ARCHAEA

Archaea shape up

Archaea come in various shapes, from cocci to filaments. However, unlike the cell shape determinants in bacteria, the factors that are important in cell shape determination in archaea are not well understood. In a recent article in *Molecular Microbiology*, Ettema and colleagues describe an actin orthologue and several related proteins in *Pyrobaculum calidifontis* (a member of the order Thermoproteales, phylum Crenarchaeota) that could have important roles in determining cell shape as well as in cell division.

All cells require a cytoskeleton to maintain their shape; in eukaryotes, this is the actin-based cytoskeleton, and in bacteria the distant actin homologue MreB is an important determinant of rod cell shape. Several archaea encode an MreB orthologue, but this protein is absent in rod-shaped archaea of the Thermoproteales. Ettema and colleagues therefore focused on an actin orthologue from *P. calidifontis*, which they named crenactin. Crenactin is present in rod-shaped archaea of the order Thermoproteales and in '*Candidatus* Korarchaeum cryptofilum', but not in rod-shaped archaea of the phylum Euryarchaeota, which contain an MreB orthologue. Similar to MreB, crenactin is an ATPase that can also use GTP. A bioinformatic analysis revealed that organisms that encode crenactin also share four hypothetical genes that are usually present in the vicinity of the crenactin gene, with the exception of '*Ca.* Korarchaeum cryptofilum', which contains only one of the four hypothetical genes. The authors named the cluster arcade (actin-related cytoskeleton in Archaea involved in shape determination). Only arcadin 4 displayed similarity to a known protein — namely, structural maintenance of chromosomes (Smc), a protein that is involved in chromosome stability in bacteria and has several orthologues in eukaryotes.

Similar to MreB, crenactin, arcadin 1, arcadin 3 and arcadin 4 were detected by immunofluorescence microscopy as forming a helical bundle that traversed the length of the cell, supporting a potential role in cell shape determination; the localization of crenactin was unaffected by inhibitors of MreB and actin. By contrast, arcadin 2 was sometimes detected between segregated nucleoids, indicating a potential role in cell division. Interestingly, members of the Thermoproteales do not encode any known cytokinesis proteins. Therefore, arcadin 2 may be part of the division machinery in these organisms, possibly in conjunction with the other arcadin proteins. Although not straightforward, deletion of the arcade genes will provide further insight into the function of these proteins.

As well as the cell biology implications, the discovery of these proteins and their potential role in cell shape formation and cell division can provide insight into the relationship of archaea and eukaryotes. As recent studies have provided evidence for eukaryotes sharing a common ancestry with crenarchaeota (the so-called eocyte theory), the authors speculate that the actin orthologues present in this archaeal precursor of eukaryotes may have endowed primitive endocytic properties on the early eukaryotes that were crucial for their further evolution.

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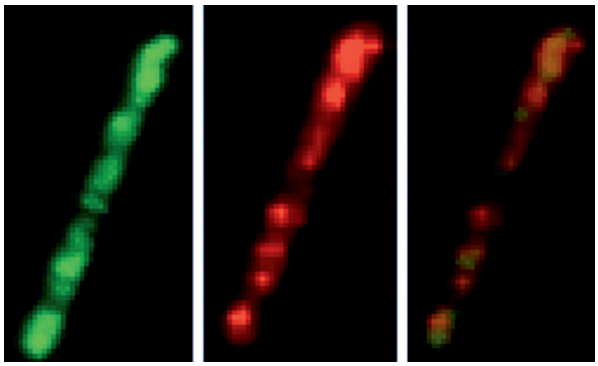

In situ immunofluorescence microscopy images of *Pyrobaculum calidifontis* cells stained with crenactin-specific antibodies (green, left panel) and arcadin 1 antibodies (red, middle panel). The right panel shows an overlay of both stainings. Both crenactin and arcadin 1 form cell-spanning, helical filaments that probably support cell shape in *P. calidifontis*. Image courtesy of T. Ettema and A.-C. Lindås, Uppsala University, Sweden.

ORIGINAL RESEARCH PAPER Ettema, T. J. G., Lindås, A.-C. & Bernander, R. An actin-based cytoskeleton in Archaea. *Mol. Microbiol.* 18 Mar 2011 (doi:10.1111/j.1365-2958.2011.07635.x)