Functional diversity of chemosymbiosis in lucinid bivalves from coastal biomes

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This project will uncover the genetic, taxonomic, and functional diversity of modern lucinid bivalve chemosymbioses from uncharacterized coastal marine biomes that range from pristine to highly disturbed conditions and will test for ways to characterize lucinid-bacteria biodiversity in the geologic past.

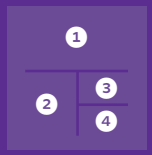
Chemosymbiosis, the association of bacteria that fix carbon and supply it to their hosts in the absence of sunlight, remains largely unexplored in shallow marine, coastal environments. Lucinids are the most taxonomically diverse clade of bivalve clams that exploit chemosymbionts to gain energy and avoid toxins. Lucinid endosymbionts have previously been considered to be sulfur-oxidizing bacteria from the class Gammaproteobacteria. However, recent molecular studies by our group of *Phacoides pectinatus* endosymbionts reveal novel genetic and metagenomic diversity associated with other biogeochemical cycles. As such, this effort reveals just how little we know of chemosymbiotic associations in shallow marine, coastal environments.

Lucinid-bacteria chemosymbiotic associations are an ideal system to unify the dimensions in biodiversity. Because lucinids have an extensive fossil record, geologic time is a "4th dimension" of biodiversity that can reveal more about the evolutionary history of lucinid chemosymbiosis. Our research will determine (1) how lucinid taxonomy, habitat, and biogeography influence endosymbiont genetic diversity, (2) how the microbial diversity and ecology of the lucinid habitat affect symbiont diversity, distribution, and biogeochemical cycling, (3) how lucinid host morphology may serve as a proxy for the presence of endosymbionts and/or degree or type of symbiotic dependence in fossil taxa, and (4) how disturbances (e.g., anthropogenic activities) within the coastal biome affect the nature and type of lucinid chemosymbiotic association.

Shallow marine biomes from Florida, California, and The Bahamas will be sampled, and Lucininae, Leucosphaerinae and Codakiinae subfamilies will be targeted. The presence of chemosymbionts and/or degree or type of symbiotic dependence in fossil taxa will provide more accurate data to reconstruct trophic relationships in paleocommunities and extant habitats. The effects of anthropogenic activities on the functional diversity of chemosymbiotic associations will be evaluated from innovative geochemical and -omics approaches and compared to pristine and low-impact systems. Anthropogenic impacts will be quantitatively assessed using geochemistry and disturbance indices developed for benthic marine sediments.

This research will fill gaps in our understanding about lucinid biodiversity loss that may occur in habitats sensitive to natural and anthropogenic disturbances and will be important for coastal resource management decisions.

At each of the PI institutions, graduate and undergraduate students will be trained in interdisciplinary geochemistry, microbiology, and paleobiology disciplines, including a field studies course to occur in the Bahamas, as well as museum collection standards, laboratory research, and computational bioinformatics. Students from underrepresented STEM groups will be involved on the project, and involvement with university outreach and mentoring programs will target symbiosis and biodiversity topics through formal and informal classroom, public speaking opportunities, and museum activities.



1 Lucinids will be studied from shallow marine habitats, including seagrass meadows and mangrove swamps, that vary in natural and anthropogenic disturbances.

2 The commonly named Thick Lucine, *Phacoides pectinatus*, collected from sediments near Fort Pierce, Florida. Ongoing metagenomic and biochemical research focused on *P. pectinatus* is revealing a much more diverse assemblage of chemosymbionts than previously recognized, including bacteria associated with nitrogen and methane in addition to sulfur and cycling.

3 Collecting *Phacoides pectinatus* from sandy sediments near Fort Pierce, Florida.

4 Dissected *Phacoides pectinatus* showing purple gills, white foot, and other internal parts.

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