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Chapter 1

Introductory Chapter: A Brief Overview of Archaeal Applications

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http://dx.doi.org/10.5772/intechopen.70289

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**.

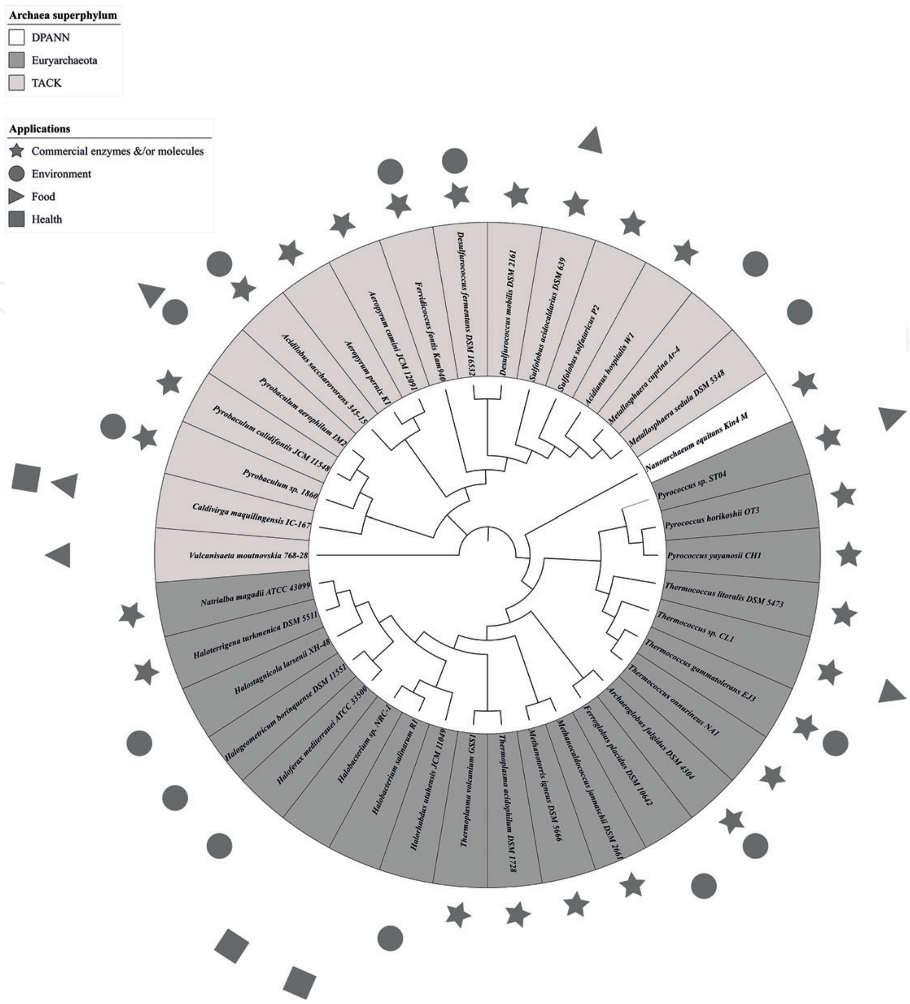

Figure 1. Examples of potential applications of Archaea in biotechnology depicted in a 16S rDNA phylogenetic tree visualized *via* the iTOL (Interactive Tree Of Life) tool [33]. Potential applications of Archaea were subdivided into four fields (commercial enzymes and/or molecules (stars), environment (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].

http://dx.doi.org/10.5772/intechopen.70289

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.

Finally, we would like to thank all authors for their contributions. We are also grateful to InTech Publishing Process Managers, particularly Ms. Mirena Čalmić, Ms. Romina Rovan and Ms. Ana Pantar, who assisted us with patience until the publication of this book.

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