SYMASC: Bacterial Symbiosis in Ascidians

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The study of invertebrate-microbial associations is emerging as a prominent field in marine biology and biotechnology, with vast implications that range from a fundamental knowledge of host ecology and symbiont biodiversity to the advanced understanding of natural products discovery and sustainable production. While considerable incentives exist to unravel the complex metabolic interactions between host invertebrates and symbiotic microbes, basic questions regarding the biodiversity and stability of these relationships remain unanswered. As a result of this IRG grant, we have now learned that:

- The ascidian microbiota is clearly differentiated from free-living seawater microbial communities and includes symbiont lineages shared with other invertebrate hosts as well as unique, ascidian-specific phylotypes. Several rare seawater microbes are markedly enriched in the ascidian microbiota, suggesting that the rare biosphere of seawater may act as a conduit for horizontal symbiont transfer among hosts.
- The complex ascidian microbiota revealed herein appears to be maintained by the dynamic microenvironments within the ascidian tunic, offering optimal conditions for different metabolic pathways such as ample chemical substrate (ammonia-rich host waste) and physical habitat (high oxygen, low irradiance) for nitrification. Thus, ascidian hosts provide unique and fertile niches for diverse microorganisms and may represent an important and previously unrecognized habitat for nitrite/nitrate regeneration in coral reef ecosystems.
- Ascidian-microbial associations appear to be stable over time, at least for colonial species. Bacteria are generally present in both adults and larvae suggesting that some degree of vertical transmission also exists. Our results indicate that symbiotic relationships between ascidians and bacteria are unique and independent of fluctuating biotic and abiotic factors, such as the host's life-cycle, host stress levels and ambient seawater temperature.
- Finally, using an invasive ascidian (*Styela plicata*) as a model species, we have learned that diverse and variable bacterial communities also inhabit the tunic of invasive species, including environmental and host-associated bacterial lineages that appear to be re-established each host generation. We believe that bacterial communities in *S. plicata* are dynamic and have the potential to aid host acclimation to new habitats by establishing relationships with beneficial, locally sourced bacteria.

The multi-scale and interdisciplinary research approach used here represents the first holistic account of host-symbiont interactions between ascidians and microbes. The full completion of this research proposal has yielded substantial advancements in the field of invertebrate-microbial symbioses, including a better understanding of how these symbionts respond to changing environmental conditions and interact with their hosts. The research conducted here has also provided new insights into the short-term vulnerability and long-term resilience of these important benthic organisms, as well as some preliminary information on the potential importance of bacterial associates for invasive processes. We hope that this information will set a useful baseline for future studies and to design adequate management plans to ensure the long-term preservation of the existent biodiversity.