24.11.06 earth science: biogeochemical cycles

- Bio-geo-chemical cycles: bio=life, geo=earth, chemical=chemical
- These are cycles as the go from some reservoir through the environment and back
- These are known as sources and sinks
- Often the reservoir will be the key to identifying the cycle

Carbon cycle: air and living things

Unavailable Apple Wiki media: the exported data did not include file dca21605-3090-4a29-adc9-26202d2432b3.

Notice:

- fast processes involve living things (you eat sugar, exhale **carbon** dioxide)
- slow processes involve minerals, rocks and soil, **hydrocarbons**, and the oceans
- photosynthesis: light energy creates chemical energy (e.g. sugar)
- respiration: oxygen combines with sugar or other **carbon** fuel, releasing carbon dioxide and energy
- chemosynthesis: same process only using heat instead of light, sulfur instead of oxygen (look on periodic table)
- aerobic respiration: uses oxygen
- anaerobic respiration: uses **carbon** based fuels without oxygen, much less efficient
- **carbon** stored in the ocean as carbonate (H_2CO_3 or carbonic acid)
- **carbon** stored in corals as $CaCO_3$ (calcium carbonate)
- **carbon** sediments can turn into fossil fuels (coal, oil, natural gas) with time, heat and pressure
- steady state: sources and sinks are equal
- fossil fuel extraction: combines with oxygen to form **carbon** dioxide and energy (reverse of photosynthesis)
- released **CO_2** increases the heating of the earth:

Unavailable Apple Wiki media: the exported data did not include file 35f2ee0e-239c-4f70-8abb-f3fa45b24157.

This has caused the planet to warm like a greenhouse, since fossil fuels were used as fuel (coal, then oil and natural gas):

Unavailable Apple Wiki media: the exported data did not include file 7770b7d7-b17c-454c-a700-b1f19621b9dd.

How fast is this changing?:
In 1990, the CO2 parts per million was increasing 0.4 ppm/year
In 2025, it is increasing 2.5 ppm per year
54% of the CO2 in the atmosphere has been added since ~1975
OMG...
A global temp increase of +1.5° by the year 2100 when you are ~80 years old WAS the warming target in 2000
+2° was the next one in 2010...
Latest predictions in 2025: +3° C and perhaps several meters of water rise
Last time the CO2 was this high: prehistoric water levels were 300m higher (Kamuela is at 800m).

Nitrogen cycle: proteins

- **Nitrogen** is in the air as N2, a diatomic molecule
- We can't metabolize this as is, it needs to be incorporated into plants or animals we eat.
- Plants cannot use **nitrogen** directly from the atmosphere, it has be in the form of nitrates ("plants ate nitrate")
- **Nitrogen** goes through many changes to get from the air to food, usually involving oxygen, like nitrates (NO3)
- **Nitrogen** fixation "fixes" nitrogen in the air into forms plants can use, either biotically (living things) or abiotically (not living things)
- **Nitrogen** is the basis for amino acids, and therefore proteins in living thing

Unavailable Apple Wiki media: the exported data did not include file 6f4a56d8-b613-45a0-bba5-c2216f203a53.

Biotic process: Nitrogen fixing, most common

1. **nitrogen** fixing bacteria (often along roots like in bean plants) fix **nitrogen** gas (N2) into ammonia (NH3)
2. this is converted into **ammonium (NH4)** which plants can use

Abiotic (non living) process:

1. lightning or fires have enough energy to combine N2 with O2, making NO3
2. NO3 is carried to the ground with rain (the rain smell)
3. can also be done using the Haber process for chemical nitrate synthesis

Next step: Nitrification
Ammonium needs to be converted to Nitrate for plants ("plants ate nitrate")

1. Ammonium (NH4) converts to nitrite (NO2) (look up sodium nitrite and what is is used for)
2. NO2 converts to NO3 (nitrate) (plants can use this)
3. commercial fertilizers are something with NO3, like NH4NO3, ammonium nitrate (a potent explosive: Beirut port explosion)

Ammonification is when dead organisms return this NH4 back into the ecosystem through denitrification:
NO3 ->N2O->N2 gas

Summary:

1. N2 gas in the air fixed by organisms into ammonia (NH3)
2. Ammonia (NH3)converts into ammonium (NH4)
3. ammonium (NH4) converts into nitrite (NO2)
4. Nitrite (NO2) converts to nitrate (NO3)

so:
N2->NH3->HN4->NO2-NO3 (nitrate)
remember: plants ate nitrate

Unavailable Apple Wiki media: the exported data did not include file 761b1031-43d1-481b-9547-3037f311c882.

Nitrogen is a limiting growth nutrient in ecosystems, excess nitrogen can cause algal blooms:

1. Nitrogen causes algae to bloom
2. Algae dies, falling to the bottom of the water body
3. As it decays, it consumes the Oxygen from the water: dead zones

Phosphorus cycle: energy

- Phosphorus is used as an energy molecule: AMP, ADP, ATP use P bonds to store energy (look these up)
- P is also a key component in DNA and RNA
- P is a limiting nutrient for plants, along with Nitrogen

Phosphorus cycle:

Unavailable Apple Wiki media: the exported data did not include file a7eae3aa-4c8d-4eaa-8219-47c3bec618a4.

Trick AP question: which cycle has no gas phase component?
Answer: Phosphorus, just between land and water

P is carried as dust from the Sahara to the US, and from the Gobi desert to Kauai (!)
Usually in the form of phosphate (PO4)
5 processes:

1. assimilation
2. mineralization
3. sedimentation (like sedimentary rocks)
4. uplift
5. weathering (erosion)

Very little P is found in rivers, so it is a limiting nutrient (eutrophication)
Algal Bloom:

Unavailable Apple Wiki media: the exported data did not include file 07ad3c4c-e68c-48bd-9a26-5f2aeb327fc6.

Dead zone, from watershed:

Unavailable Apple Wiki media: the exported data did not include file 94df6568-b113-4dc9-930b-28e80b0a08ea.

Water (hydrologic) cycle: basis of life

- **Transpiration**: when water leaves plants through leaves (not the same as evaporation)
- **Evaporation**: when water changes from liquid to gas phase (vapor)
- **Condensation**: when vapor forms into drops (liquid)
- **Precipitation**: when water drops fall from the sky (rain)
- **Evapotranspiration:** a combination of sunlight, wind, humidity, temp, to increase transpiration from plants (known as EtO)
- **Runoff** is when water moves across land into other bodies of water
- **Percolation** is when it flows through soil, think of a coffee percolator (like in your soil lab)
- **Transit time:** the time between when rain falls on the surface until it enters a stream or river body (recall #2 on your homework)

Unavailable Apple Wiki media: the exported data did not include file 0258a0dc-4b3e-4ea6-a27a-a40f7ddf4372.

Note what drives this entire cycle is solar energy...

Games to try:

https://www.classtools.net/vortex/202201-VCk3Yb

https://wordwall.net/resource/10488872/biology/eutrophication-mix-and-match

Migrated from Apple Server Wiki. Original page ID: i2e1r1f8d8

Revision #2
Created 2026-09-29 15:58:48 UTC by Admin
Updated 2026-09-29 16:20:42 UTC by Admin