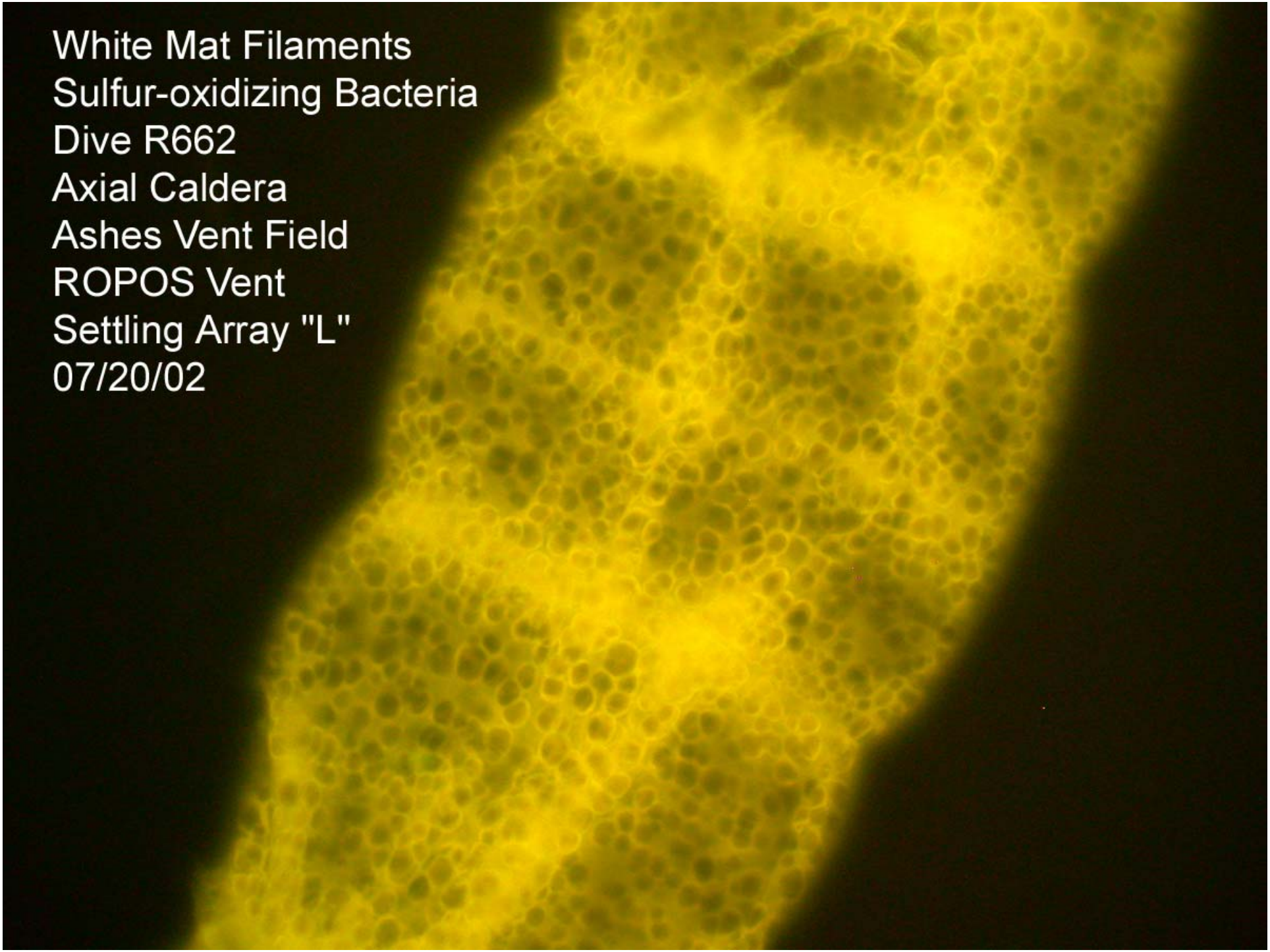
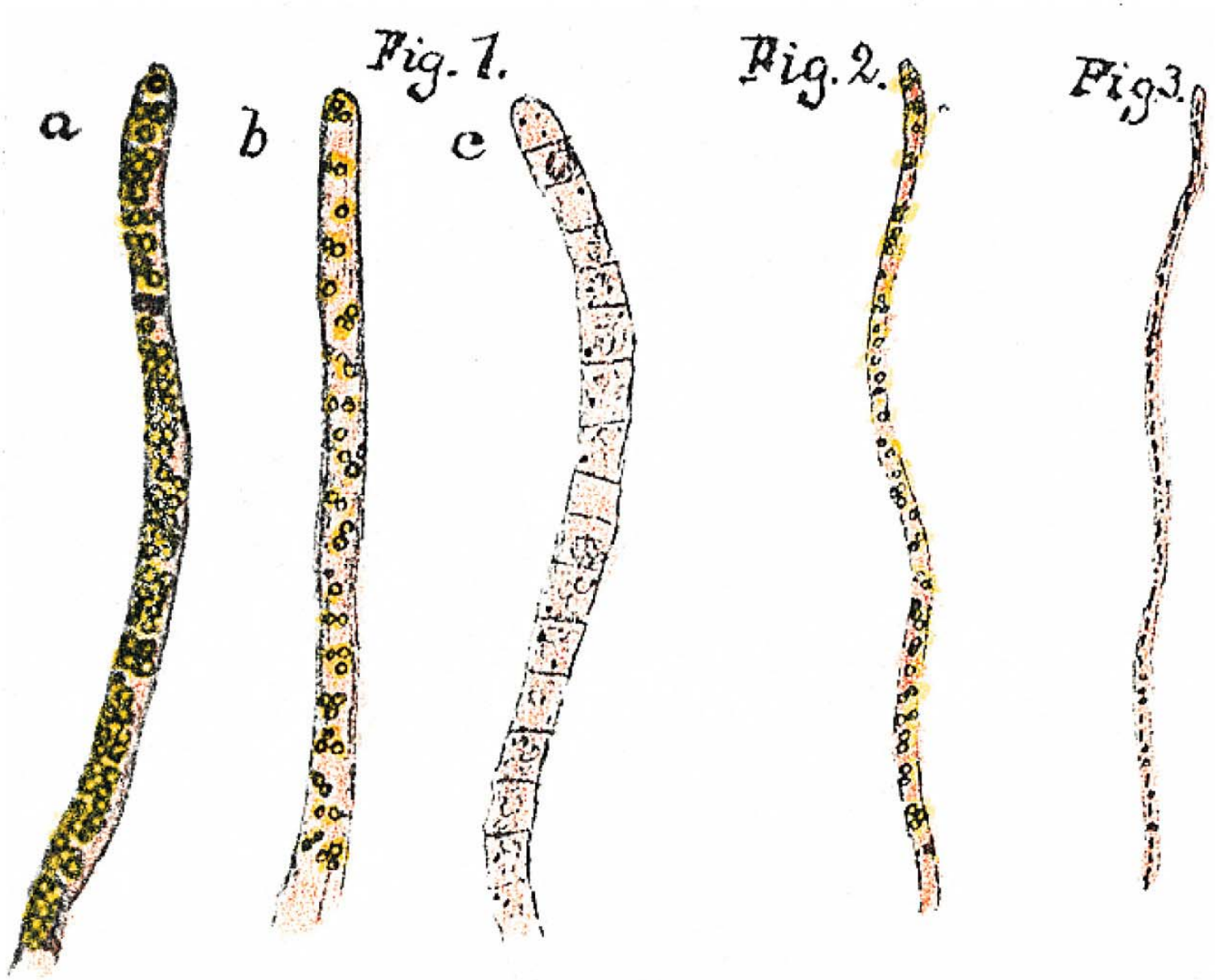
More on Chemotrophic Potential

S & Fe Cycles


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



Winogradsky's drawings of *Beggiatoa*

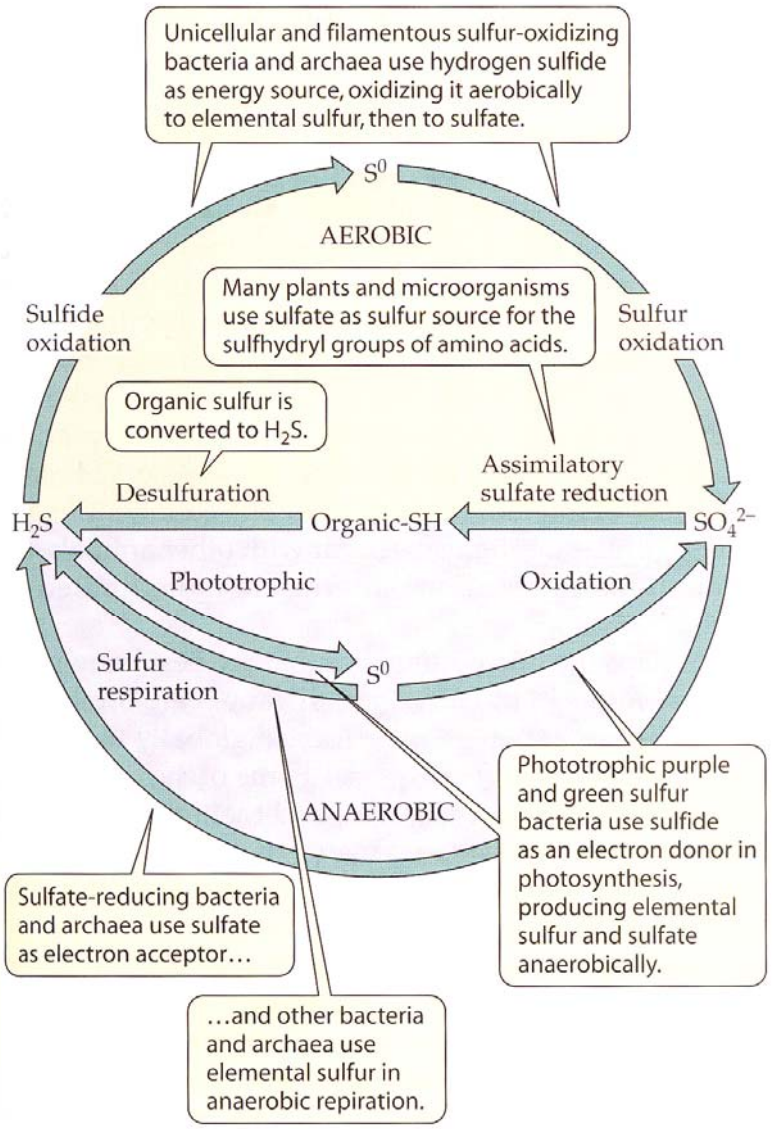
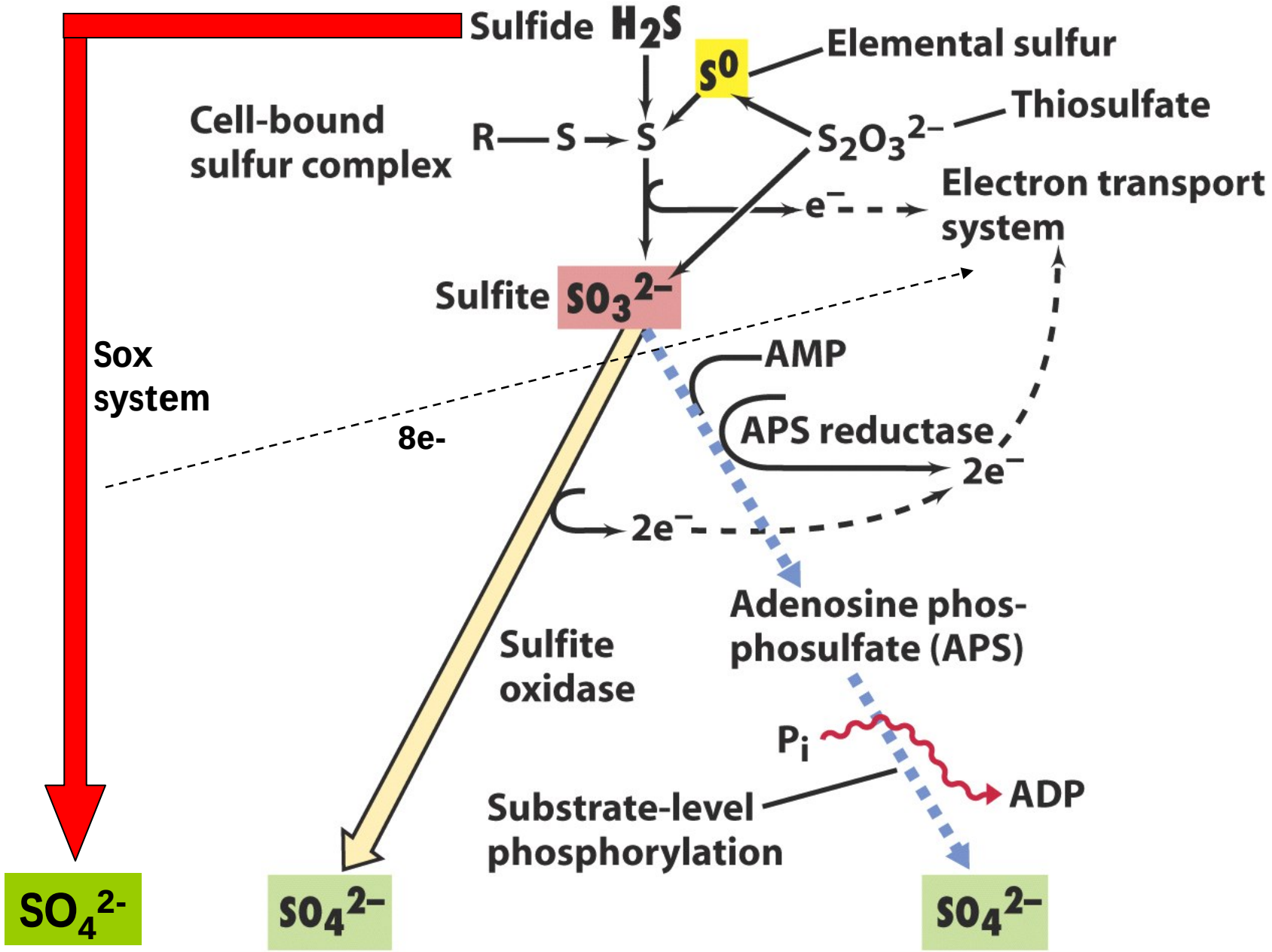


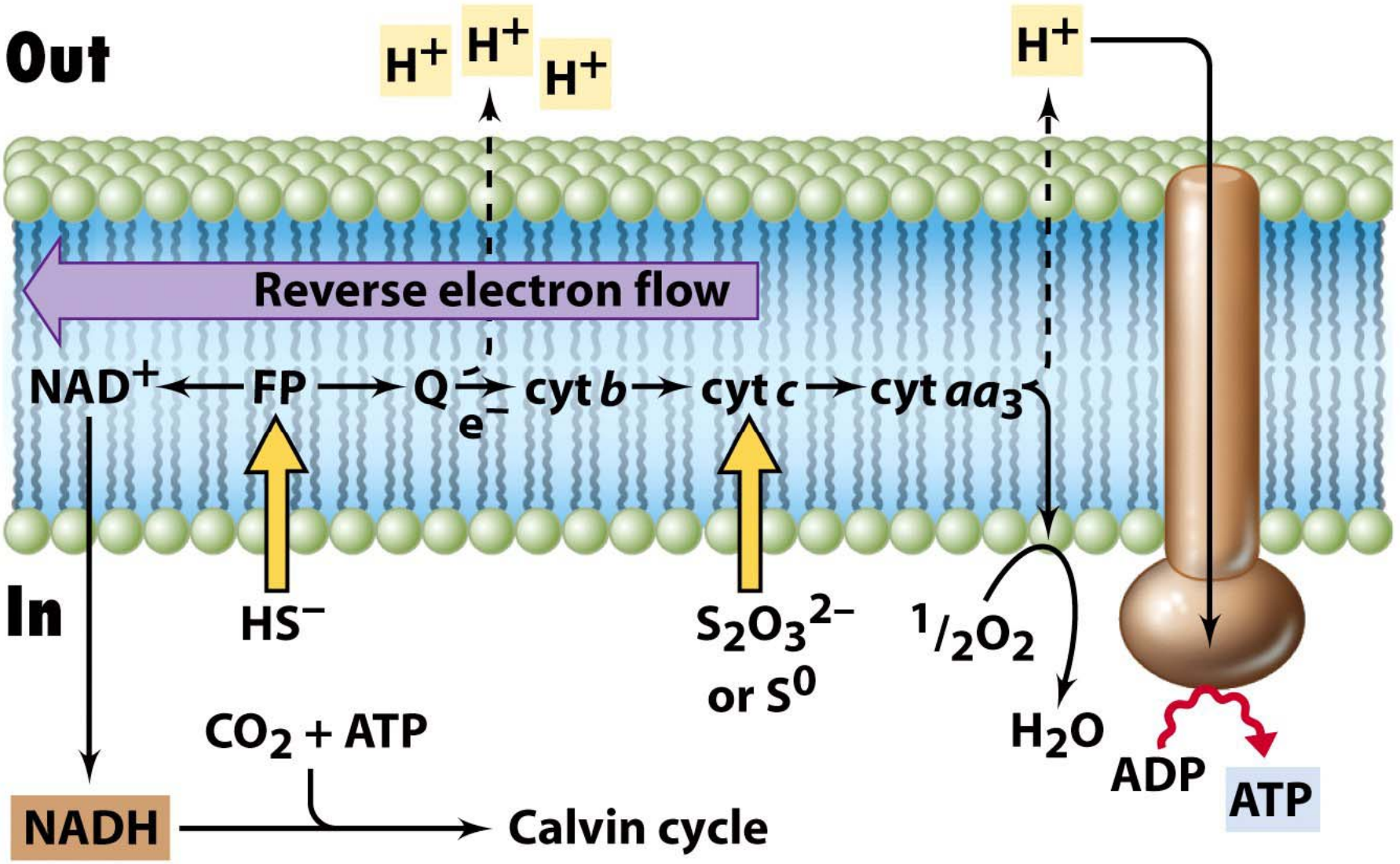
Figure 24.25 Sulfur cycle
Cycling of sulfur through the biosphere. S^0 indicates elemental sulfur.

TABLE 24.7 Bacterial groups responsible for the oxidation of reduced sulfur compounds

Microbe type	Oxidative Activity
Photosynthetic *Bacteria*	
Purple Sulfur	$H_2S \rightarrow S^0 \rightarrow SO_4^{2-}$
Green Sulfur	$H_2S \rightarrow S^0 \rightarrow SO_4^{2-}$
Some *Cyanobacteria*	$H_2S \rightarrow S^0$
Chemosynthetic *Bacteria*	
Filamentous Sulfur Oxidizers (e.g., *Beggiatoa*)	$H_2S \rightarrow S^0 \rightarrow SO_4^{2-}$
Unicellular Sulfur Oxidizers (e.g., *Thiobacillus, Microspira*)	$H_2S \rightarrow S^0 \rightarrow SO_4^{2-}$
Heterotrophic *Bacteria*	
Filamentous Sulfur Oxidizers (e.g., *Beggiatoa*)	$H_2S \rightarrow S^0 \rightarrow SO_4^{2-}$
Unicellular Sulfur Oxidizers (e.g., some *Pseudomonas* spp.)	$H_2S \rightarrow S^0 \rightarrow SO_4^{2-}$
Archaea	
Acidianus, Sulfolobus	$H_2S \rightarrow S^0 \rightarrow SO_4^{2-}$



S-oxidizers: 3 pathways are known


Out
H+
H+
H+
H+
Reverse electron flow
NAD+
FP
Q
e−
cyt b
cyt c
cyt aa3
In
HS−
S2O3 2−
or S0
1/2O2
H2O
ADP
ATP
CO2 + ATP
NADH
Calvin cycle

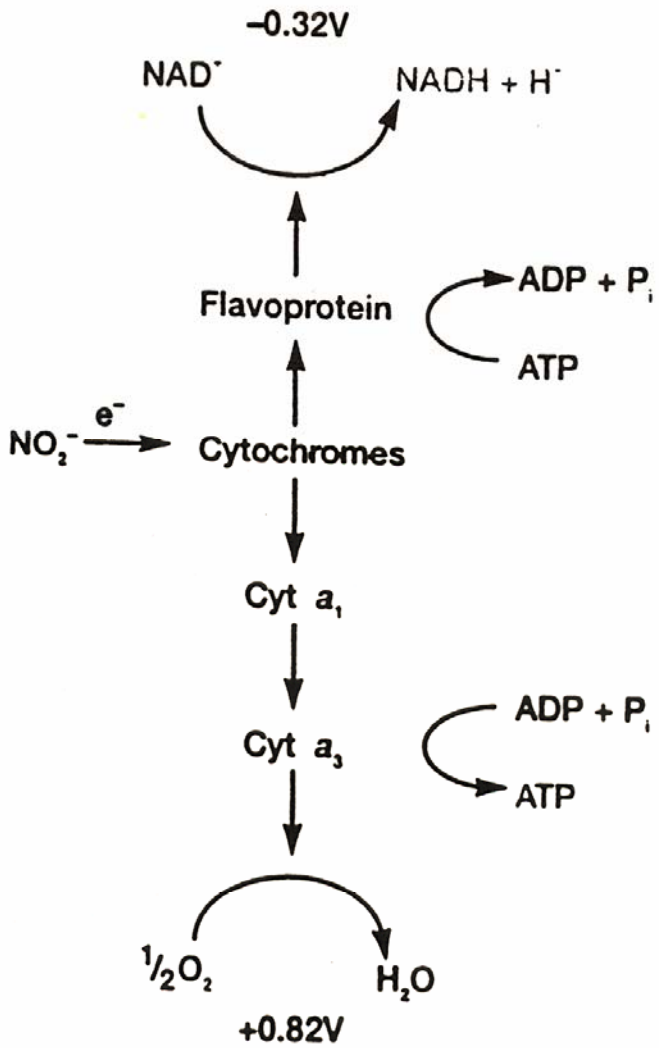


Figure 9.20 Reversed Electron Flow. The flow of electrons in the transport chain of *Nitrobacter*. Electrons flowing from nitrite to oxygen (down the reduction potential gradient) will release energy. It requires protonmotive force or ATP energy to force electrons to flow in the reverse direction from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

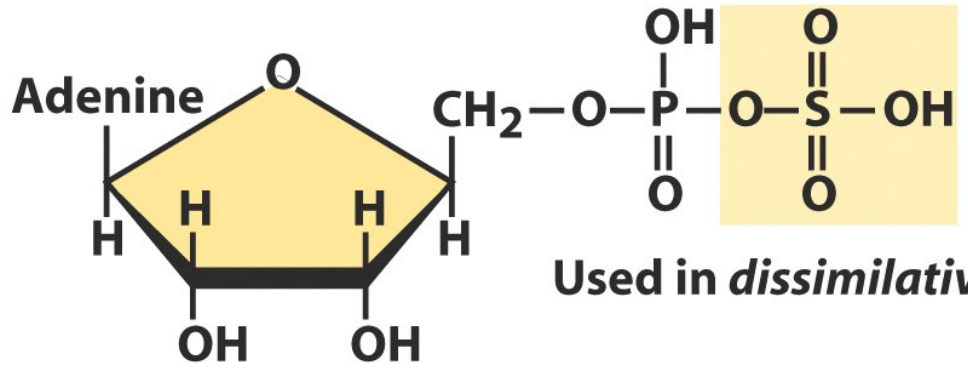
Table 17.3 **Sulfur compounds and electron donors for sulfate reduction**

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

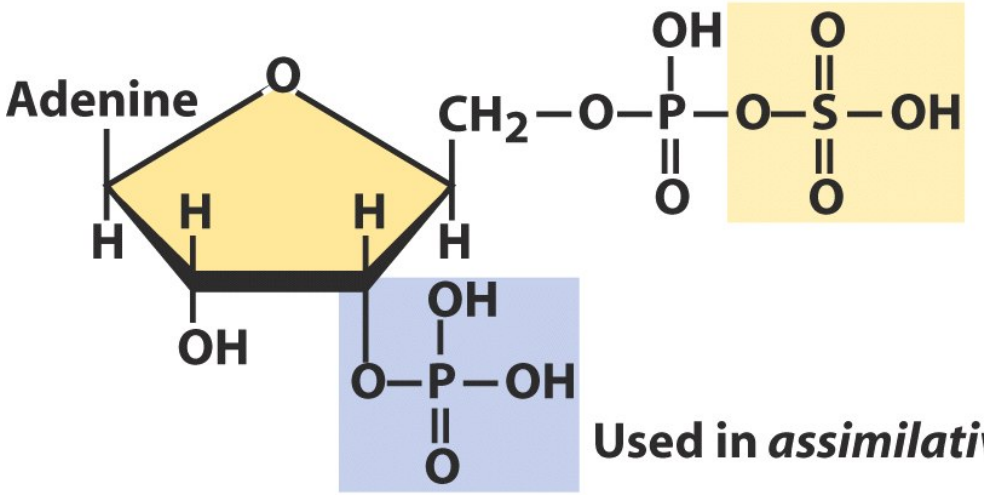
H_2	Acetate
Lactate	Propionate
Pyruvate	Butyrate
Ethanol and other alcohols	Long-chain fatty acids
Fumarate	Benzoate
Malate	Indole
Choline	Hexadecane

SRB's can make active sulfate compounds



Used in *dissimilative* metabolism

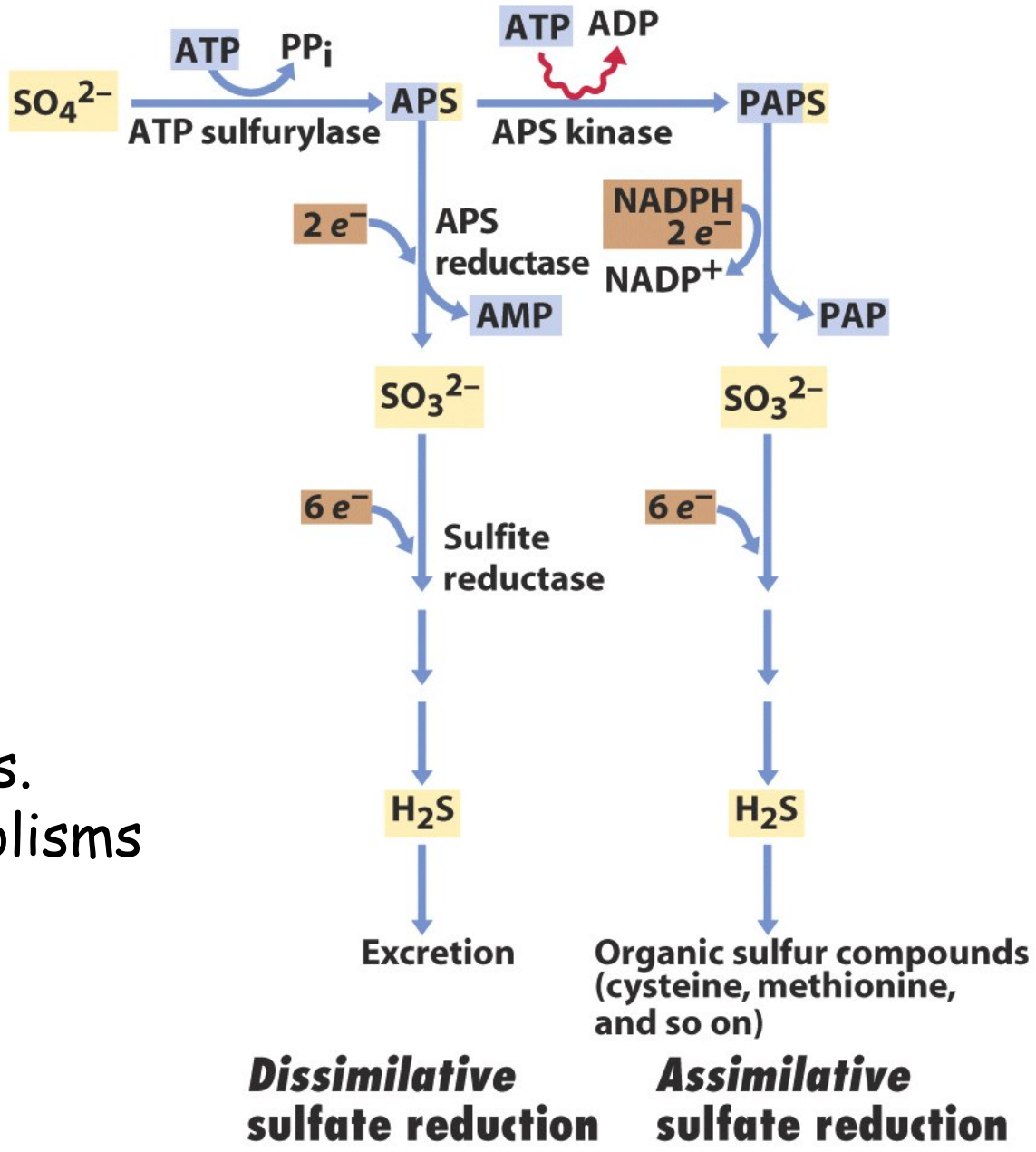
APS (Adenosine 5′-phosphosulfate)



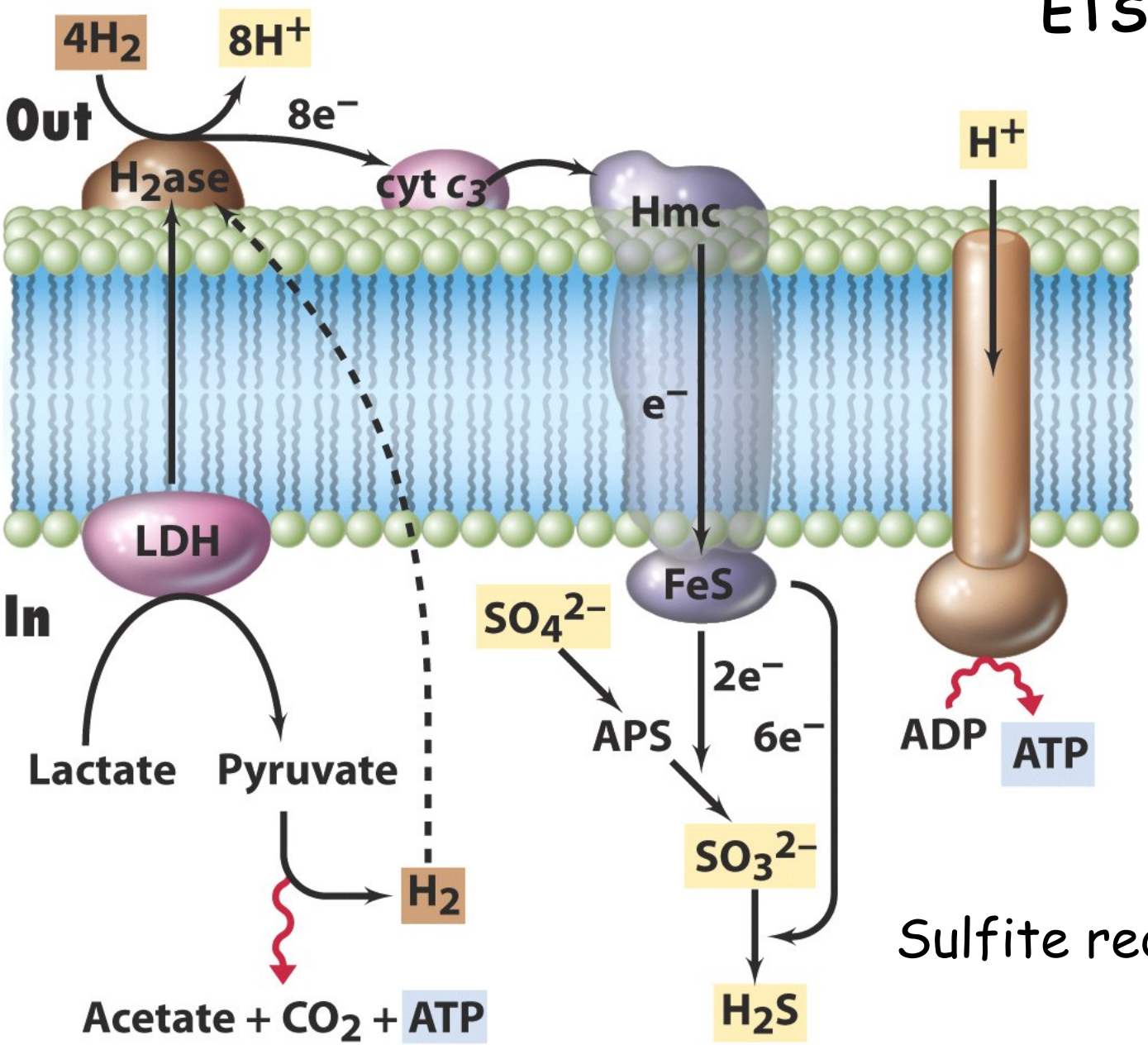
Used in *assimilative* metabolism

PAPS (Phosphoadenosine 5′-phosphosulfate)

SRB dissimilative vs. assimilative metabolisms



ETS in SRBs



Sulfite reductase

Sulfur Disproportionation

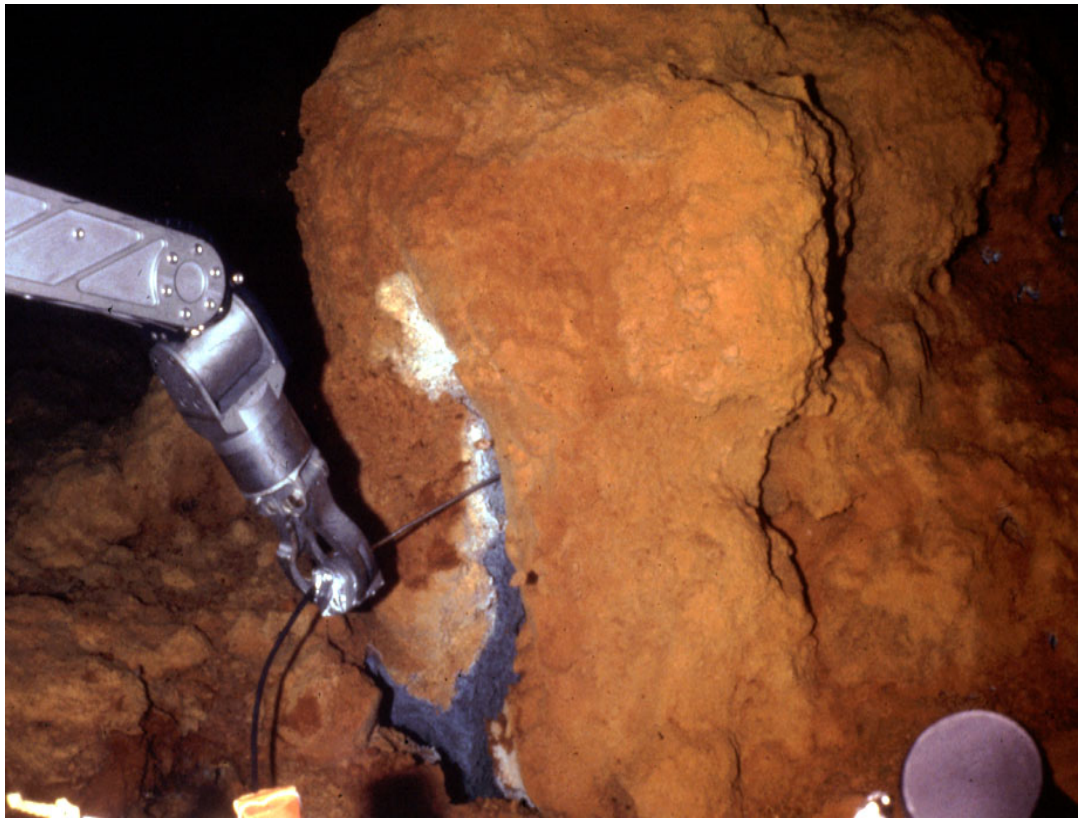
$$S_2O_3^{2-} + H_2O \rightarrow SO_4^{2-} + H_2S$$

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

Get your cake and eat it too!


Axial Volcano

Loihi Volcano



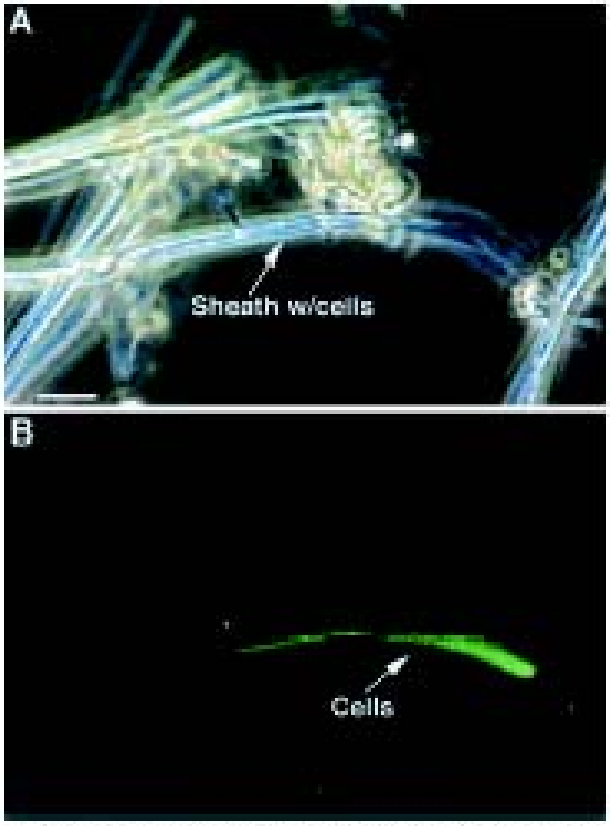
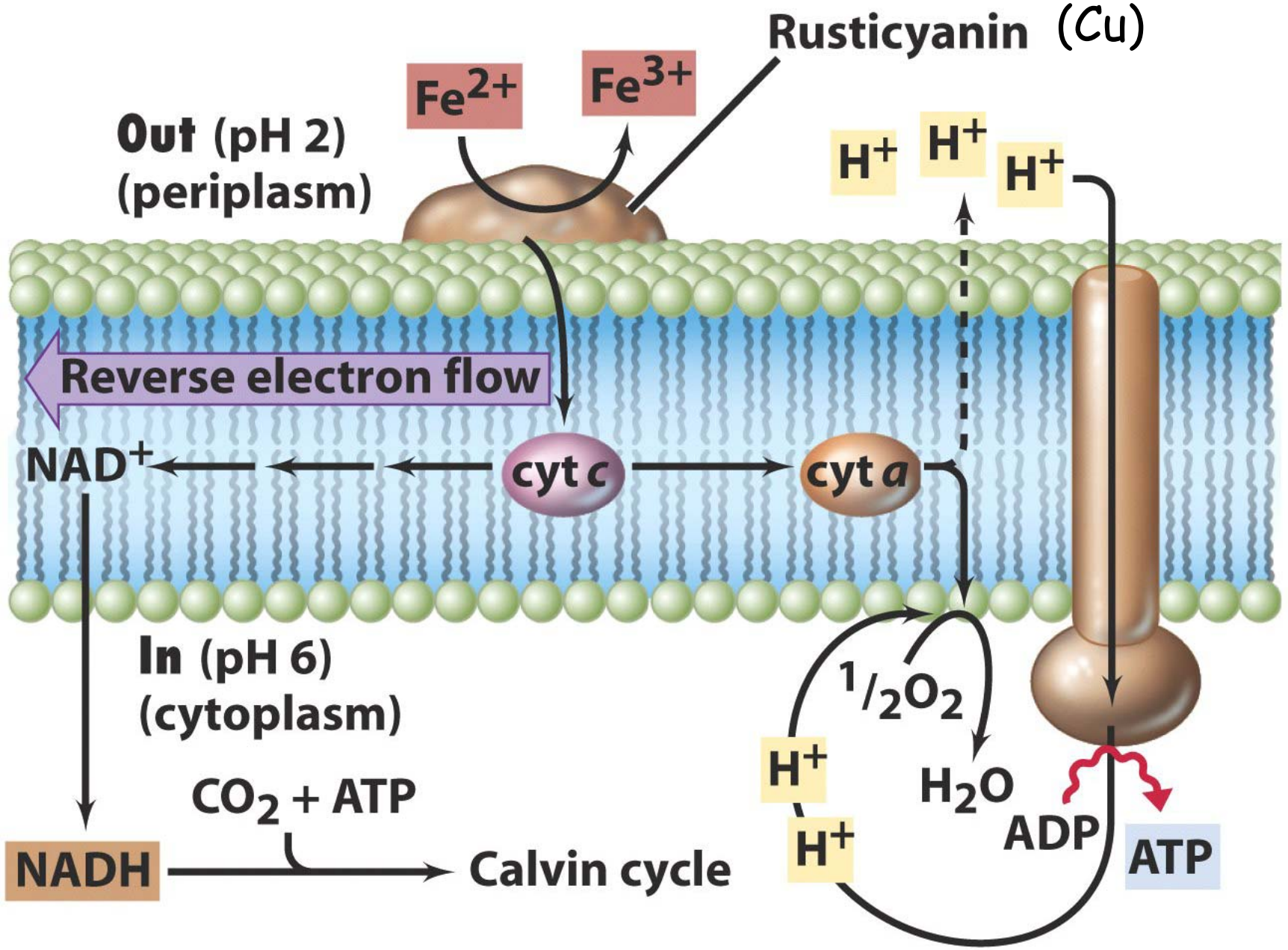
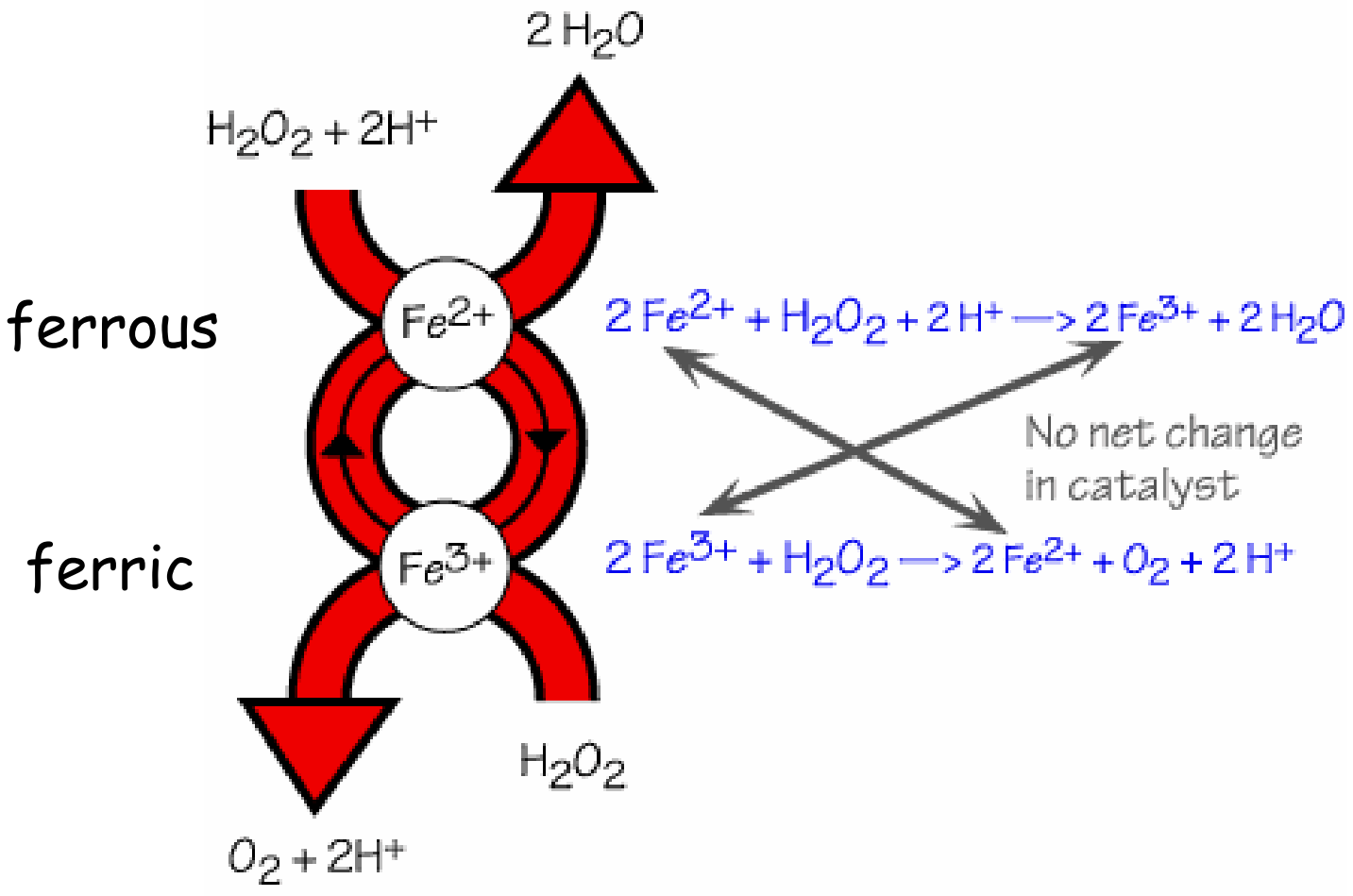


FIG. 3. *L. ochracea*-like sheaths collected at the Pohaku vents near marker 27. The sample has been stained with Syto. Panel B is the same image as in panel A but viewed by epifluorescence to reveal a filament of cells inside the iron-encrusted sheath. The cells are only visible when stained; most of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

Neutrophilic Fe-Oxidizing Bacteria
zeta-Proteobacteria (novel class)
Mariprofundus ferrooxydans (Type strain)


Rusticyanin (Cu)
Fe^{2+}
Fe^{3+}
Out (pH 2)
(periplasm)
H^+
H^+
H^+
Reverse electron flow
NAD^+
cyt *c*
cyt *a*
In (pH 6)
(cytoplasm)
$^1/_2O_2$
H^+
H^+
H_2O
ADP
ATP
CO_2 + ATP
NADH
Calvin cycle


2 H2O
H2O2 + 2H+
ferrous
Fe2+
2 Fe2+ + H2O2 + 2 H+ —> 2 Fe3+ + 2 H2O
No net change
in catalyst
ferric
Fe3+
2 Fe3+ + H2O2 —> 2 Fe2+ + O2 + 2 H+
H2O2
O2 + 2H+

Iron cycle