Arsenic and Accountability

A Retrospective on the Arsenic-Life Controversy

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I've led a team that has discovered a microbe that can substitute arsenic for phosphorus in its major biomolecules." These words, spoken by Felisa Wolfe-Simon in a National Aeronautics and Space Administration (NASA) press conference on December 2, 2010, summarize her and her team's groundbreaking findings. NASA Astrobiology Fellow — and Oberlin double-degree graduate — Wolfe-Simon was the only co-author present. Their discovery showcased a microbe able to replace phosphorus with arsenic in essential biomolecules, fundamentally challenging our traditional understanding of the building blocks of terrestrial life. Publications worldwide used the same language to impart the importance of these findings, claiming it would "alter biology textbooks" and "expand the scope of the search for life beyond Earth." Dwayne Brown from NASA's Office of Communications declared to the packed room that the following conversation would "end a week of fiction."

"Today, we begin a week of facts."

His statement seemed necessary at the time. In the lead-up to the event, NASA announced that Wolfe-Simon and the implications of her team's findings would "impact the search for evidence of extraterrestrial life." Due to an information embargo by Science, the journal in which Wolfe-Simon published her results, NASA could not precisely say the research specifics. Some blogs began to speculate on the nature of the news, comparing the CVs of each panelist at the conference to try to find common research interests among them. This, in combination with NASA's silence in anticipation of the event, led many to think that life had been found on Titan, one of Saturn's moons.

"We didn't want to deny things," said Shawn Domagal-Goldman, Deputy Director of the Sciences and Exploration Directorate at NASA's Goddard Space Flight Center, in an interview with The Synapse. "If we kept denying things that were incorrect guesses, [then] when we stopped denying things, it would confirm what the paper was about." Further fueled by magazines spreading unfounded information, this lack of transparency launched a media storm of unbridled speculation. Eventually, NASA realized that further clarification was needed without divulging sufficient information to break the embargo. Another announcement about the forthcoming press conference was eventually issued. Though the time spent correcting the misinformation was relatively brief, word spread extremely fast.

"I am not exaggerating," said Domagal-Goldman. "People filled up that room as if we were about to announce that we were not alone. … I've been at NASA for 15 years now, and I've never seen an atmosphere like that." Expressing his regret for the way the media sensationalization took precedence over the actual communication, Domagal-Goldman felt that the level of attention the news received grew out of a misunderstanding. The factual findings the Wolfe-Simon et al. paper shared, if true, would have still been a revelation for habitability research. Moreover, if arsenic, a toxic molecule, could be incorporated into an organism's DNA, that would have major implications for the types of nutrients scientists look for on exoplanets.

Detractors questioned whether the observations were genuinely indicative of arsenic incorporation into DNA or if they could be attributed to other factors. Chemist Steven A. Benner, who was on the original panel, questioned the substitution of arsenate for phosphate in the DNA, suggesting trace contaminants in the growth medium might be supplying the necessary phosphorus. He consequently proposed that arsenic could be sequestered elsewhere in the cells. Microbiologist Rosemary Redfield also expressed skepticism about the study, stating that it lacked convincing evidence for arsenic incorporation into DNA or other biological molecules. She highlighted the absence of essential washing steps and controls in the experiments, which is necessary for properly validating the conclusions. Scientific criticisms devolved into personal attacks on Wolfe-Simon's character and ability as a scientist. Researchers also critiqued Science's peer review process and NASA's motivations for sharing problematic research findings. One satirical article published on Dr. Redfield's blog, titled "Is Felisa Wolfe-Simon an Alien?," suggested that perhaps the paper's flaws are intentional, with the goal of devaluing the belief in extraterrestrial life to "allow the complex alien species to invade earth." Similarly, scientists and nonscientists took umbrage with the bacterial strain's name, GFAJ-1, for "Get Felisa A Job."

Many narratives about the arsenic–life controversy communicate a clear moral: a cautionary tale about the pitfalls of premature excitement and the importance of thorough validation in scientific research. As a society, we must learn from these experiences and appreciate the delicate balance between embracing innovation and maintaining scientific rigor, especially as we continue scientific discourse in a new age of media. That being

said, it is important to consider how we as scientists hold ourselves accountable. The personal attacks leveled at Wolfe-Simon unfairly accuse her of being a careerist who would ignore the basic tenets of the scientific process for fame, an interpretation which lacks nuance.

In 2010, Felisa Wolfe-Simon was an emerging young researcher in a field where many professionals are older men. She was encouraged to publish at every step in the process, and when her peer reviews were eventually released, they were stellar with few notes. She was catapulted to fame in just a few months and then swiftly dismantled from the same position. After the media fiasco, Wolfe-Simon was "evicted" from her lab. In an interview with Popular Science, she said it was "quite possible that [her] career was over," while none of her older male co-authors faced or continue to face the same level of scrutiny.

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Over a decade later, we can reflect upon this controversy with the luxury of knowing how it played out. There were flaws in the experiment's methods, but the paper has not been redacted as of this publication. Felisa Wolfe-Simon's career did not end, and she is now a scientific consultant and reviewer; however, that does not make the personal and professional attacks she suffered acceptable. Reviewing what happened could give us insight moving forward, especially regarding how similar high-profile discoveries might play out in today's online environment.

Since 2010, there has been an evolution in virtual harassment, with tactics such as falsely reporting emergencies for SWAT team responses and the malicious exposure of private information through 'doxxing' becoming increasingly prevalent. While it would be a stretch to claim that these tactics will replace scientific criticisms, it is important to keep such threats in mind to ensure the safety of ourselves and our teams. Striking a balance between embracing innovation and maintaining scientific rigor is paramount, but so is centering compassion within the scientific community. As we continue to navigate the ever-evolving landscape of scientific discovery, a commitment to accountability, empathy, and a nuanced understanding of individual experiences are indispensable for the progress of science and the well-being of those who contribute to it. • • •