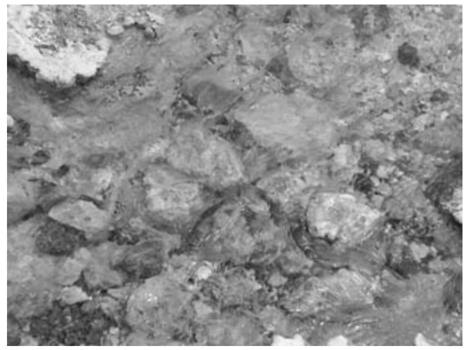
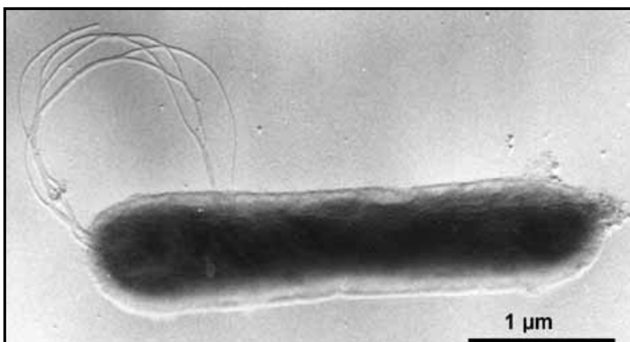
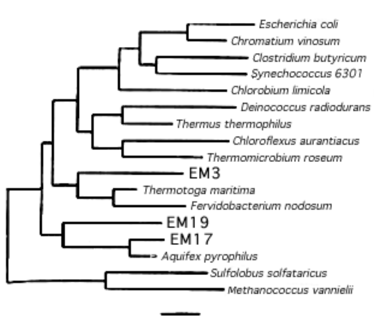
Identification for the Octopus Spring Pink Filaments



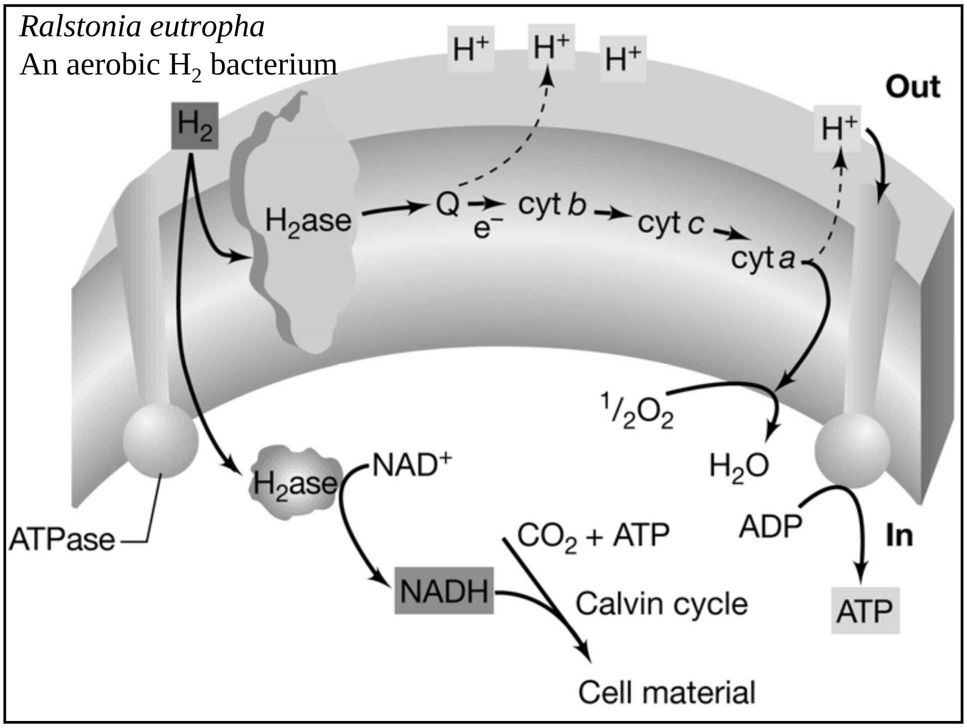



*Aquifex pyrophilus*




Yellowstone “Pink Filament” Isolates

*Ralstonia eutropha*
An aerobic $H_2$ bacterium



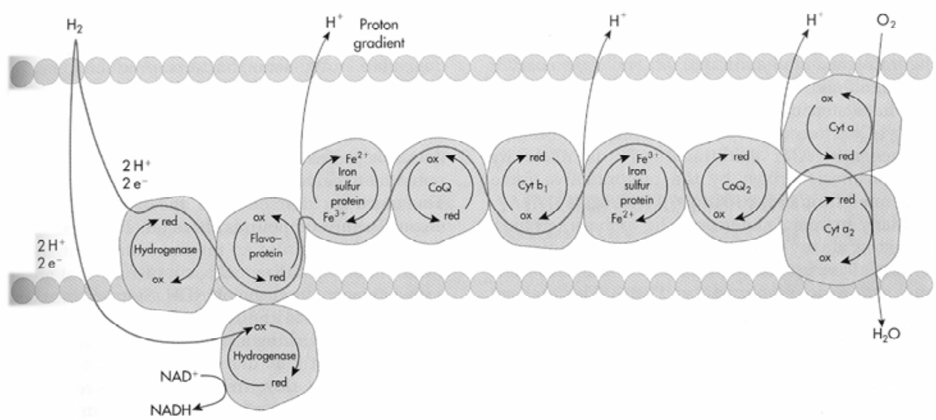




**Fig. 4-21 Hydrogenase and Chemolithotrophic Metabolism.** Hydrogenase splits hydrogen into protons and electrons that are transported via a membrane-bound electron transport system. This transport establishes a proton gradient.

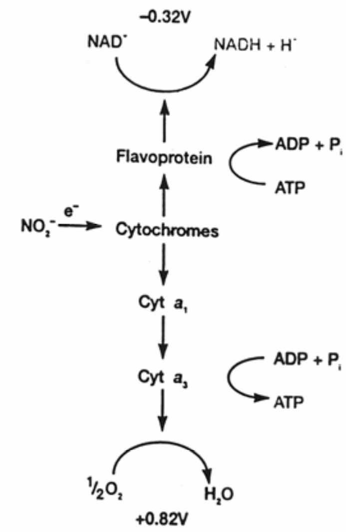
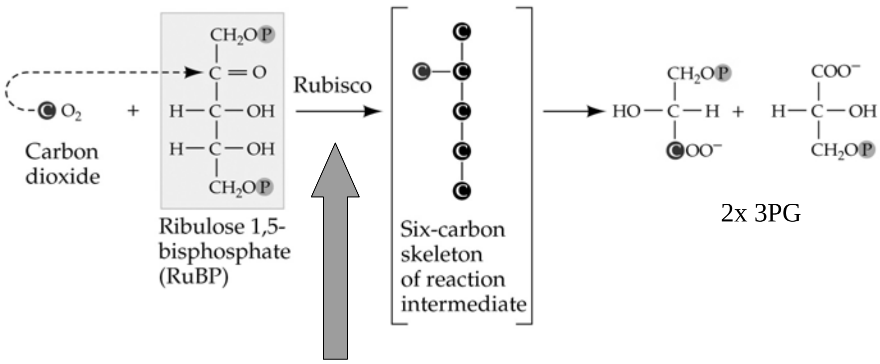



**Figure 9.20 Reversed Electron Flow.** The flow of electrons in the transport chain of *Nitrobacter*. Electrons flowing from nitrite to oxygen (down the reduction potential gradient) will release energy. It requires protonmotive force or ATP energy to force electrons to flow in the reverse direction from nitrite to $NAD^+$.

# Making Sugar from $CO_2$: The Calvin–Benson Cycle

- The Calvin–Benson cycle has three phases:
- Fixation of $CO_2$
- Reduction (and carbohydrate production)
- Regeneration of RuBP.
- RuBP is the initial $CO_2$ acceptor, 3PG is the first stable product of $CO_2$ fixation. Rubisco catalyzes the reaction of $CO_2$ and RuBP to form 3PG.

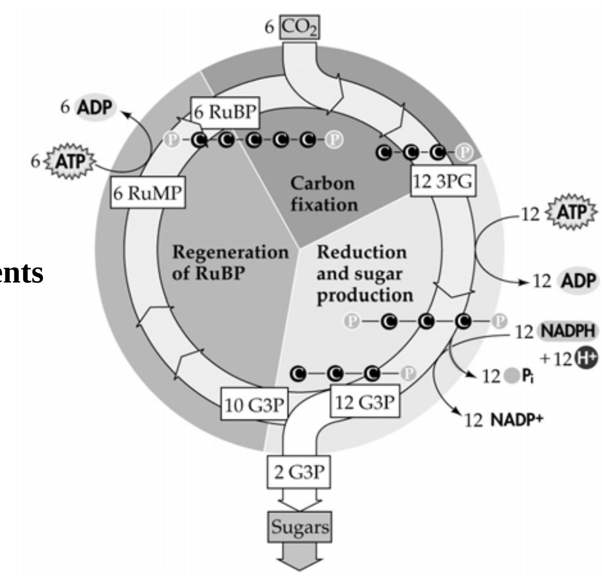
RuBP is the $CO_2$ Acceptor




**World's Most Abundant Protein!**

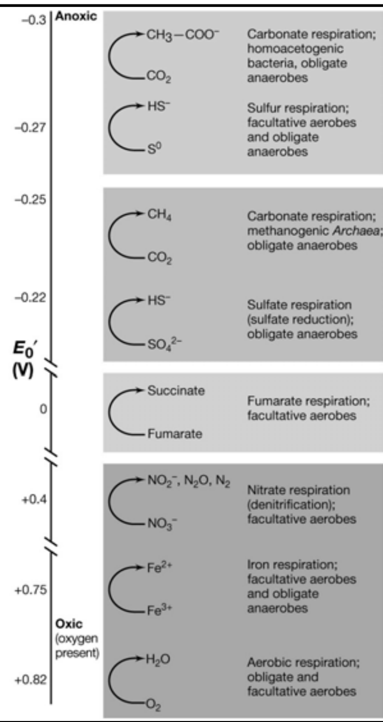
18 ATP
12 NADH+H⁺

1Glucose for
**54 ATP equivalents**

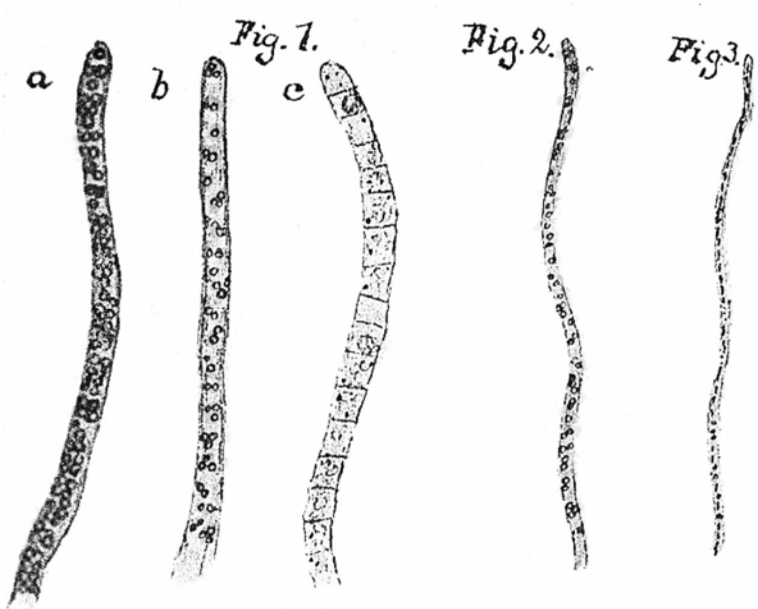



**Organic Carbon Compounds**

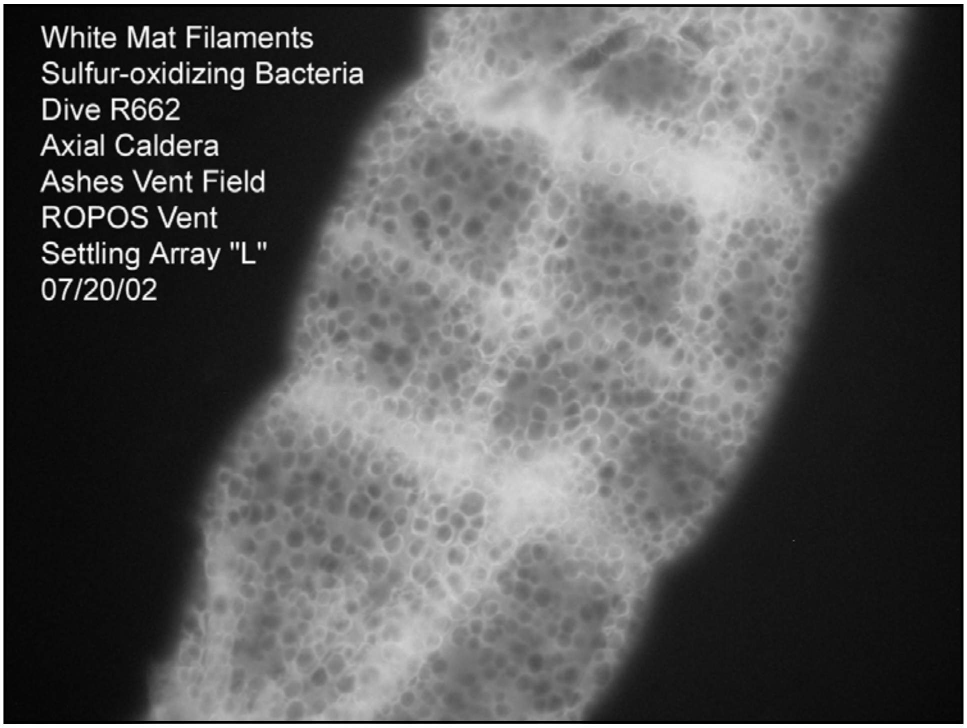
Anaerobic Respirations




Assimilative vs. Dissimilative Metabolisms




Winogradsky’s drawings of *Beggiatoa*


White Mat Filaments
Sulfur-oxidizing Bacteria
Dive R662
Axial Caldera
Ashes Vent Field
ROPOS Vent
Settling Array "L"
07/20/02

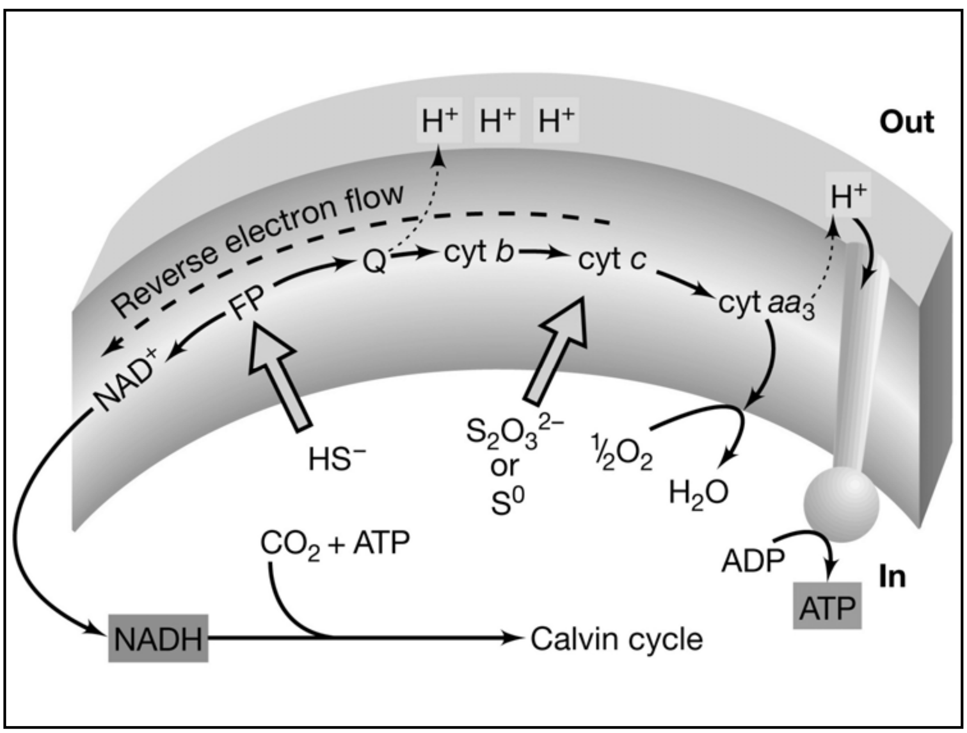
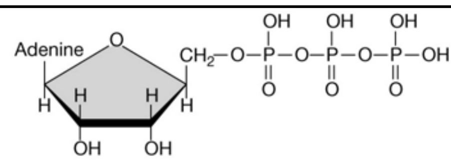

H+ H+ H+
Out
H+
Reverse electron flow
Q
cyt b
cyt c
FP
cyt aa3
NAD+
HS−
S2O3 2− or S0
½O2
H2O
CO2 + ATP
ADP
ATP
In
NADH
Calvin cycle

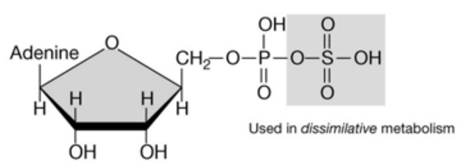
**TABLE 17.3** Sulfur compounds and electron donors for sulfate reduction

| Compound | Oxidation state |
|---|---|
| **Oxidation states of key sulfur compounds** | |
| Organic S (R—SH) | −2 |
| Sulfide ($H_2S$) | −2 |
| Elemental sulfur ($S^0$) | 0 |
| Thiosulfate ($S_2O_3^{2-}$) | +2 (average per S) |
| Sulfur dioxide ($SO_2$) | +4 |
| Sulfite ($SO_3^{2-}$) | +4 |
| Sulfate ($SO_4^{2-}$) | +6 |
| **Some electron donors used for sulfate reduction** | |
| $H_2$ | Acetate |
| Lactate | Propionate |
| Pyruvate | Butyrate |
| Ethanol and other alcohols | Long-chain fatty acids |
| Fumarate | Benzoate |
| Malate | Indole |
| Choline | Hexadecane |

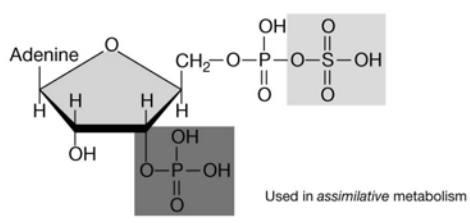
SRB's can make active sulfate compounds



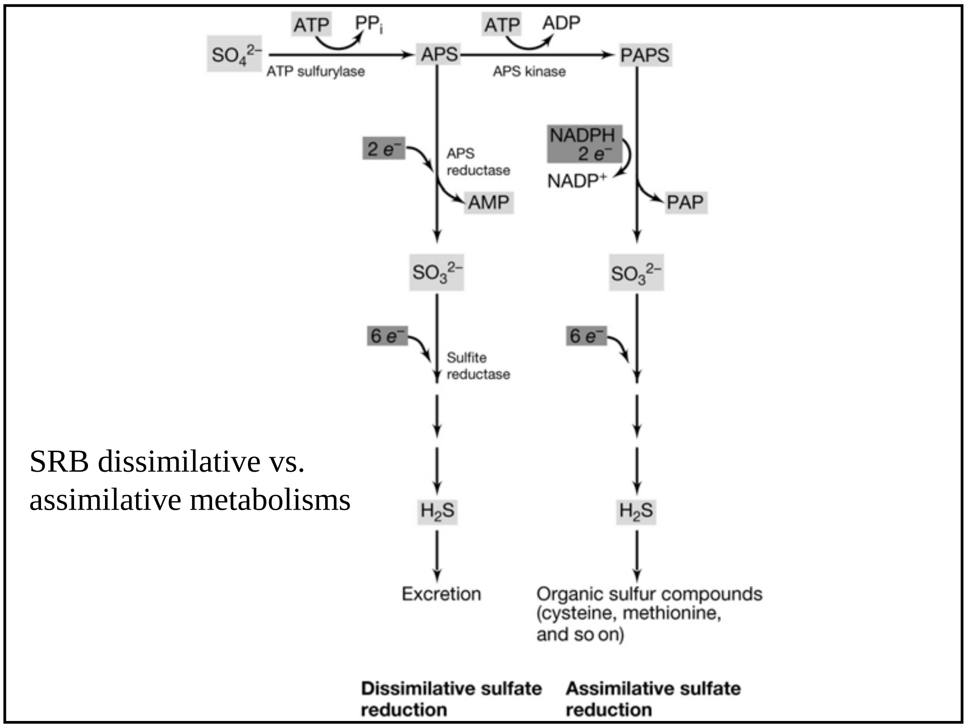

**ATP**

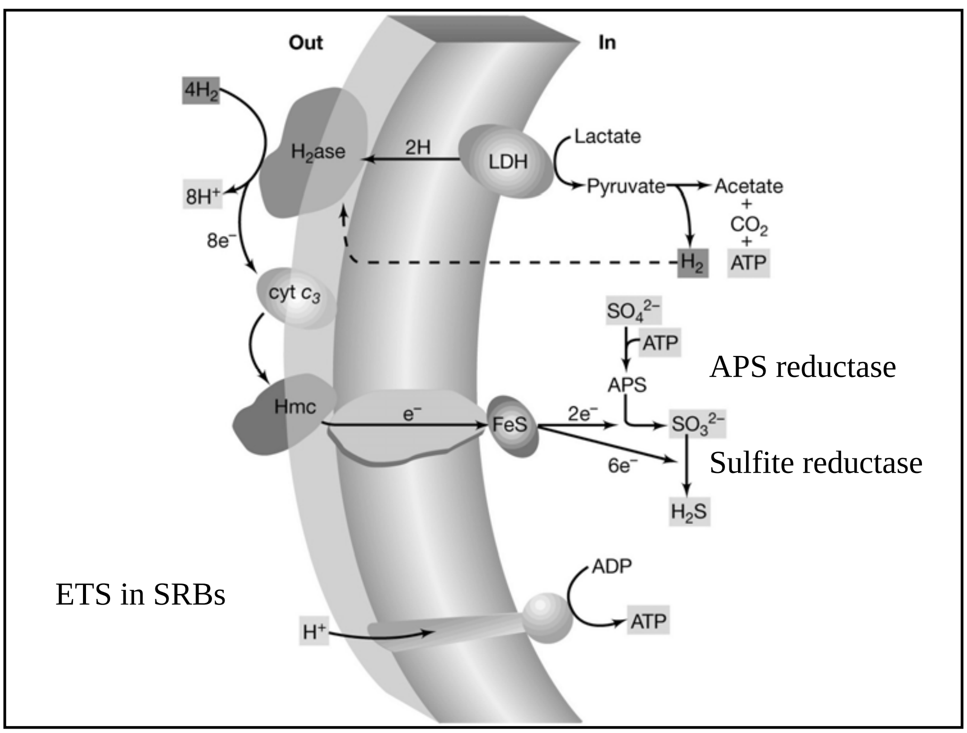



**APS** (Adenosine 5′-phosphosulfate)




**PAPS** (Phosphoadenosine 5′-phosphosulfate)


SRB dissimilative vs.
assimilative metabolisms
ATP
PPi
ADP
SO4 2–
ATP sulfurylase
APS
APS kinase
PAPS
2 e–
APS
reductase
AMP
NADPH
2 e–
NADP+
PAP
SO3 2–
6 e–
Sulfite
reductase
H2S
Excretion
Organic sulfur compounds
(cysteine, methionine,
and so on)
Dissimilative sulfate
reduction
Assimilative sulfate
reduction

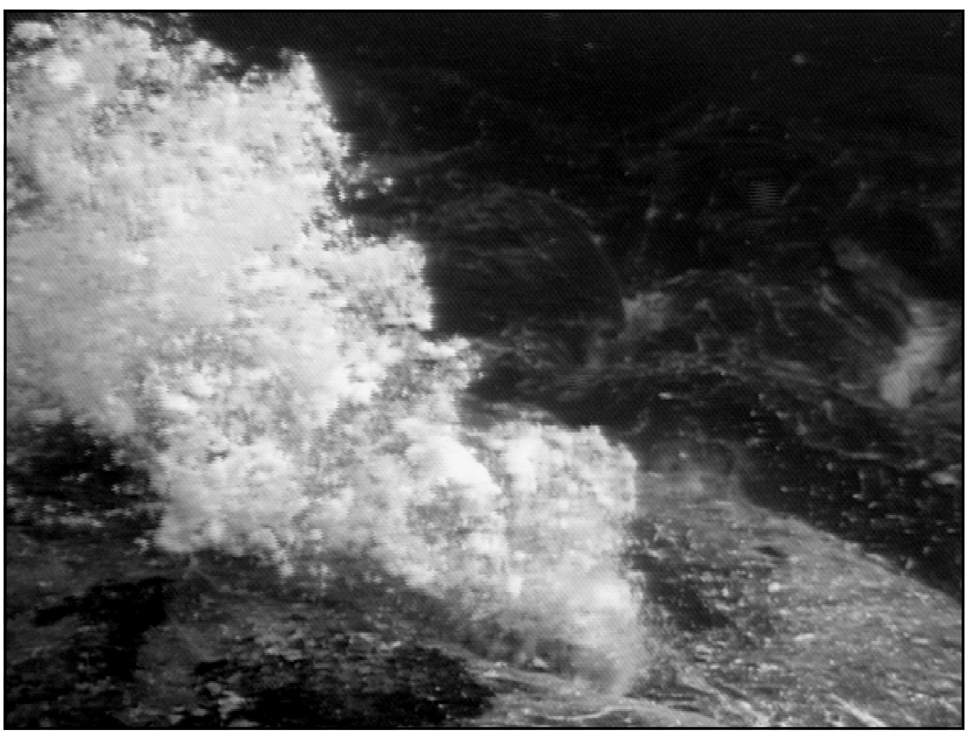

Out
In
4H2
H2ase
2H
LDH
Lactate
Pyruvate
Acetate
+
CO2
+
ATP
8H+
8e–
H2
cyt c3
SO4 2–
ATP
APS
APS reductase
Hmc
e–
FeS
2e–
SO3 2–
6e–
Sulfite reductase
H2S
ADP
ATP
ETS in SRBs
H+

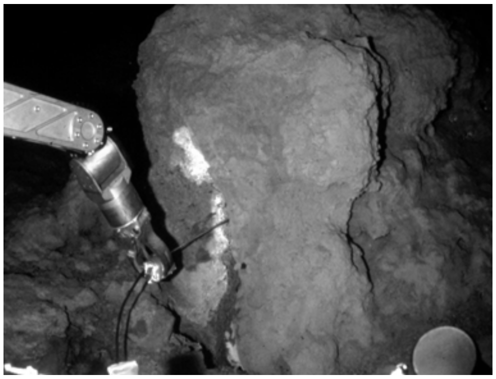
# Sulfur Disproportionation

$S_2O_3^{2-} + H_2O \rightarrow SO_4^{2-} + H_2S$

$\Delta G^{0'} = -21.9$ kJ/rxn

Get your cake and eat it too!





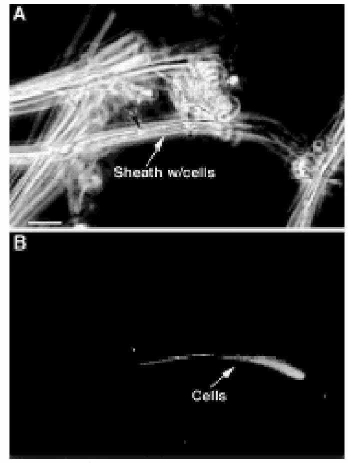
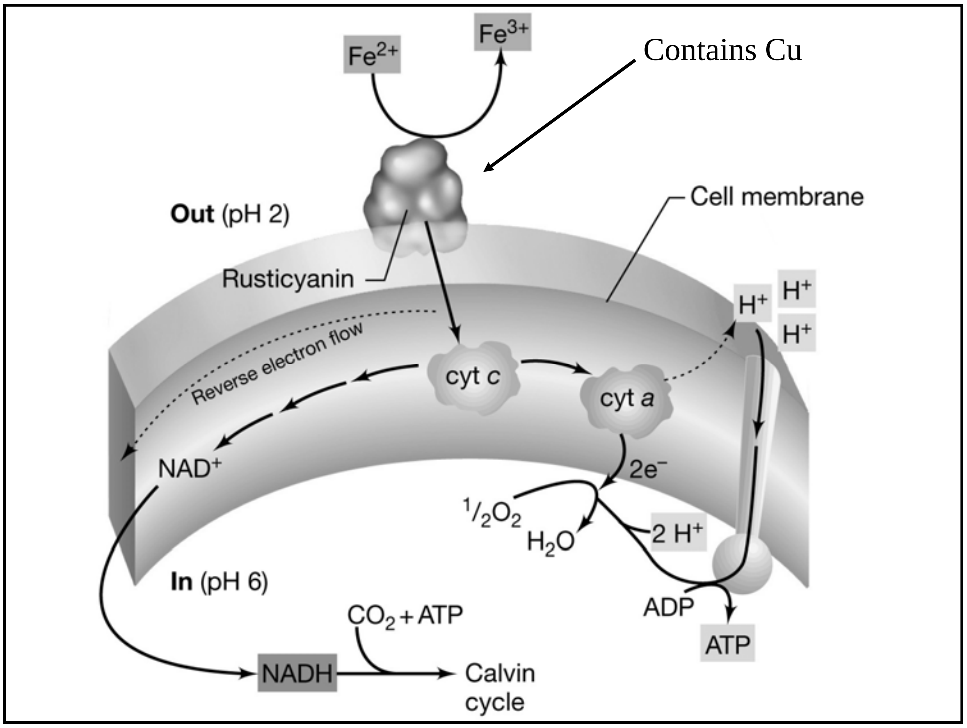



FIG. 3. *L. ochraceus*-like sheaths collected at the Pohaku vents near marker 27. The sample has been stained with Syto. Panel B is the same image as in panel A but viewed by epifluorescence to reveal a filament of cells inside the iron-encrusted sheath. The cells are only visible when stained; most of the sheaths are empty. Bar, 5 μm.

Neutrophilic Fe-Oxidizing Bacteria

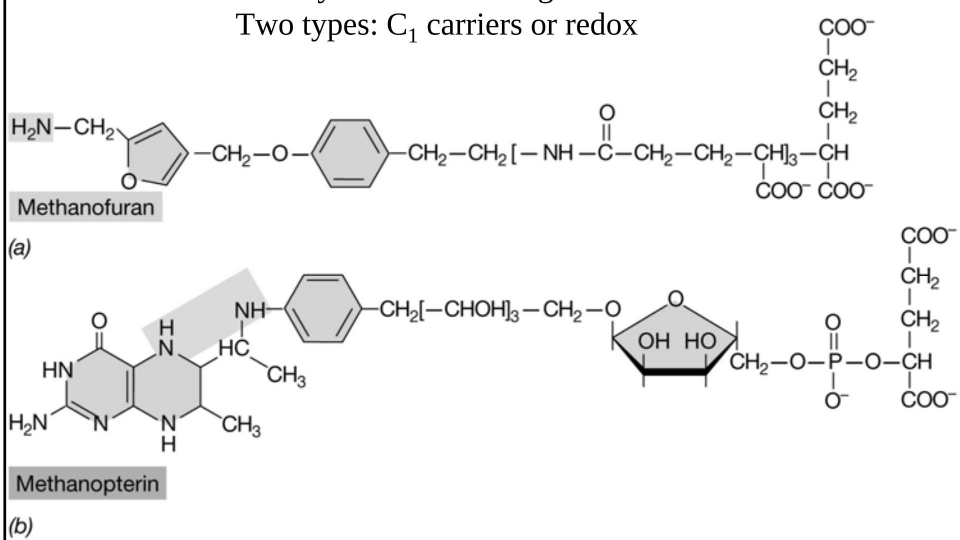
Bog in Iceland

Fe-Oxidizers

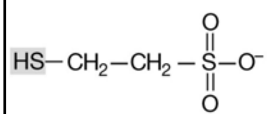



Coenzymes of methanogenesis

Two types: $C_1$ carriers or redox

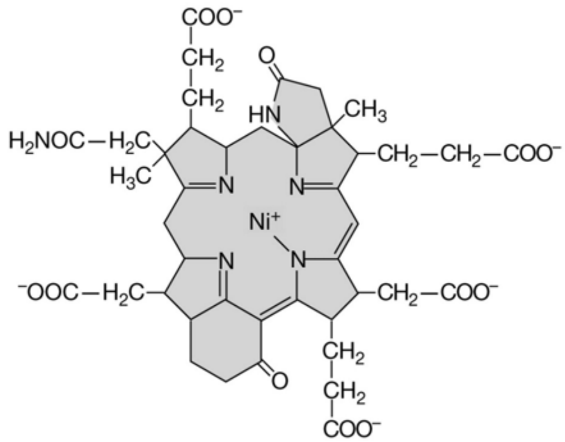


Coenzymes of methanogenesis



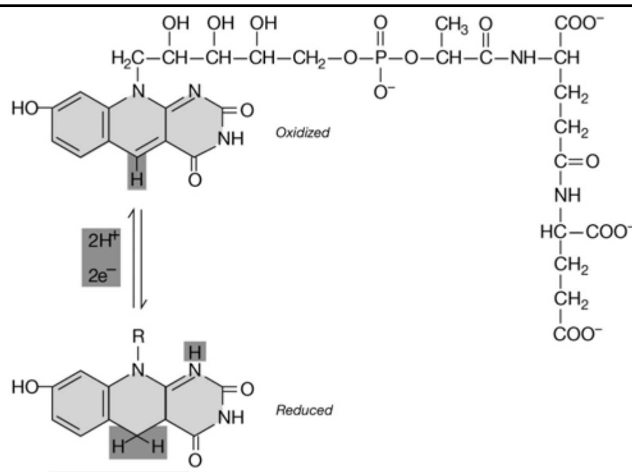

Coenzyme M (CoM)

*(c)*




Coenzyme $F_{430}$

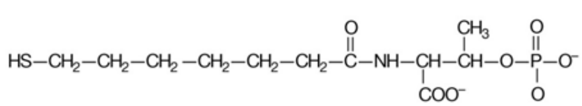
*(d)*




Coenzyme $F_{420}$

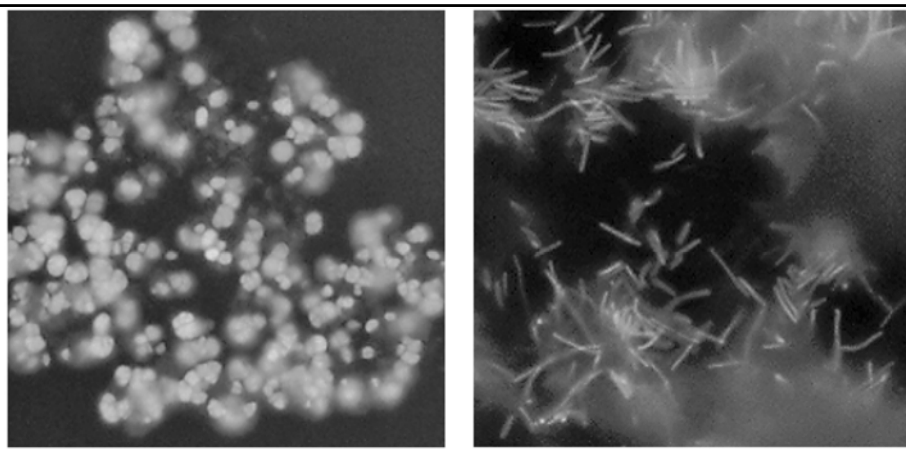
Coenzymes of methanogenesis

*(e)*




Coenzyme B (CoB)

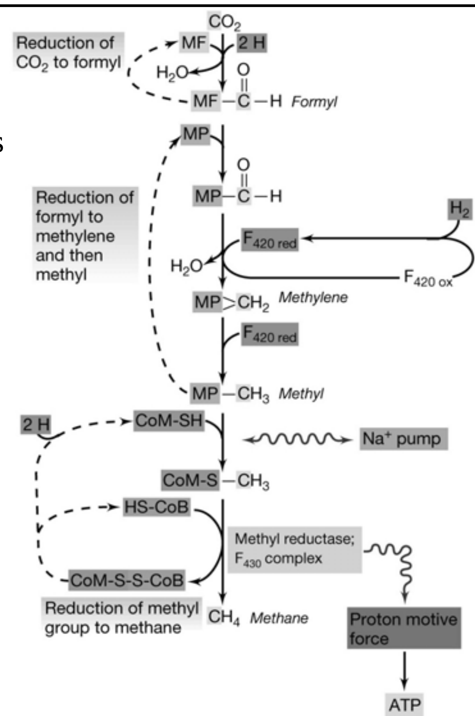
*(f)*



(a) (b)

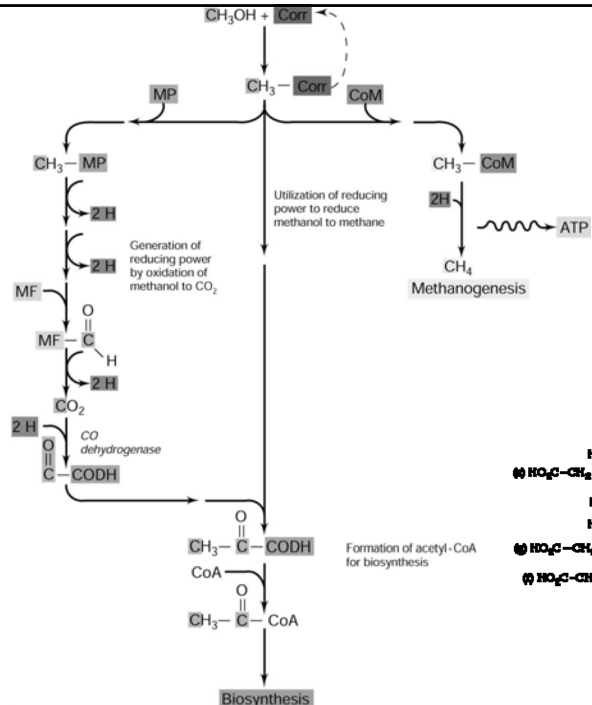
Autofluorescence in methanogen cells due to the presence of the unique electron carrier $F_{420}$

Methanogenesis



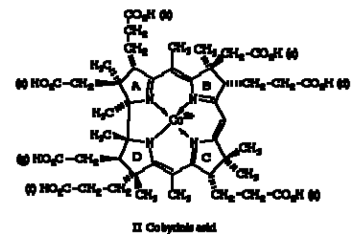

$H_2 + CO_2$

$CH_4$

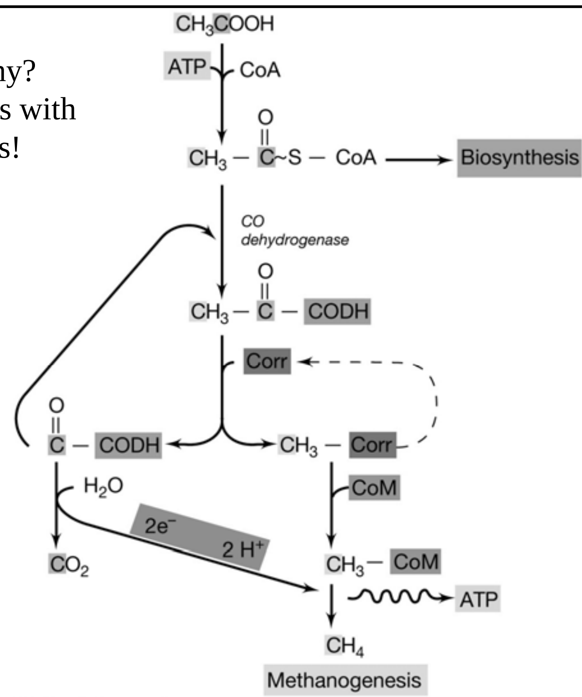



*(a)* Methanol reactions

Autotrophy?
Corrinoids with
Co centers!

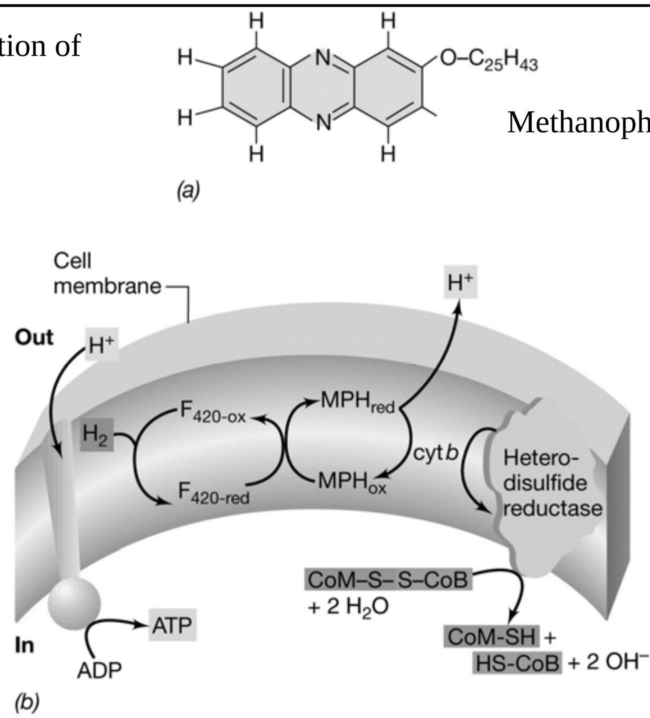


Autotrophy?
Corrinoids with
Co centers!




*(b)* Acetate reactions

Conservation of Energy




# Methanogenesis

Chemoautotrophs:
$CO_2$ → $CH_4$ + Org. C
$H_2$ as electron donor

Chemoorganotrophs:
Acetate/MeOH → $CH_4$ + $CO_2$
Org. C as electron donor

Global Biogenic Methane Production:
1/3 Chemoautotrophs
2/3 Chemoorganotrophs