Chapter 1

Introductory Chapter: A Brief Overview of Archaeal Applications

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Additional information is available at the end of the chapter

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1. Prologue

The first member of the Archaea was described in 1880 [1–3]. Yet, the recognition and formal description of the domain Archaea, as separated from Bacteria and Eukarya, occurred in 1977 during early phylogenetic analyses based upon ribosomal DNA sequences [4–6]. Indeed, members of the archaeal domain are characterized by several distinguishing traits [3] as confirmed later based on the first complete archaeal genome sequence obtained by Bult et al. [7] and the subsequent finished and ongoing archaeal sequencing projects (https://gold.jgi.doe.gov/organisms?Organism. Domain=ARCHAEAL, ftp://ftp.ncbi.nlm.nih.gov/genomes/refseq/archaea/) [8, 9].

The archaeal domain is composed of the DPANN superphylum [10]—Aenigmarchaeota, Diapherotrites, Nanoarchaeota, Nanohaloarchaeota, Pacearchaeota, Parvarchaeota and Woesearchaeota [11]—excluded from the common branch of the TACK (or TACKL [12]) superphylum [13]—Aigarchaeota [14], Bathymarchaeota [15], Crenarchaeota [16], Korarchaeota [17], Lokiarchaeota [18] and Thaumarchaeota [19]—with the Euryarchaeota phylum [16]—extreme halophilic Archaea, hyperthermophiles such as Thermococcus and Pyrococcus, most acidophilic-thermophilic prokaryotes, the thermophilic-acidophilic cell wall-less Thermoplasma, methanogens [20] and the Altiarchaeales clade [21].

The Archaea are ubiquitous in most terrestrial, aquatic and extreme environments (acidophilic, halophilic, mesophilic, methanogenic, psychrophilic and thermophilic) [20, 22]. Although very diversified with a great number of species, luckily, no member of the domain Archaea has been described as a pathogen for humans, animals or plants [23–25]. Thus, Archaea are a potentially valuable resource in the development of new biocatalysts, novel pharmaceuticals and various biotechnological applications. Applications of Archaea (for review, see [26–32] and references therein) may be subdivided into four main fields (Figure 1): (i) commercial enzymes and/or molecules, (ii) environment, (iii) food and (iv) health.
Figure 1. Examples of potential applications of Archaea in biotechnology depicted in a 16S rDNA phylogenetic tree visualized via the iTOL (Interactive Tree Of Life) tool [33]. Potential applications of Archaea were subdivided into four fields (commercial enzymes and/or molecules (stars), environment (circles), food (triangles) and health (squares)) based on the reference(s) listed following each species. Thirty eight (n=38) archaeal species were integrated into the above phylogenetic tree (one DPANN species (white color), 21 Euryarchaeota species (dark grey color), 16 TACK species (light grey color)): Acidianus hospitalis W1 (NC_015518) [34, 35], Acidilobus saccharovorans 345-15 (NC_014374) [36, 37], Aeropyrum pernix K1 (NC_000854) [39], Archaeoglobus fulgidus DSM 4304 (NC_000917) [40, 41], Caldibacillus maquiltingensis IC-167 (NC_009954) [42], Desulfurococcus fermentans DSM 16532 (NC_018001) [43], Desulfurococcus mobilis DSM 2161 (NC_014961) [44], Ferroglobus placidus DSM 10642 (NC_013849) [45], Ferrobacillus fontis Kam940 (NC_017461) [46], Halobacterium salinarum R1 (NC_010364) [47], Halobacterium sp. NRC-1 (NC_002607) [48], Halofex mediterranei ATCC 33500 (NC_017941) [49], Halogeometricum borinquense DSM 11551 (NC_014729) [50], Halorhabdus utahensis JCM 11049 (NC_013158) [51], Halostagnicola larsenii XH-48 (NZ_CP007055) [52], Haloterrigena turkmenica DSM 5511 (NC_013743) [53], Metallosphaera cuprina Ar-4 (NC_015435) [54], Metallosphaera sedula DSM 5348 (NC_009440) [55], Methanocaldococcus jannaschii DSM 2661 (NC_000909) [27, 56], Methanoterris igneus DSM 5666 (NC_015562) [57], Natrionala magadii ATCC 43099 (NC_013922) [58], Nanoarchaeum equitans K14-M (NC_005213) [59, 60], Pyrodictium occultum IM2 (NC_041958) [61, 62], Pyrodictium occultum JCM 11548 (NC_009073) [63], Pyrobaculum sp. 1860 (NC_016645) [64, 65], Pyrococcus horikoshii OT3 (NC_000961) [66], Pyrococcus sp. ST04 (NC_017946) [67], Pyrococcobacter sp. Chloroflexus CH1 (NC_015680) [68], Sulfolobus acidocaldarius DSM 639 (NC_007181) [69], Sulfolobus solfataricus P2 (NZ_LT549890) [70], Thermococcus gammatolerans EJ3 (NC_012804) [71], Thermococcus litoralis DSM 5473 (NC_022084) [72], Thermococcus onnurineus NA1 (NC_011529) [73], Thermococcus sp. CL1 (NC_018015) [74], Thermoplasmata acidophilum DSM 1728 (NC_002578) [75, 76], Thermoplasma volcanium GSS1 (NC_002689) [77], Vulcanaeta moutnovskia 768-28 (NC_015151) [78].
The book ‘Archaea - New Biocatalysts, Novel Pharmaceuticals and Various Biotechnological Applications’ contains five chapters.

The first chapter is an Introductory Chapter, where editors give a general overview of the content of the book.

The second chapter by Castro-Fernandez et al., entitled ‘Evolution, metabolism and molecular mechanisms underlying extreme adaptation of Euryarchaeota and its biotechnological potential’, provides an interesting depiction of the phylum Euryarchaeota in terms of evolutive history, metabolic strategies, lipid composition, proteic structural adaptations and its biotechnological applications.

The third chapter ‘Archaebiotics: archaea as pharmabiotics for treating chronic disease in humans?’ was written by Ben Hania and co-authors. It promotes the idea that some specific archaea are potential next-generation probiotics.

The fourth chapter ‘Biocompounds from haloarchaea and their uses in biotechnology’ by Torregrosa-Crespo et al., emphasizes the main characteristics of biocompounds from haloarchaea and their potential uses in biomedicine, pharmacy and industry.

The book concludes with a (fifth) chapter by Mizuno et al., entitled ‘Plasmid curing is a promising approach to improve thermophiles for biotechnological applications: perspectives in archaea’, providing a new tip based on the plasmid-curing approach for improving the potential of thermophiles in various biotechnological applications.

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