Methanogens

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Methanogens

- Methanogens are strict anaerobes that obtain energy by converting CO_2, H_2, formate, methanol, acetate, and other compounds to either methane or methane and CO_2.
- They are autotrophic when growing on H_2 and CO_2.
- These are the largest group of archaea.
- There are five orders (*Methanobacteriales, Methanococcales, Methanomicrobiales, Methanosarcinales,* and *Methanopyrales*) and 26 genera, which differ greatly in overall shape, 16S rRNA sequence, cell wall chemistry and structure, membrane lipids, and other features.
- Eg., methanogens construct three different types of cell walls.
  - Several genera have walls with pseudomurein
  - Other walls contain either proteins or
  - heteropolysaccharides.

Methanopyrus kandleri

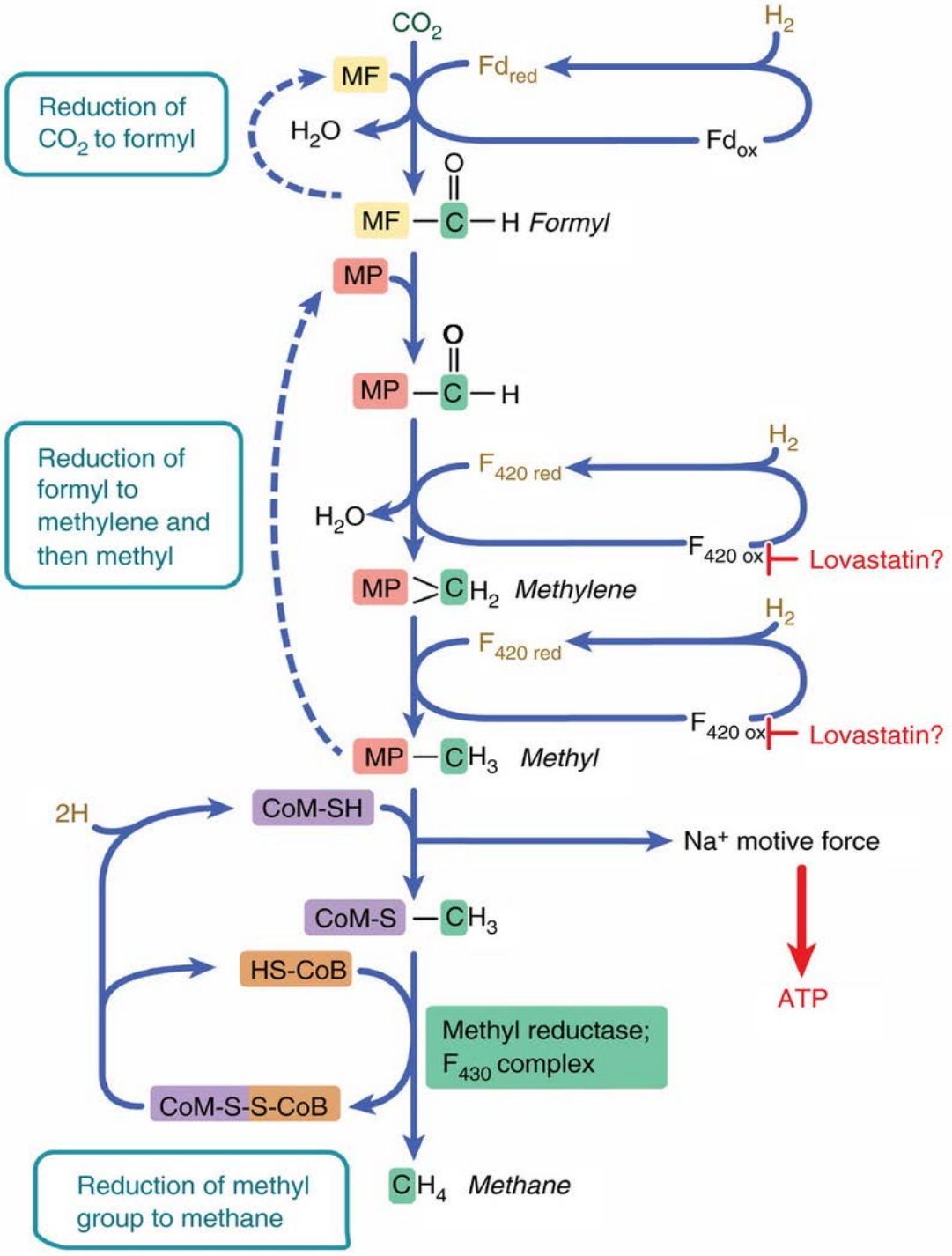
- One of the most unusual methanogenic groups is the class Methanopyri.
- It has one order, Methanopyrales, one family and a single genus, *Methanopyrus.*
- This extremely thermophilic rod shaped methanogen has been isolated from a marine hydrothermal vent.
- *Methanopyrus kandleri* has a temperature minimum at 84°C and an optimum of 98°C; it will grow up to 110°C (above the boiling point of water).
- *Methanopyrus* occupies the deepest and most ancient branch of the euryarchaeotes.

Methanogenesis

- As might be inferred from the methanogens' ability to produce methane anaerobically, their metabolism is unusual.
- These procaryotes contain several unique cofactors: tetrahydromethanopterin (H_4MPT), methanofuran (MFR), coenzyme M (2-mercaptoethanesulfonic acid), coenzyme F420, and coenzyme F430.
- The first three cofactors bear the C1 unit when CO_2 is reduced to CH_4.
- F420 carries electrons and hydrogens, and F430 is a nickel tetrapyrrole serving as a cofactor for the enzyme methyl-CoM methylreductase.
- The pathway for methane synthesis is thought to function as shown in **figure 1.**
- It appears that ATP synthesis is linked with methanogenesis by electron transport, proton pumping, and a chemiosmotic mechanism.
- Some methanogens can live autotrophically by forming acetyl-CoA from two molecules of CO_2 and then converting the acetyl-CoA to pyruvate and other products.

Figure 1. Methanogenesis pathway.

- The carbon atom reduced is highlighted in green.
- MF, methanofuran;
- MP, tetrahydromethanopterin;
- CoM, coenzyme M;
- Fd, ferredoxin;
- CoB, coenzyme B



Ecological significance

- Methanogens thrive in anaerobic environments rich in organic matter: the rumen and intestinal system of animals, freshwater and marine sediments, swamps and marshes, hot springs, anaerobic sludge digesters, and even within anaerobic protozoa.
- Methanogens often are of ecological significance.
- The rate of methane production can be so great that bubbles of methane will sometimes rise to the surface of a lake or pond.
- Rumen methanogens are so active that a cow can belch 200 to 400 liters of methane a day.

… Ecological significance

- Methanogenic archaea are potentially of great practical importance since methane is a clean-burning fuel and an excellent energy source.
- For many years sewage treatment plants have been using the methane they produce as a source of energy for heat and electricity.
- Methanogenesis also can be an ecological problem.
- Methane absorbs infrared radiation and thus is a greenhouse gas.
- Recently it has been discovered that methanogens can oxidize Fe^0 and use it to produce methane and energy.
- This means that methanogens growing around buried or submerged iron pipes and other objects may contribute significantly to iron corrosion.

Questions

- Write an essay on methanogenesis mentioning its importance.
- Explain ecological significance of methanogens.
- Diagrammatically explain the methanogenesis pathway.