SUBJECT – ENVIRONMENTAL CHEMISTRY
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Biosphere & its Pollution

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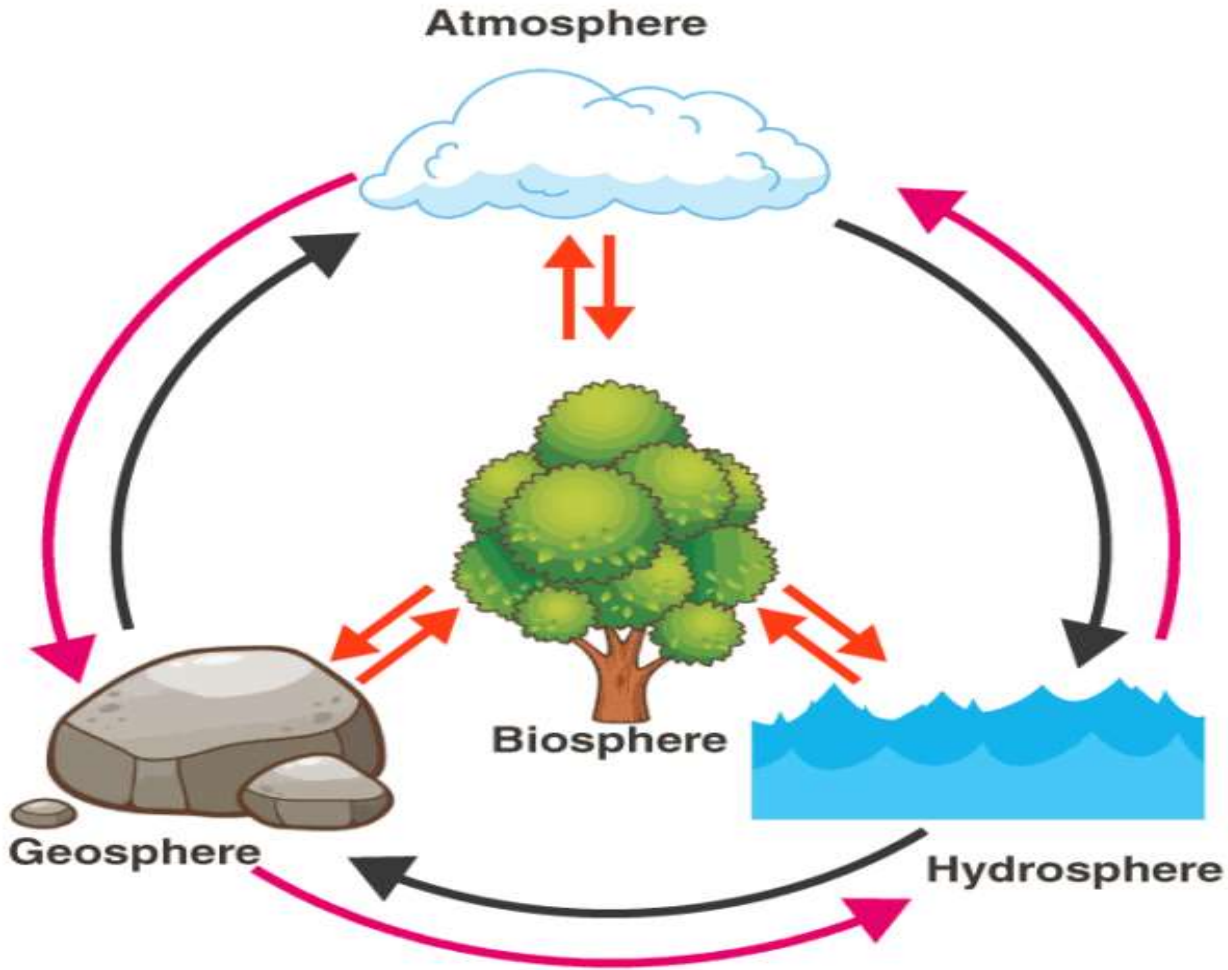
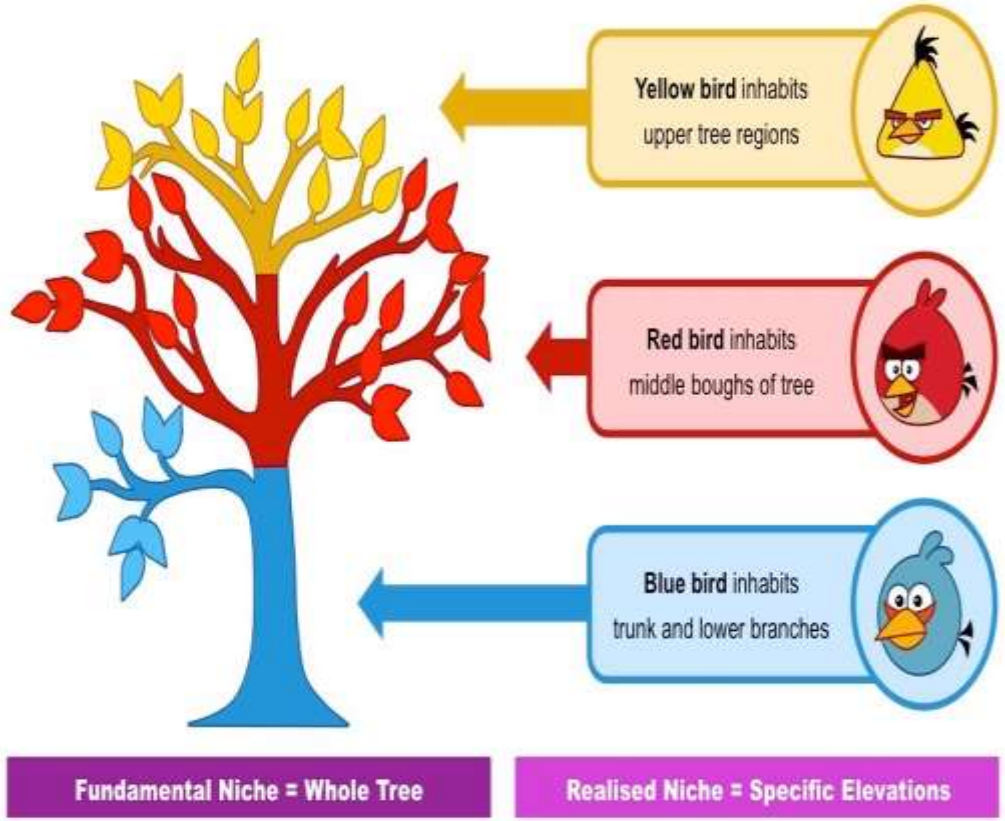

Atmosphere
Biosphere
Geosphere
Hydrosphere

Concept Of Ecology

- **Biosphere/ecosphere** is the part of the earth and atmosphere inhabited by living organisms.
- The **habitat** is a specific locality with a particular set of conditions where organisms live. Habitats are categorized into Terrestrial (Land) and aquatic(Water).
- An **ecological niche** is the position that animal occupies in a habitat. It includes physical **space** where the organism is found and its role in that habitat in terms of feeding relationships and other interactions with other species.



Habitat vs Niche

Habitat

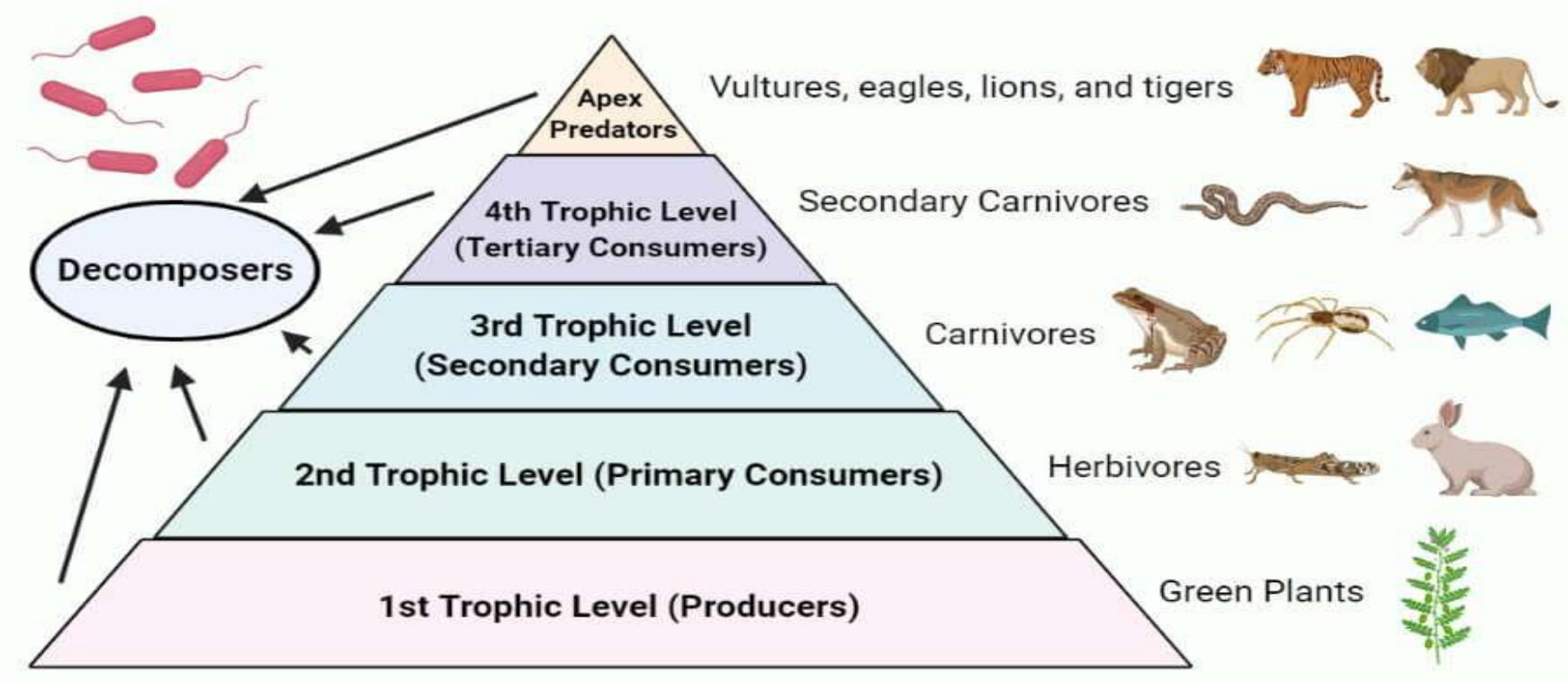
- The habitat is the place where an organism lives out its life.
  - It is where the organism finds food, shelter and mates.

Niche

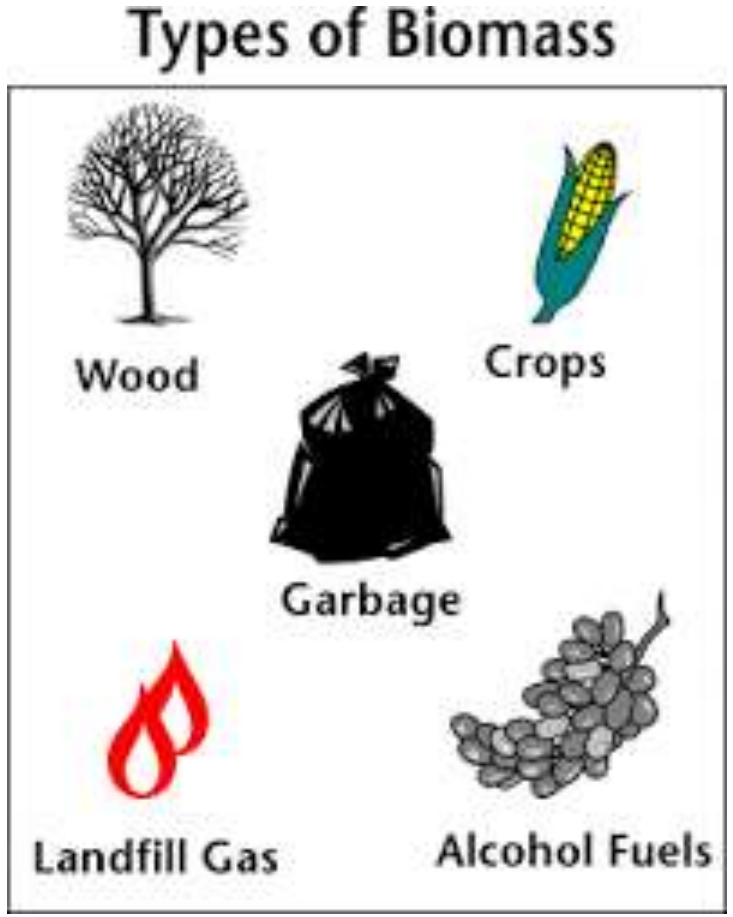
- A niche is its role in the community and how it interacts with the environment.
  - How it obtains food, mates and protection from predators.

- **Population** refers to all members of a given species in a particular habitat, at a particular time.
- **Community** refers to all organisms belonging to different species that interact in the same habitat. A community therefore is made up of populations.
- An **ecosystem** is a natural unit composed of abiotic and biotic factors whose interactions leads to **self-sustaining** system e.g a small pond or a large ecosystem such as tropical forest.

Tropic level in Ecosystem



- **Biomass** is the total dry weight of living organisms at a particular tropic level or per unit area e.g total weight of maize crop per hectare.
- **Carrying Capacity** is the maximum number of organisms in an area can comfortably support without depletion of the available resources.



Ecology in terms of Environment

- Environment is the sum total of all conditions and influences that affect the development and life of all organisms on earth.
- Ecology is the branch of science that deals with the study of interactions between living organisms and their physical environment.
- Both are closely interrelated and they have continuous interaction so that any change in the environment has an effect on the living organisms and vice-versa.

MAIN DIFFERENCES

ECOLOGY AND ECOSYSTEM

DEFINITION

Ecology is a branch of biology which deals with the relationships of organisms to one another and to their physical environment	Ecosystem is a community of interacting organisms and their physical environment; an ecosystem is a subpart of ecology

RELATIONSHIP

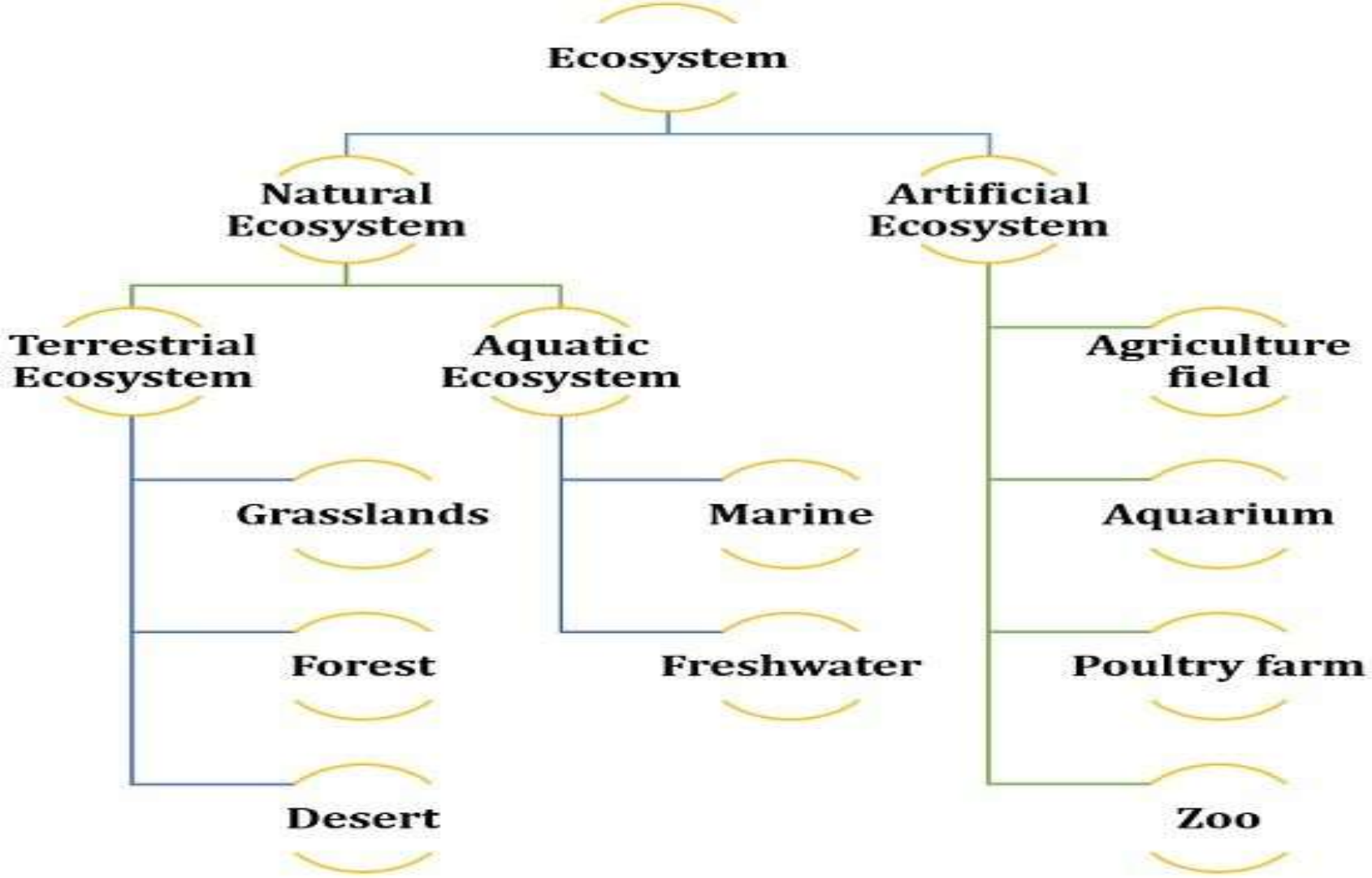
Ecology includes the study of relationship between living organisms and their environment	Ecosystem is a place like a forest, taiga, grass land, desert, stillwater, river or a stream, coral reefs etc

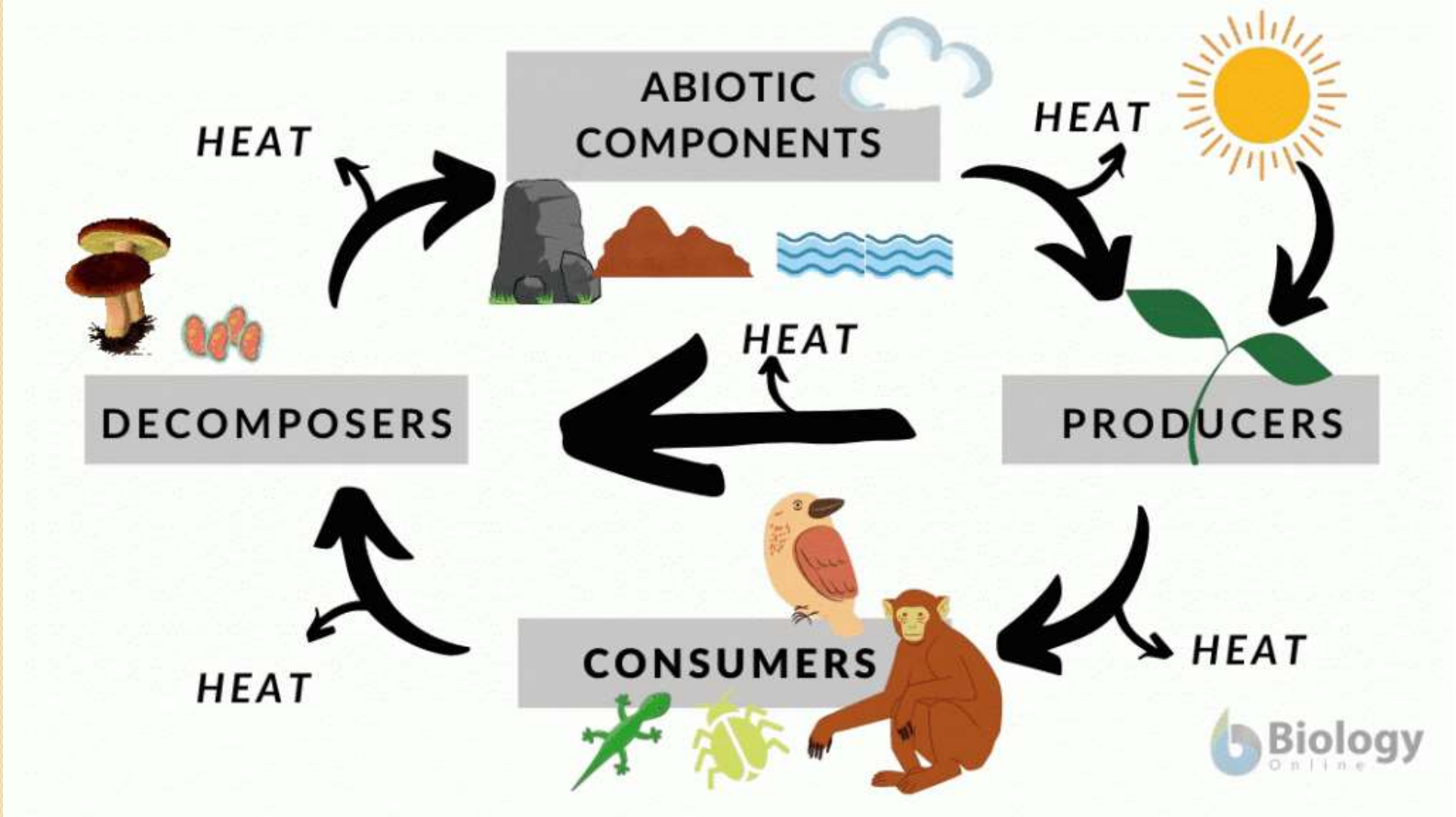
Ecosystem

- The term ecosystem was coined in 1935 by the Oxford ecologist Arthur Tansley to encompass the interactions among biotic and abiotic components of the environment at a given site.
- The living and non-living components of an ecosystem are known as biotic and abiotic components, respectively.

Ecosystem By Odum

According to Eugene Odum "an unit that includes all the organisms, i.e., the community in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity and material cycles, i.e., exchange of materials between living and non-living, within the system".

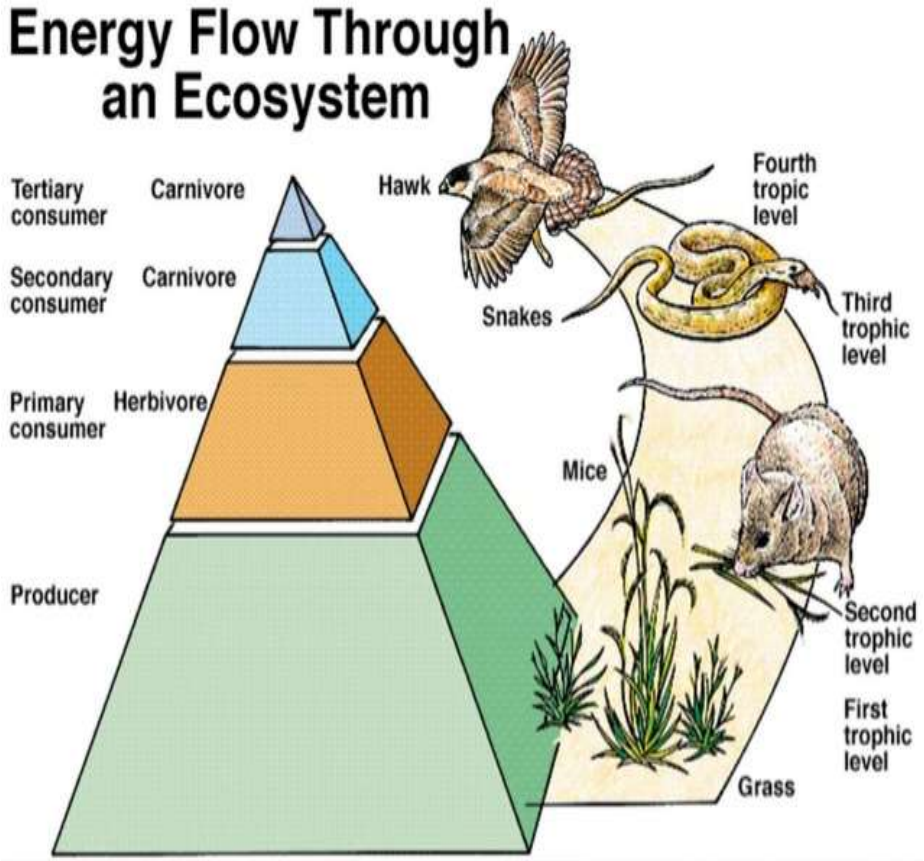

Ecosystem
Natural Ecosystem
Artificial Ecosystem
Terrestrial Ecosystem
Aquatic Ecosystem
Agriculture field
Grasslands
Marine
Aquarium
Forest
Freshwater
Poultry farm
Desert
Zoo


ABIOTIC COMPONENTS
HEAT
HEAT
HEAT
DECOMPOSERS
PRODUCERS
HEAT
CONSUMERS
HEAT
Biology Online

Characteristics of Ecosystem

- The ecosystem is a major structural and functional unit of ecology.
- The structure of an ecosystem is related to its species diversity in the sense that complex ecosystem have high species diversity.
- The function of ecosystem is related to energy flow and material cycles within and outside the system.
- The relative amount of energy needed to maintain an ecosystem depends on its structure. Complex ecosystems needed less energy to maintain themselves.
- Young ecosystems develop and change from less complex to more complex ecosystems, through the process called succession.

- Adaptation to local environmental conditions is the important feature of the biotic components of an ecosystem, failing which they might perish.
- The function of every ecosystem involves a series of cycles, e.g., water cycle, nitrogen cycle, oxygen cycle, etc. these cycles are driven by energy.
- A continuation or existence of ecosystem demands exchange of materials/nutrients to and from the different components.



Biogeochemical cycle

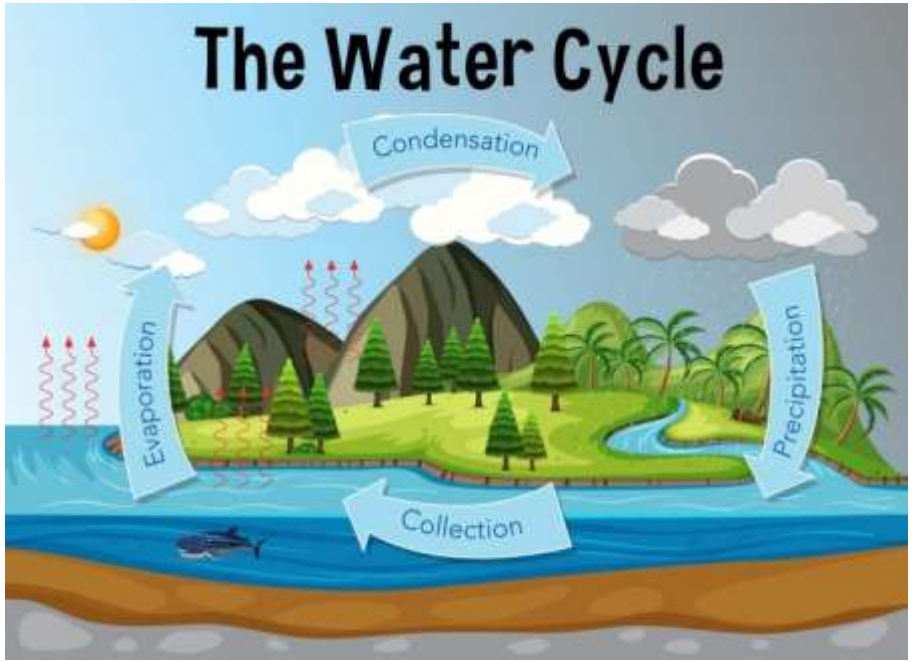
- The term biogeochemical is derived from **"bio"** meaning **biosphere**, **"geo"** meaning the **geological components** and "**chemical**" meaning the **elements that move through a cycle**.
- The matter on Earth is conserved and present in the form of atoms. Since matter can neither be created nor destroyed, it is recycled in the earth's system in various forms.
- The earth obtains energy from the sun which is radiated back as heat, rest all other elements are present in a closed system. The major elements include:
- Carbon, Hydrogen, Nitrogen, Oxygen, Phosphorus, Sulphur
- These elements are recycled through the biotic and abiotic components of the ecosystem. The atmosphere, hydrosphere and lithosphere are the abiotic components of the ecosystem.

Types

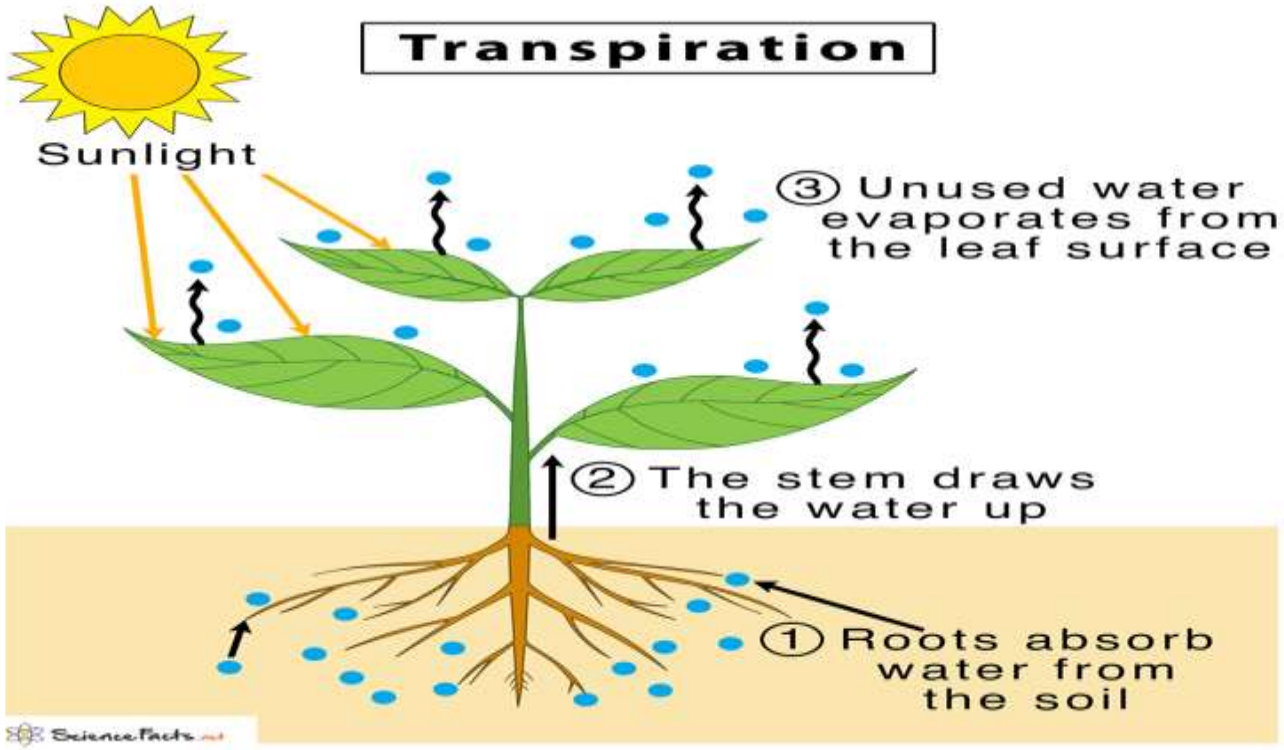
- Types of Biogeochemical Cycles
- Biogeochemical cycles are basically divided into two types:
- **Gaseous cycles** – Includes Carbon, Oxygen, Nitrogen, and the Water cycle.
- **Sedimentary cycles** – Includes Sulphur, Phosphorus, Rock cycle, etc.

Water Cycle

- The water from the different water bodies evaporates, cools, condenses and falls back to the earth as rain.
- This biogeochemical cycle is responsible for maintaining weather conditions. The water in its various forms interacts with the surroundings and changes the temperature and pressure of the atmosphere.
- There's another process called Evapotranspiration (i.e. vapour produced from leaves) which aids this process. It is the evaporation of water from the leaves, soil and water bodies to the atmosphere which again condenses and falls as rain.



Evapotranspiration -

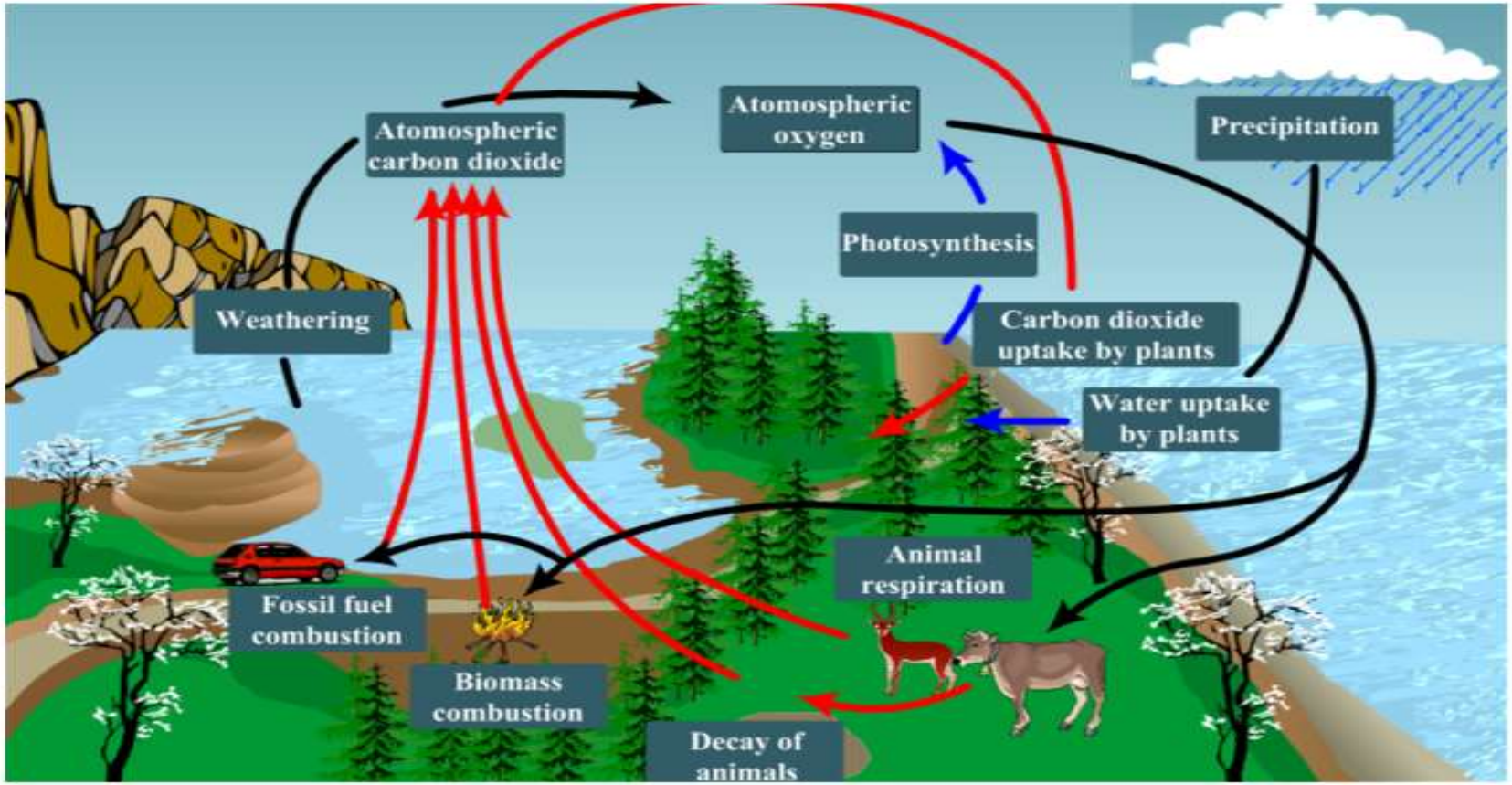


Oxygen Cycle

- The **oxygen cycle** is the **cycle** that helps move **oxygen** through the three main regions of the Earth, the Atmosphere, the Biosphere, and the Lithosphere.
- The Biosphere is the sum of all the Earth's ecosystems. This also has some free **oxygen** produced from photosynthesis and other life processes.

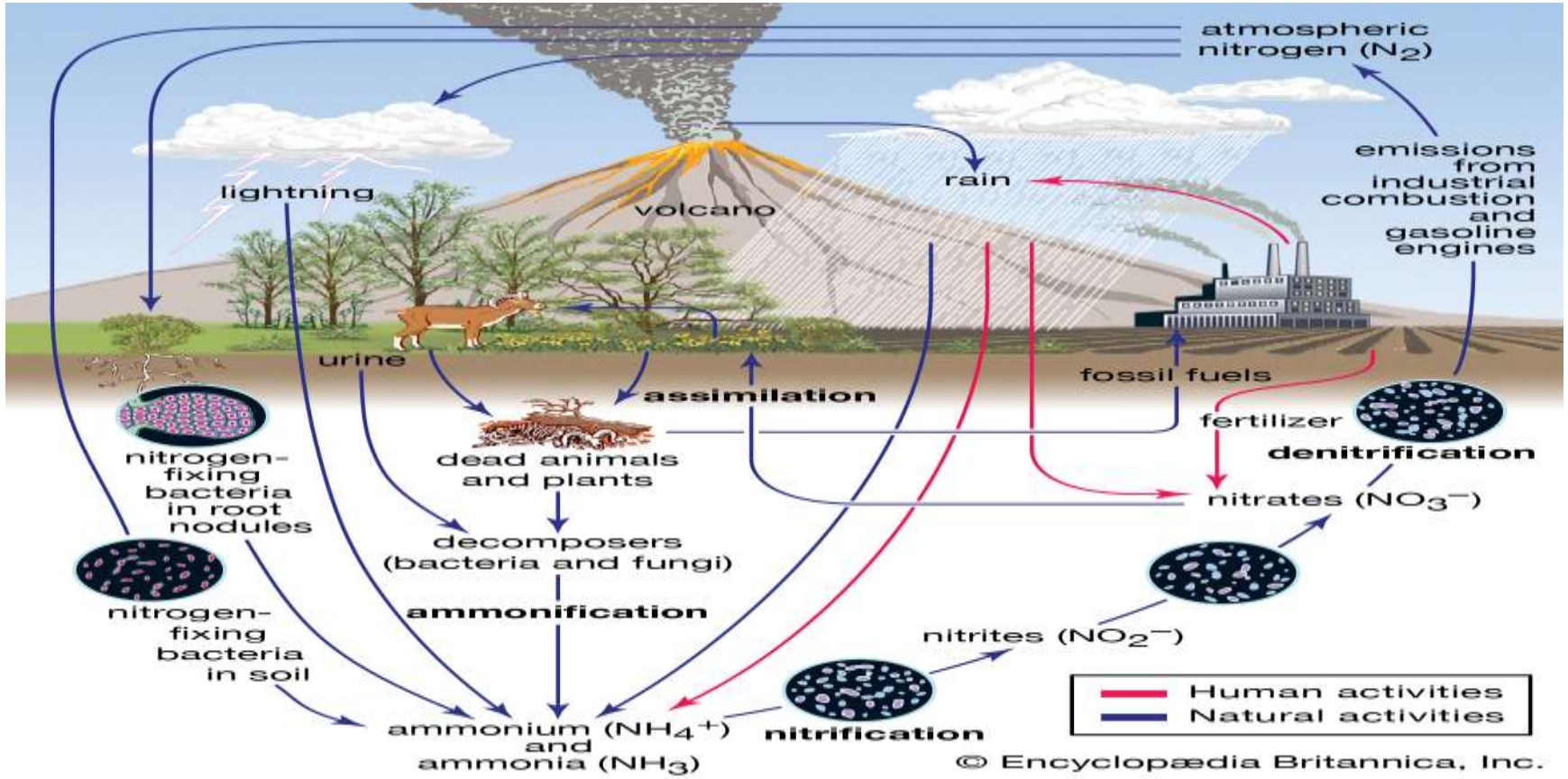
- **Stage-**1: All green plants during the **process** of photosynthesis, release **oxygen** back into the atmosphere as a by-product.
- **Stage-**2: All aerobic organisms use free **oxygen** for respiration.
- **Stage-**3: Animals exhale Carbon dioxide back into the atmosphere which is again used by the plants during photosynthesis.

Diagrammatic Representation



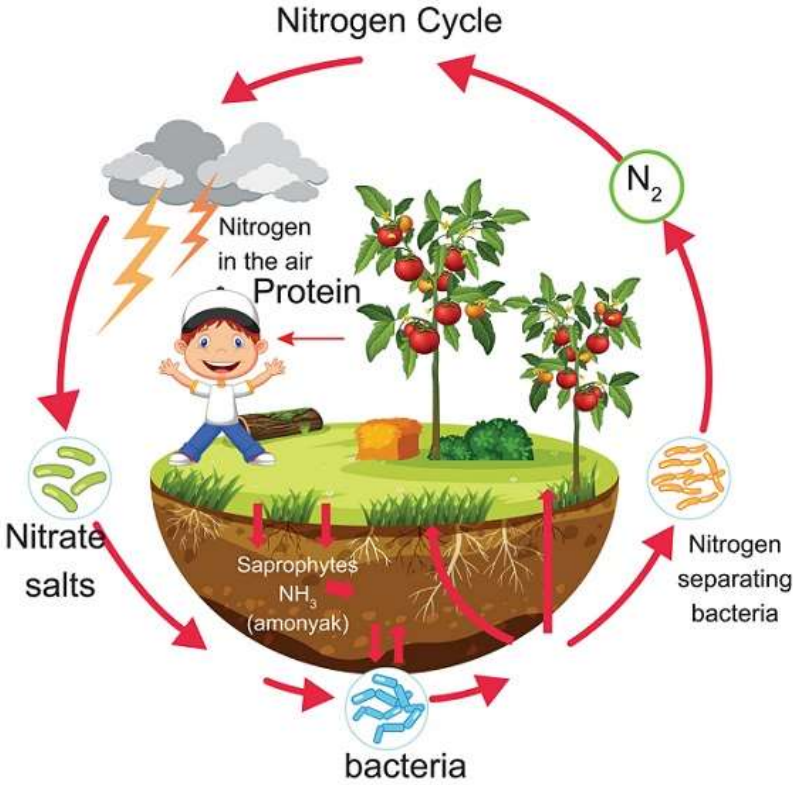
- In the atmosphere, a process called **photolysis** plays an important role. In this reaction, high-energy UV radiation from the sun breaks down atmospheric water and nitrous oxide, releasing **free oxygen molecules into the atmosphere**.
- The lithosphere can take in oxygen from the atmosphere through **chemical weathering** and other surface reactions, such as the formation of iron oxides (rust). Some types of chemical weathering can also release oxygen back into the atmosphere when the oxygen-containing minerals in rock begin to break down.
- Oxygen can also cycle between the biosphere and lithosphere. Marine organisms in the biosphere create **calcium carbonate shells** which are full of oxygen. When the organism dies, the shell settles at the ocean floor. It eventually forms limestone **sedimentary rock**, becoming a part of the lithosphere. Likewise, oxygen can be cycled from the lithosphere back into the biosphere when organisms use minerals found in rock and then release oxygen from it.

Nitrogen Cycle



- Nitrogen is required by all living organisms for the synthesis of proteins, nucleic acids and other nitrogen containing compounds.
- The Earth's atmosphere contains almost 80 % nitrogen gas. It cannot be used in this form by most living organisms until it has been fixed, that is reduced (combined with hydrogen), to ammonia.
- The nitrogen cycle is a series of processes that convert nitrogen gas to organic substances and back to nitrogen in nature.
- It is a continuous cycle that is maintained by the decomposers and nitrogen bacteria.

- **Nitrogen Cycle** is a biogeochemical process through which **nitrogen** is converted into many forms, consecutively passing from the atmosphere to the soil to organism and back into the atmosphere.
- It involves several processes such as **nitrogen fixation**, nitrification, denitrification, decay and purification.
- **Nitrogen fixation** (N_2 to NH_3/ NH_4^+ or NO_3^-)
- Nitrification (NH_3 to NO_3^-)
- Assimilation (Incorporation of NH_3 and NO_3^- into biological tissues)
- Ammonification (organic **nitrogen** compounds to NH_3)
- Denitrification (NO_3^- to N_2)



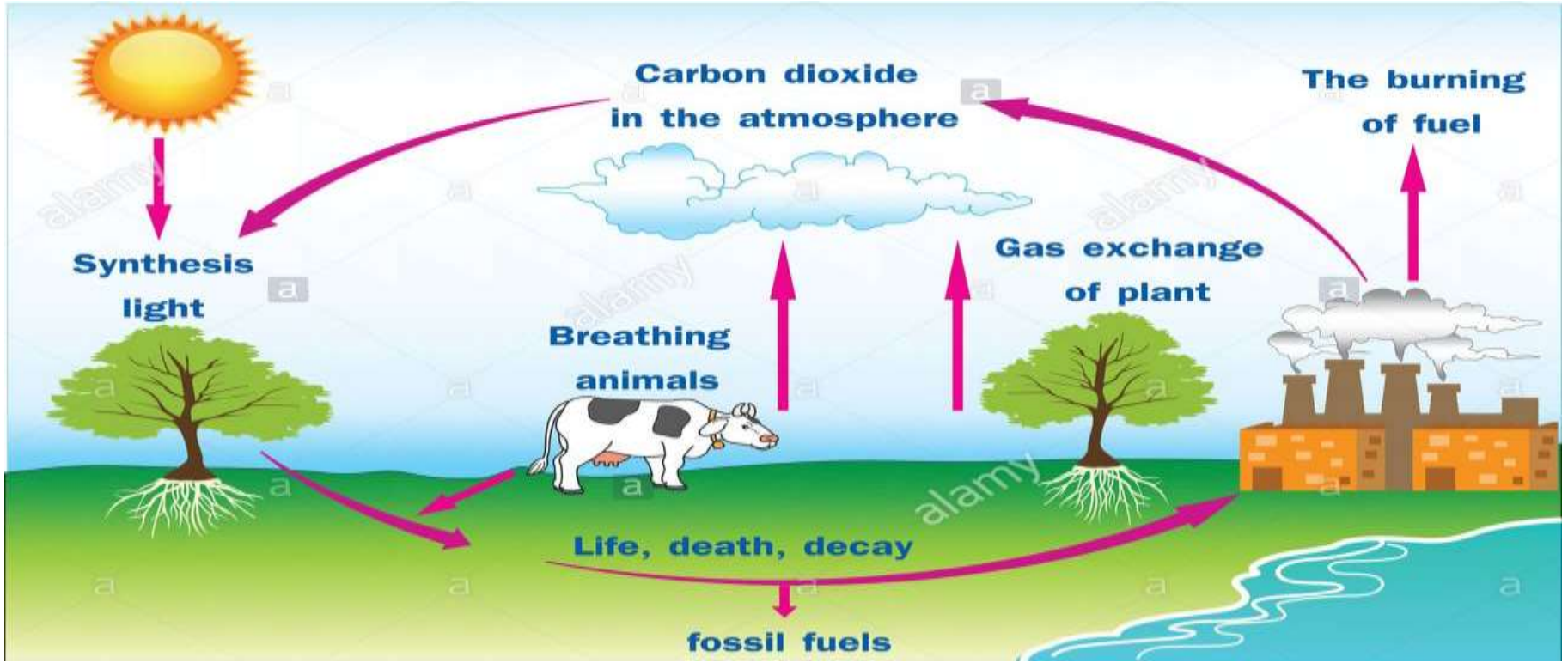
Carbon cycle

- The element carbon is a part of seawater, the atmosphere, rocks such as limestone and coal, soils, as well as all living things. On our dynamic planet, carbon is able to move from one of these realms to another as a part of the carbon cycle.
- Carbon moves from the atmosphere to plants. In the atmosphere, carbon is attached to oxygen in a gas called carbon dioxide (CO_2).
- Through the process of photosynthesis, carbon dioxide is pulled from the air to produce food made from carbon for plant growth.
- Carbon moves from plants to animals. Through food chains, the carbon that is in plants moves to the animals that eat them. Animals that eat other animals get the carbon from their food too.
- Carbon moves from plants and animals to soils. When plants and animals die, their bodies, wood and leaves decays bringing the carbon into the ground. Some is buried and will become fossil fuels in millions and millions of years.

- Carbon moves from living things to the atmosphere. Each time you exhale, you are releasing carbon dioxide gas (CO_2) into the atmosphere. Animals and plants need to get rid of carbon dioxide gas through a process called respiration.
- Carbon moves from fossil fuels to the atmosphere when fuels are burned.
- When humans burn fossil fuels to power factories, power plants, cars and trucks, most of the carbon quickly enters the atmosphere as carbon dioxide gas.
- Each year, five and a half billion tons of carbon is released by burning fossil fuels.
- Of this massive amount, 3.3 billion tons stays in the atmosphere. Most of the remainder becomes dissolved in seawater.
- Carbon moves from the atmosphere to the oceans. The oceans, and other bodies of water, absorb some carbon from the atmosphere.
- The carbon is dissolved into the water.

- Carbon dioxide is a greenhouse gas and traps heat in the atmosphere. Without it and other greenhouse gases, Earth would be a frozen world.
- But since the start of the Industrial Revolution about 150 years ago humans have burned so much fuel and released so much carbon dioxide into the air that global climate has risen over one degree Fahrenheit.
- The atmosphere has not held this much carbon for at least 420,000 years according to data from ice cores.
- The recent increase in amounts of greenhouse gases such as carbon dioxide is having a significant impact on the warming of our planet.

Carbon cycle



Sulphur Cycle

- Sulfur is found in oxidation states ranging from +6 in SO_4^{2-} to -2 in sulfides.
- Thus, elemental sulfur can either give or receive electrons depending on its environment.
- On the anoxic early Earth, most sulfur was present in minerals such as pyrite (FeS_2).
- Over Earth history, the amount of mobile sulfur increased through volcanic activity as well as weathering of the crust in an oxygenated atmosphere.
- Earth's main sulfur sink is the oceans SO_4^{2-}, where it is the major oxidizing agent.

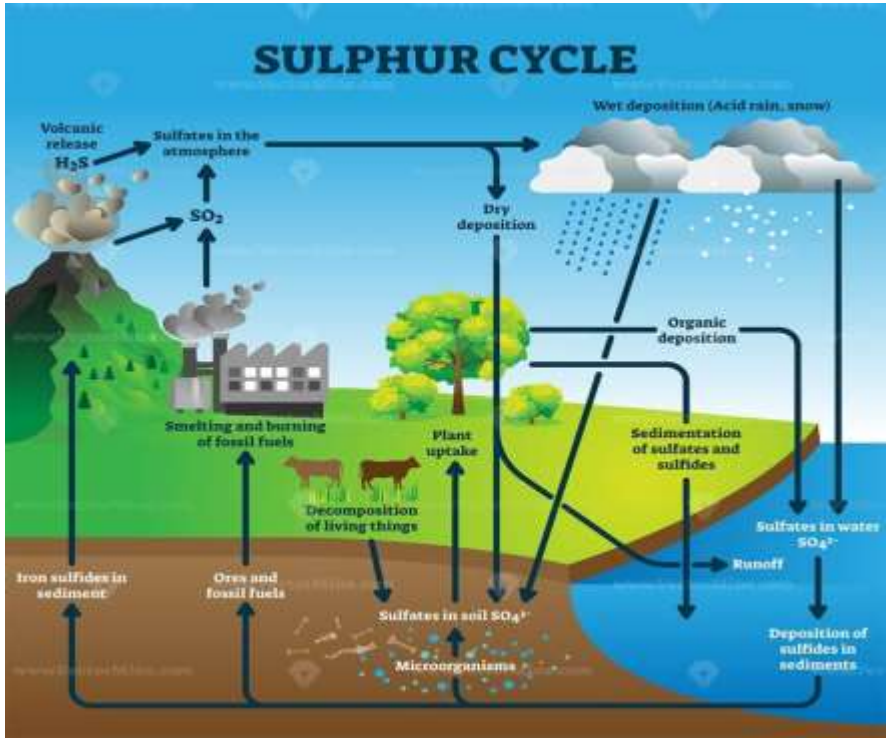
- When SO_4^{2-} is assimilated by organisms, it is reduced and converted to organic sulfur, which is an essential component of proteins.
- However, the biosphere does not act as a major sink for sulfur, instead the majority of sulfur is found in seawater or sedimentary rocks including: pyrite rich shales, evaporite rocks (anhydrite and baryte), and calcium and magnesium carbonates (i.e. carbonate-associated sulfate).

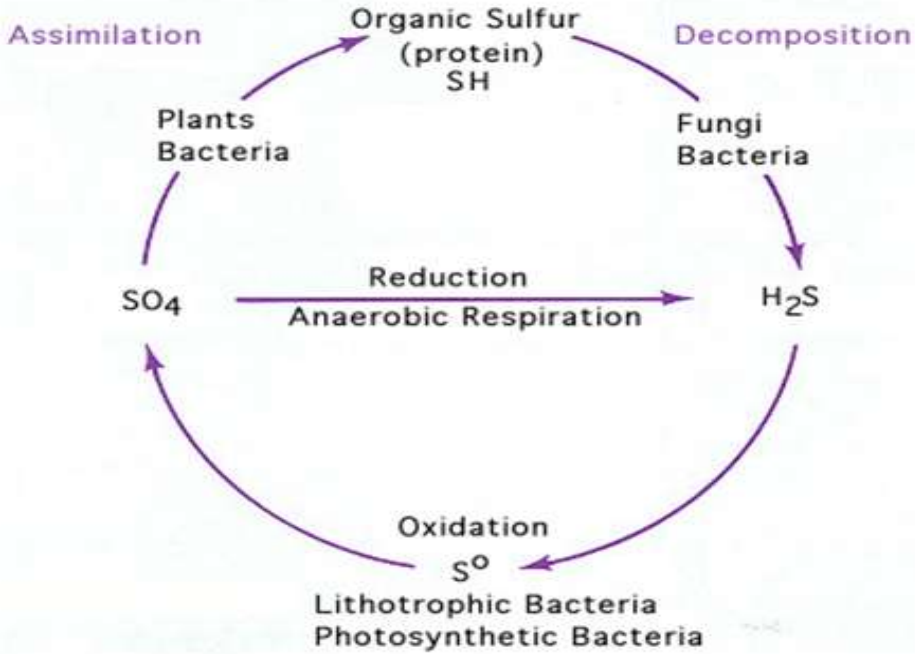
- The **sulfur cycle** is the collection of processes by which sulfur moves between rocks, waterways and living systems.
- Such biogeochemical cycles are important in geology because they affect many minerals. Biochemical cycles are also important for life because sulfur is an essential element, being a constituent of many proteins and cofactors, and sulfur compounds can be used as oxidants or reductants in microbial respiration.
- The global sulfur cycle involves the transformations of sulfur species through different oxidation states, which play an important role in both geological and biological processes.

Steps involved in Sulphur cycle

- Mineralization of organic sulfur into inorganic forms, such as hydrogen sulfide (H_2S), elemental sulfur, as well as sulfide minerals.
- Oxidation of hydrogen sulfide, sulfide, and elemental sulfur (S) to sulfate (SO_4^{2-}).
- Reduction of sulfate to sulfide.
- Incorporation of sulfide into organic compounds (including metal-containing derivatives).

Sulphur Cycle





Phosphorus Cycle

- The **phosphorus cycle** is the process by which **phosphorus** moves through the lithosphere, hydrosphere, and biosphere.
- **Phosphorus** is essential for plant and animal growth, as well as the health of microbes inhabiting the soil, but is gradually depleted from the soil over time.
- Phosphorus moves in a cycle through rocks, **water**, soil and sediments and organisms. Over time, rain and **weathering** cause rocks to release phosphate ions and other minerals.
- This inorganic phosphate is then distributed in soils and **water**. Plants take up inorganic phosphate from the soil.

Phosphorus Cycle