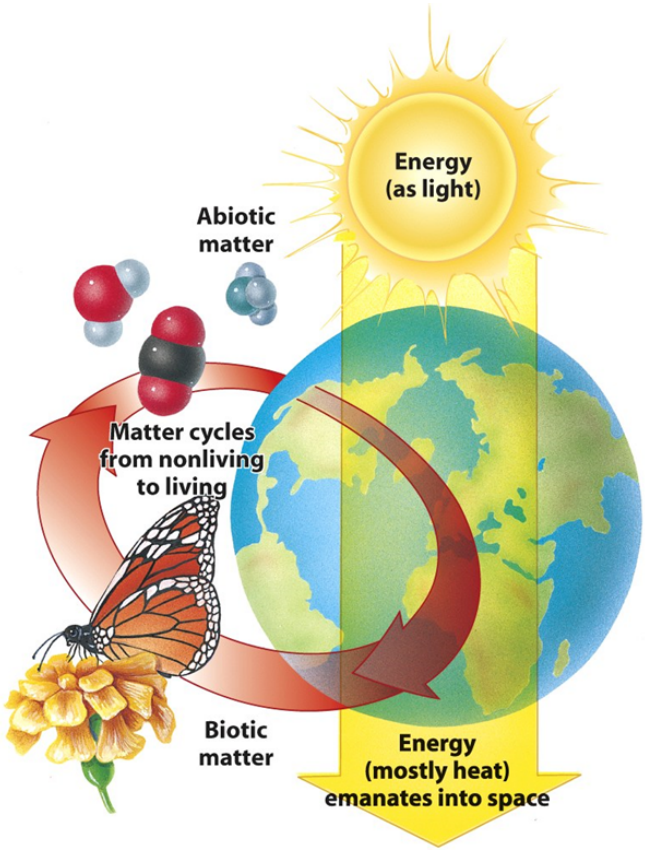
2.3.1 C Cycle

Material flow

- Flow in ecosystem is illustrated by **biogeochemical cycles**
- Matter moves between ecosystems, biotic & abiotic environments, and organisms, unlike energy
- Biogeochemical cycling involves: Biological, geologic and chemical interactions
- Five major cycles: Carbon, Nitrogen, Phosphorus, Sulfur and Water (hydrologic)



Biogeochemical cycles

- Cycles of nutrients in ecosystems are called biogeochemical cycles.
  - carbon cycle (both SL and HL) and
  - nitrogen cycle (HL only).
- The cycling of nutrients is essential in the maintenance of ecosystems because nutrients provide the chemical elements needed for biological molecules. (Carbon is needed for carbohydrates, fats and proteins. Nitrogen is needed for proteins.)

The factors that affect the store of nutrients and their transfer include:

- ?

The factors that affect the store of nutrients and their transfer include:

- the amount and type of weathering
- overland run-off and soil erosion
- the amount of rainfall
- rates of decomposition
- the type of vegetation (woody perennial species hold onto nutrients for much longer than annuals)
- the age and health of plants
- plant density
- fire.

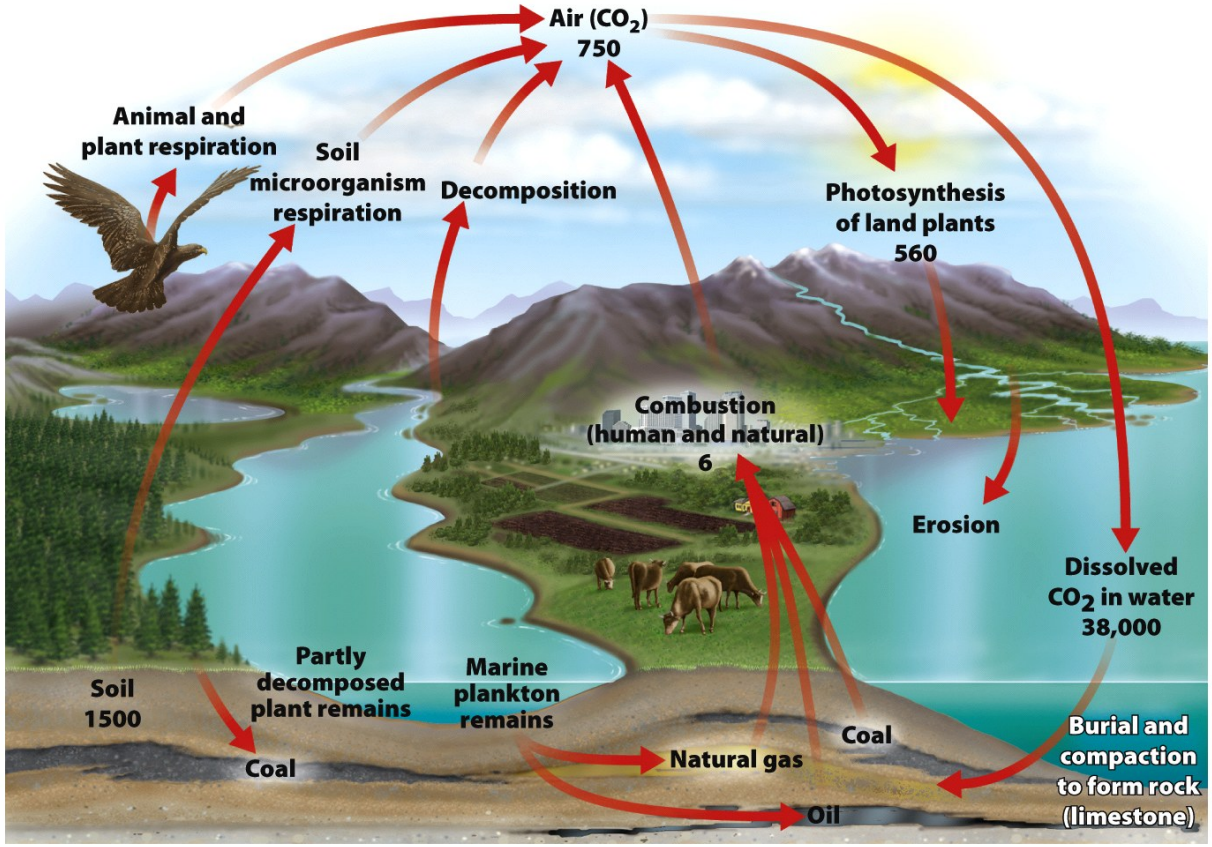
Carbon

- All living things are composed of carbon
- 0.037% of the atmosphere (approximately) is composed of carbon as a gas, CO_2
- It is present in the oceans in several forms:
- Carbonate- CO_3, and Bicarbonate HCO_3

Storages in the carbon cycle include:
- organisms and forests (both organic)
- atmosphere, soil, fossil fuels, oceans (all inorganic)

Flows in the carbon cycle include:
- consumption (feeding), death and decomposition, photosynthesis, respiration, dissolving and fossilization

The Carbon Cycle : Simplified



Units are expressed as 10^{15}g of carbon. Notice that sedimentary rocks and fossil fuels hold almost all of the worlds carbon…hmm…

Residence time is the average period that a carbon atom remains in a store. Without human interference (i.e. mining) the residence time of carbon in fossil fuels, such as coal, could be measured in hundreds of millions of years

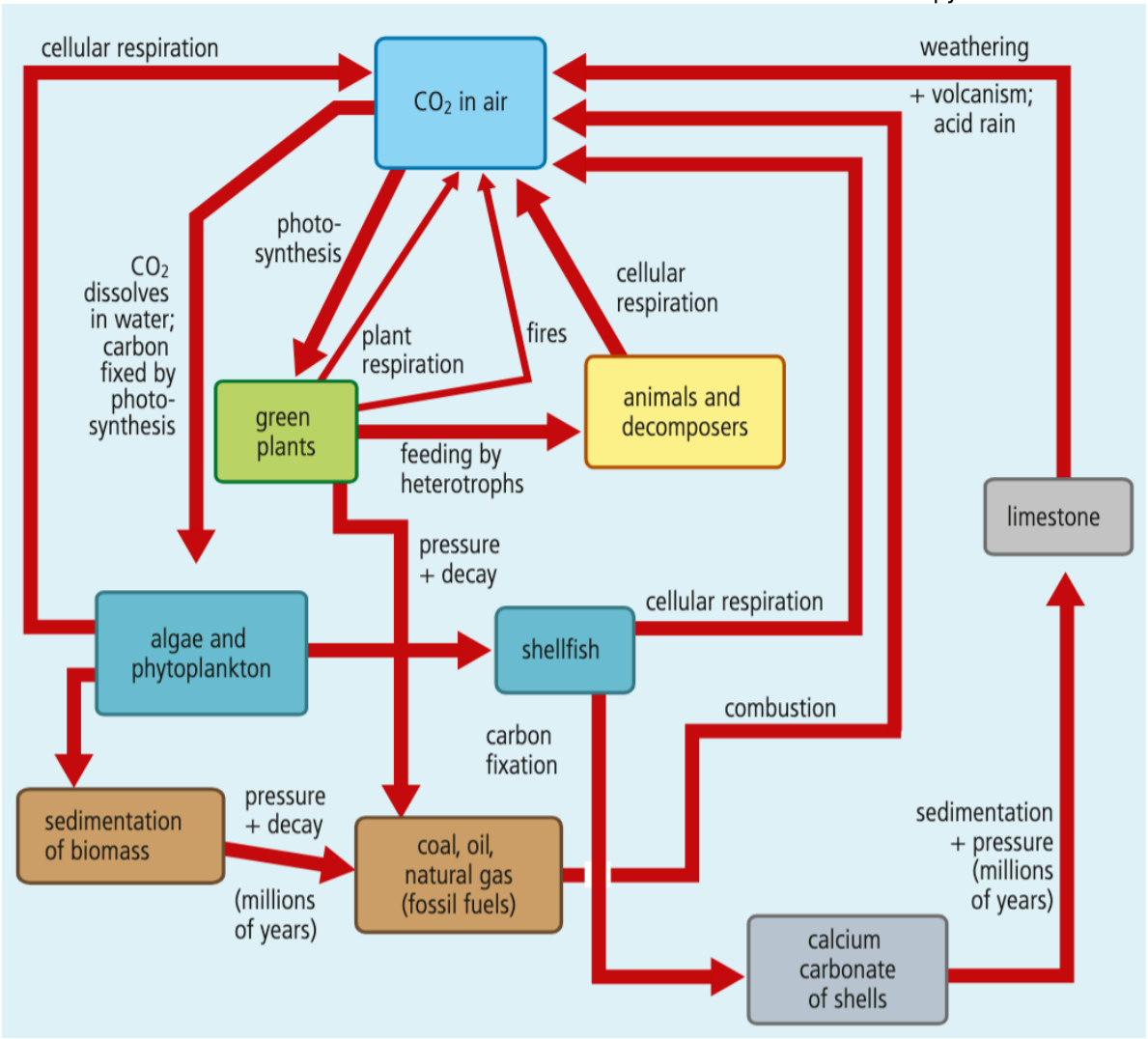
C Cycle

Transfers in the carbon cycle include:

- herbivores feeding on producers
- carnivores feeding on herbivores
- decomposers feeding on dead organic matter.

Transformations in the carbon cycle include:

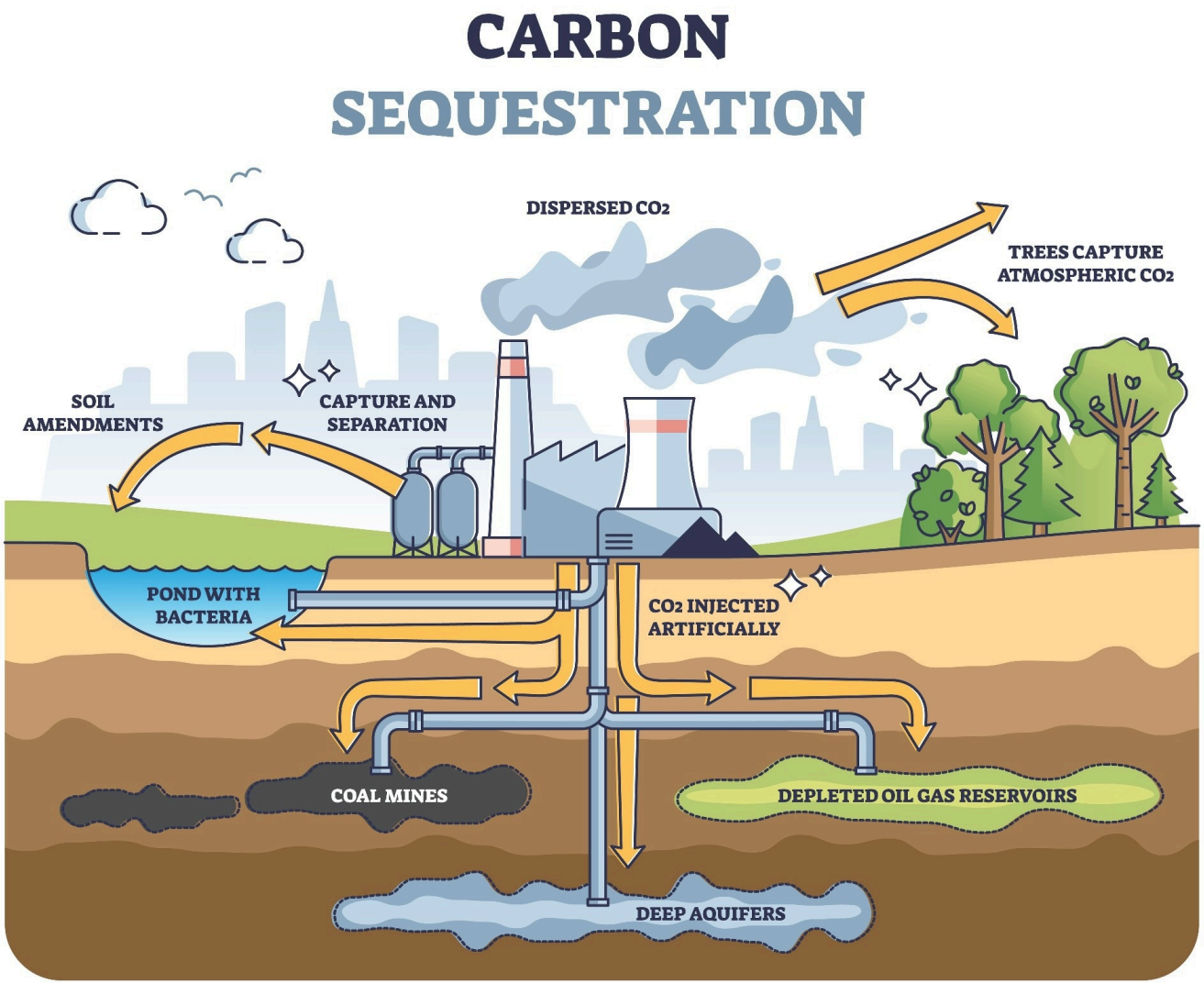
- photosynthesis, involving the conversion of inorganic CO_2 and water into organic glucose using sunlight energy trapped by chlorophyll
- cellular respiration, involving the conversion of organic glucose into inorganic CO_2 and water
- dissolution of CO_2 from the atmosphere into the oceans
- conversion of organic biomass into CO_2 and water during combustion
- fossilization of organic matter in dead organisms into fossil fuels through incomplete decay and pressure.



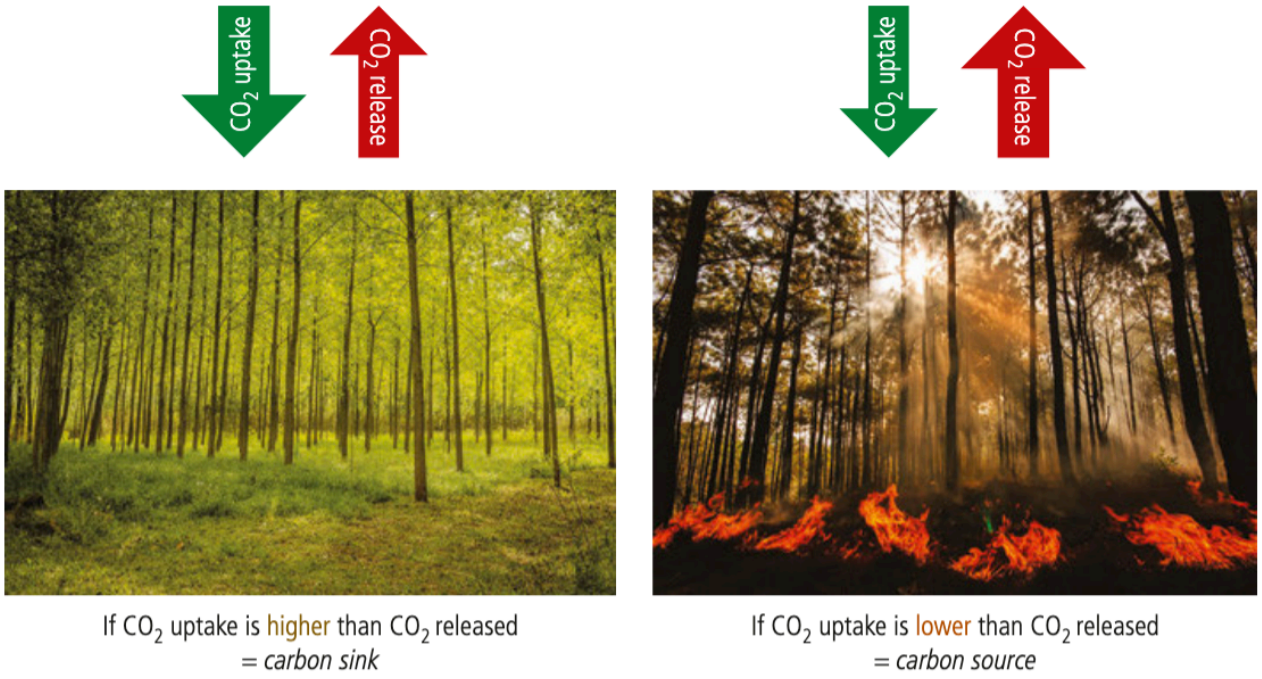
Carbon sequestration is the natural capture and storage of CO 2 from the atmosphere by physical or biological processes such as photosynthesis.

Trees sequester carbon naturally by absorbing CO2 and converting it into biomass.

Organic matter is fossilized into coal, oil and natural gas.



Ecosystems as stores, sinks or sources of carbon



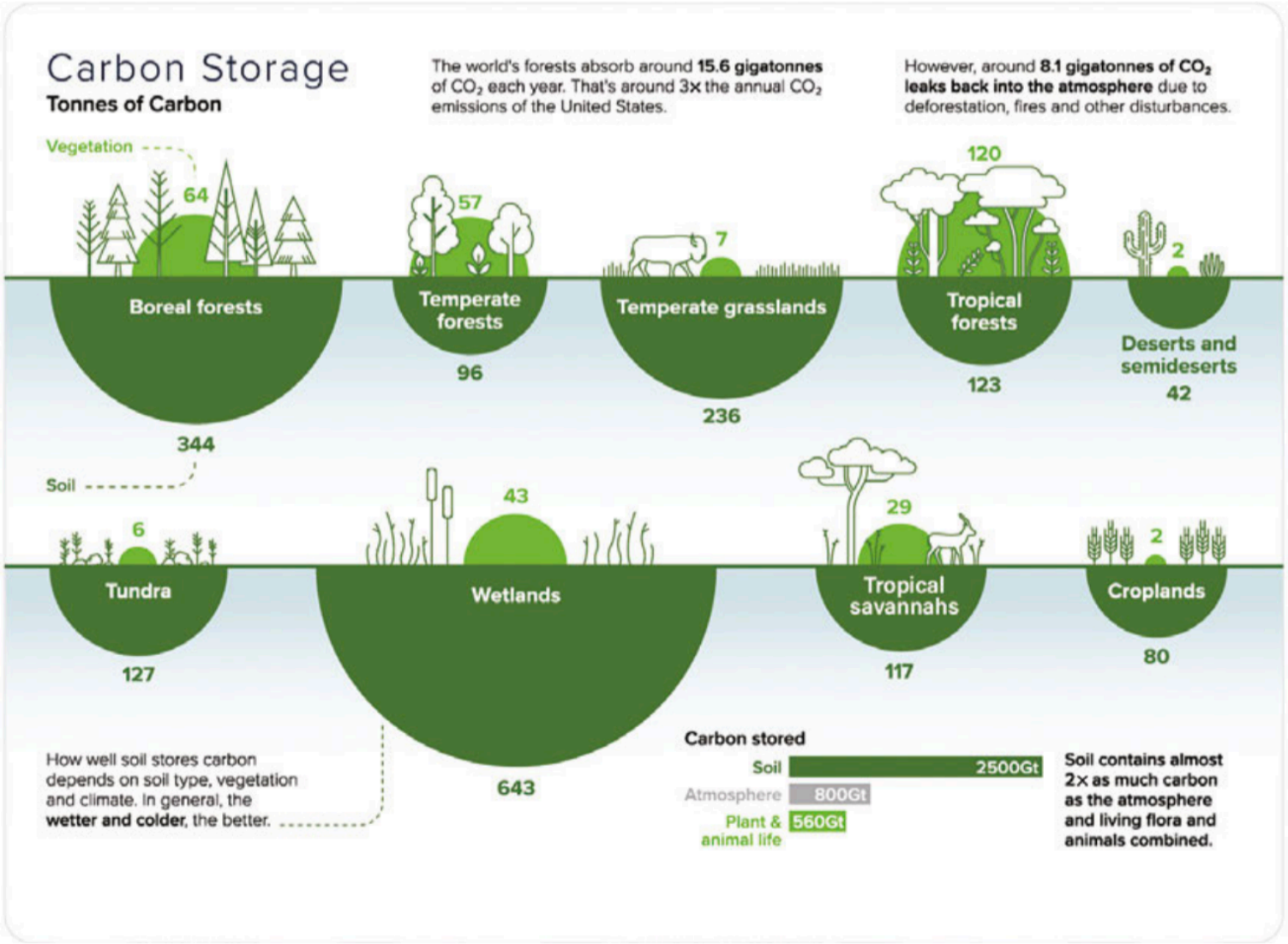
If CO_2 uptake is higher than CO_2 released
= *carbon sink*

If CO_2 uptake is lower than CO_2 released
= *carbon source*

Carbon is stored in..

- the soil of an ecosystem,
- the biomass (e.g. trunk, leaves and roots) and
- dead biomass (e.g. woody debris and leaf litter).

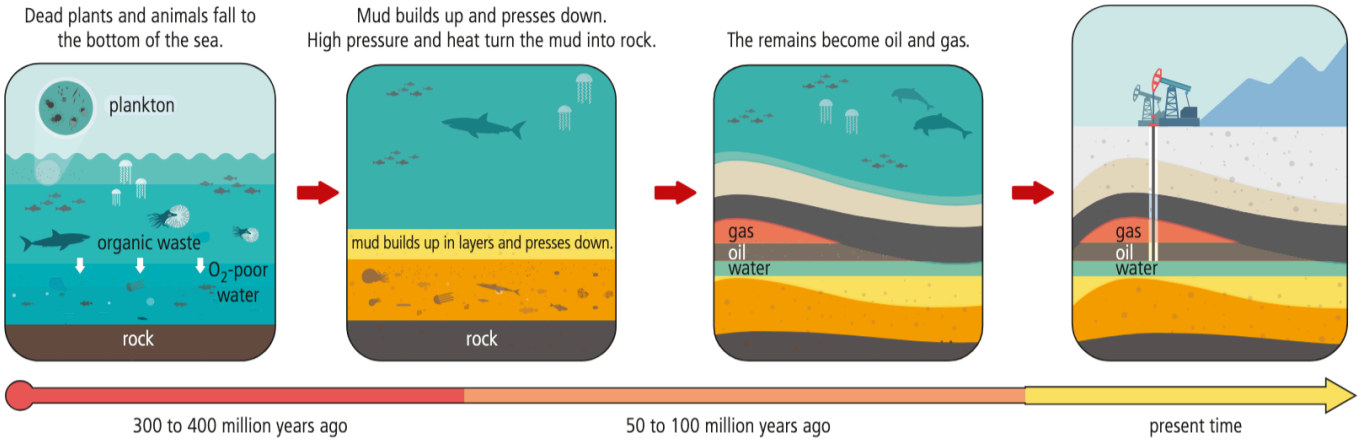
The largest land storage of carbon is in the soil



Storage of carbon in ecosystems. Numbers are average stored carbon in tonnes per hectare

Key:
- Soil
- Plants and animals

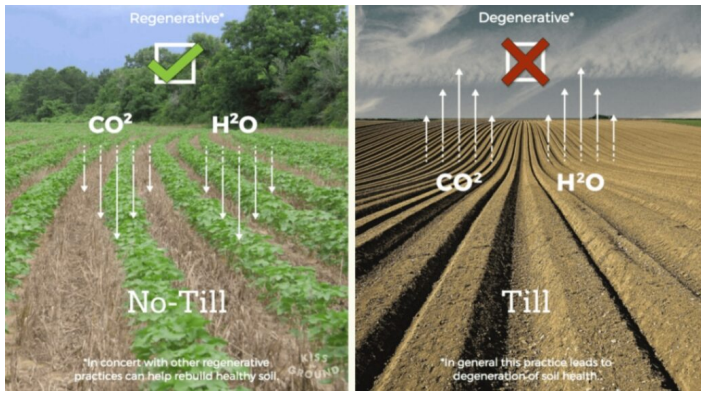
Fossil fuels as stores of carbon



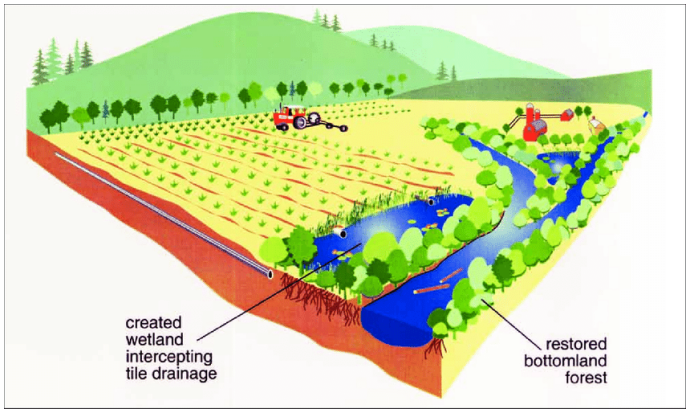
unlimited residence times

Agricultural systems

Regenerative agricultural methods such as crop rotation, cover crops and no till, preserve soil structure and maintain carbon in soil, promoting the role of soil as a carbon sink



Drainage of wetland, monoculture and heavy tillage will result in the agricultural system becoming a carbon source



Oceans as a carbon sink

- CO_2 moves from the atmosphere to the ocean by a process called diffusion.
- CO_2 dissolved in the surface of the ocean can be transferred to the deep ocean in areas where cold dense surface waters sink.
- This process carries CO_2 molecules to great depths in the ocean where they may remain for centuries.
- The level of CO_2 diffusion also determines the acidity of the oceans

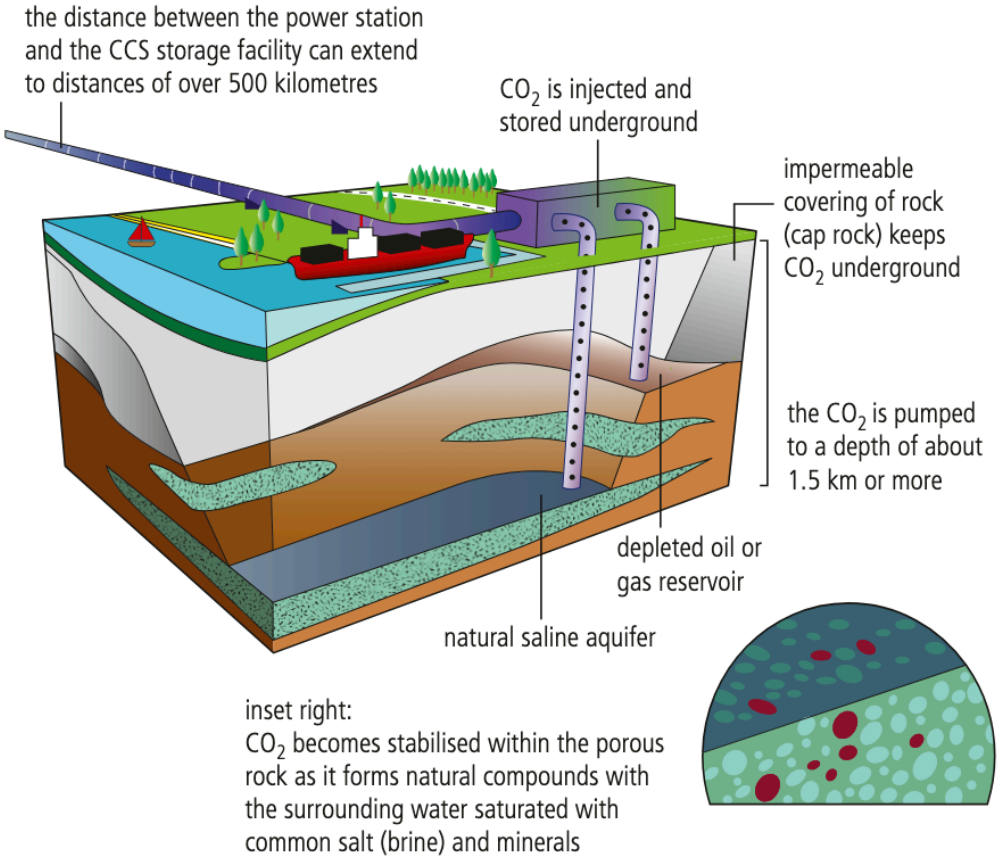
Ocean acidification

- CO_2 dissolves in water to form hydrogencarbonate ions and hydrogen ions, which make the water more acidic.
- Increases in the concentration of dissolved CO_2 , therefore, cause ocean acidification, which in turn harms marine animals
- Coral reefs are made of calcium carbonate ($CaCO_3$).
- A decrease in pH, meaning an increase in acidity, can lead to reduced calcification rates and destruction of coral reefs as the acid reacts with the alkali coral skeleton.
- Small decreases in pH can also interfere with calcium carbonate deposition in aquatic mollusc shells, which are also made from calcium carbonate

Alleviating the effects of human activities on the carbon cycle

Measures that are required to alleviate the effects of human activities on the carbon cycle include

- Low carbon technologies. These are renewable energy resources such as solar heating, air-source heat pumps, ground-source heat pumps, biomass heating, solar panels, photovoltaics (PV), and wind turbines.
- Reduction in the use of fossil fuels. A reduced combustion of fossil fuels will reduce CO2 emissions.
- Reduction in soil disruption. The majority of carbon in ecosystems is stored in soil, so conserving soils is an important way of reducing carbon emissions.
- Reduction in deforestation. Trees are an important store and sink of carbon, so maintaining forest ecosystems maintains the equilibrium of the carbon cycle.
- Carbon capture through reforestation and artificial sequestration. Carbon capture is the process of capturing CO2 and depositing it where it will not enter the atmosphere



Carbon capture and storage

Methane

- Methane (CH_4) is a colourless gas produced from dead organic matter in anaerobic conditions by methanogenic bacteria (i.e. bacteria which release CH_4 as a waste product).
- The production of CH_4 is known as methanogenesis.
- CH_4 accumulates in the ground in porous rocks, under permafrost in decomposing plant material or underwater, but may diffuse into the atmosphere.
- In air and light, CH_4 is oxidized to CO_2 and water.
- Anaerobic conditions suitable for methanogenesis occur in swamps, rice paddies and the stomachs of cattle and other ruminants. Cattle alone emit between 65 and 85 million tonnes of CH_4 per year, produced by methanogenic bacteria in their stomachs.
- Natural wetlands and paddy fields are another important source – paddy