Atmospheric Gases

- ✓ Nitrogen, oxygen, argon, water vapor, carbon dioxide, and most other gases are invisible.
- ✓ Clouds are not gas, but condensed vapor in the form of liquid droplets.
- ✓ Ground based smog, which is visible, contains reactants of nitrogen and ozone.
- ✓ Composition of Atmosphere
  - Nitrogen – 78%
  - Oxygen – 21%
  - Carbon Dioxide – 0.038%
  - Other gases make up the rest
- ✓ % of CO_2 is very low but its very important for Photosynthesis
- ✓ CO_2 also helps in the heat balance

Ozone – is the primary ingredient of smog

Atmospheric Gases

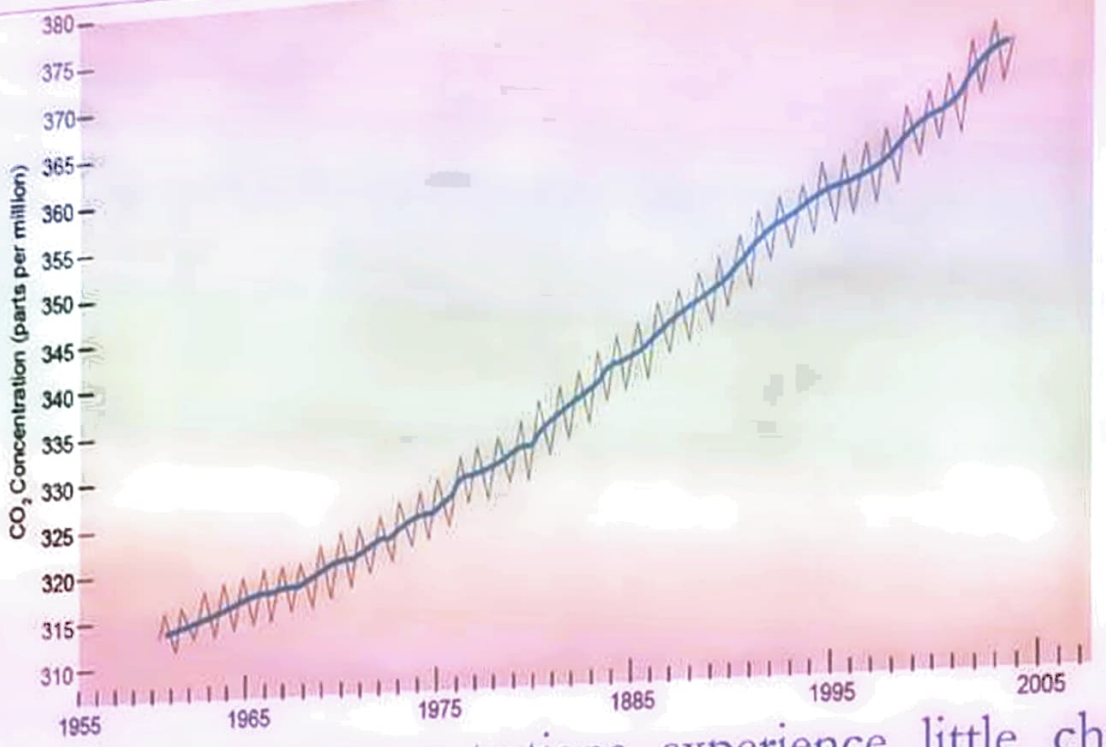
- ✓ Water vapor also present in the atmosphere and in the range of 0.1 % - 5 % (based on temperature, precipitation, rate of evaporation)

- ✓ On average 3 % of water vapor is present in air
  - 3rd most abundant constituent of air

- ✓ At ambient condition
  - <1 % of water vapor at 0 °C (even at freezing point water gets evaporated)
  - ~5 % of water vapor at 35 °C

- ✓ The basic composition of air always same (if we exclude the role of pollution). This is due to constant circulation of air in troposphere

Variable & Increasing Gases



- ✓ Nitrogen and oxygen concentrations experience little change, but carbon dioxide, methane, nitrous oxides, and chlorofluorocarbons are greenhouse gases experiencing discernible increases in concentration. CO_2 has risen more than 18% since 1958.
- ✓ Fossil fuels are the biggest problem!

Aerosols & Pollutants

- ✓ Human and natural activities displace tiny soil, salt, and ash particles as suspended aerosols, as well as sulfur and nitrogen oxides, and hydrocarbons as pollutants.

Aerosols & Pollutants

✓ **Aerosols** are solid or liquid particles <100 μm in diameter

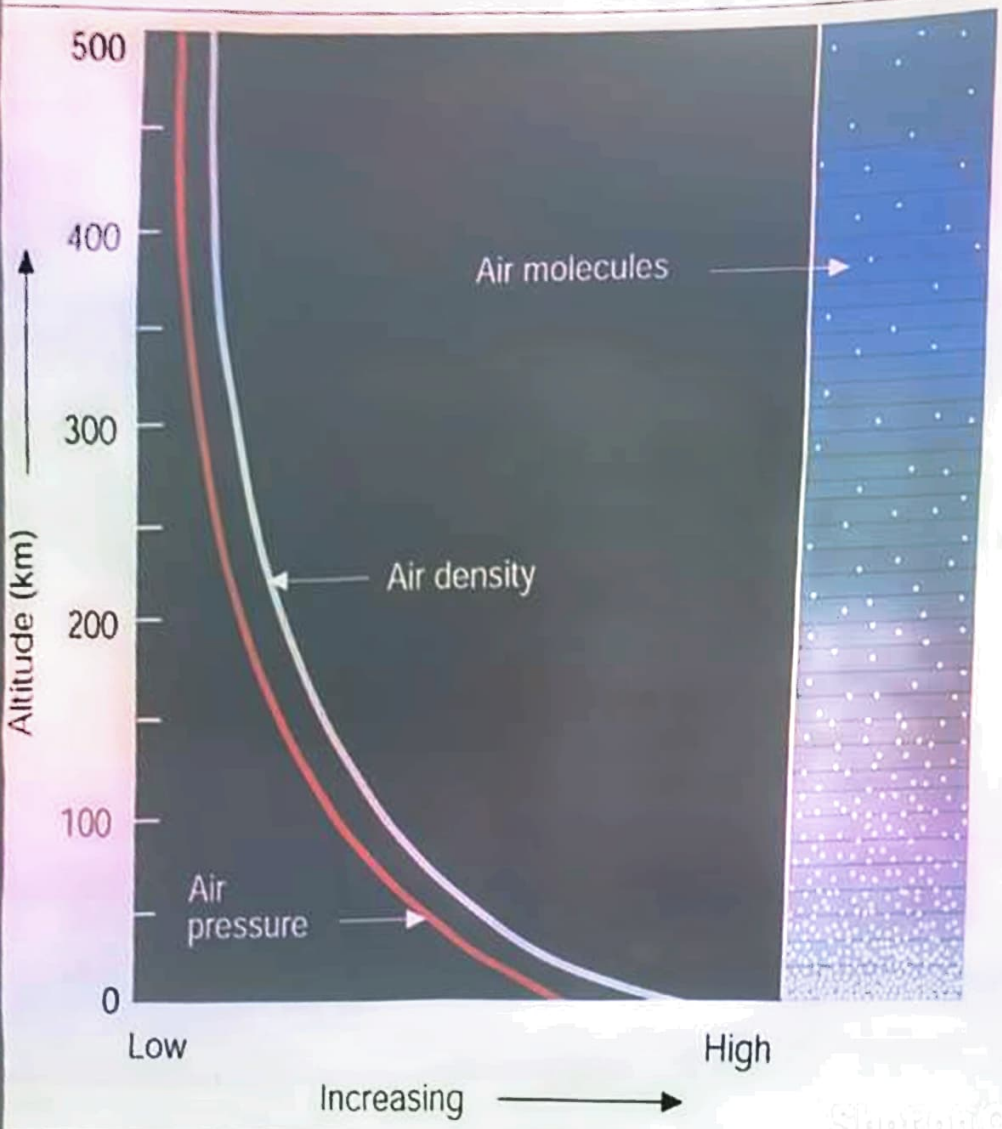
✓ Pollutant particles in the 0.001 to 10 μm range are commonly suspended in the air near pollution areas

- Carbon black, silver iodide, combustion nuclei, and sea-salt nuclei
- **Biological origin particles:** viruses, bacteria, bacterial spores, fungal spores, and pollen

Table 10.1. Important Terms Describing Atmospheric Particles

Term	Meaning
Aerosol	Colloidal-sized atmospheric particle
Condensation aerosol	Formed by condensation of vapors or reactions of gases
Dispersion aerosol	Formed by grinding of solids, atomization of liquids, or dispersion of dusts
Fog	Term denoting high level of water droplets
Haze	Denotes decreased visibility due to the presence of particles
Mists	Liquid particles
Smoke	Particles formed by incomplete combustion of fuel

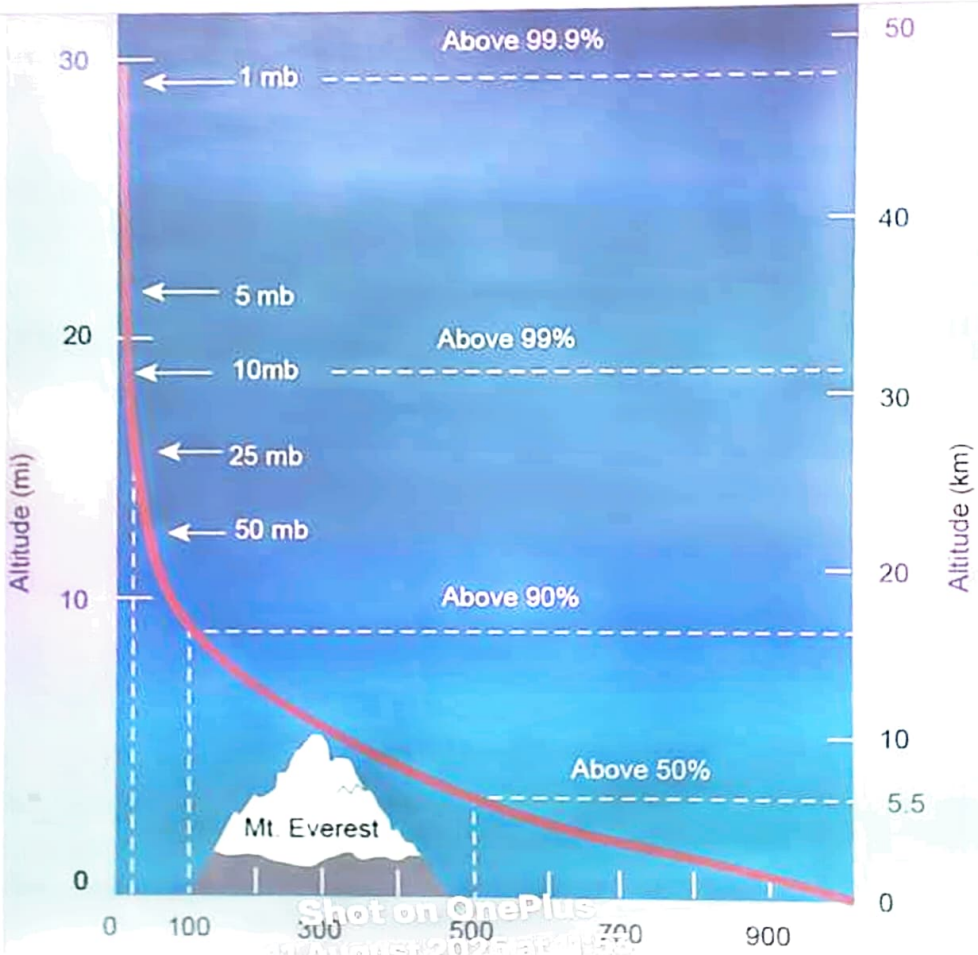
Pressure & Density



- ✓ The amount of force exerted Over an area of surface is called Air pressure!
- ✓ Air Density is The number of air Molecules in a given Space (volume)
- ✓ Gravity pulls gases toward earth's surface, and the whole column of gases weighs
  - o 14.7 psi at sea level
  - o 1013.25 mbar
  - o 1,01,325 Pa
  - o 1 atm
  - o 760 torr

Vertical Pressure Profile

- ✓ Atmospheric pressure decreases rapidly with height.
- ✓ Climbing to an altitude of only 5.5 km where the pressure is 500 mb (milli bar), would put you above one-half of the atmosphere's molecules.



Ecosystems

- ✓ Environment has been divided into small sections or functional groups for easy studies – Ecosystems

- ✓ An ecosystem is a community of living organisms in conjunction with the non-living components of their environment, interacting as a system
  - Forest
  - Desert
  - Grassland
  - Marsh
  - Pond
  - Field

Producers and Consumers

- ✓ Ecosystems are sustained by the energy that flows through them

- ✓ **Producers**: Produce their own food
  - Plants
  - Cyanobacteria (blue-green algae)
- ✓ **Consumers**: Consume plants or other organisms to obtain the nutrients and energy they need
  - Divided into four main groups
    - **Herbivores**: feed directly on producers – deer, cows, mice, and grasshoppers
    - **Carnivores**: eat other animals – spiders, frogs, hawks, and all cats (lions, tigers and domestic cats)
    - **Omnivores**: feed on both plants and animals – Rats, Raccoons, Bears, and most humans
    - **Decomposers**: feed on detritus – a freshly dead or partly decomposed remains of plants and animals – Bacteria, Fungi, Earthworms, many insects

Flow of energy through ecosystems

✓ **Energy**: The ability to do work or bring about change

(or) Energy is the capacity to make something happen

- Kinetic energy
- Potential energy

✓ Energy exits in many forms including Light, Heat, Electrical energy, Nuclear energy and Chemical energy

✓ **Energy Transformations:**

- Stars convert nuclear energy into light and heat
- Plants convert light energy into chemical energy
- Animals convert chemical energy into energy of motion

but none of them are 100% efficient

Flow of energy through ecosystems

- ✓ First law of thermodynamics
  - Energy can be neither created nor destroyed. It can only be transformed from one form to another

- ✓ Second law of thermodynamics
  - when energy changes from one form to another form, or matter moves freely, entropy (disorder) in a closed system increases.
  - During energy is transferred or transformed, more and more of it is wasted.

- ✓ Most of the inefficient energy conversions lead to release heat
  - Gasoline engine is only 10% efficient

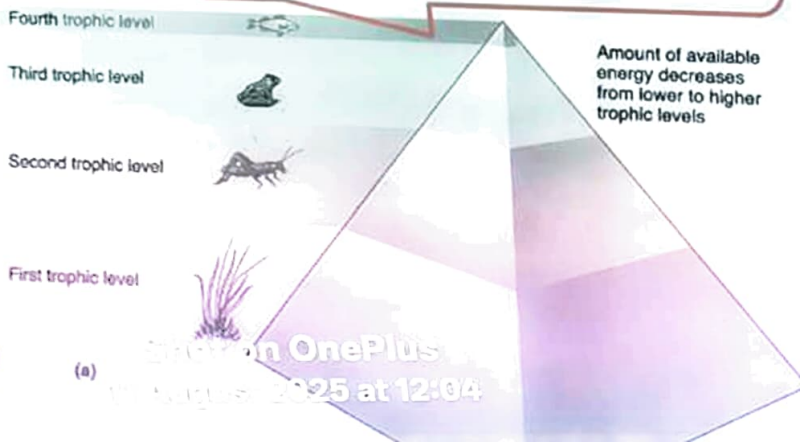
Food chains and Tropic levels

- ✓ A **food chain** is a sequence that shows how energy and nutrients flow through an ecosystem from one organism to another.
- ✓ Green plants are the only organism that can take energy from the sun and use the process of photosynthesis to store some of that energy in chemicals bonds in the form of sugars, starches and other large molecules.

Food chains and Tropic levels

- ✓ A **food chain** is a sequence that shows how energy and nutrients flow through an ecosystem from one organism to another.
- ✓ Green plants are the only organism that can take energy from the sun and use the process of photosynthesis to store some of that energy in chemicals bonds in the form of sugars, starches and other large molecules.
- ✓ Ecosystem has innumerable feeding pathways or food chains through which energy flows.
  - Grasshoppers eat green leaves
  - Frogs eat Grasshoppers
  - Fish eats Frogs

A **trophic level** refers to each step or position in a food chain



Grass → Grasshopper → Frog → Snake → Eagle

Nutrient cycles

- ✓ All the living being to exist requires constant supply of both **Energy** and **Nutrients**
- ✓ Energy flows endlessly from producers to consumers
- ✓ Light energy from Sun comes as the waste energy that can't be reused by Sun itself
- ✓ In contrary, Nutrients are continually recycled and reused.
- ✓ Living beings die, their tissues are broken down and vital chemicals are returned to soil, water and atmosphere

Nutrient cycles

✓ Tissues of living organism shows more than 95% of the mass of the tissues is made from just 6 of Earth's 92 naturally occurring elements

- Carbon
- Hydrogen
- Oxygen
- Nitrogen
- Sulfur
- Phosphorous

Also Building blocks for the manufacture of Carbohydrates, Proteins and Fats

Plants composed of Carbohydrates & Animals composed of Proteins primarily

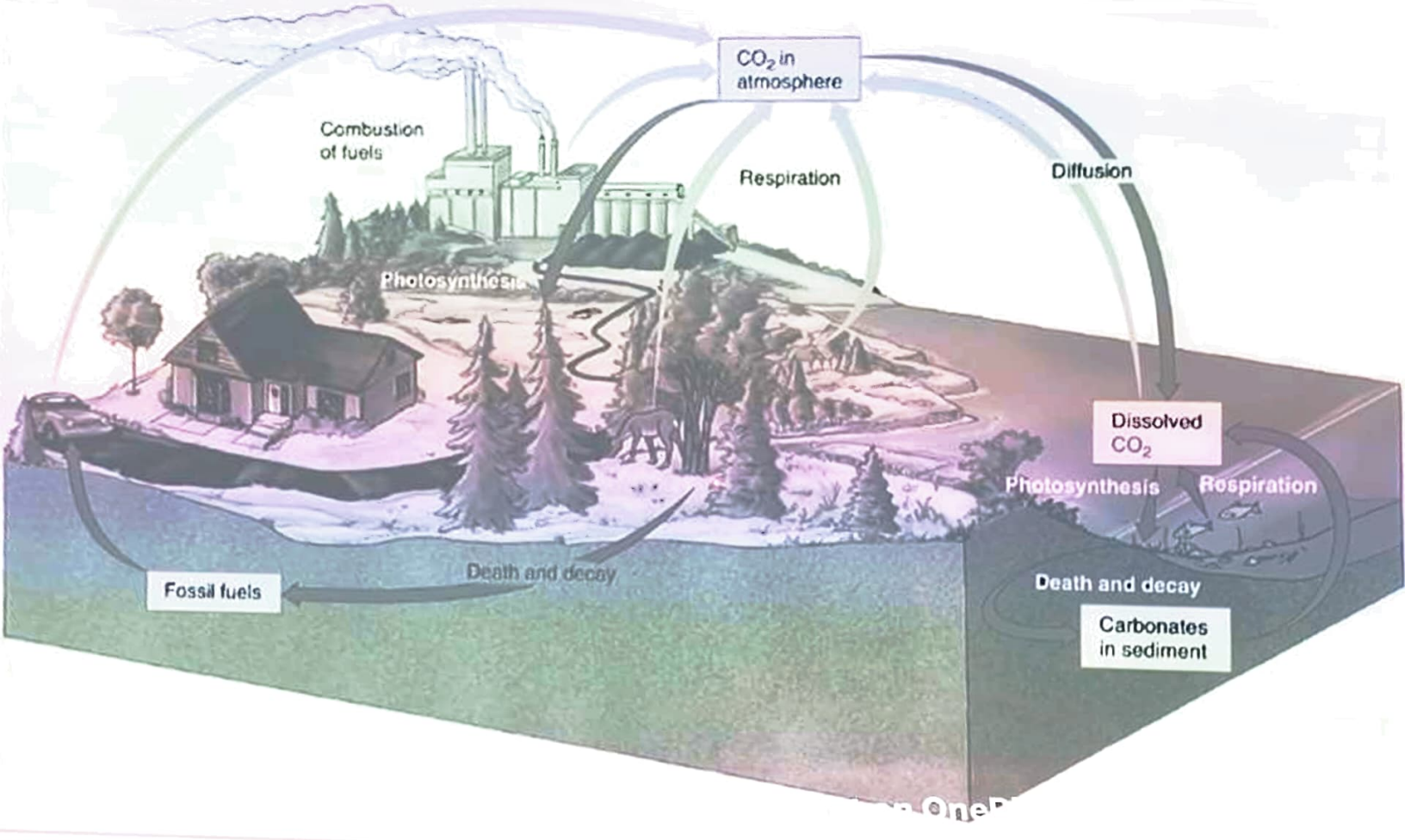
✓ Other main elements for rest 5% are

- Iron (Fe) – Mostly in Hemoglobin
- Magnesium (Mg) – Mostly Chlorophyll
- Calcium (Ca) – Bones and Cartilage

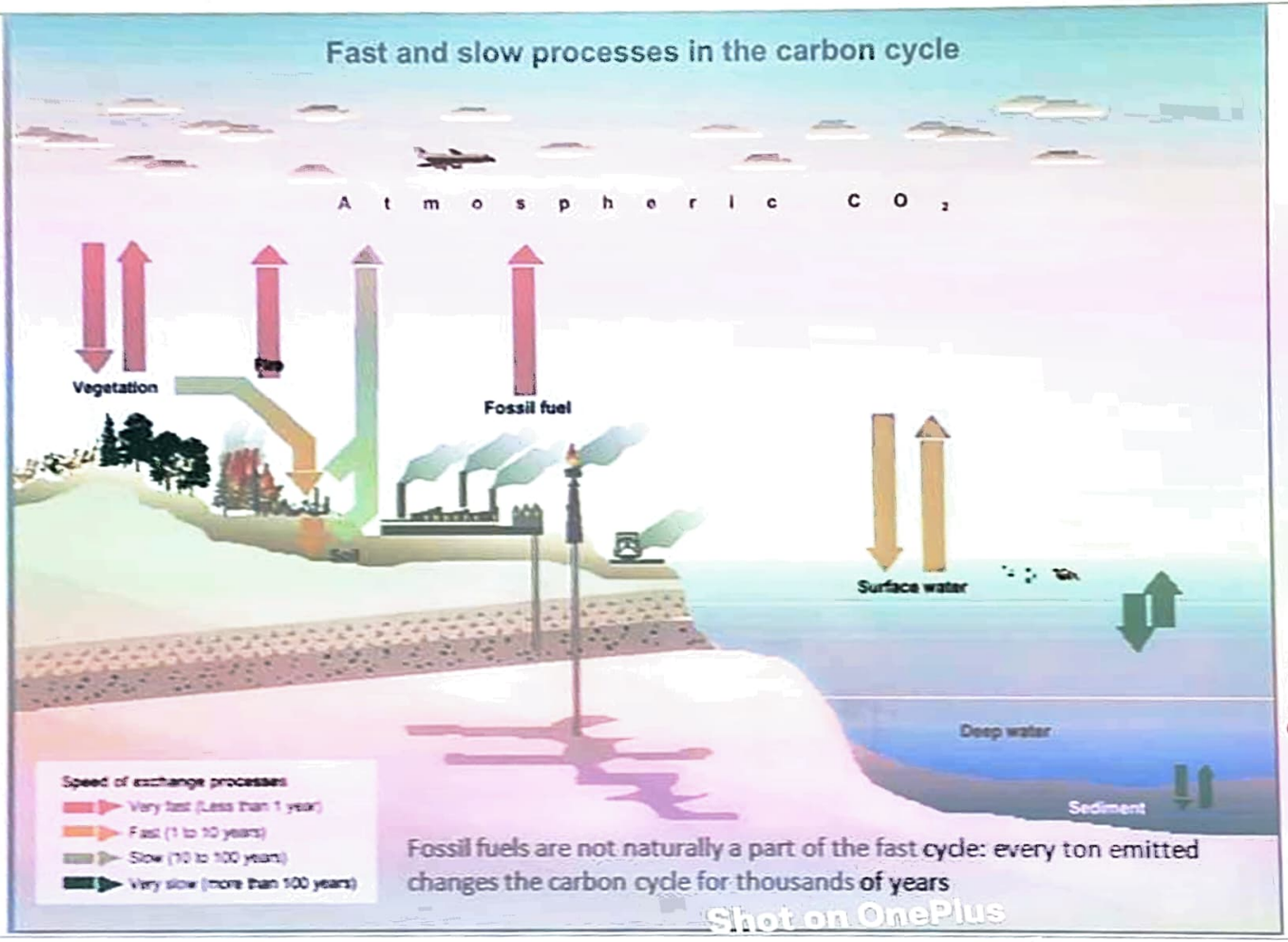
✓ Other elements (trace quantities): 16 elements, like Cu, Zn, Na, K

✓ All these elements are flowed through Trophic levels

Carbon Cycle



Carbon Cycle



Carbon Pools

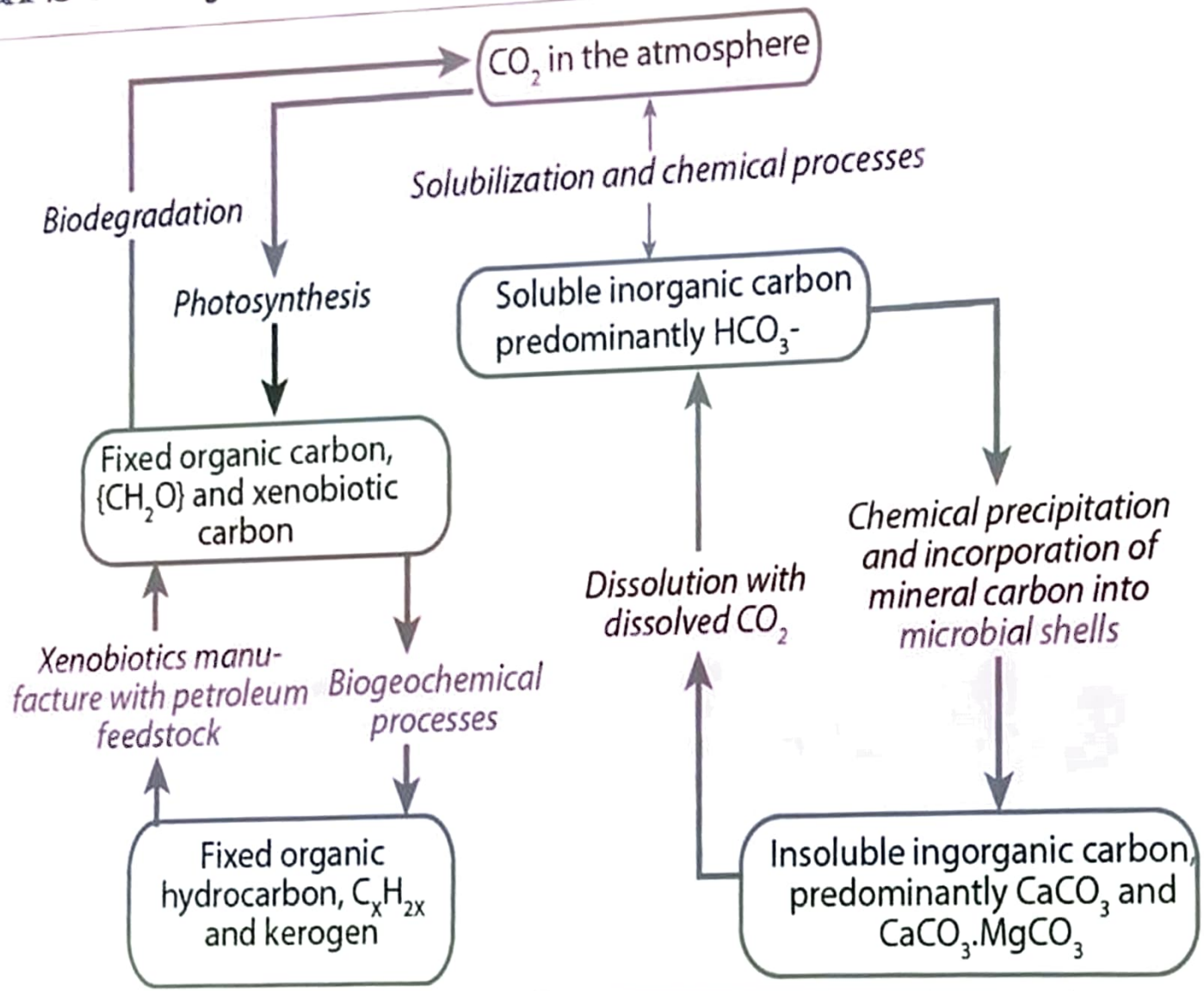
- ✓ Carbon is stored on our planet in the following major pools:
  - as organic molecules in living and dead organisms found in the biosphere;
  - as the gas carbon dioxide in the atmosphere;
  - as organic matter in soils;
  - in the lithosphere as fossil fuels and sedimentary rock deposits such as limestone ($CaCO_3$) , dolomite ($CaMg(CO_3)_2$) and chalk;
  - in the oceans as dissolved atmospheric carbon dioxide and as $CaCO_3$ shells in marine organisms.

Pool	Amount in Billions of Metric Tons
Atmosphere	578 (as of 1700) - 766 (as of 1999)
Terrestrial Plants	540 to 610
Soil Organic matter	1500 to 1600
Ocean	38,000 to 40,000
Fossil Fuel Deposits	4000
Marine Sediments and Sedimentary Rocks	66,000,000 to 100,000,000

Carbon Cycle

- ✓ Microorganisms are strongly involved in the carbon cycle, mediating crucial biochemical reactions.
- ✓ Photosynthetic algae are the predominant carbon-fixing organisms in water; as they consume CO_2, the pH of the water is raised enabling precipitation of $CaCO_3$ and $CaCO_3$, $MgCO_3$.
- ✓ Organic carbon fixed by microorganisms is transformed by biogeochemical processes to fossil petroleum, kerosene, coal, and lignite.
- ✓ Microorganisms degrade organic carbon from biomass, petroleum, and xenobiotic sources, ultimately returning it to the atmosphere as CO_2.

Carbon Cycle



Carbon Cycle

- ✓ Photosynthesis in which algae, higher plants, and photosynthetic bacteria use light energy to fix inorganic carbon in a high-energy organic form

$$\text{Solar energy} + \underset{\text{carbon dioxide}}{6\,CO_2} + \underset{\text{water}}{6\,H_2O} \xrightarrow{\text{chlorophyll}} \underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6\,O_2}$$

- ✓ Respiration in which organic matter is oxidized in the presence of molecular O_2 (aerobic respiration) or anaerobic respiration, which uses oxidants other than O_2, such as NO_3^- or SO_4^{2-}

$$C_6H_{12}O_6 + O_2 \rightarrow 6\,CO_2 + 6\,H_2O + \text{energy}$$

- ✓ Degradation of biomass by bacteria and fungi.
  - o Biodegradation of dead organic matter leads in the accumulation of excess waste residue and converts organic carbon, nitrogen, sulfur, and phosphorus to simple organic forms that can be utilized by plants as fertilizer.

Carbon Cycle

- ✓ Biodegradation of organic matter occurs in treatment of municipal wastewater by reactions represented in a general sense by,

$$\{CH_2O\} + O_2(g) \rightarrow CO_2 + H_2O + \text{biomass}$$

- ✓ Methane production by methane-forming bacteria, such as **Methanobacterium**, in anoxic (oxygen-less) sediments, plays a key role in local and global carbon cycles as the final step in the anaerobic decomposition of organic matter.
- ✓ Source of about 80% of the methane entering the atmosphere.

$$2\{CH_2O\} \rightarrow CH_4 + CO_2$$

- ✓ Microbial methane production is a fermentation reaction, defined as an oxidation-reduction process in which both the oxidizing agent and reducing agent are organic substances.