# A comparative view on the evolution of symbioses of chemosynthetic symbioses and photosynthetic symbioses in marine environments

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Some heterotrophic organisms, like animals, have developed symbiotic relationships with autotrophic microorganisms and have expanded their habitats. The newly developed symbioses, e.g. corals and deep-sea tubeworms, have affected not only the evolutions of these host and symbiont organisms but also the productivities of the ecosystems, e.g. coral reefs and deep-sea ecosystems. Although it is interesting to study how these symbioses have evolved in the respective organisms for understanding their evolutions but also the basic environmental factors in these ecosystems, little is known about these questions and the factors affecting the evolution. In the present study, I would like to get a bird-eye view of the symbiotic relationships of both chemosymbioses and photsymbioses and to analyze the possible factors and the possible result caused by their evolution. I would like to get a perspective of the research direction of the nutritional symbioses.

In chemosymbioses, the major host animals are protists (ciliates), sponges, molluscs (bivalves and snails), annelids (polychaetes and oligochaetes) and arthropods (crustaceans). In photosymbioses, the major host animals are, protists (ciliates and foraminifers), sponges, cnidarians, molluscs (bivalve and sea slugs) and ascidians. It is prominent that annelids are important hosts of chemisymbioses but not in photosymbioses, while they are also found in shallow euphotic zone. On the other hand, cnidarians are very important in photosymbioses in coral reefs but not in chemosymbioses in the deep-sea, though many cnidarians are dwelling there.

In the symbionts of chemosymbioses, all of them belong to prokaryots, most of which are bacteria. Especially proteoracterial (many of them belong to gamma-proteobacteria) sulfur oxidizer are important. On the other hand, in the photosymbioses, the major symbionts are eukaryotic microalgae. In marine environments, although some cyanobacterial symbionts are also known as ascidian symbiont, dinoflagellates belonging to a genus, *Symbiodinium*, are very important.

In both chemosymbiosis and photosymbiosis, inorganic carbon (Ci) is fixed and organic substances are made by using chemical or light energy. The heterotorphic host animals can not fix Ci and they have a system to oxidize organic substances and discharge Ci to the outside. As the host for chemosymbiosis or phtosymbiosis, they have to reverse direction but need this Ci intake system. Other environmental factors, e.g. pressure and temperature, are the common factors if they live in the habitats, either shallow water or deep-sea. Since, chemosymbioses use energy obtained from the oxidation of reduced chemical substances, they have to live at the boundary between oxic and anoxic environments. And the photosymbioses require light for the photosynthesis, they have to live in the euphotic zone. In addition, the partners of photosymbioses must tolerate the high oxygen concentration stress, which is derived from the photosynthesis. These two factors may be very important for the evolution of these nutritional symbioses.

In the various host animal lineages and also in various symbiont microorganisms, their respective chemosymbioses or photosymbioses seemed to be acquired independently. In the present presentation, I would like to discuss not only about the possible factors affecting the evolution of the symbioses but also about the possible effect (metabolism, organ structure, and genome modification etc) caused by the acquisition of the symbioses.

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