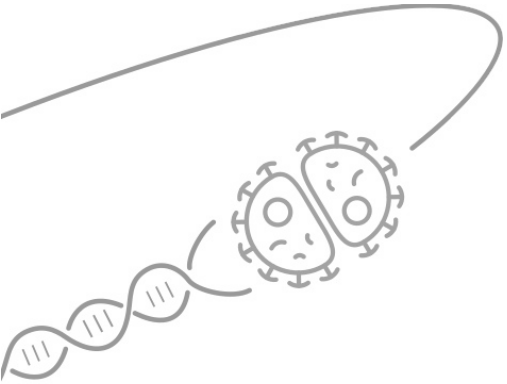
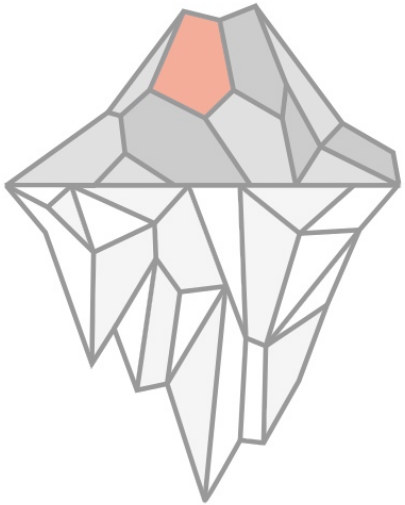


MICROBIAL METABOLISM AND PLANETARY HABITABILITY

BIOGEOCHEMICAL CYCLING



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BIOLOGY OF EXTREME ENVIRONMENTS

DIPARTIMENTO DI BIOLOGIA

BIOGEOCHEMICAL CYCLE

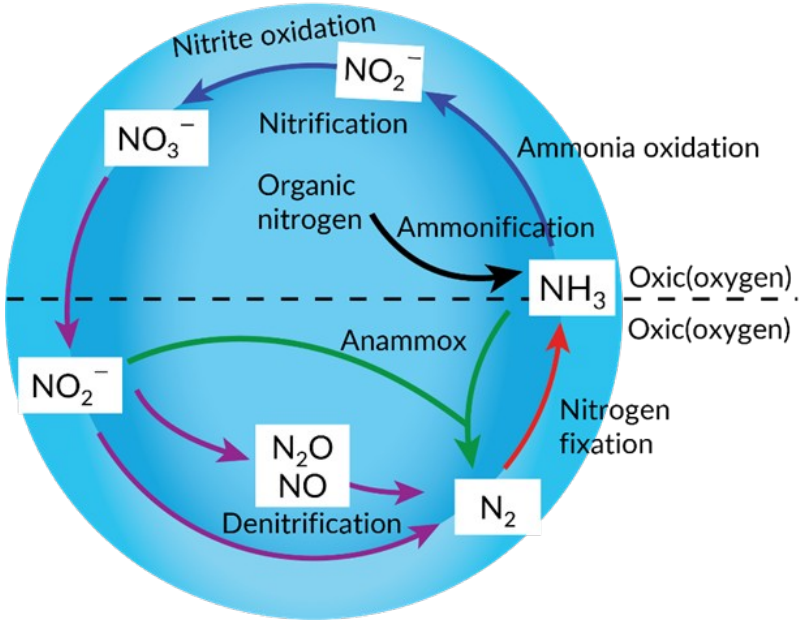
A biogeochemical cycle is the pathway by which a chemical substance moves (sometimes in different forms) through the biotic and the abiotic compartments of Earth.

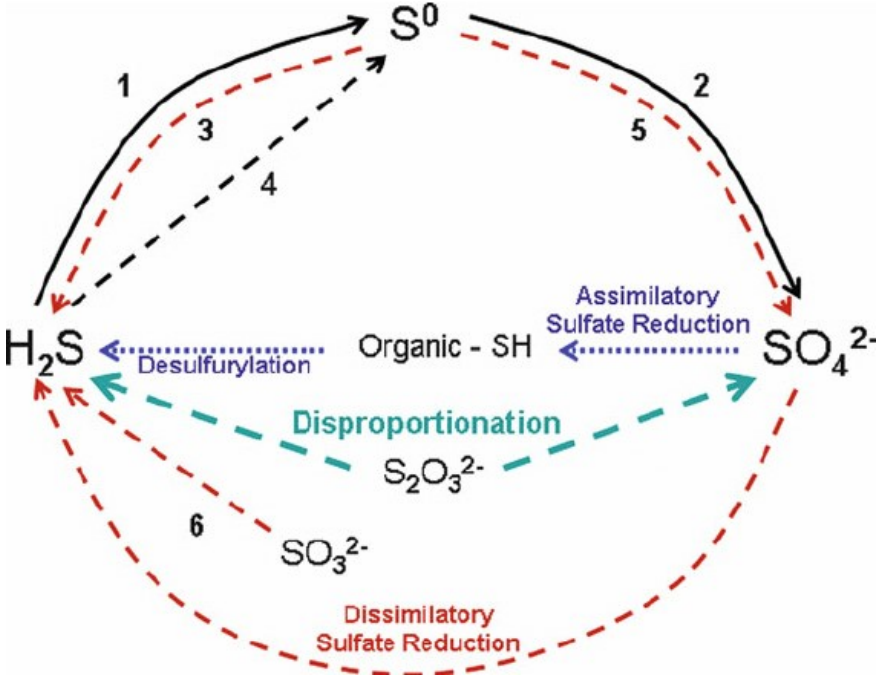
There are biogeochemical cycles for chemical elements (Ca, C, H, Hg, N, O, P, Se, Fe and S) as well as molecular cycles, such as for water.

There human-generated cycles, like those for synthetic compounds such as polychlorinated biphenyls (PCBs)

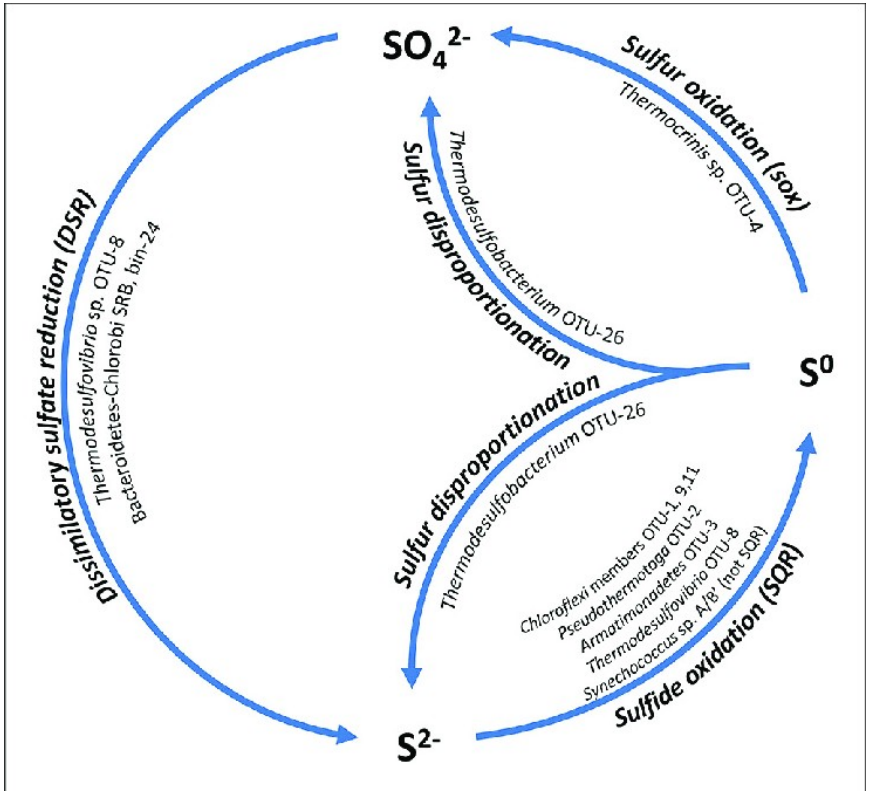
BIOGEOCHEMISTRY: BIO AND GEO

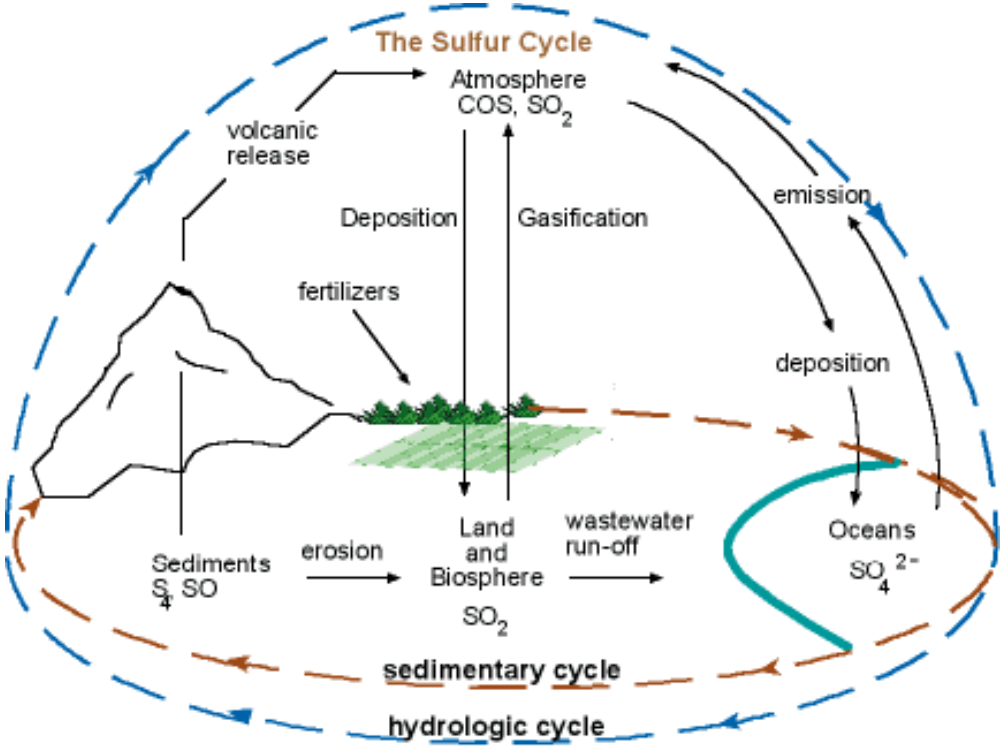
*The **biotic** and **abiotic** side of a cycle might be very different in each cycle, and their relative importance changes depending o the element or molecule under consideration*





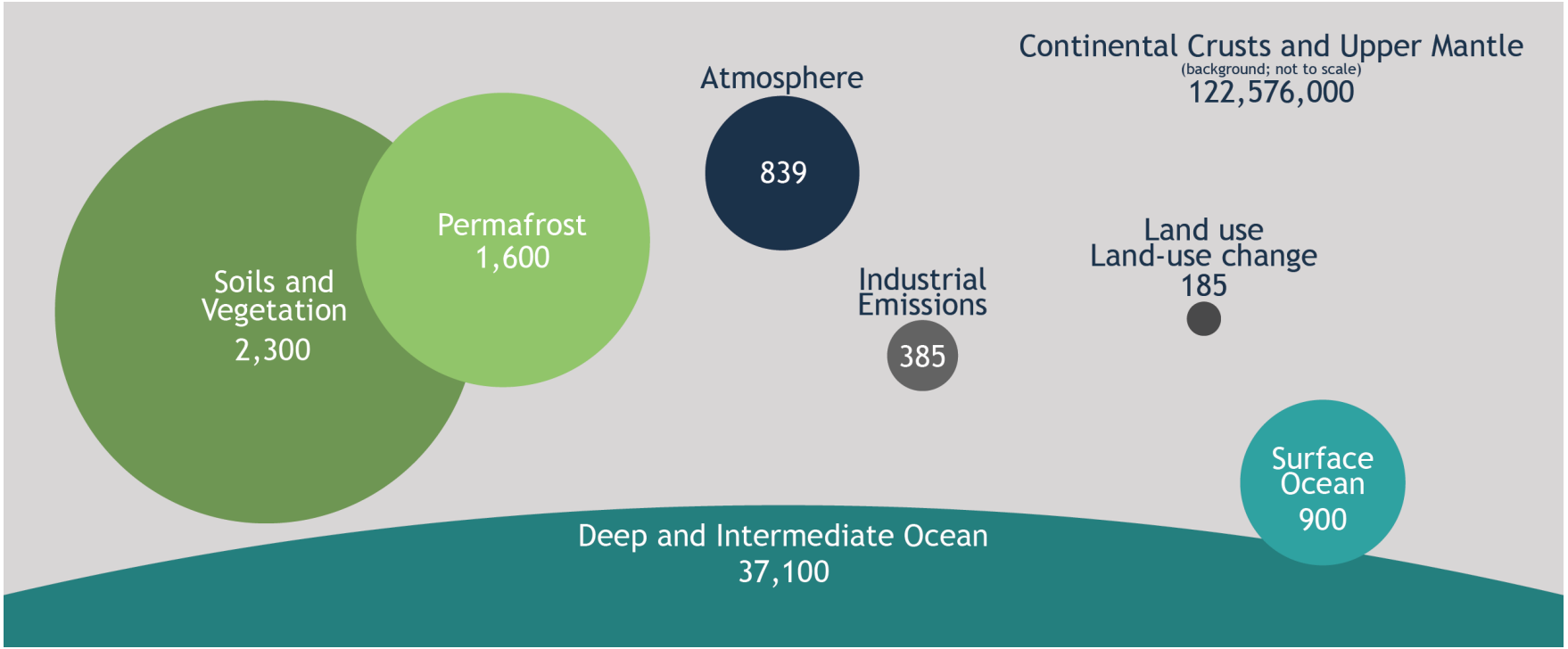
BIOGEOCHEMISTRY: BIO AND GEO





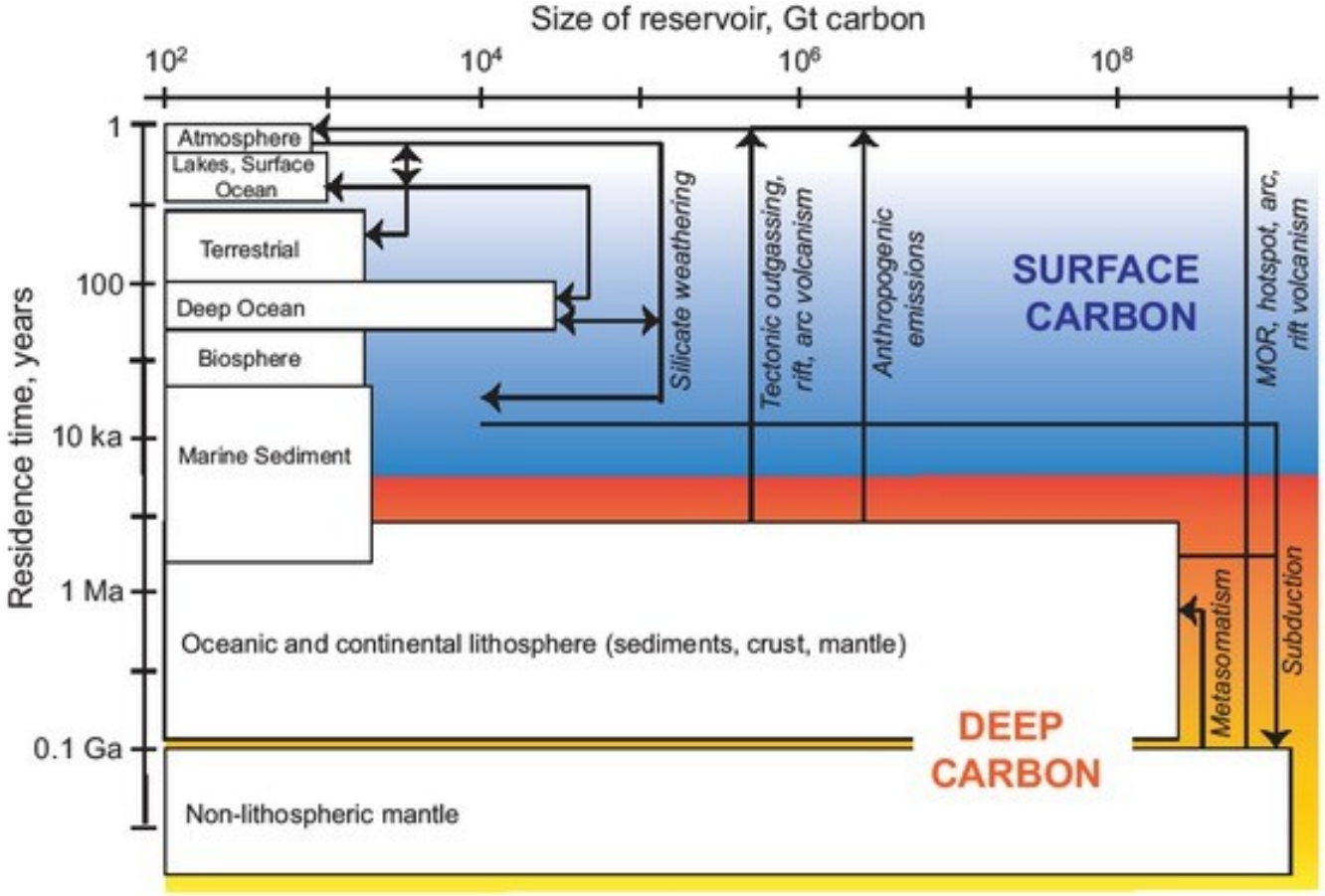
BIOGEOCHEMISTRY: RESERVOIR AND RESIDENCE

Two key concepts are the size of the different reservoir and their residence time



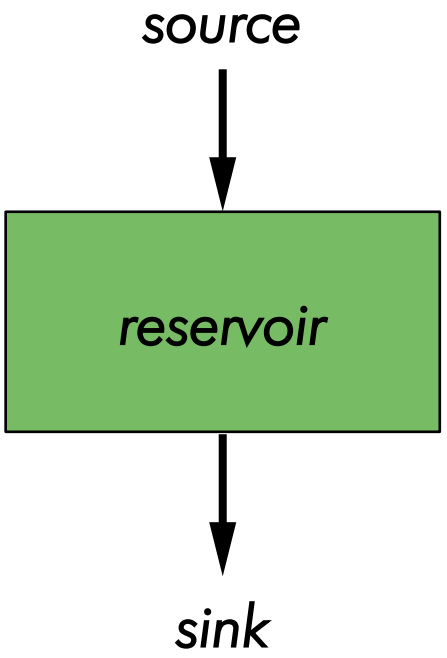
https://www.fs.usda.gov/ccrc/topics/global-carbon

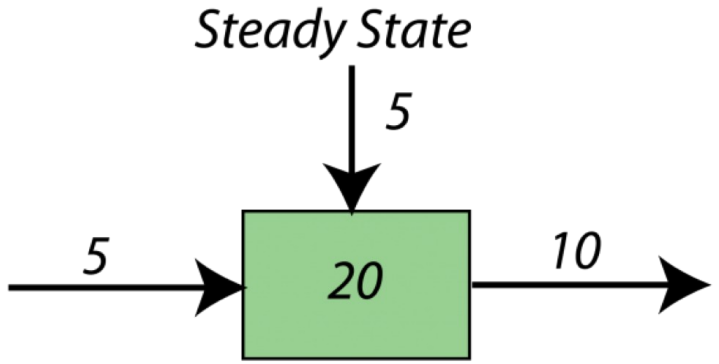
BIOGEOCHEMISTRY: RESERVOIR AND RESIDENCE



https://www.fs.usda.gov/ccrc/topics/global-carbon

BIOGEOCHEMISTRY: BOX MODELS



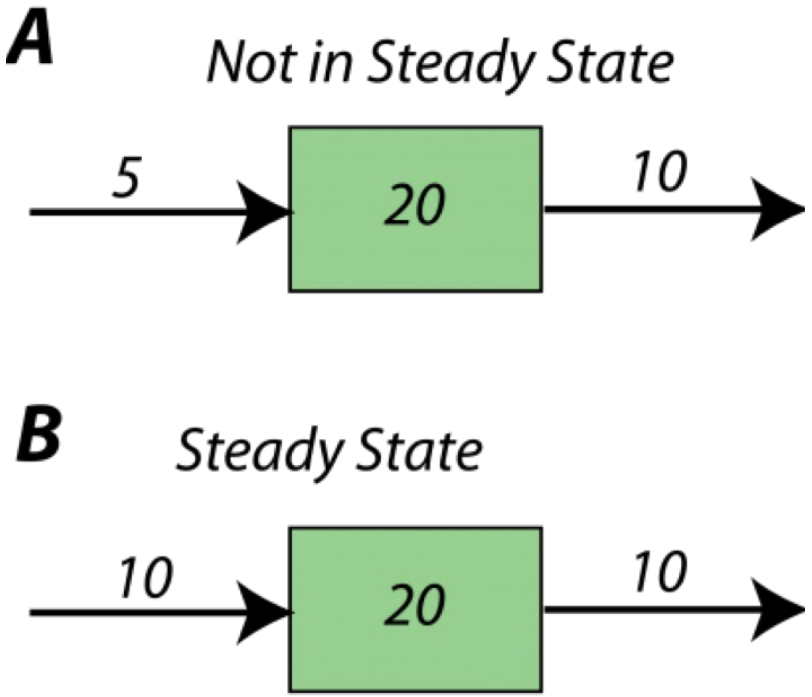


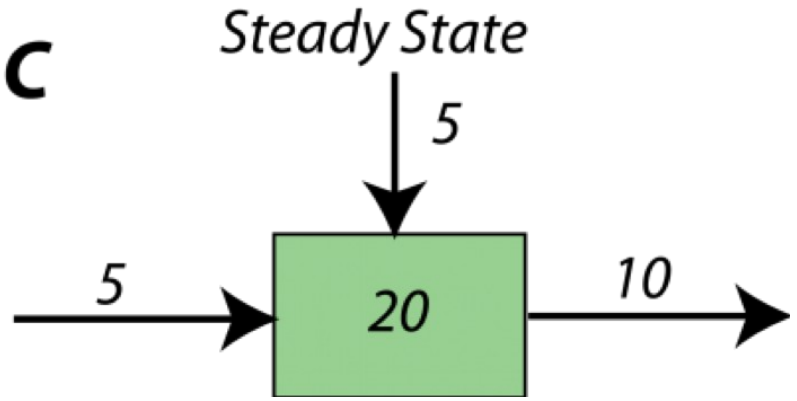
$$\text{Residence Time} = \frac{\text{Amount in Reservoir}}{\text{Flows in } \mathbf{or} \text{ out}}$$

$$\text{Residence Time} = \frac{20\ \text{GT}}{10\ \text{GT/yr}} = 2\ \text{yr}$$

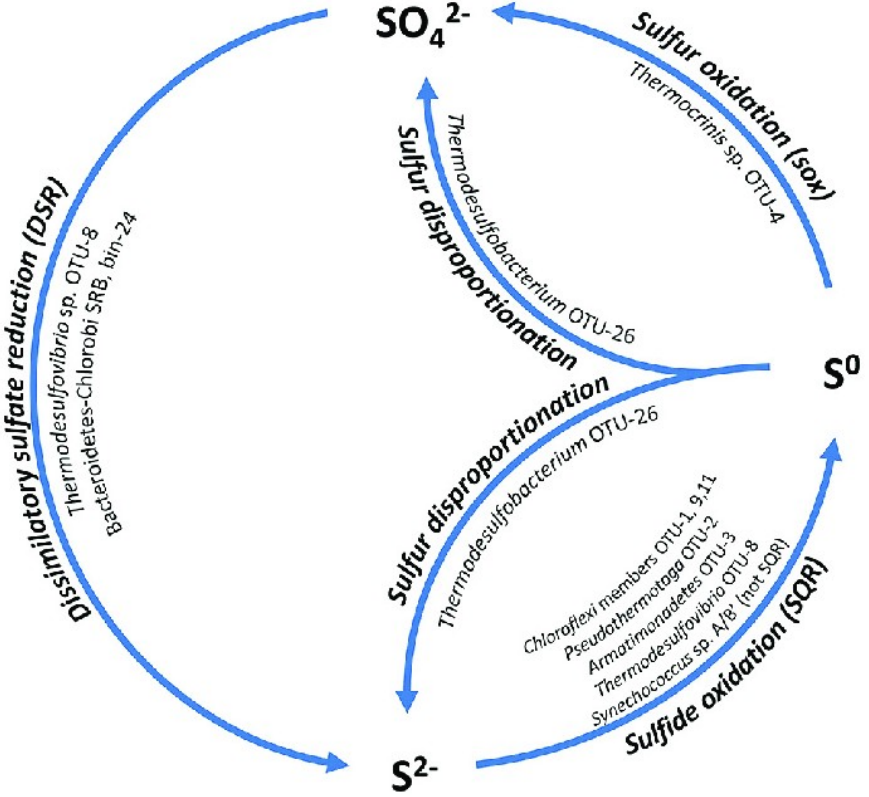
Dave Bice Images

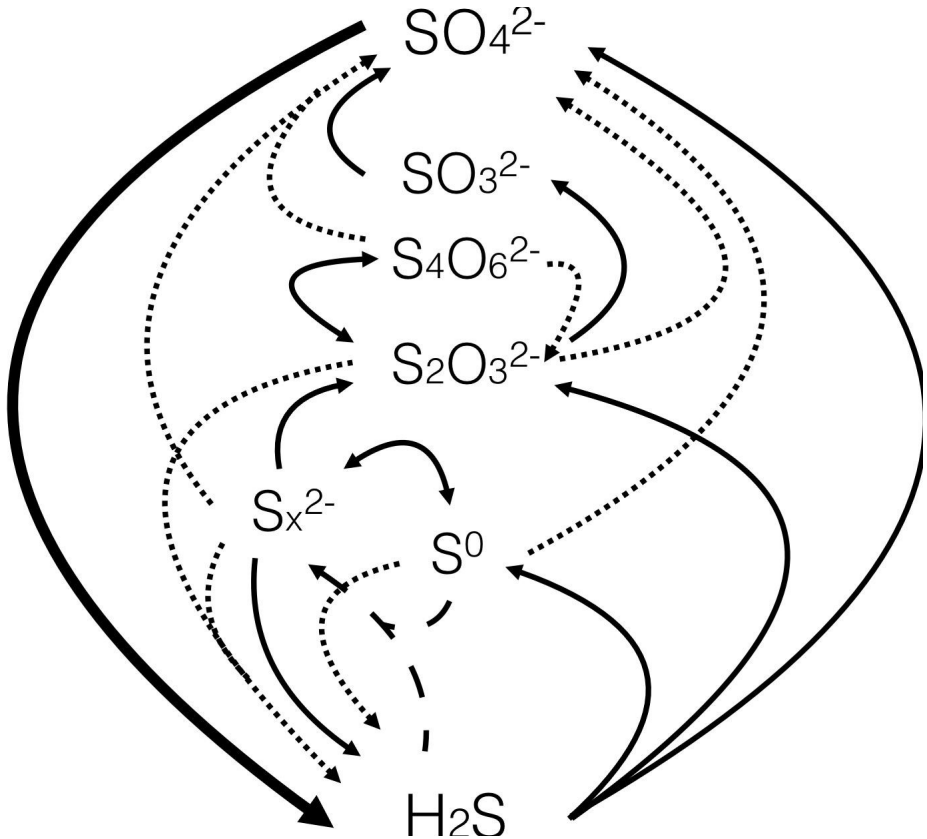
BIOGEOCHEMISTRY: BOX MODELS



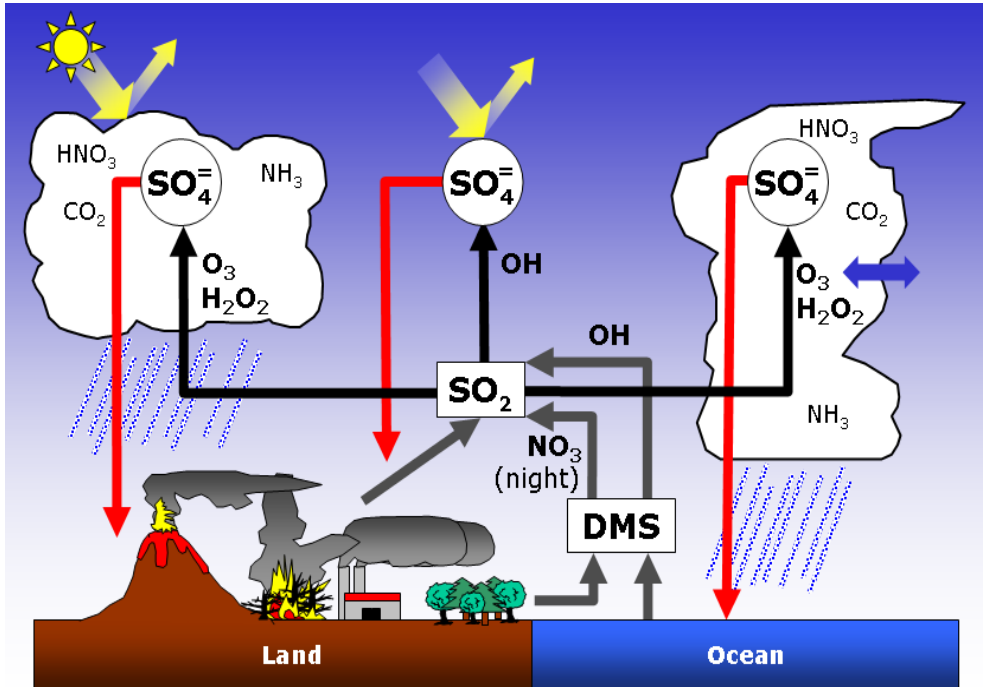


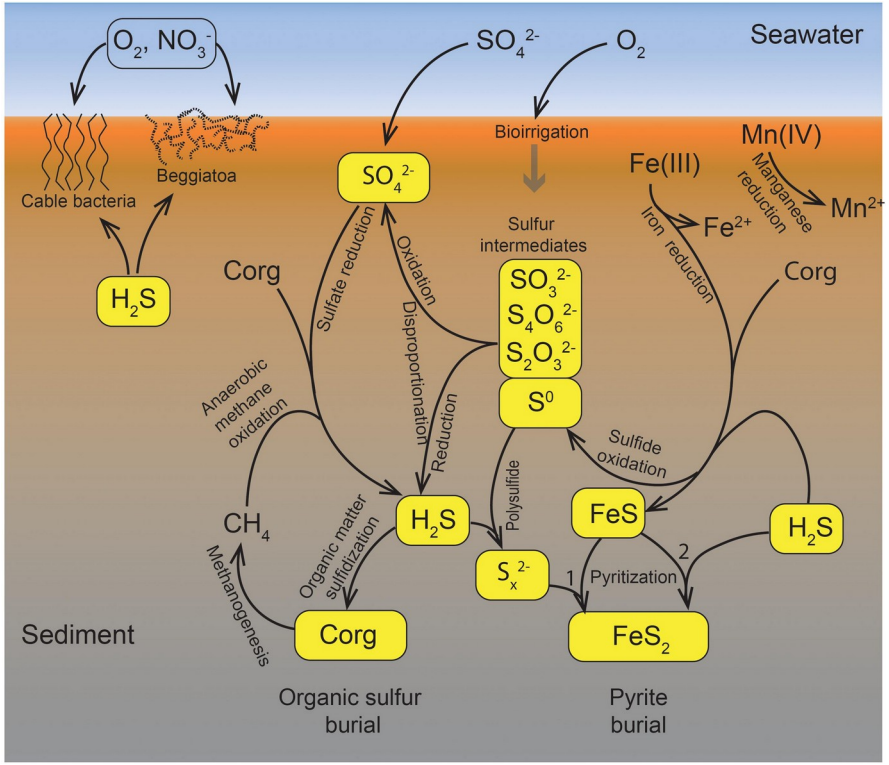
BIOGEOCHEMISTRY: GRANULARITY



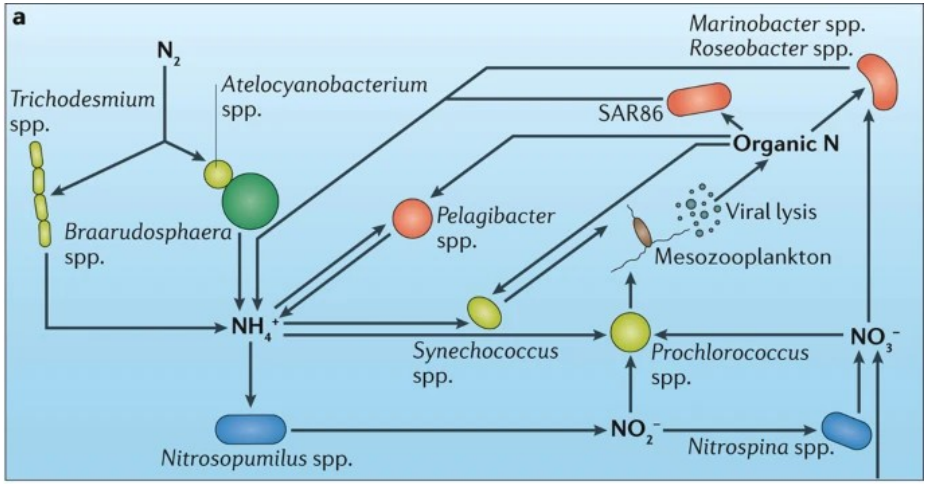


BIOGEOCHEMISTRY: RELATIVITY

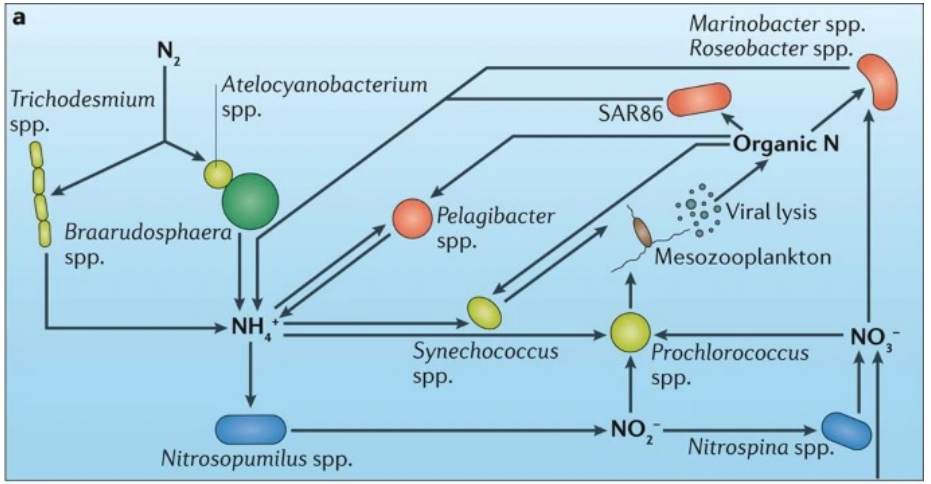


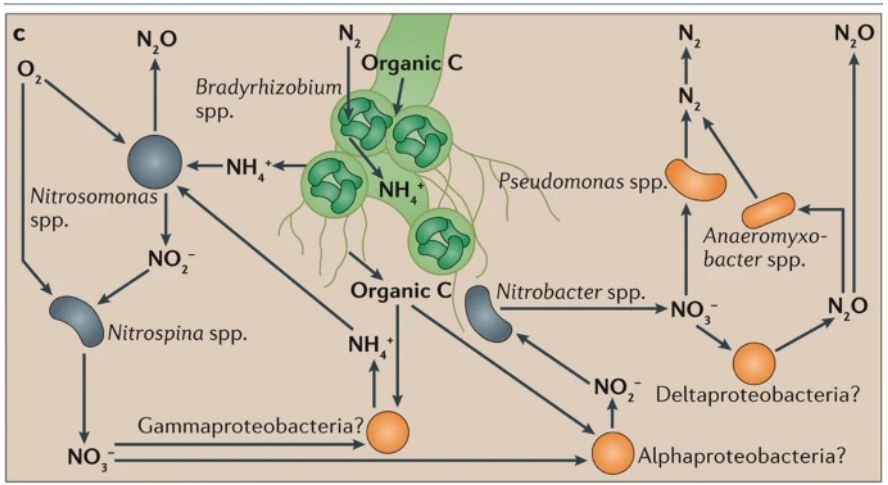


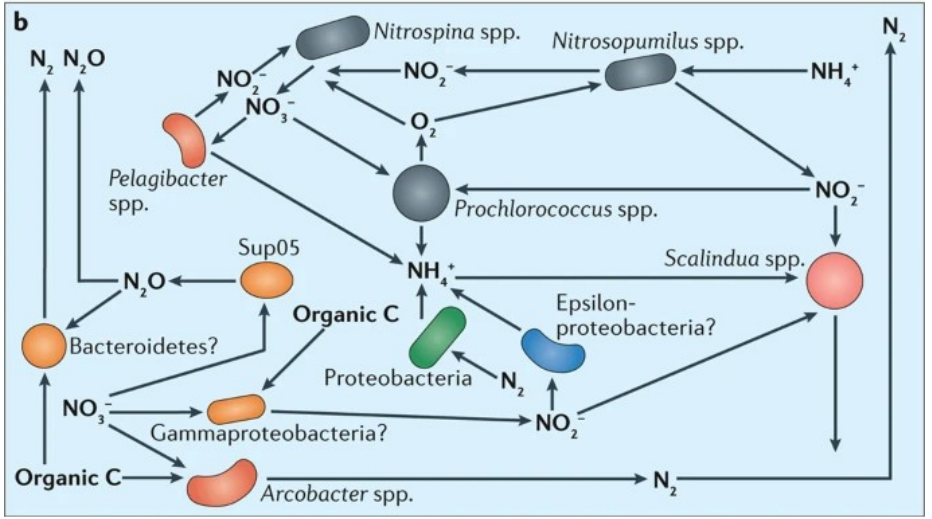
BIOGEOCHEMISTRY: RELATIVITY

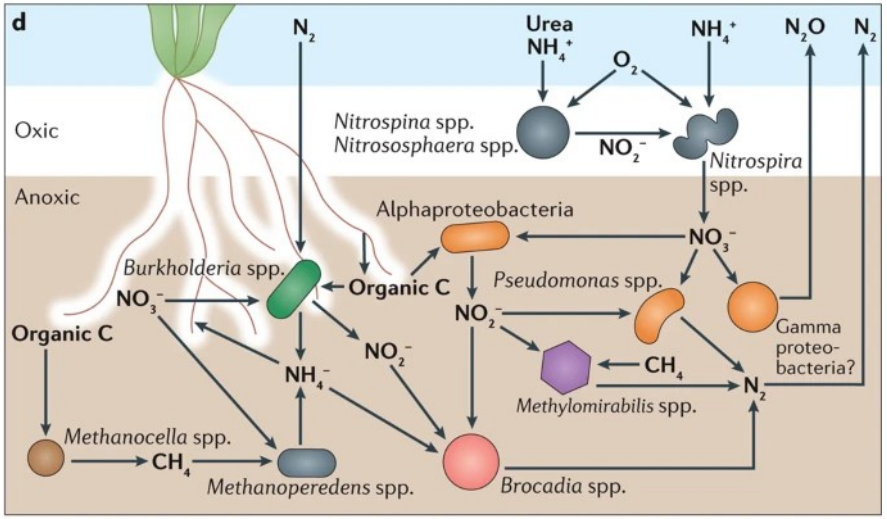


BIOGEOCHEMISTRY: RELATIVITY

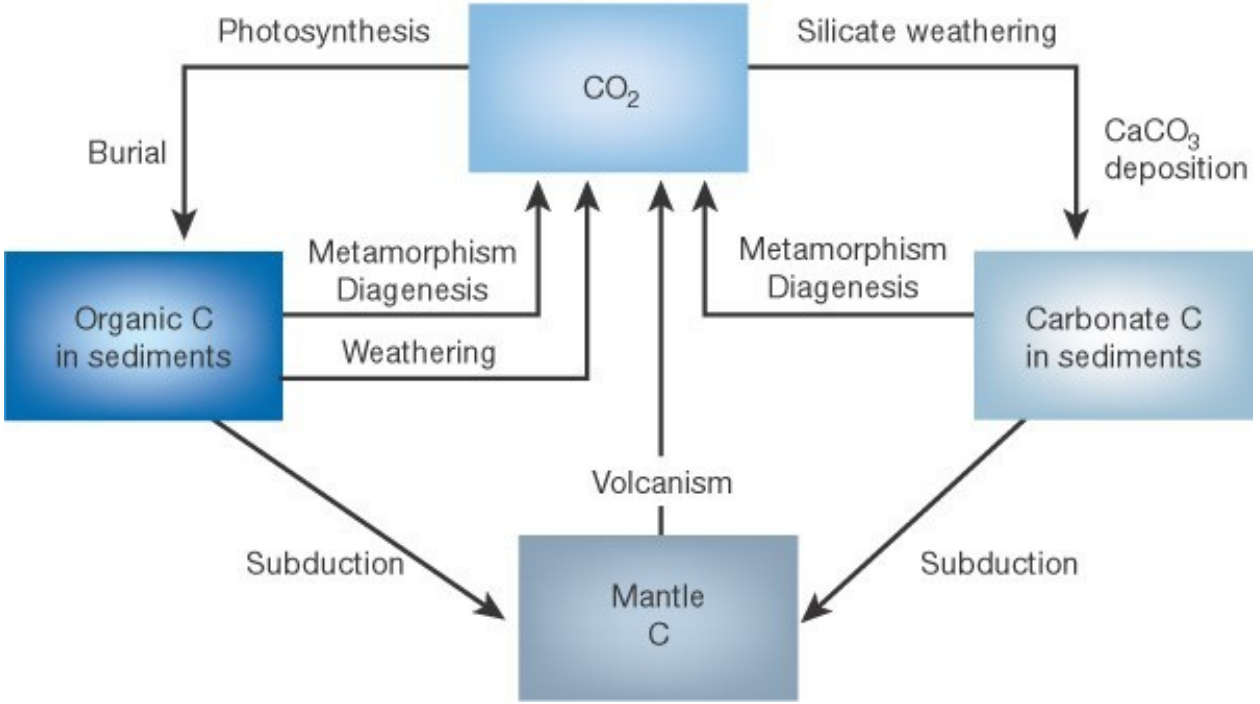




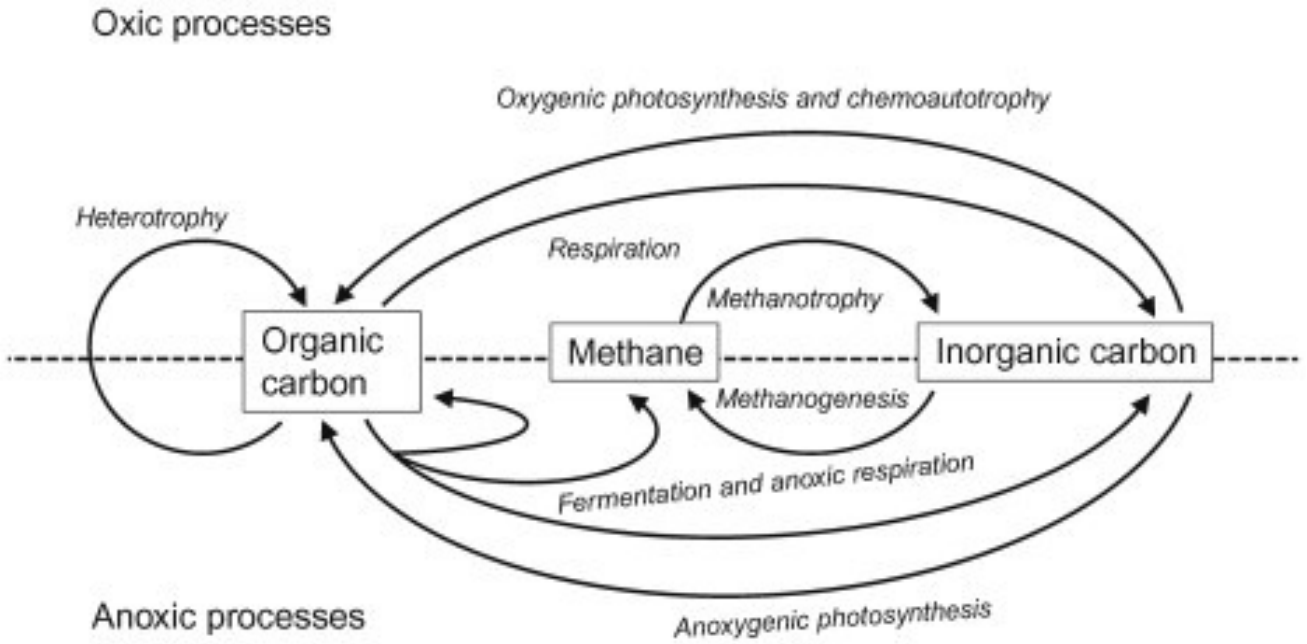


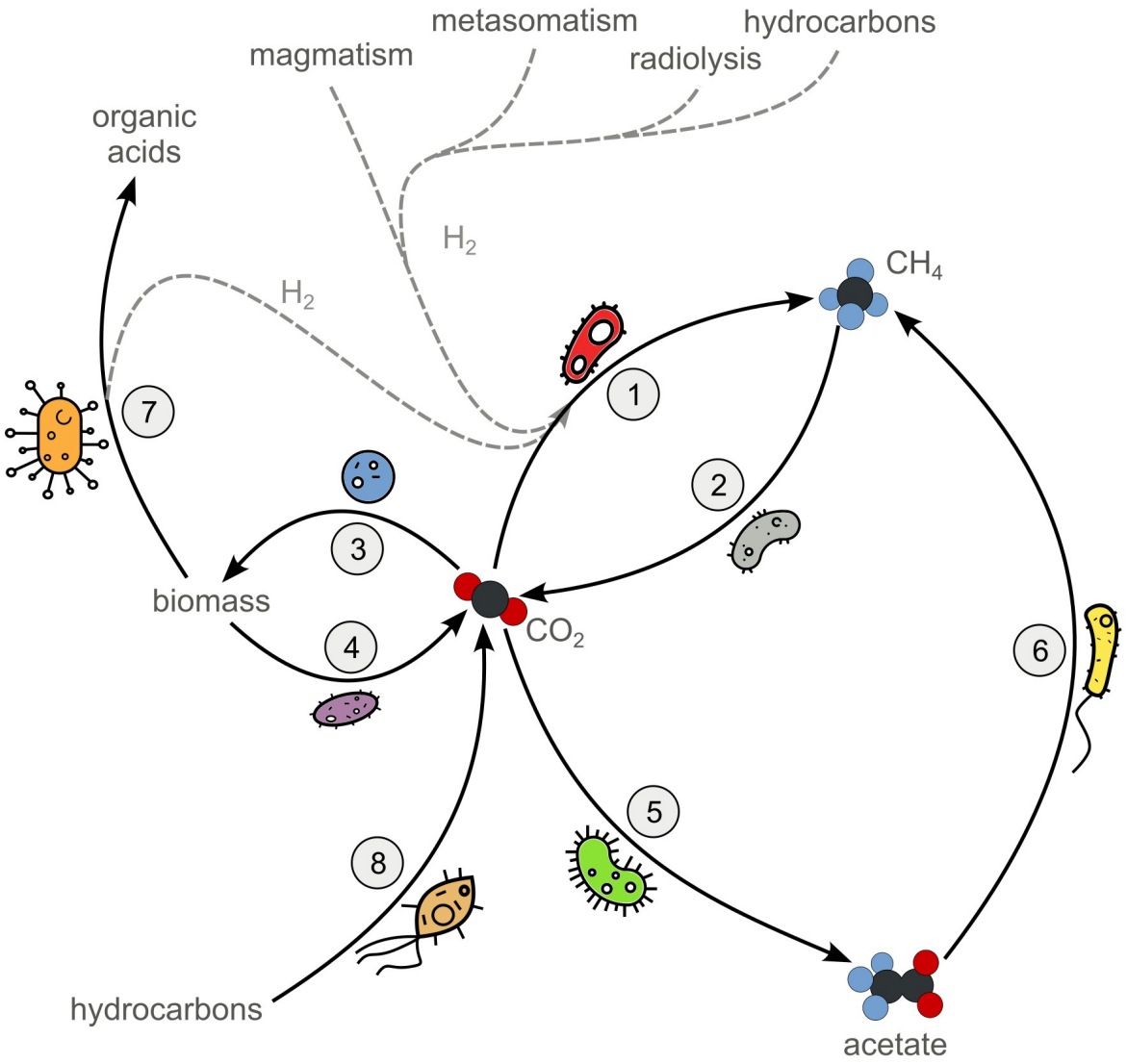


THE CARBON CYCLE: THE SLOW CYCLE

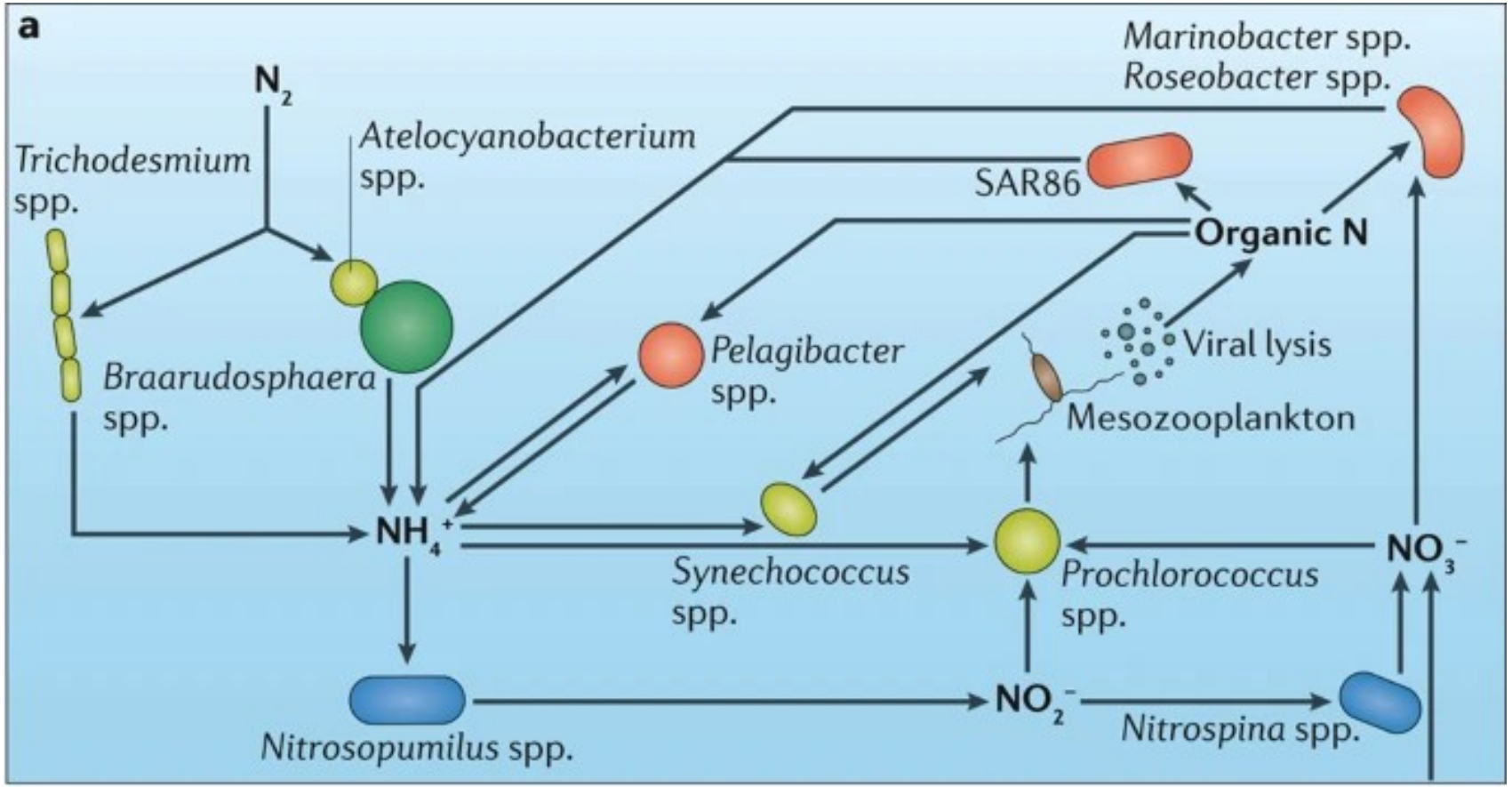


THE CARBON CYCLE: THE FAST CYCLE

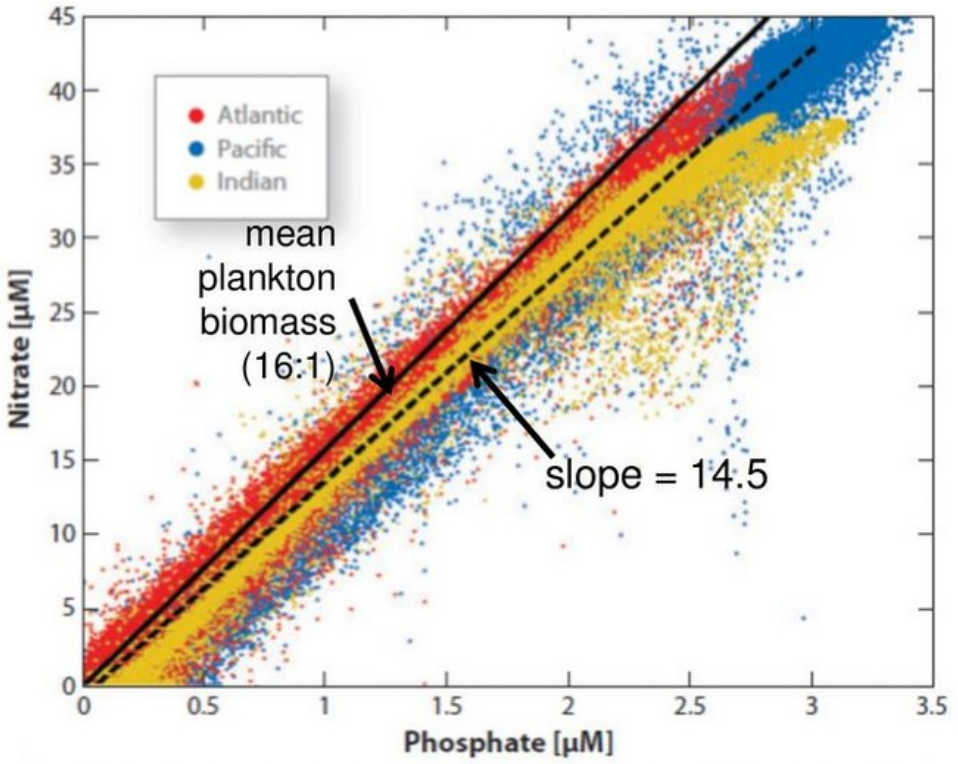



metasomatism
hydrocarbons
magmatism
radiolysis
organic
acids
H_2
H_2
CH_4
1
2
3
4
5
6
7
8
biomass
CO_2
hydrocarbons
acetate

INTEGRATING AND INTERSECTING CYCLES



REDFIELD RATIO

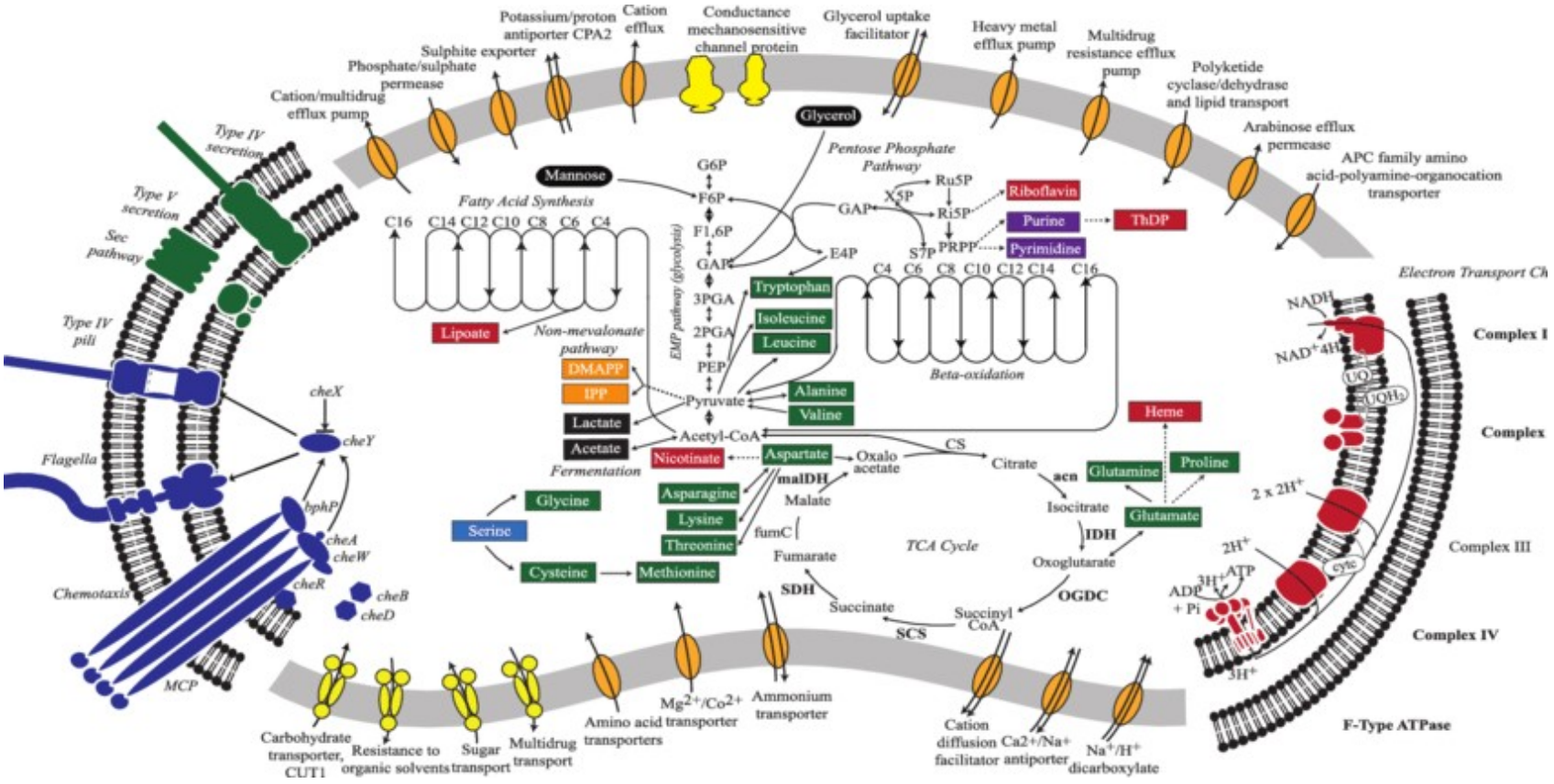


Webber & Dutch; Annu. Rev. Marine. Sci. 2012.4:113-141

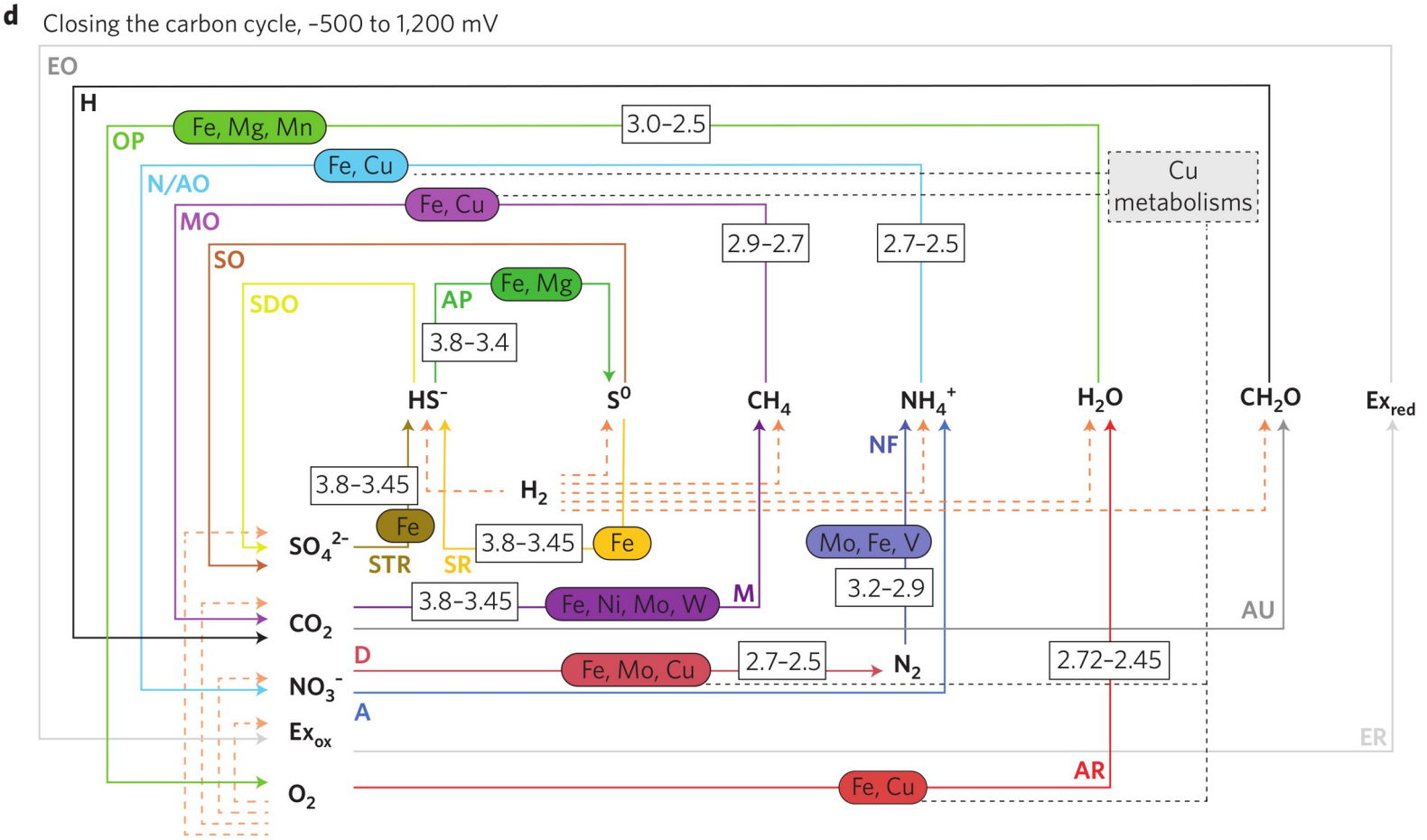
The mean elemental composition of ocean plankton with respect to the macroelements carbon (C), nitrogen (N) and phosphorus (P) was first discussed by Redfield (1934, 1958) and the ratio of:

106C:16N:1P

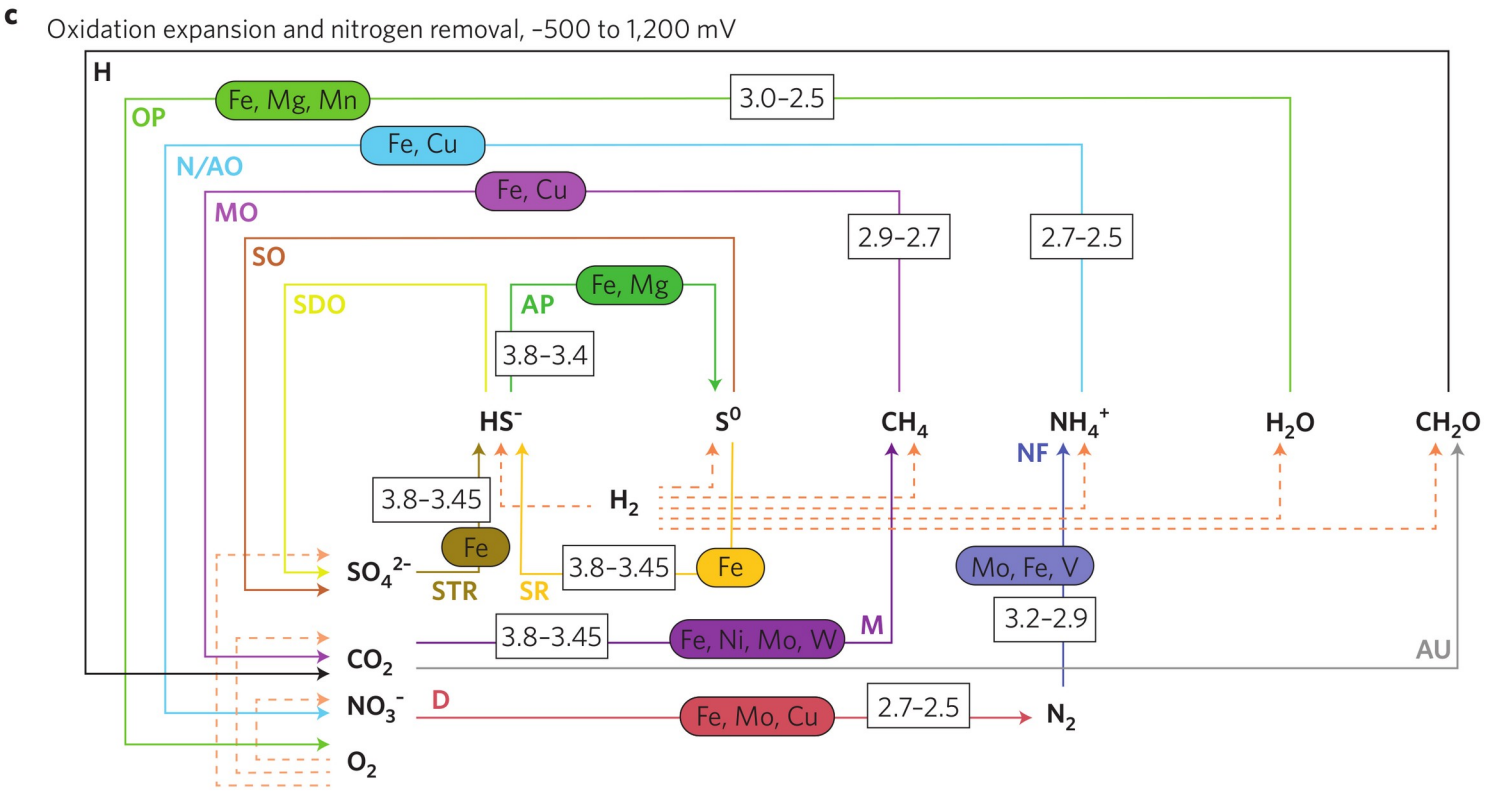
THE CELL AS GATEWAY OF CYCLES



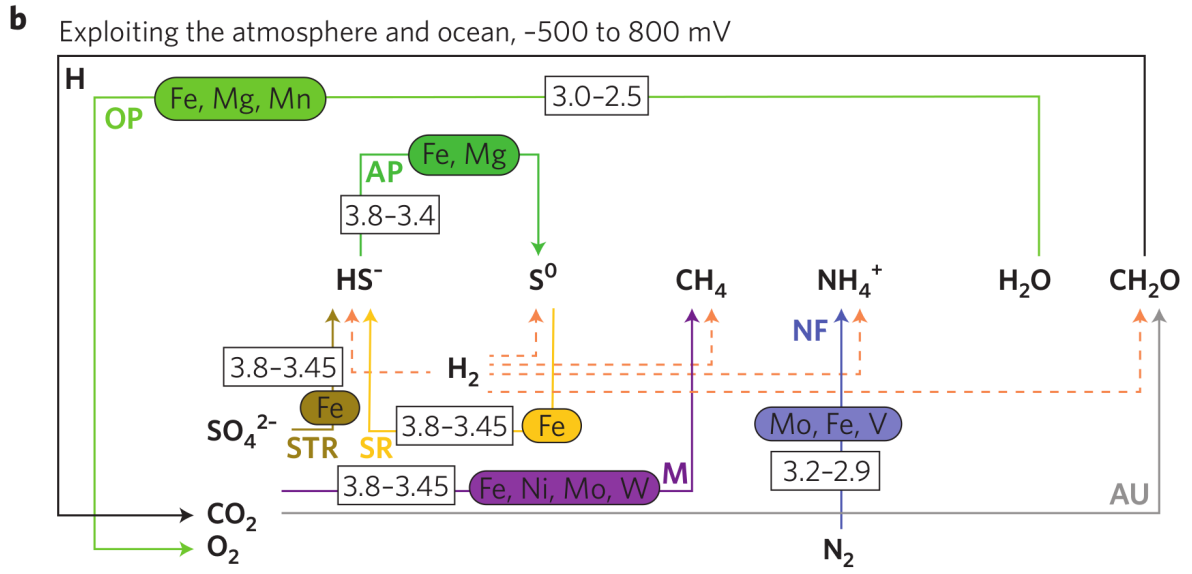
BIOGEOCHEMISTRY THROUGH SPACE AND TIME



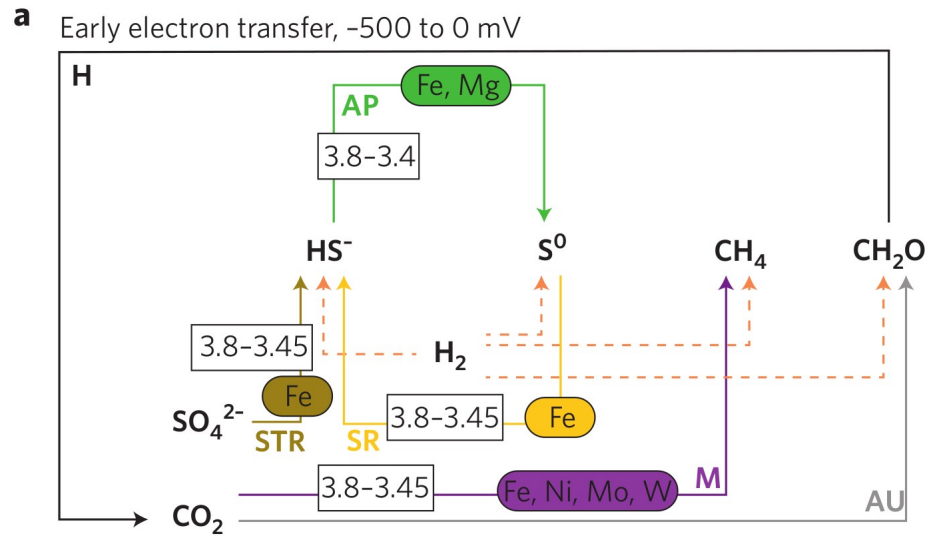
BIOGEOCHEMISTRY THROUGH SPACE AND TIME



BIOGEOCHEMISTRY THROUGH SPACE AND TIME



BIOGEOCHEMISTRY THROUGH SPACE AND TIME



READINGS

Gruber, N., Galloway, J. An Earth-system perspective of the global nitrogen cycle. Nature 451, 293–296 (2008). https://doi.org/10.1038/nature06592

Kuypers, M., Marchant, H. & Kartal, B. The microbial nitrogen-cycling network. Nat Rev Microbiol 16, 263–276 (2018). https://doi.org/10.1038/nrmicro.2018.9

Zakem, E.J., Polz, M.F. & Follows, M.J. Redox-informed models of global biogeochemical cycles. Nat Commun 11, 5680 (2020). https://doi.org/10.1038/s41467-020-19454-w

GROUP EXERCISE

GROUP EXERCISE

Divide in groups of 2-3 people and draw a comprehensive biogeochemical cycle for each of the CHNOS elements

Make a planetary scale cycle

Try to include all the redox relevant intermediates and the different key molecules involved in each cycle

Make explicit statement about the condition under which each step happens (anoxic, oxic, microaerophilic)