Formation of modern stromatolite-like structures by *in vitro* culturing cyanobacteria

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Stromatolites are layered microbialites formed mainly by cyanobacteria. The morphology of cyanobacterial biomat likely controls 3-D domal structure of stromatolites. We already reported on the *in vitro* formation of the stromatolite-like domal structures by culturing the same cyanobacterial genus as those found in Recent stromatolites. In order to form internal lamination within these *in vitro* domal structures as a next step, we performed additional experiment by covering a biomat with fine-grained calcite powder every week. Through 2 month-long culturing, we could form well-laminated domal structures. The layered domes closely resemble some taxa of the Precambrian stromatolites. These domes are still different from the Recent stromatolites in lacking cm-sized pores called fenestra common in the latter. As the genus *Phormidium* is the most common in modern stromatolites, we cultured *Phormidium luridum* var. olivace (IAM M-99) *in vitro*, to form fenestra-bearing stromatolitic structures. Under non-sediment-cover conditions, conical convex structures appeared on the biomat of M-99, however these cones did not maintain their morphology no longer than a week. To make *in vitro* environment more natural, we cover the M-99 biomat with a 1 mm-thick layer of glass-beads every week, and tried to form stromatolitic structures identical to the modern examples. In this experiment, we confirmed that the M-99 cyanobacteria could migrate through the 1 mm beads-layer to the surface every time it was covered. After 1 year-long experiment, we succeeded to form 4 sets of alternating layers of beads and organic matter. The duration for making each set, i.e, 3 months, corresponds to the cycle of blooming and withering of M-99. The organic layer consists of small spheres (1 - 5 mm in diameter) made of cyanobacteria and their secretions (extracellular polymeric substances). The laminated structure became porous, because the gas released from cyanobacteria formed about 5 mm-thick, 10 mm-long bubbles in the organic layer. The size of these bubbles is similar to that of fenestra in modern stromatolites, in which many cyanobacterial spheres are exposed to the bubbles. Also in some fossil porous stromatolites, many similar hemispheric structures of the same size and shape are observed on the inner surface of the fenestra. These hemispheres in fossil stromatolites may represent calcified cyanobacterial spheres. Thus the layered structures formed *in vitro* are analogous to fossil and modern porous stromatolites not only in external morphology but also in internal textures. The laminated structure that we report have the best example of cultured stromatolitic structures ever made in laboratory.