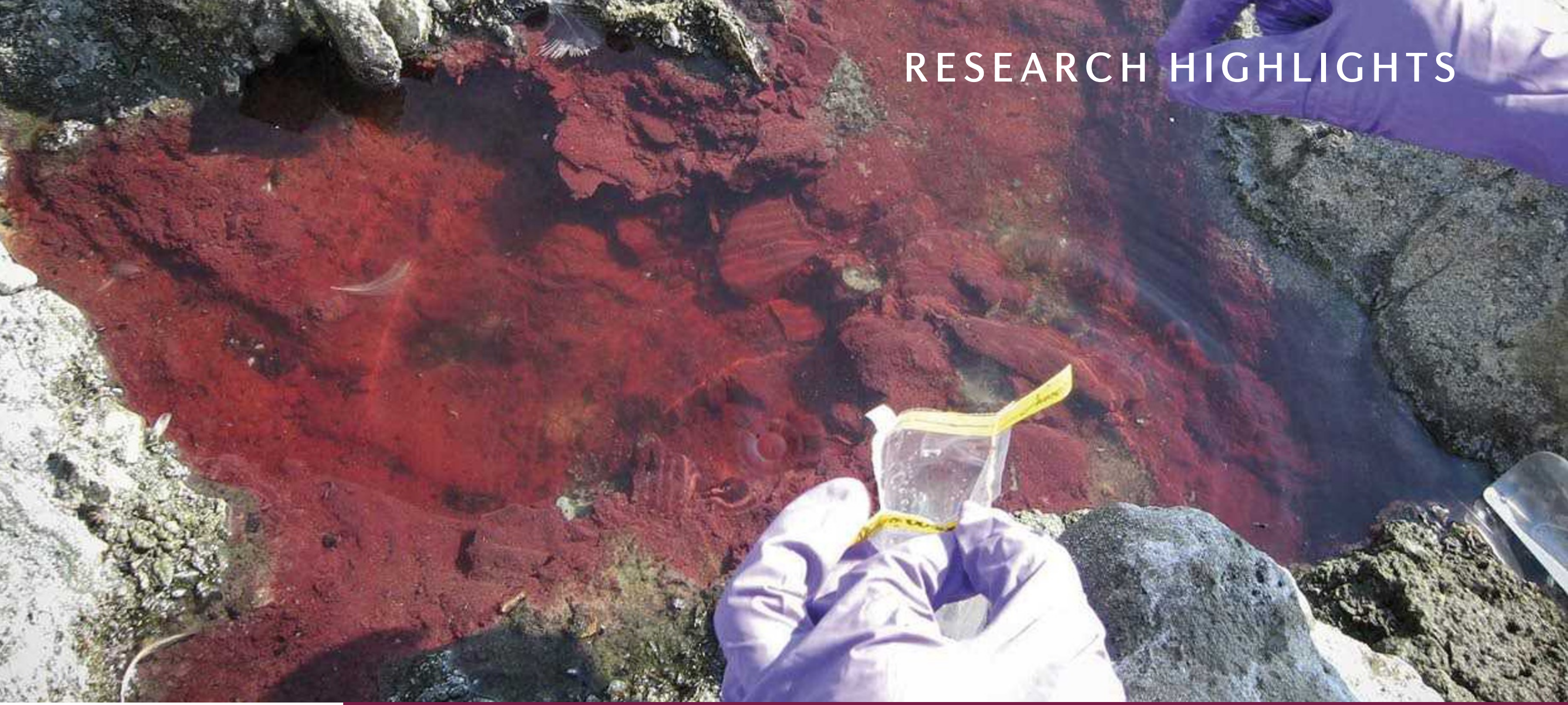

Shelley Hoeft, of the United States Geological Survey (USGS), sampling the 'red' pool. Image kindly provided by Shaun Baesman of the USGS.

ENVIRONMENTAL MICROBIOLOGY

Arsenic in action

The first species of bacteria that derives its energy from arsenic through anoxygenic photosynthesis has now been discovered. As reported in *Science*, this finding by Kulp and colleagues may have important implications for how the arsenic cycle was established and maintained on the ancient anoxic Earth.

Previous studies indicated that microbial arsenic metabolism is an ancient process that possibly occurred on primodial Earth. Similarly, anoxygenic photosynthesis seems to be ancient, perhaps dating as far back as the Archean (3.8–2.5 billion years ago). However, because the oxidation of arsenite, As(III), to arsenate, As(V), had only been observed in chemolithotrophic microorganisms and required strong oxidants, such as oxygen, it had been presumed that microorganisms only developed a taste for As(V) after the evolution of oxygenic photosynthesis, which may have occurred some 2.7 billion years ago, but perhaps occurred more recently.

Kulp and colleagues sampled biofilms from two small, hot-spring-fed ponds in Mono Lake, California, USA. One pond was coated with a green biofilm, and the other was coated with a red biofilm. When slurries of the red and green biofilms were incubated in the laboratory, it became apparent that these films were oxidizing As(III), but in a manner that was dependent on anoxygenic photosynthesis; As(III) was oxidized to As(V) in the absence of oxygen when the slurries were exposed to light, but not when the slurries were kept in the dark. To confirm that As(III)-linked anoxygenic photosynthesis was occuring, the authors isolated a strain of the photosynthetic bacterium from the red biofilm. This strain, named PHS-1, indeed exhibited As(III)-linked anoxygenic photosynthesis. As yet, pure cultures have not been isolated from the green biofilm samples.

16S ribosomal RNA analysis revealed that PHS-1 was most closely related to the gammaproteobacterial species *Ectothiorhodospira shaposhnikovii*. Surprisingly, PHS-1 seems to lack AoxB, a widely conserved protein that oxidizes As(III), but has a homologue of Arr, which normally reduces As(V). These findings suggest either that the putative Arr homologue in PHS-1 functions in reverse of its normal activity or that PHS-1 has an as-yet-unidentified mechanism for As(III) oxidation.

The authors propose that organisms in other environments, such as the hot springs of Yellowstone National Park, United States, may also be able to carry out the anoxygenic oxidation of As(III) to As(V), thereby broadening the ecological importance of this phenomenon. Moreover, the authors propose that "production of As(V) by anoxygenic photosynthesis probably opened niches for primordial Earth's first As(V)-respiring prokaryotes." Taken together, these findings suggest that the history of prokaryotic arsenate respiration should be re-evaluated, which may have crucial implications for various aspects of the ancient arsenic cycle.

> "...the history of prokaryotic arsenate respiration should be re-evaluated, which may have crucial implications for various aspects of the ancient arsenic cycle."

Asher Mullard

ORIGINAL RESEARCH PAPER Kulp, T. R. *et al.* Arsenic(III) fuels anoxygenic photosynthesis in hot spring biofilms from Mono Lake, California. *Science* **321**, 967–970 (2008)