Biomass recycling using novel thermophilic enzymes and importance for sustainable space exploration

Brian P. Hedlund (UNLV), Nancy Nou (UNLV), Jonathan Covington (UNLV), Allison Cook (UNLV), Nicole Torosian (UNLV), Marike Palmer (UNLV), Natasha Sushenko (DRI/UNLV), Nitin Singh (JPL), Duane P. Moser (DRI/UNLV), Kasthuri Venkateswaran (JPL)

Lignocellulose is the structurally complex building block of all plants and would be the dominant waste from crop materials during spaceflight missions as it is on Earth. Technologies for degradation of diverse lignocellulose waste streams depend on diverse organisms and enzymes, regardless of the downstream application (e.g., soil formation, biofuels, specialty chemicals, etc.), and has been prioritized by NASA for sustainable space exploration. To address this need, we have explored the range of polysaccharides that are degraded by novel thermophilic bacteria that specialize on polysaccharide metabolism, uncovered patterns in the expression of these enzymes as they degrade different polysaccharides, and documented the properties of several purified glycoside hydrolase (GH) enzymes. Both *Fervidibacter sacchari* and *Kallotenue papyrolyticum* can grow by depolymerizing and oxidizing a wide variety of polysaccharides, which are then respired or fermented. *F. sacchari* expresses all annotated 114 GH genes during growth on polysaccharides, with some enzymes being co-expressed that likely work in concert to depolymerize specific substrates. Three *F. sacchari* enzymes were successfully expressed, purified to >95% homogeneity and have been partially characterized with regard to pH and temperature range and optima, enzyme kinetics, substrate range, and glycosidic bond cleavage. One of these enzymes has also been shown to function under microgravity conditions necessary for activity during spaceflight and colonization of other worlds.