Prokaryote or eukaryote? A unique microorganism from the deep sea in Japan

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There are only two kinds of organisms on Earth: prokaryotes and eukaryotes. Although eukaryotes are considered to have evolved from prokaryotes, there were no previously known intermediate forms between them until recently. The differences in their cellular structures are so vast that the problem of how eukaryotes could have evolved from prokaryotes is one of the greatest enigmas in biology. In 2012, we discovered a unique organism with cellular structures appearing to have intermediate features between prokaryotes and eukaryotes in the deep-sea off the coast of Japan by using electron microscopy and structome analysis [1]. The organism was 10 micrometers long and 3 micrometers in diameter, having more than 50 times volume of *Escherichia coli*. It had a large 'nucleoid', consisting of naked DNA fibers, with a single layered 'nucleoid membrane', and 'endosymbionts' that resemble bacteria, but no mitochondria (Fig. 1-3, Table 1). We named this unique microorganism the 'Myojin parakaryote' with the scientific name of *Parakaryon myojinensis* ("next to (eu)karyote from Myojin") after the location of discovery and its intermediate morphology [2]. The existence of this organism is an indication of a potential evolutionary path between prokaryotes and eukaryotes, and strongly supports the endosymbiotic theory for the origin of mitochondria and the karyogenetic hypothesis for the origin of the nucleus.

[1] Yamaguchi M: Structome of *Exophiala* yeast cells determined by freeze-substitution and serial ultrathin sectioning electron microscopy, Current Trends in Microbiology 2: 1-12, 2006.

[2] Yamaguchi M, *et al.*: Prokaryote or eukaryote? A unique microorganism from the deep sea. *J. Electron Microsc.* **61**: 423-431, 2012.

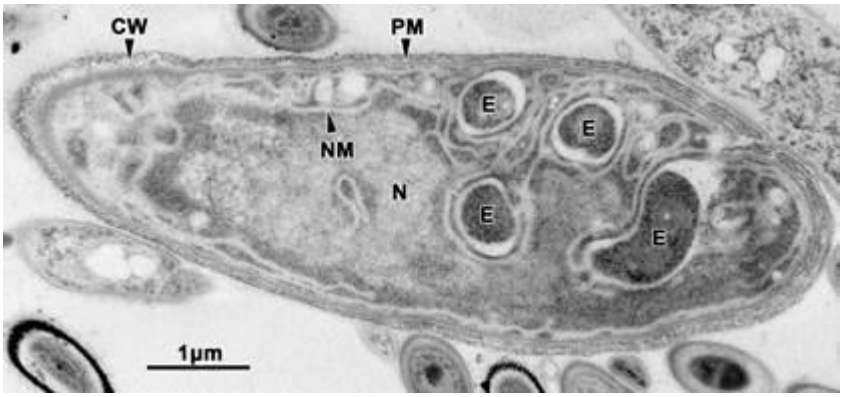

Fig. 1. An ultrathin section of *Parakaryon myojinensis*. Note the large irregular 'nucleoid' (N) with single layer 'nucleoid' membrane (NM), the presence of endosymbionts (E), and the absence of mitochondria. CW, cell wall; PM, plasma membrane.

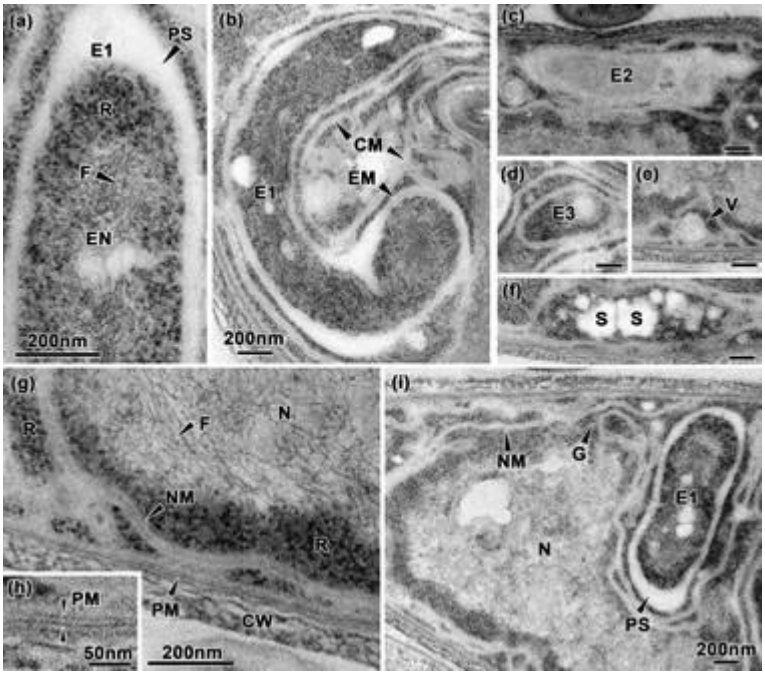

Fig. 2. *P. myojinensis* cellular components. **(a)** and **(b)** Endo-symbiont 1 (E1). **(c)** Endosymbiont 2 (E2). **(d)** Endo- symbiont 3 (E3). **(e)** A vacuole (V). **(f)** The small materials (S). **(g)** The host 'nucleoid' region (N). **(h)** Plasma membrane (PM). **(i)** The 'nucleoid' membrane (NM) with a gap (G).

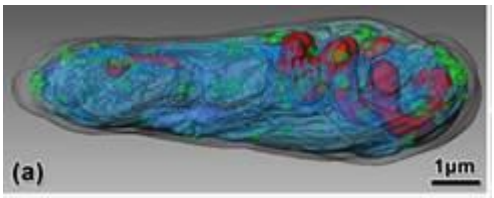

Fig. 3. The three dimensional reconstruction of *P. myojinensis*. Red: endosymbionts.

Table 1. Features of *P. myojinensis*.

1	Cell size	Much larger than ordinary prokaryotes; more than 50 times larger than *E. coli*; three times larger than *S. cerevisiae*
2	'Nucleoid'	Consists of prokaryote type DNA fibers and no chromosome structure; very large and consists of more than 40 % of the cell volume
3	'Nucleoid' membrane	Single membrane surrounding the 'nucleoid'; pierced with gaps
4	Endo-symbionts	Similar ultrastructure to modern eubacteria consisting DNA fibers and ribosomes; lack cell walls but enclosed by cell membranes
5	Other organelles	Cell wall, plasma membrane, complex cytomembrane systems, many vacuoles, small granular electron-transparent materials; none of the following: mitochondria, chloroplasts, plastids, Golgi apparatus, peroxisomes, centrioles, spindle pole body, microtubules