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Theory and Funding for 21st Century Biology—Maybe

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Compared with other scientific disciplines, some leaders in the science community have said, biology is too heavily centered on facts, with too little emphasis on underlying theory. The propagation of this misperception in recent years has very likely contributed to a drive to allocate larger portions of the federal research budget to nonbiological disciplines, a move that some assume will have a "transformative" impact on the nation's research enterprise.

To stimulate thinking about the role of theory in biology, the National Science Foundation (NSF) Directorate for Biological Sciences (BIO) commissioned the National Academies of Science to study the explicit role that theory plays in shaping basic biological research. According to James Collins, the NSF's assistant director for BIO, the report—*The Role of Theory in Advancing 21st Century Biology: Catalyzing Transformative Research*—"shines a bright light on the fact that there are lots of theories in biology; it is a theory-rich discipline that goes beyond the theory of evolution."

Michael Mares, presidential professor of zoology and distinguished research curator of mammals at the University of Oklahoma, and chairman of the NSF BIO Advisory Committee, notes that much of the report will be self-evident to biologists. He points to one of the publication's chapters, "Are There Still New Life Forms to Be Discovered?" and comments, "I search for new species of mammals...and see new species and even genera or families being discovered on a regular basis—this is an easy question to answer. Certainly any entomologist would chuckle at the question." Yet Mares and other advocates for biology recognize the importance of restating this and similar questions so that the entire scientific and engineering enterprise can better understand the robust theoretical framework underlying biology.

Although the report was released with little fanfare in 2007, the document is quite good and deserves the attention of scientists from all disciplines, Mares says. Collins agrees, pointing out that *The Role of Theory* articulates opportunities for exciting new research at the fuzzy boundaries between biology and other disciplines. One chapter asks, "What Are the Engineering Principles of Life?" and proceeds to describe opportunities for applying engineering practices to the study of life: for example, in the emerging field of synthetic biology, biological units such as proteins, cells, and organs are viewed as modules that can be built, combined, or deconstructed. Another chapter explores how biology and other disciplines that grapple with the storage, accumulation, and transmission of information—including mathematics, computer science, and statistics—could mutually benefit from the exchange and application of theoretical ideas and tools.

To support the report's recommendations, the NSF's BIO has launched a grant program intended to encourage biologists to think about advancing the theoretical and conceptual understanding of biology in transformative ways, cutting across traditional disciplinary boundaries. However, a look at President Bush's 2006 American Competitiveness Initiative and at recent federal science budgets—in which investments in the physical sciences and engineering take priority over other disciplines—gives natural and social science advocates serious cause for concern. With so many calls for breaking down disciplinary boundaries and pursuing the best, most transformative research, why do the budget requests for the biological and social sciences lag so far behind others?

Take the fiscal year 2009 budget for the NSF, delivered to Congress on 4 February 2008 as part of President Bush's last budget proposal for the federal government. For two consecutive years, the percentage increases proposed by the administration for the NSF directorates that support physical science and engineering have been nearly twice the percentage increases proposed for BIO and the Social, Behavioral, and Economic Sciences Directorate. At a briefing after the budget's release, NSF Director Arden Bement eloquently described the scientific opportunities and discoveries that lay before the nation. His remarks justifying the NSF's $6.9 billion budget request included references to cutting-edge research in biology and the social sciences, research that has produced remarkable societal benefits—for example, findings from studies of neural networks have directly informed the development of artificial intelligence systems.

Following Bement's presentation, a member of the audience asked him about the less than robust investment in social science research, compared with other disciplines. The inquiry was particularly interesting, given the examples that Bement had just presented, coupled with research from the social science community—frequently cited by the Bush administration—that links American scientific research and innovation directly to global economic competitiveness. A growing segment of the scientific community continues to wait for an adequate answer.

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