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Physiological and Molecular Adaptations to Symbiosis of Zooxanthellae and their Hosts

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Introduction

Only in the 18th century, when a medical doctor from Marseilles, Jean-André Peyssonnel, definitively identified the animal origin of the red coral, was the evolutionary position of the Cnidarians within the animals determined. Despite this, due of their animal-flower shape, the name zoophytes (a small composite organism with both animal and plant features) remained linked to them until the beginning of the twentieth century. Many aspects of their physiology, however, are consistent with this definition, as nearly half of cnidarians house photosynthetic bacteria known as zooxanthellae. As a result, the notion of holobiont or Meta organism was born. This relationship has molded not only these animals' functional characteristics, but also an entire ecosystem, the coral reef, which is referred to as "an oasis in a barren ocean". Coral reefs, which cover less than 0.2 percent of the ocean's surface, are home to 30 percent of all known marine species. This high biodiversity supports various ecosystem services, including food for about 500 million people, tourism revenues, and coastline protection worth an estimated 375 billion dollars. Cnidarians have been actively studied over the last two decades due to their huge ecological and human relevance, as well as the risks they face. Furthermore, their evolutionary position as the sister group of Bilateria adds to their scientific appeal. According to ITS2 sequences, each clade is made up of several types (or subclades) (up to 258). Their diversification happened around 15 million years ago during the Miocene epoch, while coral symbiosis appeared during the Triassic epoch. The concept was changed in the 1980s to one Symbiodinium clade per host, but it now appears that the association is far more complex, with a dynamic equilibrium between different clades and subclades per host depending on environmental conditions, with the possibility of parasitic relationships on occasion. However, while evidence suggests that the genetic structure of the host and symbionts are different, host and symbiont genotypes have rarely been analysed concurrently. Zooxanthellae are found in the gastrodermal (= endodermal) cells of corals, where they are protected by a host-derived membrane. While zooxanthellae are by far the most well-known coral symbionts, the coral holobiont is made up of a variety of other symbionts, including protists (Apicomplexa), endolithic algae, eubacteria, Archaea, and viruses, all of whose functions are unknown, but could include carbon fixation, nitrogen fixation and cycling, sulphur cycling, and antibiotic synthesis. Although dozoicomonas spp. (Gammaproteobacteria, Oceanospirillales) are dominant members of the microbiota of tropical and temperate corals, the presence of Spirochaetales (genera Borrelia, Spirochaeta, and Leptospira, known to be parasitic in a variety of land vertebrates) within the Mediterranean red coral was recently discovered. While some corals transmit their symbionts directly to their eggs or brooded larvae (vertical–closed– transmission), 85 percent of them must obtain their symbionts from the environment (horizontal–open–transmission), necessitating specific identification systems. The innate immune system of corals, which is as complicated as that of vertebrates, is responsible for these mechanisms. The recognition and regulation of symbiotic populations have been thoroughly examined. Symbiodinium glycans and host Pattern Recognition Receptors (PRR) like as lectins, but also Toll-like receptors or Complement C3 receptors, can recognise symbionts in the host mucus.