### 1.3

1. Methane, ammonia, carbon dioxide and hydrogen
2. Bacteria
3. Because of photosynthesis
4. Monera, Protista, Fungi, Plantae and Animalia

#### 1.4

1. Surroundings or condition in which an organism lives and operates.
2. Biotic- living organism of all kinds including microbes.
3. Abiotic – light, humidity temperature, atmosphere and substratum
4. Because it threatens the survival of living organisms including humans.