The Next Innovation Revolution

U.S. FEDERAL INVESTMENTS IN BASIC RESEARCH TRANSFORMED LIFE AND COMMERCE IN THE 20th century. They sent us to the Moon and beyond, revolutionized communications, helped to feed the planet, reinvented work processes, and drove the remarkable economic growth of the post-1950s era in the United States. These advances and more grew out of the convergence between engineering and the early 20th-century discoveries in the physical sciences. The United States can anticipate comparable world-changing innovations in the 21st century if we adapt our education and research funding strategies to capitalize on new opportunities emerging at the convergence of the life sciences with the physical sciences and engineering.

This next convergence follows from the elucidation of the structure of DNA in the 1950s and from subsequent fundamental discoveries in molecular and cellular biology. These discoveries created a revolution in the life sciences and drove the development of recombinant DNA technology and the launch of the biotechnology industry. By the mid-1980s, the explosion of data from genomics and proteomics brought about a second revolution, further accelerating life science innovation.

These revolutions sowed the seeds of a third revolution that links the life sciences with engineering and the physical sciences in powerful new ways. Many of molecular biology’s founders came from the physical sciences, bringing to biology new analytical strategies and technologies. With the evolution of data- and technology-based biology, biologists worked increasingly closely with mathematicians, engineers, and physical scientists. Yet too often the relationship focused simply on developing new tools, with engineers serving more as service providers rather than as true collaborators, separately developing analytical technologies or computational strategies for analyzing data. With the demands for analyzing increasingly large data sets in genomics, understanding the complex network of molecular interactions in cells, and increasing resolution and accuracy in measuring and manipulating molecular and cellular events, what began as a relationship of convenience has become a flourishing partnership that now is rapidly advancing life science discoveries toward practical uses for society.

At the Massachusetts Institute of Technology (MIT), a third of the almost 400 engineering faculty engage the life sciences in their research. In many fields, the research frontiers are populated by biologists, engineers, computational scientists, and chemists. MIT’s new Koch Institute for Integrative Cancer Research includes biologists, chemists, and engineers working together to develop new strategies for cancer diagnosis, treatment, and prevention. Here and elsewhere, labs are, for instance, engineering nanoparticles to transport cancer-fighting agents selectively to tumor cells, thus minimizing injury to healthy tissue. Approaches like this could become a clinical reality within a decade. The evolving third revolution has, not surprisingly, produced a new academic discipline. The field is burgeoning: in 1996, U.S. universities awarded only 220 Ph.D.s in bioengineering and biomedical engineering; in 2006, that figure soared to 525.

Today, this convergence is spawning new discoveries and applications in areas from biomedicine to environmental science to energy technology. Accelerating these innovations will require many changes, from how we teach to how we fund research. Science and engineering students need a broad, more integrated education, so that they can work fluently across disciplines. We must also find more effective ways to evaluate and fund interdisciplinary research in the United States, including specifically promoting interdisciplinary work in the National Institutes of Health’s (NIH’s) programs for young investigators. Grant review committees will increasingly require multidisciplinary membership, and we will need to change the rules and practices that inhibit funding for projects that cut across federal funding agencies and NIH divisions. Finally, we need to change the way in which grants are awarded and administered: It’s needlessly difficult to secure funding for research that involves multiple investigators, departments, or institutions. Above all, scientists must convince the public, the Congress, and the Obama administration that funding research that cuts across the life, physical, and engineering sciences is a vital investment in human health, environmental well-being, and economic prosperity.

– Susan Hockfield

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