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], *Bathyarchaeota* [15], *Crenarchaeota* [16], *Korarchaeota* [17], *Lokiarchaeota* [18] and *Thaumarchaeot*a [19]—with the **Euryarchaeota phylum** [16]—extreme halophilic Archaea, hyperthermephiles 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**.

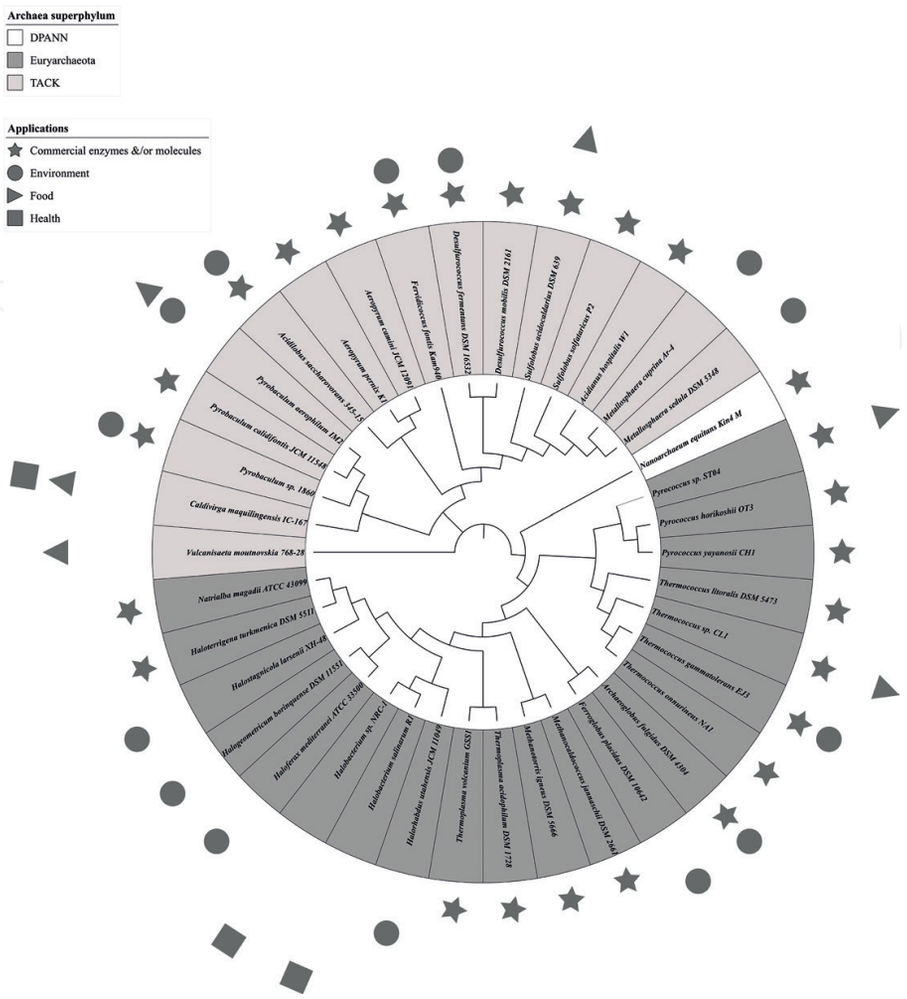

Figure 1. Examples of potential applications of Archaea in biotechnology depicted in a 16S rDNA phylogenetic tree visualized *via* the iTOL (Interactive Tree Of Life) tool [33]. Potential applications of Archaea were subdivided into four fields (commercial enzymes and/or molecules (stars), environment (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 camini* JCM 12091 (NC_121692) [38], *Aeropyrum pernix* K1 (NC_000854) [39], *Archaeoglobus fulgidus* DSM 4304 (NC_000917) [40, 41], *Caldivirga maquilingensis* 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], *Fervidicoccus fontis* Kam940 (NC_017461) [46], *Halobacterium salinarum* R1 (NC_010364) [47], *Halobacterium* sp. NRC-1 (NC_002607) [48], *Haloferax 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], *Methanotorris igneus* DSM 5666 (NC_015562) [57], *Natrialba magadii* ATCC 43099 (NC_013922) [58], *Nanoarchaeum equitans* Kin4-M (NC_005213) [59, 60], *Pyrobaculum aerophilum* IM2 (NC_041958) [61, 62], *Pyrobaculum calidifontis* JCM 11548 (NC_009073) [63], *Pyrobaculum* sp. 1860 (NC_016645) [64, 65], *Pyrococcus horikoshii* OT3 (NC_000961) [66], *Pyrococcus* sp. ST04 (NC_017946) [67], *Pyrococcus yayanosii* 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], *Thermoplasma acidophilum* DSM 1728 (NC_002578) [75, 76], *Thermoplasma volcanium* GSS1 (NC_002689) [77], *Vulcanisaeta 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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