What a shrimp can teach a submarine: The benefits of strange science

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A female Odontodactylus Scyllarus mantis shrimp photographed by Roy L. Caldwell, University of California, Berkeley.

When I enter my lab, I'm greeted by the pops and crackles of mantis shrimp smashing snail shells with tiny hammers moving at bullet-like accelerations. Other days, I listen to their eerie, low-frequency rumbles, joined by the scratchy rasps of the violin- like mechanism that spiny lobsters use to scare away predators. For the past twenty years, I have probed the physics and evolution of these and other strange and wonderful creatures. Many have revealed unexpected insights into extraordinary capabilities that are unmatched by human- made systems.

One cold winter day in February 2009, I attempted to convey the joy of discovery in this research, and the importance of it, to a group of leading artists, scientists, filmmakers, and public figures—my colleagues during a sabbatical at Harvard's Radcliffe Institute. I was excited to present my research, but also nervous. The oddball systems that organisms use to survive are endlessly fascinating to me. But I wondered if this critically minded audience would think my work had value. I've always been worried, if not obsessed, that what I do will not matter outside my field.

During that wintry talk at Radcliffe, one person in the audience seemed decidedly unconvinced by my case for the significance of my research. A world-famous Nigerian lawyer and women's-rights advocate, whom I'd gotten to know quite well at the institute, was paying close attention to my talk. But instead of smiling and laughing with everyone else, she seemed solemn and possibly angry. As people approached me with excited questions afterwards, I couldn't help but notice that this woman I greatly admired had left immediately without comment.

A few days later, she approached me as I left a luncheon. Her first words to me were, "Your research disgusted me." It felt like a punch in the gut—removing the air from my lungs and rending me speechless. I then remember her saying, "It was as if your cup runneth over with such waste studying trivial and useless problems." In that moment, she had voiced my most vulnerable thoughts: that the science to which I'd dedicated much of my life was actually useless.

"But," she added, her tone warming,"I had an epiphany while teaching my students this week." She said she hadn't known that science could be purely about discovery. "I thought that science was about medicine and solving human problems. And I realized something important: I want what you have for my country." In Nigeria, there was no funding or infrastructure for studying the surrounding world purely for the sake of discovering how biological systems work. She hadn't considered that

science could be about creativity, unanticipated outcomes, and inspiration.

Needless to say, I left that conversation reeling with emotion. With her incredible choice of words that somehow both insulted and inspired, I felt galvanized to do a better job articulating my research program's significance and its day-to-day impact on society. I wrote and published my lab's guiding principles and why our research matters to society. I read about the current needs in our country for science training and launched multiple outreach programs that used best practices for maximizing access to exciting and meaningful scientific experiences. One program (now at two universities) links undergraduates to research labs through a Web-based platform that levels the playing field for all students potentially interested in research. In another program, I recruit high-school teachers to work as paid researchers in my lab so that they can experience the joy of scientific discovery and bring those experiences and new teaching initiatives back to their classrooms.

Memories of that transformative time period, now six years ago, came back with a vengeance recently when U.S. Senator Jeff Flake listed my research program at Duke in a congressional Wastebook. Once again, I found myself confronting accusations that my work is frivolous and wasteful, but this time the scorn came from an elected official of the country that has led the world in scientific discoveries—made possible by discovery-based research labs similar to mine.

The news came via an e-mail from ABC News/Good Morning America asking me to comment. Politics can be both ridiculous and ridiculously important, and so although I wanted to dismiss this as a mere political stunt, I knew the implications could be serious. Several of my colleagues had endured years of ridicule as a result of their placement in a government Wastebook. The quality of their research wasn't affected, and their scientific reputations remained intact, but the media frenzy

allowed millions of Americans to get the wrong idea about the significance of non-applied, basic research.

ABC News did cover the story, and, to my horror, they parroted the senator's inaccurate statements about the costs of one of my federally funded research projects. As I had feared, this moment was ridiculous in its lack of basis in fact, but became important when other news outlets propagated the fallacious statements. I wondered: How many people watched that program and walked away outraged by the frivolous use of their tax dollars, not knowing that these statements were untrue? As a scientist committed to the importance and influence of research to society, I found this a crushing moment. My requests to ABC News for a correction were declined.

This unfortunate press coverage was a missed opportunity. My basic research program, alongside many others in my field, actually does have a wide range of practical and vital applications. For example, engineers have developed new fracture-resistant materials based on the extraordinary performance of the mantis shrimp's hammer, which was discovered in my lab. Computer scientists who design physics-based synthesizers have been able to use our knowledge of the violin-like sounds of spiny lobsters to refine their acoustic systems. The surprising fluid dynamics of mantis shrimp strikes likely will inform the design of ultra-rapid aquatic systems.

These fundamental discoveries and their potential for translation are why my research program is now funded by the Department of Defense. However, engineering-related applications are not the primary reason we do this research. The nature of discovery is that it is impossible to anticipate. The potential impacts on the world are often unknown at the time of discovery. For these reasons, discovery-based research is most fruitful when new knowledge is sought for its own sake without an eye toward solving specific human problems.

Nowadays, back in my lab, it is still a total thrill when we bring in new creatures and get to see their ultra-fast motions for the first time. Each movement that we visualize, each new increment in biological performance that we document, each time we solve the mechanics of a new system, and each analysis of the evolutionary processes underlying these extraordinary creatures is worthwhile. There is joy in these exciting, unanticipated discoveries, and at the same time, I feel confident that the unforeseeable outcomes of our basic scientific research will yield far-reaching and tangible contributions to the world.

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