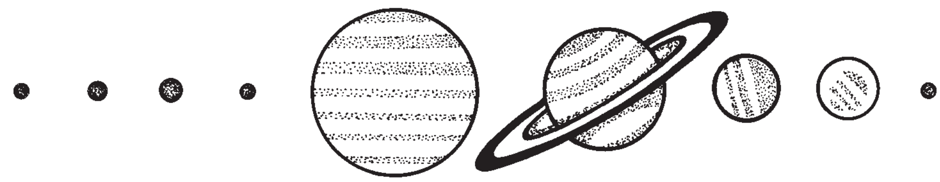
Earth: The Living Planet 1

STRUCTURE



1.1

Look out of your window and you will see an abundance of different life forms—from weeds growing out of cracks in the pavement to humans going about their daily business; from the lizard on the wall to the cat at the kitchen door. As far as we know, however, no other planet supports any life at all. So what is it about Planet Earth that allows all this life to exist? As you will read in this unit, all of Earth's are dependent on a fragile web of conditions that took billions of years to emerge.

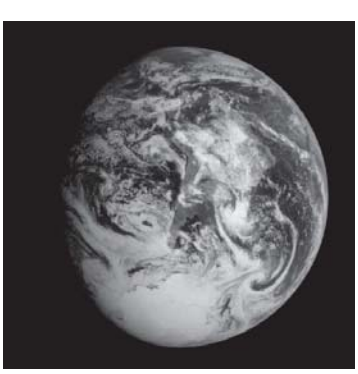
In this unit, you will learn about some of the Earth's unique qualities that make life possible on this planet. You will also learn how these conditions arose, and how they function together. After reading this unit, you would have a holistic understanding of the life-supporting systems of the Earth.

1.2

On completion of this unit, you should be able to

- List the conditions of Earth that make the existence of life possible
- Identify the properties of water that made life possible on earth
- Relate the composition and functions of Earth's atmosphere to it's ability to support life
- Describe the processes affecting the formation and modification of the features of the lithosphere
- Define the biosphere
- Recognize that the processes of each of the spheres are interrelated

1.3 EARTH

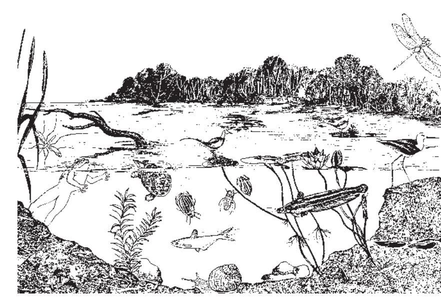


How many factors can you list that make Earth different from other planets? They are innumerable: the position of the earth in our solar system; the tilt of the Earth on its axis; and its rotation and revolution around the Sun. Other unique features include the strength of the gravitational pull of our planet, and of course the chemical and physical composition of the earth and the processes that have taken place on our planet since its birth.

The Earth was formed some 4.6 billion years ago, as dust and particles orbiting our newly formed Sun began to come together to form the nine planets of our solar system. But for the first 3 billion years of it's existence, Earth was a barren and harsh planet. The surface was covered in molten lava and exposed to the ultra-violet rays of the Sun. The atmosphere was made up of poisonous gases, and there were no lakes, oceans or rivers. The oldest evidence of life dates to 3.5 billion years ago, but it was not until about 1.4 billion years ago that the first multicellular organisms appeared. These organisms, and the other that evolved from them, could only survive when the systems on the planet began to stabilize.

1.4 HYDROSPHERE

As you know, our planet is also referred to as the 'blue planet' because so much of it is covered with water that it appears blue from outer space. Much of Earth is covered by a layer of water or ice called the hydrosphere. About 71 percent of Earth's surface is covered by water. Most of this water is in the oceans, with only about 3 per cent being fresh water. Earth is the only planet in the solar system with abundant liquid water on its surface, and this is one of the factors making life possible on the Earth. Water has chemical and physical properties unlike any other substance, and is essential for life on Earth. In fact, life originated in water. Water, as compared to other substances, exhibit several anomalous properties (physical and chemical), that enables life exist on the earth. Let us look at some such unique properties of water, thanks to which it has supported evolution of life.



SPECIFIC HEAT

Specific heat is a physical property of all matter. Specific heat is defined as the amount of heat energy required to raise 1 g of a substance by 1° Celsius. This value is different for various types of matter-aluminum's specific heat is 0.22 cal/g°C, copper's is 0.09 and freshwater's is 1.00 cal/g°C. Note that water has a high specific heat. This explains why coastal areas seem to have more moderate climates than areas further inland. Water is slower to heat, but is also slower to lose heat, so the temperatures in the area do not fluctuate to the extremes as areas distanced from large bodies of water.

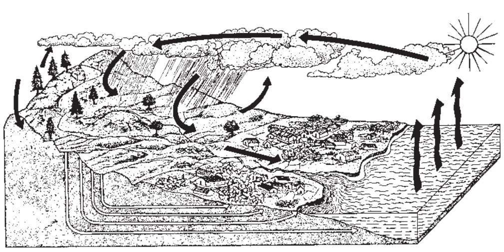
Water requires a lot of energy to raise its temperature, and also to convert it from its liquid state into a gaseous state (see the box 'Specific Heat'). When it is converted from liquid to gas, water gives off energy in the form of heat. Think of it this way: On a very hot day, water bodies help keep atmospheric temperatures cool by absorbing heat from the Sun; when the Sun goes down, the heat that water has been absorbing all day is returned to the atmosphere as water evaporates.

Recall that much of the Earth's surface is covered by oceans. This means that, on the global scale, the water that covers three-quarters of the Earth's surface helps to regulate earth's climate. Such regulation is crucial for the survival of many of the organisms that exist today.

Further, this resistance to sudden changes in temperature makes water an excellent habitat. Because water absorbs and stores heat, it's temperatures are much more stable than those of the air. Fluctuations in water temperature occur very gradually, and seasonal and diurnal extremes are small in comparison to terrestrial environments. Such a stable environment is necessary for many marine and aquatic organisms. Thus water is an excellent habitat to many lifeforms.

WATER CYCLE

As the sun heats the oceans, lakes and land, water evaporates and rises into the atmosphere. The clouds we see in the sky contain water molecules that only a few days before may have been part of the ocean, an irrigation ditch, or a drop of sweat on your forehead. In the atmosphere, water is transported as part of weather systems. As it rises, the air cools it, forming clouds. The cooling causes the water to condense (return to the liquid state). It then falls as rain or snow. Some of this water will remain stored in glaciers as ice. Much of the water will be absorbed by plants, some will percolate deep into underground aquifers and the rest will flow over the land in rivers, making its way back to the ocean.



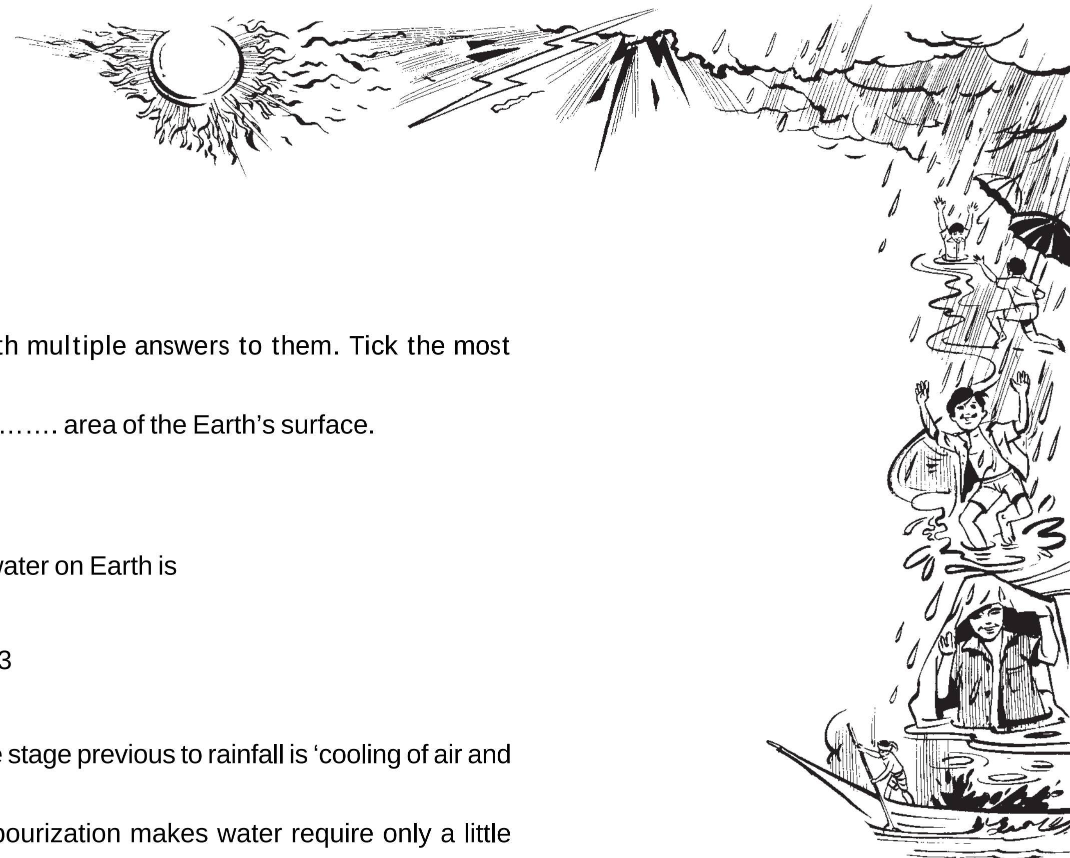
Similarly, at 4°C water expands on heating or cooling. This density maximum together with the low ice density results in (i) the necessity that all of a body of water (not just its surface) is close to 0°C before any freezing can occur, (ii) the freezing of rivers, lakes and oceans is from the top down, so permitting survival of the bottom ecology, insulating the water from further freezing, reflecting back sunlight into space and allowing rapid thawing, and (iii) density driven thermal convection causing seasonal mixing in deeper temperate waters carrying life-providing oxygen into the depths. The **large heat capacity** of the oceans and seas allows them to act as heat reservoirs such that sea temperatures vary only a third as much as land temperatures and so moderate our climate. Water's **high surface tension** and its tendency to **expand on freezing** helps in weathering of rocks, which make part of numerous natural processes.

WATER: SOME ANOMALIES

Water has unusually high:

- Melting point
- Boiling point
- Surface tension and can bounce
- Viscosity
- Heat of vaporization
- Density that increases on heating

Water shrinks on melting.



1.4.1

Given below are questions with multiple answers to them. Tick the most appropriate answer:

1) Water covers ……………. area of the Earth's surface.

   a. ½ b. ¾

   c. ¼ d. 4/5

2) Percentage of freshwater on Earth is

   a. 71 b. 45

   c. 3 d. 0.03

State true or false

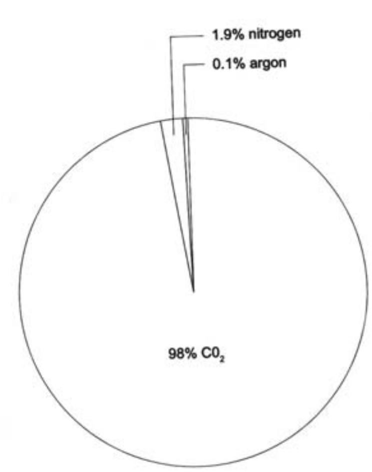
3) In the water cycle, the stage previous to rainfall is 'cooling of air and condensation'.

4) The high heat of vapourization makes water require only a little energy to vapourize

1.5 ATMOSPHERE

The atmosphere is a colourless, odourless, tasteless 'sea' of gases, water and fine dust surrounding the earth. Normally the atmosphere is composed of 78 per cent nitrogen, 21 per cent oxygen and small quantities of other gases such as argon, carbon-di-oxide, etc. Trace of water, in the form of water vapours, dust particles, etc. are also present in the atmosphere.

Though earth's gravity keeps the air close to the earth, the air is not static. As it absorbs heat from the earth, it expands and rises. When its heat is radiated into space, the air cools, becomes dense, and flows toward the earth. As the air circulates due to heating and cooling, it also moves horizontally over the surface of the earth because the earth rotates on its axis. The combination of all air movements creates the wind patterns characteristic of different regions of the world.

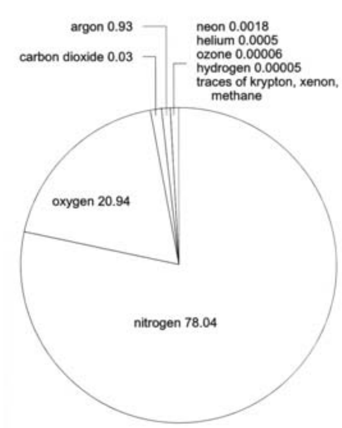


Atmosphere 25 billion years ago

The atmosphere is divided into four layers. In the lowest level, is the **troposphere**. It is here that most of the weather of Earth is created. Air circulates vertically through this layer, bringing hot air up, and cold air down. In fact, *tropo* means "turning" in Greek. The next layer is the **stratosphere**. *Strato* means "stable" in Greek, and this layer is said to be stable because it does not turn in the same way the troposphere does. The upper stratosphere contains a special form of oxygen called **ozone**. This gas prevents harmful ultraviolet rays of the Sun from reaching Earth's surface and harming life.

Do you think that the atmosphere surrounding us has always been like this?

As you will read in the following section, the atmosphere was first formed by volcanoes, but this early atmosphere was different in composition from what



The present Atmosphere

blankets us today. It contained much more carbon-di-oxide and less oxygen. It was the first aquatic plants that began to change the composition of our atmosphere by converting carbon-dioxide to oxygen. Thus gradually the atmosphere developed its present composition, which is ideally suited to humans and the other Lifeforms that exist today.

The change that the atmosphere went through was important for life for several reasons: It was not until the first aquatic plants had produced enough oxygen that the unique molecule called ozone could be formed. Once enough ozone was present, life was able to colonize the land, because the land was then protected against the strong UVs. As plants continued to convert cabon-di-oxide to oxygen, other oxygen-consuming Lifeforms were able to evolve.

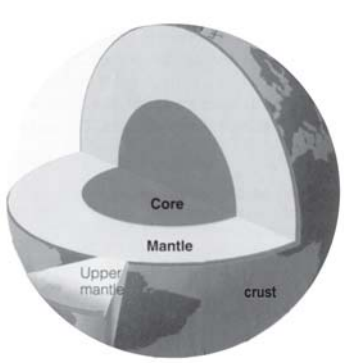
However, we need carbon-di-oxide as well as oxygen. Carbon-dioxide plays an important role in stabilizing the surface temperature of the earth and preventing heat loss, especially at night time. This gas, comprising 0.03 per cent of the atmosphere, covers the earth like a quilt and preventing heat from dissipating into the upper layers of the atmosphere. However, if the amount of carbon- di-oxide were to increase beyond this, the temperature of the earth would increase excessively, causing climatic instability and posing a serious threat against living beings.

1.5.1

Fill in the blanks:

1. When air is heated, it moves _______. When it cools, it moves ________.
2. ______ means "turning" in Greek, while _________ means stable.
3. ______________________ prevents most of the harmful UV rays of the Sun from reaching Earth's surface.
4. Billions of years ago, there was high __________________ in the atmosphere, and low _________.

1.6 LITHOSPHERE



Simply put, the lithosphere is the surface, or *crust* of the Earth. It forms the mountains, plains and ocean floors**.** The upper boundary of the lithosphere begins at the soil beneath our feet, and may extend as deep as 150 km below the surface. We know that the surface of the Earth is cool and solid, but what if we could tunnel to the center of the Earth? What would we find? As we moved into the layer below the lithosphere, that is the **mantle**, heat and pressure would begin to increase, causing rocks to melt and deform. At its center (or *core*), the temperature of Earth may be about 5000ºC. However, we may never know exactly how hot it is, because no machine can measure its temperature without melting in the process.

AN EGG TO THE EARTH

It may help to imagine the Earth as an egg. The lithosphere is much like the in, brittle shell. The mantle is like the egg white. It is fluid, and much thicker than the shell. The core of the Earth is like the yoke of the egg. It is more dense than the mantle, because it contains mostly metal.

The more fluid nature of the mantle is what causes tectonic plates (pieces of the Earth's crust) to float freely over the surface of the Earth, occasionally resulting in earthquakes. Such tectonic movements may change the Earth's landscape.

Tectonics is not the only force that shapes the features of the landscape, but there are more. Wind and water also cause changes to the landscape through **erosion** and **deposition**. As water flows across a landscape, it collects and transports small particles. If you look at a river flowing down a hillside, you may notice that has cut a steep channel, where soil and rocks were washed into the river through erosion. These particles are then carried downstream, until the river reaches a flatter plain or delta. Here the water flows with less energy and deposit the particles it has transported. Areas in which there is a high amount of such deposition are often very fertile.

What is it about Earth's lithosphere that allows life to flourish upon it, unlike the barren surfaces of other planets?

As you now know, the planets of our solar system were formed by the cosmic particles circling around the newly formed Sun. These particles contained carbon, hydrogen, nitrogen, oxygen, and phosphorous, elements which provide the building blocks necessary for life to exist. But for several billions of years, these elements were confined to the surface of the Earth. As the surface cooled, the hot interior of the Earth released carbon, nitrogen and hydrogen through volcanic eruptions. These elements were oxidized, that is they got attached to oxygen molecules. This is how the first thin atmosphere was formed. Further cooling allowed the first drops of water to condense out of atmospheric hydrogen and oxygen. *Can you begin to see how the spheres are interconnected?*

DID YOU KNOW?

On certain parts of the Earth, we can still see **volcanoes** erupting. They continue to release gases into the atmosphere, and build new features on the landscape. Volcanic eruptions are disruptive in the short-term, but did you know that they also contribute positively to life on Earth? The gases they release help maintain our atmosphere. Volcanoes also bring nutrients & minerals from deep within the Earth to the surface, where they eventually fertilize the soil.

Later (in Module 2) you will learn how the climate is affected when fossil fuels from within the lithosphere are released into the atmosphere through human activities.

1.6.1

Choose the odd item and briefly explain why it does not fit with the other items:

1. a. rock b. crust c. mantle d. core

____

2. a. mountains b. rift valleys c. trenches d. lakes

____

3. a. carbon b. oxygen c. hydrogen d. nitrogen

____

4. a. sunlight b. wind c. water d. tectonic plates

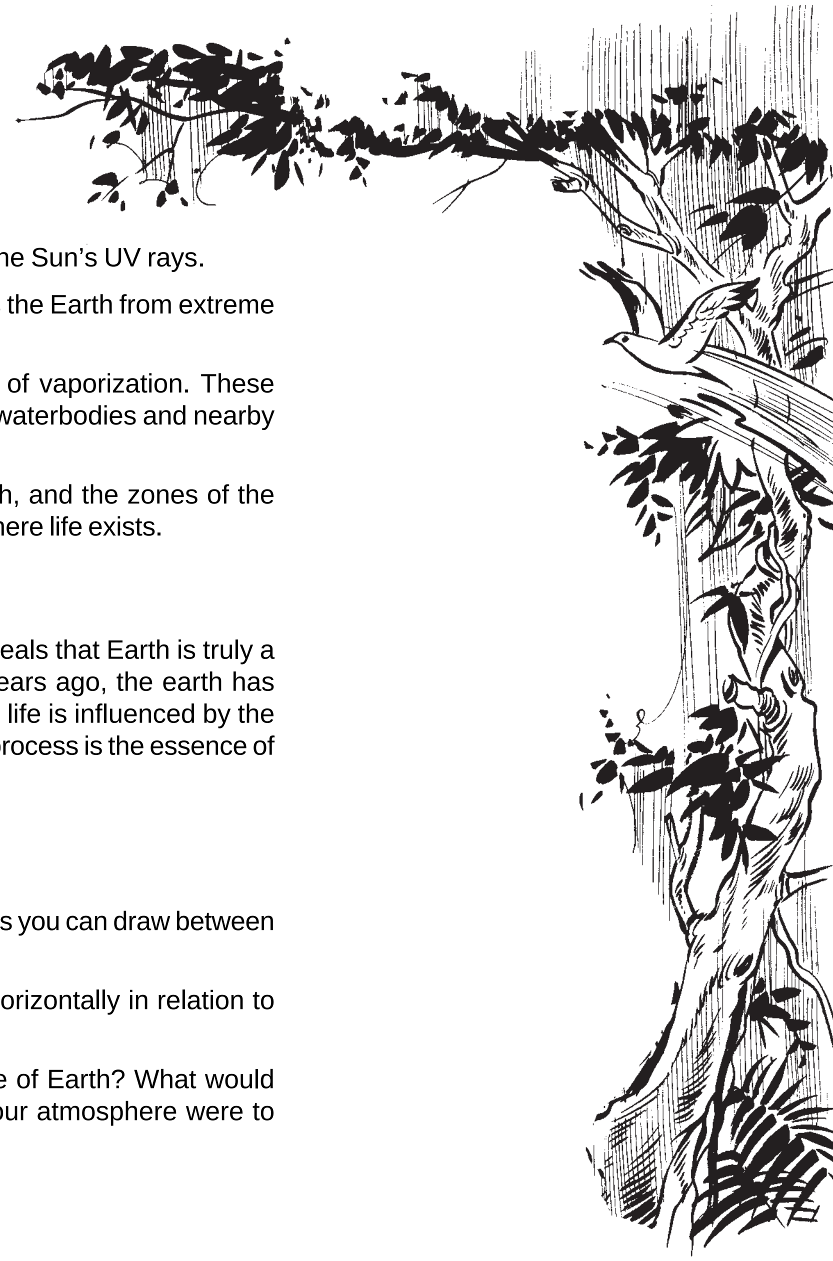
____

1.7 BIOSPHERE

We have looked at the lithosphere, atmosphere and hydrosphere. Together, these zones make up the biosphere. The biosphere can be defined as the sum total of all organisms and their habitats. So its boundaries are defined by where organisms live and interact with each other and their environment. The biosphere extends only a few kilometers below the surface of the Earth, and only a few kilometers into the atmosphere. By now, you've read about a number of the ways that life has helped to create and maintain the conditions that support its existence. As a system, the functions of the biosphere are fascinating and extremely complex. In the units to come, you will learn a great deal about the biosphere.

1.8 RECAPITULATION

- Earth has the right conditions and environment (through atmosphere, lithosphere and hydrosphere) to support life
- The lithosphere is a thin crust on the surface of the Earth. It is made up of tectonic plates which float above the mantle. The lithosphere contains elementssuch as phosphorous, nitrogen, carbon, oxygen and hydrogen, which are necessary for life.
- The composition of the atmosphere is optimal for the life that exists on Earth today.
- Plants help maintain the optimal proportion of gases in our atmosphere
- Air circulates within the troposphere, creating weather systems.



- Ozone protects life on Earth's surface from the Sun's UV rays.
- Carbon-di-oxide in our atmosphere insulates the Earth from extreme temperature variations.
- Water's high specific heat and a high heat of vaporization. These properties help stabilize the temperature of waterbodies and nearby areas,
- The biosphere encompasses all life on earth, and the zones of the lithosphere, atmosphere and hydrosphere where life exists.

1.9 CONCLUSION

Detailed study and understanding of our planet reveals that Earth is truly a dynamic planet. Since its birth, about 4.6 billion years ago, the earth has evolved and continues to evolve. On the Earth, the life is influenced by the physical environment and vice versa. This two way process is the essence of the dynamic nature of our planet.

1.10

1. Based on this Unit, see how many connections you can draw between hydrosphere, atmosphere and lithosphere.
2. What causes air to circulate vertically and horizontally in relation to the surface of the Earth?
3. How does carbon-di-oxide affect the climate of Earth? What would happen if the amount of carbon dioxide in our atmosphere were to increase significantly?