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Comment on "A Bacterium That Can Grow by Using Arsenic Instead of Phosphorus"

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Wolfe-Simon *et al.* (*Science* Express Research Article, published online 2 December 2010; 10.1126/science. 1197258) reported that the bacterial strain GFAJ-1 can grow by using arsenic (As) instead of phosphorus (P), noting that the P content in bacteria grown in +As/–P culture medium was far below the quantity needed to support growth. However, low P content is a common phenotype across a broad range of environmental bacteria that experience P limitation.

Wolfe-Simon *et al*. reported that arsenic (As) can substitute for phosphorus (P) in the biomolecules of the bacterium GFAJ-1 (*1*). The authors stated that the 0.02% (±0.01%) phosphorus (P) they measured in GFAJ-1 in the +As/–P treatment was "far below the 1 to 3% P by dry weight required to support growth in a typical heterotrophic bacterium" and cited our work on the phosphorus content of bacteria (*2*) to support this claim. However, it should be noted that our work was done with *Escherichia coli*, a gastrointestinal bacterium cultured on high (0.013 to 1.3 mM) P and at growth rates that were much higher than those typical of environmental bacteria. We used dilution rates between 8 and 28 per day, about 10 times as fast as what typically is measured in lakes and oceans (*3*, *4*) and 80 to 280 times the growth rate reported for GFAJ-1. These faster growth rates, which require more P-rich ribosomal RNA per cell, combined with the P-rich media of our study make it a poor reference for comparison with the P content of an environmental bacterium.

We recently published a survey of the elemental content of bacteria from more than 120 freshwater ecosystems (*5*). Our findings show that the P content of aquatic bacterial communities sampled in situ and of individual isolates grown in chemostats can be highly depleted in P. Measurements of individual bacterial cells from one lake indicated that cells contained between 0.01 and 0.1 fmol P per cell with a mean of 0.5% P, with some individuals as low as 0.03% P of dry weight. Additionally, numerous bacterial isolates from temperate lakes grown in chemostats at dilution rates of 1.2 to 2.4 d^{-1} had P content consistently ranging from 0.2 to 0.4% under P-limiting conditions. We conclude that the P content reported for GFAJ-1, although low, falls within the range we observed for environmental bacteria from a diverse set of aquatic environments. Therefore, considering the low growth rate and concentration of P used in the culture media of GFAJ-1, a P content <0.1% cannot necessarily be used to support the exceptional claim that GFAJ-1 is substituting As for P in its core macromolecules. Rather, low P content is a readily observed phenotype used by a broad range of phylogenetically diverse environmental bacteria to deal with extreme P limitation.

References

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