Syntrophic Associations in Methanogenic Degradation

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1 Introduction

For many decades, microbiology has tried to understand the activities of microorganisms in nature on the basis of pure culture studies which allow reliable identification of the actors in play and reproducible assessments of their activities under defined conditions. This approach has undoubtedly been successful, but it has overlooked that microbes in nature interact with each other and may depend on these interactions to a various extent. The mutual relationship of partner organisms to each other may vary from only marginal interaction to absolute mutual dependence on each other. Some microorganisms excrete metabolites, e.g., precursors of vitamins or certain amino acids, which are used by a partner organism that lacks specific synthesis pathways and profits from this support, even if it could synthesize the respective compound on its own and this way only saves biosynthetic energy. Types of more intense cooperation and mutual interdependence are found preferentially among anaerobic bacteria, although we have to admit that our view is probably constrained by the cultures we know: Since especially aerobic bacteria are usually isolated with simple media that select for easy-to-cultivate organisms degrading a simple cocktail of substrates on their own, we may overlook other bacteria that are outcompeted under such conditions, and may display more-refined types of interaction with others. Since we know of only a small fraction of all the microorganisms present in the environment, we cannot exclude that other bacteria in the natural environment might depend to a large extent upon cooperations with partners, and perhaps this is just one of the reasons why we so far have failed to cultivate them.

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Types of Cooperation Among Anaerobic Microorganisms

Whereas aerobic bacteria are usually considered to be able to degrade complex organic matter completely to CO_2 and H_2O, this is true in the anaerobic world only in some exceptional cases. Complex biomass is typically degraded in several steps, including classical (primary) fermentations, with subsequent further oxidation by sulfate reduction or iron reduction, or by coupling primary fermentations with secondary fermentations to methanogenesis at the very end (Bryant 1979; McInerney 1988; Stams 1994; Schink 1997). This kind of job-sharing among anaerobic microorganisms makes the whole process more complicated at first sight, but ascribes to every single organism only a limited task it has to fulfill and, with this, far less effort is needed for regulation of its metabolism.

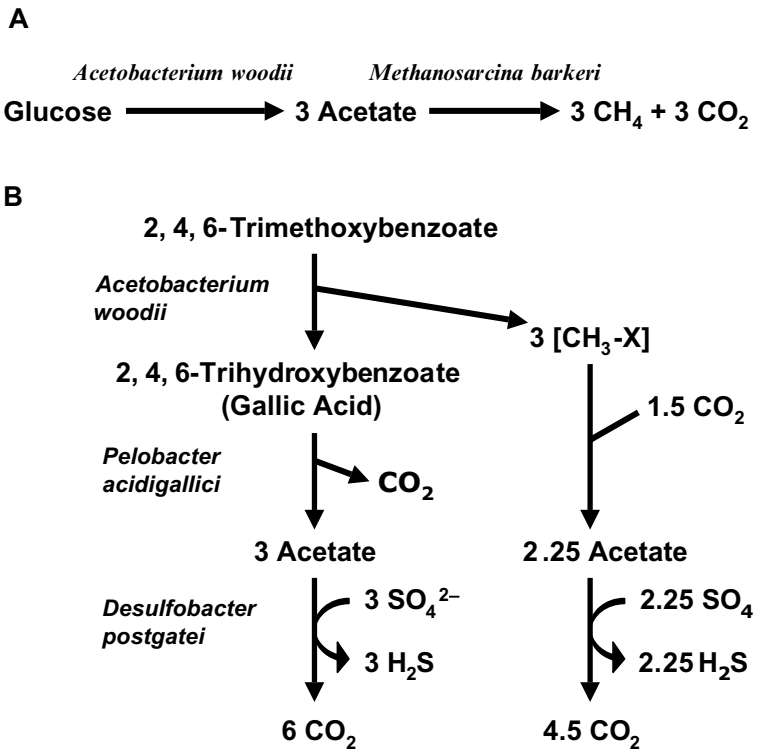

Fig. 1. Metabiotic cooperations in defined cocultures degrading glucose (**A**) and trimethoxybenzoate to methane and CO_2 (**B**)