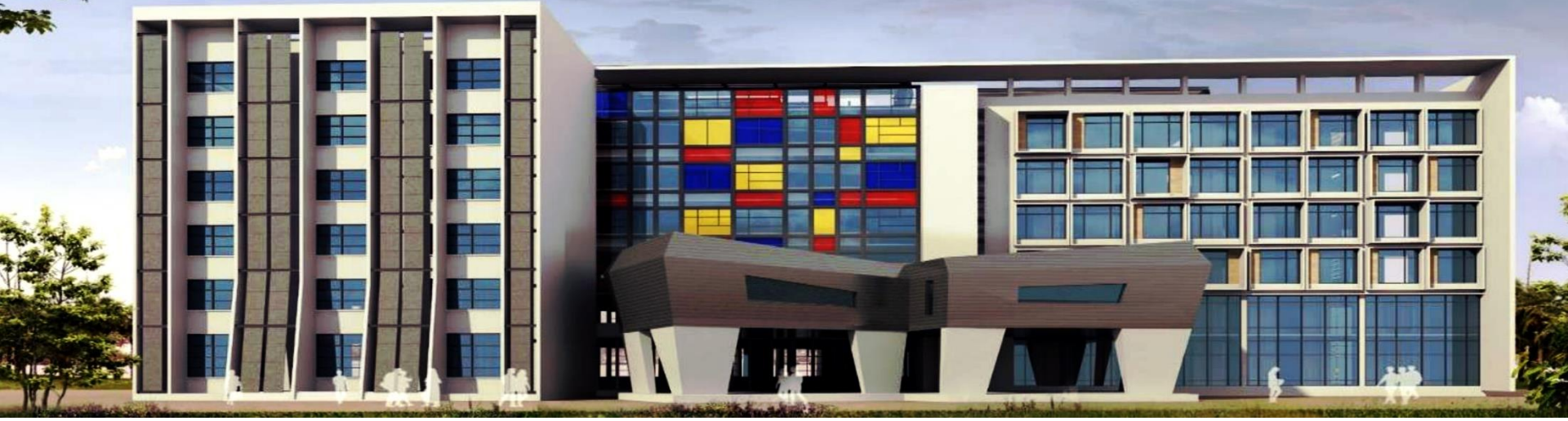


Environmental Chemistry Theory

CY1018

भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

Department of Chemistry

Course Content

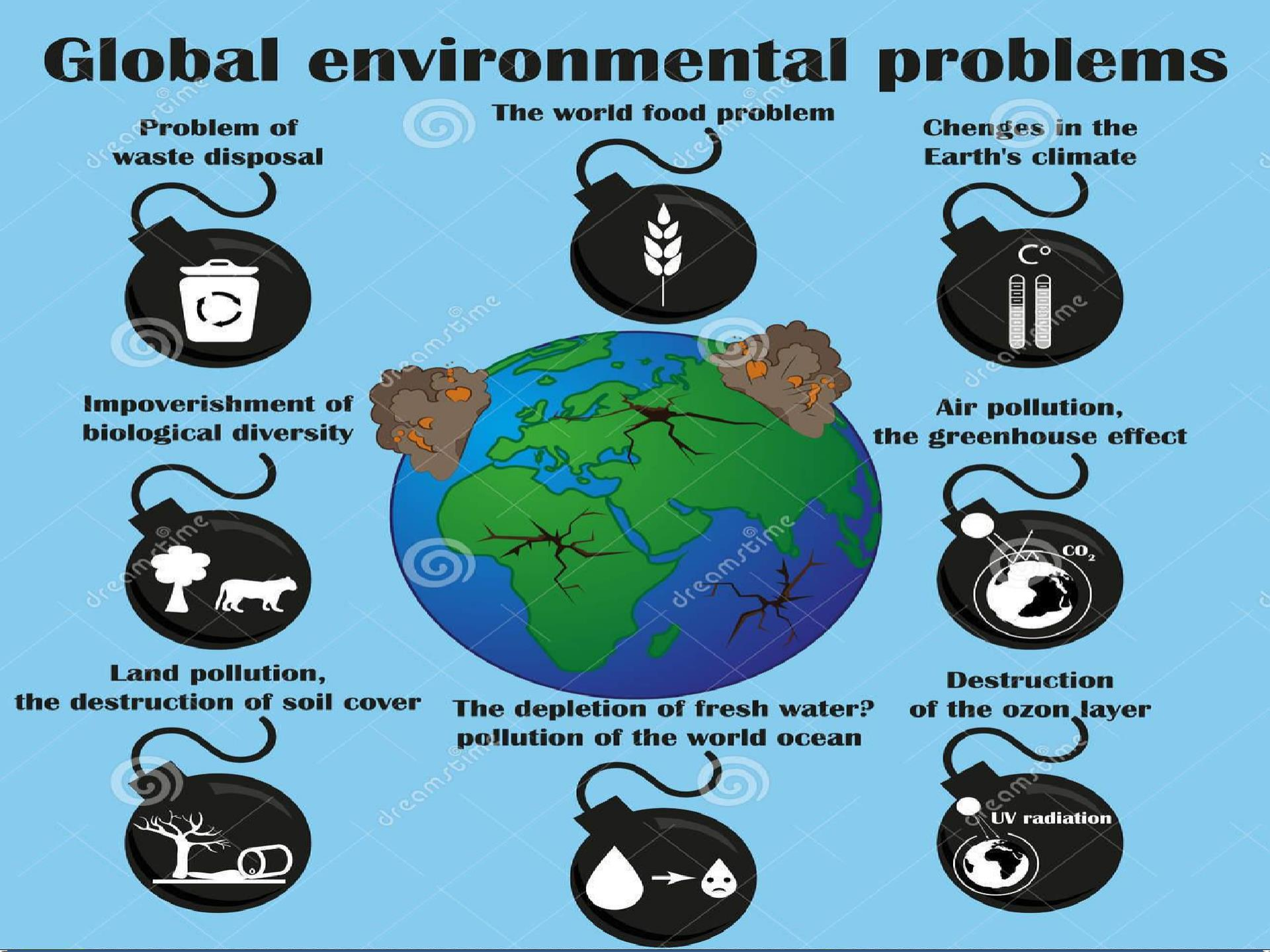
Know our environment (chemistry of lithosphere, energy balance, sustainability and recycle), Know about global warming (infrared absorption, molecular vibration, atmospheric window, residence time of greenhouse gases, evidences and effects of global warming)

Deeper analysis of atmospheric pollution (Chemistry of CO, NOx, VOCs, SO_2, Industrial smog, photochemical smog), Ozone depletion (production, catalytic destruction)

Organic Chemicals in the Environment, Insecticides, Pesticides, Herbicides and Insect Control, Soaps, Synthetic Surfactants, Polymers, and Haloorganics. Fate of organic/inorganic chemicals in natural and engineered systems (fate of polymers after use, detergents, synthetic surfactants insecticides, pesticides etc. after use)

Aspects of transformations in atmosphere (microbial degradation of organics-environmental degradation of polymers, atmospheric lifetime, toxicity). Green Chemistry and Industrial Ecology. Future challenges (CO_2 sequestering, Nuclear energy). A project on environment related topic.

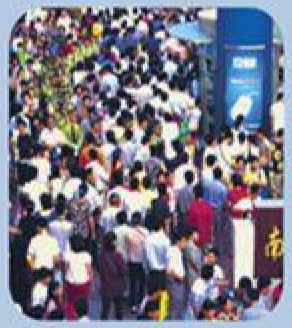
Global environmental problems



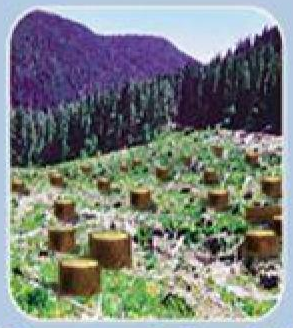
Experts Have Identified Four Basic Causes of Environmental Problems

1. Population growth
2. Wasteful and unsustainable resource use
3. Poverty
4. Failure to include the harmful environmental costs of goods and services in market prices

Causes of Environmental Problems



Population growth



Unsustainable resource use

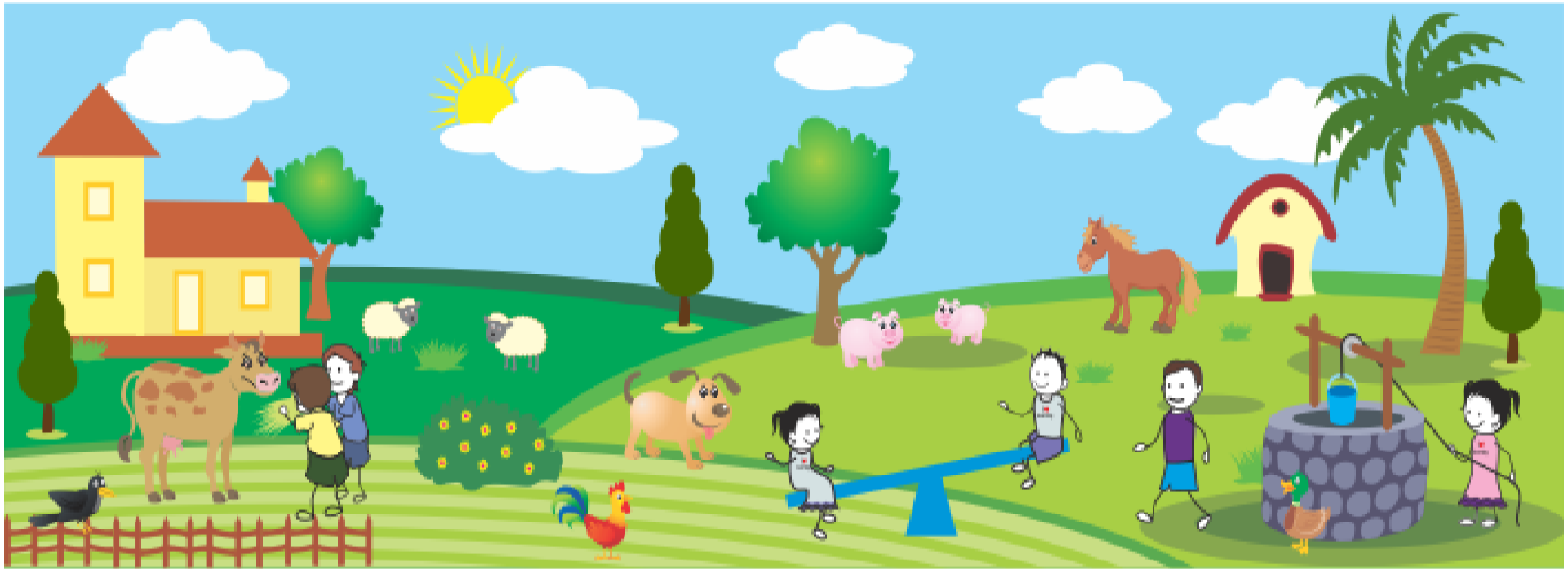
Poverty

Excluding environmental costs from market prices


Environement
&
Ecosystem

Our Environment

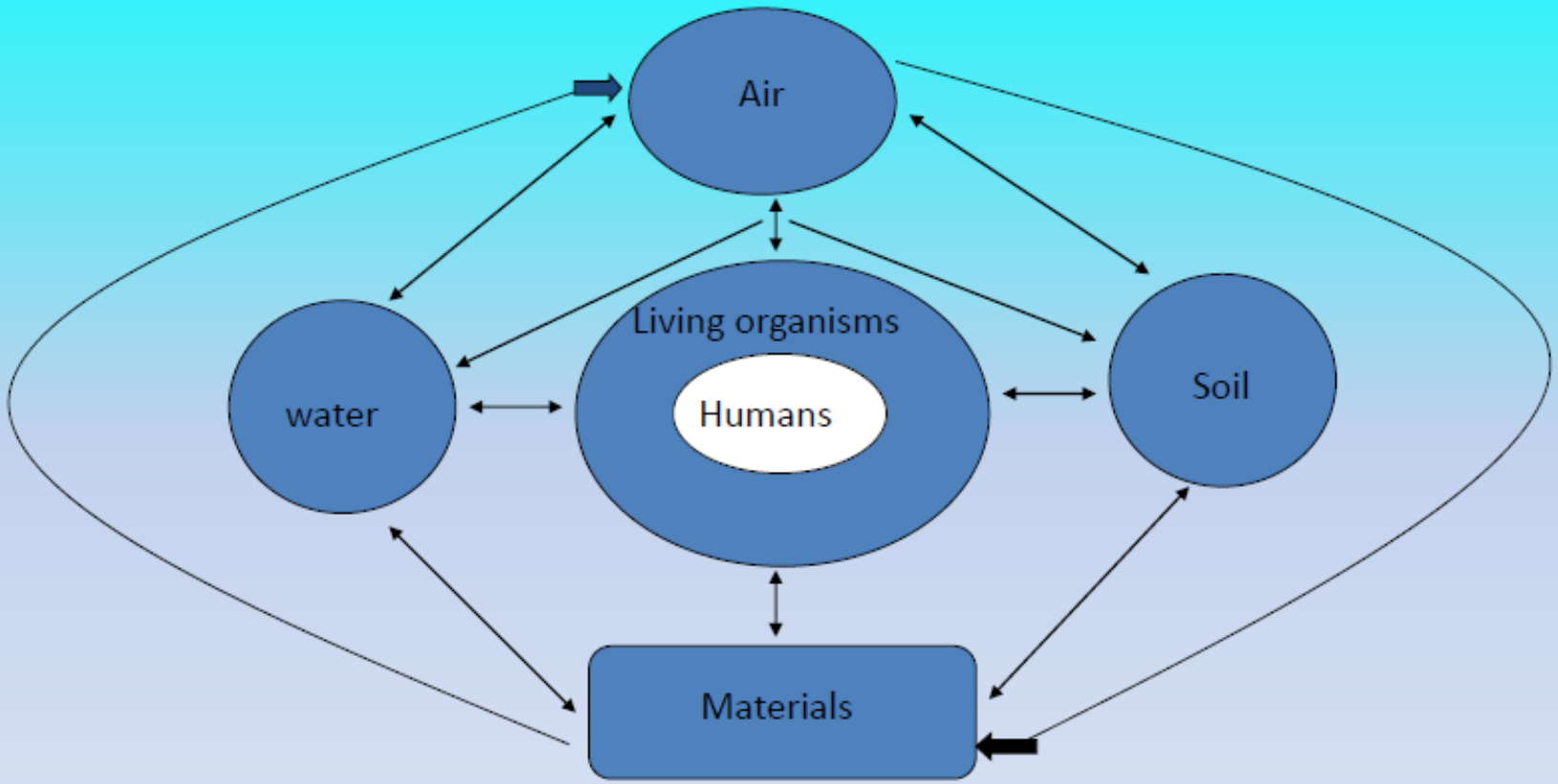
Everything surrounding us and affecting us is called Environment.



Environment

- **Biotic component**
  Living things (animals and plants)
- **Abiotic component**
  Non-living things (soil, air, water and sunshine)

What is environment?



Air, water, land, living organisms and materials surrounding us and their interactions together constitute environment

All these are Earth-Life support systems

Definitions

Environment -Surroundings.

- Environmental study means study of our surroundings
- In this course we concentrate more on the study of surroundings of us, human beings.

What is meant by surroundings?

Things or conditions around a person or place.

- which include materials (non living), non-materials and living things.

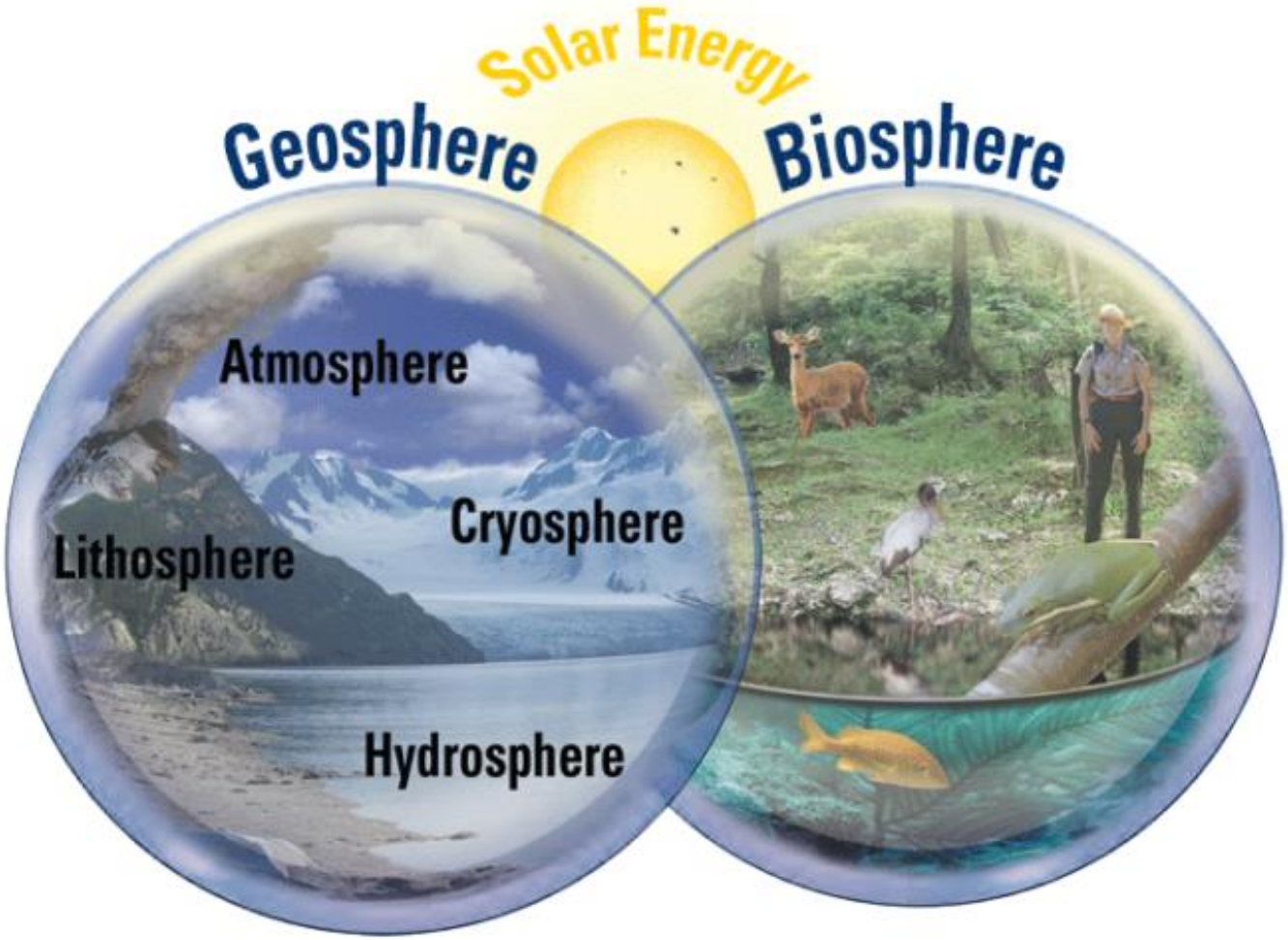
What are the components of our environment?

One way of classification of our surroundings is into Chemical, Physical and Biological components.

Chemical – all material things

Physical – mainly concerned with energy processes

Biological – both flora and fauna, as well as their interactions.



The four major components of the earth-life-support system are the

- ❖ **Atmosphere (air)**
- ❖ **Lithosphere (rock, soil, and sediment)**
- ❖ **Hydrosphere (water)**
- ❖ **Biosphere (living things).**

Life is sustained by the flow of energy from the sun through the biosphere, the cycling of nutrients within the biosphere and gravity.

Atmosphere - Air

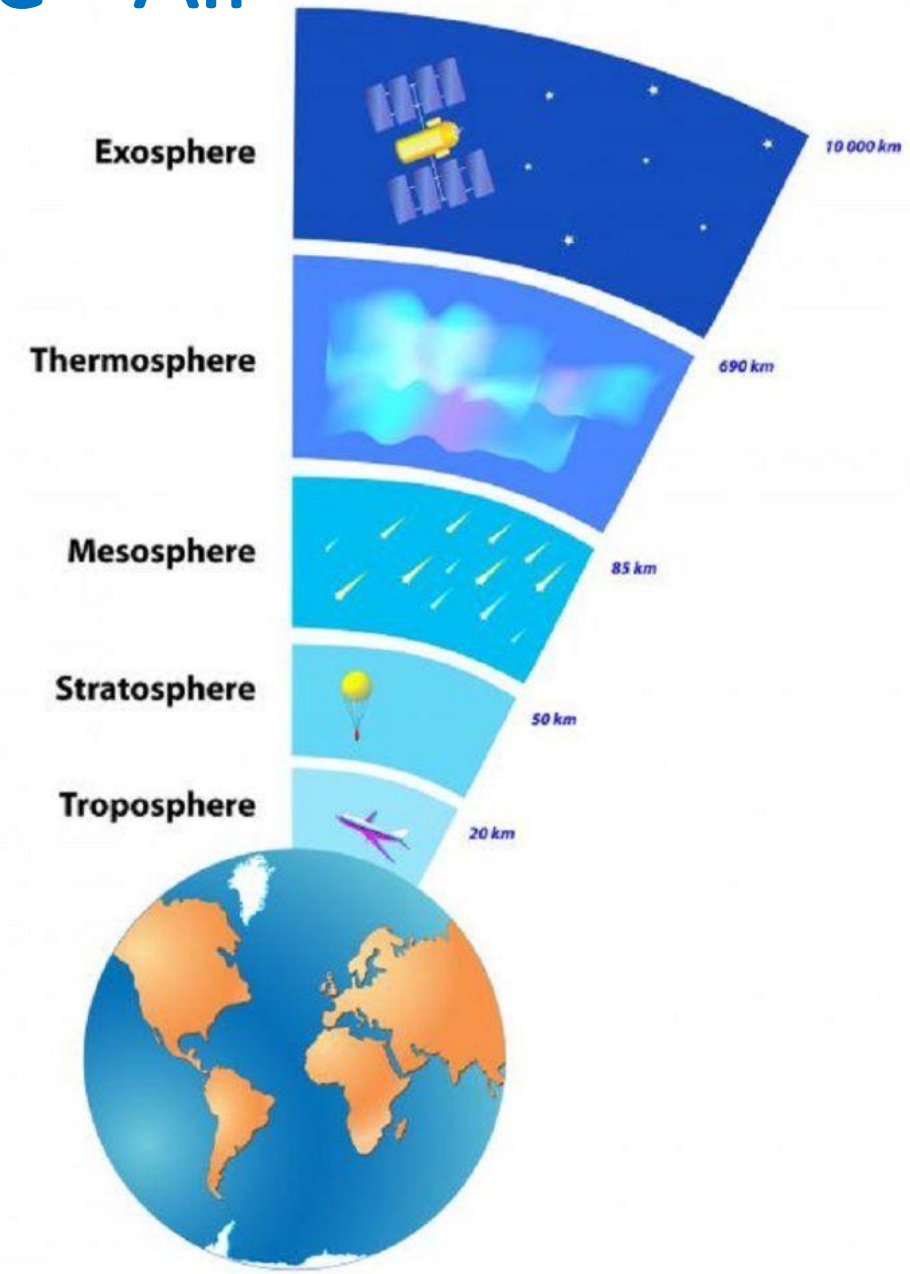
Exosphere
- 1600 km; Very high Temp.,
- H_2, HE, Outer Space

Thermosphere
- 90-500 km; -92 to 1200 °C Temp.,
- O_2, NO+

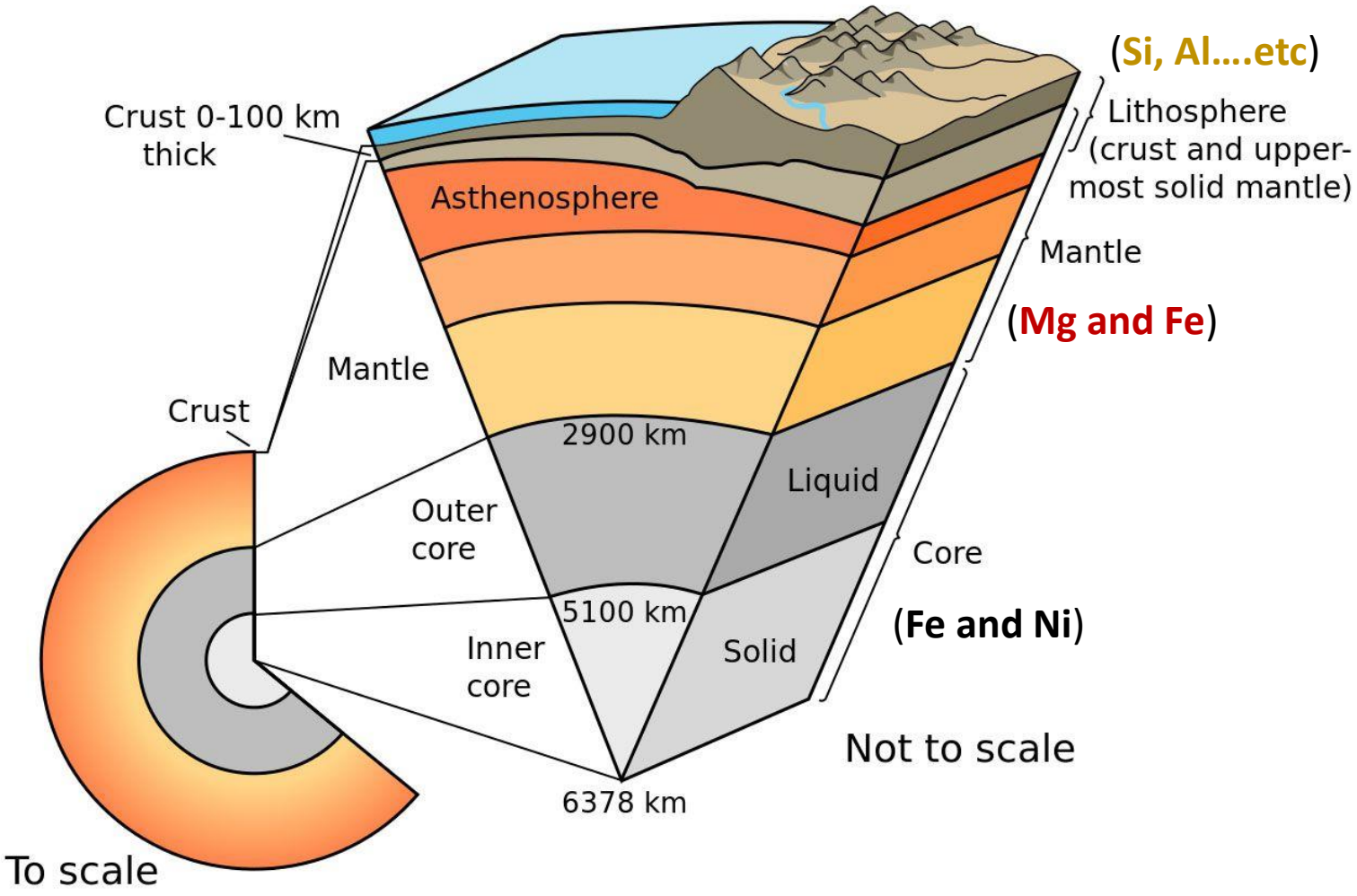
Mesosphere
- 50-90 km; -2 to -92 oC Temp,
- (Ionoshere: O^+_2, O+ , NO+ , e-)

Stratosphere
- 11-50 km; -56 to -2 °C Temp,
- O_3(Ozone Layer: 15 km)

Troposphere
- 0-11 km; 15 to -56 °C Temp,
- N_2, O_2, CO_2, H_2O



Lithosphere – Earth's crust



The mass of the Earth ~ 6 x 10^{24} kg

Lithosphere - Chemistry

TABLE 12-2

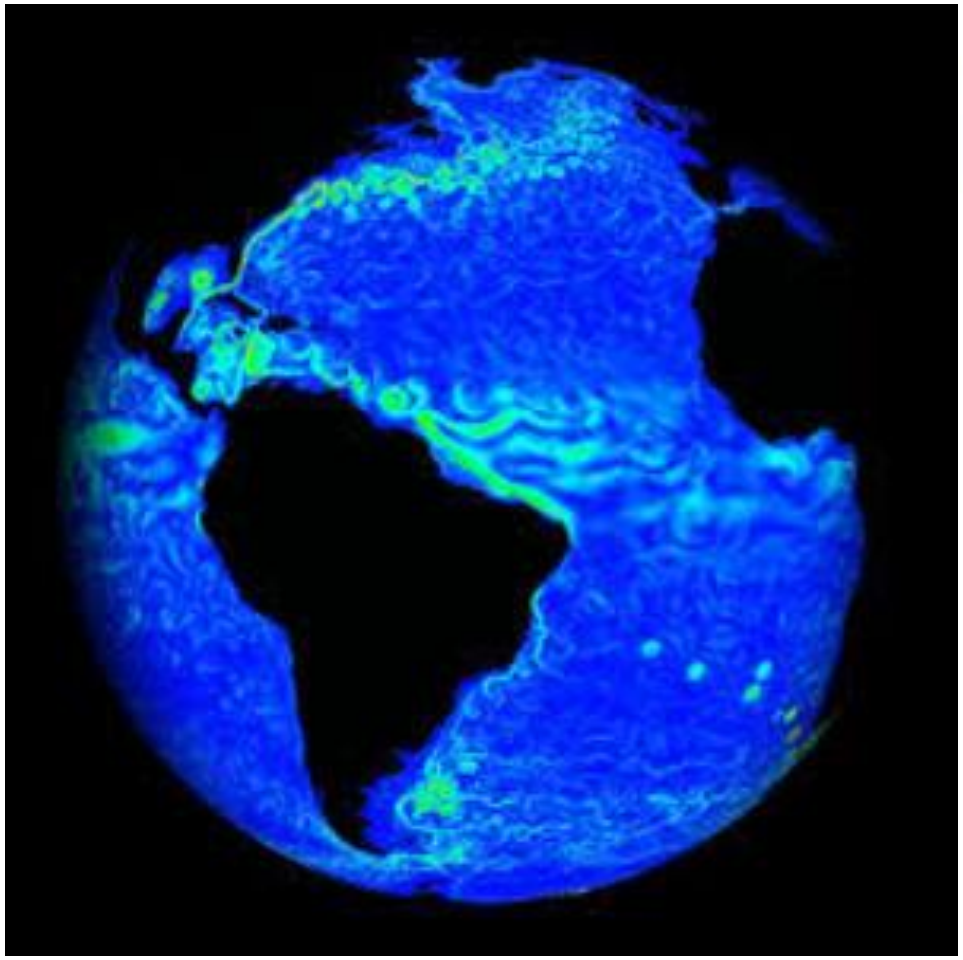
Relative Abundance of Some Elements in the Earth's Crust

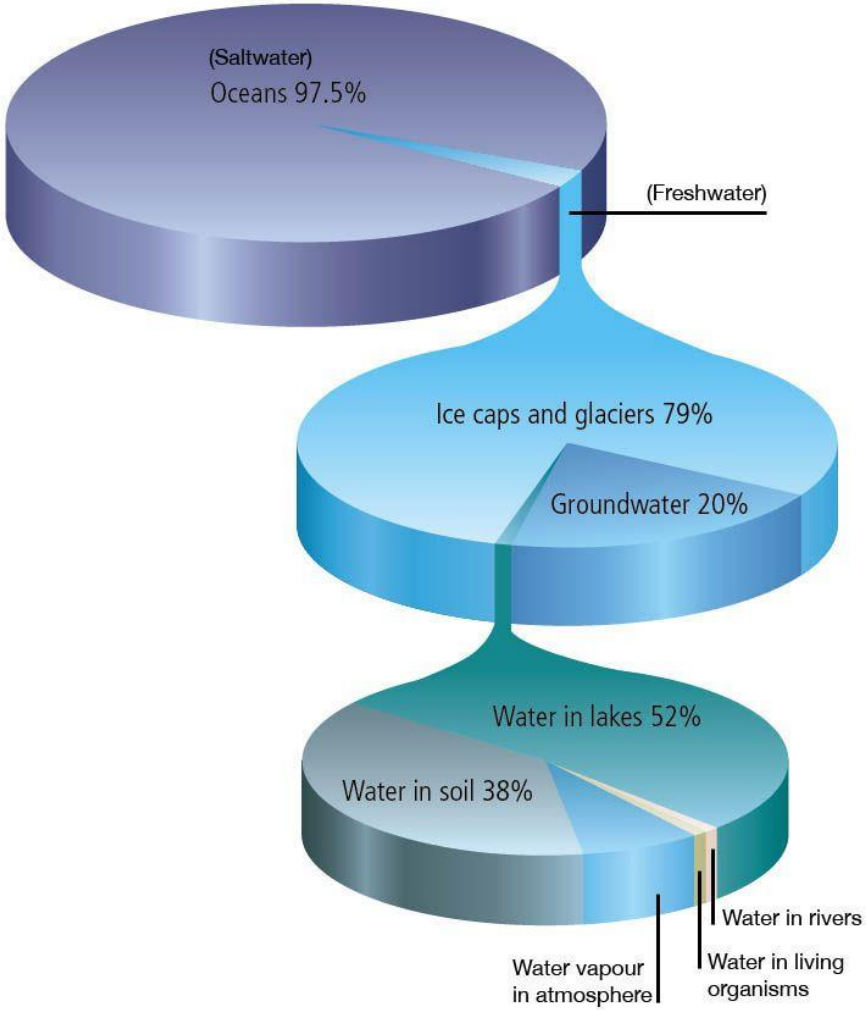
Element	Abundance (at. %)	Abundance (wt %)
Oxygen	63	47
Silicon	21	28
Aluminum	6.5	8
Iron	1.9	5
Calcium	1.9	3.6
Sodium	2.6	2.8
Potassium	1.4	2.6
Magnesium	1.8	2.1
Titanium		0.44
Hydrogen		0.14
Manganese		0.1
Phosphorus		0.1
Cu, Cr, Ni, Pb, Zn		10^{-2}–10^{-3} each
Mn, Sn, U, W		$\sim 10^{-4}$ each
Ag, Hg		$\sim 10^{-6}$ each
Au, Pt		$\sim 10^{-7}$ each

Most common rock-forming minerals

Mineral	Type	Formula
Olivine		$(Fe,Mg)_2SiO_4$
Quartz		SiO_2
Feldspar	Plagioclase feldspar	$NaAlSi_3O_8$ to $CaAl_2Si_2O_8$ (continuous series)
	Potassium feldspar	$KAlSi_3O_8$
Mica	Muscovite	$KAl_2(AlSi_3O_{10})(F, OH)_2$
	Lepidolite	$KLi_2Al(Al,Si)_3O_{10}(F, OH)_2$
	Staurolite	$(Fe,Mg,Zn)_2Al_9(Si,Al)_4O_{22}(OH)_2$
	Biotite	$K(Fe,Mg)_3AlSi_3O_{10}(OH)_2$
Pyroxene	Enstatite series	$(Mg,Fe)_2Si_2O_6$
	Augite	$Ca(Mg,Fe)Si_2O_6$
Amphibole	Hornblende (an inosilicate)	$(Ca,Na)_{2-3}(Mg,Fe,Al)_5[(Si,Al)_8O_{22}](OH)_2$
	Actinolite	$Ca_2(MgFe)_5Si_8O_{22}(OH)_2$
	Glaucophane	$Na_2(Mg_3Al_2)(Si_8O_{22}(OH)_2)$ or $Na_2(Mg,Fe)_3Al_2Si_8O_{22}(OH)_2$
Other common minerals:		
Magnetite		Fe_3O_4
Garnet		$(Ca,Mg,Fe^{2+})_3(Al,Fe^{3+})_2Si_3O_{12}$
Calcite		$CaCO_3$
Dolomite		$CaMg(CO_3)_2$

Hydrosphere - Water





71% of Earth constitute of H2O…

Only 0.3% of it is usable by humans !

Reason for the salinity of ocean water

TABLE 6.5. Major ions that define salinity in ocean water

Ion	M (mol/L)	ppm
Cl^-	5.6×10^{-1}	19,000–19,500
Na^+	4.8×10^{-1}	10,500–10,805
Mg^{2+}	5.4×10^{-2}	1,290–1,350
SO_4^{2-}	2.89×10^{-2}	2,688–2,700
Ca^{2+}	1.05×10^{-2}	401–410
K^+	1.05×10^{-2}	391
HCO_3^-	2.4×10^{-3}	142–146
Br^-	8.6×10^{-4}	67
BO_3^{3-}	4.1×10^{-4}	24
Sr^{2+}	9.51×10^{-5}	8
F^-	7.5×10^{-5}	1.4

Molarity = mol/L

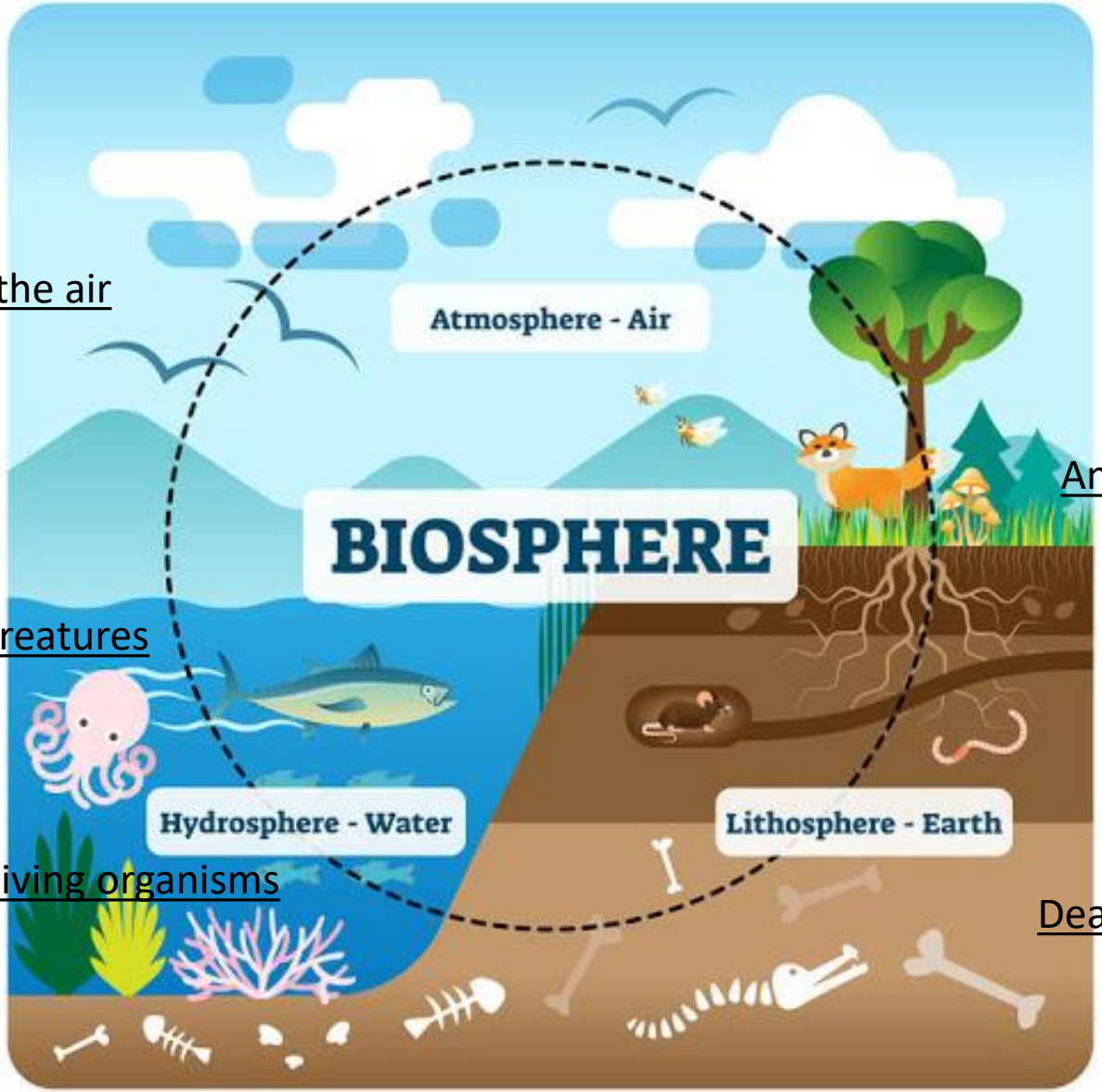
ppm = parts per million (mg/L)

Classification of water based on salinity !

Water type	Electrical conductivity, dS m^{-1}	Salt concentration, mg L^{-1}	Examples
Non-saline	<0.7	<500	Drinking, irrigation, and surface water
Slightly saline	0.7–2	500–1,500	Surface and irrigation water, and ground water
Moderately saline	2–10	1,500–7,000	Runoff and groundwater
Highly saline	10–25	7,000–15,000	Saline groundwater and runoff
Exceptionally saline	25–45	15,000–35,000	Very saline groundwater and seawater
Brine	>45	>45,000	Saline inland lakes and seas

***Rain water's TDS (total dissolved solids) = < 20mg/L**

Biosphere - Life



Birds in the air

Animals, Vegetation

Sea creatures

Marine living organisms

Dead plants and animals

❖**Levels of the organization of matter in nature.**

❖**Ecology focuses on the top five of these levels.**

Biosphere	Parts of the earth's air, water, and soil where life is found
Ecosystem	A community of different species interacting with one another and with their nonliving environment of matter and energy
Community	Populations of different species living in a particular place, and potentially interacting with each other
Population	A group of individuals of the same species living in a particular place
Organism	An individual living being
Cell	The fundamental structural and functional unit of life
Molecule	Chemical combination of two or more atoms of the same or different elements
Atom	Smallest unit of a chemical element that exhibits its chemical properties

Ecology

Definitions:

Ecology is the study of interactions among organisms or group of organisms with their environment. ***Ecosystem** is a community of different species.

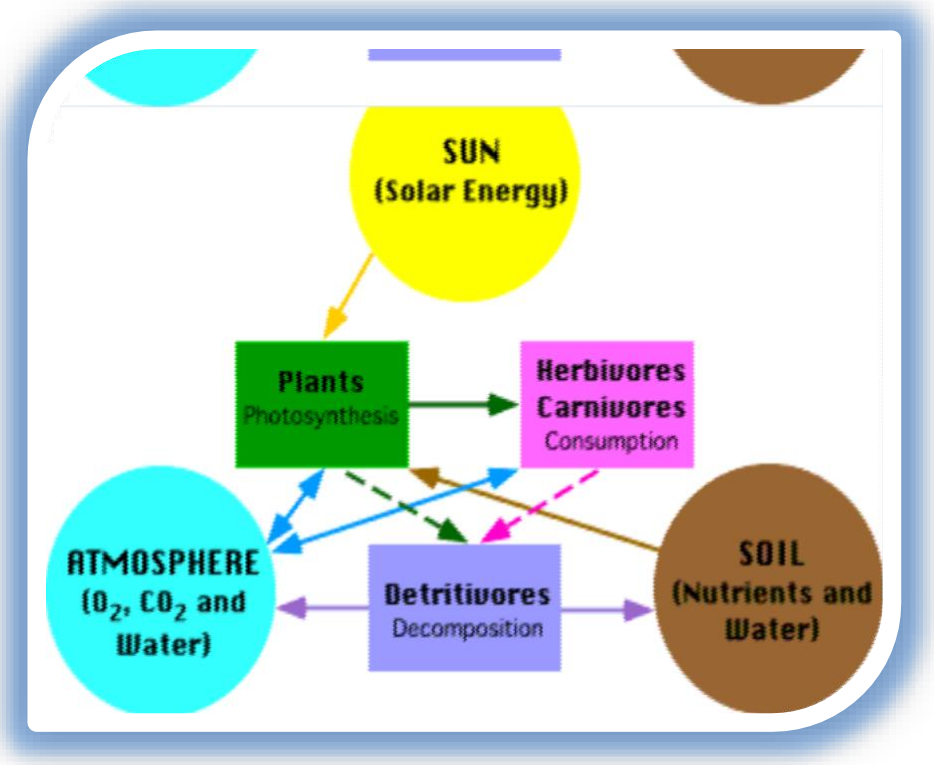
The environment consists of both **biotic components** (living organisms) and **abiotic components** (non-living organisms).

Habitat refers to the physical and chemical factors of the place where the organisms live. A species's habitat is those places where the species can find food, shelter, protection and mates for reproduction. It is characterized by both physical and biological features.

Ecosystem

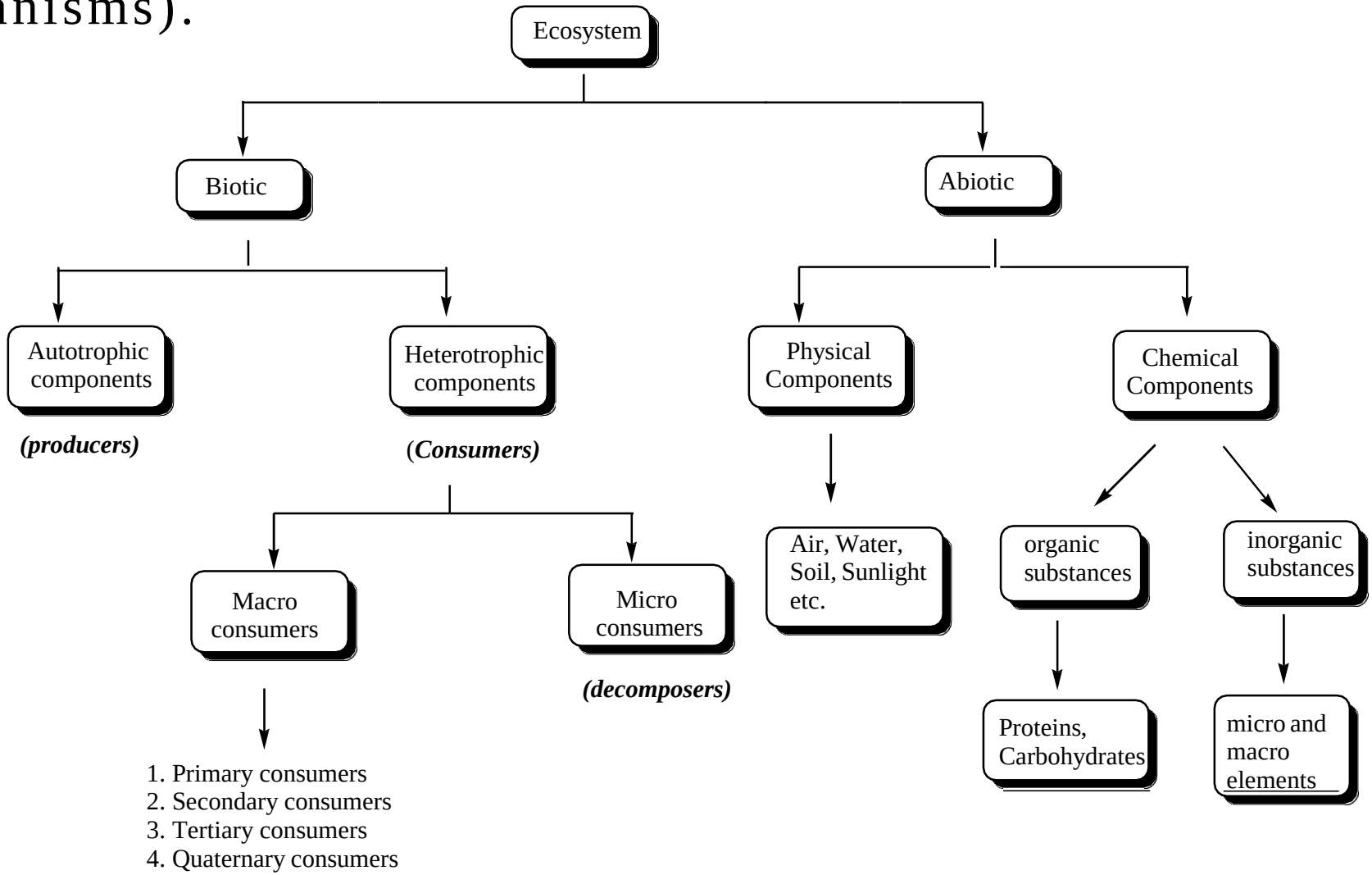
Definition:

- ♣ The term ecosystem was first coined by **A.G. Tansley 1935**.
- ♣ **'*eco*' means environment** and **'*system*' implies a complex of co-ordinated units.**
- ♣ An ecosystem is a community of different species interacting with one another and with their non-living environment exchanging energy and matter.



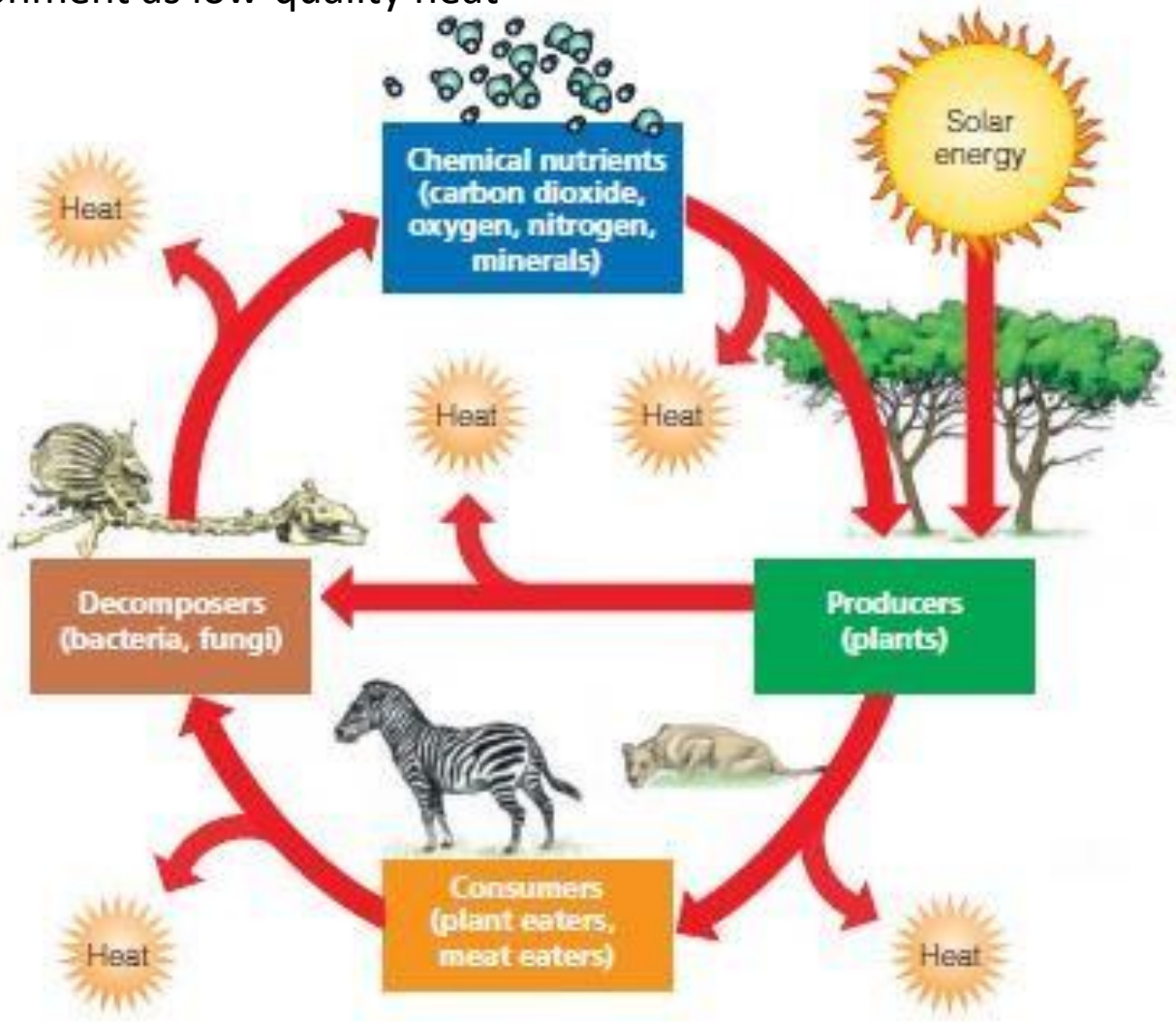
Structure of Ecosystem

The environment consists of both **biotic components** (living organisms) and **abiotic components** (non-living organisms).



Natural Capital

- The main **structural components** of an ecosystem (energy, chemicals, and organisms).
- Nutrient cycling and the flow of energy—first from the sun, then through organisms, and finally into the environment as low-quality heat



Energy flow in the Ecosystem

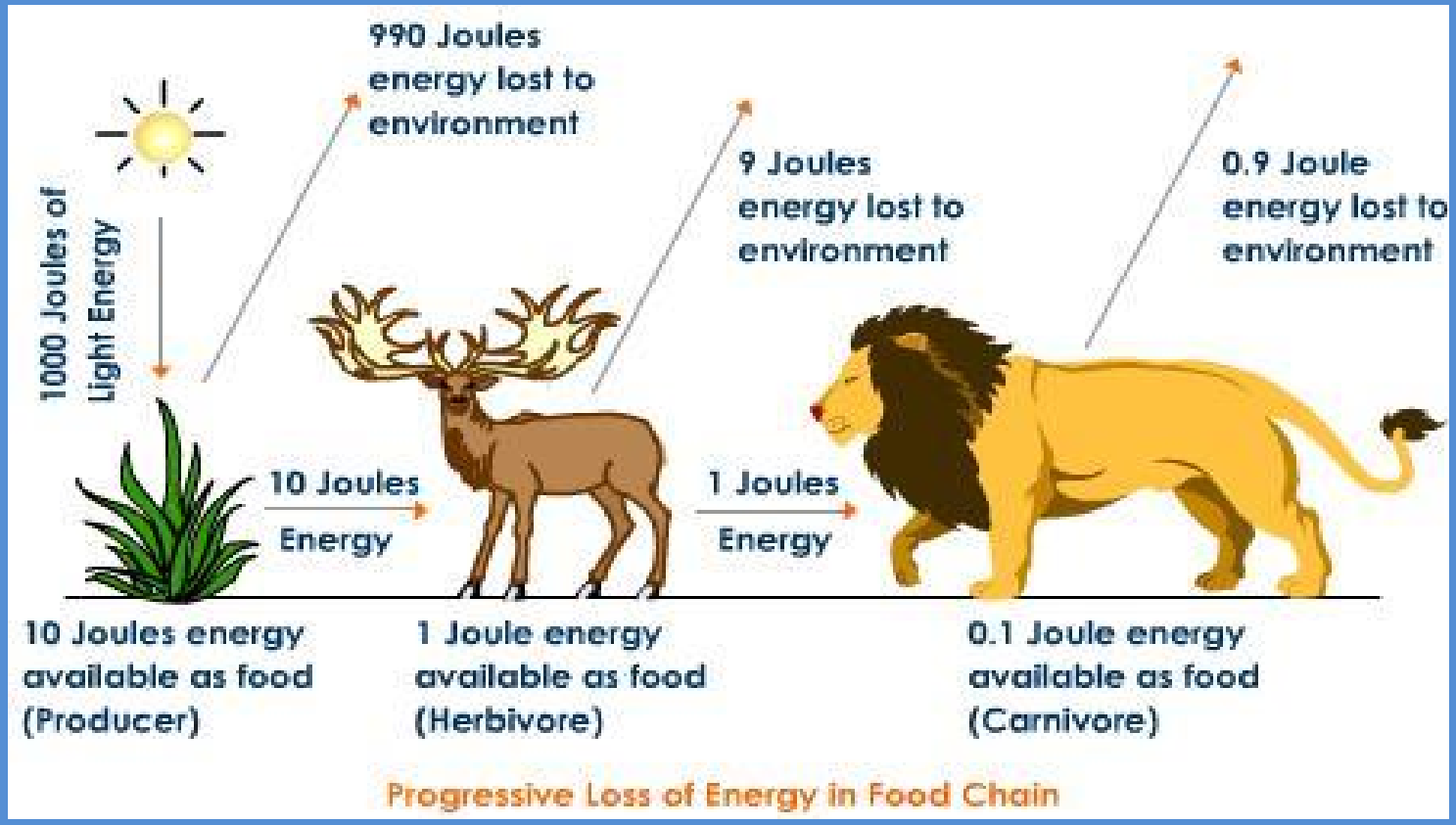
- **Energy is needed for every biological activity.**

- **Solar energy is transformed into chemical energy by a process of photosynthesis. This energy is stored in plant tissue, and then transformed in to mechanical and heat form during metabolic activities.**

- **In the biological world, the energy flows from sun to plants and then to all heterotrophic organisms like micro-organisms, animals, and man i.e. from producers to consumers. 1% of the total sunlight falling on the green plants is utilized in photosynthesis.**

- **This is sufficient to maintain all life on this earth. There is no 100% flow of energy from producers to consumers. Some is always lost to environment. Because of this, energy cannot be recycled in an ecosystem *'it can only flow one way'*.**

Energy balance



The flow of energy follows two laws of thermodynamics

Ist law of thermodynamics:

The law states that energy can neither be created nor be destroyed but it can be transformed from one form to another. Similarly, solar energy utilized by green plants (producers) in photosynthesis converted into biochemical energy of plants and later into that of consumers..

IInd law of thermodynamics:

The law states that energy transformation involves degradation or dissipation of energy from a concentrated to a dispersed form. We have seen dissipation of energy occurs at every trophic level. There is loss of 90% energy, only 10% is transferred from one trophic level to the other.

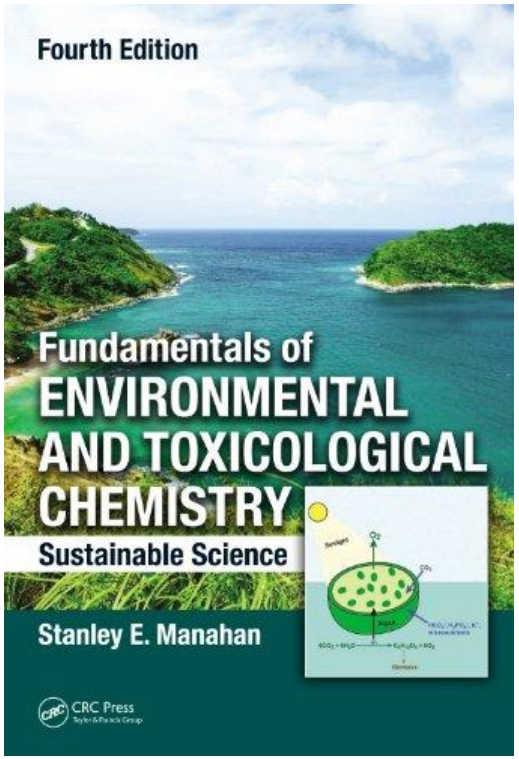
Home assignment

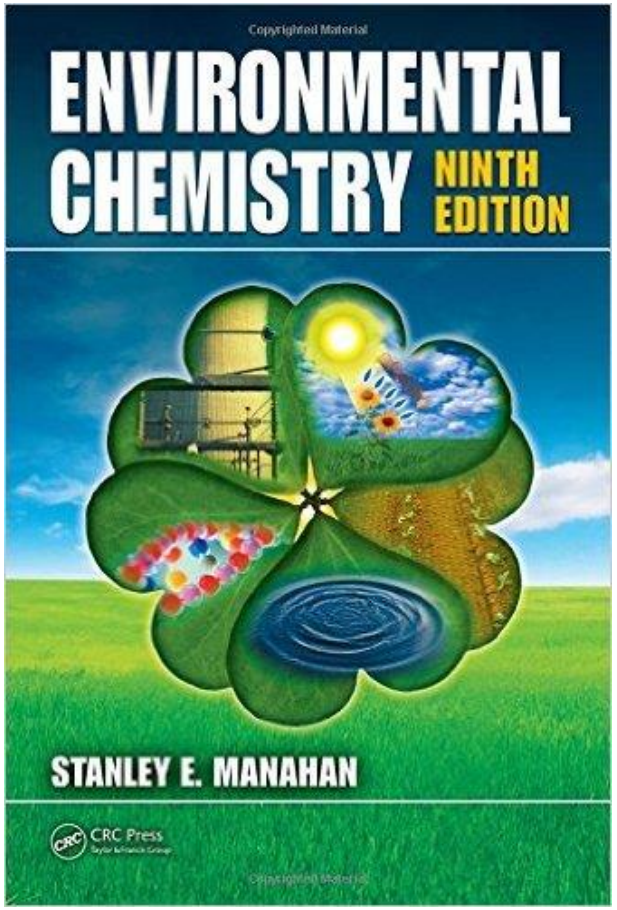
Let’s plant at least a tree during this course work….

Environmental Chemistry Theory

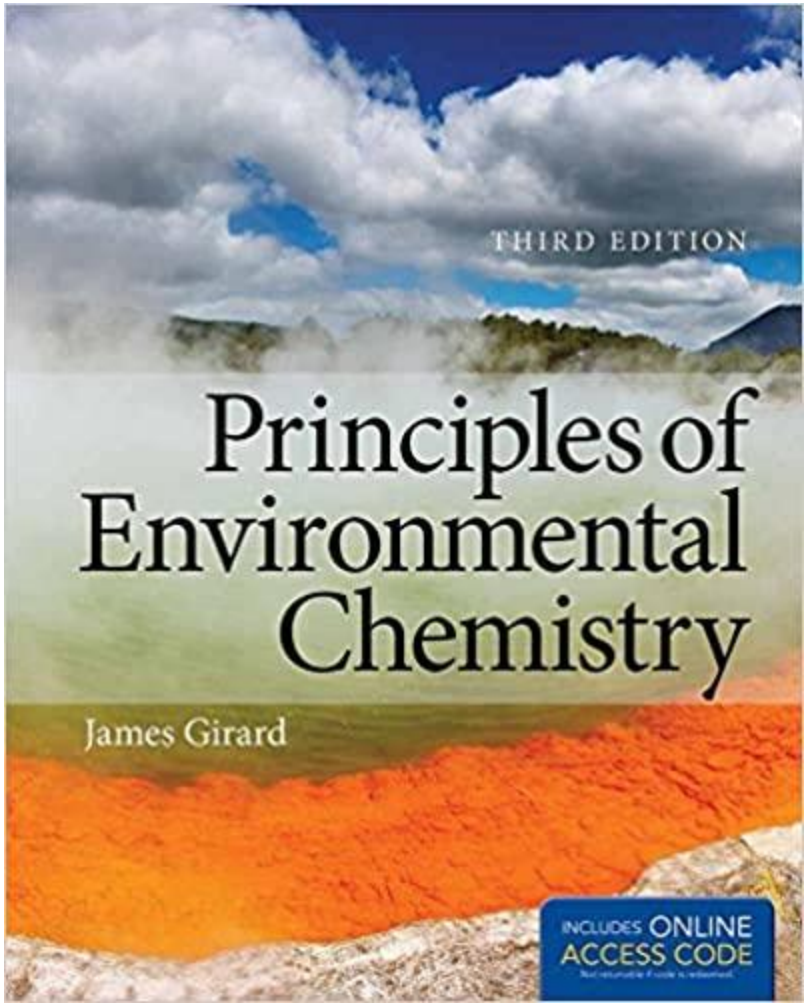
Reference books

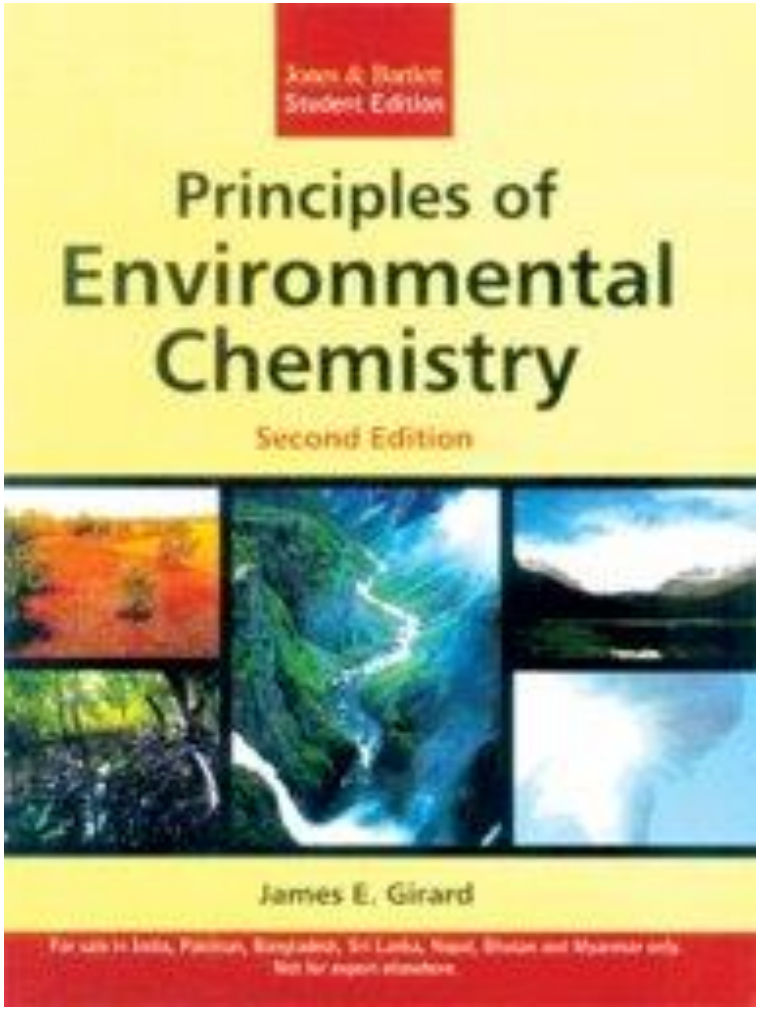
Fundamentals of Environmental and Toxicological Chemistry: Sustainable Science, Fourth Edition Kindle Edition





Principles of Environmental Chemistry By James E. Girard





Chemistry of the Environment, Second Edition by R. A. Bailey, H. M. Clark, J. P. Ferris, S. Krause, R. L. Strong