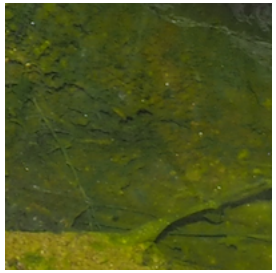


# An autotrophic microbial community including *Chloroflexus aggregans* in Nakabusa hot springs as a hypothetical model of the emergence of photosynthesis from chemosynthesis

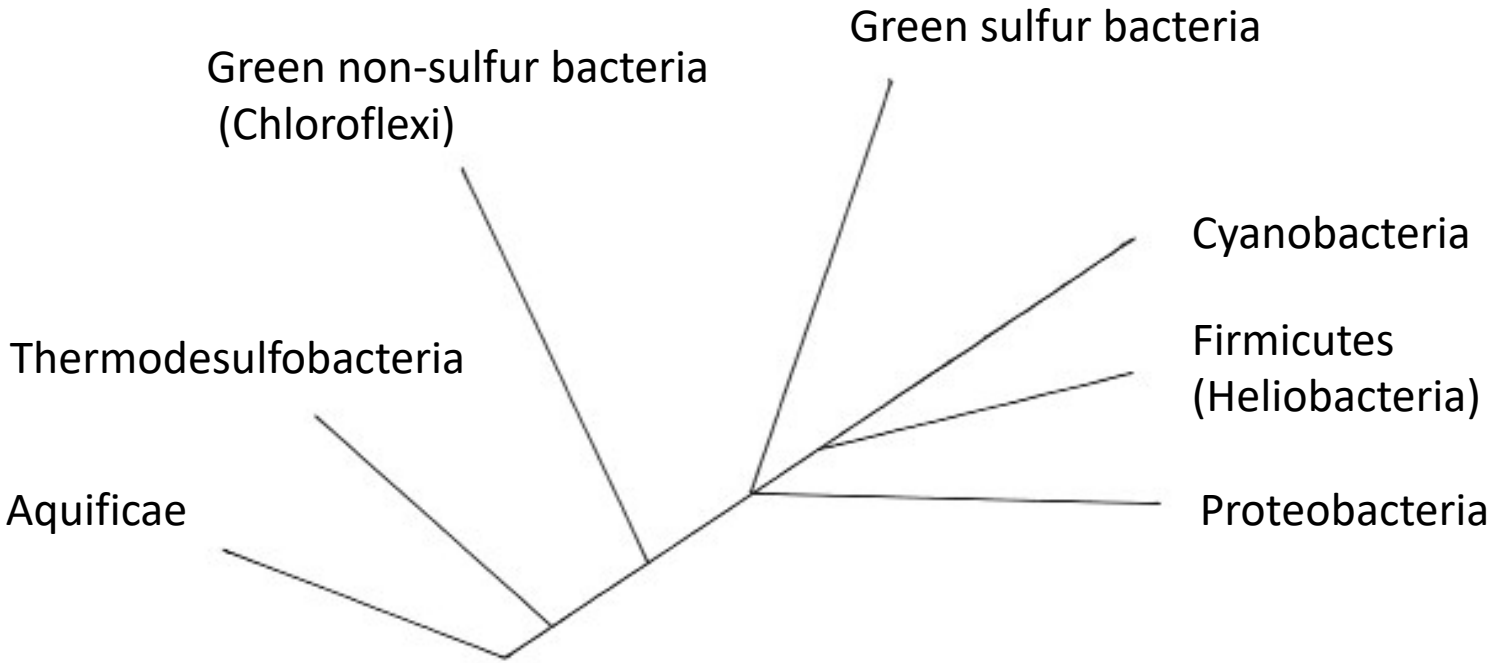
Katsumi Matsuura[1), 2)] , Shawn E. McGlynn [2)] , Shigeru Kawai [3)]

[1)] Inst. Early Metabolic Evolution, [2)] ELSI, Tokyo Tech, [3)] JAMSTEC

# Oyaizu & Woese proposed deep blanching of *Chloroflexus* in 1987

The green non-sulfur bacteria: A deep branching in the eubacterial line of descent
H.Oyaizu B.Debrunner-Vossbrinck L.MandelcoJ.A.Studier C.R.Woese

Systematic and Applied Microbiology Volume 9, 1987, 47-53



# Big questions

1. What was the first photosynthesis?

   Oxygenic and Autotrophic
   Anoxygenic and Heterotrophic
   Anoxygenic and Autotrophic

2. What kind of biological community with energy metabolism did photosynthesis begin?

   Fermentation
   Anaerobic respiration  Aerobic respiration
   Anaerobic chemosynthesis  Aerobic chemosynthesis

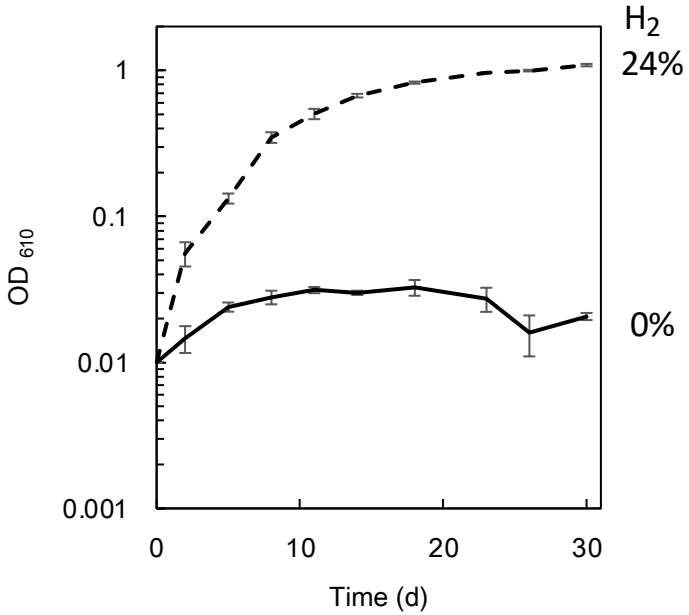
# *Chloroflexus* as a candidate for the first photosynthetic organism

1. Grow up to the highest temperature (70°) as a photosynthetic organism
2. Branch deepest in photosynthetic organisms by phylogenetic analysis of 16s rRNA
3. Previously, it was known to grow well with heterotrophic photosynthesis and aerobic respiration
4. In 2019, Chloroflexus aggregans was reorted to grows well in vitro with autotrophic photosynthesis and grows slightly with chemosynthesis. ⇒ Next 2 slides

# *C. aggregans* grows by photosynthesis and chemosynthesis using hydrogen as an electron source

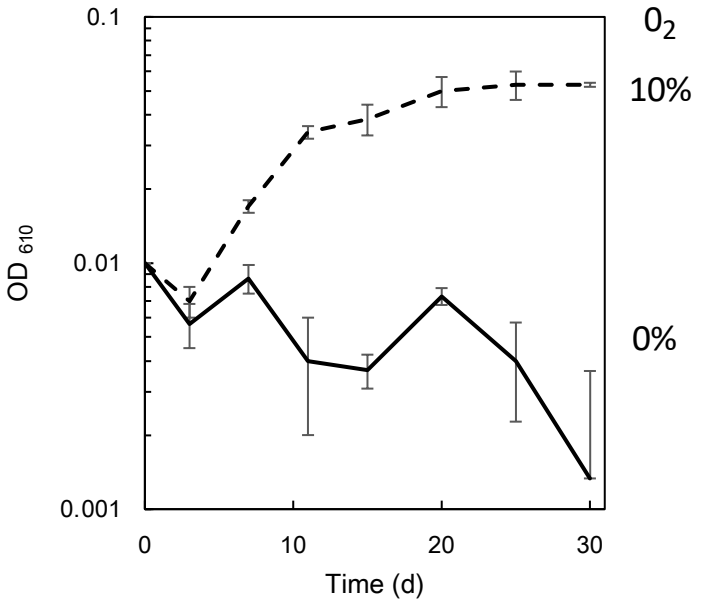
Kawai, Nishihara, Matsuura, Haruta, 2019

## Anaerobic photosynthetic growth




Grows well in the initial doubling time of 1 day

## Semiaerobic chemosynthetic growth



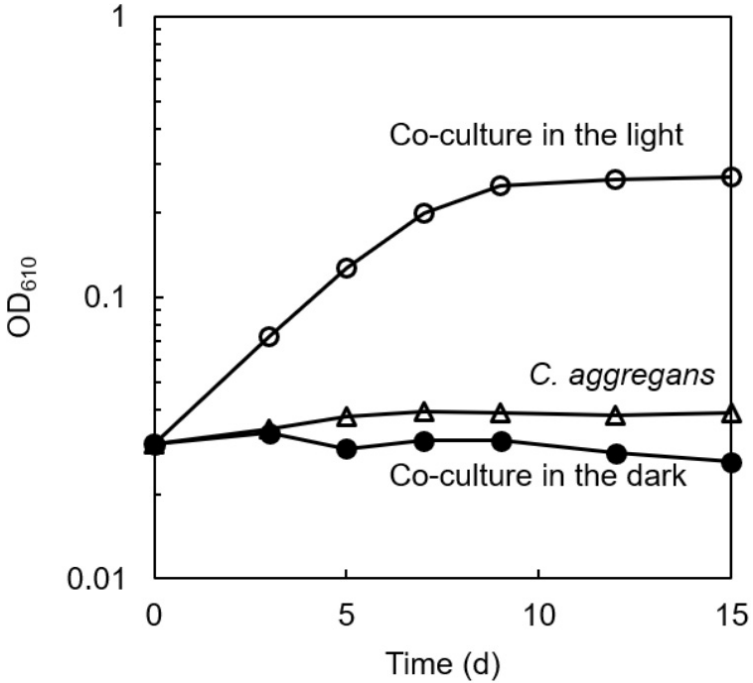

Grows a little in the initial doubling time of 5 days

# *C. aggregans* grows on $HS^-$ together with sulfur disproportionating bacteria

Kawai, Kamiya, Matsuura, Haruta, 2019

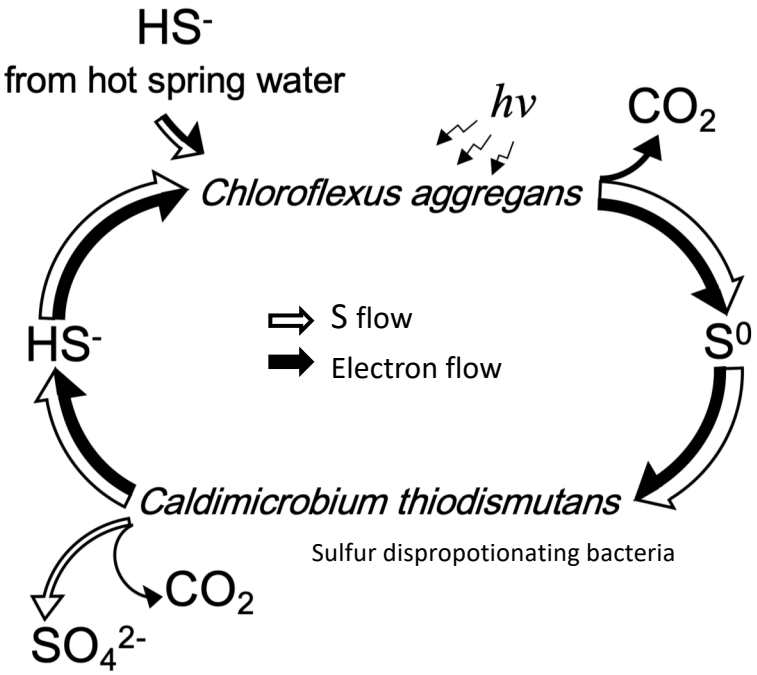
Co-culture:

$HS^-$ dependent anaerobic growth




Grows with light and disproportionating bacteria

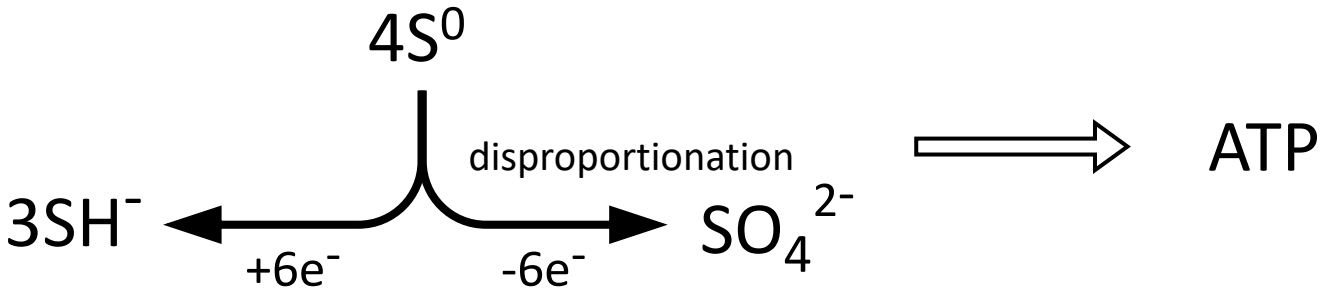
Electron and S Flow in the co-culture



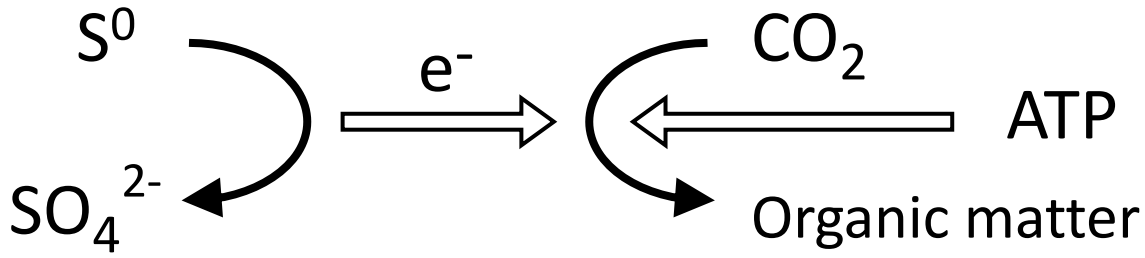
# Electron transfer and energy conversion of sulfur disproportionating bacteria

1. $S^0$ for energy source

Sulfur disproportionating chemosynthetic bacteria



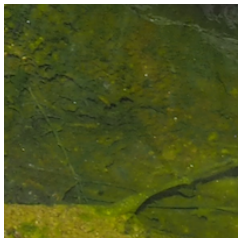

2. $S^0$ for electron source



# Photosynthetic and chemosynthetic microbial communities in Nakabusa

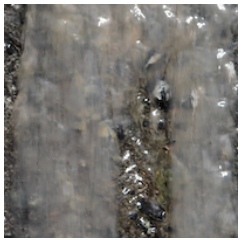
## Kassen-no-Yu: 86°C at top:  horizontal flow

86°C



66°C

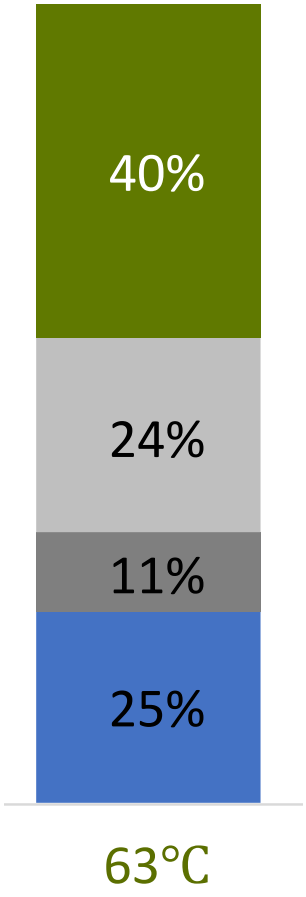
## Kojiki-no-Yu: 80°C at top: vertical flow



78°C

63°C

# Composition in a photosynthetic microbial communy




*C. aggregans*

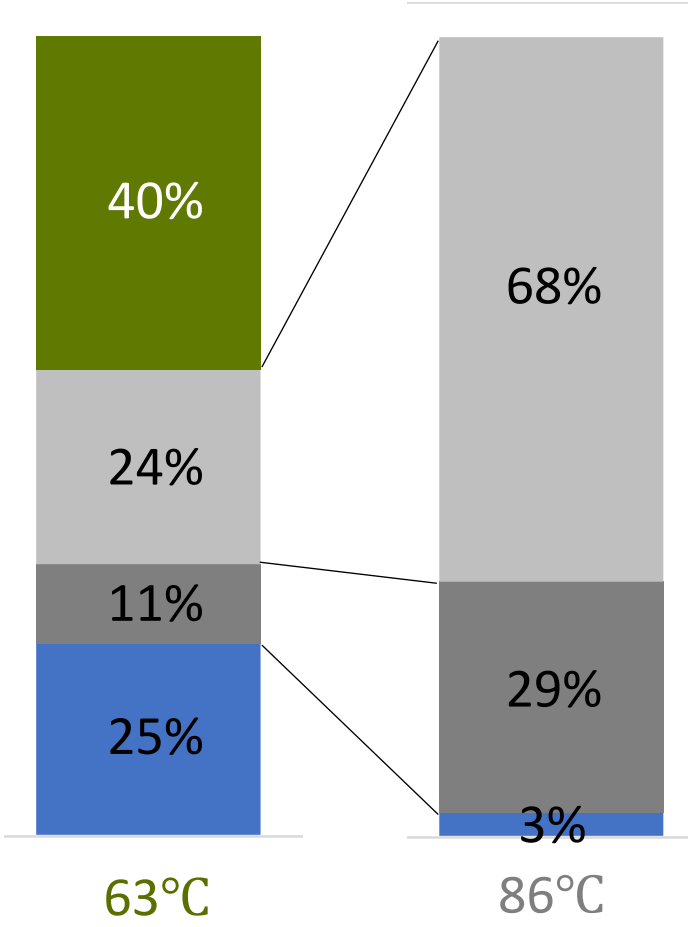
$HS^-$ oxidizing chemosynthetic bacteria

Sulfur disproportionating bacteria

others

# Comparison of microbial composition of photosynthetic and chemosynthetic communities

*C. aggregans*




$HS^-$ oxidizing chemosynthetic bacteria

Sulfur disproportionating bacteria

others

# Environmental chemical conditions and microbial compositions

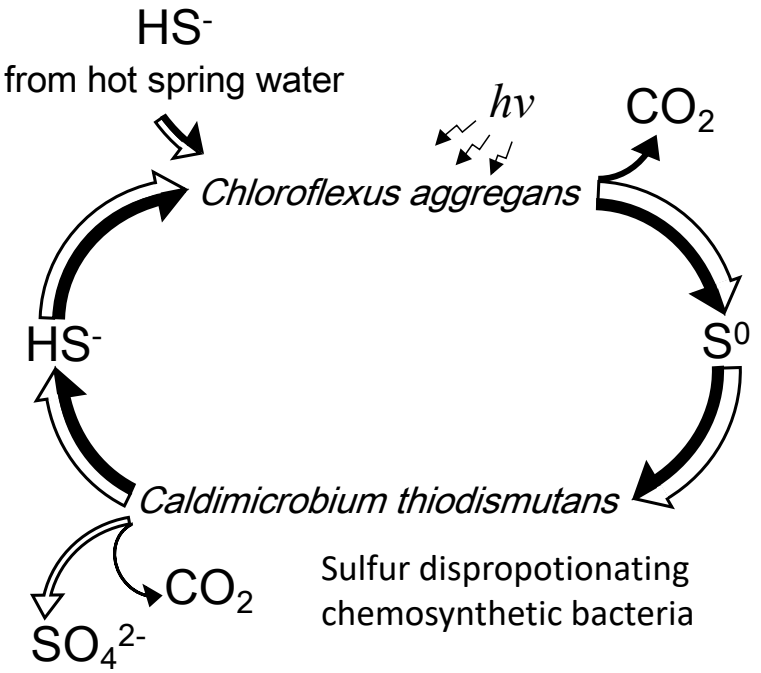
| | | | | | |
|---|---|---|---|---|---|
| Temp. (℃) | 86 | 78 | 66 | 63 | 66 |
| $HS^-$ (μmol/L) | 238 | 239 | 109 | 146 | 2 |
| $O_2$ (μmol/L) | 16 | 39 | 16 | 42 | 66 |
| *C. aggregans* (%) | 0 | 0 | 52 | 40 | 21 |
| $HS^-$ oxidiziing chemosynthetic bac. (%) | 68 | 87 | 1 | 24 | 34 |
| sulfur dispropor-tionating bac. (%) | 29 | 8 | 14 | 11 | 10 |

# Questions of this study

1. Is there a sufficient amount of sulfur disproportionating bacteria in the hot-spring microbial communities to support the photosynthetic growth of *C. aggregans*?
2. Is the chemosynthetic community on the hot side (>70℃) without *C. aggregans* metabolically similar to the photosynthetic community on the cold side (<70℃) ?
3. Is it meaningful to study further the autotrophic microbial communities at Nakabusa hot springs as a hypothetical model for the emergence of photosynthesis from chemosynthesis?

# Electron and S Floow in photosynthetic and chemosynthetic microbial communities

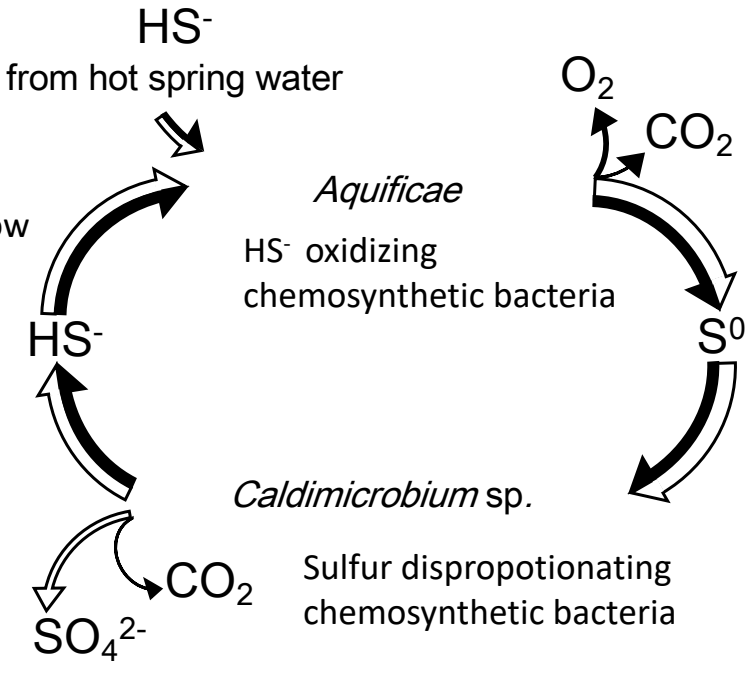
## Electron and S flow in photosynthetic communities (<70℃)




S flow

electron flow

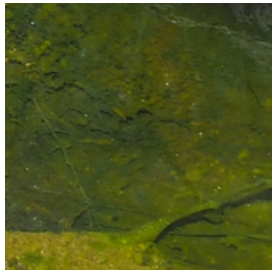
## Electron and S flow in chemosynthetic communities (>70℃)



# Conclusions

1. Is there a sufficient amount of sulfur disproportionating bacteria in the hot-spring microbial communities to support the photosynthetic growth of *C. aggregans*? →**YES**
2. Is the chemosynthetic community on the hot side (>70℃) without *C. aggregans* metabolically similar to the photosynthetic community on the cold side (<70℃) ? →**YES**
3. Is it meaningful to study further the autotrophic microbial communities at Nakabusa hot springs as a hypothetical model for the emergence of photosynthesis from chemosynthesis? →**YES**

謝辞：百瀬孝仁様（中房温泉）：中房温泉の温泉水中の微生物の利用の許可と諸便宜
広瀬侑様（豊橋技術科学大学）：光合成微生物群集の 16s rRNA アンプリコン解析



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