Metabolic adaptation of sulfate reducing bacteria to a syntrophic partnership with anaerobic methanotrophic archaea

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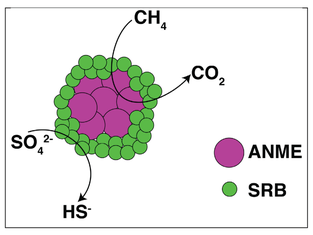
A syntrophic partnership mediating anaerobic oxidation of methane (AOM)

Multicellular aggregates of anaerobic methanotrophic archaea (ANME) and sulfate reducing bacteria[1,2] perform the geochemically important process of anaerobic oxidation of methane (AOM).

Phylogenetic placement of ANME clades within Halobacterota



Phylogenetic placement of syntrophic SRB clades within Desulfobacterota

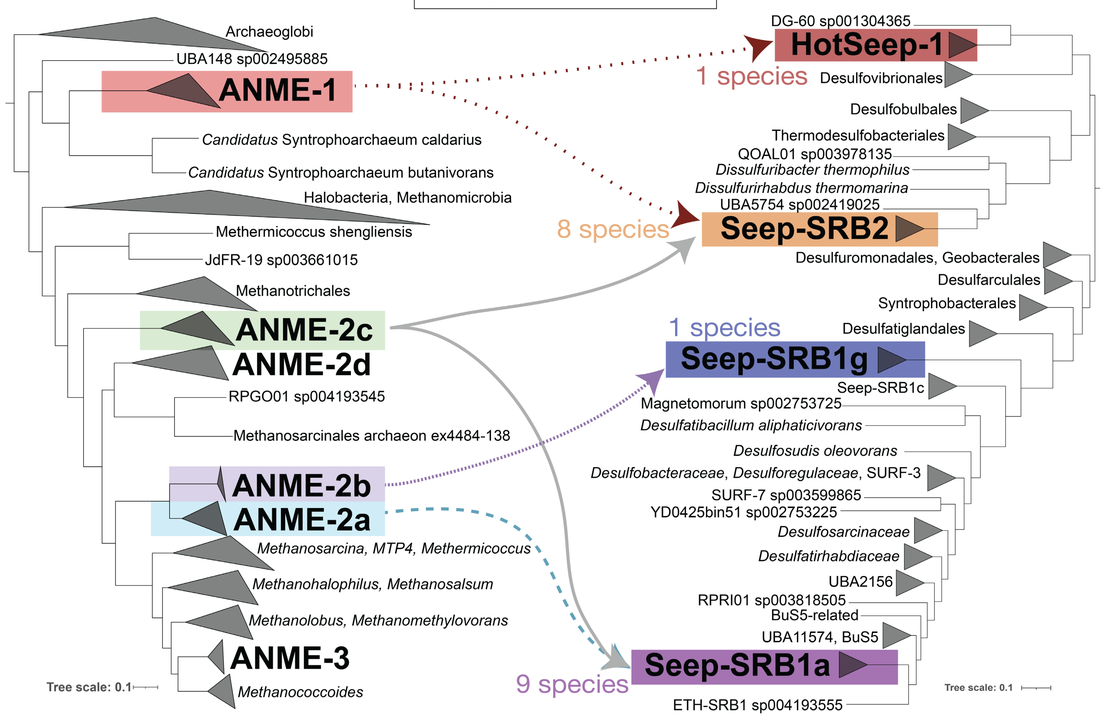


Figure 1. Phylogenetic diversity in ANME and SRB with associated partnership diversity

What is the physiological basis for the syntrophic partnership that drives anaerobic oxidation of methane?

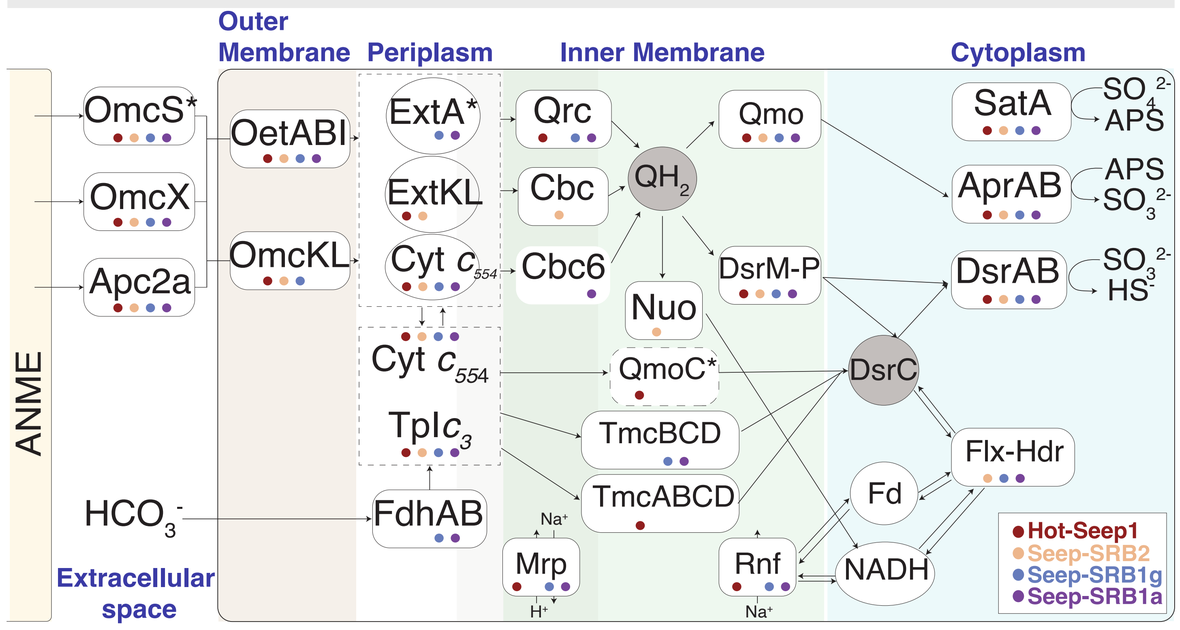


Figure 2. Clade-specific similarities and differences in respiration[3-7].

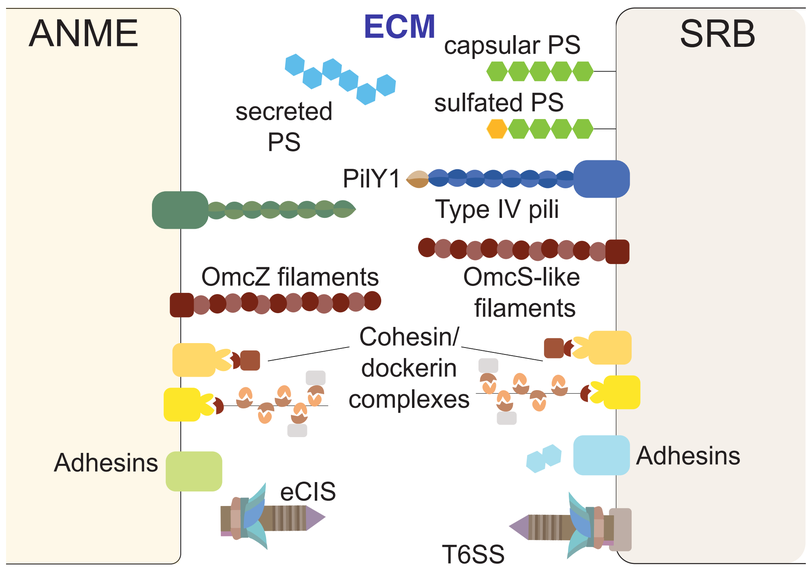
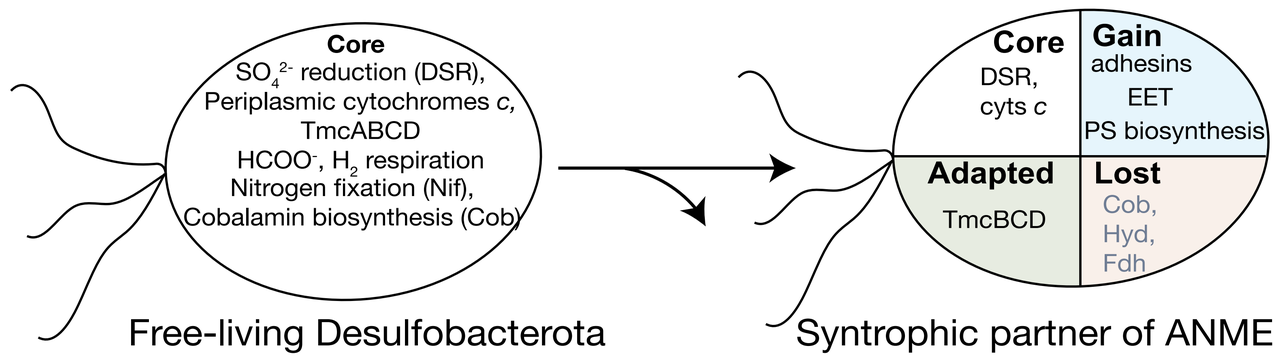


Figure 3. Pathways involved in the formation of ANME/SRB consortia.
- conductive biofilm
- matrix proteins
- cellular adhesion
- partner identification

Methods 1. Sequencing of translationally active single ANME/SRB consortia, first sorted using BONCAT-FACS[2].
2. Comparing the genomes of syntrophic SRB and other bacteria in the phylum Desulfobacterota to identify genes and pathways unique to the syntrophic partners.
3. Comparing the genomes of different species within a syntrophic SRB clade to identify partnership specific characteristics.
3. Phylogenetics to differentiate vertically, horizontally acquired genes.

What drove the evolution of the bacterial partner to this syntrophic lifestyle?



Can we identify physiological characteristics that differentiate bacterial species that partner different ANME?

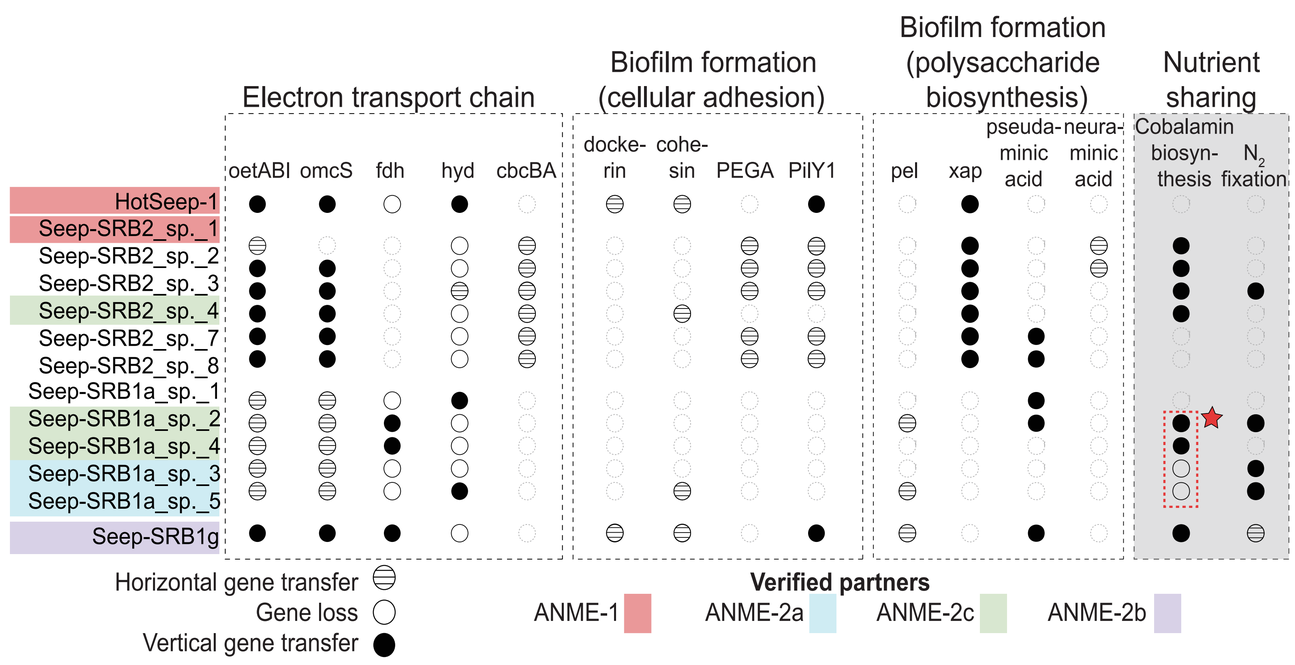


Figure 4. Genes gained, lost and highly diversified in the adaptation of SRB to a syntrophic lifestyle.

Conclusions 1. The most taxonomically diverse syntrophic SRB clades partner multiple ANME clades.
2. Free-living Desulfobacterota and syntrophic partners of ANME differ in pathways involved in **extracellular electron transfer, nutrient sharing, cellular adhesion and biofilm formation.**
3. Each partner SRB clade has unique adaptations to its syntrophic lifestyle.
4. This adaptation involves **multiple horizontal gene transfers, gene losses** and biochemical diversification of proteins.
4. A potential **cobalamin dependence differentiates ANME-2a and ANME-2c partners**.

References 1. Orphan *et al.* Science 2001
2. Hinrichs *et al.* Nature 1999
3. McGlynn/Chadwick *et al.* 2015 4. Skennerton *et al.* mBio 2017
5. Krukenberg *et al.* AEM 2018 6. Yu *et al.* ISME 2021
7. Chadwick *et al.* PLOS Bio 2022

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