NC State Researchers Redesign Life for Mars and Beyond

October 18 2005

Researchers at North Carolina State University are looking deep under water for clues on how to redesign plants for life deep in outer space. Some of the stresses inherent with travel and life in space – extreme temperatures, drought, radiation and gravity, for example – are not easily remedied with traditional plant defenses.

So Dr. Wendy Boss, William Neal Reynolds Distinguished Professor of Botany, and Dr. Amy Grunden, assistant professor of microbiology, have combined their expertise to transfer beneficial characteristics from a sea-dwelling, single-celled organism called Pyrococcus furiosus into model plants like tobacco and *Arabidopsis*, or mustard weed.

P. furiosus is one of Earth's earliest life forms, a microbe that can survive in extreme temperatures. It grows and dwells in underwater sea volcanoes where temperatures reach more than 100 degrees Celsius, or that of boiling water. Occasionally, the organism is spewed out into near freezing deep-sea water.

The NC State research, funded for two years and $400,000 by the NASA Institute for Advanced Concepts, entails extracting a gene – called superoxide reductase – from P. furiosus and expressing it in plants. That gene, one of nature's best antioxidants, reduces superoxide, which in plants is a chemical signal given off when stressful conditions are encountered. This signal essentially puts the plant on alert, but staying on alert too long can be harmful: If not reduced quickly, the toxic superoxide will kill plant cells.

Since the superoxide reductase gene is not found in plants, Boss, an expert in plant metabolism and plant responses to stimuli, and Grunden, an expert in organisms that grow in extreme environments, wanted to use this genetic manipulation as a test run to gauge the feasibility of inserting a gene from an extremophile – an organism that survives, and thrives, in extreme environments – into a plant, and then seeing whether the gene would function the way it does in its original organism.

“The bottom line is that we were able to produce the *P. furiosus* superoxide reductase gene in a model plant cell line and to show that the enzyme has the same function and properties of the native *P. furiosus* enzyme,” Boss said. “The fact that the plant cells would produce a protein with all the properties of the *P. furiosus* protein opens new avenues for research in designing plants to survive and thrive in extreme conditions.”

But people living on the Arctic Circle shouldn’t be rushing out to buy palm trees just yet. It’ll take years and much more study before plants will be able to survive outside of their usual habitats. Moreover, there could be deleterious side effects to this type of genetic manipulation.

What’s important, the researchers say, is the fact that *P. furiosus* and other extremophiles might be able to lend their beneficial traits to plants sometime in the future.

“This is very fundamental research,” Boss said. “If we could add new genes to plants, we could potentially make the plants more resistant to extreme conditions such as drought and extreme temperatures that we have on Earth, but also to the extreme conditions that one might find on Mars.”

Now that the concept of inserting a single gene from an extremophile into a plant has been proven, the researchers are working to insert

associated genes in hopes of providing even more extreme-temperature protection to plants. And, they're involving more great minds to come up with more answers – they've team-taught an honors undergraduate class called "Redesigning Living Organisms to Survive on Mars: Development of Virtual Plants" and plan to offer another class to investigate new mechanisms for reducing radiation damage in spring 2007.

Source: North Carolina State University