Will you take the 'arsenic-life' test?

Critiques prompt researchers to offer samples of poison-tolerant microbe to doubters.

Erika Check Hayden

At first, it sounded like the discovery of the century: a bacterium that can survive by using the toxic element arsenic instead of phosphorus in its DNA and in other biomolecules.

Felisa Wolfe-Simon has been criticized for her work on bacteria recovered from an arsenic-rich lake.H. BORTMAN

But scientists have lined up to criticize the claim since it appeared in Science six months ago[1]. Last week, the journal published a volley of eight technical comments [2-9] summarizing the key objections to the original paper, along with a response from the authors[10], who stand by their work.

The authors of the original paper are also offering to distribute samples of the bacterium, GFAJ-1, so that others can attempt to replicate their work. The big question is whether researchers will grab the opportunity to test such an eye-popping claim or, as some are already saying, they will reject as a waste of time the chance to repeat work they believe is fundamentally flawed. "I have not found anybody outside of that laboratory who supports the work," says Barry Rosen of Florida International University in Miami, who published an earlier critique of the paper[11].

Some are also frustrated that the authors did not release any new data in their response, despite having had ample time to conduct follow-up experiments of their own to bolster their case. "I'm tired of rehashing these preliminary data," says John Helmann of Cornell University in Ithaca, New York, who critiqued the work in January on the Faculty of 1000 website[12]. "I look forward to the time when they or others in the field start doing the sort of rigorous experiments that need to be done to test this hypothesis."

The original study[1], led by Felisa Wolfe-Simon, a NASA astrobiology research fellow at the US Geological Survey in Menlo Park, California, looked at bacteria

taken from the arsenic-rich Mono Lake in southern California. The authors grew the bacteria in their lab using a medium that contained arsenic but no phosphorus. Even without this essential element of life, the bacteria reproduced and integrated arsenic into their DNA to replace the missing phosphorus, the paper reported.

"We maintain that our interpretation of As [arsenic] substitution, based on multiple congruent lines of evidence, is viable," Wolfe-Simon and her colleagues wrote in last week's response[10].

But critics have pointed out that the growth medium contained trace amounts of phosphorus[2,3] — enough to support a few rounds of bacterial growth[5]. They also note that the culturing process could have helped arsenic-tolerant bacteria to survive by killing off less well-equipped microbes[3].

Others say that there is simply not enough evidence that arsenic atoms were incorporated into the bacterium's DNA[4,6–9]. The chemical instability of arsenate relative to phosphate makes this an extraordinary claim that would "set aside nearly a century of chemical data concerning arsenate and phosphate molecules", writes Steven Benner[4] of the Foundation for Applied Molecular Evolution in Gainesville, Florida.

A leading critic of the work, Rosemary Redfield of the University of British Columbia in Vancouver, Canada, says that it would be "relatively straightforward" to grow the bacteria in arsenic-containing media and then analyse them using mass spectrometry to test whether arsenic is covalently bonded into their DNA backbone.

Redfield says that she will probably get samples of GFAJ-1 to run these follow-up tests, and hopes that a handful of other laboratories will collaborate to repeat the experiments independently and publish their results together.

But some principal investigators are reluctant to spend their resources, and their students' time, replicating the work. "If you extended the results to show there is no detectable arsenic, where could you publish that?" asks Simon Silver of the University of Illinois at Chicago. "How could the young person who was asked to do that work ever get a job?"

Helmann says that he is in the process of installing a highly sensitive mass spectrometer that can measure trace quantities of elements, which could help refute or corroborate the findings. But the equipment would be better employed on original research, he says. "I've got my own science to do."

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- #23228

I have carefully read all the Science-published criticisms and compared them with a Science-rejected criticism which was published on March 9, 2011 in Logical Biology (see http://im1.biz/albums/userpics/10001/LB2011V11N1A1_AsLife_P1.htm).

The author, who's name is actually quite famous or infamous because he was one of the earliest public critics on the controversy AsLife and has been posting comments on the Science website very frequently (http://news.sciencemag.org/sciencenow/2010/12/arsenic-researcher-asks-for-time.html) , stated

"so-called arsenic-based life (As-life) is very likely a mistake originated from mistaken experiments. It can be easily invalidated with correct tests."

The correct tests that the author prescribed include a study for observing "cell age-homogeneous mother bacteria (12-14) attached to a solid surface so that their continued growth and reproduction can be tracked over time (15-16)". The author actually detailed the experimental protocol by teaching us "The cellular contents of these mother cells and their offspring cells, growing under different testing conditions, should be separately analyzed" because in this way "it can effectively distinguish the inclusion of As in mother cells from the usage of As for building As-macromolecules in daughter cells".

The author, whose name is Shi V. Liu by the way, concluded that, "if As is found only or mainly inside the mother cells but not their daughter cells, then the claim for an As-based life form capable of As-dependent growth and reproduction is very likely invalid. If the mother cells even do not reproduce daughter cells under an As-rich but P-limited condition, then As may even exert some detrimental rather than beneficial effects on the As bio-accumulating bacteria."

What a well designed experiment and what a clear way for settling the controversy!
I am wondering why Science would rather reject this not only very solid but also extremely constructive Technical Comment AND experimental design. If this manuscript was sent to the NASA scientists, they might even disapproved their claim and thus avoided another round of arguments.
Somethings have been seriously wrong in Science. But as nature has given us an opportunity to re-test a shaky discovery we should grab this opportunity.
Let us do some right tests on these still viable As-supporting bacteria. I am confident that Nature will publish the results even if they would be very "negative".

- Report this comment
- 2011-06-01 01:33:12 PM
- Posted by: Dick Baltimore

- #23247

It worries me that there has no follow up on this work. I remember we were very exited when the news of arsenic incorporated life form was published, but now people are not replicating it because there's no money involved in it. Moving at a caveman's pace.

- Report this comment
- 2011-06-01 04:45:38 PM
- Posted by: sean dunn

- #23255

It is sad that some "good" scientists would make such a big mistake in Science. It is more sad that even most "ordinary" scientists do not even care about mistakes in science.
What is the real goal of scientific research? Getting high in publishing in a high-impact factor journal and hiding low when facing problems?
Come on my dear NASA scientists, you should either repeat your public-doubted success by yourselves or retract your publication entirely. Tax-payers have paid you to do a job and you cannot just let a half-done job hanging up in Science.
Listen Science, it is forgivable for you to publish one or more flawed researches because your trusted experts really lack some true insight on frontier science. But it is unforgettable that you would rather try all the measures to delay and even deny some solid scientific criticisms to your flawed publications.
Last time Science sold the whole world a NASA discovery of Martian life. But that centennial discovery has become an unresolvable myth as no trace of life can be found even when the search for Martian life has gone from its surface to subsurface.
But this recent "astrobiological" discovery should not be that difficult to re-confirm or disapprove.
The problem is that even NASA scientists have lost their "interest" in getting more

evidence. Then, when top journals are generally not interested in publishing repeated research and, more sadly, "negative" findings, who would do the "silly" things of becoming unpublished and certainly perished?
I feel sad for today's Science in particular and science in general!

- Report this comment
- 2011-06-01 06:44:40 PM
- Posted by: Dick Baltimore

- #23256

Just face it: NOBODY wants to do the science for the sake of science unless there is a substantial incentive behind it like a publication-grant-job. Are we really that bad? What we are bogging into?

- Report this comment
- 2011-06-01 07:29:47 PM
- Posted by: Pavel Prosselkov

- #23272

When I face this reality I become even more sad. When NASA astrobiologists would not spend more time in playing with this extremely important bacterium that actually altered the way science is practiced in some places whom would be counted on for coming to save this dying form of life?
How about pressing Science into a pre-study agreement of guaranteeing publishing any new results on this life science-changing bacterium? Then some publish-or-perish-educated scientists may come to do repeated but nevertheless truth-telling important research. But I am not confident that Science would even bother to deal with this hot potato any more.

- Report this comment
- 2011-06-01 09:21:12 PM
- Posted by: Dick Baltimore

- #23325

Perhaps the best approach to encourage scientists to pursue the necessary experimental work to either disprove or prove a highly controversial study such as this one is to publish the subsequent research in the same high profile journal. This research may not be as news worthy as the original paper but then I was under the impression that journals are there to publish scientific results, not to grab news headlines.

- Report this comment
- 2011-06-02 07:49:05 AM
- Posted by: David Lea-Smith

- #23341

I am sure that a "very negative" finding on the arsenic life would be even more interesting and grab much greater attention than the original "highly positive" discovery. The problem is whether the original journal brought the "breakthrough"

would be willing to breakthrough again. But even if that journal will not be willing to do that, other competitors such as Nature would be more than happy to continue on this very important research and publishing business.

- Report this comment
- 2011-06-02 09:02:16 AM
- Posted by: Dick Baltimore

- #23371

Since when does a PI care about a student getting a job?

- Report this comment
- 2011-06-02 04:33:32 PM
- Posted by: Wesley Button

- #23440

A good or bad news depending on your perspective or position.
Shi V. Liu, a former microbiologist who actually published in Science once for discovering thermophilic iron-reducing bacteria from deep subsurface and could be more times if his other more important discoveries, wished to take the Nature's challenge of repeating the experiments at a much higher level. He requested only one-tenth of the money spent for the original project and promised to get conclusive results within one year or less if provided with viable and un-mutated bacteria claimed to be As-based life. His disadvantages or additional requests for doing this job are a provision of wet-lab access with the needed materials and equipment since he does not have such capacity AND a guarantee from either Science or Nature to publish his results no matter how negative they are.

- Report this comment
- 2011-06-03 10:54:05 AM
- Posted by: Dick Baltimore