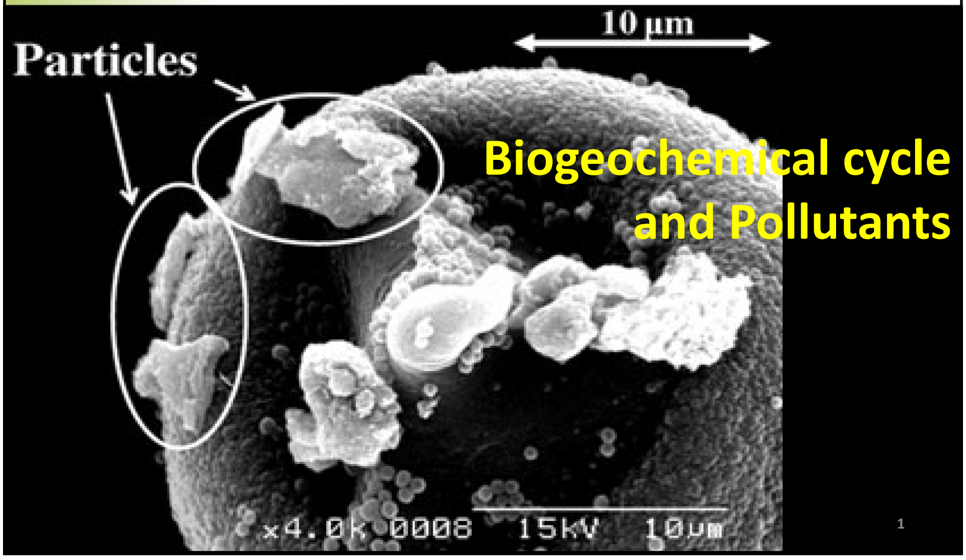
Laurea / B.A.
in Global Governance



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Dionea muscipula

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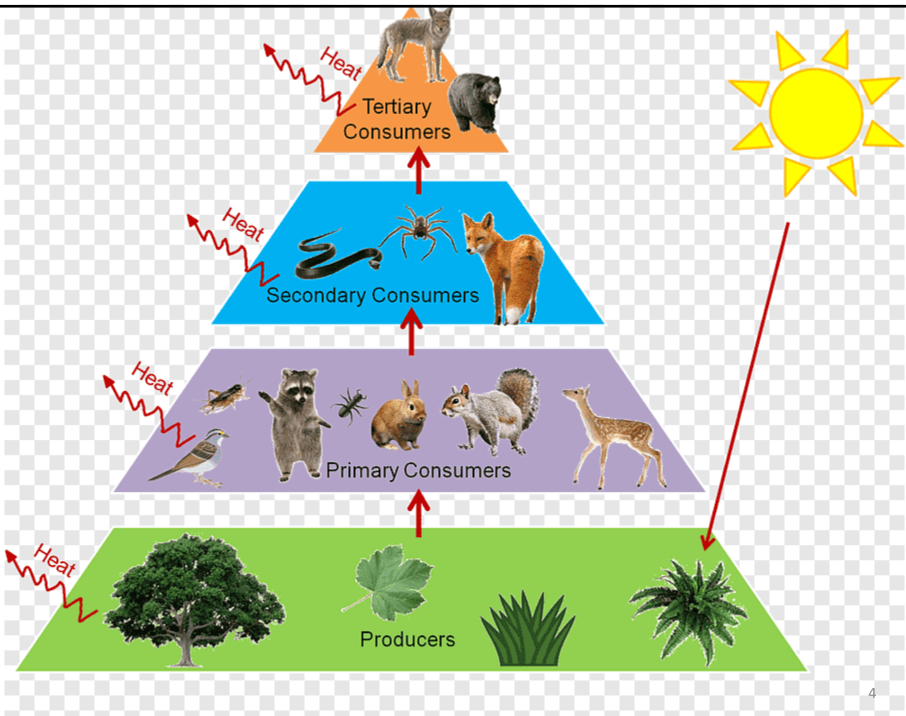

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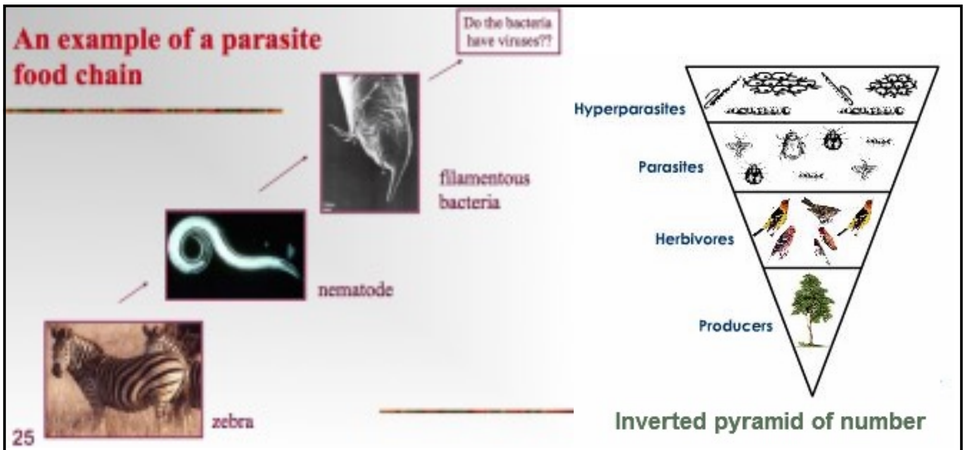
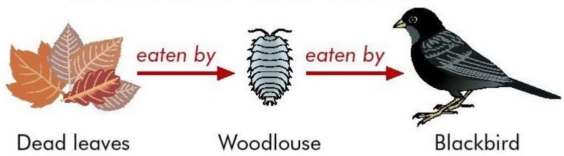


Detritus Food Chain



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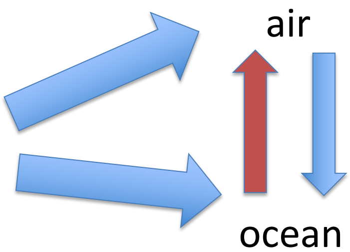
Biogeochemical cycles



- Gaseous — Nitrogen, Oxigen, Carbon, Water
- Sedimentary → Earth' s crust — Iron, Calcium, Phosphorus, Oxigen, Sulphur

SOLUTION AND ROCK PHASE

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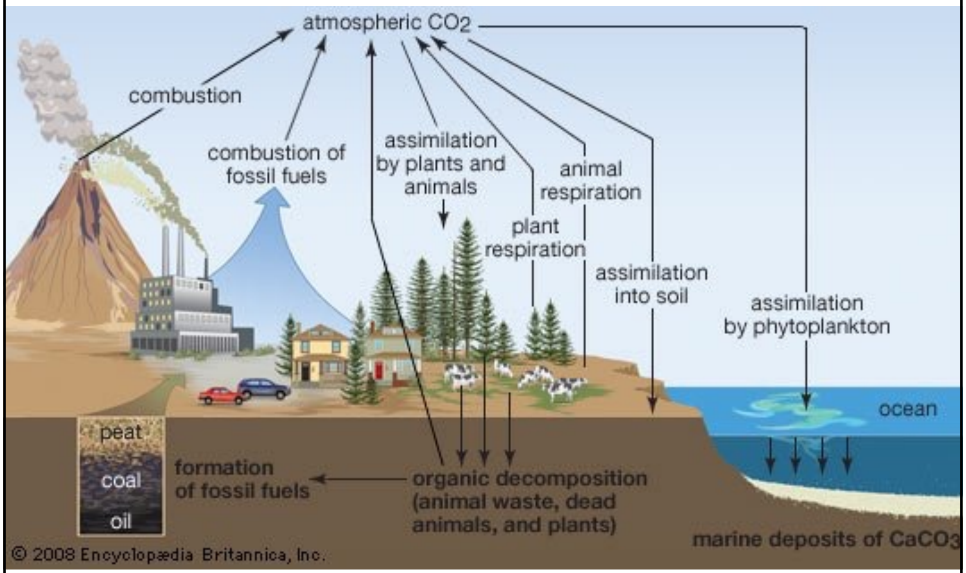
Carbon cycle



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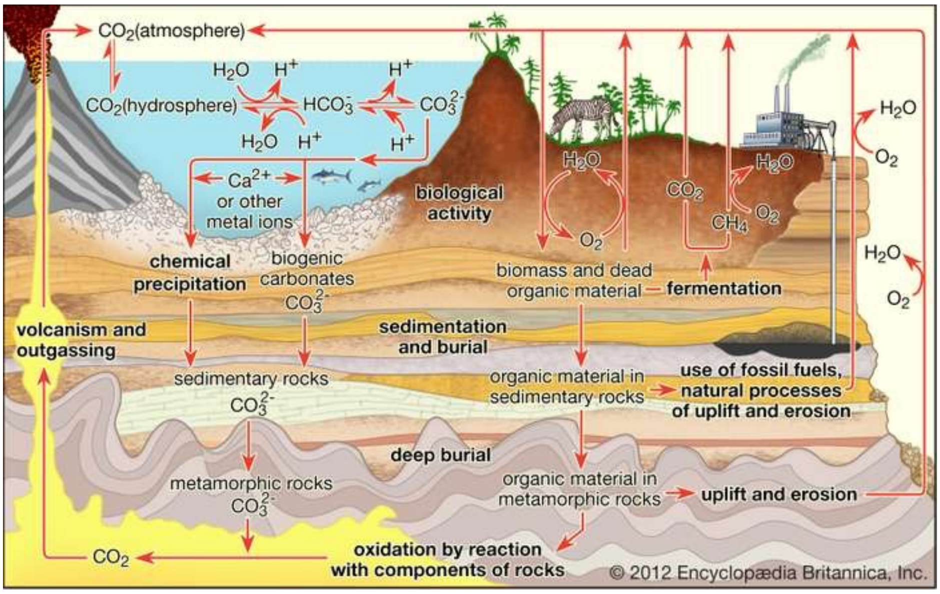

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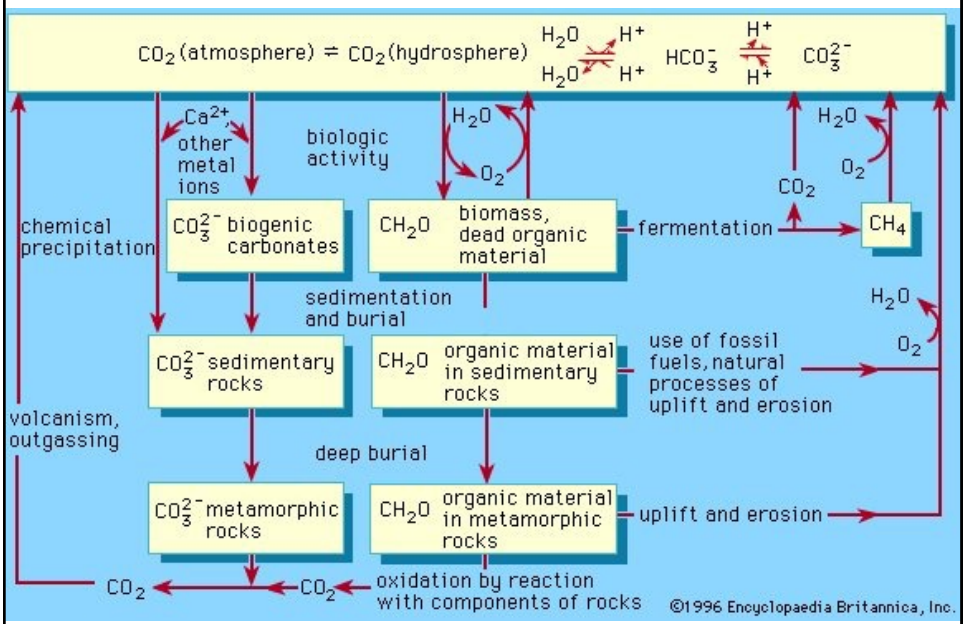

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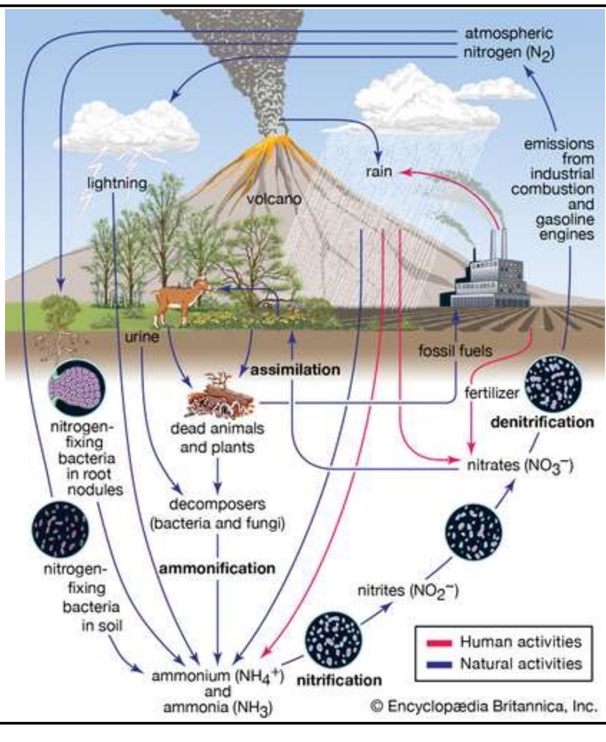

Nitrogen cycle

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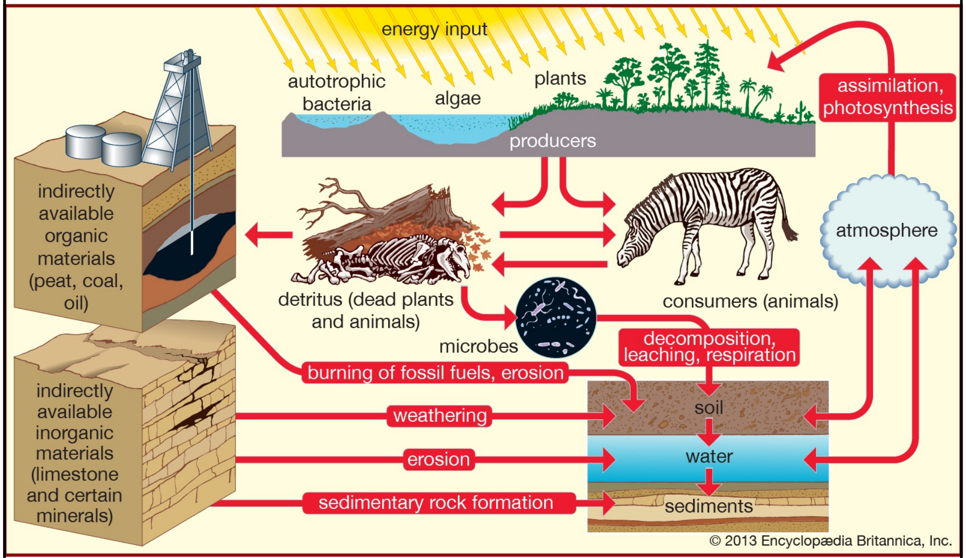
energy input
autotrophic bacteria
algae
plants
producers
assimilation, photosynthesis
indirectly available organic materials (peat, coal, oil)
detritus (dead plants and animals)
consumers (animals)
atmosphere
microbes
decomposition, leaching, respiration
burning of fossil fuels, erosion
indirectly available inorganic materials (limestone and certain minerals)
weathering
erosion
sedimentary rock formation
soil
water
sediments
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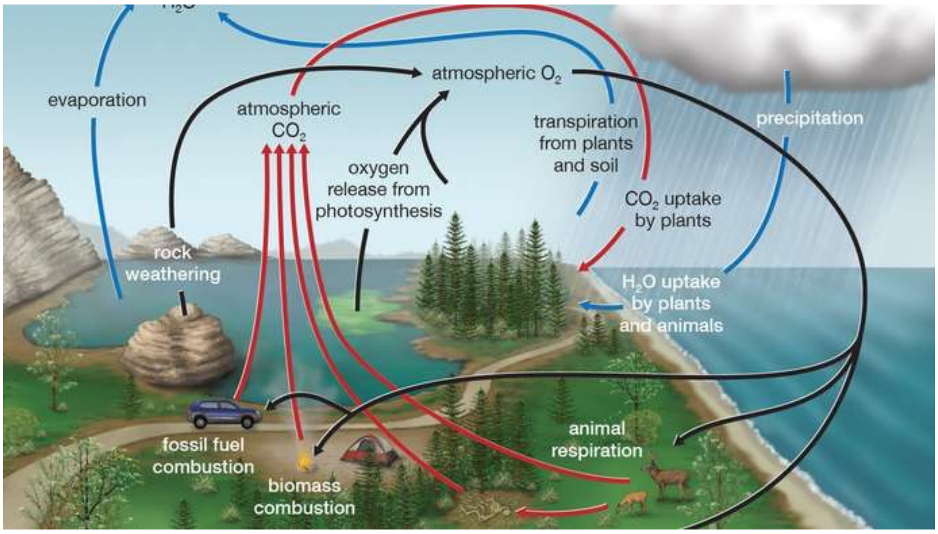
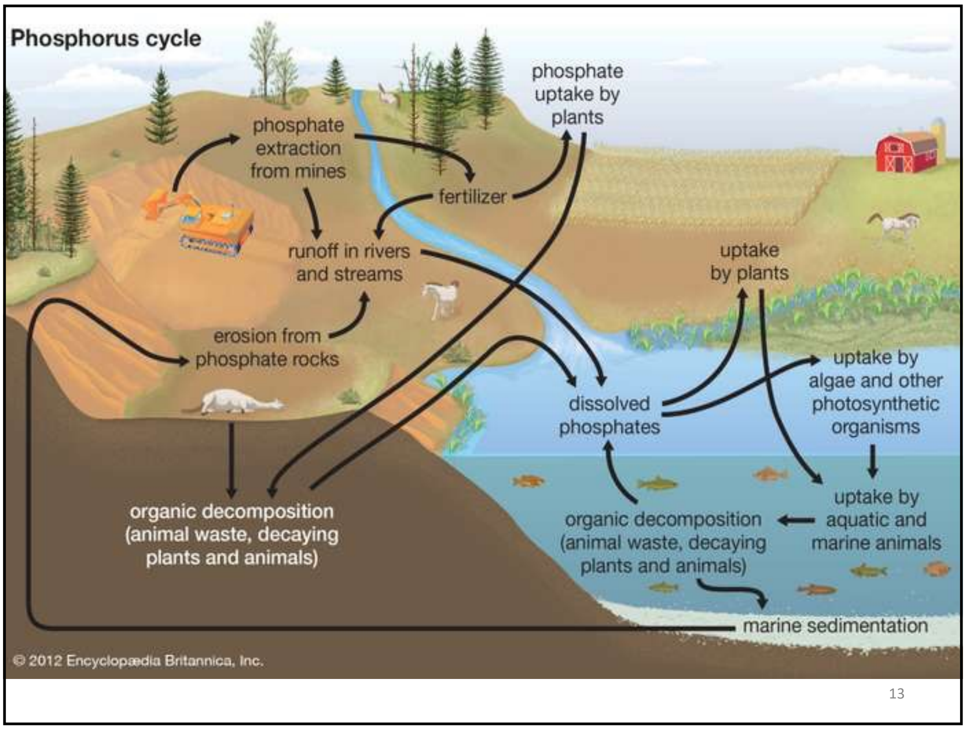

evaporation
atmospheric O_2
atmospheric CO_2
oxygen release from photosynthesis
transpiration from plants and soil
precipitation
CO_2 uptake by plants
rock weathering
H_2O uptake by plants and animals
animal respiration
fossil fuel combustion
biomass combustion

12

12


Phosphorus cycle
phosphate extraction from mines
fertilizer
phosphate uptake by plants
runoff in rivers and streams
erosion from phosphate rocks
uptake by plants
uptake by algae and other photosynthetic organisms
dissolved phosphates
organic decomposition (animal waste, decaying plants and animals)
uptake by aquatic and marine animals
organic decomposition (animal waste, decaying plants and animals)
marine sedimentation
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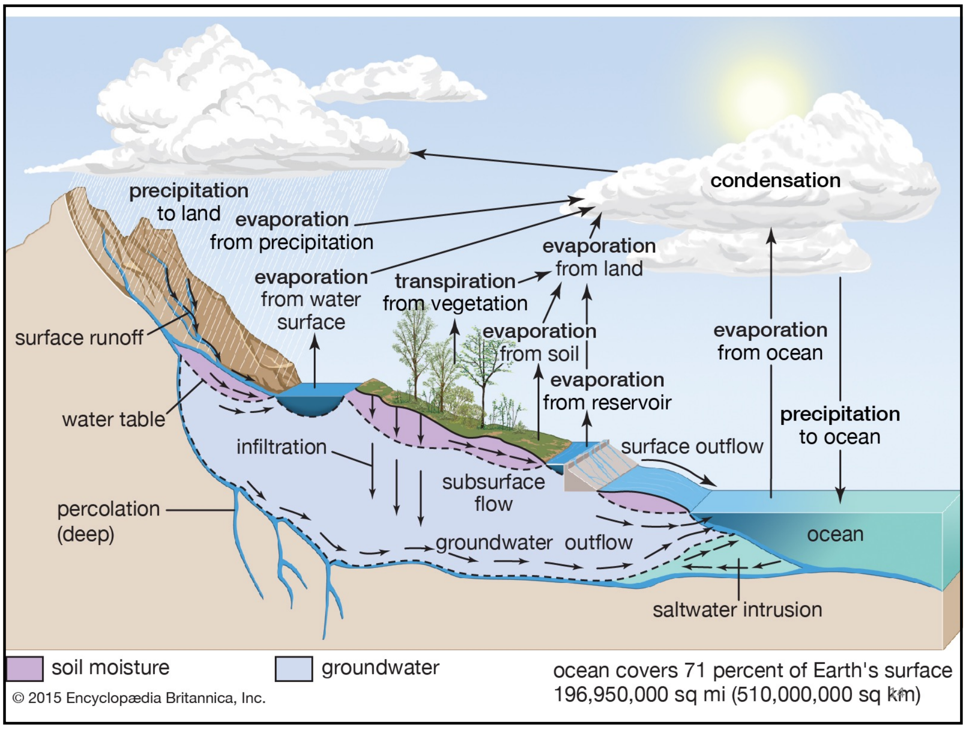
precipitation to land
evaporation from precipitation
condensation
evaporation from land
evaporation from water surface
transpiration from vegetation
surface runoff
evaporation from soil
evaporation from ocean
evaporation from reservoir
precipitation to ocean
water table
infiltration
surface outflow
subsurface flow
percolation (deep)
ocean
groundwater outflow
saltwater intrusion
soil moisture
groundwater
ocean covers 71 percent of Earth's surface 196,950,000 sq mi (510,000,000 sq km)
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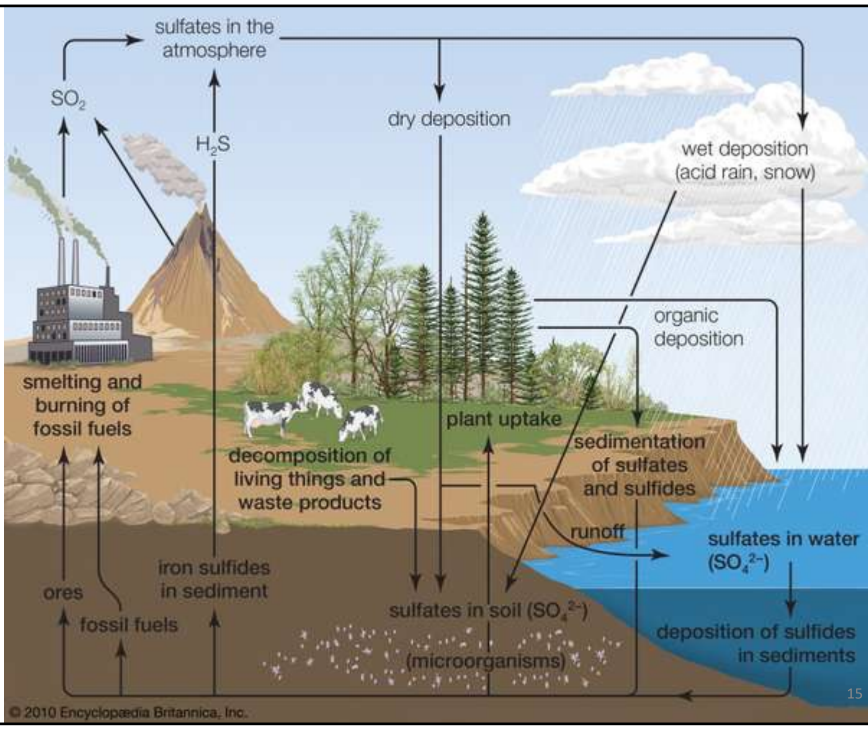

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1952 London: smog

London 1952: in the second week of December, a dense fog formed in the English capital that gripped the population for six days low temperature 0 ° C, and high humidity, between 80 and 100%, made the air stagnant, while the absence of wind made the city a real gas chamber.

In a few hours a huge cloud reduced visibility to 50 m.

the mixture of smoke (fog) and fog (fog) entered the lungs and irritated the mucous membranes:

there were 4,000 dead and 20,000 hospitalized for serious consequences to the respiratory tract.

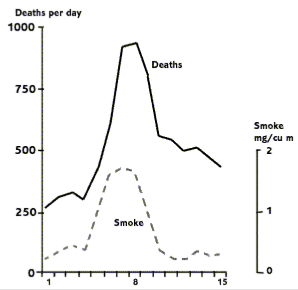
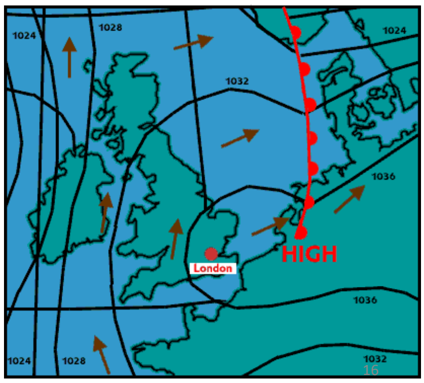


Chart for 0600 UTC on 5 December 1952



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1986 Chernobyl: explosion of the reactor

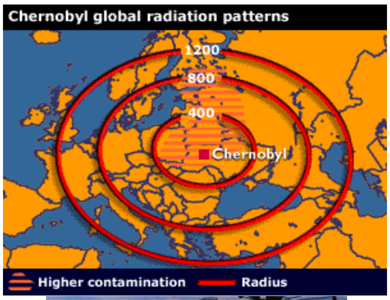
On the night of April 26, 1986, reactor number 4 of the Chernobyl nuclear power plant exploded during routine maintenance.

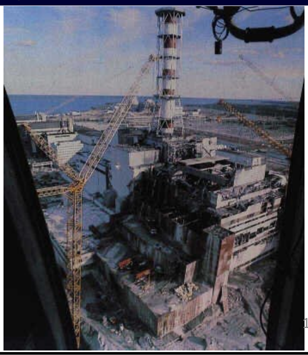
The disaster killed thousands of people.

It is the most serious nuclear disaster in the history of nuclear energy.

In the atmosphere were released:
45 million Curie of 133 xenon;
7 million Curie of Iodine 131;
one million Curie of cesium 134 and 137.

The release of radionuclides into the atmosphere continued until 10 May and then decreased.





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What is air pollution

It is the presence in the air of substances that are not present in its natural composition (or are at a lower concentration level) that cause damage to living beings or things

The composition of the atmosphere gradually changes over time both because of natural processes and anthropic processes

Picture of Mount St. Helens by US Geological Survey scientist Austin Post on May 18, 1980

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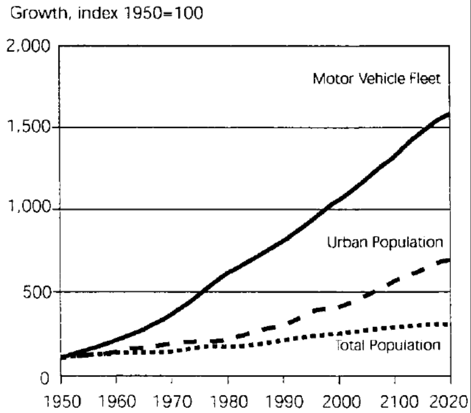
Air quality from historical and economic a perspective

1. From 1945 to today the world population has gone from 2.5 to 7 billion inhabitants;
2. Following growing migratory phenomena, in the world, the inhabitants of urban areas exceeded those of the countryside in 2010 (in China alone in 2011);
3. In Asia, Latin America and Africa, urbanization is accompanied by the proliferation of slums and polluting industries (relocated there from the more industrialized countries);
4. From 1950 to today, the global number of vehicles has gone from around 100 million to over 1 billion (today around 1.2 billion);
5. **Most of the energy is produced from fossil fuels:**

- Global emissions of air pollutants increased consequently (since 1950 global SO2 emissions have doubled and NOX emissions increased 4 times)



The increase since 1950 of the total world population, the urban population and the number of motor vehicles - excluding motorbikes and three wheelers

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Austin, Brimblecombe, Sturges. Air Pollution Science for the 21st Century, 2002

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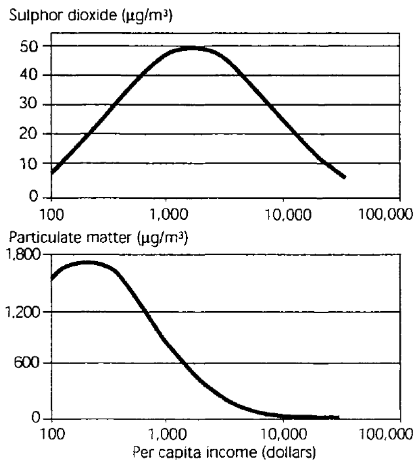
In general, the environmental quality in a country is related to the average income of the inhabitants;

The availability of drinking water and sanitation increases with income;

Air pollution, however, initially increases with income and then decreases (see Fig. ->);

On the basis of more recent data it is estimated that, in most cases, the maximum for the various pollutants is reached around a per capita income of 8,000 USD;

Global emissions are estimated to decrease only in the long run, while global air pollution is expected to continue growing over the next decades.



Urban concentrations of SO_2 and particulate matter as a function of national per capita income
(The curves show general tendencies, there are marked deviations. In the early 1980s Kuwait had both some of the highest incomes and highest pollution levels)

Austin, Brimblecombe, Air Pollution Science for the 21st Century, 2002

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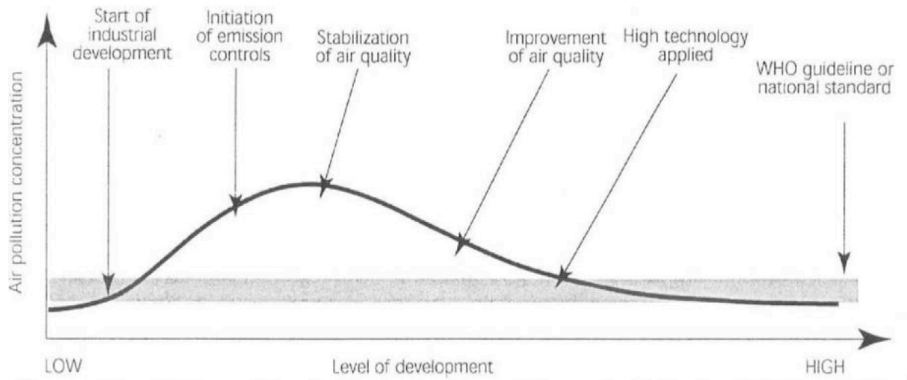
From a temporal perspective, the air pollution of a developing area initially increases, passes through a maximum and is then reduced again when pollution reduction systems become effective:



Schematic presentation of a typical development of urban air pollution levels.
Depending upon the time of initiation of emission control the stabilization and subsequent improvement of the air quality may occur sooner or later in the development.

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Austin, Brimblecombe, Air Pollution Science for the 21st Century, 2002

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Earth atmosphere

Primitive Earth atmosphere (reducing):

Carbon dioxide, CO_2;
Nitrogen, N_2;
Water vapor, H_2O;
Hydrogen, H_2 (traces).
(mixture similar to that emitted by volcanoes)

From the primitive atmosphere to today's (oxidizing):

Most of the WATER VAPOR originally emitted from inside the Earth condensed leaving the atmosphere and forming the oceans;
Much of the CO_2 first dissolved in them and then formed carbonate rocks;
NITROGEN (chemically inert, insoluble in water and non-condensable) has accumulated in the atmosphere becoming its most abundant component.
OXYGEN (O_2) emitted as a product of photosynthesis by plant organisms has accumulated in the atmosphere becoming the second component by abundance.

J.H. Seinfeld, Chimica dell'atmosfera , Treccani, 2007

Permanent gasses

Gas	*Chemical formula*	*% in volume*
Nitigen	N_2	*78,08*
Oxigen	O_2	*20,95*
Argon	*Ar*	*0,93*
Neon	*Ne*	*0,0018*
Helium	*He*	*0,0005*
Hydrogen	H_2	*0,00005*
Xenon	*Xe*	*0,000009*

Components in variable concentration

Gas	*Chemical formula*	*% in volume*
Water vapour	H_2O	*da 0 a 4*
Carbon dioxide	CO_2	*0,0408 (2018)*
Methane	CH_4	*0,000175*
Nitrogen oxide	N_2O	*0,000031*
Ozone	O_3	*0,000025*
Particulate material	---	*0,000001*
Chlorofluorocarbons	---	*0,00000001*

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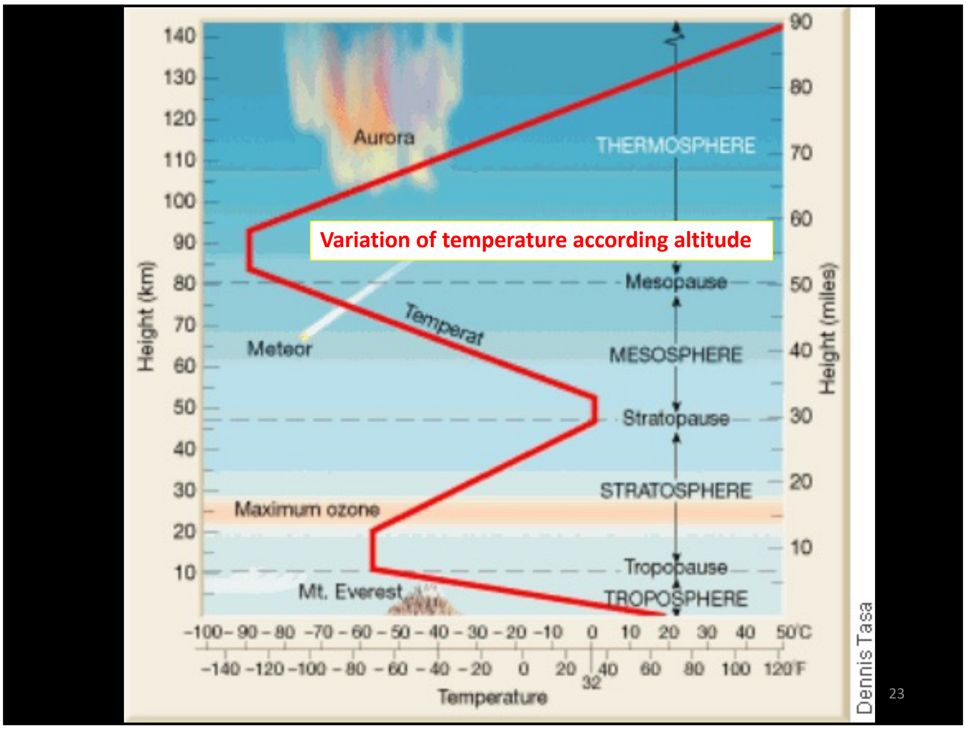

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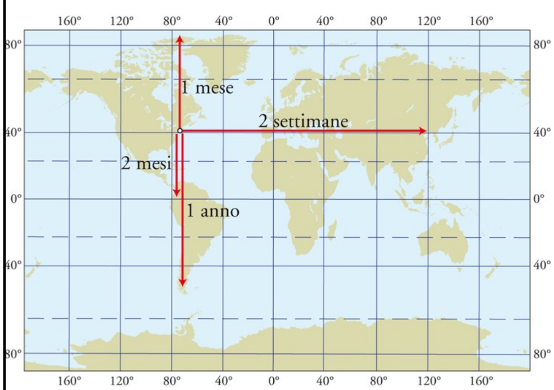
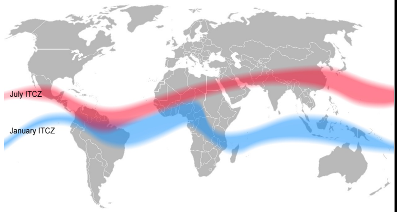
Residence time of the compounds in the atmosphere



Zona di convergenza intertropicale
ITCZ



The long time required for mixing between the North and South hemispheres derives from the presence at the Equator of the so-called **intertropical convergence zone**, where atmospheric conditions do not favor the mixing of gases between the two hemispheres.

Dispersion time of a chemical species in a hemisphere: 1-2 months;
Dispersion time of a chemical species in the whole atmosphere: 1-2 years;
Vertical mixing is fast in **troposphere**: chemical species mixed in a few days;
Vertical mixing is slow in **stratosphere**: several years to reach the highest levels.

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J.H. Seinfeld, Chimica dell'atmosfera , Treccani, 2007

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Residence time of the compounds in the atmosphere

The PERMANENCE TIME (or life time) of a substance in the atmosphere represents the average time during which a molecule of this species remains in it before being eliminated

By applying the conservation principle to substances present in the atmosphere, in stationary conditions, it is obtained that the residence time **τ** can be expressed as:

$$\tau = \frac{Q}{R} = \frac{Q}{P}$$

Q: total mass;
R: speed of species removal;
P: speed of introduction from a source.

MIXING TIME: time necessary for the concentration of a compound to be uniform in a certain volume**.**
A particular volume can present a good mixing with respect to some species and bad with respect to others, depending on their residence time.
The mixing of the stratosphere is considered bad with respect to all atmospheric components present in traces and can be considered well mixed only with respect to species that have a residence time of over 50 years.

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J.H. Seinfeld, Chimica dell'atmosfera , Treccani, 2007

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Planetary Boundary Layer

The atmospheric boundary layer can be defined as the part of the atmosphere subject to the effects of the surface.
The time scale of the atmospheric response to a surface forcing date (heat transfer, evaporation, friction effect, etc.) is approximately one hour.

This time scale is much greater above the PBL, in the so-called free atmosphere (Free Atmosphere FA; free with respect to the influence of the Earth's surface).

For example, the evolution of the temperature in the PBL is regulated by the diurnal cycle, contrary to that of the FA (in first approximation).
This evolution is connected to the variation of the vertical turbulent heat flow:

- **DURING THE DAY, the surface is heated by solar radiation and turbulent heat flows are generated in the PBL;**

- **DURING THE NIGHT, the surface cools down, releasing heat upwards, creating a stable layer close to the ground.**

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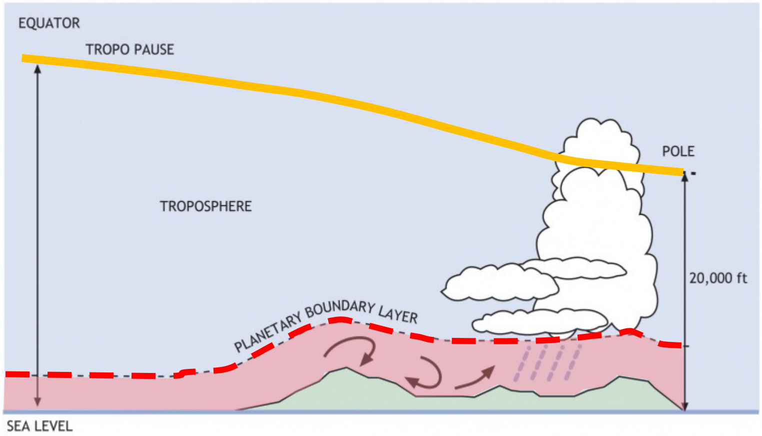
B. Sportisse, Fundamentals in air pollution, 2010

26

Planetary Boundary Layer (PBL)



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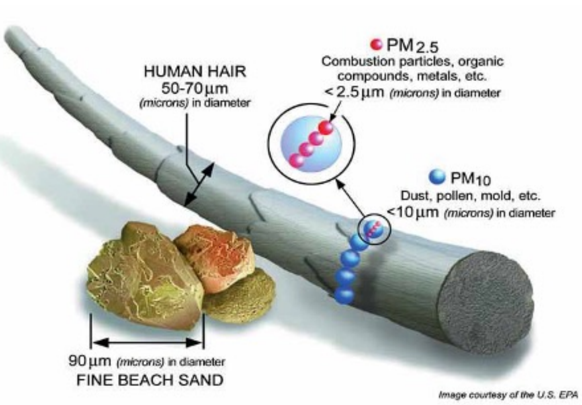
Aerosol – abiologic particles

- dimensions vary on 5 orders of magnitude (from about 0.002 to 100 millionths of a meter, µm).
- diversity of form and composition
- variability of time elapsed from the moment of release to deposition.
- the particles are transformed both immediately after the emission and during their "life" in suspension, with profound modifications of the original physical and chemical structure.



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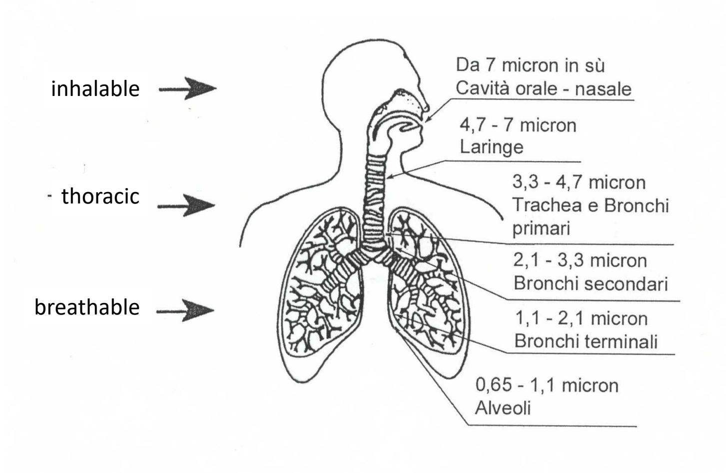
Aerosol – abiologic particles

Penetration level of the different particle sizes in the human respiratory system



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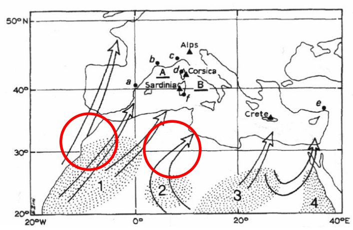
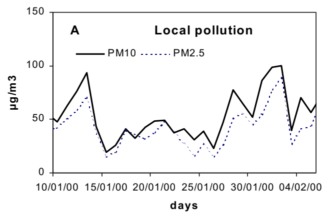
Long-distance transport of particulate matter of natural origin

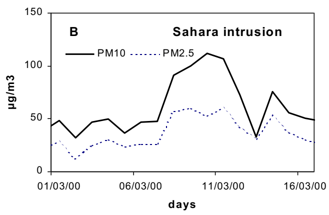


Saharan dust event: in Italy tens of episodes per year (specially from zone 1 or 2)

	SAHARA	EUROPE
SiO_2	60.95	56.49
Al_2O_3	11.02	13.91
Fe_2O_3	4.05	6.37
FeO		
MgO	0.76	3.08
CaO	2.31	8.60
Na_2O	1.39	1.14
K_2O	2.81	2.63
TiO_2	0.82	1.04
P_2O_5	0.20	0.24
MnO	0.09	
SO_3		
CO_2	5.26	
H_2O	8.75	

Average composition of natural particles (%)





Main components of natural particles from Sahara are: CALCITE, DOLOMITE, IRON OXIDES, QUARTZ and CLAY MINERALS 30

30