

**Unique Chemotrophs**

Mostly Chapters 12, 13, 17, 19  
Most nitrogen reactions covered in lab.

**Target Phyla and Groups**

- Proteobacteria - various H, S, Fe, C reactions
- Gram Positives - bioremediation
- Aquifex - H<sub>2</sub>-oxidizing
- Hyperthermophiles - S/Fe-reducing
- Methanogens - CO<sub>2</sub>-reducing (CO<sub>2</sub> to CH<sub>4</sub>)

**Chemolithotrophic Respiration**

**Hydrogen Oxidation (17.9)**

- ONLY high-energy yielding lithotroph
- Archaea & Bacteria - all use conserved hydrogenase

All others - cytoplasmic membranes that increase ETC.

Example 1: Alcaligenes, Proteobacteria (12.5)

Aerobic: H<sub>2</sub> + O<sub>2</sub> yields H<sub>2</sub>O  
Ecology: soil, freshwater

Example 2: Aquifex, Aquifex/Thermophile (12.37)

Anaerobic: H<sub>2</sub> + NO<sub>3</sub> yields HNO<sub>2</sub>  
Ecology: hot springs, deep sea vents

**Reduced Sulfur Oxidation (17.10)**

- H<sub>2</sub>S or S donates e<sup>-</sup>, yielding S or SO<sub>4</sub>
- Many pathways/enzymes, other donor/products
- S as cytoplasmic granules or secreted acid (H<sub>2</sub>SO<sub>4</sub>)

Example 1: Beggiatoa, Proteobacteria (12.4)

Aerobic: H<sub>2</sub>S + O<sub>2</sub> yields S (granules) + H<sub>2</sub>O  
Ecology: cool neutral freshwater sulfide springs

First lithotroph discovered, by Winogradsky in 1889.

Example 2: Thiovulum, Proteobacteria (12.4)

Aerobic: H<sub>2</sub>S + O<sub>2</sub> yields H<sub>2</sub>SO<sub>4</sub> (secreted)  
Ecology: by deep sea vents, tube worm symbionts

HUGE tube worms house in adapted trophosome, hemoglobin carries both O<sub>2</sub> and H<sub>2</sub>S.

Example 3: Sulfolobus, Hyperthermophile (13.9)

Aerobic: H<sub>2</sub>S + O<sub>2</sub> yields H<sub>2</sub>SO<sub>4</sub> (secreted)  
Ecology: thermal, acidic volcanic areas, pH 1-5

**Ferrous Iron Oxidation (17.11)**

- Acid-soluble Fe<sup>+2</sup> to insoluble Fe<sup>+3</sup> by rusticyanin
- Aerobic - cool acidic geological rifts, mines
- Example 1: Acidithiobacillus, Proteobacteria (12.4)
- Example 2: Ferroplasma, Archaea (13.5)

*Acidithiobacillus* also oxidizes sulfide/sulfur; *Sulfolobus* also oxidizes ferrous iron - at high temperature/acid.

**Anaerobic Respiration**

**Be Careful**

- Some organotrophs: CH<sub>2</sub>O (e<sup>-</sup> donor) + not O<sub>2</sub>
- Some lithotrophs: e.g. Aquifex H<sub>2</sub> (e<sup>-</sup> donor) + not O<sub>2</sub>

Many other examples - environmental, applied, medical; also basis for medical identification tests.

**Sulfate Reduction (17.15)**

- Dissimilative: SO<sub>4</sub> to H<sub>2</sub>S (only prokaryotes)
- Assimilative: SO<sub>4</sub> to -SH (most living things)
- As with H<sub>2</sub>S/S oxidation, varied pathways/enzymes

Example 1: Desulfobacter, Proteobacteria (12.18)

Organotroph: SO<sub>4</sub> + CH<sub>2</sub>O yields H<sub>2</sub>S + CO<sub>2</sub>  
Ecology: soil, freshwater, marine

Example 2: Subsurface Proteobacteria (p. 622)

Lithotroph: SO<sub>4</sub> + H<sub>2</sub> yields H<sub>2</sub>S + H<sub>2</sub>O  
Ecology: 3-10 km deep Columbia basalts (ROCK)

Other subsurface microbes - methanogenic Archaea.

**Methanogenesis (17.17)**

- CO<sub>2</sub> accepts e<sup>-</sup>, yielding CH<sub>4</sub> - OBLIGATE anaerobe
- Unique, fluorescent coenzymes - ONLY Archaea

Example 1: Methanococcus (13.4)

Organotroph: CH<sub>2</sub>O + CO<sub>2</sub> yields CH<sub>4</sub> + H<sub>2</sub>O  
Ecology: moderate rumen, water treatment, landfills...

Rumen, water treatment - FYI sections 19.16, 28.2

Example 2: Methanopyrus (13.4 and 6)

Lithotroph: H<sub>2</sub> + CO<sub>2</sub> yields CH<sub>4</sub> + H<sub>2</sub>O  
Ecology: thermal sediments near/in deep sea vents

**Useful Applications and Syntrophy Recap**

**Bioremediation (19.17 and 19.18)**

- Natural - petroleum, with Hg and H<sub>2</sub>S byproducts
- Xenobiotic PCB/PAH - poly-Cl, poly-aromatic...
- Examples include DDT, other insecticides, herbicides

Microbes resist, uptake, or transform many toxic metals - FYI section 19.16.

Example 1: Burkholderia, Proteobacteria (17.18)

Organotroph: PCB/PAH or petroleum + O<sub>2</sub>  
Ecology: oxic sediments - freshwater

10% oil degraded by bacteria every year; in the *Pseudomonad* subgroup (section 12.7, also in lab).

Example 2: Dehalobacter, Gram Positive (17.18)

Lithotroph: H<sub>2</sub> + PCB  
Ecology: anoxic sediments - freshwater and marine

**Mining and Ore-Leaching (19.14 and 19.15)**

- Bad - open pit mine, acid products run-off
- Good - closed, recycle acid, enhance leaching
- Common contaminant to leach - pyrite (FeS<sub>2</sub>)
- Syntrophs Acidithiobacillus, Ferroplasma, Sulfolobus

**Methano/Methylotrophy (17.24 and 12.6)**

- Proteobacteria syntrophs with Archaea methanogens
- CH<sub>4</sub>/CH<sub>3</sub> + O<sub>2</sub> yields CO<sub>2</sub> + H<sub>2</sub>O via MMO enzyme
- Oxic/anoxic interface - CH<sub>4</sub> percolating from below
- Example 1 - moderate rumen Methylococcus
- Example 2 - by deep CH<sub>4</sub> seep, mussel symbionts

Mussels adapted to house *Methylococcus*-like bacteria.