Methylotrophs

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Introduction

- The family Methylococcaceae contains rods, vibrios, and cocci that use methane, methanol, and other reduced one-carbon compounds as their sole carbon and energy sources under aerobic or microaerobic conditions.
- **Methylotrophs** are a diverse group of microorganisms that can use reduced one-carbon compounds, such as methanol or methane, as the carbon source for their growth; and multi-carbon compounds that contain no carbon-carbon bonds, such as dimethyl ether and dimethylamine.
- **Methanotrophs**, a specific type of methylotroph, are able to metabolize methane as their only source of carbon and energy.
- Methane-oxiding bacteria are unique among prokaryotes in possessing relatively large amounts of sterols.

Substrates used for growth:

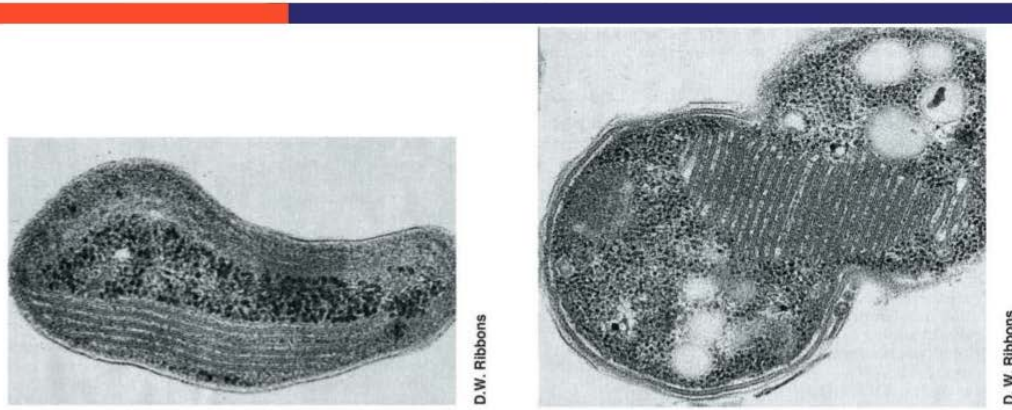
Methane, CH_4
Methanol, CH_3OH
Methylamine, CH_3NH_2
Dimethylamine, $(CH_3)_2NH$
Trimethylamine, $(CH_3)_3N$
Formate, $HCOO^-$
Formamide, $HCONH_2$
Carbon monoxide, CO
Dimethyl ether, $(CH_3)_2O$,
Dimethyl sulfoxide, $(CH_3)_2SO$
Dimethylsulfide, $(CH_3)_2S$

- Here are examples of methylotrophs:
  - *Methanosarcina*, which can both utilize and produce methane;
  - *Methylococcus capsulatus*, which requires methane to survive;
  - *Pichia pastoris*, a biotechnologically important model organism that can use methanol as a carbon and energy source.

Methanotrophs

- Methanotrophs are common near environments where methane is produced, such as: oceans, mud, marshes, underground environments, soils, rice paddies, landfills, and in symbiotic associtionwith marine mussels.
- Methanotrophs can be divided into two major groups:
  - Type I: assimilate one carbon compound via ribulose monophosphate (RuMP) cycle
    - Internal membranes arranged as bundles of disc shaped vesicles distributed throughout the cell
    - Lack complete citric acid cycle (α-ketoglutarate dehydrogenase is absent)
  - Type II: assimilate one carbon compound via serine pathway
    - Possess paired membranes running along the periphery of the cell
    - Possess complete citric acid cycle

Electron Micrographs of Methanotrophs



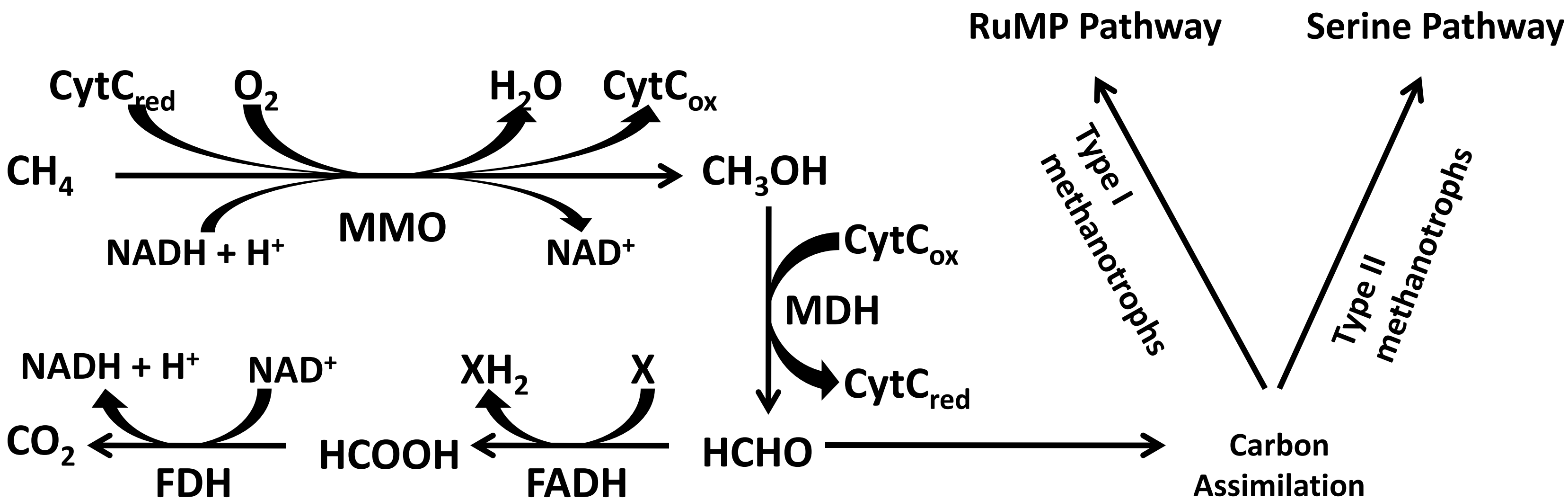
(a) Type II membrane system
Methylosinus *(α Proteobacteria)*
Carbon assimilation pathway: serine

(b) Type I membrane system
Methylococcus capsulatans (β-Proteobacteria)
Carbon asimilation pathwy: ribulose monophosphate pathway

Biochemistry of Methane oxidation

- Methylotrophs aerobically utilize C1 compounds by oxidizing them to yield formaldehyde, which in turn can either be used for energy or assimilated into biomass.
- Methane is first oxidized to methanol by the enzyme methane monooxygenase. The methanol is then oxidized to formaldehyde by methanol dehydrogenase, and the electrons from this oxidation are donated to an electron transport chain for ATP synthesis.
- No ATP synthesis occurs during the first step, the oxidation of methane to methanol, and this is consistent with the fact that growth yield of methanotrophs are the same wherther methane or methanol is used as substrate.
- Formaldehyde can be assimilated into cell material by the activity of either of two pathways, one involving the formation of the amino acid serine (serine pathway in Type II organisms) and the other proceeding through the synthesis of sugars such as fructose 6-phosphate and ribulose 5-phosphate (RuMP pathway in type I organisms).
- Consistent with the lower energy requirements of the RuMP pathway over serine pathway, the cell yield of type I organisms from a given amount of methane or methanol is higher than the cell yield of type II organisms.

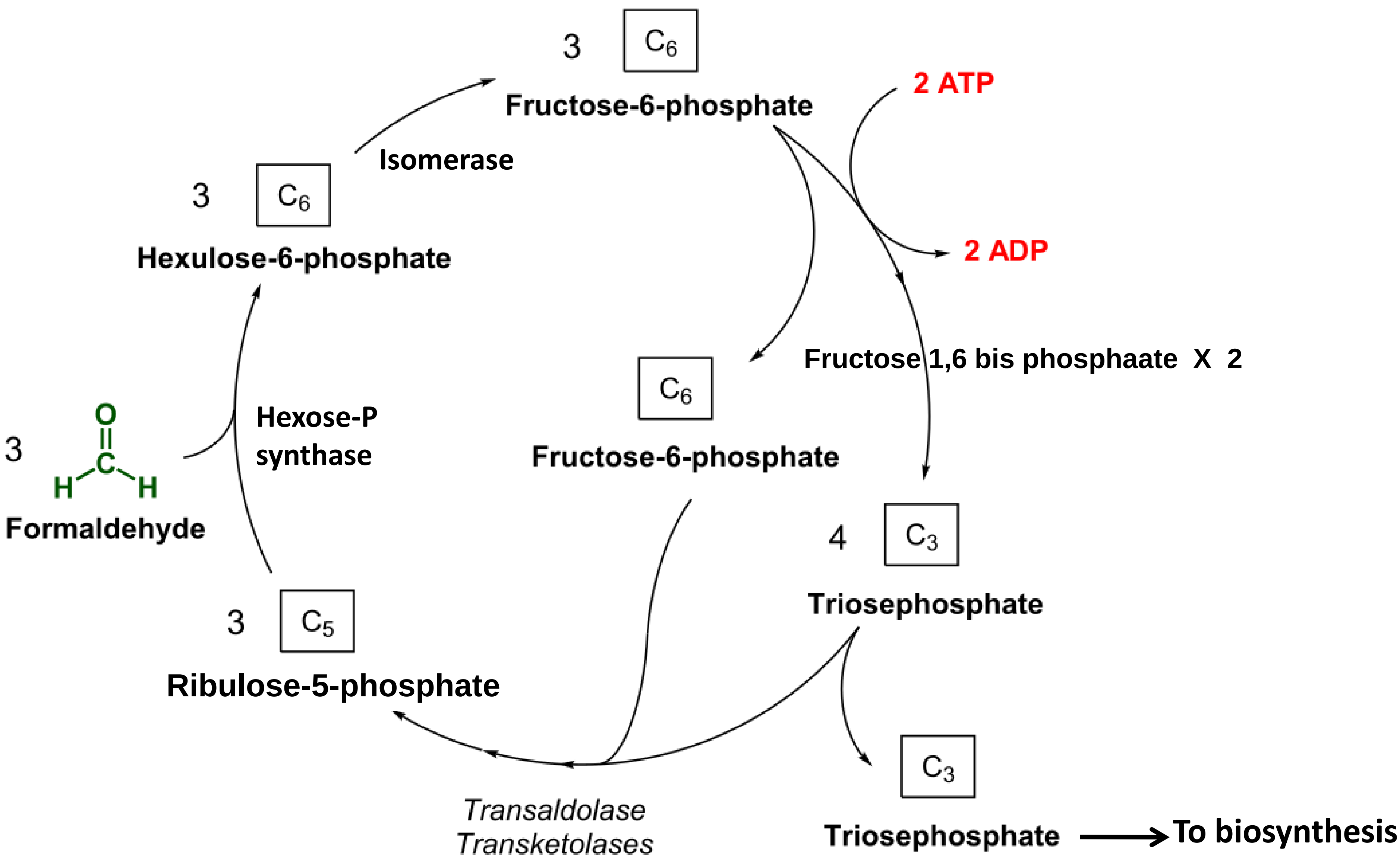
Biochemistry of Methane oxidation



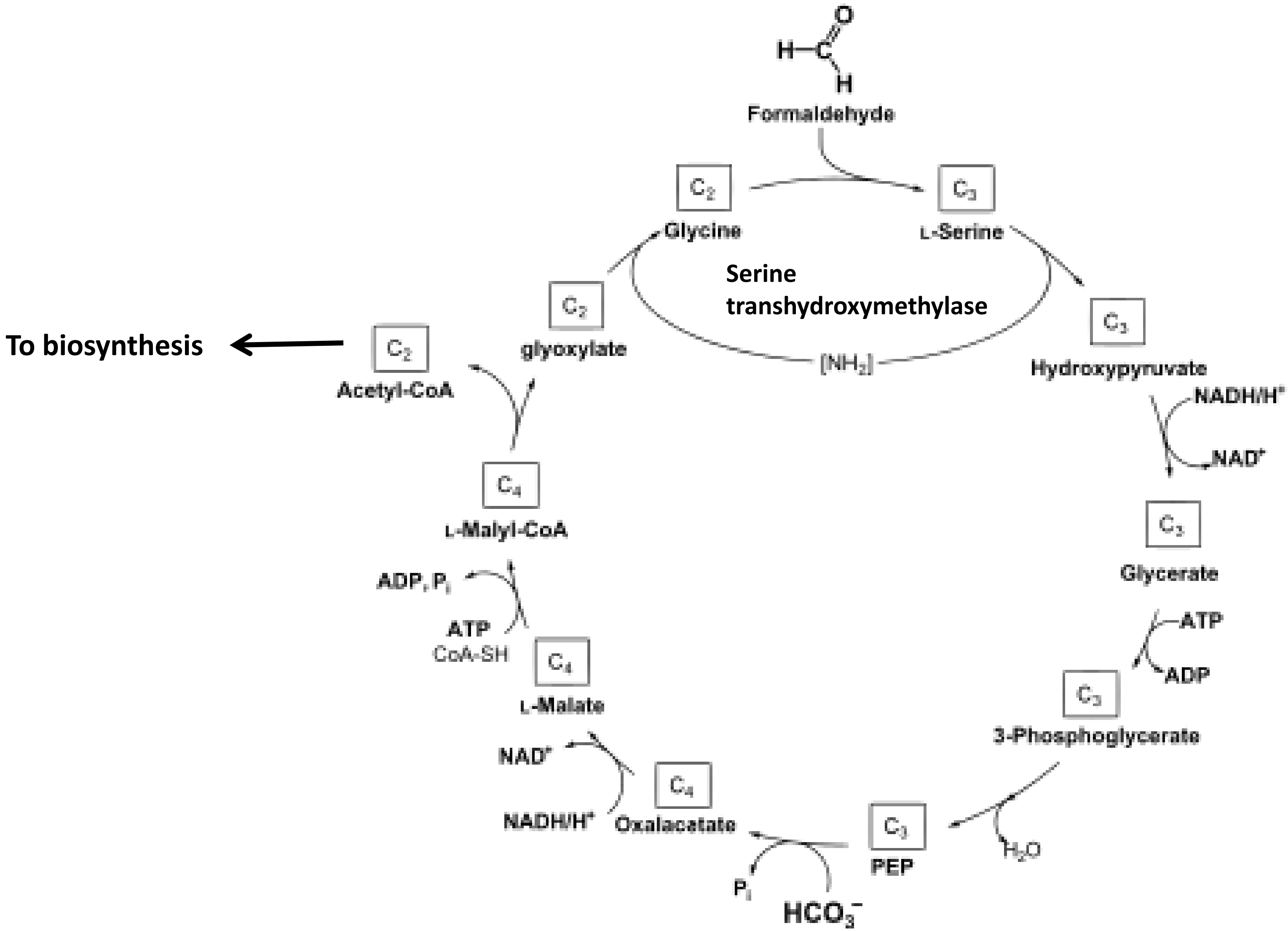
Where, MMO: Methane monooxygenase; MDH: Methanol dehydrogenase; FADH: Formaldehyde dehydrogenase; FDH: Formate dehydrogenase; RuMP: Ribulose monophosphate; NADH: Nicotinamide adenine dinucleotide; CytC: Cytochrome c

***Depending upon bacteria either CytC or NADH act as electron donor in reaction of MMO**

Ribulose monophosphate pathway



Serine pathway



Questions

- What are methanotrophs? What are the relation between methanotrophs and methyotrophs. Explain the biochemistry of methane oxidation.
- How methane oxidation used by bacteria for energy generation and biomass production.
- Discuss assimilatory pathways of methanotrophs.
- Write short note on methanotrophs.
- Differentiate between type I and type II methanothophs.