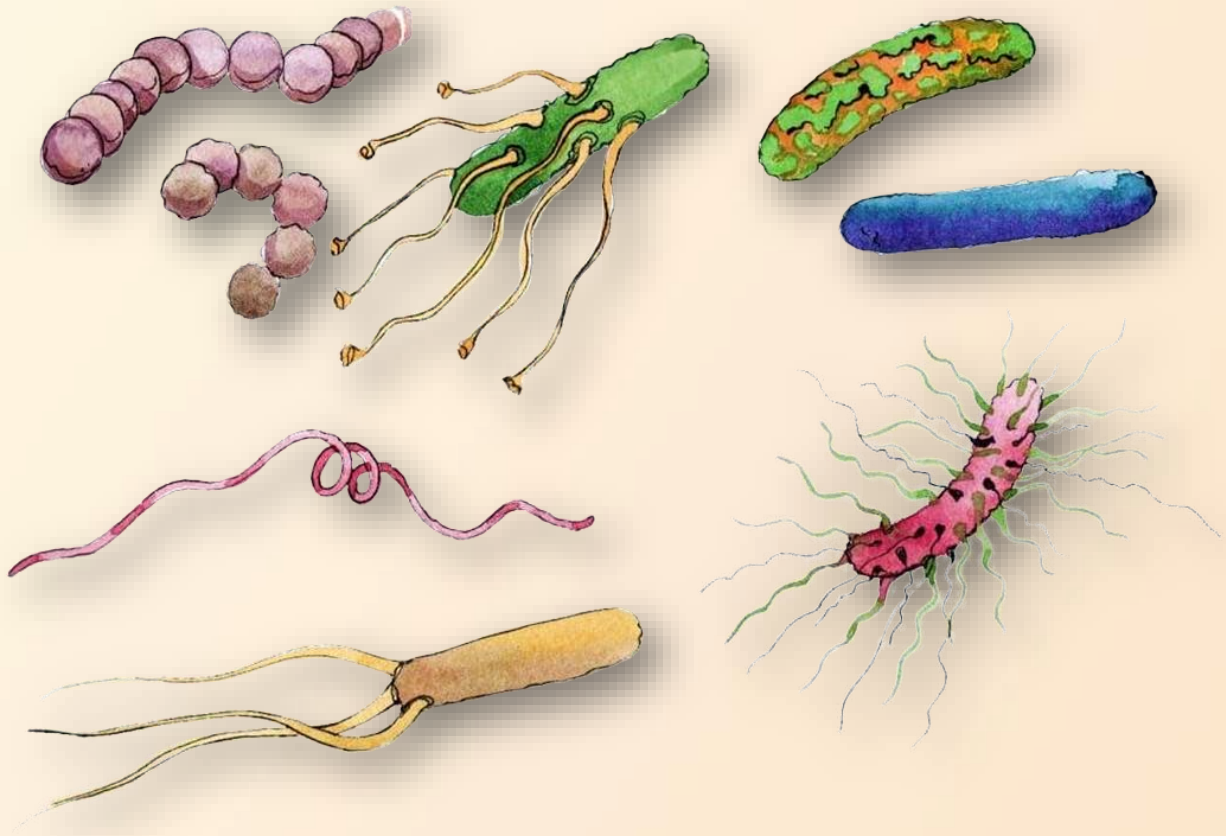
Understanding the effect of light on soil microbial diversity and function



université de BORDEAUX

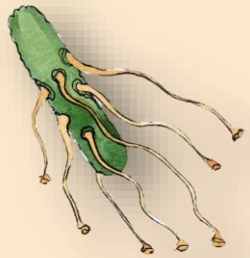
INRA SCIENCE & IMPACT

Referent : Lisa WINGATE

Clément FOUCAULT

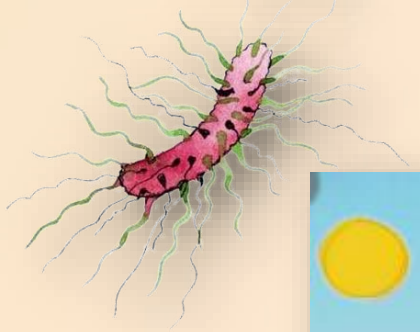
Carbon cycle main fluxes in natural ecosystems are

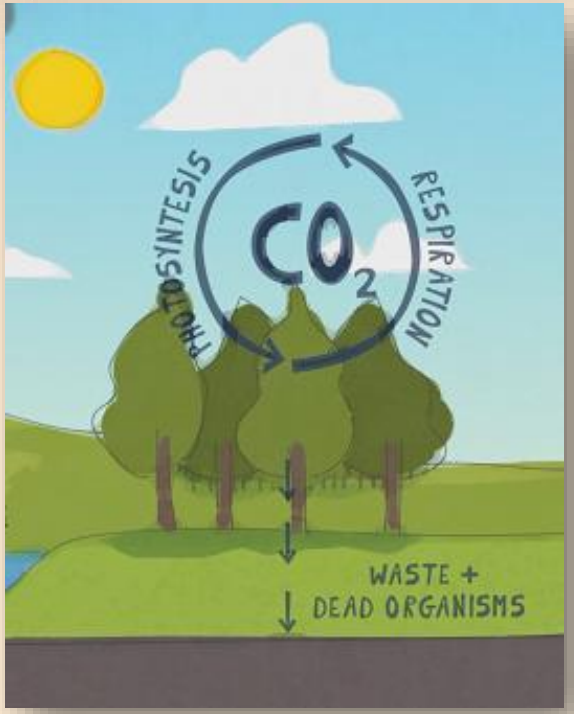
PHOTOSYNTHESIS



and

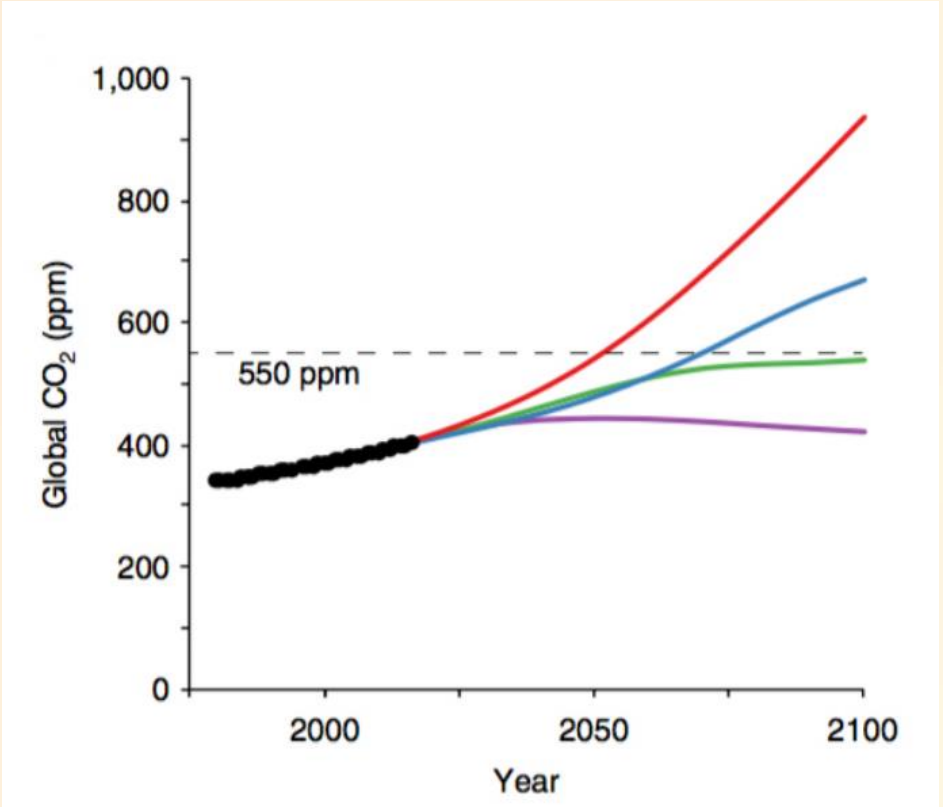
RESPIRATION





Will lands ecosystems act as source or sink ?

→ Crucial knowledge to estimate future atmospheric CO2 concentrations.

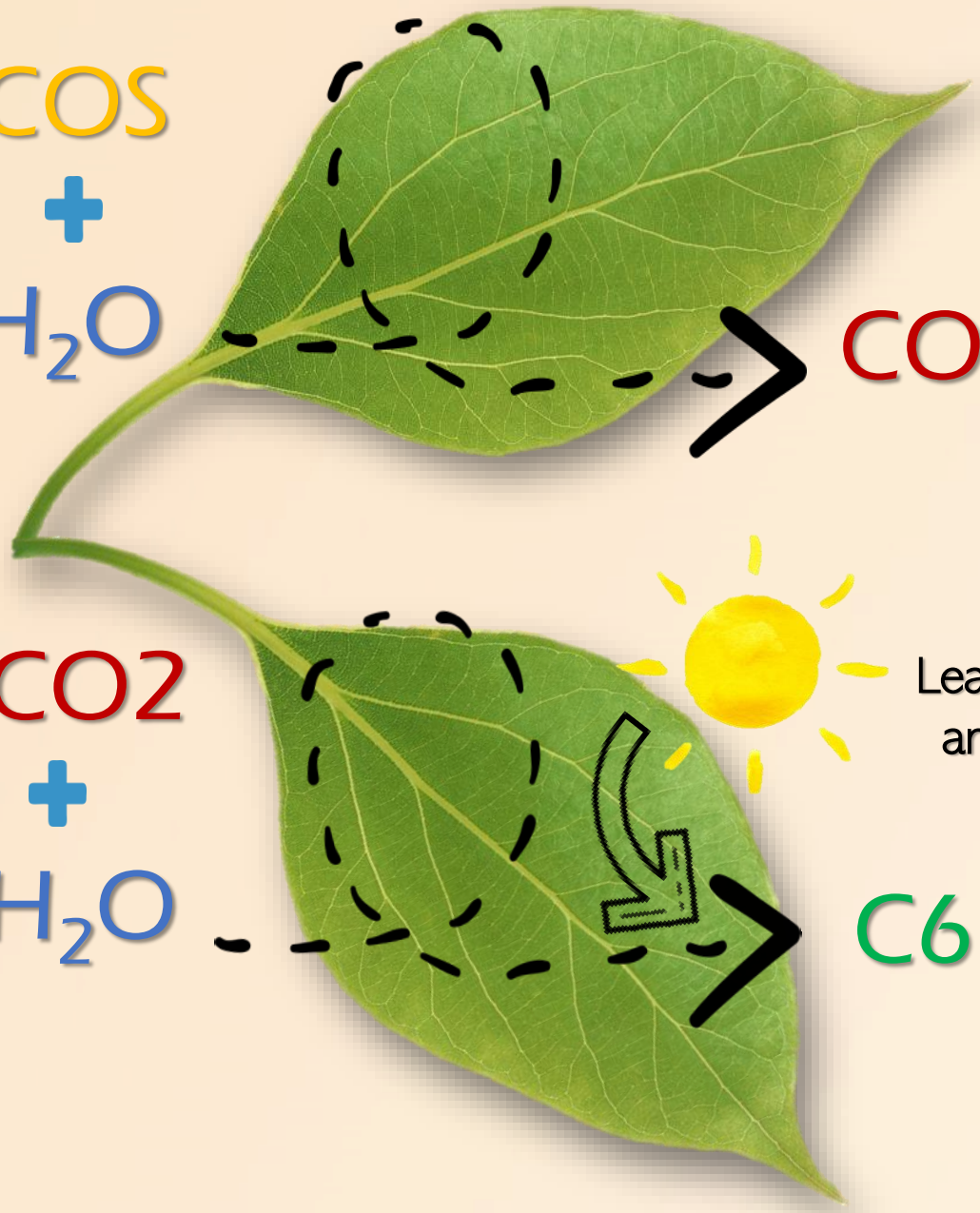


Source data : Global Carbon Project

$COS + H_2O \rightarrow CO_2 + H_2S$

COS is hydrolyzed in leaves by carbonic anhydrase (CA).

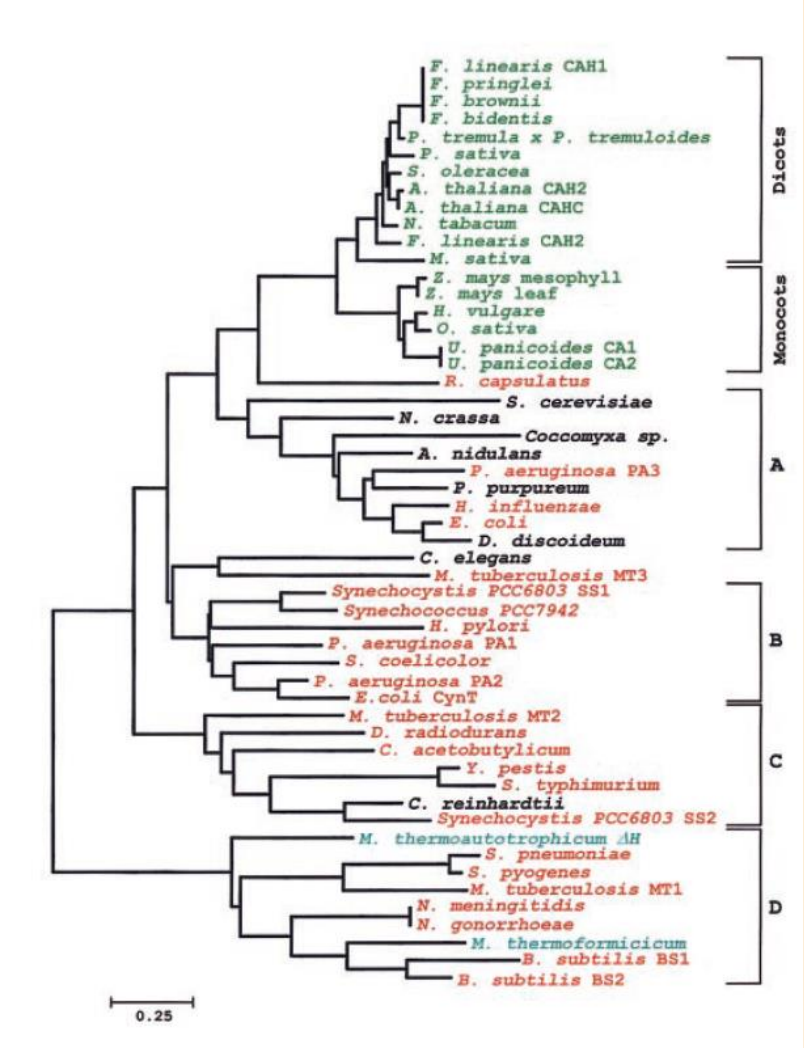
Source : Sandoval-Soto et.al, 2005



$6CO2 + 6H_2O \rightarrow C6H12O6 + 6O2$

Leaves harness solar energy in presence of CO2 and water and convert it into chemical energy.

CA : an ubiquitous enzyme !



Phylogeny of B-class CA

Eukaryotes are in green.

Lower eukaryotes in black.

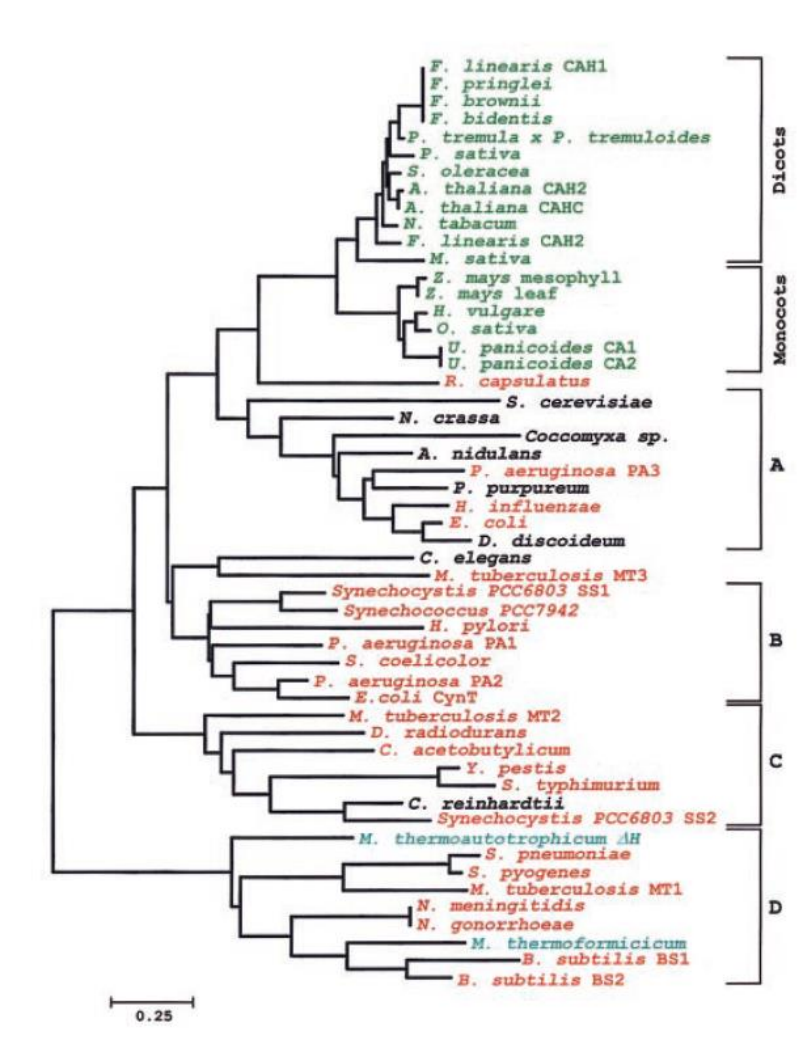
Bacteria in red.

Archaea in blue.

Carbonic anhydrase is a very ancient enzyme. Root of CA on the tree is estimated around - 4.2Ga.

Source : Smith et.al, 1999

CA : an ubiquitous enzyme !



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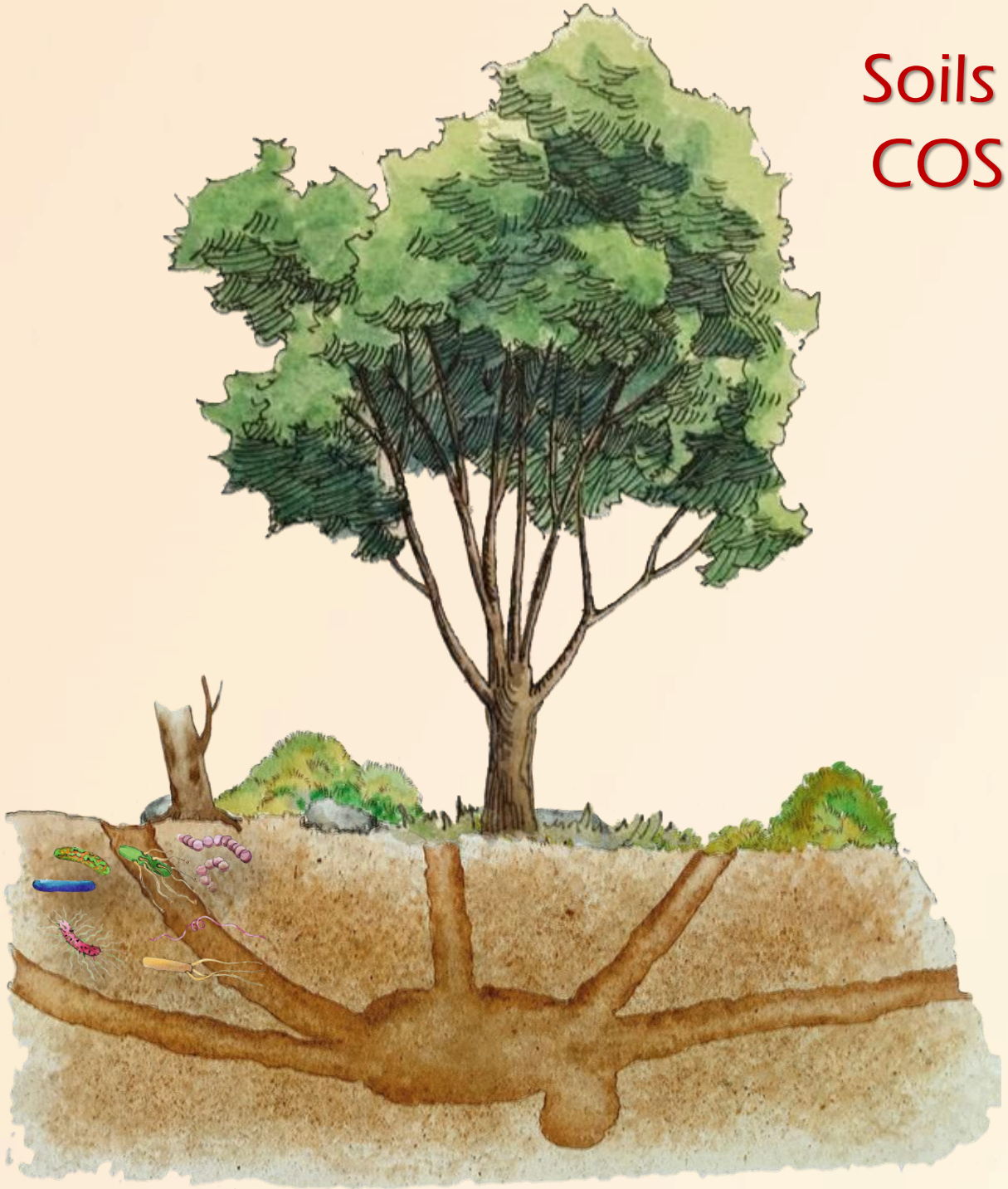
Soils are significant COS contributors !



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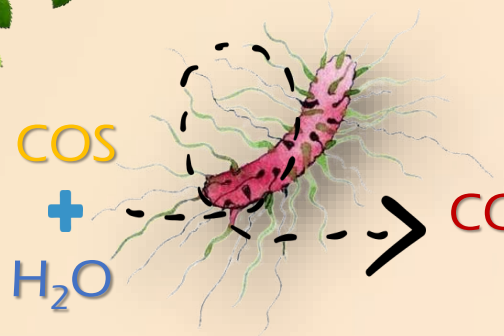
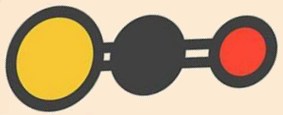


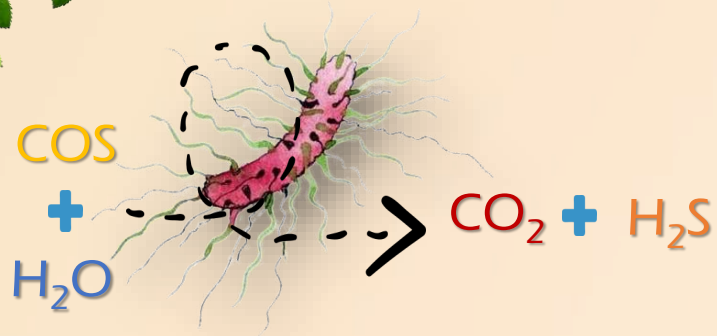
COS



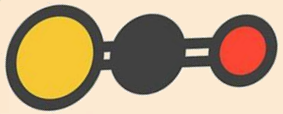
COS hydrolysis by CA

Source : Kesselmeier et.al, 1999

Soils are significant COS contributors !



COS



COS hydrolysis by CA

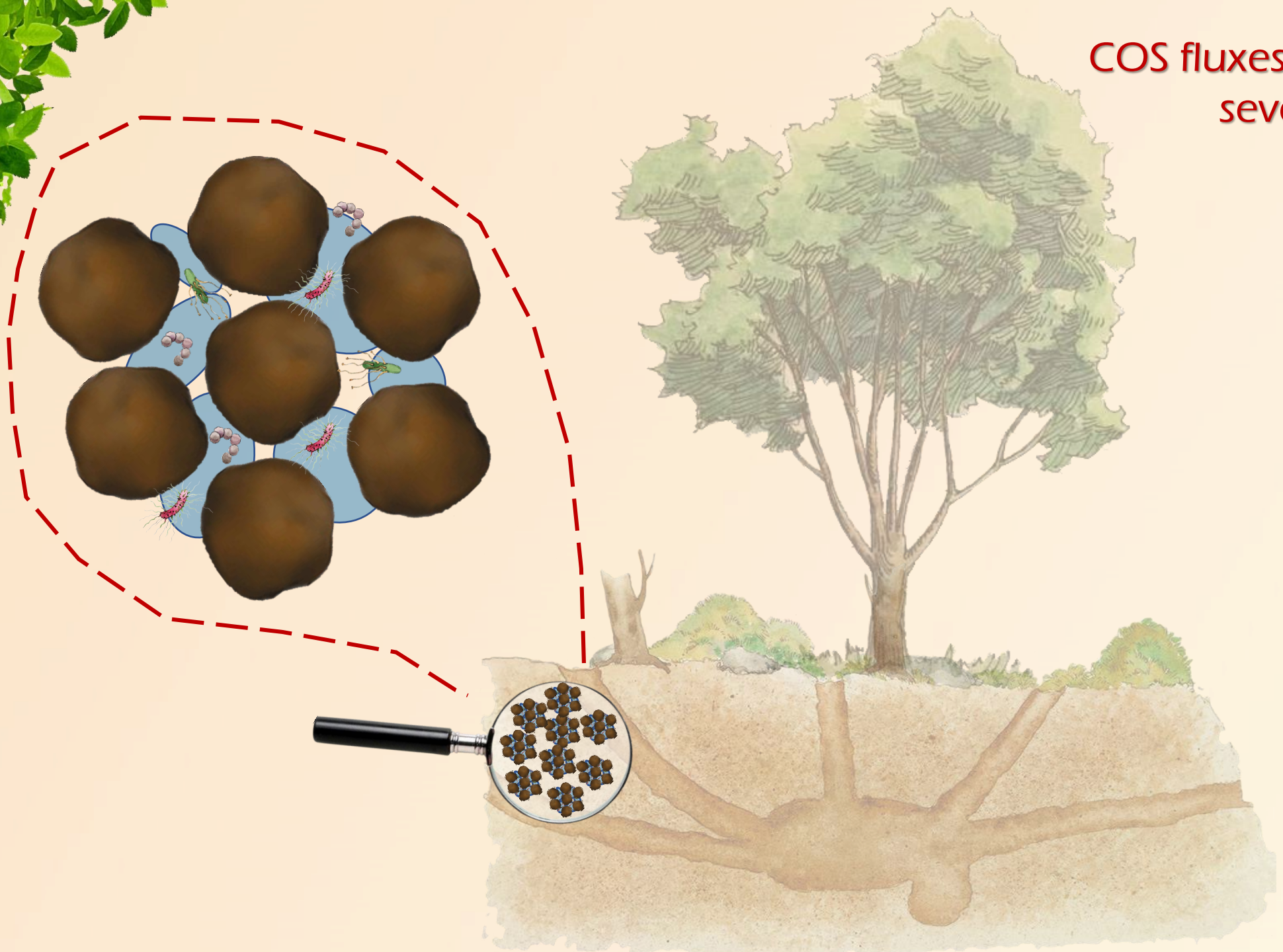
COS

Biotic and abiotic COS production in soils

Source : Kesselmeier et.al, 1999

Source : Whelan et.al, 2018

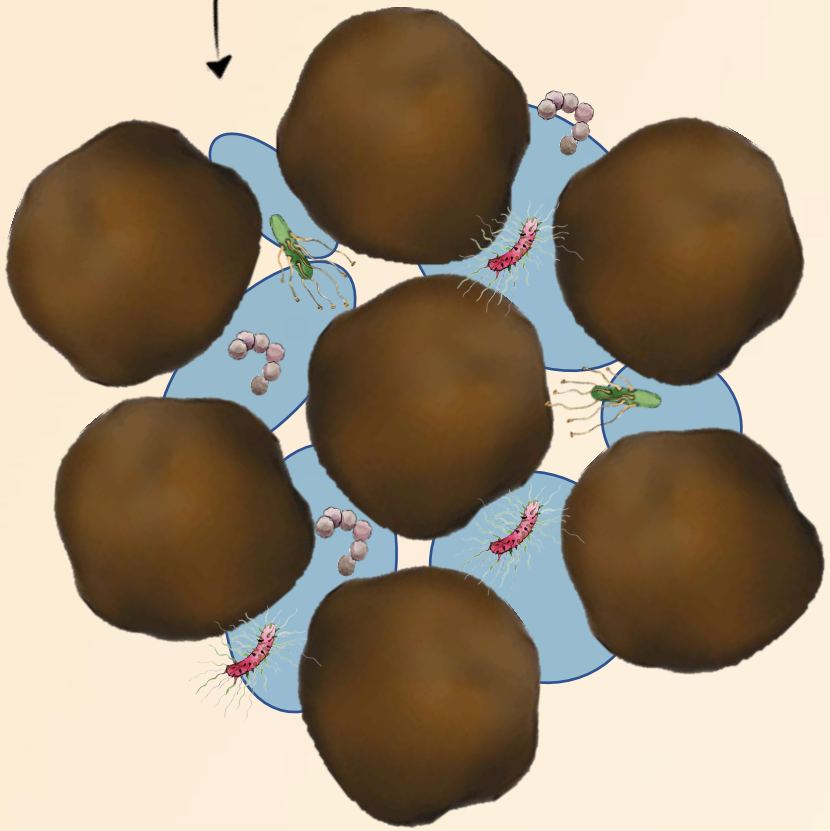
COS fluxes are dependent on several factors !

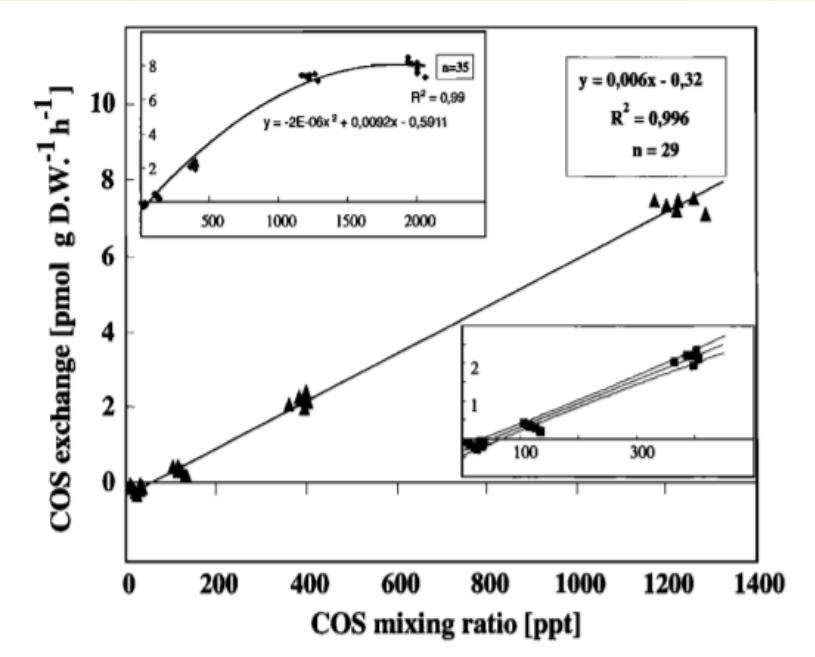


→ Higher [COS] facilitate COS uptake by organisms

[COS] atm

Source : Kesselmeier et.al, 1999



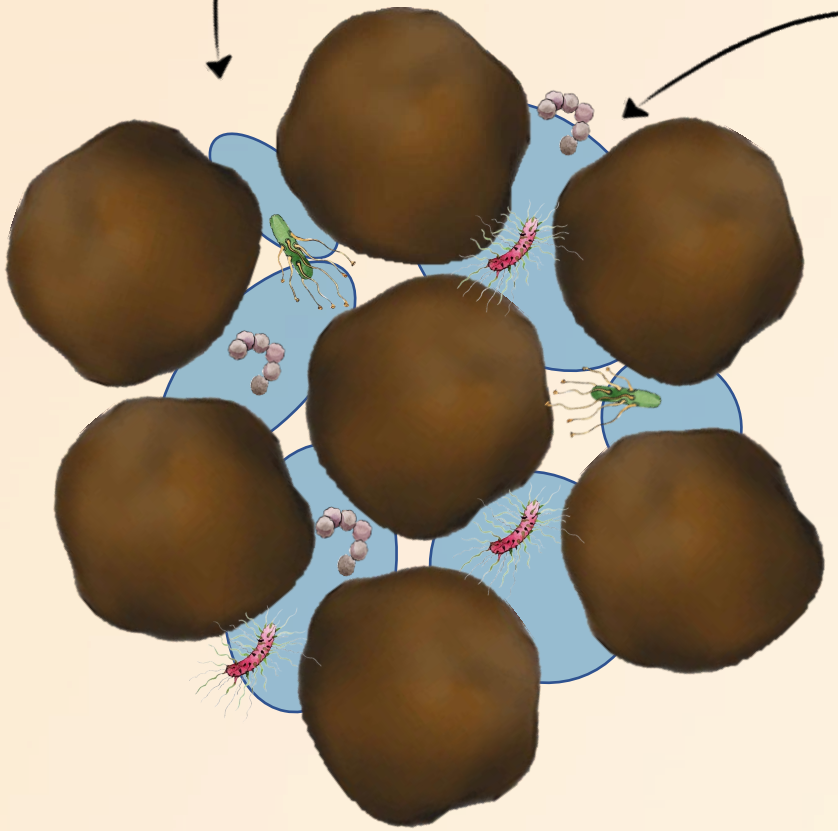


Effect of COS atmospheric concentration on soil COS uptake

→ Temperature affects CA efficiency and thus the uptake of COS

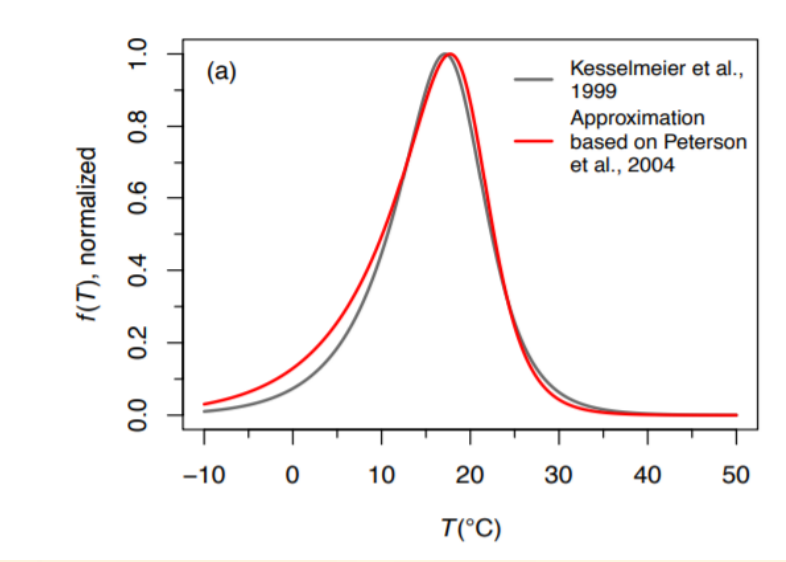
[COS] atm

Source : Kesselmeier et.al, 1999



Temperature

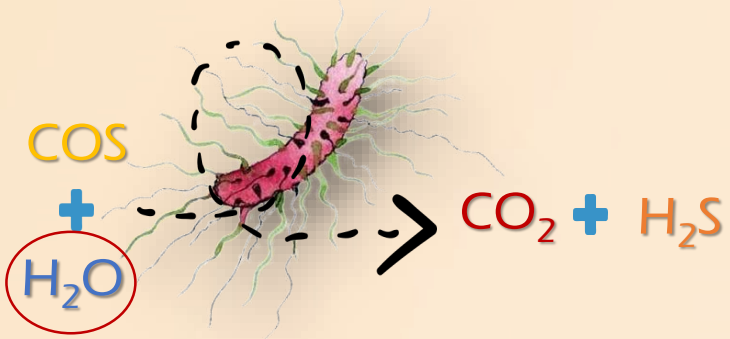
Source : Kesselmeier et.al, 1999

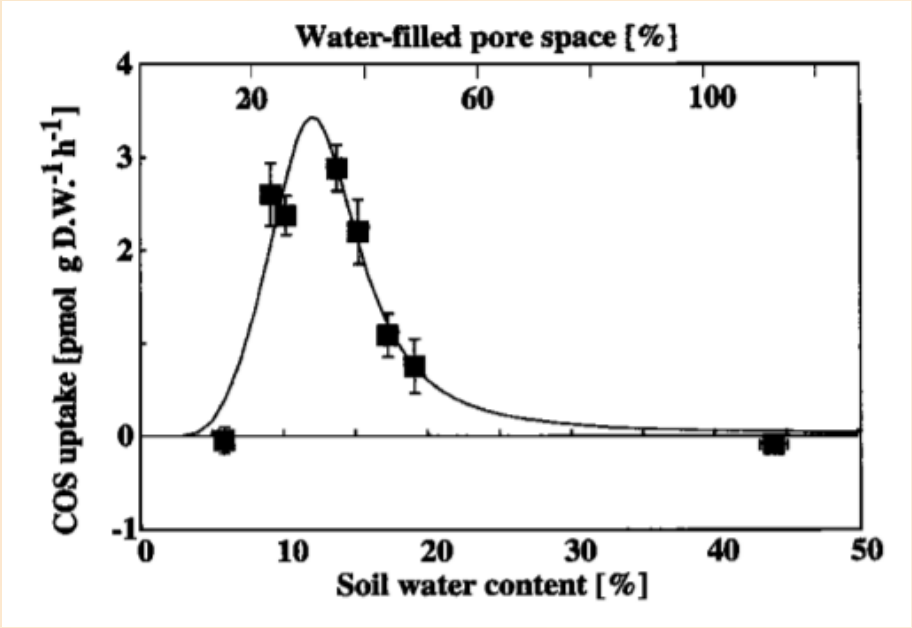


T°C function of soil COS uptake

Source : Sun et.al, 2015

→ Water is an essential part of the chemical reaction

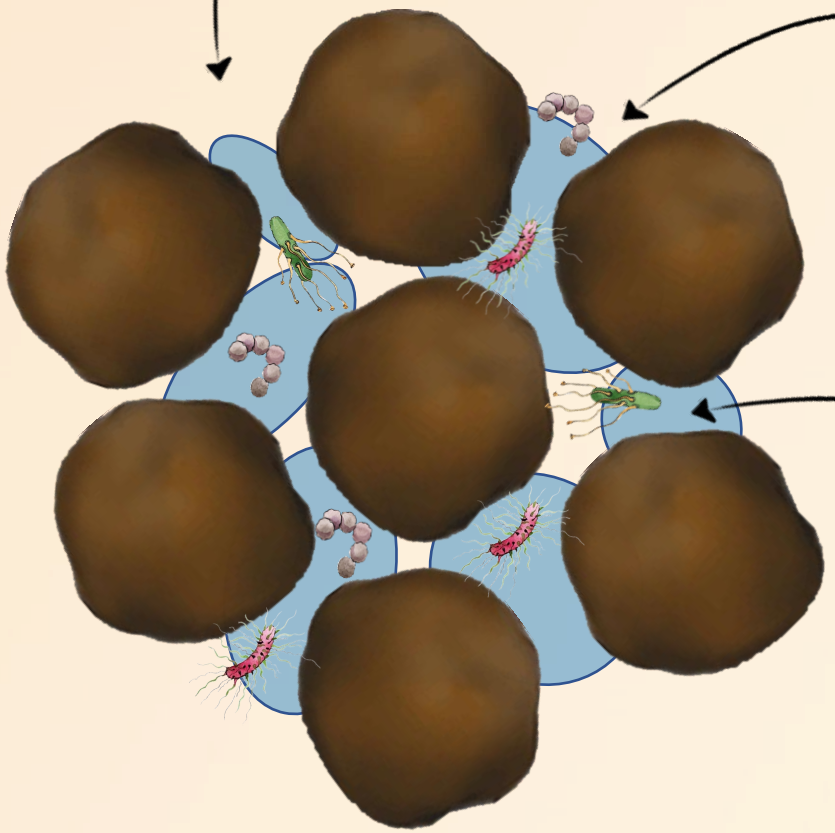




Effect of soil moisture on soil COS uptake

[COS] atm

Source : Kesselmeier et.al, 1999



Temperature

Source : Kesselmeier et.al, 1999

Soil moisture

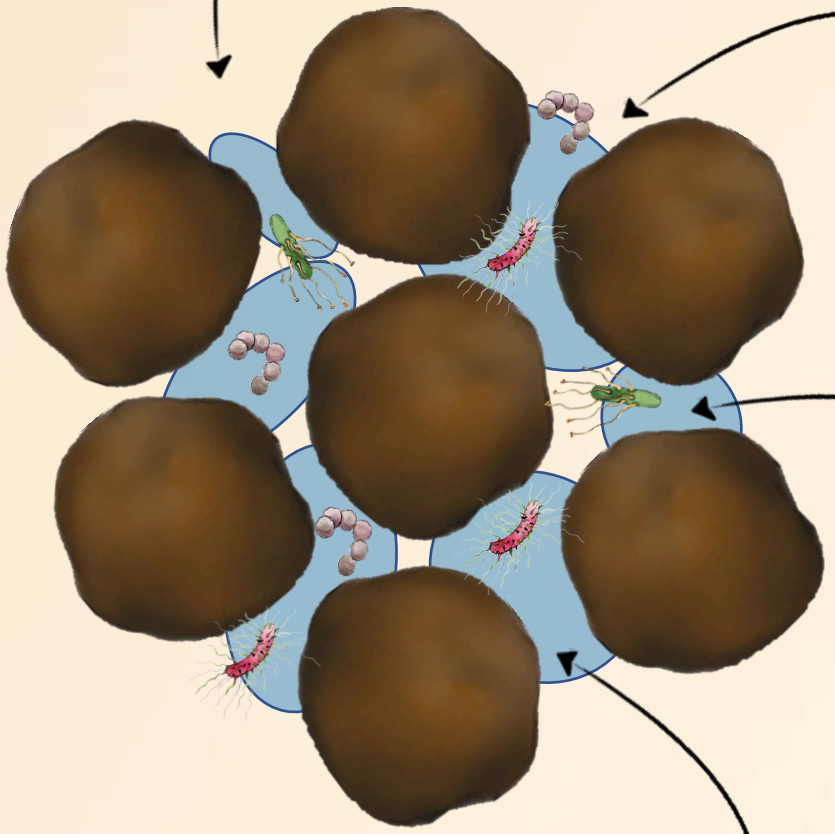
Source : Kesselmeier et.al, 1999

→ If the soil moisture is too high, then COS diffusion in soil is impaired

→ Water is an essential part of the chemical reaction

[COS] atm

Source : Kesselmeier et.al, 1999



Temperature

Source : Kesselmeier et.al, 1999

Soil moisture

Source : Kesselmeier et.al, 1999

pH

Effect of light on COS fluxes

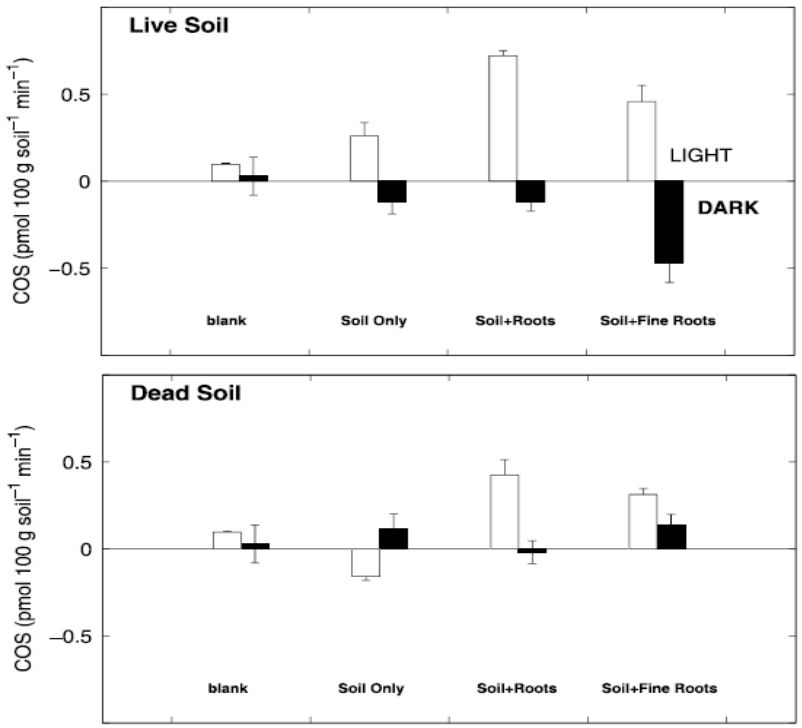


Figure 3. COS fluxes from subsample incubation experiments under light and dark conditions. Error bars indicate the standard deviation of repeated measurements. All measurements were performed with incubation temperature at 19°C.

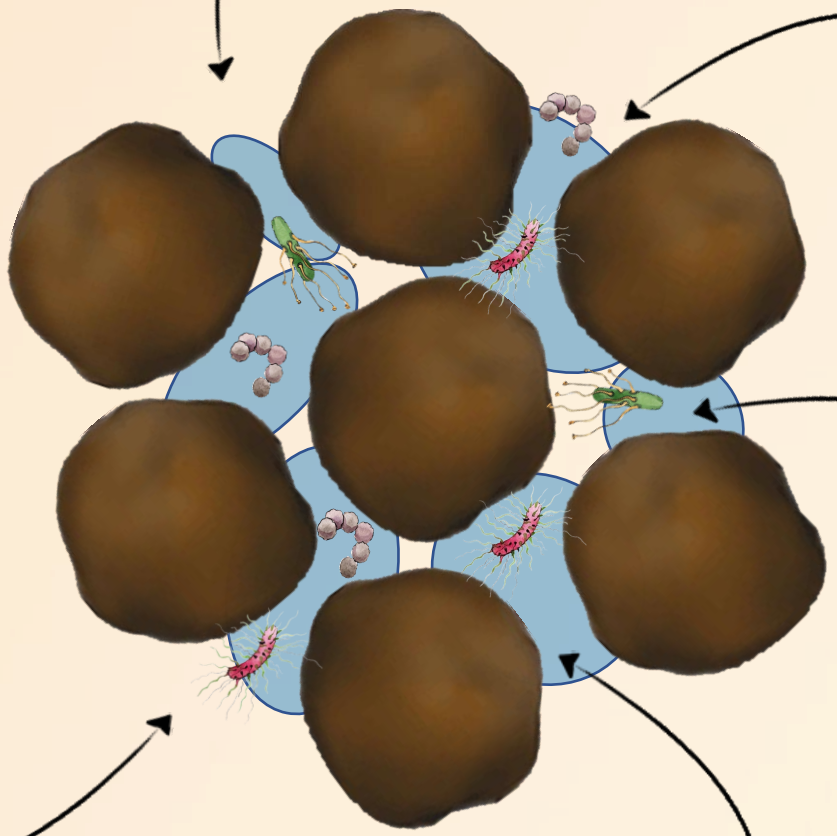
Source : Whelan & Rhew, 2014

[COS] atm

Source : Kesselmeier et.al, 1999

Temperature

Source : Kesselmeier et.al, 1999



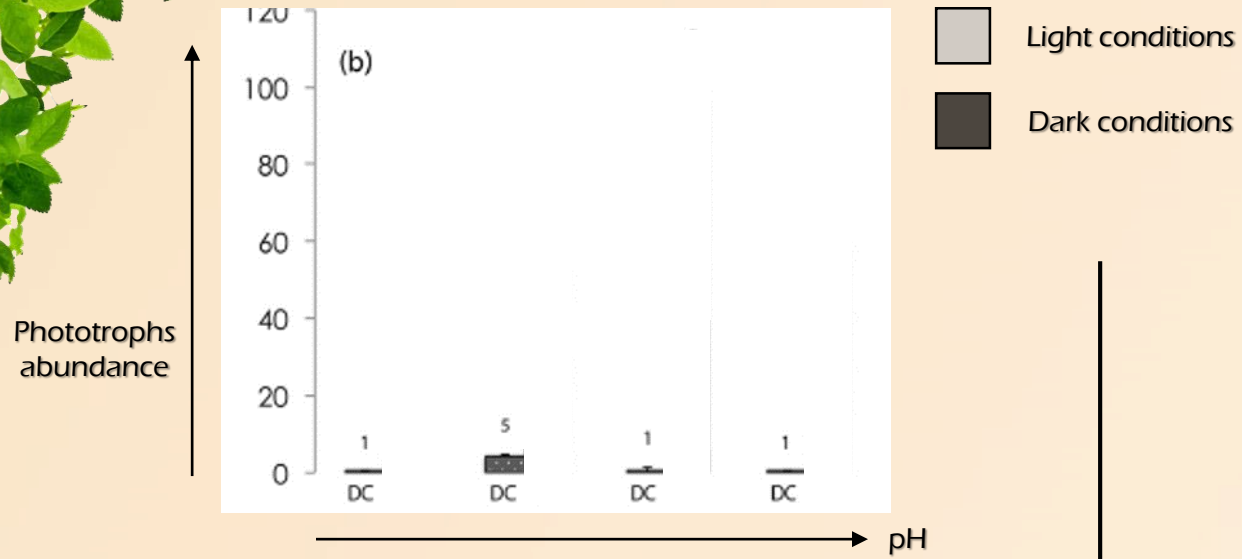
Soil moisture

Source : Kesselmeier et.al, 1999

Light

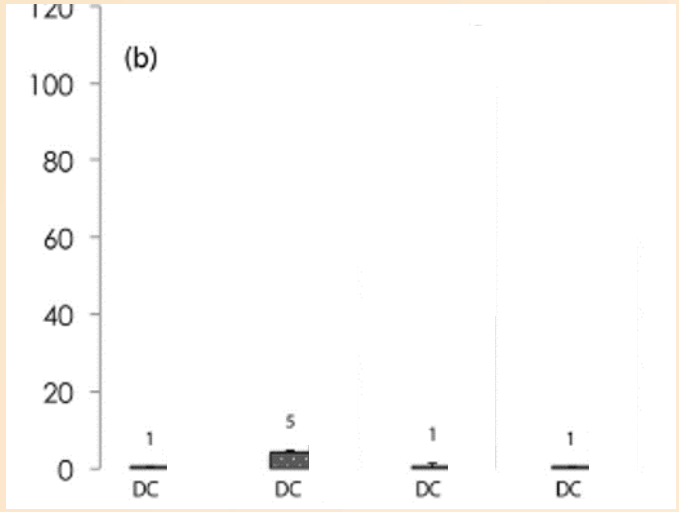
Source : Sauze et.al, 2017

pH



Phototrophs gene copies function of pH and light

Source : Sauze et.al, 2017



Light conditions

Dark conditions

Phototrophs abundance

pH

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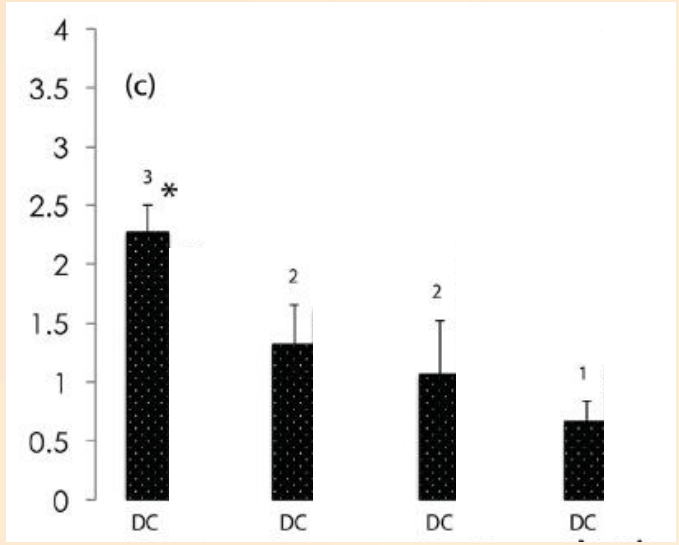
Source : Sauze et.al, 2017

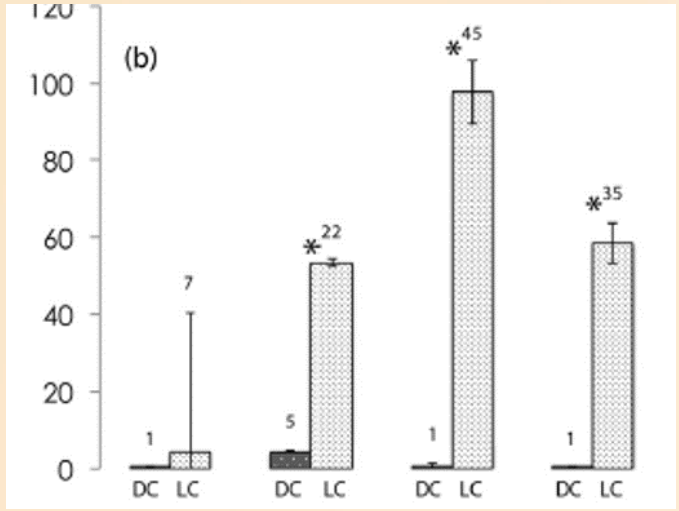


Fungal abundance

pH

Fungal gene copies function of pH and light

Source : Sauze et.al, 2017



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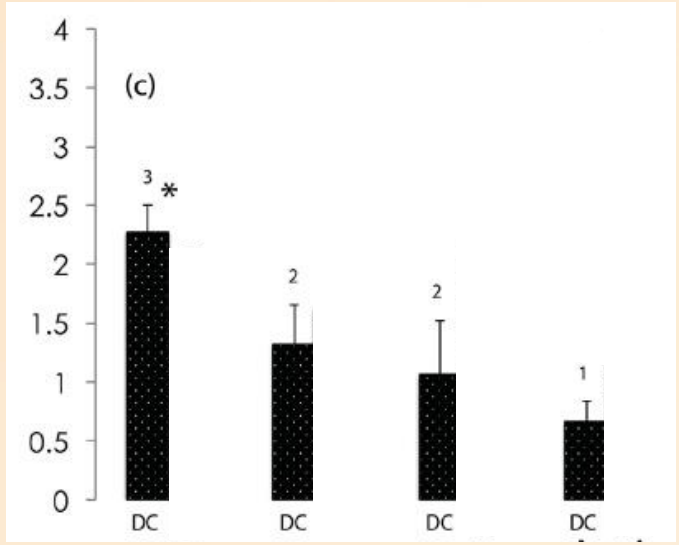

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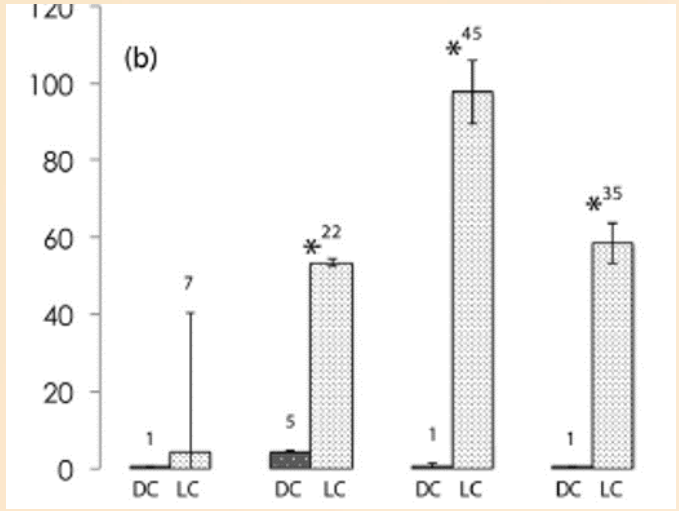

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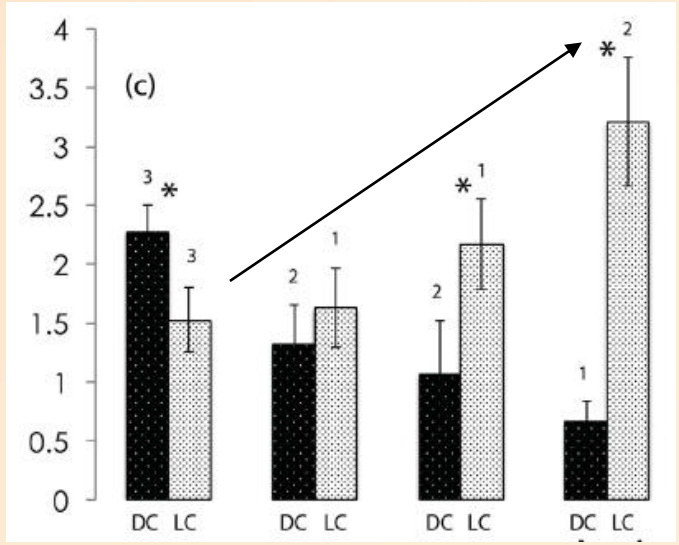

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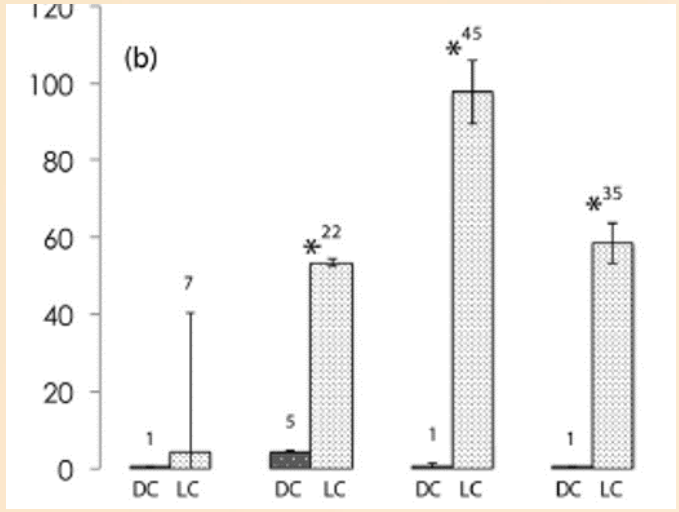

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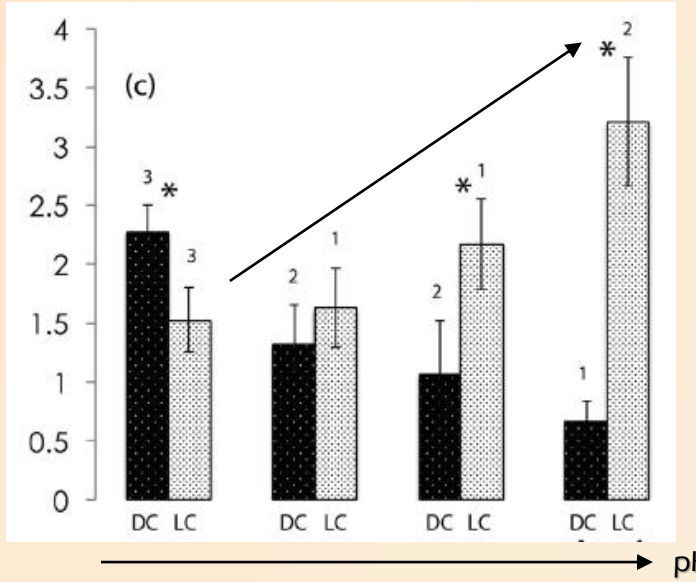
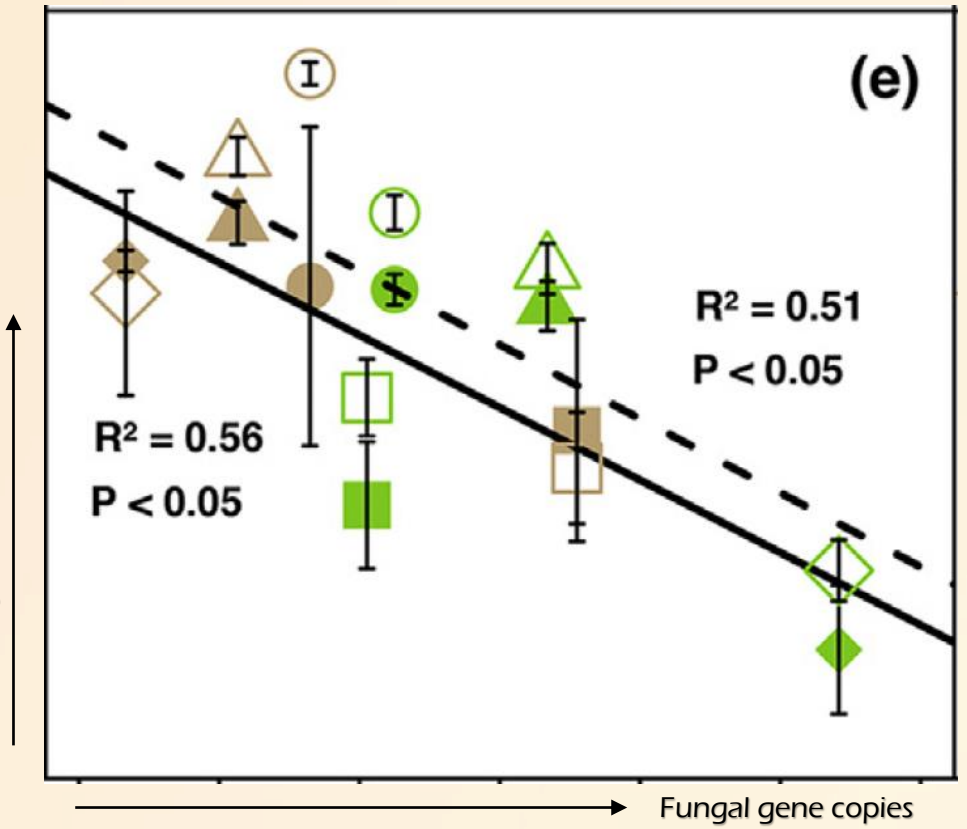


Fungal gene copies function of pH and light

Source : Sauze et.al, 2017



COS flux function of fungal gene copies

Source : Sauze et.al, 2017

Differences in COS fluxes cannot be explained only by microbes' abundances.

→ Understanding community interactions is key

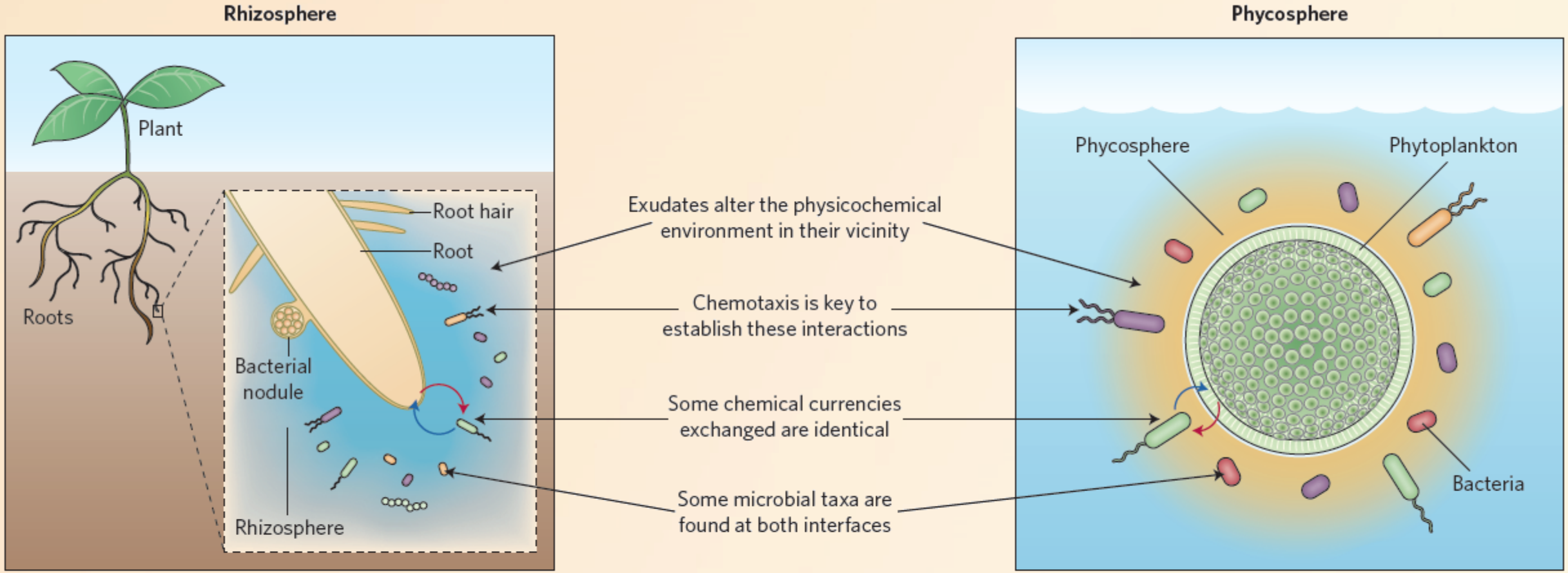
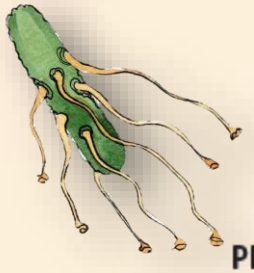
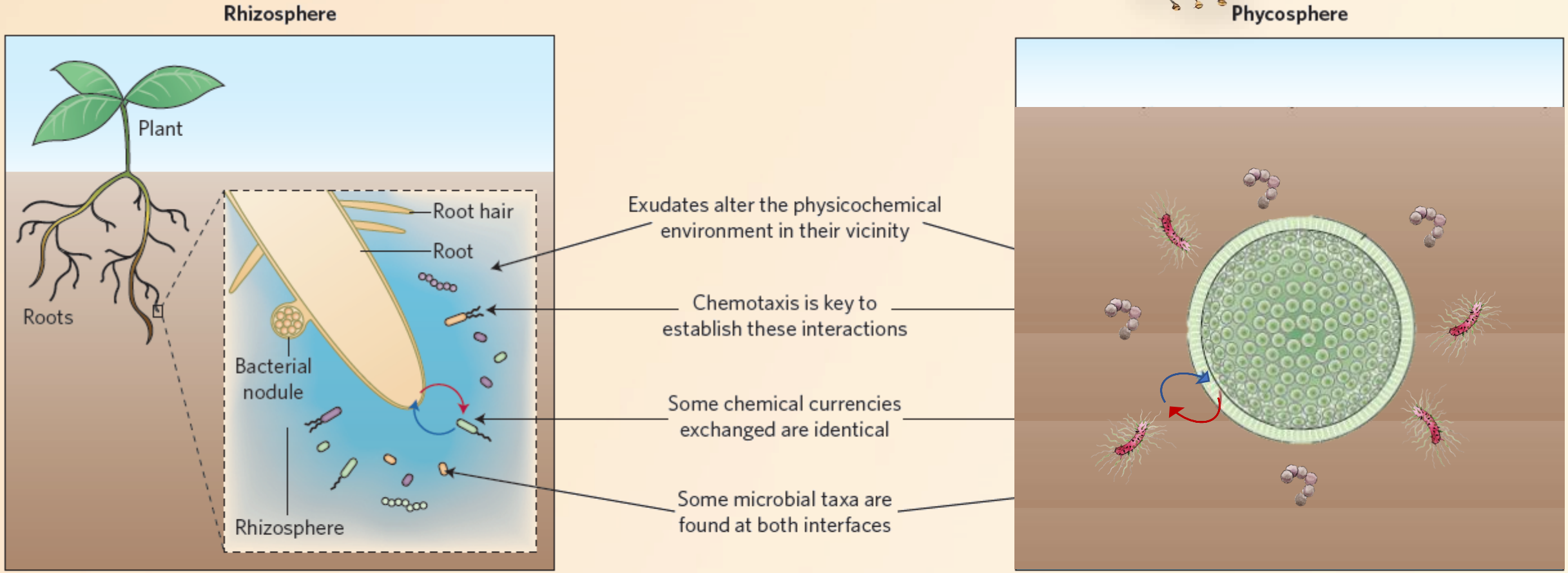


Figure 2 | The rhizosphere and the phycosphere are analogous microenvironments. The phycosphere, defined as the region surrounding a phytoplankton cell that is enriched in organic substrates exuded by the cell, is an important microenvironment for planktonic aquatic bacteria. It is the aquatic analogue of the rhizosphere, which is the key ecological interface for plant–microorganism interactions in terrestrial habitats.

Source : Seymour et.al, 2017

And this could also apply to free photoautotrophic soil organisms !





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Source : Seymour et.al, 2017

Eukaryotic phototrophs are rarely included in soil studies when it comes to studying microbial communities …

→ scarce tools for taxonomic assignment.

2018 : **µGREEN-DB**

from Djemiel et.al, to be published.

→ reference database for eukaryotic algae and cyanobacteria

→ aim to provide taxonomic assignment for photoautotrophic organisms

Phototrophic organisms can shape ecosystems on the long term !

→ Cryptogam communities !

Most of them are diazotrophic

→ impact on microbial communities / plants

Depending on pH, moisture, [CO2], they can produce or dissolve limestone.

→ geological shaping.

Source : Budel et.al, 2004

Biocrust in Canyonlands National Park on the Colorado Plateau

Source : Bill Bowman

Our study aim to :

→ describe photoautotrophic diversity in soil.

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→ determinate whether light affects photoautotrophic, bacterial and fungal community composition.

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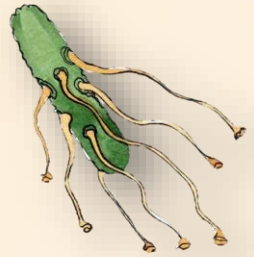
→ determinate whether light affects photoautotrophic, bacterial and fungal community composition.

→ evaluate whether changes in microbial community lead to changes in ecosystem function :

- → soil respiration
- → photosynthesis rate
- → COS exchange
- → CA activity

Thank you



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