ELSI Symposium, March 27, 2013

Porphyrin

a key molecular group for chemical evolution and early Earth

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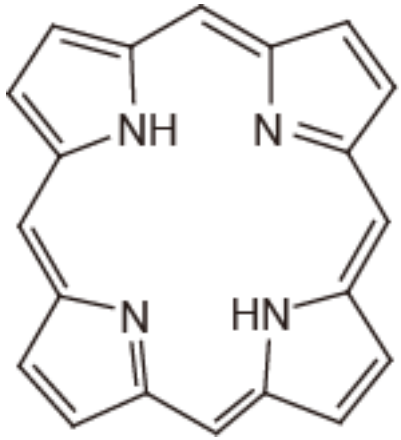
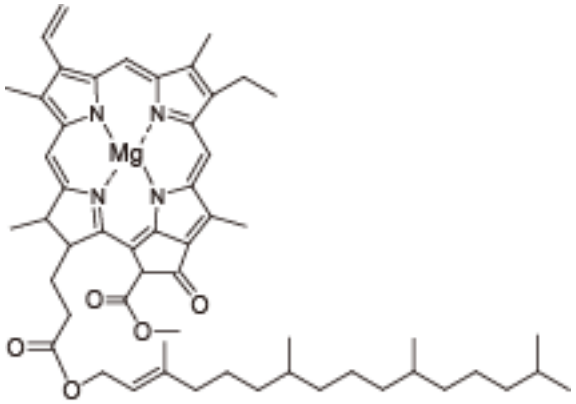
Japan Agency for Marine-Earth Science and Technology



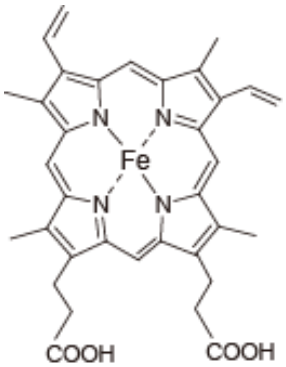
Porphyrin

Compound class containing four pyrrole rings held together by one-carbon bridges

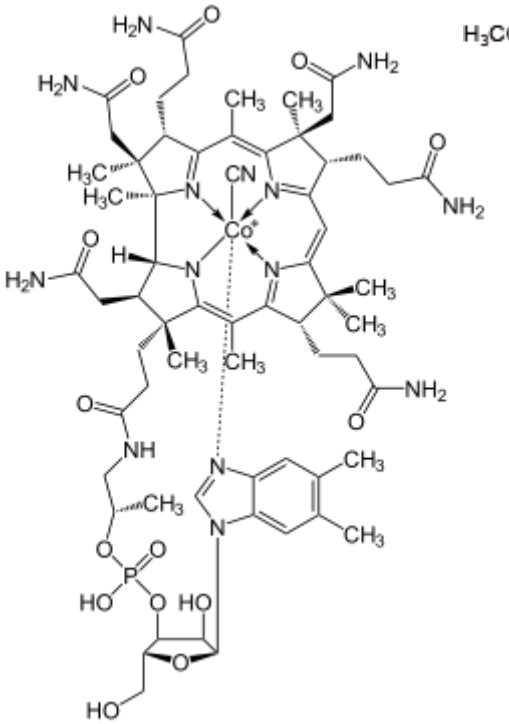
Porphyrins in the cell



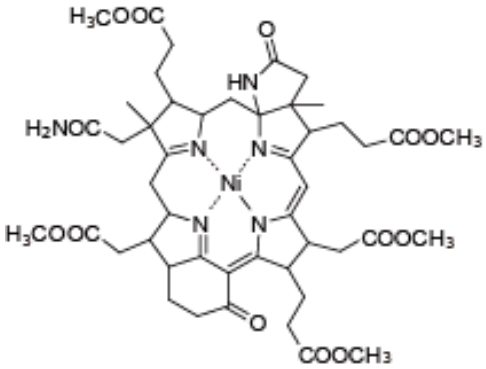
Chlorophylls



Hemes

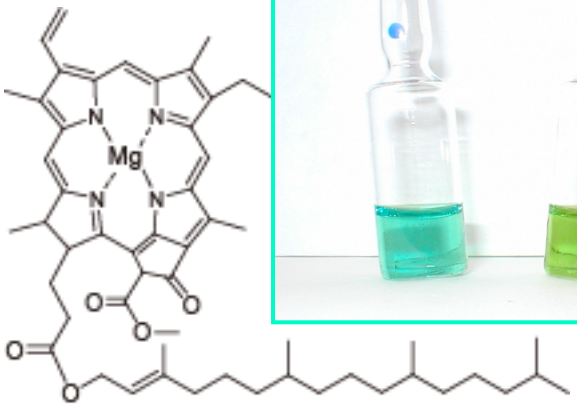


Vitamin B_{12}

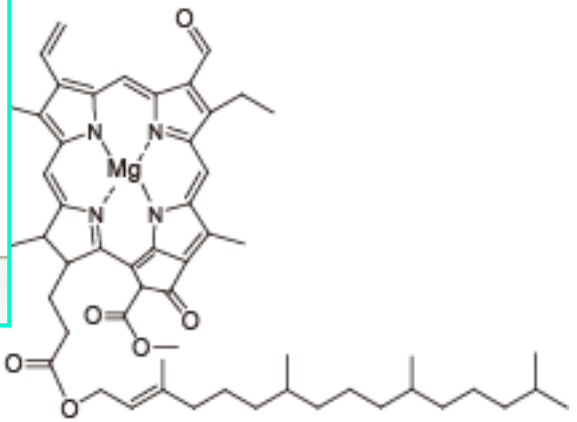


F430

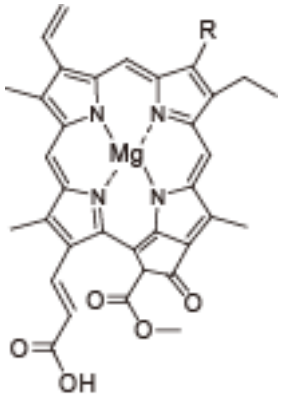
Chlorophylls in oxygenic photoautotrophs



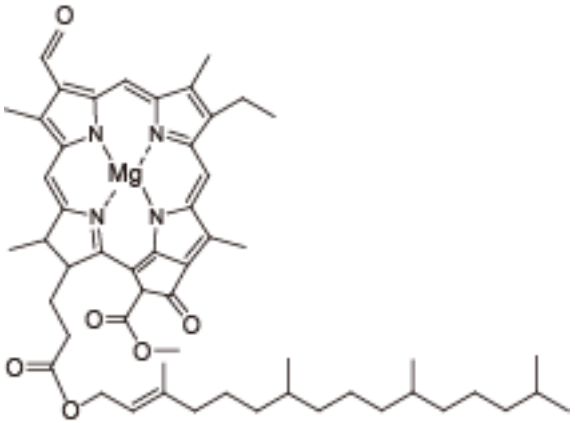
Chl *a*



Chl *b*

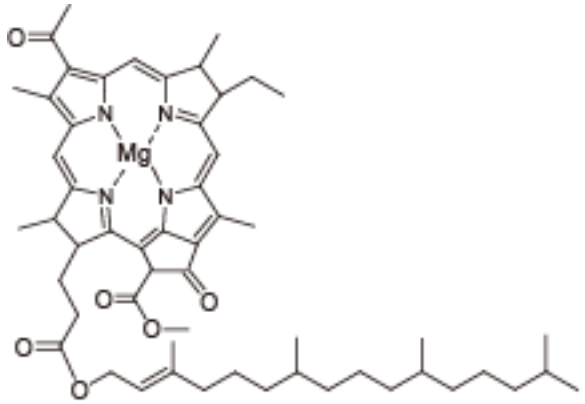


Chl *c*

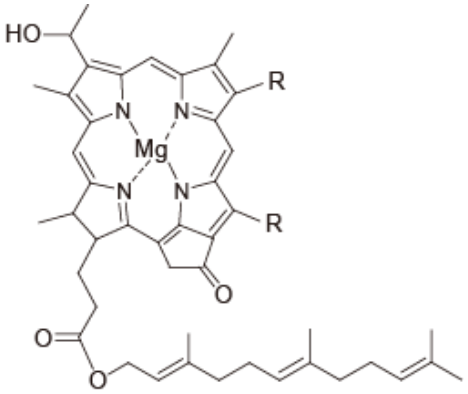


Chl *d*

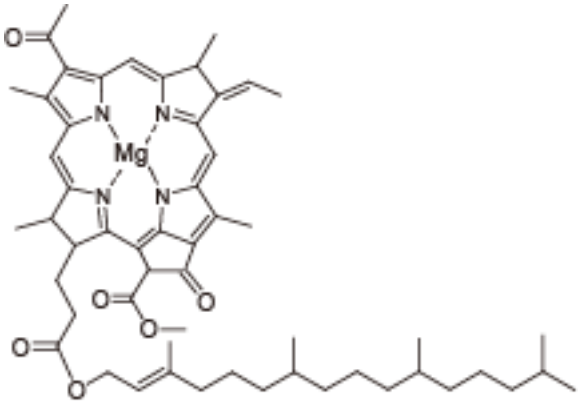
Bacteriochlorophylls in anoxygenic photoautotrophs



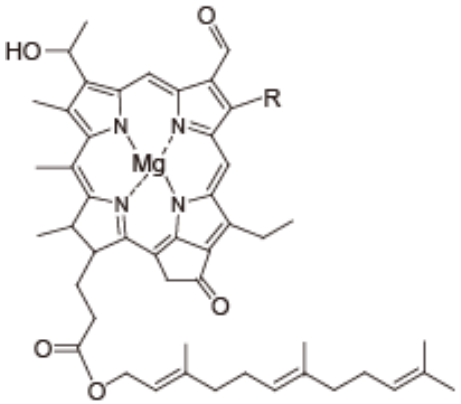
BChl *a*



BChl *d*



BChl *b*

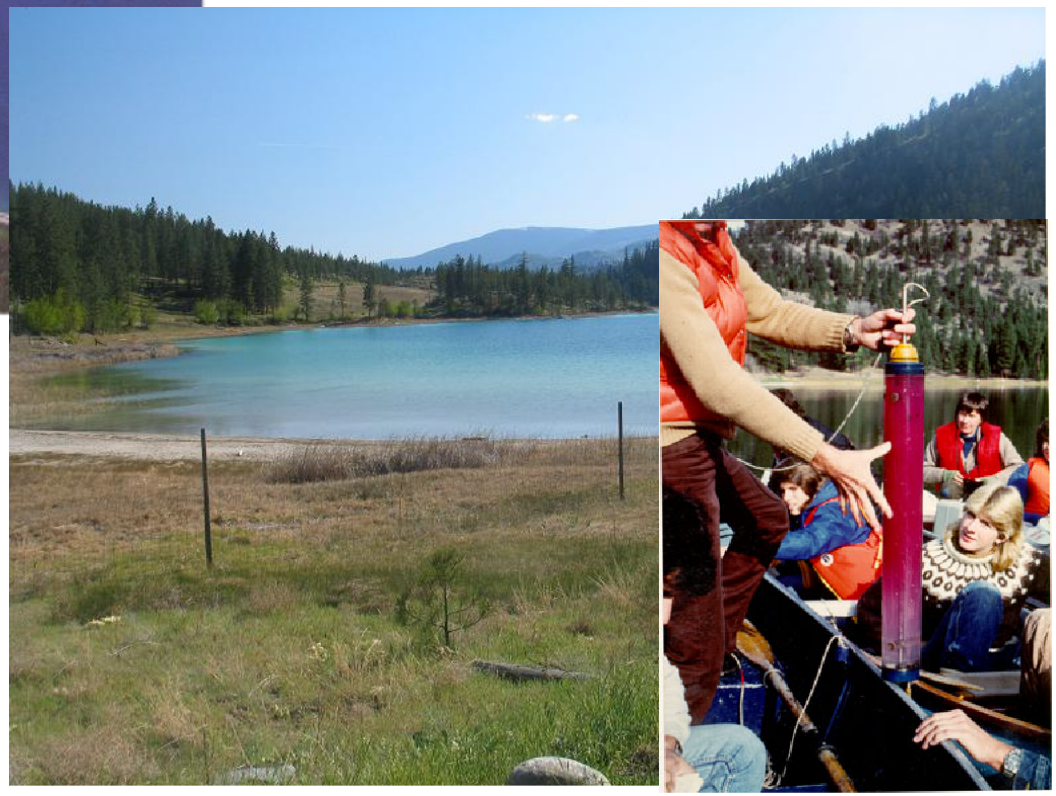


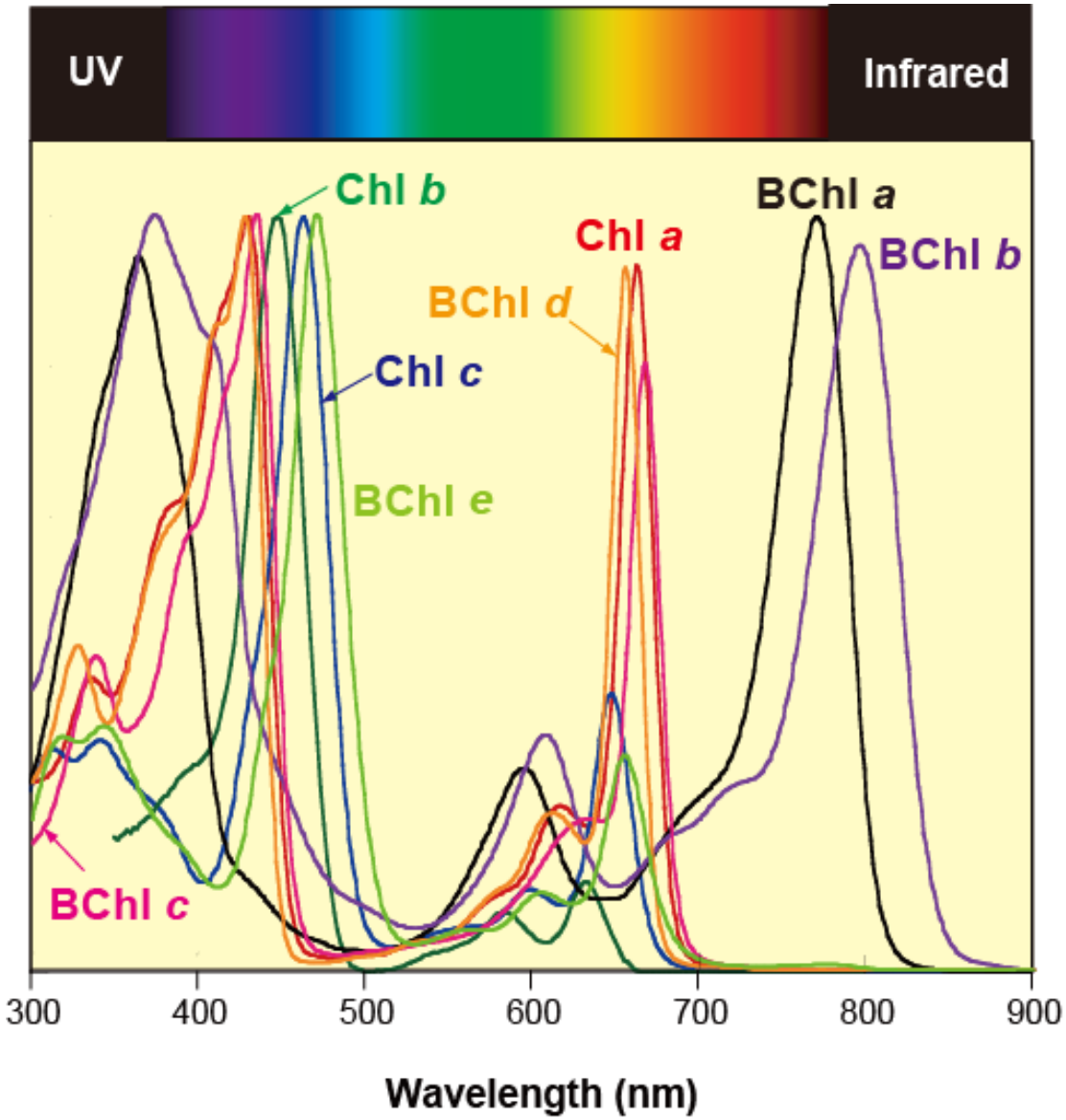
BChl *e*

Bacteriochlorophylls are important pigments in the anoxic water column

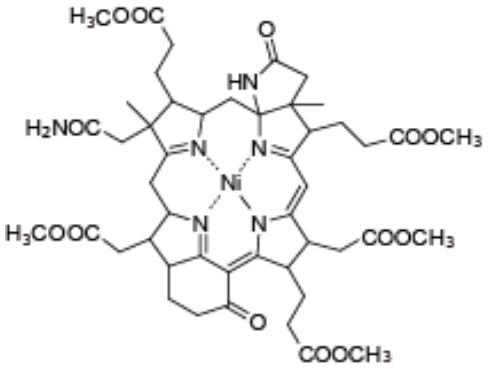
Lake Kaiike, Japan

Mahoney Lake, Canada

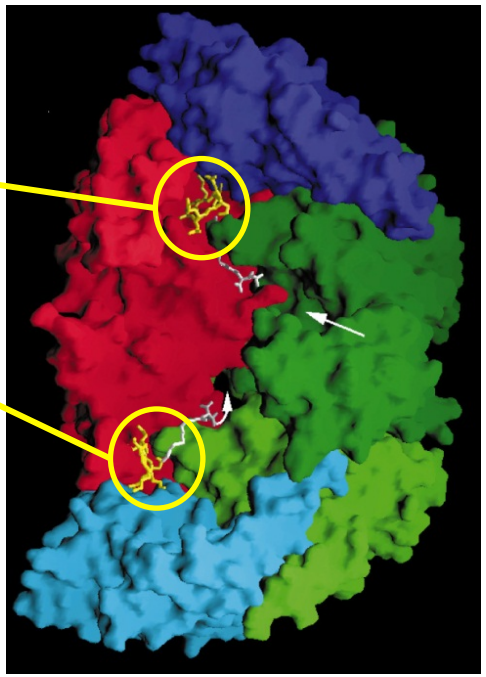



UV
Infrared
Chl b
Chl a
BChl a
BChl b
BChl d
Chl c
BChl e
BChl c
300
400
500
600
700
800
900
Wavelength (nm)

Factor 430 or F430



Methyl-Coenzyme M reductase (mcr)



Elmer et al., 1997

Biological methane formation

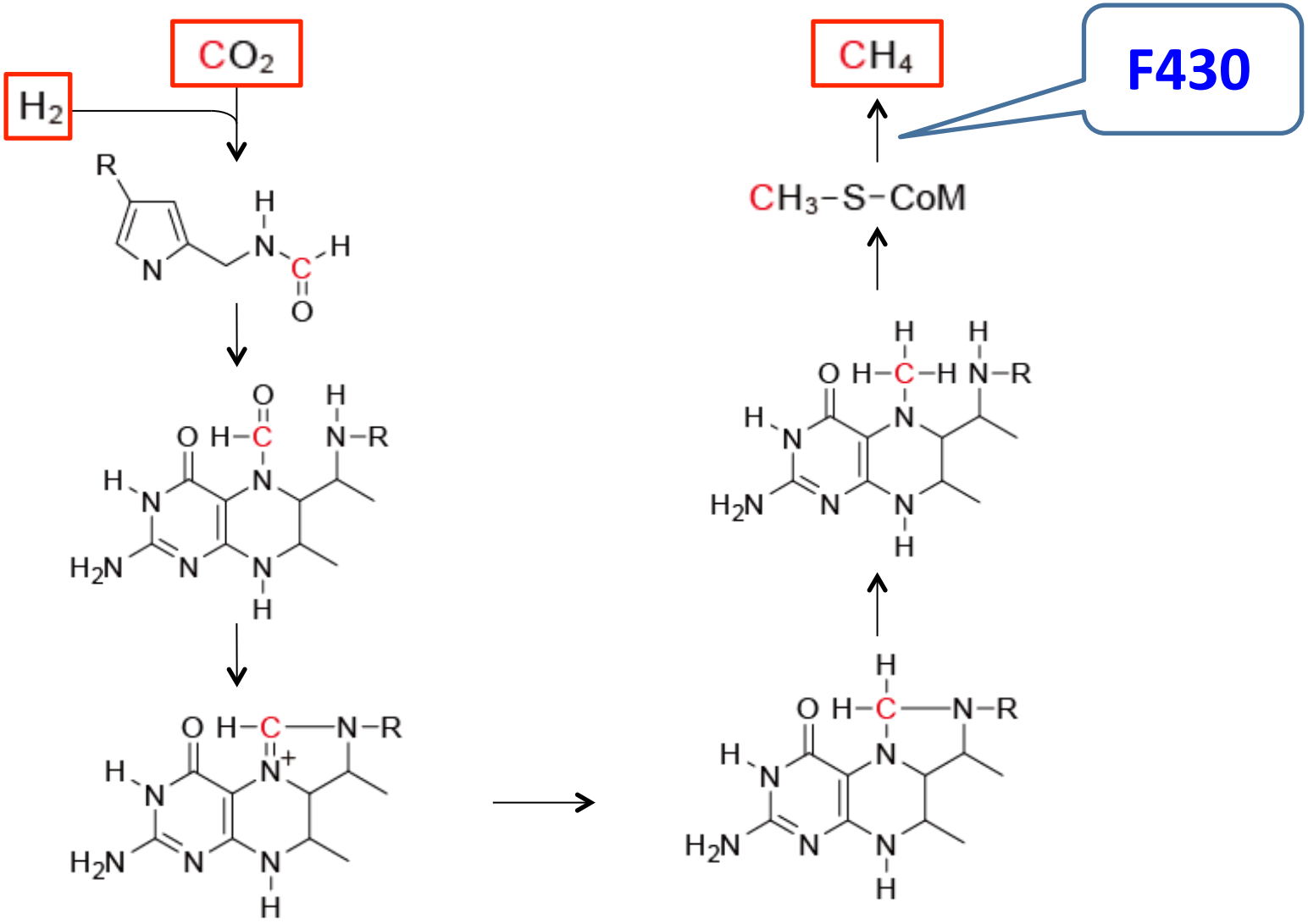
Geochemist's view

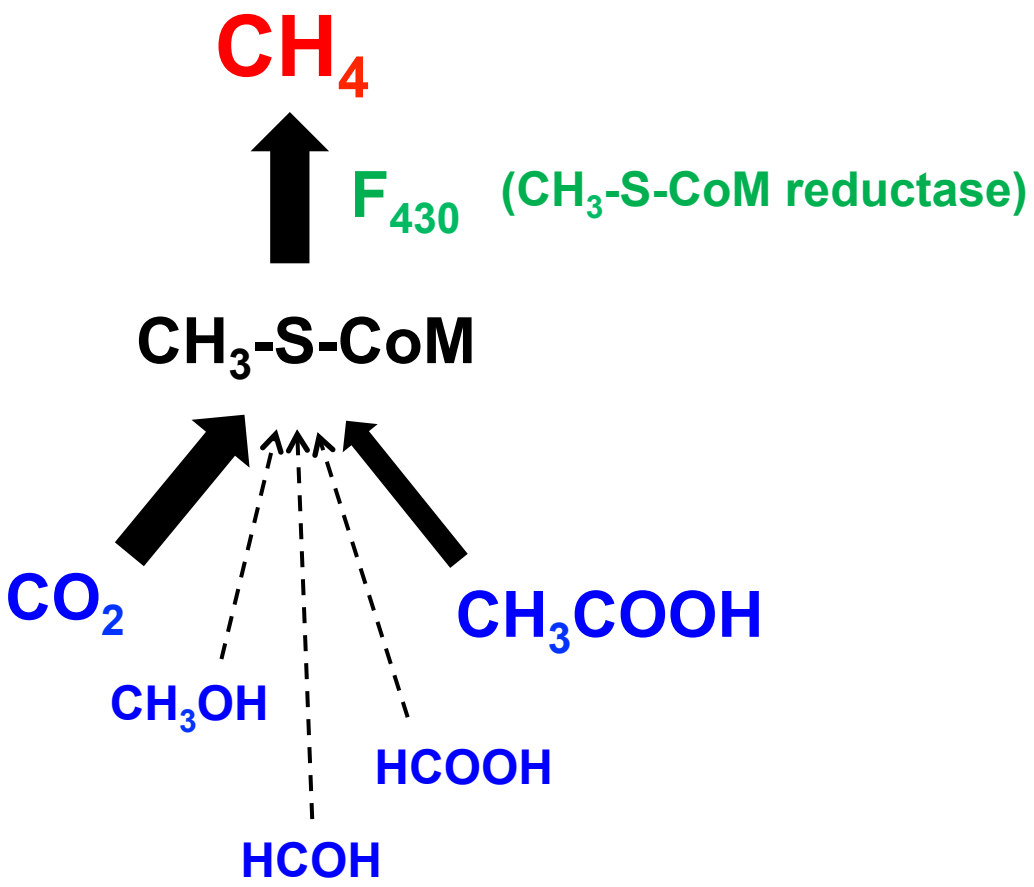
$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O$$

($\Delta G^{0\prime} = -131$ kJ/mol)

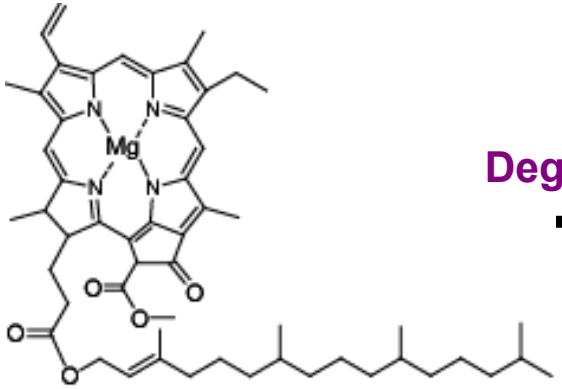
Biological methane formation

Biochemist's view



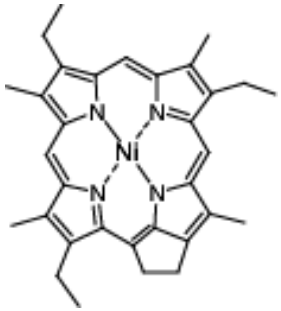

CH4
F430
(CH3-S-CoM reductase)
CH3-S-CoM
CO2
CH3OH
HCOH
HCOOH
CH3COOH

Porphyrins are long preserved in the sediment

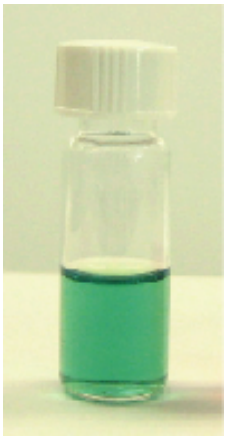


Chl *a*

Degradation



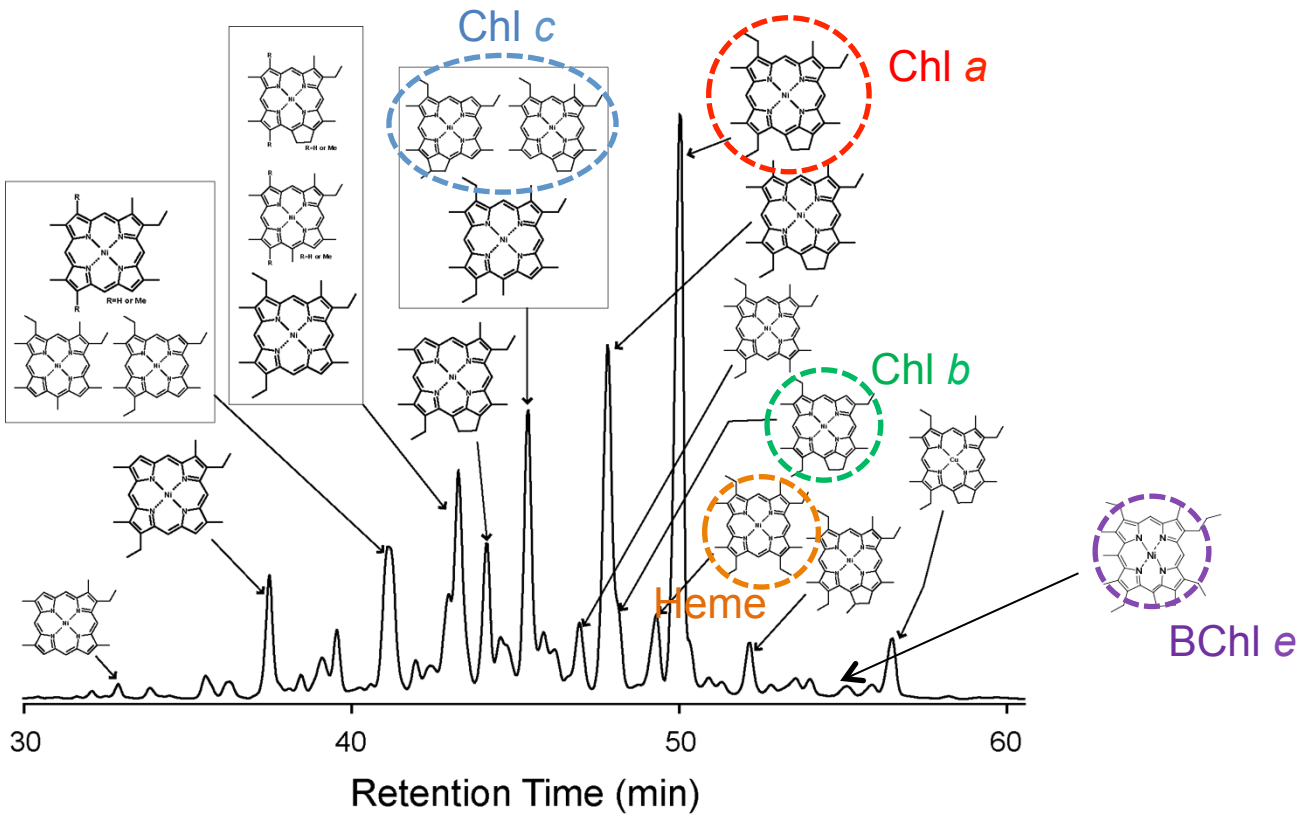
Porphyrin (DPEP)



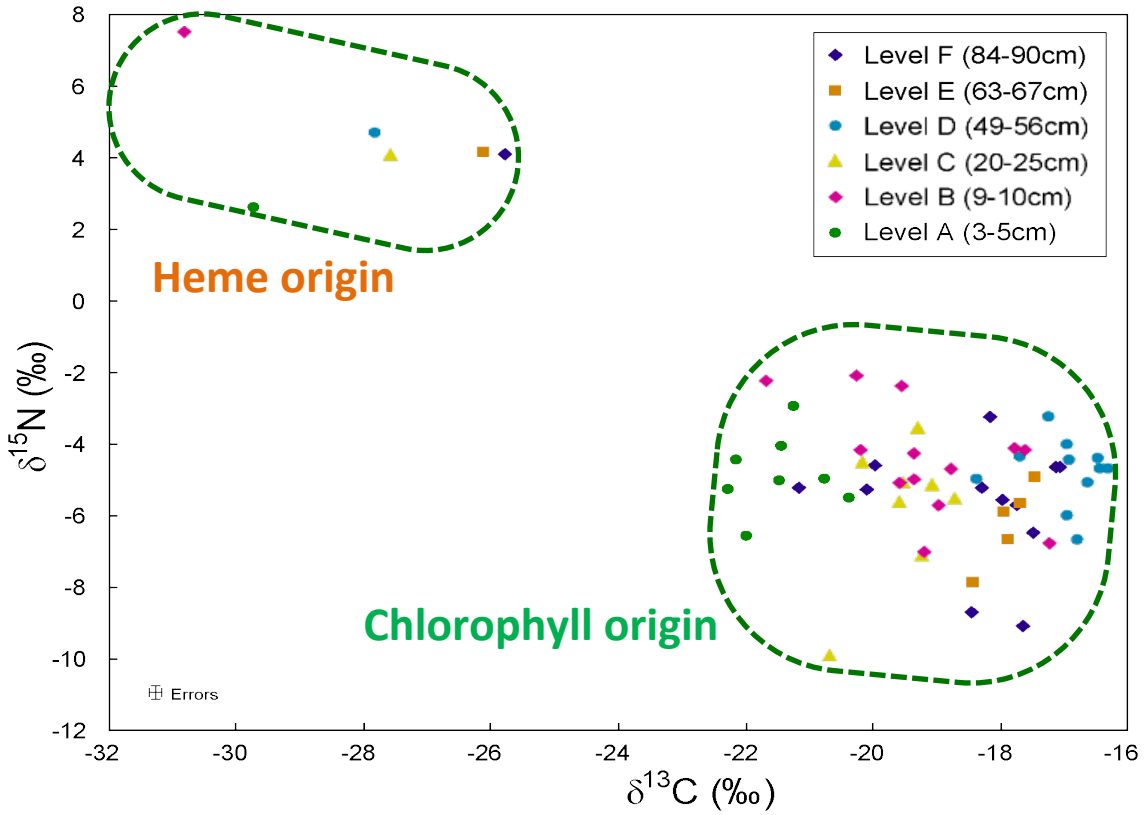
Isolated from modern Metasequoia

Isolated from Cretaceous black shale

Porphyrins from 100 Ma rock

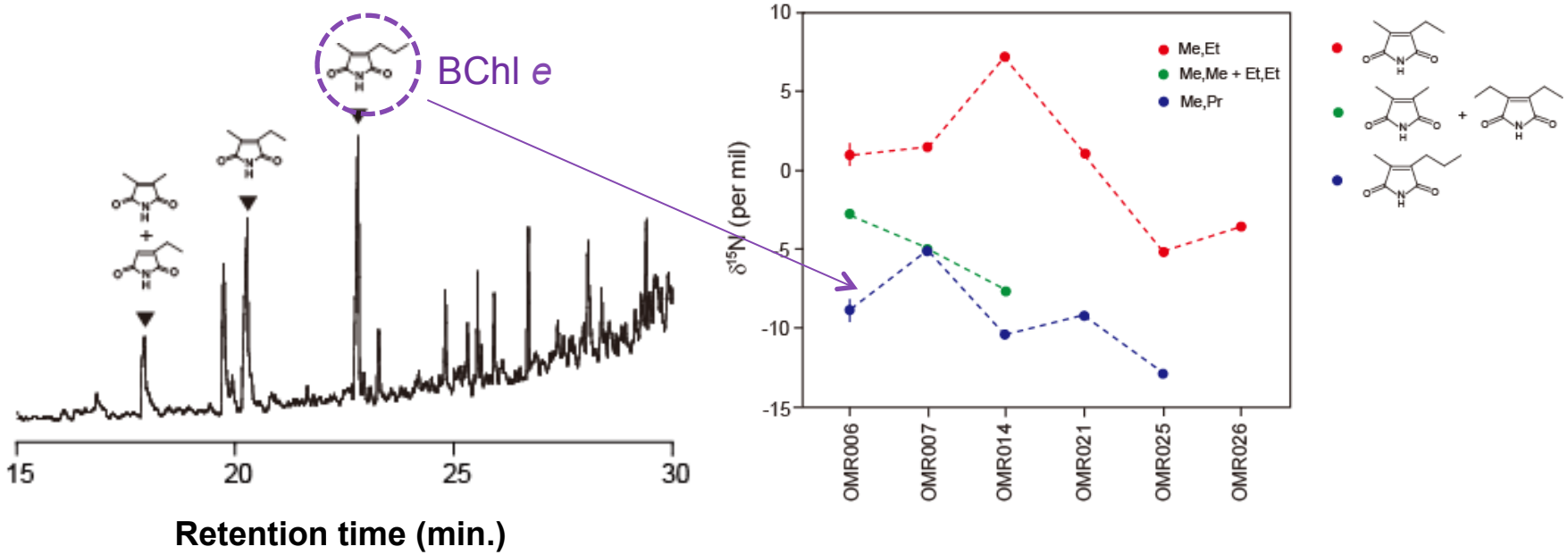


Carbon and nitrogen isotopic compositions of porphyrins

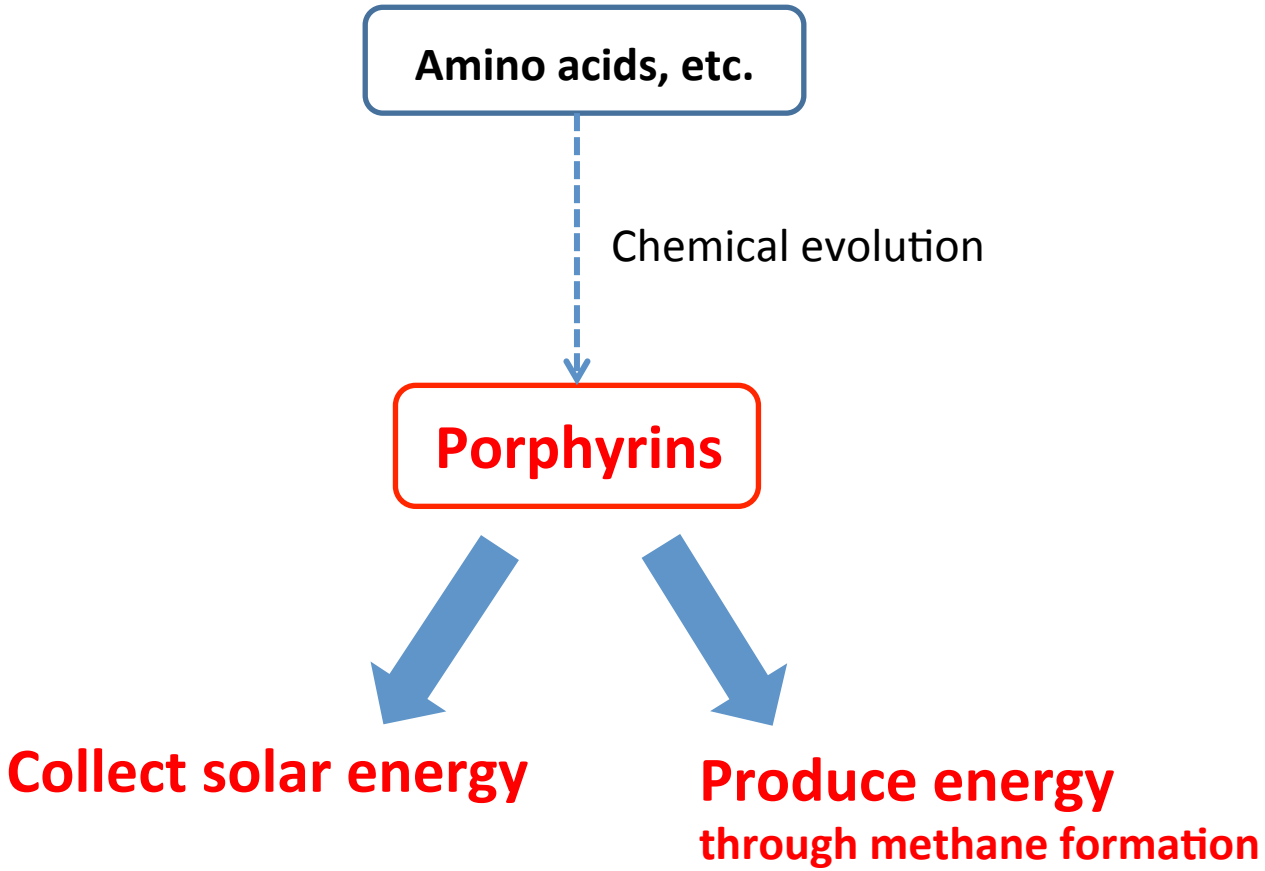


Kashiyama et al. (2008, 2010)

Porphyrins from 500 Ma rock

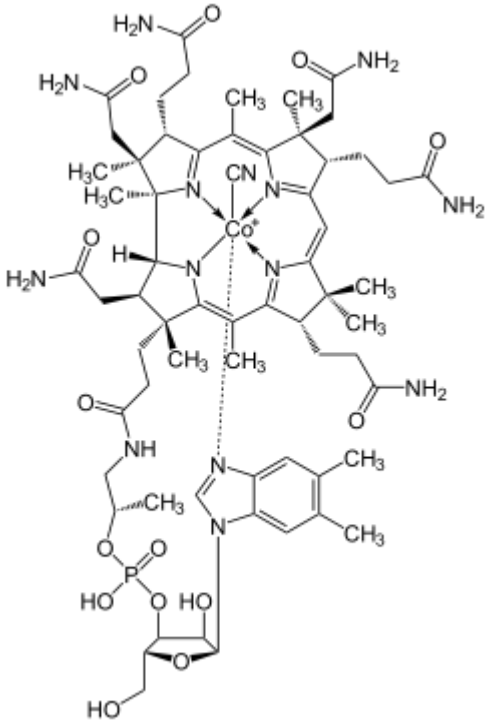


Hallam et al., in prep.



Chemical evolutionary production of porphyrins from smaller compounds could have been a key step for early phase of evolution of life

Vitamin B_{12}



Involved in the metabolism, especially affecting DNA synthesis and regulation, and fatty acid synthesis