Chp5. Material cycles and conditions of existence

Hydrological cycle

Material cycles

Atmospheric pollutants

Nutrient cycling in nutrient poor soils

Recycling

Limiting factors

Factor compansation

Biological clocks

Fire as an ecological factor

Soil resistance

Soil development

Soil types

Soil displacement

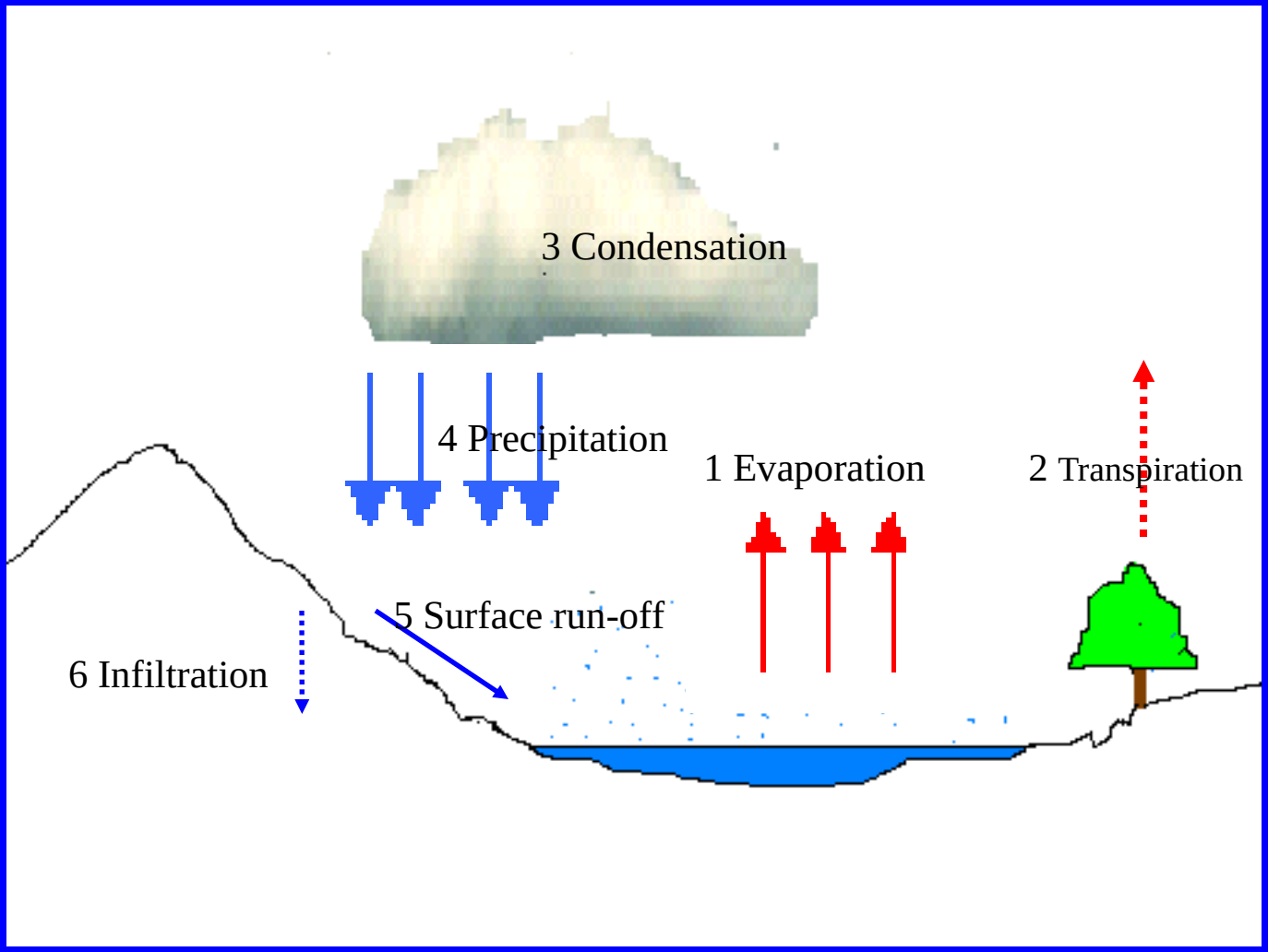
Sustainable tillage

Toxic wastes

Source reduction

Subsidy-stress model

Hydrological cycle



20% of rainfall on land runs off to sea

80% recharges the surface and groundwater reservoirs

1) Evaporation

Due to the influence of sunlight the water in oceans and lakes will warm up. As a result of that it will evaporate and rise up into the atmosphere.
The evaporation of oceans is the most important kind of evaporation.

2) Transpiration

Plants and other forms of vegetation take up water from the soil and excrete it again as water vapour. About 10% of the precipitation that falls on the ground vapourizes again through transpiration of plants, the rest evaporates from seas and oceans.

3) Condensation

In contact with the atmosphere the water vapour will transform back to liquid, so that it will be visible in the air. These accumulations of water in the air are what we call clouds.

4) Precipitation

Transported through the circulating atmosphere the clouds move themselves inland, as a result of gravity, and lose their water as it falls back unto the ground. This phenomenon is called rain or precipitation.

5) Surface run-off

The rainwater that does not infiltrate into the soil will directly reach the surface water, as it will run-off to rivers and lakes. After that it will be transported back to the seas and oceans. This water is called surface run-off.

6) Infiltration

Rainwater infiltrates into the ground and sinks to the saturated zone, where it becomes groundwater. Groundwater slowly moves from places of high elevation and pressure to places with low elevation and pressure. It moves from the area of infiltration through an aquifer and out to a discharge area, which can be either a sea or an ocean.

Groundwater

Water bearing rocks or aquifers are important underground reservoirs

Unconfined

Aquifer is exposed to the surface

recharges freely

water rises to the level of water table (the depth at which air spaces in soil saturated with water)

pumping necessary to bring water to the surface)

Confined

Occur in a syncline (between two impermeable rocks)

Water rises to piezometrik surface (artesian well)

Perched

Localised

Above a layer of impermeable clay

Groundwater is increasingly being used by humans for irrigation, industry and drinking water

Problems:

The lack of groundwater recharges and toxic contamination

Salinization (sea water incursion in coastal areas)

LAND & WATER RESOURCES OF TURKEY

LAND RESOURCES (million ha)

Area of Turkey (projection area) 77,95
Agricultural Land 28,05
Irrigable Land 25,85
Economicaly 8,50
Irrigation Land Developed by DSI (net area as of 2001).....2,334

WATER RESOURCES

Mean (arithmetic) Annual Precipitation ..... 642,6 mm
Mean Annual Volume of Precipitation ..... 501,0 km^3

SURFACE WATERS

Annual Surface Runoff.....186,05 km^3
Annual Surface / Rainfall Ratio 0,37
Annual Depletible Volume..... .95,00 km^3
Actual Annual Utilization ....33,90 km^3

GROUNDWATERS

Annual Extractable (available) Groundwater Reserve.....13,66 km^3
(Annual Safe Yield)
Annual Volume Allocated by DSI ..... 10,39 km^3
Actual Annual Utilization .....6,23 km^3

1 km^3 = 1 billion m^3

Water Quantities Per Capita in Some Water-Rich And Middle East Countries for the year 1993

(cubic meters per year per capita)

Water-Rich Countries(7)	10 000
Iraq(8)	2 110
Turkey(8)	1 830
Syria(8)	1 420
Israel(9)	300
Jordan(9)	250
Palestine(9)	100

Biogeochemical cycles

Biogeochemistry:

Study of exchange of materials between the living and non-living components of the biosphere

Natural recycling: It is driven by sunlight

Artificial recycling: with the help of additional work.

Work energy has to be available at a cost not exceeding the value of recycled product

Two basic types of cycles

Gaseous: large reservoirs in atmosphere. Limiting factor for primary production in sea.

Sedimentary type: reservoirs in soil and sediment. Limiting factor for fresh water.

Nitrogen Cycle

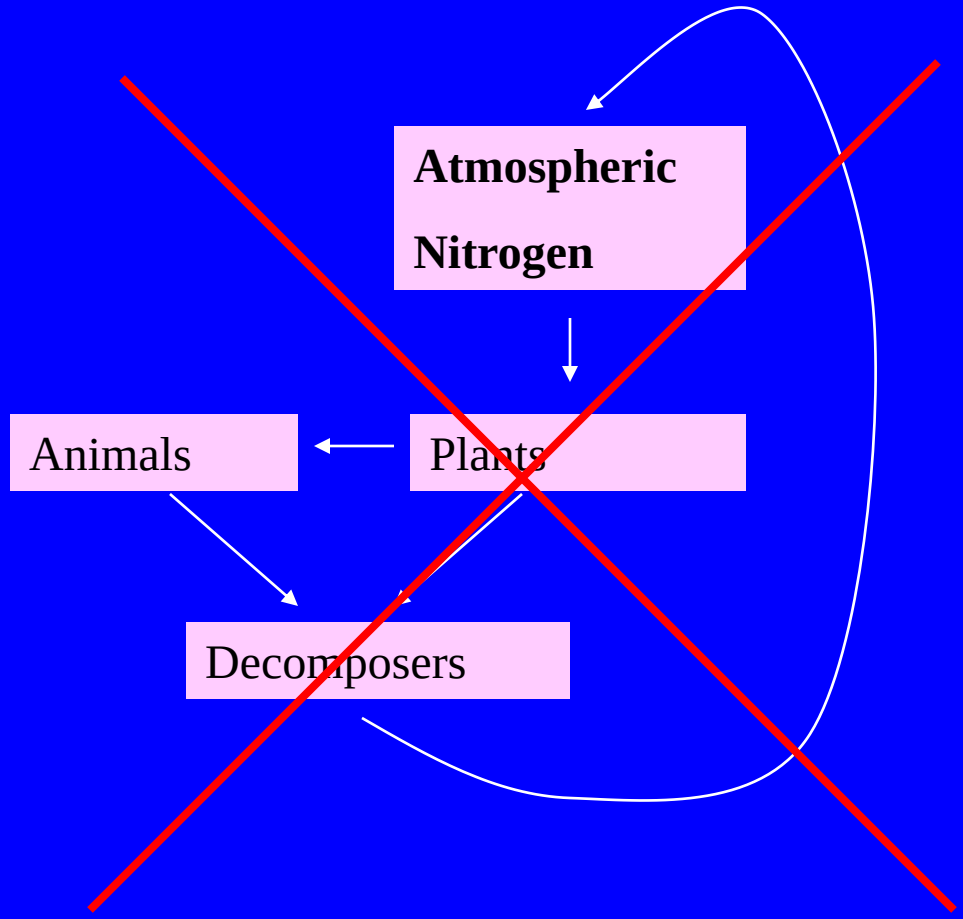
Vital organic compounds in microrganisms, such as amino acids, proteins and DNA contain nitrogen.

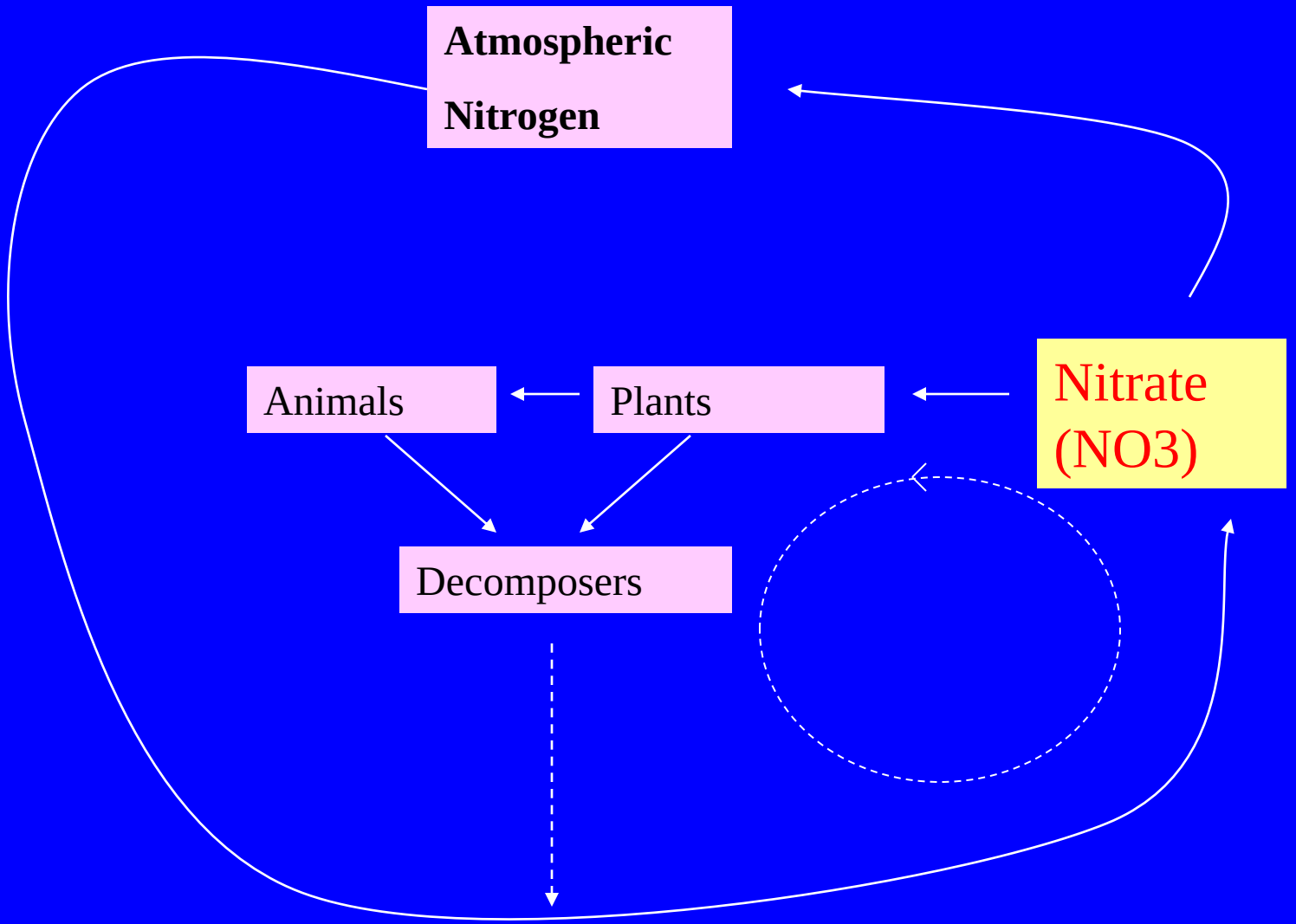
Nitrogen in its gaseous form (N_2), makes up 78% of the troposphere.

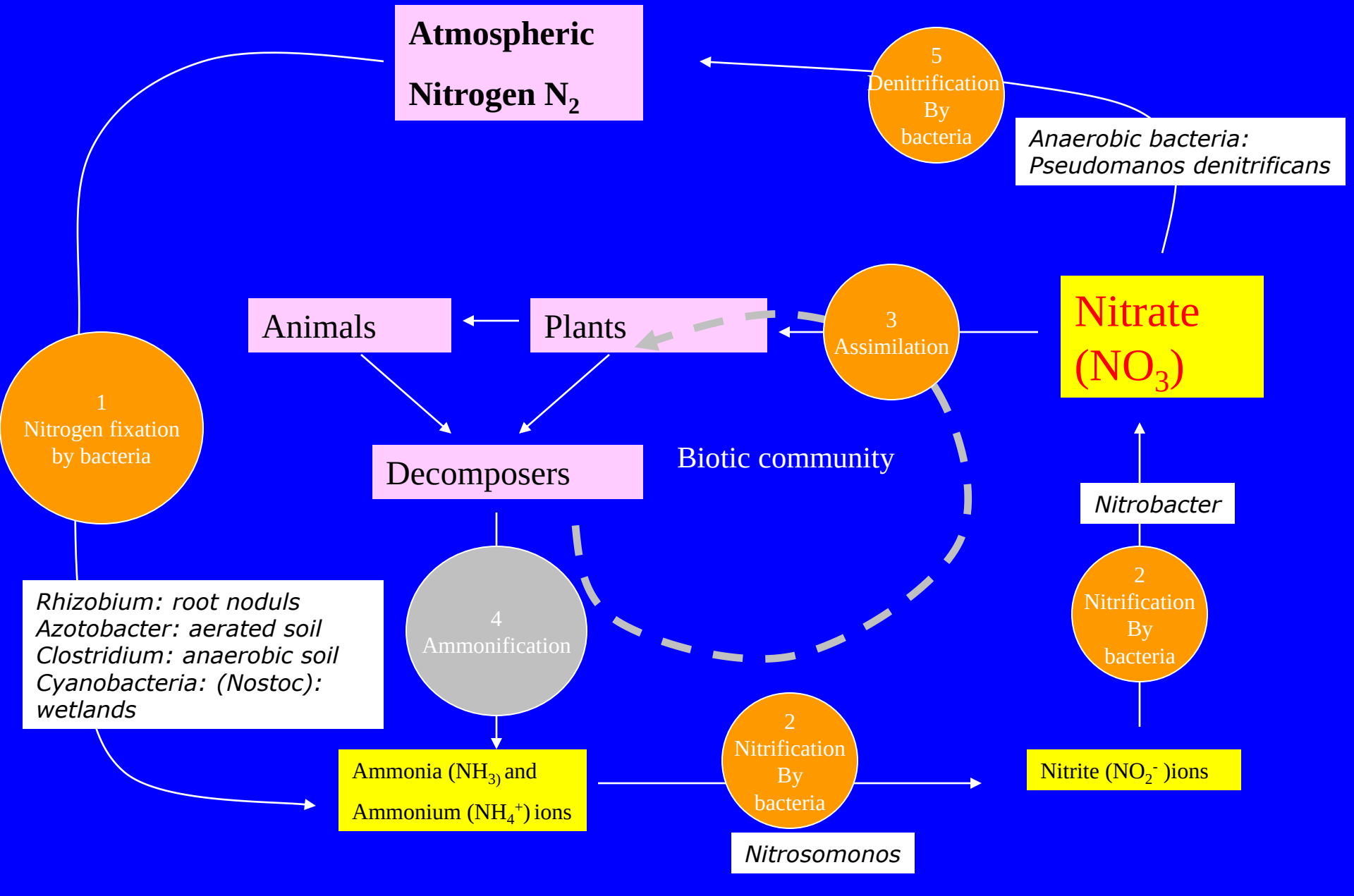
Nitrogen in the gaseous form cannot be absorbed and used as a nutrient by plants and animals; it must first be converted into ammonium ion $\mathbf{NH_4^-}$ and nitrate $\mathbf{NO_3^-}$ by nitrifying bacteria.

Steps in the cycle:

1. Nitrogen fixation (ammonia and ammonium)
2. Nitrification (nitrate)
3. Assimilation (ammonium and nitrate)
4. Ammonification
5. Denitrification


Atmospheric
Nitrogen
Animals
Plants
Decomposers


Atmospheric
Nitrogen
Animals
Plants
Nitrate
(NO3)
Decomposers


Atmospheric
Nitrogen N_2
5
Denitrification
By
bacteria
Anaerobic bacteria:
Pseudomanos denitrificans
Animals
Plants
3
Assimilation
Nitrate
(NO_3)
1
Nitrogen fixation
by bacteria
Decomposers
Biotic community
Nitrobacter
2
Nitrification
By
bacteria
Rhizobium: root noduls
Azotobacter: aerated soil
Clostridium: anaerobic soil
Cyanobacteria: (Nostoc):
wetlands
4
Ammonification
Ammonia (NH_3) and
Ammonium (NH_4^+) ions
2
Nitrification
By
bacteria
Nitrite (NO_2^-)ions
Nitrosomonos

1) Nitrogen fixation : (*by Rhizobium: root noduls, Azotobacter: aerated soil, Clostridium: anaerobic soil, Cyanobacteria: (e.g.Nostoc): wetlands*)

$\mathbf{N_2 + 3\ H_2 \longrightarrow 2\ NH_3}$ **(NH_3 : ammonia**)

2) Nitrification (*by aerobic bacteria*)

$\mathbf{2\ NH_3 + 3O_2 \longrightarrow 2\ NO_2^- + 2\ H^+ + 2\ H_2O}$

(*NO_2:nitrite by nitrosomanos*)

$\mathbf{2\ NO_2^- + \ O_2 \longrightarrow 2\ NO_3^-}$

(*NO_3^-:nitrate by nitrobacter*).

3) Assimilation

Ammonium ions (step 4) **and nitrate** (step 2) are absorbed by plants during the assimilation process, later converted into nitrogen-containing organic molecules, such as amino acids and DNA.

Animals receive their nutrient supplies indirectly by consuming plants or plant-consuming animals.

4) Ammonification

When nitrogen nutrients have completed their function in plants and animals, specialized decomposing bacteria will start a process called ammonification, to convert them back into **ammonia** and water-soluble **ammonium salts**→*NH_4^+: ammonium ion.*

5) Denitrification

After the nutrients are converted back into nitrate, anaerobic bacteria will convert them back into nitrogen gas.

The nitrogen will than be released into the atmosphere again. The whole process will start over after release

Nitrogen as a limiting factor

Although the nitrogen conversion processes will often take place and large quantities of plant nutrients are produced, nitrogen is often a limiting factor for plant growth. This is caused by water flowing across the soil. Nitrogen nutrients are water-soluble and as a result they will be easily drained away, so that they are no longer available for plants.

Sulfur Cycle

Sulfur is one of the components that make up proteins and vitamins. Proteins consist of amino acids that contain sulfur atoms.

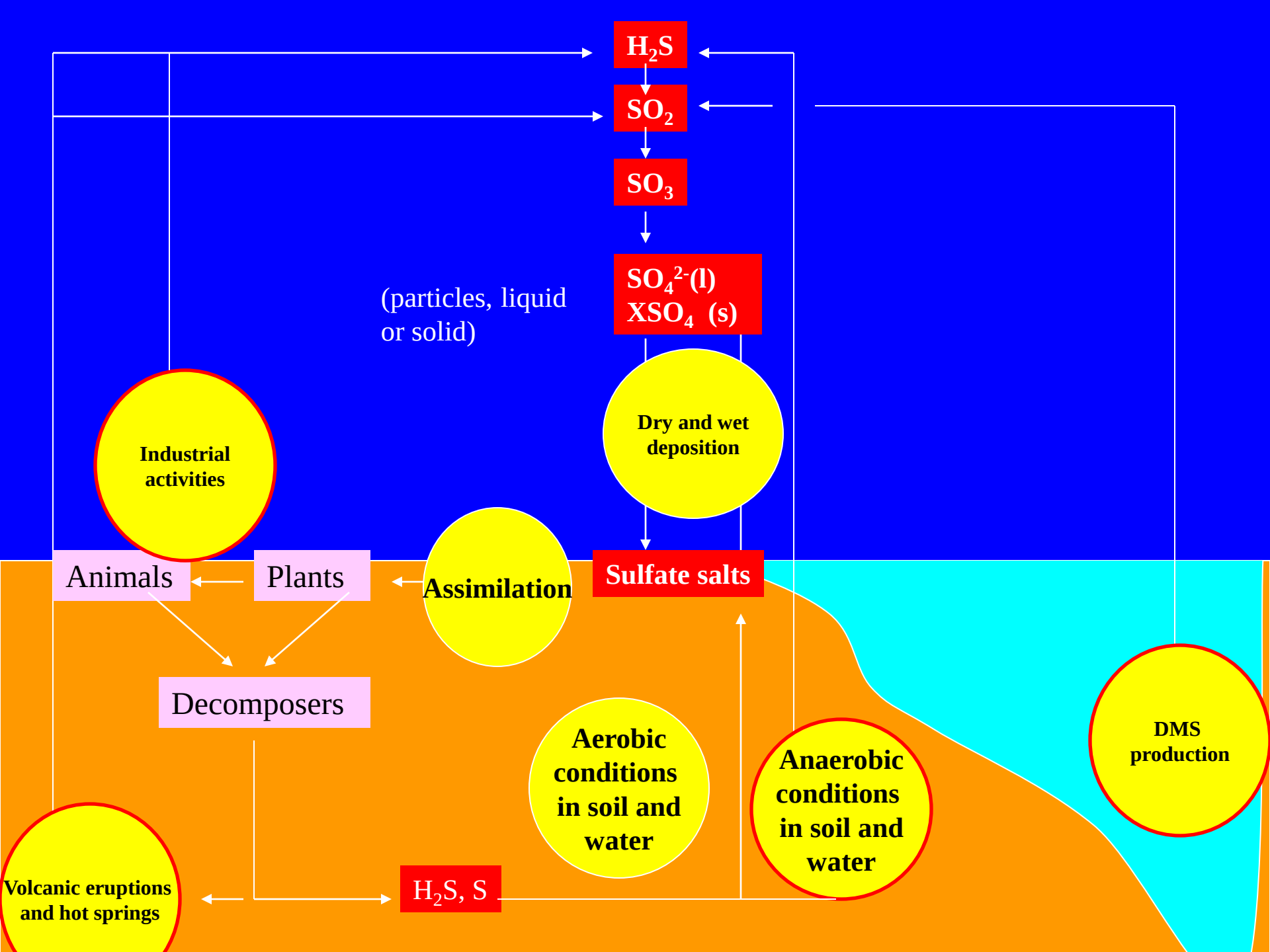
Plants absorb sulfur when it is dissolved in water. Animals will consume these plants, so that they will take up sulfur into their bodies.

Most of the earth's sulfur is tied up in rocks and salts or buried deep in the ocean in oceanic sediments.

Atmospheric sulfur:
***Natural sources*: volcanic eruptions, bacterial processes, evaporation from water, or decaying organisms,**
***Man made*: industrial processes, sulfur dioxide (SO_2) and hydrogen sulphide (H_2S)**

When sulfur dioxide enters the atmosphere it will react with oxygen to produce sulfur trioxide gas (SO_3), or with other chemicals in the atmosphere, to produce sulfur salts. Sulfur dioxide may also react with water to produce sulphuric acid (H_2SO_4). Sulphuric acid and sulfates may also be produced from demethylsulphide (DMS), which is emitted to the atmosphere by plankton species.

All these particles will settle back onto earth, or serve as cloud condensation nuclei (CCN), react with rain and fall back onto earth as acid deposition or in salt form. The particles will than be absorbed by plants again and are released back into the atmosphere via decaying processes, so that the sulfur cycle will start over again.


H_2S
SO_2
SO_3
SO_4^{2-}(l)
XSO_4 (s)
(particles, liquid or solid)
Dry and wet deposition
Industrial activities
Animals
Plants
Assimilation
Sulfate salts
Decomposers
Aerobic conditions in soil and water
Anaerobic conditions in soil and water
DMS production
Volcanic eruptions and hot springs
H_2S, S

The phosphorus cycle

Phosphorus is an essential nutrient for plants and animals in the form of ions PO_4^{3-} and HPO_4^{2-}. It is a part of DNA-molecules, molecules that store energy (ATP and ADP) and fats of cell membranes. Phosphorus is also a building block of certain parts of the human and animal body, such as the bones and teeth.

Phosphorus can be found on earth in water, soil and sediments.

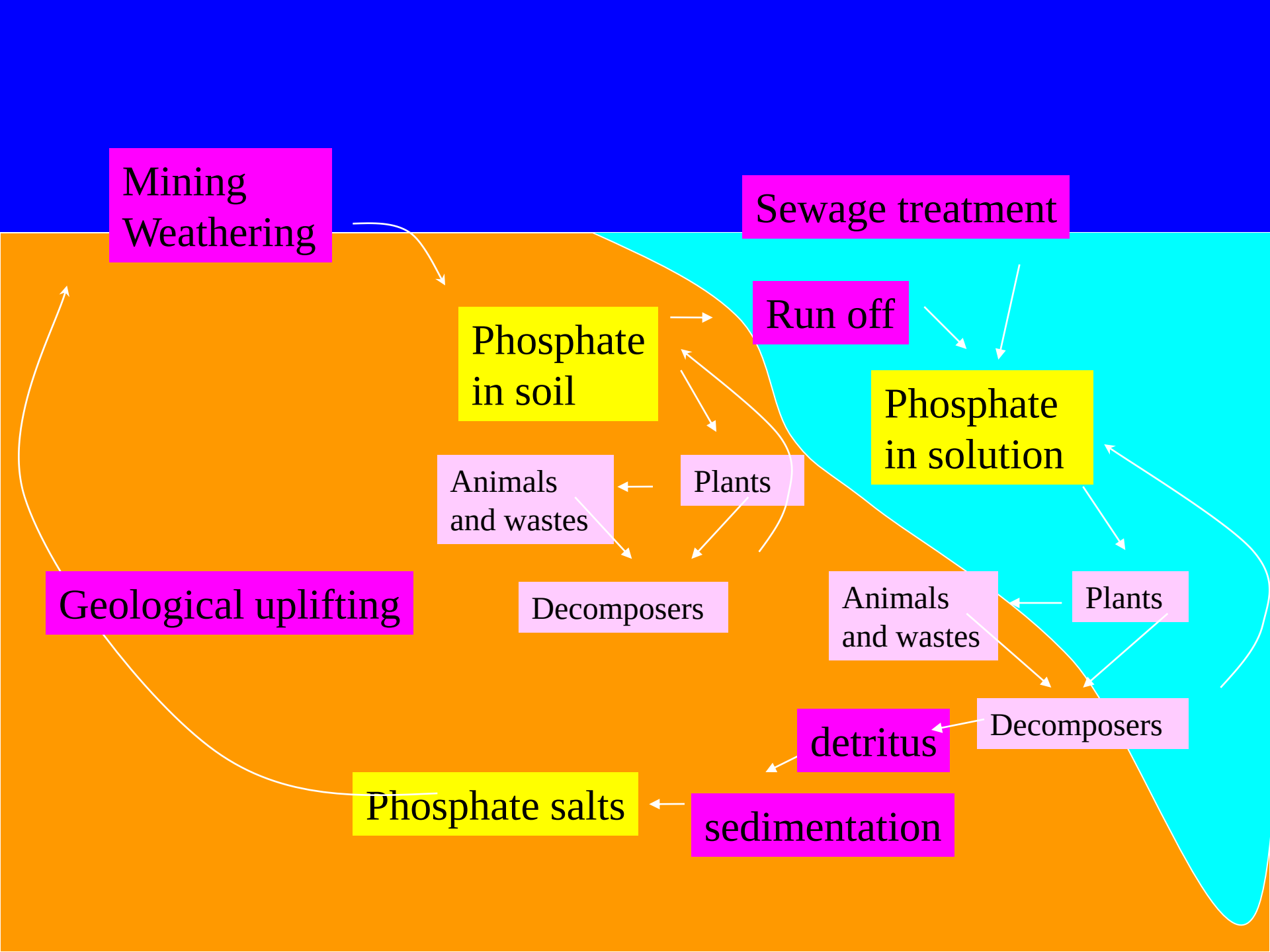
Unlike the compounds of other matter cycles *phosphorus cannot be found in air in the gaseous state*. This is because phosphorus is usually liquid at normal temperatures and pressures.

It is mainly cycling through water, soil and sediments.

In the atmosphere phosphorus can be found as very small dust particles. Phosphorus moves slowly from deposits on land and in sediments, to living organisms, and than much more slowly back into the soil and water sediment. The phosphorus cycle is the slowest one of the matter cycles that are described here.

Phosphorus is most commonly found in rock formations and ocean sediments as phosphate salts. Phosphate salts that are released from rocks through weathering usually dissolve in soil water and will be absorbed by plants. Because the quantities of phosphorus in soil are generally small, it is often the limiting factor for plant growth. That is why humans often apply phosphate fertilizers on farmland. Phosphates are also limiting factors for plant-growth in marine ecosystems, because they are not very water-soluble.

Animals absorb phosphates by eating plants or plant-eating animals. **Phosphorus cycles through plants and animals much faster than it does through rocks and sediments.** When animals and plants die, phosphates will return to the soils or oceans again during decay. After that, phosphorus will end up in sediments or rock formations again, remaining there for millions of years. Eventually, phosphorus is released again through weathering and the cycle starts over.


Mining
Weathering
Sewage treatment
Run off
Phosphate
in soil
Phosphate
in solution
Animals
and wastes
Plants
Geological uplifting
Decomposers
Animals
and wastes
Plants
Decomposers
detritus
Phosphate salts
sedimentation

Carbon Cycle

Carbon is a very important element, as it makes up organic matter, which is a part of all life.

Carbon follows a certain route on earth, which is called the carbon cycle.

Through following the carbon cycle we can also study energy flows on earth, because most of the chemical energy needed for life is stored in organic compounds as bonds between carbon atoms and other atoms.

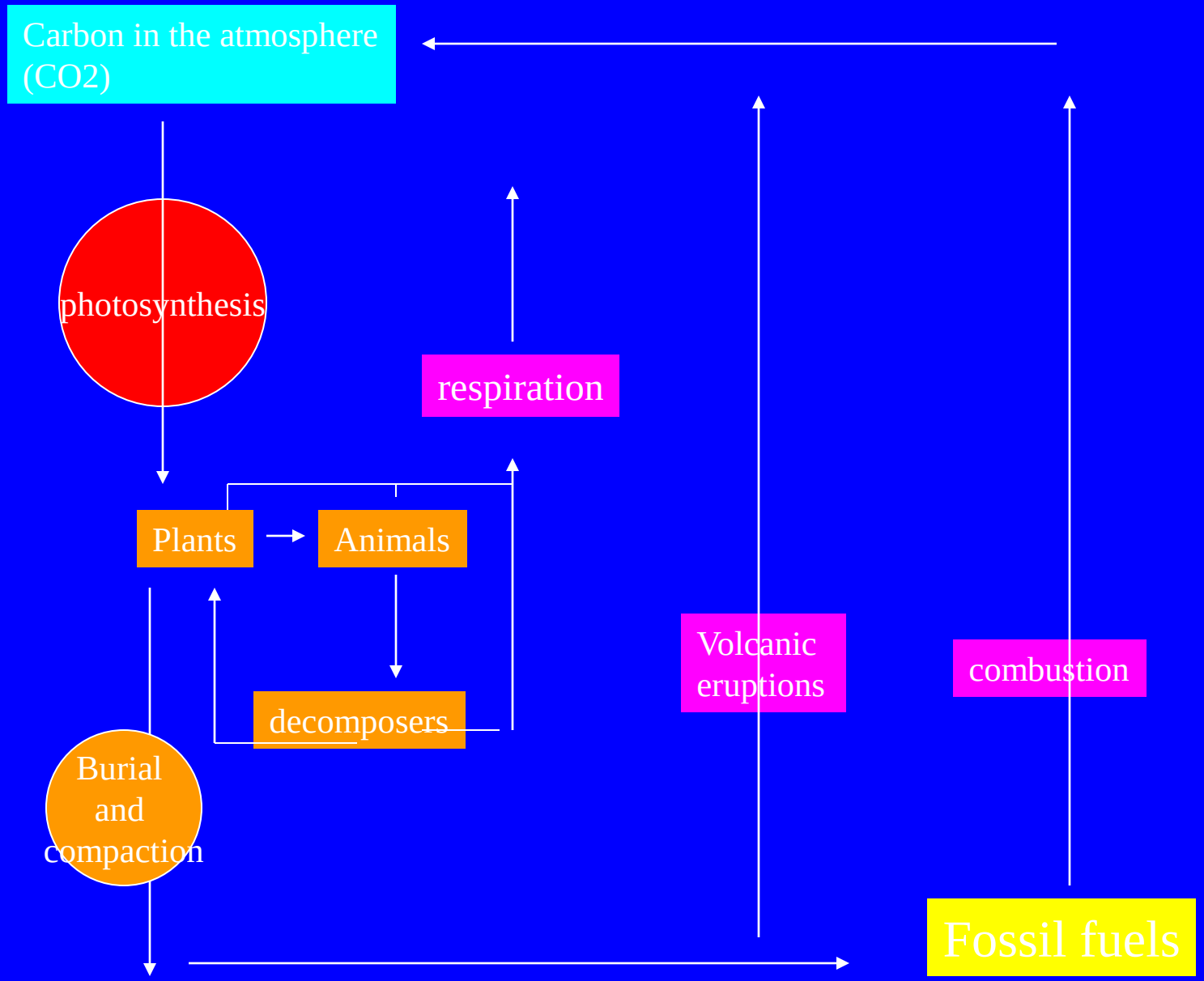
The carbon cycle is based on carbon dioxide (CO_2), which can be found in air in the gaseous form, and in water in dissolved form.

The carbon cycle naturally consists of two parts:

the terrestrial carbon cycle

the aquatic carbon cycle.

Terrestrial plants use carbon dioxide from the atmosphere, to generate oxygen that will sustain animal life. Aquatic plants also generate oxygen, but they use carbon dioxide from water.


Carbon in the atmosphere (CO2)
photosynthesis
respiration
Plants
Animals
decomposers
Burial and compaction
Volcanic eruptions
combustion
Fossil fuels

The aquatic carbon cycle

In the aquatic ecosystem carbon dioxide can be stored in rocks and sediments. It will take a long time before this carbon dioxide will be released, through weathering of rocks or geologic processes that bring sediment to the surface of water.

Carbon dioxide that is stored in water will be present as either carbonate or bicarbonate ions. These ions are an important part of natural buffers that prevent the water from becoming too acidic or too basic. When the sun warms up the water carbonate and bicarbonate ions will be returned to the atmosphere as carbon dioxide.

Resources out of place - Pollutants

SO_2, NO_x, CO_2 take place in natural cyles

Man-made contributions alter the natural cycles

combustion of fossil fuels

coal : SO_2

gasoline-industrial combustion

natural gas : NO_x

Other pollutants

Volatile organic compounds, greenhouse gases

Scale of pollution

Local

- air pollution
- deposition (dry/wet)

Regional

- acidic deposition

Global

- Global warming
- Ozone depletion

Nutrient Cycling in nutrient poor soils

Soils in tropical areas are quite poor
However luxuriant forests are able to persists

Because of efficient biotic recycling mechanisms
less than 50% of nutrients are in soil
other regions more than 90%

Forest removal takes away the the land's ability to hold and recycle nutrients
Any nutrients left is drained away.
Crop production declined, the land is abondoned: shifting agriculture

Biotic mechanisms in tropical forest

Root mats
Mycorrzial fungi
Evergreen leaves
Algae and lichens

aid in keeping nutrients recycling in tropical forest.

Recycling pathways

Recycling paper

- less destruction of forest
- avoiding landfill problem
- save money

Factor compensation

Ecotypes: Species with wide geographic ranges develop locally adapted genetic races or subpopulations.

Different limits of tolerance for

- temperature
- light
- nutrients

Example:

jelly fish (aurelia aurita) can be seen living in warm and cold temperatures

Yarrow: high altitude : short

low altitude : tall

keeps the same behaviour if grown from the seed at the same garden.

Biological clocks

Organisms use natural periodicities in the physical environment to time their activities.

Circadian rhythm: ability to time and repeat functions at about 24 hour intervals.

Photoperiod: the length of day.

timer or trigger that setts off physiological sequences

- growth and flowering
- migration of birds and animals
- diapouse (resting stage of insects)

Amount of rainfall

- spread of seeds