Protection from Oxidative Stress in Algal-Bacterial Co-Cultures

Danielle YoungSmith1, Michelle R. Brann2, Xavier Mayali3, Oana E. Marcu4,5*
(oana.marcu@nasa.gov)

1Barnard College, New York, NY; 2Wellesley College, Wellesley, MA; 3Lawrence Livermore National Laboratory, Livermore CA; 4Carl Sagan Center, SETI Institute, Mountain View, CA; and 5NASA Ames Research Center, Moffett Field, CA

Project Goals: The LLNL Biofuels SFA seeks to support robust and sustainable microalgae fuel production through a systems biology understanding of algal-bacterial interactions. We hypothesize that by understanding the factors that control cellular physiology and biogeochemical fluxes in and out of algal cells, particularly through the phycosphere, we can advance the efficiency and reliability of algal biofuel production. Our research includes studies of probiotic traits of phycosphere-associated bacteria, systems biology studies of model algae, and genome-enabled metabolic modeling to predict the interspecies exchanges that promote algal growth, lipid production and healthy co-cultures. Our overall goal is to develop a comprehensive understanding of complex microbial communities needed to advance the use of biological properties for practical energy production.

As part of a new SFA project focused on algal-bacterial interactions, the LLNL Biofuels SFA has recently initiated collaborations with O. Marcu's group at the SETI Institute. The Marcu lab is focused on laboratory co-cultures of the green alga Chlamydomonas reinhardtii grown in co-culture with bacterial strains that enhance the growth and lipid production of the microalga. The bacteria were isolated from the topsoil of Mojave Desert and are pre-adapted to the oxidative stress imposed by the surface exposure to UV radiation and desiccation. In the presence of these bacteria, the Chlamydomonas cultures show an initial slight increase in the levels of reactive oxygen species (ROS), but increased growth and photosynthetic efficiency. Remarkably, in the presence of a secondary stress induced by heat, the ROS levels in algae decrease as compared to controls, suggesting that the bacteria provide priming and protection against oxidative stress. Bacteria also protect the algae from hydrogen peroxide-induced stress, most likely through the activity of extracellular bacterial catalase, and from the stress induced by the removal of copper. Monitoring of ROS levels in the intracellular compartment versus supernatant suggests a role for the extracellular matrix in buffering their toxicity. Co-cultures that show increased lipid production can be reconstructed in laboratory conditions.

Currently the work focuses on the multiple bacterial consortia in co-cultures and their physical association with the algae, gene expression under stress conditions, the lipid metabolism and metal transport, and the role of the algal extracellular matrix in mediating the association and response to stress, for short- and long-term growth of algal cultures with enhanced productivity.

This material is based upon work supported partly by the National Aeronautics and Space Administration Science Mission Directorate, Astrobiology: Exobiology and Evolutionary Biology Program under Agreement No. NNX10AI34A to O.M, and by NASA OSSI internships to DYS and MRB. Future collaboration is to be supported by the U.S. Department of Energy Office of Science, Office of Biological and Environmental Research Genomic Science program under the LLNL Biofuels SFA, FWP SCW1039. Work at LLNL is performed under the auspices of the U.S. Department of Energy under Contract DE-AC52-07NA27344.