Melanie Graysmith, March 1, 2011

Unconventional Bacteria Thrives on Arsenic

Research has it that arsenic is indisputably poisonous to virtually all life forms. Science also knows that all living things require six key survival elements: carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur. Yet, a recent discovery in the muddy waters of California's Mono Lake is exposing a gap in what scientists thought of as fact, while challenging long-held assumptions. Although prior discoveries of other element substitutions in living organisms have not surprised scientists, they had no confirmation of any major element switch, not until now.

The discovery and subsequent research of the first living organism to use arsenic in place of phosphorus for its survival, while seemingly amazing, may not be conclusive just yet. Scientists have already discovered approximately 20 organisms that breathe in arsenic, generally in environments where oxygen is in scant supply. They considered this situation typical for organisms forced to compensate with other available matter. The surprise was that such bizarre bacteria were actually able to exist without using phosphorous at all.

Phosphorus is part of the chemical structure of DNA and RNA, the structures that transmit genetic directions necessary for life. It seemed the particular atypical bacteria had changed in such a way where it was capable of using arsenic, not phosphorus, to grow and multiply. It was this ability that surprised scientists, who knew arsenic as an especially toxic substance.

Based on information scientists had, a research team was led by Dr. Felisa Wolfe-Simon of Palo Alto, a NASA astrobiology researcher at the U.S. Geological Survey in Menlo Park, California. They embarked on a mission to study bacteria that uses arsenic instead of phosphorous. Mono Lake's Ten Mile Beach was selected as a good research

point, due to its location near Yosemite at an edge of the desert region known as the Great Basin. Mono Lake, a closed basin lake, catches runoff from the Sierra Nevada mountain range, and has a higher than average concentration of arsenic; its arsenic level is so high in fact, that it supercedes the maximum allowable limit for drinking water.

The strain of bacterium that the team isolated at the lake, one that can survive using arsenic, was identified as GFAJ-1, a strain of Halomonadaceae bacteria. Not only does this strain thrive virtually phosphate-free, but it can also integrate arsenic into its DNA and RNA, in addition to its other biological means of support.

Back at the lab, the researchers grew the newfound bacteria in Petri dishes, gradually replacing phosphate salt with arsenic, until the bacteria could grow without added phosphate. The team monitored the arsenic in the bacteria to find answers Wolfe-Simon set as the overall goal of the experiments: was the arsenic thoroughly integrated into the bacterial cells, or merely attached outside? The team conducted experiments confirming that arsenic did replace phosphorus within the bacterial cells, not just absorbing it from the outside. The team plans additional tests to further investigate specific ways the bacteria uses arsenic.

In the aftermath of these findings, a flood of criticism has arisen from fellow scientists and researchers who feel there are too many holes in the study. Some doubting scientists believe the Wolfe-Simon led researchers may have simply detected arsenic attached to the bacteria's DNA. Others assert the growth medium tested actually included enough phosphorus, as a contaminant, to eke out a living without having to actually test for arsenic itself.

One thing seems certain: with additional testing planned, more will be coming from the mighty bacteria -- as we know it and as we *will* know it.