

# THE ART NOUVEAU OF BIOLOGY: EXHIBITING SEAWEED-BACTERIAL SYMBIOSES

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Symbiosis highlights the beauty in biology. The symbiotic 'two become one' principle defines no longer a concept in biology; it basically is biology covering diverse forms of in nature widespread relationships among multiple partners and supporting fundamentally important processes. This essential significance of symbiosis is well outlined in the 'endosymbiotic theory' which claims that eukaryotic organelles like mitochondria and chloroplasts evolved by symbiogenesis. In the masterpiece of evolution algae and bacteria certainly take the leading part. As for their ancestors, marine macroalgae (seaweeds) form the modern-day canvas for heaps of bacterial symbioses ranging from beneficial, harmful or neutral, over obligate or facultative, to ecto- or endophytic interactions. Elaborating the latter, endobiotic associations between marine macroalgal hosts and bacteria have been reported over the past 40 years. Only in the siphonous (single celled, multinucleate) marine green alga *Bryopsis*, however, endogenous bacteria have been electron microscopically visualized in the cytoplasm at every stage of development, including the gametes, suggesting vertical transmission of the endosymbionts (Burr and West, 1970). This indicates a more stable and specific relationship between the algal host and its symbionts in which both partners may provide mutualistic ecological benefits. Although this remarkable algal-bacterial partnership was noticed in the early '70s, little or no research has been performed to explore the specificity and ecological significance of this alliance. To bring a new élan to this symbiosis-study, bacteria inside *Bryopsis* algae were visualized with fluorescent probes (FISH) and the endophytic bacterial diversity was analyzed by means of Denaturing Gradient Gel Electrophoresis (DGGE) and clone libraries. Sequencing results covered e.g. Rhizobiales, Rickettsiales, Rhodobacterales, and Bacteroides species with well-known symbiotic features. Moreover, when the identified endobacterial diversity was analyzed in regard to the *Bryopsis* samples' phylogeny and geographic distribution, some patterns could be observed: Rhizobiales and Rhodobacterales species seem widespread in *Bryopsis* plants, whereas Rickettsiales and Bacteroides species are restricted to *Bryopsis* algae from, respectively, temperate and tropical seas. Also the phylogenies of the bacterial partners themselves indicate a more facultative life style of the Rhizobiales and Rhodobacterales species in contrast to a more obligate nature of the Bacteroides and Rickettsiales symbionts. These and additional results on the potential function and the host-, time- and site-specificity of the bacterial partners show *Bryopsis* algae harbor host-specific endobacterial communities which (1) are distinct from the epiphytic and surrounding seawater populations, (2) differ with geographic distribution of the algal samples, (3) have the potential to fix nitrogen in situ and (4) can vary over time indicating the presence of both facultative and obligate endosymbiotic bacteria. Future investigations will include quantitative PCR and FISH experiments with species-specific probes to fine-tune the bigger *Bryopsis*-bacterial symbiosis picture.

## References

Burr F.A. and J.A. West. 1970. Light and electron microscope observations on the vegetative and reproductive structures of *Bryopsis hypnoides*. *Phycologia* 9(1):17-37.