Bacteria get new badge as planet's detoxifier

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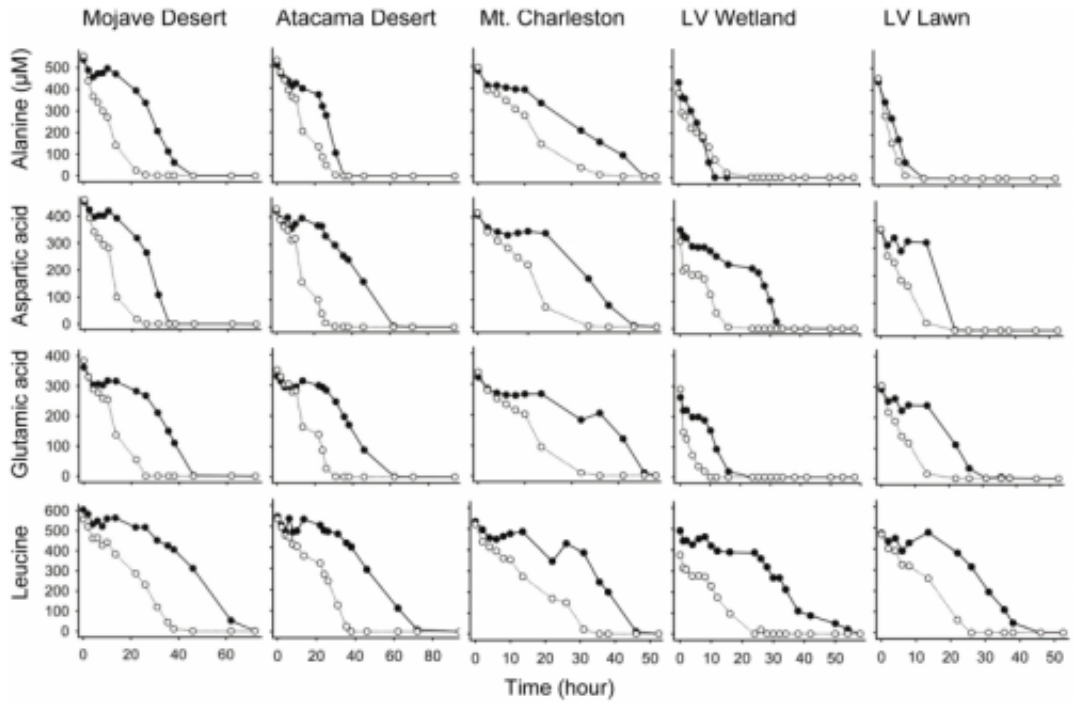

Microbial consumption dynamics of racemic amino acids (L-enantiomers: open symbol; D-enantiomers: filled symbol) following addition to soils. Credit: Gaosen Zhang

A study published recently in *PLOS ONE* authored by Dr. Henry Sun and his postdoctoral student Dr. Gaosen Zhang of Nevada based research institute DRI provides new evidence that Earth bacteria can do something that is quite unusual. Despite the fact that these bacteria are made of left-handed (L) amino acids, they are able to grow on right-handed (D) amino acids. This DRI study, funded by the NASA

Astrobiology Institute and the NASA Exobiology Program, takes a closer look at what these implications mean for studying organisms on Earth and beyond.

"This finding is important because D-amino acids are slowly produced in soils through geochemical transformation of L amino acids. If they were allowed to accumulate, they would poison the environment for plants and animals. Our research shows that it is the bacteria that prevent D-amino acids from accumulating to toxic levels," explains Dr. Sun, who has studied microbial life in extreme environments in the Antarctic dry valleys, the Atacama Desert, and Death Valley.

Amino acids, the fundamental building blocks of life, come in two forms that, like our left and right hand, have identical parts. But the two forms are not the same from a three dimensional perspective. One is the mirror image of the other. Proteins and enzymes in Earth organisms, without exception, all use L-forms. As expected, soil bacteria are very efficient at consuming L-amino acids from the medium. The researchers then presented the same bacteria D-amino acids. To their surprise, these life-incompatible forms too were rapidly consumed.

"We are not saying that the D-amino acids are assimilated as is. If incorporated into proteins, this amount of D-amino acids would kill the organisms," says Dr. Sun. "Rather, we think that a conversion occurred in the bacteria that turned the D-amino acids back into L-forms. All bacteria carry a specialized enzyme known as racemase which converts amino acids from one form to another," adds Dr. Sun.

This then raises another question: If all organisms on Earth synthesize L-amino acids, where do D-amino acids come from? Amino acids have the property of being able to spontaneously flip from one form to another, a process called racemization. Racemization is very slow. Most organisms do not live long enough for this process to kill the proteins and,

ultimately, the organisms themselves. In soils, however, amino acids can be sequestered for thousands or even millions of years, allowing racemization to accumulate. Eventually, the concentrated D-amino acids are released into the environments – to the waiting bacteria, rather than poisoning plant and animal life.

Bacteriologists have known that bacteria contain racemases, but they have always assumed that the enzymes were invented for making D-amino acids. Unlike plants and animals, bacteria need a small amount of D-amino acids, not to incorporate into proteins, but to incorporate into cell walls to increase resistance and stability.

"But this cannot be the reason that bacteria invented the racemase. If D-amino acids are toxic, you have to invent a detoxification mechanism first before you go around and make more of the stuff. We think it is much more likely that the racemase originated initially as a detoxification enzyme. Only later, do bacteria, now immune to D-amino acid toxicity, start to make D-amino acids for constructive purposes. The D-amino acid-making function, therefore, is a secondary biological invention," says Dr. Sun.

"The implications of our study go beyond Earth. The steps that led to the invention of racemases on Earth would also exist on other planets, even if life uses D- instead of L-amino acids. This means that D-bacteria would also have to invent racemases and, as a result, would consume L-amino acids for nutrients. This creates a scenario that scientists charged with the duty of protecting Earth from foreign organisms haven't thought about," says Dr. Sun. "If D-bacteria ever visit us on Earth, they would compete with native bacteria for nutrients," he adds.

More information: dx.plos.org/10.1371/journal.pone.0092101