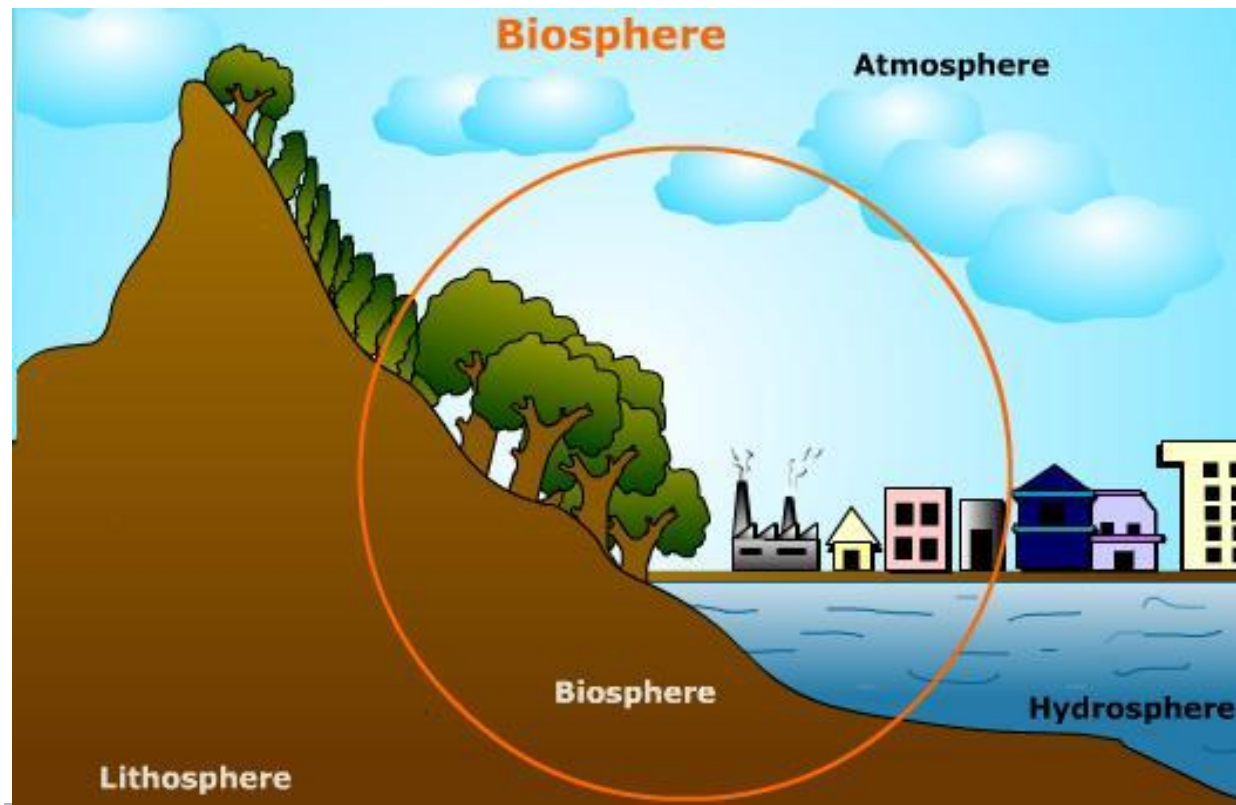


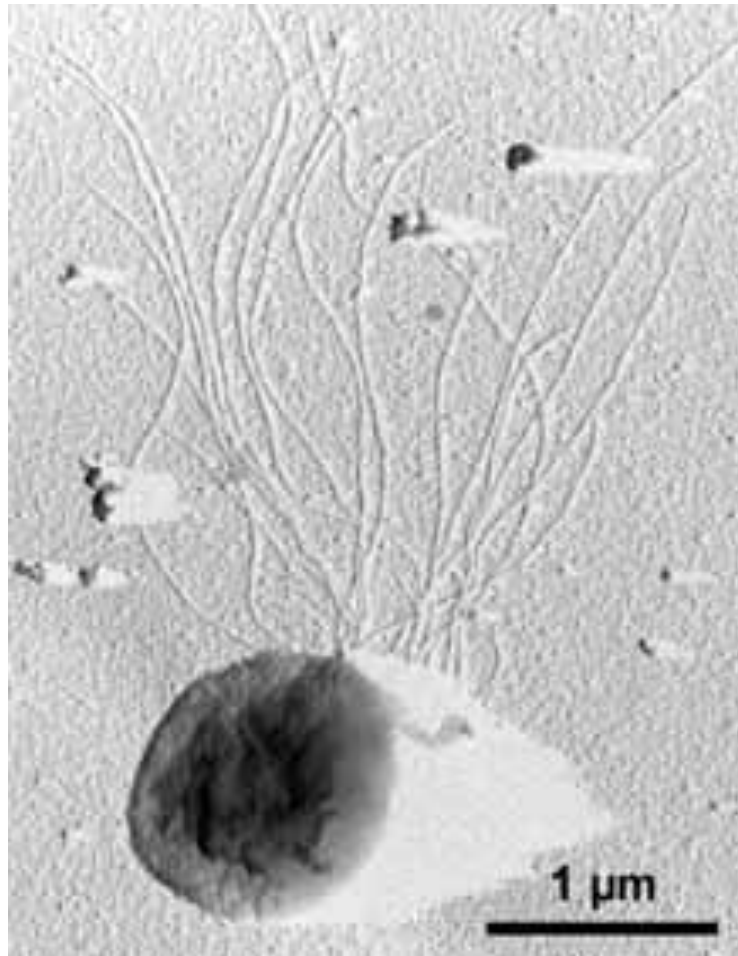
Biosphere and ecosystems

Course module: Ecological geology
Lecturer: A.M. Mezhibor, PhD, associate professor

The biosphere

- ▶ (also called the ecosphere) is the natural environment of living organisms and is the complex biological epidermis of the Earth whose dimensions are not precisely defined

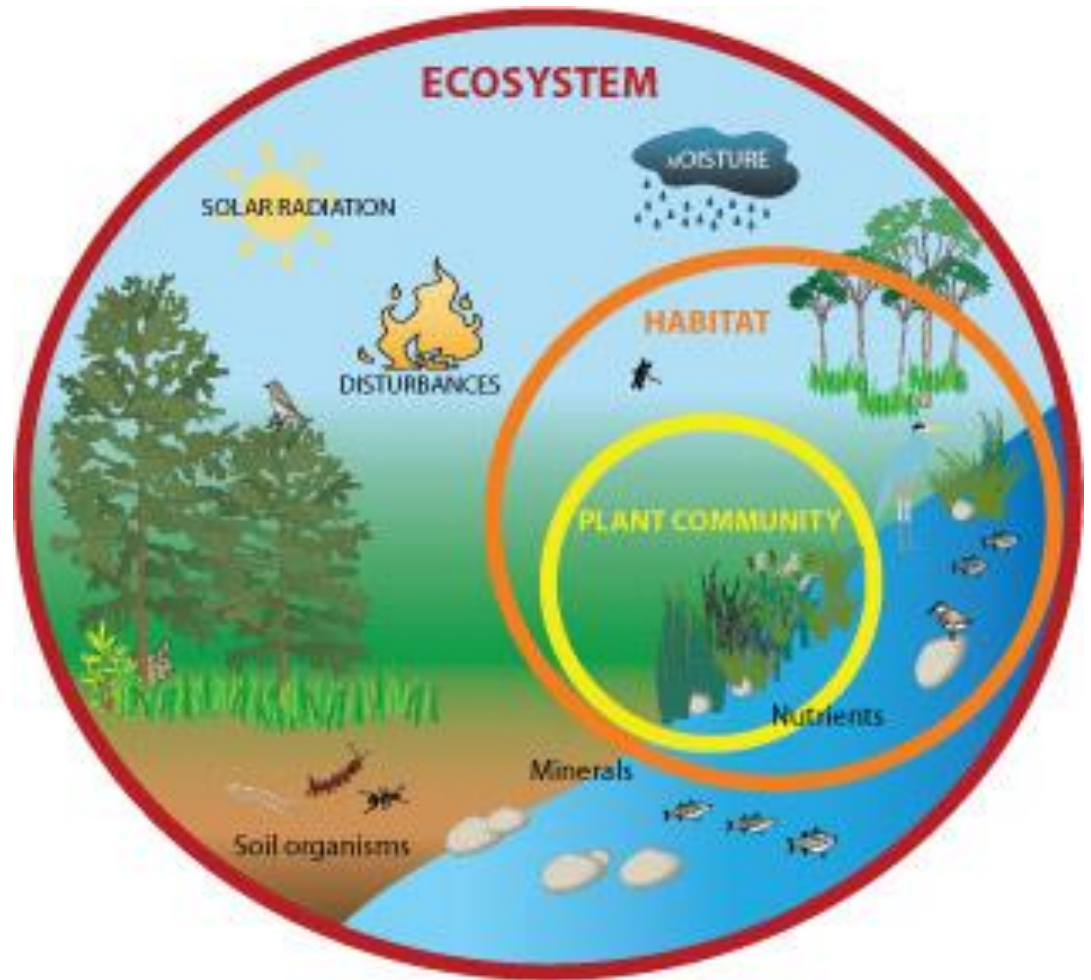




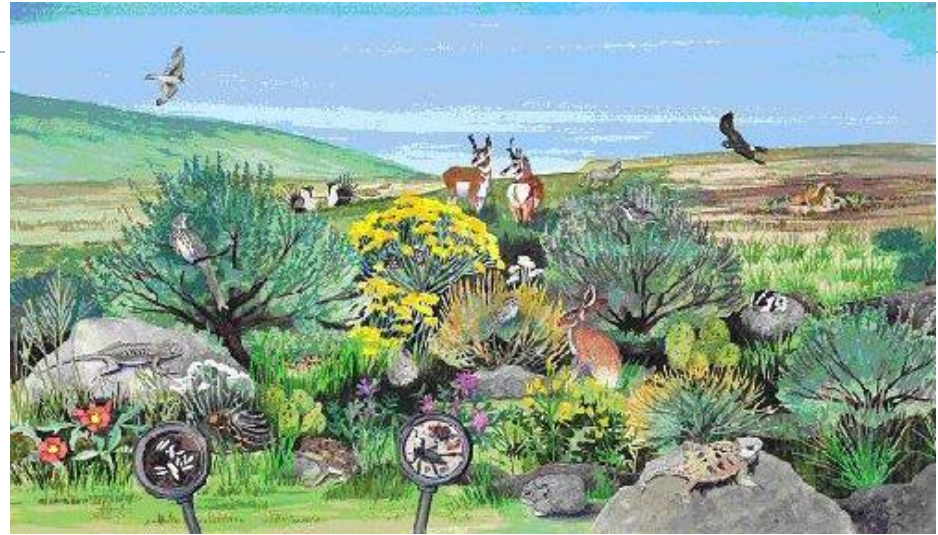
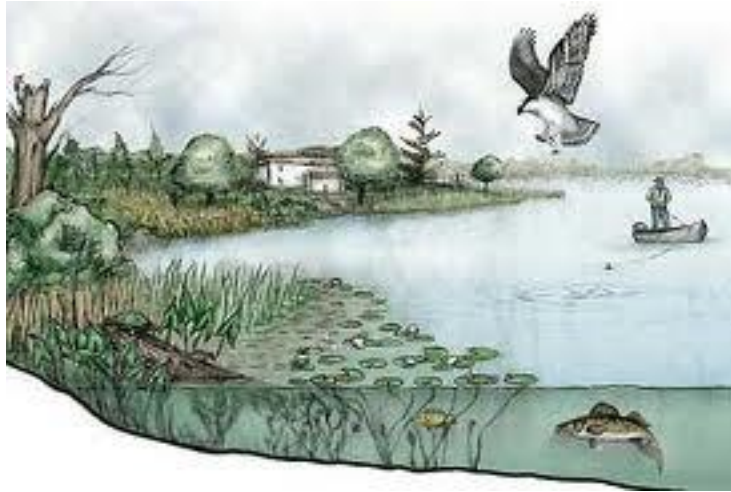
- ▶ *Thermococcus* — one of specific inhabitants of deep hot earth crust. Prefer the temperature from 60 to 100°C.
- ▶ Source: microbewiki.kenyon.edu

Ecosystems inside the biosphere

- ▶ Each ecosystem is a fundamental division of the total environment consisting of living organisms in a given area and having a *balanced* cycling of chemical elements and energy flow



Various types of ecosystems



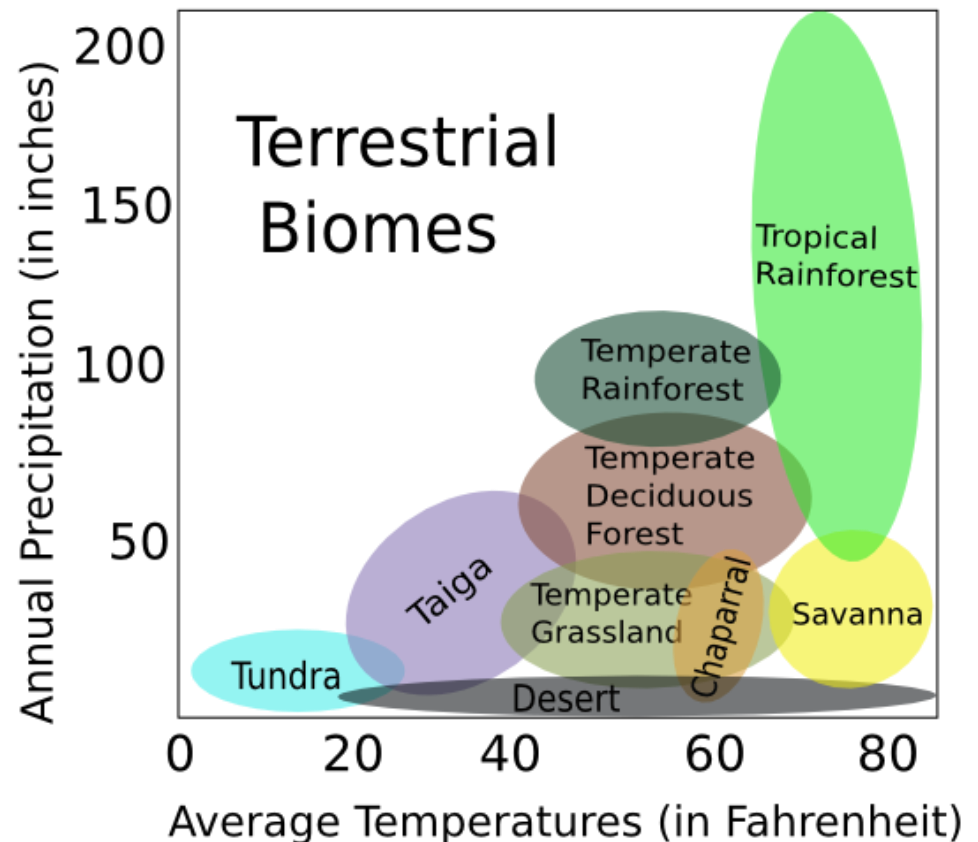
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- ▶ Each ecosystem is a fundamental division of the total environment consisting of living organisms in a given area and having a *balanced* cycling of chemical elements and energy flow.
 - ▶ Among the principal resources of which man disposes, are terrestrial ecosystems consisting of soil and water, and associated animal and plant life.
 - ▶ Ecosystems are functional environmental units, having *balanced* cycles of chemical elements, organic materials and energy flow.

- ▶ An ecosystem is a natural ecological niche with unique physical and chemical characteristics.
- ▶ It supports a complex community of dynamically interacting populations of organisms called a **biome**.

Biomes are large areas on Earth with similar conditions, such as climates and living organisms. There are two main categories of biomes:

- **Terrestrial biomes** are usually defined by the type of vegetation that is present. The major climatic factors contributing to the vegetation types in these biomes are temperature and precipitation.

- **Aquatic biomes** are defined by the type of water they contain.



Environmental factors

- ▶ The interactions in the ecosystems involve the search and competition for food, the use of space and natural resources, and nutrient recycling through a food web. There is a natural mutual regulation of population size in the community that maintains an ecological balance and benefits all organisms. This natural ecological entity is wee or grand in size. Its biome or community of organisms is distinguished by vegetation.
- ▶ The ecosystem is defined by the adaptation of living populations to unique environmental attributes.

Environmental attributes

- ▶ Together, temperature, rainfall, and soil composition largely determine the vegetation assemblage in an environment. This creates ecological regimes in geographically distinct regions that sustain flourishing biomes or biomes in a constant struggle for survival.
- ▶ Terrestrial ecosystems with clean air to breathe, safe water for drinking and hygiene, and uncontaminated fertile soils sustain and nurture all living creatures. Vegetation that roots and grows with vigor, watered by rainfall or by irrigation, feeds humans and other life forms with its vegetables, grains, fruits, nuts, berries and leaves. It is a nutrient source for food animals (e.g., cattle, sheep, goats, fish, fowl). Similarly, clean fluvial, lacustrine, estuarine and ocean ecosystems provide nutrition to sustain their communities of organisms.

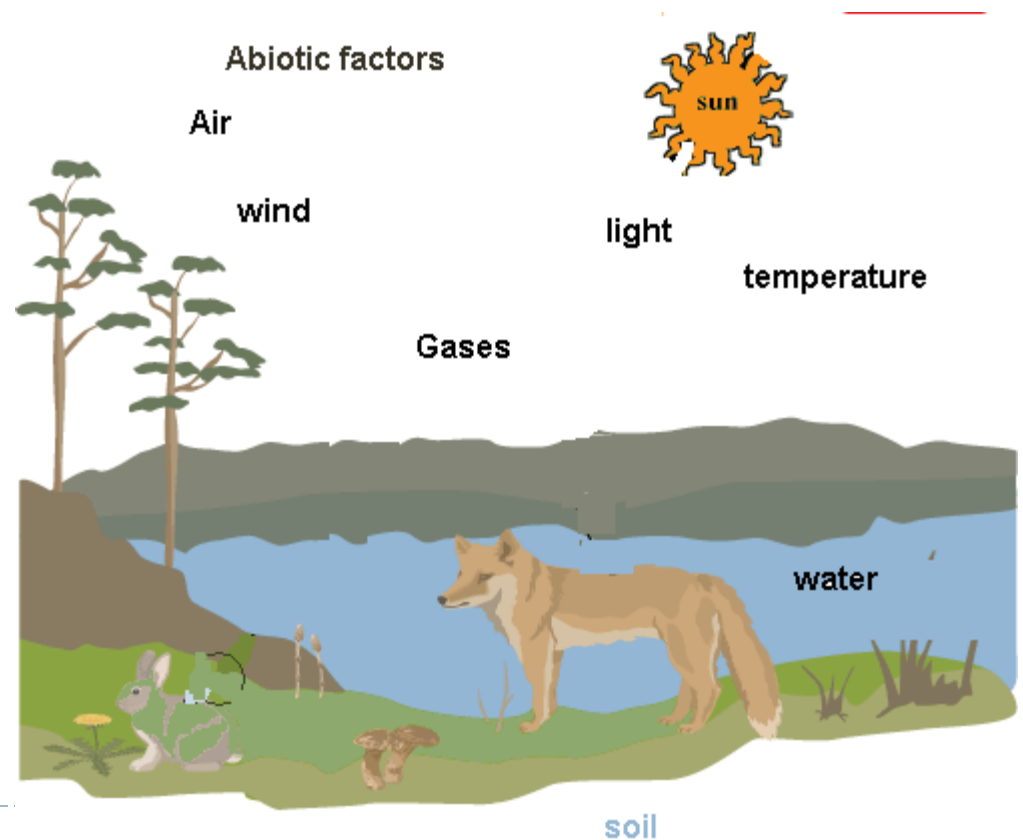
Biotic and abiotic Factors

▶ Biotic Factors

Biotic, meaning of or related to life, are living factors. Plants, animals, fungi, protist and bacteria are all biotic or living factors.

Abiotic Factors

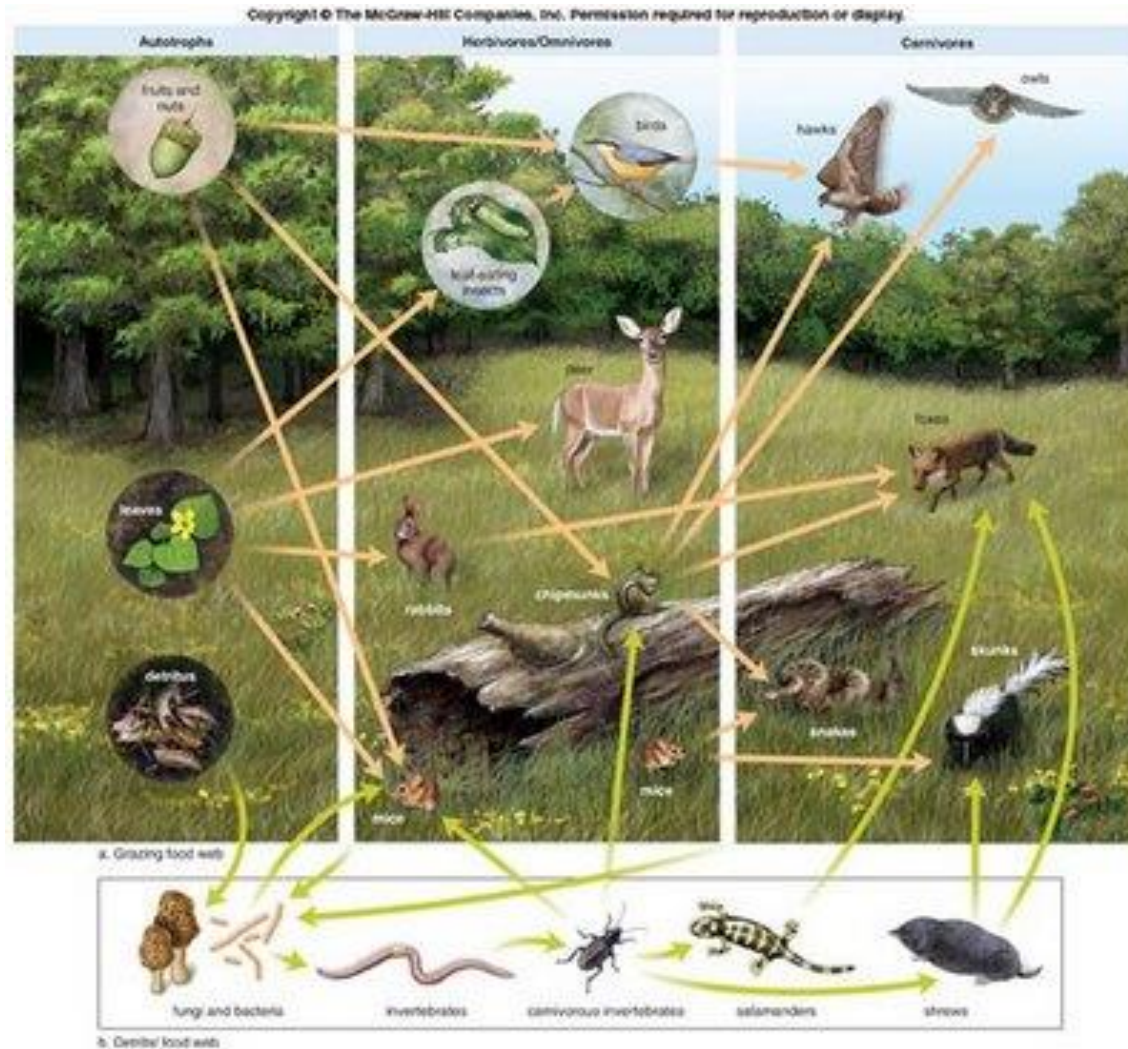
Abiotic, meaning not alive, are nonliving factors that affect living organisms. Environmental factors such as habitat (pond, lake, ocean, desert, mountain) or weather such as temperature, cloud cover, rain, snow, hurricanes, etc. are abiotic factors.



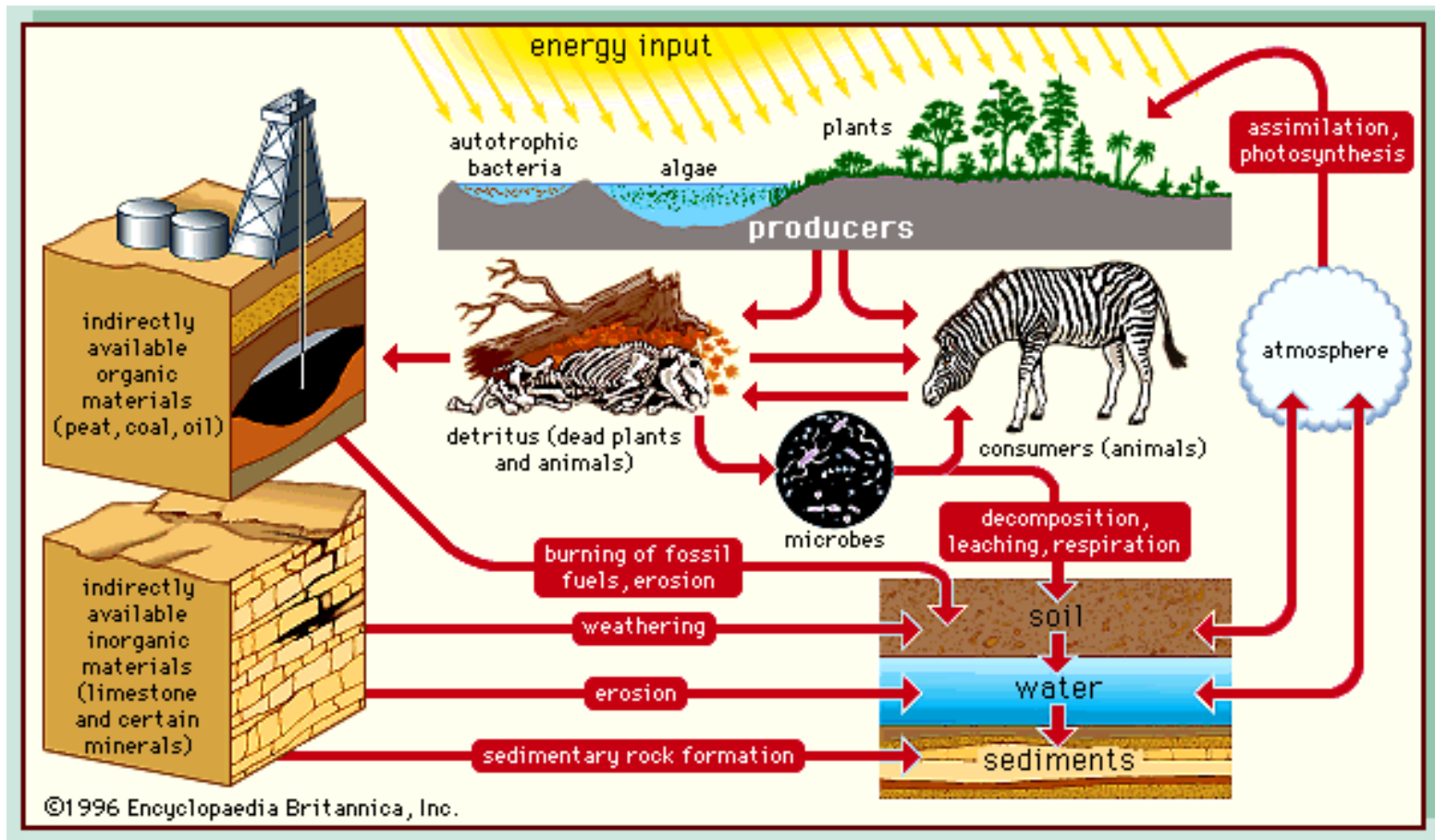
Abiotic and biotic factors

- ▶ Although air and water can be considered abiotic in a strict sense, the atmosphere contains airborne organisms such as Roseobacteria which aid in the formation of clouds by producing gases that nucleate water droplets.
- ▶ The hydrosphere contains minute to large algae/vegetation species and a grand diversity of aqueous life.
- ▶ Soils sustain productivity with their nutrients (from rock/mineral decomposition) and the activity of bacteria and other organisms in soils.
- ▶ The so-called abiotic matter nourishes biotic forms from the lowest to the highest trophic levels. A continuum of this relationship preserves equilibrium in food chains and food webs, and in ecosystem vitality.

Co-existence of living organisms in the environment

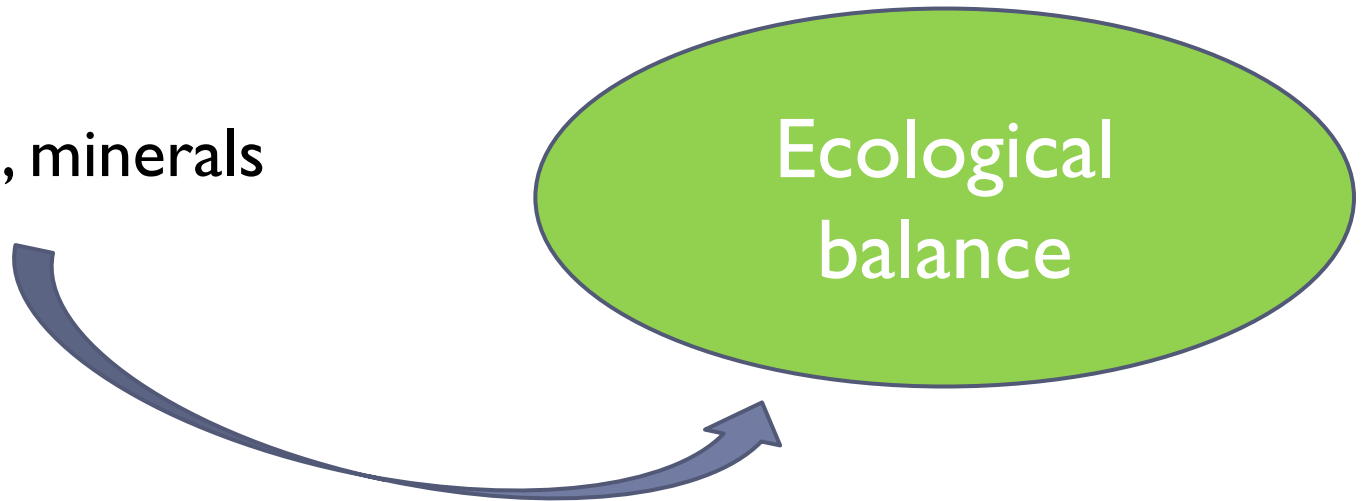


Biogeochemical cycles of the biosphere



Resources for humans

- ▶ clean air
- ▶ safe water
- ▶ untainted, fertile soils
- ▶ energy sources
- ▶ wood
- ▶ metal ores, minerals



Ecological balance

- ▶ Life forms adjust to changing natural or anthropogenic induced physical and/or chemical properties in ecosystems in different ways to reproduce and survive.

Organisms may adapt to changes and stay as inhospitable conditions evolve, perhaps with a slowdown of activity. Some mobile species move away to find favorable ecological conditions. Others do not readily adapt to a deteriorating ecosystem and try to survive environmental intrusions despite high death tolls in their populations. When ecosystem conditions return to “livable”, organisms revive from their survival modes to reestablish their biorhythms and natural activities.

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- ▶ Ecosystem degradation can cause a rupture in the interrelationships between populations dependent on each other symbiotically or as a source of nutrition along a food chain or within a food web

When there is a great diversity of organisms, predators that lose their prey may switch to other prey.

In ecosystems with limited diversity, a rupture between dependent populations can endanger biome niches or threaten organism survival within the ecological system.

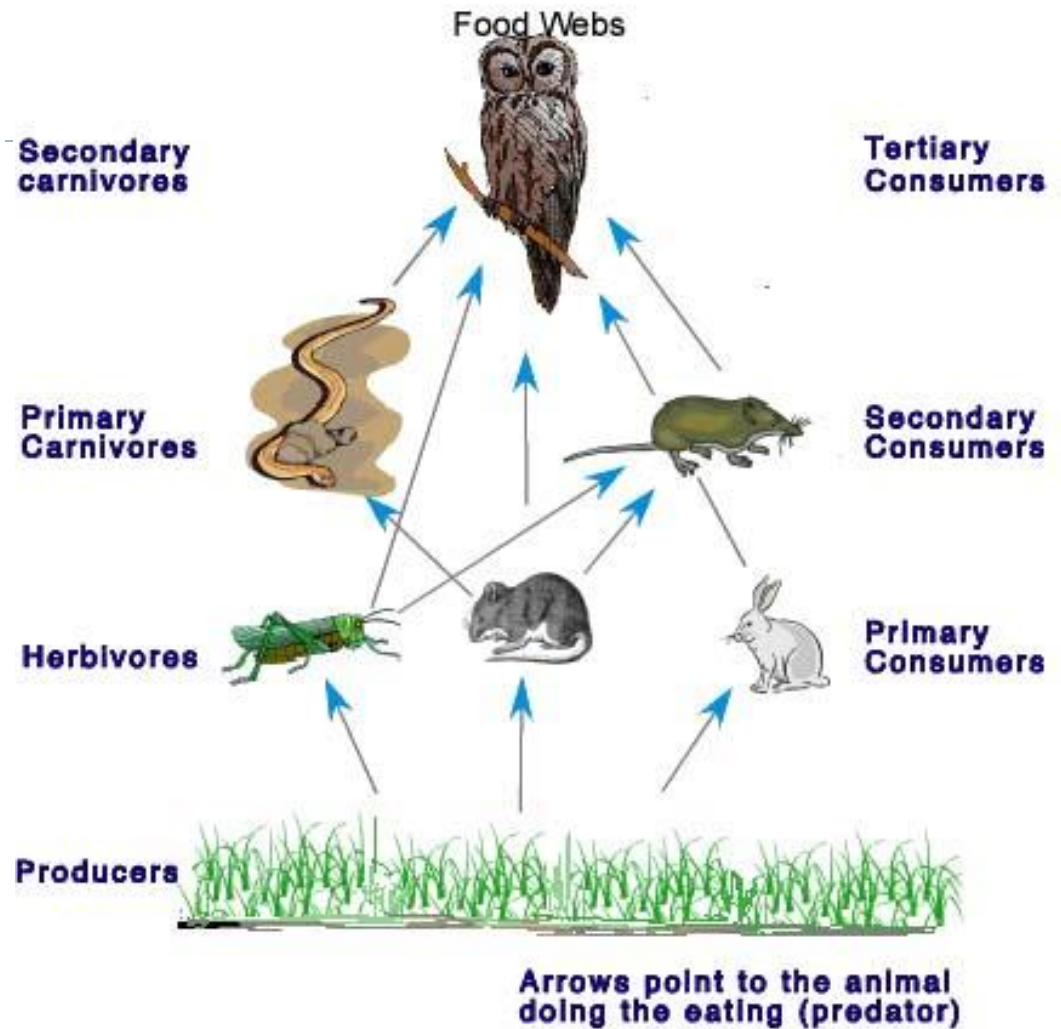
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- ▶ If a cascading effect of changing conditions (e.g., salinity, drought, wildfires) or missing biological links in the food chain/food web continues, more organism populations can decline and an ecosystem can crash

Even with a crash, there will be survivors that adapt to the new conditions and live on. Others do not adapt and will either move to habitable ecosystems or die.

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- ▶ There is a homeostatic interrelationship between the nonliving media (abiotic compartments) and the living organisms (biotic compartments). However, a significant part of the ecosystems has already been considerably modified by humans, and these processes will continue.

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- ▶ Organisms have adjusted during the course of evolution and life to the chemistry of their environment and have developed their biochemistry in close connection to the composition of the natural environment. These phenomena have been easily observed, mainly in microorganisms and plant populations that have evolved tolerance to high concentrations of trace elements either in natural geochemical provinces, or under man-induced conditions.

- ▶ A proper balance between trace and major elements plays a significant role in biochemical processes

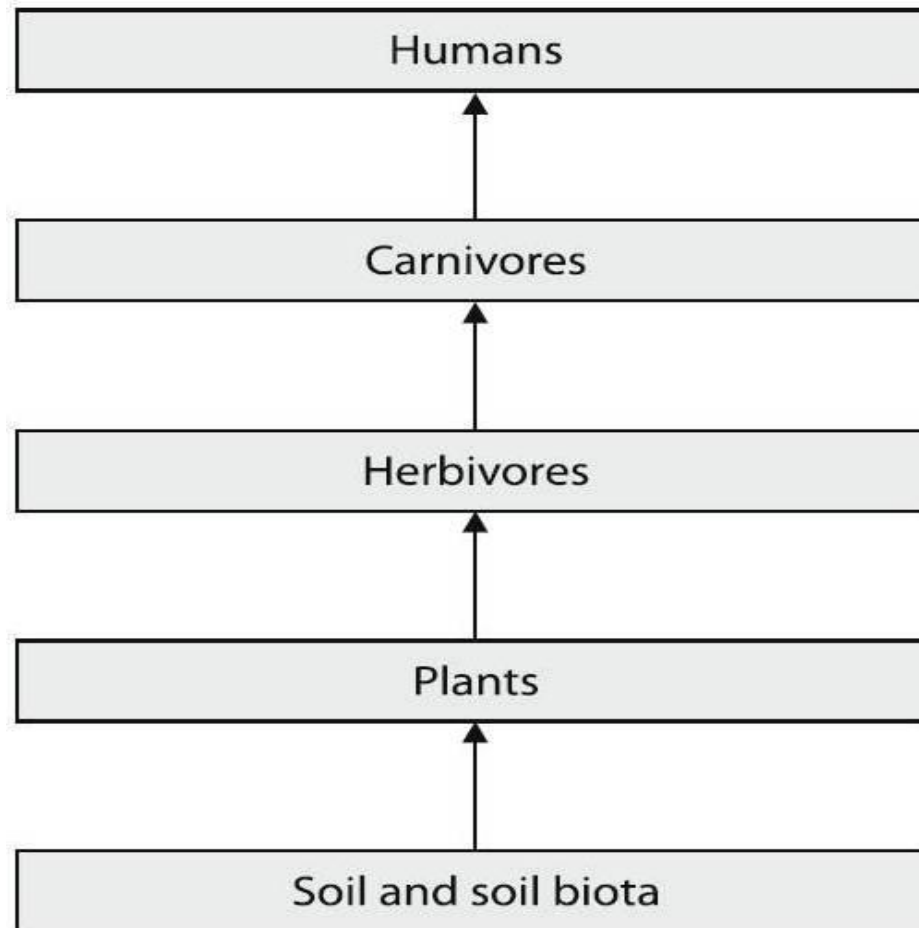


Most of the chemical elements for life on the land are supplied mainly from the soil overlying the surficial lithosphere

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- ▶ Although mechanisms of biological selection of chemical elements allow plants to control, to a certain extent, their chemical composition, this barrier is somewhat limited in respect to trace elements. Therefore concentrations of trace elements in plants are often positively correlated with the abundance of these elements in growth media. This creates several problems for plants, animals and humans associated either with deficiency or with excess. Usually the quantitative differences between essential amounts and biological excesses of trace elements are very small.
 - ▶ The bioavailability of these elements is variable and is controlled by specific properties of abiotic and biotic media as well as by physical and chemical properties of a given element.

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- ▶ The biochemical functions of essential trace elements are already known. A great number of trace elements are known to have a biological role, often as cofactors or part of cofactor in enzymes and as structural elements in proteins. Some of them also are used in several processes of electron transfer.
 - ▶ Non-essential elements seem to be involved in vital processes but their biochemical functions are not yet understood. The essentiality of other trace elements, possible at very minor concentrations, may be discovered in the future.
 - ▶ Most of trace elements that are essential to humans are also essential to plants. Unfortunately, contents of most elements that may be harmful to humans and animals are not toxic to plants. This has created an increased transfer of some elements in the food chain.

The transfer of chemical elements in schematic terrestrial trophic chain



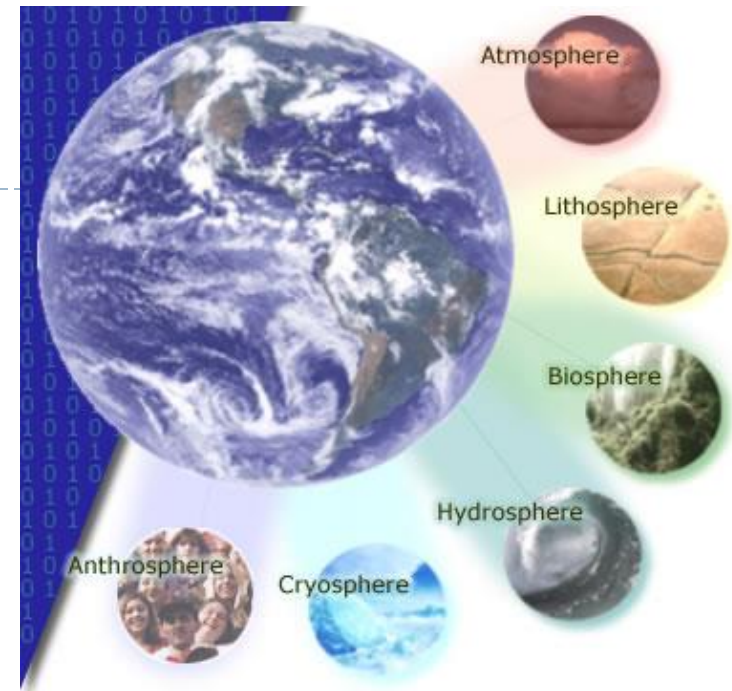
Trace elements in the biosphere

Essential and Beneficial Elements in Higher Plants																	
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt									
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb		
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No		

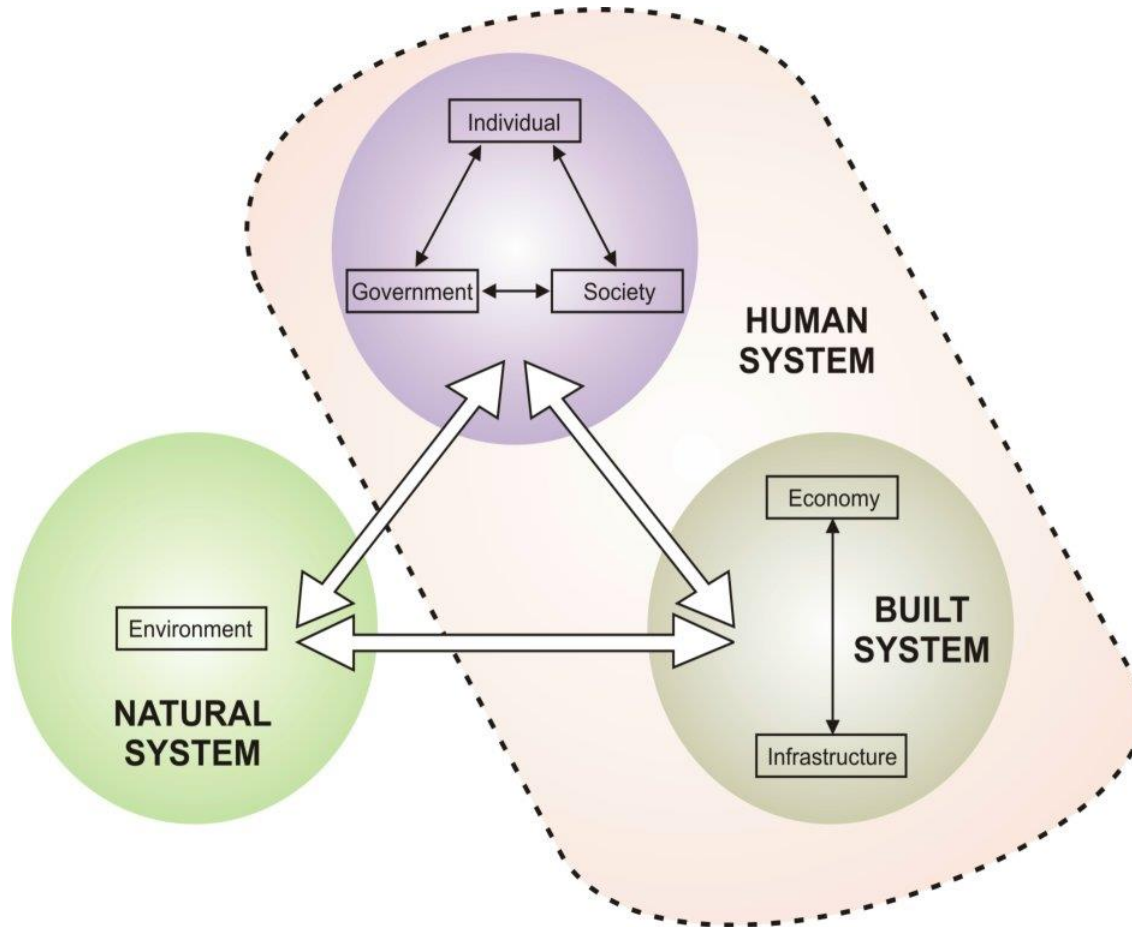
All substances are poisonous, there are none which is not a poison; the right dose is what differentiates a poison from a remedy

Paracelsus (1538)

The anthroposphere



- ▶ Many ecosystems have been considerably modified by humans and therefore it has become necessary to distinguish the anthroposphere – the sphere of man’s settlement and activity. The anthroposphere does not represent a separate sphere, but may be applied to any part of the biosphere that has been changed under an influence of technical civilization.

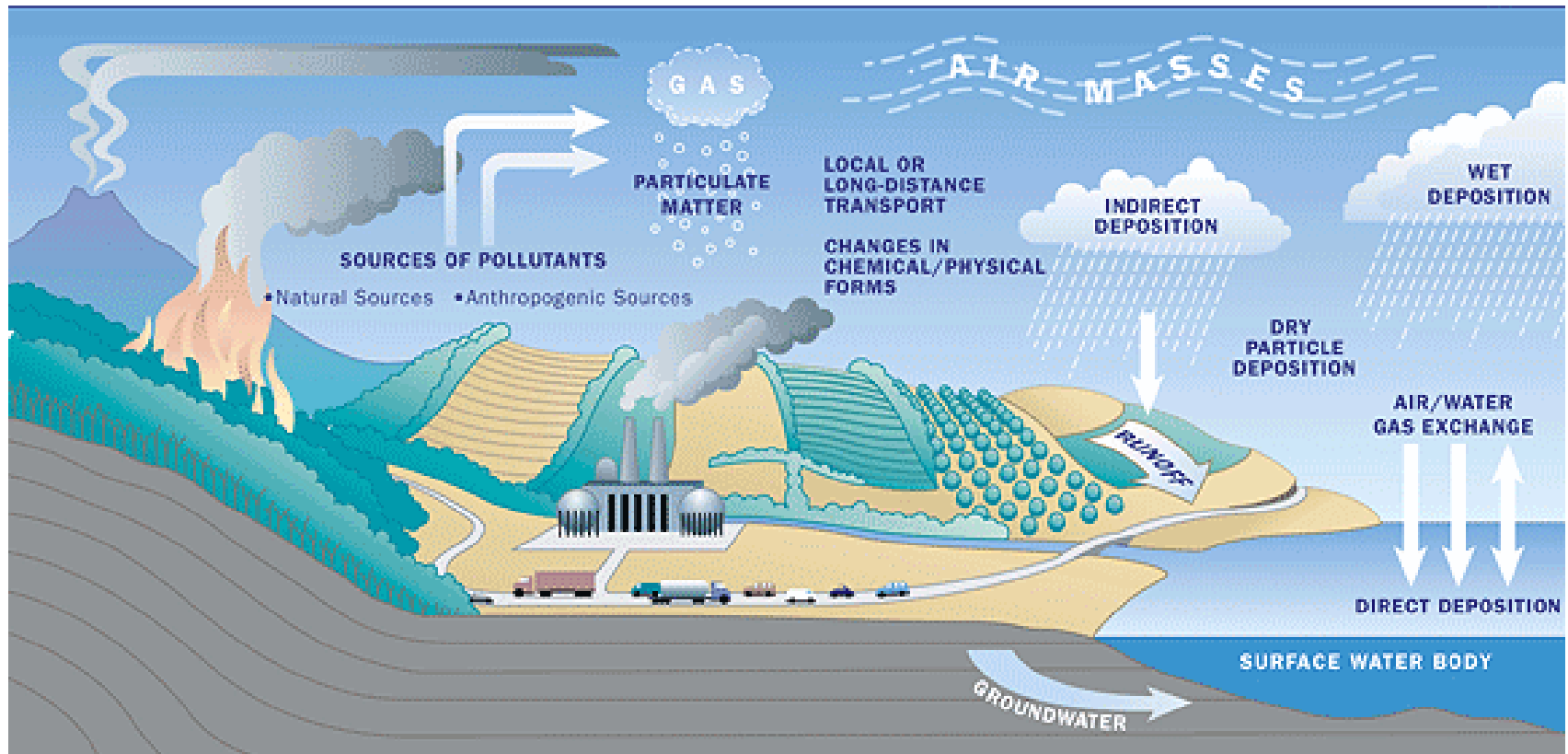


- ▶ The six major systems of the anthroposphere and their major relationships.

▶ <http://www.eolss.com/eolss/5a.htm>

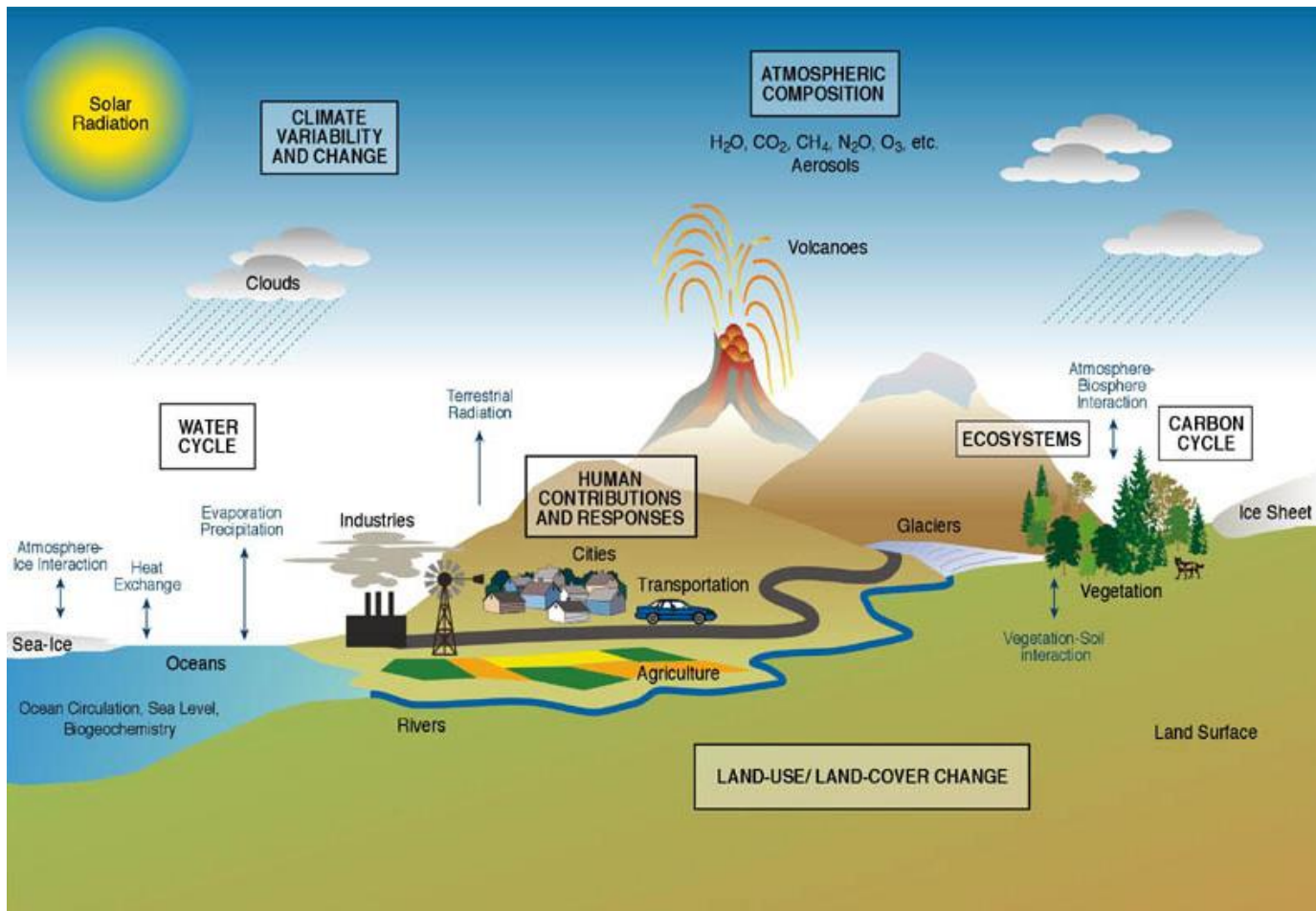
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- ▶ While geological, geochemical and biological alterations of the lithosphere have been very slow, changes introduced or stimulated by humans have been accumulated extremely quickly in recent decades of the past century.
 - ▶ Anthropogenic changes, associated mainly with chemical pollution, lead most often to a degradation of the natural human environment. Among all chemical pollutants, trace elements are of a special ecological, biological and health significance.

Sources of trace elements in the biosphere



Source: <http://www.genesee.eu/en/page/about-genesee-oceanographics>

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- ▶ The production of energy and the consumption of natural resources are the main source of trace elements as contaminants. However, agricultural activities and especially application of sewage sludge, manure, mineral fertilizers (NPK), and pesticides also contribute significantly to the trace metal status of agroecosystems.



source: <http://www.agci.org/classroom/>

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- ▶ Bowen (1979)* has suggested that when the rate of mining of a given element exceeds the natural rate of its cycling by a factor of ten or more, the element should be considered a **potential pollutant**. Thus, the potentially most hazardous trace metals to the biosphere may be: Ag, Au, Cd, Hg, Pb, Sb, Sn, Te, W. Also those elements that are essential to plants and humans, such as: Cr, Cu, Mn, and Zn, may be released, in some regions, in excessive amounts.

*Bowen H.J.M. Environmental chemistry of the elements. London: Acad. Press, 1979

Biodiversity

▶ (video):

<http://www.youtube.com/watch?v=HA3xNMJnFuo>

The International Union for Conservation of Nature (IUCN) notes in a video that many species are threatened with extinction. In addition,

At threat of extinction are

1 out of 8 birds

1 out of 4 mammals

1 out of 4 conifers

1 out of 3 amphibians

6 out of 7 marine turtles

75% of genetic diversity of agricultural crops has been lost

75% of the world's fisheries are fully or over exploited

Up to 70% of the world's known species risk extinction if the global temperatures rise by more than 3.5°C

1/3rd of reef-building corals around the world are threatened with extinction

Over 350 million people suffer from severe water scarcity

▶ <http://www.globalissues.org/article/171/loss-of-biodiversity-and-extinctions#MassiveExtinctionsFromHumanActivity>



Easter Island

- ▶ Civilization disaster

