

EXPLORING THE PROMISES AND PERILS OF TECHNOLOGY

Molly Macauley

In the 20th century, environmental and natural resource problems were addressed mainly through command-and-control regulations. Now, in the 21st century, new approaches will be needed to deal with the less-tangible, less-easily managed problems that are emerging. New technologies will likely play a significant role in conquering complex challenges such as storing electrical energy and developing drought-resistant crops.

A distinguished panel of speakers joined the symposium to discuss these issues. In his opening remarks as panel moderator, John W. Rowe, chairman and chief executive officer of Exelon Corporation, emphasized the critical role of research and policy analysis that combines economics, understanding of social and environmental effects, and technological consequences. Cryogenically cooled transmission and switching equipment, more economic fuel cells, carbon sequestration technology, advanced biomass-based fuel cycles, and photovoltaics are examples of

emerging technologies that may confer not only economic advantages but possibly large environmental benefits, he said.

Dr. Rita R. Colwell, director of the National Science Foundation (NSF), described a dominant and radical change in the perspective of researchers working at this intersection of technology and quality of life. There is a shift from what has traditionally been labeled the study of “ecosystems” to the new field of “biocomplexity.” In biocomplexity, increasingly powerful information and communication technologies allow researchers to conduct ever more detailed analysis of the complexities and dynamics of the impacts of humans on natural systems.

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New technology in three areas—nanotechnology, biotechnology, and cognitive science—provides the foundation to enable biocomplexity research, Colwell said. To illustrate, nanoscale science now permits study of structures that are several billionths of a meter in size. At this scale, research is likely to open doors to new resource-conserving products, environmentally benign manufacturing processes, and less expensive and cleaner energy. Study of the behavior of microbial organisms is already leading to new approaches for environmental remediation.

Genomics and its offspring, biotechnology, have long enabled salt-tolerant and drought-resistant crops, but new research is producing nutritionally enhanced foods and charting relationships between the smallest living organisms and human development, including possible evidence of microorganisms inhabiting areas of the world that weren't thought to be capable of supporting life, such as the south pole ice, arctic glaciers, and volcanic lava. Colwell's own research in biotechnology and genomics discovered a link between mine tailings discarded in streams and other waterways and the development of antibiotic-resistant bacteria.

In cognitive science, better understanding of how humans learn has major implications for resource use. For example, pioneering work at the nexus of the psychology of cognition and experimental economics (for which, Colwell noted, the 2002 Nobel Prize in Economics was awarded) is paving the way for designing new ways to allocate scarce public resources such as auctioning the electromagnetic spectrum and trading permits for managing air emissions.

Sergey Brin, co-founder and president for technology at Google, Inc., echoed Colwell's optimism about the future of technology. He described a project under development at Google and in collaboration with Stanford University to make use of a new public good—the “down time” of millions of personal computers. Individuals can agree to allow Stanford to use the computing capacity of their computers overnight; Stanford will access the computers by way of the Google browser. Stanford will use this capacity to assist



Panelists: Paul M. Romer, Stanford University Graduate School of Business; Sergey Brin, co-founder and president—technology, Google, Inc.; Rita R. Colwell, director, National Science Foundation; John W. Rowe, chairman and CEO, Exelon Corp.; and Thomas Friedman, foreign affairs columnist, *New York Times*, and symposium moderator.

in performing the huge number of calculations that are required to simulate how proteins work for medical research. Using just one computer, a single simulation would require some 3,000 years, but by marshalling millions of computers, the research will progress fast enough to be manageable.

Brin also agreed with Colwell on the promise of nanotechnology. Brin noted its potential contribution to development of stronger, lighter-weight materials

that, for instance, could offer easier access to outer space (by way of space “tethers”). Manufacturing these materials remains prohibitively expensive, but use of massive computational capacity, again by way of using spare capacity on personal computers, may enable faster progress in researching new materials manufacturing processes.

Paul M. Romer, professor of economics, Stanford University School of Business, emphasized the role of property rights in encouraging new, environmentally beneficial technology. He cited a lightweight means of storing electrical energy as one of the most important current environmental challenges, and noted recent progress in alternatives to conventional lithium ion batteries. The alternatives involve developing creative modifications of the “recipe” to add materials to improve conductivity, and protecting rights to these recipes, which will be key to encouraging their development.

Romer called for training of more scientists and engineers and developing new ways to encourage them to work in the “mixing zone” of research and application, namely the private sector. He expressed regret that incentives work against attracting talent to the mixing zone and that there is “no effective constituency for the public good of producing scientists and engineers to create idea-based benefits.” More thought should be given to designing such incentives,

much in the same way that environmental economists have created market-like incentives for managing natural resources, he said.

During the question-and-answer session, panelists agreed that new research often brings unexpected results and that, when appropriate, these results must be effectively channeled into useful products and services.

Brin mentioned, for example, that the technology that his company originally developed was not intended to be an algorithm for Google’s search engine capability, and Colwell noted that high-tech robots called into play for searching rubble in the aftermath of the destruction of New York’s World Trade Center in September 2001 were developed under basic research funding by NSF and the Defense Advanced Research Projects Agency. In both cases, researchers were quick to spot useful although unanticipated

applications for these new technologies.

Given the potentially significant contributions that new technologies can make to the world’s problems, the panelists called for a better balance between unfettered science and engineering research, much like that funded by NSF, and more encouragement for researchers to work at the intersection of the laboratory and the private sector. ■

**WE NEED BALANCED AND
THOUGHTFUL CONSIDERATION
OF THE CONSEQUENCES OF
DEPLOYING OUR NEW KNOWLEDGE AND TECHNOLOGIES ON
THE PLANET AND OURSELVES.
IN WORKING THROUGH THESE
CONUNDRUMS, WE’RE GOING
TO NEED THE CONTRIBUTIONS
OF [ORGANIZATIONS] LIKE RFF
MORE THAN EVER BEFORE.**

—RITA R. COLWELL