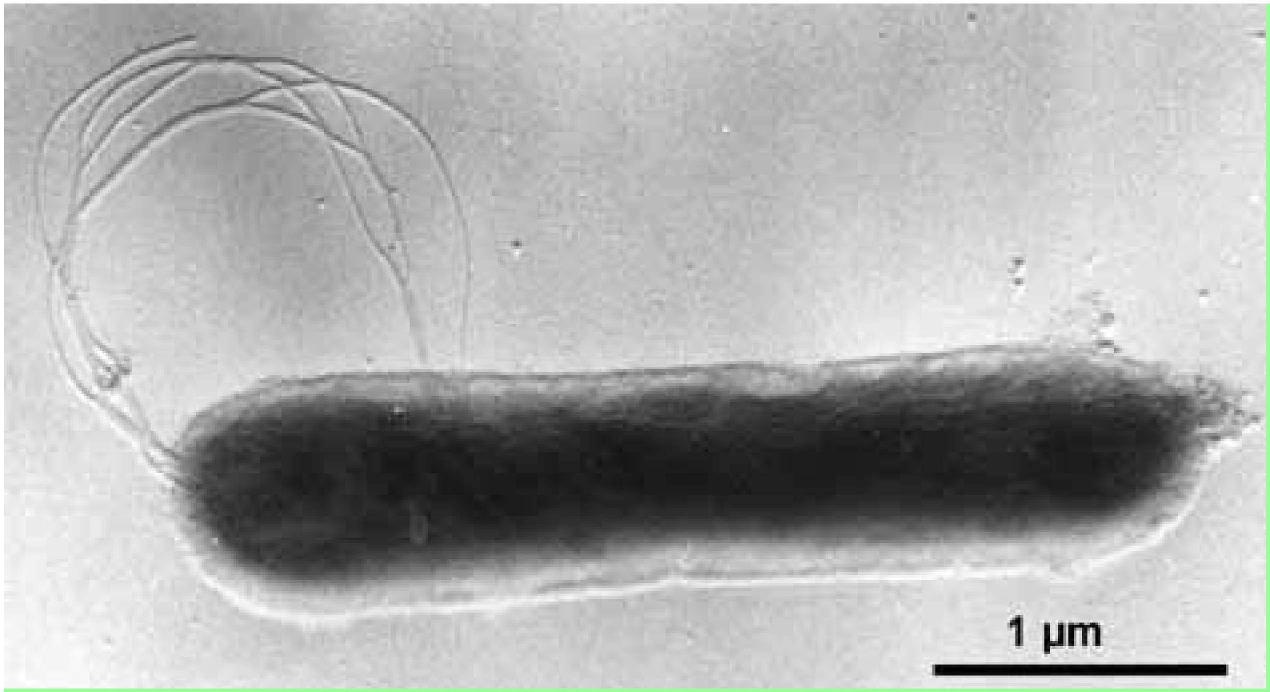
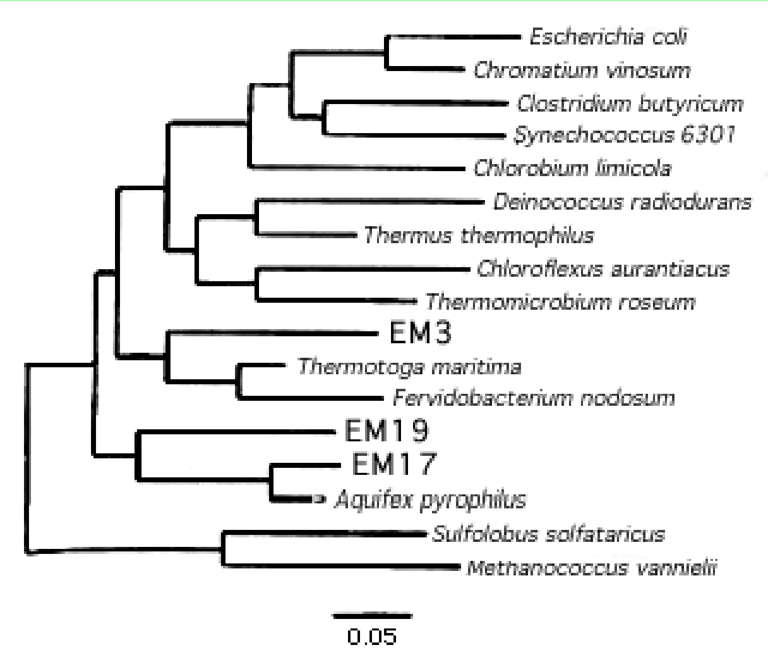
More on Chemotrophic Potential

Identification for the Octopus Spring Pink Filaments

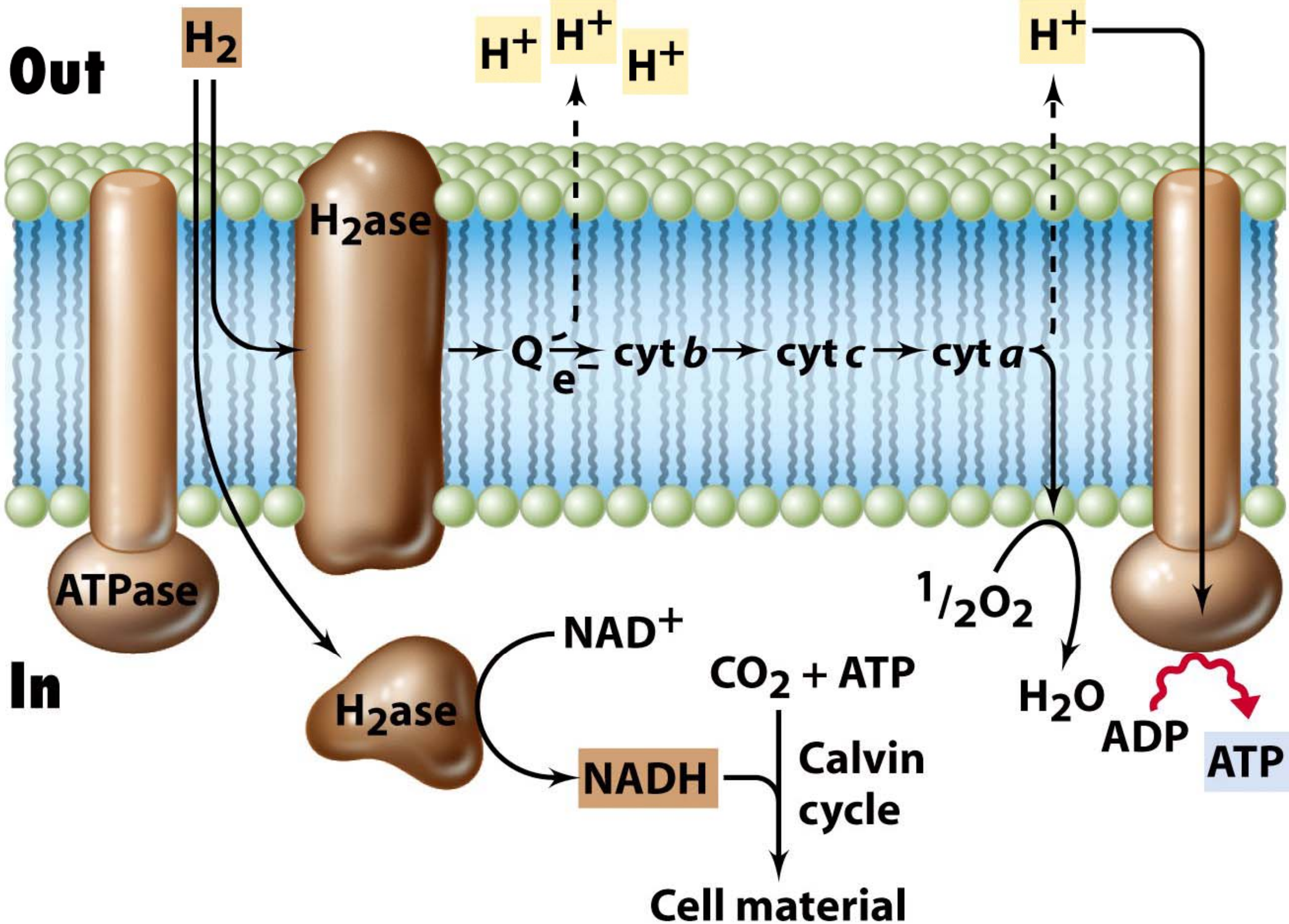


Aquifex pyrophilus



Yellowstone "Pink Filament"
Isolates

Ralstonia eutropha: An aerobic H_2 bacterium



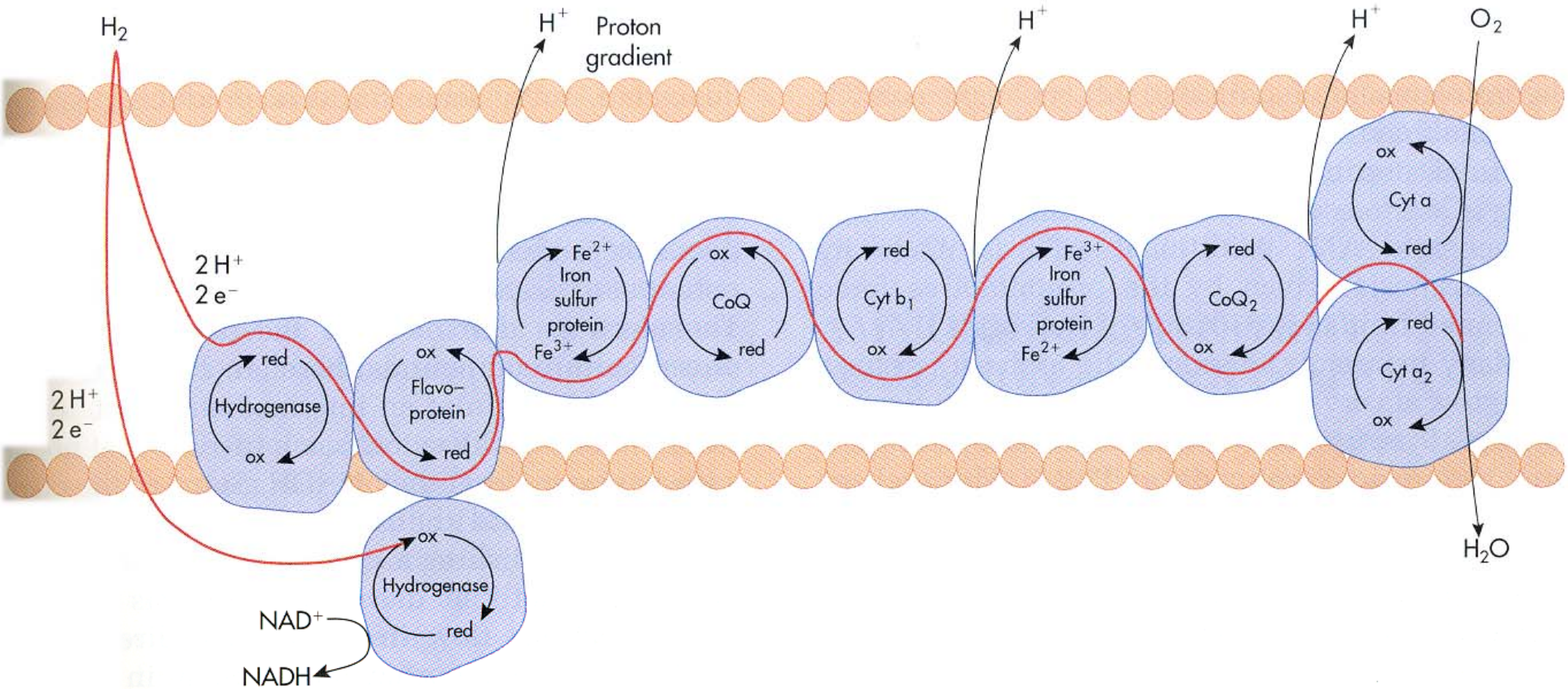


Fig. 4-21 Hydrogenase and Chemolithotrophic Metabolism. Hydrogenase splits hydrogen into protons and electrons that are transported via a membrane-bound electron transport system. This transport establishes a proton gradient.

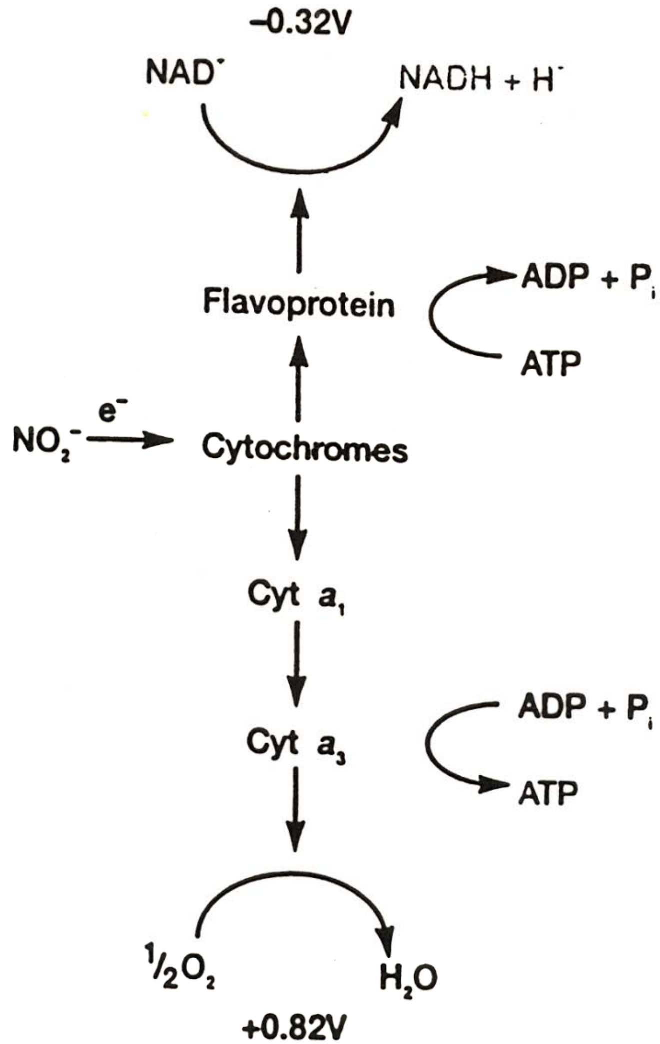
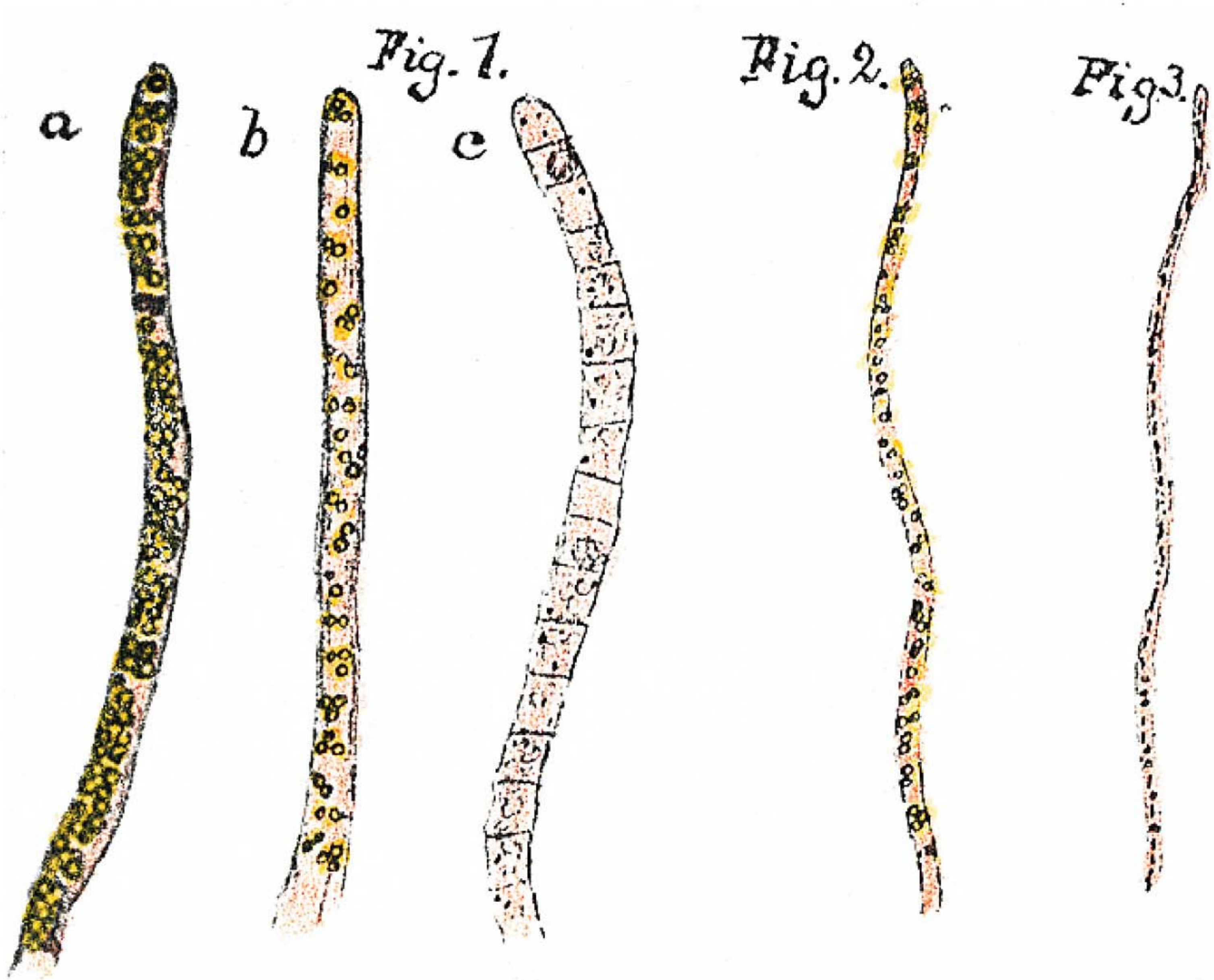
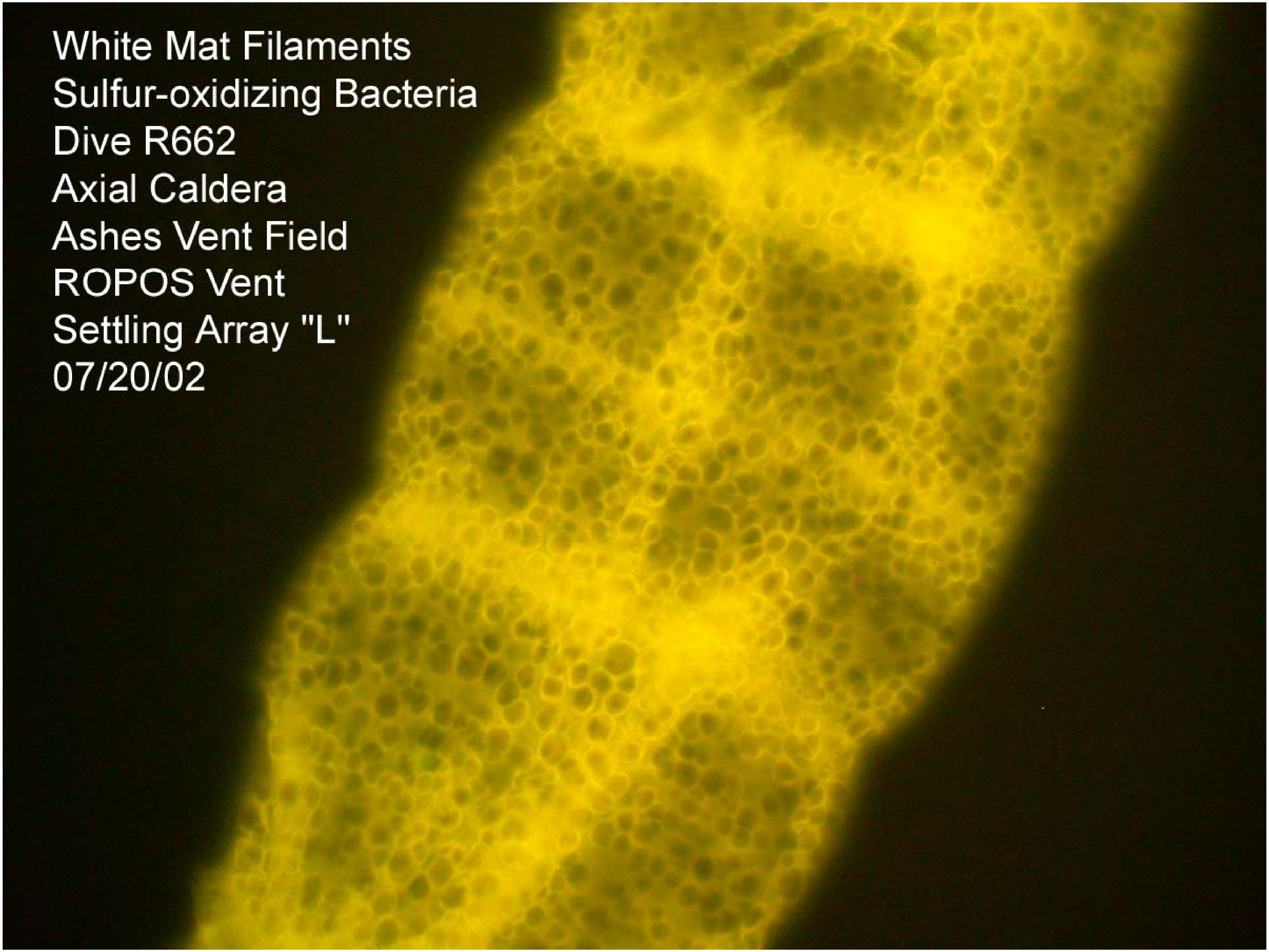
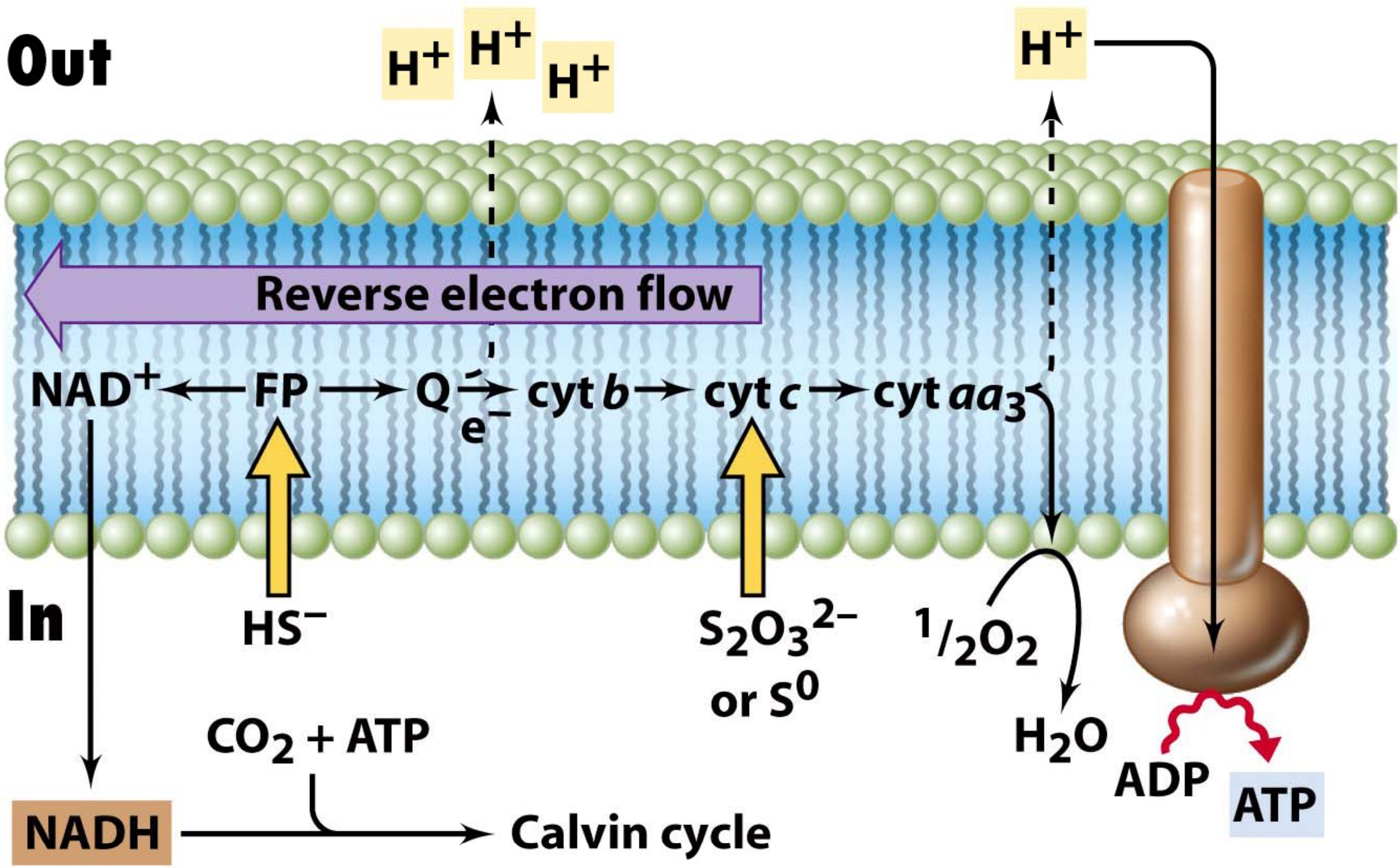


Figure 9.20 Reversed Electron Flow. The flow of electrons in the transport chain of *Nitrobacter*. Electrons flowing from nitrite to oxygen (down the reduction potential gradient) will release energy. It requires protonmotive force or ATP energy to force electrons to flow in the reverse direction from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



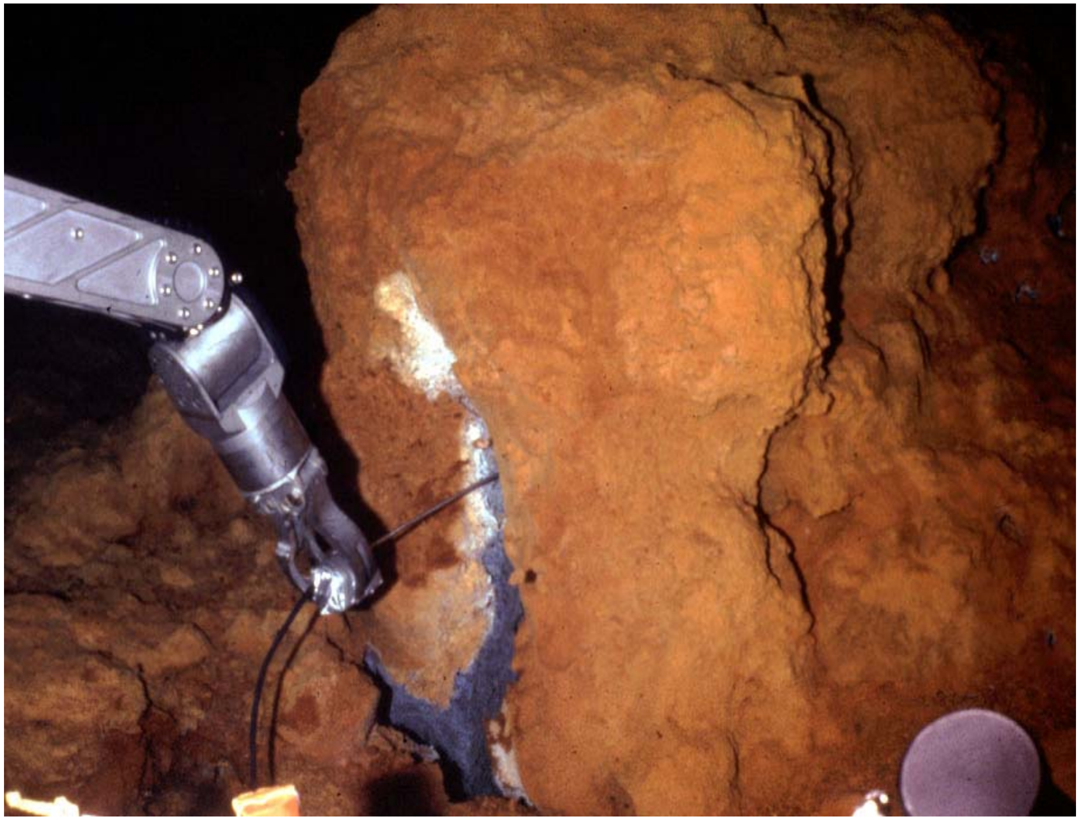
Winogradsky's drawings of *Beggiatoa*


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



Out
H^+
H^+
H^+
H^+
Reverse electron flow
NAD^+
FP
Q
e^-
cyt *b*
cyt *c*
cyt *aa*$_3$
In
HS^-
$S_2O_3^{2-}$ or S^0
$^1/_2O_2$
H_2O
ADP
ATP
CO_2 + ATP
NADH
Calvin cycle

Loihi Volcano



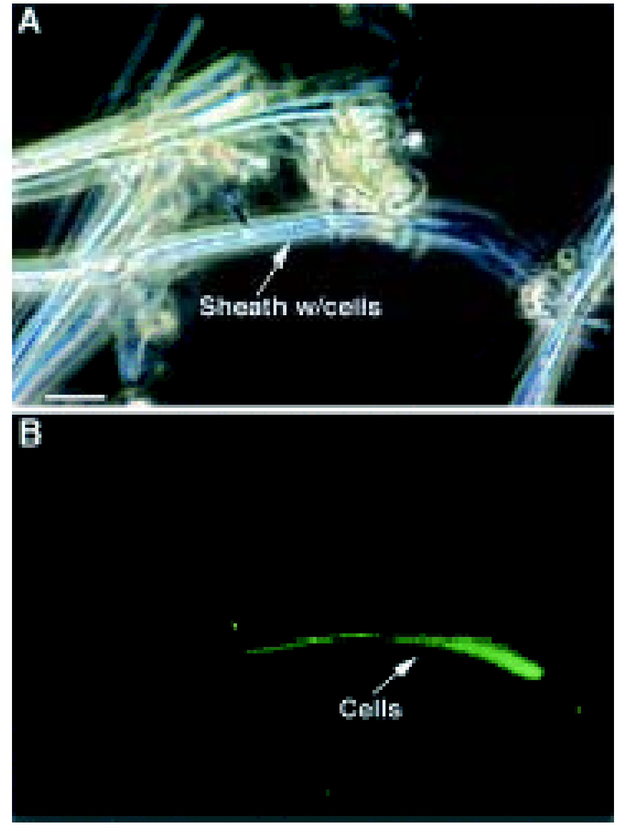
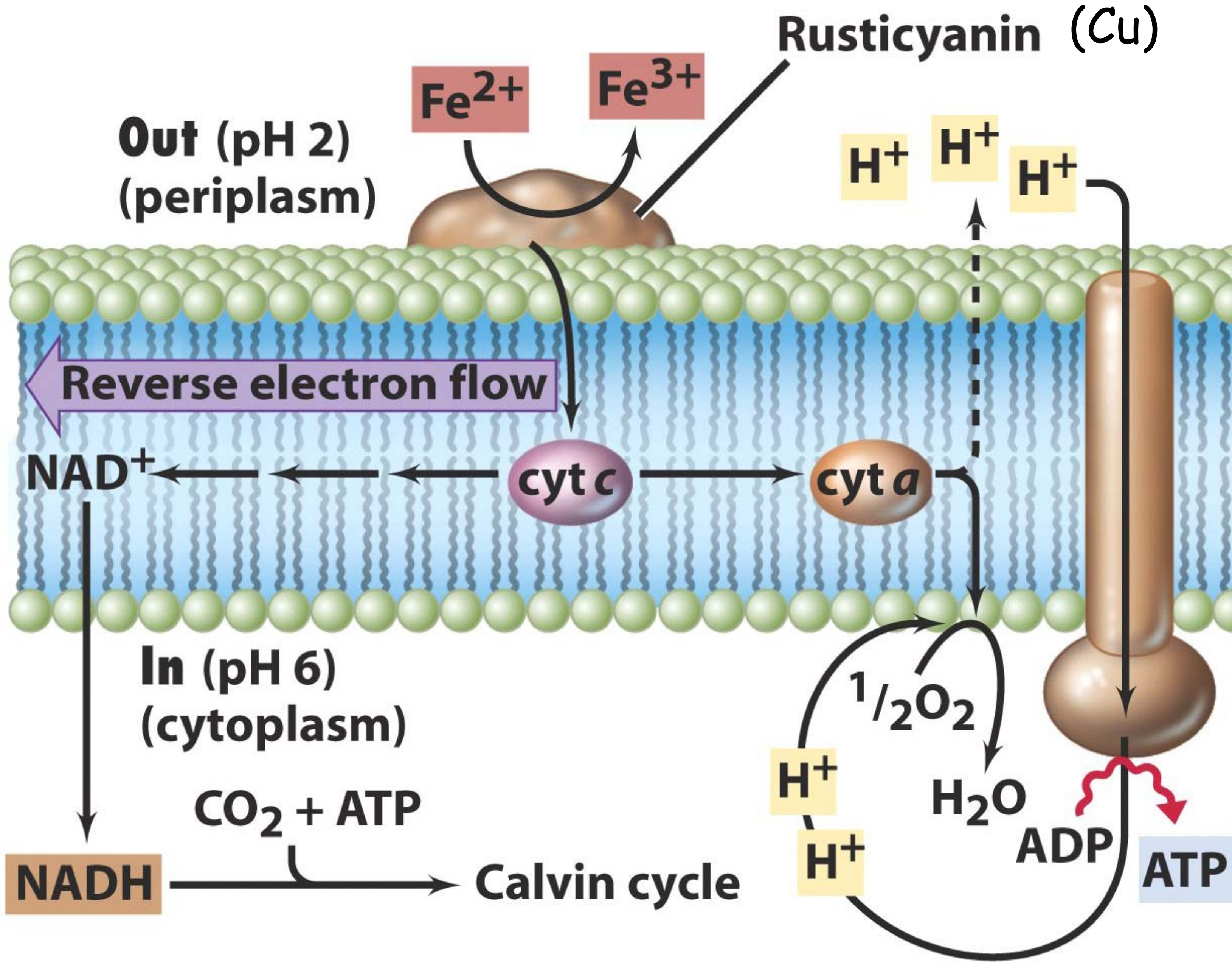


FIG. 3. *L. ochracea*-like sheaths collected at the Pohaku vents near marker 27. The sample has been stained with Syto. Panel B is the same image as in panel A but viewed by epifluorescence to reveal a filament of cells inside the iron-encrusted sheath. The cells are only visible when stained: most of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

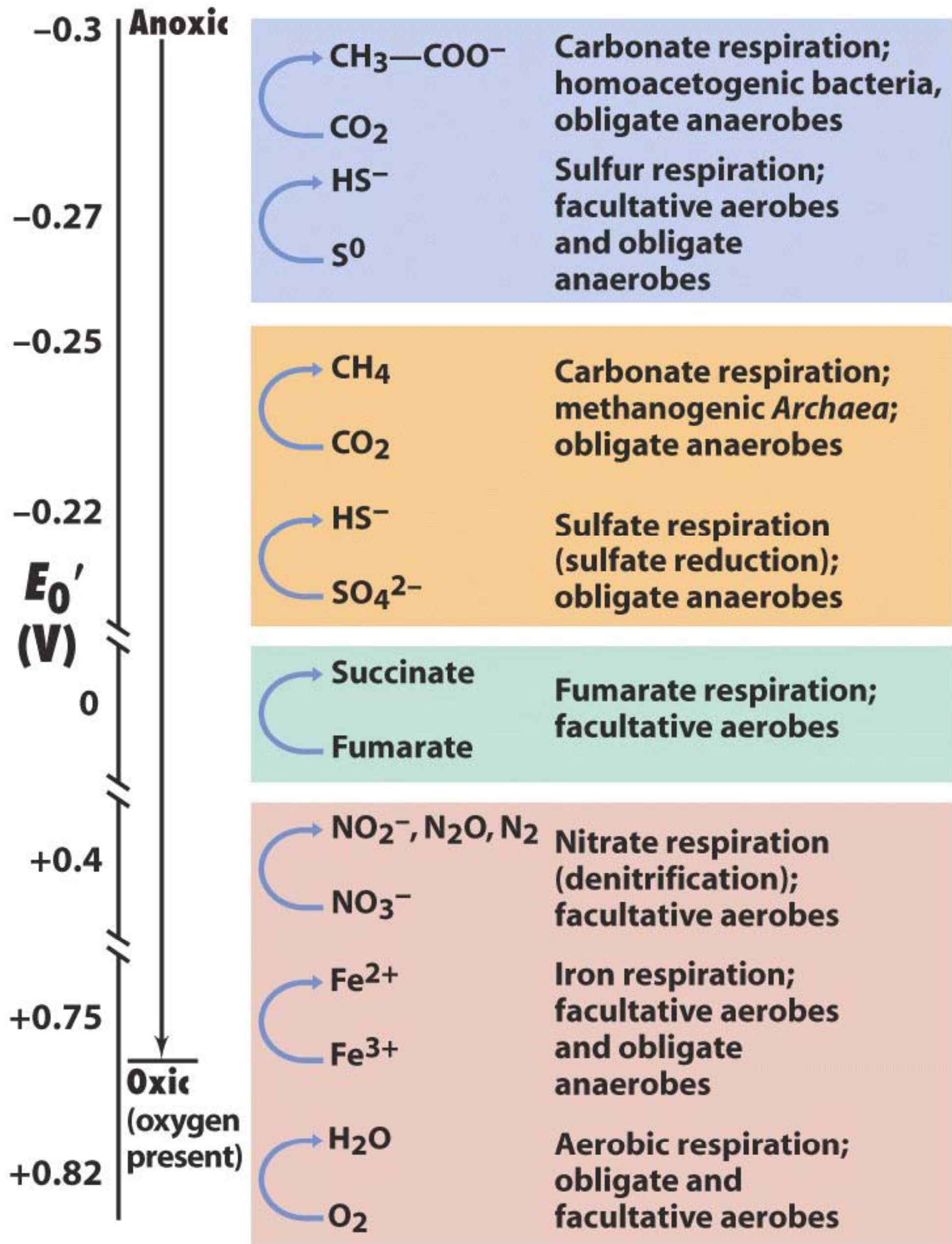
Neutrophilic Fe-Oxidizing Bacteria

zeta-Proteobacteria (novel class)



Rusticyanin (Cu)
Fe2+
Fe3+
Out (pH 2)
(periplasm)
H+
H+
H+
Reverse electron flow
NAD+
cyt c
cyt a
In (pH 6)
(cytoplasm)
1/2O2
H+
H2O
H+
ADP
ATP
CO2 + ATP
NADH
Calvin cycle

Anaerobic Respirations

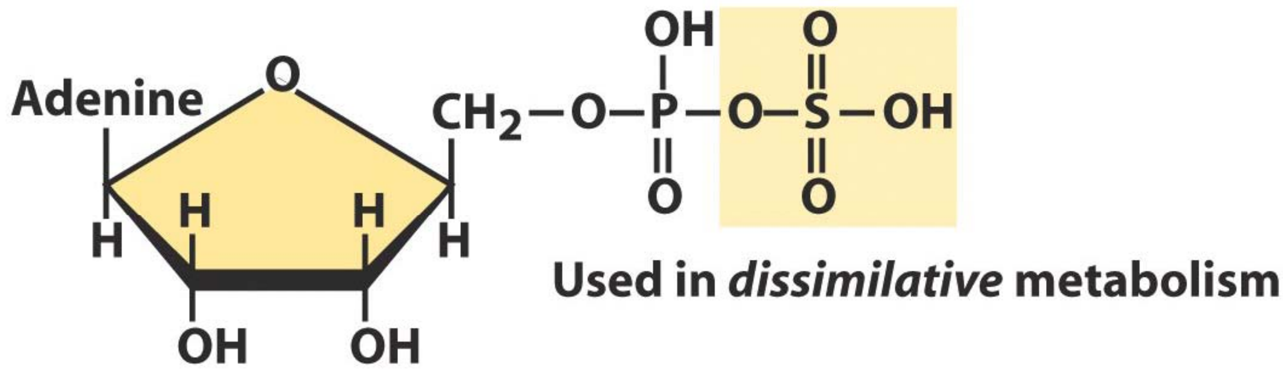


Assimilative vs. Dissimilative Metabolisms

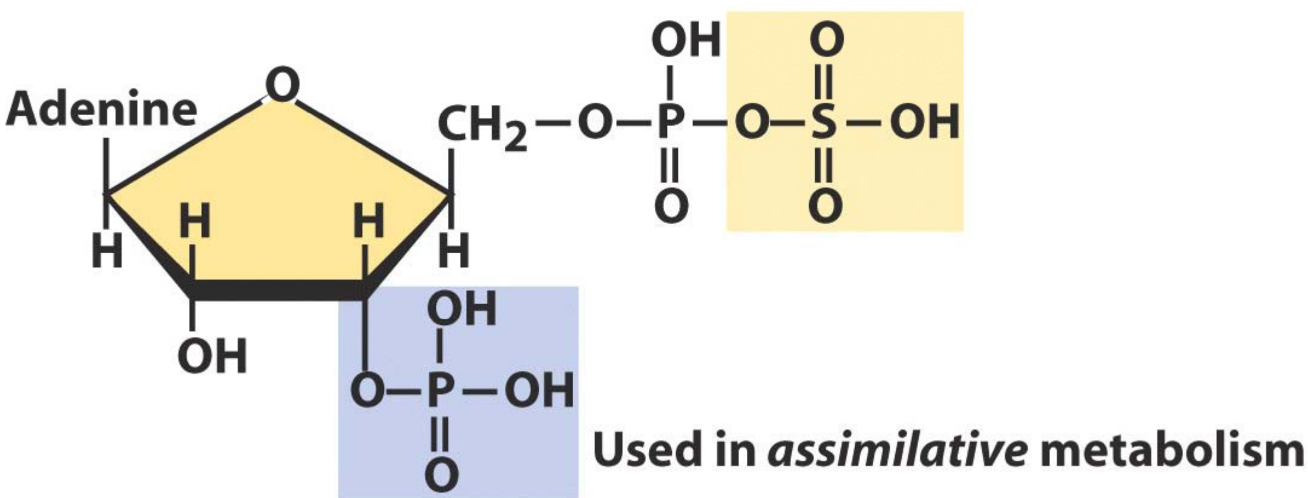
Table 17.3 Sulfur compounds and electron donors for sulfate reduction

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

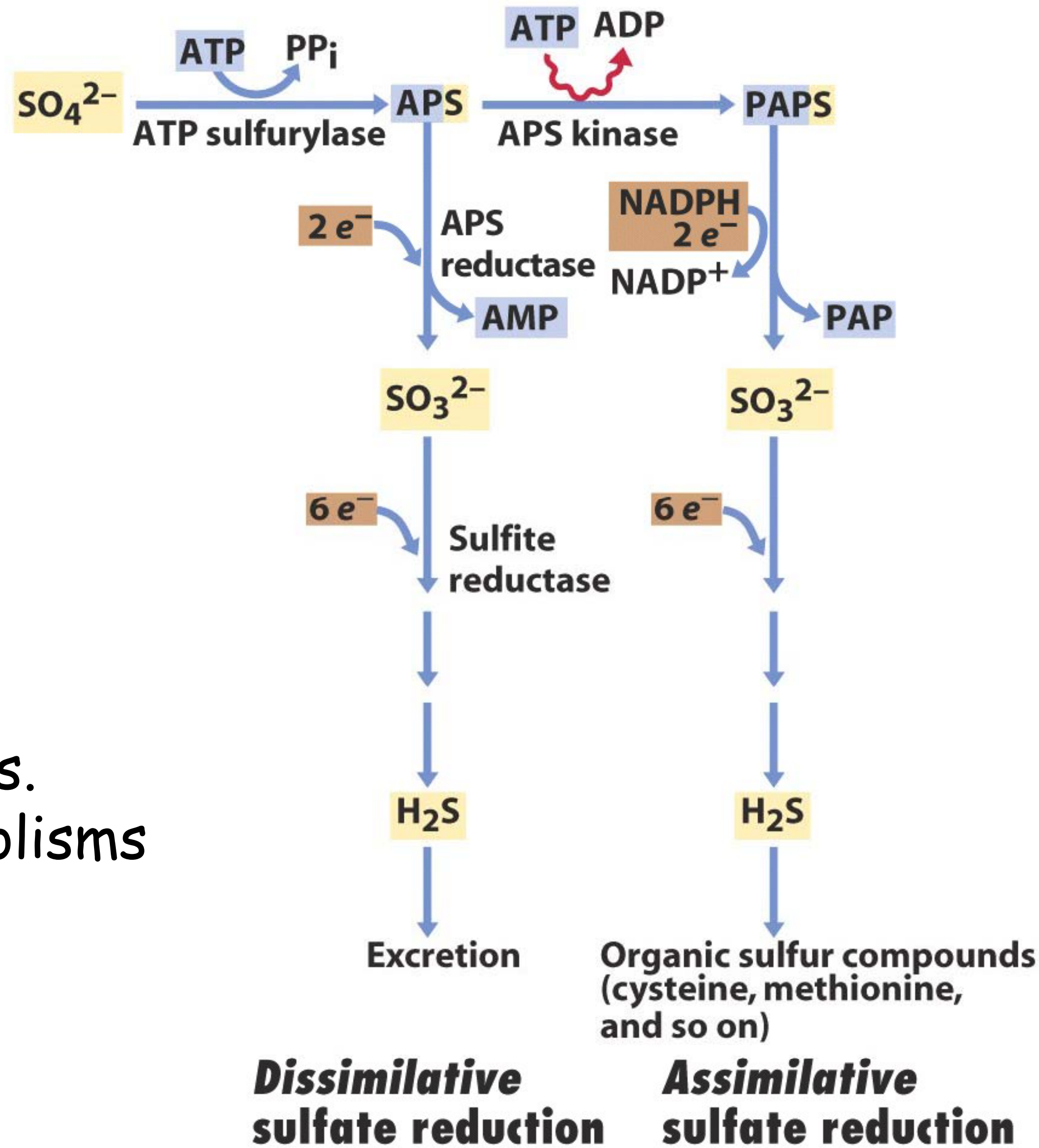
SRB's can make active sulfate compounds



APS (Adenosine 5′-phosphosulfate)

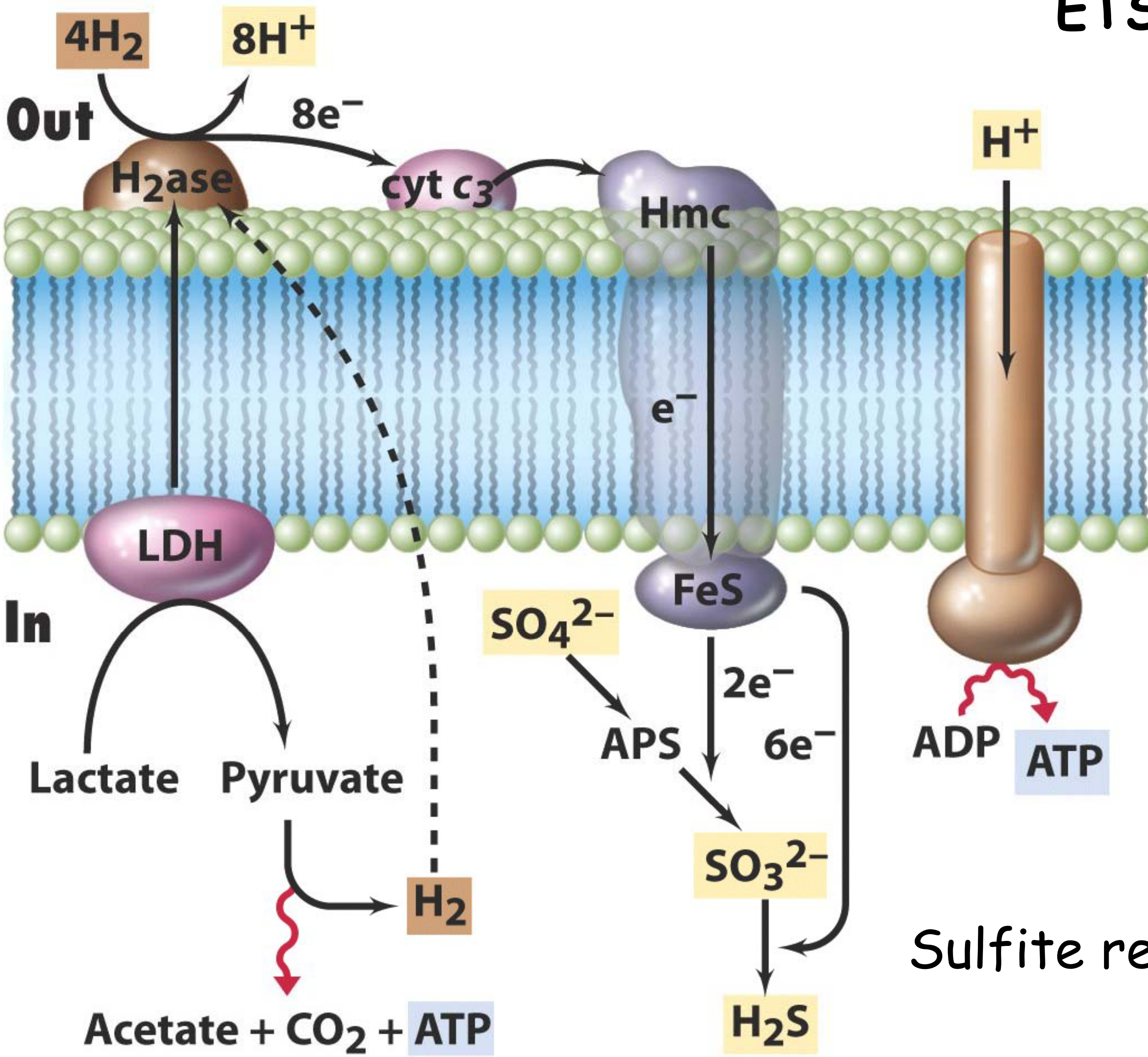


PAPS (Phosphoadenosine 5′-phosphosulfate)



SRB dissimilative vs. assimilative metabolisms

ETS in SRBs



Sulfite reductase

Sulfur Disproportionation

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

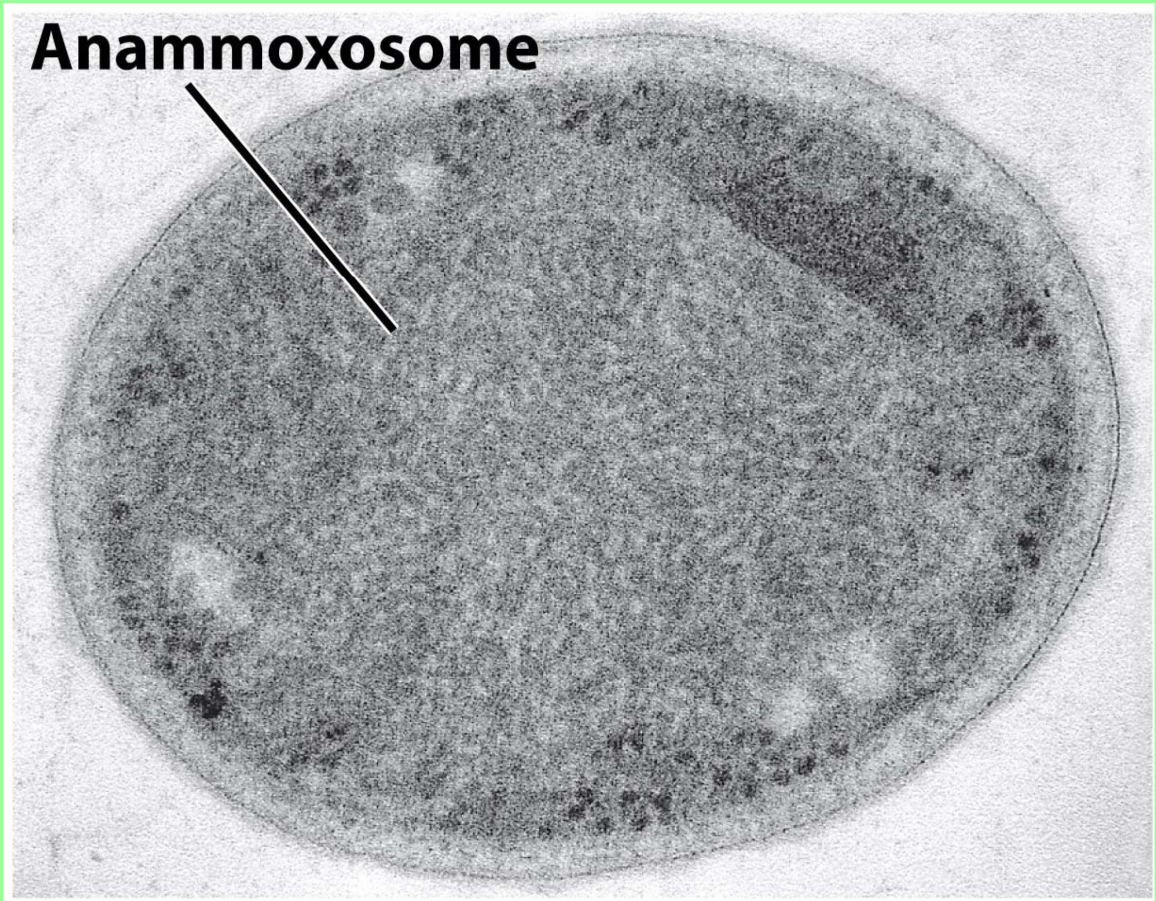
$\Delta G^{0'} = -21.9$ kJ/rxn (not huge!)

Get your cake and eat it too!


Axial Volcano

Anoxic ammonia oxidation: Anammox

A bizarre, toxin-filled microbe that could clean up sewage plants across the globe.



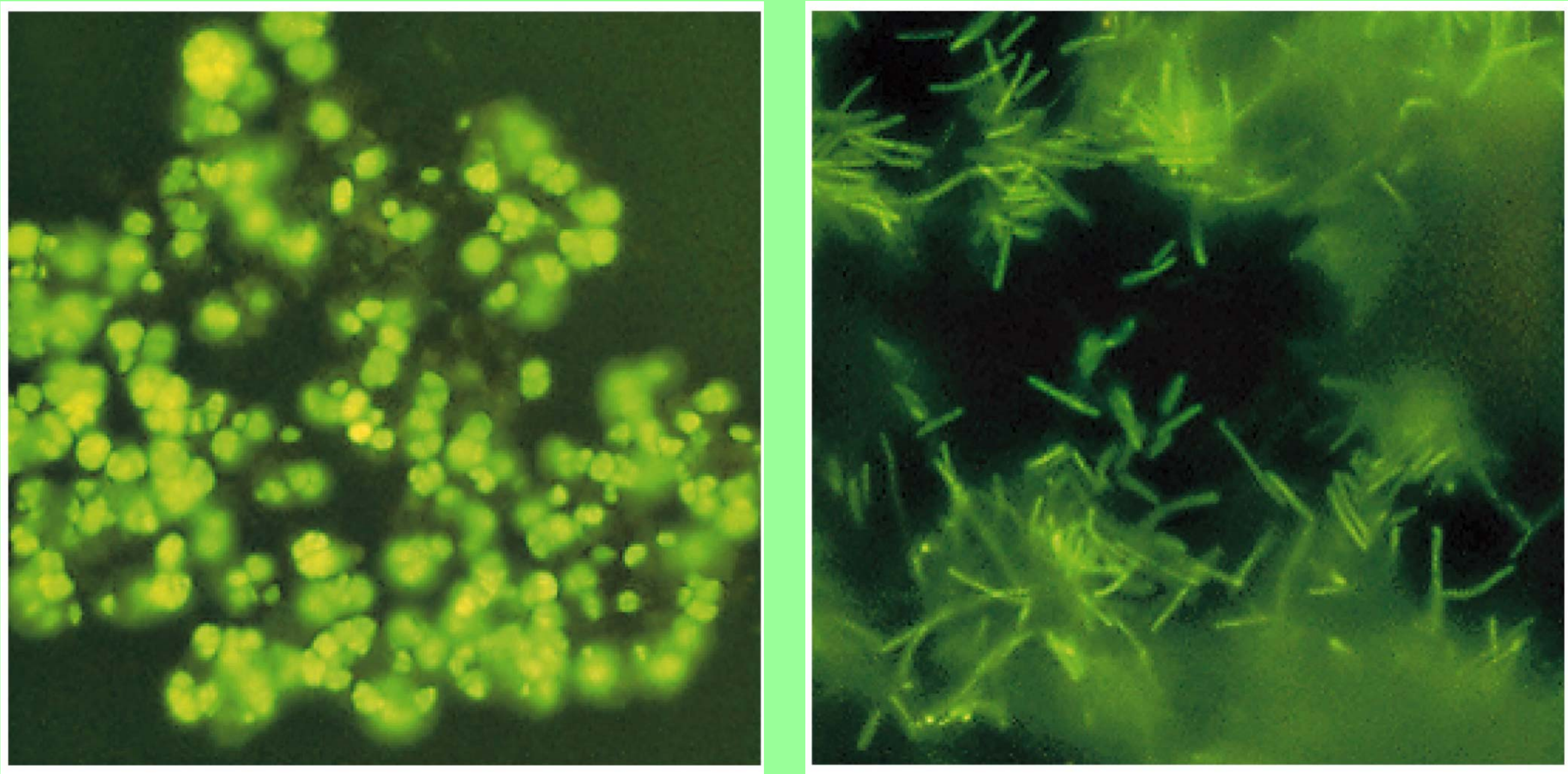
Contains: hydrazine

Brocadia anammoxidans (another *Planctomyces*)

Table 17.2 Oxidation states of key nitrogen compounds

Compound	Oxidation state
Organic N ($R—NH_2$)	−3
Ammonia (NH_3)	−3
Nitrogen gas (N_2)	0
Nitrous oxide (N_2O)	+1 (average per N)
Nitrogen oxide (NO)	+2
Nitrite (NO_2^-)	+3
Nitrogen dioxide (NO_2)	+4
Nitrate (NO_3^-)	+5

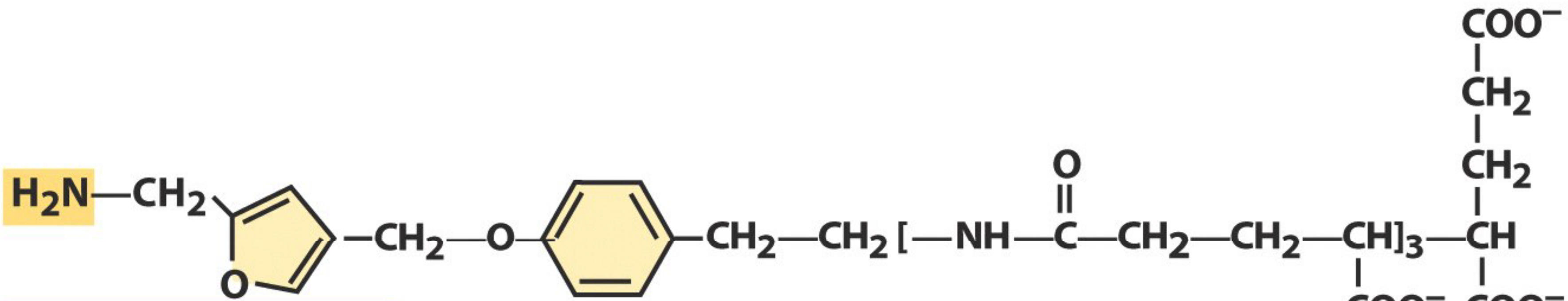
$$NH_4^+ + NO_2^- \rightarrow N_2 + H_2O$$



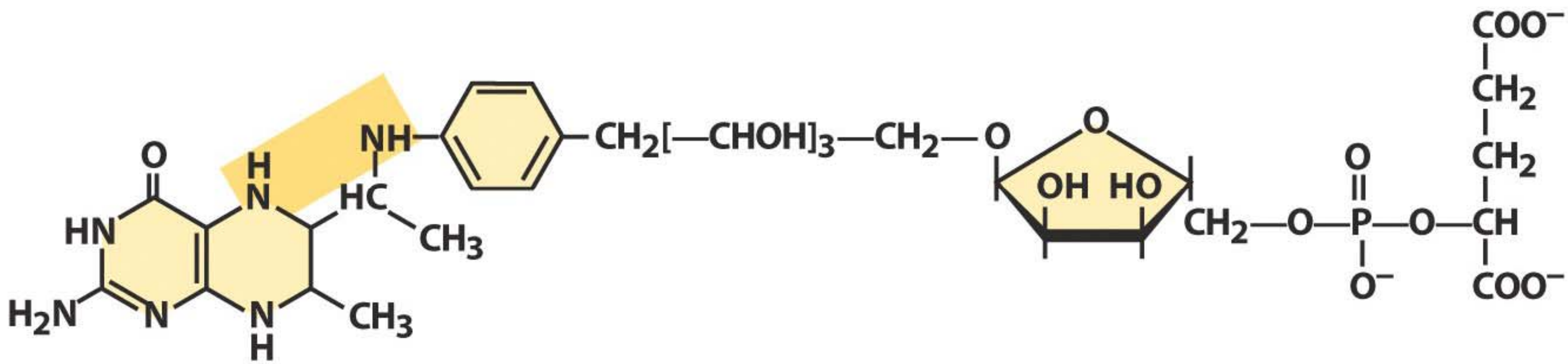
Autofluorescence in methanogen cells due to the presence of the unique electron carrier F_{420}

Coenzymes of methanogenesis

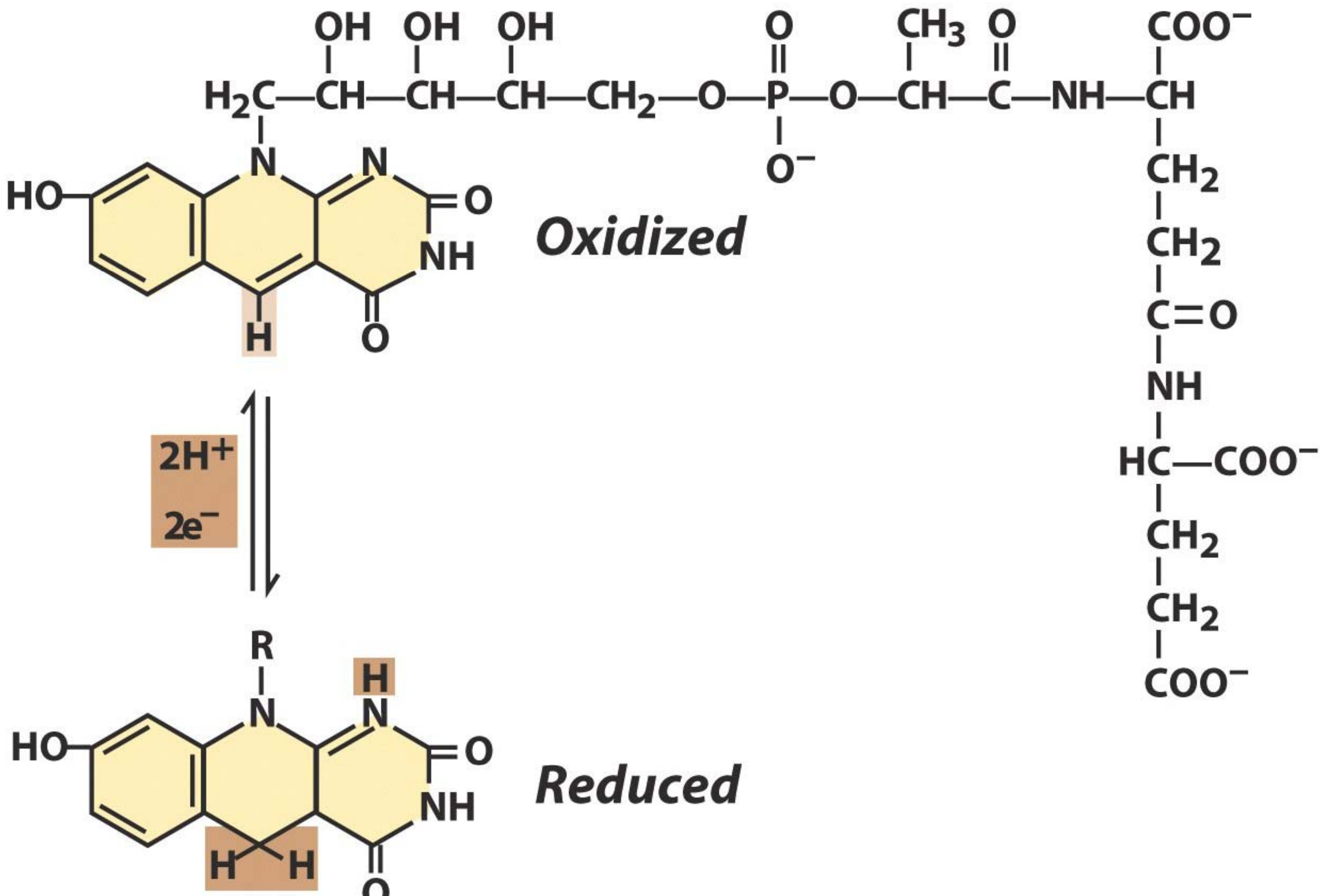
Two types: C_1 carriers or redox



Methanofuran



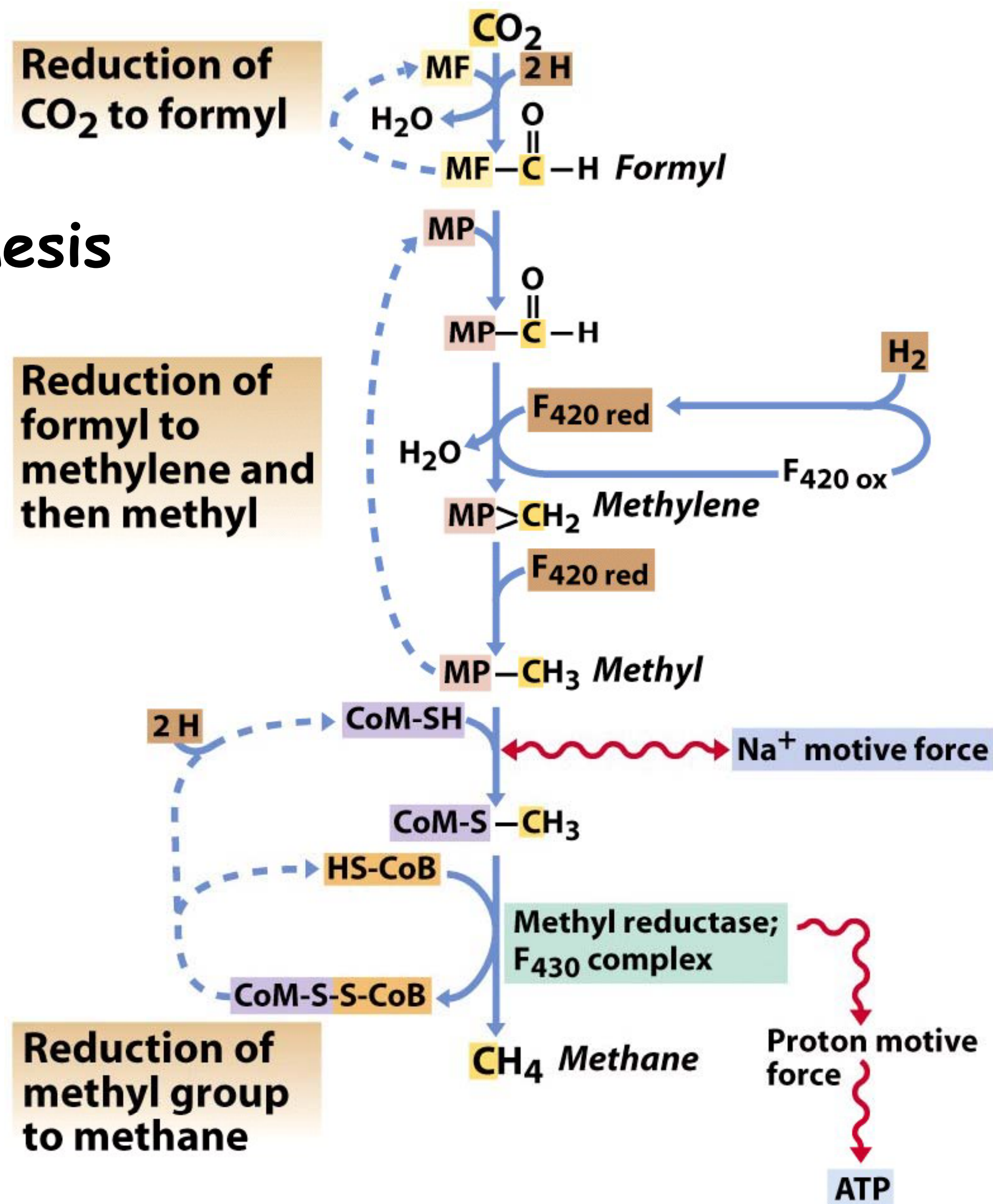
Methanopterin



Coenzyme F_{420}

Coenzymes of methanogenesis

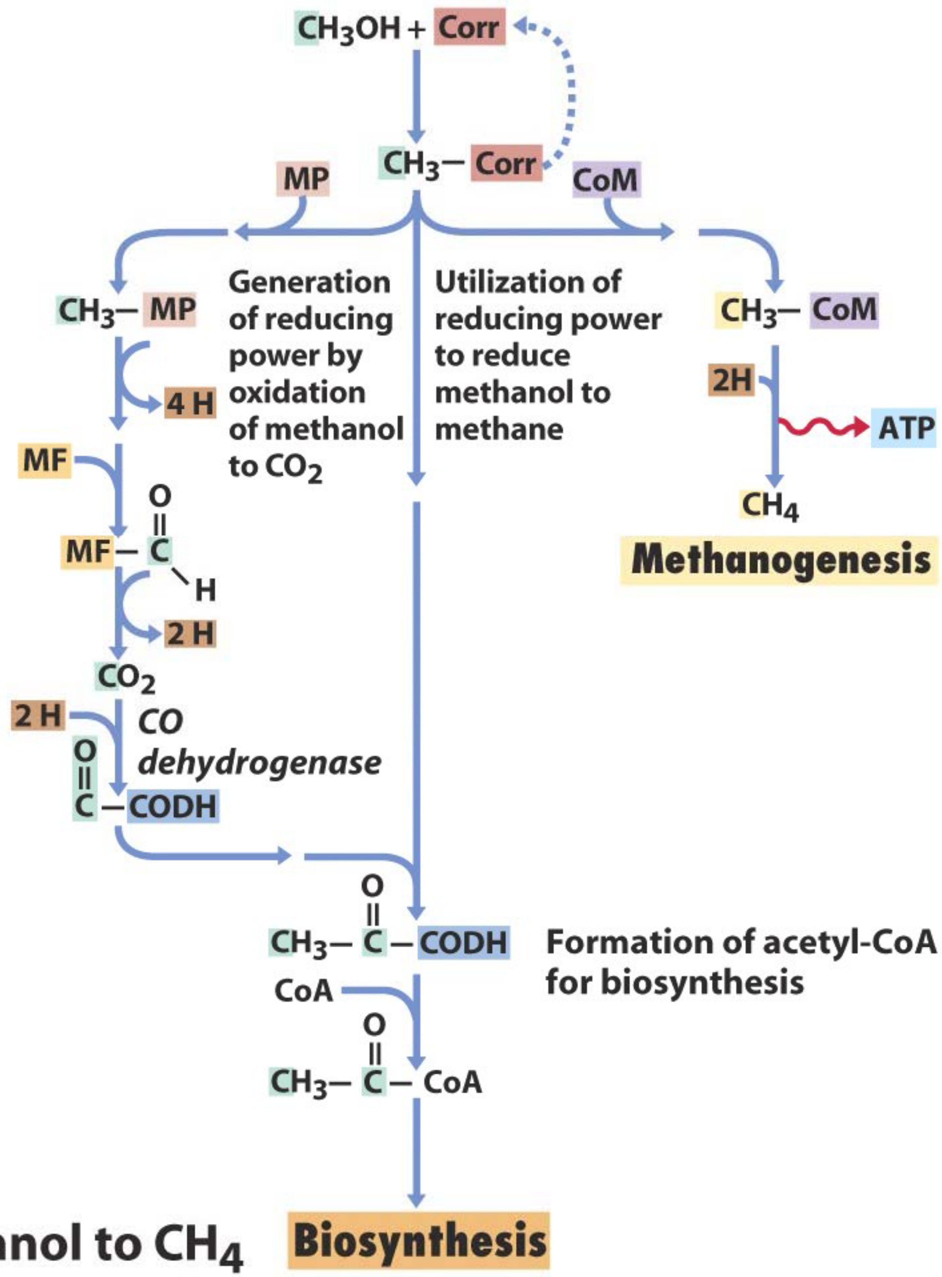
Methanogenesis



$H_2 + CO_2$

$\downarrow$

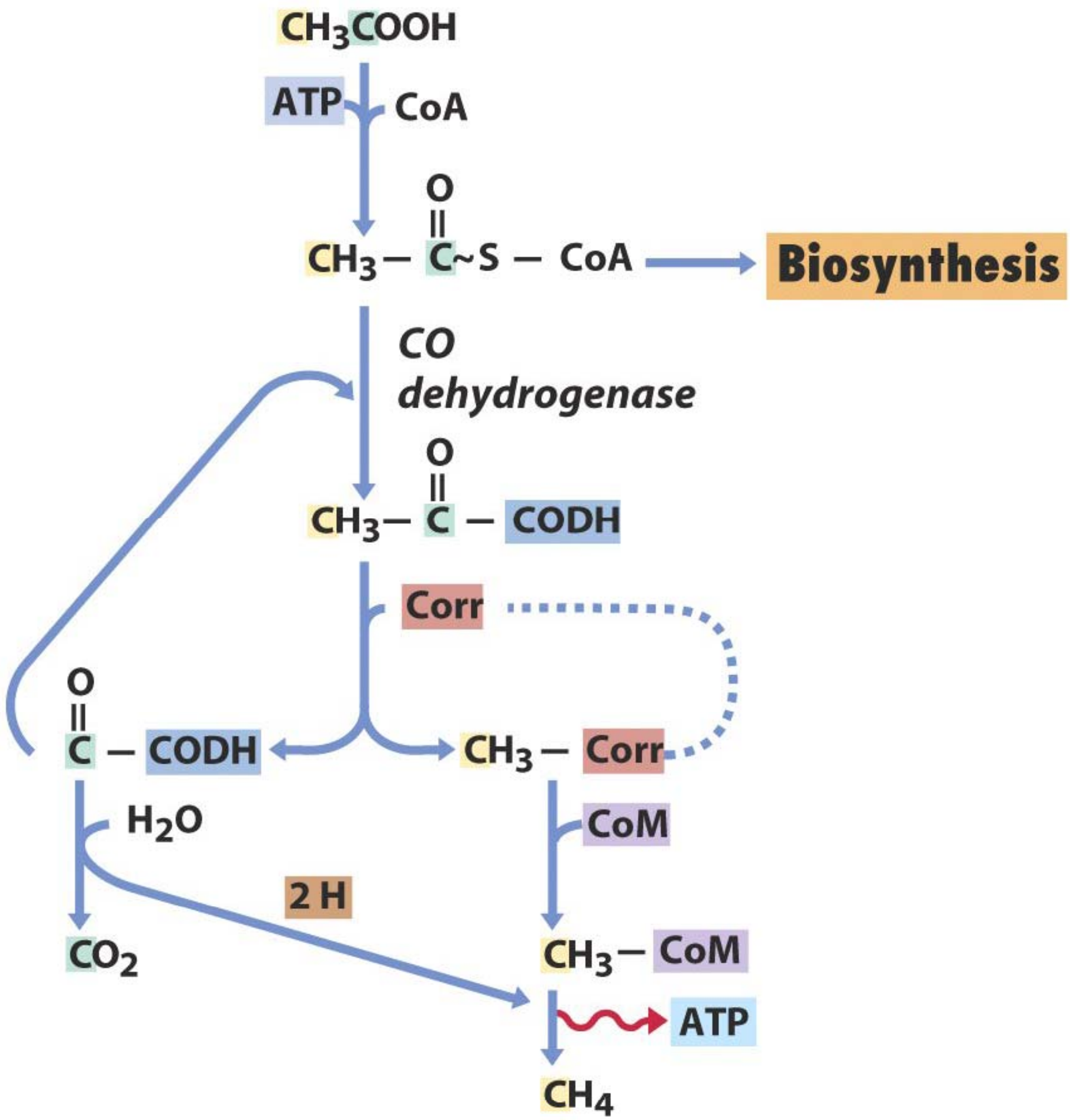
CH_4



Methanol to CH_4

Autotrophy?
Corrinoids with
Co centers!

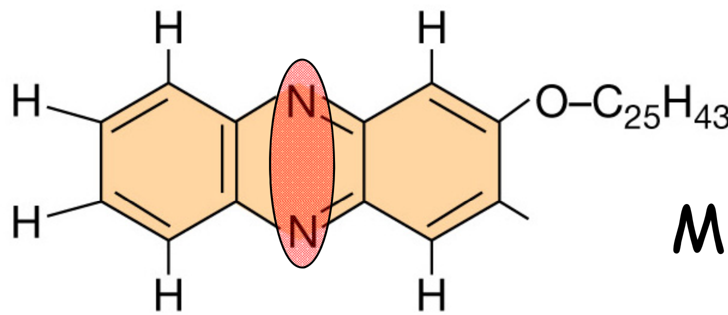
Autotrophy?
Corrinoids with
Co centers!



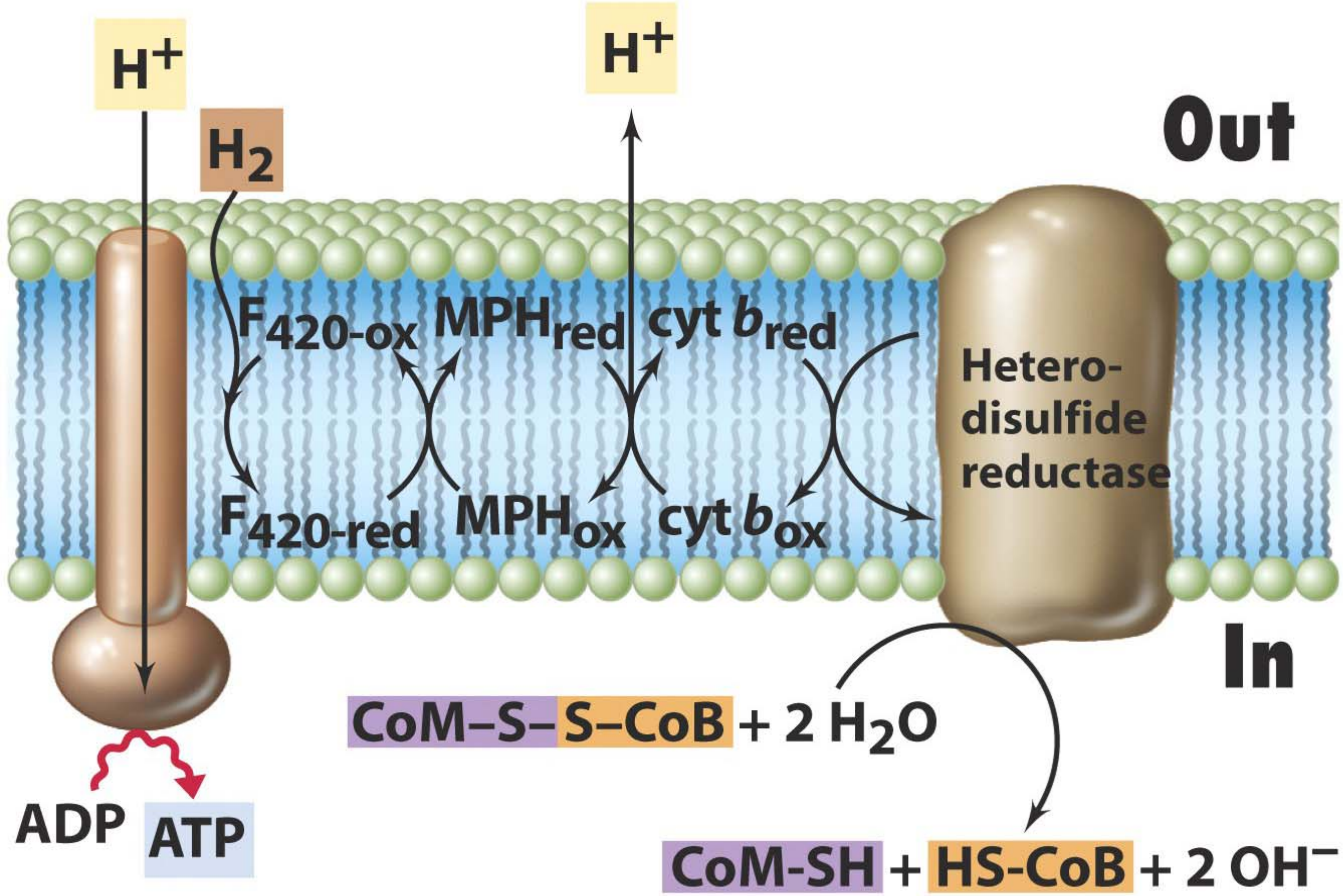
Acetate to CH_4

Methanogenesis

Conservation of Energy



Methanophenazine



Methanogenesis

Chemoautotrophs:

$CO_2 \rightarrow CH_4 + \text{Org. C}$

H_2 as electron donor

Chemoorganotrophs:

Acetate/MeOH $\rightarrow CH_4 + CO_2$

Org. C as electron donor

Global Biogenic Methane Production:

1/3 Chemoautotrophs

2/3 Chemoorganotrophs

Take Home Message
Methanogenesis

- Methanogenesis is the biological production of CH_4 from either CO_2 plus H_2 or from methylated compounds.

- A variety of unique coenzymes are involved in methanogenesis, and the process is strictly anaerobic.

- Energy conservation in methanogenesis involves both proton and sodium ion gradients.

- Only *Archaea* are able to pull this weird metabolism off.