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Growth of <i>Methylobacterium extorquens</i> on multicarbon compounds
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My review in Science Progress [Now published]: Science Progress (2011), 94(2), 109–137 doi: 10.3184/003685011X13044430633960 How half a century of research was required to understand bacterial growth on C1 and C2 compounds; the story of the serine cycle and the ethylmalonyl-CoA pathway
<i>Methylobacterium extorquens</i> AM1 [previously known as <i>Pseudomonas</i> AM1] is a pink facultative methylotroph. This page summarises what we found about its pathways for growth on multicarbon compounds. This was the work of my group including Pat Dunstan [now Pat Goodwin], Ian Taylor and John Bolbot [see references below]. This was published between 1972 and 1980 but it has become relevant in the light of the solution of the final part of the Serine cycle - the EthylmalonylCoA pathway, which is also invoved in growth on ethanol and other substrates metabolised by way of acetylCoA. For a description of this pathway click here.
Pat Dunstan showed that there are some common steps in the pathways for growth on methanol [the Serine Cycle] and the unknown pathway for assimilataion of ethanol, acetate and 3-hydroxybutyrate. These steps involve the oxidation of acetate to glyoxylate. This is summarised on another page [click here]. The section below summarises our later work on growth of <i>M.extorquens</i> on multicarbon compounds.

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The role of the Krebs' TCA cycle in *M. extorquens* [Taylor & Anthony 1976]

A complete TCA cycle is not required during methylotrophic growth although some of the reactions are involved in assimilation of methanol. The key observation is that mutation of the 2-oxoglutarate dehydrogenase complex [making it inactive] was sufficient to convert the facultative methylotroph *M. extorquens* into an obligate methylotroph. This is consistent with previous suggestions that the biochemical basis for obligate methylotrophy is the lack of a complete TCA cycle.

Acetyl-CoA Production and Utilization during Growth of the Facultative Methylotroph Pseudomonas AM1 on Ethanol, Malonate and 3-Hydroxybutyrate [Taylor & Anthony 1976]

The key conclusions of this paper are summarised below.

Oxidation of ethanol to acetaldehyde is catalysed by the quinoprotein methanol dehydrogenase [MDH]; mutants lacking MDH are unable to oxidise ethanol; mutants lacking cytochrome c are able to oxidise multicarbon compounds but not ethanol or methanol [the specific electron acceptor for MDH is cytochrome cL]; inhibitors of methanol oxidation in whole cells also inhibit ethanol oxidation.

The oxidation of acetaldehyde to acetate. There is no NAD linked aldehyde dehydrogenase in these bacteria and it is assumed that the non-specific NAD-independent aldehyde dehydrogenase is responsible. Its low activity presumably accounts for the accumulation of acetaldehyde during the slow growth of *M. extorquens* on ethanol.

The conversion of acetate to acetylCoA is catalysed by acetyl-CoA synthetase. The purified enzyme requires ATP and coenzyme A, the products being acetyl-CoA and AMP. Confirmation of the role of this enzyme was achieved by isolation of mutant ICT54. This mutant was isolated as being able to grow on malate but unable to grow on a combination of acetate and glyoxylate. It grew well on C1-compounds and all other multicarbon compounds, but was unable to grow on ethanol or malonate,

confirming that there is no route for oxidation of acetate to glyoxylate without the intermediacy of acetyl-CoA.

Glycollate is not an intermediate in the oxidation of acetate to glyoxylate.

3-hydroxybutyrate was used as growth substrate in this study because it is a better substrate than ethanol, and is metabolised by way of acetyl-CoA. It had been suggested that glycollate is an intermediate in oxidation of acetate during growth on C1 and C2 compounds, its oxidation to glyoxylate being catalysed by hydroxypyruvate reductase. However mutant 20BL, lacking this enzyme while unable to grow on C1 compounds was able to grow on ethanol or 3-hydroxybutyrate. When incubated with ¹⁴C-acetate the *glycollate/*malate ratio was much lower in the mutant. This suggests that the radioactive glycollate seen to accumulate in experiments with wild-type *M. extorquens* is due to reduction of glyoxylate catalysed by hydroxypyruvate reductase.

The Metabolism of Pyruvate by the Facultative Methylophilic *Pseudomonas* AM1. Bolbot & Anthony, 1980

This paper showed that loss of pyruvate dehydrogenase by mutation led to growth properties similar to those of restricted facultative methylophilic bacteria such as *Hyphomicrobium* which grow only on C1 and C2 compounds.

The enzymes that are usually involved in growth of other bacteria on pyruvate are absent: these are pyruvate carboxylase, phosphoenolpyruvate synthetase and pyruvate:orthophosphate kinase. Pyruvate and lactate are metabolised after oxidative decarboxylation to acetylCoA which is then assimilated by the same route as operates in growth on C2 compounds and 3-hydroxybutyrate [part of this route is now known to be the EthylmalonylCoA pathway].

Evidence for this is that mutant JAB40 was able to grow on C4 compounds but not on C1, C2 or C3-compounds [pyruvate and lactate] unless supplemented with glyoxylate, consistent with pathway proposed below.

The Metabolism of 1,2-Propanediol by the Facultative Methylotroph *Pseudomonas* AM1. Bolbot & Anthony 1980

Properties of mutants indicated that this substrate is also assimilated by the pathway involving oxidation of acetylCoA to glyoxylate. The enzymes for assimilation of propanediol that are present in other bacteria are absent in this methylotroph.

Metabolism of ethanol, 3-hydroxybutyrate and lactate in *Methylobacterium extorquens* AM1

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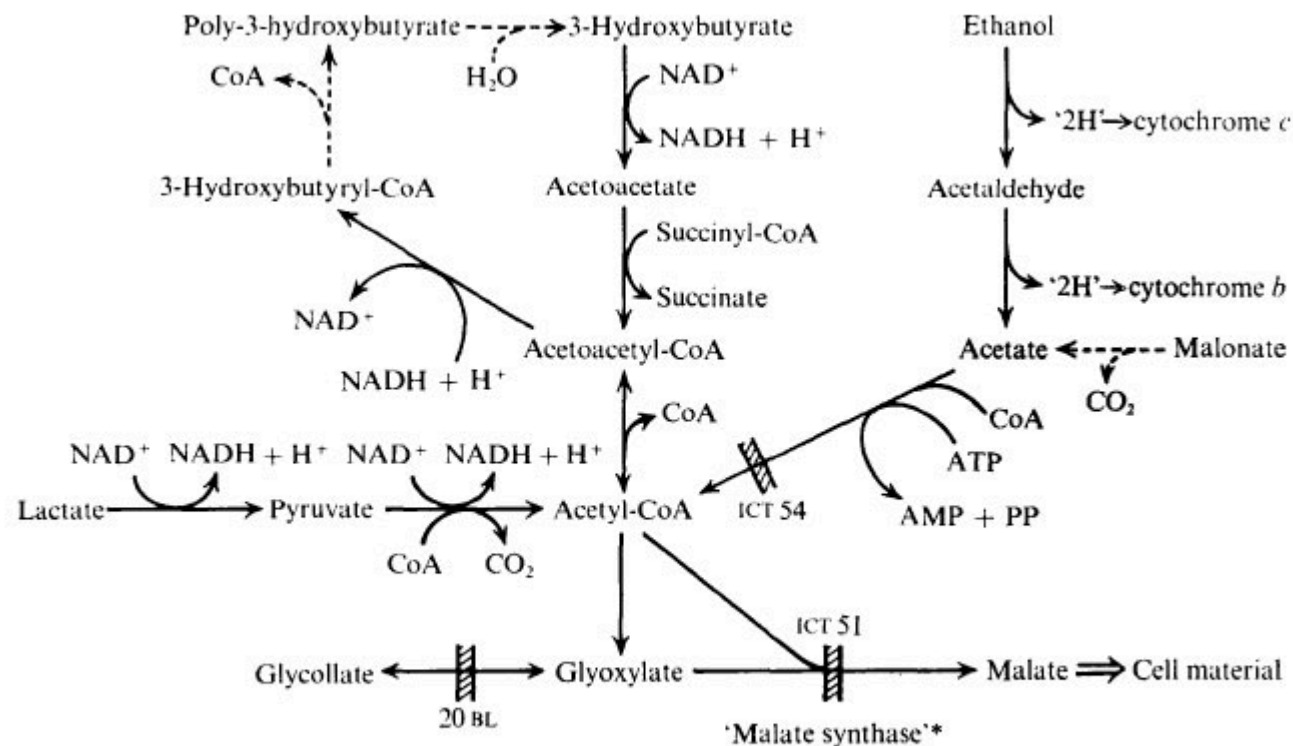


Fig. 1. Pathways for assimilation of ethanol, malonate, 3-hydroxybutyrate, pyruvate and lactate in *Pseudomonas* AM1. Hatched bars indicate metabolic lesions in mutants. Reactions shown as dotted lines have not been investigated. * The 'malate synthase' activity is catalysed by malyl-CoA lyase and malyl-CoA hydrolase (Cox & Quayle, 1976).

References. Note: pdf files of these papers can be accessed from the [Society for General Microbiology](https://www.sgm.ac.uk/) website.

Dunstan, P.M., Anthony, C. and Drabble, W.T. (1972). The involvement of glycollate in the metabolism of ethanol and of acetate by *Pseudomonas* AM1. *Biochemical Journal* **128**, 99-106.

Dunstan, P.M., Anthony, C. and Drabble, W.T. (1972). The role of glyoxylate, glycollate and acetate in the growth of *Pseudomonas* AM1 on ethanol and C-1 compounds. *Journal of General Microbiology* **128**, 107-115.

Dunstan, P.M. and Anthony, C. (1973). The role of acetate during growth of *Pseudomonas* AM1 C1 compounds, ethanol and 3-hydroxybutyrate. *Biochemical Journal* **132**, 797-801.

Taylor, I.J. and Anthony, C. (1976). A biochemical basis for obligate methylotrophy: properties of a mutant of *Pseudomonas* AM1 lacking 2-oxoglutarate dehydrogenase. *Journal of General Microbiology* **93**, 259-265.

Taylor, I.J. and Anthony, C. (1976). Acetyl-CoA production and utilization during growth of the facultative methylotroph, *Pseudomonas* AM1, on ethanol, malonate and 3-hydroxybutyrate. *Journal of General Microbiology* **95**, 134-143.

Cox, R. B. & QUAYLE, J. R. (1976). Synthesis and hydrolysis of malyl-coenzyme A by *Pseudomonas* AM1: an apparent malate synthase activity. *Journal of General Microbiology* **95**, 121-133.

Bolbot, J.A. and Anthony, C. (1980). The metabolism of pyruvate by the facultative methylotroph, *Pseudomonas* AM1. *Journal of General Microbiology* **120**, 233-244.

Bolbot, J.A. and Anthony, C. (1980). The metabolism of 1,2-propanediol by the facultative methylotroph, *Pseudomonas* AM1. *Journal of General Microbiology* **120**, 245-254.

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