Chapter Nine
The Human Biospheric Environment

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Introduction

This chapter deals with environmental properties that give support to life. The biosphere is the offspring of the other spheres which interact cooperatively to support life. It is believed that life would not exist if any of water, air or minerals was lacking. Yet these life-supports neither exist nor function in isolation of the cosmic environment. Forces from the space, beyond the solar system, and forces within it cooperate or conspire to influence life and human activities, most often beyond human comprehension; in spite of all the existing scientific and technological knowledge which we think we have. Such influences may however be minimal compared to the effect of human actions, reactions and inactions on the biosphere. Nature has her peculiar way of reacting to human challenges. Consequently a good understanding of the interrelationships among the various spheres of life and in relation to the cosmic environment can better equip humans in their march towards sustainable development. That is what the chapter focuses on.

The Human Environment

That which surrounds is the environment. Every system except the largest has an environment. It is from the environment that life inputs are derived and into it life outputs are sent. Therefore the environment determines, to a great extent, the nature, life style, human culture and activities among other things. But human actions, reactions and inactions also have a wide variety of impact on the environment.

Humans live within the environment, so also do plants and animals. This is because human environment is life supporting. It is the life-sphere (biosphere or ecosphere) see figure 9.1.

The biosphere comes into existence as a result of the interaction effect of three other spheres which represent the three states of matter: solid, liquid and gas. These three spheres are: the lithosphere (solid rock), the hydrosphere (water sphere) and the atmosphere (gas sphere). These are all dependent on the solar energy and radiation balance. The balance is possible because energy absorbed by earth is equal to the planetary energy output into the outer space. Moreover the planetary winds and water transport energy from regions of surplus to those of scarcity. Nature therefore always seeks to balance the inherent inequality or disequilibrium.

A good knowledge of the interaction and the working process of the other three spheres is absolutely necessary for proper understanding of the behaviour of the biosphere. This in turn can facilitate better and more friendly interaction with the biosphere among humans.

The Biosphere

The biosphere consists of all living organisms together with their environment. It exists because the other three spheres interact cooperatively. Within the biosphere there are a wide variety of inter-dependent organisms and matter: gas, minerals, plants and animals. They interact between and among themselves giving rise to self-regulating and self-sustaining ecological system (ecosystem) balance. When such natural balances is seriously disturbed by man's unfriendly activities, the obvious result is disaster: desertification, erosion, flood, global warming, diseases, death. To a great extent, the degree of human interaction with the life-sphere is a function of human culture (including technology). The effect of such interaction, even if it is only at one level of the ecosystem, rebounds and spreads throughout the entire ecosystem. This is because all living things are linked together through energy flow and mineral cycle. Strahler and Strahler (1979) identify two types of this cycle: sedimentary cycle and gaseous cycle.

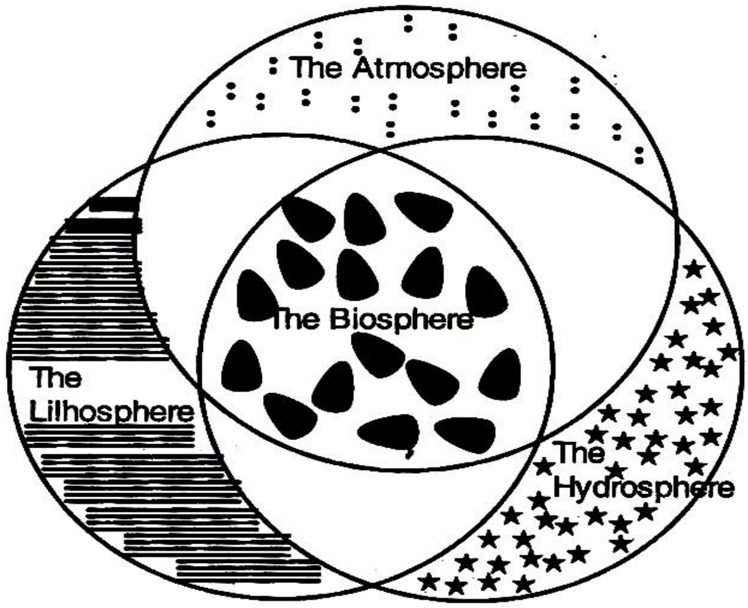


Fig 9.1 THE BIOSPHERE
Source: Inyang-Abia and Usang (1992:5)

Sedimentary Cycle

This involves the release of compounds or elements from the rocks through the process of weathering. The weathered materials are then eroded, transported and deposited into the sea where they precipitate, sediment, solidify and form new rocks. Various internal movements of the earth eventually uplift the rocks and expose them to subsequent weathering which starts a new cycle.

Closely related to the sedimentary cycle is the rock (see figure 9.2). This involves the on-going or continuous recycling of mineral and crustal matter or soil through geologic time-scale in the presence of external and internal energy sources. The rock cycle suggests that through the weathering process activated by solar (external) energy, rock particles undergo continuous breakdown and chemical changes. Through the process of erosion, transportation and deposition the rock fragments and particles become sedimentary rocks. The increasing deposition mounts greater pressure which, in addition to internal heat (geothermal energy) generated by radioactivity (radiogenic heat) change the sedimentary into igneous rocks. Through geologic movements these igneous rocks are subsequently exposed to the surface of the earth where further weathering sets in to start a new cycle.

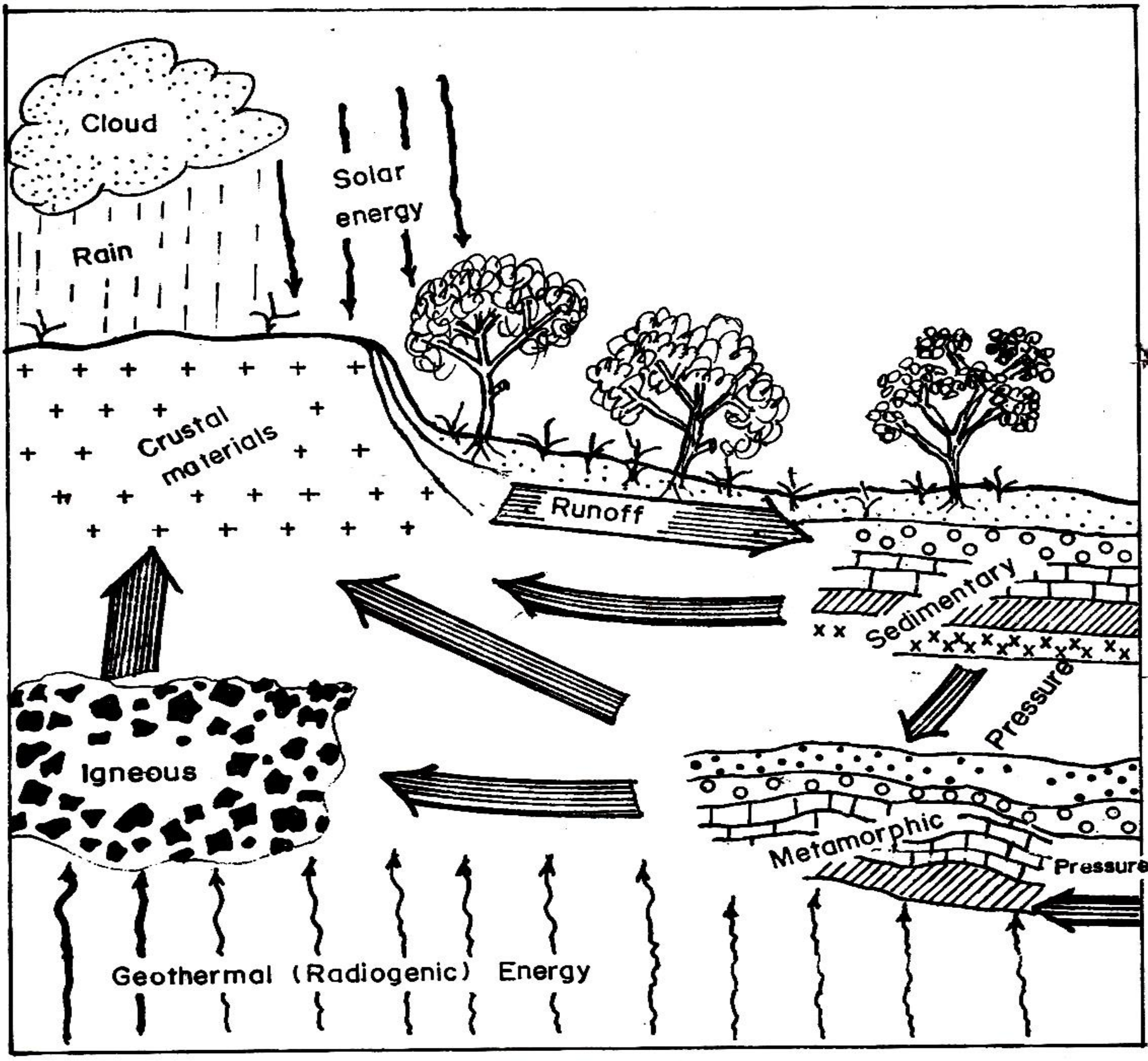


Figure 9.2 The Rock Cycle

The Gaseous Cycle

The macroelements comprising the basic compositon of living matter are hydrogen (49.74%), carbon (24.90%), oxygen (24.83%) and nitrogen (0.27%) according to Deevey (1970), see table 9.1. Yet nitrogen constitutes 78% of the atmosphere.

Table 9.1 Relative Percentage of Volume and Weight of Gases

Gas	% Volume	% Weight
Nitrogen	79	75.4
Oxygen	20.9	23.1
Argon	0.9	1.3
Others	0.2	0.2

(Source: Deevey, B. S. (1970): **Mineral Cycles**, *Scientific America, 223*).

The first two macroelements are necessary for all living matter. These macroelements which can be expressed as gas cycles are explained below.

The Nitrogen Cycle

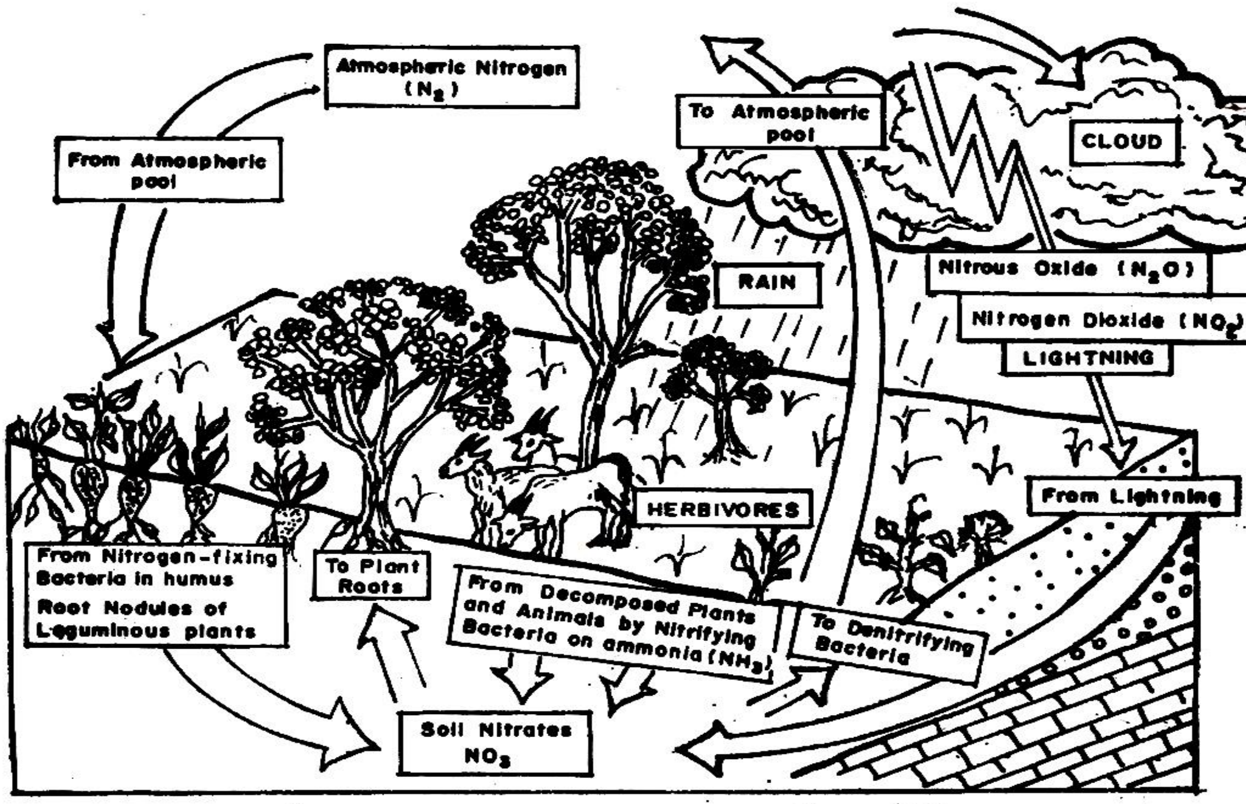


Figure 9.3 The Nitrogen Cycle

This expresses the natural circulation of nitrogen required by all living organisms. It is the process by which nitrogen passes through the ecosystem. Although nitrogen constitutes the basic component of amino-acid in protein and forms almost 78% of the atmosphere, its natural form cannot be directly used by the biome (plants and animals). In order to use it the biome has therefore to depend on the necessary mechanisms that replenish the soil with nitrogen. Plants get their essential nitrogen as nitrates (NO_3) from the soil while animals get theirs by eating plants or other animals.

From figure 9.3 it can be seen that nitrous Oxide (N_2O) and nitrogen dioxide (NO_2) are derived from the atmospheric nitrogen (N_2) during rain and thunder-storm. They get to the soil as nitric acid (HNO_3) and form soil nitrates (NO_3). The root nodules (see figure 9.4) of leguminous plants also have special bacteria with the capability of capturing the atmospheric nitrogen directly and making them available to the soil as soil nitrates for other plants to use. These in-organic compounds (soil nitrates) are absorbed by plants and turned into organic compounds (protein) in plant tissues. Part of this is eaten up by herbivores which may in turn be eaten by carnivores. The nitrogen is again returned to the soil either as excreta or when the organisms die. The bacterial decomposers then break down the proteins into ammonium compounds (NH_4) which are subsequently oxidized by the nitrifying bacteria into nitrates, a form capable of being taken up again by plants.

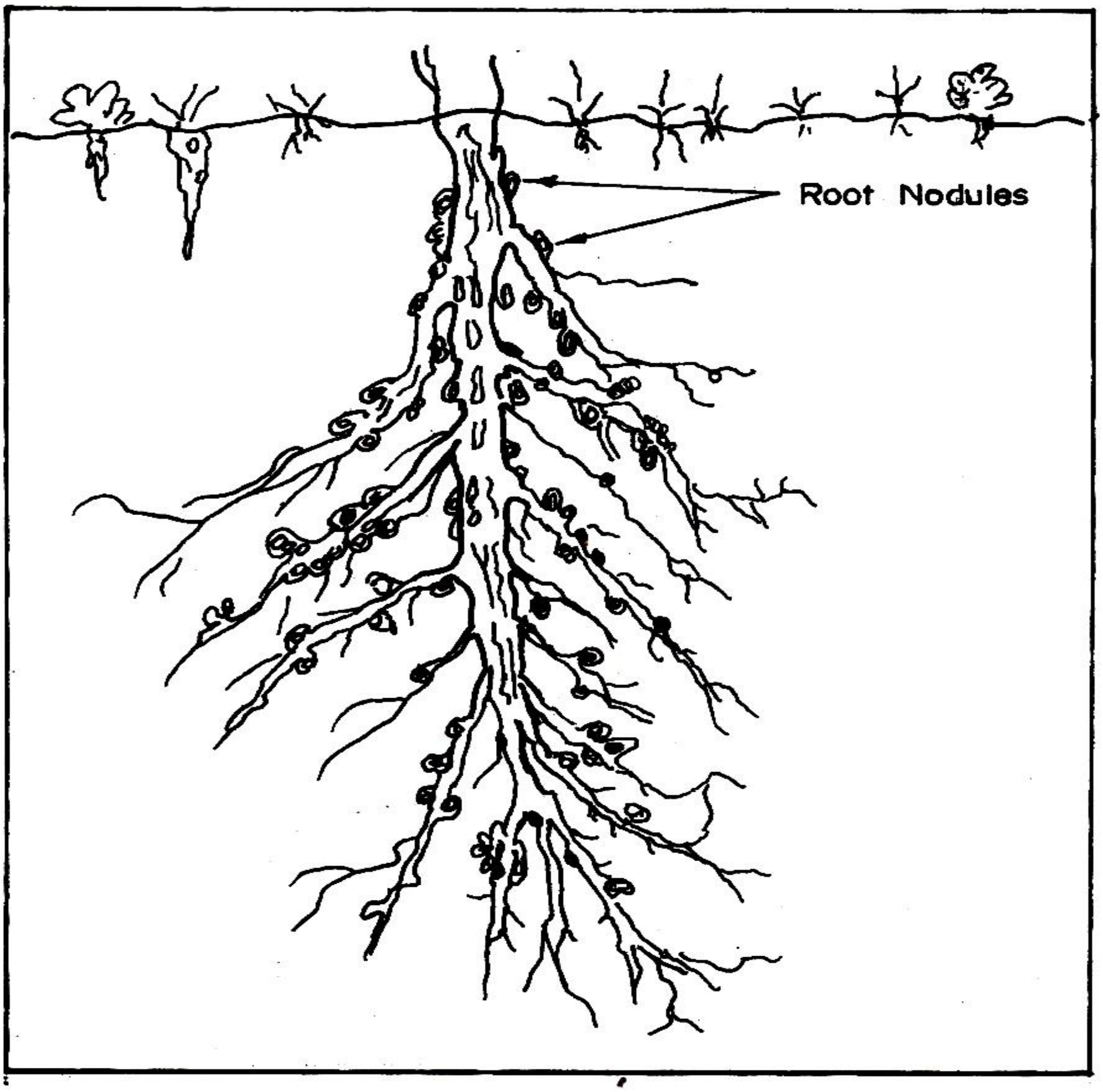


Figure 9.4 Root Nodules

The Oxygen Cycle

Oxygen which is essential to all forms of life forms about 20.9% of the gases in the atmosphere (see figure 9.5). The main supply source of the atmospheric oxygen is green plants. It can easily combine with almost all other atmospheric elements to form oxides. It is necessary for oxidation, respiration and combustion, among others. The atmospheric oxygen is derived from green, aquatic and terrestrial plants which through the process of photosynthesis release it into the atmosphere. This is then used by animals in the process of respiration.

Another source of oxygen is the phytoplankton (vegetable plankton). These aquatic organisms send small quantities of oxygen into the atmosphere through the process of photosynthesis. When dead they leave accumulations of carbonate and hydrocarbons among other organic sediments on the sea beds. Part of the accumulated underground oxygen get to the atmospheric oxygen pool through volcanic eruptions. Through various processes, hydrocarbons and carbon dioxide combine with other elements to form fossil fuels in solid forms (peat, lignite, anthracite), in liquid form (mineral oil) and in gaseous form (natural gas). Combustion of fossil fuels, wood fuels and bush, among other human activities generate carbon dioxide while depleting the supply of oxygen. Respiration by land, soil and marine animals also depend upon the atmospheric oxygen supply.

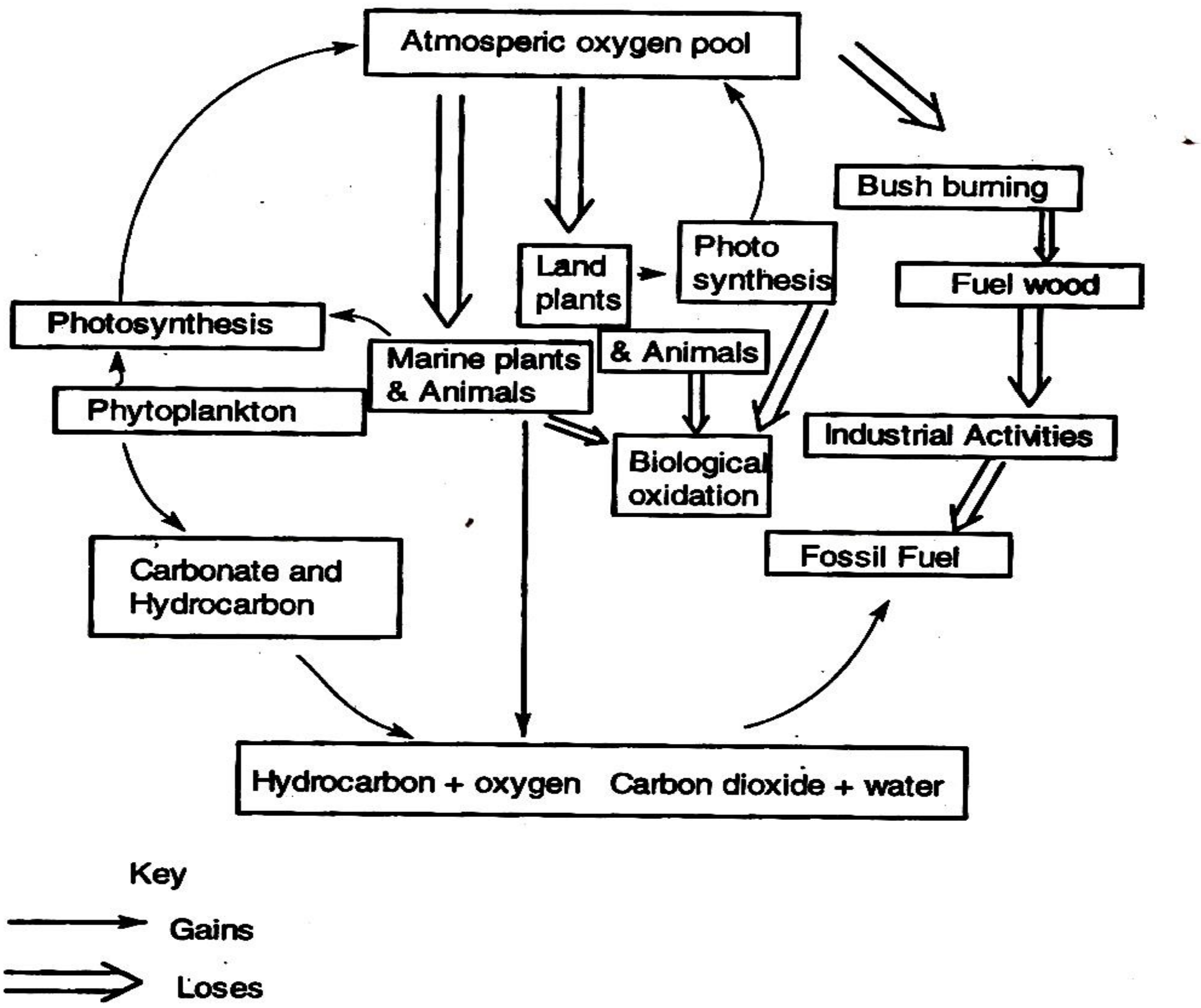


Figure 9.5: THE OXYGEN CYCLE

The Carbon Cycle

Carbon exists in both gaseous form (atmospheric and aquatic carbon dioxide) and in non-gaseous form (biological molecules in organic matter, hydrocarbon compounds such as coal and petroleum and in mineral carbonate compounds such as calcium carbonate ($CaCO_3$)).

The atmospheric carbon dioxide supply is derived mostly from volcanic activities which produce carbon monoxide (CO), carbon dioxide (CO_2) and water (H_2O). Respiration of plants and animals on both land and sea, and human activities particularly combustion fuels for vehicular traffic and industrial activities; wood and bush burning are other major sources of carbon dioxide.

Minute marine plants (phytoplankton meaning vegetable plankton) which are primary producers in the oceanic ecosystem attract for photosynthesis some carbon dioxide from the atmospheric pool. Carbon dioxide is released into the atmosphere during all respiratory processes of both marine and terrestrial animals and plants. It is essential too for all photosynthetic processes.

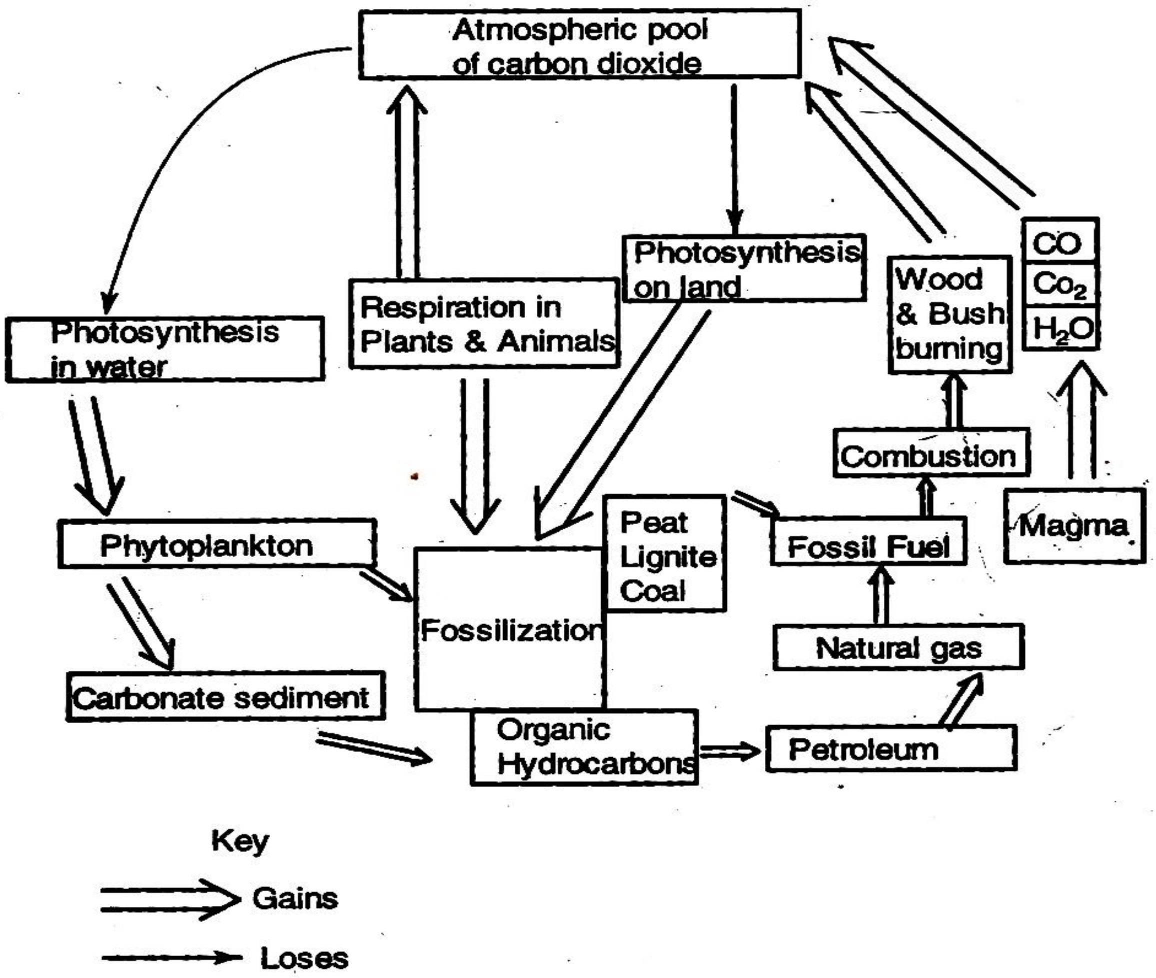


Figure 9.6: THE CARBON CYCLE

When dead, the phytoplankton build up calcium carbonate ($CaCO_3$) and organic compounds as sedimentary strata. After millions of years the strata transform into hydrocarbon compounds which result in natural gas and petroleum. Coal formations (peat, lignite, anthracite, etc) too are derived from plant matter which have undergone geological transformation in the presence of water (H_2O). Fossil fuels store up abundance of carbon which is released into the atmosphere through the combustion process.

These cycles and many more keep the "biospheric engine" in motion making it possible for energy exchange and transformations to occur as illustrated in the food chain and other relevant energy cycles.

The Food Chains (Food Webs)

Closely related to the biogeochemical (energy and material) cycles are the food chains or webs. They refer to the sequential energy transformation in the ecosystem. These complex mechanical sequences of organisms through which various forms of food nutrients and energy are successively transferred from the primary producers to the tertiary consumers are essential for ecological balance. This does not however imply absolute dependence of each level upon the next lower one because of variety of any given species and their nutritional orientations. Thus the relationship between the species in an ecosystem is complex and delicately balanced. Complete extinction of any one species or level of the food web can however spell doom for the entire system. For example, eliminating the major predators can result in over-grazing by the herbivores. This can lead to ecosystem destruction beoause the herbs eaten by the animals would be completely destroyed probably leading to over-grazing, erosion, aridity, desertification, reduction of atmospheric oxygen among other unfriendly environmental phenomena, apart from leading to extinction of both the herbivores and other species that depended on green plants for survival as well as the vegetative species. Balance in the food chain depends upon the balance in the other biospheric components including that in the atmosphere.

The Atmosphere

This is a mixture of gases which through the earth's gravitational pull continuously surrounds the earth. It consists of several concentric shells or layers separated by atmospheric discontinuity zones known as pauses (see figure 9.7).

The Troposphere

This is the closest layer that surrounds the earth. It consists of nitrogen (78%), oxygen 21% and 1% argon and other gases including water vapour. This layer has the greatest pressure (density) and is capable of sustaining life. It is the layer of clouds, winds and weather. The troposphere is on the average about 11 km ($6\frac{1}{2}$ miles) thick from the sea level being thickest around the equator than at the poles. In this layer temperature decreases with increasing height (the adiabatic (lapse) rate is 1.6^oF per 300 ft or 6^oC per 1000 metres), except where there is a temperature inversion.

The Tropopause

This is a transitional region between the troposphere and the next layer, the stratosphere. In this thin layer (4-7 km thick) the decreasing temperature from the earth's surface stabilizes at about - 60^oC or increase slightly with height.

The Stratosphere

This is the second concentric layer from the surface of the earth. Although it is less dense, the chemical components of the air remain constant. It extends between 12 km (8 miles) to about 50 km (32 miles) into the space from the sea level. Here temperature increases from about - $55^oC(-67^oF)$ at the floor level, just above the tropopause to over 150^oC at the ozone or warm layer (over 24 km above sea level), then it decreases to about - 55^oC again at the ceiling.

The height of this clean and dry sphere varies with season and the weather conditions of the troposphere. The stratosphere is cloudless and therefore increased visibility is obvious. The wind blows from same direction at any given point or time. Because it is completely free from storm it can be excellent for air transportation. One very important sub-zone of the stratosphere is the ***ozonosphere*** or the *ozone* layer. At this thin layer the high frequency ultraviolet solar rays transform the existing oxygen (O_2) into the ozone (O_3), at about 30 km (18 miles) above the sea level. The ozone layer stops the ultra-violet rays from reaching the earth.

This trapping of the ultra-violet rays is very important for life on earth because these rays penetrate the atmosphere with lethal intensity and would therefore burn out all life if they were not filtered out by the ozone. Beyond the ozone the temperature starts decreasing with height until it gets to a minimum of about - $55^\circ C$ at the ceiling of the stratosphere.

The Ionosphere

This is the ionized layer of our atmosphere, about 60 - 1000 km (38 - 620 miles) from the sea level. It is an air vacuum - no air at all. It reflects our radio (long) waves back to the earth. This is thought to be produced by the absorption of the ultraviolet solar radiation by the freely moving electrons. Three layers (D, E, F) of ionized particles can be located in the ionosphere, "D" being the lowest and "F" the highest. At about 160 km (100 miles) the temperature is about - $21^\circ C$; at 240 km (150 miles) it is about $650^\circ C$ and at over 480 km (300 miles) above the sea level, temperature rises above $2000^\circ C$. That means temperature increases with height owing to the increasing solar radiation which effectively bombards the particles in space thus generating excess heat with almost nothing to absorb such heat.

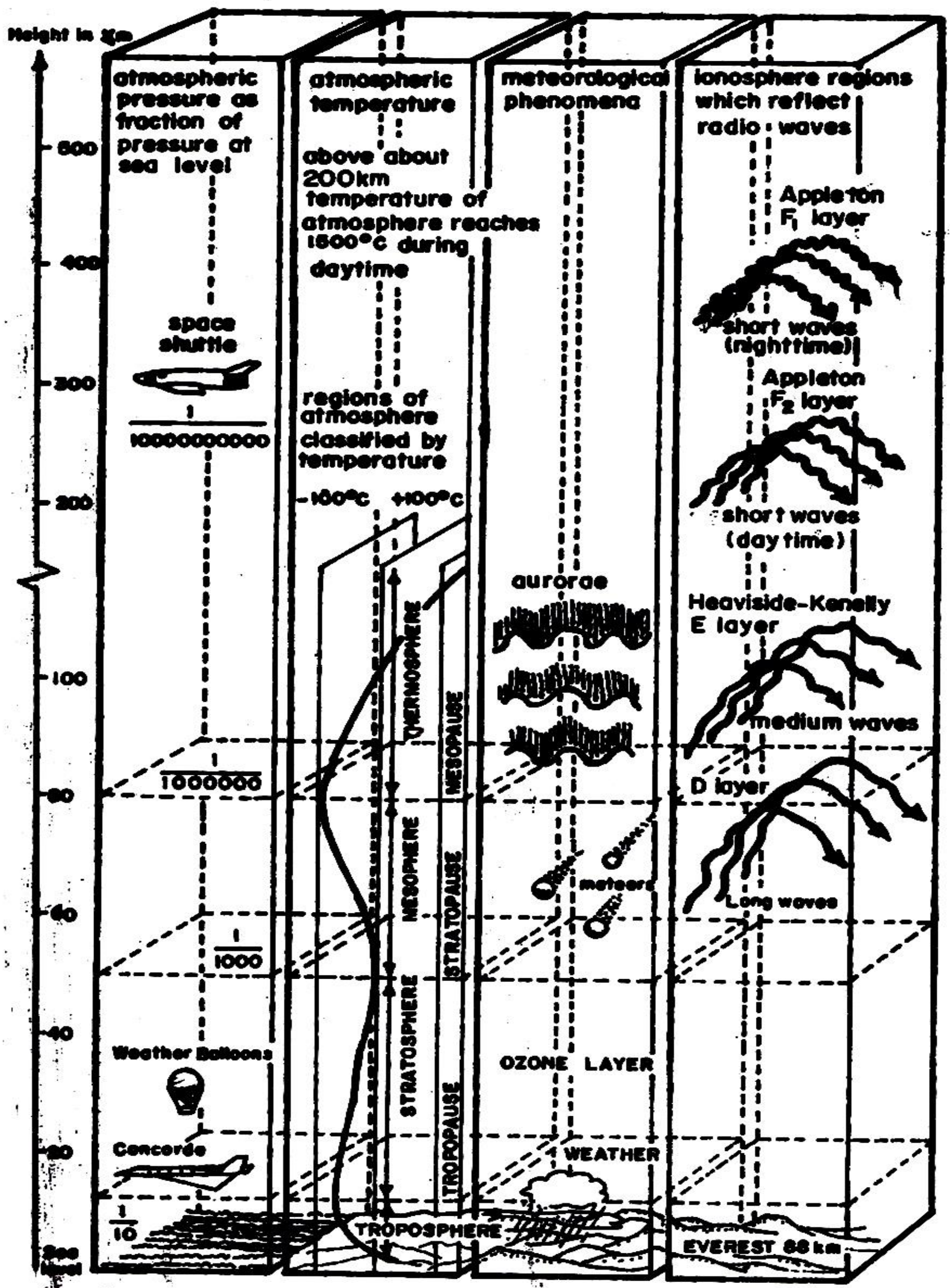
While the ionosphere reflects the radio (long) waves back to the earth, radar waves on the other hand pass through it. The television waves are short and are not reflected back by the ionosphere.

The Exosphere

This is the outermost layer of the atmosphere. It lies about 800 km (500 miles) above the sea level. It gradually fades into the space. Temperature of over $2000^\circ C$ remains almost constant in the exosphere. What happens in the atmosphere affects life on earth partly because of the air and partly because of the effect the atmosphere has on water supply. The hydrosphere is therefore seriously affected by the atmospheric dynamics and vice versa.

The Hydrosphere

This refers to the water sphere. The water component of the earth includes the oceans, seas, rivers, swamps, lakes, ground water, the glaciers and the atmospheric water vapour. The hydrosphere occupies over 70% of the surface of the earth, and like oxygen which forms part of it, is necessary for all forms of life on earth. Water is virtually incompressible, and in its solid form (ice, snow frost) it crystallizes. Water vapour is lighter than air. That means moist air is less dense than dry air, given the same temperature.



Source: Century Hutchinson (1989 : 70)

Figure 9.7 The Earth's Atmosphere

The Water Cycle

Through the process of evapotranspiration, water rises in the form of vapour into the atmosphere where it expands, cools, saturates, condenses and precipitates as rain, ice, snow or frost. Part of the precipitated water percolates through the permeable soil into the crust to form underground water. Another part gets back as run-off into springs, streams, rivers, lakes and oceans while still a fraction evaporates into the thin air in the form of water vapour. The process keeps on over and again (see figure 9.8).

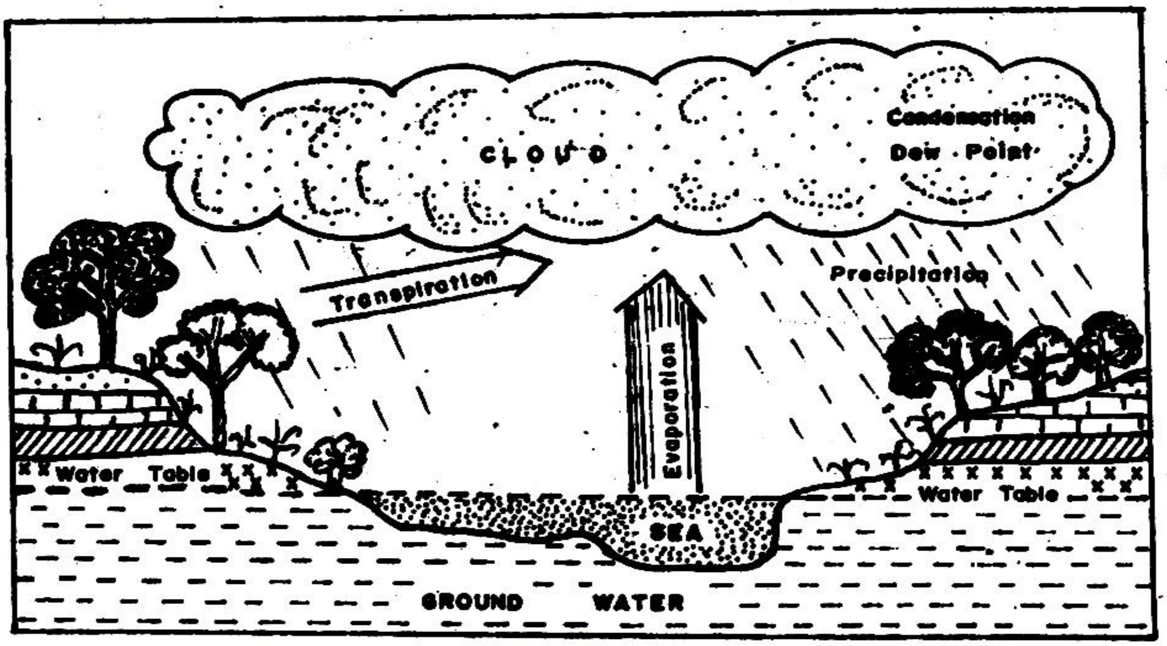


Figure 9.8 The Water Cycle

Influence of Lunar Gravitational Force or Water Bodies

The gravitational force generated by the moon has domineering effect on water and other bodies on earth. For example, during the new and full moon period (see figure 9.9) when the sun and the moon align with the earth, the tides in the oceans are higher and the frictional force apply "temporary break" on the rotational speed of the earth, slowing it down by a second. That happens because during such times the water on the side of the earth facing the moon is nearer to the moon than the earth's centre is. The water body is attracted more strongly to the moon. There is greater lunar gravitational pull on the water body.

As the earth rotates, the water in the oceans swings. It becomes magnetized as it heaps up on the moon-facing side of the earth, giving rise to high tide there. On the side diametrically opposite the moon-facing side there is also the heap-up of water arising from centrifugal force generated by rotation. That means both the side of the earth facing the moon and the side exactly opposite it accumulates water which form the high tides while all other parts of the earth experience a fall in the level of water (low tides) at the same time.

The highest (spring) tides occur during new and full moon while the lowest (neap) happen when the moon is in its first and third quarter. High tides occur at an average interval of 12 hours 24 minutes 30 seconds. It is therefore possible for all places influenced by the lunar gravitational pull and those exactly opposite them to have two high tides daily. Because the moon travels in its orbit in the same direction as the earth spins (rotates) it takes one lunar day (about 24 hours 49 minutes) to complete the sequence of two high and two low tides. All these have significant effect on both human activities and the ecosystem or biospheric balance.

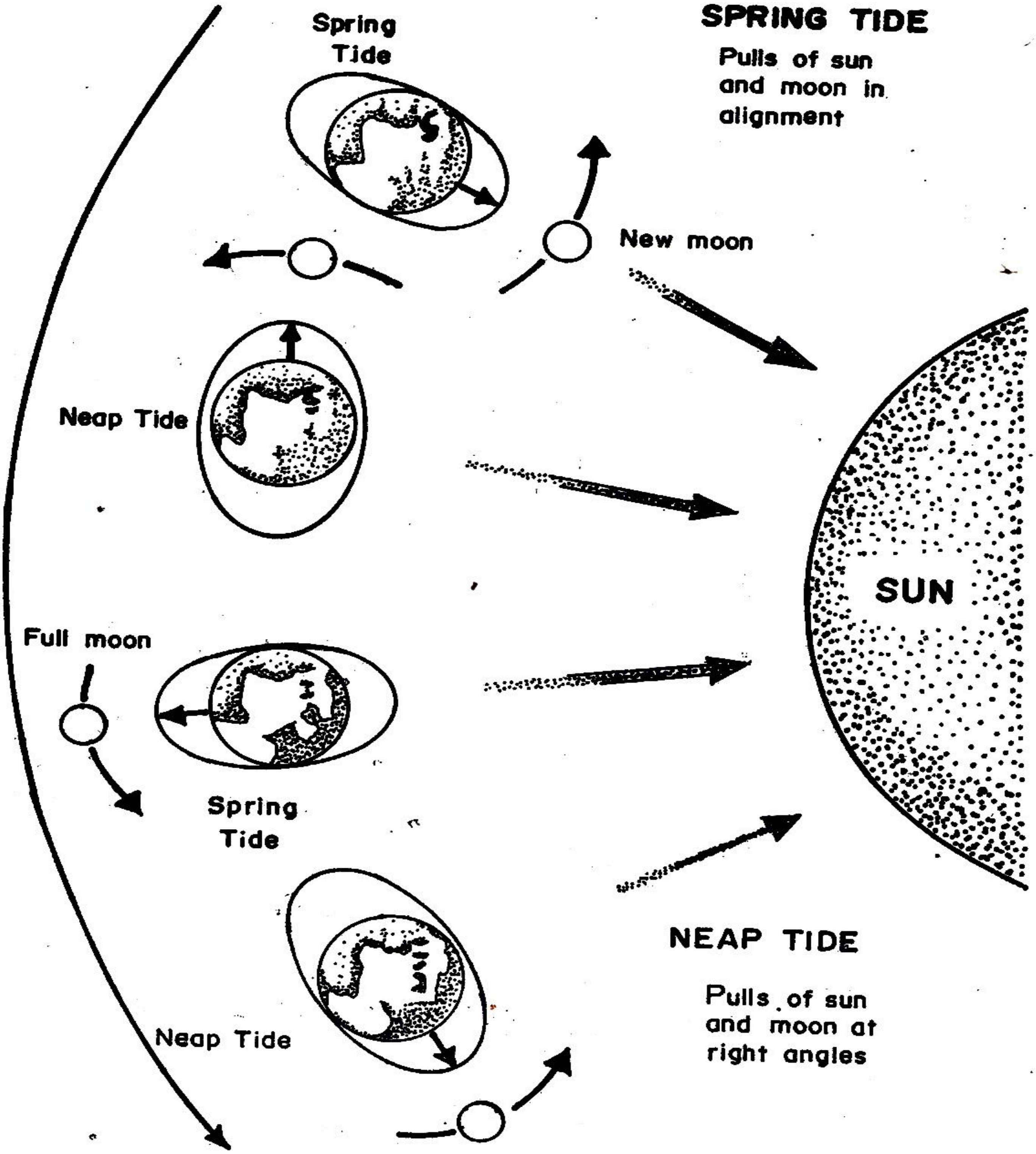


Figure 9.9 Influence of Lunar Gravitational Force on Sea Water

REFERENCES

Beckett, B. S. & Usua, E. J. (1979). *Biology for West African Certificate.* Oxford: Oxford University Press.

Deevey, E. S. (1970). Mineral Cycles. *Scientific America* 223.

Hutchinson, C. (1989). *The Hutchinson Concise Encyclopedia.* London: Guid Publishing.

Inyang-Abia, M. E. & Usang, E. (1992). *Environmental Education for Teachers.* Zaria: Nirvana Publishing Co. Ltd.

Strahler, A. H. & Strahler, A. N. (1977). *Geography and Man's Environment.* New York: John Wiley & Sons.